Profitable New Aerospace Technology With Potential Industrial Application

NASA SP-5926(02)

Measurement Technology

National
Aeronautics
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Space
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Small
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FOREWORD

It is possible that your company's economic growth can be increased through the use of new and improved materials, equipment, and techniques developed by the aerospace industry. The results of the research and development efforts can assist you in achieving lower unit costs, an improved competitive position, developing new products, and increasing the profits of your business. By assisting you in realizing these goals, NASA's and SBA's Technology Utilization Programs are helping to apply the results of the aerospace industry's research and development activities. Thus, the public earns an increased return on their investment in the space effort.

Additional technical information on the material presented can be requested by circling the appropriate number on the Reader Service Card which is included in this compilation.

Unless otherwise stated, neither NASA nor SBA contemplates any patent action on the technology described.

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CONTENTS

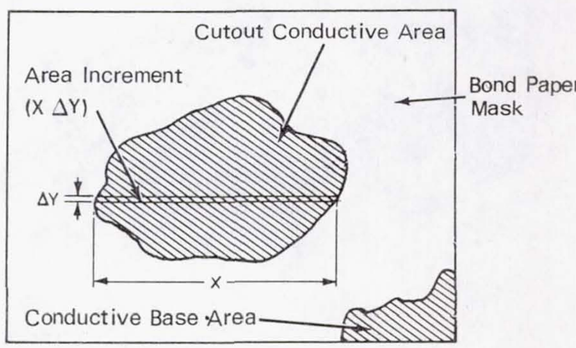
SECTION 1. SURFACE MEASUREMENT

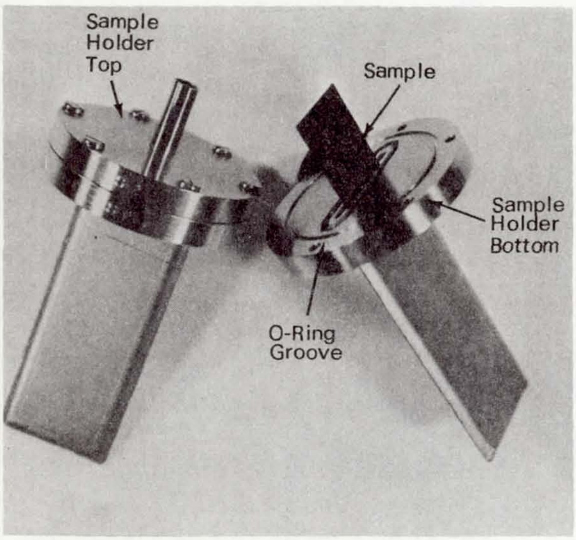
INSTRUMENT CALCULATES MOMENTS OF INERTIA OF COMPLEX PLANE FIGURES

An instrument is now available that will calculate distributive-area properties, such as centroids and moments of inertia, of complex or irregular plane figures representing cross sections of structural members. For figures of this type, the required properties cannot be obtained from tables or calculated analytically, as in the case of simple geometrical figures. Manual methods, which yield approximations of the true area properties, are laborious and time consuming.

A calculator, consisting of a narrow field scanner coupled with a relatively simple preprogrammed computer, uses a servoed X-Y plotter with a linear sweep voltage applied to one input axis and a linear step voltage applied to the other input axis, to scan the area in small incremental steps. The output data from the scanner are fed to an analog computer, which performs a series of discrete summations, closely approximating the exact integration, to yield the value of the desired property (e.g., centroid or moment of inertia).

The area whose properties are to be computed is cut from a sheet of bond paper and the remaining outline is cemented as a mask on an electrically conductive base. The exposed conductive area is then used for incremental scanning. A linear sweep voltage causes the probe of the X-Y plotter to scan across the conductive area in the X direction, and a linear step voltage applied at the end of each sweep causes the probe to step a constant small increment (ΔY) in the Y direction. In this manner, each incremental area ($X\Delta Y$) is swept out over the entire conductive area. The stepping voltage at any given time corresponds to the distance from a selected arbitrary reference axis (which serves as a base for calculation of the desired property, e.g., centroid or moment of inertia) to the incremental area being swept out. As the probe makes one sweep across the surface, a sweep voltage pulse is generated as long as the probe





is in contact with the conductive surface. Since the probe sweeps at constant speed, the time of the sweep voltage pulse is proportional to each incremental area. The outputs from the plotter and the conductive surface are fed to a preprogrammed analog computer which uses an integrator to compute the desired distributed-area property represented by the conductive area. To determine the area property with respect to an orthogonal reference axis, the step and sweep voltage input axes of the plotter are interchanged.

Tests have shown that the average time for making a mask and running a computation with respect to two orthogonal axes is approximately 15 minutes. The computations are accurate to within 2 percent when the area is scanned in 0.254 mm (0.01 in.) steps. Greater accuracy can be obtained using shorter steps in the scanning process.

An electro-optical scanner or pure mechanical scanner can be used in place of an X-Y plotter.

Source: W. J. Myers of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-628)

Circle 1 on Reader Service Card.

HOLDER FOR PORE-SIZE DISTRIBUTION MEASUREMENTS OF FLAT MATERIALS

A new sample holder exposes the maximum amount of sample material surface area in minute detail during measurements of flat materials. The holder permits measurements to be made on pieces of thin flat materials, particularly battery plates of the type used in aerospace power sources. It would also be useful in making surface area investigations on flat plate-like samples of any composition.

The sample holder was dimensioned to fit a particular surface area pore-volume analyzer. The "O"-ring concept makes the sample holder reusable, permitting loading and sealing by the laboratory technician. This design eliminates the requirement for heat sealing used in prior devices, as well as the grinding or machining operations required to open and reuse such devices.

Performance of this device has been acceptable with no leakage after 30 surface area determinations. The surface area accommodated by this sample holder is approximately 0.025 m^2.

Source: W. A. Campbell Jr.
Goddard Space Flight Center
(GSC-10938)

Circle 2 on Reader Service Card.

CONTOUR VERIFICATION TOOL

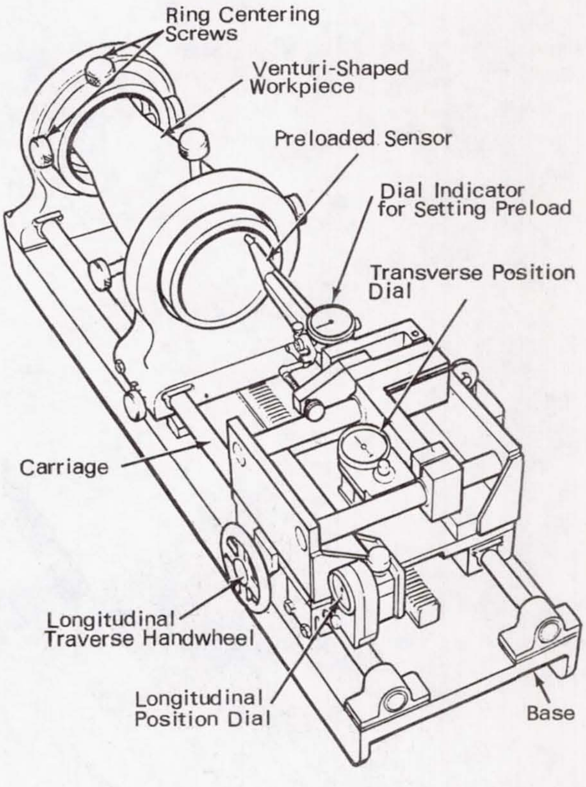
This device accurately measures predetermined points of interest in two axes of a varying profile. Though originally made to measure the venturi of a space vehicle engine, the tool should be useful for measuring any industrial device having a similar configuration.

The two-axis contour verification tool has a sensor that extends the length of the workpiece. This sensor is on a hinged mechanism which has a dial indicator to register the amount of preload of the sensor probe against the workpiece. The carriage (see fig.) is movable in two axes, with the amount of travel registered in thousandths of an inch by two position-indicating dials.

With this equipment, uniform preloaded contact can be made at discrete linear positions to verify the workpiece profile.

Source: T. M. Spence of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11523)

No further documentation is available.



MEASURING COPLANARITY OF SURFACES

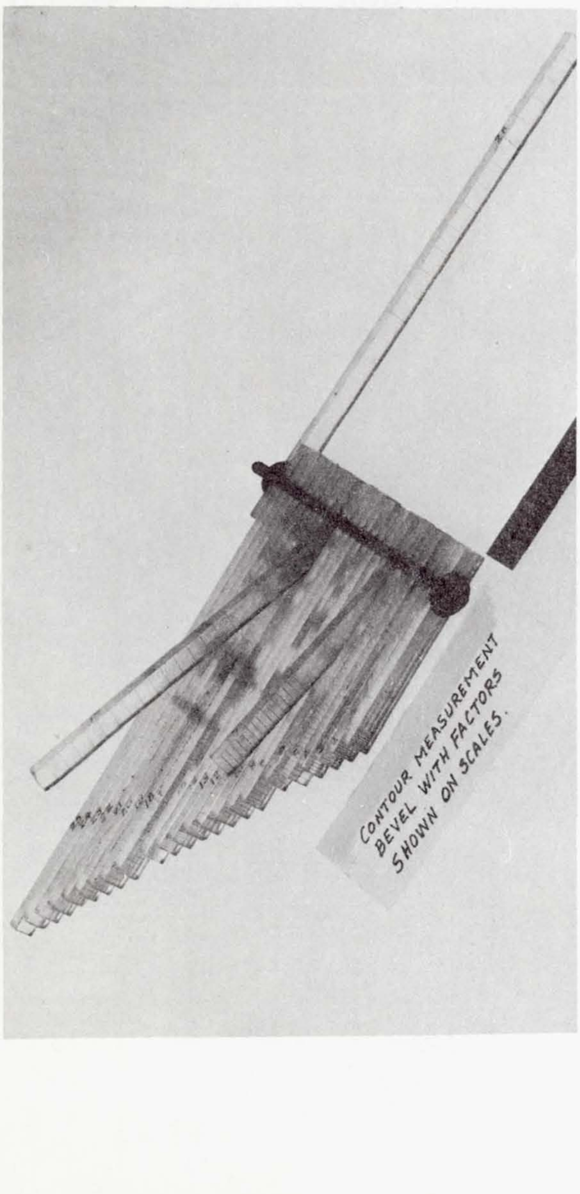
An interferometric technique measures the coplanarity and flatness of lapped surfaces on which a high-precision mirror is to be mounted. This measurement technique differs from standard interferometric techniques in that it measures minute height variations of several small discrete surfaces simultaneously, whereas the standard techniques measure the height variations of a single continuous surface.

Conventional means of generating interference patterns on the test surfaces are employed. The patterns are obtained by placing an optical flat in simultaneous contact with the test surfaces and illuminating the setup with monochromatic light. The resulting interference patterns are photographed. The photographs are then analyzed to determine the height differences between the test surfaces as well as the flatness deviation of each of the surfaces. The determination is based on the number and straightness of interference lines appearing on each surface, the relative directions of line groups, the area of each test surface, and the wavelength of the monochromatic light.

This technique is applicable to any instrument on which mirrors, prisms, or other optical components are to be mounted on three or more pads.

Source: M. M. Werner of
Kollsman Instrument Corp.
under contract to
Manned Spacecraft Center
(MSC-12044)

Circle 3 on Reader Service Card.



BEVEL SCALE ASSEMBLY

An assembly of scales (see fig.), scored with graduations from 0 to 15, has been developed to determine the amount that beveled or contoured surfaces deviate from design specifications. It offers a useful alternative to the protractors, templates, etc., normally used to make such measurements.

The assembly is composed of a series of scales made from durable material. Increments of 0.01745 rad (1.0°) are marked on each scale face, plus the "side opposite" factor of a triangle that is compatible with such increment markings. Through the use of this device, involved calculations of bevel factors are eliminated.

Source: D. E. Evans of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15847)

No further documentation is available.

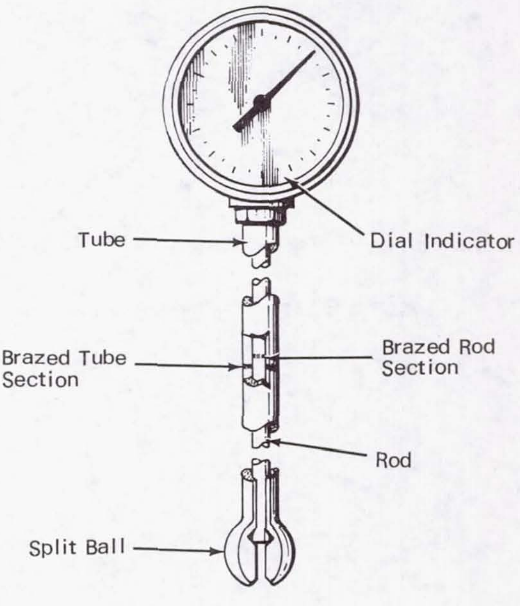
MODIFICATION OF BORE GAGE PERMITS MEASUREMENT OF LONG, SMALL-DIAMETER HOLES

This modified bore gage accurately measures the bores of small-diameter holes up to 127 cm (50 in.) long. No commercially available gage proved suitable for this job.

The dial-type bore gage consists of a dial indicator, a long tube (at least half as long as the hole, assuming the hole is open at both ends), and a rod which travels inside the tube. A split ball is fastened to the end of the tube. As the split ball expands or contracts in contacting the walls of the hole, the rod is moved, causing the dial indicator to register the change in split-ball configuration. This technique has been used successfully to measure the bores of very small diameter holes over 1.22 m. (4 ft.) long.

Source: A. W. Hunter of
Westinghouse Astronuclear Laboratory
under contract to
AEC-NASA Space Nuclear Systems Office
(NUC-10026)

No further documentation is available.



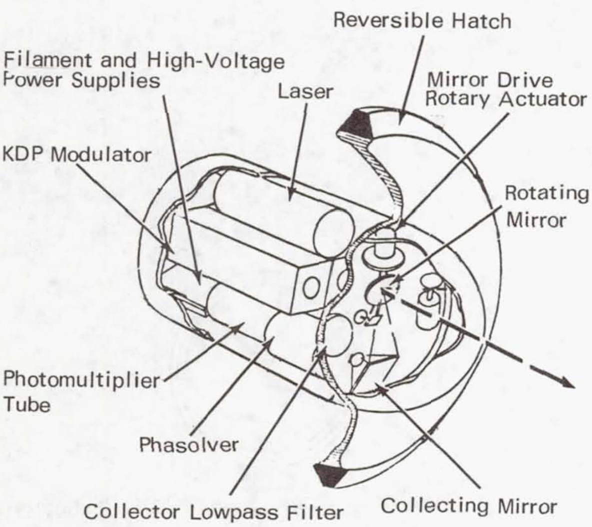


Figure 1. Laser Measurement Unit

PROPOSED LASER MEASUREMENT SYSTEM FOR DETERMINING SURFACE CONTOUR: A CONCEPT

A proposed electro-optical concept has the capability of scanning a large 30.48 m (100 ft.) antenna in 30 seconds. The conceptual system incorporates a laser beam amplitude modulated by a Pockel-cell modulator. A comparison of the reflected signal with a reference signal from the modulator driver yields a signal which can be correlated with the distance covered by the laser beam. A scanning arrangement then enables the contour to be measured.

Many advanced communication systems currently being developed have requirements for such large antenna systems. When the antenna is not properly aligned, beam pointing errors result in a severe loss of rf gain. Antenna surface contour measurements must also be made in order to determine the effects of the environment and to establish a correlation between antenna pattern measurements and surface distortion. Contour deviations are a result of the combined effects of manufacturing tolerances, mechanical misalignments, stress relief of structural members, and unequal solar heating. The development of a technique for rapidly and accurately determining the surface contour is a complex problem and no satisfactory method is presently available.

Details of the instrumentation and a flow diagram for this concept are shown in Figures 1 and 2. Coherent light from the laser passes through a set of potassium dihydrogen phosphate (KDP) amplitude modulators which modulate the light. Each device consists of an optical cavity which functions on the same principle as a traveling wave tube. The light beam is polarized when it passes through angled windows that form the ends of the tube. Modulation of an applied electric field modulates the polarization angle of the light, hence giving the laser beam amplitude modulation. The modulated light beam is then directed towards a set of mirrors which reflect the beam toward the antenna surface. The antenna mesh surface diffusely scatters the incident light energy; however, sufficient reflection is returned to the collecting mirror because the mesh is woven of wire with a circular cross section. The weak reflection is then directed to a collecting lens, passed through a narrow band pass filter, and focused on the photomultiplier tube detector. The photomultiplier amplifies the signal which is then compared to the reference signal from the modulation driver in a phase sensitive detector. Cancellation of the phase modulation yields a voltage which is directly proportional to the distance covered by the laser light beam. Since the frequency of the laser is known, distance measurements are straightforward and consist of making phase comparisons at the selected frequency between the reference and the probing beam.

The scan technique proposed for measurement of the reflector surface, based on a spherical coordinate system, incorporates a device which converts minute mechanical movements into electrical phase shifts. These phase shifts can be displayed in analog or digital form to provide the instantaneous position of the antenna.

The laser measurement technique is capable of any degree of precision in the number of sweeps since targets are not required. Also, the laser beam may scan the surface at any rate consistent with the detector bandwidth, or it can be pointed at a single point on the surface.

Source: H. D. Neubert of
General Dynamics Corp.
under contract to
NASA Headquarters
(HQN-10326)

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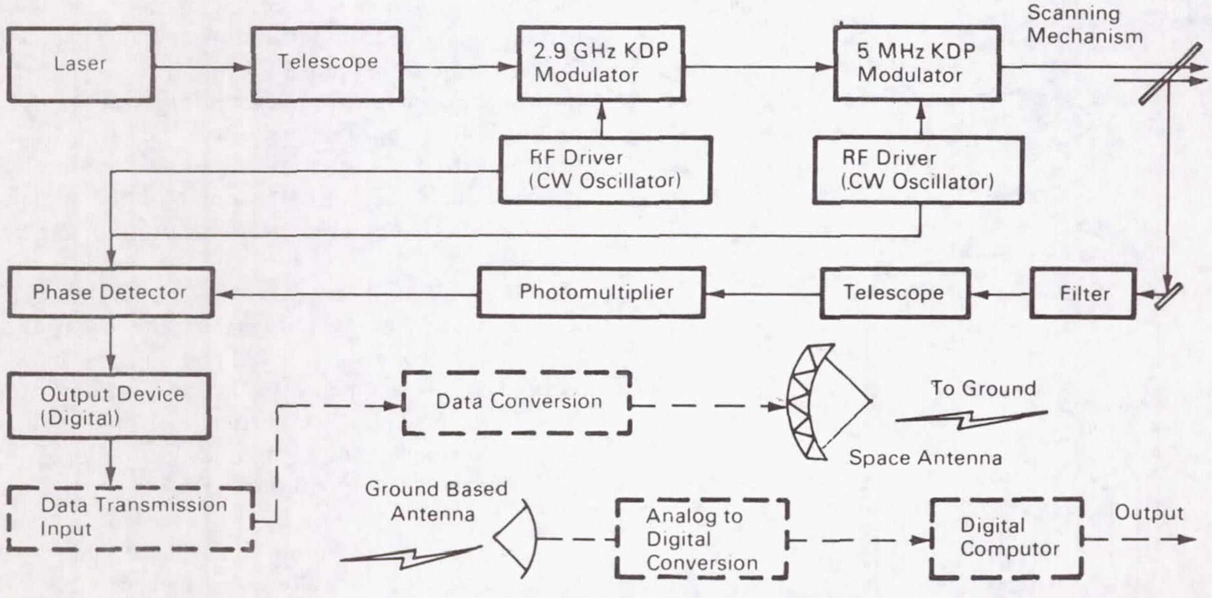
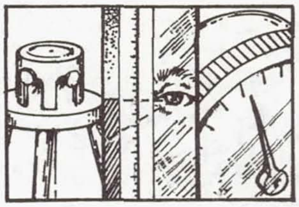
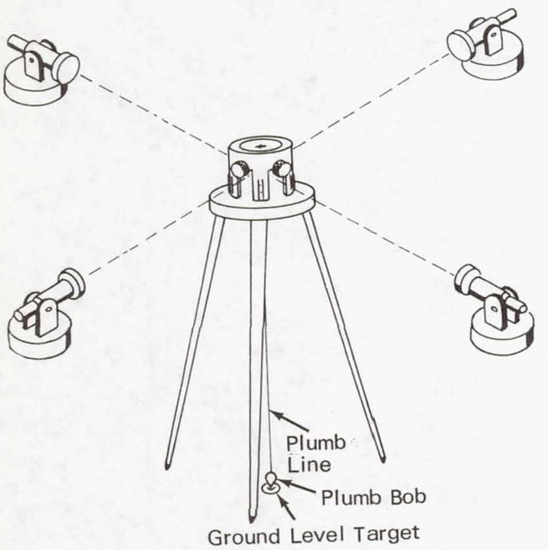
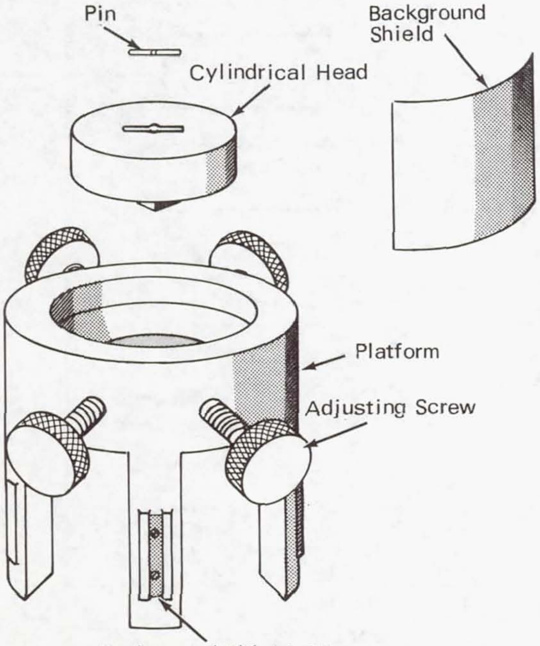


Figure 2. Antenna Tolerance Measurement Diagram





Sighting on Plumb Line from Four Directions



INSTRUMENT QUICKLY TRANSPOSES GROUND REFERENCE TARGET TO EYE LEVEL

A traverse target uses a string suspending a plumb bob to transpose the ground level point to eye-level operation. The unit need not be level because the plumb bob string will always be perfectly perpendicular.

Optical alignment of equipment such as star simulators for star tracker checkout is both difficult and time consuming. Using a bore sighting instrument above a ground reference point, removing it and putting the target in place is tedious and requires a perfectly level platform. Otherwise, the target is of no value.

In this application, a platform provides for the lateral adjustment of a cylindrical head from which a plumb line is suspended. The head rests on a circular flange and is moved laterally by four thumb screws which engage a square protrusion on the head's bottom side. The plumb line is tied to a pin resting across the head aperture. An aperture in the head and an opening through the center of the platform allow the plumb line to be suspended to the ground when the entire instrument is rested on its four base legs on a suitable tripod or stand.

The tripod supporting the instrument is positioned over the ground level target so that the plumb bob is approximately over the target. The four adjustment screws are then used to laterally position the head until the point of the plumb bob is exactly centered over the ground target. Leveling of the instrument is not required as the plumb string itself serves as the eye level target. The string may be sighted between the legs of the instrument from different directions. A background shield snapped into the clips on any two base legs provides for better viewing of the string. Normally, only 5 minutes are required to perform the total operation. This is an appreciable reduction in time from the present method of using a bore sighting instrument, and the same degree of precision is achieved. The instrument may be used in situations where optical alignment is accomplished using a ground level reference point, and where sighting on the North Star is utilized for accurately locating a point source within optically confined areas.

Source: B. E. Green and E. L. Van Deventer of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-275)

Circle 5 on Reader Service Card.

STRINGER MISMATCH VERIFICATION INSTRUMENT

This instrument quickly and accurately gages stringer centerline misalignment. The device uses two centering fixtures, and a dial indicator that is mounted on one stringer, in contact with a gage seat mounted on the stringer to be mated. Through the use of this instrument, detail stringer tolerances are cancelled out, direct offset readings are provided, and operator errors are minimized.

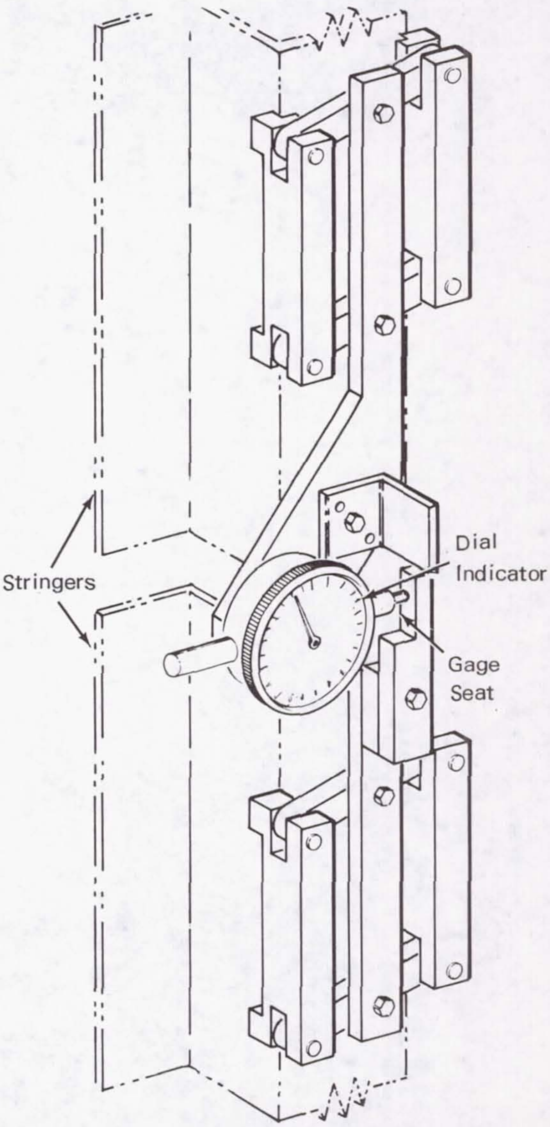
Source: A. L. Bahm of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-16500)

No further documentation is available.

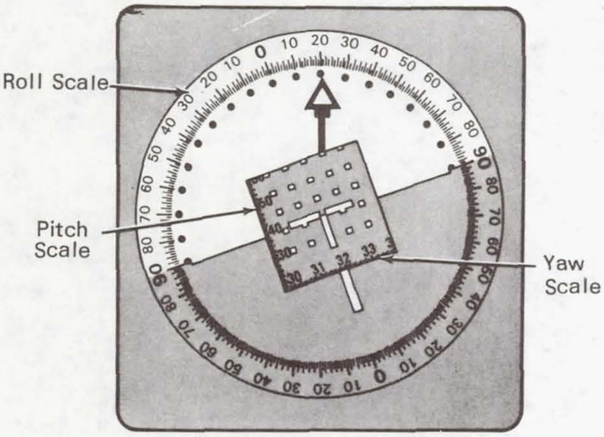
INSTRUMENT SUPPLIES ACCURATE ATTITUDE AND ATTITUDE-RATE DATA

A three orthogonal-plane projection has a longitudinal length which is constant and therefore independent of the pitch and roll attitudes of a moving body. The configuration is similar to the outer framework of a child's spinning gyroscope top.

The instrument is used to provide readout accuracy of both attitude and attitude-rate information in an easily interpreted, uncluttered arrangement where blind navigation of a moving body is involved. The "All Attitude Ball" that gives a spherical presentation suffers from the fact that its longitudinal length (yaw) scale indication declines with changes in latitude (pitch).



Stringer Mismatch Verification Instrument



Three orthogonally mounted tapes are installed on drive members behind a back-lighted display plate. The tapes are divided into scale increments that indicate the degrees of roll, pitch, and yaw, respectively, being experienced by the moving body. This reference attitude indicator is a repeater type of display that uses transducers as rate gyros to operate synchronous motors which drive the scaled tapes in response to attitude changes of the moving body.

The pitch and yaw servos have a velocity constant of 97, while that of the roll servo is 55. Servo bandwidth is about 6 cps for pitch and yaw, and 5 cps for roll.

Source: Bolt, Beranek, and Newman, Inc.
under contract to
NASA Headquarters
(HQ-57)

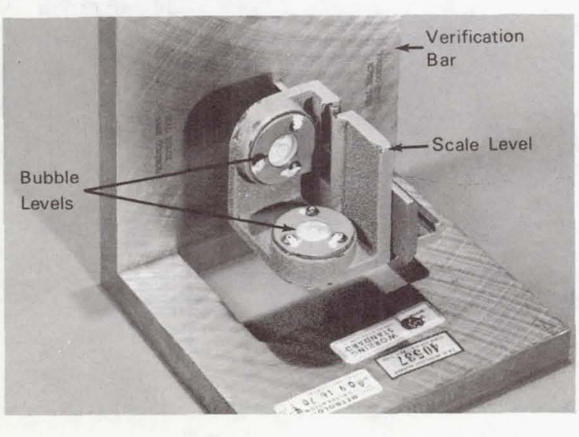
Circle 6 on Reader Service Card.

SURVEYOR'S SCALE LEVEL VERIFICATION BAR

A unique right-angle fixture with a surveyor's scale level attached eliminates the requirement for surface plate setups during scale level calibration. This new method has reduced calibration time by one half. Since such scale levels are widely used for aligning industrial tooling as well as for surveying, the time saving and the assured accuracy constitute an appreciable improvement.

The design of the right-angle gage block incorporates a precision verification bar that simulates section of the surveyor's scale. This bar section is fixed to the block in precision alignment. After a scale level is mounted on the bar, both bubble levels are checked and recalibrated by simply turning the right-angle block on a leveled surface plate that acts as a standard.

Source: R. C. Hutchison and A. V. Alvarez of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16893)



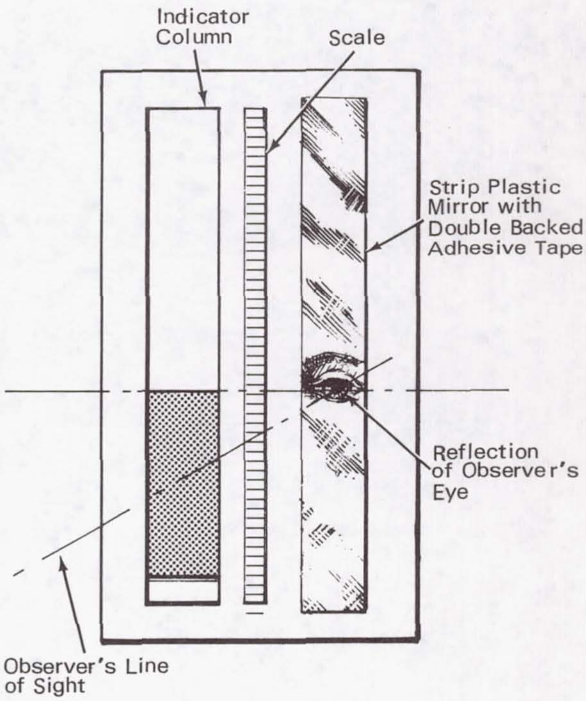
No further documentation is available.

ELIMINATION OF PARALLAX FROM INSTRUMENT READINGS

A strip mirror, attached in a parallel location to a vertical instrument scale (see fig.), helps to eliminate parallax errors when readings are being taken. The mirror is attached by means of double-backed adhesive tape. The observer moves his eye vertically until the center of the pupil, as reflected by the mirror, is in alignment with the indicator column to be read against the instrument scale. The mirror ensures that the observation is made with the eye perpendicular to the scale, thus eliminating parallax error.

Source: H. W. Sossaman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-17200)

No further documentation is available.



MEASURING CONDUCTOR SPACING IN FLAT CONDUCTOR CABLES

A newly developed interference method produces a moiré pattern, the shape of which is correlated with the lead spacing. In addition to the advantages of speed, accuracy, convenience, and simplicity of operation. this technique permits continuous rather than spot checking of the spacing. The only requirement is that the material between the leads on the test cable be translucent. Shielded cables must therefore be tested before the shields are added.

Moiré patterns are produced by the interference between two periodic geometric designs. In this application, one design is formed by the flat conductors in the cable to be measured; the other is a precision-fabricated master design of uniformly spaced rectangular bars. When the two designs are superimposed, a moiré pattern appears, with dark bands in each region where the bars of one design lie over the spaces of the other, and light zones where the bars of the two designs coincide. Given the situation that the two designs are superimposed at a precisely known, small angle, the following typical patterns may be observed: (1) If the master and the test designs are uniform and identically spaced, the moiré pattern will consist of equally spaced, linear bands approximately perpendicular to the bars. (2) If the master and the test designs are uniform but different in spacing, the pattern will consist of equally spaced, linear bands inclined with respect to the bars at an angle which is a known function of the difference in spacing. (3) If there is any nonuniformity of spacing in the test design, the moiré pattern will consist of wavy, angular, or ragged-edged dark bands, the slope of which at any point determines the spacing of the nearby conductors.

In the referenced report, the various moiré patterns are explained and the method of calculating the interconductor spacing from the moiré slant angle is given.

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference:
NASA-TM-X-53843 (N69-35124), Measuring the Conductor Spacing in Flat Conductor Cables

Source: W. Angele
Marshall Space Flight Center
(MFS-20560)

HYPERBOLA GENERATOR FOR LOCATION OF APERIODIC EVENTS

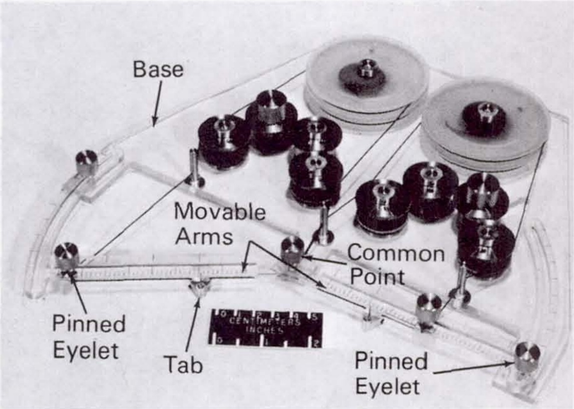
A new device, when used in conjunction with three or more detectors and a local receiver and recorder, can quickly pinpoint the location of any aperiodic event. It is essential that the position of each detector be accurately known; however, neither the distances between them nor the angles subtended by the base lines that join them are critical. Transmission between detectors and receiver may be by either radio or land line.

The key requirement is that the detector signals be received and recorded as functions of time. Two commonly available recording devices are a high-speed oscillograph and an oscilloscope equipped with a long-duration phosphor. The time data can be scaled directly from traces of the detector signals. The oscilloscope's sweep or the oscillograph's drive mechanism can be actuated be the detector's incoming signal.

The device consists of: a clear plastic base, each half of which carries a pair of concentrically mounted storage spools and two meshed metering gears (see fig.); an arrangement of two slotted arms rotating about a common point; an eyelet pinned to a map through the common point and through each arm slot; a cord for each pair of spools, linking them by way of the gears and eyelets; and a tab with a hole in it, fastened to the cord between each pair of eyelets. The cords are held at a constant tension by spiral springs within the spools.

For three detectors, A, B, and C, the left-arm slot, common point, and right-arm slot are pinned at points A, B, and C on a map. When the recorder shows corresponding traces from A and B, the difference (x feet) in distance of A and B from the source is calculated from the difference in arrival times of the two signals and from the propagation velocity. The tab between A and B is then offset from the center of the baseline between A and B by (x/2) ft. A pencil point is inserted through the hole in the A-B tab and pulled away from the base line to describe a hyperbola locating all points that are x ft. closer to A than to B. This procedure is repeated for points B and C, and the intersection of the two hyperbolae locates the site of the disturbance.

Operation requires minimal training and is readily adapted to the field. The mechanical error in the device's prototype was ≤ 3 percent of the longest base line; refinement should reduce this error to ≤ 1.5 percent. If there is a 1 percent error in the location of the detectors in terms of the longest base line, a 2 percent error in the



offsetting produces a 1.5 percent error in the location of the disturbance; and a 4 percent error in the offset generates a 4 percent error in location. The technique could be applied to locating explosions and to navigation.

Source: C. R. Spitzer, H. R. Paucker, and D. S. Vann
Langley Research Center
(LAR-10312)

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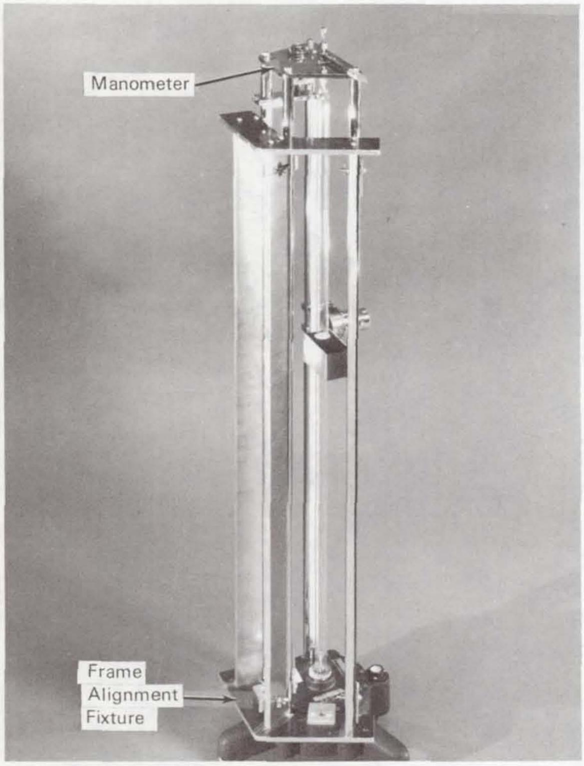


ALIGNMENT FIXTURE FOR PRECISION MERCURY MANOMETERS

This fixture provides quick and accurate alignment of mercury manometers and is a very useful tool in laboratories where numbers of these instruments are frequently moved. A prototype fixture (see fig.) has been used to realign as many as 120 Wallace and Tiernan FA-187 precision mercury manometers.

The manometer has interchangeable scale tapes with temperature compensating tension controls and an optically read magnetic zeroing device. The adjustable tubular frame must be kept in precise alignment or the reticle will not line up on the tape scale.

The alignment fixture is taken to the manometer and installed as shown in the illustration. The support rod adjusting screws above the manometer frame top plate are used for realignment. The fixture is clamped to the central rod of three support rods and the adjusting screws on the other (manometer) rods are loosened. The frame is then aligned so that the outer rods are brought into line with the gaging surfaces of the fixture. The top plate is positioned with these three supports and the fourth column adjustment is then secured to the plate.

This procedure can be completed in a few minutes by one technician, as compared to the previous method of transporting the instrument to a test area and using a transit to measure support rod positions, a procedure which required several hours.

Source: G. W. Smith and E. A. Ernst of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-17201)

No further documentation is available.

DETERMINATION OF LARGE ASSEMBLY PARALLELISM PRIOR TO MATING

Visual aid target devices are used to determine the parallelism of mating assemblies. The instruments employ a special sighting pattern base on optical tooling target design, with two lights, activated by microswitches, serving as a backup for the target pattern system.

In a specific application, accurate parallel positioning of large assemblies is required prior to actual mating. Because of the hazards involved, the operation is performed remotely from safe areas. The innovation solves the distortion problems in viewing through glass from a distance, and overcomes the lack of depth perception inherent in television viewing.

The measurement technique starts with three target devices remotely placed at equal spacing on the periphery of the stationary assembly (Figure 1). The mating assembly is then lowered to a position contacting the tops of the target devices. As the assembly continues downward, the relative position of the sensing unit's movable center black bar (Figure 2) on a white background is noted. As the center position is reached by the bar, the upper light comes on; as the center point is passed in either direction, the lower light comes on (upper light goes off), indicating a nonparallel condition. With both lights on, precise parallelism is indicated, the three targets are removed, and the mating assembly is lowered into place.

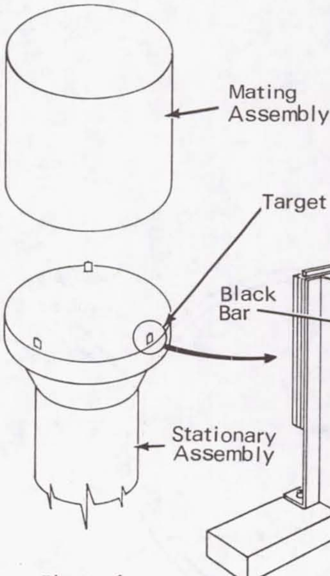


Figure 1

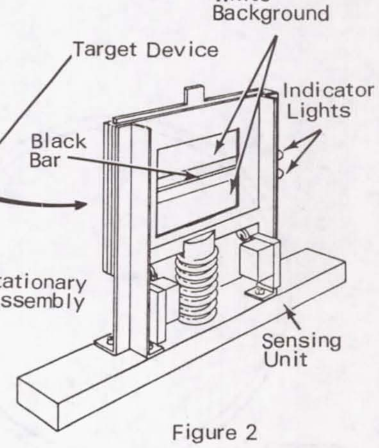
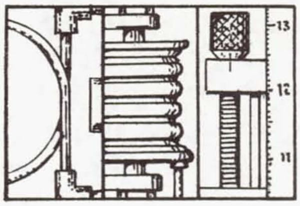


Figure 2

Source: D. W. Graham of
Aerojet-General Corp.
under contract to
AEC-NASA Space Nuclear Systems Office
(NUC-10080)

No further documentation is available.



ECONOMIC MEASUREMENT OF ULTRA-LOW FLOW RATES OF FLUIDS

A capillary tube flowmeter measures ultralow flows of corrosive and noncorrosive liquids. The method used is economical and should be of interest to the chemical industry.

A differential pressure transducer measures the linear pressure drop across a coil of capillary tubing. Through calibration with water and analytical conversion, flow rates as low as 0.005 gpm of very corrosive fluids (such as chlorine trifluoride and liquid fluorine) can be measured with reasonable accuracy.

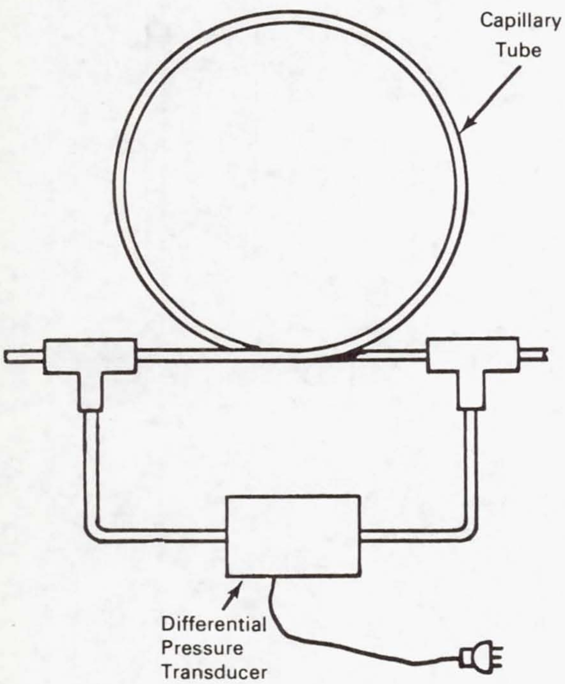


Figure 1. Capillary Tube Flowmeter

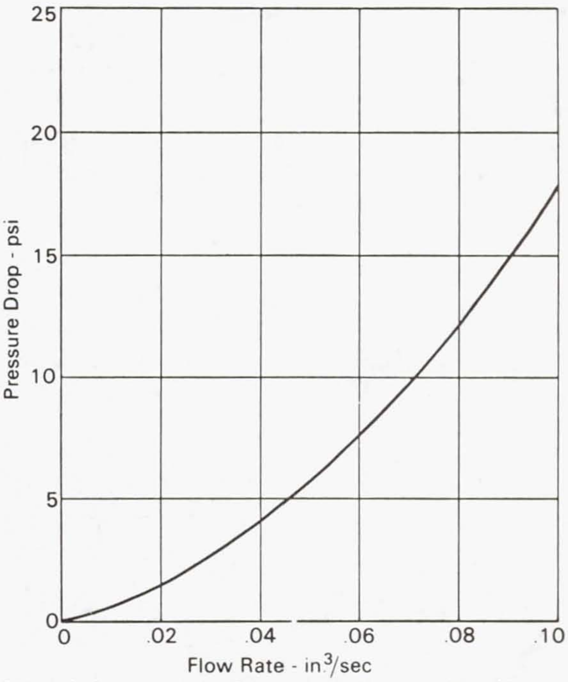


Figure 2. Capillary Tube Flowmeter - Pressure Drop Versus Flow Rate for Chlorine Trifluoride

The essential elements of the capillary tube flowmeter, shown in Figure 1, include a length of tubing and a differential pressure transducer. The flowmeter operates on the principle that, for laminar flow in the tube, the pressure drop is proportional to the flow rate. Since the capillary tube is smaller in diameter than the rest of the system's lines, reducers are required at each line. The abrupt changes in line size are also sensed by the differential pressure transducer and should follow the pressure drop function. The total pressure drop which a transducer senses is expressed by the formula

$$P = K_1Q^2 + K_2Q$$

where Q is the fluid flow, and K_1 and K_2 are functions of the fluid flowing through the meter and the meter geometry. The calibration test using water results in one set of values for K_1 and K_2. Once the meter has been calibrated with water, the equation can be modified for any liquid. The coefficients K_1 and K_2 are proportional to the viscosity and density ratios of the liquid to water, respectively. Applying the viscosity and density for chlorine trifluoride, the result is

$$P = 1314Q^2 + 45.7Q$$

which is shown graphically in Figure 2.

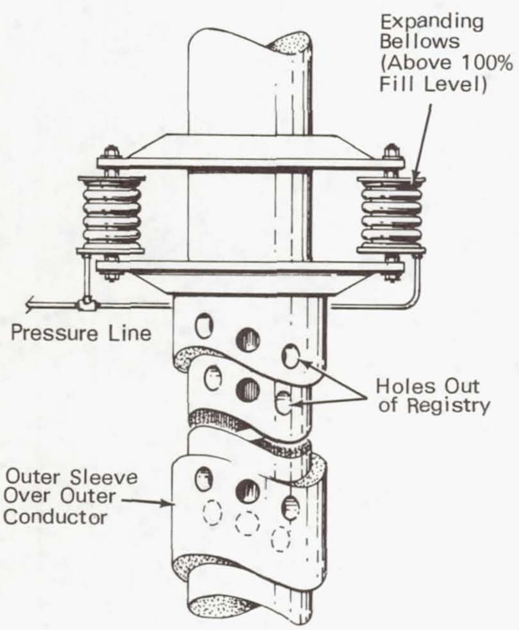
During valve opening and closing transients, flow measurements cannot be made because of cavitation or water hammer in the differential pressure transducer lines. Once the valve transient has damped out, the flowmeter reading can be made with reasonable accuracy. Flow rate error can be shown mathematically to be a function of pressure differential and pressure differential error.

Source: J. A. Bogdanovic and W. F. Keller of
Northrop Corp.
under contract to
NASA Pasadena Office
(NPO-12064)

Circle 8 on Reader Service Card.

IMPROVED CAPACITANCE PROBE FOR LIQUID LEVEL MEASUREMENT: A CONCEPT

A conceptual dual-purpose probe is designed to obtain either a steady, relatively noise-free level measurement, or a measurement of level changes, including sloshing and surface instability due to boiling. This dual capability is accomplished through the use of a double outer tube with a series of holes, arranged so that movement of the tube leaves only a single inlet for the liquid.



An auxiliary sleeve with a series of holes in it is placed over the outer conductor of a standard coaxial probe. In one position of the auxiliary sleeve, the holes are in registry with those of the outer conductor; in the other position, they are out of registry so that the holes are closed and no liquid can flow through the probe. During periods when the liquid level is being accurately adjusted and maintained, the holes are closed to eliminate effects of surface undulations or liquid convection currents. During periods when sloshing is being evaluated, or when the tank is being depleted at a high rate, the holes are aligned to permit relatively unrestricted flow. The sleeve may be positioned to effect hole registry or nonregistry using either a timed mechanism, which can be hydraulic or electrical, or a gravity device responsive to acceleration, in the case of a space vehicle fuel tank. Modification of flow characteristics through the probe, as functions of liquid level, acceleration field, tank pressure, time, etc., may be employed to adjust probe accuracy and response characteristics.

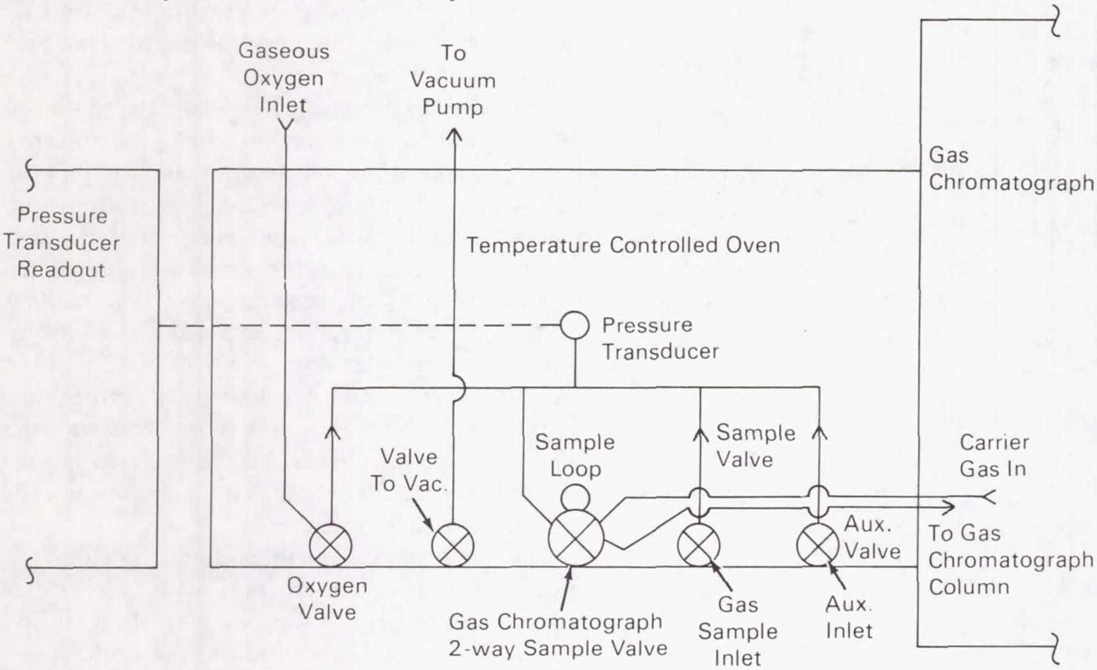
Source: C. C. Wilhite of
Bellcomm, Inc.
under contract to
NASA Headquarters
(HQN-9986)

Circle 9 on Reader Service Card.

ECONOMIC CHROMATOGRAPH FOR SUBAMBIENT GAS SAMPLING

A new gas chromatograph (GC) sampling system consists of a manifold with a GC gas-sample valve, a minimum-volume pressure transducer with a readout device, a vacuum-source valve, and sample-inlet valve (see figure). The system is useful in the analysis of subambient pressure gas samples, particularly those from propulsion units. Three prototypes have been constructed and are currently in use.

Previous GC sampling systems consisted of a manifold with a GC two-way sample valve, a pressure gage, a vacuum-source valve, and a sample-inlet valve. In these systems, the manifold was traced with externally controlled heating tapes and insulated with glass wool batting. In the new sampling system, however, a low-volume pressure transducer with a portable monitor replaces the pressure gage, and the manifold and its components are enclosed in a controlled air-circulating, constant-temperature oven that is attached to the GC cabinet. This arrangement of the manifold eliminates such objectionable features as the necessity for tracing all the sharp bends of the system lines with heating tapes to abolish cold spots where condensation might take place, and the possibility of electrical short circuits that frequently cause irreparable damage to the tapes and valves, decompose the sample at the resultant "hot spot," and create a safety hazard. In the old system, the

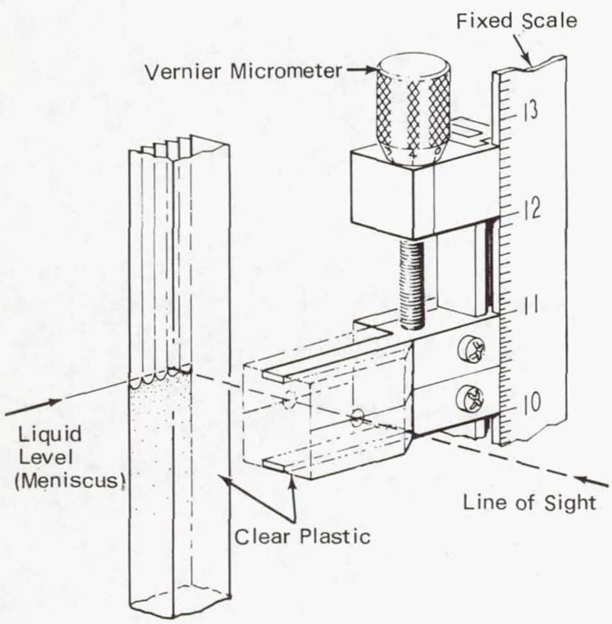


pressure gage required a relatively large volume of gas to obtain a sample pressure reading; and the face of the gage was an unwanted cold trap for condensation of sample components, as well as being subject to shattering. These shortcomings are eliminated by the pressure transducer in the new system, and the accuracy of pressure measurements is increased.

The new GC sampling system has time-saving and safety features that are not commercially available. The increased analysis accuracy is brought about by better control of the sample size.

Source: S. M. Mitchell of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16298)

Circle 10 on Reader Service Card.



VOLUMETRIC DISPLACEMENT MEASUREMENT

A lightweight measuring device determines the weight of a liquid being transferred to a tank under pressure. Existing methods, such as weighing on scales or employing load cells or flowmeters, involve cumbersome mechanisms and are not precisely accurate.

The new technique determines the quantity of a liquid under pressure being transferred from one vessel to another, to an accuracy of 0.5 to 1 percent by weight, by reading the meniscus level in a sight glass between two points and correcting for density using an indicated temperature readout. Precision reading of the meniscus level is obtained by adjusting a vernier micrometer which controls two separated parallel lines, and developing a three-point alignment to eliminate parallax involved with the meniscus height. A fixed scale, graduated in millimeters and located beside a sight indicator, is used to align the vernier.

This anti-parallax, three-point line-of-sight method, used in conjunction with micrometer adjustment, presents a novel means of measuring the quantities of liquids transferred under pressure.

Source: G. M. Funk and W. K. Quick of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-1268)

No further documentation is available.

CALCULATION OF INCOMPRESSIBLE FLUID FLOW THROUGH CAMBERED BLADES

The problem of calculating the flow of an incompressible fluid through a staggered array of cambered blades has been investigated theoretically. Linear approximate solutions have been achieved by conformal mapping techniques, for the cases of flow with partial cavitation and supercavitation. Although these solutions are subject to the usual accuracy limitations of linear approximations, the design situations encountered in practice are such that useful results may be obtained. From the analysis, it is possible to determine lift and drag coefficients, cavitation number, cavity shape, and exit flow conditions for any given cascade geometry, blade shape, cavity length, and initial inflow conditions.

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference:

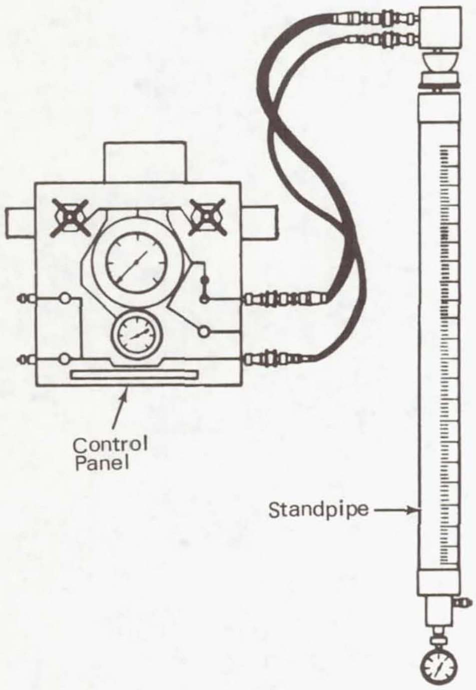
NASA-CR-100773 (N69-24357), On Flow Past a Supercavitating Cascade of Cambered Blades

NASA-CR-102416 (N70-15791), On Flow Past a Cascade of Partially Cavitating Cambered Blades

Source: C. C. Hsu of
Hydronautics, Inc.
under contract to
Marshall Space Flight Center
(MFS-20503)

VOLUME MEASUREMENT TOOL

The amount of fluid in a closed system of known or unknown volume can be determined with a novel volume-checking tool. Similarly, the amount of gas entrained by fluid in a closed system, the amount of fluid remaining in a dried



system of known volume, or the volume of a container of unknown size can be determined.

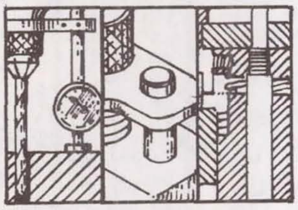
The tool was developed for checking the contents of a closed-circuit, pressurized loop containing a coolant mixture of water and methanol. During system operation, a certain amount of fluid leaked from the system, and small amounts of gas were generated by galvanic action within it. Since the volume of entrained gas could not exceed the allowable amount, it was necessary to determine accurately (1) the original and final (after operation) fluid contents on which the leakage rate could be based, and (2) the rate of gas generation.

The tool consists of two modules (see fig.): a standpipe or graduated storage vessel, and a control panel. Accuracy is limited to that of the off-the-shelf instruments incorporated.

Source: C. J. Erbe and L. J. Poulos of
IBM Corp.
under contract to
Kennedy Space Center
(KSC-10514)

Circle 11 on Reader Service Card.

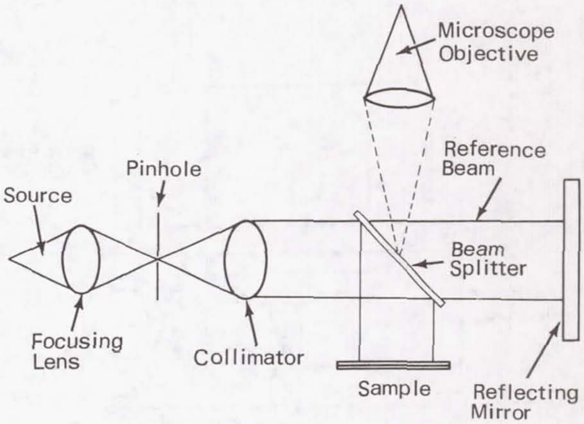
SECTION 4. LINEAR AND ANGULAR MEASUREMENTS



IMPROVED METHOD FOR THIN FILM THICKNESS MEASUREMENTS

Thin film thickness can be measured by scanning the photograph of a Fizeau interferogram with a microdensitometer. While each technique (use of an interferogram and use of a microdensitometer) is well known, the combination of the two to measure thin film thickness offers a new tool to measurement technology.

An interference objective lens mounted on a microscope (see fig.) is used to produce the interference pattern. After the alignment procedure, the image can be transferred to a film by a set of focusing lenses. The resultant film is developed and the negative is then scanned by the microdensitometer, which provides a high degree of repeatability in determining fringe spacing and fringe shift. These values are then used to determine film thickness.



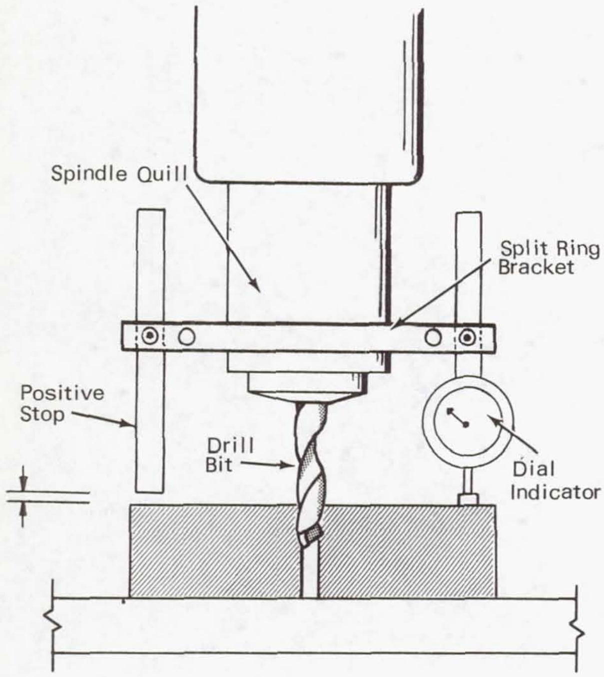
The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference:

NASA-TM-X-53979 (N70-19806), An Improved Method for Thin-Film Thickness Measurements

Source: J. L. Zurasky
Marshall Space Flight Center, and
R. Forsten of
Sperry Rand Corp.
under contract to
Marshall Space Flight Center
(MFS-20820)



DEPTH INDICATOR AND STOP AID MACHINING TO PRECISE TOLERANCES

Drill presses, vertical milling machines, and jig borers consistently hold depths of cut to close tolerances by means of an attachment that provides a visual indication of the depth of cut and also provides a positive stop to prevent overcutting.

The attachment consists of a split-ring bracket (shown attached to a drill-press spindle quill) that attaches to the machine. A travel dial indicator is mounted at one end and an adjustable stop bar is attached at the other. The rod holding the travel dial indicator is positioned so that the indicator will contact a reference surface. With the cutting tool mounted in the spindle, the quill and spindle are lowered until the tool reaches the precise depth of cut desired. The travel dial indicator is engaged with the reference surface and set to zero. The stop rod is then set to engage the workpiece, fixture, or press bed at the depth of cut. The tool, spindle, and quill are retracted and the workpiece put in place.

With this attachment, an operator can make repeated cuts to precise depth by observing the travel dial indicator for a zero indication.

Source: J. L. Laverty of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-553)

No further documentation is available.

POLYMER DEFORMATION GAGE MEASURES THICKNESS CHANGE IN TENSILE TESTS

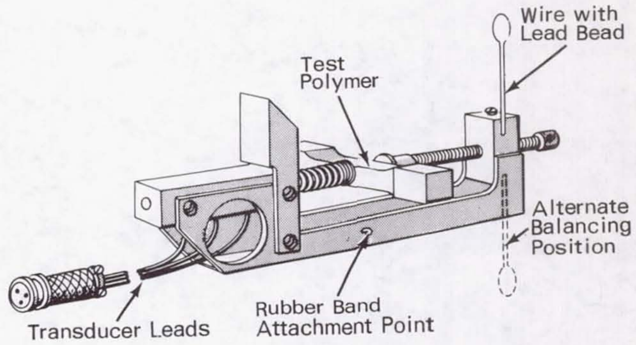
A lightweight deformation gage that remains attached to the specimen throughout testing determines the thickness (or cross-sectional) changes undergone by a polymer specimen during tensile and elongation. This allows continuous measurement of thickness changes with minimum effect on the test specimen.

The gage body mounts an adjustable screw and a spring-loaded feeler that lightly engage the test specimen. The gage is suspended from the sample, but because of its light weight, only minimum contact pressure is exerted on the specimen. A transducer attached to the spring-loaded feeler converts any change in specimen cross section into an electrical signal that registers on readout instrumentation. The gage is finely balanced about the neutral center-line of the test specimen by means of a wire with a lead bead on one end. The wire is inserted into a tight hole at one end of the gage after correct wire length for perfect balance has been determined by trial and error.

If it is desired to measure the thickness of an especially delicate moving test specimen, a rubberband from the gage body to a moving platform is used to balance the assembly. The wire with the lead bead is placed in the alternate position, shifting the balance point to the center of the rubberband attachment point. In this mode, with the specimen suspended from a platform which is mechanically driven to coincide with the moving test point desired on the sample (usually 1/2 sample extension spread for midpoint gaging), the test specimen is influenced only by the light spring forces needed to overcome the sliding friction of the transducer, and does not bear the weight of the deformation gage assembly.

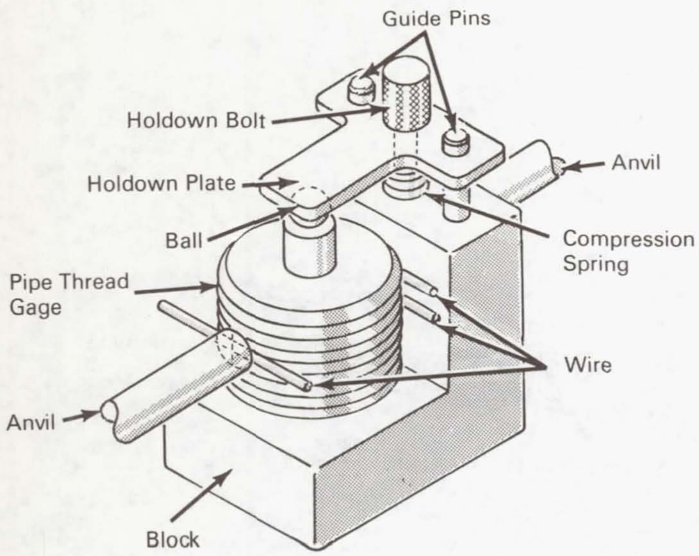
Source: H. Broyles and F. Broyles
Jet Propulsion Laboratory
(JPL-745)

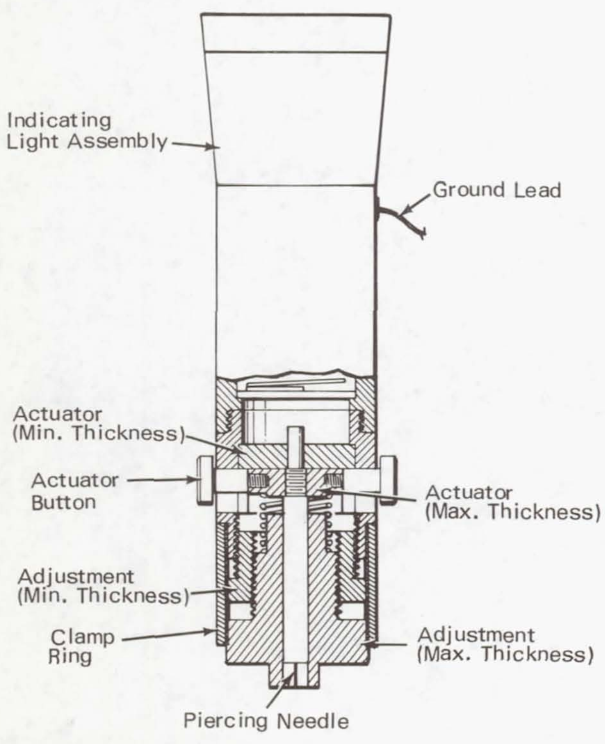
No further documentation is available.



HOLDING FIXTURE AIDS PIPE THREAD GAGE MEASUREMENTS

This fixture facilitates measuring pitch diameter of the tapered threads of a pipe thread gage. Two wires are held in position in the threads while a third wire is similarly held on the opposite side of the gage. The three wires and thread gage are held in this manner while the wires are brought between the two anvils of a micrometer measuring instrument.





The pipe thread gage is placed on the holding fixture with two wires engaged in the threads. The mounted fixture is then placed between the anvils of the measuring instrument and the third wire is engaged in the proper position, opposite the other two. The anvils are then brought into contact with the third wire and the back of the holder.

This device, with slight modification, can be used to hold two wires and straight or tapered thread gages, as well as involute spur gears.

Source: J. Hill and B. Cupps of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-2009)

Circle 12 on Reader Service Card.

COATING THICKNESS GAGE

This gage is calibrated to indicate the thickness of coatings on metal substrates within relatively broad tolerances. It is useful for checking the thickness of insulation, for instance, on piping, tanks, or walls of refrigerated or heated spaces.

The ground lead is clamped to the metal substrate and the piercing needle penetrates the coating and thus contacts the substrate to complete an electrical circuit that lights a battery-operated bulb in the top of the housing. The gage body base is placed on the coating with the gage in the vertical position as shown in the figure. Depressing the actuator button releases the piercing needle assembly, which then falls freely to penetrate the coating in accordance with the minimum and maximum that have been predetermined by setting the adjustments. If the bulb lights immediately, it indicates "no-go too thin"; if it fails to light at all, it indicates "no-go too thick." The bulb lighting after a predetermined time increment indicates a coating thickness within tolerance.

Source: D. K. Mitchell of
The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-14011)

Circle 13 on Reader Service Card.

FLARE ANGLES MEASURED WITH BALL GAGE

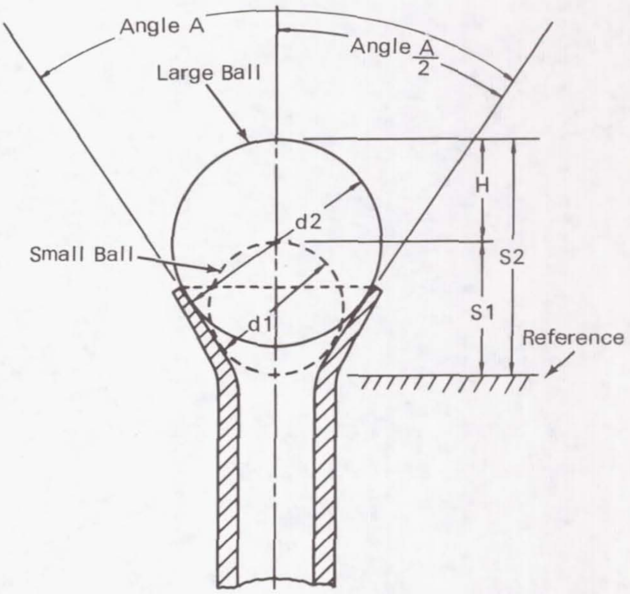
A new technique uses precision tungsten carbide balls to measure the internal flare angle of high-pressure tubing joints. Such joints have always been subject to leakage problems wherever high pressures, extreme temperature gradients, or excessive vibration have been involved. As a result, it is necessary to fabricate flared joints to very exacting standards and this requires precise means of measuring the internal angle of the planes. Prior methods involved making a plaster or plastic cast of the internal flare and then inspecting the cast on an optical comparator.

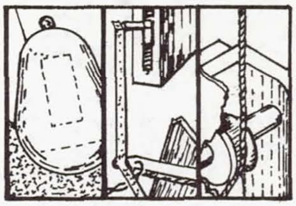
In the new technique, the measurement is made by placing a small ball into the throat of the flare, as shown in the sketch. The distance S_1 from the top of the ball to an external reference point is then measured. A larger ball is then placed in the flare and the distance S_2 from the top of the ball to the same reference point is measured. The difference H in distances $(S_2\text{-}S_1)$ to the reference point, and the difference in diameters d_1 and d_2 of the two balls determine the average slope of the flare between the points of ball contact. Thus, the required angle A is determined by:

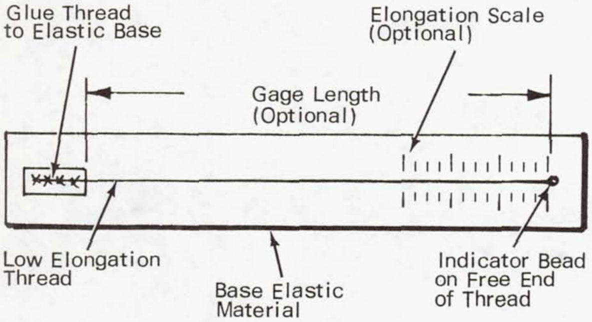
$$\operatorname{cosec}\frac{A}{2} = \frac{2H}{d_2-d_1} - 1.$$

This invention has been patented by NASA (U.S. Patent No. 3,360,864), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to: Patent Counsel, Mail Code A&TS, George C. Marshall Space Flight Center, Marshall Space Flight Center, Huntsville, Alabama 35812.

Source: D. Cleghorn and W. A. Wall
Marshall Space Flight Center
(MFS-14690)







NONELECTRICAL STRAIN GAGE

A simple, self-contained, nonelectrical gage is capable of measuring and recording strain or elongation in fabric components of aerodynamic decelerators (parachutes) such as canopy cloth, reinforcing tapes, suspension lines, webbing risers, etc. The gage (see fig.) consists of a length of elastic material, such as dressmaker's elastic band fabric, that has a low-elongation thread or string attached to it. One end of the thread is secured by glue to the elastic band and the other end is provided with a bead or knot to serve as an indicator. The elastic band is marked with an elongation scale located under the bead or knot.

The assembled gage is attached by an adhesive to the material to be measured. As the material stretches, the elastic band stretches also, but the thread does not; and movement of the bead or knot along the scale indicates the total elongation or strain of the material measured.

Source: R. L. Ranes of
Northrop Corp.
under contract to
Langley Research Center
(LAR-10593)

No further documentation is available.

SEISMOMETER FOR REMOTE OPERATION IN RANDOM ORIENTATION

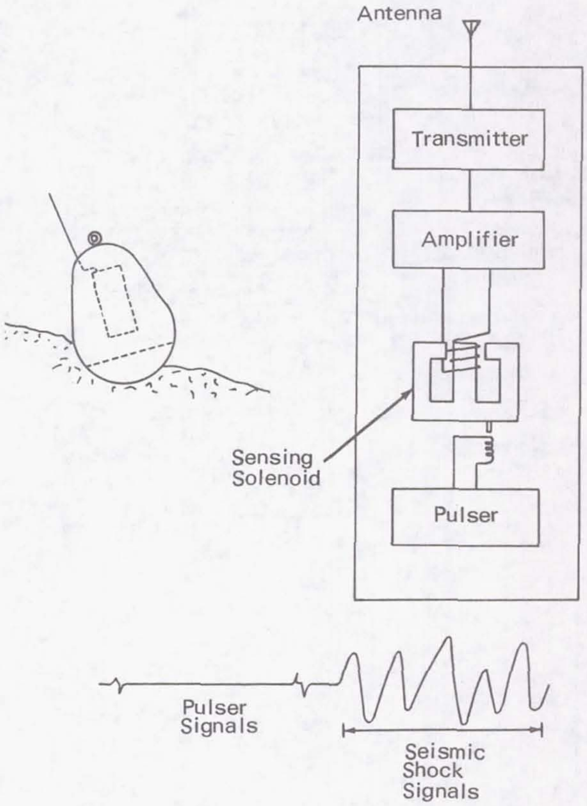
A portable seismometer can be placed in normally inaccessible locations and will operate efficiently in other than a vertically upright position. The seismometer is packaged with appropriate telemetry equipment in order to transmit its measurements to a receiving station.

The seismometer is mounted in a rugged housing that contains an amplifier, transmitter, and antenna for relaying measurement data to a receiving station. The instrument incorporates automatic angular adjustment to minimize the effect of angular error between the seismic mass axis and local vertical.

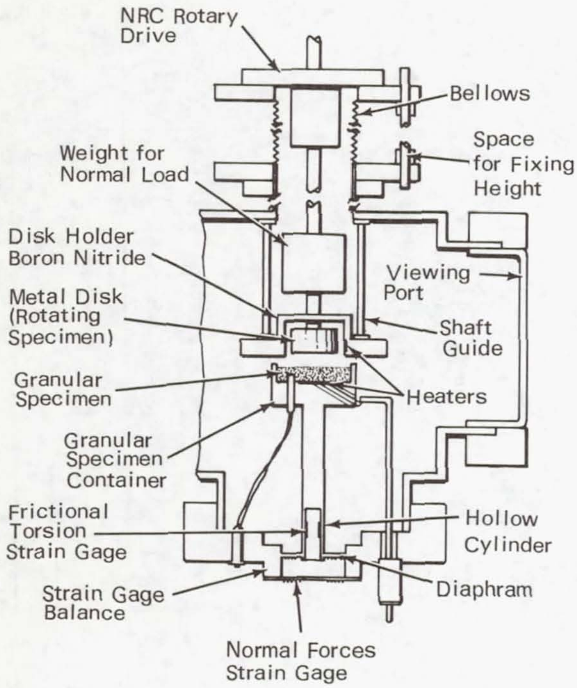
The instrument responds to local disturbances by measuring the relative movement of its housing with respect to an inertial or seismic mass, and supplying an output voltage proportional to the relative displacement. Shocks to the casing, caused by slight movements of the surface that the unit is resting on, cause the case to move in relation to the seismic mass. A sensing solenoid, rigidly held by the case, reacts to the change in plunger-to-coil relationship, and generates a signal. This signal is amplified and fed to a transmitter for relay to a receiving station. The seismometer also incorporates a self-monitoring system that periodically signals the device's operational readiness. This system is made up of a pulser that is timed to feed impulses at regular intervals to a solenoid whose plunger is attached to the base of the seismic mass. This causes the mass to move slightly in relation to the case, and a signal is generated in the sensing solenoid. This signal has a slight amplitude and is, because of its programmed repetition rate, readily distinguished from signals generated due to surface disturbances.

The seismometer case, in the area of the seismic mass, may be filled with a damping fluid to withstand hard impact. Automatic means may be included to vent the damping fluid following impact. Electronic components in the seismometer package are protected from impact damage by standard potting techniques. This seismometer may be dropped into bores in the earth or lowered to rest on the bottom of a body of water. The only modification required in such cases would be that necessary to maintain electronic system effectiveness.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)] to California Institute of Technology, Pasadena, California 91109.



Source: F. E. Lehner of
California Institute of Technology
under contract to
Jet Propulsion Laboratory
(JPL-320)



MEASUREMENT OF COEFFICIENT OF FRICTION

A prototype device (see fig.) measures the coefficient of friction between metal disks and nonmetallic granular materials in ultrahigh vacuum. A predetermined amount of the granular material is placed in a cup-shaped specimen container and a weighted rotating disk is lowered and allowed to rest on the contained granular material. The container is mounted on a column supported by and integral with a diaphragm located in the base of the unit.

The force of the specimen disk against the granular material is a function of diaphragm deflection. This force is measured by the normal force strain gages attached to the bottom of the diaphragm on either side of the column. Similarly, the torque transmitted through the granular test material is a function of the torque exerted on the column. This is measured by four frictional torsion strain gages attached to the interior of the hollow cylinder.

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $0.95)

Reference:
NASA-CR-61439 (N68-14579), Determination of the Coefficient of Friction Between Metals and Nonmetals in Ultrahigh Vacuum.

Source: G. Mohr of
Grumman Aerospace Corp.
under contract to
Marshall Space Flight Center
(MFS-13770)

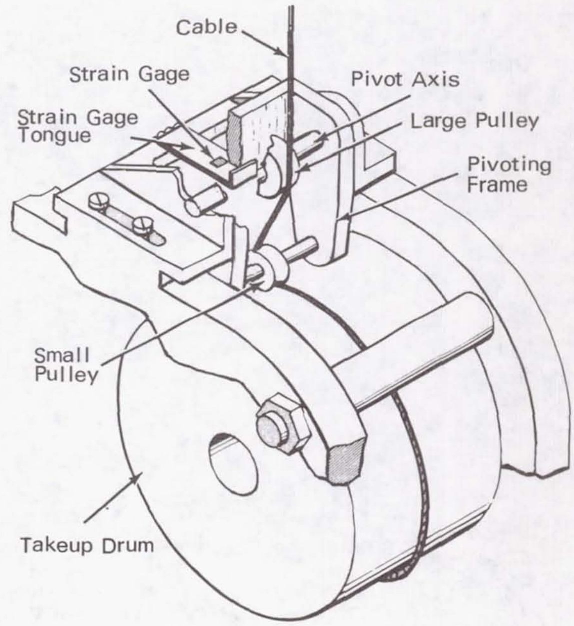
MECHANISM CONTINUOUSLY MEASURES STATIC AND DYNAMIC CABLE LOADS

A mechanism measures the tensile loads on a cable under static and dynamic conditions, without disturbing the continuity of operation of the system. Prior methods using load cells and other load measuring instruments required temporary interruption of the cable system for in-line installation. Cumbersome electrical lines, which are often required for the instrumentation, may become tangled if there is any appreciable movement of the cable being tested.

The mechanism consists of a set of takeoff pulleys mounted on a pivoted frame that is linked to a strain gage, which measures the frame displacement as a function of the static or dynamic tensile load on the cable.

The pivoting frame has a small pulley mounted at its lower end and a larger pulley at its upper end. This frame is mounted on a support containing a strain gage. The entire assembly is mounted over the takeup drum of a cable turn-control motor. The pulleys are arranged relative to the drum so that the cable makes a fixed angle at the points of incidence to and departure from the small pulley. The load on the small pulley will therefore be proportional to the load on the cable. An increasing load on the cable transmitted through the small pulley causes the frame to swing about the pivot axis and deflect the strain gage tongue downward in proportion to the cable load. The resulting output from the strain gage can be continuously monitored to give direct readings of the cable load. The two pulleys on the pivoting frame are free to translate on their axes of rotation in order to allow proper positioning of the cable as it transveres the takeup drum during winding or unwinding.

As a possible modification, a third pulley might be added to the two-pulley assembly. Since the takeoff angle is a critical factor in calibrating the mechanism, the third pulley would be made adjustable in accordance with the anticipated load it is to carry. Under heavy load, the added pulley would be set approximately in the plane of the other pulleys, so that only



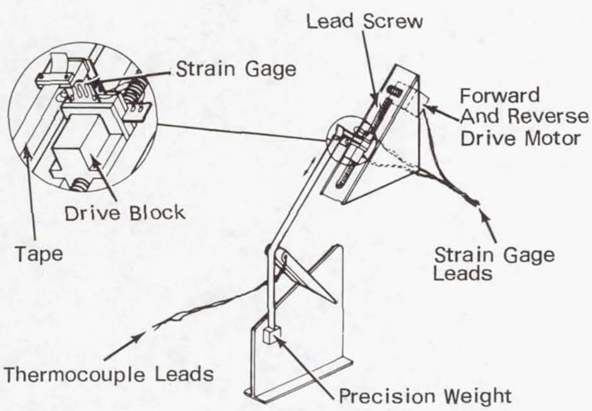
a small component of the main load would be applied to the strain gage. Under light loads, the third pulley would be set nearly perpendicular to the other two pulleys in order to maximize the load on the strain gage.

This mechanism could be used to monitor the tensile load on any material, including cable, wire, sheet metal, fabric, and paper, that can pass through a series of rollers.

Source: T. Grubbs
Manned Spacecraft Center
(MSC-217)

Circle 14 on Reader Service Card.

DEVICE MEASURES STATIC FRICTION INVOLVING MAGNETIC TAPE



This device uses a strain gage to measure the force of friction between a reference surface and the tape drawn at a constant velocity of approximately 0.0000254 mm (0.0001 in.) per second relative to the reference surface. At a constant velocity of this small magnitude, the difference in value between static and kinetic friction is negligible for practical purposes.

The device is mounted so that the test surfaces are enclosed in an environmental chamber. A sample of tape to be tested is clamped at its upper end to a cantilever spring containing a strain gage. The base of the cantilever spring is mounted on the drive block of a motor-driven lead screw mechanism. The tape, with a precision weight secured to the lower end, is suspended over a rounded face block made of any desired metal. For testing the tape against other materials, a film of the desired material can be wrapped around the metal block and held in tension by a weight. A thermocouple is embedded in the metal block close to the test surfaces which are enclosed in the test chamber. The environment in this chamber can be controlled at temperatures ranging from 273.15 to 393.15 K (0° to 120° C) and relative humidities from 1 to 90 percent.

When the drive block is moved upward at the 0.0000254 mm/sec (0.0001 ips) rate, the strain gage output will rise to a steady maximum value. This output is amplified and converted (by calibration) to the value of the friction load plus the suspended precision weight in ounces. With the use of a simple equation, the coefficient of friction can then be determined for any frictional load.

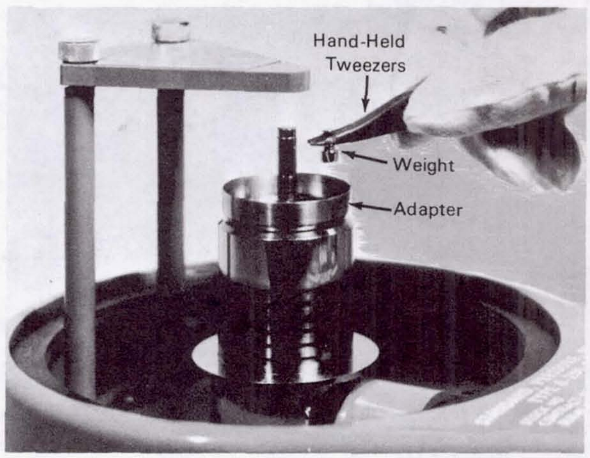
This device can also be adapted to measuring kinetic friction, and an inductance transducer may be used in place of a strain gage.

Source: P. T. Cole
Goddard Space Flight Center
(GSC-10360)

Circle 15 on Reader Service Card.

WEIGHT CUP FOR DEAD-WEIGHT TESTER TEMPERATURE COMPENSATION

A dead-weight pressure calibration standard has been modified by the addition of a cup that will hold small weights used to compensate for temperature variations. The stainless steel cup of exactly 0.4 gram weight aids in the use of temperature/weight correction tables that are made up for each dead-weight tester when certified by metrology.



The correction table for the tester shown gives ranges from 0.6895 kN/m^2 to 413.7 kN/m^2 (0.1 to 600 psi) and requires weight corrections up to 3 grams. The deviation is primarily attributable to variations in the fluid viscosity within the tester cylinder.

This represents an appreciable improvement over the previous method in which a pressure equivalent was calculated by a technician and used to correct the instrument deviation as read.

Source: D. L. Burke and R. N. Glidden of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16903)

Circle 16 on Reader Service Card.

STRAIN MEASUREMENTS ON LARGE SURFACES USING A SPRAYABLE BIREFRINGENT COATING

A birefringent coating contains constituents that can be premixed and sprayed as a single component with conventional paint spray equipment. Elevated temperatures are not required for spraying or curing of the coating material. The material has a long pot life and cures in a short time after spraying to produce a coating with a relatively high and stable strain-optic coefficient.

Although birefringent coatings have been widely used for the photoelastic analysis of surface strains on structures, their use has been primarily limited to small-area coverage. Two-component spray systems have been proposed for large-area coverage because short pot life precludes the premixing of conventional curing agents and resins in sufficient quantities for spraying. Such systems, however, are quite expensive and require precise metering of the coating constituents. In addition, these coating compositions must be heated to reduce their viscosities sufficiently to allow spraying.

The new formulation consists of an epoxy resin, a thixotroping agent, two different curing agents or hardeners, and a solvent. Total hardener concentration is at or near the stoichiometric ratio based on the epoxide equivalent of the resins. The unique feature of the formulation is provided by a ketimine used as the primary curing agent.

In the absence of moisture, the ketimine reacts very slowly with the epoxy resin and thus ensures a long pot life. However, in the presence of moisture, which accumulates during spraying, the ketimine converts to an amine and a ketone. The resultant amine reacts with the epoxy resin, allowing the sprayed coating to cure rapidly, and the ketone is expelled. A second amine, which also functions as a hardener in the formulation, is used in sufficiently small concentration to have no appreciable effect on pot life. This amine also serves to accelerate coating gel formation during conversion of the ketimine. The solvent reduces the viscosity of the mixture sufficiently to allow spraying. The thixotroping agent is used so that thick coats can be applied to vertical surfaces.

Source: W. M. McGee and F. T. Humphrey of
Lockheed Aircraft Corp.
under contract to
Marshall Space Flight Center
(MFS-1484)

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NASA-Langley, 1972