ON A SYSTEM OF

SCREW THREADS AND NUTS.

By WILLIAM SELLERS.

[Read before the FRANKLIN INSTITUTE, April 21, 1864.]

The importance of a uniform system of screw threads and nuts is so generally acknowledged by the engineering profession, that it needs no argument to set forth its advantages; and in offering any plan for their acceptance, it remains only to demonstrate its practicability and its superiority over any of the numerous special proportions now used by the different manufacturers. In this country no organized attempt has as yet been made to establish any system, each manufacturer having adopted whatever his judgment may have dictated as the best, or as most convenient for himself; but the importance of the works now in progress, and the extent to which manufacturing has attained, admonish us that so radical a defect should be allowed to exist no longer. The importance of this subject was long ago recognised in England, and the engineers of that country, by mutual agreement, adopted the proportions now in universal use there. Our standard of length being the same as theirs, it would seem desirable that the system which they have adopted should also be employed by us, unless grave objections can be urged against it and a better one substituted. In examining the details of their system, the first in importance appears to be the pitch or the distance from centre to centre of the threads upon each diameter of screw, which is as follows, viz:

Diameter of screw, . . .	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
No. of threads per inch, .	20	18	16	14	12	11	10	9	8	7	7
Diameter of screw, . . .	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$
No. of threads per inch, .	6	6	5	5	$4\frac{1}{2}$	$4\frac{1}{2}$	4	4	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$
Diameter of screw, . . .	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6
No. of threads per inch, .	$3\frac{1}{4}$	3	3	$2\frac{7}{8}$	$2\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$

It is probable that this scale, with the exception of the half-inch, would be a fair compromise of all the proportions used in this country.

The accompanying diagram, Plate II, Fig. 4, will serve to show the comparative relation which these pitches bear to each other and to their diameter. This indicates also that the pitch of the half-inch screw is too coarse; our practice would probably average finer. It is interesting to observe the general regularity of the curve produced by these proportions, showing, that notwithstanding they have been determined arbitrarily, they must follow some rule, and we accordingly find that the number of threads per inch may be expressed to the nearest aliquot of an inch by the formula $1 \div \frac{\sqrt{d}-a}{c}$, in which d variable = number of sixteenths of an inch in the diameter of the screw, plus ten, a = constant 2·909, and c = divisor 16·64. The table herewith, calculated to this formula, shows that the English screws, with the exception of six sizes, do not vary from the rule until they reach $4\frac{1}{2}$ inches diameter, and then but slightly. It is believed the pitches as given by the formula would be found an improvement, but not sufficiently so to warrant us in adopting them, providing the other peculiarities of the English system should meet our approval.

Diameter of screw,	¼	5/16	⅜	7/16	½	9/16	¾	⅞	1	1⅛	1¼
Formula-thread, .	20	17·54	15·5	13·9	12·5	10·8	9·34	8·40	7·63	6·98	6·48
Nearest aliquot, .	20	18	16	14	13	11	10	9	8	7	7
English thread, .	20	18	16	14	12	11	10	9	8	7	7
Diameter of screw,	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3	3¼
Formula-thread, .	6·06	5·77	5·40	5·11	4·87	4·64	4·31	4·00	3·76	3·54	3·35
Nearest aliquot, .	6	6	5½	5	5	4½	4½	4	4	3½	3½
English thread, .	6	6	5	5	4½	4½	4	4	3½	3½	3¼
Diameter of screw,	3½	3¾	4	4¼	4½	4¾	5	5¼	5½	5¾	6
Formula-thread, .	3·19	3·04	2·92	2·81	2·71	2·61	2·53	2·45	2·38	2·31	2·25
Nearest aliquot, .	3¼	3	3	2⅞	2¾	2⅝	2½	2½	2⅜	2⅜	2¼
English thread, .	3¼	3	3	2⅞	2⅞	2¾	2¾	2⅝	2⅝	2½	2½

The form of thread adopted by the English Engineers is one, with flat sides at an angle to each other of 55°, with a rounded top and bottom. The proportions for the rounded top and bottom are obtained by dividing the depth of a sharp thread having sides at an angle of 55°, into six equal parts and within the lines formed by the sides of the thread and the top and bottom dividing lines, inscribing a circle which determines the form of top and bottom of thread, as illustrated by Fig. 2, Plate II. Judging from the practice of this country, the

English form of thread has not met with the same favor that has been accorded to their pitches. Its advantages over the sharp thread are, increased strength to the screw from the absence of acute corners, and the greater security from accidental injury which the rounded top possesses. Its objectionable features are, first, that the angle of 55° is a difficult one to verify; it is probable, no gauges to this angle, made independently of each other and without special tools, would correspond with sufficient accuracy. Secondly, the curve at the top and bottom of the thread of the screw will not fit the corresponding curve in the nut, and the wearing surface on the thread will be thus reduced to the straight sides merely. It is not to be inferred from this that these curves cannot be made to fit, but only that the difficulties in producing contact are so much increased by the peculiar form, that in practice it will not be accomplished. Thirdly, the increased cost and complication of cutting tools required to form this kind of thread in a lathe, it being requisite that this tool shall have at least three cutting sides, in order to form the round top between two of them. The English practice for small work, is to rough out in a slide-lathe with a single-point tool having sides of the proper angle, and finish in a hand lathe with a comb chaser, which has been dressed to the proper form upon a hob kept for that purpose, requiring three kinds of cutters and two lathes to perform what with our practice requires but one cutter and one lathe. On large work, the screw is finished in the slide lathe, with a chasing tool dressed to the proper form upon a hob; and as these hobs are necessarily the standards of form until worn out, it is fair to suppose the shape must be undergoing a continual change. The necessity of guarding the edge of the thread from accidental injury, becomes more and more apparent as the size of the bolt is increased, and we have recognised this by finishing such bolts with a small flat upon the top of the thread; but no plan has been proposed for general adoption upon all screws, nor have any proportions been suggested where a flat is desired, or where from the size of the bolt it would seem to be necessary. As it is very desirable that some uniform rule should be observed in the formation of all threads, and as the sharp top is objectionable upon large screws, this form must be abandoned if we would accomplish our object. It being conceded that the flat angular sides are necessary, we have only to choose between the rounded and flat top; and having examined the former, it only remains to notice whether the flat will be found free from the objections urged against the round. As the sides of the thread are the only parts requiring to be fitted, and as these are of the same shape as the sharp thread, the one will be as easily made as the other. The width of the flat top will be determined by the depth to which the thread is cut, so that the same tool can be used in both cases. The flat on the top of the thread being required to protect it from injury, it is evident a similar shape at the bottom would give increased strength to the bolt as well as improve its appearance. To give this form requires only that the point of the cutting tool shall be taken off and then it is evident this thread can be cut in a lathe with

the same tool and in the same manner as the sharp thread. The width of flat in the bottom of thread being dependent upon the amount taken off the point of the tool, it becomes necessary not only to determine what this amount shall be, but also to provide a means of measuring it. The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagrams, Plate II, in which Fig. 1 represents a sharp thread, Fig. 2 a rounded top and bottom to the English proportions, and Fig. 3 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at 60°, the same as the sharp thread, it being more readily obtained than 55°, and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread, into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch, the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula diam. $-\frac{1{\cdot}299}{\text{per in.}}$. These proportions will give the depth of the thread almost precisely the same as the English, and as the wearing surface on all screws will be confined practically to the flat sides, we shall find that upon the proposed plan this will be 36 per cent. greater than on the English. The accompanying drawing, Plate III, represents a gauge, designed for measuring the flat upon the chasing tool. D is the main frame of the instrument made in three thicknesses, so that the central pieces may be hardened and ground to shape, the outer pieces serving to keep the central ones in their proper positions. A is an angle of 60° cut in the edge of the frame D, and having its two sides to form equal angles with the edge of the frame. B is similar to A, but having the apex of the angle cut away so as to permit the wedge piece C to pass above the point of junction of the two sides of B. The side of C is graduated, so that upon bringing any particular mark to coincide with a fixed point or mark in the frame D, the edge of C will pass the proper distance above the apex of the angle B, which will indicate the amount to be taken off the point of the chasing tool which has first been accurately fitted to the angle A. In setting the chasing tool in the lathe, the side F of the gauge should be placed against the surface of the work to be cut, which is suspended upon the centres, and while in this position the chasing tool must be adjusted to it and securely fastened. This will insure the thread when cut being perpendicular to the surface. The width of the flat top and bottom may also be obtained by the use of a chasing tool having a flat on its end of known width, but less than required in the bottom of the thread, the depth of the thread having been determined, the tool may cut in to this point and finish by a side movement sufficient to give the required amount of flat.

A system of uniform dimensions for bolt-heads and nuts being intimately connected with the subject just discussed, it is believed that

a convenient formula that would express the required size would go far towards inducing a uniform practice and with this view the following formulæ and tables for screw threads and nuts are offered for the acceptance of our Engineers. Should they meet the approval and be adopted by any considerable portion of the profession, there is every reason to believe they would soon be applied universally, and to enable a comparison to be readily instituted between the systems which have been discussed, diagrams Figs. 5 and 6, Plate II, have been prepared, the former representing the pitch as obtained by the formula, with that proposed to be adopted, and the latter representing a section of a ten inch bolt having its threads to the same proportion. To compare the form of thread, two of the $\frac{7}{8}$ and 2 in taps exhibited are by Whitworth & Co., to the English standard and the other two of same size are to the proposed thread. Formulæ:

Δ = diameter of screws. d = No. of sixteenths plus ten in Δ.

x = pitch of screws. v = No. of threads per in.

a = constant 2·909. c = divisor 16·64.

m = flat top and bottom. n = diameter of screws at bottom.

s = short diam. of nut or bolt-head = $1\frac{1}{2}$ diam. of screws + $\frac{1}{8}$ in.

u = long diam. hexagonal nut or bolt-head.

t = long diam. square nut or bolt-head.

$$x = \frac{\sqrt{d} - a}{c} \qquad v = \frac{1}{x} \qquad t = s \times 1{\cdot}414$$

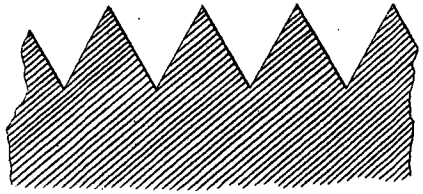
$$m = \frac{x}{8} \qquad n = \Delta - \frac{1{\cdot}299}{v}$$

$$s = \frac{3\Delta}{2} + \tfrac{1}{8}\text{-in.} \qquad u = s \times 1{\cdot}155$$

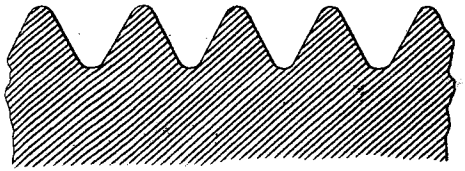
PROPORTIONS OF BOLTS AND NUTS.

Diameter of bolt.	Number of threads per inch.	Diameter of root of thread.	Width of flat top, bottom of thread.	Size hole in nut.	Short diameter of hex-nut.	Long diameter of hex-nut.	Long diameter of sq. nut.
$\frac{1}{4}$	20	·185	·0062	·185	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{11}{16}$
$\frac{5}{16}$	18	·240	·0070	·240	$\frac{19}{32}$	$\frac{11}{16}$	$\frac{13}{16}$
$\frac{3}{8}$	16	·294	·0078	·294	$\frac{11}{16}$	$\frac{25}{32}$	$\frac{33}{32}$
$\frac{7}{16}$	14	·344	·0089	·344	$\frac{23}{32}$	$\frac{27}{32}$	$\frac{17}{32}$
$\frac{1}{2}$	13	·400	·0096	·400	$\frac{7}{8}$	$\frac{29}{32}$	$1\frac{1}{16}$
$\frac{9}{16}$	12	·454	·0104	·454	$\frac{31}{32}$	1	$1\frac{1}{4}$
$\frac{5}{8}$	11	·507	·0113	·507	$1\frac{1}{16}$	$1\frac{7}{64}$	$1\frac{5}{16}$
$\frac{3}{4}$	10	·620	·0125	·620	$1\frac{1}{4}$	$1\frac{7}{32}$	$1\frac{1}{2}$
$\frac{7}{8}$	9	·731	·0140	·731	$1\frac{7}{16}$	$1\frac{7}{16}$	$1\frac{3}{4}$
1	8	·837	·0156	·837	$1\frac{5}{8}$	$1\frac{21}{32}$	$2\frac{1}{32}$
$1\frac{1}{8}$	7	·940	·0180	·940	$1\frac{13}{16}$	$1\frac{7}{8}$	$2\frac{5}{16}$
$1\frac{1}{4}$	7	1·065	·0180	1·065	2	$2\frac{3}{32}$	$2\frac{1}{2}$
$1\frac{3}{8}$	6	1·160	·0210	1·160	$2\frac{3}{16}$	$2\frac{5}{16}$	$2\frac{23}{32}$
$1\frac{1}{2}$	6	1·284	·0210	1·284	$2\frac{3}{8}$	$2\frac{1}{2}$	$3\frac{1}{16}$
$1\frac{5}{8}$	$5\frac{1}{2}$	1·389	·0227	1·389	$2\frac{9}{16}$	$2\frac{3}{4}$	$3\frac{3}{8}$
$1\frac{3}{4}$	5	1·490	·0250	1·490	$2\frac{3}{4}$	$2\frac{15}{16}$	$3\frac{5}{8}$
$1\frac{7}{8}$	5	1·615	·0250	1·615	$2\frac{15}{16}$	$3\frac{3}{16}$	$3\frac{29}{32}$
2	$4\frac{1}{2}$	1·712	·0280	1·712	$3\frac{1}{8}$	$3\frac{13}{32}$	$4\frac{3}{16}$
$2\frac{1}{4}$	$4\frac{1}{2}$	1·962	·0280	1·962	$3\frac{1}{2}$	$3\frac{5}{8}$	$4\frac{7}{16}$
$2\frac{1}{2}$	4	2·175	·0310	2·175	$3\frac{7}{8}$	$4\frac{1}{16}$	$4\frac{31}{32}$
$2\frac{3}{4}$	4	2·425	·0310	2·425	$4\frac{1}{4}$	$4\frac{1}{2}$	$5\frac{1}{2}$
3	$3\frac{1}{2}$	2·628	·0357	2·628	$4\frac{5}{8}$	$4\frac{29}{32}$	6
$3\frac{1}{4}$	$3\frac{1}{2}$	2·878	·0357	2·878	5	$5\frac{3}{8}$	$6\frac{9}{16}$
$3\frac{1}{2}$	$3\frac{1}{4}$	3·100	·0384	3·100	$5\frac{3}{8}$	$5\frac{3}{4}$	$7\frac{1}{8}$
$3\frac{3}{4}$	3	3·317	·0410	3·317	$5\frac{3}{4}$	$6\frac{7}{64}$	$7\frac{5}{8}$
4	3	3·566	·0410	3·566	$6\frac{1}{8}$	$6\frac{5}{8}$	$8\frac{3}{16}$
$4\frac{1}{4}$	$2\frac{7}{8}$	3·798	·0435	3·825	$6\frac{1}{2}$	$7\frac{3}{64}$	$8\frac{11}{16}$
$4\frac{1}{2}$	$2\frac{3}{4}$	4·027	·0460	4·027	$6\frac{7}{8}$	$7\frac{1}{2}$	$9\frac{1}{4}$
$4\frac{3}{4}$	$2\frac{5}{8}$	4·255	·0480	4·255	$7\frac{1}{4}$	$7\frac{33}{32}$	$9\frac{3}{4}$
5	$2\frac{1}{2}$	4·480	·0500	4·480	$7\frac{5}{8}$	$8\frac{3}{8}$	$10\frac{9}{32}$
$5\frac{1}{4}$	$2\frac{1}{2}$	4·730	·0500	4·730	8	$8\frac{13}{16}$	$10\frac{13}{16}$
$5\frac{1}{2}$	$2\frac{3}{8}$	4·953	·0526	5·053	$8\frac{3}{8}$	$9\frac{1}{4}$	$11\frac{3}{8}$
$5\frac{3}{4}$	$2\frac{3}{8}$	5·203	·0526	5·203	$8\frac{3}{4}$	$9\frac{11}{16}$	$11\frac{29}{32}$
6	$2\frac{1}{4}$	5·423	·0555	5·423	$9\frac{1}{8}$	$10\frac{1}{8}$	$12\frac{7}{16}$
						$10\frac{9}{16}$	$12\frac{9}{10}$

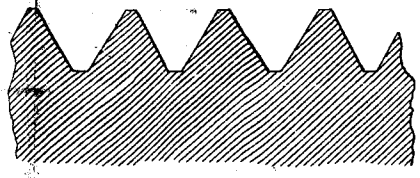
— FIG. 1 —



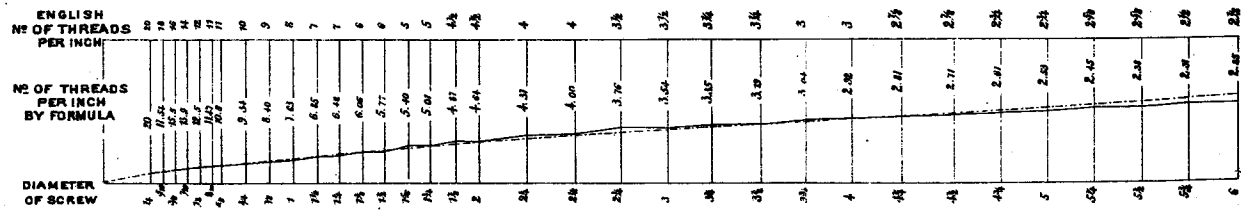
— FIG. 2 —



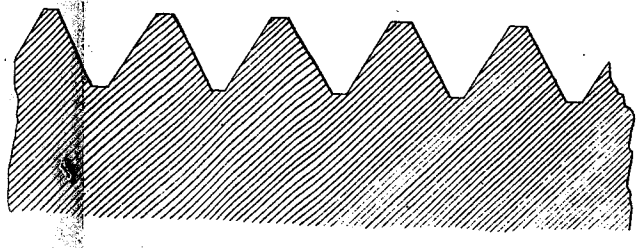
— FIG. 3 —



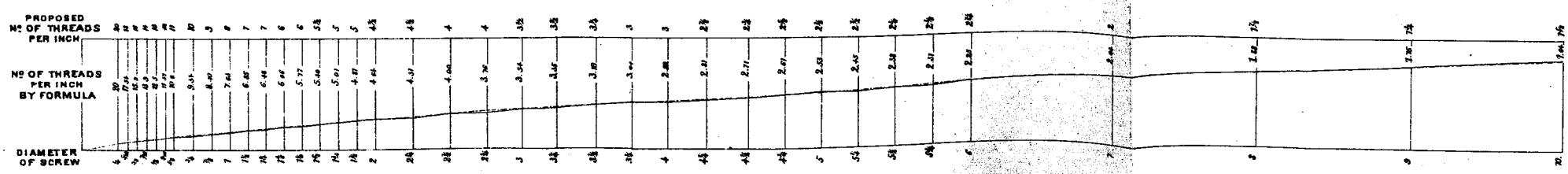
— FIG. 4 —



— FIG. 6 —



— FIG. 5 —



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