

PATENT SPECIFICATION (11)

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- (21) Application No. 30964/75 (22) Filed 24 July 1975 (19)
 (44) Complete Specification published 19 Jan. 1977
 (51) INT. CL.² B23G 5/20 F16B 25/00
 (52) Index at acceptance
 B3N 5H12 5H5
 B3C 1B6G 1B6J 1B6N 1B6X



(54) A THREAD-FORMING SCREW

(71) I, FUMIO HIRABAYASHI, a citizen of Japan, of 11-11, 3-chome, Nishimikuni, Yodogawa-ku, Osaka, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, 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 a thread-forming sheet screw, and more particularly to an improvement in such a screw which is especially designed for screwing into a metallic sheet or plate member of small thickness.

In fastening a screw into a thin metallic sheet member, a certain conventional method is known wherein a screw is inserted with its threaded shank through a previously drilled hole of greater diameter than the external thread diameter of the screw shank and is then screwed up tightly onto a nut provided at the reverse side of the sheet member for holding the inserted screw. A further method is also known wherein a sheet member is at first formed with a smooth pilot hole, which hole is in the next stage forcibly enlarged by inserting a conical punch thereinto in order to form an integral socket with an annular flange that protrudes outwardly from the opening of the hole at the reverse side of the sheet member, and in the final stage said hole as well as said protruding socket being internally threaded with a tapping device for facilitating engagement with a mating external thread of a screw. However, such conventional methods are extremely uneconomical. Thus, there have recently been proposed several types of self-tapping sheet screws which are applicable merely to a previously drilled hole of smaller diameter than the external thread diameter of the screw shank. However, such types of screws still waste time and cost, since those require at least two separate steps, viz. a first drilling operation and then a screwing-in operation.

Thus, more recently, several different types of self-tapping sheet screws have been proposed which are provided at one shank end with a tapered work-entering portion which has sharp ridges extending respectively along an entire tapered surface of said work-

entering portion to terminate in a pointed end, whereby a sheet is pierced to form an initial pilot aperture of small diameter, which is, in turn, forcibly enlarged and deformed to form a substantially annular protrusion extending outwardly from the edges of the aperture on the opposite side of the sheet, as said work-entering portion intrudes thereinto. Though this type of prior art screw is convenient to use in a sense, since it permits fastening in a single screwing-in operation, it still has many disadvantages, the first and most significant being that the sheet is not only easily cracked around the vicinity of the aperture formed during the forcible intrusion of said tapered work-entering portion, but also suffers from early propagation of fatigue cracks. Further, the initial development of the cracks invites the second disadvantage that the protrusion formed is not sufficient in height, so that the mating threads to be formed on the internal face of the protrusion are not enough in number to support the screw shank to be received therein. The third disadvantage is that the aperture is not only excessively enlarged, but the peripheral wall of the aperture is also partially reduced in thickness due to the tearing or scratching-off function of the sharp ridges of said tapered portion, so that the desired securing force of the screw is not obtained. This third disadvantage is especially important when screwing into aluminium plate or other sheet of mild character as well as with a very thin tinned sheet-iron. The fourth disadvantage is that the screw is likely to advance into the sheet at an angle due to the presence of the cracks caused by the forcible intrusion of the work-entering portion as well as the probable lack of uniformity in wall thickness surrounding the aperture caused by scratching-off of the sharp ridges of the work-entering portion.

According to this invention, there is provided a thread-forming sheet screw comprising a screw head, a self-tapping threaded shank connected at its top end to said screw head, a pyramidal or substantially pyramidal end forming the bottom end of the screw and terminating in a point, said pyramidal end having a tip portion disposed adjacent said point, and a base portion disposed be-

tween said tip portion and the threaded shank, said tip portion having a plurality of sharp ridges extending divergently from said point toward said base portion, said base portion having a plurality of rounded ridges with curved outer surfaces extending continually from each of said sharp ridges towards the bottom end of said threaded shank, and said curved outer surfaces of said rounded ridges becoming greater as they approach the bottom end of said threaded shank.

Further, preferable, features of the invention will be apparent from Claims 2 to 8.

The features and advantages of the present invention will become more apparent from the following description of some of the preferred embodiments thereof taken in conjunction with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purpose of illustration only and are not intended as definition of the limits of the present invention.

In the drawings:

Figure 1 is a front elevation of a first embodiment of a sheet screw according to the present invention;

Figure 2 is a greatly enlarged fragmentary elevation showing in detail the end portion of the screw of Figure 1;

Figures 3 to 5 are horizontal cross sections taken along the lines II—III, IV—IV and V—V of Figure 2, respectively;

Figure 6 is an enlarged fragmentary elevational view of the sheet screw of Figure 1, illustrating the end portion thereof piercing a sheet member to form an initial aperture therein;

Figure 7 is a similar view to Figure 6 illustrating an integral burred protrusion being formed around the aperture in the sheet member;

Figure 8 is an enlarged fragmentary perspective view of a pyramidal end of a second embodiment of a sheet screw according to the present invention;

Figure 9 is a horizontal cross sectional view taken along the line IX—IX of Figure 8;

Figure 10 is a similar view to Figure 8, but showing a third embodiment of the present invention;

Figure 11 is a cross section along the line XI—XI of Figure 10;

Figure 12 is a likewise a similar view to Figure 8, but showing a fourth embodiment of the screw in accordance with the present invention;

Figure 13 is a cross section on the line XIII—XIII of Figure 12;

Figure 14 is an enlarged fragmentary elevation showing a fifth embodiment of the screw of the present invention;

Figure 15 is a vertical cross sectional

view taken along the line XV—XV of Figure 14;

Figure 16 is an enlarged fragmentary elevation of a sixth embodiment of a sheet screw according to the present invention;

Figure 17 is a horizontal cross sectional view taken along the line XVII—XVII of Figure 16; and

Figure 18 is an enlarged fragmentary elevation of a seventh embodiment of a sheet screw according to the present invention.

Referring now to the drawings, firstly in particular to Figures 1 to 5 illustrating the first embodiment, a sheet screw 10 has a screw head 11, a threaded shank 12 of substantially cylindrical shape connected at its top end to said screw head 11, and a non-threaded pyramidal end 13 which extends from the bottom end of said threaded shank 12 to terminate in a point 14. Said pyramidal end 13 is divided into two parts, viz. a tip portion 15 with sharp ridges 16 extending divergently from the point 14, and a base or frustum portion 17 with rounded ridges 18, the former being of the height defined by the reference (h) in Figure 2 and having a square shape in horizontal cross section as shown in Figure 3, while the latter is substantially bounded by the lines III—III and V—V and increases in diameter as it approaches the bottom end of said threaded shank 12. The curved surface of each rounded ridge 18 spreads wider as said base portion 17 increases in diameter. Said tip portion 15 performs a drilling or cutting operation, while the base portion 17 principally carries out aperture-enlarging and protrusion-forming operations, as will be hereinafter described in detail. Incidentally, it will be easily understood that the quadrangular pyramidal end 13 as illustrated in Figures 1 to 5 may be replaced by a trigonal or other polygonal end.

In the above-described construction of the sheet screw 10, the included angle of the pyramidal end 13 as indicated by its vertically opposite angle θ in Figure 2 may vary preferably within the range of 25 to 65 degrees in accordance with the hardness of the sheet material to which the screw is to be applied. In the case of the sheet 19 being made of iron or the like hard material, the angle θ should be decreased to about 25 degrees, while if the sheet is of aluminium or the like softer material, the value of θ should be increased to about 65 degrees. Further, the number of sides of the pyramidal end may also vary in accordance with the hardness of the sheet. Generally, it is preferable to increase the number of polygonal sides for harder sheet materials. However, ten or more polygonal sides should be avoided because a pyramidal end having so many sides will come near to being a circular cone, and as a result, the stress con-

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centration on each of the rounded ridges and the initial aperture 20¹ (Figure 6) cannot be effectively enlarged enough to form a protrusion 21 of the desired height without development of undesirable cracks around the aperture 20. The height of the tip portion 15 as indicated at reference (h) in Figure 2 should be determined in dependence on the thickness of the sheet. Further, the size and curvature of the rounded ridges 18 may preferably be determined in accordance with the thickness as well as the characteristics of the sheet material to which the screw is to be applied.

In operation, when the screw 10 is driven by means of a known power driver, the point 14 at first pierces the sheet member 19 at the desired location to form a pin hole therein. The hole is then enlarged by a drilling function of the sharp ridges 16 to form an aperture 20¹ as shown in Figure 6. As soon as the aperture 20¹ is enlarged to give a diameter (d) which substantially corresponds to the maximum external diameter of the tip portion 15, the base portion 17 enters the aperture 20¹ to expand it forcibly to form an enlarged aperture 20 together with a substantially annular burred protrusion 21 which extends out from the reverse side 22 of the sheet 19, as shown in Figure 7. Next, the threaded shank 12 is driven through the enlarged aperture 20 into said protrusion 21 to form mating internal threads therewith by the self-tapping function of the external threads 23 rolled on the shank 12.

In the above operation, owing to the construction of the base portion 17 wherein each of the rounded ridges 18 has a gradually expanding smooth outer surface as shown in Figures 2, 6 and 7, the initial aperture 20¹ of small diameter formed by the drilling function of the tip portion 15 will be smoothly and gradually enlarged to form a protrusion 21 of the desired height without producing undesirable cracks therearound. Further, the interior walls of the aperture 20 as well as those of protrusion 21 will be substantially free from tearing or scratching during the operation.

Now, Figures 8 to 17 illustrate second to sixth embodiments distinguished by provision of means for removal of chips which are cut from the body of the sheet 19 before the tapping operation. It will be understood that the removal of chips is very important since they frequently damage the internal surfaces of the aperture 20 and the protrusion 21 to cause easy development of cracks therearound. It will be also understood that the aperture 20 should be finished as smooth as possible in order to make it easy to form a protrusion 21 with the desired height without cracks for attainment of tight screwing-in. Further, the presence

of the chips wastes effort on driving the screw.

Thus, the modified pyramidal end 13a as shown in Figures 8 and 9 is provided with a pair of recesses 24a at opposite sides of the tip portion 15. Each recess 24a expands upwardly from a point 14 along one of the sharp ridges 16 so as to give an acute-angled cutting edges 25a and a flat vertical rake face 26a, for raking or scooping the chips clear of the aperture 20, extending diagonally towards the vertical axis of the pyramidal end 13a as shown in Figures 8 and 9. In operation, the chips which are cut off by said cutting edges 25a can be easily removed through said recesses 24a.

In a further modified pyramidal end 13b as shown in Figures 10 and 11, half of the tip portion 15b is cut off diagonally so as to give a vertical rake face 26b and a pair of acute-angled cutting edges 25b. In operation, the chips are produced mainly by said cutting edges 25b and then can be easily removed through the space adjacent said rake face 26b.

Figures 12 and 13 present a further modified pyramidal end 13c having a number of V-shaped grooves 27 formed in the sloping sides of the tip portion 15c so that each of them extends straight toward the point 14. As an alternative to the arrangement shown, one or more grooves may be formed in all the sides, or only in one pair of the sides. In this connection, it will be obvious that the V-shaped grooves 27 may be replaced with other adequately shaped ones. In operation, the chips formed are easily removed through said grooves 27. Each of the modified pyramidal ends 13a, 13b and 13c described above has an additional advantage that a desired height of protrusion 21 is easily obtained since the diameter of the initial aperture 20¹ is actually smaller than that seen in relation to the first embodiment shown in Figures 1 to 5, because each of the tip portions 15a, 15b or 15c is cut away in part and because the formed chips can be easily removed. The selection of one of the modified tip portions 15a, 15b, 15c may be made in accordance with the hardness, thickness, etc. of a sheet member to which the sheet screw 10 is to be applied.

Figures 14 and 15 illustrate a further modified pyramidal end 13d, in which a substantially spiral groove 28 is formed in the pyramidal outer surface of a tip portion 15d, so that it extends from a place near the point 14 toward said base portion 17 in substantially the same direction as the direction of the threads 23 of the shank 12. With this groove 28, not only can the chips be easily removed through said groove 28 but also the initial drilling can be done quite easily since the spiral groove 28 permits the tip portion 15d to start self-advancingly in the

formed aperture 20¹. Consequently, a high driving torque is not required for screwing-in, and therefore, undesirable downward forces on the sheet member 19 are avoided.

5 This spiral groove 28 may be formed in combination with any of the aforementioned tip portions 13a, 13b or 13c, when desired.

Figures 16 and 17 illustrate a still further modified pyramidal end 13e, wherein vertical recesses 24 are formed in each or in just some of the pyramidal planes in positions spaced from each of said sharp ridges 16, so that the chips formed by the drilling operation of the tip portion 15e are allowed to escape into said recesses 24e, and the inside wall of the protrusion 21 is prevented being damaged. Furthermore, the frictional area of the pyramidal planes can be reduced and, as a result, a greater driving torque is effectively delivered to the formation of protrusion 21.

Figure 18 illustrates a modification of the sheet screw, in which a non-threaded cylindrical portion 29 is disposed between the threaded shank 12 and the pyramidal end 13, the diameter of said cylindrical portion 29 being equal to or less than the pitch diameter of threads 23. In use, when said portion 29 passes through the protrusion 21, the latter is corrected in shape to meet the cylindrical surface of said portion 29, so that it is almost accurately circular in cross section as well as being perpendicular to the sheet member, and the screw shank 12 is then guided to advance into the sheet member correctly without inclination.

WHAT I CLAIM IS:—

1. A thread-forming sheet screw comprising a screw head, a self-tapping threaded shank connected at its top end to said screw head, a pyramidal or substantially pyramidal end forming the bottom end of the screw and terminating in a point said pyramidal end having a tip portion disposed adjacent said point, and a base portion disposed between said tip portion and the threaded shank, said tip portion having a plurality of sharp ridges extending divergently from said point toward said base portion, said base portion having a plurality of rounded ridges with curved outer surfaces extending continually from each of said sharp ridges towards the bottom end of said threaded shank, and said curved outer surface of each of said rounded ridges becoming greater as they approach the bottom end of said threaded shank.

2. A thread-forming sheet screw as claimed in Claim 1, which includes at least one recess formed in said tip portion, which recess expands upwardly from said point

along the side of one of said sharp ridges, a cutting edge being formed at the sharp ridge, said cutting edge extending upwardly from said point along the sharp ridge, and a flat rake face extending from said cutting edge toward the central axis of the screw.

3. A thread-forming sheet screw as claimed in Claim 1, wherein said tip portion is cut away to give a vertical surface passing through a pair of opposite sharp ridges, said surface being a vertical rake face, with a pair of acute-angled cutting edges extending upwardly from the point along each of said pair of opposite sharp ridges.

4. A thread-forming sheet screw as claimed in Claim 3, wherein the tip portion is cut away in half to give a diagonal vertical cutting plane.

5. A thread-forming sheet screw as claimed in Claim 1, wherein at least one substantially V-shaped groove is formed in at least one side of said tip portion, and said at least one V-shaped groove extends straight from said point toward said base portion.

6. A thread-forming sheet screw as claimed in any preceding claim, wherein a substantially spiral groove is formed in the pyramidal outer surface of said tip portion, said spiral groove extending from a place near said point towards said base portion, and said spiral groove running in the same direction as the threads of said threaded shank.

7. A thread-forming sheet screw, as claimed in any one of Claims 1, 2, 3, 4 and 5, wherein at least one vertical recess is formed within at least one of the pyramidal planes of said pyramidal end, and said vertical recess is spaced from the adjacent sharp ridges.

8. A thread-forming sheet screw as claimed in any one of the preceding claims, wherein a non-threaded cylindrical portion is disposed between said threaded shank and said pyramidal end, and the diameter of said non-threaded cylindrical portion is equal to or less than the pitch diameter of the threads of said threaded shank.

9. A thread-forming sheet screw substantially as herein described, with reference to Figures 1 to 7, Figures 8 and 9, Figures 10 and 11, Figures 12 and 13, Figures 14 and 15, Figures 16 and 17, or Figure 18 of the accompanying drawings.

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formed aperture 20¹. Consequently, a high driving torque is not required for screwing-in, and therefore, undesirable downward forces on the sheet member 19 are avoided. This spiral groove 28 may be formed in combination with any of the aforementioned tip portions 13a, 13b or 13c, when desired.

Figures 16 and 17 illustrate a still further modified pyramidal end 13e, wherein vertical recesses 24 are formed in each or in just some of the pyramidal planes in positions spaced from each of said sharp ridges 16, so that the chips formed by the drilling operation of the tip portion 15e are allowed to escape into said recesses 24e, and the inside wall of the protrusion 21 is prevented being damaged. Furthermore, the frictional area of the pyramidal planes can be reduced and, as a result, a greater driving torque is effectively delivered to the formation of protrusion 21.

Figure 18 illustrates a modification of the sheet screw, in which a non-threaded cylindrical portion 29 is disposed between the threaded shank 12 and the pyramidal end 13, the diameter of said cylindrical portion 29 being equal to or less than the pitch diameter of threads 23. In use, when said portion 29 passes through the protrusion 21, the latter is corrected in shape to meet the cylindrical surface of said portion 29, so that it is almost accurately circular in cross section as well as being perpendicular to the sheet member, and the screw shank 12 is then guided to advance into the sheet member correctly without inclination.

WHAT I CLAIM IS:—

1. A thread-forming sheet screw comprising a screw head, a self-tapping threaded shank connected at its top end to said screw head, a pyramidal or substantially pyramidal end forming the bottom end of the screw and terminating in a point said pyramidal end having a tip portion disposed adjacent said point, and a base portion disposed between said tip portion and the threaded shank, said tip portion having a plurality of sharp ridges extending divergently from said point toward said base portion, said base portion having a plurality of rounded ridges with curved outer surfaces extending continually from each of said sharp ridges towards the bottom end of said threaded shank, and said curved outer surface of each of said rounded ridges becoming greater as they approach the bottom end of said threaded shank.

2. A thread-forming sheet screw as claimed in Claim 1, which includes at least one recess formed in said tip portion, which recess expands upwardly from said point

along the side of one of said sharp ridges, a cutting edge being formed at the sharp ridge, said cutting edge extending upwardly from said point along the sharp ridge, and a flat rake face extending from said cutting edge toward the central axis of the screw.

3. A thread-forming sheet screw as claimed in Claim 1, wherein said tip portion is cut away to give a vertical surface passing through a pair of opposite sharp ridges, said surface being a vertical rake face, with a pair of acute-angled cutting edges extending upwardly from the point along each of said pair of opposite sharp ridges.

4. A thread-forming sheet screw as claimed in Claim 3, wherein the tip portion is cut away in half to give a diagonal vertical cutting plane.

5. A thread-forming sheet screw as claimed in Claim 1, wherein at least one substantially V-shaped groove is formed in at least one side of said tip portion, and said at least one V-shaped groove extends straight from said point toward said base portion.

6. A thread-forming sheet screw as claimed in any preceding claim, wherein a substantially spiral groove is formed in the pyramidal outer surface of said tip portion, said spiral groove extending from a place near said point towards said base portion, and said spiral groove running in the same direction as the threads of said threaded shank.

7. A thread-forming sheet screw, as claimed in any one of Claims 1, 2, 3, 4 and 5, wherein at least one vertical recess is formed within at least one of the pyramidal planes of said pyramidal end, and said vertical recess is spaced from the adjacent sharp ridges.

8. A thread-forming sheet screw as claimed in any one of the preceding claims, wherein a non-threaded cylindrical portion is disposed between said threaded shank and said pyramidal end, and the diameter of said non-threaded cylindrical portion is equal to or less than the pitch diameter of the threads of said threaded shank.

9. A thread-forming sheet screw substantially as herein described, with reference to Figures 1 to 7, Figures 8 and 9, Figures 10 and 11, Figures 12 and 13, Figures 14 and 15, Figures 16 and 17, or Figure 18 of the accompanying drawings.

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