CHAPTER 2

MINIATURIZED CIRCUIT EQUIPMENT

Miniaturized equipment offers the major advantages of great reduction in size and weight of components, increased life and reliability of circuitry, and reduced power requirements and heat generation. However, because of the reduced size and compactness of components, the troubleshooting and servicing of equipment containing miniaturized components has become more difficult.

Printed circuits consist of a conductive circuit-pattern of copper, aluminum, silver, or brass applied to a laminated plastic base to form the wiring. Parts are mounted on the base and soldered to the printed wiring. Printed component parts such as capacitors and inductors can be formed. A protective lacquer, epoxy, or similar finish is applied to the board to prolong the life of the board, facilitate soldering, and prevent damage due to dirt or moisture.

MIL-STD-275C, MIL-STD-429, and MIL-P-55110 provide terms and definitions, design principle, and specifications for printed wiring for electronic equipment.

Troubleshooting procedures for printed circuits are similar to those for conventional circuits; however, because of the fragile nature of the printed wiring and the composite nature of the circuitry more skill, care, and patience must be used. The principal causes of maintenance problems and failures are the application of excessive heat, pressure, and solder to components and the board.

Navy training course, NAVPERS 10558, contains detailed information and instructions on the servicing and repair of printed wiring circuits.

Transistors are designed for lower operating voltages and are particularly sensitive to overload conditions. They can be easily burned out when subjected to a slight increase above maximum allowable voltage and extreme care must be exercised by maintenance personnel when troubleshooting transistorized equipment.

2.1 SPECIAL LIMITATIONS

All personnel using or servicing transistorized equipment must be thoroughly familiar with the characteristics and limitations of the transistors used in the equipment. Before applying any test signal, the technician should check the maximum allowable current, voltage, and power dissipation of each transistor. Excessive voltage and current will not only burn out transistors but will damage associated by-pass and coupling capacitors used in transistorized circuits which are also designed for lower maximum voltages. Test Set AN/USM-206 can be used when testing transistors but due to the many types of transistors base connections care must be taken to identify the leads properly before connecting them to the tester.

2.2 SERVICING PRECAUTIONS

Transistors are generally more rugged mechanically than vacuum tubes; however, the following precautions must be taken when troubleshooting transistors to prevent damage by excessive heat or electrical overload:

a. Before troubleshooting transistor circuits, perform a visual inspection of the equipment for loose connections and broken leads and any other visual damage. Repair these defects before further examination.

b. Test equipment and soldering irons must be checked to make certain that there is no leakage current from the power source. If leakage current is detected, an isolation transformer must be used between the equipment and the power supply.

c. Ohmmeter ranges which require a current or more than 1 milliampere in the test circuit must not be used for testing transistors. Check the current passed by the ohmmeter on all ranges by setting the meter for resistance measurements and connecting a milliammeter in series with the test leads.

d. The heat applied to a transistor by a soldering iron should be kept to a minimum by using a low wattage iron (25 to 40 watts) and a heat shunt to dissipate the heat. Pointed-nose pliers, clipped on the lead to be soldered, serve as an effective heat shunt. The soldering iron should have a small tip so that heat can be applied directly to the terminal of the part without overheating the printed board or adjacent parts.

e. Battery eliminators should not be used to furnish power for transistorized equipment because of poor voltage regulation, and, possibly high ripple voltage.

f. When working on equipment with closely-spaced parts, conventional test probes are often the cause of accidental short circuits between adjacent terminals. Momentary short circuits may cause serious damage to a transistor. To avoid accidental shorts, the test probes can be covered with insulation for all but a very short length of the tips.

2.3 LOCATING BREAKS IN PRINTED WIRING

A source of intermittent or permanent trouble in printed wiring is the occurrence of small breaks in the conducting strip (foil). Some breaks will be so small as to be invisible to the naked eye, and will require the use of a magnifying glass to aid in detection. When a break in the conducting strip is suspect, the following procedure should be used in its location:

a. Use a multimeter that does not pass current in excess of one milliampere for making resistance measurements. Use needle-nose probes to penetrate the protective coating on the strip.

b. Place one probe on or close to one terminal and the other near the other end of the strip. The meter should indicate an open circuit if a break has occurred.

c. Move the probe along the strip at intervals and puncture the protective coating to make contact with the strip, when the meter indicates continuity, the break has been passed.

d. Examine the strip between the last two checkpoints on the probe and locate the break with a light or magnifying glass. Repair the break in the following manner.

2.4 REPAIR OF BREAKS IN CONDUCTING STRIP (FOIL)

Repair breaks in the conducting strip as follows:

a. Carefully scrape away the protective coating covering the area of the break. Clean the break area with a firm bristle brush and an approved solvent.

b. If the break is small, flow solder over the break area as shown in A, figure 2-1. Use a small pencil soldering iron of not more than 35 watts to prevent overheating of the strip.

c. For larger breaks, place a strip of 22 AWG wire over the break gap and solder the length of the wire to the conducting strips or terminals as shown in B and C, figure 2-1.

d. Recoat the area with an approved protective insulating finish.

2.5 REPLACEMENT OF PRINTED CIRCUIT BOARD COMPONENTS

The replacement of components on printed circuit boards should be done with care to avoid damage to the boards and, if possible, without the application of heat directly to the conducting strip. Excessive heat and sudden thermal changes may cause damage to the printed circuit conductors, semiconductors, and other heat sensitive components.

Always place a heat shield (asbestos or similar substance) between the components to be replaced and the adjacent heat-sensitive component. Also, place heat sink clamps and shunts on all leads from the heat sensitive part.

2.5.1 Removal of Axial-Lead Parts

To remove and replace an axial lead part, cut the leads as close as possible to the body of the part, then connect the leads of the replacement part to the leads remaining on the board. The cutting is accomplished with a pair of end-cutting pliers. Clean and straighten the leads remaining on the board. Fashion small loops in the leads of the replacement part, making the loop size and lead length such that the loops slip easily over the leads projecting from the board. Secure these connections by bending the old leads away from the part. Place a heat sink clamp on the lead from the board, between the board and the connection to be soldered, then solder the connection. The heat sink prevents the leads connected to the board from becoming unsoldered and causing a short or open circuit. Recoat the soldered area with an insulating compound or varnish.

If cutting the leads of a defective axial lead part would result in leads that are too short for the replacement part to be connected properly, cut the defective part in half with a pair of diagonal or end-cutting pliers. Then carefully cut away the pieces of the part from each lead. This will yield leads of sufficient length to permit the replacement part to be fitted and soldered.

2.5.2 Removal of Parts From Bonding Compound

The removal of a part imbedded in bonding compound requires great care to prevent damage to the printed circuit board or nearby parts. Applying heat to the compound may help to loosen the parts. If the part cannot be removed by heat, apply the end of a pointed tool or spade end of a screwdriver against the bonding compound between the part and the printed circuit board as shown in A and B, figure 2-2. Use the tool in such a way that it works away the bonding compound from the part to be broken away, until enough has been removed for the tool to exert pressure against the part. Keep the leverage surface area of the tool flat against the surface of the printed circuit board; this helps to prevent the tool from gouging or breaking the board. Never apply heavy pressure against a printed circuit board.

When the part to be replaced is closely positioned between other parts, it may be necessary to cut the defective part with end-cutting pliers or diagonals as shown in C, figure 2-2.

2.5.3 Replacement of Parts

After the defective part has been removed from the bonding compound, remove the leads or tabs from their terminals on the printed circuit board. Clean the area thoroughly before installing the new part. Do not remove the compound left on the board under the removed part unless its condition requires it. The mold left in the compound should be the same as the new part; thus inserting the new part in this mold helps to secure it from vibration. After repairs have been completed and the circuit tested, spray the newly soldered area with an insulating varnish or equivalent. Coat the new part or parts with a bonding compound.

2.6 REPLACEMENT OF TRANSISTORS

2.6.1 Removal

Transistors are mounted on printed circuit boards in several different ways. They may be clamp or socket mounted, or bolted through the board and bonded. The latter is the more difficult to remove. To remove a "through-the-board" mounted transistor, a drift pin or tapered rod of a diameter less than that of the transistor is required. Mount the board in a device in such a way that pressure exerted against the board is relieved by a support on the other side. Apply a hot soldering iron to the top of the transistor with sufficient pressure to remove the transistor from the softened compound and on through and out the board as illustrated in figure 2-3.

2.6.2 Replacement

Test the replacement transistor prior to installation. Preshape and cut the transistor leads as required for easy replacement. Use sharp cutters and do not place undue stress on any lead entering the transistor, as the leads are fragile. To ensure that the lead will not break off at the base, it is a good practice to use two pairs of needle-nose pliers. With one pair grasp the lead close to the transistor base while shaping the rest of the lead with the other pair. After the remaining pieces of the defective transistor terminal leads have been removed and the terminals on the board are cleaned, connect the new transistor to its proper terminals. Test the circuit to ensure that it is operative, then, using bonding compound, rebond the transistor to the board. Do not use heat to rebond replaced transistors or other semiconductors.

2.7 REPLACEMENT OF MULTILUG COMPONENTS

2.7.1 Removal

To remove and replace a multilug transformer, choke, filter, or other similar potted, canned, or molded part, release the part from its mounting before disconnecting or cutting its conductors. Before applying pressure to remove such a part, inspect it carefully to be sure that the part is completely free of all its connections to the printed circuit board, and that all bent or twisted mounting lugs have been straightened; otherwise you may break the board by applying pressure to it. Do not wrench or twist a multilug part to free it, as this may cause the conducting strip to become unbonded from the board. Work this type of part in and out in line with its lugs, while applying a hot soldering iron using a bar type tiplet adapter or similar tool as shown in A, figure 2-4.

When possible, cut the conducting or mounting leads and lugs of the defective multilug part on the mounting side of the board as shown in B, figure 2-4. Heat and straighten the clipped leads with a hot soldering iron and slotted soldering-aid tool (or slotted soldering iron tiplet or similar desoldering tool) applied to the circuit side of the board; pull the leads or tabs through with pliers as shown in C, figure 2-4.

2.7.2 Replacement

To replace the new multilug part, check to be sure that all of the lead holes or slots are free and clean, allowing easy insertion of the multilug part. Do not force the part; if it does not position easily, check and rework the terminals and holes or slots until it does seat freely, then proceed to solder.

2.8 REPLACEMENT OF TUBE SOCKETS

2.8.1 Removal

Remove tube sockets, whether mounted on the wiring side or the component side of the board as follows:

a. Heat each lug until the solder melts and the lugs break connection to the conducting strip. Clean with a stiff-bristled brush and then insert a knife blade between each lug and the conducting strip and bend the lugs until they are perpendicular to the board.

b. Apply heat to the tubular center connection and, as the solder melts, slowly pull the socket away from the board.

c. Inspect the conducting strip and, if damaged, repair as suggested in paragraph 2.6. Clean the area with a brush and approved solvent.

2.8.2 Replacement

Insert the new tube socket in the same position as the old socket and solder the lugs to the conducting strip. Coat the area with an approved insulating varnish being careful to mark the socket holes.

2.9 REPAIR OF BROKEN PRINTED CIRCUIT BOARDS

It may be possible to repair broken printed circuit boards in an emergency when no replacement board is available. Figure 2-5 illustrates various methods which can be used.

If the board is only cracked, drill a hole at the end of each crack to prevent lengthening of the crack and place a conductive material across the defective area. If a small part of the board is broken off, it may be rebonded with a nonconductive cement.

If the above does not hold satisfactorily, form wire staples cut from solid conducting wire of the diameter and length required, depending on the width of the conducting strip to be repaired. Drill holes slightly larger than the diameter of the wire through the conducting strips about 1/4 inch from each side of break and insert the staples. Insert additional staples at all possible points to give the board more support and alternate the staples from the top and then the other side, bending the ends flush against the board. Rebond any loose conducting strips with a nonconductive bonding cement, then apply nonconductive cement to both sides of the break and joint the section together. Solder the staples to the conducting strip. When repairs are completed, clean both sides of the break with a stiff brush and solvent. After the board is dry, coat the area with an approved epoxy resin or similar compound.

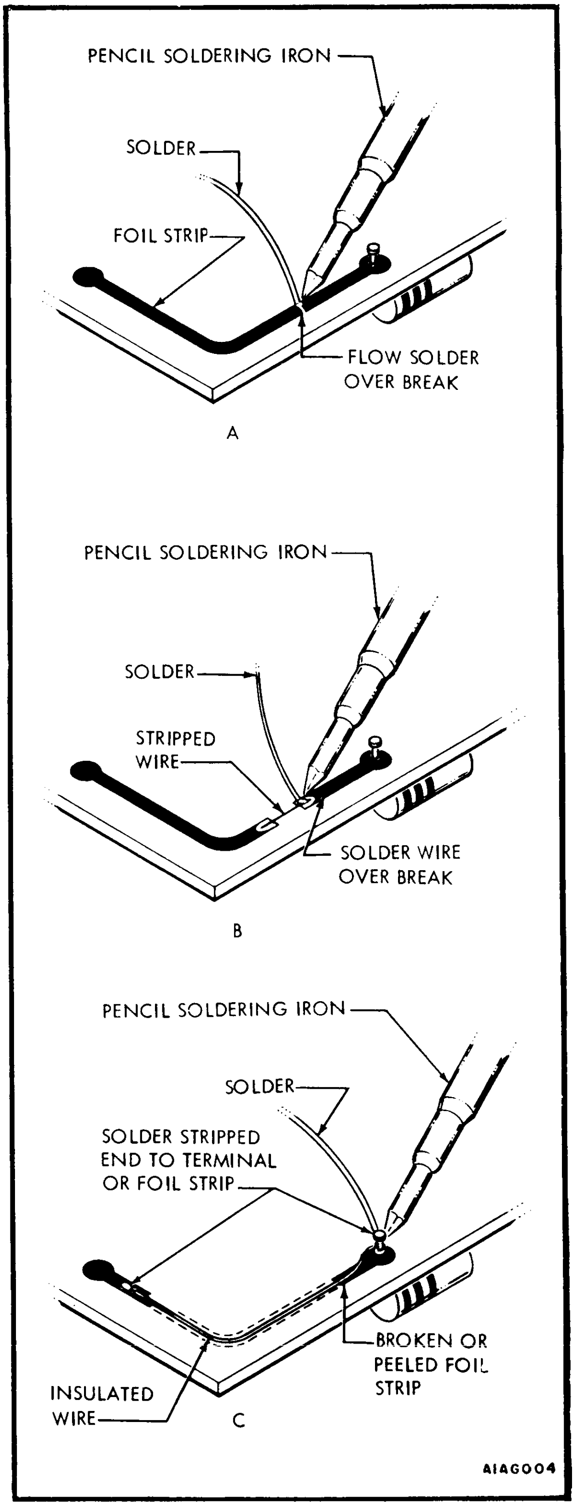

Figure 2-1. Methods of Repairing Broken Conducting Strips

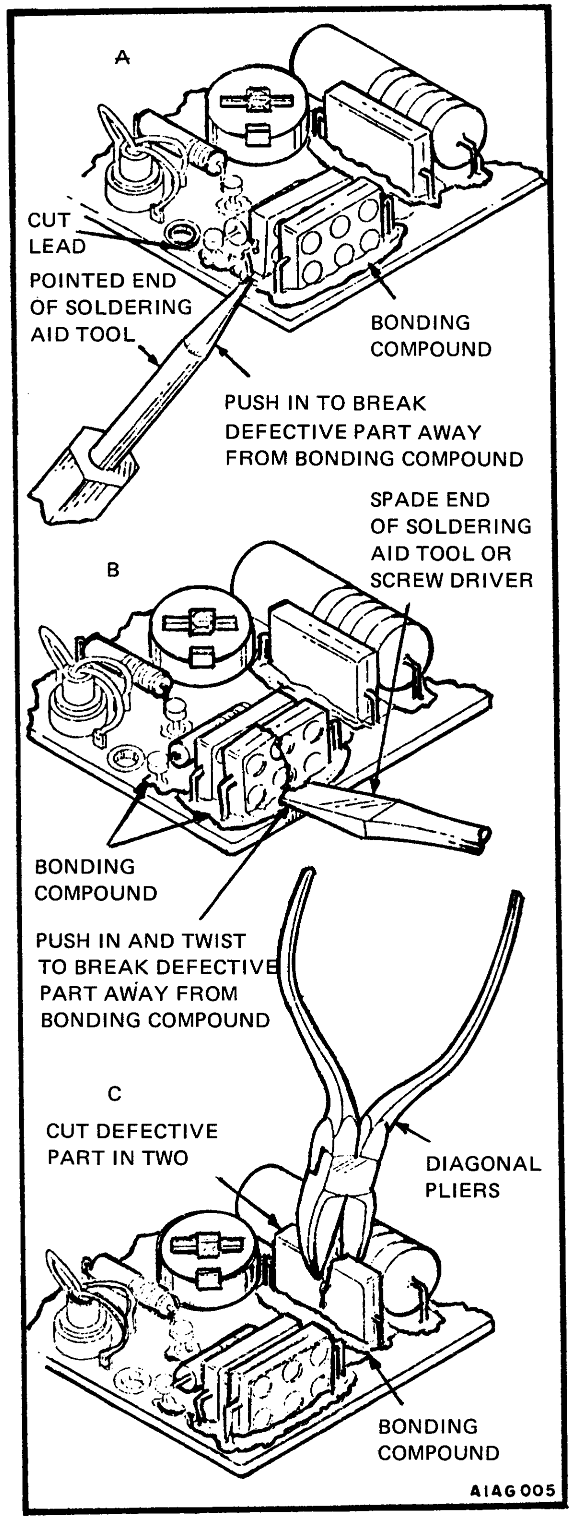

Figure 2-2. Separation of Part From Bonding Compound

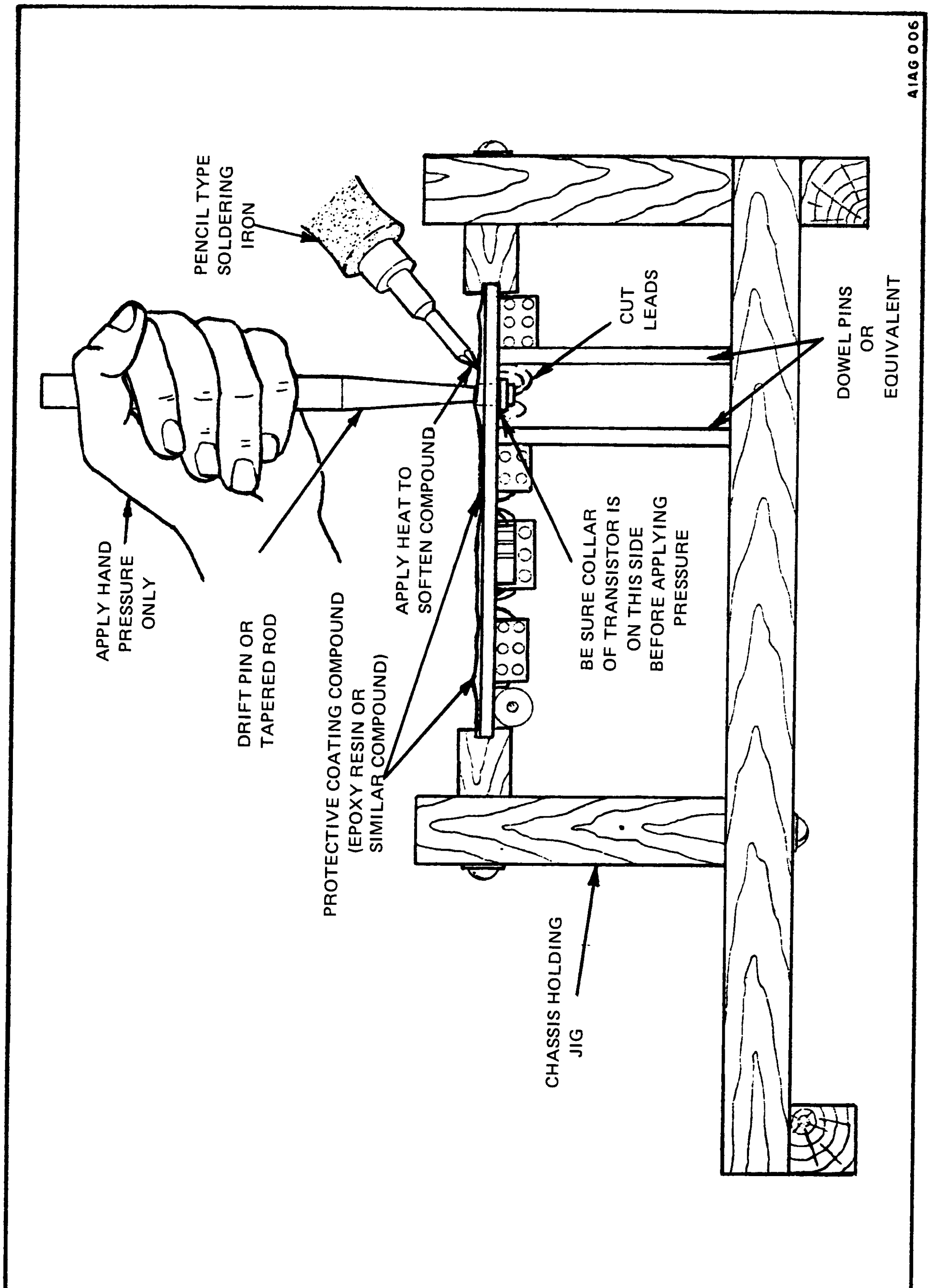

Figure 2-3. Removal of Transistor Through-Mounted

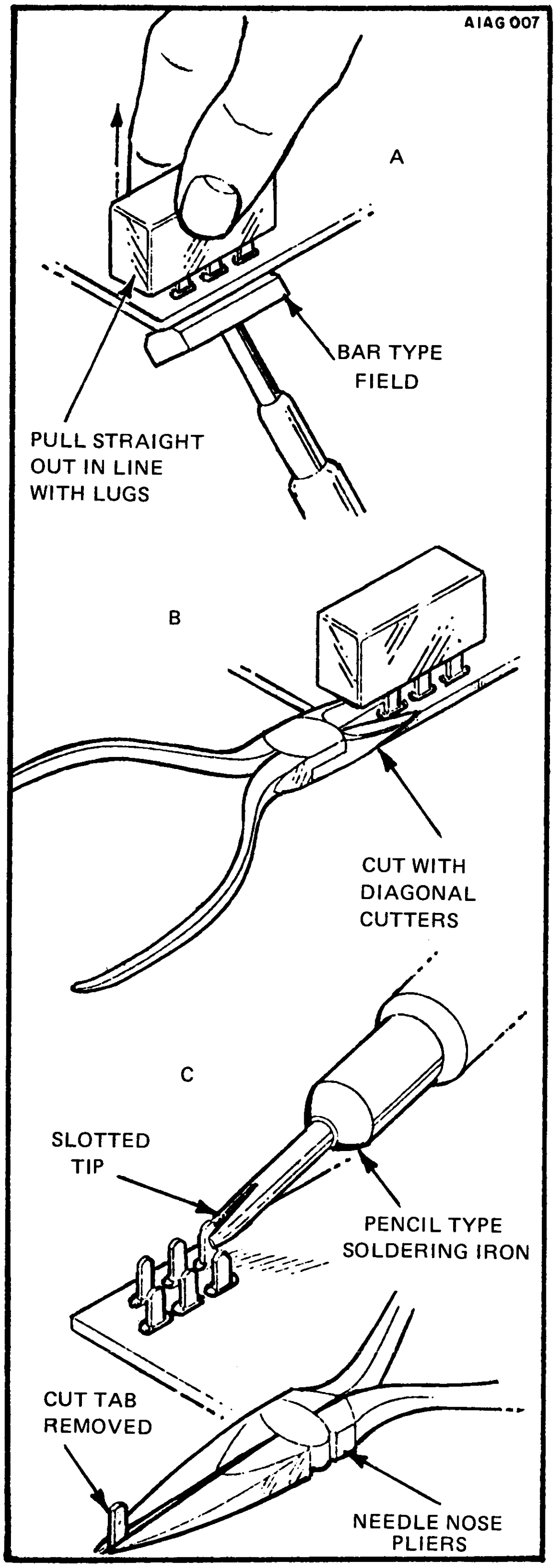

Figure 2-4. Removal of Multi-Lug Part

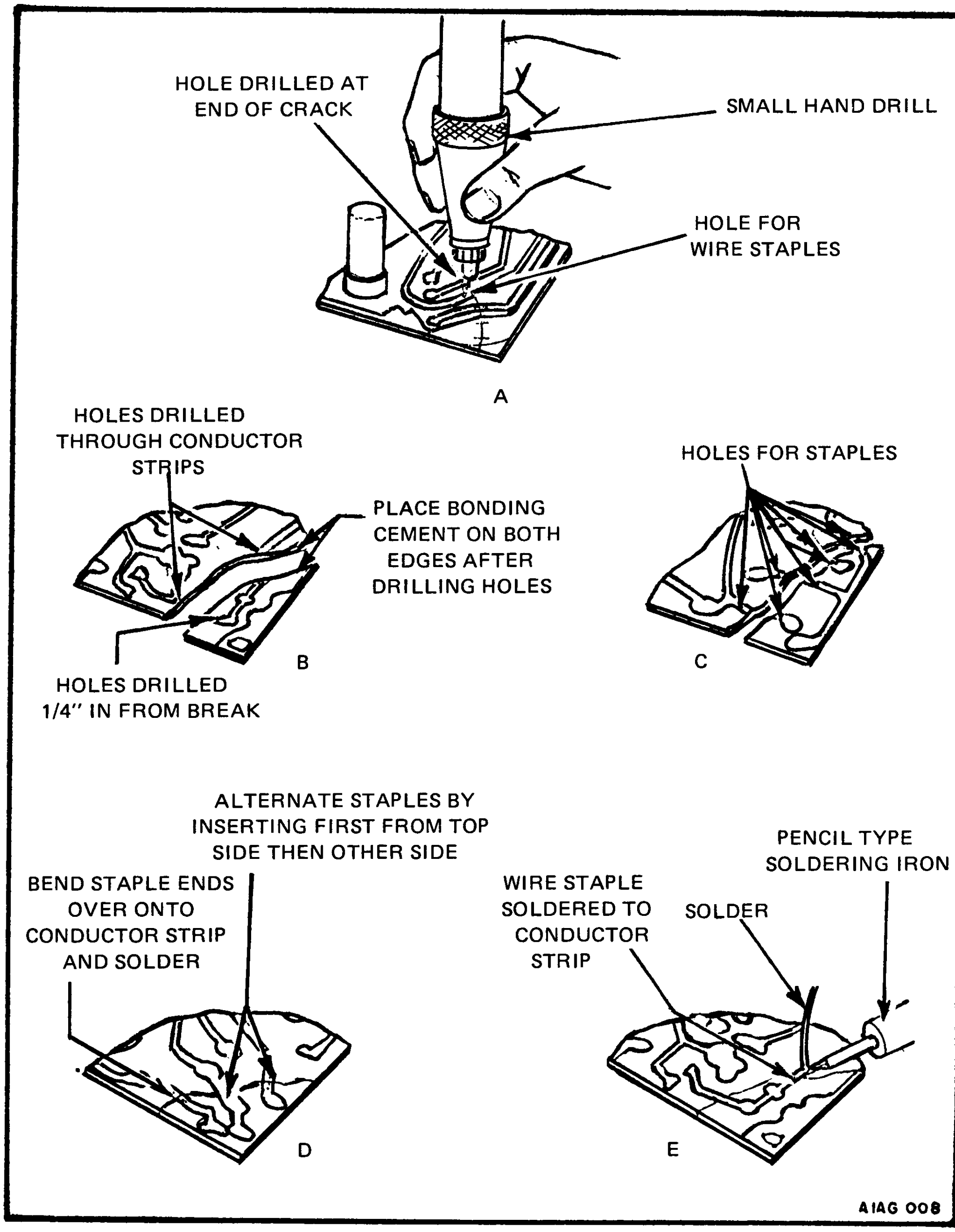

Figure 2-5. Emergency Repair of Broken Printed Circuit Board