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WAR DEPARTMENT

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AIRCRAFT RADIO SHOP PRACTICE

May 1, 1942

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AIRCRAFT RADIO SHOP PRACTICE

SECTION I

TOOLS AND THEIR USE

1. General.—*a.* Mechanical work in connection with maintenance and repair of the component parts of aircraft radio equipment depends to a very large extent upon the correct use of tools, and in order to accomplish good work, it is very important for these tools to be kept in excellent condition *at all times.* It is impossible to do the best work with tools that are not in good condition. The condition of a mechanic's tools is considered a good indication of the man's proficiency.

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b. Tools should at all times be kept free from dirt, grease, rust and any foreign matter. It is sometimes difficult to clean a tool after excessive dirt or rust has been allowed to accumulate; therefore, its accumulation should be prevented. Tools should be *carefully cleaned after use* and oiled with the proper grade of lubricant.

c. Carelessly dropping tools into the tool drawer or upon the work bench should be avoided, as such practice may be injurious to the tools or work bench.

d. Tools with cutting edges should at all times be kept sharp, for good work cannot be accomplished with dull tools. If a tool becomes dull, or if the cutting edge is injured in any way while in use, it should be sharpened or repaired *before* it is put away. There is nothing more irritating than reaching for a tool during the performance of a certain job and discovering that it is not in working order.

e. Tools which are kept in a tool room, tool chest or kit should be thoroughly cleaned and then coated with a thin film of lubricating oil by wiping with an oiled rag *before* putting them back in the tool room or chest. This prevents the possible absorption of moisture which will result in rusting. Tools, with the possible exception of delicate precision tools, when placed in permanent storage, should be coated with a heavy rust-preventive compound. Delicate precision tools may be coated with a lighter substance such as lubricating oil or vaseline.

f. It is very important to provide the proper lubricant to the bearings and other moving parts of power tools such as portable drills, drill presses, lathes, etc. The manufacturer's handbooks should always be consulted when operating and caring for power tools.

2. Work bench.—*a.* A sturdy work bench of steel or wood construction is essential to the radio mechanic. It is very desirable to provide drawers or compartments in the work bench for storing tools and small parts. Shelves and small bins along the back of the bench are very convenient for arranging tools, screws, etc., while working.

b. A 3-inch or 4-inch machinist vise should be permanently installed at a convenient place on the work bench.

3. Vise.—*a.* The vise is a very important tool and is found in every well equipped shop. The vise is a tool for holding objects rigidly and consists of a base and two jaws which may be adjusted by a screw with a bar for a handle. Figure 1 illustrates a small vise suitable for a radio shop.

b. When using a vise to hold objects while filing, sawing, or drilling, care should be exercised to keep the cutting tools from marring the vise. Some vises have hardened steel jaws which will dull the cutting tools.

c. Small vises can be easily ruined by trying to bend or shape work that is too large. Placing a pipe on the handle or using a hammer to tighten the vise very tight is bad practice.

d. A vise should not be used for a general purpose anvil. Some vises have a small anvil shaped at the rear. This is very handy for centerpunching, riveting and other light work.

4. Pliers.—*a.* Of the tools used by communication personnel, pliers are the most common. There are many types and sizes of pliers, each intended for a specific purpose. The pliers intended for a given job

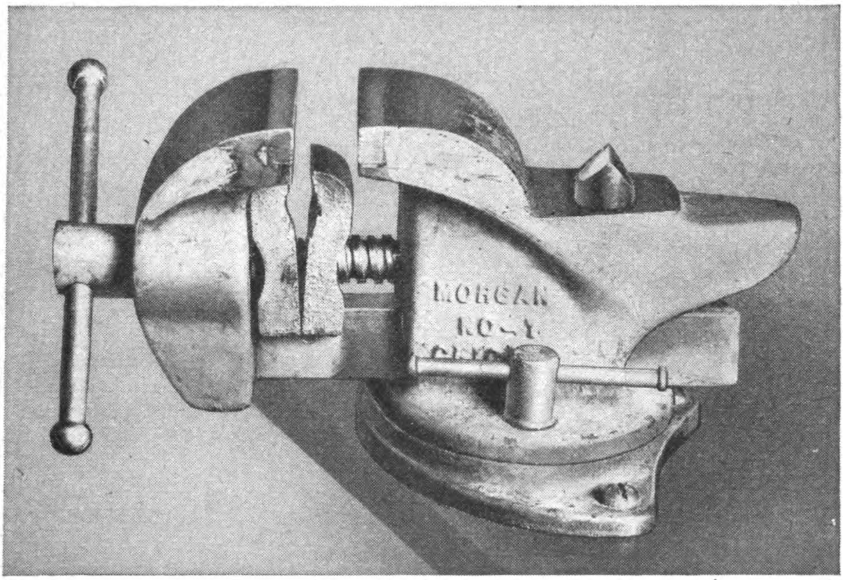


FIGURE 1.—Vise.

should be used for that job. The most common fault of an untrained workman is to use pliers as an all purpose tool. Figure 2 shows an assortment of pliers used by the radio mechanic.

b. Diagonal pliers are very useful. The jaws of these pliers consist of two cutting edges set at an angle of 15° to 20° with the length of the tool. They are intended only for wire cutting and are made in larger sizes to do heavier work. Their advantage over side cutting pliers is that, due to their construction, they can cut a wire off closer to its point of attachment than can the side cutting pliers. The chief misuse of diagonal pliers is forcing them to cut heavier wire than that for which they are intended. The sizes in most common use

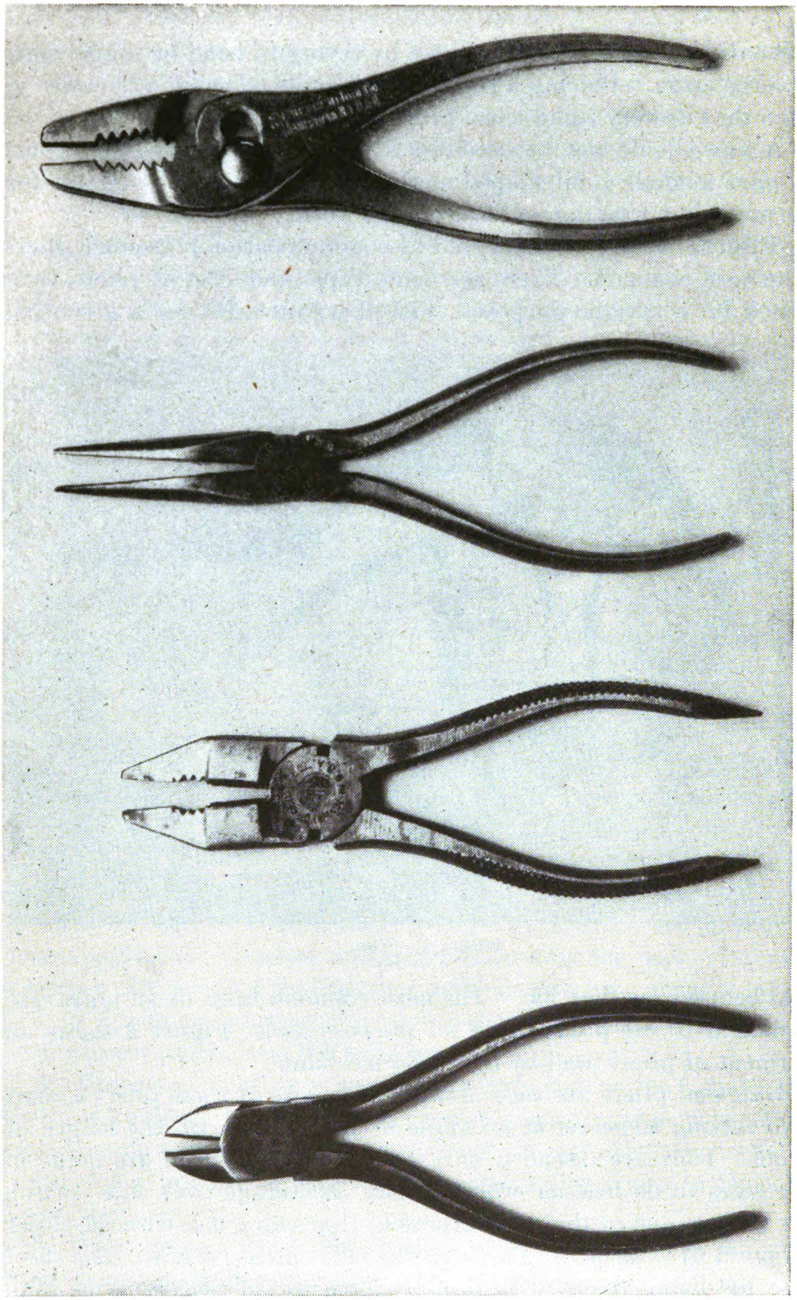


FIGURE 2.—Pliers.

are the 5-inch and 6-inch types which will cut up to No. 16 hard steel wire. For heavier wire cutting the side cutting pliers should be used. Diagonal pliers are often referred to as "diagonals."

c. Side cutting or lineman's pliers have square gripping surfaces on the ends of the jaws; behind the gripping surfaces are cutting blades. These pliers are used for gripping, splicing, wire cutting, etc. They are not intended to be used as a substitute for a wrench of any description. Skinning wire with pliers of any sort is not recommended in aircraft work. The most useful sizes of these pliers are the 6-inch and 8-inch; the larger sizes are, of course, for cutting and handling heavier wire.

d. Long nose pliers are primarily for light gripping and holding operations and for use in small spaces. They consist of a pair of long tapering jaws, half round on the outside and flat on the inside. The long nose pliers may or may not have side cutters behind the gripping surface of the jaws. These pliers are often misused by being forced to do heavier work than that for which they were intended. The result is either to break the jaws or to bend them so they do not close firmly on small objects. Five-inch or 5½-inch is the usual size of long nose pliers.

e. Needle nose and chain nose pliers are similar in appearance and construction to long nose pliers except that the jaws are circular instead of semicircular cross section. They should be used only for forming and for work on instruments. One of the principal applications of this type is forming a loop on the end of a wire in order to attach the wire to a binding post.

f. Slip joint or gas pliers have square nose gripping jaws with serrated gripping jaws behind them, close to the hinge. The method of hinging permits the jaws to be operated in either one of two positions, thus increasing the gripping range of the pliers. Gas pliers are primarily a make-shift tool and are normally used because the proper tool is not among the mechanic's equipment. They are a probable cause of damage to any surface on which they are used and their use should be strictly limited.

g. Combination pliers are intended as an all-purpose tool. They have serrated jaws, wire cutters, one handle sharpened into a reamer and the other handle sharpened as a screw driver. Like most combination tools they are not much good for any one purpose. Although combination pliers are frequently used in lieu of a wrench, this should be guarded against as a slip mars the surface of the equipment worked on and dulls the serrated jaws. If it is essential to use pliers instead of a wrench, a padding should be used if possible.

5. Knives and scissors.—*a.* Knives were among the first tools fashioned by mankind, and through the ages they have assumed a great variety of shapes, depending more or less upon the use to which they were placed. The type of knife with which we are concerned is the electrician's knife, which is designated as TL–29 by the Signal Corps. It is comprised of three major parts: the handle or frame, the cutting blade, and the screw driver blade. A protective feature of this knife is that the screw driver when opened is locked in this position. This prevents the screw driver blade from closing when being used and inflicting injury to the user.

b. The screw driver and the cutting blade should never be open at the same time. In the old knife the screw driver blade is unlocked by pressing on the back of the cutting blade when it is closed. While the pressure is on the cutting blade, the screw driver is closed. The new knife has a different type of locking feature. A spring pushes over when the screw driver blade opens and catches under a front projection of the screw driver blade. This type is much safer than the old type as the grip on the handle may tighten as pressure is applied to the screw driver. This has been known to release the lock on the old type and cause serious injury to the user. This cannot happen in the new type.

c. The front edge of the screw driver blade is fairly sharp. It should never be sharpened beyond the edge it has when it is received. One cutting edge on the knife should be enough.

d. The cutting blade is used by communication men to whittle wood and for removing insulation from wire. The blade is sharpened by sloping it on both sides toward the cutting edge. This should be a long bevel, never a short blunt bevel. The knife should not have a feather or wire edge nor should it have a razor edge.

e. There are several ways in which the knife may be held to remove insulation from wire, but the method outlined here is believed to be as good as any and it has one good feature, in that there is very little danger of injury to the user of the knife or to the wire. Also it may be used with a fairly dull knife. Grasp the insulated wire in the left hand with the end from which the insulation is to be removed pointing to the right. Hold the knife in the right hand. Place the blade of the knife at the point where the insulation is to be removed. Place the hands against the body so that the lower arms are in line with each other. Keep the blade on the side of the wire away from the body. Place the thumb of the right hand on the side of the wire next to the body. Have the knife blade flat against the wire. Do not ring the insulation, as this might nick the wire. Field wire is composed of many small wires and a nick may cause one or more of the wires to break. Work the knife blade up and down through the insulation, so that it acts as a saw, at the same time pull it toward the end of the wire. Keep both hands against the body. This action is somewhat similar to paring fruit or vegetables. Use the back of the blade to clean the wire after the insulation has been removed. Do not use the cutting edge for cleaning as this will dull the edge and nick the wire.

f. The electrician uses the scissors mainly in splicing cable, though it is very often convenient to use them when working on small wires. Their greatest advantage in splicing cable is the ease of handling in cutting the small wires, and skinning insulation from the ends of the wires for making joints. The opening in the handles also make them convenient to handle, as they can be looped over a finger when it is necessary to use the entire hand and they do not have to be continually laid down and picked up again as would be the case if pliers were used. The blades of the electrician's scissors are made heavier and more substantial than those used for other purposes. This allows them to stand up under hard service in cutting wires and shielding braid.

6. **Screw drivers.**—*a*. The appearance of the common screw driver is familiar to everyone. It is an important tool and one frequently misused. The screw driver is a tool the blade point of which is designed to fit into and nearly fill the slot in the head of the screw; turning the screw driver tightens or loosens the screw. The screw driver is wrongly used for prying, opening boxes or as a chisel. Figure 3 shows an assortment of screw drivers.

b. Two faults can be found with the average man's use of a screw driver, assuming that he uses them for no other purpose than turning screws. First is the failure to use a proper assortment of screw drivers. When a screw driver too small for a job is used, the blade of the screw driver does not fill the width of the slot in the screw head, and the force necessary to turn the screw is exerted upon too small a surface and with inadequate leverage. The result is damage to the screw head. Who has not at some time or other completely ruined a screw head because he did not have an adequate assortment of screw drivers to do that particular job?

c. The other fault in the use of the screw driver is improper sharpening. The two faces of the screw driver blade should be nearly parallel and the end square. The point of the blade should not be sharpened to an edge like a chisel. The blade of the screw driver should be the same width at the point as the slot in the screw head for which it is intended, and it should be ground with sufficient thickness to be a snug fit in the slot and yet reach the bottom of the slot. The ideal screw driver should completely fill the slot for its entire

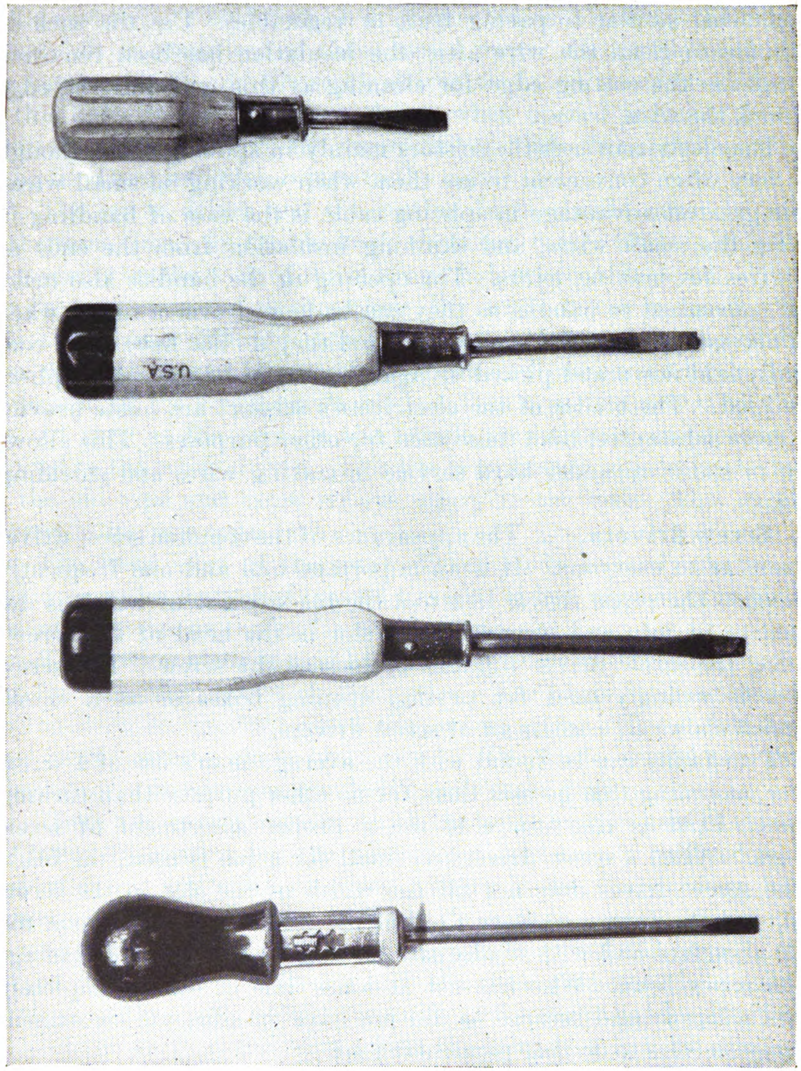


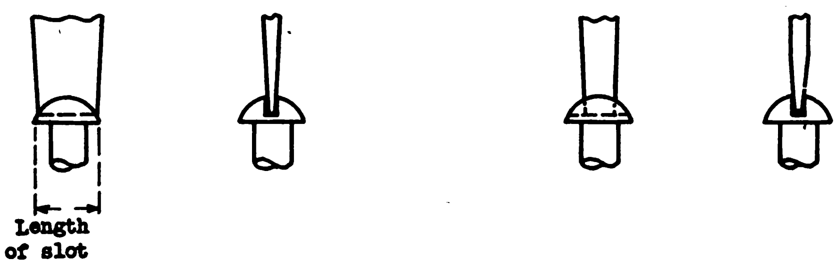
FIGURE 3.—Screw drivers.

depth and width. The further this ideal is departed from, the greater is the likelihood of damage to the screw driver and the screw head. Sharpening is best done upon a small bench grinder. Figure 4 shows the correct and incorrect way of sharpening a screw driver blade.

d. Screw drivers are classified according to length, purpose, type of handle, etc. For example, the cabinetmaker's screw driver has a long thin blade to permit working into small spaces. The handle of an electrician's screw driver must be insulated from the blade, whereas the blade of an ordinary screw driver may be enlarged at one end to form part of the handle. For work in small spaces an offset screw driver is often a great convenience.

e. Ratchet screw drivers consist of a handle with ratchet mechanism and a set of blades of different sizes. The use of a ratchet screw driver is not only a labor saver, but it also conduces to correct habits since a complete set of blades is furnished and the mechanic should take the whole kit with him when going on a job.

7. Files.—*a.* A file is a bar of hard steel having cutting edges or teeth on its surface and perpendicular to its length. The name given to various parts of the file are shown in figure 5 which represents a single cut flat file. Files are made in a number of shapes, the most



① Correct. ② Incorrect.

FIGURE 4.—Sharpening screw drivers.

common of which are flat straight, and flat taper; square straight, square taper, round straight, round taper, half-round and triangular. Figure 6 illustrates some of these shapes.

b. Teeth of a file are made by cutting a series of parallel grooves in the surface of the file, which make an angle other than 90° with the length of the file. If one such set of grooves has been cut the file is a single cut. If a second set of grooves have been cut so as to make an angle with the first set of grooves, the file is a double cut. A triple cut file is, of course, possible, but its only common example is a nail file. The upper files in figure 7 illustrate the appearance of the single cut file and the lower part of the figure illustrates the double cut files.

c. The depth of the grooves and the distance between them determines the size of the teeth and hence the coarseness of the file. Files are graded according to the coarseness or fineness of their cut. The

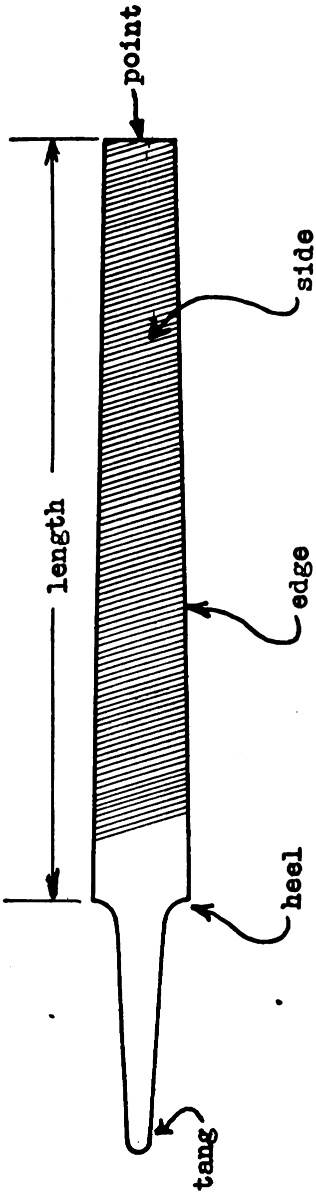
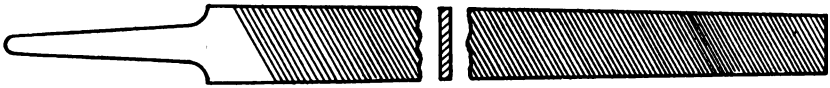


FIGURE 5.—Single cut flat file.

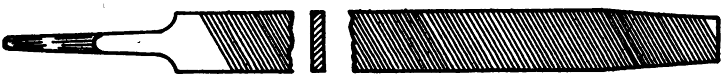
different grades in general use are: rough, coarse, bastard, second cut, smooth and dead smooth. The grades of coarseness of a file are comparable only when files of the same name and length are considered.



① Flat.

② Three-cornered.

③ Half-round bastard.



④ Mill bastard.

⑤ Rat tail.

FIGURE 6.—Files.

The Army Air Force designates the grade of files by number. The numbers for the various grades are as follows:

	Cut
No. 000	Coarse.
No. 00	Bastard.
No. 0 to No. 1	Second.
No. 2 to No. 3	Smooth.
No. 4 to No. 5	Dead smooth.

d. The tang or the spike shaped end of a file fits into a properly shaped recess in a wooden handle. This handle increases the ease of handling the file and improves the quality of workmanship. The file cuts when the point moves away from the work and the tang of the file moves toward the work. The tang is in the right hand of the user and the point should be held between thumb and the first two fingers of the left hand. To file a surface straight is difficult and requires considerable practice. When the file begins its stroke, the downward pressure exerted by the left hand should be greater than

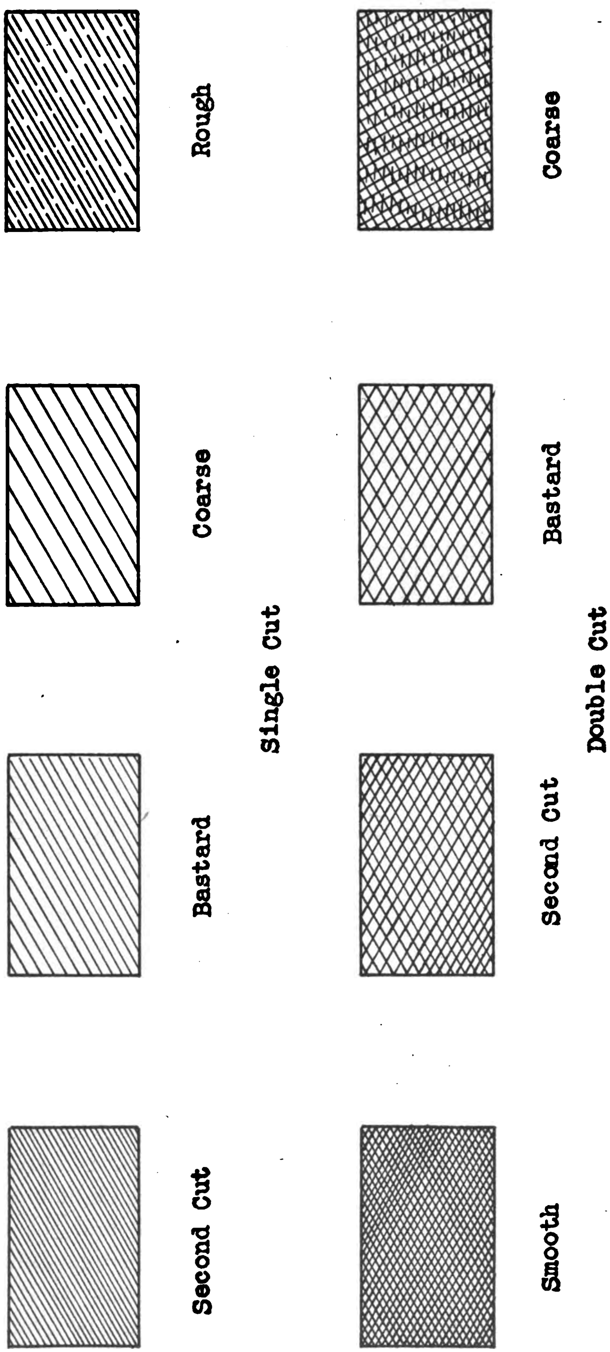


FIGURE 7.—File teeth.

the pressure exerted by the right hand. As the file advances, the pressure of the left hand decreases while that of the right hand increases. It is by this application of pressure that the file stays on an even level and produces a straight surface. Without this changing of pressure the file will move with a rocking motion across the work and the resulting surface will become round instead of flat. This faulty procedure in handling a file is called rocking. (See fig. 8.)

e. In moving the file endwise across the work, a process commonly known as cross-filing, the handle should be grasped in such a manner that its end fits into and against the flesh part of the palm with the thumb lying along the top of the handle in a lengthwise direction. The end of the file should be grasped between the thumb and first two fingers, the hand being in such a position that the ball of the thumb

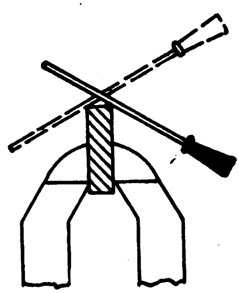


FIGURE 8.—Common fault in filing (rocking).

presses upon the top of the file. The teeth of the file are so formed that they can cut on the forward stroke only. To prevent undue wear the pressure should be relieved during the back or return stroke, similar to the stroke employed when using the hack saw. Work surfaces that are narrow should be held near the top of the vise jaws to prevent vibration and noise. If the surface is straight it should be placed parallel with the top of the vise.

f. Files are sometimes used by grasping at each end and moving them sidewise across the work, after the manner of using the draw knife. When this is properly done, work may be finished somewhat more finely and the scratches are more closely congregated than with the ordinary use of the same file. In draw-filing, the teeth of the file produce a shearing or shaving effect. To accomplish this, the angle at which the file is held with respect to its line of movement must vary with different files, depending upon the angle at which the teeth are cut. The pressure should also be relieved during the back stroke, as in cross-filing.

g. Sometimes particles of metal collect between the teeth of a file and make deep scratches as the file is passed over the work. When these tiny particles of metal are lodged too firmly between the teeth and cannot be removed by tapping the edge of the file against the bench, they should be removed either by using a file card or wire brush which is drawn across the file in the direction in which the teeth run, or some other cleaning device. Figure 9 shows a file card. Soaking a clogged file in kerosene for a while before using a file card will make the cleaning easier.

h. The life of a file may be prolonged by exercising care in selecting the right file for the work at hand. In order to prevent breaking and dulling the teeth, a new file should never be used on rough cast iron or other surfaces from which sand and scale have not been removed, nor on narrow surfaces. Files should never be thrown promiscuously into a tool kit or drawer. If it is necessary to keep files and other tools together, lay the files in carefully after the other tools have been placed in the kit or drawer.

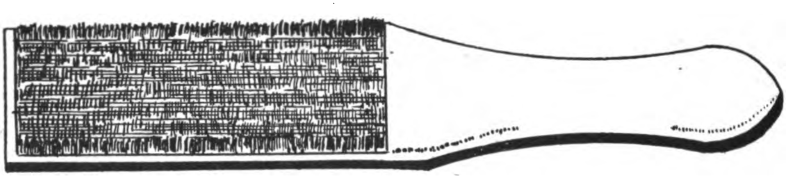


FIGURE 9.—File card.

i. The rasp resembles a file except that the irregularities on its surface are not grooves chiseled out but are made by a sharp punch. The more common shape of rasps are the flat and half-round. Rasps are largely used in woodworking and horseshoeing. Rasps do not work well on metal.

8. Abrasives.—*a.* There are a great many tools and materials used for abrasive purposes. They vary widely according to the fineness of the work to be done, the manner of their use, etc. Some of the more common will be mentioned under this heading.

b. Wire brushes are to be had in many sizes and forms. They are useful in cleaning surfaces, smoothing up rough castings, etc.

c. Sandpaper is heavy, tough paper, to one surface of which sand has been glued. It is graded according to the coarseness of the sand: No. 3 is as coarse as will be found necessary and No. 000 as fine as will be found necessary in a small shop. Sandpaper is primarily for use on wood, although fine sandpaper is useful for dressing down a slightly pitted commutator. For work on commutators, no grade coarser than

No. 000 should ever be used. Sandpaper is also used to fit new brushes to motors and generators.

d. Emery cloth consists of powdered emery glued to cloth. It is used on metals, as sandpaper is used on woods. It is graded according to coarseness, as is sandpaper. Crocus cloth is made by gluing iron oxide to cloth and is used to obtain a very high polish on the surface being treated.

e. Steel wool consists of a tangled mass of steel wires, each wire having an approximately rectangular cross section. It is graded according to coarseness, and is used in polishing metal, removing paint, cleaning, etc.

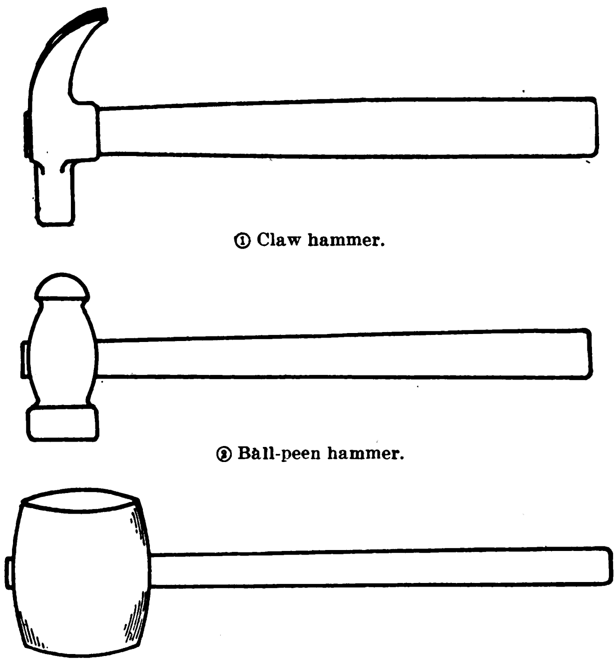
f. Grinding or polishing powders are often very convenient for smoothing or polishing metal or stone. Various grades of powdered emery, pumice, carborundum, rouge, etc., are obtainable. They may be used by smearing the powder on a soft metal plate and working the job over the plate, or the powder may be used on a cloth or on a buffer wheel. It may be dry or in a paste, the body of which is liquid or grease. Grinding or polishing powders find more application in manufacturing processes than in ordinary shop work. Valve grinding on a gasoline engine is an example of shop use of such abrasives.

g. Do not use abrasives around machine tools without caution lest the abrasive dust get into the gears, or on bearing surfaces, etc. Lubrication of gears, etc., is useless if there is abrasive mixed with the lubricant. Do not use emery, carborundum or steel wool around electrical machinery; all three are conductors and can cause short circuits. *In particular, never use any one of the three on a commutator.*

h. When the use of an abrasive is contemplated, be sure that the correct one is selected and that it is properly used. Abrasives properly selected and used are very helpful; used without discrimination they cause damage that requires a long time to correct.

9. Grinders.—*a.* A disk shaped wheel of emery, carborundum, or other abrasive when arranged to be rotated at high speed by a hand crank and gear train or by an electric motor is useful for sharpening tools as well as shaping small parts or removing burs from drilled stock. Small electric grinders are on the market which have a coarse wheel on one end and a fine wheel on the other end of an electric motor. A tool rest and a glass eyeprotector are also included. Wheels may be obtained in a variety of shapes, grades, and sizes. For normal shop purposes, a 4-inch or 6-inch wheel, about 1 inch thick and of a medium grade of carborundum is satisfactory. Before using a wheel on a power driven grinder, the safe speed of the wheel should be ascertained. A wheel that is running too fast may disintegrate and cause considerable damage. In using a wheel, care must be taken not to groove its surface. The surface of a grooved wheel may be restored by using a wheel dresser, but this operation requires the service of an experienced workman and should be avoided.

b. In using a grinder to sharpen tools, care should be taken not to remove the temper by pressing too hard and grinding too long at a stretch. When this is done the cutting edge turns blue. To prevent this, use light pressure and remove the tool frequently to inspect it



① Claw hammer.

② Ball-peen hammer.

③ Mallet.

FIGURE 10.—Hammers.

and let it cool. Where much grinding is necessary a pail of water should be at hand to dip the tool in at each inspection.

c. Always wear goggles to protect the eyes from flying particles of steel and abrasive when using a grinder unless the machine is provided with a glass shield.

10. Hammers.—*a.* A hammer consists of a head attached to a handle and is used for striking. The head is shaped according to the purpose for which the hammer is intended; the material of the head may be soft, as, for example, rawhide, rubber, brass, copper or lead, or it may be hard. Hammers are classified according to the work in which they are used, as machinist's, carpenter's, blacksmith's, etc., and according to the shape of the head as claw, ball-peen, mallet, etc. Figure 10 shows several types of hammers.

b. A hammer should be held near the end of its handle. Choking a hammer (holding it near the head) reduces its efficiency and is an earmark of the novice. The face of the hammer head should be kept in its original shape, free from chips, dents, and dirt. Failure to do so increases the likelihood of glancing blows with resulting damage to the job and to the person.

c. In hammering machine work, a soft metal drift or block of wood should be used between the stock and the hammer, or a soft (lead or bronze) hammer should be used. A soft headed hammer should not be used on a cold chisel or the hammer head will be damaged. The claws on the common or carpenter's hammer are intended for drawing nails and for light prying; they should not be used to replace the pinch bar. The size of the hammer should be suited to the job. Do not attempt spike driving with a tack hammer or tack driving with a sledge. Such practice wastes time, causes irritation, and produces sloppy work.

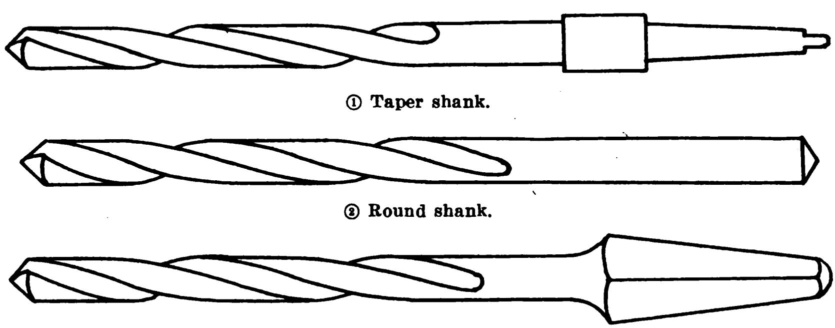
11. **Drills.**—*a.* The twist drill is a tool designed to bore a hole in practically any material. The twist drill may have a straight shank which is intended to be held by a 3-jaw chuck, a square shank like a wood bit which is intended to fit into the 2-jaw chuck of a brace, or it may have a taper shank designed to fitting drill presses and lathes. These types of shank and the general appearance of the twist drill are shown in figure 11.

b. There are three classes of drills, according to size. One series begins with a smallest size of $\frac{1}{64}$-inch and increases in fractional steps of $\frac{1}{64}$-inch. One series is numbered from 1 to 80; No. 1 is 0.288 inch in diameter and No. 80 is 0.0135 inch in diameter. A third series called lettered drills, are lettered from A to Z; these vary in sizes from 0.234 to 0.413 inch. No drill of any one series is the same size as any drill in any other series. The last two series described provide sizes intermediate between the $\frac{1}{64}$-inch series. The size of the larger drills is stamped on the shank. This is impracticable for the smaller drills; the size of these is determined by fitting the drill into the hole of a drill gage or by using a micrometer and a table of drill sizes. Table I gives the decimal equivalent of the drill sizes, numbers and letters.

c. Drills are made of different grades of steel for different purposes. The twist drill for ordinary work is made of carbon steel; for high speed work, and for production, high speed steel is used. Due to the great friction in working bakelite with power drills, a high speed twist drill should be used on that material.

d. The cutting speed of a twist drill will be increased and the life of the drill prolonged if a lubricant is used when certain materials are worked. Lubrication should be used when the stock is steel or iron; no lubrication is necessary when the stock is cast iron or brass. The primary purpose of the lubricant is to keep the drill's cutting surface cool and thus to retain the temper. Any light machine oil, kerosene or turpentine will do as a lubricant.

e. Two important points in using a drill are the speed and the feed. The speed is of course the rate at which the drill turns and the feed is the rate at which the drill progresses into the stock. Speed and feed are of prime importance in any cutting process. A general rule is



① Taper shank.

② Round shank.

③ Square shank.

FIGURE 11.—Twist drills.

"the harder the material, the slower the speed and the lighter the feed." The underlying principle is that heat generated by the friction *must not* be allowed to rise to a point at which the temper of the drill will be destroyed. For example, even in such soft material as bakelite, high speed will soon ruin a carbon steel drill. The smaller the drill the faster may be the speed. Examples of proper speeds are: in hard steel 350 rpm, in cast iron 532 rpm, in brass 912 rpm. The feed is different for each material and each size of drill; it is a matter in which experience is worth more than any rule.

f. In starting a drill, a dent should be made in the stock at the center of the intended hole by using a center punch. When placed in the dent, the drill will take hold with less danger of wandering around and scarring the job or of taking hold in the wrong place. When using a large drill, it will be helpful to drill first a pilot hole with a small drill. In removing a drill from a hole, the drill rotation should be continued until the drill is clear of the hole.

TABLE I.—*Decimal equivalent of drill sizes*

Size	Decimal equivalent	Size	Decimal equivalent	Size	Decimal equivalent
1/2	0.500	7/32	0.2187	40	0.098
31/64	.4843	3	.213	41	.096
15/32	.4678	4	.209	3/32	.0937
29/64	.4531	5	.2055	42	.0935
7/16	.4375	6	.204	43	.089
27/64	.4218	13/64	.2031	44	.086
Z	.413	7	.201	45	.082
13/32	.4062	8	.199	46	.081
Y	.404	9	.196	47	.0785
X	.397	10	.1935	5/64	.0781
25/64	.3906	11	.191	48	.076
W	.386	12	.189	49	.073
V	.377	3/16	.1875	50	.070
3/8	.375	13	.185	51	.067
U	.368	14	.182	52	.0635
23/64	.3594	15	.180	1/16	.0625
T	.358	16	.177	53	.0595
S	.348	17	.173	54	.055
11/32	.3437	11/64	.1718	55	.052
R	.339	18	.1695	56	.0465
Q	.332	19	.166	57	.043
21/64	.3281	20	.161	58	.042
P	.323	21	.159	59	.041
O	.316	22	.157	60	.040
5/16	3125	5/32	.1562	61	.039
N	.302	23	.154	62	.038
19/64	.2968	24	.152	63	.037
M	.295	25	.1495	64	.036
L	.290	26	.147	65	.035
9/32	.2812	27	.144	66	.033
K	.281	9/64	.1406	67	.0313
J	.277	28	.1405	68	.031
I	.272	29	.136	69	.029
H	.266	30	.1285	70	.028
17/64	.2656	1/8	.125	71	.026
G	.261	31	.120	72	.025
F	.257	32	.116	73	.024
E–1/4	.250	33	.113	74	.0225
D	.246	34	.111	75	.021
C	.242	35	.110	76	.020
B	238	7/64	.1093	77	.018
15/64	.2343	36	.1065	78	.0156
A	.234	37	.104	79	.0145
1	.228	38	.1015	80	.0135
2	.221	39	.0995		

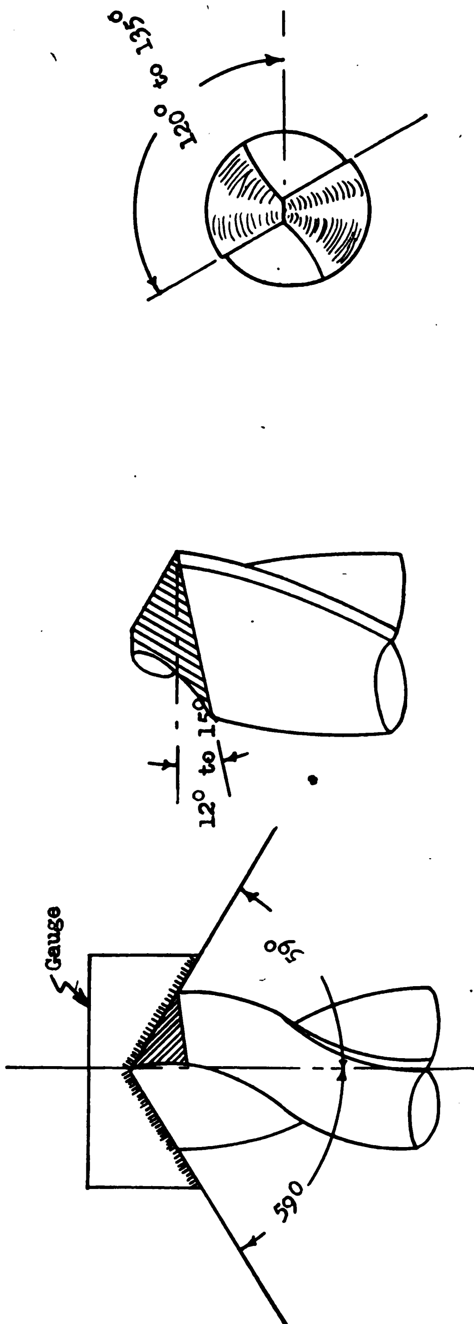
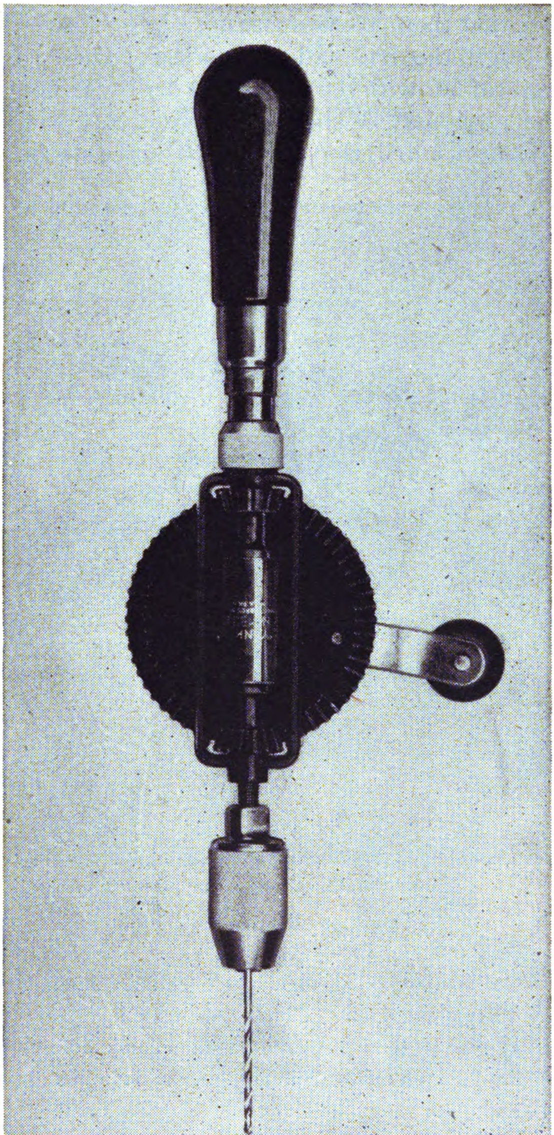


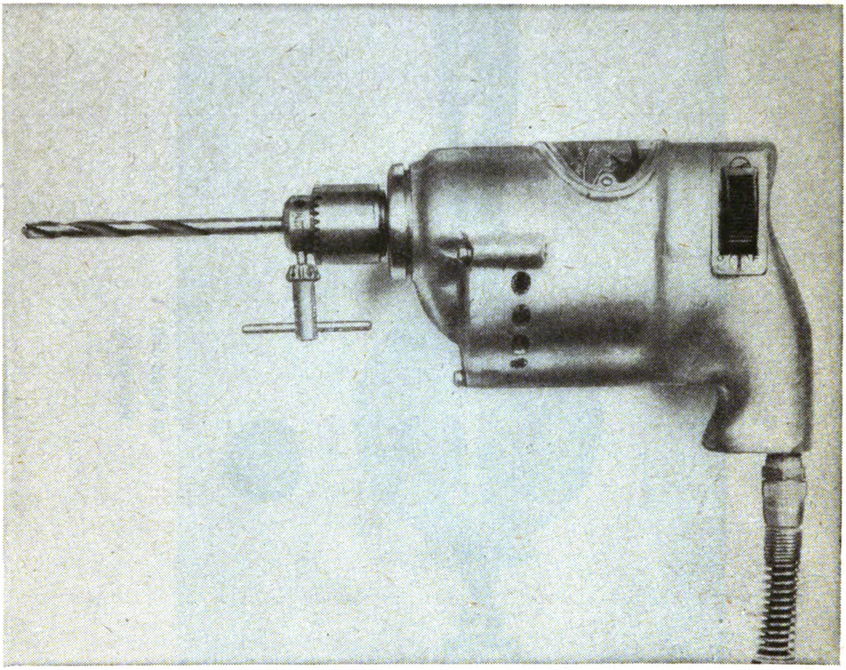
FIGURE 12.—Drill points.



① Hand drill.

FIGURE 13.

g. Drills may and should be resharpened when dull. In order to do this, it is essential to know the characteristics of a properly sharpened drill. Figure 12 shows three views of a properly sharpened drill point. Note that there are two cutting edges; unless these edges are of the same length the drill will cut oversize. These edges should each make an angle of 59° with the axis of the drill. Although for special purposes the angle may be slightly different, any wide deviation therefrom will result in a drill that cuts poorly and dulls quickly. The



② Portable electric drill.

FIGURE 13—Continued.

12° to 15° clearance is also very important. In fact all these angles must be approximately correct. Drills should be sharpened on a grinder, preferably one that is power driven. Facility in drill sharpening is the result of experience and the job should not be entrusted to an untrained man.

h. A hand drill, shown in figure 13①, consists essentially of a chuck driven by a crank through a train of two bevel gears. The handle at the upper end of the drill is for holding and applying pressure to the drill while turning with the other hand. Usually hand drills are arranged to have two gear ratios. The chuck has three jaws and is intended to hold a straight shank drill. For heavier work a breast

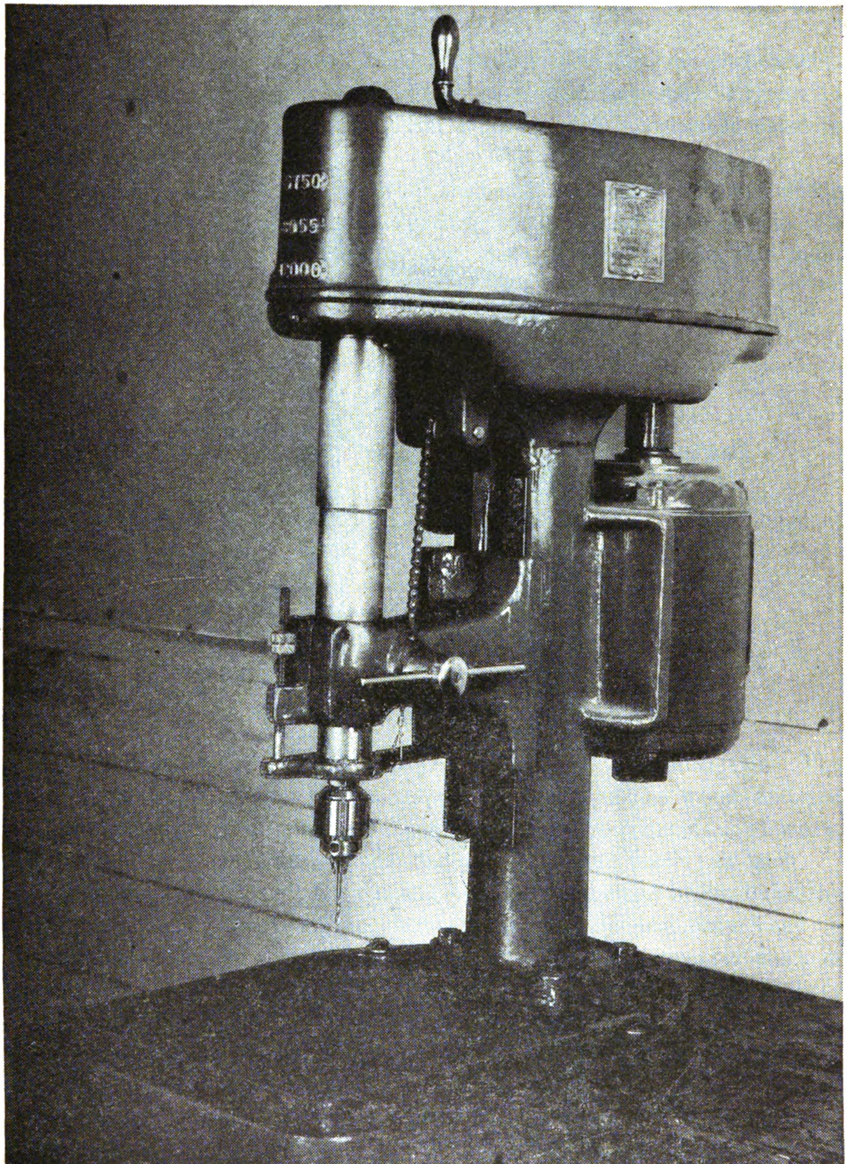


FIGURE 14.—Drill press.

plate is substituted for the handle and an additional handle is provided to steady the drill. This type is known as a breast drill.

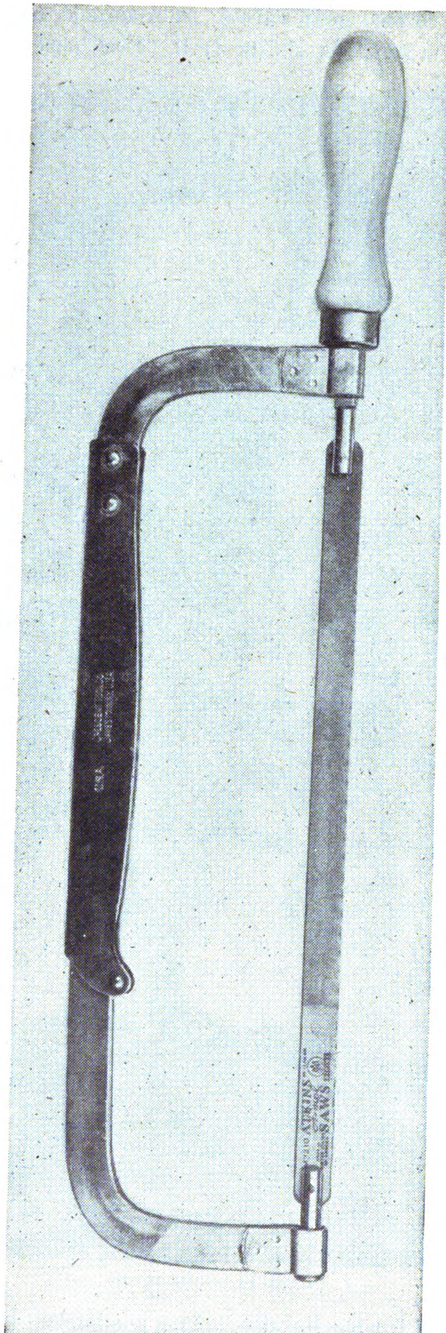


FIGURE 15.—Hacksaw.

i. Where many holes are required, the portable electric drill is almost indispensable. The electric drill consists of an electric motor in a case with a handle, a set of speed reducing gears and a 3-jaw chuck. Figure 13② illustrates a drill of this type.

j. Where holes need to be placed accurately to a lay-out and exactly at right angles to the stock, a drill press should be used. Figure 14 illustrates a small drill press which would make a valuable asset to the radio shop.

12. Saws.—*a.* The saw is a tool that cuts by means of teeth along its blade. Saws are classified according to the material to be cut, the shape of the saw, the size of the saw, the number of teeth per inch, and the shape of the teeth.

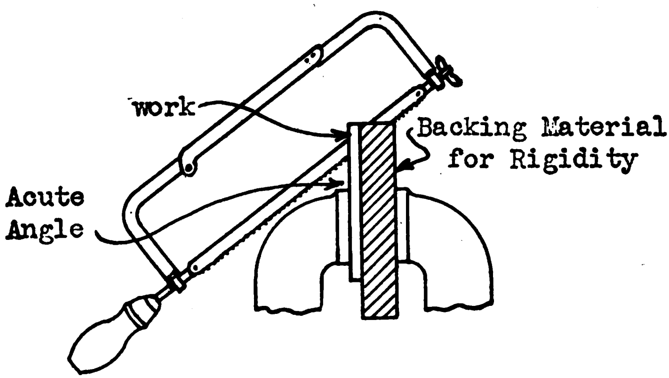


FIGURE 16.—Sawing thin stock.

b. Wood saws are of two general classes, crosscut and rip. The crosscut saw is designed to cut across the grain of the wood and the rip saw to cut with the grain of the wood. For the same class of work, the crosscut saw is generally smaller and has more teeth per inch.

c. The hacksaw is used for cutting hard stock such as brass, bakelite, mild steel, etc. The blade is about ½ inch wide and may vary in length from 8 to 12 inches. The number of teeth is greater than in wood saws. The blade is held in a frame which allows it to be tightly stretched. (See fig. 15.) Because of the nature of the material to be cut by the hacksaw, the blade is hardened and tempered and can easily be broken by a side strain.

d. The following rules apply to the use of all saws. When starting a cut, the saw should be steadied with one hand while making short, light cuts with the other until the groove is well started. The length and weight of the cut should then be increased. Weight should be applied only on the cutting stroke and the saw lifted slightly on the return stroke; failure to follow this procedure wastes effort and dulls the saw. A saw cut has an appreciable width so that in cutting material to size, the cut should not be on the line but outside the line. In cutting thin stock, particularly with a hacksaw, the saw should be held as shown in figure 16 so as to reduce chattering. If this is not done, the teeth will be dulled or broken, and the operation will be very noisy. Coarse toothed hacksaws should be used for heavy metal, and fine toothed hacksaws should be used for light metal and for pipe and tubing.

e. Wood saws are normally resharpened when they become dull. Sharpening is a job which requires skill and experience. Unless one expects to sharpen more than one or two saws, it will be found economical and convenient to have the sharpening done by someone

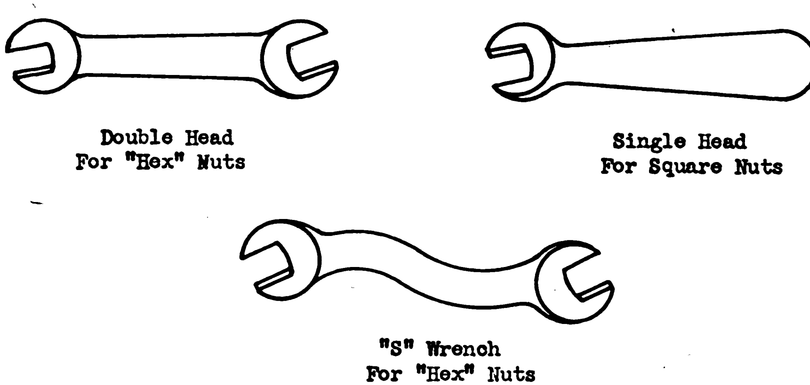


FIGURE 17.—End wrenches.

experienced in the business. Sharpening consists in filing the teeth with a small triangular file and then bending them out to the original flare by means of a saw set. Hacksaws are not resharpened. A dull hacksaw blade is replaced with a new one.

13. Wrenches.—*a.* A wrench is a tool for gripping a bolt head or a nut so that pressure applied to the handle of the wrench will turn the bolt or nut. The only exception to the above definition of a wrench is the Stilson wrench which is used for gripping and turning cylindrical objects such as pipe. The Stilson wrench is not made for use on bolts and nuts, and its use on them should be strictly prohibited.

b. Wrenches may be adjustable or nonadjustable. Nonadjustable wrenches are likely to be one of the types shown in figure 17. These are intended to fit only one type of nut or bolt head, or two sizes in the case of double end wrenches. Wrenches such as those of figure 17 can be had singly or in sets. A set consists of a sufficient number of wrenches to fit every standard size of nut between certain limits. The jaws of an end wrench for hexagonal nuts make an angle of 15° with the length of the wrench. To turn a hexagonal nut in a restricted space, the nut must be turned 60° so that the wrench can then be shifted to the next face of the nut. By the 15° offset the wrench can turn the nut 30° after which the wrench is turned over and fitted to the same face of the nut in order to turn it another 30°. Thus the required play for the wrench in turning a hexagonal nut is only 30°. Similarly, a wrench for square nuts should have jaws making an angle of 22° with the length of the wrench, and the play of the wrench must be at least 45°. End wrenches are often carelessly used. It is often found that

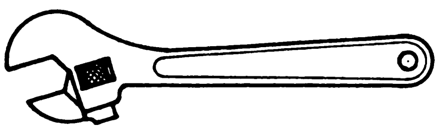


FIGURE 18.—Crescent wrench.

the next larger size will turn a nut and that the correct size is not lying within reach. If the larger size is used, the nut may be burred, the jaws of the wrench will be nicked and they may be sprung or even broken. Another common fault is hammering a wrench onto a damaged nut; the proper shape of the nut should be restored with a file before trying to fit the wrench onto the nut. The crescent wrench is a handy adjustable type which will take the place of a set of end wrenches. (See fig. 18.)

c. Stronger and usually more useful than the end wrench is the socket wrench. The socket wrench is normally a set consisting of

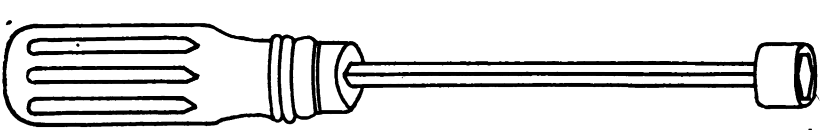
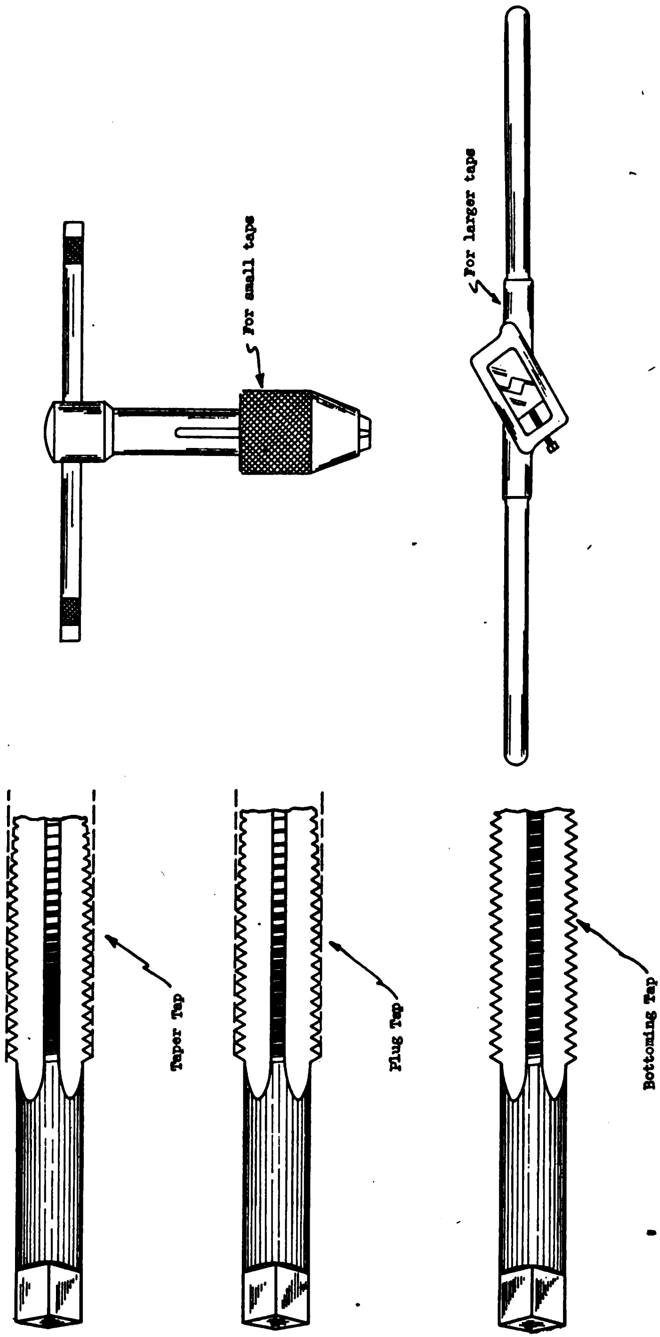


FIGURE 19.—Socket wrench.

sockets of graded size, each designed to fit closely over a nut, and one or more handles to fit into the sockets. Figure 19 shows a socket wrench with a screw driver type handle. This wrench lends itself very well to radio work, as many nuts and bolts are in close places.

14. Taps, dies, and reamers.—*a.* Threading may be done on a screw cutting lathe or by special tools called taps and dies. A tap is a tool used to thread a hole; a rod is threaded by a die.

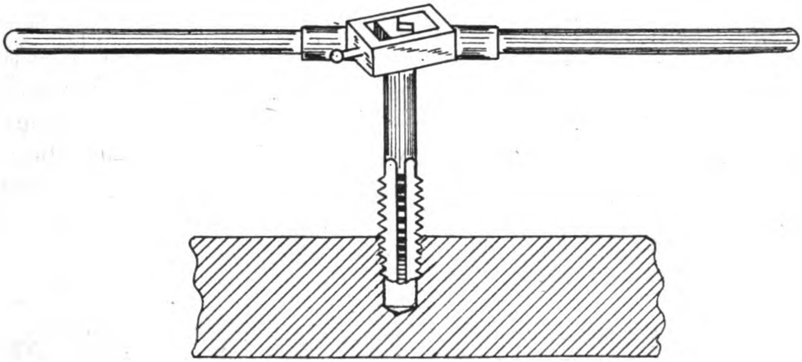


① Taps.

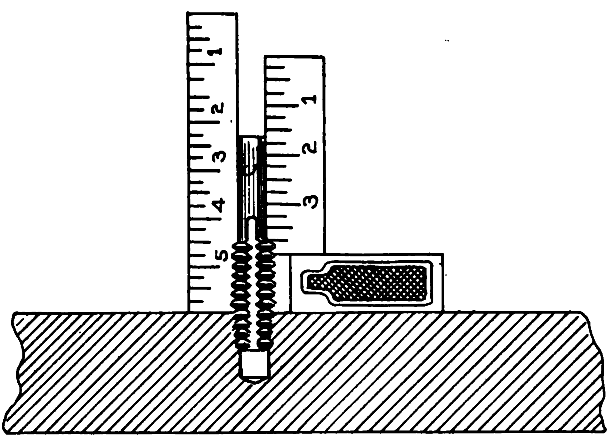
② Tap wrenches.

FIGURE 20.

b. The tap is a steel screw of proper size, across the threads of which are cut three slots the length of the threaded portion. The end of the tap away from the threaded portion has a head designed to fit into a tap wrench. The slots interrupt the threads so that the segments of the threads act as cutters. Three types of taps are shown in figure 20①. Tap wrenches are illustrated in figure 20②. The taper and



① Starting a tap.



② Truing the tap.

FIGURE 21.

plug taps taper toward the point so that the cuts are made gradually deeper by successive threads.

c. If a hole goes entirely through the material, a taper tap can be used to complete the job. To thread a hole which does not pass through the stock, the thread is started with a taper tap. When this tap has struck the bottom of the hole, it is backed out and the hole threaded with the plug tap. This is in turn removed and the job completed with the bottoming tap. In soft material the use of the plug tap is not necessary and the hole may be threaded in two steps. Broken taper taps may be squared off on a grinder and used as bottoming taps.

d. Taps are highly tempered and therefore very brittle. Great care to avoid lateral stresses must be exercised to prevent breaking the tap. A tap broken off in the hole is a source of great annoyance, particularly if it breaks off flush with the stock while the hole is being bottom-tapped. In using a tap, see that it starts straight into the hole. Figure 21① shows a tap being started. After the tap is started, it should be checked to see if it is true; the method of checking is shown in figure 21②. If the tap is slightly crooked, make the attempt to straighten it while turning and not when the tap is standing still; this will reduce the chance of breaking off the tap. In

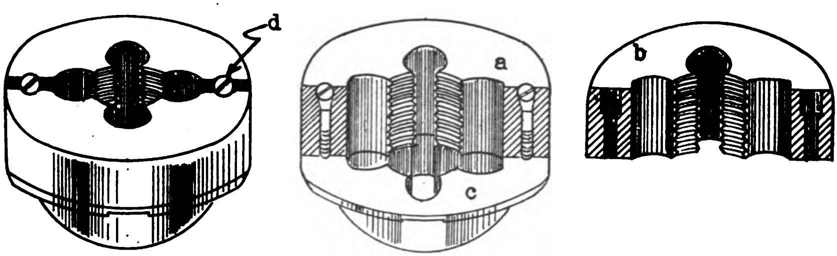
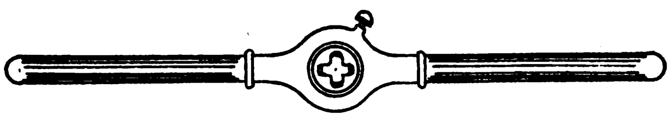


FIGURE 22.—Thread cutting die.

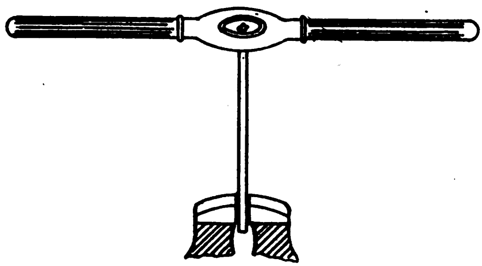
tapping thin brass or bakelite, no lubrication is necessary. For heavier and harder materials, the same lubrication as used in drilling will be satisfactory. To keep the tap from binding it should be turned in only about a quarter to a half turn, then backed up and this process repeated until the job is finished. This is very important when tapping aluminum. For the first few turns considerable pressure must be applied to keep the threads from stripping. After this the tap will force its way through the stock as it is turned.

e. One type of die is shown in figure 22. It is seen to consist of a screwplate *c*, into which screw the two adjusting screws *d*, which hold the cutters *a* and *b* to the screwplate. The hole through the screwplate is the size of the outside of the threads and therefore the die is started from the screwplate side. It is seen that the die is a hardened nut whose threads are interrupted in four places so that these edges cut just as a tap does. As with the tap, the threads are so arranged that the cut is made gradually. To thread up to an enlargement on a rod, operate the die as far as possible, back it off and then run it on in the reverse position, completing the last two or three threads. Dies should be started straight just as taps are, but there is much less danger of breaking a die. Figure 23① shows a die held in a die stock and figure 23② shows a die being started. Pressure must be applied for a few turns until the threads are started.

f. The reamer is a tool designed to enlarge a hole. A reamer may be straight or taper; the type used in machine work consists of a steel rod of appropriate size having either longitudinal or spiral grooves so that the cross section resembles a rotary saw. Some reamers are adjustable by screws whose motion expands or contracts the split body of the reamer. A triangular file of appropriate size can be used in



① Stock and die.



② Starting a die.

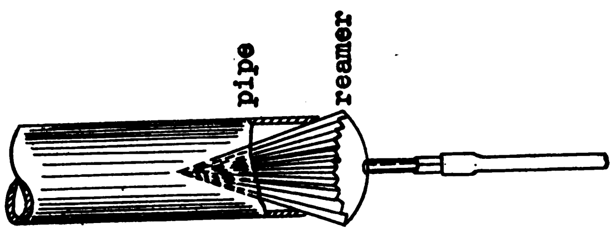
FIGURE 23.

an emergency to do reaming; when so used, it should be twisted in a counterclockwise direction. Figure 24 shows several types of reamers which might be used by radio mechanics.

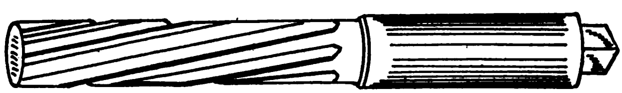
15. Soldering irons.—*a.* The process of uniting metals by heating them and applying a fusible alloy is called soldering. The alloy is called solder and for small work the heat is usually applied by placing a heated piece of copper to the metals which are to be joined. The piece of copper, along with its handle, is called a soldering copper or iron.

b. The soldiering iron may be heated by placing the copper tip in the flame of a blow torch or by passing an electric current through a resistance heating element which constitutes an integral part of the electric soldering iron. Figure 25 illustrates the electric soldering iron which modern radio shops use almost exclusively. These irons may be obtained in various sizes, the more common sizes being 3/8-inch, 5/8-inch, 7/8-inch, and 1 1/8-inch, which indicates the diameter of the copper bit.

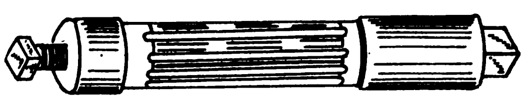
c. Before attempting to solder with an iron, that portion of the bit which is brought into contact with the joint must be covered with a coating of solder. This is called tinning the iron. The iron is heated and the tip cleaned and dressed smooth with an old file. The tip of the soldering iron should be approximately the shape of a rectangular pyramid. This shape is obtained by filing the bit, after it has been removed from the heating element.



① Pipe reamer.



② Spiral fluted reamer.



③ Expansion reamer.

FIGURE 24.—Reamers.

d. The iron is heated until the bit turns a light mahogany hue. The tip is now cleaned again very bright over a distance of about 1/2 inch, and if it shows prismatic colors a small amount of rosin core solder is applied to each face of the tip and all surplus solder is wiped off with a damp cloth. The solder that cannot be wiped off because it has fused with the copper bit is the proper amount for tinning. The bit is now tinned and should have a bright silvery finish. Keep the tip well tinned and the life and usefulness of the bit will be greatly increased. A well tinned bit will hold sufficient solder for the average electrical connection. Do not burn the material being soldered by

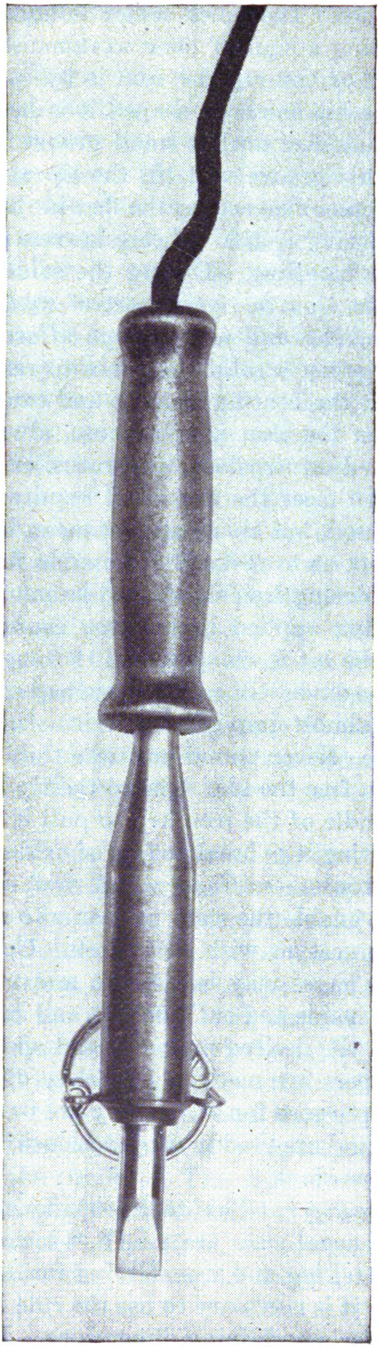


FIGURE 25.—Electric soldering iron.

having the iron too hot. Too much solder is unnecessary and often dangerous, besides being a sign of poor workmanship.

e. Another method of tinning the iron is by using a block of sal ammoniac. After the bit has been shaped it is heated as above and rubbed on the sal ammoniac until a small groove is formed. A few drops of solder in this groove will tin the tip as it is rubbed back and forth. The sal ammoniac acts as the flux in this case.

f. The electric soldering iron is delicate in construction, and therefore requires careful handling. During the soldering operation *do not swing or jerk the iron to remove excess solder as this practice endangers nearby workmen and may damage adjacent equipment.* Do not strike the iron against a solid substance to remove the solder as this is likely to crack the heating element and cause a breakdown of the insulation. When the iron is not in use, always keep it in the holder. If it is placed on the floor, apparatus, or other work, a fire hazard is created. To meet the approved requirements of soldering a hot iron must be used, but this *does not* mean that you should let the iron become so hot as to make it impossible for solder to adhere to it. An electric soldering iron should not be put in water to cool it.

g. The heat and flux applied to the iron causes oxidation of the copper bit. Unless the bit is removed and thoroughly cleaned before each soldering job, the oxide will collect in such quantities that removal of the bit becomes almost impossible. When this happens the bit has to be drilled out. Never pound or strike the iron against a hard substance in order to free the bit. Clamp the tip of the bit in a vise and grasping the handle of the iron, try to pull it away from the bit, at the same time twisting it to break it free of oxide.

16. Measuring tools.—*a. General.*—A few simple tools are all that are necessary to enable the shop mechanic to make the necessary measurements in connection with this work. Calipers, scales, protractors and various gages may be used to measure length, breadth, thickness, diameter (inside and out), angles, and determine wire, drill, and screw sizes with the desired precision and speed.

b. Calipers.—Calipers are made in a variety of styles and shapes, depending upon the purpose for which they are to be used. Some are very simple in form and are used in conjunction with a rule for taking and transferring dimensions.

(1) *Spring joint caliper.*—This tool is made in two styles, inside and outside, and its usual sizes are 4-inch, 6-inch, and 8-inch. It is used principally for taking and transferring inside or outside dimensions. In most cases it is necessary to use the rule in conjunction with this type of caliper for ascertaining dimensions. It is not used where

close precision is required. For precision work the micrometer is used.

(2) *Micrometer caliper.*—The micrometer caliper is made in various styles and sizes depending upon the purpose for which it is to be used. The most common types are the outside, the inside, and the outside thread micrometers. This tool is used where close precision is required, as it is capable of taking measurements to within .001 inch, and where a vernier is employed, to .0001 inch. All types of micrometer calipers are similar in principle, and instructions in the use of only the outside type will be given herein, as it is the type which is most generally used. It consists of a frame, the anvil, or fixed measuring point, the spindle which has a thread cut 40 to the inch on the portion inside the sleeve or barrel, and the thimble which goes outside the sleeve and turns the spindle. One turn of the screw moves the spindle $1/40$ inch or 0.025 inch and the marks on the sleeve show the number of turns the screw is moved. Every fourth graduation is marked 1, 2, 3, etc., representing tenths of an inch, or as each mark is 0.025 inch, the first four mean 0.025 x 4 equals 0.100 inch, the third means 0.025 x 4 x 3 equals 0.300 inch. The thimble has a beveled edge divided into 25 parts and numbered 0, 5, 10, 15, 20 and to 0 again. Each of these mean $1/25$ of a turn or $1/25$ of $1/40$ equals $1/1000$ (0.001) inch. To read, multiply the marks on the barrel by 25 and add the graduations on the edge of the thimble. Figure 26① shows the micrometer adjusted to measure the thickness of a transformer lamination. The reading is 0.017 inch. Figure 26② shows a micrometer set to 0.716 inch.

(3) *Vernier scale.*—Some micrometers have a vernier scale on the frame in addition to the regular graduations so that measurements within 0.0001 inch can be taken. Micrometers of this type are read as follows: first, determine the number of thousandths, as with the ordinary micrometer; then, find a line on the vernier scale that exactly coincides with one on the thimble. The number of this line represents the number of ten-thousandths to be added to the number of thousandths contained on the regular graduations. The relation between the graduation of the vernier and those of the thimble is as follows: The vernier has ten divisions which occupy the same space as nine divisions on the thimble. The difference between the width of a vernier division and one on the thimble is equal to one-tenth of the space on the thimble. Therefore, a movement of the thimble, equal to the difference between the vernier and the thimble graduation, represents 0.0001 inch.

c. Gages.—Gages in general are tools made with certain set dimensions and are for the purpose of readily checking sizes, etc., of parts and materials. The thickness gage is a typical example. Measurements in all cases may be taken by the use of the caliper and rule, but it is much easier and a great deal more accurate to use a gage if possible. There are gages for nearly every class of work or kind of measurement. A number of these gages will never be used by the average radio mechanic; therefore, only those most commonly used will be mentioned.

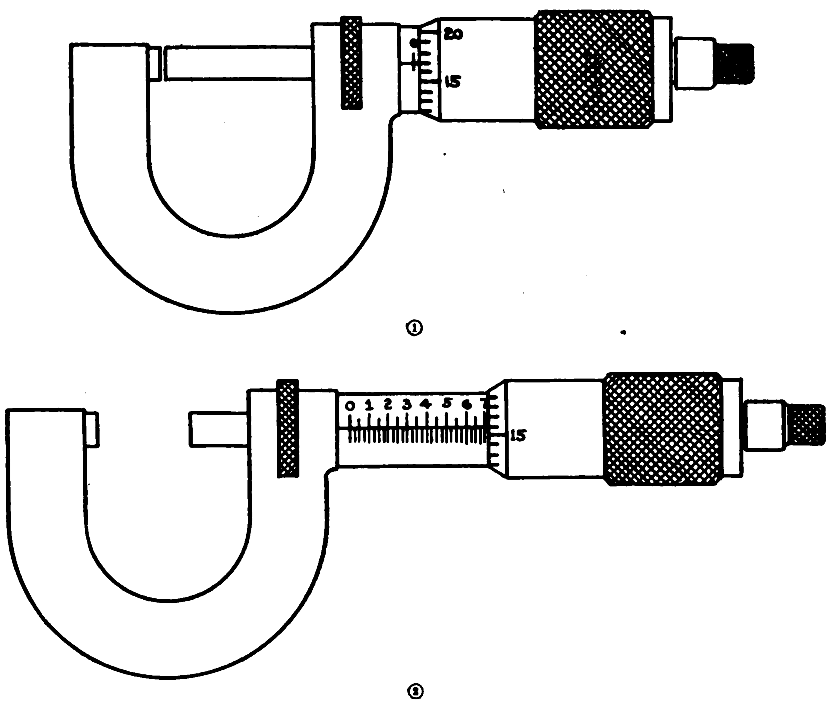


FIGURE 26.—Micrometers.

(1) *Thickness gage.*—This gage consists of a holder with hardened steel blades of various thicknesses. These blades vary in thickness from .001 inch to .025 inch, the thickness of each being stamped on the blade. It is used for determining clearances.

(2) *Twist drill gage.*—The twist drill gage consists of a rectangular metal plate with holes corresponding to the various drill sizes, each of which is marked to indicate the size. Separate gages are used for either letter, number, or fractional sizes of drills.

(3) *Screw pitch gage.*—This gage consists of a holder which contains a number of blades with teeth corresponding to the various screw threads. Each blade is stamped with a number indicating the particular thread pitch to which it is adapted. It is used for checking screw threads on bolts and nuts.

(4) *Drill grinding gage.*—The drill grinding gage is used for measuring the angle and length of the cutting edge of a drill. The blade of the gage is ground to an angle of 59° and is graduated into $\frac{1}{64}$-inch divisions.

d. Scales.—The scales or rules commonly used by mechanics consist of the 6-inch and 12-inch flexible steel rule and the 3-inch, 6-inch, and 12-inch spring steel rule. These rules are usually graduated into 1-inch, $\frac{1}{2}$-inch, $\frac{1}{4}$-inch, $\frac{1}{8}$-inch, $\frac{1}{16}$-inch, $\frac{1}{32}$-inch, and $\frac{1}{64}$-inch graduations. They are used for taking measurements where close precision is not essential. A 6-foot steel tape is also very useful.

e. Bevel protractor.—The bevel protractor is used principally for measuring and laying out work to various angles. There are two types which are most commonly used, one being a part of the combination set and capable of adjustment to within 1°. The other is known as the universal type and incorporates a vernier attachment whereby adjustments to within 5 inches may be made.

f. Combination set.—The combination set consists of four independent tools; namely, steel rule or blade, square head, center head, and protractor head. The blade, which is 12 inches long, has 4 separate scales. One graduated in inches and eighths of an inch, one graduated in inches and sixteenths of an inch, one graduated in inches and thirty-seconds of an inch, and one graduated in inches and sixty-fourths of an inch. The square head is used to lay off right angle lines and for checking the accuracy of a machined or filed edge. The center head is used for locating the center of round, hexagon, and octagon bar stock. It is also effectively used in locating accurately the center of an inscribed circle prior to drilling. The protractor head is used for laying out work to various angles.

g. Spring joint dividers.—Spring joint dividers are similar to the spring joint caliper except the long ends are ground to a sharp point. They are used for inscribing circles, arcs, and marking off spacings.

Section II

CONSTRUCTION PRACTICE

17. General.—*a.* Current practice in aircraft radio set construction is to house all parts in a metal cabinet with the front panel, on which the meters, switches, and other controls are mounted, forming one side of this cabinet. The parts are fastened to this front panel and also on subpanels and the metal chassis. Many parts are mounted above holes in the chassis so that other small parts may be mounted below and connected through these holes to the parts on top of the chassis. Figure 27 shows a communication receiver removed from its cabinet.

b. The wiring in a radio set may be of bare rigid bus bar construction, insulated wires of various colors neatly cabled in bunches or the direct point to point wiring giving no indication of symmetry.

c. It is very important to have good low resistance electrical connections. This is generally obtained by using solder and a noncorrosive flux. It is very important for the radio mechanic to be skilled in the art of soldering.

18. Soldering.—*a.* Soldering is the uniting of two or more metals by means of fusible alloys such as lead and tin, silver and nickel or brass, etc. The solder used in the operation must be such that it will melt at a lower temperature than the metals being joined together. However, the nearer the melting points of the solder and the soldered metals, the stronger the completed joint will be.

b. Fluxes are substances used in soldering operation for the sole purpose of preventing the oxygen in the air from combining with the metals to be worked with. When a metal is heated the combining of the oxygen and the metal will result in a film of oxide which will prevent the solder from fusing with the metal. This oxide is, for example, the red rust or black scale of iron or steel, the white oxide of zinc, the red oxide of lead and the black oxide of copper. If, prior to the soldering operation, the metals are thoroughly cleaned and immediately coated with a very thin film of flux, the oxidizing of the metal is prevented and solder will fuse nicely with the surface of the metal. This is the purpose of all fluxes in welding, brazing, and soldering.

c. There are two distinct classes of fluxes: corrosive and noncorrosive. Zinc chloride, hydrochloric acid, sal-ammoniac, etc., are corrosive fluxes and should never be used in radio installations as there is always the possibility of a small amount remaining in the joint which will, in time, eat through the connection, thus opening the circuit.

d. Rosin is a noncorrosive flux and is used for electrical work in either paste, liquid, or powdered form. A suitable commercial form of paste known as "Nokorode" is available at most Army Air Force

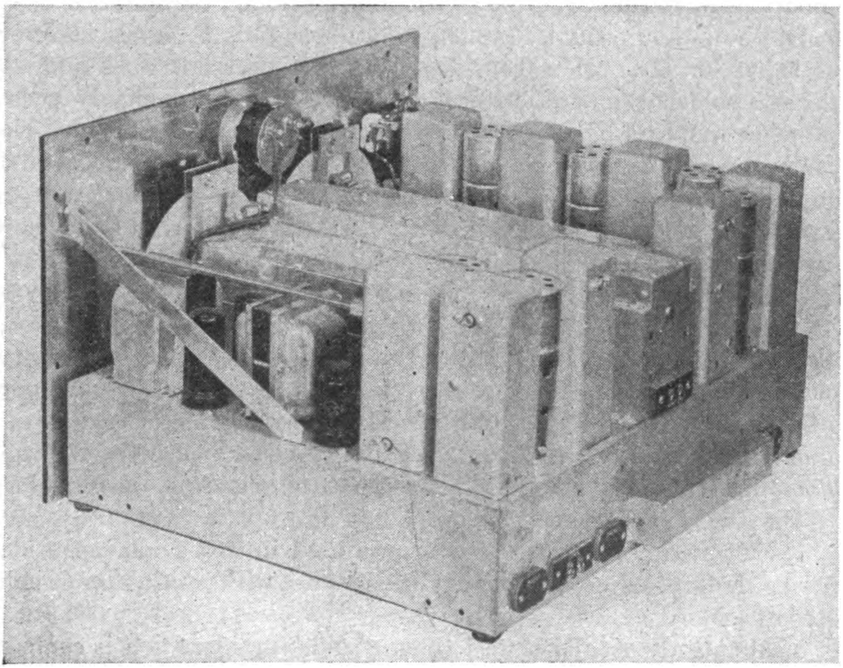


FIGURE 27.—Receiver chassis.

stock rooms. Nokorode is easier to use than rosin, but joints soldered with it must be carefully cleaned with alcohol. In order to have a cleaning effect, a flux must melt at or below the fusing temperature of the solder.

e. Certain metals solder better with certain fluxes, although rosin is the best all-around noncorrosive flux. The usual fluxes for common metals are as follows:

Metal	*Flux*
Aluminum	Stearine.
Brass	Rosin.
Copper	Rosin.

Metal	*Flux*
Lead	Rosin, tallow, or stearine.
Tin	Rosin.
Iron and steel	Borax.
Zinc	Zinc chloride.
Galvanized iron	Zinc chloride.

f. Solders are divided into two classes: hard and soft solder. The difference between the two lies in the composition of the fusing metal used. Hard solders are usually made from silver and its alloys, which explains the name silver solder, commonly used. Soft solders are combinations of tin and lead. The best flowing solder is composed of 60 parts tin and 40 parts lead, melting at about 340° F. and is referred to as 60–40. The solder considered best for electrical work and for general soldering operations is known as grade A, commonly called 50–50 or half-and-half, and consists of equal parts lead and tin. The melting point of this grade of solder is about 370° F. It is procurable in bar and in wire form. Rosin core solder, which is used to a great extent for soldering electrical work, comes in the form of a hollow wire filled with rosin flux.

g. Half-and-half (50–50) solder has an electrical conductivity about 1/7 that of copper. That means, wire made of solder would have to be made with a cross section area 7 times as great as that of a copper wire of the same length in order to offer the same resistance to the flow of current. All connections, therefore, between current carrying conductors should have *only a small amount of solder separating the conductors*, because any surplus solder will naturally increase the resistance of the particular circuit.

19. Tinning.—*a*. Tinning is a term used in soft soldering to describe the process whereby a surface is coated with a thin film or skin of soft solder.

b. Metals are usually tinned when a soldering operation is contemplated between such materials, especially if the metals to be soldered together have a large surface, are thick or heavy, or of such a nature that it would be difficult to draw the solder thoroughly between the metals and make it adhere properly. Also if the soldering operation is to be performed in some location which will be difficult to reach, the materials are first tinned so as to make soldering easy and the joint electrically secure.

c. It is good practice to tin any soldering job before attempting to perform the actual soldering operation, except when soldering terminals which come from the manufacturer ready tinned.

d. Two things are very important when applying a smooth thin tinning to a metal surface:

(1) The material to be tinned must be thoroughly cleaned.

(2) There must be enough heat applied to make the solder flow easily, but not too much heat, as it is possible to burn the bakelite insulators, etc., that are usually adjacent to metal strips and connectors.

e. If a satisfactory tinning operation is to be performed, the first thing to do is to see that the metal surface is thoroughly cleaned. All grease must be removed, using some cutting fluid. After this the material must be scoured down to a bright finish by the use of some abrasive, such as fine grade sandpaper, steel wool, emery cloth, or even a file or back of a knife blade if nothing else is available. When using a file, care must be taken to cut off the corrosion and foreign matter only, and not unduly cut into the metal.

f. Before attempting to apply the heat to the surface, care must be taken to see that the soldering iron is well tinned at the point and extending a short way up from the point. If the iron is not well tinned, the heat from it will not be transferred effectively to the object being tinned. Nor will the solder, when applied at or near the point of the iron, flow properly from the point to the metal. It is essential that this operation be performed with an iron that will permit the solder to flow smoothly and easily from soldering iron to metal.

g. After the above operations have been performed satisfactorily, the surface is ready to have the heat applied to it, using the point of the iron and holding it at such an angle that the largest possible area of the point of the iron is brought into contact with the metal being tinned.

h. When the metal begins to get hot enough to oxidize, the flux is added and spread over the metal with the iron. As the metal reaches the proper temperature to flow solder easily, a small portion of solder is added at the point of the iron, which is rubbed back and forth over the space to be tinned until fusion takes place between the metal and the solder. After a little practice you will be able to tell instantly when the solder has begun to take. After the solder has apparently taken over the complete surface being tinned, the iron is lifted and the excess solder wiped off the metal with a cloth, This should leave the tinned surface with a bright silvery finish.

20. Sweating.—The process of holding previously tinned surfaces together and applying heat until the coating of solder melts and joins the metals is called sweating. Sweating is used to advantage in various places such as joining overlapped flat strips, fastening flat braided conductors to flexible conduit and fastening lugs to the end of wire and cable.

21. Bus bar.—*a*. Bus bar is generally used in radio transmitters and receivers where rigidity and strength are desired in the internal connections of the set. It is widely used, especially in short wave (high frequency) transmitters, where the set is subject to vibrations and jars, as in airplanes. High frequency being so critical, a small displacement of one or two of the internal wires of the set will cause a shift in frequency to which the instrument is tuned. This makes operation unstable and critical.

b. Sets that are wired with bus bar are much more difficult to construct or repair than are the sets wired with the flexible type of connections, but the completed job is always very neat and orderly looking if the proper precautions are observed in running the wires from terminal to terminal. Every change of direction or bending of a wire is nearly always made with a right angle turn of the wire, and care must be exercised that the wires run straight and parallel to the panel. Also the wires are usually left bare and in this case ample space must be left between wires so that no two will come in contact with each other and create a short circuit.

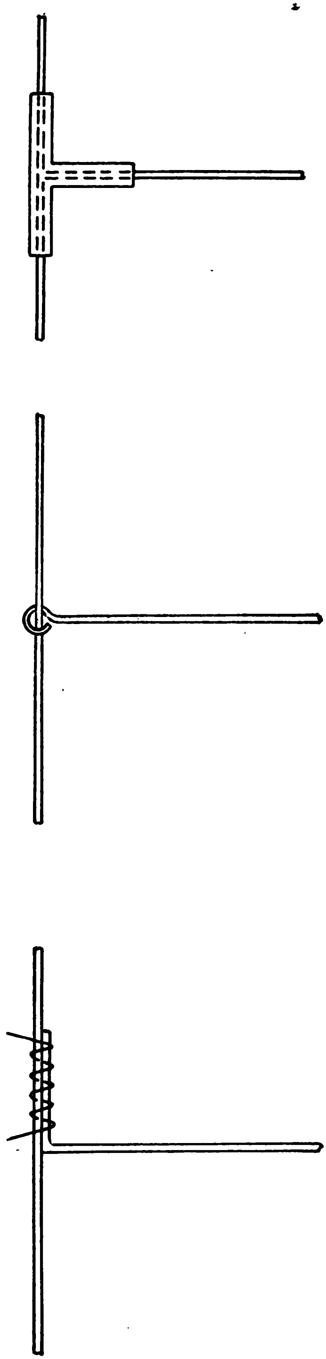
c. In some cases where several bus bar wires are run close together or parallel, a fiber tube insulation, called spaghetti, is slipped over the wire before soldering to the terminal to insure against a short circuit, but it is always best to use air for the insulation between the wires, as any kind of insulation introduces a dielectric loss, especially in high frequency circuits.

d. Instead of inserting the bus bar in the spaghetti tubing and introducing losses, long parallel leads may be fastened every few inches in bakelite clamps, and the rigidity of the wires between the clamps is sufficient to keep them from short circuiting. By this method much more area of the wiring is encased by an insulation of air, rather than loss producing material.

e. The types of bus bar are round and square. Of the two mentioned the square is the most universally used. The bus bar used in wiring sets is usually about the size of No. 14 wire, although it can be procured in several different sizes.

f. Bus bar tap, seized and sweated, bus bar hook tap, and bus bar sleeve tap are the three general methods of making a bus bar tap splice, that is, connecting one end of a bus bar wiring on the middle portion of another wire without the use of a terminal.

g. For an illustration of the first type (bus bar tap, seized and sweated) see figure 28①. In this case the wire is clipped off to extend



① Bus bar tap.

② Bus bar hook tap.

③ Bus bar sleeve tap.

FIGURE 28.—Bus bar splices.

about ¾ inch past the wire to be seized to, then the ¾-inch extension is bent at right angles to lay flat along the side of the wire to be tapped. Next some small seizing wire is wrapped around the portion of the wires where they adjoin. The joint is then soldered with rosin core solder. Hold the iron under the joint and let the solder flow down through the joint from the top side.

h. In the second type (bus bar hook tap) one of the wires is bent into a small hook at the end, and this hook placed over the second wire and solder applied. This is the most popular type of splice for bus bar, because it is quicker to make. (See fig. 28②.)

i. The third method (bus bar sleeve tap) is not so often seen but makes a very stable and neat connection. In this case a small T-shaped sleeve is used. The bus bar is laid in these sleeves and then the sleeve is clamped down snug over the wires and soldered by holding the iron under the sleeve and allowing the solder to flow down around the wire. Figure 28③ shows this type tap.

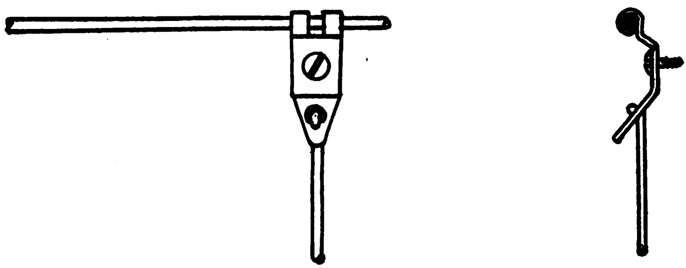


FIGURE 29.—Bus bar terminal.

j. Several types of bus bar terminal connections are in use. Figure 29 illustrates a terminal suitable for bus bar. This terminal has a double eyelet at one end and a single round eyelet at the opposite end. Both eyelets curve up for easy connections of the wire. The double eyelet terminal makes the best connection for mechanical and electrical security. The double eyelet allows more surface of the terminal to be in contact with the bus bar and has the advantage of a stronger soldered joint also. The wire is inserted straight through and solder applied from the top, the iron held below the terminal until the solder flows through.

k. In some cases it is better to clamp the bus bar under a washer and nut. This method is used on voltmeters, ammeters, etc. Some terminals which extend through the panels have nuts and washers that can be used. Where the nut and washer are used for a terminal connection, the end of the bus wire is bent in a small loop, by use of the long nose pliers, and this loop is placed over the bolt. Next is added a flat washer, then a lock washer to hold the nut, which is placed on last. Always be sure to screw the nut down securely on the lock washer to prevent a loose connection due to sustained vibration.

l. In bending bus bar, if possible make every bend at right angles, and in the right position along the length of the wire to make a neat appearance with the bends of the remainder of the wiring in the set; also to conform to the general line of direction in which the other wires travel.

m. Some high frequency precautions are: space as much as possible, make the wires of adjoining circuits cross at right angles, and use the higher grade of insulators such as ceramic, porcelain and isolantite for clamps, sockets and standoff insulators. Use air for insulation if possible. These are the three main precautions to observe in wiring radio sets and instruments for use in the higher frequencies. There is a fourth which applies both to high and low frequencies: make as near a metal to metal contact on your connections as possible, and be sure the connections are soldered, not merely stuck together.

22. Cabling.—It is common practice to bunch certain insulated wires into a neat bundle, fastening them by looping cord about the bundle at frequent intervals. Figure 30 shows a cable of this type. The use of various colored wires facilitate tracing circuits wired by this method. Many times this type of wiring is used only for the low frequency and power circuits, bus bar being used for the radio frequency portion of the circuit. This combination makes a very neat yet efficient method of set wiring.

23. Dismantling of equipment.—*a.* When a set is brought into the shop, never throw it on a work bench and start stripping it down expecting to find the trouble by visual means altogether.

b. First give the set an operating check. Most shops have a test bench installed adjacent to the work bench on which the set can be mounted with its component parts and hooked up by cables and leads permanently attached to the test bench for that purpose. In testing for operating characteristics or failures, note any meter indications. These will give you many valuable tips as to what is wrong internally. Note the sensitivity, selectivity, and amount of noise present. After a thorough operating test you will have a better idea just how far the stripping process will have to go, and generally a very good idea of what part of the circuit is giving trouble.

c. If it is a modern type of set with many screws and bolts extending through the case, look these over carefully to determine which hold the case only. Some of them hold smaller parts inside on the panel

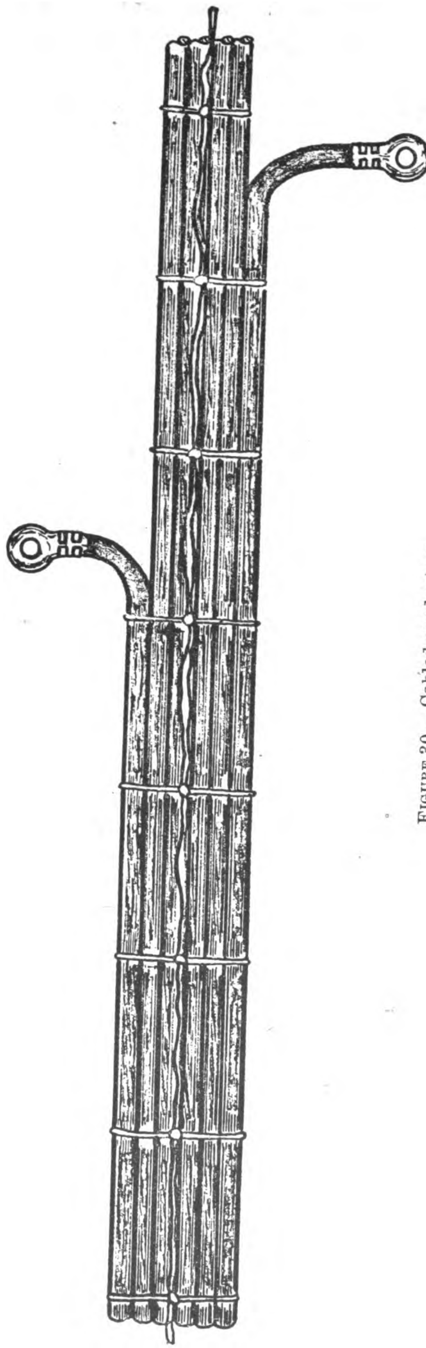


FIGURE 30.—Cabled conductors.

and have nothing to do with holding the case on the set, and they should not be loosened indiscriminately. This will allow parts to fall down inside the set, probably breaking some small flexible leads on coils, etc. Strip the set only as far down as is necessary to get to the part which is defective; or only as far as is necessary for a test to be made on a suspected defective part.

d. Do not leave nuts, bolts, screws, etc., lying around loose on the work bench. They may be knocked off and lost and some are not easily replaced. Store all pieces of equipment that are removed from the set to protect them from damages. Have some small boxes to store different kinds of nuts, bolts, etc., and put all of a similar kind in the same box.

e. Before starting work on the set, have the work bench clean of all trash, dirt, loose solder, and parts that may have accumulated on it. Handle the set carefully and try to keep it as clean and free of dirt and grease as possible.

f. Do not have tools lying around in ragged looking arrangements. Either have them in an orderly array at back of table, or have a special rack made for each tool that fits at the back top edge of the bench and is easily accessible. Plyboard serves nicely for this purpose. If the outline of each tool is drawn on the board in black paint, a missing tool is instantly identified.

g. Keep your iron tinned throughout the work, tinning every few minutes if necessary.

h. After any piece of equipment is removed from the set it should be thoroughly cleaned before reinstalling it.

i. In dismantling sets that are equipped with coils be careful in the soldering and unsoldering of the small leads extending from these coils to terminals. Heat the terminal only and work the small wire loose gradually so as not to break it off. After the coil is removed from the set, place it in a position where it will not be accidentally knocked about, or have heavy equipment laid on it. Be careful not to jar or move the wires wrapped around the coil, as these are precision units and the dials are calibrated in relation to the values in these coils. Any moving or replacing of wires on coils will change their value, thus making the set calibration valueless.

j. After the set has been repaired and reassembled, give it another operation check on the test bench, testing for noises, sensitivity, and selectivity. If it is calibrated, check the calibrations to see if any error has resulted from the disassembly of the set. If so, this should be corrected.

k. In taking off parts with many terminal connections about which you are likely to become confused in reconnecting, it is good practice to tag or mark the wires in some manner to facilitate rewiring as it was originally.

l. After the set is repaired and checked, it should be tagged with the date, trouble, the name of the repairman who did the work, and marked repaired.

m. In some of the more complicated components it is sometimes necessary to make a wiring diagram, as each part or wire is removed, so as to be able to reconnect it; especially is this true if the set is to be considerably stripped down.

Section III

SCREWS, NUTS, AND WASHERS

24. General.—Many types of screws, nuts, and washers are used daily by the radio mechanic. For this reason it is well for him to be familiar with these items and their nomenclature as well as their use. Special types are designed to perform special functions and other types should not be substituted when replacements are required.

25. Machine screws.—Prior to the meeting of the Hoover National Screw Commission in 1925, there were no nationally recognized standards for machine screws. This commission established standards, which are now used by manufacturers. By the standards so established, screws were divided into two main classifications: the national final thread series, and the national coarse thread series. The national fine and coarse thread series have a **V**-type thread, as the angle of the sides is 60°, and the top and root of the thread are sharp.

26. Identification of machine screws.—Standard machine screws are identified by—

a. Type of head.

b. Size number.

c. Number of threads per inch, or pitch.

d. Length of screw in inches.

27. Standard types of machine screws.—In radio there are seven main types of machine screws, which are designated by the type of head as shown in figure 31.

28. Size and thread.—By screw size is meant the stock number of material from which the screw is manufactured; that is, for a 6-32 screw, 6, the first numeral of the description, means that the screw is manufactured from No. 6 stock. The second numeral of the description, 32, shows the number of threads per inch. This number varies for the same size screw, the number depending on whether the screw belongs to the fine or coarse series. This is also called pitch of a screw and is the distance it will advance in one revolution. Thus a 32 thread per inch screw has a pitch of $\frac{1}{32}$ inch.

29. Type of screw to use.—*a.* Use coarse thread series screws for work where quick and easy assembly of parts is desired, and for all work where conditions do not require the use of fine pitch threads. (See table II.)

b. Use fine thread series screws for general use in automotive and aircraft work, for use where the design requires both strength and reduction in weight and where special conditions require a fine thread. (See table III.)

c. Due to more metal being cut away, the coarse thread series is not as strong as the fine thread series.

d. In radio work, when using metal, the coarse thread series is practically always used for sizes smaller than 10-32 and the fine thread series used for larger sizes.

e. When using bakelite or other insulating materials of a like nature, the coarse thread series is used, because the fine thread series does not have a deep enough thread to hold.

30. Determining size of screws.—*a.* Compare the screw to illustrations in figure 31 for the type of head. Then using a micrometer, measure the diameter of the screw, and refer this measurement to table II or III, column headed "Diameter in inches." Opposite this in the column headed "Size" the size of the screw will be found. If a steel wire or drill gage is available, insert the screw into the hole that it will fit snugly, read the number or decimal equivalent from the gage

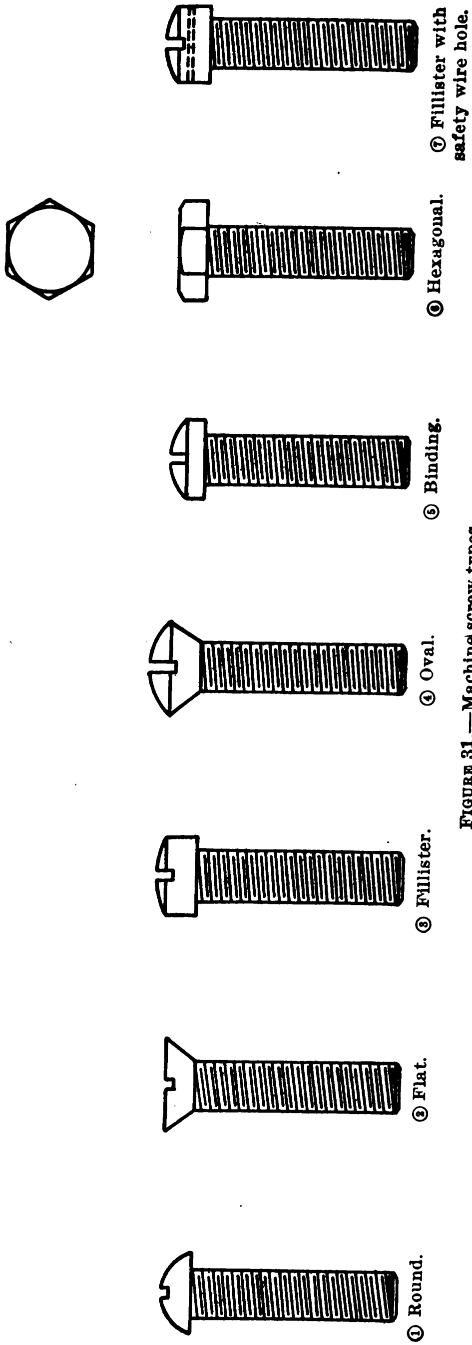


FIGURE 31.—Machine screw types.

opposite hole and the proper size of the screw may be obtained from table II or III.

b. A screw pitch gage is used for measuring the number of threads per inch (see fig. 32). This is a tool that has a number of notched blades, each blade having the same number of notches per inch as the thread it represents. To determine the number of threads per inch on a screw take the screw and select a blade from the screw pitch gage and try to fit the notches of the gage with the threads of the screw; if they mesh or fit exactly down into the threads, it is the proper

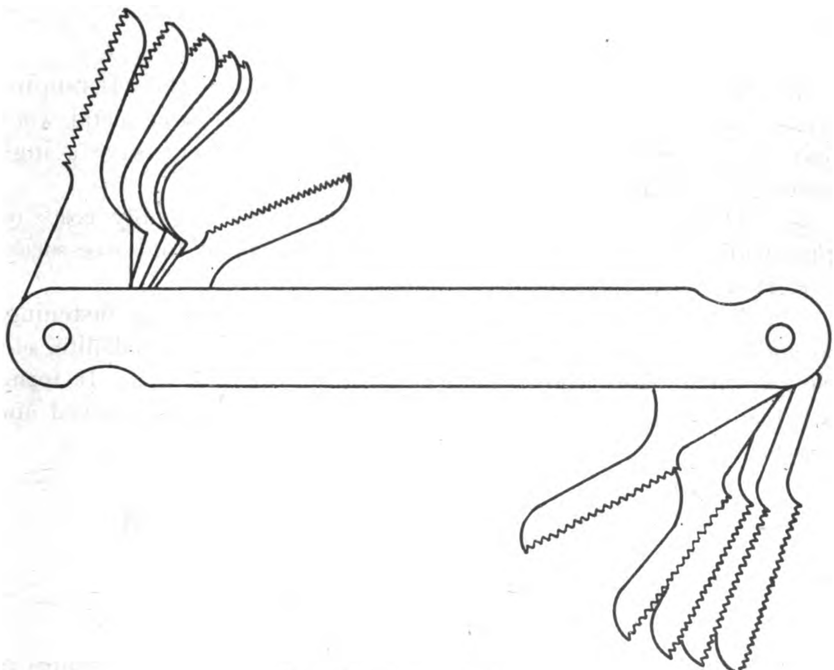


FIGURE 32.—Screw pitch gage.

blade and the size can be read from the number stamped on the side of the blade. If the notches and threads do not mesh, try another blade and so on until the proper blade is located.

31. Screws used in radio work.—*a.* The machine screws most used in radio work are 2-56, 4-40, 6-32, 8-32, 10-32, 12-24, and ¼-20.

b. Machine screws generally used in radio work are threaded full length, as shown by figure 31.

c. It is very important for the radioman to be familiar with the screw sizes and threads, otherwise he ruins the apparatus by forcing

8-36 screws into 8-32 holes, or 6-40 screws into 6-32 holes, etc. Many a loose connection has been caused by using the wrong size screw.

32. Set screws.—Another screw used a great deal in radio construction is the set screw. Its purpose is to hold gears or knobs to rotating shafts. The size depends upon the amount of holding surface required and its length varies. There are mainly two types, the square head and headless as shown by figure 33.

① Square head. ② Headless.

FIGURE 33.—Set screws.

33. Self-tapping screws.—*a.* A screw known as the self-tapping screw has appeared on the market and is used in sheet metal work and with castings. In actual production these screws save a high percentage of labor.

b. Self-tapping screws are used to cut metal assembly costs on practically all well-known radio receivers, equipment, and accessories.

c. There are two types of self-tapping screws:

(1) Type Z (fig. 34①) is used for joining and making fastenings to sheet metal up to 6-gage, aluminum, die castings, bakelite, etc. Simply turn screw into drilled, punched, or molded hole. It forms a thread in the material as it is turned in. It can be removed and replaced.

① Type Z. ② Type U.

FIGURE 34.—Self-tapping screws.

(2) Type U (fig. 34②) is used for making permanent fastenings to iron, brass, and aluminum castings, steel, bakelite, dural, etc. Just hammer the screw into drilled or molded hole. It forms a thread as it is driven. As it has a smooth head, it cannot be easily removed.

34. Elastic stop nut.—Standard nut with increased height to incorporate a fiber collar. In figure 35 is shown a cross section of an elastic stop nut.

35. Castellated nuts.—*a.* Castellated nuts are hexagon nuts with slots cut to permit the use of cotter keys for locking. Figure 36① shows two types of castellated nuts.

b. Cotter keys are formed from half-round wire and are made in various sizes. (See fig. 36②.)

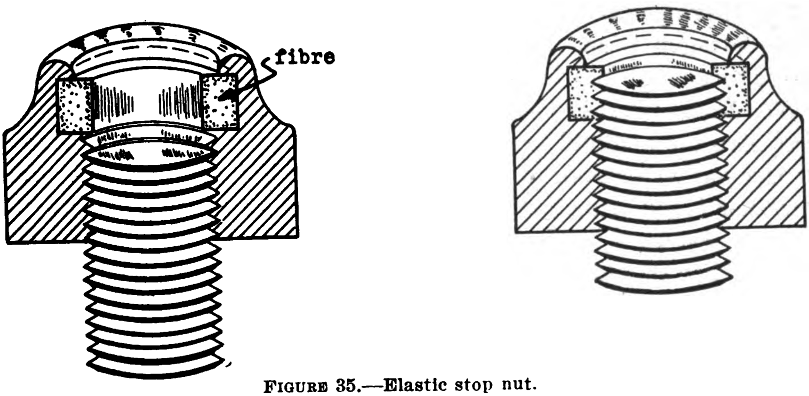


FIGURE 35.—Elastic stop nut.

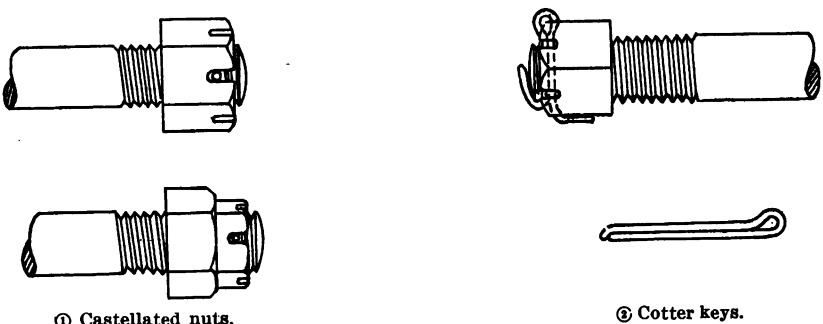


FIGURE 36.

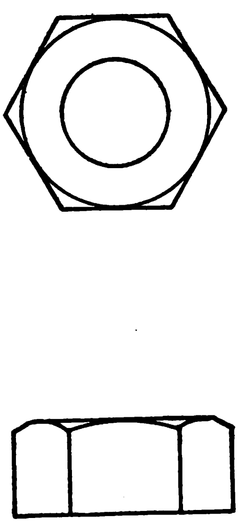


FIGURE 37.—Hexagonal nuts.

36. Hexagonal nuts.—Nuts generally used with machine screws have hexagon heads as shown in figure 37. The thickness of the nut is seven-eighths of the diameter of the screw.

37. Lock washers.—*a.* In designating the size of a lock washer, first give the nominal or bolt size, and then the width and thickness of the washer section, in the order named. For example, the size of a washer (regular section) for a quarter-inch screw would be specified as $\frac{1}{4}$ by $\frac{3}{32}$ by $\frac{1}{16}$. In making a temper test, the free height of the lock washer should be at least one and two thirds times its thickness after the first compression to a flat form.

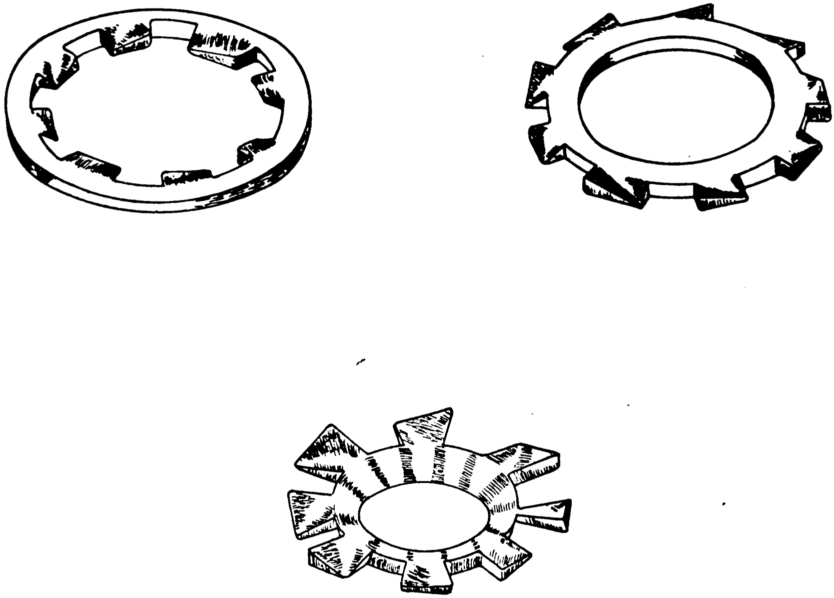


FIGURE 38.—Shake proof lock washers.

b. Additional compressions to flat forms should not further reduce this free height.

c. Small spring bronze and steel washers vary in size from No. 2 to No. 12. These washers are ordered according to size of screws; for example, a No. 10 lock washer fits a No. 10 screw, etc.

d. There are several other types of lock washers used in radio and machinery practice. Figure 38 illustrates some of these types. Figure 39 shows self-locking terminals for radio or electrical work.

38. Wood screws.—*a.* Wood screws are designated by length, size, or diameter in inches, type head, and material. The diameter of wood screws for a given size is the same as for machine screws of the same size. (See table IV.)

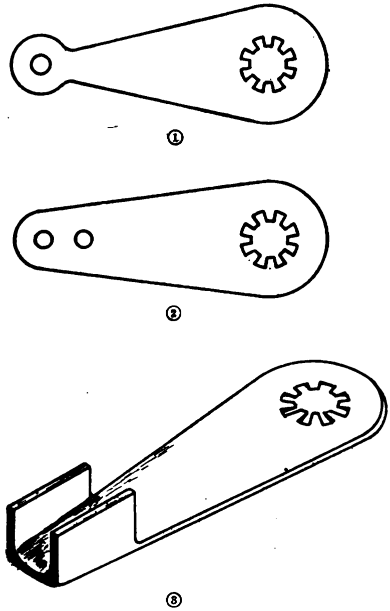
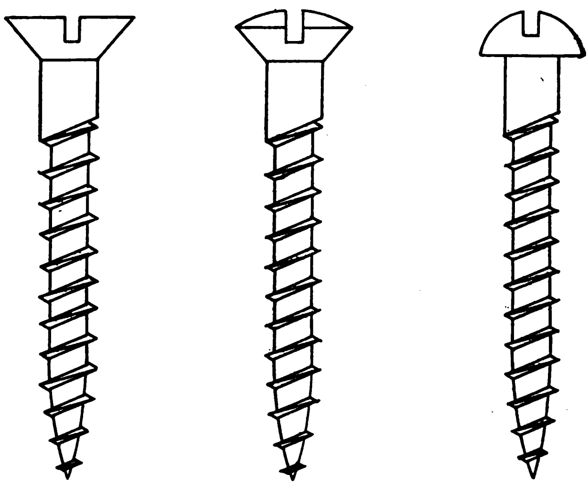


FIGURE 39.—Self-locking terminals.



① Flat head. ② Oval head. ③ Round head.

FIGURE 40.—Wood screws.

b. Three different types of wood screws are illustrated in figure 40.

c. When ordering wood screws the length is given first and then the stock size desired. As ½–10 means a ½ inch No. 10 screw. Then must follow the type of head and the type of material the screw is to be made of, for example, ½–10 flat head, brass means a ½ inch No. 10, flat head, brass wood screw.

d. The lead hole drilled for the screw should be 70 percent of the core diameter, in softwoods, and 90 percent in hardwoods, to develop the maximum strength of the screw. Use soap or beeswax as a lubricant where necessary for easy insertion. Where holding power is unusually important, select screws with thin, sharp threads, rough, unpolished surface, full gage and shallow slots.

39. Tables and dimensions of screws.

TABLE II.—*Machine screws, coarse thread*

Size	Threads per inch	Diameter inches	Tapping drill	Clearance drill
0		0.060		
1	64	0.073	53	49
2	56	0.086	49	43
3	48	0.099	45	39
4	40	0.112	42	33
5	40	0.125	38	30
6	32	0.138	35	28
8	32	0.164	29	18
10	24	0.190	25	11
12	24	0.216	16	2
¼	20	0.250	7	¼
5/16	18	0.3125	¼	5/16
⅜	16	0.375	5/16	⅜
7/16	14	0.4375	23/64	7/16
½	13	0.5000	27/64	½
9/16	12	0.5625	31/64	9/16
⅝	11	0.625	17/32	⅝
¾	10	0.750	21/32	¾
⅞	9	0.875	49/64	⅞
1	8	1.000	⅞	1

NOTE.—Use drill one size larger diameter to tap bakelite and hard-rubber.

TABLE III.—*Machine screws, fine thread*

Size	Threads per inch	Diameter inches	Tapping drill	Clearance drill
0	80	0. 060	56	52
1	72	0. 073	53	49
2	64	0. 086	50	44
3	56	0. 099	45	39
4	48	0. 112	42	33
5	44	0. 125	37	30
6	40	0. 138	33	28
8	36	0. 164	29	19
10	32	0. 190	21	10
12	28	0. 216	14	2
1/4	28	0. 250	3	1/4
5/16	24	0. 3125	17/64	5/16
3/8	24	0. 375	21/64	3/8
7/16	20	0. 4375	25/64	7/16
1/2	20	0. 500	29/64	1/2
9/16	18	0. 5625	33/64	9/16
5/8	18	0. 625	37/64	5/8
3/4	16	0. 750	11/16	3/4
7/8	14	0. 875	13/16	7/8
1	14	1. 000	15/16	1

TABLE IV.—*Wood screws*

Screw number	Thread per inch	Diameter in inches
0	32	. 060
1	28	. 073
2	26	. 086
3	24	. 099
4	22	. 112
5	20	. 125
6	18	. 138
7	16	. 151
8	15	. 164
9	14	. 177
10	13	. 190
11	12	. 203
12	11	. 216
14	10	. 242
16	9	. 268
18	8	. 294
20	8	. 320
24	7	. 372

Section IV

WIRE AND CABLE

40. General.—There are many types of wire and cable which the aircraft radio mechanic may come in contact with. He should be familiar with these types and the methods of working the various sizes. Working with wire the size of a hair is entirely different from working with cable a half inch in diameter, although their fundamental purpose is the same, that is, to carry current.

41. Types.—There are many types and kinds of wire used in electrical work. Some are bare copper or copper coated steel and others are covered with various types of insulating material. Some wires have only one solid conductor while others are constructed of many strands of small wire and are quite flexible. The above methods, as well as others, are used for classifying wire and cable.

a. Magnet wire.—Insulated wire used for winding coils, armatures, transformers, etc., is called magnet wire. It may be very fine or quite coarse; even square and rectangular sections are used. Magnet wire is usually insulated by enamel, silk or cotton covering. The enamel is baked on, and the silk or cotton is a single or double wrapping of thread. Some wires are insulated by both enamel and cotton or silk. Various abbreviations are used such as DCC, meaning double cotton covered, or SSC for single silk covered.

b. Wire for light and power.—(1) Wire for light and power is usually solid copper for the smaller sizes and stranded for the large sizes. It is insulated with an inner coating of rubber and outer covering of one or two layers of impregnated cotton braid. Wires for exterior use are known as weatherproof and for underground service are covered with a lead sheath.

(2) Much interior wiring is accomplished with some of the twin conductor or duplex wires which are on the market. These have two insulated conductors protected by an outer covering of metallic or nonmetallic material and are usually known by their trade names such as BX, Romex, etc.

c. Flexible appliance cord.—Various kinds of appliance cord are in use. Soldering irons, electric drills, desk lamps, radio sets, etc., all have a length of cord with a plug on the end. These cords have two flexible insulated conductors protected with a covering of moulded rubber or cotton braid. The cords used with soldering irons or other heating units are insulated with asbestos and a cotton braid.

42. Wire size.—*a. Systems of indicating.*—Several systems are used for indicating the size of wire and cable. One system assigns numbers to represent various diameters of the bare wire while another system indicates the area of the cross section of the conductor in circular mils. The circular mil is the area of a circle .001 inch in diameter. Circular mils are used for large cables, the number system being used for the small and medium wires and cables. Numbers are used for small stranded wire and in this case it means that the area of the stranded conductor is the same as that of a solid wire of the same numbered size. Steel and iron wire are measured by a different set of numbers than the ones used for copper wire. In other words, a No. 14 copper wire is not the same size as a No. 14 iron wire. Copper wire is measured with the AWG system (American wire gage). This is the same as the B&S gage.

b. AWG or B&S wire gage.—The table below indicates the number and diameter in mils. One mil is equal to .001 inch.

Gage number	Diameter in mils	Gage number	Diameter in mils
0000	460. 0	20	31. 96
000	409. 6	21	28. 46
00	364. 8	22	25. 35
0	324. 9	23	22. 57
1	289. 3	24	20. 10
2	257. 6	25	17. 90
3	229. 4	26	15. 94
4	204. 3	27	14. 20
5	181. 9	28	12. 64
6	162. 0	29	11. 26
7	144. 3	30	10. 03
8	128. 5	31	8. 928
10	101. 9	32	7. 950
12	80. 81	33	7. 080
14	64. 08	34	6. 305
15	57. 07	35	5. 615
16	50. 82	36	5. 000
17	45. 26	38	3. 965
18	40. 30	40	3. 145
19	35. 89		

c. Large cable.—Cable larger than No. 0000 is given in circular mils. The area of No. 0000 cable is 211,600 circular mils.

43. Splicing.—*a.* Various methods are used for splicing wires and cables depending on their size, type, and the mechanical strain which the splice must withstand. All but temporary splices should be soldered to keep the surfaces which make contact from oxidizing. The splice should give a good electrical and mechanical joint without the solder. The splice should be taped to give insulation equivalent to the rest of the wire. For ordinary power and lighting conductors this requires a layer of rubber tape covered with a layer of friction tape. In an aircraft installation a splice must be considered a temporary connection only and the conductor involved should be replaced at the earliest possible time by an unbroken length of wire.

b. The Western Union splice should be used for all solid wires which will be under tension. A properly made splice of this kind will withstand as much strain as the wires which it fastens together. Figure 41 shows the method of making this splice. Figure 42 shows the splice completed and ready for taping.

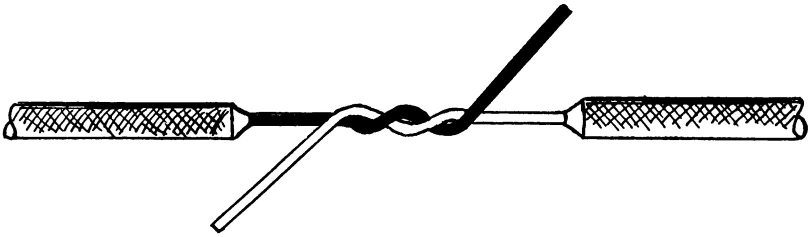


FIGURE 41.—Making Western Union splice.

FIGURE 42.—Western Union splice completed.

c. When twin conductors are spliced one wire should be cut longer than the other so the two splices can be staggered. This keeps the splice from being so bulky when it is taped. (See fig. 43.)

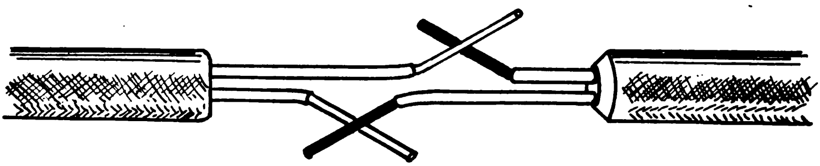
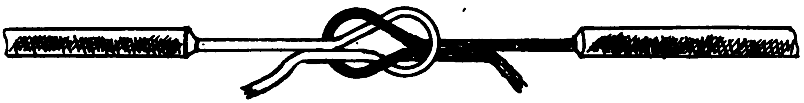


FIGURE 43.—Staggering the twin conductor splice.

d. To get a splice which will withstand tension in flexible stranded wire, knots may be required. A square knot with the ends wrapped around the remaining bare section of wire makes a good splice for small flexible wire. (See fig. 44.)



① Square knot.

② Ends wrapped around wire.

FIGURE 44.—Flexible wire splice.

e. Sometimes it is necessary to splice a stranded conductor to a solid one. Figure 45 illustrates a method which will stand considerable tension.

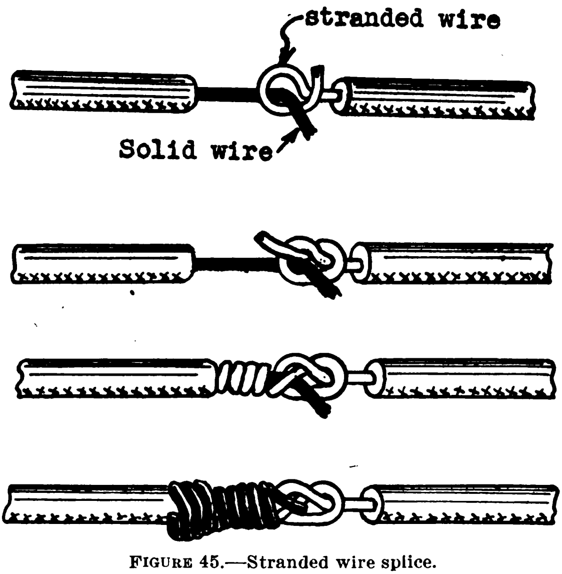


FIGURE 45.—Stranded wire splice.

44. Terminating wires.—*a. General.*—The ends of wires and cables are fastened to switches, fuse blocks, plugs, sockets, etc., in various manners. Small magnet wire ends are usually soldered to eyelets or other type of terminals. Both solid and stranded wire is fastened with screws or binding posts by forming a loop in the end of the wire.

b. Solid wire.—The ends of solid wire should be freed from insulation and scraped bright with the back of the knife blade, then formed into a loop with the long nose pliers. This loop should be of such size to fit snugly over the screw. Figure 46 shows a loop of this kind.

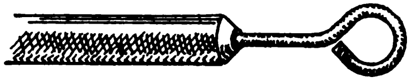


FIGURE 46.—Solid wire terminal.

c. Stranded wire.—The ends of stranded wire should be carefully freed from insulation and untwisted. Each strand should be scraped bright with the back of the knife blade, or if the strands are very fine they may be spread out flat over the thumb and scraped between the

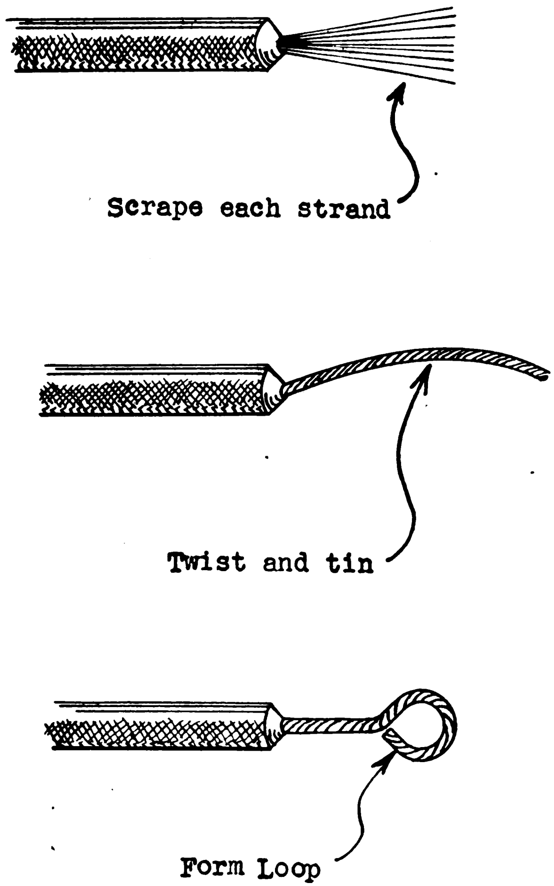


FIGURE 47.—Stranded wire terminal.

thumb and the back of the knife blade, and the wire rotated until they are bright and clean. After this operation the end is twisted and tinned. It is advisable to retwist the wire in the same manner as was done by the manufacturer. The tinned end is stiff enough to form into a loop. (See fig. 47.)

d. Upset screws.—Many times the screws have been upset (end enlarged or turned over by hammer) so that they cannot be completely removed. This is to prevent them from being dropped and lost. In this case the ends are prepared as described above except the bare end is made slightly longer. This bare end is then bent around the screw, usually by the fingers, and snipped off close with the diagonal pliers. (See fig. 48.)

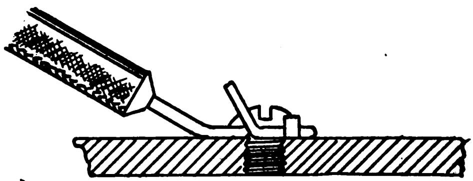


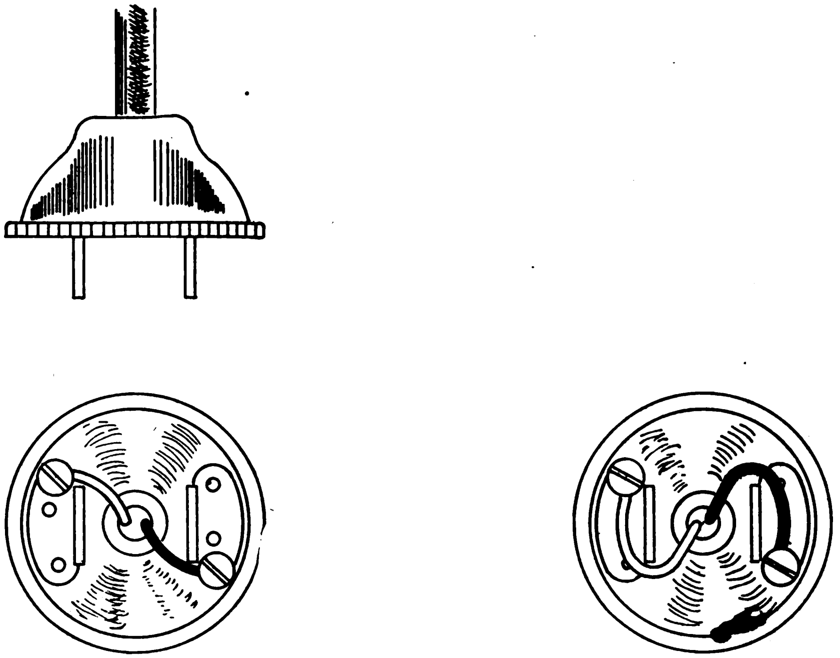
FIGURE 48.—Fastening wire to upset screws.

e. Important.—In every case the loop should be around the screw in the same direction that the screw must be turned to tighten it. Otherwise, the loop will have a tendency to spread and creep out from under the screw head.

f. Convenience outlet plugs.—The ends of the flexible cord should be prepared as described above and fastened under the screw of the plug. Instead of taking the wires to the screws by the shortest path they should be placed around the plug prongs to keep them separated as far as possible and thereby reduce the chance of a short circuit at the plug if a strand or so were to break loose near the screw. Figure 49 shows views of a plug with the wires fastened correctly and incorrectly.

45. Sweating on terminals.—*a. Cup lugs.*—Wiring that terminates at power boards and other apparatus is generally sweated into terminal lugs. Terminal lugs, especially for the larger sizes of wire, usually have a cup socket or a socket closed at the bottom. When soldering a solid or a stranded wire into a socket, it is difficult to get the solder heated and drawn into the socket with the soldering iron. The preferred method is to tin the stripped end of the wire and fill the socket with solder. First the insulation is removed from the wire, then the wire is cleaned and tinned, the inside of the socket is cleaned and tinned and the stripped end of the wire is cut to such length that it does not quite reach the bottom of the socket. Next the socket is reheated and filled with solder, with an allowance for wire displacement. Then insert the tinned end of the wire in the socket with the insulation of the wire just touching the rim of the terminal lug. Remove the soldering iron and allow joint to cool for a second or two while the wire is held steady with a pair of long nose pliers.

b. Clamp lugs.—Small lugs with a spade or eyelet end are used extensively with stranded conductors. These lugs usually have sev-



① Incorrect. ② Correct.

FIGURE 49.—Convenience outlet plug.

eral clamps for holding the conductor and its insulation. Figure 50 illustrates these clamp lugs. When fastening a conductor to lugs of this type it is important to clamp at least two ears over the insulation to keep it from fraying. This procedure also keeps the strands of wire from bending so sharply and breaking where they enter the lug. The wire should be soldered to the lug to insure a good permanent electrical connection. If the lug has a small hole in it the strands should not be pre-tinned but instead pulled through this hole, divided, bent back and soldered. This relieves mechanical strain from the soldered connection. The exposed metal part of the lug should be taped or have a piece of rubber tubing slipped over it if many terminals are close together or for some other reason there may be danger of a short circuit.

c. Soldering precautions.—(1) Only a small amount of solder should be used when making any electrical connection. Too much solder results in a lumpy joint; it also might affect the resistance value of the circuit. An imperfect joint, one that is likely to cause trouble, is what is known as a rosin connection. In such a case the solder sticks to only half of the connection and between the two surfaces

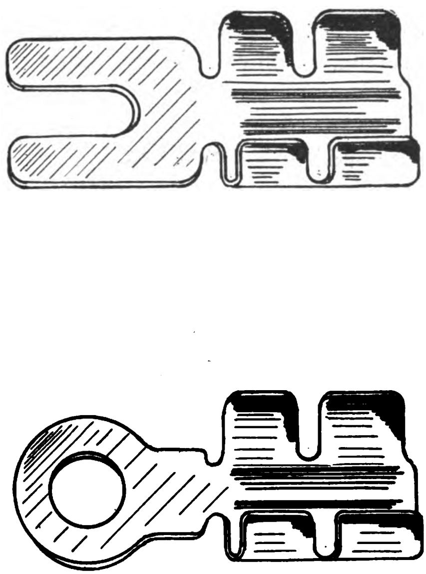


FIGURE 50.—Clamp lugs.

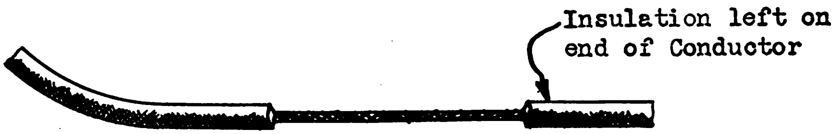
is a layer of rosin which acts as an insulator. A rosin connection is usually caused by using rosin cored solder with an iron not hot enough. While the rosin melts and spreads over the metal, the solder is not ready to flow and when it does, it merely piles up on the metal.

(2) When soldering wires to jacks, two or more terminals are very close together. Care must be taken, therefore, to keep solder from lumping and dropping from one terminal to the other one, thus creating a short circuit. If insulation is stripped too far back from the end of the wire, any moving of the wire might cause a short circuit.

46. Tinsel wire.—*a.* Tinsel wire is composed of a great number of very fine hair-like wires bound inside a fabric insulation to form one conductor. It is very flexible.

b. Figure 51 shows a piece of tinsel wire cut and stripped correctly and incorrectly. The very fine woven wires unravel, and are then impossible to fasten to a terminal if the correct method is not used. In stripping tinsel wire of insulation in preparation to soldering, it is best to back a slight distance from the end of the wire and cut the insulation off of the wire, leaving a small amount of insulation at the end of the wire to hold the small hair-like wire together. Scissors are used principally in stripping insulation from tinsel. There are two layers of insulation, a coarse woven outside, and light cotton twist, inside the outer covering. The outer covering is easily removed with the scissors, but the inner is more difficult to remove without damaging the wires. It is best to slightly twist the tinsel after the outer covering is removed. This pulls the inner insulation

① Incorrect.



② Correct.

FIGURE 51.—Stripping tinsel wire.

up slightly and away from the tinsel, so the ends of the scissors may be inserted and the cotton fibers clipped away.

c. After the insulation is stripped off a slight distance from the end, a small piece of copper wire about No. 32 to No. 36 is wrapped around the basket weave of the conductors in the tinsel cord. This is then tinned before the end of the wire on which the insulation was left for holding purposes is clipped off. If the tinsel conductors are not seized before clipping off the ends of the insulation holding them together, they will unravel as soon as the wire is cut.

d. In soldering tinsel wire, never place the hot iron directly on the small wires of the tinsel cord. Place the end of the prepared tinsel on or in the terminal and hold the iron on the terminal until solder flows freely when applied.

e. When fastening tinsel wire to spade or eye terminals, it is desirable to have the insulation extend a short distance inside the terminal which is clamped down on the insulation to keep it from unraveling. It may also be necessary to seize the end of the insulation a slight distance from the end where stripped, with a very light cord to help keep the thread from unraveling. This should be done before clamping.

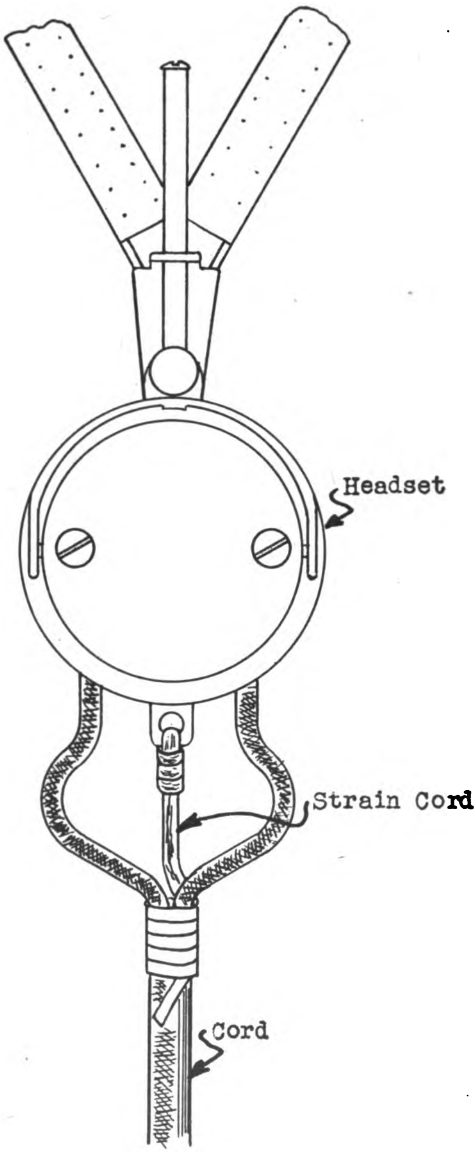


FIGURE 52.—Fabric cord to relieve strain.

f. Tinsel wire is principally used in headset and microphone cords. It can be used anywhere a cord of no great tensile strength and light current carrying capacity is needed. It is especially useful if great flexibility is desired, for tinsel supplies this need admirably. To relieve the strain on the terminals a fabric cord is usually woven into the insulating braid near the end. This cord is tied to the appliance so as to leave some slack in the conductors. (See fig. 52.)

47. Army Air Force and Signal Corps types.—Both Army Air Force and Signal Corps wire, cable and cordage are used by the aircraft radio mechanic in his work. The correct nomenclature and description of the types which are used to the greatest extent are given below.

a. Army Air Force types.—(1) Cable, aircraft, power and lighting, Nos. 6, 8, 14, 16, 18, and 20, AWG, Specification No. 27074 or AN-J-C-48, is used by the Army Air Force.

(2) The above cable is used for interconnecting interphones and radio set components where rigid and flexible conduit is used.

b. Signal Corps types.—(1) *W-106 and W-106-A, wire, antenna.*—This is a steel center, copper coated wire. Pliers should never be used on this wire in making a tie, because when the wire is nicked or bent sharply it will break or give way. All ties should be made entirely by hand. This wire is used for aircraft antenna and transmitter lead-ins.

(2) *W-65, wire, single conductor No. 16.*—Has 26 strands, and will withstand 10,000 volts. This wire is generally used for the lead-in to the receiver in the airplane. It is not suitable for transmitter lead-in construction. Army Air Force ignition wire, Specification No. 95-28003 or AN-J-C-56 is equivalent to the above.

(3) *CO-76, 5 feet, 3 conductor cord.*—Constructed from cordage CO-122, with terminals TM-47 on one end and conductors of other end twisted and twined to fit plug PL-68. Part of microphone T-17.

(4) *CO-121, cordage, 2 conductor, shielded.*—Used for interconnecting radio sets SCR-183 and SCR-187-A.

(5) *CO-120, cordage, 8 conductor, shielded.*—Used for interconnecting radio sets SCR-183 and SCR-187-A.

(6) *CO-127, cordage, single conductor, shielded.*—Used for high voltage on SCR-187-A and SCR-238 sets.

Section V

AIRCRAFT RADIO INSTALLATIONS

48. General.—*a.* In the design and construction of practically all aircraft now in service, provisions have been made for installing radio equipment. Detailed instructions for the installation of radio equipment in each model of airplane is covered by Army Air Force or airplane manufacturers' drawings. Contracts for the procurement of aircraft specify that the manufacturer make provisions for and install radio equipment except in the case of primary training ships. As new types of radio equipment and new models of airplanes are developed, detailed drawings of all radio equipment and installations will be prepared.

b. The component parts of the radio set are installed at different locations in the aircraft due to space limitation. This complicates the interconnection of components and the connections to the central power systems and controls. Components are mounted in such a way that, even when located in out of the way and hard to get at places, they can be removed with minimum effort for inspection or replacement. This is accomplished by the use of special mounts equipped with snap slide fasteners and plug socket arrangements.

49. Mountings.—The mountings are fastened securely to the aircraft structure and may include a rubber shock absorber for limiting the vibration of the radio component. Ingenious snap slide or other fasteners are provided for securely attaching the radio component to its mounting. Provisions are included for keeping the snap slide fasteners closed with safety wire. The mounting comes as a part of the radio component but is of such nature as to be interchangeable with other similar components.

50. Junction boxes.—To facilitate the wiring of the radio sets, junction boxes are provided at convenient places. These are metal boxes with removable or hinged covers containing terminal strips or other equipment. The junction box with the attached conduit may form a permanent part of the aircraft wiring installation and is installed at the aircraft factory or may be fastened to a mount with snap slides. The junction box also facilitates trouble shooting in the interconnecting wiring.

51. Cord and plug assembly.—*a. General.*—Multiconductor shielded cable fitted with plugs at each end and used to connect the various components of radio sets is known as a cordage installation. The Signal Corps PL series of plugs is used for both cordage and individual conductor installations. The cordage comes in various sizes and number of conductors. Great care must be exercised in the construction and installation of a cord and plug assembly, for the failure of any one of the many conductors within the cords may cause the

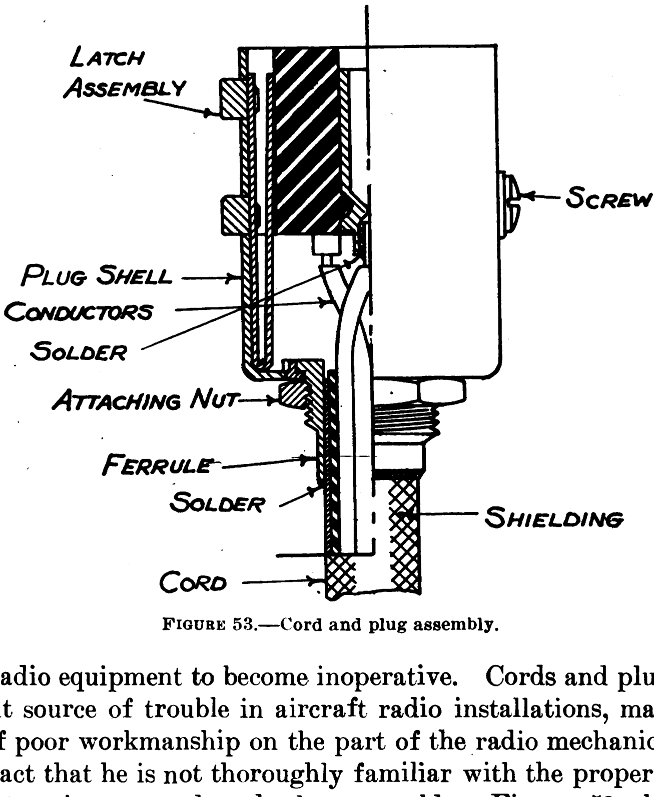


FIGURE 53.—Cord and plug assembly.

entire radio equipment to become inoperative. Cords and plugs are a frequent source of trouble in aircraft radio installations, mainly because of poor workmanship on the part of the radio mechanic, or due to the fact that he is not thoroughly familiar with the proper method of constructing a cord and plug assembly. Figure 53 shows an assembly of this kind.

b. Method and procedure of constructing a cord and plug assembly.—(1) Measure the desired length of cord with a flexible tape. Run the tape along the most practicable route in the aircraft between the components you wish to connect. Be certain that the cord is to be installed in such a manner as to permit adequate bonding to the airplane structure every 18 inches or less; be certain, also, that the cords, when installed, will not interfere with any moving parts of the aircraft, such as control cables, bomb racks, etc.

(2) Cut the proper type cord to the above measured length, allowing an additional 3 inches on both ends.

(3) Procure the proper plug or plugs desired for the cord.

(4) Most plugs are similar in assemblage but will vary to a certain extent. Disassemble PL-P and PL-Q plugs by removing screw only. It is not necessary to remove the attaching nut.

(5) Clean ferrule inside and on the outer edges to assist in the soldering operation.

(6) Thoroughly clean plug contacts, especially inside and on edges. Fill contacts with rosin core solder, being careful not to scorch or burn the insulation of the plug between the contacts.

(7) Carefully clean the shielding of the cord approximately 1½ inches from the ends. Make two marks 1$\frac{3}{16}$ inch and 1$\frac{9}{16}$ inches from the ends and apply a thin ring of solder between the two marks just made. Be careful with the iron, which must be very hot. Keeping the iron too long at one place might tend to ruin the insulation under the shielding.

(8) Remove the shielding by cutting with a knife or electricians scissors 1$\frac{3}{16}$ inches from the end of the cord. You should cut about half of the soldered ring away. This will result in a smooth edge. Be careful not to cut the rubber insulation.

(9) Cut the rubber insulation away for a distance ¾ inch from the end of the cord. Be careful not to cut the insulation of the individual conductors during this operation.

(10) Cut the packing cord from around the individual conductors.

(11) Strip the insulation from the individual conductors approximately $\frac{5}{32}$ inch from their ends.

(12) Slightly twist the strands of the conductors, following their original twist, and tin them very carefully, being sure that there are no single strands sticking away from the tinned ends.

(13) Place the attaching nut, washer, plug shell, and ferrule on the cord, moving them toward the center of the cord out of the way of the soldering operation.

(14) Consult the cording diagram of the radio installation on which you are working. This diagram is found in the Technical Order or instruction book pertaining to the particular set.

(15) Solder the large wires first, then complete the whole operation, consulting the cording diagram frequently for color code and

plug contact numbers. Be careful not to burn any insulation with the soldering iron.

NOTE.—Where a No. 8 conductor cable is used with a No. 5 contact plug, and the cording diagram shows two and sometimes three of the conductors soldered to a single contact in the plug, this requires most intricate and careful work. Under no circumstances cut off the surplus conductors or solder them in a different manner than that shown in the Technical Order. The particular circuits are heavy current carrying lines and it is desirable that the plugs be wired as indicated to reduce voltage drops in the cords.

(16) Clean off all excess flux from the plug and contacts with carbon tetrachloride and then put a protective coating of "Glyptal" varnish on each soldered connection. This prevents corrosion at the connections.

(17) Assemble the plug carefully, lining up the latch assembly and the lock screw hole. The latch assembly is placed in the holes of the plug shell in the correct position and held in place with a thin screwdriver while the plug is slid into the shell. Line up the screw hole and insert screw with a coat of Glyptal varnish on the washer.

(18) Hold the plug assembly in one hand and with the other pull on the cord until it is taut, place thumbnail on the shielding approximately 3/16 inch from the ferrule and push the cord into the ferrule until stopped by the thumbnail. This takes the strain off the soldered connections.

(19) Heat the iron, clean it with a damp rag and sweat the ferrule to the shielding. If your measurements have been correct, the edge of the ferrule should cover the tinned ring on the shielding. In view of the fact that solder is brittle and crystallizes readily, it is advisable that no solder show on the outside of the ferrule, otherwise the flexibility of the cord is destroyed and there is danger of the shielding breaking at the ferrule.

(20) Prepare the other end of the cord the same way, unless of course there is no plug on the other end, as in a battery connection.

(21) When both plugs are completely assembled on the cord, check the cord with a voltohmmeter. The correct way of checking is as follows:

(*a*) Form a loop with the cord and put one plug between thumb and forefinger, and the other one between forefinger and middle finger of your left hand, so as to have your forefinger separating the metal of the two plugs.

(*b*) Insert one test prong of the meter into one contact hole in one plug and with the other prong go into each hole in the other plug, winding up by touching the shell.

(*c*) Move the first prong to the next hole in the first plug and again go through every hole in the second plug.

(*d*) Only the same numbered holes should show a total deflection of the meter, with the exception of the grounded conductor which also should show a total deflection when the shell or the shielding is touched.

(22) Solder bonding pigtails (see par. 53*c*) every 18 inches along the length of the cord.

NOTE.—When high frequency sets are used in the airplane the distance between the bonding pigtails should be reduced to 14 inches.

(23) Tape the entire length of the cord with friction tape.

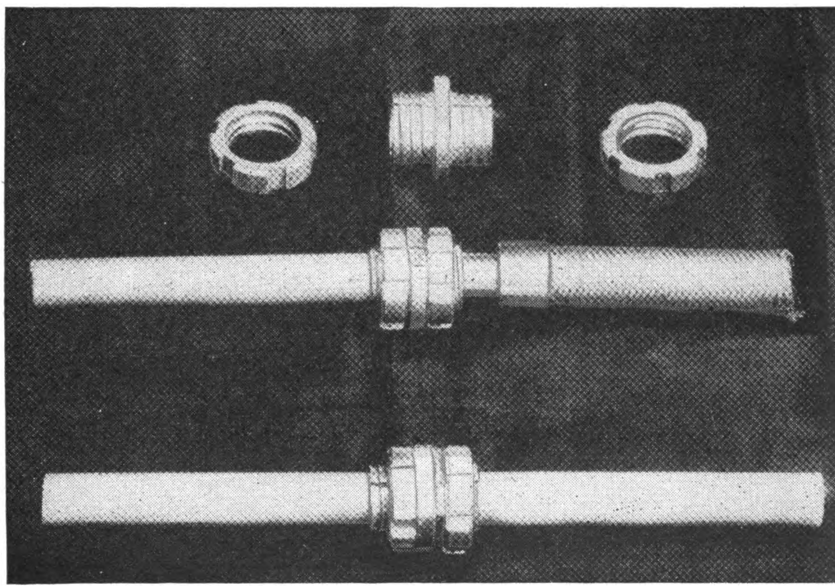


FIGURE 54.—Conduit union, tube size.

(24) Cover the tape with a coat of shellac and let dry. The cord and plug assembly is now ready for installation.

52. Conduit installations.—Rigid and flexible conduit is used in modern aircraft to protect and shield the wires which connect radio set components instead of cord and plug assemblies. Rigid conduit is used to within about 18 inches of the radio set components, then flexible conduit with a PL, PL-P, or PL-Q series plug is used to connect into the internal wiring of the radio equipment. A conduit union and ferrule are used to join rigid and flexible conduit. (See fig. 54.) It is very important for the aircraft radio mechanic to be familiar with the nomenclature, description, and use of the accessories used in conduit installation. The various clamps, ferrules, unions, plugs, etc., will be described with the correct nomenclature.

a. Tubing, aluminum, class 23-A, Spec. 10235 or WW-T-783.—This is a round seamless aluminum tubing used as conduit for airplane electrical wiring. (See fig. 55.) It provides electro-static shielding, and at the same time protects the wiring system. This tubing comes in different sizes, the size referring to the *outside* diameter. In determining the inside diameter, the wall thickness (see table, *o* below) must be considered. It also is available in different grades or hardness, the one in general use being the half-hard grade. The bending of this tubing is done either with the hand bender (size determines the size of tubing it will bend efficiently) or with the tube bending machine

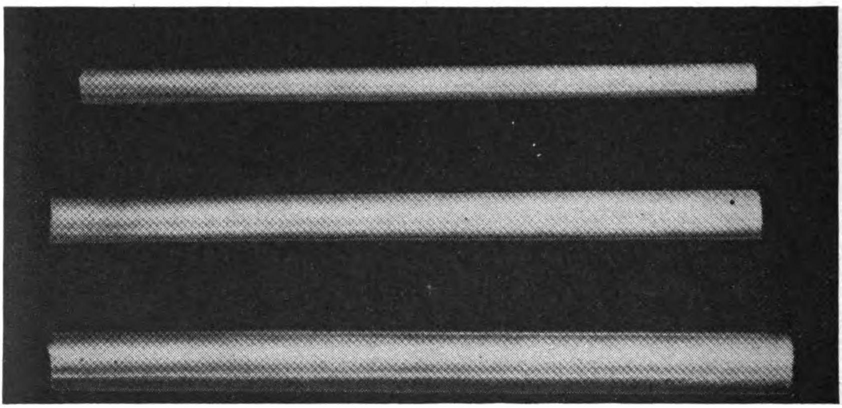


FIGURE 55.—Aluminum tubing.

which is kept in the post engineering department. The latter is used chiefly on hard tubing and such operation involves heat treating. (Read Technical Order 23-15-1.)

b. Conduit, flexible, class 08, Spec. 32007 or AN-WW-C-561.—This type of tubing is made flexible by its construction. It consists of a spirally wound aluminum strip covered with braided, tinned copper or aluminum shielding. (See fig. 56.) It also comes in different sizes, the nominal size being the inside diameter. As a result, the sizes are not physically the same as the same nominal sizes of rigid conduit. It is used to make a flexible connection between junction boxes and the component parts of the radio set.

c. Ferrule, flexible conduit, end plain, class 04-A.—This is a short connection with different diameters on its two ends. It comes in different sizes, the size referring to the *outside* diameter of the *small* end. This end fits into either the clamp or the union. It serves as the connecting part between flexible conduit and the junction box or between flexible conduit and rigid conduit. This type ferrule is illustrated in figure 57.

d. Ferrule, flexible conduit, end shoulder, class 04-A.—This is a small fitting used on the end of flexible conduit. A shoulder on the end

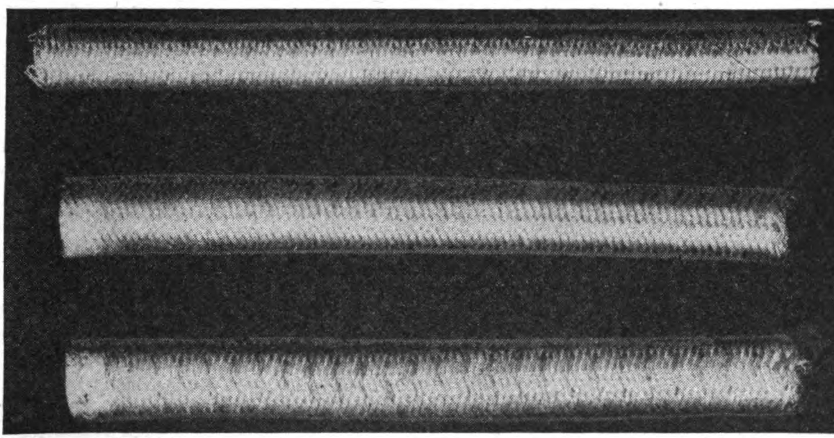


FIGURE 56.—Flexible conduit.

of it holds a threaded nut in place. (See fig. 58.) It is used to make connections between flexible conduit and any accessory using a standard threaded section, as for instance certain instruments. There is also procurable a completely assembled end shoulder ferrule.

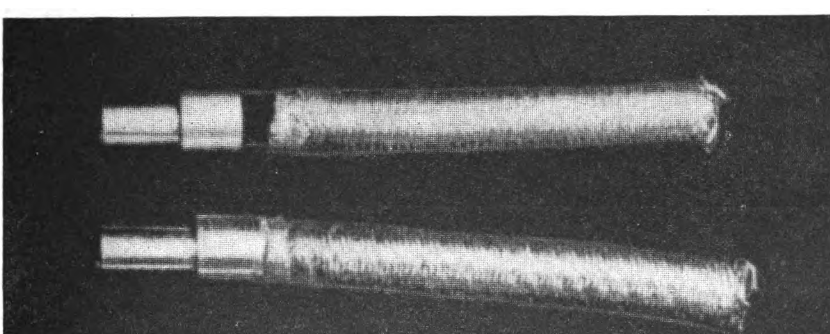


FIGURE 57.—Flexible conduit ferrule, plain end.

e. Clamp, conduit, tube size, class 04-A.—This is a turned section of aluminum alloy for anchoring the end of rigid conduit or the ferruled end of flexible conduit in the junction box. The outside of this unit is threaded and takes a nut with a conical thread. A gap along the whole section allows the diameter to be reduced slightly when the nut is screwed on tightly. A shoulder on one end of the clamp is placed on the inside of the junction box, the conduit or ferrule slipped into the other end of the clamp and the nut screwed tight. (See fig. 59.)

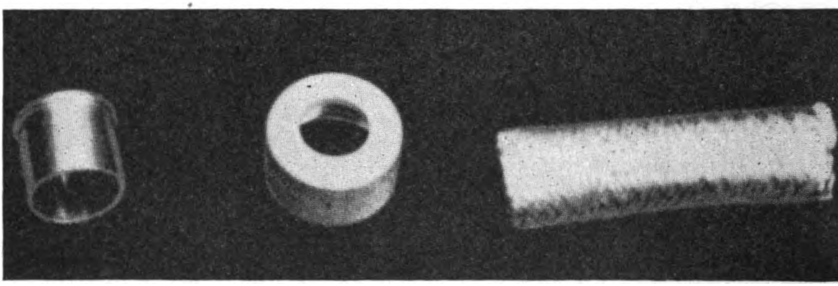


FIGURE 58.—Flexible conduit ferrule, end shoulder.

f. Union, conduit, tube size, class 04-A.—The union is in effect the same as two clamps fastened together; that is, both ends are threaded and both ends take a nut with a conical thread. It is used to connect rigid conduit to rigid conduit or flexible conduit to rigid conduit. (See fig. 54.)

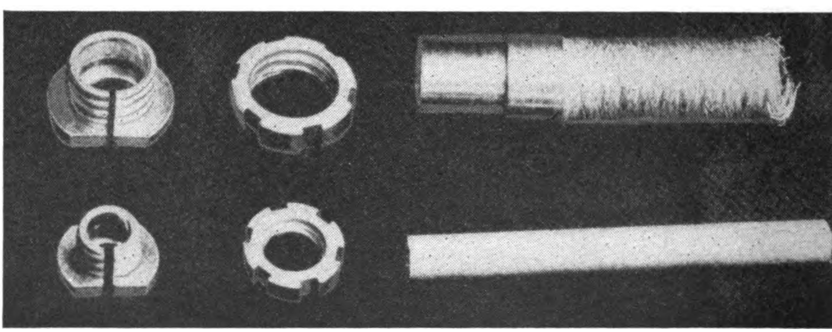


FIGURE 59.—Conduit clamp, tube size.

g. Clamp, bonding, class 04-A.—This simple clamp fits around the proper size conduit. It is used for bonding the tubing to the airplane structure and also to prevent vibration by bonding two or more parallel conduits together. (See fig. 60.)

h. Clamp, tubing, one bolt, class 04-A.—This is another simple clamp for securing rigid conduit against a flat surface or for supporting two parallel sections of rigid conduit.

i. Clamp, tubing, two bolts, class 04-A.—The only use for this clamp is to secure the tubing against a flat surface. This clamp takes a bolt on each side of the tubing, while the one bolt clamp fits around the tubing and is secured with only one bolt.

j. Clamp, support, tube, class 04-A.—This clamp somewhat resembles the well-known hose clamp. It fits around a brace in the airplane and takes a one bolt clamp at the same time. It is used, as the name implies, to support a section of tubing against the airplane structure, where it is impossible to secure such tubing against a flat surface.

k. Terminal, electrical, copper, soldering lug, light, class 29.—These are eye terminals to be soldered to the ends of aircraft cable, class 08. Each terminal has four small tabs, the outer two are clamped over the insulation of the wire, and the other two are bent over the soldered connection and sweated. (See fig. 61.)

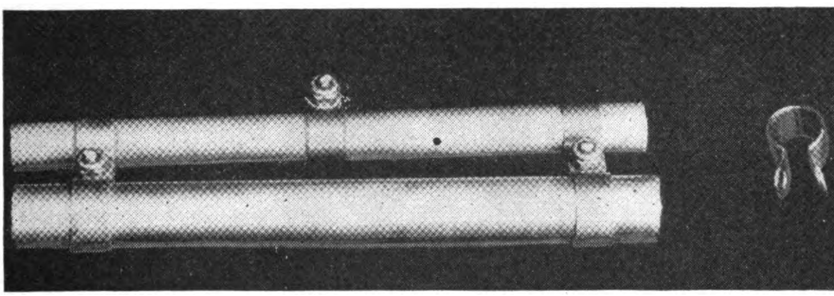


FIGURE 60.—Bonding clamp.

l. Plugs, type PL-P ( ) or PL-Q ( ).—Many plugs used with flexible conduit are of the PL-P ( ) or PL-Q ( ) type, which means that they are equipped with a ferrule of the correct size to fit the associated flexible conduit. The number of contacts in the plug determines the size of the ferrule, which in turn will fit snugly over the correct size of flexible conduit which is used with it. (See fig. 62.)

m. Straight and right angle plugs.—Plugs PL-P ( ) are constructed so the flexible conduit attaches directly to the rear of the plug. If a plug and socket connection is in a location which is comparatively close to the fuselage or another part of the radio set, a Q ( ) type plug can be used. In this type plug the flexible conduit will leave the plug proper at right angles which facilitates the handling of the plug considerably and prevents unnecessary bending of the conduit. (See fig. 63.)

n. Plug, pin type.—This type plug is quite different from the other types mentioned. It has no plug shell screw and no latch assembly. The ferrule is locked against the shell by a knurled threaded collar. The plug proper is held in place inside the shell by means of a spring retainer ring. Into each of the contacts, holes of the plug proper fits a cylindrical terminal. These terminals are held in place by a slotted bakelite disk which slides sideways into or out of place when the plug proper is removed from its shell. The fact that the individual

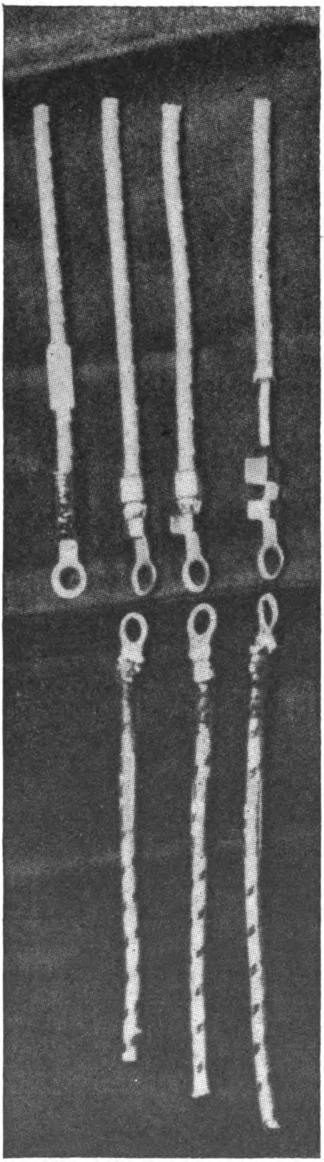


FIGURE 61.—Copper electric terminal, light soldering lug.

terminals may be removed from their contacts facilitates soldering operation. This type plug is held in its socket by means of threads on outside of plug shell.

o. Rigid conduit.—(1) In all calculations of conduit diameter, the wall thickness table must be carefully considered. To determine the size of conduit necessary for a given number of cables, bundle the group together, and measure the maximum width of the bundle. This dimension must not exceed the percentage of the inside diameter shown in table V for each size of conduit. Following the above procedure leaves enough space in the conduit so wires can be pulled in without too much trouble.

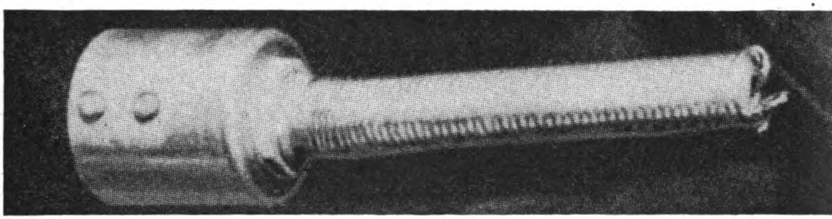


FIGURE 62.—P-type plug sweated to a length of flexible conduit.

TABLE V.—*Rigid conduit*

Conduit (outside diameter)	Wall thickness	Percentage of inside diameter
¼″	0. 022	74
⅜″	. 022	74
½″	. 028	74
⅝″	. 028	75
¾″	. 032	75
1″	. 032	80
1¼″	. 042	80
1½″	. 042	80
2″	. 049	--------
2½″	. 058	--------

TABLE VI.—*Cable sizes*

Gage	Diameter	Gage	Diameter
00	0. 575	10	0. 208
0	. 525	12	. 186
2	. 440	14	. 166
4	. 370	16	. 146
6	. 300	18	. 136
8	. 250	20	. 126
------	-----	22	. 090

(2) Rigid conduit must be adequately attached to the airplane structure. Figure 64 shows a clamp used in connection with rigid conduit installations. Conduit sections in the fuselage, except from the rear compartment to the empennage, should be easily removable to facilitate replacement.

(3) Rigid conduit is bent by using bending machines. Figure 65 shows several of these hand bending machines. A hacksaw may be used to cut conduit, in which case the bur should be removed with a pipe reamer, a round or half-round file.

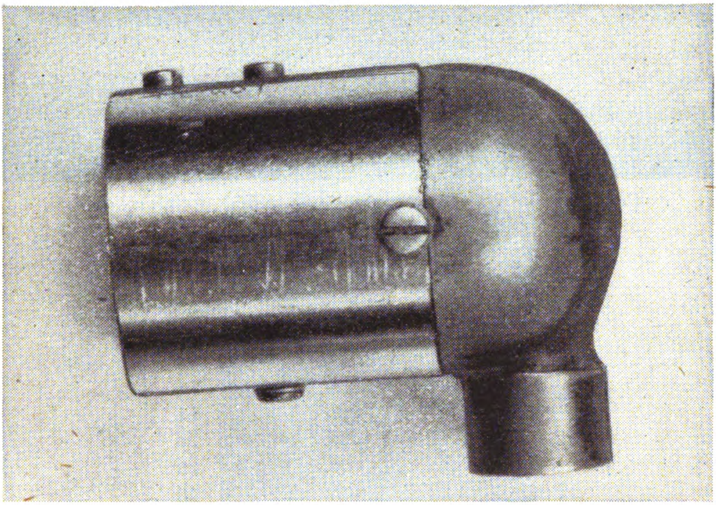


FIGURE 63.—Q-type plug.

p. Attaching plugs to flexible conduit.—(1) In general the methods described for constructing a cord and plug assembly can be used when working with flexible conduit. Before cutting the conduit with a hacksaw, tin a strip around the copper braid covering the conduit to prevent it from fraying. If the conduit is stretched before it is tinned the outside diameter will be slightly smaller and this makes it fit easier into the plug or ferrule. Always remove the bur from both ends of the conduit. The above procedure does not apply to aluminum covered flexible conduit which cannot be tinned.

(2) Disassemble the plug and clean and tin the inside of the ferrule. The attaching nut does not usually need to be removed if the plug is new, as the ferrule will slip easily over the conduit.

(3) Cut the proper type and number of power and lighting cables. Always cut the cable a few inches longer than necessary to allow for mistakes. (See par. 51*e*(2).)

(4) Carefully cut the insulation from each conductor and tin the ends after they have been twisted slightly in the direction of their original twist.

(5) Solder the conductors into the plug terminal cups, being careful not to burn the insulation or allow any movement while the solder is cooling. Blowing on the soldered joint will hasten cooling. A damp cloth is useful to clean, hold, and cool soldered connections. The plug terminals should be cleaned and filled with rosin core solder before the tinned end of the conductor is inserted.

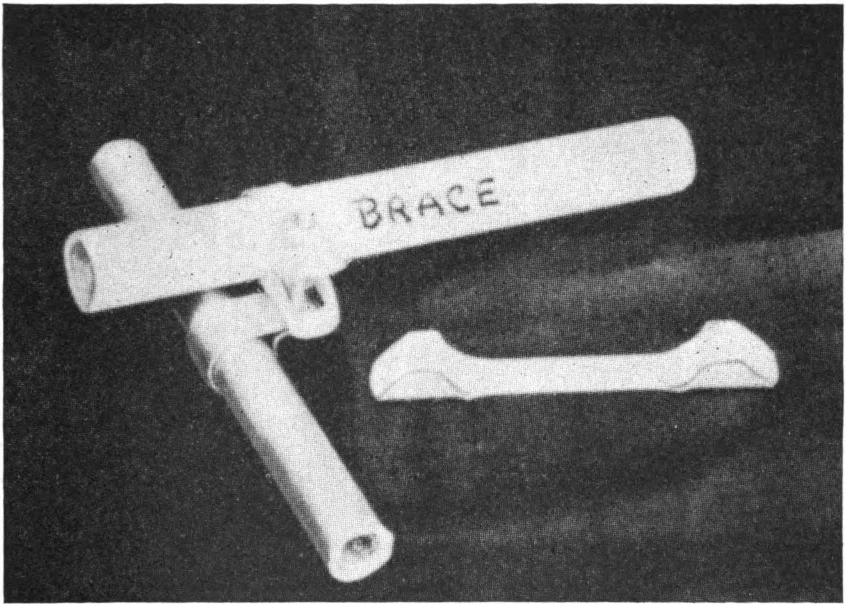


FIGURE 64.—Plain support clamp.

(6) To prevent corrosion, clean the soldered joints with carbon tetrachloride and coat with Glyptal varnish.

(7) Place the attaching nut, washer, plug shell, and ferrule over the conduit in the above order and sweat the ferrule to the conduit. Be sure that the conduit has been tinned clear back to the end of the ferrule but no further. Heat is applied to the outside of the ferrule with the soldering iron until the entire circumference of the joint is thoroughly sweated. If solder is added to the iron during this procedure, it aids in conducting heat to the ferrule. Care must be taken to wipe this solder off and keep it from the flexible conduit.

(8) Assemble the plug shell, attaching nut, and washer to the ferrule.

(9) Push the wires into the plug shell and thence through the flexible conduit. Next assemble the plug core and shell by slipping the core into the shell at the same time holding the latch assembly

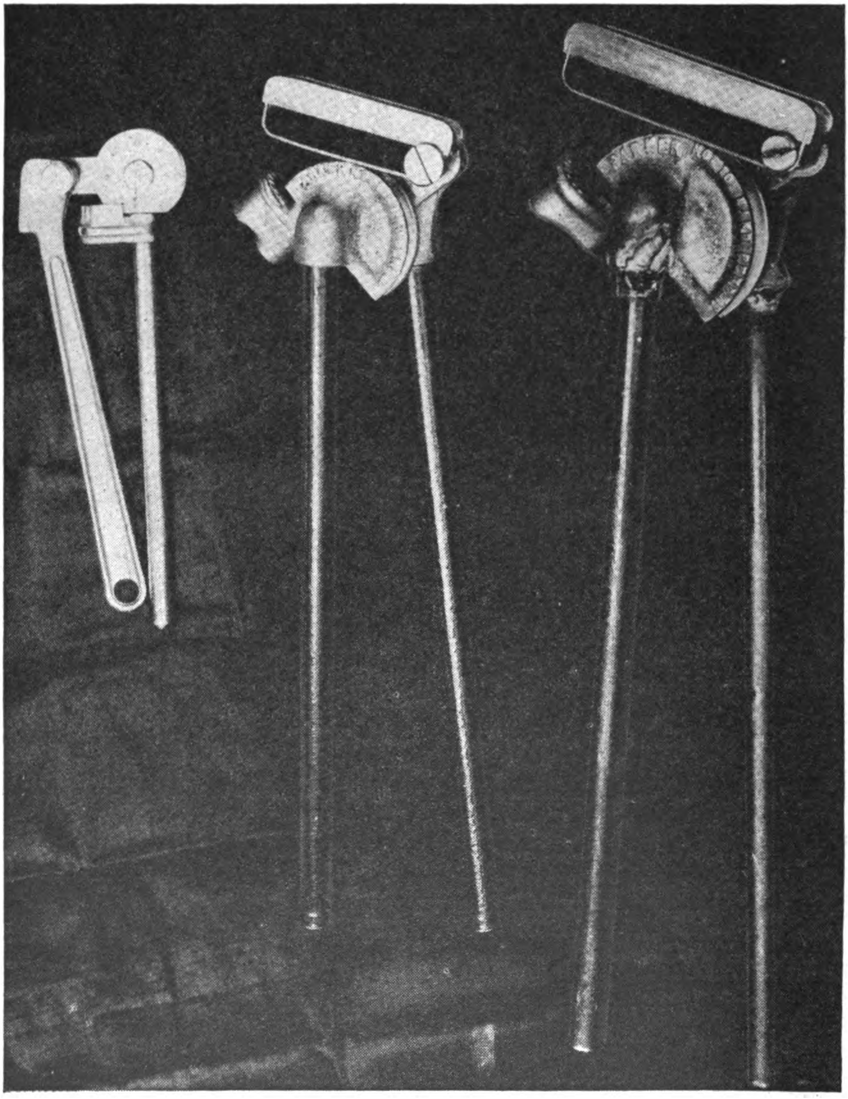


FIGURE 65.—Hand bending machines for three different sizes of conduit.

in place with a thin screw driver or similar object. If the wires are a little crowded in the shell pull them taut from the other end of the conduit. However, if the cables were cut to the proper length neither stretching nor crowding will result when the plug is asembled. Figure 62 shows a completed plug and flexible conduit assembly.

(10) If the assembly requires a plug on the opposite end of the conduit the same procedure may be used on the other plug.

(11) If the flexible conduit is to be joined to a piece of rigid conduit by means of a union, a plain end ferrule must be sweated on the flexible conduit. The wires are then pushed through the union and into the rigid conduit until the two can be fastened together by the union.

(12) If the flexible conduit terminates at a junction box a plain end ferrule should be sweated onto the conduit and a conduit clamp used. The wires are pushed through the clamp and into the junction box. The conduit clamp is then tightened and the wires, which are recut to the proper length if necessary, are soldered to the terminals in the junction box.

(13) Figure 66 shows a PL–Q type plug completely disassembled. Attaching this type plug to flexible conduit requires slightly different procedure, as is evidenced from the picture. The base of the plug is sweated directly to the flexible conduit, as no ferrule or attaching nut is required. The cable is soldered to the plug terminals in the usual manner. The plug is assembled by inserting the latch in the shell, holding it down with a screw driver while the shell is slipped in place and fastened with the screws. If the cable is cut to the right length there will be neither crowding nor stretching of the conductors. When possible, it will facilitate soldering if the cable is cut slightly longer than necessary and tightened up to the correct length after soldering by pulling from the other end of the conduit.

(14) When pin type plugs are used the following steps are suggested:

(*a*) Slip threaded collar over conduit and sweat ferrule to end of conduit.

(*b*) Disassemble plug by removing retainer ring with a screw driver.

(*c*) Prepare ends of conductors and slip a short length of spaghetti tubing over each.

(*d*) Solder the tinned ends of the cables to the individual plug conductors and slip the spaghetti over the soldered joint.

(*e*) Slip the metal plug shell over the plug terminals and pull them through so that the slotted bakelite retainer can be slid into place. Be sure to get the pins located properly with the slot back of the shoulder, and in the right order. Use an ohmmeter to check continuity.

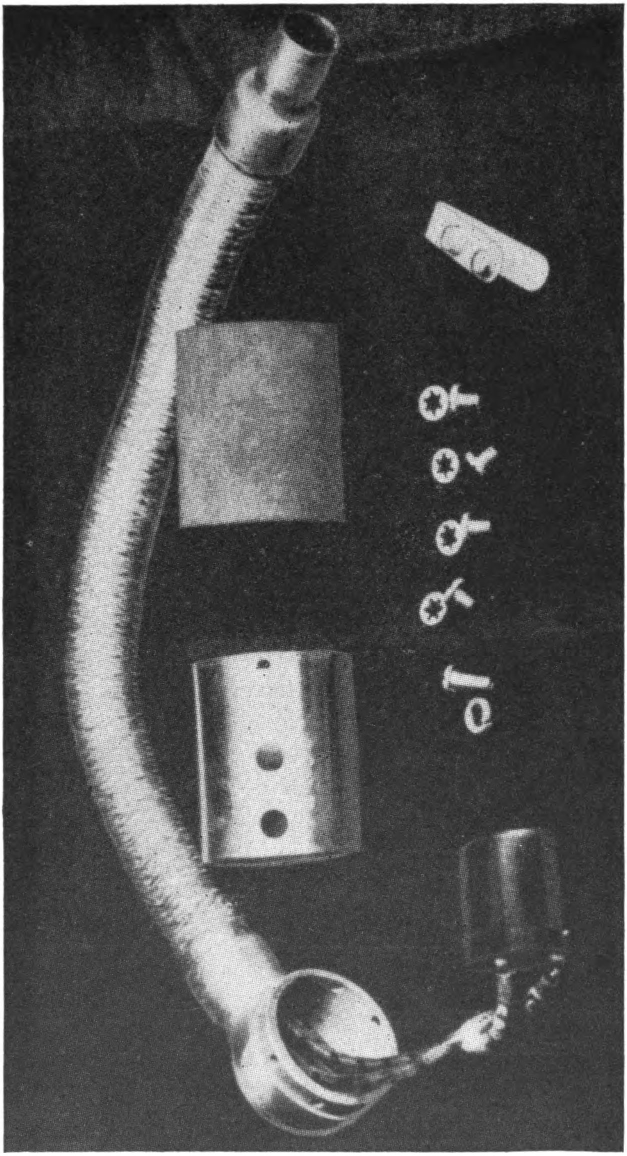


FIGURE 66.—Q-type plug, completely disassembled.

(*f*) Slip the plug proper over the terminals, move the plug shell in place and lock by inserting the spring retainer ring. This may be easy or difficult depending on the number of contacts on the plug and also on the possibility of tightening up on the wire from the other end. In this case, the individual plug terminals may be pulled out far enough to place them into the plug proper one at a time before the slotted bakelite retainer is slipped in place. Otherwise the terminals are fitted in the slotted retainer first, then the plug proper is slipped over the terminals simultaneously. Sometimes with multi-contact plugs this is very difficult. One way is to cut short pieces of bare wire and push them through the plug holes and into the individual terminals. These wires will then act as a guide and start all terminals simultaneously. A careful workman can, by tilting the plug slightly, and using a small screw driver get each row of terminals started as the plug is progressively tilted back to the position for slipping over all terminals.

53, Bonding.—*a. General.*—An important factor in aircraft equipped with radio is the bonding of all metal parts into a homogeneous electric conductor. This is accomplished by connecting, with a few exceptions, all isolated or insulated metal parts to the fuselage by short strips of tinned copper braid. These strips of braid are referred to as bonding pigtails. The conduit or cordage of a radio installation should be bonded thoroughly. Bonding will not follow any definite rule, but will depend on installations and individual requirements. In most cases the bonding will be accomplished by the mechanical supports used to clamp the aluminum conduit, when used, to the airplane structure. Technical Order 08–5–1 gives details for different installations in the Army Air Force.

b. Installing bonding pigtails (procedure does not apply to new type aluminum covered flexible conduit).—(1) With a hot, well tinned iron, spot the shielding over about ¼ inch and not exceeding the width of the bonding strip. (See fig. 67①.) Use rosin core solder wherever possible.

(2) Clean the spot with carbon tetrachloride in order to remove the excess flux.

(3) Tin the end of the bonding strip over a distance not to exceed ⅜ inch. (See fig. 67①.) Clean with carbon tetrachloride and place the tinned end of the pigtail over the spotted place of the cord or conduit lengthwise. By means of two wrappings of No. 26 soft copper wire, make the connection as tight as possible. (See fig. 67②.)

(4) Sweat the tinned end of the pigtail to the cord or conduit with a hot iron, using the solder which has been used for the tinning and spotting. Do not use any additional solder. Be careful not to burn the insulating material under the shielding. The connection must be as tight as possible so no excess solder will separate the shielding and the pigtail and form a high resistance connection. For radio installations the pigtail should never have a resistance of more than .001 ohm.

(5) Remove the No. 26 wire wrappings. (See fig. 67③.) Tape and shellac the entire length of any cord or flexible conduit in order to prevent metallic contact. (See fig. 67④.)

(6) Tin about ½ inch of the free end of the pigtail and punch or drill a hole in it to accommodate a No. 8 machine screw.

(7) Rigid conduit is bonded by use of special bonding clamps. (See fig. 60.)

NOTE: Combat airplanes are now being wired without aluminum tubing except where mechanical protection is needed. See Army Air Force Specifications Nos. 32300 and 32310.

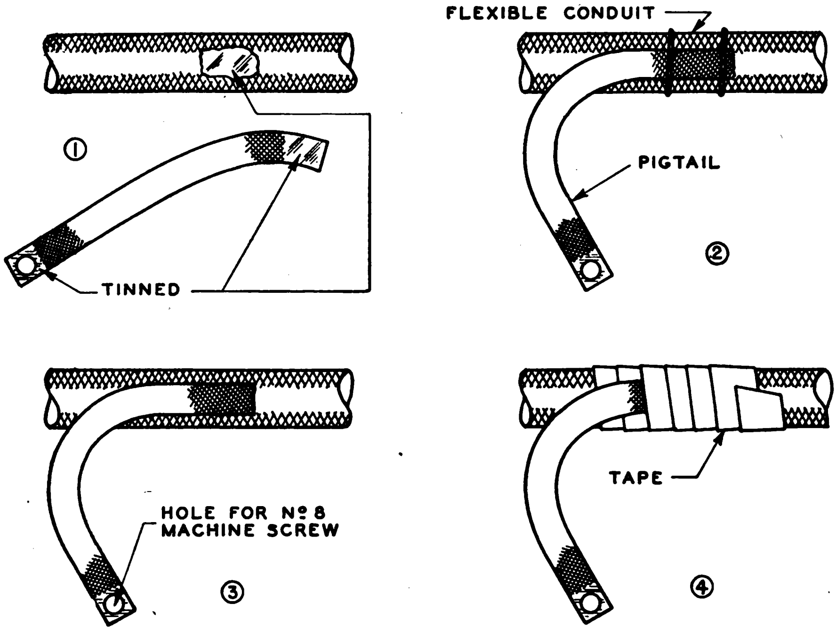


FIGURE 67.—Bonding pigtail.

54. Noise suppression.—*a. General information.*—(1) Disturbances which interfere with radio reception originate from vibrating contacts of isolated metal parts against the airplane structure, and from sources of alternating or fluctuating voltages and currents, such as generator, voltage regulator, and ignition systems.

(2) Fluctuating voltages cause electrostatic radiation and fluctuating currents cause electromagnetic radiation. In order to suppress such disturbances it becomes necessary to neutralize both types of radiation.

(3) Disturbances, which are introduced into the receiver through the power supply circuits, hereafter referred to as feedback, are not

affected by any treatment intended to suppress radiation. These disturbances are the result of *varying supply voltages and currents as provided by the generators and voltage regulator.*

(4) Disturbances which result from vibrating contacts are propagated by radiation and can be divided into two distinct types.

(*a*) As an example, an improperly supported length of tubing has the effect of an antenna which can receive energy. This energy may be dissipated either by reradiation or by intermittent contact with the airplane structure. Reradiation will not cause additional interference. However, in the second case, the discharge is a damped wave containing a great many frequencies and interference therefore results.

(*b*) During the reception of a radio signal the antenna forms, in effect, one plate of a condenser while the airplane structure forms the other. The capacity of this combination is a function of the airplane structural area. A signal is tuned by adjusting a capacity and inductance which are in series with the capacity between antenna and airplane. The constancy of the signal depends upon the permanence of the latter capacity. An aileron, for example, at times makes good contact through the hinges with the wing and forms part of one plate of the condenser, at other times it is insulated by lubricant and is not part of the condenser. This intermittent contact has the same effect as rapidly oscillating a receiver tuning dial through a station signal, and is heard as noise.

b. General methods of noise suppression.—In *a* above four different types of disturbances have been mentioned: electrostatic radiation, electromagnetic radiation, feedback, and noise due to vibrating contacts. Although somewhat similar in effect, entirely different methods of treatment are required for their suppression.

c. Electromagnetic radiation.—This radiation is caused by the magnetic field around a conductor which varies as the current in the conductor fluctuates. It can be neutralized by setting up an equally strong field of opposite direction. By enclosing separate conductors for supply and return currents in one shield, there will be only a slight resulting field, which the shielding can absorb. In the modern airplane the contractor plans the electric wiring system very carefully, so that the neutralizing effect of currents in opposite directions is utilized to the fullest advantage.

d. Electrostatic radiation.—This radiation is caused by varying potential fields around a conductor. By capacitive action this type of field is also transferred across switches to isolated conductors. Such radiation can be neutralized by an opposing field of potential. To supply such an opposing field it is necessary to enclose the entire circuit in a chamber of low resistance, which is electrically connected to the airplane structure at many points. A given state of potential is neutralized by maintaining the shield at ground, or structural potential. In order that this shield be effective it is necessary that it be a complete enclosure so the neutralizing charge will be at all points, and be of low resistance so there will be no voltage drop in any direction between the shield and the farthest bonding point.

e. Feedback.—This disturbance is directly proportional to the variations of current and voltage in the circuit. The obvious remedy is to localize these fluctuations to the source by means of filters. These filters will not reduce the disturbance in the source itself, but reduces the variations throughout the external circuits. Such filters usually consist of by-pass condensers between the offending supply circuits and ground, with the possible addition of a series choke in one line. For filtering out audio frequency variations a condenser of .5 mfd to 10 mfd is usually used and for radio frequency .001 mfd to .1 mfd depending on the impedance of the source. The filters are mounted close to the source.

f. Vibrating contacts.—The most practical method of eliminating disturbances which result from vibrating contacts is to bond (electrically connect) the vibrating member to the airplane structure. When connected in such manner, there can be no storage of electrical energy on the member with resulting discharges, and further the member is always a part of the capacitive system.

SECTION VI

TEST EQUIPMENT

55. General.—*a.* The intelligent use of adequate test equipment is essential for the proper maintenance of modern radio equipment. The Signal Corps test equipment, which is used by Army Air Force radio mechanics, is very modern and of such design as not to become obsolete quickly. This test equipment is described with pictures and circuit diagrams in the manufacturers' handbooks, which are available in the Technical Order files. The I-56-A Technical Order also gives much useful information and test data concerning the various Signal Corps radio sets and the vacuum tubes used in them.

b. A few hints about the use of the I–56–A test set components are given below. This information applies equally well to any other similar test equipment. Handle this equipment with care. The instruments are very sensitive and can be damaged easily.

56. Volt-ohmmeter.—*a.* Direct current voltage and resistance can be measured with the volt-ohmmeter. Several ranges are available for both voltage and resistance and it is very important to use the proper range when making measurements. The meter has a self contained battery type BA–31. This battery should be replaced when the ohmmeter cannot be "zeroed" on the lowest range.

b. Always use the R range of the 3C type and the R÷100 range of the 3B type ohmmeter when making continuity measurement. Otherwise a corroded connection may not be found.

c. Always use the R×1000 range of the 3C type and the R×10 range of the 3B type ohmmeter when testing for shorts and grounds. If this is not done high resistance shorts and grounds such as might be caused by charred insulation will not be indicated.

d. When actually measuring resistance be sure to zero the ohmmeter each time before a reading or series of readings is taken. This is done by holding the test prod leads together firmly between the thumb and fingers while the adjusting knob is turned with the other hand.

e. Keep the fingers off the metal ends of the test prods when testing either voltage or resistance. The resistance of the human body when placed in parallel with the resistor to be measured may seriously affect the reading obtained, especially if a high resistance is being measured. For instance when measuring a 60,000 ohm resistor the ohmmeter might indicate only 30,000 ohms if the fingers were touching the metal tips. Figure 68 shows the reason for this.

f. Body resistance can also upset voltage readings. A high resistance voltmeter is required for accurately measuring voltages in many circuits. This voltmeter has a sensitivity of 1,000 ohms per volt. This means on the 300 volt range the total resistance of the meter would be 300,000 ohms, which probably would not upset the circuit enough to give a serious error in voltage. If the fingers were placed on the metal tips of the test prods, the above mentioned 60,000-ohm body resistance would be placed in parallel with the voltmeter. This would cause the total resistance to be less than 60,000 ohms, which might be low enough to materially affect the reading. In addition to the above, keeping the fingers away from the metal tips is a good safety habit to form.

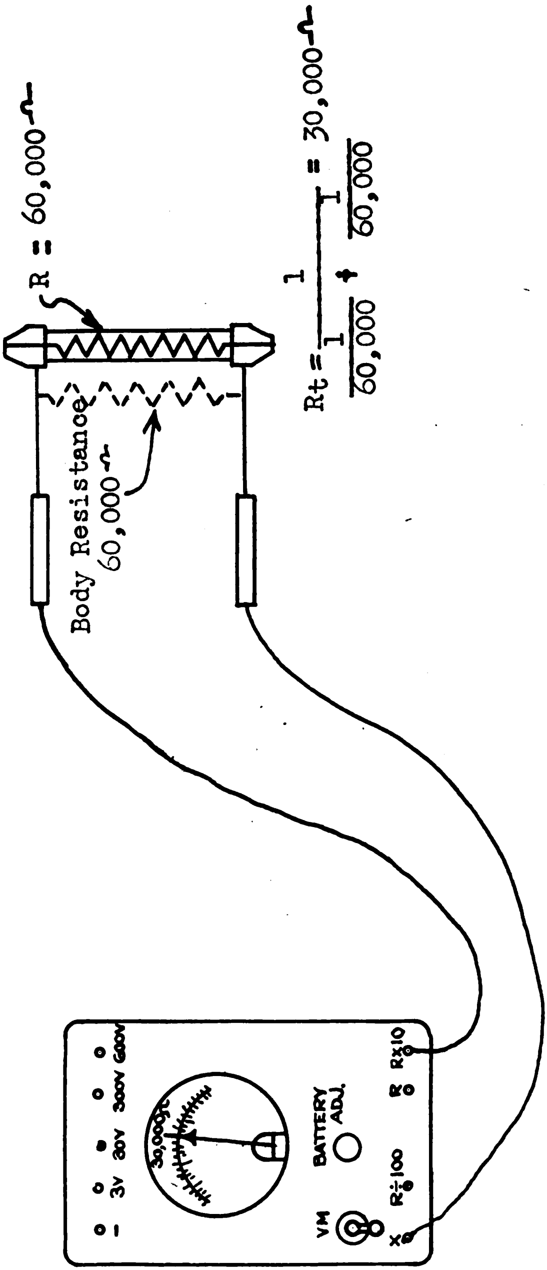


FIGURE 68.—Effect of touching test prods.

57. Output meter.—*a.* This instrument is a multi-range rectifier type a-c voltmeter. Instead of having a sensitivity of so many ohms per volt it has a constant impedance of 4000 ohms on all ranges. This enables receiver outputs to be measured and compared under the same condition of load regardless of the output meter range in use. This constant impedance is a disadvantage when the output meter is used as a voltmeter, due to the low impedance on the high ranges. On the 1½-volt range this meter is a very good high resistance a-c voltmeter, but this cannot be said for the other ranges. For instance,

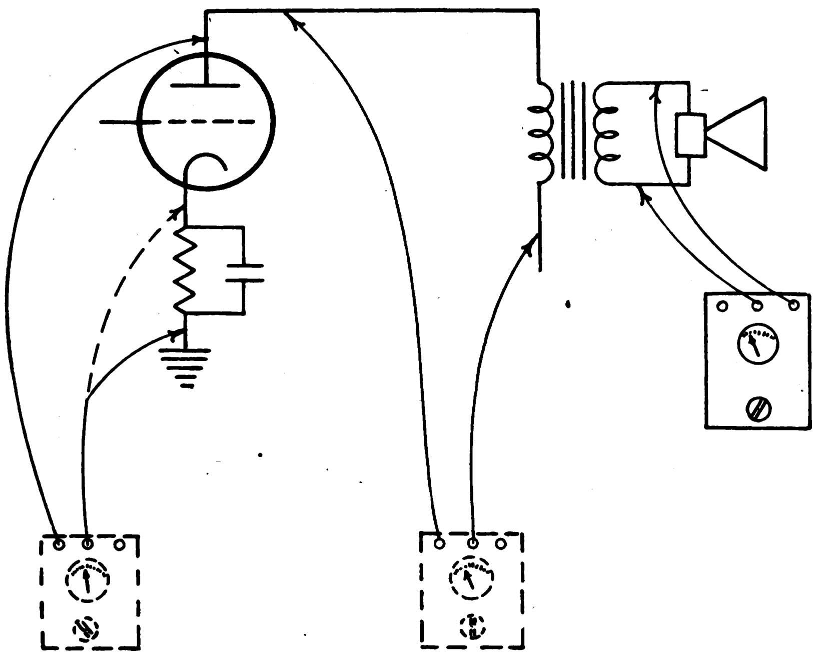


FIGURE 69.—Connecting output meter.

on the 150-volt range the meter only has 4000/150 or 26.6 ohms per volt sensitivity which is extremely low. Ordinary rectifier type voltmeters have a sensitivity of a thousand ohms per volt.

b. The output meter is used mainly for alining radio receivers. It gives a visual indication of maximum output, which enables the radio mechanic to adjust the various tuned circuits more accurately than if the ear were used to determine the correct setting of the trimmer and padder condensers by noting the loudness of the signal. A suitable signal generator is also required for this work.

c. The output meter may be connected in the receivers output circuit in various ways. Figure 69 indicates several of these methods.

It is very important to use the series condenser pin-jack when d-c voltage is present. This precaution is necessary to protect the instrument and also to cause the reading to be accurate. The d-c potential will upset the a-c reading and if it is high enough may burn out the meter. A condenser is incorporated in the output meter to block direct current, but is in the circuit only when the test prods are plugged in as shown by figure 70. Since the reactance of a condenser is inversely proportional to frequency, the meter will read low on low frequencies if the series condenser pinjack is used. For this reason, when making a fre-

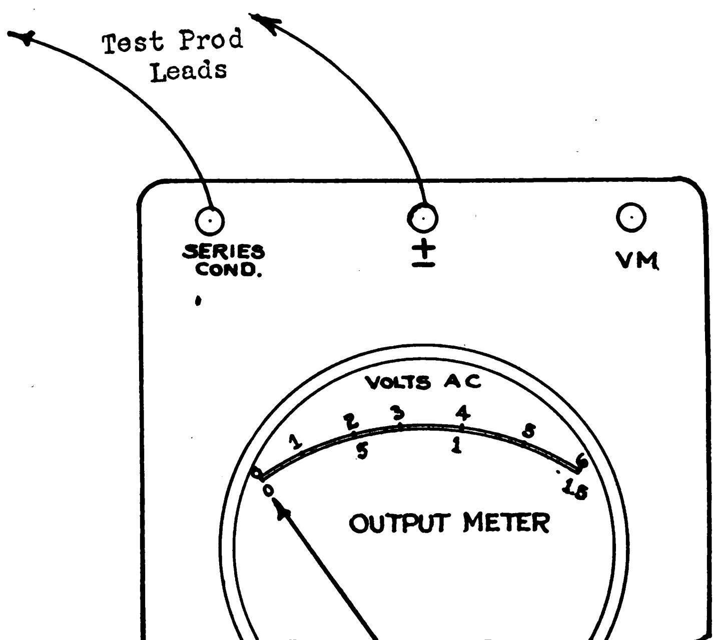


FIGURE 70.—Output meter connection, condenser in circuit.

quency response check, it is desirable to connect the output meter directly across the secondary of the output transformer and not to use the series condenser.

58. Tube tester.—*a.* This instrument quickly indicates the condition of practically any receiving tube. Data are available for testing both Signal Corps and commercial types of tubes. A tube may be tested for shorts or leakage between elements, open connections and proper emission. All these tests are made while the tube is hot, that is, with the filament voltage applied. In order for these tests to be accurate and hence of value, the instructions furnished with the instrument must be followed very carefully.

b. When making a shorts test, the tube should be tapped lightly with the finger while watching for a glow in the neon bulb. If this bulb glows very faintly during a shorts test the tube should be removed from the socket to see if the neon bulb still glows. If this is the case and the brilliancy does not increase when the tube is inserted the tube is not at fault. The shorts test circuit should be tested occasionally by shorting a couple of tube prongs (*not filament*) with a small piece of wire and see if the neon bulb lights when this tube is tested. Another way to make this test is to place the test prods of a voltmeter in contact with two of the socket terminals other than filament and proceed with the short test. The voltmeter connection should cause the neon lamp to glow when the proper switch is thrown.

c. When making an emission test, erroneous indications are usually due to one of the following reasons:

(1) Failure to make the line voltage adjustment.

(2) "Diodes only" or "battery type" switches in wrong position.

(3) Not testing each section of dual purpose tubes separately.

(4) Improper setting of tube selector on filament selector control.

d. An indication of an open connection to the tube elements may be obtained in an indirect manner. Each element affects the reading of the meter during an emission test to some extent; some more than others. If during an emission test, each switch which is in the IN position is thrown out and back, to see if the meter reading changes, open connections may be detected. An open connection causes the meter to remain constant as the switch is changed. Of course an open or burned out filament results in no meter indication when making the emission test. An open cathode will also cause the same result. A visual observation will indicate whether the filament is lit. In some battery type tubes the filament glows so dimly that an ohmmeter may be required to make a continuity test on the filament. To be sure of an open cathode and not a faulty tube tester another good tube should be tested to check the tube tester circuit.

59. Set analyzer.—*a.* The selective set analyzer enables voltage, current and resistance measurements to be made on the stages of a radio receiver without removing it from the case. It consists of a multi-range volt-ohm-milliammeter with a special cord, plug and socket arrangement for making meter connections to the vacuum tube circuits. A twin pin-jack is arranged to break the circuit for taking current readings. Figure 71 shows how this is accomplished. It can be seen by studying figure 71 that in order to measure current two adjacent pin-jacks must be used. This permits the current to flow out from the inside jack through the meter and back to the adjacent outside jack. When measuring voltage or resistance the *outside* jacks must be used in order not to break the circuit.

b. Provisions have been made to shift the grid voltage so that the corresponding change in plate current can be noted. This grid shift, or mutual conductance test, is not incorporated in the I-56-A tube checker circuit. Two voltage shifts are available. The high shift is to be used for power tubes only and changes the grid voltage 10.5 volts. The low grid shift changes the voltage 4.5 volts. These shift-

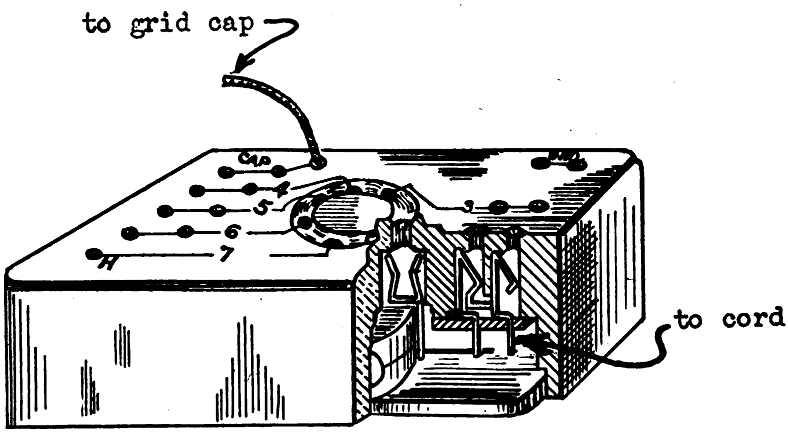


FIGURE 71.—Analyzer socket.

ing voltages should be connected in series with the control grid in the same manner that a milliammeter would be connected. That is, short leads are connected between the adjacent jacks in the control grid lead and the two jacks marked "grid test." Be sure that the lead from the jack marked "G" is connected to the inside socket jack. While making a grid test the usual connections for plate current must also be used.

c. The scales, jacks, and switches are clearly marked. To hold the "press to read" switch closed it should be turned while depressed. Test leads should be connected to adjacent jacks for resistance measurements. A series condenser has been incorporated to clock direct current when using the a-c voltmeter. Be sure to use the correct scale for the various ranges. The microfarad scale is useful only in connection with the capacity unit. Two batteries, type BA-34, are required for the set analyzer.

60. Capacity unit.—*a.* The capacity unit is a voltage divider with suitable taps for connecting the condensers and the analyzer's a-c voltmeter ranges. If the voltage is 115 volts, 60 cycles, the capacity calibration will be accurate on the high capacity range and approximately .1 and .01 of the indicated value on the medium and low capacity ranges respectively.

b. For determining capacity with greater accuracy the reading should be taken on the meter's d-c 0–25 scale and the corresponding capacity determined from the curves in Technical Order I–56–A.

c. The calibration is based on the a-c line voltage being 115 volts and 60 cycles. The capacity reading is directly proportional to both voltage and frequency. For accurate measurements the line voltage should be adjusted to 115, or until the meter reads exactly full scale when the condenser jacks are short circuited.

d. Since a shorted condenser merely gives full scale deflection, there is no possibility of damaging the meter provided the connections are made properly. *However, should the incorrect voltage range be used with the low or medium mf jacks the meter may be damaged* if the condenser happens to be shorted.

61. Interpreting results.—*a.* Although a thorough knowledge of the test set components and the proper method of using them is essential, it is not enough to enable a radio mechanic to cope successfully with the maintenance of modern aircraft radio equipment. In addition to the above, the radio mechanic must apply his radio theory and ability to read circuit diagrams in order to determine why some voltage, current, or resistance is high or low; or even to decide whether the fault lies in the radio set or the associated wiring.

b. Suppose the superheterodyne receiver whose circuit is shown in figure 72 will not receive continuous wave, although it works perfectly on voice or tone modulated signals. In this case the radio mechanic would probably proceed as follows:

(1) Test the triode section of the third tube.

(2) If this is found to be in order, a logical procedure would be to check, with the ohmmeter, between ground and the triode section grid and plate socket terminals respectively before replacing the tube.

(3) If this test shows infinite resistance between plate and ground and a value equal to the grid leak resistance R_2 between grid and ground, further search must be made.

(4) On the other hand, should the resistance between grid and ground be about 500 ohms, C_1 is probably shorted and this can be verified by measuring between grid and cathode, which will be approximately zero if this condenser is at fault.

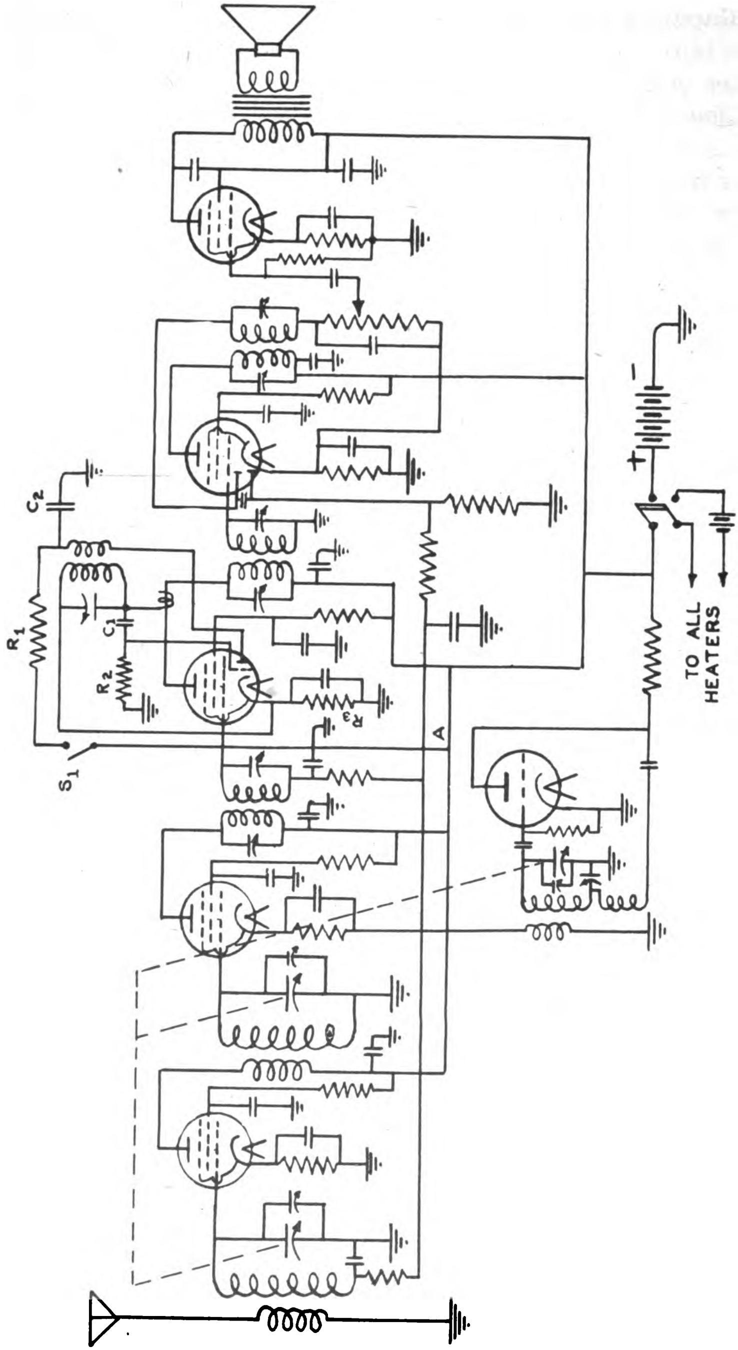


FIGURE 72.—Superheterodyne circuit.

(5) If all the above tests have been favorable the set can be turned on (without replacing the tube), switch S_1 closed, and the plate voltage measured between the triode plate and cathode or ground.

(6) Zero plate voltage means an open circuit some place between the plate terminal and point *A*. This might be an open transformer winding, open R_1, or a defective switch S_1. Shorted C_2 would also cause zero plate voltage, but this cause is eliminated by the infinite resistance between plate and ground found in a previous test. Since the other tubes must receive plate voltage to enable the set to operate on voice or tone it is not necessary to look further than point *A*.

(7) If no fault was indicated by any of the above tests it is time to see if the triode tube prongs actually make contact with the socket. This can be determined by measuring plate current on the set analyzer and making a grid shift test. In addition to showing that the plate and grid of the triode section make contact with the socket this test also indicates whether the mutual conductance of the triode has changed enough to keep the circuit from oscillating.

(8) The above procedure would normally locate the trouble, although it could be an open or shorted tuned grid circuit or a faulty coupling between this tuned circuit and the plate of the pentode section of this tube. To locate troubles of this nature would require the removal of the set from the cabinet and a very careful point to point resistance check.

(9) It should be appreciated that all the above testing has been on one small part of the receiver's circuit, which was made possible by a knowledge of how continuous wave is received in a superheterodyne receiver.

SECTION VII

ANTENNAS

62. General.—*a.* Just as a chain is no stronger than its weakest link, a communication system can be no better than the antenna system used. The best of transmitting and receiving equipment is of little value unless the proper antennas are provided. A poorly designed or constructed antenna can form a very weak link in the communication chain.

b. One of the first considerations is to locate the antenna so that it will be as free from losses as possible. It should be in the clear, that is, away from both conducting and solid insulating material. Eddy currents which are induced in nearby conductors extract energy from the antenna, and the dielectric losses are considerable in most of the solid insulating materials. Air produces very low dielectric losses. These losses go up with the frequency and may become very excessive at the ultrahigh frequencies if special precautions are not observed. The free end of an antenna, being at a high radio frequency potential, is especially susceptible to dielectric losses if there are any but the best of solid insulating materials in this vicinity. Distributed capacity on leads and insulators, etc., inside the airplane fuselage prevents radio frequency energy from being radiated, yet shows a good reading on the antenna current ammeter.

c. In order to radiate a uniform field the capacitance of an antenna should be uniformly distributed. Thus a vertical antenna or a horizontal antenna with all points equidistant from the metal of the airplane would be most desirable from this standpoint.

63. Tuning and loading.—*a. Tuning.*—The antenna can be tuned to respond more vigorously to a certain frequency than to any other. In other words, antennas possess resonant characteristics. Merely changing the length of the antenna, for instance, will change its resonant frequency. In fact, this is the best method of tuning an antenna, and whenever possible the length should be exactly right for the desired frequency. In aircraft this principle is put to practice by allowing the antenna wire to unroll from a reel until the correct length is obtained. This is referred to as the trailing wire antenna.

b. Inductive loading.—If a coil of wire is connected in series with an antenna system, the inductance of the coil is added to that of the antenna wire and the total inductance of the antenna system is increased. The same effect could have been obtained by simply increasing the total length of the wire. The result in either case is, that the frequency, to which the antenna responds, has been lowered. A coil used for this purpose is known as a loading coil.

c. Capacitive loading.—Just as inductive loading increases, in effect, the overall length of an antenna and thereby decreases its resonant frequency, so can the opposite result be obtained by the use of capacitive loading. A condenser, inserted in series with the antenna system, will increase the frequency to which the antenna responds. This, in effect, is the same as decreasing the overall length of the antenna.

64. Aircraft antennas.—*a.* The transmitting and receiving antennas installed on any aircraft form a complementary system, and theoretically a sacrifice in electrical efficiency of one will harm a system just as much as a sacrifice in the other. But it is a fact of considerable importance that the reduction of a transmitting antenna below a certain minimum of size and efficiency will render the transmitter practically inoperative on account of the unavoidable physical limitations inherent in the method of coupling the transmitter to its antenna. For practical reasons, therefore, it may be permissible to reduce the receiving antenna to a structure far below that which would be required for effective transmission, in cases where a compromise is demanded somewhere in the system. An antenna switching relay is usually used which permits the same antenna to be used with both the transmitter and the receiver.

b. The antenna should not possess a strong directional effect. This is a theoretical consideration which, in many cases, must be disregarded for practical reasons. When it is reported that two airplanes have been in communication, and that the signals faded out severely whenever one of the airplanes maneuvered, the reason for the fading may be attributed to the directional effect of the antenna system.

c. In practice, transmitting antennas employed on military aircraft are generally operated at a frequency which is considerably below their fundamental. Thus, if a radio transmitter is to operate at any frequency in the band 6,200 to 7,700 kc, the antenna used with this transmitter would have a fundamental of somewhat greater than 7,700 kc. Then, by using inductive loading, it will be possible to tune the antenna to any frequency within the entire range of the band.

d. An antenna having a fundamental as high as 8,000 kc, is a fairly short antenna and such antennas are generally mounted on pursuit aircraft. If the transmitter is to operate at higher frequencies, say 10,000 to 12,000 kc, it would necessitate an abnormally short antenna which would not be capable of radiating much power. Consequently, at these high frequencies capacitive loading is usually employed together with a longer antenna.

65. Types of aircraft antennas.—*a. General.*—A number of different forms of antennas are used on aircraft. The type used depends upon the purpose and upon the type of airplane on which it is installed. It may be necessary to install more than one antenna on the airplane under special circumstances. For example, a radio range beacon receiver requires a vertical mast, a direction finder employs a loop and a fixed antenna, and the two way communication set uses a fixed or trailing wire antenna. A description of the various types of antennas in use on military aircraft at the present time follows.

b. Vertical mast antenna.—This antenna consists of a streamlined mast from 3½ feet to 7 feet in length with a suitable attachment lug near the base for connecting it by means of a wire to the receiver binding post. It is installed in such manner that it extends vertically through an insulated bracket at the top of the fuselage into the air for a distance of 1½ feet to 5 feet, in a direction perpendicular to the line of flight. The main purpose of the vertical mast is the reception of radio range beacon signals. It is particularly well adapted for this function, because its physical shape makes it nondirectional. It also is a means of supporting various types of fixed antennas. When used as a support it is placed either ahead of the tail section as replacement for the tail mast or at the center section of the wings to support a wing-tip to wing-tip antenna. The advantage of this type antenna are: it is nondirectional, and it is safe. It also has certain disadvantages: its limited dimensions prevent its use as a transmitting antenna; it is not as responsive to weak signals as a longer antenna; and it slows up the airplane sometimes as much as 5 to 7 miles per hour due to its air resistance.

c. Whip antenna.—Because of excessive drag caused by the rigid vertical antenna described in *b* above, buggy whip antennas have been used as radio compass sense antennas. The whip consists of a tapering steel rod ¼ inch or ⅜ inch at the butt and about 5 feet long. The whip must be made of high strength carbon steel if it is to withstand high speeds. The whip is flexible enough to bend and move around under varying conditions of drag and icing. It cannot be used to support a fixed wire antenna. Whip antennas should be used only when there is no room for a suitable fixed wire sense antenna.

d. Fixed antenna.—(1) *General.*—Any wire antenna supported by the physical structure of the airplane with a portion of it suspended in the free space about the airplane is called a fixed wire antenna. It can be installed in many different ways and an acceptable method for installing can be found for all types of aircraft. The different methods used to install a fixed antenna results in the different types which are in use. The selection of a particular type is determined by the type of airplane, the service it must perform, and the type of radio set used. In all cases the antenna must be installed so that it will not interfere with the safety of the pilot and passengers in case of an emergency jump from the airplane.

(2) *V-type antenna.*—This antenna extends from each wing tip to a stub mast or the vertical fin at the tail of the airplane. When used with radio installations which require separate receiving and transmitting antennas, it is divided by strain insulators and one side of the V is used for transmitting, the other side for receiving. When used in this manner, the antenna is more suitable for transmission in the higher frequency bands. The V-type can also be used as a single antenna for both transmission and reception. In such a case the natural wave length of the antenna is greater and communication in the lower frequency bands is made possible. The V-type fixed antenna is not used on low wing monoplanes because the antenna structure would be below the level of the cockpit, a dangerous condition if the pilot has to bail out.

(3) *T-type antenna.*—The top or horizontal section of this type is usually suspended between a fitting at the tail of the airplane and a fitting or stub mast at the center of the upper wing. The perpendicular section or down-lead connects to the flat top section somewhere between the two ends. When this down-lead is connected to the geometrical center of the flat top and is perpendicular to it, we speak of a symmetrical T-antenna. The electrical characteristics of a symmetrical T are about the same as those of a vertical mast antenna of greater physical height.

(4) *Inverted L-type antenna.*—The only physical difference between the inverted L- and the T-type antenna lies in the position of the down lead. The down lead of the inverted L is connected to the end of the flat top section instead of the center. While this antenna is suitable for two-way communication it is not very good for the reception of radio range beacon signals. The more the down-lead connection is moved from the center of the flat top section, the more directional the antenna becomes.

(5) *Transverse antenna.*—(*a*) This type was formerly a very popular installation as a transmitting antenna on low wing monoplanes because it provided the needed length of wire without jeopardizing the safety of the pilot. It is attached to both wing tips of the airplane and supported in the center by a mast to give it height. There are a few variations in the use of this antenna:

1. It can be used as a single transmitting and receiving antenna by insulating it from the supporting mast and connecting the down-lead to an antenna switching relay.

2. It can be used as a transmitting antenna alone and insulated from the supporting mast, which then can be used as a receiving antenna.

3. It can be used as a transmitting antenna and a short L or T run from the tail to the head rest as a receiving antenna.

(*b*) Transverse antennas produce considerable drag and are especially susceptible to breaking under icing conditions. Their use on high speed airplanes is therefore particularly undesirable.

e. Trailing wire antenna.—(1) About 250 to 500 feet of antenna wire are coiled on a reel which is located in the fuselage. The wire passes through an insulated path (fairlead) in the bottom of the fuselage and has a weight attached to its end. The length of this antenna can be adjusted to suit the condition of operation and trails out behind the airplane while in flight.

(2) The trailing wire antenna is used for long distance transmitting and can only be used on airplanes not required to maneuver, such as bombardment and long range observation planes. It is used with liaison sets. There are a number of advantages connected with this type antenna: it will cover longer distances than the fixed antenna; it permits the choice of a wide range of transmitting frequencies as its length can be changed from the interior of the airplane by changing the amount of wire reeled out; it offers no hazard to the safety of the pilot and passengers in case of a forced jump from the airplane; its noise pickup from the engine is a minimum since it is farther from the engine than other types of antennas. But it also has its disadvantages: It interferes with maneuvers and with low flying. Therefore, it cannot be used on airplanes which are required to maneuver. It must be reeled in when the airplane is about to land, which makes communication from the ground impossible unless some means of using the antenna on the ground is provided. The weight at the end of the antenna is a hazard in that it may strike someone on the ground if it should break loose from the antenna.

(3) The trailing wire antenna operates as a fundamental Marconi antenna at the lower frequencies but is used as a $\frac{3}{4}$ wave length antenna at frequencies above 3,000 kc and sometimes as a $\frac{5}{4}$ wave length antenna at still higher frequencies.

f. Antenna combinations.—(1) From the preceding subparagraphs it is seen that it is possible to install a number of different types of antennas on aircraft. In some instances a combination of two or more types may be necessary for one complete installation.

(2) The radio compass reference, or sense, antenna must be nondirectional and hence a vertical mast, whip, or a balanced T-antenna

used. This may be mounted either above or below the fuselage of the airplane.

(3) The marker beacon antenna is an inverted T-type antenna mounted under the fuselage whose length must be exactly as specified to within 1/8 inch. The center tie must also be at the point specified, which is slightly off center.

(4) Care should be taken that any antenna mounted under the airplane does not interfere with the action of the retractile landing gear. The marker beacon and compass reference antennas should also be mounted so they will not be in the propeller blast.

66. Materials and nomenclature.—*a. General.*—The materials used in aircraft antenna installations must be of the best procurable quality and must be capable of withstanding severe wear and tear. In addition to having the proper electrical characteristics, the aircraft antenna system must also be mechanically sound so that it will withstand the strains due to vibration, wind pressure icing, and landing shocks. The following subparagraphs describe some of the more important materials commonly used in aircraft antenna installation work.

b. Wire, types W-106 and W-106-A.—This antenna wire is of copper coated steel and will withstand intense vibration as long as it is kept in good condition. The steel core gives this wire considerable tensile strength, while the copper coating gives it conductivity. These two types of antenna wire are very similar, but the W-106-A has more steel and less copper than the W-106. Both types are worked the same and must *never* be nicked or kinked, as this will weaken the wire and may cause it to break. *Never use pliers or any other tool on this antenna wire.*

c. Insulator, type IN-88.—This is a small cylindrical isolantite strain insulator.

d. Insulator, type IN-79.—This is a lead-in insulator which serves as a connection through the fuselage between the down-lead and the lead-in, or to be more specific, between the antenna and the radio set. It is made of isolantite and consists of two halves, one being mounted on the inside, the other on the outside of the airplane. A long machine screw holds the two halves together when the insulator is installed and also serves as a conductor of antenna current. Another similar but smaller insulator is the type IN-84. Other insulators used are the stand-off insulators, type IN-81, 1½ inches high and 1⅓ inches in diameter and the type IN-82, 3 inches high and 1⅓ inches in diameter. These are used to prevent the wires of the antenna system from grounding to the metal parts of the ship inside the fuselage. Isolantite beads (IN-83) are explained in paragraph 66*g*.

e. Stub masts.—Stub masts are used to support the antenna, keep it from fouling the ailerons, and give it added height. They are provided with holes at the top for securing the antenna.

f. Shock assembly.—The shock assembly is used to keep the antenna taut and prevent damage due to the shock of landing. A shock assembly includes a spring or shock absorber cord mounted between the insulator at one end of the antenna and the anchoring point. On late type airplanes concealed springs are used to which access is obtained by opening a small hatch in the wing.

g. Isolantite beads.—Isolantite beads are small insulators with one side concave, the other side convex. They are strung on the lead-in wires inside the fuselage at points where a low loss, flexible insulation is desired. Due to their shape they fit into each other like ball and socket joints and permit flexibility of the wire.

h. Thimbles.—Thimbles are used to prevent sharp kinking of the wire at points where it is attached to stub masts. A thimble is simply a U-shaped metal fitting with a groove on its outer surface. After the thimble is attached, the open end of the U is closed, and antenna wire is placed into the groove, and the tie is made.

i. Nomenclature.—With antenna installation are connected certain terms, some of which are explained below.

(1) *Single antenna.*—One antenna, used for either receiving or transmitting, which is connected to an antenna switching relay, is called single antenna.

(2) *Separate antenna.*—The transmitter and receiver are in this case connected to different antennas. Separate antennas are used where it is impossible to install the transmitter and receiver close to each other, or with sets which are not supplied with an antenna switching relay.

(3) *Flat top.*—The horizontal part of a fixed antenna, whether from wing tip to tail, center section to tail, or wing tip to wing tip, is called a flat top.

(4) *Down-lead.*—The part of the antenna system which connects the flat top section to the lead-in insulator is a down-lead. When separate receiving and transmitting antennas are used, two down-leads are required.

(5) *Lead-in.*—That part of the antenna system which connects the lead-in insulator to the antenna switching relay, or, in case of separate antennas, to the appropriate set boxes, is called a lead-in.

(6) *Down-lead splice.*—The connection between the down-lead and the flat top section of the antenna system is a down-lead splice.

(7) *End tie.*—The connection between the antenna wire and strain insulators or thimbles is an end tie.

67. Installation of fixed antennas.—*a.* The general procedure for installing any of the fixed antenna types is the same. It is desirable to have an assistant when making an antenna installation. The wire should be run from the spool, taking care not to let it unwind too rapidly in order to prevent kinks from forming as they make the wire unserviceable. Care must be exercised to prevent the wire left on the spool from unreeling and becoming damaged when it is cut loose.

b. The antenna must be stretched taut and all splices and ties made in the approved manner. Insulators, shock assemblies, clevises and thimbles must be used as prescribed for the particular installation. The reader is referred to the training film, "Airplane Antennas, Part I, Types and Typical Installation".

c. When replacing a defective antenna the old installation should be studied carefully and measurements taken so that it can be duplicated, using new materials where necessary.

d. Stub masts are sometimes used to support the antenna. With the exception of the construction of the base, all stub masts are essentially alike. The type of base construction will depend upon the type of airplane on which the mast is to be installed and upon the location of the mast on the airplane. The top of the mast is constructed so that a clevis and a thimble may be used to attach wire with an end tie, or the cadmium-plated sleeve of the shock assembly may be fastened directly to the mast with a bolt.

68. Constructing the shock assembly.—*a.* The following procedure should be followed when fabricating a shock assembly locally. Figure 73 shows this in four steps.

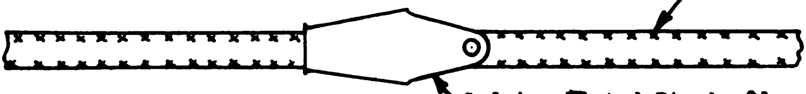
(1) Procure an 18-inch length of standard 3/8-inch aircraft shock cord. This is an item issued by the Army Air Forces. The correct name is Cord, shock absorber, 3/8-inch diameter, Specification No. 20-23.

(2) Thread one end of the shock cord through the small end of a sleeve, pulling about 6 inches of the cord through (fig. 73①).

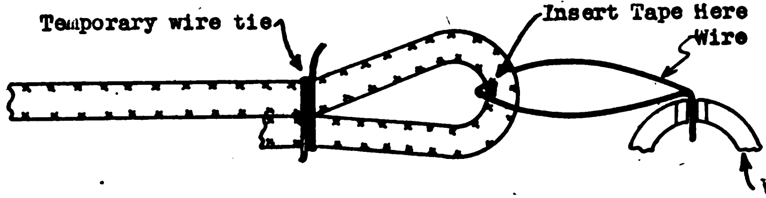
(3) Form a loop in the end of the cord by bending 1½ inches of the cord back on itself (fig. 73②).

(4) Wrap several turns of wire around the open end of the loop to hold it in place. This wire will not be a part of the finished job and will later be removed. It is advisable to make these turns as tight as possible, to prevent slipping later on.

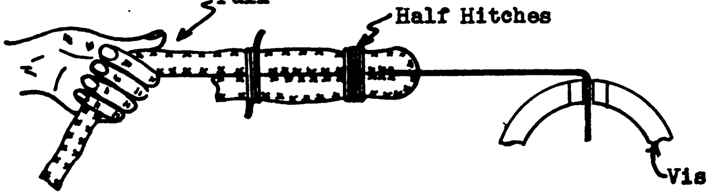
(5) Thread a 6-inch length of antenna wire through the eye of the loop just formed and clamp both ends of this wire in a vise. A small piece of friction tape should be inserted between the wire and the shock cord to prevent the wire from cutting the cord during operations 6, 7 and 8.



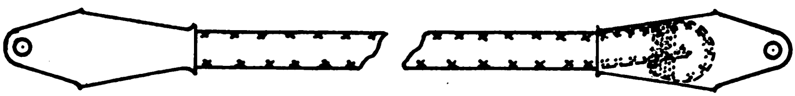
① Step 1.



② Step 2.



③ Step 3.



④ Step 4.

FIGURE 73.—Shock assembly.

(6) Have someone pull hard on the free end of the shock cord, so that the cord is stretched out as nearly as possible to its full length.

(7) While the shock cord is stretched, tightly wrap the loop with about 10 turns of No. 6 waxed linen cord. Double the linen cord and use the lockstitch method of binding (fig. 73③).

(8) Apply a coat of shellac to this wrapping.

(9) Release the tension on the cord by removing it from the vise and allow the shellac to dry.

(10) Remove the temporary wire wrapping and cut off the free end of the loop at a bias and as close as possible below the seizing.

(11) Put the cord back into the vise, and with the cord stretched to its maximum length move the sleeve over the loop. The loop should go into the sleeve far enough to clear the holes drilled through the tabs of the sleeve.

(12) Pull out the wire, place the sleeve tabs into the vise and carefully force them together until the holes of the two tabs are close together.

(13) Slip a thimble through the holes of the sleeve tabs.

(14) Attach another sleeve to the other end of the shock cord in the same manner.

b. Figure 73, step 4, illustrates the completed shock assembly. This assembly should be stretched to about half its full length when stretched as far as possible to give a fixed antenna the proper tension.

69. Typical installation.—*a. General.*—This section will describe the installation of a typical fixed antenna on a pursuit plane for the purpose of showing the interconnection and relationship between the parts of the antenna described in the preceding sections. The dimensions of any fixed antenna and its position on the airplane will depend upon the type of plane, type of radio equipment, and the frequency of the communication band to be used. Nevertheless, the method of using the end ties, down-leads, splices, shock assembly, etc., will be, in general, the same for all installations. In making any antenna installation the antenna drawings for the particular type airplane should be used.

b. Terms used.—In order to simplify the directions for installing a fixed antenna, the antenna is divided into three sections called, for convenience, the wing section, the tail section, and the live section. The term, live section, refers to the actual *live* part of the antenna system, the wing section is that part which runs from either wing mast to the live section, and the tail section is that part from the live section to the tail support mast.

c. Sequence of installation.—(1) When installing an antenna on a small airplane it is best to install the wing and tail sections first, and make them as short as possible. This leaves a maximum amount of space for the actual live wire, an important point for consideration in airplanes which have a very limited available space for antenna installation.

(2) On the larger type airplanes where space is not such an important factor, the wing and the tail sections must be of sufficient length to cover the remaining space from each end of the live section to the antenna supports.

d. Fixed antenna.—(1) *Wing section.*—(*a*) Attach one end of a 2-foot piece of antenna wire, type W-106 or W-106-A, to one of the wing masts by passing it through the hole in the top and making an end tie.

(*b*) Attach the other end of the wire to an insulator, type IN-88, again using an end tie.

(*c*) Repeat steps (*a*) and (*b*) above for the other wing mast.

(2) *Tail section.*—(*a*) Attach the shock assembly directly to the tail stub mast using a standard AN bolt.

(*b*) Attach a 1-foot length of wire to the other end of the assembly, using an end tie.

(*c*) Attach an insulator, type IN-88, to the other end of this wire, again using an end tie.

(3) *Live section.*—(*a*) The spacing of the insulators now installed should be such that when the live section of the antenna is attached, it will at no place be closer to the airplane structure than 1 foot, except for the lead-in position.

(*b*) Thread the W-106 or W-106-A wire from the spool through the tail insulator and attach the end to one of the wing insulators, using an end tie.

(*c*) Carry the spool to the other wing tip, keeping the wire taut. Leaving about 14 inches to make the end tie, cut the wire.

(*d*) Have someone put tension on the shock assembly until it is stretched to a length about 1½ times its original length. Keeping the wire taut, pass it through the remaining wing insulator and make the end tie.

(*e*) Mount lead-in insulator, type IN-79.

(*f*) Connect a suitable length of antenna wire to lead-in insulator with authorized connection.

(*g*) Run the free end of this wire up to the live section of the flat top and connect to the latter using an authorized down-lead splice. The point of connection can best be determined by experience but in general will be 45 inches to 50 inches on one side of the tail insulator.

(*h*) Run lead-in inside the airplane from the lead-in insulator to the antenna switching relay binding post by the most practicable route, being careful to provide plenty of clearance for control cables, rods, etc.

70. Maintenance of fixed antennas.—*a.* Past experience has shown that most cases of broken antennas occur during flight, and when this does happen, it not only renders the radio installation inoperative, but *it creates a tremendous hazard for the safety of the* *flying personnel.* It must be obvious, then, that the importance of careful, conscientious inspections of the antenna system cannot be emphasized too much. It is the duty of the flight operator to make a painstaking inspection of the complete antenna system daily, and to repair or replace *immediately* any defective parts. Recent technical orders specify that each fixed wire antenna be replaced every 200 flying hours. The cases of antenna failures will be in direct proportion to the manner in which the daily inspections are performed.

b. The outline below is a good one to follow when inspecting a fixed antenna system for flaws.

(1) Examine the shock assembly, noting whether or not the outer covering is cut or rotted. Stretch it to see that the rubber does not pull out of the sleeves. Replace the assembly if any defect is found.

(2) Examine all end ties and down-lead splices for stiffness, corrosion or nicks. Repair any defects by replacing the whole assembly of wire in which the defect is found.

(3) Inspect the stub masts, searching carefully for minute cracks.

(4) Shake the stub masts to see if they are secure at the base. See that the mounting bolts are locked with cotter pins.

(5) Clean all strain and lead-in insulators with carbon tetrachloride. Replace any insulator that is chipped or shows small cracks.

(6) Test the lead-in insulators to see that they are tight in their mountings.

(7) Inspect the lead-in wires to see that they—

(*a*) Are not too tight, that is, have a small amount of slack.

(*b*) Do not rub against the set boxes or other metal parts.

(*c*) Make good connection with the lead-in insulator.

(*d*) Are securely fastened to the respective binding posts.

71. Installation and maintenance of the vertical mast antenna.—*a. Description.*—The vertical mast is a hollow metal tube 3½ feet to 7 feet in length. It is made of cadmium plated steel. The base of the mast is round and about 3 inches in diameter. From a point about 1 foot from the base to the top the mast is tapered and streamlined. Some masts are fitted at the top with a ceramic insulator to which a fixed antenna may be attached when the mast is to be used as a support. A lead-in terminal near the base of the mast is provided.

b. Installation.—(1) *Information.*—The installation of the mast antenna requires changes to the aircraft; therefore, initial installations are the function of the post engineering department. Masts and blueprints for their installation are furnished by the Matériel Division, Wright Field, Dayton, Ohio. Radio personnel may replace defective masts or remove and replace a mast from its mounting for the convenience of other departments when so authorized.

(2) *Rules for replacing masts.*—(*a*) In order to get the proper streamlining effect, the broad edge of the mast must point toward the nose of the airplane.

(*b*) Make the lead-in wire, from the base of the mast to the receiver, of bare wire, type W-106, or Specification No. 95-27074, and as short as possible.

(*c*) Allow a little slack in the lead-in wire to prevent airplane vibrations from being transmitted to the receiver through the lead-in.

(*d*) If the lead-in is likely to come in contact with any metal part of the airplane, insulate it with isolantite beads.

(*e*) The mast must be perpendicular to the longitudinal axis of the airplane in normal flight.

c. Maintenance.—(1) *Information.*—The maintenance inspection of the mast antenna should take place *daily* at the time of the regular radio inspection.

(2) *Directions.*—(*a*) Carefully inspect the entire surface of the mast for cracks. Replace the mast if a crack, no matter how small or insignificant, is found.

(*b*) Inspect the insulated supporting brackets at the base of the mast and at the point where the mast goes through the fuselage. Replace if cracked.

(*c*) Clean the insulated brackets with carbon tetrachloride.

(*d*) See that the lead-in is not too taut and that it does not touch any part of the airplane structure.

(*e*) Inspect the clamps holding the insulated brackets. See that they are tight and safetied.

72. Trailing wire antenna.—*a. Description.*—The trailing wire antenna differs from the fixed antenna in that its physical length, and therefore, its resonant frequency, can be changed during flight by the operator. It is a length of antenna wire 250 to 450 feet long, one end of which has a small weight attached to it and the other end fastened to a rotating spool inside the fuselage. A sliding contact makes connection between the wire and the transmitter binding post. The amount of wire unreeled from the antenna determines the frequency to which the antenna is tuned. In order to insulate the antenna from the airplane structure, the antenna coming from the spool is guided out through an insulating tube in the bottom of the fuselage. This pipe-like guide is called the fairlead. The spool with its housing is known as the antenna reel.

b. Antenna reel, type RL-30-B.—Reel RL-30-B utilizes a free wheeling or coaster brake principle for letting out the antenna, and incorporates a fine-tooth ratchet mechanism in combination with a self-locking brake for holding the antenna wire at any desired length. Its spool, cover, and backplate are molded from a phenolic insulating compound. The operating mechanism and ball bearings are located in the center metal housing which effectively seals these parts from dust, moisture, and other foreign matter. The rear metal housing also serves as a mounting base for the reel and for the mechanical counter used to indicate the approximate length of wire, in feet. The handle of the operating crank is arranged so that it can be folded parallel to the spool when not in use. The spool has a capacity of 450 feet of wire W-106 when random wound to three-fourths the height of the flanges.

c. Mounting reel.—(1) The reel should be mounted in such a position that the crank is readily accessible and the counter is visible. In order to prevent excessive piling when the wire is being reeled in, the reel should be mounted at least 6 inches above the fairlead and so placed that the point at which the antenna wire leaves the spool is in line with the axis of the fairlead; that is, for best operation there should be no bends in the antenna wire between the point where it leaves the reel and the far end of the fairlead. The four mounting bolts can be inserted in the reel base through the hole provided in the web of the spool. Unless the mounting screws themselves are grounded, a heavy grounding wire or strap should be clamped under the nut of one of the mounting screws for the purpose of thoroughly grounding all metal parts of the reel.

(2) To fasten antenna wire to the bottom of the spool channel it is first necessary to remove the spool cover by withdrawing it forward over the spool. This can best be done by placing the fingers of both hands on opposite sides of the cover and pressing on the spool with the thumbs. The end of the wire should be looped under the anchor pin in the spool hub and then twisted around the wire itself a few times. The twisted loop should then be placed in the groove and all of the wire wound on the spool by turning the crank in a clockwise direction. At this point the cover should be replaced by passing the wire through the slot opposite the wire opening and pushing the cover over the spool until it rests against the flange on the back plate. The cover should now be rotated so that the wire from the fairlead to the spool will not rub the edges of the wire opening in the cover either when the spool is full or nearly empty. The counter should now be set to zero. This should be done each

time the reel is used in order to reduce the error in the reading caused by irregularities in winding.

(3) Electrical connection is made by means of connector clamp MC–163, the installation of which is as follows:

(*a*) Remove the brass bushing from connector clamp MC–163 by loosening screw in top of cover and fasten the antenna lead from the radio transmitter to this bushing by means of the screw provided.

(*b*) Replace the bushing in cover and place the connector over the top of the fairlead, clamping it into place by means of the screw in the side of the cover.

(*c*) Wind approximately 250 feet of wire W–106 on the spool and feed end through the connector clamp and fairlead until it touches the ground below the airplane.

(*d*) Connect the free end of the wire to the cable loop on weight WT–7–A. Considerable care should be taken in making the connection between the antenna wire and the weight cable in order that the joint will run smoothly through the connector clamp when the antenna is being let out or reeled in. The loop formed in the antenna wire should be as small as practicable and the section where the antenna wire is twisted back upon itself should be tapered and made as short as a safe joint will permit.

(*e*) Wind up the antenna wire in the reel until the weight WT–7–A rests securely in the fairlead socket. Let out and reel in approximately 10 feet of the antenna several times (have someone pull lightly on the weight to keep the antenna wire tight) to insure that the connector clamp is working properly and that the joint between the antenna wire and weight cable runs smoothly through the clamp.

(4) Fairlead extension F–9 is used when the standard fairlead F–8 is not long enough. It consists of coupling MC–161 and a 36-inch length of standard phenolic tubing of the same cross section as the tube of fairlead F–8. The extension is installed by slipping coupling MC–161 over the top of the fairlead tube so that it covers approximately 3 inches of the tube when secured in place by means of one of the clamps provided. The tubing may then be clamped into the coupling by means of the remaining clamp. This tubing may be cut to fit a particular installation, or more than one extension may be used if required.

d. Operation of reel.—(1) Braking, locking, and winding operations are controlled from the crank on the reel. Normally, the reel is in the locked position so that the wire will not unwind from the spool. Reeling in is accomplished by rotating the crank in a clockwise direction, as indicated by the direction arrow "Wind" on the nameplate at the center of the reel spool. A rachet mechanism on the spool prevents the wire from unreeling when the crank is released. By rotating the crank in a counterclockwise direction the braking mechanism is released, thereby permitting the wire to be reeled out. Braking force decreases gradually as the handle is rotated through approximately the first 40° of its motion. Beyond this point and up to the extreme limit of its motion the brake is completely released and the spool is free to spin. The speed of unwinding can be readily controlled by regulating the braking effect with the crank. A spring return on the crank automatically resets the brake to the normal or locked position when it is released.

(2) Tuning the antenna should be accomplished by allowing slightly more wire than is necessary to run from the reel and then reeling in slowly to obtain the proper length by observing the resonant condition. During the reeling out operation, care should be taken that all of the wire is not unreeled. The speed with which the reeling takes place would be sufficient to snap the wire if it reached its ultimate length, causing a loss of both the weight and wire. While unreeling wire, never allow the crank to snap into the locking position when the spool is rotating rapidly. The sudden stop which would result may break the antenna wire and place undue stress on the reel mechanism.

e. Servicing the reel.—The reel is to be serviced according to the specific instructions contained in the instruction book for the particular transmitter with which it is used, great care being taken to employ the best quality lubricant of the correct type and quantity.

f. Antenna reels, types RL–41 and RL–42.—These reels are operated by electric motors and can therefore be located at a distance from the radio operator in more advantageous positions than would otherwise be the case. A control box which includes an "in-out" control switch and a turn counter is provided for the radio operator. Reel RL–41 requires a 12-volt power supply and RL–42 a 24-volt supply, but are otherwise identical. The method of installation in relation to fairlead F–10 is shown on AC drawing No. H42G4623.

Section VIII

POWER EQUIPMENT

73. General.—*a.* The electric power necessary to operate aircraft communication equipment is obtained from various sources and converted into a suitable form for operating transmitters, receivers, etc. Both high and low voltage is necessary and is obtained from the aircraft battery in case of airplane installations and from the regular 110-volt supply or portable gasoline driven generators in case of ground installations.

b. This section deals mainly with the practical operation and maintenance of batteries, motors, generators, dynamotors, transformers, rectifier power supplies and gas engines. This information is very general; specific information concerning lubrication, etc., should be obtained from the manufacturers hand book of instruction on each piece of equipment.

74. Motors, generators and dynamotors.—*a.* Rotating electrical machinery should be cleaned frequently. This is accomplished by blowing the dust out with an air hose, wiping with a lintless cloth and washing with a solvent such as carbon tetrachloride. The solvent is necessary where oil or grease has accumulated. Care must be exercised to keep this solvent from coming in contact with the carbon brushes as it will damage them.

b. Bearings should be lubricated with the specified grade of oil or grease as directed by the manufacturer. The oil or grease depends on the type of bearing to be lubricated. Ball bearings are packed with one kind of grease while a wick lubricated bearing uses another type. A good grade mineral oil should be used for oil ring type bearings. It is very important to follow the manufacturer's instructions and use the proper grade and amount of lubricant. Too much oil or grease is bad, as it may get on the commutator and brushes where it will cause trouble.

c. Brushes are usually made of carbon with sufficient graphite to provide the necessary lubrication. Brushes make a sliding contact, but should never be oiled. The brush should slide freely up and down in its holder and should make contact with the commutator over its entire end surface. If these two requirements are not met, the condition should be remedied as follows: A tight brush can be relieved by sanding or filing the sides of the brush until the proper clearance is obtained. Figure 74 illustrates the methods of sanding the face of a brush to cause it to make good contact with the commutator. No. 000 or finer sandpaper should be used for this purpose. Be sure to hold the strip of sandpaper in close contact with the commutator on both sides of the brush so that the corners of the brush will not be rounded as the armature is rotated or the sandpaper is pulled back and forth. Remove the brush frequently as it is being seated to inspect for a perfect fit. This will be indicated by the sandpaper marks covering the entire brush face. A new brush should be sanded in by the above method when it is installed. *Never use emery cloth*, as emery is a conductor and the particles may cause a short circuit.

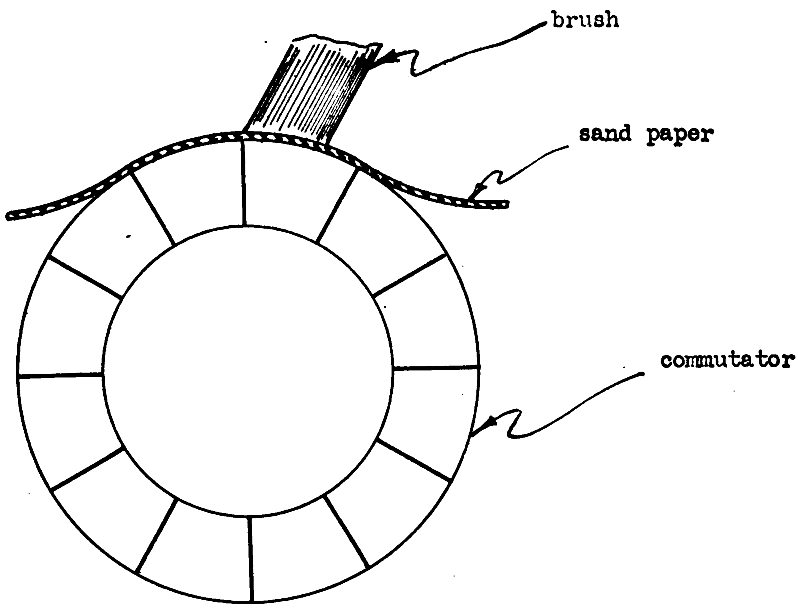


FIGURE 74.—Sanding in a brush.

d. A commutator should be smooth and bright or tinted a dark brown where the brushes ride. The mica insulation should be undercut slightly. Figure 75 illustrates what is meant by the term undercut. If a commutator is found slightly rough or pitted it can be smoothed by pressing a piece of fine sandpaper against it with a block of soft wood while the machine is running. In case of severe roughness or pits the armature should be mounted in a lathe and a light cut taken, after which the mica should be undercut. The electrician usually uses a piece of hacksaw blade for this purpose. The sides of the saw teeth should be ground off until it makes a cut exactly the width of the mica. Undercutting commutators by this method requires care and skillful hand work.

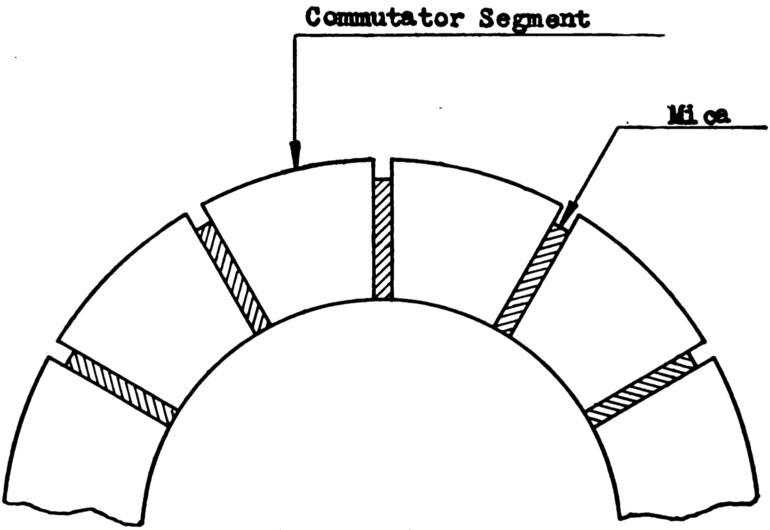


FIGURE 75.—Undercutting a commutator.

e. The starters and compensators used with the larger motors require but slight care. The contacts should be inspected frequently for pits caused by arcing and, if found, the contact should be dressed with a file or replaced as necessary.

75. Dry batteries.—*a.* Dry cells should only be used where relatively large currents are needed momentarily or very small currents are required for longer periods of time. For services of this kind dry cells are very satisfactory. A battery made of the proper number and size cells should be used if maximum economy is desired. The battery operated equipment used in the Army Air Forces is designed to use a certain type Signal Corps battery. The correct type should always be used when a replacement is made.

b. Dry cells cannot be recharged but must be discarded and replaced with new cells when they become exhausted. Dry batteries deteriorate with age and usually have the date of manufacture stamped on them. To lessen this tendency and increase the shelf life, batteries should be stored in a cool dry place. Never test a dry cell by short circuiting it with an ammeter as this materially shortens the life of the battery. Instead use a voltmeter to measure the voltage while the battery is loaded with a resistor. The voltage should be very close to 1½ volts per cell, assuming a series connection.

76. Lead acid storage battery.—*a.* The outside of a battery should be kept dry and clean. This may be accomplished by periodically using a stiff bristle brush and a cloth or a piece of waste. Ammonia or a soda solution (1 pound of bicarbonate of soda to a gallon of water) should be used if acid is spilled on the battery top. The battery terminals, bolts and exposed metal parts of the connecting wires should be coated with clear vaseline to prevent corrosion. If corrosion has taken place the parts should be scraped clean, washed with ammonia or soda solution and coated with vaseline.

b. Distilled water should be added at intervals in sufficient quantities to keep the level about ½ inch above the plates. This water should be stored in glass, earthenware or rubber receptacles. The only metal container which may be used is lead and this is not very practical. Do not add water in freezing weather unless the battery is to be charged, because the added water may freeze before it has had time to mix with the electrolyte. A written record should be kept of the amount of water taken by each cell. If one cell consistently uses more water than the others it should be carefully inspected for leaks.

c. When testing a battery with a hydrometer care should be exercised to see that the electrolyte is returned to the cell from which it was withdrawn and that none is spilled while the reading is being taken. If conditions permit, it is desirable to read the hydrometer without removing the nozzle from the cell. This eliminates any possibility of spilling or returning the electrolyte to the wrong cell.

d. The specific gravity of a fully charged battery varies to some extent with different manufacturers and temperature as well as with the age and care the battery has had. In general, a specific gravity of 1.275 to 1.300 represents a fully charged condition. When the specific gravity reaches 1.125 the battery is getting low and needs recharging.

e. The specific gravity of electrolyte at 50° F. may change from 1.280 to 1.270 if the temperature rises to 80° F. and 1.260 at a temperature of 110° F. That is, a 30° F. change of temperature causes a 10 point change in specific gravity.

f. Hydrometer readings should not be taken immediately after adding water to a battery. A day or so should be allowed for the water to mix thoroughly with the electrolyte unless the battery is on charge, in which case an hour is sufficient.

77. Charging lead acid batteries.—*a.* Direct current must be used to charge a storage battery. Never attempt to charge a battery with alternating current. If alternating current is the only power available, a rectifier or other type of converter must be used. Pulsating direct current may be used without filtering.

b. Hydrogen gas is liberated during the charging process. This gas when mixed with air is very explosive so it is important to have good ventilation in the charging room and avoid lighting matches or smoking in the vicinity of batteries on charge.

c. The electrolyte should be kept above the plates by adding water as required during the charging period, and periodic specific gravity readings should be taken to determine whether the charge is progressing satisfactorily. The specific gravity of each cell should gradually increase and finally remain constant. As the battery cools after the charging current is cut off, the specific gravity will rise slightly.

d. The manufacturer's instructions should be followed in every case, but in general the vent plugs should not be removed except when water is added or a hydrometer test is being made. Be sure that the vent hole is not obstructed. If the cells flood or spew electrolyte, the level is too high and should have some withdrawn. This electrolyte should be returned later to the cell from which it was taken.

78. Edison storage battery.—*a.* Edison batteries should be kept clean and dry. The slight deposit of potash salts which collect under normal conditions on the tops of the cells is not injurious but should be brushed off if it becomes too heavy. The outside of the cell containers is coated with a vaseline compound containing a small amount of resin to prevent corrosion. If this coating is wiped off it should be replaced. Any ordinary commercial vaseline may be used for this purpose.

b. The electrolyte should be kept ½ inch above the plates by adding distilled water. The cells should always be filled before placing them on charge, as the gas formed during charging lifts the electrolyte to a false level. A convenient filling outfit is manufactured by the Edison Storage Battery Co. which automatically rings a bell when the electrolyte reaches the proper level.

c. It is more difficult to determine the state of charge of an Edison battery than a battery of the lead acid type. The specific gravity cannot be used and neither can the open or standing voltage of the battery. The cell voltage must be observed over a period of time during charge or discharge. On charge, if the voltage remains constant at 1.8 volts or above per cell for 30 minutes with normal charge current flowing through the battery, then the battery can be considered fully charged. Although overcharging does not harm the Edison battery it is a waste of current and should be avoided unless it is very important to have an absolutely fully charged battery, and no positive means of testing is available.

d. Edison batteries are charged in the same manner as the lead acid type. They may be charged by either the constant current or the tapering current method. Unless the manufacturer states otherwise, leave the filler caps closed during charge. Be sure that the positive lead from the charger is connected to the positive pole of the battery. It is also possible to charge Edison batteries at high rates during brief periods of idleness. This is referred to as a boosting charge. In this connection Edison batteries may be charged as follows:

Minutes charge.	*Times normal rate.*
5	5
10	4
20	3
40	2

In cases of emergency these values may be exceeded somewhat.

79. Storing batteries.—*a.* When it becomes necessary to retain storage batteries in stock and unused for periods varying in length from a few months to several years, many considerations must be taken into account if the batteries are to be prevented from undergoing permanent deterioration. In general, the Edison battery may be stored for an indefinite time absolutely without deterioration. The lead acid battery, however, cannot be safely stored under any condition for much longer than 2 years.

b. When lead acid batteries are placed in wet storage they should be kept fully charged by periodically charging them or better still by placing them on trickle charge. That is, continually pass about 0.2 ampere, per 100 ampere-hour capacity, through them. Very detailed instructions must be obtained from the manufacturer in order to successfully place batteries in dry storage for extended periods.

80. Battery chargers.—*a.* Charging equipment varies greatly, the type depending on the battery installation to be charged. Large installations usually employ a d-c generator and a control panel with the necessary switches, meters, rheostats, circuit breakers, etc., mounted thereon. An ampere-hour meter is included on many installations. This gives a positive indication as to the state of the batteries charged.

b. For smaller installations, and where batteries are occasionally charged, a rectifier type charger is usually employed. This may be of the dry oxide type or a gaseous tube of the Tungar variety.

c. Before operating any battery charging equipment, the manufacturer's instructions should be studied carefully or specific instructions should be obtained from a person thoroughly experienced in operating the equipment.

81. Transformers.—Transformers have no moving parts and hence require very little attention. Excess dust and dirt should be blown or wiped off and in large oil cooled transformers a close check on the temperature rise should be made in very hot weather if the electrical load is heavy. The oil should be changed or cleaned at specified intervals.

82. Rectifier power supplies.—*a*. Low voltage power supplies used with receiving equipment require no attention other than an occasional cleaning by blowing out the dust.

b. It is very important to allow the filaments of mercury vapor rectifier tubes to heat up before the plate voltage is applied. Most power supplies which use these tubes have an automatic time delay relay incorporated which applies the plate voltage after the filament has had time to heat.

c. In operating and maintaining high voltage rectifier equipment it is very important to follow the manufacturer's instructions which should be thoroughly understood by every radio mechanic who is to operate the equipment.

83. Gasoline engines.—*a*. Gasoline engines are employed to drive generators for supplying power to certain radio field sets. These may be either of the 2-cycle or 4-cycle type. In either case it is very important to use the proper fuel and lubrication if satisfactory results are to be obtained. The manufacturer's instructions should be followed explicitly when operating and maintaining these engines.

b. Proper carburetor adjustment, a positive ignition system, perfect valve seating, good compression, as well as correct value and ignition timing are necessary for easy starting and smooth running. A new engine has the above characteristics and if the manufacturer's instructions are followed, it can be kept in this condition.

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