

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Self-tapping Screw with Lobular Work-entering End and Methods for Manufacturing Same

We, RESEARCH ENGINEERING & MANUFACTURING, INC., a corporation organized and existing under the laws of the State of Massachusetts, of 459 Mt. Pleasant Street, New Bedford, Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to improvements in self-tapping screws and to methods for manufacturing such screws.

The self-tapping screws with which this application is concerned are of the type which form internal threads by a swaging action. While conventional screws of this type have the advantage of forming no chips, as compared with self-tapping screws which form internal threads by a cutting action, the former screws also have certain well recognized limitations. These limitations include a high driving torque, which frequently makes the differential between the driving torque and the stripping torque of such screws so small as to cause difficulty in driving them into a fully seated position in an assembly without exceeding their stripping torques and thus stripping their threads. This difficulty occurs most frequently when screws are driven using clutch-controlled power drivers commonly used in assembly lines, since the clutches of power drivers cannot be relied upon to disengage each time exactly at the preset torque release value. Naturally, such screw failures result in costly production delays.

Self-tapping screws of the swaging type have been previously proposed in which the differential between driving torque and stripping torque is substantially increased, principally

by providing such screws with threaded portions of arcuate polygonal cross-sectional shape throughout the full length thereof. Although effecting a substantial reduction in driving torque, certain varieties of screws of such shape have the disadvantage of a stripping torque less than that which is desired in certain applications.

It is the principal object of the present invention to provide a new and improved screw which offers advantages over self-tapping screws which have generally been known and used in the past.

The present invention accordingly provides a fluteless self-tapping threaded screw for swaging threads in a parent body and securing another body to parent body, which screw has a continuous rolled thread formation on both shank and work-entering end portions, wherein:—

- (a) the shank portion is formed with a plurality of thread turns having a pitch surface which is of circular shape in cross-section,
- (b) the crest of the thread on the work-entering end portion has diameters which decrease progressively towards the work-entering tip,
- (c) the thread formation on the work-entering end portion has pitch surface cross sections in the form of generally arcuate polygons,
- (d) the polygons include an odd number of symmetrically arranged arcuate sides which merge gradually with intermediate arcuate lobes,
- (e) the radius of curvature of the said sides along the pitch surface in each transverse cross-section is greater than one-half of the width of such cross section, and

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- (f) the radius of curvature of the said lobes along the pitch surface in each transverse cross section is substantially less than one-half of the width of such cross section.

The invention further provides a fluteless self-tapping thread screen for swaging threads in a parent body and securing another body to the parent body, which screw has a continuous rolled thread formation on both shank and work-entering end portions, wherein:—

- (a) the said shank portion is formed by a plurality of thread turns having a pitch surface which is of circular shape in cross-section,
- (b) the crest of the thread on the work-entering end portion has diameters which decrease progressively towards the work-entering tip,
- (c) the thread on the end portion has a pitch surface which in cross-section is of arcuate, triangular, lobular shape having arcuate sides which merge with intermediate arcuate lobes having a lesser radius of curvature than the said sides, and
- (d) the maximum width of the lobular pitch surface of the said end portion is less than the diameter of the circular pitch surface of the said thread turns on the shank portion, and
- (e) the lobular pitch surface merges smoothly with the circular pitch surface.

With the self-tapping screws provided by this invention the shape of the shank portion provides a high stripping torque, while the work-entering end portion is characterised by a low driving torque, as is more particularly explained in the following description.

The invention will now be more fully described, by way of example, with reference to the accompanying drawings. These show a number of self-tapping screws constructed in accordance with the invention.

In the drawings:—

Fig. 1 is a side elevation of a two-section, self-tapping screw which exemplifies the invention;

Fig. 2 is an end view of the work-entering end of the screw shown in Fig. 1;

Figure 3 is a side elevation of a three-section, self-tapping screw which represents a further modification of the invention;

Fig. 4 is an end view of the work-entering end of the screw of Fig. 3;

Fig. 5 is a side view of a blank from which the screw of Fig. 1 is made;

Fig. 6 is an end view of the blank of Fig. 3;

Fig. 7 is a diagram illustrating one convolution of a thread, such as along the line 7—7 of Fig. 1;

Fig. 8 is a top plan view of a face of one of a pair of dies used for making the screw shown in Fig. 1;

Fig. 9 is an end view from the right of the die of Fig. 8;

Fig. 10 is an enlarged profile of the surface of the die of Fig. 8, as viewed in the direction of the arrows 10—10 of Fig. 9;

Fig. 11 is a top plan view of one of a pair of dies used for making the screw shown in Fig. 3;

Fig. 12 is an end view from the left of the die of Fig. 11;

Fig. 13 is an end view from the right of the die of Fig. 11;

Fig. 14 is a sectional view of the die taken along the line 14—14 of Fig. 11;

Fig. 15 is a side plan view of the die of Fig. 11;

Fig. 16 is a side view showing another modification of a screw made in accordance with the present invention;

Fig. 17 is an end view of the screw shown in Fig. 16;

Fig. 18 is a side elevation of a blank used for the screw shown in Fig. 16;

Fig. 19 is an end view of the blank shown in Fig. 18;

Fig. 20 is a side elevation of a screw according to a still further modification;

Fig. 21 is an end view of the screw shown in Fig. 20;

Fig. 22 is a side elevation of a blank for the screw of Fig. 20; and

Fig. 23 is an end view of the blank of Fig. 20.

In this specification, the following definitions shall be applicable:

"Pitch diameter" is used as a generic term to designate the diameter, that is the maximum width, of any section of either the "pitch cylinder" or the "pitch cone."

"Pitch cylinder is, on a straight thread, an imaginary coaxial cylinder round or otherwise, the surface of which would pass through the thread profiles, or the projection thereof, at such points as to make the width of the groove, or the projection thereof, equal to one-half the basic pitch.

"Pitch cone" on a taper thread, is an imaginary coaxial cone, the surface of which would pass through the thread profiles, or the projection thereof, at such points as to make the width of the groove, or the projection thereof, equal to one-half the basic pitch. See, for example, the section of a pitch cone indicated in dotted lines 36 in Fig. 7.

"Pitch surface" is used to designate the surface of either the pitch cylinder or the pitch cone.

"Pitch surface cross section" is used to designate the transverse cross section of any pitch surface, such as that of either the pitch cylinder or the pitch cone, as defined above.



It will be observed that the pitch cylinder and pitch cone of the lobular portions of the screws herein described are not a round cylinder and not a cone of round cross section. The divergence in the case of the cylinder arises from the lobular or arcuate polygonal cross section of the threaded intermediate shank portion, and, in the case of the cone, it arises from the lobular or arcuate polygonal cross section of the ~~thread~~ work-entering portion.

The self-tapping screw, generally indicated at 5, of Figs. 1 and 2 is shown as having a head 6 provided with a tool-receiving recess 7, which may be of any type. The shank 5 of the screw consists of a first, main shank portion 8 of circular cross section and a tapered, lobular work-entering or thread-forming end portion 9 whose cross-sectional shape is shown as being approximately that of a curvilinear, equilateral triangle. Both sections are provided with a continuous helical thread 10. While the screw illustrated is of the gimlet point type, it is understood that the invention is applicable to other conventional types of screws.

The main shank, as illustrated, has a straight thread formation having constant major, pitch and minor diameters of circular cross section. It is to be understood that this is not a limitation in that, for example, the round shank may have a slight up-taper toward the head, if desired. The work-entering or thread-forming end portion 9 has a tapered thread formation having major, pitch and minor diameters progressively decreasing toward the work-entering end or tip.

It will be noted that, because of the generally polygonal cross-sectional shape of the tapered work-entering end portion 9, the thread 10 establishes a series of arcuate lobes 11 whose radial extent or distance from the screw axis 22 increases progressively toward the shank portion 8 until the thread crest of the last such lobe defines, as the screw is rotated, a circle whose diameter is approximately that of the outside or major diameter of the thread 10 in the main shank portion 8.

As previously mentioned, each lobe 11 is shown as being arcuate and has at its outer extremity a thread sufficiently developed with respect to its position relative to the work-entering end of the screw to carry out its thread-forming function, whereas the arcuate sides 23 between the lobes need not have a similarly developed thread because such sides do not perform any thread-forming function. It is important that the sides 23 merge smoothly and gradually with the lobes 11 in order that the lobes may carry out their swaging function without cutting chips from the walls of the pilot hole with which they are in frictional contact. The arcuate lobes 11 have a pitch radius of curvature sub-

stantially less than one-half the pitch diameter in the corresponding cross section, and also less than one-half the distance from the screw axis 22 to the lobe extremity, so as to reduce the frictional contact between the lobes and the walls of the pilot hole to a minimum. The arcuate sides 23, on the other hand, have a pitch radius of curvature greater than one-half of the pitch diameter in the corresponding cross section.

It will be understood that a screw of arcuate triangular cross section throughout the main shank, as well as in the work-entering end thereof, will not have a high stripping strength in thin metals, as compared with that of one having a round main shank. Full thread engagement with the female thread in the parent body is limited, in the case of an arcuate triangular shank, to the lobes only, with only limited overlapping of threads or thread engagement occurring along the arcuate sides between such lobes. However, with a round shank, maximum thread engagement is effected throughout 360 degrees. Thus the screw of Fig. 1 represents a very desirable form of self-tapping screw in that the main shank is shaped like a conventional screw to provide very good holding power and the work-entering end is shaped to provide a low driving torque.

In Figs. 3 and 4 is shown a further modification of a self-tapping screw, which is shown at 12 and which is of the gimlet point type, being provided with a head 13 having a tool-receiving recess 14. The screw has a straight main shank or holding portion 15 of circular cross-sectional shape, a tapered work-entering or thread-forming end portion 16 of arcuate equilateral triangular cross-sectional shape, and a straight intermediate shank portion 17, also of arcuate equilateral triangular shape. A thread formation 18 is arranged and disposed to provide a straight thread in the intermediate portion 17 and the shank or holding portion 15, and a tapered thread in the work-entering end portion 16. The thread formation in the main shank portion 15 has circular cross sections, while the cross-sectional shape of the portions 16 and 17 is shown as being approximately that of an arcuate, equilateral triangle, establishing lobes 19 with intermediate broad sides 24.

The radial extent of the lobes 19 in the tapered thread-forming portion 16 increases toward the intermediate shank portion 17 until the radial extent of the lobe next adjacent such portion is the same as that of the lobes in the portion 17. The radial extent of the lobes in the portion 17 is such that they define, when rotated, a circle whose diameter is approximately the same as that of the outside or major diameter of the thread 18 in the circular holding portion 15. Each



lobe 19, at least in the tapered portion 16; has the function of swaging a portion of the thread in the workpiece and is arcuate with a pitch radius of curvature considerably less than one-half the pitch diameter in the corresponding cross section, similar to the screw in Fig. 1.

The arcuate intermediate sides 24 of the screw of Figs. 3 and 4 do not effect any frictional engagement with the walls of the pilot hole and, since they are continued over an intermediate portion of the screw shank, the driving torque is reduced to an even greater degree than that of the screw of Fig. 1. Such a screw having a lobular intermediate shank portion is especially useful where a driving torque even lower than that provided by the screw of Fig. 1 is desired and where the intermediate portion 17 is not needed to develop holding power as, for example, in very hard thin plates or in sheet metal where the intermediate portion, as well as the tapered point, will be driven completely through the work.

In Figs. 5 and 6 is shown a blank from which the screw of Fig. 1 may be made, which blank is provided with an enlarged driving head 26 corresponding to the head 6 in Fig. 1, and a main shank 27 of round, i.e. circular, cross section. A lobular portion 28 is provided at the end opposite the head 26. As shown especially in Fig. 6, the end portion 28 is of arcuate triangular cross section. The blank 25 may be formed by first severing a predetermined length of round wire or rod stock in a cold heading machine, and then upsetting the head portion 26 and also extruding a short opposite end portion through a die orifice of arcuate triangular shape to form the portion 28.

For manufacturing the screw shown in Figs. 3 and 4, a blank will be prepared similar to that shown in Figs. 5 and 6, except that the lobular end portion 28 will be given a length at least equal to the combined lengths of the end and intermediate portions 16 and 17 of the screw.

With reference to Fig. 6 it will be observed that the transverse width of the lobular portion of the blank is substantially constant throughout 360 degrees around this blank portion, even though it is not round. Threads may be rolled on such blanks although, due to the fact that the two portions are of different cross section, especially prepared thread-rolling dies must be provided. Two different modifications of rolling dies will be described herein. With either of these forms of thread-rolling dies, it is possible to form threads on the lobular portion of the blank having lobular pitch surface cross sections, while the thread portion on the round part of the blank will have circular pitch surface cross sections. This is important to the

present invention as will appear from a consideration of the view of Fig. 7.

In Fig. 7 the line 31 illustrates the peripheral or crest contour of a single spiral revolution of thread on the tapered end portion, for example, of the screw 5 next adjacent the round portion 8. The root of the thread portions which will be formed in a parent body by the crests of the lobes 11a, 11b and 11c may be represented by the circular arcs 32, 33 and 34, the extent of which may be further represented by the arcs D, E and F. From the crests of the lobes the screw thread recedes from contacting engagement with the surfaces of the thread formed in the parent body and hence there is no frictional contact throughout the entire extent of the arcs D, E and F.

The working engagement of the lobes 11b, 11c and 11 with the body of parent material is indicated by the arcs A, B and C, respectively. It will be observed that the total engagement amounts to approximately twenty-five per cent of the total peripheral extent of the screw thread. Due to the fact that approximately three-fourths of the screw thread is thus held out of engagement with the metal of the parent body, the frictional drag is held down and the driving torque of the screw is also thus reduced to low value. For this reason, the screw as illustrated may readily be driven through relatively thick metal members with a very low driving torque requirement. At the same time, the angle of inclination of the thread portions over the distances A, B and C is not so steep that they will cut chips from the body being threaded.

The dotted circle 35 indicates the root diameter of the thread formed by a complete revolution of the last lobe 11. Since it is assumed that the line 31 represents the last lobular thread before it merges into the circular thread on the round shank portion of the screw, the circle 35 may therefore also represent the crest diameter of the thread on such shank portion.

Since the portions 23 of the thread between the lobes 11 do not engage the metal during the thread-forming operation, these portions 23 need not be perfectly formed during the thread-rolling procedure. In fact, with some types of screws even the lobes toward the tip of the work-entering end need not have fully formed crests. It is important, however, that the lobes of the pitch surface cross section have a pitch radius of curvature substantially less than one-half the diameter of such cross section.

Referring to Fig. 7, the dotted line 36 represents a typical pitch surface cross section, or pitch cone cross section, of the tapered work-entering end 9 of the screw 5.

This pitch surface cross section is of uniform width throughout 360 degrees. In other

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words, the maximum transverse dimension 38 is constant throughout 360 degrees, and attention is directed to the fact that this maximum dimension, or width, is not always measured through the central axis of the member. The radius of curvature of the lobes of such cross section, indicated at 37, is substantially less than one-half, and in this case more nearly one-fourth, the width 38 of such cross section. With the lobes of the threads thus formed, the swaging of the female thread over the lobular distances A, B and C will take place smoothly with a minimum of driving effort and without formation of any chips.

It may be noted that the radius of curvature of the generally arcuate sides (represented by the parts of the line 36, between the lobes) of the cross-section indicated by this line is greater than one half the width of such cross-section so that these sides can merge smoothly with the lobes.

With reference to Figs. 8, 9 and 10, a die 40 is shown having a modified die face 41 especially adapted for rolling the blank 25 of Fig. 5. It is to be understood that a pair of similar cooperating dies are required, but only one will be described. As is shown most clearly in Fig. 9, the die face 41 in cross section has a first, generally-flat rolling section 42 for rolling the circular portion 27 of the blank 25 and a second rolling section 43 laterally adjacent and inclined to the first section for rolling threads on the lobular work-entering portion 28 of such blank. These sections are shown incorporated in a so-called flat thread-rolling die, although it is to be understood that the same general scheme could be incorporated in rotary or planetary thread-rolling dies. Each of the two rolling sections 42 and 43 is provided with a series of generally parallel angularly extending ridges 44 and valleys 45 of a form complementary to that of the root and crest, respectively, of the screw thread being rolled, at least in the finishing section 46 of the die face as shown in Fig. 8.

However, as shown in Fig. 10, the inclined rolling section 43 of the die face in the longitudinal direction is scalloped or undulating to provide a series of bumps 47 and depressions 48 which form the arcuate sides and lobes respectively of the thread in the lobular portion of the screw. This enables both the round and lobular portions of the blank to be threaded simultaneously by permitting the axis of the blank in the round portion to remain at a substantially constant distance from the flat die face 42 while the axis of the lobular portion of the blank can undulate relative to the adjacent scalloped die face 43.

In other words, as a screw blank is rolled the length of the die face shown in Figs. 8 and 10 the path of the screw axis will

be defined by the flat, first thread-rolling section 42 and the second thread-rolling section will undulate with respect to this path.

A screw produced by the die 40 may have any number of sides and intermediate lobes in the work-entering end portion thereof, by providing a corresponding number of bumps and depressions in the portion 43 for each revolution of the blank. However, in screws of small size, a three-lobed screw is preferable as more lobes will cause the screw point to approximate too closely to a circular configuration.

While it may be preferred to use a blank having a preformed lobular end portion 28, this not necessary, especially in the case of a gimlet point screw where the end is heavily worked and the excess material pinched off. Accordingly, the screw of Fig. 1 may be made by the use of the same dies as are illustrated in Figs. 8, 9 and 10, but by the insertion of a blank of circular cross section throughout, in which case the end of the blank will be formed into the required tapered lobular cross section.

With reference to Fig. 11, a flat die 50 is shown having another form of die face and which is, in this instance, designed especially for rolling threads upon a blank for the type of screw shown in Fig. 3 having an intermediate lobular shank portion in addition to a lobular work-entering end and a round shank portion. The die 50 is, of course, one of a pair, and in this case is adapted to first roll threads on the lobular portions of the blank in the rolling section 51 of the die face and thereafter to roll threads on the circular portion of the blank in the section 52 of the die face, although both portions of the blank are threaded in one continuous stroke of the movable die.

Interposed between the lobular and round rolling sections of the die is a short transfer section 53 to insure a smooth continuous die stroke at the point where threading of the lobular blank portion ends and threading of the circular blank portion begins. Both the lobular and round rolling sections of the die face are divided into three subsections, a first or starting sub-section 58 and 61 where initial penetration of the blank by the die takes place, a second or transition section 59 and 62, and a finishing section 60 and 63 where the threads are rolled to their finished form.

As shown more clearly in Fig. 12, the lobular rolling section 51 includes a flat section 54 for rolling threads on the straight lobular portion 17 of the screw and an inclined section 56 for rolling threads on the tapered lobular portion 16 of the blank. In addition, a relieved plane die surface 57 is provided adjacent the ridged die face 54 and has sufficient relief so that the round portion of the blank is out of contact therewith and

is permitted to undulate as the lobular blank portion is threaded.

In Fig. 13 is shown an end view of the round blank portion rolling section 52 at its finishing end, including the adjacent relieved plane surfaced portion 58 which provides clearance between the previously threaded lobular tapered section and the die as the round portion of the blank is threaded. It is to be understood that the portion 58, instead of being relieved as shown, may be provided with thread ridges, the same as are provided on the section 52.

Fig. 14 shows the transfer section 53 which includes the end of the finishing section 60 in the lobular rolling portion and the beginning of the starting section 61 of the round rolling portion 52 of the die face.

As shown in Fig. 15, both the lobular and round rolling sections 51 and 52 of the die face are flat in profile in the longitudinal direction of the die, which makes such a pair of dies considerably less expensive to manufacture than the partially scalloped dies of Fig. 8. Also, although the dies of Fig. 8 thread the lobular and round blank portions simultaneously, the speed at which parts can be threaded is not appreciably greater than with the flat die of Fig. 11.

However, in threading blanks using dies as shown in Fig. 11, it is desirable that the blank should have at least a small straight shank portion adjacent the work-entering end of the same arcuate polygonal cross section as such end so that the lobular rolling sections of the dies have a sufficient length of the blank to grip during the rolling operation to maintain the blank in a constant orientation relative to the dies as the blank is rotated.

A limiting factor in the use of the flat dies of the type illustrated in Fig. 11 is that the cross-sectional shape of the lobular blank portions should be such that they may be rolled smoothly between a pair of relatively uniformly spaced die faces. Specifically referring again to Fig. 6, the lobular blank portion is of arcuate equilateral triangular shape having arcuate sides 29 merging smoothly with the arcuate lobes 30. The arcuate lobes 30 have a radius of curvature less than one-half the diameter in the corresponding section. The width through any lobular cross section is approximately constant throughout 360 degrees so that such portion will roll smoothly between uniformly spaced-apart rolling die face portions.

In Figs. 16 and 17 is shown a machine screw 80 embodying the present invention having a round main shank 81 and a tapered lobular thread-forming portion 82 similar to the screw of Fig. 1 but terminating in a blunt end 84. The thread formation 85 has a constant pitch diameter in the main shank and also has a slightly less but constant pitch diameter in the lobular work-entering

portion. The major diameter in the work-entering portion decreases toward the work-entering end 84, however, and the thread crests 85 become increasingly unfinished toward such end.

In Figs. 18 and 19 is illustrated a blank 67 required for the screw of Figs. 16 and 17, having a round shank portion 68 and a tapered lobular end portion 69, which is illustrated more clearly by the end view of Fig. 19. Figs. 22 and 23 are similar views illustrating a blank 75 for use in making the screw shown in Figs. 20 and 21. This blank has a round shank portion 76, a lobular intermediate portion 77 and a tapered lobular end portion 78.

In Figs. 20 and 21 is shown a machine screw 70 similar to that of Fig. 16 but having a lobular intermediate shank portion 71 interposed between the round main shank portion 72 and the lobular thread-forming end portion 73, so that such screw can be formed by thread-rolling dies somewhat similar to those described with reference to Figs. 11 to 15. The die face portion 51 would be flat in the transverse direction, however, like the face portion 52, and the pair of dies could be mounted in the machine in a tapered or inclined relation in the longitudinal direction with respect to each other to provide for the closer spacing required for threading the lobular portions of the blank.

As previously explained with reference to Fig. 7, it is not necessary that the thread crests of the lobes be finished, that is, fully formed, especially at the tip of the work-entering end. This condition is clearly shown in the screws shown in Figs. 16 and 20. However, as the thread approaches the shank portion of the screw, the crests of the lobes become more fully formed. The lobular thread merges smoothly into the round thread on the main shank, that is, the radius of curvature of the lobes increases until it equals the radius of curvature of the round thread. The flattened arcuate sides between such lobes disappear gradually as the lobular thread blends into the circular shape.

Screws in accordance with the invention may be of any general type and thread formation. In any case, each such screw has a tapered work-entering section provided with a series of threaded arcuate lobes, as described, for accurately forming internal threads with the driving torque suitably minimized, while the thread or threads in the main circular shank section remote from the extremity are primarily holding threads and ensure maximum stripping strength.

WHAT WE CLAIM IS:—

1. A fluteless self-tapping threaded screw for swaging threads in a parent body and securing another body to the parent body, which screw has a continuous rolled thread



is permitted to undulate as the lobular blank portion is threaded.

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30 However, in threading blanks using dies as shown in Fig. 11, it is desirable that the blank should have at least a small straight shank portion adjacent the work-entering end of the same arcuate polygonal cross section as such end so that the lobular rolling sections of the dies have a sufficient length of the blank to grip during the rolling operation to maintain the blank in a constant orientation relative to the dies as the blank is rotated.

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80 As previously explained with reference to Fig. 7, it is not necessary that the thread crests of the lobes be finished, that is, fully formed, especially at the tip of the work-entering end. This condition is clearly shown in the screws shown in Figs. 16 and 20. However, as the thread approaches the shank portion of the screw, the crests of the lobes become more fully formed. The lobular thread merges smoothly into the round thread on the main shank, that is, the radius of curvature of the lobes increases until it equals the radius of curvature of the round thread. The flattened arcuate sides between such lobes disappear gradually as the lobular thread blends into the circular shape.

85 Screws in accordance with the invention may be of any general type and thread formation. In any case, each such screw has a tapered work-entering section provided with a series of threaded arcuate lobes, as described, for accurately forming internal threads with the driving torque suitably minimized, while the thread or threads in the main circular shank section remote from the extremity are primarily holding threads and ensure maximum stripping strength.

WHAT WE CLAIM IS:—

1. A fluteless self-tapping threaded screw for swaging threads in a parent body and securing another body to the parent body, which screw has a continuous rolled thread

formation on both shank and work-entering end portions, wherein:—

- 5 (a) the said shank portion is formed with a plurality of thread turns having a pitch surface which is of circular shape in cross-section,
- (b) the crest of the thread on the work-entering end portion has diameters which decrease progressively towards the work-entering tip,
- 10 (c) the thread formation on the work-entering end portion has pitch surface cross sections in the form of generally arcuate polygons,
- 15 (d) the polygons include an odd number of symmetrically arranged arcuate sides which merge gradually with intermediate arcuate lobes,
- 20 (e) the radius of curvature of the said sides along the pitch surface in each transverse cross section is greater than one-half of the width of such cross section, and
- 25 (f) the radius of curvature of the said lobes along the pitch surface in each transverse cross section is substantially less than one-half of the width of such cross section.

30 2. A screw according to claim 1, in which the said arcuate polygons are of arcuate triangular form having three arcuate sides which merge with intermediate arcuate lobes.

35 3. A screw according to claim 1 or claim 2, wherein each pitch surface cross section on the work-entering end portion is of equal width throughout 360°.

40 4. A screw according to any of the preceding claims, wherein the arcuate polygonal thread of the work-entering end portion merges smoothly with the thread of circular shank portion in the region of the juncture of the work-entering and shank portions.

45 5. A screw according to any of the preceding claims, wherein the arcuate polygonal cross-sectional shape of the tapered work-entering end portion continues slightly onto the shank portion immediately adjacent said tapered end portion and merges smoothly with the round shape of said shank portion.

50 6. A fluteless self-tapping threaded screw for swaging threads in a parent body and securing another body to the parent body, which screw has a continuous rolled thread

formation on both shank and work-entering end portions, wherein:—

- 55 (a) the said shank portion is formed with a plurality of thread turns having a pitch surface which is of circular shape in cross-section,
- 60 (b) the crest of the thread on the work-entering end portion has diameters which decrease progressively towards the work-entering tip,
- 65 (c) the thread on the end portion has a pitch surface which in cross-section is of arcuate, triangular, lobular shape having arcuate sides which merge with intermediate arcuate lobes having a lesser radius of curvature than the said sides, and
- 70 (d) the maximum width of the lobular pitch surface of the said end portion is less than the diameter of the circular pitch surface of the said thread turns on the shank portion, and,
- 75 (e) the lobular pitch surface merges smoothly with the circular pitch surface.

80 7. A screw according to claim 1 or claim 2, wherein a threaded intermediate shank portion is provided between the tapered work-entering end portion and the main shank portion, the thread formation on the said intermediate shank portion having pitch surface cross sections of the same arcuate polygonal cross-sectional shape as the thread formation on the tapered end portion.

85 8. A screw according to claim 1 or claim 2, wherein the radius of curvature of the direction away from the tip of the said lobes ~~increases progressively in the~~ tapered portion until at a point on the main shank the said radius of curvature becomes equal to the radius of curvature along the pitch surface of the thread on the main shank.

90 9. A fluteless self-tapping threaded screw substantially as hereinbefore described with reference to the accompanying drawings.

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said lobes increases progressively in the