TECHNICAL MANUAL

COMMON WOOD AND METAL REPAIR

HEADQUARTERS, DEPARTMENT OF THE ARMY

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COMMON WOOD AND METAL REPAIR

*This manual supersedes TM 10-270, 26 January 1965.

CHAPTER 1

INTRODUCTION

1–1. Purpose

This manual is published as a guide for personnel engaged in the repair of furniture, mess equipment, tools, and implements. The instructions listed are applicable for either mobile or fixed repair units or installations.

1–2. Scope

a. The manual discusses preliminary inspection of items, preparation of the items for repair, repair procedures, and inspection of the finished work.

b. The manual covers the general procedures to be followed in the repair of wood and metal items and the repair of tools and implements.

1–3. Recommended Changes

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commanding General, U.S. Army Ordnance Center and School, ATTN: ATSOR–INT, Aberdeen Proving Ground, Md. 21005.

1–4. Support Maintenance Activities

Consolidated support maintenance activities are organized to fit the needs of a particular installation and are designed to provide flexibility in repair operations. Such an activity may include a clothing and textile repair shop, a footwear and leather goods repair shop, a metal and wood repair shop, a furniture repair shop, a heavy tentage repair shop, a canvas and webbing repair shop, an office machine repair shop, and an airdrop equipment repair shop.

CHAPTER 2

REPAIR OF WOOD, PLYWOOD, AND FIBER ITEMS

Section I. BASIC REPAIR

2–1. General

a. The variety of operations in the repair of wood items is so great that not all of them can be anticipated and discussed in this manual. The success of a repair job depends, many times, not on specific repair instructions for the article being repaired, but on the repairman's knowledge of both hand- and power-operated woodworking tools. The purpose, limitations, and operation of each tool in the shop should be understood; and the decision on how to effect a repair should be made before the repair is begun. TM 5–461 and TM 9–243 should be consulted for the proper use of woodworking handtools, such as planes, hammers, saws, and chisels. The various types of woodworking machine tools, such as bandsaws, jointers, surfacers, shapers, mortisers, and lathes are covered in separate technical manuals. These manuals should be consulted for woodworking procedures involving the use of these machine tools.

b. The repairs covered in this chapter would be done in the furniture repair shop within the consolidated support maintenance activity at an installation. A model layout of such a repair shop is shown in figure 2–1.

2–2. Gluing

a. General.

(1) Whenever practicable, glue should be used to repair broken tables, chairs, chests, and other articles constructed of wood. Glue makes a neat, strong, and durable repair. On side and edge grain, glue is as strong as the wood it holds; on end grain, however, additional support is necessary, usually in the form of tenons and dowel pins.

(2) Satisfactory glue repairs depend on such factors as the density and structure of the wood, the presence of extractives or infiltrated materials in the wood, and the kind of glue used. Heavy woods are harder to glue than light woods; hardwoods are harder to glue than softwoods; and heartwoods are harder to glue than sapwoods.

b. Types of Glues. The following types of glues are available for the repair of wood articles:

(1) *Dry animal glues.* Dry animal glues are made in flake or granular form. They are easy to prepare and are usable at least 8 hours after preparation. They are applied either by hand or by a mechanical spreader. Both the wood and the glue must be warm on application. The glue begins to set almost immediately; therefore, assembly time is kept under 5 minutes, and, if possible, under 3 minutes. The work is cold-pressed and the clamps are left on for at least 2 hours. Animal glues have practically no staining tendency and only a moderate dulling effect on tools. These glues are very strong when kept dry but weaken rapidly when exposed to moisture. The best grade, fortified with a fungicide to prevent mildew, should be used.

(2) *Liquid animal and fish glues.* Animal and fish glues are supplied in liquid form ready for use and are applied cold by hand. Assembly time is somewhat longer than that for dry animal glues but should not exceed 5 minutes. The work is cold-pressed for 2 to 3 hours. Liquid glues cause little or no staining and dull tool edges only slightly. Better grades of these glues have a moderate dry strength, but all grades weaken rapidly when exposed to moisture. Therefore, these glues should be used only where moderate moisture conditions are to be expected.

(3) *Blood-albumin glues.* Blood-albumin glues are mixed at the time of use and applied cold either by hand or by mechanical spreader. The length of their working life varies, and the manufacturer's recommendations should be followed. The assembly time should not exceed 5 minutes. Most blood-albumin glues require hot pressing, which limits their use. They stain wood slightly and have a moderate dulling effect on tool edges. They are high in strength both when dry and after exposure to moisture.

LEGEND

A. DeWalt saw	H. Sander spindle	O. Clamp rack	U. Drill press (portable)
B. Table saw 10"	I. Grinder	P. Round bin	V. Panelyte rack
C. Mortiser	J. Lathe	Q. Buffer (portable)	W. Work bench
D. Jointer 8"	K. Band saw	R. Parts cabinet	X. Paint agitator
E. Jointer 6"	L. Shaper	S. Wall locker	Y. Air compressor
F. Planer	M. Gumming machine	T. Key cabinet	Z. Shelves
G. Sander disk	N. Wall locker		

Figure 2–1. Model layout of a furniture repair shop.

(4) *Synthetic resin glues.* The most common and successfully used types of synthetic resin glues are as follows:

(*a*) *Urea resin glues.* Urea resin glues are prepared in both powder and liquid forms. They are mixed with cold water and applied either by hand or by a mechanical spreader. Joints are either cold- or hot-pressed. For cold-pressed joints, the pressure time is 4 hours. For hot-pressed joints, the pressure time is 5 minutes after the temperature at the glue line has been raised to about 250° F. These glues stain wood slightly and have a moderate dulling effect on tool edges. They have a high dry strength and, although more moisture-resistant than animal glues, are not as resistant as the phenolic, resorcinol, or melamine resin glues. Cold-setting urea resin glues cannot be used if the temperature of the shop or the wood is below 70° F.

(*b*) *Phenolic, resorcinol, and melamine resin glues.* These resin glues are used on all outside grades of plywood and on exposed gluing assemblies because they have higher moisture resistance than other glues. They are prepared in both aqueous suspension and dry-film forms. Hot-pressing is essential with both dry-film and aqueous forms. These glues have a moderate staining effect and a moderate dulling action on tool edges. They are recommended for any assembly in which heat and pressure can be used to set the glue. A joint properly made with these glues is almost indestructible regardless of exposure conditions.

(5) *Casein glue.* Casein glue, or "cold water" glue, is mixed fresh every day and used cold. Temperature control and speed are not necessary, since this glue does not begin to set until 10 to 15 minutes after its application.

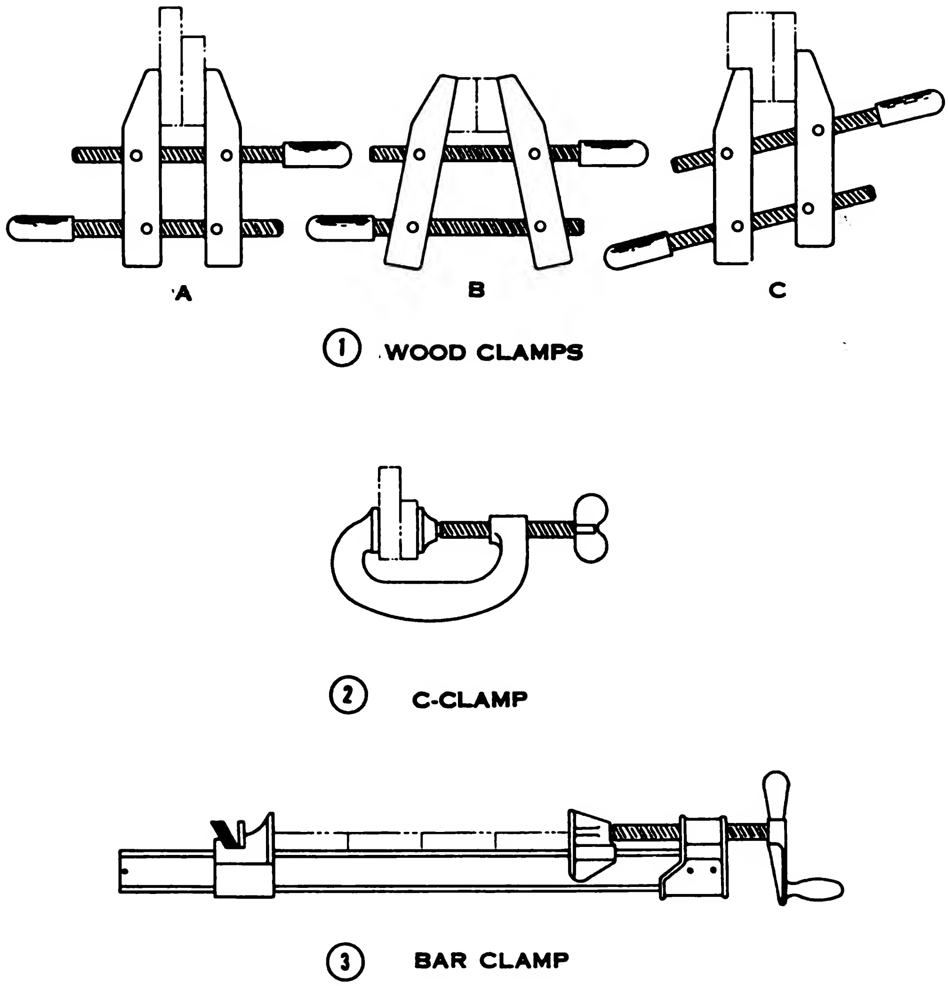


Figure 2–2. Various clamps used to apply pressure to glued joints.

Casein glue should be fortified with a fungicide to prevent mildew. This glue is not as water-resistant as the resin glues.

(6) *Other glues.* Other ready prepared and fast setting glues are also available.

c. Rules for Gluing. Observe the following rules when making glue repairs:

(1) Do not sandpaper surfaces to be glued.

(2) Before applying the glue, make certain that the wood surfaces to be glued fit tightly together and that all the old glue is removed.

(3) Use a glue thin enough to run freely from a full brush.

(4) Apply pressure with one or more of the various clamps provided for holding the parts together until the glue sets (fig. 2–2).

(5) Apply hand screws and clamps as quickly as possible.

(6) Use softwood blocks over finished sides and edges to protect the surfaces from being marred by clamps.

(7) Apply only light pressure if the surfaces are well matched and the contact area is small.

(8) Apply pressure up to the crushing strength of the wood when the glued area is large. (Do not exert pressure beyond the crushing strength of the wood.)

(9) Apply pressure for at least 2 hours if heat is not used.

(10) Reduce pressure time when using hot-setting urea, or phenolic, resorcinol, and melamine resin glues. (The pressure time for hot-setting glues may be reduced to 5 minutes or less.)

(11) When adjusting a wood clamp, use the inner screw as a fulcrum, adjusting it to the work first; then turn the outer screw to tighten the clamp.

(12) When several clamps are used, reverse every other one to prevent warping and pulling.

d. Additional Information. For additional information on adhesives or glues consult Military Standardization Handbook—691–A.

2–3. Warped Parts

Repair warped parts by reconstructing or streightening.

a. Reconstructing. Use a glued-up part instead of a solid part. For example, if an 18- by 36-inch board is needed, glue up a board from three 6-inch pieces or rip an 18-inch piece into three 6-inch pieces and glue them together, inverting the center piece so that the grain stresses are balanced (fig. 2–3).

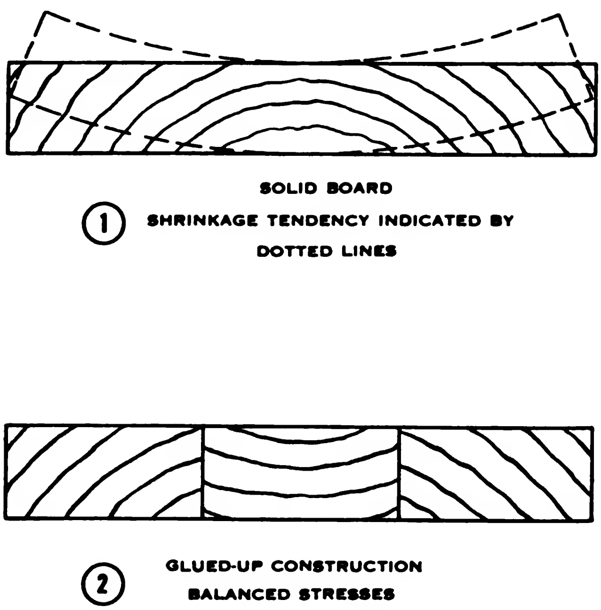


Figure 2–3. Method of repairing warped board by ripping and gluing.

b. Straightening. Straighten a warped part by using one of the following methods:

(1) Apply hot water to a piece of canvas laid on the convex side of the warped part. Keep the opposite side dry and allow free circulation of air around the part being straightened. When the wood has reached the desired degree of straightness, place it in clamps or forms to hold it into position until dry.

(2) Place a wet pad on the concave surface so that the wood fibers may absorb moisture and expand. When the part is straight, clamp it and let it remain overnight. A board moistened to such an extent that it becomes warped in the opposite direction may be brought back with an application of hot sand on the convex surface.

2–4. Broken Parts

Replace broken parts with new parts. If replacement is not feasible, repair the break in one of the following ways:

a. Double Wedge. Glue a snug-fitting double wedge of hardwood into a mortise cut at the point of the break (fig. 2–4). When the glue has set, sand and refinish.

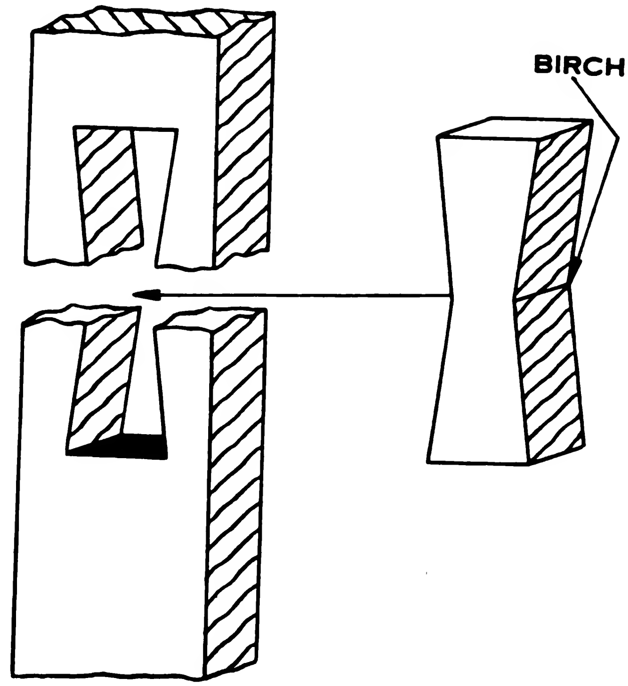


Figure 2–4. Repairing a break with a double wedge.

b. Splints. When the broken part is too slender to be repaired with a double wedge, cut away the outer surface and apply splint (figs. 2–5). Glue the splints in place, sand and refinish.

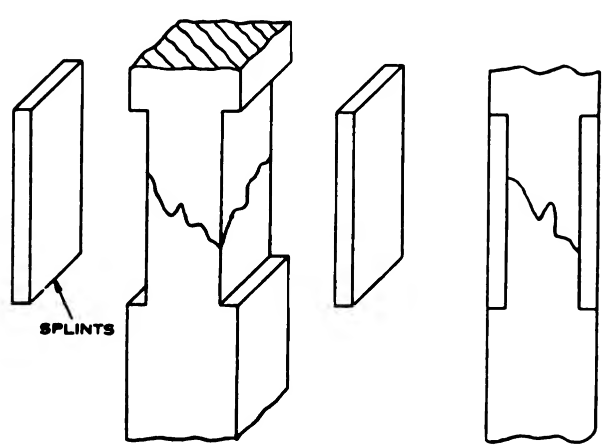


Figure 2–5. Repairing a break with splints.

c. Wood or Metal Backing. Where projecting material does not interfere with the operation or detract from the appearance of the article being repaired, use wood or metal backing to hold the broken parts together (fig. 2–6).

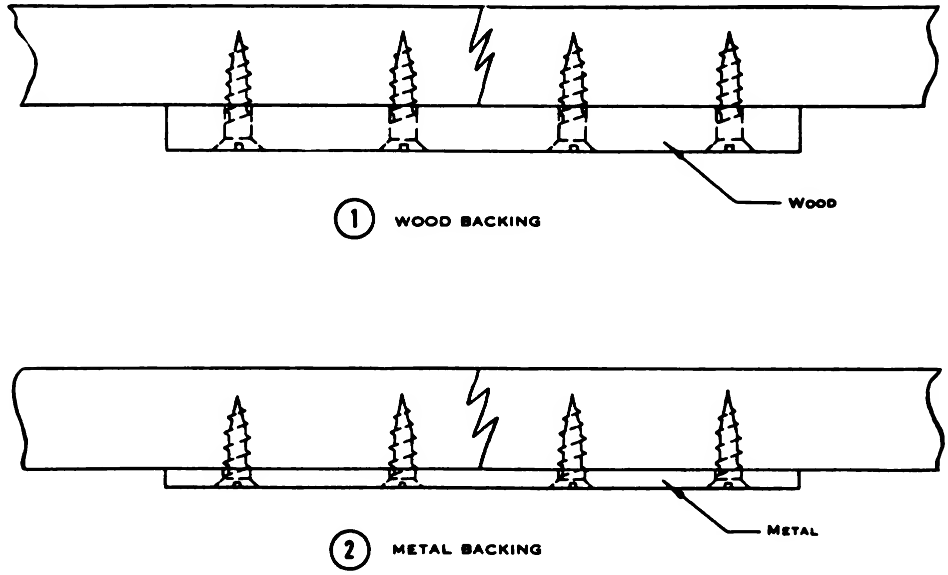


Figure 2–6. Repairing a break with backing.

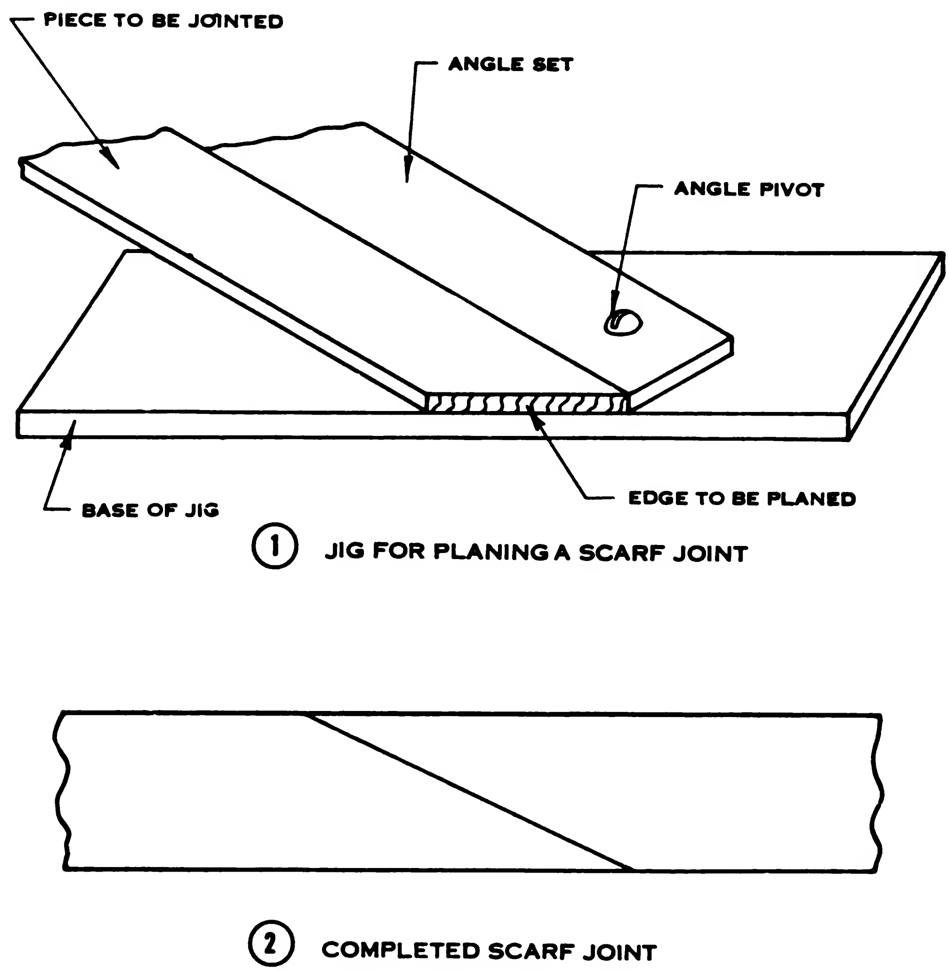


Figure 2–7. Repairing a break by scarf splicing.

d. Glue. Repair lengthwise breaks with glue. Clamp the glued parts together and refinish when dry.

e. Scarf Splice. The scarf splice requires close-fitting contact surfaces. Handtools can be used with a simple jig (1, fig. 2–7) to insure accurate work. With C-clamps, fasten the jig, the guide, and the pieces to be spliced to the work-bench. Cut the bevel by splicing, using a hand plane, side down, against the edge of the jig base. Glue and clamp the planed ends together and refinish when dry (2, fig. 2–7).

2–5. Surface Parts

a. Solid Surfaces. The repair procedure for smoothing a damaged solid surface depends upon the degree of damage. Determine the extent of the damage and make the repair in accordance with the following procedures:

(1) *Light scratches.* On a varnished surface, apply liquid amalgamator to the damaged area; this softens the old varnish, causing it to flow and level itself, after which it hardens again.

(2) *Checking.* Wash and thoroughly scrub the checked surface with a mild soap, using a stiff-bristled brush to remove all dirt from the cracks. When dry, apply the amalgamator on the surface like a thin varnish. After the amalgamator has dried, renew the surface by waxing and polishing.

(3) *Shallow dents.* A shallow dent may be removed by one of the following methods:

(*a*) Carefully remove the varnish covering the dent to bare the wood. Apply a few drops of water to the bared wood; the water will swell the compressed wood fibers so that they will return to their original position.

(*b*) If simply soaking does not remove the dent, use heat. Moisten the wood as in (*a*) above. After the water has penetrated the wood fibers, place a pad over the dent and hold a hot soldering iron on the pad (fig. 2–8). After the wood has returned to its original position, stain it to match the original finish and revarnish it. Finish when dry by applying amalgamator to blend the edges of the new varnish into the old.

(*c*) If neither of the above methods is practical, remove the dent by sandpapering or planing.

CAUTION

Use stick shellac in open air or in a well-ventilated room.

(4) *Deep defects.* If a defect is deep, clean out the defect, removing all the loose or crushed wood fiber. Enlarge it if necessary and undercut the edges slightly. Fill defect with wood cement, commonly known as stick shellac. Use stick shellac of appropriate color to match the original finish (cement from different colored sticks may be blended together). Use a soldering iron to soften the cement so that it will drop into the defect (fig. 2–9). Care should be taken to see that the cement is not heated to such a temperature as to become charred. The heat should be just enough to make it flow without bubbling. After filling the defect even with the surrounding surface, smooth the cement with a knife blade which has been heated over an alcohol burner. Do not use a candle or other flame to heat the knife because soot from the flame will ruin the cement. After the cement has hardened, rub the surface with an oiled felt pad dipped in

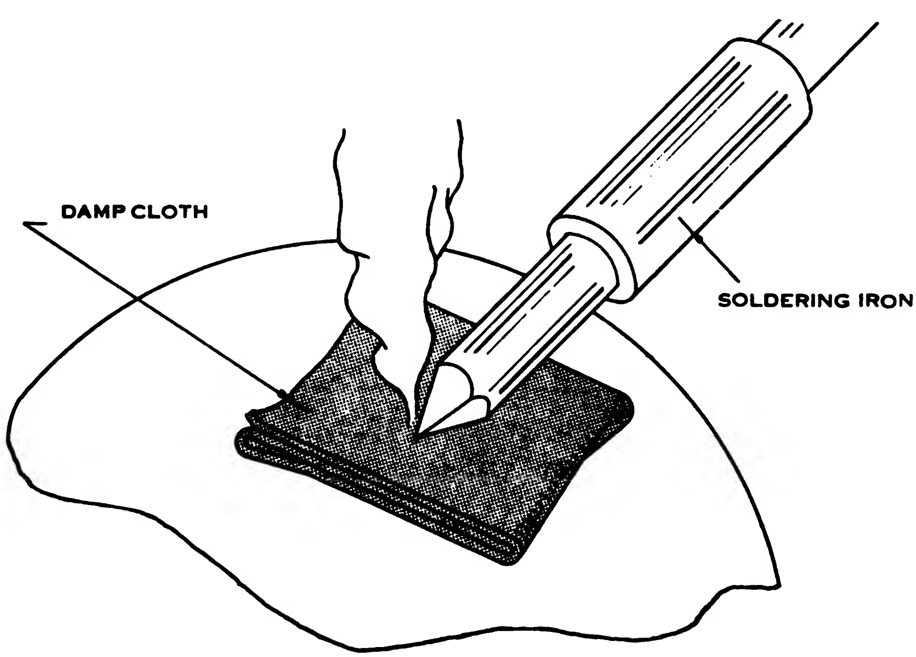


Figure 2–8. Removing dents with a damp cloth and a soldering iron.

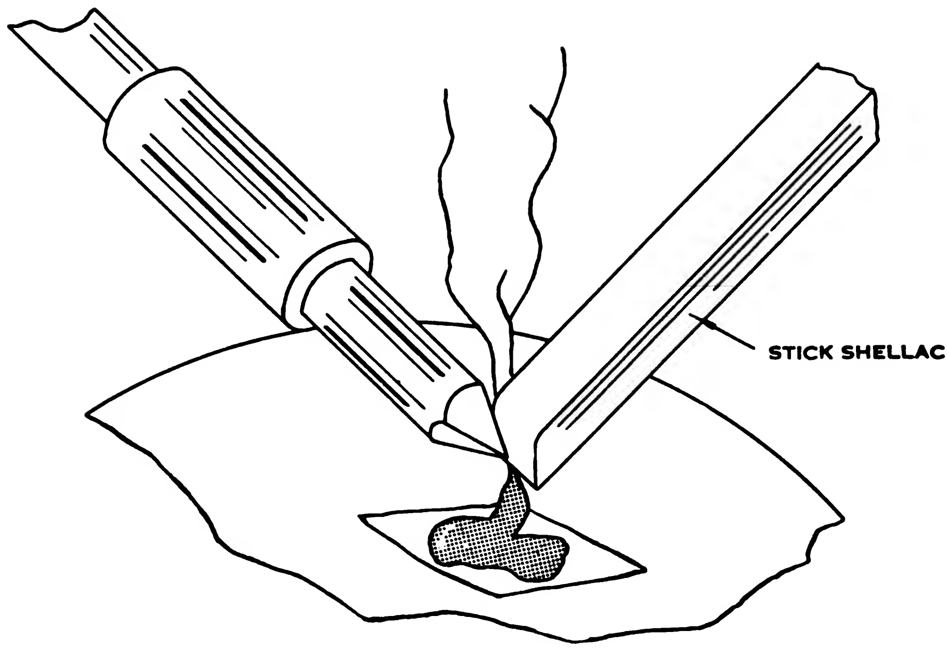


Figure 2–9. Repairing surface defects with stick shellac and soldering iron.

rottenstone to remove the glaze. If a defect is unusually deep, first fill it to slightly below the finish level with fresh plastic wood or sawdust mixed with casein glue. After the filling has dried, apply stick shellac to match the finish.

(5) *Extensive defects.* If the surface is so greatly damaged that none of the above procedures is practical, cover the entire surface with plywood or composition board cemented down with glue. First, remove the finish and sandpaper the old surface until it is smooth and free of irregularities. Cut the edges of the new covering flush with the old top edge. If the old edge is marred, use a thin wood banding of the same wood and finish as that of the original surface. Make sure the top edge of the banding is flush with or just below the surface level of the new top. Make the banding wide enough to cover both the old edge and the new surface material. A tempered prestwood surface need not be finished.

(6) *Warped parts.* For the repair of warped parts, refer to paragraph 2–3.

b. Veneered Surfaces. Repair veneered surfaces in the following ways:

(1) *Minor defects.* Use stick shellac to repair minor defects in veneered surfaces, observing the same procedure as that discussed in *a*(4) above.

(2) *Small defective areas.* If the damage is confined to a small area, repair it with a veneer patch slightly larger than the damaged section. Apply three or four small spots of glue to the damaged area. Press the patch over the glue and allow it to set. With a sharp knife held vertically, cut through both the patch and the damaged veneer. This cut need not follow a rectangle; it is better if tapered to a point. Detach the patch and clean out the damaged veneer within the cut area. Apply glue, insert the patch, and place a weight on it. After the glued patch has set, remove the excess glue from the surface and refinish.

(3) *Blisters.* To repair loose or blistered veneer, steam the damaged area to make the veneer pliable. With a sharp knife cut the blister open, apply glue, and press the veneer into place again, working fast to get the job completed before the veneer dries out and breaks. Squeeze out the excess glue at the edges, wipe if off, and place a weight on the reglued area. When the glue has dried, finish the repair by sanding, staining, and revarnishing.

2–6. Joints

a. A badly worn joint, a fractured joint, or any joint that cannot be successfully fastened by glue alone may be repaired in the following ways:

(1) *Bracing.*

(*a*) Brace with a woodblock (1, fig. 2–10).

(*b*) Brace with a wood crosspiece (2, fig. 2–10).

(*c*) Brace with an iron strap (3, fig. 2–10).

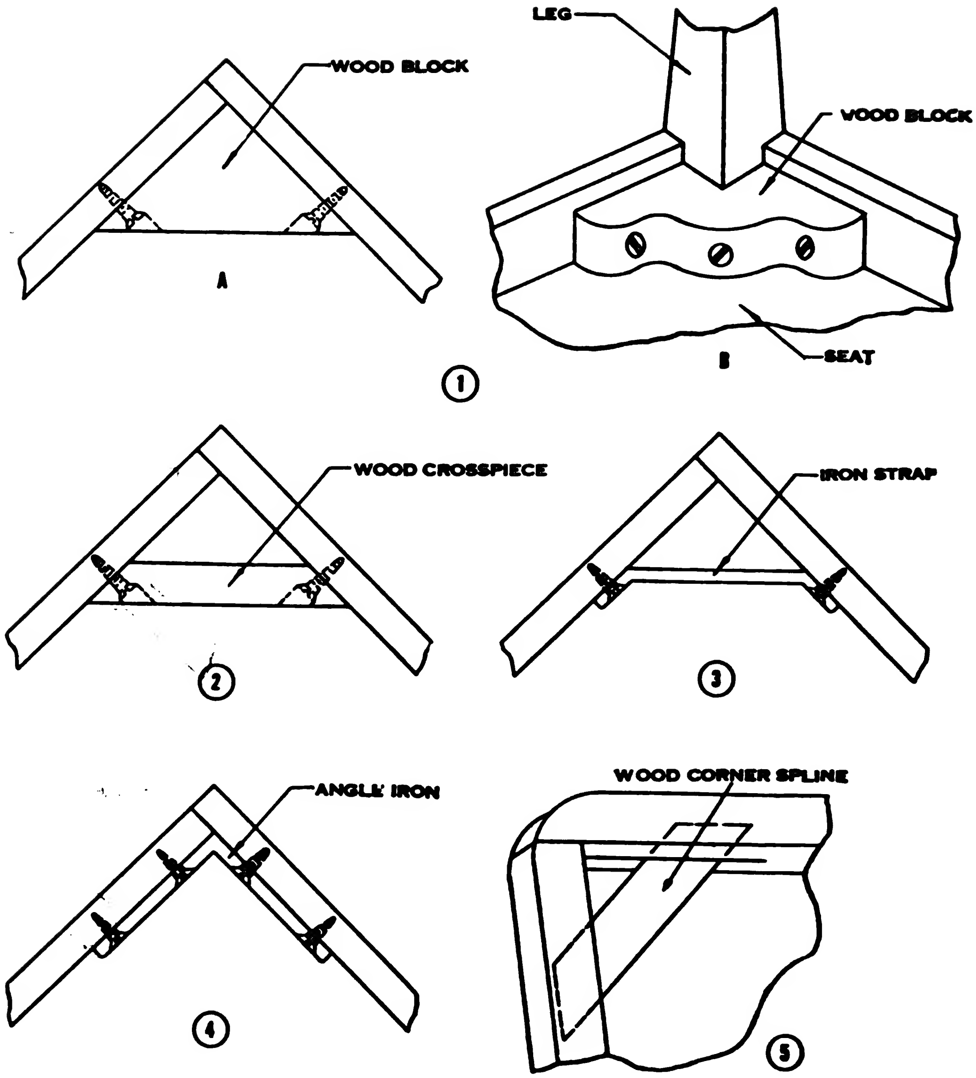


Figure 2–10. Methods of bracing.

(*d*) Brace with an angle iron (4, fig. 2–10).

(*e*) Brace with a corner spline (5, fig. 2–10).

(2) *Wedging.*

(*a*) If a tenon is rectangular, insert a wedge in the edge of the tenon and angle-cut the mortise to securely hold the wedged tenon (1, fig. 2–11).

(*b*) If a tenon is round, insert a wedge in the end of the tenon and drive the tenon back into place (2, fig. 2–11).

(3) *Fastening.*

(*a*) Fasten with a wood screw (1, fig. 2–12).

(*b*) Fasten with dowels (2, fig. 2–12).

(*c*) Anchor with a cross-screw or cross-dowel (3, A and B, fig. 2–12).

b. When it is not practicable to repair a fractured joint by one of the methods in *a* above, the joint in some cases may be reconstructed. For example, to repair a broken tenon on the rung of a chair (1, fig. 2–13), proceed in the following manner:

(1) Saw off the broken tenon flush with the tenon shoulder (2, fig. 2–13).

(2) Drill a hole in the rung (2, A, fig. 2–13) and insert a dowel.

(3) Bore out the socket to a size slightly larger than it was originally and glue in place a snug-fitting bushing (2, B, fig. 2–13).

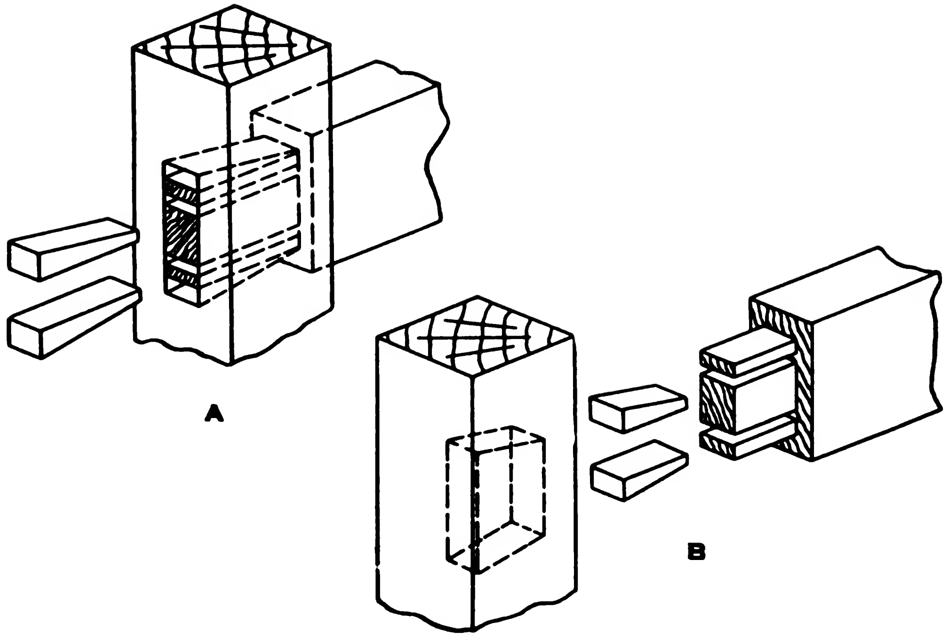
(4) Bore the bushing to receive a dowel (2, B, fig. 2–13).

(5) Apply glue to the dowel and the socket and clamp the pieces together.

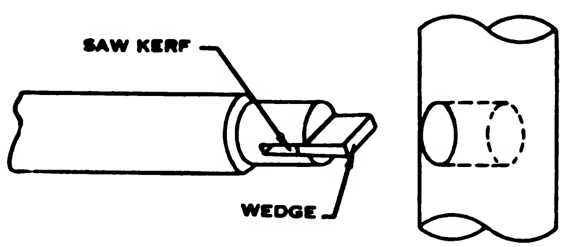
(6) Finish by removing the excess dried glue.

2–7. Fastenings and Attachments

Fastenings and attachments consist of locks,



(1) WEDGING OPEN AND BLIND TENONS



(2) WEDGING A DOWEL TENON

Figure 2–11. Methods of wedging.

catches, hinges, corner plates, strike plates, knobs, handles, and other fittings, all commonly referred to as hardware. If an article of hardware is badly damaged or missing, replace it with one similar to that used in the original construction. Minor damage causing hardware to loosen and become faulty in operation should be repaired.

a. Locks and Catches. When minor shrinkage or warpage makes door locks and catches fail to work properly, repair by shifting strike plates or adjusting hinge positions.

b. Loose Hardware. When screw holes or nail holes become enlarged, causing hinges, strike plates, latches, handles, and similar fittings to loosen, fill the holes with plastic wood or insert softwood plugs. Once the holes are plugged and securely fastened, replace the fitting.

c. Worn Areas Around Fitting. If wood surfaces around a fitting become badly worn, remove the fitting, inlay a piece of wood in the worn area, and refasten the fitting. If this is not practical, relocate the fitting. Use the following method to relocate the butt hinge on a door or on a lid:

(1) Mortise the door or the lid to a depth double the thickness of the hinge. This eliminates the second mortise and reduces the chance of an error in marking or mortising.

(2) Fasten the hinge on the door or the lid.

(3) Set the door or the lid in position and, with a marker set in the hinge, press the hinge against the frame. Drill a screw hole in the frame at the point indicated by the marker. (To make a marker, cut off a screw to a length just long enough to project 1/16 of an inch through the hinge. File the stub to a point and set it in the hinge.)

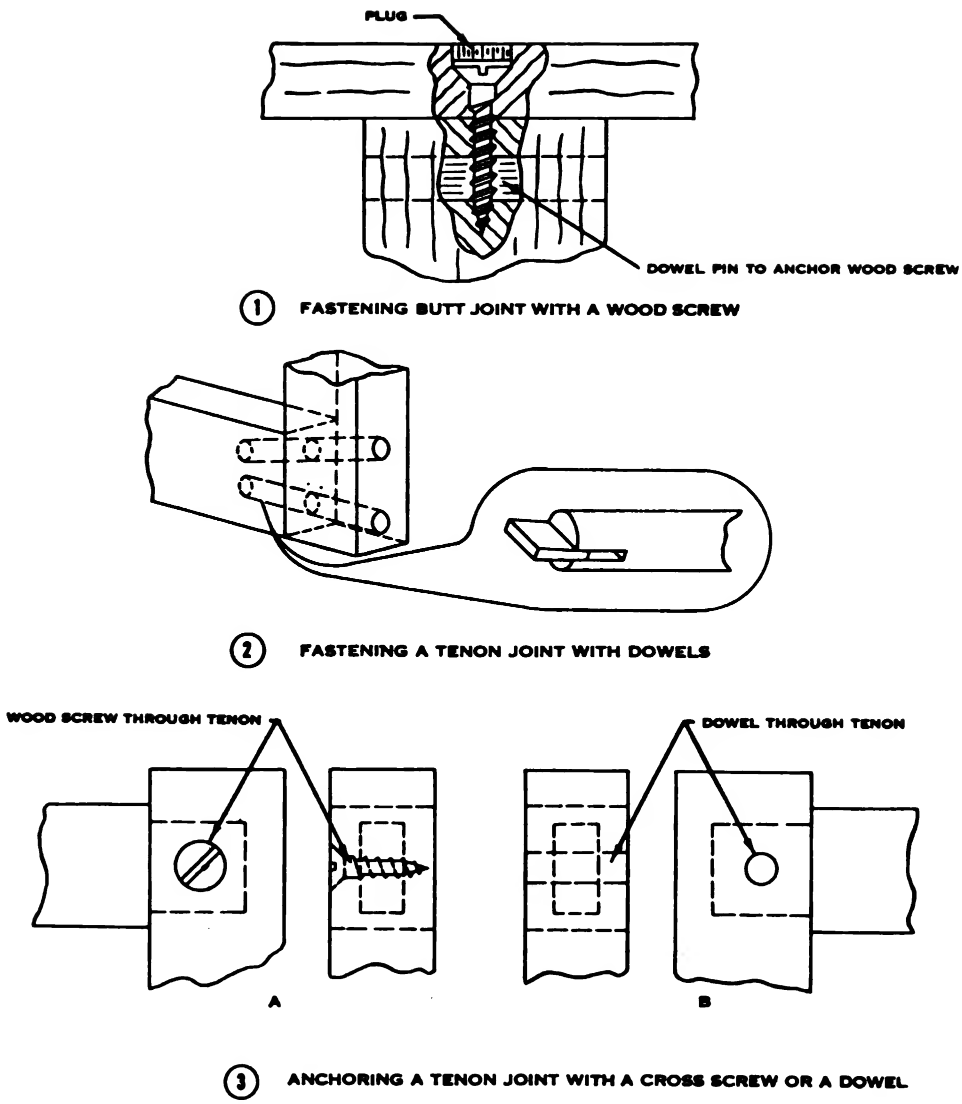


Figure 2–12. Miscellaneous methods of fastening joints.

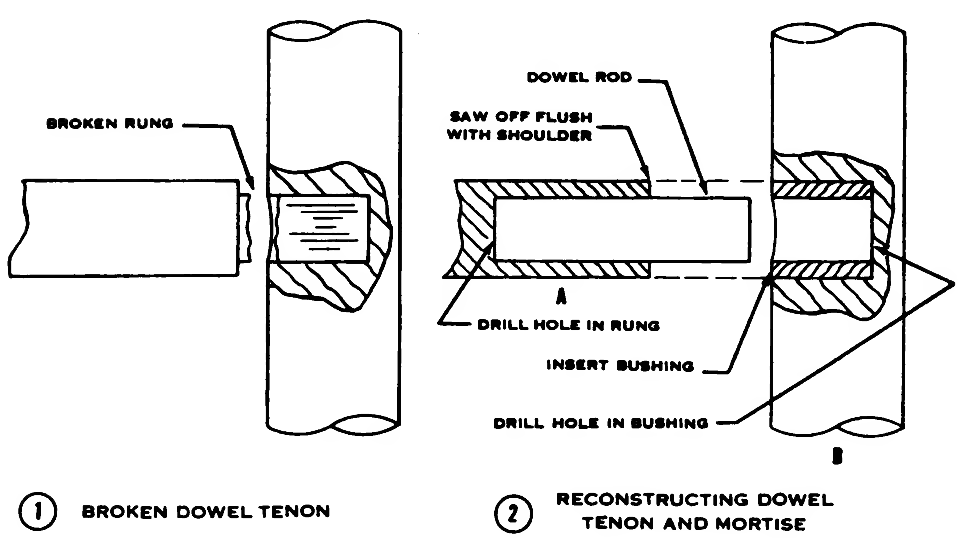


Figure 2–13. Replacing a broken dowel tenon.

2–8. Upholstery

Repairs needed on upholstered furniture consist of recovering, replacement, or redistribution of padding; replacement or refastening of webbing; and regluing, reinforcing, or replacing frame parts. With spring construction, replacing, anchoring, and retying springs may also be necessary.

a. Cover. Replace the entire cover if the fabric on the seat, back, or arms is torn, soiled, or worn beyond repair. Since it usually is impossible to match new fabric to worn or faded fabric, all sections in most cases must be recovered when one is damaged. Procedures for recovering upholstered furniture vary with furniture designs, but the following general procedures apply to most types:

(1) Remove the old cover carefully, taking out all tacks.

(2) Remove the padding.

(3) Overhaul the frame, the webbing, the springs, and the padding (*b* below).

(4) Using the old cover as a pattern, cut a piece of new material of the same size and shape.

(5) Smooth out and replace any lumpy or torn padding.

(6) Lay the new cover in place, making certain that all four sides have the same amount of surplus material.

(7) Tack the center of opposite sides, stretching the material lightly but firmly. Do not drive the tacks all the way in. Work from the center to the edges, stretching the fabric or material evenly. If wrinkles develop, remove the tacks and work the wrinkles out. Note how the old covering was folded and fitted at the corners. If this was satisfactory, fit the new cover the same way.

(8) After the covering has been tacked to the sides of the frame, cover the tack heads with an edging or gimp. Fasten the gimp with large-headed upholstery nails spaced about 2 inches apart.

b. Padding. Padding of tow, cotton batting, excelsior, or moss is used over the springs in the case of spring construction, or on the webbing in the case of padded construction. When the padding shifts or becomes lumpy, remove the cover and rearrange or replace the padding, using the following procedure:

(1) Remove all the old padding and tack a piece of burlap smoothly over the entire surface to be padded.

(2) Spread the padding evenly over the burlap, forming a compact cushion about 1 1/2 inches thick.

(3) Cover this with a second piece of burlap or muslin, tacked down securely, and place a 2-inch layer of cotton batting on top. Pull off the surplus cotton around the edges; do not cut the cotton, since this would make a ridge under the cover.

(4) Tack a cambric cover over the frame bottom to keep the padding from working through to the springs or the webbing and falling out.

(5) Replace the cover (*a* above).

c. Frame. To repair a frame, use the same methods as those used on ordinary furniture.

(1) *Loose frame joints.* Repair loose frame joints by one of the methods discussed in paragraph 2–6.

(2) *Other frame damage.* Repair other frame damage by following the procedures discussed in paragraphs 2–3 and 2–4.

d. Webbing. Whenever the covering is removed, inspect the webbing for signs of wear or breakage. Replace the damaged webbing and refasten the loose strips. Run the strips of webbing crisscross (fig. 2–14). It is not necessary to close the entire bottom with webbing, but to much webbing is better than too little. If the springs are to be anchored to the webbing, space the webbing to support the spring bases. Similarly, anchor metal strips or wood cleats and space them properly for the springs.

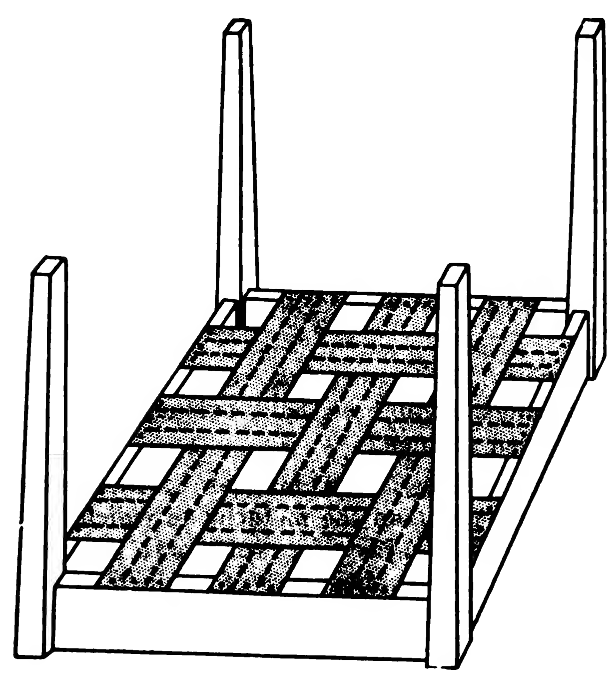


Figure 2–14. Replacing webbing.

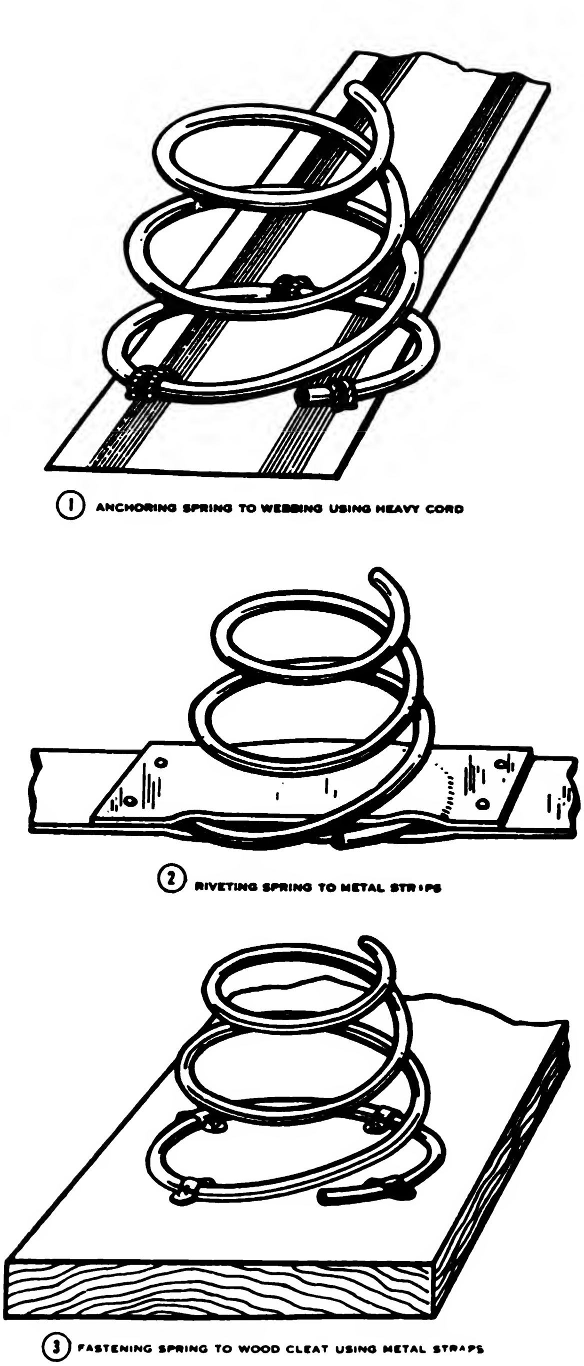


Figure 2–15. Methods of anchoring springs.

e. Springs. Reanchor and retie shifted and loose springs, straighten bent springs, and replace broken springs.

(1) *Anchoring.* The method of anchoring springs depends upon the material to which they are fastened. When fastening springs to webbing, use heavy flax cord about 1/8 of an inch in diameter. Fasten the springs securely to the webbing (1, fig. 2–15). Fasten each spring in three places. At each point of fastening, secure the spring with two stitches and tie the ends underneath; if a spring is merely sewed round and round, it will shift; if the twine breaks, the spring will loosen entirely. When anchoring springs to metal strips, use metal clamps. If clamps loosen, rerivet them (2, fig. 2–15). When fastening springs to wood cleats, use staples or metal straps and nails (3, fig. 2–15).

(2) *Retying.* After the springs are anchored, retie them with heavy flax cord, using the following procedure:

(*a*) Nail the cord to the center of one side of the frame. Pull it over the top of the springs to an opposite anchoring nail. Allow enough cord to tie two double half hitches.

(*b*) Bring the cord up to the top of the first coil spring and tie it with a double half hitch to the nearest rim of the first spring. Before drawing the knot tight, pull the spring down to the shape of the seat or the back (fig. 2–16). Continue to the opposite side of the top on the same spring and tie it.

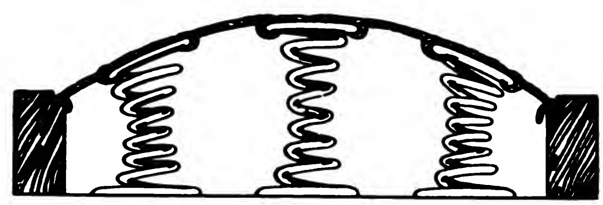


Figure 2–16. Springs tied in place.

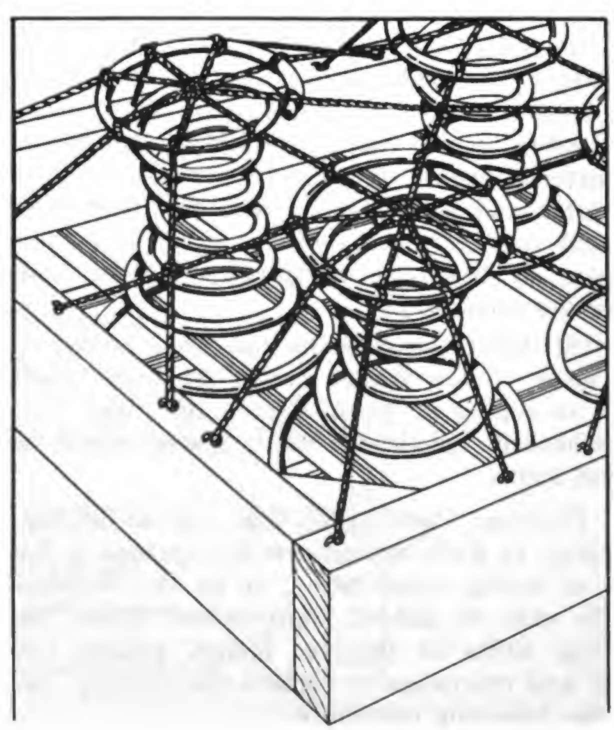


Figure 2–17. Springs tied lengthwise, crosswise, and diagonally.

(*c*) Continue in like fashion, tying two points on each spring and finally anchoring the cord to the nail on the opposite side of the frame. Run the cords in both directions (side to side and front to back) at right angles to each other until all the springs are tied in two directions.

(*d*) Tie springs diagonally in the same manner, beginning at one corner of the frame and anchoring the cord on the opposite corner.

(*e*) Repeat with the cord at right angles to the first set of diagonal cords. Tie this cord to the spring with two double half hitches and to the other three cords at their junction in the center of the coil. The finished work should show each spring tied at eight places around the top edge and at the point where the cords cross in the center (fig. 2–17).

Section III. REFINISHING

2–9. Preparation of Surface

Before attempting to refinish a wood article, be sure that the surface is smooth and free from dirt, dust, and grease.

a. Materials. The following materials are suitable for cleaning and smoothing wood surfaces:

(1) *Abrasives.*

(*a*) *Disks, sanding.* Sanding disks are flat, circular pieces of sandpaper of various types, sizes, and coarseness to be used with motor-driven sanders. The disks are glued to the rotating element.

(*b*) *Paper, flint, class B.* Flint paper is common sandpaper of crushed flint rock glued to heavy paper sheets. Grain sizes range from No. 4/0 to No. 3. No. 4/0 is used for sandpapering wood and metal surfaces requiring an extra fine finish; No. 2/0 for a fine finish; No. 1/2 for rubbing down undercoats of paint and varnish in preparation for the final coat; and No 1 to No 3 for rubbing down old coats of paint when the old coat of paint is in bad condition and must be removed before repainting.

(*c*) *Wool, steel, commercial.* Steel wool, which is a fluffy or wool-like mass of steel turnings or threads, is prepared in grades No. 00, 0, 1, and 3, ranging from extra fine to coarse. It is a mild abrasive for rubbing down and smoothing wood or for the removal of light rust from metal before repainting.

(2) *Cloth, sponges, and waste.*

(*a*) *Burlap, jute.* Jute burlap is a coarse, heavy, loose-woven, general-purpose cloth.

(*b*) *Osnaburg, bottom, unbleached, class B.* Osnaburg (cloth, cotton, osnaburg) is a coarse, heavy cloth used as a substitute for jute burlap.

(*c*) *Cloth, wiping, cotton, type II, class A.* This is a cloth that is relatively free from lint. It is used as a substitute for cotton waste, especially when lint deposits are undesirable; as a substitute for sponges when washing wood and metal work; and as an applicator for strong soap, lyes, soda ash, or other alkaline solutions, which cause sponges to deteriorate quickly.

(*d*) *Sponge, cellulose, coarse-pore, rectangular.* This is a synthetic sponge available in sizes 6 and 10. It is not for use with solutions containing soda ash, trisodium phosphate, or caustic soda (lye).

(*e*) *Sponge, natural, unbleached, size E, type III or type VIII.* This is a natural material, which has a large liquid-absorption capacity and becomes soft when wet without losing its original toughness. It is used with mild cleaning solutions. It is not to be used with solutions containing soda ash, trisodium phosphate, or caustic soda (lye).

(*f*) *Waste, cotton, white.* This is a good grade of cotton waste used for general cleaning.

(3) *Fluids.*

WARNING

Acetone is toxic. Prolonged exposure to its fumes will cause nausea, headache, and eventually chronic illness. It should, therefore, be used in the open air or in a well-ventilated room and not near an open flame. Acetone must be kept in a tightly sealed container.

(*a*) *Acetone, grade B.* Acetone is a clear, colorless, volatile, flammable liquid. It has a sweetish odor and is soluble in water and alcohol. It is used in the preparation of paint and varnish remover.

WARNING

Denatured alcohol is poisonous. It must not be used near an open flame and must be kept in a tightly sealed container.

(*b*) *Alcohol, denatured, grade 2.* Denatured alcohol is a clear, colorless, volatile, flammable liquid. It is used in the preparation of paint and varnish remover; as an emergency substitute for paint thinner; as a solvent for shellac varnish; as a cleaner for shellac varnish brushes; and as a liquid for cutting shellac.

WARNING

Ammonia fumes are very irritating to the nose, throat, and lungs and should, therefore, be used in a well-ventilated place. If splashed in the eyes, wash the eyes with large amounts of water. Fresh air is the antidote for nausea. Ammonia on the skin will cause smarting and burning. The antidote is to wash the area with water and apply petrolatum, olive oil, lard, or similar greases or oils.

(*c*) *Ammonia, aqua A. C. S., grade B.* Aqua ammonia (ammonium hydroxide) is a colorless solution of ammonia gas in water, containing about 27 percent of ammonia by weight. Ammonia must be kept in tightly sealed containers. Solutions in glass containers may develop a slight cloudiness during prolonged periods, but this does not reduce the cleaning qualities. Ammonia is diluted with water and used for general cleaning purposes.

WARNING

Because of its flammable, explosive, and toxic nature, benzol should be used in the open air or in a well-ventilated room and not near an open flame. It must be kept in a tightly sealed container. If it is absorbed into the body, it will cause nausea, headache, extreme fatigue, and anemia.

(*d*) *Benzol, technical (benzene, grade C).* Technical benzol (benzene, grade C) is a clear, colorless, volatile, flammable liquid, having an odor similar to that of gasoline. It is soluble in alcohol, insoluble in water. Vapors of benzene are heavier than air, with which it forms to make explosive mixtures. It is used to remove certain gum deposits from metal surfaces and grease and oil spots from wood. It is also used in the preparation of paint and varnish remover.

(*e*) *Remover, paint and varnish, type II.* Type II paint and varnish remover is a nonflammable, organic solvent with suitable evaporation retarders. It is used for removing paint and varnish from both metal and wood surfaces.

(4) *Miscellaneous.*

(*a*) *Soap, castile, white.* Castile soap is a neutral soda soap made from vegetable oils. It is used in the preparation of soap-sponging solutions.

(*b*) *Powder, scouring, type C.* Scouring powder is a cleaning powder which is mixed with water and used according to directions on the package. It is used for cleaning grease, oil, and dirt from wood.

WARNING

Caustic soda is very harmful to the body and clothing. Flush affected area of body immediately with water for at least 20 minutes. Get medical attention. If taken internally, a large dose of vinegar or lemon juice should be given, followed by butter, olive oil, or cottonseed oil. Induce vomiting by drinking large quantities of tepid water. Precautions should be taken to prevent inhaling particles when handled in dry form.

(*c*) *Soda, caustic (lye).* Caustic soda is a highly corrosive substance which readily dissolves in water. Solutions should be kept in containers of iron or glass. Caustic soda is used to prepare paint remover and to quicken the action of other cleaning solutions. Caustic soda is not to be used on aluminum or galvanized items.

b. Procedure. Observe the following procedure when preparing a wood surface for refinishing:

(1) *Cleaning.*

(*a*) Remove the loose dirt with a rag or brush.

(*b*) When dirt cannot be brushed loose, sponge the surface with a soap solution.

(*c*) Use benzene to remove grease and oil spots.

(2) *Removing oil finish.*

(*a*) Apply enough paint and varnish remover to completely soften the old paint and varnish.

(*b*) Scrape off the softened material with a hand scraper, scraping with the grain.

(*c*) Wipe the wood with a cloth dipped in turpentine to remove the wax deposited by the paint and varnish remover.

(*d*) Smooth the stripped surface with sandpaper or steel wool.

(3) *Sandpapering.*

(*a*) Always sandpaper with the grain; scratches across the grain show badly through a finish.

(*b*) Sandpaper flat surfaces with the sandpaper wrapped around a softwood block.

(*c*) Sandpaper concave surfaces with the sandpaper wrapped around a rounded stick or half-round file.

(*d*) Sandpaper convex surfaces holding the sandpaper in the hollow of the hand.

(*e*) Do not sandpaper surfaces to be glued; the perfectly flat surface required for gluing can be produced only with an edge tool.

(*f*) Begin sandpapering usually with a coarse grade of sandpaper such as No. 1 and finish with a fine grade such as No. 2/0.

2–10. Materials

a. General. Wood furniture will be refinished in its original color. As an alternate method, laminated thermosetting plastic sheets (top) in matching wood grain color can be used. Laminated plastic sheets will meet all specifications and tolerances as set forth in applicable military or Federal specifications. Items so repaired will retain the current Federal stock numbers and identifications. Exceptions to the above are those items requiring repairs to the extent that the cost of refinishing in original color would be prohibitive. Such items may be refinished in color chip No. 26134 gray*, semigloss, and laminated thermosetting plastic sheets (top), applied where required, providing such repairs are within the permissible expenditure limitations. General office wood furniture refinished in gray will be designated nonstandard. The materials described below are to be used when refinishing a wood item. The item should be refinished with the same kind of material as that used in the original finish. If a different finish is desired, all the old finish should be removed before the application of a new finish.

b. Paint.

(1) Before beginning to repair a paint finish, apply a priming coat (aluminum paint is excellent) to the surface of the item. After the priming coat has dried, apply the paint finish, using either a brush or a spray gun. Two coats of finish are usually enough for a good solid color.

(2) On porous wood such as ash, chestnut, and oak, use a wood filler mixed to a heavy consistency (table 2–1). Cover knots with a clear coat of shellac or, preferably, aluminum paint.

c. Enamel. If the wood to be given an enamel finish has pores larger than those of birch, apply natural wood filler before beginning the repair work. Touch up all bare areas with enamel undercoater and sandpaper them when dry with No. 5/0 and No. 8/0 sandpaper. After the surface has been smoothed, apply the enamel (two coats if necessary) over the entire surface. The enamel may be applied with either a brush or a spray gun.

d. Lacquer. If the surface to be finished has been treated with oil stain, paste-wood filling, varnish, or paint, apply a tin sealing coat of shellac. After the shellac has dried (at least 4 hours should be allowed for drying), rub it down with No. 2/0 steel wool and apply the lacquer. The lacquer (two coats usually are sufficient) may be applied with either a brush or a spray gun. If the area to be finished is small, a brush is more practical. Since lacquer dries very quickly, care should be taken in brushing to avoid lap marks.

Table 2–1. Filler Mix Required for Various Woods

Wood	Filler mix
Ash	Heavy
Basswood	None
Beech	Thin
Butternut	Thin
Cedar	None
Cherry	Thin
Chestnut	Heavy
Cypress	None
Fir	None
Gum	Thin
Locust	Heavy
Mahogany	Medium
Maple	Thin
Oak	Heavy
Orientalwood	Medium
Pine	None
Poplar	None
Rosewood	Medium
Sycamore	Thin
Teak	Heavy
Tanquile	Heavy
Walnut	Medium
Zebrawood	Medium

e. Varnish. Varnish may be applied either on wood in its natural color or on wood that has been stained. If the wood has been oil-stained, apply a coat of wood sealer before applying the varnish. If a smooth surface is desired, whether on wood in its natural color or on wood that has been oil-stained, apply a wood filler before applying the varnish. The varnish may be applied with either a brush or a spray gun.

f. Stains.

(1) To obtain a natural finish, color new wood slightly with oil stain made from painter's tinting colors. Stain bare areas to match the old wood, using the same stain as that in the original finish. After applying water stain, sandpaper the wood lightly. On wood with pores larger than those of birch, apply wood filler after staining, using filler of the same color as that of the original finish. Color natural finish by adding oil stain or painter's tinting colors.

(2) Apply stains by brushing, dipping, or spraying (or, in repair work, by mopping with a clean rag or cotton waste). Allow the oil stains to remain on the surface a few minutes before wiping off the excess. Staining should be done quickly so that all laps may be picked up while their edges are still wet.

g. Wood Filler.

(1) To obtain a smooth surface, use wood filler preparatory to the application of paint, enamel, varnish, lacquer, or stains.

*See Federal Standard 595A for complete Color Chart.

(2) Apply wood filler with a brush. After the filler has remained for a few minutes, wipe off the excess with burlap, clean rags, or cotton waste, stroking first across and then along the grain of the wood (table 2–1).

h. Undercoaters and Sealers. Enamel undercoater, paint primer, aluminum paint, and shellac, as well as varnish and wood sealer, are used as bases for glossy finish paint and enamel finish. They are also used on concealed wood surfaces, such as the undersides of table tops, the backs of side panels, and the insides of drawers, to protect against the changes in moisture content of the air and to minimize the tendencies to warp. When used other than as a base coating, two coats (applied with either a brush or a spray gun) should be used.

2–11. Methods of Application

The methods generally used in the application of finishing materials are the brush method and the spray gun method. For further information on the application of finishing materials, refer to TM 5–618.

2–12. Inspection

a. Initial Inspection. When making the initial inspection on wood items, use the checklist in appendix B for guidance.

b. Repairing the Item. After inspecting and noting the amount of damage, repair the item. If no special instructions are given, repair the damage in accordance with the methods illustrated in paragraphs 2–1 through 2–11. Make the repairs in the following order:

(1) Repair broken parts.
(2) Repair broken joints.
(3) Secure loose joints.
(4) Replace damaged or missing hardware.
(5) Tighten loose hardware.
(6) Repair surface damage.
(7) Prepare surface for refinishing.
(8) Apply finishing material.

c. Final Inspection. Upon completion of repairs, give the article a final inspection to make sure that the following conditions have been met:

(1) The species of wood used for replaced parts is similar to that used in the original construction.

(2) All joints have been properly repaired and braced sufficiently to withstand hard use.

(3) No hardware is loose, damaged, or missing.

(4) Complementary hardware, such as locks and strike plates, is in proper alinement and functions smoothly.

(5) All hardware has been properly fastened, screws countersunk, and metal surfaces freed of sharp silvers.

(6) Components fit properly, stationary parts fit with precision, and movable parts function without sticking or jamming.

(7) All surface defects have been repaired and sandpapered.

(8) The proper finishing material has been applied and there are no sandy spots, orange-peel effects, or skips in the covering.

CHAPTER 3

REPAIR OF TOOLS AND IMPLEMENTS

Section I. BASIC REPAIR

3–1. Responsibility

The general repair of handtools and implements is a responsibility of the using organization. Such repair includes shaping, sharpening, straightening, and replacing and finishing handles.

3–2. Cleaning

All dirt, grease, corrosion, and rust must be removed from tools and implements before any repairs are attempted.

a. Cleaning Materials. In addition to the materials discussed in paragraph 2–9, such as benzol, caustic soda, cotton waste, paint and varnish remover, and sponges, the following materials, specially designed for cleaning metals, should be used.

(1) *Abrasives.*

(*a*) *Cloth, abrasive, aluminum oxide.* Aluminum oxide abrasive cloth is natural emery or artificial aluminum oxide abrasive on cotton drill or jean cloth. Grade 2/0 and finer grades are used for polishing, while grade 0 and other coarser grades are used for the general preparation of metal surfaces for painting.

(*b*) *Cloth, crocus.* Crocus cloth is a fine, soft, red, or reddish-brown powder (tripoli or iron oxide) on cotton drill or jean cloth. It is used for producing a fine finish on metals.

(*c*) *Cloth, emery.* Emery cloth is the same as aluminum oxide abrasive cloth described in (*a*) above.

(*d*) *Paper, abrasive, aluminum oxide, production-type.* Production-type aluminum oxide abrasive paper is similar to aluminum oxide abrasive cloth, but has a special construction and type of grain to provide a more rapid cutting action. It is used with a solvent for the wet-sanding of bare metals preparatory to painting.

(*e*) *Paper, abrasive, artificial, waterproof, silicon carbide.* This abrasive is a silicon carbide on a strong, waterproof paper backing. It is available in various grain sizes and consists chiefly of finer grades than aluminum oxide abrasive cloth. It is used for wet-sanding metal surfaces where fine finishes are desired. Water must be used with this abrasive in connection with the sanding operation.

(2) *Fluids.*

(*a*) *Conditioner, metal, acid, phosphoric, concentrated.*

1. Type I—wash-off type. Type I acid metal conditioner is diluted phosphoric acid containing water-soluble, nontoxic grease solvents. It is diluted with water and used as a dip application for the removal of rust and for the preparation of metal surfaces for painting. It must be washed off with water, preferably hot water.

2. Type II—wash-off type. Type II acid metal conditioner is similar to type I, but the acid concentration is much less. It is diluted with water and applied with a swab or brush for the removal of rust and for the preparation of metal surfaces for painting. It is removed by wiping with dry or dampened rags.

WARNING

The use of a drycleaning solvent without gloves will dry the skin and may cause slight irritation. The antidote is to rub grease or oil into the skin to replace the natural oils.

(*b*) *Solvent, drycleaning.* This solvent, known as Stoddard solvent and as petroleum distillate solvent, is a colorless, flammable liquid distilled from petroleum. It is used to clean metal surfaces and to remove oil and grease spots from wood and upholstery. It is not to be used near an open flame. It evaporates quickly without leaving a corrosion-inducing film on metal surfaces.

(3) *Compounds.*

(*a*) *Compound, cleaning, alkaline.* Alkaline cleaning compound is a granular, solid compound, soluble in water. It is used to remove grease, tar, paint, etc, from metal surfaces. It is not to be used on aluminum or zinc.

(*b*) *Compound, paint-stripping, alkali-type.* This compound, which is soluble in water, is used for removing paint, lacquer, and enamel from metal surfaces. It is not to be used on aluminum. A hot solution is made from 3 pounds of compound to each gallon of water and applied by flow, trickle, or brush method.

(4) *Miscellaneous.*

(*a*) *Polish, metal, paste, type III.* Type III metal polish is an iron oxide base paste of fine consistency and mild abrasive action. It is used for polishing metal surfaces.

CAUTION

Solutions containing soda ash will attack aluminum and remove galvanized finishers.

(*b*) *Ash, soda, type I.* Type I soda ash, also called sodium carbonate, is a white, odorless, alkaline powder. It is soluble in water but not in alcohol. It is used to remove grease and oil preparatory to painting.

b. Cleaning procedure. Use the following procedure to clean ferrous metals:

CAUTION

The following method of chemically cleaning steel surfaces is not orginarily used on polished surfaces. Acids and similar materials not only dissolve the rust but also attack the steel itself. In case it is necessary to use chemicals, care must be taken to remove every trace of the acid from the surface of the metal; otherwise, corrosive action beneath the protective finish may be accelerated later. The use of acids or other chemicals to remove rust should not be attempted unless authorized for the items being cleaned.

(1) Remove heavy dirt and loose soil with a wire brush.

(2) Use a wiping cloth soaked in drycleaning solvent to remove grease and oil, making certain to wipe the surfaces dry afterward.

(3) Use abrasives or other mechanical means to remove surface rust.

(4) If the rust has progressed to such an extent that pits are formed, use acids or specially prepared compounds.

3–3. Straightening

Bent tools and implements should be straightened before other repairs are attempted. Small parts, such as screwdriver shanks, should be squeezed in a vise. Heavy solids and large flat surfaces should be hammered on a flat block or on an anvil. For information on the straightening of sheet metal, refer to paragraph 4–2.

3–4. Shaping and Sharpening

Grinding wheels, oilstones, grindstones, strops, and files are used for shaping and sharpening damaged tools and implements (fig. 3–1). A grinding wheel (1) is used for reshaping worn-away edges, for removing nicks and mushroomed ends, and for restoring cutting-edge bevels. An oilstone (2) or a grindstone is used for fine-finishing a reground edge and for sharpening tools not badly dulled. A strop (3) is used for producing a very fine edge. A file (4) is used for turning over the scraper edges and for sharpening saw teeth.

a. Grinding Wheels. The grinding wheel generally is used in the initial stages of sharpening tools and implements. When fine-edged tools are being sharpened, the grinding wheel is used only when the edges are badly nicked or bevels so badly worn that sharpening by oilstone or grindstone is impractical.

(1) *Grades.* Abrasive wheels generally are graded as hard or soft. Wheels that shed particles slowly are known as *hard;* wheels that shed particles easily are known as *soft.* Manufacturers specify the grades of their wheels by numbers or letters, usually with the lower numbers or letters identifying soft wheels and the higher numbers or letters identifying hard wheels.

(2) *Wheel selection.* Selection of the proper wheel depends upon the materials on which the wheel is to be used and on the line of contact between the work and the wheel. In general, it may be said that a soft wheel is preferred for grinding tools and implements. A soft wheel, although it wears away somewhat faster, has less tendency to heat the work and thus is preferable.

(*a*) Hard materials, such as cast iron, most of the alloy steels, and hardened steel, require sharp cutting edges. Therefore, a soft wheel which sheds particles more easily under cutting pressure, exposing new sharp particles, is used for grinding harder materials.

(*b*) Unhardened carbon steel and untreated machine steel can be ground to a satisfactory finish with a cutting wheel too worn to produce an acceptable finish on harder materials; therefore, a wheel somewhat harder, a medium-grade wheel which will retain its cutting particles longer, may be used on soft steels.

(*c*) Softer materials, such as brass, bronze, copper, and hard rubber, exert less pressure against the wheel than soft steel; therefore, a soft wheel should be used. A hard wheel would fuse the chips, become clogged and glazed, and heat the work.

(*d*) The more narrow the line of contact

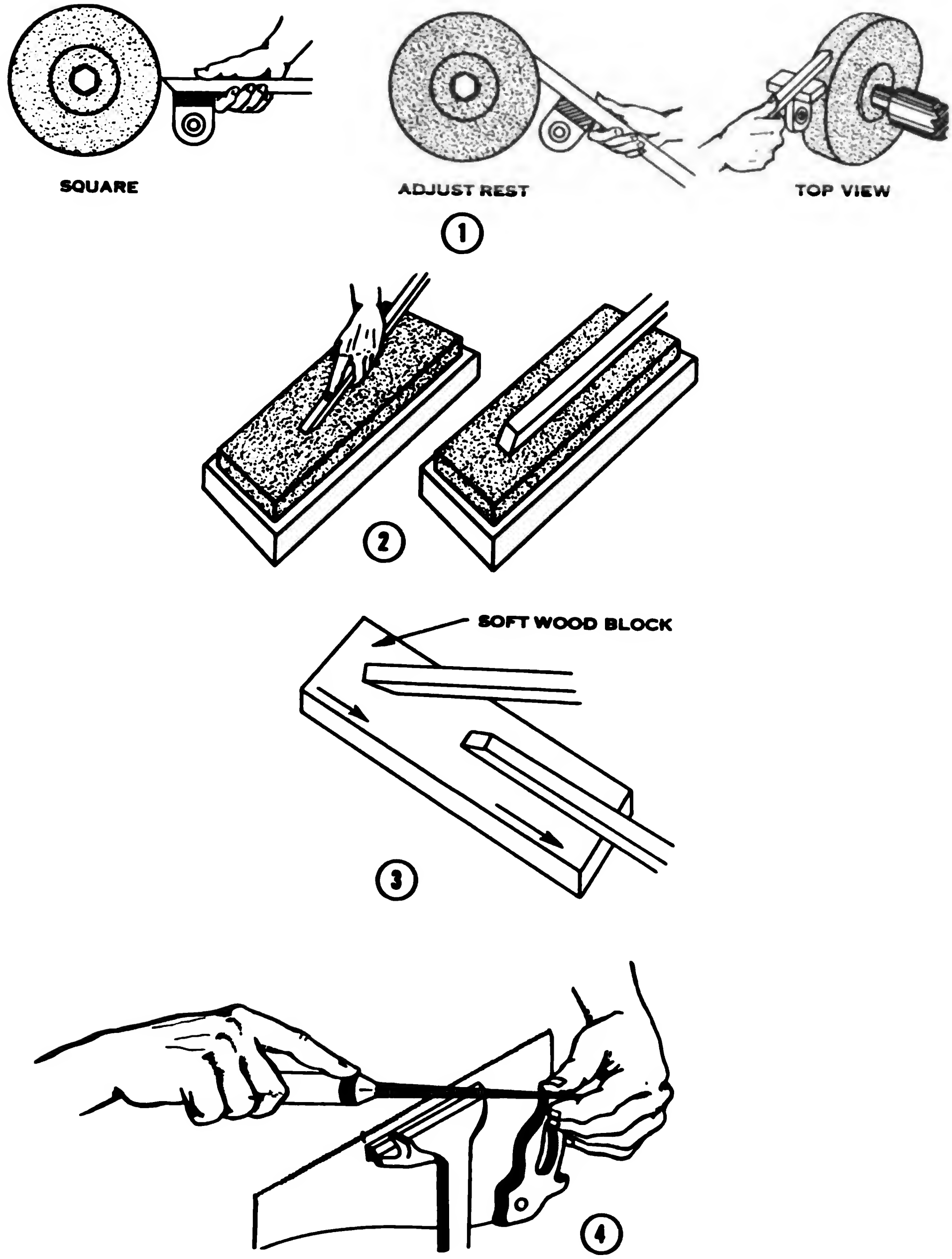


Figure 3-1. Methods of shaping and sharpening.

between the work and the wheel, the harder the wheel must be.

(3) *Aluminum oxide and silicon carbide wheels.* A general rule is to use silicon carbide abrasives only for materials of low tensile strength, regardless of their hardness, and use aluminum oxide for materials of high tensile strength, such as steels (table 3-1).

(4) *Dressing.* With use, an abrasive wheel loses its cylindrical shape. For precision grinding, the wheel must be trued with a dressing tool. The tool is held on the machine in such a way that it travels across the face of the wheel, the tool being tilted so as to wipe across its face rather than dig into it. Moving the dressing tool too rapidly across

Table 3-1. Wheels and Materials

Wheel	*Material*
Aluminum oxide	Alloy steels
	Annealed malleable iron
	Carbon steels
	High speed steels
	Rough and hard bronzes
	Wrought iron
Silicon carbide	Aluminum and copper
	Brass and soft bronze
	Cemented carbides
	Gray and chilled iron
	Rubber and leather
	Very hard alloys

the face of the wheel cuts a spiral or thread in the wheel which will produce a mottled or frosted appearance on the work and spoil the finish. Light cuts should be taken with the dressing tool, no more of the wheel being cut away than is necessary.

(5) *Precautions.* Take special precautions when grinding the cutting edges of tools and implements. Rapid grinding withdraws the temper in steel through the heat caused by friction. Careless grinding leaves cutting edges too thin to withstand normal usage. When grinding tempered tools and implements observe the following rules:

(*a*) Do not use a high-speed grinding wheel.

(*b*) Keep the fingers near the grinding edge while grinding to determine whether the material is becoming too hot.

(*c*) Cool the material in water at frequent intervals.

(*d*) Grind cutting edges to the angle prescribed in the original specifications.

(*e*) Use the grinding wheel tool holder for precision grinding and set it at the proper angle.

(*f*) Wear goggles when using any grinding machine.

(*g*) Never grind on the side of the grinding wheel.

b. Oilstones. After a tool or implement has been ground on a wheel, it may be whetted on an oilstone in order to remove the wire edge and the fine scratches made by the wheel. A tool or implement with the edge in good condition and not nicked may be sharpened by being whetted only.

(1) *Grades.* Oilstones are of three grades: coarse, medium, and fine. The coarse and the medium stones are used on badly dulled edges. The fine stones are used for woodworking tools and for classes of tools requiring a fine cutting edge.

(2) *Shapes.* Oilstones are of various shapes, those with round edges being known as slip stones.

(3) *Methods of using.* When using an oilstone, always keep it moistened with a clean light oil. When sharpening a beveled edge, place the bevel flat on the stone, holding the stone stationary and moving the beveled edge over the surface of the stone in either a circular or a figure-eight motion. When sharpening a concave edge, such as the inside edge of a gouge, hold the tool stationary and rub a slip stone along the edge. When sharpening a thin or knife-type edge, hold the blade at 20° angle and draw it over the stone (cutting edge leading), turning the blade over on the blackstroke.

c. Grindstones. Grindstones generally are used to sharpen tools other than those with a fine edge. The ax, mattock, and similar tools can be sharpened by use of the grindstone. Water is used on the grindstone for lubrication of the surface and to keep tools and implements from overheating.

d. Strops. To remove a fine wire edge and to accomplish additional sharpening, strop the tool or implement on leather, canvas, or a smooth woodblock.

e. Files. Files generally are used to sharpen saw teeth, auger lips and nibs, and scraper edges. Both single-cut and double-cut files are used, the most common shapes being flat and triangular. For draw filing, the single-cut file is preferred; for other types of filing, the double-cut is preferred. Coarse files are never used on hard steel; only second-cut or finer prove satisfactory.

3–5. Procedures for Shaping and Sharpening

The type of tool and its use will determine the shape of its head or blade and the bevel of its cutting edge.

a. Saw Sharpening. To keep saw teeth in top condition, touch up (dress) the teeth with a file occasionally. A triangular, tapered file normally is used for handsaws. Under usual conditions a saw may be sharpened with a file four or five times before it needs a complete sharpening and setting job. Sharpening a saw consists of four major steps: jointing, shaping, setting, and sharpening.

(1) *Jointing.* Jointing consists of cutting the points of the highest teeth down to the level of the lowest points, so all teeth will cut equally. Secure the saw in a vise; then place a mill file on the teeth points of the saw, move it lightly over the saw teeth from heel to toe, without rocking the file, until all teeth are the same height. Remove as little metal as possible for this operation so as to minimize unnecessary removal of metal.

(2) *Shaping.* Saw teeth are shaped only when they are evenly spaced and shaped.

(*a*) Place the saw in the vise so that the gullets of the teeth are about 1/4 inch above the edge of the vise jaws.

(*b*) Place a tapered, triangular file in a file holder, then place the file in the first gullet at the saw handle end (heel). This serves as a guide as the teeth at the heel are seldom used. Hold the file snugly in the gullet at a right angle to the saw blade and file each tooth to its original shape, making sure the bases of the gullets are uniform and in a line parallel to the points of the teeth. The file must be held at a right angle to the saw and parallel to the floor, because saw teeth are not beveled during the shaping operation.

(3) *Setting.* Setting is accomplished by bending the teeth slightly with a saw set. To effectively use the saw set, adjust it so the saw teeth will be bent to their original angle. The correct set usually can be found on the teeth next to the heel, as they are relatively unused. Place the saw blade in the saw vise so that the first tooth at the heel is bent away from the centerline of the saw blade. Put the saw set over this tooth, positioning the anvil behind the tooth and the plunger in front of it. Press the saw set handles together so the plunger pushes the tooth against the anvil to set the saw tooth. Release the grip of the saw set, skip the next tooth, and apply the same operation to the third tooth. Proceed along the saw blade, setting every other tooth in the same direction. Turn the saw around in the vise so it faces the opposite direction. Bend the alternate (unset) teeth in the same way, so the teeth are alined in two even rows (fig. 3–2).

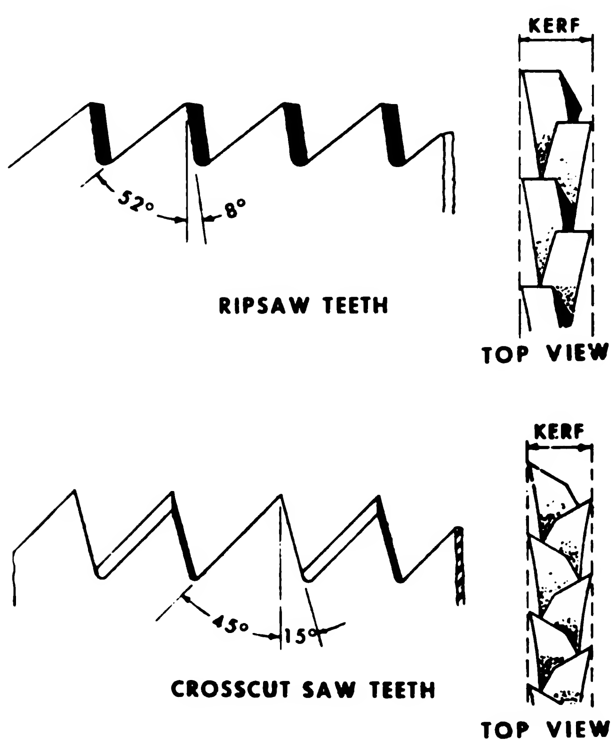


Figure 3–2. Comparison of crosscut and ripsaw (showing alinement of teeth).

(4) *Sharpening.* To sharpen handsaws, place the saw in the vise with the gullet bases about 1/16 inch above the vise jaws and the saw handle to the worker's right. Place the file in the gullet to the left of the first tooth set toward the worker. Adjust the file holder so the triangular file is held at the same bevel angle as a comparable gullet in the little-used teeth near the saw's heel.

(*a*) For the crosscut saw, the file will be held at a 45° to 60° angle to the saw blade, retaining a horizontal or a 5° to 10° off-horizontal level (1, fig. 3–3).

(*b*) On a ripsaw, each tooth is filed at a right angle (90°) to the saw blade. This provides sharp square edges like a series of little chisels in two parallel rows that overlap each other (2, fig. 3–3). After every other tooth of the saw has been sharpened, turn the saw around and proceed to sharpen the opposite side of the saw blade, following the same procedure. When filing saw teeth, always keep in mind that the file should cut only on the movement away from the worker. The file should be raised clear of the saw teeth on the return movement.

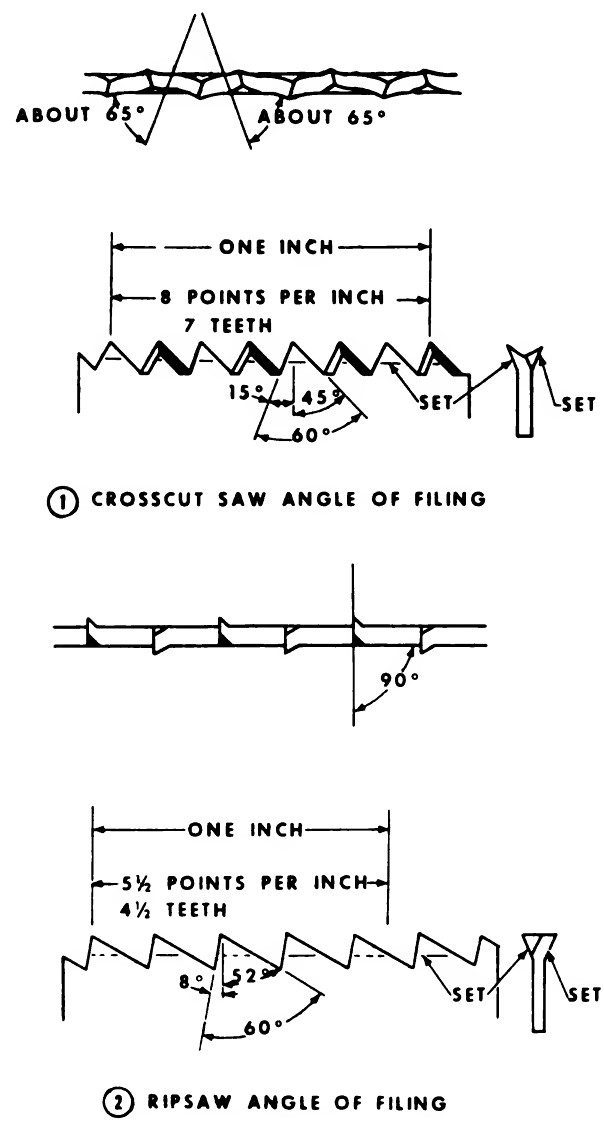


Figure 3–3. Saw setting and sharpening.

b. Additional Information. For additional information on shaping and sharpening of tools refer to TM 5-461 and TM 9-243.

3-6. Heat treating

a. General.

(1) Steel is iron that contains carbon in any amount up to 1.7 percent (table 3-2). Since subjection to heat is one phase of the process used in the production of steel, an accurate knowledge of heat treating is necessary in the repair of steel tools and implements.

Table 3-2. Approximate Carbon Content of Certain Steels

Steel	*Carbon content (percentage)*
Axle	0.40
Cold chisel	0.75
Forging	0.30
Gear	0.35
Hammer	0.65
Lathe tool	1.10
Machinery	0.35
Metal file	1.25
Metal tool	0.95
Pipe	0.10
Rail	0.60
Saw for steel	1.55
Saw for wood	0.80
Setscrew	0.65
Shaft	0.50
Spring	1.00
Steel for stamping	0.90
Tubing	0.08
Wood-cutting tool	1.10

(2) Heat treating is the heating and cooling of steel in the solid state. By controlling the rate of the heating temperature, the degree of the final temperature (table 3-3), and the rate of the cooling temperature, steel can be softened or hardened as required for a particular operation.

b. Types of Steel. Listed below are several types of steel used in the repair of tools and implements.

(1) *Austenite.* Austenite is an exceedingly tough steel but not as hard as other steels.

(2) *Martensite.* Martensite is the hardest and most brittle type of steel.

(3) *Troostite.* Troostite is a steel almost as hard as martensite but noticeably less brittle.

(4) *Sorbite.* Sorbite is a steel with less hardness than troostite but with added toughness.

(5) *Pearlite.* Pearlite is an annealed steel, which is easily machineable.

c. Types of Treatment. By being heated, quenched, and in some instances drawn, steel of any degree of ductility or hardness can be produced. The following types of treatment are common in the heat treating of steel.

Table 3-3. Color Chart for Steels at Various Temperatures

Color	*Temperature (degrees F.)*
Faint red	900
Blood red	1,050
Dark cherry	1,075
Medium cherry	1,250
Cherry or full red	1,375
Bright red	1,550
Salmon	1,650
Orange	1,725
Lemon	1,825
Light yellow	1,975
White	2,200
Dazzling white	2,350

(1) *Annealing.* Metals which have been rolled, drawn, hammered, or forged, or which have been hardened by heating and quenching can be made soft and ductile by annealing. Annealing is heating to a temperature of about 100° F. above the critical temperature range (table 3-4) and cooling slowly in a confined space. Annealing is also used to change the structure and toughness of the metals and to remove any gases. Steel, when annealed, can be worked into any shape desired.

*Table 3-4. Critical Temperatures for Various Carbon Steels**

Percentage of carbon	*Temperature (degrees F.)*
0.10	1,675-1,760
0.20	1,625-1,700
0.30	1,560-1,650
0.40	1,500-1,600
0.50	1,450-1,560
0.60	1,440-1,520
0.70	1,400-1,490
0.80	1,370-1,450
0.90	1,350-1,440
1.00	1,350-1,440
1.10	1,350-1,440
1.30	1,350-1,440
1.50	1,350-1,440
1.70	1,350-1,440

*Cool slowly to anneal; cool rapidly to harden.

(2) *Hardening.*

(*a*) The property of steel which causes it to harden when heated and rapidly cooled is associated with the physical changes of iron. When heated, the iron undergoes a transformation in passing through a critical temperature point (about 1,350° F.), changing from a form which has a low solubility for carbon to a form which has a high solubility for carbon. Upon cooling, the reverse transformation occurs; but since the changes are progressive and require time for completion, they may be arrested if the rate of cooling is increased.

(*b*) If the cooling is very rapid, as in water quenching, the transformation takes place at a temperature (400° to 600° F.) very much below the critical temperature point and the carbon is held in a forced and finely divided state, with the result that the steel becomes hard and brittle and a great deal stronger than slowly cooled steel. Increasing the carbon content increases the degree of hardening possible for a given cooling rate.

(*c*) Alloy additions alter the rate of transformation on cooling and permit deeper hardening, with less severe rates of cooling. Since, however, each alloy or combination of alloys shows individuality in its effect, alloy steels are made up and heat treated with a view to the specific properties required for the structures for which they are to be used.

(3) *Tempering.* When a steel is hardened by quenching it is too brittle for ordinary purposes; therefore, some of the hardness must be removed by reheating the steel to a temperature lower than the critical temperature and quenching again. This process is known as tempering or drawing. It is not necessary to quench after reheating, provided the correct tempering temperature (table 3–5) has not been exceeded.

d. Procedure. Desired results in the heat treating of steel may be attained by heating and quenching alone, or by heating, quenching, and drawing.

(1) *Heating and quenching.* If steel with a carbon content of 0.85 percent, for example, is heated to 1,350° F. and then quenched in very cold brine, austenite is formed; if heated to 1,350° F. and quenched in cold water, martensite is formed; if heated to 1,350° F. and quenched in oil, troostite is formed; if heated to 1,350° F. and quenched in a molten metal bath, sorbite and pearlite are formed. This procedure shows that the rapidity of cooling affects the final structure of the steel. Quenching methods and quenching materials, therefore, have much to do with the type of steel desired.

(2) *Heating, quenching, and drawing.* The same results as those above can be obtained by the following procedure: First heat the steel (again taking 0.85 percent carbon content steel as an example; to 1,350° F. and quench it in cold brine to form austenite. Then, if martensite is desired, reheat to 400° F. and cool; if troostite is desired, reheat to 600° F. and cool; if sorbite is desired, reheat to 800° F. and cool; if pearlite is desired, reheat to 1,000° F. and cool.

e. Precautions. Successful heat treating of steel necessitates several precautions.

(1) *Heating.*

(*a*) Control the rate of heat to prevent cracking of thick and irregular sections.

(*b*) Heat until the desired temperature of the article is uniform throughout.

(*c*) Do not overheat the article; when steel is heated close to its melting point, certain elements are burned out and the grain of the steel becomes coarse. In general, the lower the carbon content, the higher the temperature to which steel can be heated without being burned.

(*d*) Do not judge the temperature of the steel by its color when accurate temperature measuring instruments are available.

(2) *Quenching.*

(*a*) Move the article around in the bath to prevent warping and cracking.

(*b*) Quench the article in a position that will cool all of its parts uniformly; immerse shafts vertically.

(*c*) When using a water quench, keep the temperature of the water at 70° F. to prevent warping and cracking the steel.

(*d*) Use salt brine (10 percent solution of ordinary salt in water) where a comparatively rapid cooling rate is necessary, as in the case of carbon steel.

(*e*) Use an oil quench to reduce warping and cracking in cases where maximum hardness is needed.

Table 3–5. Color Chart of Various Tempering Temperatures of Carbon Steels

Color	Temperature (degrees F.)	Use
Faint straw	400	
Dark straw	460	Scrapers; hammer faces; lathe, shaper, and planer tools.
Very deep straw	480	Taps and dies
Brown yellow	500	Punches and dies; knives and reamers.
Bronze or brown purple	520	Drift pins
Peacock or full blue purple	540	Augers; cold chisels for steel
Bluish purple	550	Axes; cold chisels for iron; screwdrivers; springs
Blue	570	Saws for wood
Full blue	590	
Very dark blue	600	
Light blue	640	

3–7. Brazing

Brazing is the joining of broken parts by means of a nonferrous metal or alloy with a melting point higher than 1,000° F., but lower than the melting point of the parts to be joined. Many broken tools, even those of high-speed steels, such as taps and drills, may be repaired by this method. The degree of damage usually determines the alloy to be used. Silver alloy is used to braze together pieces of a badly shattered tool of high-carbon steel; other brazing alloys, less expensive than silver, are used for simple fractures. A 1,300° F. alloy is used in all cases where great binding strength is required and a slight local loss of hardness does not matter. A 940° F. alloy is used where full hardness must be maintained at the cost of slightly less strength. For additional information on brazing refer to TM 9–237.

3–8. Welding

When practicable, welding is used to repair metal tools and implements. This is especially true in instances where fractured parts are irreplaceable or so valuable as to make welding an economical repair procedure. Welding is fusing the fractured surfaces together while they are in a molten state. To produce the intense heat necessary for fusion, the oxyacetylene torch is commonly used. Whether to weld or not depends a great deal upon the carbon content of the steel to be welded. In general, the lower the carbon content, the more easily and satisfactorily the fracture can be welded (table 3–2). For additional information on welding refer to TM 9–237.

3–9. Oiling

Repaired tools and implements, if to be placed in storage for any length of time, should be washed with drycleaning solvent and coated with a rust-preventive compound (para 3–13). If, however, the repaired tools and implements are to be placed into immediate use, they should be lubricated to facilitate operation and to prevent rust. When lubrication is necessary, the following instructions apply:

a. On moving parts, friction surfaces, pivots, slides, and worms, use engine oil (SAE 10) or preservative lubricating oil (special).

b. On nonoperating surfaces, use preservative lubricating oil (special).

c. On nonoperating surfaces where there is extreme humidity, moisture, or salt air, use preservative lubricating oil (medium).

d. In oiltight gearcases, use engine oil (SAE 30).

e. In grease-type enclosed gearcases, use general purpose grease (No. 0).

Section II. REPAIR OF COMPONENTS

3–10. Handles

Damaged tool and implement handles must be either replaced or repaired.

a. Metal Handles.

(1) *Smoothing.* Metal handles with the surface damaged in such a manner as to leave rough burs or sharp slivers should be smoothed with abrasives. Use emery paper if the damage is slight. Use a file or a grinding wheel if the damage is extensive and requires the removal of a large amount of material.

(2) *Straightening.* Straighten bent handles in a vise or on an anvil.

(3) *Repairing fractures.* Repair broken handles by brazing (para 3–7) or by welding (para 3–8).

b. Wood Handles. Smooth roughened wood handles with sandpaper. If handles are fractured, they may sometimes be repaired by gluing; however, handles on all percussion tools (hammers, axes, sledges, etc), which are designed to withstand considerable strain, must be replaced with new handles or with serviceable used handles.

(1) *Kind of wood.* When it is necessary to make a handle from stock lumber, select thoroughly seasoned wood, straight-grained and free from defects. If strength is desired, use hickory (shagbark (shellbark), pignut, or mockernut). When strength is not a major consideration, use elm, ash, beech, maple, Sitka spruce, or southern gum. Use only straight-grain wood, free from warp, decay, loose knots, checks, shakes, splits, slivers, bark pockets, larvae channels, and pitch pockets.

(2) *Replacement procedure.* The procedure for replacing a handle varies with the type of handle and the tool to which it is attached. The following procedure governs replacement:

(*a*) *Handles with ferrules.*

1. Pry the ferrule from the old handle and tap it onto the new one.

2. Pick-punch the old ferrule to the new handle.

3. Tap the new handle onto the tool.

(*b*) *Handles for sockets.*

1. Pull the old handle out of the tool socket. If the handle is broken off in the socket, drill out the center and pry away the remaining wood.

2. Shape the end of the new handle to make it fit snugly in the socket.

3. Tap the handle to seat it in the socket.

(*c*) *Handles pinned to shafts.*

1. File off the peened ends of the pin which attach the handle to the shaft.

2. Drive out the pin with a punch. Do not use a cone-shaped punch because it will spread the pin.

3. Unscrew or drive the handle from the shaft.

4. Screw or force the new handle into position, with the pinhole in the handle alined with those in the shaft.

5. Tap the pin into place and peen the pin ends to hold the pin in place.

(*d*) *Handles on tangs.*

1. Select a handle to fit the tang. If necessary, use a handle having a hole too small for the tang; take a salvage tool with a tang of the proper size, heat it, and insert it in the handle to burn the handle opening to the proper size.

2. After wetting the tang, insert it in the new handle.

3. Tap the end of the handle on a flat surface to properly seat it on the tool.

(*e*) *Screw-on handles.* Several types of screw-on handles are used as replacements. Install these types of handles according to the manufacturer's directions.

(*f*) *Hammer handles (fig. 3–4, 3–5).*

1. Remove the old handle from the hammer head. If the handle is tight, saw off the

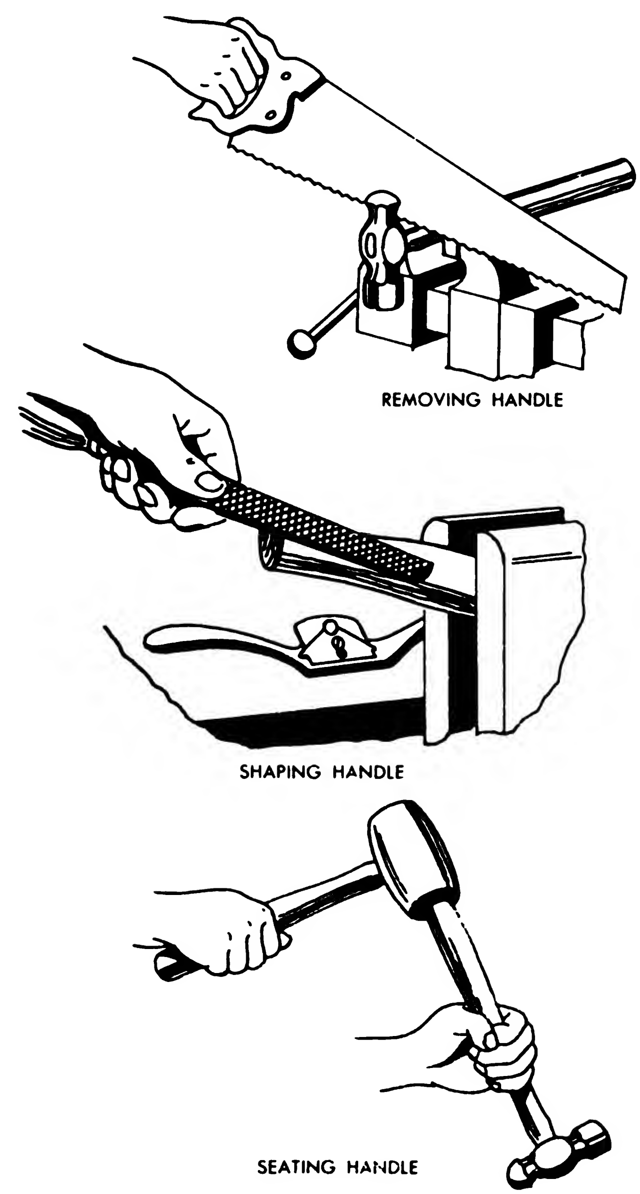


Figure 3–4. Replacing hammer handle.

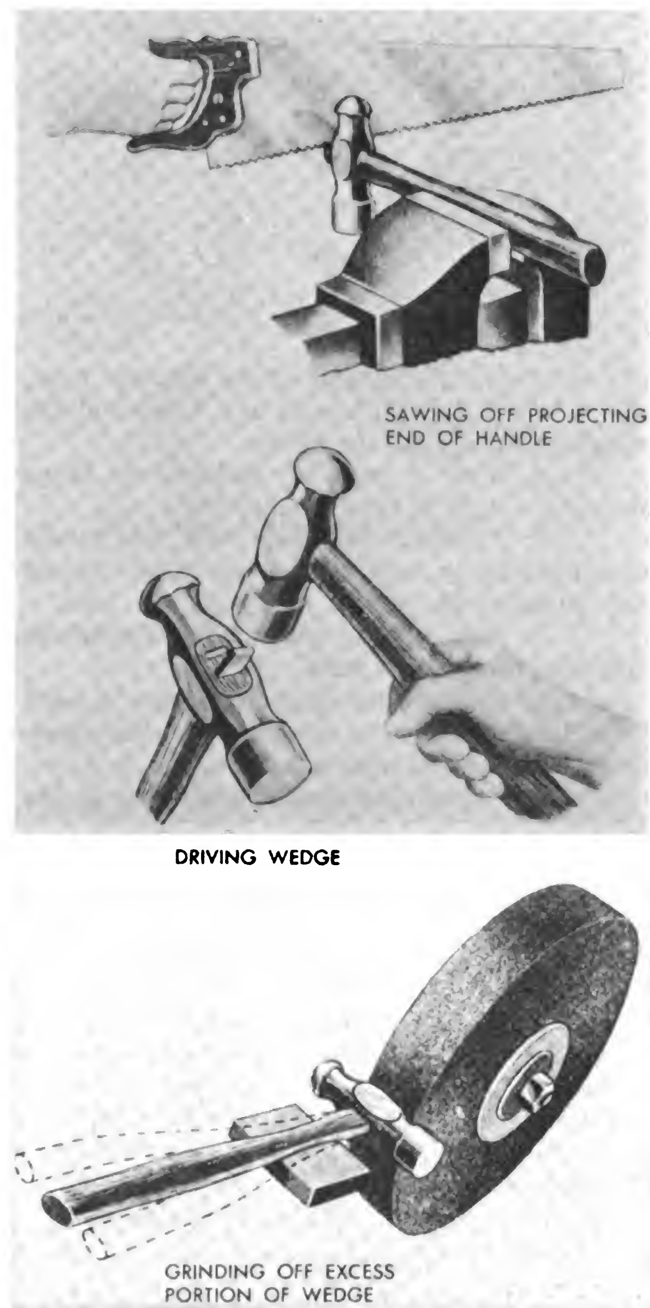


Figure 3–5. Installing wedges.

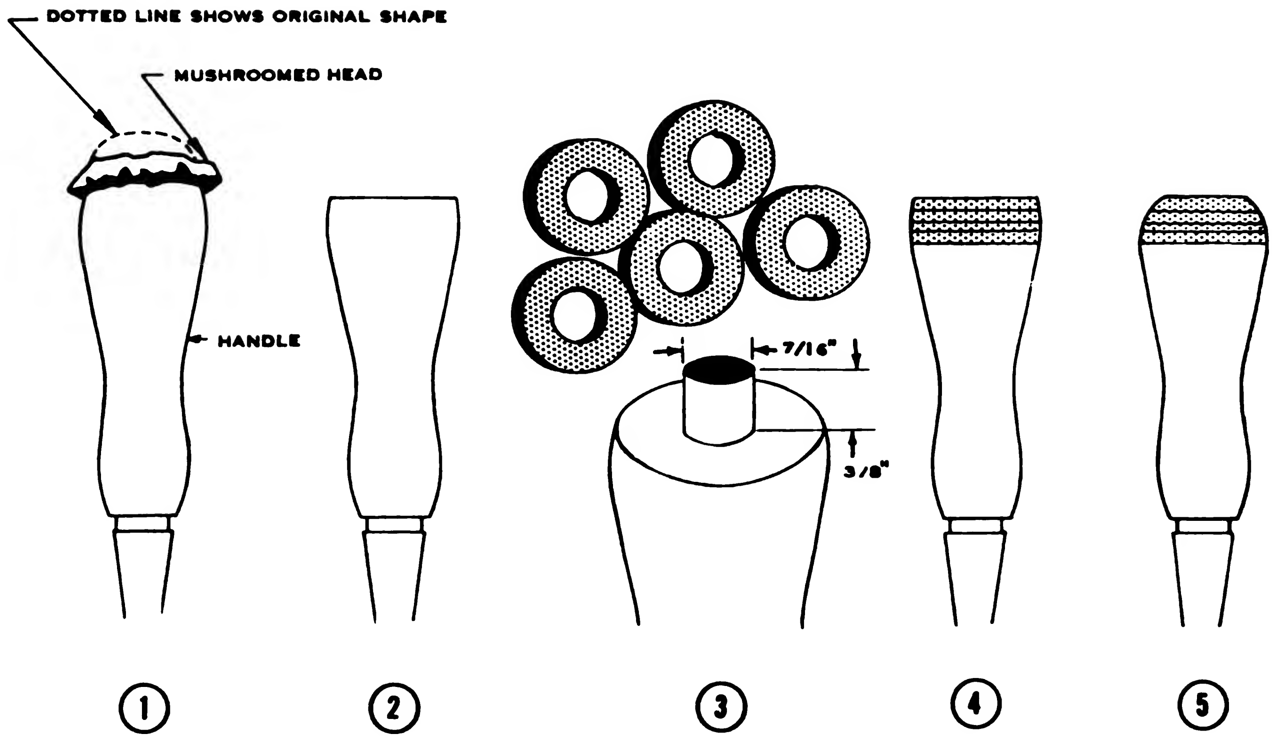


Figure 3–6. Repairing a mushroomed wood head.

old handle close to the neck of the hammer head. Drill a hole in the old handle and knock out the remaining wood. Save the wedge.

2. With a rasp or spokeshave, shape the new handle to fit the hammer head.

3. Assemble the head and the handle for a tight fit by striking the end of the handle with a mallet to seat it firmly in the head.

4. Saw off any portion of the handle projecting through the head.

5. Remove the handle and saw a kerf in the head end for the wedge. Note the placement of wedges in similar-type hammers.

6. Replace the handle and drive in the wedge.

7. Smooth off the wedge end of the handle. If a wood wedge is used, finish the end with a wood rasp; if a metal wedge is used, finish the off the end of a grinding wheel.

NOTE

Sometimes a hammer handle needs only tightening. To tighten the handle, remove the loose wedge and put in a larger one. If the wedge remains tight in the handle, but the handle is still loose, drive a thin hardwood wedge or an iron wedge into the handle beside the original wedge.

(*g*) *Handles for mallets, mauls, sledges, hatchets, axes, and adzes.* Replace the handle of each in the same manner as a hammer handle.

(*h*) *Mattock handles.*

1. Tap the butt of the handle on a solid surface to loosen the head.

2. Slide the head from the butt of the handle.

3. Insert the new handle, butt first, through the head and slide the head into its approximate position.

4. Rap the head end of the handle on a flat surface to tighten it to the handle.

(*i*) *Shovel handles.*

1. Cut, grind off, or drill out the peened heads of the rivets attaching the shovel to the handle.

2. Drive out the rivets and pull the handle from the shovel.

3. Insert the new handle into position on the shovel.

4. Drill rivet holes through the new handle.

5. Insert the rivets and peen the rivet ends to hold them in place.

(*j*) *Saw handles.*

1. Remove the special screws and nuts which attach the handle to the blade.

2. Slide the handle off the blade.

3. Position the new handle on the butt end of the blade, with the screw holes in the handle and blade alined.

4. Install the special screws and nuts which attach the handle to the blade.

3–11. Tool Handle Heads

Tool handle heads (such as those on chisels) that have become battered or mushroomed from constant hammering must be repaired.

a. Wood Head. Use the following procedure for repairing a mushroomed wood head (fig. 3–6):

(1) Remove the handle from the tool (1).

(2) Saw off the mushroomed head, sawing as close to the mushrooming as possible and still leaving a clear end (2).

(3) Turn the end of the handle down to about 7/16 of an inch diameter for approximately 3/8 of an inch (3).

(4) Cut leather or fiber washers to fit snugly over the tip on the end of the handle, making certain that the outside diameter of the washers is slightly larger than the outside diameter of the handle (3).

(5) Place enough washers on the handle to insure that their total thickness equals or slightly exceeds the height of the tip on the end of the handle (4).

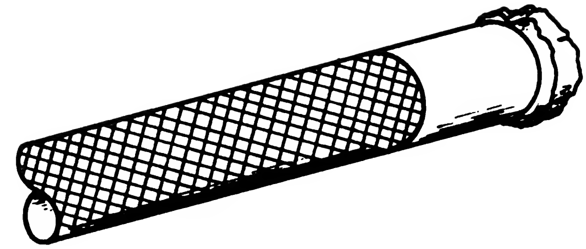
(6) Glue the washers onto the end of the handle and clamp until dry (4).

(7) Sand or grind the washers to conform to the shape of the handle (5).

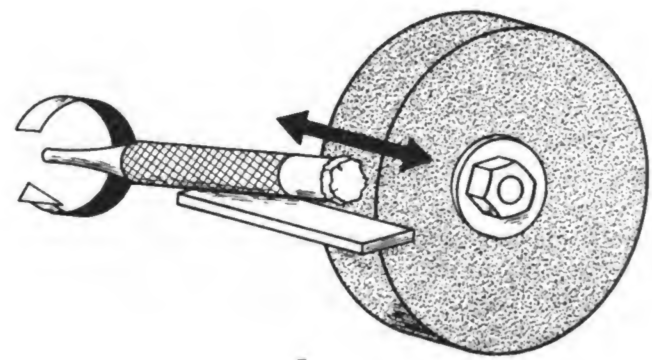
b. Metal Head. Use the following procedure for repairing a mushroomed metal head (fig. 3–7):

(1) Grind the head to original shape.

(2) Temper the reground head (para 3–6c-(3)).



MUSHROOMED METAL HEAD



GRINDING AWAY MUSHROOMED METAL

Figure 3–7. Repairing a mushroomed metal head.

Section III. REFINISHING

3–12. Preparation of Surface

Before attempting to refinish a tool or implement, be sure that it is free from dirt, grease, and old finishing material. For the preparation of the surface, observe the following procedure:

a. Wood. Smooth wood parts by sandpapering with fine-grained sandpaper.

b. Metal. Wash metal parts in drycleaning solvent and dry thoroughly.

3–13. Materials

The chief reason for applying finishing materials or preservatives to tools and implements is to prevent them from rusting, corroding, and deteriorating during periods of nonuse or shipment.

a. Paint, Enamel, Lacquer, Varnish, and Allied Materials. Refer to paragraph 2–10.

b. Compound, Rust Preventive, Heavy (5-lb can). This is a viscous, greaselike, nondrying petrolatum-type compound. When used on unpainted metal surfaces it provides protection from rust for long periods and withstands direct exposure to the weather. It is not a lubricant and all traces of it must be removed from coated articles before they are placed in service. It can be removed with drycleaning solvent.

c. Compound, Rust Preventive, Light (5-lb can). This is a greaselike, nondrying petroleum compound less viscous than heavy rust-preventive compounds. It provides protection for unpainted metal surfaces for relatively long periods when the preserved surfaces are not directly exposed to the weather. It is not a lubricant and all traces of it must be removed with drycleaning solvent.

WARNING

The solvent used in the following compound is volatile and flammable and the compound must be applied in the open or in a well-ventilated room and away from open flames.

d. Compound, Rust Preventive, Thin-Film (1-Gal Can). This is a liquid consisting of a heavy, nonfluid, waxy compound thinned with a volatile petroleum solvent. It protects against rusting for long periods and can be applied over painted or other surfaces without harmful effect. It is extremely adhesive and must be removed with drycleaning solvent.

3–14. Methods of Application

For the best results, use the following methods of application:

a. Paint, Enamel, Lacquer, Varnish, and Allied Materials. Refer to paragraphs 2–10 and 2–11.

b. Compound, Rust Preventive. Apply rust preventive compound (para 3–13*b* and *c*) hot in order to obtain sufficient fluidity to adhere to the metal surface. To accomplish this, place the compound container in a vessel of water and heat until the temperature of the compound is between 180° F. and 200° F. Do not apply a flame directly to the compound container; overheating destroys the protective qualities and creates a fire hazard. Apply the compound by use of one of the following methods:

(1) *Dipping.* The dipping process is the most desirable because there is less danger of air bubbles forming in the preservative film. The compound film cools quickly after application to the metal, thus tightening the film. The film obtained by dipping is smoother and the thickness is more uniform than that obtained by other methods.

(*a*) Heat the metal surfaces before dipping; heat drives off some of the moisture film adhering to the surface of the metal. The temperature of the metal when dipped should be lower than that of the compound in order to set the film as rapidly as possible after dipping; otherwise, a thin film will be obtained. If the metal is not given a preliminary heating, the pieces dipped should be allowed to remain in the solution for a short time. This permits absorption of the water film by the compound and heats the surface of the metal sufficiently to obtain good adhesion.

(*b*) Dip pieces containing cavities in such a manner as to allow the easiest escape of air and complete coverage of surface.

(*c*) After dipping, allow the pieces to drain until cooled to room temperature. The drippings are suitable for future use and should be kept free of dirt.

(2) *Swabbing.* When dipping is not practical, the swabbing process may be used.

(*a*) Heat the compound to a slightly higher temperature than for dipping, as it cools before reaching the metal surface.

(*b*) Make several applications of the compound to work out the air bubbles and to produce a uniform coating.

c. Compound, Rust Preventive, Thin-Film. Thin-film rust preventive compound is applied cold. Dipping, brushing, or spraying is a satisfactory method. Since the solvent used in the compound is volatile and flammable, it should be applied in the open or in a well-ventilated room away from open flames. Do not add solvent because the compound already contains the correct percentage of solvent. Do not use heat at any time when applying thin-film rust preventive compound.

3–15. Precautions

Preparation of the metal surface before the application of a protective finish is most important, because much corrosion is due to improper cleaning of the metal surface before the finish is applied. Before applying protective finish, make sure that the following precautions are taken:

a. Metal surface is clean, dry, and free of all traces of corrosion.

b. Gloves are worn to prevent acid stains and corrosion resulting from body perspiration.

c. All condensation or sweating, caused by the metals being brought into a heated room from outdoors, is removed from metal surface.

d. Finishing material is not applied until the metal reaches room temperature and is thoroughly dry.

Section IV. INSPECTION

3–16. Essential Points of Inspection

When inspecting tools and implements for repair, use the checklist in appendix B for guidance.

3–17. Methods of Inspection

Use the following procedure to inspect tools and implements for repair:

a. Inspecting Items for Damage. Handle in a systematic manner each tool or implement to be repaired. In most instances the order of the inspection will be the tool or implement handle; the joining or fastening of the handle to the tool or implement body; and the body, blade, and cutting edges.

b. Repairing Items. After inspecting and noting the amount of damage, repair the articles. If no special instructions are given, repair the damage in accordance with the methods discussed in paragraphs 3–1 through 3–15. Make the repairs in the following order:

(1) Straighten bent parts.
(2) Repair broken parts.
(3) Repair broken joints.
(4) Secure loose joints.
(5) Replace missing parts.
(6) Repair surface damage.
(7) Regrind and sharpen.
(8) Retemper.
(9) Prepare surface for refinishing.
(10) Apply finishing material (preservative).

c. Final Inspection. Upon completion of repairs, give the item a final inspection to insure that the following conditions are met:

(1) All dirt, grease, and rust have been removed.

(2) The metal and wood used in replaced parts are similar to that used in the original construction.

(3) Replacement handles are of standard size.

(4) Handles are made of sound material and securely attached.

(5) All cutting edges have been ground to the correct bevel and sharpened, and wire edges have been removed.

(6) None of the parts are missing.

(7) All components fit properly, stationary parts fit with precision, and moving parts function without sticking or jamming.

(8) All surface defects have been repaired, worn serrations reworked, and jagged protrusions filed smooth.

(9) Proper finishing or preservative material has been applied and there are no skips in the covering.

CHAPTER 4

REPAIR OF OTHER ITEMS

Section I. BASIC REPAIR

4–1. Cleaning

Dirt, grease, corrosion, rust, and in some instances old finishing material, must be removed from articles before repairs are attempted.

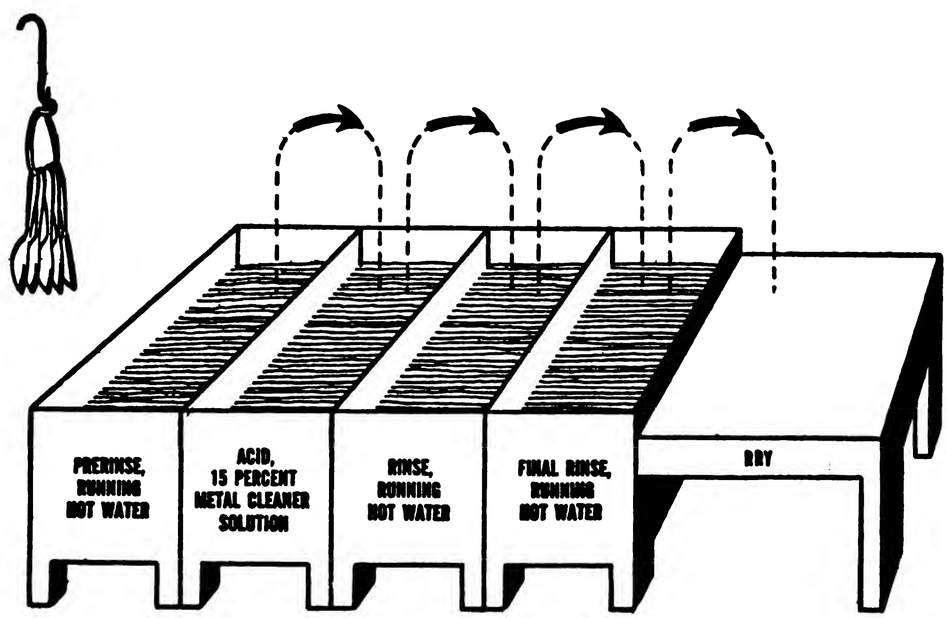


Figure 4–1. Procedure for cleaning aluminum and stainless steel.

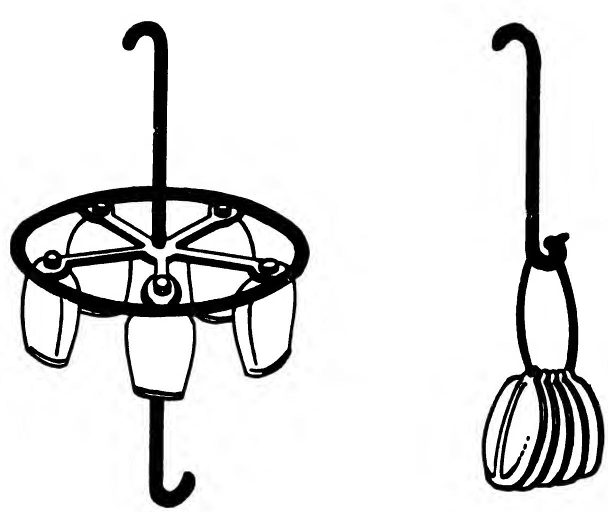


Figure 4–2. Methods of holding aluminum items for dipping.

a. Wood. For instructions on cleaning of wood articles, refer to paragraph 2–9*b*.

b. Aluminum and Stainless Steel. To clean aluminum and stainless steel articles, such as canteens or other articles of the same material, use four tanks (fig. 4–1) with special racks or wire hooks, not constructed of brass or copper, to hold articles (fig. 4–2). The uses of these tanks in cleaning procedures are as follows:

(1) *Prerinse, running hot water.* Dip articles in prerinse tank for 1 minute in water, constantly overflowing at a temperature of 180° to 212° F. Remove and drain articles.

(2) *Acid, 15 percent, liquid metal cleaner solution.* Combine 15 parts by volume of metal cleaner solution with 85 parts of tap water. Dip articles for 1 minute in rubber-lined tank containing liquid metal cleaner acid bath solution. Keep temperature of the bath at 190° to 200° F.

Remove and drain articles. Drain and recharge the acid bath tank whenever, for example, 200 stainless steel or 100 aluminum canteens, or the equivalent surface area of other articles per gallon of solution have been cleaned; or, when it is evident that the solution is so contaminated with grease, dirt, or other foreign matter that its effectiveness is impaired. Test acid bath solutions once every 8 working hours to see whether more metal cleaner is needed.

(3) *Rinse, running hot water.* Dip articles in rinse tank for 1 minute in water constantly overflowing, at a temperature of 100° to 200° F. Remove and drain the articles.

(4) *Final rinse, running hot water.* Dip articles in final rinse tank for 1 minute in water at a temperature of 100° to 200° F., with water constantly overflowing. Remove articles drain thoroughly, and let stand to dry. Drain rinse tanks after 15,000 canteens or articles of equivalent surface area have been treated.

4–2. Straightening

Many articles are constructed in whole or in part of sheet metal. Distorted sheeting on otherwise serviceable articles must be straightened. Dents, ridges, and channels are removed with special straightening tools, both hand- and power-operated.

a. Purpose of Sheet Metal Tools. Sheet metal working tools consist of stakes, dolly blocks, calking tools, rivet sets, and dolly bars. Punches, shears, and hammers are also sheet metal working tools. Rivet sets and dolly bars are used to form heads on rivets after joining sections of sheet metal and steel work. Stakes are used to support sheet metal while the metal is being shaped. Calking tools are used to shape joints of sheet metal. Dolly blocks are used in conjunction with bumping body hammers to straighten damaged sheet metal.

(1) *Types of stakes.* Stakes (fig. 4–3) are issued in a variety of types; each type is used to fabricate sheet metal into a particular shape. Most stakes can be clamped in a vise; the hollow mandrel type is clamped onto a piece of work.

(2) *Types of dolly blocks.* Dolly blocks (fig. 4–4) or hand anvils are available in several types; heel, low crown, toe, general purpose, heavy duty, and utility. Each type is used for supporting damaged sheet metal during straightening operations.

(3) *Types of calking tools.* Calking tools (fig. 4–5) either have a long or short, straight, square nose, or a bent or offset nose.

(4) *Types of rivet sets.* Rivet sets used by tinsmiths and blacksmiths to force pieces together are used similarly, but differ in shape and capacity. Tinsmith's rivet sets (fig. 4–5) are lighter in weight and can only use small size rivets, up to 5/32 inch. The blacksmith's rivet set handles 1/2-inch rivets.

(5) *Types of dolly bars.* Ironworkers use dolly bars (fig. 4–4) to form heads on 1/2- to

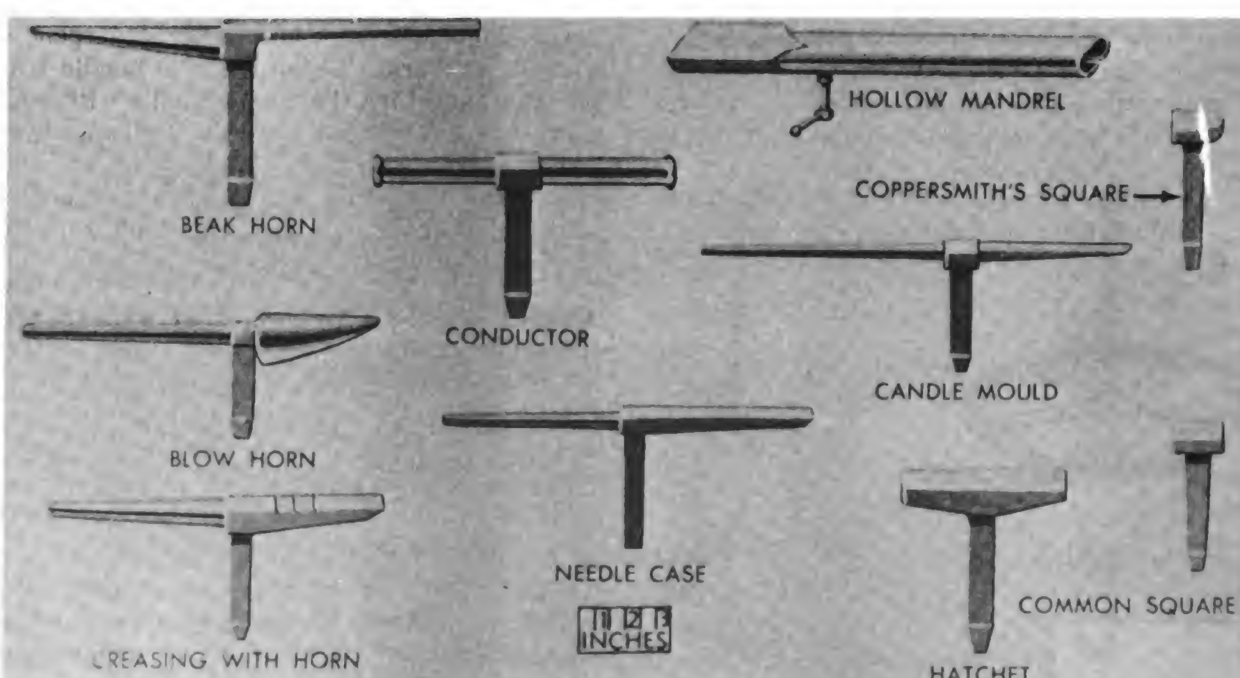


Figure 4–3. Types of stakes.

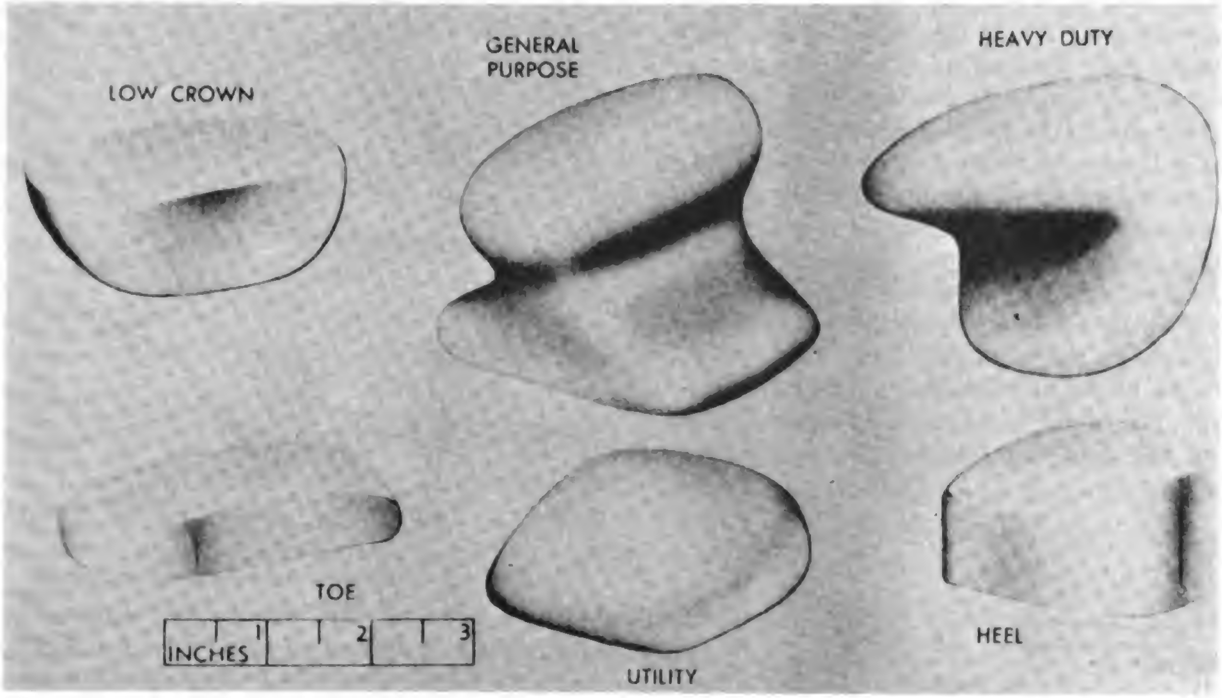


Figure 4–4. Dolly blocks.

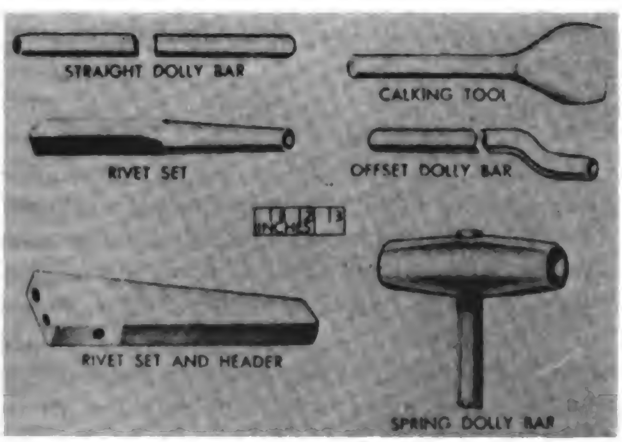


Figure 4–5. Calking tool, rivet sets, and dolly bars.

1-inch rivets. These bars are either straight, offset, or of the spring type. The straight and offset types are 24 and 30 inches long; the spring type is 6 inches long and with a 1-inch diameter handle.

(6) *Use of stakes.* Each stake is used to form a different shape, as indicated by the illustration (fig. 4–3). The work is positioned over these anvils (stakes) and pounded with a heavy hammer until the work is formed to the contour of the stake.

(7) *Use of dolly blocks.* A dolly block is held against one side of a sheet metal panel with one hand. The other hand strikes the opposite side of the panel with a bumping body hammer. As the hammer blow is struck, the dolly rebounds slightly from the panel, but returns immediately because of the pressure exerted by your hand. As the dolly block returns, accurately place it for the next spot to be bumped.

(*a*) *Dinging on the dolly.* Dinging on the dolly means a glancing or slapping blow of the bumping body hammer on top of sheet metal with the dolly block held directly below tne hammer blow as shown in figure 4–6. The result of this process is that the metal is ironed smooth between the working faces of the dolly and the hammer. Each blow dings a spot about 3/8 inch in diameter. Succeeding blows should be struck

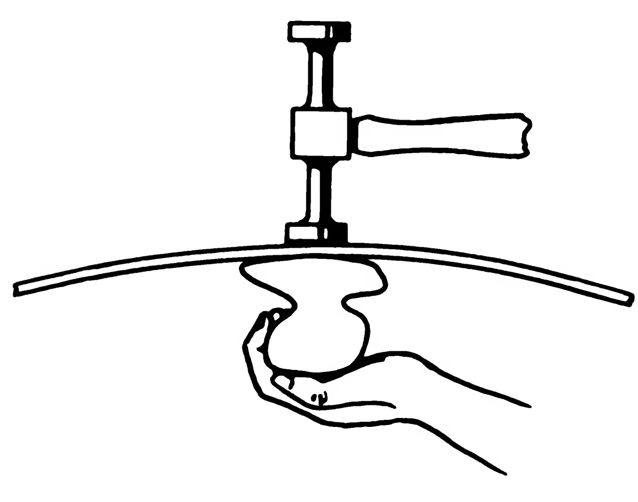


Figure 4–6. Dinging on the dolly.

so that each new spot overlaps the previous spot. Ding a row of spots across the edge of a damaged panel. Next, ding another row adjacent to the first row, and so on, until the damaged area is covered with parallel rows of spots. This stretches the metal only very slightly. The low-crown hammer face striking against the dolly, which closely fits the contour of the panel, minimizes the stretching.

(*b*) *Dinging off the dolly.* Figure 4–7 illustrates dinging off the dolly process. The high-crowned face of the bumping body hammer is used and the blows are directed against the rim of a dent. The dolly block is held against the bottom of the dent and pressure is exerted to force the dent out.

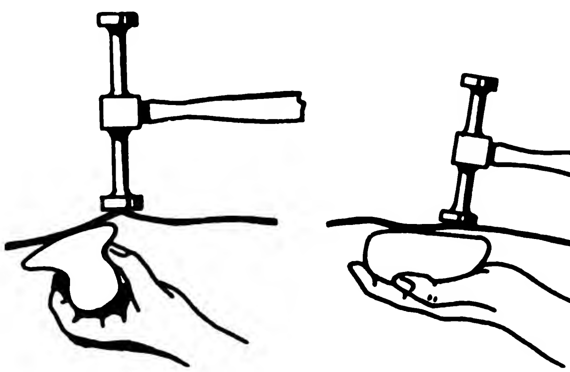


Figure 4–7. Dinging off the dolly.

(*c*) *Using the bumping body hammer.* The blow used in dinging is not a followthrough blow such as used in driving a nail or in riveting. The hammer must be held loosely and swung with a wrist action, producing a slapping blow. Figure 4–8 illustrates the path through which the hammer travels. The average number of blows per minute is 120 and in regular rhythm. As each succeeding blow is struck, the hammer rebounds as shown. It is then lifted by wrist action to a point high enough to start the next blow. Then, by a snap of the wrist, the hammer descends for the next slapping blow. At no time is the hammer gripped firmly. The fingers are used to guide and control the hammer at the beginning and at the end of the blow. During the downward and upward path of the hammer head, the end of the handle moves through a short arc, and the hand by continued wrist action follows along, loosely holding the handle and ready to grasp the handle more firmly at the end of the rebound. This operation requires skill, but it can be acquired with practice.

(*d*) *Low-crown dolly.* The low-crown dolly is used in low-crown panels where medium- and high-crown dollies would stretch the metal.

(*e*) *Toe dolly.* The toe dolly, or shrinking

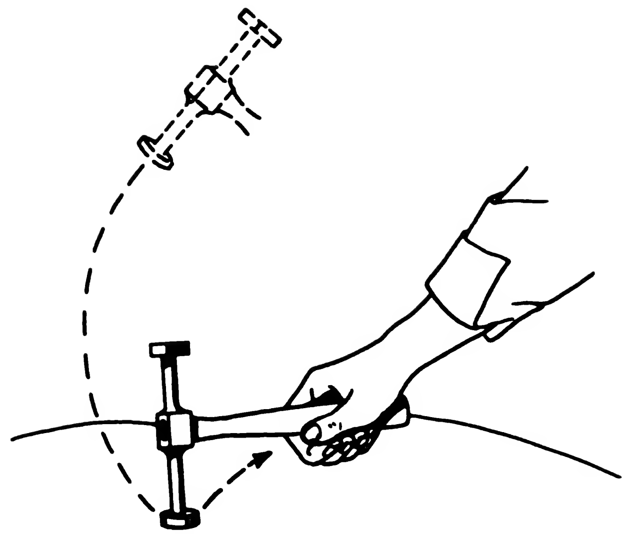


Figure 4–8. Using a bumping body hammer.

dolly, is used on flat panels. Its thinness and length make it accessible in narrow pockets. The large flat face is convenient when shrinking metal ((8) below). The flat sides are used as an anvil for repairing flanges on metal.

(*f*) *General purpose dolly.* The general purpose dolly is convenient to hold and has several different working faces and two beading and flanging lips. It is the most useful of the dollies, since it has unlimited applications.

(*g*) *Utility dolly.* The utility dolly has a high crown with one narrow beading edge. The thick rounded sides are used in short radii curves.

(*h*) *Heavy-duty dolly.* The heavy-duty dolly is used on extra-heavy gage sheet metal which resists the action of lighter dollies.

(*i*) *Heel dolly.* The heel dolly is used both to reach into sharp corners and into areas having large radii.

(8) *Shrinking sheet metal.* When a panel has been damaged so that it is permanently stretched, it will, after it is restored to shape, be too high in the stretched area. It cannot be dinged down since there is no place for the metal to go. It must be shrunk. Shrinking should always be done following the metal bumping and before the metal is finished. Basically, the shinking operation is simply the heating of a small spot in the center of the stretched area and then upsetting the stretched metal into this heated spot, making it thicker. Shrink a stretched area in sheet metal as outlined in (*a*) through (*e*) below.

(*e*) Using a suitable torch with a small tip, heat a spot 3/8 inch in diameter to a little past cherry red in the center of the stretched area (fig. 4–9). The heat expands the metal in the entire stretched area, while the spot itself

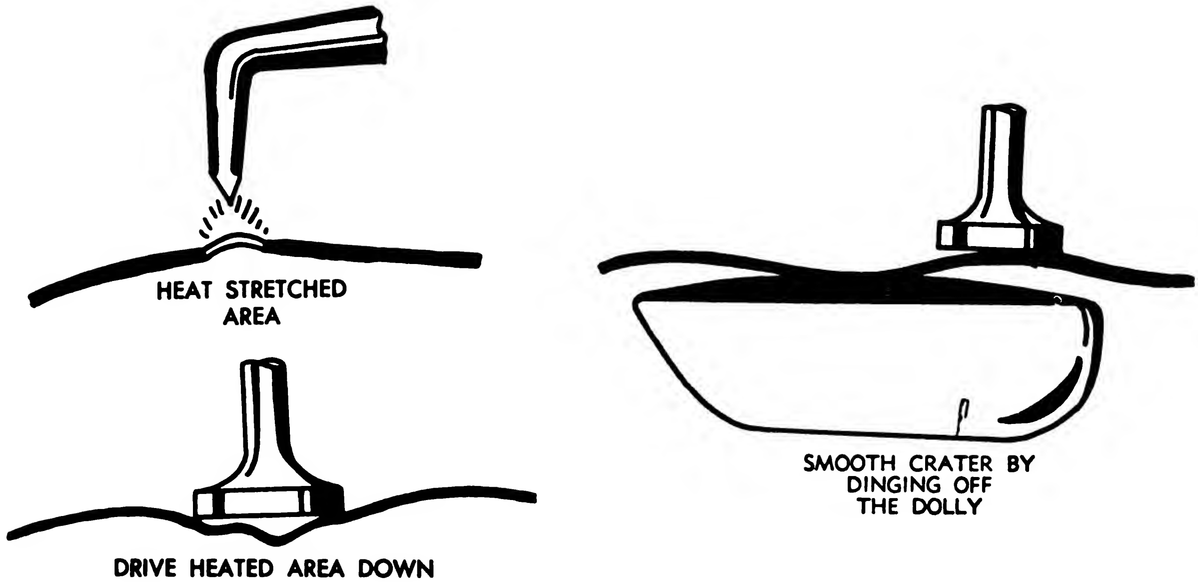


Figure 4–9. Shrinking sheet metal.

rises into a low peak. Use care to avoid burning a hole in the metal.

(*b*) *Remove the torch.* After the spot turns cheery red, strike the spot with a hard blow of the bumping body hammer to drive the spot down. This hammer blow upsets the hot metal and is the mechanical action which shrinks the metal. The spot will now form a crater instead of a peak.

(*c*) Very quickly, hold a dolly block up against the bottom of the crater. At the same time, tap down the rim of the crater with the bumping body hammer (fig. 4–9). This is simply a dinging off the dolly operation to smooth the spot to proper level before metal finishing. The expansion in the metal from the heat remains in the metal during this operation. When dinging the upset metal smooth, use a low-crown face dolly block under low-crown metal, and a high-crown face dolly block under high-crown metal.

(*d*) Finally, quench or chill an area about 6 inches in diameter around the spot with a water-soaked sponge. This chilling draws the expansion out of the metal very quickly.

(*e*) Continue shrinking additional spots until the contour of the panel is in proper shape, as determined by examining and by feeling with the hand.

b. Care of Sheet Metal Tools. Keep all tools free from rust and their working faces clean and smooth. When not in use, wipe them with light oil and store carefully. Do not use tools for a purpose other than that for which they were intended. For long periods of storage, coat all metal parts with a rust preventive compound and store in a dry place.

4–3. Soldering and Brazing

Both soft and hard soldering are used for repair purposes. Soldering has some advantages over welding and riveting, such as savings in equipment and time; adaptability to inaccessible places; use of low temperatures, affording protection to enamel, paint, and other finishes; and protection against distortion caused by tremendous heat of the welding torch.

a. Soft Soldering. This process is used for joining most common metals with a fusible alloy that melts at a temperature below that of the base metal. Soldering operations that require a temperature of less than 750° F. are known as soft soldering. The base metal is heated and tinned on the surface by the solder filler metal. A joint soldered by this method obtains its strength from the penetration of the solder into the pores of the base metal. Soft solders are used where air- or water-tight joints, which are not exposed to high temperatures, are required.

b. Hard Soldering (*Silver Soldering, Brazing*). This is a low temperature brazing process with rods (filler metal) having melting points ranging from 1,145° to 1,650° F. These temperatures are higher than those used in soft soldering, but considerably less than those of copper alloy brazing.

c. Joint Preparation. The parts to be soldered should be free of all oxide, scale, oil, and dirt to insure sound joints. Cleaning may be done by pickling in caustic or acid solutions, filing, scraping, sandblasting, or other suitable means.

d. Flux. All soldering operations require a flux in order to obtain a complete bond and full strength at the joints. Fluxes clean the joint area, prevent oxidation, and increase the wetting power of the solder by decreasing its surface tension.

(1) The following types of soft-soldering fluxes are in common use: Rosin flux, the best flux when soldering copper, electrical connections, fine instruments, and small parts. Rosin flux is noncorrosive and nonconductive. Zinc chloride flux is used in heavier work and on untinned copper, brass, bronze, Monel metal, nickel-plated parts, galvanized iron, zinc, steel, and german silver. A solution of zinc cut in hydrochloric (muriatic) acid is commonly used by tinworkers as a flux. Since zinc chloride and hydrochloric acid are corrosive, all traces should be washed off with a bicarbonate of soda solution.

(2) When silver soldering, flux also usually is required. The melting point of the flux, which is composed of chlorides and fluorides, must be lower than the melting point of the silver brazing filler metal so that it will clean the base metal and properly flux the molten metal.

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

f. Application. Solder joints may be made by using gas flames, torches, electric soldering irons, and nonelectric soldering guns. Electrical connections and sheet metal are soldered with a soldering iron or gun. Sweated joints may be made by applying a mixture of solder powder or paste flux to the joints, then heating the part until the solder mixture liquifies and flows into the joints. This is usually accomplished by the use of a torch.

g. Types of Soldering Irons. There are two general types of soldering irons: electric heated and nonelectric heated. The essential parts of both types are the tip and the handle. The tip is made of copper.

(1) *Electric soldering iron.* The electric soldering iron (fig. 4–10) transmits heat to the copper tip after the heat is produced by electric

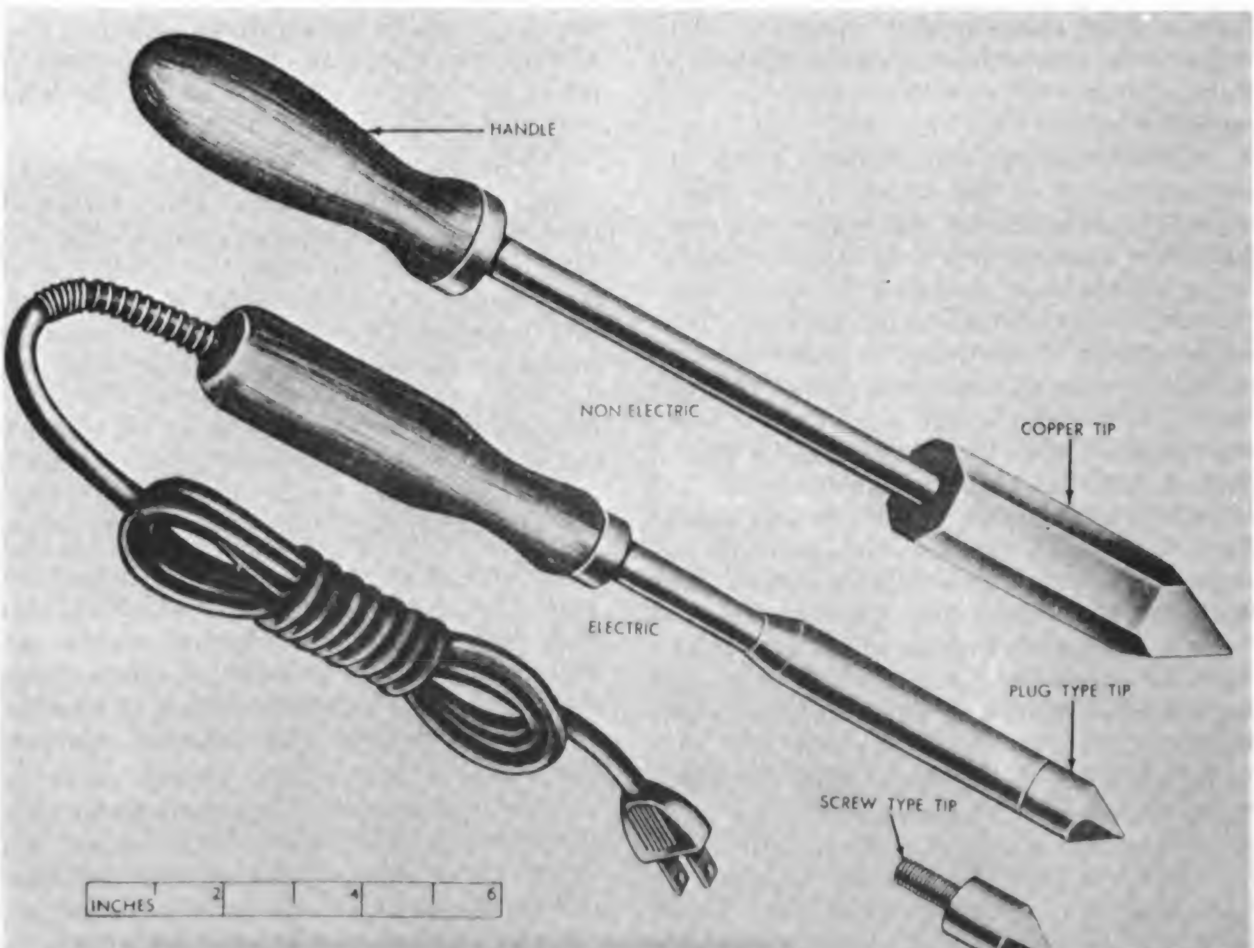


Figure 4–10. Soldering irons.

current which flows through a self-contained coil of resistance wire called the heating element. Electric soldering irons are rated according to the number of watts they consume when operated at the voltage stamped on the iron. There are two types of tips on electric irons: plug tips which slip into the heater head and are held in place by a setscrew, and screw tips which are threaded and screw into the heater head. Some tips are offset and have a 90° angle for soldering joints that are difficult to reach.

(2) *Nonelectric soldering iron.* A nonelectric soldering iron (fig. 4–10) is sized according to its weight. The commonly used sizes are the 1/4-, 1/2-, 3/4-, 1-, 1 1/2-, 2-, and 2 1/2-pound irons. The 3-, 4-, and 5-pound sizes are not used in ordinary work. Nonelectric irons have permanent tips and must be heated over an ordinary flame or with a blowtorch.

h. Additional Information. For additional informaton on soldering or brazing refer to TM 9–237 and TM 9–243.

4–4. Riveting

In many instances, repairs require the removal of the old rivets to disengage a damaged part and the installation of new rivets to fasten the replacement.

a. Removing Old Rivets. Old rivets may be removed in one of the following ways:

(1) Grind off the head of the old rivet with a power grinder and drive out the remaining part with a pin punch or taper punch (fig. 4–11). Do not use a cone-shaped punch; it might spread the end of the rivet and damage the work.

(2) Cut off the head of the rivet with a cold chisel, and drive out the remaining part with a punch (fig. 4–12). To facilitate removal of the rivet head with a cold chisel, slot the head with a hacksaw and chisel off half of the head at a time.

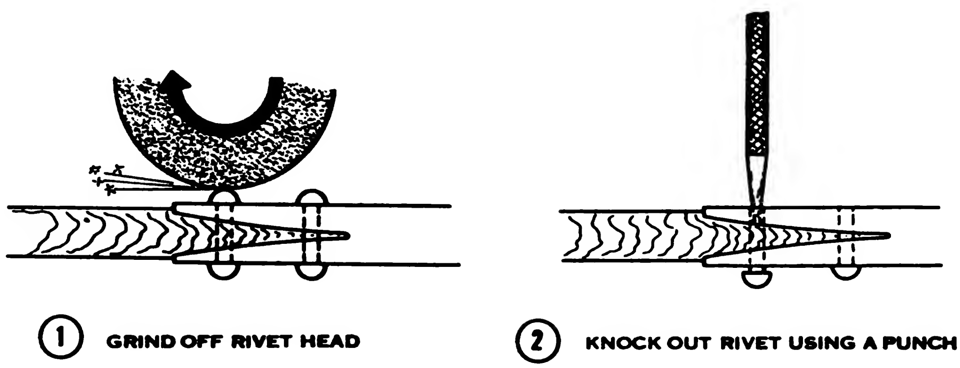


Figure 4–11. Removing rivet with grinder and punch.

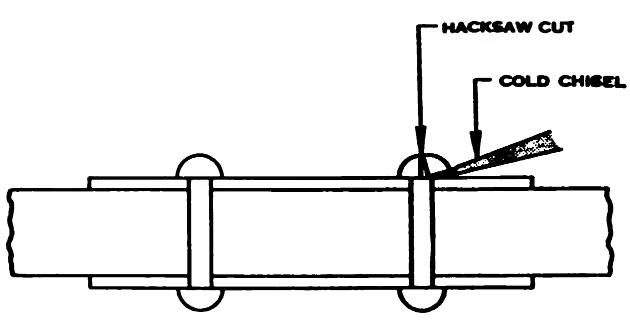


Figure 4–12. Removing rivet head with cold chisel.

(3) If the rivet is countersunk, drill out the rivet head and punch the remainder of the rivet from the hole with a taper punch (fig. 4–13).

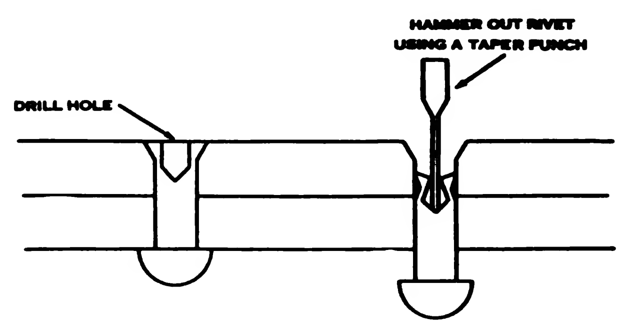


Figure 4–13. Removing a countersunk rivet.

b. Inserting New Rivets. The following rules govern the insertion of new rivets:

(1) Select a rivet similar to the one removed, making certain the body of the rivet fits snugly in the hole and has sufficient length to allow material for peening.

(2) Insure a tight joint by cleaning thoroughly the faying surface (the surface between the pieces), removing all burs and chips.

(3) Aline the holes before inserting the rivet. If the holes are unfair (do not exactly meet), ream them out and use a larger rivet (fig. 4–14).

(4) Avoid all riveting faults (fig. 4–15).

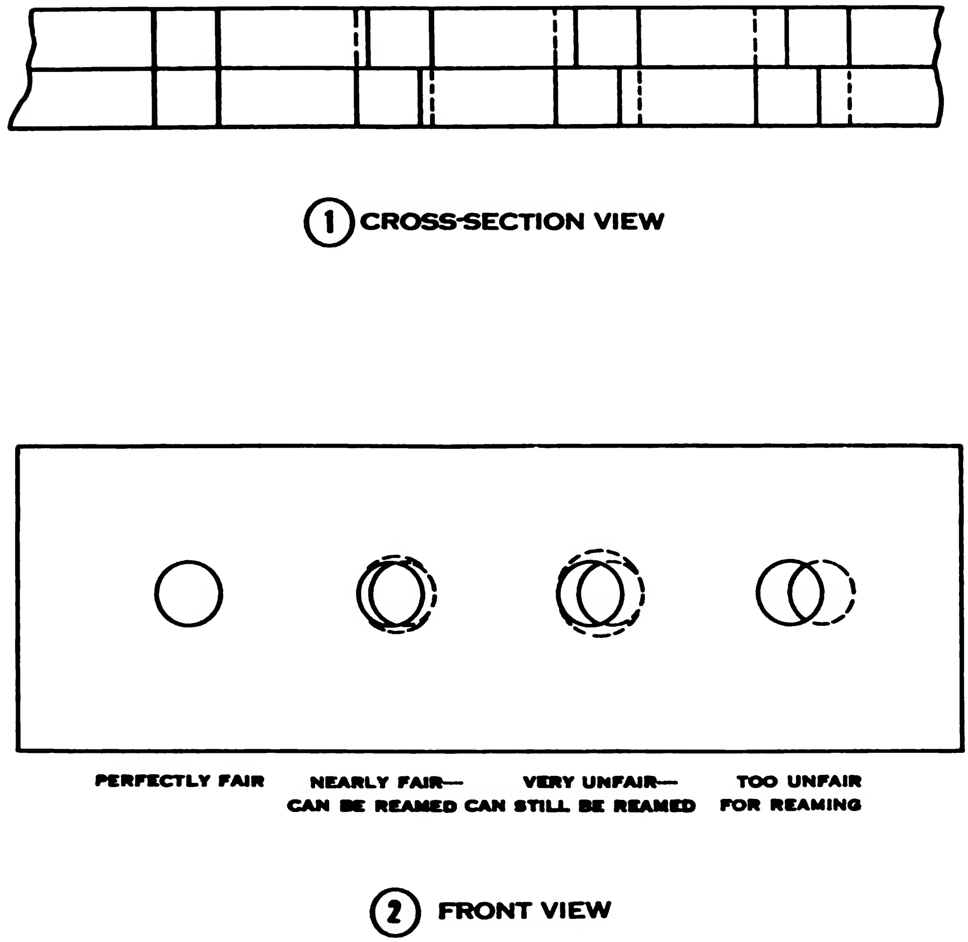


Figure 4-14. Method of alining rivet holes.

4–5. Welding

Welding is the only satisfactory method of repairing certain items made of sheet metal (a term which, in this manual, is restricted to metal thicknesses up to and including 1/8 of an inch (No. 11 gage)). When fractures occur on such items, they usually occur at joints. For additional information on welding refer to TM 9–237.

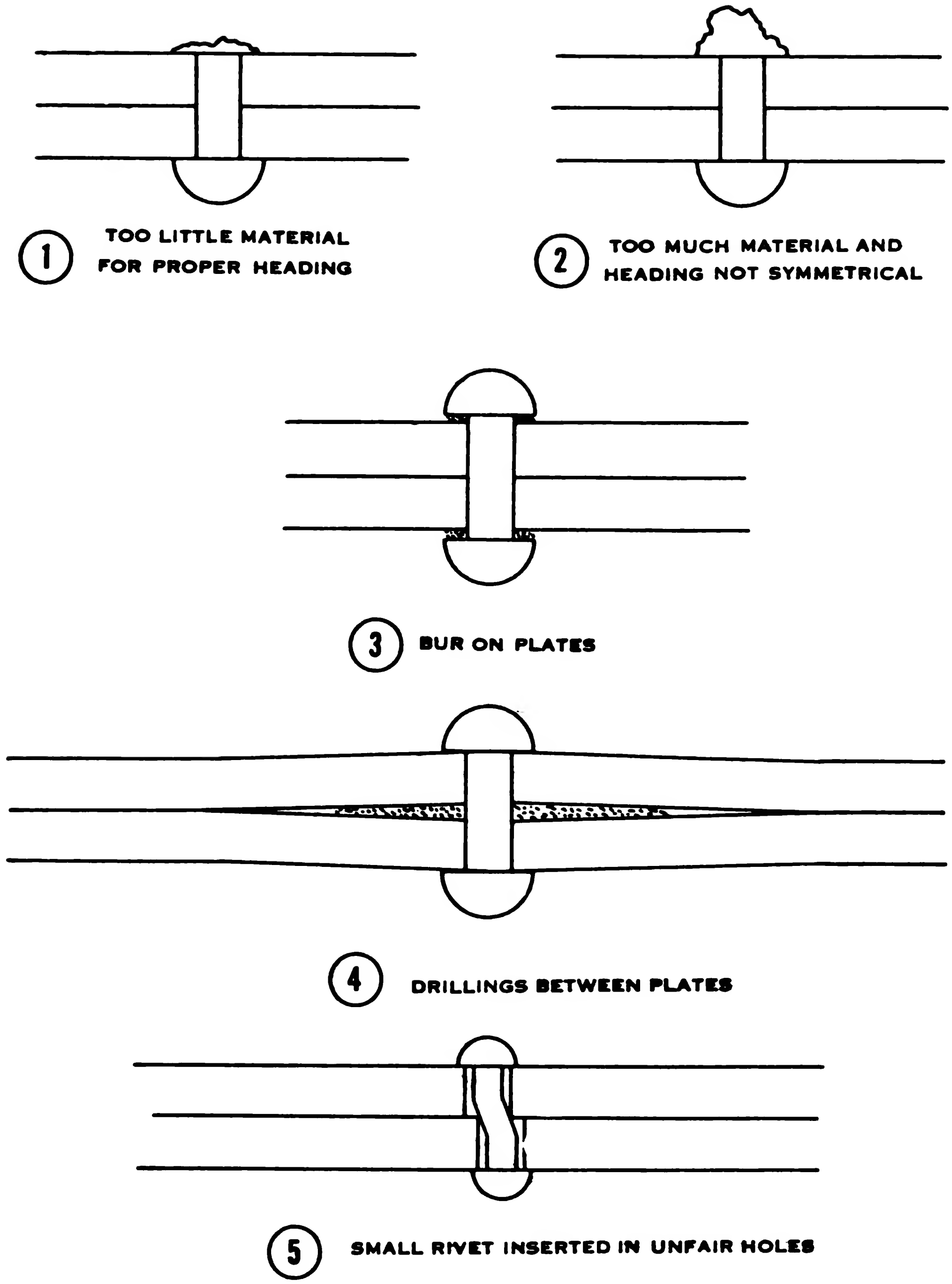


Figure 4–15. Improperly driven rivets.

Section II. REPAIR OF COMPONENTS

4–6. Broken Parts

Replace all broken parts. If replacing is not practicable, repair them by soldering, brazing, welding, or riveting.

a. Soldering. Refer to paragraph 4–3.

b. Brazing. Refer to paragraphs 3–7 and 4–3.

c. Welding. Welding repairs vary with the form of material being worked upon. Refer to paragraph 3–8.

(1) *Tubing.* To repair a part made of tubing, use one of the following methods:

(*a*) Butt weld the broken edges together (1, fig. 4–16).

(*b*) Make a backup-ring joint by inserting a ring and butt welding the broken edges (2, fig. 4–16).

(*c*) Make a fishtail joint by slipping a larger tube with V-shaped ends over the fracture and welding it in place (3, fig. 4–16).

(2) *Sheet metal.*

(*a*) When repairing sheet metal, spread the far edges of the fracture to allow for contraction of the metal. Generally, the distance allowed between the far edges amounts to 2 1/2 percent of the total length of the weld or approximately 5/16 of an inch for every 12 1/2 inches.

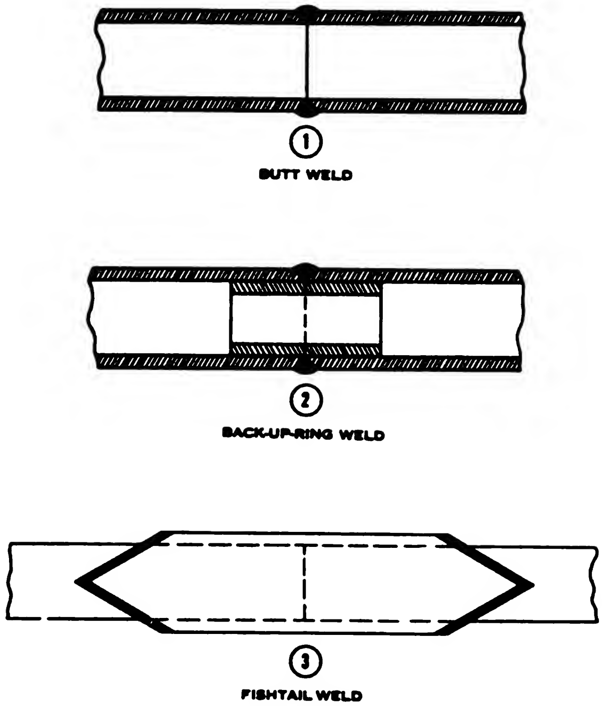


Figure 4–16. Welding tubing.

Where welding is intermittent, a greater allowance must be made (fig. 4–17).

(*b*) If reinforcements are necessary, tack weld a metal patch above and below the break.

(3) *Heavy stock.* Refer to paragraph 3–8.

d. Riveting. When practical, bridge the fracture with butt straps and rivet them into place (fig. 4–18).

4–7. Joints

For the repair of loose and broken joints, observe the following instructions:

a. Refastening. To refasten a loosened joint, clamp the parts together and run a bead of weld along the length of the separation.

b. Bracing. When it is evident that a bead weld alone will not withstand the strain of normal use, tack weld either an angle, a U-brace, or a strap reinforcement to the severely stressed area. Place the reinforcement in an angle so that it does not detract from the appearance of the article and does not obstruct the operation of any moving part.

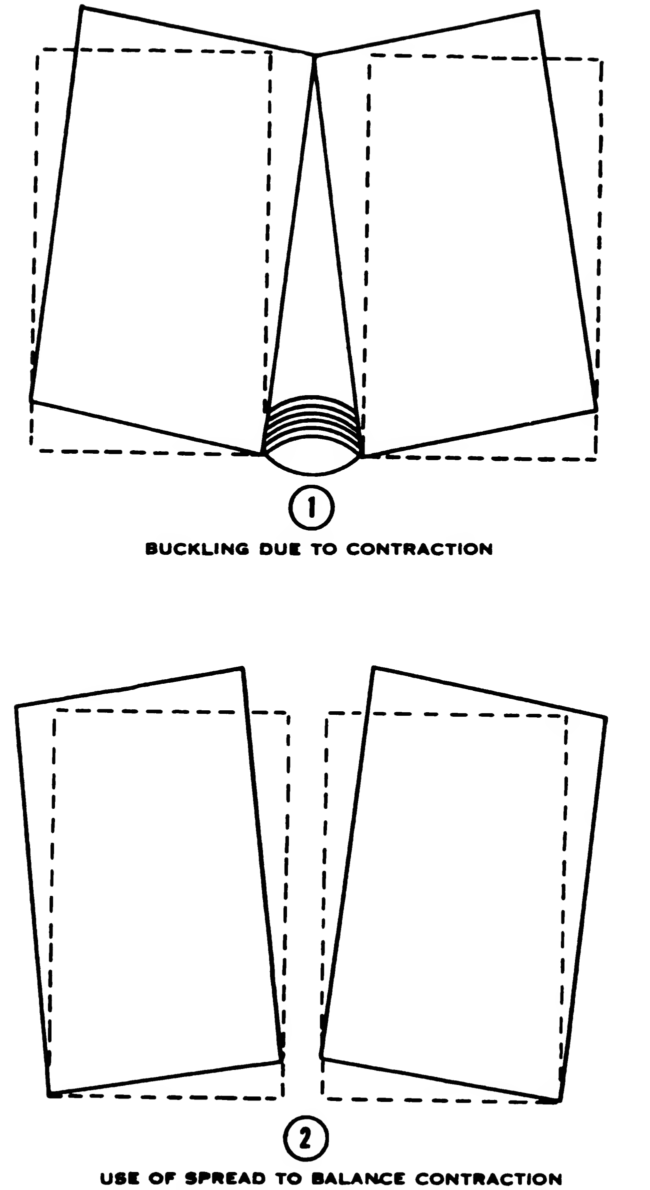


Figure 4–17. Method of avoiding buckling when welding sheet metal.

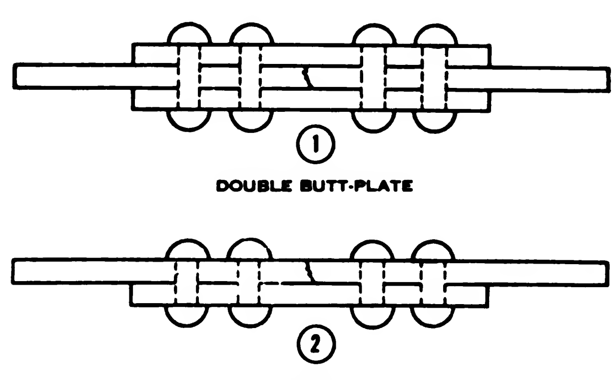


Figure 4–18. Repairing a fracture with butt straps and rivets.

4–8. Preparation of Surface

Before attempting to refinish an article, be sure that it is free from dirt, dust, grease, and oil finishing material. For the preparation of the surface, observe the following procedures:

a. General. Refer to paragraphs 2–9 and 3–12.

b. Metal Furniture. If the old paint is in bad condition, remove it completely, using one of the following methods:

(1) *Stripping.* Use an alkali paint stripper, 6 to 10 ounces to a gallon of water, and apply it hot in one of the following ways:

(*a*) Allow the stripper solution to drip from an overhead perforated pipe onto the piece being stripped until all the paint is off.

(*b*) Apply the hot stripper solution heavily with an old brush. Do not use a spray gun because the solution will go where it is not wanted, and it may also ruin the spray gun. Let the solution remain on the paint about 5 minutes, then hose it off with cold water. Repeat the process on spots where the paint has not come off.

NOTE

If it is not convenient or desirable to use alkali stripper, apply paint remover or chlorinated solvents.

(2) *Sanding.* Sand the old paint down to the metal, using a portable electric sander to reduce time and labor. After sanding, clean the surface with a metal conditioner.

4–9. Materials

a. Wood Components. Refer to paragraph 2–10.

b. Metal Components.

(1) *General.* Refer to paragraph 3–13.

(2) *Brass.* To get an oxidized finish (blue black), throughly clean the brass and immerse it in a solution of 1 pound of copper carbonate, 1 quart of ammonium hydroxide (commercial), and 3 quarts of water. First mix the copper carbonate and the ammonia, then add the water. Allow the work to remain in the solution (kept at a temperature of 175° F.) until the desired color is obtained.

(3) *Iron and Steel.* To get a galvanized finish, thoroughly clean the article in hydrochloric acid, then dry it. Prepare a wrought iron or mild steel pot of molten zinc. Sprinkle the molten metal with sal ammoniac and carefully dip the article into it. Drain off the surplus zinc and plunge the article into water to wash away any used sal ammoniac remaining on the surface.

c. Metal Furniture.

(1) *Sheet steel.* After cleaning the piece of furniture with a metal conditioner, coat it with a metal primer, such as zinc chromate. Apply three to five coats of enamel or lacquer, lightly sandpapering the work between coats to produce a deep luster.

(2) *Aluminum tubing and trimming.* Give aluminum tubing and trimming a satin finish by rubbing with steel wool lubricated with a thick, soapy solution; with a greaseless polishing compound; or with No. 120 emery cloth to scratch fine, light parallel lines into the surface sufficient to eliminate all scratches or other blemishes picked up during the repair. The lines should run parallel with the edges of the tubing or of the trimming. If welds have been made, they should be blended in by being rubbed and given a mist coat of aluminum lacquer (fine aluminum paste in lacquer) or a shade that will blend in smoothly and harmonize with adjacent surfaces.

4–10. Methods of Application

a. Brush. Refer to TM 5–618 and TM 9–213.

b. Spray Gun. Refer to TM 5–618 and TM 9–213.

c. Dipping. Refer to paragraphs 3–14*b*(1) and 4–1*b*.

d. Swabbing. Refer to paragraph 3–14*b*(2).

4–11. Inspection

a. Initial Inspection. When making the initial inspection, use the checklist in appendix B for guidance as to the essential points of inspection.

b. Repair the Item. After inspecting and noting the amount of damage, repair the articles. If no special instructions are given, repair the damage in accordance with the methods discussed in paragraphs 2–1 through 2–11, 3–1 through 3–15, and 4–1 through 4–11. Make the repairs in the following order:

(1) Straighten bent parts.
(2) Repair broken parts.
(3) Repair broken joints.
(4) Replace missing parts.
(5) Tighten loose joints.
(6) Repair surface damage.
(7) Prepare surface for refinishing.
(8) Apply finishing material.

c. Final Inspection. Upon completion of repairs, give the articles a final inspection to insure that the following conditions have been met:

(1) The materials used for repair and replacement are similar to those used in the original construction.

(2) All welded, brazed, and soldered repairs have been thoroughly cleaned and smoothed.

(3) All metal furniture joints have been secured and braced sufficiently to withstand hard use.

(4) No parts are missing.

(5) Components fit properly, stationary parts fit with precision, and moving parts function without sticking or jamming.

(6) All surfaces have been properly prepared for refinishing.

(7) The proper finishing material has been applied and there are no sandy spots, orange-peel effects, or skips in the covering.

(8) All special instructions for the inspection and repair of the articles have been followed.

APPENDIX A

REFERENCES

1. Army Regulations

AR 310–1	Military Publications—General Policies.
AR 310–25	Dictionary of United States Army Terms.
AR 310–50	Authorized Abbreviations and Brevity Codes.

2. Department of the Army Pamphlets

DA Pam 108–1	Index of Motion Pictures, and related Audio-Visual Aids.
DA Pam 310-series	Military Publications Indexes (as applicable).

3. Field Manuals

FM 21–5	Military Training Management.
FM 21–6	Techniques of Military Instruction.
FM 21–30	Military Symbols.

4. Technical Manuals

TM 5–460	Carpentry and Building Construction.
TM 5–461	Engineer Handtools.
TM 5–611	Repairs and Utilities: Post Engineer Shops.
TM 5–618	Paints and Protective Coating.
TM 5–704	Construction Print Reading in the Field.
TM 9–208–1	Cleaning of Ordnance Materiel.
TM 9–213	Painting Instructions for Field Use.
TM 9–237	Operating Manual: Welding Theory and Application.
TM 9–243	Use and Care of Handtools and Measuring Tools.
TM 9–247	Materials Used for Cleaning, Preserving, Abrading, and Cementing Ordnance Materiel; and Related Materials Including Chemicals.
TM 10–450	Sheet Metal Work; Body, Fender, and Radiator Repairs.
TM 10–455	Body Finisher, Woodworker, Upholsterer, Painter, and Glassworker.

5. Technical Bulletins

TB QM 40	Quartermaster Maintenance Instructions; Refinishing of General Office Furniture.

6. Federal Specifications

FED–SPEC–511–L–P	Plastic Sheet, Laminated, Thermosetting, Cotton Fabric Base, Phenolic-Resin, Post Forming.
FED–SPEC–513C–L–P	Plastic Sheet, Laminated, Thermo-Setting, Paper-Base Phenolic-Resin.

7. Military Specification

MIL–P–15035–C	Plastic Sheet, Laminated, Thermo-Setting Cotton-Fabric-Base, Phenolic-Resin.

8. Military Standard

MIL–STD 20	Welding Terms and Definitions.
MIL–STD–171–B	Finishing of Metal and Wood Surfaces.

9. Military Standardization Handbook

MIL–HDBK–691–A	Adhesives.

APPENDIX B

INSPECTION CHECKLIST

Material		Surface		Construction	Cutting edge (tools)	Parts (including hardware)		
Wood	Metal	Wood	Metal					
Checks	Flaws	Blisters	Burs	Badly fitted joints	Beveled angle incorrect.	Bails	Cabinets	Cutters
Decay	Irregularities	Burns	Chips	Badly fitted parts	Bevel not uniform	Bases	Cans	Eyes
Excessive cross grain	Wrong metal	Chips	Corrosion	Bents parts	Beveled on wrong side of the blade.	Bearings	Caps	Fasteners
Improper species		Damaged finish	Cracks	Broken joints	Dulled	Blades	Chains	Ferrules
Knots		Dents	Damaged finish	Broken parts	Faulty fit of edges	Bodies	Chests	Frames
Mixed species		Dirt	Dents	Faulty riveting	Incorrect shape	Bolts	Chucks	Frogs
Shakes		Flaked finish	Dirt and grease	Incorrect dimensions	Nicked	Bottoms	Clamps	Funnels
Splits		Gouges	Holes	Loose joints	Scratched	Boxes	Connectors	Gears
Worm holes		Loosened grain	Improper finish	Missing parts	Temper burned out	Braces	Covers	Generators
		Not sanded	Loose filings	Poor soldering	Wire edge not removed.	Burners	Cranks	Globes
		Peeled finish	Open welds	Warped parts		Grates	Lines	Rings
		Poor finish	Poor finish	Weak welds		Grips	Locks	Rivets
		Saw cuts	Rough welds	Wrong parts		Handles	Lugs	Rods
		Scratches	Rust			Hasps	Nozzles	Screens
		Skips	Scratches			Heads	Nuts	Screws
		Spots and stains	Slivers			Hinges	Pans	Shanks
		Torn grain	Worn serrations			Holders	Pins	Sleeves
		Wrong finish	Wrong finish			Hooks	Pipes	Slides
						Inserts	Plates	Sockets
						Irons	Racks	Springs
						Jaws	Rails	Staples
						Knobs	Ratchets	Straps
						Levers	Reflectors	Tangs
						Teeth	Tubes	Wedges
						Thimbles	Valves	Wheels
						Tines	Washers	Wrenches

GLOSSARY

Adherend	—An object bonded or to be bonded to another object by an adhesive.
Adhesion	—Sticking or being stuck together.
Alloy	—A substance composed of two or more metals intimately united, with characteristics different from those of its ingredients.
Austenite	—An exceedingly tough steel, but not as hard as other steels.
Bond	—To attach materials together by adhesives.
Braze	—To join two pieces of metal by fusing a layer of brass or brass alloy between the adjoining surfaces.
Cohesion	—The state in which the particles of a single substance are held together by chemical forces.
Concave	—Curved inward.
Convex	—Curved outward.
Corrosion	—The slow wearing away of metals by chemical attack, of which rust is a common form.
Ferrule	—A metal ring or band put around the end of a tool handle.
Fire on	—To bake on with intense heat.
Flux	—A substance used to remove oxide from metal surfaces to be soldered or welded, and thus promote their union.
Laminate	—A product made by bonding together two or more layers of material with adhesive. To unite layers of material with adhesive.
Martensite	—The hardest and most brittle type of steel.
Mortise	—A cavity cut into a piece of wood or other material to receive a tenon.
Oxide	—To combine with oxygen; rust and burning are common forms of oxidation.
Pickle	—A bath of acid to cleanse a metal surface in preparation for painting or soldering.
Ply	—Thickness or layer.
Rosin	—A rosin obtained from pine trees, either as a residue in the distillation of the sap (gum rosin) or as an extract of the stumps and other parts of the tree (wood rosin).
Scribe	—To scratch with a pointed instrument, such as a scriber or pair of dividers.
Sorbite	—This is a steel with less hardness than troostite, but with added toughness.
Square on	—The position of a spray gun when it is at right angles to the area to be sprayed.
Tang	—A projecting prong or tongue on a tool to which the handle is connected.
Tenon	—A projecting portion of a member left by cutting away the material around it for insertion into a mortise to make a joint.
Tepid	—Moderately warm.
Thermosetting	—Capable of being converted to a relatively infusible state (by the action of heat, catalysts, ultraviolet light, and similar means).
Tine	—A tooth on a fork or rake.
Troostite	—A steel almost as hard as martensite, but noticeably less brittle.
Turn	—To turn or round off, as on a lathe.
Veneer	—Thin sheets of material such as wood.
Viscosity	—The measure of a liquid's internal resistance to flow or its degree of thickness.

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
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Chief of Staff.

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VERNE L. BOWERS
Major General, United States Army,
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For explanation of abbreviations used, see AR 310–50.

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