United States Patent [19]

Holmes

[11] E **Re. 31,284**

[45] Reissued **Jun. 21, 1983**

[54] **LOCKING FASTENER**

[76] Inventor: **Horace D. Holmes**, 28576 Green Willow, Farmington Hills, Mich. 48018

[21] Appl. No.: **253,464**

[22] Filed: **Apr. 13, 1981**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **4,150,702**
Issued: **Apr. 24, 1979**
Appl. No.: **876,863**
Filed: **Feb. 10, 1978**

[51] **Int. Cl.**[3] **F16B 39/30**
[52] **U.S. Cl.** **411/311**
[58] **Field of Search** 411/311, 310, 309, 308, 411/307, 259, 416, 411

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,447,056	2/1923	Bates	411/307
1,828,856	10/1931	Bridges	411/308
2,352,540	6/1944	Hanneman	411/308
2,377,405	6/1945	Davies	411/309
2,437,638	3/1948	Evans	411/311
3,346,278	10/1967	Yocum	411/307 X
4,071,067	1/1978	Goldby	411/307
4,076,064	2/1978	Holmes	411/285

FOREIGN PATENT DOCUMENTS

2355189	5/1974	Fed. Rep. of Germany	411/307
548516	10/1942	United Kingdom	411/311

Primary Examiner—Ramon S. Britts
Attorney, Agent, or Firm—Krass, Young & Schivley

[57] **ABSTRACT**

A vibration-resistant prevailing torque fastener combination comprising a conventional first element having a standard thread form with first flank angles and a modified second element having a thread form characterized by second steeper flank angles over the entire length thereof, and a truncated root caused by foreshortening of the flanks over a portion of the thread length to produce a helical flat which firmly engages and typically deforms the crest of the first element when threadedly engaged therewith. A difference in flank angles provides longitudinal clearance to receive the deformed material during the threaded engagement. Tapping tools are disclosed.

10 Claims, 7 Drawing Figures

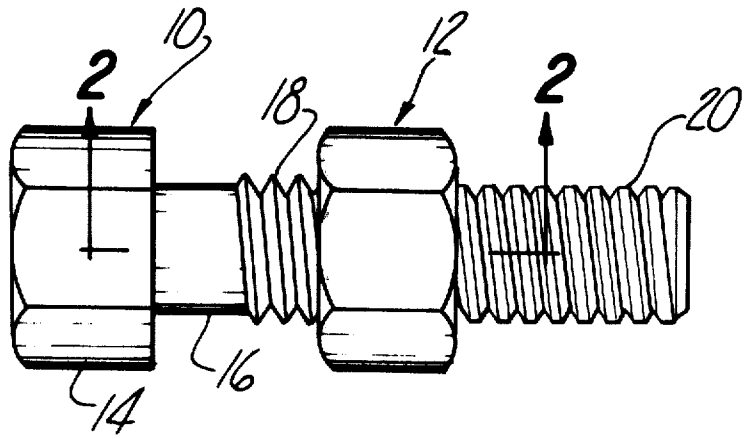
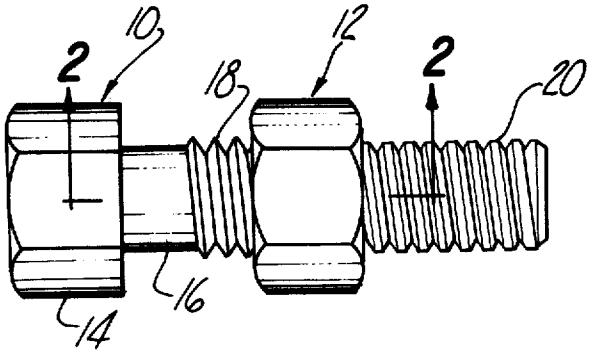


Fig-1



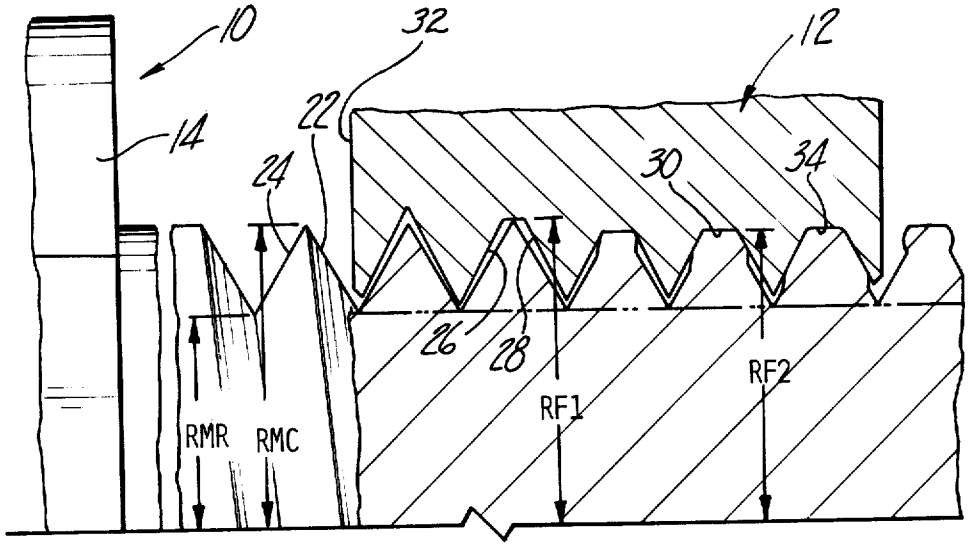
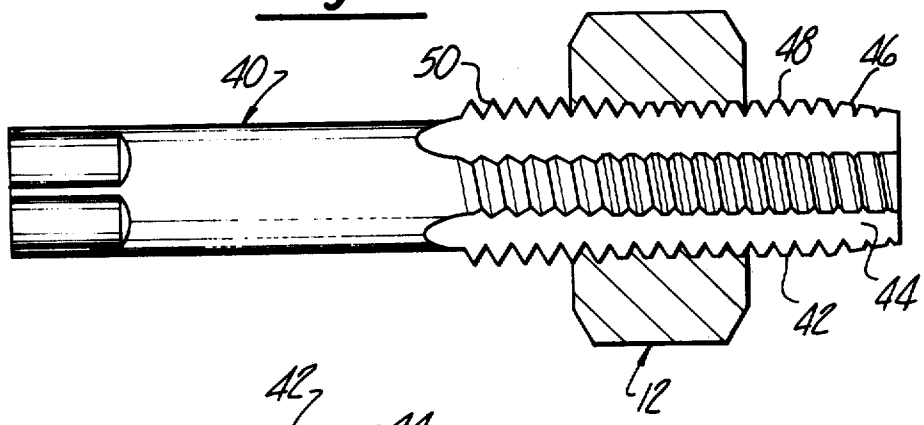


Fig-2

Fig-3



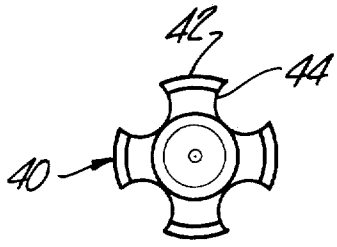


Fig-4

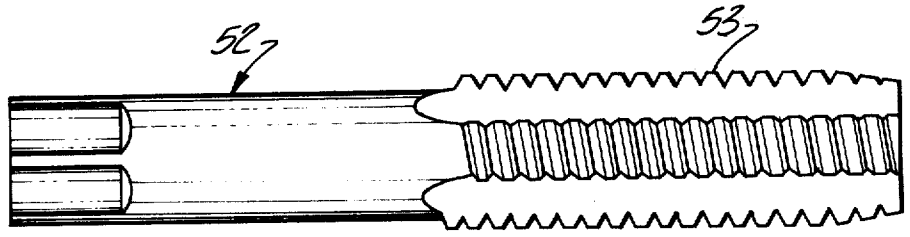


Fig-5

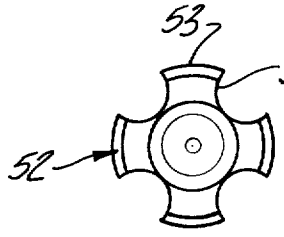


Fig-6

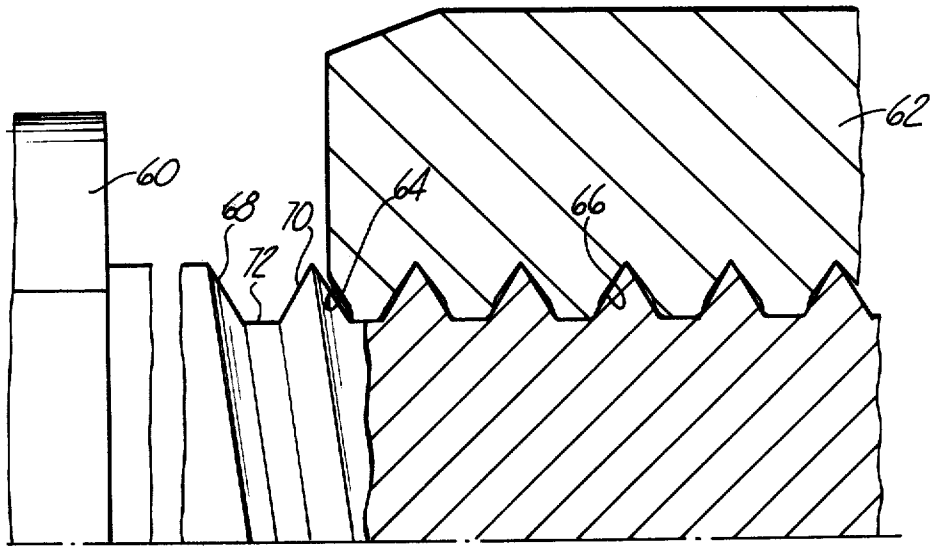


Fig-7

LOCKING FASTENER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

INTRODUCTION

This invention relates to vibration-resistant fasteners of the prevailing torque type and to tapping tools for forming threads which result in vibration-resistant fasteners of the prevailing torque type.

BACKGROUND OF THE INVENTION

The prior art shows many years of concern over the production of vibration-resistant fastener combinations. Simply stated, one approach involves the use of additional elements such as lock washers, cotter pins and glue bonds which are separate and distinct from the male and female elements of the fastener combination. The assembly of such elements adds significant cost to a high production application. Another approach involves the formation of shallow angled surfaces in the male and female thread forms which telescopically engage under axial tension to produce a self-locking effect. This approach has the negative effect of being very difficult and expensive to manufacture because of the close tolerances required. Other approaches such as deforming the nut after application are also disclosed in the prior art.

I have discovered that the key to a vibration-resistant self-locking fastener combination lies in the realization of firm radial contact between the male and female thread forms such that all lateral movement is constrained under vibration conditions. By eliminating the possibility for lateral shifting or relative movement between the thread forms, the high friction condition is maintained and an unwinding of the threads under axial tension conditions is eliminated. I have embodied this concept in a free-running fastener combination as disclosed in my co-pending application for U.S. Patent Ser. No. 755,437, filed Dec. 29, 1976 as a continuation of U.S. Ser. No. 620,566, filed Oct. 8, 1975, now abandoned. I have now found that I can apply this concept to a prevailing torque fastener combination.

BRIEF SUMMARY OF THE INVENTION

The principal object of my invention is to provide a prevailing torque fastener combination consisting of conjugate male and female threaded elements, which is extremely vibration resistant by reason of the achievement of firm radial engagement between the crest of one thread form and the root of the other thread form. By the term "prevailing-torque," I refer to a threaded fastener combination which requires a given and substantial turning force to move the threaded elements over one another even in the absence of axial load. This is to be contrasted with a free-running combination in which the turning force is insubstantial until axial tensioning develops.

In general, I accomplish this object through the provision of conjugate threaded elements, one of which exhibits normal well-defined flank intersections at one diameter, and substantially truncated or foreshortened flanks at the other diameter, such that when the elements are threaded together, firm radial contact occurs at the mating point of the truncation surface and the

crest of the other element. In addition, the threads are shaped to provide clearance between corresponding flanks thereby to accommodate material which is deformed from the crest of said other element during the threading process.

In the preferred form, I provide a female threaded element, the flanks of which are more greatly angled than the corresponding flanks of the male element with which it is intended to mate, thereby to provide longitudinal clearance between the crest of the male and the roots of the female threads when engaged, and a helical surface of truncation formed over at least a portion of the female root which is of lesser diameter than that of the male crest so as to produce firm radial contact therebetween when said elements are threadedly engaged. In stating that the female root is of "lesser diameter" than the diameter of the male crown, I intend to embrace not only a combination in which the difference between the diameters are significantly different, but also one in which the difference is substantially unmeasurable; i.e., the diameters are substantially the same. However, because of the tolerances which are normally required in standard manufacturing practices, it is realistic and accurate to anticipate that the skilled artisan will design and strive for a perceptible difference in diameters as aforesaid.

Because a perceptible difference in diameters between the male crest and the female root necessarily results in material deformation and a flattening or spreading of the material at the crest of the male thread, I have found that the longitudinal clearance provided by a perceptible difference in flank angles as between the male and female thread forms is required. This longitudinal clearance permits a helical volume of open space into which the deformed material can flow, thus to eliminate or substantially reduce any tendency to bind the fastener combination and make assembly or disassembly unnecessarily difficult.

I have also disclosed herein tapping tools which are capable of generating thread forms realizing the end objectives of my fastener invention as set forth above. In one form, the tapping tool is characterized by a cutting thread form having a constant diameter helical root over the working length thereof and a flat truncated crown or crest at a shallower or lesser diameter than that which would normally be associated with a male thread form having conjugally matable pitch and flank angles. In another form, I provide a tapping tool having a substantially constant diameter root and a varying diameter crest, the later-engaged crest diameter being the greater so as to result in a female thread form, the initial threads of which are substantially free-running thereby to permit easy early engagement of the elements, and the latter threads of which are of a reduced diameter so as to produce the prevailing torque effect and the firm radial engagement which is necessary to the realization of my inventive objectives.

The invention will be better understood from a reference to the following detailed descriptions and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a fastener combination comprising a machine bolt and nut constructed in accordance with the invention and being partially threaded together;

FIG. 2 is an enlarged sectional view through the fastener combination of FIG. 1 illustrating the internal

configuration and self-locking phenomenon which occurs;

FIG. 3 is a side view of a tapping tool useful in manufacturing the thread form of the female element in the combination of FIG. 2;

FIG. 4 is an end view of the tap of FIG. 3;

FIG. 5 is a side view of another tapping tool;

FIG. 6 is an end view of the tapping tool of FIG. 5; and

FIG. 7 is a side view, partly in section, of an alternative thread form where the truncated flanks are on the male thread.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENTS

FIG. 1 shows a fastener combination to comprise a male element in the form of a machine bolt **10** and a female element in the form of a nut **12** which is conjugally threaded onto the machine bolt **10** sufficiently to illustrate the effects of the preferred implementation of the invention. Machine bolt **10** includes an enlarged head having flat surfaces **14** formed thereon for application of a wrench or other torquing device, and a reduced diameter shank **16** approximately half of which is provided with conventional helical thread form **18**. Note that the crests of the thread form **18** between the nut **12** and the unthreaded shank portion **16** are characterized by relatively sharp intersection of the leading and trailing thread flanks. Because the nut **12** is constructed in accordance with the invention as hereinafter set forth, a firm radial engagement between the crest of the bolt thread form and the root of the nut thread form has been achieved; this has been evidenced by the flattening of the crests on the threaded portion **20** between the end of the bolt **10** and the nut **12** as is apparent in FIG. **1**.

Referring now to FIG. **2**, a substantially enlarged section through the fastener combination of FIG. **1** reveals the configurations of the nut and bolt thread forms which give rise to the self-locking and prevailing torque effects. The bolt **10** is manufactured according to conventional practices to exhibit a thread form having leading and trailing flanks **22** and **24** which lie at first, equal and opposite angles relative to the thread axis; i.e., the center line of the bolt **10**. The flanks **22** and **24** intersect to define a helical root having a constant radius RMR over the working length of the bolt **10**. The flanks **22** and **24** also define a relatively sharp crest which initially, i.e., prior to assembly with the nut **12**, has a constant radius RMC over the entire working length of the bolt **10**.

The female fastener or nut **12** is manufactured to provide thread form flanks **26** and **28** which correspond to the leading and trailing flanks **22** and **24** of the bolt **10** but which lie at second equal and opposite angles relative to the thread axis, which angles are greater than the angles of the flanks **22** and **24**. Accordingly, a longitudinal clearance initially exists between the flanks of the bolt and the flanks of the nut if projected over one another without actual threaded engagement. In addition, the female thread form includes over at least a portion of its length a flat helical surface of truncation **30** which is caused by a foreshortening of the female thread form from the thread depth which would obtain if the flanks **26** and **28** were continuous to intersection in the conventional manner. Adjacent the surface **32** of the nut **12** the truncation or foreshortening is minimal or zero so as to result in a first radius RF1 which is slightly greater than the radius RMC so as to facilitate early engagement and correct threading or seating of the nut **12** on the threads of the bolt **10**. About $1\frac{1}{2}$ turns will suffice. However, toward the opposite surface of the nut **12**, the truncation is increased so as to result in a second lesser radial dimension RF2 which is not only less than the dimension RF1 but also less than the dimension RMC. By way of example, the difference between RF1 and RF2 may be on the order of 0.017" for a 7/16-14 bolt. Accordingly, when the nut **12** is threaded onto the bolt **10** more than $1\frac{1}{2}$ turns, firm radial engagement between the crest of the male thread form and the root **30** of the female thread form obtains and a prevailing torque effect quickly results. As the nut **12** is threaded farther and farther onto the bolt **10**, the sharp crests of the male thread form are deformed and flattened off as shown at **34**, material from the flattening process flowing into and occupying part of the longitudinal clearance which had previously existed between the male and female thread forms. This clearance provides adequate volume to receive the material from the male thread form as it is deformed and thus prevents any binding effect which might otherwise occur.

It is of course clear that the entire female thread form root may be formed at the dimension RF2 in which case it is desirable that the first one or two threads of the bolt **10** are of a reduced diameter thus to obtain proper seating and threading of the elements. Also, the invention may be embodied in an asymmetric thread form if desired; i.e., one in which the leading and trailing flank angles are dissimilar.

Referring now to FIGS. **3** and **4**, a tap **40** which is useful in generating a female thread form of the type shown in FIG. **2** will be described in detail.

Tap **40** comprises an elongated cylindrical body having thread form ridges **42** separated by four circumferentially spaced flutes **44**. The right end of the tap **40** as shown in FIG. **3** comprises an entry or pilot portion **46** followed by a working length about half or more of which is characterized by truncated cutting teeth **48** of constant pitch and flank angle and of constant major and minor diameters; i.e., the diameter of the tap measured between roots is constant and the diameter of the tap measured between thread form crests is also constant. The final one-third of the working length of tap **40** is characterized by full crested or non-truncated cutting teeth **50** also arranged in a spiral or helical pattern of constant pitch and flank angle equal to the pitch and flank angle of the truncated teeth **48**. Although the minor diameter of the full crested teeth is equal to that of the truncated teeth, the major diameter; i.e., the distance measured diametrically between crests, is greater than that of the major diameter of truncated teeth **48**. It is clear that in tapping a bored or formed hole in a nut such as female fastener **12** in FIG. **2**, the truncated cutting teeth **48** form the truncated or clamping thread form portions having the surface **30** where firm radial engagement with the bolt occurs and the full crested cutting teeth **50** form the initial high clearance female thread forms shown to the left of female fastener **12** in FIG. **2**. Appropriate depth control is exercised in the tapping process.

FIGS. **5** and **6** illustrate a second tap **52** which is also elongated and cylindrical and provided with four rows of cutting teeth **53** separated by flutes **54**. The major difference between the tap **52** of FIGS. **5** and **6** and the tap **40** of FIGS. **3** and **4** lies in the fact that the cutting teeth are truncated throughout the entire length of the

tap so as to result in a female thread form exhibiting the surface of truncation **30** evident in FIG. **2** over the entire length of the thread form. As stated above, although the reduced diameter thread form which results from the use of the tap **52** may be used in combination with a conventional threaded bolt, it is preferable from the application standpoint to utilize a bolt having reduced diameter threads for one or two turns adjacent the entry end of the bolt so as to facilitate proper seating and threading of the fastener combination when threaded engagement is first begun.

The flank angles of both of the taps **40** and **52** are selected to be substantially steeper than the flank angles of a standard bolt having a pitch and thread diameter to be conjugal therewith. A difference of about 15° is contemplated, although this figure is not intended by way of limitation. Accordingly, the fastener combination results in the longitudinal clearance which is evident in FIG. **2** and described above.

FIG. **7** illustrates a fastener combination comprising bolt **60** and conjugate nut **62**. The thread form of the nut **62** is conventional, comprising helical flanks **64** and **66** which, before the nut is threaded onto the bolt **60**, exhibit conventionally sharp crest and root formations at the major and minor diameters thereof. Both the major and minor diameters are constant over the working length of the nut. The bolt thread, however, comprises steep-angled helical flanks **68** and **70** which form sharp crests at the major diameter but are substantially truncated at the minor diameter to form surface **72**. The thread depth of the bolt is therefore less than the thread depth of the nut.

When threaded together, the crest of the nut **62** firmly engages the surface **72** and deforms the nut crest to fill the lateral clearance between flanks and to provide the feel associated with a prevailing torque fastener.

Various modifications and applications to the invention as described above are possible; for example, the female thread form may be formed not only in a nut or other discrete fastener but also in a blind hole, threaded insert or other device. The nut **12**, although not necessarily requiring a separate heat treating or hardening process, may be selected so as to exhibit slightly greater hardness than the material of the male fastener so as to facilitate the deformation or Brinneling of the male thread form crest. I have also found that the clearance between thread flanks may be achieved in a combination having relatively similar flank angles in both nut and bolt. While I do not disclaim such a combination, I prefer the dissimilar flank angles because of the greater strip-strength which results. I can also apply my invention to prevailing torque nuts which are made of very hard materials and deformed such that the firm lateral contact referred to above is discontinuous around the circumference of the thread forms.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a prevailing-torque fastener combination;

a first element having a helical thread form with leading and trailing flanks which lie at respective first angles to the thread axis and which, before threaded engagement with another element, [intersect] *converge* to define a crest of substantially constant diameter over the working length of said element;

a second element having a helical thread form with leading and trailing flanks which lie at respective second angles relative to the thread axis and which are [truncated] *foreshortened* to define a root surface;

the first and second elements being conjugally threadable with one another;

at least a portion of the second element having a thread depth of lesser dimension than the thread depth of the first element thereby to cause firm radial engagement between the crest of the first element and the root surface when said elements are at least substantially fully threaded together;

[the threads of said elements being configured] *at least one of said second angles being greater than the corresponding one of said first angles by an angle of no greater than about 15°* to create longitudinal clearance between the flanks adjacent the engaging crest and [truncated] root sufficient to receive deformed material from said engaging crest when threaded together.

2. The combination defined in claim **1** wherein the first angles are the same and the second angles are the same such as to produce symmetrical thread forms in each of said male and female elements.

3. In a prevailing torque-fastener combination:

a male element having a helical thread form with leading and trailing flanks which lie at respective first angles to the thread axis and which [intersect] *converge* to define a crest of substantially constant diameter over the working length of said element;

a female element having a helical thread form with leading and trailing flanks which lie at respective second angles relative to the thread axis and which [intersect] *converge* to define a root;

the first and second elements being conjugally threadable with one another;

at least a portion of the female thread form root being of lesser diameter than the male crest to cause firm radial engagement therebetween when said elements are at least substantially fully threaded together;

at least one of the second angles being greater than the corresponding first [angles] *angle* to create longitudinal clearance between the flanks adjacent the male crest and female root sufficient to receive deformed material from one of said elements when threaded together, *the difference in flank angles being on the order of about 15°*.

4. The combination defined in claim **3** wherein the root of the female element is truncated to form a helical flat.

5. The combination defined in claim **4** wherein the helical flat is substantially parallel to the thread axis.

6. The combination defined in claim **4** wherein said female element exhibits a crest of constant diameter and a root of varying diameter such that at least partial threaded engagement between the male and female elements can be achieved before radial engagement between the male crest and the female root occurs.

7. The combination defined in claim **2** wherein the first angles are the same and the second angles are the same such as to produce symmetrical thread forms in each of said male and female elements.

8. For use in combination with a male threaded element having angled flanks and a constant thread diameter;

a female threaded element, *at least one of* the flanks of which [lie] *lies* at a greater angle relative to the thread axis than the corresponding [flanks] *flank* of the male element to provide longitudinal clearance between the flanks adjacent the crest of the male element and the root of the female element when the two elements are engaged, *said flanks being substantially uniplanar and lying at angles of no greater than about 75° from the longitudinal thread form axis,* and a helical surface of truncation formed over at least a portion of the female root and which is of lesser diameter than the diameter of the male crown so as to produce firm radial engagement between said elements when substantially fully threadedly engaged, *the difference in flank angles being on the order of about 15°.*

9. Apparatus as defined in claim 8 wherein the female element is characterized by a constant diameter crest and a varying diameter root, the greater root diameter being contiguous to one end of the thread form to permit a free-running starting engagement.

10. The apparatus defined in claim 8 wherein the angles of the flanks are equal and opposite so as to create a symmetrical thread form.

* * * * *