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TECHNOLOGY UTILIZATION

TESTING METHODS AND TECHNIQUES:
TESTING ELECTRICAL
AND ELECTRONIC DEVICES

A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration and the Atomic Energy Commission have established a Technology Utilization Program for the rapid dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of its research and development, NASA and AEC earn for the public an increased return on the public investment in aerospace and nuclear R&D programs.

The methods, techniques, and devices presented in this compilation are used in testing various electrical and electronic apparatus. The items described range from semiconductor package leak detectors to automatic circuit analyzers and antenna simulators for system checkout. In many cases, the approaches presented can result in considerable cost savings, together with improved quality control.

The compilation is presented in three sections. The first describes the testing of various electronic components, assemblies, and systems; the second treats the testing of various electrical devices; and the third deals with the testing of cables and connectors. This compilation is not intended as a complete survey of the field of electrical and electronic equipment testing. Rather, it presents a sampling of many diverse activities for the interest of electrical, electronic, and quality control designers and engineers. Its diversity of content may even lend this compilation some interest as an introduction to the field, for those unfamiliar with the principals and practices of electrical and electronic equipment testing.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader Service Card enclosed in this compilation.

Unless otherwise stated, neither NASA nor AEC contemplate patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

*Technology Utilization Office
National Aeronautics and Space Administration*

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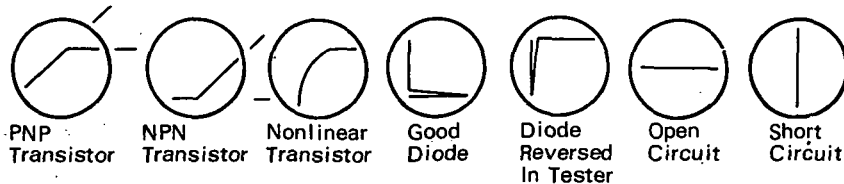
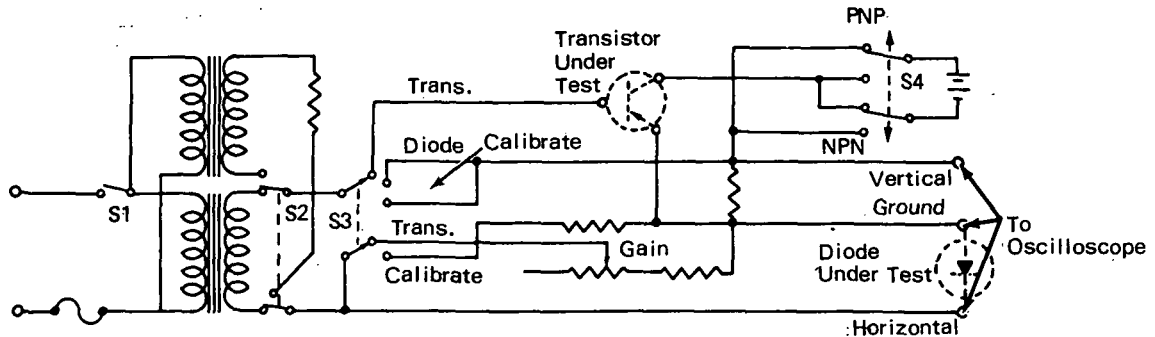
Contents

SECTION 1. Testing Electronic Components, Assemblies and Systems	Page
Testing Semiconductors Without Disconnecting Them from Circuit	1
Semiautomatic Device Tests Components with Biaxial Leads	1
Test and Inspection Techniques for Monolithic Circuit Production	2
Component Package Leak Detection	2
Heating Stage for Scanning Electron Microscope	3
Powdered Styrofoam Substitutes for Potting Material in Vibration Testing	4
Tooling Compound Used to Encapsulate Small Components for Testing	4
Vibration Test Detects Intermittent Electrical Faults	5
Inspection of Potted Cordwood Modules	5
Monopulse-Antenna Simulator	5
Cold-Testing Printed Circuit Boards	6
Preliminary Isolation Test Protects Low-Voltage Circuits	6
Modified PCB Extender Is Troubleshooting Aid	7
Module-Carrier Design Gives Easy Access with Minimum Wear	7
Ventilated Test Enclosure	8
Noise-Testing Device Facilitates Data Acquisition System Calibration	8
Testing Power Supply Recovery Time	9
Automatic Telemetry Checkout System	9
SECTION 2. Testing Electrical Devices	
Identification of Thermocouple Materials	10
Thermocouple Resistance Measured Without Disconnection from System	10
Measuring Battery Charge Leakage	11
Measuring Set/Release Pressure and Travel of a Circuit Breaker	12
Torque Meter Aids Study of Hysteresis-Motor Rings	12
Recommended Operating Torques for Rotary Controls	13
DC Motor Commutating Brushes Tested in Dry Argon Atmosphere	14
Microphone Calibration at High Sound Pressures	14

SECTION 3. Testing Cables and Connectors	Page
Moire Pattern Used to Check Flat Conductor Cable Spacing	15
Experimental Prediction of Superconducting-Cable Performance	15
Measuring Insulation Mechanical Failure Rates	16
Cable Insulation Resistance Tester	16
Tester Automatically Checks Insulation in Multiconductor Cables	17
Shielded Cable Tester	17
Grid-Plate Adapter for Wire Tester	18
Measuring Tensile Loads Induced in Connector Pins by Cable Bending	18
Measuring the Connect/Disconnect Forces of an Electrical Connector	19
Measuring RF Leakage from Coaxial Connectors	20
Fuse-Holder Adapter for Ammeter Probe	21
Measuring the Length of Electrical Connector Pins	21
Quick-Connect Device for Monitoring Signal on Barrier-Type Terminal Strips	22
Test Device Prevents Weld-Joint Damage on Unpotted Modules	22

Section 1. Testing Electronic Components, Assemblies and Systems

TESTING SEMICONDUCTORS WITHOUT DISCONNECTING THEM FROM CIRCUIT



An oscilloscope, together with the test circuitry shown in the figure, can be used to check semiconductors that are wired into a circuit. For transistors, approximate gain and linearity can be determined; for diodes, open circuits, short circuits, and reversed polarity are indicated clearly. The quality and breakdown point of low-voltage (<10 V) zener diodes can be measured.

The idealized oscilloscope traces show the types of waveforms to be expected under various circumstances, provided that the impedance of the external circuit is much greater than that of

the component under test. If this is not so, the waveforms obtained will vary, depending on the external circuit properties. In either case, when an assembly to be tested contains multiple identical circuits, the tester may be employed comparatively to identify a defective component.

Source: B. C. Allen of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-1163)

Circle 1 on Reader Service Card.

SEMAUTOMATIC DEVICE TESTS COMPONENTS WITH BIAxIAL LEADS

The device shown in the illustration is used for environmental testing of electronic components equipped with biaxial leads. The components to be tested are loaded in a slotted clip. A remotely

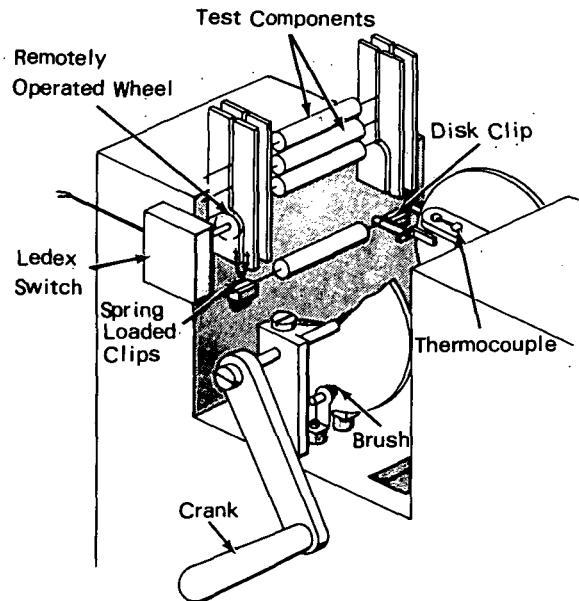
operated wheel with two notches diametrically opposed on its perimeter feeds the components one at a time into the load station. The load station consists of four spring-loaded clips

mounted on two dual-sided, copper-clad revolving disks. These clips close on the component leads when the disks are rotated clockwise to the measuring station position. The component surface temperature is measured by the thermocouple. Electrical connection to the component under test is made through spring-loaded metal brushes riding on the disks.

After the component is tested, the crank is turned clockwise to the release station, which opens the clips. The component slides down a ramp to a storage compartment.

Source: T. C. Marshall of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-516)

Circle 2 on Reader Service Card.



TEST AND INSPECTION TECHNIQUES FOR MONOLITHIC CIRCUIT PRODUCTION

Quality assurance procedures have been developed for the mass production of high reliability monolithic integrated circuits at reasonable cost. Many of the suggested controls may be too stringent for engineering prototype work or for small quantity production, but may provide a basis for a homogeneous process in moderate or mass production quantities.

A report detailing the test and inspection procedures covers the following areas:

- Configuration Control
- Basic Fundamentals of Quality Control
- Control Charts
- Wafer Process Evaluation
- Process Evaluation

- Evaluation Score System
- Diffusion Evaluation
- Wafer Scribing
- Bonding Operation
- Test Controls

Copies of the report, Test and Inspection for Process Control of Monolithic Circuits, are available.

Source: E. Spangenberg of
Westinghouse Electric Corp.
under contract to
Marshall Space Flight Center
(MFS-13084)

Circle 3 on Reader Service Card.

COMPONENT PACKAGE LEAK DETECTION

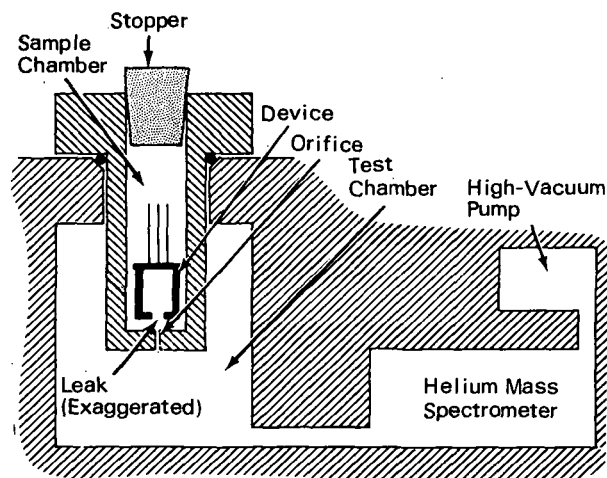
A simple, reliable, inexpensive method for gross-leak testing of electronic devices is based on the conventional fine-leak technique. The method can detect leaks as small as 10^{-7} cc helium per sec. As shown in the diagram, the tester includes a sample chamber connected by

a small orifice to a test chamber, a helium mass spectrometer, and a high-vacuum pump. The test chamber is continuously evacuated, eliminating the necessity of vacuum cycling for each test and greatly simplifying the testing procedure.

In summary, the test consists of the following steps:

1. The devices, housed in open bottles, are placed in a pressure vessel, with helium at 515 kN/m² (60 psig), for at least 2 hours.
2. Immediately after pressurization, the bottles containing the devices are closed.
3. The device to be tested is removed from its bottle and placed in the sample chamber, which is then immediately closed with the rubber stopper. A high-vacuum pump continuously evacuates the test chamber through the helium mass spectrometer. The orifice at the bottom of the sample chamber limits gas flow so that the gas pressure within the test chamber remains at approximately 0.01 micron, even though the pressure within the sample chamber is atmospheric. Helium gas diffuses out of the device into the sample chamber. The resulting helium and air mixture flows through the orifice into the mass spectrometer, where the helium leak rate is measured.
4. After gross leak testing is completed, the device is removed from the sample chamber, which is then purged with nitrogen gas in readiness for the next gross-leak test.

Fine-leak testing of the device should be done after gross-leak testing. This may be accomplished by inserting the device into the test



chamber, without using a sample chamber. The mouth of the test chamber is then sealed with a cap and the helium leak test is conducted in the conventional manner. It is not necessary to repressurize the device with helium, and only those devices that do not show gross leaks should be subjected to the fine-leak test. Because of the testing range of the gross-leak test, it may be sufficient for many applications.

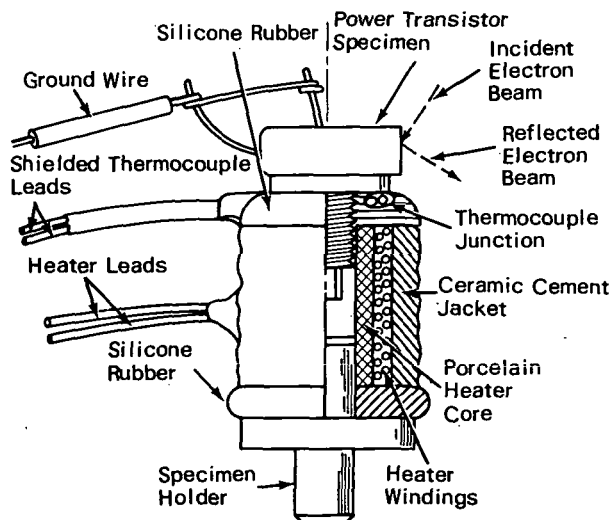
Source: T. L. Altshuler
 Electronics Research Center
 (ERC-10150)

Circle 4 on Reader Service Card.

HEATING STAGE FOR SCANNING ELECTRON MICROSCOPE

A heating stage and holder for use in a scanning electron microscope allows examination of a power transistor at various temperatures. This capability is used in quality control testing to check for leaks resulting from different coefficients of thermal expansion at the plastic/metal interface of the transistor package.

A heating coil is attached with silicone rubber to a standard specimen holder and is incorporated in the scanning electron microscope stage, as shown in the sketch. The power transistor is also attached with silicone rubber to the heating stage, together with an embedded thermocouple that contacts the bottom of the specimen. A ground wire is connected to the transistor leads



to avoid accumulation of charge from the electron beam.

Specimen, heating stage, and holder are placed in the scanning electron microscope, and a direct current voltage is applied across the heating coil. The power transistor temperature is monitored with a thermocouple bridge, and the voltage is adjusted to maintain the required temperature.

Source: G. Jacobs and B. Slaughter of Sperry Rand Corp. under contract to Goddard Space Flight Center (GSC-10963)

No further documentation is available.

POWDERED STYROFOAM SUBSTITUTES FOR POTTING MATERIAL IN VIBRATION TESTING

A metal box made to contain an electronic module and powdered styrofoam potting material facilitates testing (particularly failure-analysis vibration testing) of small components that are normally potted. Monitor wires are fed through slots in the top of the box and connected to the component, which is placed in the box on a bed of powdered styrofoam. After the box is overfilled with powdered foam, the cover is clamped down, compressing the foam and essentially duplicating the potted condition for

the purposes of vibration testing. Removing the component for inspection is easily accomplished by opening the box and pouring out the powder.

Source: F. B. Squires of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-15473)

No further documentation is available.

TOOLING COMPOUND USED TO ENCAPSULATE SMALL COMPONENTS FOR TESTING

Another temporary substitute for potting compound during the dynamic testing of small electronic assemblies is a standard, commercially available tooling compound. The compound, which has the desirable properties of low melting point (340 K; 150° F), low density (1.4 g/cc; 0.05 lb/in³), high rigidity, and water solubility, is cast around the assembly to be tested, and the casting is cut to form a standard sized cube. The casting is poured in layers about 1 cm thick, to prevent the development of internal cavities due to temperature gradients and thermal expansion of the compound.

After machining, the cubic specimen is mounted on the dynamic testing apparatus, using a rubber-

coated compression plate to damp the natural resonance of the cube. Acceleration, shock, and vibration testing are then performed.

After testing, the specimen is placed in a beaker atop a hot plate, and sufficient compound is melted to release the test part. The rest of the compound is washed off with water.

Source: K. O. Campbell of The Boeing Co. under contract to Marshall Space Flight Center (MFS-15161)

Circle 5 on Reader Service Card.

VIBRATION TEST DETECTS INTERMITTENT ELECTRICAL FAULTS

A novel, nondestructive test method can detect intermittent discontinuities (faulty crimps on electrical connections, cold solder joints, loose pin contacts, etc.) in electronic cable harnesses and circuits. The circuit under test is ultrasonically vibrated, and the resultant noise signal due to any intermittent discontinuity is observed on an oscilloscope. This test method employs readily available commercial equipment and is particularly useful for detecting faulty electrical connections in inaccessible or hidden portions of electronic harness assemblies and connectors.

Acoustic power is applied across an air gap to the circuit under test. The power is generated by a 250 W loudspeaker horn positioned about 5 cm from the test circuit terminal board. Noise

levels developed in the test specimen are measured across a shielded 100 k Ω wire-wound resistor and read on an oscilloscope. A direct current of 60 μ A (maximum) is supplied from a 6 V battery to leads clipped to terminal points on the test specimen.

A permanent record of the test signal traces can be made by using a logic plug-in unit to print frame numbers and a frequency plug-in unit with a response to 50 kHz.

Source: D. E. Roberts and S. M. Grieve of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-15158)

Circle 6 on Reader Service Card.

INSPECTION OF POTTED CORDWOOD MODULES

X-ray superimposition techniques improve the inspection reliability of potted electronic modules, while greatly reducing the time, effort, and cost required for the inspection.

The components in small, precision cordwood modules are usually interconnected by means of numerous small (0.5 x 0.25 mm) rectangular ribbons spot welded to the component leads. These ribbons frequently break during potting. Conventionally, potted modules are inspected for such defects by X-raying the completed module, projecting the magnified negative, and then visually tracing each ribbon to detect separation. This process is tedious, time-consuming, and costly.

The inspection is greatly simplified by X-raying the module before potting. An X-ray positive is then printed from the negative. After potting and curing, the conventional X-ray is made, and the negative is overlaid on the previously made positive. Any physical movement of the ribbons is indicative of a break and will show up immediately as a white area on an otherwise uniformly dark image. This method allows inspection with nearly 100% reliability.

Source: W. C. Johnson of North American Rockwell, Inc. under contract to Marshall Space Flight Center (MFS-18090)

No further documentation is available.

MONOPULSE-ANTENNA SIMULATOR

A simple, easily controlled monopulse antenna simulator is used in a shielded environment for the evaluation checkout of various electronic sub-assemblies, corporate feeds, monopulse sum-and-difference networks, etc., prior to system

checkout on an antenna-pattern range. It can also be used for system checkout in place of actual phase-sensing, amplitude-sensing, or hybrid antennas. The simulator consists of four types of components: square hybrids, phase delays, load

terminations, and variable phase shifters. Three weighting circuits are used; each has one variable parameter (phase shift).

In the simulation of a pure phase-sensing antenna, the phase shifts are set to produce equal-amplitude signals. The phases of these signals are then adjusted according to the interferometric equations. To simulate a pure amplitude-sensing antenna, the phase shifts are set so that the derived

voltage ratios of field strength are obtained at the output terminals. When used as a hybrid-antenna simulator, the phase shifts are set to provide the desired amplitudes, and phase adjustment is used to simulate the phase relationships among the received signals.

Source: R. F. Schmidt and A. D. Elia
Goddard Space Flight Center
(GSC-522)

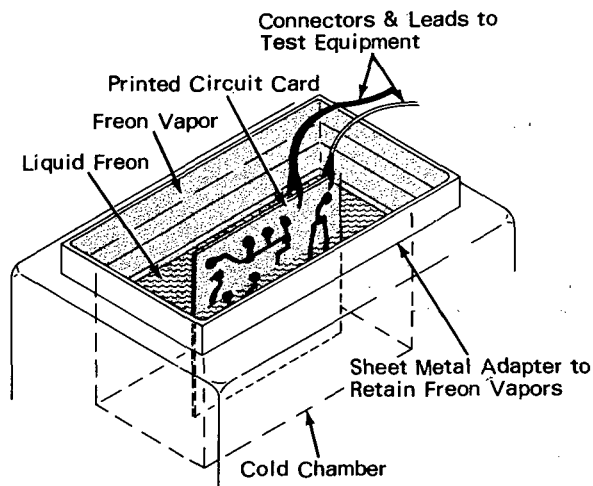
No further documentation is available.

COLD-TESTING PRINTED CIRCUIT BOARDS

In cold-environment testing of printed circuit boards (PCB) and board holders, the device shown in the illustration prevents the formation of frost on components during the test. Where previous methods required the use of a dry box installed over the cold chamber and pressurized with dried gas, the new method uses a barrier layer of freon vapor. The vapor is evaporated from the tank of liquid freon used to cool the part being tested.

Source: R. E. McNeill and D. A. Cross of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-15115)

Circle 7 on Reader Service Card.



PRELIMINARY ISOLATION TEST PROTECTS LOW-VOLTAGE CIRCUITS

A simple test that supplements the checkout of electronic systems with automatic circuit analyzers can detect inadequate insulation between high and low voltage circuits. Correction of such a condition before the high voltage circuits are energized can prevent damage to low voltage components.

Automatic circuit analyzers enable the insulation resistance and continuity of the hundreds of circuits in complex electronic systems to be checked quickly. After connection to the system, usually by several test cables, the analyzer first tests the high voltage insulation. A "short bus"

internally connects all test terminals in the analyzer. The analyzer's program disconnects the circuits to be checked from the bus, applies high voltage (over 100 Vdc) to these circuits, and measures the leakage current on the short bus. A problem arises when a defect shorts the high voltage to a low voltage line. Even the small (3 mA) maximum current from the tester can damage some low voltage components. Such damage can be prevented by first performing the new test.

Since standard circuit analyzers are not arranged to permit disconnecting low voltage

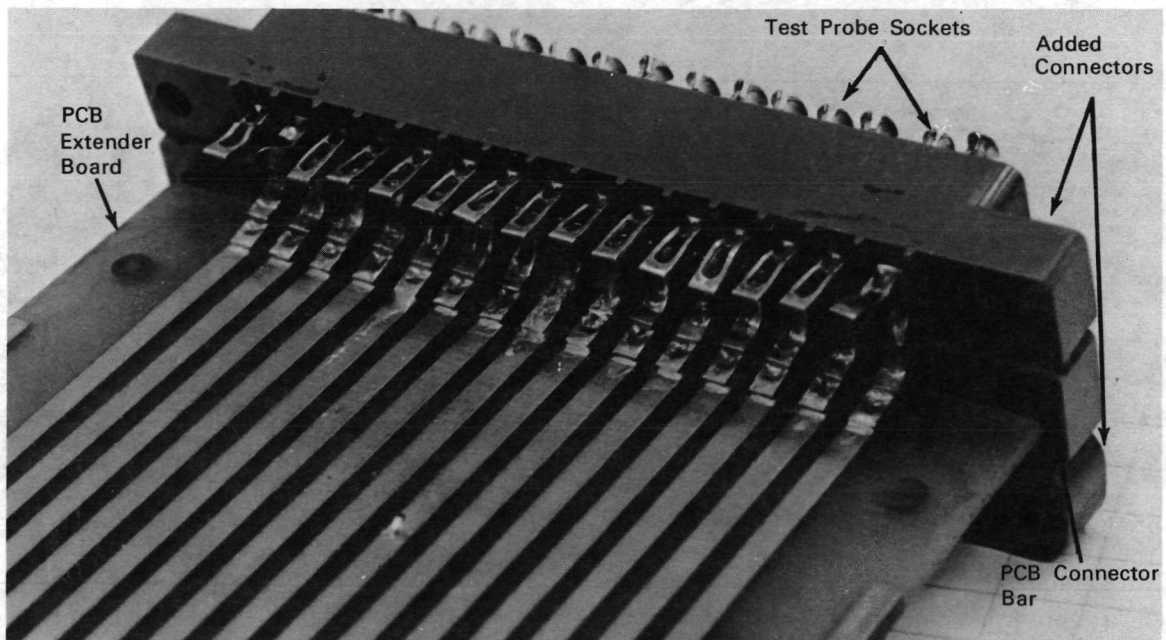
circuits from the short bus as a group, an external connection scheme is required. Each of the cables that carry low voltage lines is disconnected from the analyzer, and connected instead to a special plug, which is wired to connect all low voltage lines to one common lead and all high voltage lines to another lead. These two leads are then connected across a

standard megohmmeter, to check for adequate insulation resistance between them.

Source: W. Hufeld of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15669)

Circle 8 on Reader Service Card.

MODIFIED PCB EXTENDER IS TROUBLESHOOTING AID



A modified PCB extender provides contact points for troubleshooting protectively coated PCB's without damaging the coating. The modification consists of two additional connector bars, wired in parallel with the bar into which the PCB is inserted. Brass sockets, sized to accept a male test probe, are then placed in each slot of the added connectors.

Source: R. L. Durham of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10285)

No further documentation is available.

MODULE-CARRIER DESIGN GIVES EASY ACCESS WITH MINIMUM WEAR

A novel chassis design for an assembly of logic modules or other microelectronic components mounted in a tray provides easy access to the un-

derside of the modules and minimizes the degree of bending to which electrical cables connected to the chassis are subjected. The two essential

features of this design are (1) the module assembly is not attached directly to the frame but rather to two rotatable carriers, and (2) the connector panel in the rear, also attached to the rotatable carrier, is inclined at about $\pi/4$ rad (45°) to the vertical. The mounting of the module assembly allows it to be tilted into a vertical position, providing easy access to the underside of the assembly for modification or maintenance. At the same time, the inclination of the connector panel minimizes flexure and eliminates any possibility of stretching the electrical cables.

This design would be most useful when incorporated into custom test apparatus, prototype assemblies, and specialized equipment, where frequent modifications are expected.

Source: D. F. Smith of
Lockheed Electronics Co.
under contract to
Manned Spacecraft Center
(MSC-13488)

Circle 9 on Reader Service Card.

VENTILATED TEST ENCLOSURE

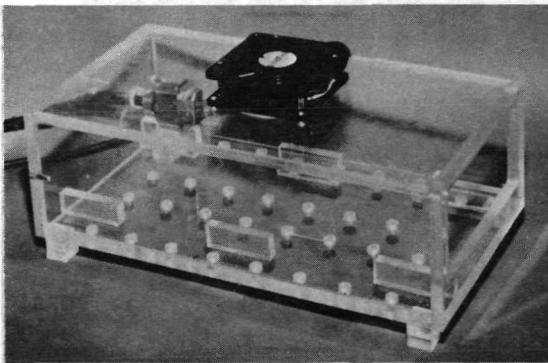


Figure 1

The illustrations show a transparent enclosure useful for testing electronic subassemblies that are prone to overheat unless adequately ventilated. The enclosure approximates the environment of the subassemblies when rack mounted for use, including forced ventilation which is supplied by the fan mounted on top of the enclosure.

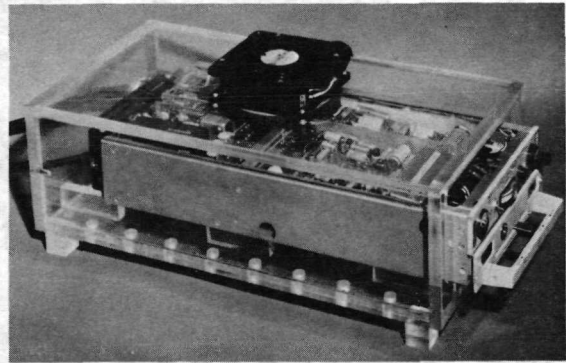


Figure 2

Source: J. E. Edwards and D. W. deCarle of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16955)

No further documentation is available.

NOISE-TESTING DEVICE FACILITATES DATA ACQUISITION SYSTEM CALIBRATION

An automatic testing device measures the noise content of analog inputs to a data acquisition system and determines whether the electronic calibration units (EC) on the data channels are operating properly. The two checks were pre-

viously accomplished manually, using a digital to analog converter and a storage-type oscilloscope. Since anywhere from 50 to 400 individual channels had to be checked, this method required several operators, was very time con-

suming, and called for a good deal of judgment on the part of the operators.

The automatic digital noise checker has the following characteristics: (1) Operates on-line using real-time data, or off-line using prerecorded check data; (2) uses digital data rather than reconstructed analog data; (3) sequences automatically through all system channels; (4) prints out the channel, noise content, and a representative data value occurring in a number of noise check samples; and (5) prints out the channel calibration within a predetermined EC range.

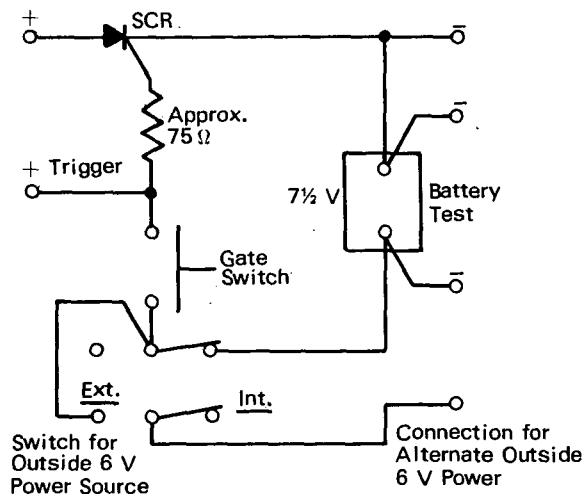
The noise checker consists of four digital logic chassis, a control panel, a printer, and power supplies. The unit has four operating modes. Modes 1 and 4 provide automatic noise checks, mode 2 provides the EC check, and mode 3 provides a multiplexer pattern-sorting capability for the data acquisition system.

Source: J. L. Harrold and C. F. Weegmann
Lewis Research Center
(LEW-10173)

Circle 10 on Reader Service Card.

TESTING POWER SUPPLY RECOVERY TIME

An electronic switching circuit enables measuring the full-load recovery time of solid state power supplies. Because of the high current and



short time element (recovery times of 1000 μ s or less are not uncommon), this parameter has not been easy to measure for large power supplies. No mechanical switch combines sufficient current handling capability with high enough speed.

The illustrated circuit, on the other hand, uses a high-current silicon controlled rectifier, has switching times on the order of 1 μ s, and can handle currents up to 35 A. As shown, the circuit is mounted in a small metal box which also serves as a heat sink for the rectifier.

Source: G. S. Sosack of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16371)

No further documentation is available.

AUTOMATIC TELEMETRY CHECKOUT SYSTEM

A telemetry checkout station automatically performs many measurements on a telemetry link. Its unique features include real-time digitizing and computer controlled station setup, data processing, and self-check.

Telemetry checkout was previously performed manually, but, with the increasing number of measurements that must be made on more

sophisticated equipment, automation became necessary.

Standard telemetry equipment is used to receive, demodulate, and process the various signals. Continuous and time-multiplexed signals from discriminators are automatically digitized and assembled into a predetermined time slot. Each word of the constructed wavetrain is scaled

and calibrated using stored calibration values. These data are then forwarded to a computer for evaluation.

The checkout system can be made to perform a wide variety of automatic tests by supplying the appropriate computer programs.

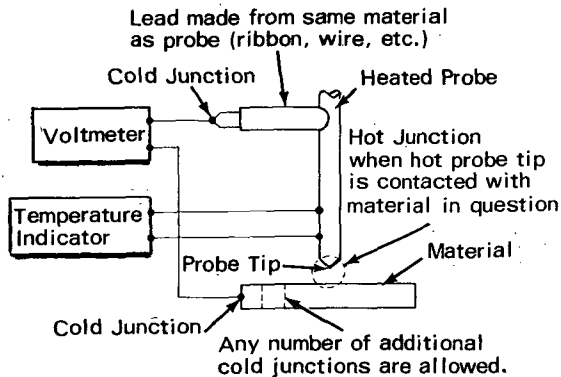
Source: W. V. George of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-12580)

Circle 11 on Reader Service Card.

Section 2. Testing Electrical Devices

IDENTIFICATION OF THERMOCOUPLE MATERIALS

Materials used in the fabrication of thermocouple junctions can be positively identified by



comparison with a standard set of probes made from representative thermocouple materials. A probe made of a known material is heated by any convenient means and placed in contact

with the material to be identified, forming a hot thermocouple junction at the probe tip. If the probe and test materials are the same, no thermoelectric voltage will be measured, regardless of the temperature of the hot junction. If the test material is not identical to the probe material, a thermoelectric voltage will be generated, and this voltage will be a function of the probe-object-junction temperature, the cold-junction temperature, and the Seebeck coefficients of the two materials.

Source: J. J. Vrolyk and R. F. Nelson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18540)

No further documentation is available.

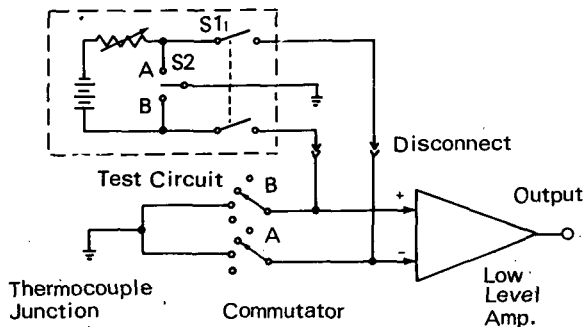
THERMOCOUPLE RESISTANCE MEASURED WITHOUT DISCONNECTION FROM SYSTEM

To monitor the electrical resistance of multiple thermocouple installations without disconnecting them, a test circuit is connected across the input of the telemetry data system. The constant current test circuit shown in the figure consists of a battery, a potentiometer, and two switches connected across the output of the commutator. The test circuit output is adjusted so that the voltage across a known resistance, which is greater than the resistances to be measured, equals the full scale range of the data sys-

tem. Each thermocouple loop is sampled by the commutator, and the voltage measured across the loop is proportional to the thermocouple resistance. A readout is taken first with the battery disconnected (S1 open), to confirm the absence of tare voltages. A readout with S1 closed then directly reflects the thermocouple total resistance. Placing S2 in the A or B position provides a measurement of the resistance of a leg in the thermocouple circuit.

A shorted thermocouple gives a zero or

very low reading, depending on where the short occurs. An open circuit gives a full scale reading on the data system. In many cases, the measurements give sufficient indication of the



nature and location of the defects to simplify the repair operation.

Typical resistances in the system used ranged from 20 to 400 Ω. The test circuit was set for 0.1 mA, so that the 50 mV range of the system represented 500 Ω full scale.

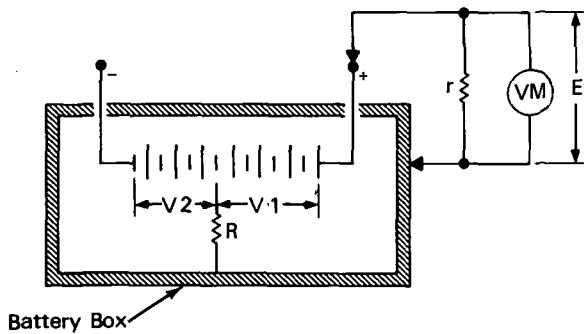
Though a pulse duration modulation (PDM) system was used in the test case, the technique should be applicable to pulse amplitude modulation (PAM) or other modulation systems.

Source: O. Rosenes and W. Altemouse of Republic Aviation Corp. under contract to Langley Research Center (LAR-182)

No further documentation is available.

MEASURING BATTERY CHARGE LEAKAGE

A technique for safely and accurately determining the leakage resistance in an activated battery is shown in the illustration. A low-impedance voltmeter is grounded to the battery case



and connected alternately to the two battery terminals. Given the parameters,

- R = leakage resistance between one battery cell and the battery box
- E = open circuit battery output voltage (terminal voltage)
- r = measuring resistor with a value $\ll R$
- n = cell number (counting from the negative terminal)
- N = total number of battery cells

V_1 = absolute value of the voltage measured between the positive battery terminal and the battery case

V_2 = absolute value of the voltage measured between the negative battery terminal and the case,

the leakage resistance R, and its position, n, within the battery can be computed from the equations:

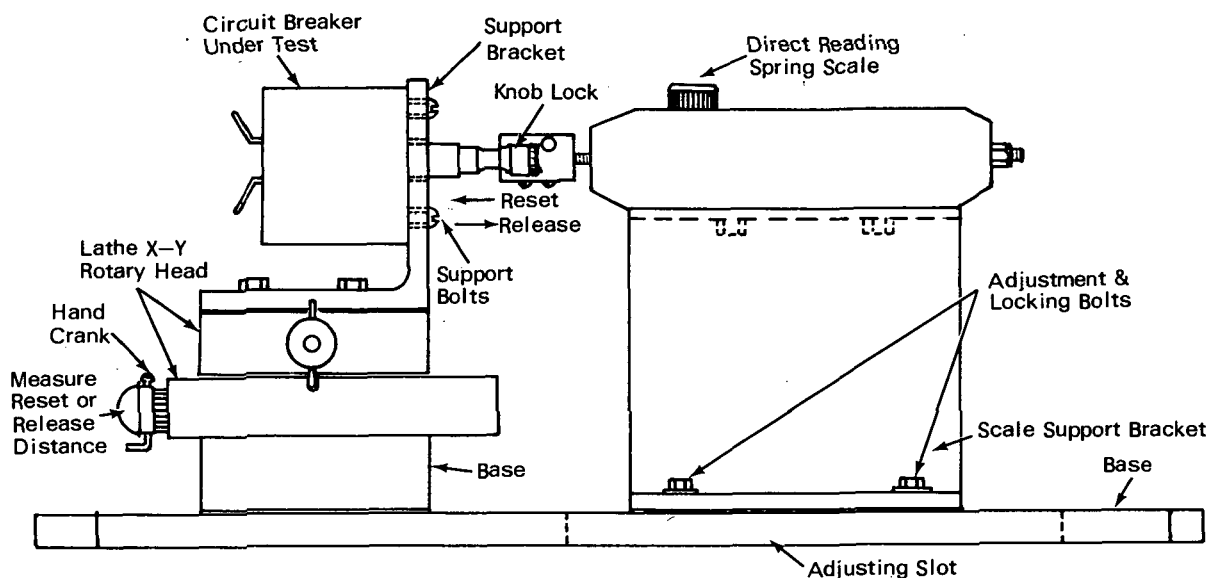
$$R = \frac{r E}{V_1 + V_2} \quad \text{and} \quad n = \frac{N V_2}{V_1 + V_2}$$

Prior methods for measuring leakage resistance used microammeters, high-impedance voltmeters, or ohmmeters. Since the high values of leakage resistance are accompanied by minute currents and voltages, the meters used had to be extremely sensitive. Such meters, however, were also highly susceptible to ambient electromagnetic fields, which could cause incorrect meter readings.

Source: G. Hano and H. G. Solewin of IBM Corp. under contract to Marshall Space Flight Center (MFS-14689)

No further documentation is available.

MEASURING SET/RELEASE PRESSURE AND TRAVEL OF A CIRCUIT BREAKER



A test device for measuring circuit breaker plunger travel and actuation pressure uses a direct-reading gage to record the forces necessary to set or release the circuit breaker. The apparatus (see fig.) is assembled in two sections. The first is a standard lathe X-Y rotary head, onto which the circuit breaker is mounted via an L-bracket. The other is a direct-reading spring scale mounted on a supporting bracket at the same height as the circuit breaker's pushbutton. Locking bolts clamp the scale against the pushbutton, and the

hand crank is used to press the button against the scale. Actuation pressure is read from the spring scale, and travel distance is read from a scale at the crank.

Source: J. N. Jenkins of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15630)

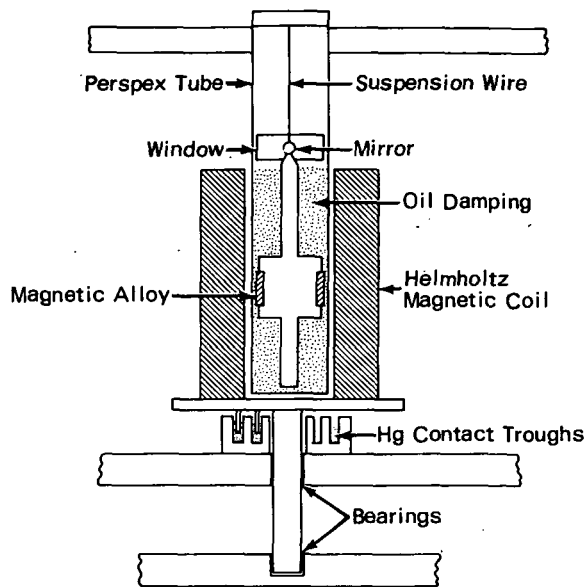
No further documentation is available.

TORQUE METER AIDS STUDY OF HYSTERESIS-MOTOR RINGS

The illustrated hysteresis torque meter simulates the operation of a high-speed hysteresis motor. This allows the performance characteristics of candidate rotor-ring materials to be analyzed, without actually building and testing a hysteresis motor. The meter determines the motor torque, monitors the actual stress in the ring, aids in the study of asymmetries or defects in rotor rings, and measures rotational hysteresis. In the slowly rotating magnetic field made possible with this instrument, the dependence of torque on the position of the field relative to the ring

can be examined, and the effect of discontinuities or directional properties can be measured.

The hysteresis torque meter is based on the principle that the torque exerted on the rotor ring of a hysteresis motor is very small when it is operating near synchronous speed. Such a motor may be spinning at 25,000 rpm, but the applied field will be rotating relative to the ring and at only a few rpm out of synchronism. Therefore, the meter simulates motor operation by slowly rotating a magnetic field around a ring held stationary by an elastic suspension.



In the meter shown, a rotor ring is held in a brass clamp. The clamp, hung from a fixed post on a tungsten wire, has a mirror cemented on the top. The whole suspension is inside a Perspex

tube, immersed in a damping oil. A pair of Helmholtz magnetic coils, 11.5 cm in diameter, is capable of generating a field of 6,050 A/m (76 oersteds). Contact to the coils is made through mercury-filled troughs, and the coil platform is rotated by a belt-drive from a 5 rpm motor.

The rotor ring is held horizontally at the center of the magnetic field while the Helmholtz coils rotate at 1 to 10 rpm. The torque exerted on the specimen is measured by the angular deflection of a light beam reflected from the mirror on the suspension wire. The light beam is 200 cm long, giving a deflection of 200 mm for 124 dyne-cm of torque. When the torque measurements at various speeds are extrapolated to zero speed, the synchronous torque of the motor can be measured and the ring properties can be assessed.

Source: M. Cole of Metals Research Ltd.

under contract to
Marshall Space Flight Center
(MFS-12219)

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RECOMMENDED OPERATING TORQUES FOR ROTARY CONTROLS

Maximum and minimum operating torque standards for rotary selector switches and control knobs have been compiled. Tests were conducted with various sized hands, both bare and gloved, on recessed rotary selector-bar knobs and on non-recessed cylindrical knobs, both smooth-surfaced and knurled.

The recommendations are useful as human engineering requirements in designing control panels where visibility at low sight angles is important.

The results indicate that: (1) maximum torque transmission capability increases monotonically with diameter for controls of any given configuration; (2) for recessed bar knobs, torque transmission is significantly better for the 4.45 cm (1.75 in.) size than for the 3.81 cm (1.50 in.)

size; (3) for knobs up to about 5 cm (2 in.) in diameter, knurled cylindrical knobs show the highest torque capability; (4) for larger diameters, recessed bar knobs show the greatest torqueability; (5) the maximum torque exerted on smooth-surfaced cylindrical knobs is greater for the gloved hand than for the bare hand; (6) the recommended operating torque for recessed bar knobs is approximately one-half the maximum torque capability.

Source: J. A. Roebuck, Jr., of North American Rockwell, Inc.

under contract to
Manned Spacecraft Center
(MSC-90566 & 90569)

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DC MOTOR COMMUTATING BRUSHES TESTED IN DRY ARGON ATMOSPHERE

Tests to determine the most suitable material for use as commutator brushes for special purpose manipulator drive motors were performed by operating the motors in an enclosure containing an atmosphere of high-purity argon. A gas-purification system was used to control the moisture and oxygen contents of the enclosure. Brushes were supplied by three vendors on the basis of their brush-grade recommendations for use in dry atmospheres.

The tests resulted in the selection of a brush material that is being used successfully in manipulator-drive motors. Similar brushes have also been installed in other dc motors used in processing equipment undergoing test in argon atmospheres. The same material has been employed in universal motors used in vacuum cleaners and hand-drill units working in argon atmospheres; here, the material has greatly increased the life of motors with high commutator peripheral speeds.

One such vacuum-cleaner motor ran for only about 15 min in a dry argon atmosphere on the brushes provided with the unit; the brushes had then worn completely down and caused short-circuiting of the armature commutator. However, an identical motor with brushes made from the new material, has now been in heavy use for about 1 year in a similar atmosphere. The new brushes still wear faster than in normal-humidity atmospheres, but at a reasonable rate that can be tolerated. Limited tests show promise for other grades of brushes in low-impurity atmospheres.

Source: M. A. Slawecki, G. J. Bernstein,
and L. F. Coleman
Argonne National Laboratory
(ARG-10243)

Circle 14 on Reader Service Card.

MICROPHONE CALIBRATION AT HIGH SOUND PRESSURES

A coupling device for accurately calibrating microphones at high sound intensities employs a liquid as the coupling medium. Air is not a suitable medium because of its inherent nonlinearity at high sound intensities. With the liquid coupling device, microphones can be calibrated at sound intensities from 110 to 175 dB (referred to a pressure of 2×10^{-4} dyne/cm²) in the frequency range from 16 Hz to 10 kHz.

The device incorporates a small liquid-filled cavity driven at one end by a cylindrical stack of electrically excited piezoelectric disks and a piston with an effective diameter of 3.8 cm. The cavity, in the shape of a rectangular prism at one end and a conical frustum at the other, has an overall volume of approximately 19.6 cc. An ac voltage applied across the faces of each disk sets the composite piston into mechanical vibration over a displacement amplitude required to

produce the desired sound level. Motion of the sealed piston against a diaphragm tends to compress the liquid in the cavity, thereby producing relatively high calibration pressures for small displacements. These pressures vary proportionally to the displacement of the piston. Needle valves in the device isolate the flow of liquid to and from the cavity and also to and from a pressure gage, which is used to set the sound level. The needle valves have a built-in safety adjustment which protects the microphones from excessive pressures.

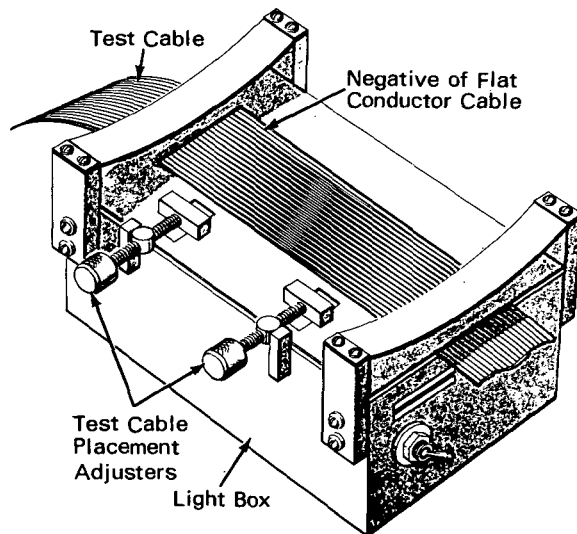
Source: A. Gillen of
Gulton Industries, Inc.
under contract to
Marshall Space Flight Center
(MFS-11980)

Circle 15 on Reader Service Card.

Section 3. Testing Cables and Connectors

MOIRE PATTERN USED TO CHECK FLAT CONDUCTOR CABLE SPACING

The moire tester shown in the drawing can quickly detect small variations in flat conductor



cable (FCC) spacing by comparing the cable to be tested with the negative of a very precise

standard cable. The standard negative is mounted on top of a box containing a light source and a diffuser plate for uniform illumination. The test cable is aligned in parallel with the standard cable negative so that the conductors cover the openings of the standard negative; no light should be visible. Any imperfection in conductor width or spacing will form small cracks between the negative and the test cable lines.

A moire pattern can be formed by placing the test cable on a slight angle to the standard negative. This pattern consists of alternate light and dark bands, the irregularities in which can be interpreted to reveal errors in spacing. A cable angle of one degree will amplify the spacing error 114 times.

Source: W. Angele
Marshall Space Flight Center
(MFS-20426)

No further documentation is available.

EXPERIMENTAL PREDICTION OF SUPERCONDUCTING-CABLE PERFORMANCE

A "broken superconductor" method of short-sample testing can be used to predict the performance of well-cooled, stabilized, superconducting cable coils. It yields a field-versus-current curve for a short sample of cable with a length of superconductor removed from its middle.

The broken-superconductor method of testing permits separating the performance characteristics of the superconductor and copper constituents of a stabilized cable. The break in the superconductor is, in effect, an artificially induced steady-state normal region that forces complete transfer of current into the stabilizing copper in the region of the break. Potential taps

are placed at the ends of a superconducting section of cable and, as current through the sample is increased, a potential appears across these taps. The current observed is the maximum superconducting current at a given field.

As current through the sample is increased further, current is shared between the superconductor and the stabilized copper. At sufficiently high current, the heat generated in the copper is greater than that which can be carried away by nucleate boiling of a helium bath, so that the heat-transfer characteristic changes from nucleate boiling to film boiling, and the temperature difference between the copper and the helium

changes from about 0.3 K to about 5 K. This rise in temperature causes all the current to transfer from the superconductor into the copper, and thermal runaway results. The characteristics of the copper are obtained by plotting the thermal-runaway point as a function of field strength.

Source: J. R. Purcell and J. M. Brooks
Argonne National Laboratory
(ARG-10215)

Circle 16 on Reader Service Card.

MEASURING INSULATION MECHANICAL FAILURE RATES

A novel cut-through tester can accurately measure the failure rate of various wire and cable insulating materials as functions of time and cutting pressure. The tester consists of the following bench mounted components: a counterweighted beam on which the penetrator is mounted; an elapsed-time indicator; a mercury reservoir connected by valved tubing to a receiver that rides on the outboard end of the beam; and associated electronics.

During operation, an insulated sample is placed beneath the penetrator and the valve in the mercury line is opened. As the mercury flows into the receiver, the beam pivots, bringing the penetrator

into contact with the insulation under test and starting the timer. When the penetrator cuts through, the associated electronic circuitry simultaneously stops the timer and closes the mercury valve. The weight of mercury in the receiver, related to the elapsed time, indicates the resistance of the specific tested insulation to sharp objects.

Source: E. U. Baker of
Douglas Aircraft Co.
under contract to
Marshall Space Flight Center
(MFS-12506)

Circle 17 on Reader Service Card.

CABLE INSULATION RESISTANCE TESTER

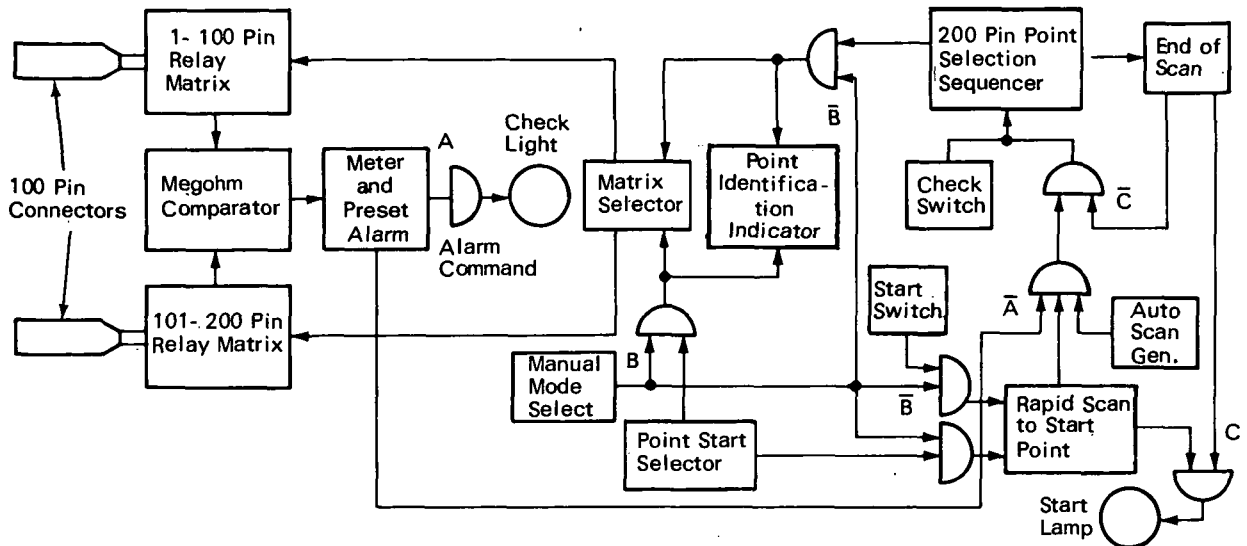
A switching unit can greatly simplify the job of checking the insulation resistance between individual leads in a multiconductor cable. The circuit contains an array of double-throw, spring-return switches, whose movable contacts are wired to individual pins in the cable connector, and whose fixed contacts are wired in parallel for connection to a megohmmeter. In their normal position, all switches connect the negative megohmmeter lead to the cable conductors. When a switch is operated, the positive megohmmeter lead is applied to a single cable conductor, and the meter registers the total (parallel)

insulation resistance between that conductor and all others in the cable. Use of the switching unit greatly speeds the job of checking insulation resistance, particularly in large cables, and averts possible damage to the cable connector due to insertion of meter leads directly into the connector.

Source: G. W. Waite of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16951)

No further documentation is available.

TESTER AUTOMATICALLY CHECKS INSULATION IN MULTICONDUCTOR CABLES



An automatic cable insulation tester can quickly check the insulation of each conductor in a multiple-strand cable containing up to 200 conductors. The tester consists of two relay matrices, a combination megohm and low-alarm comparator, and associated readout and control systems. The comparator contains a regulated power supply with outputs of 10, 50, and 500 Vdc, a decade set of precision resistors, and a transistorized meter amplifier. An optical meter relay performs the functions of resistance value readout and alarm.

The tester operates by sequentially measuring the resistance between each pin and all other pins, which are grounded. If the measured resistance

falls below a preset value, the sequence is stopped by the comparator at the alarm point, a lamp in the check switch is lighted, and the point identification indicator displays the pin number in question. When the start switch is depressed, the comparison sequence continues.

Source: M. Vuckovich and J. Shaw of Westinghouse Astronuclear Laboratory under contract to Space Nuclear Systems Office (NUC-10068)

Circle 18 on Reader Service Card.

SHIELDED CABLE TESTER

An ac signal generator and an ac ammeter rapidly verify the wiring of multiconductor, shielded-group cables. The generator is connected to one conductor and grounded to a shield. The ammeter is connected from ground to another conductor, to measure the leakage current. This current is caused mainly by capacitive coupling of the two leads and of each lead with the shield. Because the interlead capacitance is significant when both are in the same shield group,

and negligible when one lead is outside the group, the measured current will be greater when both leads are within the same shield.

Source: G. Dibbs and K. E. Priestman of General Electric Co. under contract to NASA Headquarters (HQN-10102)

Circle 19 on Reader Service Card.

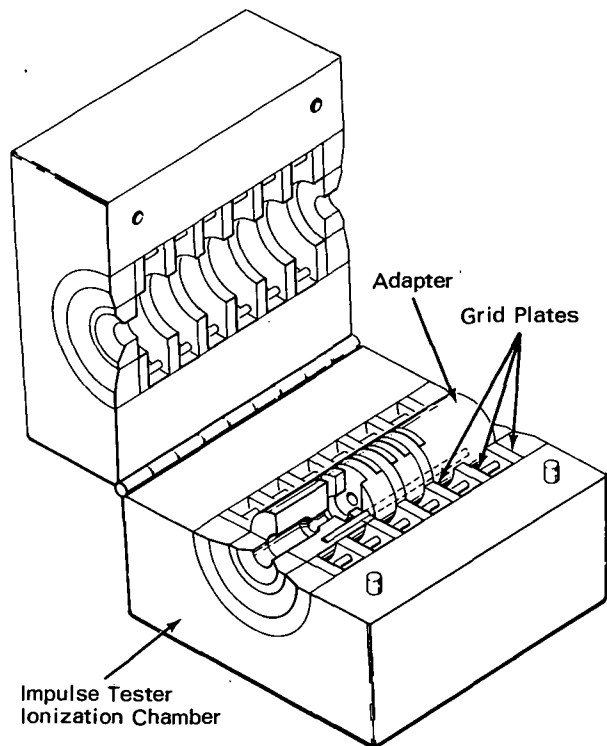
GRID PLATE ADAPTER FOR WIRE TESTER

A modification to a standard impulse tester ionization chamber used for verifying electric wire insulation lessens degradation of the wire insulation by using shorter exposure time and a lower test voltage.

Standard impulse testers with seven grid plates are designed for use in high-speed wire manufacturing runs. Under such conditions, the wire is pulled through the ionization chamber with sufficient tension to maintain concentricity, and with sufficient speed to keep the high voltage exposure time for each length of wire relatively low.

However, wire is often tested by the user at a much slower speed, with frequent stops for marking and cutting operations. During such stops, the wire in the ionization chamber is exposed to high voltages for overly long periods.

The modified grid plate chamber shown in the figure reduces the incidence of insulation failure due to stoppages during testing and to loss of concentricity between the grid plates and the wire. First, the large orifice of the standard tester (about 1.25 cm) has been reduced to less than 0.5 cm. Second, the number of plates has been reduced from seven to three. Finally, because of the smaller orifice, a lower test voltage is used.



Source: M. A. Vanasse of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15198)

Circle 20 on Reader Service Card.

MEASURING TENSILE LOADS INDUCED IN CONNECTOR PINS BY CABLE BENDING

Another electrical connector test is performed by the illustrated test fixture, which measures the longitudinal tensile loads induced in electrical connector pins by wire or cable bending. The essential parts of the fixture, and their associated functions, are as follows:

1. Tensile load sensing elements (strain gages), mounted between each connector pin and the device structure, to measure the induced load in each pin.
2. A mobile cable loading assembly, attached to the movable end of the test specimen, to

apply a known constant load along the longitudinal axis of the cable.

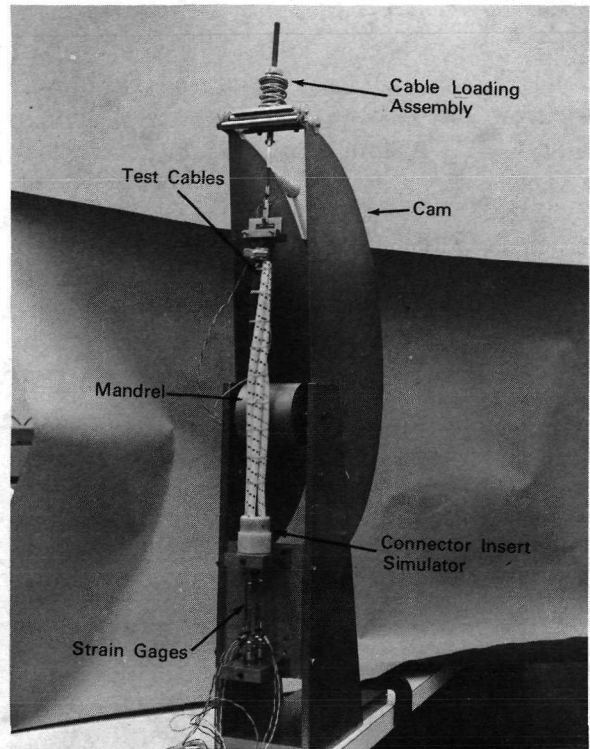
3. A mandrel, to govern the cable bend radius.
4. A cam, around which the mobile loading element traverses, to bend the cable around the mandrel.
5. A connector insert simulator, to accommodate the required connector pin spacing and prevent lateral movement of the pins during specimen bending.

The cable is mounted in the device with its longitudinal axis perpendicular to the mandrel

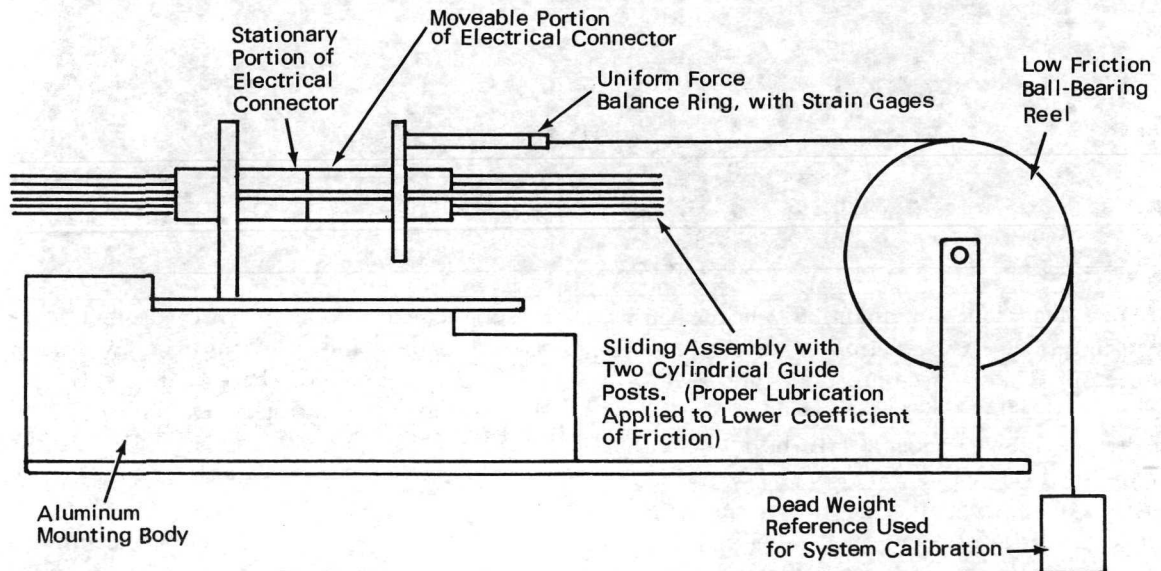
axis and its surface tangent to the mandrel. The wires to which connector pins have been attached are inserted into the connector insert simulator, and each pin is then attached to one end of a strain gage. The other end of the gage is connected to the device structure. A clamp is attached to the free end of the cable and connected to the loading assembly by means of a pin joint. After a specified axial load is applied to the specimen, the loading assembly and the free end of the specimen are moved in an arc around the cam, thus bending the specimen around the mandrel. While the specimen is being bent, forces induced in the strain gages are continuously monitored, and plots of induced tensile load versus degree of bend are made.

Source: F. M. Torre of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-14577)

No further documentation is available.



MEASURING THE CONNECT/DISCONNECT FORCES OF AN ELECTRICAL CONNECTOR



A test fixture easily and conveniently measures the forces needed to mate or separate electrical connectors, and verifies acceptable maximum

and minimum force levels. It may be used in quality assurance programs wherever connector mating forces may be critical.

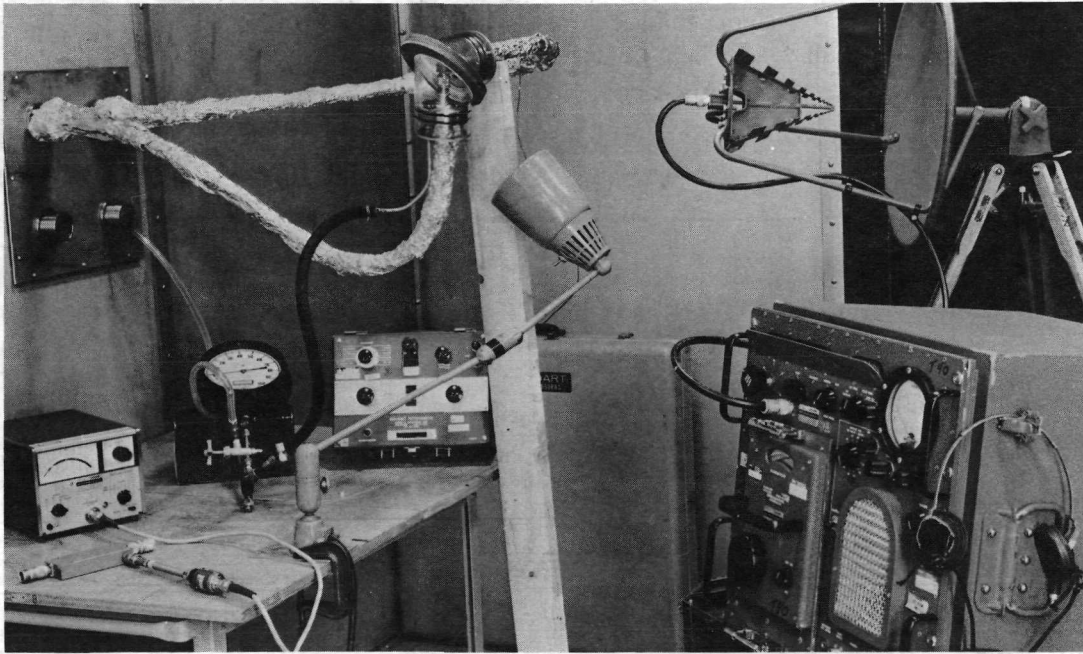
The fixture shown in the illustration is assembled on a rectangular base. It consists of a solid aluminum block, on one end of which is mounted a connector and strain gage support bracket. On the opposite end, a large diameter reel is mounted to a low friction bearing and a reel support stand. A flexible steel cable is joined to the strain gage ring with a standard weight suspended from the reel on the opposite end. The weight establishes a strain on the gage, which is part of an electrical bridge circuit. Any unbalance in the bridge creates an error

signal which may be recorded and interpreted as a deflection proportional to weight. Thus, a means is established for recording the dynamic forces applied to the connectors during engagement and disengagement.

Source: R. D. Clemente of
North American Rockwell, Inc.
under contract to
Marshall Space Flight Center
(MFS-13163)

No further documentation is available.

MEASURING RF LEAKAGE FROM COAXIAL CONNECTORS



A new technique for quantitatively measuring the electromagnetic radiation from RF coaxial connectors is more accurate than the previously used coaxial cylinder or untuned cavity techniques. Further, it allows connectors to be tested under varying environmental conditions. The technique consists of placing the connector in a glass enclosure made from annealed borosilicate glass and sealed at both ends to allow evacuation. (A special enclosure made to contain right angle connectors appears in the illustration.) RF power

is supplied to the connector through shielded coaxial cables and is monitored by means of a directional coupler. The actual radiated power is measured with conventional apparatus.

Source: P. W. Edwards of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11170)

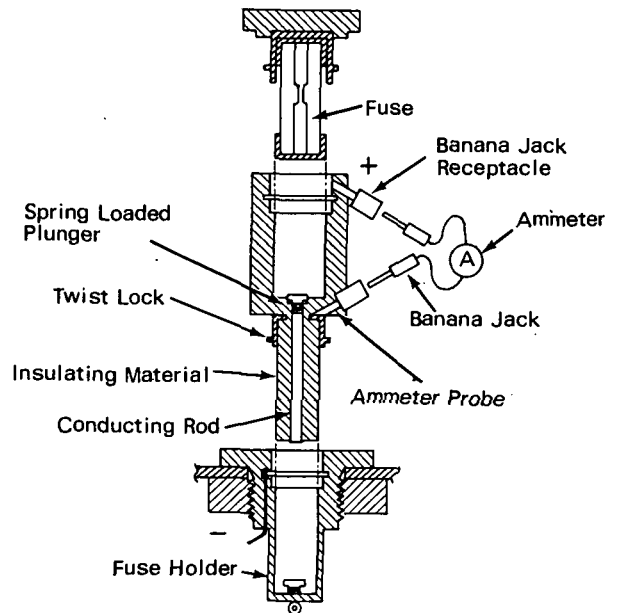
Circle 21 on Reader Service Card.

FUSE-HOLDER ADAPTER FOR AMMETER PROBE

The illustration shows an adapter, made to fit conventional electronic fuse holders, that allows current readings to be made without disconnecting wiring and without losing the protection provided by the fuse. The adapter is essentially a fuse extender, i.e., a fuse holder equipped with jacks for the insertion of meter leads and fitted with an insulated connecting rod the same length as the fuse.

For use, the fuse is removed from the holder and the adapter inserted. Then the fuse is inserted into the adapter and the ammeter leads connected as shown to complete the circuit.

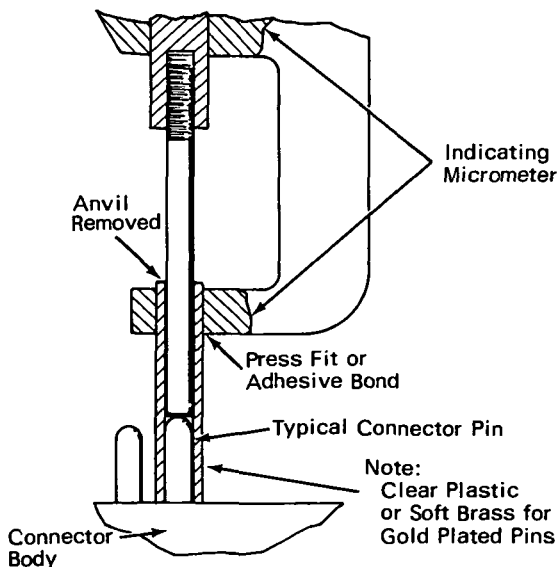
Source: R. L. Riley of The Boeing Co. under contract to Kennedy Space Center (KSC-10187)



Circle 22 on Reader Service Card.

MEASURING THE LENGTH OF ELECTRICAL CONNECTOR PINS

A simple modification to the measuring probe of a micrometer gage allows the length and insertion depth of electrical connector pins to be



accurately measured. As shown in the illustration, the modified instrument has a thin-walled, small-diameter, cylindrical tube attached to the instrument body in place of the anvil that normally limits the gage's travel. The tube's internal diameter is somewhat larger than that of a standard connector pin, while the wall thickness is less than the spacing between pins. A small-diameter pin is attached to the micrometer shaft and passed through the tube. The pin is long enough that its end lies at the end of the tube when the micrometer registers zero. The tube may then be placed over a connector pin and the height of the pin above the connector base measured.

Source: A. W. Patterson and D. G. Rohrdanz, Jr., of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-17068)

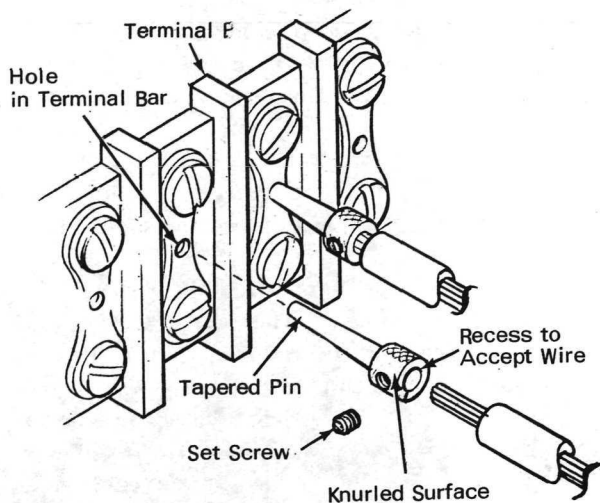
No further documentation is available.

QUICK-CONNECT DEVICE FOR MONITORING SIGNAL ON BARRIER-TYPE TERMINAL STRIPS

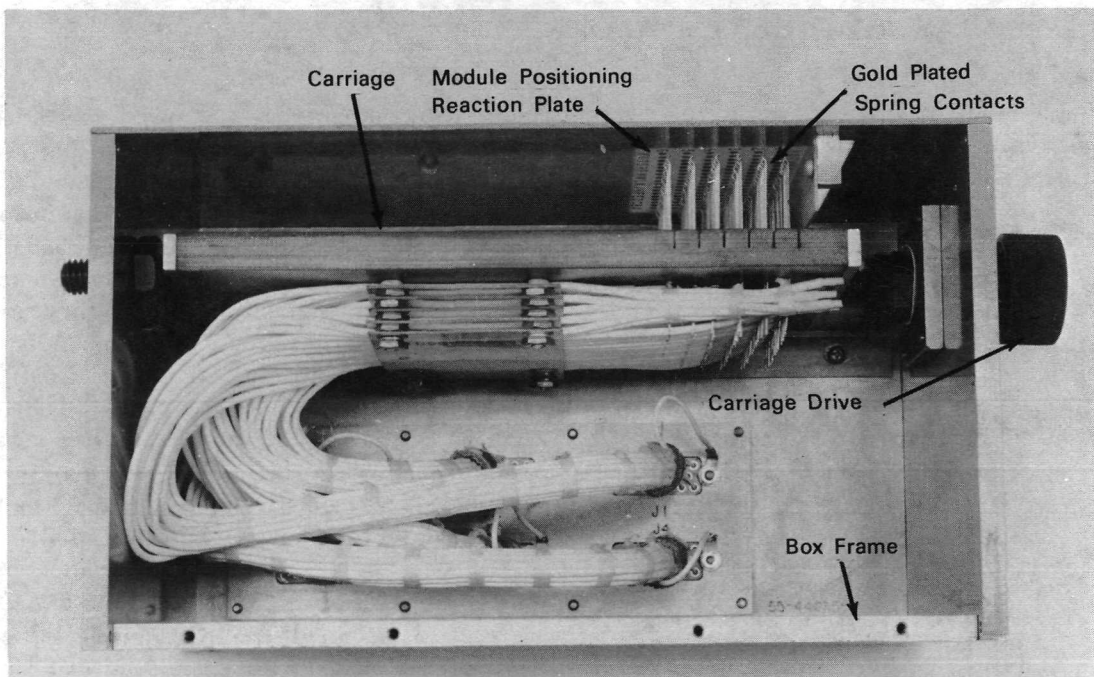
The illustration shows a modified barrier-type terminal-strip to which monitor leads may be easily attached. Holes are bored in the center of each strip midway between the screws, and test leads are terminated with tapered pins. These are then press fit into the holes with sufficient force to hold the test leads securely while measurements are made.

Source: R. J. Unger of
North American Rockwell Corp.
Marshall Space Flight Center
(MFS-18349)

No further documentation is available.



TEST DEVICE PREVENTS WELD-JOINT DAMAGE ON UNPOTTED MODULES



A device for testing unpotted electronic modules while preventing weld joint damage makes electrical connections to pins on unpotted modules without introducing any axial or displacement forces on the pins. The pins are spaced in a pot-

ting header, but are free to slide in and out except for the restraint from welded wire joints. The device consists of a box frame, a carriage with gold-plated, phosphor-bronze contact springs, a module-positioning reaction plate, a carriage

drive, stops, wiring, and miscellaneous hardware.

The carriage holds the contact springs in a matrix identical to the module pin matrix and the positioning plate matrix. With the carriage in the retracted position, the springs are completely clear of the positioning plate holes. The holes are slightly larger than the unpotted module pins; thus, the pins may enter without force.

Advancing the carriage with the drive screw brings the springs into contact with the pins immediately below the positioning plate, preventing the module pins from moving away. A mechanical stop prevents carriage overtravel and

allows a controlled spring pressure to be exerted on the module pins. The position of the contact springs allows testing of unpotted modules with pins extending only 0.65 cm (0.25 in.) or modules with pins up to 2.54 cm (1.0 in.) in length.

Source: R. E. Cree of
General Dynamics/Convair
under contract to
Lewis Research Center
(LEW-10201)

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