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Simplified Subminiature Assemblies for Experimenters

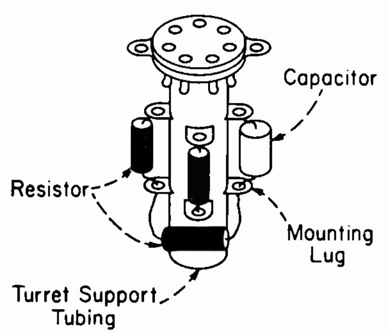
By the Engineering Department, Aerovox Corporation

SUBMINIATURE electronic components of many types now are available to the experimenter without procurement priority rating. Aside from transistors, there are tiny vacuum tubes, capacitors, resistors, crystal diodes, transformers, potentiometers, rotary selector switches, pilot lamps, coils, chokes, meters, and batteries, all obtainable at any well-stocked parts distributor.

Availability of these parts will enable the experimenter to subminiaturize various pieces of his equipment. In addition, there is the intriguing challenge to create new equipment of the personal-portable type. But the average hobbyist who has concentrated on the conventional chassis-and-panel type of electronic construction discovers considerable personal clumsiness and lack of mechanical ingenuity when first attempting to work with subminiature components. This article will explain how simple assemblies may be made using these parts. Its purpose is to show how to do a satisfactory job without special tools. These discussions supplement those on printed-circuit techniques (See *Aerovox Research Worker*, April 1951 issue) which dealt with an entirely different method of sub-miniature circuit construction.

Turret Sockets

One of the simplest devices for compact miniature construction is the turret-type tube socket, also called a *socket turret*. As shown in Figure 1, there is attached under this socket a short length of insulating tubing (the "turret") around which mounting lugs are fastened. Circuit components may be attached by means of their pigtail leads between these lugs and from lugs to the socket contacts. Complete amplifier, oscillator, and control circuits may be assembled around a tube in this fashion and can be installed or removed as units. The only external connections required are for the operating voltages and coupling between stages. Socket turrets are available in miniature, as well as octal, types. While the socket turret is not a true *sub*-miniature component, its small size and the compactness it provides aid materially in reducing the dimensions of equipment which normally is spread over and under a chassis.



TURRET-SOCKET METHOD OF MOUNTING COMPONENTS
FIG. 1

Terminal Boards

The small *terminal board* is a simple and straightforward supporting medium for circuit components in subminiature assemblies. Complete stages and circuits, as well, including small supply batteries, can be assembled on small boards or cards of this type. This type of construction often is employed in hearing aids, test instruments, pocket radio receivers, and similar devices which do not employ printed circuits.

Figure 2 shows three representative types of terminal boards which can be made easily by the experimenter. Each uses a thin sheet of bakelite or fiber as the board. The first unit (Figure 2A) employs ordinary soldering lugs for terminals, and these are held in place by short machine screws and nuts. The lugs also could be rivetted in place, but most experimenters do not have the tools or machines to do this job.

Figure 2(B) shows a board made up with the popular turret-type pin terminals of the CTC (Cambridge Thermionic) and USES (United States Engineering) types. Advantages of

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this style of terminal are its smaller size, rigidity, and provision in each terminal pin of several grooves for attaching separate pigtails. In general, it is easier to tie leads to and remove them from the turret terminal pins than from lugs. Turret-type terminal boards are available ready-made in several sizes and with various numbers of pins. The pins can be bought separately and fastened to an individual terminal board with simple tools.

The board shown in Figure 2(C) eliminates all lugs, pins, and other terminals, substituting pin-holes through which the pigtail leads of the components are passed and drawn tightly. On the other side of the board, the leads may be interconnected, as required by the circuit, or attached to those of other components. This type of construction provides mechanical support for the components, as well as permitting a direct and easy method of wiring the circuit. Elimination of the protruding terminals usually found on a terminal board further reduces the space and weight totals of the assembly. Using the "pin-hole" terminal board, it is possible to build an entire unit of equipment (including several stages) using only the pigtails of components for mounting and wiring. It is possible at the same time to obtain a tight construction. Single-end-mounted components, such as subminiature tubes, may be tied down by means of strap-clamps or clips.

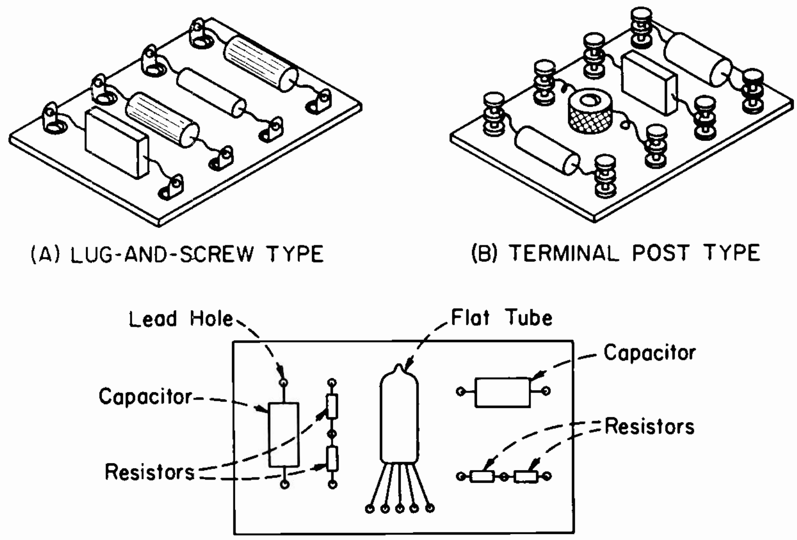
Components may be mounted on both sides of any type of terminal board. The pins or lug-screws then may be utilized to carry connections through the board, or the leads themselves passing through the pin-hole board may be attached directly to those of components on the reverse side of the board.

Board-assembled circuits subsequently may be encased or may be potted as will be described later in this article.

The board-type subminiature assembly is compact and usually represents the smallest size and lightest weight attainable in a particular construction, short of printed circuitry. It has the slight disadvantage, however, that components sometimes are not easily removable by unsoldering when replacements must be made. This is true particularly of the pinhole-type board and to a lesser extent of those boards using pins or lugs.

Well-Block Housing

The mounting shown in Figure 3 is a solid block of some insulant, such as bakelite or other plastic, with holes or "wells" cut to hold capacitors, resistors, and other components. Lugs are attached also to the sides of the block for the attachment of external components. Well-blocks of this sort are used in some multimeters to contain the multiplier and shunt resistors.



(A) LUG-AND-SCREW TYPE

(B) TERMINAL POST TYPE

(C) SELF-SUPPORTING "LEAD-THRU-HOLE" TYPE

TERMINAL BOARD METHOD OF MOUNTING

FIG. 2

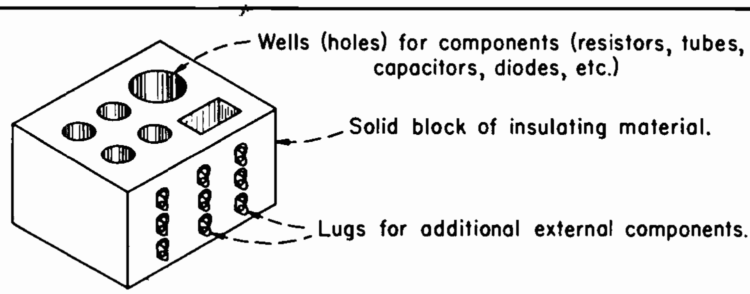
After wiring is completed, panels may be attached to the top and bottom of the structure to enclose the components completely.

The well-block has the advantages of solidity and rigidity. However, components, such as heated tubes and resistors, which require the free circulation of air for cooling cannot be placed in the wells.

Component Combination

Component combination refers to associating two or more components intimately in a mechanical construction, in order to conserve space. Examples are: a coil wound on the insulating body of a resistor, a trimmer capacitor mounted inside a coil form, a coil wound around the glass envelope of a vacuum tube, and a shunt resistance element painted on the bakelite case of a capacitor. This technique is an invaluable aid to subminiaturization when it does not degrade the electrical performance of the circuit.

Whether component combination can be employed successfully depends upon the pertinent factors in an individual case. For example, the Q of a coil is lowered by conducting components within its field. Thus, the advisability of mounting a trimmer capacitor inside a coil form depends upon how much Q reduction can be tolerated in the coil. The same applies to a resistor made to function as a coil form. A coil wound on the glass envelope of a vacuum tube



WELL-BLOCK MOUNTING SCHEME

FIG. 3

might have its characteristics altered not only by the presence of the metallic electrodes of the tube within its magnetic field but also by heating from the tube.

Before undertaking component combination, it is advisable to make actual tests of the effects upon electrical characteristics of one component by the proximity of the other. In this way, the feasibility of the combination may be established, or a more efficient way of mechanically combining the components devised.

Aside from the chance of altering electrical characteristics (principally capacitance, inductance, and Q) in combining components, the greatest interference perhaps arises from heat. A coil, capacitor, diode, transistor, or thermistor will, unless it is suitably temperature-compensated, exhibit instability when closely associated with a hot resistor or tube. And the addition of correct compensating devices often defeats the original purpose of size reduction.

Potting Subminiature Circuits

A technique which has found wide acceptance in commercial subminiaturization is that of *potting*. This refers to the practice of casting the component assemblies into a solid block or capsule of insulating material. The end result is a compact, neat, and rigid assembly which resists mechanical and electrical disturbance. Large-scale potting of subminiature circuitry is found in the radar and guided missile fields.

There are many materials and methods of potting. Some are older than radio itself but have been employed for some time. Well-known examples are the potting in waxes of transformers, chokes, capacitors and similar components.

Although casting of multiple components has many advantages, its full usage in the electronic industry is retarded by certain drawbacks. These include the additional weight, higher cost and the fact that the failure of one potted component necessitates the discarding of the entire cast assembly.

The modern media for potting subminiature electronic circuits are "polymerizing" synthetic resins which "cure" from a liquid to a rigid solid with or without the application of cast.

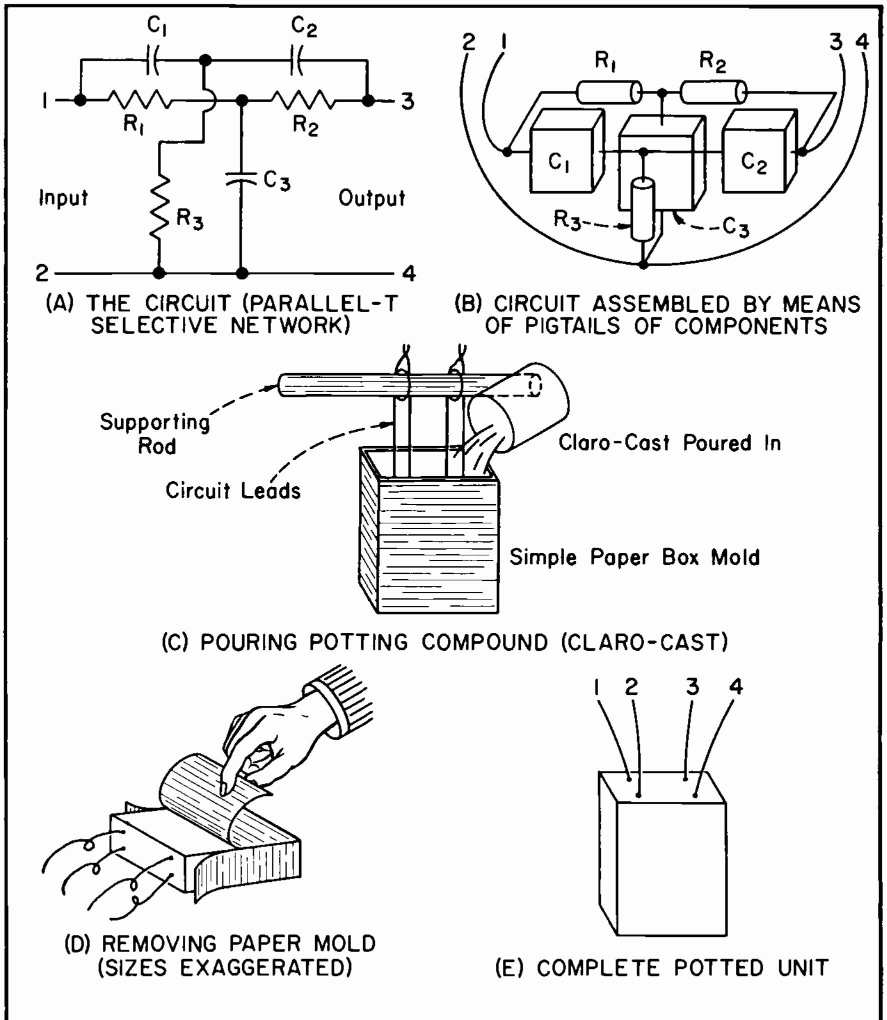
There are many casting materials (aside from coil dope, which does not set up quickly and satisfactorily) which can be handled by the amateur. A popular one in the electronic industry is an epoxy type casting resin which sets up at resin temperature after it has been mixed with a "hardener". Another one which is easy to use in the small shop is a polyester type resin which "cures" in a similar manner. While this material is used extensively by hobbyists for the mounting of flowers, insects, coins, medals, etc., it also has good electrical characteristics and can thus be used successfully for electronic potting.

Figure 4 illustrates typical steps in assembling a miniature electronic circuit and imbedding it in a block of polyester resin. A parallel-T selective R-C network has been selected for illustration.

Figure 4(A) shows the circuit, and 4(B) the components assembled by the direct connections together of their pigtail leads. The assembly then is hung in a mold made of a small paper box. The inside of this box must be lightly coated with furniture wax or soap. The hanging is shown in Figure 4(C).

The casting material is prepared in the following manner: Work outdoors or in a well-ventilated room. Measure out the amount of resin liquid required with a tablespoon. Add 1 drop of the supplied hardener for each tablespoon of resin. Stir the mixture thoroughly, allow to stand for 5 to 10 minutes, and break any bubbles with a straw or long toothpick. Pour the mixture into the mold slowly, avoiding bubble formation. The mixture will thicken and jell. There will be heating due to chemical action. Allow to cool slowly to room temperature. After 8 hours, the mold may be removed (See Figure 4D) if the mass has hardened sufficiently. An alternative procedure for fast hardening and curing is, after the mass has cooled to room temperature, to heat it for 30 minutes in an oven at 160° to 225°F.

The potted block is transparent and colorless and will reveal the imbedded components and wring.



STEP-BY-STEP PROCEDURE IN PLOTTING SUBMINIATURE CIRCUIT

FIG. 4

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