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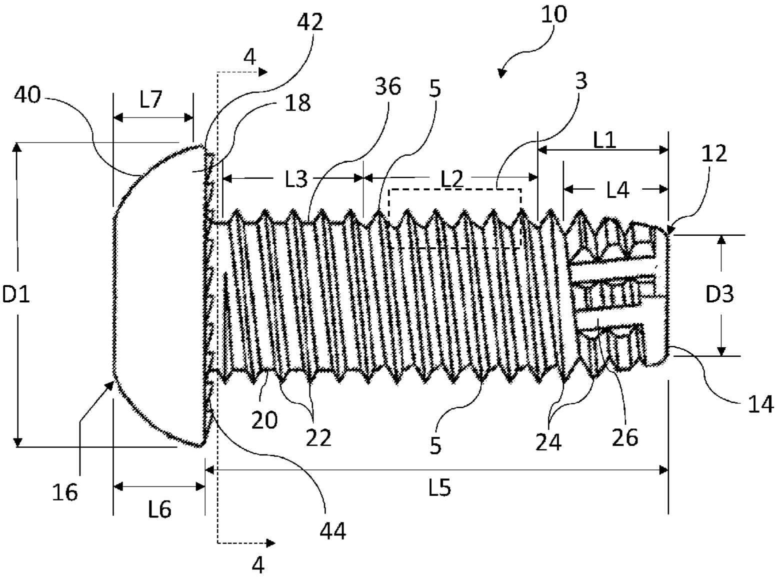


FIG. 1

**(57) Abstract:** A fastener with variable threads. The shank of the fastener has a stepped thread along a middle portion, flanked by conventional threads on the point end, and modified radial threads with flat roots near the head. The stepped threads have a front flank at a 60 degree angle, and a back flank with an initial threaded portion having a 60 degree angle and a secondary thread portion having a 30 degree angle. The screw has multiple debris cleaning flutes on its point end. The head of the fastener has a six-lobed recess, and serrations on its bottom side.

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# SELF-LOCKING, ANTI-VIBRATORY, THREAD-FORMING THREAD DESIGN

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## CROSS-REFERENCE TO RELATED APPLICATIONS.

**[0001]** This application claims priority to U.S. Provisional Patent Application No. 62/460,010 filed 16 February 2017, the contents of which are hereby incorporated by reference as if fully recited herein.

## TECHNICAL FIELD

**[0002]** The present invention relates to threaded fasteners, particularly to screw fasteners used to join two or more materials together.

## BACKGROUND OF THE ART

**[0003]** Various types of fasteners, particularly screws, are commonly used for connecting different materials together. It is desirable that fasteners achieve and maintain a tight grip and clamp between the materials being fastened. One example is screws used to install base rails on truck trailers. In this application, the base rails are subject to a high degree of vibration, load and stress. Without the use of locknuts or thread locking patches, base rail screws are typically highly susceptible to losing their grip and disengaging from their installed position, which can jeopardize the stability of the base rail and the overall safety of the vehicle. This is but one example of why it is desirable to have a screw that can maintain a strong grip on the materials it connects while withstanding vibration and loosening and maintaining clamp.

**[0004]** It is also desirable to have a screw that is hardened and can withstand high pressure and forces without losing its grip and clamp on the materials or otherwise deforming while maintaining high shear and tensile strengths.

**[0005]** It is also desirable to have a screw that can be installed by a single operator, and does not require lock nuts or lock washers. This can reduce the amount of manpower needed, as well as the time it takes to install.

**[0006]** It is also desirable to have a screw that can be installed without the need for anti-vibration thread patches, such as nylon locking patches.

**[0007]** It is also desirable to have a screw that is less weight, to decrease the amount of weight added to a project during installation. This can be particularly useful in trucking applications, where keeping overall truck weight to a minimum without sacrificing performance is desirable.

## SUMMARY OF THE INVENTION

**[0008]** It is an object of the present invention to provide a novel threaded fastener which effects a firmer grip between two or more materials being fastened together, is durable, can be installed by a single operator, is extremely versatile, and avoids vibration and loosening while maintaining clamp. In an embodiment, a novel fastener is provided with a multi-angle thread that has a front flank with a 60-degree angle, and a back flank with an initial portion having an angle of 60 degrees and a secondary stepped portion having an angle of 30 degrees. In other embodiments, the angle degrees may vary, with the back flank comprised of two different angles or even three different angles. In an embodiment of a screw fastener, the screw is comprised of a shank with a stepped thread along a predetermined portion of the screw and modified radial threads located on another portion of the screw, where the modified radial threads have flat roots. In an embodiment of the screw fastener, the screw has stepped threads on a middle portion of the shaft, conventional threads on a portion of the shaft between the stepped threads and the point, and modified radial threads with flat roots on a portion of the shaft between the stepped threads and the head of the fastener. In some embodiments, a threaded fastener may have conventional threads, stepped threads, and radial threads in various configurations. In an exemplary embodiment, a screw may have stepped threads in a middle portion of the shank, with conventional threads on the outer portions of the shank.

**[0009]** In an exemplary embodiment, the screw has a six-lobed recess in the screw head to allow the screw to be installed with a six-lobed screwdriver. The bottom side of the head of the screw may be serrated to help the screw engage with the bearing surface and help the screw stay locked into place once fully installed. In an exemplary embodiment, the stepped threads, in conjunction with other present threads, maintain the screw's grip on surrounding materials and make it unnecessary to use washers or nuts. The screw may be made from hardened steel.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** A better understanding of the exemplary embodiments will be obtained from a reading of the following detailed description and the accompanying drawings, wherein identical reference characters refer to identical parts and in which:

**[0011]** FIG. 1 is a side elevational view of a first embodiment of a screw fastener with stepped threads;

**[0012]** FIG. 2 is a magnified view of outlined area 3 of Fig. 1, and illustrates the stepped threads of the screw fastener of Fig. 1;

**[0013]** FIG. 3 is a right side cross-sectional view taken along line 4-4 of Fig. 1, which illustrates the bottom side of the screw head;

**[0014]** FIG. 4 is a left end elevational view of the screw fastener of Fig. 1;

**[0015]** FIG. 5 is a magnified side sectional view of the head of the screw fastener of Fig. 1, which illustrates the recessed lobe;

**[0016]** FIG. 6 is a right side elevational view showing the point of the screw fastener of Fig. 1;

**[0017]** FIG. 7 is a right side elevational view of an exemplary embodiment of a trilobular point for a screw fastener;

**[0018]** FIG. 8 is a cross-sectional view showing a screw fastener according to the exemplary embodiment of Fig.1 installed into a steel plate;

**[0019]** FIG. 9 is a side elevational view of a second embodiment of a screw fastener;

**[0020]** FIG. 10 is a side elevational view of a third embodiment of a screw fastener;

**[0021]** FIG. 11 is a side elevational view of a steel cross member and end clip connected by multiple screw fasteners according to the embodiment of Fig. 1;

**[0022]** FIG. 12 is a side view of the steel cross member and end clip being held together by multiple screw fasteners according to the embodiment of Fig. 1;

**[0023]** FIG. 13 is a side exploded view of the steel cross member and end clip;

**[0024]** FIG. 14 is a perspective view of eight screw fasteners according to the embodiment of Fig. 1 in a vibration test setup; and

**[0025]** FIG. 15 is a vibration control plot generated from the test setup shown in FIG. 14.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0026]** **Figure 1** illustrates an exemplary embodiment of a stepped thread **5**, as part of a screw fastener of a first embodiment **10,** which may be used to secure two or more materials together. In Fig. 1, the stepped thread **5** is formed along a pre-determined portion of a fastener **10**, where the fastener **10** has a first end **12** with a point **14** and a second end **16** with a head **18.** A shank **20** runs between the first end **12** and second end **16**.

**[0027]** The stepped thread **5** begins at a predetermined axial length, **L1**, from the point **14**, and wraps around the shank **20** towards the head **18** for a predetermined additional axial length, **L2**. A series of modified, flat-crested radial threads **22** are located along a predetermined axial length, **L3** between the head **18** and the stepped thread **5**. Between the point **14** and the stepped thread **5** the fastener has conventional threads **24**. Debris cleaning flutes **26** are located on the first end **12**, causing gaps in the continuity of the conventional threads **24** along a distance **L4.** As shown in Fig. 1 and **Figure 6,** four flutes **26** may be spaced evenly or substantially evenly around the diameter of the fastener **10**. The flutes **26** may be designed according to industry standard Type F. In other embodiments various numbers of flutes, spacing of flutes, and dimensions of flutes may be used as desired.

**[0028]** In the exemplary embodiment of Fig. 1, and as further illustrated in **Figure 2**, the stepped thread **5** exhibits multiple flank angles. The front flank **28** (a first side) of each stepped thread **5** has a first flank side angle, $\Theta_a$, which in this exemplary embodiment is a 60-degree angle. The back flank **30** of each stepped thread (a second side) **5** has an initial portion **32** with the same angle as the first flank side, $\Theta_a$, (in this exemplary embodiment a 60-degree angle), and a second stepped portion **34** angle, $\Theta_b$, (in this exemplary embodiment a 30-degree angle). The "step down" from 60 degrees to 30 degrees on the back flanks **30** of the stepped threads **5** prevents the screw **10** from vibrating loose after installation. The stepped thread **5** forms the self-locking feature, while the flat-crested radial threads **22** lock the fastener **10** into place.

**[0029]** The modified radial threads **22** as illustrated in Fig. 1 are comprised of a single continuous thread. Between the flat-crested radial threads **22** are flat roots **36** which help prevent the fastener **10** from becoming dislodged after installation. Both the modified radial threads **22** and the conventional threads **24** may exhibit 60 degree angles.

**[0030]** In some embodiments, a fastener may have stepped threads in different locations along the screw shaft as necessary based upon the intended application. The angles of the front flanks and initial and second portions of the back flanks may also differ. In some embodiments, there may be stepped threads in multiple places on the screw.

**[0031]** As illustrated in Fig. 1, the head **18** extends outward radially from the shank **20.** The head **18** has a top side **40** and a bottom side **42**. Referring to **Figure 3**, the bottom side **42** of the head **18** contains serrations **44** that provide additional locking strength between the screw **10** and the bearing surface with which it engages. The serrations are adapted to cut into a fastened material in aid in locking. In the fastener of the exemplary embodiment of Fig. 1, there are 18 serrations **44** on the bottom side **42** of the head. However, in other embodiments, the bottom side **42** of the head **18** may have a different number of serrations, or may even have no serrations.

**[0032]** At its widest point, the head **18** of the fastener **10** has a diameter **D1**. Referring to Fig. 1 and **Figure 4** and **Figure 5**, the top side **40** of the head **18** is rounded, with a six-lobed recess **46** with major diameter **D2** centrally located on the top side **40**. A tool such as a six-lobed screwdriver may be inserted into the recess **46** to induce rotation of the fastener **10** and aid in installation of the fastener **10**. In other embodiments, the recess **46** may have a different number of lobes or a different shape as necessary to allow different tools to be used to install the screw. In some embodiments, there may be no recess at all, such as those embodiments having a hexagonal head shape.

**[0033]** Referring to Fig. 6, an F Type tapping point **14** as used in the exemplary embodiment of Fig. 1 is shown. The four flutes **26** allow the fastener **10** to grind the threads into a fastened material. In other exemplary embodiments, the tapping point used on a fastener may have a variety of points including a trilobular point. Referring to **Figure 7**, a trilobular thread tapping point **48** of an exemplary embodiment of a fastener **50** is shown. The trilobular thread tapping point **48** is capable of forming its own thread.

**[0034]** While the exemplary fastener embodiment of Fig. 1 has four debris cleaning flutes **26**, in other embodiments different numbers and combinations of flutes, flats, and/or shank slots may be located on the point **14** to help allow the screw **10** to auger into a material.

**[0035]** A screw of the exemplary embodiment of Fig. 1 may have the following dimensions: an axial shank length **L5** of 1"; a conventional thread length **L1** of .3125"; a stepped thread length **L2** of .375"; a modified radial thread length **L3** of .3125"; a head diameter **D1** of 21/32"; a head height **L6** of .20"; a six-lobe recess major diameter **D2** of .275"; a six-lobe recess depth **L7** of .109", and a major shaft diameter **D3** of .375" (3/8"). The overall length of the entire screw **10** may be 1.2" long. The thread count may be 16 threads per inch equally spaced apart. However, in different embodiments the screw dimensions may be altered in numerous ways as desired without departing from the inventive concept, and the above example of dimensions is in no way limiting. For example, in some embodiments the overall length of the screw may be reduced to ¾ inches. A shorter screw length may not only result in less cost in manufacturing the screw, but also reduces the weight of a screw. In applications where numerous screws may be used, screws of a shorter length can reduce the added weight by several pounds. Such weight reduction is particularly favorable in at least the trucking industry where lessening the weight of a trailer can reduce fuel consumption.

**[0036]** Referring to **Figure 8**, a cross-sectional view of a fastener **10** according to the exemplary embodiment of Fig. 1 is shown as installed into a steel plate **105** containing a 0.323” diameter predrilled hole .

**[0037]** In **Figure 9**, a second embodiment of a screw **60** with stepped screw threads **62,** flat-crested radial threads **66**, and conventional threads **68**, is illustrated. This second embodiment **60** is similar to the first embodiment **10** except that it does not have debris cleaning flutes.

**[0038]** In **Figure 10**, a third embodiment of a screw **70** with stepped screw threads **72** is illustrated. This embodiment does not have modified flat-crested radial threads. The screw **70** has conventional threads **74** on either side of the shank **76** for distances **L8, L9**, respectively, with stepped threads **72** located a distance of **L10** along a middle portion of the shank **76.**

**[0039]** Although the screw threads of the embodiments of Figs. 1, 9, and 10 have a single lead at their respective points, **14**, **64**, **78**, in other embodiments the screw thread may have a single, double or quadruple lead as desired.

**[0040]** In some embodiments, a stepped thread may be formed along the entire length of the shank of a screw. The angles may be similar to those of the fastener of Figs. 1 or they may differ. For example, the front flank may be 60 degrees and the initial and secondary portions of the back flank may be 65 and 25 degrees, respectively. In another exemplary embodiment, the initial and secondary portions of the back flank may be 55 and 35, respectively. One of ordinary skill in the art will recognize that the exact angles may be altered in various embodiments as desired. In still other embodiments, both the front and back flanks of the thread may be sectioned into portions with varying angles. In some embodiments the front and/or back portions of the stepped thread may have more than two sections with different angles.

**[0041]** In some embodiments, the stepped threads are present on various types of threaded fasteners used in a wide variety of applications, including, but not limited to, thumb screws, pipe plugs, hanger bolts, step bolts, U-bolts, patch bolts, lag screws, carriage bolts, hook bolts, and wood screws. One of ordinary skill in the art would recognize that the stepped threads disclosed herein could be used in many threaded fastener applications across many different industries. Furthermore, the stepped thread may be used as the only type of thread on such a fastener, or in conjunction with other threads on such fasteners. One of ordinary skill in the art would also recognize that the heads of such fasteners may widely vary as well,

**[0042]** **Figures 11-13** illustrate how stepped thread screws **10** of the first exemplary embodiment may be used to fasten a steel cross-member **100** and an aluminum lower rail (base rail) **110**. The steel cross-member **100** and aluminum lower rail **110** are of a type commonly used in the construction of truck trailers, which are subject to a high amount of vibration during use. The screws **10** may be installed through use of a hand or power tool that has an attachment corresponding to the six-lobed recess **46**. It will be appreciated by one of ordinary skill in the art that embodiments of the screw may be used in a variety of applications, and used to connect different types of materials. Because the stepped-thread screw **10** is self-locking, there is no need for the screw to be used with a lock nut or lock washer. There is also no need for anti-vibration thread patches. This allows the screw to be particularly useful for installation in “blind holes” where the back surface cannot be accessed. A single person can perform installations of the screws without the need for a second person to put lock nuts or lock washers on the other side. The lack of any need for a nut or lock washer may also allow for a smoother finished surface, promoting aerodynamic efficiency in certain applications.

**[0043]** In an exemplary embodiment, stepped thread fasteners may be made from a material such as steel that undergoes case hardening. In many applications, it may be desirable to harden the steel to ensure that the fasteners are harder than the material they are installed into. However, in certain applications it may not be necessary to harden the steel. In other embodiments 410 stainless steel may be used, or a hardened aluminum. However, various other metal and non-metal materials may be used as desired, including plastics and ceramics. It is recognized that fasteners may be made from a variety of materials that are harder than the materials the fasteners are intended to be installed into.

**[0044]** **EXAMPLE 1:**

**[0045]** An improved fastener with stepped threads according to the exemplary embodiment of Fig. 1 (no nut) is tested against a standard fastener a nut. The improved fastener has an axial shank length **L5** of 1"; a conventional thread length **L1** of .3125"; a stepped thread length **L2** of .375"; a modified radial thread length **L3** of .3125"; a head diameter **D1** of 21/32"; a head height **L6** of .20"; a six-lobe recess major diameter **D2** of .275"; a six-lobe recess depth **L7** of .109", and a major shaft diameter **D3** of .375" (3/8"). The overall length of the entire screw **10** is 1.2" long. The standard fastener does not have stepped threads, but rather has only conventional threads with an F-type point. Breakaway is tested for both fasteners as installed into an aluminum base rail and steel cross member for a truck trailer. The material stackup consists of approximately .184 inch thick aluminum and .15 inch thick steel (total stackup of approximately .334 inches).

**[0046]** The standard fastener is a 3/8-16 X 1 ¼ button socket cap Gr. 5.1 Permeaplate 3/8-16 nylon stop nut cad /JD5. The standard fastener adheres to ASME B18.16.6 standards. The standard fastener does not have stepped threads.

**[0047]** Twelve (12) fasteners of the exemplary embodiment and twelve (12) of the standard fasteners are inserted at 50 ft-lb into the cross member and base rail stackup.

**[0048]** The break-away test results for the standard fastener with nut are shown in Table 1:

**Table 1: Breakaway test results for standard fastener with nut**

| Bolt | Breakaway Test Results (in-lb) | |
|---|---|---|
| | 1st Off | 5th Off |
| Bolt 1 | 25 | 10 |
| Bolt 2 | 20 | 15 |
| Bolt 3 | 25 | 10 |

| | | |
|---|---|---|
| Bolt 4 | 25 | 10 |
| Bolt 5 | 20 | 13 |
| Bolt 6 | 25 | 12 |
| Bolt 7 | 23 | 12 |
| Bolt 8 | 29 | 18 |
| Bolt 9 | 25 | 12 |
| Bolt 10 | 22 | 10 |
| Bolt 11 | 20 | 10 |
| Bolt 12 | 21 | 12 |
| **Average:** | **23** | **12** |

**[0049]** The installation torque for first off is 45 in-lb, and the installation torque for fifth off is 55 in-lb. The clamp load when seated at 600 in-lb is approximately 6,700 lbs.

**[0050]** Break-away test results for the improved fastener, with no nut, are displayed in Table 2:

**Table 2: Breakaway test results for improved thread (no nut)**

| **Bolt** | **Breakaway Test Results (in-lb)** | |
|---|---|---|
| | **1st Off** | **5th Off** |
| Bolt 1 | 600 | 480 |
| Bolt 2 | 528 | 480 |
| Bolt 3 | 468 | 492 |
| Bolt 4 | 564 | 492 |
| Bolt 5 | 576 | 528 |
| Bolt 6 | 558 | 468 |
| Bolt 7 | 504 | 528 |
| Bolt 8 | 552 | 492 |
| Bolt 9 | 600 | 480 |
| Bolt 10 | 552 | 468 |

| | | |
|---|---|---|
| Bolt 11 | 444 | 480 |
| Bolt 12 | 456 | 444 |
| **Average** | **534** | **486** |

**[0051]** The installation torque for first off is 216 in-lb, and the installation torque for fifth off is 240 in-lb. The clamp load when seated at 600 in-lb is approximately 10,667 lbs.

**[0052]** As shown in the tables above, when compared to the standard fastener with nut, on average the improved fastener, without any nut, requires more than 20 times greater breakaway force in the first off test, and approximately 40 times greater breakaway force in the fifth off test. The clamp load also increased significantly.

**[0053]** **EXAMPLE 2:**

An improved fastener with stepped threads according to the exemplary embodiment of Fig. 1 is tested for proof load and tensile strength. “Sample 1” is a standard .375” – 16 X 1” screw with conventional threads and a type F point, used with a nut. “Sample 2” is a .375” – 16 X 1” improved fastener according to the exemplary embodiment of Fig. 1, with the dimensions set forth in Example 1, without a nut. Proof load and tensile strength testing is conducted in accordance with ASTM Standard F606M using an Instron Model 3385H Universal Testing System. Shear testing is performed in accordance with NASM 1312-20 using an Instron Model 3385H Universal Testing system and shear fixture assembly shown in Fig. 3a of NASM 1312-20. Pull-out testing is performed using one combination of .125” thick steel and .185” thick aluminum plates and another combination of .0185” thick aluminum plates to simulate the actual operating design that the screw would be subjected. The plates contain .323” and .339” diameter holes and pull-out testing is accomplished using an Instron Model 3385H Universal Testing System. A second pull-out test is accomplished using industry recognized fastener test plates, .340” thick, containing both .323” and .339” diameter holes. The second round of pull-out testing is accomplished using an Instron Model 3385H Universal Testing System. Proof load is held for 10 seconds in accordance with

ASTM Standard F606M. Results of the test are shown in Tables 3 through 8 below.

**Table 3: Tensile Strength Evaluation:**

| Sample | Tensile Strength (psi) | Required | Result |
|---|---|---|---|
| #1 | 155,000 | ≥ 120,000 | PASS |
| #2 | 157,000 | | |

**Table 4: Proof Loading**

| Sample | Proof Strength (psi) | Required | Result |
|---|---|---|---|
| #1 | 88,100 | ≥ 85,000 | PASS |
| #2 | 87,700 | | |

**Table 5: Ultimate Shear Strength**

| Sample | Shear Strength (psi) | Required* | Result |
|---|---|---|---|
| #1 | 107,000 | ≥ 90,000 | PASS |
| #2 | 99,000 | | |

**Table 6: Pull-Out Testing: Aluminum/Aluminum**

| Al/Al Pull-Out | .323" Hole | .339" Hole |
|---|---|---|
| Sample #1 | 4632 lb | 3882 lb |
| Sample #2 | 5386 lb | 4105 lb |

**Table 7: Pull-Out Testing: Aluminum/Iron**

| Al/Fe Pull-Out | .323" Hole | .339" Hole |
|---|---|---|
| Sample #1 | 5970 lb | 3156 lb |
| Sample #2 | 4975 lb | 4623 lb |

**Table 8: Pull-Out Testing: Fastener Steel Test Plate**

| Fastener Steel Test Plate | .323" Hole | .339" Hole |
|---|---|---|
| Sample #1 | 8764 lb | 7194 lb |
| Sample #2 | 9900 lb | 9528 lb |

**[0054]** Accepted practice is Ultimate Shear Strength is 75% of the Ultimate Tensile Strength; stress area 0.0775 $in^2$.

**[0055]** Where industry specifications are available the exemplary fastener (Sample #2) exceeded industry standard requirements. Without the use of a nut, the exemplary fastener also either out performed or similarly performed to the standard fastener (Sample #2).

**[0056]** **EXAMPLE 3:**

**[0057]** A vibration test is performed on eight improved fasteners **10** according to the exemplary embodiment of Fig. 1 (with no nuts), with the dimensions set forth in Example 1. The testing method used was MIL-STD-810G, Method 514.6 ANNEX C, Figure 514.6C-1-Category 4-Common carrier (US Highway truck vibration exposure) Vertical Axis Vibration profile. A 30 hour duration in the Vertical Axis (MIL-STD-810G, METHOD 514.6 ANNEX C. a. Test time of 60 minutes = 1,000 miles. Test setup is shown in Fig. 14. Bolt positions are marked and visually checked for movement at the completion of the test. No obvious physical discrepancies are observed before, during, or upon completion of testing. The eight fasteners **10** remain in position during testing. The vibration control plot for the test is shown in Fig. **15**. For this test the parameters are:

**[0058]** **Table 7: Breakpoint Table**

| Frequency | $G^2$/Hz | dB/Octave |
|---|---|---|
| 10 Hz | 0.015 | 0 |
| 40 Hz | 0.015 | -5.489 |
| 500 Hz | 0.00015 | |

**[0059]** The Demand is 1.045 G RMS with 0.1355 in pk-pk, and Control is 1.046 G RMS with 0.1246 in pk-pk.

**[0060]** **EXAMPLE 4:**

**[0061]** An exemplary fastener of Fig. 1 (with no nut), with the dimensions set forth in Example 1, is subject to tensile strength testing to measure elongation. The SAE Standard J429 “Mechanical and Material Requirements for Externally Threaded Fasteners” Grade 5.1 requirements for a .375”-16 screw are applied. The testing is conducted in accordance with ASTM Standard F606M using an Instron Model 3385 Universal Testing System. The result is shown in Table 8 below:

**[0062]** **Table 8: Tensile Strength**

| Sample | Tensile Strength (psi) | % Elongation* |
|---|---|---|
| #1 | 164,000 | 1.2 |
| Required | ≥ 120,000 | ---- |

**[0063]** While the foregoing written description of the invention enables one of ordinary skill to make and use what is considered presently to be the best mode thereof, those of ordinary skill will understand and appreciate the existence of variations, combinations, and equivalents of the specific embodiments and examples herein. The invention should therefore not be limited by the above described embodiments, methods, and examples, but by all embodiments within the scope and spirit of the invention.

## CLAIMS

1. A fastener for joining two or more items, said fastener comprising:
a head, said head having a top side with a top surface, and a bottom side; and
a shank, said shank unitary with said head and terminating at a point end, said point end defined by a diameter, said shank comprising a stepped thread located along a first portion of said shank, said stepped thread comprising:
a first flank side having a first flank side angle; and
a second flank side, said second flank side comprising a first stepped portion with a first stepped portion angle, and a second stepped portion with a second stepped portion angle.

2. The fastener of Claim 1, wherein said first stepped portion angle is not equal to said second stepped portion angle.

3. The fastener of Claim 1, wherein said first flank side angle is 60 degrees, said first stepped portion angle is 60 degrees, and said second stepped portion angle is 30 degrees.

4. The fastener of Claim 1, further comprising modified radial threads with flat roots on a second portion of said shank.

5. The fastener of Claim 4, further comprising conventional threads on a third portion of said shank.

6. The fastener of Claim 5, wherein said second portion of said shank is located proximate to said head, said third portion of said shank is located proximate to said point end, and said first portion of said shank is located along a middle portion of said shaft, in-between said third and second portions.

7. The fastener of Claim 1, wherein said bottom side of said head comprises multiple serrations.

8. The fastener of Claim 7, wherein there are 18 serrations on said bottom side of said head.

9. The fastener of Claim 1, further comprising four debris cleaning flutes located around said diameter of said point end.

10. The fastener of Claim 9, wherein said four debris cleaning flutes are evenly spaced around said diameter of said point end.

11. The fastener of Claim 6 wherein said modified radial threads and said conventional threads have 60 degree angles.

12. The fastener of Claim 1, wherein said top surface of said head has a recess, said recess adapted to receive a tool.

13. A screw fastener with variable threads, said fastener comprising:

a head, said head having a top side with a top surface and a bottom side with a bottom surface, said top surface having a six lobed recess for receiving a tool, and said bottom surface defined by multiple serrations;

a shaft unitary with said head and terminating in an point end; said shaft defined by a first portion proximate to said head, a second portion proximate to said point end; and a third portion in between said first and second portions;

a stepped thread cylindrically formed along said third portion of said shaft, said stepped thread comprising a first flank side having a first flank side angle, and a second flank side comprising a first stepped portion having a first stepped portion angle, and a second stepped portion having a second stepped portion angle, a conventional thread cylindrically formed along said second portion; and

a radial thread formed along said first portion, said radial thread having flat roots.

14. The screw fastener of Claim 13, wherein said first stepped portion angle and said second stepped portion angle are not equal.

15. The screw fastener of Claim 14, wherein said first flank side angle and said first stepped portion angle are both 60 degrees, and said second stepped portion angle is 30 degrees.

16. The screw fastener of Claim 13, wherein said conventional thread and said radial thread have an angle of 60 degrees.

17. The screw fastener of Claim 13, wherein said conventional thread is intersected by at least one debris cleaning flute.

18. The screw fastener of Claim 17, wherein said conventional thread is intersected by four at least one debris cleaning flutes, said four at least one debris cleaning flutes located substantially evenly around said diameter of said point end.

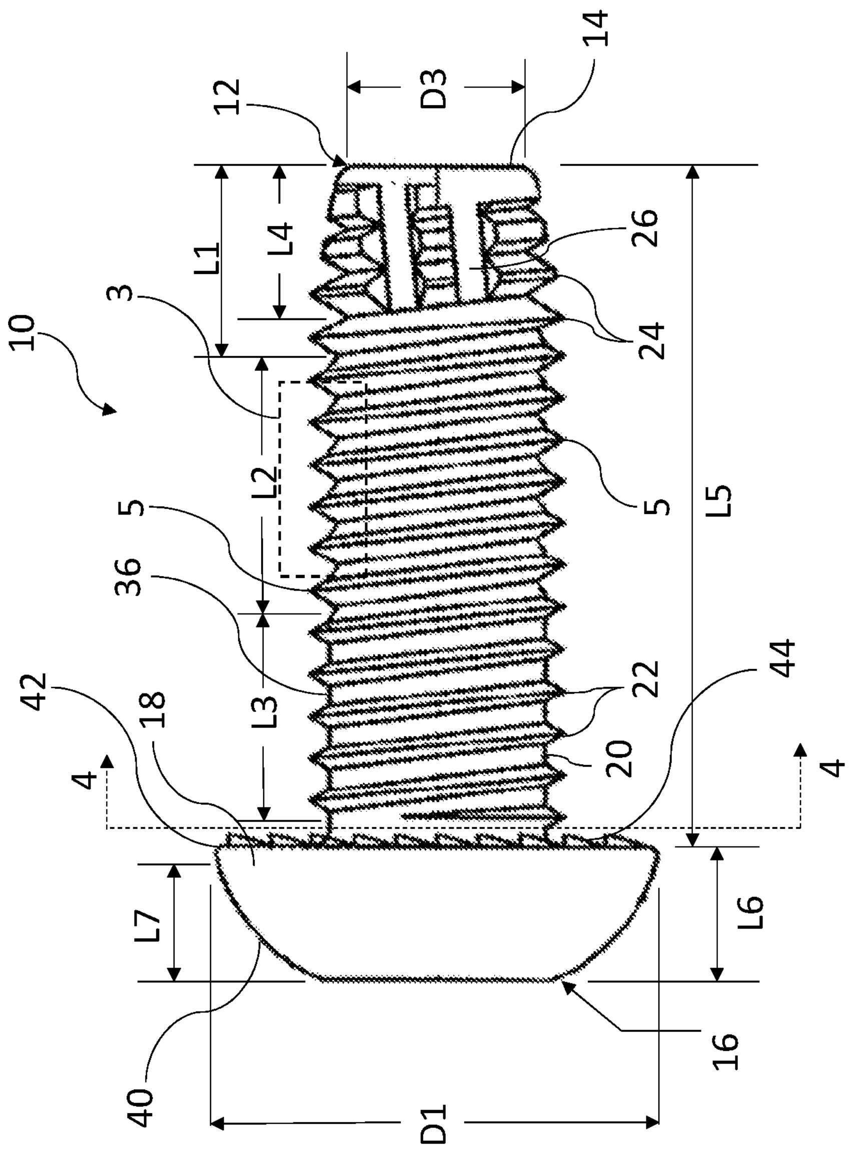


FIG. 1

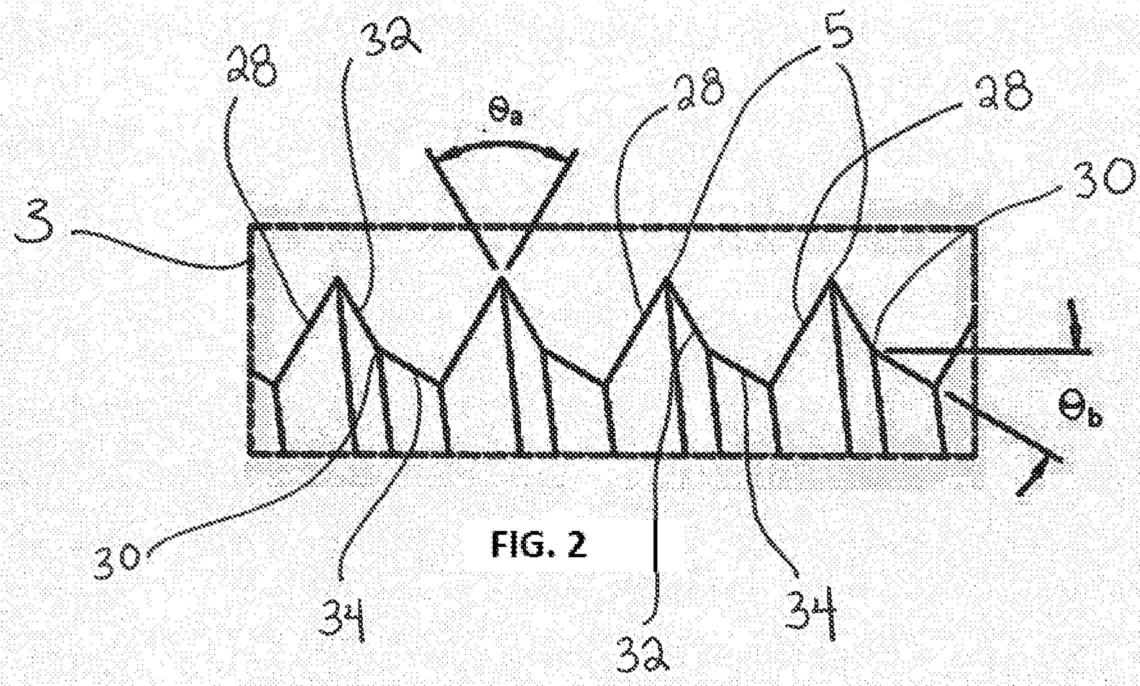


FIG. 2

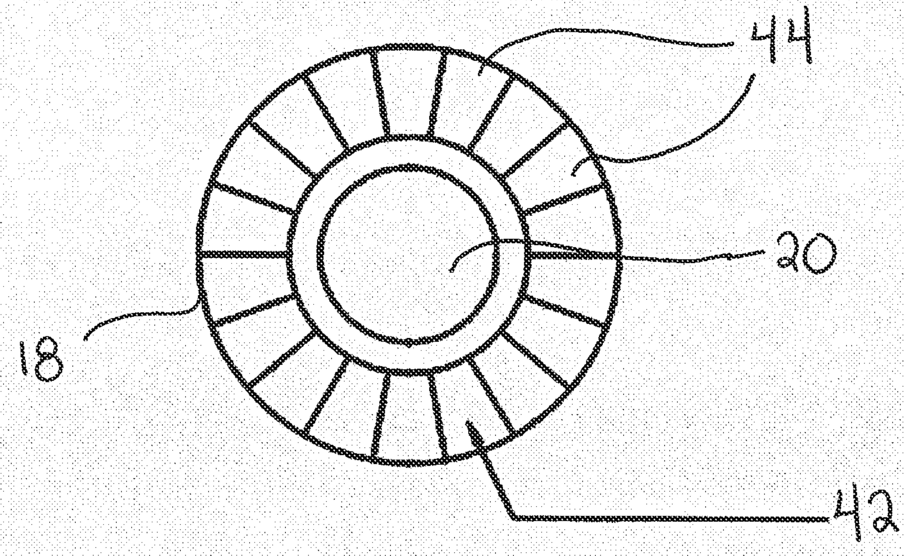


FIG. 3

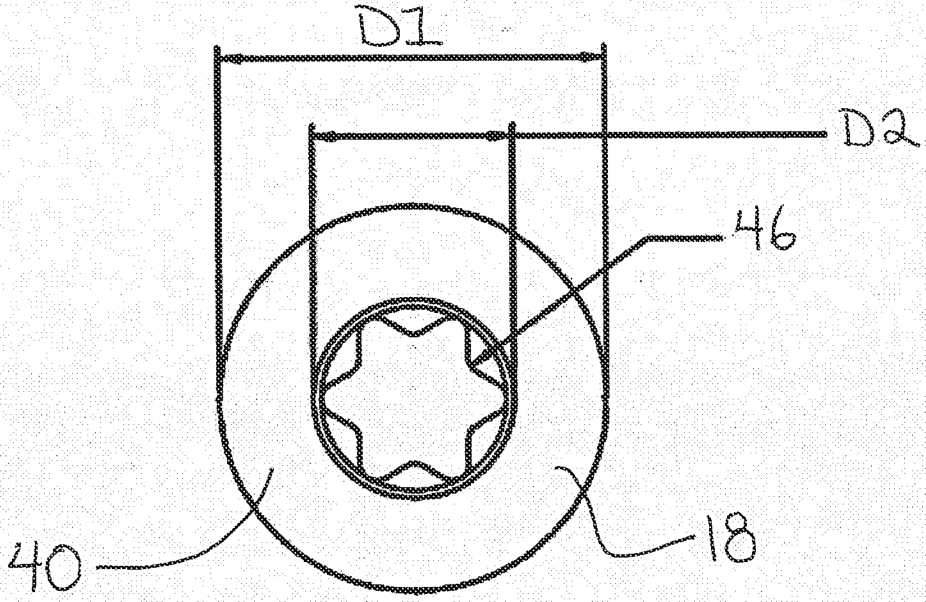


FIG. 4

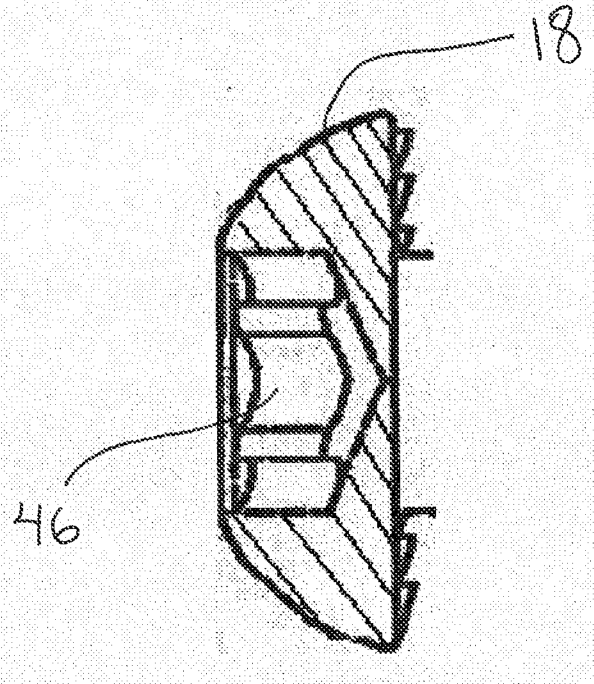


FIG. 5

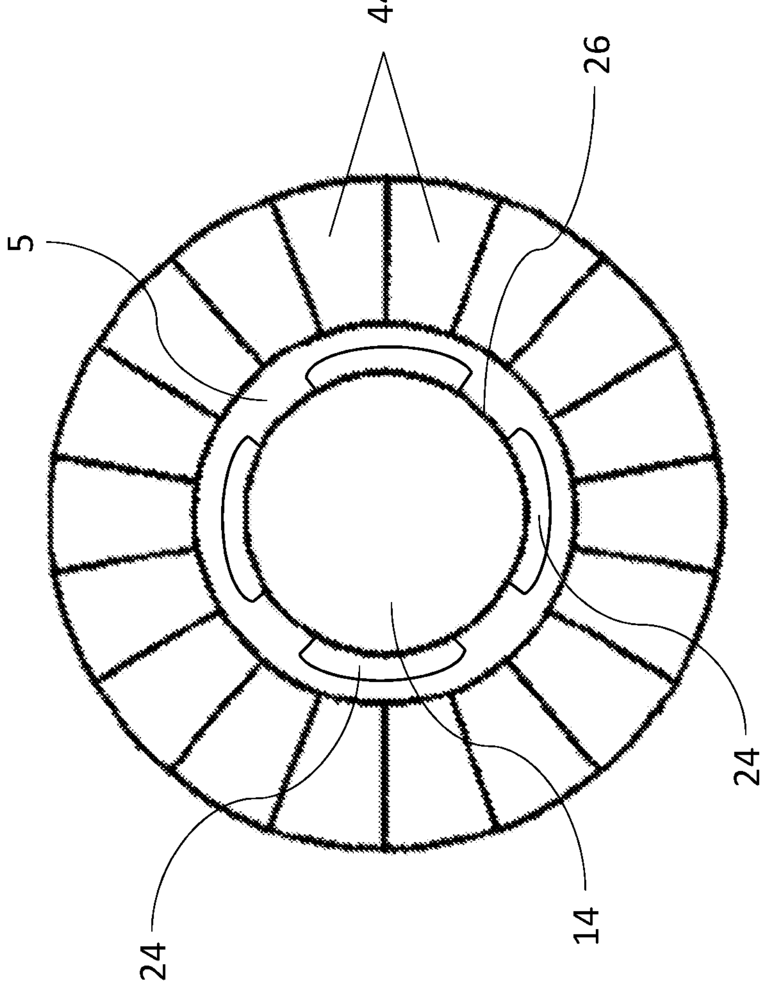


FIG. 6

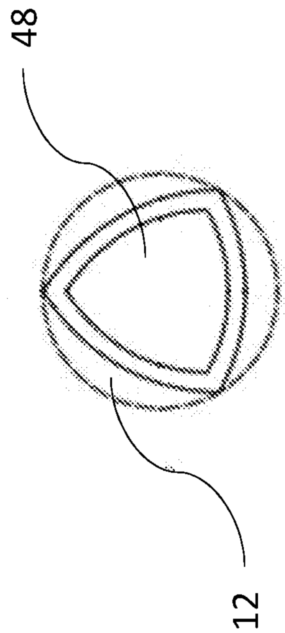


FIG. 7

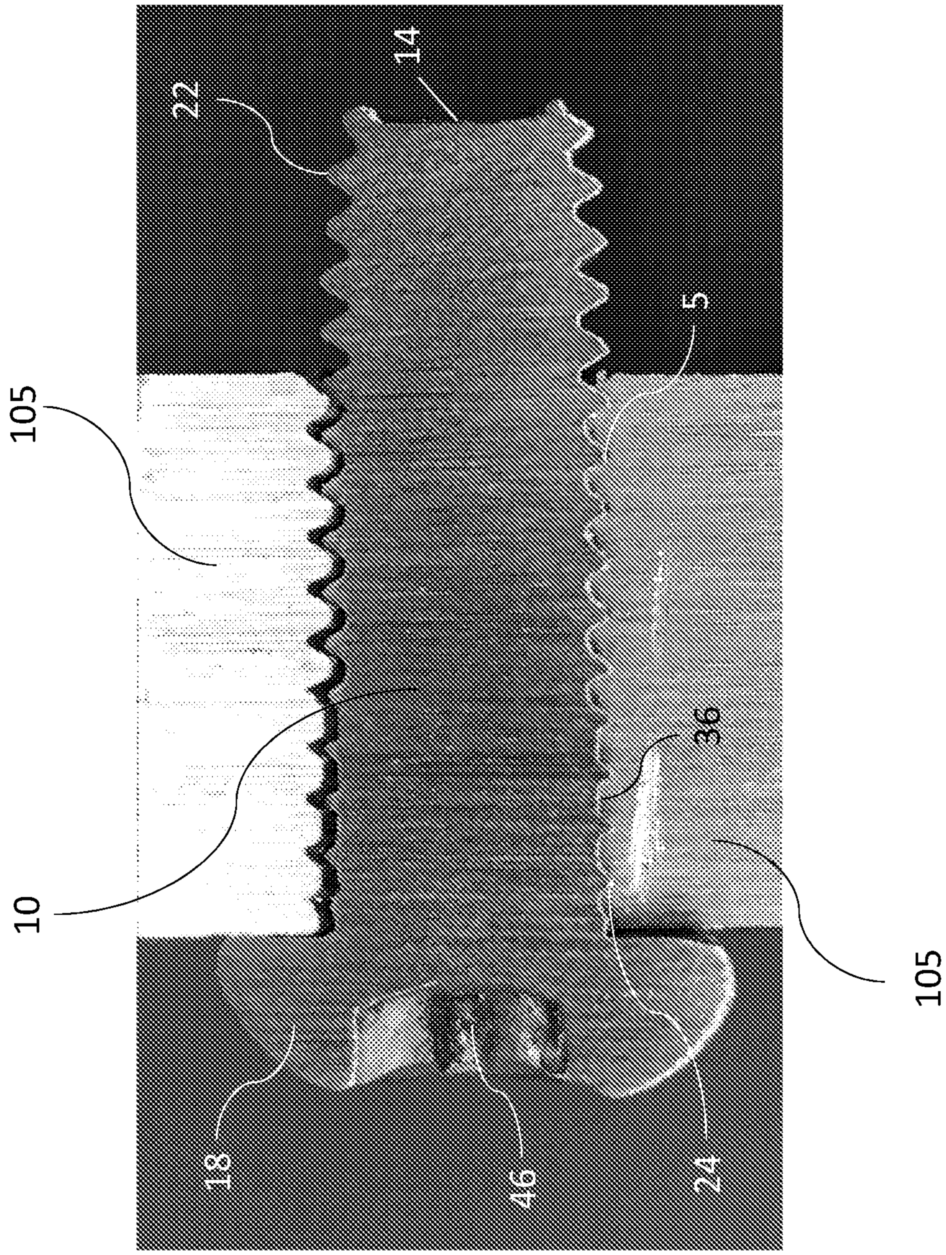


FIG. 8

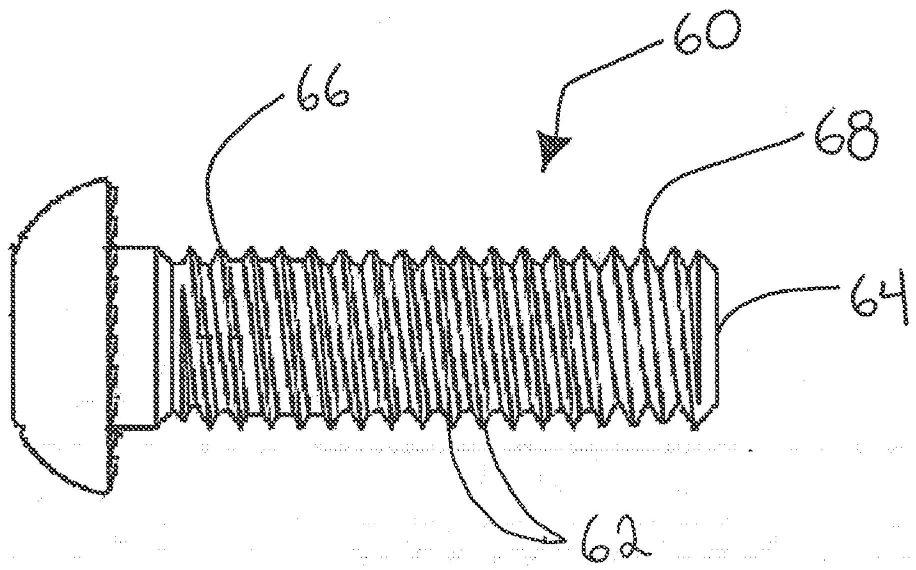


FIG. 9

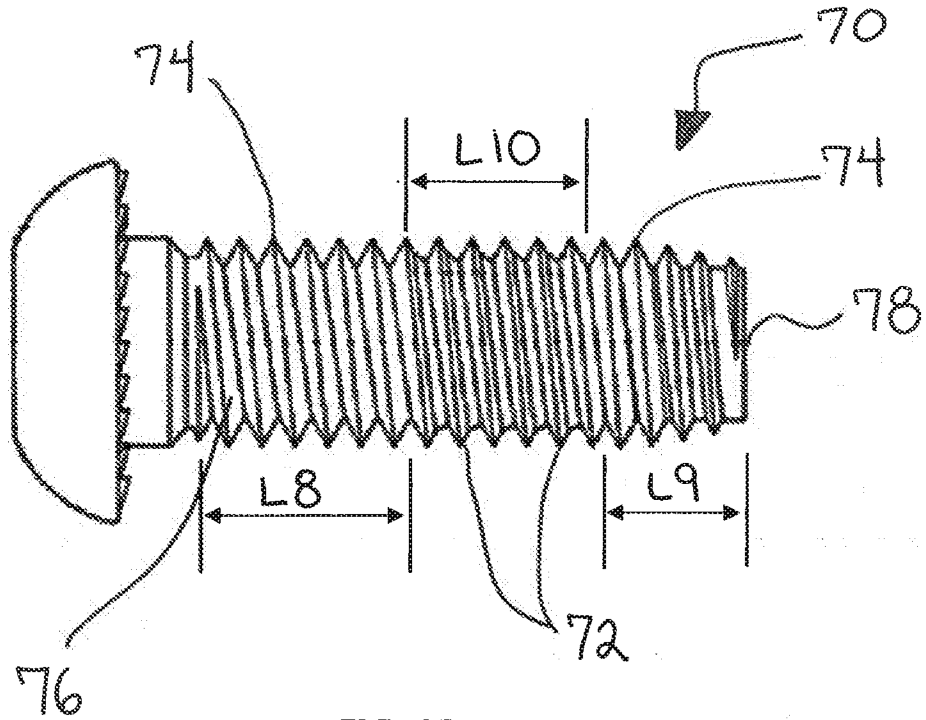


FIG. 10

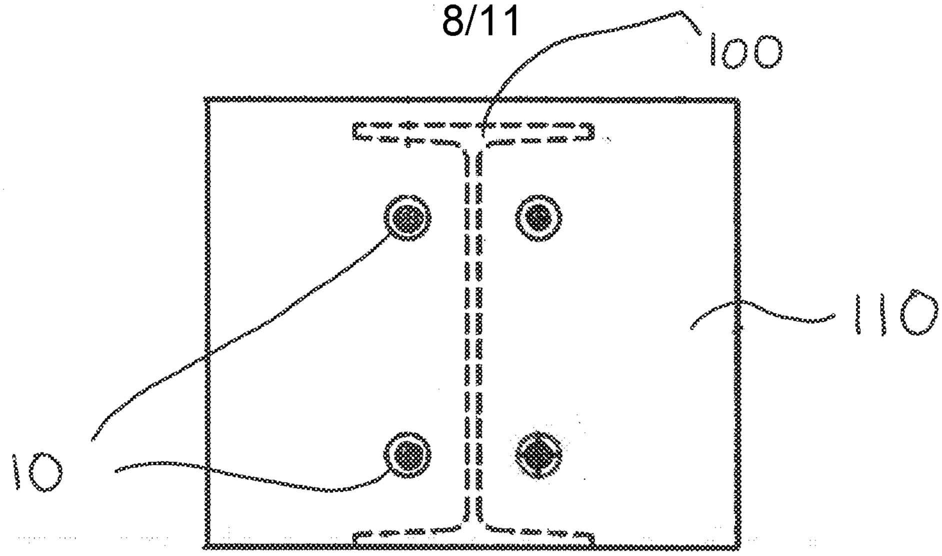


FIG. 11

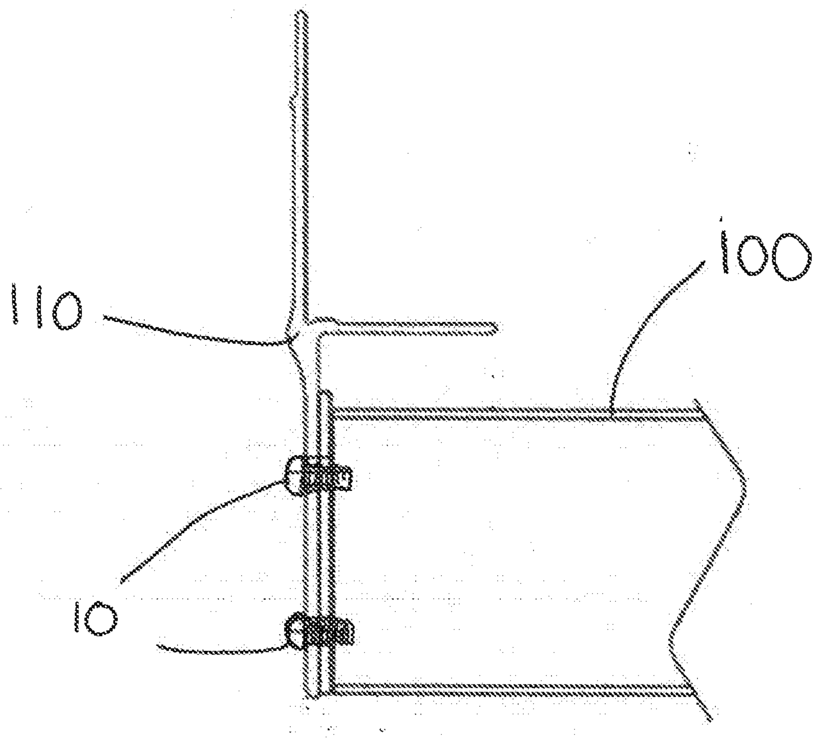


FIG. 12

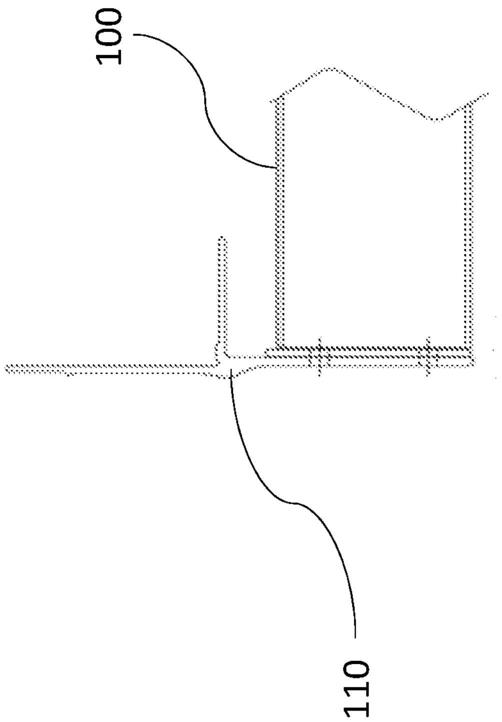


FIG. 13

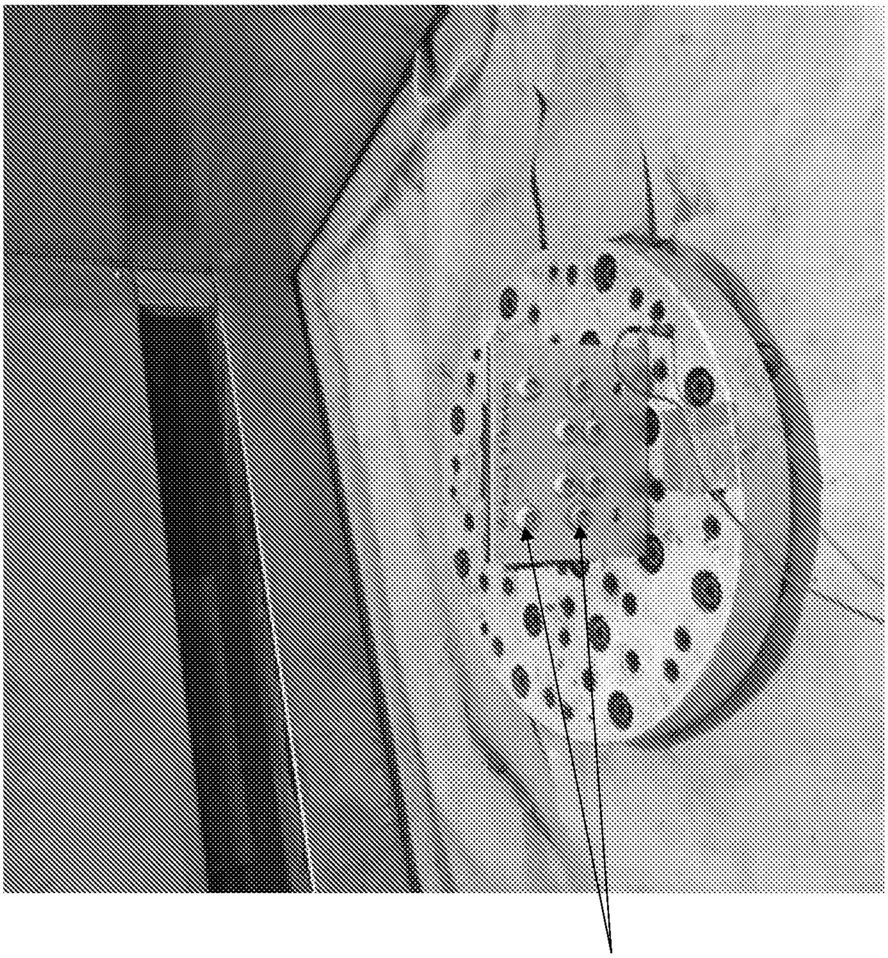

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FIG. 14

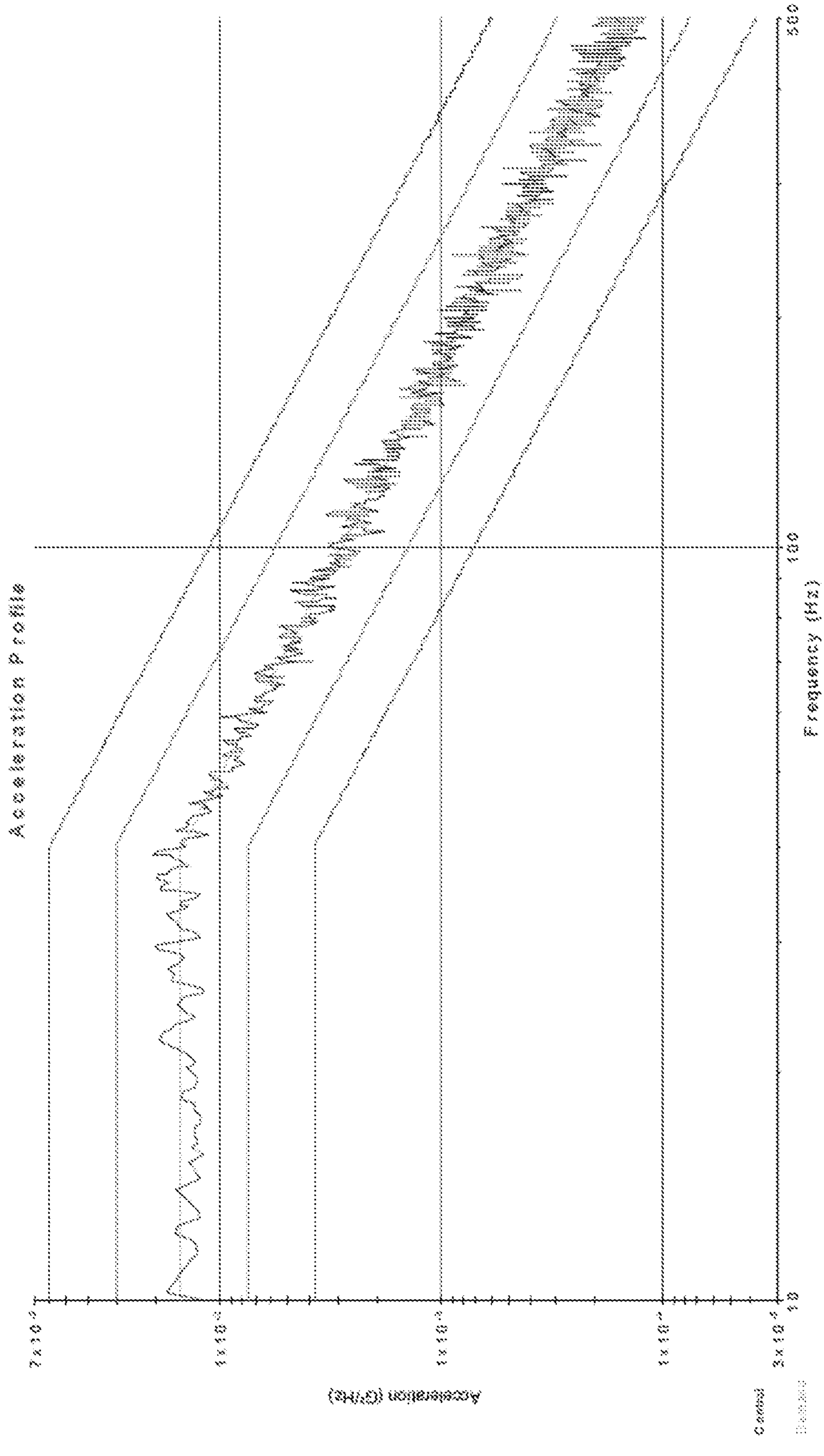


FIG. 15

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/18524

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F16B 39/30, F16B 39/282, F16B 33/02, F16B 39/22 (2018.01)
CPC - F16B 39/30, F16B 25/0057, F16B 39/28, F16B 33/02, F16B 25/0042, F16B 25/0047

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2017/0030393 A1 (INFASTECH INTELLECTUAL PROPERTIES PTE.LTD.) 02 February 2017 (02.02.2017) Entire document, especially para [0029], [0033] and figs. 1 and 3. | 1, 2-3, 12 |
| X | US 2015/0010374 A1 (SIMPSON STRONG-TIE COMPANY, INC.) 08 January 2015 (08.01.2015) Entire document, especially para [0038], [0049]-[0050], [0053], [0056] and figs. 7-8 and 14-17. | 1-18 |
| X | US 2016/0153486 A1 (XU) 02 June 2016 (02.06.2016) Entire document. | 1-2 |
| X | US 2013/0230364 A1 (MORI et al.) 05 September 2013 (05.09.2013) Entire document. | 1-2 |
| A | US 4,540,321 A (BERECZ) 10 September 1985 (10.09.1985) Entire document. | 1-18 |
| A | US 1,300,801 A (WOODWARD) 15 April 1919 (15.04.1919) Entire document. | 1-18 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 05 April 2018 | 03 MAY 2018 |

| Name and mailing address of the ISA/US | Authorized officer: |
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| Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Lee W. Young<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |