NASA SP-5931 (02)

TECHNOLOGY UTILIZATION

TESTING METHODS AND TECHNIQUES

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 dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This Compilation of Testing Methods and Techniques has been divided into four categories: (1) Mechanical Testing Techniques, (2) Electrical and Electronics Testing Techniques, (3) Thermal Testing Techniques, and (4) Optical Testing Techniques.

In general, the Compilation items are moderately complex and appeal to the applications engineer. However, selection criteria were such that the items reflect fundamental design principles and applications, with the additional requirement of simplicity whenever possible.

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

The latest patent information available at the final preparation of this Compilation is presented on the page following the last article in the text. For those innovations on which NASA and AEC have decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

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

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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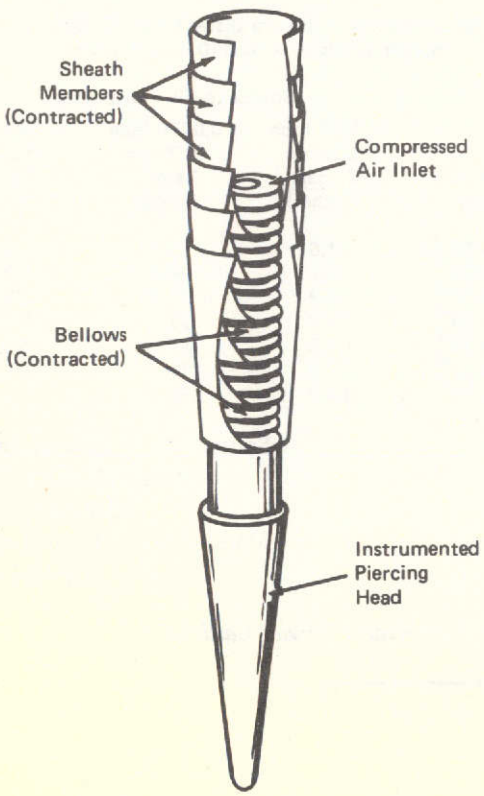
Contents

Section 1. Mechanical Testing Techniques

EXTENDABLE MAST USED IN ONE-SHOT SOIL PENETROMETER

To make a quick test of soil characteristics, the testing apparatus must be easily set up with a minimum of supporting equipment.



Extendable Mask for Soil Penetrometer

An extendable mast (see figure) was developed to be used with a soil penetrometer. As the mast pushes the piercing head through the soil or mud being tested, the penetrometer will give a continuous measurement of soil characteristics.

The mast consists of a bellows and a telescoping concentric sheath. The bellows is expanded by compressed air from an external source through the base inlet. As the bellows receives compressed air, the sheath telescopes out. By virtue of its overlapping elements, the sheath directs the expansion of the bellows and guides the piercing head through soil or mud. The entire bellows is extended beyond its elastic limit by the compressed air. The reaction of the penetrometer may be taken against a simple foldable platform held down with rocks or soil.

Tests have indicated an expanded length of the bellows to as great as 50 times the original compressed length.

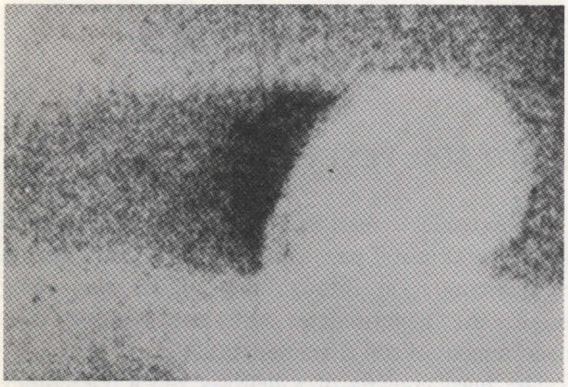
The expandable mast can have varied applications. It can be used as an anchoring device, as a portable antenna, and as a tool for oceanographic study. The mast is simple to fabricate and to use. It requires only a supply of compressed air for extension and is therefore portable.

Source: E. A. Howard and G. M. Hotz
Jet Propulsion Laboratory
(JPL-00685)

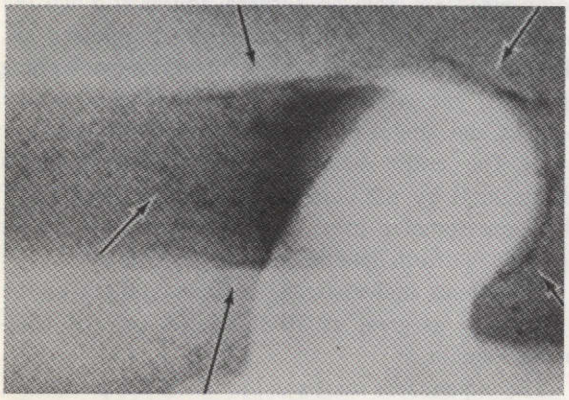
Circle 1 on Reader Service Card.

NONDESTRUCTIVE TEST FOR FINE CRACKS AND POROSITY IN SOLDER JOINTS

A high-resolution radiographic X-ray technique permits nondestructive testing of solder joints. The process enables detection of porosity on the order of 0.001 inch (0.025 mm) in diameter and cracks that are even smaller in width. The technique is applicable to the inspection of electronic components, small mechanical devices, multilayer board assemblies, flex harnesses, small motors, and timing devices.



Standard Radiograph 75X



High-Resolution X-Ray 75X

Comparison showing relative resolution achieved on the same solder joint with the same X-ray source employing the standard and the high-resolution processes.

High-resolution X-ray testing requires: (1) a small X-ray target source (0.7 mm or smaller), (2) high-resolution film, and (3) high-magnification enlargements (10X to 75X). The illustration shows a comparison of a high-resolution X-ray with a standard radiograph.

The recommended exposure distances are given in the table for detecting specifically sized defects, using a high-resolution X-ray with any one of three specific target sizes.

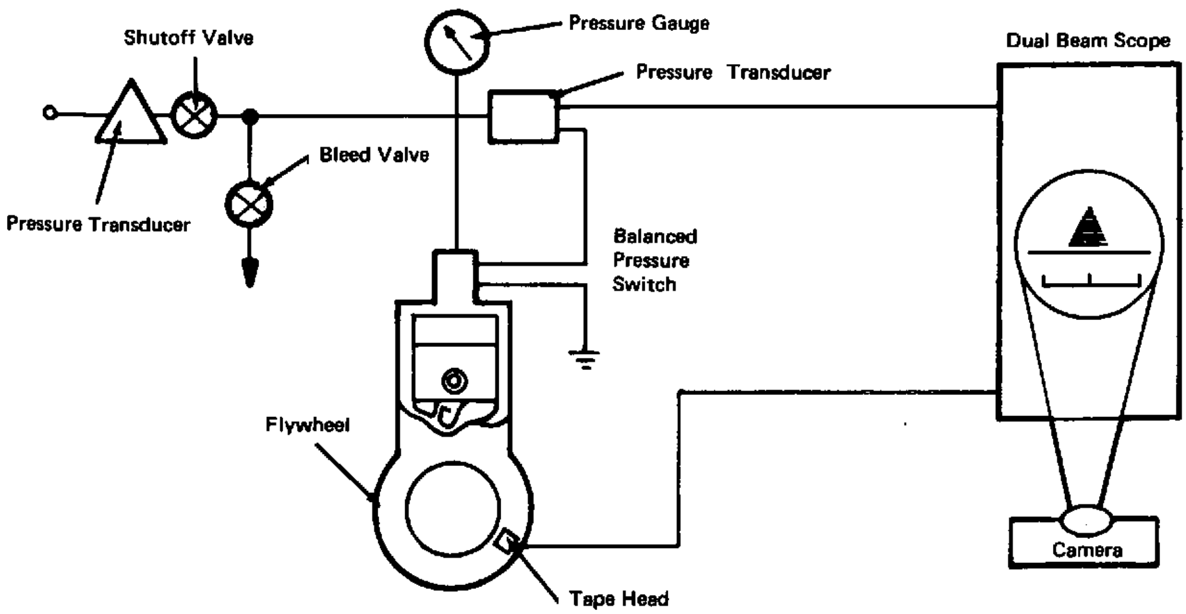
Recommended Exposure Distances for Defects in Solder Joints 0.02 Inch (0.5 mm) Thick

	Source-to-Film Distances		
Defect Size (inch)	0.0197 Inch (0.5-mm Target) (inches)	0.0276 Inch (0.7-mm Target) (inches)	0.059 Inch (1.5-mm Target) (inches)
1×10^{-3}	1.6	2.2	4.75
5×10^{-4}	3.15	4.4	9.5
2×10^{-4}	7.9	11.7	23.7
1×10^{-4}	15.8	22.1	47.3
5×10^{-5}	31.5	44.2	94.7
3×10^{-5}	52.5	73.6	
2.5×10^{-5}	63.0	88.3	

Source: W. R. Hutchinson of
Martin Marietta Corp.
under contract to
Marshall Space Flight Center
(MFS-21065)

Circle 2 on Reader Service Card.

INDICATOR SYSTEM PROVIDES COMPLETE DATA OF ENGINE CYLINDER PRESSURE VARIATION



Indicator System

Laboratory tests on high-speed internal combustion engines often require a rapid method of obtaining precise engine cylinder pressure data. The technique generally used employs a balanced pressure-diaphragm pickup, with a controlled reference pressure on one side and a cylinder pressure on the other. A history of cylinder pressure over a large number of cycles can be obtained by plotting many individual data points, to obtain a complete picture of the cyclic cylinder pressure variation.

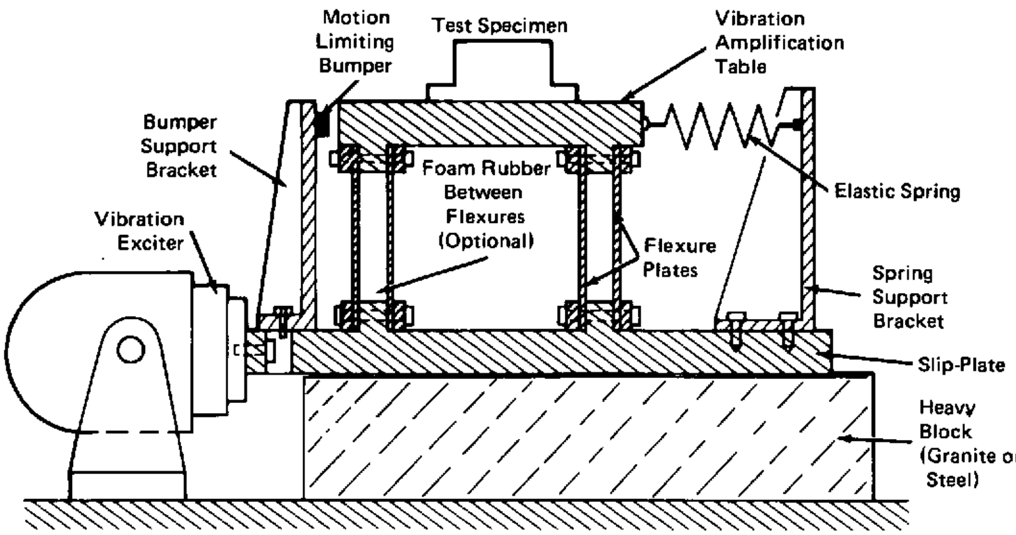
A practical alternative is to use a varying reference pressure, together with a balanced pressure pickup (a diaphragm switch), to switch the electric output of the pressure transducer in the reference pressure line (see figure). The magnitude of the cylinder pressure, as well as a crank angle at which the switch opens and closes, is displayed on a dual beam scope and is photographed. The other beam of the scope displays crank-angle position blips, which are picked up by a tape recorder head from a magnetic tape mounted on the engine flywheel.

The reference pressure side of the balanced pressure switch is initially pressurized to a level above peak cylinder pressure. The pressure is then allowed to decay at a controlled rate (with the engine running), while a time-exposure photograph of the oscillograph display is taken. The decaying reference pressure sequentially changes the crank-angle position at which the switch is activated and each succeeding data point is recorded. The resulting photograph consists of a series of horizontal lines whose extremities represent points of cylinder pressure equal to reference pressure. The envelope of this series of lines provides a pressure-time history of cylinder pressure over the number of cycles which occur while the camera shutter is open (usually about 2 seconds).

Source: R. W. McJones and N. E. Morgan of
Vickers Inc.
under contract to
Lewis Research Center
(LEW-00291)

Circle 3 on Reader Service Card.

VIBRATION AMPLIFICATION FIXTURE WITH LINEAR MOTION



Vibration Amplification Fixture Installed on Slip-Plate

An auxiliary fixture was developed, as shown in the figure, for use in vibration testing of specimens that are subjected to linear vibrations over a narrow frequency range at high amplitudes. This fixture permits linear motion of the test specimen without rotation, as would occur in a conventional cantilever beam fixture.

The fixture operates on the principle of resonance amplification. The assembly consists of the following components:

a. A table on which the test item is mounted;
b. A set of flex plates, having one end attached to the table;
c. A set of guides to enable linear table motion;
d. An amplitude limiting device, such as a rubber bumper, to prevent excessively high amplitudes and damage; and
e. A vibration exciter, or an exciter/slip table combination, which supplies the energy at the other end of the spring.

In a typical system, as illustrated, an amplifier table supports the specimen. A system of parallel flexure plates restrains the table, which is free to vibrate along one linear direction only, as shown. A layer of foam rubber may be used between each pair of flexures to dampen higher harmonics.

A slip-plate is driven to a desired amplitude by the vibration exciter. A heavy granite block, lubricated on its top surface, is used to guide the slip-plate. Other methods of guiding may be used, such as linear bearings.

The mass of the table and of the specimen represent the total effective mass of the system. Vibration is sustained by the flex-plates and an additional coil spring.

The spring constant K of the flex-plates is calculated as follows:

$$K = nE \frac{(h)^3}{(L)} b$$

where: n = number of flexures
E = modulus of elasticity of flexure material
L = unsupported length of flexure
h = thickness
b = width

For some tests, the flex-plates may be designed with the proper spring constant K, to provide near-resonant conditions with the specific test specimens. This, however, is not possible in every case, and an additional spring having constant K_2 can be included in the setup so that

$$K_{Required} = K_1 + K_2$$

where: $K_{Required} = (2 \pi f)^2$ m,

m being the effective mass of the system and fitting the resonant frequency.

The coil spring may be replaced with an adjustable spring to extend frequency range. A pneumatic spring is particularly advantageous in that its spring constant depends upon the pressure, which is easily adjustable.

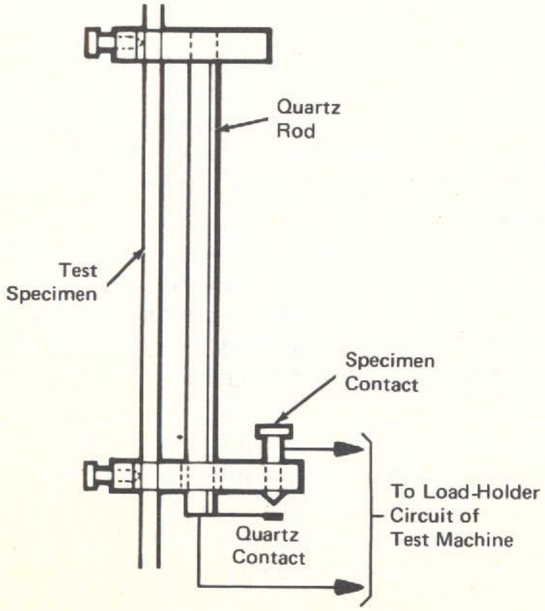
Another possible arrangement is to attach the system directly to the exciter, without using a support block.

Source: A. J. Yorgiadis, L. J. Allison, and A. J. Webber of Rockwell International Corp. under contract to Marshall Space Flight Center (MFS-24018)

Circle 4 on Reader Service Card.

MEASURING MECHANICAL STRAIN INDUCED BY THERMAL CONTRACTION

A new instrument measures mechanical strain resulting from thermal contraction. Previously, the specimen was installed in an environmental chamber which, in turn, was installed in a universal tensile-test machine. When the chamber was chilled, the test specimen contracted and the resultant load was indicated by the test machine. Because of the movement in the weighing mechanism of the test machine, it was necessary to adjust manually the load on the specimen to maintain a constant length. Error was inherent using this procedure, as the indicated load resulted not only from chilling the specimen, but from chilling the loading fixtures as well.



Mechanical Strain Measuring System

With this new instrument (see figure), a quartz rod is affixed to the test specimen. At a second point on the specimen, a known distance from the first point, an electrical contact is affixed. Another electrical contact is attached to the quartz rod. As the temperature lowers, the test specimen tends to contract, but the length of the quartz rod remains essentially constant. The electrical contacts are part of a circuit that automatically adds load to the specimen and keeps its length constant.

Source: W. G. Boyd and H. L. Pontious of Rockwell International Corp. under contract to Marshall Space Flight Center (MFS-24150)

Circle 5 on Reader Service Card.

GRIPPING TECHNIQUE FOR FIBER/MATRIX COMPOSITE TUBES

A tubular specimen for characterising fiber/matrix composite systems offers a distinct advantage. All of the loads (tension, compression, torsion, and internal or external pressure) required to characterize the mechanical properties of a composite system can be applied to a single tubular specimen. However, composite tubes are difficult to hold without the grip itself inducing failures.

A recently developed grip (see Figure 1) is simple, inexpensive, and holds the tubes without distorting the test results. Essentially, the tubes are held by potting the unreinforced tube ends into metal grips with an epoxy resin.

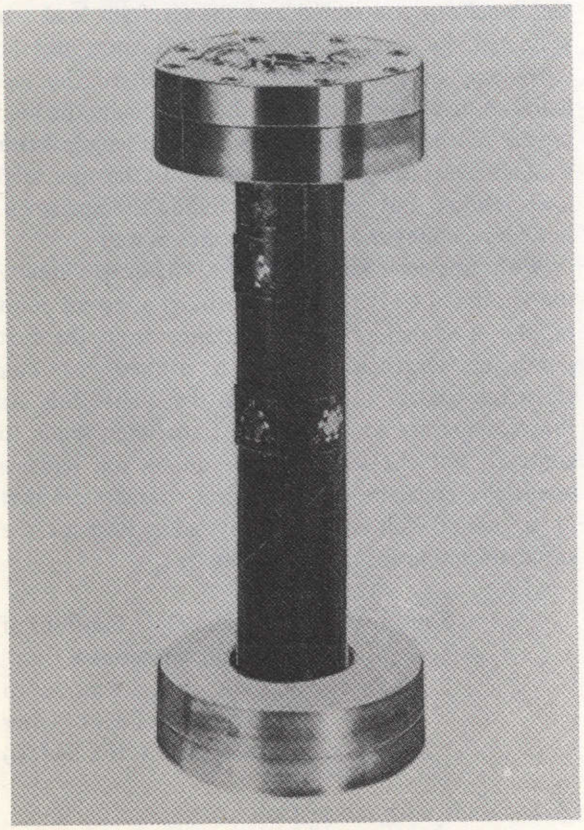


Figure 1. Instrumented Tube Mounted in Grips.

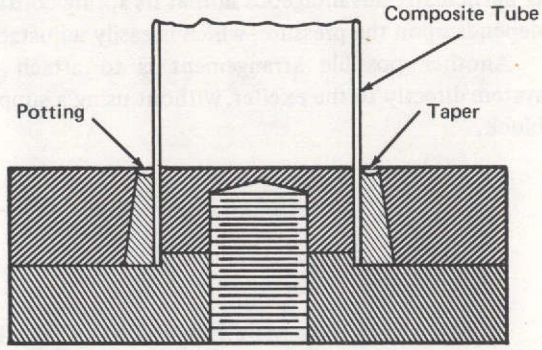


Figure 2. Tubular Specimen Grip Configuration

The grips are made in three parts; these are coated with a release agent for easy disassembly after a test. The outer portion of the grip is tapered, as illustrated in Figure 2, to apply additional gripping force when the tube is loaded in tension. The inner portion of the grip can also be slightly tapered, so that Poisson's contraction in the tube can take place unrestrictedly. Conversely, for compressive tests, the tubes can be potted on the inside, and the outer portion can be slightly tapered, to allow for Poisson's expansion.

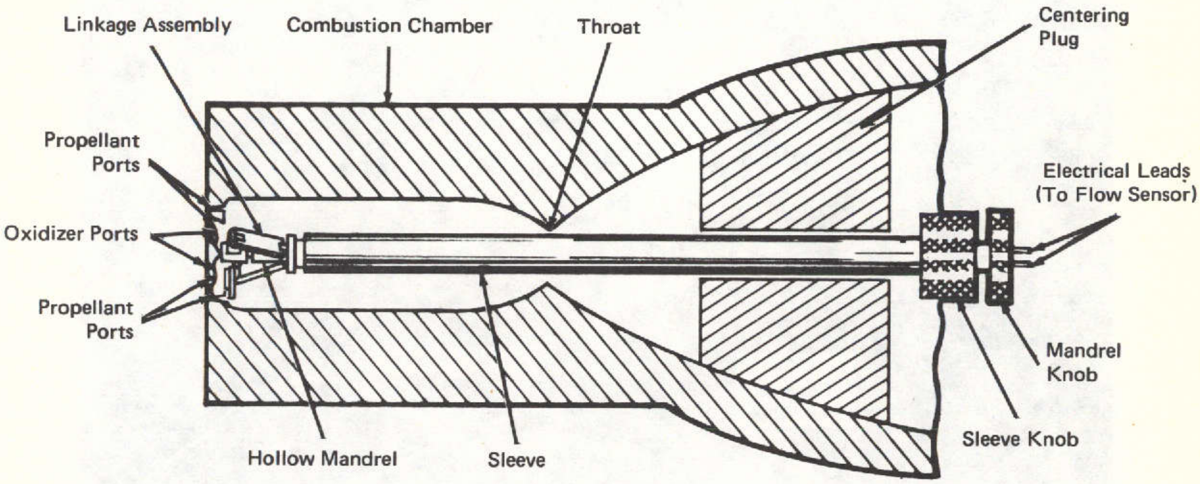
Using this gripping technique, tubes of high-modulus graphite/epoxy and high-strength glass/epoxy have been tested to failure in uniaxial tension. The gripping technique is presently being used to apply multiaxial loads to composite tubes.

The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $1.45)

Reference: NASA TM-X-68045 (N72-23583), Some Important Aspects in Testing High-Modulus Fiber Composite Tubes Designed for Multiaxial Loading

Source: T. L. Sullivan and C. C. Chamis
Lewis Research Center
(LEW-11798)

FLOW-TEST DEVICE FITS INTO RESTRICTED ACCESS PASSAGES



A new test device enables a fluid flow sensor to be properly positioned with respect to fluid (propellant and oxidizer) injector orifices, or ports. These are located at the end of a restricted passage in the combustion chamber of a rocket motor.

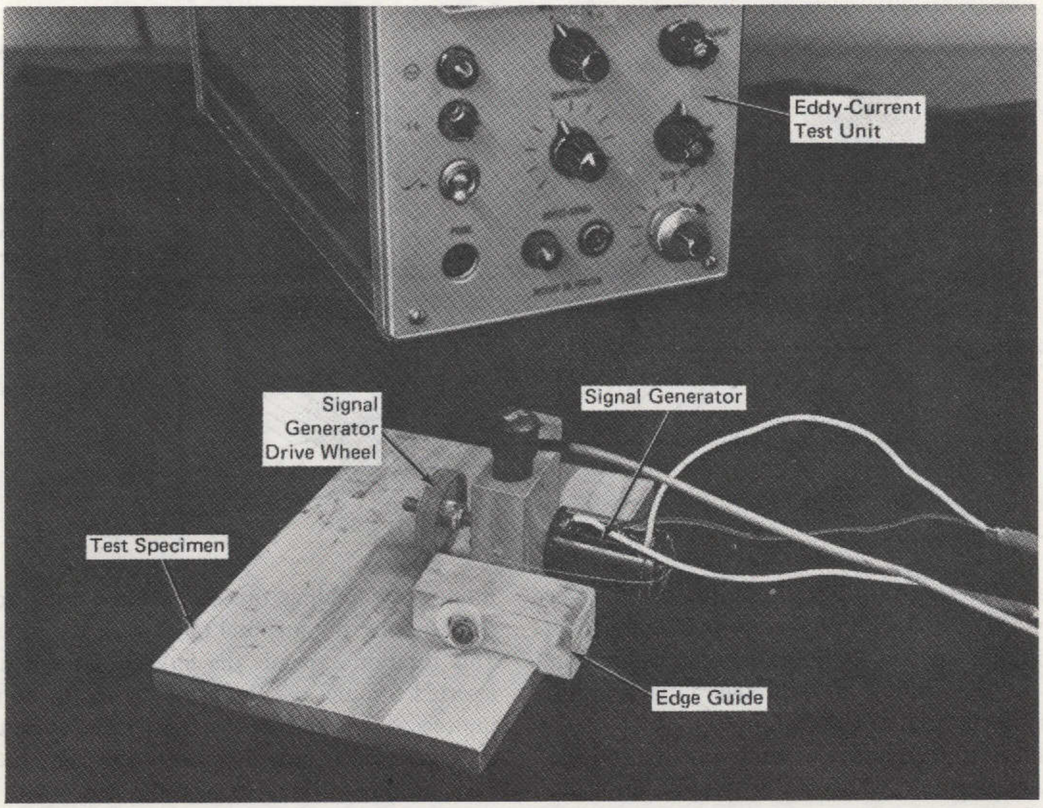
This device incorporates a mandrel with a collapsible linkage assembly, which can be inserted through a restricted passage (combustion chamber throat) and externally manipulated to position a fluid flow sensor (e.g., resistance thermometer) in proper relation to the flow port.

The collapsible linkage assembly (see figure), at the forward end of the hollow mandrel, carries three expandable support fingers uniformly spaced about the periphery of the mandrel. One of these fingers carries the flow sensor; the other fingers serve as means of support and positioning. The mandrel, threaded to the inner sleeve circumference, can be rotated by holding the sleeve knob with one hand and rotating the mandrel knob with the other hand. This rotation expands the linkage, after it has been inserted through the throat of the motor, to position the sensor over one of the flow ports. Once the flow in a particular port has been checked, the entire device can be rotated to align the sensor with each of the other ports, in sequence. To remove the device, the mandrel is rotated in the opposite direction, with respect to the sleeve, to collapse the linkage; then the device is easily withdrawn through the throat.

Source: B. J. Rosenbaum, M. Oberschmidt,
and J. J. Fitzgerald
Johnson Space Center
(MSC-01078)

Circle 6 on Reader Service Card.

NONDESTRUCTIVE STRUCTURAL CRACK DETECTION



Eddy Current Scanner Used to Locate Cracks in Test Specimen

A nondestructive determination of the existence and location of cracks in a ferrous structural part is made possible by the equipment shown in the figure. A portable eddy-current scanner is traversed manually over the surface of the specimen, while a wheel-driven signal generator is employed to provide position information along a guided line or path. The output consists of a series of curves on an X-Y plotter.

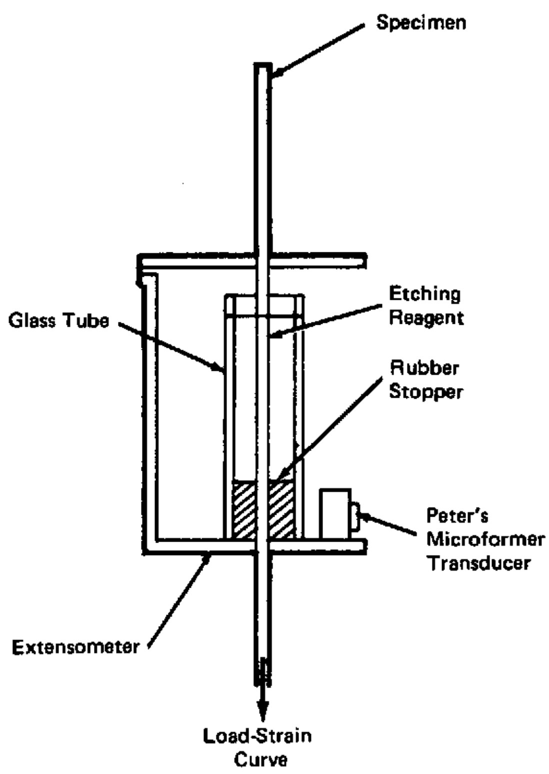
This technique offers greater resolution than was previously obtainable from other field inspection systems. It will detect near-side surface cracks over 0.025 mm (10 mils) deep. Even when located around bolt holes or other recessed structural configurations, cracks over 0.075 mm (30 mils) can be detected.

Source: F. Stuckenberg of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17455)

No further documentation is available.

DETERMINATION OF RESIDUAL STRAIN IN METAL-SHEATHED WIRE

A chemical etching technique can be used to remove the metallic sheath around a heater wire, in order to measure the residual strain on the wire. This measurement was needed for a complete heater appraisal by design engineers for the Apollo space project. A special type 321 stainless steel sheath-encased nichrome heater was fabricated for the CSM (Command and Service Module) liquid-oxygen storage tanks.



Test Setup

The device, developed to determine the residual strain in the sheathed wire, is a microformer transducer-type extensometer (see figure), which is attached to the outer sheath of the wire at two points defining a known gauge length. The sheath element is passed through a rubber-stoppered glass tube located between the attached points of the extensometer.

Loading grips are attached to the ends of the element outside of the extensometer, and the assembly is installed in a universal testing machine. The tube is then filled with a suitable reagent to remove chemically the stainless steel outer sheath. The residual strain in the inner wire element is automatically recorded on a strain recorder, as the reagent completely removes the sheath material.

The specimen is then loaded, to provide an autographic recording of tensile load versus strain. This graph supplies the data for determining elastic modulus, yield strength, and ultimate tensile strength. The elastic modulus data are used to calculate the residual strain (E_R) of the sheathed wire as follows:

$$E_R = \frac{\delta_R}{E}$$

where δ_R is the residual stress and E is the elastic modulus.

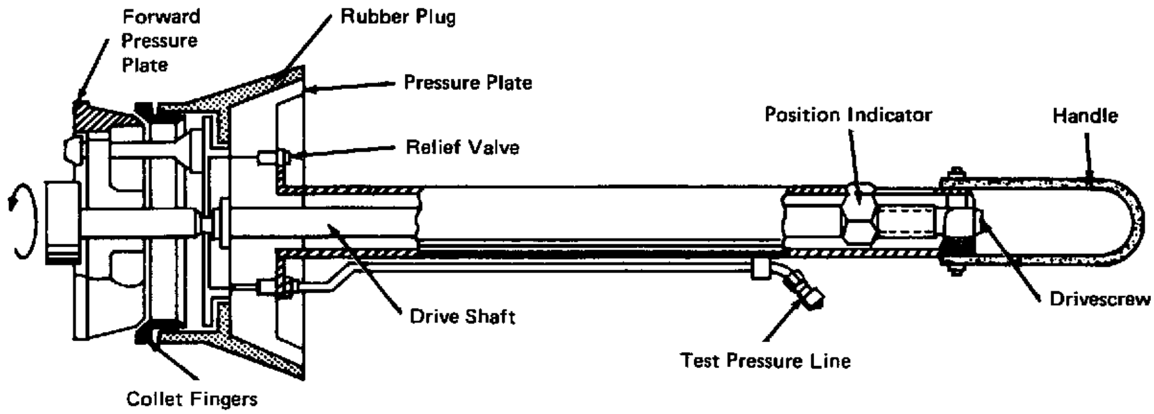
Residual stress = residual strain times elastic modulus

$$\delta_R = E_R \bullet E.$$

Source: J. C. Newland, J. Derbyshire, Jr.,
W. G. Boyd, and E. G. Stevens of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17667)

No further documentation is available.

EXPANDABLE RUBBER PLUG SEALS OPENINGS FOR PRESSURE TESTING



A single plug can be used to seal the openings in piping systems, vessels, and chambers for low-pressure leak testing. The plug provides adequate sealing of irregular diameters without damage to mating surfaces. The expandable plug assembly (see figure) is inserted in the opening to be sealed. A convenient handle on the end of the shaft swings out of the way to expose a drivescrew. Turning the drivescrew clockwise operates a drive shaft, to force a pressure plate in the plug head against a set of split-ring metal collet fingers. The collet fingers expand against the inner surface of the rubber plug, causing it to bear against the walls of the opening to be sealed.

Test pressures are supplied through a line attached to the pressure plate, and they are kept within desired control limits by a relief valve, also in the pressure plate. A threaded-nut position indicator on the drive shaft moves axially in a slot in the plug shaft, to indicate the degree of expansion of the plug. This device has been tested and found to be an effective seal for helium to 446.4 N/m^2.

Source: R. B. Brown of
Aerojet-General Corp.
under contract to
Space Nuclear Systems Office
(NUC-00048)

No further documentation is available.

QUALITY CONTROL CRITERIA FOR ACCEPTANCE TESTING OF CROSS-WIRE WELDS

An investigation was carried out to establish visual inspection criteria, for assuring the metallurgical integrity of spotwelds joining nickel leads and nickel ribbon in a 90-degree cross-wire configuration. Quality control procedures that have been used for acceptance testing of such welds appear to be unduly complex and costly, and they often result in the rejection of satisfactory units.

The results of this investigation indicate that there is sufficient correlation between weld strength and, principally, two visually observable and easily measurable characteristics to serve as criteria for acceptance testing of the cross-wire welds. The first of these characteristics, "expulsion," is the percentage of the total distance around a welded joint which the width of the expelled weld material exceeds one mil. The other characteristic, "embedment," is the distance that the lead and ribbon are forced together (by heat and pressure) during welding.

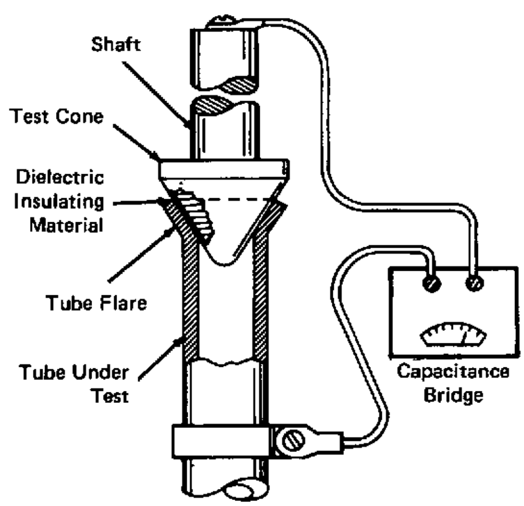
Although this investigation was carried out on gold-plated nickel leads and bare nickel ribbons, it is believed that the results obtained will apply to bare nickel-to-nickel connections which are spotwelded under controlled production conditions.

Source: R. D. Bryant of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-627)

Circle 7 on Reader Service Card.

GAUGE TESTS TUBE FLARES QUICKLY AND ACCURATELY

Previously, tube flare was inspected with instruments that required considerable time, supplemented with visual inspections. While imperfections in tube flares are not critical in many areas, they are in pneumatic and hydraulic systems under high pressure. Resulting failures are often costly because the flared tubes may be installed in inaccessible locations.



Flared-Tube Gauge

Flared tubes may be conveniently inspected with a new flared-tube gauge fitted with a test cone. The cone is precisely made with a tapering surface to complement the tube flare that is to be tested. The surface of the test cone is coated with a thin uniform layer of dielectric insulating material.

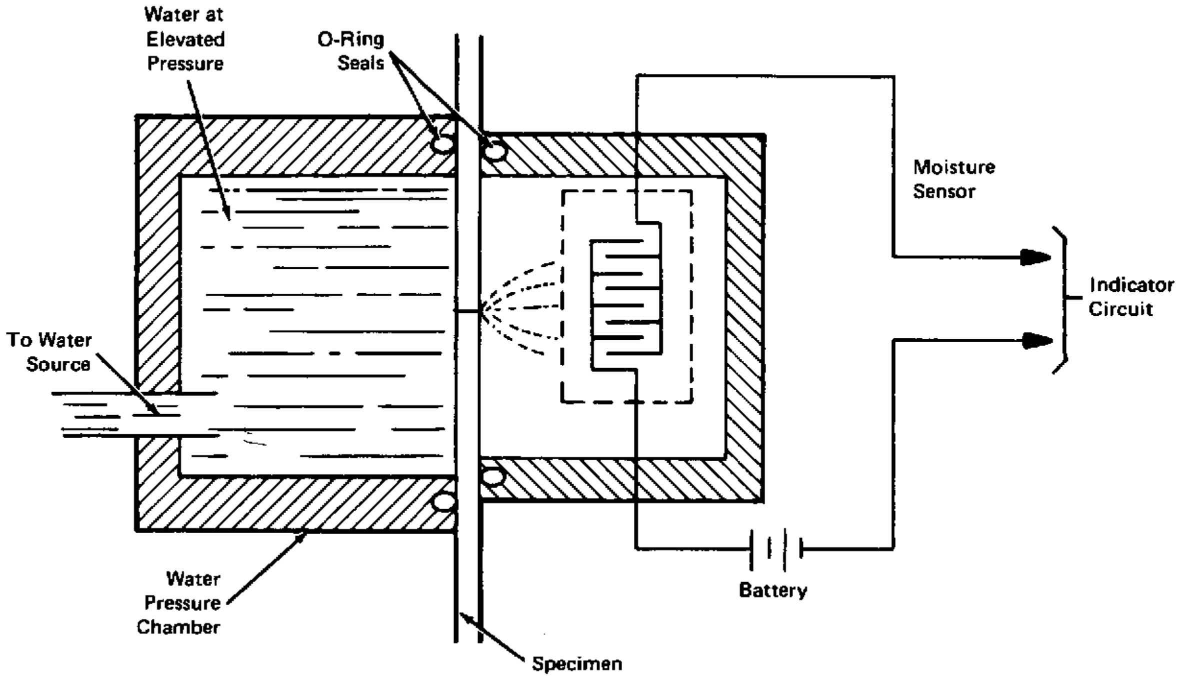
The flared-tube gauge (see figure) consists of a test cone, a shaft, and a capacitance bridge meter. The meter is connected to the test cone shaft and to the tube to be tested. To test the tube flare, the test cone is placed in the tube flare in mating position and remains there by its own weight. Imperfections in the flare, or an improper flush fit of the test cone with the inside flare surface, will produce a meter reading that gives an instant check on whether or not the tube flare imperfection is within permissible tolerances.

This device should improve the speed, efficiency, and accuracy of tube flare inspections. The simplicity of operation may permit 100 percent inspection of tube flares. The device is portable and can be used in shop or field. The test cone can be reshaped and used to test the internal surfaces of various geometric shapes.

Source: F. D. Griffin
Kennedy Space Center
(KSC-66-19)

Circle 8 on Reader Service Card.

LABORATORY FRACTURE PENETRATION DETECTOR

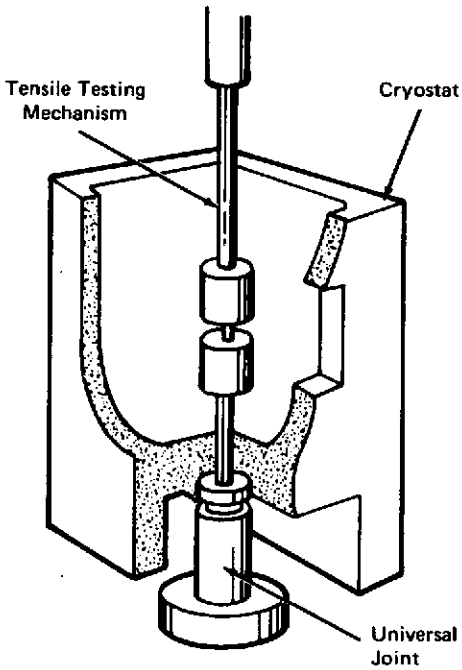


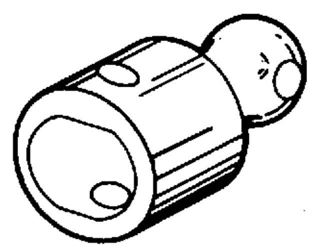
A procedure for determining whether a crack penetrates through a tensile or fatigue test specimen is shown in the figure. Water under pressure (about 1.4×10^5 N/m^2) in a sealed chamber is applied to one side of the specimen. Paper, treated with sodium nitrate and used as a moisture sensor, is mounted on the opposite side of the specimen. The sensor is a series of interlaced filaments in contact with the sodium-nitrate paper. The instant that water goes through the fissure of the test specimen, it is collected by the sensor. The sensor then conducts current supplied by a battery, generating a signal in the external indicator circuit.

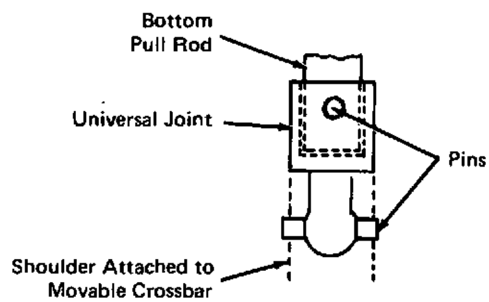
Source: J. S. Fritzen of
Lockheed-California Co.
under contract to
Johnson Space Center
(MSC-14290)

No further documentation is available.

SELF-ALIGNING ROD PREVENTS ECCENTRIC LOADING OF TENSILE SPECIMENS




Detail of Universal Joint



During assembly of a specimen for tensile testing in a liquid nitrogen-filled cryostat, the cryostat is frequently subjected to tilting.

A universal joint with a semielliptical head and socket was developed to prevent this tilting.

The semielliptical head of the universal joint is seated in the shoulder attached to the bottom movable crossbar and moves about a pin-loaded joint. The universal joint socket also has a semi-elliptical contour, but it has the flats at right angles to the flats of the head. The socket receives the bottom pull rod and also moves about a pin-loaded joint, which is at right angles to the pin through the head. With this design, misalignment effects are reduced; the cryostat (attached to the bottom pull rod) remains relatively rigid, preventing spillage of the liquid nitrogen and facilitating assembly of the specimen.

Source: E. F. Vandergrift of
Westinghouse Corp.
under contract to
Space Nuclear Systems Office
(NUC-10525)

No further documentation is available.

VIBRATION TESTS ON VIDICONS MADE BY IMPROVED METHOD

It was decided to devise a sensitive method for checking the performance of vidicons in mechanical vibration tests. The tests require auxiliary equipment, including a light box and test pattern, a lens system, a deflection yoke, scan generators, video amplifiers, and a display monitor. Previous methods required that the light box and test pattern, the lens system, and the deflection yoke be mounted with the vidicon on the vibration table. Since such mounting was not practical, no high resolution testing has been done. These methods used an overlay test pattern illuminated by a point source of light; and the resolution was limited to approximately 100 lines, because the overlay test pattern was separated by a relatively large distance.

One solution is to store the image of the desired fine-detail test pattern in the photosensitive surface of the vidicon and observe the effects of the applied vibration on this image.

The image is stored while the system is free of mechanical vibration. While the image is being stored and until the last part of the test, the reading beam is cut off. The desired mechanical excitation is then applied, and all mechanical adjustments are made. Then, while the tube is being vibrated, the beam is turned on, and the stored image is read out and displayed. The only equipment that is required to be mounted on the vibration table and held in a fixed relationship is the deflection yoke.

This method can be used in the experimental analysis of storage-type imaging tubes.

Source: Hughes Aircraft Company
under contract to
Jet Propulsion Laboratory
(JPL-SC-115)

Circle 9 on Reader Service Card.

SURFACE CONDITION ASSESSMENT OF INCONEL 718 THIN-SHEET MATERIAL

The use of 500X magnification, instead of the customary 100X, for metallographic examination of Inconel 718 thin-sheet material will reveal surface conditions (contamination) that may be critical in thin-wall bellows applications. These surface conditions, depending upon their causes and origins, could produce low-fatigue characteristics which may result in early failure.

Metallographic evaluation of thin-sheet material at 500X magnification, with adequately defined standards, was the approach used in the development and fabrication of bellows for the Saturn rocket engines of the Apollo space program. The technique has direct application in the fabrication of thin-wall tube assemblies and of pressure vessels for petroleum; in the chemical, plastic, and automotive industries; and may be of use in the laboratory and with medical equipment fields.

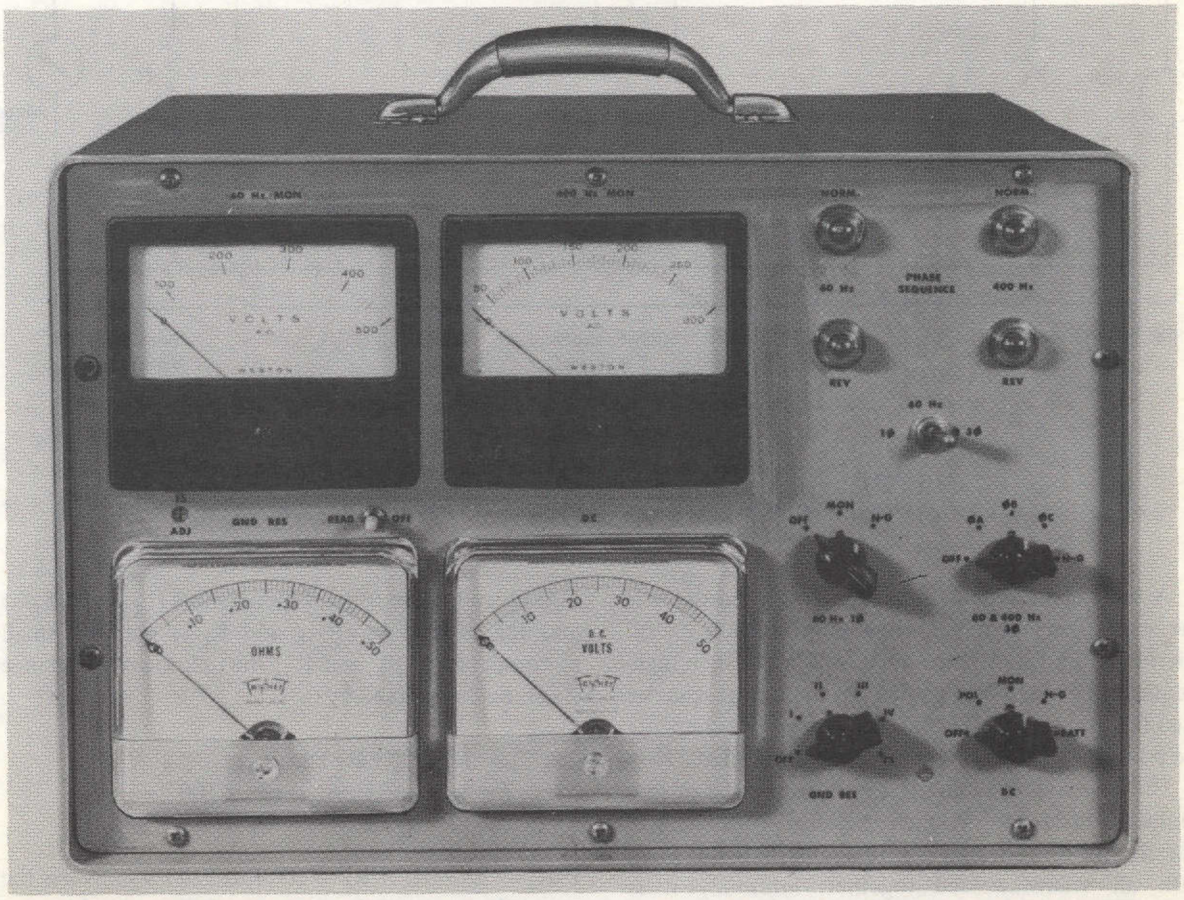
Source: R. H. Henry and T. W. McCrary of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24048)

Circle 10 on Reader Service Card.

Section 2.

Electrical and Electronics Testing Techniques

POWER UTILITY CHECKOUT KIT



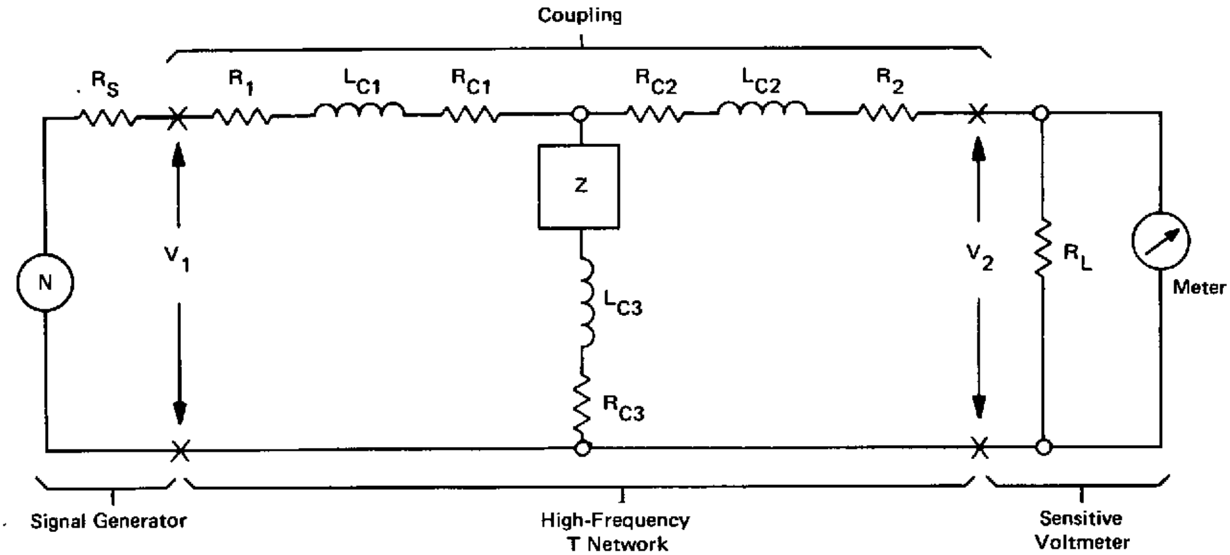
The apparatus shown in the figure is a compact (40 cm wide, 28 cm high, and 33 cm deep) hand-carried testing device used for power installation checkout and verification. The unit incorporates an internal adapter-cable storage compartment. Plug-in adapter cables are used to permit direct readings of power system parameters. This equipment can be used for the checking of power receptacles supplying direct current at 28 V, both single- and triple-phase at 60 Hz, and at voltages of 120, 208, and 480. The receptacles are properly keyed to accept the conventional test plugs.

The unit combines the functions of a phasemeter, a voltmeter, and an ohmmeter. It checks polarity and ground resistance, as electrical equipment "sees" them. Meters on the front panel provide voltage and resistance readings, and rotary switches provide function selection and range variations.

Source: G. A. Tuthill of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-15770)

Circle 11 on Reader Service Card.

HIGH-FREQUENCY T NETWORK



R_S, R_1	Source and Load Resistance (50 Ohms Typical)
R_1, R_2	Series Resistance (50 Ohms Used)
L_{C1}, L_{C2}, L_{C3}	Inductance of Contact Between Test Sample and Fixture
R_{C1}, R_{C2}, R_{C3}	Resistance of Contact Between Test Sample and Fixture
Z	Shunt Unknown Impedance

A basic requirement in certain test procedures is the measurement of very low impedance (e.g., 20 microhms) at frequencies up to 400 MHz. The high-frequency T network shown in the figure can be used for this purpose. Higher frequency measurements are possible, but these have not been attempted.

The controlling factor is the maintenance of low contact impedance through physical construction. The fixture to be tested is a box constructed of brass with all seams welded together; internally it is compartmented. The cover mounting flanges are ground flat, to insure extremely high isolation between the compartments at high frequencies. The mating surfaces of the test sample and of the test fixture should be ground flat, to guarantee good mating and low contact impedance. The connector and the grounded standoffs are soldered to the case, to eliminate joint resistance and to insure isolation of input from output.

The electrical circuit shown is extremely simple. Its effective coupling, which influences the measurement results, is between the input and the output terminals. If the coupling is maintained to less than 100 db and if the contact inductances (L_{C1} and L_{C2}) and the resistances (R_{C1} and R_{C2}) are very small as compared to R_1 and R_2, the unknown impedance Z can be determined by

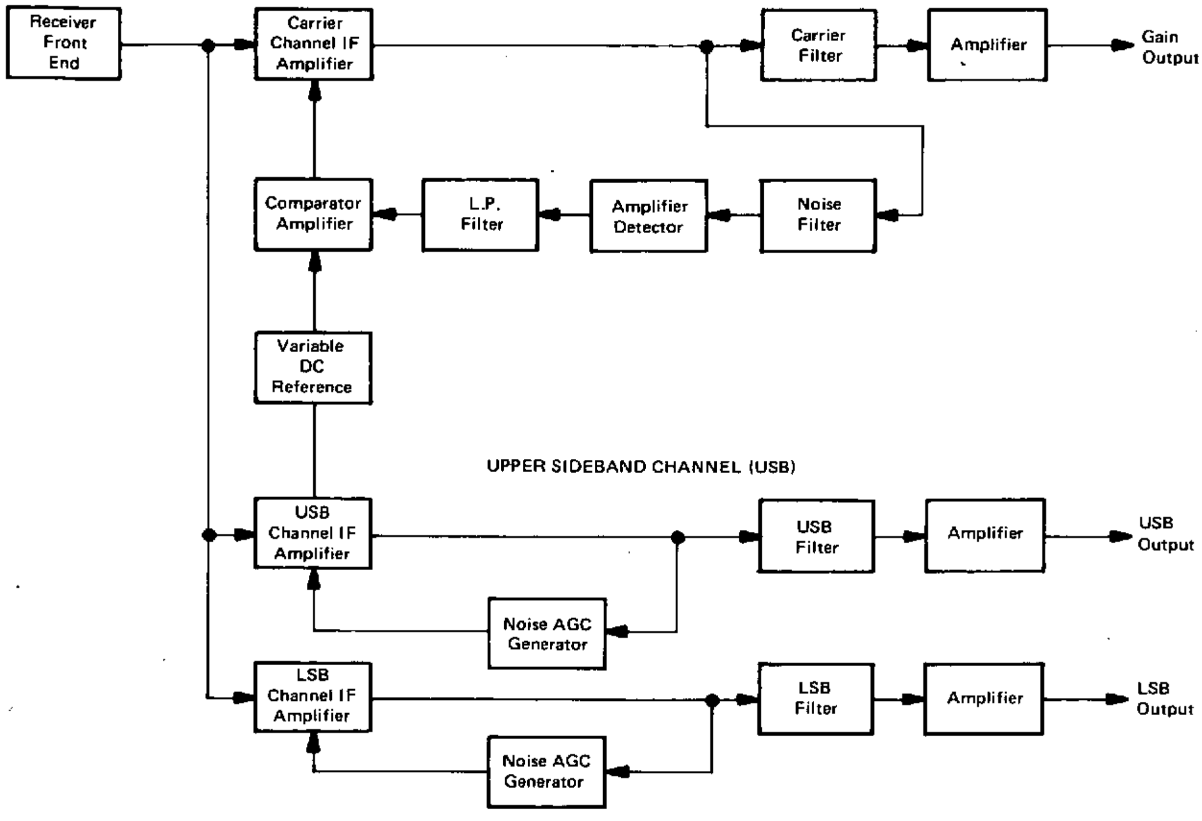
$$Z = \frac{R_1 (R_2 + R_L)}{R_L} \quad \frac{V_2}{V_1} = 100 \; \frac{V_2}{V_1}$$

if $R_1 = R_2 = R_S = R_L = 50$ ohms, and $V_2 \div V_1$ is the network insertion loss at any frequency. The unknown impedance Z is assumed to be less than R_1 and R_2. If Z is less than 50 ohms, it seems that it is still high as compared to the low impedances measured (microhm range). Elements R_{C3} and L_{C3} must be very small as compared to Z.

Source: A. W. DiMarzio of
RCA Corp.
under contract to
Johnson Space Center
(MSC-12203)

No further documentation is available.

RECEIVER-GAIN STABILIZATION SYSTEM



A receiver-gain stabilization system has been developed that provides constant gain for all operating signal levels in the 31.65-GHz frequency range. The gain in each channel is maintained constant, by detecting and averaging the noise output from each channel and by using the resulting voltage in a feedback loop to control the gain of the IF amplifiers. The basic principle may be useful as a stabilizing scheme for electronic test and calibration equipment.

As shown by the simplified block diagram (see figure), the output of each channel IF amplifier is applied to both a signal filter and a noise filter. The frequency of the noise filter is offset from the signal filter, to prevent the signal from affecting the receiver gain. The output noise is rectified, averaged, compared to a reference voltage, and applied to the channel IF amplifier as an automatic gain-control voltage. This output noise (N_{out}) is equal to FkTBG

where: F is the receiver noise figure,
k is Boltzman's constant,
T is the system temperature,
B is the effective bandwidth of the noise filter, and
G is the receiver gain.

Source: F. L. McCormick of
Martin Marietta Corp.
under contract to
Goddard Space Flight Center
(GSC-10641)

Circle 12 on Reader Service Card.

"IN-PLACE" RELAY TESTER

A portable relay tester can test relays that are electrically connected and operating in a circuit. To determine the source of relay trouble, the relay is removed from the circuit and then is connected to it by cables. In previously-available relay testers, suspected relays had to be removed from the circuit and tested separately. This procedure made troubleshooting more difficult.

This new tester was designed specifically to test control relays in nickel-cadmium battery chargers. The relay to be tested is removed from the charger and inserted into the proper socket in the tester, and the appropriate cable is plugged into both the tester and the charger. The displaced relay is then completely evaluated under actual working conditions.

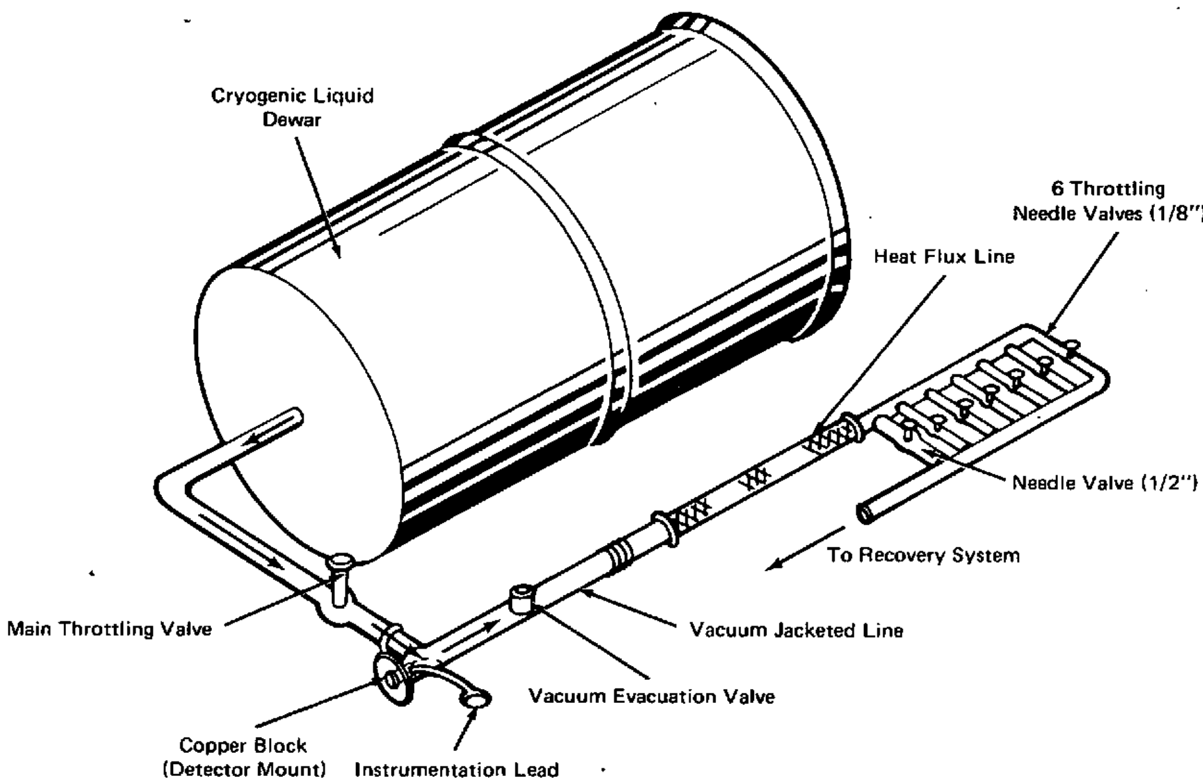
Relays can also be tested independently of a circuit. A questionable relay can be plugged into the tester, and no cable is required. An external source of dc power is connected to the tester, and the test is conducted as previously described.

Source: C. P. Jones of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10367)

Circle 13 on Reader Service Card.

Section 3. Thermal Testing Techniques

APPARATUS FOR TESTING OVER A WIDE RANGE OF CRYOGENIC TEMPERATURES



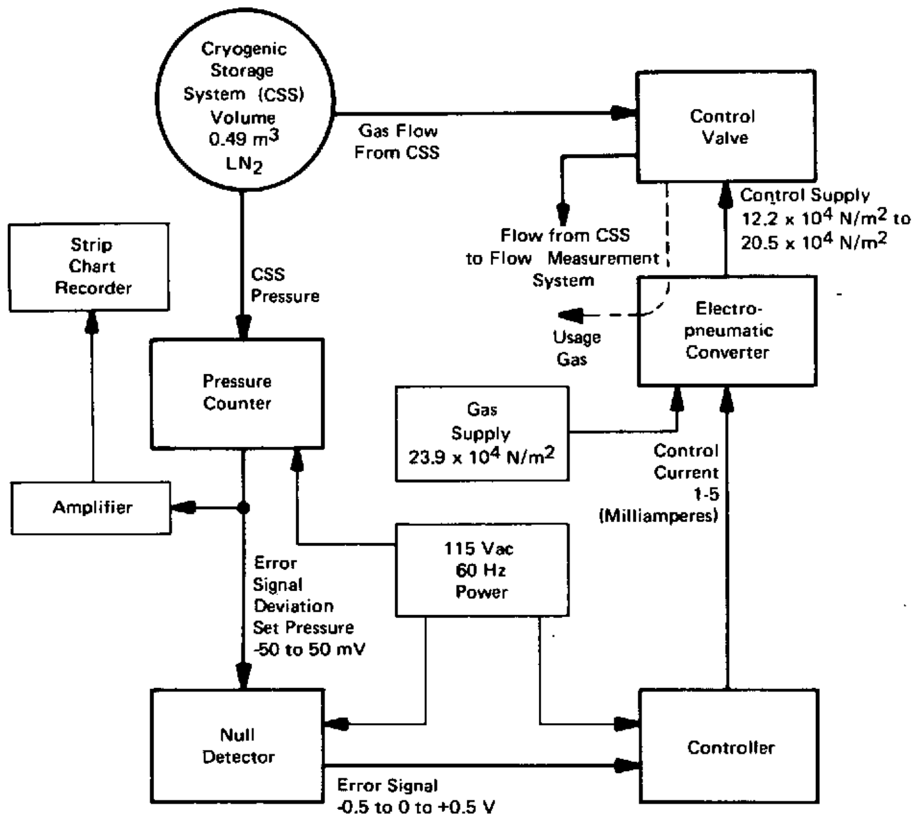
The apparatus shown in the illustration selectively provides temperatures over the range of from 4.2 K (-452° F) to slightly below room temperature. It was developed to test solid-state radiation detectors over a wide range of cryogenic temperatures. Conventional systems using liquid helium, liquid hydrogen, and liquid nitrogen provided certain specific temperatures; however, variations from these temperatures were limited to small temperature excursions near the boiling points of these fluids.

The apparatus consists of a copper block, on which the test items are mounted, and a system for cooling the block with cryogenic fluid or vapor. Throttling valves in the cryogenic liquid inflow line and in the cryogenic vapor outflow manifold, along with a heat input section, provide for fine adjustment of the cryogenic fluid flow to obtain the temperature desired. A germanium resistor in the copper block monitors the block temperature.

Source: J. M. Lambert and H. Bulger
Lewis Research Center
(LEW-11596)

No further documentation is available.

PRESSURE CONTROL SYSTEM TO TEST CRYOGENIC STORAGE VESSELS



Block Diagram of Pressure Control System

An automatic system has been developed to accurately control the internal pressure of cryogenic storage systems (CSS). The system also maintains a near-constant bleed-off flow from the CSS. A block diagram of this control system is shown in the figure.

The system senses pressure, using a pressure counter. When the CSS pressure is exactly equal to set pressures, the output from the pressure counter is zero. When the pressure deviates slightly from a set point, the pressure counter sends a corresponding error signal to a null detector. The null detector amplifies the signal and matches the impedance between the pressure counter and a controller. A voltage signal from the null detector is fed directly to an error comparator circuit of the controller. The controller supplies an electrical current control signal to an electropneumatic converter.

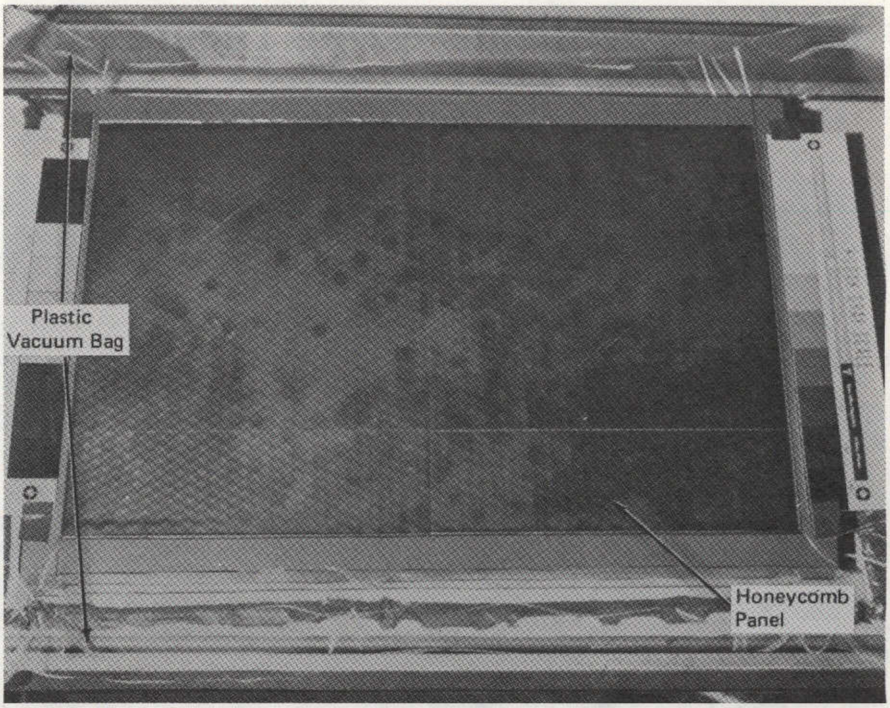
The electropneumatic converter supplies 12.2×10^4 to 20.5×10^4 N/m^2 gas pressure, to modulate a dome control valve. The pressure to the dome valve determines valve position, thereby regulating the gas flow to maintain a near null output from the pressure counter.

A major advantage of this system over most common control and instrumentation systems is that the entire control signal is referenced to a null. Thus, even large changes in amplification factors and in power supply outputs have no appreciable effect on a control point.

Source: F. H. Meissner of
Brown and Root-Northrop Corp.
under contract to
Johnson Space Center
(MSC-13847)

Circle 14 on Reader Service Card.

NONDESTRUCTIVE TESTING OF FILLED HONEYCOMB ABLATOR PANELS WITH LIQUID CRYSTAL THERMOGRAPHY



Honeycomb Test Panel in Plastic Bag

A nondestructive thermographic technique (see figure), utilizing cholesteric liquid crystals, is now being used in the detection of structural defects and unfilled cells in honeycomb ablator panels. A liquid-crystal-coated, clear plastic vacuum bag is held in contact with the test panel, while the panel is heated by photofloodlamps. The use of floodlamps, as opposed to heat lamps, provides uniform heat transfer.

The film temperature is varied, by exposure to the floodlamps, through its color transformation range or from 35° to 36° C. The liquid-crystal coating visually displays a distinct color pattern, which reflects variations in heat flow caused by structural defects or by the presence of empty cells.

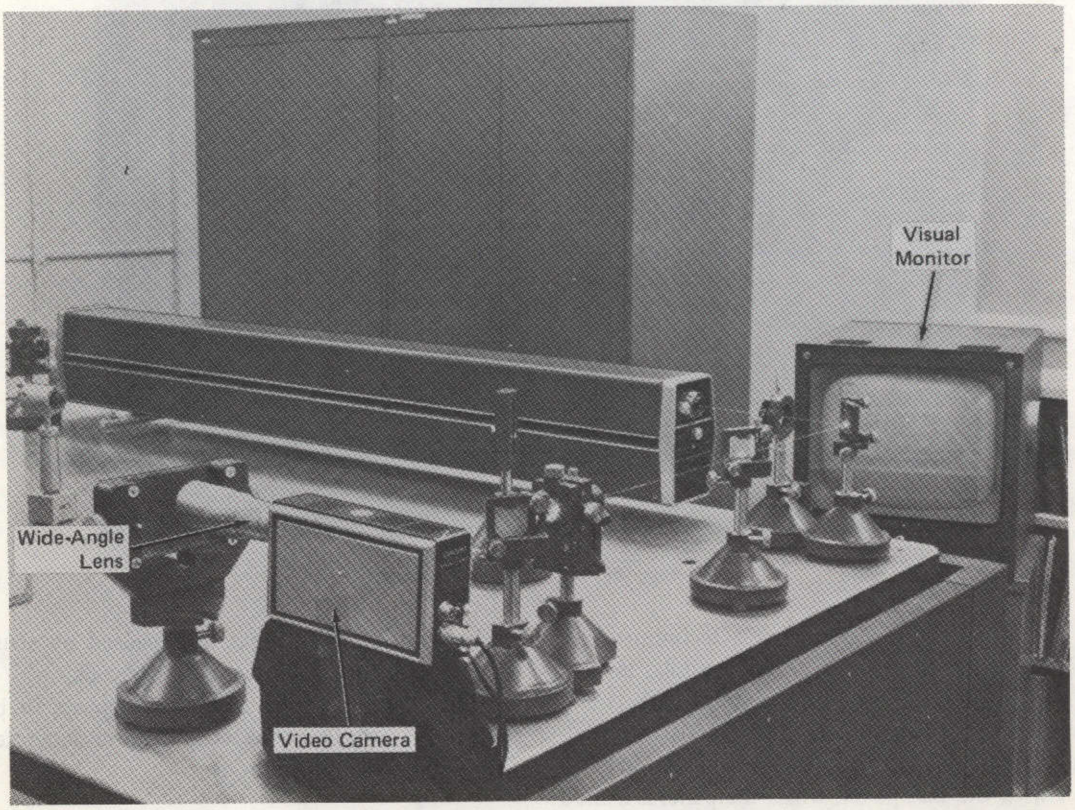
This thermographic technique appears to be less expensive and to be faster and more accurate than X-ray or ultrasonic methods.

Source: R. G. Poe and J. Mamon of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17363)

No further documentation is available.

Section 4. Optical Testing Techniques

VIDEO RECORDING OF HOLOGRAPHIC PATTERNS



Video Camera Used with Holography System

An advanced holographic interferometry system incorporates closed-circuit television viewing and recording equipment in the nondestructive testing of structural components. As shown in the figure, a standard video camera with a wide-angle lens takes the place of a photographic camera. The video signals from the camera are monitored visually and are recorded in a closed-circuit video system.

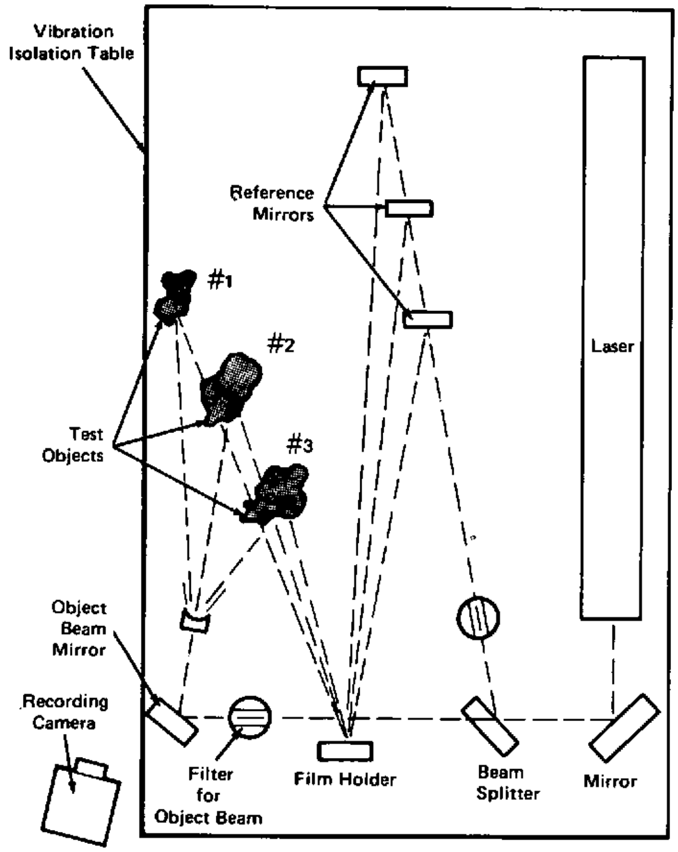
This system permits immediate viewing, recording, and analysis of holographic patterns. In addition, a real-time continuous response permits the system to record short-lived transients, which otherwise go unobserved on common photographic plates.

The closed-circuit video system is fast and flexible. Despite the relatively-high initial investment, it significantly reduces the cost of performing nondestructive holographic testing, by decreasing the required man-hours.

Source: F. H. Stuckenberg of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17525)

No further documentation is available.

MULTIPLE SEQUENCE FOR HOLOGRAPHIC INTERFEROMETRIC NONDESTRUCTIVE TESTING



Multiple Holographic Testing

A technique for multiple sequencing of holographic interferometric nondestructive tests has been devised. The materials to be tested and an equal number of reference mirrors are arranged in sequence. Each subject is holographed and removed from the test setup progressively. This timesaving procedure was developed for the nondestructive testing of space shuttle parts by holographic interferometry.

Previously, test objects were investigated one at a time; no further test setups or testing could be accomplished during the 20 to 60 minutes required for the development of the holographic film plate. The test sequence involved (1) alignment and adjustment of the various parts of the system, (2) exposure and development of the film plate, and, (3) placement of the developed plate back into the system for comparison testing. During the development period, the setup could not be disturbed for the substitution of another test specimen or for altering adjustments. An adjustment back to original settings, with the precision required for comparison tests with a first subject, was not practical.

With the new multiple-sequence approach, the setup for the next test object can proceed during film processing (see figure). This technique allows more time for careful film processing, reduces required facility time, and cuts costs.

Source: F. H. Stuckenberg of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17523)

No further documentation is available.

Patent Information

The following innovations, described in this Compilation, have been patented or are being considered for patent action as indicated below:

Flow-Test Device Fits Into Restricted Access Passages (Page 7) MSC-01078

This invention has been patented by NASA (U.S. Patent No. 3,287,832). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Johnson Space Center
Code AM
Houston, Texas 77058

Gauge Tests Tube Flares Quickly and Accurately (Page 11) KSC-66-19

This invention has been patented by NASA (U.S. Patent No. 3,426,272). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Kennedy Space Center
Code AP-PAT
Kennedy Space Center, Florida 32899