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[54] DRILLING AND THREAD FORMING FASTENER

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[52] **U.S. Cl.** **85/47**, 10/10, 408/230
[51] **Int. Cl.** **F16b 25/00**
[58] **Field of Search** .... 85/47, 41; 76/108 R, 76/108 T; 408/230; 10/10

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Attorney—Albert H. Pendleton, Sidney Neuman, William J. Birmingham et al.

[57] **ABSTRACT**

This improved non-walking, non-skittering drilling and thread forming fastening screw, which may be manufactured by simplified, versatile techniques, features a pair of oppositely disposed, substantially longitudinally extending flutes at the entering end, the flutes having at least one curved flute side, at least a portion of which includes the cutting edge, said curved flute side being convexly curved adjacent the cutting edge, a plane tangent to the convexly curved surface at the cutting edge being inclined at an angle to and traversing the axis of the screw at an intermediate point of the shank.

3 Claims, 13 Drawing Figures

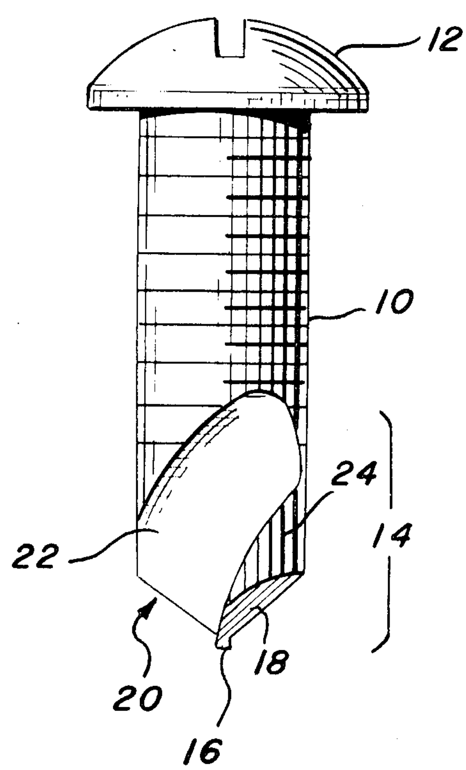


FIG. 1

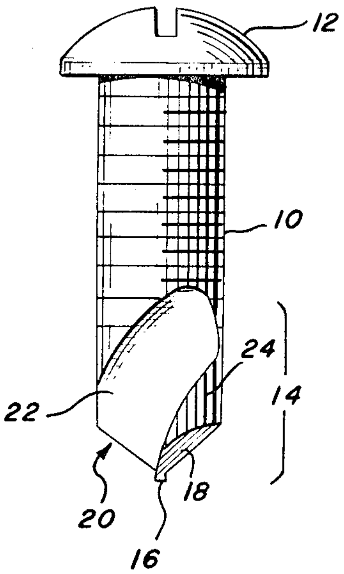


FIG. 2

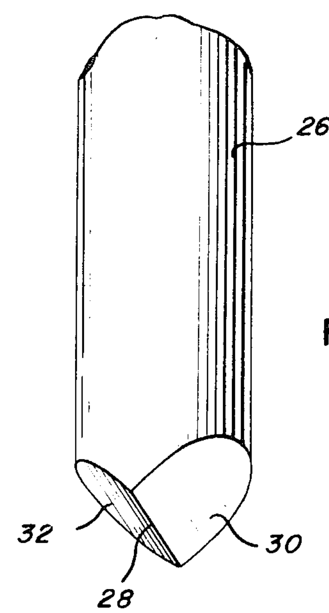


FIG. 3

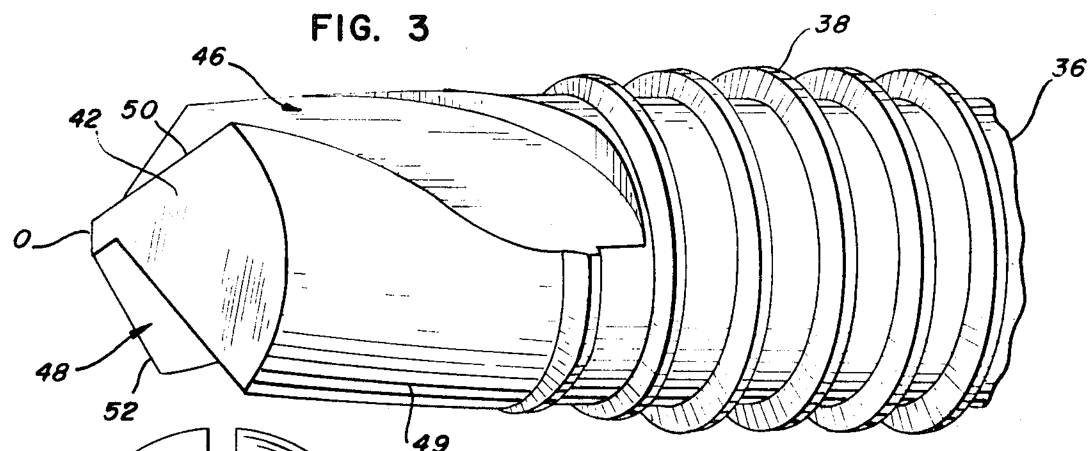


FIG. 4

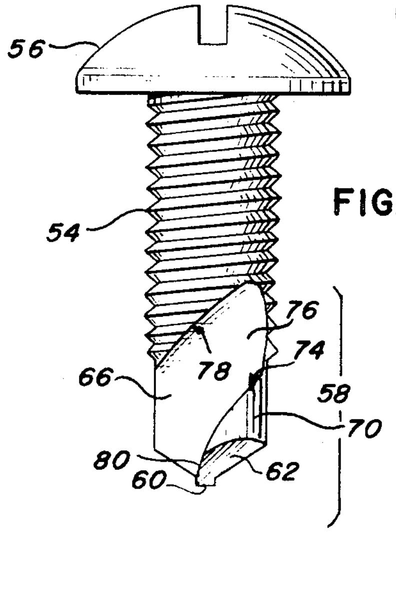
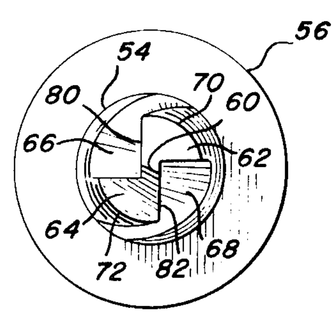


FIG. 5



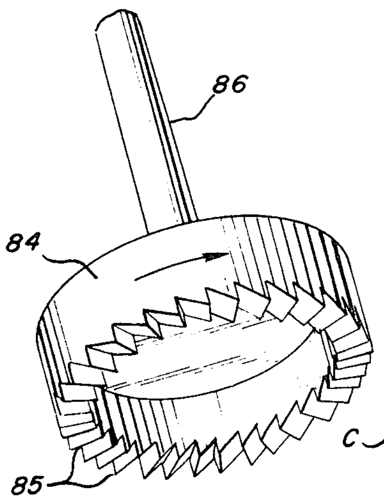


FIG. 6

FIG. 8

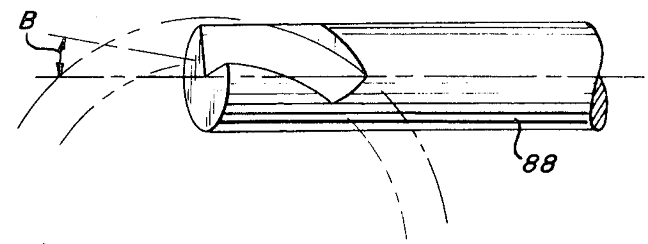
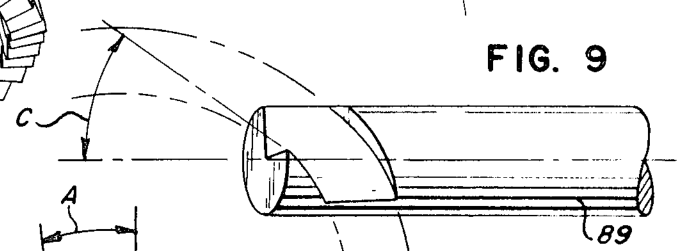


FIG. 9



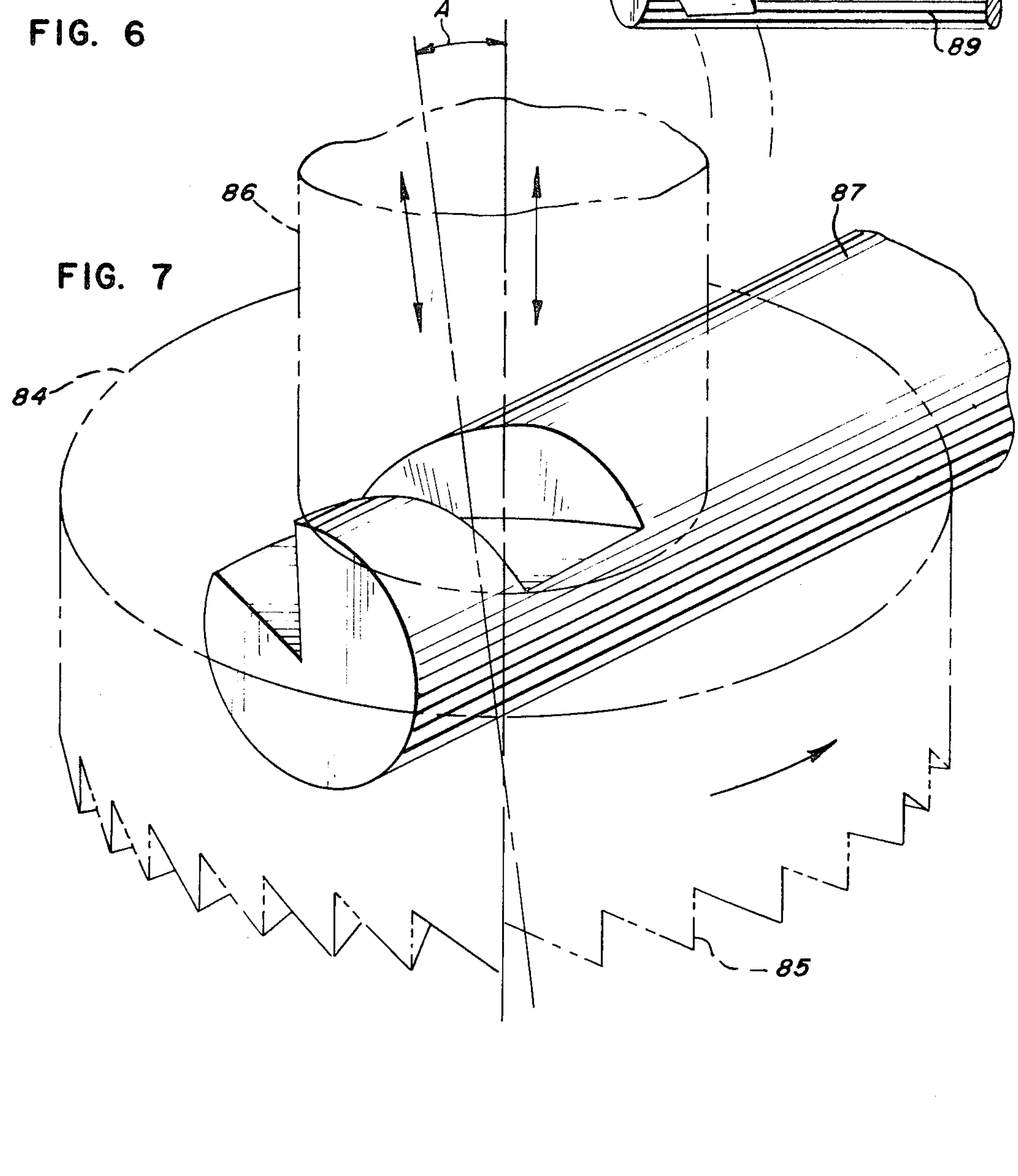
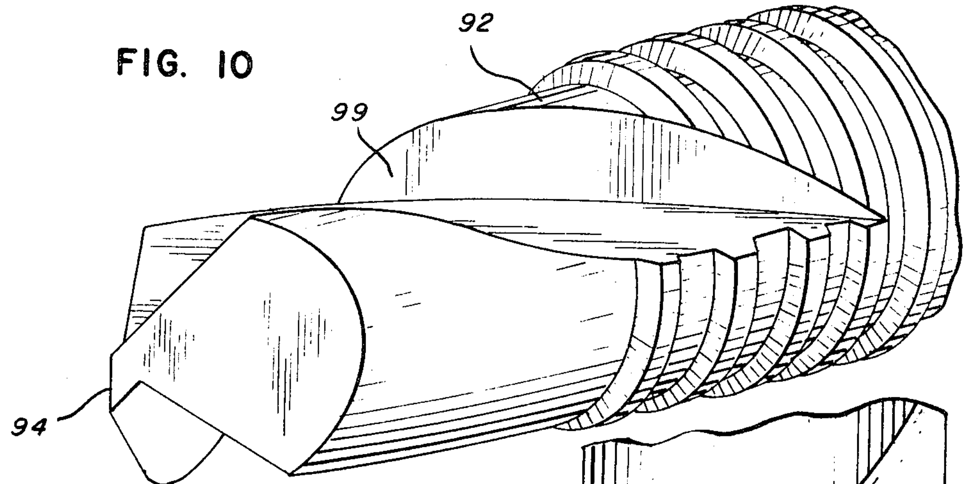


FIG. 7

FIG. 10



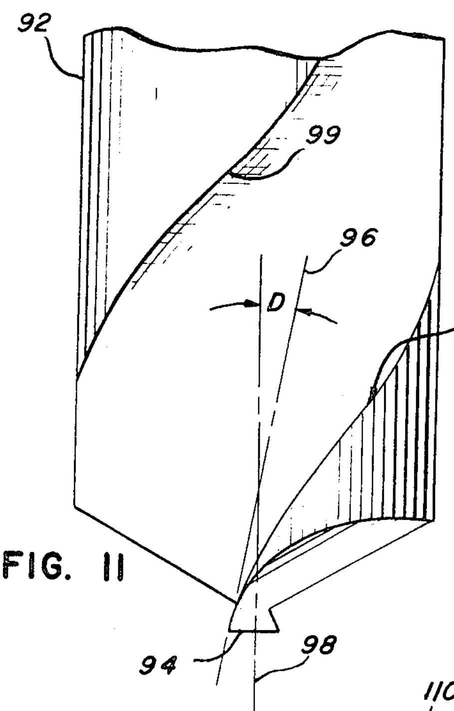


FIG. 11

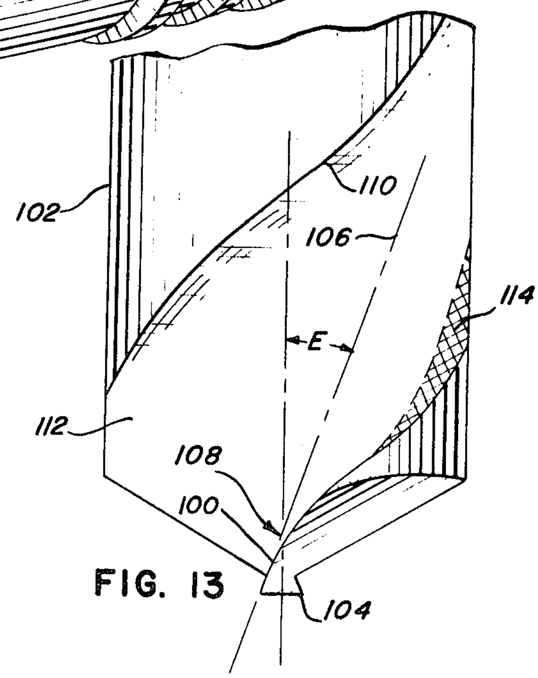


FIG. 13

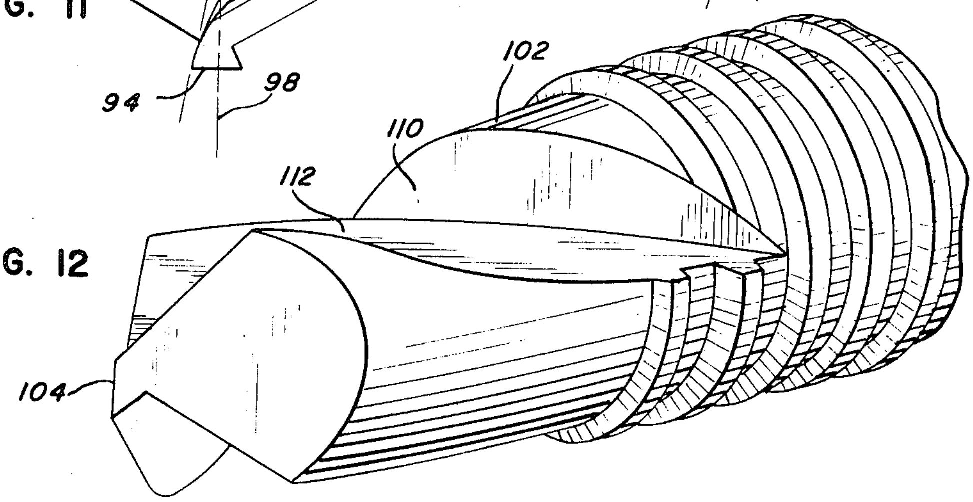


FIG. 12

DRILLING AND THREAD FORMING FASTENER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved drilling and thread forming fastener having a pair of opposed flutes of unique configuration and disposition which impart improved drilling performance thereto. More specifically, it relates to a fluted self-drilling and self-tapping threaded fastener wherein the flutes have a "tangential rake-angled" configuration and are disposed relative to complementary structure of the fastener, as herein described, so as to produce a fastener having desired anti-walking and anti-skittering qualities, reduced drilling time and pressure requirements and a design which lends itself to simplified, low cost manufacture.

While the present invention will be described with particular reference to advantageous embodiments designed specifically to cope with problems associated with drilling "sticky" soft metal such as aluminum, it should be understood that the invention is not limited thereto. The design can also be readily adapted to various screw-type fasteners for various other metals including steel as well as non-metallic materials having distinctly different properties, e.g., plastic, wood, and the like, as those skilled in the art will recognize in the light of the present disclosure.

2. Description of the Prior Art

Self-drilling and self-tapping screws in one form or another have been proposed, particularly for specific purposes, for many years, as exemplified by the disclosures of such patents as U.S. Pats. Nos. 1,294,268, 2,388,482, 2,403,359, 2,479,730, 2,871,752 and 2,956,470. The assignee of the present invention and application has also been active in this field, as evidenced by a number of patents issued to it, i.e., U.S. Pats. No. 3,094,893, 3,094,894 and 3,094,895.

The interest in self-drilling and self-tapping fasteners has greatly increased in recent years, as reflected in many patents such as, for example, U.S. Pats. Nos. 3,044,341, 3,079,831, 3,125,923, 3,207,024, 3,238,836, 3,241,426, 3,288,015, 3,318,182, 3,395,603, 3,438,299, 3,463,045, 3,507,183, 3,517,581 and 3,578,762. Several of these prior art self-drilling and self-tapping screws have met with considerable commercial success, thus offering incentives for improved designs which may develop new applications and new markets or achieve a share of existing markets.

Any successful design must at the minimum take into consideration at least two vital factors. These are performance of the self-drilling and self-tapping fastener and the economic feasibility of producing and selling it profitably.

Fastener performance is reflected, for example, in the axial force or pressure and time required to drill and tap the hole and secure the fastener in place. The workman who must apply axial forces with an extended arm is immediately aware of these critical force-time interrelationships. Excessive force-time interrelationships also limit the maximum practical diameter of the fastener for many purposes.

Another important performance criterion is whether the fastener has an excessive tendency to "walk" or "skitter" when it is first rotated against the surface to be drilled and fastened, particularly when no centering indentation is present. Another important consideration is whether the fastener design can be readily tailored for various fastening requirements, including the drilling of metals of various hardnesses and thicknesses, the drilling of holes of various diameters, and the like.

Another factor is whether the fastener design can be readily adapted to provide desired chip breaking characteristics. A related factor is whether the fastener can cope with abnormal amounts of chips and whether it can rid itself of chips before they enter and befoul the threads. Still another related consideration is whether the fastener can purge itself of soft metal chips which tend to cling to the flutes and stick or self-weld, thereby stopping chip removal and in turn stopping the drilling action.

The art is aware of structural features which enhance such performance characteristics, e.g., thin webs, short chisel edges, and the like. But prior art fasteners have necessitated severe comprises of optimum design in order to meet other requirements, e.g., adequate structural strength, ease of manufacture and the like. For example, one commercial drill screw employs an undesirably long chisel edge so that the cutters employed in the manufacture thereof do not collide and the interflute webs are not unduly thin.

The economic feasibility of marketing a fastener is determined by a number of factors such as, for example, whether the fastener design lends itself to simplified production techniques, the speed or rate at which the fastener can be produced, the complexity and thus capital investment for the production machinery and the like. The finest fastener from a performance standpoint has little value if it can't be produced and used at costs reasonably competitive with alternative fastening means. The interrelationship of performance and costs must, however, be considered in determining the overall cost of the fastening function.

The fastener of the present invention provides both improved performance along the lines above indicated and a design which lends itself to simplified manufacture, as more fully reflected in the following objects.

OBJECTS OF THE INVENTION

It is therefore a general object of the present invention to provide a fastener having improved performance characteristics. It is another general object to provide a fastener having a design which lends itself to high speed manufacture by relatively simple production techniques and non-complex production machinery. It is another general object to provide a self-drilling and self-tapping fastener having a geometry which does not require the comprise of optimum design for manufacturing convenience or expediency.

It is a specific object to provide a self-drilling and self-tapping fluted fastener, the design of which can be readily adapted for fastening a variety of materials, including aluminum, by, for example, varying the size, length, width, depth, angular relationships and disposition of the flutes. It is another specific object to provide a self-drilling, self-tapping fluted screw which can be varied in configuration, particularly the length of the flute and the rake angle, without substantial alteration of the machinery producing it.

It is another specific object to provide a self-drilling fastener which has little tendency to "walk" or "skitter". It is another specific object to provide a self-drilling and self-tapping screw requiring lower drilling forces or pressures. It is another specific object to provide a self-drilling and self-tapping screw having reduced drilling times.

It is another specific object to provide a self-drilling and self-tapping fastener having desirable chip breaking characteristics and the capability of getting rid of abnormal amounts of chips as well as soft metal chips which tend to stick to the flutes. It is still another specific object to provide a self-drilling and self-tapping screw which purges itself of chips which might otherwise enter and befoul the threads.

It is still another specific object to provide a fluted self-drilling and self-tapping screw having flutes which do not diminish in width from the point area. It is still another specific object to provide a fluted self-drilling and self-tapping screw having a relatively thin web and short chisel edge as well as adequate structural strength. It is still another specific object to provide a design for a self-drilling, self-tapping fastener which permits large practical shank diameters for a given drilling force-drilling time relationship.

These and other objects of the present invention will become apparent as the detailed description proceeds.

SUMMARY OF THE INVENTION

These objects are achieved, in brief, by a fastener comprising an elongated threaded shank with means at one end for turning the fastener and a fluted entering end portion having a unique design and disposition. The unique design of the entering end portion is characterized by a pair of "tangential rake-angled" flutes. By this is meant that the flute has at least one curved side, at least a portion of which includes the cutting edge, the curved flute side adjacent the cutting edge being convexly curved and a plane tangent thereto being inclined at an angle to and tranversing the axis of the shank at an intermediate point.

In a particular embodiment, the flute is defined by three flute sides including two spaced, opposed, curved surfaces having at least portions with a common axis of curvature and an intermediate connecting surface. In still another embodiment, the curved surface having the convexly curved portion adjacent the cutting edge has a reverse curvature flowing therefrom resulting in a concavely curved portion, the entire curved flute side lying on one side of the plane tangent to the convexly curved surface at the cutting edge.

In still other particular embodiments, the design and disposition of the flute is such that the cutting edges of the screw are disposed at an angle of about 10° to 80° to the chisel edge forming the tip, the rake angle at the cutting edge is about 5° to 25°, the web thickness is in the range of about 0.01 to 0.04 inch, and the included angles is in the range of about 90° to 150°. In all embodiments adequate clearances are present, and shank portions intermediate the flutes provide sufficient strength and bearing surface for efficient drilling and thread forming action. These parameters and structural details and the disposition of the flutes in relation thereto are more fully explained in connection with the specific description set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the following detailed description of a specific embodiment read in conjunction with the accompanying drawings, wherein:

FIG. **1** is a diagrammatic elevation view showing a screw incorporating features of the present invention;

FIG. **2** is an enlarged fragmentary perspective view showing a screw blank with a chisel edge formed thereon preparatory to milling the flutes of the present invention thereon;

FIG. **3** is a still further enlarged fragmentary perspective view of the entering end portion of an embodiment of the fastener of the present invention which is similar to that of FIG. **1**;

FIG. **4** is an elevation view of a preferred embodiment similar to that of FIG. **1** but on a slightly enlarged scale and showing additional details;

FIG. **5** is an entering end view or bottom view of the embodiment of FIG. **4**;

FIG. **6** is a perspective view of one form of the end mill cutter employed in milling the flutes of the fastener of the present invention;

FIG. **7** is a diagrammatic view showing how a cutter of the type portrayed in FIG. **6** may be adjusted to cut flutes of differing configurations in screw blanks;

FIGS. **8** and **9** are fragmentary perspective views of screw blanks, further illustrating how the shape and position of the flute can be readily varied;

FIG. **10** is a fragmentary perspective view of an entering end portion having a reverse curvature flute;

FIG. **11** is a fragmentary elevation view providing further details of the reverse curvature flute of FIG. **10**;

FIG. **12** is a fragmentary perspective view similar to FIG. **10** but illustrating a flute having a more pronounced rake angle for the cutting edge;

FIG. **13** is an elevation view providing further details of the reverse curvature flute of FIG. **12**.

It should be understood that the drawings are not necessarily to scale and that graphic symbols and diagrammatic representations are employed in certain instances. Thus, the drawings may depart in certain respects from appearances when visually observed. It should also be understood that the invention is not necessarily limited to the particular embodiments illustrated herein.

DETAILED DESCRIPTION OF THE DRAWINGS INCLUDING PREFERRED EMBODIMENT

Referring to FIG. **1**, the drilling and thread forming screw of the present invention comprises elongated shank **10** having a slotted head **12** and an entering end portion generally indicated at **14**. The entering end portion **14** includes a tip, having a centered terminal chisel edge **16**, which is substantially perpendicular to the longitudinal axis of the shank, and a pair of symmetrically disposed flat side surfaces **18** and **20** (hidden except for the edge) on each side of chisel edge **16** so as to diverge angularly outwardly and intersect the shank periphery.

The shank includes a pair of oppositely-disposed, substantially longitudinally extending identical milled flutes **22** with intermediate strengthening shank portions **24** between the flutes to provide sufficient bearing surface. While flutes **22** are substantially longitudinally extending, they also extend substantially transversely relative to the axis as viewed, for example, in FIGS. **1**, **4**, **8**, **9**, **11** and **13**. As set forth hereinafter, certain aspects of the design and disposition of the flute are critical to overall performance.

The drilling and thread forming screw may have a shank diameter of any desired size up to the practical limits dictated by the maximum tolerable drilling forces for a given set of conditions. Some prior art screws of the present type were often limited by such practical considerations to shank diameters of about one-fourth inch. It is expected that the greater drilling efficiency of the screw of the present invention would increase maximum shank diameters to as much as 5/16 to ⅜ inch under similar conditions.

Referring to FIG. 2, a fragmentary screw shank **26** is shown in an intermediate stage of production. A center chisel edge **28** is formed by milling intersecting flat side surfaces **30** and **32** at the terminal end. The included angle between the intersecting flat side surfaces is in the range of about 90° to 150°, preferably 100° to 140°. As will be apparent from consideration of subsequent figures, particularly FIG. **5**, the angular relationship of the chisel edge and the cutting edges of the unique flutes of the present invention, as seen from a plane perpendicular to the axis of the drill, is predetermined empirically and usually falls in the range of about 10° to 80°, preferably about 20° to 70°, e.g., about 60°.

Referring to FIG. **3**, screw shank **36** has a thread convolution **38** commencing at an intermediate portion thereof and an end portion with chisel edge **40**, opposed flat side surfaces **42** (only one being visible), and elongated flutes **46** and **48** having opposed intermediate strengthening shank portions **49** (only one being visible). The intersection of one of the side walls of each of the flutes with the respective flat side surfaces produces cutting edges **50** and **52**.

Referring to FIGS. **4** and **5**, threaded shank **54** has slotted head **56** at one extremity and entering end portion **58** at the other extremity. The thread convolutions adjacent the entering end portion have a progressively increasing diameter, the greatest diameter being greater than the diameter of the entering end portion. The entering end portion comprises chisel edge **60**, flat side surfaces **62** and **64** and milled flutes **66** and **68**. Intermediate shank portions **70** and **72** strengthen the structure and provide sufficient bearing surface for efficient drilling and thread forming action.

The flutes are defined by respective intersecting flute sides **74, 76** and **78**. In a preferred embodiment, flute side surfaces **74** and **78** are curved as arcs of circles having a common center of curvature. Flute side **74** intersects flat side surface **62** and a portion of flat side surface **64** on opposite sides of chisel edge **60**. As already indicated, the flutes are disposed so that the resulting cutting edges **80** and **82** are at an angle of about 10° to 80° to chisel edge **60**.

In general, the web (the central portion of the drill body connecting the lands) should be as thin as possible, taking into consideration the need for adequate structural strength. The thinner the web, the faster the drill time. Webs substantially thinner than about 0.01 inch, however, may result in excessive point breakage. Webs thicker than about 0.04 inch may fail to drill.

As will be apparent from subsequent figures, a plane tangent to convexly curved surface **74** at chisel edge **60** is inclined at an angle with respect to the longitudinal axis of the shank so as to traverse the axis at an acute angle intermediate chisel edge **60** and head **56**. This assures a positive rake angle, e.g., about 5° to 25°, preferably about 10° to 20°.

The milled flutes or slots of the present invention lend themselves to simplified high-speed production techniques. For example, the flutes can be readily milled into a screw shank by use of a rotating end mill cutter. As illustrated in FIG. **6**, such a cutter may comprise circular head **84** with end cutting teeth **85** and concentric shaft **86** for rotation.

As diagrammatically illustrated in FIG. **7**, the end mill cutter straddles the blank **87** adjacent the end and, upon being rotated and reciprocated, cuts the significant drilling surfaces with the inside wall of the cutter. This provides the desired tangential radius effect plus a rake angle. This tangential radius effect does not permit a curling chip to follow the contours of the flute and thus stick or weld to it, a significant advantage when drilling soft "sticky" materials such as aluminum. Moreover, the flute does not diminish in width as it leaves the flute area and, in fact, broadens.

Another advantage lies in the fact that the size, length and disposition of the flute can be readily adjusted by using different size cutters, by locating the axis of the cutter at different locations, and by tilting or otherwise adjusting the angular relationship of the axis relative to that of the screw blank. This tilting of the axis is suggested, for example, by angle A in FIG. **7**.

The use of different size cutters and the different locations thereof relative to the screw blank are illustrated in FIGS. **8** and **9**. It is readily apparent that the length, width, and rake angle of the flutes in blanks **88** and **89** are readily varied. As a result, for example, the rake angle B of the flute in FIG. **8** is substantially smaller than rake angle C of the shorter flute in FIG. **9**.

Manifestly, where the flute extends into the threaded area, several thread cutting notch options are present by tilting the cutter axis. For example, one may design a sharp cutting edge having an acute angle to tap threads or one may have the cutting slot above center where an obtuse cutting edge will tap threads that provide a prevailing torque or thread lock.

In FIGS. **10** through **13**, alternate embodiments are presented wherein the flute side forming the cutting edge (as well as the opposed side) is characterized by a reverse curvature. Thus, in FIGS. **10** and **11**, as in the embodiments of the other figures, flute side **90** formed in shank **92** is convexly curved adjacent chisel edge **94** and the cutting edge so that a plane tangent thereto, as suggested by plane **96**, intersects axis **98** at an acute angle D, e.g., about 5° to 25°. Above the chisel edge and cutting edge, however, the curvature reverses whereby a concave contour is produced. This provides a stronger, less fragile point than if the convex curvature continued.

While both flute sides **90** and **99** have similar reverse curvatures, such need not necessarily be the case. Only one may have the reverse curvature; or if both have the reverse curvatures, they need not be similar as those skilled in the art will recognize in the light of the present disclosure.

Similarly, in FIGS. **12** and **13**, flute side **100** in shank **102** is convexly curved adjacent the cutting edge and chisel edge **104** and concavely curved at the upper portion thereof. A plane tangent to side **100** adjacent chisel edge **104**, as depicted by plane **106**, intersects a plane through the axis of the screw shank at point **108**, thereby forming an acute angle E in a range of about 5° to 25°. This imparts the desired positive rake angle to the cutting edge.

Similarly, flute side **110**, which is separated from side **100** by flat intermediate flute bottom **112**, has a reverse curvature, convex adjacent the chisel edge and concave towards the threaded portion. The curvature of flute side **100** (and optionally, flute side **110**) can be adjusted to strengthen the point still further, as indicated, for example, by the dashed and crosshatched section **114.**

Because of manufacturing complexities associated with the double curvature of the flute sides in the embodiments of FIGS. **10–13,** it may be desirable to employ the forging method for fabricating the entering end. Alternatively, programmed dadoing could also be used.

From the above description it is apparent that the objects of the present invention have been achieved. While only certain embodiments have been set forth, alternative embodiments and various modifications will be apparent from the above description to those skilled in the art. These and other alternatives are considered equivalents and within the spirit and scope of the present invention.

Having described the invention, what is claimed is:

1. A drilling and thread forming screw comprising an elongated shank and means at one end of said shank co-operable with a tool for turning the screw,

a. said shank having at the other end thereof an entering end portion having a tip centered about the longitudinal axis of the screw and comprising a terminal chisel edge intersecting and substantially perpendicular to the longitudinal axis of the shank with a symmetrically disposed substantially flat side surface on each side of said terminal chisel edge, each diverging angularly outwardly at an included angle of about 90° to 150° and each intersecting the shank periphery intermediate the terminal chisel edge and said means for turning the screw,

b. said shank including a trailing portion having a plurality of integral thread convolutions, the convolutions adjacent the entering end portion having a progressively increasing diameter, the greatest diameter of the thread convolutions being greater than the diameter of the entering end portion,

c. said entering end portion having a pair of oppositely disposed substantially longitudinally extending flutes therein with intermediate strengthening shank portions between the flutes to provide sufficient bearing surface for efficient drilling and thread forming action,

d. each of said flutes being defined by first and second opposed curved flute sides having at least portions with a common axis of curvature and a connecting substantially flat flute side, each of said first curved flute sides extending from the shank periphery adjacent said trailing portion into and beyond said terminal chisel edge, thereby intersecting the adjacent of said symmetrically disposed flat side surfaces and a portion of the other of said symmetrically flat side surfaces at opposite sides of said terminal chisel edge,

e. the intersection of each said first curved flute side with the respective adjacent of said symmetrically disposed flat side surfaces providing a cutting edge disposed at an angle of about 10° to 80° to said terminal chisel edge, the web between the respective cutting edges having a thickness of about 0.01 to 0.04 inch,

f. each of said first curved flute sides being convexly curved at least adjacent said cutting edge, a plane tangent to the convexly curved surface at the cutting edge being inclined at an angle with respect to a plane containing the longitudinal axis of the shank so as to traverse the plane containing the longitudinal axis at an angle of about 5° to 25° intermediate said chisel edge and said means for turning the screw, whereby to provide a positive rake angle at said cutting edge,

g. said terminal chisel edge being disposed to initially engage and extrude material from the workpiece, thereby progressively exposing the workpiece to said cutting edges and the thread convolutions.

2. The drilling and thread forming screw of claim **1** wherein said first curved flute side has a reverse curvature including the convexly curved portion adjacent said cutting edge and a concavely curved portion flowing therefrom, substantially all portions of said first curved flute side lying on one side of said plane tangent to the convexly curved surface at the cutting edge.

3. The drilling and thread forming screw of claim **1** wherein said milled flutes extend into at least a portion of the shank having thread convolutions of progressively increasing diameter.

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