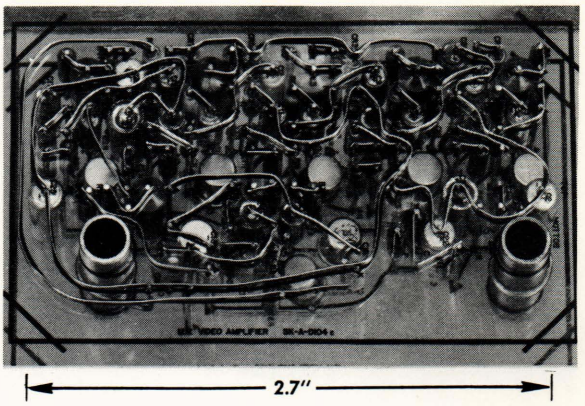
"WELDED CORDWOOD"

Last Step in Conventional Circuits?

A technique of "3-D" welded-circuit assembly has been developed after more than three years of investigation at APL, producing electronic packages that may be hard to improve upon with conventional components. The Laboratory has been a leading proponent of this type of packaging, long recognizing the need for increased reliability, reduced size, and lighter weight. Development of the new technique was the work of the Laboratory staff, chief among whom were F. R. Muccino and co-workers, encouraged and assisted by R. T. Ellis and K. G. Dyer. The cooperation and efforts of Autonetics, Convair, General Electric, Hughes Aircraft, Sippican Corporation, Weldmatic, and WEMS, Inc., who were independently and simultaneously making studies in this field, made possible the rapid development of this process.

The present welded circuitry evolved gradually. Initially, it was intended to reduce weight and cost by eliminating castings, machined parts, and brackets through the use of rigid potting. The usual printed circuit board not only occupied considerable volume but reduced reliability by use of soldered connections. Elimination of this board allowed greater use of available volume through use of the third dimension. At the same time, welding was investigated as a modern electronic packaging technique.

The technique is simple. Miniature components, active and passive, selected for uniformity of size, are stacked together as a pile of cordwood, but with welded interconnections. A schematic diagram is converted to a three-dimensional layout by placing all components vertically in such an arrangement as to provide short interconnections. The connection scheme employs top and bottom patterns that duplicate the electrical schematic. These are reproduced actual size on thin Mylar film, which is then punched to permit insertion of the component leads in the appropriate holes between the top and bottom films. The leads are then clipped off 0.1 inch from the film to accommodate nickel interconnecting ribbon. The ribbon is then welded to the stubby leads, following the pattern photographically reproduced on the Mylar film. Finally, the assembly is potted with one of many different compounds, as determined by such local conditions as stress, temperature, and electrical properties.



A typical example of a high-reliability type of welded module; 100 parts are contained in this assembly, occupying only 4 cubic inches.

The inherent superiority lies in the weld, which is subjected to rigorous metallurgical examination to assure complete bonding.

Military usage and space requirements impose severe limitations on any electronic packaging system. To evaluate this new technique, therefore, one must measure its effectiveness in terms of size, weight, reliability, and cost.

Many missiles and space vehicles perform complex computations of the analog or digital variety, often both, with the data-handling capabilities normally requiring bulky wiring and mechanical supports. Welded cordwood circuits take less space and weight than conventional circuit assemblies.

Reliability of the welded cordwood technique can be directly attributed to several factors: minimum handling of components; leads are never bent; components are not internally heated during the welding operation; and welded joints are far superior to soldered joints since they are permanently bonded. The use of pretested components offers another assurance of reliability through experience.

The simplicity and ease of assembly yields a low cost, highly reliable package. Heat damage during manufacturing is completely eliminated thereby reducing the loss of expensive components.

Already in use in missiles and space vehicles, welded cordwood is assured a useful future in electronic packaging.