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Proper Electronic Wiring Techniques

By the Engineering Department, Aerovox Corporation

THE old adage that warns that "a chain is no stronger than its weakest link" is nowhere truer than in the art of electronic wiring. Especially in today's advanced circuitry, where *ruggedization* and *reliability* are the keynotes, proper wiring is a prerequisite. Where the destination of a guided missile, the proper functioning of an airport blind landing radar equipment, or the final answer of an electronic computer may depend upon any one of thousands of tiny soldered connections, meticulous attention must be paid to such small details. Even in the research and development field, it is impossible to estimate how many important experiments may have failed because trivial circuit troubles masked the desired results. And in less glamorous applications, such as the telephone industry and the radio and television manufacturing and servicing fields, the extra effort expended in producing dependable wiring has been found to pay dividends. For these reasons, a working knowledge of the proper methods of producing a neat, dependable wiring job are required of every technician and engineer in the field of electronics.

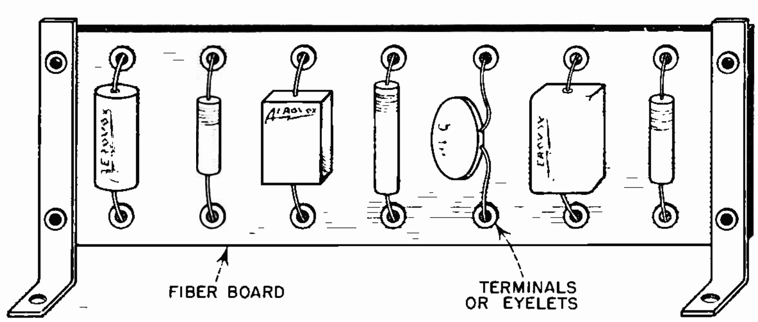
The basic steps in wiring an electronic device are essentially the same regardless of whether the unit is an entire telephone central office or an a.c./d.c. midget radio chassis. They are:

(a) Mounting the circuit components.
(b) Wiring and cabling.
(c) Connecting and lead dress.
(d) Visual inspection.
(e) Electrical inspection.

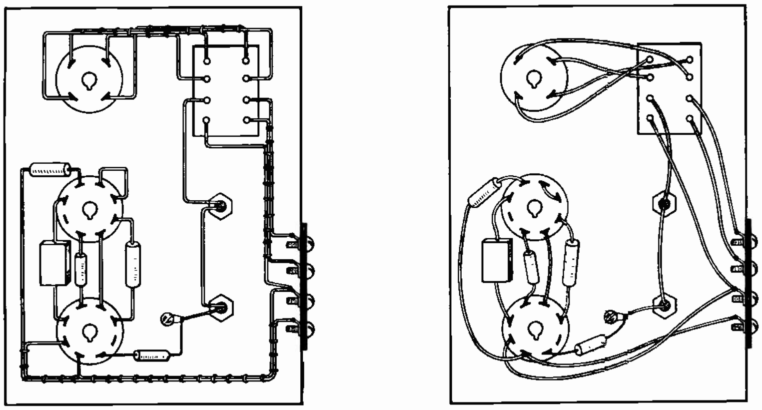
This article discusses these wiring operations in some detail, with special emphasis on (b) and (c).

Mounting Circuit Components

Here it is assumed that the circuit lay-out has been engineered so that the components are located in the unit in positions which give short lead lengths for critical circuits, minimize the effects of hum fields radiated by chokes and transformers, and places temperature sensitive components in the most desirable environmental locations. This lay-out is usually arrived at by using a "mock-up" of the unit and parts and moving the parts around until a suitable arrangement is found. The lay-out en-



USE OF TERMINAL BOARD FOR RELIABLE MOUNTING OF SMALL COMPONENTS
FIG. 1



COMPARISON BETWEEN "CUSTOM" AND "STANDARD" WIRING

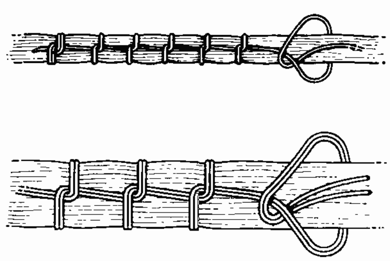
FIG. 2

gineering should also provide for the use of the components which have the most suitable terminal arrangements for that particular job.

When all parts have been located, the chassis holes required to mount them are drilled or punched. For reliability, all parts except small capacitors, r.f. chokes, and resistors which are light enough to be self-supported on their wire leads must be securely fastened to the chassis. Strip-type terminal boards of the kind illustrated in Fig. 1 are useful for mounting such small components. All other components must be securely attached to the chassis. Where wires must go through metal panels or chassis, the holes should be suitably insulated. Rubber *grommets* are used for low voltage leads and ceramic *feed-thru* insulators are employed for high voltage circuits. These precautions improve the reliability of the circuit by providing additional electrical insulation and prevent the rough edges of the hole from chafing the wire insulation.

Wiring and Cabling

When all circuit components are mounted, the unit is ready for wiring. If the unit is a one-of-a-kind wiring job, the wires may be run individually from one terminal to another, working from the wiring diagram. The routing of the wires depends upon the nature of the circuit, the permanence of the wiring, and the allowable cost of the job. In low-cost production wiring, such as is found in broadcast receivers and television sets, direct point-to-point wiring is employed, without much regard to appearance. In "custom" wired units, such as commercial communication equipment, telephone central office equipment, and quality audio equipment, all wiring and component parts



SINGLE AND DOUBLE LACING STITCH

FIG. 3

are kept parallel to the sides of the chassis, so that the finished job presents a neat, "right-angled" appearance. Where groups of wires take the same path, they are "cabled" or "laced" together with waxed cord. The comparison between a chassis wired in this manner and one in which point-to-point wiring is employed, is shown in Fig. 2.

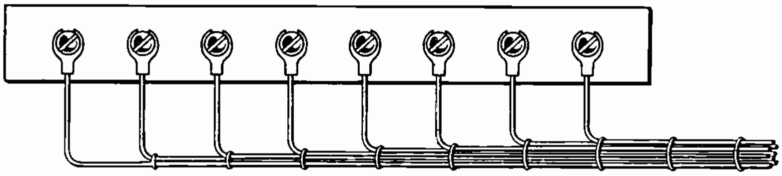
The proper use of the techniques of lacing wire forms is a sure mark of the skilled wiring technician. The lacing stitch illustrated in Fig. 3 is standard throughout the Bell System and is simple and efficient. Note that the parts of the lacing cord which run parallel to the wires emerge from *under* the part that encircles the wires. This stitch is self-locking and will remain tight even when the stitches on either side of it are cut. Wire forms which run from one chassis to another in a relay rack, as well as within-the-chassis wiring, present a much neater appearance and are stronger and more dependable if laced together in this manner to form a compact cable. Lacing also provides an index to the proper location of wires on a terminal strip or other circuit component by "breaking-out" each wire at its proper location with a separate stitch, as illustrated in Fig. 4. This allows the wires to be disconnected at any future time and subsequently returned to the proper terminals.

If more than one unit of a kind is to be wired with cabled wires, or if an especially neat job is desired, the production technique of using a "forming board" is employed. This consists of a large wooden board (Fig. 5) on which pegs or nails are laid out to represent the shape the laced wire form must take. Holes may also be drilled through the board at the location of each terminal to which the wires must be connected. The location of bends and terminals on the forming board are determined by carefully measuring the corresponding distances between the components in the chassis or between chassis. Then the individual wires are run between the proper points on the board as indicated by the wiring diagram. Unskilled labor can perform complex wiring in this manner with few mistakes, since the forming board can be clearly marked with numbers or color coding to indicate the proper points of attachment for each wire as well as its proper routing and sequence in the wiring operation. The end of each wire is anchored on the board by wrapping it around a nail or peg placed in a position representing the location of the terminal it will ultimately be connected to. Enough excess should be allowed to permit stripping the insulation to the proper length. If holes are used in the board to "fan" the wires through at the desired locations, the points of attachment will be on the back side of the forming board.

When all of the wires have been run on the forming board, they are cabled together while still on the board. Here they are usually more accessible than in the chassis, making for a faster and neater job. The wires may also be stripped of their insulation and readied for connecting after the cabling is complete so that they are held firmly in the positions they will assume in the chassis.

Connecting and Lead Dress

Connecting is the operation of electrically attaching the wires to the component terminals. The type of connection employed depends on the kind of terminals provided on the circuit components. These may be binding screws, soldering lugs, or directly soldered connections. Soldering in some form is employed in all of these methods but in none of them



USE OF LACING STITCH AT TERMINAL STRIP

FIG. 4

should the strength of the joint depend upon the strength of the solder. A firm mechanical attachment must be made between the wire and the terminal which is independent of the solder.

In the binding screw type of connection where soldering lugs are not used, the wire should be "tinned" with solder and then formed into a *clockwise* loop around the screw, so that it will tighten as the screw is tightened. If soldering lugs are used, the grippers on the lug are crimped around the insulation on the wire for mechanical strength and the bared tip of the wire is soldered to the lug. For directly soldered connections, the well-cleaned wire is wound once around the pre-tinned terminal for strength before soldering. Winding the wire around the terminal more than once usually makes subsequent removal of the connection difficult.

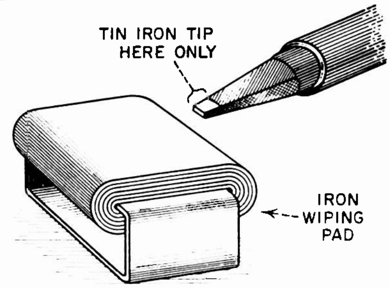
The main secrets of producing good soldered connections are the preparation of the joint to be soldered and the maintenance of the soldering iron. Of course, the materials used play an important part also. Tinned wire of the "push-back" variety should be used where possible for ease of "skinning" and connecting. The solder for all radio wiring should have a rosin flux in the core and be a high tin content alloy.

If enameled wire is used, the insulation must be stripped back and the enamel scraped off to expose the bare metal. Otherwise, a dependable soldered joint cannot be made. The methods used to strip the insulation from hook-up wire depend upon the kind used. Most types are conveniently stripped by crushing the insulation with long nose pliers and dressing the frayed ends with the diagonals. For the tougher types of insulation, such as the cellulose acetate braided kinds, a stripping tool is required. Care must be exercised to prevent "nicking" the wire during stripping and cleaning, as this frequently results in a broken connection later. As mentioned above, when the wiring is done by running the wires between holes in a forming board, the wires can all be skinned at one time by reversing the board and removing the insulation to the right length.

To produce a clean, dependable soldered connection, the soldering iron must be of a type well adapted to the job and carefully maintained. A versatile type of soldering iron tip for general connecting is shown in Fig. 6. The tip should be dressed frequently with a file and tinned while still bright only on the surface indicated in the drawing. The remaining parts of the tip should be allowed to oxidize. An iron tinned in this manner can be used in close places where it is necessary for it to touch other connections without flowing them since the oxide acts as a heat insulator.

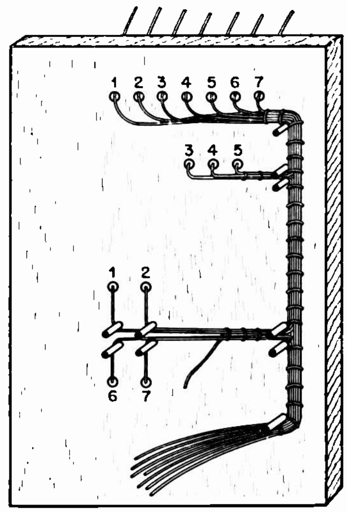
The tinned portion of the soldering iron tip should be wiped on a canvas or leather pad attached to the soldering iron stand before each use. This removes excess solder and "slag" and delays erosion of the tip. This operation greatly improves the quality of the job.

In the actual mechanics of soldering a connection, the professional wireman does not apply the solder to the iron and transfer it to the joint being soldered. Little flux reaches a joint soldered in this manner. Instead, the well cleaned iron is applied to the junction of the wire and terminal until both have been heated to near the soldering temperature. Then the solder is applied between the iron and the connection until it flows



PROPER TINNING OF SOLDERING IRON TIP

FIG. 6



ILLUSTRATING USE OF CABLE FORMING BOARD

FIG. 5

freely around the junction. A rotary motion of the wrist which "rocks" the iron tip on the joint will serve to work the solder into the joint. The finished connection should be rounded and smooth and the solder should have a bright, shiny appearance. If the joint is disturbed before the molten solder has solidified, the solder will look dull and "sugary" and must be melted again.

After the wires have been connected, the leads are dressed to improve the appearance of the wiring job. The insulation on each wire is pushed up against the terminal so that no exposed wire is visible. A small amount of slack is left in each wire to facilitate future reconnecting and to remove tension from the soldered joint.

Visual and Electrical Inspection

Before a newly wired circuit is placed in actual operation, it should be subjected to both a visual and electrical inspection so that any wiring errors can be eliminated before the application of operating voltages causes damage to circuit components.

The first inspection should consist of a thorough visual examination of the wiring to detect shorts caused by blobs of solder or loose wire ends between terminals, poorly soldered joints, broken wires or terminals, etc. When such defects have been rectified, the circuit should be given an electrical continuity test with an ohmmeter or lamp or buzzer tester. Short circuits between wires and to ground should be tested for as well as electrical continuity between points indicated as common on the circuit diagram.

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