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| Inventor(s) | Dilling; Gary |

Fastener system with stabilizer ribs

Abstract

Fasteners, drivers, punches, fastener systems, and methods of making fasteners, drivers, punches, and fastener systems are disclosed herein. The fasteners, drivers, punches, and fastener systems include, in one example, stabilizing ribs and corresponding recesses.

| | |
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Background/Summary

RELATED APPLICATIONS (1) This application is a continuation of U.S. patent application Ser. No. 15/616,461, filed Jun. 7, 2017, now U.S. Pat. No. 10,953,522, which claims priority under 35 U.S.C. § 119(e) to U.S. provisional patent application 62/360,741 filed on Jul. 11, 2016, the entirety of each of which are incorporated herein by reference.

BACKGROUND

(1) Use of powered tools to drive threaded fasteners at high speed and high torque loads results in high forces applied by the driver to the fastener. Although many threaded fastener drive systems, particularly those with a driver-engageable recess in the fastener head, are designed to have surfaces that are engaged by corresponding surfaces on the driver, such ideal surface-to-surface engagement, at best, is difficult to achieve in practice. Rather than surface-to-surface engagement between the driver and fastener, by which the driving load can be distributed over a broad surface area, driver-recess engagement often is concentrated in small areas or points. Further, this is exasperated when the driver-recess engagement is not in line.

(2) This may result from a number of factors such as inconsistencies in the manufacture of the fastener or the driver, as well as difficulties encountered in the field. Field-encountered difficulties may include, for example, misalignment of the driver and fastener or inability to fully seat the driver in the recess because of paint or other debris that may have collected in the recess. Even slight misalignment between the driver and the fastener, or a variation of the fastener or driver from design specifications, can result in substantial reduction in the area of contact between the driver and fastener, in many cases resulting in near point-like contact of several portions of the driver and fastener. Application of high torque under such circumstances necessarily results in concentrated stresses in the materials of the driver and the recess that, in turn, can lead to failure of the material, either by plastic deformation or fracture. Even slight plastic deformation of the engagement surfaces of the recess and driver can adversely affect system performance. If the recess deforms to define ramp-like surfaces inclined from the vertical, the driver may “cam-out” of the recess under the influence of the applied load. Such cam-out is undesirable, not only because it results in premature or uncontrollable disengagement of the driver and recess, but also because the suddenly disengaged driver can slip onto and damage the work piece. Additionally, excessive stress in the driver blade while driving the fastener can cause the blade to deform in a manner that reduces the surface area contact with the fastener and effectively shifts the region of contact radially inwardly, thereby reducing the effectiveness of driver-recess engagement and increasing the risk of failure.

(3) It would be desirable to provide improvements in recessed head fasteners and drivers by which the foregoing and other difficulties are reduced or eliminated and stability is increased.

SUMMARY

(4) Disclosed herein are various fasteners, fastener systems, drivers, punches, and methods of forming fasteners systems. Example fasteners may include a driver-engageable recess formed at an end thereof, the recess including a central core having a bottom region and a plurality of wings radiating outwardly from the central core, the wings each being defined by a pair of sidewalls and an outer transition surface adjoining the sidewalls, the outer transition surface extending from a top of the recess and connected to the bottom region and forming a bottom region transition edge at the intersection of the bottom region and the outer transition surface. In one example, a fastener may include an inner transition surface connecting a sidewall of a first wing to a sidewall of a second wing, the first and second wings being adjacent to each other. In another example, the fastener may include a groove in an inner transition surface extending in a radially outward direction from the inner transition surface, the groove extending from a first distance from the bottom region transition edge to a second distance from the bottom region transition edge. In one particular

example, the first distance is non zero. In one example, the groove extends to a top of the recess. And in yet another example the groove comprises a first and second groove walls, the first and second groove walls meeting at a groove apex, the groove apex being tapered radially inward toward a longitudinal axis of the fastener as the recess groove extends in a direction from the top of the recess toward the bottom region.

(5) In one example, a groove apex is tapered at an angle of about 10.4 degrees from the longitudinal axis of the fastener. In another example, there is an angle of about 50.4 degrees between a first and a second groove walls. In one example, a groove apex intersects the inner transition surface at the first distance from the bottom region transition edge. And in yet another example a bottom region has a bottom recess tip that is a third distance from the bottom region transition edge. In one example the first distance is greater than about 0.04 inches.

(6) Disclosed herein are example fasteners, where, in one example a first and second intersection lines, formed at the intersection of the first and second groove walls with the transition surface, respectively, form an angle of between about 6.5-7.0 degrees between them. In another example the inner transition surface is tapered at an angle of between about 3.5 degrees and about 4.0 degrees from a longitudinal axis of the fastener. In one example at least one of the sidewalls further includes a relieved region defined radially inward of its associated outer transition surface to define a relatively raised torque pad between its respective outer transition surface and the relieved region, the torque pad being an elongate strip and extending longitudinally along a margin of the sidewall that adjoins the outer transition surface. And in yet another example the recess comprises four wings and at least two of the inner transition surfaces have the recess groove. And in yet another example at least one of the sidewalls is configured to define a segment of a spiral. In one example, at least one of the inner transition surfaces includes an interference surface having a top and a distance from the top to the bottom region transition edge is less than the first distance.

(7) Disclosed herein are fastener systems. In one example a fastener includes a central recess core having a bottom region. In one example a fastener includes a plurality of wings radiating outwardly from the central recess core, the wings each being defined by a pair of recess sidewalls and a recess outer transition surface adjoining the recess sidewalls, the recess outer transition surface extending from a top of the recess and connected to the bottom region and forming a bottom region transition edge at the intersection of the bottom region and the outer transition surface. And in another example, at least one recess inner transition surface connecting a recess sidewall of a first wing to a recess sidewall of a second wing, the first and second wings being adjacent to each other. And in yet another example a recess includes a groove in the inner transition surface extending in a radially outward direction from the inner transition surface, the groove extending from a first distance from the bottom region transition edge to a second distance from the bottom region transition edge. And in yet another example, the first distance being non zero.

(8) In one example a fastener system includes a driver for engaging the recess of a fastener, the driver including a shank portion and a recess-engaging portion formed at an end of the shank portion, the recess-engaging portion comprising a central driver core having an end region and a plurality of lobes radiating outwardly from the driver central core, each lobe being defined by a pair of driver sidewalls and a driver outer transition surface adjoining the driver sidewalls, the driver outer transition surface extending from the shank portion and connected to the end region and forming an end region outer transition edge at the intersection with the driver end region. And in yet another example, at least one driver inner transition surface connecting a driver sidewall of a first lobe to a driver sidewall of a second lobe, the first and second lobes being adjacent to each other. In one example, a driver includes a stabilizing rib on the driver inner transition surface extending in a radially outward direction from the driver central core, the stabilizing rib extending from a first distance from end region outer transition edge to a second distance from the end region outer transition edge, the first distance being non-zero. And in yet another example the groove comprises a first and second groove walls, the first and second groove walls meeting at a groove

apex, the groove apex being tapered radially inward as the recess groove extends in a direction from the top of the recess toward the bottom region. And in another example, a stabilizer rib comprises a first and second rib walls, the first and second rib walls meeting at a rib apex, the rib apex being tapered radially inward as the stabilizer rib extends toward the end region.

(9) In one example, the groove apex is tapered at an angle with respect to a longitudinal axis of the fastener and the stabilizer apex is tapered at an angle with respect to a longitudinal axis of the driver, the groove apex taper angle being larger than the stabilizer apex taper. And in another example a groove apex is tapered at an angle of about 10.4 degrees from the longitudinal axis of the fastener. And in another example the stabilizer apex is tapered at an angle of about 7.5 and 8.5 degrees from the longitudinal axis of the driver. And in yet another example, there is an angle of about 50.4 degrees between the first and second groove walls. In one example wherein there is an angle of about 70 degrees between the first and second stabilizer walls. In another example, the groove apex intersects the inner transition surface at the first distance from the bottom region transition edge. And in yet another example the stabilizer apex meets the inner transition surface at the first distance from the end region outer transition edge.

(10) In one example of disclosed fastener systems, a first and second intersection line, formed at the intersection of the first and second groove walls with the recess inner transition surface, respectively, form an angle of between about 6.5-7.0 degrees between the groove walls. In another example the driver inner transition surfaces are tapered at an angle with respect to the longitudinal axis of the driver and the recess inner transition surfaces are tapered at an angle with respect to the longitudinal axis of the recess, the driver inner transition surface taper angle being less than the recess inner transition surface taper angle. And in yet another example the recess inner transition surface is tapered at an angle of about 3.5-4.0 degrees, inclusive from a longitudinal axis of the fastener. And in another example the driver inner transition surface is tapered at an angle of about 2.25-2.75 degrees, inclusive from a longitudinal axis of the fastener. And in yet another example, at least one of the recess sidewalls further comprises a relieved region defined radially inwardly of its associated recess outer transition surface to define a relatively raised torque pad between the recess outer transition surface and the recess central core, the torque pad being an elongate strip and extending longitudinally along a margin of the sidewall that adjoins the outer transition surface.

(11) In a further example, disclosed example faster systems include a recess having four wings and at least two of the inner transition surfaces have the recess groove. In one example a driver includes at least one torque rib formed on at least one sidewall of at least one of the sidewalls of the lobes, the at least one torque rib being oriented to extend substantially perpendicular to the outer transition surface of the lobe and increasing in cross-sectional area in a radially outward direction. In another example, a radially outermost end of the at least one torque rib define the widest portion of the lobe. And in another example, at least one torque rib is generally triangular in a transverse cross-section. And in yet another example, at least one of the recess inner transition surfaces comprises an interference surface having a top defined by a design recess interference region and a distance from the top to the bottom region transition edge is less than the first distance to the groove. In one disclosed fastener system, at least one of the driver inner transition surfaces comprises an interference surface having a top defined by a design driver interference region and a distance from the top to the end region outer transition edge is less than the first distance to the stabilizing rib. And in another example fastener system, the fastener system includes a clearance distance between the top of the recess interference region and the groove. And in yet another example fastener system, the fastener system includes a clearance distance between the top of the driver interference region and the rib.

(12) Disclosed herein are methods of forming a threaded fastener. In one example method, the method includes forming a threaded fastener having a driver-engageable recess formed at an end thereof. In one example, the method includes using a punch to form the recess, the punch including, a central core having a bottom forming portion and a plurality of wing forming portions radiating

outwardly from the central core, the wing forming portions each being defined by a pair of sidewall forming portions and an outer transition surface forming portion adjoining the sidewall forming portions, the outer transition surface forming portion connected to the bottom region forming portion and forming a bottom region transition edge forming portion at the intersection of the bottom region forming portion and the outer transition surface forming portion. In another example method, the punch includes at least one inner transition surface forming portion connecting a sidewall forming portion of a first wing forming portion to a sidewall of a second wing forming portion, the first and second wing forming portions being adjacent to each other. In yet another example method, the punch includes a groove forming portion in the inner transition surface forming portion extending in a radially outward direction from the inner transition surface forming portion, the groove forming extending from a first distance from the bottom region transition edge forming portion to a second distance from the bottom region transition edge forming portion, the first distance being non zero.

(13) In one example method, the punch includes a groove forming portion having a first and second groove wall forming portions, the first and second groove wall forming portions meeting at a groove apex forming portion, the groove apex forming portion being tapered radially inward toward a longitudinal axis of the fastener as the recess groove forming portions extends in a direction from a body toward the bottom region forming portion. In another example method, a punch includes a groove apex forming portion is tapered at an angle of about 10.4 degrees from the longitudinal axis of the punch.

(14) Additional details will be provided in the accompanying figures and the detailed description below.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 is a partial perspective view of an example fastener recess in accordance with disclosed embodiments;
- (2) FIG. 2 is an end view of an example fastener recess in accordance with disclosed embodiments;
- (3) FIG. 3 is a cross section view of the example fastener recess of FIG. 2 in accordance with disclosed embodiments;
- (4) FIG. 4 is a perspective view of an example punch in accordance with disclosed embodiments;
- (5) FIG. 5 is a perspective view of an example punch in accordance with disclosed embodiments;
- (6) FIG. 6 is a side view of an example punch in accordance with disclosed embodiments;
- (7) FIG. 7 is a cross section of an example punch in accordance with disclosed embodiments;
- (8) FIG. 8 is a cross section view of an example punch in accordance with disclosed embodiments;
- (9) FIG. 9 is a perspective view of an example driver in accordance with disclosed embodiments;
- (10) FIG. 10 is a side view of an example driver in accordance with disclosed embodiments;
- (11) FIG. 11 is an end view of an example driver in accordance with disclosed embodiments;
- (12) FIG. 12 is a cross section view of an example driver in accordance with disclosed embodiments;
- (13) FIG. 13 is an end view of an example driver mated with an example recess in accordance with disclosed embodiments;
- (14) FIG. 14 is a cross section view of an example driver mated with an example recess in accordance with disclosed embodiments;
- (15) FIG. 15 is a perspective view of an example driver being mated with an example recess in accordance with disclosed embodiments;
- (16) FIG. 16 is a perspective view of an example driver mated with an example recess in accordance with disclosed embodiments;

(17) FIG. 17 is a cross section view of an example driver mated with an example recess in accordance with disclosed embodiments;

DETAILED DESCRIPTION

(18) Like reference numerals throughout this specification refer to similar features throughout the figures.

(19) FIGS. 1-3 show various views of an example fastener recess. Fastener **100** has a driver-engageable recess **102** formed in head **101**. The driver-engageable recess is of polygonal form that may be defined as generally cruciform in plan. The recess includes a central core and a plurality of wings **103** that radiate outwardly from the central portion. The wings **103** are each defined by an installation sidewall **104**, a removal sidewall **106**, which are separated from each other by an outer transition surface **108**, which is shown as downwardly (away from the head **101**) and inwardly inclined. The sidewalls **104** and **106** are referred to herein as installation sidewalls **104** and removal sidewalls assuming a right handed fastener thread. An inner transition surface **110** extends between the installation and removal surfaces of adjacent wings.

(20) In one example, the wings **103** generally conform in dimension to that of a standard cruciform shape, for example the dimensions described with respect to various cruciform recesses within the Industrial Fasteners Institute's *IFI Inch Fastener Standards Book*, 9^{sup}.th edition, 2014 ("the IFI standards"), which is herein incorporated by reference in its entirety. For the remainder of this disclosure a reference to "standard" refers to those standards established by the IFI standards unless otherwise specified. The inner transition surfaces **110**, in one example, generally conform to the shape of a standard square recess, for example those square recesses described in the IFI standards. Modifications to those standards will be apparent from the present disclosure. The recess **102**, having wings **103** and inner transition surfaces **110**, along with a corresponding driver, may in one example generally conform to the various dimensions of a Phillips Square-Drive® (PSD) recess and driver, available as of this writing from Phillips Screw Company of Burlington, Massachusetts, USA. However, features of the present disclosure may also be incorporated into non-driving surfaces of other fasteners and fastener systems. For example, embodiments of the present disclosure can be incorporated into existing fastener designs, for example Phillips Screw Company's commercially available fasteners, for example, those available under the trade designations Pozidriv®, Torq-Set®, Tri-Wing®, Phillips II®, Hexstix®, Torq-Set®, Mortorq®, Mortorq® Super, External Mortorq® Super, among other multi-winged fasteners having, for example, 2, 3, 4, 5, 6, or more wings. In addition, those fasteners/drivers disclosed that are, at least in part, defined by spiral segments, for example, those described in U.S. Pat. Nos. 5,957,645, 6,234,914, and 6,367,358 issued to Stacy (the Stacy patents), U.S. Pat. Nos. 7,891,274, 8,171,826, and 8,387,491 issued to Dilling (the Dilling patents), and U.S. provisional pat. application No. 62/351,540 filed on Jun. 17, 2016 (the '540 application), all of which are commonly owned with this application. The disclosures of these patents are incorporated herein by reference in each of their entireties.

(21) Continuing with the example embodiments of FIGS. 1-3, the outer transition surfaces **108** and the inner transition surfaces **110** merge into a generally concave recess bottom region **120**. The outer transition surfaces **108** meet the bottom region **120** at bottom region transition edge **122**. The inner transition surfaces **110** meet the bottom region **120** at the inner transition bottom edge **124**. At least one inner transition surface **110** includes a groove **112** within the inner transition surface **110**. The groove **112** extends radially outward from the inner transition surface. Therefore, a driver conforming to the dimensions of the recess **102** will fit within the recess **102** whether or not the driver includes a stabilizing rib (discussed in more detail below). The groove(s) **112** interact with corresponding stabilizing rib(s) to stabilize the driver within the recess and to minimize rocking of the driver. This feature will be discussed further below.

(22) In one example, the recess **102** includes more than one inner transition surfaces **110** having a groove **112**. For example, in one embodiment, diametrically opposed inner transition surfaces each

have grooves **112**. The recess **102** can include, for example, any number of pairs of diametrically opposed grooves **112**. As shown in FIGS. **1-2**, the recess **102** includes two pairs of diametrically opposed grooves **112**, or in the alternative one, three, four, or more pairs for recesses with different configurations.

(23) The groove **112**, in one example, includes groove walls **114** connected together at groove apex **115**. The groove walls intersect the inner transition surfaces **110** at intersection lines **116**. The angle between the groove walls may be any angle configured to provide the desired stability and also based on the size and configuration of the recess. In one example, the angle between the groove walls **114** is between about 40 degrees and about 60 degrees, or about 50.4 degrees for a PSD size 1-2 recess. In one example, a PSD size nomenclature M-N refers to a PSD recess/driver conforming to an “M” size square and a “N” size Phillips/cruciform in accordance with sizes available from Phillips Screw Company and as disclosed in the IFI standards.

(24) The inner transition surfaces **110**, in one example, are tapered inward toward the longitudinal axis of the fastener from the top of the recess towards the bottom region **120**. The taper of the inner transition surfaces **110** establishes interference surfaces **156** (indicated in diagonal markings) for providing an interference fit with cooperating surfaces of the corresponding driver.

(25) One or both of the installation or removal sidewalls **104,106** may be provided, in one example, with a relieved region **118** that extends from the upper edge of the corresponding sidewall **104,106** downwardly toward the bottom of the sidewall. The relieved regions **118** are formed so that the unrelieved portion of their respective sidewall defines a torque pad **119** in the form of a relatively raised strip that extends along the outer margin of its associated sidewall, that is, where the sidewall meets with the outer transition surface **108** of the wing **103**. The torque pad **119** is intended to be engaged by the most radially outward regions of the lobes of the mating driver to assure that the driving torque will be applied to the recess drive walls at the most radially outward location of the recess drive walls. The relieved region **118** is designed and configured so that the driver blade, in one example, will not engage those portions of the sidewalls **104, 106** defined by the relieved regions **118**. Additional information regarding example torque pads and relieved regions **118** may be found, for example in U.S. Pat. Nos. 6,223,634, 6,601,482, and 6,786,827 to Hughes et al (“the '634 patents”), which are herein incorporated by reference in their entirety. By maintaining engagement of the driver blades with the outermost regions of the sidewalls, the moment arm of the applied torque is maximized, thereby reducing the force necessary to develop the desired level of torque and, consequently reducing the risk of undesirable deformation of the recess. The top of the recess may also include head markings **140**, which may contact a top surface of the grooves **112** without detrimental impact to the grooves **112**.

(26) With respect to FIG. **3**, groove **112** begins a distance **152** from the bottom region transition edge **122** and continues to the top of the recess **102**, which is a distance **150** from the bottom region transition edge **122**. In one particular example, distance **152** is greater zero such that the groove **112** does not extend to the bottom region **120** thus not interfering with a stick fit feature. In one particular example, groove **112** has a groove clearance distance **154** greater than about zero from the top of the interference surface **156**.

(27) Disclosed example recesses may be formed by a heading punch adapted to form the head of the fastener with the disclosed corresponding recess. The recess can be formed in conventional heading techniques in, for example, a two blow header. FIGS. **4-8** illustrate a punch **300** configured to form an example disclosed recess. The punch is a positive corresponding to the negative of the recess **102** embodiments described with respect to FIGS. **1-3**. Thus, features and dimensions described with reference to disclosed punches **300** are also applicable to corresponding recess **102** features and embodiments and vice versa.

(28) The punch includes body portion **370** having a face **374** and an integral nib **376** that protrudes from the face **374**. The nib **376** is the complement of the shape of the recess and the face of the punch is of complementary shape to that of the intended screw head, shown here as a flathead.

With respect to FIG. 5, the nib 376 includes a central core and a plurality of wing forming portions 303 that extend generally radially and outwardly from the core. Each wing forming portion 303, as shown, includes a relieved region forming portion 318 and a torque pad forming portion 319 forming the respective installation and removal sidewall forming portions 304, 306, and an outer transition surface forming portion 308. An inner transition surface forming portion 310 extends between the installation and removal surface forming portions of adjacent wings.

(29) The outer transition surface forming portion 308 and the inner transition surface forming portions 310 merge into a bottom region forming portion 320. The outer transition surface forming portions 308 meet the bottom region forming portions 320 at bottom region transition edge forming portion 322. The inner transition surface forming portions 310 meet the bottom region forming portion 320 at the inner transition bottom edge forming portion 324. At least one inner transition surface forming portions 310 includes a groove forming portion 312 in the inner transition surface forming portion 310. The groove forming portion 312 extends radially outward from the inner transition surface forming portion 310.

(30) The inner transition surface forming portions 310, in one example, are tapered inward toward the longitudinal axis of the punch 300 from the body portion 370 towards the bottom region forming portion 320. The taper of the inner transition surface forming regions 310 establish (on the corresponding formed recess) interference surfaces, which are shown on the punch as interference surface gauging area 356 (indicated in diagonal markings). The location of the resulting interference surfaces on the formed recess will depend on the size and configuration of the recess and the size and configuration of the driver used within the recess. For example, the resulting interference surface 156 (FIGS. 1 and 3) are regions of the inner transition surface 110 in which the corresponding driver is designed to make contact with the recess (before applying installing or removing torque) and where an interference or stick-fit occurs between the recess and the driver. During manufacture and operation of the punch, the interference surface forming gauging area 356 can be checked (or gauged) to ensure interference surface gauging area 356 fall within design tolerances. Provided the inference surface gauging area 356 is within tolerances, the interference fit between the recess and the driver should occur in the proper location, i.e. between the groove 112 and bottom region 120 of the recess and between the stabilizing rib 212 and the end region 220 of the driver, discussed below. This location of the interference surface/interference surface gauging area 356 can be altered, that is moved higher or lower in the recess (and on the corresponding recess forming punch) depending on the recess/driver design and at what recess depths an interference fit is desired.

(31) With reference to FIG. 6, the groove forming portion 312, in one example, includes groove wall forming portions 314 connected together at groove apex forming portion 315. The groove wall forming portions intersect the inner transition surface forming portions 310 at intersection lines 316. The angle between the groove wall forming portions may be any angle configured to provide the desired recess groove. In one example, the angle δ (FIG. 8) between the groove wall forming portions 314 is between about 40 degrees and about 60 degrees, or about 50.4 degrees for a PSD size 1-2 recess. The angle α between the intersection lines 316, within the plane of the inner transition surface forming portion 310, is between about 6.5 and about 7.0 degrees, inclusive, for a punch design to form a recess for a PSD size 1-2 recess.

(32) The bottom region forming portion has a distance 350 between a tip forming portion 321 and the bottom region transition edge forming portion 322. The top 380 of the interference surface gauging area 356 is a distance 358 from the bottom region transition edge forming portion 322 and has a distance 357 between the top 380 and bottom 382 of the interference surface gauging area 356 defining, in one example, the location of acceptable design limits of the interference surface gauging area 356 for gauging. Distance 357, in one example may be between about 0.001 inches and about 0.012 inches, inclusive. And in one example is about 1 hundredth of an inch. Or, for example, about 0.012 inches. And in another example, no more than 0.012 inches.

(33) The top **380** of the interference surface gauging area **356** has a distance **359** from a tip forming portion **321**. Groove forming portion **312** may begin, i.e., the point of intersection of intersecting lines **316** to each other and the inner transition surface forming portion **310**, at a distance **352** from the bottom region transition edge forming portion **322**, resulting in a clearance distance **354** between the top **380** of the interference surface gauging area **356** and the groove forming portion **312**.

(34) The clearance distance **354** may be determined to provide clearance from the interference surface gauging area **356** such that the groove forming portion **312** will not interfere with gauging the interference surface gauging area **356** of inner transition surfaces **310**. Gauging is important to ensure that formed fasteners are within tolerances. In one example, the clearance distance **354** may also depend on the desired amount of engagement between the resulting groove and driver stabilizer rib, discussed in more detail below. In certain non-limiting examples, the clearance distance **354** may be between about 0.005 inches and about 0.011 inches, inclusive, between about 0.005 and about 0.012 inches, inclusive, or about 0.011 inches.

(35) Table 1 includes non-limiting examples of the dimension references discussed with reference to FIG. 6. The example dimensions are listed with reference to corresponding PSD driver sizes. The drivers are commercial available from Phillips Screw Company.

(36) TABLE-US-00001
TABLE 1 (inches) DRIVE SIZE 359 354 357 350 352 358 PSD 0-1 .057
.005 .012 .013 .049 .044 PSD 1-2 .052 .011 .012 .023 .040 .029 PSD 2-2 .074 .011 .012 .023 .062
.051 PSD 3-3 .069 .011 .012 .039 .041 .030 Dimension Formulas: $(359 + 354) - 350 = 352$ $359 - 350 = 358$

(37) With reference to FIG. 7, in one example, the distance **360** between the opposing inner transition surfaces **310** at the inner transition bottom edge forming portion **324** conforms to a standard square recess for the respective driver size. In one example, distance **360** is between about 0.0852 inches and about 0.0842 inches, inclusive for a PSD 1-2 size driver. In one example, the inner transition surface forming portion (and resulting inner transition surfaces), are tapered inward toward the longitudinal axis of the punch integral nib **376** toward the tip forming portion **321** at a taper angle β with respect to the longitudinal axis of the integral nib **376**. In one example the taper angle β is between about 3.5 degrees and about 4 degrees, inclusive. In another example, the taper angle β is between about 2.5 degrees and about 4 degrees, inclusive. The taper angle β will establish the interference fit with the driver as will be discussed below. Therefore, other taper angles may also be appropriate in accordance with the design of the respective driver.

(38) In one example, the groove apex forming portion **315** is tapered inward toward the longitudinal axis of the punch integral nib **376** toward the tip forming portion **321** at a groove apex taper angle γ with respect to the longitudinal axis of the integral nib **376**. In one example the groove apex taper angle γ is between about 8 degrees and about 12 degrees, inclusive. In one example the groove apex taper angle γ is about 10.4 degrees. The groove apex taper angle γ will establish the stabilizing effect with the driver as will be discussed below. Therefore, other taper angles may also be appropriate in accordance with the design of the respective driver.

(39) FIG. 8 shows a cross section of one example of a groove forming portion **312**. Groove forming portion **312** includes groove wall forming portions **314** connected together at groove apex forming portion **315**. The groove wall forming portions **314** intersect the inner transition surface forming portions **310** at intersection lines **316**. The angle δ between the groove wall forming portions may be any angle configured to provide the desired stability and based on the size and configuration of the recess. In one example, the angle δ is between about 40 degrees and about 60 degrees, or about 50.4 degrees for a PSD size 1-2 recess. However, other angles will be apparent from the present disclosure.

(40) FIGS. 9-13 show various views of an example driver **200**. Driver **200** has a recess-engageable portion formed on a shank (not shown). The driver **200** is of polygonal form that may be defined as generally cruciform in plan. The driver includes a central portion and a plurality of lobes **203** that

radiate outwardly from the central portion. The lobes **203** are each defined by an installation sidewall **204**, a removal sidewall **206**, which are separated from each other by an outer transition surface **208**, which is shown as downwardly and inwardly inclined (assuming the driver tip **221** is pointed down into a recess). The sidewalls **204** and **206** are referred to herein as installation sidewalls **204** and removal sidewalls **206** assuming the driver is installing or removing right handed fastener thread. An inner transition surface **210** extends between the installation and removal surfaces **204**, **206** of adjacent lobes **203**.

(41) In one example, the lobes **203** generally conform in dimension to that of a standard cruciform shape or standard cruciform driver. The inner transition surfaces **110**, in one example, generally conform to the shape of a standard square driver, for example those square drivers described in the IFI standard or otherwise dimensioned to engage with the standard recesses described in the IFI standard. Modifications to those standards will be apparent from the present disclosures. The recess engageable portion **202**, in one example, has lobes **203** and inner transition surfaces **210**, that may, in one example, generally conform to the various dimensions of a PSD driver, available as of this writing from Phillips Screw Company. However, features of the present disclosure may also be incorporated into non-driving surfaces of other fasteners and fastener systems. For example, embodiments of the present disclosure can be incorporated into existing driver designs, for example Phillips Screw Company's commercially available drivers, for example, those available under the trade designations Pozidriv®, Torq-Set®, Tri-Wing®, Phillips II®, Hexstix®, Torq-Set®, Mortorq®, Mortorq® Super, External Mortorq® Super, among others multi-winged fasteners having, for example, 2, 3, 4, 5, 6, or more wings. In addition, those fasteners/drivers disclosed that are, at least in part, defined by spiral segments, for example, those described in the Stacy patents, the Dilling patents, and/or the '540 application.

(42) Continuing with the example embodiments of FIGS. 9-12, the outer transition surfaces **208** and the inner transition surfaces **210** merge into a generally convex driver end region **220**. The outer transition surfaces **208** meet the end region **220** at end region outer transition edge **222**. The inner transition surfaces **210** meet the end region **220** at the end region inner transition edge **224**. At least one inner transition surface **210** includes a stabilizing rib **212**. The stabilizing rib **212** extends radially outward from the inner transition surface **210**. The stabilizing rib(s) **212** interact with corresponding stabilizing groove(s) to stabilize the driver within the recess and to minimize rocking of the driver.

(43) In one example, the recess-engageable portion **202** includes more than one inner transition surfaces **208** having a stabilizing rib **212**. For example, in one embodiment, diametrically opposed inner transition surfaces **210** each have stabilizing ribs **212**. The recess-engageable portion **202** can include, for example, any number of pairs of diametrically opposed stabilizing ribs **212**. As shown in FIGS. 9 and 11, the recess-engageable portion **202** includes two pairs of diametrically opposed stabilizing ribs **212**, or in the alternative one, three, four, or more pairs for drivers with different configurations.

(44) The stabilizing ribs **212**, in one example, includes rib walls **214** connected together at rib apex **215** (FIG. 11). The rib walls **214** intersect the inner transition surfaces **210** at intersection lines **216**. The angle between the groove walls may be any angle configured to provide the desired stability and also based on the size and configuration of the recess. In one example, the angle between the rib walls **214** is between about 60 degrees and about 80 degrees, or about 70 degrees for a PSD size 1-2 driver. In one example, the angle between the rib walls **214** is greater than the angle δ between groove wall forming portions **314** (and the corresponding formed recess). In one example having an angle between the rib walls **214** greater than the angle δ between groove wall forming portions **314** (or groove walls **114**) promotes stability and surface contact between the driver bit rib and the recess groove when needed based on any imperfections of the primary square sticking feature, for example at the inner transition surfaces. Further, it helps eliminate unwanted rock of the driver bit within the recess back and forth.

(45) The inner transition surfaces **210**, in one example, are tapered inward toward the longitudinal axis of the fastener from the shank of the driver towards the end region **220**/tip **221**. The taper of the inner transition surfaces **210** establishes interference surfaces **256** (indicated in diagonal markings) for providing an interference fit with cooperating surfaces of the corresponding recess.

(46) One or both of the installation or removal sidewalls **204,206** may be provided, in one example, with torque ribs **230**. The torque ribs **230** can be provided to reduce cam-out and other advantages disclosed within the '634 patents.

(47) With respect to FIG. **10**, stabilizing ribs **212** begin a distance **252** from the end region outer transition edge **222** and continues to a distance **250** from the end region outer transition edge **222**. In one example, the distance **250** may end at the upper limit of lobes **203**, or in another example, continue past lobes **203**. The edges of the inner transition surfaces **210**, i.e., where the inner transition surfaces **210** meet the lobes **203** may form an angle ϵ , which may also conform to a corresponding recess angle. In one example ϵ is about 1.5 degrees for PSD size 1-2 driver. In one particular example, distance **252** is greater than zero such that the groove **112** does not extend to the bottom region **120**. In one particular example, stabilizing rib **212** has a rib clearance distance **254** greater than about zero from the top of the interference surface **256**.

(48) FIG. **11** shows an end view looking towards the tip **221** of driver **200** having four lobes **203** and four stabilizing ribs **212**. From this view it can be seen that inner transition surfaces **210** are tapered inward toward the tip **221**.

(49) FIG. **12** shows a cross section of FIG. **11**. In one example, the distance **260** between the opposing inner transition surfaces **210** at the end region inner transition edge **224** conforms to a standard square driver size. In one example, distance **260** is between about 0.0889 inches and about 0.0879 inches, inclusive for a PSD 1-2 size driver. In one example, the inner transition surface, are tapered inward toward the longitudinal axis of the driver at a taper angle ζ with respect to the longitudinal axis of the driver **200**. In one example the taper angle ζ is between about 4.5 degrees and about 5.5 degrees, inclusive. In addition, those fasteners/drivers disclosed that are, at least in part, defined by spiral segments, for example, the Stacy patents, the Dilling patents, and/or the '540 application. The disclosures of these patents are incorporated herein by reference in each of their entireties. In one particular example, the taper angle ζ is larger than taper angle β of the associated recess, thereby creating, in one example, an interference fit in interference fit region **256**. Other taper angles may also be appropriate in accordance with the design of the respective recess.

(50) In one example, the stabilizing rib apex **215** is tapered inward toward the longitudinal axis of the driver **200** toward the tip **221** at a stabilizing rib apex taper angle η with respect to the longitudinal axis of the integral nib driver **200**. In one example, the stabilizing rib apex taper angle η is between about 6 degrees and about 10 degrees, or between about 7.5 degrees and about 8.5 degrees, inclusive for a PSD 1-2 size driver. In one example, the stabilizing rib apex taper angle η is less than the taper angle γ of the corresponding recess groove **112** which can provide additional clearance between the stabilizing rib **212** and corresponding groove **112** when mated, Other taper angles may also be appropriate in accordance with the design of the respective recess.

(51) FIG. **13** shows a top view of an example fastener **100** with driver **200** inserted therein. The remaining portion of the driver including the shaft is not shown for clarity.

(52) FIG. **14** shows a cross section view of FIG. **13** showing driver **200** engaged within recess **102**. Dashed lines **264** has been added to indicate the profile of the corresponding stabilizer ribs **212** outside of the dashed lines. The inner transition surfaces **110** and **210** in normal coaxial insertion between the driver **200** and fastener **100** establish an interference fit **456** preventing the driver tip **221** from bottoming out in the recess. The amount and degree of stick fit can be manipulated according to fastener and driver design requirements in accordance with this specification. Further, in normal coaxial insertion between the driver **200** and fastener **100**, clearance **459** is present between the stabilizing rib **212** and groove **112**. This clearance, in one example, may also be included in order to favor establishing a stick fit **456** over rib **212** to groove **112** contact.

(53) However, if the driver **200** were to be rocked within the recess **102**, or inserted at an angle with respect to the longitudinal axis of the recess **102**, the stabilizing rib **212** would engage the corresponding groove **112** to provide stability. Further, the stabilizing ribs **212** and grooves **112** may also provide stability should the dimensions of the inner transition surfaces **210** or other driver dimensions be out of normal tolerances such that a desired stick fit **456** is not fully obtained.

(54) With continuing reference to FIGS. **15** and **16**, in one example, the driver lobe **203** and recess wings **103** may be configured such that a clearance **458** (FIG. **16**) is present between the outer transition surfaces **108**, **208** of the recess and drivers, respectively. This clearance **458** (FIG. **16**) may be included to further ensure a stick fit **456** is established between respective inner transition surfaces **110**, **210** instead of bottoming the driver outer transition surfaces **208** to the recess outer transition surfaces **108**. In one non-limiting example, clearance **458** may be about .0020 inches for a PSD 1-2 sized driver and corresponding recess. In one non-limiting example, clearance **458** in between about 0.002 inches and about 0.010 inches, inclusive for a PSD 0-1, 1-2, 2-2 and 3-3 sized drivers.

(55) Increasing the stability of the driver, i.e., the driver axis is more in line with the recess axis, has a number of non-limiting advantages. For example, by maintaining stability of the driver within the recess, an improved stick fit **456** may occur which may increase the speed of application fasteners to the work piece. Further the lobes **203** may have improved engagement with the wings **103** which will decrease cam-out and drive/recess damage.

(56) FIG. **17** shows and shows an example driver **200** engaged with example fastener **100**, as well as example, non-limiting dimensions in accompanying table 2.

(57) TABLE-US-00002 TABLE 2 (inches) DRIVE SIZE 550 552 554 556 PSD 0-1 .049 .033 .020 .036 PSD 1-2 .040 .015 .035 .060 PSD 2-2 .062 .037 .035 .060 PSD 3-3 .041 .020 .045 .066
Dimension Formulas: (554 + 550) – 552 = 556

(58) In this manner a new and unique fasteners, drivers, punches, and fastener systems are presented that provides an improvement in stability characteristics with respect to the driver recess engagement and also improve the overall performance of the fastener system.

(59) It should be understood that the above description is only illustrative of the invention. Various alternatives and modifications can be devised by those skilled in the art without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances.

Claims

1. A fastener system, comprising: a fastener having a recess, the recess comprising: a central recess core having a bottom region; a plurality of recess surfaces extending from a top of the recess and connected to the bottom region and forming a bottom region transition edge at an intersection of the bottom region and the recess surfaces; a groove in at least one of the recess surfaces extending in a radially outward direction from the at least one recess surface, the groove extending from a first distance from the bottom region transition edge to a second distance from the bottom region transition edge, the first distance being non zero, wherein the at least one of the recess surfaces includes a recess interference surface defining a design recess interference region located between the groove and the bottom region; and a driver for engaging the recess of the fastener, the driver comprising: a shank portion and a recess-engaging portion formed at an end of the shank portion, the recess-engaging portion comprising a central driver core having a driver end region and a plurality of driver surfaces extending from the shank portion and connected to the driver end region and forming an end region outer transition edge at an intersection with the driver end region; a stabilizing rib on at least one of the driver surfaces extending in a radially outward direction from the driver central core, the stabilizing rib extending from a first distance from the end region outer transition edge to a second distance from the end region outer transition edge, the first distance

being non-zero, wherein the at least one of the driver surfaces includes a driver interference surface defining a design driver interference region located between the stabilizing rib and the driver end region; wherein, in coaxial insertion between the driver and the fastener, the recess interference surface and the driver interference surface are configured to establish an interference fit with each other, the interference fit being located in an interference region that is entirely below the groove and entirely above the bottom region, and entirely below the stabilizing rib and entirely above the end region outer transition edge preventing the driver end region from bottoming out in the bottom region; wherein the fastener includes a plurality of wings radiating outwardly from the central recess core, the wings each being defined by a pair of recess surfaces forming sidewalls and a recess surface forming a recess outer transition surface adjoining the recess sidewalls; wherein the fastener includes at least one recess inner transition surface connecting a recess sidewall of a first wing to a recess sidewall of a second wing, the first and second wings being adjacent to each other, and wherein the groove is formed in the recess inner transition surface; wherein the driver includes a plurality of lobes radiating outwardly from the driver central core, each lobe being defined by a pair of driver surfaces forming driver sidewalls and a driver outer transition surface adjoining the driver sidewalls; and wherein the driver includes at least one driver inner transition surface connecting a driver sidewall of a first lobe to a driver sidewall of a second lobe, the first and second lobes being adjacent to each other, the stabilizer rib being formed on the driver inner transition surface.

2. The fastener system of claim 1, wherein the groove comprises first and second groove walls, the first and second groove walls meeting at a groove apex, the groove apex being tapered radially inward as the groove extends in a direction from the top of the recess toward the bottom region; wherein the stabilizing rib comprises first and second rib walls, the first and second rib walls meeting at a stabilizing rib apex, the stabilizing rib apex being tapered radially inward as the stabilizer rib extends toward the end region; wherein the groove apex is tapered at a groove apex taper angle with respect to a longitudinal axis of the fastener and the stabilizing rib apex is tapered at a stabilizing apex taper angle with respect to a longitudinal axis of the driver, the groove apex taper angle being larger than the stabilizing apex taper angle.
