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MACHINERY'S HANDBOOK

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MACHINERY'S HANDBOOK

FOR MACHINE SHOP
AND DRAWING-OFFICE

A REFERENCE BOOK ON MACHINE DE-
SIGN AND SHOP PRACTICE FOR THE
MECHANICAL ENGINEER, DRAFTS-
MAN, TOOLMAKER AND MACHINIST

THIRD EDITION

TWENTY-FIRST THOUSAND

NEW YORK
THE INDUSTRIAL PRESS

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NEW YORK

TO THE
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Stanbope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

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PREFACE TO THE THIRD EDITION

EVERY great trade should from time to time collect, systematize and publish its established principles and working data. This handbook endeavors to render that important service for the useful arts of machine design, construction and operation, and was undertaken because, while there are many books, there is none which attempts to do this adequately and specifically.

For twenty years **MACHINERY** has been accumulating material indispensable for such a handbook, and the best of this is in the book. In addition, there is a great deal of material published for the first time, and much valuable information gleaned from hundreds of books and catalogues that were searched for special data to amplify or complete particular subjects. There are, however, many points in machine shop practice upon which opinions differ, and no book can reconcile these. Conditions, methods and processes vary, and as new ones constantly develop, users of this handbook will confer a favor upon the publishers in advising of any errors, omissions or improvements.

MACHINERY is indebted to the whole mechanical field for the data contained in this handbook; and in its own behalf, and for the thousands who will use the book, **MACHINERY** hereby expresses its appreciation to all who have assisted in furnishing data and to that far greater number whose labors in the past have made such a work possible.

This preface would be incomplete without the names of the men who compiled and edited this book. For the capable and long-continued labors bestowed on this work by Erik Oberg, who had charge of it, and Franklin D. Jones, his associate, the publishers hereby express their sincere thanks and appreciation; also to Fred E. Rogers whose counsel and co-operation were freely given.

This book has been received by the mechanical world in a manner most gratifying to the authors and the publishers. Nearly the whole of the first edition, 10,000 copies, was sold before publication, in January, 1914; the second edition, 5000 copies, was exhausted in April; and the present — the third — edition, 6000 copies, is, therefore, brought out within less than three months after the first publication of the book.

MACHINERY

NEW YORK, *April*, 1914

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BOLTS, NUTS AND MACHINE DETAILS

In the following is given general information relating to the dimensions of bolts, nuts and screws used in machine construction. For detailed data relating to the proportions of various forms of screw threads, see the section on "Screw Thread Systems."

Whitworth Standard Threads, Bolts and Nuts

Diameter	No. of Threads per Inch	Diameter at Root of Thread	Diameter of Tap Drill	Area at Root of Threads, Sq. Ins.							
					Max.	Min.		Max.	Min.	Max.	Min.
1/4	20	0.1860	3/16	0.0272	0.525	0.520	0.61	0.26	0.25	0.23	0.22
5/16	18	0.2414	1/4	0.0458	0.600	0.595	0.69	0.32	0.31	0.28	0.27
3/8	16	0.2950	13/64	0.0683	0.710	0.705	0.82	0.39	0.38	0.34	0.33
7/16	14	0.3460	23/64	0.0940	0.820	0.815	0.95	0.45	0.44	0.39	0.38
1/2	12	0.3933	15/32	0.1215	0.920	0.915	1.06	0.51	0.50	0.45	0.44
5/8	12	0.4558	15/32	0.1632	1.010	1.002	1.17	0.57	0.56	0.50	0.49
3/4	11	0.5086	23/64	0.2032	1.100	1.092	1.27	0.64	0.63	0.56	0.55
1 1/16	11	0.5711	27/64	0.2562	1.200	1.192	1.39	0.70	0.69	0.61	0.60
3/4	10	0.6219	5/8	0.3038	1.300	1.292	1.50	0.76	0.75	0.67	0.66
1 1/8	10	0.6844	1 1/16	0.3679	1.390	1.382	1.61	0.82	0.81	0.72	0.71
7/8	9	0.7327	47/64	0.4216	1.480	1.472	1.71	0.89	0.88	0.78	0.77
1	8	0.8399	27/32	0.5540	1.670	1.662	1.93	1.01	1.00	0.89	0.88
1 1/8	7	0.9420	51/64	0.6969	1.860	1.850	2.15	1.15	1.13	1.00	0.98
1 1/4	7	1.0670	1 1/8	0.8942	2.050	2.040	2.37	1.27	1.25	1.11	1.09
1 3/8	6	1.1616	1 13/16	1.0597	2.220	2.210	2.56	1.40	1.38	1.22	1.20
1 1/2	6	1.2866	1 15/16	1.3001	2.410	2.400	2.78	1.52	1.50	1.33	1.31
1 5/8	5	1.3689	1 3/8	1.4718	2.580	2.570	2.98	1.65	1.63	1.44	1.42
1 3/4	5	1.4939	1 1/2	1.7528	2.760	2.750	3.19	1.77	1.75	1.55	1.53
2	4 1/2	1.7154	1 23/32	2.3111	3.150	3.140	3.64	2.02	2.00	1.77	1.75
2 1/4	4	1.9298	1 15/16	2.9249	3.550	3.535	4.10	2.27	2.25	1.99	1.97
2 1/2	4	2.1798	2 1/8	3.7318	3.890	3.875	4.49	2.52	2.50	2.21	2.19
2 3/4	3 1/2	2.3841	2 13/32	4.4641	4.180	4.165	4.83	2.77	2.75	2.43	2.41
3	3 1/2	2.6341	2 11/16	5.4496	4.530	4.515	5.23	3.02	3.00	2.65	2.63
3 1/4	3 1/4	2.8560	2 55/64	6.4063	4.850	4.830	5.60	3.27	3.25	2.86	2.84
3 1/2	3 3/4	3.1060	3 1/8	7.5769	5.180	5.160	5.98	3.52	3.50	3.08	3.06
3 3/4	3	3.3231	3 5/16	8.6732	5.550	5.530	6.41	3.77	3.75	3.30	3.28
4	3	3.5731	3 3/8	10.0272	5.950	5.930	6.87	4.02	4.00	3.52	3.50
4 1/2	2 3/8	4.0546	4 1/16	12.9118	6.820	6.795	7.88	4.53	4.50	3.97	3.94
5	2 3/4	4.5343	4 3/8	16.1477	7.800	7.775	9.01	5.03	5.00	4.41	4.38
5 1/2	2 5/8	5.0121	5	19.7301	8.850	8.820	10.22	5.53	5.50	4.84	4.81
6	2 1/2	5.4877	5 1/2	23.6521	10.000	9.970	11.55	6.03	6.00	5.28	5.25

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U. S. Standard Threads, Bolts and Nuts

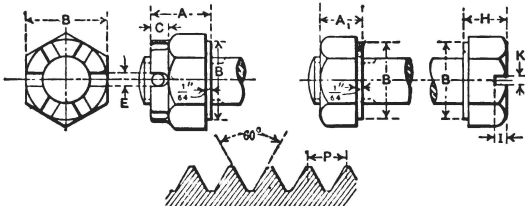
The tap drill diameters in the table provide for a slight clearance at the root of the thread, in order to facilitate tapping and reduce tap breakages. If full threads are required, use the diameters at the root of the threads for the tap drill diameters.

Diameter	No. of Threads per Inch	Diameter at Root of Thread	Diameter of Tap Drill	Area in Sq. Inches		Tensile Strength at Stress of 6000 Pounds per Sq. Inch	Dimensions of Nuts and Bolt Heads					
				Of Bolt	At Root of Thread							
1/4	20	0.185	15/64	0.049	0.026	160	1/2	0.578	0.707	1/4	1/4	
5/16	18	0.240	1/4	0.076	0.045	270	15/32	0.686	0.840	5/16	15/64	
3/8	16	0.294	5/16	0.110	0.068	410	1 1/16	0.794	0.972	3/8	1 1/32	
7/16	14	0.345	23/64	0.150	0.093	560	25/32	0.902	1.105	7/16	25/64	
1/2	13	0.400	27/64	0.196	0.126	760	3/8	1.011	1.237	1/2	7/16	
5/8	12	0.454	15/32	0.248	0.162	1,000	21/32	1.119	1.370	5/8	21/64	
3/4	11	0.507	17/32	0.307	0.202	1,210	1 1/8	1.227	1.502	3/4	1 1/32	
7/8	10	0.620	41/64	0.442	0.302	1,810	1 1/4	1.444	1.768	7/8	5/8	
1	9	0.731	3/4	0.601	0.419	2,520	1 1/2	1.660	2.033	1	23/32	
1 1/8	8	0.838	55/64	0.785	0.551	3,300	1 5/8	1.877	2.298	1 1/8	1 1/16	
1 1/4	7	0.939	21/32	0.994	0.694	4,160	1 3/4	2.093	2.563	1 1/4	27/32	
1 1/2	7	1.064	15/32	1.227	0.893	5,350	2	2.310	2.828	1 1/2	1	
1 3/4	6	1.158	17/32	1.485	1.057	6,340	2 1/8	2.527	3.093	1 3/4	1 5/8	
2	6	1.283	1 1/32	1.767	1.295	7,770	2 1/2	2.743	3.358	2	1 7/8	
2 1/8	5 1/2	1.389	1 27/64	2.074	1.515	9,090	2 3/4	2.960	3.623	2 1/8	1 3/4	
2 1/4	5	1.490	1 17/32	2.405	1.746	10,470	3	3.176	3.889	2 1/4	1 5/8	
2 1/2	5	1.615	1 23/32	2.761	2.051	12,300	3 1/8	3.393	4.154	2 1/2	1 3/4	
2 3/4	4 1/2	1.711	1 49/64	3.142	2.302	13,600	3 1/2	3.609	4.419	2 3/4	1 7/8	
3	4 1/2	1.961	2 1/64	3.976	3.023	18,100	3 3/4	4.043	4.949	3	2	
3 1/8	4	2.175	2 15/64	4.909	3.719	22,300	4	4.476	5.479	3 1/8	2 1/8	
3 1/4	4	2.425	2 31/64	5.940	4.620	27,700	4 1/4	4.909	6.010	3 1/4	2 1/4	
3 1/2	3 1/2	2.629	2 1 1/16	7.069	5.428	32,500	4 1/2	5.342	6.540	3 1/2	2 1/2	
3 3/4	3 1/2	2.879	2 1 1/8	8.296	6.510	39,000	5	5.775	7.070	3 3/4	2 3/4	
4	3 1/2	3.100	3 1 1/64	9.621	7.548	45,300	5 1/8	6.208	7.600	4	2 3/4	
4 1/8	3	3.317	3 3/8	11.045	8.641	51,800	5 1/4	6.641	8.131	4 1/8	2 3/4	
4 1/4	3	3.567	3 5/8	12.566	9.963	59,700	6	7.074	8.661	4 1/4	3	
4 1/2	2 3/4	3.798	3 27/32	14.186	11.340	68,000	6 1/2	7.508	9.191	4 1/2	3 1/4	
4 3/4	2 3/4	4.028	4 1/32	15.904	12.750	76,500	6 3/4	7.941	9.721	4 3/4	3 1/2	
5	2 3/4	4.255	4 15/64	17.721	14.215	85,500	7	8.374	10.252	5	3 3/4	
5 1/8	2 1/2	4.480	4 1 1/8	19.635	15.760	94,000	7 1/8	8.807	10.782	5 1/8	3 3/4	
5 1/4	2 1/2	4.730	4 1 1/8	21.648	17.570	105,500	8	9.240	11.312	5 1/4	4	
5 1/2	2 1/2	4.953	4 1 1/2	23.758	19.260	116,000	8 1/8	9.673	11.842	5 1/2	4 1/4	
5 3/4	2 1/2	5.203	5 1/32	25.967	21.250	127,000	8 3/4	10.106	12.373	5 3/4	4 1/2	
6	2 1/2	5.423	5 1/2	28.274	23.090	138,000	9	10.539	12.903	6	4 3/4	

S. A. E. Standard Screws and Nuts.—The proportions of standard screw threads adopted by the Society of Automobile Engineers are given in the table "S. A. E. Standard Screws and Nuts." The material from which the screws and nuts are made is steel having a tensile strength of not less than 100,000 pounds per square inch and an elastic limit of 60,000 pounds per square inch. The screws, as well as the screw heads and plain nuts, are to be left soft; the castle-nuts are to be casehardened. The shape of the thread is the same as the U. S. standard, but the number of threads per inch is greater. The length of the threaded portion equals one and one-half times the body diameter. The clearance between the top of the bolt thread and the bottom of the thread in the nut is proportionately the same as that adopted by machine-screw makers, the top being between 0.002 and 0.003 inch large. The body diameter of the screw is 0.001 inch less than the nominal diameter, and should be made within such limits that it is not larger than the nominal diameter, nor smaller than 0.002 inch less than the nominal diameter. It is assumed that when screws are to be used in soft materials, such as aluminum, brass, etc., the pitch of the threads will be made to conform to the U. S. standard, in order to provide for adequate proportions of the thread.

The S. A. E. screw standard supplants the A. L. A. M. standard adopted by the Association of Licensed Automobile Manufacturers in April, 1906.

S. A. E. Standard Screws and Nuts

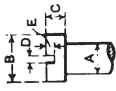
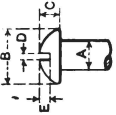


D (in table) = Diameter of screw;
 N = Number of threads per inch;
 B applies to all nuts and screw heads;
 d = Diameter of cotter pin;

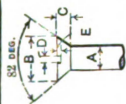
S = Tap drill size;
 $D \times 1.5$ = Length of thread;
 $\frac{P}{8}$ = Width of flat.

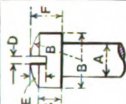
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$1\frac{1}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$
N	28	24	24	20	20	18	18	16	16	14	14	12	12	12	12
A	$\frac{9}{32}$	$\frac{21}{64}$	$\frac{13}{32}$	$\frac{29}{64}$	$\frac{9}{16}$	$\frac{89}{64}$	$\frac{23}{32}$	$\frac{49}{64}$	$\frac{13}{16}$	$\frac{29}{32}$	1	$\frac{15}{32}$	$1\frac{1}{4}$	$\frac{113}{32}$	$1\frac{1}{2}$
A_1	$\frac{7}{32}$	$\frac{17}{64}$	$\frac{21}{64}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{81}{64}$	$\frac{85}{64}$	$\frac{19}{32}$	$\frac{21}{32}$	$\frac{49}{64}$	$\frac{7}{8}$	$\frac{63}{64}$	$\frac{13}{32}$	$\frac{113}{64}$	$\frac{151}{64}$
B	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{13}{16}$	2	$2\frac{1}{8}$
C	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$
E	$\frac{9}{64}$	$\frac{9}{64}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{1}{4}$
H	$\frac{3}{16}$	$\frac{15}{64}$	$\frac{9}{32}$	$\frac{21}{64}$	$\frac{3}{8}$	$\frac{27}{64}$	$\frac{15}{32}$	$\frac{33}{64}$	$\frac{9}{16}$	$\frac{21}{32}$	$\frac{3}{4}$	$\frac{27}{32}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$
I	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{1}{4}$
K	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{5}{64}$	$\frac{5}{64}$	$\frac{3}{16}$	$\frac{3}{16}$
d	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{11}{64}$	$\frac{11}{64}$	$\frac{13}{64}$	$\frac{13}{64}$
S	$\frac{7}{32}$	$\frac{17}{64}$	$\frac{21}{64}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{43}{64}$	$\frac{25}{32}$	$\frac{29}{32}$	$1\frac{1}{64}$	$1\frac{9}{64}$	$1\frac{17}{64}$	$1\frac{25}{64}$

Standard Proportions for Machine Screw Heads

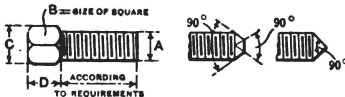
Flat Filler Head Screws					
 A = Diameter of body; $B = 1.64 A - 0.009$ = Diameter of head; $C = 0.66 A - 0.002$ = Height of head; $D = 0.173 A + 0.015$ = Width of slot; $E = \frac{1}{2} C$ = Depth of slot.					
A	B	C	D	E	
0.060	0.0894	0.0376	0.025	0.019	
0.073	0.1107	0.0461	0.028	0.023	
0.086	0.1320	0.0548	0.030	0.027	
0.099	0.1530	0.0633	0.032	0.032	
0.112	0.1747	0.0719	0.034	0.036	
0.125	0.1960	0.0805	0.037	0.040	
0.138	0.2170	0.0890	0.039	0.044	
0.151	0.2386	0.0976	0.041	0.049	
0.164	0.2599	0.1062	0.043	0.053	
0.177	0.2813	0.1148	0.046	0.057	
0.190	0.3026	0.1234	0.048	0.062	
0.216	0.3452	0.1405	0.052	0.070	
0.242	0.3879	0.1577	0.057	0.079	
0.268	0.4305	0.1748	0.061	0.087	
0.294	0.4731	0.1920	0.066	0.096	
0.320	0.5158	0.2092	0.070	0.104	
0.346	0.5584	0.2263	0.075	0.113	
0.372	0.6010	0.2435	0.079	0.122	
0.398	0.6437	0.2606	0.084	0.130	
0.424	0.6863	0.2778	0.088	0.139	
0.450	0.7270	0.2950	0.093	0.147	
Round Head Screws					
 A = Diameter of body; $B = 1.85 A - 0.005$ = Diameter of head; $C = 0.7 A$ = Height of head; $D = 0.173 A + 0.015$ = Width of slot; $E = \frac{1}{2} C + 0.01$ = Depth of slot.					
A	B	C	D	E	
0.060	0.106	0.042	0.025	0.031	
0.073	0.130	0.051	0.028	0.035	
0.086	0.154	0.060	0.030	0.040	
0.099	0.178	0.069	0.032	0.044	
0.112	0.202	0.078	0.034	0.049	
0.125	0.226	0.087	0.037	0.053	
0.138	0.250	0.096	0.039	0.058	
0.151	0.274	0.105	0.041	0.062	
0.164	0.298	0.114	0.043	0.067	
0.177	0.322	0.123	0.046	0.071	
0.190	0.346	0.133	0.048	0.076	
0.216	0.394	0.151	0.052	0.085	
0.242	0.443	0.169	0.057	0.094	
0.268	0.491	0.187	0.061	0.103	
0.294	0.539	0.205	0.066	0.112	
0.320	0.587	0.224	0.070	0.122	
0.346	0.635	0.242	0.075	0.131	
0.372	0.683	0.260	0.079	0.140	
0.398	0.731	0.278	0.084	0.149	
0.424	0.779	0.296	0.088	0.158	
0.450	0.827	0.315	0.093	0.167	

Standard Proportions for Machine Screw Heads

Flat Head Screws					
					
A = Diameter of body $B = 2A - 0.008$ = Diameter of head; $C = A - \frac{0.008}{1.739}$ = Thickness of head; $D = 0.173A + 0.015$ = Width of slot; $E = \frac{1}{8}C$ = Depth of slot.					
A	B	C	D	E	
0.060	0.112	0.029	0.025	0.010	
0.073	0.138	0.037	0.028	0.012	
0.086	0.164	0.045	0.030	0.015	
0.099	0.190	0.052	0.032	0.017	
0.112	0.216	0.060	0.034	0.020	
0.125	0.242	0.067	0.037	0.022	
0.138	0.262	0.075	0.039	0.025	
0.151	0.294	0.082	0.041	0.027	
0.164	0.320	0.090	0.043	0.030	
0.177	0.346	0.097	0.046	0.032	
0.190	0.372	0.105	0.048	0.035	
0.216	0.424	0.120	0.052	0.040	
0.242	0.472	0.135	0.057	0.045	
0.268	0.528	0.150	0.061	0.050	
0.294	0.580	0.164	0.066	0.055	
0.320	0.632	0.179	0.070	0.060	
0.346	0.682	0.194	0.075	0.065	
0.372	0.732	0.209	0.079	0.070	
0.398	0.788	0.224	0.084	0.075	
0.424	0.840	0.239	0.088	0.080	
0.450	0.892	0.254	0.093	0.085	

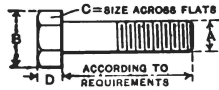
Oval Fillister Head Screws					
					
A = Diameter of body; $B = 1.64A - 0.009$ = Diameter of head and radius for oval; $C = 0.66A - 0.002$ = Height of side; $D = 0.173A + 0.015$ = Width of slot; $E = \frac{3}{8}F$ = Depth of slot; $F = 0.134B + C$ = Height of head.					
A	B	C	D	E	F
0.060	0.0894	0.0376	0.025	0.025	0.0496
0.073	0.1107	0.0461	0.028	0.030	0.0609
0.086	0.1320	0.0548	0.030	0.036	0.0725
0.099	0.1530	0.0633	0.032	0.042	0.0838
0.112	0.1747	0.0719	0.034	0.048	0.0953
0.125	0.1960	0.0805	0.037	0.053	0.1068
0.138	0.2170	0.0890	0.039	0.059	0.1180
0.151	0.2386	0.0976	0.041	0.065	0.1296
0.164	0.2599	0.1062	0.043	0.071	0.1410
0.177	0.2813	0.1148	0.046	0.076	0.1524
0.190	0.3026	0.1234	0.048	0.082	0.1639
0.216	0.3452	0.1405	0.052	0.093	0.1868
0.242	0.3879	0.1577	0.057	0.105	0.2097
0.268	0.4305	0.1748	0.061	0.116	0.2325
0.294	0.4731	0.1920	0.066	0.128	0.2554
0.320	0.5158	0.2092	0.070	0.140	0.2783
0.346	0.5584	0.2263	0.075	0.150	0.3011
0.372	0.6010	0.2435	0.079	0.162	0.3240
0.398	0.6437	0.2606	0.084	0.173	0.3469
0.424	0.6863	0.2778	0.088	0.185	0.3698
0.450	0.7270	0.2950	0.093	0.201	0.4024

Square-head Screws



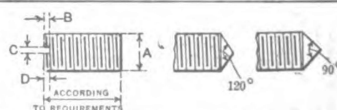
A	B	C	D	A	B	C	D	A	B	C	D
$\frac{9}{16}$	$\frac{9}{16}$	0.26	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	0.62	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{9}{16}$	0.79	$\frac{5}{8}$
$\frac{1}{4}$	$\frac{1}{4}$	0.35	$\frac{9}{16}$	$\frac{7}{16}$	$\frac{3}{8}$	0.53	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{5}{8}$	0.88	$1\frac{1}{16}$
$\frac{1}{4}$	$\frac{5}{16}$	0.44	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{16}$	0.62	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{9}{16}$	0.79	$\frac{5}{8}$
$\frac{9}{16}$	$\frac{1}{4}$	0.35	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	0.71	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{5}{8}$	0.88	$1\frac{1}{16}$
$\frac{9}{16}$	$\frac{5}{16}$	0.44	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	0.62	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1.06	$1\frac{3}{16}$
$\frac{5}{16}$	$\frac{3}{8}$	0.53	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	0.71	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{5}{8}$	0.88	$1\frac{1}{16}$
$\frac{3}{8}$	$\frac{5}{16}$	0.44	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	0.79	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	1.06	$1\frac{3}{16}$
$\frac{3}{8}$	$\frac{3}{8}$	0.53	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{1}{2}$	0.71	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1.24	$1\frac{5}{16}$

Hexagon-head Screws



A	B	C	D	A	B	C	D	A	B	C	D
$\frac{3}{8}$	$1\frac{1}{16}$	$1\frac{1}{4}$	$\frac{9}{16}$	$1\frac{1}{4}$	$2\frac{1}{64}$	$1\frac{3}{4}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$2\frac{5}{64}$	$2\frac{1}{2}$	$1\frac{5}{16}$
$\frac{7}{8}$	$1\frac{9}{16}$	$1\frac{3}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$2\frac{1}{64}$	$1\frac{15}{16}$	$\frac{3}{4}$	$1\frac{5}{8}$	$2\frac{4}{64}$	$2\frac{5}{16}$	$\frac{7}{8}$
I	$1\frac{3}{8}$	$1\frac{3}{8}$	$\frac{9}{16}$	$1\frac{1}{4}$	$2\frac{29}{64}$	$2\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{5}{8}$	$2\frac{5}{64}$	$2\frac{1}{2}$	$1\frac{5}{16}$
I	$1\frac{3}{16}$	$1\frac{9}{16}$	$\frac{5}{8}$	$1\frac{3}{8}$	$2\frac{1}{64}$	$1\frac{15}{16}$	$\frac{3}{4}$	$1\frac{5}{8}$	$3\frac{3}{64}$	$2\frac{1}{16}$	I
I	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{16}$	$1\frac{3}{8}$	$2\frac{29}{64}$	$2\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{5}{8}$	$2\frac{5}{64}$	$2\frac{1}{2}$	$1\frac{5}{16}$
$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{9}{16}$	$\frac{5}{8}$	$1\frac{3}{8}$	$2\frac{4}{64}$	$2\frac{5}{16}$	$\frac{3}{8}$	$1\frac{5}{8}$	$3\frac{3}{64}$	$2\frac{1}{16}$	I
$1\frac{1}{8}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$2\frac{29}{64}$	$2\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{5}{8}$	$3\frac{5}{64}$	$2\frac{1}{4}$	$1\frac{1}{16}$
$1\frac{1}{8}$	$2\frac{1}{64}$	$1\frac{15}{16}$	$\frac{3}{4}$	$1\frac{1}{2}$	$2\frac{4}{64}$	$2\frac{5}{16}$	$\frac{3}{8}$	....	...	....	....

Headless Set-screws



A	B	C	D	A	B	C	D	A	B	C	D
$\frac{1}{8}$	0.02	0.020	$\frac{1}{64}$	$\frac{3}{8}$	$\frac{5}{64}$	0.058	$\frac{1}{32}$	$\frac{5}{8}$	$\frac{1}{8}$	0.112	$\frac{3}{64}$
$\frac{9}{16}$	$\frac{1}{32}$	0.025	$\frac{1}{32}$	$\frac{7}{16}$	$\frac{5}{64}$	0.071	$\frac{1}{32}$	$1\frac{1}{16}$	$\frac{1}{8}$	0.112	$\frac{3}{64}$
$\frac{1}{4}$	$\frac{1}{16}$	0.039	$\frac{1}{32}$	$\frac{1}{2}$	$\frac{7}{64}$	0.086	$\frac{1}{32}$	$\frac{3}{4}$	$\frac{9}{64}$	0.133	$\frac{3}{64}$
$\frac{5}{16}$	...	...	$\frac{1}{32}$	$\frac{9}{16}$	$\frac{7}{64}$	0.099	$\frac{1}{32}$	...	...	...	...

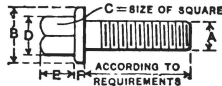
Fillister-head Screws



A	B	C	D	E	F	A	B	C	D	E	F
$\frac{1}{16}$	0.02	0.020	$\frac{1}{8}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{9}{16}$	$\frac{3}{4}$	0.133	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
$\frac{3}{32}$	0.02	0.020	$\frac{5}{32}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{5}{8}$	$\frac{5}{8}$	0.133	$\frac{3}{4}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{1}{8}$	$\frac{1}{32}$	0.025	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{1}{2}$	$\frac{1}{2}$	0.133	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{5}{32}$	$\frac{1}{32}$	0.025	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{3}{4}$	$\frac{3}{4}$	0.133	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{3}{16}$	$\frac{3}{64}$	0.039	$\frac{1}{4}$	$\frac{1}{32}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	0.133	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{1}{2}$	$\frac{1}{16}$	0.039	$\frac{5}{16}$	$\frac{1}{32}$	$\frac{5}{32}$	$\frac{7}{8}$	$\frac{7}{8}$	0.133	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{1}{4}$	$\frac{3}{64}$	0.058	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{5}{32}$	$\frac{1}{2}$	$\frac{1}{2}$	0.165	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{5}{16}$	$\frac{3}{64}$	0.071	$\frac{1}{16}$	$\frac{3}{64}$	$\frac{1}{2}$	I	$\frac{1}{4}$	0.165	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{3}{8}$	$\frac{1}{16}$	0.086	$\frac{1}{2}$	$\frac{3}{64}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{8}$	0.165	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{1}{2}$	$\frac{1}{16}$	0.099	$\frac{1}{2}$	$\frac{3}{64}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	0.165	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$
$\frac{1}{2}$	$\frac{1}{16}$	0.112	$\frac{1}{2}$	$\frac{3}{64}$	$\frac{1}{4}$	....	....	....	....	....	....

Collar-head Screws

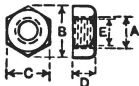
G = radius of rounded edge of collar



A	B	C	D	E	F	G	A	B	C	D	E	F	G
$\frac{3}{16}$	$\frac{3}{8}$	$\frac{3}{16}$	0.26	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{1}{32}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0.62	$\frac{1}{2}$	$\frac{3}{32}$	$\frac{1}{16}$
$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	0.35	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	$\frac{7}{8}$	$\frac{1}{2}$	0.71	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	0.44	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	I	$\frac{1}{2}$	0.79	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{5}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	0.35	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0.71	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{5}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	0.44	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	I	$\frac{1}{2}$	0.79	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{5}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	0.53	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0.88	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	0.44	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	I	$\frac{1}{2}$	0.79	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	0.53	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{3}{64}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0.88	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	0.62	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1.06	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	0.53	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0.88	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	0.62	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1.06	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	0.71	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1.24	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$

BOLTS AND NUTS

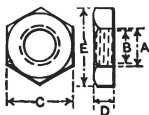
Standard Hexagon Nuts



A = Size of tap;
E = Size of plain hole;
N (in table) = Number of threads per inch.

A	B	C	D	E	N	A	B	C	D	E	N	
$\frac{1}{4}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{3}{4}$	$\frac{3}{4}$	20	1	$1\frac{13}{16}$	$1\frac{9}{16}$	$\frac{5}{8}$	1	$2\frac{7}{32}$	8
$\frac{5}{16}$	$\frac{37}{64}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	18	$1\frac{1}{8}$	$2\frac{1}{64}$	$1\frac{3}{4}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$\frac{61}{64}$	7
$\frac{3}{8}$	$\frac{23}{32}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{19}{64}$	16	$1\frac{1}{4}$	$2\frac{15}{64}$	$1\frac{15}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{5}{64}$	7
$\frac{7}{16}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{16}$	$2\frac{3}{64}$	14	$1\frac{3}{8}$	$2\frac{29}{64}$	$2\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$1\frac{11}{64}$	6
$\frac{1}{2}$	$1\frac{1}{64}$	$\frac{7}{8}$	$\frac{3}{8}$	$1\frac{13}{32}$	13	$1\frac{1}{2}$	$2\frac{43}{64}$	$2\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{19}{64}$	6
$\frac{9}{16}$	$1\frac{1}{64}$	$\frac{7}{8}$	$\frac{7}{16}$	$1\frac{5}{32}$	12	$1\frac{5}{8}$	$2\frac{57}{64}$	$2\frac{1}{2}$	$1\frac{5}{16}$	$1\frac{5}{8}$	$1\frac{25}{64}$	$5\frac{1}{2}$
$\frac{5}{8}$	$1\frac{15}{64}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{33}{64}$	11	$1\frac{3}{4}$	$3\frac{7}{64}$	$2\frac{1}{16}$	1	$1\frac{1}{4}$	5
$1\frac{1}{16}$	$1\frac{15}{64}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{37}{64}$	11	2	$3\frac{17}{32}$	$3\frac{1}{16}$	2	$1\frac{23}{32}$	$4\frac{1}{2}$
$\frac{3}{4}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	10	$2\frac{1}{2}$	$4\frac{13}{32}$	$3\frac{3}{16}$	$2\frac{1}{2}$	$2\frac{9}{16}$	4
$\frac{7}{8}$	$1\frac{19}{32}$	$1\frac{3}{8}$	$\frac{9}{16}$	$\frac{7}{8}$	$\frac{47}{64}$	9	3	$5\frac{1}{8}$	$4\frac{7}{16}$	3	$2\frac{41}{64}$	$3\frac{1}{2}$

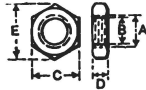
Hexagon Nuts with Special Fine Threads



A = Size of tap;
B = Size of plain hole;
N (in table) = Number of threads per inch.

A	B	C	D	E	N	A	B	C	D	E	N
$\frac{5}{8}$	$\frac{25}{64}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{15}{64}$	16	$1\frac{1}{4}$	$1\frac{11}{64}$	$1\frac{3}{4}$	$\frac{5}{16}$	$2\frac{1}{64}$	16
$1\frac{1}{16}$	$\frac{29}{64}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{19}{64}$	16	$1\frac{3}{8}$	$1\frac{19}{64}$	$2\frac{1}{8}$	$\frac{3}{8}$	$2\frac{29}{64}$	16
$\frac{3}{4}$	$\frac{43}{64}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{15}{64}$	16	$1\frac{7}{8}$	$1\frac{23}{64}$	$2\frac{1}{8}$	$\frac{3}{8}$	$2\frac{29}{64}$	16
$1\frac{3}{16}$	$\frac{47}{64}$	$1\frac{1}{4}$	$\frac{5}{16}$	$1\frac{7}{16}$	16	$1\frac{1}{2}$	$1\frac{27}{64}$	$2\frac{1}{8}$	$\frac{3}{8}$	$2\frac{29}{64}$	16
$\frac{7}{8}$	$\frac{51}{64}$	$1\frac{1}{4}$	$\frac{5}{16}$	$1\frac{7}{16}$	16	$1\frac{9}{16}$	$1\frac{31}{64}$	$2\frac{1}{8}$	$\frac{3}{8}$	$2\frac{29}{64}$	16
$1\frac{5}{16}$	$\frac{55}{64}$	$1\frac{7}{16}$	$\frac{5}{16}$	$1\frac{21}{32}$	16	$1\frac{5}{8}$	$1\frac{35}{64}$	$2\frac{1}{8}$	$\frac{1}{2}$	$2\frac{29}{64}$	16
I	$\frac{59}{64}$	$1\frac{7}{16}$	$\frac{5}{16}$	$1\frac{21}{32}$	16	$1\frac{3}{4}$	$1\frac{39}{64}$	$2\frac{1}{8}$	$\frac{1}{2}$	$2\frac{29}{64}$	16
$1\frac{1}{16}$	$\frac{63}{64}$	$1\frac{7}{16}$	$\frac{5}{16}$	$1\frac{21}{32}$	16	$1\frac{7}{8}$	$1\frac{43}{64}$	$2\frac{1}{8}$	$\frac{5}{8}$	$3\frac{7}{64}$	16
$1\frac{3}{8}$	$1\frac{67}{64}$	$1\frac{3}{4}$	$\frac{5}{16}$	$2\frac{1}{64}$	16	2	$1\frac{47}{64}$	$2\frac{1}{8}$	$\frac{5}{8}$	$3\frac{7}{64}$	16
$1\frac{1}{2}$	$1\frac{71}{64}$	$1\frac{3}{4}$	$\frac{5}{16}$	$2\frac{1}{64}$	16	...	...	...	...	...	...

Hexagon Check Nuts



A = Size of tap;
 B = Size of plain hole;
 N (in table) = Number of threads per inch.

A	B	C	D	E	N	A	B	C	D	E	N
$\frac{3}{16}$	$\frac{9}{64}$	$\frac{7}{16}$	$\frac{5}{32}$	$\frac{1}{2}$	32	$\frac{3}{16}$	$\frac{15}{32}$	$\frac{7}{8}$	$\frac{5}{16}$	$1\frac{1}{64}$	12
$\frac{1}{4}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{5}{32}$	$\frac{1}{2}$	20	$\frac{3}{16}$	$\frac{15}{32}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{15}{64}$	12
$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{7}{32}$	$\frac{27}{64}$	20	$\frac{3}{16}$	$\frac{27}{64}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{15}{64}$	11
$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{7}{32}$	$\frac{27}{64}$	18	$1\frac{1}{16}$	$\frac{27}{64}$	$1\frac{1}{16}$	$\frac{5}{16}$	$1\frac{15}{64}$	11
$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{23}{32}$	18	$1\frac{1}{16}$	$\frac{27}{64}$	$1\frac{1}{4}$	$\frac{5}{8}$	$1\frac{7}{16}$	11
$\frac{3}{8}$	$1\frac{9}{64}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{23}{32}$	16	$\frac{3}{4}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{3}{8}$	$1\frac{7}{16}$	10
$\frac{3}{8}$	$1\frac{9}{64}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{7}{8}$	16	$\frac{3}{8}$	$\frac{47}{64}$	$1\frac{1}{4}$	$\frac{3}{8}$	$1\frac{7}{16}$	9
$\frac{7}{16}$	$\frac{27}{64}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{7}{8}$	14	$\frac{3}{4}$	$\frac{5}{8}$	$1\frac{3}{8}$	$\frac{3}{8}$	$1\frac{19}{32}$	10
$\frac{7}{16}$	$\frac{27}{64}$	$\frac{7}{8}$	$\frac{5}{16}$	$1\frac{1}{64}$	14	$\frac{7}{8}$	$\frac{47}{64}$	$1\frac{3}{8}$	$\frac{3}{8}$	$1\frac{19}{32}$	9
$\frac{1}{2}$	$1\frac{15}{32}$	$\frac{7}{8}$	$\frac{5}{16}$	$1\frac{1}{64}$	13	1	$\frac{27}{32}$	$1\frac{3}{8}$	$\frac{3}{8}$	$1\frac{19}{32}$	8

Dimensions and Weight of Wrought Iron and Steel Washers

(Manufacturers' Standard Sizes)

Size of Bolt, Inches	Outside Diam., Inches	Size of Hole, Inches	Thickness, U. S. S. Plate Gage	Approximate Thickness, Inches	Approximate Number in 100 Pounds	Approximate Weight per 100, in Pounds	Size of Bolt, Inches	Outside Diam., Inches	Size of Hole, Inches	Thickness, U. S. S. Plate Gage	Approximate Thickness, Inches	Approximate Number in 100 Pounds	Approximate Weight per 100, in Pounds
$\frac{3}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	18	$\frac{1}{20}$	44,075	0.2	1	$2\frac{1}{2}$	$1\frac{1}{16}$	9	$\frac{5}{32}$	617	16
$\frac{1}{4}$	$\frac{3}{4}$	$\frac{5}{16}$	16	$\frac{1}{16}$	13,845	0.7	$1\frac{1}{8}$	$2\frac{3}{4}$	$1\frac{1}{4}$	9	$\frac{5}{32}$	516	20
$\frac{5}{16}$	$\frac{7}{8}$	$\frac{3}{8}$	16	$\frac{1}{16}$	11,220	0.9	$1\frac{1}{4}$	3	$1\frac{3}{8}$	8	$1\frac{1}{64}$	403	25
$\frac{3}{8}$	1	$\frac{7}{16}$	14	$\frac{5}{64}$	6,573	1.5	$1\frac{3}{8}$	$3\frac{1}{4}$	$1\frac{1}{2}$	8	$1\frac{1}{64}$	320	30
$\frac{7}{16}$	$1\frac{1}{4}$	$\frac{1}{2}$	14	$\frac{5}{64}$	4,261	3.9	$1\frac{1}{2}$	$3\frac{1}{2}$	$1\frac{5}{8}$	8	$1\frac{1}{64}$	278	36
$\frac{1}{2}$	$1\frac{3}{8}$	$\frac{9}{16}$	12	$\frac{7}{64}$	2,683	5	$1\frac{5}{8}$	$3\frac{3}{4}$	$1\frac{3}{4}$	8	$1\frac{1}{64}$	247	40
$\frac{5}{8}$	$1\frac{1}{2}$	$\frac{5}{8}$	12	$\frac{7}{64}$	2,249	6	$1\frac{3}{4}$	4	$1\frac{7}{8}$	8	$1\frac{1}{64}$	224	45
$\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{16}$	10	$\frac{9}{64}$	1,315	8	$1\frac{7}{8}$	$4\frac{1}{4}$	2	8	$1\frac{1}{64}$	200	50
$\frac{3}{4}$	2	$1\frac{3}{16}$	10	$\frac{9}{64}$	1,013	10	2	$4\frac{1}{2}$	$2\frac{1}{8}$	8	$1\frac{1}{64}$	180	60
$\frac{7}{8}$	$2\frac{1}{4}$	$1\frac{5}{16}$	9	$\frac{5}{32}$	858	12	..	..	..	..	...	...	...

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Length of Thread Cut on Bolts *

Diameter of Bolt, Inches	Length of Bolt, Inches							
	1 to 1½	1½ to 2	2½ to 2½	2½ to 3	3½ to 4	4½ to 5	5½ to 6	6½ to 8
¼	¾	¾	1	1	1½	1½	.....	.....
⅜	¾	¾	1	1	1½	1½	.....	.....
½	¾	1	1½	1½	1½	1½	1½	.....
⅝	¾	1	1½	1½	1½	1½	1½	.....
¾	¾	1	1½	1½	1½	1½	1½	1½
⅞	¾	1	1½	1½	1½	1½	1½	1½
1	1	1½	1½	1½	1½	1½	1½	2
1¼	.....	1½	1½	1½	1½	1½	2	2½
1½	.....	1½	1½	1½	1½	2	2½	2½
1¾	.....	.....	1½	2	2½	2½	2½	3
2	.....	.....	.....	2½	2½	2½	3	3½
2¼	.....	.....	.....	.....	2½	3	3½	3½

* Bolts larger in diameter and longer than given in the table are threaded a length equal to three times their diameter.

Working Strength of Bolts *

Diam. of Bolt, Inches	Strength of Bolt, 5000 Pounds Stress	Strength of Bolt, 6000 Pounds Stress	Strength of Bolt, 7000 Pounds Stress	Strength of Bolt, 8000 Pounds Stress	Strength of Bolt, 10,000 Pounds Stress	Strength of Bolt, 12,000 Pounds Stress
⅝	220	265	300	350	440	525
¾	565	680	790	900	1,130	1,355
⅞	1,000	1,200	1,400	1,600	2,000	2,400
1	1,490	1,790	2,085	2,385	2,980	3,475
1¼	2,055	2,465	2,875	3,290	4,110	4,930
1½	2,890	3,470	4,045	4,625	5,780	6,935
1¾	3,550	4,260	4,970	5,680	7,100	8,520
1½	4,585	5,500	6,420	7,335	9,170	10,500
1¾	5,525	6,630	7,735	8,840	11,050	13,260
1¾	6,525	7,830	9,135	10,440	13,050	15,660
1¾	7,890	9,470	11,045	12,625	15,780	18,935
2	8,990	10,790	12,585	14,385	17,980	21,575
2¼	12,280	14,735	17,190	19,650	24,560	29,470
2½	15,445	18,535	21,620	24,710	30,890	37,070
2¾	19,635	23,560	27,490	31,415	39,270	47,125
3	23,360	28,030	32,700	37,375	46,720	56,065
3¼	28,450	34,140	39,830	45,520	56,900	68,280
3½	33,330	39,995	46,665	53,330	66,660	79,990

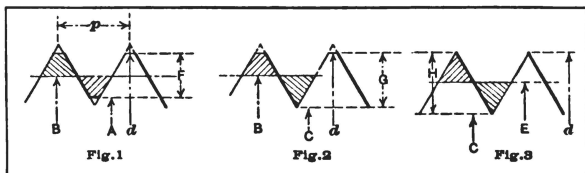
* The figures given in the table above show the stress to which it is safe to subject the bolt when due allowance has been made for the stresses in the bolt caused by tightening. The table refers specifically to bolts for cylinder heads, receivers containing reboilers, etc. For work of this character, bolts less than ⅝ inch in diameter are not used.

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Thread Rolling

The Thread Rolling Process. — The formation of threads by rolling is effected by hardened rolls or dies having threads or ridges which roll grooves into the blank and raise enough material above the surface of the blank to form a thread. The thread rolling dies may be flat or circular in form. When threads are rolled in the automatic screw machine, the tool used is in the form of a disk having a threaded periphery and mounted so as to revolve freely when forced against the blank to be threaded. In one type of machine, designed especially for threading such parts as machine screws, stove bolts, track bolts, wood screws, etc., flat dies are used. There are two dies having V-shaped ridges corresponding to the pitch and helix angle of the thread. One of the dies is stationary and the other has a reciprocating movement; the thread is formed by passing the blank between the dies. In another type of thread rolling machine, a cylindrical die, rotating on its axis and provided with thread grooves on the outside, is set horizontally within a hollow cylindrical die having threads on the inside. This is known as the rotary type of machine. The main advantage of the thread rolling process is the rapidity with which threads can be formed.

Thread Rolling in Automatic Screw Machines. — Thread rolling is done in automatic screw machines when a thread is required behind a shoulder where it would be impossible to cut it with a die. In this way, a second operation on the work is obviated. The roll used for forming the thread should be large enough in



diameter to turn freely on the pin on which it is mounted. The thread on the roll should be the opposite hand to that which is to be produced on the work; that is, if the thread required on the work is to be right-hand, then the roll should be left-hand, and *vice versa*. For rolling a right-hand thread, the work should revolve in the same direction as when a thread is cut in the lathe. Whenever practicable, the roll should pass under the thread. The roll holder should have a vertical adjustment so that the roll can be set to the proper height.

Thread rolling in automatic screw machine practice is generally only applied to brass and similar materials, owing to the difficulty of securing a roll that will withstand the severe service incident to rolling threads in harder metals. Thread rolls for steel work, however, have given fairly good results, when made of chrome-nickel steel containing from 0.15 to 0.20 per cent carbon. The following information applies to the rolling of threads in brass and other soft materials, and is largely based upon experiments made by the Brown & Sharpe Mfg. Co.

Obtaining the Blank Diameter. — As a rule, the diameter of the blank for brass should be approximately equal to the pitch diameter. When rolling a U. S. standard thread, the diameter of the blank should be slightly less than the pitch diameter of the thread, because of the impracticability of using a thread roll with a flat top. If the threads on the roll are not made sharp at the top, considerably more pressure will be required to force the roll into the work, and it will not produce

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as smooth and perfect a thread. Therefore, all thread rolls, whether for forming a sharp V or a U. S. standard thread, are made with a sharp V, top and bottom. It is not necessary to make the bottom of the thread on the roll sharp, but there would be no advantage in having it flat, as the outside diameter of the screw is governed by the diameter of the blank. The shape of the thread produced by a thread roll, when the U. S. standard form is required, is shown in Fig. 2. The pitch diameter B is the same as the pitch diameter of the U. S. standard form, Fig. 1. The root diameter C , however, is less than the root diameter A of the U. S. standard thread. The approximate diameter of the blank can be found by the following formula, in which D = diameter of the blank; B = pitch diameter of the screw; F = depth of U. S. standard thread = $0.6495 p$:

$$D = B - \frac{1}{2} F.$$

The pitch diameter $B = d - F$, in which d = nominal external diameter of the screw.

When rolling a thread having a sharp V-form, the pitch diameter E , Fig. 3, can be used as the approximate diameter of the blank. The pitch diameter for a V-thread is found by the formula: $E = d - H$, in which $H = 0.866 p$. The correct diameter of the blank, in any case, must be determined by experiments, owing to variations in hardness of different materials. It is a simple matter, however, in the automatic screw machine, to reduce or increase the diameter of the blank so as to obtain a screw of the required diameter.

The Thread Roll. — The best results are obtained by using a thread roll with a single thread, but, when the piece to be rolled is less than $\frac{1}{4}$ inch in diameter, it is necessary to make the roll with a multiple thread because the diameter of the roll must then be made twice the diameter of the blank. The Brown & Sharpe Mfg. Co. has found that the pitch diameter of the roll should not be an exact multiple of the pitch diameter of the finished piece, but slightly less. The pitch diameter of the roll for a U. S. standard thread can be found by the following formula, in which K = pitch diameter of roll; N = approximate ratio between pitch diameter of roll and pitch diameter of piece to be threaded; D = outside diameter of blank; G = depth of thread:

$$K = N \times (D - \frac{1}{2} G).$$

For a sharp V-thread, the root, pitch and outside diameters of the roll are found by the following formulas, in which D_1 = pitch diameter of thread roll; D_2 = root diameter of thread roll; D_3 = outside diameter of thread roll; N = approximate ratio between pitch diameter of roll and pitch diameter of piece to be threaded; E = pitch diameter of thread or diameter of blank; H = depth of thread = $0.866 p$:

$$D_1 = N \times (E - \frac{1}{2} H); \quad D_2 = D_1 - H; \quad D_3 = D_1 + H.$$

The thread rolls used by the National-Acme Mfg. Co. are made from $1\frac{1}{4}$ to $2\frac{1}{4}$ inches in diameter and sometimes larger, multiple threads being used when the work is smaller than the outside diameter of the thread roll. Assuming that D_1 = outside diameter of thread roll; n = number of "starts" or threads on the roll; d = outside diameter of part to be threaded (diameter after completion of thread); G = depth of thread; then:

$$D_1 = n \times (d - 1.25 G).$$

Example: — A thread is to be rolled $\frac{1}{4}$ inch in diameter, with 24 sharp V-threads per inch. Assuming that there are to be eight threads on the roll, then:

$$D_1 = 8 \times (0.250 - 1.25 \times 0.0361) = 1.639 \text{ inch.}$$

The number of threads on the roll (whether double, triple, quadruple, etc.) is selected, as a rule, so that the diameter of the thread roll will be somewhere between $1\frac{1}{4}$ and $2\frac{1}{4}$ inches.

In making a thread roll, the ends are beveled at an angle of 45 degrees, to prevent the threads on the ends of the roll from chipping. Precautions should be taken in hardening, because if the sharp edges are burnt, the roll will be useless. Thread rolls, as a rule, are lapped after hardening. This is done by holding them on an arbor in the lathe and using emery and oil on a piece of hard wood. A thread roll, to give good results, should fit closely in the holder. If the roll is made to fit loosely, it will mar the threads. The hole in the roll should be made a good running fit on the pin in the holder, and, in most cases, should not be larger than $\frac{5}{16}$ inch, $\frac{1}{4}$ inch usually being adopted for rolls 1 inch in diameter or less. Rolls made of 3 per cent nickel steel containing about 0.12 per cent carbon have proved satisfactory for threading brass.

Application of Thread Roll. — The shape of the work, and the character of the operations necessary to produce it, govern, to a large extent, the method employed in applying the thread roll. Some of the points to consider are as follows: 1. Diameter of the part to be threaded. 2. Location of the part to be threaded. 3. Length of the part to be threaded. 4. Relation that the thread rolling operation bears to the other operations. 5. Shape of the part to be threaded, whether straight, tapered or otherwise. 6. Method of applying the support. When the diameter to be rolled is much smaller than the diameter of the shoulder preceding it, a cross-slide knurl-holder should be used. If the part to be threaded is not behind a shoulder, a holder on the swing principle should be used. When the work is long (greater in length than two-and-one-half times its diameter) a swing roll-holder should be employed, carrying a support. When the work can be cut off after the thread is rolled, a cross-slide roll-holder should be used. The method of applying the support to the work also governs to some extent the method of applying the thread roll. When no other tool is working at the same time as the thread roll, and when there is freedom from chips, the roll can be held more rigidly by passing it under instead of over the work. When passing the roll over the work, it has a tendency to raise the cross-slide. Where the part to be threaded is tapered, the roll can best be presented to the work by holding it in a cross-slide roll-holder.

Speeds and Feeds for Thread Rolling. — When the thread roll is made from high-carbon steel and used on brass, a surface speed as high as 200 feet per minute can be used. Better results, however, are obtained by using a lower speed than this. When the roll is held in a holder attached to the cross-slide, and is presented either tangentially or radially to the work, a considerably higher speed can be used than if it is held in a swing tool. This is due to the lack of rigidity in a holder of the swing type. The feeds to be used when a cross-slide roll-holder is used are given in the upper half of the table "Feeds for Thread Rolling"; the lower half of the table gives the feeds for thread rolling with swing tools. These feeds are applicable for rolling threads without a support, when the root diameter of the blank is not less than five times the double depth of the thread. When the root diameter is less than this, a support should be used. A support should also be used when the width of the roll is more than two-and-one-half times the smallest diameter of the piece to be rolled, irrespective of the pitch of the thread. When the smallest diameter of the piece to be rolled is much less than the root diameter of the thread, the smallest diameter should be taken as the deciding factor for the feed to be used.

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Lag Screws Thread Systems in Common Use

Diam- eter	Alternate Systems		Diam- eter	Alternate Systems		Diam- eter	Alternate Systems	
	Threads per Inch	Threads per Inch		Threads per Inch	Threads per Inch		Threads per Inch	Threads per Inch
$\frac{1}{4}$	10	10	$\frac{1}{2}$	6	6	$\frac{3}{4}$	$4\frac{1}{2}$	5
$\frac{5}{16}$	$9\frac{1}{2}$	9	$\frac{3}{8}$	5	6	$\frac{7}{8}$	$4\frac{1}{2}$	4
$\frac{3}{8}$	7	8	$\frac{5}{8}$	5	5	1	3	4
$\frac{7}{8}$	7	7	$1\frac{1}{16}$	$4\frac{1}{2}$	5	....	.....	.....

Measuring Screw Threads

Pitch and Lead of Screw Threads.—The *pitch* of a screw thread is the distance from the center of one thread to the center of the next thread. This applies no matter whether the screw has a single, double, triple or quadruple thread. The *lead* of a screw thread is the distance the nut will move forward on the screw if it is turned around one full revolution. In a single-threaded screw, the pitch and lead are equal, because the nut would move forward the distance from one thread to the next, if turned around once. In a double-threaded screw, the nut will move forward two threads, or twice the pitch, so that in this case the lead equals twice the pitch. In a triple-threaded screw, the lead equals three times the pitch, and so on.

The word "pitch" is often, although improperly, used to denote the *number of threads per inch*. Screws are spoken of as having a 12-pitch thread, when twelve threads per inch is what is really meant. The number of threads per inch equals 1 divided by the pitch, or expressed as a formula:

$$\text{Number of threads per inch} = \frac{1}{\text{pitch}}$$

The pitch of a screw equals 1 divided by the number of threads per inch, or:

$$\text{Pitch} = \frac{1}{\text{number of threads per inch}}$$

If the number of threads per inch equals 16, the pitch = $\frac{1}{16}$. If the pitch equals 0.05, the number of threads equals $1 \div 0.05 = 20$. If the pitch is $\frac{3}{8}$ inch, the number of threads per inch equals $1 \div \frac{3}{8} = 2\frac{2}{3}$.

Confusion is often caused by the indefinite designation of multiple-thread screws (double, triple, quadruple, etc.). The expression, "four threads per inch, triple," for example, is not to be recommended. It means that the screw is cut with four triple threads or with twelve threads per inch, if the threads are counted by placing a scale alongside the screw. To cut this screw, the lathe would be geared to cut four threads per inch, but they would be cut only to the depth required for twelve threads per inch. The best expression, when a multiple-thread is to be cut, is to say, in this case, " $\frac{1}{4}$ inch lead, $\frac{1}{12}$ inch pitch, triple thread." For single-threaded screws, only the number of threads per inch and the form of the thread are specified. The word "single" is not required.

Measuring Screw Thread Pitch Diameters by Thread Micrometers.—As the pitch or angle diameter of a tap or screw is the most important dimension, it is necessary that the pitch diameter of screw threads be measured, in addition to the outside diameter. The best means for measuring in the angle of a thread is by

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