United States Patent [19]

Yankee et al.

[11] **3,818,749**

[45] **June 25, 1974**

[54] **THREAD ROLLING DIES AND METHOD OF MANUFACTURING SAME**

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[22] Filed: **Oct. 2, 1972**

[21] Appl. No.: **294,219**

[52] **U.S. Cl.** **72/469,** 151/22

[51] **Int. Cl.** **B21h 3/06**

[58] **Field of Search** .... 72/88, 90, 469; 151/22; 85/46; 10/10, 27, 153, 152 R, 152 T

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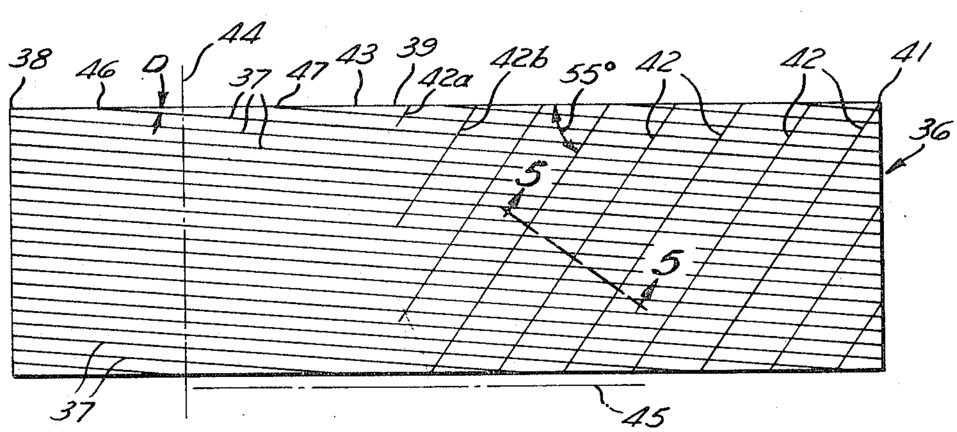
[57] **ABSTRACT**

A thread rolling die and a method of manufacturing such die is disclosed for forming self-locking threads having helically arranged arrays of thread form projections. The dies include thread forming convolutions spaced along the length of the die by a distance equal to π times the diameter of the blank to be threaded. Projection forming troughs are formed in the die at spaced locations along the length of the die a distance biased upon π times the sum of the blank diameter and two times the height of the projections. In the illustrated embodiment wherein three arrays of projections are provided around the thread to be formed, the spacing of the troughs is π divided by three times the sum of the blank diameter plus two times the height of the projections. The troughs are formed by a shaped pressing tool which is pressed into the face of the die prior to hardening wherein the spacing is arranged as set forth.

8 Claims, 7 Drawing Figures



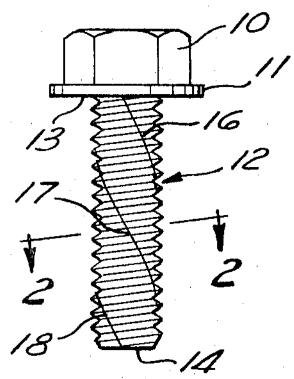


Fig. 1

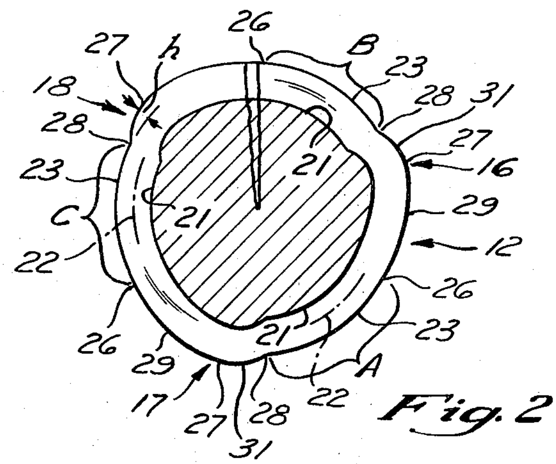


Fig. 2

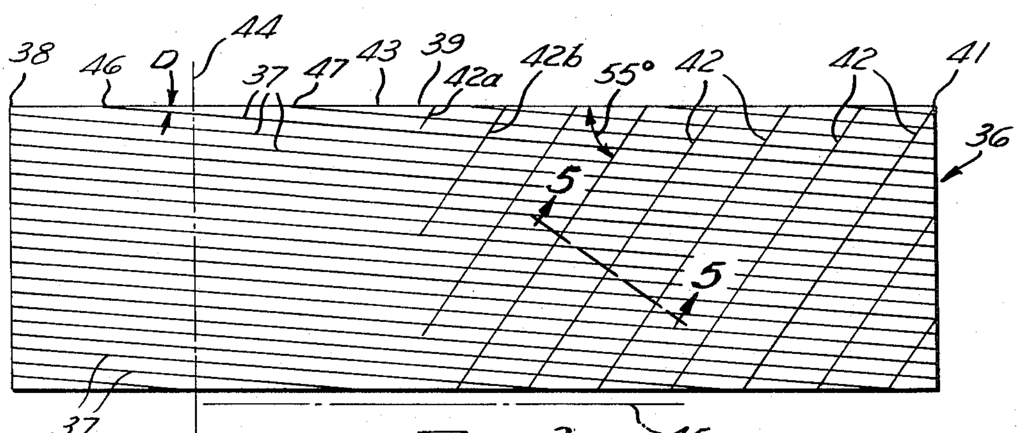


Fig. 3

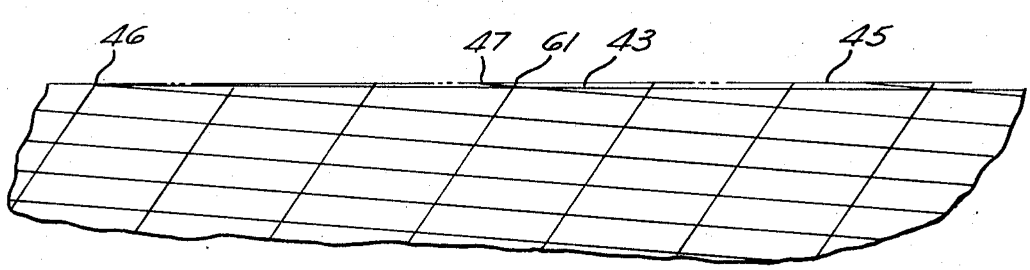


Fig. 4

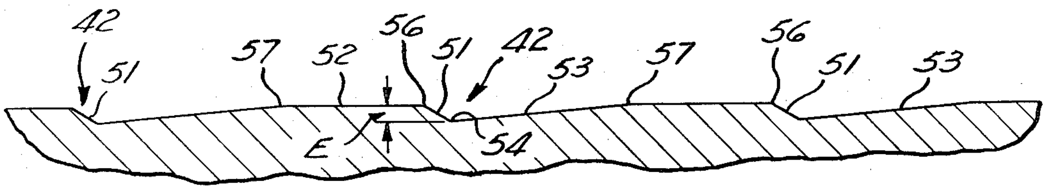


Fig. 5

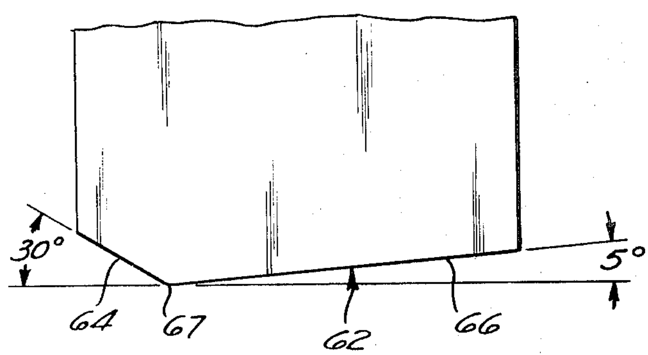


Fig. 6

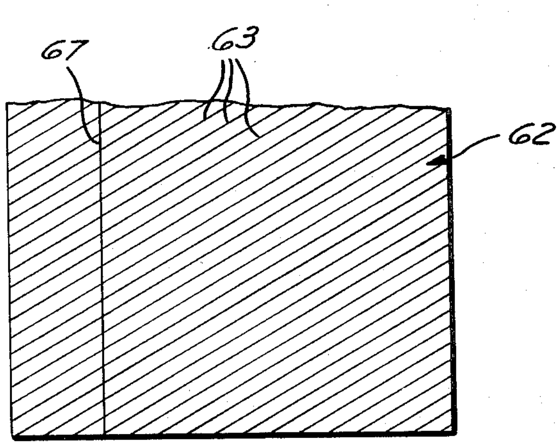


Fig. 7

THREAD ROLLING DIES AND METHOD OF MANUFACTURING SAME

BACKGROUND OF THE INVENTION

This invention relates generally to thread rolling and more particularly to novel and improved dies for forming threads having arrays of projections or the like and to a method of forming such dies.

PRIOR ART

Various types of thread arrangements are provided to perform special functions. For example, it is known to provide irregular thread shapes to provide a fastener which has self-locking characteristics. One such type of irregular thread form includes a plurality of helically arranged thread form projections in which the projections are shaped to resist loosening or threading out of the mating part and without substantially increasing the force of threading a fastener into a mating part. Such thread form projections have a lead ramp of gradually increasing radius and a trailing ramp of relatively rapidly increasing radius.

Such fasteners are usually self-tapping and form the thread in the mating part as they are threaded into position. When such fastener is threaded into the mating part, the lead ramps are on the forward side of the projections and because of their gradually increasing radius, do not require excessive torque to thread the fastener into the mating part. However, when the fastener is turned in the opposite direction to thread the fastener out of the mating part, the trailing ramps are on the forward side of the projections and because of their relatively rapid change in radius, produce a substantially increased resistance to removal or loosening of the fastener.

It was also known that projections could be formed on rolled fasteners with thread rolling dies with depressed or troughed portions.

When a blank is roll-threaded between two thread rolling dies, slippage must occur between the blank surface and the surface of the thread rolling die because of the different diameter of different thread portions. However, there is a diameter at which no slippage occurs and a substantially pure rolling action takes place. Such diameter is the diameter of the unthreaded blank which is roll-threaded by the dies. When the thread being formed is a typical machine screw thread form, the blank diameter is usually substantially equal to the pitch diameter but in other types of thread, this relationship may not be present. When dies were first manufactured to form threads having helically arranged arrays of thread form projections, a plurality of troughs were formed in the thread rolling dies spaced lengthwise of the die a distance based upon the blank diameter or pitch diameter of the basic thread.

With such dies, it was discovered that a partially-formed projection produced by the troughs first encountered by the blank surface did not properly register with subsequent troughs formed in the die and as a result, satisfactory threads were not produced.

SUMMARY OF THE INVENTION

It has been discovered that dies for producing helically arranged arrays of thread form projections will produce good quality threads when the dies are formed with thread forming convolutions spaced along the die axis a distance substantially equal to π times the blank diameter and are also provided with spaced troughs wherein the spacing of the troughs is based upon the blank diameter plus two times the height of the projections. In the illustrated embodiment, thread rolling dies are formed with a plurality of troughs spaced along the dies a distance substantially equal to π divided by the number of arrays to be formed in the thread times the sum of the blank diameter plus two times the height of the projections.

The troughs are formed, in the illustrated embodiment, to form a lead ramp of gradually increasing radius and a trailing ramp of relatively rapidly decreasing radius. The trough portion for forming the lead ramp, in the illustrated embodiment, is formed with a five degree angle with respect to the plane of the die face. The trough portion for forming the trailing ramp is formed with a 30° angle with respect to the plane of the die face.

Further, in the illustrated embodiment, the troughs extend at an angle of 35° with respect to planes perpendicular to the lengthwise direction of the die.

Because the blank must follow the basic thread form convolutions as it is rolled between the dies and because the lead angle of such thread form convolutions is based upon the blank diameter whereas the rolling movement of the blank is based upon the blank diameter plus two times the projection height, the blank moves axially within the die a limited amount as it is rolled. Therefore, in the preferred embodiment, the edge of the die adjacent to the head of the fastener is inclined to allow such axial movement of the blank within the die during the thread forming operation.

Still further, in the illustrated embodiment of this invention, the troughs are arranged in a pattern so that all portions of the thread are engaged and worked by substantially the same number of troughs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a bolt-type fastener having a thread formed thereon of the type formed by dies incorporating this invention in which helically extending arrays of thread form projections are formed at symmetrically located positions around the shank of the bolt;

FIG. 2 is a cross section taken generally along 2—2 of FIG. 1 in which the plane of the section is helical to conform to the thread;

FIG. 3 is a side elevation of one of a pair of thread rolling dies incorporating this invention;

FIG. 4 is an enlarged fragmentary view of the die illustrated in FIG. 3 with a view taken along the upper edge of the die;

FIG. 5 is an enlarged fragmentary section taken generally along 5—5 of FIG. 3 with the thread convolutions eliminated to better illustrate the shape of the troughs;

FIG. 6 is an end view of a pressing tool used to from the troughs in the dies; and

FIG. 7 is a bottom view of the tool illustrated in FIG. 6 showing the thread convolutions formed on the pressing tool.

DETAILED DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 illustrate a bolt fastener with threads formed by the illustrated dies incorporating this invention. The fastener illustrated in the figures include a hexagonal head **10**, a washer face **11**, and a threaded shank **12**. The threads extend along the entire shank **12** from the under surface **13** of the washer **11** to the end **14** of the shank. The end of the shank is slightly pointed so that the bolt can be started into an opening and form its own thread in the mating part. The illustrated thread form is a standard machine screw type but other types of thread forms can be rolled in accordance with this invention. The shank is, in the illustrated embodiment, formed with helically extending arrays **16, 17,** and **18** of thread form projections symmetrically positioned around the shank. The shape of these projections and the principal thread form is best illustrated in FIG. **2** which is a broken section taken along the lead angle of the thread.

The portions of the thread along the bracket zones A, B, and C have a constant and similar radius with a root diameter **21**, a pitch diameter **22**, and a crest diameter **23**. These diameters are determined by the standards established for the thread form being rolled on the blank. The pitch diameter **22** will be referred to herein as the principal pitch diameter of the thread being formed and, in the illustrated embodiment, is substantially equal to the blank diameter.

It is recognized that sufficient material must be present in the blank to properly fill the projections. Therefore, when the illustrated bolt is rolled with a given blank, the pitch diameter along the thread portions between projections will be less than the pitch diameter of a similar standard thread formed from the same blank without projections, and the effective pitch diameter along the crest of the projection will be greater than the pitch diameter of such a standard thread.

Between the zones A, B, and C, the thread is formed with the projections **16, 17,** and **18**. The three projections have a similar shape and each includes a lead ramp extending from **26** to **27** and a trailing ramp extending from **27** to **28**. The shape of the thread, excepting for the differences in radius occurring along the projections, is preferably the same as the shape of the thread in the zones A, B, and C. The lead ramp, however, is formed with a gradually increasing radius from the point **26** to the crest of the projections at **27** and the trailing ramp **31** is formed with a relatively rapidly decreasing radius from the crest of the projections at **27** to the point **28**.

The ramps are positioned so that as the bolt is threaded into a mating part, the lead ramps **29** are on the forward side of the projections in the direction of turning. On the other hand, when the thread is to be threaded out of the mating part or rotated in an anticlockwise direction as illustrated in FIG. **2**, the trailing or steep ramp **31** leads the projection and because of its relatively steep angle provides a relatively high resistance to rotation. Consequently, the fastener formed with the thread as illustrated tends to be self-locking in that it resists loosening but does not provide excessive torque requirement when the fastener is threaded into a mating part.

The particular thread illustrated is at about an eight times actual size scale for a standard 0.250 inch–20 thread, and the height of the projections **16, 17,** and **18** is about 0.10 inches. This height is represented by the distance h in FIG. **2**. The projections of each array are offset from the next or adjacent projection of the array so that the crest **27** extends with a helical pattern around the shank **12** of the bolt as illustrated in FIG. **1**. In the illustrated embodiment, the angle of the helix of the arrays is thirty-five degrees, and there are three arrays symmetrically positioned around the shank with angular spacing of 120°. Further, the length of the shank end and the helix angle of the arrays of thread form projections are arranged so that at least two arrays exist in any axially extending zone of the thread.

The thread rolling dies for forming the thread illustrated in FIGS. **1** and **2** are illustrated in FIGS. **3** through **5**. Only a single die is actually illustrated, but it should be understood that two similar dies are provided each of which is formed with the thread forming convolutions which are the same. The dies of a pair of such dies, however, usually differ in that one die is longer than the other.

The die **36** is a rectangular block of hardened metal provided with a working face having thread forming convolutions **37** therein. The shape of the convolutions **37** is arranged to produce the desired thread form on the fastener **10** when the fastener is rolled between the pair of dies. The convolutions are shaped so that as the fastener rolls between the dies from a location in which it engages the left end of the die as viewed in FIG. **3**, the threads are progressively formed and are completed when the blank rolls off the right hand end of the die.

The portion of the die between the left end at **38** and a midpoint at about **39** is free of troughs and is conventional in form. However, the portion of the die between **39** and **41** is provided with a plurality of angulated troughs indicated by the lines **42**. The particular shape of the troughs will be discussed in greater detail below with reference to FIG. **5**.

During rolling, the washer face **11** is positioned adjacent to the upper edge or side **43** of the die and the shank extends perpendicular to the lengthwise direction or axis **45** of the die. The spacing between the thread convolutions in a plane **44** perpendicular to the axis **45** of the die is equal to the pitch of the thread to be formed, and the spacing of the thread forming convolutions in the axial direction of the dies as indicated by the spacing between the points **46** and **47** is equal to π times the blank diameter. The thread forming convolutions extend diagonally across the die face with an angle D which is equal to the lead angle of the thread. The illustrated die forms a single lead thread and is therefore provided with this relationship. Of course, if multiple lead threads are desired, the angle of the thread convolutions **37** is appropriately changed.

The troughs **42** extend diagonally across the thread convolutions at an angle of 55° with respect to the die axis **45** and are formed with a profile, best illustrated in FIG. **5**. It should be understood that the thread form convolutions extend without interruption through the troughs with the crests and roots remaining the same distance apart. However, in FIG. **5**, the profile of the troughs is illustrated with the thread forms eliminated for purposes of illustration. In the illustrated embodiment, each trough includes a steep ramp **51** extending downwardly from the plane **52** of the die face at an angle of 30°, and a shallow ramp **53** extending back up toward the plane **52** with an angle with respect to the plane of 5°. The two ramps **51** and **53** meet at the bottom **54** of the troughs and the depth of the trough is represented by the distance E. This depth of the trough determines the height of the projections formed on the threaded fastener and equals the height. The bottom 54 of the troughs is represented by the lines indicated at 42 in FIG. 3. The junction of the trough with the plane 52 is not illustrated in FIG. 3, but occurs at 56 and 57. The face of the die between the junction at 57 of the shallow ramp of one trough and the junction at 56 of the steep ramp of the adjacent trough has the normal thread form convolutions and forms the portion of the blank indicated by the zones A, B, and C, on FIG. 2. The projections, on the other hand, are formed by the engagement with the respective troughs as the blank rolls along the dies.

When it was initially desired to manufacture thread rolling dies to form threads of the shape illustrated in FIGS. 1 and 2, it was believed that the spacing of the troughs in the direction of the die axis 45 should be based upon the same spacing as the spacing between the thread convolutions in this direction, namely, π times the diameter of the blank on which the thread was to be formed. Such spacing, because three arrays of projections are provided, was believed to be the principal pitch diameter or blank diameter times π divided by three. It was discovered, however, when the dies are manufactured with such trough spacing that the partially formed projection formed by one trough did not register properly with a subsequent trough and an unsuitable thread was formed.

It has now been determined that the spacing of the troughs in the axial direction of 45 should not be based upon the blank diameter but rather upon the sum of the blank diameter of the threads plus the height of the projections. Therefore, in the illustrated dies, the spacing between the troughs 42 in the direction of the die axis 45 is equal to π divided by three times the sum of the blank diameter plus two times the height of the projections. With such a spacing of the troughs, it has been determined that the partially formed troughs register properly with the subsequent troughs and that properly formed projections are obtained. In the illustrated embodiment, it appears that as the blank rolls across the troughs, it rolls at a diameter equivalent to the pitch diameter of the threads at the crests of the projections.

Of course, the spacing need not be mathematically in exact accordance with this formula to produce satisfactory threads, and satisfactory threads are obtained when the troughs are spaced within the range between π divided by three times the sum of the blank diameter plus one and a half times the projection height to π divided by three times the sum of the blank diameter and two and a half times the projection height.

Since proper registration of the projections occurs as they are progressively worked by the troughs, the blank is rolling along the die face at a diameter greater than the blank diameter. However, since the thread forming convolutions are spaced a distance determined by the blank diameter of the threads, the blank actually moves axially down into the die a small amount as it rolls across the troughs. Therefore, when it is desired to produce well-defined projections all the way up to the under surface 13 of the washer face 11, it is desirable to taper the side 43 of the die in the zone between the location 39 and 41 a slight amount so that interference will not be developed as the blank moves axially down into the die. Reference should be made to FIG. 4 wherein the axis of the die is indicated at 45. The side 43 of the die between the locations 38 and 39 is preferably in exact alignment with the axis 45. However, the side 43 between the points 39 and 41 is inclined slightly away from the axis 45 as illustrated. In FIG. 4, the thread convolutions and the troughs are illustrated as projected to the axis line 45 for purposes of illustration. The axial spacing of the thread convolutions is therefore illustrated by the spacing between the points 46 and 47. However, the axial spacing of the troughs is arranged so that the axial spacing of each set of three troughs is a greater distance represented by the distance between the points 46 and 61. The difference in spacing represented by the distance between the points 47 and 61 is equal to π times two times the projection height.

Because the blank rolls through one revolution in the distance between 46 and 61 and because it must track with the thread forming convolutions, the blank moves down into the die a distance equal to the spacing between the side edge 43 and the axis 45. Therefore, the side 43 of the die is preferably inclined with respect to the axis at an angle determined by this distance. It is not necessary in all cases to form the side of the die with this angle since the angle is very small and it may not be necessary to form the threads and projections accurately all the way to the underside 13 of the washer face.

In order to provide good control of the blank as it is rolling along the troughs it is preferable to arrange the angle of the helix of the arrays of projections and the length of the thread so that the blank will engage two troughs at any point when it is rolling along the final portion of the die. When such proportions are provided, at least two troughs 42 exist in any plane 44 perpendicular to the die axis 45 in the final portion of the die. In some instances, it is desirable to form partial troughs 42*a* and 42*b* at the beginning of the projection forming portion of the die so that all locations along the blank length will be worked by substantially the same numbers of troughs.

The troughs 42 are preferably formed by a tool as illustrated in FIGS. 6 and 7. This tool is provided with a lower face 62 formed with thread form convolutions 63 shaped to mate with the thread form convolutions 37 of the die. In FIG. 6, the face 62 is not illustrated with such thread form convolutions for purposes of illustration. The face 62 includes two face portions 64 and 66. The first portion 64 is inclined at thirty degrees upward from a junction 67 and the other surface portion 66 extends upwardly from the junction 67 at an angle of five degrees. In practice, a small radius exists at the junction 67.

In the manufacture of the dies, the die is formed with the convolutions 37 extending the full length of the die while the material of the die is in the soft and unhardened state. The tool of FIGS. 6 and 7 is then positioned against the face of the die block with the junction line 67 positioned immediately above the location of the desired trough bottom 54. The tool is then pressed into the face of the die blank a distance equal to the desired projection height to form a trough. This operation is repeated until all of the required troughs are formed in the unhardened die block. Because the tool is formed with thread convolutions matching the thread convolutions of the die, the pressing operation does not alter materially the shape of the die thread convolutions but merely depresses them in the trough zone. The die is then hardened to complete its manufacture.

With a die manufactured in accordance with the present invention, it is possible to accurately form threaded fasteners having arrays of thread form projections of the general type illustrated. It should be understood, however, that dies formed in accordance with the present invention can be formed to roll other thread forms and other types of threaded fasteners. For example, pointed self-tapping screws or the like can be rolled with appropriately shaped dies having troughs formed therein with a spacing in accordance with the present invention.

Although a preferred embodiment of this invention is illustrated, it should be understood that various modifications and rearrangements of parts may be resorted to without departing from the scope of the invention disclosed and claimed herein.

What is claimed is:

1. Dies for forming threads on a fastener having a principal pitch diameter and a plurality of helically arranged arrays of thread form projections symmetrically positioned around the periphery of said fastener comprising a pair of dies each having a face formed with thread forming convolutions extending therealong with a lead angle of the thread to be formed and spaced in the lengthwise direction of said dies by a distance substantially equal to the diameter of the blank to be threaded times π, and a plurality of thread form troughs extending diagonally across said face, said troughs being spaced in said direction by a distance substantially equal to π divided by the number of arrays times the sum of said blank diameter and two times the height of said projections.

2. Dies as set forth in claim **1** wherein the helix angle of said arrays and the axial length of the thread to be formed insures that at least two of said troughs are provided in planes perpendicular to the length of said dies.

3. Dies as set forth in claim **2** wherein said surface provides a first portion along which initial forming of threads is performed, and the second portion along which thread forming is completed, and said troughs are provided along said second portion.

4. Dies as set forth in claim **3** wherein said troughs are provided only along said second portion.

5. Dies for forming threads as set forth in claim **4** wherein said dies are each provided with a side edge which is aligned with said lengthwise direction along said first portion and is inclined at a small angle with respect to said lengthwise direction along said second portion.

6. Dies for forming threads as set forth in claim **5** wherein said troughs have two ramp surfaces which are inclined with respect to said face at different angles.

7. Dies for forming threads as set forth in claim **1** wherein said troughs have two ramp surfaces which are inclined with respect to said face at different angles.

8. Dies as set forth in claim **1** wherein said troughs are spaced in said direction by a distance at least equal to π divided by the number of arrays times the sum of said blank diameter and one and one half times the height of said projections, and said troughs are spaced in said direction by a distance no greater than π divided by the number of arrays times the sum of said blank diameter and two and one half times the height of said projections.

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