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A FAST AND ECONOMICAL TECHNIQUE FOR WELDED CORDWOOD ELECTRONIC MODULE FABRICATION

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SUMMARY

A reliable technique for the fabrication of welded cordwood modules has been developed that is faster and more economical than most other techniques for small quantities or for prototypes. It utilizes a molded plastic preform which retains the components during welding. The preform adds mechanical strength to the unencapsulated circuit and provides a means of centering and holding it in a conventional potting shell. Approved welding and encapsulating techniques may be used to enable the module to be readily flight qualified.

INTRODUCTION

In the fabrication of electronic devices for space applications it is often necessary to produce one or a relatively few modules of a given type. These may be special circuits for use in an otherwise integrated system, one of a kind circuits in a cordwood system, or possibly last minute modifications. In any of these cases the requirement exists to produce a small number of circuit modules quickly and with a minimum of effort. In many cases the modules must also meet rigid environmental requirements. Because of the small quantity required, a standardized procedure that eliminates fabrication of special jigs, fixtures, or molds, as well as much of the drafting, is desirable.

The technique to be described meets these requirements quite well over the limited range of circuits that it has been applied to. This includes predominantly digital logic circuits requiring 3 to 8 transistors and up to 33 additional axial lead components. The maximum number of components was limited in this particular case by the availability of only one preform and shell combination. Extension of this technique to larger modules should be practical; in fact, it might result in improved component density.

DESCRIPTION OF TECHNIQUE

The essential feature of this technique is the use of a molded plastic preform, sometimes called a nesting jig, to retain the components during fabrication and testing. This preform also facilitates encapsulation when used with a conventional potting shell. All experience to date has been with the one preform and shell combination shown in figure 1. Although relatively small, it has proven to be quite versatile and easy to handle for circuits within its limitations.

Four large holes through the preform were provided originally to accept standard TO-18 transistors. With the increasing availability of transistors in TO-47 and TO-56 cases the same preform can accommodate up to eight transistors in these sizes if they are placed back to back from each face. Axial lead components fit in the 33 smaller holes, which are provided with lands at one end to retain the components during the welding operation. These holes are 0. 1 inch in diameter, which is sufficient to accept most RN 55 size resistors, ceramic capacitors up to 1000 picofarads, tantalum capacitors to several microfarads, and many diodes. Some diodes used were slightly larger than 0. 1 inch, in which case the holes were successfully enlarged by drilling. Although not a desirable operation, drilling out a few holes when necessary for slightly larger components eliminates the problems of sloppy fit of the normal size components that would result if larger holes were used originally. A second argument against enlarging the hole size as originally molded is the resulting increase in overall size. This would be necessary because the present wall thickness between holes is about as small as practical.

Provision for feedthrough of wires was not made in the preform since the holes required are too small to be economically molded. Space is provided for 12 drilled holes, as shown in figure 1.

Passive component leads are usually used for the inputs and outputs of the module. The fit between components and the preform is sufficiently close to locate the leads quite accurately. If more accurate location is required, drilled holes could be provided; however, this has not been necessary for the one preform used by the author. Any passive component lead could be used for an input or output connection, but it has been found desirable to use every other one around the periphery of the module. This gives a maximum of 12 leads. When all or most of these leads are used, a dummy lead for keying is added. This is necessary because of the otherwise perfect symmetry of the module.

Use of a preform also facilitates the welding operation. Since each component has a hole that will retain it, components can be inserted as they are welded together and excess lead material immediately trimmed off. This simplifies the welding procedure in that it is not necessary to work on a module with many protruding leads as in the Mylar film technique. Since components can be inserted at any time, it is also practical to weld up particularly difficult sections of a module with a preform as a jig and then transfer the completed section into the final module. This technique can aid materially in fabricating cirucuits with a high connection density such as are encountered when duel transistors in six lead TO-18 cans are used. Using a preform also eases the welding process by providing a rigid assembly for the operator to grasp.

After welding, the completed circuit module is rigid enough to be readily handled and tested before potting. Small reusable matrix jacks, which will accept nominal 0. 025 inch leads, have been used very successfully in both module testing and building of experimental logic networks.

Testing completed, the assembly is slipped into a potting shell and filled with a suitable encapsulant. Projections on the faces and sides of the preform center it in the shell and ensure proper flow of encapsulant. Any type of encapsulant can be used (e. g. , rigid epoxy or polyurethane for permanent encapsulation or a silicone resin if repairability is desired). Ease and quality of plotting are enhanced by the elimination of dividing planes, which are present when Mylar film techniques are employed, and the fact that each component is initially well supported by the preform, which reduces the effect of small voids.

Figure 2 shows some typical modules in various stages of completion. In the foreground is the preform, shell, and components. Behind, from left to right, are shown a welded assembly ready for testing, a preform and circuit in the shell ready for potting, and a finished module potted in clear silicone resin. The particular module shown is a micropower flip-flop circuit containing 4 transitors, 11 capacitors, and 12 resistors. The overall size is 1 inch square by 1/2 inch deep, and the weight is just under 1/2 ounce. As can be seen on careful examination, three holes for axial lead components were unused.

Comparing these dimensions to those for similar modules designed for minimum size and weight shows some increases. Volume and weight are increased by approximately 75 and 30 percent, respectively. It is felt that this is not a serious drawback to this technique, particularly since part of this increase can be saved by eliminating the potting shell. A mold would then be required for encapsulation, but most of the other desirable features of this method would be retained.

None of the modules fabricated to date has been fully flight qualified; however, some have been subjected to thermal and vibration tests. Modules using glass-filled diallylphthalate preforms and shells which were potted in silicone resin have been tested over the temperature range -75^{o} to 175^{o} C. All held up perfectly, showing no mechanical or electrical degradation. Vibration tests of an astable multivibrator were also run with the module under power. No failures occurred when it was vibrated along two major axes at a constant amplitude of 0. 4 inch and frequencies of 20 to 45 cps, at an amplitude of 0. 3 inch and frequencies of 45 to 100 cps, and at 76 g's over the frequency range 105 to 10 000 cps. No visible damage occurred, and the circuit functioned electrically both during and after the test.

CONCLUSIONS

A construction technique has been described that facilitates the fabrication of small lots of welded cordwood circuits. It has the advantages of being extremely flexible and requiring no special jigs, fixtures, or potting molds[1] and a minimum of layout time. The fact that the preform and shell add considerable structural support makes it possible to use relatively soft silicone resins as encapsulants, which add the feature of repairability. Welding and potting using this technique are also faster and easier than with other methods. Availability of molded parts in many colors also simplifies circuit identification.

The applications for which this technique was developed were not particularly sensitive to cost. However, this technique turned out to be considerably less expensive than those previously used. This technique should also be useful for commercial applications where cost is a major factor. Slight modification of the preform design to eliminate all machining and the use of inexpensive molding materials should lead to a very flexible and economical module system.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, November 23, 1965.

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[1] Tooling is required for the preform and shell; however, many standard shells are commercially available.

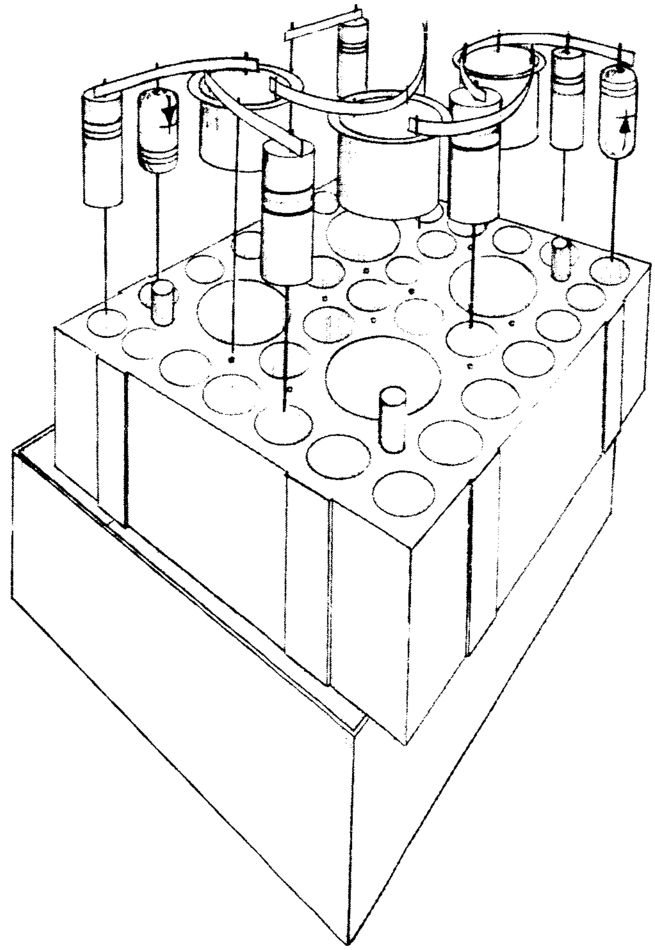

Figure 1. - Exploded view of module.

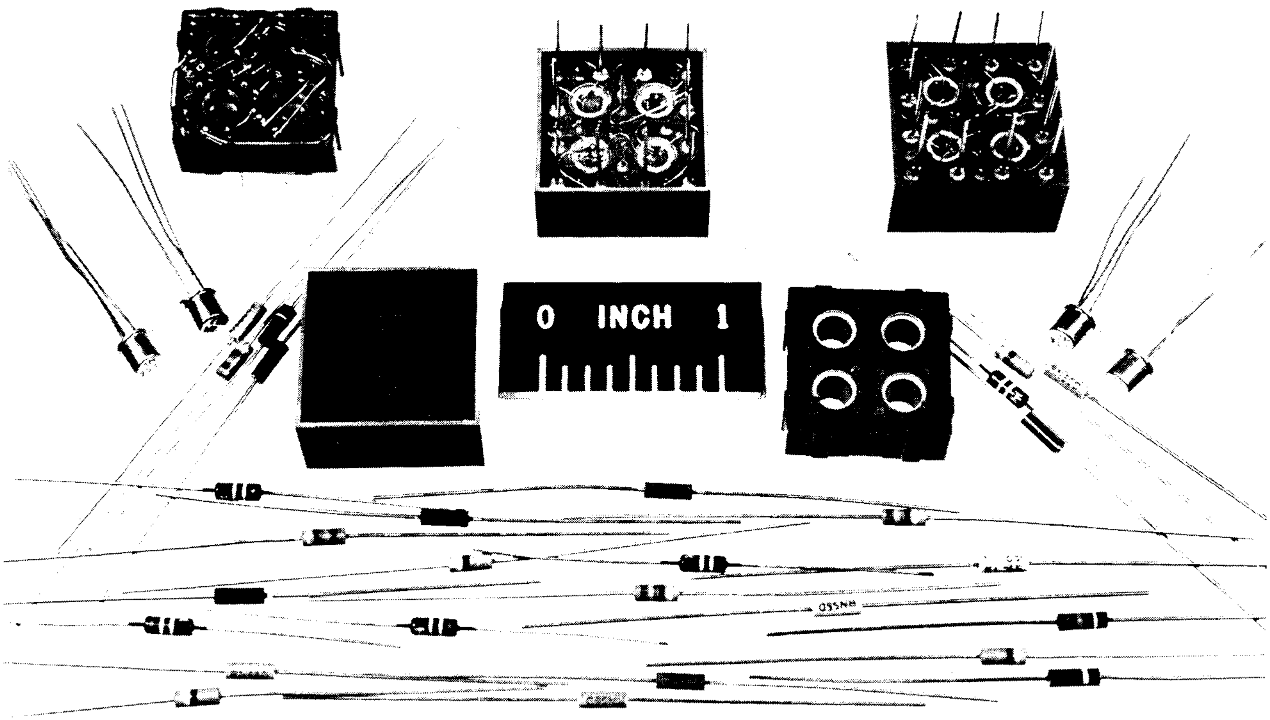

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Figure 2. - Steps in module construction.

NASA-Langley, 1966 E-3230