TM 9-243

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

U.S. Dept. of the Army

USE AND CARE OF HANDTOOLS AND MEASURING TOOLS

HEADQUARTERS, DEPARTMENT OF THE ARMY

2

TECHNICAL MANUAL
No. 9-243

[redacted]

HEADQUARTERS,
DEPARTMENT OF THE ARMY,
WASHINGTON 25, D. C., *14 September 1960*

USE AND CARE OF HANDTOOLS AND MEASURING TOOLS

***This manual supersedes TM 9–867, 19 April 1945.**

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Purpose

This manual is published for the use of all concerned to provide a ready reference on the proper use, care, and application of handtools and measuring tools in the Ordnance supply system.

2. Scope

a. This manual contains a general description of handtools and measuring tools. Individual chapters covering measuring tools, nonedged handtools, and edged handtools explain the many types of tools in these categories and their function, and provide instructions for their proper use and care, including safety precautions. Instructions for accomplishing special operations are also given, as well as tables of data pertinent to the tools.

b. The appendix contains a list of current references, including supply and technical manuals, forms, technical bulletins, and other available publications applicable to handtools and measuring tools covered by this manual.

3. Differences from Previous Manual

This manual differs from TM 9–867 as indicated in *a* through *c* below.

a. Adds information on—

Anvils	Drill point gage
Awls	Drill and wire gages
Bars	Drilling machine
Bevel protractor	Extractors
Blacksmith's tools	Flaring tools
Bolt cutters	Grinders
Breast drill	Height gages
Cable cutters	Iron working tools
Center gages	Jacks
Depth gages	Marking gages
Oilstones	Surface gages
Precision tapes	Surface plates
Pullers	Telescoping gages
Screw pitch gages	Thread chasers
Sheet metal tools	Torches
Small hole gages	Trammels

b. Revised information on—

Calipers	Pliers
Chisels	Punches
Clamps	Reamers
Files	Rules
Fixed gages	Scrapers
Gage blocks	Screwdrivers
Knives	Shears
Levels	Soldering irons
Nippers	Taps and Dies
Oilstones	Vises
Pipe cutters	Wrenches

c. Deletes reference to—

Abrasive wheels	Mauls
Adzes	Paint brushes
Axes	Planes
Boring tools	Saws
Hatchets	Shovels
Hydrometers	Twist drills

4. Definitions

a. Handtools are defined as hand powered and hand operated tools that are designed to perform mechanical operations.

b. Measuring tools are defined as tools that will measure work. Measuring tools can be classed as precision and nonprecision tools.

5. Listing of Handtools and Measuring Tools

A list of common handtools and measuring tools currently authorized for issue is listed in the SM 9–1–5100-series and SM 9–1–5200.

6. Special Tools

a. No attempt has been made to include in this manual information on special handtools such as vulcanizers, lubricating guns, and welding electrode holders. Refer to the pertinent technical manual which covers the particular special handtool. For example, TM 9–1871 covers tire repair and retread procedures, which includes vulcanizing tools. TM 9–2835 covers lubrication procedures and includes lubricating guns.

b. Special machine tools such as drill chuck keys and lathe tailstock chucks are not covered in this manual.

c. Electrical testing instruments such as ammeters, ohmmeters, and voltmeters are omitted from this manual, since manufactures of this type equipment vary in their design and operating characteristics.

Section II. SHOPWORK

7. General

Shopwork is generally understood to include all work where the use of handtools and measuring tools is required.

8. Layout of Work

"Laying out" is a shop term which means to place lines, circles, centers, and so forth, upon the surface of any material to serve as a guide in shaping the finished piece. This laying out procedure is similar to mechanical drawing, but differs from it in one important respect. The lines on a mechanical drawing are used for reference purposes only and are not measured or transferred; therefore, accurate spacing is not required. In laid out work, even a slight error in placing a line or center may result in a corresponding or greater error in the finished piece. For that reason, all lines should be exactly located, and all scriber, divider, and center points should be exact and sharp.

9. Safety Precautions

It is extremely important for all concerned to recognize the possibilities of injury when using handtools and measuring tools. The following safety precautions are included as a guide to prevent or minimize personal injury:

a. Make certain all tool handles are securely attached before using them.

b. Exercise extreme caution when handling edged tools.

c. Do not use a tool for a purpose other than that for which it was intended.

d. Do not handle tools carelessly—carelessly piling tools in drawers, dropping tools on hard surfaces, etc., can damage tools. Damaged tools can cause mishaps.

e. Keep your mind on your work so that you do not strike yourself or someone else with a hammer or sledge.

f. Do not carry edged or pointed tools in your pocket.

g. Always wear goggles when chipping metal and when grinding edges on tools.

h. Hold driving tools correctly so that they will not slip off the work surface.

i. Use the right tool for the job. The wrong tool may damage materials, injure workers, or both.

j. Do not use punches with improper points or mushroomed heads.

k. Do not use a tool that is oily or greasy. It may slip out of your hand, causing injury.

l. When using jacks, make certain to use blocking or other supports when lifting a vehicle, in case of jack failure.

m. Make sure work to be cut, sheared, chiseled, filed, etc., is steadied and secure, to prevent the tool from slipping.

n. When using a knife, always cut away from your body, except in the case of a spoke shave or draw knife.

o. Use torches and soldering irons with extreme care to prevent burns and explosions. The soldering iron must be so placed that the hot point cannot come in contact with flammable material or with the body.

p. Familiarize yourself with the composition and hardness of the material to be worked.

CHAPTER 2

MEASURING TOOLS

Section I. GENERAL

10. General

Measuring tools are designed for measuring work accurately. They include level indicating devices (levels), noncalibrated measuring tools (calipers, dividers, trammels) for transferring dimensions and/or layouts from one medium to another, calibrated measuring tools (rules, precision tapes, micrometers) designed to

Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches
1	0.039370	26	1.023622	51	2.007874	76	2.992126
2	0.078740	27	1.062992	52	2.047244	77	3.031496
3	0.118110	28	1.102362	53	2.086614	78	3.070866
4	0.157480	29	1.141732	54	2.125984	79	3.110236
5	0.196850	30	1.181102	55	2.165354	80	3.149606
6	0.236220	31	1.220472	56	2.204724	81	3.188976
7	0.275591	32	1.259843	57	2.244094	82	3.228346
8	0.314961	33	1.299213	58	2.283465	83	3.267717
9	0.354331	34	1.338583	59	2.322835	84	3.307087
10	0.393701	35	1.377953	60	2.362205	85	3.346457
11	0.433071	36	1.417323	61	2.401575	86	3.385827
12	0.472441	37	1.456693	62	2.440945	87	3.425197
13	0.511811	38	1.496063	63	2.480315	88	3.464567
14	0.551181	39	1.535433	64	2.519685	89	3.503937
15	0.590551	40	1.574803	65	2.559055	90	3.543307
16	0.629921	41	1.614173	66	2.598425	91	3.582677
17	0.669291	42	1.653543	67	2.637795	92	3.622047
18	0.708661	43	1.692913	68	2.677165	93	3.661417
19	0.748031	44	1.732283	69	2.716535	94	3.700787
20	0.787402	45	1.771654	70	2.755906	95	3.740157
21	0.826772	46	1.811024	71	2.795276	96	3.779528
22	0.866142	47	1.850394	72	2.834646	97	3.818898
23	0.905512	48	1.889764	73	2.874016	98	3.858268
24	0.944882	49	1.929134	74	2.913386	99	3.897638
25	0.984252	50	1.968504	75	2.952756	100	3.937008

RA PD 257524

Figure 1. Conversion chart—millimeters to inches.

measure distances in accordance with one of several standards of measurement, gages (go and no-go gages, thread gages) which are machined to predetermined shapes and/or sizes for measurement by comparison, and combination tools such as a combination square which is designed to perform two or more types of operation.

11. Standards of Measurement

a. *Standards of Length.* Two systems, the English and Metric, are commonly used in the design of measuring tools for linear measurements. The English system uses inches, feet, and yards, while the Metric system uses millimeters, centimeters, and meters. In relation

Fraction of Inch	Decimal of Inch	Millimeters	Fraction of Inch	Decimal of Inch	Millimeters
1/64	0.015625	0.3968	33/64	0.515625	13.0966
1/32	0.03125	0.7937	17/32	0.53125	13.4934
3/64	0.046875	1.1906	35/64	0.546875	13.8903
1/16	0.0625	1.5875	9/16	0.5625	14.2872
5/64	0.078125	1.9843	37/64	0.578125	14.6841
3/32	0.09375	2.3812	19/32	0.59375	15.0809
7/64	0.109375	2.7780	39/64	0.609375	15.4778
1/8	0.125	3.1749	5/8	0.625	15.8747
9/64	0.140625	3.5718	41/64	0.640625	16.2715
5/32	0.15625	3.9686	21/32	0.65625	16.6684
11/64	0.171875	4.3655	43/64	0.671875	17.0653
3/16	0.1875	4.7624	11/16	0.6875	17.4621
13/64	0.203125	5.1592	45/64	0.703125	17.8590
7/32	0.21875	5.5561	23/32	0.71875	18.2559
15/64	0.234375	5.9530	47/64	0.734375	18.6527
1/4	0.25	6.3498	3/4	0.75	19.0496
17/64	0.265625	6.7467	49/64	0.765625	19.4465
9/32	0.28125	7.1436	25/32	0.78125	19.8433
19/64	0.296875	7.5404	51/64	0.796875	20.2402
5/16	0.3125	7.9373	13/16	0.8125	20.6371
21/64	0.328125	8.3342	53/64	0.828125	21.0339
11/32	0.34375	8.7310	27/32	0.843750	21.4308
23/64	0.359375	9.1279	55/64	0.859375	21.8277
3/8	0.375	9.5248	7/8	0.875	22.2245
25/64	0.390625	9.9216	57/64	0.890625	22.6214
13/32	0.40625	10.3185	29/32	0.90625	23.0183
27/64	0.421875	10.7154	59/64	0.921875	23.4151
7/16	0.4375	11.1122	15/16	0.9375	23.8120
29/64	0.453125	11.5091	61/64	0.953125	24.2089
15/32	0.46875	11.9060	31/32	0.96875	24.6057
31/64	0.484375	12.3029	63/64	0.984375	25.0026
1/2	0.5	12.6997	1	1.0	25.3995

RA PD 257472

Figure 2. Conversion chart—fractions of an inch to decimals of an inch, and millimeters.

to each other, 1 inch is equivalent to 25.4 millimeters, or 1 millimeter is equivalent to 0.039370 inch. Refer to figures 1 through 6 to facilitate conversion between systems.

Decimals of inch	Millimeter	Decimals of inch	Millimeter	Decimals of inch	Millimeter
0.001	0.02540	0.035	0.88900	0.068	1.72720
0.002	0.05080	0.036	0.91440	0.069	1.75260
0.003	0.07620	0.037	0.93980	0.070	1.77800
0.004	0.10160	0.038	0.96520	0.071	1.80340
0.005	0.12700	0.039	0.99060	0.072	1.82880
0.006	0.15240	0.040	1.01600	0.073	1.85420
0.007	0.17780	0.041	1.04140	0.074	1.87960
0.008	0.20320	0.042	1.06680	0.075	1.90500
0.009	0.22860	0.043	1.09220	0.076	1.93040
0.010	0.25400	0.044	1.11760	0.077	1.95580
0.011	0.27940	0.045	1.14300	0.078	1.98120
0.012	0.30480	0.046	1.16840	0.079	2.00660
0.013	0.33020	0.047	1.19380	0.080	2.03200
0.014	0.35560	0.048	1.21920	0.081	2.05740
0.015	0.38100	0.049	1.24460	0.082	2.08280
0.016	0.40640	0.050	1.27000	0.083	2.10820
0.017	0.43180	0.051	1.29540	0.084	2.13360
0.018	0.45720	0.052	1.32080	0.085	2.15900
0.019	0.48260	0.053	1.34620	0.086	2.18440
0.020	0.50800	0.054	1.37160	0.087	2.20980
0.021	0.53340	0.055	1.39700	0.088	2.23520
0.022	0.55880	0.056	1.42240	0.089	2.26060
0.023	0.58420	0.057	1.44780	0.090	2.28600
0.024	0.60960	0.058	1.47320	0.091	2.31140
0.025	0.63500	0.059	1.49860	0.092	2.33680
0.026	0.66040	0.060	1.52400	0.093	2.36220
0.027	0.68580	0.061	1.54940	0.094	2.38760
0.028	0.71120	0.062	1.57480	0.095	2.41300
0.029	0.73660	0.063	1.60020	0.096	2.43840
0.030	0.76200	0.064	1.62560	0.097	2.46380
0.031	0.78740	0.065	1.65100	0.098	2.48920
0.032	0.81280	0.066	1.67640	0.099	2.51460
0.033	0.83820	0.067	1.70180	0.100	2.54000
0.034	0.86360				

RA PD 257473

Figure 3. Conversion chart—decimals of an inch to millimeters.

Inches	Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches	Milli meters
1	25.4	26	660.4	51	1295.4	76	1930.4
2	50.8	27	685.8	52	1320.8	77	1955.8
3	76.2	28	711.2	53	1346.2	78	1981.2
4	101.6	29	736.6	54	1371.6	79	2006.6
5	127.0	30	762.0	55	1397.0	80	2032.0
6	152.4	31	787.4	56	1422.4	81	2057.4
7	177.8	32	812.8	57	1447.8	82	2082.8
8	203.2	33	838.2	58	1473.2	83	2108.2
9	228.6	34	863.6	59	1498.6	84	2133.6
10	254.0	35	889.0	60	1524.0	85	2159.0
11	279.4	36	914.4	61	1549.4	86	2184.4
12	304.8	37	939.8	62	1574.8	87	2209.8
13	330.2	38	965.2	63	1600.2	88	2235.2
14	355.6	39	990.6	64	1625.6	89	2260.6
15	381.0	40	1016.0	65	1651.0	90	2286.0
16	406.4	41	1041.4	66	1676.4	91	2311.4
17	431.8	42	1066.8	67	1701.8	92	2336.8
18	457.2	43	1092.2	68	1727.2	93	2362.2
19	482.6	44	1117.6	69	1752.6	94	2387.6
20	508.0	45	1143.0	70	1778.0	95	2413.0
21	533.4	46	1168.4	71	1803.4	96	2438.4
22	558.8	47	1193.8	72	1828.8	97	2463.8
23	584.2	48	1219.2	73	1854.2	98	2489.2
24	609.6	49	1244.6	74	1879.6	99	2514.6
25	635.0	50	1270.0	75	1905.0	100	2540.0

RA PD 257474

Figure 4. Conversion chart—inches to millimeters.

Feet	Meters	Feet	Meters	Feet	Meters
1	0.3048	35	10.6680	68	20.7264
2	0.6096	36	10.9728	69	21.0312
3	0.9144	37	11.2776	70	21.3360
4	1.2192	38	11.5824	71	21.6408
5	1.5240	39	11.8872	72	21.9456
6	1.8288	40	12.1920	73	22.2504
7	2.1336	41	12.4968	74	22.5552
8	2.4384	42	12.8016	75	22.8600
9	2.7432	43	13.1064	76	23.1648
10	3.0480	44	13.4112	77	23.4696
11	3.3528	45	13.7160	78	23.7744
12	3.6576	46	14.0208	79	24.0792
13	3.9624	47	14.3256	80	24.3840
14	4.2672	48	14.6304	81	24.6888
15	4.5720	49	14.9352	82	24.9936
16	4.8768	50	15.2400	83	25.2984
17	5.1816	51	15.5448	84	25.6032
18	5.4864	52	15.8496	85	25.9080
19	5.7912	53	16.1544	86	26.2128
20	6.0960	54	16.4592	87	26.5176
21	6.4008	55	16.7640	88	26.8224
22	6.7056	56	17.0688	89	27.1272
23	7.0104	57	17.3736	90	27.4320
24	7.3152	58	17.6784	91	27.7368
25	7.6200	59	17.9832	92	28.0416
26	7.9248	60	18.2880	93	28.3464
27	8.2296	61	18.5928	94	28.6512
28	8.5344	62	18.8976	95	28.9560
29	8.8392	63	19.2024	96	29.2608
30	9.1440	64	19.5072	97	29.5656
31	9.4488	65	19.8120	98	29.8704
32	9.7536	66	20.1168	99	30.1752
33	10.0584	67	20.4216	100	30.4800
34	10.3632				

RA PD 257475

Figure 5. Conversion chart—feet to meters.

Meters	Feet	Meters	Feet	Meters	Feet
1	3.28083	35	113.81805	68	222.08534
2	6.56166	36	117.09888	69	225.36617
3	9.84249	37	120.37971	70	228.65700
4	13.12332	38	123.66054	71	231.93783
5	16.40415	39	126.94137	72	235.21866
6	19.68498	40	130.22220	73	238.49949
7	22.96181	41	133.50303	74	241.78032
8	26.24164	42	136.78386	75	245.06115
9	29.52147	43	140.06469	76	248.34198
10	32.80130	44	143.34552	77	251.62281
11	36.08113	45	146.62635	78	254.90364
12	39.36196	46	149.90718	79	258.18447
13	42.64179	47	153.18801	80	261.46530
14	45.92162	48	156.46884	81	265.74613
15	49.20145	49	159.74967	82	269.02696
16	52.48228	50	163.03050	83	272.30779
17	55.76311	51	166.31133	84	275.58862
18	59.04394	52	169.59216	85	278.86945
19	62.32477	53	172.87299	86	282.15028
20	65.60560	54	176.15382	87	285.43111
21	68.88643	55	179.43465	88	288.71194
22	72.16726	56	182.71548	89	291.99277
23	75.44809	57	185.99631	90	295.27360
24	78.72892	58	189.27714	91	298.55443
25	82.00975	59	192.55797	92	301.83526
26	85.29058	60	195.83870	93	305.11609
27	88.57141	61	199.11953	94	308.29692
28	91.85224	62	202.40036	95	311.67775
29	94.13307	63	205.68119	96	314.95858
30	97.41390	64	208.96202	97	318.23941
31	100.69473	65	212.24285	98	321.52024
32	103.97556	66	215.52368	99	324.80107
33	107.25639	67	218.80451	100	328.08190
34	110.53722				

RA PD 257476

Figure 6. Conversion chart—meters to feet.

b. Standards of Screw Threads. There are several screw thread systems that are recognized as standards throughout the world. All threaded items for Ordnance use in the United States, Great Britain, and Canada are specified in the Unified System. The existing inch-measure screw-thread systems should be understood despite the existence of the Unified System.

(1) *Inch-measure systems.*

(*a*) *Whitworth.* Introduced in England in 1841. The thread form is based on a 55° thread angle, and the crests and roots are rounded.

(*b*) *American National.* The American National screw-thread system was developed in 1933. This system is based on the 60° thread angle and the flat crests and roots and is included in the following series:

1. Coarse thread sizes of 1 to 12 and ¼ to 4 inches.

2. The fine thread series in sizes 0 to 12 and ¼ to 1½ inches.

3. The extra-fine thread series in sizes 0 to 12 and ½ to 2 inches.

4. The 8–pitch series in sizes from 1 to 6 inches.

5. The 12–pitch series from ½ to 6 inches.

6. The 16–pitch series from ¾ to 4 inches.

(*c*) *Classes of fit.* The American National screw-thread system calls for four regular classes of fit.

Class I. Loose fit, with no possibility for interference between screw and tapped hole.

Class II. Medium or free fit, but permitting slight interference in the worst combination of maximum screw and maximum nut.

Class III. Close tolerances on mating parts may require this fit, applied to the highest grade of interchangable work.

Class IV. A fine snug fit, where a screwdriver or wrench may be necessary for assembly.

Note. An additional class V, or jaw fit, is recognized for studs.

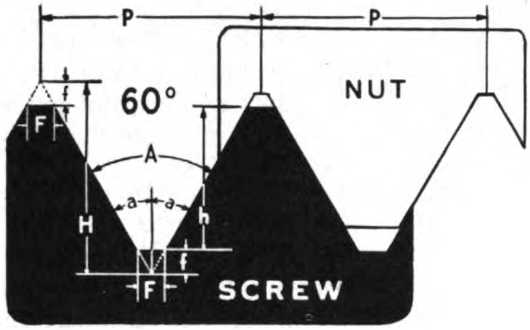
(2) *Unified System.* Since the Whitworth and American National thread forms do not assemble because of the difference in thread angle, the 60° thread angle was adapted in 1949; however, the British may still use rounded crests and roots and their products will assemble with those made in United States plants. In the Unified System, class signifies tolerance, or tolerance and allowance. Fit is determined by the selected combination of classes for mating external and internal threads. New classes of tolerance are listed below: 3 for screws, 1A, 2A, and 3A; and 3 for nuts, 1B, 2B, and 3B.

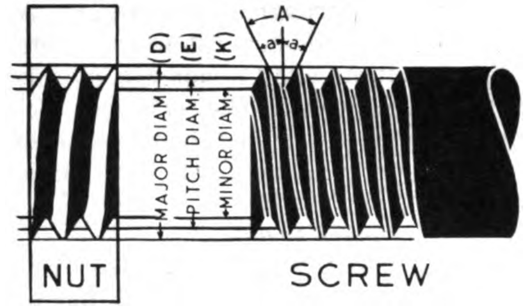
(*a*) *Classes 1A and 1B, loose fit.* A fit giving quick and easy assembly, even when threads are bruised or dirty. Applications: Ordnance and special uses.

(*b*) *Classes 2A and 2B, medium fit.* This fit permits wrenching with minimum galling and seizure. This medium fit is suited for the majority of commercial fasterners and is interchangeable with the American National Class II fit.

(*c*) *Classes 3A and 3B, close fit.* No allowance is provided. Applications are those where close fit and accuracy of lead and thread angle are required.

(3) *Tables.* Thread dimensions as shown on figures 7 and 8 are the most commonly used in the United States. The additional columns of tap drill sizes are included for quick reference.





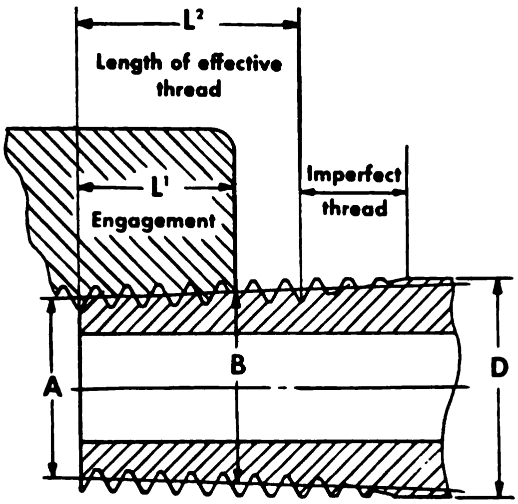
Adopted by the National Screw Thread Commission and formerly known as "United States Standard" this form of thread is the most common in the United States and one of the most widely used thread forms in the world. There are two standard series in commercial use — NC (National Coarse) and NF (National Fine). Threads of this form not included in the NC and NF series are designated as NS (National Special).

A = 60° = Angle of thread
a = 30° = ½ Angle of thread
F = 0.125000p, or ⅛p = Width of flat at crest and root
f = 0.108253p, or ⅛H, or 1 6h = Depth of truncation
H = 0.866025p = Depth Theoretical V 60° thread
h = 0.649519p, or 6 8H = Depth American National form thread
n = Number threads per inch
p = 1/n, = Pitch

NOMINAL SIZE Inches	D MAJOR DIAM. Inches	E PITCH DIAM. Inches	K MINOR DIAM. Inches	DRILL FOR APPROX. 75% THREAD	DEC. EQUIV. TAP DRILL	ACTUAL % FULL THREAD
1/16–64 NS	.0625	.0524	.0422	3/64	.0469	77
72 NS	.0625	.0535	.0445	3/64	.0469	86
5/64–60 NS	.0781	.0673	.0563	1/16	.0625	72
72 NS	.0781	.0691	.0601	52	.0635	81
3/32–48 NS	.0938	.0803	.0667	49	.0730	77
50 NS	.0938	.0808	.0678	49	.0730	80
7/64–48 NS	.1094	.0959	.0823	43	.0890	75
1/8–32 NS	.1250	.1047	.0844	3/32	.0937	77
40 NS	.1250	.1088	.0925	38	.1015	72
9/64–40 NS	.1406	.1244	.1081	32	.1160	76
5/32–32 NS	.1563	.1360	.1157	1/8	.1250	77
36 NS	.1563	.1382	.1202	30	.1285	77
11/64–32 NS	.1719	.1516	.1313	9/64	.1406	77
3/16–24 NS	.1875	.1604	.1334	26	.1470	75
32 NS	.1875	.1672	.1469	22	.1570	75
13/64–24 NS	.2031	.1760	.1490	20	.1610	78
7/32–24 NS	.2188	.1917	.1646	16	.1770	77
32 NS	.2188	.1985	.1782	12	.1890	73
15/64–24 NS	.2344	.2073	.1806	10	.1935	76
1/4–20 NC	.2500	.2175	.1850	7	.2010	75
24 NS	.2500	.2229	.1959	4	.2090	76
27 NS	.2500	.2259	.2019	3	.2130	77
28 NF	.2500	.2268	.2036	3	.2130	80
32 NS	.2500	.2297	.2094	7/32	.2188	77
5/16–18 NC	.3125	.2764	.2403	F	.2570	77
20 NS	.3125	.2800	.2476	17/64	.2656	72
24 NF	.3125	.2854	.2584	I	.2720	75
27 NS	.3125	.2884	.2644	J	.2770	74
32 NS	.3125	.2922	.2719	9/32	.2812	78
3/8–16 NC	.3750	.3344	.2938	5/16	.3125	77
20 NS	.3750	.3425	.3100	21/64	.3281	72
24 NF	.3750	.3479	.3209	Q	.3320	79
27 NS	.3750	.3509	.3269	R	.3390	75
7/16–14 NC	.4375	.3911	.3447	U	.3680	75
20 NF	.4375	.4050	.3726	25/64	.3906	72
24 NS	.4375	.4104	.3834	X	.3970	75
27 NS	.4375	.4134	.3894	Y	.4040	70
1/2–12 NS	.5000	.4459	.3918	27/64	.4219	72
13 NC	.5000	.4500	.4001	27/64	.4219	78
20 NF	.5000	.4675	.4351	29/64	.4531	72
24 NS	.5000	.4729	.4459	29/64	.4531	87
27 NS	.5000	.4759	.4519	15/32	.4687	65
9/16–12 NC	.5625	.5084	.4542	31/64	.4844	72
18 NF	.5625	.5264	.4903	33/64	.5156	65
27 NS	.5625	.5384	.5144	17/32	.5312	65
5/8–11 NC	.6250	.5660	.5069	17/32	.5312	79
12 NS	.6250	.5709	.5168	35/64	.5469	72
18 NF	.6250	.5889	.5528	37/64	.5781	65
27 NS	.6250	.6009	.5769	19/32	.5937	65
11/16–11 NS	.6875	.6285	.5694	19/32	.5937	79
16 NS	.6875	.6469	.6063	5/8	.6250	77
3/4–10 NC	.7500	.6850	.6201	21/32	.6562	72
12 NS	.7500	.6959	.6418	43/64	.6719	72
16 NF	.7500	.7094	.6688	11/16	.6875	77
27 NS	.7500	.7259	.7019	23/32	.7187	65
13/16–10 NS	.8125	.7476	.6826	23/32	.7187	72
7/8– 9 NC	.8750	.8028	.7307	49/64	.7656	76
12 NS	.8750	.8209	.7668	51/64	.7969	72
14 NF	.8750	.8286	.7822	13/16	.8125	67
18 NS	.8750	.8389	.8028	53/64	.8281	65
27 NS	.8750	.8509	.8269	27/32	.8437	65
15/16– 9 NS	.9375	.8654	.7932	53/64	.8281	76
1-8 NC	1.0000	.9188	.8376	7/8	.8750	77
12 NS	1.0000	.9459	.8918	59/64	.9219	72
14 NF	1.0000	.9536	.9072	15/16	.9375	67
27 NS	1.0000	.9759	.9519	31/32	.9687	65
1 1/8– 7 NC	1.1250	1.0322	.9394	63/64	.9844	76
12 NF	1.1250	1.0709	1.0168	1 3/64	1.0469	72
1 1/4– 7 NC	1.2500	1.1572	1.0644	1 7/64	1.1094	76
12 NF	1.2500	1.1959	1.1418	1 11/64	1.1719	72
1 3/8– 6 NC	1.3750	1.2667	1.1585	1 7/32	1.2187	72
12 NF	1.3750	1.3209	1.2668	1 19/64	1.2969	72
1 1/2– 6 NC	1.5000	1.3917	1.2835	1 11/32	1.3437	79
12 NF	1.5000	1.4459	1.3918	1 27/64	1.4219	72
1 5/8–5 1/2 NS	1.6250	1.5069	1.3888	1 29/64	1.4531	73
1 3/4–5 NC	1.7500	1.6201	1.4902	1 9/16	1.5625	78
1 7/8–5 NS	1.8750	1.7451	1.6152	1 11/16	1.6875	72
2–4 1/2 NC	2.0000	1.8557	1.7113	1 25/32	1.7812	76
2 1/8–4 1/2 NS	2.1250	1.9807	1.8363	1 29/32	1.9062	76
2 1/4–4 1/2 NS	2.2500	2.1057	1.9613	2 1/32	2.0312	76
2 3/8–4 NS	2.3750	2.2126	2.0502	2 1/8	2.1250	77
2 1/2–4 NS	2.5000	2.3376	2.1752	2 1/4	2.2500	77
2 3/4–4 NS	2.7500	2.5876	2.4252	2 1/2	2.5000	77
3–4 NS	3.0000	2.8376	2.6752	2 3/4	2.7500	77
3 1/4–4 NS	3.2500	3.0876	2.9252	3	3.0000	77
3 1/2–4 NS	3.5000	3.3376	3.1752	3 1/4	3.2500	77
3 3/4–4 NS	3.7500	3.5876	3.4252	3 1/2	3.5000	77
4–4 NS	4.0000	3.8376	3.6752	3 3/4	3.7500	77

RA PD 257477

Figure 7. American national coarse and fine thread dimensions and tap drill sizes.



Taper ¾ in. per foot on diameter

A Pitch Diameter of thread at end of pipe

B Pitch Diameter of thread at gauging notch

D Outside Diameter of pipe

L1 Normal engagement by hand between external and internal thread.

Nominal Size Inches	No. of Threads per Inch	Pitch Diameter		Length		Pipe O. D. D Inches	Depth of Thread Inches	Tap Drills for Pipe Threads	
		A Inches	B Inches	L2 Inches	L1 Inches			Minor Diameter Small End of Pipe	Size Drill
⅛	27	.36351	.37476	.2638	.180	.405	.02963	.33388	R
¼	18	.47739	.48989	.4018	.200	.540	.04444	.43294	7/16
⅜	18	.61201	.62701	.4078	.240	.675	.04444	.56757	37/64
½	14	.75843	.77843	.5337	.320	.840	.05714	.70129	23/32
¾	14	.96768	.98887	.5457	.339	1.050	.05714	.91054	59/64
1	11½	1.21363	1.23863	.6828	.400	1.315	.06957	1.14407	1 5/32
1¼	11½	1.55713	1.58338	.7068	.420	1.660	.06957	1.48757	1½
1½	11½	1.79609	1.82234	.7235	.420	1.900	.06957	1.72652	1 47/64
2	11½	2.26902	2.29627	.7565	.436	2.375	.06957	2.19946	2 7/32
2½	8	2.71953	2.76216	1.1375	.682	2.875	.10000	2.61953	2⅝
3	8	3.34062	3.38850	1.2000	.766	3.500	.10000	3.24063	3¼
3½	8	3.83750	3.88881	1.2500	.821	4.000	.10000	3.73750	3¾
4	8	4.33438	4.38712	1.3000	.844	4.500	.10000	4.23438	4¼

RA PD 257478

Figure 8. American national pipe thread dimensions and tap drill sizes.

c. Standards of Wire and Sheet Metal. Sheet metal, strip, wire, and tubing are produced with thickness diameters or wall thicknesses, according to several gaging systems, depending on the article and metal. This situation is the result of natural development and preferences of the industries that produce these products. No single standard for all manufacturers has been established, since practical considerations stand in the way of adoption. In the case of steel, large users are thoroughly familiar with the behavior of existing gages in tooling, especially dies, and do not intend that their shop personnel be burdened with learning how preferred thicknesses behave. Another important factor is the sum total of orders of warehouse stock manufactured with existing gages. You must keep abreast of any change in availability of metals in these common gaging systems, as opposed to simplified systems. For example; in the brass industry, the American Standards Association (ASA) numbers are said to be preferred for simplicity of stocking, but actually most of the metal is still made to Brown and Sharpe (B&S) gage numbers. Until single standards are adopted, selecting the right gaging system and the proper decimal equivalent of the gage numbers are simplified by table I, index of gaging systems used for various metals and commodities, and conversion chart—wire and sheet metal gages in inch equivalents (fig. 9). It is good practice to use the inch equivalent in decimals to at least the third digit and not a gaging system number, since the gaging system numbers have different inch equivalents, depending on the article and metal, as mentioned above.

Table I. Index of Gaging Systems Used for Various Metals and Commodities

Metal	Commodity			
	Sheet	Strip	Wire	Tubing
Steel:				
Carbon (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Carbon (cold-rolled)	Mfr's std.	U.S. std.		
Alloy (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Alloy (cold-rolled)	Mfr's std.	U.S. std.		
Stainless	(*)	(*)	SWG	U.S. std.
Copper:	Oz. per sq. ft.	B&S	B&S	BWG#
Copper alloys (brass, bronze). **	B&S	B&S	B&S	BWG
Aluminum	B&S	—	B&S	Studs
Magnesium	B&S	—	—	Studs
Nickel alloys	U.S. std.	U.S. std.	B&S, U.S. std.	Studs

*Eastern warehouses stock cold-rolled stainless in U.S. Standard Gage, whereas Pacific coast and some middle western warehouses follow ASA preferred thicknesses.

#For most sizes.

**The copper and brass industry prefer ASA preferred thicknesses, but most material is still fabricated to customer orders in terms of the Brown and Sharpe gaging system.

NUMBER OF GAGE	AMERICAN OR BROWN AND SHARPE	WASHBURN AND MOEN OR AMERICAN STEEL AND WIRE CO.	BIRMINGHAM OR STUBS IRON WIRE	MUSIC WIRE	TWIST DRILL SIZES	IMPERIAL WIRE GAGE	UNITED STATES STD. FOR PLATE
0000000	---------	0.4900	----------	-----------	-----------	0.5000	0.5000
000000	---------	0.4615	0.5800	0.004	-----------	0.4640	0.4688
00000	0.500	0.4305	0.5165	0.005	-----------	0.4320	0.4375
0000	0.454	0.3938	0.4600	0.006	-----------	0.4000	0.4688
000	0.425	0.3625	0.4096	0.007	-----------	0.3720	0.3750
00	0.380	0.3310	0.3648	0.008	-----------	0.3480	0.3438
0	0.340	0.3065	0.3249	0.009	-----------	0.3240	0.3125
1	0.300	0.2830	0.2893	0.010	0.2280	0.3000	0.2813
2	0.284	0.2625	0.2576	0.011	0.2210	0.2760	0.2656
3	0.259	0.2437	0.2294	0.012	0.2130	0.2520	0.2500
4	0.238	0.2253	0.2043	0.013	0.2090	0.2320	0.2344
5	0.220	0.2070	0.1819	0.014	0.2055	0.2120	0.2188
6	0.203	0.1920	0.1620	0.016	0.2040	0.1920	0.2031
7	0.180	0.1770	0.1443	0.018	0.2010	0.1760	0.1875
8	0.165	0.1620	0.1285	0.020	0.1990	0.1600	0.1719
9	0.148	0.1483	0.1144	0.022	0.1960	0.1440	0.1563
10	0.134	0.1350	0.1019	0.024	0.1935	0.1280	0.1406
11	0.120	0.1205	0.0907	0.026	0.1910	0.1160	0.1250
12	0.109	0.1055	0.0808	0.029	0.1890	0.1040	0.1094
13	0.095	0.0915	0.0720	0.031	0.1850	0.0920	0.0938
14	0.083	0.0800	0.0641	0.033	0.1820	0.0800	0.0781
15	0.072	0.0720	0.0571	0.035	0.1800	0.0720	0.0703
16	0.065	0.0625	0.0508	0.037	0.1770	0.0650	0.0625
17	0.058	0.0540	0.0453	0.039	0.1730	0.0560	0.0563
18	0.049	0.0475	0.0403	0.041	0.1695	0.0480	0.0500
19	0.042	0.0410	0.0359	0.043	0.1660	0.0400	0.0438
20	0.035	0.0348	0.0320	0.045	0.1510	0.0360	0.0375
21	0.032	0.0317	0.0285	0.047	0.1590	0.0320	0.0344
22	0.028	0.0286	0.0253	0,049	0.1570	0.0280	0.0313
23	0.025	0.0258	0.0226	0.051	0.1540	0.0240	0.0281
24	0.022	0.0230	0.0201	0.055	0.1520	0.0220	0.0250
25	0.020	0.0204	0.0179	0.059	0.1495	0.0200	0.0219
26	0.018	0.0181	0.0159	0.063	0.1470	0.0180	0.0188
27	0.016	0.0173	0.0142	0.067	0.1440	0.0164	0.0172
28	0.014	0.0162	0.0126	0.071	0.1405	0.0148	0.0156
29	0.013	0.0150	0.0113	0.075	0.1360	0.0136	0.0141
30	0.012	0.0140	0.0100	0.080	0.1285	0.0124	0.0125
31	0.010	0.0132	0.0089	0.085	0.1200	0.0116	0.0109
32	0.009	0.0128	0.0080	0.090	0.1160	0.0108	0.0102
33	0.008	0.0118	0.0071	0.095	0.1130	0.0100	0.0094
34	0.007	0.0104	0.0063	0.100	0.1110	0.0092	0.0086
35	0.005	0.0095	0.0056	0.106	0.1100	0.0084	0.0078
36	0.004	0.0090	0.0050	0.112	0.1065	0.0076	0.0070
37	--------	0.0085	0.0045	0.118	0.1040	0.0068	0.0066
38	---------	0.0080	0.0040	0.124	0.1015	0.0060	0.0063
39	---------	0.0075	0.0035	0.130	0.0095	0.0052	--------
40	---------	0.0070	0.0031	0.138	0.0980	0.0048	--------

RA PD 257479

Figure 9. Wire and sheet metal gages in inch equivalents.

(1) *Sheet metal gaging systems.* Several gaging systems are used for sheet and strip metal.

(*a*) *Manufacturer's standard gaging system (Mfr's std).* This gaging system is currently used for carbon and alloy sheets. This system is based on steel weighing 41.82 psf, 1 inch thick. Gage thickness equivalents are based on 0.0014945 in. per oz per sq ft; 0.023912 in. per lb per sq ft (reciprocal of 41.82 lb per sq ft per in. thick); 3.443329 in. per lb per sq in.

(*b*) *U.S. standard gaging system (U.S. std).* This gaging system is obsolete except for stainless steel sheets, cold-rolled steel strip (both carbon and alloy), stainless steel tubing, and nickel-alloy sheet and strip.

(*c*) *Birmingham wire gaging system (BWG).* This gaging system is also called the Stubs iron wire gaging system, and is used for hot-rolled steel carbon and alloy strip and steel tubing.

(*d*) *Brown and Sharpe, or American wire gaging system (B&S or AWG).* This gaging system is used for copper strip, brass and bronze sheet and strip, and aluminum and magnesium sheet.

(2) *Wire gaging systems.*

(*a*) *Steel wire gaging system (SWG) or Washburn & Moen gaging system.* This gaging system is used for

METRIC MEASURES OF WEIGHT

10 milligrams (mg)	=	1 centigram (cg)
10 centigrams	=	1 decigram (dg)
10 decigrams	=	1 gram (gm)
10 grams	=	1 dekagram (dkg)
10 dekagrams	=	1 hektogram (hg)
10 hektograms	=	1 kilogram (kg)
1000 kilograms	=	1 ton (T)

ENGLISH MEASURES OF WEIGHT

437.5 grains (gr)	=	1 ounce (oz)
16 ounces	=	1 pound (lb)
100 pounds	=	1 hundredweight (cwt)
2000 pounds	=	1 ton
2240 pounds	=	1 long ton

1 ton = 20 cwt = 2000 lbs. = 32,000 ozs. = 14,000,000 grs.

CONVERSIONS OF METRIC AND ENGLISH

1 gram	=	15.432 grains
1 kilogram	=	2.2046 pounds
1 metric ton	=	0.9842 ton of 2240 pounds
1 metric ton	=	19.68 hundredweight
1 metric ton	=	2204.6 pounds
1 grain	=	0.0648 gram
1 ounce	=	28.35 grams
1 pound	=	0.4536 kilogram
1 ton	=	1.016 metric tons
1 ton	=	1016 kilograms

RA PD 257480

Figure 10. Conversion chart—metric and English weight measures.

steel wire, carbon-steel mechanical spring wire, alloy-steel spring wire, stainless steel wire, and so forth. Carbon steel or music wire (wire used in the manufacture of musical instruments) is nominally specified to the sizes in the American Steel & Wire Company music wire sizes, although it is referred to by a number of other names found in steel catalogs.

(b) *Brown & Sharpe (B&S) or American wire gaging system. (AWG).* This gaging system is used for cop-

C		F	C		F	C		F	C		F	C		F	C		F
−273.1	**−459.4**		−17.8	**0**	32	10.0	**50**	122.0	38	**100**	212	260	**500**	932	538	**1000**	1832
−268	**−450**		−17.2	**1**	33.8	10.6	**51**	123.8	43	**109**	230	266	**510**	950	543	**1010**	1850
−262	**−440**		−16.7	**2**	35.6	11.1	**52**	125.6	49	**120**	248	271	**520**	968	549	**1020**	1868
−257	**−430**		−16.1	**3**	37.4	11.7	**53**	127.4	54	**130**	266	277	**530**	986	554	**1030**	1886
−251	**−420**		−15.6	**4**	39.2	12.2	**54**	129.2	60	**140**	284	282	**540**	1004	560	**1040**	1904
−246	**−410**		−15.0	**5**	41.0	12.8	**55**	131.0	66	**150**	302	288	**550**	1022	566	**1050**	1922
−240	**−400**		−14.4	**6**	42.8	13.3	**56**	132.8	71	**160**	320	293	**560**	1040	571	**1060**	1940
−234	**−390**		−13.9	**7**	44.6	13.9	**57**	134.6	77	**170**	338	299	**570**	1058	577	**1070**	1958
−229	**−380**		−13.3	**8**	46.4	14.4	**58**	136.4	82	**180**	356	304	**580**	1076	582	**1080**	1976
−223	**−370**		−12.8	**9**	48.2	15.0	**59**	138.2	88	**190**	374	310	**590**	1094	588	**1090**	1994
−218	**−360**		−12.2	**10**	50.0	15.6	**60**	140.0	93	**200**	392	316	**600**	1112	593	**1100**	2012
−212	**−350**		−11.7	**11**	51.8	16.1	**61**	141.8	99	**210**	410	321	**610**	1130	599	**1110**	2030
−207	**−340**		−11.1	**12**	53.6	16.7	**62**	143.6	100	**212**	413	327	**620**	1184	604	**1120**	2048
−201	**−330**		−10.6	**13**	55.4	17.2	**63**	145.4	104	**220**	428	332	**630**	1166	610	**1130**	2066
−196	**−320**		−10.0	**14**	57.2	17.8	**64**	147.2	110	**230**	446	338	**640**	1184	616	**1140**	2084
−190	**−310**		− 9.44	**15**	59.0	18.3	**65**	149.0	116	**240**	464	343	**650**	1202	621	**1150**	2102
−184	**−300**		− 8.89	**16**	60.8	18.9	**66**	150.8	121	**250**	482	349	**660**	1220	627	**1160**	2120
−179	**−290**		− 8.33	**17**	62.6	19.4	**67**	152.6	127	**260**	500	354	**670**	1238	632	**1170**	2138
−173	**−280**		− 7.78	**18**	64.4	20.0	**68**	154.4	132	**270**	518	360	**680**	1256	638	**1180**	2156
−169	**−273**	−459.4	− 7.22	**19**	66.2	20.6	**69**	156.2	138	**280**	536	366	**690**	1274	643	**1190**	2174
−168	**−270**	−454	− 6.67	**20**	68.0	21.1	**70**	158.0	143	**290**	554	371	**700**	1292	649	**1200**	2192
−162	**−260**	−436	− 6.11	**21**	69.8	21.7	**71**	159.8	140	**300**	572	377	**710**	1310	654	**1210**	2210
−157	**−250**	−418	− 5.56	**22**	71.6	22.2	**72**	161.6	154	**310**	590	382	**720**	1328	660	**1220**	2228
−151	**−240**	−400	− 5.00	**23**	73.4	22.8	**73**	163.4	160	**320**	608	388	**730**	1346	666	**1230**	2246
−146	**−230**	−382	− 4.44	**24**	75.2	23.3	**74**	165.2	166	**330**	626	393	**740**	1364	671	**1240**	2264
−140	**−220**	−364	− 3.89	**25**	77.0	23.9	**75**	167.0	171	**340**	644	399	**750**	1382	677	**1250**	2282
−134	**−210**	−346	− 3.33	**26**	78.8	24.4	**76**	168.8	177	**350**	662	404	**760**	1400	682	**1260**	2300
−129	**−200**	−328	− 2.78	**27**	80.6	25.0	**77**	170.6	182	**360**	680	410	**770**	1418	688	**1270**	2318
−123	**−190**	−310	− 2.22	**28**	82.4	25.6	**78**	172.4	188	**370**	698	416	**780**	1436	693	**1280**	2336
−118	**−180**	−292	− 1.67	**29**	84.2	26.1	**79**	174.2	193	**380**	716	421	**790**	1454	699	**1290**	2354
−112	**−170**	−274	− 1.11	**30**	86.0	26.7	**80**	176.0	199	**390**	734	427	**800**	1472	704	**1300**	2372
−107	**−160**	−256	− 0.56	**31**	87.8	27.2	**81**	177.8	204	**400**	752	432	**810**	1490	710	**1310**	2390
−101	**−150**	−238	0	**32**	89.6	27.8	**82**	179.6	210	**410**	770	438	**820**	1508	716	**1320**	2408
− 95.6	**−140**	−220	0.56	**33**	91.4	28.3	**83**	181.4	216	**420**	788	443	**830**	1526	721	**1330**	2426
− 90.0	**−130**	−202	1.11	**34**	93.2	28.9	**84**	183.2	221	**430**	806	449	**840**	1544	727	**1340**	2444
− 84.4	**−120**	−184	1.67	**35**	95.0	29.4	**85**	185.0	227	**440**	824	454	**850**	1562	732	**1350**	2462
− 78.9	**−110**	−166	2.22	**36**	96.8	30.0	**86**	186.6	232	**450**	842	460	**860**	1580	738	**1360**	2480
− 73.3	**−100**	−148	2.78	**37**	98.6	30.6	**87**	188.6	238	**460**	860	466	**870**	1598	743	**1370**	2498
− 67.8	**− 90**	−130	3.33	**38**	100.4	31.1	**88**	190.4	243	**470**	878	471	**880**	1616	749	**1380**	2516
− 62.2	**− 80**	−112	3.89	**39**	102.2	31.7	**89**	192.2	249	**480**	896	477	**890**	1634	754	**1390**	2534
− 56.7	**− 70**	− 94	4.44	**40**	104.0	32.2	**90**	194.0	254	**490**	914	482	**900**	1652	760	**1400**	2552
− 51.1	**− 60**	− 76	5.00	**41**	105.8	32.8	**91**	195.8				488	**910**	1670	766	**1410**	2570
− 45.6	**− 50**	− 58	5.56	**42**	107.6	33.3	**92**	197.6				493	**920**	1688	771	**1420**	2588
− 40.0	**− 40**	− 40	6.11	**43**	109.4	33.9	**93**	199.4				409	**930**	1706	777	**1430**	2606
− 34.4	**− 30**	− 22	6.67	**44**	111.2	34.4	**94**	201.2				504	**940**	1724	782	**1440**	2624
− 28.9	**− 20**	− 4	7.22	**45**	113.0	35.0	**95**	203.0				510	**950**	1742	788	**1450**	2642
− 23.3	**− 10**	14	7.78	**46**	114.8	35.6	**96**	204.8				516	**960**	1760	793	**1460**	2660
			8.33	**47**	116.6	36.1	**97**	206.6				521	**970**	1778	799	**1470**	2678
			8.89	**48**	118.4	36.7	**98**	208.4				527	**980**	1796	804	**1480**	2696
			9.44	**49**	120.2	37.2	**99**	210.2				532	**990**	1814	810	**1490**	2714
						37.8	**100**	212.0									

RA PD 257481

Figure 11. Temperature conversion chart.

per, copper alloy, aluminum, magnesium, nickel alloy, and other nonferrous metal wires used commercially.

(3) *Rod gaging systems.* The Brown & Sharpe gaging system is used for copper, brass, and aluminum rods. Steel rods are nominally listed in fractional sizes, but drill rod may be listed in Stubs steel wire gage or the twist drill and steel wire gage. It is preferable to refer to twist drill sizes in inch equivalents instead of the Stubs or twist drill numbers.

d. Standards of Weight. Two standards of weight that are most commonly used are the Metric and English weight measures.

(1) *Metric standards.* The principal unit of weight in the Metric system is the gram (gm). Multiples of grams are obtained by prefixing the Greek words deka (10), hekto (100), and kilo (1,000). Divisions are obtained by prefixing the Latin words deci (1/10), centi (1/100), and milli (1/1000). The gram is the weight of 1 cubic centimeter of pure distilled water at a temperature of 39.2° F.; the kilogram is the weight of 1 liter (one cubic decimeter) of pure distilled water at a temperature of 39.2° F.; the metric ton is the weight of 1 cubic meter of pure distilled water at a temperature of 39.2° F.

(2) *English standards.* The principal unit of weight in the English system is the grain (gr). We are more familiar with the ounce (oz), which is equal to 437.5 grains. Refer to figure 10 for the conversion chart of Metric and English weight measures.

e. Standards of Temperature. The universal standard measuring temperature is 68° F., or 20° C. At this temperature, the standard 1 inch equals 2.54 centimeters, which is also a universal conversion factor for measuring length (*a* above). The Fahrenheit and Centigrade measuring standards are used throughout the world; however, there is a third temperature measuring system called the Reaumur which is rapidly becoming obsolete. For our purposes, refer to figure 11 for converting Fahrenheit to Centigrade and vice versa. The temperature conversion formulas used are as described in (1) through (3) below.

(1) To convert Centigrade to Fahrenheit, multiply the temperature in Centigrade by 9/5 and add 32° to the result; $F = (9/5 \times {}^\circ C) + 32^\circ$.

(2) To convert Fahrenheit to Centigrade, subtract 32° from the Fahrenheit temperature and multiply the result by 5/9; $C = ({}^\circ F - 32^\circ) \times 5/9$.

(3) The boldface numbers on the temperature conversion chart (fig. 11) refer to temperatures that are to be converted from Fahrenheit (F) to Centigrade (C), or vice versa. For example, what is Fahrenheit equivalent of 60° C? At boldface 60, look to F. column and read 140.0°.

Section II. LEVELS

12. Purpose of Levels

(fig. 12)

Levels are tools designed to prove whether a plane or surface is true horizontal or true vertical. Some levels are calibrated so that they will indicate the angle inclination in relation to a horizontal or vertical surface in degrees, minutes, and seconds.

13. Types of Levels

The level is a simple instrument consisting of a liquid sealed in a glass tube. The tube is mounted in a frame which may be of aluminum, iron, or wood. Aluminum levels, light in weight, will not rust. Wood levels are light and are not cold to the touch when used outdoors in cold weather. Iron levels, which are heavier and which will rust, hold their shapes better and withstand more abuse than either wood or aluminum levels. Levels are equipped with one, two, or more vials (glass tubes). One set of tubes is built in the frame at right angles to the other set, with an air bubble in each tube.

a. Master Precision Level. The master precision level (fig. 12) has an accurately ground and graduated main vial of 10-second accuracy; one division equals 0.00058 inch per foot. This accuracy refers to the arc of the vial. Sixty-seconds equal 1 minute of arc and 60 minutes equals 1° of arc. The master precision level aids in setting true horizontal while being held horizontally on the surface. This level is equipped with two additional shorter tubes at right angles to the main vial. These serve in setting the true vertical, while the level is being held at the side of the surface. The top and bottom of the level is milled and ground to make both surfaces absolutely parallel.

c. Iron Bench Levels. Iron bench levels (fig. 12) are commonly used by machinists, plumbers, millwrights, electricians, and in all forms of construction. They are made of strong castings of special construction which insure lightness, strength, and rigidity. They all have ground and graduated vials.

d. Striding Levels. Striding levels (fig. 12) are machinist's bench levels specially adapted for spanning over obstructions. The vial is mounted on a support that has two legs. The legs are machined concave in the center to span obstructions, such as a pipe that runs parallel

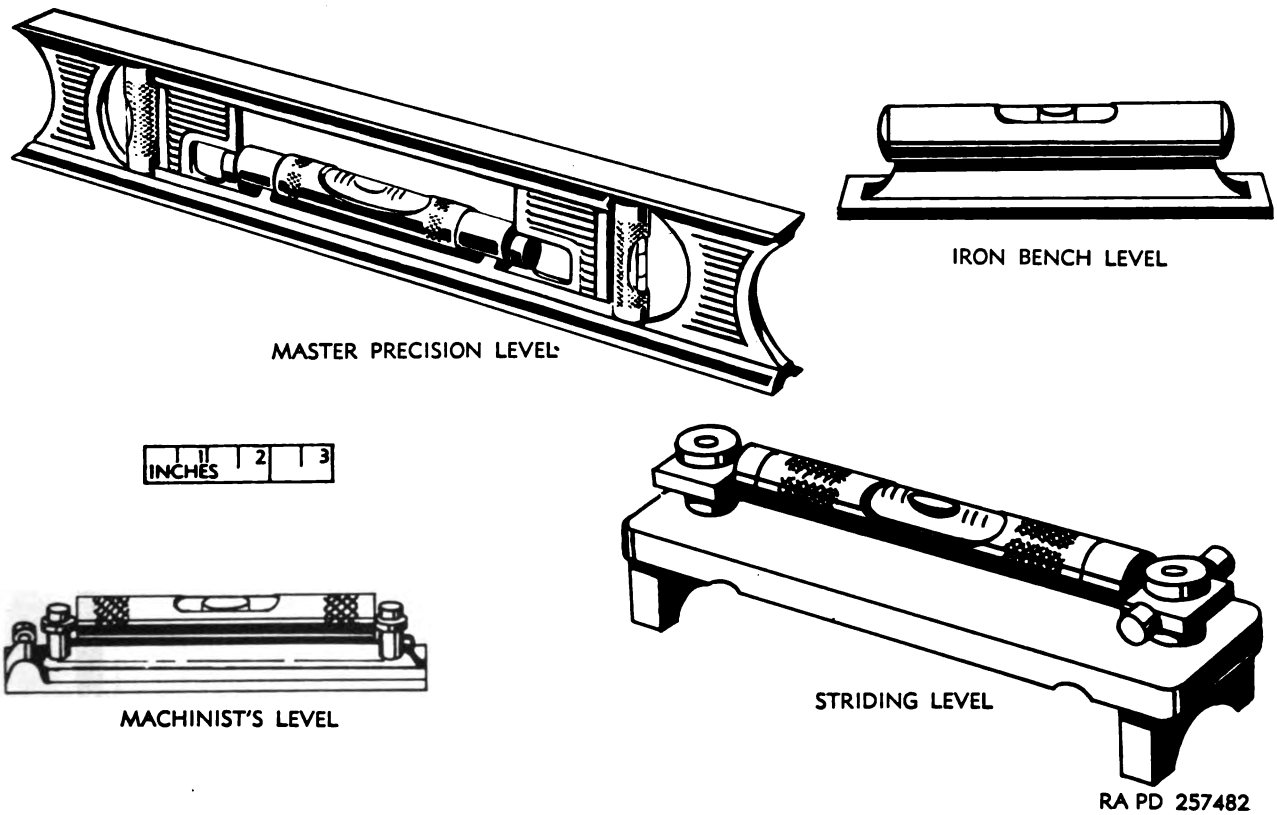


Figure 12. Types of levels.

b. Machinist's Levels. Levels of this type (fig. 12) come in various sizes with adjustable ground glasses and graduated vials with cross levels. The adjustable ground glasses are extra long and of large diameter arc, making them a sensitive and accurate level for machinists' use. Some of these levels have grooved bottoms, making them particularly valuable for leveling shafting, pipes, and so forth.

to the surface being checked. The raised support provides the necessary room to clear obstructions, such as the V-ways on a lathe when checking true horizontal of the flatways on a lathe.

14. Mechanics of Levels

The vials or glass tubes used in levels today are either bent or ground.

a. Bent glass tube vials are made from glass tubing and are slightly curved in an arc so that the high point is exactly in the center. The bubble in a bent glass vial settles quickly but with sufficient accuracy for carpenters' and masons' work.

b. Ground vials are also made of glass tubing, straight on the outside, but with the inside ground barrel shaped so that the high point is in the center. The bubble in a ground vial works slower, but is extremely accurate.

15. Using the Level

a. Checking for True Horizontal. Choose the longest level most convenient for the job. After positioning level horizontally on work, note vial or graduated tube for proper indication. Ground glass vials usually have 2 or more etched lines on the glass. For true horizontal, bubble should be centered between lines; on graduated vials, proper indication is dependent on the accuracy required. The bubble should be centered between divisions on the vial that indicate desired position of work. See figure 13 for use of level.

b. Checking for True Vertical. With the level placed vertically against the work, check for true vertical (plumb) by observing position of the cross-vial bubble. Bubble should be centered between lines on vial (fig. 13).

16. Care of Levels

a. Test. Place level on a true horizontal surface and note vial indication. Reverse level end for end. If bubble appears on one side of markings with reference to the operator on first reading and on other side for second reading, level is out of true. Place level against a true vertical surface to check for vertical accuracy. Take reading. Twist level one-half turn about its vertical axis and reread. If bubble appears on opposite side of hairline with reference to the operator, level is out of true.

b. Adjustments. On adjustable-type levels, turn adjusting screw or nut to move vial in desired direction. Tighten adjustment and retest on a true horizontal surface. Bubble should be centered between markings on vial. On nonadjustable metal framed levels, remove vial-attaching hardware and shim necessary end of vial so that when retested bubble is centered and true. On nonadjustable wood framed levels, remove vial from frame. Set level on a true horizontal surface; spread calcined gypsum and water mixture for a vial tube bed; position vial so that bubble is centered. Allow gypsum to set before removing level.

c. Maintenance. Use levels with caution; do not drop, handle roughly, or use for purposes other than those intended. When not in use, store level in a rack or other suitable place to prevent damage. Make certain storage place is dry. Spread a thin film of rust-preventive compound or oil on all metal parts before storage. Remove rust-preventive compound by washing with a suitable cleaning solvent before reusing.

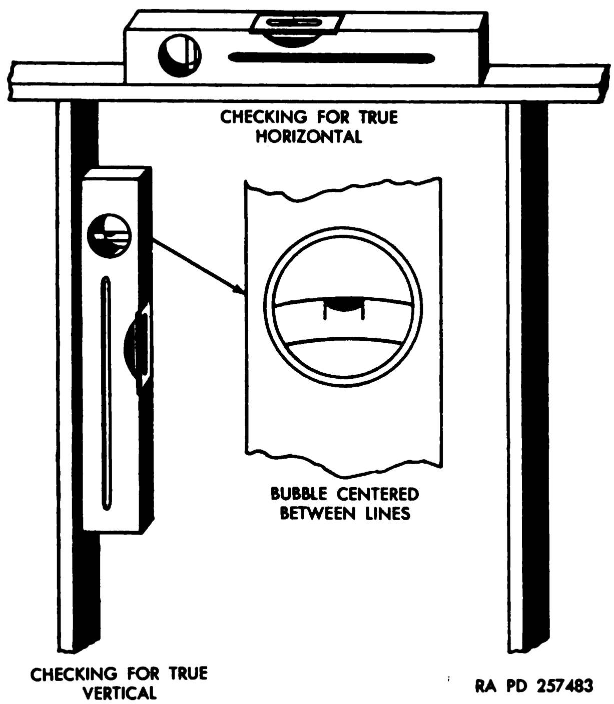


Figure 13. Horizontal and vertical use of level.

Section III. PLUMB BOBS

17. Purpose of Plumb Bobs (fig. 14)

The common plumb bob is used to determine true verticality. It is used in carpentry when erecting vertical uprights and corner posts of framework. Surveyors use it for transferring and lining up points. Special plumb bobs are designed for use with steel tapes or line to measure tank contents (oil, water, etc.).

18. Types of Plumb Bobs

a. Plumb bobs (fig. 14) are made of solid brass or steel. Most plumb bobs that are made of brass have removable steel points. One end tapers to a point and the other end has a drilled hole or a removable top. A string or a steel tape having a snap hook may be secured in the hole or attached to the top so that when the plumb bob is suspended the point falls directly under the centerline of the string or the tape. Plumb bobs are available in 5–, 6–, 8–, 9½–, 16–, 18–, and 32-ounce sizes.

e. The long neck brass bob (D, fig. 14) has a removable steel point (E) and a knurled removable screw top.

f. The plumb bob shown in F, figure 14, is made of brass with a steel point. It has a knurled removable screw top. A string is attached to this bob and to the bob shown in D, figure 14 through the hole in the top.

19. Use of Plumb Bobs

a. Plumb bobs are used by carpenters to make certain corner posts of structures and all uprights are plumb (true vertical). To plumb a corner with a plumb bob, attach a string long enough to extend to or below the bottom of the post. Lay a rule on top of the post so

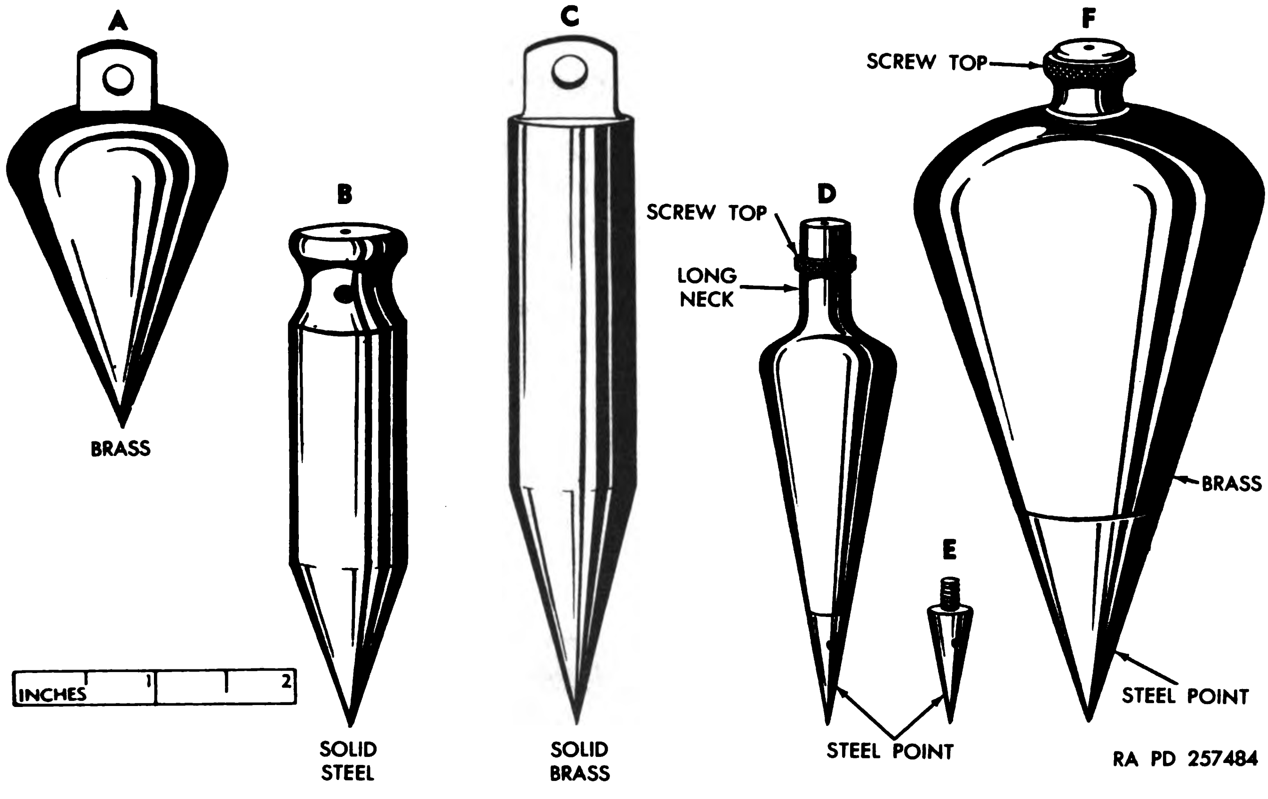


Figure 14. Types of plumb bobs.

b. The brass plumb bob shown in A, figure 14, is cone-shaped, weighs 6 ounces, and is used with a steel tape or string.

c. B, figure 14, is a solid steel cylindrical bob, weighs 9 ounces, and is used with a string only.

d. The solid brass plumb bob (C, fig. 14) weighs 18 ounces and is used with a string or a tape.

that 2 inches of the rule extend over an outside face of the post. Then, hang the string over the rule so that the string is 2 inches from the side of the post and the plumb bob extends to the bottom. With another rule, measure the distance from the side of the post, at the bottom of the post, to the center of the string; if it does not measure 2 inches, the post is not plumb. Move the post in or out until the distance from the post to the center of the string is exactly 2 inches. Repeat this procedure for the other outside face of the post.

b. Surveyors use a plumb bob to transfer and lineup points when measuring terrain, building lines, and so forth.

c. Some plumb bobs, when attached to special oil gaging steel tapes, are used to measure tank contents. A snapring at the end of the tape is hooked in the hole of the plumb bob. The length of the bob and the snapring is included in the measurement of the tape.

d. Plumb bobs are also used by structural steel personnel to make certain all columns and framework are plumb before tightening all braces and diagonal supports.

20. Care of Plumb Bobs

a. Handle plumb bobs with care; do not drop or use plumb bobs for purposes other than those intended.

b. Apply a thin film of rust-preventive compound or oil on bobs for short periods of storage. For long periods of storage, apply a heavy film of compound on bobs and wrap in oil-soaked paper. Store in a dry place or box. Wipe bobs clean before using.

c. Make certain screw threads on removable points and tops are not damaged. Apply a light lubricating compound on threads to insure ease of removal.

Note. Any metal removed from the bob will result in an incorrect plumb or reading, since its balance will be affected. The true vertical of the lower point will be canted.

Section IV. SCRIBERS

21. Purpose of Scribers
(fig. 15)

Scribers are used to mark and lay out a pattern of work, to be followed in subsequent machining operations. Scribers are made for scribing, scoring, or marking many different materials such as glass, steel, aluminum, copper, and so forth.

22. Types of Scribers

a. Machinist's Scribers. Machinist's single point pocket-type scribers (fig. 15) have a scriber point made of tempered high grade steel and a handle of steel tubing that is nickel plated. The point is reversible, telescoping into the knurled handle when not in use. This type scriber usually has a ¼– or ⅜–inch diameter handle with a point length of 2⅜ or 2⅞ inches. Bent point scribers are usually 8 to 12 inches long with one straight point, and one long or one short bent point. Some of these scribers are threaded and can be engaged in either end of the handle. The long bent point is designed for reaching through holes beyond a lip or ridge. Portions of these scribers are knurled for firm grip.

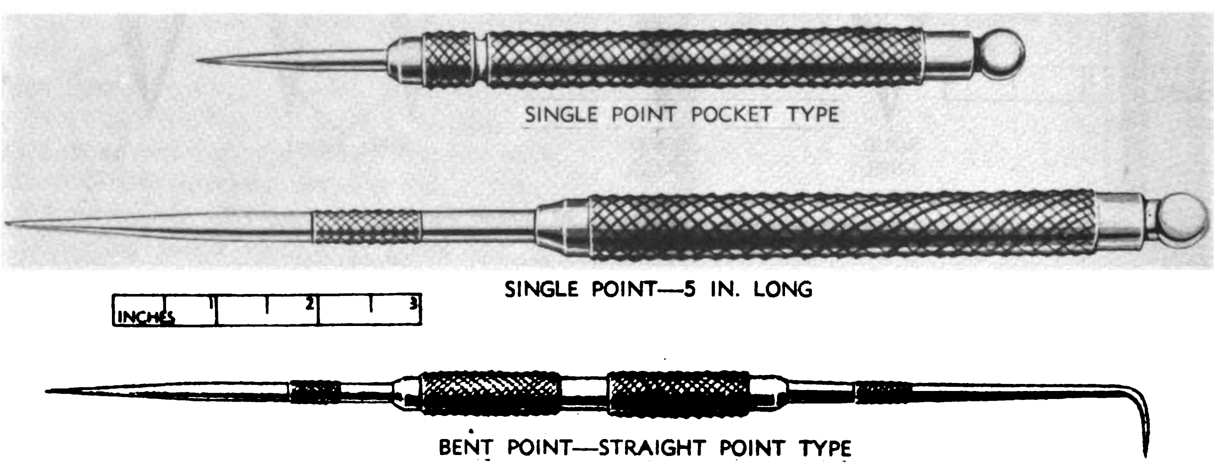


Figure 15. Types of machinist's scribers.

b. Tungsten Carbide Scribers. These scribers are used to lay out lines on very hard materials, such as hardened steel and glass. The scriber point is made of tungsten carbide, a long wearing material, which makes it possible to scribe sharp, well defined lines on the hardest materials. Some of these scribers are used with an extension in conjunction with a venier height gage which allows reverse measurements to be taken from the top of the bottom side of the gage jaw. This type scriber is hardened, ground, and lapped to a point so that a line or series of lines may be drawn and spaced as required in laying out of dies, and so forth.

23. Using the Scribers

a. Make sure the point of the scriber is sharp. To sharpen, rotate the scriber between thumb and forefinger while moving the point back and forth on an oilstone.

b. Clean work surfaces of all dirt and oil.

c. Place the steel rule or straightedge on the work beside the line to be scribed.

d. Use the fingertips of one hand to hold the rule in position and hold the scriber in the other hand as you would a pencil (fig. 16).

e. Scribe the line by drawing the scriber along the edge of the rule, at a 45° angle and tipped outward and slightly in the direction it is being moved.

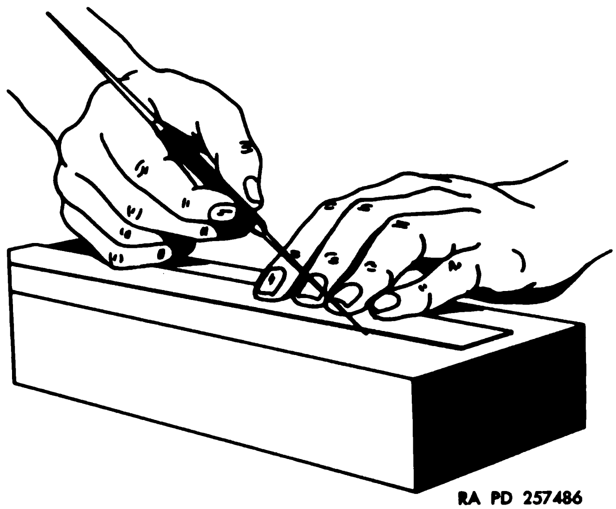


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Figure 16. Using the scriber.

24. Care of Scribers

Place a cork or soft wood over point of scribed when not in use. Coat scriber with rust-preventive compound before storage. Do not throw scribers in drawer with other tools. This practice can cause damage to scribers and injury to personnel. Rack properly or stow in suitable box. Do not use scribers for purposes other than those intended.

Section V. RULES OR SCALES

25. Purpose of Rules
(figs. 17, 19, 20, and 21)

All rules (scales) are used to measure linear dimensions. They are read by a comparison of the etched lines on the scale with an edge or surface. Most scale dimensions are read with the naked eye, although a magnifying glass can be used to read graduations on a scale smaller than $\frac{1}{64}$ inch.

26. Types of Rules

a. Steel Rules. Steel rules (fig. 17) are available from a fraction of an inch in length up to 4 feet or more, but in machine shops the 6–inch pocket rule is the one most commonly use. There are also several standard systems of graduations. In the English system, rules are graduated in 10ths, 20ths, 50ths, and 100ths; 12ths, 24ths, and 48ths; 14ths, and 28ths; 16ths, 32ds, and 64ths of an inch. In the Metric system, rules are graduated in millimeters and one-half millimeters. Some steel rules have four scales, two on each side (one graduated in 32ds and the other in 64ths), with the scales on the reverse side running in the opposite direction. There are rules made that have both an inch scale and millimeter scale, which makes this type rule adaptable to work involving both systems of measure. Another feature on some rules is a scale etched across the end of the rule which facilitates measurement in restricted places.

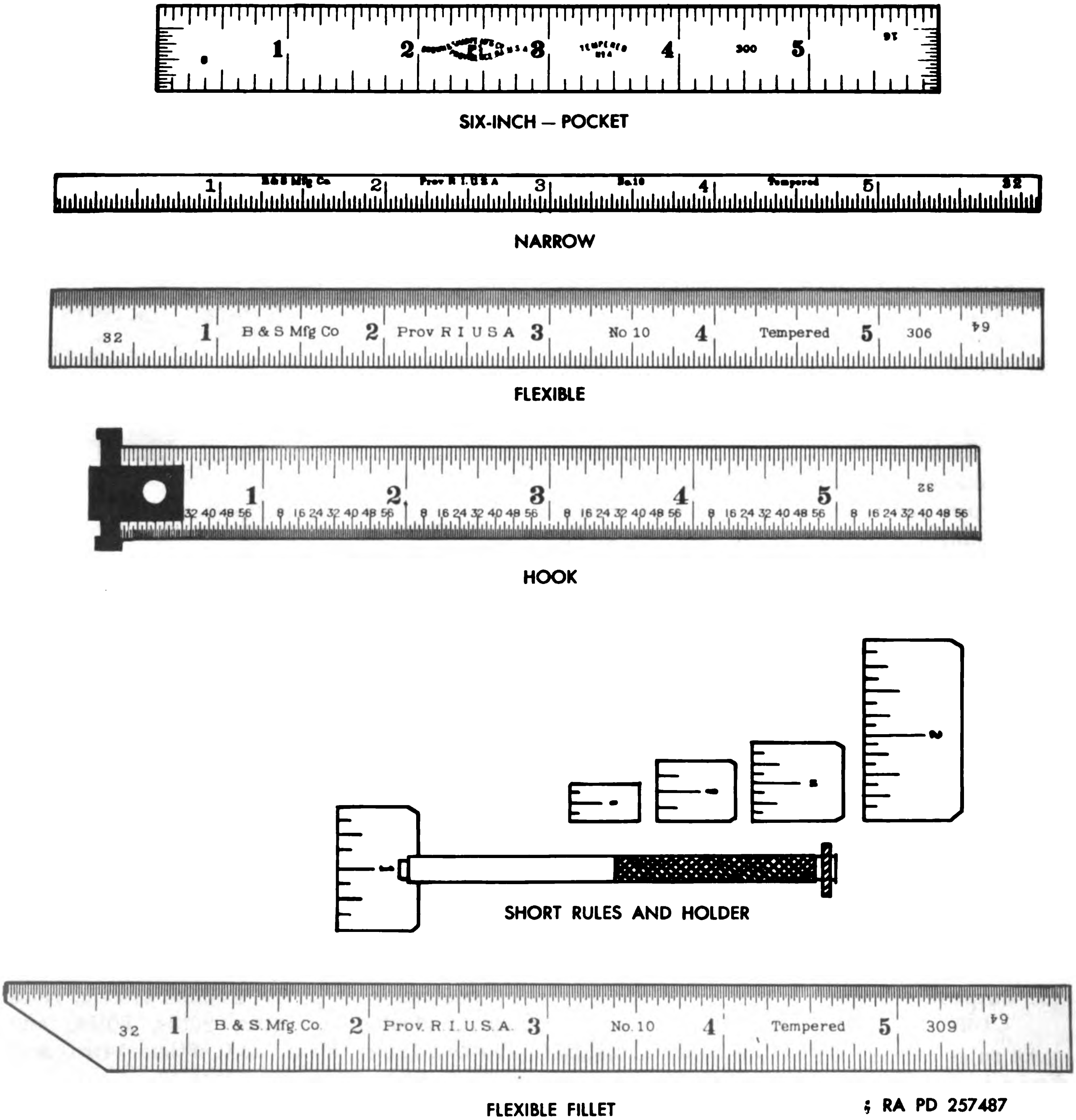

Figure 17. Types of steel rules.

(1) *Flexible rule.* A flexible rule (fig. 17) is made of thin, tempered spring steel which permits it to be bent over a rounded surface.

(2) *Hook rule.* A hook rule (fig. 17) has a sliding hook which facilitates measuring from a shoulder, particularly if the end of the rule is hidden so that it cannot be lined up with the shoulder. The sliding hook is also convenient in setting calipers and dividers.

(3) *Short rules and holders.* Short rules with a holder (fig. 17) are available for measuring in a recess or in a restricted area.

(4) *Flexible fillet rule.* A flexible fillet rule (fig. 17) is used to span fillets and corner fills which are frequently in the way when measuring flanges, shoulders, and so forth.

(5) *Key seat clamps.* Key seat clamps (fig. 18) are made of steel, case-hardened, and weigh 1 ounce each. They are designed to transform any staight steel rule into a rule that can be used to lay out keyways on a cylindrical surface of a shaft.

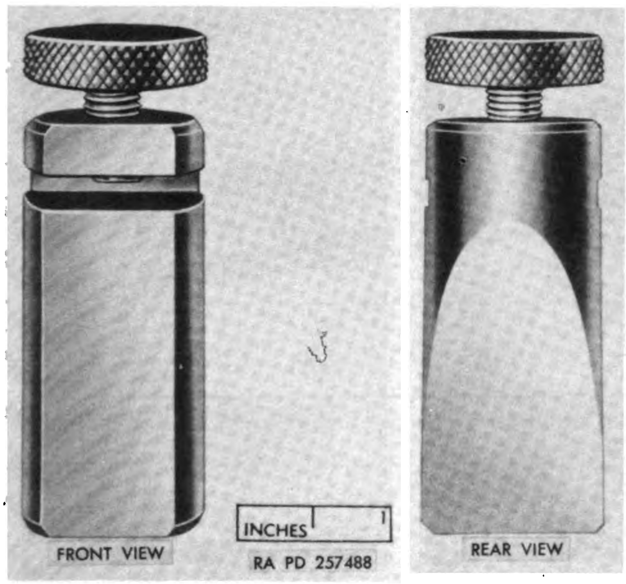

Figure 18. Key seat clamp.

b. Shrink Rule. The shrink rule (fig. 19) resembles an ordinary rule, differing only in its scale, which automatically compensates for the shrinkage in castings. In the manufacture of a casting, molten metal is poured into a cavity formed in sand with a wooden or metal pattern of the part. The impression in the sand is that of the pattern and is of the same size and shape. The molten metal fills the cavity, solidifies, and cools. As all metals expand when heated and contract when cooled, the casting shrinks as it cools, and becomes smaller than the cavity. To compensate for this shrinkage so that the casting will be of correct size when it cools, the pattern must be made larger than the part itself. So, in making the pattern from the blueprints of the part, it is necessary for the patternmaker to add just the correct amount to every dimension to take care of this shrinkage. Rather than calculate this shrinkage, the patternmaker uses a shrink rule, which automatically compensates for it. Every metal has its own particular shrinkage value; the expansion or contraction for each degree change in temperature is not the same. Shrinkage for the two common casting metals are: iron—$\frac{1}{8}$ inch per foot; brass—$\frac{3}{16}$ inch per foot. A special shrink rule is required for each of these casting metals. In figure 19 two shrink rules, A for brass and C for cast iron, are shown in comparison with a standard foot rule, B. Note that the inch marks on the shrink rule do not match the corresponding marks on the standard rule and that this variation increases with the length of the rule until the total length of the shrink rule exceeds that of the standard by the amount of shrinkage per foot required.

c. Folding Rules. Folding rules (fig. 20) are obtainable in wood or metal, having 4 to 12 folds, from 2 to 6 feet long, total length. See figure 20 for variation of folding rules.

A
B
C

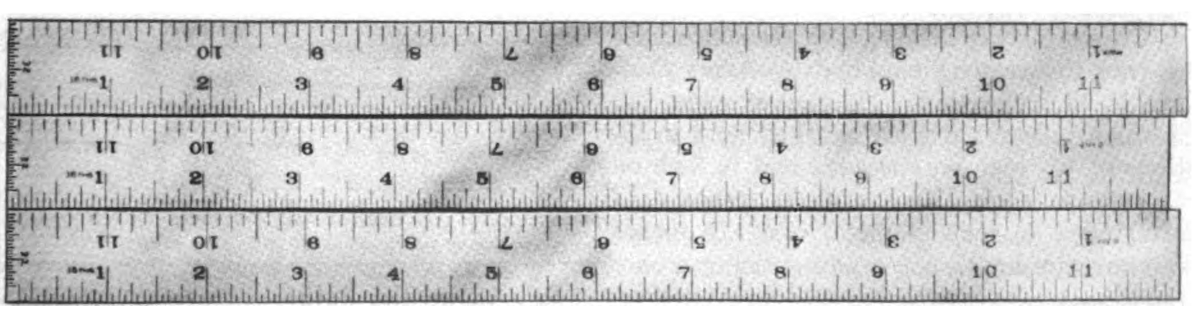

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Figure 19. Shrink rules compared to standard rule.

These rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after they have been used for a time.

adjustable and is used as a rest. It is held against the glass edge when measuring. This rule is normally 5 feet long, 5/16 inch thick, and 2 inches wide.

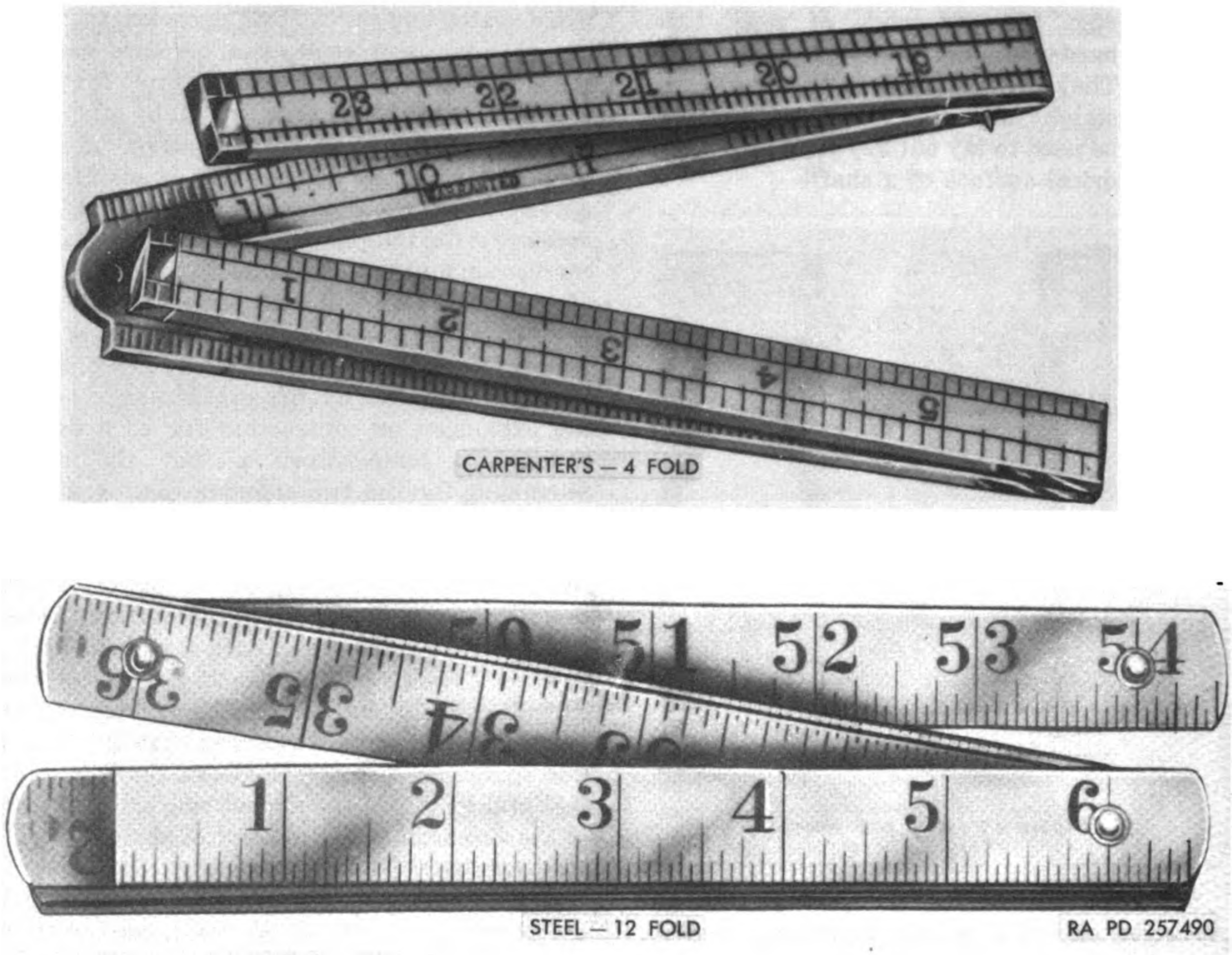

Figure 20. Types of folding rules.

d. Circumference Rule. The circumference rule (not illustrated) supplied by Army Ordnance is 36 inches long, 1¼ inches wide, 1/16 inch thick. Both sides are marked with graduations of 1/16 inch on one edge and ⅛ inch on the opposite edge. This rule is capable of measuring a 36–inch diameter and 113 inches maximum circumference reading, using a conversion scale.

e. Glazier's Rule. A glazier's rule (fig. 21) is used primarily for measuring glass and has a lip, similar to a hook rule. The lip is non-

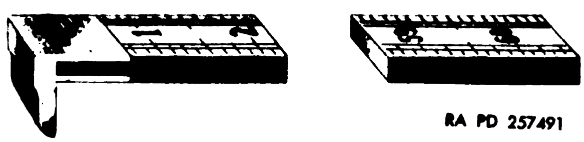

Figure 21. Glazier's rule.

27. Using the Rule

a. Select Proper Scale. When using a rule to check a dimension, the proper graduated scale should be used to control the reading of the dimension (A, fig. 22). If the work being measured lines up between two graduations on the scale as shown in B and C, figure 22, and it is not possible to read this dimension to a $\frac{1}{16}$ on a $\frac{1}{16}$–inch scale, a $\frac{1}{32}$–inch scale should be used; and if it is still impossible to read

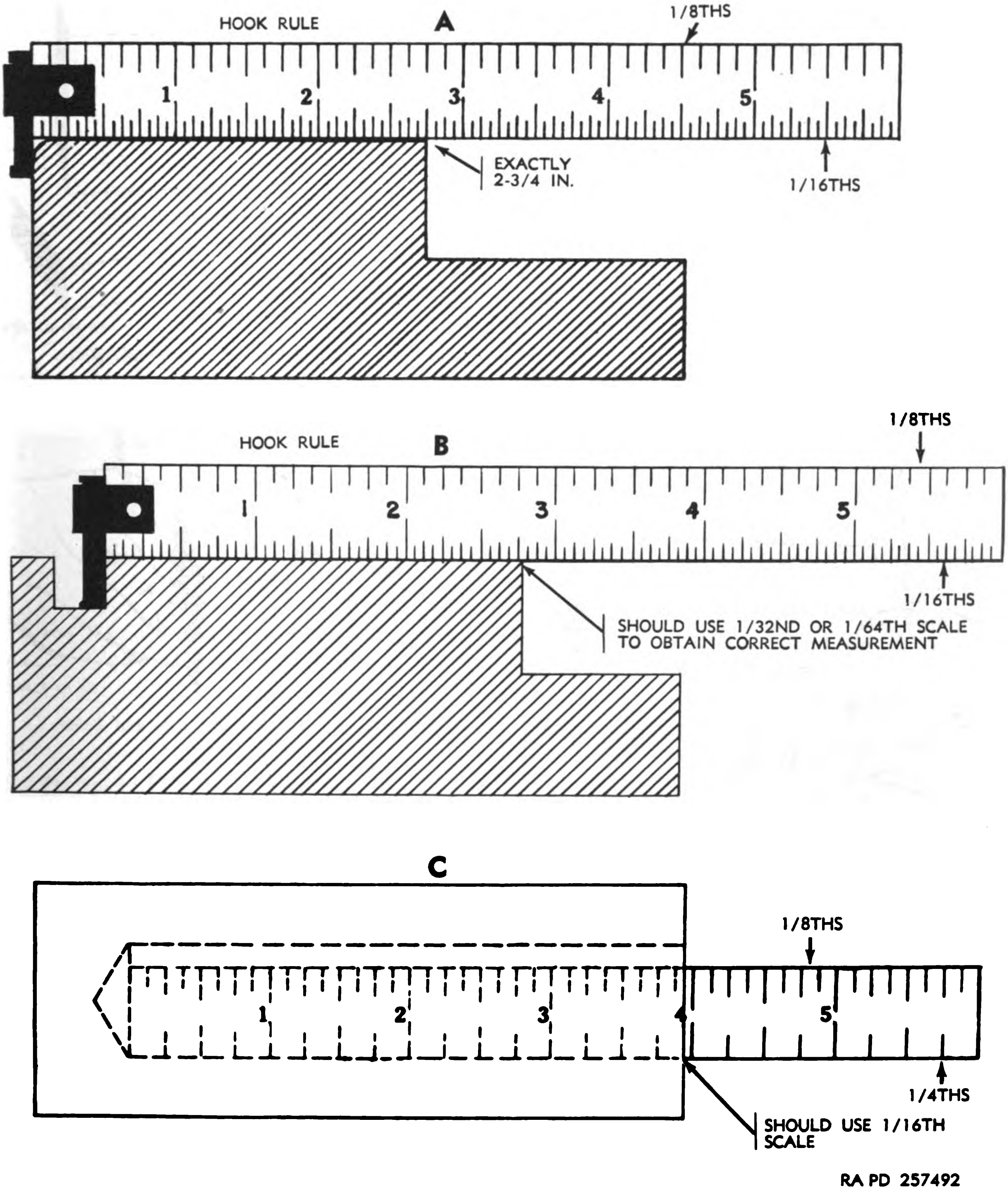

Figure 22. Determining proper graduated rule.

a dimension to a $\frac{1}{32}$, a $\frac{1}{64}$-inch scale should be used.

b. *Applications.*

(1) *Six-inch rule.* It is good practice to carefully line up the end of the rule with the surface from which the measurement is to be taken. Figure 23 shows the mechanic holding the part and the rule firmly against an angle block. This allows the user to devote his entire attention to reading the scale correctly. Figure 24 illustrates the use of a rule in checking the location of a gaging surface from a surface plate. The surface plate in this case serves as a common base and locates the rule in relation to the surface on the part measured.

Note. Always measure stock at right angles.

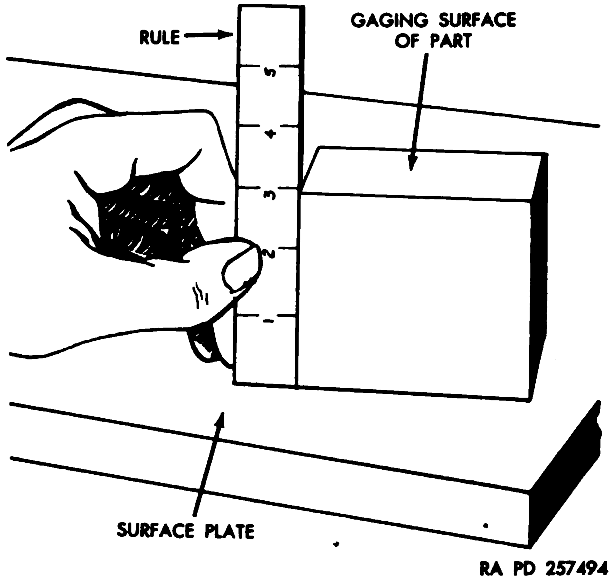

Figure 24. Using rule on surface plate.

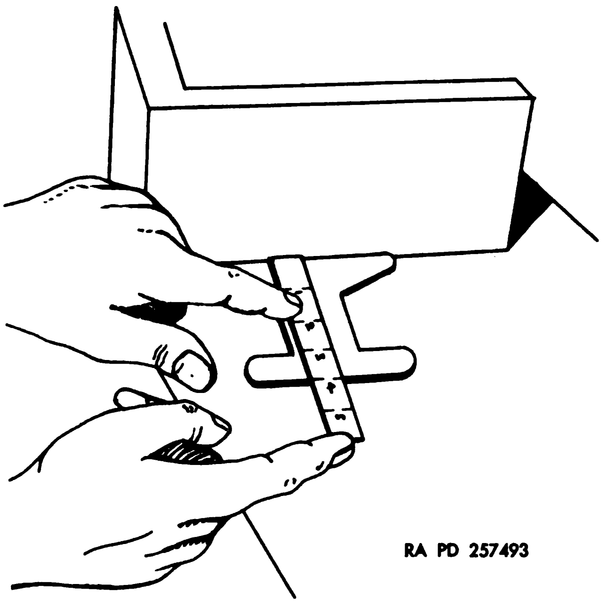

Figure 23. Using 6-inch rule.

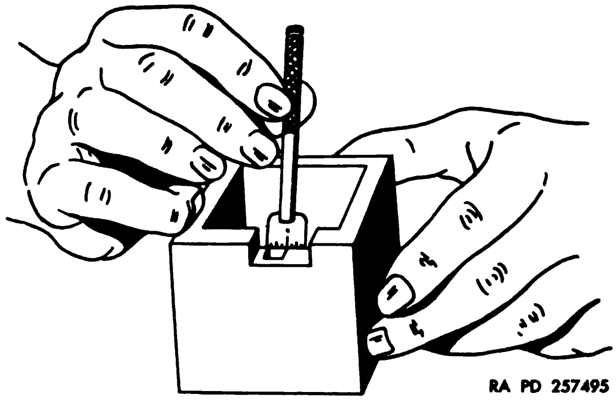

Figure 25. Using small rule and holder.

(2) *Short rule and holder.* Figure 25 shows how a short steel rule with holder may be usefully applied to a measurement in a recess inaccessible to the longer type rule.

(3) *Narrow rule.* The narrow rule is used to advantage in measuring the depth of a narrow slot (fig. 26).

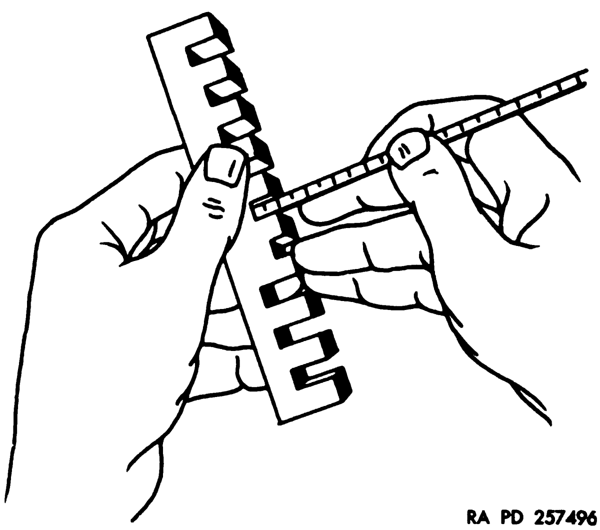

Figure 26. Usng a narrow rule.

(4) *Hook rule.* Figure 22 shows applications of the hook rule. In one case, the hook serves to line up the end of the rule with the edge of the shoulder from which the measurement is taken; the other case shows the hook being used from the square edge of a part.

(5) *Shrink rule.* A shrink rule is used to check a dimension on a pattern, as shown in figure 27, and at the same time to automatically compensate for the amount of shrinkage of the metal after casting or molding, as discussed in paragraph 26*b*.

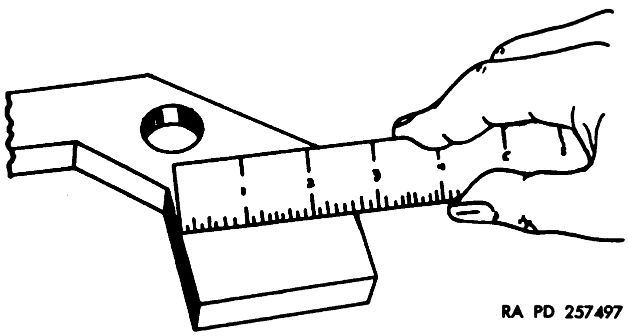

Figure 27. Using a shrink rule.

(6) *Key seat clamps and rule.* Figure 28 illustrates the method of scribing a line on cylindrical stock, using key seat clamps and rule.

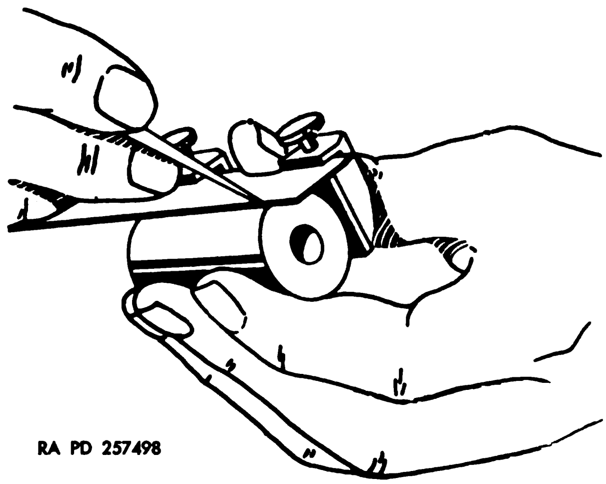

Figure 28. Using key seat clamps, rule and scriber.

28. Care of Rules

Coat all steel rules with a rust-preventive compound or oil before storage. Make certain wood rules are stored in a dry place and are properly wrapped to preserve the wood. Clean rules before and after use, so that graduations are always legible. Periodically, check straightedges against a master surface plate for accuracy. The slightest nick will result in an incorrect reading. Do not use rules for purposes other than those intended.

Section VI. PRECISION TAPES

29. Purpose of Precision Tapes
(fig. 29)

Precision tapes are used for measuring circumferences and long distances where rules cannot be applied.

30. Types of Precision Tapes

The Ordnance supply system stocks only two precision tapes.

a. Fish Tape. A steel tape, 0.060 inch thick by ¼ inch wide, having a reel and puller, is supplied in 100–foot lengths.

b. Circumferential Tape. A steel tape, ¾ inch wide, 14 feet long, having retaining loops at each end, is supplied with a vernier ¼–inch graduated base plate (0 to 2 inches in each direction). Figure 29 illustrates the two tapes. Steel tapes will not shrink or stretch as much as other tapes made of different materials under varying moisture and temperature changes, and will therefore give more accurate measurements.

31. Mechanics of Tapes

a. Fish Tape. The fish tape (fig. 29) consists of a reel, a wood grip handle, and a steel, folding, winding handle for winding the ¼-inch wide, 100-foot long precision steel tape on the reel. A puller is attached to the end of the tape for ease of unwinding.

b. Circumferential Tape. The circumferential tape (fig. 29) is a steel tape that is 14 feet long, ¾ inch wide, and $\frac{1}{32}$ inch thick. It has a vernier ¼-inch graduated base plate that is electric welded to one end of the tape. The vernier graduations are marked for 4 inches (0 to 2 inches in each direction). The base plate is slotted so that the opposite end of the tape can be pulled across the vernier. The end of the tape has a retaining loop which prevents the tape from slipping out through the base plate slots.

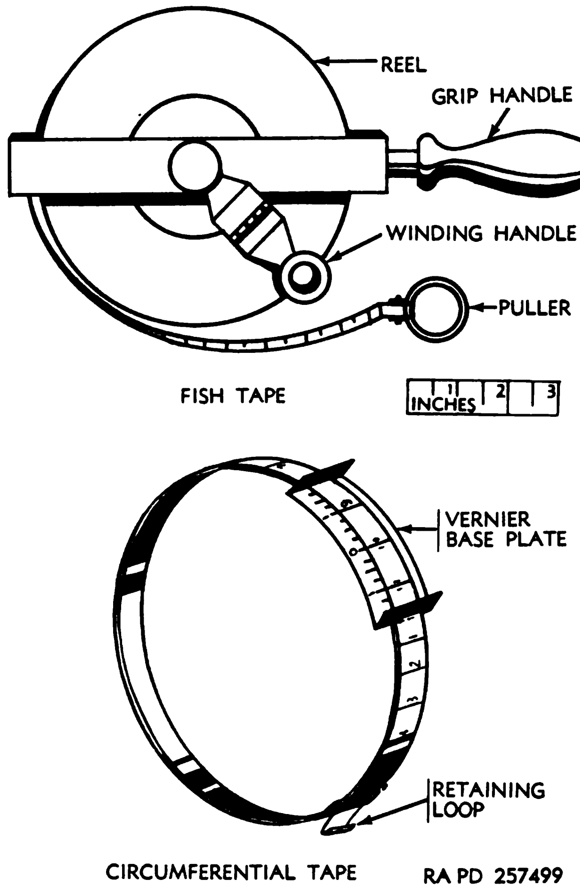

Figure 29. Precision tapes.

32. Using the Tapes

a. Fish Tape.

(1) To take measurement, pull on puller (fig. 29) to unwind tape. Read measurement as you would a rule. Rewind tape by rotating the folding winding handle.

(2) To pull wiring through conduit, remove tape from reel; attach one end of wire to reel. Attach new wire to old wire at opposite end. Wind handle. As old wire is wound on reel, new wire is being pulled through conduit.

b. Circumferential Tape.

(1) The circumferential tape is used to measure circumference of tires which will be mated together as duals. When two tires are mounted on a dual wheel, the tires should be within ½ inch of the same circumference, with the larger tire usually mounted on the outside.

(2) To use tape, open tape enough to slip tape around circumference of tire; pull retaining loop end of tape until tape is tight around the tire.

(3) Read measurement opposite the 0 mark on the vernier base plate (fig. 29). The tape is graduated in inches and feet and the vernier base plate is graduated in ¼-inch increments, as discussed in paragraph 31*b*. The measurement is read as follows:

(*a*) For example, if the 12-foot 10-inch graduated mark on the tape is in line with the zero mark on the base plate, the circumference of the tire is 12 feet 10 inches.

(*b*) If no mark on the tape coincides with the zero mark on the vernier base plate; read the measurement as follow: For example, if the 12-foot 10-inch mark on the tape coincides with the ¼-inch mark to the right of the zero mark on the vernier base plate, add ¼ inch to the measurement, and the circumference of the tire is 12 feet 10¼ inches. If the 12-foot 10-inch mark on the tape coincides with the ¼-inch mark to the left of the zero mark on vernier base plate, subtract ¼ inch; the tire circumference is 12 feet 9¾ inches.

(*c*) The circumferential tape is not a precision tape since its use is restricted to just mating tires to be mounted on the same dual wheel assembly. Accuracy greater than ⅛ inch is not required for this operation. Since the vernier is graduated in quarters of an inch, an eighth of an inch can easily be estimated.

33. Care of Tapes

a. In drawing the fish tape from the case at the opening, do not pull backward as this is liable to damage the tape.

b. In pulling the fish tape out, hold the case in a position that will avoid its being pulled against the edges of the opening.

c. Occasionally, fish tapes will pull hard and sometimes stick. Rap the side of the case against any flat surface and the tape will invariably free itself.

d. When not in use, coat both steel tapes with rust-preventive compound or oil. Rewind the fish tape. Wrap friction tape around the circumferential tape to hold the retaining loop end to prevent it from becoming damaged.

e. Make certain all graduations on the fish tape, on the vernier base plate, and on the 14-foot circumferential tape are legible at all times.

f. Wipe tapes clean before using.

Section VII. SQUARES

34. Purpose of Squares
(figs. 30 and 32)

The purpose of a square is to test work for squareness and trueness. It is also used as a guide when marking work for subsequent machining, sawing, planing, and chiseling operations.

35. Types of Squares

There are several types of squares (fig. 30) used in wood work and metal work.

a. Carpenter's Square. The size of a carpenter's steel square is usually 12 inch x 8 inch, 24 inch x 16 inch, or 24 inch x 18 inch. The 12– or 24–inch side is called the body and the 8–, 16–, or 18–inch side, at right angles to the body, is called the tongue. The flat sides of the body and the tongue are graduated in inches and fractions of an inch. Both the body and the tongue may be used as a rule and also as a straightedge in layout operations. Besides the inch and fractional graduations on the

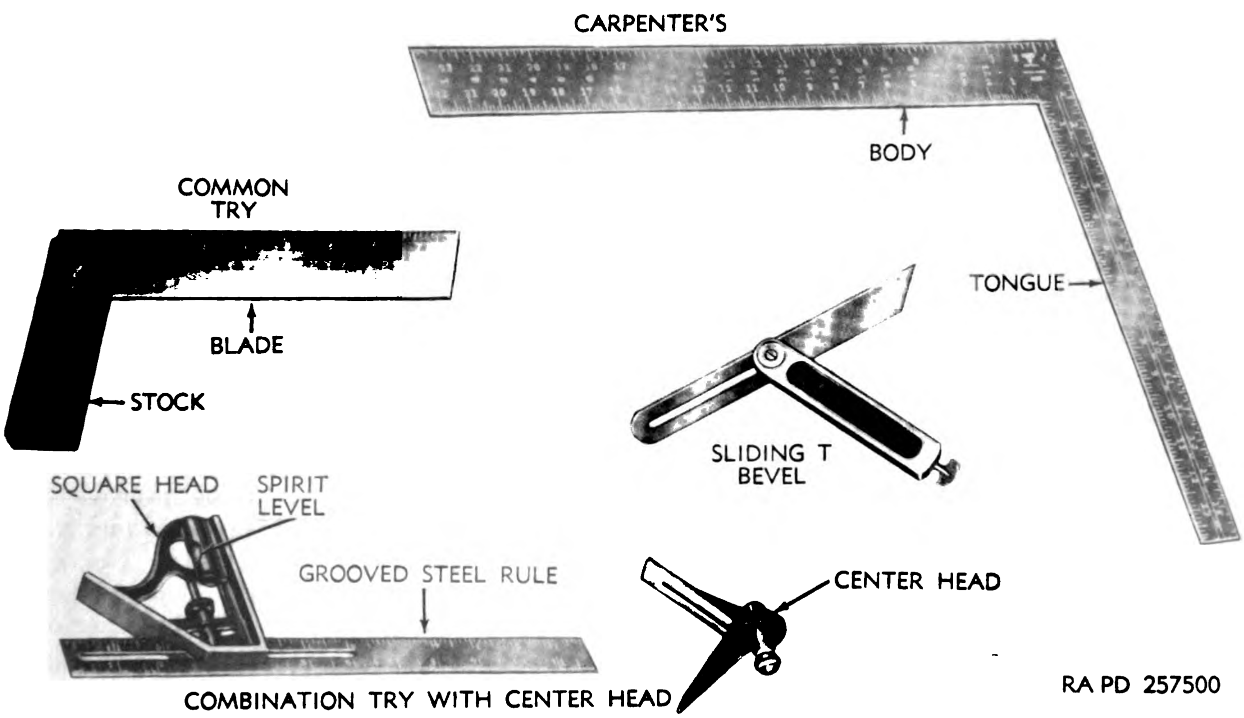

Figure 30. Types of squares.

square, several tables (fig. 31) are marked on it, as indicated in (1) through (5) below.

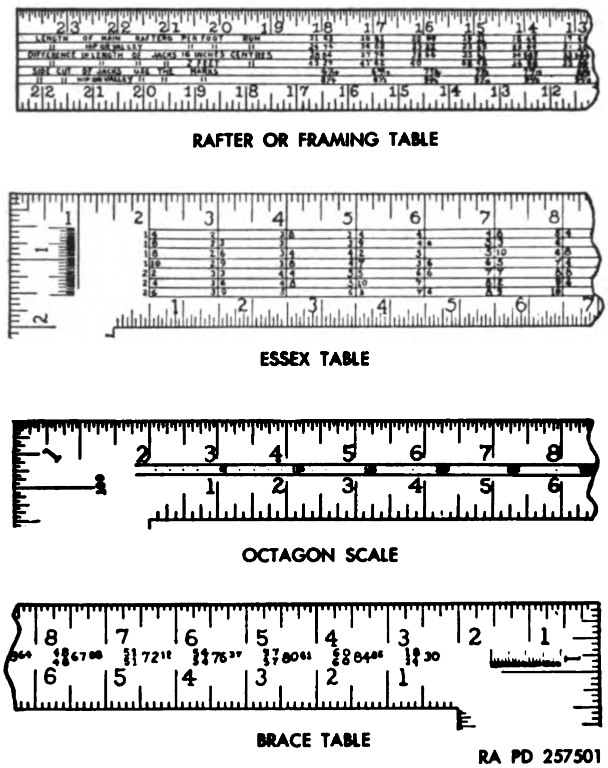

Figure 31. Tables on carpenter's square.

(1) *Rafter or framing table.* This table appears on the body of the square. It is used to determine the length of the common, valley, hip, and jack rafters, and the angles at which they must be cut to fit at the ridge and plate.

(2) *Essex table.* This table appears on body of the square. It shows the board measure in feet and 12ths of feet, of boards 1 inch thick of usual length and widths.

(3) *Octagon scale.* This scale appears on the tongue of the squares. It is used to lay out a figure with eight equal sides on a square piece of timber, as for a pillar.

(4) *Brace table.* This table appears on the tongue of the square. It shows the length of the common braces.

(5) *Hundredths scale.* This scale appears on the tongue of the square. With a pair of dividers, decimals of an inch can be obtained quickly.

b. Try Square. The common try square (fig. 30) consists of two parts at right angles to each other; a thick wood or iron stock and a thin steel blade. The best try squares are made with the blades graduated in inches and fractions of an inch. The blade length varies from 2 inches to 12 inches. This square is used for setting or checking lines or surfaces which have to be at right angles to each other.

c. Combination Squares or Sets.

(1) The combination try square shown in figure 30 consists of a square sliding head and a grooved steel rule. The square head has a spirit level. The steel rule usually has four graduated scales; $1/64$, $1/32$, $1/16$, and $1/8$ inch. The steel rule is removable, permitting the head to be used as an ordinary level. It is possible to use this combination square to square a piece with a surface and at the same time determine whether one or the other is plumb. By using the miter, it is possible to lay out 45° and 90° angles. This square can also be used as a depth gage.

(2) By adding a center head on the combination try square, another combination is formed. By substituting the center head for the square head, a center square is obtained for finding the centerline of cylindrical objects. The center head is slotted so that the rule, when inserted, bisects the 90° angle. When used this way, the measuring surfaces become tangent to the circumference of cylindrical work.

(3) The combination square set shown in figure 32 includes a protractor in addition to the square and center heads. The protractor can be inserted in the steel rule in the same manner as the square and center heads. The revolving turret can be graduated in degrees from 0 to 180 or to 90 in either direction. The square head contains a spirit level to facilitate the measuring of angles in relation to the horizontal or vertical plane. The protractor

controls the accuracy of measuring and laying out angles within 1°. Some protractor heads have a shoulder extending from only one side of the blade, and these are known as "single", "plain", or "not reversible." Others have a shoulder extending from both sides, and are known as "double" or "reversible" protractors. This combination square set takes the place of a whole set of common tools capable of serving as a height gage, bevel protractor, level, steel rule, depth gage, marking gage, and plumb.

This protractor is equipped with an acute angle attachment which is used in measuring extremely small angles.

f. Tire Mating Square. This square (not illustrated), made of aluminum, has a 48–inch body and a 26–inch tongue. It is used to check tires for matching dimensions.

36. Use of Squares

a. Carpenter's Square. The carpenter's square enables the carpenter to lay out guidelines for cutting rafters, oblique joints, stairs, and so forth. He performs many of his calculations with the aid of the tables and grad-

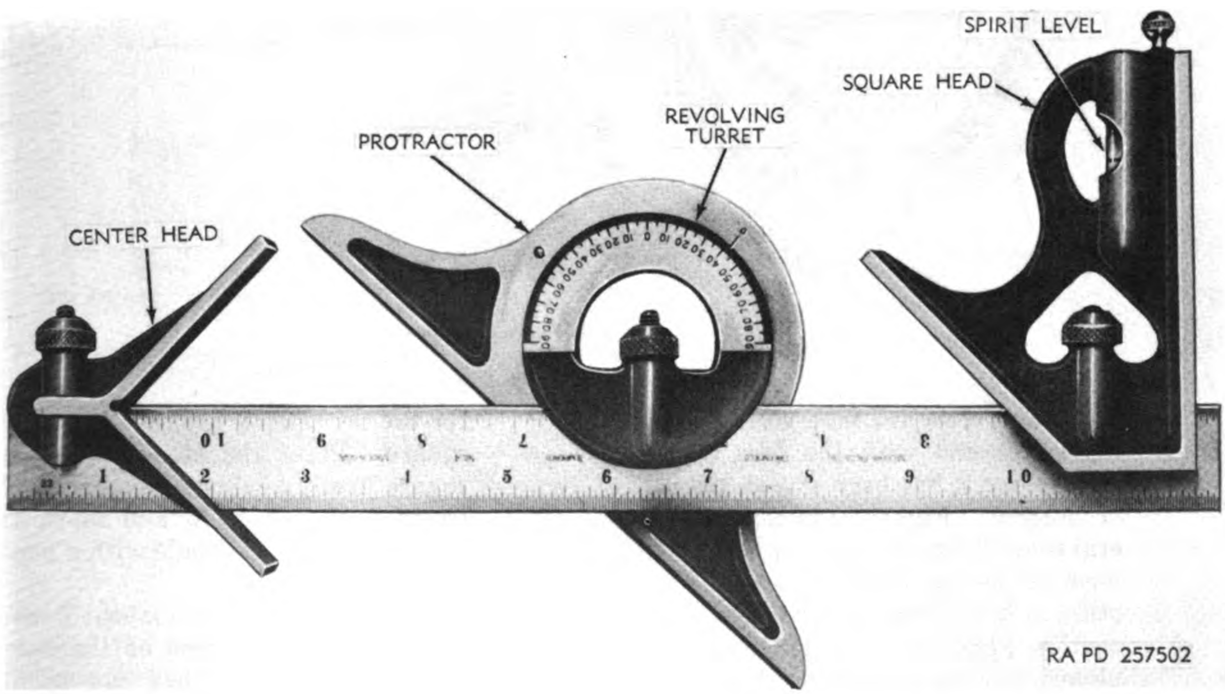

Figure 32. Combination square set.

d. Sliding T Bevel. The sliding T-bevel shown in figure 30 is an adjustable try square with a slotted beveled blade. Blades are normally 6 or 8 inches long. It is used for laying out angles other than right angles, and for testing bevels. These squares are made with metal and wood handles.

e. Bevel Protractor. A bevel protractor (fig. 33) consists of an adjustable blade with a graduated dial. The blade is usually 12 inches long and $\frac{1}{16}$ inch thick. The dial is graduated in degrees through a complete circle of 360°.

uations marked on the body and tongue of the square. The most common use for this square is laying out and squaring up large stock and large patterns, and for testing the flatness and squareness of large surfaces by placing the square at right angles to adjacent surfaces and observing if light shows between the work and square. It is used like the try square, as discussed in *b* below.

b. Try Square.

(1) The try square is used constantly for laying out and to determine whether

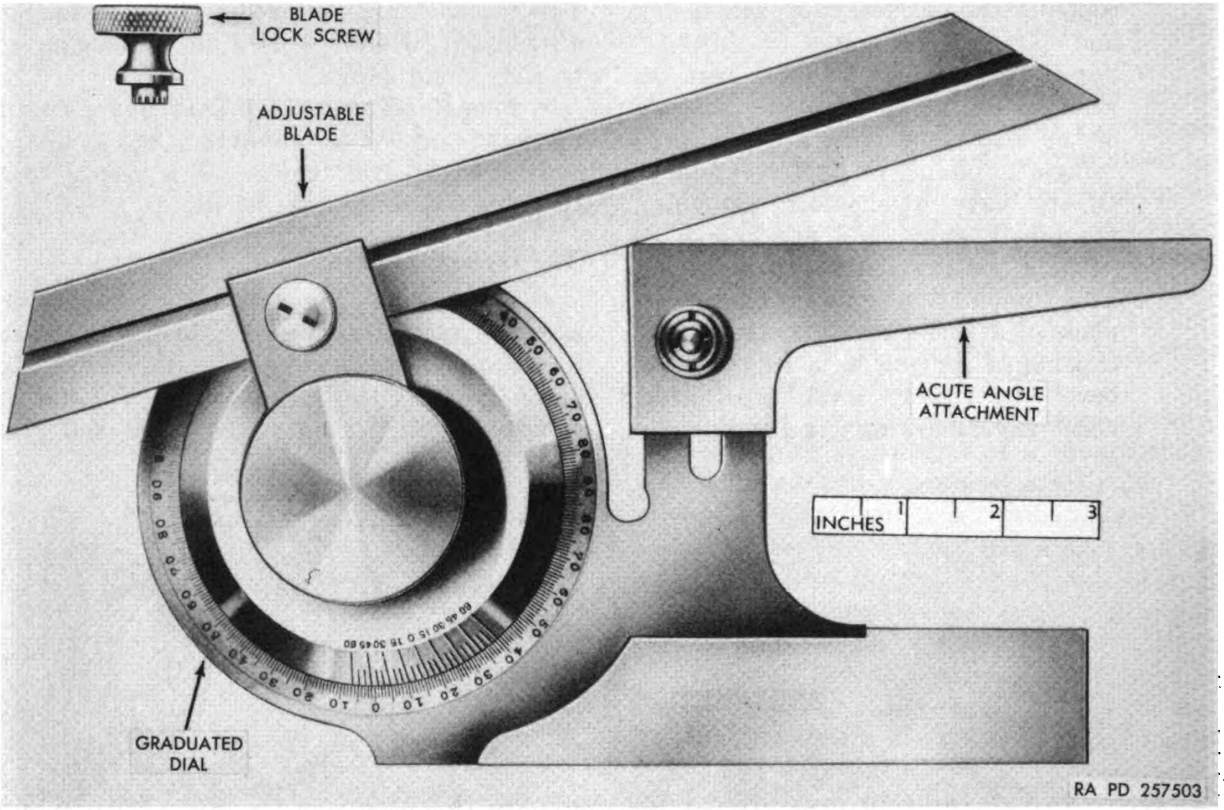

Figure 33. Bevel protractor.

edges and ends are true with adjoining edges and with the face of the work after it has been sawed, planed, or chiseled. Figure 34 illustrates several uses of the try square where faces have to be at right angles to each other. A reference plane such as a surface plate or a machined, sawed, planed, or chiseled surface of the work is essential to its use. As shown in E, figure 34, a thickness or feeler gage is used to check the squareness of a surface which cannot touch the blade of the square. When try square allows no light to show (A and B, fig. 34), work is square and true. When light shows (C and D, fig. 34), work is not square.

(2) When a board is to be cut, planed, or chiseled square, a guideline must be marked across its surface. The guideline must be exactly at the required point and must be square with the edges. If the board is too wide for the try square, use the carpenter's square. Press the stock of the try square firmly against the edge of the board with one hand and mark the guideline along the blade with a pencil in the other hand.

(3) To square a line around a board, mark one edge and one face of the board with an X so that they can be distinguished readily as the working edge and face. Square a line from the working edge across the face by holding the stock of the square firmly against the working edge and marking a line across the face. Then square a line across each edge; turn board over and square a line across the opposite face. Edge of board must be perfectly square to prevent the square from rocking. Use a carpenter's square if the board is too wide for a try square.

c. Combination Square. Figure 35 illustrates various applications of a combination

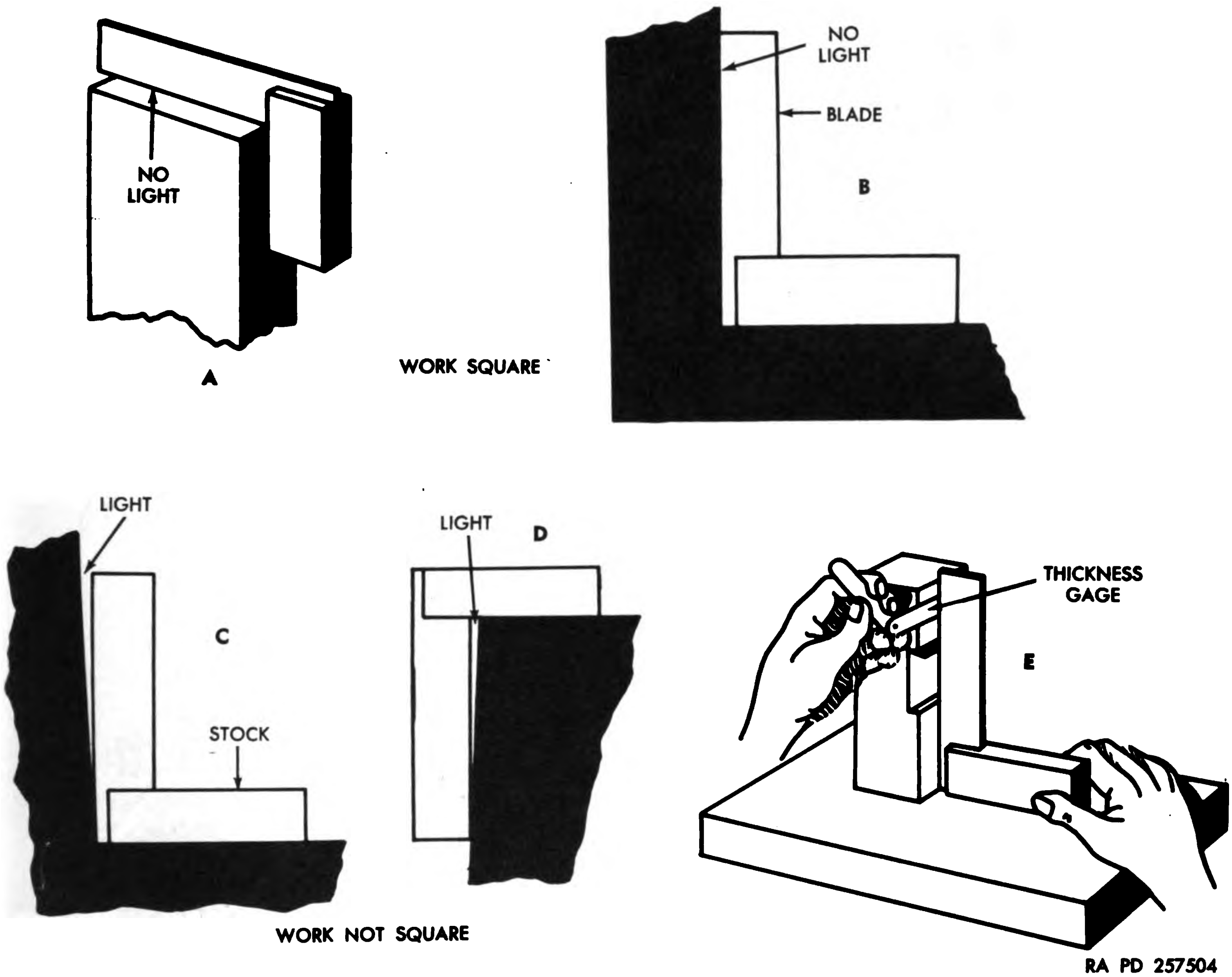

Figure 34. Using a try square.

square. Loosen the knurled nut on the head and slide the head along the blade to the desired position. Tighten nut and place the particular head and blade in position on the work. As illustrated, the combination square is a versatile unit having many varied uses. Figure 36 shows the protractor head being used to check the angle of a lathe way. By setting the head at a definite angle, the variation can be measured by using thickness or feeler gages between the blade and the face of the way.

d. Sliding T-*Bevel.* Adjust the blade by loosening the locking device. Set the blade to any desired angle and lock. Use the sliding T-bevel as you would the try square. The adjustable sliding blade is the advantage over the try square.

e. Bevel Protractor. Laying out precision angles is the primary function of this tool. The tool can be laid flat upon paper or work. The vernier scale is used for accurate angle adjustments, and reads to 5 minutes of $\frac{1}{12}°$. The dial is held rigidly in position and the blade can be moved back and forth and clamped independently of the dial.

(1) *Reading the protractor vernier scale.* The protractor vernier scale indicates every 5 minutes (5′) or $\frac{1}{12}°$. Each space on the vernier scale is 5 minutes less than two spaces on the main scale. When the zero on the vernier scale exactly coincides with a graduation on the main scale, the reading is in exact degrees, as shown in A, figure 37. When the zero of the vernier scale does not exactly coincide with a

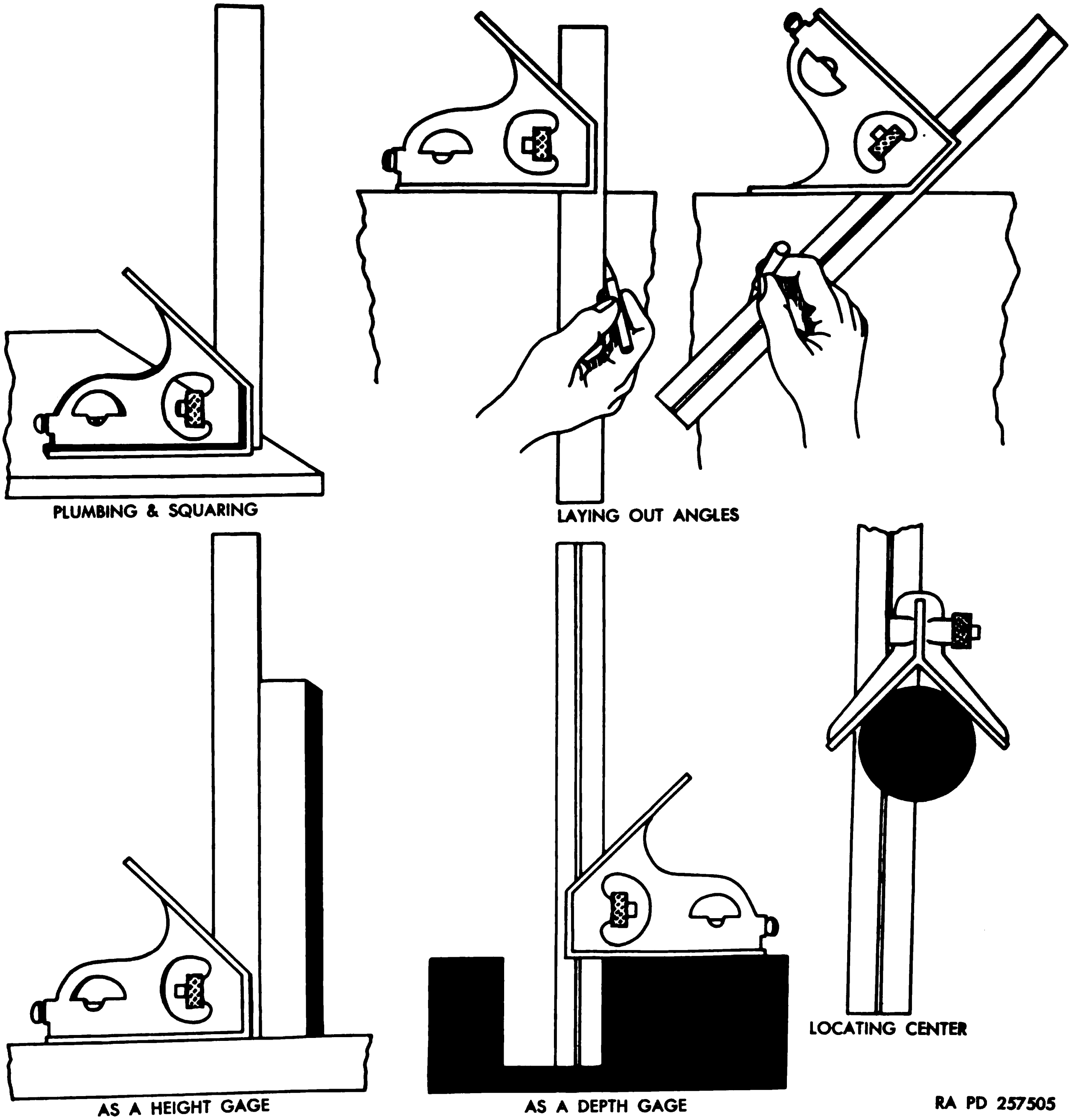

Figure 35. Various uses of combination square.

graduation on the main scale, the graduation on the vernier that does coincide indicates the number of 12ths of a degree or units of 5 minutes to be added to the whole degree reading. Example: Reading in B, figure 37, shows the zero on the vernier between 12° and 13° on the main scale. Counting to the right from 0 on the main scale, the 0 on the vernier has therefore moved 12 whole degrees. Reading in the same direction (to the right), note that the 10th line of the vernier exactly coincides with a line on the main scale. The 10th line of the vernier indicates 50 minutes (50′), since each line indicates 5 minutes. Now add 50 minutes to the 12° and the final reading is 12° 50 minutes. Since the spaces, both on the main scale and on the vernier scale, are numbered both to the right and left from zero, any size angle can be measured. The readings can be taken either to the right or left, according to the direction in which the 0 on the vernier scale is moved.

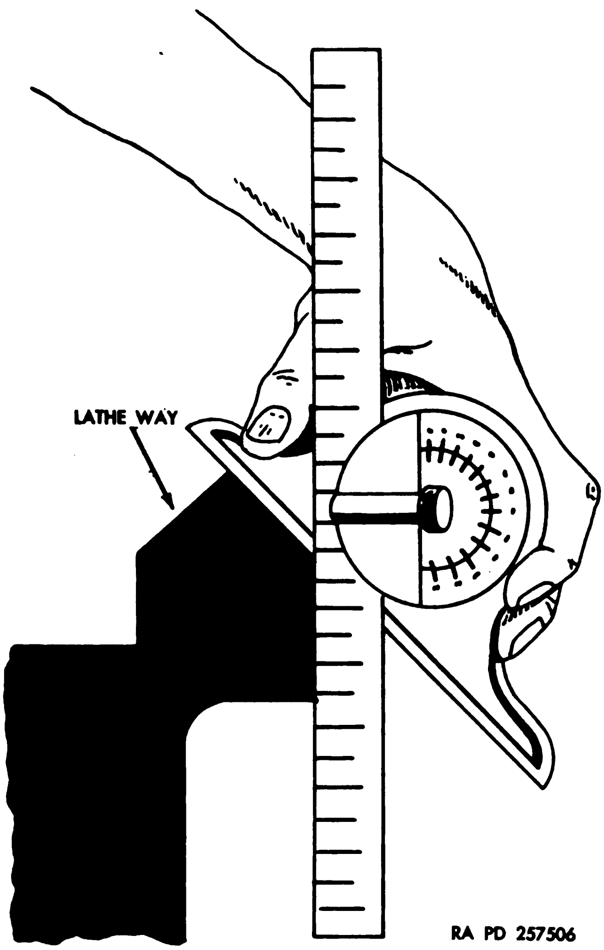

Figure 36. Using protractor head.

(2) *Application.* A, figure 38 shows the bevel protractor being used to measure the angular clearance on a ring gear. The bevel protractor can be used to establish an angle and determine its relationship to other surfaces as shown in B, figure 38. The acute angle attachment is attached to the slotted extension of the dial and is used as shown in C, figure 38 to accurately measure acute angles.

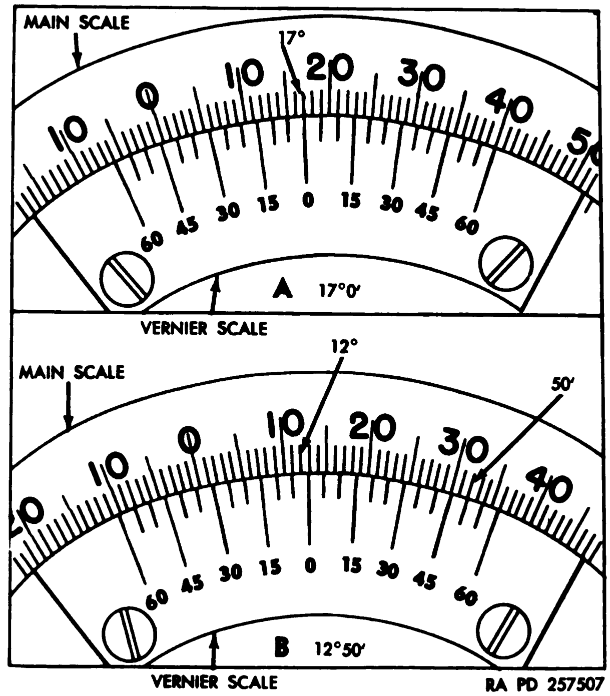

Figure 37. Protractor vernier scale readings.

37. Care of Squares

Make certain the blades, heads, dials, and all accessories are kept clean. Apply a light coat of oil on all machined surfaces to prevent rusting, when not in use. Do not use try squares or miter heads for purposes other than those intended. A try square with a loose handle is a useless tool. When storing squares or bevels for long periods of time, apply a liberal amount of oil or rust-preventive compound to all surfaces, wrap in oiled paper, and place in individual containers or on racks.

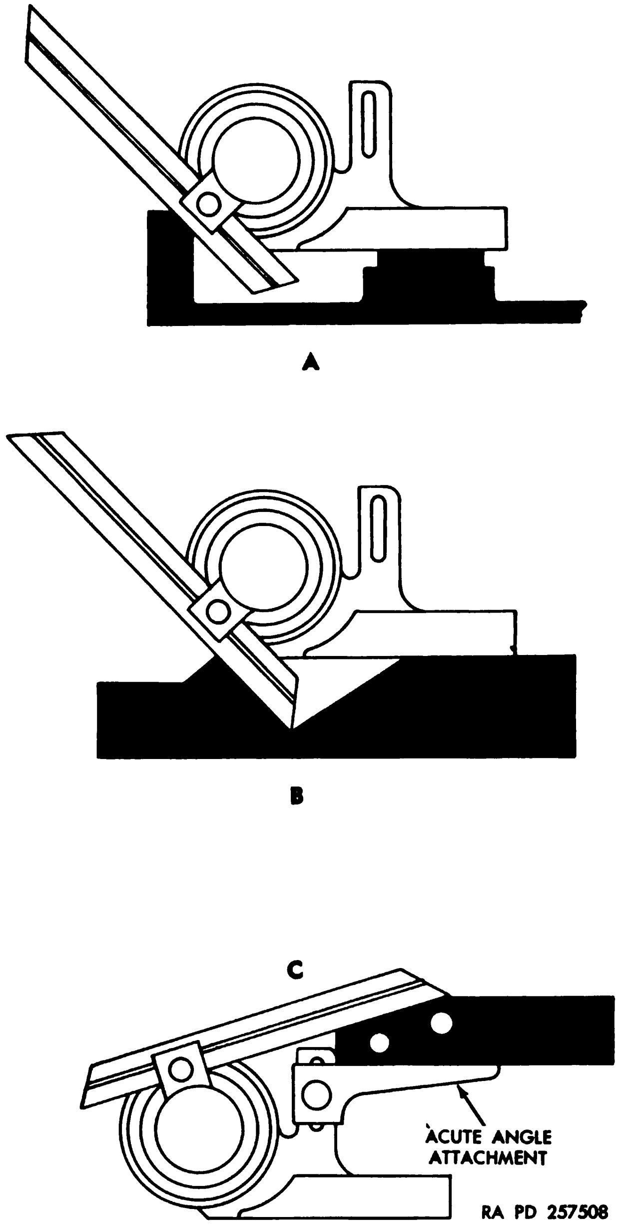

Figure 38. Using bevel protractor.

Section VIII. CALIPERS AND DIVIDERS

38. Purpose of Calipers and Dividers
(figs. 39–42)

Dividers are used for measuring distances between two points, for transferring or comparing measurements directly from a rule, or for scribing an arc, radius, or circle. Calipers are used for measuring diameters and distances, or for comparing dimensions or sizes with standards such as a graduated rule.

39. Types of Calipers and Dividers

a. Dividers.

(1) *Spring divider.* A spring divider (fig. 39) consists of two sharp points at the end of straight legs, held apart by a spring and adjusted by means of a screw and nut. The spring divider is available in sizes from 3 to 10 inches in length.

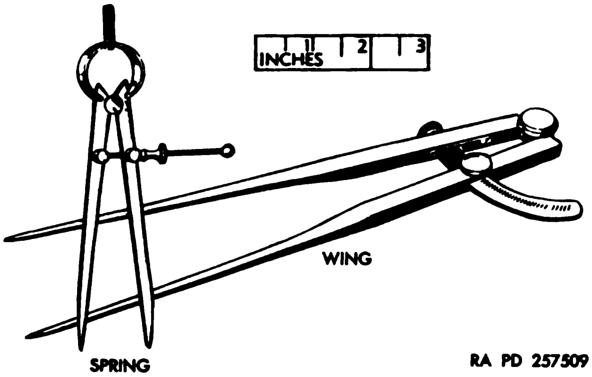

Figure 39. Dividers.

(2) *Wing divider.* A wing-type divider (fig. 39) has a steel bar that separates the legs, a locking nut for securing a rough measurement, and an adjusting screw for fine adjustments. The wing-type divider is available in 6–, 8–, and 12–inch lengths. An improved version of this type has the tip of one leg removable so that a pencil can be inserted.

b. Outside Calipers. Outside calipers (fig. 40) are used to measure distances over and around adjacent surfaces and to transfer the measurements to a rule. Several types are made in several sizes to accommodate a wide range in measurement. The size of the caliper is expressed in terms of the maximum dimension it is capable of measuring. A 3-inch

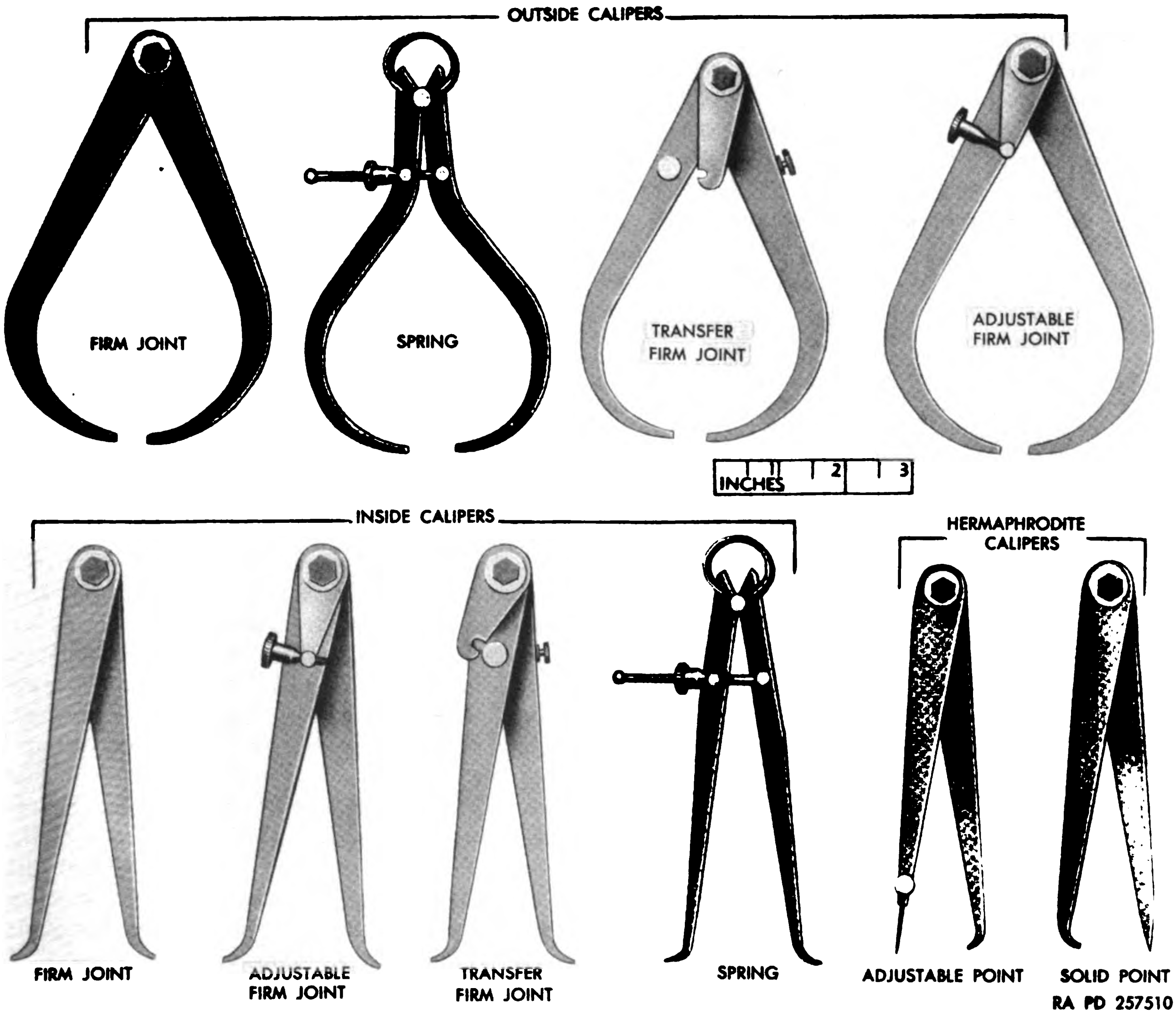

Figure 40. Calipers—noncalibrated.

caliper, for example, will measure a distance of 3 inches. Actually, the maximum capacity of the caliper will be greater, often as much as one-third. This means that a 3–inch caliper will actually measure up to 4 inches. It is not recommended that you use a 3–inch caliper to measure 4 inches, since you may spring the legs, resulting in an inaccurate measurement.

c. Inside Calipers. Inside calipers (fig. 40) have the same general function as outside calipers except that where the latter are used in measuring distances over outside surfaces, the inside caliper is used in measuring distances between inside surfaces. The points are rounded so that they are slightly ball-shaped. This ball shape establishes the point of contact, and in inside calipering where the surfaces are likely to have an inside curvature error might occur if the radius of the hole being calipered were less than the radius of the points. Some inside calipers are equipped with an adjusting screw on one leg which provides a fine adjustment of the caliper legs.

(1) *Spring caliper.*

(*a*) The spring caliper is available in sizes from 2 to 8 inches. The friction of the adjusting nut and screw works against the tension of the spring which holds the legs in any set position. This type of inside caliper is known as the toolmaker's spring caliper.

(*b*) Thread spring calipers are used to measure diameter and distances in tapped holes. The ends of the legs of thread calipers are shaped to a fine point so that exact contact may be made between threads.

(2) *Firm joint caliper.* The firm joint type is available in a number of sizes from 3 to 24 inches. This type of caliper is equipped with a nut and stud that provides sufficient friction to hold the legs in any set position. Some of this type caliper are equipped with an adjusting screw for fine adjustments.

(3) *Transfer firm joint caliper.* Inside transfer firm joint calipers are shaped for inside measurements and are used for measuring recesses where the seting cannot be transferred to a scale directly because the legs must be collapsed to remove them from the work.

d. Hermaphrodite Calipers. Hermaphrodite calipers (fig. 40) are a cross between a divider and an inside caliper, having one leg of each. These calipers are used for scribing parallel lines from an edge or for locating the center of cylindrical work. Some are equipped with an adjustable point.

e. Trammels. A trammel is a tool used for the same purposes as a divider or caliper, but usually for distances beyond the range of either of these two instruments. A steel beam trammel with all of the attachments required in measuring and layout work is shown in figure 41. The instrument consists of a rod or beam to which trams may be clamped. These steel beams will range in length from 9 to 20 inches, but may be increased further through the use of extensions. Longer beams are often made of wood. The trams carry spring chucks in which divider points, caliper points, and ball points may be inserted so that the trammel may be readily converted from a divider to an outside or inside caliper or to a hexmaphrodite caliper. Ball points are used to position a tram in the center of a hole. By using different size balls or V-points, it is possible to position the tram in any size hole up to 1½ inches in diameter. On top of the trams are knurled handles which swivel so that the handles may be gripped firmly when describing a circle or an arc. An adjusting screw is provided on one of the trams which permits a fine adjustment of the points.

f. Vernier Calipers. This type of caliper utilizes the vernier scale. The vernier scale consists of a short auxiliary scale having usually one more graduation in the same length as the longer main scale. Reading the vernier scales is discussed in paragraphs 36*e* and 41*e*. The vernier caliper (fig. 42) consists of a L-shaped frame, the end of which is a fixed jaw; the long arm of the L is inscribed with the main true scale or fixed scale. The sliding jaw carries the vernier scale on either side. The scale on the front side is for outside measurements; the scale on the back is for inside measurements. On some vernier calipers, the metric system of measurement is placed on the back side of the caliper in lieu of a scale used for inside measurements. In such cases, add

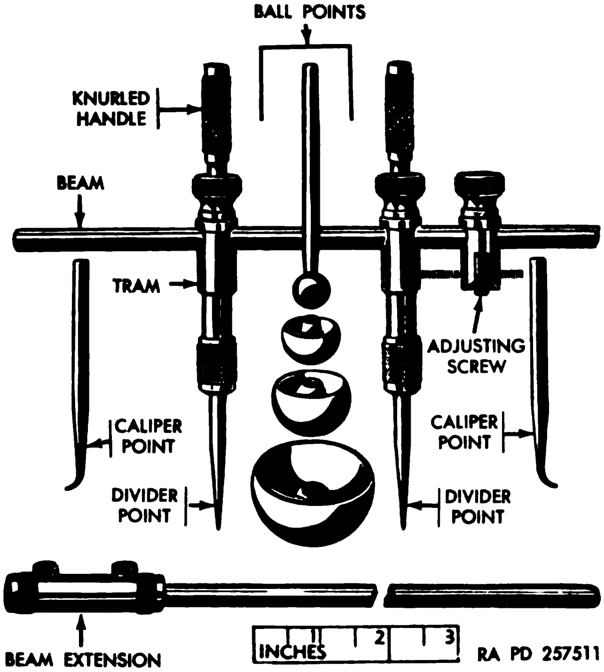

Figure 41. Trammel set.

thickness of the nibs to the reading when making inside measurements. The tips of the jaws are formed so that inside measurements can be taken. The thickness of the measuring points is automatically compensated for on the inside scale. The length of the jaws will range from 1¼ inches to 3½ inches, and the minimum inside measurement with the smallest caliper is ¼ inch or 6 millimeters. Vernier calipers are made in standard sizes of 6, 12, 23, 36, and 48 inches, and 150, 300, 600, and 900 millimeters. The jaws of all vernier calipers, except the larger sizes, have two center points, which are particularly useful in setting dividers to exact dimensions.

g. Slide Caliper. The slide caliper (fig. 42) has one fixed jaw and one sliding jaw. When the two jaws are brought in contact with surfaces to be measured, the distance between the surfaces may be read from the scale. The ends of the jaws are so shaped that it is possible to measure both inside and outside surfaces. Slide calipers are usually made in 3-inch sizes, although larger size calipers are made. The

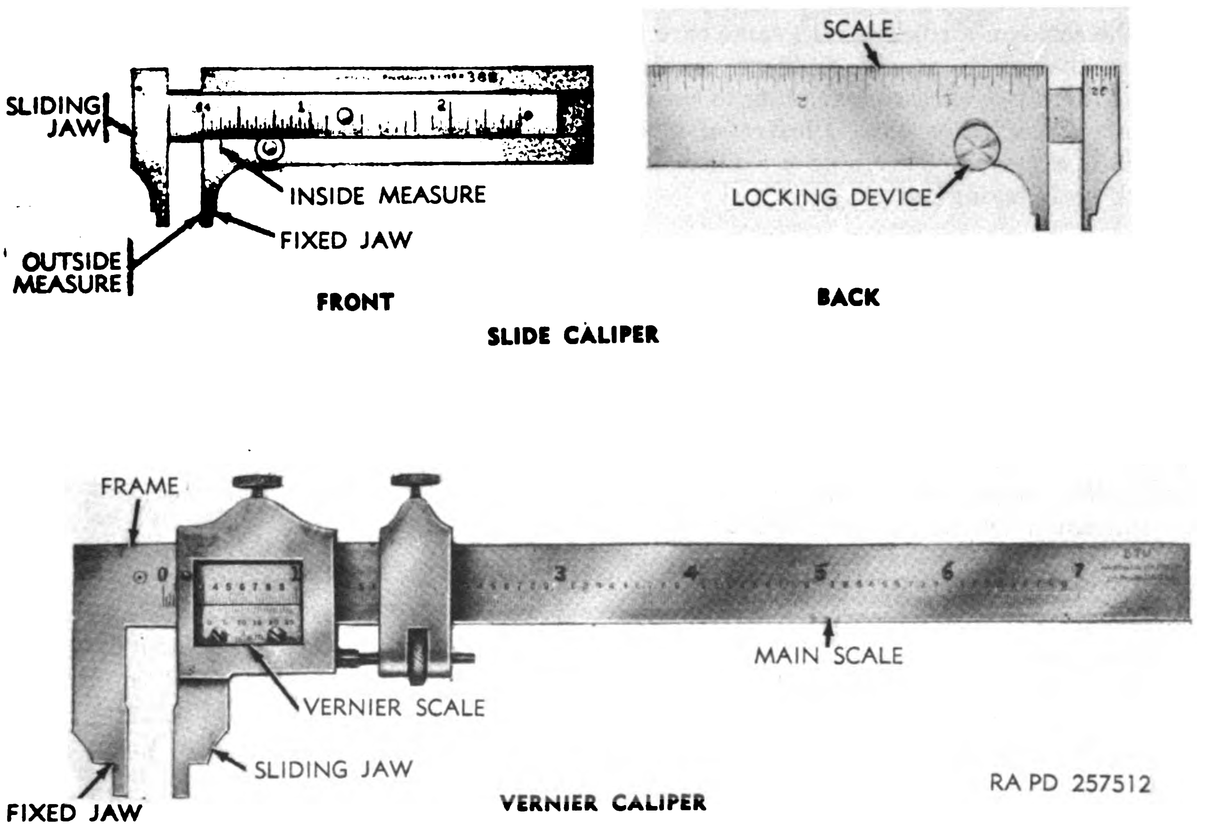

Figure 42. Calipers—calibrated.

standard 3-inch slide caliper will measure from 0 to about 2 inches outside, and from ⅛ inch to a little more than 2 inches inside. The caliper shown has a mark or graduation line on the fixed jaw which enables the user to read the inside measure, while the outside measure can be read from the inner edge of the fixed jaw directly. If these marks were not on the slide caliper, it would be necessary to add the thickness of the nibs to the reading when using it as an inside caliper. All slide calipers are equipped with a locking device which makes it possible to hold the jaws in any desired position. On the other side it is an ordinary rule.

40. Use of Dividers

In setting a divider to a dimension on a scale, the usual procedure is to locate one point in one of the inch graduations of the rule and to adjust the nut or screw so that the other point falls easily into the correct graduation (A, fig. 43). Make certain points of the divider are not blunt (B, fig. 43).

Note. Do not set to end of rule.

When transferring a dimension from a part or tool to the scale on a rule, use the same care in adjusting the points of the dividers, making sure that there is no pressure tending to spring the points either in or out. Illustrated in C, figure 43 is a mechanic scribing a radius on a die block he is laying out.

41. Use of Calipers

a. Outside Calipers. A caliper is usually used in either of two ways. Either the caliper is set to the dimension of the work and the dimension transferred to a scale, or the caliper is set on a scale and the work machined until it checks with the dimension set up on the caliper. To adjust an outside caliper to a scale dimension, one leg of the caliper should be held firmly against one end of the scale and the other leg adjusted to the desired dimension, as shown in A, figure 44. To adjust the outside caliper to the work, open the legs wider than the work and then bring them down to the work. A sense of feel must be acquired to use calipers properly. This comes through practice and care in using the tool to eliminate the possibility of error. Always position the caliper properly on the axis of the work, as shown in B, figure 44.

Note. Never set a caliper on work that is revolving in a machine. The contact of one leg of a caliper on a revolving surface will tend to draw the other leg over the work because of the friction between the moving surfaces. Only a slight force is necessary to spring the legs of a caliper so that measurements made on moving surfaces are never accurate.

b. Inside Calipers. The inside caliper is set to a dimension by placing the end of a scale and one point of the caliper against a solid surface and adjusting the other leg to the proper graduation, as shown in A, figure 45. The spring caliper is shown being used to check the inside diameter of a bored hole in B, figure 45. Figure 46 illustrates the correct and incorrect positioning of the calipers with relation to the axis of the work. The transfer feature of the caliper is illustrated in figure 47. Note that the diameter being used is recessed and that the setting cannot be transferred to a scale directly because the legs must be collapsed to get them out of the work. The setting must be reproduced after the calipers are removed. Figure 48 shows how a micrometer can be used to transfer a dimension from an inside spring caliper.

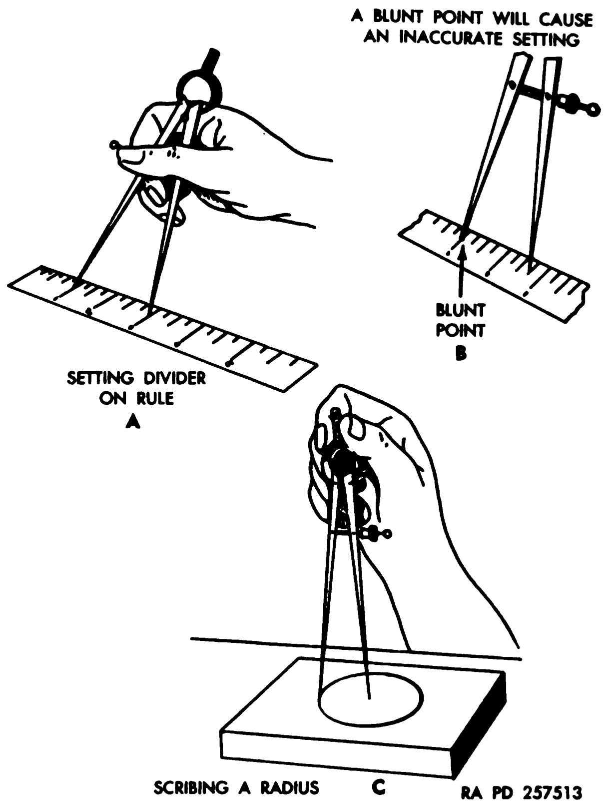

Figure 43. Using dividers.

Figure 44. Using outside calipers.

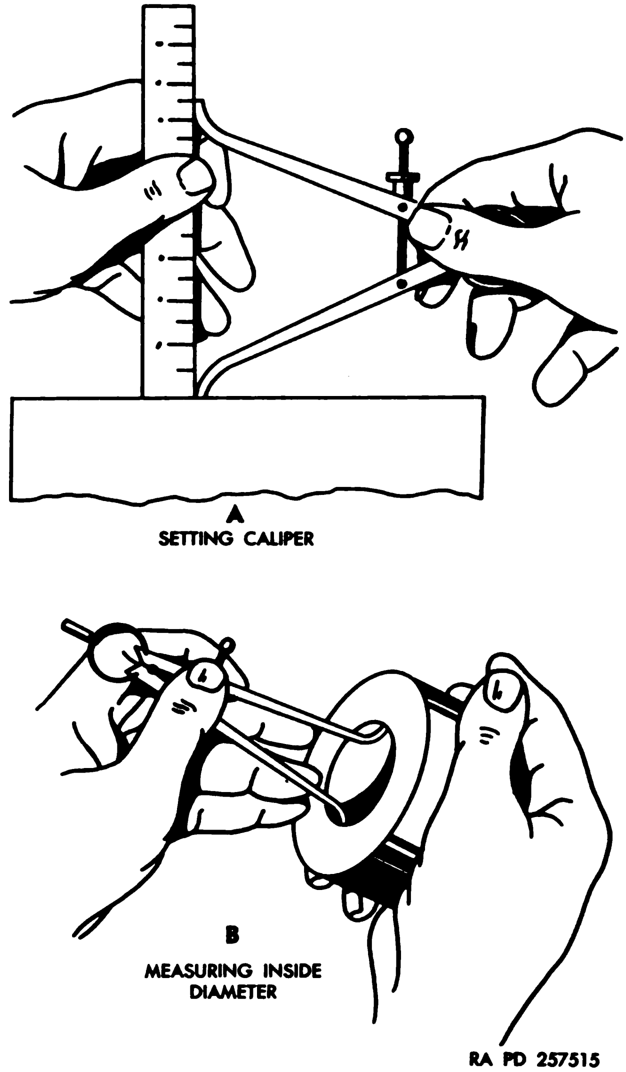

Figure 45. Setting and using inside caliper.

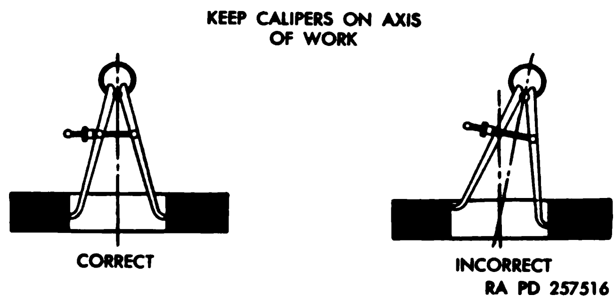

Figure 46. Positioning of inside calipers.

c. Hermaphrodite Calipers. The hermaphrodite caliper is adjusted and set in the same manner as the outside and inside caliper, depending on the position and use of the caliper leg, as shown in figure 49.

d. Trammel. The trammel set is used for the same purposes as a divider or caliper, but usually for distances beyond the range of either one. Figure 50 shows the trammel with caliper point scribing an arc or establishing a distance from the edge of a machined part. The divider point and ball point are illustrated in use in figure 51. Here, the machinist is scribing distances from precise center of hole already drilled.

e. Vernier Caliper.

(1) *Reading vernier caliper.* The vernier caliper permits precise, accurate readings by means of the graduated steel

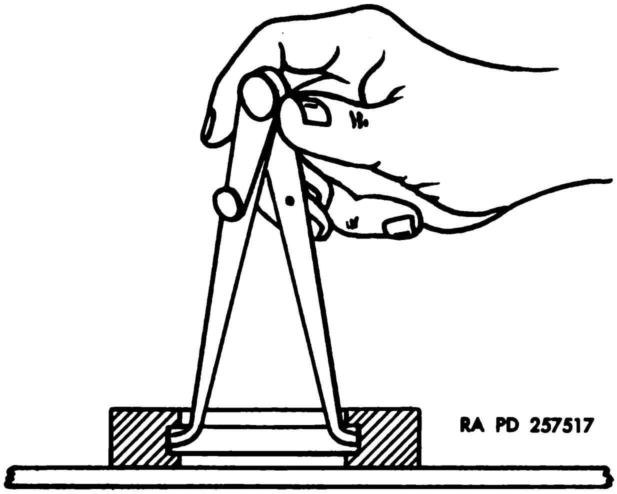

Figure 47. Using a transfer caliper to measure a recessed diameter.

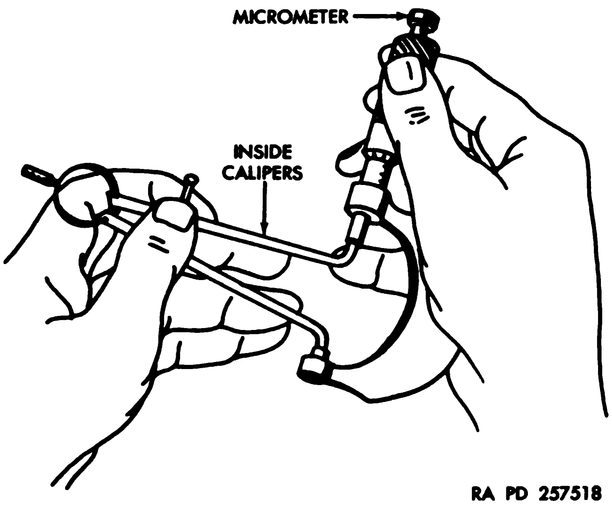

Figure 48. Transferring dimension to micrometer.

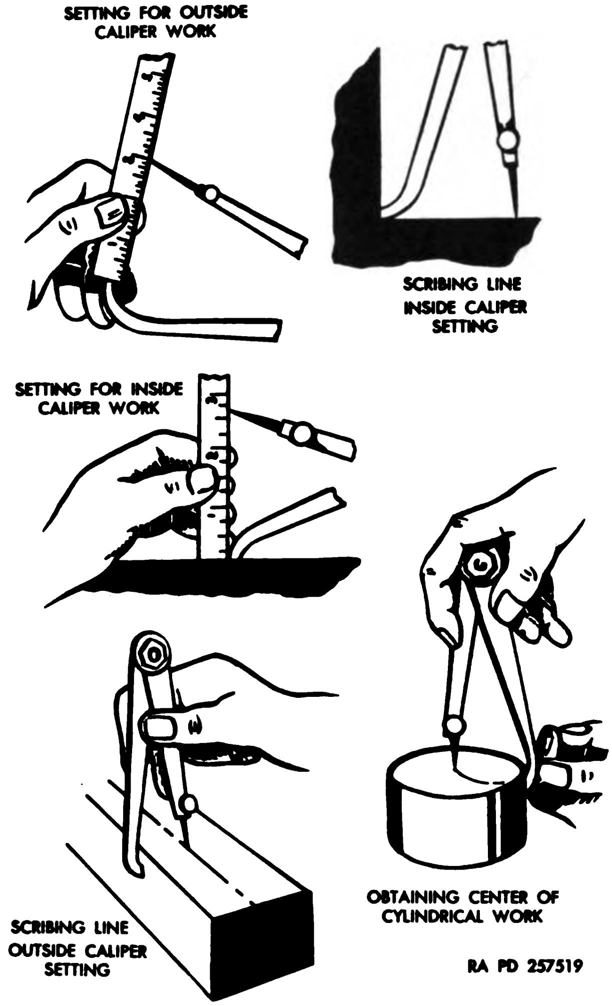

Figure 49. Setting and using hermaphrodite caliper.

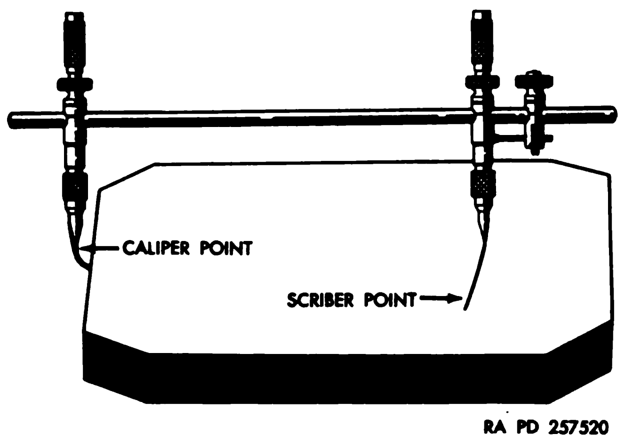

Figure 50. Using trammel with caliper and scriber points.

rule and the movable jaw which carries the vernier scale. In order to see the vernier caliper, a thorough understanding of the vernier scale and how to read it are essential.

(*a*) The steel rule of the caliper is graduated in fortieths or 0.025 of an inch. Every fourth division, representing a tenth of an inch, is numbered, as shown in the enlarged view on figure 52. The vernier scale is divided into 25 parts and numbered 0, 5, 10, 15, 20, and 25. These 25 parts are equal to and

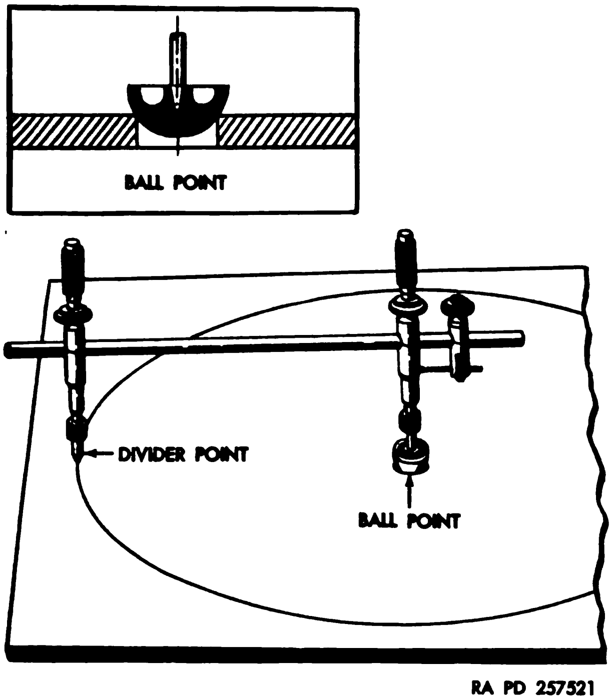

Figure 51. Using trammel with divider and ball points.

occupy the same space as 24 parts on the rule. The difference between the width of one of the 25 spaces on the vernier scale and one of the 24 spaces on the rule is $\frac{1}{25}$ of $\frac{1}{40}$, or $\frac{1}{1000}$ of an inch. If the tool is set so that the 0 line on the vernier coincides with the 0 line on the rule, the line to the right of 0 on the vernier scale will differ from the line to the right of 0 on the rule by $\frac{1}{1000}$ of an inch; the second line by $\frac{2}{1000}$ of an inch; and so on. The difference will continue to increase $\frac{1}{1000}$ of an inch for each division until the line 25 on the vernier scale coincides with the line 24 on the rule. To read the scales, note how many inches, tenths (or 0.100), and fortieths (or 0.025) the mark 0 on the vernier scale is from 0 mark on the rule; then note the number of divisions on the vernier scale from 0 to a line which exactly coincides with a line on the rule.

(*b*) For example, A, figure 52 shows the 0 mark of the vernier scale coinciding with a line on the rule. In this case, the vernier scale is not necessary since there is no fractional part of a space to determine. The reading is 2.350. The 0 mark on the vernier scale, as shown in B, figure 52, coincides with a fractional part of a space on the rule. The

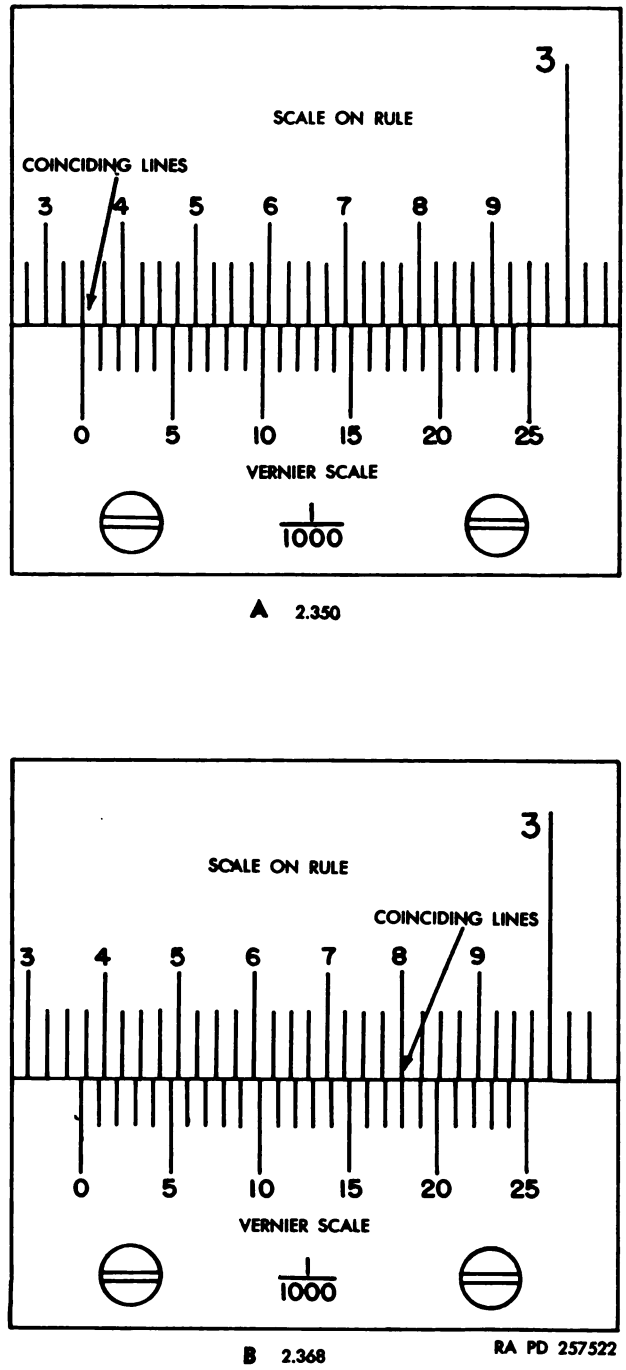

Figure 52. Reading vernier scale.

reading is 2.35 plus a fraction of the space on the rule. In order to determine what fractional part of a whole rule division, or how many thousands are to be added to the 2.35 reading, it is necessary to find the line on the vernier scale that exactly coincides with the line on the rule. In this case the line coincides at the 18th mark. This indicates $^{18}/_{25}$ of a whole space. Since each space on the rule equals 0.025 inch, this part of a space is equal to 0.018 inch, and the total reading is 2.35 plus 0.018, or 2.368 inches.

Note. Vernier scales are not necessarily 25 divisions long; they may have any number of units. For example, the ten-thousandths micrometer has a vernier scale of only ten divisions.

(2) *Applications.* The vernier caliper has a wide range of measurement applications, and the shape of the measuring jaws and their position with respect to the scale makes this tool more adaptable than a micrometer (see sec. IX for micrometer discussion). However, the vernier caliper does not have the accuracy of a micrometer. In any 1 inch of its length, a vernier caliper should be accurate within 0.001 inch. In any 12 inches, it should be accurate within 0.002 inch and increase about 0.001 for every additional 12 inches. The accuracy of measurements made with a vernier caliper is dependent on the user's ability to feel the measurement. Because the jaws are long, and because there is the possibility of some play in the adjustable jaw, especially if an excessive measuring pressure is used, it is necessary to develop an ability to handle the vernier caliper. This touch may be acquired by measuring such known standards as gage blocks and plug gages. Applications of the vernier calipers are shown in figure 53. In part A (fig. 53), a machinist is checking the outside diameter of a part. One hand holds the stationary jaw to locate it, while the other hand operates the adjusting nut and moves the sliding jaw to the work. The same procedure is used in part B (fig. 53) in checking the inside dimension.

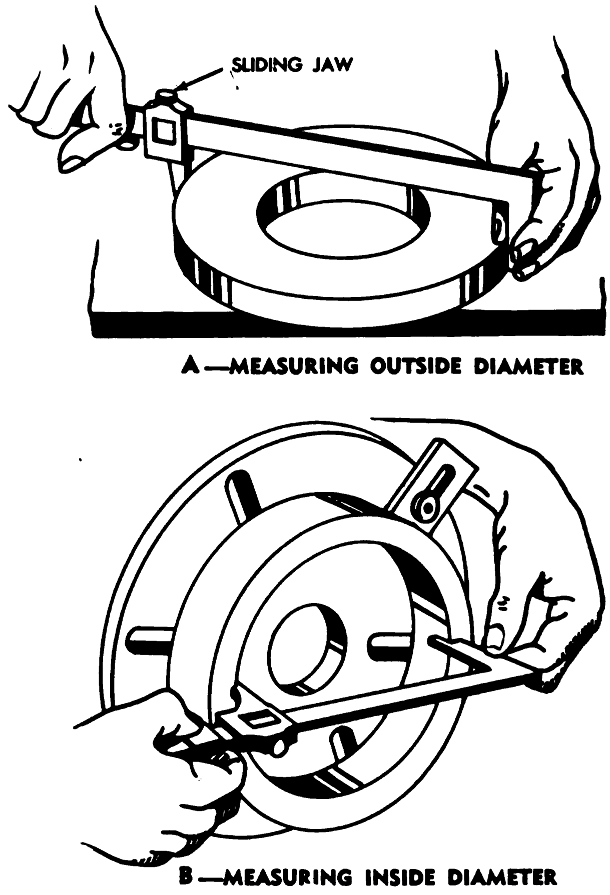

Figure 53. Using a vernier caliper.

f. Slide Caliper. All slide calipers are equipped with a locking or clamping device, which makes it possible to hold the jaws in any desired position. Outside dimensions are taken off the graduated scale line that matches the inner edge of the fixed jaw. Inside dimensions are read opposite the mark or graduation line on the fixed jaw.

42. Care of Dividers, Trammels, and Calipers

Never use a divider, trammel, or caliper for a purpose other than that for which it was intended. Never pile these tools in a drawer. Never force dividers and calipers beyond their capacity or setting. Never use these tools incorrectly—changing settings by hammering instead of loosening a clamping screw or nut, bearing down too hard when scribing with a divider or trammel, wearing measuring surfaces unnecessarily by using a heavy measuring pressure. Apply protective film of oil to tools, when not in use.

43. Care of Vernier Calipers

The accuracy of the vernier caliper depends on the condition of fit of the sliding jaw, and the wear and distortion in the measuring surfaces. The fit of the sliding jaw should be such that it can be moved easily and still not have any play. It may be adjusted by removing the gib in the sliding jaw assembly and bending it. The function of the gib is to hold the adjustable jaw against the inside surface of the blade with just the right pressure to give it the proper friction. Wear on the jaws of the vernier caliper is mostly at the tips where most measurements are made. A certain amount of this wear may be taken up by adjusting the vernier scale itself. This scale is mounted with screws in elongated holes which permit it to be adjusted slightly to compensate for wear and distortion. When the error exceeds 0.0002 inch, either in parallelism or flatness, the caliper should be returned to the manufacturer for reconditioning. Wear on the jaws can best be checked by visual means and by measuring rolls or rings of known dimensions.

Section IX. MICROMETERS

44. Purpose of Micrometers
(figs. 54 and 55)

Micrometers are used for measurements requiring precise accuracy. They are more reliable and more accurate than the calipers discussed in the preceding section.

45. Types of Micrometers

Micrometers are made in various shapes and sizes, depending upon the purpose for which they are to be used. They all have a precision screw adjustment offering great measuring accuracy.

a. Micrometer Caliper.

(1) The micrometer caliper (fig. 54) is the most common type. It has a range of 0 to 1 inch and is graduated to read in thousands of an inch or in units of the Metric system, from 0 to 25 millimeters by hundredths of a millimeter. It may or may not have—

(*a*) A stainless steel frame to resist corrosion or tarnish.

(*b*) A ratchet for applying a constant measuring pressure.

(*c*) A special vernier scale for reading tenths of thousandths of an inch.

(*d*) A clamp ring or locknut for clamping the spindle to hold a setting.

(*e*) Cemented carbide tips on the measuring anvils to reduce wear.

(2) The frame can be smaller to the extent that the range of the caliper is only 0 to ½ inch or 0 to 13 millimeters, or it can be larger so that the range is 23 to 24 inches. The head has a constant range of 0 to 1 inch. The shape of the frame may be varied to adapt it to the physical requirements of some types of work. For example—

(*a*) The frame back of the anvil may be cut away to allow the anvil to be placed in a narrow slot.

(*b*) The frame may have a deep throat to permit it to reach into center sections of a sheet (sheet metal or paper gage).

(*c*) The frame may be in the form of a base so that the gage can be used as a bench micrometer.

(*d*) The frame may have a wooden handle and may be of extra-heavy construction for use in a steel mill for gaging hot sheet metal.

(3) The spindle and anvil may vary in design to accommodate special physical requirements. For example—

(*a*) The spindle and anvil may be chamfered so that the gage can slide on and off the work easily, as when gaging hot metal.

(*b*) The ball-shaped anvil is convenient in measuring the thickness of a pipe section of small diameter.

(*c*) The V-shaped anvil is necessary on the screw thread micrometer caliper

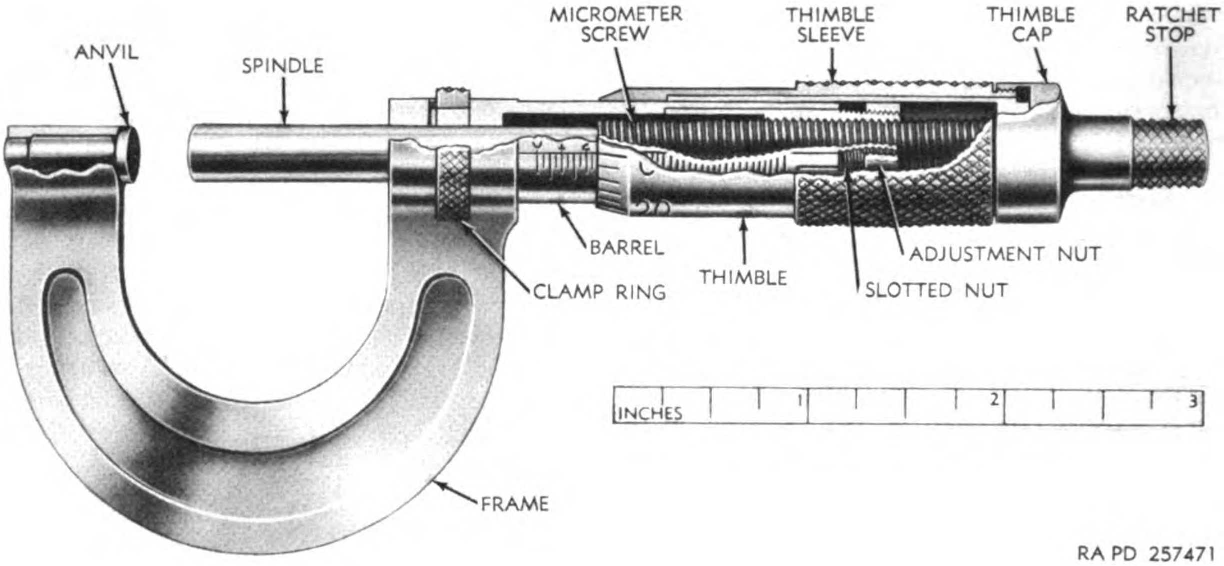

Figure 54. Micrometer caliper, cutaway view.

to mesh properly with the screw thread. The spindle of the screw thread micrometer is cone-shaped. This micrometer measures the pitch diameter.

(*d*) The interchangeable anvils of various lengths make it possible to reduce the range of the caliper. A micrometer having a range from 5 to 6 inches can be changed to one having a 4 to 5, or 3 to 4-inch range by inserting a special anvil of the proper length.

b. Inside Micrometers. Inside micrometers are used to measure inside dimensions. The minimum dimension that can be checked is determined by the length of the unit with its shortest anvil in place and the screw set up to zero. It consists of an ordinary micrometer head, except that the outer end of the sleeve carries a contact point, attached to a measuring rod. The average inside micrometer set (fig. 55) has a range that extends from 2 to 10 inches. The various steps in covering this range are obtained by means of extension rods. The micrometer set may also contain a collar for splitting the inch step between two rods. The collar, which is ½ inch long, extends the rod another half inch so that the range of each step can be made to overlap the next. The range of the micrometer screw itself is very short when compared to its measuring range. The smallest models have a ¼-inch screw, the average have a ½-inch screw, and the largest inside micrometers have only a 1-inch screw.

46. Mechanics of Micrometers

a. Design. The micrometer (fig. 54) makes use of the relation of the circular movement of a screw to its axial movement. The amount of axial movement of a screw per revolution depends on the thread, and is known as the lead. If a circular nut on a screw has its circumference divided into 25 equal spaces, and if the nut advances axially $\frac{1}{40}$ inch for each revolution, then if it is turned one division, or $\frac{1}{25}$ of a revolution, it will move axially $\frac{1}{25}$ x $\frac{1}{40}$, or $\frac{1}{1000}$ of an inch. In the micrometer the nut is stationary and the screw moves forward axially a distance proportional to the amount it is turned. The screw on a micrometer has 40 threads to the inch, and the thimble has its circumference divided into 25 parts, so 1 division on the thimble represents an advancement of $\frac{1}{1000}$ of an inch axially.

b. Construction.

(1) The steel frame is U-shaped, one end of which holds the stationary anvil. The stationary anvil is a hardened button either pressed or screwed into the frame.

(2) The steel spindle is actually the

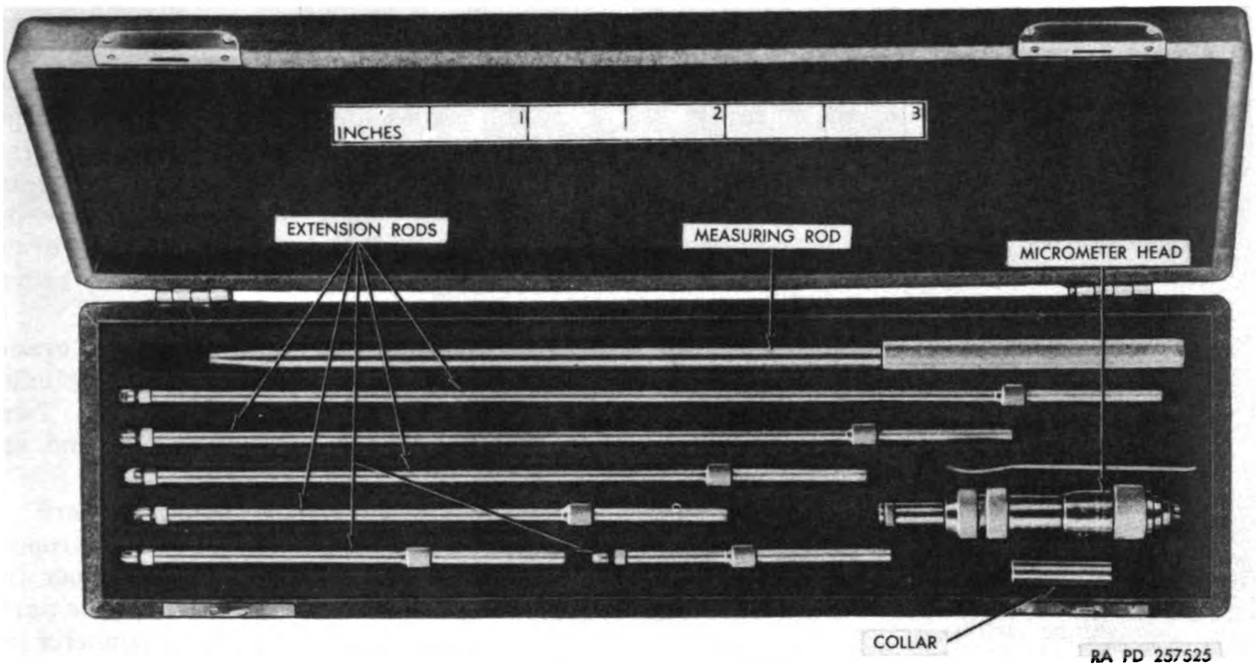

Figure 55. Inside micrometer set.

unthreaded part of the screw. It is the spindle that advances or retracts to open or close the open side of the U-frame. The spindle bearing is a plain bearing and a part of the frame.

(3) The hollow barrel extends from this bearing; on the side of the barrel is the micrometer scale, which is graduated in tenths of an inch, which are in turn divided into subdivisions of 0.025 inch. The end of the barrel supports the nut which engages the screw. This nut is slotted, and its outer surface has a taper thread and a nut which makes it possible to adjust the diameter of the slotted nut within limits to compensate for wear.

(4) The thimble is attached to the screw. The thimble is a sleeve that fits over the barrel. The front edge of the thimble carries a scale broken down into 25 parts. This scale indicates parts of a revolution, where the scale on the barrel indicates the number of revolutions. The thimble is connected to the screw through a sleeve that permits it to be slipped in relation to the screw for the purpose of adjustment. The inner sleeve is sweated to the screw. The outer sleeve is clamped to the inner one by the thimble cap. Loosening the cap makes it possible to slip one in relation to the other.

(5) On top of the thimble cap there may be a ratchet. This device consists of an overriding clutch held together by a spring in such a way that when the spindle is brought up against the work, the clutch will slip when the correct measuring pressure is reached. The purpose of the ratchet is to eliminate any difference in personal touch and so reduce the possibility of error due to a difference in measuring pressure. Not all micrometers have ratchets.

(6) The clamp ring or locknut is located in the center of the spindle bearing on those micrometers equipped with it. This clamping makes it possible to lock the spindle in any position to preserve a setting.

47. Use of Micrometers

a. Reading Standard Micrometer. Reading a micrometer is only a matter of reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer screw has 40 threads per inch. This means that one complete and exact revolution of the micrometer screw moves the spindle away from or towards the anvil exactly 0.025 inch. The lines on the barrel (fig. 56) conform to the pitch of the micrometer screw, each line indicating 0.025 inch, and each fourth line being numbered 1, 2, 3, and so forth. The beveled edge of the thimble is graduated into 25 parts, each line indicating 0.001 inch, $1/25$ of the 0.025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch. Read measurement shown in figure 56 as indicated in (1) through (4) below.

(1) Record highest figure visible on barrel	2	= 0.200 in.
(2) Number of lines visible between the No. 2 and thimble edge	1	= 0.025 in.
(3) The line on the thimble that coincides with or has passed the revolution or long line in the barrel	16	= 0.016 in.
(4) Measurement reading	TOTAL	= 0.241 in.

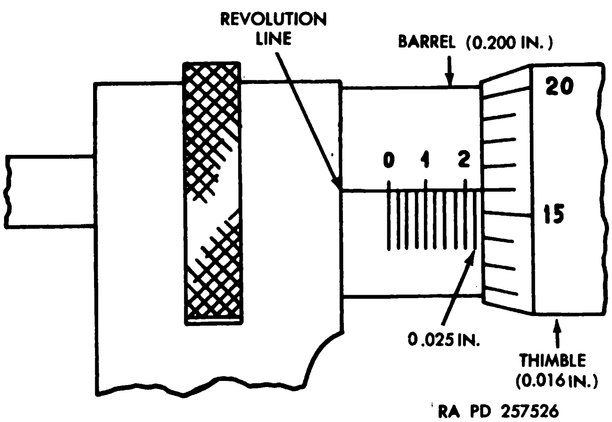

Figure 56. Reading standard micrometer scale.

b. Reading Metric Micrometer. The same principle is applied in reading the Metric graduated micrometer, but the following changes in graduations should be noted to avoid confusion:

(1) The pitch of the micrometer screw is 0.5 mm. One revolution of the spindle advances or withdraws the screw a distance equal to 0.5 mm.

(2) The barrel is graduated in millimeters, from 0 to 25; it takes two revolutions of the spindle to move 1 mm.

(3) The thimble is graduated in 50 divisions with every fifth line being numbered.

(4) Rotating the thimble from one graduation to the next moves the spindle $1/50$ of 0.5 mm, or $1/100$ mm. Two graduations equal $2/100$ mm, and so forth.

c. Adjusting Micrometer Caliper to Work.

(1) Figure 57, part A, shows the proper way to hold a micrometer caliper in checking a small part. Hold the part in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and the forefinger. The third finger is then in a position to hold the frame against the palm of the hand. The frame is supported in this manner and makes it easy to guide the work over the anvil. The thumb and forefinger are in position to turn the thimble either directly or through the ratchet and bring the spindle over against the work.

(2) On larger work, it is necessary to have the work stationary and positioned to permit access to the micrometer. The proper method of holding a micrometer when checking a part too large to be held in one hand is shown in B, figure 57. The frame is held by one hand to position it and to locate it square to the measured surface. The other hand operates the thimble either directly or through the ratchet. A large flat part should be checked in several places to determine the amount of variation.

(3) To gage a shaft as shown in C, figure 57, the frame is held by one hand while the thimble is operated by the other. In gaging a cylindrical part with a micrometer it is necessary to "feel" the setting to be sure that the

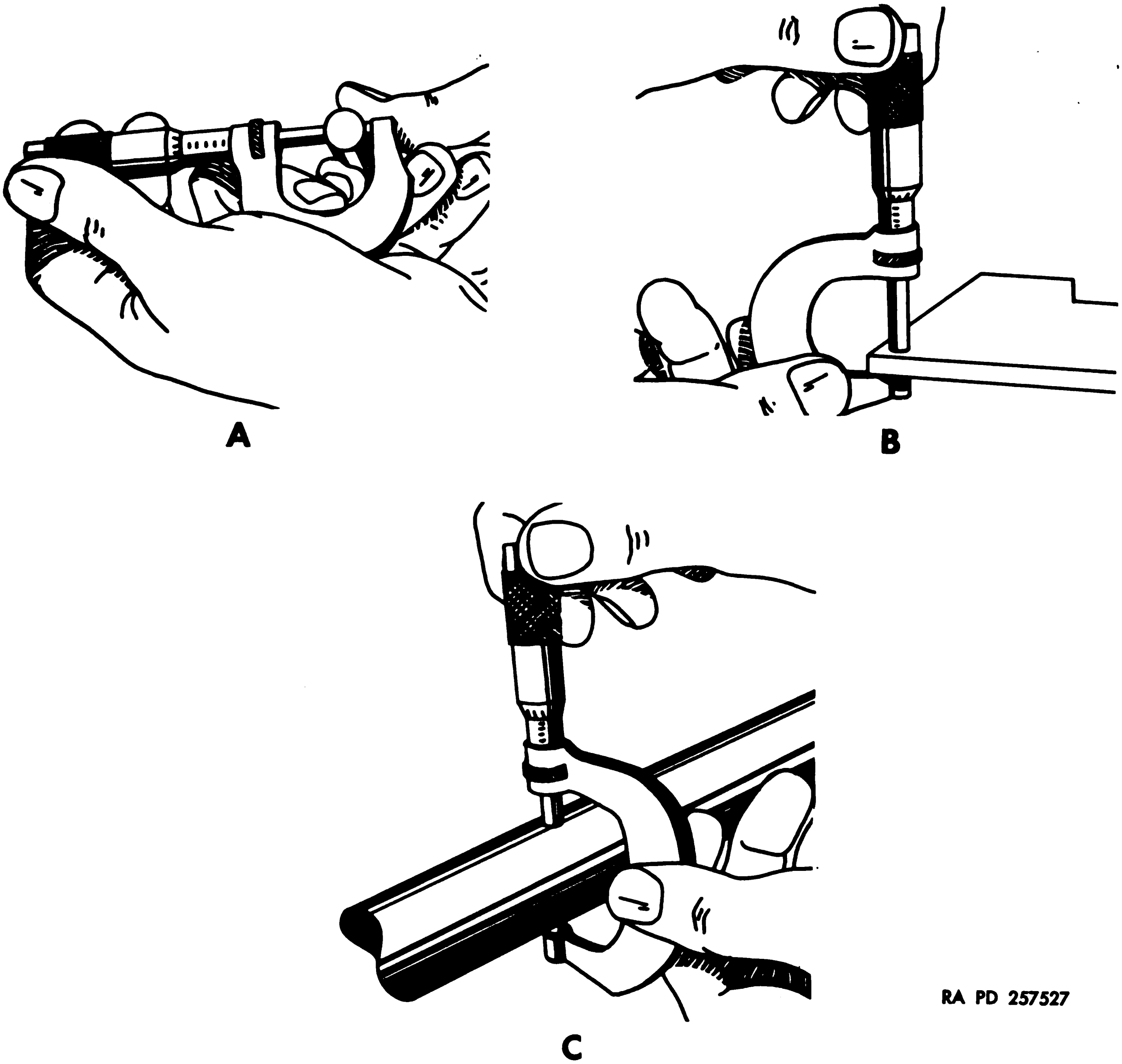

Figure 57. Using outside micrometer.

spindle is on the diameter, and also to check the diameter in several places to determine the amount of out-of-roundness.

(4) For measuring very large diameters, micrometer calipers are made in various sizes up to 168 inches. Figure 58 shows a pulley being checked with a micrometer whose range has been reduced by a special anvil which has been screwed into the frame. A set of different length anvils permits the use of this micrometer over a wide range of sizes; yet the spindle only moves 1 inch. This micrometer has been lightened in weight by the I-section construction and by boring holes in the frame.

d. Using Inside Micrometer. The normal procedure in using an inside micrometer is to set it across a diameter or between the inside surfaces, remove it, and then read the dimension. For this reason, the thimble on an inside micrometer is much stiffer than on a micrometer caliper—it holds the dimension well. It is good practice to verify the reading of an inside micrometer by measuring it with a micrometer caliper.

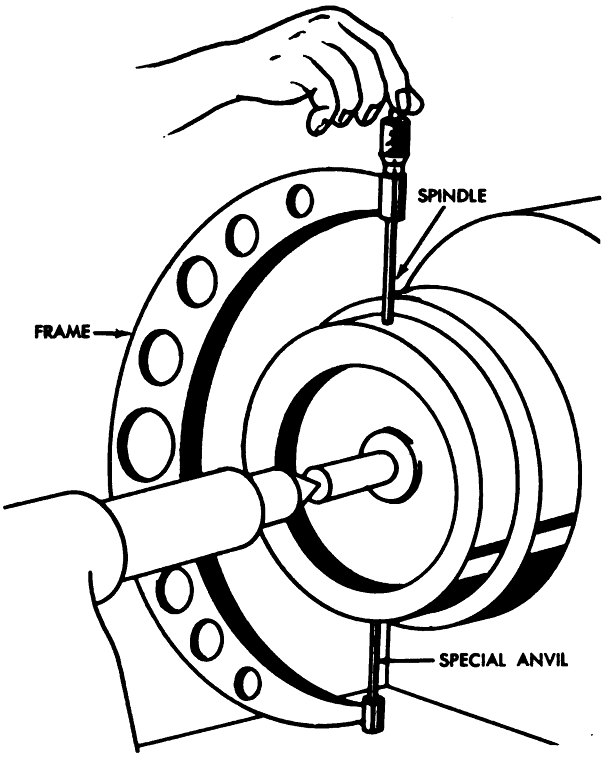

Figure 58. Checking diameter of pulley.

(1) Figure 59 shows an inside micrometer with extension rod being used to check the diameter of a bored hole. Note the arrows which indicate the direction the operator is feeling for the largest dimension horizontally and the smallest dimension vertically. Inside micrometers have spherical contact points which require more practice to "feel" the full diametral measurement. One contact point is generally held in a fixed position and the other rocked in different directions to be sure the tool is spanning the true diameter of a hole or the correct width of a slot.

(2) For probing a deep hole or in a restricted place, a handle attachment may be used. The handle clamps on to the body of the micrometer.

e. Transferring Measurements from Inside Caliper or Inside Micrometer to Micrometer Caliper.

(1) After setting inside caliper or inside micrometer to the work, hold the micrometer caliper in one hand and the inside tool in the other hand.

(2) Turn the thimble of the micrometer caliper with the thumb and forefinger until you feel inside tool legs lightly contact the anvil and spindle of the micrometer caliper.

(3) Hold the tips of the inside tool legs parallel to the axis of the micrometer caliper spindle.

(4) The micrometer caliper will be accurately set when the inside tool will just pass between the anvil and spindle by its own weight.

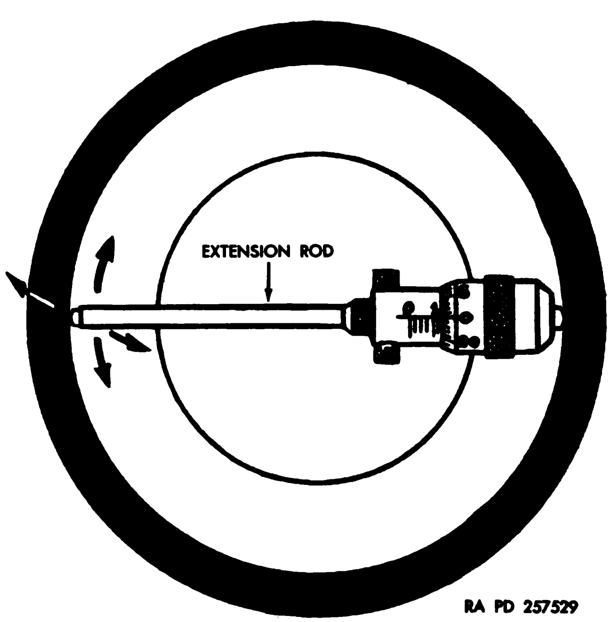

Figure 59. Using inside micrometer with extension rod.

48. Care of Micrometers

To maintain a micrometer in good condition and to preserve the accuracy of its measurements, observe the following rules of good practice and adjusting procedures:

a. Never store a micrometer with its anvil and spindle closed. Flat surfaces wrung together for any length of time tend to corrode. Leave a small gap between the anvil and spindle when storing.

b. Oil the micrometer in only one place—the micrometer screw; and only with a very light oil. If storing for long periods of time, cover the micrometer with a light film of oil and wrap it in oiled paper.

c. Never roll the thimble along the hand or arm. Likewise, holding the thimble and twirling the frame to open or close the micrometer will cause excessive wear on the screw.

d. Before using a micrometer, wipe it off and pull a piece of paper between the anvil and end of the spindle.

e. The micrometer should operate freely with no play in its travel. If a micrometer has play, or if it binds, it should be returned to the manufacturer for reconditioning. This condition is caused by abuse or uneven wear.

f. Check the micrometer screw periodically with a precision gage block in at least four places other than zero to verify its accuracy. Simply measure a selected group of blocks ranging from 0 to 1 inch.

g. Clean micrometer mechanism whenever it becomes gummy, contains abrasive grit, or whenever it is to be adjusted. Use an approved cleaning agent.

h. When the faces of the spindle and anvil become worn and they are no longer flat and parallel to each other, the error should not exceed 0.0002 inch on a micrometer which is graduated to control measurements to a limit of 0.001 inch and should not exceed 0.00005 inch on a micrometer which is graduated to control measurements to a limit of 0.0001 inch. Measuring a ball at several points over the surface of the anvils will show up any error in parallelism. Parallelism can be tested by means of two balls mounted in an aluminum holder. If the anvils are in error more than the allowable maximum, the micrometer should be returned to the manufacturer for repair.

i. In adjusting a micrometer to read correctly, the thimble is not set to 0 when the anvil is in contact with the spindle, but is set at some dimension to distribute the error. For example, if a micrometer screw had an accumulating error of 0.0003 inch in the length of its travel, and it were set correctly at 0, it would be off 0.0003 at 1 inch. However, if the micrometer were set correctly in the center of its travel, it would be 0.00015 under at 0 and 0.00015 over at 1 inch, which is a much better condition. Because a micrometer does not return exactly to 0 when anvil and spindle contact does not mean that it is not adjusted properly. Turn the friction sleeve with a small spanner wrench to compensate for minor wear on anvil and spindle or on the screw, as shown in figure 60.

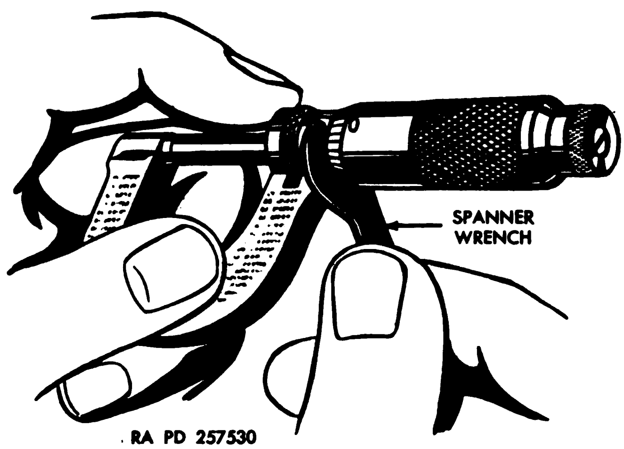

Figure 60. Micrometer adjustment.

Section X. SURFACE, DEPTH, AND HEIGHT GAGES

49. Purpose of Surface, Depth, and Height Gages
(figs. 61, 62, and 63)

a. Surface Gage. A surface gage is a measuring tool generally used to transfer measurements to work by scribing a line, and to indicate the accuracy or parallelism of surfaces.

b. Depth Gage. A depth gage is an instrument adapted to measuring the depth of holes, slots, counterbores, recesses, and the distance from a surface to some recessed part.

c. Height Gage. A height gage is used in the layout of jigs and fixtures, and on a bench, where it is used to check the location of holes and surfaces. It accurately measures and marks off vertical distances from a plane surface.

d. Surface Plate. A surface plate provides a true, smooth, plane surface. It is often used in conjunction with surface and height gages as a level base on which the gages and parts are placed to obtain accurate measurements.

50. Types of Surface Gages

The surface gage (fig. 61) consists of a base with an adjustable spindle to which may be clamped a scriber, or an indicator. Surface gages are made in several sizes and are classified by the length of the spindle, the smallest spindle being 4 inches long, the average 9 or 12 inches, and the largest 18 inches. The scriber is fastened to the spindle with a clamp. The bottom and the front end of the base of the surface gage have deep V-grooves cut in them which allows the gage to measure from a cylindrical surface. The base also has two gage pins for use against edge of surface plate or slot.

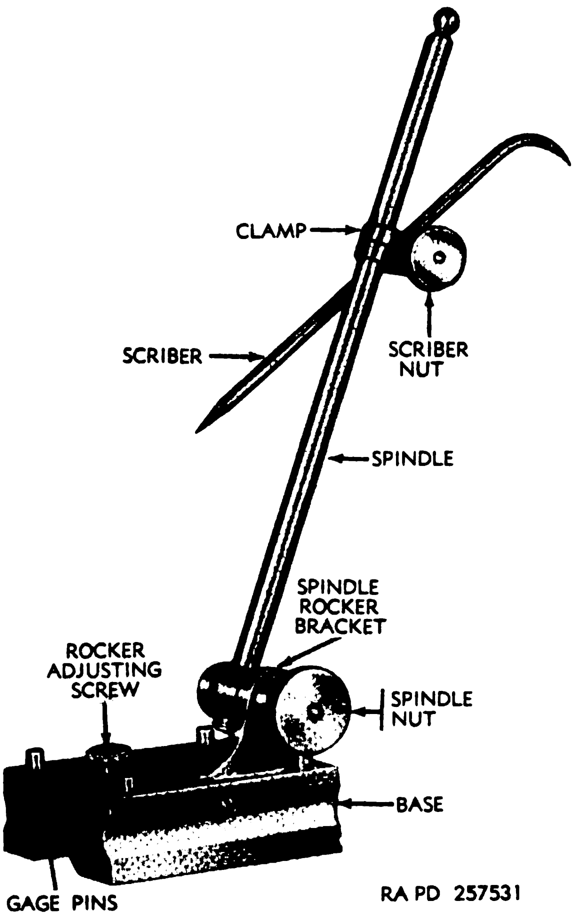

Figure 61. Surface gage.

51. Types of Depth Gages

a. Rule Depth Gage. The rule depth gage (fig. 62) is a graduated rule with a sliding head designed to bridge a hole or slot, and to hold the rule perpendicular to the surface from which the measurement is taken. This type has a measuring range of 0 to 5 inches. The sliding head has a clamping screw so that it may be clamped in any position. The sliding head is flat and perpendicular to the axis of the rule and ranges in size from 2 to 2⅝ inches wide and from ⅛ to ¼ inch thick.

b. Micrometer Depth Gage. The micrometer depth gage (fig. 62) consists of a flat base attached to the barrel of a micrometer head. These gages have a range from 9 to 9 inches, depending on the length of extension rod used. The hollow micrometer screw itself has a range of either ½ or 1 inch. Some are provided with a ratchet stop. The flat base ranges in size from 2 to 6 inches. Several extension rods are normally supplied with this type gage.

c. Vernier Depth Gage. The vernier depth gage (fig. 62) consists of a graduated scale, either 6 or 12 inches long, and a sliding head similar to the one on the vernier caliper. The sliding head is especially designed to bridge holes and slots. The vernier depth gage has the range of the rule depth gage and not quite the accuracy of a micrometer depth gage. It cannot enter holes less than ¼ inch in diameter, whereas a micrometer depth gage will enter a $\frac{3}{32}$-inch hole. However, it will enter a $\frac{1}{32}$-inch slot, whereas a micrometer gage will not. The vernier scale is adjustable and may be adjusted to compensate for wear.

52. Types of Height Gages

The vernier height gage (fig. 63) is a caliper with a special foot block to adapt it for use on a surface plate. Height gages are available in several sizes: the most common are the 10–, 18–, and 24–inch gages in English measure; and the 25– and 46–cm gages in Metric measure. Height gages are classified by the dimension they will measure above the surface plate. Like the vernier caliper, these height gages are graduated in divisions of 0.025 inch and a vernier scale of 25 units for reading measurements to thousandths of an inch. The 10–inch height gages are usually equipped with a scale and a design of foot block that permits them to be used as inside and outside vernier calipers.

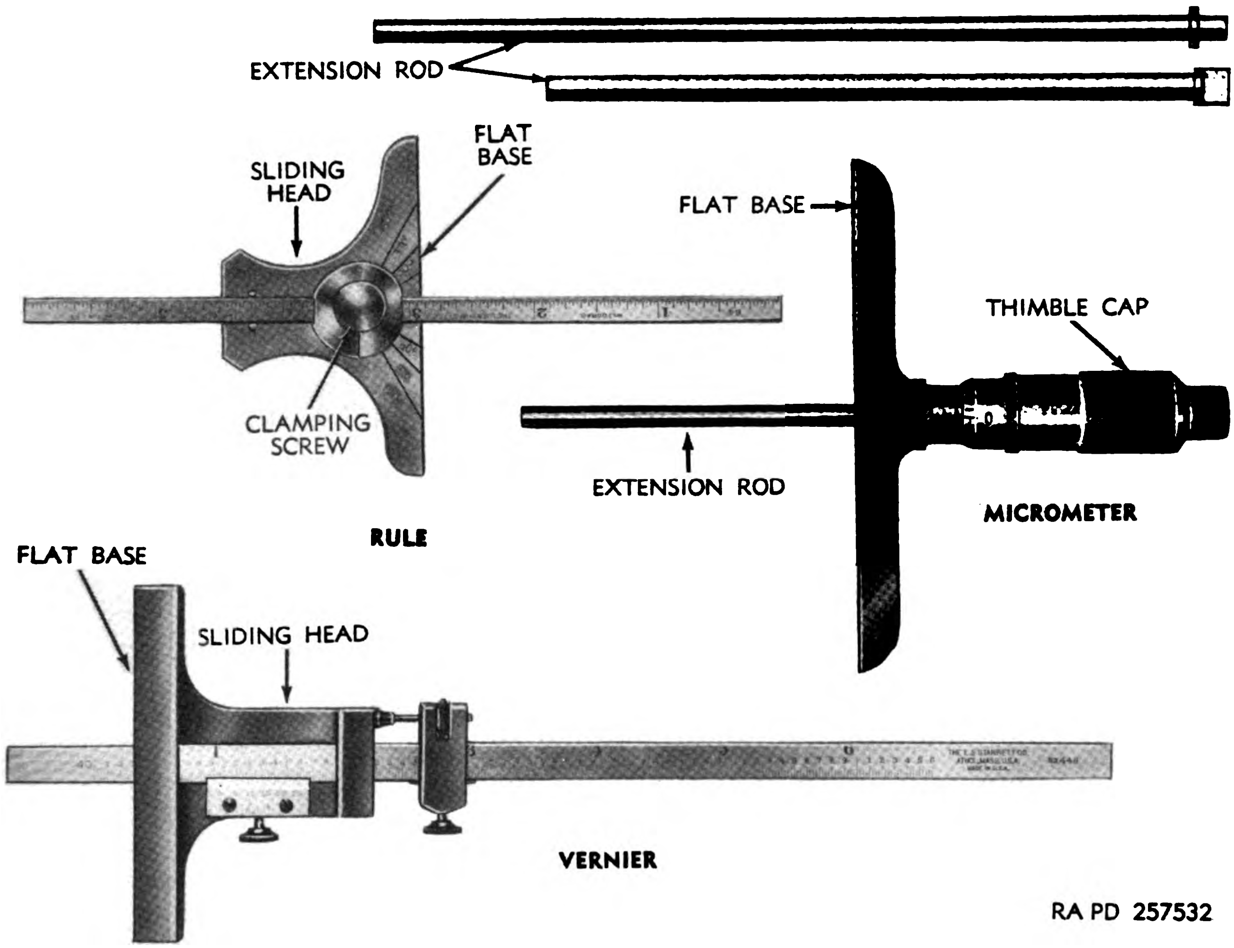

Figure 62. Types of depth gages.

53. Types of Surface Plates

Surface plates are usually made of close grained cast iron and are rectangular in shape. Three leveling screws are provided in the base of the plate. They are available in two sizes; 12 inches long by 8 inches wide and 36 inches long by 24 inches wide. Each plate has a wooden preserving cover and two carrying handles.

54. Use of Surface Gages

a. Adjustments. The spindle may be adjusted to any position with respect to the base and tightened in place with the spindle nut (fig. 61). The rocker adjusting screw provides for the finer adjustment of the spindle by pivoting the spindle rocker bracket. The scriber can be positioned at any height and in any desired direction on the spindle by tightening the scriber nut. The scriber may also be mounted directly in the spindle nut mounting, in place of the spindle, and used where the working space is limited and the height of the work is within range of the scriber.

b. Applications. A surface gage may be considered either as a nonprecision measuring tool or as a precision tool, depending on the measuring tool used in connection with it.

(1) *Lay out work.* When equipped with a scriber, the gage is considered a nonprecision tool. It is often necessary to prepare the surface of the work when using the scriber so that the line will be clean cut and visible. When scribing rough castings, chalk the surface and rub it in. On smooth or finished surfaces, a solution of copper sulphate and nitric acid may be used

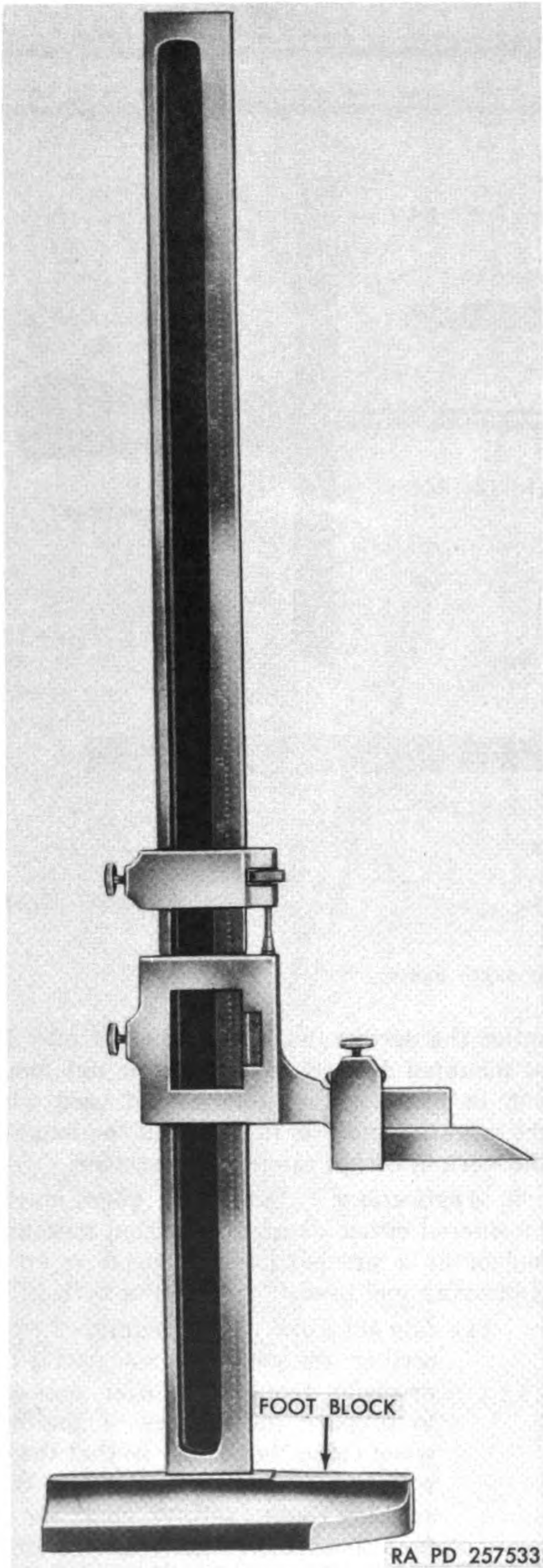

Figure 63. Vernier height gage.

to produce a dull reddish brown coat on the surface. The scribed lines will show up distinctly against the dark background. If the temper of the work is not to be considered, the part may be blued by heating it and the lines scribed on this surface.

(*a*) Figure 64 shows the surface gage being set to the scale of a combination square on a surface plate previous to scribing a surface. Note that the final adjustment of the scriber point is being made with the rocker adjusting screw.

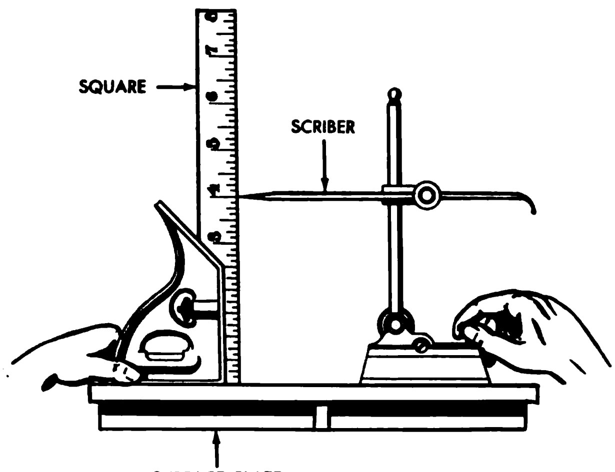

Figure 64. Setting surface gage scriber on surface plate.

(*b*) A common use of the surface gage is to locate a point on a fixture, as shown in figure 65. Here again, the surface plate is used as a level base.

(*c*) The gage pins (fig. 61) in the base permits the surface gage to be used against the edge of a machine table or of a surface plate in laying out and lining up work. The pins are pushed down to bear against the edge of the table or of the surface plate and the gage is moved along the edge to scribe a line.

(2) *Precision checking.* A surface gage used with a dial indicator makes the combination a precision measuring tool. Figure 66 shows the surface

gage in use with a dial indicator and a gage block checking the height and parallelism of the upper surface with respect to the lower surface of the part.

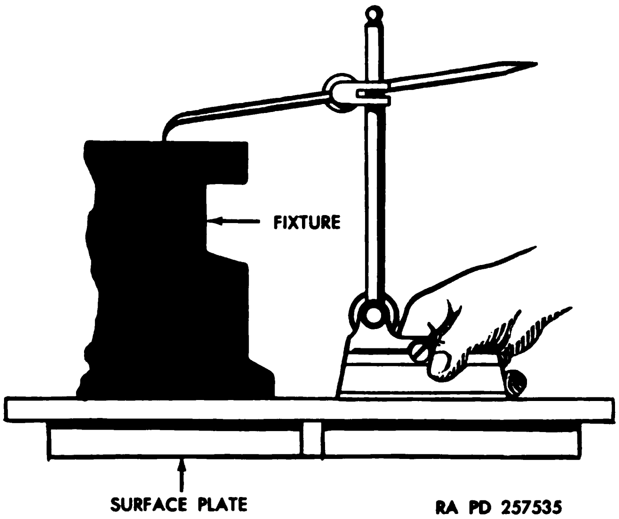

Figure 65. Locating point on fixture with surface gage.

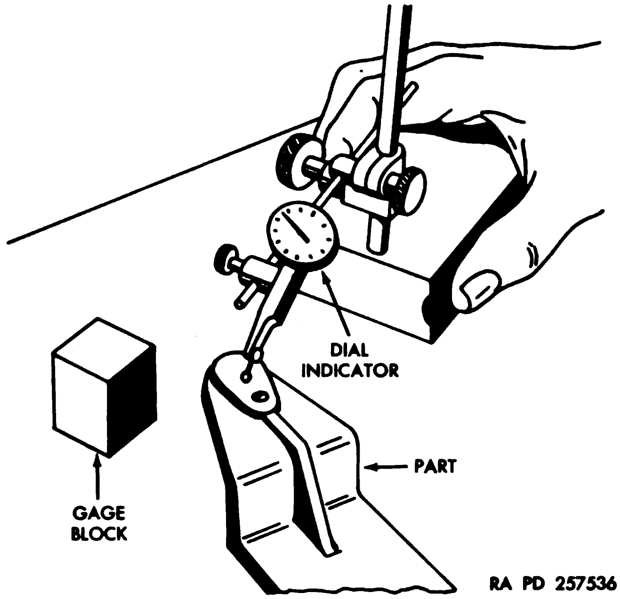

Figure 66. Surface gage used with dial indicator.

55. Use of Depth Gages

a. Rule Depth Gage. An application of the rule depth gage (fig. 62) to measure the depth of a slot from a nonadjacent shoulder is shown in A, figure 67. The use of this gage is limited by the width of its base. Depth measurements taken with this rule are not precise to thousands of an inch.

b. Micrometer Depth Gage. One application of the micrometer depth gage (fig. 62) is shown in B, figure 67. A measurement is taken between the end of a cylinder and a flange on the cylinder. To change extension rods, unscrew the thimble cap (fig. 62) and insert the desired length rod through the hollow micrometer screw. Screw thimble cap on to secure rod in place.

c. Vernier Depth Gage. The vernier depth gage in use checking a recess is shown in C, figure 67. This gage provides a precise measurement to a 0.001 of an inch.

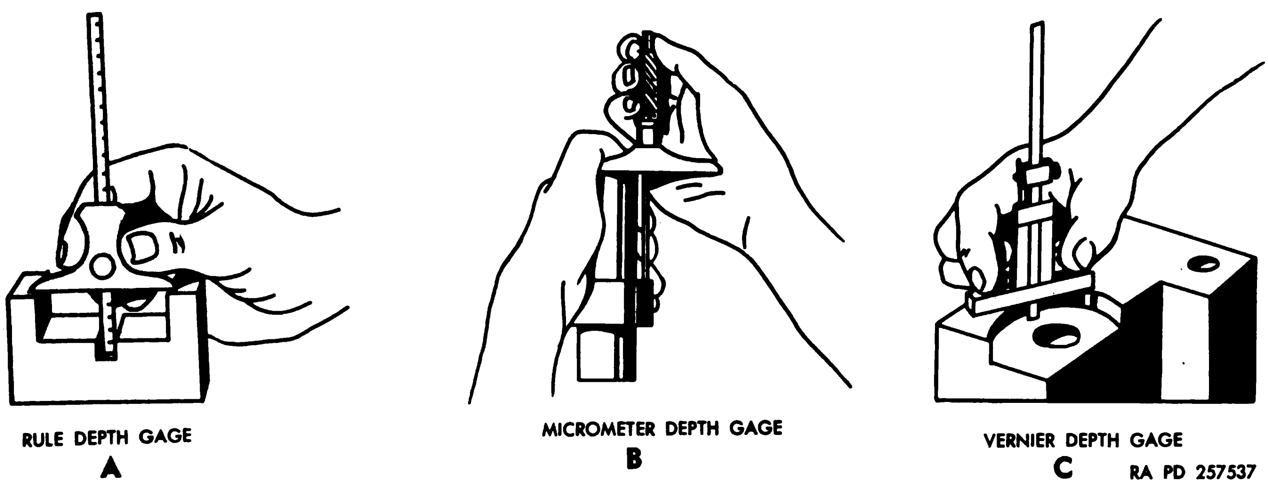

Figure 67. Using depth gages.

56. Use of Height Gages

Always be sure the bottom of the foot block (fig. 63) is clean and free from burs. Figure 68 shows the height gage with a tungsten carbide marker. This marker is used to lay out lines on glass, hardened steel, or other hard materials. Figure 69 illustrates the use of an offset scriber with height gage. This scriber reaches below the gage base. Do not attempt to adjust the sliding jaw while it is clamped to the upright.

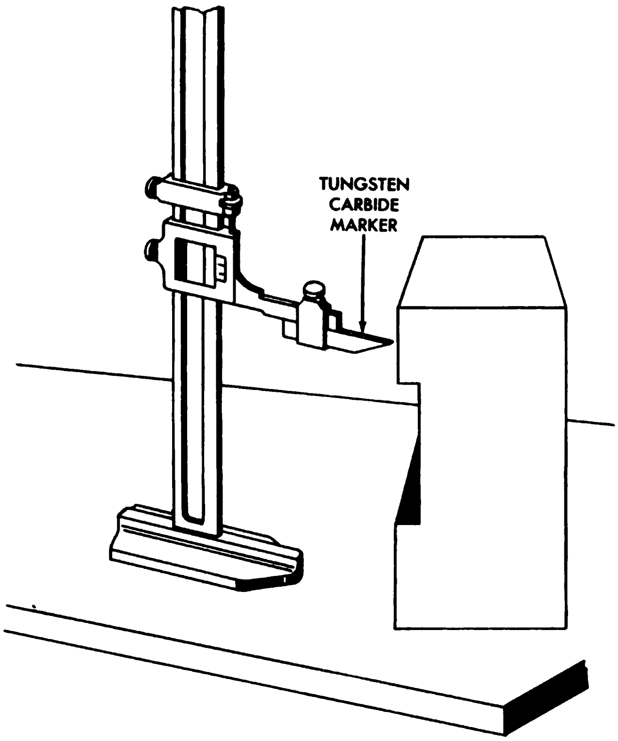

Figure 68. Using height gage with marker.

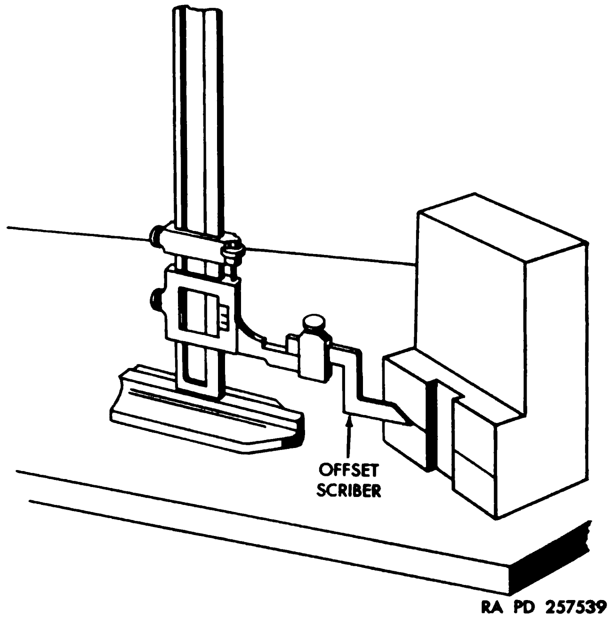

Figure 69. Using height gage with offset scriber.

57. Caring for Gages

Maintain and adjust the vernier gages as discussed in paragraph 43 (care of vernier calipers). Make sure all gages are carefully stored, using rust-preventive oil on all surfaces and wrapped in oiled paper. Store gages in separate containers—most gages are supplied in individual cases.

Section XI. PLUG, RING, AND SNAP GAGES AND GAGE BLOCKS

58. Purpose of Plug, Ring, and Snap Gages and Gage Blocks
(figs. 71–77)

Plug, ring, and snap gages, and precision gage blocks are used as standards to determine whether or not one or more dimensions of a manufactured part are within specified limits. Their measurements are included in the construction of each gage, and they are called fixed gages; however, some snap gages are adjustable. In the average shop, gages are used for a wide range of work, from rough machining to the finest tool and die making. The accuracy required of the same type gage will be different, depending on the application. The following classes of gages and their limits of accuracy are standard for all makes:

Class XX—(Male gages only). Precision lapped to laboratory tolerances. For master or setup standards.

Class X—Precision lapped to close tolerances for many types of masters and the highest quality working and inspection gages.

Class Y—Good lapped finish to slightly increased tolerances for inspection and working gages.

Class Z—Commercial finish (ground and

polished, but not fully lapped) for a large percentage of working gages in which tolerances are fairly wide, and where production quantities are not so large.

Class ZZ—(Ring gages only). Ground only to meet the demand for an inexpensive gage, where quantities are small and tolerances liberal.

Figure 70 charts the tolerances for various sized plug and ring gages in each class.

limit. Usually the "GO" and "NO GO" limits are stamped on the handles. Sometimes the "NO GO" plug is made shorter than the "GO" plug. When both gaging members are mounted on the same end, as shown in A, figure 72, the gage is known as a progressive, or stepped, plug gage. This gage is able to check the "GO" and "NO GO" dimension limits in one motion. Another style, shown in part B, figure 72, is a plain gage with only one plug or gaging member. Part C, figure 72, illustrates a

ABOVE	TO AND INCL.	(MALE GAGES ONLY) XX	X	Y	Z	(RING GAGES ONLY) ZZ
0.029	0.825	0.00002	0.00004	0.00007	0.00010	0.00020
0.825	1.510	0.00003	0.00006	0.00009	0.00012	0.00024
1.510	2.510	0.00004	0.00008	0.00012	0.00016	0.00032
2.510	4.510	0.00005	0.00010	0.00015	0.00020	0.00040
4.510	6.510	0.000065	0.00013	0.00019	0.00025	0.00050
6.510	9.010	0.00008	0.00016	0.00024	0.00032	0.00064
9.010	12.010	0.00010	0.00020	0.00030	0.00040	0.00080

XX Precision lapped (plugs or male masters only)
X Precision lapped plugs or rings
Y Lapped plugs or rings
Z Ground and polished (grinding marks may be in evidence)
ZZ Ground only (for rings only)

RA PD 257540

Figure 70. Plug and ring gage tolerance chart.

59. Types of Plug Gages

The design of plug gages has been standardized by the American Gage Design Committee to three different designs. Each design is for a specific range of sizes. Some plug gages are carboloy tipped.

a. Taper Lock Design. The taper lock design plug gages (fig. 71) usually range from 0.059 to 1.510 inches in diameter. This type gage has a tapered shank that fits snugly into the handle. A hole or slot is provided for the insertion of a drift pin for use in removing one gaging member. The two gaging members are known as the "GO" and "NO GO" plugs. The "GO" plug measures the lower limit of the hole and the "NO GO" checks the upper pilot end on the "GO" and to facilitate inserting the plug in soft metals. This prevents the shaving action which often results with the use of standard plugs.

b. Reversible Design. The reversible type of plug gage (A, figure 73) is usually made in larger dimensions covering a range of 1.510 to 8.010 inches in diameter. The gaging member is a cylinder with a hole through the center, which is counterbored from both ends. Three wedge-shaped locking prongs on the handle are forced into corresponding grooves in the gaging member by a single screw through the center which provides a self-centering support with a positive lock equivalent to that of a solid gage. Another style of reversible plug gage is shown

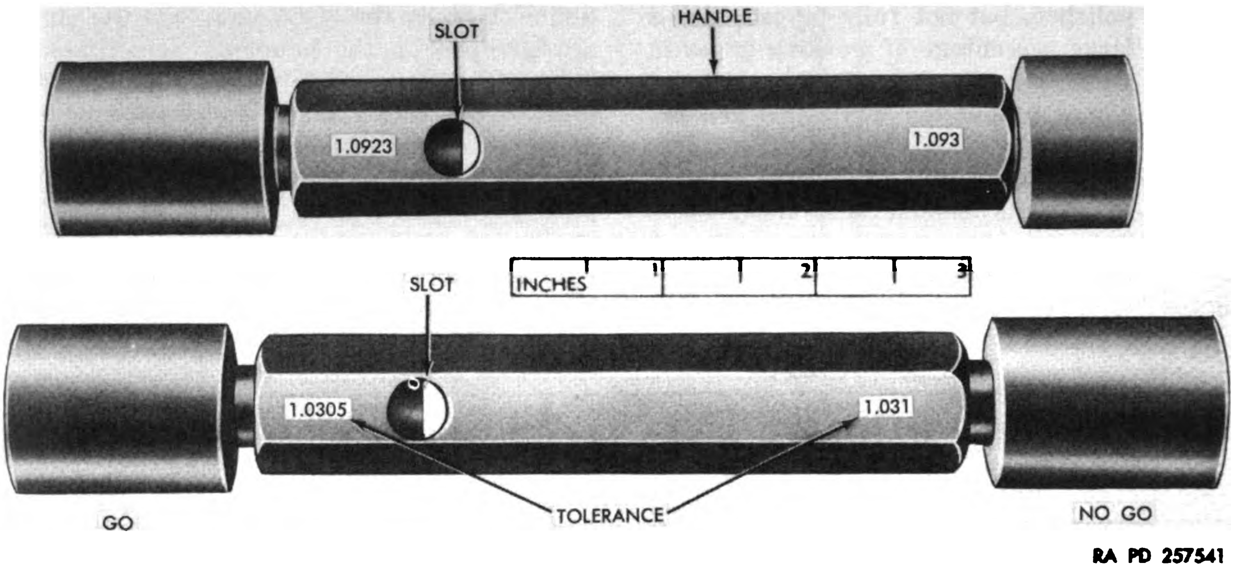

Figure 71. Taper lock plug gages.

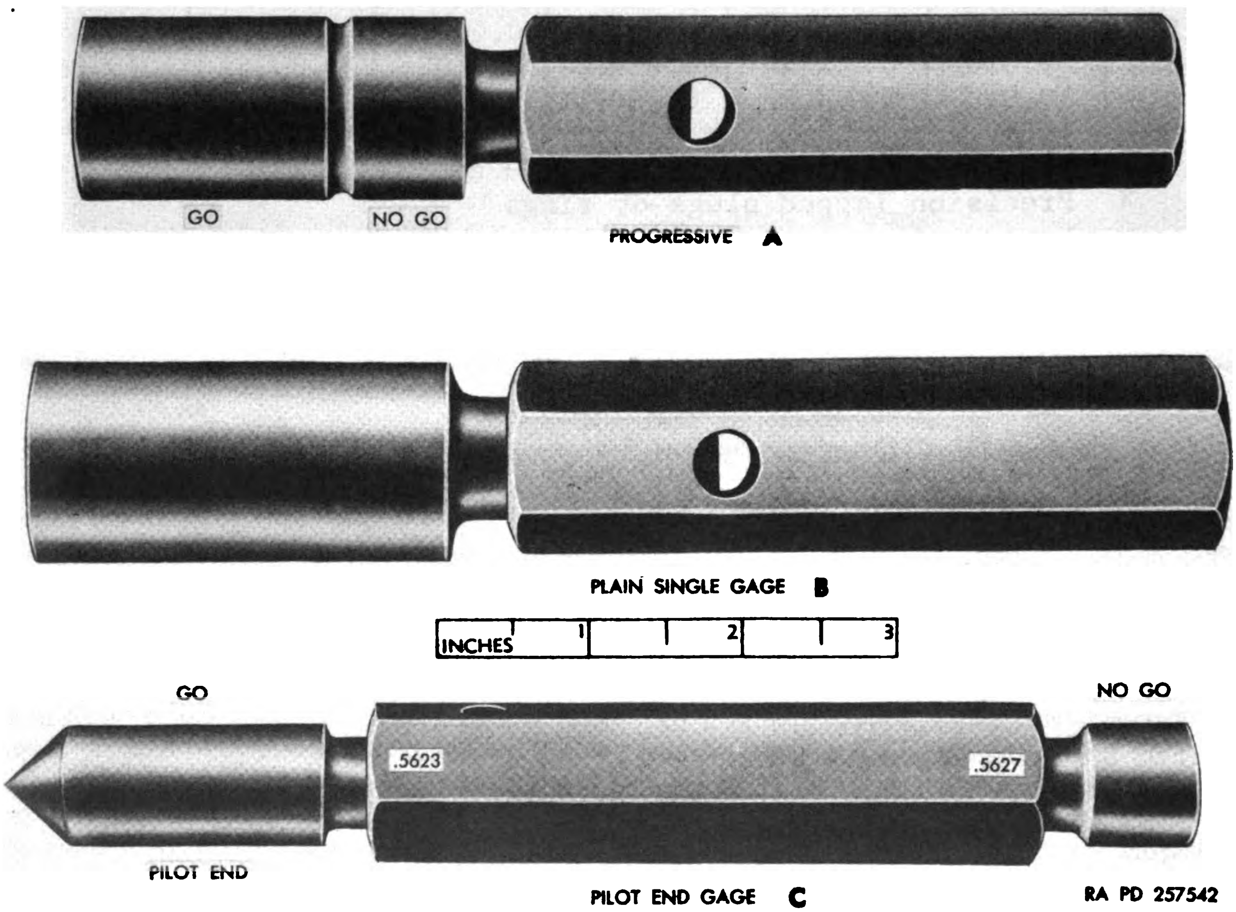

Figure 72. Progressive, plain, and pilot plug gages.

in B, figure 73. The small setscrews are loosened and the gages can be removed from the hande and reversed or pulled out enough so that they can be cut off at the end without need for shortening the gage.

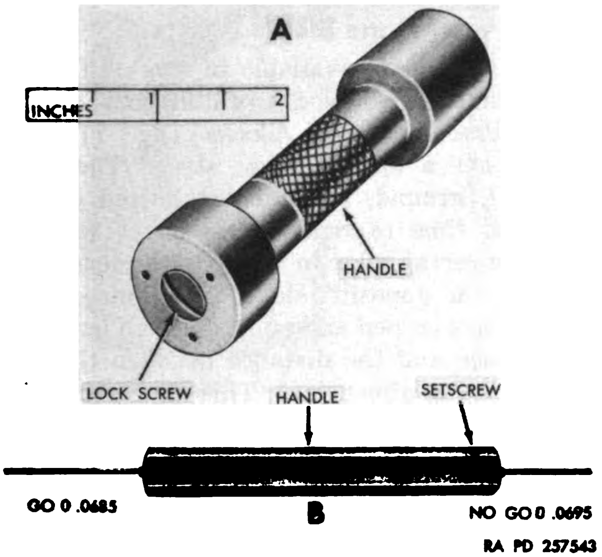

Figure 73. Reversible plug gages.

c. Annular Design. The annular design plug gage (not illustrated) has a rim and a web which has been bored out to reduce the weight. The web has four equally spaced threaded holes to receive handles or to provide a means of attaching the gage to a face plate.

60. Types of Ring Gages

The plain ring gage (fig. 74) is an external gage of circular form. The design of ring gages is standardized and they are made in four classes of finish and tolerance, as shown in figure 70 and described in paragraph 58. For sizes between 0.059 and 0.510 inch, ring gages are made with a hardened bushing pressed into a soft body, as shown in A, figure 74. The thickness of the gage will range from $\frac{3}{16}$ to $1\frac{5}{16}$ inches. On ring gages, the direction the gage tolerance is applied to is opposite to that applied on a plug gage; namely, the "GO" gage is larger than the "NO GO" gage. The "GO" and "NO GO" ring gages are separate units. They can be distinguished from each other by an annular groove cut in the knurled outer surface of the "NO GO" gage (fig. 74). Ring gages are made for diameters of 0.510 to 1.510 inches are the same as those shown in figure 74, except there is no bushing; they are made all in one piece. Ring gages, sized from 1.510 to 5.510 inches are made with a flange (B, fig. 74). This design reduces the weight, making the larger sizes easier to handle.

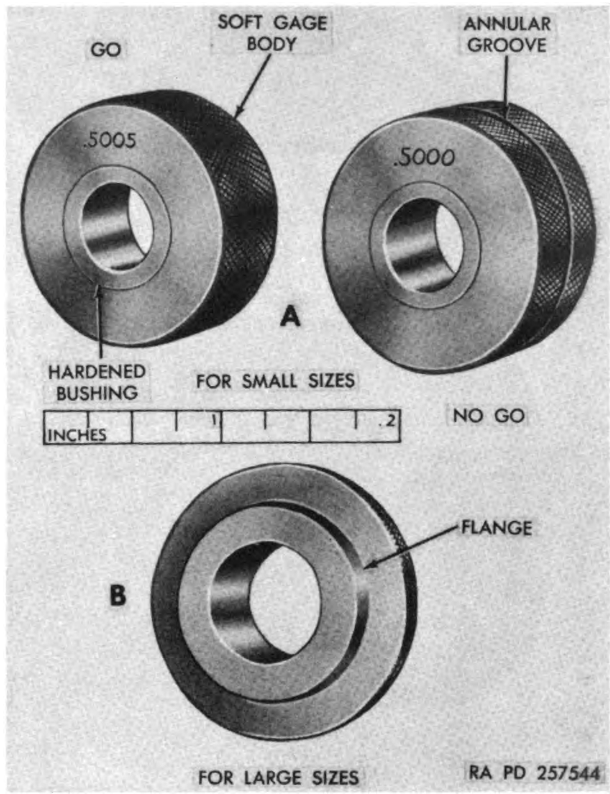

Figure 74. Plain ring gages.

61. Types of Snap Gages

The plain snap gage is made in two general types, the nonadjustable and adjustable.

a. Nonadjustable Type. The nonadjustable type is of solid construction, having two gaging member, "GO" and "NO GO" (A, fig. 75). The part to be inspected is first tried on the "GO" side and then the gage is reversed and the part tried on the "NO GO" side. Some solid snap gages have combined gaging members in the same set of jaws (B, fig. 75), known as a progressive snap gage. The outer member gages the "GO" dimension and the inner member the "NO GO" dimension.

b. Adjustable Type. Three standard designs of this type of snap gage are available,

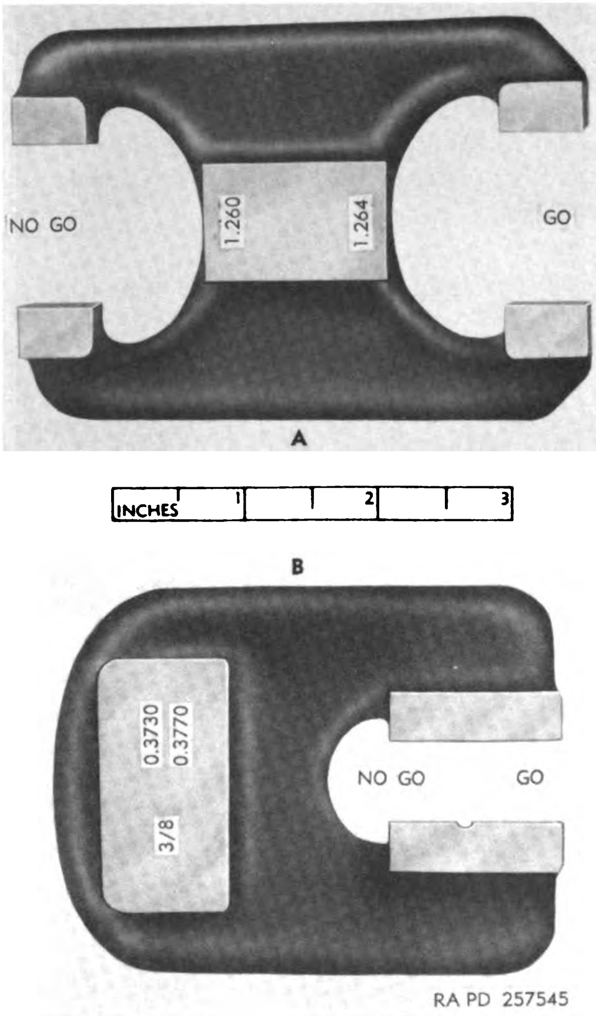

Figure 75. Nonadjustable snap gages.

consisting of a light, rigid frame with adjustable gaging pins, buttons, or anvils, which may be securely locked in place after adjustment, and locking screws which are tightened to hold the gaging dimensions.

(1) An adjustable snap gage made in sizes that range from ½ to 12 inches is shown in A, figure 76. It is equipped with four gaging pins and is suitable for checking the dimension between surfaces.

(2) B, figure 76, is made in sizes that range from ½ to 11¼ inches. It is equipped with four gaging buttons and is suitable for checking flat or cylindrical work.

(3) C, figure 76, is made in sizes from ½ to 11⅝ inches. It is equipped with two gaging buttons and a single block anvil, and is especially suitable for checking the diameters of shafts, pins, studs, and hubs.

62. Types of Gage Blocks

Gage blocks are available in sets of from 5 to as many as 85 blocks of different dimensions. Precision gage blocks (fig. 77) are made from a special alloy steel. They are hardened, ground, and then stabilized over a period of time to reduce subsequent waxing. They are rectangular in shape with measuring surfaces on opposite sides. The measuring surfaces are lapped and polished to an optically flat surface and the distance between them is the measuring dimension. This dimension may range from 0.010 inch up to 20 inches.

63. Use of Plug Gages

The "feel" in gaging is very important, since by sensing the side wobble with the fingers it can be determined whether or not the hole is either tapered or out-of-round. Do not clamp a plug gage in a vise or use a wrench to hold it, since you will lose the feel of gaging the part and may be exerting too much force, which will shorten the life of the plug gage. In general, a plug gage should enter a hole of the smallest correct size with the exertion of no more wrist force than is necessary to wind a watch. Make certain dirt, chips, and abrasive particles are removed from holes before inserting gage. Also, remove burs from drilled holes before gaging. Burs will scratch the gage surface and may work in between the gage and the wall of the hole and cause excessive wear or damage to the gage. Figure 78 shows the gaging of a hole in a bushing. Note that the 0.312 end enters the bushing and the 0.313 does not. By checking the bushing on both ends of the gage, the bushing hole diameter is established between two limits.

64. Use of Ring Gages

Ring gages are used more often in the inspection of finished parts than parts in process. The reason for this is that the finished parts are usually readily accessible; whereas, parts in a machine and when supported at both ends would have to be removed to gage them.

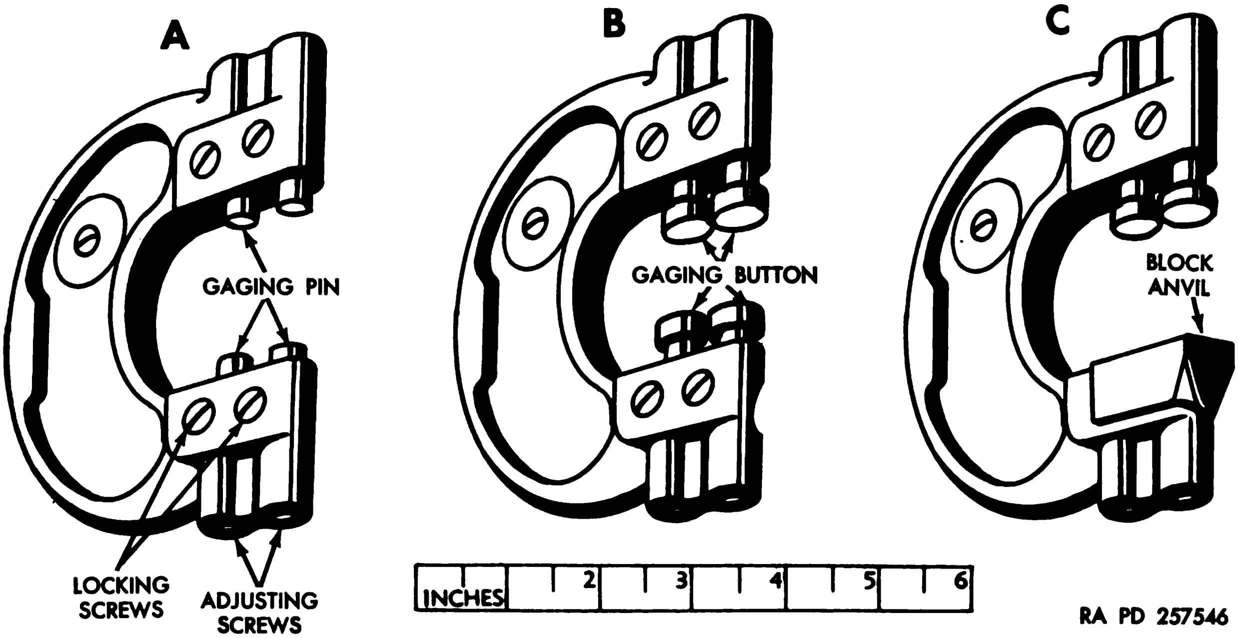

Figure 76. Adjustable snap gages.

Figure 77. Set of gage blocks.

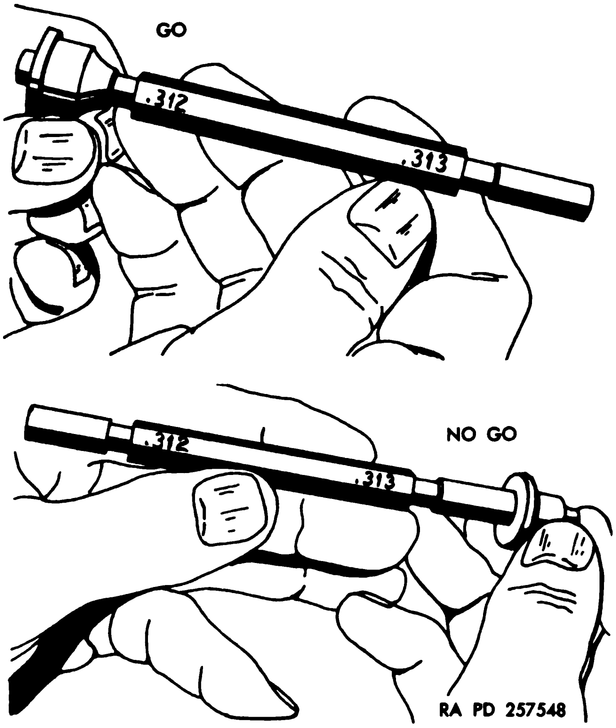

Figure 78. Gaging a bushing with plug gage.

Figure 79 shows a "GO" ring gage being used to check the shank diameter of a pivot stud. The stud is lined up with the hole and pressed in gently. If the stud does not enter, the shank is too large. If it does enter, the stud is not oversize. With the stud in the hole, check the piece for taper and out-of-roundness by sensing any wobble. After checking the part in the "GO" gage, check it in the "NO GO" gage. The stud must not enter this gage to establish it as being between the desired limits.

Note. The "GO" ring gage controls the maximum dimension of a part and "GO" plug gages control the minimum dimension of a hole. Therefore, "GO" gages control the tightness of fit of mating parts and "NO GO" gages control the looseness of fit of mating parts.

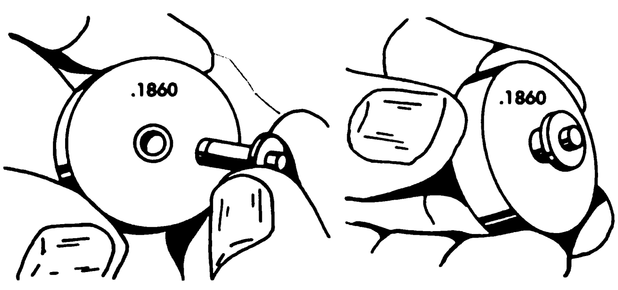

Figure 79. Gaging with a ring gage.

65. Use of Snap Gages

a. Adjusting a Snap Gage. Before an adjustable snap gage can be used to check parts, the "GO" and "NO GO" buttons, pins, or anvils must be set to the proper dimensions. The snap gage must first be clamped in a holder. Loosen the locking screws and turn the adjusting screws until the dimensions are set. The desired dimension may be taken from a master disk, a precision gage block, or a master plug. After adjusting for proper dimensions, with the master precision piece in place, tighten the locking screws. Recheck to make sure the dimensions have not changed before using the gage. Usually wax is melted into the heads of the screws to prevent or indicate tampering.

b. Application. The plain, adjustable limit snap gages can be used wherever ordinary calipers, micrometers, ring gages, and similar instruments are applicable. They are commonly used by machine operators to check a part at intervals, by process inspectors to check the accuracy of parts as they come off the machine, and by final inspectors to check parts before they are assembled. The snap gage is limited in the following respects:

(1) For checking of a small number of parts, it is more practical and time saving to use a micrometer or a vernier caliper, since the "GO" and "NO GO" dimensions must be set. It is not advisable to use this gage unless there are more than 50 parts to check.

(2) This gage checks a part at only one point at a time. If necessary to check the part in several places to control its accuracy, another type of gage may do the job better. For example, if necessary to check a shaft for out-of-roundness, and taper as well as diameter, it may be more practical to use a ring gage, since a ring gage checks all three in one gaging operation.

(3) The depth of the throat of the adjustable snap gage limits its use to around the edge of large, flat parts.

(4) The snap gage will not indicate how many thousandths of an inch remain to be taken off a part, although it indicates the part is still oversize.

Figure 80 shows a snap gage being used to gage the diameter of a shaft while it is in a machine. Figure 81 shows a pin being gaged by rolling it between the buttons and the anvil. Note that the pin checks all right since it passes the "GO" button and is stopped by the "NO GO" button.

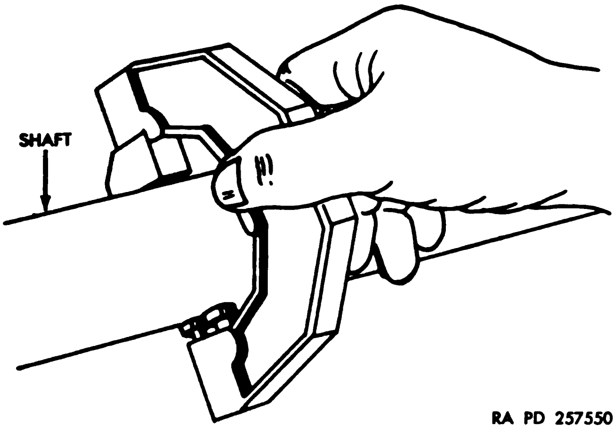

Figure 80. Measuring shaft diameter with snap gage.

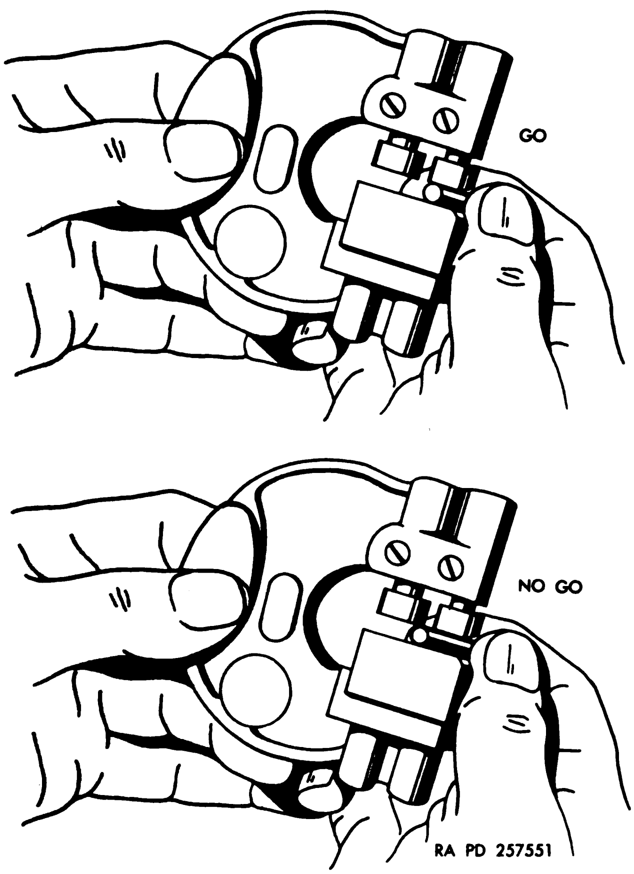

Figure 81. Measuring small pin with snap gage.

c. Gaging Flat Parts. The correct method of gaging a flat part is shown in figure 82.

(1) Position the gage so that the pins or buttons are square with the flat surfaces on the part.

(2) Using a slight hand pressure, push the gage over the part. The "GO" pins should pass over the part.

(3) If the part is within limits, the "NO GO" pins will stop the part, as shown in C, figure 82.

(4) If the part is undersize, it will be possible to push it past the "NO GO" pins, as shown in D, figure 82.

d. Gaging Cylindrical Parts. The correct procedure for gaging a cylindrical part is shown in figure 83. This procedure applies to large pieces and not to small parts, as shown in figure 81, which are rolled between the buttons and the anvil.

(1) Locate the gage on the part with the solid anvil on top, as shown in A, figure 83. Rock the gage, as indicated by the shaded segment in part B, figure 83, where the "GO" dimension is checked.

(2) If the shaft is not oversized, the first button will pass over it easily.

(3) Advance the gage to the position shown in part C, figure 83. If the "NO GO" button stops the gage, the shaft is within limits.

(4) If the gage can be rocked further to the position shown in D, figure 83, the part diameter is too small, since it has passed the "NO GO" button.

66. Use of Gage Blocks

a. Precautions. Before using gage blocks, remove the coat of rust-preventive compound with a chamois or a piece of cleansing tissue or by cleaning with an approved solvent. Gage blocks and any measuring tool used with them must be free of grease, oil, dirt, and other foreign matter to avoid a lapping action whenever the block is moved, and to assure accurate measurement. Use particular care when using gage blocks to measure hardened work to avoid scratching the measuring surfaces.

b. Wringing Gage Blocks Together. When building gage blocks to obtain a desired dimension, care should be exercised to avoid damaging them.

(1) Bring the chosen blocks together flat

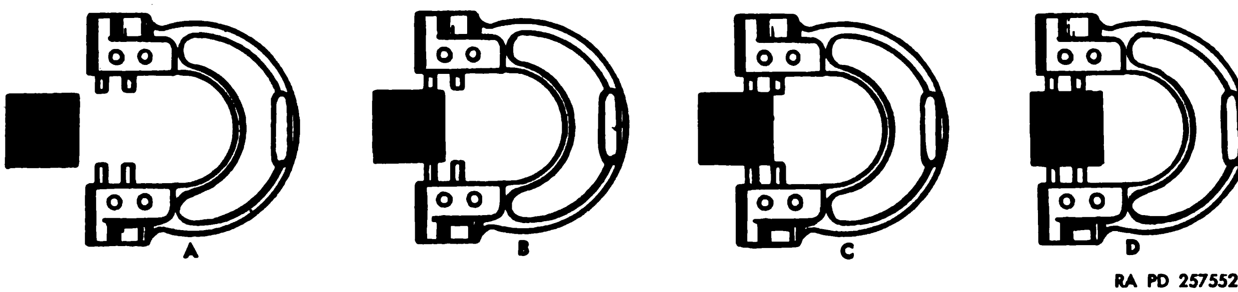

Figure 82. Measuring flat parts with snap gage.

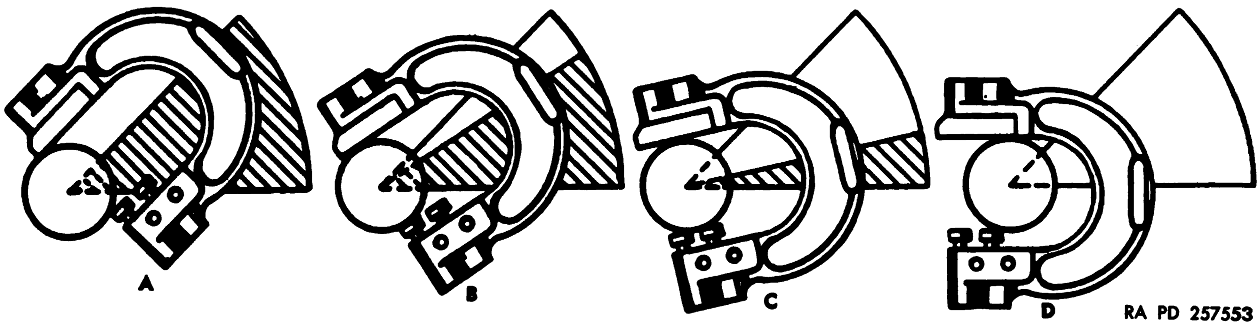

Figure 83. Measuring cylindrical parts with snap gage.

and oscillate them slightly, as shown in A, figure 84. This minimizes scratching as it will detect any foreign particles between the surfaces.

(2) Shift the blocks as shown in B, figure 84. If the blocks are clear they will begin to take hold.

(3) Slide the two blocks together, using a slight pressure and a rotary motion, as shown in C, figure 84.

(4) Shift gage blocks so that their sides are in line. Any combination of gage blocks may be stacked together in this manner. The combination will be as solid as a single block.

Note. The adhesive force that binds two gage blocks together is a combination of molecular attraction and the suction cup action due to the film of oil or moisture on the surfaces wrung together.

(5) Separate gage blocks by sliding them apart, using the same movement as when wringing them together.

Note. Do not leave blocks wrung together for long periods of time, since surfaces in contact will tend to corrode.

c. *Effect of Temperature.* Ordinary changes in temperature have a sizable effect on measurements made with precision gage blocks. The standard measuring temperature is 68° F., which is just a little lower than the average temperature in most shops. Since the room temperature affects the work as well as the block, the expansion in the work will be matched in most cases by a similar expansion in the block. The coefficient of linear expansion of several metals and blocks is listed below:

	millionths of an inch
Steel	5.5 to 7.2 per degree F.
Iron	5.5 to 6.7
Phosphor bronze	9.3
Aluminum	12.8
Copper	9.4
Gage blocks	6.36 to 7.0

Handle blocks only when they must be moved and hold them between the tips of the fingers so that the area of contact is small, and hold them for short periods of time only.

Note. Avoid conducting body heat into the block by careless handling. Body heat may raise the temperature of the block, causing a serious error in a measurement, particularly if a long stack of blocks is being handled.

When using gage blocks consider the sources of error resulting from temperature, and it will be found that—

(1) In measuring metals other than iron

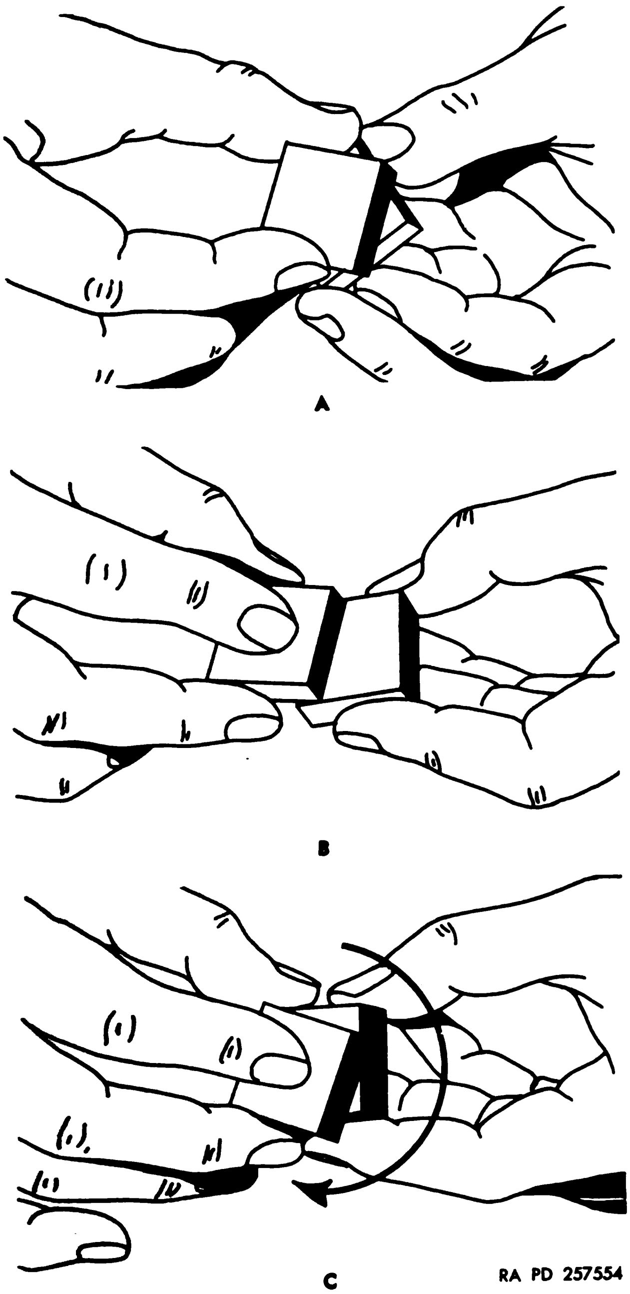

Figure 84. Wringing gage blocks.

and steel (such as aluminum) which have an appreciably different coefficient of linear expansion, there will be a difference between the room temperature measurment and the standard measuring temperature measurement.

(2) Careless handling of gage blocks may produce an error of several millionths of an inch and this error increases proportionally with the dimension of the block.

(3) The temperature of the work may be either lower or higher than the room temperature as a result of a machining operation and this difference may be sufficient to cause a sizable error.

d. Effect of Measuring Pressure. Theoretically, the measuring pressure should increase proportionally with the area of contact. For practical purposes, it is better to use a standard measuring pressure. The most commonly used pressure is ½ to 2 pounds.

e. Application. Gage blocks are used in the layout and in checking the accuracy of tools, dies, and fixtures. They are also used in machine setups and in checking parts in process of manufacture and in checking finished parts. Gage blocks are commonly used in setting adjustable instruments and indicating gages and verifying inspection gages. Gage blocks are used to verify the accuracy and wear of plug, ring, and snap gages, and many other special-purpose gages. The classification of blocks depends largely on the accuracy required. Typical classification is shown below.

Class	*Work*	*Error range millionths of an inch*
I	Verifying gages, setting instruments, and tool inspection.	5. to 20
II	Layout of jigs, fixtures, and dies, setting instruments, and tool inspection.	20 to 40
III	Setup of grinding, milling, and drilling machines, and parts inspection.	40 to 100

67. Care of Plug, Ring, and Snap Gages

a. Always make certain that the surfaces of the parts gaged and the gage itself are kept free from abrasives, dirt, grit, chips, and all foreign matter.

b. Always consider the abrasive action of the part on the gage. Cast iron, steel, and cast aluminum are both more abrasive than brass, bronze, and nonmetals such as plastics. Use particular care when gaging cast iron, steel, and cast aluminum.

c. The wear on a plug gage begins at the tip and gradually advances back along the gage. When the wear tolerance has reached the first quarter of an inch, the plug gage should be reprocessed or scrapped.

d. When gages are stored, arrange them neatly in a drawer or case so that they do not contact other tools or each other.

e. Always hold the gages in your hands when checking; never clamp them in a vise.

f. At frequent intervals, check all gages for accuracy and wear with gage blocks or master gages.

68. Care of Gage Blocks

a. Observe particular care when using gage blocks to measure hardened work. The danger of scratching is increased when the work is as hard as the block, or harder.

b. Never touch the measuring surfaces of blocks any more than necessary. Moisture of the hands contains an acid, which will eventually stain the blocks, if not removed.

c. Before using blocks, they must be free from grease, oil, dirt, and all foreign substances.

d. Every time a set of blocks is used, all the blocks which have been cleaned for use must be covered with a film of acid-free oil, such as boiled petrolatum, before they are put away. Wipe them with an oiled chamois as you return the blocks to their places in the case.

Section XII. MISCELLANEOUS MEASURING GAGES

69. Description and Purpose of Gages (figs. 85–92)

a. *Thickness (Feeler) Gages.* These gages are fixed in leaf form, which permits the checking and measuring of small openings such as contact points, narrow slots, and so forth. They are widely used to check the flatness of parts in straightening and grinding operations and in squaring objects with a try square.

b. *Wire and Drill Gages.* The wire gage is used for gaging metal wire, and a similar gage is also used to check the size of hot and cold rolled steel, sheet and plate iron, and music wire. Drill gages determine the size of a drill and indicate the correct size of drill to use for given tap size. Drill number and decimal size is also shown in this type gage.

c. *Drill Rods or Blanks.* Drill rods or blanks (not illustrated) are used on line inspection work to check the size of drilled holes in the same manner as with plug gages (par. 63). They are also used for setup inspection to check the location of holes.

d. *Thread Gages.* Among the many gages used in connection with the machining and inspection of threads are the center gage and the screw pitch gages.

(1) *Center gage.* The center gage is used to set thread cutting tools. Four scales on the gage are used for determining the number of threads per inch.

(2) *Screw pitch gage.* Screw pitch gages are used to determine the pitch of an unknown thread. The pitch of a screw thread is the distance between the center of one tooth to the center of the next tooth.

e. *Small Hole Gage Set.* This set of 4 or more gages is used to check dimensions of small holes, slots, grooves, and so forth; from approximately 1/8 to 1/2 inch in diameter.

f. *Telescoping Gages.* These gages are used for measuring the inside size of slots or holes up to 6 inches in width or diameter.

g. *Thread Cutting Tool Gages.* These gages provide a standard for thread cutting tools. They have an inclosed angle of 29° and include a 29° setting tool. One gage furnishes the correct form for square threads and the other for Acme standard threads.

h. *Fillet and Radius Gages.* These gages are used to check convex and convave radii in corners or against shoulders.

i. *Drill Point Gage.* This gage is used to check the accuracy of drill cutting edges after grinding. It is also equipped with a 6-inch hook rule. This tool can be used as a drill point gage, hook rule, plain rule, and a slide caliper for taking outside measurements.

j. *Marking Gauges.* A marking gage is used to mark off guidelines parallel to an edge, end, or surface of a piece of wood. It has a sharp spur or pin that does the marking.

k. *Tension Gage.* This type of gage (not illustrated) is used to check contact point pressure and brush spring tension in 1 ounce graduations.

l. *Saw Tooth Micrometer Gage.* This special gage (not illustrated checks the depth of saw teeth in thousands of an inch from 0 to 0.075 inch.

70. Types of Thickness (Feeler) Gages

Thickness (feeler) gages are made in many shapes and sizes; usually 2 to 26 blades are grouped into one tool and graduated in thousandths of an inch. Most thickness blades are straight, while others are bent at the end at 45° and 90° angles. Some thickness gages are grouped so that there are several short and several long blades together. Thickness gages are also available in single blades and in strip form for specific measurements. For convenience, many groups of thickness gages are equipped with a locking screw in the case that locks the blade to be used in the extended position. Figure 85 shows several types of thickness gages supplied by the Army Ordnance supply system.

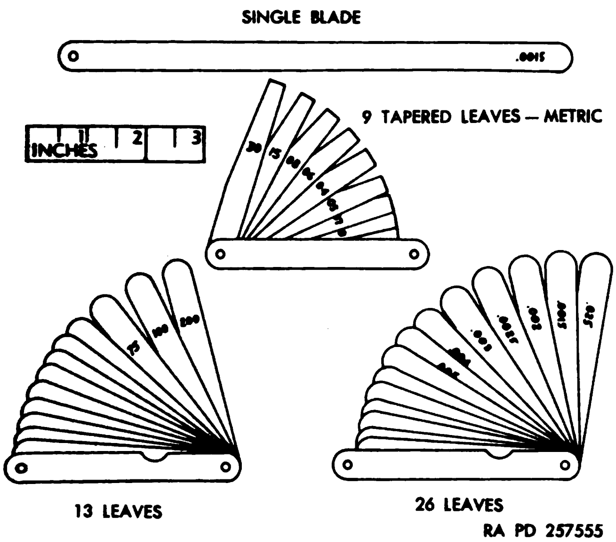

Figure 85. Thickness (feeler) gages.

71. Types of Wire and Drill Gages

a. Twist Drill and Drill Rod. The twist drill and drill rod gage (fig. 86) has a series of holes with size and decimal equivalents stamped adjacent to each hole. One gage measures drill sizes Nos. 1 to 60; the other gage measures drill sizes $\frac{1}{16}$ to ½ inch by $\frac{1}{64}$-inch intervals.

b. Wire Gages. A wire gage (fig. 86) is circular in shape with cutouts in the outer perimeter. Each cutout gages a different size wire, from 0 to 36 of the English Standard Wire Gage. A separate gage is used for American standard wire and another for U.S. standard sheet and plate iron and steel.

72. Types of Thread Gages

a. Center Gage. The center gage (fig. 87) is graduated in 14ths, 20ths, 24ths, and 32ds of an inch. The back of the center gage has a table giving the double depth of thread in thousandths of an inch for each pitch. This information is useful in determining the size of tap drills. Sixty-degree angles in the shape of the gage are used for checking Unified and American threads as well as for older American National or U.S. standard threads and for checking thread cutting tools.

b. Screw Pitch Gages. Screw pitch gages (fig. 87) are made for checking the pitch of U.S. Standard, Metric, National Form, V-form, and Whitworth cut threads. These gages are grouped in a case or handle, as are the thickness gages. The number of threads per inch is stamped on each blade. Some types are equipped with blade locks. The triangular shaped gage has 51 blades covering a very wide range of pitches, including 11½ and 27 threads per inch for V-form threads.

73. Types of Small Hole and Telescoping Gages

a. Small Hole Gages. Small hole gages (fig. 88) are adjustable, having a rounded measuring member. A knurled screw in the end of the handle is turned to expand the ball-shaped end in small holes and recesses. A micrometer caliper is used to measure the ball end. Maximum measuring capacity is ½ inch.

b. Telescoping Gages. Telescoping gages (fig. 88) are used to gage larger holes and to measure inside distances. These gages are equipped with a plunger that can be locked in the measuring position by a knurled screw in the end of the handle. Maximum measuring capacity is 6 inches. Measurements must be calipered on the gage by a micrometer, as in the case of the small hole gages.

74. Types of Thread Cutting Tool Gages

Thread cutting tool gages (fig. 89) are hardened steel plates with cutouts around the perimeter. Each cutout is marked with a number that represents the number of threads per inch.

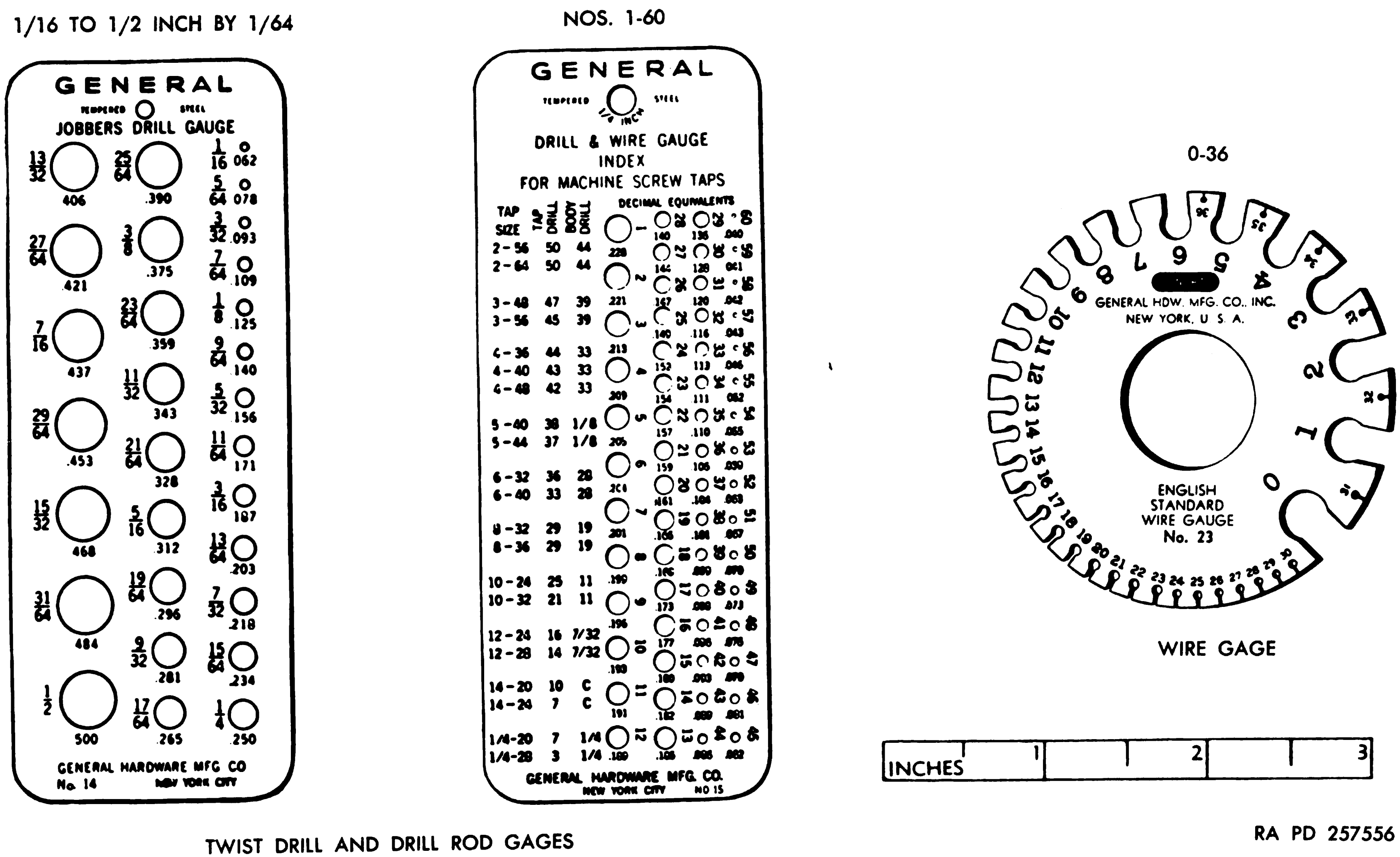

Figure 86. Drill and wire gages.

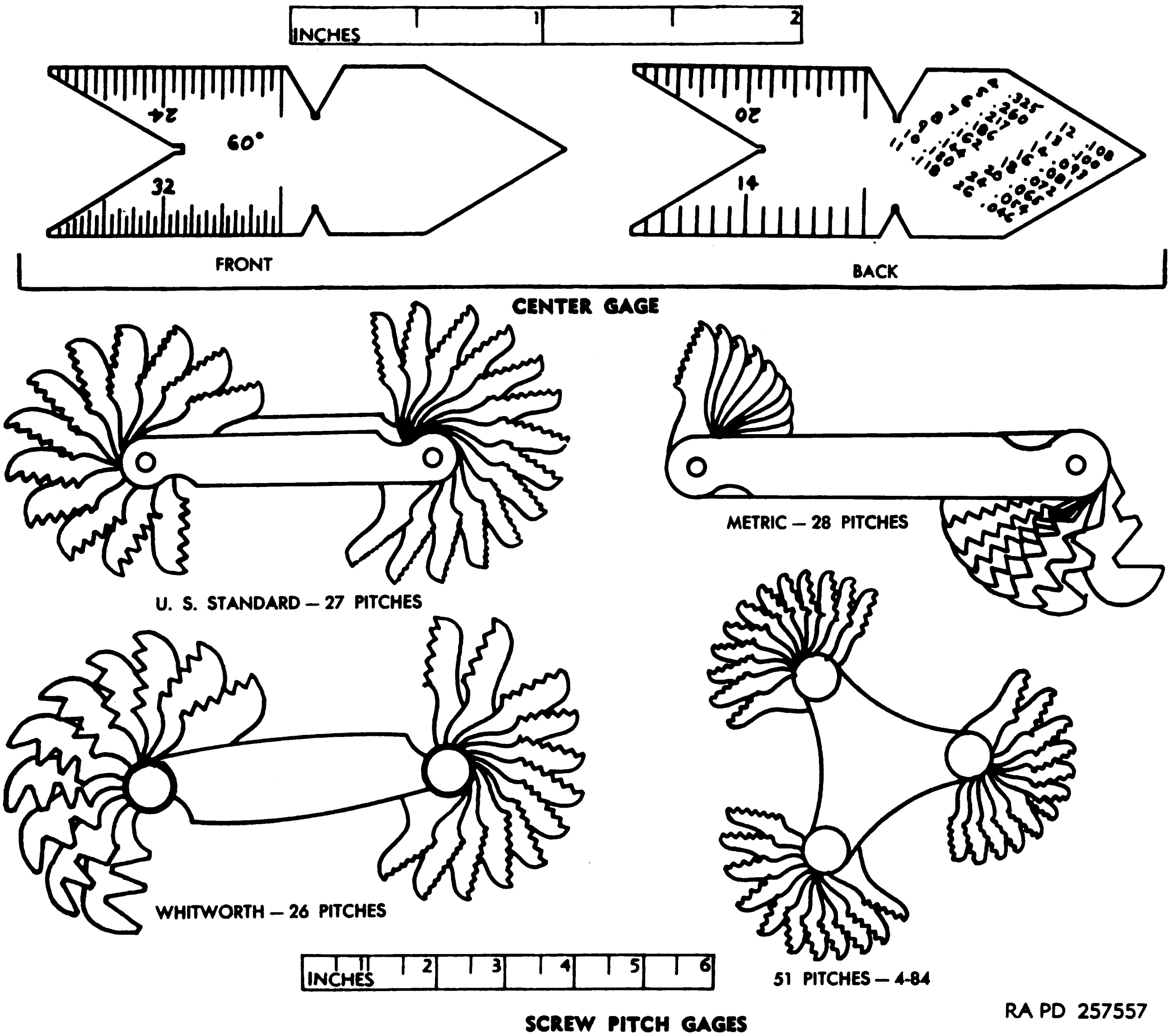

Figure 87. Center and screw pitch thread gages.

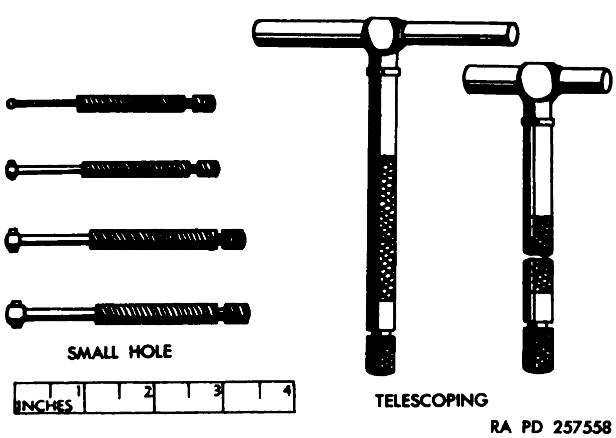

Figure 88. Small hole and telescoping gages.

A 29° angle, included with each gage, is used to set the thread cutting tool. One gage is used for Acme standard threads and the other for square cut threads.

75. Types of Fillet and Radius Gages

The blades of fillet and radius gages are made of hard rolled steel. The double ended blades of gage (A, fig. 90) have a lock which holds the blades in position. The inside and outside radii of the same are on one blade. The other gage (B, fig. 90) has separate blades for inside and outside measurements. Each blade of each gage is marked in 64ths. Gage A, figure 90, has a range of sizes from $^{17}/_{64}$ to

½ inch. Gage B, figure 90, has a range of sizes from 1/32 to 17/64 inch. Each gage has 16 blades.

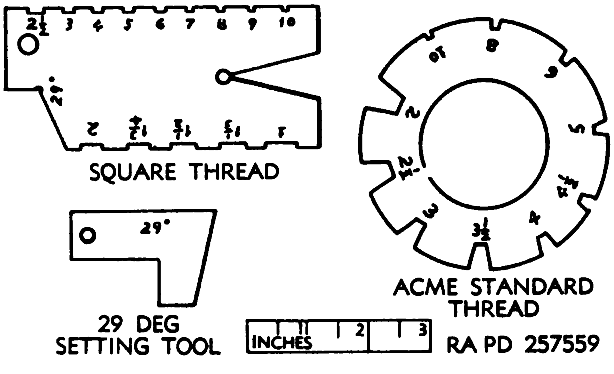

Figure 89. Thread cutting tool gages.

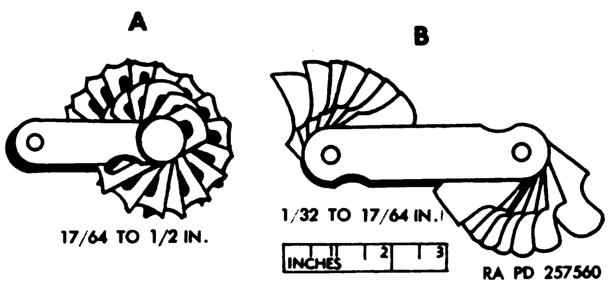

Figure 90. Fillet and radius gages.

76. Types of Drill Point Gages

The drill point gage (fig. 91) consists of a 6-inch hook rule with a 59° sliding head that slides up and down the rule. The sliding head can be locked at any position on the rule. The sliding head is graduated in 1/32 inch.

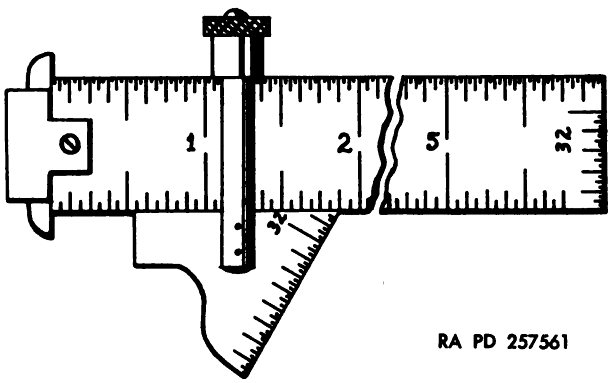

Figure 91. Drill point gage.

77. Types of Marking Gages

Marking gages (fig. 92) are made of wood or steel. They consist of a graduated beam about 8 inches long, on which a head slides. The head can be fastened at any point on the beam by means of a thumbscrew. The thumbscrew presses a brass shoe tightly against the beam and locks it firmly in position. A steel pin or spur marks the wood. The spur projects from the beam about 1/16 inch.

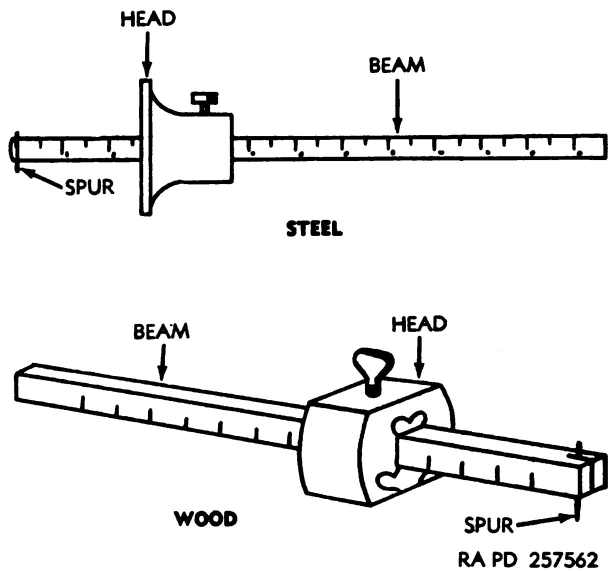

Figure 92. Marking gages.

78. Use of Thickness (Feeler) Gages

Thickness (feeler) gages are used in one of two ways, as a means for determining a measure or a means for adjusting to a definite limit. Part A, figure 93, shows a thickness gage being used to check piston ring gap clearance in a cylinder bore. A long glade thickness gage is being used to determine the fit between large mating surfaces in B, figure 93. By combining blades it is possible to obtain a wide variation of thicknesses.

79. Use of Wire and Drill Gages

The use of a drill gage is shown in A, figure 94. The size of a drill is being determined; the drill size or number and decimal size are stamped on the gage beside each hole. A chart on the gage indicates the correct size of drill to use for a given tap size. Determine the size of both sheet stock and wire by using a correct sheet and plate or wire gage as shown in B, figure 94.

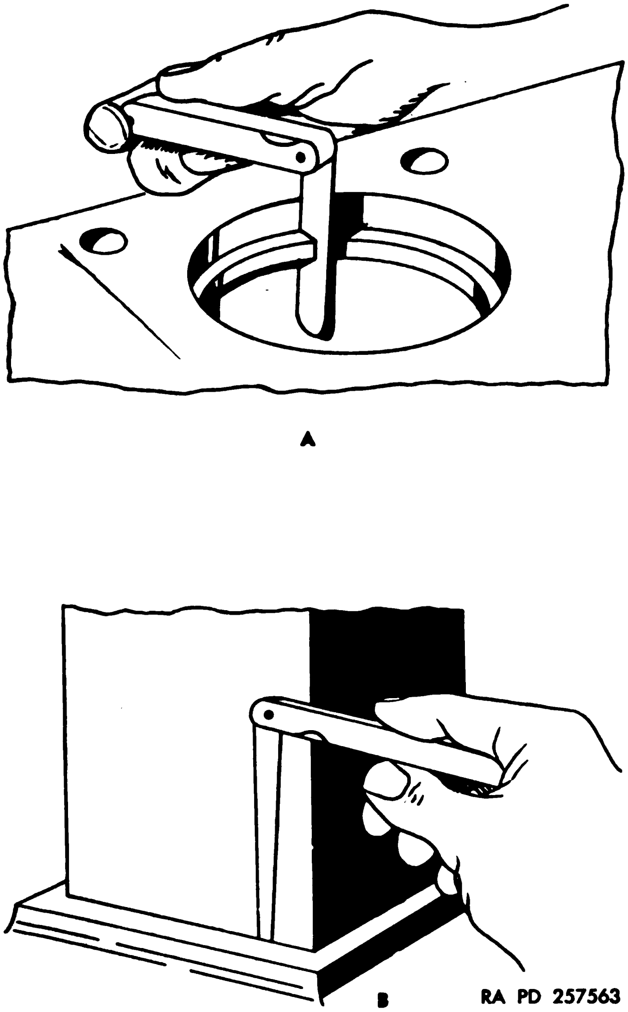

Figure 93. Using thickness (feeler) gages.

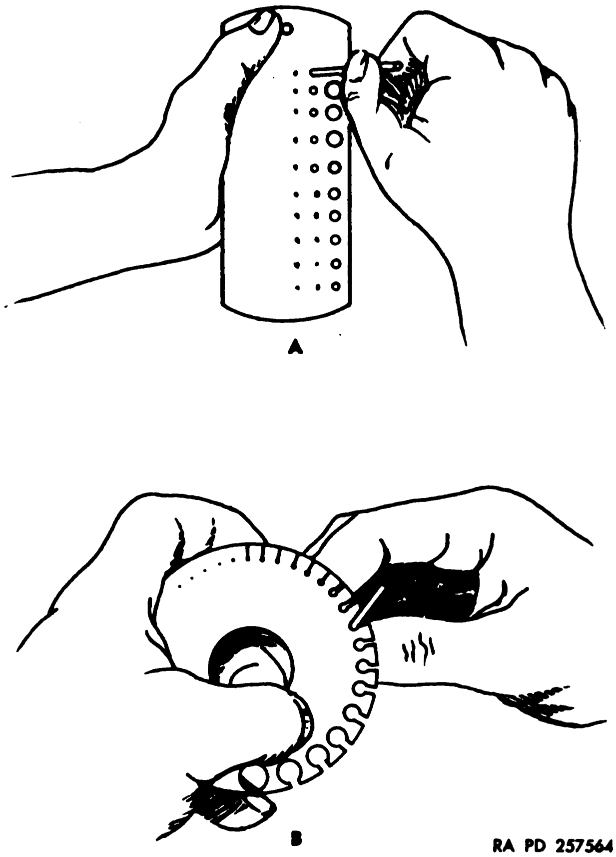

Figure 94. Using drill and wire gages.

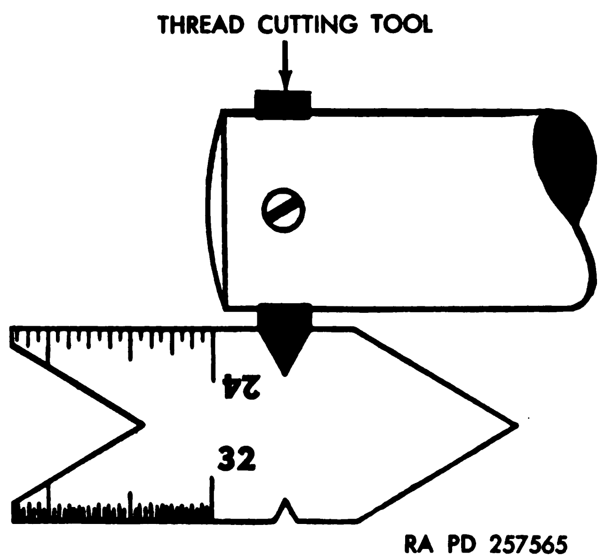

Figure 95. Using center gage.

80. Use of Thread Gages

a. Center Gage. Check the angle of thread cutting tools as shown in figure 95. The gage is also used to check cut threads and the scales are used to measure threads per inch.

b. Screw Pitch Gages. If the pitch of a thread is not known, it can be determined by comparing it with the standards on the various screw pitch gages. Place a blade of a gage over the threads, and check to see whether it meshes; if not, successively check each blade of the gage against the thread until it meshes. The pitch can be read off the correct blade. The blades are made pointed so that they can be inserted in small nuts to check inside threads as well as outside threads. Refer to figure 96 for use of screw pitch gages.

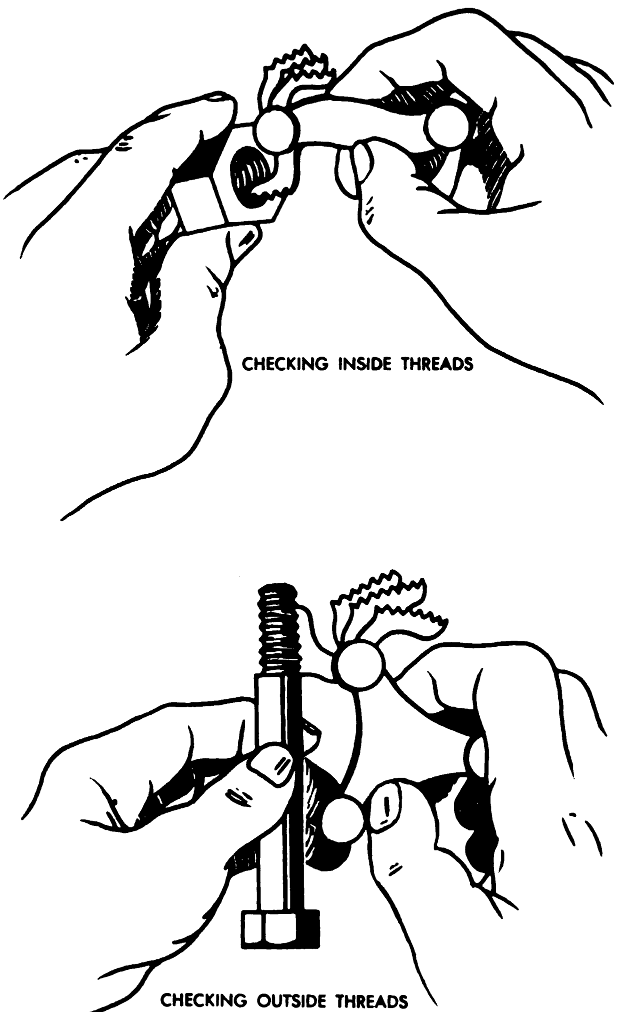

Figure 96. Using screw pitch gages.

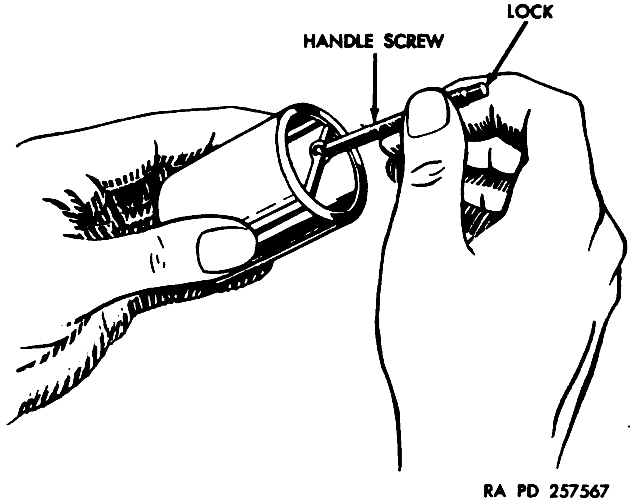

Figure 97. Using telescoping gage.

81. Use of Small Hole and Telescoping Gages

a. These gages are used when measurements cannot be taken with a standard micrometer, or for which there are no plug gages available. Telescoping gages are particularly adaptable for rough bored work and odd sizes and shapes of holes. Compress plungers and lock by turning handle screw. Insert gage in hole (fig. 97); release lock; plunger expands to exact size of hole. Lock plunger by turning handle. After locking, remove the gage and check measurement with a micrometer.

b. The small hole gages perform the same function as telescoping gages, except that they are used in smaller work. Fit the ball-shaped point into the hole or slot as shown in A, figure 98; expand the ball-shaped end by turning the

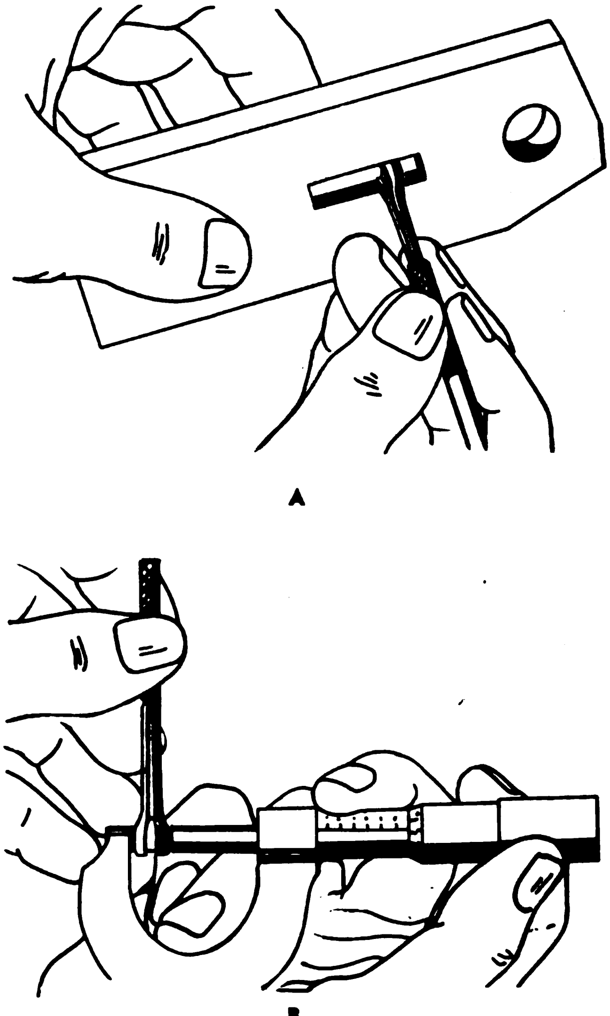

Figure 98. Using small hole gage.

screw at the end of the handle. Use micrometer to gage the measurement, as shown in B, figure 98.

82. Use of Thread Cutting Tool Gages

To check the correct form of a thread cutting tool, place thep roper gage over the tool, as shown in figure 99. The Acme standard gage is used here. The tool must mesh properly with no light showing between the tool and the gage. Use 29° angle as a guide when grinding cutting tool. After tool fits the angle, the point should be ground off to fit the proper place on the gage for the particular number of threads per inch to be cut.

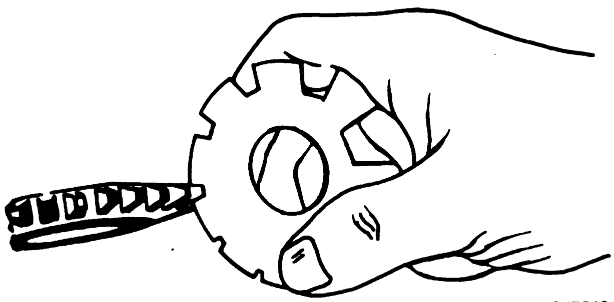

Figure 99. Using thread cutting tool gage.

83. Use of Fillet and Radius Gages

A double ended radius gage blade being used to check the inside corner or fillet of a machined part is shown in A, figure 100. Each blade can be locked in position by tightening the clamp. These gages can be used in any position and at any angle for both inside and outside radii (B, figure 100).

84. Use of Drill Point Gage

The method for sharpening the cutting edges of a drill is to do one lip at a time. Each lip must have the same length and have the same angle in relation to the axis of the drill. Set the sliding head securely on the rule at the mark equal to the length of the drill. Place the drill vertically against the rule so that the drill lip contacts the 59° angle of the sliding head. Hold up to light; correct angle is obtained when no light is seen between gage and drill.

85. Use of Marking Gages

A marking gage must be adjusted by setting the head the desired distance from the spur. Although the bar of a marking gage is

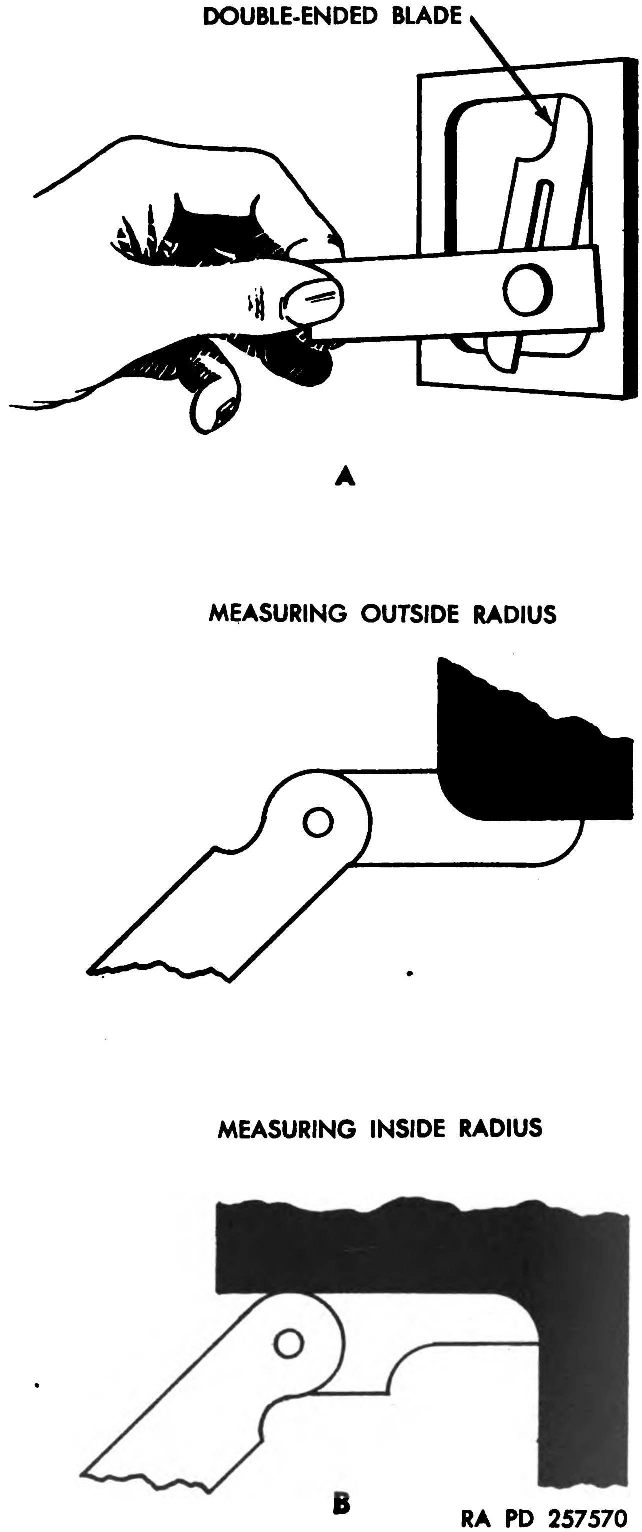

Figure 100. Using fillet and radius gages.

graduated in inches, the spur may work loose or bend. If this occurs, accurate measurement should be made with a rule between the head and spur (A, fig. 101). To draw a line after setting gage, grasp the head with the palm and fingers (B, fig. 101); extend the thumb along the beam towards the spur. Press the head firmly against the edge of the work to be marked and with a wrist motion tip the gage forward until the spur touches the work. Push the gage along the edge to mark the work, keeping the head firmly against the work.

86. Care of Gages

a. Exercise care when using thickness gages to measure clearance of knives and cutters on machines. Do not lower knife on thickness blade and then try to remove the gage since the blade may be shaved off if it is too tight. Never use gages for cleaning slots or holes. When blades are damaged or worn, they should be replaced. Blades in a case are removed by loosening the clamp and sliding out the damaged blade. Install new blade and tighten clamp.

b. Always coat metal parts of all gages with a light film of oil when not in use to prevent rust. Store gages in separate containers. Do not pile gages on each other. Always return blades of leaf-type gages to case after use. Keep graduations and markings on all gages clean and legible. Do not drop any gage; minute scratches or nicks will result in inaccurate measurements.

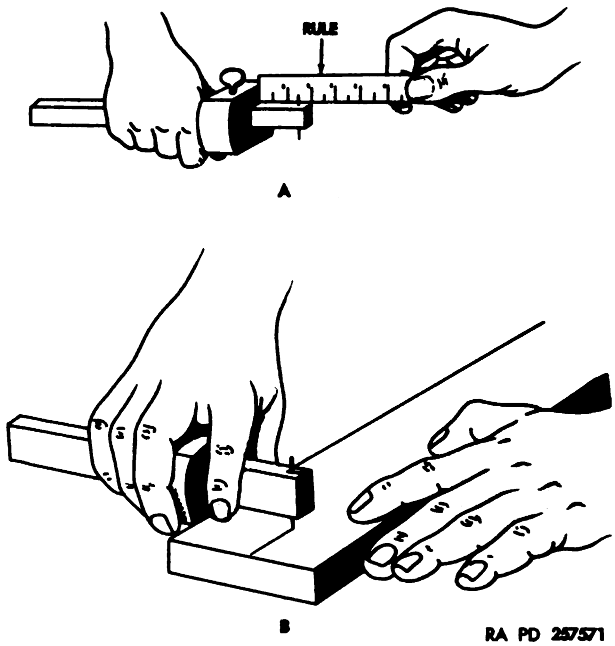

Figure 101. Using marking gage.

CHAPTER 3

NONEDGED HANDTOOLS

Section I. GENERAL

87. General

This chapter encompasses a large group of general purpose handtools. These tools are termed nonedged handtools because they are not used for cutting purposes and do not have sharpened or cutting edges. They are designed to facilitate mechanical operations such as clamping, hammering, twisting, turning, etc. This group includes such tools as hammers, mallets, and screwdrivers; which are commonly referred to as driving tools. Other types of nonedged tools covered in this chapter are wrenches, pliers, clamps, pullers, soldering irons, torches, and many others of similar nature. Several types of pliers have cutting edges (exceptions to the rule) and are discussed in the pertinent section with the nonedged pliers, for convenience.

88. Description

The following sections, II through XV, discuss the types of tools, as indicated by the section title, their description and particular construction, as well as the use and care of each tool.

Section II. HAMMERS AND MALLETS

89. Purpose of Hammers and Mallets
(figs. 102 and 103)

Hammers and mallets are used to drive nails, spikes, drift pins, bolts, and wedges. They are also used to strike chisels, punches, and to shape metals. Sledge hammers are used to drive spikes and large nails, to break rock and concrete, and to drift heavy timbers.

90. Types of Hammers

a. Carpenter's Hammers. A carpenter's hammer is a steel-headed, wood-handled, nail-driving tool. There are two types of carpenter's hammers. Both types have claws at the back of the hammer head for pulling nails. However, the difference between them lies mainly in their faces. One type has a flat face and is known as a plain-faced claw hammer (B, fig. 102). The other type has a rounded or convex face and is known as a bell-faced claw hammer (P, fig. 102). Carpenter's hammers are issued in 7-ounce, 10-ounce, and 1-pound sizes.

b. Machinist's Peen Hammers. Machinist's peen hammers are generally used by machine shop personnel and auto mechanics. Machinist's peen hammers are made in several different styles.

(1) *Ball-peen hammer.* The most common is the machinist's ball-peen hammer (C, fig. 102). It has a round ball-shaped head and is used for all general purpose work. Ball-peen hammers are classed according to the weight of the head without the handle. They usually weigh 2, 4, 8, or 12 ounces, or 1, 1¼, 1½, 2 or 3 pounds.

(2) *Cross-peen hammer.* The machinist's cross-peen hammer (D, fig. 102) has a dull chisel head at right angles to the handle and is used for spreading or drawing out metal. This hammer is issued in 3–, 6–, 8–, 10–, and 12–pound sizes.

(3) *Straight-peen hammer.* The Machinist's straight-peen hammer (H, fig.

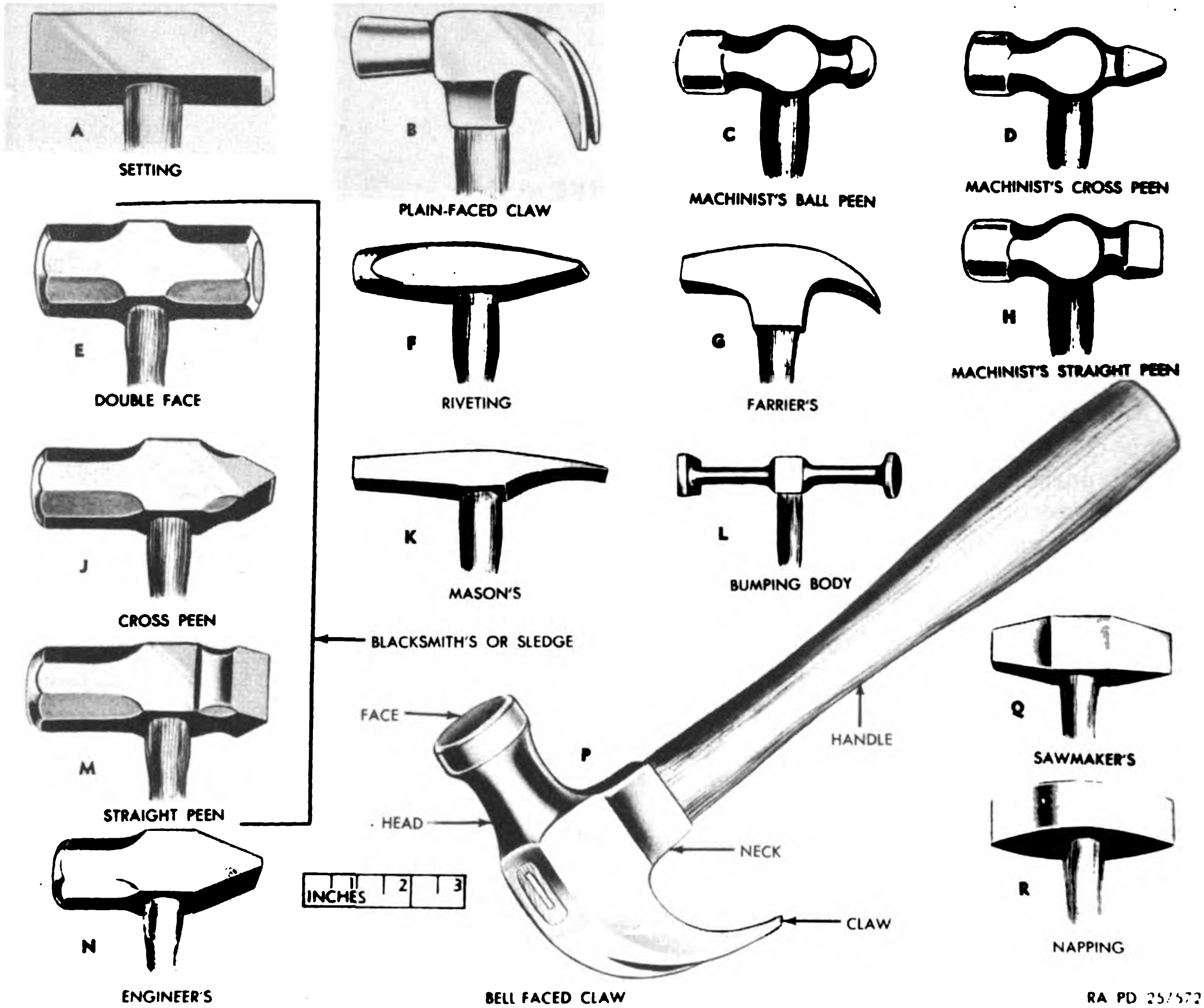

Figure 102. Types of hammers.

102) has a drill chisel head in line with the axis of the handle and is used for spreading and drawing out metal.

c. *Mason's Hammer.* The mason's hammer (K, fig. 102) has a flat face on one end of the head and a long chisel-like blade on the other. This hammer is used for cutting brick.

d. *Napping Hammer.* The napping hammer (R, fig. 102) has two narrow tapered faces. The head is made of high carbon steel. This hammer weighs 3 pounds and is used to nap or shape the surface of stones.

e. *Riveting Hammer.* The riveting hammer (F, fig. 102) is used to peen the ends of rivets and to upset rivets. The round face is used for peening and the narrow tapered, chisel-like face is used to upset rivets.

f. *Sawmaker's Hammer.* The sawmaker's hammer (Q, fig. 102) is used to set the teeth in saws when a setting tool is not available. The saw is placed with its teeth against a small beveled anvil and the teeth are driven against the bevel with the hammer to set the teeth at the proper angle.

g. *Setting Hammer.* The setting hammer (A, fig. 102) is used for bending and leveling metal edges and for setting double seams in sheet metal.

h. *Blacksmith's or Sledge Hammers.* Blacksmith's or sledge hammers are similar to machinist's peen hammers, except that they are made for heavy duty. Short handled sledge hammers are used to drive bolts, drift pins, and large nails, and to strike cold chisels when chipping and small hand rock drills when drilling holes in rock. Long handled sledge hammers are used to break rock and concrete, to drive spikes and bolts, to strike rock drills and chisels, and to drift heavy timbers. The handle is usually made of the best grade clear-grain hickory, ash, or maple; completely free from defects. Some sledge hammers have a double face (both sides alike) (E, fig. 102), cross-peen (J, fig. 102), or straight-peen (M, fig. 102) faces, usually made in sizes from 6 to 20 pounds, having handles 30 to 36 inches long.

i. Bumping Body Hammers. A bumping body hammer (L, fig. 102) is used for straightening and bumping metal. The hammer shown has one round and one square face and the head is 4 inches long. Other bumping body hammers may have an offset cross and straight-peen faces or two round faces, or an offset square face and a cross-peen face.

j. Engineer's Hammer. The engineer's hammer (N, fig. 102) has a cross-peen face and weighs 3 pounds. This hammer is similar to the blacksmith's or sledge cross-peen hammer, only it is lighter in weight and is used on lighter duty work.

k. Farrier's Hammer. A farrier's hammer (G, fig. 102) is used to shoe horses.

l. Jeweler's Hammer. A jeweler's hammer (D, fig. 103) is used for light hammering and for driving small shafts and pins. This hammer weights 1¾ to 2 ounces and generally has a hardwood handle.

m. Trimmer's Hammer. A trimmer's hammer (C, fig. 103) has one face chisel-like, the other round. It weigh 7 ounces, the head is 5⅛ inches long, and the overall length of the hammer is 12 inches. A claw, which is used to pull tacks, is attached to the end of the handle.

n. Magnetic Hammer. A magnetic hammer (B, fig. 103) weights 4 ounces, has a 4-inch head, and an overall length of 12 inches. The round face is magnetized so that a tack head

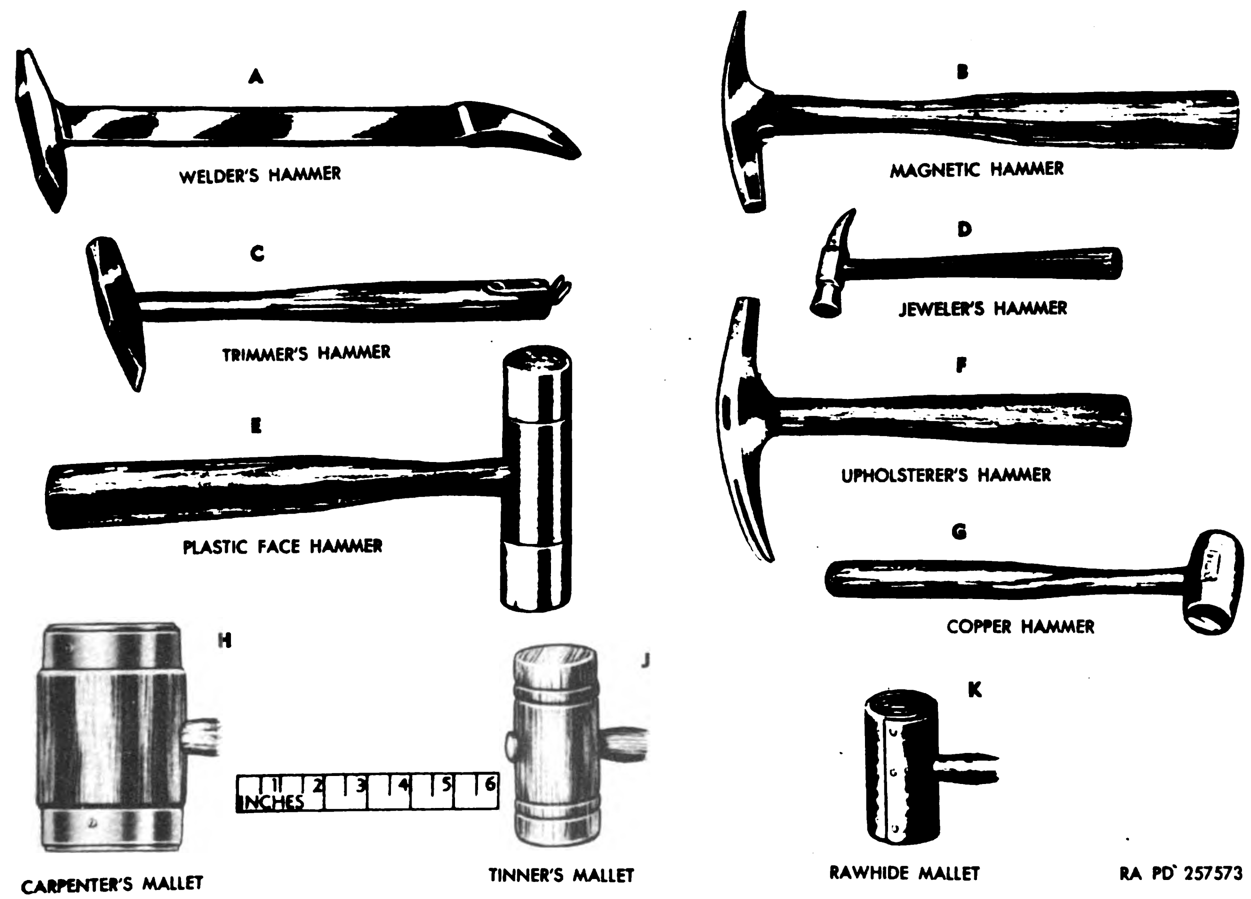

Figure 103. Mallets and hammers.

clings to it. The user does not have to hold the tack in one hand and the hammer in the other. One hand is free to hold work. The other end of the head is shaped like a claw and is used to pull tacks.

o. Upholsterer's Hammer. The upholsterer's hammer (F, fig. 103) has a magnetic face and a tack pulling end. It weighs 7 ounces, has a head length of 5½ inches, and an overall length of 10¾ inches. The magnetic face of the hammer holds the tack while the upholsterer uses one hand to fit cloth and the other to hammer with.

p. Welder's Hammer. A welder's hammer (A, fig. 103) is used for chipping welds. The opposite end of the hammer is sometimes equipped with a wire brush for cleaning metals before welding and brushing slag away after chipping.

q. Soft-Faced Hammers. Wood-handled, soft-faced hammers are used for striking heavy blows where the steel faced hammers would bruise or mar the surface of the work. The soft faces are made of rubber, wood, rawhide, copper, lead, or plastic, and the head may vary in weight from 6 ounces to 6 pounds. The Ordnance supply system issues a 3–pound copper hammer (G, fig. 103) and several inserted plastic-face hammers. The plastic-face hammers (E, fig. 103) are supplied with two soft, two medium, two tough, and two nylon replaceable faces.

91. Types of Mallets

a. Carpenter's Mallet. A carpenter's mallet (H, fig. 103) is a wooden, short-handled tool used to drive wooden handled chisels, wooden dowels, or small stakes. The head is cylindrical and has two flat driving faces. It is sometimes reinforced with iron bands at each end. This mallet is also used for smoothing out dents in sheet metal and for turning thin metal edges and seams without cutting the metal surface.

b. Rawhide Mallet. The rawhide mallet (K, fig. 103) is used to form or shape sheet metal where hard-faced or steel hammers might mar or injure the work.

c. Tinner's Mallet. A tinner's mallet (J, fig. 103) is made of wood ranging in size from 1¼-inch head diameter and 3-inch head length to 3½-inch head diameter and 6-inch head length.

92. Use of Hammers and Mallets

a. Using a Carpenter's Hammer.

(1) *Driving nails.* The wrist and arm motion, used when driving nails, depends upon the power of the impact required. Small nails require light blows which are struck almost entirely with a wrist motion. Heavy blows required to drive a large nail come from the wrist, forearm, and shoulder. Always strike the nail with the center of the hammer face. Do not strike with the side or cheek. Sometimes the grain of the wood, a knot, or a hidden obstruction will cause a nail to bend slightly when it is being driven. Striking a nail with the face of the hammer at a slight angle will also cause a nail to bend. Changing the angle of the hammer face will help to straighten the nail out. If a nail bends excessively when it is driven, pull it out and discard it. Start another nail in its place. If the second nail also bends excessively, inspect the work for a knot or other obstruction. Drive a new nail in a new position or drill a hole past the obstruction and try again. Tacks and small nails (brads) can be driven with a magnetic hammer, upholsterer's hammer, or a light carpenter's hammer. The bell-faced claw hammer is used to drive nails flush, and even slightly below the surface of the work, without leaving marks. The basic procedure for driving nails is as described in (*a*) through (*e*) below.

(*a*) Grip the hammer handle firmly with one hand near the end of the handle (fig. 104).

(*b*) Hold the nail near its point with the thumb and forefinger of the other hand.

(*c*) Place the point of the nail on the work at the exact spot it is to be driven.

(*d*) To start the nail, tap it squarely, but lightly, until it has penetrated the work to a depth sufficient to hold securely.

(*e*) Remove fingers and drive the nail into the work.

Note. When using a plain-faced hammer, the nail head must be parallel to the face of the hammer at the moment of impact. The bell-faced hammer offers a uniform face to the nail head ever though the hammer is slightly tipped.

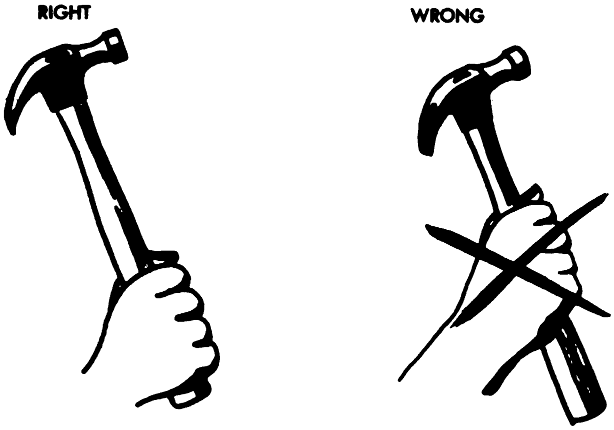

Figure 104. Holding hammer correctly.

(2) *Pulling nails*. Slip the claw of the carpenter's hammer under the nail head. Make certain the head of the nail is caught securely in the slot of the claw. Raise the hammer handle until it is nearly vertical. If the nail is short, this will withdraw it from the work. If the nail is long and the hammer handle is pulled past the vertical position, it will mar the work, bend the nail, and enlarge the hole. Most of the leverage is lost when the hammer handle passes the vertical position, requiring a great deal of force to withdraw the nail. To simplify pulling long nails, place a piece of wood under the hammer head so that the handle is again nearly horizontal and the leverage is increased.

b. Using a Mason's Hammer. To cut a brick with a mason's hammer, hold the brick in one hand and tap gently along the line where the brick is to be broken, with the chisel end of the hammer. Strike sharp repeated blows along this line, rotating the brick, until it separates into two parts. Rough edges of the brick can be chipped with the chisel end of the hammer to form a straight edge.

c. Using a Blacksmith's or Sledge Hammer. Since a sledge hammer is used for heavy-duty work, it is designed with a longer handle which requires a greater swing, and a heavy head which supplies a greater impact. Grasp the sledge hammer near the end of the handle with both hands; spread feet apart; raise the sledge hammer up over your head and bring it down. You must practice this swing until you are properly balanced and the work is struck with the least effort. Let the head of the sledge do the work. After raising the sledge hammer over your head, use wrists, forearms, and shoulders to deliver heavier blows. Light blows are struck with motion of wrist only. Observe the following precautions when using a sledge hammer.

(1) Wear safety goggles when using a sledge.

(2) Do not use a sledge whose head is worn round by overuse; it may glance off the work and cause serious injury.

(3) Make certain the area behind you is clear, so that on the backswing the sledge head will not strike anyone.

(4) Take a slight practice swing first, to help you gage distance, balance, and contact of the sledge with the work to be hit.

(5) Before striking a chisel bar with a sledge, attach a disk to the bar about one-fourth of the distance from the top of the bar. The disk will protect the hands of the helper who holds the chisel.

(6) Keep hammer and sledge faces free from oil or other material that would cause the tool to glance off nails, spikes, or stakes.

d. Using a Mallet. A mallet is swung in the same manner as a hammer. Never use a mallet to drive nails; it will spoil the face of the mallet. Never use a wooden mallet on sharp corners; it will mar the work and the mallet.

93. Care of Hammers and Mallets

a. Storage. If a hammer, mallet, or sledge is used often, it should be stored in a wall rack when not in use. Clean, repair, and oil metal portions of tools before storing them for long periods of time. Store wooden mallets out of direct sunlight and away from all sources of heat, since excessive drying will cause cracking and splitting. A light film of oil should be placed on wooden mallets to keep a little moisture in the wood.

b. Maintenance. Faces of hammer heads should be regularly dressed to remove battered edges. Hammer and sledge heads should be securely attached to a good solid handle of the proper type. Make sure the steel or hardwood wedges are tight in place. If wedges work loose, drive them into place. Replace missing wedges. Never use screws or nails as wedges, because they may come out or split the handle. Keep the claws of all hammers sharp enough to grip nail heads firmly. See that the handles are in perfect condition. Always replace a defective handle to avoid accidents.

94. Repair and Replacement of Handles

a. Repair. Handles on hammers and sledge hammers must be inspected constantly to see that they are tight and to check for split or broken wood. If the handle is loose, seat it into the eye of the hammer head by striking the end of the handle with a mallet (fig. 105), and then drive the wedges back into the handle. If the wedges are not tight or do not spread the handle sufficiently to make it tight, add another wedge or use larger wedges, if possible. In an emergency, loose handle may be temporarily tightened by soaking it in water until the wood swells within the head. If the handle does not become tight, replace the handle.

b. Replacement. If a handle is split or broken, remove it from the head of the tool. If the handle is too tight to pull out of the head, saw off the handle close to the head (fig. 105) and drive the remaining end out through the large end of the eye. Save the wedges. Shape a new handle from hickory or maple to fit, using a spoke shave or wood rasp (fig. 105). If using a wooden wedge, make a saw cut in the end of the handle as shown in figure 106. Wedges may be metal or straight-grained hardwood. Never use nails or screws for wedges. Seat the new handle and check to see whether the handle fits properly. If it does, saw off the projecting end and drive the wedges into the handle (fig. 107). If the handle is tightened with metal wedges, smooth them off by grinding (fig. 107). If the handle is secured with wooden wedges, use a wood rasp to smooth them off.

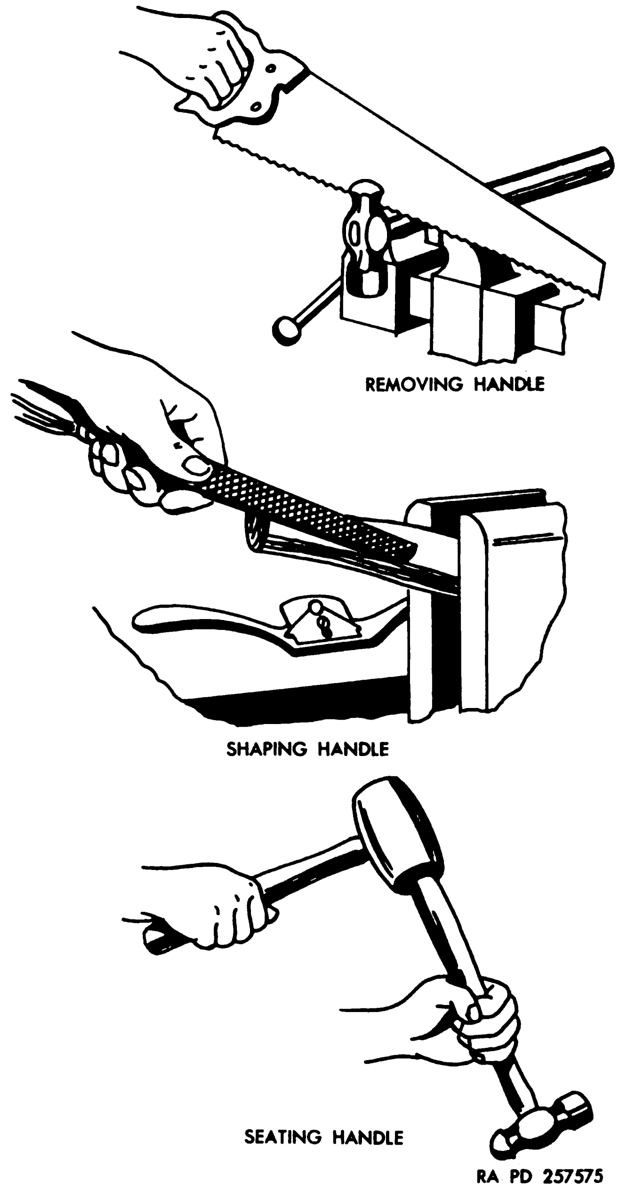

Figure 105. Replacing hammer handle.

95. Restoring Worn Faces

Incorrect or abusive use of hammers and mallets frequently results in uneven face wear. Faces also wear after considerable use and must be restored.

a. Determine if the face should be flat or rounded by examining the unworn portion of the face, or by comparing with an unworn tool of the same type.

b. Grind the face to the proper shape. Dip the head in water often to prevent loss of temper by overheating.

c. For mallets or double-faced hammers or sledges, remove the same amount of material from both sides to preserve the balance.

Note. **Do not remove any more material than is necessary.**

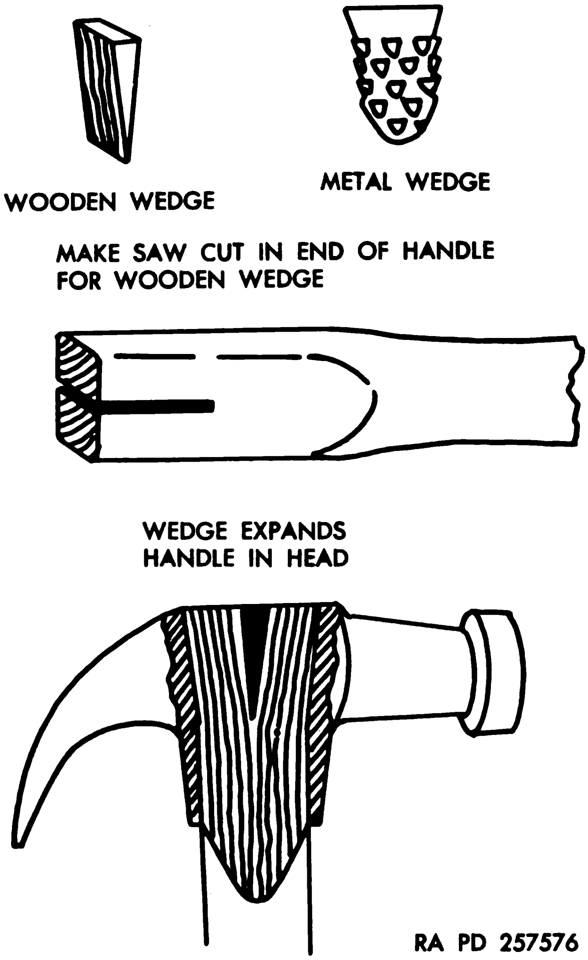

Figure 106. Hammer handle wedges.

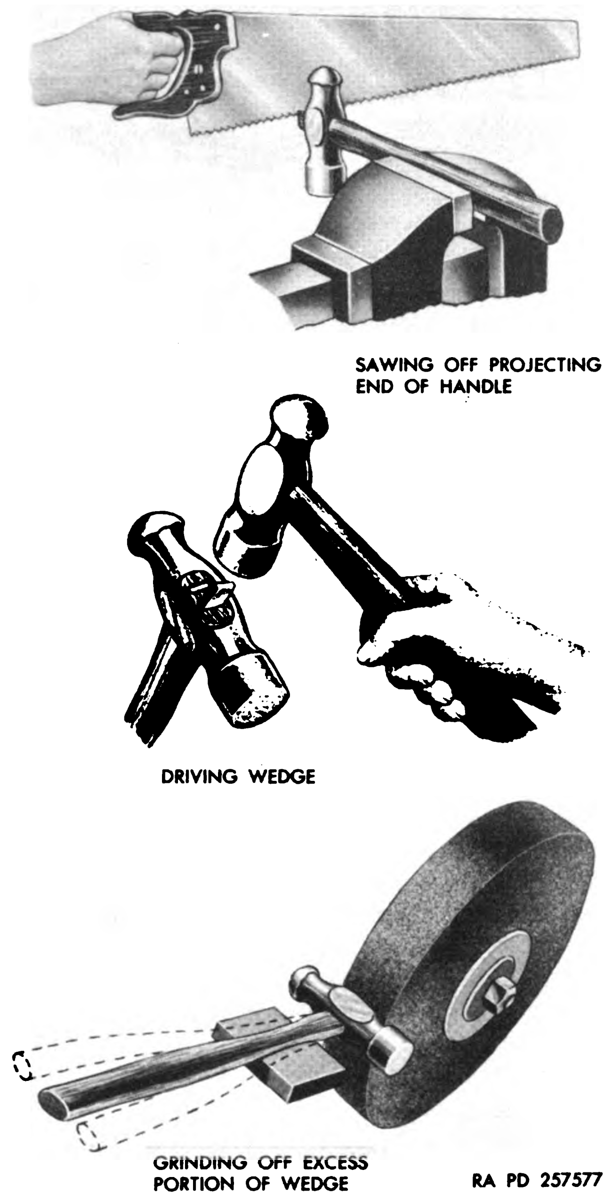

Figure 107. Installing wedges.

Section III. SCREWDRIVERS

96. Purpose of Screwdrivers
(figs. 108–112)

Screwdrivers are used for driving or removing screws or bolts with slotted or special heads.

97. Types of Screwdrivers

Screwdrivers are made in various shapes and lengths to perform specific jobs. The size of a screwdriver (fig. 108) is indicated by the length of the blade; i.e.; a 6–inch screwdriver has a 6–inch blade. The width and shape of the blade tip vary from a narrow parallel sided tip to a wide tapered tip. Some screwdrivers have special tips for cross-slotted recessed screws or bolts and clutch-bit screws. Special screwdrivers are provided with a ratchet arrangement.

a. Common Screwdriver. The common screwdriver (fig. 109) has a round steel blade

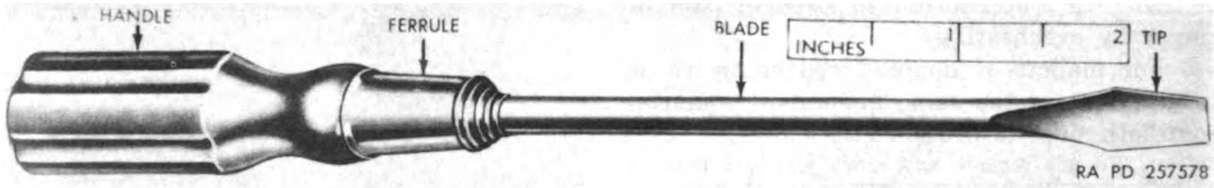

Figure 108. Standard screwdriver.

anchored in a wood or plastic handle. The blade is forged from alloy steel and tempered. The tip is flat, hot forged to size and heat treated. Common screwdrivers are tapered to give maximum strength. Handles are made of hardwood or plastic composition, usually fluted for a good grip. The blade is anchored in the handle by two or more tongs on the end of the blade and in case of wood handle by a pin or rivet through the ferrule, handle, and blade. Some handles are integral; that is, the blade forms an integral part of some of the outside surface of the handle and is locked in place by rivets. Integral blade screwdrivers are used for heavy-duty work. The blade can be tapped with a hammer to seat the blade tip in rusty screws. Other common heavy-duty screwdrivers have square blades so that a wrench can be used to turn them.

b. Phillips Screwdrivers (Cross-Tip). The tip of a Phillips screwdriver (fig. 110) is shaped like a cross so that it fits into Phillips-head screws. Phillips-head screws have two slots which cross at the center. These screwdrivers are made with four different sized tips. Size 1 will fit No. 4 and smaller size Phillips screws; size 2 will fit Nos. 5 to 9 inclusive; size 3 will fit Nos. 10 to 16 inclusive; and size 4 will fit No. 18 and larger size Phillips-head screws. Phillips screwdrivers also have different length blades ranging from 1 inch to 8 inches.

c. Reed & Prince Screwdrivers (Cross-Point). Reed & Prince screwdrivers are similar to the Phillips type; however, do not confuse them, for the tip is different, as shown in figure 110. These screwdrivers are issued in 3– to 8–inch sizes.

d. Clutch-Head Screwdrivers. Clutch-head

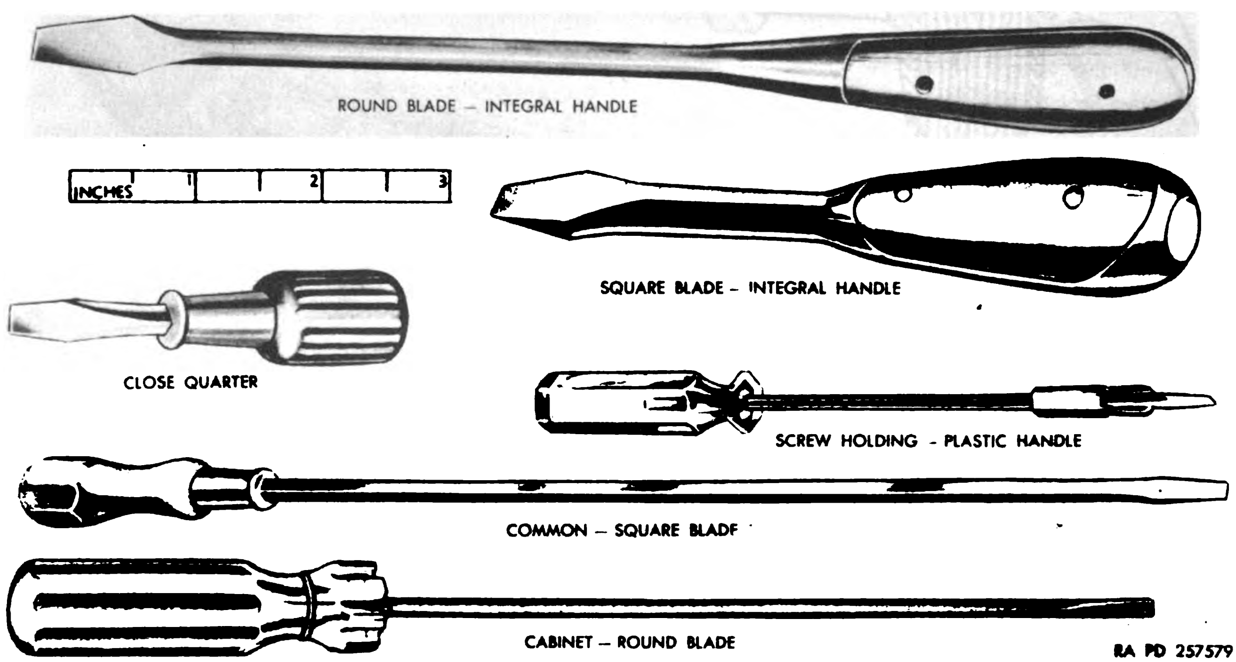

Figure 109. Common, flat-tip screwdrivers.

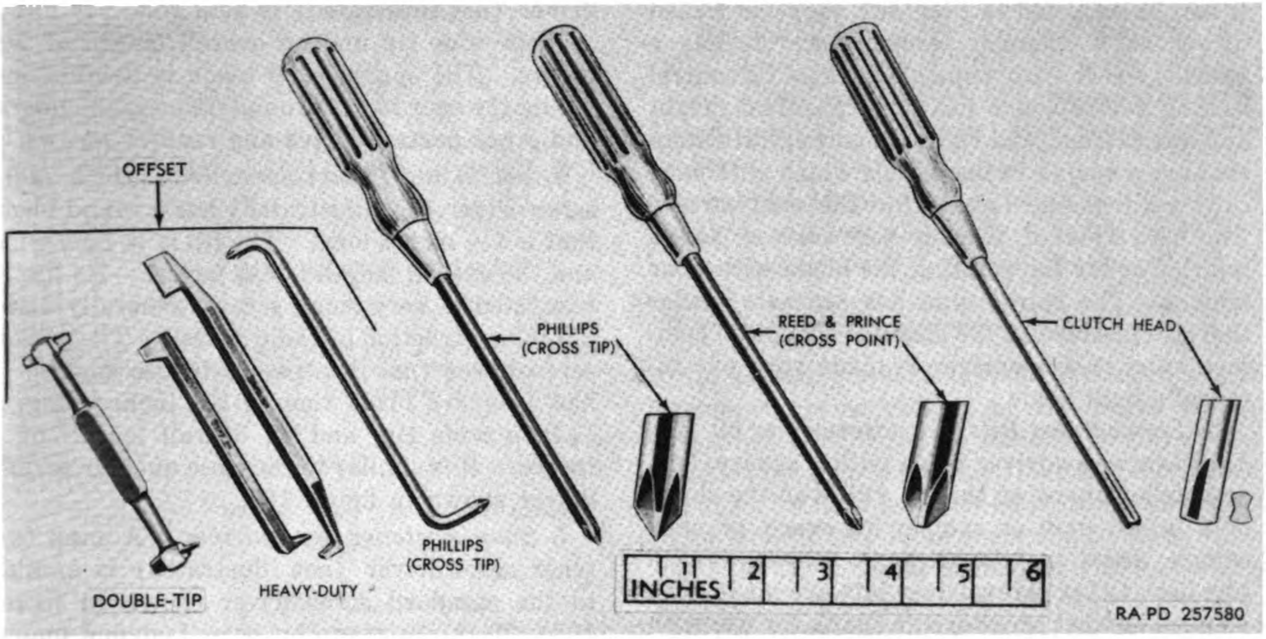

Figure 110. Special tipped screwdrivers.

screwdrivers (fig. 110) are used to drive clutch-bit screws. These screws are commonly called butterfly or figure 8 screws and have recessed heads. The clutch-type screwdriver is issued in 3–, 4–, 5– and 6–inch sizes.

e. Offset Screwdrivers. Offset screwdrivers (fig. 110) are designed to drive or remove screws that cannot be lined up with the axis of common screwdrivers or are located in tight corners. An offset screwdriver is usually made from a piece of steel, round or octagonal in shape, machined so that the end portion is at right angles to its longitudinal axis. They are made in a variety of sizes having different width tips. Some offset screwdrivers are made with two blades, one of different size at each end. A double-tip offset screwdriver has four blades.

f. Ratchet Screwdrivers. Ratchet screw drivers (fig. 111) are used to drive or remove small screws rapidly. The spiral ratchet screw-driver automatically drives or removes screws.

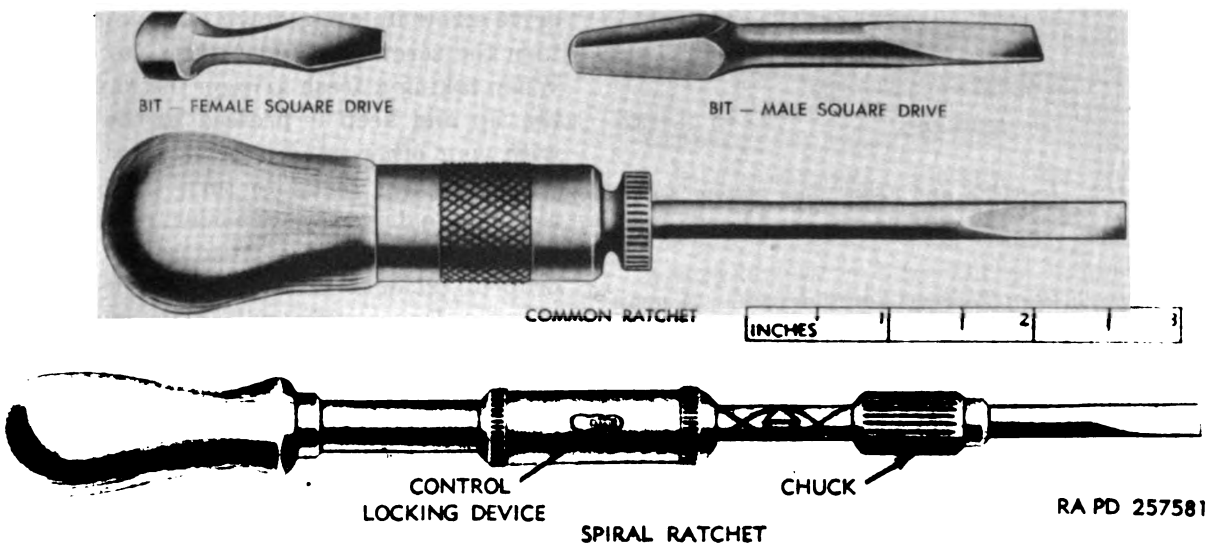

Figure 111. Ratchet screwdrivers and screwdriver bits.

It can be adjusted to turn left, right or locked to act as a common screwdriver. It has a knurled sleeve with a spiral chuck and a control locking device which has three positions; right and left ratchet, and rigid. Some spiral ratchets have a spring in the handle which automatically returns the handle for the next stroke. Another style of ratchet screwdriver has a knurled collar for rotating the blade with your fingers. The spiral type has separate blades that are inserted in the chuck. The plain common ratchet screwdriver is made with one integrally built blade.

g. Screwdriver Bits. A screwdriver bit (fig. 111) is a screwdriver blade with a square, hex, or notched shank so that it will fit in the chuck of a breast drill or ratchet bit brace, or on a square drive tool, such as a socket wrench handle. Other screwdriver bits are made with a spiral ratchet screwdriver shank for use with spiral ratchets.

h. Jeweler's Screwdrivers. Jeweler's screwdrivers (fig. 112) are made for driving and removing small size screws. The tips range from 0.025 inch to 0.1406 inch wide. They usually have knurled handles, a swivel end finger rest plate, and some have removable blades.

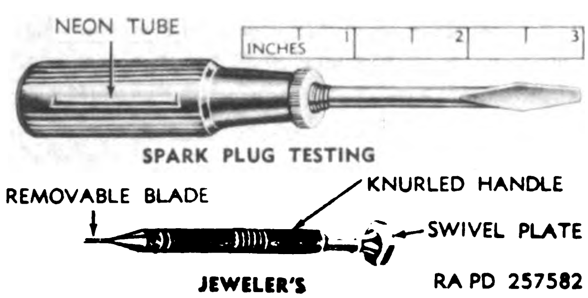

Figure 112. Jeweler's and spark plug testing screwdrivers.

i. Spark Plug Testing Screwdriver. A neon tube, inserted in an electric shock proof handle of a common screwdriver, tells the condition of a spark plug by the type of flash. A brilliant flash means good condition, a thin flash indicates too narrow a gap, and no flash means a short. This screwdriver is equipped with a 2¼-inch blade and a pocket clip (fig. 112).

j. Flexible Screwdriver. A flexible screwdriver (not illustrated) is available. It has a ¼-inch wide tip and an overall length of 7½ inches. The spring steel blade is flexible, enabling the user to get around flanges, shoulders, and other parts to drive and remove screws.

k. Radio and Pocket Screwdrivers. A radio screwdriver (not illustrated) has a round blade that is 1½ inches long. The tip is ⅛ inch wide and the overall length is 3¼ inches. Its use is restricted to very small screws generally, used in the construction of radio chassis. The pocket screwdriver (not illustrated) is also small. It has a square blade that is 1¾ inches long, a ¼-inch wide tip, and an overall length of 4 inches. It is similar to the close quarter screwdriver shown in figure 109.

l. Snap Fastener Screwdriver. A snap fastener screwdriver (not illustrated) is similar to the standard screwdriver shown in figure 108. They are made by snap fastener manufacturers to fit their products only.

98. Using a Screwdriver

a. Driving Screws. Use the longest screwdriver available which is convenient for the work. The width of the tip should equal the length of the screw slot and the tip must be thick enough to fit the width of the screw slot (fig. 113). Hold the handle firmly in one hand with the head of the handle against the palm and grasp the handle near the ferrule with your thumb and fingers (fig. 114). Hold the screwdriver in line with the axis of the screw and center the tip in the screw slot. To drive screw in, press down with your palm and turn the screwdriver clockwise (to the right). When taking a fresh grip on the handle, steady the tip and keep it pressed in the screw slot with your other hand. Relax your other hand when you are ready to turn the screwdriver again. To drive screws easier, rub a little soap into the threads of a wood screw and put a drop of oil or a little graphite on a machine screw. Doing this will also minimize the chances of rust forming on the screws and will make them easier to remove.

b. Removing Tight Screws. When a screw cannot be turned at the first attempt to remove it, try to tighten it first, then turn the screwdriver opposite. Sequentially, tighten and loosen the screw until completely removed.

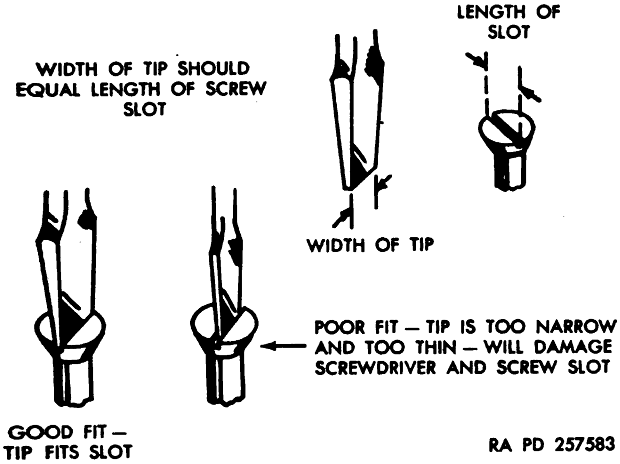

Figure 113. Proper blade for specific screw.

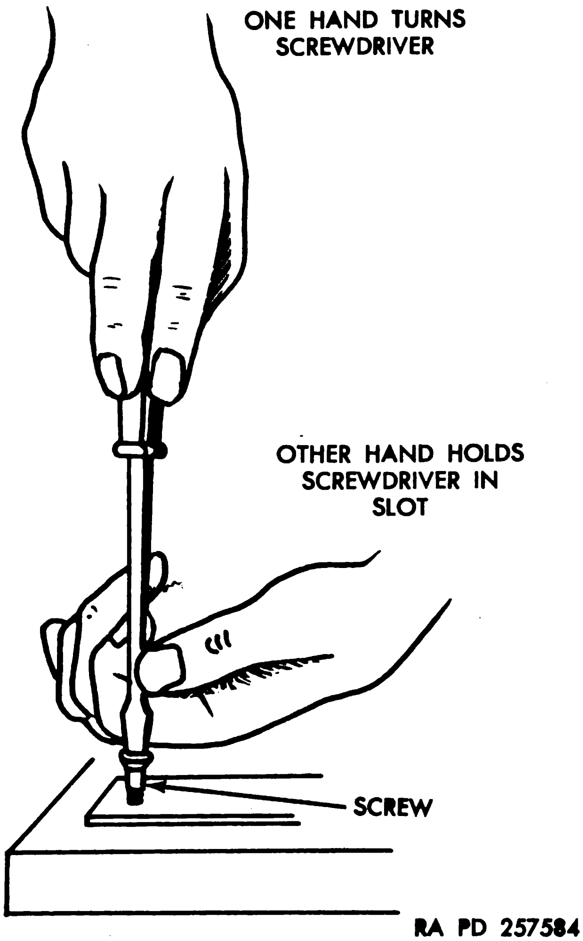

Figure 114. Holding screwdriver properly.

Caution: **Use a screwdriver that has parallel sides and exactly fits the screw slot. A poor fitting screwdriver will damage the screw head, slip off the screw, and cause personal injury.**

If a tight screw with a damaged slot can be backed out partially, it is possible to remove it completely with a pair of pliers.

99. Care of Screwdrivers

a. Dressing and Shaping. When a screwdriver becomes nicked, or the edges become rounded, or when other damage occurs so that it does not fit a screw slot, it must be reground or filed. The sides must be parallel to keep the tool from lifting from the screw slot (fig. 115) and the tip must be square, at right angles to the sides and to the blade. If using a file, place the screwdriver in a vise. When using a grinder, adjust the rest to hold the screwdriver against the wheel to produce the desired shape, parallel or concave. Do not grind away more material than necessary to remove nicks or square up the end. After squaring tip, grind both sides until the tip is the required thickness. Dip the screwdriver into water frequently during grinding to prevent loss of temper by overheating. If the blade discolors (blue or yellow), the temper has been damaged. Retemper by heating about 1½ inches of blade to a cherry red with a torch. Immediately dip about ¾ inch of the blade in clean cold water. Quickly rub the hardened end with aluminum oxide abrasive to brighten it. Watch the color creep back into the tip from the heated portion of the blade. When color becomes light blue, dip blade into water. The tip is now retempered and ready for use.

b. Precautions. Handle the screwdriver carefully. Use the right sized screwdriver for the job. Keep the blade clean. Do not carry a screwdriver in your pocket unless it has a pocket clip. Never use a screwdriver for prying or chiseling operations. When difficulty is encountered in driving or removing screws that are hard to turn, do not use pliers to turn the screwdriver. Pliers will damage the screwdriver. For hard to turn screws, select a square bladed screwdriver designed for heavy duty, and a wrench which properly fits the blade.

c. Storage. After use, wipe screwdriver with light oil and place it in rack or tool box. For long-term storage, apply rust-preventive compound over all metal parts and store in a dry place.

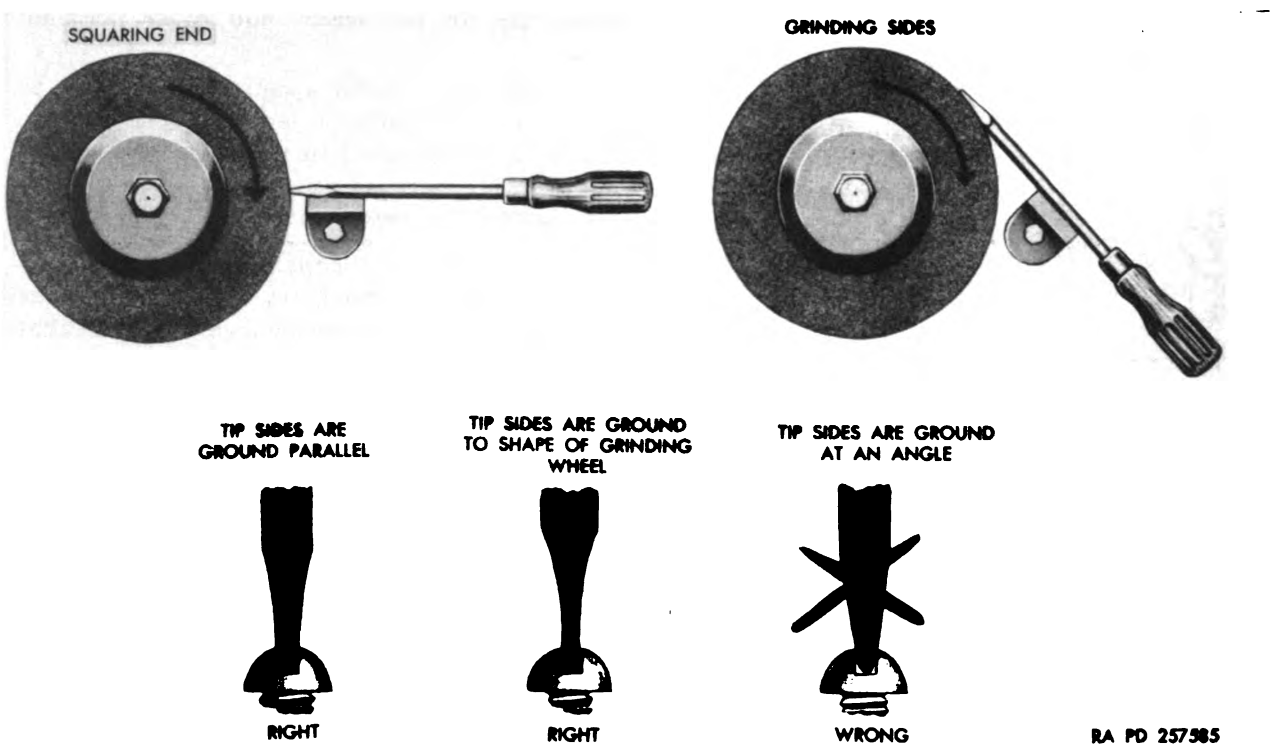

Figure 115. Grinding screwdriver blade tip.

Section IV. WRENCHES

100. Purpose of Wrenches
(figs. 116 through 124)

Wrenches are used to tighten or loosen nuts, bolts, screws, and pipe plugs. Special wrenches are made to grip round stock, such as pipe, studs, and rods. Spanner wrenches are used to turn cover plates, rings, and couplings.

101. Types of Wrenches

There are many types of wrenches; each type is designed for a specific use.

a. Fixed-End Wrenches.

(1) *Open-end wrenches.* Various open-end wrenches are shown in figure 116. They are usually double-ended wrenches, although some have a single open end. These wrenches are forged from chrome vanadium steel and heat treated. The size of the opening between the jaws determines the size of the open-end wrench. For example, a wrench with a ½-inch opening in one end and a 9/16-inch opening in the other end is called a ½ x 9/16 wrench. The size of each opening is usually stamped on the side of the wrench. The openings are from 0.005 inch to 0.015 inch larger than the size marked on the wrench, so that they will easily slip on bolt heads or nuts of that size. Open-end wrenches are made in many different sizes. Wrench sizes range upward in steps of 1/32 inch, starting with 5/32 inch up to 1¾ inches. The common open-end wrench is made with the ends at an angle of 10 to 23° to the body of the wrench so that the user can work in close quarters. Other special open-end wrenches may have

the ends at an angle of 45, 60, 75, or 90 degrees, or a combination of two angles. The length of the wrench is determined by the size of the opening, since the lever advantage of the wrench is proportional to its length; wrenches with larger openings are made longer and heavier to increase leverage and strength.

have two openings; one opening, 1/16 inch larger than the other. Some openings may be 1/32 or 1/8 inch larger than the other. A ratchet box wrench usually has two 12-point openings and is not automatically reversible. However, it can be turned around to do both tightening and loosening operations. Being of sturdy, thin construc-

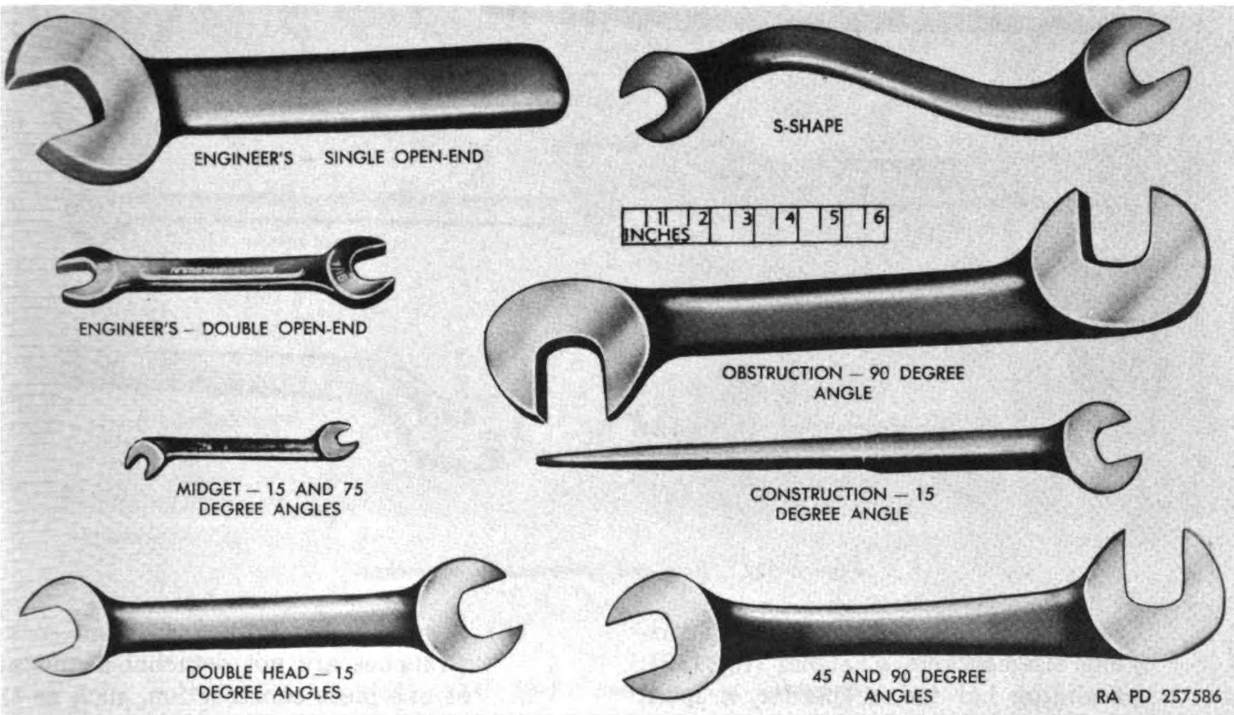

Figure 116. Open-end wrenches.

(2) *Box wrenches.* Box wrenches (fig. 117) are so named because they completely surround or box the bolt head or nut. The opening in a box wrench contains 6 or 12 notches, called points, arranged in a circle. The box wrench is a safer tool than the open-end wrench, since it will not slip off the work. As little as one-twelfth of a turn can be taken at each stroke if necessary in close quarters. Box wrenches may have straight handles, they may be offset, or the box end may be offset. Box wrenches are available in the same sizes as are open-end wrenches ((1) above) and usually tion, they are convenient for working in limited spaces. Ratchet box wrenches are issued in four sizes, ranging from 3/8 and 7/16-inch openings to 3/4 and 7/8-inch openings.

(3) *Combination open and box wrenches.* Combination wrenches (fig. 117) have one open end and a box wrench at the other end. Combination wrenches may be made with any combination of sizes, offsets, and angles, as discussed in (1) and (2) above.

(4) *Socket wrenches.* The common socket wrench is boxlike and made as a detachable socket (fig. 118) for various types of handles. A socket wrench

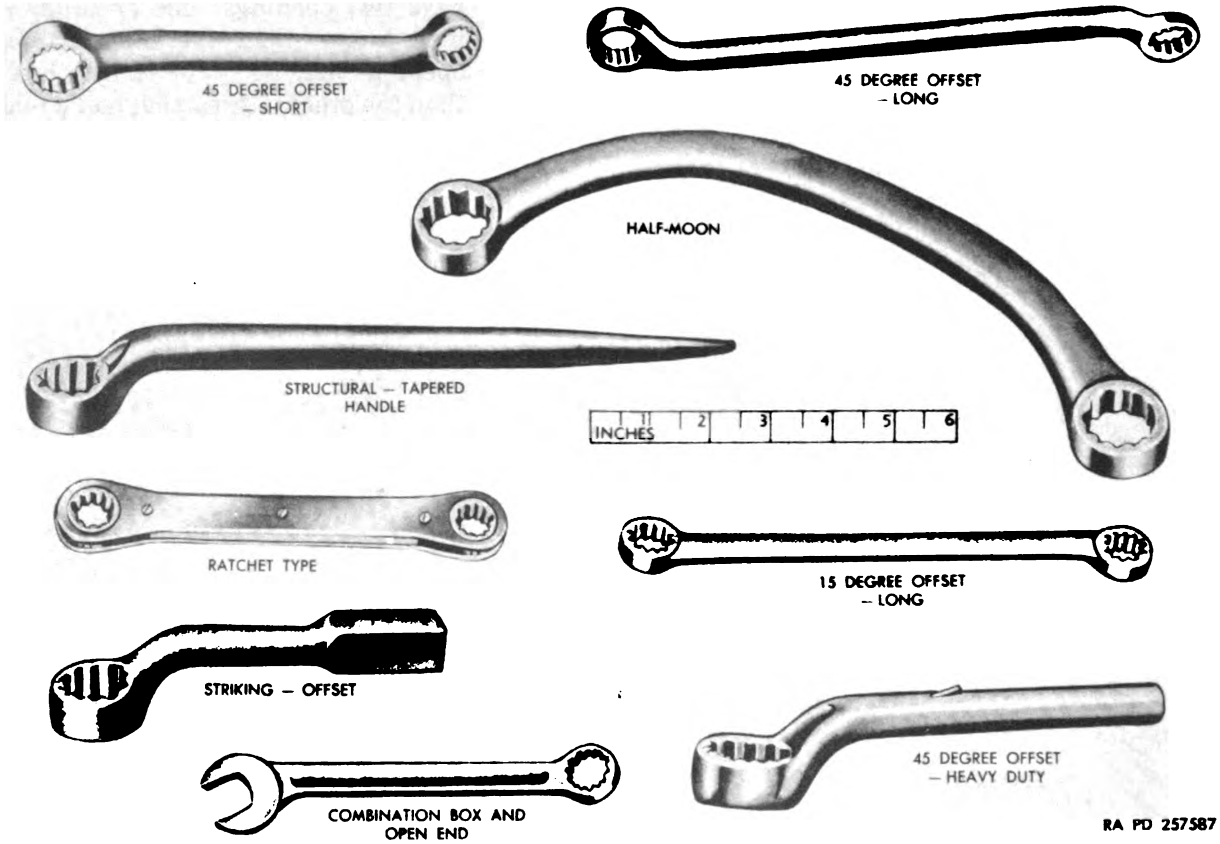

Figure 117. Box and combination wrenches.

set (fig. 118) usually consists of various sized sockets, a ratchet (fig. 119), a sliding bar tee, a speeder, a speed tee, a ratchet adapter, a nut spinner, a ⅜-inch drive handle, and extensions. Socket wrenches have two openings, one a square hole which fits the handles and the other a circular hole with notched sides to fit the bolt or screw head or nut to be turned. The square hole is made ¼, ⅜, ½, ¾, or 1 inch in diameter; each must be driven with the matching drive or speeder handle. The notched opening may have 6, 8, or 12 points. Socket wrenches are the fastest wrenches to use, since the ratchet handle permits the socket to remain on the nut or bolt and the handle does not have to be removed from the socket for turning. Socket wrenches are sized from 5/32 to 3⅛ inches in steps of 32ds, 16ths, or 8ths of an inch.

(5) *Special socket wrenches.* Some socket wrenches are not detachable and are of one piece construction, such as the four-way socket wrench and the 90° offset handle shown in figure 120. Other socket wrenches are of the screwdriver type, having a six-pointed or a square socket. These may be straight or offset and have a T-type or regular screwdriver handle. Two types of stud remover sockets are available that are used with any ¾-inch square drive socket wrench handle. One type has an eccentric cam which grips soft or hardened studs. The driving shank extends through both sides of the housing to provide a bearing surface on each side of the cam and prevents binding. The cam type has a capacity of ¼ to ¾ inch. The heavy-duty wedge-type stud remover socket works on the wedge principle and takes a positive grip

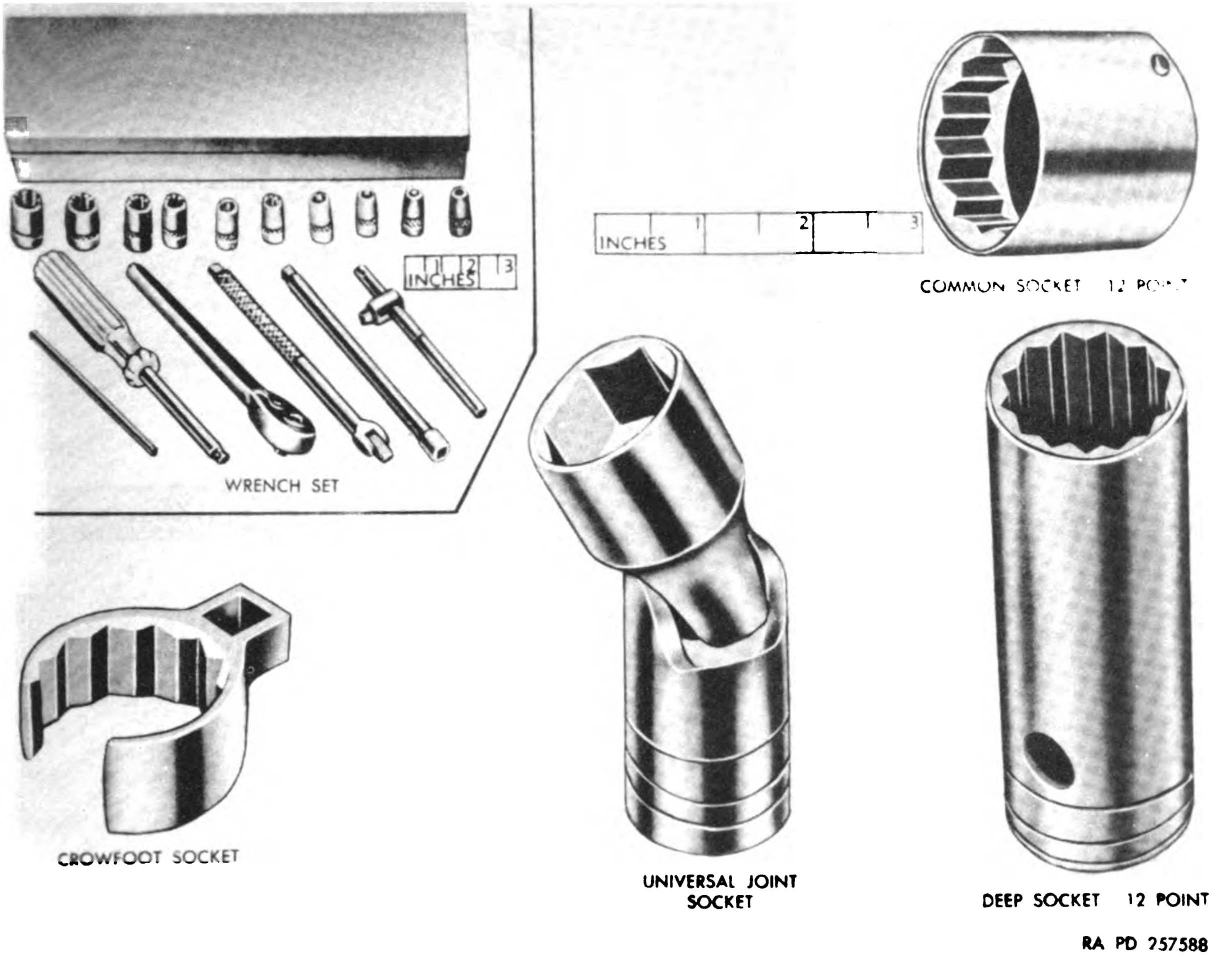

Figure 118. Socket and crowfoot wrenches.

which can be released only when the tool is turned in the reverse direction. Two sizes of steel wedges are included with the socket. This type has a capacity of $\frac{9}{16}$ to 1 inch.

(6) *Crowfoot wrenches.* A crowfoot wrench (fig. 118) has an open end in the box containing notches and a square hole which fits the handle. They are used in conjunction with the socket wrench handles having a $\frac{3}{8}$- or $\frac{1}{2}$-inch square drive. They range in size from $\frac{3}{8}$ to $2\frac{1}{2}$ inches.

(7) *Setscrew and hollow-head capscrew wrenches.* Most setscrews and hollow-head capscrews have a hexagon (six-sided) socket. The commonly known key (Allen) wrench (fig. 121) is L-shaped, made of tool steel having a hexagonal or square section to fit these screws. Splined setscrew wrenches (fig. 121) are made of round stock with ends to fit little flutes or splines in headless setscrews. A hollow-head capscrew set is also supplied. This set has detachable sockets which are used with the accompanying handles.

(8) *Plug wrenches.* A plug wrench (fig. 121) is a straight bar having a hexagon or square shape and is available in a range of sizes from $\frac{3}{8}$ to 1 inch in width. They are usually 2 inches long. Plug wrenches are also made to fit drain plugs of transmissions, differentials, and all types of gear cases. The multiple plug wrench shown in figure 121 is a combination type,

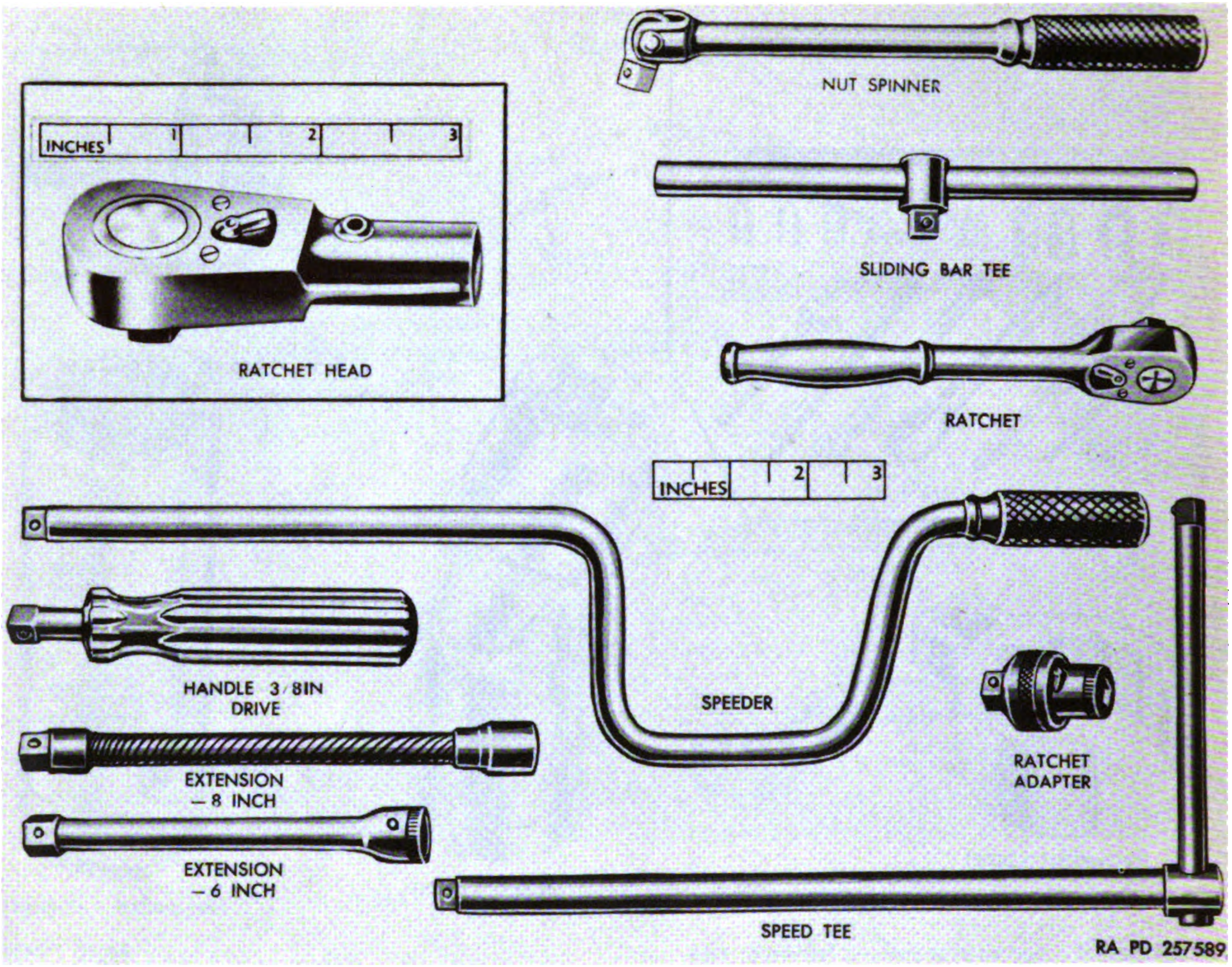

Figure 119. Socket wrench ratchets, handles and extensions.

having several different size and shape ends. Most plug wrenches are made for a specific size plug. There are single-end plug wrenches that range in size from 3/16 to 11/16 inch with a hexagonal or square end. Double-end plug wrenches with square ends are issued for 3/8- and 1/2-inch plugs and 3/8- and 3/4-inch plugs. These wrenches are normally 8 to 12 inches long. Socket plug wrenches (fig. 121) have a 1/2-inch square drive to be used with socket wrench handles.

(9) *Flare nut wrenches.* A flare nut wrench (fig. 121) is a notched thin-walled split box wrench especially designed to fit over nuts in very close places. It is ideal for tightening brass tube flare nuts. It grips the nut on five sides; does not slip and mar the nut. Flare nut wrenches are of 12 point design and have either a single or double end. Openings range in size from 3/4 to 1 5/8 inches.

b. Adjustable Wrenches.

(1) *Single open-end wrench.* The single open-end adjustable wrench (fig. 122) is similar in shape to the fixed-end nonadjustable open-end wrench, but has one adjustable jaw and one stationary jaw. The adjustable end wrenches issued by the Army Ordnance supply system have a 1 3/8 to 2 7/8–inch jaw openings and are 24 inches long. A knurled nut is rotated to bring the movable jaw up to fit the nut or bolt head.

(2) *Auto and monkey wrenches.* The

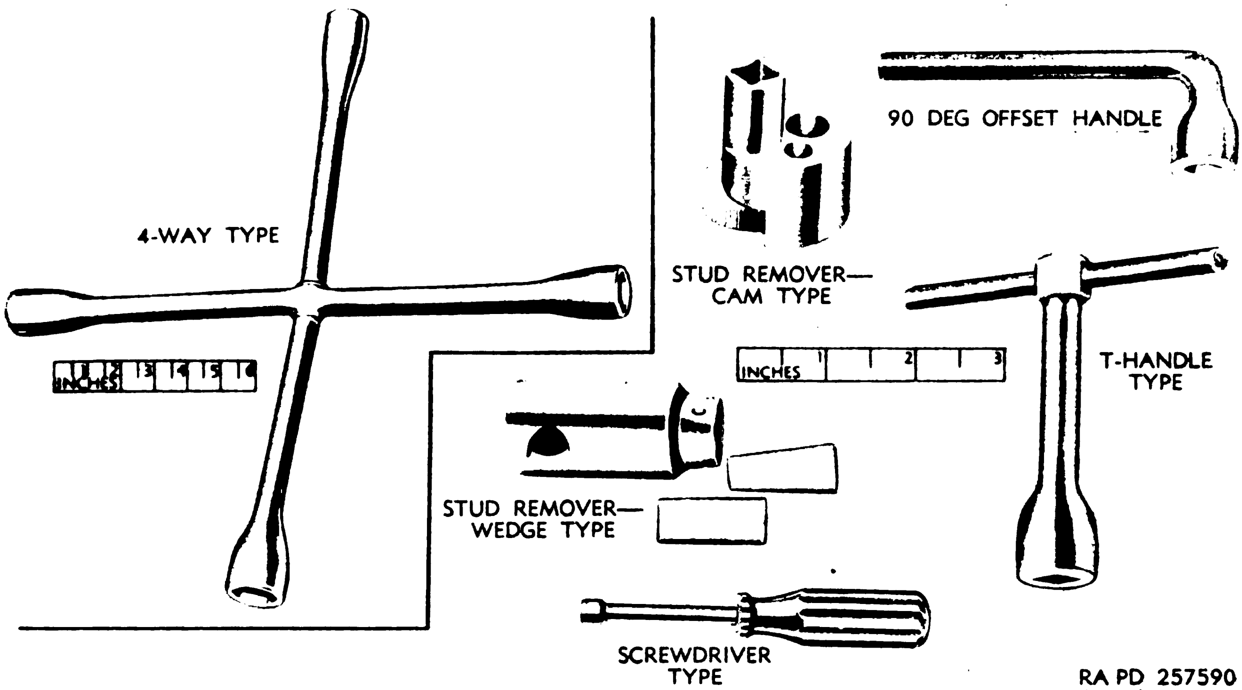

Figure 120. Special socket wrenches.

auto and monkey wrenches (fig. 122) are similar in design. They are of sturdy construction and are made to fit a wide range of nuts and bolts. They are designed principally for turning odd sized nuts or bolts which the open end, box, or socket wrenches will not fit, and when work requires a sturdy wrench. They are supplied in several sizes, from 5 to 21 inches long.

(3) *Clamp pliers and vise grip wrench.* The clamp pliers and vise grip wrench (fig. 122) has one movable jaw and one stationary jaw. The movable jaw is adjusted by an adjusting screw in the base of the stationary jaw handle. The movable jaw can be clamped around a nut or bolt after setting the jaw to the desired size. This type wrench is issued in two sizes; 1⅛-inch jaw opening capacity and 7 inches long, and 1¼-inch capacity and 10 inches long.

c. Pipe Wrenches.

(1) *Adjustable pipe wrench.* The adjustable pipe wrench (fig. 122) has two jaws that are not parallel. The outer jaw, which is adjustable, is made with a small amount of play which provides a tight grip on the pipe when the wrench is turned in the direction of the movable jaw. This is the only wrench which will take a bite on round objects. The jaw always leaves marks on the work and should never be used on nuts or bolts unless the corners have been rounded so that you cannot turn it with another type of wrench.

(2) *Strap pipe wrench.* The strap pipe wrench (fig. 122) is also used to turn cylindrical parts, but will not mar the work because the strap serves as jaws. These wrenches are issued in a ⅛- to 2-inch pipe capacity size and a 1- to 5-inch pipe capacity size.

(3) *Adjustable chain pipe wrench.* The adjustable chain pipe wrench (fig. 122) is a long-handled tool with a single jaw and a length of chain that fits around the pipe to be turned and over the connection at the end of the jaw. The chain acts as the other jaw. It is used for gripping rough pipe work on large diameter pipe. These

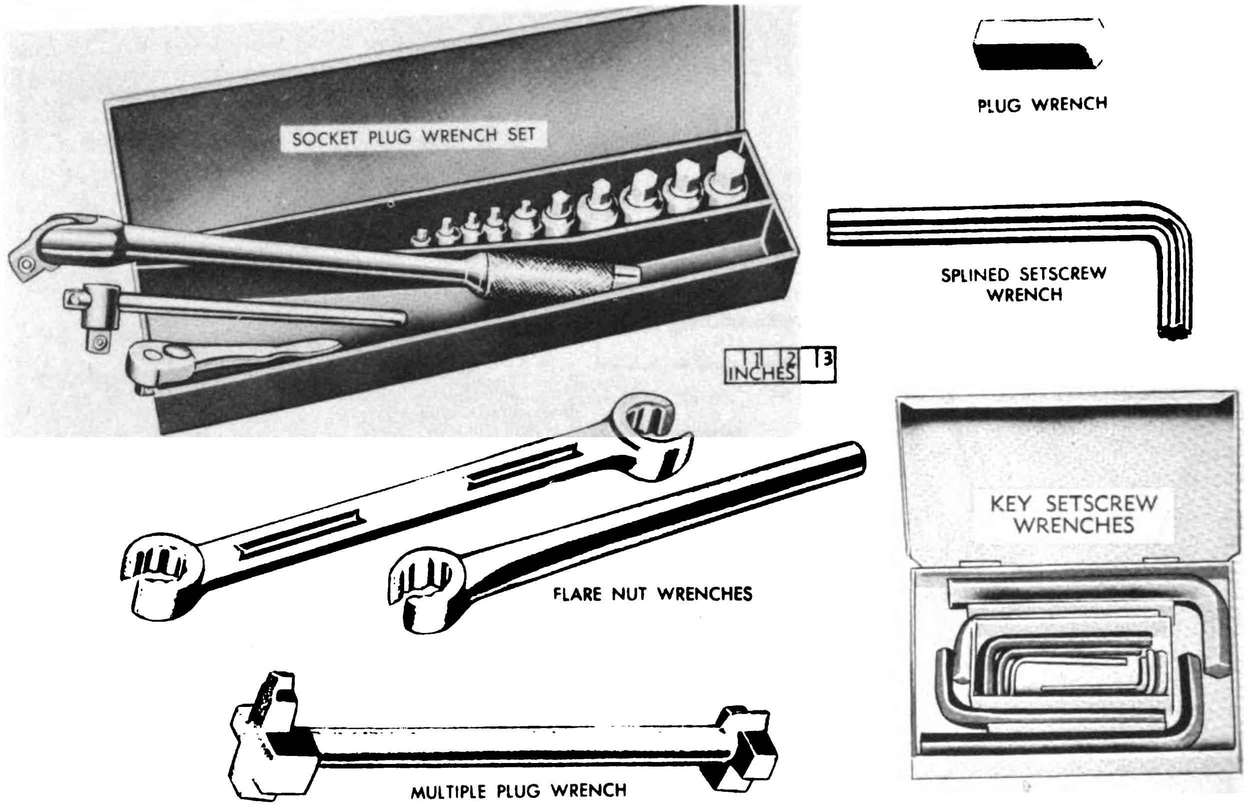

Figure 121. Setscrew, plug, and flare nut wrenches.

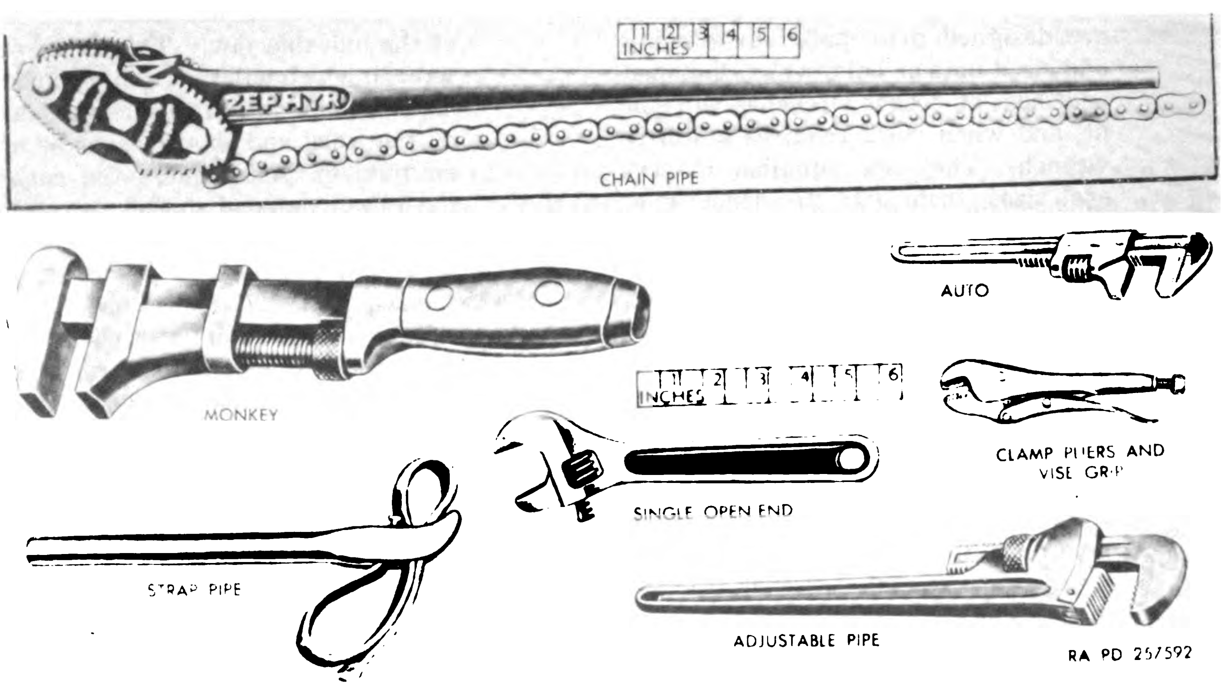

Figure 122. Adjustable wrenches.

wrenches range in size from 35 to 64 inches long and have a pipe capacity of from ¾ inch to 12 inches.

d. Torque Wrenches. A torque wrench (fig. 123) is used for work requiring a particular force (torque) to tighten bolts, nuts, cap screws, etc., to a desired degree of pressure. A dial or scale calibrated in foot-pounds indicates the degree of torque placed on the work. The pointer moves to the right or left of zero, depending on the bolt (left or right hand threads) being tightened. These wrenches are issued in several sizes; they may have a ¼–½–, or ¾–inch square drive to receive socket wrenches, and the capacity may range up to 600–foot pounds.

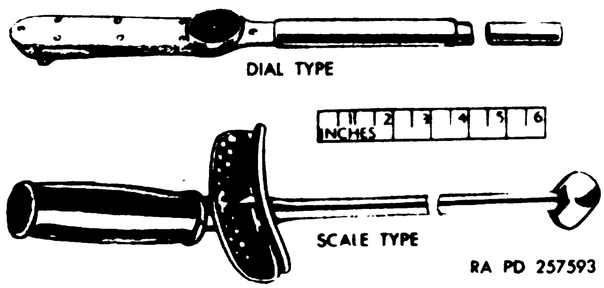

Figure 123. Torque wrenches.

e. Spanner Wrenches.

(1) *Fixed spanner wrenches.* Fixed spanner wrenches (fig. 124) are used to turn flush type and recessed retaining rings, cover plates, plugs, hose couplings, and parts which have holes or slots for insertion of the wrench pins or lugs. Each of this type spanner wrenches is designed for a particular job.

(2) *Adjustable spanner wrenches.* An adjustable face spanner wrench (fig. 124) has two legs joined together with a pivot pin. The legs can be opened and closed, allowing the pins at the end of the legs to fit the various distances between holes found in many types of cover plates and plugs. Another type of adjustable spanner wrench is shaped like a hook, called an adjustable hook spanner wrench. The position of the hook can be adjusted to fit different size couplings and other parts.

102. Using Wrenches

a. Open-End Wrenches. It is important for a wrench to be a snug fit on a nut or bolt head.

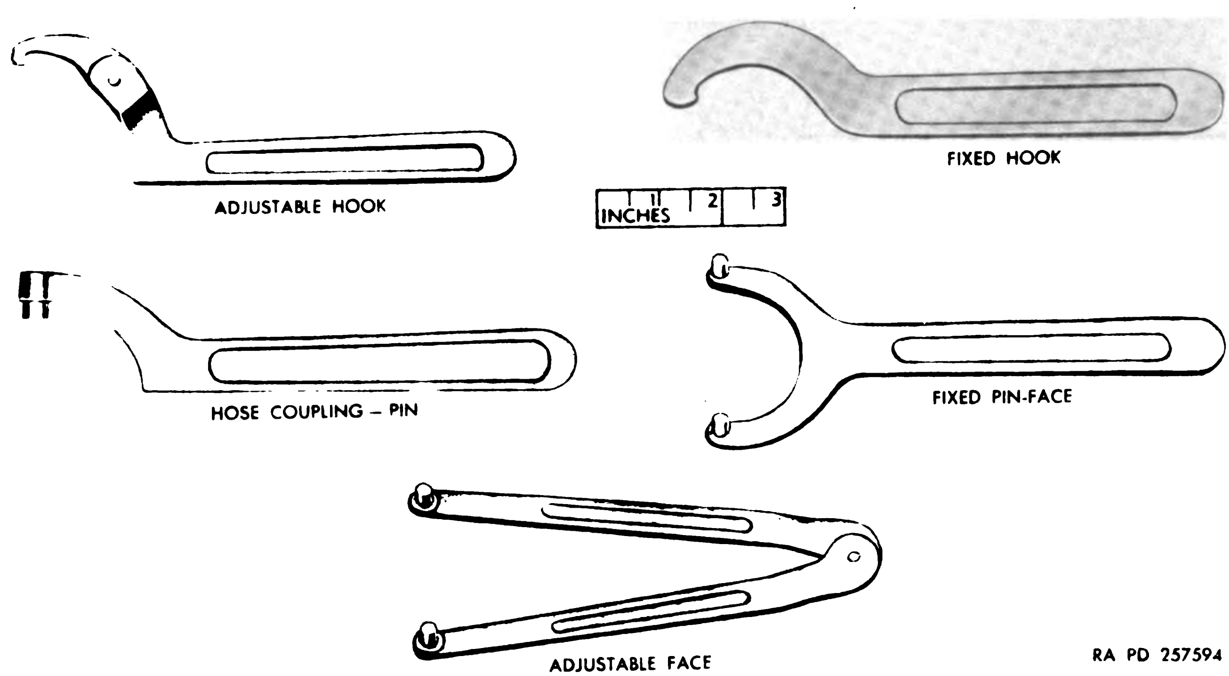

Figure 124. Spanner wrenches.

If it is too loose, the wrench will slip and round the corners. Make certain that the wrench fits squarely on the sides of the nut or bolt head, as shown in figure 125. Offset open-end wrenches make it possible to turn a nut or bolt that is recessed, and in limited quarters where there is little space to swing the wrench. Turn the wrench over after each swing so that the opposite face is down; and the angle of the wrench opening is reversed, as shown in figure 126. Always place yourself so that you can pull on the wrench to turn the work in the desired direction.

***Caution:* Do not push on a wrench; if the wrench slips or the bolt breaks loose suddenly, you may skin your knuckles and be thrown off balance.**

There are times, however, when the only way you can move the wrench is by pushing it. In this case, do not wrap your fingers around it. Push it with the palm of your hand and hold your hand open.

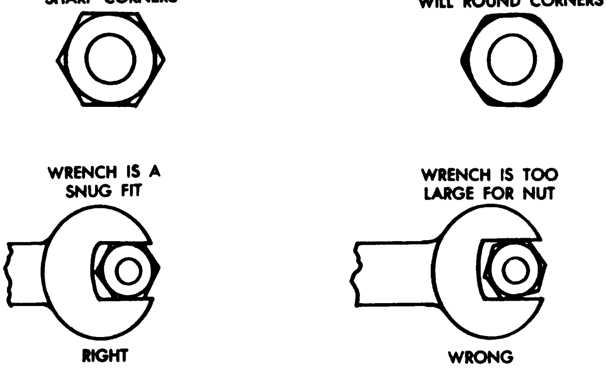

Figure 125. Fitting open-end wrench.

b. Box Wrench. Always select the size of wrench that fits the nut or bolt head. Box wrenches will not slip off and are preferably used before open-end wrenches. A swing through an arc of 15 degrees is sufficient to continuously loosen or tighten a nut or bolt. Unless there is room to swing a box wrench in a full circle, lift it completely off the nut when it comes to the limit of its swing, and place it in a new position which will permit it to be swung again. Since a box wrench cannot slip off a nut, it is ideal for loosening tight nuts and bolts, and for setting them up. To set up means to give already tight nuts or bolts their final tightening. After a nut is started, it can usually be worked more quickly with an open-end wrench than with a box wrench. For this reason, combination box and open-end wrenches are very popular and more convenient; the box end to break loose or set up, and the open end to do the actual turning.

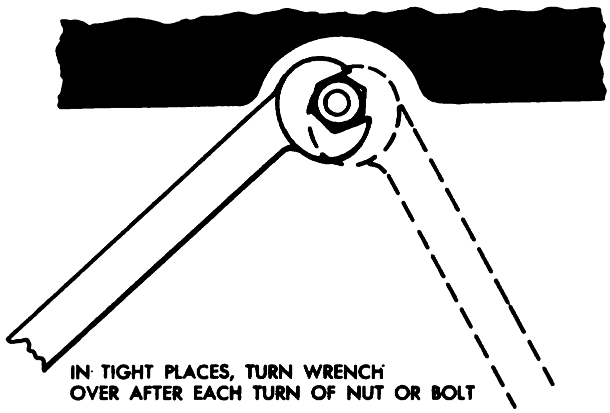

Figure 126. Use of open-end wrench.

c. Socket Wrenches. To use a socket wrench, select the size of socket that fits the nut or bolt to be turned and push it onto the handle which is best suited to the job. If there is room to swing it, use the ratchet handle. The handle may be made to ratchet in one direction for tightening, and in the other direction for loosening work. It is necessary only to swing the handle back and forth in order to turn the nut in the desired direction. The socket need not be raised from the nut at the end of each swing. A nut spinner handle (fig. 119) also saves time. When a tight nut is to be loosened or a nut is to be set up, the handle can be swung at right angles to the socket to provide the most leverage. At the point where the nut turns easily, the handle can be swung to a vertical position and twisted rapidly between the fingers in the same manner as a screwdriver. A universal joint socket wrench (fig. 118) makes it possible to turn nuts where a straight wrench could not be used unless some part of the machine or equipment is removed.

d. Key (Allen) Setscrew Wrenches. Select the proper type and size that fits the recess of the screw being worked on. The short end of the wrench is used to give a final tightening or break loose tight screws. The long end of the wrench is used to turn the screw rapidly when very little leverage is needed.

e. *Adjustable Open-End Wrench.* Always place the wrench on a nut or bolt so that the force used to turn it is applied to the stationary jaw side of the wrench, as shown in figure 127. After placing the wrench in position, tighten the knurled adjusting nut until the wrench fits the nut or bolt head as tightly as possible. If it does not fit tightly, it will slip, which may result in an injury to your hand and which may also round the corners of the nut or bolt head.

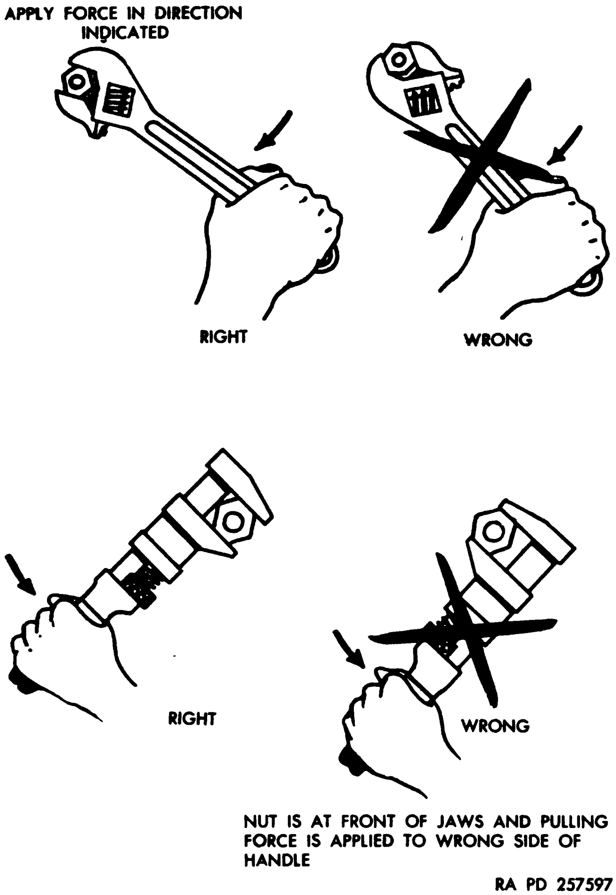

Figure 127. Using adjustable wrenches.

f. *Auto and Monkey Wrenches.* Use the auto or monkey wrench in the same manner as you would the adjustable open-end wrench.

Note. Always place the wrench on a nut or bolt so that the turning force is applied to the back of the handle; that is, the side of the wrench opposite the jaw opening, as shown in figure 127.

g. *Pipe Wrenches.*

(1) *Adjustable pipe wrench.* The adjustable pipe wrench will work in one direction only. Always turn the wrench in the direction of the opening of the jaws. Apply force to the back of the handle; since, the top jaw is capable of a slight angular movement, the grip on the work is increased by pressure on the handle (fig. 128).

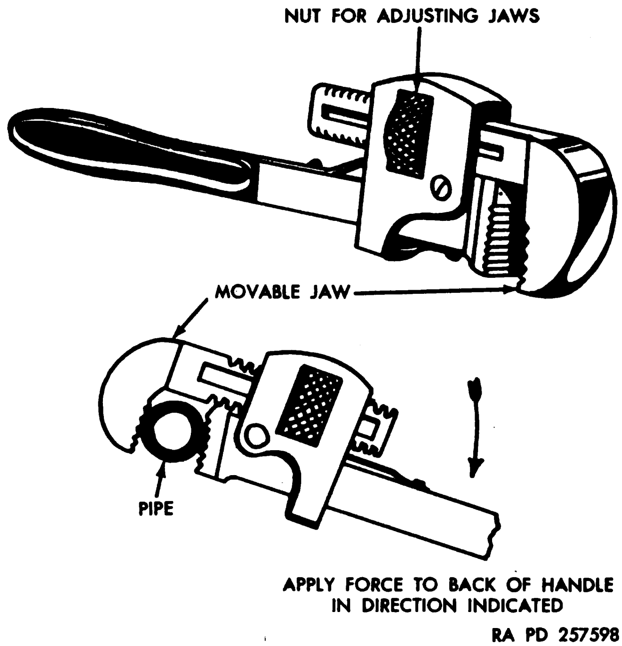

Figure 128. Using adjustable pipe wrench.

(2) *Adjustable strap pipe wrench.* When using the adjustable strap pipe wrench, loop the strap around the pipe in the opposite direction to that in which the pipe is to be rotated (fig. 129). Slip the end of the strap through the shackle and draw it up tightly. Pull the handle to turn the pipe in the desired direction. The jaw at the end of the shackle will seat against the strap, and as the handle is pulled, the strap will tighten and turn the pipe.

(3) *Adjustable chain pipe wrench.* The adjustable chain pipe wrench is used in the same manner as the strap wrench. The chain acts as a jaw when looped around the pipe, gripping

the pipe on the entire outer circumference. It is used for rough pipework on very large diameter pipe.

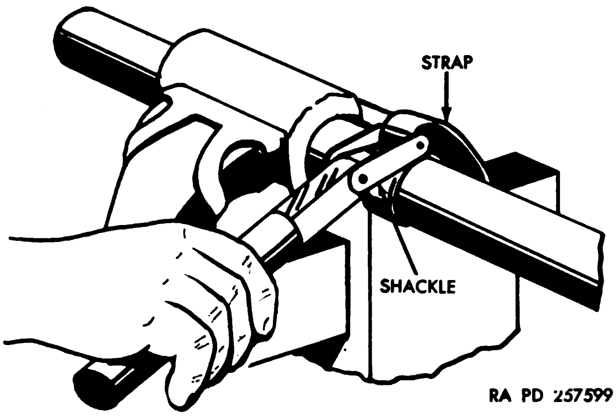

Figure 129. Using a strap pipe wrench.

h. Torque Wrench. A torque wrench enables you to set up a nut or bolt when the force applied to the handle reaches the specified limit. Manufacturers' instructions specify these limits of turning force. Cylinder head nuts and bolts, rod bearing caps, and other places on automotive and airplane engines usually require torque wrench limits. Select proper size socket wrench and attach to torque wrench square drive. Place socket wrench on work and pull the torque wrench handle in the desired direction to tighten the work. The tightening torque will be indicated on the dial or scale, depending on the type of the torque wrench used.

i. Spanner Wrenches. When using a pin-face spanner wrench (fig. 130), insert the pins or lugs into the pin holes of the part. Keep the pin face of the wrench flush with the part surface and turn the wrench. Exert enough force against the wrench so that the pins do not jump out of the holes. Hose coupling spanner wrenches are shaped so that they fit around the coupling with the pin or lug at right angles to the handle. Insert the pin in the hose coupling pin hole. Pull or push the handle in the direction opposite the hook of the spanner wrench. Make certain the pin fits the hole and the force is applied with the handle perpendicular to the work. Use of an adjustable spanner wrench is shown in figure 131.

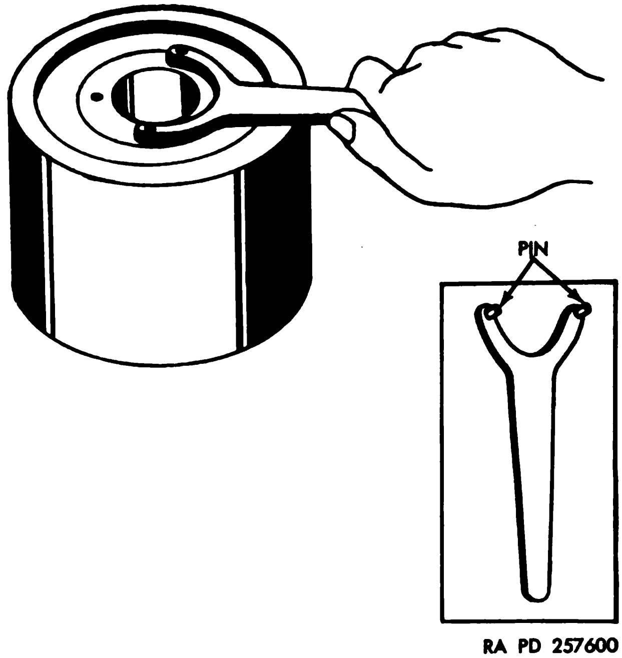

Figure 130. Using a pin-face spanner wrench.

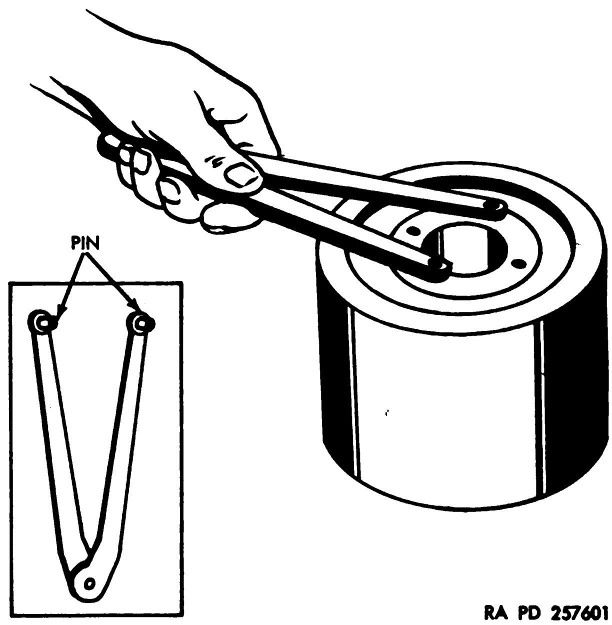

Figure 131. Using adjustable spanner wrench.

103. Care of Wrenches

Clean all wrenches after use. Apply a thin film of oil to metal parts of all wrenches prior to storing. Wrenches that come in sets, such as socket wrenches, should be returned to their cases after being used. The torque wrench, in particular, must be carefully placed in its box to prevent damage to the dial or scale. For long periods of storage, the wrenches should be covered with a rust-preventive compound and carefully stored in a dry place.

104. Safety Precautions

a. Wrenches should fit the nuts or bolt heads they are to loosen or tighten.

b. Never turn adjustable wrenches so that the pulling force is applied to the adjustable jaw.

c. Do not use a pipe, or extend the handle in any way, to increase the leverage on a wrench (fig. 132).

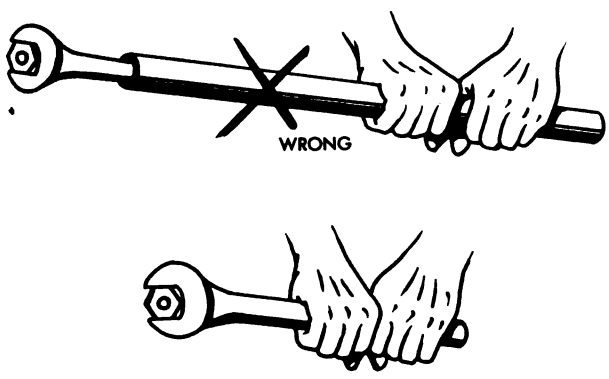

Figure 132. Applying leverage on wrench.

d. Apply penetrating oil to rusted nuts and/or bolts that resist turning. Allow time for oil to penetrate before attempting to turn.

e. Do not strike wrenches with hammers to tighten or loosen nuts or bolts.

f. Do not exert a hard pull on a pipe wrench until it has a firm grip on the work.

g. Remember to pull on the wrench when possible, in order to protect your knuckles in case the wrench slips.

h. Always keep the wrench in good condition; clean, and free from oil or grease.

105. Maintenance of Wrenches

a. Grinding and Filing Damaged Jaws. Fixed open-end and adjustable open-end wrenches having damaged jaws can be made serviceable by grinding and/or filing. When attempting this repair, finish-grind or file the jaw opening of the fixed open-end wrench to the next largest standard size. Jaw faces must must be flat and parallel. Use a part of known size or a gage block to test for correct size and parallelism. Dip jaws in water frequently when grinding to preserve temper which can be lost because of overheating.

b. Renewing Jaw Serrations. To renew the serrations in auto, monkey, pipe, and vise grip wrenches, use a fine triangular or flat

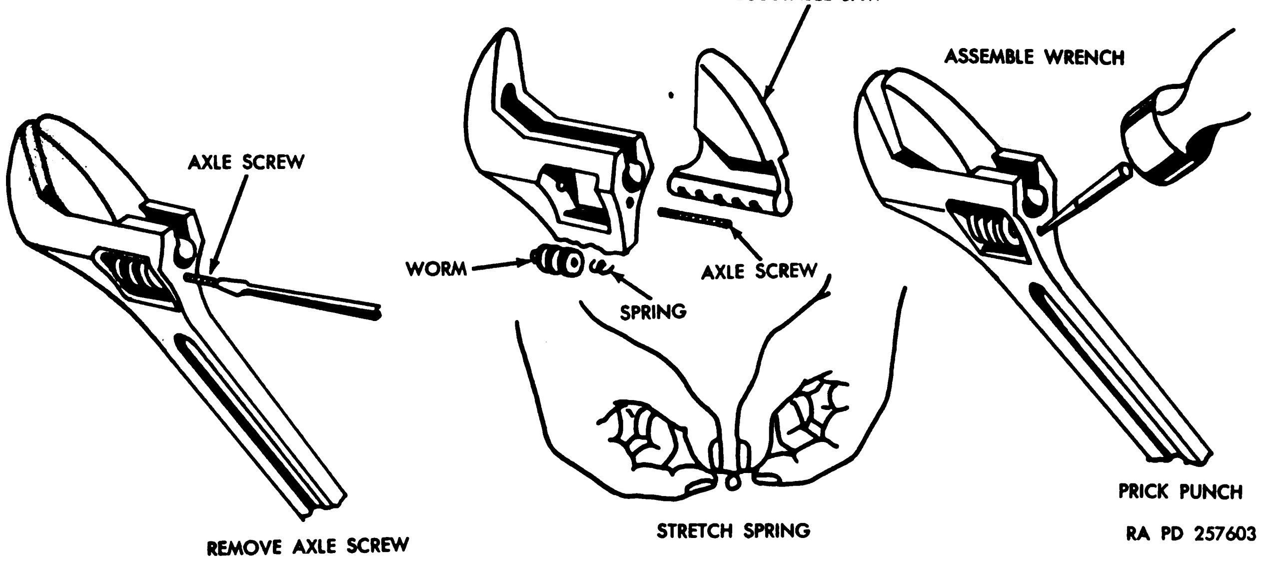

Figure 133. Adjusting for play in adjustable wrench.

tapered file, and carefully deepen the low points between the serrations. Do not remove more material than is absolutely necessary.

c. Adjustment for Play. The movable jaw on adjustable open-end wrenches may not remain parallel to the stationary jaw after prolonged use. In most cases the trouble is due to wear and likewise the worm spring has been weakened. To increase spring resiliency, remove the axle screw from wrench and separate adjustable jaw, worm, and worm spring from handle (fig. 133). Stretch worm spring if the spring is not cracked and in good condition. Stretching the spring will increase its tension and help keep the adjustable jaw from tipping. Reassemble wrench and prick punch wrench adjacent to tightened axle screw to lock it in position.

Section V. PLIERS AND TONGS

106. Purpose of Pliers and Tongs
(figs. 134 through 138)

Pliers are used for gripping, cutting, bending, forming, or holding work, and for special jobs. Tongs look like long-handled pliers and are mainly used for holding or handling hot pieces of metal work to be forged or quenched, or hot pieces of glass.

107. Types of Pliers

Pliers basically consist of a pair of jaws designed for a specific purpose, a pivot or hinge, and a pair of handles. They are made in many shapes and sizes to handle a variety of jobs. The size is determined by the overall length, which usually is 5 to 10 inches.

a. Slip Joint Combination Pliers. The slip joint combination pliers (fig. 134) are most commonly used to hold or bend wires, small bars, and a wide variety of miscellaneous items. Some have short cutting edges near the hinge for cutting wire. The slip joint permits adjustment and wider opening of the jaws. The jaws have serrations or teeth for gripping.

b. Diagonal Cutting Pliers. Diagonal cutting pliers (fig. 135) have short jaws with the cutting edges at a slight angle. They are used for cutting soft wire and stock and for removing cotter pins. They are also used for cutting cotter pins to desired length and for spreading the ends after the pin is inserted through a hole.

c. Lineman's Side Cutting Pliers. Lineman's side cutting pliers (fig. 135) are used for cutting wire and peeling insulation. The flat serrated jaws are also used to twist wire ends together in making splices.

d. Parallel Jaws, Flat, and Round Nose Pliers. These pliers (fig. 136) are used to bend or form metal into various shapes and to work in limited spaces. The nose is made in a variety of widths and lengths. The parallel jaws pliers are supplied with or without side cutters.

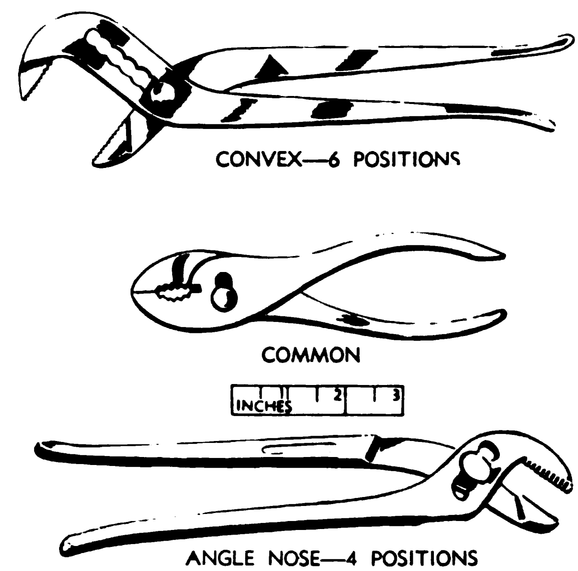

Figure 134. Slip joint combination pliers.

e. Special Purpose Pliers (fig. 137). Some pliers are made for specific jobs, such as the brake spring pliers, glass holding and breaking pliers, ignition pliers, battery terminal pliers, and brake key and snap ring pliers.

f. Tongs. Tongs (fig. 138) differ according to their use. The blacksmith's tongs are used for picking up and holding hot metal. The straight lip, flat jaw tongs are used to hold bearings and bearing inserts, while setting them in place.

108. Use of Pliers and Tongs

a. Pliers. When using pliers, keep your fingers away from the jaws and cutting edges.

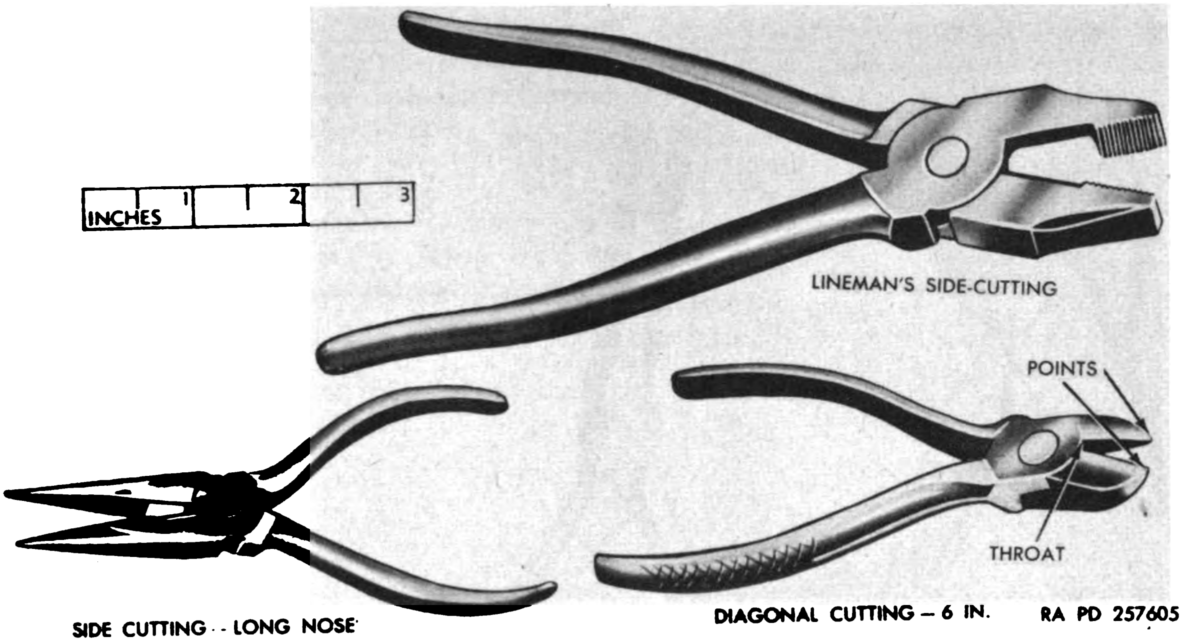

Figure 135. Diagonal and side cutting pliers.

Make sure the hinge or joint is tight before using pliers. Insulate handles of pliers when using them in electrical work with several thicknesses of friction tape, rubber tape, or specially manufactured rubber grips. When cutting large material within the capacity of diagonal cutting pliers (fig. 135), cut with the throat of the jaws, not with the points. The tendency of misalining the jaws will be greatly reduced. Once the jaws are misalined (sprung), it will be impossible to cut fine wire. To preserve the life of slip joint combination pliers (fig. 134), do not use them on very hard metal. Hard metal will wear off the teeth and the pliers will lose their grip. Use pliers only for the purpose for which they are intended. Do not try to increase the leverage of their handles by lengthening them with sections of pipe or other extensions.

b. Tongs. Light tongs should not be used to handle heavy work, since the heavy material may cause a bending or springing of the jaws. Keep the jaws in line when handling work. When handling hot metal, hold the metal securely and keep the tongs away from your body. Make certain all joints are tight before use.

109. Care of Pliers and Tongs

a. Maintenance. When the serrations of plier jaws become damaged or worn, or when the cutting edges become dulled or nicked, they must be repaired. The jaw serrations must be either ground on a V-shaped wheel or filed with a V-shaped or triangular shaped file.

(1) *Grinding serrations.* Separate the jaws of the pliers by removing the nut and screw, if so designed, and place one plier jaw in a grinding vise. Use a narrow grinding wheel that has an included angle of 60° (30° on each side of the centerline) (fig. 139) and grind the serrations.

(2) *Filing serrations.* Place the pliers in a vise protected with soft jaws and file the serrations with a triangular shaped file.

(3) *Sharpening cutting edges.* Some side cutting pliers are designed so they can be reground. Examine pliers carefully to see if the design will permit them to close completely if material is ground from the cutting edges. Do not attempt to sharpen pliers not designed to be ground, such as diagonal cutting pliers. Separate pliers, if possible, and place in a vise. Grind the cutting edges so that the ground bevel is at right angles with the inside

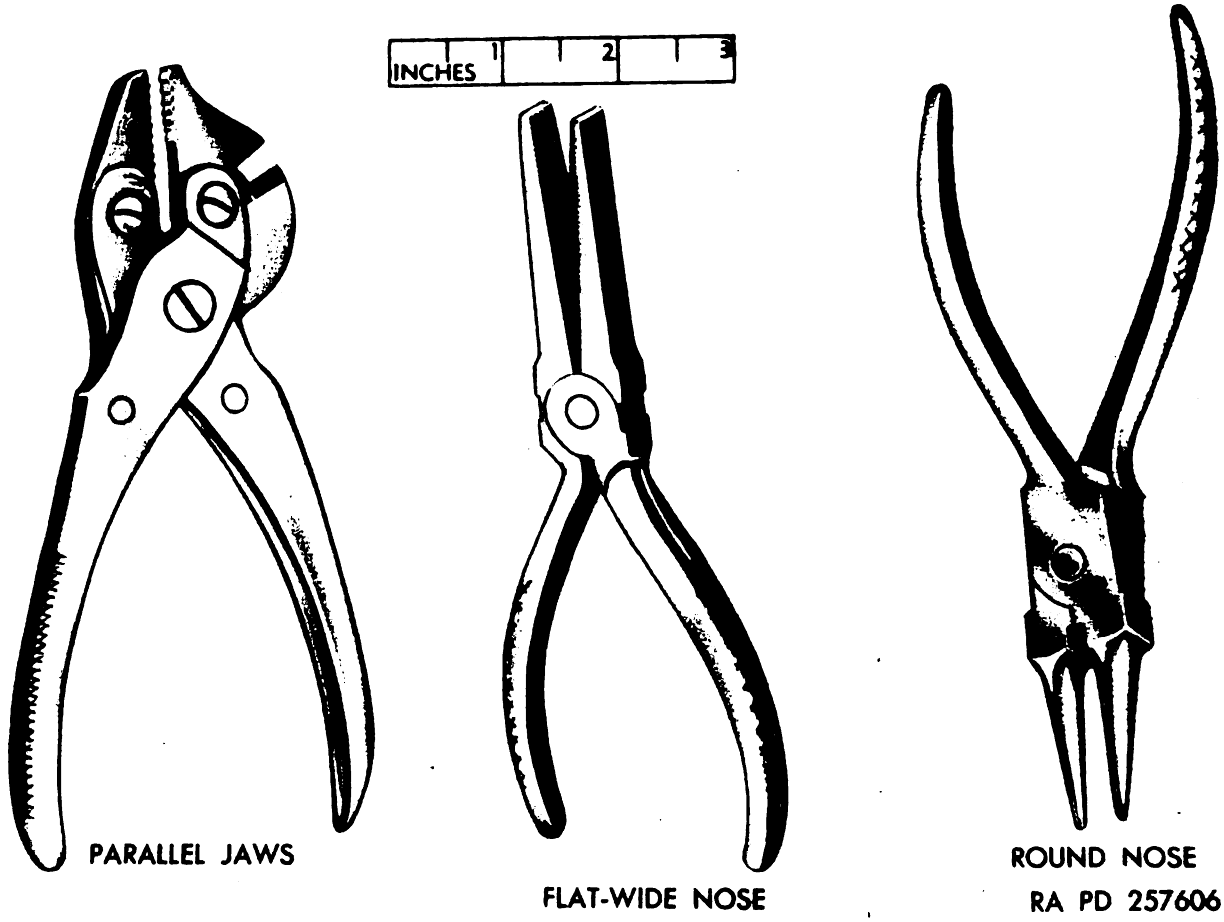

Figure 136. Parallel jaws, flat, and round nose pliers.

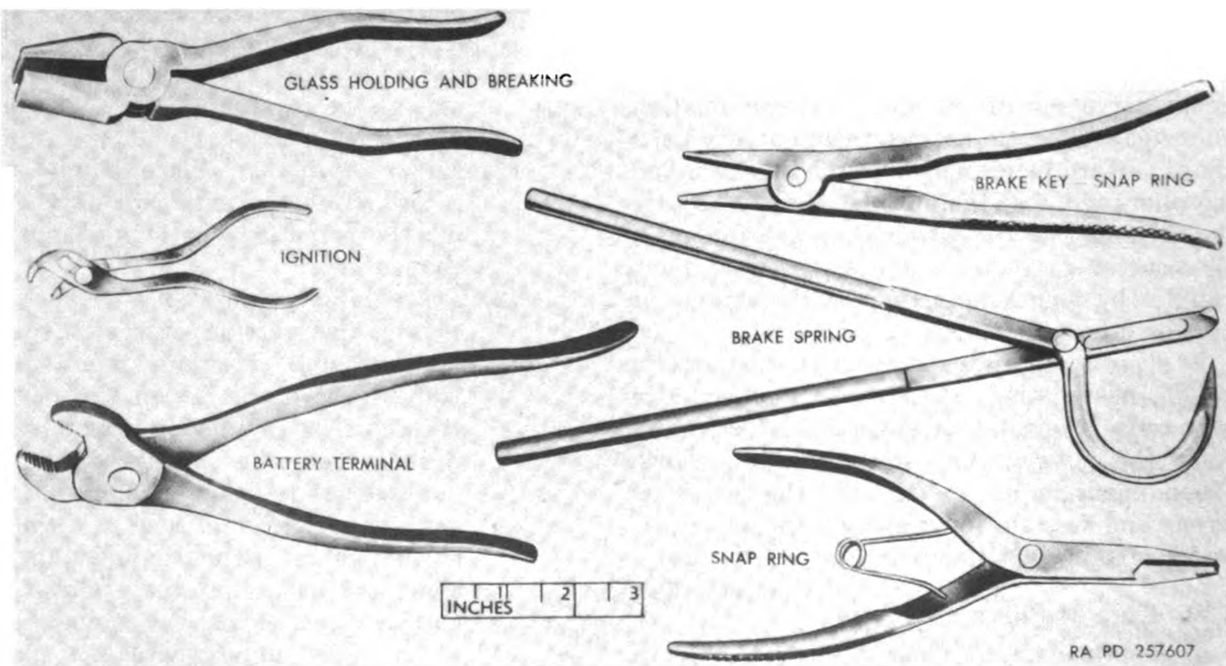

Figure 137. Special purpose pliers.

machined bevel (fig. 140). Grind same amount of stock from both jaws, but no more than necessary to remove nicks. Use extreme care to retain the temper of the cutting edges. Dip jaws in water frequently to retain temper. After sharpening, reassemble pliers and make certain the cutting edges meet and that the hinge is secure.

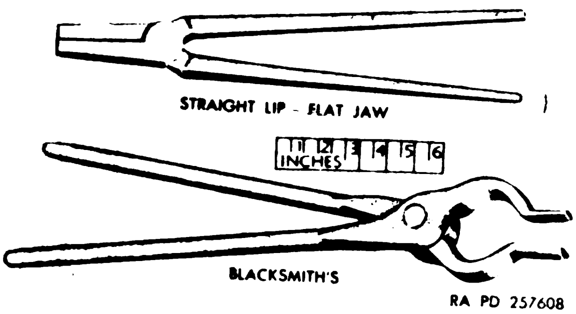

Figure 138. Tongs.

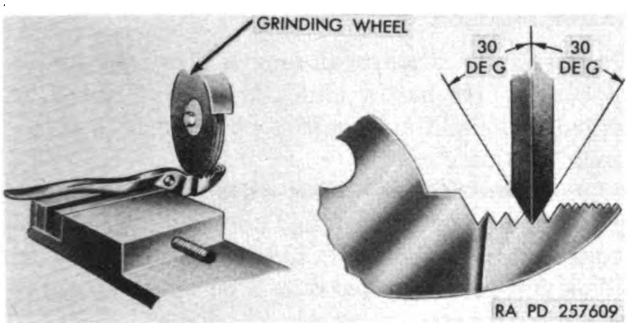

Figure 139. Reconditioning plier jaws.

b. Care. Pliers and tongs should be kept free from dirt and grease; otherwise they may slip, damaging the work and causing injury to you. Apply a thin film of light oil and carefully place in a tool box when not in use. Make certain the cutting edges do not strike other metal or hard objects that would nick or dull them. Cover pliers and tongs with rust-preventive compound and hang in a dry place if they are to be stored for long periods of time. Never use pliers to turn nuts or bolts, and do not use them for prying.

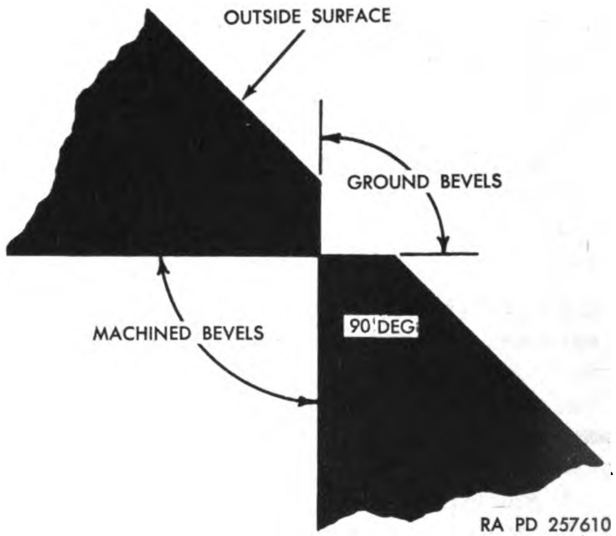

Figure 140. Grinding angle when sharpening plier cutting edges.

Section VI. CLAMPING DEVICES

110. Purpose of Clamping Devices (figs. 141 through 144)

Vises are used for holding work on the bench when it is being planed, sawed, drilled, shaped, sharpened, riveted, or when wood is being glued. Clamps are used for holding work that cannot be satisfactorily held in a vise because of its shape or size, or when a vise is not available. Clamps are generally used for light work.

111. Types of Vises

a. Machinist's Bench Vise. A machinist's bench vise (fig. 141) is a large steel vise with rough jaws that prevent the work from slipping. Most of these vises have a swivel base with jaws that can be rotated, while others cannot be rotated. A similar light duty model is equipped with a cutoff. These vises are usually bolt-mounted onto a bench.

b. Bench and Pipe Vise. The bench and pipe vise (fig. 141) has integral pipe jaws for holding pipe from ¾ inch to 3 inches in diameter. The maximum working main jaw opening is usually 5 inches, having a jaw width of 4 to 5 inches. The base can be swiveled to any position and locked. These vises are equipped with an anvil and are also bolted onto a workbench.

c. Clamp Base Bench Vises. The clamp base

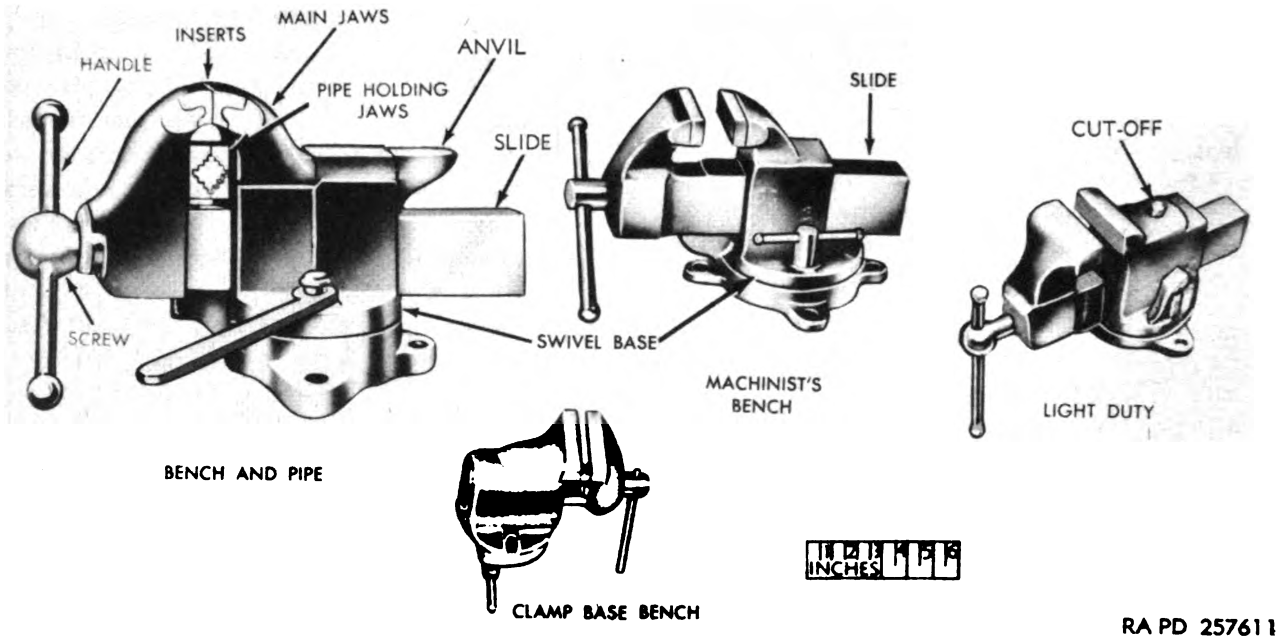

Figure 141. Types of vises.

bench vise (fig. 141) usually has a smaller holding capacity than the machinist's or bench and pipe vises and is clamped to the edge of a bench. Holding capacity is generally 1½ to 3 inches. These vises normally do not have pipe holding jaws.

d. Blacksmith's Vise. The blacksmith's vise (fig. 142) is used for holding work that must be pounded with a heavy hammer. It is fastened to a sturdy workbench or wall, and the long leg is secured into a solid base on the floor.

e. Pipe Vises. A pipe vise (fig. 142) is specifically designed to hold round stock. The vise shown has a capacity of 1 to 3 inches. One jaw is hinged so that the work can be positioned and then the jaw brought down and locked. This vise is also used on a bench. Some pipe vises are designed to use a section of chain to hold down the work. Chain pipe vises range in size from ⅛ to 2½–inch pipe capacity up to ½ to 8–inch pipe capacity.

f. Machine Table Vise. The machine table vise (fig. 143) is constructed so that it may be secured on a machine table and work held for subsequent machining operations. These vises either have a 3½–inch jaw width and a 3–inch jaw opening, or a 6–inch jaw width with a 6–inch jaw opening.

g. Pin Vise. A pin vise (fig. 143) is held in the hand. Its overall length is usually about 4 inches. It has a chuck-type jaw which is capable of holding small stock from 0 to 0.187 inch in diameter.

h. Piston Holding Vise. The piston holding vise (fig. 143) is designed to hold engine pistons up to and including 5½ inches in diameter. This vise can be bolted onto a bench or machine table.

i. Handsaw Filing Vise. The handsaw filing vise (fig. 143) is another specially designed vise. It has a 9½– to 11–inch jaw width which holds handsaws in the correct position for sharpening their teeth, and an attachment for holding the file at a definite constant angle.

112. Types of Clamps

a. C-Clamps. A C-clamp (fig. 144) is shaped like the letter C. It consists of a steel frame threaded to receive an operating screw with a swivel head. They are made for light, medium, and heavy service in a variety of sizes.

b. Hand Screw Clamps. A hand screw clamp (fig. 144) consists of two hard maple jaws connected with two operating screws. Each jaw has two metal inserts into which the screws are threaded. These clamps are also issued in a variety of sizes.

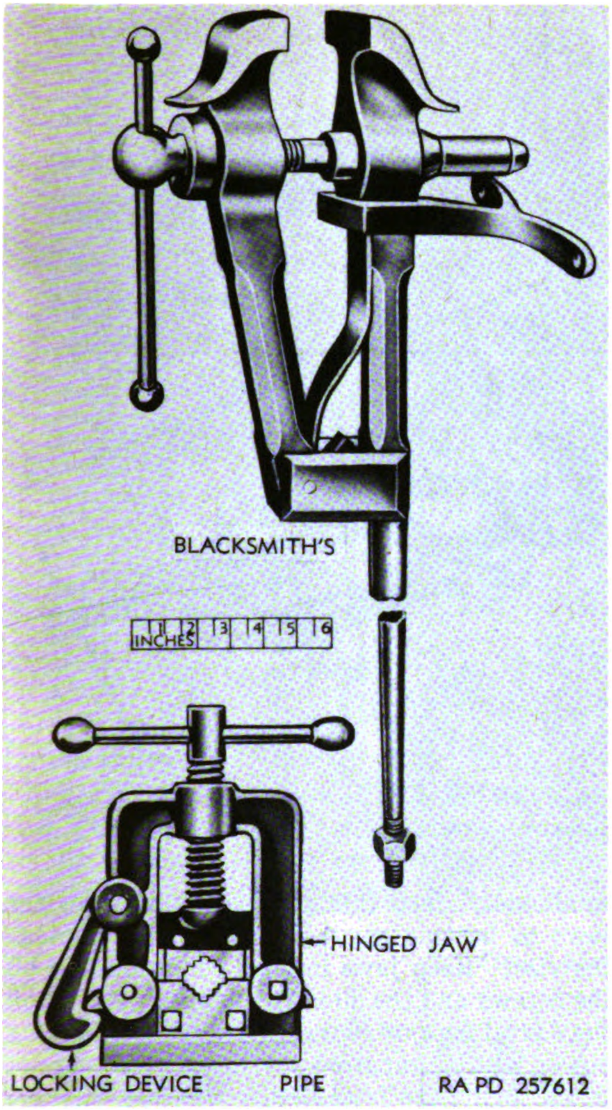

Figure 142. Blacksmith's and pipe vises.

c. Toolmaker's Clamps. One type of toolmaker's clamp (fig. 144) is similar to the hand screw clamp, except that the jaws are made of forged steel. The screws pass through one jaw and thread into the opposite jaw. One jaw is kept from sliding down the screw by means of a clip which slips under the knurled head of the screw. The other screw, farthest from the clamp opening, is threaded through one jaw and enters a shallow bearing hole in the other. These clamps are issued in 1¼–, 2½–, and 3½–inch capacities. Another type of toolmaker's clamp has one adjustable jaw and uses takeup blocks. The takeup blocks are slipped on and off the end of the adjustable jaw. The clamp can be attached to a bench so that it can be used as a small vise.

113. Use of Vises

a. When holding soft metal in a vise, material softer than the workpiece must be used in the jaws to prevent damage to the work. The work should be held securely to prevent it from slipping, but not so tight that it will damage the work.

b. When holding hard material, turn the screw of the vise up tight and tap the end of the handle sharply for the final tightening.

c. To hold irregularly shaped work in a vise requires a little thought. Make certain the jaws grip on a firm even surface of the work. The swivel jaw type of vise (not illustrated) is especially suited to hold tapered or irregular work, since one jaw can be swiveled. A tapered pin must be removed before the jaw can be swiveled.

d. Cylindrical work can be held between straight jaws; however, it is better to insert V-cut jaws over the straight jaws for this work.

e. Finished work should be held between jaws of soft material, soft metal, such as copper, brass, lead, or plastic. A piece of rawhide or soft leather laid over the vise jaws will prevent damage to highly polished surfaces.

114. Use of Clamps

a. When using the hand screw clamp, keep the jaws parallel to apply even pressure along the work and to properly hold the pieces of work together (fig. 145).

b. When soft material can be damaged by the jaws, soft material should be placed over the face of each jaw.

c. Use rawhide or soft leather to protect highly polished surfaces.

d. Never use the hand screw clamp on material other than wood. Other materials may damage the wooden jaws.

e. A C-clamp may be used on any kind of material. When holding glass or work with a high polish or paint finish, protect the finish by using brass shims or wooden blocks on each side of the work.

f. Clamps should be screwed up tight, but not so tight that the pressure will spring the clamp.

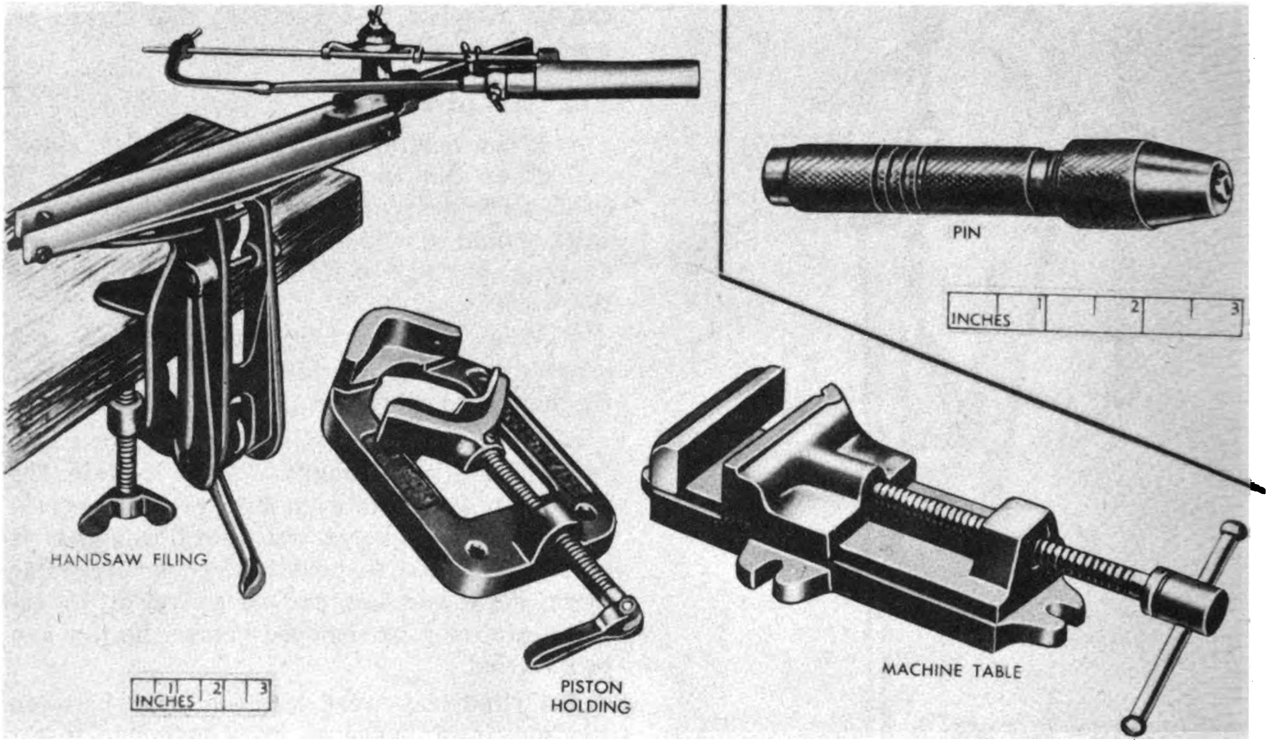

Figure 143. Special purpose vises.

g. Use hand pressure to tighten clamps; never use wrenches or bars (fig. 146).

h. Always use the right size clamp and observe clamps for signs of undue strain when using them.

i. When using the toolmaker's steel jaw clamp, both screws are turned to adjust the clamp roughly, then the screw nearest the open end of the clamp is adjusted until the clamp fits the work snugly. Then, tighten the clamp by turning the other screw. The jaws should be parallel and should clamp the work evenly. If one screw leads or lags the other, the clamp is useless; it will allow the work to turn. Back off one screw and tighten the other to correct uneven clamping condition. The knurled heads of these screws are drilled for insertion of a short, steel rod which can be used to increase leverage.

115. Care of Vises and Clamps

a. Vises. Keep vises clean at all times. They should be cleaned and wiped with light oil after using. Never strike a vise with a heavy object and never hold large work in a small vise, since this practice will cause the jaws to become sprung or otherwise damage the vise. Keep jaws in good condition and oil the screws and the slide frequently. Never oil the swivel base or swivel jaw joint; its holding power will be impaired. When the vise is not in use, bring the jaws lightly together or leave a very small gap and leave the handle in a vertical position.

b. Clamps

(1) *C-clamps.* Keep threads of C-clamps clean and free from rust by oiling properly. The swivel head must be kept clean, smooth, and grit free. If the swivel head becomes damaged, replace it as follows: Pry open the crimped portion of the head and remove the head from the ball end of the screw (fig. 147). Replace with a new head and crimp. Oil screw threads regularly (fig. 148). For short storage, oil clamps with a light coat of engine oil and wipe them off before they are hung on racks or pins, or carefully placed in a tool box. For

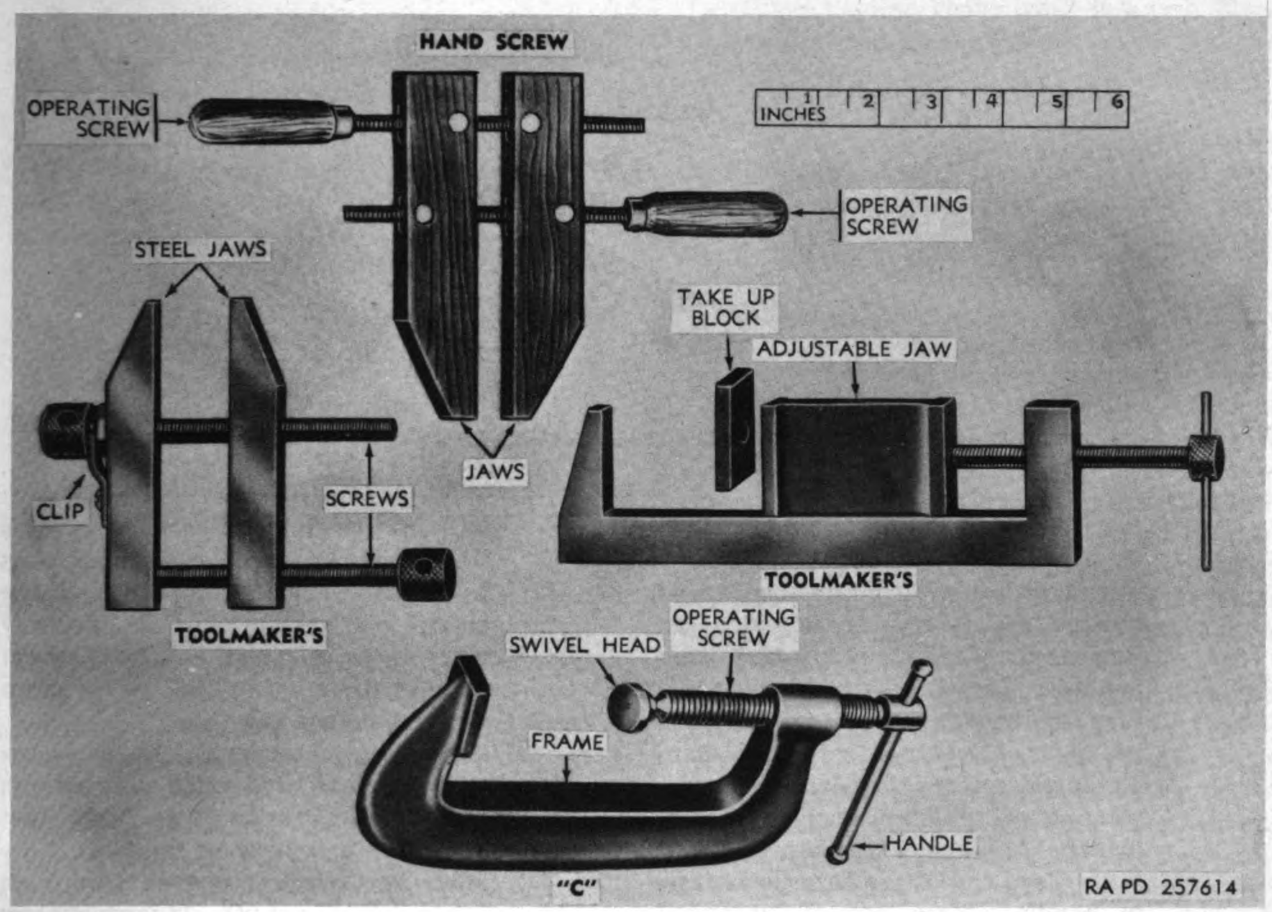

Figure 144. Types of clamps.

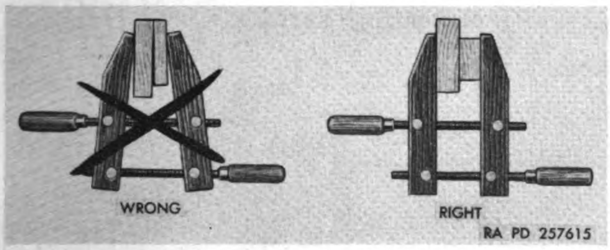

Figure 145. Using hand screw clamps—jaws parallel.

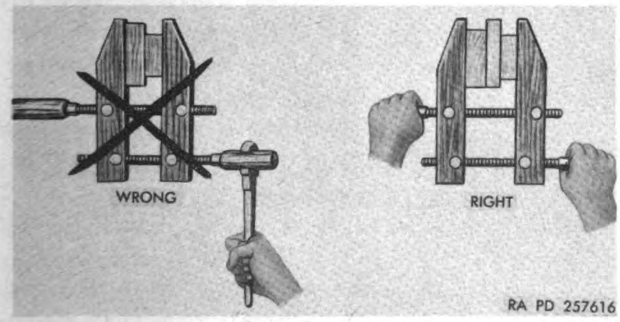

Figure 146. Using hand screw clamps—hand tightened.

long storage, apply a rust-preventive compound to the C-clamp.

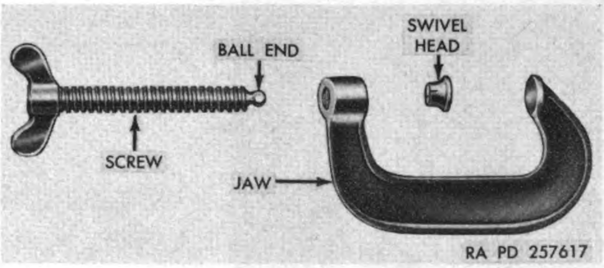

Figure 147. C-clamp, exploded view.

(2) *Hand screw clamps.* The screws of these clamps may break or become damaged, the inserts may become worn, or the wooden jaws may split or warp. When necessary to replace any of these parts, disassemble the clamp (fig. 149). Remove handles

Figure 148. Clamp maintenance.

from screws by filing off peened ends of attaching pins. Drive out pins. Turn both screws from the inserts and remove the inserts from the jaws. Replace damaged screws, inserts, and handles. Install inserts in jaws and turn the screws into position in the two jaws. Turn new screw into handle or old screw into new handle, depending on which part is being replaced Aline holes and tap in a new pin. Peen end of pin to secure screw in handle. Keep screws lubricated with a few drops of light oil. Apply a light coat of linseed oil to wood surfaces to prevent them from drying out. If the finish of wooden jaws is worn and bare wood is exposed, coat jaws with varnish (fig. 148). Hang clamps on racks or pins, or carefully place them in a tool box, to prevent damage when not in use. Wipe clean before storing.

(3) *Toolmaker's clamps.* Keep screw threads clean and oiled for smooth operation. Protect jaws from rust with a thin coating of light oil. Remove rust with crocus or aluminum oxide cloth (fig. 148) If jaws become chipped or marred, dress them with an oilstone to provide a smooth contacting surface.

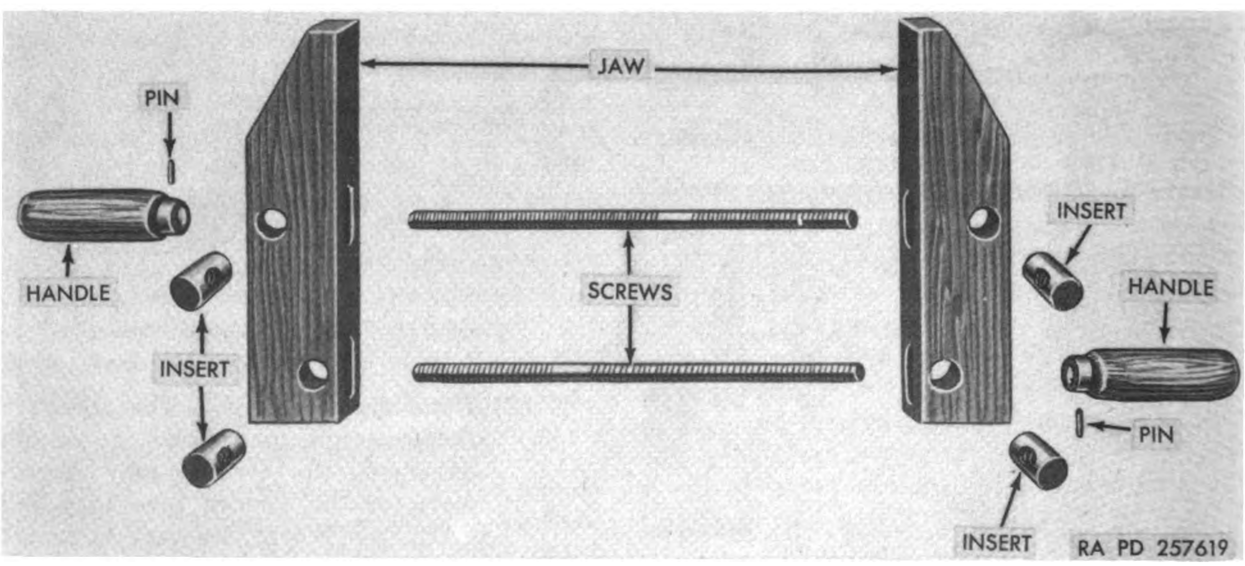

Figure 149. Hand screw clamp, exploded view.

116. Safety Precautions

a. When closing the jaw of a vise or clamp, avoid getting any portion of your hands or body between the jaws or between one jaw and the work.

b. Use care to keep from being pinched between the end of the handle and the screw.

c. When holding heavy work in a vise, place a block of wood under the work as a prop to prevent it from sliding down and falling on your foot.

d. Do not open the jaws of a vise beyond their capacity, as the movable jaw will drop off, causing personal injury and possible damage to the jaw.

Section VII. JACKS

117. Purpose of Jacks
(figs. 150 through 155)

Jacks are used to raise or lower work and heavy loads short distances. Some jacks are used for pushing and pulling operations, or for spreading and clamping.

118. Types of Jacks

Jacks are available in capacities from 1½ to 100 tons. Small capacity jacks are operated through a rack bar or screw, while those of large capacity are usually operated hydraulically.

a. Screw Jacks. The vertical screw jack (fig. 150) is operated by hand through a collapsible handle which is inserted in a socket. The screw moves up or down, depending on the direction of rotation in which the handle is turned. Some of these jacks are equipped with a ratchet for automatic lowering. Mechanical screw jacks are issued in several capacities having different contracted and extended heights. Another type of screw jack is called an outrigger jack. It is equipped with end fittings which permit pulling parts together or pushing them apart and has a capacity of 10 tons.

b. Ratchet Lever Jacks. A vertical ratchet lever jack (fig. 150) has a rack bar that is raised or lowered through a ratchet lever. Some of these jacks are equipped with a double socket; one for lowering, one for raising. Others have one socket and have an automatic lowering feature. An outrigger-ratchet jack

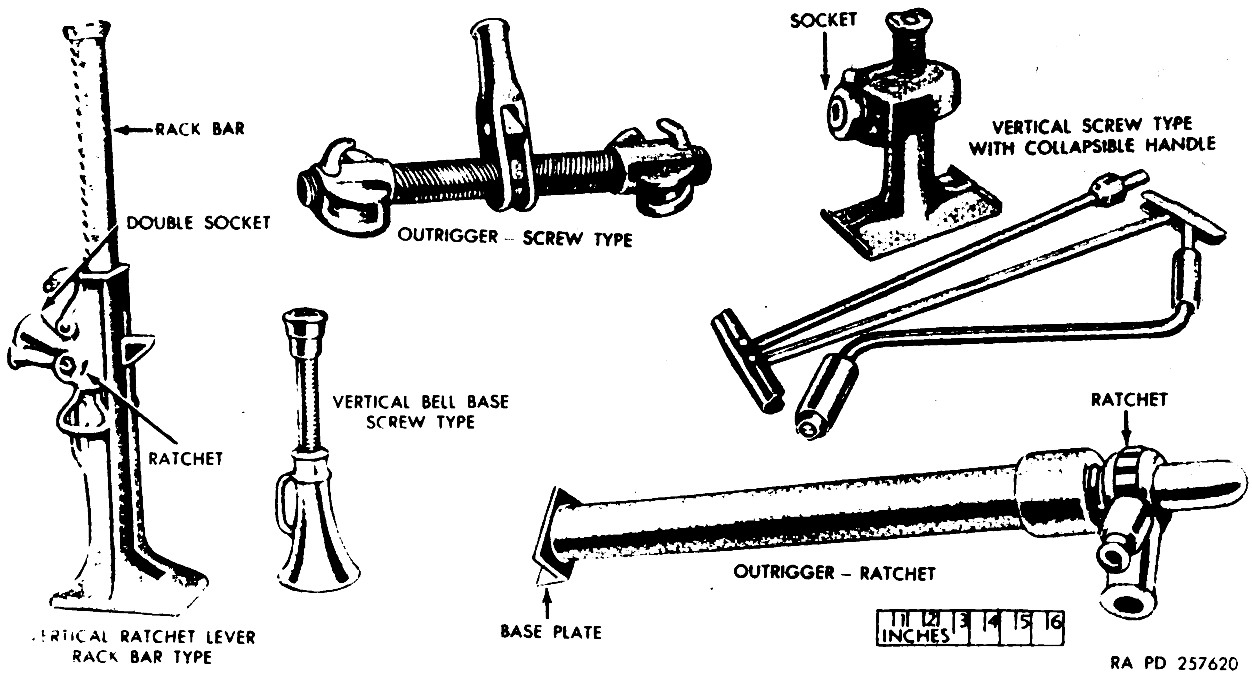

Figure 150. Mechanical jacks.

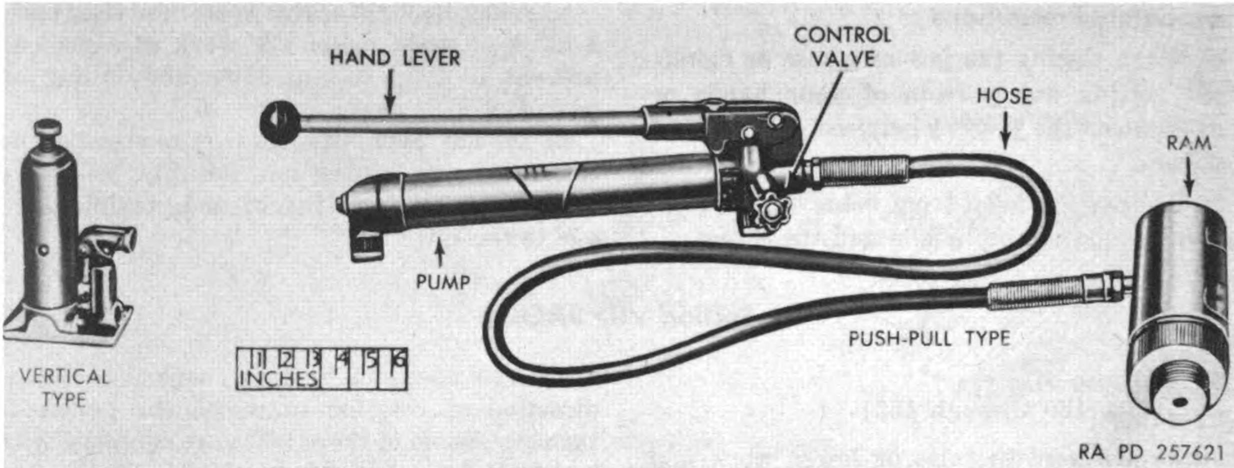

Figure 151. Hydraulic jacks.

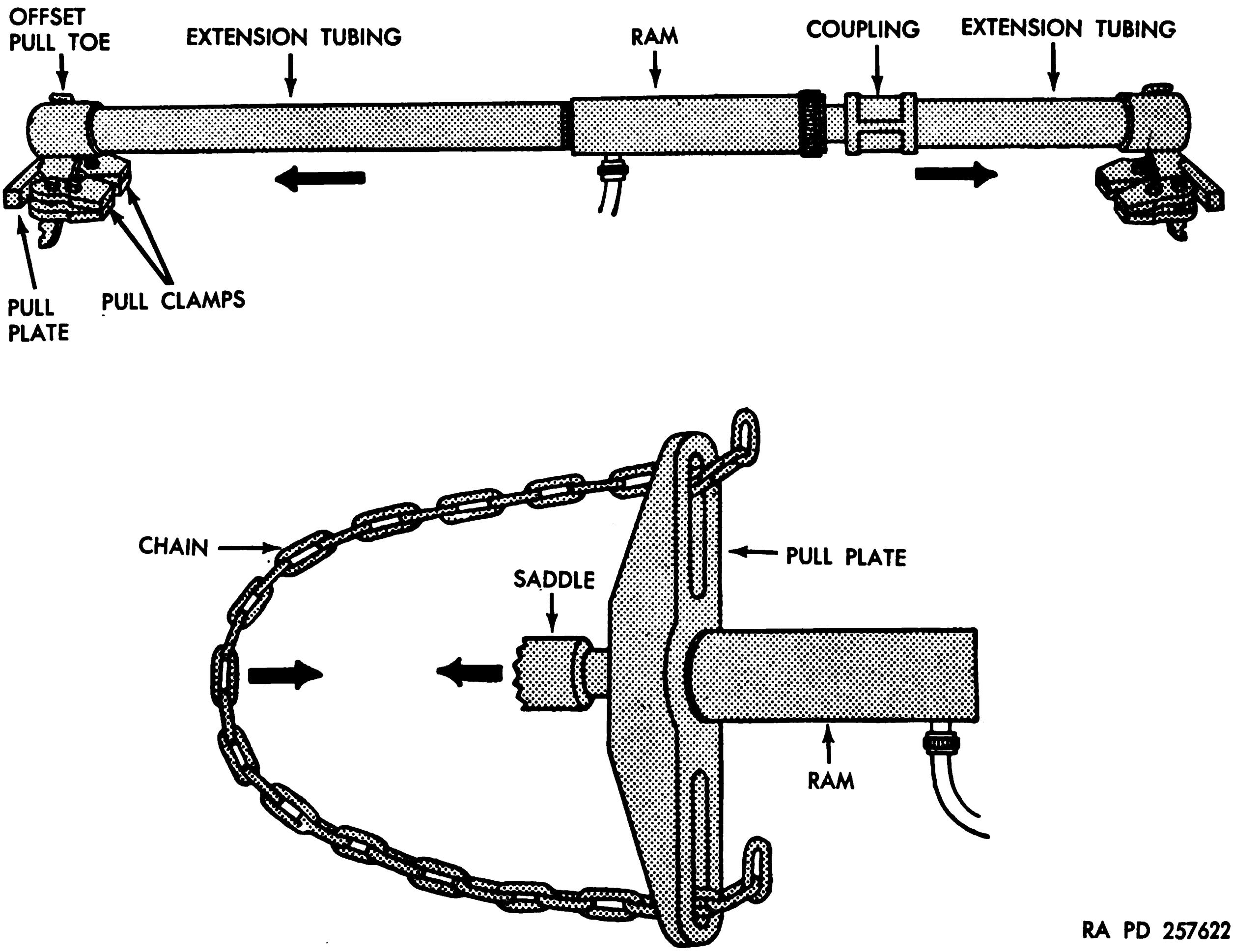

Figure 152. Jack pulling combinations.

is ratchet operated and has an extra reverse ratchet handle and a base plate.

c. Vertical Hydraulic Jacks. A hydraulic jack (fig. 151) operates through pressure applied to one side of a hydraulic cylinder which moves the jack head. These jacks are automatically lowered or released by releasing the pressure. Vertical hydraulic jacks are issued in a variety of types, in capacities from 3 to 100 tons, having different extended heights.

d. Push-Pull Hydraulic Jacks. A push-pull hydraulic jack (fig. 151) consists of a pump and ram connected by a hydraulic or oil hose. These jacks are rated at 3–, 7–, 20–, 30–, and 100–ton capacities and have diversified applications.

119. Using Jacks

a. Lifting Vehicles. The vertical jacks are used to lift one side of or the end of a vehicle to permit removal of the wheel or tires or to effect repairs that would not be possible with the vehicle standing on its wheels. The jack can be used on each side alternately by jacking one side of the vehicle up, then blocking it and moving the jack to the other side, continuing this operation until the vehicle has been raised to the desired height.

b. Miscellaneous Lifting. The jack can also be used to raise heavy crates, small buildings, or other items too heavy to be raised by prying with wrecking bars. It is essential that the jack be placed on solid ground or on planks to spread the weight so that it will not give way or tip when being used.

c. Push-Pull Hydraulic Jacks. The push-pull hydraulic jacks are furnished with an assortment of attachments that enable you to perform countless pushing, pulling, lifting, pressing, bending, spreading, and clamping operations. The pump is hand operated. Simply turn the control valve (fig. 151) on the side of the pump clockwise, stroke the hand lever up and down and the ram will extend. The 6–foot flexible hydraulic or oil hose allows you to operate the ram in any desired position and from a safe distance. The ram retracts automatically by turning the control valve counterclockwise. The attachments can be threaded to the end of the plunger, to the ram body, or into the ram base. Figures 152 through 155 illustrate some standard

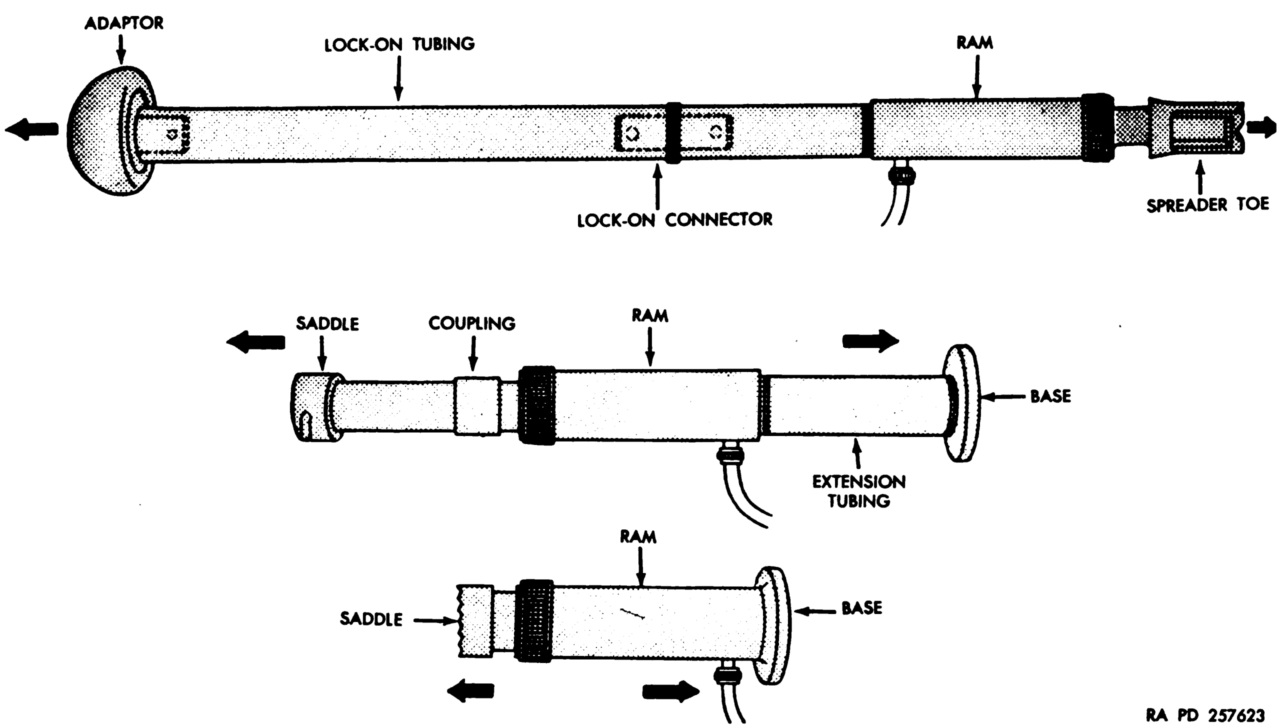

Figure 153. Jack pushing combinations.

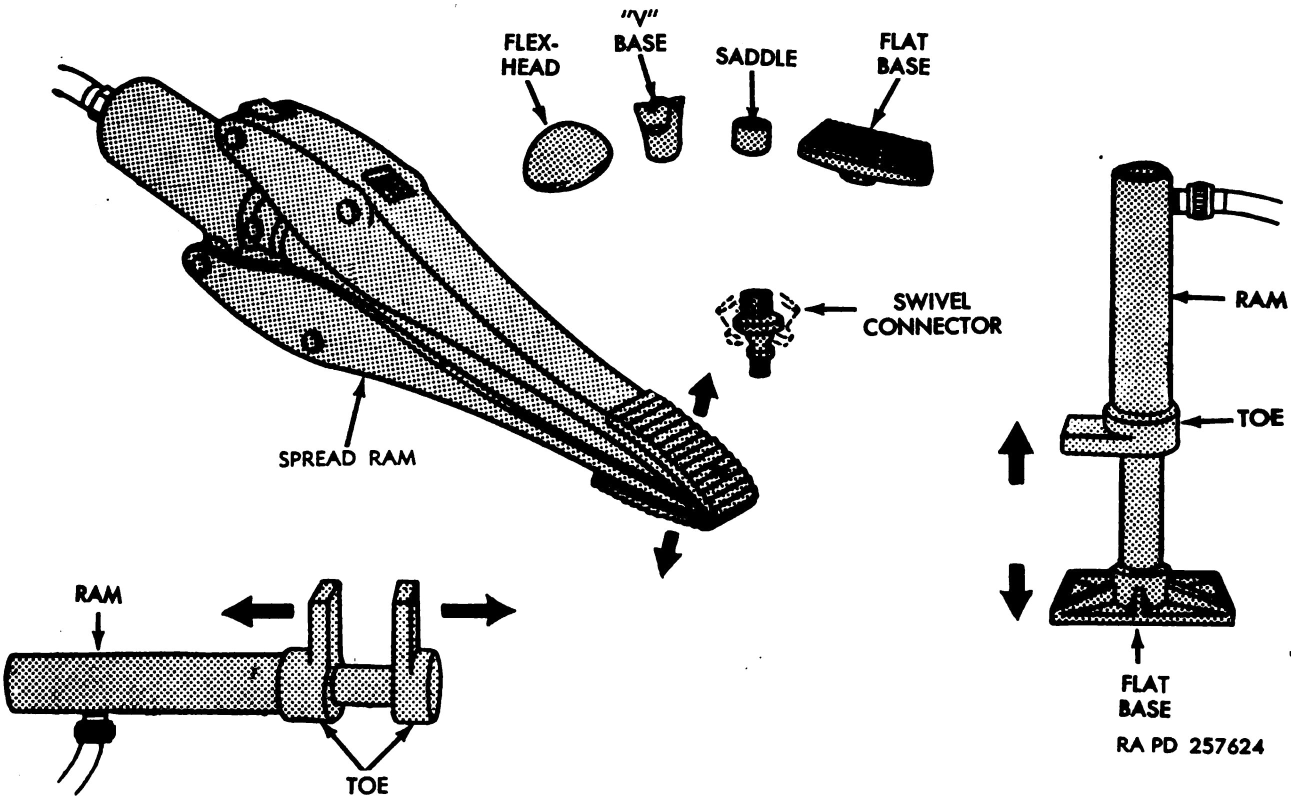

Figure 154. Jack spreading combinations.

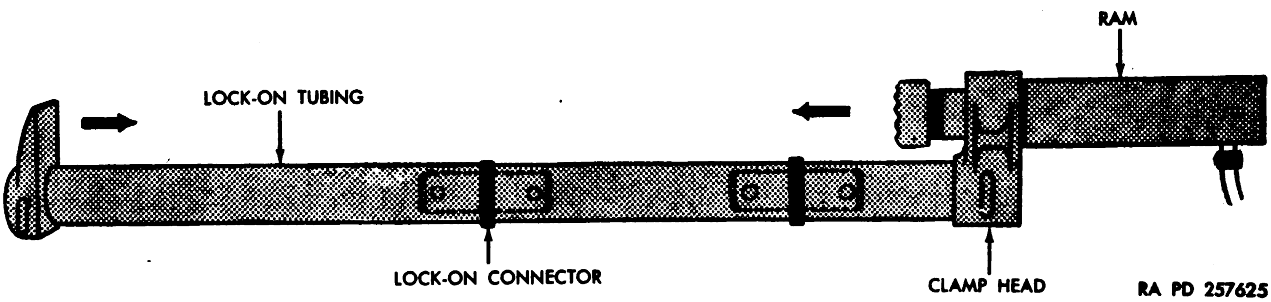

Figure 155. Jack clamping combinations.

combinations of the push-pull hydraulic jack attachments for various operations, including a specially designed spread ram.

120. Care of Jacks

Coat all surfaces with a thin film of light oil when not in use. For a long period of storage the jacks should be covered with a rust-preventive compound and stored in a dry place. Periodically, check hydraulic pump fluid level in push-pull hydraulic jacks. They are equipped with a fill plug. It is necessary to stand the pump on end before filling. Make certain the ram is in the retracted position when checking level of oil and when filling.

121. Precautions

Keep fingers away from all moving parts. When jacking up vehicles make certain no one is under the vehicle to be raised. Place blocking or other supports under the vehicle when it is raised to the desired height to prevent it from dropping if the jack fails. Make certain hydraulic jacks are filled with oil and there are no visible oil leaks before using.

122. Purpose of Bars and Mattock (fig. 156)

Bars are heavy steel tools used to lift and move heavy objects and to pry where leverage is needed. They are also used to remove nails and spikes during wrecking operations. The mattock is used for digging in hard ground, cutting roots underground, and to loosen clay formations in which there is little or no rock. The mattock may also be used for light prying when no bars are available.

123. Types of Bars and Mattock

a. Crowbar. The crowbar (fig. 156) is made of high grade steel and has a slightly bent wedge point at one end and tapers a little throughout its length. The wedge end is used for prying or for moving heavy timbers and objects. The blunt end is used for loosening rock formations. Crowbars are available in 4– and 5–foot lengths and with a diameter of 1 or 1¼ inches.

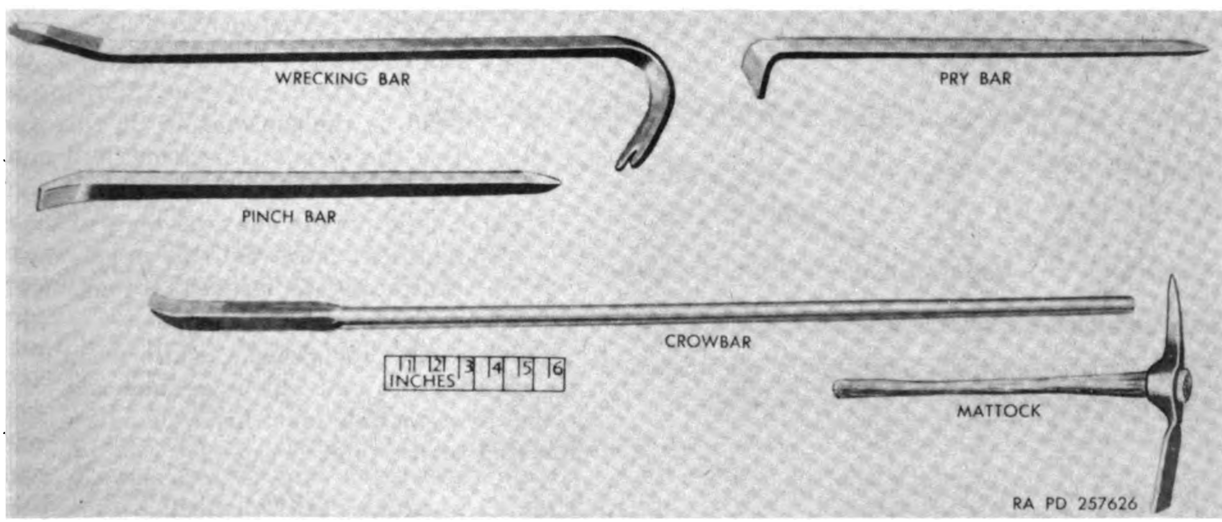

Figure 156. Bars and mattock.

b. Pinch Bar. The pinch bar (fig. 156) has one end bent slightly to a chisel or pinch point and has a tapered point at the other end. Another type has a pinch point at one end and a claw at the other end. Pinch bars range in size from ½ to 1 inch in diameter and from 12 to 36 inches long. The pinch bar is used in general as the crowbar is used except for lighter work, and in addition it is used to pull spikes and nails, and for light prying.

c. Pry Bar. The pry bar (fig. 156) is 16 inches long and has one end tapered to a point. The opposite end is offset 90 degrees to the bar. It is a combination alining and prying bar. The tapered point can be used for lining up work, and the offset end can be used for prying out gears, bushings, and so forth, since the offset point provides a great amount of leverage.

d. Wrecking Bar. The wrecking bar (fig. 156) has a gooseneck claw at one end and a pinch point at the other end. Other types may have two gooseneck ends, one with a claw and one with a straight point. Another variation is one gooseneck end with a claw and the other end offset, having a wedge shape. Wrecking bars range in size from 12 to 60 inches long and ½ to 1⅛ inches in diameter. They are used in the same manner as the crowbar and pinch bar.

e. Mattock. The head of the mattock (fig. 156) has two ends. One end is rectangular in cross section and tapers to a point like a pick. The other end has a finely tempered 4–inch wide blade that has a double bevel. The mattock head weights 5 pounds and is supplied with a wood handle.

124. Use of Bars and Mattock

a. Bars. To use a crowbar, operate it as a simple lever (fig. 157). It is mostly used in a position where the weight of the body is exerted downward on the narrow end of the bar. The pinch and wrecking bars are used in the same manner for prying and wrecking. The claw is used as you would a carpenter's claw hammer to remove nails and spikes. When prying, be cautious so that the bar does not slip and cause personal injury. Wrecking bars are exceptionally heavy and care must be taken to keep them from falling and striking someone. Do not use bars for extra heavy work, since they will bend.

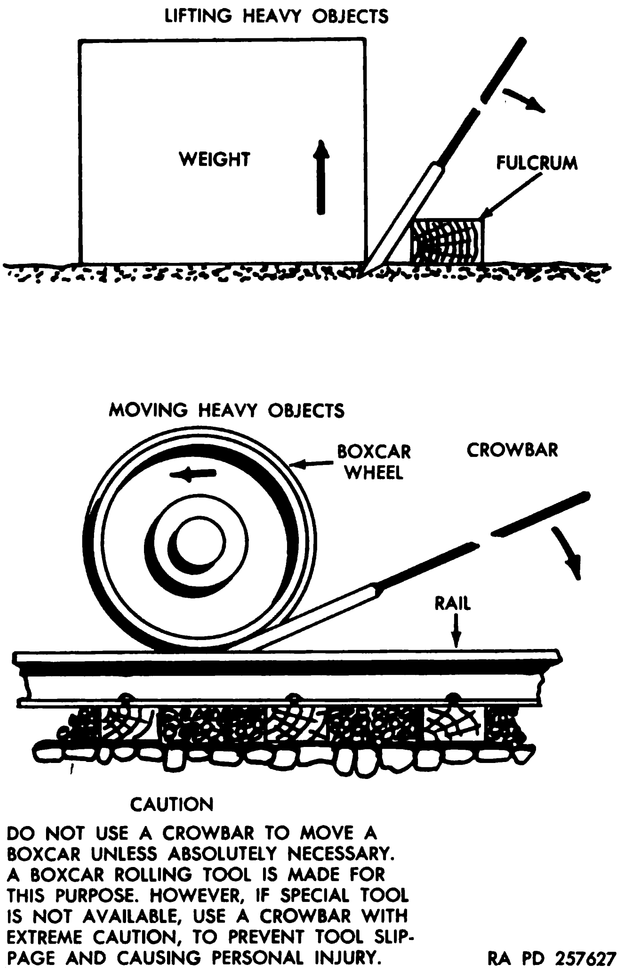

Figure 157. Using a crowbar.

b. Mattock.

(1) When using the mattock, it is important to have a firm footing and correct posture to prevent the mattock from glancing and striking the feet or legs if the mark is missed. Distribute body weight equally on both legs; the knees should be set but not tense, and feet should be spread apart at a comfortable distance. Body should be relaxed and free to swing and bend from the hips. Practice using the mattock either with the right hand or the left hand leading in order to prevent tiring quickly. With the right hand leading, the left foot should be brought slightly toward the work. To start the swing, hold the handle at the end with the left hand and near the center with the right hand. Raise the mattock over the right shoulder. Swing the mattock down toward the work allowing the right hand to slide back along the handle toward the left hand so that, at the finish of the swing, the hands are close together.

(2) With the left hand in the center of the handle, the mattock is swung in the same manner, except that the positions are reversed.

(3) Light swings are accomplished with wrist motion only and allowing the head of the mattock to do the work. Use the wrists, forearms, and shoulders for heavy swings.

(4) Slight prying may be done with the mattock; however, this must be done cautiously to prevent breaking the wood handle.

***Caution:* Do not swing a mattock until you are sure that no one will be endangered by the swing, by a possible loose head, or by a possible glancing of the tool.**

125. Care of Bars and Mattock

a. Bars.

(1) *Storage.* Bars are sturdy tools which require little maintenance, but they should be thoroughly cleaned after use and covered with a light film of oil before placing them on a rack. For long-term storage, they should be covered with a rust-preventive compound and stored in a dry place.

(2) *Shaping*. When misused or used extensively, bars may lose the shape of their ends and must be reshaped. Normally, the chisel end or pinch point can be filed or ground back to shape very easily. The claw end of a bar must be filed and kept sharp so that it can properly engage the nails or spikes that are to be pulled.

b. Mattock.

(1) *Storage*. Store the mattock so that the head will not be struck against metal or other hard surfaces. The mattock should be placed against a wall on its head or hung on a rack. For long-term storage, coat the head with a rust-preventive compound and store in a dry place in a rack or box with the cutting edges protected. Thoroughly, clean the mattock after use and before short or long-term storage.

(2) *Sharpening*. The point of the mattock can be sharpened with a file or on a grindstone. If the point becomes too dull to be sharpened with a file or grindstone, it should be heated in a charcoal fire and hammered to shape on an anvil, after which it must be tempered. If properly forged, the point should not require grinding. The head must be removed from its handle before tempering and before the blade can be sharpened on a grindstone or abrasive wheel. Hold the head of the mattock and tap the opposite end of the handle on a solid surface to loosen the head. Slide the head from the top of the handle. Remove nicks from the blade by moving it back and forth across a grindstone. Make sure the edge is square across the head. Grind the double bevel on the mattock blade by adjusting the rest on the grinder; hold the blade against the rest and move the blade down onto the abrasive wheel; do one bevel at a time and grind to the original bevel. Dip the head in cold water frequently to prevent burning or loss of temper. After sharpening, slide the head over the bottom end of the handle and into approximate position at the top of the handle. Tap the head end of the handle on a solid surface to tighten head on the handle.

Section IX. SOLDERING IRONS

126. Purpose of Soldering Irons (fig. 158)

Soldering is joining two pieces of metal by adhesion. The soldering iron is the source of heat for melting solder and heating the parts to be joined to the proper temperature.

127. Types of Soldering Irons

There are two general types of soldering irons, electric heated and nonelectric heated. The essential parts of both types are the tip and the handle. The tip is made of copper.

a. Electric Soldering Iron. The electric soldering iron (fig. 158) transmits heat to the copper tip after the heat is produced by electric current which flows through a self-contained coil of resistance wire, called the heating element. Electric soldering irons are rated according to the number of watts they consume when operated at the voltage stamped on the iron. There are two types of tips on electric irons. Plug tips which slip into the heater head and are held in place by a setscrew, and screw tips which are threaded, and which screw into the heater head. Some tips are offset and have a 90–degree angle for soldering joints that are difficult to reach (not illustrated).

b. Nonelectric Soldering Iron. A nonelectric soldering iron (fig. 158) is sized according to its weight. The commonly used sizes are the ¼–, ½–, ¾–, 1–, 1½, 2–, and 2½– pound irons. The 3–, 4–, and 5–pound sizes are not used in ordinary work. Nonelectric irons have permanent tips and must be heated over an ordinary flame, or with a blowtorch.

128. Use of Soldering Irons

a. Tinning. Before any soldering iron can be used, the faces of the tip must be filed smooth and tinned (coated with solder). For ordinary work, a soldering iron is tinned on

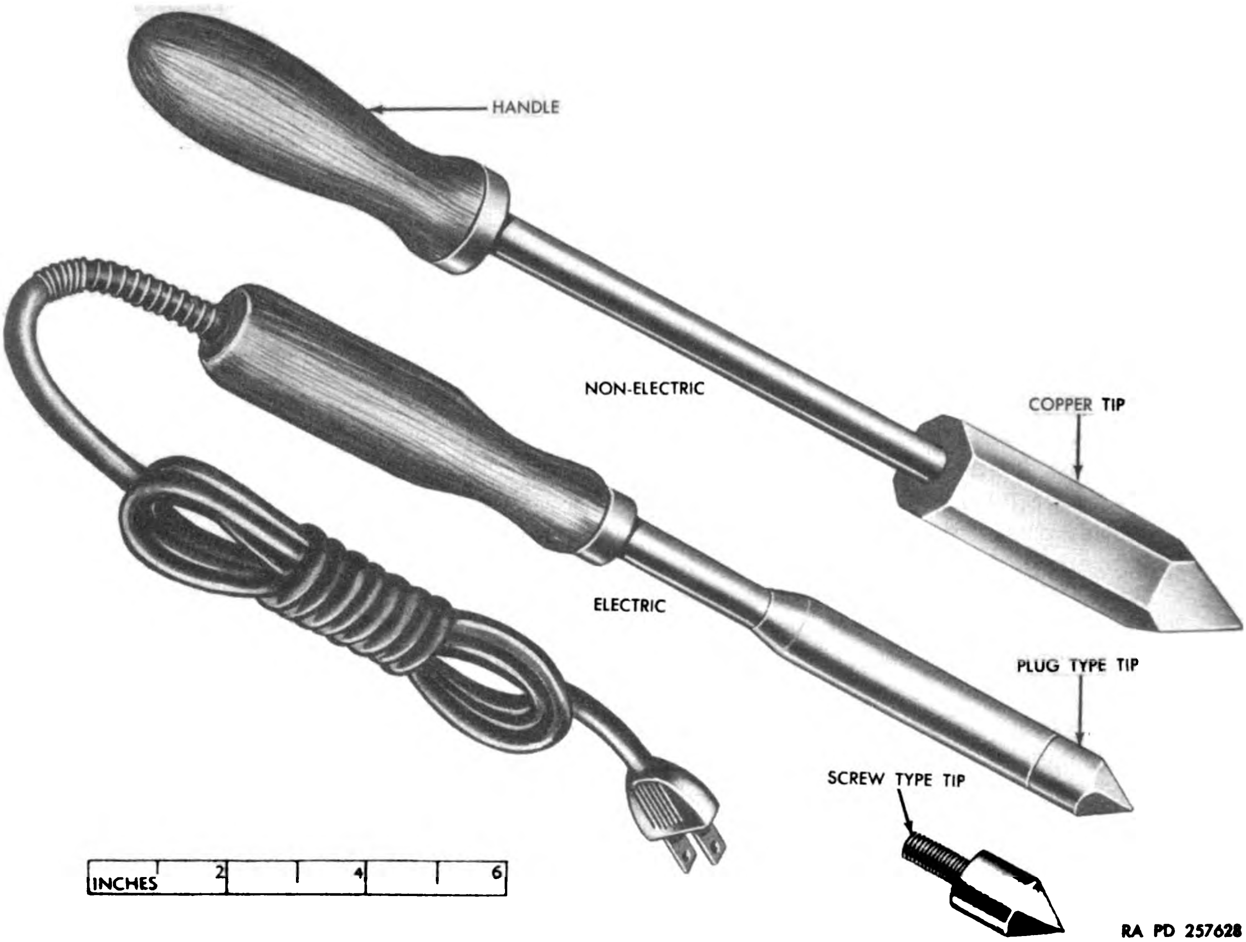

Figure 158. Soldering irons.

all four faces. For work where the iron is held under the object to be soldered, as when soldering wire splices, only one face is tinned (fig. 159). Molten solder on a tip with all faces tinned will not remain on the upper face, but will run to the bottom, forming a drop. When only one face is tinned and that face is turned up, solder melted upon it will not drip off. Tin an electric soldering iron as indicated in (1) through (4) below.

(1) Clamp the iron in a vise and file the tip faces bright while the iron is cold (fig. 160).

(2) Remove the iron from the vise. Plug electrical cord into outlet and as the iron heats up rub flux core solder over the tip faces every 15 or 20 seconds. At first, the iron will not be hot enough to melt the solder.

(3) As soon as the temperature has risen sufficiently, the solder will spread smoothly and evenly over the faces. The purpose of this procedure is to do the tinning as soon as the copper is hot enough to melt the solder and before it has had a chance to oxidize.

(4) When the tinning is completed, wipe the tip with a rag while the solder is hot and molten. This will expose an even, almost mirror-like layer of molten solder on the tip faces.

Note. If the iron is large, either acid core or rosin core solder my be used. Small irons used for soldering electrical parts and wiring should be tinned only with rosin core solder or solid solder and rosin.

b. Regulating Temperature of Electric Soldering Iron. Electric soldering irons are designed for continued use. Once connected, they develop heat so rapidly that the tip becomes overheated and oxidized, corrodes rapidly if the

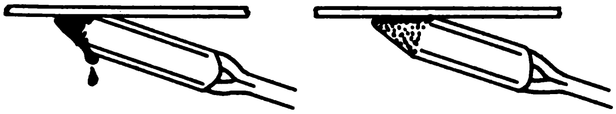

Figure 159. Proper tinning of soldering iron.

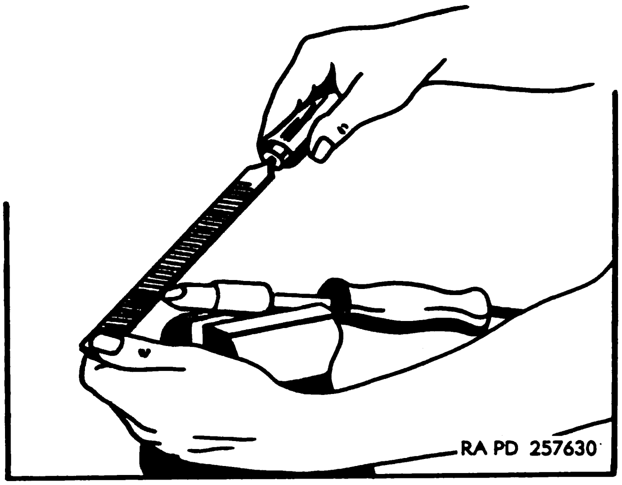

Figure 160. Filing tip of iron.

iron is not used constantly. It is often convenient to have a hot iron ready for use without having to wait to heat it up. This can be done by connecting the iron in series with a light bulb and a switch, as shown in figure 161. The resistance of the lamp reduces the amount of current flowing through the iron, thereby preventing it from developing its maximum temperature. When the switch is open so that the current flows through both the iron and the lamp in series, the iron may be left connected to the power line with no danger of overheating. When the iron is to be used, close the switch to short circuit out the lamp. This increases to its normal value the current flowing through the iron, permitting it to develop its maximum heat. The size of the lamp will depend upon the size of the iron and the desired temperature while waiting and will have to be determined by experiment. It should be rated (number of watts rating) to permit the flow of that amount of current which is required to keep the iron just hot enough to melt solder, or somewhat below that temperature, if desired.

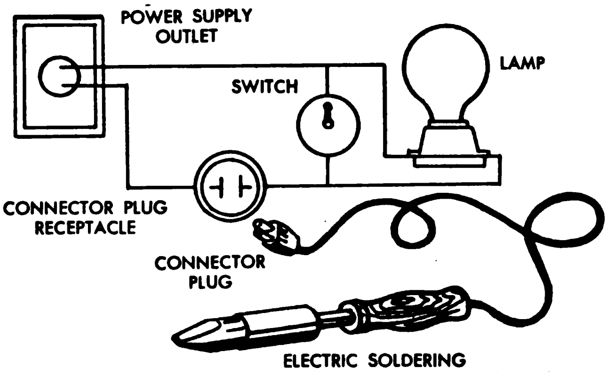

Figure 161. Electrical circuit to prevent overheating iron.

c. Using Fluxes. It is almost impossible to solder without a flux. Metal surfaces, at the point where they are to be joined together, must be absolutely clean and bright so that the solder will adhere to them. A thin layer of oxide forms on even bright surfaces in a few seconds as soon as they are heated by the iron. To remove the oxide coating, apply flux. Fluxes are chemicals; the most common in use for soldering are rosin and zinc chloride. Zinch chloride is an acid flux. Rosin fluxes are noncorrosive and nonconductive and are the best fluxes to use when soldering metals, copper, old tinware, electrical connections, radios, telephones, fine instruments, and small parts. Zinc chloride or paste solder is corrosive and is commonly used in heavier work on untinned copper, brass, bronze, monel metal, nickel-plated parts, galvanized iron, zinch, steel, and German silver. Since it is corrosive, all traces of it should be washed off the work after soldering. The only disadvantage of using rosin flux is that rosin is adhesive. Consequently, a joint which may appear to be well soldered may actually be held together by the adhesive properties of the rosin and not by the solder. To prevent this, the soldering iron must be hot enough to cause the rosin to burn and must be held against the joint until it smokes. Be constantly on the alert to avoid "rosin joints" when making electrical connections.

d. Using Solder. There are two types of soldering, soft and hard. Soft soldering uses solder which melts at temperatures under 700° F. Soft solders are alloys of lead and tin. Hard solders melt at higher temperatures and are mechanically stronger than soft solders.

Solder is made in bar, ribbon, and wire form. Wire solders may be either solid or cored. Cored solder is hollow like a tube and contains a core of flux. The flux is usually either rosin or an acid substance. Ribbon and wire solder are used with small irons on small work. Bar solder is used with large irons on heavy work.

e. Using a Soldering Iron. There are many rules to follow in order to perform a successful soldering job, but the six most important are described in (1) through (6) below.

(1) The work which is to be soldered must be perfectly clean. All oxide, corrosion, paint, grease, dust, and foreign matter must be scraped off or the solder will not stick. A steel scratch brush, emery paper, steel wool, file, knife, emery wheel, or scraper may be used whichever works best for the particular job to clean the metals and produce the required bright surface.

(2) The proper flux must be used; it must wet the entire surface to which the solder is to adhere. Too much flux will interfere with soldering. Rosin flux may be applied in the form of a powder which is sprinkled on, or it may be dissolved in alcohol and applied with a brush. In soldering small work of brass, copper, and tin-plated items, rosin core solder can be used. In heavy work it is necessary to apply flux separately. Zinc chloride, or any fluid flux, should be swabbed on. After soldering, all traces of acid and zinc chloride fluxes should be removed by washing with a solution of soap and washing soda in water.

(3) The work must be properly and rigidly supported so that it does not move while the solder is setting. If a joint is moved while the solder is cooling and setting, the solder will be broken or weakened. When holding work in clamps or vises, make sure that the heat is not conducted to the jaws of these holding devices. In most cases, several layers of newspaper or asbestos paper placed between the jaws and the work will provide an effective insulator which will prevent the escape of the heat. The best method of securing the work will vary with each job.

(4) The iron must be the right size for the job and must have the proper temperature. When using an iron to melt solder and heat the work, the iron loses its heat very rapidly. If an electric iron becomes too cool to solder, it is too small and a large iron should be used. Soldering small, light objects does not draw a great deal of heat from the iron, but large castings, pipe fittings, and so forth, will cool an iron very quickly so that a torch or flame must be used to preheat the work before the iron is applied. In some cases, soldering can be done with a torch alone, eliminating the iron.

(5) The iron must be kept well tinned and clean. The electric iron must be wiped with a rag frequently and the nonelectric iron wiped clean after it is removed from the flame.

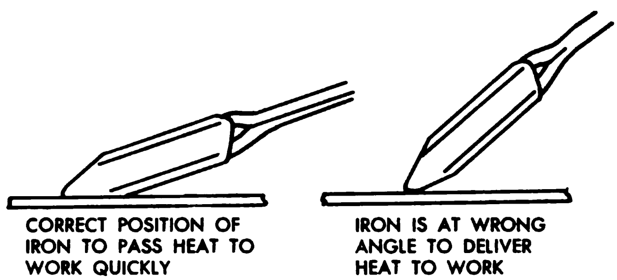

Figure 162. Position of iron to pass heat.

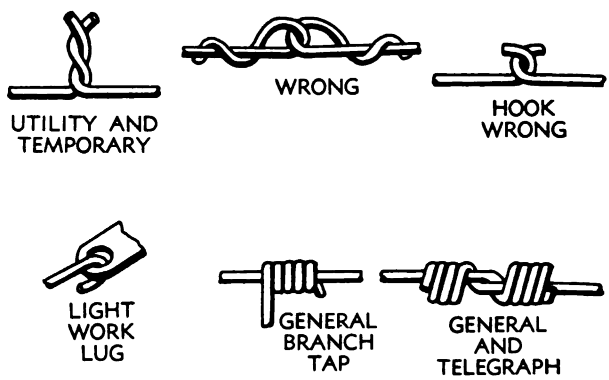

Figure 163. Wire splices for soldering.

(6) The work must be heated by the soldering iron so that the solder flows or sweats into the joint. The proper method of holding an iron to pass heat quickly to the work is by establishing sufficient contact surface as shown in figure 162. When soldering splices in wire, the splice is usually heated by the iron from below and the solder placed above the splice. Figure 163 illustrates the right and wrong methods to make wire splices for soldering.

129. Care of Soldering Irons

Electric iron tips must be kept securely fastened in the heater unit. The tips must be kept clean, free of copper oxide. Sometimes the shaft becomes oxidized and the tip may stick in place. Remove the tip occasionally and scrape off the scale. If the shaft is kept clean, the tip will not only receive more heat from the heater element, but it can be removed easily when the time comes to replace the tip. After use, hang soldering irons on a rack or place on a shelf. Do not throw irons into a tool box. When storing irons for long periods of time, coat the shaft and all metal parts with rust-preventive compound and store in a dry place.

130. Maintenance of Soldering Irons

a. Reconditioning Nonelectric Soldering Iron Tip. To recondition a nonelectric soldering iron tip, perform the operations outlined in (1) through (8) below.

(1) File all old solder and oxide scale from the faces and point of the copper tip.

(2) File the tip to the proper pyramidal shape so that the faces taper back to an efficient working angle depending on the size of the iron. The point should be slightly rounded.

(3) Use a torch or flame to heat the copper tip to a dull red color. Do not direct the flame at the extreme point; doing so will burn it.

(4) Quench red-hot tip into cold water to anneal it.

(5) Polish face of tip with a fine file so that subsequent tinning will last longer.

(6) Heat the copper tip so it will just melt solder. Wipe tip clean.

(7) Place a few drops of solder on a bar of ammonium chloride (sal ammoniac) and rub tip into melted solder and on bar until tip is tinned.

(8) Clean the tinned tip each time it is removed from the flame or source of heat. When pits form on the copper tip, heat the tip and dip it in water to remove the scale.

b. Reconditioning Electric Soldering Iron.

(1) Clean and shape point by filing. Tin the tip as discussed in paragraph 128*a*. Do not use external source of heat and do not quench tip in water.

(2) If iron does not heat with the plug connected into the power outlet, an open circuit is indicated in the plug, cord, or heater element. Inspect cord for breaks, and plug for bent prongs. Feel along wire for breaks inside insulation. If open circuit cannot be found, disconnect cord from handle and test cord and heater element separately with a test lamp. Replace faulty part.

(3) A blown fuse in the power circuit when the plug of a soldering iron is connected indicates a short circuit. Inspect plug for loose wire ends and cord for damaged insulation. Test cord, plug, and heater element separately with a test lamp. Correct faults and replace faulty parts.

Section X. GRINDERS AND SHARPENING STONES

131. Purpose of Grinders and Stone (figs. 164 and 165)

Grinders are devices that are designed to mount abrasive wheels that will wear away other materials to varying degrees. Special grinders are designed to receive engine valves. Sharpening stones are used for whetting or final sharpening of sharp edged tools that have been ground to shape or to a fine point on a grinder.

132. Types of Grinders

a. Bench Grinder. A bench grinder (fig. 164) is a device with an axle to mount an abrasive wheel and a handcrank that will permit turning the wheel. The grinder is geared so that the wheel spins faster than the crank. This type grinder is clamped onto a bench and is equipped with a rest for alinement of the work when grinding.

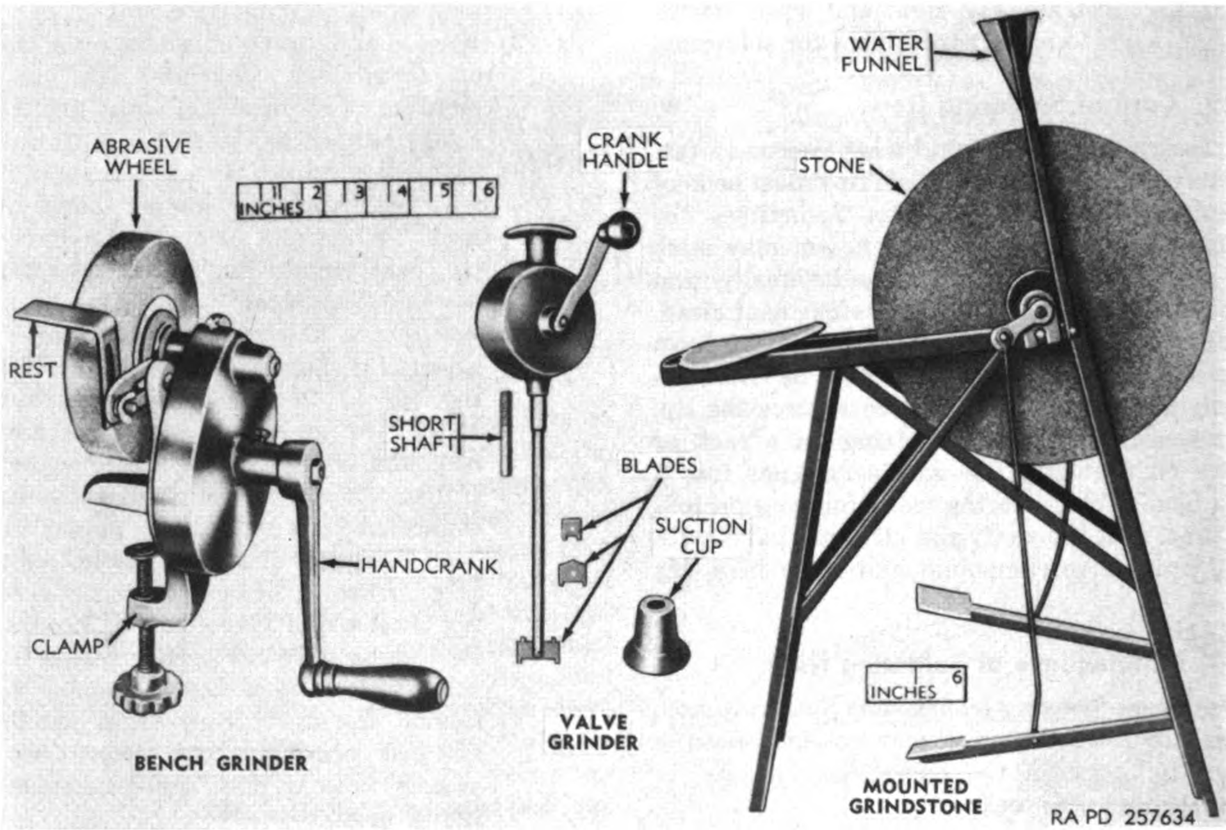

Figure 164. Grinders and grindstone.

b. Mounted Grindstone. The mounted grindstone (fig. 164) is foot powered. The nonglaze grit stone is 2 inches wide and 22 inches in diameter. A funnel-shaped container of water, which constantly wets the stone during grinding, is suspended over the stone.

c. Valve Grinder. The hand valve grinder (fig. 164) is a device that is used to lap engine valves in their seats. It consists of pinion gearing enclosed in a heavy machined cast iron housing. An external crank handle drives the gears, which rotate a shaft. The end of the shaft is designed to hold any one of three driving blades for use on slotted valves. Nonslotted valves can be driven by a rubber suction cup that is supplied with the grinder, that fits the shaft. Two shafts are furnished; one short and one long.

133. Types of Sharpening Stones and Oilstones

Sharpening stones and oilstones are natural or artificial stones. Most sharpening stones have one coarse and one fine face and are normally made of silicon carbide, aluminum oxide, or natural stone. Natural oilstones have very fine grains and are excellent for putting razor-like edges on fine cutting tools. Some of these stones are mounted and the working face of some of the sharpening stones is a combination of coarse and fine grains. Stones are available in a variety of shapes, as shown in figure 165.

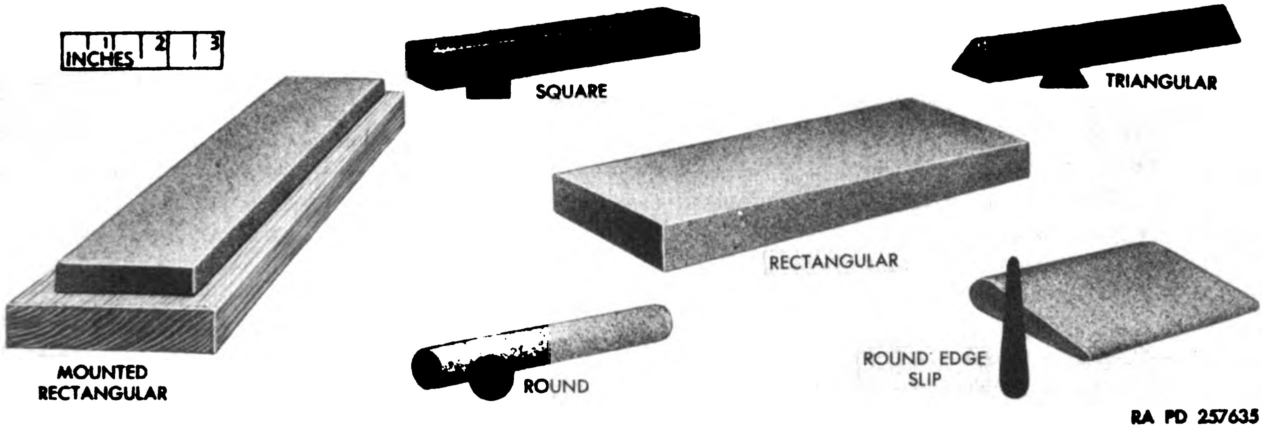

Figure 165. Shapes of sharpening stones and oilstones.

134. Using Grinders

a. Bench Grinder and Grindstone. Wear goggles when using a bench-type grinder and the grindstone. Use the rest (fig. 164) provided on the grinder frames to support the work when grinding. Hold the tools that are being shaped properly so that they will not catch in the abrasive wheel; otherwise, they will slip and injure the operator or wear the wheel excessively. To grind specific tools, refer to instructions covered in pertinent section on the particular tool you desire to grind or sharpen. Never use a cracked wheel. Before using a wheel, tap it lightly with a mallet. A ringing sound indicates that the wheel is satisfactory; a dull sound indicates that the wheel may be cracked.

b. Valve Grinder. A hand valve grinder (fig. 164) is used for grinding or lapping a valve. By applying a small amount of grinding compound around the valve face and rotating the valve in its seat with the grinder, a perfect lap can be made. The grinder is geared so that the attached blade rotates quickly. One complete revolution of the crank handle advances the blade several revolutions. Check your grinding operation by removing the valve and applying a thin coat of Prussian blue on the face of the valve. Reinsert the valve and with hand pressure on the valve head, rotate the valve about one-quarter turn on its seat. Remove and inspect the impression made on the Prussian blue. This impression will indicate the accuracy of the seating. Continue to lap grind the valve face until the entire circumference of the valve seat, without a gap, indicates contact with the valve face on 90 percent of its area. The grinder shaft mounts a suction cup to hold those valves that have no recessed holes or slots.

135. Using Sharpening Stones and Oilstones

Sharpening stones and oilstones (fig. 165) are used with a fine oil, sometimes kerosene, and in some cases are used dry. When a tool has been sharpened on a grinder or grindstone, there is usually a wire edge or a feather edge left by the coarse wheel. The sharpening stones and the oilstones are used to hone this wire or feather edge off the cutting edge of the tool. Do not attempt to do a honing job with the wrong stone. Use a coarse stone to sharpen large and very dull or nicked tools. Use a medium grain stone to sharpen tools not requiring a finished edge, such as tools for working soft wood, cloth, leather, and rubber. Use a fine stone and an oilstone to sharpen and hone tools requiring a razor edge.

136. Care of Grinders

Keep grinders clean and make certain housing screws are tight. Periodically, drain oil from bench grinder and regrease valve grinder. Flush gear housings and gears with suitable cleaning solvent. Refill with manufacturer's recommended grade of lubricant. Remove rust from external surfaces with crocus cloth. After use, wipe clean and store in a suitable box or on a rack. Make certain all nuts, screws, and bolts are tight. For long periods of storage, relubricate and spread a rust-preventive compound on all metal parts. Wrap grinder in oil-soaked cloth and store in a dry place.

137. Care of Sharpening Stones and Oilstones

a. Cleaning. Prevent glazing of sharpening stones by applying a light oil during the use of the stone. Wipe the stone clean with wiping cloth or cotton waste after each use. If stone becomes glazed or gummed up, clean with aqua ammonia or dry-cleaning solvent. If necessary, scour with aluminum oxide abrasive cloth or flint paper attached to a flat block.

b. Dressing. At times, oilstones will become uneven from improper use. True the uneven surfaces on an old grinding wheel or on a grindstone. Another method is to lap the surface with a block of cast iron or other hard material covered with a waterproof abrasive paper, dipping the stone in water at regular intervals and continuing the lapping until the stone is true.

c. Repairing. Oilstones are easily broken if they are not handled carefully. Repair a broken oilstone in the manner described in (1) through (6) below. Refer to figure 166 for repair procedure.

(1) Heat the broken pieces on a hot plate or in any other satisfactory manner to drive all oil from inside the stone.
(2) Scrub the broken edges with a dry-cleaning solvent to remove gum and dirt.
(3) Dust the broken edges thickly with flaked or ground orange shellac. Carefully work shellac into all cracks and openings.
(4) Press the broken pieces together and reheat to melt the shellac.
(5) Clamp pieces together until cooled.
(6) Dress the stone until the joint is smooth and true.

d. Storage. Oilstones must be carefully put away in boxes or on special racks when not in use. Never lay them down on uneven surfaces or place them where they may be knocked off a table or bench, or where heavy objects can fall on them. Do not store in a hot place.

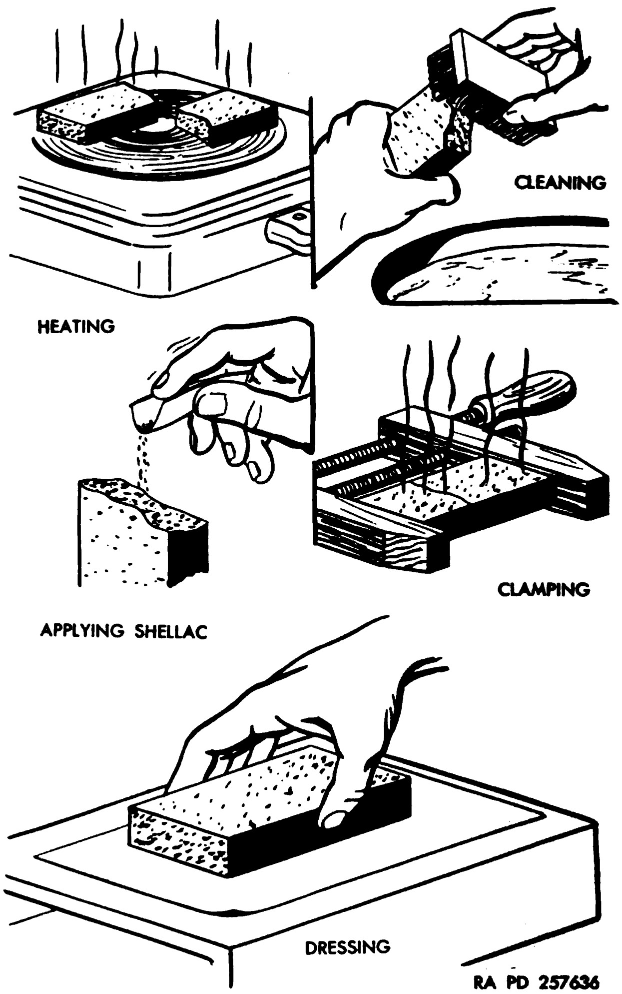

Figure 166. Repairing broken oilstone.

Section XI. BENDERS AND PULLERS

138. Purpose of Benders and Pullers
(figs. 167 through 172)

a. Benders. Benders are designed to facilitate bending brass or copper pipe and tubing.

b. Pullers. Pullers are designed to facilitate pulling operations such as removing bearings, gears, wheels, pulleys, sheaves, bushings, cylinder sleeves, shafts, and other close-fitting parts.

139. Types of Benders and Pullers

a. Benders. Benders (fig. 167) issued by the Army Ordnance supply system are of the spring type sized to fit pipe and tubing ranging from ¼ to 1 inch in diameter.

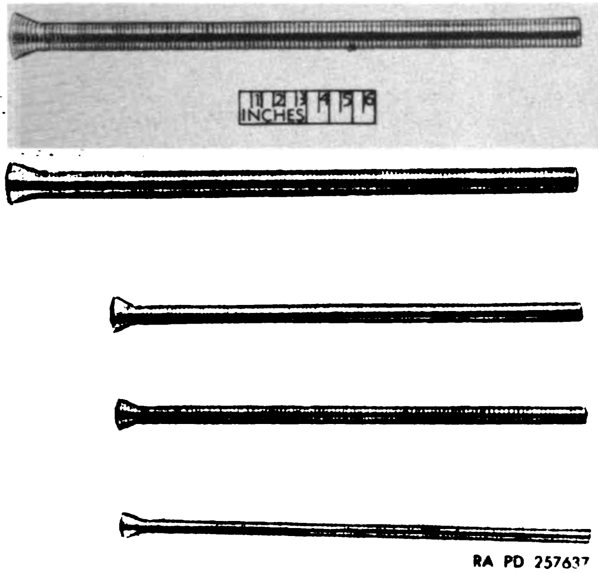

Figure 167. Hand pipe and tube benders.

b. *Pullers.*

(1) *Universal gear pullers.* Universal gear pullers (fig. 168) are usually of yoke and screw construction with two jaws. The jaws have from 0 to 14 inches diameter capacity, having a reach from 3 to 16 inches.

(2) *Universal bearing and bushing puller.* The universal bearing and bushing puller (fig. 168) has a pulling capacity of 1¼ inches. The larger jaws are designed to remove bronze or oilite bushings without crumbling them. The small jaws will pull clutch pilot bearings. This puller consists of a U-shaped body, a jaw holder, two large jaws, two small jaws, two jaw pins, and a pressure screw with slide bar.

(3) *Bearing puller, electrical units.* This type bearing puller (fig. 168) is designed to pull bearings from shafts of electrical units. It is supplied with plates to fit a variety of unit constructions and to fit behind the particular shaft bearings to be pulled.

(4) *Battery terminal and small gear puller.* The battery terminal and small gear puller (fig. 168) is of the screw type and is capable of use in

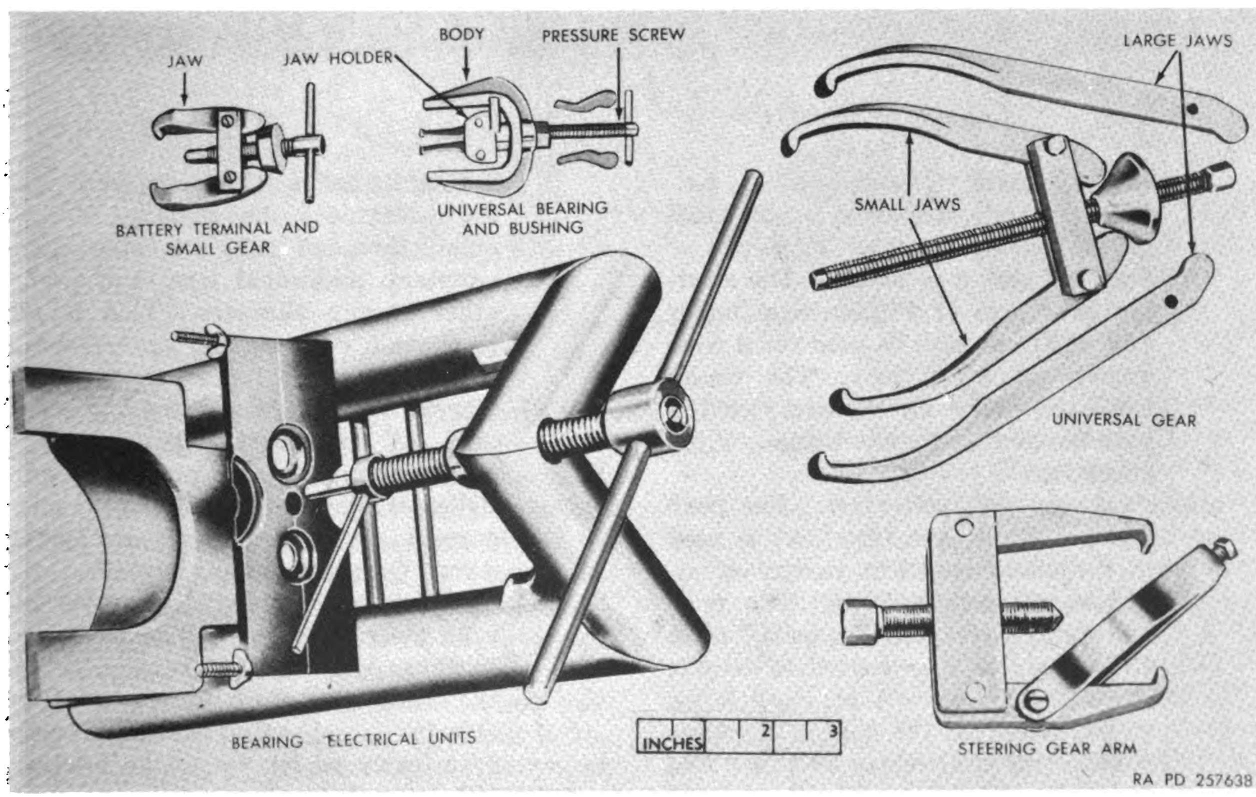

Figure 168. Bearing, bushing, and gear pullers.

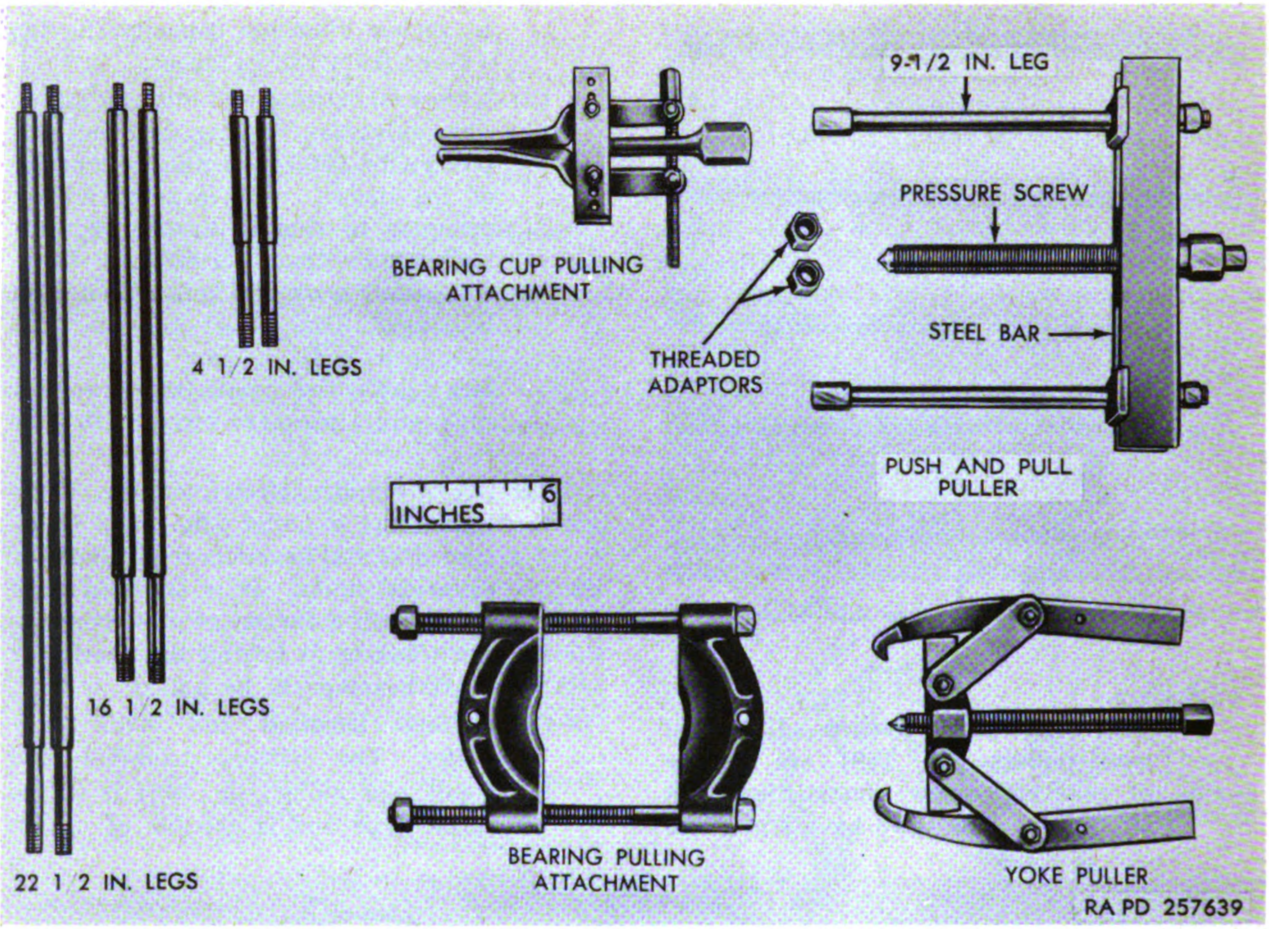

Figure 169. Push and pull puller set.

close quarters. Besides pulling battery terminals, it is used to pull small gears, bearings, and so forth.

(5) *Steering gear arm puller.* The steering gear arm or Pitman arm puller (fig. 168) can also be used for a wide variety of other jobs. The clamp locks the puller on the arm, leaving both hands free for the actual pulling operation.

(6) *Push and pull puller set.* The push and pull puller set (fig. 169) is used in conjunction with a variety of attachments and adapters. The push and pull type puller consists of a 13½-inch steel bar slotted to receive two 9½-inch legs. A pressure screw in the center of the bar is 13 inches long having a diameter of 1 inch and is threaded. This puller is universal and versatile, with the use of bearing pulling attachment, bearing cup pulling attachment, sheave puller attachment, threaded adapters, step plate adapters, additional legs, and many other special adapters. This puller is capable of removing or replacing bearings, gears, pinions, pulleys, wheels, bushings, and has many other uses. A puller set consisting of a yoke-type puller and push and pull puller, 8 adapters, and 2 attachments carried in a metal case is issued by the Army Ordnance supply system.

(7) *Steering wheel puller.* A universal-type steering wheel puller is shown in figure 170. The set consists of all the units necessary for removal of steering wheels on all cars and trucks from early models up to the present.

(8) *Wheel puller.* The universal wheel puller set (fig. 170) consists of a body

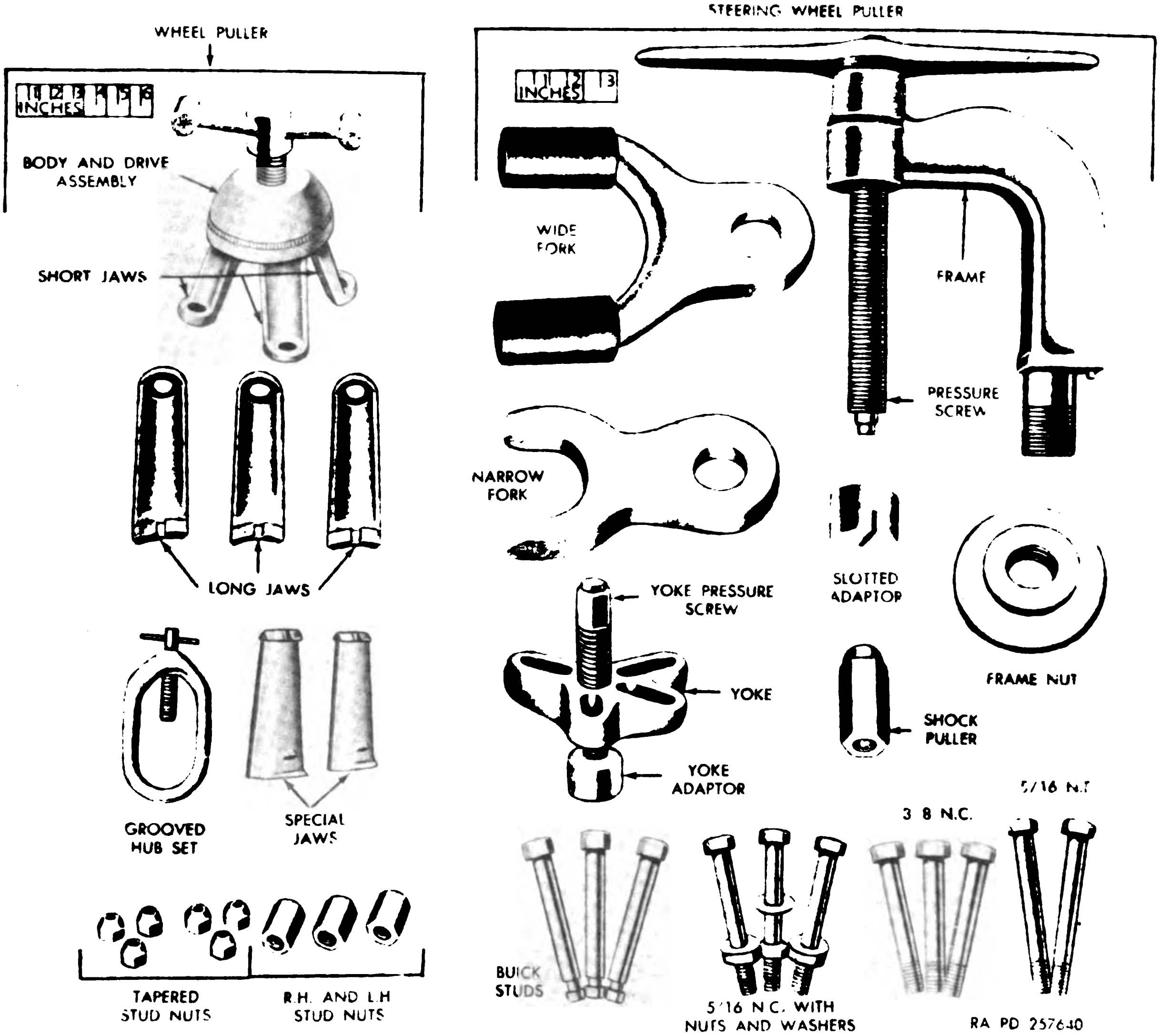

Figure 170. Steering wheel and wheel pullers.

and drive assembly that receives either three long jaws, three short jaws, or a special grooved hub set for Ford passenger cars. The interchangeable jaws pivot and swing to any desired bolt circle. Tapered, and right- and left-hand threaded stud nuts complete the set, all of which are carried in a metal case. It is capable of pulling any demountable wheel hub for any passenger car, and most lightweight trucks. A chain-type wheel puller is also available that has a 1-ton pulling capacity (not illustrated).

(9) *Cylinder sleeve puller.* The universal cylinder sleeve puller (fig. 171) will pull the cylinder sleeves on more than 200 makes and models of trucks and tractors. It is adjustable to provide clearance regardless of the position of the cylinder studs and to simplify centering the tool over the bore. This puller is used in conjunction with four adapter plates (fig. 181) supplied with the puller. The combination is capable of pulling cylinder sleeves 4¼, 4½, 4¾, and 5¾ inches in diameter.

(10) *Slide hammer puller.* The slide

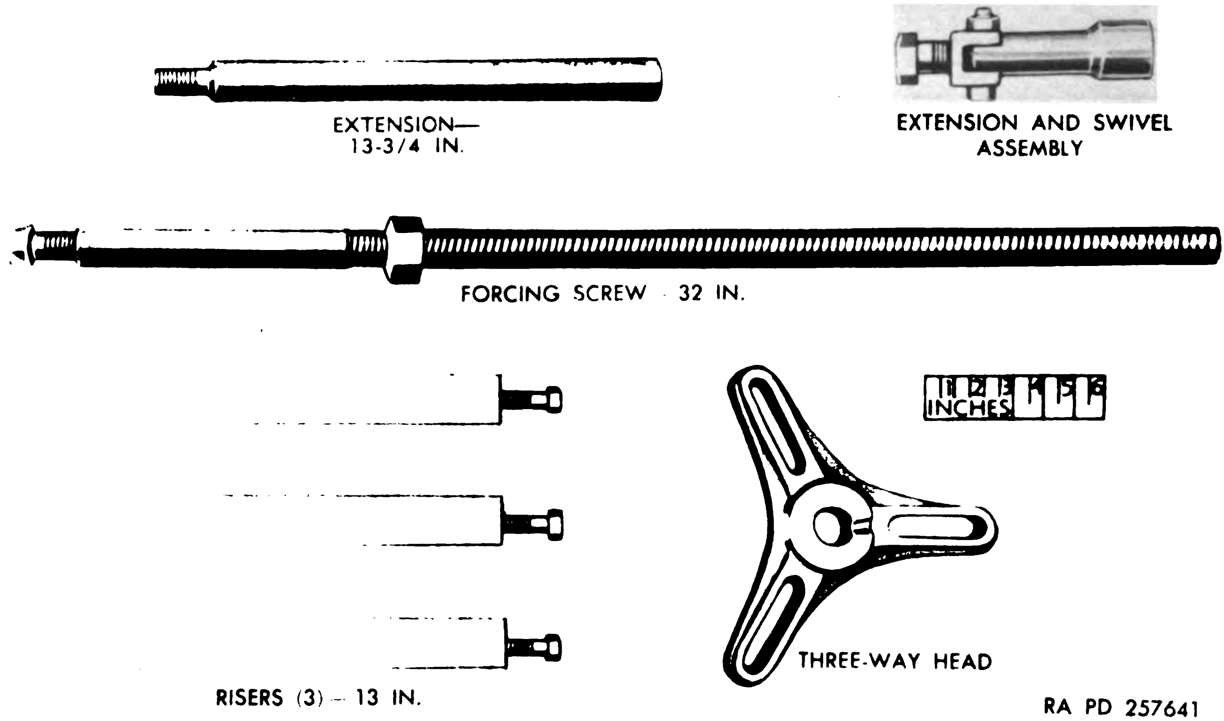

Figure 171. Cylinder sleeve puller.

hammer puller set (fig. 172) is a universal-type puller equipped with a two- and three-way yoke, and three medium jaws for outside pulls and two small jaws for inside pulling. The small jaws can be inserted through a $\frac{1}{2}$–inch opening. The capacity of the medium jaws is $6\frac{1}{4}$ inches. The slide hammer puller is also equipped with a locking feature which holds the jaws open or locks them on the work.

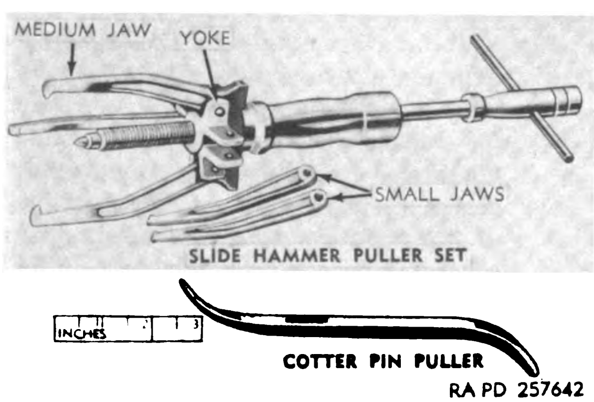

Figure 172. Slide hammer puller set and cotter pin puller.

(11) *Cotter pin puller.* A cotter pin puller (fig. 172) is used to install or to remove cotter pins. It is an S-shaped tool, 7 inches long, one end used to insert through the cotter pins for extracting, the other end used for spreading the cotter pin. The shank is beveled square for easy handling and firm grip. This type is 7 inches long.

140. Use of Pipe and Tube Benders

A tube bender is used to prevent tubing from kinking or flattening out at the desired bend. To use a bender, push it over the tube until the center portion of the bender is centered over the point in the tube where the bend is to be made. The tube can then be bent by hand to the desired radius. Pull the bender from the tube after bending.

141. Use of Pullers

a. General. Place a puller firmly in position and secure it if locking devices are part of the puller. Make certain the puller will not slip off suddenly while under strain. Check all gripping edges and threads of a puller for damage before using it. Use the proper size wrench for turning the pressure screw or nut to avoid rounding the corners of the nut or of the screw head. Use the proper size puller for the job.

b. Slide Hammer Puller. When using a slide hammer puller (fig. 172), lock the jaws with the locking feature and slide the hammer handle up the shaft in the direction of the pull. The combination yoke provided with this puller enables you to pull a variety of items by the different combinations and settings of jaws.

c. Push and Pull Puller Set. The universal push and pull puller set (fig. 169) is probably the best all-around puller combination available. Several combinations of its component parts are discussed and illustrated, as indicated in (1) through (4) below.

(1) *Removing and installing bearing cup.* Figure 173 shows a combination of the push and pull puller and the bearing cup pulling attachment used to remove a bearing cup from a cage. The same combination is used to install it back in the cage, as shown in figure 174.

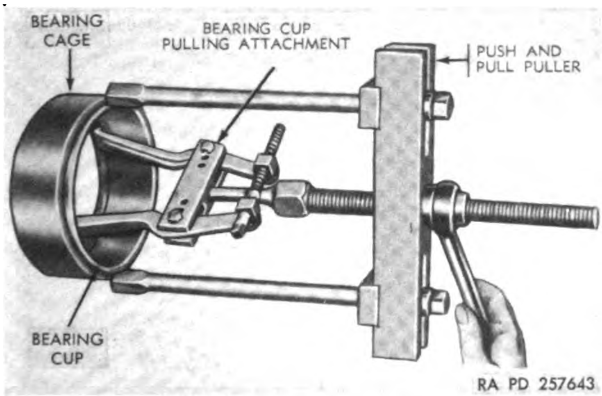

Figure 173. Removing bearing cup.

(2) *Pulling camshaft gear.* Using the push and pull puller with 9½-inch legs with two adapters is shown in figure 175. Here the camshaft gear is being removed without removing the camshaft from the engine. A protective plate should be used under the forcing screw to protect the end of the camshaft.

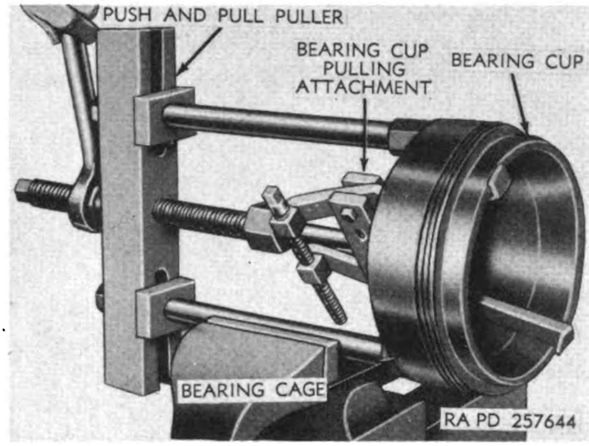

Figure 174. Installing bearing cup.

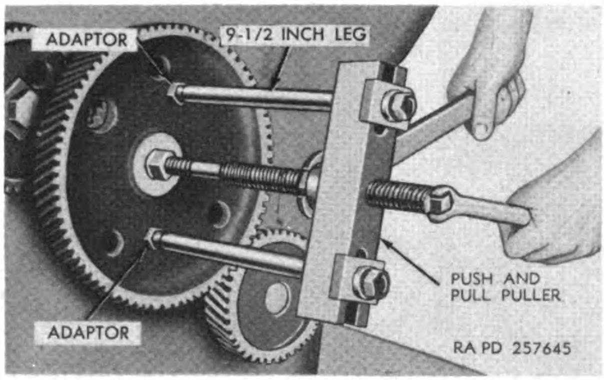

Figure 175. Pulling camshaft gear.

(3) *Pulling bevel gear pinion shaft.* Figure 176 illustrates the use of the bearing pulling attachment and a pair of forcing bolts used to remove a bevel gear pinion shaft from a transmission case. The forcing bolts bear against the case and force the pinion shaft out. Tighten bolts alternately to obtain a uniform even pull to prevent cocking.

(4) *Pulling bearing.* In figure 177 a roller bearing assembly is being removed from a transmission shaft assembly with a combination of the bearing pulling attachment and the push and pull puller.

d. Steering Wheel Puller. The steering wheel puller set (fig. 170) handles all cars and trucks. The yoke puller and its related parts are used to pull the newer models, since they have tapped wheel hubs. The fork puller and

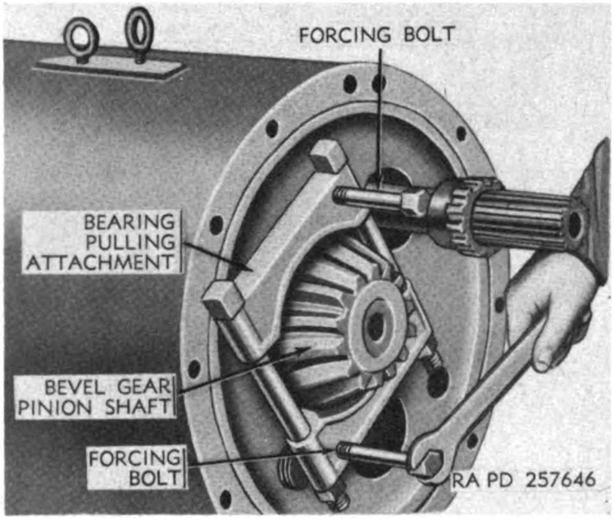

Figure 176. Pulling bevel gear pinion shaft.

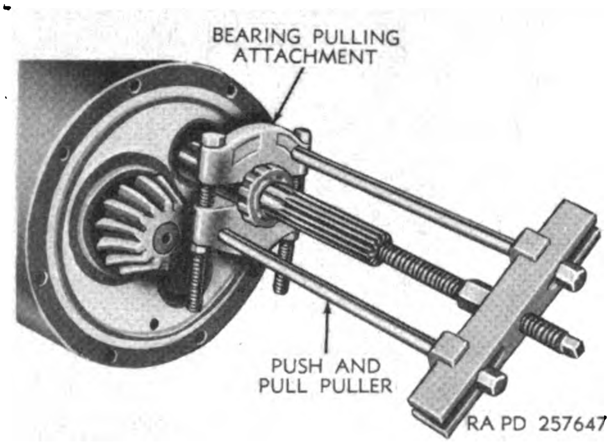

Figure 177. Pulling bearing.

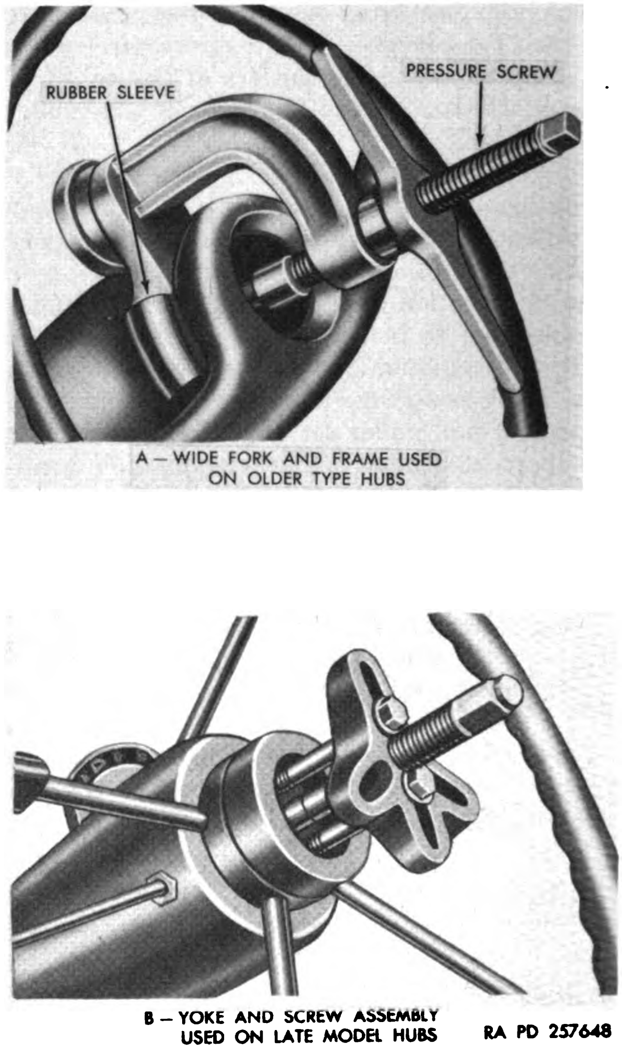

Figure 178. Using steering wheel puller set.

its related parts are used on older models. The pressure screw in the frame puller is threaded its entire length and works through a key. The narrow fork has a brass insert and the wide fork has rubber sleeves to protect the steering column. Adapters protect the shaft from damage. A, figure 178, illustrates the use of the wide fork and frame puller on older type hubs. B, figure 178, shows the yoke puller removing a late model steering wheel.

e. Wheel Puller. The universal wheel puller set (fig. 170) is quickly assembled by inserting the proper type jaws and attaching the tool to the wheel stud bolts. To interchange jaws, hold two jaws together, as shown in figure 179. This depresses the inner sleeve and allows room to remove or insert other jaws. To pull Ford

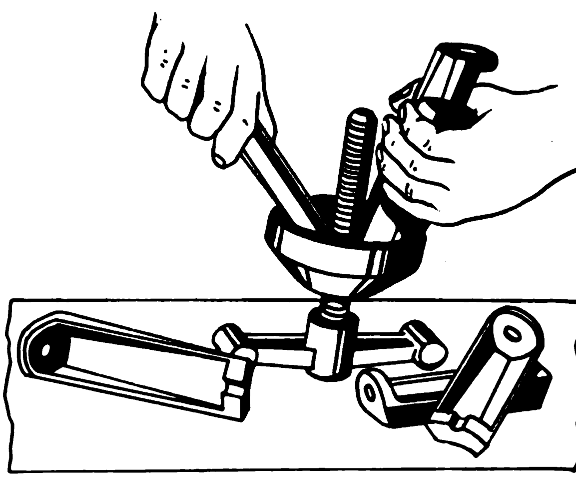

Figure 179. Interchanging wheel puller jaws.

car or truck wheels, use the three long jaws in conjunction with the special Ford grooved hub set, as shown in figure 180.

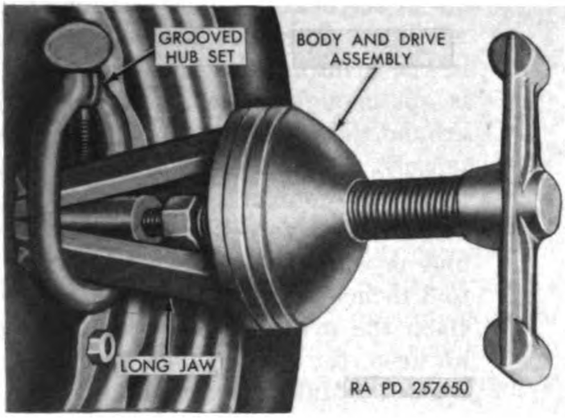

Figure 180. Using wheel puller and grooved hub set.

f. Cylinder Sleeve Puller. The cylinder sleeve puller (fig. 171) is adjustable to provide clearance regardless of the number or position of the cylinder head studs, and to accurately center the tool over the bore (fig. 181). Four adapter plates are supplied with the puller which cover sleeves from 4¼ to 5¾ inches in diameter. The adapter is positioned so that the cylinder sleeve rests on the edges of the adapter. The puller swivel assembly is inserted from the top and screwed into the adapter. By tightening the forcing screw (use suitable wrench on nut) a steady force is applied which will pull the sleeve out of the cylinder.

142. Care of Benders and Pullers

Keep benders and pullers clean at all times. Grease or oil on the gripping edges will make the tool slip. Clean all tools after use and store so that the threads and gripping surfaces will not become damaged. Make certain attachments and adapters are stored with the basic puller and do not become separated. Oil benders and pullers after use and wipe clean before using. When storing for long periods of time, apply a coat of rust-preventive compound on tools and store in a dry place.

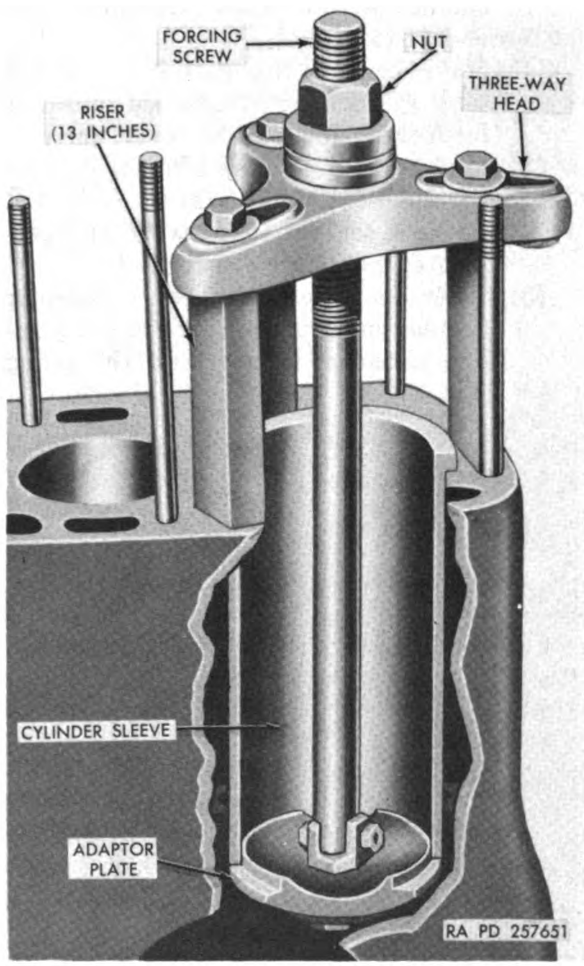

Figure 181. Using cylinder sleeve puller.

Section XII. TORCHES

143. Purpose of Torches
(fig. 182)

Torches are used as sources of heat in soldering, sweating, tinning, burning, and other miscellaneous jobs where heat is required.

144. Types of Torches

a. Blowtorch. A gasoline filled blowtorch (fig. 182) is supplied in 1–pint and 2–quart capacity sizes. It consists of a pump plunger, pressure valve, nozzle, handle, round gasoline chamber tank, and filler plug. The torch operates on gasoline which is forced out by air-pressure.

b. Oil Torch. A portable 5-gallon oil burning torch (fig. 182) is also available for burning and heating purposes.

145. Use of Torches

a. Blowtorch. The blowtorch (fig. 182) must be handled with extreme caution to prevent burns and explosions.

(1) Make certain the gasoline chamber tank is filled with unleaded gasoline, to prevent fouling the torch valve.

(2) Pour a little gasoline into the cup below the nozzle and light it. Allow it to burn so that it heats up the perforated nozzle of the torch.

(3) When the nozzle has been sufficiently heated, pump up pressure in the gasoline chamber by working the pump handle up and down about 25 to 30 strokes.

(4) Open the pressure valve slowly, letting a fine atomized stream of gasoline flow out of the nozzle. The gasoline spray will light from the burning gasoline in the priming cup, and if the nozzle is hot enough while air is drawn in around the jet, the torch will burn intensely. The intensity and size of the flame are controlled by the pressure valve. The forced flame should be blue or almost colorless and extend 2 to 3 inches beyond the nozzle.

(5) Open the pressure valve just enough to keep the flame even and under control. Make certain the filler plug is screwed in tight to prevent escape of gasoline. The point of the flame is the hottest; use it to heat work.

(6) When through using the torch, close

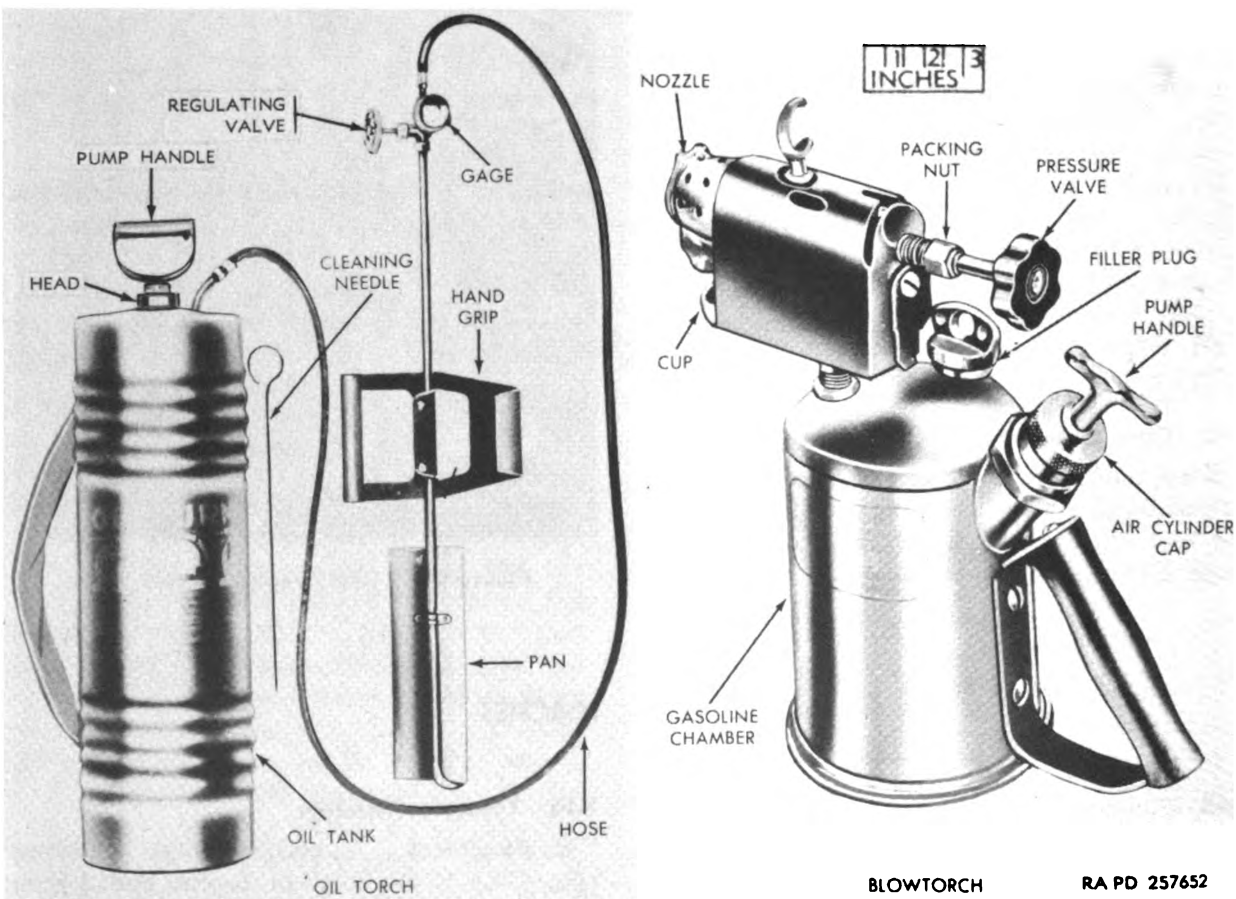

Figure 182. Torches.

the pressure valve and the flame will go out. Crack the valve open slightly after closing to prevent freezing of the valve. The metal around the valve will shrink when it cools, and tightening the valve too much will make it hard to open again.

b. Oil Torch.

(1) Fill the oil tank (fig. 182) by first locking the pump handle onto the head. Then manually unscrew the pump by turning it to the left.

(2) Fill the tank about ¾ full of kerosene, coal oil, range oil, or a good grade of light furnace oil. Never use diesel oil or gasoline. Install pump and screw in handtight.

(3) Make certain the regulating valve is closed and pump air into the oil tank with the hand pump until the gage registers 35 to 40 pounds pressure.

(4) To light the torch, place some paper, rag, or waste in the pan. Open the regulating valve slightly and fill pan one-quarter full of fuel. Close valve and light fuel in pan.

(5) Allow torch to heat up for 5 minutes. While heating, fuel in the coil will vaporize, causing the fuel to expand and causing little puffs to blow out of the torch. Wait until puffs stop.

(6) Slowly open the regulating valve to permit the vaporized fuel to come out of the burner plug. The fuel will ignite from the flame remaining in the pan. The proper flame is purple blue.

(7) Operate the torch with the regulating valve about one-quarter to one-half turn open, no more. The greater the pressure, the larger and stronger the flame will be up to a certain point. This point is where the pressure becomes so great as to force the fuel through faster than the coil can vaporize it. The moment liquid fuel is being thrown several feet, close the valve, lower the pressure, and relight the torch.

146. Care of Blowtorch

a. Keep the nozzle clean at all times to prevent obstruction of the flow of gasoline.

b. If gasoline escapes around the pressure valve, tighten the packing nut just enough to stop the leak. If the leak cannot be stopped in this manner, the valve must be repacked.

c. If the plunger rises, a leak in the air pump valve is indicated. Repair by removing the valve retaining nut and the spring-loaded valve. Clean the valve face and valve seat, and reassemble.

d. If the plunger fails to pump air, remove the air cylinder cap and withdraw the plunger and the piston. Examine the leather piston and replace it if damaged or worn.

e. If the pressure valve needle fails to seat properly, unscrew the packing nut and screw out the valve stem. Examine the needle; if a shoulder has formed, remove it with a fine abrasive cloth.

147. Care of Oil Torch

a. At times, the steel burner plug will become clogged. To clean, close the regulating valve and using the small cleaning needle furnished with the torch, put it through the hole in the plug. Relight the torch with a piece of burning paper.

b. The torch should be blown out once a month during normal use. To do so, remove the burner plug, open the regulating valve, and let the fuel, under pressure, circulate through the torch until a stream comes out of the plug holder opening, carrying along with it the dirt accumulations. Install the burner plug tightly.

Note. To remove plug, clamp the plug holder from the rear in a medium size monkey wrench and secure the wrench in a vise so that the torch is just above the vise and pointing up. Reach down through the coil and unscrew the plug with the proper size socket wrench.

c. Before opening tank, release the air pressure slowly until the gage reads zero. Be cautious; never unscrew the pump while your head or body is over the top of the tank.

d. Always release air pressure when torch is not in use.

Note. When you turn the valve off, it will take a second or two to use up the fuel that is still in the coil.

e. Lubricate pump frequently through the opening around the plunger rod. If the leather cup washer is hard and does not catch, remove the plunger rod from the pump and soften the leather with oil by working it in with your fingers.

148. Purpose of Blacksmith's Anvils and Iron Working Tools
(figs. 183 and 184)

Blacksmith's anvils are designed to provide a working surface when punching holes through metal and for supporting the metal when it is being forged and shaped. Iron working tools such as flatters, fullers, swages, hardies, and set hammers are used to form or shape forgings. Heading tools are used to shape bolts.

149. Types of Blacksmith's Anvils

The blacksmith's anvil (fig. 183) has a flat face with a horn on one end and two holes in the flat face opposite the horn. The round hole is called a spud or pritchet hole and permits slugs of metal to drop through it when holes are punched. The square hole is designed to hold hardies and bottom fullers and swages (par. 150). The cone-shaped horn is used to form curved shapes from bars and rods. The flat or top face is used to support the metal being worked on. Blacksmith's anvils are made of steel and weigh anywhere from 25 to 250 pounds. They have two mounting flanges which may be used to secure the anvil on a bench or on a concrete base.

150. Types of Blacksmith's Iron Working Tools

a. Flatter. A flatter (fig. 184) is a hammerlike tool with a flat face. It is used for smoothing and finishing flat forgings.

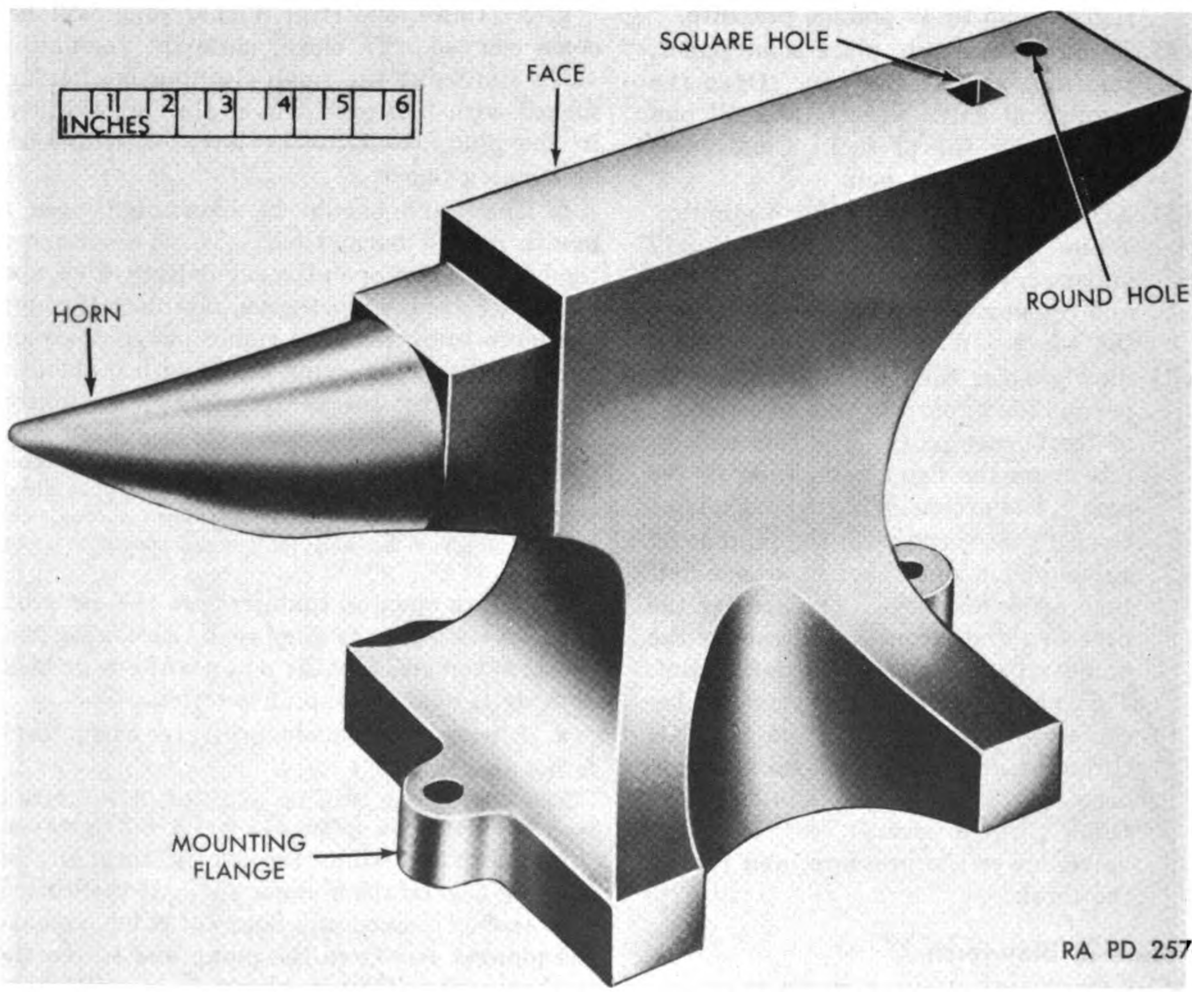

Figure 183. Blacksmith's anvil.

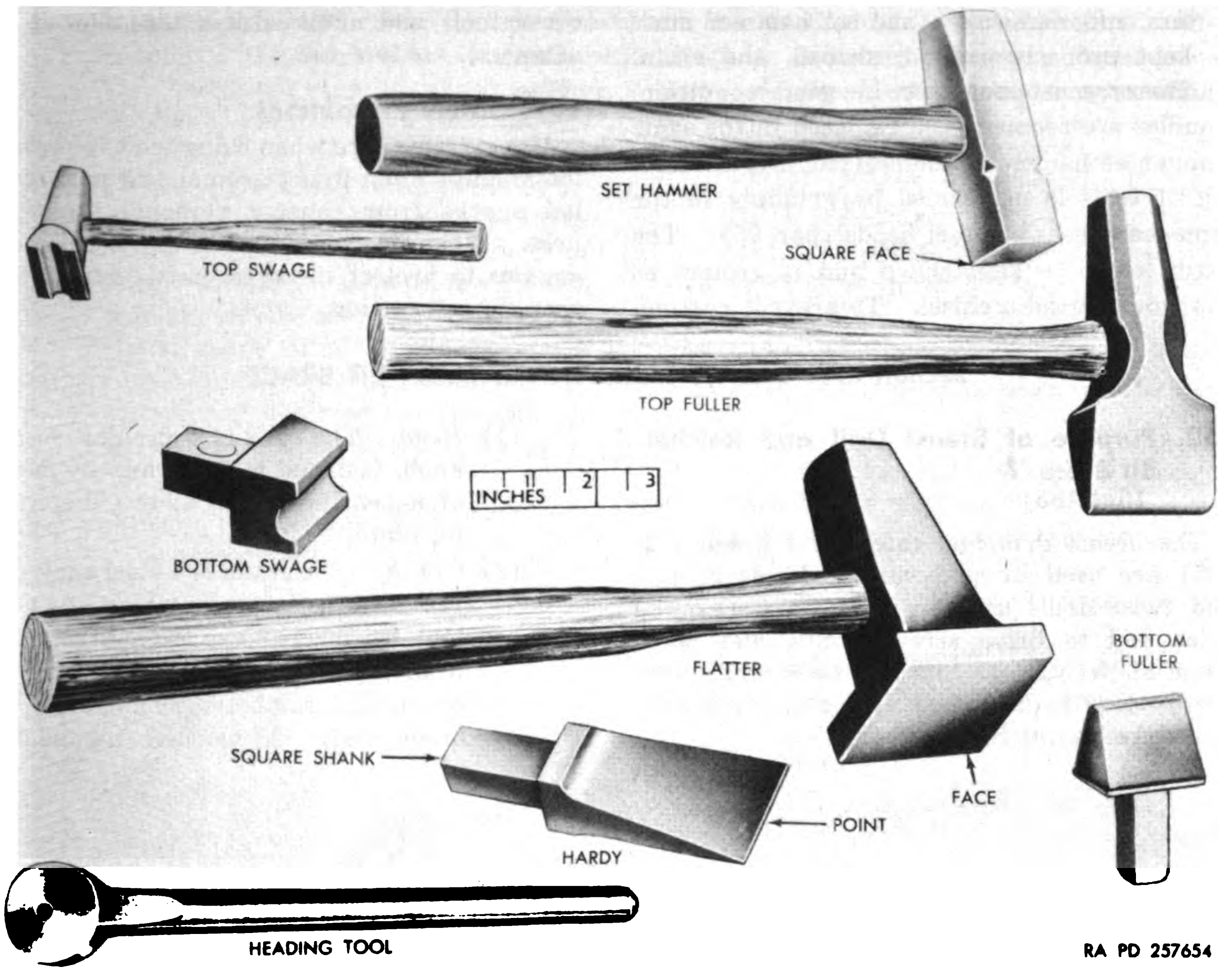

Figure 184. Blacksmith's tools.

b. Fuller. Fullers (fig. 184) are used for necking and grooving forgings and for drawing down a forging to a smaller size. Top fullers have handles and range in size from ¼ to 2 inches across the face and weigh from 2 to 4½ pounds. Bottom fullers have a square shank and are sized from ½ to 1 inch, weighing 2½ to 3 pounds.

c. Swages. Swages (fig. 184) are used for shaping, sizing, and smoothing round forgings. They are issued in sets of 6 swags, sized for ¼–, ⅜–, ½–, ⅝–, ¾–, and 1–inch round forgings. Swage blocks are also available for special jobs. These block are usually 4 inches thick, 11 or 13 inches wide, and 15 or 18 inches long. The bottom swage blocks have various shaped perforations and grooves for swaging and upsetting forgings and are square shanked. Top swages have handles and are shaped to work with bottom swages.

d. Hardy. A hardy (fig. 184) has a chisel-like point and a square shank. It fits into the square hole in the anvil. Metal to be cut is placed over the point and struck with a hammer or sledge until it separates.

e. Set Hammer. A set hammer (fig. 184) is used for setting down metal in a forging to form a square corner. It has a 1½–inch square face and weighs 3¼ pounds.

f. Heading Tool. A heading tool (fig. 184) is used to form bolt heads. It has a circular head with a hole in the center. Six heads are available with a different size hole. Hole sizes are ¼, ⅜, ½, ⅝, ¾, and 1 inch.

151. Use and Care of Anvils and Tools

The top face of the anvil, as well as the horn, must be kept smooth and clean so as not to damage the work placed upon them. The flatters, fullers, swages, and set hammer must be kept properly ground, shaped, and clean. Hammers must be kept in good condition. Handles are repaired and replaced in the same manner as hammer handles (par. 94). Shaping of tools is performed by grinding in the same manner as hammer heads (par. 95). The hardy must be kept sharp and is ground as you would grind a chisel. To prevent rusting, cover tools and anvil with a thin film of oil after use.

152. Safety Precautions

Use extreme care when using tools to prevent metal chips from flying around and to prevent hot sparks from causing personal injury or fires. When heating metal to be forged, wear goggles to protect the eyes, particularly when shaping and cutting.

Section XIV. BREAST DRILL AND RATCHET BIT BRACE

153. Purpose of Breast Drill and Ratchet Bit Brace (fig. 185)

The breast drill and ratchet bit brace (fig. 185) are used to hold various kinds of bits and twist drills used in boring and reaming holes and to drive screws, nuts, and bolts. Some of the various bits and twist drills that are used with the breast drill and ratchet bit brace are shown in figure 186.

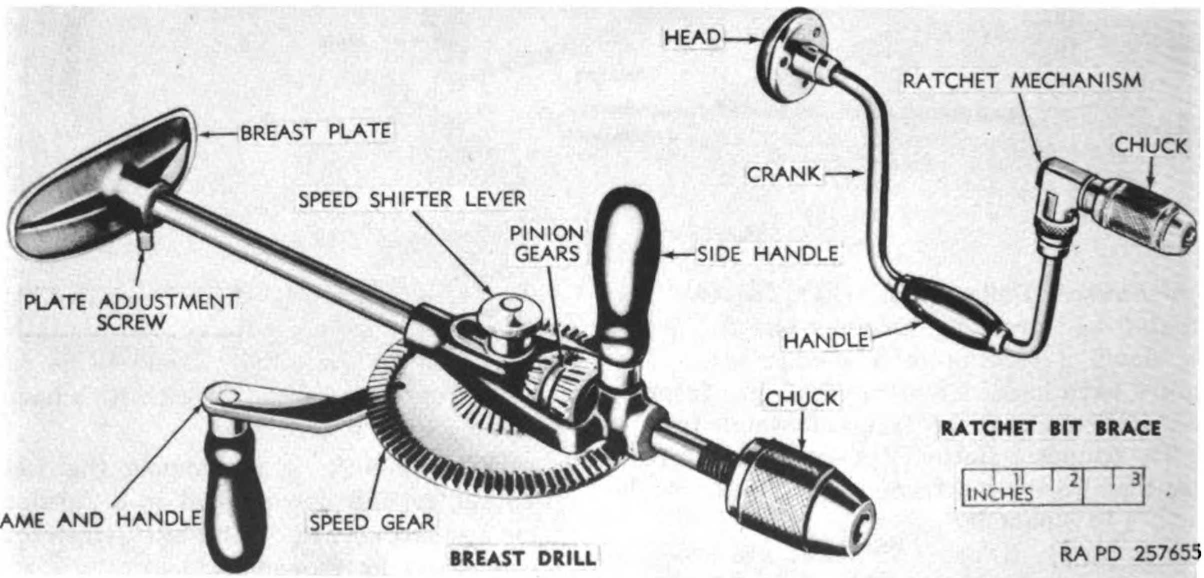

Figure 185. Breast drill and ratchet bit brace.

154. Type of Breast Drill and Ratchet Bit Brace

a. Ratchet Bit Brace. The ratchet bit brace (fig. 185) consists of a head, crank, ratchet mechanism, and a chuck. It has a capacity of holding drills and bits up to and including ½ inch.

(1) *Head.* The head is a circular wooden knob, fastened to the crank by means of a bearing which allows the crank to rotate.

(2) *Crank.* The crank is a steel shaft and provides the leverage which gives the tool its mechanical advantage. The head is fastened to one end and the chuck and ratchet mechanism to the other end. A wooden handle fits loosely around the center of the bow and allows the crank to rotate while the handle is held firmly in the hand.

(3) *Ratchet mechanism.* The ratchet mechanism is a fixture which controls the direction in which the bit and chuck turn. The bit can be made to

turn directly with the turn of the crank, or the ratchet can be set so that the crank may be turned in one direction while the bit remains stationary.

(4) *Chuck.* The chuck receives the bit or drill and holds them firmly. The chuck is composed of a number of long V-grooved fingers or jaws which hold the square shank of a bit, or the round shank of a twist drill, and a round knurled threaded metal shell or sleeve, which screws on the base of the chuck to open or close the jaws.

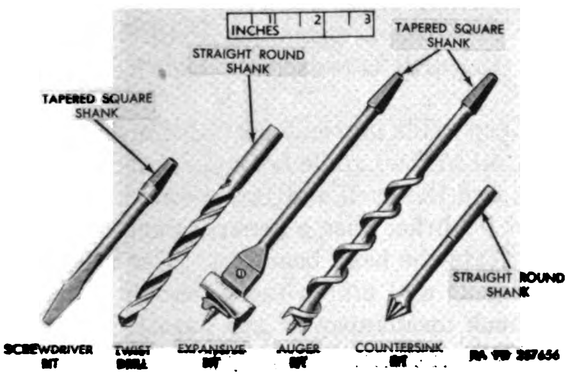

Figure 186. Types of bits and twist drills used with breast drill and ratchet bit brace.

b. Breast Drill. The breast drill (fig. 185) has a speed shifter lever which changes the speed of the drill or bit from high to low or the reverse at any time. The center position of the lever locks the gears so that the chuck can be opened or closed. The breast drill consists of gears and pinions arranged on an iron frame. A breast plate attached to the end of the frame is adjustable. The 3–jaw knurled chuck receives bits or round shank twist drills up to and including ½ inch.

155. Using the Ratchet Bit Brace

a. To open the jaws and to insert a bit or a drill, hold the chuck upward in one hand and turn the crank clockwise with your other hand. This opens the jaws. Insert the shank of the bit or drill into the jaws, placing the edges of the shank into the slots of the jaws. Allow the bit or drill to drop in as far as possible, and then turn the crank counterclockwise to secure shank drill to help center it in the chuck.

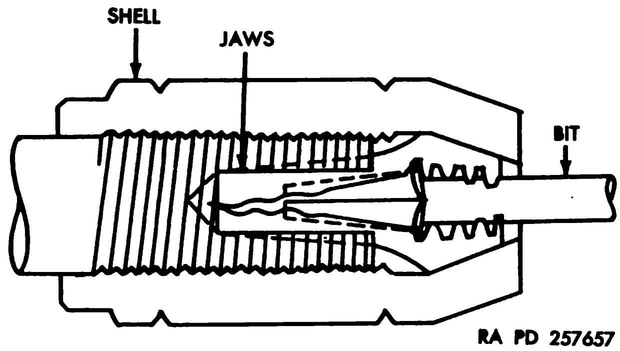

Figure 187. Bit inserted in chuck, cross section.

b. To operate the ratchet bit brace, place the end of the bit or drill at the desired point, keeping the ratchet bit brace perpendicular to the work. Hold the head in one hand and press down, turning the crank clockwise with your other hand.

c. In boring holes in wood, after a few turns the bit feeds into the wood without pressure.

d. To drive screws, or to ream, the pressure must be maintained.

e. To work in corners or other close places where a full turn of the crank is impossible, adjust the ratchet mechanism so as to allow the crank to turn counterclockwise without turning the bit.

f. To withdraw the bit, set the ratchet so that the bit turns in the opposite direction.

g. When boring a hole in wood, do not force the bit all the way through the wood; splitting will occur on the opposite side. To prevent splitting the wood, release pressure on the head, reverse direction of crank, and remove the bit after the spur just comes through. Turn wood over and bore from opposite side to complete the hole, this forms a smooth hole on both sides.

156. Using the Breast Drill

a. The breast drill (fig. 185) is used for drilling holes in metal or wood. Use an awl to start holes in wood to help center the bit. Start holes in metal with a center punch to help center the twist drill.

b. To secure a bit or twist drill in the chuck, place the speed shifter lever in the center or neutral position. Open the chuck only slightly more than the diameter of the bit or the round shank drill to help center it in the chuck.

Insert the bit or twist drill as far as it will go and tighten the chuck.

c. To drill holes of uniform depth, make a depth gage or dowel. Cut a piece of wood the exact length, so the twist drill will project the desired depth when the piece of wood is drilled and slipped over the twist drill (fig. 188).

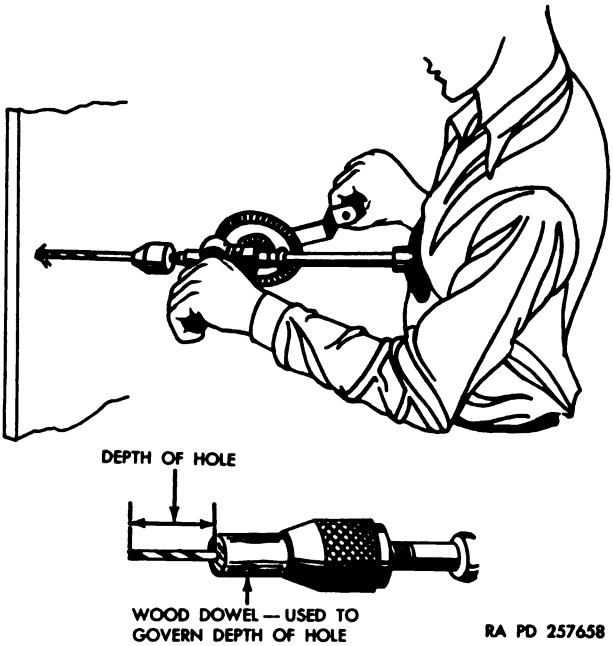

Figure 188. Using a breast drill and a wood dowel.

d. Place the breast plate against your body; loosen the adjustment screw in the side of the plate and move the plate to a position which is comfortable and tighten the adjustment screw. Set the speed shifter lever to desired speed; high or low. Hold the drill perpendicular to the work. Grasp the side handle with one hand and turn the frame handle with your other hand (fig. 188). Apply a steady, even pressure with your body.

e. The speed of the drill may be changed at any time without removing the drill from the work by moving the speed shifter lever.

157. Care of Breast Drill and Ratchet Bit Brace

a. Do not use a drill when a twist drill or bit is not firmly inserted in the jaws and tightened. To do so we place a strain on the jaws and may break the bit or twist drill.

b. Never use a squeaking drill. A squeak means the drill is wearing. Lubricate before using.

c. Keep drills lubricated at all times. Apply a light oil to the handle bearings, ratchet mechanism, and the shell and jaw mechanism of the ratchet bit brace; use a general purpose grease to lubricate the head bearings. Use a light oil on the gear and pinion teeth, handle bearings, and chuck mechanism of the breast drill.

d. Make certain all assembly screws are tight at all times.

e. When not in use, apply a film of light oil to all metal surfaces and store each drill in a safe, dry place.

f. For long periods of storage, clean with solvent to remove lubricants. Coat all metal parts with rust-preventive compound and store in a safe, dry place. Upon removal from storage, remove rust-preventive compound with cleaning solvent and lubricate as discussed in *c* above.

Section XV. SHEET METAL TOOLS

158. Purpose of Sheet Metal Tools (figs. 189, 190, and 191)

Sheet metal working tools consist of stakes, dolly blocks, calking tools, rivet sets, and dolly bars. Punches, shears, and hammers are also sheet metal working tools. However, they are covered in other sections of this manual. Rivet sets and dolly bars are used to form heads on rivets after joining sections of sheet metal and steel work. Stakes are used to support sheet metal while the metal is being shaped. Calking tools are used to shape joints of sheet metal. Dolly blocks are used in conjunction with bumping body hammers to straighten out damaged sheet metal.

159. Types of Stakes

Stakes (fig. 189) are issued in a variety of types; each type is used to fabricate sheet metal into a particular shape. Most stakes can be clamped in a vise; the hollow mandrel type is clamped onto a piece of work.

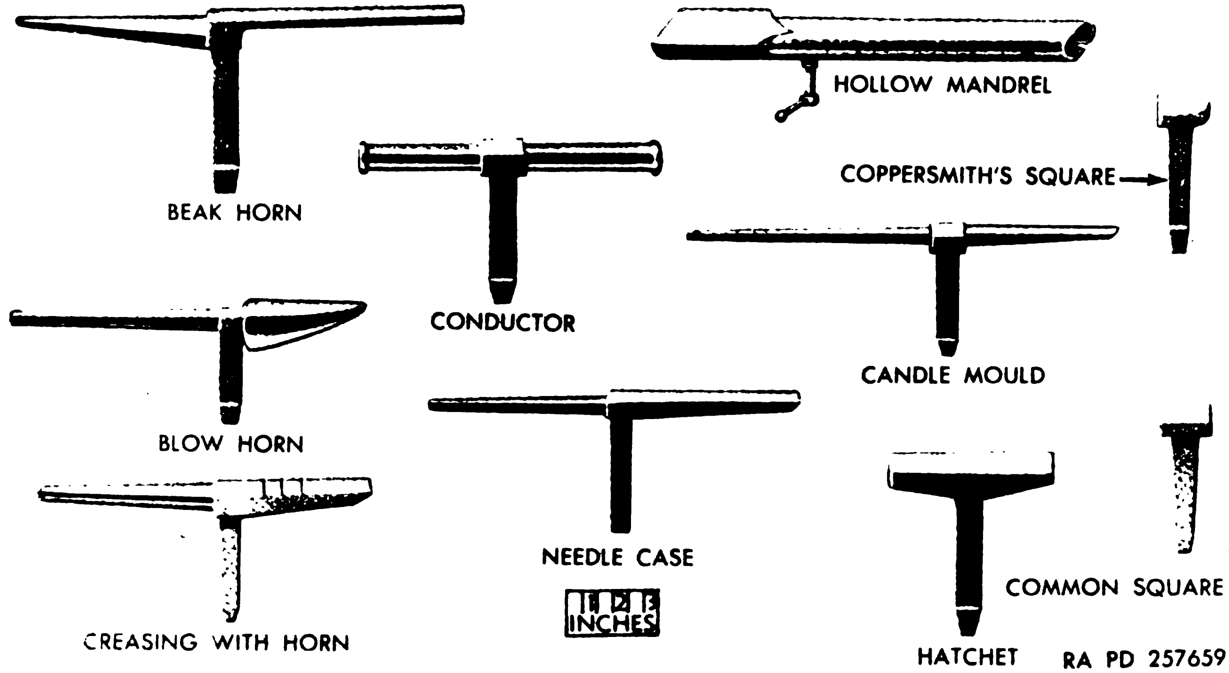

Figure 189. Types of stakes.

160. Types of Dolly Blocks

Dolly blocks (fig. 190) or hand anvils are available in several types; heel, low crown, toe, general purpose, heavy duty, and utility. Each type is used for supporting damaged sheet metal during straightening operations.

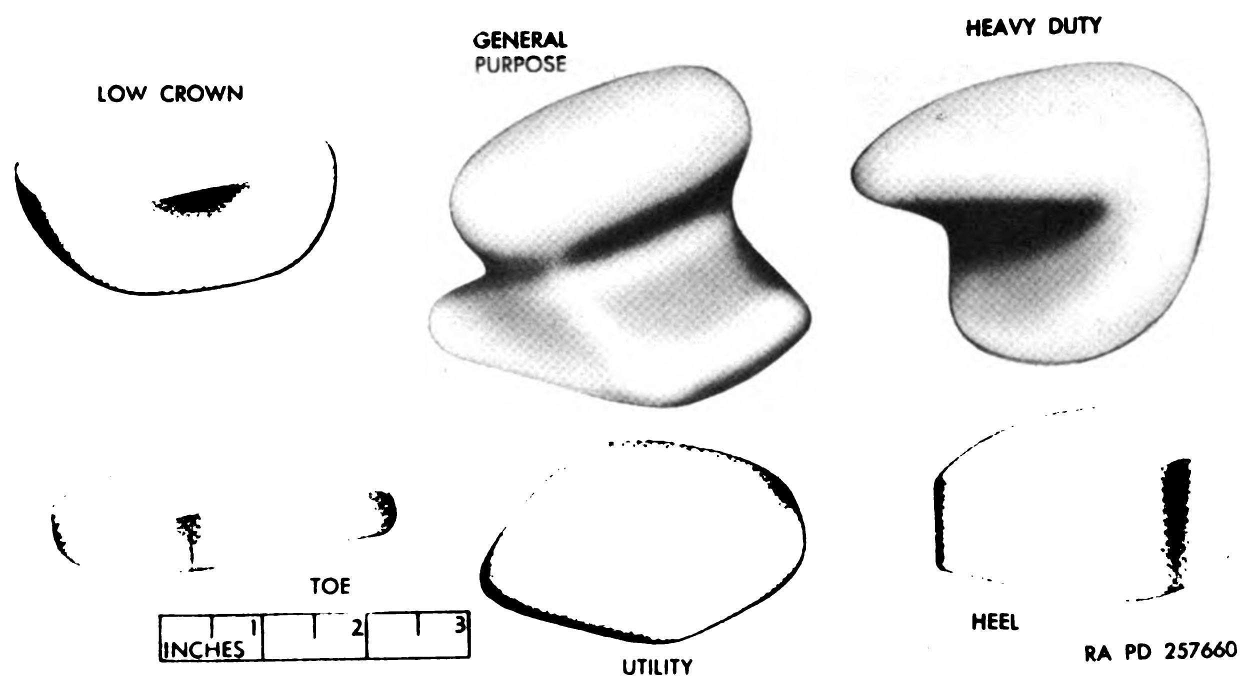

Figure 190. Dolly blocks.

161. Types of Calking Tools

Calking tools (fig. 191) either have a long or short, straight, square nose, or a bent or offset nose.

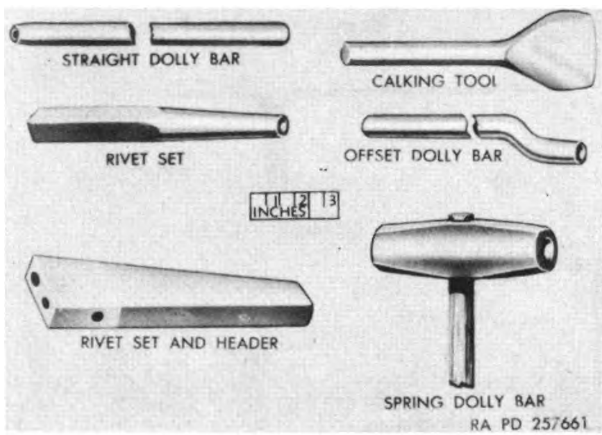

Figure 191. Calking tool, rivet sets, and dolly bars.

162. Types of Rivet Sets

Rivet sets used by tinsmiths and blacksmiths to force pieces together are used similarly, but differ in shape and capacity. Tinsmith's rivet sets (fig. 191) are lighter in weight and can only use small size rivets, up to $\frac{5}{32}$ inch. The blacksmith's rivet set handles ½-inch rivets.

163. Types of Dolly Bars

Iron workers use dolly bars (fig. 191) to form heads on rivets sized from ½ to 1 inch. These bars are either straight, offset, or of the spring type. The straight and offset types are 24 and 30 inches long; the spring type is 6 inches long and with a 1-inch diameter handle.

164. Use of Stakes

Each stake is used to form a different shape, as indicated by the illustration (fig. 189). The work is positioned over these anvils (stakes) and pounded with a heavy hammer until the work is formed to the contour of the stake.

165. Use of Dolly Blocks

A dolly block is held against one side of a sheet metal panel with one hand. The other hand strikes the opposite side of the panel with a bumping body hammer (L, fig. 102). As the hammer blow is struck, the dolly rebounds slightly from the panel, but returns immediately because of the pressure exerted by your hand. As the dolly block returns, accurately place it for the next spot to be bumped.

a. Dinging On the Dolly. Dinging on the dolly means a glancing or slapping blow of the bumping body hammer on top of sheet metal with the dolly block held directly below the hammer blow, as shown in figure 192. The result of this process is that the metal is ironed smooth between the working faces of the dolly and the hammer. Each blow dings a spot about ⅜ inch in diameter. Succeeding blows should be struck so that each new spot overlaps the previous spot. Ding a row of spots across the edge of a damaged panel. Next, ding another row adjacent to the first row, and so on, until the damaged area is covered with parallel rows of spots. This stretches the metal only very slightly. The low-crown hammer face striking against the dolly, which closely fits the contour of the panel, minimizes the stretching.

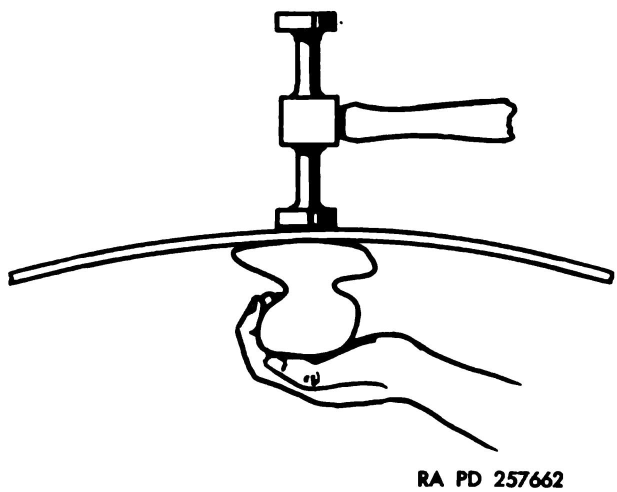

Figure 192. Dinging on the dolly.

b. Dinging Off the Dolly. Figure 193 illustrates dinging off the dolly process. The high-crowned face of the bumping body hammer is used and the blows are directed against the rim of a dent. The dolly block is held against the bottom of the dent and pressure is exerted to force the dent out, as indicated.

c. Using the Bumping Body Hammer. The blow used in dinging is not a follow through blow such as used in driving a nail or in riveting. The hammer must be held loosely and swung with a wrist action, producing a slapping blow. Figure 194 illustrates the path through which the hammer travels. The average number of blows per minute is 120 and in regular rhythm. As each succeeding blow is struck, the hammer rebounds as shown. It is then lifted by wrist action to a point high enough to start the next blow. Then, by a snap of the wrist, the hammer descends for the next slapping blow. At no time is the hammer gripped firmly. The fingers are used to guide and control the hammer at the beginning and at the end of the blow. During the downward and upward path of the hammer head, the end of the handle moves through a short arc, and the hand by continued wrist action follows along, loosely holding the handle and ready to grasp the handle more firmly at the end of the rebound. This operation requires skill, but it can be acquired with practice.

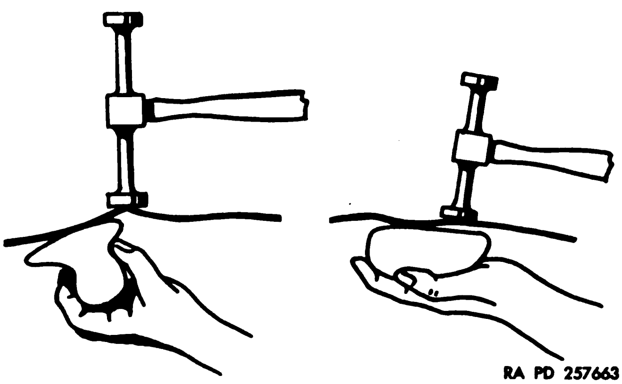

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Figure 193. Dinging off the dolly.

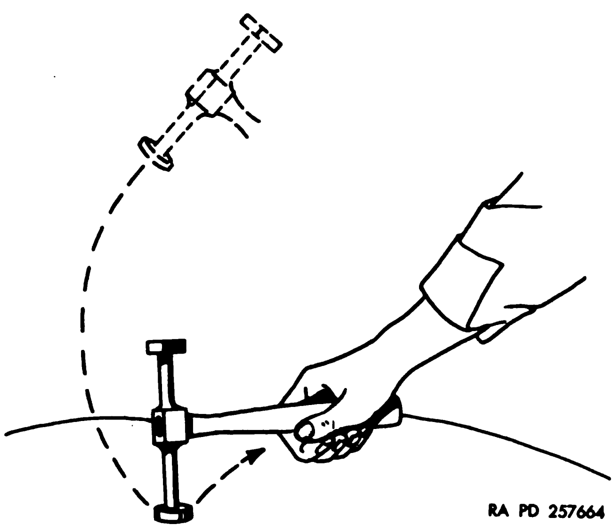

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Figure 194. Using a bumping body hammer.

d. Low-Crown Dolly. The low-crown dolly is used in low-crown panels where medium- and high-crown dollies would stretch the metal.

e. Toe Dolly. The toe dolly, or shrinking dolly, is used on flat panels. Its thinness and length make it accessible in narrow pockets. The large flat face is convenient when shrinking metal (par. 166). The flat sides are used as an anvil for repairing flanges on metal.

f. General Purpose Dolly. The general purpose dolly is convenient to hold and has several different working faces and two beading and flanging lips. It is the most useful of the dollies, since it has unlimited applications.

g. Utility Dolly. The utility dolly has a high crown with one narrow beading edge. The thick rounded sides are used in short radii curves.

h. Heavy-Duty Dolly. The heavy-duty dolly is used on extra-heavy gage sheet metal which resists the action of lighter dollies.

i. Heel Dolly. The heel dolly is used both to reach into sharp corners and into areas having large radii.

166. Shrinking Sheet Metal

When a panel has been damaged so that it is permanently stretched, it will, after it is restored to shape, be too high in the stretched area. It cannot be dinged down since there is no place for the metal to go. It must be shrunk. Shrinking should always be done following the metal bumping and before the metal is finished. Basically, the shrinking operation is simply the heating of a small spot in the center of the stretched area and then upsetting the stretched metal into this heated spot, making it thicker. Shrink a stretched area in sheet metal as outlined in *a* through *e* below.

a. Using a suitable torch with a small tip, heat a spot ⅜ inch in diameter to a little past cherry red in the center of the stretched area (fig. 195). The heat expands the metal in the entire stretched area, while the spot itself rises into a low peak. Use care to avoid burning a hole in the metal.

b. Remove the torch. After the spot turns cherry red, strike the spot with a hard blow of the bumping body hammer to drive the spot down. This hammer blow upsets the hot metal and is the mechanical action which shrinks the

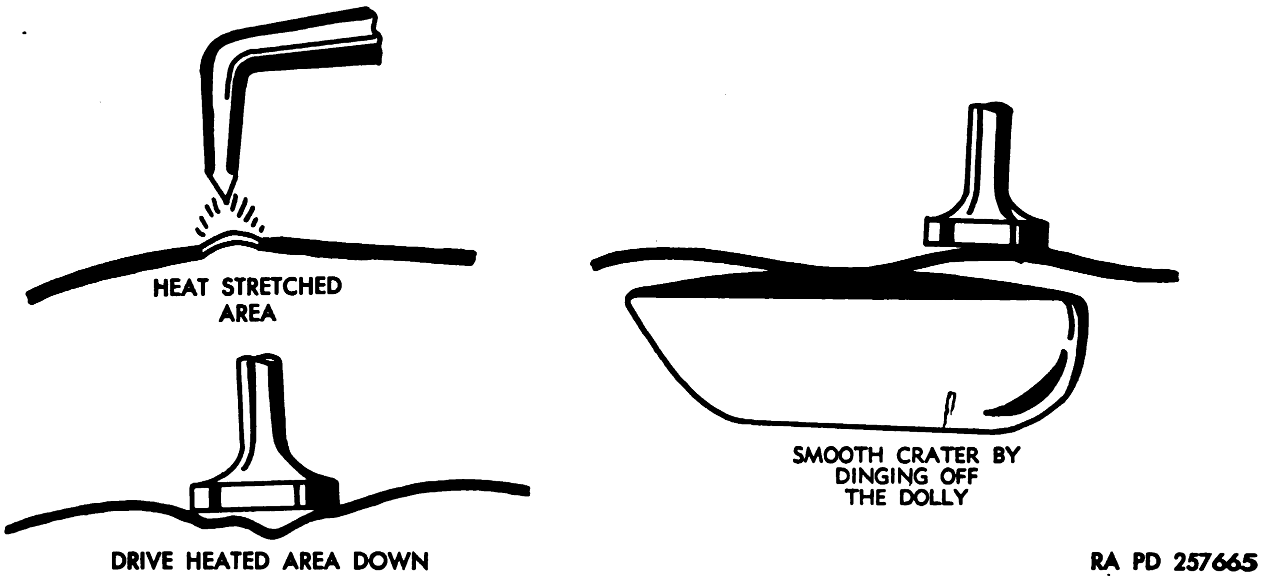


Figure 195. Shrinking sheet metal.

metal. The spot will now form a crater instead of a peak.

c. Very quickly, hold a dolly block up against the bottom of the crater. At the same time, tap down the rim of the crater with the bumping body hammer (fig. 195). This is simply a dinging off the dolly operation to smooth the spot to proper level before metal finishing. The expansion in the metal from the heat remains in the metal during this operation. When dinging the upset metal smooth, use a low-crown face dolly block under low-crown metal, and a high-crown face dolly block under high-crown metal.

d. Finally, quench or chill an area about 6 inches in diameter around the spot with a water-soaked sponge. This chilling draws the expansion out of the metal very quickly.

e. Continue shrinking additional spots until the contour of the panel is in proper shape, as determined by examining and by feeling with the hand.

167. Use of Rivet Sets and Dolly Bars

After holes are located and properly drilled in the work, rivets must be driven and headed.

a. Select the type and size of rivet. The correct length will equal the thickness of the work, plus 1½ times the diameter of the rivet.

b. Insert the rivet in the hole and see that it fits with as little clearance as possible. Place it head down on a solid surface, such as an anvil. Place the proper size rivet set hole over the rivet and strike the rivet set and header with a hammer. This will force the pieces of work together.

c. Firmly hold the work together and strike the end of the rivet a fairly heavy blow with the round head of a ball-peen hammer (fig. 196); then strike the rivet 3 or 4 heavy blows. This will expand the body of the rivet so that it completely fills the hole.

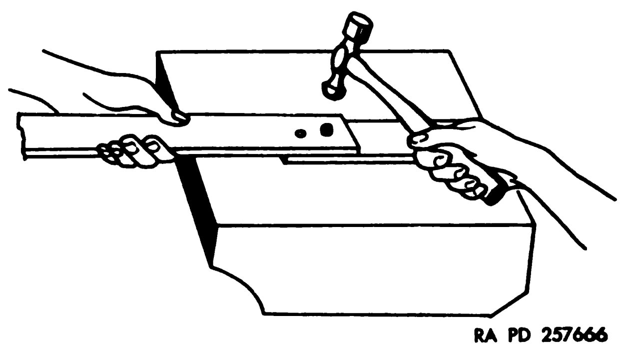


Figure 196. Driving rivets with hammer.

d. Forming a head on a rivet is best accomplished by using a rivet set and header (fig. 197). Place the proper size header hole over the rivet and strike the rivet set and header with a hammer. This will form a head on the forward end of the rivet.

e. For structural iron work, use the type and size dolly bar that fits the rivet to form a head. Hold the cup shaped end of the bar over the rivet and strike the opposite end of the bar several blows with a heavy hammer. This will form a head on the rivet.

168. Care of Sheet Metal Tools

Keep all tools free from rust and their working faces clean and smooth. When not in use, wipe them with light oil and store carefully.

Do not use tools for a purpose other than that for which they were intended. For long periods of storage, coat all metal parts with a rust-preventive compound and store in a dry place.

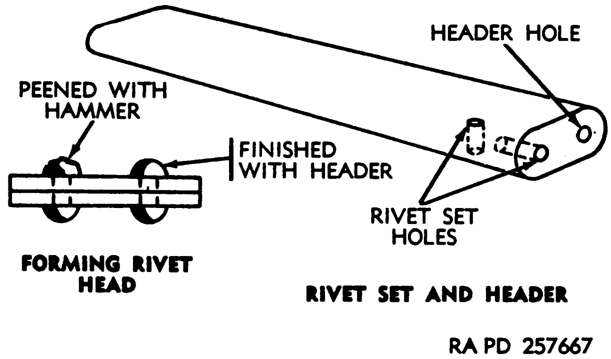


Figure 197. Use of rivet set and header.

CHAPTER 4

EDGED HANDTOOLS

Section I. INTRODUCTION

169. General

Edged handtools are designed with sharp edges for working on metal, wood, plastic, leather, cloth, glass, and other materials. They are used to remove portions from the work or to separate the work into sections by cutting, punching, scraping, chiseling, filing, and so forth.

170. Description

Most edged tools have hardened cutting edges or points and require extreme caution when using. The tools covered in this chapter are those currently issued by the Army Ordnance supply system.

Section II. CHISELS

171. Purpose of Chisels (figs. 198 and 199)

Chisels are made to cut wood, metal, hard putty, and other materials. Woodworker's chisels are used to pare off and cut wood. Cold chisels are used to chip and cut cold metal. Some blacksmith's chisels are used to cut hot metal. A special chisel that is available is used to cut hard putty so that glass may be removed from its frame channel.

172. Types of Chisels

a. Woodworker's Chisels. Woodworker's chisels (fig. 198) are made in a variety of sizes, ranging from a ⅛-inch blade width up to 2 inches wide, and blade lengths from 2 to 6 inches long. Woodworker's chisels have a beveled cutting edge. The construction of woodworker's chisels is either the socket type or the tang end type. The socket type has the blade and handle socket forged from one piece of high carbon steel. The end of the handle is inserted into the socket. The tang end type is also forged in one piece, but the handle is drilled and the tang is inserted into the handle, which is reinforced with a ferrule or metal band. The socket type is usually used for very heavy work where a hammer may be used to strike the hard end of the chisel handle. Tang-type chisels are usually lighter and have thinner blades than the socket type and are normally used with hand pressure.

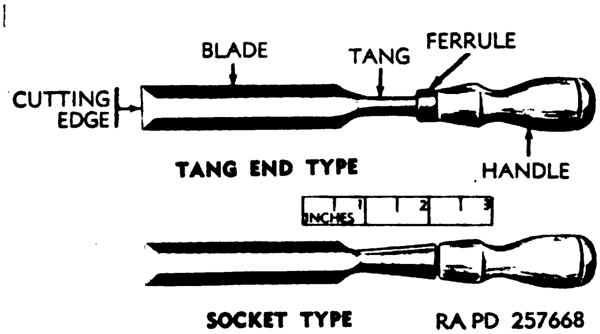


Figure 198. Woodworker's chisels.

b. Machinist's Chisels.

(1) *Flat or cold chisels.* Flat or cold chisels (fig. 199) are made of a good grade of steel with a hardened cutting edge on one end and are rounded off at the other end. The flat or cold chisel is made in sizes from a ¼-inch cutting edge up.

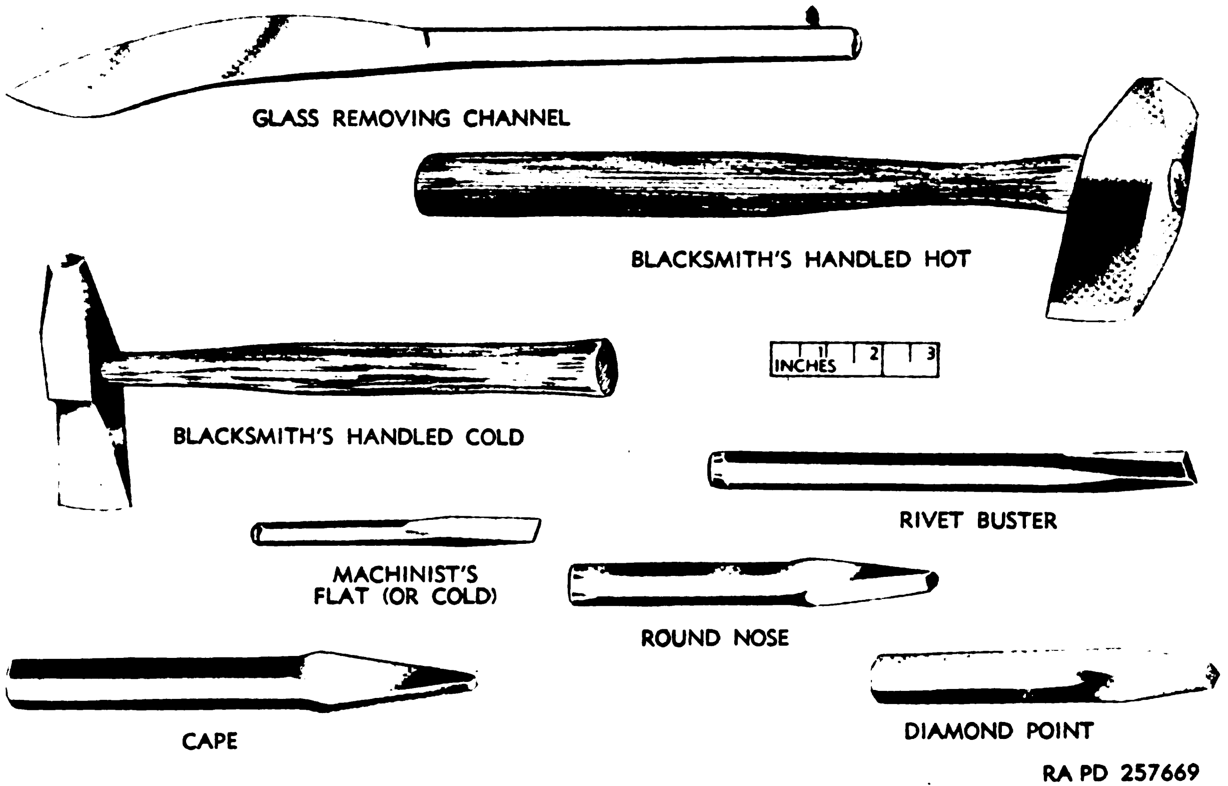


Figure 199. Machinist's and blacksmith's chisels.

(2) *Diamond point chisel.* The machinist's diamond point chisel (fig. 199) has a solid point and is used to cut V-grooves, drawing holes, and cutting holes in flat stock.

(3) *Cape chisel.* The machinist's cape chisel (fig. 199) has a point which is smaller than that of a diamond point chisel. It is used to cut keyways or slots in metal and also for dividing up work so that a flat chisel can be used for finishing.

(4) *Roundnose chisel.* The roundnose chisel (fig. 199) has its cutting edge ground at an angle of 60° with the axis of the chisel. When roundnose chisels are used to bring drilled holes, just started, concentric with the laid out drilling circles, they are called center chisels. The roundnose chisel is also used for cutting channels, such as oil grooves and similar work. The roundnose chisels are of the general shape of the cape chisel with one edge ground flat, and the other edge making a round cutting edge. The stock of these chisels is usually octagon in shape.

c. Blacksmith's Chisels.

(1) *Handled cold chisel.* The blacksmith's handled cold chisel (fig. 199) is used to cut or chip cold metal on an anvil. These chisels are supplied in two sizes, one with a 1⅝-inch cutting edge, and the other with a 1¾-inch cutting edge. The length of the chisel is about 5 inches. It is provided with a wood handle.

(2) *Handled hot chisels.* The blacksmith's handled hot chisel (fig. 199) is used only when hot metal is to be cut. It has a wood handle long enough to keep hands at a safe distance from the hot metal, as well as to provide a firm grip, because a heavy hammer or sledge is used to strike it. This chisel is heavier and more rugged than the handled cold chisel.

d. Track Chisel. A track chisel (not illustrated) weighs 5½ pounds and has a length of 9½ inches. The handle is 24 inches long. This chisel is used to cut off track bolts and boiler rivet heads, as well as to cut rail where a saw or cutting torch is not available.

e. Rivet Buster Chisel. A rivet buster chisel (fig. 199) is 9 inches long and has a ¾-inch cutting edge. It is designed to reach chassis rivets and other difficult places that other chisels cannot reach.

f. Glass Removing Channel Chisel. The glass removing channel chisel (fig. 199) is 15½ inches long with a curved blade. It is used to cut away hard putty from around glass and also to separate glass from its frame channel.

173. Use of Chisels

a. Woodworker's Chisels. A woodworker's chisel should always be held with the flat side or back of the chisel against the work for smoothing and finishing cuts. Whenever possible, it should not be pushed straight through an opening, but should be moved laterally at the same time that it is pushed forward (fig. 200). This method insures a shearing cut, which, with care, even when the work is cross-grained, will produce a smooth and even surface. On rough work, use a hammer or mallet to drive the socket-type chisel. On fine work, use your hand as the driving power on tang-type chisels. For rough cuts, the bevel edge of the chisel is held against the work. Whenever possible, other tools such as saws and planes should be used to remove as much of the waste wood as possible, and the chisel used for finishing purposes only.

(1) *Basic precautions when using a chisel.*

(*a*) Secure work so that it cannot move in any way.

(*b*) Keep both hands back of the cutting edge at all times.

(*c*) Do not start a cut on a guideline. Start slightly away from it, so that there is a small amount of material to be removed by the finishing cuts.

(*d*) When starting a cut, always chisel away from the guideline toward the waste wood, so that no splitting will occur at the edge.

(*e*) Never cut towards yourself with a chisel.

(*f*) Make the shavings thin, especially when finishing.

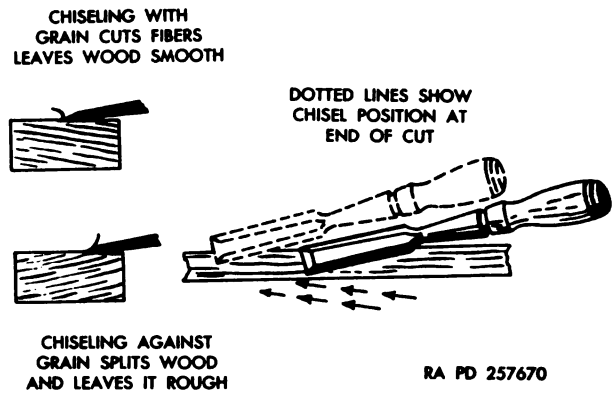


Figure 200. Paring or shearing cut—woodworker's chisel.

(*g*) Examine the grain of the wood to see which way it runs. Cut with the grain. This severs the fibers and leaves the wood smooth. Cutting against the grain splits the wood and leaves it rough. This type of cut cannot be controlled.

(2) *To cut horizontally with the grain.* Grasp the chisel handle in one hand with the thumb extended towards the blade (fig. 201). The cut is controlled by holding the blade firmly with the other hand, knuckles up and the hand well back of the cutting edge. The hand on the chisel handle is used to force the chisel into the wood. The other hand pressing downward on the chisel blade regulates the length and depth of the cut. The chisel will cut more easily and leaves a smoother surface when the cutting edge is held at a slight diagonal to the direction of the cut, or is given a slight lateral sliding motion (fig. 200). This is done by holding the tool at a slight angle and moving it to one side as it is pushed forward, or by moving it slightly from left to right at the same time you push it forward. With cross-grained wood, in case such is met, it is necessary to work from both directions to avoid splitting the wood at the edges. Do not hurry. Cut only fine shavings. If thick shavings are cut, the tool may dig in and split off a piece of wood which was never intended to be removed.

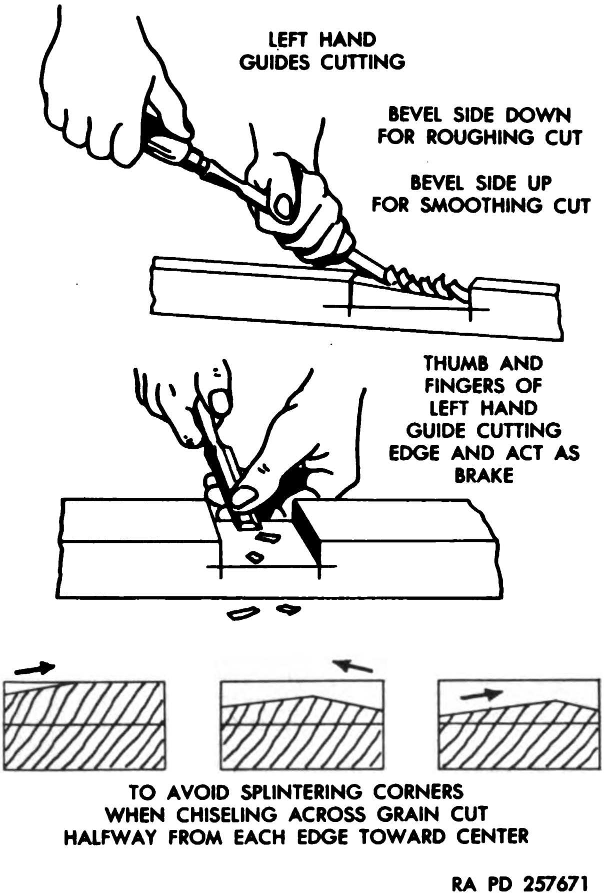


Figure 201. Chiseling horizontally.

(3) *To cut horizontally across the grain.* Work must be held in a vise and most of the waste wood is removed by the chisel with the bevel held down. On light work, use hand pressure or light blows on the end of the chisel handle with the palm of the right hand. On heavy work, use a mallet. To avoid splitting at the edges, cut from each edge to the center and slightly upward so that the waste wood at the center is removed last (fig. 201). Finishing cuts are made with the flat side of the chisel down. Never use a mallet when making finishing cuts, even on large work. One hand pressure is all that is necessary to drive the chisel which is guided by the thumb and forefinger of the other hand. Finish cuts should also be made from each edge toward the center. Do not cut all the way across from one edge to another or the far edge may become split.

(4) *To cut diagonally across the grain.* To cut a straight slanting corner, as shown in figure 202, as much waste wood as possible is first removed with a saw. Clamp the work in a bench vise with the guideline horizontal. Use the chisel as in cutting horizontally with the grain ((2) above). It is necessary to chisel with the grain and to hold the chisel so that the cutting edge is slightly diagonal to the direction of the cut.

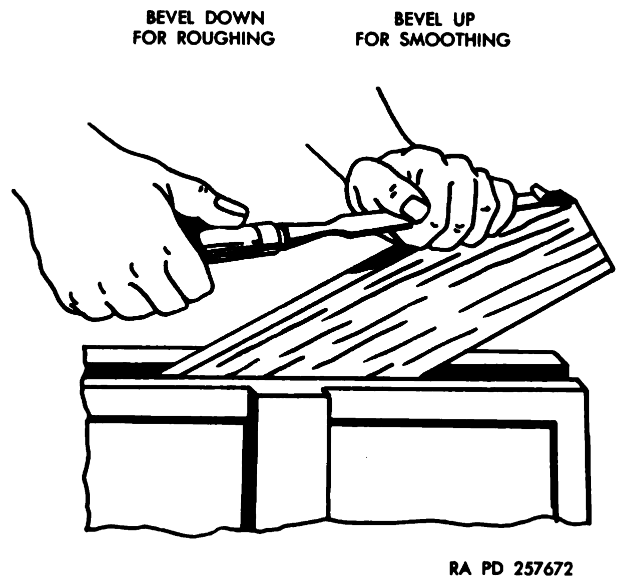


Figure 202. Chiseling diagonally across grain.

(5) *Chamfering with a chisel.* A chamfer is made by cutting off and flattening the sharp corner which exists between two surfaces which are at right angles to each other. A plain chamfer runs the full length of the edge and is usually made with a plane. A stopped chamfer does not run the full length of the edge. If a stopped chamfer is long enough, part of it can be planed and the ends finished with a chisel. A short stopped chamfer must be made entirely with a chisel. A chamfer is usually made symmetrically at 45°. Mark guidelines with a pencil; the guidelines for a 45° chamfer will

be the same distance back from the edges on both surfaces of the wood (fig. 203).

Note. Do not use a marking gage, scratch awl, or knife to make guidelines, since they leave marks in the wood which are difficult to remove.

To cut a stopped chamfer, hold the chisel with the edge parallel to the slope of the chamfer and cut with the grain as in ordinary horizontal paring (fig. 200). Begin at the ends and work towards the center. The ends of a chamfer may be either flat or curved. If flat, use the chisel with the bevel up. If curved, keep the bevel down when cutting.

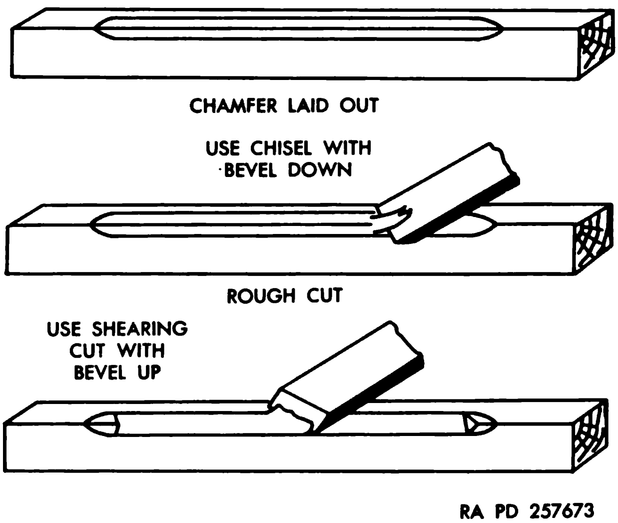


Figure 203. Chamfering with a chisel.

(6) *To chisel a round corner.* To cut a round corner on the end of a piece of wood, first lay out the work and remove as much waste as possible with a saw (fig. 204). Use the chisel with the bevel side down to make a series of straight cuts tangent to the curve. Move chisel sideways across the work as it is moved forward. Finish curve by paring with the bevel side up. Convex curves are cut in the same manner as a round corner.

(7) *To cut a concave curve.* Remove most of the waste wood with a coping saw or a compass saw. Smooth and finish the curve by chiseling (fig. 204) with the grain holding the chisel with the bevel side down. Use one hand to hold the chisel against the work. Press down on the chisel with the other hand, and, at the same time, draw back on the handle to drive the cutting edge in a sweeping curve. Care must be used to take only light cuts or the work may become damaged.

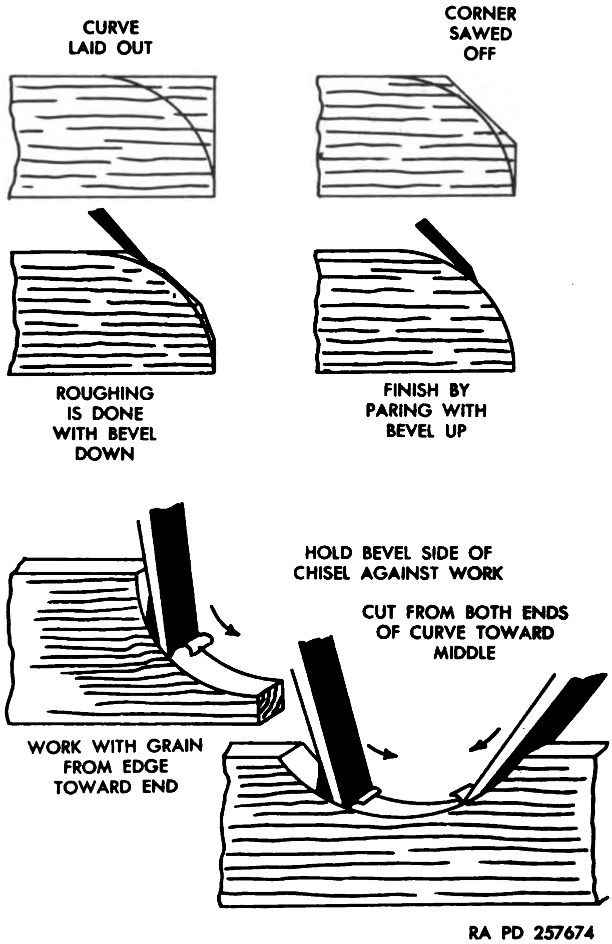


Figure 204. Chiseling corners and curves.

(8) *Vertical chiseling.* Vertical chiseling (fig. 205) means cutting at right angles to the surface of the wood which is horizontal. Usually it involves cutting across the wood fiber, as in chiseling out the ends of a mortise or making a gain on stopped dado joints. When vertically chiseling across the grain, a mallet may be

used to drive the chisel. A mallet is necessary when chiseling hardwood. Use a shearing cut in cutting across the grain. Always cut with the grain whenever possible, so that the waste wood will easily split away from the guide marks. When chiseling on the ends of wood, remove as much waste wood as possible with a saw. Observe direction of grain and start to cut at an edge to avoid splitting the wood. Use a shearing cut and make the shavings thin. Thin shavings can be made without the use of a mallet. Grasp the handle of the chisel in one hand with the thumb pressing down on top of the handle, as shown in figure 205. Use the other hand to guide the tool, and to likewise supply some of the driving force if much pressure is required to do the job.

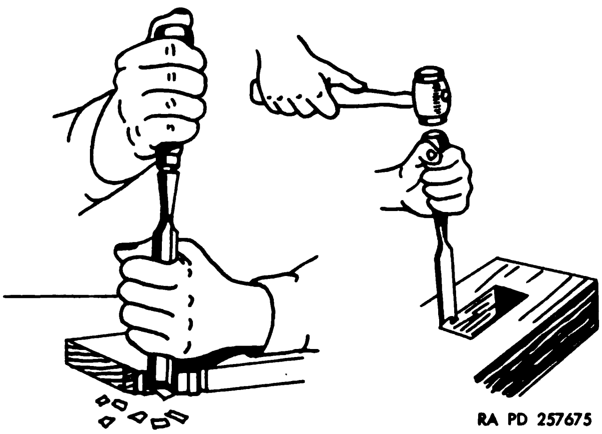


Figure 205. Vertical chiseling.

b. *Machinist's Chisels.*

(1) *Selecting a chisel.* Best results will be obtained if a chisel is used that is designed for the particular job to be done. Paragraph 172*b* discusses the different types of machinist's chisels.

(2) *Chipping.* Chipping is a term applied to the removal of metal with the cold chisel and hammer. The degree of accuracy required varies.

(*a*) Secure the work in a vise with a block under the work to prevent it from slipping down.

(*b*) Place a canvas chipping guard in front of the work to keep flying chips from hitting men working in front of you. Wear goggles to protect your eyes.

(*c*) For most ordinary chipping with a ¾-inch chisel, use a 1-pound hammer. Use a lighter hammer for a smaller chisel. Always use a well-sharpened chisel.

(*d*) Grasp the chisel with one hand, holding the cutting edge to the work and striking the other end of the chisel with the hammer, keeping your eyes on the cutting edge of the chisel to watch the progress of the work. The bevel side of the chisel is the guiding surface and is held at a very slight angle with the finished part of the work, the cutting edge is touching. Raising or lowering the shank of the chisel increases or decreases the inclination of the guiding bevel and causes the chisel to take a heavier or lighter cut. If the hand is held too low on the shank, the chisel will run out before the end of the cut; if held too high, progress will be slow, owing to the difficulty in guiding the chisel.

(*e*) When chipping wrought iron or steel, wipe the edge of the chisel with an oil saturated cloth frequently to lubricate the contacting surfaces and to preserve the cutting edge of the chisel.

(*f*) After every two or three blows, draw the chisel back slightly from the chip. This tends to ease your muscles, giving you better control over the job.

(*g*) When chipping cast metal, begin at the ends and chip toward the center to keep from breaking corners and edges.

(*h*) Take cuts from 1/16 to 1/32 inch. Leave enough stock so that the surfaces may be finished with a file.

(*i*) When chipping keyways with a cape chisel, an ample margin for filing should be left both on the sides and and on the bottom.

(j) When chipping a rather wide surface, first use a cape chisel to cut grooves, and then use the flat chisel to chip the stock between the grooves.

(3) *Cutting wire or round stock.* When a suitable hacksaw is not available to cut round stock, the chisel may be used.

(a) Mark off the guideline and place the work on the top face of an anvil or on a suitable working surface.

(b) Place the cutting edge of the chisel on the mark in a vertical position.

(c) Lightly strike the chisel with a hammer and check chisel mark for desired cut.

(d) Continue to strike chisel until cut is made. The last few cuts should be made lightly to avoid damage to the anvil, supporting surface, or to the chisel.

(e) Heavy stock is cut in the same manner, except that the cut is made halfway through the stock, the work turned over, and the cut finished from the opposite side.

(4) *Cutting sheet or plate metal.* When sheet or plate metal cutters or machines are not available, the chisel may be used. Using a chisel to cut sheet metal will cause the metal to stretch; avoid this method, whenever possible.

(a) Mark off guideline for cut.

(b) Secure work in a vise so that the guideline is even with or below the vise jaws.

(c) Use a sharp chisel; start at one edge of the work, holding the chisel perpendicular to the surface. Strike the end of the chisel sharply, keeping the chisel cutting edge firmly held against the work. Always drive the chisel towards the stationary jaw of the vise.

(d) Complete cut along guideline and finish with a file.

c. Blacksmith's Chisels. The blacksmith's cold chisel is used to cut heavy gage metal which the machinist's cold chisel will not cut. Hold the chisel by the handle with one hand, having the cutting edge perpendicular to the work, and strike the head of the chisel vigorously with a blacksmith's hammer or sledge. The blacksmith's hot chisel is used in the same manner to cut hot metal. The work is usually placed on an anvil and a piece of scrap metal placed under the work when the cut is to go completely through the stock.

d. Track and Rivet Buster Chisels. To cut a bolt or rivet head, place the cutting edge of the chisel against the bolt or rivet head where it seats against the track rail or other unit it secures, and strike the chisel head sharply with a heavy hammer or sledge. To cut a rail, place the cutting edge perpendicular to the top of the rail and strike the chisel head with a sledge until a nick or shallow cut has been made in the rail. Pick up the rail and drop it across another rail centered under the cut. The rail should snap at the point where the nick was made.

174. Maintenance and Repair of Chisels

Chisels must be kept properly ground and sharpened at all times in order to obtain good workmanship in the finished product. Grinding is necessary when the cutting edge has been badly nicked and the nicks cannot be removed by whetting on a coarse oilstone, or when the bevel has become too short or rounded as a result of frequent whetting or careless whetting.

a. Woodworkers's Chisels.

(1) *Sharpening.* A common oilstone (fig. 165) having a coarse and fine grit is used to sharpen a chisel which does not require grinding. It is also used to whet a chisel after grinding.

(a) Clamp the oilstone in a vise or make sure it is otherwise firmly held so that it cannot move.

(b) Cover stone with light machine oil so that the fine particles of steel which are ground off will float and this will prevent the stone from clogging.

(c) Hold the chisel in one hand with the bevel flat against the coarse side of the stone.

Note. For ordinary work, the bevel is sharpened at an angle of 25 to 35°. For fine cutting and paring, the angle may be slightly less.

(*d*) Use the fingers of your other hand to steady the chisel and hold it down against the stone.

(*e*) Using smooth even strokes, rub the chisel back and forth parallel to the surface of the stone (fig. 206). The entire surface of the stone should be used to avoid wearing a hollow in the center of the stone. Do not rock the blade. The angle of the blade with the stone must remain constant during the whetting process.

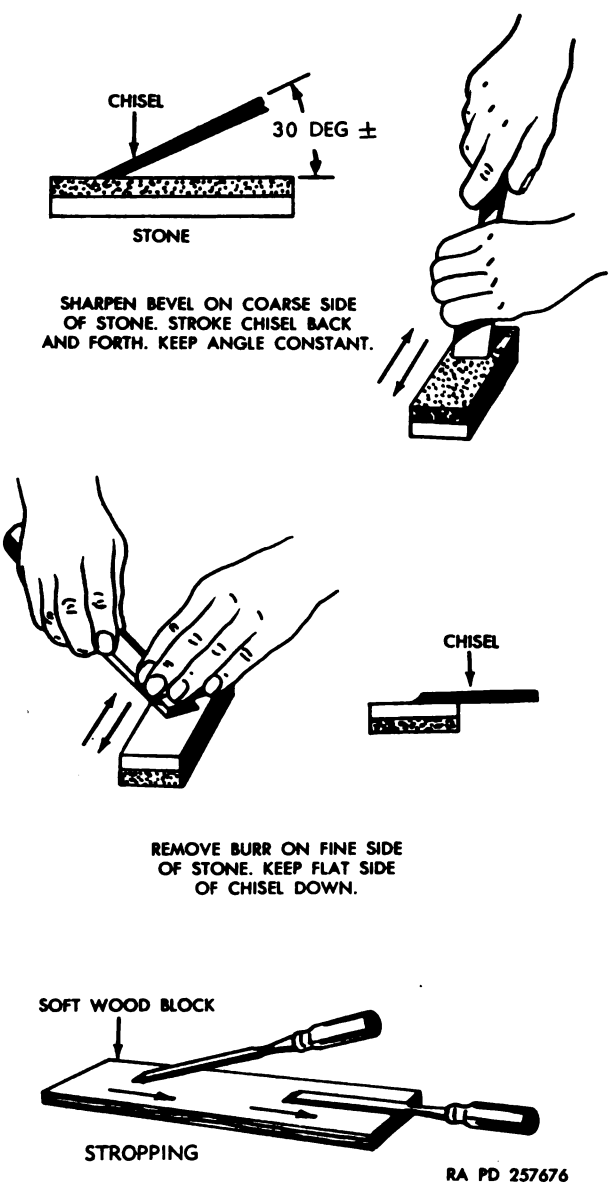


Figure 206. Sharpening a woodworker's chisel.

(*f*) After a few strokes, a bur, wire edge, or feather edge is produced. To remove the bur, first take a few strokes with the flat side of the chisel held flat on the fine grit side of the stone. Be careful not to raise the chisel even slightly, avoid putting the slightest bevel on the flat side, for then the chisel must be ground until the bevel is removed.

(*g*) After whetting the flat side on the fine grit side of the stone, turn the chisel over and place the bevel side down and hold it at the same angle as used when whetting on the coarse side of the stone. Take two or three light strokes to remove the bur.

(*h*) It may be necessary to take one or or two light strokes again on the flat side of the chisel to remove the bur.

(*i*) To get an extremely sharp edge, the chisel must be stropped. This is done by rubbing both sides of the chisel's cutting edge on a soft wood block or on a leather or canvas strap putting the chisel down and stroking the edge in one direction only, moving the chisel towards the handle end, as shown in figure 206.

(*j*) To test the sharpness of the cutting edge, hold the chisel where a good light will shine on the cutting edge. A keen edge does not reflect light in certain positions. If there are no shiny or white spots in this position, it is a good edge.

(2) *Grinding*. Grind the bevel of a woodworker's chisel concave to the shape of the abrasive wheel used, or to a perfectly flat or straight bevel (fig. 207). The length of the bevel should be approximately twice the thickness of the chisel, or slightly longer if the chisel is used to cut soft wood.

(*a*) Square the cutting edge and remove nicks. Adjust the grinder tool rest so that when the chisel is held upon it, the edge will be ground at right angles to the length of the chisel (fig. 208).

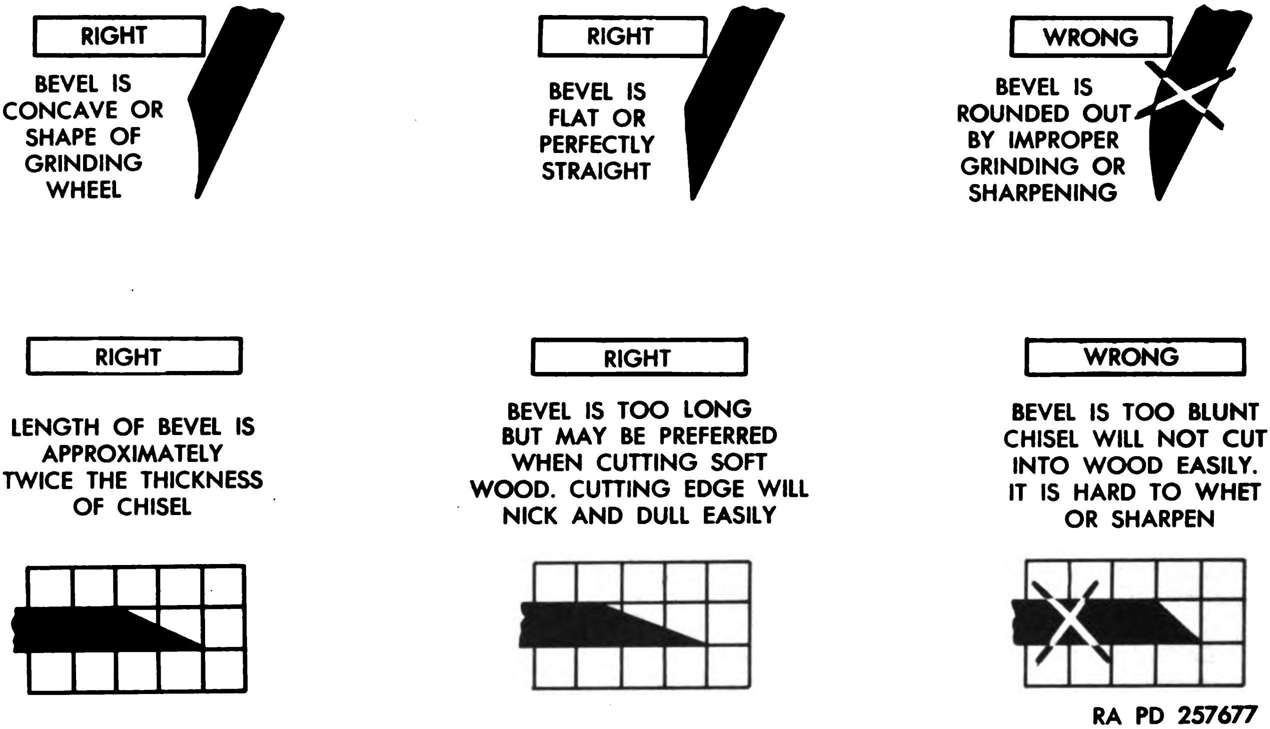


Figure 207. Right and wrong chisel bevels.

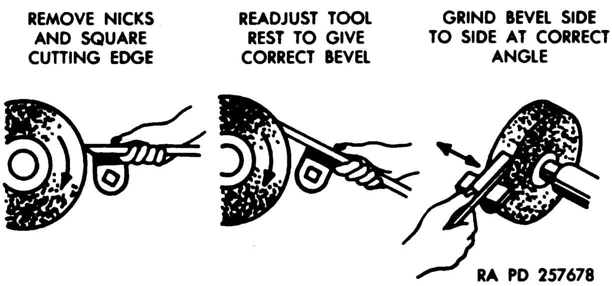


Figure 208. Grinding a woodworker's chisel.

(*b*) After squaring, readjust the grinder rest to a position that will give the correct bevel. Check the bevel angle by looking at it from the side when the grinder is not operating. The cutting edge must be maintained in grinding at right angles to the length of the chisel while the chisel blade rests on the tool rest in front of the grinder wheel.

(*c*) When the right position is found, grasp the chisel blade so that the back of the forefinger touches the tool rest. The finger acts as a stop and you do not shift its position on the blade until you are through grinding.

(*d*) Hold the chisel lightly against the wheel and move it from side to side evenly across its surface.

(*e*) Frequently dip the chisel in water to prevent loss of temper and softening of the steel. When placing chisel back on the tool rest of the wheel, use your forefinger as a stop. The grinding angle may be 25 to 35°.

(*f*) After grinding, whet the chisel as discussed above.

(3) *Repairing damaged handle heads.* If the head of a woodworker's chisel becomes mushroomed (fig. 209), it can be repaired as described in (*a*) through (*d*) below.

(*a*) Cut the head of the handle off square (fig. 210) with a saw.

(*b*) Turn down about $\frac{3}{8}$ inch of the handle length, leaving a tip about $\frac{7}{16}$ inch in diameter, as shown.

(*c*) Cut leather or fiber washers to fit snugly over the tip and glue them in place. Use enough washers so their total thickness exceeds ⅜ inch. Their diameter should be greater than the diameter of the handle.

(*d*) After glue dries, reshape the handle end by cutting and sanding the washers to conform to original rounded shape.

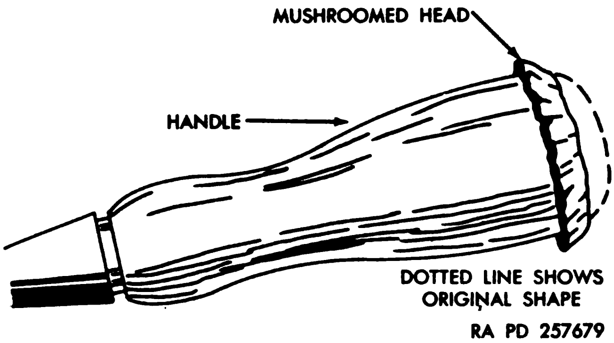


Figure 209. Mushroomed chisel handle.

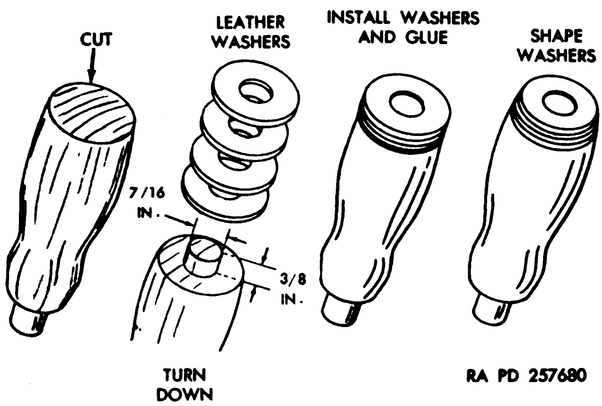


Figure 210. Repairing mushroomed handle.

(4) *Replacing broken handle.*

(*a*) If the socket-type handle is damaged beyond repair or broken off in the socket, remove the handle, drilling out the broken ends from the socket if necessary. Shape a new handle to fit snugly in the socket. Secure blade in a soft jawed vise and tap the handle to seat in the socket.

(*b*) If the tang end type handle is damaged beyond repair or is split, remove the handle. Select new handle to fit tang of chisel. Fit in ferrule on handle by tapping with a soft-faced mallet. Prick punch ferrule to handle, as shown in figure 242. Insert tang in handle. Tap back end of handle on a flat surface until chisel is properly seated.

b. Machinist's and Blacksmith's Chisels.

(1) *Grinding.* Grind chisels of this type at once when they become dull. Most of these chisels have two bevels which form the cutting edge. The included angle formed by the two bevels should be as small as possible without leaving the cutting edge weak. If the angle is too small, the chisel will soon become dull, and if the angle is too large, more force will be required to drive the tool. The best included angle for cutting cast iron is about 70°, while for wrought iron and mild steel 60° is preferred. Chisels used for cutting extremely hard metal may be ground to 90 degrees.

(*a*) To grind, set the grinder tool rest to give the chisel the desired bevel angle.

(*b*) Hold the chisel as shown in figure 211, with the left hand resting on the tool rest.

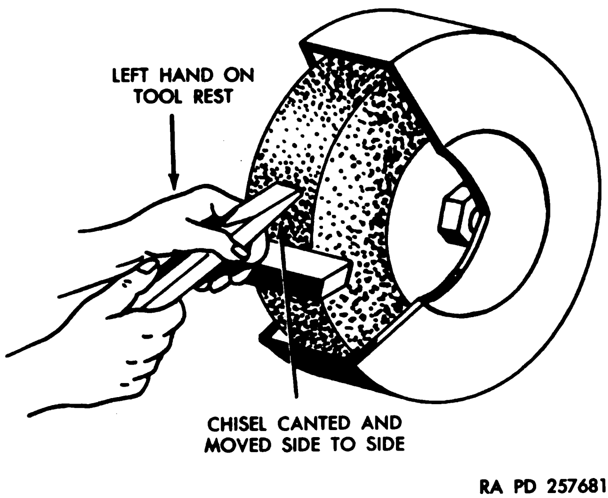


Figure 211. Grinding a cold chisel.

(*c*) Move the chisel slowly back and forth at the desired canted angle across the face of the grinding wheel.

(*d*) Do not hold the chisel against the wheel with too much pressure, or the temper will be taken out due to overheating.

(*e*) Grind the cutting edge slightly convex, as shown in figure 212. This is done to prevent the corners of the chisel from digging into the work.

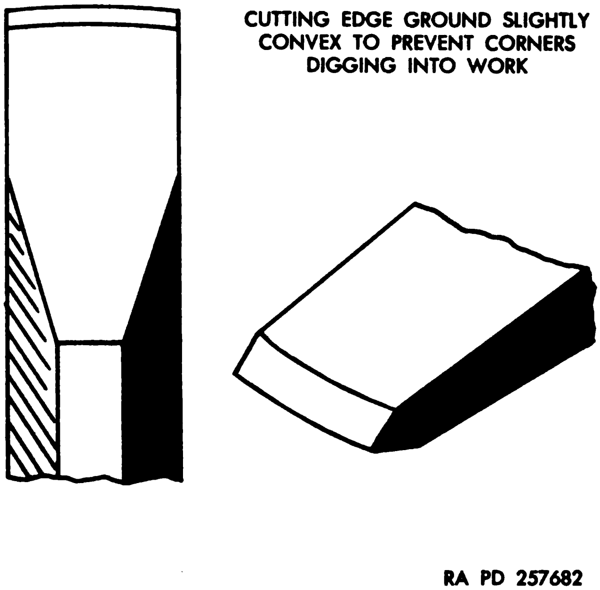


Figure 212. Cutting edge of machinist's flat or cold chisel.

(*f*) Dip chisel in water frequently to cool off and preserve temper.

(*g*) Turn chisel over in order to grind other bevel. The bevels should be ground alike in width and should form equal angles with the centerline of the chisel. The roundnosed chisels have one bevel, like a wood chisel. The standard included angle between the surfaces which form the cutting edge discussed above should be the same, whether these surfaces are both bevels, or one bevel and the other the straight or flat side of the chisel. In a one bevel chisel, the angle that the bevel forms with the centerline of the chisel should be twice as large as in one having two bevels.

(2) *Hardening and tempering.* Machinist's and blacksmith's chisels often require hardening and tempering. To harden a machinist's or a blacksmith's chisel, heat it to a cherry red in a suitable furnace or forge, after removing the wood handle in case of the blacksmith's chisel. Hold the chisel in the center with a pair of tongs and dip the cutting end in cold water to a depth of 1¼ inches. Turn chisel over and dip the chisel head to a depth of 1 inch. Polish the hardened ends with a file or aluminum oxide abrasive cloth. Watch for color to return to the ends from the very hot center section. Every time the cutting end turns purple, dip it. Redip the head every time it turns blue. When the red disappears from the chisel, dip the whole tool to check further drawing of temper. The same procedure is used on the cutting edges and heads of any other type chisel or other tool when retempering or hardening is necessary. This produces a hard cutting edge and head, and a softer and tougher center section better adapted to withstand shock.

(3) *Reshaping mushroomed head.* If machinist's or blacksmith's chisels become mushroomed after much use, the head must be reground to shape on a grinder wheel. Chisel must be hardened after reshaping the head ((2) above).

(4) *Repairing and replacing handles.* Wooden handles on blacksmith's chisels are repaired and replaced as you would a hammer handle (par. 94).

175. Precautions When Using Chisels

a. Keep your mind on your work so that you do not strike yourself or someone else with a hammer.

b. Do not carry chisels in your pockets.

c. Lay chisels down so that you or others cannot be hurt with the cutting edge.

d. Be sure chisel shanks and the hammers you are using are free from grease or oil.

e. Keep cutting edge of chisel away from yourself or others when using it.

f. Wear goggles when chipping metal and when grinding chisels.

g. Keep chisel handles in good condition.

Do not use chisels having mushroomed heads or mushroomed handle heads.

h. Do not exert too much pressure against a grinding wheel when grinding or sharpening chisels.

176. Storage and Care of Chisels

To prevent dulling the cutting edges, place the chisels in racks or arrange them so that their cutting edges do not come in contact with other tools or pieces of metal. Chisels used daily should be cleaned and wiped with an oily cloth before putting them away. For long periods of storage, apply a rust-preventive compound to all metal parts and store in a dry place.

Section III. FILES

177. Purpose of Files
(figs. 213–216)

Files are used for cutting, smoothing off, or removing small amounts of metal.

178. Types of Files

Files (fig. 213) are made in various lengths, shapes, and cuts, and spacing of their teeth. Every file has five parts: the point, edges, face or cutting teeth, heel or shoulder, and tang (fig. 214).

a. File Teeth Characteristics. Figure 215 illustrates the different types of file teeth.

(1) *Single-cut files.* Single-cut files have a single set of diagonal rows of teeth. The teeth are parallel to each other throughout the file.

(2) *Double-cut files.* Double-cut files have two sets of diagonal rows of teeth. The first set of teeth is called the overcut. On top of the overcut set, a second set is made crossing the first. The second set is called the upcut and is not as coarse or as deep as the overcut.

(3) *Rasp-cut files.* Rasp-cut files are made by a single pointed tool or punch which forms each short tooth separately. Teeth are formed consecutively, side by side, to form a line or a row of teeth.

b. File Teeth Spacing. The number of teeth per inch or spacing (fig. 215) varies slightly with the make of file. The spacing also changes with the file length, increasing proportionately as the length of the file is increased. A file may have a rough, coarse, bastard (medium coarse), second cut, smooth cut, and dead smooth grade teeth. For fast removal of metal for rough work, the rough, coarse, and bastard files are used. For finishing, the second cut (small teeth), smooth cut (very small teeth), and the dead smooth (very fine teeth) are used.

c. File Shapes.

(1) *Flat files.* A flat file (fig. 213) is rectangular in cross section and is slightly tapered towards the point in both width and thickness, and has double-cut teeth. Both edges are cut.

(2) *Hand files.* A hand file (fig. 213) is similar to a flat file, but is of uniform width and tapers in thickness only. It is double cut with one safe or uncut edge.

(3) *Square files.* A square file (fig. 213) tapers slightly towards the point on all four sides and is double cut.

(4) *Round files.* A round file (fig. 213) tapers slightly towards the point. The bastard cut files, 6 inches and longer, are double cut. The second cut round files, 12 inches and longer, are double cut; all others are single cut.

(5) *Half-round files.* A half-round file (fig. 213) tapers towards the point in widths and thickness. The flat side of all half-round files is double cut and is graded in coarseness like flat files. The round backs of all coarse and bastard half-round files are double cut. The backs of files longer than 6 inches are double cut; the backs of 4– and 6–inch files are single cut.

(6) *Mill files.* A mill file (fig. 213) is usually single cut and is tapered in width and thickness for about a third of its length.

(7) *Pillar files.* A regular or an extra narrow pillar file (fig. 213) is similar to a hand file, only it is narrower.

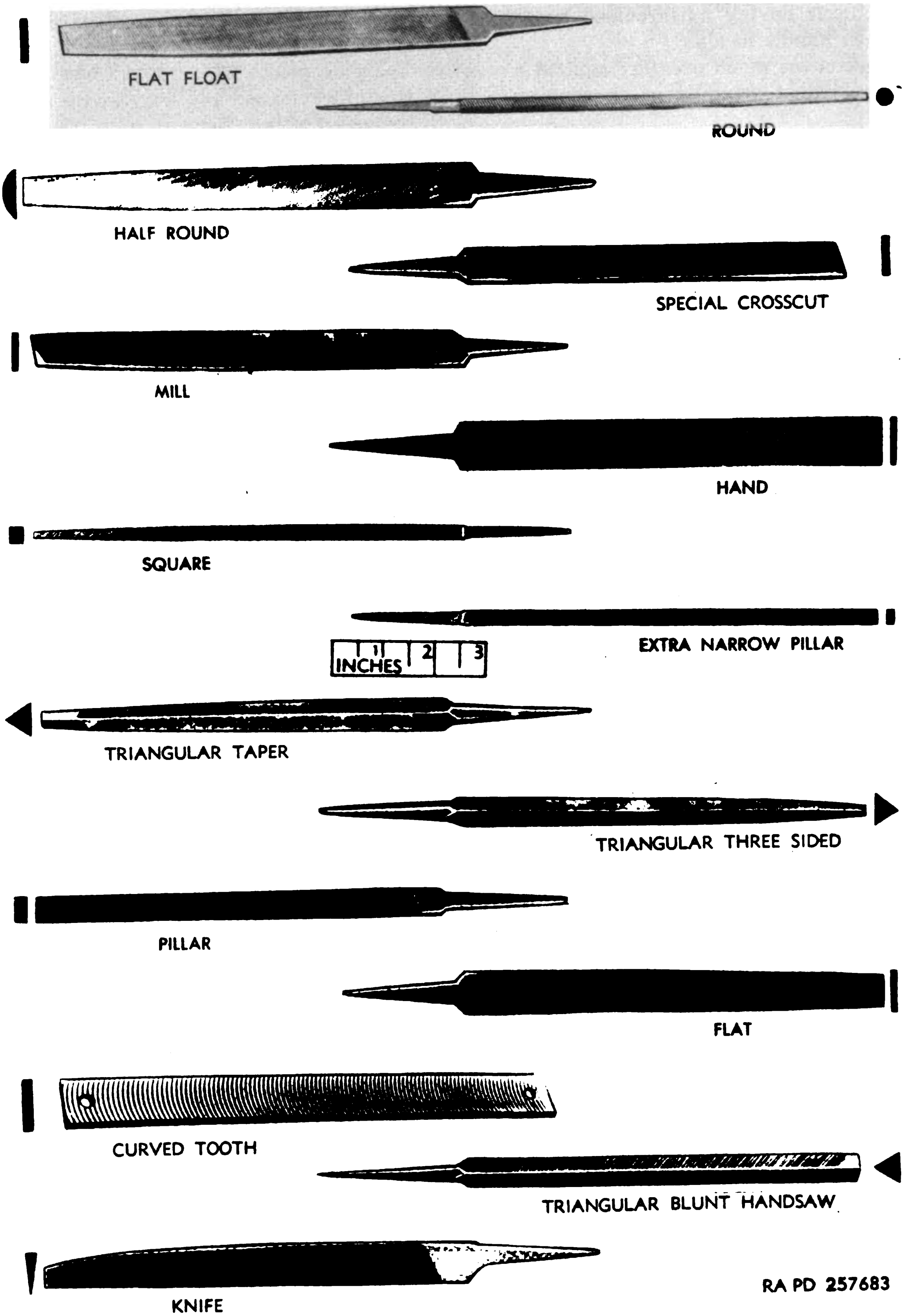


Figure 213. Types of files.

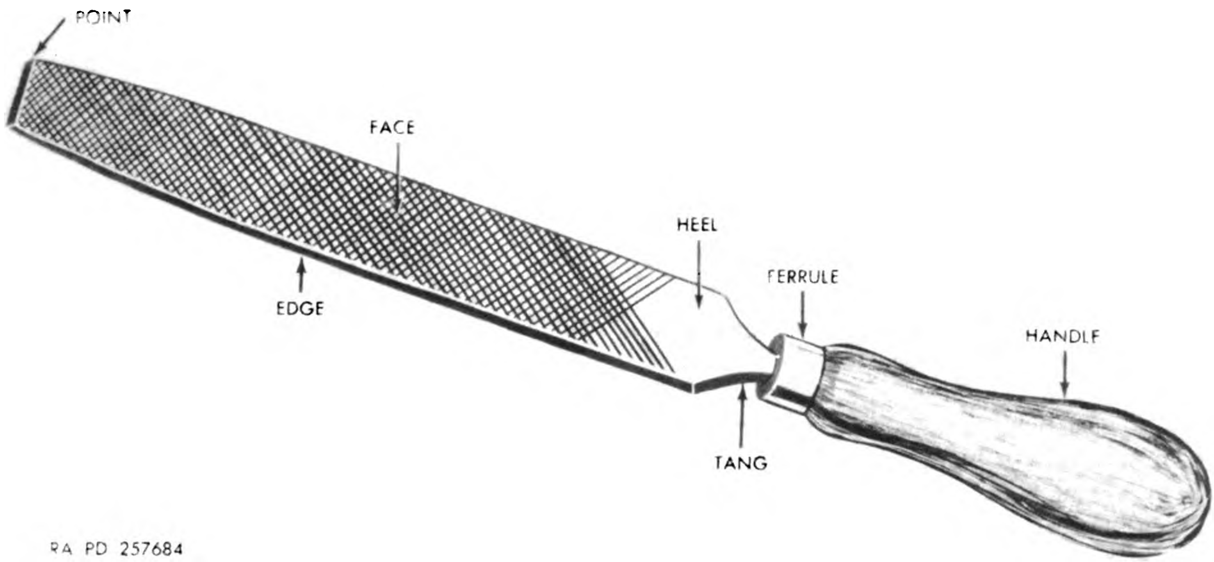


Figure 214. Parts of a file.

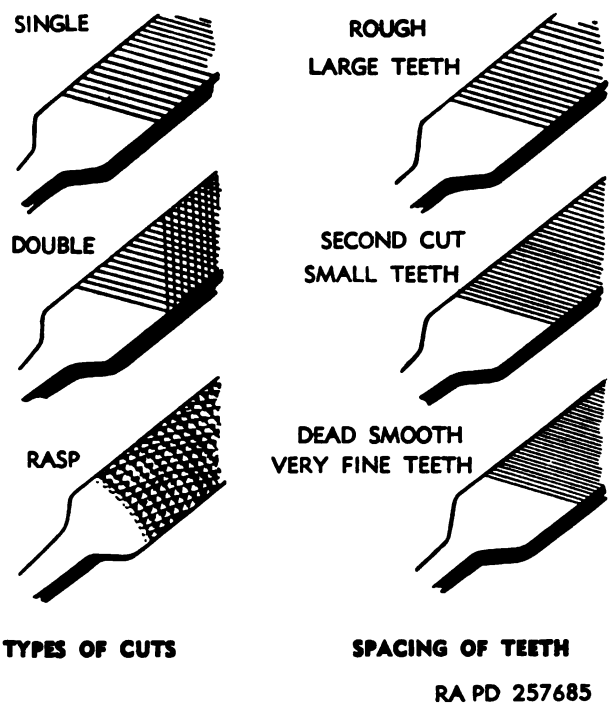


Figure 215. File teeth characteristics.

Pillar files are double cut with one safe or uncut edge. Pillar files are of the same coarseness as square files of corresponding lengths.

(8) *Triangular files.* The taper file tapers toward the point (fig. 213) is usually single cut and has edges that are set and cut for filing the gullet between saw teeth. The blunt handsaw file (fig. 213) is of uniform width and thickness and its teeth are similar to those of the taper file. The three sided file (fig. 213) tapers towards the point, is double cut and has fairly sharp corners.

(9) *Knife files.* A knife file (fig. 213) is shaped like a knife blade and is double cut on both faces.

(10) *Flat float files.* Flat float files (fig. 213) are slightly tapered in width and thickness and have a coarse single cut.

(11) *Curved tooth file.* The curved tooth file (fig. 213) has single cut, curved, milled teeth.

(12) *Special crosscut saw file.* The special crosscut saw file (fig. 213) is single cut and of uniform width and thickness.

(13) *Swiss pattern files.* Swiss pattern files (fig. 216) are small and delicate. The tang is shaped into a handle. They are most often used for fitting parts of delicate mechanisms, for filing work in instruments, and tool and die work. They are made in seven cuts; Nos. 00, 0, 1, 2, 3, 4, and 6. They are usually supplied in sets of 8 or 12 assorted files in a box,

although individual files are issued. The handles are knurled for a better grip. The Swiss pattern files are designed in twelve different shapes, as shown in figure 216.

179. Use of Files

a. *Selecting Proper File.*

(1) For heavy, rough cutting, a large coarse, double-cut file is best.

(2) For finishing cuts, use a second or smooth cut, single-cut file.

(3) When working on cast iron, start with a bastard cut file and finish with a second cut file.

(4) When filing soft metal, start with a second cut file and finish with a smooth cut file.

(5) When filing hard steel, start with a smooth cut file and finish with a dead smooth file.

(6) When filing brass or bronze, start with a bastard cut file and finish with a second or smooth cut file.

(7) When filing aluminum, lead, or babbitt metal, use a bastard cut curved tooth file.

(8) For small work use a short file, for medium sized work use an 8–inch file, for large work use a file that is most convenient.

b. *Method of Filing.*

(1) Clamp the work securely in a vise so that the area to be filed is horizontal and is parallel to and projecting slightly above the vise jaws.

(2) Hold the file handle in one hand, thumb on top, and hold the tip of the file with the fingers of the other hand, as shown in figures 217 and 220.

(3) Apply pressure on the forward stroke only. Unless the file is lifted from the work on the return stroke, it will become dull much sooner than it should. When filing soft metals, pressure on the return stroke helps keep the cuts in the file clean of waste metal.

(4) Use a rocking motion when filing round surfaces.

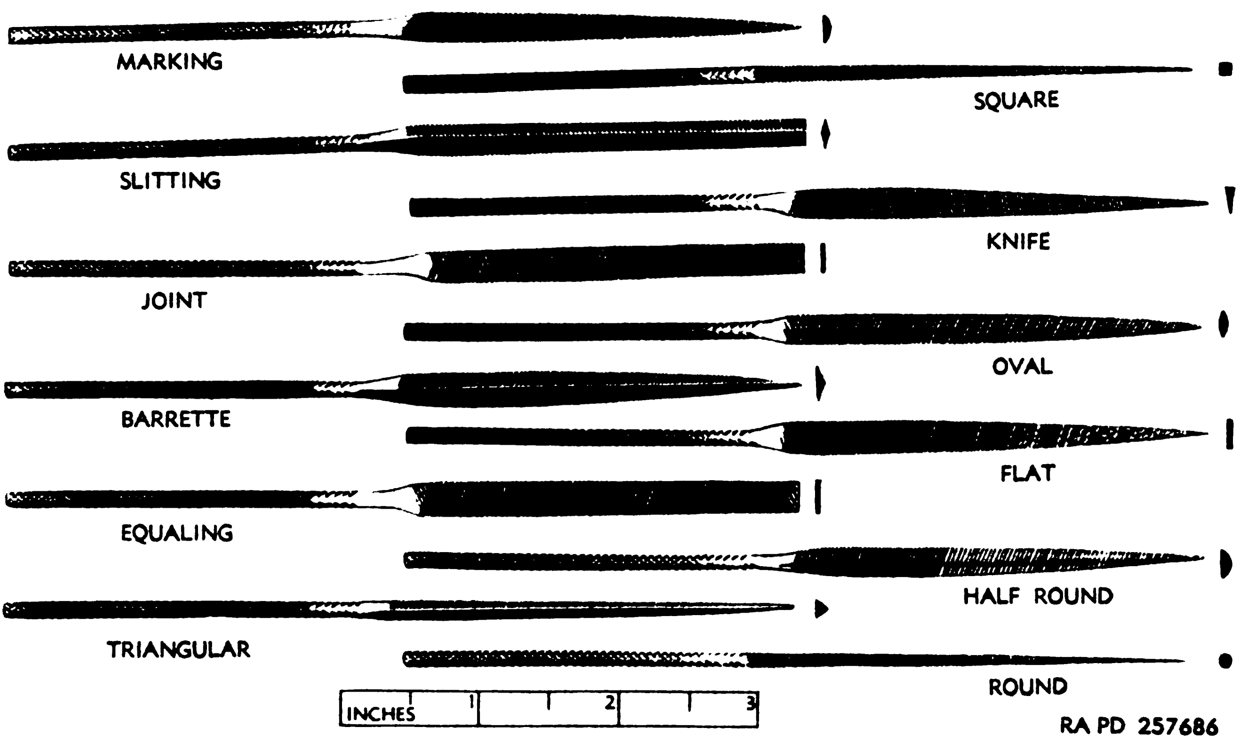
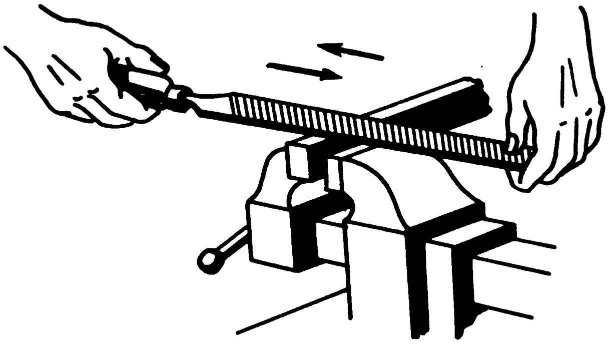


Figure 216. Swiss pattern files.



RA PD 257687

Figure 217. Normal filing procedure.

(5) When using a new file, do not apply too much pressure, since the teeth will break off—do not force the file. File slowly, lightly, and steadily. Too much speed and too much pressure causes the file to rock and will round off the corners of the work.

c. Draw Filing. Draw filing is used to produce a very smooth and true surface. To draw file, hold the file at right angles to the direction of the strokes, with your hands close together to prevent bending and breaking the file, as shown in figure 218. Pressure should not be great and can remain the same on the back stroke, as well as on the draw stroke. The speed of filing is not important. For extra smooth surfaces, wrap a piece of emery cloth around the file and stroke in the same manner.

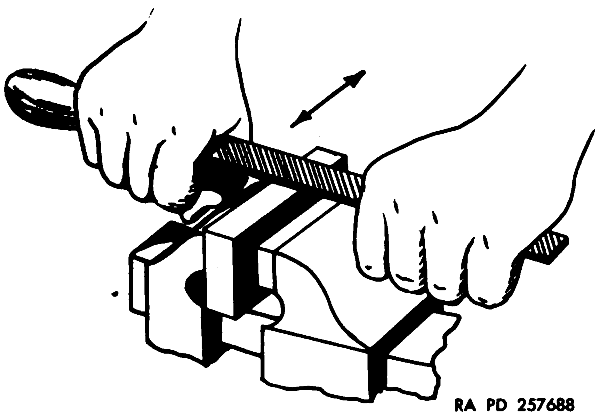


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Figure 218. Draw filing.

180. Care of Files

a. Breaking In. A new file should be broken in by using it first on brass, bronze, or smooth iron. Never use it first to remove the fins or scales on cast iron. Do not use a new file on a narrow surface, such as sheet metal, because the narrow edge of the metal is likely to break off the sharp points on the file teeth.

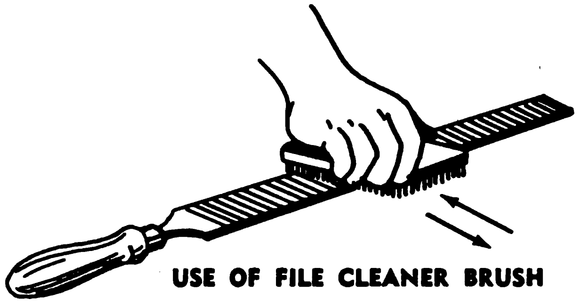

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Figure 219. Cleaning a file.

b. Cleaning. After using a new file, the teeth will clog up with metal filings. Using a clogged file will scratch the work—this condition is called pinning. One way to help prevent pinning is by rubbing chalk between the teeth before filing. However, the best method to keep the file clean is to use a file scorer and file cleaner brush (fig. 219). A scorer is a small pointed metal instrument, often furnished with the file cleaner brush, and is used for cleaning out individual teeth and grooves in the file, clogged too tightly with metal to clean with the brush. When cleaning a file with a file scorer, use a pulling motion, holding the file scorer blade parallel to the rows of teeth. Finish cleaning by brushing the file parallel to the rows of teeth with the file cleaner brush.

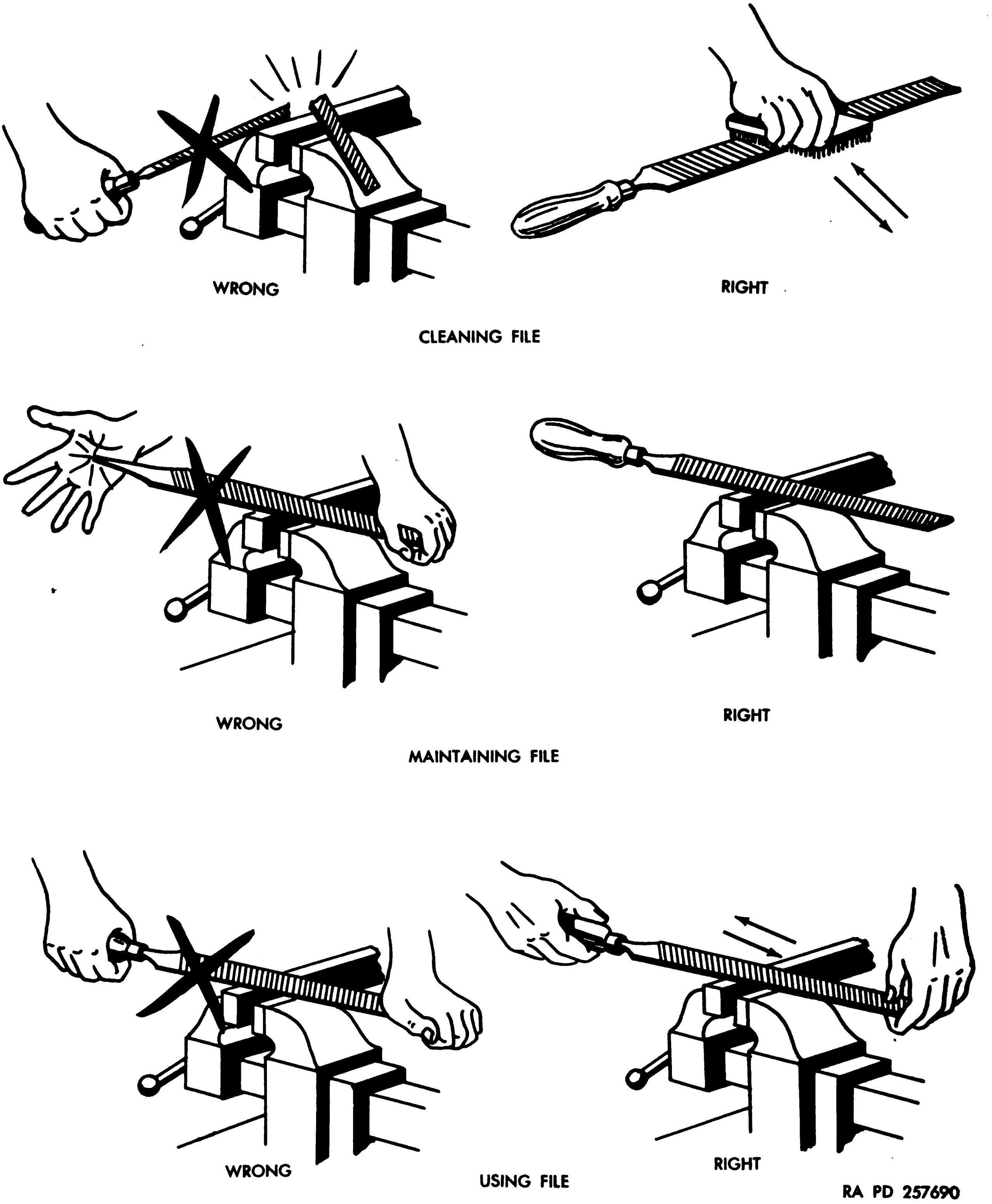


Figure 220. Filing precautions.

c. Handling Precautions.

(1) Do not throw files in drawer or tool box where they can rub against each other or against other tools. Store them in separate holders, such as clips, straps, or in holes cut in a block of wood.

(2) Use a file as instructed and clean files often.

(3) Never use a file without a securely attached handle (fig. 220) unless it is of the Swiss pattern type.

(4) Do not use files for a purpose other than for which they were intended.

(5) Do not use oil since this will cause the file to slide across the work preventing fast cutting.

(6) Never strike the file against a vise or other object to remove filings (fig. 220). Use the file cleaner brush (fig. 219).

d. Storage. Never store files with lubricants or rust-preventive compounds on them. Wrap each file in a waterproofed barrier wrapping paper and place the files in racks or boxes so that the faces or edges of the files will not touch each other. Keep files dry.

181. Replacing Handles

a. To remove a handle, hold file with one hand and the handle with the other; pull the file from the handle while striking the ferrule end of the handle against the edge of a bench, as shown in figure 221.

b. To install new handle, insert tang end of file into handle socket exerting pressure with your hands and tap the handle on the bench top until the file is seated, as shown in figure 221. Do not hammer file into handle.

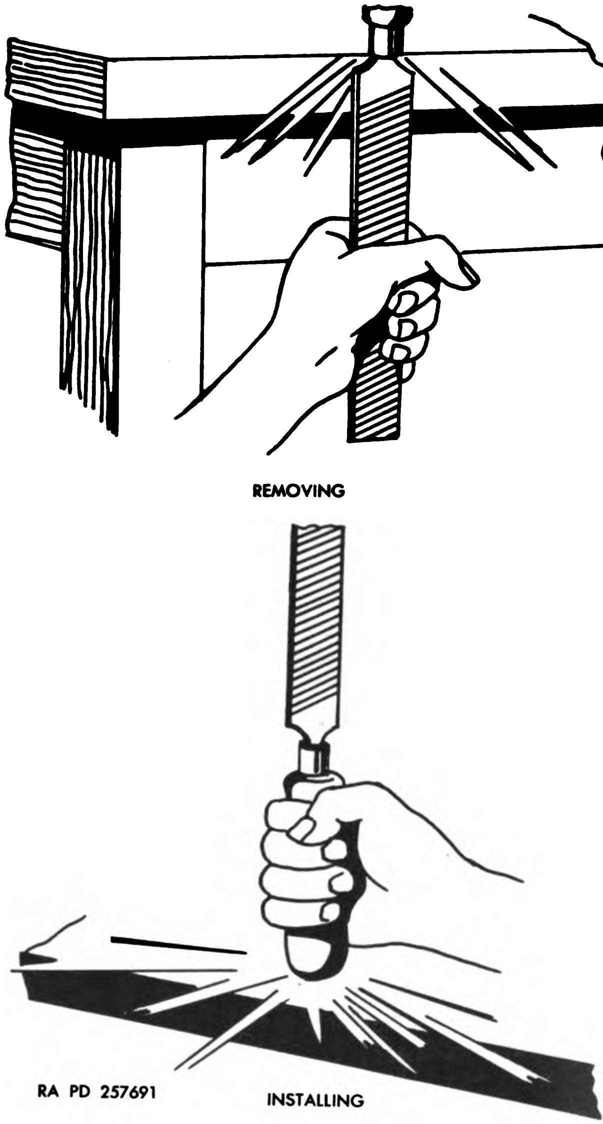


Figure 221. Replacing a file handle.

Section IV. KNIVES

182. Purpose of Knives

Most knives (fig. 222) are used to cut, pare, notch, and trim wood, leather, rubber, and other materials. Some knives used by glaziers are called putty knives; these are used to apply and spread putty when installing glass.

183. Types of Knives

a. Rubber Cutting Knives. Rubber cutting knives (fig. 222) are made in several shapes. Some are hollow ground with a 1 x 6-, 1 x 8-, or 1¼ x 10-inch blade. The handle is usually oval in shape. Some rubber cutting knives have a short wide blade, and some taper to a blunt rounded point.

b. Saddler's Knives. Saddler's knives (fig. 222) are available in three shapes; one having a broad point on a 1⅛ x 5-inch blade, one having a 5-inch round pointed blade, and one having a ⅝ x 3⅞-inch square point blade.

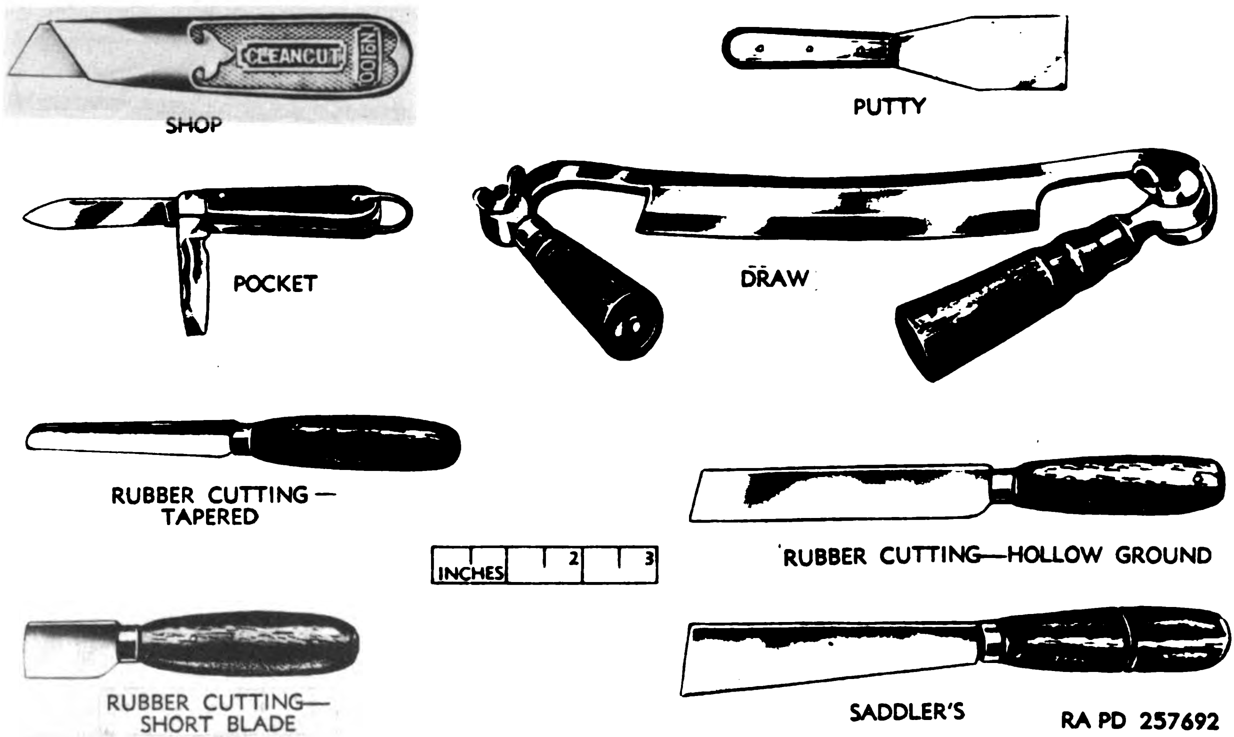


Figure 222. Types of knives.

Shoe knives are similar to the saddler's knives; they have ¾ x 3¼-inch blades.

c. Shop Knife. The shop knife (fig. 222) can be used to cut wall board, paper, cardboard, linoleum, canvas, and upholstery materials. It has an aluminum handle and is furnished with five interchangeable blades. The extra blades are stored in the 5-inch handle.

d. Pocket Knives. Pocket knives (fig. 222) are used for light cutting, sharpening pencils, cutting string, and light whittling. They are unsuited for heavy work. Multi-purpose knives have an assortment of blades designed for forcing holes, driving screws, and opening cans, as well as cutting. The blades are hinged and contained within the case when not in use and are spring loaded to keep them firmly in place when open or closed.

e. Drawknife. A drawknife (fig. 222) is a flat-edged tool used especially on round timber to rough-shape wood. It should be used to smooth wood after chopping with a hatchet or adze. It consists of a single bevel blade and two wooden handles, one at each end and at right angles to the blade.

f. Spoke Shave. A spoke shave (not illustrated) is used for the same purposes and like a drawknife and especially in shaping the wooden spokes of a wheel by hand. It provides a smoother finish. The spoke shave has an adjustable blade like a plane and can be adjusted for the thickness of the cut required.

g. Putty Knife. A putty knife (fig. 222) is used for applying putty to window sash in setting in panes of glass. The blade has a wide square point and is available in different lengths and widths.

184. Use and Care of Knives

a. Always cut away from the body, except when using the drawknife or spoke shave.

b. To use a drawknife, grasp both handles of the knife, holding the blade at a slight angle to the wood, and pull the knife towards the body. Always work with the grain of the wood. If the grain is irregular, change the direction of the stroke or the position of the work accordingly. Always clamp small work in a vise.

c. Do not use knives which are larger than can be handled safely to cut work. Use knives only for the purpose for which they were designed.

d. Do not carry open knives in your pocket.

e. Do not leave knives where they may come in contact with the body or in such a position that will cause injury to others.

f. Carefully put knives away after use, in a sheath or container, to protect the sharp cutting edges from contacting other hard objects.

g. Before storing, wipe all metal parts with an oily rag.

h. For long-term storage, apply a thin film of rust-preventive compound on all metal parts, cover cutting edge, and store in a dry place.

185. Maintenance of Knives

a. Sharpening.

(1) Most knives are generally sharpened on a medium or fine grade oilstone with a few drops of oil spread on the surface. Hold handle in one hand and place blade across stone. Press down with fingers of other hand and stroke blade following a circular motion as shown in figure 223. After several circular strokes, reverse blade and stroke opposite side, following in same type of motion. Avoid grinding the blade; use a light, even pressure. A thin blade overheats quickly and can lose its temper. The wire edge or bur that may be left on a knife blade after sharpening may be removed by stropping both sides on a soft wood block or a canvas or leather strap as described in paragraph 174*a*(1) (*i*).

(2) To sharpen a drawknife blade, place knife blade on stone and tilt it so that the bevel edge lies flat on the stone. Make certain the oilstone is high enough on the bench to provide clearance for the knife handles. Use both hands and, following a circular motion, rotate blade across stone so that the entire length of the bevel contacts the stone. Repeat sharpening on other side of blade. Wire edge can be removed by stropping both sides on a soft wood block or a canvas or leather strap as described in paragraph 174*a*(1) (*i*).

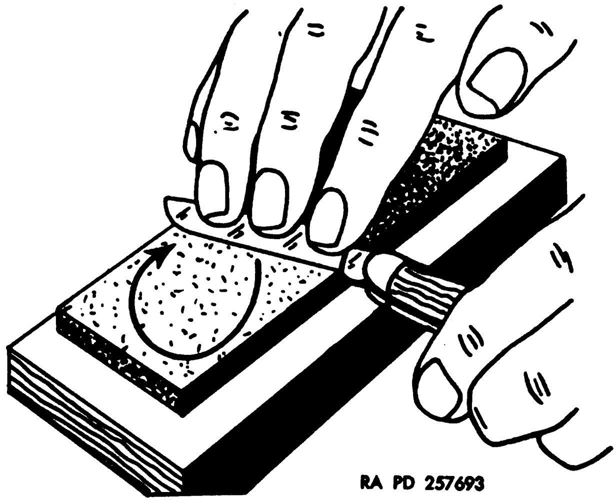


Figure 223. Sharpening a pocket knife.

b. Grinding.

(1) To reshape a broken blade or to remove nicks, grind knives on a grinding wheel or grindstone. Sharpen and hone on an oilstone after grinding. Dip blade in water frequently during grinding process.

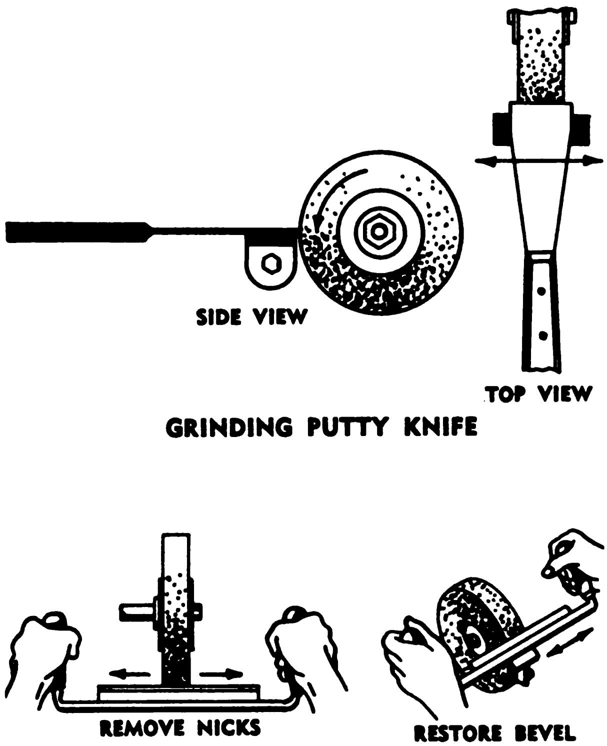


Figure 224. Grinding knives.

(2) A putty knife is ground at right angles against the edge of a grinding wheel to remove nicks and to square up a worn blade. Move blade from side to side while grinding (fig. 224). Do not remove any more metal than is necessary. Remove wire edge on an oilstone after grinding.

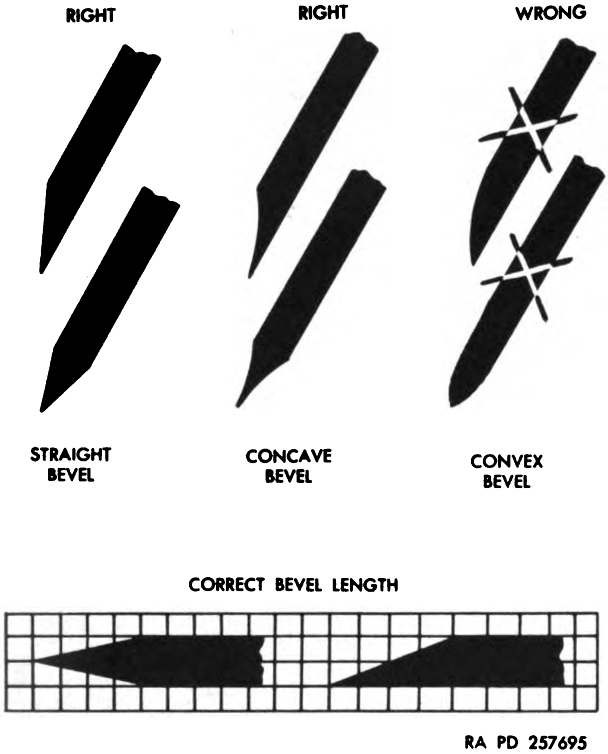


Figure 225. Drawknife bevel length and shape.

(3) The drawknife may be ground with a single or double bevel. The bevel must be restored to its original shape. Determine the original shape of the bevel by examing the unworn portions at the ends of the cutting edge. If the bevel cannot be determined by examination, make the bevel length approximately twice the thickness of the blade at the point where the bevel starts. Correct bevel length and shape for drawknives are shown in figure 225. The bevel must never be ground convex.

(*a*) Adjust grinder rest at midpoint of wheel so that the blade is at right angles against the edge of the wheel. Move blade back and forth across wheel until all nicks are removed (fig. 224).

(*b*) Adjust grinder rest toward top of wheel to provide desired bevel. Move blade back and forth across wheel until desired bevel is obtained by grinding. Dip blade in water frequently to preserve temper.

(*c*) If knife has a double bevel, turn blade over and grind second bevel.

(*d*) Sharpen blade on oilstone, as described in *a* (2) above.

(*e*) Remove wire edge by stropping as described in paragraph 174*a*(1) (*i*).

Section V. SCRAPERS

186. Purpose of Scrapers

Some scrapers (fig. 226) are used for trueing metal, wood, and plastic surfaces which have previously been machined or filed. Other scrapers are made to remove paint, stencil markings, and other coatings from various surfaces.

187. Types of Scrapers

Scrapers are made in several different shapes and for varied work.

a. Machinist's Flat Blade Scrapers. Machinist's flat blade scrapers (fig. 226) are used for removing high spots from flat surfaces only. Machinist's flat blade scrapers have a ⅝-inch flat blade.

b. Machinist's Triangular Blade Scrapers. Machinist's triangular blade scrapers (fig. 226) are used for removing high spots from flat or curved surfaces. They are issued in two sizes; with a blade 4 inches and 6 inches long.

c. Carbon Scraper. Carbon scrapers (fig. 226) are flexible and have an overall length of 9 inches. The carbon scraper consists of 10 spring steel blades whose flexibility is controlled by a sliding ferrule.

d. Bearing Scraper. Bearing scrapers (fig. 226) are used to scrape babbitt metal bearings

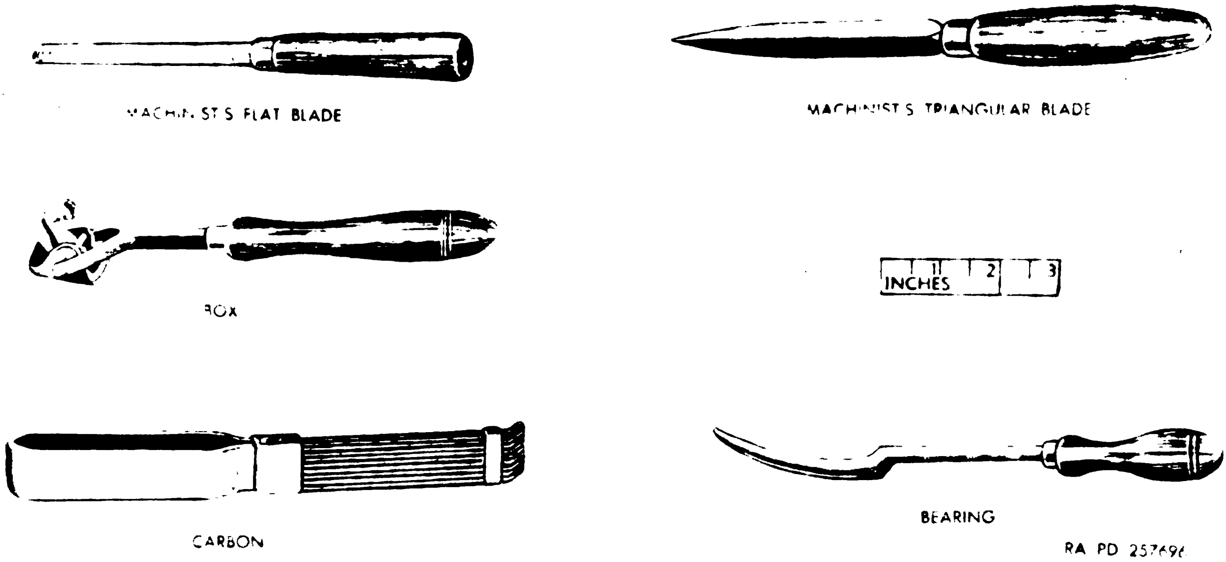


Figure 226. Types of scrapers.

that are used in many Army vehicles and equipment. Bearing scrapers are issued with a 1½-, 2-, and 4-inch cutting edge.

e. Box Scraper. A box scraper (fig. 226) is a wood scraper generally used to remove stencil markings from wood surfaces, and likewise as a common wood floor scraper. It has a 2-inch blade and a 9-inch hinged handle. The bottom of the scraper and the edge of the cutter are convex curved so that corners do not scratch up the work.

188. Use of Scrapers

a. Preparing Work Before Scraping.

(1) Do not attempt to scrape off three or four thousandths of an inch of metal that remains on work over a large surface.

(2) Surfaces that are to be made flat should be checked against a surface plate. A curved surface should be checked against its mating surface. Be sure that both the surface to be scraped and the reference surface are perfectly clean. Apply a very thin film of Prussian blue on the reference surface. To determine the high spots on the work, lightly rub the work against the blued reference surface. Remove work and examine for any blue spots. The Prussian blue transferred to the work will indicate where scraping is required. Scrape and rematch work to reference surface until the work surface is covered with uniform coating of blue.

(3) Visible burs should be removed by filing before the scraping process.

b. Using a Machinist's Flat Blade Scraper. Hold the scraper in the palm of one hand and steady it with the other hand as you push along the work (fig. 227). The scraper should be held at an angle of less than 90° to the work. The inclusive angle is varied, depending on the cut desired. The cutting action is accomplished on the forward stroke and the length of the stroke should not exceed 1 inch. Due to the slightly rounded corners of the blade, the scraper may be canted very little to the left or right without digging the corners into the work. When scraping extremely hard metal surfaces, apply turpentine to the scraper edge to aid in cutting.

c. Using a Machinist's Triangular Blade Scraper. In most instances, this scraper is held by the handle in one hand and the tip in the fingers of the other hand and drawn parallel across the work, as shown in figure 228. This scraper may also be held by the tip in one hand and used as shown in figure 229. Either the side or the tip can be used since the blade is tapered to a point. The three cutting edges of this scraper are a distinct advantage. When one edge becomes dull, the other edges may be used.

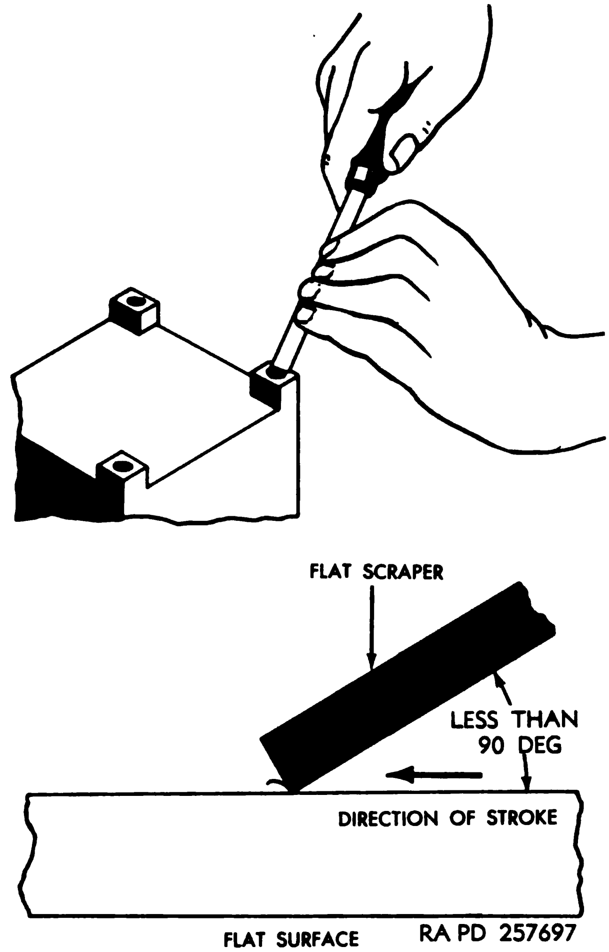


Figure 227. Using a machinist's flat blade scraper.

d. Using a Bearing Scraper. Hold the bearing scraper (fig. 226) with both hands, using the hand at the end of the handle to twist, while the other hand steadies the tool. Use a very light pressure and remove a small amount of metal with a twisting stroke. If too much pressure is applied, the scraper will chatter and leave a rough, uneven surface. When scraping a bearing, start at one top side of bearing cap; go down; and then up to the top of the other side. Do not scrape lengthwise.

e. Using a Carbon Scraper. The carbon scraper (fig. 226) is used to clean carbon deposits from cylinder heads, pistons, and other metal surfaces where carbon accumulates The blades are fairly dull to prevent scoring of a piston and cylinder wall. Slide the ferrule towards the cutting edges when removing heavy deposits and slide it back towards the handle for light scraping.

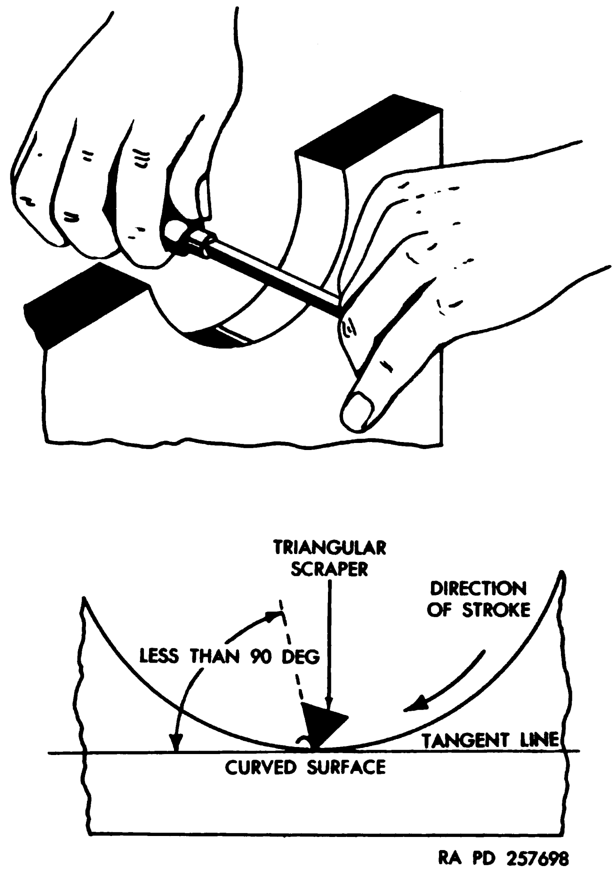


Figure 228. Using a machinist's triangular blade scraper.

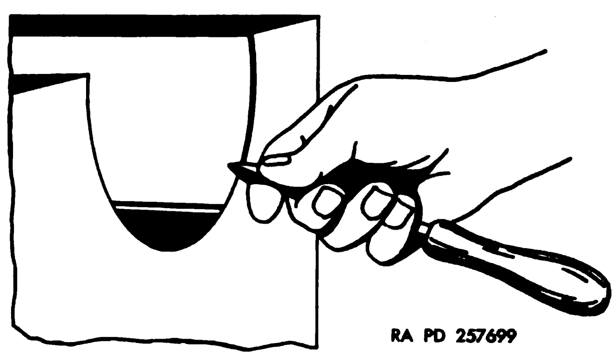


Figure 229. Using a triangular blade scraper tip.

f. Using a Box Scraper. The box scraper blade (fig. 226) can be adjusted by loosening the thumbscrew and extending or withdrawing the blade in its holder. The cutting edge of the blade may have a convex curved turned double edge or a turned single edge (fig. 231). Place the cutting edge on the surface to be scraped and pull on the handle.

189. Precautions

a. Keep work, scraper, and hands free from grease and oil, when using a scraper.

b. When scraping over a surface the second time, scrape at a different angle so that the markings are more easily distinguished.

c. Keep scrapers sharp at all times (except the carbon scraper) or they will cause an uneven surface, since increased pressure is required to make the scraper cut.

d. Use scrapers only for purposes for which they are intended.

190. Care of Scrapers

a. Sharpening.

(1) *Machinist's flat blade scraper.* The machinist's flat blade scraper is sharpened with a file and an oilstone. File the edge so that it is at right angles to the sides of the scraper and is slightly rounded at the corners. Rounding the corners prevents them from digging into the work surface and allows the tool to be canted from side to side. After filing, remove the burs or wire edge on an oilstone. Hone the sides of the scraper first; then the end, as shown in figure 230. Rock the scraper on the stone to hone the rounded corners of the end.

(2) *Machinist's triangular blade scraper.* If the machinist's triangular blade scraper becomes dull, use an oilstone to sharpen the edges. If grinding is necessary to remove nicks, or to sharpen edges after too much previous honing, grind the edges parallel from the heel to the center of the blade. From the center, the edges should taper down to a point. Be extremely careful when grinding the point to prevent loss of temper. Dip scraper in water frequently when grinding.

(3) *Bearing Scraper.* To sharpen a bearing scraper, use an oilstone with a rounded edge. Secure or hold the scraper on a bench and rub the rounded edge of the oilstone on the inside bevel of the hollow ground scraper blade. Rub stone back and forth several times. Use a piece of canvas or leather to remove wire edge after sharpening.

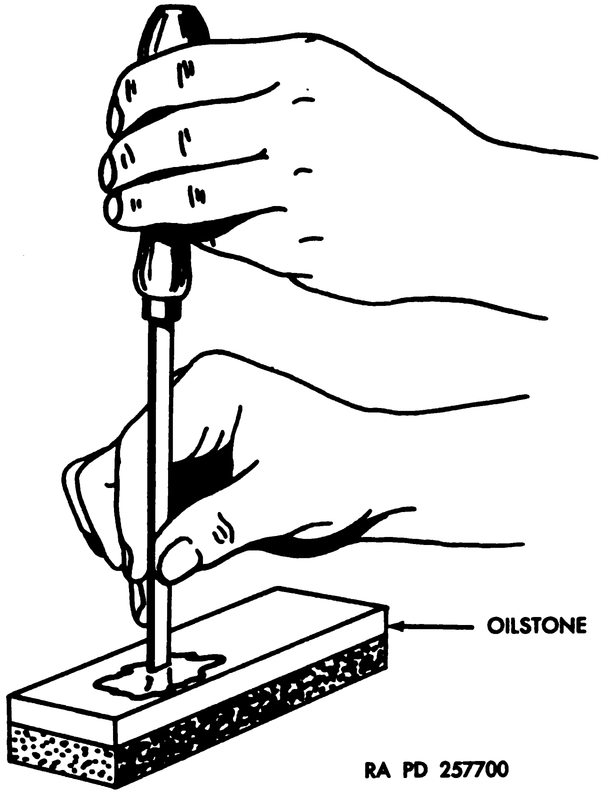


Figure 230. Sharpening the end of machinist's flat blade scraper.

(4) *Box scraper.* Two types of cutting edges are used with a box scraper, a square turned edge (double edge) and a bevel turned edge (single edge) (fig. 231). The edge of the blade is convex curved.

(*a*) *Square turned edge.* Adjust grinder rest so that the tip of the scraper blade is opposite the center of the abrasive wheel and can be ground square, as shown in figure 232. After grinding, clamp blade in a vise and smooth edge with a mill file, as shown. Make certain edge is filed flat and square with slides of blade. After filing, use a burnishing tool or a smooth piece of steel to form the square turned edge, as shown. Rub steel across edge of scraper blade, applying heavy hand pressure to form edge.

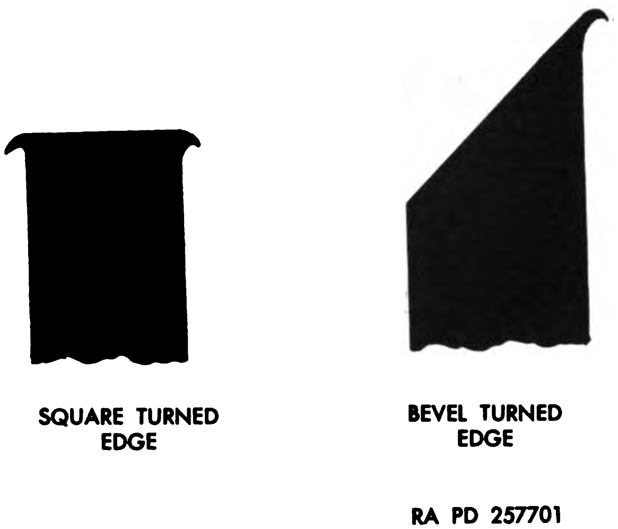


Figure 231. Square and bevel edges of box scrapers.

(*b*) *Bevel turned edge.* Adjust grinder rest so that the scraper will be at at a 45° angle during grinding. Hold scraper lightly against abrasive wheel and move it from side to side, as shown in figure 233. To obtain convex shape at corners, tilt blade when reaching the corners. Dip blade in water frequently to preserve temper. Do not grind away more metal than necessary. After grinding, sharpen edge on an oilstone by rubbing the blade in a figure-eight motion, as shown. Remove wire edge by rubbing flat side of the blade lightly over stone. Turn edge by clamping blade in a vise and rubbing edge with a burnishing tool or a piece of smooth steel, as shown in figure 233.

b. Storage. When not in use, coat scraper blade with a film of light oil. Do not throw scrapers in a pile of tools; hang or store separately to protect the cutting edges. For long periods of storage, coat all metal parts with rust-preventive compound and store in a dry place.

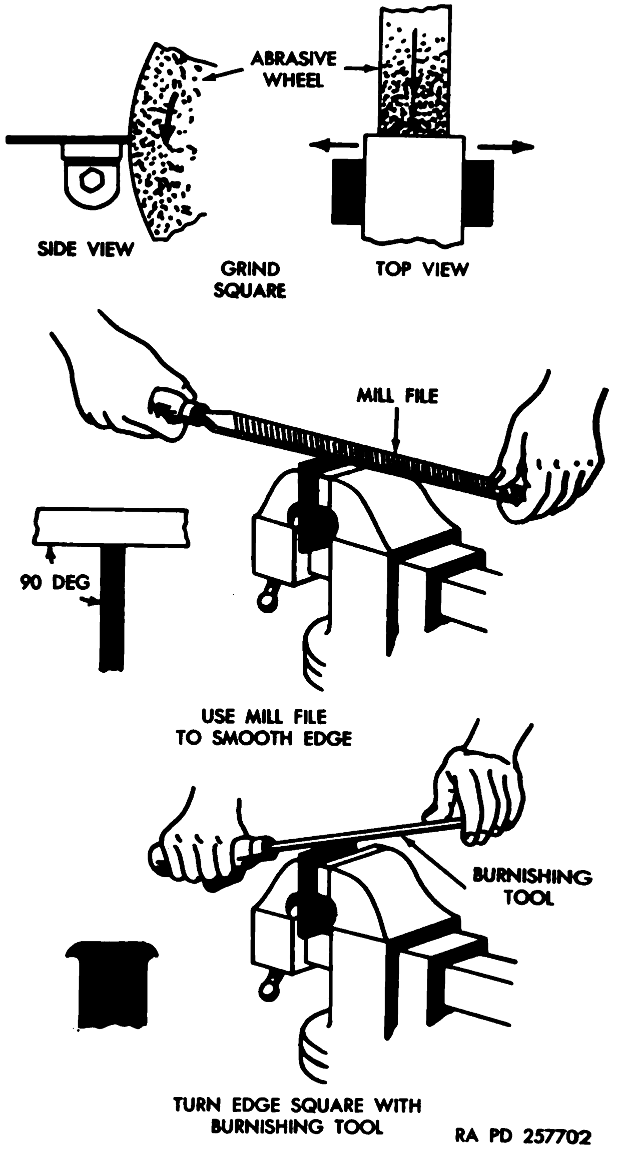


Figure 232. Restoring square turned edge on box scraper blade.

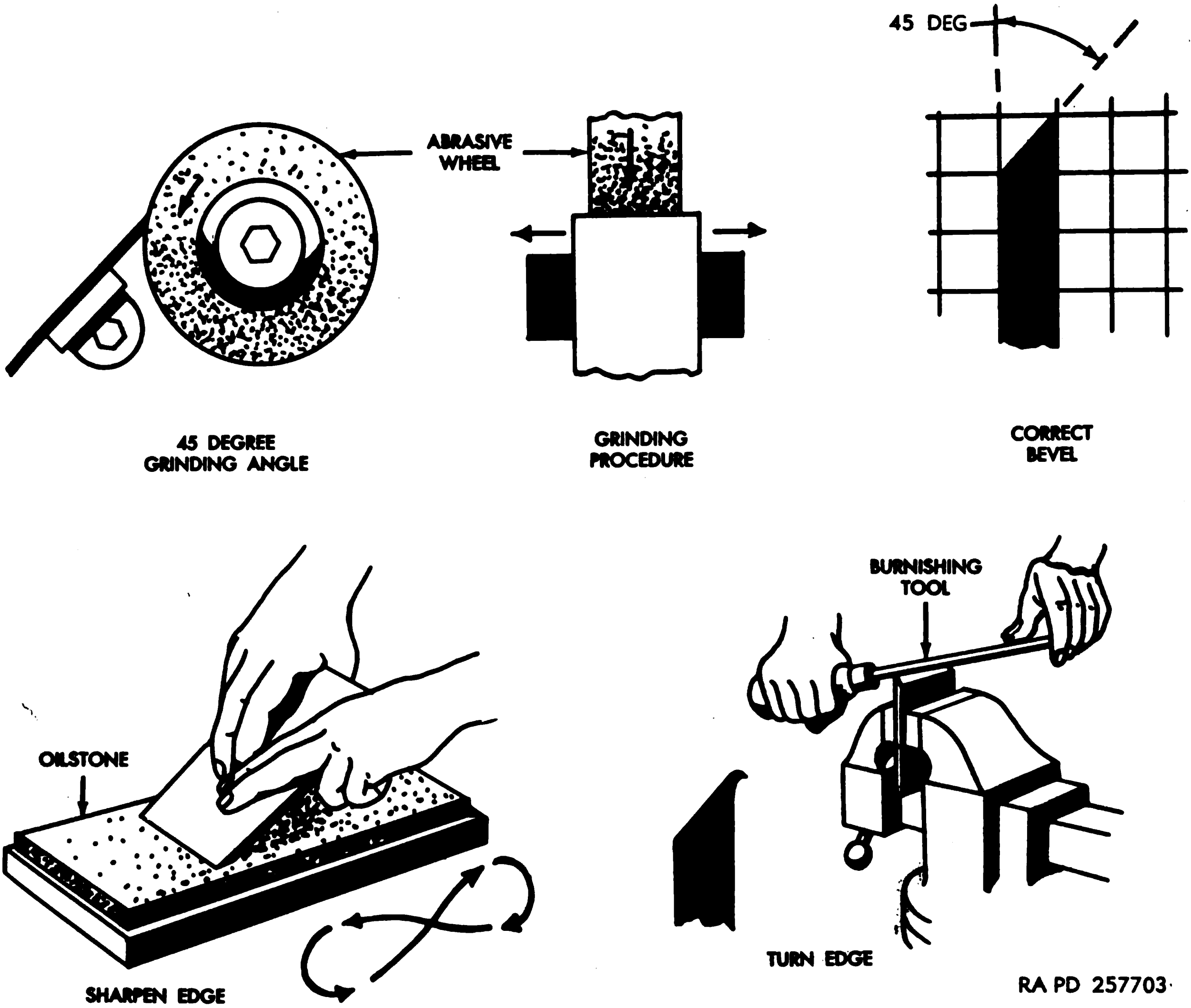


Figure 233. Restoring bevel turned edge on box scraper blade.

Section VI. PUNCHES

191. Purpose of Punches (figs. 234 and 235)

Punches are used to punch holes in metal, leather, paper, and other materials; mark metal, drive pins or rivets; to free frozen pins from their holes; and aline holes in different sections of metal. Special punches are designed to install grommets and snap fasteners. Bench mounted punching machines are used to punch holes in metal one at a time, or up to 12 holes simultaneously.

192. Types of Punches

The most common punches are the solid punches (fig. 234); they have various shaped points. Hollow punches (fig. 235) have a circular cutting edge and are sized according to their cutting diameter. Blacksmiths use solid punches that have handles. Special punches are made for snap fasteners.

a. Solid Punches. Solid punches (fig. 234) are made to mark materials, to drive out straight or tapered pins, to mark metal for starting holes to be drilled, to aline holes in different sections of metal, and to punch holes by hand in metal that is $1/32$ inch up to $1/8$ inch thick. Punching machines are capable of punching holes in metal that is from $1/16$ inch up to and including $1/4$ inch thick.

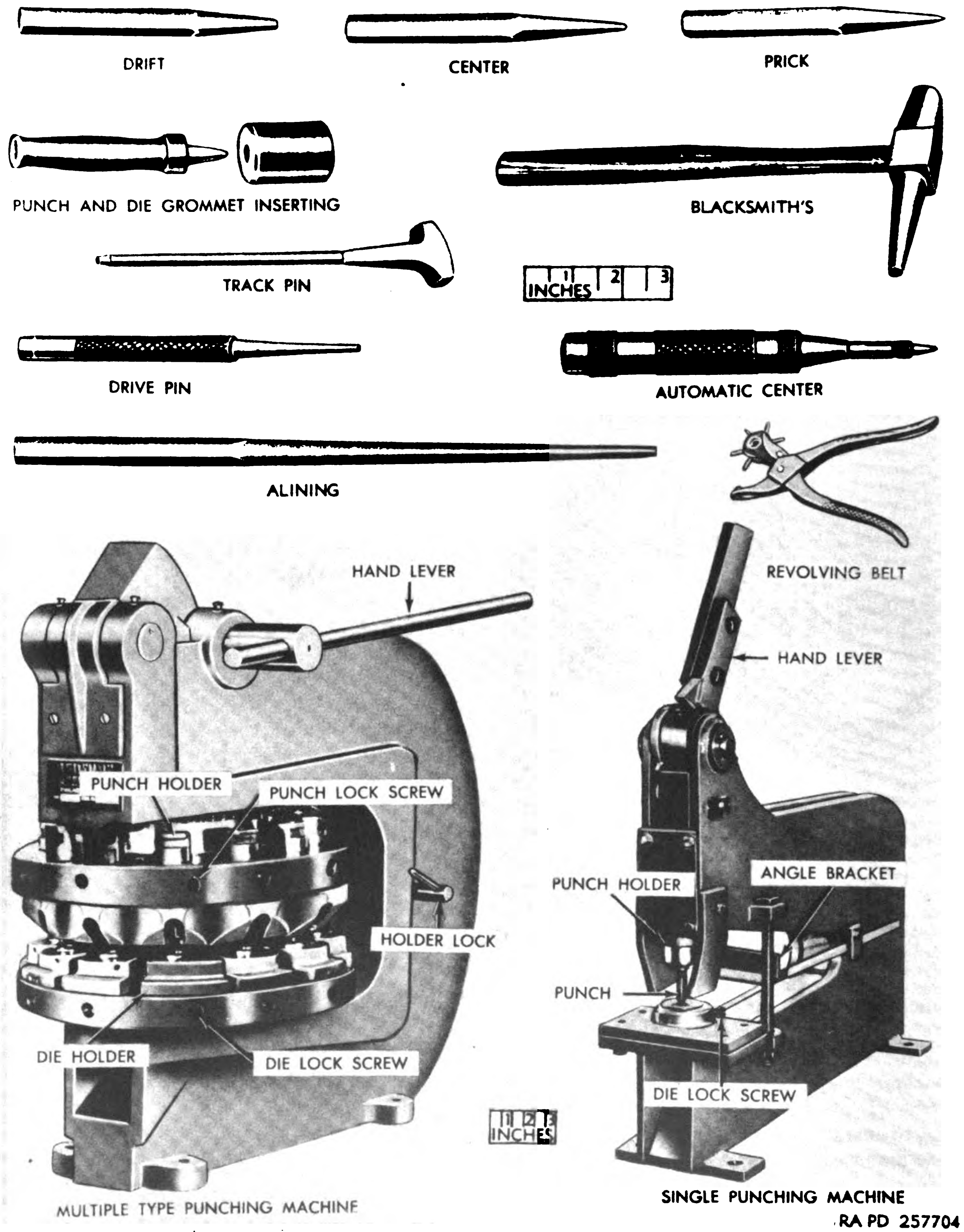


Figure 234. Solid punches and punching machines.

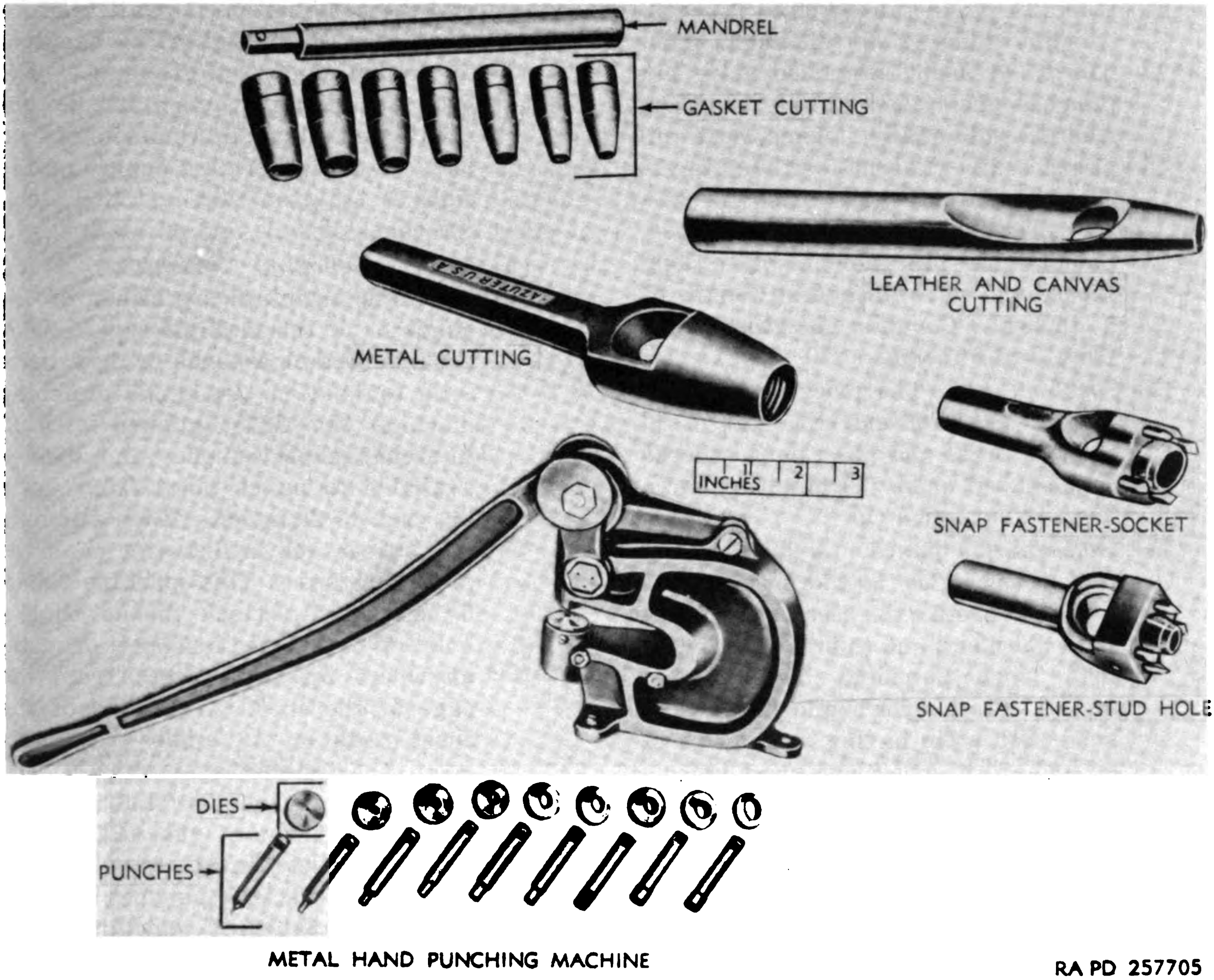


Figure 235. Hollow punches and punching machine.

(1) *Center punch.* A center punch (fig. 234) has a narrow cone-shaped point terminating in a sharp 90° conical tip. The stock of a center punch may be octagonal, round, or square in shape, with or without knurling. Center punches range in size from a ⅛-inch diameter stock to ⅝ inch and have a length of 3 to 6 inches. An automatic center punch (fig. 234) is also available. Where other center punches require a hammer blow by hand to mark metal, the automatic center punch contains a mechanism which automatically strikes a blow of the required force when the punch is in the exact position desired by the operator and is pushed forward by hand pressure. It has an adjustable cap for regulating the stroke and the point is removable for regrinding and replacement. Center punches are normally used for starting holes to be drilled.

(2) *Drift and alining punches.* Drift and alining punches (fig. 234) are normally tapered to a ⅛-, 3/16-, 7/32-, ¼-, 5/16-, ⅜-, or ½-inch points, and range in length from 7 to 15 inches. Drift and alining punches are used to line up holes in metal work.

(3) *Drive pin punch.* Drive pin punches (fig. 234) are used for driving out straight or tapered pins. The

standard drive pin punches taper to a point ranging in diameter from 0.03 to ½ inch. Standard drive pin punches are issued in sets of 9, as well as individually. Some drive pin punches are straight—without taper. The shanks may be knurled for better gripping, or hexagon shaped. Some drive pin punches have long tapers and have an overall length of 9 inches. Common lengths range from 3 to 6 inches.

(4) *Prick punch.* The prick punch (fig. 234) is used for marking soft metal such as brass and has a long tapered cone-shaped point terminating in a sharp 30° conical tip.

(5) *Blacksmith's punch.* A blacksmith's punch (fig. 234) is equipped with a handle to protect the user from contact with hot metal and to provide a better grip when punching holes in hot metal. Blacksmith's punches are issued with a tip having a diameter of ¼ inch up to and including 1 inch.

(6) *Track pin punch.* A track pin punch (fig. 234) is especially designed to drive out pins from railroad tracks. It has a ⅜-inch diameter point, is 8 inches long, and has a T-shaped head. The track pin punch is driven with a sledge hammer.

(7) *Revolving belt punch.* A revolving belt punch (fig. 234) is similar in shape to a pair of pliers. It has two handles that are pivoted together. One jaw of the punch consists of a pivoted wheel that has six tubes; each tube has a different diameter. The other jaw has an integral die that serves as the seat for a tube after the tube is squeezed through the stock. It is used for punching holes in a leather belt.

(8) *Grommet inserting punch and die.* A grommet inserting punch and die (fig. 234) consists of a solid steel punch that has a round tapered point and a flat shoulder. The second part is a round steel die having flat ends with a bored hole in one end to receive the point of the punch. The punch and die combination is available in 4 sizes (Nos. 1 through 4) to handle 4 different diameters of grommets. The grommet inserting punch and die are used to install metal grommets or eyelets in holes by forming flanges on the sides of the grommets installed along the edges of sails and on mailbags.

(9) *Metal punching machines.* Metal punching machines are either of the single or of the multiple type. They are mounted on a bench or on a more solid foundation. A single punching machine (fig. 234) supplied with 15 interchangeable punches and dies is available to punch holes from ⅛ to $\frac{9}{16}$ inch in diameter. Each punch is $\frac{1}{32}$ inch larger in diameter than the preceding size. This machine has a 6-inch throat, which means that a hole can be punched in a sheet of metal anywhere up to 6 inches from the edge of the sheet. The edge of the sheet rests on an angle bracket to keep the sheet level during the punching operation. A multiple-type punching machine (fig. 234) can punch 12 holes simultaneously. It is supplied with sets of punches and dies that are capable of punching holes from ⅛ inch to ¼-inch in diameter in $\frac{1}{16}$-inch thick metal, from ¼ inch to ½ inch in diameter in ⅛-inch thick metal, and ½ to 1¼-inch diameter holes in ¼-inch thick metal. A given size set consists of 12 sets of punches and dies of the same size. When in use, each punch is secured in a punch holder and each die is secured in a die holder. The hand lever is used to lower and raise the punch holder in punching holes. The metal hand punching machine shown in figure 235 has a short narrow throat and is supplied with 9 unches and dies capable of punching holes from ⅛ inch in diameter up to and including a ⅝-inch hole. Each punch is $\frac{1}{16}$ inch larger in diameter than the preceding size.

b. Hollow Punches. Hollow punches (fig. 235) are made to cut out gaskets, and to cut holes in leather, canvas, paper, and metal.

They are made to cut holes having diameters from ⅛ to 2½ inches, and are suitable to cut through work from 1/16 to ⅛ inch thick.

(1) *Gasket cutting punches.* Gasket cutting punches (fig. 235) are supplied in a set with one driving madrel and 7 punches, ¼- to ⅝-inch diameter cut. Each punch is 1/16 inch larger in diameter than the preceding size. Other gasket cutting punches are issued individually.

(2) *Leather and canvas cutting punches.* These punches have a double bow in their construction and range in size from a ⅜-inch diameter cut to 1¼ inches.

(3) *Paper hand punch.* A paper hand punch (not illustrated) that cuts ¼-inch holes in paper up to 3/16 inch thick is also issued by the supply system. This punch is 6½ inches long and has a 1 inch reach from the center of the die to the end of the throat.

(4) *Metal cutting punches.* Hollow metal cutting punches (fig. 235) are made in several styles. They are of a single bow or double bow construction. They range in size from a ¼-inch diameter cut to 1 inch and are used to punch holes in thin sheet metal.

c. Snap Fastener Punches. Snap fastener punches (fig. 235) are specially designed tools to install fasteners, eyelets and clinches and to cut holes for same in cloth, leather, and other soft materials. The snap fastener socket punch is used for punching holes for fastener sockets. The snap fastener stud hole punch is used to make holes for installing fastener studs and is made with or without points for punching various combination of prong holes.

193. Using Punches

a. Use a punch only for the purpose for which it is intended.

(1) Center punches are intended to start holes to be drilled with a twist drill.

(2) Prick punches are intended for marking locations on soft metal such as brass.

(3) Pin punches are intended to drive out straight or tapered pins.

(4) Blacksmith's punches are used to punch holes in hot metal.

b. Hold the punch lightly in the fingers of one hand approximately in the middle.

c. Locate end of punch at the point to be marked for a pin to be driven, or a hole to be cut, at an angle so that you can see the point. Straighten punch after locating, so that it is perpendicular to the work. Do not strike head of punch with a hammer until the punch is perpendicular.

d. When punching holes in metal, use a center or prick punch to mark the center. Scribe the desired circle with a pair of dividers. Select the proper size and type punch; locate punch on scribed circle and strike head with a heavy hammer until hole is cut. Use a solid punch and die in a punching machine for punching holes in metal up to ¼ inch thick. Use a hollow punch for holes in thin sheet metal and in soft material.

Note. Place a block of wood under the work before cutting out holes with a hollow punch to prevent damage to the edge of the punch after it finishes the cut.

e. When using blacksmith's punches, be sure the hot metal is securely held and cannot be knocked off the bench or anvil. Make certain the handle is tight.

f. Never use a punch that has a mushroomed head or whose point or cutting edge is dull.

g. To use the automatic center punch, turn cap down or clockwise for work requiring a heavy mark; for work requiring a light mark, turn cap up or counterclockwise. No hammer blow is needed. Place the punch in an upright position on the spot to be marked. A downward pressure releases the internal striking hammer and makes the impression without danger of possible injury to fingers if the hammer slides off the head of the punch. This punch is mostly used by toolmakers where more accurate and delicate work is required.

h. To use the revolving belt punch, hold the punch in one hand by the handles like a pair of pliers; position the leather belt over the die in the lower jaw with the other hand, after marking the spot to be punched. Then, using the thumb of the hand that is holding the punch, rotate the tube wheel until the desired size tube is opposite the die and likewise is directly over the marked spot on the belt. Squeeze the handles to punch the hole.

i. To use the metal punching machine, mount the machine securely onto a bench or on a more solid foundation. Select the proper size punch and die for the single punching machine and the proper size punches and dies for the multiple-type punching machine. Loosen the respective punch and die lock screws, insert punch in the upper or movable jaw and the die in the lower or stationary jaw (figs. 234 and 235). To install the 12 sets of punches and dies in the multiple punching machine, loosen the holder lock (fig. 234). This will free the punch and die holders so they can be rotated in a position to install the punches and dies. Each holder has 12 separate locking screws. After locking all punches and dies in their respective holders, place the metal on top of the dies. Rotate the punch holder until the punches are in line with the marked spots on the metal. Tighten the holder lock. Apply hand pressure on the hand lever to punch holes.

194. Care of Punches and Punching Machines

a. After using a punch or a punching machine, wipe it clean and apply a thin film of oil to prevent rusting. Carefully place punches and dies on a shelf, rack, or other suitable place to avoid damaging their cutting edges or the points of punches.

b. For long periods of storage, apply rust-preventive compound to all metal parts, protect points and cutting edges, and store carefully.

195. Grinding and Shaping

a. Drift, Drive Pin, and Blacksmith's Flat End Punches. Grind a drift, drive pin, or blacksmith's punch so that the end is perfectly flat and at right angles to the center line of the punch (fig. 236). Grind other flat end punches in a similar way.

(1) Adjust grinder rest so that the end of the punch is opposite the center of the abrasive wheel and can be ground square.

(2) Place punch on rest and feed end of punch into wheel. Rotate punch during grinding to obtain a flat surface.

(3) Dip punch in water frequently to preserve temper.

(4) Do not grind away more metal than is necessary to obtain a flat, nick-free end.

b. Cone Point Punches. Center and prick punches are ground to cone points. Correct point angle for center punches is 90°; point angle for prick punches is 30 degrees (fig. 237). These angles may be changed for special purposes.

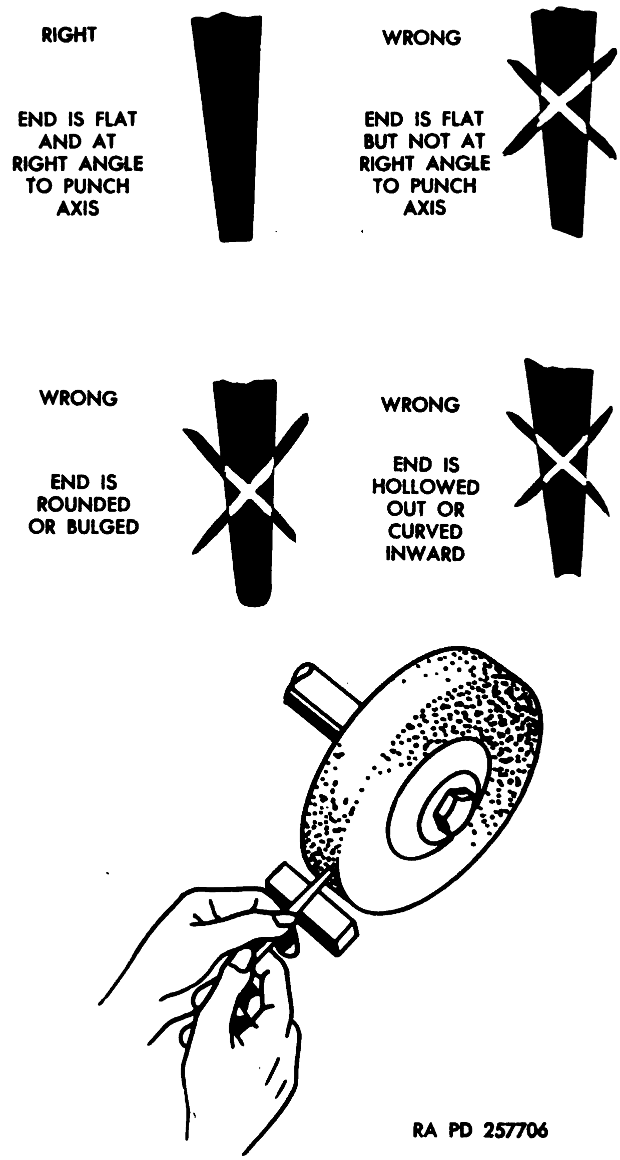


Figure 236. Grinding a flat end punch.

(1) Adjust grinder rest so that the end of the punch will be ground at the desired angle.

(2) Place punch on rest and place point on abrasive wheel. Rotate punch

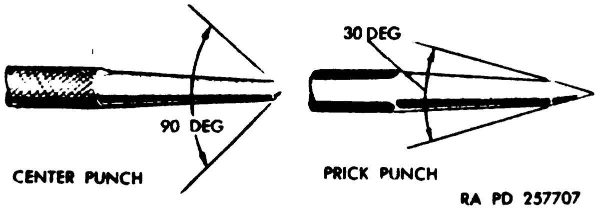


Figure 237. Cone point punch angles.

during grinding to obtain cone shape (fig. 238).

(3) Dip punch in water frequently to preserve temper.

(4) Do not grind away more metal than is necessary to obtain a sharp cone-shaped point.

c. Reshaping Mushroomed Head. If the head of a punch becomes mushroomed after extended use, grind to original shape on a grinder wheel. Restore temper after grinding.

d. Restoring Temper. If the point or the flat end of a punch is ground beyond the hardened section, if the mushroomed head was reshaped or if the punch was overheated in grinding, the punch must be hardened and tempered. Refer to paragraph 174*b*(2) for hardening and tempering procedure.

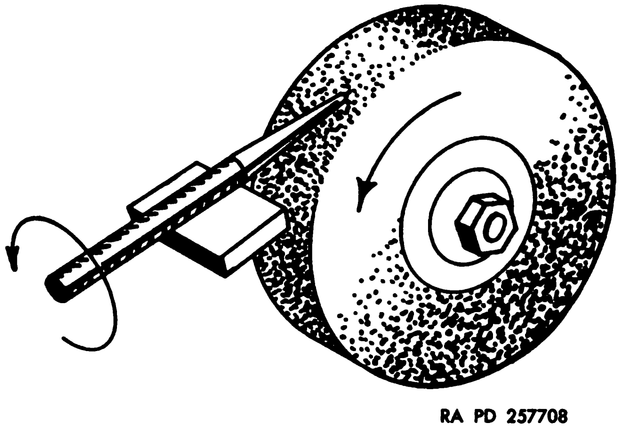


Figure 238. Grinding a cone point punch.

Section VII. AWLS

196. Purpose of Awls (fig. 239)

A saddler's awl is used for forcing holes in cloth or leather to make sewing easier. A scratch awl is used for making a center point or a small hole and for scribing lines on wood and plastics.

197. Types of Awls

a. Saddler's Awls. A saddler's sewing and stitching awl (fig. 239) has a curved blade that is 1⅝ inches long and a 2½-inch round wooden handle that is secured onto the blade by a ferrule. The blade can be replaced by loosening the collar with the wrench provided and inserting a new blade. Harness saddler's awls (not illustrated) are issued in 5 sizes, having a 1⅝-, 2-, 2¼-, 2½-, and 2¾-inch long blades. The pad saddler's awl (not illustrated) has a 4-inch blade.

b. Scratch Awls. The scratch awl (fig. 239) has a straight 3½-inch blade with a sharp cone-shaped point, a round-head wooden handle, and has an overall length of 6½ inches. The ferrule is secured onto the handle by a rivet, or by prick punching the ferrule.

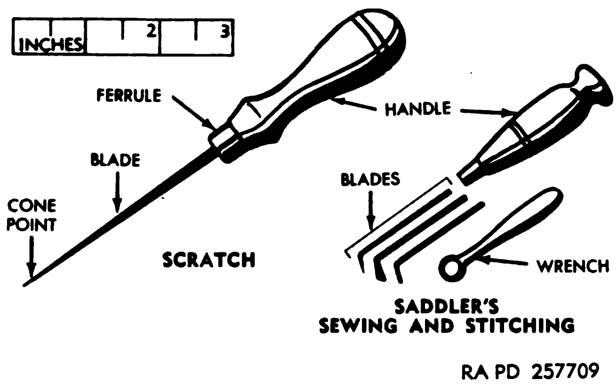


Figure 239. Types of awls.

198. Use of Awls

a. Awls are very sharp and should be used with extreme caution. Do not carry an awl in your pocket and do not place the awl on a bench or table where others may be hurt by its sharp point.

b. When using a saddler's awl, push the point through the fabric or leather in a direction away from you. Saddler's awls can be used with hand pressure or tapped lightly with a mallet or a hammer to force a hole.

c. The scratch awl is used with hand

pressure only and is rotated at the spot where a center mark or hole is to be made. Hold the awl as you would a screwdriver when locating a center. Hold it like a pencil when scribing lines on wood or plastics.

199. Care of Awls

When not in use, protect the point against damage and from injuring others by keeping it in a sheath or by hanging the awl on a rack, or place a cork on the point when stored in a tool box. Wipe metal parts of awls with a light oil for short-term storage. For long periods of storage, apply a rust-preventive compound to all metal parts and store in a dry place.

200. Reconditioning Awls

a. To regrind an awl with a cone point, use same procedure as that for grinding cone pointed prick punches (par 195*b*).

b. To grind a flat pointed or special shaped awl blade, hold the blade against the grinder abrasive wheel (fig. 240) in a position to preserve or restore the original shape.

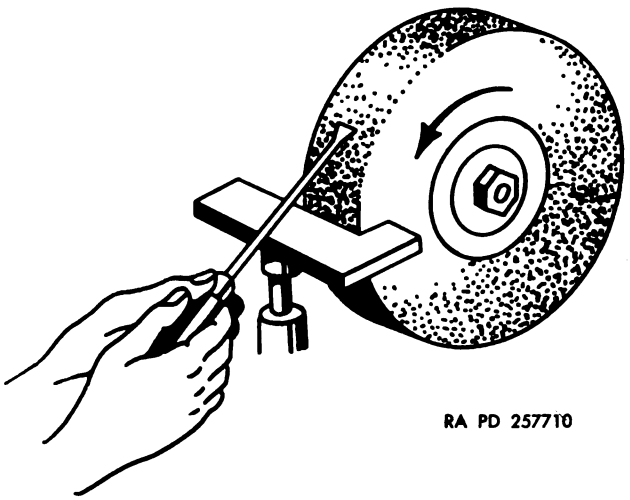


Figure 240. Grinding a flat pointed awl.

c. A cone pointed awl that has been ground properly should be sharpened by stroking it on an oilstone. Rotate awl slightly before each stroke (fig. 241). Flat pointed awls are stroked on the oilstone the same as a woodworker's chisel (par. 174*a*(1)).

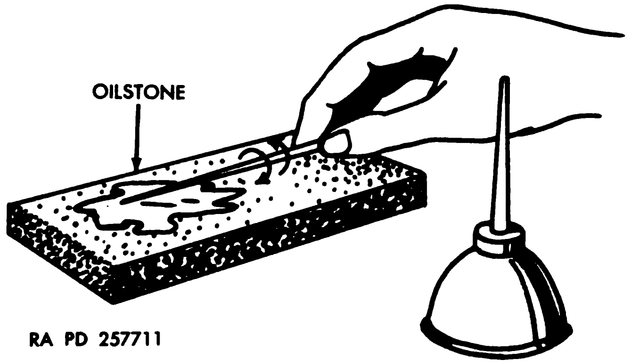


Figure 241. Sharpening cone pointed awl.

d. If the temper is lost when grinding an awl, remove the blade from the handle and retemper it as you would a machinist's chisel (par. 174*b*(2)), except that the awl should be quenched when a light straw color appears at the sharp point and the head or butt end should not be tempered or hardened.

e. When a handle has been broken or damaged so as to require replacement, place the awl blade in a soft-jawed vise and pull or tap the handle off the shank of the blade. Pry the ferrule from the handle. If ferrule is not damaged, press or tap it on a new handle with a soft-faced mallet and prick punch ferrule to handle, as shown in figure 242. If ferrule is damaged, use a new one. Position new handle on shank end of blade and press or tap handle onto blade. Remove awl from vise.

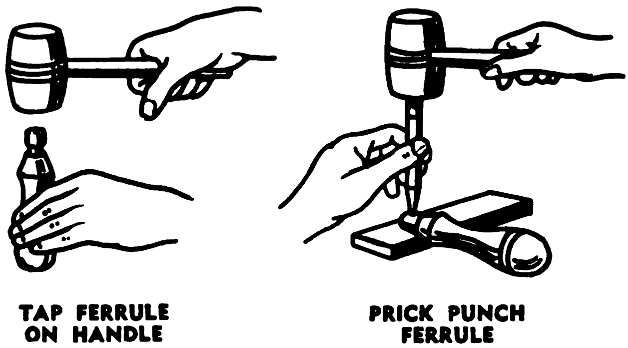


Figure 242. Installing ferrule on awl handle.

Section VIII. SHEARS, NIPPERS, AND PINCERS

201. Purpose of Shears, Nippers, and Pincers
(figs. 243, 244, and 245)

Shears are used for cutting sheet metal and steel of various thicknesses and shapes. Nippers are used to cut metal off flush with a surface, and likewise to cut wire, light metal bars, bolts, and nails. Pincers are used to pull out nails, bolts, and pins.

202. Types of Shears

Shears are made in a variety of shapes and sizes and are used according to their design and capacity.

a. Hand Shears. Hand shears (fig. 243) are made with straight or curved cutting blades. Straight bladed shears are used for cutting straight lines and also to cut curves in locations that are easily accessible. Shears with curved blades, such as the hawk bill and the curved blade hand shears, are made especially for cutting short straight lines or curves and for cutting out small intricate designs in locations where it is advantageous to keep the handles and handle-operating hand away from the the metal stock. Shears are made for right-hand operators so the cutline is always in full view for accurate cutting when the shears are held in the right hand and a cut is made.

b. Bench Shears. A tinner's bench shear (fig. 244) is larger than a hand shear and is used for cutting heavy sheet metal. The lower handle has a hook which can be placed in a hole in the bench so that the operator will have a free hand to guide the work. This bench shear makes a 6–inch cut and is 37 inches long.

c. Metal Slitting Machine. The metal slitting machine (fig. 244) is bench mounted and is used to make straight, circular, or intricate curved cuts in sheet metal. It has a capacity of handling up to 10–gage metal only.

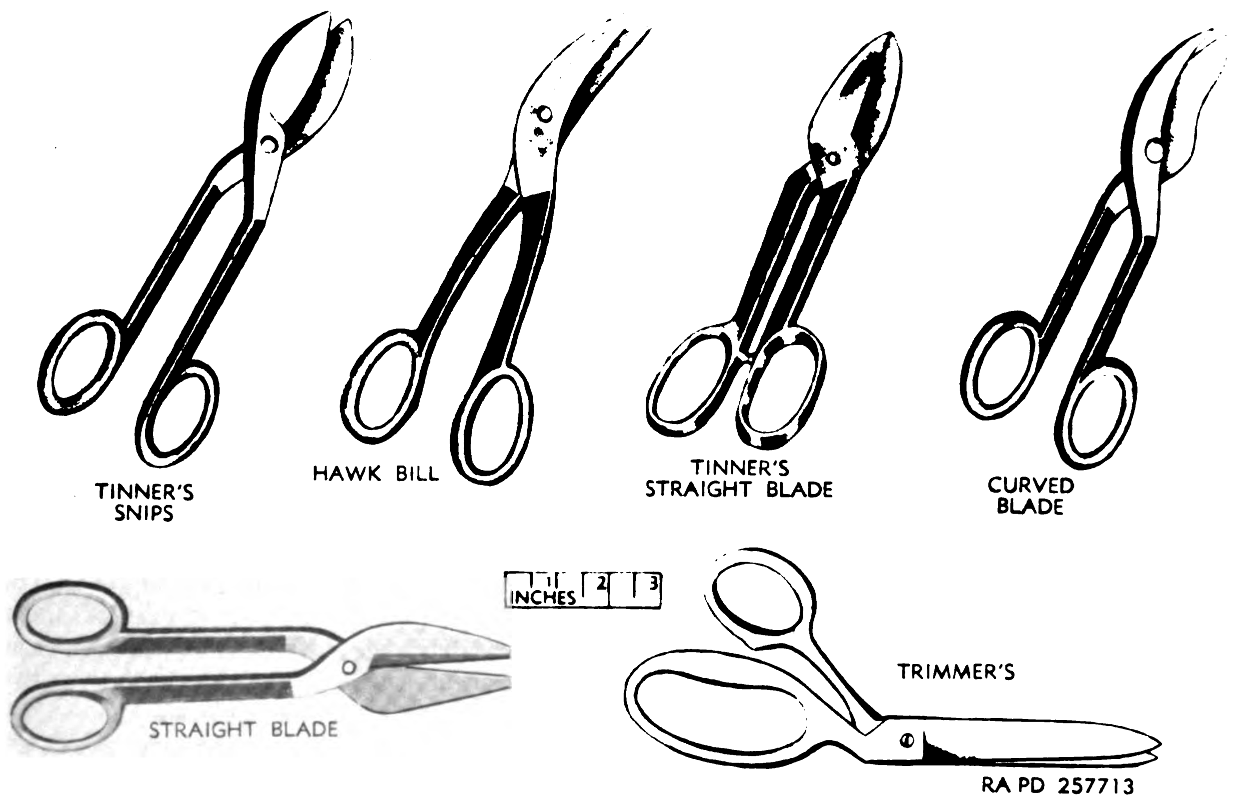


Figure 243. Hand shears.

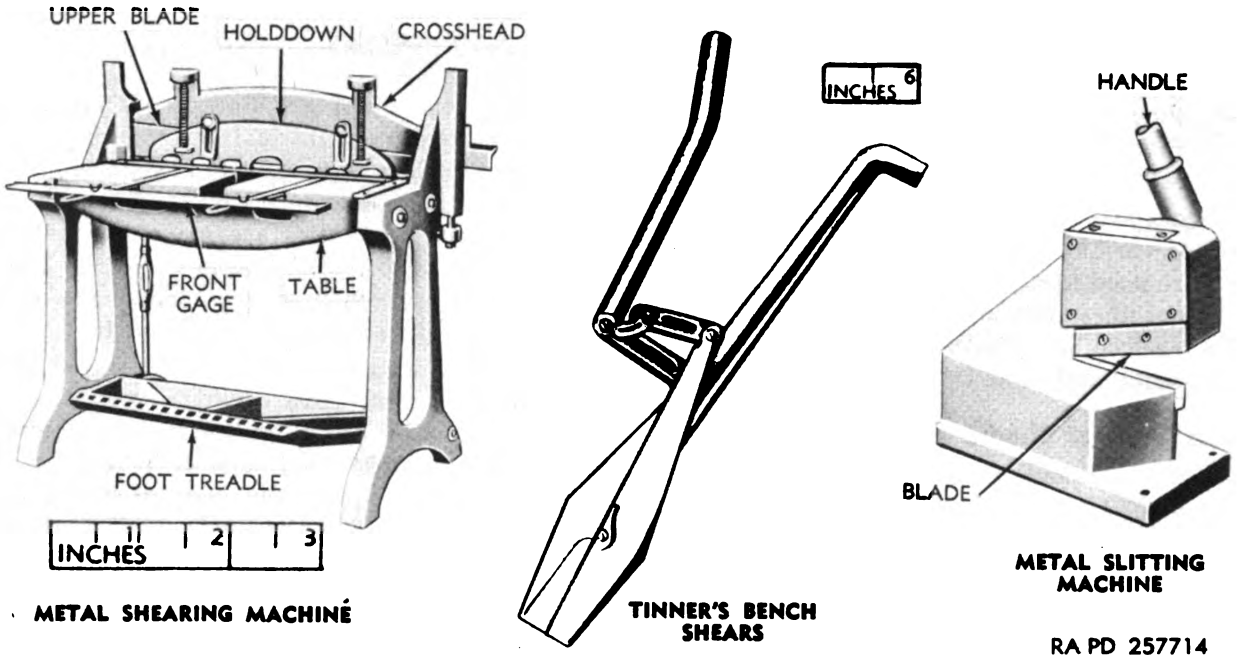


Figure 244. Bench shears and shearing machines.

d. Metal Shearing Machine. The metal shearing machine (fig. 244) is foot operated and is used to cut original sheets into right angle usable size stock. The shear blade is 36 inches long and will cut all sheet metal up to and including 1/16 inch of mild steel or 1/8 inch of iron.

203. Types of Nippers and Pincers

a. Cutting Nippers. Cutting nippers (fig. 245) are available with integral or detachable cutters. The farrier's nippers have integral cutters and are 15 inches long. Some nippers have an adjusting screw stop in the handle and have detachable jaws. Compound leverage nippers, with detachable jaws are available. Three extra pairs of jaws are supplied with these nippers. Cutting nippers range in size from 5½ to 15 inches in length. Their jaw widths range up to 1¾ inches.

b. Pincers. Pincers (fig. 245) look like nippers and are used for pulling and removing parts of work. Carpenter's pincers have the ends of the handles shaped to serve different purposes. One end has a claw for removing small nails or tacks and the other end is shaped like a screwdriver blade.

204. Use of Shears

a. Hand Shears. Hand shears are used for light work.

(1) *Straight cuts.* To make straight cuts, place the sheet metal on a bench with the marked guideline over the edge of the bench and hold the sheet down with one hand. Hold the shears so that the flat sides of the blades are at right angles to the surface of the work. If the blades are not at right angles to the surface of the work, the edges of the cut will be slightly bent and burred. The bench edge will also act as a guide when cutting with the shears. The shears will force the scrap metal down so that it does not interfere with cutting. Any of the hand shears may be used for straight cuts. When notches are too narrow to be cut out with a pair of shears, make the side cuts with the shears and cut the base of the notch with a machinist's cold chisel.

Note. When cutting, the sheet metal should be between the blades as far back as it will go and the upper blade must be exactly on the guideline.

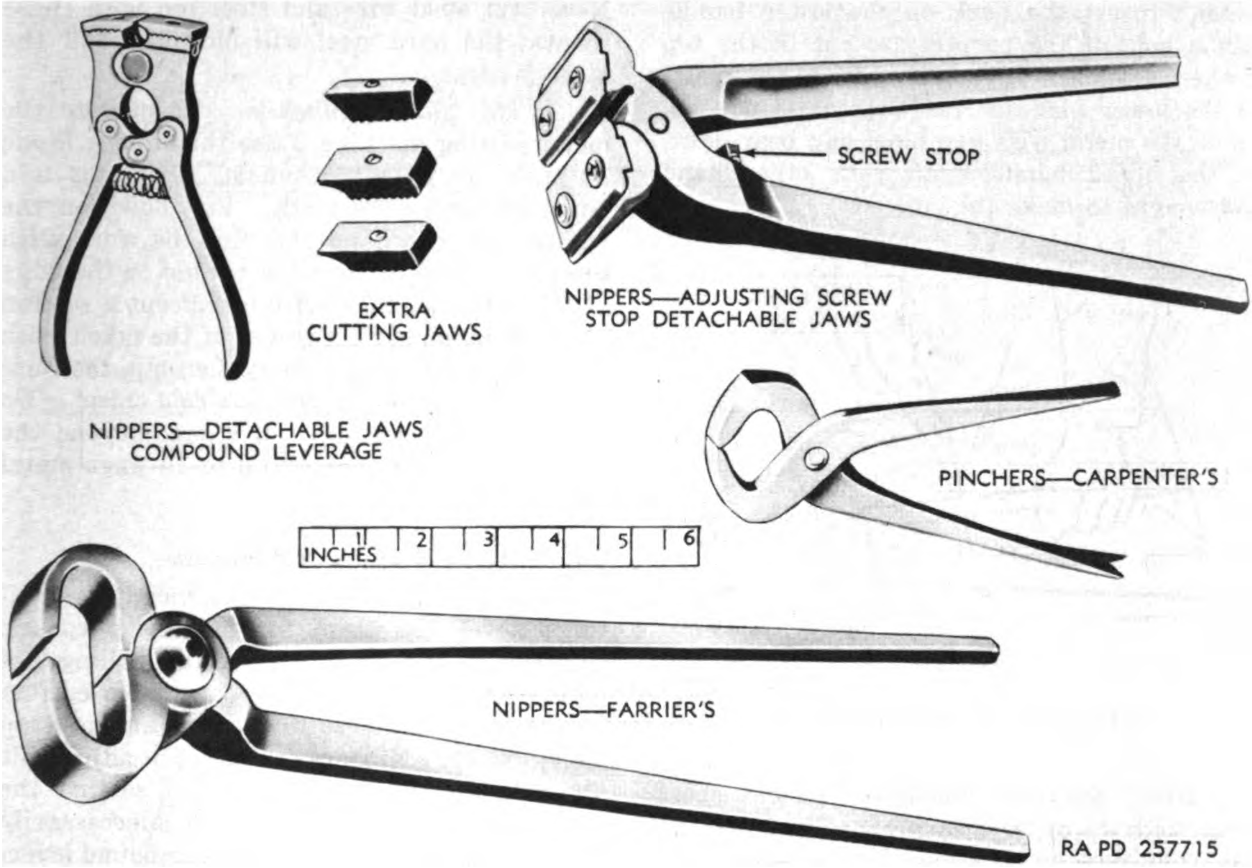


Figure 245. Nippers and pincers.

(2) *Curved cuts.* When cutting curves, the cut should be continuous. Stopping and starting at different points on a line results in rough edges and sharp slivers of metal, which will cause an injury to the fingers. Curved blade and hawk bill shears are generally used for cutting out small, intricate designs, including curves. The offset handles of these shears are convenient to use in tight places. When cutting shapes from sheet metal with straight shears, it is important to make the cuts in the right direction. Figure 246 indicates the starting point by an X and the arrows shows the direction in which the cuts should be made for various shapes. When a hole or opening is to be cut in sheet metal with a pair of shears, lay the metal on a lead or hardwood block. Use a hollow punch or small cold chisel and punch a hole large enough so that the point of the curved blade or hawk bill shears can be inserted. Complete the cut with the points of the curved shears.

b. Tinner's Bench Shears. The tinner's bench shears are used for cutting heavy gage

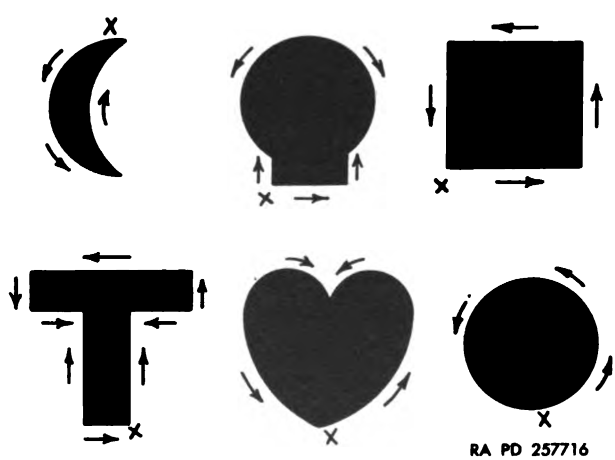


Figure 246. Direction of cutting shapes with shears.

metal. Insert the hook on the lower handle into a hole of the proper size cut in the top of the workbench (fig. 247). Place the metal on the lower blade as far back as it will go. Guide the metal with one hand and bear down on the upper handle with your other hand and weight to make the cut.

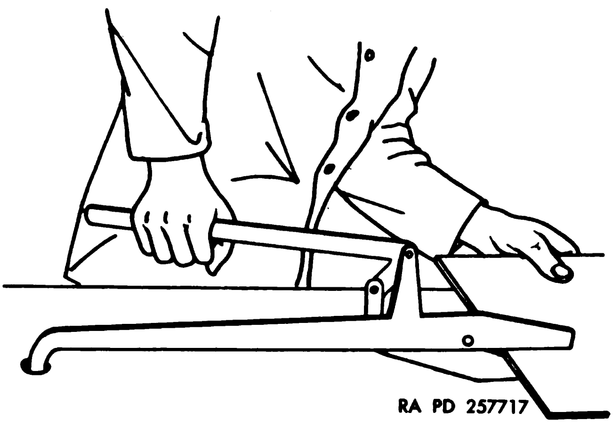


Figure 247. Using bench shears.

c. Metal Shearing Machine. To cut sheet metal with the metal shearing machine, first set the front gage or back gage by measuring the required distance from the face of the gage to the edge of the bottom blade (fig. 248). Tighten the gage clamping knobs. Measuring the gage position will result in more accurate work than the use of the graduated scale on the table bed. Insert the sheet under the cutting blade from the front (foot treadle side), push the sheet against the set gage, and hold the sheet in position. Keep hands and other parts of the body clear of the cutting blades. Operate the cutter by stepping on the foot treadle. When cutting long sheets, set the front gage and have a helper insert the sheet from the rear, as shown in figure 248. Support long sheets near the cutting line by a table or other similar means of support. The holddown on the machine operates with the stroke of the upper blade. Before the upper blade touches the metal, the holddown presses down on the sheet. If the holddown is not used or is not operating correctly, the metal will bind on the shears and cause an inaccurate cut. Never use shears on metals of a gage heavier than their rated capacity. Cutting heavier metals will dull or bend the upper blade beyond repair. Never cut steel wire and steel rod with these shears; the hard steel will nick and dull the cutting edges.

d. Metal Slitting Machine. To operate the metal slitting machine, raise the cutting blade by pushing up on the handle. Place the laid out work under the blade. Pull down on the handle with one hand and turn the work with the other hand to keep the cutline at the edge of the machine. To notch or cut out a section of sheet metal, cut both sides of the notch with the metal slitting machine; then cut the base of the notch with a machinist's cold chisel. Do not attempt to cut metal of a gage beyond the capacity of the machine (up to 10–gage metal only).

205. Use of Nippers and Pincers

Nippers and pincers are used mostly for cutting; never use them for holding purposes. Carpenter's pincers are used for pulling out nails. Large nippers with detachable cutters and the fulcrum close to the jaw are used on heavy work. Nippers having an adjustable screw in the handle should be set so that the cutting edges will not be forced unnecessarily to press together. The 7–inch compound leverage nipper has a flat spring below the cutting edges and over the joint which forms a yielding seat for the end of the wire to press against while being cut. Jaws made to cut music wire have their cutting edges ground to a short, steep bevel, while those for common use have their cutting edges ground more acute.

206. Care of Shears, Nippers, and Pincers

a. Care and Cleaning. Keep tools clean at all times. Lubricate pivot screw or bolt with a drop of light oil. Remove rust with a fine aluminum oxide abrasive cloth. Apply a thin film of oil on tools to prevent rust and hang tools on hooks or place them on a shelf when not in use. Never throw tools in a box where the cutting edges may be damaged. Never use the shearing machine table as a storage place for other tools and work. Do not attempt to cut material heavier than the tools or machines are designed to handle. Never use shears or nippers as a hammer, or as a pry bar, since they are easily damaged. The carpenter's pincers are the only tool that can be used as a nail puller and screwdriver if necessary. For

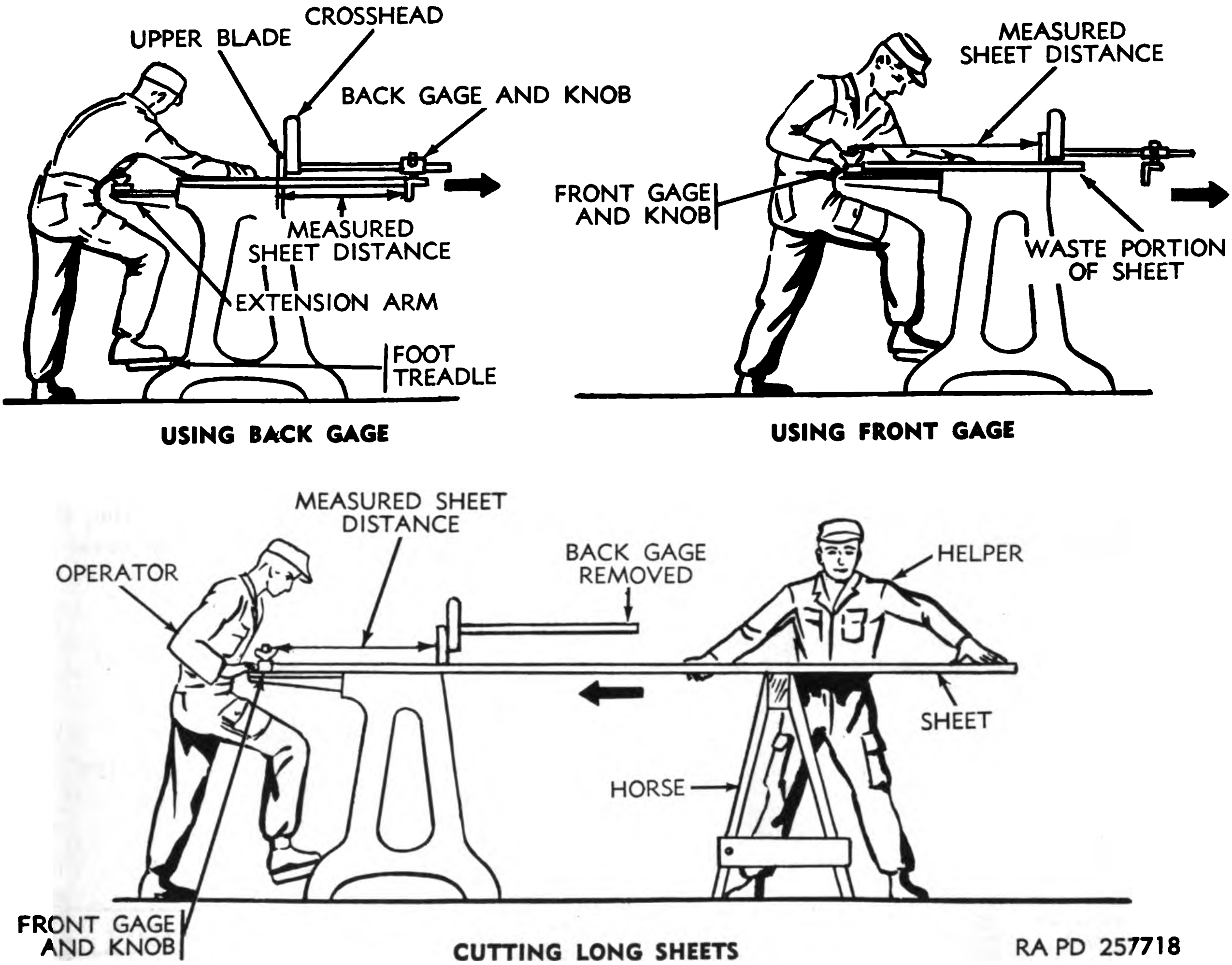


Figure 248. Using metal shearing machine.

long periods of storage, coat tools with a rust-preventive compound and store them in a dry place where the cutting edges do not come in contact with other metal objects.

b. Sharpening. Dull shears can usually be sharpened on an oilstone or with a file, without grinding. Never grind shears if sharpening will suffice, since most shears become useless after two or three grindings. To sharpen with a file, clamp shears in a vise and use a flat file, as shown in figure 249. The flat file is used on beveled edges only—not flat faces or the sharp edges. Stroke across the beveled edge away from you. Use the full length of the file in a diagonal stroke along the entire cutting edge of the blade. Stroke smoothly from heel to tip. Never file the flat face of any tool. To remove wire edge (bur), place blade on lightly oiled stone so that the flat face is on the stone with the blade crossing the stone at right angles. Draw the blade across the stone from heel to tip. Start each stroke at the heel of the blade. Repeat process to sharpen other blades.

c. Grinding.

(1) *Shears.* If the blades of shears are nicked, damaged, or if the bevel is distorted from improper sharpening or prolonged use, it is necessary to grind them. A single bevel is used; it may be flat or concave, but never convex (fig. 250). The bevel angle varies with the type of work for which the shears are used. The bevel usually makes an angle of from 60 to 85° with the flat inside face of the blade. Paper and cloth cutting shear bevels are ground to a bevel of approximately

60°. Metal cutting shears are ground to a bevel of approximately 85° Usually the bevel angle can be determined by examining an undamaged portion of the blade, but if the bevel has been distorted for its entire length, an undamaged pair of shears of a similar type should be examined to find the correct bevel. The correct bevel angle could be likewise determined by using the above figures, if it is known specifically what materials will be cut by the shears. When grinding, use a fine grain abrasive wheel properly dressed. Adjust the grinder rest to a position that will give the correct bevel. Place the shear blade on the rest with the bevel side

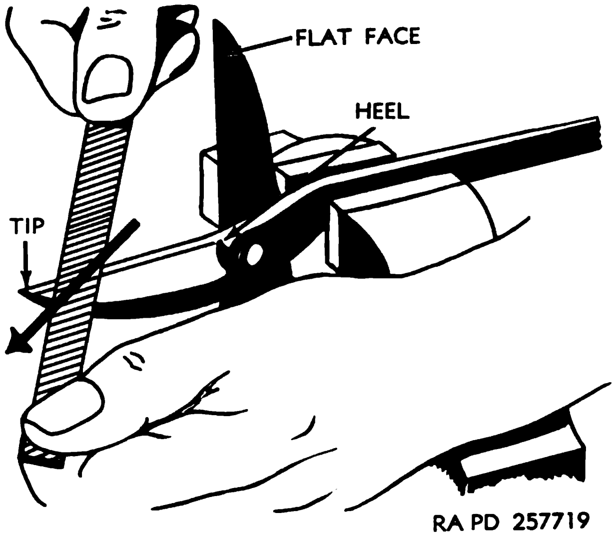


Figure 249. Sharpening beveled edge shears.

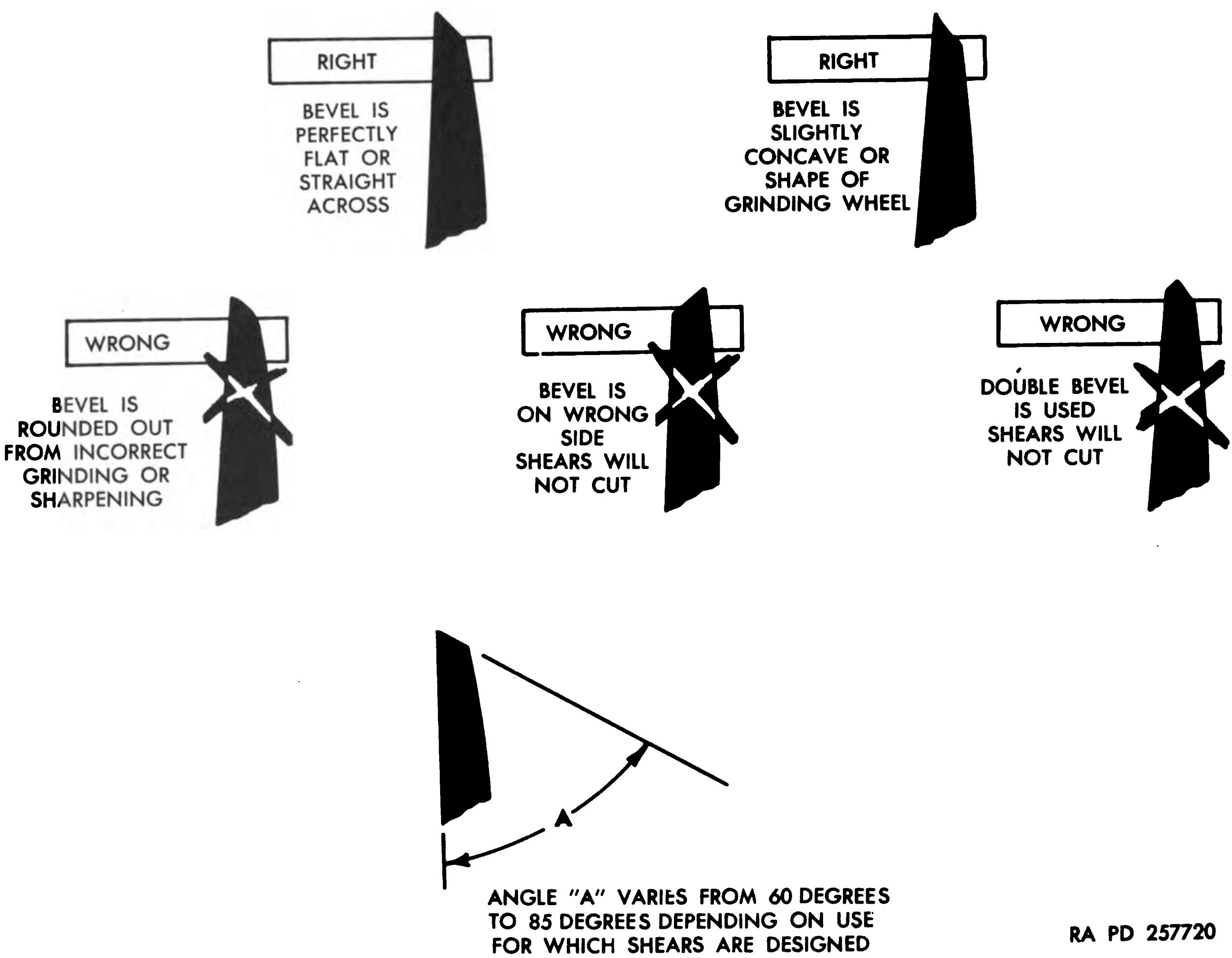


Figure 250. Grinding angles for shears.

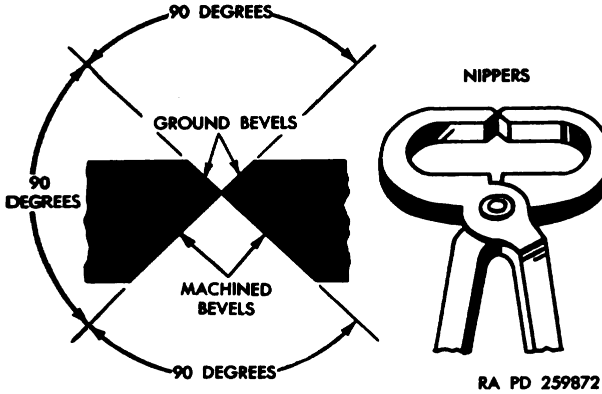


Figure 251. Grinding angles for nippers and pincers.

down and move the blade into contact with the turning wheel. Move the blade from side to side during grinding to insure a straight cutting edge. Dip blade in water frequently when grinding to preserve temper. Remove wire edge on oilstone, as discussed in *b* above.

(2) *Nippers and pincers.* When the cutting edges of nippers and pincers become dulled or nicked, they must be ground to the proper bevels on a grinding wheel or grindstone. If the jaws do not open wide enough to permit grinding, the pin or bolt holding the handles together must be removed. The bevel is ground at a 90° angle to the machined bevel, as shown in figure 251. The grinder rest is adjusted so that the proper bevel is obtained. Use the same precautions to preserve the temper as when grinding shears ((1) above). The bevels on each pair of cutting jaws used with the compound leverage detachable jaw nippers (fig. 245) vary with their use.

207. Precautions

a. Keep fingers away from the cutting edges of all hand tools in general, and keep hands and other parts of the body clear of the cutting edges of bench shears, the shearing machine, hand shears, and nippers.

b. Do not carry shears, nippers, or pincers in your pocket and do not wave them around.

c. After use, be sure to hang them or store them so that they will not cut anyone coming in contact with them.

d. Always steady the work that is about to be cut to prevent the tool from slipping.

Section IX. BOLT, CABLE, AND GLASS CUTTERS

208. Purpose of Cutters
(figs. 252, 253, and 254)

Cutters or clippers are used to cut bolts, rods, wire rope, cable, screws, rivets, nuts, bars, strips, and wire. Special cutters are made to cut glass.

209. Types of Cutters

A bolt clipper or cutter is shaped like a giant shears with short blades and long handles. Different cutting edges are designed for specific applications. Figure 252 illustrates various types of cutting edges. Figure 253 illustrates types of cable cutters. Figure 254 shows the wheel-type glass cutter.

a. Angular Cut Cutters. Angular cut cutters (fig. 252) are used for cutting against large flat surfaces. They are 36 inches long and are capable of flush cutting a ⅝-inch bolt and a ½-inch rod. The handles are at a 30° angle to the cutting edges of the jaws.

b. Center Cut Cutters. For all general purpose cutting, the center cut cutters (fig. 252) are used. The cutting jaws are firmly fixed in line with the handles and the cutting edges are in the center of the jaw between equal bevels. These cutters come in 18–, 36–, 42–, and 48–inch lengths having cutting capacities of 5⁄16–inch bolt and ¼–inch rod, ⅝–inch bolt and ½–inch rod, ¾–inch bolt and ⅝–inch rod, and ⅞–inch bolt and ¾–inch rod, respectively. The longer the handle, the greater the cutting capacity.

c. Clipper Cut Cutters. The cutting edges of clipper cut cutters (fig. 252) are in line with the handles and beveled almost entirely from one side. These cutters permit very close cutting of projecting ends. They are available in several sizes; ½–inch bolts and ⅜–inch rods, ⅝–inch bolt and ½–inch rod and ⅜–inch mild steel cutting capacities.

d. Shear Cut Cutters. Shear cut cutters (fig.

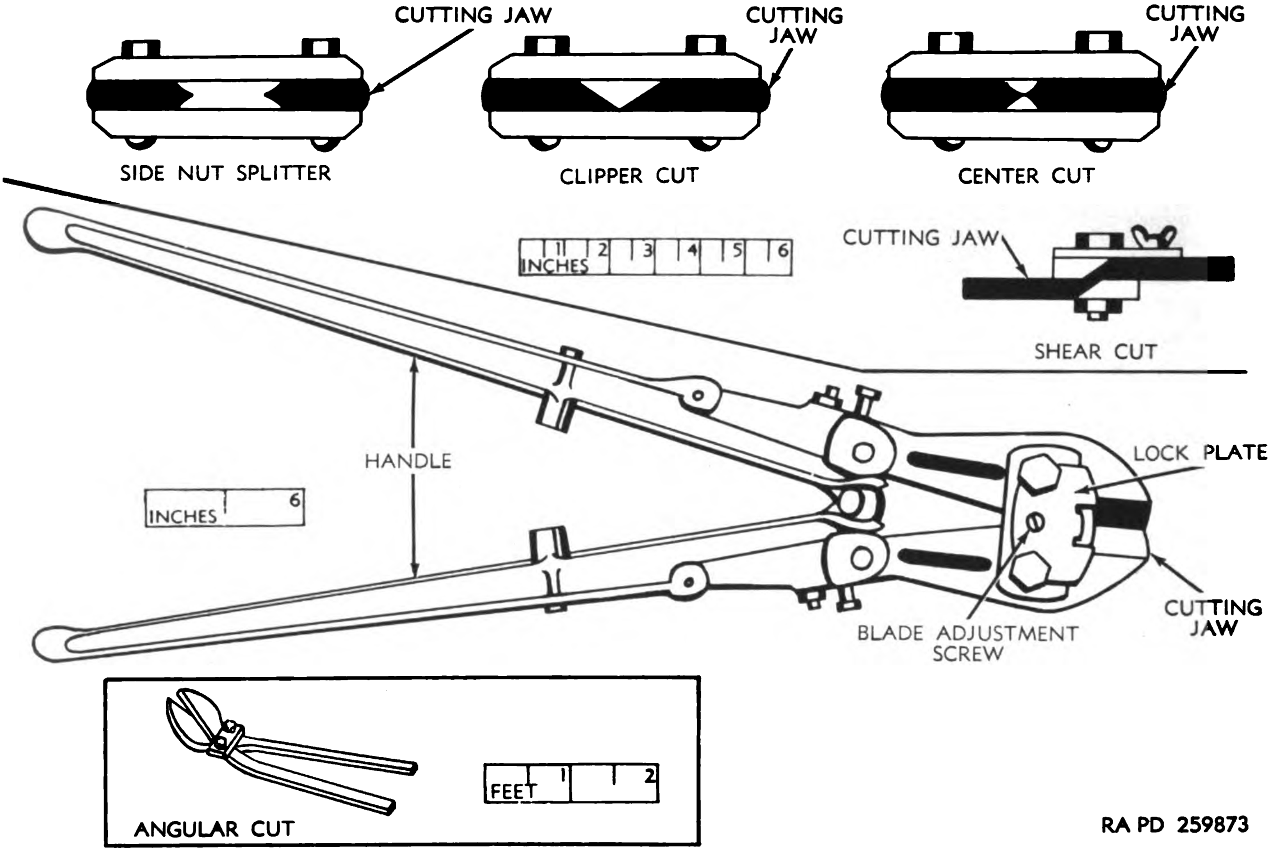


Figure 252. Types of bolt and nut cutters.

252) are used to cut steel cable, strip or flat bar stock. The cutting edges of the jaws pass each other in the manner of scissors, making a complete shear cut. The cutters are available in two capacities; $^{7}/_{16}$–inch bolt and $^{5}/_{16}$–inch steel cable with a 24–inch long handle, and a ½–inch bolt and ⅜–inch steel cable capacity with a 36-inch long handle.

e. Side Nut Splitter Cutter. The side nut splitter cutter (fig. 252) has the edges of the cutting jaws in line with the handles. This tool is used to split nuts off bolts with the tool "head on" to the bolt axis without damaging the bolt. When adjusted properly, the cutting edges will remain separated after the nut is split. Cutting capacity is rated at ⅜–inch bolt nut and is adjustable to $^{5}/_{16}$– and ¼–inch capacity. This cutter is 24 inches long.

f. Hand Cable Cutters. Cable and wire cutters (fig. 253) are available to cut 2 or 3 wire cables, Nos. 10, 12, and 14 BX cable. These are of the center cut and the shear cut type. Hammer-type cable cutters (not illustrated) are available having a ½–inch and 1–inch cutting capacity.

g. Lead-Sheathed Cable Cutter. The lead-sheathed cable cutter has symmetrical shaped hooked jaws (fig. 253) that pass each other,

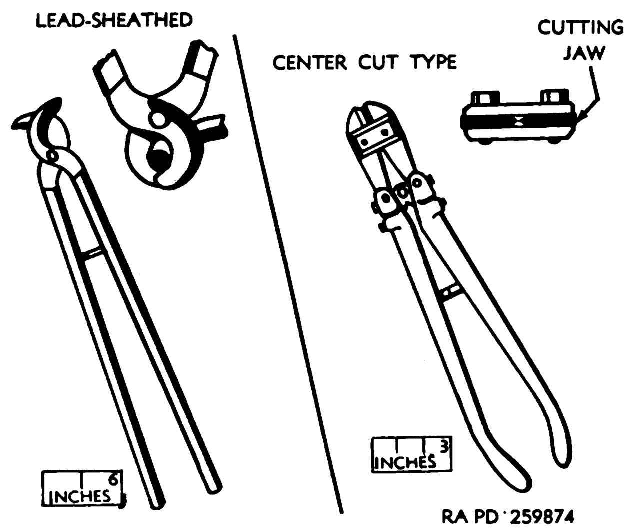


Figure 253. Types of cable cutters.

providing a shearing action. This cutter is designed to minimize flattening of communication cable and crushing the insulation inside. It has a cutting capacity of up to 1–inch diameter cable and is 23½ inches long.

h. Bench Cable Cutters. Two bench cable cutters (not illustrated) are available, both of the shear cut type. One has a cable holding die and a moveable blade that operates on hydraulic principle (1⅛–inch capacity). The other bench cutter is bolted onto a bench and has a 36–inch handle with a cutting capacity of 1 inch.

i. Glass Cutters. Two glass cutters are available; one is the single wheel, general purpose type (fig. 254), while the other has a 2– to 24–inch circular capacity incorporating a graduated beam (not illustrated).

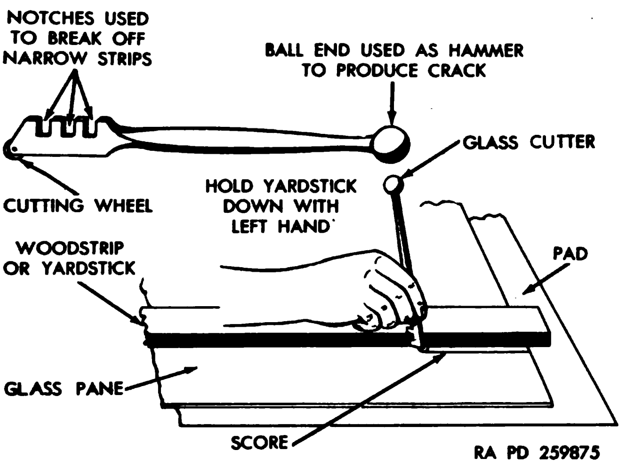


Figure 254. Using a glass cutter.

j. Gasket Circle Cutters. A gasket circle cutter (not illustrated) is available that can cut circles in gasket material from 4 to 20 inches in diameter.

210. Use of Bolt and Cable Cutters

a. Select the proper cutter for the job. Determine the kind, and hardness, of material and the thickness of the work to be cut.

b. Position the work as far back as possible into the jaws to prevent damage to the jaws as well as to reduce the pressure required for cutting.

c. Do not use cable cutters on spring steel wire, to do so will nick the cutting edges and possibly misaline the cutters.

d. Avoid cutting live electrical cable and when doing work on existing electrical circuits, make certain the handles of the cutter to be used are insulated.

e. Use extreme caution when using any cutter to avoid catching any part of the body or clothes between the handles as pressure is applied to them.

f. Be sure to dry hands and handles of cutters before using, to prevent slipping. Keep tools clean.

g. Make sure to clamp or steady the work, if unattached and before cutting, to prevent the cutters from slipping.

211. Use of Glass Cutter and File

A glass cutter (fig. 254) actually does not cut glass; it splits it. If the wheel is sharp and it is drawn over the glass at the right speed and pressure, it makes a fine score or groove by slightly crushing or pulverizing the glass under the edge of the wheel. The beveled sides of the wheel act as wedges which push against the sides of the groove and pry the glass apart so that a crack is started. If a crack fails to start in the cutting, tap the scratch or score with the ball end of the glass cutter, as you would with a hammer, to start a crack. Break off narrow strip along the edges by placing the strip into a notch in the cutter and using the handle as a leverage to break off the narrow strip. Glass tubing or rod is cut by nicking the surface with a triangular file.

a. Cutting Glass Pane. Ordinary window glass comes in two thicknesses, single light and double light. Single light is thinner and the easiest to cut. Plate glass up to ¼ inch in thickness can be cut in the same manner as ordinary window glass. Safety glass, which consists of two or more glass sheets cemented together by a transparent plastic, requires special cutting equipment.

(1) *Window or single light glass.*

(*a*) Place several layers of newspaper or a piece of carpet on a firm level surface and place the glass pane upon the padding (fig. 254).

(*b*) Make certain the glass is clean—dirty glass does not cut well and dulls the cutter.

(*c*) Brush turpentine directly along the line to be cut. This keeps the cutter bearings from gumming and keeps the cutter sharp longer.

(*d*) To make a straight cut, use a straightedge to guide the cutter. A wooden yardstick is ideal, since the wood will not slip as easily on glass as would a metal guide.

(*e*) Lubricate cutting wheel before cutting with a drop of light machine oil. Remove excess oil.

(*f*) Hold the guide with one hand against the glass and hold the cutter in a vertical position in the other hand. Your forefinger should be extended along the back of the cutter with the tip of the finger down near the wheel.

Note. The wheel does not cut exactly at the edge of the guide, but makes the groove about 1/16 inch from it. Position the guide accordingly.

(*g*) Start the groove at the far end of the guide and draw the cutter towards you. The correct pressure is important, since too much pressure may crack the pane and both too little or too much pressure may make an unsatisfactory groove. If the correct pressure is applied and the cutter is drawn towards you at the right speed, the wheel will make a scratching sound. If the wheel is dull, or too much pressure is applied, the sound obtained will be more like crunching than scratching.

(*h*) Draw the cutter over the line once only. If it becomes necessary to correct an imperfect groove, do not use a new cutter for this purpose—use an old one. Drawing a sharp cutter over a groove the second time dulls it.

(*i*) Make a continuous mark all the way from one edge to the other. If made properly, a slight crack will be visible the complete length of the mark. The crack may not extend through from one surface to the other. It is best seen from the side opposite the mark.

(*j*) To part the glass, slide the pane over to the edge of the bench or table so that the score mark is parallel to and projecting about 1/8 inch beyond the edge. Hold down the portion resting on the table with one hand and grasp the projecting end between the fingertips and palm of the other hand. Apply a light pressure and the glass will part.

(*k*) To part a narrow section of glass, slip a notch in the cutter head over the projecting end of the glass pane and apply pressure to twist the projecting end down and in towards the bench. A grooved wood block can also be used to make a clean break along the score mark.

(2) *Plate or double light glass*

(*a*) Plate glass or double light glass will part along the scored line most easily and accurately if a continuous crack is started along the bottom of the groove or the scratch. A sharp cutter and the right pressure will usually start this crack when the groove is scored.

(*b*) If the crack does not appear then, it can generally be started by turning the pane over and tapping against the unscored surface with the end of the cutter handle. Tap directly over the line scored on the opposite side. A crack which is not continuous can be extended all the way along the groove by tapping in this manner.

(3) *Cutting glass to a pattern.* First lay out a full size drawing on paper, making certain the outline is heavy and distinct. Place the drawing under the pane of glass. Cut circles, ovals, and curves by tracing them through the glass with the cutter wheel. For straight lines, use a guide such as a woodstrip or a yardstick.

b. Cutting Glass Tubing and Rod. Cut glass tubing by nicking it with a triangular file. Hold the tubing in both hands and apply pressure as if to bend the tube. The nick must be on the surface away from you. The tube will crack apart at the nick. Glass rods are cut in the same manner. In cutting large diameter glass tubing or large diameter glass rod, the nick made with the triangular file should be a continuous scratch, extending all around and circling the tubing or rod.

212. Care of Cutters

a. Sharpening and Grinding. Sharpen and grind cutter blades as you would shears (par. 206*b* and *c*). The blades of most cutters are easily removed. Sharpen dull blades with a file and an oilstone. Grind blades that are nicked, have distorted bevels, or are worn beyond a simple sharpening job. Determine bevel or shape of cutting edges and adjust grinder rest to obtain the desired angle. Dip blade in water frequently to preserve temper. Remove wire edge on an oilstone. Reassemble cutter. After grinding and sharpening, make certain the cutting edges meet perfectly and, in the case of shear cut cutters, the edges must pass each other in a tight fit.

b. Adjustments. Most cutter blades can be adjusted to compensate for small wear by tightening the adjustment screw between the blades. When assembling cutting edges on cutters, make certain attaching bolts are tight and that the bolt lock plate between the blades is in place and secure.

c. Storage. When not in use, apply a light film of oil on cutting edges and store so that the cutting edges do not contact other metals or humans. Wrap the glass cutter wheel in cotton or a small piece of rag saturated with light machine oil. For long periods of storage, coat entire cutter with rust-preventive compound and store in a dry place.

Section X. PIPE AND TUBE CUTTERS, AND FLARING TOOLS

213. Purpose of Pipe and Tube Cutters, and Flaring Tools
(figs. 255 and 256)

Pipe cutters (fig. 255) are used to cut pipe made of steel, brass, copper, wrought iron, and lead. Tube cutters (fig. 255) are used to cut tube made of iron, steel, brass, copper, and aluminum. The essential difference is that tubing has considerably thinner walls as compared to pipe. Flaring tools (fig. 256) are used to make single or double flares in the ends of tubing.

214. Types of Pipe and Tube Cutters, and Flaring Tools

a. Pipe Cutters. Two pipe cutters are issued; one has a cutting capacity of ⅛ to 2 inches, and the other from 2 to 4 inches. The pipe cutter (fig. 255) has a special alloy-steel cutting wheel and two pressure rollers which are adjusted and tightened by turning the handle.

b. Tube Cutters. Some types of tube cutters closely resemble pipe cutters, except that they are of lighter construction. A hand screw feed tubing cutter of ⅛-inch to 1¼-inch capacity (fig. 255) has two rollers with cutouts located off center so that cracked flares may be held in them and cut off without waste of tubing. It also has a retractable reamer blade that is adjusted by turning a knob. Other types of tube cutters shown are designed to cut tubing up to and including ¾ and 1 inch o.d. Some cutters have the feed screw covered to protect the threads against dirt and damage.

c. Flaring Tools. Flaring tools (fig. 256) are used to flare soft copper, brass, or aluminum to make up 45° flare joints. The single flaring tool consists of a split die block that has holes for $\frac{3}{16}$–, ¼–, $\frac{5}{16}$–, ⅜–, $\frac{7}{16}$–, and ½–inch o.d. tubing, a clamp to lock the tube in the die block, a yoke that slips over the die block that has a compressor screw, and a cone that forms a 45° flare or a bell shape on the end of the tube. The screw has a T-handle. A double flaring tool has the additional feature of adapters that turn in the edge of the tube before a regular 45° double flare is made. It consists of a die block with holes for $\frac{3}{16}$–, ¼–, $\frac{5}{16}$–, ⅜–, and ½–inch tubing, a yoke with a screw and a flaring cone, plus 5 adapters for different size tubing; all carried in a metal case.

215. Use of Pipe Cutters

a. Measuring Threaded Pipe. Before you cut pipe, make certain the required correct length is determined. There are three methods of measuring threaded pipe, and you must understand these methods if the pipe is to be cut to the correct lengths (fig. 257).

(1) *End-to-end method.* This measure-

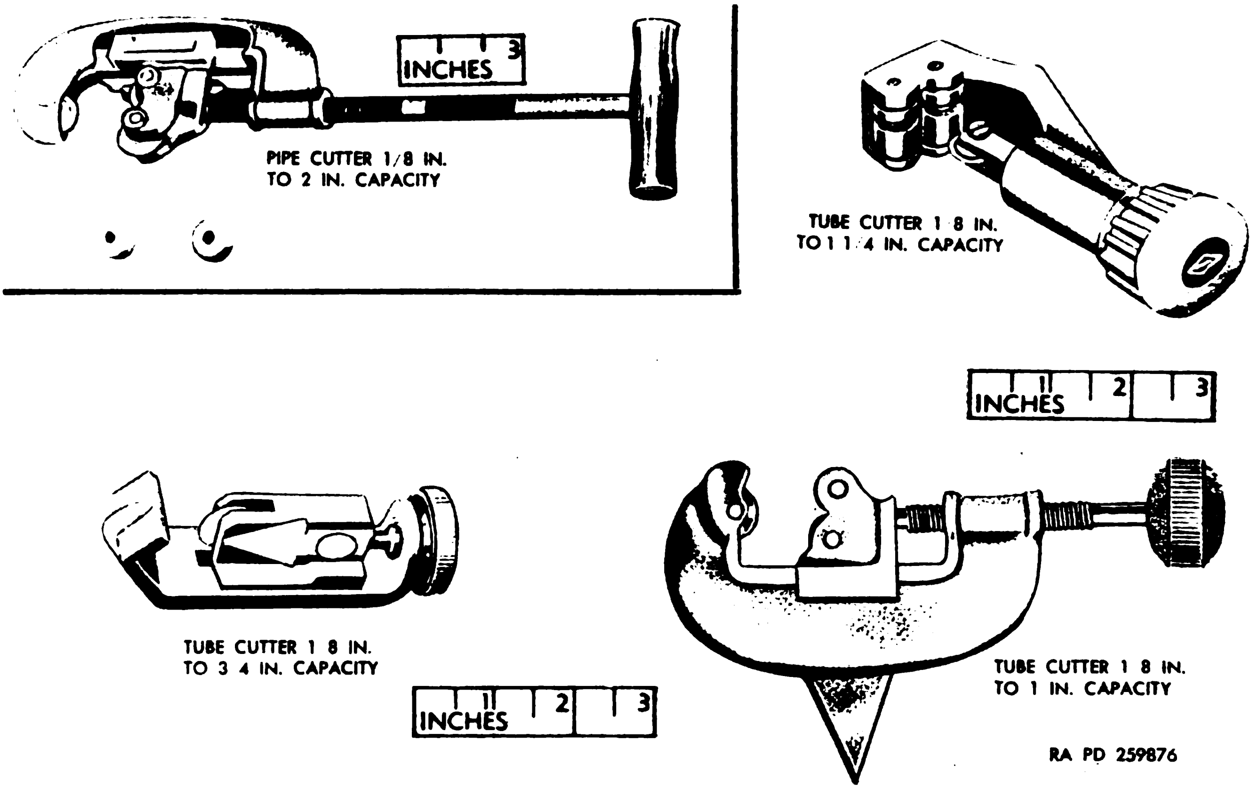


Figure 255. Pipe and Tube Cutters.

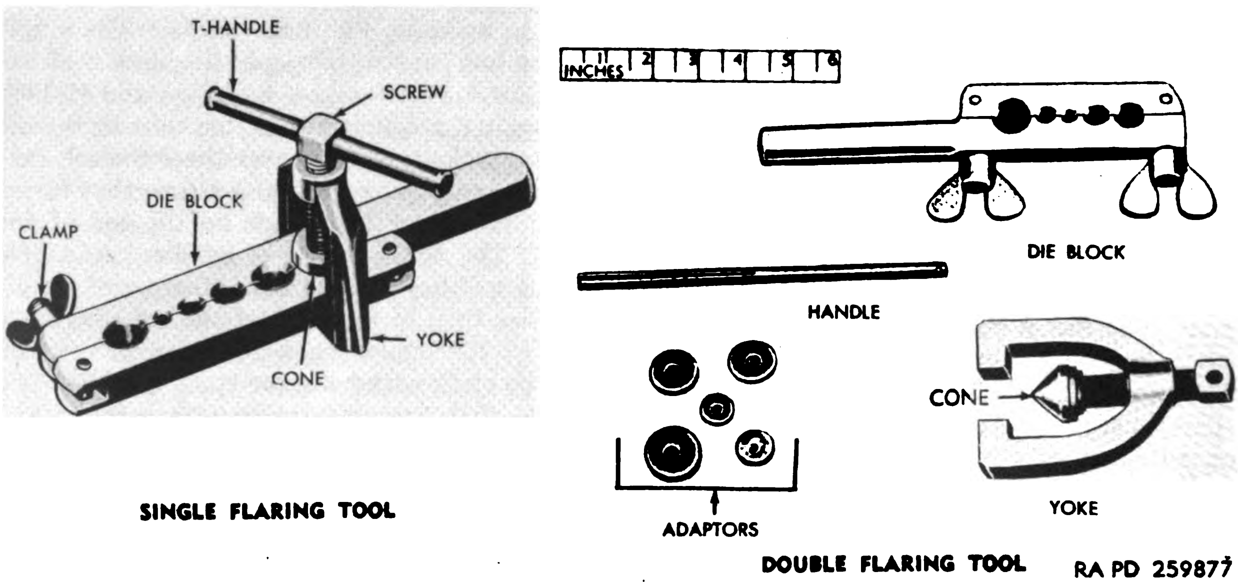


Figure 256. Flaring tools.

ment includes the threaded portions of the pipe. The pipe is measured from end to end.

(2) *End-to-center method.* This measurement is used on a section of the pipe that has a fitting screwed on one

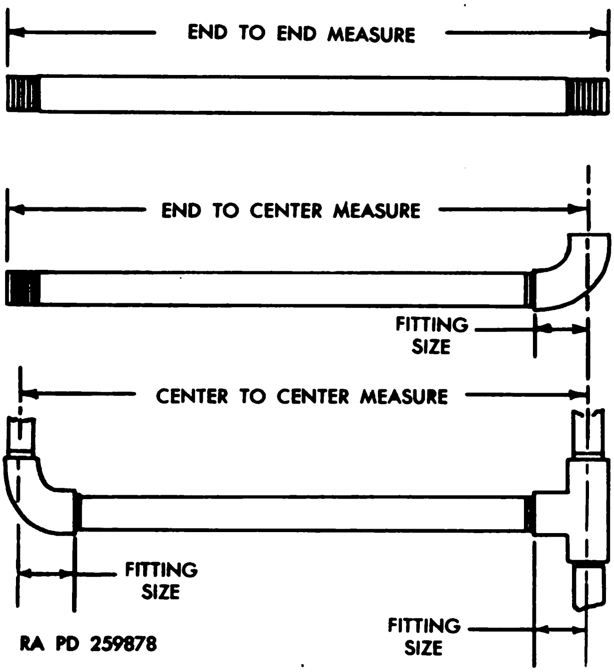


Figure 257. Measuring threaded pipe.

end only. Measure from the free end of the pipe to the center of the fitting at the other end of the pipe.

(3) *Center-to-center method.* This measurement is used when both ends of a pipe have fittings. Measure from center of one fitting to center of the other fitting at opposite end of pipe.

(4) *Approximate thread lengths.* The approximate length of thread on ½– and ¾–inch wrought iron or steel pipe is ¾ inch. On 1–, 1¼–, and 1½–inch pipe, it is approximately 1 inch long. On 2– and 2½–inch pipe, the length of thread is 1⅛ and 1½ inches respectively.

(5) *Determine pipe length.* To determine length of pipe required, compute as outlined in (*a*) through (*d*) below.

(*a*) Take measurement of installation such as center to center of pipe, requiring two fitting ((3) above).

(*b*) Measure size of fitting or fiittings as shown in figure 257.

(*c*) Subtract total size of the two fittings from measurement obtained in (*a*) above.

(*d*) Multiply approximate thread length ((4) above) by 2 and add result to length obtained in (*c*) above. This will give the length of pipe required.

b. Cutting Pipe.

(1) Measure length of pipe necessary (*a* above) and mark the spot where the cut is to be made with a scriber or crayon.

(2) Lock the pipe securely in a pipe vise (fig. 258).

(3) Inspect pipe cutter to make sure that there are no nicks or burs in the cutting wheel. Open the jaws of the cutter by turning the handle counterclockwise.

(4) Position the cutter around the pipe at the marked point. Make sure the cutting wheel is exactly on the mark and close the jaws of the cutter lightly against the pipe by turning the cutter handle clockwise.

(5) After making contact, turn the cutter handle clockwise one-fourth of a turn more. This will put a bite on the pipe.

(6) Grasp the cutter handle and rotate the cutter as a whole, one complete revolution, swinging it around the pipe in the direction indicated in figure 258.

(7) Turn the cutter handle clockwise one-fourth of a turn more to take another bite on the pipe and rotate the cutter, as a whole, another complete revolution. Keep the cutter perpendicular to the pipe at all times or the wheel will not track properly.

(8) Repeat (7) above until pipe is cut. Remove shoulder on outside of pipe with a file and the bur on the inside with a reamer.

216. Use of Tube Cutters

a. Measurement. Measure tubing as you would pipe (par 215*a*).

b. Cutting Tubing. The procedure for using a tube cutter is the same as for pipe cutters (par 215*b*), except that a vise is not necessary. Tubing is held in one hand and the cutter rotated with the other hand. For large diameter tubing, using a vise is advisable. Be certain to use soft jaws on the vise to prevent

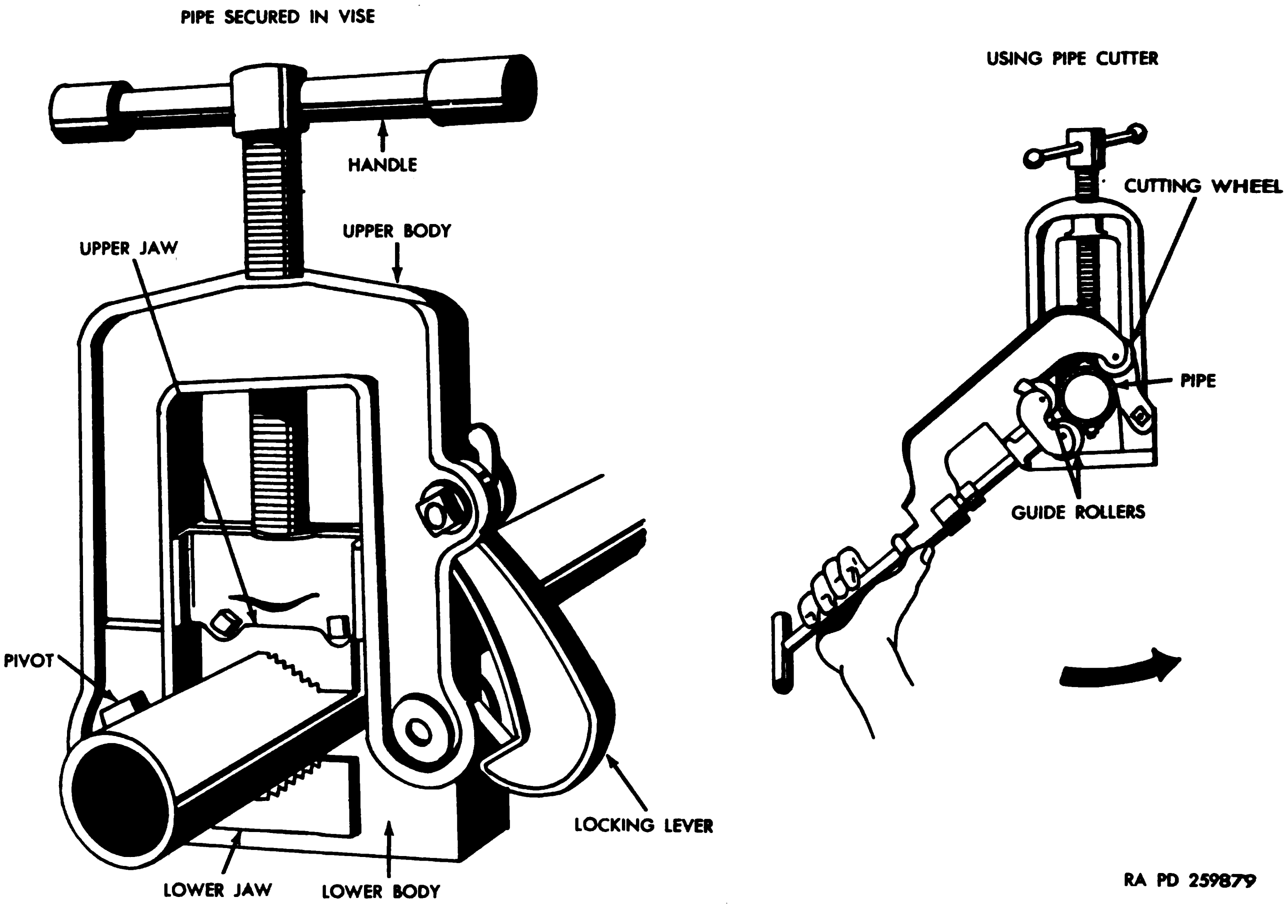


Figure 258. Cutting pipe.

damage to the tubing. Use the reamer blade, equipped with most tube cutters, to remove any burs from the inside diameter of the tube after it is cut.

217. Use of Flaring Tool

a. Single Flare. With the die block clamp screw (fig. 256) loose, inset the tube in the corresponding size hole so that the tube extends approximately ⅛ inch above the face of the block. Tighten the clamp screw firmly to hold tube in place. Slide yoke over end of die block and turn the feed screw clockwise until the flaring cone forces the end of the tube tightly against the chamfer of the die block. Tube is now flared to a 45° angle. Back out feed screw, slide yoke off die block, and loosen clamp screw to remove flared tube.

b. Double Flare.

(1) Insert tubing through the proper hole in the die block, with the end protruding above the block by the thickness of the shoulder on the appropriate adapter. Tighten the wingnuts on the die block and insert the adapter in the tubing. Move the yoke over the adapter and turn the feed screw clockwise until the shoulder of the adapter rests on the die block and a bell shape is formed on the tubing as shown in A, figure 259. Loosen the feed screw and remove the adapter from the tubing.

(2) Flare tube as you would for a single flare (B, figure 259).

218. Care of Cutters and Flaring Tools

a. Sharpening Cutter Wheels. The cutting wheel on a pipe or tube cutter must be removed and sharpened when it becomes dulled, nicked, or otherwise damaged. Remove the wheel by tapping out the pin in the center of the wheel,

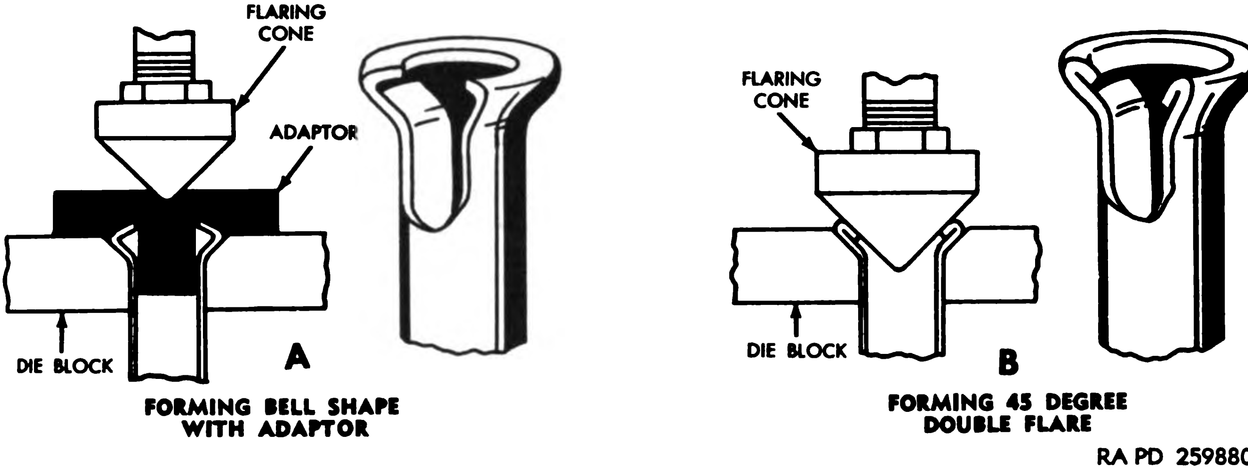


Figure 259. Double flaring a tube.

or by backing out the attaching screw on some types. Secure the wheel in a suitable jig and carefully grind the cutting edge on a grinder abrasive wheel or grindstone. Preserve the temper by frequently dipping the cutter wheel in water during grinding. Any wire edge can be removed on an oilstone.

b. Storage. Clean and wipe cutters and flaring tools with a thin film of oil before putting away after use. Carefully store tools to prevent the cutting wheels from becoming damaged. Close single flaring tool die block, install the yoke, and turn down flaring cone until it just lightly touches an opening in the block, before storing. Return parts of double flaring tool to their case after use. For long periods of storage, coat all parts of cutters and flaring tools with a rust-preventive compound; wrap cutter wheels in cotton or a small piece of rag saturated with light machine oil to prevent damage and store in a dry place.

Section XI. REAMERS

219. Purpose of Reamers
(figs. 260, 261, and 262)

Reamers are used to smoothly enlarge drilled holes to an exact size and to finish the hole at the same time. Reamers are also used to remove burs from the inside diameters of pipe and drilled holes.

220. Types of Reamers

a. Solid Straight Hole Reamers. Solid straight hole reamers (fig. 260) are made of one solid piece of high speed steel having a straight shank and straight or spiral flutes. The cutting edges or lands between the flutes are usually evenly spaced. However, some solid reamers have irregularly spaced lands to prevent the tool from chattering. Solid straight shank, straight flute reamers are issued in sizes from $1/16$ inch up to and including 3 inches in diameter. These reamers are also issued in sets incased in a wood or metal box containing 25 reamers sized from $1/8$ to $1/2$ inch and progressing by $1/64$–inch increments. Other reamer sets include solid taper pin reamers (*b* below) in addition to the solid straight hole reamers. Each reamer size is stamped on the shank of the tool.

b. Solid Taper Pin Reamers. Solid taper pin reamers (fig 260) are used to finish tapered holes for the insertion of tapered pins or other tapered parts. They are made with a standard taper of $1/4$ inch per foot. Solid taper pin reamers are issued with straight or spiral flutes in sizes ranging from Nos. 5/0 to 14, with the diameters at large end of reamer ranging from 0.0984 to 1.5412 inches. These reamers are also issued in sets of 10 reamers; Nos. 3/0 to 7, and a set of 11 reamers; Nos. 0 to 10. As mentioned in *a* above, they are also included

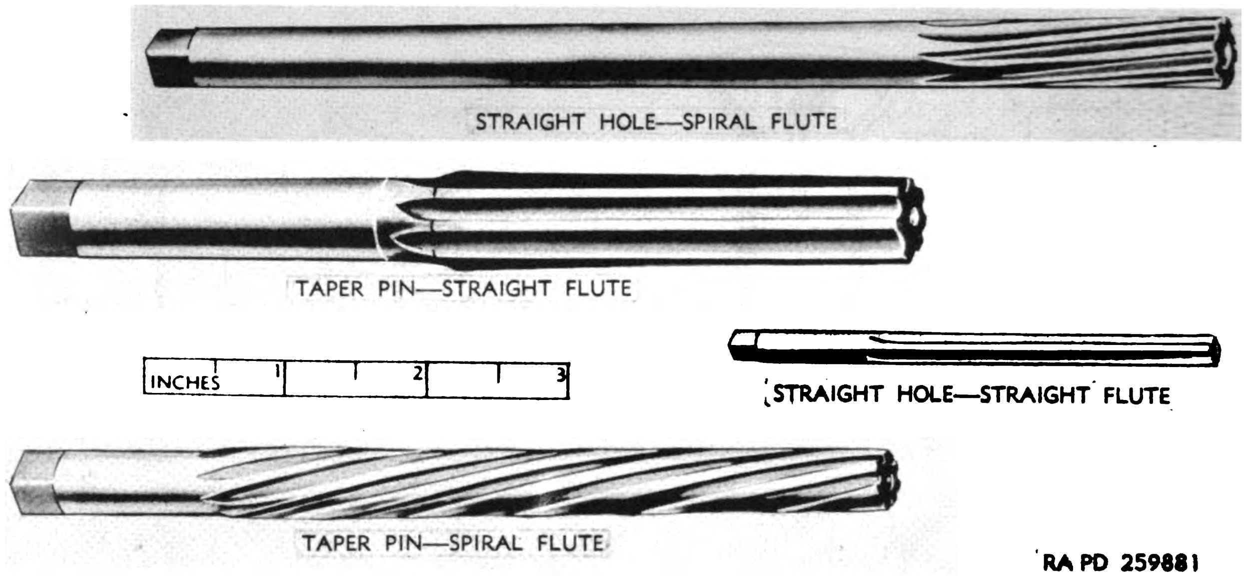


Figure 260. Solid straight hole and taper pin reamers.

in mixed sets of both straight hole and taper pin reamers.

c. *Expansion Reamers.* Expansion reamers (fig. 261) are adjustable and their sizes may be changed by 0.125 inch ($\frac{1}{8}$ inch) for a 1-inch reamer, and by 0.3125 inch ($\frac{5}{16}$ inch) for a 2-inch reamer. The expansion reamer is made of carbon steel and has longitudinal cuts in some of its flutes. It is hollowed out and threaded to receive a tapered screw plug. The diameter of the reamer is changed by screwing in or backing out the screw plug. These reamers are issued with spiral flutes in two sizes, $\frac{19}{32}$- and $1\frac{1}{4}$-inch diameters. A straight flute with a floating pilot, having a range of $\frac{1}{2}$ to $\frac{17}{32}$ inch and having a length of 9 inches, is also issued.

d. *Adjustable Blade Reamers.* The blades of an adjustable reamer (fig. 261) are separate from the body and are fitted into grooves in the threaded shank of the tool. Adjusting nuts below and above the blades control the diameter

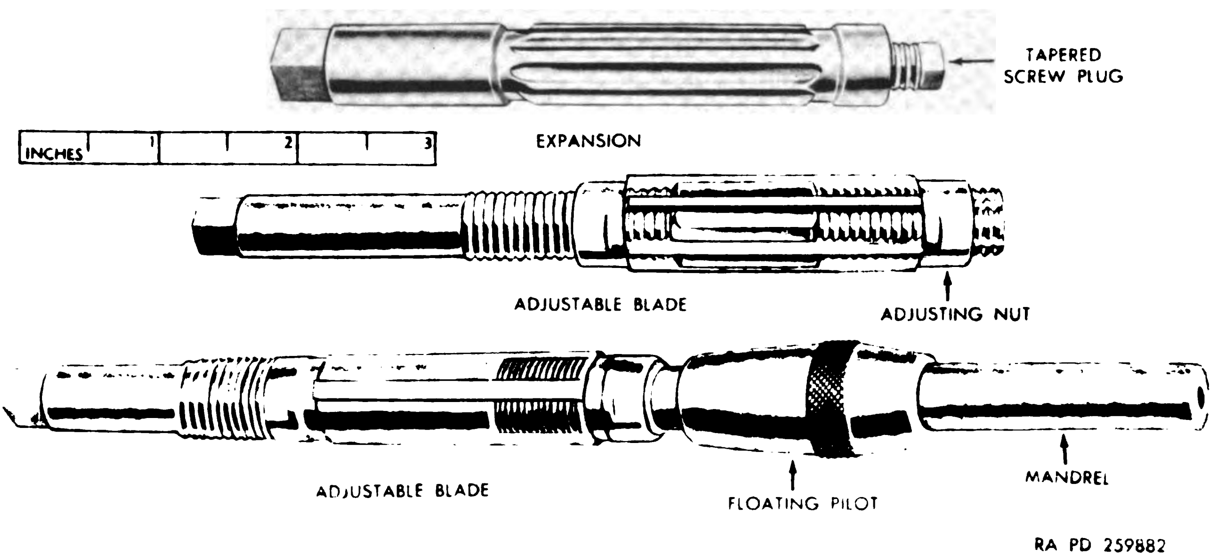


Figure 261. Adjustable reamers.

of the reamer. These reamers are issued with straight or spiral flutes, with or without a floating pilot, in several sizes. Spiral flute adjustable reamers are issued in sizes from 0.730- to 0.780-inch range up to 0.980- to 1.030-inch range. Straight flute adjustable reamers are issued in sizes from a ½- to 9/16-inch range up to a 15/16- to 1-inch range, in steps of 1/16 inch. They are also issued in steps of 1/16 inch from a 15/32- to 17/32-inch range up to a 1 25/32- to 2 9/32-inch range. Adjustable reamers are also available in sets. One set contains 5 spiral flute reamers with floating pilots on solid mandrels ranging from 0.730 to 1.030 inches. Another set of the same type contains 8 straight flute reamers ranging in size from ½ to 1 inch. Two other sets have reamers with lettered sizes A to H and A to K, 15/32- to 1 1/16-inch range and 15/32- to 1 17/32-inch range, respectively. The latter two sets do not have floating pilots or mandrels.

e. Pipe Reamers. Pipe reamers (fig. 262) are made of carbon steel, they are tapered, with straight or spiral flutes. They are issued in three sizes; ⅛- to 1-inch pipe capacity, ¼- to 1¼-inch pipe capacity, and ¼- to 2-inch pipe capacity. Most pipe reamers are designed to receive a T-handle.

221. Use of Reamers

a. General.

(1) Use a solid straight hole reamer for most work, since it is most accurate and the most rugged of the straight hole reamers.

(2) When using a taper pin, expansion, or adjustable reamer, a series of small cuts should be taken rather than one deep cut. Check the hole for size after each cut to insure that you do not remove too much metal from the hole.

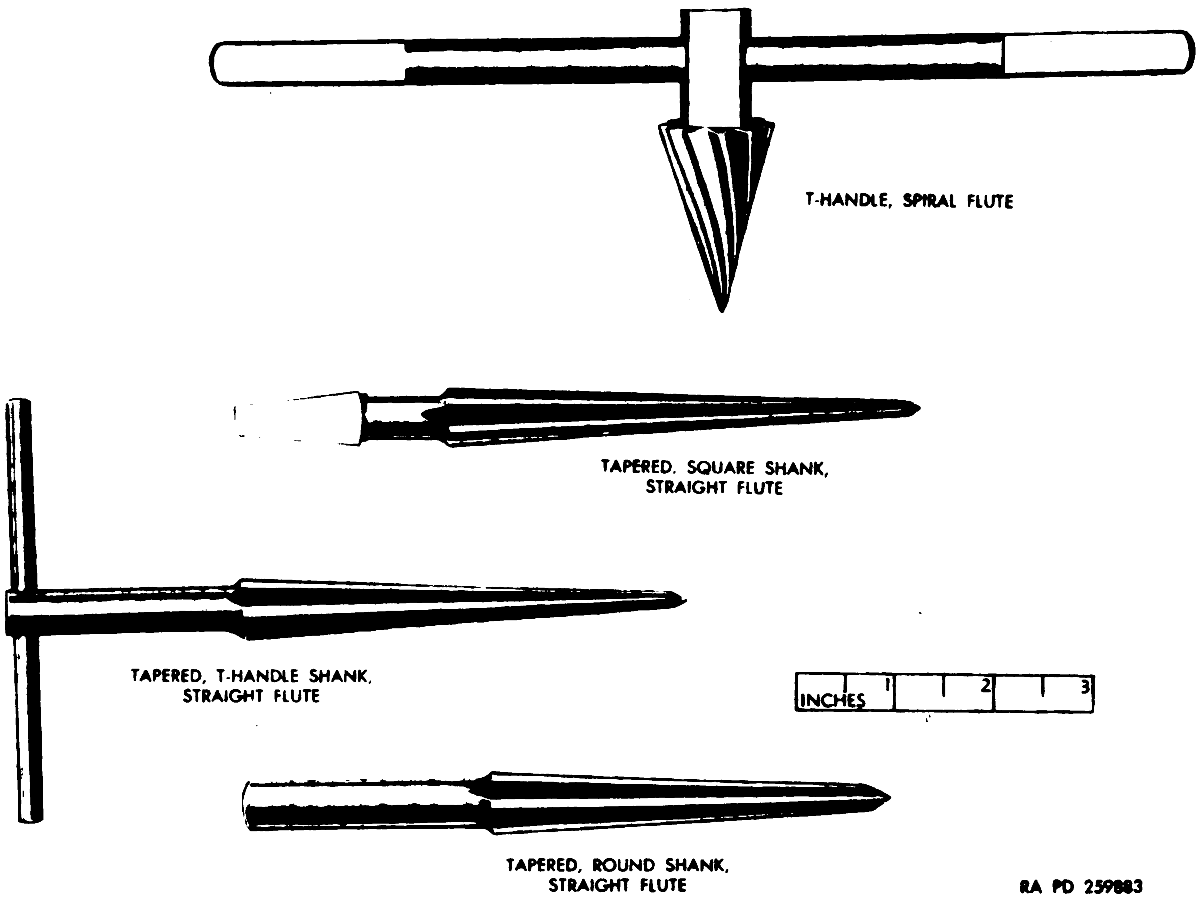


Figure 262. Pipe reamers.

(3) Never force a small reamer into a hole with too much pressure, since reamers are delicate and easily broken.

(4) Most reamers are hand-driven tools. some reamers are power-driven.

b. Straight Hole Reamers. A hand reamer is turned by means of a tap wrench that is tightened on the square end of the reamer shank. Secure the work in a vise so that the hole to be reamed is perpendicular to the top of the vise jaws. Position the reamer at the top of the hole (fig. 263). Straight hole reamers have a slight taper at the end so that they will fit into the hole easily. Turn the wrench clockwise very slowly until the reamer is centered in the hole (fig. 264).

***Caution:* Do not turn the wrench counterclockwise at any time. To do so will cause the tool to become dull, fail to cut, and become useless.**

After centering the reamer, turn the wrench clockwise with a steady firm pressure until the reamer has been turned all the way through the hole. When reaming steel, use cutting oil or machine oil to lubricate the tool. When reaming soft iron, do not lubricate the tool. To remove reamer from hole turn wrench clockwise and raise reamer simultaneously.

Note. Turning the wrench too fast or too slowly will cause the reamer to chatter, producing an unevenly reamed hole.

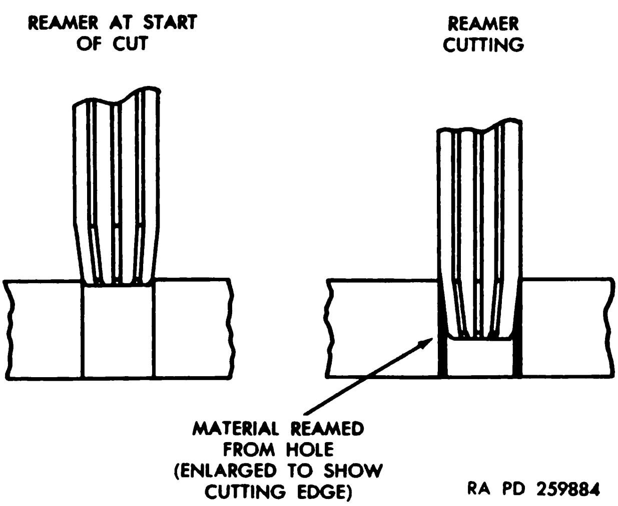


Figure 263. Reaming operation.

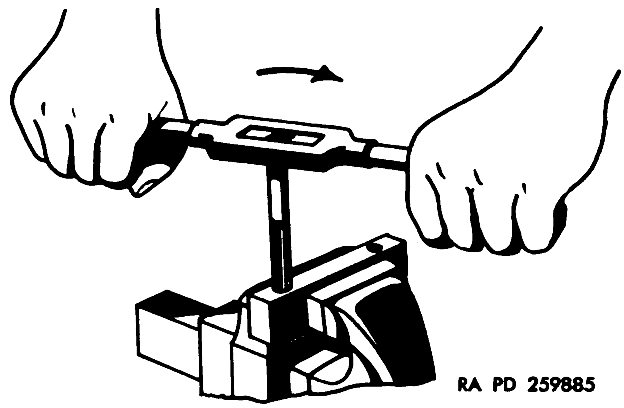


Figure 264. Use of tap wrench with reamer.

c. Taper Pin Reamers. Before using a taper pin reamer be certain that the hole is the right size, generally just large enough to allow about ½ inch of the reamer's length to go into it. The drill used to make the hole must be the largest possible size that will allow the reamer to clean up the hole along its entire depth. Keep the reamer as straight as possible and ream hole as discussed in *b* above. To prevent damage to the walls of the hole, remove the reamer frequently and brush away the metal chips that stick to the flutes.

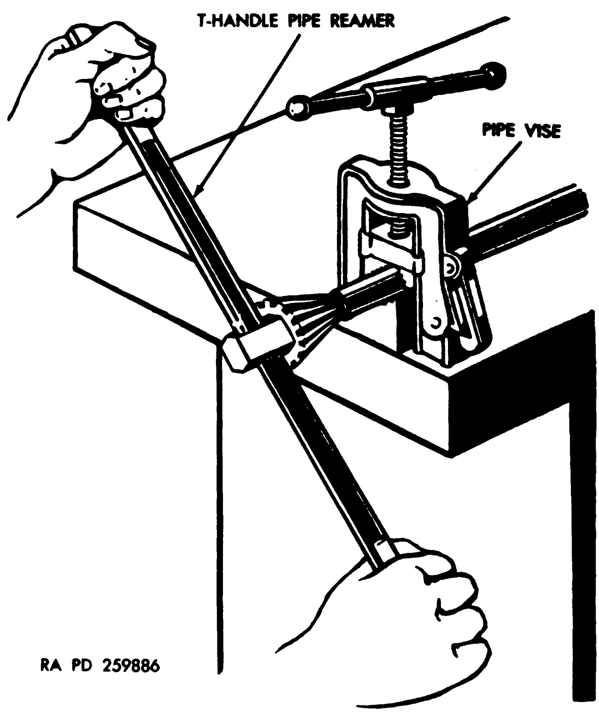


Figure 265. Removing bur from cut pipe.

d. Pipe Reamers. Before using a pipe reamer (fig. 265), inspect the flutes to see if they are sharp and even and free from nicks or burs. Insert the point of the reamer into the pipe and push firmly. Rotate the handle of the reamer clockwise in short even strokes until the burs inside the cut piece of pipe are completely removed. Remove the reamer from the pipe by rotating it clockwise and removing it simultaneously.

Note. The pipe must be secured in a pipe vise during this bur removing operation.

222. Care of Reamers

a. Do not expect a reamer to remove more than 0.002 to 0.003 inch of metal. If the hole is too small, enlarge it with a drill before reaming it.

b. Keep reamers absolutely clean to do accurate work.

c. Handle all reamers carefully; if they are dropped or thrown against other tools, their sharp edges will be nicked and dulled.

d. Wrap reamers in oiled cloth when not in use and store each reamer separately to protect its cutting edges.

e. If the proper pressure is applied in use and the reamer chatters, replace it. Chattering indicates a poorly or incorrectly sharpened tool. If the reamer edges are only slightly dulled, honing the edges on an oilstone may restore the sharpness. The blades on an adjustable reamer may be replaced. Resharpening reamers is a factory or depot operation. Special jigs and equipment are required to sharpen reamer edges correctly. To insure accurate work, always replace a reamer that requires sharpening.

f. For long periods of storage, clean reamers thoroughly and coat with a rust-preventive compound. Wrap each reamer separately in oiled cloth and store in a dry, safe place.

Section XII. TAPS AND DIES

223. Purpose of Taps and Dies (figs. 266 through 269)

Taps and dies are used to cut threads in metal, plastics, or hard rubber. The taps are used for cutting internal threads, and the dies are used to cut external threads.

224. Types of Taps

There are several types of taps issued by the Army Ordnance supply system. However, the most common are the taper, plug, bottoming, and pipe taps (fig. 266). Special purpose taps (fig. 267) such as mud or washout taps, boiler taps, and staybolt taps are also discussed in this section.

a. Taper Hand Tap. The taper or starting hand tap (fig. 266) has a chamfer length of 8 to 10 threads. These taps are used when starting the tapping operation and tapping coarse threads in through holes especially in harder metals.

b. Plug Hand Taps. Plug hand taps (fig. 266) are designed for use after the taper tap, and in through holes when tapping softer metals or fine-pitch threads. They have a chamfered length of 3 to 5 threads. These taps are the most popular.

c. Bottoming Hand Taps. Bottoming hand taps (fig. 266) are used for threading the bottom of a blind hole. They have a very short chamfer length, of only 1 to 1½ threads for this purpose. This tap is always used after the plug tap has already been used and for hard materials. Both the taper hand and plug hand taps should precede the use of the bottoming hand tap.

d. Pipe Taps. A taper pipe tap (fig. 266) is used for pipe fittings and on other places where extremely tight fits are necessary. The tap diameter, from end to end of threaded portion, increases at the rate of ¾ inch per foot. All threads on this tap cut, as compared to the straight taps where only the non-chamfered portion does the cutting.

e. Boiler Taps. Straight boiler taps (fig. 267) range in diameter from ½ to 1½ inches. The chamfered portion of the thread simplifies starting. Taper boiler taps have no chamfered portion and the threaded portion is tapered ¾ inch per foot. The overall and shank diameters are similar to those of straight boiler taps.

f. Staybolt Taps. Staybolt taps (fig. 267) are used principally in boiler locomotive and railroad shops for tapping the staybolt holes in the outer and inner plates or shells of boilers.

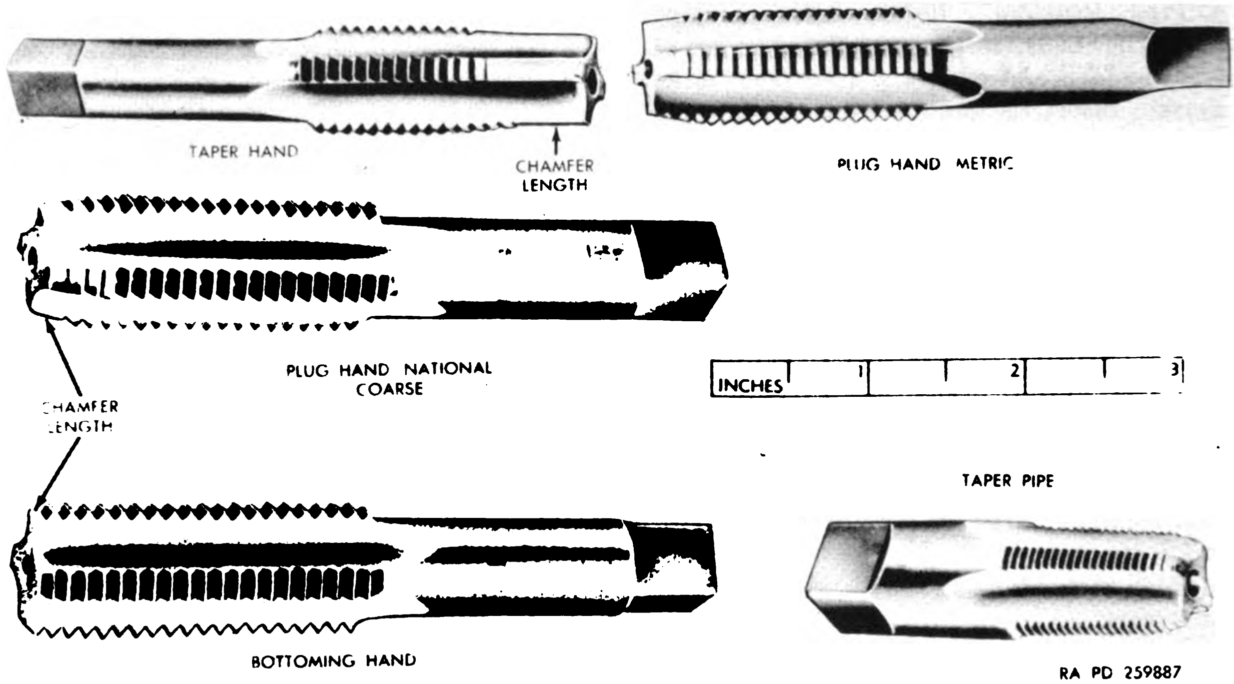


Figure 266. Types of common taps.

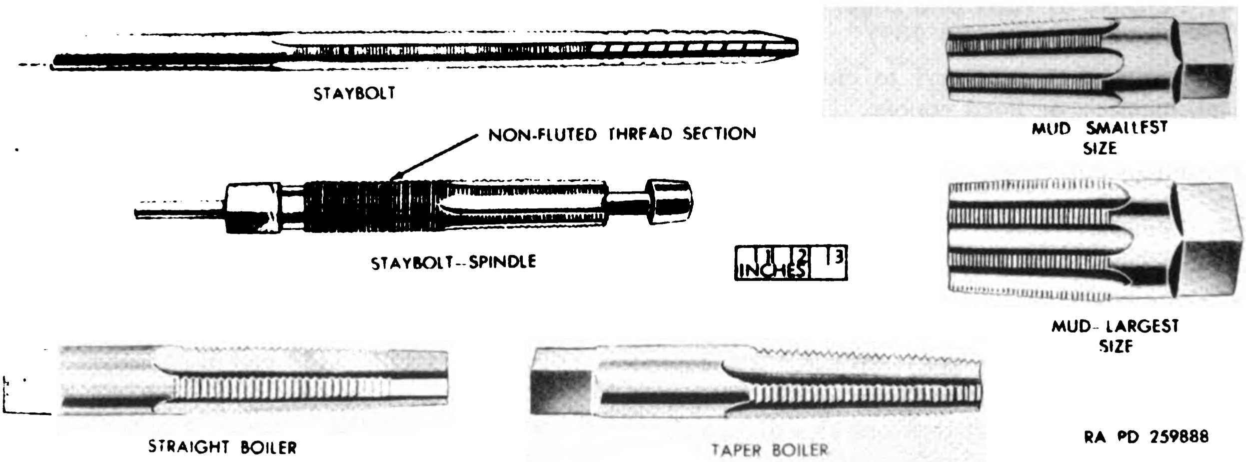


Figure 267. Special purpose taps.

The tap must have sufficient length to tap both holes in one operation so the threads in both holes will be in alinement. Staybolt spindle taps are also used for tapping staybolt holes. They have a sliding removable internal spindle with a tapered guide to insure that both tapped holes are properly lined up. The first hole is tapped; then the spindle is removed, and a non-fluted thread section at the back of the tap guides threading of the second hole.

g. Mud or Washout Taps. Mud or washout taps (fig. 267) have 6 flutes with a 1¼-inch taper per foot and 12 threads per inch. They are used to cut special American National or V-form threads when tapping mud plug drain holes.

h. Fusible Plug Tap. The fusible plug tap (not illustrated) issued by Army Ordnance is made of carbon steel and has a 1¼-inch taper per foot. It has a thread length of 4⅜ inches, is 1–inch square on the shank, has 4 flutes, and is 7 inches long.

i. Pipe Tap and Drill. A pipe tap and drill (not illustrated) is a combination twist drill and tap. The tap portion follows the twist drill tip. The tool does drilling and tapping in one operation. They are made of carbon steel with a tapered square shank and are sized to drill and tap holes ¼–18, ⅜–18, and ½–14.

225. Types of Dies

Dies are made in several different shapes and are of the solid or adjustable type.

a. Solid Dies.

(1) *Square pipe die.* The square pipe die (fig. 268) will cut American Standard Pipe Thread only. It is issued in sizes that will cut threads on pipe from ⅛–27 to 3–8.

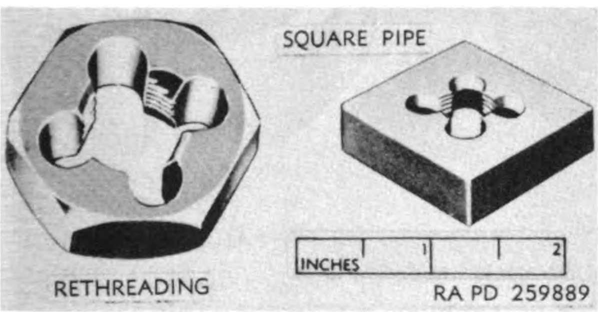


Figure 268. Types of solid dies.

(2) *Rethreading dies.* A rethreading die (fig. 268) is used principally for dressing over bruised or rusty threads on screws and bolts. However, it may be used for cutting occasional new threads. It is available in a variety of sizes for rethreading American Standard Coarse and Fine threads. These dies are usually hexagon in shape and can be turned with a socket, box, open-end, or any wrench that will fit. Rethreading dies are available in sets of 6, 10, 14, and 28 assorted sizes in a case.

b. Adjustable Dies.

(1) *Round split adjustable dies.* Round split adjustable dies (fig. 269) are called "Button" dies and can be used in either hand diestocks or machine holders. The adjustment in the screw adjusting type is made by a fine-pitch screw which forces the sides of the die apart or allows them to spring together. The adjustment in the open adjusting types is made by means of three screws in the holder, one for expanding and two for compressing the dies. Round split adjustable dies are available in a variety of sizes to cut American Standard Coarse and Fine threads, special form threads, and for the standard sizes used in Britain and other European countries. For hand threading, these dies are held in diestocks (fig. 270). One type has three pointed screws that will hold round dies of any construction, although specificially made for open adjusting-type dies.

(2) *Two-piece collet dies.* A two-piece collet dies, as shown in figure 269, is used with a collet (fig. 270). The collet consists of a cap and a guide. The die halves are placed in the cap slot and are held in place by the guide which screws into the underside of the cap. The die is adjusted by means of setscrews at either end of the internal slot. This type of adjustable die is issued in various sizes to cover the cutting range of American Standard Coarse and Fine and special form threads. Diestocks (fig. 270) to hold collets are issued in three sizes.

(3) *Two-piece rectangular pipe dies.* Two-piece rectangular pipe dies (fig. 269) are available to cut American Standard Pipe Threads. They are held in ordinary or ratchet-type diestock. The jaws of the dies are adjusted by means of setscrews. An adjustable guide serves to keep the pipe in alinement with respect to the dies. The smooth jaws of the guide are adjusted by means of a cam plate; a thumbscrew locks the jaws firmly in the desired position (fig. 271). Nonratchet-type diestock and plain guides are also available for pipe threading (fig. 272).

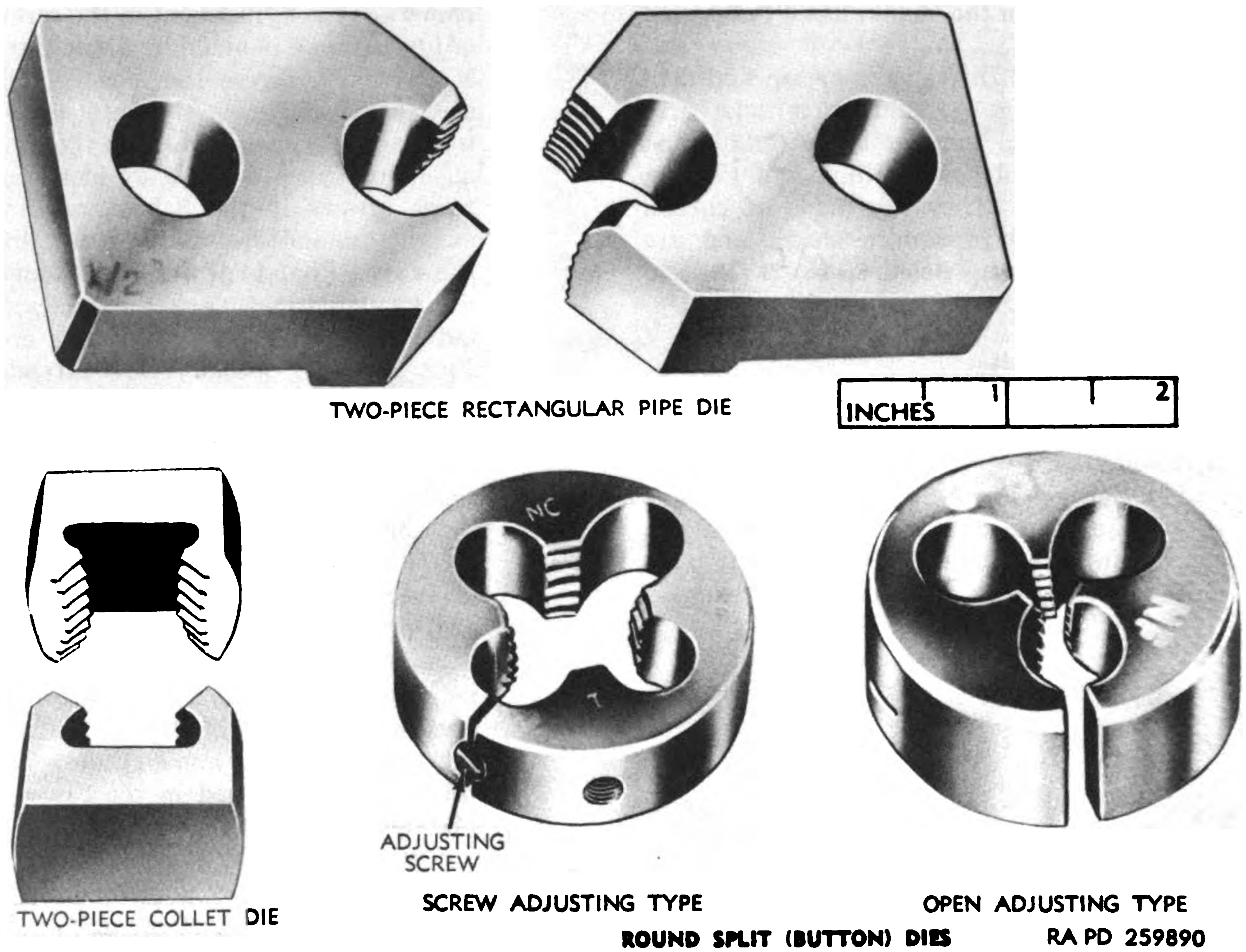


Figure 269. Types of adjustable dies.

226. Threading Sets

Threading sets are available in many different combinations of taps and dies, together with diestocks, tap wrenches, guides, and necessary screwdrivers and wrenches to loosen and tighten adjusting screws and bolts. Figure 272 illustrates typical threading sets for pipe bolts, and screws.

227. Mechanics of Taps and Dies

a. General. Taps and dies are manufactured of regular high-speed steel and surface treated high-speed steel. Surface treated high-speed steel taps have a secondary hardening which increases the hardness and wear resistance of the cutting edges without substracting from the toughness of the body of the tool as a whole.

b. Tap Design. A tap (figs. 266 and 267) is a threading tool designed to produce a completed internal thread and to make threading possible without a lead screw. A tap is basically a screw in which longitudinal channels or flutes are cut or ground. The flutes permit chips to escape and lubricants to reach the cutting area and threaded metal. Terms used when discussing taps are as indicated in (1) through (19) below (see fig. 273).

(1) *Axis of tap.* Longitudinal central through the tap.

(2) *Back taper.* A slight taper on the body of the tap which makes the pitch diameter of the thread near the shank somewhat larger than that close to the point. The pitch diameter equals outside diameter minus the single depth of the thread.

(3) *Body.* The threaded part of tap.

(4) *Chamfer.* The length at the front end of the threaded section, cut or ground tapered and relieved of teeth.

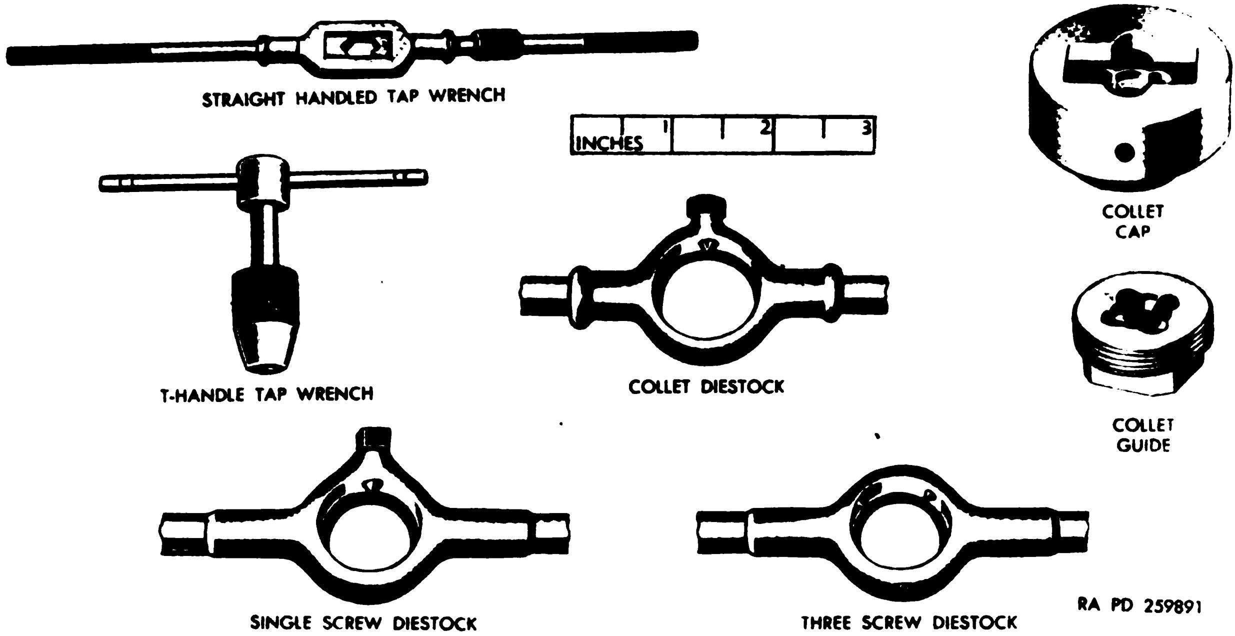


Figure 270. Diestocks, die collet, and tap wrenches.

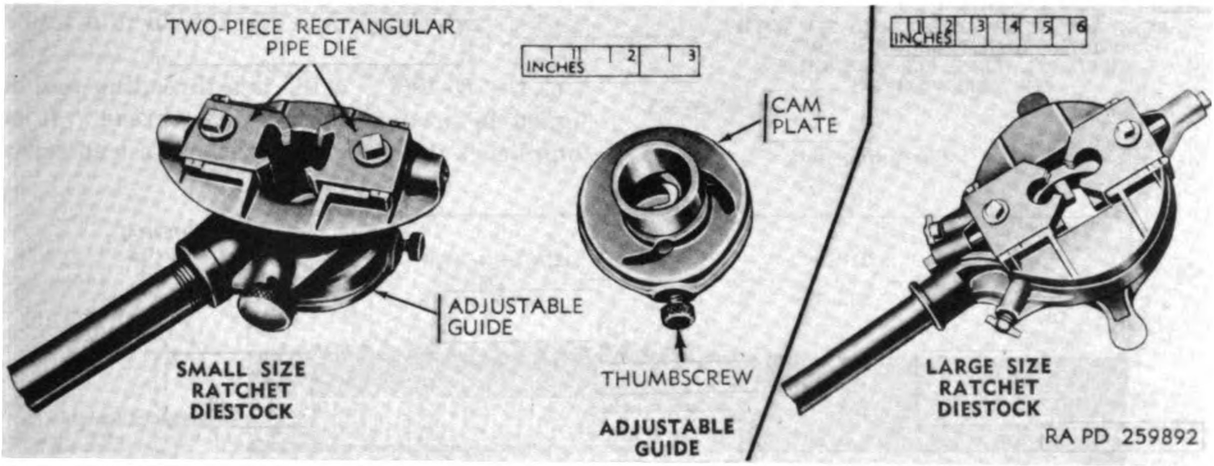


Figure 271. Adjustable die guide and ratchet diestocks.

(5) *Cutting face.* The leading side of the threaded part or land.

(6) *External center.* The cone-shaped front end of the tap. It is necessary for manufacturing purposes and usually at the threaded ends of small taps only.

(7) *Flute.* The portion cut away between the threaded parts or the lands.

(8) *Heel.* The noncutting or following side of the land.

(9) *Hook.* The curved cutting side of the flute. Used when tapping some materials.

(10) *Internal center.* The small drilled countersunk conical hole at the front end of the tap made for manufacturing purposes.

(11) *Interrupted thread.* Taps with every other tooth along the threaded part removed. Used on soft, stringy materials.

Figure 272. Threading sets.

(12) *Land.* The threaded part of the tap.

(13) *Point diameter.* The diameter at the leading end of the chamfered portion.

(14) *Radial.* The straight side of a flute which, if continued, would pass through the center of the tap.

(15) *Rake.* The angle of the cutting side of the flute in relation to an axial plane passing through the center of the tap.

(16) *Relief.* The condition whereby metal is removed from behind the cutting edge to produce clearance and reduce friction. Most taps have the chamfer relieved, but some may not have relief on the external diameter of the threads.

(17) *Shank.* The part behind the threaded section of the tap.

(18) *Square.* The length at the back end of the shank, of square cross section.

(19) *Thread.* The helical or spiral formed grooves and teeth of the tap, with intermittent deep longitudinal flutes, which produce the thread in a tapped hole.

c. Die Design. A die is a threading tool designed to produce an external thread. It accomplishes this operation without a lead screw.

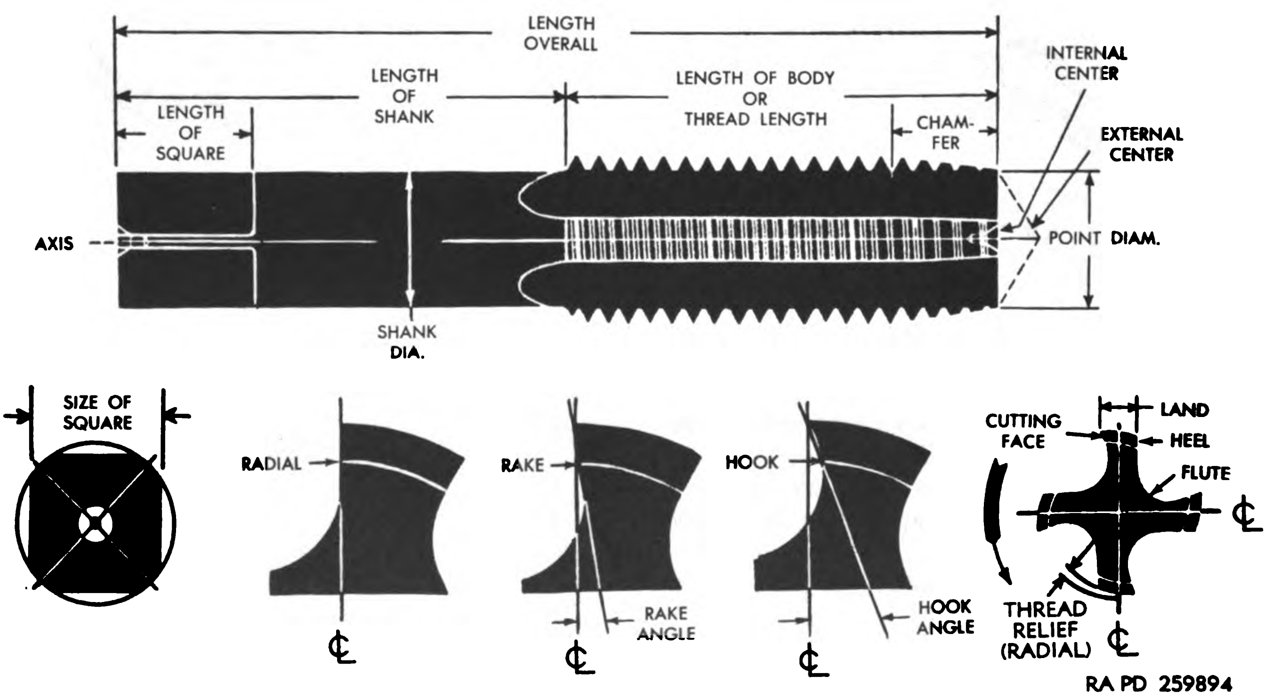


Figure 273. Tap terms.

A solid die (fig. 268) is basically a nut in which flutes have been machined at right angles to the threads, and which has been hardened to provide cutting edges. The round or button die (fig. 269) is actually an adjustable split nut. Two-piece dies (fig. 269) are machined separately. The number of threads in a die is much less than on a tap and the flutes have more of an exit for the escape of the chips of metal. A short chamfer on a die (fig. 274) is used for threading close to a shoulder. A long chamfer is used where two or three incomplete threads can be tolerated on the job to be threaded. Equal chamfering on a die provides balanced cutting. The terms usually used in connection with a die are indicated in figure 275. The standard chamfer for the front face of a straight thread die is 2 to 3 threads, or about 15°. The rear face in some dies is chamfered from 1 to 1½ threads. Standard taper thread dies have a front chamfer of 2 to 3 threads and none at the rear face. Long chamfers mean better threading performance.

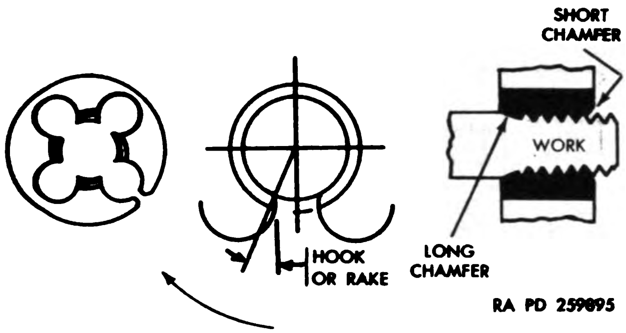


Figure 274. Die chamfers.

228. Use of Taps

a. Selecting a Tap-Drill. The size of a tap is the outside diameter of its threads; therefore, theoretically the hole drilled for tapping could be smaller than the tap by twice the depth of the thread if a full thread is cut. The shape of the thread partly determines the amount to be subtracted from the tap diameter. Figures 276 through 279 indicate the various thread dimensions of British and Metric screw thread standards, American pipe thread standards,

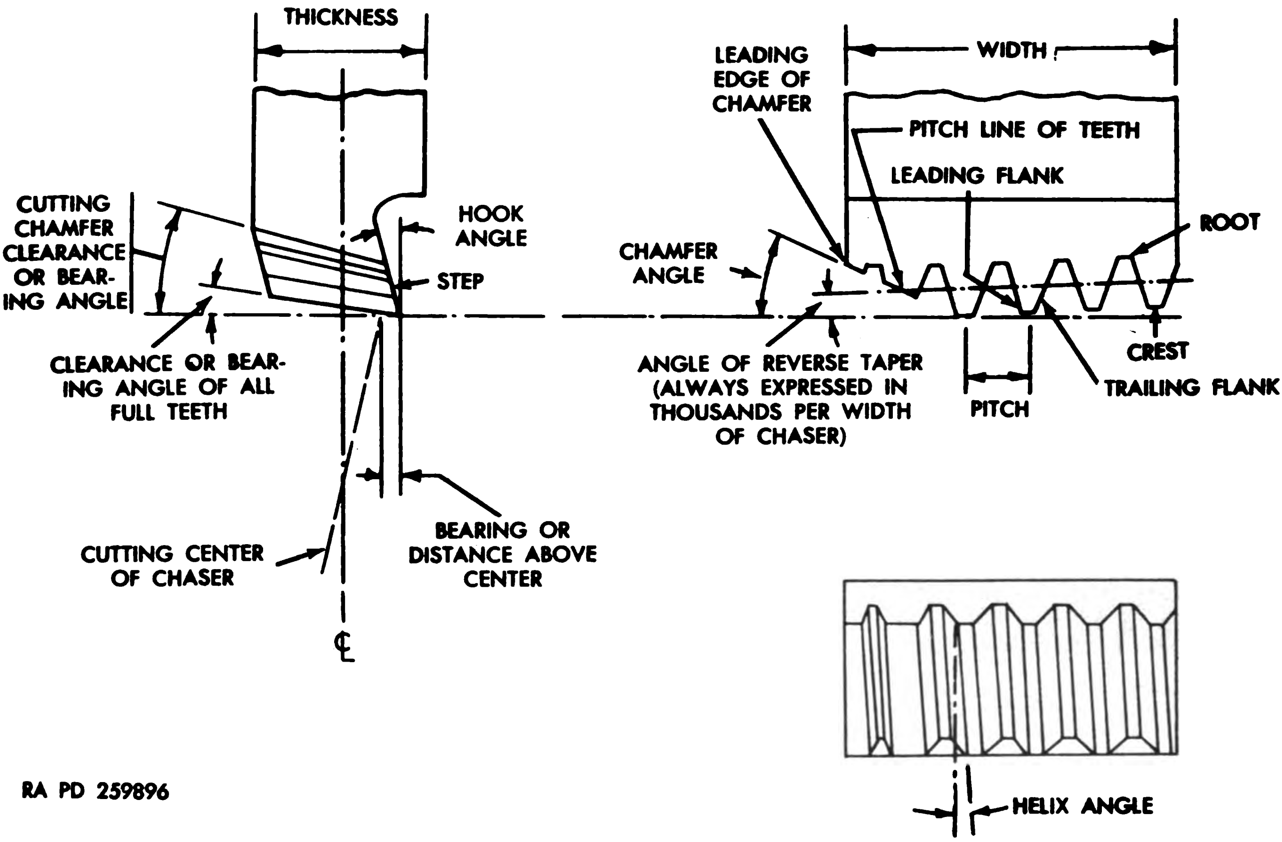
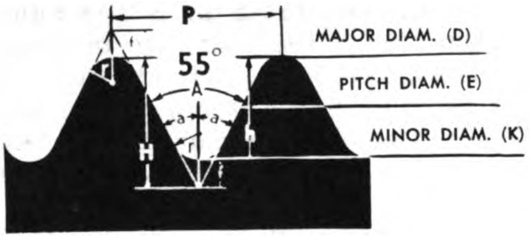


Figure 275. Die terms.

This form of thread is used almost exclusively in Great Britain and extensively in the British Dominions, Asia and South America. There are two standard series, the British Standard Whitworth which is a coarse thread series and the British Standard Fine. Threads of this form not included in the BSW and BSF series are designated simply Whitworth.



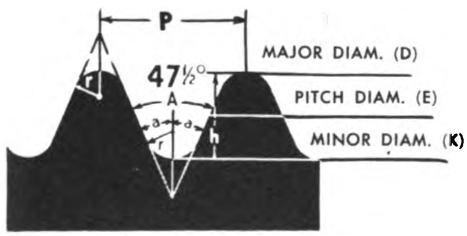
- A = 55° = Angle of thread
- a = 27½° = ½ Angle of thread
- f = 1/6H = Depth of truncation
- H = 0.960491p = Depth Theoretical V 55° thread
- h = 0.640327p, or 4/6H = Depth Whitworth form thread
- n = Number threads per inch
- p = 1/n = Pitch
- r = 0.137329p = Radius of crest and root

NOMINAL SIZE Inches	D MAJOR DIAM. Inches	E PITCH DIAM. Inches	K MINOR DIAM. Inches	COMMERCIAL TAP DRILL to Produce Approx. 75% Full Thread		
				Size	Dec. Equiv.	Actual Percent
1/16-60	.0625	.0518	.0412	3/64	.0468	72
3/32-48	.0938	.0804	.0671	5/64	.0781	58
1/8-40	.1250	.1090	.0930	3/32	.0937	96
5/32-32	.1563	.1362	.1162	1/8	.1250	77
3/16-24	.1875	.1608	.1341	9/64	.1406	87
7/32-24	.2188	.1921	.1654	11/64	.1718	86
1/4-20	.2500	.2180	.1860	13/64	.2031	72
26	.2500	.2254	.2008	7/32	.2187	63
9/32-26	.2813	.2566	.2320	1/4	.2500	62
5/16-18	.3125	.2769	.2414	17/64	.2656	65
22	.3125	.2834	.2543	17/64	.2656	79
3/8-16	.3750	.3350	.2950	5/16	.3125	77
20	.3750	.3430	.3110	21/64	.3281	72
7/16-14	.4375	.3918	.3460	3/8	.3750	67
18	.4375	.4019	.3665	25/64	.3906	65
1/2-12	.5000	.4466	.3933	27/64	.4218	81
16	.5000	.4600	.4200	7/16	.4375	77
9/16-12	.5625	.5091	.4558	31/64	.4844	72
16	.5625	.5225	.4825	1/2	.5000	77
5/8-11	.6250	.5668	.5086	17/32	.5312	79
14	.6250	.5793	.5336	9/16	.5625	67

NOMINAL SIZE Inches	D MAJOR DIAM. Inches	E PITCH DIAM. Inches	K MINOR DIAM. Inches	COMMERCIAL TAP DRILL to Produce Approx. 75% Full Thread		
				Size	Dec. Equiv.	Actual Percent
11/16 11	.6875	.6293	.5711	19/32	.5937	79
14	.6875	.6418	.5961	5/8	.6250	67
3/4-10	.7500	.6860	.6219	21/32	.6562	73
12	.7500	.6966	.6434	43/64	.6719	72
7/8- 9	.8750	.8039	.7327	49/64	.7656	76
11	.8750	.8168	.7586	25/32	.7812	79
1- 8	1.0000	.9200	.8399	7/8	.8750	77
10	1.0000	.9360	.8720	29/32	.9062	72
1 1/8- 7	1.1250	1.0335	.9420	63/64	.9843	76
9	1.1250	1.0539	.9828	1 1/64	1.0156	76
1 1/4- 7	1.2500	1.1585	1.0670	1 7/64	1.1093	76
9	1.2500	1.1789	1.1078	1 9/64	1.1406	76
1 3/8- 6	1.3750	1.2683	1.1616	1 7/32	1.2187	72
8	1.3750	1.2950	1.2150	1 1/4	1.2500	77
1 1/2- 6	1.5000	1.3933	1.2866	1 11/32	1.3437	72
8	1.5000	1.4200	1.3400	1 3/8	1.3750	77
1 5/8- 5	1.6250	1.4969	1.3689	1 7/16	1.4375	72
1 3/4- 5	1.7500	1.6219	1.4939	1 9/16	1.5625	72
1 7/8- 4 1/2	1.8750	1.7327	1.5904	1 21/32	1.6562	76
2- 4 1/2	2.0000	1.8577	1.7154	1 25/32	1.7812	76

BRITISH ASSOCIATION STANDARD

This thread is the standard used in the manufacture of small machine screws in Great Britain, and, to some extent, in other countries of Europe. It is sometimes called the Swiss Small Screw Thread system, owing to its origin in the Swiss watch and clockmaking industries.



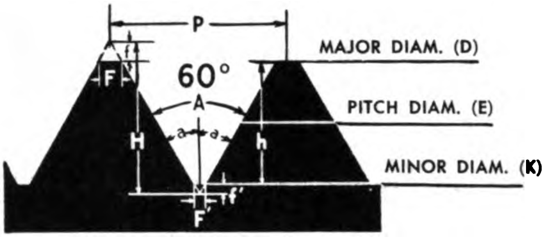
- A = 47½° = Angle of thread
- a = 23¾° = ½ Angle of thread
- h = 0.600p = Depth British Association Thread
- p = Pitch
- r = 2/11p = Radius of crest and root

SIZE No.	PITCH mm	D MAJOR DIAM. mm	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. Full Thread mm
0	1.00	6.0	5.400	4.80	4.9
1	.90	5.3	4.760	4.22	4.4
2	.81	4.7	4.215	3.73	3.9
3	.73	4.1	3.660	3.22	3.5
4	.66	3.6	3.205	2.81	3.0
5	.59	3.2	2.845	2.49	2.7
6	.53	2.8	2.480	2.16	2.3
7	.48	2.5	2.210	1.92	2.0
8	.43	2.2	1.940	1.68	1.8
9	.39	1.9	1.665	1.43	1.5
10	.35	1.7	1.490	1.28	1.3
11	.31	1.5	1.315	1.13	1.2
12	.28	1.3	1.130	.96	1.0
14	.23	1.0	.860	.72	.7

RA PD 259897

Figure 276. British thread dimensions.

This thread form is similar to the American National thread form. It is generally designated in two standards, the International Standard and the French Standard, and is used mostly in Continental European countries.



A = 60° = Angle of thread
a = 30° = $\frac{1}{2}$ Angle of thread
F = $\frac{1}{8}$p = Flat at crest
F' = $\frac{1}{16}$p = Flat at root
f = $\frac{1}{8}$H = Depth of truncation at crest
f' = $\frac{1}{16}$H = Depth of truncation at root
H = 0.866025p = Depth of theoretical sharp V thread
h = 0.70365p, or $\frac{13}{16}$H = Depth Metric form thread
p = Pitch

D NOMINAL SIZE	PITCH French Std.	PITCH Int. Std. (D.I.N.)	PITCH Op-tional	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. 75% Full Thread mm	D NOMINAL SIZE	PITCH French Std.	PITCH Int. Std. (D.I.N.)	PITCH Op-tional	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. 75% Full Thread mm
1.5	..	..	.35	1.273	1.05	1.1	13	..	..	1.75	11.863	10.73	11.5
2	..	.40	..	1.740	1.48	1.6	13	..	..	2.00	11.701	10.40	11.0
2	.45	..	..	1.708	1.42	1.5	14	..	..	1.25	13.188	12.38	13.0
2	..	..	.50	1.675	1.35	1.5	14	..	..	1.75	12.863	11.73	12.5
2.3	..	.40	..	2.040	1.78	1.9	14	2.00	2.00	..	12.701	11.40	12.0
2.5	.45	..	..	2.208	1.92	2.0	15	..	..	1.75	13.863	12.73	13.5
2.6	..	.45	..	2.308	2.02	2.1	15	..	..	2.00	13.701	12.40	13.0
3	..	.50	..	2.675	2.35	2.5	16	2.00	2.00	..	14.701	13.40	14.0
3	.60	..	..	2.610	2.22	2.4	17	..	..	2.00	15.701	14.40	15.0
3	..	..	.75	2.513	2.03	2.25	18	..	..	1.50	17.026	16.05	16.5
3.5	.60	.60	..	3.110	2.72	2.9	18	..	..	2.00	16.701	15.40	16.0
4	..	.70	..	3.545	3.09	3.3	18	2.50	2.50	..	16.376	14.75	15.5
4	.75	..	..	3.513	3.03	3.25	19	..	..	2.50	17.376	15.75	16.5
4.5	.75	.75	..	4.013	3.53	3.75	20	..	..	2.00	18.701	17.40	18.0
5	..	..	.75	4.513	4.03	4.25	20	2.50	2.50	..	18.376	16.75	17.5
5	..	.80	..	4.480	3.96	4.2	22	2.50	2.50	..	20.376	18.75	19.5
5	.90	..	..	4.415	3.83	4.1	24	3.00	3.00	..	22.051	20.10	21.0
5	..	..	1.00	4.350	3.70	4.0	26	3.00	..	..	24.051	22.10	23.0
5.5	..	..	.75	5.013	4.53	4.75	27	..	3.00	..	25.051	23.10	24.0
5.5	.90	.90	..	4.915	4.33	4.6	28	3.00	..	..	26.051	24.10	25.0
6	1.00	1.00	..	5.350	4.70	5.0	30	3.50	3.50	..	27.727	25.45	26.5
6	..	..	1.25	5.188	4.38	4.8	32	3.50	..	..	29.727	27.45	28.5
7	1.00	1.00	..	6.350	5.70	6.0	33	..	3.50	..	30.727	28.45	29.5
7	..	..	1.25	6.188	5.38	5.8	34	3.50	..	..	31.727	29.45	30.5
8	..	..	1.00	7.350	6.70	7.0	36	4.00	4.00	..	33.402	30.80	32.0
8	1.25	1.25	..	7.188	6.38	6.8	38	4.00	..	..	35.402	32.80	34.0
9	..	..	1.00	8.350	7.70	8.0	39	..	4.00	..	36.402	33.80	35.0
9	1.25	1.25	..	8.188	7.38	7.8	40	4.00	..	..	37.402	34.80	36.0
10	..	..	1.25	9.188	8.38	8.8	42	4.50	4.50	..	39.077	36.15	37.0
10	1.50	1.50	..	9.026	8.05	8.6	44	4.50	..	..	41.077	38.15	39.0
11	..	1.50	..	10.026	9.05	9.6	45	..	4.50	..	42.077	39.15	40.0
12	..	..	1.25	11.188	10.38	11.0	46	4.50	..	..	43.077	40.15	41.0
12	..	..	1.50	11.026	10.05	10.5	48	5.00	5.00	..	44.752	41.50	43.0
12	1.75	1.75	..	10.863	9.73	10.5	50	5.00	..	..	46.752	43.50	45.0
13	..	..	1.50	12.026	11.05	11.5							

RA PD 259898

Figure 277. Metric standard threads.

and the tap drill size required for each thread. Do not use a tap drill that is too small in diameter, as this will cause tapping troubles. A drilled hole should be of sufficient diameter to produce a thread depth of approximately 75 percent. This 75 percent is only an average. Actually, the percentage may vary from 50 to 53 percent for small or deep holes, to a maximum of 83 percent on any size. A definite thread depth for all sizes, under all conditions, is not practical. You must determine which is most suitable by analyzing the following conditions: diameter of tapped hole, nature of material being tapped, depth of tapped hole, and the pitch.

(1) *Diameter and pitch of tapped hole.* The coarser the pitch, the larger is the thread depth if a full thread were cut. Try a drill giving 75 percent thread depth first. If tap breakage results, reduce the thread depth gradually by using larger drills until satisfactory performance is obtained.

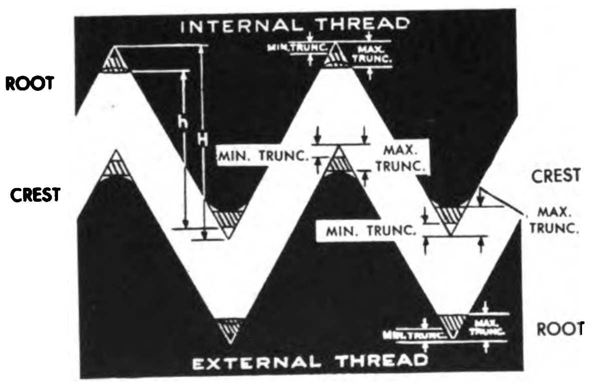
Note. A nut with only 50 percent thread depth will break the bolt before it strips the thread.

American Standard screw threads are standardized in two series, coarse and fine. As a tap size becomes smaller, the percentage of double thread depth in relation to basic major diameter of the screw generally becomes larger.

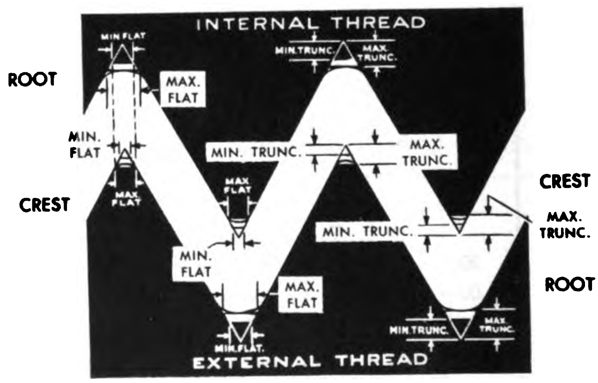
Basic major diameter	*% Double thread depth* Coarse	*Fine*
1.0 inch	16	9
0.750 inch	17	11
0.500 inch	20	13
0.375 inch	22	14
0.250 inch	26	19
No. 5 machine screw	26	24

(2) *Nature of material being tapped.* Soft metals such as copper, aluminum, monel metal, nickel silver, and the low melting point alloys have a tendency to flow towards the root of the minor diameter of the tap while being tapped. The minor diameter of tapped holes in such material will be smaller after tapping. Take this into

AMERICAN STANDARD PIPE THREADS—NPT



AMERICAN STANDARD DRYSEAL PIPE THREADS—NPTF



LIMITS ON CREST AND ROOT OF EXTERNAL AND INTERNAL PIPE THREADS—INCHES

THREADS Per Inch		DEPTH SHARP V THREAD H	STANDARD TAPER PIPE THREAD					DRYSEAL PIPE THREAD			
			Depth Taper Pipe Thread "Max" h	Truncation		Equivalent Width of Flat		Truncation		Equivalent Width of Flat	
				Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
27	Crest	.03208	.02963	.0012	.0036	.0014	.0041	.0017	.0035	.0020	.0040
	Root			.0012	.0036	.0014	.0041	.0035	.0052	.0040	.0060
18	Crest	.04811	.04444	.0018	.0049	.0021	.0057	.0026	.0043	.0030	.0050
	Root			.0018	.0049	.0021	.0057	.0043	.0061	.0050	.0070
14	Crest	.06186	.05714	.0024	.0056	.0027	.0064	.0026	.0043	.0030	.0050
	Root			.0024	.0056	.0027	.0064	.0043	.0061	.0050	.0070
11 ½	Crest	.07531	.06957	.0029	.0063	.0033	.0073	.0035	.0052	.0040	.0060
	Root			.0029	.0063	.0033	.0073	.0052	.0078	.0060	.0090
8	Crest	.10825	.10000	.0041	.0078	.0048	.0090	.0052	.0069	.0060	.0080
	Root			.0041	.0078	.0048	.0090	.0069	.0095	.0080	.0110

Note: The major diameter of standard taper pipe plug gages and the minor diameter of standard taper pipe ring gages used for gaging dryseal threads will be truncated .20p minimum or .25p maximum for all pitches.

RA PD 259899

Figure 278. American standard and dryseal pipe threads.

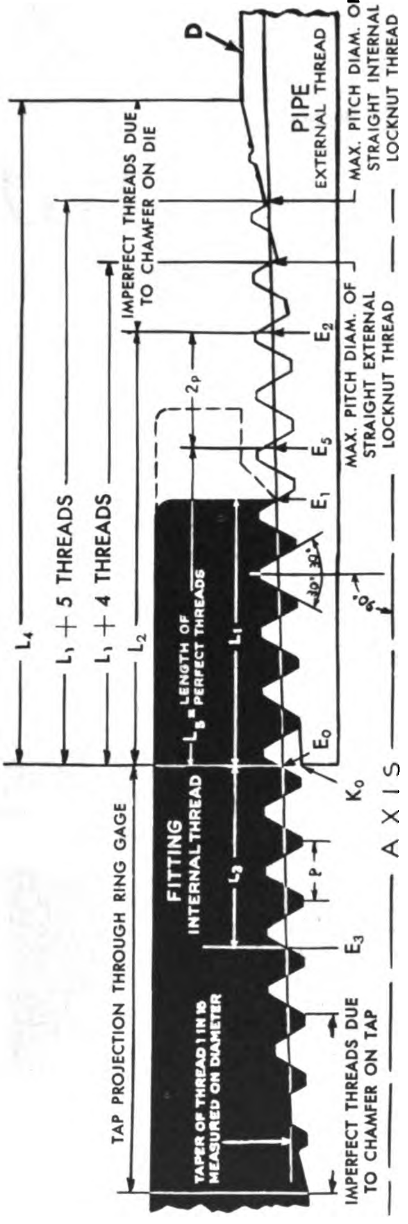
Maximum depth of pipe thread $= \frac{.8}{n}$

Basic major diam. plug gage $= E_1$ plus $\frac{.666}{n}$

Basic minor diam. ring gage $= E_1$ minus $\frac{.666}{n}$

Minimum pitch diameter of straight internal locknut thread $= E_1$ plus $\frac{.3125}{n}$

Maximum pitch diameter of straight external locknut thread $= E_1$ plus $\frac{.250}{n}$



Basic Dimensions of Taper Pipe Threads — Inches

PIPE SIZE		PITCH		HAND TIGHT ENGAGEMENT		EFFECTIVE THREAD OR WRENCH MAKEUP				TOTAL LENGTH OF THREAD	PERFECT THREADS		SMALL END OF PIPE		INCREASE IN DIAMETER PER THREAD $\frac{0.0625}{n}$	*TAP DRILL SIZES
						External		Internal								
Nominal	Outside Diameter	Threads per Inch	Length	Length, also Thickness of Thin Ring Gage and Distance from Gaging Notch to Small End of Plug Gage	Basic Pitch Diam., also Pitch Diam. at Gaging Notch, also Basic Pitch Diam. of Straight Pipe Thread	Length, also Length of Plug Gage	Pitch Diameter	Length Wrench Makeup	Pitch Diameter at Small End		Length	Pitch Diameter of Largest External	Pitch Diameter	Basic Minor Diameter		
..	D	n	p	L_1	E_1	L_2	E_2	L_3	E_3	L_4	L_5	E_5	E_0	K_0	..	..
1/16	.3125	27	.03704	.160	.28118	.2611	.28750	.1111	.26424	.3896	.1870	.28287	.27118	.2416	.00231	..
1/8	.405	27	.03704	.180	.37476	.2639	.38000	.1111	.35656	.3924	.1898	.37537	.36351	.3339	.00231	R
1/4	.540	18	.05556	.200	.48989	.4018	.50250	.1667	.46697	.5946	.2907	.49556	.47739	.4329	.00347	7/16
3/8	.675	18	.05556	.240	.62701	.4078	.63750	.1667	.60160	.6006	.2967	.63056	.61201	.5676	.00347	37/64
1/2	.840	14	.07143	.320	.77843	.5337	.79179	.2143	.74504	.7815	.3909	.78286	.75843	.7013	.00446	23/32
3/4	1.050	14	.07143	.339	.98887	.5457	1.00179	.2143	.95429	.7935	.4029	.99286	.96768	.9105	.00446	59/64
1	1.315	11 1/2	.08696	.400	1.23863	.6828	1.25630	.2609	1.19733	.9845	.5088	1.24543	1.21363	1.1441	.00543	1 5/32
1 1/4	1.660	11 1/2	.08696	.420	1.58338	.7068	1.60130	.2609	1.54083	1.0085	.5329	1.59043	1.55713	1.4876	.00543	1 1/2
1 1/2	1.900	11 1/2	.08696	.420	1.82234	.7235	1.84130	.2609	1.77978	1.0252	.5496	1.83043	1.79609	1.7265	.00543	1 47/64
2	2.375	11 1/2	.08696	.436	2.29627	.7565	2.31630	.2609	2.25272	1.0582	.5826	2.30543	2.26902	2.1995	.00543	2 7/32
2 1/2	2.875	8	.12500	.682	2.76216	1.1375	2.79062	.250	2.70391	1.5713	.8875	2.77500	2.71953	2.6195	.00781	2 5/8
3	3.500	8	.12500	.766	3.38850	1.2000	3.41562	.250	3.32500	1.6337	.9500	3.40000	3.34062	3.2406	.00781	3 1/4
3 1/2	4.000	8	.12500	.821	3.88881	1.2500	3.91562	.250	3.82188	1.6837	1.0000	3.90000	3.83750	3.7375	.00781	3 3/4
4	4.500	8	.12500	.844	4.38712	1.3000	4.41562	.250	4.31875	1.7337	1.0500	4.40000	4.33438	4.2344	.00781	4 1/4
5	5.563	8	.12500	.937	5.44929	1.4063	5.47862	.250	5.37511	1.8407	1.1563	5.46300	5.39073	5.2907	.00781	..
6	6.625	8	.12500	.958	6.50597	1.5125	6.54062	.250	6.43047	1.9467	1.2625	6.52500	6.44609	6.3461	.00781	..
8	8.625	8	.12500	1.063	8.50003	1.7125	8.54062	.250	8.41797	2.1467	1.4625	8.52500	8.43359	8.3336	.00781	..
10	10.750	8	.12500	1.210	10.62094	1.9250	10.66562	.250	10.52969	2.3587	1.6750	10.65000	10.54531	10.4453	.00781	..
12	12.750	8	.12500	1.360	12.61781	2.1250	12.66562	.250	12.51719	2.5587	1.8750	12.65000	12.53281	12.4328	.00781	..

* Methods of inspection vary. Care should be taken to use a tap drill or taper reamer which can meet thread specifications. Sizes given permit direct tapping without reaming the hole, but only give a full thread for the first two or three threads. See columns K_0 and L_5.

RA PD 259900

Figure 279. Basic dimensions of taper pipe threads.

consideration when selecting the tap-drill of sufficient size. Use the smallest thread depth possible on materials that are very tough or of high hardness. This is accomplished by using the largest drill possible, which nevertheless will be smaller than the one used for softer materials, under similar circumstances.

(3) *Depth of tapped hole.* Larger tap

drills giving 50 percent thread depth may be used when holes are deeper than 1½ times the tap diameter. Punched holes often cause binding and tap breakage, especially in thin sheet metal, which creates an "oilcan" effect. When the hole is punched, the metal is flared out. As the tap is reversed after threading, it draws in this flare and binds. Consider this when selecting punch size. The larger the punched hole, the less tendency for the tap to bind. Holes formed in castings and forgings should be checked for 75 percent depth, and reamed to size if necessary before tapping.

b. Tapping a Hole.

(1) After the proper size and type hole (fig. 280) is drilled and cleaned, secure the tap in a tap wrench (fig. 270).

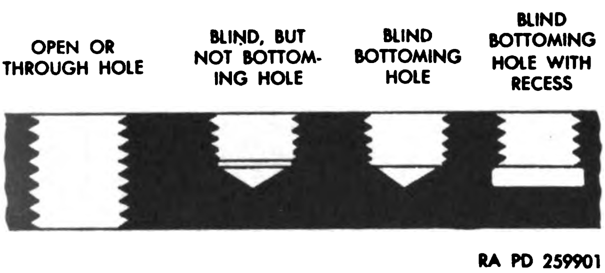


Figure 280. Types of drilled holes.

(2) Apply cutting oil to the tap and to the hole. Place the point of the tap in the hole and rotate the tap (fig. 281) clockwise for right-hand threads and counterclockwise for left-hand threads.

(3) Check the tap for straightness in the hole by using a square, as shown in figure 282. Check to see that the tap is in line with the axis of the hole and at right angles to the face of the work. Check at more than one position around the tap.

(4) It is not necessary to feed the tap into the hole with any pressure, as the threads will pull it in at the proper rate. Keep the tap straight ((3) above).

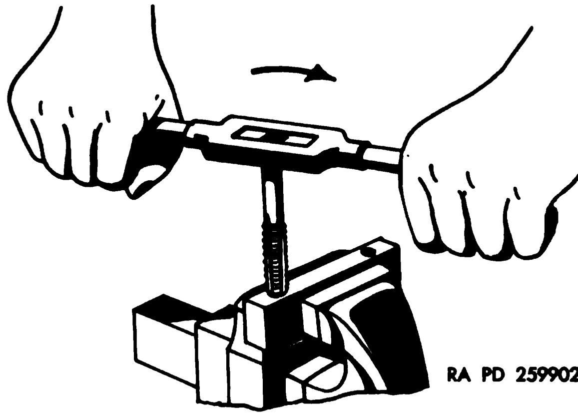


Figure 281. Using a tap and tap wrench.

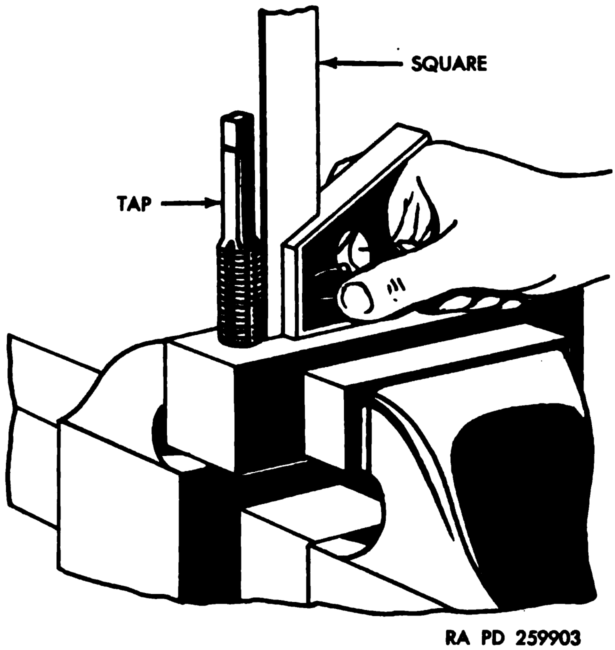


Figure 282. Checking tap for straightness.

(5) When tapping rough material, after each half turn of the tap in a forward or cutting direction, rotate the tap a quarter turn back, then a half turn forward, then a quarter turn back, etc., until the hole is tapped. Use pure lard cutting oil to keep the tap well lubricated when tapping.

(6) If the hole to be tapped is a blind hole (fig. 280), use a plug tap and finally a bottoming tap (fig. 266) to complete the tapping operation. A bottoming hole is one in which the thread has been tapped as far as the bottom.

Use extreme caution to keep the taps from being forced against the bottom of the hole. Check cut threads with the proper screw pitch gage (fig. 96)

229. Use of Dies

a. General. The general procedure for cutting threads by hand is as described in (1) through (7) below.

(1) Make certain the work to be threaded is clean and free from burs.

(2) Secure the work firmly in a vise (fig. 283).

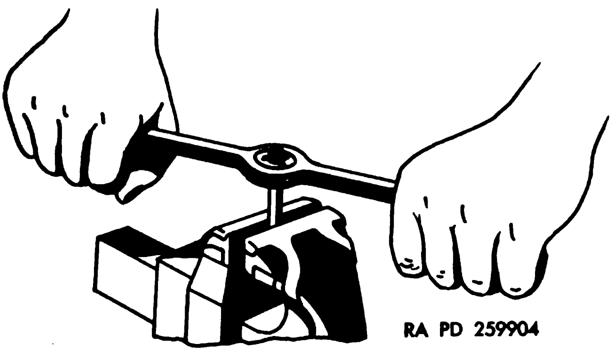


Figure 283. Using a die and diestock.

(3) See that the die is held firmly in the diestock. Set an adjustable die to the desired size before securing it in the diestock.

(4) Drop some cutting oil on the work and the die and position the chamfer of the front face of the die (side with the longest chamfer) squarely on the work.

(5) Rotate the die slowly, but firmly, until the threads take hold. After cutting several threads, stop to determine if the die is square with the work. Use a try square or suitable tool to check squareness.

(6) Turn the die back a quarter turn after each forward full turn to prevent teeth from breaking off and for ease of threading.

Note. When threading hard materials, use cutting oil liberally.

(7) Back the die off the newly cut thread carefully and check the cut threads with the proper screw pitch gage (fig. 96).

b. Adjustment for Pitch Diameter. The diestock (fig. 270) for holding round split open adjusting dies (fig. 269) has three screws. A fine pitch screw in this diestock enters the split in the die and forces the sides apart and the other two screws are on the opposite side for compressing. A single screw diestock (fig. 270) is used to hold dies of the round split screw adjusting type (fig. 269), that are provided with an adjusting screw which forces the sides apart or allows them to spring together, although this type die will fit in a three screw diestock as well. Two-piece rectangular dies (fig. 269) are adjusted by the setscrews at either end of the diestock (figs. 271 and 272) or of the slot in the collet (fig. 270) in which they are placed.

c. Threading Pipe. The procedure for threading pipe is as described in (1) through (12) below.

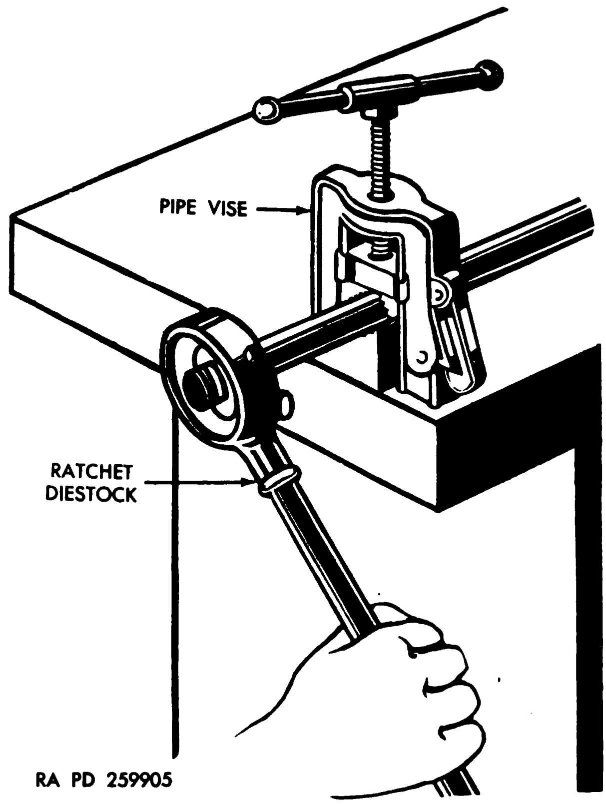


Figure 284. Threading pipe.

(1) Lock the pipe securely in a pipe vise (fig. 284).

(2) Inspect the dies to see that they are sharp and free from nicks.

(3) Assemble two-piece rectangular pipe die (fig. 269) on adjustable die guide and ratchet diestock (fig. 271).
(4) Set the die to the desired size.
(5) Apply cutting oil to cutting edges of die and to the pipe to prevent overheating of dies and marring of the cut threads.
(6) Place diestock on the pipe and push lightly with the heel of your hand until the die is up against the end of the pipe. Adjust guide to admit pipe by loosening thumbscrew (fig. 271); rotate cam plate until guide fits pipe; tighten thumbscrew after adjustment.
(7) Rotate the diestock clockwise a few short strokes to start the cut. Lock ratchet and pump handle up and down several strokes (fig. 284.
(8) Reoil die.
(9) Reverse ratchet and stroke frequently to free die of chips.
(10) Thread pipe until threaded end of pipe projects ¼ to ½ inch from diestock.
(11) After threading, set ratchet for reverse operation and back off die.
(12) Check for proper length of threaded pipe. For determining the length of threaded pipe for standard fittings and couplings for various size pipe, refer to table II.

Table II. Pipe Thread Data for Standard Pipe

Size of pipe (in.)	O.D. Inches	Number of threads per inch	Total length of threads (in.)
¼	0.540	18	⅝
⅜	0.675	18	⅝
½	0.840	14	13/16
¾	1.050	14	13/16
1	1.315	11½	1
1¼	1.660	11½	1
1½	1.900	11½	1
2	2.375	11½	1 1/16
2½	2.875	8	1 9/16
3	3.500	8	1⅝
4	4.500	8	1¾
5	5.563	8	1 13/16
6	6.625	8	1 15/16

230. Care of Taps and Dies

a. Maintenance. Do not attempt to sharpen taps or dies. Sharpening of taps and dies involves several highly precision cutting processes where the thread characteristics, chamfer angle, and in some cases the hook angle, and spiral point are involved. These cutting procedures must be accomplished by experienced personnel in order to maintain the accuracy and the cutting effectiveness of taps and dies.

b. Cleaning. Keep taps and dies clean and well oiled when not in use. Store them so that they do not contact each other or other tools.

c. Storage. For long periods of storage, coat taps and dies with a rust-preventive compound; place in individual or standard threading set boxes in a dry place.

Section XIII. THREAD CHASERS

231. Purpose of Thread Chasers (fig. 285)

Thread chasers are used to rethread damaged external or internal threads.

232. Types of Thread Chasers

Thread chasers (fig. 285) are threading tools that have several teeth. These tools are available to chase threaded parts having standard threads. The internal thread chaser has its cutting teeth located on a side face. The external thread chaser has its cutting teeth on the end of the shaft. The handle end of the tool shaft tapers to a point.

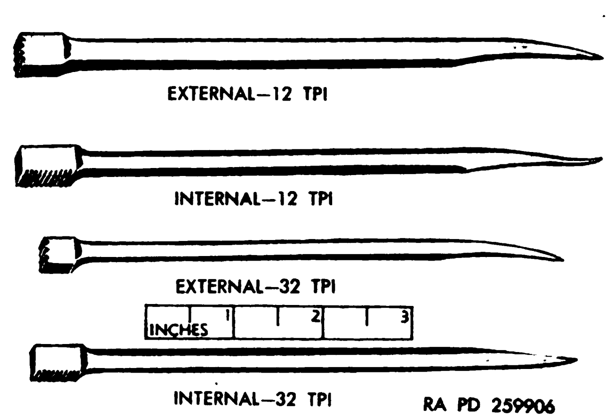


Figure 285. Thread chasers.

233. Use of Thread Chasers

Select the proper thread chaser for the job. You must know the number of threads per inch on the work. Simply use a rule to measure off a distance and count the threads in the measured distance. If screw pitch gages are available use them to determine the number of threads per inch. Secure the work securely in a vise or hold the work in one hand. Hold the chaser in the other hand and run it around the threaded section. Hold chaser firmly so that the cutting teeth are parallel to the threads in the work, as shown in figure 286. The cutting action will follow the previously cut threads and restore the damaged portion.

234. Care of Thread Chasers

Never attempt to sharpen thread chasers yourself, as this is a highly specialized cutting process and involves precision work on hard tool steel of a shape altogether not suited for simple stroking on an oilstone. Store chasers carefully when not in use. Coat with a light film of oil and rack individually so that the cutting edges do not touch other metal. For long periods of storage, coat chasers with a rust-preventive compound and store in a dry place.

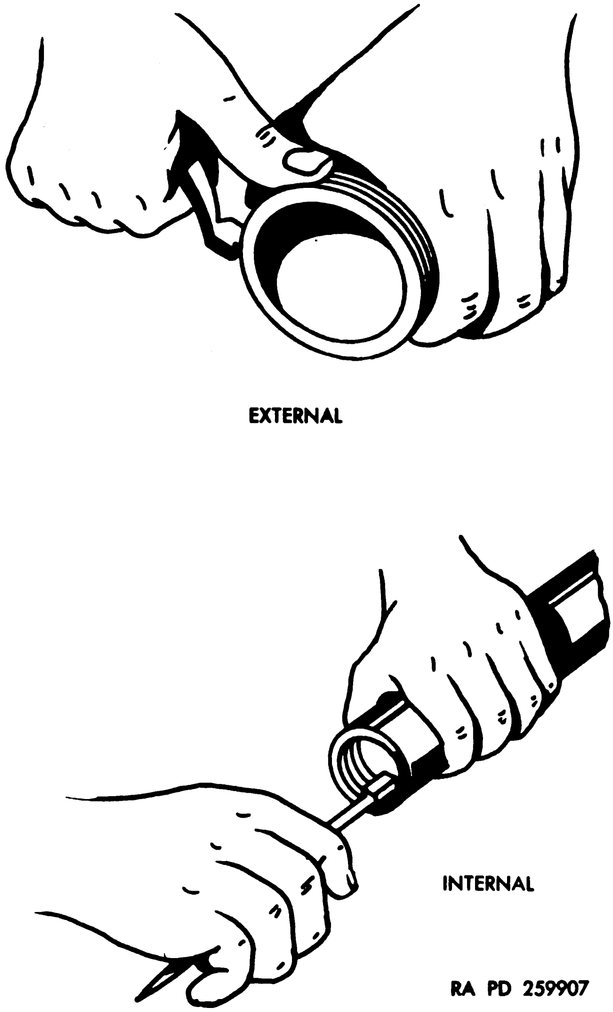


Figure 286. Using thread chasers.

Section XIV. SCREW AND TAP EXTRACTORS

235. Purpose of Extractors (fig. 287)

Screw extractors are used to remove broken screws without damaging the surrounding material or the threaded hole. Tap extractors are used to remove broken taps.

236. Types of Extractors

a. Screw Extractors. Some screw extractors (fig. 287) are straight, having flutes from end to end. These extractors are used with twist drills, drill guide, and turn nut. This type is issued in sizes to remove screws having ¼ to ½ inch outside diameter. This type is also issued in a set inclosed in a metal case. Spiral tapered extractors are also available in sets that include twist drills. Spiral tapered extractors are sized to remove screws and bolts from $\frac{3}{16}$ inch to 2⅛ inches outside diameter.

b. Tap Extractors. Tap extractors are similar to the screw extractors and are sized to remove taps ranging from $\frac{3}{16}$ to 2⅛ inches outside diameter.

237. Use of Extractors

a. Before using an extractor, make certain broken chips of screws, bolts, or taps are removed from the hole. A sharp pointed tool, such as a scriber or a small brush may be used for this purpose.

b. The use of the straight fluted-type extractor (fig. 288) requires that a well centered

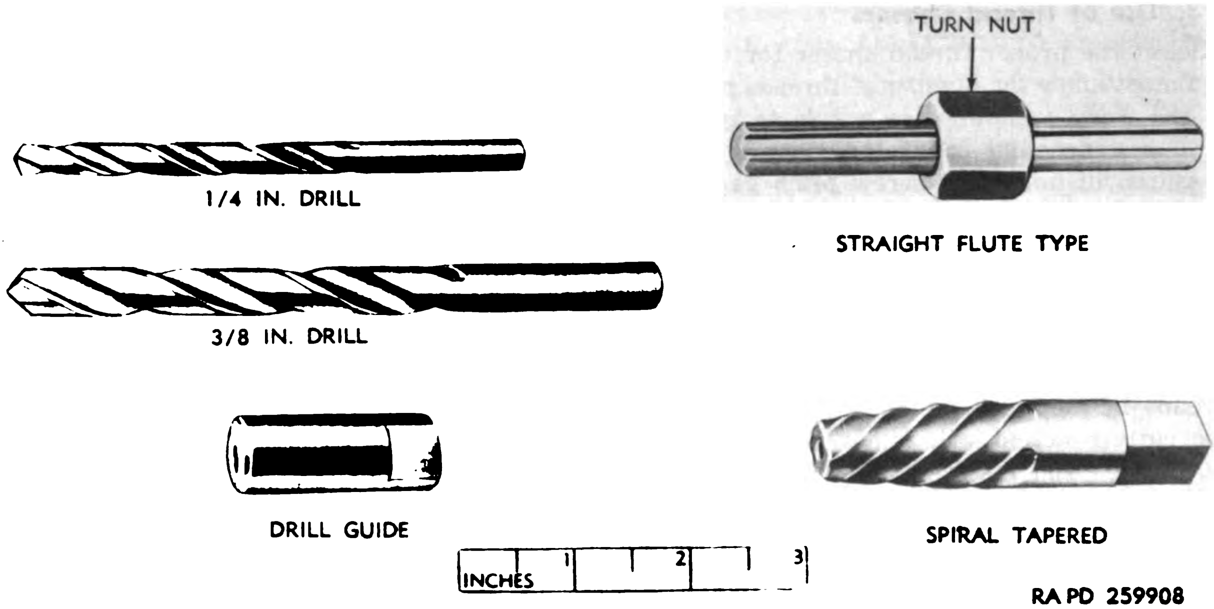


Figure 287. Screw and tap extractors.

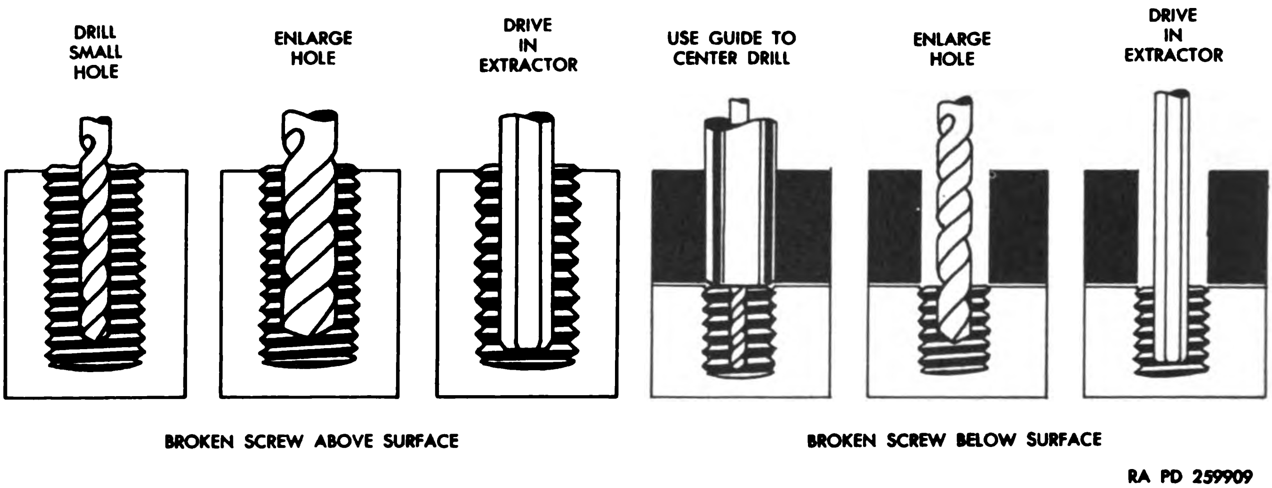


Figure 288. Using straight fluted tap and screw extractor.

small hole be drilled in the broken unit first. Enlarge the hole to receive the extractor tool. The correct drill size is one size less than the extractor size to be used.

c. Drive the extractor into the hole; slip the turn nut over the extractor, turn it counterclockwise, and turn out the broken unit. The flukes will grip the walls of the drilled unit and remove it without damaging the threads of the tapped hole.

d. For screws or taps that are broken off below the surface, use the correct sized guide to center the drill before drilling the first small hole (fig. 288). Enlarge the hole as before. Remove drill and insert extractor into the hole. Slip the turn nut over the extractor and turn out the broken screw or tap.

e. When using a spiral tapered extractor (fig. 289), drill a hole in the broken unit slightly smaller than the diameter of the extractor. Insert the extractor into the hole and turn it counterclockwise.

f. A tap wrench may be used on spiral tapered extractors and a standard open-end wrench on the turn nut of the straight fluted extractor.

238. Precautions

a. Make certain to select the proper size extractor for the job.

b. Never attempt to drill a hole in the broken screw or tap without first centering the drill. Use a drill guide, whenever possible.

c. Avoid using too much pressure when backing out the broken screw or tap. Do not apply too much leverage with the wrench as this will break off the extractor.

239. Care of Extractors

Keep extractors clean at all times. When not in use, coat with a light film of oil and place in their case or box or store separately so that they do not contact other tools or metal. For long periods of storage, coat with rust-preventive compound and store in a dry place.

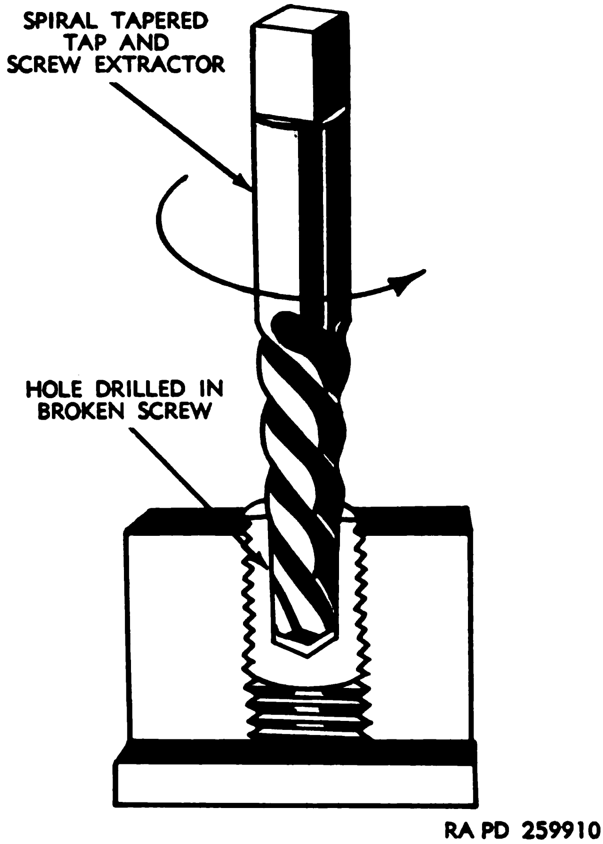


Figure 289. Using spiral tapered tap and screw extractor.

APPENDIX

REFERENCES

1. Publication Indexes

The following indexes should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this manual.

Index of Army Motion Pictures, Film Strips, Slides, and Phono-Recordings.	DA Pam 108–1
Military Publications:	
Index of Administrative Publications	DA Pam 310–1
Index of Blank Forms	DA Pam 310–2
Index of Graphic Training Aids and Devices	DA Pam 310–5
Index of Supply Manuals; Ordnance Corps	DA Pam 310–29
Index of Technical Manuals, Technical Bulletins, Supply Bulletins, Lubrication Orders and Modification Work Orders.	DA Pam 310–4
Index of Training Publications	DA Pam 310–3

2. Supply Manuals

Fuels, Lubricants, Oils, and Waxes	SM 10–1–9100
Hand Tools, Edged, non-powered Class 5110; Hand Tools nonedged, nonpowered 5120.	SM 9–1–5110, 20
Hand Tools, Power Driven, 5130; Drill Bits, Counterbores, and Countersinks: Hand and Machine, 5133; Taps, Dies, and Collets: Hand and Machine, 5136; Tools and Hardware Boxes, 5140; and Sets, Kits,	

and Outfits of Handtools. SM 9–1–5130, 33, 36, 40, 80

Hardware and Abrasives; Disks and Stones, Abrasive. SM 9–1–5345

Measuring Tools .... SM 9–1–5200

Metalworking Machinery .... SM 9–1–3400

3. Forms

DA Form 468, Unsatisfactory Equipment Report

DA Form 2028, Recommended changes to DA Technical Manual Parts Lists or Supply Manual 7, 8 or 9 (cut sheet)

DD Form 6, Report of Damaged or Improper Shipment

4. Other Publications

The following explanatory publications contain information pertinent to this materiel and associated equipment:

Field and Depot Maintenance: Repair and Rebuild of Pneumatic Tires and Tubes. TM 9–1871

Logistics (General): Unsatisfactory Equipment Report .... AR 700–38

Lubrication ..... TM 9–2835

Military Symbols ...... FM 21–30
AFM 55–3

Military Terms, Abbreviations, and Symbols:
Authorized Abbreviations and Brevity Codes ...... AR 320–50
Dictionary of United States Army Terms ..... AR 320–5

Miltary Training ..... FM 21–5

Safety: Accident Reporting and Records ...... AR 385–40

Techniques of Military Instructions FM 21–6

INDEX

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For explanation of abbreviations used, see AR 320–50.

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