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RSIC-534

ELECTRONIC PACKAGING: A BIBLIOGRAPHY

by

J. W. Klapheke, W. H. Veazie,
J. C. Holt, and J. L. Easterday

March 1966

Contract DA-01-021-AMC-11706(Z)
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31 March 1966 RSIC-534

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ABSTRACT

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This annotated bibliography of selected reports, journal articles, and manufacturers' literature on electronic packaging provides a literature basis for electronic packaging engineers to design more reliable, maintainable, and adaptable electronic equipment for aerospace application. The literature search of abstract publications, published bibliographies, specialized information centers and services, and computer searches by Redstone Scientific Information Center and Defense Documentation Center resulted in the 476 abstracts in this bibliography which were selected from an initial review of approximately 3,000 articles.

Subject indexing is provided by properties and environmental effects on packaging materials, discrete parts to module packaging, integrated circuits to module packaging, module packaging to assembly, housing and mounting, packaging products, and interconnection techniques. Author and corporate author indexes are included.

FOREWORD

This report presents abstracts of pertinent reports, magazines, and technical publications concerned with various aspects of electronic packaging. The objective of this survey, requested by Astrionics Laboratory, George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Alabama, is to present a comprehensive description of current electronic packaging techniques and procedures. The study is intended to provide basic information for the electronic package designer.

Major sources of information for this survey include computerized reference surveys at Redstone Scientific Information Center and Defense Documentation Center, Battelle Memorial Institute's library, and information centers and services.

Abstract publications and journals reviewed in this literature survey were:

1) Abstract Publications

   a) Electronics and Communication Abstracts
   b) Reliability Abstracts and Technical Review
   c) Science Abstracts - Electrical Engineering
   d) Solid State Abstracts

2) Journals

   a) IEEE Transactions on Reliability
   b) IEEE Transactions on Parts, Materials, and Packaging
   c) IEEE Transactions on Space Electronics and Telemetry
   d) Electronics
   e) Electronic Design
   f) Electronics Procurement
   g) Electromechanical Design
   h) Electronic Capabilities
   i) Electronic Products Magazine
   j) EEE Circuit Design Engineering Magazine
   k) Electronic Packaging and Production
   l) Electronic/Electromechanical Production
   m) Electronic Evaluation and Procurement
   n) Electronic Design News
   o) Electro-Technology
   p) Electronic Industries
   q) Systems Design

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CONTENTS

LITERATURE REVIEW

The purpose of this effort was to survey the open literature for current information on electronic packaging techniques and procedures. Most of the recent work encountered dealt with properties and environmental effects on packaging materials and products, circuit layout, environmental conditions and control, encapsulating compounds, potting compounds, coatings, and interconnection techniques. Areas of relatively little information include constraints, stability criteria, physical arrangement of modules, tubing, and sleeving. A general summary of each section of the bibliography is given below.

1. Introduction

Three articles that pertain to Section 1.1 were obtained. The articles introduce the reader to the micromodule concept and some basic ideas in packaging.

2. Glossary and Definition of Symbols

Two reports that would help the reader understand basic terms in electronic packaging are listed in this section. Since there are no standards for the various terminologies used in electronic packaging, a section such as Section 2 would have to be compiled and written from the references given in the bibliography.

3. Properties and Environmental Effects on Packaging Materials and Products

A significant amount of information is available for this section. General information is listed after Section 3. Low pressure and thermal environments on metals are discussed in Section 3.1, followed by a similar discussion on insulators and natural and synthetic rubbers (Sections 3.2 and 3.3, respectively), although source material in this general area seems to be limited. Section 3.5 (metal compatibility) contains information on fatigue, corrosion, and reliability of various metal-to-metal contacts. Section 3.4 on other packaging materials and products is somewhat broad. Included are discussions on adhesives, encapsulants, dielectrics, laminated plastics, etc.

INTRODUCTION

At the request of the Redstone Scientific Information Center, Battelle Memorial Institute has prepared an annotated bibliography on various aspects of electronic packaging. The report is intended to give the electronic package designer a source of information for obtaining current packaging techniques and procedures.

The literature search was conducted by information specialists from Battelle Memorial Institute's Information Operations Division with active technical guidance and review by electrical engineers from the Advanced Electronics Division.

Approximately 3,000 articles, covering the time period 1960 through 1965, were screened. Of these, 1,000 full-length articles and reports were reviewed and 476 were selected for abstracting and indexing according to a revised subject outline (see subject index) and for assignment of serial accession numbers. Following each categorical breakdown of the subject outline for the bibliography are the abstract accession numbers which apply to that specific category. Thus, if the subject of interest were in properties and environmental effects on metals, the user would check all of the accession numbers following Section 3.1, which are 25, 43, 44, 91, 142, 143, and 472. The applicable category numbers assigned to each item in the subject breakdown are also included at the end of each abstract.

4. Discrete Parts to Module Packaging

This section is weak in several areas. For instance, information on signal paths, constraints, and environmental conditions, in general, but particularly in acceleration and sterilization, is limited. Section 4.3 (reliability, maintainability, and adaptability) contains general information; but no specific examples are cited.

5. Microcircuit to Module Packaging

The literature contains general information on primary circuit layout, very limited information on isolation, stability, and constraints, and nothing on signal paths. Sections 5.2 and 5.3 (environment and reliability, maintainability, and adaptability, respectively) also contain very little literature.

6. Module Packaging to Assembly

A useful discussion on layout and electrical shielding is presented; but it is limited in stability of modules, and there is nothing in the area of isolation of modules. Ample information on physically arranging specific types of modules and various mechanical considerations is presented; but specific information on environmental considerations is very limited.

7. Housing and Mounting

General information on special types of packaging techniques and amplifier housing procedures is included.

Section 7.1 (materials) includes discussions on modular racks, cabinets, various enclosures, and standard prefabricated parts for enclosures. Section 7.2 (fastener application) presents clamping techniques for cables and assemblies; but this area could use more practical techniques than are presented by the available literature.

Literature on environmental control (Section 7.3) consists of blowers, fans, cooling liquids, etc. However, specific information on various types of environments was very limited. Reliability, maintainability, and adaptability (Section 7.4) presented interesting ideas, but nothing concrete.

8. Packaging Products

Section 8 presents an overall picture of the available packaging products. For instance, Section 8. 1 (wire and cables) includes information on flat conductors, power wire, shielded wire, flat cables, etc. However, the abstracts listed under Section 8. 2 contain only limited information on tubing and sleeving, that is, heat shrinkable tubing and thermofit insulation sleeving. Information on encapsulating compounds, potting compounds, and coatings (Section 8. 3) was very complete. Included was literature on properties of basic encapsulants, working characteristics of thermoplastics, elastomers, and ceramics. Epoxies, potting compounds, and coating material are also included. Section 8.4 (connectors and other interconnections) discusses electrical and mechanical connectors, terminal strips, terminals, printed circuit connectors, flat cable electrical connectors, etc. Section 8. 5 (insulation) presents information on dielectric insulators and thermal insulators, while Section 8. 6 (other packaging products) discusses electrical types, switches, and miscellaneous items.

9. *Interconnection Techniques*

This section presents a comprehensive discussion on various interconnection techniques. Included are various aspects of welding techniques (spot welding, fusion welding, resistance welding, flash welding, etc.), soldering techniques (hot air soldering, dip soldering, etc.), wire crimping techniques, wire wrapping techniques, and other interconnection methods.

0007
MICROMINIATURIZATION IN ELECTRONICS
Jeffries, Paul, Industrial Electronics, October, 1962, pp 22-24

A brief survey of the three most popular techniques - micromodules, microcircuits and solid circuits - being developed to reduce the size and weight of electronic apparatus and at the same time increase its reliability and reduce the cost is presented.

5.1, 5.145, 6.1

0008
SURFACE EFFECTS OF RADIATION ON TRANSISTORS
Peck, D. S., Blair, R. R., Brown, W. L., and Smits, F. M., Bell Systems Technical Journal, 17, January, 1963, pp 95-129

Observation of surface effects of gamma radiation on several types of transistors indicates that in reverse-biased devices these effects occur at much lower radiation dosage than in unbiased devices or bulk semiconductor material. Further, the total radiation dose rather than dose rate seems often to be the more important factor in the effect. The effects seem to arise from ionization of gases within a transistor encapsulation and interaction between the ionized gas and residual semiconductor surface contaminants. This results in inversion layers at the device surface and thus in alteration of junction characteristics. The changes in device properties are not permanent, but the recovery after removal from radiation is complex and proceeds with characteristic times between seconds and days. Different types of devices may respond quite differently to exposure, and the response is different even between different batches and individuals, indicating a dependence upon device processing.

4.29

0009
A COMPARISON OF PERMANENT ELECTRICAL CONNECTIONS
Mills, G. W., Bell System Technical Journal, 43, (3), May, 1964, pp 1067-1102

A comparison of soldered, solderless wrapped, percussive welded, and resistance welded permanent electrical connections under environmental conditions of vibration, shock, temperature extremes, corrosion, humidity, and bending is presented. Only high quality connections were included and they represented the current state-of-the-art for each type. Under these conditions the connections showed no significant degradation in their electrical characteristics as long as they remained mechanically secure. Differences in the four types of connections were therefore assessed in relation to their mechanical characteristics. One of the most important results of the study was the recognition of fatigue life as the most important mechanical connection characteristic when comparing connections which meet Bell System standards for electrical stability. Using fatigue life as a basis for comparison and soldered connections as a reference standard, the major conclusions with regard to the connection of wires to terminals, such as surface and local cable wiring are as follows: (1) monitored percussive welded connections are superior to soldered connections; (2) over-all, solderless wrapped connections are essentially equivalent to soldered connections; (3) resistance welded connections are significantly inferior to soldered connections.

9.1, 9.2, 9.4

0010
RECENT ADVANCES IN MICROMINIATURIZATION, RELIABLE COMPONENTS AND COOLING TECHNIQUES
Dummer, G.W.A., Solid-State Electronics, 2, (1), 1961, pp 18-34

Research conducted at the Royal Radar Establishment on electronic components, constructional techniques for equipments, including microminiaturization and cooling methods is summarized. In microminiaturization techniques maximum attention has been given to the solid-circuit approach, with microcircuit on flat plate or circuits being developed to obtain experience with film components. A schematic diagram is given for a liquid cooling system. Results obtained on the use of miniature wrapped joints as reliable connections in supersonic aircraft radar applications are discussed. Wrapped joints, using terminals of monel metal, have been used instead of plugs and sockets, also for connection of components operating at audio and video frequencies. These wrapped joints are also being used for interconnection of sub-units in a missile system. The miniature wrapped joint is of interest as a means of automatically assembling micro-miniature wafers.

7.3

0011
PACKAGED ELECTRONIC CIRCUITS INVOLVING...PRINTED CAPACITORS AND RESISTORS, CAPACITOR SUPPLEMENTS, ADJUSTABLE RESISTORS, AND ACTIVE COMPONENT PACKAGES
Khouri, A. S., Electrical Manufacturing, 64, (4), October, 1959, pp 164-166

Packaged circuits based on printed resistors and capacitors used in electronic equipments to interconnect active components such as electron tubes and semiconductor devices, or fabricated and encapsulated with subminiature tubes or semiconductors to make completely self-contained circuit stages are discussed. The basic package layout is built around a printed-circuit ceramic plate and supplemental components together with specially designed and positioned terminal hardware for attachment to other circuit elements. Circuit connections between printed capacitors and printed resistors are obtained by geometric extension and overlapping of patterns. Shielding patterns or composite plate construction using a ceramic dielectric substrate is briefly discussed. Where rating tolerances of printed circuits are wider than those called for in specific applications, one answer is to adjust one or more of the sensitive components while in operation. Flat printed-circuit bases are adaptable to the inclusion of adjustable components for this purpose. This procedure also enables circuit constants to be adjusted to the individual variations occuring in the active components.

5.1

BIBLIOGRAPHY

0001
COOLING ELECTRONIC EQUIPMENT
Kraus, Allan D., Prentice-Hall, Inc., Englewood Cliffs, N. J., 1965, 390 pp.

This book presents techniques which should be used by thermal specialists and electrical engineers to produce electronic systems which will perform reliably and to the necessary accuracy. The introductory chapters cover basic heat transfer principles. The subject of electronic system thermal analysis is introduced by a discussion of vaporization cooling of electronic systems. A comprehensive review of thermal analysis of specific electronic components is provided. Data and design procedures for thermoelectric coolers are included with the book concluding with discussion of system optimization and trade-off, dimensional analysis and the correlation of test data and thermal considerations for Spacecraft.

7.3

0002
ELECTRICAL ENCAPSULATION
Volk, Marie C., Lefforge, J. William, and Stetson, Russell, Reinhold Publishing Corporation, N. Y., and Chapman & Hall, Ltd., London, Eng., 1962, 228 pp.

This book has been written to serve as a guide to practical electrical encapsulation. Information is included on properties and characteristics of encapsulation materials to aid in the selection of the correct material for a specific application. Typical cured properties of basic encapsulants; working characteristics of thermoplastic, thermosets, elastomers, and ceramics and the trade names and manufacturers of encapsulating materials of interest to electronic packaging are tabulated. Step-by-step procedures are given for the processing of specific encapsulations which are typical and of broad and general application. Included are case historys in encapsulation, finishing and testing of completed encapsulations.

3.4, 8.3

0003
FLAT CONDUCTOR WIRING SYSTEMS FOR FEDERAL AND COMMERCIAL APPLICATIONS
Angele, Wilhelm, National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Ala., Paper presented at the National Technology Utilization Symposium in Huntsville, Ala., April, 1965, 15 pp.

General information is given on cable types, materials, design standardization, installation, performance, advantages and present limitations, savings in weight and cost are mentioned. Flexible printed cable is very adaptable to the various needs of diagram configurations, conductor widths, and termination designs, however, it is somewhat limited in conductor thickness. Laminated cables made by precisely spacing parallel flat conductors sandwiched between plastic films of suitable electrical and mechanical properties are also discussed. The termination and connector design developed by NASA is described. Flat cable is worthy of consideration when it would be used for measuring, signal, and control cables, especially where reliability, light weight, and low overall cost are essential. Installation techniques for flat cablés are relatively simple, however, the exact routing is best determined after the equipment to be connected is installed.

8.1, 8.4

0004
FATIGUE IN METAL JOINTS - 2 - WELDED JOINTS
Crum, Ralph G., Machine Design, 32, April 13, 1961, pp 176-178

The fatigue resistance of welded joints depends on the designer and fabricator. This article considers specification of high-quality weldments and presents curves for estimating fatigue life of spot-welded and fusion-welded joints. The determination of design strengths using simplified data from modified S-N curves is discussed. (See 0022 for part 1 of this article)

3.5, 9.1

0005
RELIABLE ELECTRON BEAM WELDED MICRO-CONNECTIONS
Garibotti, D. J., and Lane, W. V., Electronics Reliability and Microminiaturization, 2, August, 1963, pp 81-97

A high density termination modular interconnection system has been developed using electron beam joining techniques. The techniques are applicable to most wafer dimensions and geometry. The interconnecting system consists of ten stacked micro-assembly wafers interconnected on 0.025 inch centers by twenty electron beam welded copper ribbons on each of the four sides. The techniques have been demonstrated to be very reliable on the basis of statistical analysis of pull strength, weld resistance, thermal shock, ambient temperatures from -55 C to 200 C and vibration tests. Approach to and techniques for testing micromodules are given.

5.145, 9.1

0006
SEMI-AUTOMATIC WELDING WITH FINE WIRES
Brimble, R. V., Lucey, J. A., and Tait, D. B., British Welding Journal, 7, (5), May, 1960, pp 342-352

The welding of thin materials such as those used in microelectronic circuits is facilitated by the use of slope-controlled power sources and the positional welding of steel and stainless steel using dip transfer discussed in this paper. Metal transfer studies using short-circuiting arcs have shown two distinct types of transfer; 1) dip transfer in which the electrode tip dips into the pool of molten metal; 2) droplet dip transfer in which a droplet forms on the end of the electrode before short-circuiting to the plate. Self-contained welding guns which will handle 0.030 to 1/16 inch diameter aluminum alloy wires and 0.047 inch diameter ferrous wires at wire feed speeds from 100 to 900 inches per minute are discussed. Economic and technical advantages of the new thin wire techniques are briefly presented.

9.1

0012
CHOICE OF FLUIDS FOR COOLING ELECTRONIC EQUIPMENT
Knights, Alex. F., Electro Technology, 71, June, 1963, pp 57-63

Physical properties of coolant fluids and their effects on cooling design are discussed. For eight gases H_2, He, SF_6, CH_4, NH_3, CO_2, 40% He and 60% SF_6 and Freon C-318 and eight liquids 100% ethylene glycol, 70% ethylene glycol, N-butyl alcohol, FC-75, Pentane, Freon 22, SF97 (20), and Coolanol 35 two comparative-performance indices are developed: the heat-transfer/pumping-power index, and the ducting-weight index.

7.3

0013
THE EFFECTS OF VAN ALLEN BELT RADIATION ON MATERIAL
Shane, Robert S., IRE International Convention Record, 9, Pt. 5, March, 1961, pp 129-138

This paper is a discussion of the interaction of the Van Allen Belt with certain components including resistors, capacitors, diodes, transistors, and bolometers and materials including insulation. An estimate of the effects of Van Allen radiation on various materials and components is included as an extrapolation of data secured from nuclear fission fragment bombardment and gamma irradiation.

3.2, 4.29

0014
CONNEXIONS TO PRINTED-CIRCUIT BOARDS
Hix, K. W., Post. Office Electronic Engineers Journal, 57, Pt. 1, April, 1964, pp 22-26

This article describes some of the methods that have been used for making connections to printed-circuit boards employed on telecommunications equipment. No single method of making connections to printed-circuit boards has established its superiority over the remainder, and the choice is frequently dependent upon the designer's outlook and the factory facilities available. The British Post Office Engineering Department has issued a general specification for connectors used with printed wiring. The ultimate choice for a particular equipment depends upon an assessment of the cost and of the reliability requirements.

8.4, 9.5

0015
A NOVEL SOLUTION TO THE INTERCONNECTION PROBLEM IN MICROSYSTEM CIRCUITS
Robinson, Thomas L., Proceedings of the National Electronics Conference, 18, 1962, pp 642-668

At present, modules cannot be tested or replaced without great difficulty because of the interconnection methods employed. Plugs, sockets and wiring harnesses occupy more space than the equipment they connect. Based on a versatile printed circuit transfer process, this paper presents one solution to the interconnection problems. A detailed description of the transfer process is given including the operations of metallizing, printing and electroplating a circuit on a temporary carrier sheet. Techniques are shown for transferring the resulting electroplated circuit pattern from the carrier sheet to substrates for interconnecting thin-film circuits, and for interconnecting discrete dot and pellet components. Additional applications of the circuit transfer process are discussed, which included two methods for producing multilayer circuits, (1) a room temperature operation with only contact pressure, and (2) a laminating operation using heat and pressure. Details of a new approach to encapsulation in which components are electrically attached to the electroplated circuit on the carrier sheet and tested before encapsulation are given.

5.1, 8.3, 9.

0016
STEADY-STATE RADIATION EFFECTS ON ELECTRONIC COMPONENTS AND CIRCUITS
Magee, R. M., Proceedings of the National Electronics Conference, 19, 1963, p 603-618

Nuclear radiation effects on electronic components from steady-state radiation environments are reviewed. Much of this work relates to semiconductor devices, which are the most radiation-sensitive components usually encountered in electronic systems. Emphasis is placed on: 1. Variation of radiation effects with particle energy for neutrons, protons, and electrons. 2. Relative effects of different kinds of radiation, including neutrons, protons, electrons, and gamma rays. 3. Radiation-induced surface effects in transistors. 4. Reliability predictions based on statistical analyses of effects. The use of this kind of component information in circuit design applications is discussed. Various techniques, such as derating, redundancy, and feedback, may be used to increase the radiation-tolerance of circuits. Some specific development efforts leading to more radiation-tolerated components for future use are field-effect transistors, TIMMS, and Circuitrons.

4.29, 6.49, 7.4

0017
THE EFFECT OF ELEVATED TEMPERATURE ON FLASH-WELDED ALUMINUM-COPPER JOINTS
Dixon, C. R. and Nelson, F. G., Transactions of American Institute Electronic Engineers II, 78, January, 1960, pp 491-495

The most common type of connection for aluminum and copper is the bolted joint, as when an aluminum bus bar is bolted to a copper stud. While this type of connection is satisfactory, frequently a more efficient and less bulky connection, with better appearance, can be made by flash welding. Tests to evaluate the effects of elevated temperatures are described for flash-welded joints using improved techniques. From tests of almost 500 joints, the effects of heating on tensile strength, ductility, resistance to impact, and electrical resistance were determined. The average strengths of the welds are at least 10,000 psi when heated as high as 300 F for 2 years, 370 F for 1 year, 450 F for 144 hours, 500 F for 36 hours, 600 F for 2 hours, or 700 F for 5 minutes. The strengths of individual welds, however, may drop below 10,000 psi when joints are heated 48 hours or more at 500 F, or when heated for shorter times above that temperature. There was no evidence of embrittlement at any of the heating conditions used.

3.5, 9.1

0018
THE ROLE OF INTEGRATED ELECTRONICS IN FUTURE ARMY DIGITAL COMMUNICATIONS AND DATA PROCESSING SYSTEMS
Ziegler, Hans K., Signal, July, 1965, pp 43-44

The U. S. Army Electronics Command position toward integrated electronics is briefly presented in the four examples of miniaturization of military communication equipment. The reduced size and weight saving features of integrated electronics are related to improved mobility characteristics.

5.14

0019
COMPUTER FOR AEROSPACE APPLICATIONS
Disch, Leonard, Monitor, 3, (1), 1965, pp 18-22

Some initial considerations in developing the A-212 general purpose computer for aerospace applications indicated that monolithic integrated circuits should be used. The reasons for selecting the current-mode logic (MECL) as the most satisfactory monolithic integrated circuits available for this application are discussed. The A-212 contains the equivalent of 20,000 conventional components through the use of integrated circuits in a 950 cubic inch volume. The system used 1200 integrated circuits. The extremely high lead-density of these devices requires the use of sub-assembly techniques. Three levels of interconnection are used, the smallest of which is the module. Four basic module designs were used in order to accommodate the various circuits. The heat sink serves as the main structural member of the module. Ninety-eight modules are distributed among nine subassembly boards which represent the middle level of interconnection. The subassembly boards plug into mating connectors housed in the main interconnection printed wiring board. Both the subassembly and main interconnection board utilize a multi-layer printed wiring board to complete the circuit interconnections. The interconnection techniques used permit field repairs to be accomplished in minimum time.

5.1

0020
THE PRESENT STATUS OF INTEGRATED ELECTRONICS AND THE PROBLEMS WHICH FACE THE SEMICONDUCTOR MANUFACTURERS
Hogan, C. Lester, Signal, July, 1965, pp 47, 49, 50, & 52

The area of packaging integrated circuits in an optimum enclosure is a problem. The two types of packages in general use are: the flat pack and the TO-5 package, which are both limited as to size and to the number of leads that can be placed around their circumferences. The possible evolution of system packaging and module layout is shown.

6.1, 6.2

0021
PREVENTING ELECTRONIC HOT SPOTS
Wood, Frank William, Jr., Machine Design, 33, July 6, 1961, pp 130-133

Component layout and assembly techniques for preventing electronic hot spots are presented. Solutions discussed in this article include: tube-shields, transistor heat-sinks, high-wattage resistors, component location, stacked components, encapsulated assemblies, and forced air flow.

4.13

0022
FATIGUE IN METAL JOINTS - 1 - MECHANICAL JOINTS
Crum, Ralph G., Machine Design, 33, March 30, 1961, pp 108-113

This two-part article considers the design of an obvious region for fatigue-crack initiation within a structure--the joints. Joints are prime initiators of fatigue cracks because they not only disrupt stress flow and provide natural stress raisers, but they also alter homogeneity of the materials. A general background of fatigue-design variables and specific fatigue-design information for evaluating endurance life of riveted and threaded joints is presented in this first part of the article. (See 0004 for part 2 of this article.)

3.5, 8.4

0023
CIRCUIT CONSIDERATIONS RELATING TO MICROELECTRONICS
Suran, J. J., Proceedings of the IRE, 49, February, 1961, pp 420-426

Problems associated with microelectronic circuits: power dissipation, thermal generation and its effects on component packing density, compatibility, adjustability and reliability are discussed. It is shown that the power dissipation problems are fundamental and relate generally to all classes of electronic components. Power dissipation and heat generation are related to packing density to determine the physical limitations of microelectronic fabrication.

5.14, 5.3

0024
APPLYING DOT COMPONENTS TO ELECTRONIC PACKAGING
Goodykoontz, J. R. and Frank, R. C., Electronic Industries, 20, October, 1961, pp 88-92

The Dot packaging system uses discrete, individual components. By keeping components as basic circuit elements, adequate design flexibility is retained. The Dot system standardizes on a disc-shaped component 0.030 in. thick, however, the disc diameter may vary. The ends of the disc form the component terminals. Manufacturers of Dot components at the date this article was written are noted.

4.1

0025
RADIATION AND OTHER ENVIRONMENTAL EFFECTS ON SATELLITES
Innes, R., Journal of the British Institution of Radio Engineers, 22, September, 1961, pp 241-250

The radiation environments encountered by a satellite according to its orbit are summarized. The breakdown of high-energy radiation on meeting matter is described, indicating the mechanisms and nature of damage caused to equipment. The problem of screening against protons is considered as inefficient and uneconomical. Estimates are given of transistor lifetime in a satellite traversing the lower Van Allen belt. Means of protection against the erosive low energy radiation are discussed and requirements to meet launching conditions are mentioned.

3.1, 4.29

0026
THE BEHAVIOR OF MATERIALS USED IN ELECTRONICS EQUIPMENT UNDER SYNTHETIC ENVIRONMENTS
Gerpheide, B. A. and Lazzaro, V. C., Hughes Aircraft Company, Culver City, Calif., 1960 Proceedings of the Institute of Environmental Sciences National Meeting, Los Angeles, Calif., April 6, 7, 8, 1960, pp 353-364

Moisture occurring during ground storage, ground operation, or in flight operation of electronic equipment is particularly harmful to connectors, coaxial cables, terminal boards, etched circuits, component finishes, molded plastic parts, iridited and anodized finishes, and solder joints. The effect of temperature on adhesives, plastics, and the plating of connector pins is discussed. The results of standard environmental tests on heat reflective coatings are given.

3.

0027
RESINS FOR EMBEDDING MICROELECTRONIC DEVICES
Harper, Charles A., IEEE Transactions on Component Parts, USA, CP-11, (1), March, 1964, pp 22-27

The important properties of liquid resin systems for potting, casting or encapsulating microelectronic devices is discussed. Subject matter includes discussions on epoxies, silicones, polyurethanes, polyesters and thermosetting hydrocarbons and their modifications. Discussed in detail are the large number of modifications possible in epoxies using a variety of curing agents, flexibilizers and diluents.

3., 8.3

0028
THE EFFECT OF TEMPERATURE AND VACUUM ON MATERIALS FOR USE IN THE SPACE ENVIRONMENT
Babusci, D., The Journal of Environmental Sciences, 7, August, 1964, pp 23-27

The dielectric and insulating materials examined were polyethylene, preirradiated polyethylene, polytetrafluorethylene, nylon, silicon rubber and polyolefin. High density linear polyethylene and preirradiated polyethylene were used in the satellite's printed circuit boards and antennas. The structural materials of interest were polyester fiber, nylon fiber and nylon tape, which served as mechanical support and thermal insulation for the electronic components. The paints and finishes tested were a polyurethane base paint with titanium oxide pigment sprayed on a zinc chromate primer on an aluminum substrate, and two forms of anodized chrome oxide finish on a magnesium substrate. The adhesives examined were filled epoxies and an anaerobic acrylic.

3.

0029
AN IMPROVED EPOXY-RESIN SYSTEM FOR ELECTRONIC EMBEDMENTS
Mueller, A. H. and Harper, C. A., Electrical Manufacturing, 65, (2), February, 1960, pp 119-122

This paper discusses a program in which liquid anhydrides are compared with other curing agents that had previously achieved acceptance. Comparisons were made in relation to factors normally important in designing an electronic package: (1) thermal shock (-65 C to 85 C); (2) weight loss at elevated temperatures; (3) heat distortion temperature; (4) insulation resistance; (5) electric strength. After the laboratory development work was completed, the nadic methyl anhydride-cured epoxy resin system was put into a manufacturing operation. The pot life of the material is fairly long (90 min. at 70 C after addition of DMP-30 promoter) so that it can be easily handled for most applications. The finish on the cured resin is smooth and glass-like; therefore, it can be combined with the proper pigment to obtain a casting that needs no painting.

3.2, 8.3

0030
AN EVALUATION OF SPECIAL-PURPOSE ADHESIVES
Electrical Manufacturing, 65, (1), January, 1960, pp 125-130

The experience of Amphenol-Borg Electronics Corporation in developing a special adhesive for bonding components of a new type of electrical connector is presented. Charts are given which show the proper adhesive and associated cure schedule to choose for various applications. The final choice must be governed by the testing of the actual parts to be bonded.

3.4

0031
CONNECTORS FOR FLAT-CONDUCTOR FLEXIBLE CABLES
Angele, Wilhelm, Electrical Manufacturing, 66, (3), September, 1960, pp 164-168

A summary of advantages and limitations of flat-conductor flexible cable systems is given in chart form. The resume of advantages includes a discussion of cable preparation, cable termination, installation, weight saving, current capacity, space saving, flexibility, shielding, connectors, and inspection.

8.1

0032
ENVIRONMENTAL EVALUATION DATA FOR SILICONE ENCAPSULANTS
Christensen, D. F., Electrical Manufacturing, 66, (1), July, 1960, pp 117-120

The evaluation of various types of silicone encapsulants and potting compounds for electronic components and circuit units by means of a simplified test procedure that provides a uniform basis for materials comparison is given. The combined effect of moisture and thermal aging on the volume resistivity of encapsulants and potting compounds is tabulated. The effects of thermal aging on the electrical properties of silicone encapsulants and potting compounds is graphically depicted.

3.4, 8.3

0033
MICROELECTRONIC-INTERCONNECTION DESIGN
Branch, G. L. and Scapple, R. Y., Electro Technology, 69, (3), March, 1962, pp 76-79

This article, primarily a study of materials, describes the design of a high-density interconnection assembly used to interconnect individual substrate wafers of a thin-film computer developed by Hughes Aircraft Company. The design involves the interconnection of individual wafers by means of a short, flexible flat cable [Contour Cable] that mechanically joins the wafers by means of a restraining device. The microsoldering equipment and techniques used are discussed. The completed assembly of interconnected wafers folds into a compact modular unit which may then be unfolded for repair or accessibility.

5.1

0034
PRESSURE-SENSITIVE-ADHESIVE ELECTRICAL TAPES
Katz, Irving, Electro Technology, 70, (2), August, 1962, pp 181-184, 186

A summary is given of p.s.a. electrical tapes for insulating and mechanical functions in terms of applicable Military and Federal Specifications. The requirements and characteristics of rubber, polyethylene, polyvinyl chloride, TFE-fluorocarbon (Teflon), and glass-fabric tapes are given. It is important to make sure that the specification test procedures reflect the actual environmental conditions in which the tape will be used.

8.6

0035
STABILITY OF EPOXY-ENCAPSULATED MAGNET-WIRE SYSTEMS--AN ANALYSIS OF COMPATIBILITY FACTORS
Javitz, Alex. E., Electro Technology, 67, March, 1961, pp 24, 83-90

Thermal stability of encapsulated windings and coils are compared with untreated units. Interactions between the encapsulants and the magnet-wire insulations which affect system life are discussed. Optimum combinations are considered. Several current system compatibility studies are reviewed with their results presented in tabular and graph form. Several conclusions provide some useful design guidance: (1) It is not possible to generalize compatibility for a given compound or for a given wire. Each compound should be checked with each proposed wire; (2) Optimum thermal stability for a specific wire depends upon the epoxy encapsulant and is obtained only through a careful selection of the compound; (3) The presence of chemically active materials in the epoxy-resin system (such as viscosity depressants or corrosive curing agents) may lower the system life; (4) The AIEE No. 57 twisted pair, suitably encapsulated in a test tube or mold, provides a reasonable test specimen for compatibility work; (5) Because of the variables in encapsulating with epoxy resins, the designer and resin compounder must both understand fully the requirements for a particular encapsulated winding; (6) Since service temperatures will usually include considerable cycling, a reliable encapsulating compound must be so formulated that it will withstand the effects of repeated expansion and contraction; (7) Practically all of the encapsulant catalyst systems currently in use tend to cause lifting, wrinkling or solvent swelling of the organic wire coatings; and (8) There are many catalyst systems which may be used with epoxy resins to form insulating coatings or encapsulants to protect electrical windings from the effects of exposure to moisture, dust, chemical fumes, etc.

3.4, 8.3

0036
DIELECTRICS IN 1963: PHENOMENA/MATERIALS/DEVICES
Javitz, Alex E., Electro Technology, 73, February, 1964, pp 97-105, 140

Papers presented at the Thirty-Second Annual Conference on Electrical Insulation (National Academy of Sciences-National Research Council) held at Greenbrier, West Virginia, November 3-6, 1963 are reviewed. Special attention is given to photoconduction and the relation of this phenomenon to organic semiconductors. The use of thin-film structures to investigate the properties and behavior of materials is also emphasized. Underlying almost every paper is an analysis, often a critique, of the test procedures and in many instances a description of new techniques. A selective summary and interpretation of the papers presented is given.

3.4

0037
ADVANCED INTEGRATED CIRCUIT PACKAGING
Needham, George A., SCP and Solid State Technology, 8, (6), June, 1965, pp 22, 27-30

Current research and development in the field of integrated circuit packaging is covered in this article. The discussion includes a survey of past, present, and possible future methods of lead attachment; the "flip-chip," or up-side-down mounting technique; elimination of the individual chip package which has the potential of a twenty to one saving in space; and the inclusion of many circuit functions within a single chip. Three dimensional packaging as opposed to the planar package is also discussed.

5.1, 7., 8.4

0038
MATERIALS AND TECHNIQUES FOR RESIN-ENCAPSULATED MISSILE CIRCUITS
Electrical Manufacturing, 65, (5), May, 1960, pp 70-75

This report summarizes unit design parameters, materials selection problems, processing and application methods, and experimental results from the Royal Air Force Firestreak and the Royal Navy Sea Slug missiles. Resistance to vibration and shock, savings in space and weight, and satisfactory electrical characteristics were essential requirements. Resin encapsulation was found to provide a satisfactory method for the production of self-contained, rigid and moisture-sealed circuit units able to resist the severe vibrational environments in addition to good thermal dissipation.

4.1, 8.3

0039
EFFECT OF WELDABLE LEAD MATERIALS ON PERFORMANCE OF ELECTRONIC COMPONENT PARTS
Lawson, A. Arnold, Howard Research Corporation, Arlington, Va., June 15, 1964, 55 p. Final rept., DA 36-039-SC-90906 (AD 602047)

This study determined the electrical parameters most affected and the severity of parameter degradation when resistors, capacitors and inductors are produced with nickel A or dumet leads rather than conventional copper leads. It was found that the use of nickel A or dumet leads does affect the life and mechanical performance characteristics of electronic component parts, which previously employed conventional copper leads. The degree of degradation with respect to Military Specification limits varies, however, with the type and style of unit tested.

9.1

0040
INTRODUCTION TO THE DESIGN AND APPLICATION OF MICROMODULES
Radio Corporation of America, Communications Systems Division, Camden, N. J., September, 1963, 144 p. DA-36-039-SC-75968 (AD 437877)

This Design Guide contains the following sections: Micromodule Concept--A general description of the micromodule configuration and its attendant advantages; Micromodule Design Principles--Specifications and design geometry of available microelements, design and layout procedures for micromodules, and a list of demonstrated micromodule circuits; Construction of Experimental Micromodules--Tools and techniques for the construction of breadboard circuits and experimental and production micromodules; Procurement Specifications--Procurement procedures and applicable MIL specifications for microelements and micromodules; Design of Micromodular Equipment--Considerations and procedures in micromodular equipment design; Tools and Procedures for Assembly, Testing and Servicing of Micromodular Equipment; and Micromodule Applications--Micromodular design techniques applied to military electronic equipment.

1.1, 2.0, 5.1, 5.2, 5.3, 6.1, 6.2, 7.12

0041
MAINTAINABILITY PREDICTION: METHODS AND RESULTS
Rigney, Joseph W., University of Southern California, Dept. of Psychology, Calif., June, 1964, 135 p., Tech. rept. 40, Nonr-228(22) (AD 603241)

Six different approaches to maintainability prediction are reviewed in terms of (a) desirable attributes of maintainability criteria, (b) utility as an important characteristic of prediction methods, (c) the major prediction schemes, (d) practical criteria for selecting a procedure to use, and (e) methodological weaknesses in current empirical methods.

7.4

0042
THE EFFECT OF NUCLEAR RADIATION ON ELECTRONIC COMPONENTS
Hamman, D. J., Chapin, W. E., Hanks, C. L., and Wyler, E. N., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, June 1, 1961, 140 p. REIC Rept. 18, AF 33(616)-7375

This report presents information which covers the state of the art of knowledge on the effects of nuclear radiation on basic electronic parts that is available in the REIC files. Component results are grouped as to family within each component class type. The results presented in the report are intended to provide a basis for judging the merits of the parts when they are to be used in circuitry that will be exposed to a radiation environment. Some of the data included in the report can be considered as design oriented to the extent that they indicate radiation levels at which the parts can be expected to perform satisfactorily. Radiation effects on electron tubes, resistors, capacitors, electrical insulation, transformers, foil-clad laminates, piezoelectric crystals, electrical meters, electrical connectors, relays, and switches are included.

4.2, 6.4

0043
REFRACTORY METAL DISKS AS MOUNTS IN HIGH-POWER SEMICONDUCTORS
Malloy, Tom, SCP and Solid State Technology, 9, (1), January, 1966, pp 25, 26, 31, 32

A new type of sliced-from-rod tungsten and molybdenum disk, equivalent physically to the silicon wafer, is now being produced, and promises to eliminate current refractory disk deficiencies and enhance diode characteristics. Comparisons are drawn between existing punched and compacted type disks and the new precision-sliced types, in terms of diode performance and reliability. The disks for semiconductor mountings provide a high degree of design latitude in disk size and configuration.

3.1

0044
MATERIALS SYMPOSIUM
Hotel Westward Ho, Phoenix, Ala., July, 1961, 905 p., ASD Tech. rept. 61-322, (AD 264193)

Papers presented at this program were to convey Air Force materials requirements to materials engineers and scientists in industry and academic institutions. Space environment is briefly described. Electronic materials requirements, the effect of radiation on solid state materials and devices and materials for molecular electronics are included.

3.1, 3.4

0045
SPACE ENVIRONMENTAL EFFECTS ON MATERIALS AND COMPONENTS VOLUME I ELASTOMERIC AND PLASTIC MATERIALS
Broadway, N. J., King, R. W., and Palinchak, S., Battelle Memorial Institute, Columbus, Ohio, April 1, 1964 96 p., RSIC-150, DA-01-021-AMC-203(Z) (AD 603364, 603365, 603366, 603367, 603368, 603369, 603370, 603371, 603384, and 603372)

The results of a literature survey on Space Environmental Effects on Materials and Components are given. Of particular concern are the areas of effects of vacuum and space radiation on organic materials, and electronic and mechanical components and materials. Elastomeric and plastic materials are covered in Volume I which is divided into nine appendices. Polymeric materials used as potting, insulation, sealants, lubricants, coatings, structural adhesives, and laminates are evaluated and extensive tabular and graphic data is provided. [For volume II see No. 0094]

3.2, 3.3, 3.4, 8.

0046
DIELECTRICS IN 1962
Javitz, Alex. E., Electro Technology, January, 1963, pp 91-99

A selective summary and interpretation of the papers from the Thirty-First Annual Conference on Electrical Insulation is presented. Basic studies in dielectric phenomena were related to concrete properties. Methods of measurement used in these studies were described. New materials were examined from the standpoint of both structure and properties. Both phenomena and materials were related to continuing research in such applications as capacitors and thin-film devices.

3.2, 3.4

0047
PROBLEMS IN INSULATED WIRE AND CABLE IN SPACE-VEHICLE SYSTEMS
Adams, H. S., Electro Technology, 72, September, 1963, pp 133-136

Data obtained from evaluation studies made under simulated space environments (including the lunar environment) are reported and recommendations are made for optimum application. For external harness applications, stranded copper-alloy conductors are particularly recommended, since their use permits substantial weight economy. Insulation selection depends on the anticipated temperatures and other factors. In general, TFE fluorocarbon is the best all-around material for aerospace use. Reduction in size and weight is a primary target of present wire and cable development activity.

3.2, 3.4, 8.1

0048
RADIATION EFFECTS ON INSULATION--STATE OF THE ART
Linnenbom, V. J., Insulation, 10, March, 1964, pp 21-26

The results of studies of combined environmental effects of radiation with high temperature, low temperature, and low pressure on insulating materials are given. The necessity for combined effects studies is demonstrated by results which show that the combined effect of two or more environmental factors may be either greater or less than the sum of the separately determined effects. Probably the best method of designing a radiation-hardened circuit is to pre-select materials and components that are relatively radiation-resistant. At the present time, knowledge as to the radiation behavior of components is not sufficiently complete to guarantee a radiation-hardened circuit even though the components are pre-selected. Transient radiation effects on dielectric materials, components, and circuits are also discussed.

3.2

0049
ELECTRONIC PACKAGING WITH RESINS A PRACTICAL GUIDE FOR MATERIALS AND MANUFACTURING TECHNIQUES
Harper, Charles A., McGraw-Hill Book Company, Inc., New York, Toronto, London, 1961, 339 pp

This book provides readily understood information on embeding and encapsulating materials and techniques. Extensive graphic and tabular data is provided. Polyesters epoxies, silicones, urethanes, polysulfides, and other encapsulating materials are covered. The effects of high humidity, low temperature and thermal shock, nuclear radiation and elevated temperature environments are also discussed.

3.4, 8.3

0050
LOW TEMPERATURE PROPERTIES OF EPOXIDE RESIN COMPOUNDS
Gruenwald, Geza, General Electric Company, Locomotive and Car Equipment Dept., pp 1-10

The importance of testing flexibilized epoxy resins at low temperatures is becoming obvious because of the astonishingly poor results obtained on some commercially available compounds. An apparatus which conveniently tests epoxy resin bars at -40 C for their elastic properties is described. The mechanical properties of various epoxy resins at room temperature and at -40 C are compared.

3.4

0051
AEROSPACE ELECTRONIC MATERIALS
Linden, Erik G., Electro Technology, 68, December, 1961, pp 125-131

A study and literature review of materials successfully used in external surfaces and in metallic housings in space satellites are presented. The effects of space environment, specifically vacuum, ultraviolet light, and Van Allen belt radiations on various materials is discussed. At the time this article was written additional research was needed in the area of plastic volatility in space environments.

3.4

0052
EMBEDDING RESIN EFFECTS ON COMPONENTS AND CIRCUITS
Harper, Charles A., Electronic Packaging and Production, 5, (5), May, 1965, pp 71-78

In the design of embedded electronic packages, considerable attention must be given to the effect which embedding materials have on components and circuits being packaged. Effects can be mechanical, electrical, chemical, thermal or a combination of any of these effects. The extent of these effects is almost limitless since they depend on so many factors of the design and of the operating characteristics and environment of the embedded electronic package. This article presents the nature of some of these general effects so that they may be used as guides in evaluating specific effects for any given set of conditions.

3.4, 8.3

0053
THE SPACE ENVIRONMENT AND ITS EFFECTS ON MATERIALS AND COMPONENT PARTS
Lehr, S. N. and Tronolone, V. J., IRE Transactions on Reliability and Quality Control, RQC-10, August, 1961, pp 24-37

The best available preliminary information has been gathered on what materials can be used successfully and how these materials react in various space environments. The materials discussed include metals, inorganic materials, organic materials, and electronic parts. The space environment is defined to include: high vacuum, magnetic fields, gravitational fields, micrometeorites, cosmic rays, electromagnetic radiation, neutrons, and charged electron and proton particles.

3.4

0054
EFFECTS OF THERMAL ENVIRONMENT ON LAMINATED PLASTICS
Place, S. W., Electrical Manufacturing, 64, (3), September, 1959, pp 145-147

The effects of heat and moisture on the dimensional stability and mechanical and electrical characteristics of thermosetting laminates, based on property evaluations and standards by ASTM, NEMA and Johns Hopkins University are correlated. Continuous thermal exposure at over 100 C causes permanent dimensional shrinkage in length, width and thickness of most thermosetting laminates. Such exposures frequently cause an increase in dielectric loss properties, particularly at lower frequencies; the higher the temperature, the greater the dielectric losses at any given frequency for most laminated plastic materials.

3.4

0055
ELECTRONIC INSULATION: CRITICAL FACTOR IN HIGH RELIABILITY DESIGN
Feuchtbaum, R. B., Insulation, 8, September, 1962, pp 47-54

The description of the basic chemical reactions involved in the production of dielectric insulators provides the background for determining the role chemical structure has in establishing dielectric properties. Dielectric deterioration, high vacuum embedment, insulation system design, and an embedded electrode standard test are discussed.

3.4, 8.5

0056
NEW DEVELOPMENTS IN WELDABLE ELECTRONIC CIRCUIT BOARDS
Washer, Richard B., IEEE Transactions on Product Engineering and Production, 9, (1), April, 1965, pp 24-29

This paper reviews some of the important design considerations and developments in weldable circuit boards. The trends in electronic design indicate demands for multilayer circuit boards will be increasing because the approach, besides making interconnecting circuits smaller, simplifies interconnection where many terminations are involved. Development and evaluation programs in weldable, multilayer board materials, processes, and applications now in progress in the industry will help to increase reliability and offer greater versatility in electronic packaging.

3.5, 9.1

0057
COMPONENTS PACKAGING TECHNIQUES
Schaller, R. F., Space Technology Laboratories, Inc., Los Angeles, Calif., July 1, 1958 to December 31, 1958, 66 p. Semiannual rept., (AD 217523)

The design techniques utilized in hard and soft package configurations proved to be highly successful. The two distinct design approaches are distinguished by the manner of attachment to the missile frame: one is rigid-hard package and the other elastic-soft package. Significant size and weight reductions, increased structural integrity, and higher performance values were achieved for both packages. Successful tests were run on both package designs, however, because the soft package has proven to be simpler to fabricate and more accessible for maintenance additional tests are to be run. Several new configurations of dynamic absorbers were developed in an attempt to increase damping capacity and provide a longer absorber life. The development of apparatus which demonstrates the applicability of Paschen's Law regarding long-gap discharges between electrodes surrounded by an electrically conducting shell is reported.

4.0, 6.1, 6.2

0058
3-D PACKAGING REDUCES SIZE OF ELECTRONIC UNITS
Hall, Eldon C. and Jansson, Richard M., Electronics, 32, (41), October 9, 1959, pp 62-65

High density or 3-D packaging was developed to provide electronic devices which are capable of satisfactory operation over a wide range of environmental conditions, particularly those of temperature, humidity, vibration and acceleration or shock. The technique involves mounting and wiring circuit components in a miniature three-dimensional unit mass. Circuit elements are placed side by side and form the electrical connections on a three-dimensional basis as opposed to the two-dimensional printed circuit board. The wires are joined by electrical resistance spot welding. After assembly and electrical checkout, the unit is encapsulated in epoxy potting compounds to form a module. The resulting miniature package is a maximum-density assembly occupying all practical space within the package.

4.1, 9.1

0059
BREAKDOWN ACROSS INSULATORS IN A VACUUM
Hayes, R. and Walker, G. B., Proceedings of the Institute of Electronic Engineers, 111, (7), July, 164, p. 1373

This article provides a review of the mechanisms causing breakdown across insulators and other methods of improving the strength; such as the use of various types of coating on the insulator, conducting coatings on the ends of the insulator to ensure contact with the electrodes and the reduction of the field at the cathode-insulator interface by suitably shaping the cathode, by R. Hawley; and the author's reply stating they have had disappointing results using shaped electrodes to reduce the field in a dielectric loaded microwave cavity.

3.2

0060
PRINTED-CIRCUIT PACKAGING: CAN IT BE CARRIED FURTHER?
Cushman, Robert H., Electronic Design, 10, (9), April 26, 1962, pp 38-51

A special report based on four cases of improved designed-circuit redesign shrinks board, core logic simplified, logic system organization, and digital modules without boards. Improvements in printed-circuit packaging, from the standpoint of miniaturization, reliability or lowered costs require that the printed-circuit layout designer needs help from the circuit designers and component manufacturers. The article further points out that what is learned in producing better printed-circuit packages need not go down the drain with the advent of "functional-block" or integrated circuits. Not only can printed circuits serve as the motherboards for functional-block modules as is shown in this report, but for some of the advanced integrated circuitry approaches (Lockheed's titanium-based thin films for example), printed-circuit technology can be used to lay down the topology.

4.1

0061
SOME PROJECT SOLUTIONS--AT BENDIX: PACKAGING IS A PROBLEM IN R&D, TOO
Electronic Design, 9, (22), October 25, 1961, pp 36-40

The article discusses four module progressions which show what Bendix Corporation has learned in its process of developing a small computer. The most important lesson which Bendix feels it learned is that crowding of parts into a module does not insure the production of a small computer. Only by working with modules breadboarded into an actual operating system was Bendix able to assess in what direction and how far it should go in correcting this situation. Soldered sandwich and welded module construction are discussed.

4.1, 9.

0062
FIVE FACTORS IN DESIGNING WELDED MODULES
Corbett, P. C. and Follett, R. A., Electronic Design, 11, April 12, 1963, pp 44-49

Careful consideration of environmental requirements, frequency of operation, selection of components, length of production run, and package form factor results in a set of handy guidelines for the module designer. The article in general indicates that, humidity, vibration, shock, and altitude requirements can be met by proper selection of the encapsulant. But temperature problems can best be solved only by careful location of components and choice of encapsulant. Heat transfer may be accomplished by using high heat-conductivity epoxy or by heat sinking via a metal surface. In general, a filled epoxy is the most practical answer to the temperature problem; however, if weight is a factor, it may be necessary to use foam or micro-balloon-filled epoxy along with a separate heat sink. Single-flat, double, single-U and side matrix types are shown.

4.1

0063
PACKAGING DESIGN CONSIDERATIONS USING CONVENTIONAL COMPONENTS
Grassi, Donald A., IEEE Transactions on Product Engineering and Production, 7, (1), January, 1963, pp 24-27

Contradictory requirements of low volume, light weight, high reliability have required the development of new packaging concepts. The problem can be reduced to three major areas which must be closely scrutinized before any new packaging techniques can be evolved namely; the basic network elements to be used, the method of connecting and interconnecting the elements, and the manner in which they are physically held or mounted. Each of these areas are considered in the article.

4.1, 9.

0064
WELDED ELECTRONIC MODULE FABRICATION
Lyons, John C. and Dargo, David R., Goddard Space Flight Center, Greenbelt, Md., June, 1964, 9 pp., NASA TN D-2321 (CFSTI)

A pilot facility for the fabrication of welded electronic modules has been developed at the Goddard Space Flight Center for the purposes of: (1) providing a quick-reaction group in the research and development phases of module fabrication, and (2) determining in detail the requirements in terms of facilities and trained personnel to insure the production of high quality welded modules. The experience gained in the successful application of the welding technique to modules in Ariel I (the International Ionosphere Satellite, 1962 α 1) and Explorer XVIII (the Interplanetary Monitoring Platform, 1963 46A) has provided a firm base for the utilization of this concept in future spacecraft programs. Design, layout, assembly, inspection, and repair of welded modules are also discussed.

4.1, 4.3

0065
PACKAGING
Electronic Design, July 5, 1965, pp 21-36

A special report with the following sections: functional packaging for tomorrow's Navy, low-cost mock-ups make good sense, embedded packages can be repairable, and give your modules that 'finished' look. This report touches on packaging across the board, from systems and subsystems to tiny circuit modules. Connections, cooling, repairability, ease of testing, human factors, and low cost are considered.

4.1. 4.2

0066
ENCAPSULATING TO MILITARY SPECIFICATIONS
Koved, Frederick L., Electronic Industries, 22, July, 1963, pp 92-96

The wide range of considerations which must be reviewed by the systems engineer before the encapsulation processes may be selected are specified. Many of the restrictions on the encapsulating process are dictated by the electrical characteristics of the component involved. Resins considered for use in systems should undergo wide study including tests for pot life, immersion, gel time, viscosity at various pressures and temperatures, general handling properties and ASTM shock test, environmental considerations, use of fillers, epoxy sand, resin shells, resin stripping, fillers, and material considerations are briefly covered.

4.1, 8.3

0067
DESIGNING THE RFI SHIELDED PACKAGE
Albin, Arnold L., Electronic Industries, 24, January, 1965, pp 80-83

Basic problems in designing the shielded electronic package are considered. Designing shielded equipment is not hard if the basic means by which interference, [undesired radiation,] enters or leaves the equipment is understood. Shielding will confine the interference and prevent escape of r-f energy from the enclosure. Shielding may also reduce the influence of external fields. Highly conductive metals such as copper, aluminum or magnesium are usually used as shielding. While ferrous materials offer good shielding to magnetic fields, they are not efficient where weight is important.

4.12, 6.1

0068
TWENTY-SIX WAYS TO APPLY COOLER ELECTRONIC PACKAGES
Coren, Gerald, Product Engineering, 33, August 6, 1962, pp 55-59

Basic heat-transfer theory to package design is photographically shown. Basic heat transfer definitions and equations are given.

4.13, 6.113

0069
SYSTEM PACKAGING EFFICIENCY
MaCauley, D. O., Electronic Packaging and Production, 5, (12), December, 1965, pp 54-56

This paper is primarily concerned with relatively low power circuits of the type which can be readily microminiaturized. A digital computer may have very little circuitry not adaptable to integrated circuits, but RF components, antennae, displays, power supplies, etc., frequently account for most of the volume of a radar set. Cordwood modules drawbacks which are considered are cost and difficulty of assembly.

4.13, 4.14, 4.152

0070
COMMENTS ON "HEAT-SINKING TECHNIQUES FOR POWER TRANSISTORS IN A SPACE ENVIRONMENT"
Metz, D. F. and Smith, R. A., IEEE Transactions on Space Electronics and Telemetry, 9, December, 1963, p 138

Problems of using indium as a soft interface material for heat-sinking power transistors are considered. Cold flow is its serious drawback. The use of a brittle material such as beryllium oxide in washers further compounds this cold flow problem with indium. Therefore, while recognizing the excellent thermal characteristics of the combination, the cold flow problem together with the brittleness creates a reliability risk.

4.13

0071
A THERMAL DESIGN APPROACH FOR SOLID-STATE ENCAPSULATED HIGH-DENSITY COMPUTER CIRCUITS
Rosenberg, A. E. and Taylor, T. C., IRE Transactions on Military Electronics, 5, July, 1961, pp 216-226

The thermal resistance to the dissipation of component-generated heat is shown to consist of that of the encapsulating medium, plus that of the external circuit cooling process. Because the external cooling becomes more difficult as the size of an encapsulated circuit is reduced, a method of constructing such circuits is proposed which minimizes the thermal resistance due to the encapsulating medium. This construction makes a large fraction of the allowable component temperature rise available for use in the external heat dissipation process by providing high thermal conductance paths for the transfer of heat from the surfaces of the components to one surface of the circuit structure.

4.13

0072
HEAT-SINKING TECHNIQUES FOR POWER TRANSISTORS IN A SPACE ENVIRONMENT
John, J.E.A. and Hilliard, J. J., IEEE Transactions on Space Electronics and Telemetry, 9, June, 1963, pp. 45-51

An investigation was made of the cooling of power transistors in a space environment, where the only available mode of heat transfer is that of conduction to a heat sink and radiation from the heat sink to space. An attempt was made to minimize the thermal resistance between transistor case and heat sink, allowing the transistor to dissipate as much power as possible while maintaining its temperature within the maximum tolerable level to prevent thermal runaway. Further, it was necessary to electrically insulate the transistor from the heat sink. The use of beryllium oxide washers provided electrical insulation, while adding very little to the thermal resistance between case and sink, the BeO being a good heat conductor. However, the problem of contact thermal resistance at each interface arose, especially in vacuum--this contact resistance providing practically all the thermal resistance between case and sink. The effect on the contact resistance of surface pressure, insertion of foils, and soldering was examined. It was concluded that, for most efficient heat sinking, indium foil should be inserted at each interface, the indium foil having the effect of reducing the contact resistance in vacuum by a factor of 8. [This paper is a duplicate of NASA TN D-1753]

4.13

0073
POWER TRANSISTOR COOLING IN A SPACE ENVIRONMENT
John, James E. A. and Hilliard, John J., Goddard Space Flight Center, Greenbelt, Md., July, 1963, 10 pp., NASA TN D-1753

The cooling of power transistors was investigated in a space environment, where the only available mode of heat transfer is conduction to a heat sink and radiation from the heat sink to space. An attempt was made to minimize the thermal resistance between the transistor case and the heat sink, so that the transistor would dissipate as much power as possible while maintaining its temperature within the maximum tolerable level to prevent thermal runaway. Further, it was necessary to electrically insulate the transistor from the heat sink. Beryllium oxide washers provided electrical insulation and added very little to the thermal resistance between case and sink, the BeO being a good heat conductor. However, the problem of contact thermal resistance at each interface arose, especially in vacuum; this contact resistance provided practically all the thermal resistance between case and sink. The effect on the contact resistance of surface pressure, insertion of foil, and soldering was examined. It was concluded that, for the most efficient cooling, indium foil should be inserted at each interface, the indium foil having the effect of reducing the contact resistance in vacuum by a factor of 8. [See also No. 0072]

4.12, 4.13

0074
SOLUTIONS TO PROBLEMS IN THE EPOXY TRANSFER MOLDING OF WELDED HIGH DENSITY ELECTRONIC PACKAGING
Uglione, Hugo L., Jr. and Bell, Allen R., Jr., IEEE International Convention Record (USA), 13, Pt. 10, 1965, pp 26-32

This paper presents a brief description of transfer molding and covers in detail the problems that may occur in actual production operation and solutions to correct these problems. Proper module design, such as adequate spacing around the perimeter of the components and correct part positioning to allow compound to move freely are important. Use of compounds that flow at low pressures, cure at low temperatures, and selection of components to withstand the operating conditions are a must. Failure analysis after transfer molding, is accomplished by checking circuits electrically, by radiograph and by analyzing known component failure. Molds must have adequate gates, runners, vents and designed to be cleaned easily. Getting reliable molding compound can be achieved by having the supplier and fabricator use the same testing procedures.

4.15

0075
A PRACTICAL COMPONENT PACKAGING SYSTEM
Koenig, W. A., Electronic Industries, 24, (11), November, 1965, pp 46-47, 50-51

The packaging system described here provides for the compatible use of integrated circuits, thin film circuits, and conventional components in spaceborne digital command and data handling equipments. Design of this system allows for the incorporation of new component types without obsoleting the system. Module types discussed are clock, memory, logic, power supply, and input/output.

4.15

0076
PROS AND CONS OF 3-D WELDED CORDWOOD PACKAGING
Oswald, Anton, IRE Transactions on Product Engineering and Production, 6, (4), December, 1962, pp 24-31

The major advantages of welded cordwood packaging are greater reliability and higher package density. In welding, the amount of heat generated at the electrode tips lasts only a few milliseconds, as compared to seconds when soldering. The disadvantages of the welded cordwood technique are 1) Initial cost of welding, accessory, and metallurgical equipment is high, 2) Specifying weldable component leads increases cost and delays delivery, 3) Placement of components is critical, 4) Heat dissipation is difficult, 5) Increase in fabrication time leads to increased costs, 6) Embedded welded units are nonrepairable, and 7) Additional in-process quality control is required.

4.15, 4.152

0077
RELIABILITY OF PRINTED WIRING CORDWOOD MODULES
Gore, T. S. and Lane, W. V., Proceedings of the Ninth National Symposium on Reliability and Quality Control, 1963, pp 222-227

It was concluded from the test results that the use of military-standard components in encapsulated printed wiring cordwood modules using the construction technique described could result in component reliability levels at least equal to the levels reported for similar components in a free-air environment.

4.15, 4.152, 4.3, 6.5

0078
MINISTAC-A VERSATILE METHOD FOR CONSTRUCTING COMPONENT ASSEMBLIES
Prior, H. T., Electrical Communication, 39, (2), 1964, pp 190-198

The general trend in electronics makes it necessary to provide means of constructing modular assemblies smaller and more-tightly packed than plug-in cards. Ministac was developed as one approach to solving the problem. A typical Ministac assembly consists of a pair of parallel surfaces to which the circuit components are attached. The key feature is that a combination of "wiring" and soldering tags is provided by punching out a required pattern from a metal strip. Interconnection design for Ministac assemblies are discussed.

4.15, 5.15

0079
COMPARING KEY CHARACTERISTICS OF MAJOR MICROMINIATURIZATION APPROACHES
Electronic Design, 8, (23), November 9, 1960, pp 94-95

A chart is presented which provides a thumb-nail summary of the relative merits and characteristics of the leading approaches in microminiaturization. Basic approaches included are: high-density packaging (sandwich board), high-density packaging (welded modules), 2-D (conventional), 2-D (thin film), micromodule, integrated circuits, and molecular electronics.

4.15, 5.15

0080
ELECTRONIC PACKAGING TECHNIQUES FOR SURVEYOR LUNAR SPACECRAFT
Hawley, A. E., Klein, E. A., Lenhart, D. D., and Shrum, L. R., IEEE Transactions on Product Engineering and Production, 7, (4), September, 1963, pp 38-46

Several of the major packaging techniques and design methods used for electronics portions of the Surveyor spacecraft are presented. Descriptions are given of a typical electronic unit as it will appear on the spacecraft. The three major packaging techniques developed to accommodate the various electrical requirements and the prescribed component types were a foam sandwich chassis construction, a T-bar assembly, and a modified etched circuit board.

4.15, 6.2

0081
MODULAR CIRCUIT CONSTRUCTION
Winter, P. H., Electronic Engineering, 34, March, 1962, pp 173-175

A method of circuit construction is reported which employes a simple universal wiring board consisting of an s.r.b.p. laminated base board pierced with a regular matrix of holes. A modular approach to the layout of circuits on this type of board greatly simplifies both prototype and producction work and enables the advantages of printed circuit techniques to be retained at much reduced cost. The use of standard circuit boards is well suited to the current advances in equipment design employing modular unit construction methods.

9.2

0082
ELECTRONIC CONNECTIONS BY HOT AIR SOLDERING
Woolridge, E. J., Electronic Packaging and Production, 3, (7), July, 1963, pp 10-12

A hot air soldering machine was developed to solve a problem involved soldering a small wire-wrap pin at its intersection with an etched circuit board. The machine consists of five major parts or functions: 1) air heating and pumping, 2) conveyor drive including pallets, 3) controls for temperature and conveyor speed including safety interlocks, 4) air flow for cooling components, and 5) cabinet. Standard components were purchased and considerable latitude of operating conditions were designed into the machine.

9.2

0083
THE EFFECTS OF ENCAPSULATION ON ELECTRONIC COMPONENTS
Campbell, F. P., Electronic Engineering, 32, June, 1960, pp 366-371

A survey is presented of the effects of encapsulation on commonly used components. Tubes may be encapsulated safely provided that the correct techniques are used to remove self-generated heat and to protect the glass envelope. Little difficulty is encountered with transistors and capacitors. The effects of potting transformers and chokes are described. Wirewound resistors are not suitable for casting in rigid resins when heavily dissipating. The potting of carbon and cracked carbon resistors may affect various manufacturer's products differently; an experiment is described. The causes of component change are summarized.

4.2, 8.3

0084
COMPONENTS AND APPLICATION TECHNIQUES FOR ELECTRONIC CIRCUITRY OPERATING IN NUCLEAR ENVIRONMENTS
Bowles, L. T., Crittenden, J. R., and Davis, E. L., IRE Transactions on Nuclear Science, August, 1962, pp 5-8

This paper briefly summarizes some of the known factors which should influence the selection of electronic components for an equipment which will be least affected by radiation.

4.2

0085
RESULTS OF IRRADIATION TESTS ON ELECTRONICS PARTS AND MODULES CONDUCTED AT THE VALLECITOS ATOMICS LABORATORY
Armstrong, F. L., Lockheed Missiles & Space Company, Sunnyvale, Calif., August 27, 1962, 162 pp., LMSC-A054870 (AD 463741)

The results of a series of irradiation tests conducted at Vallecitos Atomic Laboratory on electronic parts, materials, and modules are presented. Each test attained about 10^{16} fn/cm^2 (E> 0.1 mev) and about 10^7 R of gammas. The most sensitive and critical items tested were transistors with frequencies (T-minimum)ranging from 600 kc to 600 mc. The transistors degraded rapidly in the range of 10^{12} fn/cm^2 to 10^{13} fn/cm^2. Transistors with the lower frequencies around 1 mc showed the least radiation resistance and those with frequencies above 500 mc, showed the best (in terms of β_0). In a gamma test, 7.5 x 10^7 R of cobalt gammas reduced the gain of transistors about as much as 10^{13} fn/cm^2. Other semi-conductor devices, such as unijunctions, temperature sensors, and SCR's, degraded quite rapidly. The tunnel diodes tested held up very well in their peak characteristics, but changed considerably in their valley characteristics. The various diodes tested showed different radiation resistances from poor to good. The capacitors and resistors tested held up very well with minor exceptions noted in the report. The connectors and relays held up well, with one exception noted among the relays. Potting compounds were very little affected. An RF switch containing teflon held up during and after the test. The transformers and cores tested held up satisfactorily to the end of the test. A teflon cable tested held up during the test to 10^{16} fn/cm^2 and 2 x 10^7 R of gammas. After the test the cable was removed from the reactor and placed in a coil. Insertion loss measurements made ten days later showed the cable had increased by 2.0 db (indicating about 40% loss in power). The several modules tested generally failed quite early -- in the range of 10^{12} fn/cm^2 to 10^{13} fn/cm^2. The trouble could generally be traced to semi-conductor devices: transistors, SCR's, or diodes.

4.2

0086
ELECTRICAL INSULATION AT CRYOGENIC TEMPERATURES
Mathes, K. N., Electro Technology, 73, September, 1963, pp 72-77

This report summarizes and analyzes available design-significant test data for both electrical and mechanical properties of these materials under cryogenic conditions. Flexibility, thermal cracking, electrical loss and electrical breakdown of insulating materials are discussed. It is noted that moisture and other contaminations picked up at normal temperatures usually have an adverse effect on the electrical properties, but at cryogenic temperatures the mechanical properties are likely to be degraded and the effects on the electricalrp properties are either none or limited.

3.2

0087
EVALUATION OF RESIN MATERIALS AND CASTING METHODS FOR REDUCING LOW TEMPERATURE STRESSES ON ENCAPSULATED PARTS
Strobel, Rupert F., Insulation, 11, (4), April, 1965, pp 40-42

When two dissimilar materials are combined in a modular configuration, such as a transformer encapsulated in epoxy resin, stresses will occur with changes in temperature because of differences in coefficient of linear thermal expansion.

3.4, 8.3

0088
MATERIALS AND PROCESSING FOR MULTILAYER CIRCUITS
Larsen, Vernon, Electronic Packaging and Production, 5, (12), December, 1965, pp 22-32

Most multilayer circuits are made from glass-base laminates rather than paper base because the mechanical strength of glass-base laminates is generally higher than those of the paper-base grades and the glass-base materials have a greater resistance to heat than the paper-base grades. Comparative properties of phenolic paper, epoxy paper, and epoxy-glass laminate are given. Test methods for various properties are still being developed. There have been several problems encountered in establishing standards for thin copper-clad laminates.

3.4

0089
A UNIVERSAL RESIN CASTING SYSTEM FOR ELECTRONIC APPLICATIONS
Manfield, H. G., British Plastics, 34, October, 1961, pp 539-540

The requirements for resin systems in transformers and other inductors and in potting small electronic components are listed. Recent work has shown that with one basic resin system the most arduous requirements of both applications can be met. This system is based on the use of methyl nadic anhydride with benzyl dimethylamine accelerator and crushed fuzed quartz as a filler.

3.4

0090
NEW MOLDING COMPOUND FOR 700 F ELECTRICAL USES
Materials In Design Engineering, 52, October, 1960, pp 11-12

A new mineral-filled silicone molding compound, M-6-4156, primarily designed for high temperature electrical insulation, features: 1) long-term stability at 700 F, 2) excellent thermal shock resistance (over a range of -67 to 500 F), 3) a low dissipation factor of 0.002 at 10^6 cps, and 4) arc resistance greater than 400 sec. Typical mechanical, physical, and electrical properties of the compound, both postcured and after thermal aging at various temperatures, are listed.

3.2, 3.4

0091
MATERIALS FOR PACKAGING MICROELECTRONIC DEVICES
Nixen, David, Electronic Industries, 24, January, 1965, pp 66-69, 72, 75

Consideration is given to properties of materials commonly used in these parts and feasible combinations of materials in a total package. The ultimate choice is a question of cost vs. performance. Interconnection bonding wire and die-to-case bonding material are discussed relative to interconnection techniques and choice of materials.

3.1, 3.2, 3.4, 9.

0092
RECESSED CONTACTS PREVENT DAMAGE TO MODULE COMPONENTS MATRIX
Ruehleman, H. E., Electronic Design, 10, (10), May 10, 1962, pp 90-93

A solution to the packaging problem of leads extending from one or more sides of a module is presented. The Modu-Con, developed by Elco Corporation, Philadelphia, is a module as well as a connector. In this concept, a connection point or contact is treated as a component, the same as a resistor, diode or capacitor. Instead of adding a connector to the module, the connector now is an integral part of the module. In the construction of the Modu-Con, a polycarbonate header is used as a "foundation". This helps to place the contacts for precise alignment, and offers a fully protected recess or enclosure for the contacts.

4.1, 9.

0093
RADIATION EFFECTS CONSIDERATION ON MATERIALS IN CRYOGENIC SYSTEMS OF NUCLEAR ROCKETS
Gordon, Jean W., IRE Transactions on Nuclear Science, 9, (1), January, 1962, pp 299-302

This paper presents a discussion on the effects of nuclear radiation on materials exposed in a cryogenic environment. Sealing materials, lubricants, thermal insulation, and structural materials are discussed with respect to radiation stability. Some experimental data on the effects of simultaneous exposure of metals to nuclear radiation and cryogenic temperatures are also presented. The results of this study may be summarized with five basic thoughts: 1) cryogenic irradiation of structural alloys induces changes in tensile strength which must be factored into design concepts, 2) satisfactory thermal insulations are available; however, adhesive attachment may be restricted by the radiation tolerance of the adhesives, 3) lubrication should be satisfied by gas or liquid hydrogen bearings, or by dry film lubricants, 4) metallic or inorganic sealing devices may be necessary, and 5) inorganic rather than organic electrical insulation may be more satisfactory for the anticipated radiation levels.

3., 4.27, 4.29, 6.4

0094
SPACE ENVIRONMENTAL EFFECTS ON MATERIALS AND COMPONENTS VOLUME II ELECTRONIC AND MECHANICAL COMPONENTS
Hamman, D. J. and Wyler, E. M., Battelle Memorial Institute, Columbus, Ohio, April 1, 1964, 161 pp., RSIC-151, DA-01-021-AMC-203(Z) (AD 601876)

This report is the second of two volumes which present the results of a literature survey on Space Environmental Effects upon Materials and Components. The major emphasis of this literature survey has been the effects of vacuum and space radiation on organic materials and electronic and mechanical components and materials. The effects of environment on resistors, capacitors, thermistors, relays, circuit boards, electrical meters, connectors, wire and cables, semiconductor devices, electron tubes, transformers, inductors, metallic conductors and materials, and bearings are discussed. [For volume I see No. 0045]

3.4, 4.25, 4.29

0095
INSTRUMENT PRODUCTION TECHNOLOGY MODULE OR MICROMODULE?
Gendelev, D. L., Kabak, S. Ya., and Shil'dkret, S. M., Instrument Construction, (GB), (4), April, 1963, pp 20-21

This article is a translation of a Russian paper which appeared in Priborostroenie (USSR), 1963, No. 4, 20-1, April. This article describes several disadvantages of the micromodule system and proposes a modified "cordwood" system which would give an overall density of between 5 and 10 components per cu.cm. Slots instead of holes are made in the top and bottom insulator supports in the normal cordwood system. The size of the modified cordwood module is 41 mm. long and 11 mm. wide.

4.1, 5.1

0096
INTEGRATING SPACECRAFT ELECTRONICS
Whitaker, Arnold B., Space/Aeronautics, 42, August, 1964, pp 53-59

The problem of putting electronics, space vehicles, and launch equipment together without getting electromagnetic interference is discussed. The first step in eliminating electromagnetic interference problems is accomplished by paper analysis. Interactions of components to produce unwanted component characteristics classified basically as densensitization or cross-modulation are also discussed.

4.1, 6.1

0097
A NEW CONCEPT IN ELECTRONIC COMPONENT PACKAGING
Murabito, A. J. and Russell, J. F., Transactions of American Institute Electronic Engineers, Communications and Electronics, 81, November, 1962, pp 320-326

The expensive assembly job of mounting and interconnecting components of electric equipment has been simplified by a succession of different approaches. Now, amplas, a novel method in which a plastic board is cast around component leads, offers very significant advantages in many applications. Basically, amplas is a method of mounting components in contrast to those also providing wiring, as is the case with printed wiring boards. A metal mold is used to make a plastic mold into which components are subsequently positioned. The plastic mold provides a means of holding the component leads so that the leads extend below the bottom of the mold. The first amplas production application, the N1 Carrier Channel Unit, will result in almost a 1/3 reduction in cost. These savings are realized both from the application of amplas and the design simplification of costly components permitted by amplas.

4.1, 4.155, 6.1, 6.2

0098
ENCAPSULATING WITH PLASTIC SHELLS
Ross, Milton, Industrial Electronics, 2, (9), September, 1964, pp 441-444

Small electronic components are frequently encapsulated for protection. This article explains the advantages of using pre-formed plastic shells instead of moulds. The shells are left in place and form permanent outer covers to the actual encapsulating material. Since a mould is not used, the capital investment is less because the machining and maintenance costs are eliminated.

4.1, 8.3

0099
INTERFERENCE REDUCTION GUIDE FOR DESIGN ENGINEERS - VOLUME I
Filtron Company, Inc., New York, August 1, 1964, 222 pp., DA-36-039-SC-90707 (AD 619666)

This guide is an attempt to provide the engineer with the necessary background and techniques to enable him to minimize the interference generation and interference susceptibility of the equipment that he designs. The guide is not intended for the interference experts. It is not a manual for field fixes, nor for interference suppression after field tests have shown interference problems. It is intended for the use of design engineers with little or no interference reduction experience. Some tables, curves and other handbook-type data are included but only to the extent that such data is not readily available in standard handbooks or manuals. Chapter titles are: Introduction to interference reduction design practice, Grounding, bonding and shielding design theory and practice, and Circuit design.

4.11, 4.12, 4.13

0100
RELIABILITY RESEARCH ON COMPONENTS FOR SPACE
Brueschke, Erich E., Proceedings of the Eighth National Symposium on Reliability and Quality Control, Washington, D. C., January, 1962, pp 281-295

This paper deals with research on the reliability of electronic components in a simulated space environment. Emphasis is placed on determining the basic mechanisms of the changes which take place in components after and during environmental exposure through an evaluation of electrical characteristics and materials of construction. The space environment is considered in terms of high vacuum, radiation, micrometeorites and other phenomena. Effects of the vacuum in space on plastics and metals which are related to electronic components are discussed. The general effects of vacuum, radiation, and other space environment factors are discussed as an aid to understanding and predicting the performance and reliability of components. Data on the operation of carbon composition resistors in high vacuum equivalent to approximately 200 miles altitude at various power inputs are summarized. It is pointed out that there is no substitute for the evaluation of component parts in the space environment or in the simulated space environment prior to their application and that this evaluation must be coupled with derating the protective schemes in the space vehicle.

4.2, 6.4, 6.5

0101
A STUDY OF NUCLEAR RADIATION EFFECTS ON TELEMETRY VOLUME II - NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES
Ling Temco Vought, Inc., LTV Vought Aeronautics Div., Dallas, Tex., February, 1964, 292 pp., Tech. Doc. rept. No. RTD-TDR-63-4287, AF 33(657)-11646 (AD 433088)

Approximately 1500 nuclear radiation effects "Design Allowables" on electronic materials and parts were compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. The radiation effects Design Allowable is a nuclear radiation environmental exposure under which the associated material or part is expected to exhibit certain specified characteristic changes. The information presented does not include all available data, but is felt to be representative of the current nuclear radiation effects state-of-technology. This data should serve as an aid in performing nuclear radiation effects analyses of currently available telemetry systems and provide useful inputs for hardening such systems for use in a nuclear radiation environment.

4.2, 4.29

0102
MICROELECTRONIC CIRCUITS AND APPLICATIONS CHAPTER 2. CIRCUITS USING DISCRETE COMPONENTS
Carroll, John M., McGraw-Hill Book Company, 1965, 360 pp.

Circuits using discrete components, uniform components, and packaged circuits are briefly discussed. These microelectronic circuits have a common characteristic in that, the discrete elements that provide values of inductance, capacitance, and resistance or the functions of amplification and rectification in the circuit can be identified.

4.15, 5.145, 9.1

0103
TESTING FOR VIBRATION IN PRINTED-CIRCUIT BOARDS
Lemus, F. and Haggett, P. E., Electronic Design, 10, (2), January 18, 1962, pp 190-192

Various methods for securing printed-circuit boards under vibration, are examined, and the conclusions supported by objective methods of data analysis. The rules designers might follow to avoid harmful effects on printed-circuit boards and their associated electronic equipment are discussed.

4.21, 5.21

0104
DESIGN AND PACKAGING FOR NUCLEAR EXPOSURE
Keister, Glenn L., Electronic Industries, 21, April, 1962, pp 108-111

The article shows the methods of designing and packaging electronic equipment which can be used to substantially reduce the effects of nuclear radiation. These techniques are in use or have been developed, and newer concepts should be available soon. Using these techniques, it will be possible to design electronic equipment which will function in radiation environments higher than normal electronic circuit design techniques would allow. Methods such as shielding, component replacement, circuit design, and advanced circuit concepts can be used to make the equipment radiation resistant.

4.29, 5.29

0105
THERMAL EVALUATION OF HIGH DENSITY ELECTRONIC PACKAGES
Kammerer, H. C., Electronic Design, 9, (25), December 6, 1961, pp 121-122

A nomograph which should be helpful in determining the design limitations on microminiature packages imposed by thermal factors. The nomograph shown is based on the five basic parameters which constitute the general conduction and convection heat transfer equations. The remaining mode of heat transfer, radiation, is neglected since it requires considerably higher temperature than will be encountered in this study. The five factors are 1) power (heat dissipation/unit time); 2) total temperature differential between ambient environment and center of package (external plus internal); 3) thermal conductivity of package material; 4) cooling technique (surface coefficient of convective heat transfer), and 5) the size and configuration of package.

4.2, 4.27, 5.13

0106
THE EFFECT OF NUCLEAR RADIATION ON SEMICONDUCTOR DEVICES
Reid, F. J., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, July 15, 1961, 36 pp., REIC rept. No. 10 (Addendum) (AD 262081)

The report summarizes the radiation-effects information on permanent damage introduced in various transistor- and diode-type devices for which data have been published since January, 1960. Data are presented on investigations of standard silicon and germanium transistors, diodes, rectifiers, and such devices as unipolar transistors, Esaki diodes, and SiC, GaP, and selenium rectifiers. The report is intended to be sufficiently inclusive to make it valuable as a guide on effects which can be anticipated from nuclear radiation on electronic components utilizing semiconductor devices.

4.29, 6.2

0107
IMPROVING RELIABILITY THROUGH PACKAGING
Christensen, D. F. and Nelson, M. E., Electronic Industries, 20, July, 1961, pp 106-109

Environmental protection provided by embedding compounds from effects of moisture, salt spray, oils, and fuels on electronics are discussed. Selection of the best material depends upon the design objective. For ease of repairability, it is necessary 1) to locate the fault; 2) to remove the embedding or potting compound; 3) replace or repair the defect; and 4) reseal. Few materials now used permit easy repair. A few organic resins are somewhat repairable. Removal of a potting compound may be helped by using a solvent; but usually chipping, scraping or stripping is required.

4.3

0108
FAILURE ANALYSIS OF POTTED ELECTRONIC MODULES
Levin, Burton S., Proceedings of the Ninth National Symposium on Reliability and Quality Control, 1963, pp 228-231

This paper describes some of the diagnostic techniques used at General Electric Company - Reentry Systems Department to determine the cause of potted electronic module failures, with additional emphasis on a program of corrective action to "close the loop". The importance of the failure of an epoxy encapsulated module is that it is costly since such failures are at the end of the production cycle.

4.3, 6.5

0109
COMPLEX INTERCONNECTING OF FLAT PACKS...WITHOUT MULTI-LAYER BOARDS
Katzin, Leonard, Electronic Packaging and Production, 5, (12), December, 1965, pp 60-62

The development effort at the Jet Propulsion Laboratories to find a more optimum approach to the packaging of flat-pack integrated circuits is described. It was determined that together with the flat packs, discrete conventional components would also be required. The "stick" module was evolved as a method of achieving a single-axis motherboard. Approximately 225 flat packs are used in this program which, when combined with the discrete components, will require 22 stick modules.

5.1

0110
MOUNTING INTEGRATED CIRCUITS ON PRINTED CIRCUIT BOARDS
Heal, R., Whatton, M. E., and Wogan, M., British Communications and Electronics, 12, (8), August, 1965, pp 498-499

The mounting of packaged integrated circuits on printed circuit boards, however, can present problems if the process is not to be expensive, and the intrinsic reliability of the device sacrificed by a multiplicity of soldered interconnections. In this article the authors describe a simple method of mounting devices in TO5 packages which avoids many of the usual complications.

5.1, 7.

0111
THERMAL DESIGN FOR MICROMINIATURIZED CIRCUITRY
Kammerer, H. C., Journal of Engineering for Industry, February, 1962, pp 1-7

This paper outlines some of the basic considerations in terms of heat conductivity of materials, maximum safe working temperatures, and circuit power levels as dictated by current devices. A method is described whereby a proposed design configuration can be computer-analyzed in terms of isothermal lines and maximum hot spot temperatures and decisions made on that basis as to which type of cooling is most appropriate. Now that a number of techniques exist which permit the fabrication of circuits with a theoretical packing density of 1 million or more circuits per cubic foot, thermal design is an essential initial consideration. In most cases the drive toward microminiaturization is based on the need for a large number of circuits in a small weight and volume. If present circuit designs are taken as the basis for microminiaturization, it can be shown that with most materials being considered the temperature will rapidly rise to the point where circuits will become inoperative.

4.2, 4.27, 5.13

0112
ENGINEERING A MICROCIRCUIT MODULE
Manfield, H. G. and Letchford, A., Electronic Engineering, 35, October, 1963, pp 676-681

To form a complete piece of equipment it is generally necessary to interconnect and package a number of substrates together and in this article the problems which arise in doing this are discussed. It is shown that this technique has a potential for high reliability combined with small space requirements and a distinct possibility of reduced costs.

5.1, 9.

0113
SPACE PROGRAMS SUMMARY NO. 37-34, VOLUME IV SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT
California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif., August 31, 1965, 307 pp., for period June 1, 1965 to July 31, 1965

Included in this report are sections on the development of low stress encapsulation technique for welded modules, packaging integrated circuits for space application, and sterilizable electronic packaging.

5.1, 5.28

0114
COMPONENTS PACKAGING TECHNIQUES
Beck, George R., Space Technology Laboratories, Inc., Los Angeles, Calif., July 1, 1960 through June 30, 1961, 46 pp., Final Rept. BSD-TR-61-7, AF 04(647)-619 (AD 605941)

In evaluating new design techniques for packaging electronic and electromechanical components efforts were concentrated on cordwood arrangement of electronic parts into modules, resistance welding of electrical connections, and techniques for implementing these approaches. Advanced gyro control circuits were used as a test vehicle for integration of study efforts in four specific areas: 1) design techniques, 2) materials and processes, 3) microminiaturization, and 4) thermal and vibration studies. The design study resulted in three operational prototype assemblies containing 2548 electronic parts and three gyroscopes occupying 0.6 cubic foot and weighing 34 pounds. Basic types of metallurgical joints were defined by examination of microstructure of the welded electrical connections. Other investigations included welding process control, economic studies, connection techniques, and encapsulation studies. Microminiaturization studies on the micromodule technique led to development of a hybrid design approach and sample experimental solid state circuits were evaluated. Theoretical vibration and shock studies were made on problems related to environmental testing of missile electronic equipment.

5.1, 9.

0115
INTERCONNECTION OF FUNCTIONAL ELECTRONIC BLOCKS
Garibotti, D. J. and Olson, K. O., United Aircraft Corporation, Hamilton Standard Division, Broad Brook, Conn., July 1, 1963 to September 30, 1963, 45 pp., Interim Doc. Prog. Rept. No. 5, AF 33(657)-8790 (AD 427735)

The objectives of this program were to 1) develop a reliable and high yield interconnection process; 2) automate the process; and 3) develop an interconnection matrix - packaging system for the interconnection of integral devices. An electron beam automation system is at an advanced state of assembly and check out. The primary tool is an electron beam machine which is complemented with tape programmers and function generators for automated microwelding and scribing processes. An interconnection matrix - packaging structure has been designed and is at an advanced state of development. The system consists of beryllia or alumina substrates which are provided with electron beam scribed metallized conductors and interconnected by means of vertical feed-throughs fabricated by a "vacuum casting" technique. The integral devices are banded to the top board of the structure and their tabs automatically electron beam welded to the metallized pads.

5.1, 6.1, 9.1

0116
THE MINISTICK PROCESS FOR PACKAGING INTEGRATED CIRCUIT FLAT PACKS
Noyes, Carlton F., Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Md., April, 1965, 39 pp, TG-675, NOw-69-0604 (AD 468378)

The Ministick process for fabricating flat-pack type multilayer circuitry boards has been developed because of the need for space circuitry that meets ease of design and manufacture requirements. Starting with a circuit design in the form of a logic diagram, the design phase progresses to the final artwork template. This template, photo reduced, is the basic tool in the fabrication of the assembly frames. The circuit of each layer of an assembly frame is produced by chemically milling substrates which have been sensitized with the desired circuit by use of the final artwork template. These substrates are made by laminating an epoxy glass cloth dielectric material to a Kovar sheet. Individual circuit layers are then combined to form an assembly frame, and Integrated Circuit modules are welded to the frame to complete the circuitry. When more than one assembly frame is required to complete the circuitry, the frames are electrically connected by means of a mother board. Although multilayer circuit boards are used in this procedure, no interlayer connections are required.

5.1, 6.1, 6.2

0117
ENHANCED MICRO-MODULE INTERCONNECTIONS - AN HERMETIC PACKAGING SYSTEM FOR THE INTEGRATION OF MICRO CIRCUITS
United Aircraft Corporation, Hamilton Standard Division, Broad Brook, Conn., October 1, 1963 to December 31, 1963, 40 pp., Qtly. Rept. No. 2, DA-36-039-AMC-03620(E) (AD 432492)

The assembly and electrical checkout of twenty solid state microcircuit wafers, each encompassing two Fairchild 905 integrated circuits are discussed. The samples demonstrate complete capability in semiconductor device mounting as well as thermo compression bonding of the leads. Design and fabrication of the tooling for this program are also discussed.

5.1, 6.2, 9.

0118
INVESTIGATION OF FACTORS AFFECTING EARLY EXPLOITATION OF INTEGRATED SOLID CIRCUITRY VOLUME III INTERCONNECTIONS FOR INTEGRAL ELECTRONICS
ARINC Research Corporation, Washington, D. C., April 1, 1963 - July 1, 1963, 39 pp., Interim Tech. Doc. Prog. Rept. No. ASD-TDR-7-998-4, AF 33(657)-8785 (AD 428829)

Investigations of the various research, engineering, logistic, and economic factors that enter into adoption of the integral electronics (IE) concept in military electronic systems are continuing. This volume presents qualitative assessments of various techniques and methods used for the distribution of electrical energy within an IE system. Prominent considerations include the effects of the distribution system on reliability, size and weight, cost, performance, and maintainability.

5.1, 5.3, 9.5

0119
INTERCONNECTIONS LAG DEVICE DEVELOPMENT
Electronic Design, 8, (23), November 9, 1960, pp 84-89

Three-dimensional form factors have been carefully worked out, as indicated in the discussion of sandwich-type and welded modules. The earlier 2-D approaches have received some attention, and in some cases excellent packaging schemes have been developed. The greatest promise for micromin, however, remains with the most advanced concepts--thin-film and integrated circuits and functional or molecular electronics. This area is where the greatest novelty in form factor is feasible, but also where the fewest detailed schemes have been worked out.

5.1, 6.1, 6.2, 9.

0120
SOME NEW PACKAGING SCHEMES FOR INTEGRATED CIRCUITS
Lampathakis, K. E., Proceedings of the IEEE, December, 1964, pp 1651-1654

This paper investigates interconnection schemes based on multilayer printed wiring techniques necessitated by the development and the subsequent introduction of integrated circuits into the systems technology. The integrated circuits used in the particular scheme discussed and illustrated in this paper are current mode fast digital circuits packaged in the familiar TO-5, 10-pin device package. But similar designs exist for other device packages such as the ceramic flat package. The design of the interconnection scheme evolves around a predesigned TO-5, 10-pin package matrix with sandwiched voltage planes (one layer per voltage) and with all the logic signal interconnection lines on the two outside sides of the multilayer printed circuit board.

5.1, 9.

0121
MICROMINIATURE COMPONENTS AND PACKAGING TECHNIQUES
Stuhlbarg, S. M. and Sweany, L. P., IRE International Convention Record, 9, Pt. 6, 1961, pp 3-17

This paper describes a comprehensive study which was conducted recently by P. R. Mallory & Co. Inc. concerning the important and rapidly expanding microminiaturization market. Also included is a detailed examination of the micro-components and microcircuitry currently under development, and a discussion of the unique work approach which was followed in making prototype samples available to the electronics industry at the earliest possible date.

5.1

0122
INTERCONNECTION OF INTEGRATED CIRCUIT FLAT PACKS IN AUTONETICS IMPROVED MINUTEMAN PROGRAM
Harmon, Elise F., IEEE Transaction on Component Parts, USA, CP-11, (2), June, 1964, pp 135-144

Design studies for the Improved Minuteman computer reveal the necessity for advanced microcircuit interconnection techniques in order to capture the potential advantages of integrated circuits. The development of a unique multilayer board concept is described in terms of such factors as design procedures; masking techniques; and fabrication, test and rework methods. With reliability as the dominant factor in all trade-off studies the significance of physical and electrical parameters is discussed as well as the influence of considerations of producibility, yield, and system constraints.

5.1

0123
THE TRANSISTOR TYPE INTEGRATED CIRCUIT PACKAGE
Needham, George, SCP and Solid State Technology, 8, (5), May, 1965, pp 27-30, 40

Problems encountered in the construction and hermetic sealing of integrated circuits in transistor type housings are treated. Dimensions and demensional variations are given. Advantages and disadvantages compared to a flat package are pointed out. The configuration of such packages in subsystems is dealt with.

5.1, 7.

0124
LOW COST ARMY MICROMODULE PROGRAM
Margolin, P., Radio Corporation of America, Communications Systems Division, Camden, N. J., December, 1964, 78 pp., Final Rept., DA-36-039-AMC-03259(E) (AD 458046)

A low cost 28/20 Modular Assembly having 28 internal riser wires and 20 exit leads was developed to replace the 12-leaded standard micromodule in digital applications. The new module incorporates monolithic silicon devices in flat-packs into the disciplined geometry initiated with the standard micromodule. Analysis is made in regard to cost, reliability and weight with comparisons to planar arrays of flat-packs on printed circuit boards. Life tests of 3000 hours at 85 C ambient have been successfully completed. Comparisons are also made of various microelectronic techniques in reference to availability, cost, tolerances, reliability and noise. Results are presented of the development and testing of an IFF Encoder built with 28/20 Modular Assemblies where the leads are on a .075-inch grid. Twenty-five modules of four types were mounted on a multilayered printed circuit board.

5.14

0125
RADIATION-RESISTANT EQUIPMENT-DESIGN DATA AND GUIDELINES
Corneretto, Alan, Electronic Design, 12, June 8, 1964, pp 35-46, 48-55

This special report indicates that designers can produce circuits and equipment that are resistant to radiation from nuclear weapons bursts. This is possible only if the designers know how to analyze proposed hardened circuits, how to select radiation-resistant components and devices and how to apply hardening techniques. Five distinct steps in producing effective radiation-resistant circuits and equipment are: 1. Determine the radiation environment--its type, intensity, spectrum and time and other characteristics. 2. Define the circuit in terms of components materials, placement of parts, pottings and coatings. 3. Choose a method of circuit analysis--one in which accuracy is intelligently traded off for simplicity and which allows for permanent damage if intense radiation is expected. 4. Apply the appropriate hardening techniques from the growing number now being developed. and 5. Verify performance analyses and quality for acceptance by the Government contracting agency.

3.4

0126
CONSTANT-TEMPERATURE TRANSISTOR ENCLOSURE
Electronic Design, 10, October 11, 1962, 1 p

To maintain equal temperature between various circuit elements of a frequency meter, an oven was developed consisting of an aluminum block containing the transistors, heating and sensing elements. The assembly embedded in silicone grease uses a power transistor as the heating element because of its excellent thermal contact.

4.2

0127
WHAT'S THE BEST WAY TO INSULATE A PRESSURE SENSITIVE TOROIDAL COIL? POT IT...
Insulation, December, 1965, p 47

Baker's Vorite 190 and Polycin 201 or Polycin 196 is a polyurethane potting system that provides a low-stress encapsulation giving a 50% decrease in inductance change over epoxy systems and a sharp decrease in the spread of inductance values. Typical electrical and mechanical properties of the Vorite/Polycin system are listed.

3.4, 8.3

0128
NEED A CASTING RESIN WITH EXCELLENT ELECTRICAL PROPERTIES THAT REMAIN STABLE OVER A WIDE RANGE OF FREQUENCIES, TEMPERATURES AND HUMIDITY CONDITIONS? MAYBE YOU'D LIKE TO SAVE MONEY TOO? BUTON IS THE ANSWER.
Electro Technology, December, 1965, p 53

Buton resins are viscous, essentially colorless, thermosetting butadiene-styrene or butadiene polymers, curable with free radical type initiators. Blends of Buton with various modifiers are highly suitable for embedding, encapsulating, potting, laminating and impregnating electrical and electronic components. Typical electrical properties of Buton resins are listed and are compared with those of epoxies and silicones.

3.4, 8.3

0129
USAF TO TEST TRIPLE-REDUNDANCY SYSTEM
Aviation Week and Space Technology, 83, (21), November 22, 1965, pp 87-88

An epoxy high-gain amplifier module which is employed in single-axis stability augmentation system contains an analog ac. amplifier plus discrete passive components. Seventy-six of these plug-in modules are employed in the unit performing control computations for the triply-redundant single-axis stability augmentation system. The control package of the single-axis stability augmentation system, which performs control computations for the pitch axis of high-performance aircraft, employs an unusual technique in which feedback paths around triply-redundant amplifiers force voltage at outputs to input level. Should one fail, the remaining two drive the output to nearly the same level, thus compensating for malfunction and eliminating the need for majority voting as employed in other approaches.

4.1, 4.2

0130
DESIGNING PRACTICAL CIRCUIT BOARDS
Nagy, R. A., Electronic Industries, 23, May, 1964, pp 83-85

Conductor width, conductor spacing, minimum hole size, hole-pad diameter ratio, mounting holes and hardware, warp and twist are discussed in relation to designing circuit boards which are functional and economically feasible.

4.14, 4.15113

0131
THERMAL CONSIDERATIONS FOR PLASTIC ENCAPSULATION OR COATING IN ELECTRONIC PRODUCT DESIGN
Fairbanks, D. R. and Mark, M., IRE Transactions on Product Engineering and Production, 6, (2), July, 1962, pp 9-10

The effects of using plastic compounds for encapsulation or coating of electronic circuitry are discussed with respect to cooling. The basic thermal mechanisms are presented. It is concluded that encapsulation or coating can significantly improve the cooling of small compact circuitry not employing direct metallic conduction paths or direct forced convection.

4.2, 7.3, 8.3

0132
ELECTRONIC PACKAGE DESIGN
Harper, Charles A., Electro Technology, 74, November, 1964, pp 89-94

Recent developments in electronic package design discussed include the shell-packaged module, the repairable module, and the module embedded by transfer molding. Plastic materials, including liquid resins and reinforced plastics used for embedding and encasing electronic modules are also discussed. The newly developed designs and materials provide ways to meet the increasingly stringent equipment performance, reliability, maintainability, and cost objectives in aerospace and commercial applications.

4.2, 8.3

0133
A BREAK WITH DIGITAL PACKAGING
Electronic Design, 9, (22), October 25, 1961, pp 43-45

A missile-checkout digital multimeter developed by Adage, Inc. illustrates the special type of packaging appropriate to certain military ground-support and vehicle-mounted equipment and corresponding types of industrial installations. Space limitations led to an unusual module shape. The housing and cover were made of an aluminum sand casting. The valleys cast into the rear inside surface of the housing and in the inside of the door are lined with an energy-absorbent elastic material selected for its vibration-absorbent characteristics.

6.1, 7.

0134
MICROMINIATURIZATION PROCEEDINGS OF THE AGARD CONFERENCE OSLO, JULY 24-26 1961
Dummer, G.W.A., Pergamon Press, 1962, 355 pp.

This book consists of a collection of papers dealing with microminiaturization techniques and applications, micromodules, microcircuits, and solid circuits. See Nos. 0135, 0136, 0137, and 0138 for papers of particular interest to electronic packaging.

5.1, 6.1

0135
THE MICROMODULE APPROACH TO MICROMINIATURIZATION
Danko, S. F., U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., Pergamon Press, 1962, pp 96-114 (N62-12304)

The dimensions, general characteristics, and physical features of micro-elements now available for experimental micromodule construction are given. Applications of micromodules include combat radios, inertial guidance platforms, and computers. The throw-away concept is discussed relative to micromodules and sub-assemblies.

5.145

0136
A FLEXIBLE APPROACH TO MICROMODULAR CONSTRUCTION
Prior, H. T., Standard Telecommunication Laboratories Ltd., Eng., Pergamon Press, 1962, pp 121-135 (N62-12306)

This paper is primarily concerned with assemblies of individual components. An examination of the factors limiting packing density leads to the conclusion that at present a packing density of about 20,000 components/ft^3 is a reasonable aim. In many cases, however, temperature rise caused by internal dissipation will limit the useful packing density to a lower figure. As circuits of low dissipation are introduced, higher packing densities will be attainable by the use of composite components within the circuit modules. The method of construction is simple and flexible. It permits the incorporation of a wide range of fixed and variable components with little or no modification from their conventional form.

5.145, 6.1

0137
A CONCEPT FOR MICROSYSTEMS ELECTRONICS
Bender, Bob G., Hughes Aircraft Company, Semiconductor Division, Newport Beach, Calif., Pergamon Press, 1962, pp 136-143 (N62-12307)

Size and weight reduction as well as strength, reliability, flexibility of circuit design, repairability, heat drain, and costs, must bear influence on design for the concept of microcircuits to endure. Means for automatic insertion of devices and simplicity of interconnection should be provided. These influences are shown in detail dominating the means for assembling of Microseal diodes and transistors, and small passive components, first into circuit cards, then into sub-system. The building of circuits using a technique called "Swiss Cheese" is described. Until power requirements are substantially reduced, this concept will be limited to information handling and for circuitry related to detector-type input transducers.

6.1, 6.2

0138
PRELIMINARY CONSIDERATIONS FOR THE DESIGN OF A MICRO-MINIATURE TELECOMMUNICATIONS EQUIPMENT
Goss, T. M., Plessey Company, Ltd., West Leigh, Havant, Development Laboratories of the Telecommunications Division, Eng., Pergamon Press, 1962, pp 174-183 (N62-12310)

Preliminary considerations for the design of a microminiature telecommunications equipment are described. Reasons are given for the choice of an inital method utilising the assembly of separate components. The components considered for use are described and the results of measurements made on thin film nichrome and tin oxide resistors, and on silicon monoxide and zinc sulphide capacitors, are quoted. The form of the proposed assembly of components and modules is described. Interconnections are based on the use of soldered joints and printed circuits. A volume reduction of about 10:1 on a conventional equipment of similar performance is sought, and a further objective is an improvement in reliability. A failure rate of one equipment failure per 107 component hours, under moderately severe environmental conditions, is the aim. Maintenance of the equipment by module replacement is proposed.

6.1, 6.5

0139
THE PACKAGING REVOLUTION, PART IV: BIGGER, BETTER MULTILAYER BOARDS
Hays, Stephen A., Electronics, 38, (24), November 29, 1965, pp 90-95

The high-density MLB's have been criticized as overly complex, difficult to design, modify and fabricate, ill-suited to system maintenance and repair, and hence too expensive. Actually, the reverse is true in the computers made by Autonetics. Multilayer boards with high density result in systems that are smaller, have far fewer parts to maintain and less mechanical connections to fail.

6.213

0140
HIGH-DENSITY ELECTRONIC PACKAGING--THERMAL DESIGN
Kadlec, Charles and Francis, Samuel, Electronic Design, 9, (23), November 8, 1961, pp 44-47

Close control of component temperature is an improtant consideration for tightly packed assemblies specified for high-reliability systems. High-Density Electronic Packaging (HDEP) increases the heat-dissipation density and the intercomponent heat transfer; high power dissipation components must be kept within rated operating temperature to minimize failures. The design steps involved in achieving proper thermal performance during initial assembly analysis, rather than last minute haste, are outlined.

6.1, 6.4

0141
BERLON HIGH THERMAL CONDUCTIVITY ELECTRICAL INSULATION
National Beryllia Corporation, Beryllia and Pure Oxide Ceramics, Haskell, N. J., November 1, 1965, 9 pp

A new family of plastic insulation materials has been formulated from selected resins and contains high purity beryllium oxide fillers. These materials are available either as pre-filled resins, suitable for blending with the recommended curing agent for potting or encapsulation, or in the form of fabricated sheets, blocks, rods or custom machined precision components. Mechanical, electrical, and thermal properties of these materials are listed.

3.2

0142
SURVEY OF MATERIALS PROBLEMS RESULTING FROM LOW-PRESSURE AND RADIATION ENVIRONMENT IN SPACE
Lad, Robert A., NASA, Lewis Research Center, Cleveland, Ohio, November, 1960, 18 pp., NASA TN D-47, (AD 245491)

The detrimental effects of low pressures in space may include loss of bulk material and thin coatings and changes in bulk material, frictional properties, optical transmission, and emissivity. Damage caused by space radiation, both electromagnetic and particulate, is also discussed. The materials considered are pure metals, alloys, ceramics and other inorganic compounds, plastics, and lubricants. Areas in which more research is needed are pointed out.

3.1, 3.4

0143
EVAPORATION EFFECTS ON MATERIALS IN SPACE
Jaffe, Leonard D. and Rittenhouse, John B., California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif., October 30, 1961, 18 pp., Tech. rept. No. 32-161, NASw-6 (AD 266906)

Metals and alloys are generally quite stable in the high vacuum of space at normal operating temperatures. Sublimation of cadmium, zinc, and magnesium and its alloys may be of some concern. Among the semiconductors, selenium, phosphides, and arsenides have high sublimation or decomposition rates in high vacuum at moderate temperatures. Most inorganic engineering insulators are unaffected by the vacuum of space except at high temperatures. Polymers suitable for high-temperature service are generally best; the use of plasticizers should be avoided. For both organics and inorganics, there seems to be little detrimental effect of vacuum on mechanical or electrical properties, except when appreciable loss of mass occurs.

3.1, 3.2, 3.4

0144
EFFECT OF MOISTURE ON PRINTED CIRCUIT BOARDS
McDonnell Aircraft Corporation, St. Louis, Mo., August 18, 1964, 7 pp., TR 513-439, IDEP 141.10.50.11-F4-01 (AD 454220)

Tests were run to determine if moisture absorption by the glass epoxy circuit boards was responsible for failures occurring on the circuit boards during soldering operations. Samples were solder immersion tested before and after subjecting the boards to water absorption, at which times volume resistivity and surface resistance were also measured. All but one specimen passed the solder immersion test before moisture absorption, but none passed this test after moisture absorption. Methods of preventing the interference of moisture absorption with soldering are described.

4.26

0145
ECONOMIC DECISION CRITERIA FOR REPAIR VERSUS THROWAWAY MAINTENANCE
Davis, O. E., Vitro Laboratories, Silver Spring, Md., 70 pp., Tech. rept. No. 01816.01-3, NObsr 89362 (AD 455102)

A limited cost difference model was derived which allows the designer to determine an economic comparison of the throwaway or repair maintenance procedures. Three graphs were produced to aid the designer or the person who determines the maintenance procedure used for an assembly: The Throwaway or Repair Decision Graph which allows a decision to be made for an assembly where the assembly cost is fixed, The Cost Difference Graph which shows an economic comparison of the two maintenance procedures, and the Marginal Cost and Decision Graph which can be used for optimizing the number of parts in an assembly.

4.1113, 4.15, 4.3

0146
AN EVALUATION OF INORGANIC POTTING COMPOUNDS
Vondracek, C. H., Westinghouse Electric Corporation, Research Laboratories, Pittsburgh, Pa., March 1, 1964. 20 pp., Research Paper 64-131-342-P2

The relative advantages and disadvantages in using inorganic potting compounds are described. An extensive evaluation of twenty-two commercially available inorganic potting compounds is given. Such properties as pot life, viscosity, initial and fired shrinkage, water absorption, strength, density, and electrical properties are reported. The potting compounds are classified in each of these categories to provide a ready reference for the materials engineer. The significance of each of these properties is discussed with relation to application to electrical devices.

3.4, 8.3

0147
TO EVALUATE THE EPOCAST H-1786 POTTING MATERIAL
General Motors Corporation, AC Spark Plug Division, Milwaukee, Wis., February 28, 1963, 328-5, IDEP 501.32.00.00.A4-01 (AD 421371)

Epocast H-1786 and Hardener 9115 potting system was evaluated with respect to possible cracking of susceptible components. After exposure to a thermal cycling environment, cracking occurred both in the potting compound and in glass diodes.

3.4, 8.3

0148
PARALLEL-PLATE CONFIGURATIONS AID MODULE ASSEMBLY
Rose, J. A., Electronic Engineers Design, 10, (12), October, 1965, pp 122-123

A sandwich of components is made of two circuit boards with the components mounted between them. Rather than tightly packing the components as in the cordwood technique, the components are mounted vertically along the board edges. The boards provide interconnections between the components. Module plug-in terminations can be made on all or any of the four ends of the module. The open sandwich technique has a number of advantages in the area of manufacturing and service.

4.15

0149
RESEARCH AND DEVELOPMENT FOR THREE-DIMENSIONAL WELDED CIRCUIT PACKAGING DESIGN REQUIREMENTS
Sawyer, H. F., Oldaker, D. R., and Bateman, V. G., General Dynamics, Pomona, Calif., 47 pp., Qtly Prog. rept. No. 1, June 15, 1962 to September 15, 1962, DA 36-039-SC-90754 (AD 456672)

The object of this contract is to establish design requirements for 3-D welded module packaging and to verify the adequacy of the associated welding process and parameter controls. Volume comparisons of "cordwood" electronic modules by welding and soldering techniques resulted in variations of $\pm$ 15%. Evaluation of sample welds were used in making lead material selections. These selections include copper, Kovar, Dumet and nickel. A summary of design, process and parameter controls necessary for manufacturing reliable 3-D welded modules is included.

4.15, 9.1, 9.2

0150
MAGNETIC SHIELDING PRACTICE IN ELECTRONIC PACKAGING
Longmire, D. E., Electro Technology, January, 1963, pp 63-66

Unwanted magnetic fields can affect the performance of almost any device having a magnetic structure, such as a transformer or relay or (additionally) involving electron beams, such as microwave devices. Full and completely enveloping shielding is the only sure type of magnetic shielding. Ideally, the shield should have high permeability, low retentivity, and the ability to carry a large magnetic-field density before saturating. After shielding has been applied, it is often found that the performance of the r-f device has deteriorated beyond the acceptable limit or that the shield must be made larger so that it does not drastically affect the item to be shielded. Examples of successes and failures in packaging microwave devices under severe environmental conditions are cited.

6.111

0151
HEAT-CONDUCTING WAFERS DISSIPATE HEAT IN MICROMODULES
Abel, Donald J., Fairchild Camera and Instrument Corporation, Du Mont Military Electronics Division, Clifton, N. J., Electronic Design, 9, May 10, 1961, p 224

The heat-dissipating ability of micromodule package designs can be considerably increased by building into the package wafers whose sole function is to transfer heat. The wafers absorb heat produced within the package and conduct it to their outer edges. The wafers can be made from materials such as Berlox (BeO).

5.2

0152
BOARD-TO-BOARD CONNECTOR CREATES PACKAGE FLEXIBILITY
Electronic Design, 9, (23), November 8, 1961, pp 52-53

New arrangements for assemblies of printed-circuit boards are permitted by a recently developed combined connector-mounting device. The connector is but a block of diallylphthalate plastic into which have been molded grooves to carry the contact fingers and tapped bushings for the hold-down screws. When a printed-circuit board is screwed down onto this connector the protruding contacts are compressed against the mating conductors of the boards. A virtue of this simple type of connection is that it can be placed anywhere on the board.

6.1, 8.4

0153
WELDABLE HOLLOW PIN SPEEDS FABRICATION OF MODULES
Oswald, Anton, Electronic Design, 10, (14), July 5, 1962, pp 96-101

A weldable hollow pin has been designed for use in conjunction with printed circuits. The resulting weldable printed-circuit board eliminates the need for point-to-point wiring using nickel ribbon wire.

6.1, 9.

0154
WEIGHT-SAVING DESIGN OPENS MARKET
Electronics, 33, September 2, 1960, p 34

The high-density Weld-Pak is a complete circuit module or stick consisting of conventional or miniature resistors, capacitors, diodes and transistors, packed closely together and joined by precise, space-saving welds. With interconnecting wiring matrices, especially designed connection plugs, and potting, these sticks become complete interchangeable circuits.

6.1, 6.2

0155
BOLTED-DOWN MODULE JOINS SUBCIRCUITS TO MOTHERBOARDS
Boehm, Josef and Herrmann, Adolf L., Electronic Design, 11, August 16, 1963, pp 104, 106-107

A means of securely and reliably attaching circuit subsystems to printed-circuit motherboards while at the same time being able to remove and replace these modules frequently has been designed for control systems of large space boosters. The building block for this packaging approach is not much more than a module base plate that incorporates two protruding bolts and a number of spring-like electrical contacts on its under side. When this plate is bolted onto a printed-circuit board, the resulting compressive force creates a firm mechanical and electrical union between the module and its contacts and the board. The connection is made by conventional threaded fasteners. It is possible to package many different types of circuit and component assemblies on top of this type of base plate.

6.1, 6.2

0156
ATTACHMENT OF INTEGRATED CIRCUITS TO MULTI-LAYER BOARDS
North American Aviation, Inc., Autonetics Division, Anaheim, Calif., March 15, 1965, 30 pp., Final Rept., Minuteman Producibility Study No. 18, AF 04(694)-402 (AD 462635)

A process and equipment for the precise positioning and attachment of integrated circuits to multilayer boards have been developed. The system evolved was kept within the bounds of existing process specifications to facilitate its implementation into current production. The resulting semi-automatic machine bonds integrated circuits to the heatsinks of multilayer circuit boards locating each of the fourteen leads on their respective board pads.

6.1, 9.5

0157
HIGH-DENSITY ELECTRONIC PACKAGING -- STRUCTURAL DESIGN
Converse, Courtland B. and James, Paul N., Electronic Design, 9, (15), July 19, 1961, pp 60-63

The inherent compressive strength of encapsulated components can be used to achieve a reliable structural assembly for a High-Density Electronic Package. Reinforced and postloaded structural design analysis, applied to HDEP assemblies, has resulted in rugged units which have passed the stringent military requirements for shock, vibration, and temperature cycling. The mathematical calculations and test results are presented. Although a single encapsulated module may be capable of withstanding compressive forces in the order of tons, a unified structure is required to brace groups of modules as well as cooling devices, connectors and cabling. Internal loads must be kept to a minimum and, under vibration stresses, amplifications must be low.

6.1, 6.2, 6.4

0158
HIGH DENSITY ELECTRONIC PACKAGING MODULE LAYOUT AND DESIGN
Coutu, Alfred J. and James, Paul N., Electronic Design, 9, May 10, 1961, pp 44-47

The High Density Electronic Packaging (HDEP) technique employs two basic modular electronic subassemblies: circuit modules and wiring modules. The design of circuit modules and wiring modules is outlined in terms of module size, cost and efficient layout. Ground rules are presented for various design approaches.

6.1, 6.2

0159
MICROELECTRONIC COMPONENTS: CAPABILITY AND AVAILABILITY
Electro Technology, 73, October, 1963, pp 103-108

The results of a Electro Technology survey of component manufacturers provides information on discrete modular components, thin-film integrated circuits and semiconductor integrated circuits. Definitions are given for: Module, Thin-film integrated circuit, Semiconductor integrated circuit, Electrical element, Device (micro systems electronics), Circuit, Substrate, and Microsystems electronics or microelectronics. A partial list of sources of discrete modular circuit elements, some modular packaging schemes, sources of thin-film and hybrid integrated circuits, and sources of semiconductor integrated circuits are included.

5.1

0160
HOW TO DESIGN MICROMODULES
DiStefano, Renato, Jr., Electronics, 35, September 14, 1962, pp 37-41

Step-by-step procedures for designing wafer-mounted microelements and assembling them to riser wires, with design considerations, module assembly methods and system assembly methods are presented.

5.1

0161
INTEGRATED CIRCUITS TODAY AND TOMORROW
Hogan, C. Lester, Electronic Industries, 23, June, 1964, pp 58-64, 67

Significant approaches being followed in the area of integrated circuits are discussed. Acceptance of integrated circuits is predicated on the ability to manufacture such devices with performance and price advantages, as well as other features predicted for integrated circuits over the past several years. To achieve these advantages, a number of techniques have been developed and are in somewhat common use. Among these are the thin-film approach, the semiconductor approach, comprising silicon monolithic circuits and hybrid (multichip) devices, the magnetic element technique, and magnetic and superconducting thin-film technologies.

5.1

0162
NEW DEVELOPMENTS IN MICROCIRCUIT PACKAGING
McElroy, David E., Electronic Industries, 23, April, 1964, pp 57-60

Packaging methods which are now receiving the most attention, Micromodule, Dot, hybrid, and integrated systems are briefly discussed.

5.1

0163
FOR LOW-COST FLATPACKS: REMOVE THE WIRES, PUT CIRCUITS IN GLASS
Cook, Charles R., Jr, Mohnkern, Ronald W., and Sampiere, Salvatore M., Electronics, 38, (14), July 12, 1965, pp 99-104

The package developed at ITT Semiconductors encloses the silicon integrated circuit in a solid structure of glass and ceramic or metal. In the construction process the tips of Kovar ribbon leads are bonded directly to thin-film aluminum bonding pads on the chips. These pads are made 10 mils square (0.010 inch square). Of the total pad area of 100 square mils, about half is the bond area. The bonds are about 10 times larger than conventional gold-wire bonds and consequently stronger. After the leads are bonded, the chips and lead tips are hermetically sealed by coating them with silicon dioxide and molding glass around them. The package may be made of glass alone, or by the use of glazed metal or ceramic lids that fit over the chip and leads. After plating, the packages look like regular 14-lead flatpacks and can be tested and assembled into equipment without changing those methods.

5.1, 8.3

0164
MICROMINIATURE LOGIC MODULES
Schlanger, Sam, Electro Technology, October, 1962, pp 199-200, 202

Progress in the field of microminiature logic modules is indicated to be well advanced as far as component density is concerned. With the power levels that are now used, all of the module types described are sufficiently dense for most applications. Modules fabricated from individual components offer the circuit designer the greatest latitude of choice. Inevitably, at some stage of the design or in test or production, circuit changes become necessary. These changes can most easily be made with soldered, two-dimensional fabricated modules.

5.1

0165
PACKAGING--HOW DO YOU JUGGLE THE TRADEOFFS?
Electronic Design, October 25, 1965, pp 44-45, 47

Problems of circuit board selection, lead spacing, flip-chips, heat sinking, noise, interconnections and standards are briefly discussed.

5.1, 6.3

0166
IC PACKAGING METHOD JOINS HIGH RELIABILITY, LOW COST
Connolly, Ray, Electronic News, Monday, December 27, 1965, p 4

An interconnection technique for integrated circuits is reported on which couples high system reliability with low production cost. The technique developed by Raytheon Company's Space and Information System is being used in the M3X digital differential analyzer, a 5.7 pound computer. Fourteen of its 16 modules are composed completely of integrated circuits. Two of the flat pack circuits, each 1/4 x 1/8 inch, can perform all the functions of a single, discrete component package substantially larger than an M3X module containing all 42 circuits.

5.1

0167
ADVANCED PACKAGING TECHNIQUES MEET THE FLAT PACK
Reimann, William, IEEE International Convention Record, USA, 13, Pt. 10, pp 33-40

The use of integrated circuits in flat packages instead of another configuration, such as the multi-lead TO-5 shape, is discussed. While it is not the purpose of this paper to debate the advantages of one over the other, some of the reasons for the development of the flat pack are included. In the TO-5 configuration the leads are neatly positioned in a circle. This makes further miniaturization of the package unlikely. The flat pack, on the other hand, does not share these particular deficiencies. New joining techniques which were developed for bonding the ribbon leads of the flat pack to the surface of a printed circuit pattern are discussed.

5.1, 9.

0168
CONNECTOR PROBLEMS...RELIABILITY...AND PRINTED CIRCUIT CONNECTORS
Sheriff, D. R., Electronic Industries, 19, October, 1960, pp 94-97

Progress being achieved in developing better electrical connectors is discussed. Some characteristics which the ideal connector should have are: minimize wear of circuit foil, high volume and weight efficiency, high pressure moisture and dust seal, and use circuit itself as part of connector.

8.4

0169
SELECTING AND SPECIFYING SOLDERLESS TERMINALS AND SPLICES
Electronic Design, 12, July 6, 1964, pp 40-44

The leading manufacturers of terminals have designed their solderless wiring hardware to perform a variety of jobs in almost any environment. Knowledge about the functional characteristics of terminals is aided by a checklist provided with this article.

8.4

0170
PRINTED CIRCUIT CONNECTORS FOR MICROASSEMBLIES
United-Carr Fastener Corporation, Cinch Manufacturing Company, Chicago, Ill, 59 pp., Qtly. Prog. Rept. No. 3, August 1, 1963 to November 1, 1963, DA-36-039-AMC-00122(E) (AD 427353)

Connector design approaches which were studied, tested and analyzed during the period of the report are discussed. The appr aches were pursued based on a header design compatible with electron beam welding in the microassembly stack.

8.4

0171
NEW DEVELOPMENTS IN INTERCONNECTION TECHNIQUES
Buster, Warren V., Electronic Industries, 23, (6), June, 1964, pp 129-130, 132

The following interconnection techniques are briefly discussed: intra-module, module-to-motherboard, intra-motherboard, motherboard-to-back panel, and input/output.

8.4

0172
PRINTED-CIRCUIT CONNECTORS - IV A GENERAL SURVEY
Electronic Components, (GB), 5, (7), July, 1964, pp 586-604

This survey consists of short articles prepared by manufacturers, agents and distributors of printed-circuit connectors in the United Kingdom. These articles present the supplier's own assessment of the types of connectors available. Reference is made to special features. materials used, dimensions, special aplications, ratings, numbers of ways, reliability factors and design features.

8.4

0173
IMPROVING RELIABILITY OF MICROCIRCUIT CONNECTORS
Anderson, Jack R. and Saunders, John B., Electro Technology, October, 1962, pp 74-78

The results of a study of surface treatments intended to decrease friction and wear in microcircuit connectors are presented. Special films developed for boundary lubrication of contact metals are evaluated. Comparative test results have been tabulated. The information obtained has general application for electrical connectors and relay contacts used in low-signal-level circuits.

8.4

0174
DESIGN AND DEVELOPMENT OF FLAT CABLE ELECTRICAL CONNECTORS
Riley, Charles E. and Plunkett, Kenneth W., U. S. Army Missile Command. Redstone Arsenal, Ala., September 5, 1963, 62 pp., Final Rept. RG-TR-63-25 (AD 421566)

Four connector concepts were developed and evaluated. Out of these four concepts, one connector was selected for further evaluation, pilot production, and environmental testing. The results of the environmental tests conducted indicate that there are certain basic deficiencies in the selected connector concept which require major design modifications. Although deficiencies do exist, much experience was gained in the area of design requirements and production techniques.

8.4

0175
PRINTED CIRCUIT CONNECTORS FOR MICROASSEMBLIES
Dwan, Howard E., Cinch Manufacturing Company, Chicago, Ill., 84 pp., Final Progress Rept. No. 4, February 1, 1963 to February 1, 1964, DA-36-039-AMC-00122(E) (AD 437234)

This report summarizes the results of an intensive program leading to the development and evaluation of printed circuit connectors for microassemblies. The study developed printed circuit connectors for plug-in-microassemblies. The study was conducted in two tasks. Task A provided for the development of an contact for a female printed circuit receptacle whose overall height does not exceed 0.100 inch. The receptacle contacts are capable of mating with established hermetic microassembly pin terminations (0.016 to 0.020 inch diameter) spaced on a 0.075 in. grid. Task B provided for the development of feasibility models of printed circuit connectors for encapsulated microassemblies having 36 and 80 conductor ribbons 0.010 by 0.002 in. extending from the base. The ribbons protrude from the base on 0.025 in. centers around 0.310 and 0.600 in. squares located symetrically within the square area of the base. Basic design requirements, contact designs and connector concepts developed, and background information showing the relationships of these developments with the Micro-Circuit Module Program are discussed. The contact designs and connector concepts developed are capable of meeting the rigorous reliability and environmental demands of Military equipment. The qualification test procedure, test data and analysis of connector hardware made from temporary tooling in this program are discussed.

8.4

0176
QUALIFICATION TEST RELIABILITY TEST REPORT CONNECTOR, ELECTRICAL, RECEPTACLE, PRINTED CIRCUIT
Abraham, Ray A., Consolidated Electrodynamics Corporation, Data Recorders Division, Pasadena, Calif., May 22, 1963, 7 pp., RTR 1, IDEP 201.50.62.00-08-01 (AD 431368)

Printed circuit connectors were subjected to the following tests: dry circuit resistance, insulation resistance, voltage breakdown, contact resistance (rated current), separating and engaging forces, and individual separating force. No failures occurred as a result of the tests.

8.4

0177
BIT SOLDER - ELECTRICAL AND ELECTRONIC ASSEMBLIES
Robinson, W. L., North American Aviation, Inc., Autonetics Division, Anaheim, Calif., May 13, 1964, 11 pp., AA0107-012(E), IDEP 085.10.00.00-C1-01 (AD 454180)

This specification establishes the requirements for bit soldering electrical and electronic assemblies with solders having flow temperatures below 426 C (800 F). Detail requirements are given for (1) Printed Wiring and Terminal Boards; (2) Connectors, Wires and Cables Only; and (3) Post Solder Processing.

9.2

0178
A NEW SYSTEM PROVIDING REPRODUCIBILITY AND HIGH RELIABILITY IN SOLDERED AND INSULATED WIRE TERMINATIONS
Sherlock, Paul, IEEE International Convention Record, (USA), 12, Pt. 9, 1964, pp 99-104

The use of an insulated soldered termination produced in a single, controlled operation has been accomplished by Raychem Corporation through the development of a device which consists of a fluxed solder preform inside a heat-shrinkable, encapsulating, insulating sleeve. In a controlled-heating operation the sleeve shrinks, sealing rings in the ends melt, and solder flows to form an encapsulated termination which can be reproduced with a consistent reliability impossible with more conventional soldering techniques.

9.2

0179
INTERCONNECTION TECHNIQUES FOR MICROCIRCUITS
Keister, F. Z., Engquist, R. D., and Holley, J. H., IEEE Transactions on Component Parts, (USA), CP-11, (1), March, 1964, pp 33-41

This paper describes twelve interconnection techniques: 1) soft soldering, 2) resistance welding, 3) series welding, 4) parallel-gap welding, 5) ultrasonic welding, 6) thermocompression bonding, 7) electroplating, 8) conductive adhesives, 9) deposited films, 10) percussive arc welding, 11) electron beam welding, and 12) laser welding. An attempt has been made to present not only the mechanics of the various techniques, but to emphasize the materials, processes and equipment involved in each specific microcircuit interconnection method.

9.2

0180
HOT GAS SOLDERING FOR INTERCONNECTION OF INTEGRATED ELECTRONIC PACKAGES
Archey, William B., Proceedings of the IEEE, 52, (12), December, 1964, pp 1657-1660

A major problem facing users of integrated electronics has been the lack of high-speed automated processes for interconnection of flat profile packages, in large quantities, into higher order subsystem assemblies. The hot gas soldering process employs jets of heated hydrogen which are scanned across the joint rows of planar package arrays. Joining speeds in excess of 100 leads per minute for each jet have been obtained, without causing thermal damage to package seals or wiring boards. This paper discusses in detail the process parameters of gas temperature, board feel rate, and joint mass as they effect soldering speed and joint quality. A multinozzle production machine which also positions microcircuit packages is described. Selection of printed wiring boards and materials for hot gas soldering is discussed.

9.2

0181
TOOL SPEEDS SOLDERLESS TERMINATIONS
Electronics, 36, (31), August 2, 1963, pp 68, 70

A new development by AMP, Inc. in solderless termination that permits high-speed connection of solid, stranded, printed, enamel and tinsel wires is discussed. The advantages of the technique over other solderless joining methods include increased density of connections and easier serviceability. Increased density is said to result from the combined use of the thin, metal terminals and a small-nosed pneumatic fastening tool.

9.2

0182
QUANTIFICATION OF ELECTRONIC CIRCUIT CONNECTION TECHNIQUES
Hughes Aircraft Company, Ground Systems Group, Fullerton, Calif., May, 1964, 126 pp., Tech. Doc. Rept. No. RADC-TDR-64-46, AF 30(602)-3177 (AD 603250)

The study was directed toward gathering reliability data on several presently used electronic circuit connection types. Laboratory and field reliability reports were gathered from known producers and users of electronic equipment. The study covered 6 types of connections: solder, resistance welding, wire wrap, crimp, ultrasonic welding, and thermal compression bonding. The number of operating hours was small and no failures were noted in the reports obtained on the latter two types of connections, hence, the remainder of the study, therefore, was concentrated on the four connection types on which sufficient data were available. Failure rates and confidence intervals were calculated and compared for each of the four connection types. The results of tests showed that no statistically significant differences exist between the resistance-welded connection failure rate and the solder connection failure rate, nor between the resistance-welded connection failure rate and the crimp connection failure rate.

9.1, 9.2, 9.3, 9.4

0183
STUDY AND APPLICATION OF WELDING TECHNIQUES TO MODULAR ASSEMBLIES
Namaroff, J. H., U. S. Naval Air Development Center, Johnsville, Pa., November 4, 1963, 29 pp., Final Rept. NADC-EL-6341, N62269-1732 (AD 425210)

The application of welding techniques to modular assemblies is reported to be not only feasible, but minimizes the size and weight of such assemblies, and is comparable in cost to other packaging methods. It is concluded that it is reasonable to design and manufacture welded modules within the dimensions set forth in Specification No. MIL-E-19600A (Weps).

9.1

0184
MICROMINIATURIZATION DESIGN TECHNIQUES
Boron, P. E., Hughes Aircraft Company, Digital Systems Dept., 5th MIL-E-CON National Convention on Military Electronics, 1961 Conference Proceedings, June 26, 27, 28, 1961, Shoreham Hotel, Washinton, D. C., pp 17-31

This paper discusses and compares the approaches taken, techniques involved and results achieved in three generations of equipment developed. The first generation of electronic equipment under discussion is represented by the Polaris Mark I computer. Completely transistorized, the circuits were divided into 29 unique subassemblies. It is 800 cubic inches in size, weighs 19 pounds, and has an over-all component density of 12,000 parts per cubic foot. The second generation was the Polaris Mark II computer, an improved logical design, circuit design and equipment design over the Mark I but performing the same identical function for the missile guidance system. The computer is 150 cubic inches in size, weights 8 pounds, and achieves an over-all component density of 48,000 parts per cubic foot. The third generation of miniaturization design techniques the computer designed was based on Mark I circuits because the Mark II circuits were not near to being finished at the start of this project. This computer has proven itself to be the most advanced integrated unit of hardware yet built.

6.1, 6.2, 6.3

0185
A VERSATILE MODULAR PACKAGING CONCEPT
Ritter, J., Electronic Modules Corporation, 5th MIL-E-CON National Convention on Military Electronics, 1961, Conference Proceedings, June 26, 27, 28, 1961, Shoreham Hotel, Washington, D. C., pp 44-47

The subject of component density is discussed. A typical module, which is shown has a component density of approximately 74,000 components per cubic foot (20 components in 0.47 cubic inch). This packaging density could be increased but this may be offset by such other considerations as economy, producibility, maintainability, and system integration. Each of these considerations tends to moderate the component density figures which could otherwise be attained if such factors were of negligible importance. Packaging efficiency takes into account the problems of interconnecting modules and heat transfer. Packaging efficiency is defined as

$$\frac{\text{subassembly component density}}{\text{module component density}} \times 100\%.$$

4.15, 6.2

0186
A VALUE ANALYSIS STUDY SUMMARY REPORT ON DIP SOLDER VS WELDED JOINTS
Bubnekovich, J. R., Burroughs Corporation, Great Valley Laboratories, Paoli, Calif., April 26, 1963, 44 pp., IDEP 347.70.00.00-D3-01 (AD 459816)

A value analysis study involving dip soldered versus welded joints was conducted to determine which process provided the more reliable connection for the Track Evaluation Computer (TEC) circuit modules. Final assessment was based on the results of the encapsulation process, environmental and life tests, failure rates, and cost analysis. This report presents a recapitulation of objectives, condition, findings, and recommendations. The data developed during the study showed that modules encapsulated by the transfer molding process are superior in reliability to those encapsulated by the epoxy casting process, and that they suffer no penalty in costs. Therefore, it was recommended that the transfer molding process be adopted for future production of modules for MAULER.

8.3, 9.1, 9.2

0187
SOME PROPERTIES OF TWO EPON RESIN SYSTEMS FOR USE AS ELECTRICAL ENCAPSULANTS
Abelson, R. J. and Ditzler, J. A., Proceedings of the 4th Electrical Insulation Conference, NEMA-AIEE, 1962, pp 25-30

Mechanical and electrical properties of two highly filled epoxy resin systems which might serve as starting points in the formulation of candidates for encapsulating not only distribution transformers but other type transformers and electrical components as well are discussed. Also included is a brief study of the effect of some filler characteristics.

3.4

0188
IMPROVED ELECTRICAL PROPERTIES OF ELECTRONIC PACKAGING BASED ON EPOXYPOLYBUTADIENE RESIN
Johnston, Christian W. and Stackhouse, Donald F., Proceedings of the 4th Electrical Insulation Conference, NEMA-AIEE, 1962, pp 154-157

Epoxypolybutadiene resins are discussed which can be formulated to produce castings that will thermal cycle. These formulations can be soft like conventional epoxy thermal cycling castings or they may be made to be rigid enough to possess a heat distortion temperature above room temperature and exhibit respectable flexural strength and modulus.

Several fillers are shown to be useful in these formulations. The rigid epoxypolybutadiene formulation shows improved electrical properties. Although the addition of fillers lowers the electrical properties at low frequencies they are still excellent at high frequencies. By studying the losses in potted coils it was established that at high frequencies the dielectric measurements are proportional to the loss measurements and that no significant magnetic field dispersion losses are encountered. Because of limitations in the bridges used this comparison was only valid at high frequency.

3.4

0189
HOW TO ENCAPSULATE WITH ALKYDS
Moylan, J. J. and Long, J. T., Modern Plastics, 37, March, 1960, pp 124, 126, 128

Encapsulating by molding a thermosetting material around the electronic subassembly in matched steel molds is able to isolate the unit electrically and thermally and to protect it from moisture and physical damage. The specific use of alkyd material has become especially popular because of its electrical and thermal properties--which result in high functional efficiency of the unit in a minimum space; and its low pressure molding characteristics--which prevent distortion of the subassembly during molding. Two types of alkyd compounds can be considered for encapsulating a component: alkyd putty and granular alkyd. Encapsulating processes using these materials are discussed.

8.3

0190
WHY DESIGN FOR MAITAINABILITY
Wohl, Joseph G., IRE International Convention Record, Pt. 5, March, 1961, pp 312-321

The relationships among down time (a system maintainability measure), time between failures (a system reliability measure), equipment availability, number of equipments, number of on-call technicians, and system readiness reliability are developed under the assumption of constant failure and repair rates. Design trade-off between reliability and maintainability is shown to be feasible with resulting reduction in both design and operating costs. A technique for specifying combined reliability, maintainability, and availability constraints to manufacturers is reported which allows the latter a great deal of design flexibility in meeting operational requirements at least cost. The need for research to establish the quantitative effects of maintainability design practice upon down time is explored.

7.4

0191
LIQUID URETHANE ELASTOMERS AS ENCAPSULATING COMPOUNDS
Delmonte, John, Insulation, 10, October, 1964, pp 23-26

The justification for cured polyurethane encapsulants stems more from their unique properties rather than from their somewhat arcane handling characteristics. As cured materials, there are grades of polyurethanes with high tensile strength and high elongation which are without peer. Polyurethanes of lower orders of magnitude in strength may be more desirable for encapsulating purposes. These materials will lend themselves to ease of repair which may require the cutting-out of a section to change a component. Furthermore, the lower viscosity systems, characteristic of those using polyethylene or polypropylene glycols, have improved processing. The tensile properties, hardness, flammability, electrical properties, effect of temperature, effect of moisture, aging, and adhesion of polyurethanes are discussed.

8.3

0192
DESIGNING AGAINST DIELECTRIC BREAKDOWN OF PRINTED WIRING ASSEMBLIES PART I
Noble, Robert P., Electronic Packaging and Production, 4, (3), March, 1964

The principles of dielectric breakdown are presented. Electrical breakdown in gases is classified into Townsend discharge, glow discharge and arc discharge. Breakdown of solids are classified as electronic polarization, atomic polarization, orientation polarization, and space charge polarization.

3.4

0193
WHAT THE ELECTRONIC ENGINEER SHOULD KNOW ABOUT EPOXIES
Harper, Charles A., Electronic Design, 9, May 10, 1961, pp 30-33

The chemical aspects of epoxies are discussed in order to assist electronic engineers in becoming more conversant with epoxy suppliers. Epoxy resins may be the best embedment selection if environmental resistance, good packaging, close dimensional control, or adhesion are of prime importance. Although most epoxy formulations are based on the same basic resin, bisphenol, the varied selection available comes from different curing agents. Trade names and suppliers of epoxy formulations are listed.

3.0, 8.3

0194
2000 F POWER WIRE FOR AEROSPACE ENVIRONMENT
Melpar Inc., Westinghouse Air Brake Company, Falls Church, Va., 23 pp., Qtly. Rept. No. 5, April 5, 1964 to July 5, 1964, AF 33(657)-11046 (AD 602144)

A brazing study was undertaken to produce reliable end seals for power wire systems. The best results were obtained with 99.5 percent dense alumina end plugs, vacuum brazed under controlled conditions. During the 2000 F - 1200 v test breakdown occured over the surface of the ceramic. Small modifications of the present end seal configuration in which the shoulder between the termination and sheath was raised and a ceramic insert was added to interrupt the direct path of the breakdown between the rhodium wire and the sheath, show promise of overcoming this difficulty.

8.1

0195
CRITERIA FOR SOLDERED INTERCONNECTIONS - METALLURGICAL COMPLETENESS
Keller, J. D., Proceedings of the Ninth National Symposium on Reliability and Quality Control, 1963, pp 204-210

The validity of the soldering operation was first studied on a specimen level. Spread tests on copper coupons disclosed discontinuities, grain size, dihedral angle of wetting and other metallurical bonding requirements. Data collected was transposed into actual configurations, and the importance of wetting, solder quantity, solder flow and dihedral angle was noted on various printed circuit connections. Identical fundamentals were then explained in configurations of vast differences such as, printed circuit connections versus lugs. The all-important dihedral angle of wetting principle was used to predict the integrity of the metallurgical attachments. Firm standards for visual joint acceptance with minimum inspector training were derived.

9.2

0196
SOLDERING AND BRAZING
Kohl, Walter H., Vacuum, 14, (5), May, 1964, pp 175-198

A broad outline is presented of the physical principles that underline both soldering and brazing. The properties and compositions of the currently used materials are described, and examples are given of their practical application in the electronic industry.

9.2

0197
MODERN CONSTRUCTION PRACTICES FOR CBS AUDIO-VIDEO SYSTEMS
Neenan, Charles J., IEEE Trans. Broadcasting, USA, BC-9, (2), August, 1963, pp 37-44

Equipment Construction practices developed in recent years by the CBS Television Network have contributed to improving the reliability of audio-video systems, and to reducing installation and maintenance costs. Much of the subject matter applies to the electronics industry in general. Recent improvements in mechanical assemblies, wire and cable, electrical connections, and connectors and terminal blocks are presented.

8.4, 9.2, 9.4

0198
AN EVALUATION OF PRINTED CIRCUIT BOARD COATINGS FOR HIGH-HUMIDITY ENVIRONMENTS
Cabot, J. A., Radiation Incorporated, Melbourne, Fla., May 5, 1964, Rept. No. 1722-49-001, IDEP 525.50.00.00-M3-01, NAS9-150 , 95 pp.

The test reported in this study was conducted to evaluate a number of printed circuit board coatings, various combinations of coatings, and coating processes to obtain one which would meet the following requirements: a) high electrical insulation resistance at both room ambient temperature and 75 C. b) high electrical insulation resistance upon completion of the Humidity Test, MIL-E-5272C, Procedure 1, c) fulfill the requirements of the Apollo Program Materials Qualification Specification, d) satisfy the following: 1) simple to apply, 2) cure at a temperature under 100 C, and 3) result in a thin, uniform, flexible coating that is easy to repair. In achieving superior moisture resistance, developing a satisfactory method of cleaning, drying and coating printed circuit boards was found to be more important than choosing between many almost equivalent coatings. Superior results necessitate ascertaining the presence of a continuous pinhole-free coating by testing the specimen.

8.3

0199
VIBRATION CAPABILITIES OF CORDWOOD MODULES
Minneapolis-Honeywell Regulator Company, Aeronautical Division, Minneapolis, Minn., January 16, 1963, 15 pp., Rept. No. AEX 38303, IDEP 525.10.80.00-F5-01

The object of the study was to determine the vibration capabilities of Cordwood Modules along the three major axes. In this destructive vibration test the module welds were stronger than the (1) component leadwires and (2) module exit leadwires. These leadwires failed in fatigue. There were no weld failures. The seven exit leadwires of the module are not sufficiently strong to support the module on the terminal board at 60 g vibration level.

4.21

0200
SELECTING EPOXIES FOR HIGH-Z CIRCUITS
Lyles, Marvin E., Electronic Industries, 24, January, 1965, pp 85-87

Circuit designers often consider only electrical resistance when picking an encapsulant for high impedance circuits. However, chemical resistance, electrical polarization, nuclear radiation, and thermal effects are also important factors. The wrong selection can affect impedance, create hot spots, break wires, and cause undue stress. The properties of some good encapsulating epoxy resin systems are tabulated.

8.3

0201
HIGH-DENSITY ELECTRONIC PACKAGING--RESISTANCE WELDING
Gray, P. J., Steigerwald, R., and James, P. N., Electronic Design, 9, (11), May 24, 1961, pp 44-47

Resistance spot welding, used throughout a high-density electronic packaging program, requires close control of process parameters and special lead materials. The techniques developed for reliable welds are outlined.

9.1

0202
WELDING OF ELECTRONIC MODULES FOR THE POLARIS MISSILE
Allen, G. and Wettstein, J., IEEE Transactions on Product Engineering and Production, 7, (4), September, 1963, pp 1-7

This paper summarizes the status of findings to date of the potential value of welding electronic modules, the number of problems still under investigation, and other subjects requiring study. The investigations offer evidence that nickel, Dumet, and Kovar are weldable lead materials to nickel interconnecting media. To meet standards, separate weld schedules are required for each material size; moreover, variations in material composition and temper must be limited.

9.1

0203
TITAN, POLARIS PROGRAMS SPARK RISE IN WELDED MODULES
Electronic Design, 8, (20), September 28, 1960, pp 4, 6, 7

The role of welded-wire modules in miniaturization as an interim step before more advanced micromin concepts reach the hardware stage is discussed. Advantages of the welded module over soldered units in missile systems are listed.

9.1

0204
A NEW CONNECTOR FOR PRINTED WIRING BOARDS
Hecht, R. A., Bell Laboratories Record, 41, (5), May, 1963, pp 193-195

A variety of circuit boards will be accepted by the new connector, which is shown here in models for both one- and two-sided wiring. The Bell System "applique unit" is mounted on a printed circuit board and the assembly inserted into the connector. Clips on the lower connector fit slots in the board, providing a convenient and foolproof means of coding.

8.4

0205
INTERCONNECTION METHODS FOR MICROCIRCUITS
Slemmons, J. W. and Howell, J. R., Electronic Design, 12, September 14, 1964, pp 78-83

Resistance soldering, cross-wire welding, resistance welding, electron-beam welding, laser welding, thermocompression bonding, ultrasonic bonding, and series (Micro-Gap) bonding are briefly presented.

9.1

0206
RESISTANCE-WELDING FOR ELECTRONIC CIRCUIT PACKAGING REQUIREMENTS
Becker, W. E., IRE Transactions on Product Engineering and Production, 6, (4), December, 1962, pp 1-5

Basic information is given on resistance welding for electronic circuit packaging. The power supply is one of the critical features of producing high quality welds. Best welding metallurgically is attained in weld pulse currents between 0.003 and 0.008 seconds. Welding heads and calibrators used to secure desired weld strengths are included in the paper.

9.1

0207
RELIABILITY OF WELDED ELECTRONIC CONNECTIONS
Hurowitz, Mark, 1962 Conference Proceedings, 6th National Convention on Military Electronics, sponsored by Professional Group on Military Electronics, Institute of Radio Engineers, Washington, D. C., June, 1962, pp 310-318

This paper is concerned with the most fundamental of three potential processing areas capable of introducing unreliability in any module. Rather than premature failure of components due to thermal and mechanical stress during assembly, or mechanical and thermal damage from encapsulation, the basic consideration here is reliability in joints themselves. It is reliability in welded joints utilized for electrical connections between components for space technology and high strength electronic assemblies which is emphasized.

9.1

0208
MUST ALL PACKAGES BE WELDED
Ritter, Joseph and Houck, David J., Electronic Design, 10, (6), March 15, 1962, pp 78-81

Soldered connections are compared with welded joints. Reliability, packaging density, weight savings, production economy, and design modifications are included in the discussion.

6.3, 6.4, 9.1

0209
CONFORMAL COATINGS FOR PRINTED CIRCUIT ASSEMBLIES
Beccasio, Anthony J., Motorola Inc., Military Electronics Division, Chicago, Ill., 17 pp., Qtly. Rept. No. 4, April 15, 1962 to July 15, 1962, DA-36-039-sc-89136 (AD 283475)

Commercially available conformal coating materials used as protective coatings on printed circuit boards were evaluated in order to obtain data for the preparation of a three services coordinated military specification which would provide sufficient physical, mechanical and electrical properties to assure satisfactory performance of printed circuit assemblies over long storage periods and under high humidity conditions. A method of removing the coating from the board to permit replacement of parts when necessary without impairing the functional operations of the unit was also investigated. Allowable minimum spacings between conductors on uncoated and coated boards as described in MIL-STD-275A were also evaluated.

7.4, 8.3

0210
EVALUATION OF PRINTED CIRCUIT BOARD CONNECTORS
Wiedeman, D. H., IBM Federal Systems Division, Owego, N. Y., May 15, 1963, 9 pp., Rept. 5475 (AD 439557)

The results of an evaluatory study of connectors designed and built for IBM and utilize AMP's MECCA (Maintainable Electronic Component Assembly) contact philosphy are presented. There was no evidence of excessive contact resistance or circuit malfunction during the test series; only 7 contact gaps out of 336 gaps tested, failed to meet the maximum limit of .007 inch. These connectors were approved for use in the OAO project.

8.4

0219
PACKAGING HYBRID MODULES CONTAINING INTEGRATED CIRCUITS
Beigel, George L., Electronic Packaging and Production, 4, (7), July, 1964, pp 16, 19-23

Small size, minimum weight, and more reliable internal connections are some of the advantages gained by using molecular-integrated circuits. Factors considered by this article in using these elements with other types of components to form hybrid modules are: reliable interconnections between components, component protection, maintainability, electrical isolation or shielding, adequate cooling, and availability of fabrication techniques.

5.12, 5.144

0220
IC FIXTURE ALLOWS SOLDERLESS INTERCONNECTIONS
Rose, J. A., Electronic Design News, 10, (14), November, 1965, pp 102

Enclosing an integrated-circuit flat package, according to this article, in a nylon fixture allows pressure connections between circuit board and device. Greater freedom in design and maintenance is provided by elimination of soldering or welded connections minimizes heat and mechanical stress during fabrication.

8.4

0221
PC CONNECTOR ALLOWS RADIAL INTERCONNECTIONS
Socolovsky, A., Electronic Design News, 10, (12), October, 1965, p 124

Connectors centered on a printed-circuit board cuts to 50 per cent the conductor runs required with an edge-type connector. The central location works best with a radial arrangement of components on the board, instead of the row arrangement characteristic with edge-type connectors.

8.4

0222
RESISTANCE WELDING OF DISSIMILAR METALS
Evans, William, IEEE Transactions Components Parts USA, CP-11, (2), June, 1964, pp 157-162

The resistance welding of various dissimilar metals, primarily component parts such as ribbons, leads, and cases to one another are discussed. The study was made and is being continued to improve production welding in the manufacture of aluminum electrolytic, and tantalum capacitors. Resistance welding is primarily used by capacitor production because it is a fast, economical process, which lends itself readily to automation. The welds associated with the higher conductive, dissimilar metals are not fusion welds, but can be described as solid state bonds.

9.1

0223
LIGHTWEIGHT, SOLUBLE ENCAPSULATING COMPOUND PERMITS REPAIR OF ELECTRONICS
Steigerwald, R. M., Insulation, 10, February, 1964, pp 35-38

A jacketed microballoon encapsulant that gives excellent strength and thermal properties while furnishing an extremely light-weight and repairable system is discussed. The core of this encapsulant, glass microballoons with acetone as the carrier and polyvinyl butyral as the binder, is known as compound 2251-38-1. The repairability requirement is fulfilled, since the microballoon compound is readily soluble in acetone. A dense circuit module, for example, can be quickly and simply repaired without damage to delicate components.

6.5, 8.3

0224
MODERN ELECTRONICS PACKAGING
McKenzie, Alexander A., Electronics, 37, February 7, 1964, pp 33-48

Various aspects of electronics packaging discussed in this article include physically locating, connecting, and protecting devices or components. Interconnection, environments, cooling, encapsulation, and microcircuits are each discussed.

6.4, 7.3, 9.1, 9.2

0225
THE APPLICATION OF THERMOELECTRIC SPOT COOLING TO ELECTRONIC EQUIPMENT
Stubstad, W. R., IRE International Convention Record, 9, Pt. 6, March, 1961, pp 38-46

The paper discusses thermoelectric coolers for spot cooling of electronic equipment. Spot coolers can efficiently pump 5 watts over a 30 C temperature difference, maintain a 46 C temperature difference under no-heat-load conditions, increase the operational temperature environment of self-cooled equipment, and reduce the cooling requirements of a remotely-cooled equipment or elimate the need for remote cooling. The largest benefits from spot cooling can be obtained in applications where the limiting components dissipate a small portion of the equipment heat.

6.4, 7.3

0226
NRL CENTRALIZED ELECTRONIC CONTROL PACKAGING
Venn, D. A., Toth, E., and West, J. S., Report of NRL Progress, May, 1965, pp 8-19, (CFSTI - PB 1 6730)

New concepts in electronic equipment packaging have been developed by the Naval Research Laboratory in the course of its exploratory research program in Centralized Electronic Control. This form of packaging implements the principle of functional modularization of the basic electronic circuits, and the assembly and interconnection of the modules in modular racks and cabinets grouped in a central location to provide equipment and system functions. Heat exchanger and interwiring facilities are incorporated in the cabinets, also in modular form. Modular elements designed in accordance with these concepts, including the interconnection devices and other special features, are discussed and illustrated.

6.3, 7.1, 7.2

0211
ULTRASONIC TESTING OF WELDS
Sproule, D. O., British Welding Journal, 6, (10), October, 1959, pp 470-479

The paper reviews the main principles and procedures that have found practical application in the testing of welds. The discussion of physical principles concentrates on the correct choice of frequency and pulse length as affected by surface condition, grain size, and the required resolving power. The potentialities of focussing probes and point probes are discussed, together with single and double probe working.

9.1

0212
A TOUGH HIGH TEMPERATURE SHRINKABLE TUBING
Electronic Capabilities, 3, (3), 1965, pp 42-43

Heat shrinkable tubing made by Alpha Wire Corporation from Kynar, a Pennsalt Chemical thermoplastic resin is discussed. Kynar is the homopolymer of vinylidene fluoride, a new member of the family of fluorocarbon polymers which include Teflon, Halon and Kel-F. Kynar is a semi-rigid, transparent material that is strong, tough and very resistant to cold flow. Thermal, electrical, and chemical properties are given.

8.2

0213
HEAT TRANSFER DESIGN FOR ELECTRONIC EQUIPMENT. Pt. I NATURAL CONVECTION
Katz, Leonhard, Electromechanical Design, 7, October, 1963, pp 32-38

The purpose of this short report is to present to the electronic designer and packaging engineer a simplified version of the theory of heat transfer and provide him with as many simple charts, examples, nomographs, and time saving devices as possible. The math has been kept to a minimum, simplified formulas are used wherever possible even though this may make pure thermodynamicists shudder. A number of worked out problems typify those encountered daily in complex electronic equipment.

7.37

0214
HEAT TRANSFER DESIGN FOR ELECTRONIC EQUIPMENT Pt. II FORCED CONVECTION
Katz, Leonhard, Electromechanical Design, 7, November, 1963, pp 28-32

Applications of forced convection of air are presented. An example of designing a transistorized power supply in which eight transistors are to be mounted is presented. Rules for proper, balanced heat transfer design are given.

7.37

0215
HEAT TRANSFER DESIGN FOR ELECTRONIC EQUIPMENT Pt. II LIQUID COOLING
Katz, Leonhard, Electromechanical Design, 7, December, 1963, p 36, 40, 42

This paper concentrates on the problems of liquid cooling, since it finds considerable application in electronic equipment. The heat transfer in liquid cooling is similar to that in air cooling, except that the heat transfer coefficients are very much larger than with air cooling. Viscosities of liquids used for heat transfer in electronic equipment at varying temperatures are graphically shown.

7.37

0216
SHIELDING PROBLEMS DEMAND NEW SOLUTIONS
Electronic Capabilities, 1, (1), November, 1963, pp 19-21

Netic, Co-Netic or a combination of both of these foil or sheet stocks serve as effective materials. The materials were developed by the Magnetic Shield Division, Perfection Mica Company for electromagnetic shielding and, when properly grounded, serve as excellent electrostatic shields. They are insensitive to mechanical shock and their ductility is such that they can be easily cut and then formed, banded, or wrapped around a component.

6.111

0217
DESIGN CHECK FOR AIRBORNE ELECTROMECHANICAL PACKAGES
Maue, Erich O., Electromechanical Design, 8, (3), March, 1964, pp 31-38

This article shows how to apply the requirements of MIL-E-5400 in the design of Airborne Electronics. The size of a box including front panel and dust cover may be obtained from drawings in Mil Spec No. Mil-C-6781. This specification is a part of Mil-E-5400 which regulate the dimensions for Type I Control Panels whose length, width, and depth and mounting arrangement are established and are not to be deviated from. The article includes a brief discussion of mechanical design parameters, electrical packaging design parameters, and environments.

9.4

0218
A CLAMPING TECHNIQUE FOR CABLES AND ASSEMBLIES
Russel, Robert H., Electronic Packaging and Production, 5, (12), December, 1965, pp 16-18

The development of the "Ty-Block" method for clamping cables is discussed. The Ty-Block is an injection-molded, nylon, cable-anchoring device. It is used in conjunction with an adjustable nylon strap (MIL-S-23190) to provide a quicker, cheaper, and more reliable means of clamping cables. The Ty-Block is 7/8 in. high, 1 in. wide, and 1/2 in. deep. It weighs less than an ounce. The operation is simple, quick, and requires no judgement or guesswork.

7.2, 8.1

0227
SLIDING RACK DRAWERS COIL, UNCOIL CABLES NEATLY AND WITHOUT SLACK
Silverstein, Bernard, Electronic Design, 10, (7), March 29, 1962, pp 60-63

The problem of how cables carrying electrical data and power to the chassis may be coiled and uncoiled as the drawer slides in and out has been solved by using flat, multiple conductor connection cables and reeling them into a Negator spring motor. The Negator motor reels up and lets out the flat cables with a constant spring torque. The cables are wound on cable-reels attached to the motor's casing. No slack is permitted in the cable as the drawers are moved into and out of the cabinet.

6.3

0228
MULTILAYER PRINTED CIRCUIT INTERCONNECTION TECHNIQUES
Levy, Alfred, IEEE Transactions on Product Engineering and Production, 8, (1), April, 1964, pp 16-20

Multi-layer circuit boards seem to give the most feasible interconnection device for high density applications. While reliability has been questioned it is indicated that internal-connection reliability is just as great as the care taken in the manufacturing control. Multi-layer boards can therefore be considered as an excellent solution to high-density interconnection problems.

6.21

0229
SEMICONDUCTORS AND SPACE RADIATION
Gardner, Leonard B., Solid/State/Design, 3, April, 1962, pp 42-46

The mechanisms of radiation damage in semiconductors are very briefly summarized. When the fluxes of the constituent particles comprising the different space radiations are examined with regard to the damage they might produce in semiconductors, it is seen that the proton flux of the inner belt is the most significant. Some of the difficulties of ascertaining the severity of space radiation are presented. Included with the selection criterion is a table of several recently developed semiconductors, listed according to their resistance to space radiation.

4.29

0230
DEVELOPMENT OF A HIGH DENSITY AIRBORNE PACKAGE
Schultz, D. L., Electronic Packaging and Production, 4, (5), May, 1964, pp 10-12

The development of a concept of electronic packaging which, when applied to an airborne device, provides a unit that is compact, reliable, easily maintained, and economical to produce is presented. The use of standard low cost items such as extrusions, die casting, and a printed circuit board formed the basis of the concept. Some of the newer expedients such as dip brazing, resistance soldering, plug-in modules, and flexible printed circuit cable were also incorporated into the design. This approach allows a relatively large amount of the fabrication and assembly to be mechanized or automated.

6.2, 6.3

0231
TITAN II AIRBORNE MULTIPLEXER-ENCODER PCM TELEMETRY SYSTEM
Singletary, B. H. and Little, C. T., Electronic Packaging and Production, 4, (9), September, 1964, pp 56-63

The system weighs 29.8 lb, occupies a volume of 820 cu in., and consumes 8 w of power at 28 vdc. It uses welded circuit modules and cordwood packaging. All circuitry is solid-state. Features of the package include: cast aluminum housing, internal shock and vibration isolators, fuel and oxidizer compatibility, welded circuitry, compression packaging, and circuitry accessibility.

6.2, 6.31, 7.2, 7.31

0232
A STANDARD GRID "5-TO-1" COMPONENT DENSITY PRINTED CIRCUIT CARD
Mallon, Marvin, Electronic Packaging and Production, 3, (1), January, 1963, pp 8-11

A special printed circuit connector was designed for the 3 x 3 in. card. Pin-to-pin spacing is .078 in. compared to the 1/10 or 1/8 in. spacing of previous connectors. A combination of vertical and horizontal mounting was used to obtain the most efficient use of space.

6.21

0233
MULTI-POLE PRINTED-CIRCUIT CONNECTORS WITH 0-10 IN. CONTACT PITCH
Standard Electric Lorenz, Stuttgart and Standard Telephones, and Cables Ltd., London, Radio and Electronic Components, 4, (2), February, 1963, pp 120-127

The design problems concerned with a new multi-pole printed-circuit connector having a contact pitch of only 0-10 in. are outlined. A new connector was developed which is a combination of the integral (one-part) and separately mounted (two-part) connector types. This new connector combines the advantages of both methods.

7.2, 8.4

0234
COOLING ELECTRONIC EQUIPMENT
Hay, A. Donald, Electronic Equipment Engineering, 9, (8), August, 1961, pp 18-20

The design of an efficient cooling system for electronic equipment requires consideration of factors such as air velocity, pressure, filters, and type of blower used. Local hot spots in electronic equipment will be created if the air velocity moves too slowly past concentrated heat sources. The heat to be removed must pass from the hot body to the cooling air through an air film surrounding the hot body. The designers must know the amount of dissipated heat which they desire removed and the temperature rise desired for the coolant. Equations applicable to such problems are given.

7.3

0235
RIGID-FOAM STRUCTURES FOR SHOCK PROTECTION OF ELECTRONIC SUBASSEMBLIES
Anderson, Brooke H., Electro-Technology, 72, September, 1963, pp 90-94

Electronic modules encounter shock loads up to several thousand g in aerospace applications and mechanical and thermal protection can be achieved by means of rigid urethane-foam support structures, machined or molded to the configuration of components within the assembly. Properties of urethane foams are appraised in terms of mechanical energy absorption, strength-to-weight ratios, dielectric properties, humidity and temperature effects, design flexibility, and manufacturing costs.

7.3

0236
VAPOR COOLING VS WATER COOLING
Langer, Helmuth and Rose, Richard, Electronic Design, 11, December 20, 1963, pp 52, 54, 55

In conventional water-cooled power-tube systems, the thermal energy of the anode is transferred to the circulating coolant, which subsequently exhibits an increase in temperature. In vapor cooling, however, thermal energy is absorbed by a change in the physical state of the coolant, rather than an increase in its temperature. The vapor cooling system of the 250-Kw transmitter described in this paper operated at a pressure of 6 in. of water; tube weight alone (130 lb) maintains the tube in proper position in the boiler, the system being sealed by an "O" ring gasket located on the tube just below the upper flange on the anode.

7.3

0237
INSULATING AGAINST NUCLEAR EFFECTS
Kyle, James C. and Baird, Leslie E., Electronic Industries, 20, December, 1961, pp 124-127

Silico-ceramic materials developed by Physical Sciences Corp. and marketed under the general title PSC-Durock are discussed. The use of the material as: (1) electrical connectors, headers; (2) magnet wire coating; and (3) potting/encapsulation are considered. The long-term temperature ratings range from 2000 F to 3500 F; short term 2400 F to 4000 F. Nuclear resistance is rated in barns cross-section capture; absorption 0.0349 to 0.0609; scatter 16.8 to 22.4. Nuclear flux rating, mixed field, 6000 hour test is 1 x 10^{13}.

7.3

0238
A STUDY OF DESIGN PARAMETERS IN THE VAPORIZATION COOLING OF ELECTRONIC COMPONENTS
Asch, Victor, IRE Transactions on Component Parts, September, 1962, pp 105-114

This paper briefly reviews the principles of vaporization cooling. Findings on the effects of varying certain design variables on system performance, and presents a method of predicting system behavior are included. The design variables considered are: the proximity of components to each other, the position of components, the effect on components of impinging bubble flow, and the use of a wetting agent. System performance is evaluated by considering the relationship between heat flux and surface-to-liquid temperature difference.

7.3

0239
PACKAGING WITH A FLEXIBLE CONTAINER FOR OIL-FILLED OR EVAPORATIVE-COOLED ELECTRONIC EQUIPMENT
Goltsos, C. E. and Mark, M., IRE Transactions on Product Engineering and Production, 6, (3), September, 1962, pp 44-48

In electronic packages where high voltages exist, a high dielectric strength environment surrounding the components is necessary. Liquid-filled units have used various oils which in addition to dielectric strength provide good thermal paths for cooling; evaporative-cooled units often use refrigerants. In either case allowance, volume-wise, must be made for thermal expansion of the fluid. A simple, novel, weight-saving technique for accomplishing this consists essentially of replacing the conventional container with a flexible one. The flexible container then expands and contracts accomodating volume variations in the fluid. Design details, test results, and a general evaluation illustrating the adaptability of the flexible container as a practical design tool are discussed.

7.3

0240
THERMAL ENVIRONMENTAL CONTROL TECHNIQUES APPLIED TO ELECTRONIC EQUIPMENT
Sepsy, Charles F., The Journal of Environmental Sciences, 6, April, 1963, pp 15-19

Efforts to increase reliability by miniaturization, plug-in subassemblies, isolation of sensitive components from environmental effects, improved mechanical design, and reduction of operating temperatures are discussed in this paper. Methods of effective heat removal are classified as direct and indirect systems and refer to the supply of the ultimate coolant to equipment items directly or to an intermediate heat exchange system. The improvement in component reliability by proper control of the thermal environment is illustrated by using redesigned airborne electronic equipment as models.

7.3

0241
SUCTION VS PRESSURE FORCED AIR COOLING
Rezek, Gerard, IEEE Transactions on Product Engineering and Production, 9, (1), April, 1965, pp 30-35

An investigation was made of the merits of suction vs pressure cooling, to find an effective cooling design for a certain module assembly. The study showed that suction cooling has certain advantages because of the air flow escape from the circuitry section to adjacent spaces. Its air flow pattern provides maximum air accretion at the air exit, which is a critical area. That suction cooling will minimize air temperatures in that area is qualitatively developed and then quantitatively analyzed.

7.3

0242
THERMAL DESIGN OF THE ELECTRONICS CANISTER
Haury, P. T., Bell Laboratories Record, 41, (4), April, 1963, pp 161-166

The electronic assemblies of the Telstar satellite contained in a single cylindrical unit called the electronics package are discussed. Interconnecting wiring between units is almost entirely spliced with crimped-sleeve joints. Connectors are used only on coaxial cables in which splices were impractical. Sub-units for the various transistorized circuits take several forms, depending on the factors involved. These include weight, shielding against high frequency interference, heat dissipation, types of components, and shape factors controlled by mounting arrangements.

7.3

0243
BALANCING THERMAL INSULATION AND ABSORPTION IN ELECTRONIC PACKAGES
Keller, Walter F., Space/Aeronautics, 35, June, 1961, pp 129-135

A relatively simple method of explaining the steps in the thermal design of an electronic package is to set up hypothetical but realistic parameters and solve the specific problem they describe. After giving a simple equation stating the constituents of total package weight, this article analyzes each of these constituents and derives equations showing the factors that contribute to the constituents' weights. From iterative solutions of these derived equations, three series of curves are plotted to show the relationships among the important problem parameters: package weight vs insulation thickness, division of package weight vs cold-plate area, and minimum package weight vs plate area for optimum insulation. Another point brought out in the analysis is that the size of the heating area has no effect on evaporation. This shows that heat flow rate remains constant while temperature differential and film coefficient vary inversely with the plate area.

7.3, 8.5

0244
FLAT CABLE SHRINKS MICROCIRCUIT MODULES
Electronics, 37, February 21, 1964, pp 44-45

Through use of a new thin, flat, high-density microminiature cable, it may be possible to hook up 80,000 integrated microcircuits in a volume of one cubic inch. The new microcable, a microminiature version of flat conductor cable is electroplated on a mylar sheet and then transferred to pressure sensitive, mylar-backed adhesive tape 0.001 inches thick. Mylar tape encapsulates the circuit. The cable can be connected to a small circuit chip--up to 1,000 connections per linear inch.

8.1

0245
POTTING ELECTRICAL CONNECTORS
Kelly, Joseph F., Electronic Packaging and Production, 4, (10), October, 1964, pp 90-94

The technique of potting may be summarized in eight general rules: 1. Select a potting compound that fulfills the environmental requirements of the application, and which, at the same time, is the most economical and practical material that can be used with that particular connector. 2. Use available or improvised potting forms for most connector potting applications. 3. Use connector potting alignment fixtures that align the contacts until the potting is cured, especially in applications where rigid materials are used. 4. Take extreme care to maintain a high degree of cleanliness. 5. Use primers when specified. 6. Prepot when leakage through the connector may be a problem. 7. After pre-potting, final potting must be done with care to insure complete coverage and eliminate voids and air bubbles. 8. Cure potting compounds as prescribed by the manufacturer.

8.4

0246
A NEW CONCEPT FOR MISSILE GROUND SUPPORT INTERCONNECTING ASSEMBLIES
Roache, J. J., IEEE Transactions on Aerospace USA, AS-1, (2), August, 1963, pp 1153-1160

This paper covers an improved and novel approach to missile cable assemblies. The only metal parts employed are those required for conductivity. The technique required for fabrication of these assemblies is relatively simple, will not be proprietary, yet this end product is practically indestructible and tamper proof. Crimped terminations are preferred over soldered for reasons of product uniformity and reliability. Gold plated contacts should be used to insure a smooth, tarnish-free surface with high conductivity. Contact material should be tellurium copper. Connectors should be of the integral molded design. Except for special applications, the molding material should be polyurethane. Recommendations for future development are listed.

9.5

0247
MINIATURIZATION AND THE INTERCONNECTION PROBLEM
Shue, John I., Jr., Electronic Industries, 23, (9), September, 1964, pp 40-44

AMP Inc. has devised a system to fulfill the needs of the interconnection's role in the electronic industry today. This system is called MECA (Maintainable Electronic Component Assembly). MECA has three major distinctions which were set forward at its conception to be absolute necessities in the design of an interconnection system. These are: (1) Redundant four point friction contact making the system pluggable down to a function level. (2) Three dimensional (3-D) circuitry putting a vertical layer of interconnections compactly between the circuit functions making multilayer circuit board almost unnecessary. (3) Completely automatable system providing flexibility in a hard wiring system.

9.5

0248
A NEW CONCEPT FOR MICROMINIATURE INTERCONNECTIONS
Peel, M. E., IEEE Transactions Component Parts, USA, CP-11, (2), June, 1964, pp 173-181

Attempts at miniaturizing connectors to meet the demands of the packaging revolution has met with limited success. A unique connector concept has been designed to meet the following objectives: 1. Maximazation of contact density while minimizing space and weight. 2. Maintainance of satisfactory performance characteristics and structural stability at an adequate reliability level. 3. Allowing the greatest possible design flexibility with a broad system applicability. The connector insulator is constructed similar to a checkerboard configuration with individual contact openings or cavities. The mating face of the panel consists of square, protruding posts in which as many as four contact springs can be accommodated.

9.5

0249
RESEARCH STUDIES OF PLASTIC COMPOUNDS FOR CASTING, *ENCAPSULATING AND POTTING*
MacKenzie, Alfred K. and Dearborn, Elizabeth C., United States Testing Company, Inc., Boston Research Division, Boston, Mass., October 14, 1953, 25 pp., Qtly. Prog. Rept. No. 5, June 15, 1953 through September 14, 1953, DA-36-039-SC-42459 (AD 19241)

Resins from the polyglycidyl ethers cured with 40% of phthalic anhydride, were tested. Thermal shock resistance and electrical behavior were found to meet Bureau of Ships Specification MIL-C-16923 for type B and C potting resins, except that Resin 2255-phthalic anhydride appears to be slightly high in dissipation factor at 60 cycles. The heat stability of Resin 2255-phthalic anhydride is excellent over the range of highest thermal yield points, at the minimum it has a value of 0.035% weight loss after 20 hours at 200 C. Resins cured with polyfunctional amines appear to exhibit very much higher thermal yield points than those cured with monofunctional amines.

8.3

0250
EFFECTS OF ELEVATED TEMPERATURE AND REDUCED ATMOSPHERIC PRESSURE ON ADHESIVES, POTTING COMPOUNDS AND SEALANTS
Thomas, J. P. and Stout, R. J., General Dynamics/Fort Worth, Fort Worth, Tex., September 14, 1962, 38 pp., ERR-FW-129, AF 33(657)-7248 (AD 285488)

Five materials: 1) a silicone rubber sealant, Dow Corning Q-2-0103, 2) a butyl rubber general purpose cement, Permalastic PX-1040, 3) an epoxy room temperature curing adhesive, Epon 931, 4) a phenylsilane-based adhesive, Dynabond 118 and 5) a Vitron rubber-based cement, Fairprene 5159 which might have specialized uses on glide and boost-glide type vehicles were evaluated under space environmental conditions of up to 700 F and reduced pressure in the order of 1×10^{-3} mm Hg. An environment of 200 F and reduced pressure of approximately 1.0×10^{-3} mm Hg for 300 hours did not appear to significantly affect the strenghts of the five materials tested, however, above this level the various properties began to deteriorate.

3.4, 8.3

0251
ENCAPSULATION OF ELECTRONIC CIRCUITS
Calicchia, Richard, USAF, Rome Air Development Center, Griffiss Air Force Base, N. Y., January, 1958, 17 pp., RADC-TR-58-8 (AD 148557)

The quantitative effects of the encapsulating dielectric upon the electrical characteristics of the embedment are discussed. Of interest is the work initiated on the electrical performance of resistors, capacitors, inductors, and simple circuits, at frequencies up to 240 megacycles. The investigation of the electrical and mechanical properties of various resins was necessary in order that the most suitable encapsulent be selected for the specific application.

3.4, 8.3

0252
STRUCTURES WITH FOAM PLASTIC FILLERS
Alexandrov, A. Ya., Borodin, M. Ya., and Pavlov, V. V., Gosudarstvennoye Nauchno-Tekhnicheskoye Izdatel'stvo, Oborongiz, Moskva, Russia, 1962, 187 pp., FTD-TT-63-61/1+2 (AD 418030)

This translation of a Russian book discusses foam plastics, construction and methods of making products containing foam plastics, special features of the operation and design of filled structures, and testing structural elements with foam plastic fillers.

3.4

0253
BEHAVIOR OF MATERIALS IN SPACE ENVIRONMENTS
Jaffe, L. D. and Rittenhouse, J. B., California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif., November 1, 1961, 116 pp., Tech. Rept. No. JPL-TR-32-150, NASw-6 (AD 266548)

The quantitative effects of the environments encountered in various regions of space upon several kinds of engineering materials are discussed. In the vacuum of space, magnesium sublimes appreciably at elevated service temperatures; zinc and cadmium sublime at ordinary temperatures. Most other engineering metals will be unaffected by vacuum except for a slight surface roughening. Among the organics, polysulfides, cellulosics, acrylics, polyvinyl chloride, neoprene, and some nylons, polyesters, epoxys, polyurethanes, and alkyds break down at rather low temperatures in vacuum. Polyehtylene, polypropylene, most fluorocarbons, and silicone resins do not decompose significantly in vacuum below 250 C. Except for plasticized materials, significant loss of engineering properties in vacuum is unlikely without appreciable accompanying sublimation or decomposition. For parts intended to move in contact with each other in vacuum, lubrication is a serious problem.

3.4

0254
EFFECTS OF SPACE ENVIRONMENT UPON PLASTICS AND ELASTOMERS
Jaffe, L. D., California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif., November 16, 1961, 22 pp., Tech. Rept. No. JPL-TR-32-176, NASw-6 (AD 268432)

Most polymers are reported to be stable in the vacuum of space at temperatures as high as they can withstand in air. Important exceptions are some nylons, polysulfides, cellulosics, acrylics, polyesters, epoxies, and urethanes. Vacuum stability is sensitive to formulation and curing procedure; addition agents such as plasticizers, mold lubricants, and polymerization catalysts are generally detrimental. Exposure to vacuum will not cause loss of engineering properties unless appreciable loss in weight occurs. The particles of the Van Allen radiation belts will damage engineering properties of all exposed polymer surfaces; solar flare emissions will probably affect exposed surfaces of the materials more sensitive to radiation damage.

3.4

0255
INTERCONNECTION AND ORGANIZATION OF FUNCTIONAL ELECTRONIC BLOCKS
United Aircraft Corporation, Norden Division, Norwalk, Conn., October, 1963, 111 pp., Tech. Doc. Rept. No. RTD-TDR-63-4042, AF 33(657)-8720 (AD 423795)

This report covers methods of interconnecting and organizing functional electronic blocks (FEB). Efforts were directed towards forming a three-dimensional submodule of stacked and encapsulated FEB's which are interconnected on a batch process basis by vapor phase plating and etching. The studies resulted in the choice of a highly filled organic potting compound for encapsulating the FEB's. A vapor phase plating system was developed capable of producing uniform plates of nickel, .001-inch thick, on submodules varying in size from .2 x .4 x .4 inch to .43 x .43 x .8 inch. Methods of applying photo-resist and etching the nickel plate to create the desired interconnection pattern were established and a procedure was developed for applying a protective outer coating to the finished submodule. Investigations indicated that wire wrapping is a desirable method of connecting a submodule to a mother board and that reliable wire wrap terminations can be made on .050-inch centers. An automatic tool was developed to make wire wrap connections. Organizational and heat transfer studies showed that three-dimensional submodules of high packaging densities can dissipate heat effectively by either conduction or convection; are flexible in terms of size, shape and complexity; are easily integrated into hybrid structures; and can be competitive with, or more economical to produce than other forms of FEB packaging.

6.2, 6.3, 8.3, 8.4

0256
EPOXY RESIN POTTING COMPOUNDS
Bacon Industries Inc., Watertown, Mass., October, 1965, 4 pp., Tech. Data Sheet No. 1001

Typical physical properties of Bacon Industries' potting compounds are provided. Potting compounds P-11, P-14, P-14A, P-19, P-20, P-20A, P-23, P-24, P-24A, P-37(1), P-37A, P-38, P-56(2), and P-56A are included.

8.3

0257
RECOMMENDED PROCEDURES FOR CLEANING METAL PARTS TO BE ENCAPSULATED OR BONDED
Bacon Industries Inc., Watertown, Mass., May, 1965, 2 pp., Tech. Data Sheet No. 1021

Chemical cleaning of beryllium, aluminum, brass, magnesium, and steel (including stainless) are briefly outlined. The mechanical cleaning and solvent wipe of all metals is also included.

8.3

0258
ENCAPSULATION AND IMPREGNATION TECHNIQUE USING BACON INDUSTRIES MATERIALS
Bacon Industries Inc., Watertown, Mass., February, 1963, 3 pp., Tech. Data Sheet No. 1031

The equipment necessary for vacuum encapsulation and impregnation of electronics is shown. The procedures for the process are also given.

8.3

0259
ENCAPSULATION WITH BACON INDUSTRIES POTTING COMPOUNDS
Bacon Industries Inc., Watertown, Mass., 10 pp., Tech. Data Sheets

Vacuum pressure casting and vacuum pressure transfer molding are discussed. Encapsulation using mixtures of P74, P75, and P56 is also included in the manufacturer's technical data sheets.

8.3

0260
FAILURE ANALYSIS OF MINIATURE COAXIAL CONNECTORS
General Electric Company, Defense Electronics Division, Syracuse, N. Y., May 19, 1964, 7 pp., IDEP 201.20.77.34-E3-01, AF 04(695)-481

UG-type connectors have been prone to a use "unreliability" because of the nature of the design. The degree to which a connector plug will hold up under field use--especially where the connector sees frequent mating and unmating--depends on the number of items comprising the internal parts of the connector and the size and type of coaxial cable being utilized. The "wedge-lock" connector produced by Automatic Metal Products Corporation was concluded to be an improved connector which should be utilized for the application discussed.

8.4

0261
BUSSED CONTACTS FOR ELECTRICAL CONNECTORS
Noonan, Michael P., Electrical Design News, 10, (14), November, 1965, pp 104-107

A unique solution to connector-contact problems that is briefly discussed is an assembly consisting of a number of identical contacts that are joined to a common termination pot. By removing the contacts from the connector and replacing these contacts with this assembly, a higher common current rating can be obtained without changing connectors.

8.4, 8.6

0262
STUDIES AND SURVEYS IN THE FIELD OF PRINTED CIRCUIT BOARDS AND FOIL CLAD LAMINATES
Jackman, John, Litton Industries, U. S. Engineering Company Division, Van Nuys, Calif., 48 pp., Qtly. Prog. Rept. No. 2, October 1, 1960 to December 31, 1960, DA-36-039-SC-85383 (AD 254434)

This report presents the completion of the evaluation of the physical, mechanical and electrical properties of copper-clad paper base epoxy laminate material. The data are to be applicable to Spec MIL-P-13949. A detailed discussion of the completed design for measuring surface resistance is presented. The basic circuit and method of measuring temperature rise in a conductor is described.

8.6

0263
LABORATORY DEVELOPMENT CONTRIBUTIONS TO HIGH RELIABILITY IN PRINTED CIRCUIT PRODUCTION PROCESSES

Bruner, R. C. and Shroff, P. D., North American Aviation, Inc., Autonetics Division, Downey, Calif., March 15, 1962, 90 pp., EM-2955 (AD 292486)

Experimental evaluations of many of the process parameters involved in production of etched circuit boards were conducted in order to determine modifications needed to obtain high reliability circuits. Following a review of the present state-of-the-art, laboratory studies on selected and significant parameters were carried out to justify modifications in the overall process. Conclusions based on the work emphasize particularly the need for maintaining, by frequent testing, controlled conditions within narrow limits throughout the entire process. Also, for the process to function effectively, materials used for production of the circuit boards must be standardized.

8.6

0264
RESEARCH AND DEVELOPMENT FOR THREE-DIMENSIONAL WELDED CIRCUIT PACKAGING DESIGN REQUIREMENTS

Sawyer, H. F., Oldaker, D. R., and Bateman, V. G., General Dynamics/Pomona, Pomona, Calif., 93 pp., Qtly. Prog. Rept. No. 3, December 15, 1962 to March 15, 1963, DA-36-039-SC-90754 (AD 456673)

The design, process and parameter controls documentation was continued with the completion of lead control, weld schedule development, qualification of manufacturing equipment and process controls discussed at the third level of identure. Additions to the requirements previously discussed are also included. All sample modules and test models have been welded and are presently being encapsulated. Lead Crimping was improved by using a redesigned crimping tool. The revised tool is described and illustrated herein. Application of the DC-271 coating and lead crimping details are discussed which completes the requirements for Task B. Data on thermal cycling versus resistance tests, and thermal cycling versus pull tests on all seven of the weld designs under study is included and discussed. The affect of pull rate on the measurement of weld strength was determined and the analysis is included.

9.1, 9.3

0265
WELDED CONNECTIONS FOR ELECTRONIC PACKAGES

Allen, D. W. and Fisher, H. D., Royal Aircraft Establishment, Ministry of Aviation, London, Eng., August, 1964, 22 pp., Tech. Note Space 70 (AD 455159)

Welding techniques are described which are proposed as an alternative to soldering for the interconnection of components in electronic packages. The arguments for and against it are reviewed; the results of some comparative tests are given and designs for miniature welded modules described.

9.1

0266
SPACE MATERIALS HANDBOOK

Goetzel, Claus G. and Singletary, John B., Lockheed Aircraft Corporation, Lockheed Missiles and Space Company, Sunnyvale, Calif., 522 pp., AF 04(647)-673 (AD 284547)

This handbook contains AF 04(647)-673 information on space environments and interprets the effects of these environments on materials. The volume is not intended to serve as a complete design handbook but rather as a source of answers to those important questions relating to the effect of the space environment on materials which a designer might decide to use from other considerations. The handbook is organized into three parts: space environment is discussed in the first, its effects on materials are outlined in the second, and recommended materials for some specific missions are presented in the third.

3.4

0267
FINAL DEVELOPMENT REPORT DESIGN STUDIES FOR A HYBRID COMPUTER SYSTEM

Control Data Corporation, Minneapolis, Minn., July 31, 1965, 270 pp., Final Development Rept., September 1, 1964 to July 1, 1965, NObsr 93003 (AD 620911)

This report presents the results of a study conducted for the purpose of determining design requirements and operational philosophies for a hybrid data processing system in a realtime shipboard automation and control system utilizing an optimum combination of digital and analog techniques. The following investigations were included: automation tasks, hybrid simulation techniques, approaches to integrating digital and analog processing, microelectronic circuits and packaging available at present and in the future, and functional separability of the digital portion of the system for general purpose data processing. Pertinent design criteria of the hybrid system are described, with particular attention to the hardware and software provisions for priority multi-level interrupts and task execution priority selection, to the remote display and data entry units, and to the computer logic circuitry and standard NAFI packaging. Microelectronics (integrated circuits) should be employed using NOT-AND/OR circuits of the Transistor-Transistor Logic type.

5.1

0268
THE EFFECTS OF SIMULATED SPACE ENVIRONMENTS ON STRUCTURAL PLASTIC MATERIALS

Brownlee, J. and McNally, J. P., Aerojet-General Corporation, Structural Materials Division, Azusa, Calif., August, 1960, 41 pp., SP-TP-24 RD-R60-80 (AD 293597)

This evaluation of reinforced plastics is based on the resistance of these materials to space environments including: 1) radiation, 2) high vacuum, 3) meteorite dust erosion, 4) temperature (-80 to 175 F), and 5) prolonged exposure (1 year minimum). Other properties under consideration are thermal, electrical, and surface radiation reflectance.

3.4

0269
EVALUATION OF EPOXY RESIN FORMULATIONS FOR USE IN HIGH VOLTAGE, HIGH TEMPERATURE COMPONENTS
Feuchtbaum, R. B. and Bahun, C. J., Hughes Aircraft Company, Culver City, Calif., April 15, 1964, 53 pp., TM-780, Part 1, NOw 63-0379

The weight and performance characteristics of the AMCS power supply modules for the PHOENIX weapon system involve such a variety of physical and electrical characteristics that a specific knowledge of the properties of each resin suitable for encapsulation and embedment is needed to permit selection of the optimum embedment for each module. A comprehensive investigation was outlined that would produce a compilation of the needed engineering data for such specific design. This study presents the results of the first portion of the investigation. The physical design of any module requires knowledge of the strength-to-weight ratios of the resins as a function of temperature, the coefficients of linear thermal expansion, the thermal conductivities, and the degree of moisture absorption. Electrical design considerations require detailed knowledge of the temperature coefficients of the dielectric constant of a resin formulation, the percent dissipation factor, the volume resistivity, and the dielectric strength. In addition, the marine environment of the PHOENIX system makes the effect of humidity on the dielectric properties of the embedment resins a very important consideration. These properties have been measured as functions of test environments and as functions of the resin-hardener mixing ratios and the amount and type of filler.

3.4, 8.3

0270
INTERNAL STRESSES DEVELOPED IN AN EPOXY RESIN POTTING COMPOUND DURING LONG TERM STORAGE
Steele, Doris V., U. S. Naval Ordnance Laboratory, White Oak, Md., May 10, 1962, 10 pp., NOLTR 62-79

Test methods and instrumentation were developed to monitor internal stresses in epoxy resins by strain gage techniques. Test results show that the stresses developed during the first 70 hours of room temperature polymerization reached 900 psi in axial compression on the transducer. Further polymerization during storage increased the stress to 2300 psi after 12 months. Thermal cycling developed approximately 10,000 psi in compressive stress at -54 C. These stresses were relieved at 71 C but reappeared at the lower temperatures upon subsequent cooling.

3.4, 8.3

0271
A REVIEW OF FLAT CABLE TECHNOLOGY IN SPACE APPLICATIONS
Angele, Wilhelm, Marshall Space Flight Center, Huntsville, Ala., 55 pp., Electrical Manufacturing Coordination Meeting, November 5-6, 1964

The manufacturing and application of flat cables are discussed. Besides inspecting for dimensional accuracy, the cable has to pass a high voltage test after exposure to humidity and moisture; a vacuum test under load and rated temperature (100 C or 200 C); a flex test at high and low temperature; and a folding test. A flat cable connector has been developed in which a beryllium copper contact spring bridges over from one cable to the other. The cable termination design and manufacturing procedure of molding a plug to a cable is also described.

8.1, 8.4

0272
CONNECTION TECHNIQUES FOR ELECTRONIC PACKAGING
Antle, W. K., Boeing Airplane Company, Seattle, Washington, October 18, 1965, 207 pp., D2-13923 (AD 442783)

In order to either evaluate contemporary connection techniques or to plan any investigations into new techniques or applications, an understanding of the present methods is needed. All commonly used connection methods are discussed in this report in their present state of development. Among the topics presented for each technique are definitions, descriptions, applications, reliability, advantages, disadvantages, state of development, extent of usage, and an indication of the capability at Boeing. The extent to which these topics are discussed depends on the present state of development and applicability to electronic packaging of the particular method. A general comparison table of connection techniques is included.

9.1, 9.2, 9.3, 9.4

0273
RESISTANCE WELDING OF ELECTRONIC MODULES AND ELECTRICAL CONNECTIONS
Rockwell, R. G. and Willis, A. C., North American Aviation, Inc., Space and Information Systems Division, Downey, Calif., February 17, 1964, 24 pp., MA0107-014 (AD 448574)

This specification establishes the requirements for the interconnecting of electronic components and electrical connectors by resistance welding. The requirements of this specification are limited to the resistance welding of the following metals: nickel ribbon and wire, nickel-base and iron-base alloys, and copper and copper-base alloys, for use on the Saturn S-II Program. This specification is limited to Battle ship and EMM hardware only.

9.1

0274
FABRICATION OF WELDED ELECTRONIC MODULES
George C. Marshall Space Flight Center, Huntsville, Ala., April 30, 1964, 50 pp., MSFC-STD-271 (AD 443130)

This standard provides design criteria, requirements for documentation, and approved methods and materials for welded electronic modules.

9.1

0275
OPTIMUM MECHANICAL PACKAGING OF ELECTRONIC EQUIPMENT PROGRAM
Jones, Audrey H., Hughes Aircraft Company, Ground Systems, Fullerton, Calif., November 15, 1964, 100 pp., Qtly. Rept. No. 2, August 1, 1964 to October 31, 1964, DA-28-043-AMC-00060(E) (AD 457821)

The purpose of this program is to investigate mechanical packaging designs and construction techniques for application in military electronic equipments. The procedure and data obtained from this investigation will be valuable in the establishment and standardization of new and improved techniques for use in the design and construction of electronic equipments.

7.1, 7.3, 7.4

0276
SOUTHERN CROSS STANDARDIZED PACKAGING PROGRAM
Hauser, H. K., U. S. Navy Electronics Laboratory, San Diego, Calif., December 29, 1964, 101 pp., (AD 459087)

A set of plans for a standardized family of electronic enclosures that theroetically meets the severe shipboard environmental criteria has been developed, and a general purchase specification for electronic equipment enclosures is given. The enclosures are to be used for the SOUTHERN CROSS, Naval Ships Advanced Communications Systems (NSACS) and are capable of meeting the severe environmental stresses imposed by nature, mechanical devices found on board ship, and finally, stresses imposed by near-miss air and underwater nuclear blasts.

7.1, 7.2, 7.3

0277
REMOVAL OF INTEGRATED CIRCUIT PACKAGES FROM MULTILAYER BOARDS
O'Farrell, H. W., North American Aviation, Inc., Autonetics Division, Anaheim, Calif., September 28, 1965, 15 pp., Final Rept., Minuteman Producibility Study No. 31 (AD 471496)

Results of tests conducted indicated that Methyl Ethyl-Ketdne (MEK) will release integrated circuit packages from their heat sinks when Neoprene EC-1357 cement is used as the bonding agent. All attempts with mechanical removal methods resulted in damage to the circuit package, and further testing was terminated. A hand held tool, which will de-solder one lead at a time, has been developed. This tool will melt the solder and lift the lead off the pad.

6.5

0278
ENCAPSULATING RESINS AND POTTING COMPOUNDS
Linden, Erik G., USA, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., October 1, 1955, 35 pp., Engineering Rept. E-1101 (AD 96112)

Encapsulating materials are described and discussed in relation to their applications, specifications and properties. Included in this report is information regarding encapsulating materials in relation to cure, molds, mold-releases, thermal properties, electrical characteristics, moisture barrier ratings, weathering, adhesiveness, flame-retardancy, corrosiveness, fungal growth, shrinkage, density, nuclear radiation, shock and impact. The types of materials discussed include hot melts, foams, castable ceramics, polyesters, epoxies, polyurethanes, furanes, phenolics, polyvinyl formal resins, plastisols, and styrene based polymers.

3.4, 8.3

0279
RESEARCH STUDIES OF PLASTIC COMPOUNDS FOR CASTING, ENCAPSULATING AND POTTING
Shepherd, R. G., Jr, MacKenzie, Alfred K., and Dearborn, Elizabeth B., United States Testing Company, Inc., Boston Research Division, Boston, Mass., January 15, 1953, 27 pp., Qtly. Prog. Rept. No. 2, September 15 through December 14, 1952, DA-36-039-SC-42459 (AD 6473)

Early developmental work on synthetic resinous materials which can be used for the casting, encapsulating or potting of military electrical and electronic equipment is reported.

8.3

0280
INVESTIGATION OF PLASTIC CASTING RESINS
Springfield Armory, Springfield, Mass., December 16, 1954, 19 pp., SA-TR18-1041 (AD 73433)

The utility of various types and makes of casting resins for making plastic models and prototypes, as well as for potting and "encapsulating" of electrical components are discussed.

8.3

0281
ULTRA HIGH TEMPERATURE DIELECTRIC EMBEDDING MATERIALS
Barr, F. A. and Rodney, S., Mycalex Corporation of America, Synthetic Mica Company Division, West Caldwell, N. J., 24 pp., Qtly. Prog. Rept. No. 1, October 27, 1961 to January 27, 1962, NObs-86219 (AD 272038)

Investigations were conducted on using a devitrified sealing glass as a coating for a synthetic mica-phosphate dielectric embedding material. Various methods of applying the coating were studied with a "hot dipping" method showing the most promise. The dielectric constant and power factor were measured for different coated samples and found to be satisfactory at temperatures up to 350 C. Several commercial high temperature resistors of the carbon film type were successfully encapsulated using ceramoplastic injection molding techniques in combination with the synthetic mica-phosphate embedding material.

8.3

0282
CONFORMAL COATINGS FOR PRINTED CIRCUIT ASSEMBLIES
Beccasio, Anthony J., Motorola Inc., Military Electronics Division, Chicago, Ill., 20 pp., Qtly. Rept. No. 2, November 1, 1961 to January 31, 1962, DA-36-039-SC-89136 (AD 273080)

The evaluation of the physical and electrical properties of epoxy resin, polyurethane resin, and silicone-based polymer coatings are reported.

8.3

0283
PRELIMINARY TEST OF CPR #9002-4 POLYURETHANE FOR IR AND POTENTIAL CORROSIVE EFFECTS WHEN SUBJECTED TO HEAT AND HUMIDITY
Motorola Inc., Military Electronics Division, Western Center, Scottsdale, Ariz., February 12, 1964, 7 pp., TM 812 (AD 447360)

This evaluating report discusses possible defect creation in polyurethane foam when it is exposed to reduced pressure, heat and humidity. Examination of all the test panels revealed that none of the panels with foam were corroded or oxidized more than similar panels without foam. Coatings exposed to heat and humidity were damaged more than coatings exposed only to heat, and the presence of foam appears to cause lifting or blistering of the coatings. Dennis 1162 was found to be the most satisfactory coating tested. The IR of the foam changes greatly with moisture and may present a problem. The use of silicone rubber foam in packaging in place of urethane foam should be considered.

8.3

0284
COMPARATIVE TESTS ON CONFORMAL COATING TYPES: POLYURETHANE, POLYURETHANE ELASTOMER, AND FLEXIBILIZED EPOXY
Hayashi, F. Y., North American Aviation, Inc., Autonetics Division, Anaheim, Calif., January 2, 1964, 15 pp., Test Rept. TR-64-200 (AD 454353)

The surface coatings tested were Chem Seal's CS 2630, Products Research's PR 1538, Organoceram's Utiliplast 5-3022, and Magna's Laminar X-500. Results indicate the urethane elastomer, PR 1538, has good insulative properties even in 4 to 6 mil thicknesses. As an elastomer, this material has superior elongation, tear strength, tensile strength and abrasion resistance when compared to conventional coating materials. Utiliplast performed satisfactorily on epoxy-glass test patterns but very poorly on ceramic probably because of insufficient adhesion. This material also failed the flexibility test. CS 2630 performed unusually well in the ceramic test patterns. Based on these results, further tests were to be conducted to determine if it can qualify as a second or alternate source for Laminar X-500.

8.3

0285
ABC'S OF STORED-ENERGY WELDING PART II
Sosoka, John R., EDN, 11, (1), January, 1966, pp 106-109

The importance of having electrode force and current in the proper ratio for a proper weld is discussed. The temperature distribution that occurs during a resistance weld is pictured and methods of correcting improper heat balance are given. With some material combinations polarity can have a marked effect on weld characteristics.

9.1

0286
STACKED SANDWICH MINIMIZES IC MODULE SIZE
Lieb, B. L., EDN, 10, (5), May, 1965, pp 96-99

A stacked sandwich of integrated-circuit flat packs results in high circuit performance while maintaining maximum advantage of the small size of the flat-pack configuration. Each welded module is made up of a group of integrated-circuit card assemblies stacked upon a header and interconnected with nickel ribbons to external terminals available for system interconnection. After electrical and mechanical testing, the stacked assembly is encapsulated to complete the module.

5.1

0287
CUSTOM ENCLOSURES FROM PREFABBED PARTS
Pass, Charles, EDN, 10, (7), June, 1965, pp 96, 98-103

A modular packaging system which uses standardized prefabricated parts that can be assembled in a variety of sizes and configurations is described. Enclosures to house tube-type circuits, printed-circuit cards and integrated-circuit modules all are constructed from the same basic packaging hardware.

7.1

0288
HOW TO SELECT WIRE INSULATION
Finocchi, Anthony J., Electronic Production, 6, (3), August, 1963, pp 39-41

The selection of wire insulation, sheathing, or jacketing must be consistent with the potential on the line, the expected temperature rise of the conductor, dielectric constant, dissipation, impedance, flexibility, reaction to heat and cold, corrosive vapors, and abrasion. Characteristics of the following classes of insulation and jacketing materials are discussed: 1) rubber, including silicone, neoprene, butyl, fluorocarbon, and polyurethane; 2) vinyl; 3) polyolefins, including standard polyethylene, linear polyethylene, and polypropylene; 4) fluorocarbons, including Kel F, Teflon, and Teflon 100; and 5) nylon.

8.5

0289
THE EFFECT OF NUCLEAR RADIATION ON ELECTRONIC COMPONENTS, INCLUDING SEMICONDUCTORS
Thatcher, R. K., Hamman, D. J., Chapin, W. E., Hanks, C. L., and Wyler, E. N., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, October 1, 1964, 222 pp., REIC Rept. 36

This report presents information available in the REIC files that covers the state of the art of knowledge on the effects of nuclear radiation on basic electronic parts. This report presents component results that are grouped as to family within each component class type. The results presented in the report are intended to provide a basis for judging the merits of the parts when they are to be used in circuitry that will be exposed to a radiation environment. Some of the data included in the report can be considered as design oriented to the extent that they indicate radiation levels at which the parts would be expected to perform satisfactorily.

3.4, 4.29, 5.29

0290
THE SPACE-RADIATION ENVIRONMENT AND ITS INTERACTIONS WITH MATTER
Leach, E. R., Fairand, B. P., and Bettenhausen, L. H., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, January 15, 1965, 54 pp., REIC Rept. 37 (AD 456854)

Space-radiation data are summarized and evaluated. Radiation-measurement techniques are discussed, and the apparatus used on several American space probes and satellites is described. Particle flux as a function of type of radiation and energy is summarized in graphic form, and basic concepts of the interaction of space radiation with matter are discussed.

3.

0291
SPACE-RADIATION DAMAGE TO ELECTRONIC COMPONENTS AND MATERIALS
Chapin, W. E., Hamman, D. J., Wyler, E. N., and Jones, D., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, October 30, 1963, 60 pp., REIC Rept. 32 (AD 422325)

This report presents the results of research experiments conducted at various radiation facilities to determine the effects of proton and electron radiation on the electrical and physical properties of electronic components and their materials. Most of the investigations are concerned with radiation effects on such semiconductor devices as solar cells, solid-state diodes, and transistors. This arises from the knowledge that these components will cause most of the problems in space applications. A limited amount of experimentation has been conducted for other commonly used electronic components because gamma- and neutron-radiation data indicate that they do not present problems comparable to solid-state devices. Metals are also discussed. Some discussion concerning shielding is included with the hope that research in directions of improving devices and their operating conditions will be encouraged.

3., 4.29

0292
"KAPTON" POLYIMIDE FILM - A NEW INSULATION FOR AEROSPACE WIRE AND CABLE
Stabler, R. E. and Lewis, L. L., 8th National SAMPE Symposium, "INSULATION-MATERIALS AND PROCESSES FOR AEROSPACE AND HYDROSPACE APPLICATIONS", May 25,26,27, 28, 1965, Society of Aerospace Material and Process Engineers, pp 1-7

"Kapton" polyimide film Type H, formerly called H Film, is a condensation product of pyromellitic dianhydride and an aromatic diamine. Exceptional mechanical and electrical properties combine with the thermal stability of the "Kapton" to provide a durable electrical insulation that offers distinct advantages in wire and cable applications. Wire and cable insulated with "Kapton" has been under development for several years. This paper will review the merits of wire insulated with "Kapton".

3.4, 8.1, 8.5

0293
THE VACUUM-THERMAL STABILITY OF ORGANIC COATING MATERIALS PART I. THE POLYURETHANES
Mattice, James J., United States Air Force, Wright-Patterson Air Force Base, Ohio, August, 1960, 36 pp., WADD Tech. Rept. 60-126 (AD 245327)

This report includes a survey of the basic knowledge of polyurethane chemistry and the results of the vacuum-thermal exposures of commercially available, unmodified polyurethane resins. The relationship between structure, cure, film thickness and weight losses of the polymers is discussed. The urethane bond appears to be the major labile species, leading to a characteristic degradation, which is complete at 500 F. The physical appearance and properties of degrading films is good and pigmentation of a film with titanium dioxide has different effects at differing temperature levels.

3.4, 8.3

0294
INFRARED SOLDERING OF PRINTED CIRCUITS
Costello, Bernard J., Electronic Products, 7, (8), January, 1965, pp 26, 27, 57, 58

Where thermally sensitive components must be attached to a printed circuit or where contamination must be minimized, soldering by automatic wave or an iron is often not satisfactory. In contra,t, soldering with infrared radiation can be done at the lowest possible temperature for a given solder and the work is not contacted. However, these advantages are gained at the expense of speed. IR soldering was compared with soldering by iron under accurate laboratory conditions.

9.2

0295
PROPERTIES OF ENCAPSULATING COMPOUNDS
Electronic Products, 5, (11), April, 1963, pp 44-55

A chart is presented which tabulates the electrical, physical, and chemical properties of about 100 encapsulants. The information given includes manufacturer's name, trade name, chemical composition, drying time, curing time, pot life, temperature range, cured state hardness, viscosity, acid/salt/moisture resistance, dielectric strength constant, and specific volume resistivity.

8.3

0296
FLAT CONDUCTOR CABLES AND CONNECTORS
George C. Marshall Space Flight Center, Huntsville, Ala., July, 1964, 24 pp.

A collection of tables and graphs is presented in which various characteristics of round and flat cable are compared, the designs of flat conductor cable receptacles and plugs are shown and flat cable standards are given. Connector data sheets are also included.

8.1, 8.4

0297
HI-DENSITY ELECTRONIC PACKAGING PROGRAM
Morgan, H., Sylvania Electronic Systems-West Reconnaissance Systems Laboratories, Mountain View, Calif., December 21, 1962, 39 pp., Rept. 62R246 (AD 457779)

Welding procedures were established and preliminary designs of selected module application were determined. The most practical compounds for encapsulation of modules and construction of molds were determined and their desirable characteristics tabulated. Welded circuits offer advantages in reduction of size and weight and increased reliability. Potted modules provide additional advantage in the areas of thermal control, protection from moisture, and the high-vacuum effect of space environment.

8.3, 9.1

0298
IC PACKAGING REVISITED
Rose, James A., Electronic Design News, 11, (1), January, 1966, pp 105-108

Since the inception of the integrated circuit, a variety of methods of packaging them has been developed. Several of these layouts are pictured and are briefly discussed.

5.1

0299
EVALUATION OF EPOXY FOAM MATERIAL
Knapp, J. E., Northrop Corporation, Norair Division, Hawthorne, Calif., November 8, 1960, 3 pp., Rept. No. NOR-60-346 (AD 294 73)

Eccofoam GL is a plastic foam-in-place powder. It is poured to completely fill a mold or a cavity and flows evenly and uniformly into small void areas and around complex shapes. This material is employed in the embedment of electronic circuits and components, as core material for fiberglas laminates, double walled radomes and reinforcement for sandwich structures. Properties of the foam material such as thermal conductivity, compressive strength, shear strength, and water absorption are listed. The material is deemed suitable where maximum service temperature does not exceed 325 F.

8.3

0300
INVESTIGATION OF ELECTRONIC MODULE POTTING RESINS
Dallimore, George R., Lockheed Aircraft Corporation, Lockheed Missiles and Space Company, Sunnyvale, Calif., August, 1962, 40 pp., Tech. Rept., AF 04(647)-787 (AD 294977)

Three PAM amplifier modules were encapsulated, respectively, in one of the following resins: Furane Plastics Epocast 202/9615 at 110 phr, Products Research PR 1538, and Emerson and Cumings Stycast 2651 MM. The three resins were measured for shrinkage, insulation resistance, hardness, exotherm and strain.

8.3

0301
THEORY AND OPERATION OF VARIOUS COOLING TECHNIQUES
Zolg, R. H., Boeing Airplane Company, Seattle, Wash., June 17, 1963, 81 pp., D2-90382 (AD 441999)

Electronic packages are cooled by three heat transfer processes: conduction, convection and radiation. The cooling techniques, liquid (direct and indirect) vaporization, refrigeration, thermoelectric and cryogenic use these processes in cooling electronic equipment. The possible power dissipation of each of these techniques and heat transfer processes are given. The theory of operation and how these techniques apply to the cooling design are presented. The advantages and disadvantages of the various techniques together with the practical design parameters are discussed to enable the designer to arrive at an optium thermal design for a given package.

7.3

0302
MATERIALS, TECHNIQUES, AND ECONOMICS OF FOAMED-IN-PLACE POLYURETHANE CUSHIONING FOR PACKAGING
Childers, Sidney, USAF, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, April, 1959, 30 pp., WADC TR 58-601 (AD 211913)

This report describes an investigation into various aspects of foaming-in-place molded shapes of polyurethane cushioning material. The chemistry of the foam reactions and the foam systems are described. The aging characteristics of the materials and the effect on metals and humidity indicators of the vapors given off during foaming are discussed. Various facts about foaming methods and equipment are presented. Of the foaming techniques investigated, it was found that completely premolding or a combination of premolding and foaming into the container was the best technique. It was also found that one can create molds by utilization of simple methods and low cost, reusable materials, such as hot melt plastics. The cost of creating the molded shape is shown to be less, in most cases, than the present practise of procuring molded curled hair shapes.

7.3

0303
NEW MEDIUM FOR THE PROTECTION OF ELECTRONIC EQUIPMENT AGAINST SHOCK AND VIBRATION
Jacobson, Robert H., Illinois Institute of Technology, Armour Research Foundation, Chicago, Ill., April, 1958, 141 pp., WADC TR 57-530 (AD 151169)

Fifty-seven materials and combinations of materials were investigated in this program to develop a new medium for protecting electronic equipment in guided missiles against shock and vibration. The proposed new medium consists of a multi-layer grid of 3/32-in. Teflon rods embedded in a matrix of Silastic S-6508. Samples of the medium prepared for test purposes were produced as specimens 1/2-in. thick and 3 by 3 in. in cross section. However, the medium can be manufactured in large slabs of different thickness, and pieces of the medium can be cut to size and shape as required for particular applications. High internal damping is the salient feature of the new medium. The maximum transmissibility obtained during vibration transmissibility tests conducted at 0.010-in. input double amplitude was only 2.1. The materials comprising the new medium are able to withstand the temperature requirements of -85 to 482 F, as well as most of the other environmental requirements of the project contract.

7.3

0304
VOYAGER EFFORT FOCUSES ON STERILIZATION
Watkins, Harold D., Aviation Week and Space Technology, 84, (1), pp 58-59, 61, 64, 65, 67, 68

Preliminary hardware development and design for the Voyager capsule have produced optimism that severe sterilization standards for the spacecraft can be met, although serious problems are anticpated. Sterilization is necessary to prevent contamination of Mars by organisms from earth. Because all parts of the assembled capsule will not heat at the same rate-a wide variety of materials will be used-it will be important to organize the subsystems so that those most susceptible to damage from heat will receive the least amount. Heat shields and solid propellants act as major thermal barriers to retard both heating and cooling. Some means of forced convection is being considered to reduce the total heat-soak time. In many instances solutions to the sterilization heat problems lie in selection of materials or design concepts that do not offer the most efficient system, as in electronic parts and probably in on-board propulsion. Over-design and added weight may be necessary to secure satisfactory reliability and performance in such areas.

7.38

0305
ENHANCED MICRO-MODULE INTERCONNECTIONS AN HERMATIC PACKAGING SYSTEM FOR THE INTEGRATION OF MICRO CIRCUITS
United Aircraft Corporation, Hamilton Standard Division, Broad Brook, Conn., 35 pp., Qtly. Rept. No. 3, January 1, 1964 to March 31, 1964, DA-36-039-AMC-03620(E) (AD 602271)

The Enhanced Micro-Module - EMM - is an all electron beam welded, hermetically sealed interconnection - packaging system which is compatible with all approaches to microminiaturization. Each module comprises up to ten stacked microwafers .310 x .310 inches on a side which are interconnected by 36 electron beam welded conductor ribbons. Communication with external circuitry is achieved through a hermetic header which is electron beam welded to the can. The high interconnection capability of the system is suited for packaging of uncased active devices and semiconductor circuits, thus eliminating the need for expensive individual enclosures. The objective of this program is to establish the capability to manufacture Enhanced Micro-Modules on a Pilot Line basis.

8.3

0306
ELECTRONIC PACKAGING FOR 5000g SURVIVAL
Miller, Wayne F., California Institute of Technology, Pasadena, Calif., August, 1961, 34 pp., Rept. No. 1041, NASw-81 (X64-15553)

There are four steps in the design of an electronic package to withstand severe shock. (1) Avoid fragile components in the electronic circuit design. (2) Test and evaluate components selecting the most rugged types applicable. (3) Design a rugged mechanical package taking into account component mounting and orientation relative to the expected direction of acceleration. (4) Test the package under actual or simulated conditions.

4.22

0307
THE DESIGN AND CONSTRUCTION OF THE ELECTRONICS PACKAGE
Shennum, R. H. and Reid, E. J., Telstar I, NASA SP-32, Volume 3, June, 1963, pp 1749-1763 (N64-11084)

The electronics system of the Telstar satellite is described from the point of view of philosophy of design and construction rather than that of circuit details. The reliability is emphasized, and steps taken to preserve the inherent reliability of the components are discussed. The physical construction of modules, subsystems, and finally the entire system is described, including the foam encapsulation and the eventual hermetic sealing of the canister.

4.1, 7., 8.3

0308
EXTRA FLEXIBLE TACTICAL CABLE
Rigling, W. S., Martin Company, Orlando, Fla., July, 1965, 32 pp., Qtly. Rept. No. 5, April 1, 1965 through June 30, 1965, DA-28-043-AMC-00045(E) (AD 474083)

Evaluation testing of Telephone (Class E) and Tactical Cables (Class B) was completed during this period. These tests demonstrated that the Class E cable met all design requirements while the Class B cable was marginal in mechanical test performance. A summary of all test results is presented. A complete analysis of cable weaknesses and attributes is provided. Preliminary tests have been performed on a new polyether-urethane sheath material. The manufacturer's data on this material are presented.

8.1

0309
PREDICTION OF SHOCK RESISTANCE OF ELECTRONIC EQUIPMENT
D'Agostino, Robert, Electronic Packaging and Production, 2, (5), September/October, 1962, pp 13-20

Three methods of determining the fragility factor for electronic equipment are: destructive testing, stress analysis, and estimates based on experience. Once the fragility factor is acquired, a flexible suspension or cushioning system can be designed to protect the equipment against shock damage.

6.42

0310
ASSURED RELIABILITY IN SOLDERED CONNECTIONS
Fessel, Leopold, Electronic Packaging and Production, 3, (3), March, 1963, pp 14-16, 18

A comparison of soldering and welding with respect to reliability and assurance based upon an analysis of the factors or parameters involved in the establishment of a connecting metal lattice, adequate initially as well as after prolonged service life is given. A new solderability test which is based upon an estimate of the contact angle between a molten solder droplet and the surface of the component wire is presented.

9.2

0311
WELDABLE INTERCONNECT CIRCUITRY
Douglas, Richard R. and Gross, Leon, Electronic Packaging and Production, 4, (1), January, 1964, pp 56-59

Presently used techniques for welded interconnect systems may be broadly categorized into three areas: (1) point-to-point wiring, (2) welded matrics, and (3) weldable tabs formed with interconnect circuitry. Choice of techniques may be dictated by a specific design situation, equipment limitations, or the personal preference of the designer. In each of these categories, however, limiting factors exist that may tend to reduce the ultimate reliability of the system. In point-to-point wiring, it may be operator error in mis-routing interconnecting nickel ribbon. In the second category, it may be the possibility of lead shorting between layers or operator error again in clipping the wiring segments of the matrix. In all three areas, we are faced with the problem of locating and holding either two cylindrical bodies (two wires) or a cylindrical body and a flat surface in close juxtaposition without slipping while the welding operation is taking place. In addition, there is the complication of weld scheduling where a variety of materials and types of welding electrodes are required, and the frequent need to concern ourselves with optimum electrode polarity.

4.15, 9.1

0312
CORDWOOD MODULE DESIGN
Kramer, Joel A., Electronic Packaging and Production, 4, (1), January, 1964, pp 6 -63

This article outlines a generalized procedure that has been found to be useful in the design of cordwood modules. The cordwood module offers one of the highest packaging densities possible. The actual design of the module differs from the planar printed circuit in the fact that the module is a three-dimensional circuit. In order to package a system effectively using the cordwood technique, the designer must lay out the circuit so that it can be divided into basic units. Since the module is not repairable, consideration must be given to the cost of replacement in the event a failure does occur.

4.152

0313
TWO-AXIS SOLAR SUN TRACKER
Van Zyl, Roelof, Electronic Packaging and Production, 4, (4), April, 1964, pp 10-14, 16-17

The two-axis solar servo sun tracker is an electronic packaging design employing advanced electrical interconnections and packaging techniques. The purpose of the sun tracker is to obtain electrical power by aligning large solar arrays toward the sun. The housing for the forward sensors and rear sensors is mounted on the panel shaft. The following design objectives were considered: minimum weight, ease of maintenance, low manufacturing costs, and design compatibility with manufacturing techniques already developed. The materials used in the housing, fastners, potting, and components are briefly discussed.

7.1, 7.37, 7.39

0314
DESIGNING AGAINST DIELECTRIC BREAKDOWN OF PRINTED WIRING ASSEMBLIES
Noble, Robert P., Electronic Packaging and Production, 4, (4), April, 1964, pp 71-74

The theories and principles of dielectric breakdown are applied to the presentation of parameters useful in the design of printed wiring boards.

3.4

0315
PACKAGED SEMICONDUCTOR NETWORKS
Vanous, Donald D., Electronic Packaging and Production, 2, (2), March/April, 1962, pp 13-16

An advanced packaging technique which promises increased system reliability includes semiconductor networks. By the careful layout of a network, the number of connections usually associated with conventional components can be reduced considerably. At the present, standard semiconductor networks are packaged in rectangular, hermetically sealed packages, 0.250 x 0.125 x 0.031 inch or in standard TO-5, TO-8, or TO-46 cans by such companies as Texas Instruments, and Micro-Semiconductors, Inc.

6.2

0316
METHODS OF CLEANING PRINTED-CIRCUIT BOARDS Pt. I
Heuring, Harvey F. and Matzinger, J. Robert, Electronic Packaging and Production, 2, (2), March/April, 1962, pp 17-19

Detergent cleaning, abrasive cleaning, cleaning with slight etching, cleaning boards after etching, ultrasonic cleaning, electro-cleaning, and protective coatings are briefly discussed.

6.5

0317
METHODS OF CLEANING PRINTED-CIRCUIT BOARDS Pt. II
Prise, Walter, Electronic Packaging and Production, 2, (2), March/April, 1962, pp 20-21

Good housekeeping is the most important requirement in the control of contamination. Board and components should be protected from damage in storage, handling, and in all steps of processing. The boards should be handled by their edges to prevent fingerprinting of the material. Gloves should be worn by those who consistently handle boards and components. Re-packing of component parts should be avoided.

6.5

0318
A VERSATILE PACKAGING MODULE
Ritter, Joseph, Electronic Packaging and Production, 2, (2), March/April, 1962, pp 61-63

Easy access to components is a distinct advantage of packaging technique shown which is based on sandwich construction. The packages consists of two thin printed circuit boards having tapered notches on their edges. The components are mounted between the boards, and the leads are wedged into the notches.

4.15

0319
PLANAR WELDING: NEW PRODUCTION TECHNIQUE
Heitert, Donald G., Electronic Packaging and Production, 2, (6), November/December, 1962, pp 8-13

The planar welded module process is one of simplicity; it integrates the requirements of design, tooling, quality control, and inspection. No one process parameter has been made subservient to any others. The process can be applied with equal efficiency to electronic equipment requirements in quantities of 1, 100, or 100,000. The planar welded module packaging form factor has the optimum surface area-to volume (aspect) ratio for application in adverse thermal environments. Assemblies fabricated with this process are more reliable than those made using other processes because the planar welded module process provides better quality control and inspection features.

9.1

0320
PACKAGING OF RF AND IF AMPLIFIERS
deRonde, Henry M., Electronic Packaging and Production, 2, (6), November/December, 1962, pp 14-15

Packaging of IF and RF amplifiers on printed circuit boards has long been a source of difficulty. Considering the basic requirements, the problem resolves itself to a construction technique that incorporated the following points: 1. Short lead length and conductive path. 2. Ease of fabrication and repairability (economy). 3. Mechanically sound construction. The approach to resolving the problem resulted in an amplifier in which all components could be changed by unsoldering both leads and pulling the component out of its foam cavity.

4.11, 4.12, 4.13, 4.15

0321
COMPATIBILITY PACKAGING
Daniels, Rexford, Electronic Packaging and Production, 1, (1), July/August, 1961, pp 11-14

Compatiblity packaging is the final step in packaging everything from microelectronic components to large operational assemblies in order to achieve electromagnetic compatiblity between all so-called "packages"; that is, to keep radio-frequency interference between separate pieces of equipment at a minimum. The term includes packaging everything which can cause radio-frequency interference (RFI) or be affected by it, it embraces all sources which can create electrical sparks, including static from friction, and everything susceptible to it.

6.111

0322
CONNECTOR PROBLEMS IN MINIATURIZED ELECTRONIC PACKAGES
Prise, Walter, Electronic Packaging and Production, 1, (1), July/August, 1961, pp 19-20, 22, 24

A State of the Art review of the connector field, from the point of view of miniature package requirements, describing characteristics of available connectors and outling trends for development of new connecting devices.

8.4

0323
PARALLEL-GAP WELDING
Bywaters, Richard P., Electronic Packaging and Production, 3, (4), April, 1963, pp 10-12, 14, 16

A review is given in this article of the fundamentals of a parallel-electrode welding technique and the application of this method to the field of high density planar packaging. Parallel-gap welding was developed to attach semiconductor networks to printed boards; however, microcomponents with ribbon leads may also be attached to printed circuitry. Slight changes in electrode design may permit welding round component leads to printed circuitry on organic base materials. This welding technique has the potential to make significant reductions in the manufacturing costs of welded assemblies because all interconnections may be printed. Parallel-gap welding can greatly expand the concept of welded electronics by making high-density planar packaging a reality.

9.1

0324
RFI SHIELDING--EXPLAINED BY ANALOGY
Schreiber, O. P., Electronic Packaging and Production, 2, (1), January/February, 1962, pp 13-14, 16

This article attempts to explain by analogy some of the principles of radio frequency interferennce and its control, without recourse to terms which may be unfamiliar to the nonelectrical engineer. The solution of the problem involved in RF shielding embodies mechanical principles. Often dual problems such as RF gasketing and fluid sealing or RF shielding and air cooling are combined.

6.111

0325
PACKAGING FLAT-PACK INTEGRATED CIRCUIT BLOCKS
Carter, H. G., Electronic Packaging and Production, 3, (12), December, 1963, pp 8-10

Solid-state integrated circuits packaged in a thin flat-pack configuration enjoy a 5:1 volume and weight advantage over the same circuits packaged in the TO-5 transistor can configuration. Use of the flat-pack design, however, has been somewhat limited owing to problems of interconnection. Detailed in this article is a packaging plan that uses fabrication techniques in a manner that takes full advantage of the extremely small size of the flat-pack configuration, and provides a direct conduction path for heat removal from the completed module. The result of this technique is a small, lightweight, all-welded package of maximum reliability.

5.15

0326
CELLULAR PACKAGING IMPROVES RELIABILITY
Church, S. E. and Geroulo, M., Electronic Packaging and Production, 2, (3), May/June, 1962, pp 15-16

A novel packaging technique of cellular construction is illustrated. It incorporates two shift register circuits housed in a pre-molded, cellular plastic housing, including terminals, and allows for terminal connections on both the top and bottom of the unit. Assembly of components is followed by an intermediate electrical inspection and final encapsulation and testing. The features of this design in terms of reliability, cost, and miniaturization are given.

4.155

0327
CLEANING PRINTED CIRCUIT BOARDS AND ASSEMBLIES
Wolff, C. F. and King, E. J., Electronic Packaging and Production, 2, (3), May/June, 1962, pp 68-71

A step-by-step procedure is outlined suitable for cleaning printed-circuit boards ultimately used in guided missiles. Flux residues and body salts and grease can be removed from board surfaces by carefully scrubbing the surfaces in distilled water then in isopropyl alcohol and finally again in water. For a production cleaning process, however, the scrubbing procedure is undesirable because it is slow. Cleaning of printed circuit assemblies has been accomplished by two basic methods; manul brushing and ultrasonic agitation. The manual method is accomplished by immersing the assembly in ACS Isopropyl alcohol and scrubbing with a nylon brush for approximately 45 seconds. The assembly is then removed, and the excess solvent allowed to drain. The assembly is then blown dry with oil-free compressed air before alcohol evaporation occurs. The second method employed is ultrasonic cleaning. The sequence of operation is the same as the brushing method, but the time in each bath is reduced to 15 seconds. After the assembled board is cleaned, it should be oven dryed at 150 F for a period of two hours.

6.5

0328
PRINTED CIRCUITS IN WELDED MODULES
Oswald, Anton, Electronic Packaging and Production, 2, (4), July/August, 1962, pp 16-18

Kearfott Division of General Precision, Inc. have developed an interconnection design concept that uses a printed circuit in conjunction with a weldable hollow pin. With this weldable printed circuit board, the need for point-to-point wiring using nickel-ribbon wire has been eliminated. Electrical continuity between the weldable hollow pin and the printed circuit is assured by material and process specifications. Reliability is maintained even if a dry mechanical connection is introduced into a welded package.

4.14, 4.15, 9.1, 9.5

0329
TO WELD...OR NOT TO WELD
Kirchoff, Wesley L., Electronic Packaging and Production, 2, (4), July/August, 1962, pp 38-43

The relative merits of resistance welding and soft soldering are discussed. A comparative analysis of production speed, size, quality control, joint uniformity, cost, repairability, reliability, strength of connections, and heat damage to other components is presented.

9.112

0330
CUTTING COSTS OF MANUFACTURING WELDED MODULES
Tanny, M. W., Electronic Packaging and Production, 2, (4), July/August, 1962, pp 77-78

Improved methods for pin location and prototype development as an approach to more economical methods of producing welded modules are discussed. Objections which some companies have to locating pins in optimum positions for ease of assembly are usually confined to three categories: 1. The PC board will be too complicated. 2. The units will not match other units. 3. Interference or ringing will occur in the circuit.

4.15113, 8.4

0331
CRUCIFORM PACKAGING
Stern, Daniel, Electronic Packaging and Production, 1, (3), November/December, 1961, pp 11-14

A new concept of efficient high density packaging which is based on the cruciform shape is shown. Each quadrant of the cruciform may take component modules of various lengths while the void between the beams may be used for wiring. KIA magneium is recommended as the most desirable material because it can be cast by many magnesium foundries, and it is relatively simple to machine. The present cruciform weight ranges from 30 to 60 pounds per cubic foot; frame weight accounts for approximately 70 percent of these totals. Consequently any change in frame material play, a substantial part in an attempt to lighten the unit.

4.155

0332
ELECTRONIC WIRE HARNESS CABLING
Leftow, Jerry, Electronic Packaging and Production, 1, (3), November/December, 1961, pp 15-16, 18

The art of harness cabling is the design of a cable for the purpose of pre-forming circuit conductors. It is done on a tool board with the assistance of certain fixtures to maintain the wires in the desired position during lacing operations. The finished product is then transferred to the chassis or cabinet and soldered to the components. Timesaving ideas for such wiring harnesses are given.

8.1

0333
AN ELECTRO-CLEANING PROCESS FOR PRINTED-WIRING BOARDS
Matzinger, J. Robert, Electronic Packaging and Production, 1, (3), November/December, 1961, pp 58-59

Advantages of electro-cleaning of printed-wiring boards over conventional chemical methods include: 1. Improved appearance, because it produces a bright luster finish; 2. Less reduction of the printed wiring conductor line width due to etching. The method of electro-cleaning printed-wiring boards which is given is simple, efficient, and gives consistent results.

6.5

0334
THE PACKAGING REVOLUTION Pt. I FORM AND FUNCTION INTERACT
Staller, Jack J., Electronics, 38, (21), October 18, 1965, pp 72-87

The major barrier to full realization of the advantages of integrated circuits is the protecting, connecting, cooling, and housing the circuits. Designing the system packaging as covered by this article includes modular interconnection concepts, maintainability, fault isolation, and package size and shape. Integrated-circuit packaging systems are tabularized.

5.1, 6.1, 6.2, 6.3, 8.4

0335
THE PACKAGING REVOLUTION Pt. II DESIGN AND MANUFACTURING OVERLAP
Staller, Jack J. and Sideris, George, Electronics, 38, (22), November 1, 1965, pp 75-87

The assembly of integrated-circuit systems requires special fabrication processes which are discussed. The package form and lead-joining method to use should be early decisions made by designers and the manufacturing department. Package selection, lead joints and connections, thermal management, and other systems are considered. "The System Designer's Role" by Matthew Abbott and "Packaging the Big Computers" are included as inserts in this article.

5.1, 5.3, 6.1, 6.2, 6.3, 6.5, 8.4, 9.

0336
VIBRATION PROTECTION FOR ELECTRONIC EQUIPMENT
Ruther, Frank J., USAF, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, November, 1953, 13 pp., WADC TR-54-48 (AD 27582)

General solutions are presented to the problem of protecting electronic equipment from shock and vibration, which are the end result of properly applied theoretical considerations. The system presented for protecting airborne equipment from vibration and shock is composed of three parts: (1) the immediate support structures, (2) the vibration and shock isolators, and (3) the internal structure of the equipment. Each part of the system is treated individually along with explanations of its effect on the other two. The limits to which any one of the three parts can go and still be compensated by the other two are finely drawn.

7.3

0337
JOINING DISSIMILAR METALS--TRY PERCUSSION WELDING
Kleis, J., Welding Design and Fabrication, 35, (8), August, 1962, pp 34-35

Fansteel Metallurgical Corp., North Chicago, Joins copper and steel to refractory and precious metals by means of percussion welding. Results: bonds of 99% total weldable areas are obtained as compared with 70 - 85% bonds obtained with processes previously used for making these electrical contacts.

3.5, 9.1

0338
NEW METHODS OF WELDING ("BALL" WELDING) BY CONDENSER DISCHARGE
Evtifeev, P. I., Instrument Construction, (10), October, 1961, pp 14-17

Rapid welding of small sections of copper wire with accurate control of the energy and of the stability of quality of the welded products is described in detail and illustrated. A little ball is formed by the discharge of a condenser between an electrode and the pieces to be welded which are held in a copper clamp.

9.1

0339
ADHESIVES IN PRINTED CIRCUIT APPLICATIONS
Rider, D. K., Journal of Applied Polymer Science, 6, (20), March-April, 1962, pp 166-175

Adhesives are used in etched foil, plated, transfer, and applique circuit processes; for copper cladding printed circuit boards, vinyl-modified phenolics, acrylonitrile rubber-modified phenolics, and modified epoxies are used; tables list process characteristics and general adhesive requirements.

3.4

0340
JOINING DISSIMILAR METALS
Peckner, D., Materials in Design Engineering, 56, (2), August, 1962, pp 115-122, (M/DE Manual No. 198)

Metallurgical problems involved in dissimilar metal joining, factors to be considered no matter which joining process is selected for making the joint. Tabular data shows thermal expansion and relative corrodability of metals and alloys.

3.5

0341
"WELDED CORDWOOD" IMPROVES ELECTRONIC PACKAGES
Electrical Engineering, 81, (5), May, 1962, p 384

A 3-D welded circuit assembly is described. Miniature components, both active and passive, with uniformity of size, are stacked in cordwood fashion, between top and bottom Mylar films which are punched for insertion of component leads, and bear duplicate tracery of electrical wiring schematic. Leads are clipped off 0.1 inch from the film to accommodate nickel interconnecting ribbon which is welded to the stubby leads, according to the traced pattern. The entire assembly is then potted. Special features include: high reliability with a minimum of handling; leads are never bent; no internal heating during welding operation; welded joints are permanently bonded.

4.152, 9.5

0342
CONNECTORS AND TERMINATIONS
Ruth, S. B., Electronic Industries, 22, (4), April, 1963, pp 56-67

Four major methods of contact termination: solder; crimp; solderless wrap; weld methods, are briefly discussed. Also discussed are contact types and new devices; plating materials insert materials; standardization; new designs. Illustrations are shown for several new types of connectors. List of contributors to the article constitutes a brief listing of connector manufacturers.

9.1, 9.2, 9.3, 9.4

0343
SYSTEM PACKAGING USES BOOK CONFIGURATIONS
Goodykoontz, J. R., Electronics, 36, (14), April, 1963, pp 56-58

A welded tube matrix that acts as "book binder" and holds leads connecting thin, card-shaped dotand pellet modules is discussed. Intraconnections within each individual module are made with sild-screened conductive adhesive. The "book binder" or interconnection matrix with a horizontal welded tub configuration accepts those wires that are solder-connected inside the tubes. Modules, separately held by balsa wood spacers, open out like pages of a book, for ease of inspection or repair without disconnecting any part of the system. After dot-shaped or pellet components have been molded and cleaned, contacts are cemented to them. Advantages of the packaging include potential cost savings in terms of hundreds of connections possible in a single operation; possibilities of automated assembly; greater reliability; greater repairability: high resistance of conductive pattern to thermal shock.

4.155

0344
COOLING CARD-MOUNTED SOLID STATE COMPONENT CIRCUITS
Hay, A. D., Electrical Design News, 7, (14), December, 1962, pp 80-87

Information presented here was obtained from tests of assemblies of live cards conducted in a precision airflow test chamber and from custom designs of packaged air moving equipment built to create uniform air velocities across banks of circuit cards.

7.37

0345
STEP-BY-STEP DESIGN TECHNIQUES FOR COOL ELECTRONIC
Matisoff, B., Product Engineering, 3, (22), October 29, 1962, pp 50-55

Bar charts, illustrations, brief descriptions of cooling methods and component location point out methods for determining the best combination of enclosure size and cooling method for a given heat dissipation. Special stress is placed on conduction across joints, and the best joints for thermal conductivity.

4.12, 7.37

0346
THERMAL DESIGN SOLUTIONS FOR MICROMODULAR EQUIPMENT
Rezek, G., and Taylor, P. K., IRE. Transactions of Product Engineering and Production, 5, (2), July, 1961, pp 71-84

An empirical formula is started for the rate of heat transfer by radiation and convection from the surface of a module of standard cross-section and arbitrary length. Graphs of this formula are plotted giving heat dissipation as a function of module length, with module surface temperature as parameter. The steady-state elevation of the internal temperature of the module is then evaluated, under certain assumptions with regard to the heat flow mechanism, and nomographs are provided for the determination of this quantity.

7.37

0347
THERMAL ENVIRONMENTAL CONTROL TECHNIQUES APPLIED TO ELECTRONIC EQUIPMENT
Sepsy, C. F., The Journal of Environmental Sciences, 6, (2), April, 1963, pp 15-19

Text and illustrations describing methods of cooling electronic equipment by such methods as improved design; equipment cooling systems, direct and indirect; forced air crossflow cooling; pressurized unit utilizing intermediate heate exchanger as chassis; indirect liquid cooling of omponents. Over-all aims; to increase reliability, and to decrease weight and volume requirements with a saving in energy required to achieve the task.

7.37

0348
A GUIDE TO TESTS FOR MOLDING COMPOUNDS USED FOR AEROSPACE ELECTRONIC COMPONENTS
Stefanski, S. F., Insulation, 9, (1), January, 196[illegible], pp 22-25

This is a description of the most widely used molding compounds and their suitability for aerospace electronic components and other high-performing electrical parts. Tests are described, and warnings given of possibilities inherent in a poor test result, for: spiral flow and cup closing time; environmental conditioning; arc resistance; dielectric strength; dielectric breakdown; dielectric constant and dissipation factor; volume and surface resistance; insulation resistance; flame resistance; radiography; water extract conductance; heat distortion temperatures; physical strength; other tests, such as thermal expansion, chemical resistance, etc.

3.4, 8.3

0349
PROPERTIES OF ENCAPSULATING COMPOUNDS
Electronic Products Magazine, 5, (11), April, 1963, pp 46-55

Electrical, chemical and physical properties of over 100 encapsulating compounds shown in tabular form, with this breakdown of data: name of manufacturer; trade name; chemical composition; drying time; curing time; pot life; temperature range; cured state hardness; viscosity; resistance to acid, salt moisture; dielectric strength constant; specific volume resistivity; special features; intended application or combination of components.

3.4, 8.3

0350
WELDABLE PRINTED CIRCUITS
Grabbe, D., Messner, G., and Saffery, J., Paper presented at 1962 Western Electronic Show and Convention, August, 1962, 5 pp

Interconnection density is achieved by laminating together a number of single-sided printed circuits, and by drilling and building up the conducting layers in the plated-through holes. The new technique developed by Photocircuits Corporation is briefly described, a weldable type pin inserted into a plated through hole. For this process high nickel alloy for spot welding is coated with gallium, tin or indium on one side. The terminal is then inserted into a plated-through hole and the entire assembly is heat treated, so that there is a two-directional diffusion of the terminal metal forming a new binary or tenary alloy which joins, or is actually an extension of both the plated-through hole and the terminal. Pins thus coated have a high melting point and great strength. Terminals so developed can accommodate wire wrapping, crimping, welding, and soldering.

9.1

0351
WELDED ELECTRONICS CLEANING REQUIREMENTS
Torgeson, D. R., Lockheed Aircraft Corporation, Sunnyvale, Calif., June, 1962, 34 pp., Rept. No. 3-26-62-1, NOw 62-0363 (AD 281830)

Cleanliness requirements designed to increase the reliability of lead welds for electronic components are described. Mechanical cleaning of component leads prior to welding resulted in welds superior to those attempted on uncleaned material. Mechanical cleaning was performed manually by means of a proprietary abrasive material consisting of Alundum deposited on nylon filaments.

4.3

0352
TECHNIQUES IN THE FABRICATION OF WELDED AND ENCAPSULATED HIGH DENSITY ELECTRONIC PACKAGING

Maszy, S. and Uglione, H., Jr., Paper presented at IEEE International Convention, New York, N.Y., March 25-28, 1963, Paper No. 54.3, Session 54, Advanced Techniques in Product Engineering

Problems of resistance welding of dissimilar materials used as leads in various electronic components; means for establishing reliability through welding schedules and careful control of manufacturing processes. In-process production controls discussed: metallurgical testing; weld joint strength tests; visual examination and careful inspection of module before and after encapsulation. Selection of encapsulating materials, handling characteristics, economic aspects of use of flexible or rigid encapsulating and supporting materials, and preparation of molds are also discussed.

3.5

0353
HIGH DENSITY PACKAGING-WELDING

Plaskett, V. A., Lockheed Aircraft Corporation, Sunnyvale, Calif., March, 1961, 61 pp., Manufacturing Research Investigation Final Rept., Rept. No. MRI 243.01, IDEP 347.00.00-E9-04 (AD 277884)

An investigation was made of high density packaging-welding. The purpose was to establish the feasiblity of using a resistance welding technique in the assembly of high density electronic packages. The results are given of weld equipment evaluation and qualification; metallurgical analysis of typical welds; evaluation of component lead materials; weld schedule development and certification; sample module assembly; and observance of changes in the state-of-the-art.

9.1

0354
PACKAGING OF SEMICONDUCTOR NETWORKS

Singletary, E. C., Advances in Electronic Circuit Packaging, 2, Proceedings of the Second International Electronic Circuit Packaging Symposium, Boulder, Colo., 1962, pp 91-103

For the semiconductor network of interest in this case, interconnections for the welded stack modules are formed by resistance welding. Advantages of this welding method: reliability; does not damage adjacent components; highly localized heat input does not raise the temperature of components; uniform joints and high production rates are possible by this process. In addition, the Kovar conductors and leads used in semiconductor network assembly are well suited to the tweezer welding process used. Joint combinations used in the stack assembly require only one setting. Network leads are welded to network leads and to interconnections. Longitudinal conductors of 0.020 by 0.002 in. in. Kovar are welded, as required, to network leads and to interconnections. To make a flat connection with the longitudinal conductor, network leads and interconnection tabs are twisted 90 deg.

9.1

0355
SOLDERABILITY OF WELDABLE LEAD MATERIALS

Bester, M. H., Symposium of the Welded Electronic Packaging Association, April 9, 1962, paper presented at the Sixth Symposium of the Welded Electronic Packaging Association, General Precision, Inc., Kearfott Division, Little Falls, N. Y.

Reliability data are reported on for an improved solderability test device. Some of the test data are drawn from experience with the Minuteman program (current reliability data for Minuteman showed 12 x 10^9 solder joint-hours with no reported failures, exceeding the original objective by a factor of five).

9.2

0356
CIRCUITS AND PACKAGING METHODS IN AN AIRBORNE DIGITAL COMPUTER

Chernikoff, L. and Staller, J., National Aerospace Electronics Conference, May 8-10, 1961, Dayton, Ohio, pp 451-459

Spot welding is used for forming densely packed three-dimensional units containing approximately 50 components each. Welded wire interconnections accommodate large number of connections between elements, permitting ground planes and the shielding made necessary by the higher frequencies to be integrated into the wiring assembly. These welded interconnections contained in a solid interconnection block with all connections made internally. Pin-to-pin wire wrap cnonnect the circuit elements back wiring interconnections, and the solid interconnection block. Cold plate heat exchanger using finned tubes and closed cooling system handle the heat transfer.

9.1

0357
MAINTAINABLE ELECTRONIC COMPONENT ASSEMBLIES

Wasiele, H., Jr., Advances in Electronic Circuit Packaging, Proceedings of the Second International Electronic Circuit Packaging Symposium, Boulder, Colo., 1962, 2, Plenum Press, N. Y., pp 143-165

Applications for MECA (Maintainable Electronic Component Assemblies) and the interconnecting means used in each application - soldering, welding, etc., or combined methods. Adaptations are being worked out for wire wrap techniques - special rib tines to be used in conjunction with conductor circuit rails.

4.3, 9.4

0366
MICROWAVE PACKAGING AND LAYOUT PROCEDURES
Christen, Albert E., Electronic Packaging and Production, 3, (5), May, 1963, pp 42-44

Microwave plumbing requires packaging in the same sense that any other electronic unit requires proper packaging. Components must be assembled, supported, cooled, shielded, and connected electrically. Microwave packaging differs to the extent that while solid state components used in most electronic devices are small and getting smaller all the time, the units that comprise the plumbing of a microwave assembly are fairly large in size, requiring a careful planning technique that integrates electrical and mechanical aspects into a complete final configuration.

4.11

0367
APPLYING SHIELDED CABLES TO REDUCE INTERFERENCE
Albin, Arnold L., Electronic Design, 10, (1), January 4, 1962, pp 48-51

Interference in electronic equipment can be less of a problem if cable shields are used effectively. General rules suggested include: unshielded wire for external power circuits (115 v, 400 cps and 28 v dc), shielded wire for multiple-ground audio-frequency or power circuits, twisted pair for audio-frequency circuits grounded at a single point, and for internal power circuits, shielded twisted pair for single-point ground circuits and for multiple-ground circuits, where maximum low-frequency isolation is required, and coaxial cable for transmission of rf pulses, high-frequency applications, and where impedance match is critical.

7.3, 8.1

0368
RFI OPTIMUM SHIELDING OF EQUIPMENT ENCLOSURES
Albin, Arnold L., Electronic Design, 8, (3), February 3, 1960, pp 48-49

Electromagnetic shielding may be applied to radiating devices to prevent escape of rf energy from an enclosure or may be used in receivers to minimize extraneous pickup. The factors influencing shielding material selection and the use of design curves to determine shield thickness are discussed.

7.3

0369
THE WELDED JOINT VERSUS THE EPOXY JOINT FOR ATTACHMENT OF ACCELEROMETER COUPLING CUBES
Sheridan, A. A. and Miller, R. W., Marine Engineering Laboratory, Annapolis, Md., October, 1965, 9 pp., MEL-253/65, Final Rept. (AD 473186)

Where poor accelerometer mounting surfaces are encountered on machinery items undergoing structureborne noise measurement, a 'coupling cube' may be used to simulate a good mounting surface. The method of attaching the cube so that it is, effectively, a part of the machine may introduce errors in noise measurement. Welding, epoxy cementing, and stud mounting, as solutions, were explored for the frequency range from 4 to 10 kc. Complete welding about the periphery of the cube is recommended as a suitable method of attachment, assuring validity of vibration measurements to 10 kc. The epoxy mounted cube appears to perform equally well, but is not recommended as common practice until some means is found to determine the uniformity of the epoxy interface bond so as to ensure good high-frequency response.

9.1, 9.5

0370
AN EXAMINATION OF EPOXY SYSTEMS USEFUL IN PACKAGING "HIGH G" RADIO TELEMETERS
Young, R. P., ARO, Inc., von Karman Gas Dynamics Facility, Arnold Air Force Station, Tenn., March, 1962, 24 pp, Tech. Doc. Rept. No. AEDC-TDR-62-58, AF 40(600)-800 (AD 273681)

The electrical components used in "high g" (500,000 g) telemetry packages will survive gun launchings only if potted in suitable materials. The materials considered for this application were: polyesters, epoxies, silicones, phenolics, and urethanes. The epoxy materials appeared to fulfill most of the requirements for this application. This report describes epoxy materials, their curing, methods of potting, and the tests performed to select an epoxy material for embedding telemetry packages launched from hypervelocity guns in aeroballistic ranges. The specific materials tested were: Stycast 1090, Stycast 4030 CM, Eccomold L-28, Epon 828, Epon 815, Armstrong C-7, Araldite 502, Maraset 121E, RP 1710, and Eccospheres Filler. Stycast 1090 has been temporarily selected, as the embedding but it is believed that a lower density formulation can be made if Eccospheres with a density of 0.3 gr/cc can be acquired.

3.4, 8.3

0371
EVALUATION ON CRITICAL PROPERTIES OF SELECTED MATERIALS FOR ELECTRONIC PACKAGING PURPOSES
Redd Inc., Anaheim, Calif., June 1, 1962, 12 pp., Summary Rept RML-3, May 1, 1962 through May 30, 1962, (N63-23042)

Selected non-metallic materials utilized in electronic equipment are evaluated under simulated space environment conditions. The following materials were evaluated. Adhesive, Eccobond 55 w/No. 9 Catalyst (Emerson and Cuming); Conformal Coatings, Tuf-On 74TS (Brooklyn Paint and Varnish); and Solithane 113 w/300 Catalyst (Thiokol); Potting Compounds, Stycast 1090 w/No. 9 and No. 11 Catalysts (Emerson and Cuming); and Foams, Eccofoam FP w/12-6 Catalyst (Emerson and Cuming) and Eccofoam FPH w/12-6H Catalyst (high temperature). Mechanical, electrical, and physical property tests were conducted.

3.4

0372
THE VALIDATION OF A MAINTAINABILITY PREDICTION TECHNIQUE FOR AN AIRBORNE ELECTRONIC SYSTEM
Retterer, B. L., Griswold, G. H., McLaughlin, R. L., and Topmiller, Donald A., May, 1965, 75 pp., Final Rept., January-September, 1964, AF 33(615)-1338 (AD 622804)

A technique for predicting the maintainability, at the field maintenance level, of airborne electronic equipment was investigated. In the technique, which was based on one previously developed for ground electronic systems, design features, skill requirements, facilities and the maintenance environment are used to predict maintenance times. It appears that portions of the technique could be used to evaluate the relative maintainability of alternative designs. Suggestions for modifying the techniques and for improving the predictions are presented.

7.4

0358
FEASIBILITY STUDY OF THE WRAP-AROUND (SOLDERLESS) ELECTRICAL CONNECTORS
Huber, J. C., Chrysler Corporation, Missile Division, Detroit, Mich., October 25, 1957, 34 pp., Tech. Memo. No. MT-M47J (AD 290891)

The results of an investigation of the wrap-around (solderless) connections as compared to soldered connections is presented. Wrap-around connections are solderless and reportedly more reliable than a soldered connection. Tests were designed to determine the best material from which terminals should be made, and further tests were conducted to compare wrapped connections to soldered connections.

9.4

0359
INSULATING MATERIALS FOR DESIGN AND ENGINEERING PRACTICE
Clark, F. M., Wiley, N. Y., 1962, p. 1218

The contents of this book include material selection; insulation technology; general survey of resin polymers; composite structures, including insulated wires and conductors; natural and synthetic rubbers and elastomers; and inorganic insulation, including glass, ceramics, mica asbestos. Radiation effects are discussed briefly.

3.2, 3.3

0360
COOLING MICROMODULES INTERNALLY WITH PELTIER JUNCTIONS
Allison, D. K., Electronic Components Conference, Washington, D. C., May 8-10, 1962, pp 162-165

Various solutions for cooling encapsulated or enclosed modules; analysis of Peltier junctions, their operating papameters and automatic control of cooling.

7.37

0361
A USER-ORIENTED DATA GUIDE TO POTTING AND ENCAPSULATING COMPOUNDS
Drinkard, E.V.O. and Snyder, E. E., American Machine and Foundry Company, Alexandria, Va., June, 1960 - June, 1961, 503 pp, ASD TR 61-297, AF 33(616)7048 (AD 290823)

The important properties of currently available compounds are listed on standard format sheets. Materials covered include epoxies, polyesters, polyurethanes, polysulfieds, polystyrenes, silicones, and ceramics. Also included are related varnishes, copolymers, and miscellaneous potting and encapsulating materials. Detailed information is presented on the general characteristics, applications, chemical resistance, fillers, curing, and formulations.

3.4, 8.3

0362
APPLICATION OF HIGH DENSITY ELECTRONIC PACKAGING SYSTEMS
Elders, D. S., National Conference on Military Electronics, 6th MIL-E-CON, Washington, D. C., June 25-27, 1962, pp 2 1-226

A review of current approaches to high density packaging using a basic building blocks the more or less conventional components of miniature size or shape. The discussion centers around two specific high density packaging systems - the cordwood module system and the micro-module system. Hybridization of technologies is also discussed - hybrid uses of these two modules with conventional components and with thin film and solid state circuits are outlined in the test and shown in illustrations. For the cordwood modules, various hybrid interconnection and lead attachments are shown, in addition to the more usual type of welded or soldered interconnections for small axial leaded parts sandwiched between two parallel planes.

4.152, 5.145

0363
RADIATION-EFFECTS CONSIDERATIONS IN THE DESIGN OF ELECTRONIC CIRCUIT PACKAGING FOR NUCLEAR VEHICLES
Levine, J. H., Advances in Electronic Circuit Packaging, 2, Proceedings of the Second International Electronic Circuit Packaging Symposium, Boulder, Colo., 1962, Plenum Press, N. Y., pp 239-253

Nuclear radiation in combination with other environments, as it affects design of modular electronics packages; radiation resistance of various packaging materials and components; test results, based on experience of General Dynamics.

4.29

0364
INTERCON - PREFABRICATED WELDABLE CIRCUITRY
McFadden, B. R., Welded Electronic Packaging Association, Sixth Symposium, April 9, 1962, at the General Precision, Inc., Kearfott Division, Little Falls, N. Y.

Intercon - a method of holding conductors in a predetermined pattern with tabs extending from the plane of the circuit so that component leads or other conductors may be welded to them. This prefabricated weldable circuitry may be used with all levels of packaging at the module level - three dimensional cordwood types, or two dimensional. Tabs are the special feature of Intercon - L. shaped tabs where one or more welds is needed; the straight or standard tab, with the lead coming through the board and welded to the tab; inline tabs for two dimensional boards and T-shaped tabs for wider targets or multiple welds on one tab.

9.5

0365
PART III: COMPUTERS DESIGN THE LAYOUT
Cohler, Edmund U., Electronics, 38, (22), November 1, 1965, pp 88-89

As logic circuits become faster, their location and connection in complex systems becomes increasingly important. By analyzing all possible configurations, a computer can reduce wiring delay and crosstalk.

4.1

0373
PACKAGING ELECTRONICS FOR 250,000-g APPLICATIONS
Finger, D. W., The Shock and Vibration Bulletin, December, 1964, Bulletin 34, Part 2, pp 153-158 (AD 460000)

Techniques for packaging telemetry components and systems to withstand gun launch accelerations up to 250,000 g are discussed, and the necessary and sufficient conditions for their survival are established. The principal requirements are that all voids be eliminated from the package and that any encapsulating resin be adequately contained to prevent its rupture. The ultra-high-g projectiles used in hypervelocity research for which these telemeters were designed are briefly described. In addition, a brief description is given of high-g telemetry systems used in the gun-fired rockets and projectiles of project HARP.

7.33

0374
COMBINED ANALYTICAL AND EXPERIMENTAL APPROACH FOR DESIGNING AND EVALUATING STRUCTURAL SYSTEMS FOR VIBRATION ENVIRONMENTS
McClymonds, J. C. and Ganoung, J. K., The Shock and Vibration Bulletin, December, 1964, Bulletin 34, Part 2, pp 159-175 (AD 460000)

This paper presents a combined analytical and experimental approach for the prediction of the fatigue life of a complex structural installation in a cryogenic environment subjected to various vibration spectra. This approach is applied to the analysis of the cold helium sphere installation (S-IV) on the Saturn I space vehicle, and the results are compared with the results from both sinusoidal and randum vibration qualification tests performed at cryogenic temperature.

7.31, 7.37

0375
CYLINDRICAL CONNECTORS
Economon, Thomas, Systems Designer's Handbook, January, 1965, pp 183-200

This digest provides background information on cylindrical connectors. The following cylindrical connector specifications: MIL-C-5015, MIL-C-26482, MIL-C-26500, MIL-C-38300, and NAS-1599 are covered. A glossary of connector nomenclature and terminology often used in the description of connectors is included. Performance requirements for the specification which are tabulated include: contact insertion and removal force, maintenance aging, connector mating and unmating forces, contact retention, insert retention, durability, air leakage, thermal shock, corrosion, fluid immersion, vibration, physical shock, temperature life, dielectric test, insulation resistance, contact resistance, contact engaging and separating forces, humidity, altitude immersion, and moisture resistance.

2.0, 8.4

0376
BREADBOARDING IC SYSTEMS WITH COLOR-CODED MODULES
Field, Eugene L., Electronics, 39, (1), January 10, 1966, pp 102-103

A technique is reported on which permits repeated changes in interconnections and also saves a great deal of time in the design of new circuitry. An illustration shows a typical breadboard arrangement with integrated circuit modules plugged into power-supply strips that are mounted across the face of a standard 19-inch rack. Each integrated circuit is mounted on its own printed circuit module with provisions for such additional discrete components. All modules are color-coded with decals that identify the pin connections and the logic function. Interconnections between modules are made with wires that have small pin-plugs on each end. The plugs mate with pin jacks mounted on the modules.

4.1, 7., 8.4

0377
MICRO SWITCH SELECTION
Holden, B. A. and Dodds, J. F., Electrical Review, 166, (7), February 12, 1960, pp 293-296

This article provides a guide to the selection and use of micro switches. The performance of microswitches varies with the conditions under which they are operated. Taking extreme conditions, it may be a sensibly infinite force such as a cam with controlled movement or it may be an increasing force with uncontrolled movement such as bellows or springs. These variations are discussed and illustrated by diagrams. Snap action, repeat accuracy and life are of primary importance but cost, size and method of mounting are considered to be only secondary. Change-over time may be affected by circuit conditions causing contact resistance or welding and contact pressures have to be adjusted to suit the type of contact material. The correct approach to design is discussed and it is pointed out that since the release force and contact pressure are fundamental to the switch design, it is preferable to try and alter the working conditions to suit the switch rather than design special switches.

8.6

0378
MAINTAINABILITY AS A DESIGN TOOL
Weber, T., Jr. and Borkum, D., Proceedings of the National Electronics Conference, 21, 1965, pp 873-877

This presentation outlines Grumman Aircraft Engineering Corporation's approach and accomplishments in providing positive and specific maintainability guidance. The use of a simulation model provides a valuable tool for quantitatively assessing the effect of various design and support parameters on maintainability. One of the models used is discussed. The method used is essentially one of repeated trials, converging on those values of the parameters which ensure a high probability of satisfying operational objectives.

7.4

0379
SIGNAL CONDITIONING AND ISOLATION WITH FIELD EFFECT TRANSISTORS
Ruhberg, Delbert L. and Anderson, Robert K., Proceedings of the National Electronics Conference, 21, 1965, pp 926-930

The concept of isolator - operational amplifier signal conditioning has been presented. Thin-film resistors and miniature components were utilized to implement the signal conditioning system. The use of field effect transistors has been shown to adequately perform the reouired isolation. The operational amplifier has provided a convenient means of obtaining filtering, common mode rejection, and introduction of an offset output. The concept lends itself well to microminiaturization. Further reduction in size is possible by use of integrated circuits for the amplifier proper.

4.12

0380
RADIATION EFFECTS ON MICROELECTRONIC CIRCUITS (SEMICONDUCTOR)
Perkins, C. W., Marshall, R. W., Mitchelland, E. P., and Liebschutz, A. M., Hughes Aircraft Company, Fullerton, Calif., November, 1965, 59 pp., Qtly. Rept. No. 1, May 1-July 31, 1965, Rept. No. FR-65-10-182, DA-28-043-AMC-01313(E) (AD 624561)

The first quarter of the program was devoted entirely to the preparation of devices and instrumentation for the radiation tests. The circuits were procured and subjected to a thorough pre-irradiation test in the laboratory. The report describes the circuits chosen for study and the measurements made in the laboratory bench tests.

5.29

0381
ELECTROMAGNETIC SHIELDING EFFECTIVENESS MEASUREMENTS USING LOW CONDUCTIVITY CLOSED SURFACES
Lasiter, H. A., Naval Civil Engineering Laboratory, Port Hueneme, Calif., December, 1965, 30 pp., Rept. No. TR-R-416, June-September, 1964 (AD 624708)

In an investigation to predict the shielding effectiveness of low-conductivity materials used in electromagnetic interference-shielded structures, the symmetrical configuration of a spherical shell was adapted to approximate the closed walls of a normally cubical or rectangular shielded enclosure. A hemisphere was used for the experiments and a half cube with the same surface area and conductivity (0.1 mho/meter) was used for comparison of an equivalent rectangular structure. In measurements over a frequency range of 20 to 900 Mc (or MHz), the half cube showed a greater shielding effectiveness than the hemisphere over a major portion of the frequency range. The primary advantage of the hemisphere is the ability to predict the absorption over a wide band of frequencies.

6.111

0382
OPTIMUM MECHANICAL PACKAGING OF ELECTRONIC EQUIPMENT PROGRAM
Jones, Aubrey H., Hughes Aircraft Company, Fullerton, Calif., July 31, 1965, 139 pp., Final Rept. FR-65-10-260, May 1, 1964 - July 31, 1965, DA-28-043-AMC-00060(E) (AD 474666)

The report finalizes the investigation and presents a compendium summarizing the mechanical aspects of packaging and describes how the pertinent design characteristics are interrelated. The methodology established on this program is designed to aid in the development of optimum packaging designs for electronic equipment. It provides a desciplined and organized guide to packaging and forces objective decisions to be made when performing the various design tasks.

4.1

0383
ENCAPSULATED COMPONENT STRESS TESTING
Johnson, Lennart I. and Ryan, R. James, Honeywell, Inc., Military Products Group, Plastics Laboratory, Minneapolis, Minn., Electrical Insulation Conference, 6th, New York, N. Y., September 13-16, 1965, pp. 11-15 (A66-11287)

Description of procedures for evaluating and eliminating the deleterious effects of embedment stress on the electrical characteistics of encapsulated components. Various techniques and materials for packaging miniaturized capacitors were examined. The use of protective coatings to relieve embedment stress is discussed, as is the effect of changing the component orientation within the package.

8.3

0384
EFFECTS OF THE SPACE ENVIRONMENT ON ELECTRICAL INSULATION "KEYNOTE PAPER"
Feuchtbaum, R. B., Electrical Insulation Conference, 6th, New York, N. Y., September 13-16, 1965, Conference sponsored by the Institute of Electrical and Electronics Engineers, The National Electrical Manufacturers Association, and the Bureau of Ships, Dept. of the Navy, N. Y., pp 216-218 (A66-11290)

A discussion is presented of environmental factors to be considered in the design of electrical insulation systems for space vehicles. Factors considered are the absence of atmospheric pressure, the presence of high-velocity microparticles and meteoroids, electromagnetic and particulate radiation, and great temperature extremes. Design criteria for electrical insulation systems for space are outlined.

8.5

0385
SPACE ENVIRONMENTAL EFFECTS ON SILICONE INSULATING MATERIALS
Thorne, J. A., Whipple, C. L., and Boehm, A. B., Electrical Insulation Conference, 6th, New York, N. Y., Conference sponsored by the Institute of Electrical and Electronics Engineers, the National Electrical Manufacturers Association, and the Bureau of Ships, Dept. of the Navy, N. Y., pp 219-223 (A66-11291)

A study of the effects of a simulated space enronment on the performance of silicone insulating materials is presented. The basic types of silicone elastomers and resins, and of silicone potting and encapsulating materials used in aerospace, electrical and electronic systems are described. The vacuum and temperature characteristics of the space environment are reviewed, and techniques for simulating them are described. Tests indicate that the weight loss of silicones in a combined simulated space thermal/vacuum environment is exceptionally low. In addition, silicones retain their physical and electrical properties quite well under these conditions, and also have a good resistance to UV and particle radiation.

8.5

0386
A NOVEL APPROACH TO MICROCIRCUIT INTERCONNECTION AND PACKAGING
Cohen, Norman I., Electronic Packaging Conference, Los Angeles, Calif., October 20, 21, 1965, Conference sponsored by the Society of Automotive Engineers, N. Y., Society of Automotive Engineers, Inc., pp 8-14, 22 (A66-11322)

A description is given of how one packaging concept using a carrier-mother board, rack approach, interconnected by wire-wrap technique solves some of the problems imposed by these small components. Flexibility, cost, reliability and their influence on the selection of the final configuration are investigated. The application of hot gas soldering for mounting flat packs to carriers is described along with the advantages gained by its use.

8.4, 9.2

0387
PACKAGING TRADEOFFS FOR PERSHING GROUND SUPPORT EQUIPMENT
Kahn, William J.,Wescon/65; Proceedings of the Western Electronic Show and Convention, San Francisco,Calif., August 24-27, 1965, Tech. Papers, Part I - Military Electronics, North Hollywood, Calif., 1965, 19 pp (A66-11459)

Review of the overall approach taken in the Pershing ground support equipment (GSE) package development, considering building block tradeoffs, general packaging constraints, and automated hardware implementation methods as they apply to two GSE programs. Tradeoffs of system variables to the building block are considered, packaging restraints are discussed, and automated hardware implementation methods are analyzed.

4.1, 5.1, 6.1

0388
PERSHING GSE PACKAGING
Carlson, R. H., Sr., Wescon/65; Proceedings of the Western Electronic Show and Convention, San Francisco, Calif., August 24-27, 1965, Tech. Papers, Part 1 - Military Electronics, North Hollywood, Calif., 10 pp. (A66-11460)

Description of electronic packaging concepts used in Pershing weapon system ground support equipment (GSE). The system is briefly described, and functional requirements, location parameters, and module development are considered. Thermal characteristics of the module components and multilayer printed wiring board interconnections are discussed. Module outline dimensions are given in a schematic diagram, and module internal temperature is plotted for worst-case conditions.

5.1, 7.37

0389
METHODS FOR DESIGN OF HIGH RELIABILITY WELDED ELECTRICAL CONNECTORS
Tierney, R. R., Electronic Packaging Conference, Los Angeles, Calif., October 20, 21, 1965, Conference sponsored by the Society of Automotive Engineers, N. Y., Society of Automotive Engineers, Inc., pp 41-48 (A66-11325)

Analysis of welded electrical connections in order to illustrate the principles of worst-case design by which the large gains in reliability needed for deep-space missions may be achieved. The present reliability of welded electrical connections can be improved by taking into account two major factors which have been underestimated or overlooked: the importance of encapsulation stresses and the need for quantitative parameter studies. It has been believed that encapsulants protected welded electrical connections from stresses; however, studies have shown that there is no inherent limit on the stress to which an encapsulated connection may be subjected. The data show that for the particular weld systems tested, the worst ribbon position is at the toe of the electrode. Test results have proved that worst-case analysis can lead to higher reliability of welded connections by accounting for extreme variations in process parameters. It is concluded that no design of a high-reliability component or product can be called complete until significant process parameter extremes have been considered.

9.1

0390
WELD STRESS EVALUATION - ELECTRONIC MODULES
Dorfman, Herbert, Electronic Packaging Conference, Los Angeles, Calif., October 20, 21, 1965, Conference sponsored by the Society of Automotive Engineers, N. Y., Society of Automotive Engineers, Inc., pp 49-53 (A66-11326)

A study is presented of the development of weld joints, of specific tensile strengths, which are encapsulated with various resins and temperature-cycled to determine failure caused by internal stress. Equipment and materials are considered, together with processing and testing, and results are discussed. It is concluded that resins with high coefficients of thermal expansion and high shrinkage values cause weld failures after cure, and that stress reduction can be accomplished by proper spacing of weld interconnects.

8.3, 9.1

0391
TRANSFER MOLDING OF HIGH DENSITY MODULES FOR THE PERSHING WEAPON SYSTEM
Uglione, Hugo L., Jr. and Bell, Allen R., Jr., Wescon/65, Proceedings of the Western Electronic Show and Convention, San Francisco, Calif., August 24-27, 1965, Tech. Papers, Part 1 - Military Electronics, North Hollywood, Calif., 13 pp., (A66-11462)

An investigation of packaging techniques, materials, and processes related to high-density modules to obtain higher reliability and lower production costs for the Pershing weapon system is discussed. The evaluation program is discussed, and the module molding operation and repairs are detailed. The transfer molding method using epoxy resin is chosen for application because it allows low to high production rates at minimum cost, and comparatively few rejects due to encapsulation. Possible problems which might be encountered in transfer molding of modules are considered, together with failure analysis and process control of the module fabrication.

8.3

0392
PHYSICAL PROPERTIES OF SOME ENGINEERING MATERIALS - UNPUBLISHED DATA FROM COMPANY SPONSORED PROGRAMS
Peterson, J. J., LTV Aerospace Corporation, LTV Vought Aeronautics Division, Dallas, Tex., March 15, 1962, Qtly. Rept. No. 4, Vol. 2 on Phase 1, Rept. 2-53420/2R374, AF 33(616)-7986 (AD 273801)

Physical and mechanical properties data for electrical insulation, electrical coatings, encapsulating and embedding substances are tabulated.

3.4, 8.3, 8.5

0393
INTERCONNECTING MICROELECTRONIC CIRCUITRY
Design Engineering Staff, Electronic Packaging and Production, 3, (8), August, 1963, pp 70-73

The trends in electrical interconnections and connector applications are presented by the printed circuit connectors, substrate interconnection, solderless wrap, standardization efforts, connector receptacle, and module-level connectors are briefly discussed. Illustrations of cordwood mounted printed circuit microconnector, hermetically sealed connector receptacles and solder printed circuit booklet developed by RCA are shown.

4.152, 4.155, 8.4, 9.

0394
ELECTRONIC MATERIALS AND COMPONENTS FOR EXTREME ENVIRONMENTAL PROBLEMS
Javitz, A. E. and Jacobs, P. G., Electronic Manufacturing, 62, 1958, pp 111-134

The materials and components surveyed from the point of view of use at ultra-high temperature and in nuclear radiation environments are: capacitors, ceramics, conductors, contacts, embedding compounds and encapsulants, instrumentation, electrical insulation, lubricants, magnet wire, magnetic materials, plastics, printed circuits, resistors, semiconductors, solders, transformers and valves. Several sets of tabulated data are given.

3., 3.4

0395
NEW DEVELOPMENTS IN MULTILAYERED ETCHED CIRCUITRY
Schuster, N. and Reimann, W., Proceedings of the IRE 49, No. 3, March, 1961, p 657

A survey is made of high-density computer module construction techniques including flat card, board-to-board, welded, and microcircuitry. Comparative volumes, weights and maintainability are discussed. Interconnection problems are indicated and it is shown that the wiring can consume a disproportionate percentage of the volume in high-density construction. A solution to this problem is shown in the form of multilayer etched circuit wiring developed for this purpose. Various examples of applications are shown. Size, weight, cost, reliability, and maintainability of this technique are discussed and comparisons are made with standard wiring.

4.15

0396
ELECTRONIC CIRCUIT RESEARCH AND DEVELOPMENT FOR NUCLEAR PROPELLED VEHICLES
Green, R. C., Bendix Corporation, Bendix Systems Division, Ann Arbor, Mich., 195 pp., Interim Engineering Rept. No. 1, BSR-439, October 1, 1960 to January 1, 1961

To show how the radiation resistance of electronic equipment can be increased, a mission and traffic control sub-system was modified for radiation resistance and then tested. The subsystem contained the following: marker beacon receiver, UHF transceiver, radio receiving set, TACAN transceiver, air-to-air ground identification system. The results are summarized for the following pieces of electronic equipment: transformers (power, audio, pulse), relays, and capacitors (Ta, Nb, film mica). Materials to be avoided in construction of the above pieces are given. Cannon connectors and transistors were also radiation-tested.

3.4

0397
HOW TO DESIGN ELECTRIC AND ELECTRONIC PACKAGES USING FLEXIBLE PRINTED CIRCUITS
Dahlgren, V., Machine Design, 32, (6), March 17, 1960, pp pp 146-159

Flexible printed circuits are flat, thin cables; they can be bent, twisted, coiled, preformed, and fitted flat into corners.

8.1

0398
RELIABILITY TESTING FOR COMMERCIAL INSTRUMENTS
Marsh, Clee O., Electronic Equipment Engineering, 9, (1), January, 1961, pp 60-63

An interview...with Clee O. Marsh, vice-president and chief engineer, Analab Instrument Corporation, Cedar Grove, N. J. is reported. The reliability and environmental test program used is to determine that the commercial products produced have a maximum of reliability and life without inordinate costs, without excessive size and without over-design. An altitude test which follows heat tests is important since altitude can present serious problems in instruments cooled by convection. Air at high altitudes being thinner will move much less heat and the instruments, which might have been satisfactory near sea-level, may be quite inadequate when operated at 10,000 ft. Test conditions for the altitude test are briefly discussed.

4.24, 4.3

0399
RELIABILITY CHECK LIST FOR DESIGN ENGINEERS
Fonda, E. G., Electronic Equipment Engineering, 9, (6), June, 1961, pp 21-22

This worksheet has been arranged into a checkoff list for engineers who wish to retain the list along with pertinent design data and test results in their design handbooks. The list is not complete in its present form, but it suggests the questions normally concerned with and covered in reliability design reviews of various subequipment modules.

4.3

0400
I.F. PACKAGING USING THIN-FILM TECHNIQUES
Doyel, A. T., Electronic Packaging and Production, 6, (1), January, 1966, pp 10-14

This paper discusses mechanical parameters as applied to the development of a 60 Mc I.F. amplifier using thin-film circuits. A technique of packaging is presented which describes the combined functional approach of various mechanical components, the use of special alloys in achieving the required mechanical support, shielding, and thermal heat transfer. The amplifier housing was configured in a three-part assembly to provide ease of assembly and maintenance. The three details consisted of a housing shell, lower cover, and thermal interface. The interconnection techniques and thermal characteristics are also discussed.

4., 7.3, 7.37, 8.4

0401
ELASTOMETIC SEALANTS - WHERE AND HOW TO USE THEM
West, Philip, Materials in Design Engineering, 61, (2), February, 1965, pp 87-91

Elastomeric compounds which are available to seal joints that cannot be sealed by conventional adhesives, gaskets, or O-rings are discussed. This article provides a brief review of available sealants and a guide for selecting the best one to meet specific requirements.

3.4

0402
DESIGN OF ELECTRIC INTERCONNECTING CABLES AND CONNECTORS FOR SPACE POWER SYSTEMS
Franks, Ralph, IEEE Transactions on Aerospace, AS-3, (1), February, 1965, pp 14-21

This presentation illustrates the steps necessary for the development of space interconnecting systems. After the requirements of the space mission have been outlined and the basic electrical power system has been established, the designer can start design of the interconnecting system. Two major parts make up the system. The first is connecting interface, consisting of connectors and terminals, and the second consists of the conductors with the associated electrical and mechanical protection. The following methods of harnessing are included in the discussion: string tied harness, molded harness, and heat shrinkable harness. Characteristics of the most common insulation materials are given.

8.1, 8.4, 8.5

0403
TRANSIENT RADIATION EFFECTS ON ELECTRONICS HANDBOOK
Jones, Dale C., Battelle Memorial Institute, Columbus, Ohio, February 26, 1965, DASA 1420, 125 pp. (AD 432213)

This Handbook is intended to provide the basic information necessary to design and evaluate electronic equipment with the required tolerance to transient neutron and gamma radiation, and to aid the system analyst in determining equipment vulnerability to this environment. The effects of transient radiation on semiconductor devices, capacitors, resistors, electron tubes, magnetic devices, cables and wiring, frequency control devices, microwave devices, and on microelectric devices are evaluated. The handbook is to be updated periodically.

3.4, 4.29

0404
MICROELECTRONIC CIRCUIT PACKAGING
Electronic Capabilities, 3, (1), February, 1965, pp 16-18

The microelectronic circuit requires a careful choice of interconnection techniques and connectors to make the best possible use of this growing technique. Several of the off-the-shelf connector and contact arrangements have been shown. But in this field of rapid change, in both the circuits and their connectors, these indicate only some of the current methods which will evolve into other methods to reduce the costs, increase the reliability, and extend the usefulness of micro-circuits.

5.1

0405
MAGNETIC SHIELDING IN COMMUNICATIONS
Electronic Capabilities, 3, (1), February, 1965, pp 42-44

One material, in wide use for shields is Netic Alloy, a medium permeability, high saturation alloy, rolled particularly for high level attenuation. Co-Netic Alloy is a second shielding material; it is an extremely high permeability material for low level shielding; it also eliminates hum and will retain its remarkable shielding qualities indefinitely without the necessity of hydrogen annealing at regular intervals.

4.11, 4.12

0406
ENGINEERING PARAMETERS FOR CIRCUIT CONNECTOR SELECTION
Goodman, David S., Electronic Capabilities, 2, (2), May, 1964, pp 18-20

Some of these significant parameters which must be considered in the design and development of printed circuit connectors as well as the selection of connectors for a specific environment are given for high voltage breakdown, contact resistance, contact wear, current carrying capacity, fungus resistance, temperature cycling, shock, vibration, board thickness tolerance, and temperature-humidity.

8.4

0407
THE EVOLUTION OF ELECTRONIC ENCLOSURES
Electronic Capabilities, 2, (2), May, 1964, pp 22-24

Developments in electronics have necessitated parallel developments in electronics cabinetry and fittings which are discussed.

6.3, 7.1

0408
LABORATORY EVALUATION OF MAGNETIC SHIELDING
Electronic Capabilities, 2, (2), May, 1964, pp 36-38

Several methods are suggested for combatting the adverse effects of magnetic phenomena in the laboratory. A major difficulty in designing high efficiency and compact electronic equipment has been the limiting factor of adequate shielding. This has made it necessary to sometimes limit sensitivity, compromise on performance and in many cases, bulky components have had to be incorporated. A shield may combine magnetic shielding, high intensity, low intensity, magnetostatic, electro-magnetic and electrostatic shielding. The Netic and Co-Netic alloys used in the Magnetic evaluation kit are designed expressly for magnetic shielding. However, grounding assures effective electrostatic shielding and is therefore recommended.

6.111

0409
WHAT'S NEW IN SOLDERING
Powell, Ralph, Electronic Products, 8, (7), December, 1965, pp 28-36

Perfection in electrical connections is the newest thing in soldering. Obtaining 100 per cent reliability has now become a reality. A solder made up of 63 per cent tin and 37 per cent lead is the best solder in that it melts the fastest without going through a plastic state; has the best wetting ability in the first stage of soldering and wets at a lower temperature than any other solder with the same ingredients; has a high fluidity to penetrate small interstices; has a higher resistance to fatigue and corrosion with a good ability to withstand temperatures as any other solder. Solders for microelectronics, solubility, physics, flaws and solders, and soldering micro-circuits are discussed.

9.2

0410
SOLDERABLE CONDUCTIVE PAINT
Electronc Products, 8, (7), December, 1965, p 37

Soldering at room temperatures directly to aluminum, glass, ceramics, rubber and plastics is possible with a new polymer alloy, Dynaloy 350. This coating requires no formulating. It is applied directly from the container by dip, brush, silk screen or roller coating. The alloy has a volume resistivity of 0.001 ohm-cm and an operating temperature range of -60 to +175 C.

9.2

0411
SELECTION CHECK LIST FOR SOLDERING IRONS
Falzone, C. J., Electronic Products, 8, (7), December, 1965, pp 47-49

The check list helps to narrow down the number of irons to be chosen for an actual performance test. Soldering iron tip, tip shape and size, tip materials, tip construction, and tip temperatures are included.

9.2

0412
DESIGN GUIDE-LINES FOR SPACE THERMAL ENVIRONMENTS
Jones, Edward W., Electronic Industries, 24, April, 1965, pp 82-84, 86, 131-132

This article forms some basic design guidelines for vehicles which must survive space thermal stresses. It is intended to increase the probability for vehicle survival and to save time for the design engineer. A convenient data sheet with pertinent engineering parameters relative to both the material and the thermal environment in which the material will be used is given.

7.37

0413
AN ENGINEERED PACKAGE FOR MICROMINIATURE ELEMENTS
Mayhew, A. J., Electronic Engineering, 38, January, 1966, pp 12-20

After a critical review of prevailing practice in digital engineering, the features required of an ideal module are stated and a new package is presented to meet them. It is shown that high packing densities can be achieved with discrete wiring and circular-shaped components and that compatible modules can employ multi-layer circuits. Several varieties, old and new, of the latter are briefly discussed as is the application of automation to their design, construction and test.

5.1

0414
A REVIEW OF TRENDS IN POTTED AND PRINTED CIRCUIT TECHNIQUES
Manfield, H. G., Proceedings of the Institution of Electrical Engineers (G.B.), 109B, 1962, pp 251-258

The status of potted-circuit constructions and materials is considered, together with the evaluated properties of resin systems which have increased heat resistance and more stable electrical properties. The mechanism of failure and remedies are discussed. Developments of printed wiring and printed circuits are compared, and details given of currently available techniques. Materials for both forms of construction are discussed in detail and their physical properties evaluated over a wide range of temperatures and climatic conditions.

8.3

0415
A REVIEW OF SOME OF THE CHARACTERISTICS OF EPOXY RESINS USED IN ELECTRICAL COMPONENTS
Davies, H., Proceedings of the Institution of Electrical Engineers (G.B.), 109B, 1962, pp 259-265

The paper reviews briefly some of the characteristics of epoxy-resin systems that are of importance in their application to electrical components by encapsulation, impregnating, laminating, etc. The characteristic properties of these materials are those peculiar to their processing, i.e. low shrinkage and absence of volatile matter on cure. Characteristics important in their application, such as pot life, viscosity, exotherm and shrinkage, are therefore discussed. Some aspects of their electrical and mechanical properties are also discussed.

8.3

0416
SILICONE ENCAPSULATING AND POTTING MATERIALS
Davis, J. H., Rees, D. W., and Riley, I. H., Proceedings of the Institution of Electrical Engineers (G.B.), 109B, 1962, pp 266-272

Applications of silicone materials for potting and encapsulation are discussed. After introductory notes on general requirements and alternative materials, a description is given of the good dielectric characteristics and thermal endurance of the silicones. Reference is made to cost and, for some applications, limited physical strength. Silicone fluids are then described, with a note on their chemical structure. Graphs illustrate the variation of permittivity and vapour pressure with viscosity, and the effects of frequency and temperature on power factor and permittivity. Following a section on compounds, an account is given of silicone rubbers, especially of the cold-curing types. The lengthening of pot life for the catalyzed materials by adding solvent or silicone fluid is illustrated graphically. A silicone gel with novel self-healing characteristics is then described. After describing the use of silicone resin-based cements to encapsulate wire-wound resistors, and solventless silicone resins for encapsulating and potting other components, the paper concludes by referring to present and future requirements.

3.3, 8.3

0417
THE RELIABILITY OF POTTED COMPONENTS
Fletcher, K. A., Proceedings of the Institution of Electrical Engineers (G.B.), 109B, 1962, pp 271-280

The development of epoxide-resin casting systems for the potting of electronic components and the results of some long-term investigations of the effect of various resin formulations on component values are reviewed. The first part of the paper deals with the chemical aspects of the reliability of resin-cast components, together with an assessment of the results of some long-term chemical immersion tests. The second part covers the drift of component values during temperature cycling and storage, with particular reference to grade I high-stability resistors.

7.4, 8.3

0418
PROTECTIVE INSULATING COATING FOR PRINTED CIRCUITRY AND/OR PRINTED CIRCUIT ASSEMBLIES
Goodyear, Mark V., and Melfi, Alphonse, Houghton Laboratories, Olean, N. Y., 35 pp, Qtly. Rept. No. 2, June 1 - Aug. 31, 1957, DA-36-039-SC-73190 (AD 145482)

An investigation of epoxy resins as protective coatings on XXXP etched copper foil clad paper base phenolic laminate is reported on. An acid anhydride cured system has been developed by Houghton Laboratories, Inc. This system, which consists of a eutetic mixture of acid anhydrides, a small amount of Epon BF_3-400, and the epoxy resin, cures within the time and temperature of 2 hours at 75 C and shows promise as a possible acid cured type epoxy coating. The system has good wetting ability and adhesion to phenolic laminate. Comparative testing of specimen panels that were coated with a HYSOL 6232 system at the Squier Signal Corps Laboratory with specimen panels coated with HYSOL 6232 at Houghton Laboratories has been completed. The test results met the electrical resistance specification, MIL-STD-202A, Method 106.

8.3

0419
PROTECTIVE INSULATING COATINGS FOR PRINTED CIRCUITRY AND/OR PRINTED CIRCUIT ASSEMBLIES
Goodyear, Mark V., Houghton Laboratories, Olean, N. Y., Qtly. Rpt. No. 3, September 1 - November 30, 1957, DA-36-039-SC-73190, 35 pp (AD 157790)

The S8-41-1 system developed for a printed circuit coating has properties comparable to the HYSOL 6232 coating. The advantage that S8-41-1 has over the HYSOL 6232 is its longer pot life. This property contributes to an easier handling, epoxy-coating system, and elimates the critical time period of preparation needed with the HYSOL 6232.

8.3

0420
PROTECTIVE INSULATING COATINGS FOR PRINTED CIRCUITRY AND/OR PRINTED CIRCUIT ASSEMBLIES
Goodyear, Mark, V., Houghton Laboratories, Inc., Olean, N. Y., 28 pp, February 28, 1958, Final Rept., December 1, 1957 - February 28, 1958, DA-36-039-SC-73190 (AD 158528)

A coating, S9-138-1 which has properties comparable to HYSOL 6232 coating while still retaining the easier handling and longer pot life characteristics was developed. The coating also wets and adheres to phenolic laminate as well as 6232. All of the specimen panels coated using the modified HYSOL 6232 and the long pot life coatings met the electrical resistance specification MIL-STD-202A, Method 106A. These test results are comparable to the results obtained with the HYSOL 6232 coating. A comparison of some physical and electrical properties of the HYSOL 6232, S9-138-1 and S10-100-2 coatings are reported.

6.5, 8.3

0421
MATERIALS EVALUATION UNDER HIGH VACUUM AND OTHER SATELLITE ENVIRONMENTAL CONDITIONS
Blackmon, P. H., Clauss, F. J., Ledger, G. E., and Mauri, R. E., Lockheed Aircraft Corp., Missiles and Space Division, Sunnyvale, Calif., 35 pp, January, 1962, AF 04(647)-787 (AD 270279)

Lockheed Missiles & Space Company's program on the testing of materials for satellite applications is reviewed. Among the more important classes being investigated, are lubricants and bearings, paints and other temperature control surfaces, bulk plastics and polymer films, and adhesives. Adhesives and polymers are being subjected to ultraviolet and gamma radiation at elevated temperature. Equipment and data are discussed.

3.4

0422
VIBRATION CAPABILITIES OF CORDWOOD MODULES
Gustafson, F., Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., 15 pp, January 16, 1963, (AD 417006)

The object of this study was to determine the vibration capabilities of Cordwood Modules along the three major axes. In this destructive vibration test the module welds were found to be stronger than the (1) component leadwires and (2) module exit leadwires. The module exit leadwires failed in fatigue. There were no weld failures as a result of the test. It was determined that the seven exit leadwires of the module were not sufficiently strong to support the module on the terminal board at 60 g vibration level.

4.21

0423
DEVELOPMENT OF ULTRA HIGH TEMPERATURE DIELECTRIC MATERIALS FOR EMBEDDING AND ENCAPSULATING ELECTRONIC COMPONENTS
Barr, F. A., and McCarthy, J. P., Synthetic Mica Corp., Clifton, N. J., 54 pp, Final Rept., May 16, 1960 - May 16, 1961 (AD 265499)

Phosphate synthetic mica was investigated as a dielectric material for encapsulating and embedding electronic components for 500 C use. Physical properties of the system were determined and found to be suitable for high temperature use.

8.3

0424
ENCAPSULATION OF ELECTRONIC CIRCUITS
Calicchia, R., Rome Air Development Center, Griffiss Air Force Base, N. Y., 17 pp, RADC-TR-58-8, January, 1958 (AD 148557)

A program aimed at developing experimental design data for engineers confronted with problems of selecting proper encapsulents for electronic equipment. It is intended to indicate the quantitative effects of the encapsulating dielectric upon the electrical characteristics of the embedment. Of major interest is the work initiated on the electrical performance of resistors, capacitors, inductors, and simple circuits, at frequencies up to 240 megacycles. The investigation of the electrical and mechanical properties of various resins was necessary in order that the most suitable encapsulent be selected.

8.3

0425
POTTING, EMBEDMENT, AND ENCAPSULATION OF WELDED ELECTRONIC CIRCUITS
Clark, C. G., Space Technology Laboratories, Los Angeles, Calif., November, 1960, 48 pp., Rept. No. STL/TR 60-0000-19354, (PB155-755)

A wide variety of detailed information is given on methods, materials, and techniques for potting, embedment, and encapsulation of electronic circuits. A discussion of quality control is also included.

8.3

0426
MAXIMUM DENSITY PACKAGING OF ANALOG ELECTRONICS
Jansson, R. M., Massachusetts Institute of Technology, Instrumentation Laboratory, Cambridge, Mass., October, 1958, Rept. No. MIT IL E-765

The M.I.T. Instrumentation Laboratory has developed electronic packaging techniques which can be supplied to subminiature electronic devices and complex systems. These techniques are based on the mounting and wiring of circuit components in a three-dimensional unit mass. Using the most suitable electronic circuit components now available, the Instrumentation Laboratory has achieved maximum component densities without sacrificing production feasibility.

5.1

0427
A MODERN CONCEPT OF ELECTRONIC PACKAGING
Noble, R. P., Sandia Corporation, Albuquerque, N. Mex., January 8, 1957, 33 pp., Rept. No. SCTM-275-56(14)

The relationship between human engineering, design approach, and engineering management is presented. Application of electronic packaging with printed circuit design is discussed.

5.1

0428
CASTING TO CLOSE TOLERANCES WITH UNFILLED EPOXY RESINS
Nelson, B. W., et. al., SPE Journal, 17, March, 1961, pp 257-259

The casting of epoxy resins for embedding delicate electrical and electronic machine components is described. Means of reducing volumetric and exothermic shrinkage is also discussed.

8.3

0429
CERAMIC ENCAPSULANTS
Cuming, W. R., Electronic Design, 8, May 25, 1960, pp 54-55

Ceramic encapsulants become increasingly important as temperature requirements of electronic equipment go up. About 600 F is the highest temperature for the best epoxides; about 800 F is the top limit of the very best silicones. Certain inorganic encapsulating compounds, however, can be used well in excess of 2500 F. The author lists the available inorganic bonding agents and the inorganic fillers which may be used with them.

8.3

0430
DEVELOPMENT OF A HIGH-TEMPERATURE EPOXY CASTING COMPOUND
Reynolds, H. I., Insulation, 7, July, 1961, pp 33-37

A new, long pot life, epoxy casting compound has been developed for high temperature use (400 F continuous) in potting and encapsulating electrical and electronic components and devices. The casting compound features a low, stable, coefficient of thermal expansion over a wide temperature range. It also possesses a room temperature pot life of several days, which is a decided advantage for small production lots, and good dimensional stability at elevated temperatures.

8.3

0431
DEVELOPMENT OF IMPROVED THERMAL SHOCK RESISTANT DIELECTRIC MATERIALS FOR EMBEDDING ELECTRONIC COMPONENTS
Rust, J. B., et al., Hughes Aircraft Company, December, 1960, 35 pp., Rept. No. P61-01 (AD258295)

New polyhydridosilanes have been prepared which are capable of crosslinking commercial solventless silicone resins. Disilylbenzene has been successfully added to R65 yielding a fluid product which can be used as a crosslinking agent. Gelling of silicone resins with disilylbenzene has been found to be adversely affected by air. A method has been found to minimize the adverse effects of the reaction exotherm

8.3

0432
DEVELOPMENT OF INORGANIC FOAM MATERIAL OF CONTROLLED DIELECTRIC PROPERTIES FOR HIGH-TEMPERATURE SERVICE
Emerson and Cuming, Inc., December, 1958, 26 pp., Final Rept. November, 1956 - December, 1958, NOas-57-357-c (AD 211222; PB 146291)

A low density (18 to 30 lbs/cu ft) fine grained structural material capable of withstanding 900 F has been developed by autogenous bonding of tiny glass bubbles. Research on bonding techniques including silicone resin bonds as well as the autogenous bond is described. Increase in service temperature range of these materials by 500 to 1000 F is believed possible by chemical modification of the Eccosphere glass composition.

3.4

0433
DEVELOPMENT OF ULTRA HIGH TEMPERATURE DIELECTRIC MATERIALS FOR EMBEDDING ELECTRONIC PARTS
Rust, J. B. and Segal, C. L., Hughes Aircraft Company, March, 1960, 61 p., Final Rept. No. TM-658, February, 1959 - February, 1960 (AD 256721)

Thermal tests showed that a distinct improvements over the conventional peroxide cure was effected by use of disilybenzene as a crosslinking agent. Electrical and thermal shock tests showed that the use of disilylbenzene improved the electrical or mechanical properties of the embedding compound. Specimens which passed the thermal shock resistance requirement were prepared by vacuum impregnation incorporating polyvinyl siloxane prepolymer, alumina, disilylbenzene, and dicumyl peroxide.

8.3

0434
ENCAPSULATION OF WELDED MODULES
Dorfman, H., Lockheed Aircraft Corporation, Missiles and Space Division, Sunnyvale, Calif., April, 1961, 25 pp., Rept. MRI 270.02

A three-objective program was conducted regarding (1) selection of suitable encapsulants, (2) evaluating various encapsulating processes, and (3) improving electronic reliability by the use of a conductive adhesive on weld joints. Test results are discussed.

8.3

0435
EPOXY PACKAGES FOR ENCAPSULATING COMPONENTS
Ringel, S., Electronics, 34, July 7, 1961, pp 40, 72-73

Preformed shells, pellets, and headers are available in a wide variety of standard shapes and sizes for packaging components. Advantages of preformed cases over casting and molding processes are discussed.

8.3

0436
FOAMS AND LOW DENSITY COMPOUNDS
Harper, C. A., Insulation, 7, May, 1961, pp 34-41

Tables showing properties of typical urethane, epoxy, phenolic, and silicone foams are presented.

3.2

0437
HIGH TEMPERATURE DIELECTRIC LIQUID MATERIALS FOR POTTING OF ELECTRONIC COMPONENTS
Wilson, G. R., et al., Monsanto Chemical Company, December, 1960, 123 pp., Final Rept. December, 1959-December, 1960, NObs-78294 (AD 256759)

The objective of this program was the preparation and evaluation of thermally stable liquids that possess acceptable dielectric properties for the potting of electronic components operating at high temperatures. Several organic liquids and low-melting solids were found that are quite thermally stable for long periods (500 to 2000 hr) at 350 C. Benzylated o-terphenyl met all the requirements for capacitor use.

8.3

0438
MEASUREMENT OF CURE OF SOME THERMOSETTING RESINS
Fineman, M. N. and Puddington, I. E., National Research Laboratories, Chemistry Division, Ottawa, Canada, Canadian Journal of Research, 25, Section B, July 26, 1946, pp 101-107

The rate and degree of cure of resorcinol-formaldehyde resins and unsaturated polyesters are determined by measuring changes in their electrical resistance and density during the process of cure. Data thus obtained are interpreted in terms of the rate and extent of cross-bonding in these thermosetting resins.

3.4

0439
EPOXY RESINS: THEIR APPLICATIONS AND TECHNOLOGY
Lee, Henry and Neville, Kris, Epoxylite Corporation, El Monte, Calif., McGraw-Hill, N. Y., 1957, 316 pp.

This is a comprehensive but lucid introduction to the new chemical field of epoxy resins. It covers their preparation and applications in industry.

3.2

0440
HEAT SHRINKABLE TUBING
Electronic Products, 5, (7), December, 1962, p 26

Thermofit SCL tubing, available from Rayclad Tubes Inc., is made of an irradiated, modified polyolefin. Upon heating briefly in excess of 275 F, the tubing shrinks to 1/6 its original diameter, while the inside becomes viscous, flows into voids, and adheres to itself. Applications include encapsulation of capacitors and resistors.

8.2

0441
WIRE, CABLE HARNESSES, ACCESSORIES
Electronic Products, 4, (11), April, 1962, p 81

Thermofit PVC, radiation cross-linked heat shrinkable polyvinylchloride insulation sleeving is flexible and meets performance requirements of MIL-I-621 for general purpose sleeving. This tubing is available from Rayclad Tubes, Inc. to cover all diameters from 0.023 to 4.000 inches.

8.2

0442
THE MICROMODULE COMES OF AGE
Electronic Products, 5, (5), October, 1962, pp 44-45

The physical composition and advantages of micromodules are presented. A temperature compensated precision micromodul resistor providing a low temperature coefficient of resistance, manufactured by Vishay Instruments, Inc., is also discussed.

0443
COAXIAL CABLES FOR HIGH TEMPERATURE
Electromechanical Components and Systems Design, 5, (1), January, 1961, pp 54-55

Selection of a particular type of coaxial cable design for high temperature service was based upon consideration of several aspects: potential electrical performance, adaptability to possible materials, physical stability, and subsequent manufacture.

8.1

0444
CERAMOPLASTICS
Electromechanical Components and Systems Design, 5, (4), April, 1961, pp 40

Supramica 620 is a ceramoplastic precision-moldable insulation material which withstands up to 1200 F.

3.2

0445
WELDED ELECTRONIC PACKAGING
Circuits Manufacturing, 4, (6), November-December, 1964, pp 26-28

Several papers given at the Welded Electronic Packaging Conference held October 27-28, 1964, are summarized. Three microjoining processes commonly used are precision microsoldering for discrete components, micro-gap diffusion bonding for joining encapsulated micro devices, and thermocompression bonding processes for uncased semiconductor devices. Hybrid thin film circuits use the advantages of uncased active devices in preference to conventional packaged devices. Causes of weld defects and methods of weldment testing were also discussed.

9.1

0446
SILICONE RUBBER LIQUID IS POURABLE
Electronic Evaluation and Procurement, 4, (9), September, 1964, pp 38-39

New precatalyzed RTV-12 silicone rubber comes in liquid form for production line application, where a durable, self-bonding, high temperature rubber coating, potting material, or sealant is desired.

8.3

0447
WHAT'S NEW IN SOLDERING
Powell, R., Electronic Products, 8, (7), December, 1965

The advantages to soldering in microcircuits include ease of setup, costs, and repairability. The advantages of the following soldering techniques are discussed: multiple-lead, flat-pack soldering; single-point soldering; and parallel-gap soldering.

9.2

0448
VIBRATION PERFORMANCE OF PANELS AND BOARDS
Shafer, R. E., Electronic Products, 5, (8), January, 1963, pp 54-55, 58

Charts are presented to aid in estimating and analyzing variations in performance caused by modifications in chassis panels and printed circuit boards when subjected to the vibration environment encountered in various multiple applications.

7.31

0449
ENCAPSULATION OF PRINTED WIRING ASSEMBLIES
Hawkins, J. W., Paper presented at the National Conference on the Application of Electrical Insulation -- Third Annual, 1960, December 7, 1960 - Session 4C

This paper is intended to provide general information that will be of help in the selection of encapsulating materials for printed wiring components and assemblies. It defines an encapsulant, tests some of the materials that are now used and sources of information that will be helpful in selecting the right material or materials. Suggestions for screening the material are given. The final portion of the paper describes production applications of RTV liquid silicone rubber to solve specific printed wiring and electronic component problems.

8.3

0450
HIGH DENSITY WELDED PACKAGES
Liss, S. and Maida, Z., Electromechanical Components and Systems Design, 5, (8), August, 1961, pp 24-31

The component analysis, high density packaging, joining techniques, encapsulation, and interwiring studies that led to the development of a welded cordwood packaging technique are discussed.

4.152

0451
EVALUATING PC BOARD INTERCONNECTIONS
Burstein, E. B., Electronic Evaluation and Procurement, 4, (3), March, 1964

Placing components on both sides of printed circuit boards requires a reliable method of connecting between sides. Results of an evaluation program, including both thermal cycling and vibration testing, showed the relative merits of the following interconnection techniques: exelets, both mechanically set and fused; plated-thruholes; and bare holes with the component lead and/or z wire making the interconnections.

8.4

0452
AN EVALUATION OF PRINTED CIRCUIT BOARD COATINGS FOR HIGH-HUMIDITY ENVIRONMENTS
Cabot, J. A., Radiation Inc., May 5, 1964, 78 pp., Rept. No. 1722-49-001, NAS9-150 (AD 444230)

This test was conducted to evaluate a number of printed circuit board coatings, various combinations of coatings, and coating processes to obtain one which would meet the following requirements: (a) High electrical insulation resistance at both room ambient temperature and 75 C. (b) High electrical insulation resistance upon completion of the Humidity Test, MIL-E-5272C, Procedure 1. (c) Fulfil the requirements of the Apollo Program Materials Qualification Specification. (d) Satisfy the following application requirements: (1) Simple to apply, (2) Cure at a temperature under 100 C, and (3) Result in a thin, uniform, flexible coating that is easy to repair.

8.3

0453
THE EFFECT OF NUCLEAR RADIATION ON ELASTOMERIC AND PLASTIC COMPONENTS AND MATERIALS
King, R. W., Broadway, N. J., and Palinchak, S., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, September 1, 1961, 192 pp., REIC Rept. No. 21, (AD 267890)

This report presents the state of the art of the effects of nuclear radiation on elastomeric and plastic components and materials from 1947 to the present. The mechanism of radiation damage and the effects of radiation in various environments are briefly discussed. Data summarizing the radiation-effects information on specific components and on the various types of elastomers and plastics are presented in detail. This report is intended to be sufficiently inclusive to make it valuable as a reference guide on the effects which can be anticipated from nuclear radiation on elastomeric and plastic components and materials. The effects of radiation in combined environments including elevated temperature, liquids and gases, and vacuum are discussed. Radiation effects on adhesives, coatings, electrical insulation, and films are given.

3.2, 3.3, 3.4

0454
THE EFFECT OF NUCLEAR RADIATION ON ELASTOMERIC AND PLASTIC COMPONENTS AND MATERIALS
Broadway, N. J. and Palinchak, S., Radiation Effects Information Center, Battelle Memorial Institute, Columbus, Ohio, August 31, 1964, 124 pp., REIC Rept. No. 21 (Addendum) (AD 454056)

This report is an addendum to REIC Report No. 21 and presents the state of the art of the effects of nuclear radiation on elastomeric and plastic components and materials from 1961 to the present. The mechanism of radiation damage and the effects of radiation in various environments are briefly dicussed. Data summarizing the radiation-effects information on specific components and on the various types of elastomers and plastics are presented in detail. Areas in which additional work is needed are indicated. Adhesives, coatings, electrical insulation, laminates, and potting compounds are included in the review.

3.2, 3.3, 3.4

0455
HANDBOOK OF DESIGN DATA ON ELASTOMERIC MATERIALS USED IN AEROSPACE SYSTEMS
Pickett, A. G. and Lemcoe, M. M., Southwest Research Institute, January, 1962, 222 pp., Tech. Rept. No. ASD-TR-61-234, February 5, 1960 - June 30, 1961, AF 33(616)-7093 (AD 273880)

The objective of this handbook is to provide aerospace weapons system design engineers with useful data on the materials properties of elastomers. The properties considered are original mechanical and physical properties and the changes in these properties that result from aging and exposure to environments of aerospace weapons systems. An attempt has been made to provide information on which to base decisions as to the selection of an elastomeric material for use as a component. The elastomeric materials considered in this handbook include those currently being used in aircraft and missiles and several materials which are presently only available in pilot plant quantities.

3.3, 3.4

0456
JOINING DISSIMILAR METALS?
Kleis, John, Welding Design and Fabrication, <u>35</u>, (8), August, 1962, pp 34-35

Fansteel Metallurgical Corporation use of percussion welding to join refractory and precious metals to copper and steel is described. Bonds of 99 percent of the total weldable areas are obtained. This compares to 70-85 percent bonds achieved with previous joining processes.

9.1

0457
CONNECTORS--AND TERMINATIONS
Ruth, Smedley B., Electronic Industries, <u>22</u>, (4), April, 1963, pp 56-67

The problems associated with connectors, the termination methods and trends are discussed in this article. Crimp, manual snap-in contacts used in an AMP printed circuit connectors can be terminated at rates up to 3,000/hr. These contacts are available strip-mounted for fast automated assembly. Some of the various connector types, contacts and termination methods which are in use today are shown in photographs.

8.4, 9.3

0458
JOINING DISSIMILAR METALS
Peckner, Donald, Materials in Design Engineering, <u>56</u>, (2), August, 1962, pp 115-122

In this article the authors summarize the general rules and precautions that have been developed over the years in dealing with dissimilar metal joints. An extensive checklist of some dissimilar metal joints that have been made, as well as the type of process used to make them are given.

3.5, 9.1, 9.2

0459
FOAMS AND LOW DENSITY COMPOUNDS
Harper, Charles A., Insulation, 7, May, 1961, pp 34-41

Some of the lesser known embedding products have properties which make them very suitable for some applications. Foams and low density compounds included in this article are urethane, phenolic, silicone, and foamed in place polystyrene. Properties covered are density, compressive strength, thermal conductivity, dielectric strength, tensile strength, elongation, modulus of elasticity, shear strength, and modulus of rigidity.

3.4

0460
COOL ELECTRONIC PACKAGES
Matisoff, B., Product Engineering, 33, (22), October 29, 1962, pp 50-55

A step-by-step design technique for producing cool electronic packages is presented. Conduction, convection, radiation as methods of designing such packages--all are covered in this short-cut procedure. Conduction across joints is often the most significant technique. Electrically insulated mountings and two surface coatings of use in such designs are given.

4.133, 8.3

0461
APPLICATIONS OF PHOTO-ETCHING IN THE MANUFACTURE, INTERCONNECTION AND PACKAGING OF MICRO-CIRCUITS
Strauss, W. A., Jr., SCP and Solid State Technology, 9, (2), February, 1966, pp 15-18

New applications of photo-etching are discussed. New developments in masking techniques, metallized glass replicas of photographic masks, and the bimetal mask structure are treated. Lead preforms for flat packs etched from glass-to-metal seal alloys are described. Design suggestions based on the problems encountered in etching are given, followed by a review of methods and materials used in packaging, including weldable multilayer circuit boards.

8.4

0462
MODULAR ARRAYS--THE PATH TO SINGLE-CIRCUIT SYSTEMS
Melcher, H. T., Electronics, 39, (4), February 21, 1966, pp 115-120

A new combination of hybrid-circuit and sealing techniques in analog subsystems which provide the power, precision and small size needed to use large numbers of monolithic circuit chips in one package is described. The construction technique allows the designer to build many different analog functions with a few standard monolithic integrated circuits by tailoring their operating characteristics with precision thin-film resistors. The films are supplemented by power resistors and interconnections that are screen-printed on a ceramic base. The combination multiplies the power-handling capability of the circuit package by approximately five times.

5.15

0463
A NEW CONCEPT IN MICROELECTRONICS
Barnet, P. A., Interavia - Electronics, 21, (1), 1966, p 77

Rational Packaging is a system of equipment construction developed by the General Electric Company Limited of England. With this system, small individual components, semiconductor networks and thin-film circuits can be combined in compact assemblies to achieve high part densities. The equipment designer is not limited, therefore, to using a single type of part, but can choose the parts he considers most suitable from a wide range. Present techniques are based on the use of small welded modules that are rectangular in shape and standardised in size with a constant trapezoidal cross-section. Rows of such modules are assembled on mounting plates which provide milti-layer interconnections.

4.1, 5.1, 6.1

0464
SOLDERS AND SOLDERING
Manko, Howard H., McGraw-Hill Book Company, New York, N. Y., 1964, 323 pp.

This book presents the science of soldering in its proper dimension. Theory as well as practice is covered to provide a base of solder understanding which should achieve a higher degree of reliability of soldered joints and connections. The physics of wetting during solder-bond formation, chemistry of fluxes, metallurgy of solder, solder bond, designing solder joints, equipment and production techniques, and inspection are included. The application of soldering to printed circuits is briefly discussed.

9.2

0465
INVESTIGATION OF RTV SILICONE COMPOUNDS FOR SEALING HIGH TEMPERATURE (200 -450F) AIRCRAFT ELECTRICAL CONNECTORS AND ELECTRIC SYSTEMS
Nadler, C., Naval Air Material Center, Aeronautical Materials Laboratory, Philadelphia, Pa., July, 6, 1960, 18 pp., Rept. No. NAMC AML 1127, Project No. TED NAM AE 42127

An investigation was conducted to evaluate room temperature vulcanizing silicone potting compounds for use in sealing high temperature (200 -450F) aircraft electrical connectors and to develop related sealing processes. Physical and heat resistance properties, electrical properties, methods for bonding to teflon surfaces, adhesion primers, adhesion to various type electrical wires, metals, plastics and elastomers, performance of potted connectors and sealing methods are given. Based on the results obtained the silicone compounds were considered suitable for the connector potting application.

3.4, 8.3

0466
ELECTRONICS' HANDBOOK OF CIRCUIT DESIGN
McGraw-Hill Book Company, New York, N. Y., 1966, 254 pp.

New ideas and developments in circuit design are included. Practical calculations and shortcuts to aid in packaging design problems are included. The use of micro packaging techniques to squeeze in discrete components is included in sections 1 and 2 of the handbook.

1.1, 4.1, 5.1, 6.1

0467
GENERAL SURVEY OF MICROELECTRONIC TECHNIQUES
Sokcloski, A. F., U. S. Naval Air Development Center, Aeronautical Electronic and Electrical Laboratory, Johnsville, Pa., April 1, 1964, 12 pp., Rept. No. NADC-EL-6416, (AD 440877)

A state-of-the-art survey was performed on semiconductor integrated microelectronic packaging and interconnection techniques to determine progress and anticipate future design improvements. In general, the scope of the survey was in the problem areas of encapsulation, packaging, interconnection systems, and electrical connections. Results of the survey indicated that constant improvements and novel developments are being incorporated into the new generation of thin-film microelectronic systems to overcome problem areas.

1.1, 5.1, 9.

0468
EVALUATION OF CRITICAL PROPERTIES OF SELECTED MATERIALS FOR ELECTRONIC PACKAGING PURPOSES
Redd Inc., Anaheim, Calif., August 1, 1962, 75 pp., Final Rept. RML-4, March 5, 1962 - June 30, 1962, NAS7-100 (N63-21313)

An extensive examination of selected mechanical, electrical and physical properties of a group of commercially available polymeric materials, including epoxy and polyurethane coatings, adhesives, potting compounds and foams, has been made according to ASTM standards but under vacuum conditions of 10^{-4} to 10^{-6} Torr and over a temperature range of -40 F to 300 F. Not only were measurements made on samples after 24 hours exposure to the various combined environments, but also while the materials were in those environments. Comparative one atmosphere values were also taken. In general, no catastrophic changes were noted in the properties of any of the materials measured in vacuum compared with their characteristic one atmosphere values at equivalent temperatures. Increasing temperatures caused more noticeable changes in most cases than the short time vacuum exposures. Unique equipment and fixtures for accomplishing the various tests on samples while in combined thermal-vacuum environments are also described.

3.4, 8.3

0469
THE PROPERTIES AND APPLICATIONS OF SYNTACTIC FOAM SF-1 POTTING COMPOUND AS USED IN SABRE ELECTRONICS
Petkunas, Frank, Massachusetts Institute of Technology, Cambridge Instrumentation Laboratory, Cambridge, Mass., August 31, 1965, 42 pp., Rept. No. E-1844, AF 04(694)-553 (AD 474089)

This report describes the properties of Syntactic Foam, SF-1, a dissolvable material of low density for potting electronic modules. Procedures for potting and unpotting modules are summarized. Limitations due to package geometry and susceptibility of components to the methyl-ethyl ketone solvent are discussed.

3.4, 8.3

0470
AN ECONOMICAL FLAT PACKAGE FOR INTEGRATED CIRCUITS
Signetics Corporation, Sunnyvale, Calif., October 17, 42 pp., Final development rept., June 15, 1964-October 15, 1965, NObsr-91298 (AD 474240)

This report is a summary of the work completed in developing an economical flat package for integrated circuits. This is covered by a design description and reliability test results.

5.1

0471
PARTS AND MATERIALS
NASA, George C. Marshall Space Flight Center, Astrionics Division, Huntsville, Ala., DGL 2, Vol. 1, July 1, 1964, 65 pp.

Electrical hardware including printed circuits, control knobs, binding posts, solder terminals, insulation sleeving, and fuseholders are discussed.

8.2, 8.5, 8.6

0472
PARTS AND MATERIALS
NASA, George C. Marshall Space Flight Center, Astrionics Division, Huntsville, Ala., DGL 2, Vol. 2, July 1, 1964, 100 pp.

Included in this volume are switches, semiconductor devices, electronic tubes, circuit protection, electrical connectors, metals, nonmetals, and mechanical hardware.

3.1, 3.4, 8.1, 8.3, 8.4, 8.6

0473
PROCEDURES DESIGN GUIDE LINE BOOK
NASA, George C. Marshall Space Flight Center, Astrionics Division, Huntsville, Ala., DGL 1, Vol. 1, January 1, 1964, 60 pp.

Astrionics Laboratory Design Guide Line Manuals serve as a primary source of general design criteria applicable to the design and development of Saturn System electrical parts, materials, and procedures. Briefly, the purpose of the manuals is to establish uniformity and reliability in design criteria, and to provide a convenient single source of current, approved information useful in design engineering. Instrumentation; electrical components including capacitors, resistors, and transistors; miscellaneous electrical items including shield terminations, printed circuits, mounting of "Pygmy" (Jam-Nut) connectors, isolation of electrical power circuitry, insulation, and sleeving; metals joining; selection of encapsulating compounds; and the effects of nuclear radiation on electronic components are discussed.

3.5, 4.29, 6.111, 7.12, 8.2, 8.3, 9.2

0474
ESE, APPROVED PARTS LISTS, ELECTRONIC SUPPORT EQUIPMENT
NASA, George C. Marshall Space Flight Center, General Electric, Apollo Support Department, ESE Program Operation, Huntsville, Ala., January 1, 1966, 105 pp.

This document lists the electrical/electronic parts used in the Electrical Support Equipment designed by the General Electric Company for George C. Marshall Space Flight Center. Circuit boards, cable, capacitors, circuit breakers, potting compounds, connectors, welded modules, relays, resistors, rotating components, semiconductor devices, binding posts, shunts, solder, terminals, tubing, and wire are included.

8.1, 8.2, 8.3, 8.4, 8.5, 8.6

0475
PREFERRED PARTS--ELECTRICAL
NASA, George C. Marshall Space Flight Center, Huntsville, Ala., July 1, 1964, MSFC-PPD-600, Vol. 1, 85 pp.

The document is the result of an MSFC coordinated effort to establish, as a basic element of MSFC's present and future parts program, a listing of preferred parts for use by design activities in selecting reliable parts for space vehicle systems application. The document contains the best available information for the parts listed, but is by no means all inclusive. The PPD-600 is intended as a guide to the selection of parts for space systems applications and, as such, should be utilized to the maximum extent deemed practical. The contents include: printed circuit and terminal boards, cable, capacitors, circuit breakers, microelectronic circuits, potting compounds, connectors, counters, fuse holders, welded modules, binding posts, relays, resistors, semiconductor devices, shunts, relay sockets, electrical solder, switches, terminals, tubing, and wire.

3.4, 8.1, 8.2, 8.4, 8.6, 9.2

0476
POTTING, EMBEDMENT, AND ENCAPSULATION OF WELDED ELECTRONIC CIRCUITS
Space Technology Laboratories, Inc., Los Angeles, Calif., November, 1960, 49 pp, Rept. STL/TR-60-0000-19354 (X63-80865)

This report summarizes information on the wide variety of available methods, materials, and techniques for the potting, embedment, and encapsulation of electronic circuits.

3.3, 3.4, 4.133, 4.14, 4.3, 8.3

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3. REPORT TITLE

ELECTRONIC PACKAGING: A BIBLIOGRAPHY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Klapheke, J. W.; Veazie, W. H.; Holt, J. C.; and Easterday, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
31 March 1966	85	

8a. CONTRACT OR GRANT NO. DA-01-021-AMC-11706(Z) b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) RSIC-534 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD ________

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13. ABSTRACT

This annotated bibliography of selected reports, journal articles, and manufacturers' literature on electronic packaging provides a literature basis for electronic packaging engineers to design more reliable, maintainable, and adaptable electronic equipment for aerospace application. The literature search of abstract publications, published bibliographies, specialized information centers and services, and computer searches by Redstone Scientific Information Center and Defense Documentation Center resulted in the 476 abstracts in this bibliography which were selected from an initial review of approximately 3,000 articles.

Subject indexing is provided by properties and environmental effects on packaging materials, discrete parts to module packaging, integrated circuits to module packaging, module packaging to assembly, housing and mounting, packaging products, and interconnection techniques. Author and corporate author indexes are included.

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