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GTE

TR 73-842.3

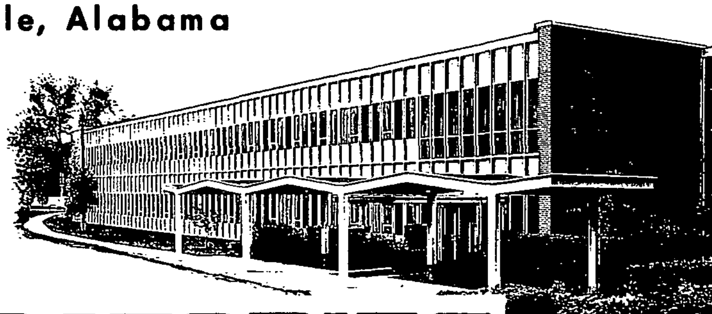
DESIGN. FABRICATION, TESTING, AND DELIVERY OF IMPROVED BEAM STEERING DEVICES

FINAL REPORT
Contract NAS 8-26846

April 1973

Submitted to

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama



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ABSTRACT

This report covers work performed on the development, manufacture, and testing of an optical beam steerer intended for use in space-borne optical radar systems. Included are design principles and design modifications made to harden the device against launch and space environments, the quality program and procedures developed to insure consistent product quality throughout the manufacturing phase, and Engineering Qualification Model testing and evaluation. The delivered hardware design was deemed conditionally qualified pending action on further recommended design modifications.

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CONTENTS

BACKGROUND

During previous contract work for NASA[1] a design for an electromechanical optical beam steering device was developed. The characteristics of the device (low power, large aperture, high accuracy) made it a prime contender for use in space-borne optical radar systems. Test models built to this design and furnished to NASA have been used successfully in an optical rendezvous and docking system brass board demonstrator.

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1. CONTRACTUAL WORK REQUIREMENTS

The requirements described in this section constitute the work necessary to achieve the following contractual objectives:

a) To improve the previously developed beam steerer functional characteristics to insure reliable operation after launch and in a space environment.

b) To document the hardware manufacture in such a manner as to allow reproduction of the device by any qualified supplier.

c) To test hardware manufactured according to specifications to insure conformance with all environmental and functional performance requirements.

d) To deliver design qualified models.

1.1 DESIGN MODIFICATIONS

The beam steerer design developed on a previous contract (NAS8-11459) is to be modified to improve the characteristics as described in Sections 1.1.1 through 1.1.4.

1.1.1 Reduce Thermally Induced Mirror Deflection

Imperfect matching of thermal expansion coefficients of the base material, piezoelectric transducer, and mirror has caused deflection of the mirror with respect to the base with changes in temperature. This is to be reduced by closer matching of material expansion coefficients and symmetrical construction techniques.

1.1.2 Increase Strain Gage Bridge Stability

The strain gage bridge which senses the piezoelectric transducer deflection is susceptible to drift in the zero balance due to thermal effects and aging with use. Methods are to be pursued to reduce the thermal and aging effects through thermal compensation and improved construction techniques.

1.1.3 Reduce Drive Signal Feedthrough

The deflection sensing strain gages are mounted directly on the surface of the piezoelectric transducer and are susceptible to pickup of the transducer drive signal, causing errors in the readout of deflection. This is to be reduced by running the transducer drive electrode under the strain gage and making it a more perfect ground plane.

1.1.4 Mirror Size

The deflecting mirror is to remain unchanged in aperture at 1.78 cm by 1.54 cm.

1.2 QUALITY AND RELIABILITY REQUIREMENTS

1.2.1 Inspection Plan

An inspection plan is to be written which details the inspection system to be used, etc., when manufacturing deliverable hardware. The inspection system must satisfy the requirements of NASA Quality Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services".

1.2.2 Parts and Materials List

A Parts and Materials List shall be compiled and submitted to NASA for review and approval. No hardware shall be fabricated prior to receipt of approval.

1.2.3 Failure Mode, Effect and Criticality Analysis

A failure mode, effect and criticality analysis (FMECA) shall be performed on the beam steerer to determine possible methods of failure, the effect of failure on operation capabilities, and the criticality of this failure. The primary objective shall be to discover critical failure areas in the design phase and remove susceptibility to such failures from the system.

1.2.4 Qualification Test Procedure

A detailed procedure is to be written for performance of tests on a beam steerer qualification model to establish that the design and manufacturing procedures result in a product which conforms to all of the established environmental and functional specification requirements.

1.2.5 Acceptance Test Procedure

A detailed procedure is to be written for performance of tests on beam steerers manufactured for delivery as flight qualified hardware. The tests will insure that these units have been produced according to the manufacturing specifications and meet all applicable functional and environmental requirements.

1.2.6 Data Package

A data package shall be compiled and submitted with the delivered hardware. It shall include the part name, drawing number, contract number, serial number, vendor and the following:

- Complete set of final drawings (reproducible)
- List of deviation approvals
- List of missing components or parts
- List of outstanding defects
- List of serialized parts
- In-process inspection report
- Dimensional inspection report
- Qualification status report
- Configuration status report
- Copy of shipping document

1.3 HARDWARE MANUFACTURE

Two engineering model beam steerers are to be manufactured, incorporating all design improvements listed in Section 1.1 and any design modifications required to conform to environmental and functional testing requirements. All drawings, specifications and tests shall incorporate the latest design information.

1.4 HARDWARE TESTING

The two engineering models are to be thoroughly tested in accordance with the Qualification Test Procedure. Testing is to be performed under the supervision of the contractor's reliability engineer.

1.4.1 Qualification Testing

Qualification testing is performed to test the success of the device design in withstanding environmental conditions of temperature, humidity, shock, and vibration, without critically affecting the operational and functional parameters. A qualification model which shall be one of the above engineering models is to be tested in accordance with the Qualification Test Procedure.

1.4.1.1 Environmental Tests

The beam steerer is to be exposed to environmental conditions, and tested, as prescribed in the Qualification Test Procedure.

1.4.1.2 Functional Tests

The important beam steerer mechanical, optical and electro-optical characteristics are to be determined by tests conducted in accordance with the Functional Test Procedure.

1.4.2 Acceptance Testing

Beam steerer units manufactured as flight hardware, whose design has been previously qualified through qualification testing, shall be tested in accordance with the Acceptance Test Procedure.

1.5 DELIVERABLE ITEMS

1.5.1 Hardware

Two engineering models shall be delivered which have been constructed in accordance with a qualified design meeting qualification test requirements as per Section 1.4.1.

1.5.2 Documentation and Reports

The following items constitute the Data Requirements List of data documentation, and reports to be furnished under this contract. (The Data Requirement List line item number is given in parenthesis.)

1.5.2.1 Drawings and Associated Lists (1)

This shall provide a complete description of the beam steerer manufacturing process.

1.5.2.2 Microfilm (Drawings, Specifications, and Procedure) (2)

Prepared in accordance with NHB 1440.4A, "Specifications and Standards for NASA Engineering Data Microreproduction Systems".

1.5.2.3 Acceptance Test Procedure (3)

This shall provide procedures for determining compliance with the acceptance test requirements specified in the beam steerer specification.

1.5.2.4 Acceptance Test Report (4)

This shall provide the results of tests made in accordance with the Acceptance Test Procedure as a basis for acceptance of beam steerers in conformance to the specifications.

1.5.2.5 Progress Report (Letter) (5)

This shall advise NASA of all significant progress and events occurring during the monthly reporting period.

1.5.2.6 Final Summary Report (6)

This shall provide a complete summary of the work performed under the contract.

1.5.2.7 Inspection Plan (7)

This shall provide visibility into the inspection system instituted to insure the required quality of materials, parts, components, and services for space systems. It shall be prepared in accordance with NASA Quality Publication NPC 200-3.

1.5.2.8 Failure Mode, Effect, and Criticality Analysis (8)

This analysis shall determine the possible modes of failure, the effect of the failure on operation capabilities, and the criticality of the failure in accordance with MSFC Drawing 10M30111.

1.5.2.9 Qualification Test Procedure (9)

This shall provide detailed procedures to be followed in the performance of tests conducted in accordance with specification requirements to assure qualified beam steerer design.

1.5.2.10 Qualification Test Report (10)

This shall provide accountability of tests conducted, results obtained, and recommendations made relative to the design qualification of the beam steerer.

1.5.2.11 Data Package

A data package shall accompany the delivered hardware and shall contain a summary of the information pertaining to the present status of the hardware relative to future installation and application in higher level systems. It shall contain those items listed in Section 1.2.5, as applicable.

2. SUMMARY OF WORK ACCOMPLISHED

2.1 INCORPORATION OF SPECIFIED DESIGN MODIFICATIONS

2.1.1 Thermally Induced Mirror Deflection

A metal alloy was chosen for the piezoelectric transducer mounting base which closely matched the thermal expansion coefficient of the transducer. In addition, the transducer was mounted in such a way that the portion attached to the base is sandwiched between two metal pieces. The resulting structural symmetry tends to cancel any residual thermally induced deflection. A similar type of geometry was used for mounting the mirror with a mirror substrate of matching expansion coefficient.

2.1.2 Strain Gage Bridge Stability

A modified method of bonding the strain gages to the transducer has resulted in reduced residual strain in the gages and much closer matching of the resistance of the two gages. This close match has made it possible to balance the strain gage bridge to within 4% of its peak-to-peak output with, at most, two trim resistors. This eliminates the instabilities and unreliability associated with the formerly used trim potentiometer.

The improved bonding of the gages has also nearly eliminated the drift of the bridge balance with strain cycling. While extensive life testing has not been done, checks of some units after 10^7 cycles showed no significant drift of the bridge balance.

It was found that the only major thermal instability of the strain gage bridge was an imbalance due to unequal cooling of the two gages caused by air drafts. This is completely eliminated when the beam steerer is used in an enclosed housing or in a vacuum environment such as space. Because of this it was felt neither necessary nor desirable to attempt to develop a thermally protective encapsulating coating for the gages which could affect other properties of the device such as maximum deflection, outgassing, mechanical stability, or lifetime.

2.1.3 Drive Signal Feedthrough

Isolating the strain gage from the transducer drive signal has been accomplished by placing the gage on the ground plane electrode of the transducer, insulated from it by a one micrometer thick layer of sapphire. With this arrangement the gage has shown no capacitively induced signal pickup, is fully isolated from ground, and is closely coupled mechanically to the underlying transducer for accurate strain sensing.

2.1.4 Mirror Size and Mounting

The mirror aperature has remained at 1.78 x 2.54 cm. However, the mounting geometry on the transducer has been modified to strengthen it and reduce the tendency for mirror surface distortion.

2.2 QUALITY AND RELIABILITY PROGRAM

2.2.1 Inspection System

An Inspection Plan has been written which is in accordance with NASA Quality Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services". A Quality Procedures Manual has also been prepared as an implementation of this plan and these procedures have been followed during the manufacture of the beam steerer engineering models. These documents may be found in Appendix A.

2.2.2 Parts and Materials List

A partial Parts and Materials List was compiled and submitted to NASA-MSFC on November 30, 1971. Approvals have been obtained for those parts and materials which were submitted and subsequently specified and used on the Engineering and Qualification Models. Those items which were incorporated in these models but have yet to be submitted for review are listed in Appendix D, Section 2.13 of the Data Package. Before production of flight hardware is begun the entire parts and materials list must be resubmitted for final approval.

2.2.3 Failure Mode, Effect and Criticality Analysis (FMECA)

An FMECA was prepared and submitted in February 1972 in accordance with the requirements of MSFC Drawing 10M30111A. The areas deemed most susceptible to failure were examined and modifications made in the beam steerer design to reduce the failure probability. These features are highlighted in Section 3.1.3, Detailed Design Considerations. The FMECA may be found in Appendix B.

2.2.4 Qualification Test Procedure

A Qualification Test Procedure was written to prescribe the environmental and functional testing to be performed on a qualification test model beam steerer. The tests incorporate all of the environmental conditions which have been imposed by the contract and those functional tests which are critical to the performance of the beam steerer. The Qualification Test Procedure is a part of the drawing package included in Appendix E, drawing 842-500-101.

2.2.5 Acceptance Test Procedure

An Acceptance Test Procedure for environmental and functional testing of all flight model hardware has been written and is included as part of the drawing package in Appendix E, drawing 842-500-102.

2.2.6 Data Package

The Data Package contains a summary of all of the information pertaining to the present status of the delivered hardware and indicates the degree to which it may be considered fully qualified in accordance with contract requirements. It is included here as Appendix D.

2.3 HARDWARE

Hardware development was divided into three phases during the contract period: design development assemblies, engineering test model fabrication, and engineering qualification model fabrication.

2.3.1 Design Development

During the initial portion of the contract, the design modifications called for in Section 1.1 were incorporated in partial assemblies which were tested and reworked as necessary to give the desired characteristics. In addition, design refinements were introduced to enhance reliability and to provide better resistance to the specified environmental conditions. These design features are discussed in Section 3.1.3.

2.3.2 Engineering Test Model Fabrication and Evaluation

A fabrication run of six beam steerers was begun based upon the revised design developed during the first phase of the program. Although not specifically required, this fabrication sequence was monitored by, and subject to, the inspection system requirements being developed as part of the quality control program to highlight possible shortcomings or weak points in the system. Production methods, process specifications and in-process tests were also more comprehensively defined and documented during the period.

Three beam steerers were completed and each was given complete functional testing as per the Beam Steerer Functional Test Procedure, drawing 842-500-103. The test values were all within the satisfactory range of values as given in Table 1 of the above Procedure.

These units were then exposed to certain of the environments specified in the Qualification Test Procedure, drawing 842-500-101, including acoustic noise, sinusoidal vibration and random vibration. Functional testing after acoustic noise showed no change in the beam steerer characteristics. This same unit later failed in random vibration when the mirror separated from the transducer.

A second unit exhibited failed adhesive bonds when exposed to humidity-temperature cycling comprised of six hours at 70°C, 95% RH and 18 hours at 27°C, 85% RH in nine 24-hour cycles. This military-level environment was inadvertently imposed where much less severe conditions were intended, and the failure is not considered representative of beam steerer performance under normal conditions. Therefore, no immediate design changes were felt necessary to cope with this failure until additional information was obtained at humidity-temperature levels more representative of the projected mission profile.

The failure in random vibration indicated an improved method was needed for attaching the mirror to the transducer. The original method was a compromise between maintaining the mirror flat during adhesive bonding and achieving high structural strength. A reduction in maximum nonoperating temperature environment from +121°C to +60°C was requested and approved by NASA-MSFC. This eased the problem of maintaining mirror flatness over a temperature range, allowing greater latitude in mirror-transducer bonding methods and geometries.

2.3.3 Engineering Qualification Model Fabrication and Evaluation

Before initiating production of Qualification Test Models, techniques were sought to strengthen the mirror-transducer bond without compromising flatness. Changes in the mirror bonding method and mounting geometry were evaluated by subjecting mechanical test models to sinusoidal vibration, static moments, and optical flatness tests.

A satisfactory solution was obtained which would meet the vibration and flatness specifications and withstand a moment about the mirror-transducer bond of 3000 gm-cm before transducer failure. This is illustrated in drawings 842-100-603 and 842-100-601.

These design changes were incorporated in the drawings and three engineering models were fabricated, one of which would undergo full scale qualification testing. All operations were monitored as set forth in the Quality Procedures Manual, Appendix A, including record maintenance of all Inspections, tests, drawing control, and equipment calibration.

The unit having serial number 006 was chosen as the Qualification Test Model, and tested in accordance with the Qualification Test Procedure, drawing 842-500-101. It successfully met all test requirements with the exception of Peak Mirror Deflection Angle. The deflection angle was determined to be ± 15.5 arc minutes and remained constant both before and after all environmental tests. Experience with previous beam steerers and calculations from material constants have shown that this value should lie in the range ± 17 to ± 23 arc minutes. This result is discussed in more detail in Section 3.2.2.1.

3. DETAIL TECHNICAL INFORMATION

3.1 DESIGN PRINCIPLES

3.1.1 Functional Description

The PBM-8G Beam Steerer is a lightweight, compact, low-power device designed for analog electrical control of the angular position of a light beam. It consists of a tilting mirror driven by a piezoelectric bender transducer. The transducer is instrumented with a pair of strain gages which sense transducer deflection. These form part of a bridge circuit for deriving a signal proportional to the mirror tilt angle.

The beam steerer is an element of a scanning laser radar system which directs an infrared (905 nm wavelength) laser beam in a raster scan pattern over a sector of space. Two beam steerers are used to generate orthogonal scan motions. The scan pattern is magnified and imaged on a cooperative target with projection optics. A receiver image disector in the laser radar, scanned in synchronism with the laser, detects return signals from the target. To insure that the receiver and the laser are looking at the same position in space, the receiver is driven by signals derived from the beam steerer deflection sensing circuit. Drive signals for the transducer, supply voltage for the strain gage bridge, and amplification for the bridge output signal are provided by the system electronics. A representative laser radar system is shown in Figure 1.

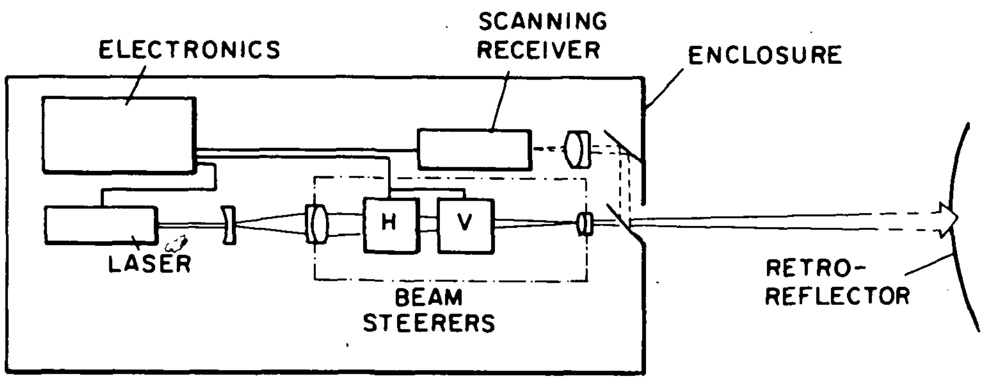

Figure 1. Representative Laser Radar System

3.1.2 Physical and Functional Characteristics

The PBM-8G Beam Steerer general physical dimensions are as shown in Figure 2. Electrical connections are made through two cables 30 cm long with terminating connectors TB_1 and TB_2, specified in drawings 842-400-024-1 and 842-400-024-2, respectively. A terminal board mounted in a cavity beneath the base contains the strain gage bridge completion and trim resistors and is protected by a bottom cover. All exposed metal surfaces are finished in flat black except for electrical terminals and connectors. The weight of the assembly including connectors (65g) is 266g. The unit is shipped with a protective cover over the top half which is to be removed before installation. Figure 3 is a photograph of the device.

The nominal functional characteristics of the beam steerer are given below:

Functional Characteristics	Nominal Value
Mirror deflection at ± 500 V peak	± 20 arc minutes
Peak drive voltage (maximum)	± 500 V peak
Mechanical resonance frequency	1200 Hz
Capacitance at 500 Hz	0.02 μF
Mirror surface deformation (maximum)	105 nm (4.2 μin)
Mirror reflectivity at 905 nm	≥ 97%
Strain gage bridge parameters with 2.000 Vdc supply voltage:	
Angular sensitivity	5.33 μV/arc second
Readout error (maximum)	0.1%
Offset voltage (maximum)	± 550 μV

3.1.3 Detailed Design Considerations

An analytical study has been conducted of the parametric tradeoffs which may be made to achieve a desired set of beam steerer characteristics. These results have been presented in the form of a set of design curves,[2] permitting a rapid determination of the beam steerer performance boundaries and what parameter tradeoffs may be made in tailoring the device to system requirements. The physical geometry and functional characteristics of the present design were dictated by the needs of the optical

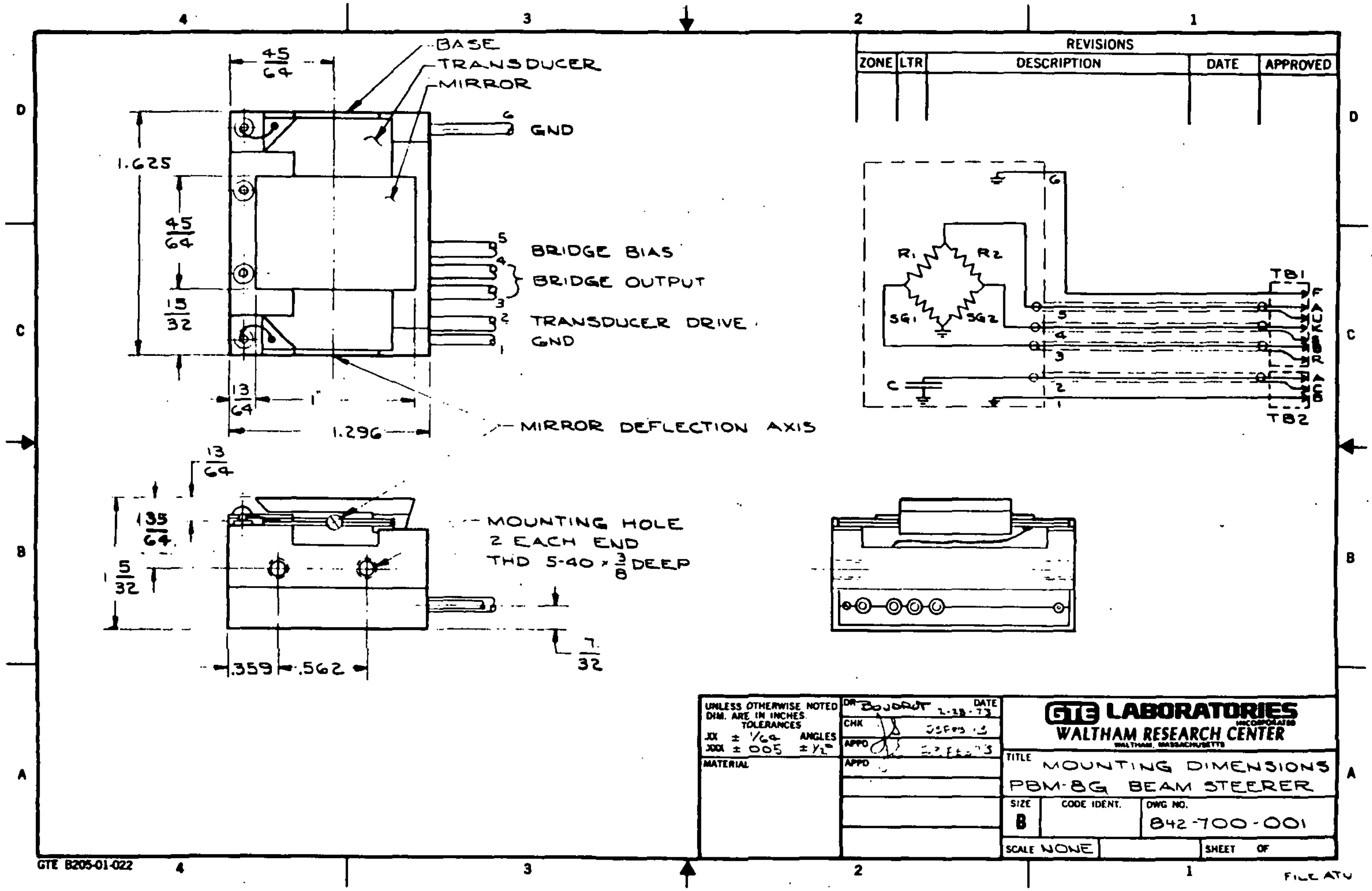

Figure 2. Mounting Dimensions and Electrical Connections for PBM-86 Beam Steerer

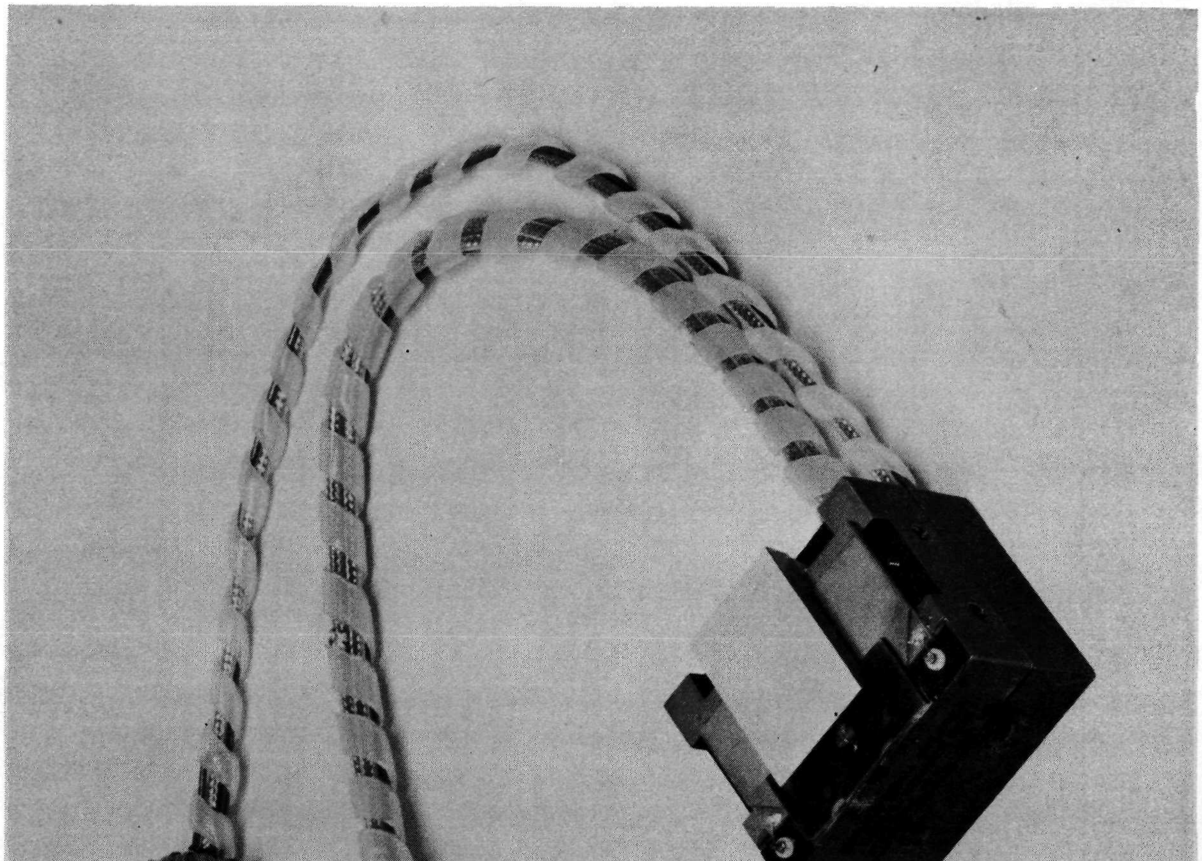

Figure 3. Photograph of PBM-8G Beam Steerer with Protective Cover Removed

radar system. Optimizing the performance to achieve a stable, reliable, and rugged device involved the design considerations described in this section.

3.1.3.1 Thermal Stability

Three problems can arise which will affect the stable functioning of the beam steerer with variations in the ambient temperature. The first of these is a deflection of the mirror which is not sensed by the strain gage bridge. This can happen if the mirror or the mounting base do not have thermal expansion coefficients similar to that of the transducer. In this situation a bending of the transducer takes place at the base or at the mirror with temperature changes which may not be fully detected by the strain gages, leading to a positioning error. In addition to the use of compatible materials the present design employs a symmetrical assembly of materials where the transducer joins both the base and the mirror. Here metal or glass is bonded to both sides of the ceramic transducer to provide symmetrical canceling of forces generated by any residual mismatch in expansion coefficient. This geometry may be seen in Figure 2.

The matching of expansion coefficients between the transducer and the mirror substrate also eliminates a second potential problem; the mirror surface will distort if the two materials have largely differing coefficients. While this condition has not been fully met on the present design, the mirror flatness has been maintained within specifications. For further discussion see Section 3.2.2.2.

A third area of concern is the temperature stability of the strain gage deflection sensing bridge. The gages have been chosen such that their temperature coefficient of gage factor is zero, in order to minimize the temperature coefficient of deflection sensitivity. Although the gage temperature coefficient of resistance is not zero, analysis has shown[2] that choosing bridge completion resistors of the same resistance as the gages and the use of a constant voltage bridge supply eliminates this source of sensitivity variation. Changes in bridge balance offset voltage with temperature differentials between the gages have been minimized by mounting the gages close together on the same substrate and by operating the beam steerer in a vacuum or in an enclosure where drafts are excluded.

3.1.3.2 Mirror Flatness

Care in design of the mirror substrate and in the mounting procedure (see drawing 842-100-603) has allowed the use of a lightweight mirror geometry for higher mechanical resonance frequency without compromise on mirror surface flatness. The effects of transient acceleration and gravity on the mirror flatness have been analyzed[3] and taken into account in the mirror design.

3.1.3.3 Resonance Damping

The mirror and transducer form a second-order resonant system with a Q greater than 50. If left undamped, vibrations or transients (electrical or mechanical) can excite large amplitude deflections at the resonance frequency leading to fracture of the transducer. To reduce the likelihood of failure due to this cause, a deflection limiting stop has been incorporated into the base which restricts the downward excursions of the transducer tip to about 150% of its normal low frequency deflection peak. This effectively damps deflection amplitude buildup at resonance without restricting freedom of motion in the normal amplitude range.

3.1.3.4 Deflection Sensing Error

To obtain a signal which indicates transducer angular deflection with an error of 0.1% or less using strain gage instrumentation, a number of criteria must be met. The gages themselves must have a large range of linear operation, well beyond the maximum transducer strain (here about 10^{-4} in/in), and should be entirely free of hysteresis. The single crystal germanium semiconductor gages used here satisfy this criterion as well as having a large gage factor $\left(\frac{\Delta R/R}{\Delta \ell/\ell} = 45\right)$

The gages cover the full length of the active portion of the transducer to integrate the entire strain developed. They are bonded to the transducer with an adhesive which, when fully cured, is nearly completely polymerized to minimize creep and hysteresis. The gages are in intimate contact with the transducer, spaced only by a one micrometer thick insulating layer of sapphire, so that the strain pattern is fully transferred to the gage. These features all contribute to the achievement of deflection sensing errors of less than 0.1%.

3.1.3.5 Bridge Balance

The development of strain gage bonding techniques which maintained a close resistance match between the gages has allowed the use of trim resistors for balancing the strain gage bridge. The presently specified trim resistor stock (see drawing 842-100-604) allows balancing to less than ±0.55 mV offset. However, gage matching has been sufficiently close that this may possibly be reduced to ±0.2 mV.

3.1.3.6 Reliability

In addition to the careful control of all assembly processes, the operational reliability of the beam steerer has been enhanced through certain design features.

While it is impractical to employ redundancy in any major way to improve reliability, the electrical connections to the transducer have been duplicated. Also wires have been shortened or eliminated, and connections are made at points where there is no dynamic strain due to flexing of the transducer. The electrodes on the transducer are set back 0.015 inch from the edges to increase the electrical path length between electrodes and reduce the possibility of electrical edge breakdown. Mechanical resonance damping of the transducer, as described in Section 3.1.3.3, adds to the device reliability.

High reliability hermetic resistors have been specified for the bridge completion and trim resistors. These and all other soldered connections are made using NASA qualified soldering procedures.

3.1.4 Operating Instructions

The beam steerer is stored with a protective aluminum cover over the mirror. This should not be removed until just prior to installation to minimize the possibility of damage to the mirror or transducer. Mounting should be on a stable platform using the two holes in each end of the base tapped for #5-40 screws.

Electrical connections are made through two cables terminated in connectors, as in Figure 2. These connectors are type NB6E14-18 PNS for TB_1 and type NB6E8-98 PNS for TB_2. Mating bulkhead recepticals are available from ITT Cannon Electric or Deutch Electric Components.

The strain gage bridge is activated by applying 2.000 Vdc to the bridge between supply lead 5 and ground lead 6. This voltage must be controlled to ±1 mV to obtain stable monitoring of deflection. About 10 minutes are required for the bridge to fully temperature stabilize. Best bridge stability is obtained by operating the beam steerer in an enclosed chamber where drafts are excluded or in a vacuum. The bridge output appears on leads 3 and 4 balanced to ground, lead 6. An operational amplifier with differential input can be used to increase this signal level. However, it should be selected to have a bandwidth of at least 10^4 times the maximum fundamental drive frequency of the transducer to minimize errors introduced by phase shift in the amplifier. One suitable basic operational amplifier is the Burr-Brown Model 3354/25.

The transducer drive signal is applied between lead 2 and ground, lead 1, and should be confined to ± 500 V peak or less. When approaching resonance, above about 900 Hz, the drive voltage should be reduced to confine the maximum mirror deflection to its low frequency value of ± 20 arc minutes. Care should be taken when applying transient signals to the transducer that large amplitude deflections are not generated through harmonic excitation of the high Q mechanical resonance. A drive source impedance of approximately 10K ohms is recommended to aid in damping this resonance.

3.2 DESIGN EVALUATION

3.2.1 Summary of Test Results

Qualification testing, which consists of functional tests conducted after exposure to specified environments, was performed in accordance with the Qualification Test Procedure, drawing 842-500-101, except where noted otherwise. These tests evaluate the success with which the beam steerer design has met the performance goals both for normal operation and after being subjected to adverse environmental conditions. A full Qualification Test Report is contained in Appendix C.

Certain specialized test procedures and test equipment developed for functional testing are described fully in the Functional Test Procedure, drawing 842-500-103.

3.2.1.1 Strain Gage Bridge Unbalance

The bridge balancing technique, described in drawing 842-100-604, worked consistently to achieve a zero offset voltage of less than ± 0.55 mV. The offset voltage values remained stable after each of the environmental tests when checked at room temperature.

On a unit which was balanced to 60 μV offset, the offset did not change appreciably with temperature over ±25°C around room temperature. However, a unit with a larger offset of 400 μV exhibited a change of 10 μV/°C. It appears that trimming the bridge to achieve a low offset voltage also yields a low temperature coefficient. More accurate trimming should be possible in future devices with the close matching of strain gages which has been achieved with present assembly techniques.

3.2.1.2 <u>Strain Gage Angular Sensitivity and Deflection Sensing Error</u>

To make these measurements, a completely new measurement technique was developed and a new optical instrument was designed and built. This is described in Section 6.2 of the Functional Test Procedure, drawing 842-500-103. Both angular sensitivity and deflection sensing error were within specifications after all tests, indicating the stability of the gage bond to the ceramic. Measurements of angular sensitivity and error were made only at room temperature due to the lack of time required to develop a suitable optically accessible temperature chamber to perform high and low temperature measurements of these parameters.

3.2.1.3 <u>Mirror Flatness Deviation</u>

A noncontacting interferometer was used to measure mirror surface distortion so that the measurement process itself would introduce no distortion. Before attachment of the mirror to the transducer typical distortion was less than 65 nm deviation from a true plane. After mounting the mirror this degraded to 90 nm deviation, although still meeting specifications. This surface distortion remained unchanged when measured after each of the environmental tests.

Measurements at +45°C showed a slight improvement in surface flatness, while at -5°C surface distortion was 120 nm where 105 nm was specified. This change in surface flatness with temperature is due to a mismatch in expansion coefficient between mirror and transducer, as detailed in Section 3.2.2.2.

3.2.1.4 <u>Resonance Frequency</u>

The mechanical resonance frequency fell within the specified limits on all units and was not a significant function of any of the environments. Through a change in frequency, this test would reveal possible fractures in the transducer induced by vibration testing but not apparent in visual inspection. It is known that the transducer deflection stops described in Section 3.1.3.3 were a significant factor in confining the deflection amplitude at resonance to within the elastic limits of the transducer during vibration testing.

3.2.1.5 Mirror Deflection

On unit serial no. 003, one of the two units supplied as engineering and qualification models, the peak deflection was below the minimum specified value at ±16.75 arc minutes. The Qualification Test Model showed a low deflection of ±15.5 arc minutes. This value was unaffected by any of the environmental tests. As previous units fabricated to the same design have exhibited deflection within the specified range of ±17 to ±23 arc minutes, the discrepancy cannot be attributed to a design fault. It is likely that insufficient testing of the transducer raw material and of the transducer at various stages of fabrication has allowed the use of material with substandard piezoelectric coefficients. This is an area where improvements in incoming inspection and in-process testing are required, and is discussed further in Section 3.2.2.1.

3.2.1.6 Mirror Reflectivity

Mirror reflectivity has been maintained at 97% or greater throughout the testing sequence and has sustained no noticeable damage to the mirror surface after having been cleaned several times.

3.2.1.7 Vacuum Outgassing

Evolution of volatiles from the materials used in beam steerer construction is very low after initial evaporation of entrapped air and adsorbed cleaning solvents. In tests performed at pressures of $4\ (10)^{-9}$ torr, no heavy organic molecules were detected. Major detected constituents were CO, CH_4, and CO_2 with an almost negligible rate of rise in pressure of less than $6\ (10)^{-12}$ torr-liter/second. At least half of this rate can be attributed to the vacuum system background. Thus, the beam steerer is fully compatible with use in a vacuum-immersed optical system where optical elements must remain free of contamination from condensed outgassing products.

3.2.2 Problem Areas

In this section are discussed those aspects of beam steerer design, testing, and specification which, in the light of fabrication experience and qualification testing, may need to be modified to optimize device performance.

3.2.2.1 Transducer Material Testing

The low deflection values experienced on some units can most likely be attributed to the use of transducer raw material with low piezoelectric coefficients. These coefficients were not directly specified in the source control drawing (842-400-001) used in purchasing this material because they are difficult to measure accurately in the bulk material. To remedy this situation an accurate nondestructive means should be found to measure the pertinent coefficient, d_{31}, in the piezoelectric disk as received. In addition the deflection of the transducer should be measured directly after fabrication as one of the in-process inspection steps on drawing 842-100-201. Capacitance and loss tangent should also be measured at this point to eliminate units which may have become lossy due to faulty processing.

3.2.2.2 Matching of Thermal Expansion Coefficients

As was described in Section 3.1.3, stable operation with variations in temperature depends upon the use of materials with similar thermal expansion coefficients. During investigation of possible causes for distortion of the mirror after the operation of bonding to the transducer, it was discovered that the piezoelectric material used in the transducer had an expansion coefficient about 15 to 20% larger than that claimed by the manufacturer. At the time this was noticed, it was not possible to find, fabricate, anneal, and coat a new glass substrate with an expansion coefficient closer to this true value for installation on the delivered hardware. This increase in transducer expansion coefficient, on the other hand, makes it a closer match to the mounting base material so that no changes will be necessary there.

For future beam steerer production, the thermal expansion coefficient of the transducer should be accurately measured and a glass specified for the mirror substrate and ribs (drawing 842-400-006) which has a closely matching coefficient and good chemical weathering properties. A new annealing schedule (drawings 842-100-403 and 406) will also be needed. The revised expansion coefficient should be made a part of the piezoelectric ceramic specification (drawing 842-400-001), to be measured either by the manufacturer or on incoming inspection.

3.2.2.3 Operational Temperature Testing

Although called for in the Qualification Test Procedure, no measurements were made of the strain gage angular sensitivity or deflection sensing error at -5°C or +45°C or any temperature other than room temperature (24°C). Time did not permit the development of a suitable environmental chamber with stable optical access to the beam steerer for measurements of these parameters with the electronic autocollimator. Proper instrumentation should be developed to make these measurements on future delivered hardware. While the deflection sensing error is not expected to change significantly, the strain gage angular sensitivity may have a small temperature coefficient and should be calibrated at various points throughout its working temperature range. To give an accurate indication of the angular sensitivity temperature coefficient, Section 6.1 of the Qualification Test Procedure (drawing 842-500-101) should be changed to include at least two other nonambient temperatures at which measurements are to be taken.

Another measurement of interest, which has not been specified and for which insufficient time was available, is the temperature induced deflection of the mirror with respect to the base. This is expected to be quite small because of the use of materials with compatible expansion coefficients; however, no hard data is available on the magnitude of errors which may be incurred as a result of thermally induced mirror deflection which is not measured by the strain gage bridge. A technique should be developed for making this measurement and it should be incorporated in the Qualification Test Procedure.

3.2.2.4 Mirror Coating

The intended operating wavelength for the beam steerer mirror is 905 nm. A broadband reflective coating was chosen for the mirror so that high reflectivity would be present not only at 905 nm but also at wavelengths in the visible spectrum where most of the optical tests would be performed. To obtain this condition a coating of silver with a protective dielectric overcoat is specified which has high reflectivity from the blue well into the near infrared. Silver has a tendency to react with airborne chemicals, especially those containing sulphur compounds, causing degradation of its reflectivity. The protective dielectric overcoat is designed to protect the silver from this loss of reflectivity; however, voids, pinholes, and unprotected edges in the coating can contribute to a gradual reduction in reflectance. Although this process is suspended in a vacuum, such as space, gradual deterioration may occur during the normal year or more ground storage before flight use. This deterioration process has been observed on mirrors delivered by one vendor which met all other criteria of the mirror coating specification.

In addition, it has been determined that this enhanced relfectivity at the visible inspection wavelengths is not necessary to perform the required measurements. Therefore, it is recommended that the Mirror Coating Specification (drawing 842-400-030) be changed to specify a mirror coating of hard dielectric refractory materials with maximum reflectivity at the beam steerer operating wavelength at 45° angle of incidence. This will enhance the device reliability and increase the maximum obtainable reflectivity from 97 to 99% or greater.

3.2.2.5 Life Testing

In preparing the Failure Mode, Effect and Criticality Analysis (FMECA), little data was available on the expected lifetime of most of the critical components. In particular the mirror, transducer, and strain gage and their long term relation to each other were unknown factors in calculations of MTBF. More life test data should be generated by actual operation of beam steerers for extended periods while monitoring the critical parameters, bridge offset voltage, peak deflection, strain gage bridge angular sensitivity, and static mirror angular position with respect to the base.

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4. CONCLUSIONS AND RECOMMENDATIONS

In spite of the existing problems mentioned in Section 3.2.2, the PBM-8G Beam Steerer design has been highly successful in meeting the functional performance specifications and in withstanding the exposure to the various environments with no catastrophic failures. With the exception of the items explained in Section 3.2.2, all of the functional performance characteristics measured were unaffected by environmental exposure.

It is recommended that the PBM-8G Beam Steerer be considered conditionally qualified pending action on the items discussed in Section 3.2.2 and NASA approval of the parts and materials listed in Section 2.13 of Appendix D. Qualification Testing should again be conducted on design modified test models performing only those tests pertinent to the recommended modifications. A formal critical design review should be held with NASA to discuss the results of qualification testing, interface configuration, reliability data and the quality control program before full qualification status is granted and production of flight hardware is begun.

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5. REFERENCES

1. "Investigation of Electro-Optical Techniques for Controlling the Direction of a Laser Beam," Final Report, Contract NAS8-11459, GTE Laboratories (March 1971).

2. "Investigation of Electro-Optical Techniques for Controlling the Direction of a Laser Beam," Interim Report, Contract NAS8-11459, GTE Laboratories (February 1969).

3. "Investigation of Electro-Optical Techniques for Controlling the Direction of a Laser Beam," Interim Report, Contract NAS8-11459, GTE Laboratories (February 1968).

APPENDIX A

INSPECTION PLAN
AND
QUALITY PROCEDURES MANUAL

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A-1. INSPECTION PLAN FOR SPACE QUALIFIED BEAM STEERER

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1. INTRODUCTION

GTE Laboratories Inc. will implement and maintain a Quality Program in accordance with MIL-Q-9858A for the Space Qualified Beam Steerer. A Quality Assurance Engineer with previous experience on MIL-Q-9858A has been assigned the responsibility of assuring the fulfillment of all the quality functions. This plan is also consistent with NASA Quality Publication NPC200-3, April 1962, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services".

2. SCOPE

The Quality Program will assure adequate quality throughout all areas of contract performance. Each area is identified and the method of accomplishment is stated. During the design phase Quality Assurance will survey all activities to assure that the engineering models are thoroughly documented in all aspects of the latest design and fabrication to the extent necessary for future manufacture. Quality Assurance will participate in all testing of the engineering models to assure qualification. The entire Quality Plan will be implemented for future manufacture should any requirement arise.

3. ORGANIZATION

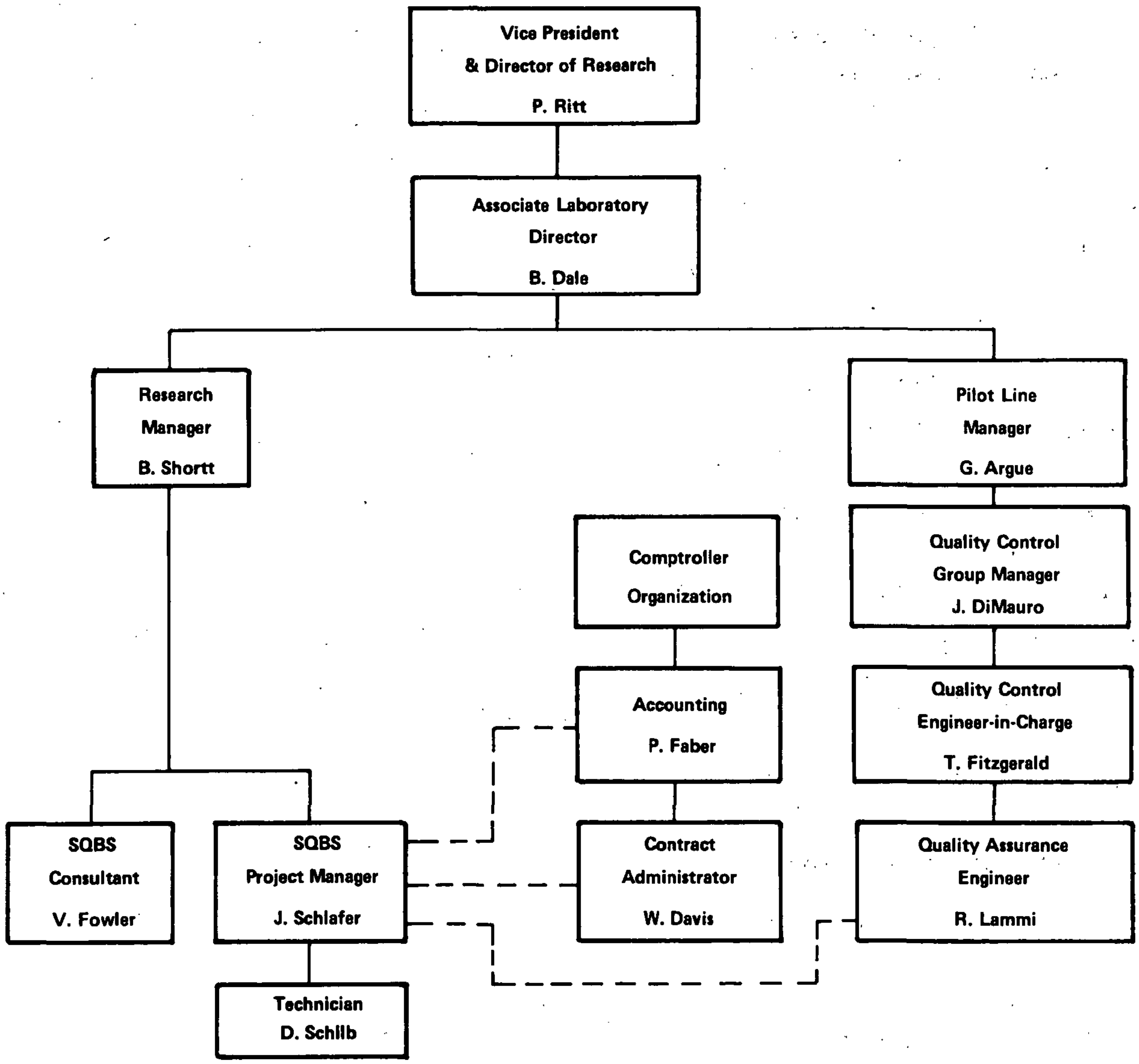
The Quality Assurance Engineer has access to the Associate Laboratory Director through a Quality Assurance organization entirely separate from the program management as shown in the organization chart.

4. PRODUCT FLOW CHART

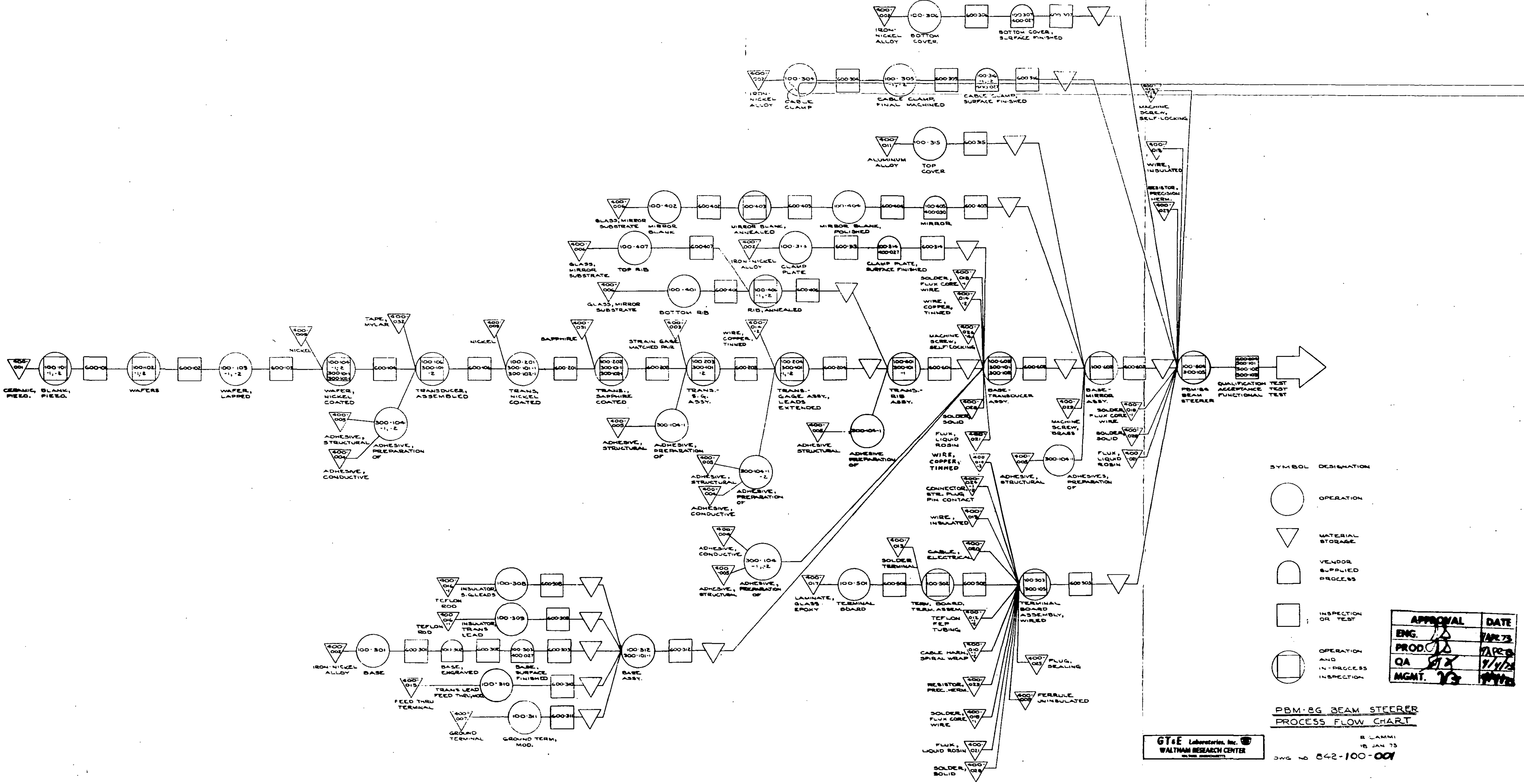
A product flow chart, a copy of which is attached, will be used to assure the correct and orderly assembly of the beam steerer and contains all materials, operations, vendor supplied processes and inspections.

5. DRAWING AND CHANGE CONTROL

A Document and Change Control Procedure will be used to assure that articles are fabricated, inspected, and tested to the latest applicable drawing or specification. The documents controlled by this procedure include, but are not limited to, drawings, test procedures, process specifications, inspection procedures, laboratory test data and incoming material test data. Necessary changes must be approved and recorded on the inspection records of the part, component or assembly. Quality Assurance shall review and approve all drawings and other documents as well as all change orders.



PROGRAM ORGANIZATION



PBM-8G Beam Steerer Process Flow Chart

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6. CONTROL OF MATERIAL PURCHASES

Materials, supplies, and services will be purchased using a procedure of purchase requisitions and purchase orders. Quality Assurance will review purchase requisitions and purchase orders and add quality assurance requirements. Certificates of compliance or analyses will be required when it is not practical nor feasible to determine quality conformance at incoming inspection. Source inspection will be used when practical. Inspection instructions will be available at incoming inspection on all material.

7. MATERIAL HANDLING AND STORAGE

Material handling and storage will be controlled through a procedure which will preclude loss, damage, deterioration, and/or substitution to raw and fabricated materials. Quality Assurance will audit the procedure to assure that all materials are identified, stored and handled properly.

8. MATERIAL IDENTIFICATION

A material identification procedure will control the identity of raw material components, fabricated parts, and assemblies. Lot numbers, labels, and serial numbers will be used as appropriate. Quality Assurance will review and audit marking methods and locations.

9. IDENTIFICATION OF REDUCED BULK STORES

Control will be maintained on items purchased in bulk and reduced to job quantities. Identification of all lots of items reduced from bulk stores will be done at the direction of Engineering. Items shall be examined for proper labeling during unscheduled floor inspections by Quality Assurance.

10. INSPECTIONS AND TEST PROCEDURES

Inspections and tests shall be performed in accordance with written procedures to assure conformance to drawings and specifications. These procedures will include receiving, processing, fabrication, assembly, end-item and shipping phases. Inspection reports and check lists will be used and kept on file. Quality Assurance will review processes, assembly procedures and fabrication operations to assure inclusion of timely inspections.

11. PROCESS CONTROL PROCEDURES

Procedures will be developed by Engineering to control processes as required to accomplish the desired results. These procedures will include operating instructions, use of tools and fixtures, and measuring equipment. The process specifications will be reviewed by Quality Assurance and the processes will be monitored by testing where required or by witnessing the operations.

12. NONCONFORMING MATERIAL

A procedure will describe the method by which nonconforming material is reviewed and dispositioned. A Material Review Board will determine whether the material will be reworked, used as is, or scrapped. Records will be kept and items involved will be identified.

13. CALIBRATION OF EQUIPMENT

A system has been established to maintain the accuracy of mechanical, electrical and electronic instruments used to assure that materials are in conformance with prescribed technical requirements. This system is in compliance with MIL-C-45662A and monitored by Quality Assurance.

14. INSPECTION STATUS

A procedure will define the method used to assure identification of the quality condition of all materials. Materials will be tagged or otherwise marked with Quality Assurance marking and cross referenced with a materials condition report.

15. PRESERVATION, PACKAGING, PACKING AND SHIPPING

Control will be maintained at the point of preservation, packaging, packing and shipping to assure that the quality of the fabricated articles is maintained and that damage, deterioration, loss and substitution are prevented. It will also be assured that all the requirements of the contract have been met, that the articles are complete, and that the necessary documentation has been provided.

16. RECORDS OF INSPECTIONS AND TESTS

Adequate records will be maintained of all inspections and tests performed. They will indicate part or component identification, inspection or test involved, number of conforming articles, number rejected, nature of defects, and basic causes for rejection. Actual measurements will be indicated when required.

17. CORRECTIVE ACTION

A procedure will specify how corrective action shall be taken on nonconforming and potentially nonconforming materials. A corrective action request will be made out by Quality Assurance and Engineering or Manufacturing will review and determine appropriate corrective action. Quality Assurance will review all corrective actions to assure proper documentation and compliance thereto.

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A-2. QUALITY PROCEDURES MANUAL

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1. INTRODUCTION

"Product Quality" refers to cosmetic and operational acceptance, i.e., it should look good and work well for a reasonable time. How good, how well, and how long are determined by the willingness to pay, but in all cases the product quality is designed into the product prior to production.

To define the design intent, specifications are developed and imposed. In addition to operational and performance parameters, these specifications also define the responsibility of production such that the end item will meet all the requirements as shown by testing to the previously established parameters.

The procedures herein have been developed to provide the system necessary to convert the customer's requirements into acceptable engineering designs and then into a deliverable end item.

Development and implementation of these procedures are dictated by the requirements of Contract NAS8-26846; however, their use on other jobs will be only at the directions of Project Management.

2. TABLE OF CONTENTS AND REVISIONS

Title	No.	Issued	A	B	C	D	E	E
Responsibilities	3.1	Oct. 71						
Corrective Action	3.5.1	Oct. 71	Mar. 3					
Documents Flow Diagram			Mar. 3					
Document and Change Control	4.1.1	Aug. 71						
Instrument Calibration	4.2.1	Oct. 71						
Control of Material Purchases	5.1.1	Aug. 71						
Material Identification	6.1.1	Aug. 71						
Process Control	6.2.1	Aug. 71						
Identification of Reduced Bulk Stores	6.2.2	Nov. 71						
Inspection and Test	6.3.1	Aug. 71						
Material Handling and Storage	6.4.1	Aug. 71						
Nonconforming Material	6.5.1	Aug. 71						
Inspection Status	6.7.1	Aug. 71						

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3. ORGANIZATION

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QUALITY PROCEDURE

SUBJECT: RESPONSIBILITIES

1.0 SCOPE

This procedure defines the general responsibility for each group participating in the overall quality efforts. Specific tasks and/or instruction shall be described in subsequent procedures and/or subsidiary documents.

2.0 APPLICABLE DOCUMENTS

None

3.0 REQUIREMENTS

3.1 General

It shall be incumbent upon each person individually to perform his task in the manner specified and to report any and all deviations.

3.2 Engineering

This group shall plan and develop items in accordance with the contract and/or performance requirements and will supply necessary and sufficient information in a timely manner so that other groups can perform correctly, maintaining at all times the controls provided to assure the integrity of the quality efforts.

3.3 Purchasing

Purchasing shall obtain from appropriate sources the specified materials and/or technical services with the required supporting documentation.

3.4 Manufacturing Facilities

This group, including the machine shop, optical shop, techniques shop, etc., shall fabricate from or perform operations on material(s) specified, in accordance with drawings and/or process control specification provided with the Work Order from Engineering.

Prepared by Jack T. Adler   Approved by J. E. Chaney

QUALITY PROCEDURE

3.5 Design/Drafting

They shall provide, or cause to be provided, the services necessary to develop the documentation specified by Engineering, in the format specified by contract or GTE standards.

3.6 Receiving & Shipping

3.6.1 Receiving shall count and identify insofar as possible, all incoming material and shall forward it appropriately packaged, to the project group.

3.6.2 Shipping shall package, pack and mark all outgoing material as specified by detail requirements.

3.6.2.1 If the shipping requirements exceed the inhouse capabilities, approved outside services shall be used.

3.7 Quality Assurance

Quality Assurance shall monitor the material and process flow as described herein to obtain objective evidence of compliance with all specifications. Such evidence will be maintained in the Quality file for review as required.

QUALITY PROCEDURE

SUBJECT: CORRECTIVE ACTION

1.0 SCOPE

This procedure specifies how corrective action shall be taken on nonconforming and potentially nonconforming materials.

2.0 APPLICABLE DOCUMENTS

The following documents are applicable to the extent specified herein:

Corrective Action Request (CAR)
QP 6.5.1 Nonconforming Material

3.0 REQUIREMENTS

3.1 MRB

During MRB of nonconforming material, as specified in QP 6.5.1, corrective action shall result in drawing and/or process changes by the issuance of a Change Order, if the deviations are not considered workmanship deviations.

3.2 Potential Deviations (Nonworkmanship)

When sudden, noncontrollable, continuing change(s) occur in a process or performance characteristic, they may be the forerunner of nonconforming material.

3.2.1 Quality Assurance shall complete the upper portion of the CAR, retain 1 copy and forward a second copy to the Project Engineer.

3.2.2 Engineering shall review and determine appropriate corrective action and shall enter the specific information where required on the CAR (CO #, etc.).

It is recommended that immediate action be taken on those problems where the resulting deviation will be noncorrectable (scrap).

3.2.3 Completed CAR shall be returned to QA for review and approval.

Prepared by Jack T. Adler   Approved by J. E. Shaw

QUALITY PROCEDURE

3.3 Potential Workmanship Deviations

3.3.1 Quality Assurance shall complete the upper portion of the CAR, retain 1 copy and forward a second copy to the supervisor of the work area.

3.3.2 The supervisor shall review and determine appropriate corrective action within 24 hours and shall enter the specific information where required on the CAR.

3.3.3 The completed CAR shall be returned to QA for review and approval.

4.0 QUALITY ASSURANCE

4.1 QA shall review all corrective actions to assure proper documentation and compliance thereto.

5.0 DEFINITIONS

5.1 Potential Workmanship Deviations

These deviations are precipitated by improper care and control by personnel (e.g., improper tools, improper materials, etc.), however they do not include individual random errors.

5.2 MRB — Material Review Board.

CORRECTIVE ACTION REQUEST #________

TO:____________________ DATE__________ DWG. #____________

Problem and Recommendations:

by______________________

Action Taken:

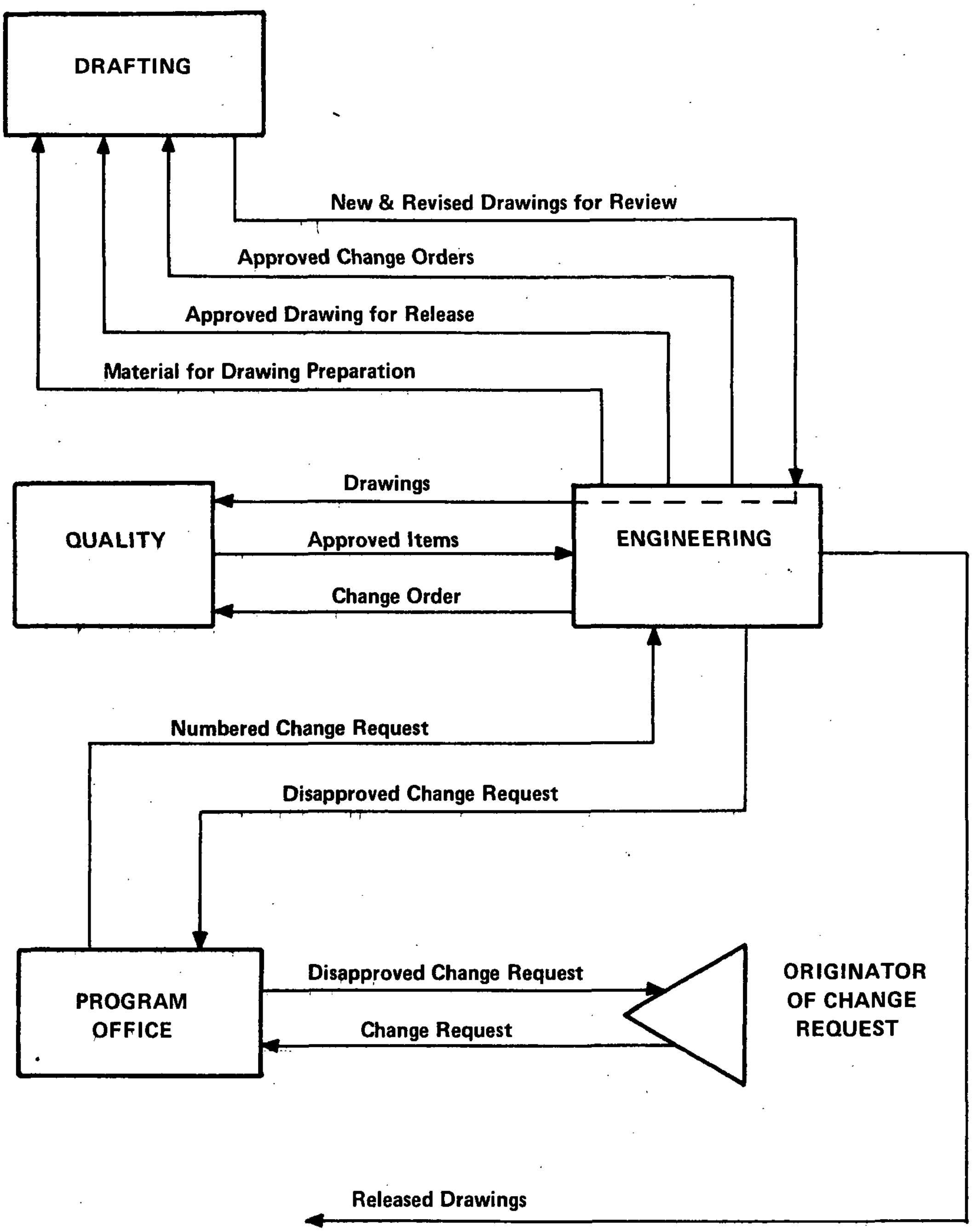
by______________________

When Completed — Return to Quality Assurance

QA Approval, by________________ Date____________

Comments:

4. FACILITIES AND STANDARDS



DOCUMENTS & CHANGE CONTROL

QUALITY PROCEDURE

SUBJECT: DOCUMENT AND CHANGE CONTROL

1.0 SCOPE

This procedure describes the methods for the control of documentation to preclude the loss of information.

2.0 DOCUMENTS

2.1 The documents controlled by this procedure include, but are not limited to, drawings, test procedures, process specifications, inspection procedures, laboratory test data and incoming material test data.

2.2 The following documents of the issue shown form a part of this procedure to the extent specified herein:

MIL-STD-100A	
MIL-STD-831	28 August 1963
Form 4.1.1	Change Request/Order

3.0 REQUIREMENTS

3.1 Numbering

3.1.1 Drawings

Drawings shall be assigned a sequence number preceded by a project number or project code (e.g., 842, QA, REL).

3.1.2 Other Documents

Documents other than drawings shall obtain numbers from specific logs (e.g., incoming data log) which shall be preceded by the project number or code.

3.2 Format

Document format shall be as required in the contract and in lieu thereof the standard shown shall be used wherever possible.

3.2.1 Drawings

MIL-STD-100A

Prepared by [signature] Approved by [signature]

QUALITY PROCEDURE

3.2.2 Procedures

MIL-STD-831 (Paragraphs 3.2, 3.3, 5.1-5.5, 5.6.1, 5.6.4 and 5.7).

3.3 Approvals

3.3.1 Documents shall not be released for distribution and/or use unless signed by at least the Project Engineer or Originator and Program Manager, or his authorized representative.

3.3.1.1 When nonproject services (e.g., Quality, Reliability, etc.) have been specified their approvals and signature shall appear on the drawings.

3.3.2 Experimental drawings, identified by the letter X prior to the drawing number, do not require the controls of this procedure.

3.4 Revisions

3.4.1 Approved documents shall have the revision letter changed each time a change is made in accordance with the Change Order.

3.4.2 The individual who has project responsibility shall approve, sign and date each document change, on the changed document.

3.4.3 Revision shall be listed on the drawing or on a revision sheet.

3.5 Change Control

3.5.1 Changes shall be issued on Change Request/Order (Form 4.1.1).

3.5.2 The Originator requesting changes shall complete all the upper portion of the Change Request including the project number, except the change number, and deliver to the project office.

3.5.2 The project office will log and assign a 4 digit sequence number. The complete change number will then be the project number plus the sequence number.

3.5.2.1 One copy will be retained in the Change Request file.

3.5.2.2 One copy will be returned to the Originator.

3.5.2.3 One copy will be sent to the Project Engineer.

QUALITY PROCEDURE

3.5.3 If the Change Request is approved by the Project Engineer, he will enter the drawings affected, sign and date the form and return to the project office, as a Change Order.

3.5.3.1 Disapproved Change Requests shall be marked "VOID" and the reason for such action shall be entered in the area provided for engineering notes, or attached on a separate paper. The form shall then be signed, dated and returned to the project office.

3.5.4 Approved Change Orders shall be delivered as required for further approvals, to Quality, Reliability, and Program Management, as authorized representatives.

3.5.4.1 Disapproved Change Requests shall be returned to the Originator after the file copy(s) are marked "VOID" and a notation is made in the change log.

3.5.5 Completely approved Change Orders shall be delivered to Drafting for the drawing changes. The draftsman shall sign and date the Change Order for each drawing changed and return the completed form to the project office.

3.5.6 Completed Change Orders shall be logged and filed in the Change Order file.

3.6 Print Control

3.6.1 Prints of the specified revision shall accompany each work order for all parts related to the order, and shall be returned with the material.

3.6.2 All work shall be done in accordance with the prints supplied.

4.0 QUALITY ASSURANCE

4.1 Quality Assurance shall review and approve all drawings and other documents as well as all Change Orders.

5.0 NOTES

5.1 Drawings include engineering drawing, test procedures and process specification.

5.2 When final approval of a document is to be the responsibility of the customer (e.g., NASA) a copy of the letter of approval shall be included as an appendix to the document, and all subsequent Change Orders shall require customer approval.

QUALITY PROCEDURE

5.3 Each document shall list the next higher assembly on which it is used.

5.4 The change log shall include the following: Change #, Date, By, App. By, Des. App. By.

CHANGE REQUEST

Page ___ of ___ page(s)

DWG.NO.	REV.	ITEM	DATE	ORIGINATOR	CHANGE NUMBER	___ -- ___ project No. sequence No.

CHANGE FROM:

CHANGE TO:

CHANGE ORDER APPROVALS

Engineering	Quality	Contractor	Program Mgm't.

Material disposition (circle one): use as is, scrap, rework, other (see below)

Reason for change (be specific)

Engineering notes:

Related drawings to be changed

Drawing No.	Rev.	By	Date	Drawing No.	Rev.	By	Date

Form 4.1.1

CHANGE LOG

Project_____

Sequence Number	Dwg./Spec. Number	Project Engineer			To Drafting	Changes Completed
		Name	Approved	Disapproved		

QUALITY PROCEDURE

SUBJECT: INSTRUMENT CALIBRATION

1.0 SCOPE

This procedure describes the system established to maintain the accuracy of mechanical, electrical and electronic instruments used to assure that materials are in conformance with prescribed technical requirements.

2.0 APPLICABLE DOCUMENTS

2.1 MIL-C-45662A (9 February 1962) — Calibration System Requirements

3.0 REQUIREMENTS

3.1 General

The Project Group shall be responsible for the identification, calibration, repair, and data control of all electrical-electronic instruments and mechanical measuring instruments.

3.2 Identification

Each instrument shall be registered upon its receipt and prior to release for operational use. Such registration shall include the following:

3.2.1 Assign and affix a permanent number to the unit by tag, label or other marking method. The manufacturer's serial number(s) may be used.

3.2.2 Prepare a record card which shall contain:

a) Description of instrument and manufacturer
b) Identification number or Serial number
c) Calibration interval (see 6.1)
d) Calibration date and recalibration date
e) Calibration source (e.g., Laboratory Name, Technician's Name)

3.3 Instrument Classification

Instruments shall be classified as active, repair, inactive or uncalibrated.

3.3.1 All active instruments shall be maintained within their prescribed calibration intervals and are usable by authorized personnel as required.

Prepared by [signature] Approved by [signature]

QUALITY PROCEDURE

3.3.2 All instruments for repair shall be segregated from other instruments and identified by a repair tag. After repair a complete calibration shall be performed to insure that the instrument meets all applicable specifications.

3.3.3 Inactive instruments, items receiving infrequent use, shall be withdrawn from the calibration cycle.

3.3.4 Instruments may be withdrawn from the calibration cycle and henceforth may be used as indicators rather than as measuring devices. Such instruments shall be labeled as follows:

UNCALIBRATED

DATE:__________________ BY:__________________

3.4 Calibration

Instruments shall be calibrated at the prescribed intervals noted on the record card.

3.4.1 A set of record cards for calibrated instruments, in calibration due date order, shall be used to establish the recall schedule. Instrument users will be notified of the requirement for recalibration.

3.4.2 Instruments requiring calibration shall be sent to an approved Laboratory for calibration (see 6.2). If calibration cannot be performed in the required period, the instrument shall be tagged in red "OUT OF CALIBRATION". In no case shall instruments be used for any measurement of quality after expiration of the calibration interval.

3.4.3 All instruments shall be identified as having been calibrated by a label or marking which shall include the date calibrated, the week and month of the next required calibration.

3.5 Repairs

Repairs shall restore the instrument to the accuracies of the original specifications of the manufacturer. Should this be impossible, the limitations in calibration shall be clearly marked on the instrument near the control(s) affected.

4.0 QUALITY ASSURANCE

Quality Assurance will monitor the procedure described herein, as required, to assure compliance.

QUALITY PROCEDURE

5.0 DEFINITIONS

5.1 Calibration

Comparison of a measurement standard or instrument of known accuracy with another standard or instrument to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the item being compared.

5.2 Instrument

All devices used to measure, gauge, test, inspect, or otherwise examine to determine compliance with specifications.

6.0 NOTES

6.1 Calibration Intervals

Intervals for instruments not listed below shall be determined by Quality Assurance.

Mechanical	Interval Months	Electronic	Interval Months
Surface Plate	12	Digital Voltmeter	6
Gauge Blocks	12	Scope	4
Micrometer	4	Attenuator	12
Optical Flat	12	Counter	6
Auto Collimeter	12	Potentiometer	12
Pressure Gauges	6	Bridges	12
Surface Roughness Ind.	6	Voltmeter RMS	6
Masses	12		
Calipers	4		
Interferometers	12		

6.2 Calibration Laboratories

Approval of calibration facilities shall be the responsibility of Quality Assurance and in all cases certification of traceability to NBS is required.

5. CONTROL OF PURCHASES

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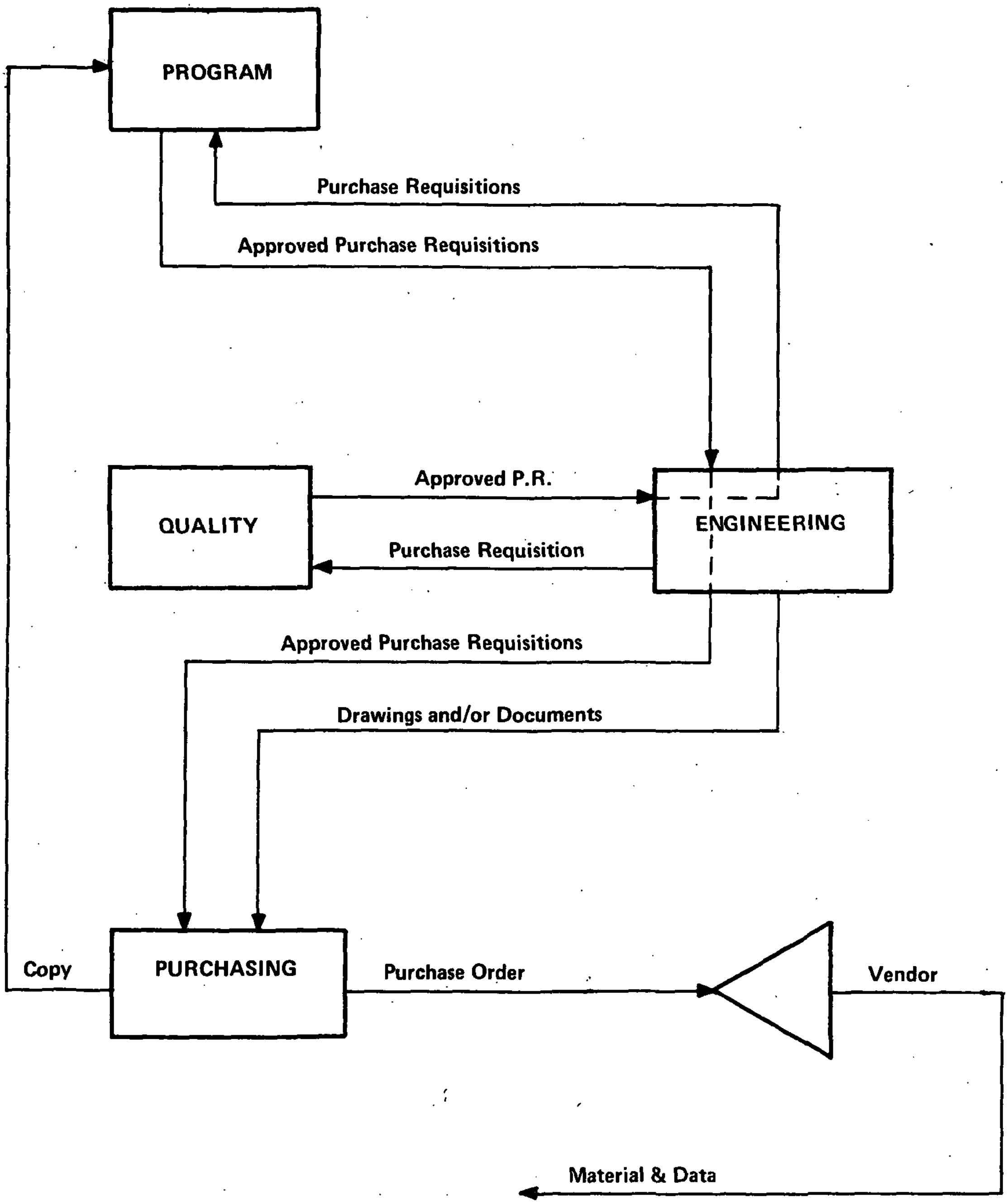

CONTROL OF MATERIAL PURCHASES

QUALITY PROCEDURE

SUBJECT: CONTROL OF MATERIAL PURCHASES

1.0 SCOPE

This procedure describes the system used to assure that material being ordered will satisfy their usage requirements.

2.0 DOCUMENTS

The following documents are applicable to this procedure to the extent specified herein.

GTE Purchase Requisitions

3.0 REQUIREMENTS

3.1 Purchase Requisitions (PR)

3.1.1 PR forms shall be completed by the requisitioner, including as applicable, QPL Sources, Parts Code (PP, NP, etc.) Drawing/Part #, etc.

3.1.2 Items on any PR shall be of like type and manufacture (e.g., resistors, capacitors, etc.).

3.1.3 Parts shall be listed by their drawing number, if any, military part number, if any, or commercial part number, in that order.

3.1.4 Completed PR shall be submitted, with all applicable drawings, to QA for review.

3.2 Purchase Orders

3.2.1 Purchase Orders shall be written for only those PR's which contain the approval(s) of Quality Assurance as well as those of Program Management.

3.2.2 Vendors shall be chosen only from those listed under "Suggested Sources of Supply". Purchasing can use any acceptable source if there are no vendors listed.

3.2.3 Purchase orders shall include the quality requirements that are listed on the PR (e.g., Certified Test Data, Mill Analysis, etc.).

Prepared by Nick Tibollia Approved by J. E. Chaney

QUALITY PROCEDURE

3.2.4 Purchase Orders shall include the Purchase Requisition number.

3.2.5 A copy of each purchase order and/or amendment shall be returned to the program office.

3.3 Amendments to purchase requisitions/orders shall follow the same procedure.

4.0 QUALITY ASSURANCE

4.1 QA shall review all purchase requisitions and append QA requirements (i.e., Certified Test Data, Chemical/Physical Tests, etc.) as required.

4.2 QA shall review the purchase orders as required.

4.3 QA shall provide source inspection, technical assistance, and/or vendor liaison as required to assure the desired quality.

4.4 When Government Source Inspection (GSI) is required, the procedures as specified in the contract or by DCAS shall be applicable.

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6. MANUFACTURING CONTROL

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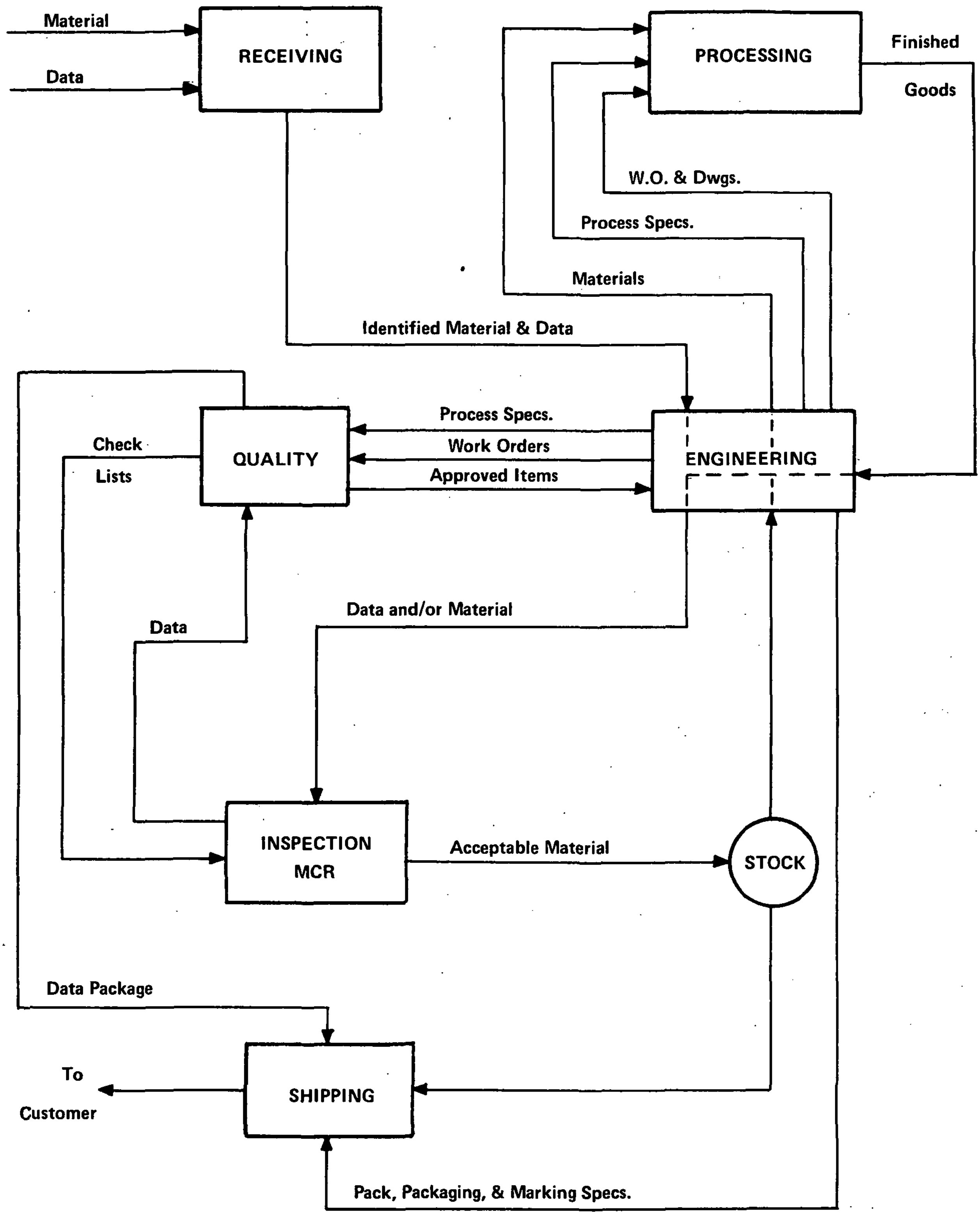

MANUFACTURING OPERATIONS

QUALITY PROCEDURE

SUBJECT: MATERIAL IDENTIFICATION

1.0 SCOPE

This procedure defines the method for control of material and fabricated part identity.

2.0 APPLICABLE DOCUMENTS

None

3.0 REQUIREMENTS

3.1 Raw Material

3.1.1 Controlled raw material shall be identified by a lot mark and/or number which shall be affixed to the material or its containers as received, and shall be transferred to all units reduced from the received material. Data received with raw material shall be marked with the appropriate number.

3.1.2 Bulk raw material which is not to be controlled will require no lot identification.

3.2 Controlled Components

Controlled components shall be identified by special labels attached to the item(s) or item container which designate the characteristic being controlled and its value(s).

3.3 Assemblies

3.3.1 Lot Control

Items using controlled raw material and/or requiring control because of special processes shall be identified by a mark and/or number which will be affixed to the item, its container and any associated paper work.

3.3.2 Serial Number Control

3.3.2.1 Serial number shall be assigned prior to the performance of any tests requiring the recording of data, as specified on the associated drawing.

3.3.2.2 Marking method and location shall be permanent and visible after assembly as specified on the associated drawing.

Prepared by ______ Approved by ______

QUALITY PROCEDURE

3.4 Control Assignment

Prior to issuance of purchase orders for material, an Identification Control document shall be issued by Program Management which provides the required lot numbers and/or serial numbers.

3.5 Data Conversion

When serial number control is started, lot control ceases and all existing lot numbers are assigned to the specific serial number.

4.0 QUALITY ASSURANCE

4.1 Review drawing for marking location and method.

4.2 Review "Identification Control" prior to release of purchase order.

4.3 Review marking of received material.

5.0 NOTES

5.1 Controlled Raw Materials include articles requiring unique data to be recorded or material which is subject to time limitations. Such material may include but not be limited to Ceramic, Quartz,. Epoxy, Adhesives. Such items will be identified by Engineering on the part drawing.

5.2 Bulk Raw Material will include those materials not specified in 5.1, such as chemicals, flux solder, etc.

5.3 Controlled components include those items which have unique characteristics, individually or severally (matched items, calibrated items) by virtue of which special control is required.

NO. QP 6.2.1

DATE: August 30, 1971

PAGE 1 OF 1

QUALITY PROCEDURE

SUBJECT: PROCESS CONTROL

1.0 SCOPE

This procedure delineates the methods used to control all steps in a process.

2.0 APPLICABLE DOCUMENTS

The following document(s) are applicable to the extent specified herein.

QP 4.1.1 Document and Change Control

3.0 REQUIREMENTS

Engineering shall develop the process as required to accomplish the desired results.

3.1 Operating instructions for the specialized equipment shall be referenced or included.

3.2 Tools, raw materials, materials used which do not form part of the end product (e.g., cleaning agents), fixtures, etc., shall be listed.

3.3 Measuring equipment and their calibration cycle shall be specified.

3.4 Methods of process control during the process shall be shown.

3.5 Final acceptance criteria shall be specified.

3.6 Process shall be documented and controlled as specified in QP 4.1.1.

4.0 QUALITY ASSURANCE

4.1 Process specifications shall be reviewed and approved by QA.

4.2 In-process monitoring shall be conducted by QA as required.

4.3 Where required, physical/chemical testing shall be reviewed and/or witnessed by QA.

4.4 Process procedures shall be in use during processing.

Prepared by ________ Approved by ________

QUALITY PROCEDURE

SUBJECT: IDENTIFICATION OF REDUCED BULK STORES

1.0 SCOPE

1.1 This procedure describes the methods whereby identification and control are maintained on items purchased in bulk when they are reduced to job quantities. Such items would be, as an example, hardware, flux, epoxies, wire, metals, solder, chemicals, etc.

2.0 APPLICABLE DOCUMENTS

None

3.0 REQUIREMENTS

The identification of all lots of items reduced from bulk stores will be done at the direction of Engineering.

3.1 Packaged Materials Labels

Labels shall be placed on all reduced items which shall contain at least the following information, as applicable:

3.1.1 The item part number and nomenclature, etc., including size, type, class, grade, manufacturer, etc.

3.1.2 Military Specification Number, including type, class, grade, etc.

3.1.3 Purchase order number and date, and project number.

3.1.4 The end of life date and/or special storage requirements (storage temperature).

3.1.5 Labels shall be such that during normal usage and handling of item, they remain legible.

3.2 MATERIAL CONDITION REPORT (MCR)

3.2.1 A copy of the MCR for the original bulk material shall be retained with the reduced material. Both the material and the MCR shall be marked with the job number.

Prepared by Jack T. Adler   Approved by J. E. Chan

QUALITY PROCEDURE

3.2.2 The original MCR shall be retained with the unreduced material for review by inspection prior to return to stores.

4.0 QUALITY ASSURANCE

During unscheduled floor inspection, items covered by this spec shall be examined for proper labeling.

QUALITY PROCEDURE

SUBJECT: INSPECTION AND TEST

1.0 SCOPE

This procedure describes the methods used to assure conformance to applicable drawings and specifications.

2.0 APPLICABLE DOCUMENTS

None

3.0 REQUIREMENTS

3.1 All inspections and tests shall be performed in accordance with written procedures. Check lists may be used where recorded data is not required; pertinent inspection points can be cited and standard measurement techniques are used.

3.1.2 Data sheets shall be used where required by drawings, test procedures or process control procedures.

3.2 Inspections shall be conducted where specified but in all cases shall occur prior to an irreversible process (e.g., sealing, encapsulation, etc.).

3.2.1 Inspection may include monitoring the process control as well as testing the final results.

3.2.2 Inspection should be accomplished after completing all characteristics of one drawing and before proceeding to the next.

3.2.3 Inspection shall include the review of the acceptability of all parts, materials and process prior to the point of inspection. Objective evidence of the acceptability of items (MCR) is required.

3.3 Preparation for final shipment shall include, in all cases, an inspection.

4.0 QUALITY ASSURANCE

4.1 Data sheets, check lists and other written procedures shall be reviewed by Quality Assurance.

4.2 Processes, assembly procedures and fabrication operations shall be reviewed to assure inclusion of timely inspections.

Prepared by [signature] Approved by [signature]

NO. QP 6.4.1

DATE: August 30, 1971

QUALITY PROCEDURE

SUBJECT: MATERIAL HANDLING AND STORAGE

1.0 SCOPE

This procedure specifies the control to be used to preclude loss, damage, deterioration, and/or substitution to raw and fabricated materials.

2.0 APPLICABLE DOCUMENTS

None

3.0 REQUIREMENTS

3.1 Identification

All material except when actually in process shall be identified by a tag or box label which contains at least quantity, drawing number, revision and lot or serial number of controlled items.

3.2 Storage

All acceptable shall be stored in the stock room.

3.2.1 Material being delivered to stock shall bear evidence of acceptability by Quality Assurance (MCR).

3.2.2 Material authorization for withdrawal from stock shall bear the signature of the Project Engineer(s).

3.3 HANDLING

All material shall be handled as befits its particular characteristics.

3.3.1 Piece parts in a box shall be separated from each other by paper, cardboard or other means.

3.3.2 Delicate parts shall be individually wrapped.

4.0 QUALITY ASSURANCE

4.1 Inspection(s) shall be made to assure that all materials are identified, stored and handled properly.

Prepared by [signature] Approved by [signature]

QUALITY PROCEDURE

SUBJECT: NONCONFORMING MATERIAL

1.0 SCOPE

This procedure describes the method by which nonconforming material is reviewed and dispositioned.

2.0 APPLICABLE DOCUMENTS

QP 6.7.1 Inspection Status

3.0 REQUIREMENTS

Nonconforming material and the MCR shall be reviewed to determine disposition.

3.1 Fabrication may designate material at review as rework or MRB (Material Review Board).

3.1.1 Rework shall be accomplished so that the completed piece meets all the drawing requirements.

3.1.2 MRB material shall be those items which cannot be practically made to meet requirements.

3.2 Engineering shall review all MRB's and may designate material as rework, scrap, and with QA concurrence, repair or use as is. Designations and approvals shall be placed on the MCR.

3.2.1 Specific instructions shall be supplied with the material for rework.

3.2.2 Scrap material shall be mutilated or marked in red and disposed of.

3.2.3 Repairs, when approved by QA, shall be acceptable when made in accordance with instructions supplied, not affecting form, fit or function, and if the repaired part could be replaced by an acceptable item.

3.2.4 If approved by QA, material may be designated "use as is" if when used it does not affect form, fit or function and could be replaced by an acceptable item.

Prepared by Jack T. Allen Approved by J. E. Chaney

QUALITY PROCEDURE

3.3 When unacceptable material conditions result in drawing changes. the material designation may become acceptable after issue of the Change Order (prior to the drawing change) if the change modifies the drawing for all characteristics.

4.0 QUALITY ASSURANCE

4.1 QA shall review all decisions affecting use of repaired or nonconforming material.

5.0 NOTES

5.1 When final design approval is the responsibility of the customer or when specified in the contract, the approval for the use of nonconforming material (and the Change Order) affecting form, fit, or function, is also the responsibility of the customer.

NO. QP 6.7.1

DATE: August 30, 1971

PAGE 1 OF 1

QUALITY PROCEDURE

SUBJECT: INSPECTION STATUS

1.0 SCOPE

This procedure defines the methods used to assure identification of the quality condition of all materials.

2.0 APPLICABLE DOCUMENTS

Form 6.7.1 Materials Condition Report (MCR).

3.0 REQUIREMENTS

Objective evidence (MCR) shall be completed for each item or group of items at the conclusion of inspection.

3.1 Material which satisfied all inspection criteria (i.e., check list, performance tests, etc.), shall be marked "Accepted", signed and dated, on the item or box label, by the inspector. In addition, the MCR shall be signed and dated in the area provided and the material may move to the next stage, with a copy of the MCR.

3.2 Material which does not satisfy the requirements shall be marked "Unacceptable". The deviations shall be listed on an MCR (Material Conditions Report) which has been signed and dated by the inspector. The material and a copy of the MCR shall be returned to its source. A copy of the MCR shall remain in QA.

3.3 Material marked "Unacceptable" may be reworked and resubmitted for inspection with the copy of the MCR showing the rework of each unacceptable item. Such material, satisfying inspection criteria, shall be marked, "Acceptable" as per 3.1.

4.0 QUALITY ASSURANCE

4.1 A copy of each MCR shall be retained by Inspection.

Prepared by [signature] Approved by J. E. Chaney

MATERIAL CONDITION REPORT

No.	Supplier		P.O./W.O.No.	Item description				Part/Dwg. No.		Rev.
Test Proc.	Check List	Inspected by	Date	Qty.Rec.	Qty.Insp.	Qty.Acc.	Mat'l MCR No.	Accepted by		Date

No.	Qty.	CHARACTERISTIC	DEVIATIONS	Disposition	Rework by	Rework date

FINAL ACTION

Notations	Approvals Eng.	Qual.	Cont.	Prog.

Form 6.7.1

APPENDIX B

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (FMECA)

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TABLE OF CONTENTS

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1. INTRODUCTION

This contract calls for modifying and proving the design of an optical laser beam steering device and qualifying it for spaceborne operation. One of the requirements is the performance of a Failure Mode, Effect and Criticality Analysis (FMECA) to determine possible modes of failure, the effect of the failure on operation capabilities of the device and associated systems, and the criticality of the failure, in accordance with the requirements of MSFC Dwg. 10M30111A.

1.1 Device Description and System Operation

The beam steerer is an element of a scanning laser radar system which directs an infrared (905 nm wavelength) laser beam in a raster scan pattern over a sector of space. Two beam steerers are used to generate orthogonal scan motions. The scan pattern is magnified and imaged on a cooperative target with projection optics. The illuminated target is imaged on a scanning receiver (image dissector) in the laser radar, which is scanned in synchronism with the laser. To insure that the receiver and the laser are looking at the same position in space, the receiver is driven by signals derived from deflection sensors on the beam steerers.

A representative laser radar system, contained in an enclosure, within which is a separate enclosure for the beam steerers, is shown in Fig. 1.

Each beam steerer consists of a mirror driven by a piezoelectric transducer. When an electric field is applied to the transducer the mirror tilts, changing the angle of the laser beam reflected from it. Attached to the transducer are two strain gage sensing elements which measure the amount of deflection. The output of these sensors is passed through an operational amplifier (not considered part of the beam steerer in this analysis), and then to the system electronics. Drive signals for the transducer are also generated by the system electronics. This device after assembly has no removeable and/or repairable components.

1.2 FMECA Approach

System specifications for the scanning laser radar have not yet been completely determined, therefore Section 2 deals qualitatively with the effects of beam steerer failures on the laser radar to identify possible problem areas which should be considered by the system designer. Section 3 is a listing of failure modes and effects, and Section 4 is an analysis of the generic failures. The operational parameters & conditions are shown in Table 1, and failure definitions are discussed in Section 3.2.

Operating Parameters

Drive Voltage E_D	$\pm$ 450 V maximum
Drive Frequency	15 Hz maximum Triangular
Bridge Supply E_B	2.000 Volts $\pm$ .01 %
Ambient Temp.	20° C $\pm$ 5°C
Humidity	50 - 70% RH

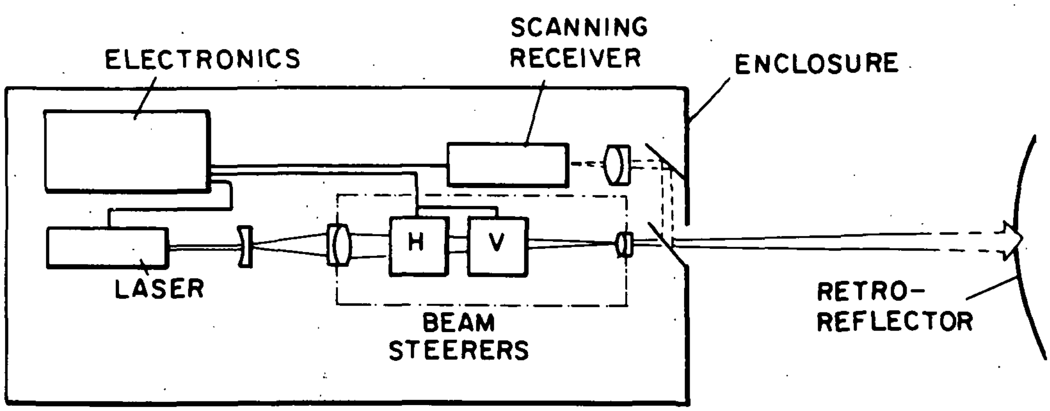


Fig. 1.

2. EFFECTS OF BEAM STEERER FAILURES ON OTHER SYSTEMS

Certain failure modes of the beam steerer may affect other systems. These failures, and their consequences, are examined herein, assuming that all operating parameters and conditions are those required for specified performance.

2.1 Spurious Signal Generation

All normal signals to and from the beam steerer are limited in bandwidth to the low audio frequency range of a few kilohertz and pose no radiative interference problems. Two other possible sources of noise due to device malfunction will also be considered.

2.1.1 Signal Generation by Vibration-Excited Transducer

When excited by external vibrations, the piezoelectric transducer on the beam steerer can generate electrical signals at frequencies up to a few kilohertz, which are coupled back to the drive electronics. These signals may appear on the power supply terminals and result in noise on the spacecraft power buss. In this case, however, filtering normally present at the power supply terminals to suppress incoming disturbances may be adequate to prevent these transducer signals from entering the power buss.

2.1.2 Electrical Breakdown

Electrical breakdown across the transducer may generate transients with high frequency components appearing at the beam steerer drive circuitry. These may be suppressed through the by-pass to ground at the drive amplifier output. Any radiation may be trapped by the metallic beam steerer enclosure.

2.2 Power Shorts

Shorts or low resistance to ground at the bridge preamplifier, the gages, or the transducer would tend to load the respective power supplies. The power systems should be protected where necessary by fusing or current-limiting circuits.

2.3 Misdirection of the Laser Beam

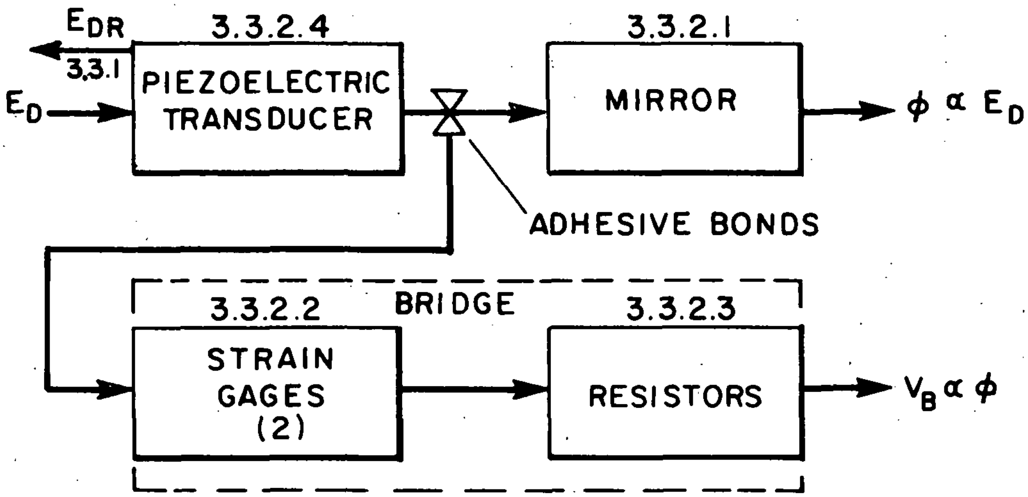
In the event that a transducer should break or a mirror become displaced on the beam steerer, the laser beam may be misdirected. This beam, exiting through the pupil, points into a sector of space; however a beam which misses the pupil is confined to the interior of the optical subsystem package of the laser radar.

2.4 Breakage and Debris

Should parts of the beam deflector break off or come free, they will be confined to the immediate area of the optical subsystem package by the package enclosure and not be free to affect other spacecraft systems.

3. FAILURES AFFECTING LASER RADAR PERFORMANCE

3.1 Block Diagram



3.2 Failure Definitions

3.2.1 Beam pointing error is an error between the strain gage bridge output (V_B) and the beam deflection angle (φ) greater than 1/2 of one spot diameter (approximately 20 μrad).

3.2.2 Reduced target illumination is a condition wherein the energy on the target is less than encountered in a correctly functioning system. Limits are not available to define the levels of degradation acceptable.

3.2.3 Reduced beam deflection angle occurs when a given drive voltage (V_B) produces an angle (φ) less than normal. It should be noted that there is no beam pointing error (the bridge output (V_B) is correct for the angle developed).

3.3 Failure Modes and Effects

3.3.1 Premature operation

Mode	Effect
Output from piezoelectric transducer into drive source (E_{DR}) at resonant frequency	Output circuit for drive voltage will see an input ac signal which may be as large as ± 450 V peak.

3.3.2 Failure to start operating or failure during operation

	Mode	Effect
3.3.2.1	Mirror	
3.3.2.1.1	Bond slippage	Beam pointing error
3.3.2.1.2	Loss of reflectivity	Reduced target illumination
3.3.2.2	Strain gage	
3.3.2.2.1	Bond slippage	Beam pointing error
3.3.2.2.2	Component/connection failure	Beam pointing error*
3.3.2.2.3	Component change	Beam pointing error
3.3.2.3	Resistors in bridge circuit	
3.3.2.3.1	Component/connection failure	Beam pointing error*
3.3.2.3.2	Component changes	Beam pointing error
3.3.2.3.3	Low resistance short to ground	Increased load on bridge supply and beam pointing error
3.3.2.4	Piezoelectric Transducer	
3.3.2.4.1	Bond slippage	Beam pointing error
3.3.2.4.2	Component/connection failure	Reduced beam deflection
3.3.2.4.3	Component change	Beam pointing error
3.3.2.4.4	Short/leakage to ground	Increased load on drive supply.

*output 10-100 times normal

4. FAILURE PROBABILITIES

The following analysis will attempt to define the relative probabilities of failures.

4.1 Electrical Elements, Passive

The circuit elements in this device are few in number and their individual failure rates are small such that the worst case analysis shows an MTBF of greater than 27,000 hours (see Appendix I).

4.2 Structural

4.2.1 The probability of structural failure is considered so low as to be negligible. This includes breakage and damage to the transducer elements and/or mirror resulting from either mechanical or electrical stresses within the operating limits.

4.2.2 Bond slippage is a condition wherein the mechanical alignment between two adjacent mechanical surfaces is changed. Limits are not available to define the levels of acceptable degradation, except that of total failure when parts may become separated from the assembly.

4.2.2.1 The adhesive bonds between the mirror and the transducer, and the transducer and the base, are not subject to continued stress during operation and their probability of failure is considered negligible.

4.2.2.2 The bonds between the two wafers of the transducer sandwich are in stress only during use, while those between the strain gages and the transducer are in stress at all times.

Life tests have shown that bond failures have not occurred subsequent to the aging process. The aging of these units stabilizes the initial "creep" in the bonds and eliminates early life failures.

4.3 Electrical Elements, Active (see appendix II)

The strain gage is subjected to continual stress during use; however there is no evidence that it exhibits chance failure, after aging, during its wear-out life. Tests have been and are being conducted on wear-out life. Tentative results indicate that approximately 90 percent of the devices will have a wear-out life which exceeds 20×10^6 cycles in system operation. End of life is defined as strain gage failure.

4.4 Conclusion

The expected minimum life of 20×10^6 cycles reduces to 5500 operating hours per Hz. At the anticipated scan rate of 1 - 15 Hz the life would range from 365 to 5500 hours of continuous scanning operation. When compared with the calculated MTBF of 27,000 hours, the wear-out life of the Beam Steerer predominates over all other factors.

5. CRITICALITY ANALYSIS

The criticality of the Beam Steerer should relate the device to mission performance and loss of life. Since neither the mission nor the system configuration will be identified prior to the expiration of this contract no such analysis will be made. However, discussions with cognizant NASA personnel have indicated that the Beam Steerer is not intended to be used in any manner such that its failure will have any effect upon mission performance and/or loss of life.

APPENDIX I

Component Failure Rate Analysis (MIL-HDBK-217A Methodology*)

Assumptions, where applicable

1. T ambient = 50°C
2. K factor for Missiles
3. Connectors mate once per 100 hours
4. Failure rate for epoxy connections = $.1 \times 10^{-6}$
5. Connector FR = FR for MIL-C-26482
6. Resistors RNR60, level M
7. Q = Quantity

1. Connectors NAS1599, 2 pieces

Method 7.9.3. 8 active pins each.

$FR_T = (\lambda_e + N_m \lambda_m) KQ$; $FR_T = 26.4 \times 10^{-6}$

$\lambda_e = .02$, $Nm = 10^4$, $\lambda_m = 2 \times 10^{-5}$, $K = 60$, $Q = 2$.

2. Resistors MIL-R-55182 RNR60, 4 pieces

Method 7.5.2 SR = 1/50/1/8 = .16 ≈ .2

$FR_T = (FR)KQ$; $FR = 2.1 \times 10^{-6}$, $K = 1$, $Q = 4$. $FR_T = 8.4 \times 10^{-6}$

3. Terminations 20 Solder, 6 Epoxy

Method 7.11.1

$FR_T = FR_S (Q_S) + FR_E (Q_E)$

$FR_S = .034 \times 10^{-6}$, $Q_S = 20$, $FR_T = 1.28 \times 10^{-6}$

$FR_E = .1 \times 10^{-6}$, $Q_E = 6$ $FR \approx 36 \times 10^{-6}$

$\frac{1}{FR}$ = MTBF ≈ 27,800 hours

*Notations used herein are taken from the Handbook

APPENDIX II

Although a life test program is not within the scope of this contract, certain information has been developed as a result of the engineering investigations related to the construction of beam steering devices.

These factors are presented below in qualitative form as guide lines to the life expectancy of the Beam Steerer.

The resistance of the strain gage (nominal value, 50 ohms) tends to increase with aging up to between 60 and 70 ohms at which time it becomes open. No data is available as to the rate at which it changes.

As used in the bridge circuit the factors effecting life become different. Instead of being concerned with the value of each gage, we are more interested in the strain gage bridge unbalance with no deflection.

An equal change in resistance in both strain gage elements will produce no decernable change in bridge output voltage. However a disproportionate change of only 2 milliohms will result in an effective deviation angle error of one-half spot position, approximately 40 μ rad.

This type of error can be corrected by recalibration of the beam deflector at a standard angle. As this offset continues to increase with use it approaches the maximum permissable strain gage bridge unbalance of $\pm$ 800 μv. There are therefore two possible end of life conditions (1) increase of either strain gage resistor beyond 60 Ω and (2) increase in strain gage bridge unbalance beyond $\pm$ 800μv.

It is possible to measure the single side bridge voltage which should not exceed 1.100 volts, the voltage when the strain gage reaches 60 ohms.

There is no information available to determine which of these effects occurs first since the parameters involved (e.g. original strain gage resistance, resistance after bonding to ceramic, etc.) vary in a random fashion on each side of the bridge.

APPENDIX C

QUALIFICATION TEST REPORT FOR PBM-8G BEAM STEERER

Contract NAS8-26846

April 1973

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Prepared by

GTE LABORATORIES INCORPORATED
Waltham, Massachusetts 02154

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TABLE OF CONTENTS

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1. TEST OBJECTIVE

Qualification Testing is performed to access the success of the device design in meeting functional performance goals under specified conditions. A determination is made of the ability to withstand environmental conditions of temperature, humidity, shock, acceleration, and vibrations without critically affecting the device operational parameters.

2. DESCRIPTION OF TEST SAMPLE

The device tested is the PBM-8G Beam Steerer. It is a piezoelectrically driven mirror optical beam steerer capable of deflecting a light beam through angles up to ± 40 arc minutes in response to an electrical drive signal. Deflection frequency extends from dc to the first mechanical resonance at approximately 1250 Hz, where a peak in deflection response occurs. A deflection sensing bridge circuit utilizing strain gages mounted on the piezoelectric transducer provides a signal proportional to the mirror deflection angle.

The general physical dimensions are as shown in Figure 1. Electrical connections are made through two cables 30 cm long with terminating connectors. All exposed metal surfaces are finished in flat black except for electrical terminals and connectors. The weight of the assembly, including connectors, is 266 g.

3. DISPOSITION OF TEST SPECIMEN

The tested unit, S/N 006, is in storage at GTE Laboratories, Waltham, Mass. It is in working order and has been tentatively scheduled for life testing and performance of additional tests on temperature coefficient of strain gage angular sensitivity.

4. CONCLUSIONS AND RECOMMENDATIONS

The information obtained during Qualification Testing of unit S/N 006 and additional testing of other units has been analyzed and the results considered in terms of recommendations for design changes and modifications in test methods. These are detailed in Sections 3.2 and 3.3 of the Final Report.

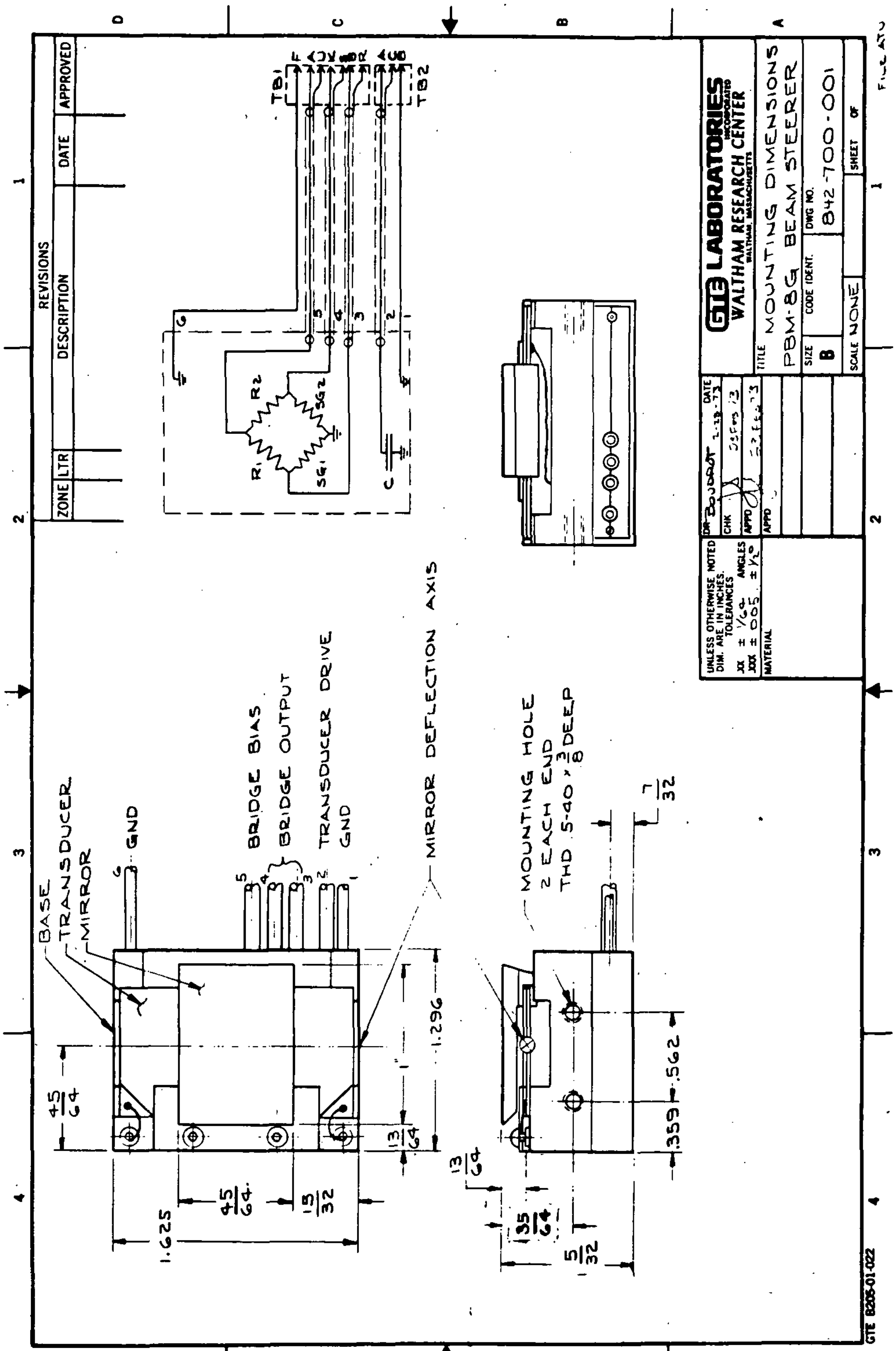
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
BASE
TRANSDUCER
MIRROR
GND
BRIDGE BIAS
BRIDGE OUTPUT
TRANSDUCER DRIVE
GND
MIRROR DEFLECTION AXIS
MOUNTING HOLE
2 EACH END
THD 5-40 × 3/8 DEEP
1.625
45/64
13/32
13/64
1.296
1"
.359
.562
35/64
5/32
7/32
TB1
TB2
R1
R2
SG1
SG2
UNLESS OTHERWISE NOTED DIM. ARE IN INCHES.
TOLERANCES
.XX ± 1/64 ANGLES
.XXX ± .005 ± 1/2°
MATERIAL
GTE LABORATORIES INCORPORATED
WALTHAM RESEARCH CENTER
WALTHAM, MASSACHUSETTS
TITLE
MOUNTING DIMENSIONS
PBM-8G BEAM STEERER
SIZE B
CODE IDENT.
DWG NO.
842-700-001
SCALE NONE
SHEET OF
GTE B205-01-022

Figure 1

5. FACTUAL DATA

5.1 Description of Test Apparatus and Test Procedure

The apparatus and procedures used in performing the qualification tests are described in the Qualification Test Procedure and Functional Test Procedure which follow:

NOTE

Pages C-9 through C-16 — Qualification Test Procedure
Pages C-17 through C-31 — Functional Test Procedure

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

842-500-101B

	REVISIONS
A	Renumbered paragraphs, Deleted Pyrotechnic Shock, Modified Altitude.
B	CN1048 Rewrote

QUALIFICATION TEST PROCEDURE

BEAM STEERER

Approval		Date
Engineering	John Schlafer	4 Apr 73
Production	John Schlafer	4 Apr 73
Quality Assurance	R. Lannin	4 Apr 73
Management	V J Fowler	4 Apr. 73

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-604

NAME	MATERIAL	PROJECT NO.
QUALIFICATION TEST PROCEDURE, BEAM STEERER		

DRAWN BY W. Gannon
DATE 1/6/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-500-101B

1. SCOPE

1.1 This procedure describes the qualification tests to be performed on an Optical Beam Steerer, Drawing number 842-100-604.

1.2 The Beam Steerer has the following physical characteristics; Weight - approximately 8 oz., Volume - approximately 1 3/4 x 1 1/2 x 1 1/4 inches, Connections - two 1 foot long 1/4 inch diameter cables attached.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of this procedure form a part of this procedure to the extent specified herein:

MIL-C-45662 Calibration System Requirements
842-100-604 PBM-8G Beam Steerer, GTE Labs.
842-500-103 Functional Test Procedure, Beam Steerer, GTE Labs.

3. ENVIRONMENT

3.1 Ambient conditions shall be considered to be 23°C ± 5°C, 45% to 75% relative humidity, and 30 ± 2 inches Hg.

3.2 All times indicated shall be considered minimums.

3.3 Environmental values for test requirements are minimums and deviations (including tolerances) shall be in a direction away from ambient.

4. SELECTION OF UNITS

The unit(s) selected for qualification testing shall be qualification models produced in accordance with Drawing 842-100-604. The testing of these units is to insure qualification of the design and production practices, and the adequacy of quality control procedures.

5. FUNCTIONAL TESTS

Functional tests (electrical, optical and/or operational), when specified, shall be performed by the manufacturer in accordance with Functional Test Procedure 842-500-103. References in parenthesis below cite the paragraph number in the test procedure. All functional tests shall be performed at ambient conditions unless otherwide specified.

5.1 Strain Gage Bridge Unbalance (6.1).

5.2 Strain Gage Angular Sensitivity (Amplified) (6.2.1).

5.3 Deflection Sensing Error (6.2.2).

5.4 Mirror Flatness Deviation (6.3).

5.5 Resonance Frequency (6.4).

5.6 Mirror Deflection (6.5).

5.7 Mirror Reflectivity (6.6).

6. QUALIFICATION TESTS

6.1 Temperature, Operating

The unit shall be exposed to the following environment for the time shown. Measurements as specified shall be taken at the operating temperature and data recorded.

6.1.1 -5°C (+23°F) for 60 minutes.

6.1.1.1 Test for strain gage bridge unbalance, per paragraph 5.1.

6.1.1.2 Test for strain gage angular sensitivity per paragraph 5.2.

6.1.1.3 Test for the mirror flatness deviation per paragraph 5.4.

6.1.2 +45°C (+113°F) for 60 minutes.

6.1.2.1 Test for strain gage bridge unbalance, per paragraph 5.1.

6.1.2.2 Test for strain gage angular sensitivity per paragraph 5.2.

6.1.2.3 Test for mirror flatness deviation per paragraph 5.4.

6.2 Temperature

The unit shall be exposed to the following environment for the times shown.

6.2.1 +60°C (+140°F) for 6 hours.

6.2.2 Ambient for 30 minutes.

6.2.3 -30°C (-22°F) for 6 hours.

6.2.4 Ambient for 30 minutes.

6.2.5 Test for strain gage bridge unbalance, per paragraph 5.1.

6.2.6 Test for strain gage angular sensitivity per paragraph 5.2.

6.3 Altitude

6.3.1 Hi Vacuum

The unit shall be spectrometrically examined at room ambient, in a pressure of no more than 1×10^{-8} Torr and the outgassing products and partial pressures shall be identified and recorded.

6.3.1.1 Pump down shall continue for at least an additional 24 hours at which time the tests shall be repeated, and all values, including pressure, shall be recorded.

6.3.2 Vacuum

The unit shall be exposed to a pressure of 1×10^{-6} Torr at 120°F for 30 minutes.

6.4 Humidity

6.4.1 The unit shall be exposed to 95% relative humidity at +30°C (+86°F) for 24 hours. No operating test will be made during the environment.

6.4.2 Dry the unit thoroughly using unheated low pressure air.

6.4.3 Test per paragraphs 5.1 through 5.7 inclusive.

6.5 Vibration and Acoustic Noise

The unit shall be exposed to the following environment for the duration shown in each of three axes.

6.5.1 Sinusoidal Sweep at one octive per minute each axis.

Frequency Range (Hz)	Amplitude
5 - 14	0.5 in (peak-to-peak)
14 - 400	5.0 g (0-peak)
400 - 2000	7.5 g (0-peak)

All resonant peaks shall be recorded.

6.5.2 Random, Broad Band. Four minutes each axis (Figure 1).

Flat 20 to 80 Hz at 0.05 g^2/Hz

Roll off below 125 Hz at 5.5 db/octave

Flat 125 to 560 Hz at 0.1 g^2/Hz.

Roll off above 560 Hz at 3.5 db/octave.

Flat 1000 to 2000 Hz at 0.05 g^2/Hz.

Overall: 12.7 g (rms).

6.5.3 Random, Narrow Band. Sweep one octive per minute (Figure 1).

.25 g^2/Hz narrow band sweep between 180 and 2000 Hz with overall value of 3.53 g (rms) and an equivalent bandwidth of 50 Hz.

6.5.4 Acoustic Noise.

The unit shall be exposed to the environment shown in Figure 2 for 3 minutes.

6.5.5 Test per paragraphs 5.1 through 5.7 inclusive.

6.6 Acceleration

The unit shall be exposed to the following environment for the times shown.

6.6.1 Linear

8 g for one minute in each axis.

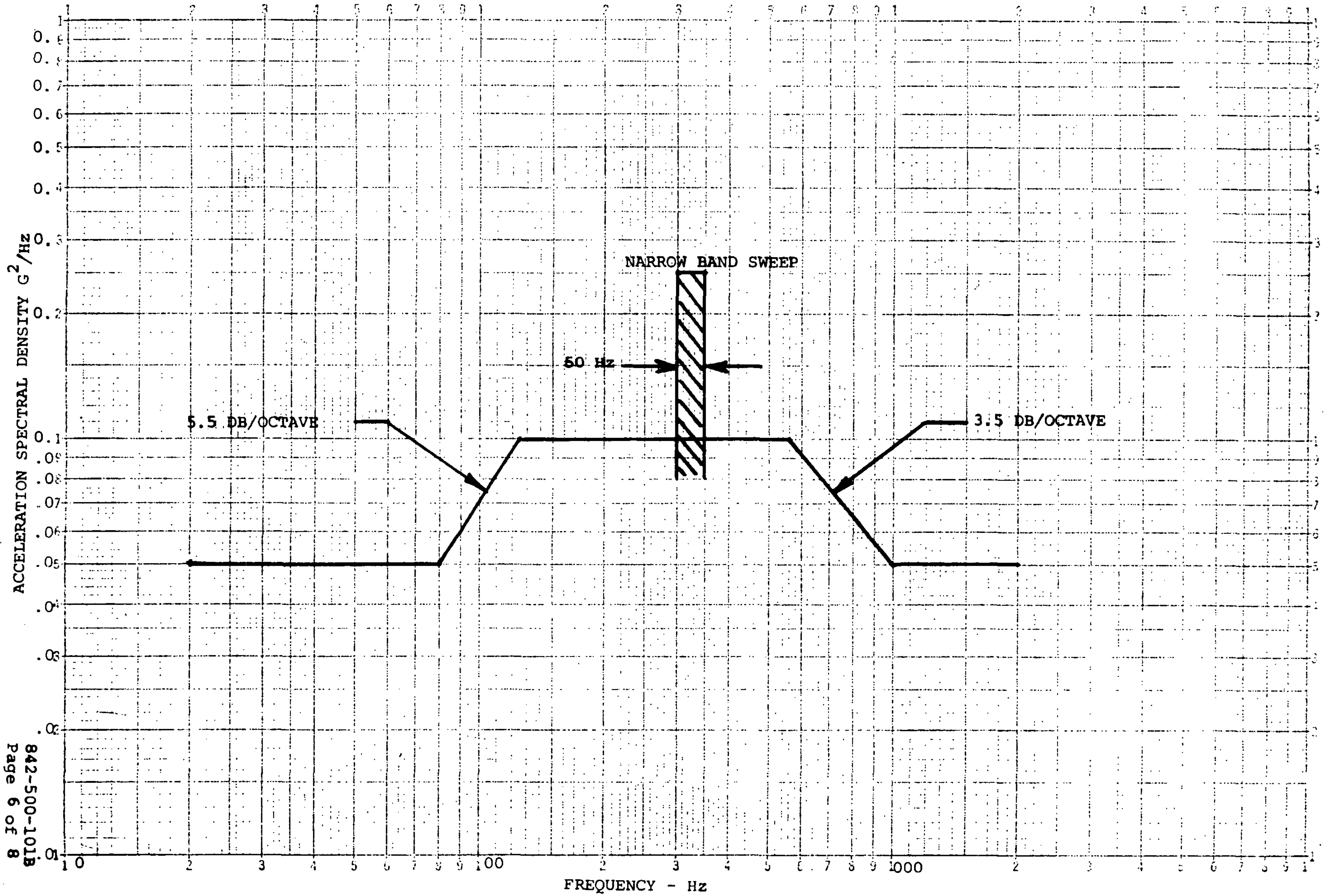

FIGURE 1
RANDOM VIBRATION

842-500-101B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±½°	
DO NOT SCALE DRAWING			

842-500-101B

REVISIONS

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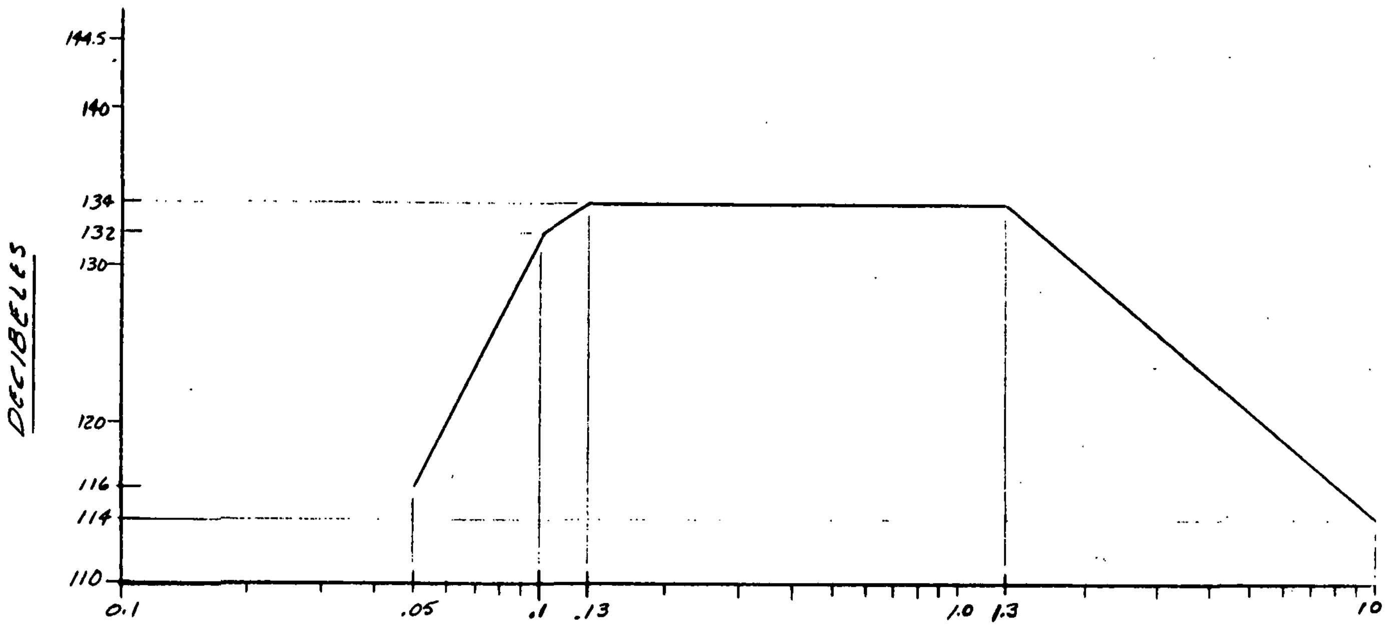

DB REFERENCE LEVEL
0.0002 DYNES/CM²

APPROVAL		DATE
ENG		22 Feb 73
PROD.		22 Feb 73
QA		2/22/73
MGMT.		2/28/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME	MATERIAL	PROJECT NO.
ACOUSTIC LEVEL VS FREQUENCY FIGURE 2		

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-500-101B PAGE 7 OF 8
DATE 3-22-72		

6.6.2 Half Sine (shock)

20 g for 11 msec, one shock in each axis.

6.6.3 Test per paragraphs 5.1 through 5.7 inclusive.

7. QUALITY ASSURANCE PROVISIONS

7.1 The equipment used shall be under calibration control in accordance with MIL-C-45662.

7.2 All tests shall be witnessed by a Quality Assurance/Reliability representative of the manufacturer.

7.3 The testing facility shall submit a report containing the following information as a minimum:

7.3.1 Tests performed referencing paragraphs of this procedure.

7.3.2 Serial number of units tested.

7.3.3 A list of the test equipment used and their last calibration dates.

7.3.4 Date of each test.

7.3.5 Visual evidence of damage after each test.

7.3.6 Signature of person performing the test.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

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842-500-103 A

REVISIONS
CN 1053
(A) Corrected Table I

A

FUNCTIONAL TEST PROCEDURE

BEAM STEERER

Approval — Date

Engineering John Schlafer 4 Apr 73

Production John Schlafer 4 Apr 73

Quality Assurance R. Hammi 4 Apr. 73

Management V Fowler 4 Apr. 73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FUNCTIONAL TEST PROCEDURE, BEAM STEERER		

DRAWN BY J. Schlafer

DATE 3/2/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-500-103 A

1. SCOPE

This procedure describes the functional tests to be performed on an optical beam steerer, Drawing 842-100-604.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of this procedure form a part of this procedure to the extent specified herein:

MIL-C-45662 Calibration Systems Requirements.

APPROVAL		DATE
ENG.	[signature]	13 MAR 73
PROD.	[signature]	13 MAR 73
QA	[signature]	3/13/73
MGMT	[signature]	3/15/73

3. ENVIRONMENT

Ambient conditions shall be considered to be 23°C ± 5°C, 45% to 75% RH and 30" Hg ± 2" Hg.

4. EQUIPMENT

4.1 Electronic Autocollimator. This instrument optically detects mirror angular position and provides a voltage step or pulse output when the mirror passes through perpendicularity to the instrument axis. This voltage step or pulse must make a total transition in less than 20 arc sec. of mirror deflection and have a phase shift of less than 45° at 16 $(10)^4$ positive transitions per second. The instrument is used as a null indicator to signify when the beam steerer passes through an angle and need not be linear through the transition region.

4.2 Calibrated Wedges. These are optical deviation wedges whose deviation angle has been calibrated to an accuracy of ± 0.6 arc sec. Three wedges are required with nominal deviation angles of:

α = 4 arc min. (nominal)
β = 12 arc min. (nominal)
γ = 10 arc sec. (nominal)

4.3 Orientation Adjustment. The beam steerer is to be mounted on a platform which will allow angular orientation about the deflection axis with control of 0.5 arc sec.

4.4 Differential Amplifier. This amplifies the bridge output voltage and must have the following minimum characteristics:

Gain	150 ± 10
Bandwidth to 3 dB points	dc to 150 KHz
Linearity over output voltage range ± 1 volt	0.01 per cent error
Offset voltage drift vs. temp. referred to input	1.0µV°C
Noise referred to the input	2µVrms
Common mode rejection ratio	10,000

4.5 Transducer Drive Source. This must be capable of driving the beam steerer transducer with sine and triangular waveforms at a variable level from zero up to 1000 Vp-p from 1 to 100 Hz. It shall have a dc offset of less than 10V.

4.6 Bridge power supply. This shall supply a current of at least 50 mA at 2V and allow the voltage to be maintained at 2.000 ± .001V throughout a test sequence. The noise shall be less than 0.5 mVp-p.

4.7 Variable reference voltage. This is a d.c. reference voltage against which the amplified strain gage voltage is compared. It must be variable from + 1.2 to -1.2V and have a noise and spurious signal level less than 1 mVp-p. The voltage control shall be fine enough to allow setting to 0.2 mV.

4.8 Digital Voltmeter. This instrument must be capable of measuring the variable reference voltage to an accuracy of 0.1 mV out of 1.0V.

4.9 Differential Comparator. The voltage from the bridge differential amplifier is compared with the reference voltage by the differential comparator. When the varying bridge voltage passes through a value equal to the reference voltage the comparator output is a voltage step. The comparator should have the following characteristics:

Response time to saturated output with 10 mv step input	< 200 ns
Input voltage differential to drive output over full voltage range	0.2 mv

4.10 Dual Beam Oscilloscope. The oscilloscope indicates when proper adjustments have been made to achieve time coincidence of the signals from the electronic autocollimator and the differential comparator. The oscilloscope should have the following minimum characteristics:

Bandwidth	d.c. to 200 KHz
Sweep Speed	to 10 μs/cm
Synchronization	triggering from either input

4.11 Temperature Controlled Chamber. The beam steerer is placed inside the chamber when measurements are to be made at other than room temperature. The chamber must be constructed with a high optical quality window so that the beam steerer mirror can be monitored by the electronic autocollimator. Temperature shall be maintained at ± 1°C for any temperature set between -30°C to +50°C.

4.12 Thermocouple for temperature range of -30°C to +50°C.

4.13 Monochomatic Parallel Light Interferometer (Twyman-Green or equivalent).

4.14 Oscilloscope with a vertical sensitivity of at least 50 mv per division.

4.15 Signal Source having the following characteristics:

Sine wave output	0 - 10 Vrms Variable
Frequency Range	200 - 1500 Hz continuously variable
Input Impedance	600Ω or less.

4.16 Drive source capable of supplying a sinewave signal from 0 to 360 Vrms at 100 Hz.

4.17 A.C. Digital Voltmeter of ± 0.5% accuracy.

4.18 Stroboscope capable of operating at 100 flashes per second.

4.19 Optical Spectrometer for measurement of mirror reflectance.

4.20 Frequency Counter with a minimum range of 10 - 2000 Hz and 0.5% accuracy.

4.21 Autocollimator having a calibrated range of 60 arc minutes.

5. DIFFERENTIAL AMPLIFIER GAIN CALIBRATION

The voltage gain of the differential amplifier 4.4, used to amplify the strain gage bridge output shall be calibrated in the following manner. Measurements as specified shall be taken and data recorded.

5.1 Connect the differential input leads of the amplifier across a fixed resistance bridge consisting of three (3) 51.0 ± 0.5 ohm resistors, and one (1) 49.0 ± 0.5 ohm resistor, as shown in Figure 1. Apply 2.0 volts to the bridge.

5.2 Measure the differential amplifier output voltage, V1, and the differential input voltage, V2, to ± 0.05% with the digital voltmeter, 4.8. Record the gain, G = V1/V2, on the Linearity Test Data Schedule, Figure 4.

5.3 Measure the differential amplifier temperature to ± 1°C with a thermocouple, 4.12, and record it on the Linearity Test Data Schedule.

6. FUNCTIONAL TESTS

The following functional tests are described herein to be performed as required by acceptance or qualification testing. The data is to be recorded in a manner prescribed by such testing. Parameters shall fall within the limits given in Table I unless otherwise specified. The order of testing of each unit need not follow the order of tests listed herein.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

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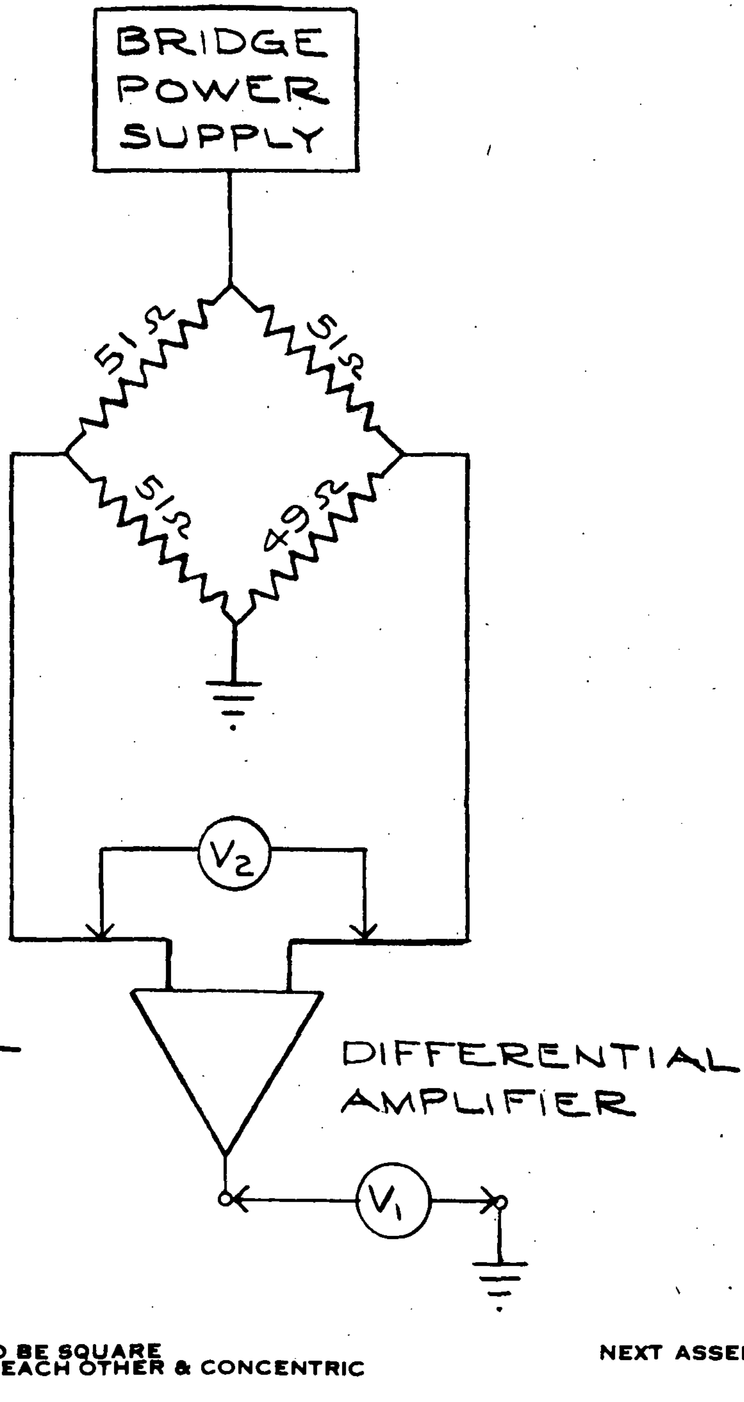

DIFFERENTIAL AMPLIFIER GAIN CALIBRATION

FIGURE 1

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME FUNCTIONAL TEST PROCEDURE, BEAM STEERER	MATERIAL	PROJECT NO.
DRAWN BY BOUDREAT	GTE LABORATORIES INCORPORATED	842-500-103A
DATE 27 FEB 73	BAYSIDE RESEARCH CENTER	PAGE 6 OF 15

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Table I
FUNCTIONAL TEST LIMITS

PAR	TEST	LIMITS	
6.1	Strain Gage Bridge Unbalance	$\pm$ .0.55 mV	
6.2.1	Strain Gage Angular Sensitivity (Amplified)	0.765 to 0.935 mV/Arc Sec.	
6.2.2	Deflection Sensing Error	$<$0.1%	△1
6.3	Mirror Flatness Deviation	$<$4.2μ in.	△1
6.4	Resonance Frequency	1120 to 1270 Hz	
6.5	Mirror Deflection	17 to 23 Arc Min.	
6.6	Mirror Reflectivity	$\geq$ 97%	

6.1 <u>Strain Gage Bridge Unbalance</u>

With the voltage as specified below applied to the strain gage bridge and no deflection drive voltage the bridge unbalance shall be determined. Measurements as specified shall be taken and data recorded.

6.1.1 Orient the beam steerer such that the mirror surface is in a vertical plane. Ground the transducer drive lead, No. 2 in Figure 2. Connect a constant voltage supply of +2.000 $\pm$ 0.001 volts between the bridge supply lead No. 5 and bridge ground No. 1. Let the bridge stabilize for 10 minutes before making measurements.

6.1.2 Measure and record the voltage and polarity across the bridge output leads, No. 3 and No. 4 to $\pm$ 0.02 millivolts.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE
DO NOT SCALE DRAWING			

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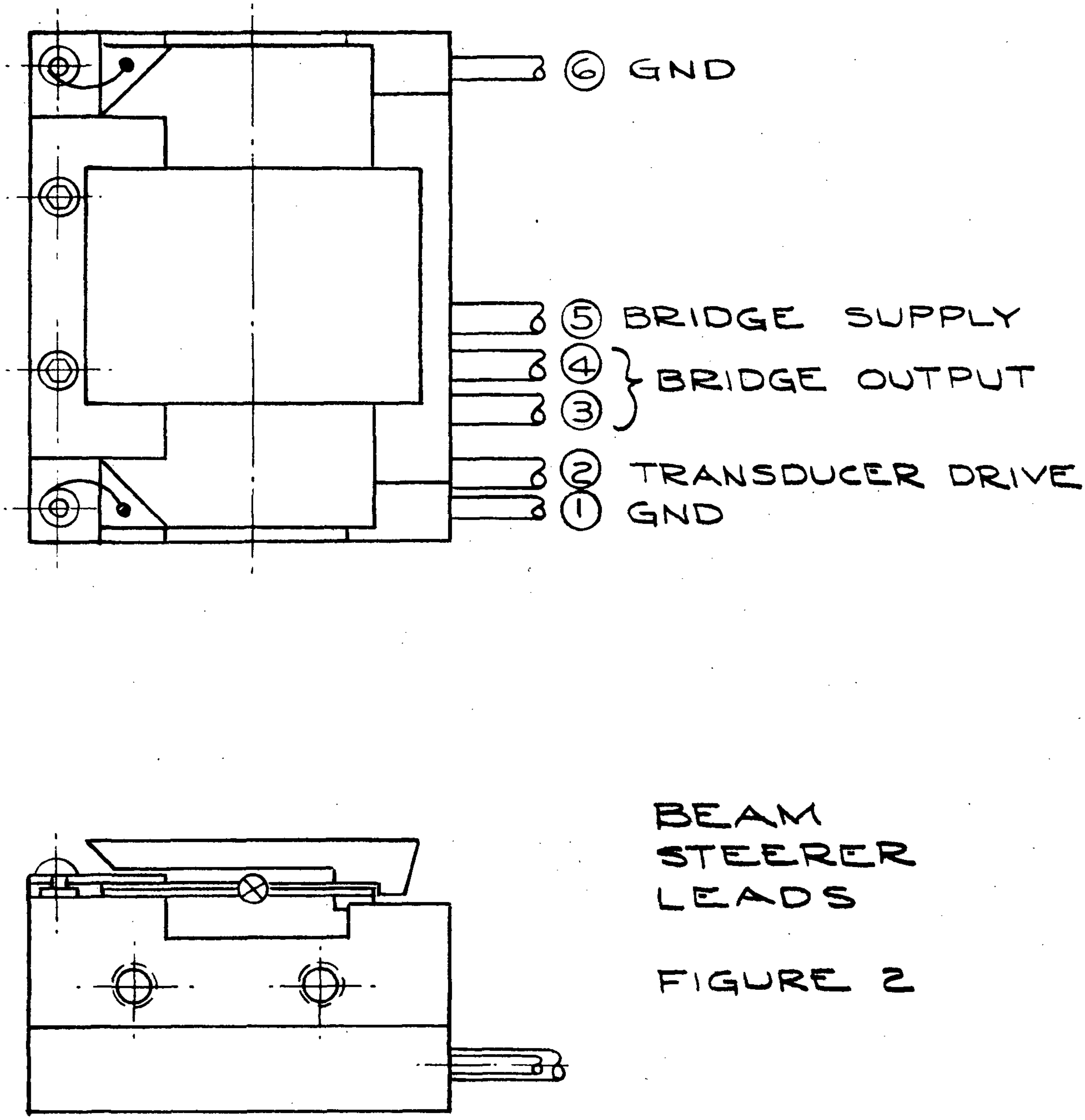

BEAM STEERER LEADS

FIGURE 2

NOTE:

SEE 842-100-503 FOR CONNECTOR PIN LETTERS CORRESPONDING TO LEAD NUMBERS

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NEXT ASSEMBLY

NAME FUNCTIONAL TEST PROCEDURE, BEAM STEERER

MATERIAL

PROJECT NO.

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DATE 27 FEB 73

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842-500-103 A

6.1.3 Measure and record the beam steerer base temperature to ± 1°C with a thermocouple, 4.12.

6.2 Strain Gage Angular Sensitivity and Deflection Sensing Error

The amplified strain gage bridge output as a function of mirror angular deflection is to be measured and a proportionality factor K (mv/arc sec.) derived. The amplified bridge output is measured at various discrete mirror deflection angles, equal to angles generated by a set of calibrated optical deviation wedges, while the beam steerer is being driven with the specified voltage waveform and frequency. The value of K is calculated as a least square fit to the data plotted as amplified bridge voltage vs. deflection angle. The maximum deviation (ε_{max}) of deflection from a line with this slope is then determined.

6.2.1 Angular Sensitivity Measurement

6.2.1.1 Assemble and arrange the equipment described in 4.1 thru 4.10 as shown in Figure 3. Calibrate the differential amplifier, 4.4, as per paragraph 5. Mount the beam steerer rigidly on the orientation adjustment mechanism, 4.3 and position it such that the mirror is perpendicular to the axis of the autocollimator, 4.1 with no wedges present. If measurements are to be made at other than room temperature, the beam steerer must be placed inside the temperature controlled chamber, 4.11.

6.2.1.2 Turn on all electronic equipment. Apply a triangular voltage waveform of 1000 Vp-p at 10 Hz to the beam steerer transducer from the transducer drive source, 4.5. Apply 2.000 ± 0.001V to the beam steerer bridge from the bridge power supply, 4.6. Wait 15 minutes after equipment turn-on before making measurements.

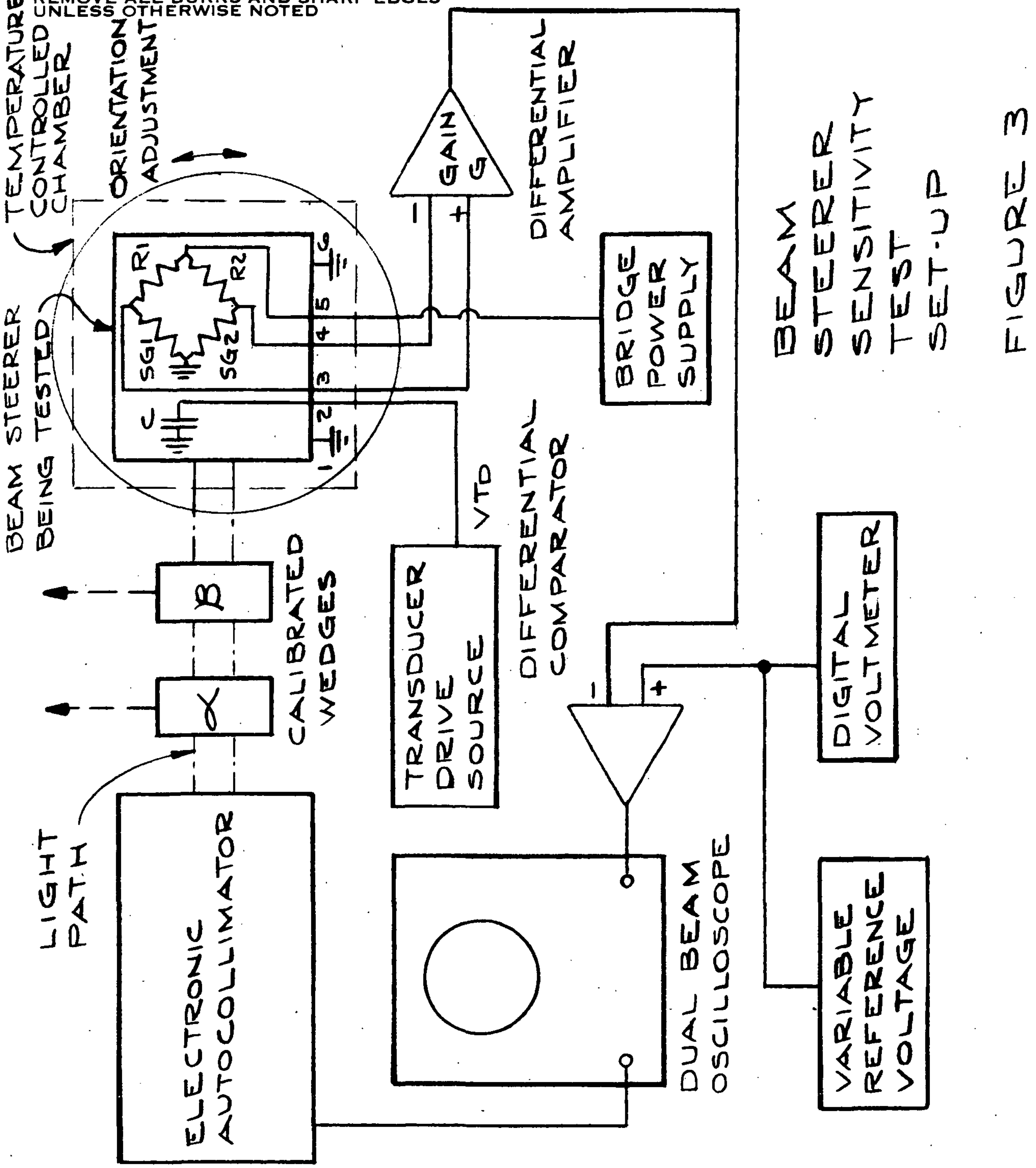
6.2.1.3 Trigger the dual beam oscilloscope 4.10, from the autocollimator step signal generated when the mirror passed through perpendicularity to the autocollimator axis. With the variable reference voltage, 4.7, set at zero, adjust the beam steerer angular orientation about an axis parallel to the deflection axis so that the step signal from the differential comparator, 4.9, is coincident with the autocollimator signal on the oscilloscope.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-103
A

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



ALL SURFACES MARKED "✗" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME FUNCTIONAL TEST PROCEDURE BEAM STEERER	MATERIAL	PROJECT NO.

DRAWN BY Boudrot

DATE 27 FEB 73

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842-500-103 A
PAGE 10 OF 15

6.2.1.4 Insert the calibrated wedge γ, 4.2, into the optical path between the autocollimator and beam steerer such that its plane of deviation is parallel to the beam steerer deflection plane. Adjust the oscilloscope sweep speed such that wedge γ shifts the comparator step signal 7 to 10 major divisions on the screen. This sweep speed is to be used on all subsequent measurements.

6.2.1.5 Record the values of the calibrated wedges α and β, 4.2, on the Linearity Test Data Schedule, Figure 4. Complete the Arc Sec column of the schedule. Insert wedges α and β into the optical path, as in 6.2.1.4, in the sequence given in the Wedges column of the Schedule. Adjust the reference voltage to bring the comparator step into coincidence with the autocollimator signal for each wedge setting, and record the value as read on the digital voltmeter, 4.8, in mV in the V_{SG} (Ø) column on the Linearity Test Data Schedule. At check points, where no wedges are inserted, the measurements shall be repeated if the reference voltage setting is greater than ± 0.3 mV with a differential amplifier, 4.4, nominal gain of 150, as determined in 5.

6.2.1.6 Record the following additional information on the Linearity Test Data Schedule:

Model
Serial #
G (amplifier gain) as per 5.2
B (differential amplifier bandwidth) in Hz.
f (transducer drive frequency) in Hz.
T (beam steerer ambient temperature) in °C.
T_A (differential amplifier temperature) in °C.
By (person performing test).
Date
Witness (quality assurance or government)

6.2.1.7 Calculate the slope, K (mV/arc sec) of the straight line passing through zero which forms the best least square fit to the data plotted as V_{SG} vs Ø. Record the value of K on the Linearity Test Data Schedule.

LINEARITY TEST DATA SCHEDULE, BEAM STEERER DEFLECTION

MODEL: ________ SERIAL NO. ________

α = ________ arc sec β = ________ arc sec

ϕ Wedges	ϕ Arc Sec	V_{SG} ($\emptyset$) mV	δV_{SG} ($\emptyset$) mV	ε ($\emptyset$) Percent
0	REF. 0	CHECK PT.*		
α				
$\beta - \alpha$				
β				
$\beta + \alpha$				
0	REF. 0	CHECK PT.*		
$-\alpha$				
$-(\beta-\alpha)$				
$-\beta$				
$-(\beta+\alpha)$				
0	REF. 0	CHECK PT.*		

K = ________ mV/arc sec ε max ________ percent

COMMENTS: ________

G = ________ (differential amplifier gain)

B = ________ Hz (differential amplifier bandwidth)

f = ________ Hz (transducer drive frequency)

T = ________ °C (beam steerer ambient)

T_A = ________ °C (differential amplifier temperature)

K = Strain Gage Ang. Sensitivity (Least square fit)

$\delta V_{SG}(\emptyset) = K\emptyset - V_{SG}(\emptyset)$ (Deviation from linear)

$\varepsilon(\emptyset) = \frac{\delta V_{SG}(\emptyset)}{2 V_{SG}(\alpha+\beta)} \times 100$ (Percent Relative Error)

*MAX ALLOWABLE V_{SG} (0) = 0.3 mV FOR G ~ 150

LARGER VALUE INDICATES NEED FOR IMPROVED MEASUREMENT STABILITY OR LONGER WARMUP.

BY: ________

DATE: ________

WITNESS: ________

FIGURE 4
FUNCTIONAL TEST PROCEDURE, BEAM STEERER

842-500-103 A
Page 12 of 15

6.2.2 Deflection Sensing Error

6.2.2.1 Using the data gathered in 6.2.1 for each angular value of the wedge settings, calculate the deviation of the amplified strain gage bridge output δV_{SG} (Ø) from a line of slope K using,

V_{SG} (Ø) = KØ - V_{SG} (Ø)

6.2.2.2 For each angular value calculate the percent relative error from linearity ε(Ø) of V_{SG}(Ø) from,

$$\epsilon(\phi) = \frac{\delta V_{SG}(\phi)}{2V_{SG}(\alpha + \beta)} \times 100$$

Enter the values for ε (Ø) on the Linearity Test Data Schedule opposite the appropriate angle.

6.2.2.3 Determine the largest ε(Ø) percent error from linearity and enter the value in the location labeled "ε max." on the Linearity Test Data Schedule.

6.3 Mirror Flatness Deviation

The peak-to-peak deviation of the mirror surface from a true plane is to be determined using non-contacting interferometric means.

6.3.1 Observe the mirror surface through a monochromatic parallel light interferometer (Twyman-Green or equivalent), 4.13. Adjust the instrument such that a set of fringes are observed which are nominally parallel to the long edge of the mirror. Calibrate the measurement apparatus utilizing the fact that the distance between two adjacent fringes is one half the wavelength of the interferometer source. Measure the peak-to-peak deviation of each fringe from a straight line passing through its end points and record the maximum value observed in microinches.

6.3.2 Orient the fringes to be nominally parallel to the short edge of the mirror and calibrate the measurement apparatus, as in 6.3.1. Measure the peak-to-peak deviation of each fringe from a straight line passing through its end points and record the maximum value observed in microinches.

6.4 Resonance Frequency

The first mechanical resonance frequency of the beam steerer transducer shall be measured according to the following procedure.

6.4.1 Connect the bridge differential amplifier, 4.4, and bridge power supply, 4.6, to the beam steerer and apply 2.0 volts to the bridge.

Monitor the output of the differential amplifier with an oscilloscope, 4.1.4, having a vertical sensitivity of at least 50 mV per division.

6.4.2 Connect the transducer to a signal source, 4.15, having the following characteristics:

Sine Wave Output	0 - 10 Vrms variable
Frequency Range	200 - 1500 Hz continuously variable
Input Impedance	600Ω or less.

With the frequency set at 200 Hz increase the drive voltage from zero until the output bridge differential amplifier is 300 mV peak-to-peak, as monitored on the oscilloscope. Slowly increase the drive frequency and reduce the drive voltage, as required, to maintain the differential amplifier output at 300 mVp-p. Hold that frequency setting at which the differential amplifier output peaks and begins to decrease with increasing frequency. Measure and record this frequency with a frequency counter, 4.20, to an accuracy of ± 1%.

6.5 Mirror Deflection

The peak mirror deflection is to be measured using an a.c. drive signal.

6.5.1 Connect the beam steerer transducer to a drive source, 4.5, capable of supplying a sinewave signal from 0 to 360 Vrms at 100 Hz. Monitor the drive voltage with an a.c. digital voltmeter to an accuracy of ± 0.5%.

6.5.2 Observe the mirror deflection with an autocollimator, 4.21, having a calibrated range of at least 60 arc minutes. The light source for the autocollimator shall be a stroboscope, 4.18, capable of operating at 100 flashes per second.

6.5.3 Set the drive source at 100 Hz and bring the voltage up from zero to 353 Vrms. Adjust the stroboscope flash rate to be slightly asynchronous with the drive signal such that the return image in the autocollimator can be observed swinging slowly across the reticle. Determine the peak-to-peak deflection of the mirror and record this numerically as ± (1/2 peak-to-peak deflection) arc minutes.

6.6 Mirror Reflectivity

The absolute mirror reflectivity shall be determined at 45° angle of incidence over the wave length band specified using an optical spectrometer or equivalent method.

6.6.1 Clean the beam steerer mirror with fresh lens tissue and alcohol to remove any surface contamination.

6.6.2 Calibrate the spectrometer over the specified wavelength band with the mirror removed such that 100% transmission is recorded.

6.6.3 Insert the mirror to be measured at 45° ± 5° angle of incidence and scan the specified wavelength band. Note the minimum single reflection reflectivity in this band and record this value in percent.

7. QUALITY ASSURANCE PROVISIONS

7.1 The equipment used shall be under calibration control in accordance with MIL-C-45662.

7.2 All tests shall be witnessed by the Quality Assurance Section.

5.2 Summary of Test Results

A summary of the tests performed and characteristic values measured are listed in Test Report Summary, S1. For some of the environments it was not considered necessary to repeat certain of the functional tests as their performance did not relate directly to the environment. These functional tests were waived by Quality Control and are so indicated on the Test Reports Q1 through Q6.

5.2.1 Altitude

A beam steerer unit which was assembled as an experimental unit using the same construction materials used in the qualification models was used in the Altitude Qualification Test. Evolution of volatiles from these materials was very low after the initial evaporation of entrapped air and absorbed cleaning solvents, with major constituents being CO, CH_4 and CO_2.

5.2.2 Acoustic Noise

These measurements were made on PBM-8G Beam Steerer S/N 002. This unit was constructed on the Engineering Test Model production run (see the Final Report, Section 2.3.2) and conformed to drawing 842-100-604. It differed in construction from the Engineering Qualification Models in that the mirror design and assembly procedure for the qualification models has been revised to strengthen the mirror bond to the transducer. Since the Acoustic Noise tests were performed on the weaker design and showed no sign of failure, these tests were taken as valid for the improved Engineering Test Model Design.

5.2.3 Vibration, Shock, and Acceleration

The low mirror deflection observed on these and subsequent tests existed directly after manufacture and was not a result of, nor altered by, these environments. An explanation of the probable cause of the low deflection is given in the Final Report, Section 3.2.2.1.

5.2.4 Humidity

Exposure to the humidity environment did not affect the beam steerer functional characteristics.

TEST REPORT SUMMARY

REPORT NO. S1

GTE LABORATORIES, WALTHAM, MASS.

TEST TITLE: QUALIFICATION TEST	CONTRACT NO.: NAS8-26846	TEST ITEM: PBM-8G BEAM STEERER
DRAWING NO.: 842-500-101 B	DATE TEST BEGUN: 1/24/72	DRAWING NO.: 842-100-604A
	DATE TEST COMPLETED: 3/27/73	SERIAL NO.: 006 *

Line	Data Ref. Page	Par. No.	TEST ENVIRONMENT	TEST CONDITIONS	PARAMETER TESTED	SPEC. LIMITS	MEAS. VALUE	REMARKS
1	Q1	6.3	ALTITUDE	10^{-6} TORR	EVOLVED GAS		AIR, H_2	TEST ON EXP. UNIT *
2				$4(10)^{-9}$ TORR	" "		CO, CH_4, CO_2	" " " "
3	Q2	6.5.4	ACOUSTIC NOISE	PER SPEC.	S.G. BRIDGE UNBAL.	≤ 550 μV	110 μV	TEST ON S/N 002 *
4				" "	S.G. SENSITIVITY	.765-.935	.888 mV/ARC SEC	
5				" "	DEFL. SENSE ERROR	≤ 0.1 %	0.109 %	WITHIN MEAS. ERROR LIMITS
6	Q3	6.1	TEMPERATURE (OPERATING)	- 5°C	S.G. BRIDGE UNBAL.	≤ 550 μV	10 μV	
7				-5°C	MIRROR FLAT DEV.	≤ 4.3 μ IN	4.8 μ IN	OUT OF SPEC.
8				+45°C	S.G. BRIDGE UNBAL.	≤ 550 μV	90 μV	
9				+45°C	MIRROR FLAT. DEV.	≤ 4.3 μ IN	3.0 μ IN	
10	Q4	6.4	SINUSOIDAL VIBRATION	PER SPEC.				
11		6.6.2	HALF SINE SHOCK	PER SPEC. ±20%				
12		6.52	RANDOM BROAD BAND VIB.	PER SPEC.				
13		6.5.3	RANDOM NARROW BAND VIB.	PER SPEC.				
14		6.6.1	LINEAR ACCELERATION	PER SPEC.	S.G. BRIDGE UNBAL.	≤ 550 μV	40 μV	
15					S.G. SENSITIVITY	.765-.935	.9106 mV/ARC SEC	
16					MIRROR FLAT. DEV.	4.3 μ IN	3.8 μ IN	
17					RESONANCE FREQ.	1120-1270 Hz	1230 Hz	
18					MIRROR DEFLECTION	17-23 ARC MIN	+15.0 -15.5 ARC MIN	LOW DEFLECTION
19					MIRROR REFLECT.	≥ 97 %	97.5 %	
20	Q5	6.4	HUMIDITY	92% AT 30°C	S.G. BRIDGE UNBAL.	≤ 550 μV	70 μV	
21					MIRROR FLAT. DEV.	≤ 4.3 μ IN	3.8 μ IN	
22					RESONANCE FREQ.	1120-1270 Hz	1250 Hz	

PAGE 1 OF 2

TEST REPORT SUMMARY

REPORT NO. 51

GTE LABORATORIES, WALTHAM, MASS.

TEST TITLE: QUALIFICATION TEST	CONTRACT NO.: NAS8-26846	TEST ITEM: PBM-8G BEAM STEERER
DRAWING NO.: 842-500-101 B	DATE TEST BEGUN: 1/24/72	DRAWING NO.: 842-100-604A
	DATE TEST COMPLETED: 3/27/73	SERIAL NO.: 006

Line	Data Ref. Page	Par. No. TEST ENVIRONMENT	TEST CONDITIONS	PARAMETER TESTED	SPEC. LIMITS	MEAS. VALUE	REMARKS
23				Mirror Deflection	17-23 MIN.	±15.5 ARC MIN	Low Deflection
24				Mirror Reflectivity	≥ 97%	98%	
25	Q6	6.2 Temperature (Non-Oper)	-170°C Overtest	S.G. Bridge Unbal	≤ 550 μV	60 μV	No Low Temp. Damage
26				Mirror Deflection	17-23 MIN.	+15.0 -15.5 ARC MIN.	Low Deflection
27				Mirror Flat. Dev.	≤4.3 μIN	3.8 μIN	
28				S.G. Sensitivity	.765-.935	.9105 MV/ARC SEC	
29				Defl. Sense Error	≤ 0.1%	0.0558%	

5.2.5 Temperature, Nonoperating

A low temperature overtest of -170°C occurred as a result of a deflective liquid nitrogen valve on the environmental chamber which allowed the chamber to reach -200°C for two hours. The beam steerer was removed at -200°C, placed in a room temperature environment, and allowed to return to room temperature in about four hours. During the first 2.5 hours of this period, a layer of condensed moisture was frozen on the beam steerer surfaces. These conditions did not significantly affect the measured functional characteristics of the units.

5.2.6 Temperature, Operating

Measurements at -5°C showed the mirror distortion to be greater than the maximum specified value. An explanation of the probable cause of this and recommendation for remedial action are given in the Final Report, Section 3.2.2.2.

5.3 Test Data

The following test data in the form of Test Reports covers testing performed by GTE Laboratories and by vendors, Ogden Technology Laboratories and Acton Environmental Testing Corporation.

All functional testing and some environmental testing were performed by GTE Laboratories and are documented in Test Reports Q1 through Q6. A letter of 24 January 1972 from D. Oblas details vacuum outgassing characteristics.

The Ogden Technology Laboratories report of 13 July 1972 (OTL Job No. 8963) covers humidity, acoustic noise, and vibration testing on Engineering Test Models. The results of the acoustic noise environment are being used as applicable to qualification testing.

Random vibration and linear acceleration environments were performed by Acton Environmental Testing Corporation and covered in their report of 5 April 1973, No. 10025.

NOTE

Test Reports, pages C-37 through C-69, follow.

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit: Beam Steerer
Type of Test: Qualification
Serial Number: Exp. Model

Drawing Number: 842-100-604A
Procedure Number: 842-500-101B
Report Number: Q1

Environmental Test Title: Altitude Paragraph: 6.3 Date: 1/24/72

Test Results and Comments:

MAJOR GAS EVOLVED AFTER 5 DA. AT 10^{-6} TORR AND 120°C BAKEOUT FOR 2 DA. WERE SMALL AMOUNTS OF ENTRAPPED AIR AND H_2.

AFTER 135°C BAKEOUT, EVOLVED GASES AT $4(10)^{-9}$ TORR WERE SMALL AMOUNTS OF CO, CH_4 AND CO_2 WITH RATE OF PRESSURE RISE OF $.6(10)^{-11}$ TORR-LITER/SEC. AT LEAST HALF OF THIS WAS DUE TO THE VACUUM SYSTEM BACKGROUND.

Performed by: D. W. Dolas Quality Assurance: R. E. Lammi

Item	Functional Test Title	Paragraph of Procedure No.	Value	Units

Comments:

Performed by: ______ Quality Assurance: ______

Equipment Used

ITEM 11 ON EQUIPMENT LIST

ITEM 12 ON EQUIPMENT LIST

Last Calibration Date

Page 1 of 1

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit BEAM STEERER PBM-8G Drawing Number 842-100-604

Type of Test QUALIFICATION Procedure Number 842-500-101B

Serial Number 002 Report Number Q2

Environmental Test Title ACOUSTIC NOISE Paragraph 6.5.4 Date 6/27/72

Test Results and Comments: (IDENTICAL TO OBSOLETE GTE SPEC TEST PROC. 842-500-101, PARA. 3.6)

UNIT GIVEN FUNCTIONAL TESTS BELOW AFTER BEING EXPOSED TO ACOUSTIC NOISE ENVIRONMENT BY VENDOR (OGDEN) SEE ATTACHED REPORT OTL JOB NO. 8963.

Performed by OGDEN TECH. LABS Quality Assurance R E Lammi

Item	Functional Test Title	Paragraph of Procedure No. 842-500-103A	Value	Units
1	STRAIN GAGE BRIDGE UNBAL.	6.1	110	μV
2	STRAIN GAGE ANGULAR SENSITIVITY	6.2.1	.8883	mV/ARC SEC
3	DEFLECTION SENSING ERROR	6.2.2	0.109	%

Comments: FUNCTIONAL TESTS 842-500-103, PARA. 6.3, 6.4, 6.5 & 6.6 WAIVED.

Performed by J Schlofer Quality Assurance R E Lammi

Equipment Used | Last Calibration Date

ITEM 6 ON EQUIPMENT LIST FOR TEST ITEM 1, 2, & 3
" 10 " " " " " 2 & 3

LINEARITY TEST DATA SCHEDULE, BEAM STEERER DEFLECTION

MODEL: PBM-8G SERIAL NO. 002

REPORT No. Q2

α = 262.72 arc sec β = 773.63 arc sec

Ø Wedges	Ø Arc Sec	V_{SG} (Ø) mV	δV_{SG} (Ø) mV	ε (Ø) Percent
0	REF. 0	✓ CHECK PT.*	—	—
α	262.72	232.7	0.6768	0.037
β − α	510.91	452.9	0.9465	0.051
β	773.63	686.4	0.8233	0.045
β + α	1036.35	920.1	0.5001	0.027
0	REF. 0	✓ CHECK PT.*	—	—
−α	−262.72	−232.8	0.5768	0.031
−(β−α)	−510.91	−453.3	0.5465	0.030
−β	−773.63	−687.5	−0.2767	0.015
−(β+α)	−1036.35	−922.6	−1.9999	0.109
0	REF. 0	✓ CHECK PT.*	—	—

K = 0.8883 mV/arc sec ε max 0.109 percent

COMMENTS: Test run after unit had been subject to acoustic noise environment.

G = 135 (differential amplifier gain)

B = 160k Hz (differential amplifier bandwidth)

f = 5 Hz (transducer drive frequency)

T = 27 °C (beam steerer ambient)

T_A = −53 °C (differential amplifier temperature)

K = Strain Gage Ang. Sensitivity (Least square fit)

$\delta V_{SG}(Ø) = KØ - V_{SG}(Ø)$ (Deviation from linear)

$\varepsilon(Ø) = \frac{\delta V_{SG}(Ø)}{2 V_{SG}(\alpha+\beta)} \times 100$ (Percent Relative deviation)

*MAX ALLOWABLE V_{SG} (0) = 0.3 mV FOR G~150

LARGER VALUE INDICATES NEED FOR IMPROVED MEASUREMENT STABILITY OR LONGER WARMUP.

BY: J Schlafer

DATE: 14 July 72

WITNESS:

PAGE 2 OF 2

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit BEAM STEERER, PBM-8G   Drawing Number 842-100-604 A
Type of Test QUALIFICATION   Procedure Number 842-500-101 B
Serial Number 006   Report Number Q3

Environmental Test Title OPERATING, TEMP. Paragraph 6.1 Date 3/18/73

Test Results and Comments:

ITEMS 1 AND 2 FUNCTIONAL TESTS PERFORMED AT $-5°C$.
ITEMS 3 AND 4 FUNCTIONAL TESTS PERFORMED AT $+45°C$

Performed by [signature]   Quality Assurance [signature]

Item	Functional Test Title	Paragraph of Procedure No. 842-500-103 A	Value	Units
1	STRAIN GAGE BRIDGE UNBALANCE	6.1	10	μV
2	MIRROR FLATNESS DEVIATION	6.3	4.8	μ in.
3	STRAIN GAGE BRIDGE UNBALANCE	6.1	90	μV
4	MIRROR FLATNESS DEVIATION	6.3	3.0	μ in.

Comments: ~~IES~~ FUNCTIONAL TEST 842-500-103, PARA. 6.2.1 WAIVED.

Performed by [signature]   Quality Assurance [signature]

Equipment Used   Last Calibration Date

ITEM 6 ON EQUIPMENT LIST FOR TEST ITEM 1 & 3   10/17/72
" 7 " " " " " " 2 & 4   3/28/72

Page 1 of 1

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit Beam Steerer

Type of Test Qualification

Serial Number 006

Drawing Number 842-100-604A

Procedure Number 842-500-101B

Report Number 94

Environmental Test Title Sinusoidal Vibration Paragraph 6.5.1 Date 3/19/73

Test Results and Comments:

Resonance occurred at approx. 1250 Hz
No visual damage

Performed by [signature]

Quality Assurance [signature]

Item	Functional Test Title	Paragraph of Procedure No.	Value	Units
1				

Comments:

Performed by ________

Quality Assurance ________

Equipment Used

Item 1 of Test Equipment List

Last Calibration Date

2/2/73

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit Beam Steerer

Type of Test Qualification

Serial Number 006

Drawing Number 842-100-604A

Procedure Number 842-500-101B

Report Number 04

Environmental Test Title Half Sine Shock Paragraph 6.6.2 Date 3/19/73

Test Results and Comments:

20 g's ± 20%

No visual damage

RANDOM BROAD BAND, PARAGRAPH 6.5.2 RANDOM NARROWBAND, PARAGRAPH 6.5.3 AND LINEAR ACCELERATION, PARAGRAPH 6.6.1 WERE ALSO PERFORMED BY A VENDOR (ACTON) BEFORE THE FOLLOWING FUNCTIONAL TEST DATA WAS TAKEN, SEE ATTACHED TEST REPORT NO. 10025. J Schlofer

Performed by R. E. Barth

Quality Assurance R E Lammi

Item	Functional Test Title	Paragraph of Procedure No. 842-500-103A	Value	Units
1	STRAIN GAGE BRIDGE UNBALANCE	6.1	40	μV
2	STRAIN GAGE ANGULAR SENSITIVITY	6.2.1	.91059	MV / ARC SEC
3	DEFLECTION SENSING ERROR	6.2.2	0.07	PCT. ~~0.07~~
4	MIRROR FLATNESS DEVIATION	6.3	3.8	μ in
5	RESONANCE FREQUENCY	6.4	1230	Hz
6	MIRROR DEFLECTION	6.5	+15.0-15.5	ARC MIN
7	MIRROR REFLECTIVITY	6.6	97.5	%

Comments: MIRROR DEFLECTION BELOW LOWER ACCEPTABLE LIMIT.

SEE ATTACHED TEST DATA SCHEDULE FOR ITEMS 2&3

Performed by J Schlofer

Quality Assurance R E Lammi

Equipment Used	Last Calibration Date
Item 4 of Test Equipment List	3/19/73
ITEM 7 ON EQUIPMENT LIST FOR TEST ITEM 4	3/28/72
" 8 " " " " " " 5	1/4/73
" 9 " " " " " " 6	3/26/73
" 10 " " " " " " 2,3	5/19/72
" 6 " " " " " " 1,2,3,6	10/17/72

BEAM STEERER DEFLECTION LINEARITY TEST DATA SCHEDULE

MODEL: PBM-8G SERIAL NO: 006

MFGR: GTE Laboratories, 40 Sylvan Road, Waltham, Mass. 02154

TEST REPORT NO. Q4

α = 262.72 arc/sec β = 773.63 arc/sec

Wedges	ø Arc/Sec	$V_{SG}(\emptyset)$ mV	$\delta V_{SG}(\emptyset)$ mV	$\epsilon(\emptyset)$ Percent
0	REF. 0	CHECK PT.* ☑	——	——
α	262.72	239.5	-0.2698	0.0143
$\beta - \alpha$	510.91	465.6	-0.3705	0.0196
β	773.63	704.9	-0.4403	0.0233
$\beta + \alpha$	1036.35	944.3	-0.6101	0.0323
0	REF. 0	CHECK PT* ☑	——	——
$-\alpha$	-262.72	-238.9	0.3302	0.0175
$-(\beta-\alpha)$	-510.91	-463.9	1.3295	0.0704
$-\beta$	-773.63	-703.2	1.2597	0.0667
$-(\beta+\alpha)$	-1036.35	-944.2	-0.5101	0.0270
0	REF. 0	CHECK PT* ☑	——	——

K = 0.91059 mV/arc sec ϵ_{max} 0.0704 Percent

G = 157 (amplifier gain)

B = 160k Hz (amplifier bandwidth)

f = 10 Hz (drive frequency)

T = 25 °C (ambient)

T_A = 25 °C (amplifier coolant)

K = Strain Gage Ang. Sensitivity (Least square fit)

$\delta V_{SG}(\emptyset) = K\emptyset - V_{SG}(\emptyset)$ (Deviation from linear)

$$\epsilon(\emptyset) = \frac{\delta V_{SG}(\emptyset)}{2 V_{SG}(\alpha+\beta)}$$ (Relative deviation)

*MAX ALLOWABLE $V_{SG}(0)$ = 0.3 mV FOR G ~ 150
LARGER VALUE INDICATES NEED FOR IMPROVED MEASUREMENT STABILITY OR LONGER WARMUP

COMMENTS: MEASUREMENTS TAKEN AFTER SHOCK AND VIBRATION.

By: John Schlafer

Date: 26 Mar 73

Witness:

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit Beam Steerer

Type of Test Qualification

Serial Number 006

Drawing Number 842-100-604A

Procedure Number 842-500-101 B

Report Number Q5

Environmental Test Title Humidity Paragraph 6.4 Date 3/26/73

Test Results and Comments:

R.H. obtained was 92% vs. 95% in spec.
No visual damage.

Performed by R.E. Barth Quality Assurance R Lammi

Item	Functional Test Title	Paragraph of Procedure No. 842-500-103A	Value	Units
1	STRAIN GAGE BRIDGE UNBALANCE	6.1	+ 70	μV
2	MIRROR FLATNESS DEVIATION	6.3	3.8	μin
3	RESONANCE FREQUENCY	6.4	1250	Hz
4	MIRROR DEFLECTION	6.5	± 15.5	ARC MIN
5	MIRROR REFLECTIVITY	6.6	98	%

Comments: MIRROR DEFLECTION BELOW LOWER ACCEPTABLE LIMIT.
FUNCTIONAL TEST 842-500-103, PARA. 6.2.1 & 6.2.2 WAIVED.

Performed by J Schlafer Quality Assurance R E Lammi

Equipment Used	Last Calibration Date
Item 2 of Test Equipment List	3/19/73
ITEM 6 ON EQUIPMENT LIST FOR TEST ITEM 1 & 4,5	10/17/72
ITEM 7 ON EQUIPMENT LIST FOR TEST ITEM 2	3/28/72
ITEM 8 ON EQUIPMENT LIST FOR TEST ITEM 3	1/4/73
ITEM 9 ON EQUIPMENT LIST FOR TEST ITEM 4	3/27/73

Page 1 of 1

TEST REPORT

GTE LABORATORIES, INC.
Waltham, Mass.

Name of Unit Beam Steerer
Type of Test Qualification
Serial Number 006

Drawing Number 842-100-604A
Procedure Number 842-500-101B
Report Number 06

Environmental Test Title Temperature Paragraph 6.2 Date 3/27/73

Test Results and Comments:
Over tested to −200°C for approx. 2 of 6 hours due to loss of control of chamber. No visual damage.

Low Temp. Test by R.E. Barth

High Temp. Performed by John Schlofer 3/28/73 Quality Assurance R.E. Hammi

Item	Functional Test Title	Paragraph of Procedure No. 842-500-103A	Value	Units
1	Strain Gage Bridge Unbalance	6.1	+60	μV
2	MIRROR DEFLECTION	6.5	+15.0-15.5	ARC MIN
3	MIRROR FLATNESS	6.3	3.8	μin
4	STRAINGAGE ANGULAR SENSITIVITY	6.2.1	0.91045	MV/ARC SEC
5	DEFLECTION SENSING ERROR	6.2.2	0.0558	%

Comments:

MIRROR DEFLECTION BELOW LOWER ACCEPTABLE LIMIT.

Performed by John Schlofer

Quality Assurance R.E. Hammi

Equipment Used / Last Calibration Date

Item 3 of Test Equipment List 3/26/73

ITEM 6 ON EQUIPMENT LIST FOR TEST ITEM 1,2,4,5 17OCT72

ITEM 9 ON EQUIPMENT LIST FOR TEST ITEM 2 3/29/73

ITEM 7 ON EQUIPMENT LIST FOR TEST ITEM 3 3/28/72

ITEM 10 " " " " " " 4,5 5/19/72

BEAM STEERER DEFLECTION LINEARITY TEST DATA SCHEDULE

MODEL: PBM-8G SERIAL NO: 006

MFGR: GTE Laboratories, 40 Sylvan Road, Waltham, Mass. 02154

TEST REPORT No. Q6

α = 262.72 arc/sec β = 773.63 arc/sec

G = 157 (amplifier gain)

B = 160k Hz (amplifier bandwidth)

f = 10 Hz (drive frequency)

T = 25°C (ambient)

T_A = 25°C (amplifier coolant)

ø Wedges	ø Arc/Sec	$V_{SG}(\phi)$ mV	$\delta V_{SG}(\phi)$ mV	$\varepsilon(\phi)$ Percent
0	REF. 0	CHECK PT.* ☑	—	—
α	262.72	238.5	0.6934	0.0367
$\beta - \alpha$	510.91	464.9	0.2580	0.0137
β	773.63	704.3	0.0514	0.0027
$\beta + \alpha$	1036.35	943.1	0.4449	0.0235
0	REF. 0	CHECK PT* ☑	—	—
$-\alpha$	-262.72	-239.2	-0.0066	0.0003
$-(\beta-\alpha)$	-510.91	-464.4	0.7580	0.0401
$-\beta$	-773.63	-704.5	-0.1486	0.0079
$-(\beta+\alpha)$	-1036.35	-944.6	-1.0551	0.0558
0	REF. 0	CHECK PT* ☑	—	—

K = 0.91045 mV/arc sec ε_{max} 0.0558 Percent

K = Strain Gage Ang. Sensitivity (Least square fit)

$\delta V_{SG}(\phi) = K\phi - V_{SG}(\phi)$ (Deviation from linear)

$$\varepsilon(\phi) = \frac{\delta V_{SG}(\phi)}{2 V_{SG}(\alpha+\beta)}$$ (Relative deviation)

*MAX ALLOWABLE $V_{SG}(0)$ = 0.3 mV FOR G ~ 150
LARGER VALUE INDICATES NEED FOR IMPROVED MEASUREMENT STABILITY OR LONGER WARMUP

COMMENTS: DATA TAKEN AFTER ALL ENVIRONMENTAL TESTS COMPLETE.

By: John Schlafer

Date: 3 apr. 73

Witness:

GTE CALIBRATED TEST EQUIPMENT LIST

1. Vari Freq. Vibrator:

   Mfr: MB Electronics
   Model: T151

   Use: Performing Vibration Noise, Vibration Variable Frequency, and High Frequency Vibration requirements as outlined in MIL STD 883 Methods 2006 and 2007, Mil Std 750 Methods 2051, 2056 and 2061.

   Limitations: Frequency Range: 5-5000 cps, 5000-10,000 cps.
   Max. unloaded acceleration: 68.5 G's
   Max. displacement (double amplitude): 1.0"
   Max. Transmitted force: 1200 lbs.
   Automatic scanning speed (logrithmic): 3.1°/min. to 350°/min in 44 steps.

2. Humidity Chamber:

   Mfr: Blue M
   Type: FR-251B
   SN: AA-829
   Limits: Steady state temp. and humidity - 18°C to +93°C, 20-98% RH.
   Use: Performance humidity test similar to Mil Std 202 Method 103

3. Automatic Temp Cycle Chamber:

   Mfr: Blue M
   Model: WSP-1098B-2
   SN: SP-1026
   Range: -73 to +204°C
   Use: Performing temp. cycle test according to Mil Std 883 Method 1010 Mil Std 202 Method 102-107

4. Shock Tester:

   Mfr: Avco
   Model: SM005

5. <u>Potentiometer with Chromel-Alumel Thermocouple</u>

Mfr:	Honeywell
Model:	2745
S/N:	P2691
Range:	0-80 mV

6. <u>Digital Voltmeter</u>

Mfr:	Data Technology
Model:	DV x 315
S/N:	
Range:	$10\mu V$ to 1000V dc

7. <u>Non-Contacting Interferometer</u>

Mfr:	Davidson Optronics, Inc.
Model:	D308
S/N:	239
Use:	Non-contacting measurement of Surface Flatness

8. <u>Digital Frequency Meter</u>

Mfr:	General Radio
Model:	1150-A
S/N:	128
Range:	0.1 - 100 kHz

9. <u>Autocollinator</u>

Mfr:	Hilger-Watts
Model:	TA60-1
S/N:	156008
Range:	± 30 arc min
Use:	Measurement of Mirror Deflection Angle

10. Optical Deviation Wedges

Mfr:	GTE Laboratories, Inc.
Part No.:	211-100-000-1, 2, 3
S/N:	102, 104, 106
Angles:	0'12.38", 4'22.72", 12'53.63"
Use:	Secondary Standards for Angle Calibrations

11. Vacuum Gage

Mfr:	Westinghouse
Type:	Bayard-Alpert Ionization Gage
S/N:	WL22619

12. Residual Gas Analyzer

Mfr:	Electronic Associates, Inc.
Model:	Series 200 Quadrupole Mass Spectrometer
S/N:	2047

INTER-OFFICE CORRESPONDENCE

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER
208-20 WILLETS POINT BOULEVARD
BAYSIDE, NEW YORK 11360
212—225-5000

TO: Mr. J. Schlafer

DATE: January 24, 1972

FROM: D. W. Oblas

SUBJECT: Vacuum Properties of the Laser Beam Steerer

This is to summarize our investigation into the vacuum properties of the Laser Beam Steerer (LBS).

The LBS was initially installed on the metal inlet system where the base pressure is approximately 10^{-6} Torr. Large amounts of gas were evolved from the LBS. Analysis of the gas on the Hitachi mass spectrometer determined that most of the gas was due to entrapped air and comparable quantities of H_2. The LBS was kept on the vacuum system for five days, where it was under bakeout at 120°C for almost half this time. The amount of gas evolved at the end of this period was quite small, however, it still showed a small air pattern.

The LBS was removed from the metal inlet system and installed in a side arm of the UHV station. It was outgassed at 100°C overnight prior to measurement with the Quadrupole mass spectrometer. Analyses showed no distinguishing or characteristic gases, over and above that of the background. However, rate of rise measurements showed that the outgassing rate from the combined system and LBS was less than 1.2×10^{-9} Torr-liter/sec. The LBS was then removed from the side arm and placed, directly, into the main vacuum chamber and baked overnight at 135°C.

The base pressure of the vacuum system settled to 4×10^{-9} Torr approximately five days after bakeout. The pumping speed of the vacuum system is estimated to be about 1 lit./sec. or less. The ion gauge filament emission was set at .84 ma. (Normal current for the Westinghouse WL 22619 ion gauge is 8.4 ma.) The rate of rise measurement, discounting the system blank, is less than $.6 \times 10^{-11}$ Torr-liter/sec. The pumping effect of the ion gauge filament is not accounted for and is probably less than .1 liter/sec. for most species, with the exception of H_2.

The rate of rise measurement was repeated with the mass spectrometer filament set at 1 ma. These results indicated that the mass spectrometer ion source was evolving gas over and above that which was evolved from the LBS and system. The residual gases, monitored during this last rate of rise measurement showed major amounts of CO and small amounts of CH_4 and CO_2.

Gas evolution from the circuit board was also measured on the metal inlet system, after an overnight bakeout at 100°C. Methyl alcohol and small quantities of water were the only species observed.

The above experiments suggest that, aside from careful procedures for assembling the LBS, a vacuum outgassing under light heat for several days should be done prior to testing.

D. W. Oblas

DWO:jr
cc: J. F. Cosgrove
D. J. Bracco
M. J. Ames
J. Adler

DEER PARK DIVISION
OGDEN TECHNOLOGY LABORATORIES, INC.
Subsidiary of OGDEN CORPORATION
COMAC ROAD, DEER PARK, LONG ISLAND, NEW YORK 11729 • TEL: 516-667-7200
TWX: 510-227-6072

13 July 1972

GTE Laboratories, Inc.
Bayside Research Center
208-20 Willets Point Boulevard
Bayside, New York 11360

Att: C.G. Guthy, Buyer cc: John Schlafer

Ref: GTE P.O. #3792; OTL Job No. 8963

Subject: Certification of work performed upon Optical Beam Steerer

Gentlemen:

This is to certify that Ogden Technology Laboratories,Inc. has performed the following tests upon two (2) Optical Beam Steerers in accordance with GTE Specification Test Procedure 842-500-101:

Humidity Test, Par. 3.4
Acoustic Noise, Para. 3.6
Vibration(partial), Para. 3.5

Unit S/N 001 was subjected to the humidity testing over the period of 6/27/72 through 7/7/72. At the conclusion of the Humidity testing an inspection revealed two (2) rusted mounting screws underneath the mirror; a loosened mirror and a loss in the reflective quality of the mirror surface as compared to the same quality at the start of the testing.

S/N 002 was subjected to the Acoustic Noise test and Vibration testing. No visual evidence of damage was observed at the completion of the Acoustic Noise testing.

Unit #002 was then subjected to the vibration testing. The Vertical Axis of vibration testing was performed in accordance with Para. 3.5.1, sinusoidal, for a period of 30 minutes. Two sweeps were conducted over the frequency range of 5-2000-5 Hz, in fifteen (15) minute cycles. No evidence of resonance was detected.

Broadband randon testing was then performed in the Vertical Axis per para. 3.5.2.1 for a period of fifteen (15) minutes. No visual evidence of damage was noted at the conclusion of the test.

Sinusoidal testing was then performed in the Major Horizontal Axis. (perpendicular to the mirror)

No evidence of resonance was detected. No visual evidence of damage was observed. After five (5) minutes of broadband random testing in this same axis, the mirror loosened; detached from the body of the unit and sustained notable scratches. The testing was stopped. GTE was notified.

If we can be of any further service, please do not hesitate to contact us.

Very truly yours,

OGDEN TECHNOLOGY LABORATORIES, INC.

A. Helfand,
General Manager

AH:ek
Enc.

TEST EQUIPMENT UTILIZED

1) Chamber
   Hotpack
   Model: 1246; S/N 32658
   Calibration: None required

2) Temp/Humidity Recorder/Controller
   Honeywell-Brown
   Model: Y602C44-WW-24-III-93; S/N L1173472001
   Calibration Interval: 3 months
   Last Calibration: 5/31/72

3) Acoustic Noise Chamber
   Ogden Technology Labs.Inc.
   Calibration: None required

4) Audio Frequency Spectrometer
   Bruel & Kjaer
   Model: 2112;S/N 95359
   Calibration Interval: Before each use
   Last Calibration: 7/10/72

5) Level Recorder
   Bruel & Kjaer
   Model: 2305
   Calibration Interval: Before each use
   Last Calibration: 7/10/72

6) Microphone
   Bruel & Kjaer
   Model: 4134; S/N 296418
   Calibration Interval: Annually
   Last Calibration: 11/22/71

7) Pistonphone
   Bruel & Kjaer
   Model: 4220; S/N 101068
   Calibration Interval: Annually
   Last Calibration: 11/22/71

8) Stop Watch
   Junghans
   Model: 18
   Calibration Interval:6 months
   Last Calibration: 2/12/72

9) Air Compressor
Foundation Equipment Co.
Calibration: None required

10) Vibration Exciter
MB Electronics
Model: C50
Calibration: None required

11) Power Amplifier
MB Electronics
Model: 4150
Calibration: None required

12) Signal Amplifier
Unholtz-Dickie Corp.
Model: 607-RMG-3A; S/N 117
Calibration Interval: 6 months
Last Calibration: 4/6/72

13) Spectral Density VTVM
MB Electronics
Model: N122; S/N 4915
Calibration Interval: 6 months
Last Calibration: 6/7/72

14) Oscilloscope
Hewlett-Packard Corp.
Model: 122AR; S/N 04998
Calibration Interval: 6 months
Last Calibration: 6/7/72

15) Automatic Equal.Console Analyzer
MB Electronics
Model: T33; 80/25
S/N: 438
Calibration: Before each use

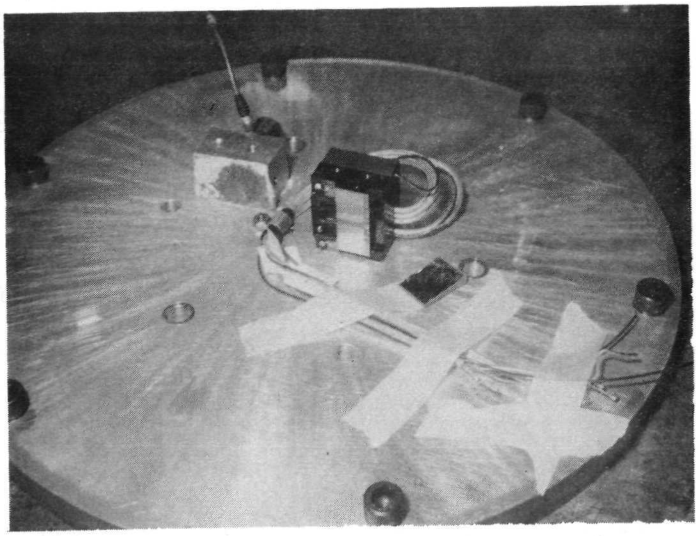
16) X-Y Plotter
Mosely
Model: 135; S/N 1877
Calibration Interval: 6 months
Last Calibration: 3/17/72

17) Log Converter
MB Electronics
Model: N165; S/N 853
Calibration Interval: 6 months
Last Calibration: 6/8/72

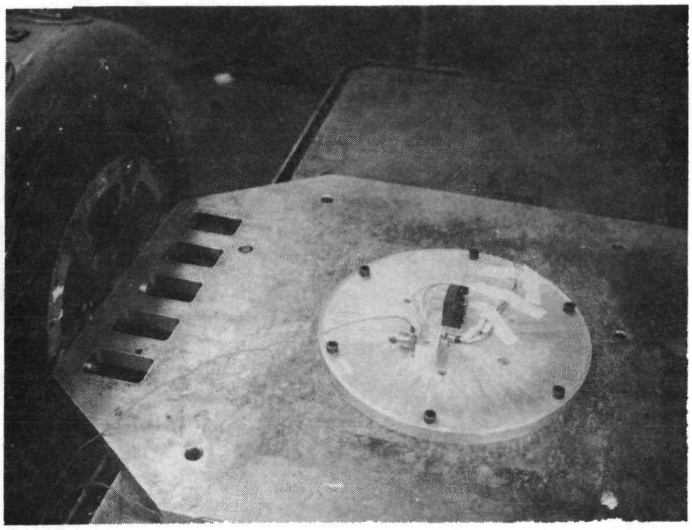
18) Accelerometer
Columbia Research Labs.
Model: 902; S/N 215
Calibration Interval: 6 months
Last Calibration: 6/6/72

All instrumentation and equipment calibration is conducted in accordance with Specification MIL-Q-9858A as further defined in MIL-C-45662A "Calibration System Requirements" and is traceable to the National Bureau of Standards.

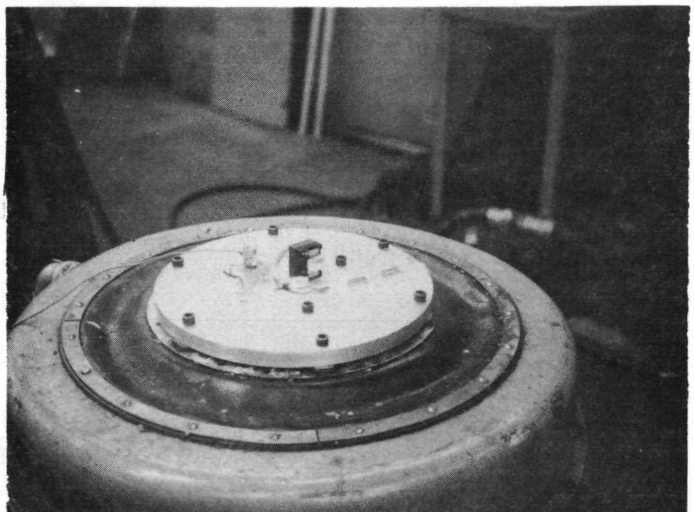
VIBRATION TEST



Major Horizontal Axis
(failure)

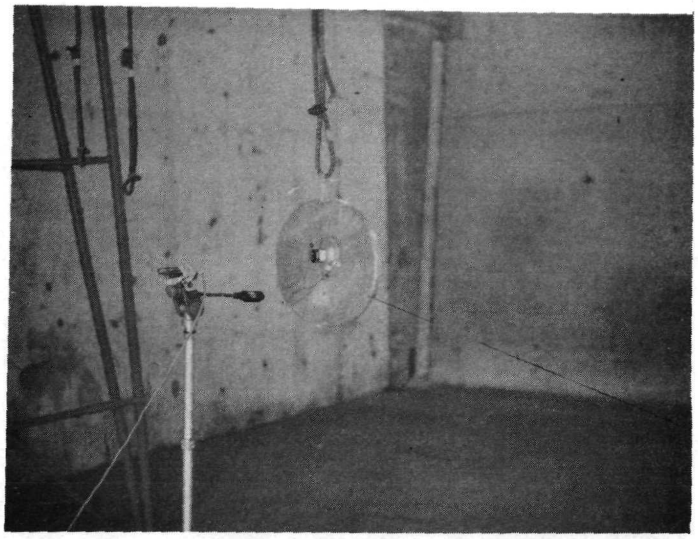


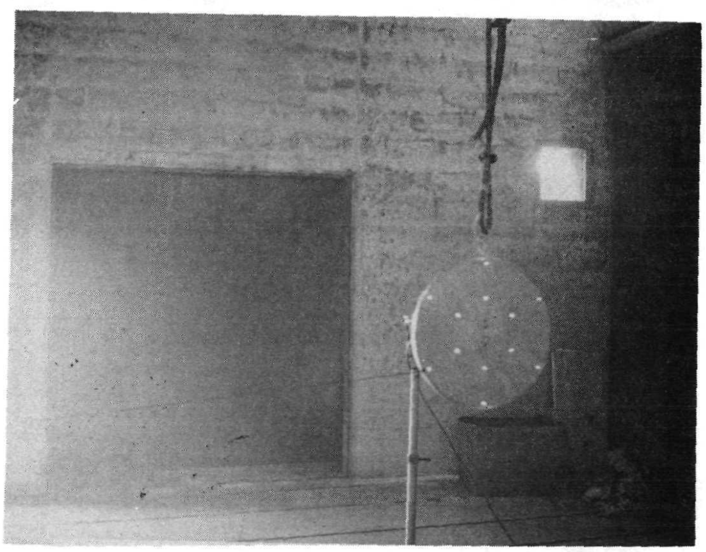
Major Horizontal Axis
(perpendicular to
mirrored surface)



Vertical Axis

ACOUSTIC NOISE TEST





Test Report No. 10025 | No. of Pages 8

Report of Test on

MIRROR BEAM STEERER, P/N 842-100-604A
for
GTE LABS
under
PURCHASE ORDER NO. WA16112J

ENVIRONMENTAL
ACTON TESTING
CORPORATION

Date April 5, 1973

	Prepared	Checked	Approved
By	A.LeBourdais	M.Casaubon	M.L.Tolf
Signed	A. LeBourdais	M Casaubon	ML Tolf
Date	4/5/73	4/5/73	4/5/73

MLT:AWL/hmf

Administrative Data

1.0 Purpose of Test: To subject test item to vibration and acceleration exposures.

2.0 Manufacturer: GTE Labs
40 Sylvan Road
Waltham, Mass.

3.0 Manufacturer's Type or Model No: Mirror Beam Steerer
P/N 842-100-604A

4.0 Drawing, Specification or Exhibit: Per GTE Labs supplied document. (See REQUIREMENTS herein).

5.0 Quantity of Items Tested: One (1), S/N 006

6.0 Security Classification of Items: UNCLASSIFIED

7.0 Date Test Completed: March 23, 1973

8.0 Test Conducted By: A.Giroux

9.0 Disposition of Specimens: Returned to GTE Labs by GTE Labs representative.

10.0 Abstract: Evaluation of the Mirror Beam Steerer during and after exposures was made by GTE Labs representative who witnessed testing.

1.0 VIBRATION

1.1 REQUIREMENTS

The test item shall be subjected to random vibration exposures as follows:

1.1.1 Broadband Random

Flat 20 - 80 Hz @ 0.05 g^2/Hz

Roll off below 125 Hz @ 5.5 db/octave

Flat 125 - 560 Hz @ 0.1 g^2/Hz

Roll off above 560 Hz @ 3.5 db/octave

Flat 1000 - 2000 Hz @ 0.05 g^2/Hz

Overall level shall be 12.7 g(rms). Vibration time shall be 1 - 4 minutes/axis.

1.1.2 Narrowband Sweep

.25 g^2/Hz narrow band sweep between 180 and 2000 Hz with overall value of 3.53 g(rms) and an equivalent bandwidth of 50 Hz.

1.2 PROCEDURES

The test item, mounted to a test fixture furnished by GTE Labs was secured to the exciter of the vibration system.

The test item was then subjected to 4 minutes of random vibration exposure per requirements.

The narrow band sweep requirements were performed simultaneously with the broad band requirements, except that the narrow band sweep was performed with an equivalent bandwidth of 20 Hz instead of 50 Hz.

The X-Y recordings of the control accelerometer which were generated during the vibration test are included with this certification.

1.3 RESULTS

There was no visible or apparent evidence of damage or deterioration to the test item as a result of random vibration testing.

Evaluation of the Beam Steerer following exposures was made by GTE Labs representative.

2.0 ACCELERATION

2.1 REQUIREMENTS

The Mirror Beam Steerer shall be subjected to acceleration testing in each of three (3) mutually perpendicular axes for a time period of one minute in each axis.

The acceleration level during the 1-minute exposure shall be 8g's.

2.2 PROCEDURES

The Mirror Beam Steerer secured by its normal means to a test fixture furnished by GTE Labs was secured to the platform of the centrifuge.

The Mirror Beam Steerer was then subjected to the required 8g acceleration test in each of three (3) mutually perpendicular axes.

2.3 RESULTS

There was no visible or apparent evidence of damage or deterioration to the Mirror Beam Steerer as a result of acceleration testing.

Further evaluation following acceleration test was made by GTE Labs representative who witnessed the test.

TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Accelerometer	B&K	4335	135298	2 Hz - 6 KHz	±2%	AC331	3 months
X-Y Recorder	Moseley	135CR	121	.5 Mv - 10V/Div.	±.1% FS	RE318	" "
Log Converter	"	60D	1328	60 DB	±.5 DB	PE322	" "
Dynamic Analyzer	Spec.Dynamics	SD101A	207	2 Hz - 25 KHz	±.25 DB	PE313	6 months
Sweep Oxc.	"	SD104-5	21	.005 Hz - 50 KHz	2%	SG315	" "
Amplifier Exciter	Ling "	CP10/16VC A300	41914 59	5 Hz - 5 KHz 6000# force	2% Freq. 5% Ampl.	PE314	1 month
Auto Random 46-channel	"	ASDE 40	35	10 Hz - 2 KHz	±1 DB	PE315	" "
Centrifuge	Amer.Mach.	LG34	20	10,000# force	±1 rpm	PE301	3 months

5

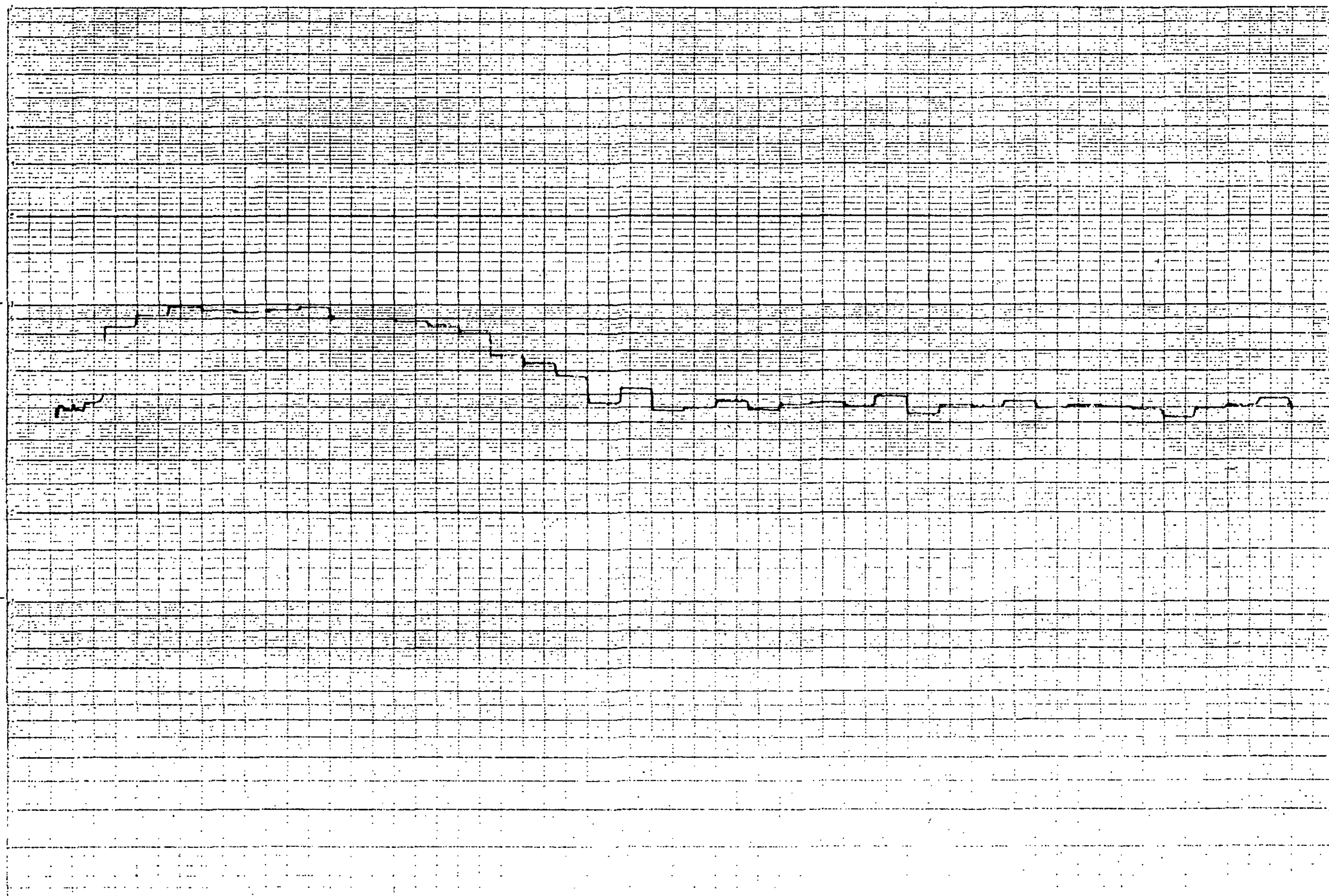
NC 31.175 POLY-PURPOSE 52 DIVISIONS BY THREE 3-INCH CYCLES RATIO RULING. CODEX GRAPH PAPER IN STOCK DIRECT FROM CODEX BOOK CO. INC. NORWOOD, MASS. 02062

DATE 3-23-73
CUSTOMER General-Tel-Labs
TEST ITEM P/N 842-100-604
SERIAL NO. 006
CONDITION N. Operating
TEMPERATURE Room PERIOD OF TEST 4.0 MIN.

OPERATOR A. Gilroy
TEST ENGINEER R. Gilroy
TYPE OF TEST
SPEC. NO. PARA.
G RMS OVERALL 12.7
TEST NO.

MACHINE NO. A 36? S/N 27
CONTR. ACCEL. NO. 4335 S/N 195247
CONTR. ACCEL. LOCATION Mounting
AXIS EXCITATION Major Vert. Long Axis
PICK UP SENSING AXIS
PICK UP SENSITIVITY MV RMS
PICK UP NO. G'S PK

TEST NO.
PHASE



CURVE NO.

TEST NO.
ITEM
DATE
CODE
S/N

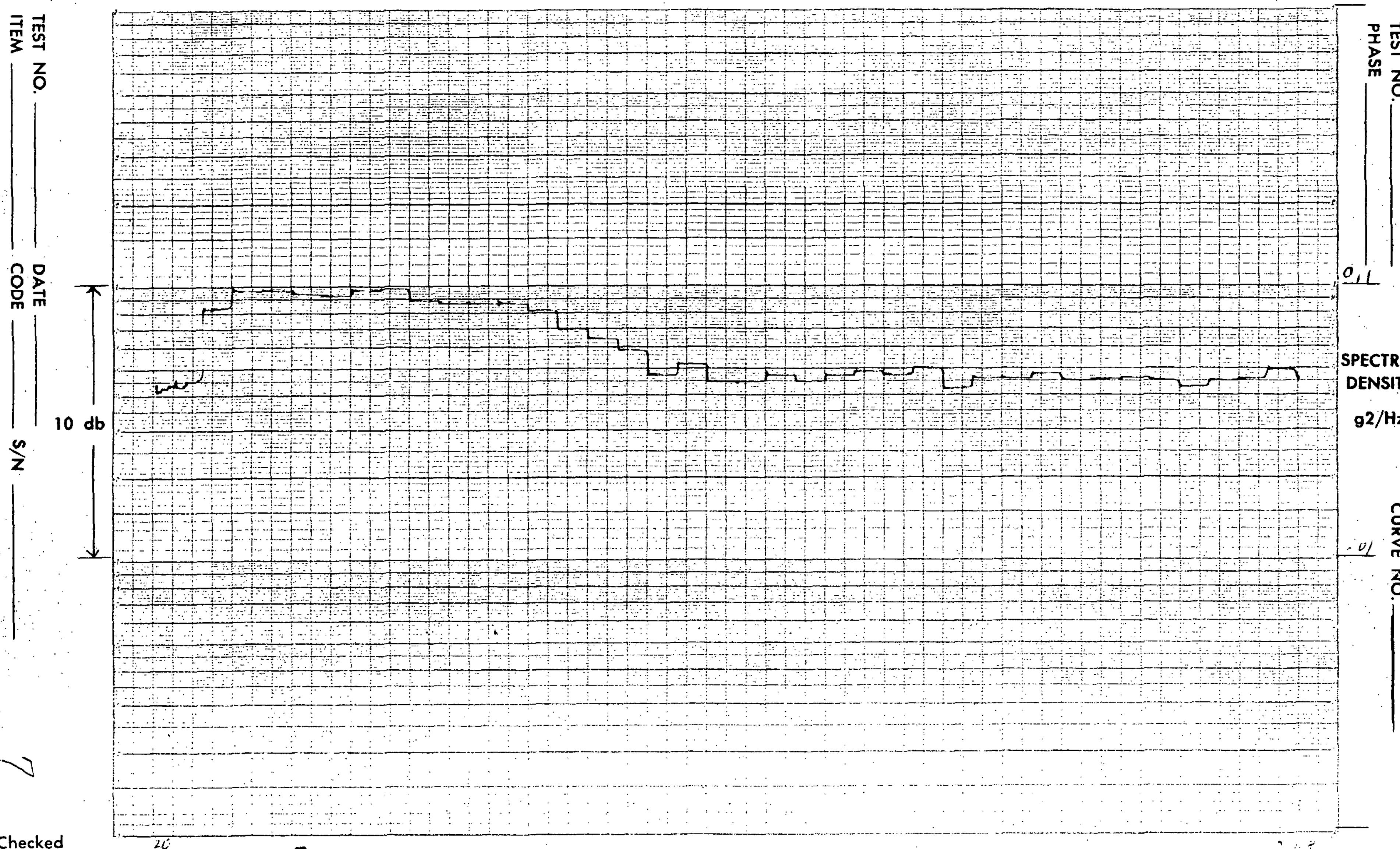
6

Checked By
Witness
Witness

HZ RANDOM VIBRATION

NO. 31 175 POLYPURPOSE 62 DIVISIONS BY THREE 3-INCH CYCLES RATIO RULING. GRAPH PAPER

DATE 3-23-73	OPERATOR A. Giroux		MACHINE NO. A30 S/N 57
CUSTOMER General Tel, Labs	TEST ENGINEER R. Gilroy		CONTR. ACCEL. NO. 4135 S/N 0135297
TEST ITEM P/N 842-100-604	TYPE OF TEST		CONTR. ACCEL. LOCATION Mounting
SERIAL NO. 006	SPEC. NO.	PARA.	AXIS EXCITATION Mirror Vert Shaft Axis
CONDITION N. Operating	G RMS OVERALL 12.1		PICK UP SENSING ______ AXIS
TEMPERATURE Room PERIOD OF TEST 4.0 MIN.		TEST NO.	PICK UP SENSITIVITY ______ MV RMS
			PICK UP NO. ______ G'S PK



7

Checked
By ______
Witness ______
Witness ______

HZ RANDOM VIBRATION

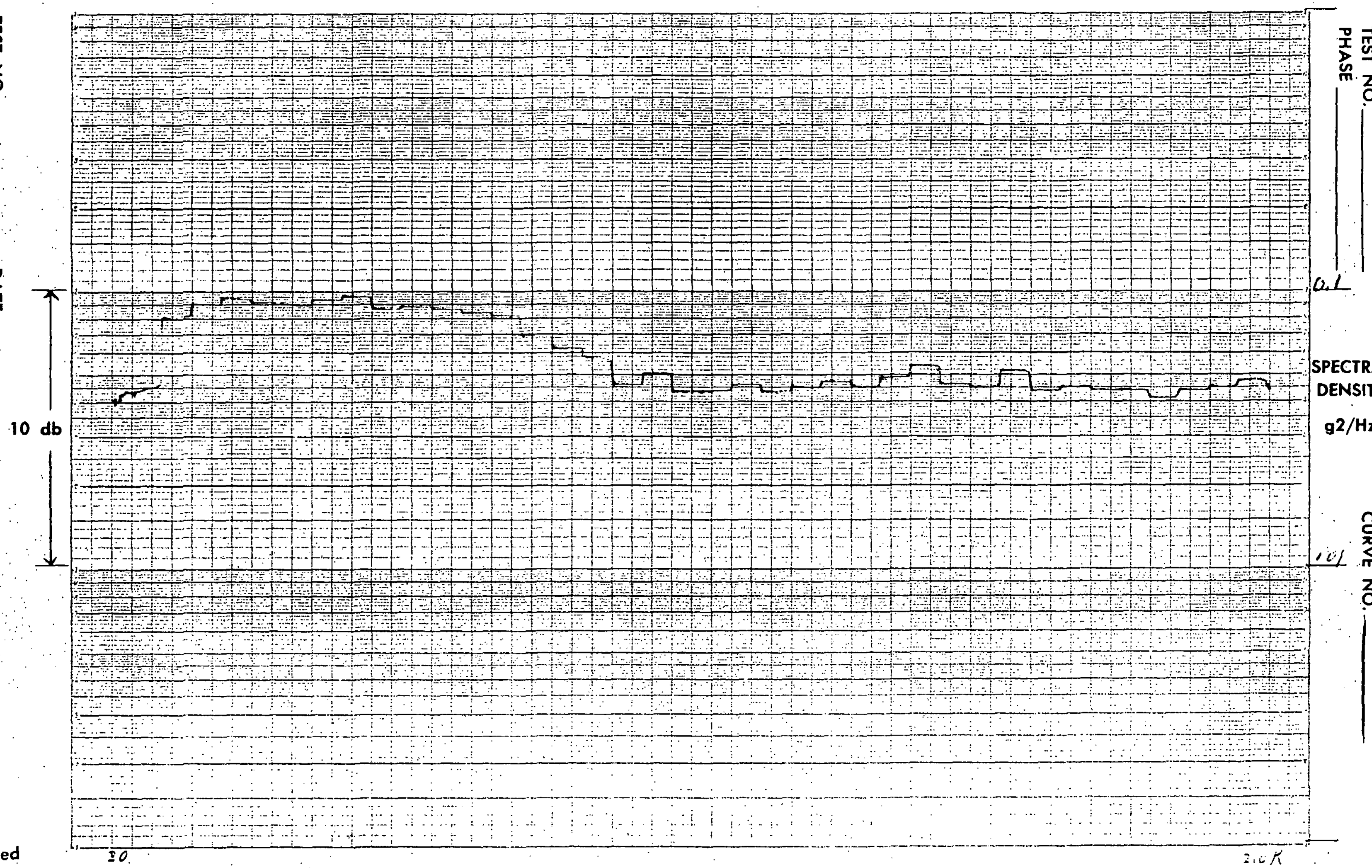
DATE 3-23-73
CUSTOMER General Tel Labs
TEST ITEM P/N 842-100-604
SERIAL NO. 006
CONDITION N. Operating
TEMPERATURE Room PERIOD OF TEST 4.0 MIN.

OPERATOR A. Giroux
TEST ENGINEER R. Gilzer
TYPE OF TEST
SPEC. NO.
G. RMS OVERALL 12.7

PARA.
TEST NO.

MACHINE NO. A-300 S/N 37
CONTR. ACCEL. NO. 4335 S/N P33287
CONTR. ACCEL. LOCATION Mounting
AXIS EXCITATION Mirror Hor.
PICK UP SENSING AXIS
PICK UP SENSITIVITY MV RMS
PICK UP NO. G'S PK

TEST NO.
PHASE
CURVE NO.



HZ RANDOM VIBRATION

TEST NO. DATE
ITEM CODE S/N

8

Checked
By
Witness
Witness

APPENDIX D

DATA PACKAGE
FOR
PBM-8G BEAM STEERERS

SERIAL NOS. 001 AND 002

DRAWING NO. 842-100-604A

DELIVERED ON CONTRACT NAS8-26846

April 1973

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Prepared by

GTE LABORATORIES INCORPORATED
Waltham, Massachusetts 02154

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CONTENTS

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1. SCOPE

This Data Package contains a summary of all of the information pertaining to the present status of the delivered hardware, and indicates the degree to which it may be considered fully qualified in accordance with contract requirements. Information contained herein is applicable to delivered hardware items PBM-8G Beam Steerer unit S/N 001 and unit S/N 003.

2. DATA ITEMS

The items listed here are those usually required to accompany the manufacture and delivery of flight hardware. Since the units delivered under this contract are Engineering and Qualification Models, certain of the data items will not be applicable and are so indicated.

2.1 Complete Set of Final Drawings (Reproducible)

A set of drawings which includes manufacturing and assembly, process control, parts and material specifications and source control, test procedures, and process flow and inspection drawings are supplied in sepia form. They are bound in a tube container accompanying this document.

2.2 List of Deviation Approvals

Only Engineering and Qualification Models are included in the delivered hardware. These have not been manufactured to NASA-approved drawings and have not required deviation approvals.

2.3 List of Missing Components or Parts

No components or parts are missing in the delivered equipment.

2.4 List of Outstanding Defects

1) The peak mirror deflection angle of unit S/N 003 was ± 16.75 arc minutes measured as per Functional Test Procedure, drawing 842-500-103A, Section 6.5. This is below the specified ± 17.0 arc minutes. The probable cause is inadequate inspection of incoming material and is discussed in Section 3.2.2.1 of the Final Report.

2) The drawing number on the metal base is incorrectly engraved as 842-100-603 on both units S/N 001 and S/N 003. This should correctly read 842-100-604A on both units.

3) Nonlocking brass screws were used in place of the self-locking steel screws (items 6 on drawing 842-100-604A) called for in assembly of the cable clamp on both units S/N 001 and S/N 003. This will not affect operation or reliability.

4) Heat-shrink PVC tubing was used instead of teflon FEP tubing (item 18 on drawing 842-100-403A) to insulate the shield termination ferrules on both units S/N 001 and S/N 003.

2.5 List of Serialized Parts

1) PBM-8G Beam Steerer: S/N 001
   - Transducer-Rib Assembly: S/N 15

2) PBM-8G Beam Steerer: S/N 003
   - Transducer-Rib Assembly: S/N 17

2.6 In-Process Inspection Report

An In-Process Inspection Summary has been compiled for each unit S/N 001 and S/N 003. This lists characteristics inspected for, deviations where found, and final disposition for all in-process inspection points. This is attached as Appendix D-1.

2.7 Dimensional Inspection Report

Dimensional inspections have been made on individual parts at incoming inspection, after manufacture and on subassemblies, and are reported in the In-Process Inspection Summary, Appendix D-1. No other inspections have been specified or made on the final hardware prior to delivery.

2.8 Nondestructuve Testing Report

Not applicable.

2.9 Acceptance Test Report

Not applicable.

2.10 Cleanliness Report

Not applicable.

2.11 Qualification Status Report

The results of qualification tests on unit S/N 006 as per the Qualification Test Procedure, drawing 842-500-101B, have been evaluated and discussed in the Qualification Test Report, Appendix C of the Final Report. Conclusions drawn from this, manufacturing experience, and contract requirements indicate that before the design can be considered fully qualified, action must be taken on the following items, discussed more fully in Section 3.2.2 of the Final Report.

2.11.1 Transducer Material Testing

Low deflection values measured on unit S/N 006 can most likely be attributed to the use of transducer raw material which had been inadequately tested for piezoelectric coefficient. An accurate test method for this coefficient should be developed and the value specified on the material source control drawing to be measured by the vendor or on incoming inspection. An early check on transducer deflection should also be incorporated in the in-process inspection requirements.

2.11.2 Matching of Thermal Expansion Coefficients

A new mirror substrate material should be specified which more closely matches a revised determination of the thermal expansion coefficient of the transducer. This will greatly reduce the changes in mirror surface distortion over the operating temperature range.

2.11.3 Operational Temperature Testing

Means should be devised for making accurate measurements of the strain gage angular sensitivity for at least four temperatures other than room ambient, to obtain a calibration of the sensitivity temperature coefficient. Supplementary to this, a determination should be made of the contribution of errors which may be introduced as a result of thermally induced mirror deflection which is not measured by the strain gage bridge.

2.11.4 Mirror Coating

To obtain the best protection against gradual deterioration of mirror reflectivity with long-term exposure to airborne reactive agents, a multilayer hard dielectric mirror should be specified in place of the present over-coated silver.

2.11.5 Life Testing

For a more accurate determination of MTBF additional life test data should be generated by actual operation of beam steerers for extended periods while monitoring the critical parameters.

2.11.6 Parts and Materials Approval

Those parts and materials not yet approved (see Section 2.13) must be submitted to NASA for review.

2.11.7 Design Review

A formal critical design review must be held at which time all aspects of the design, interfaces, quality program, reliability data, and qualification testing are examined prior to approval for fabrication of flight hardware.

2.12 Configuration Status Report

The only configuration control imposed by the contract, that the mirror size be 1.78 x 2.54 cm, has been met.

2.13 List of Unapproved Parts and Materials

Items which have been incorporated in the delivered hardware units S/N 001 and 002 but have not yet been submitted for review and approval are listed below:

Item Name	Drawing No.
Strain Gage, Matched Pair	842-400-003
Ferrule, Insulated	842-400-008
Cable Harness, Spiral Wrap	842-400-010
Aluminum Alloy	842-400-011
Feedthrough Terminal	842-400-015
Flux, Liquid Rosin	842-400-021
Connector, Straight Plug, Pin Contact	842-400-024
Plug, Sealing	842-400-025
Machine Screws, Self-locking	842-400-026
Surface Finish	842-400-027
Machine Screw, Brass	842-400-029
Mirror Coating Specifications	842-400-030
Sapphire (Aluminum Oxide)	842-400-031

2.14 Copy of Shipping Document

A copy of the shipping document, DD Form 250, is included as Appendix D-2.

2.15 Summary of Functional Characteristics

Characteristic	S/N 001	S/N 003	Unit
Mirror Deflection at ±500 V peak	± 18.0	± 16.75	arc minute
Maximum Peak Drive Voltage	± 500	± 500	V peak
Mechanical Resonance Frequency	1229	1259	Hz
Capacitance at 500 Hz	18.4	17.8	μF
Loss Factor	0.005	0.005	----
Mirror Surface Deformation	90	79	nm
Mirror Reflectivity	97	97	%
Strain Gage Bridge Parameters with Recommended dc Supply of 2.000 V			
Angular Sensitivity	6.4	6.4	μV/arc second
Maximum readout error	0.044	0.073	%
Offset voltage	210	410	μV

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DATA PACKAGE

APPENDIX D-1

IN-PROCESS INSPECTION SUMMARY

PBM-8G BEAM STEERER

SERIAL NO. 001

SERIAL NO. 003

IN PROCESS INSPECTION SUMMARY

Contract No.	Supplier	Item Description	Assembly/Dwg. No.	Rev.	Serial No.
NAS8 26846	GTE Labs.	PBM-8G Beam Steerer	842-100-604	A	001

Part/Dwg. No.	Rev.	MCR No.	Item Description	Characteristic	Deviations	Disposition Rewk/Acc,UAI	Date
842-100-604	A	2126	PBM-8G Beam Steerer		None		3/26/73
842-100-503	A	2125	Term. Bd. Assy, Wired		None		3/22/73
842-100-502	—	2118	Term. Bd. Term. Ass'd		None		2/28/73
842-100-501	C	2110	Terminal Board	.995 +.000 -.010	.002 OHL	UAI	2/20/73
842-100-307	A	1115	Bottom Cover, Surf. Fin.	Finish	Unfinished area	UAI	3/12/73
842-100-306	C	2114	Bottom Cover	1.610 ±.005	.005 OHL	UAI	2/27/73
842-100-316	—	1114	Cable Clamp, Surf. Fin.		None		3/12/73
842-100-305	—	2025	Cable Clamp Fin. Mach.		None		4/13/72
842-100-603	B	2124	Base-Mirror Assy.		None		3/15/73
842-100-405	B	2132	Mirror		None		3/9/73
842-100-404	B	2131	Mirror Blank, Pol.		None		3/8/73
842-100-403	B	2130	Mirror Blank, Ann.		None		3/8/73
842-100-402	B	2129	Mirror Blank		None		3/7/73
842-100-315	A	2033	Top Cover		None		5/9/72
842-100-602	D	2123	Base-Transducer Assy		None		3/14/73

IN PROCESS INSPECTION SUMMARY

Contract No.	Supplier	Item Description	Assembly/Dwg. No.	Rev.	Serial No.
NAS8 26846	GTE Labs	PBM-8G Beam Steerer	842-100-604	A	001

Part/Dwg. No.	Rev.	MCR No.	Item Description	Characteristic	Deviations	Disposition Rewk/Acc,UAI	Date
842-100-312	—	2122	Base Assembly		None		3/13/73
842-100-311	B	2108	Ground Term. Mod		None		2/20/73
842-100-310	B	2109	Trans. Lead Fee. Thru		None		2/20/73
842-100-308	—	2018	Insulator, S.G. Leads		None		4/11/72
842-100-309	—	2019	Insulator, Trans. Lead		None		4/11/72
842-100-303	A	1112	Base, Surf. Fin	Masking	Not masked	Rewk/Acc.	3/12/72
842-100-302	B	2024	Base, Engraved	Dwg No. 842-100-604	842-100-603	UAI	4/13/72
842-100-301	A	2015	Base		None		4/5/72
842-100-314	A	1113	Clamp Plate, Surf. Fin		None		3/12/73
842-100-313	B	2112	Clamp Plate		None		2/20/73
842-100-601	A	2121	Trans. - Rib Assy.		None		3/12/73
842-100-406-1	A	2107	Rib, Annealed		None		2/6/73
842-100-406-2	A	2128	Rib, Annealed		None		3/9/73
842-100-401	B	2106	Bottom Rib	.063 ± .005	.004 OHL	UAI	2/6/73
842-100-407	—	2127	Top Rib		None		3/8/73
842-100-204	A	2120	Trans.-Base Assy. L. Ext.	1/16 cond adhesive	OHL 4 places	UAI	3/9/73
842-100-203	C	2119	Trans. S.G. Assy.	1/32 adhesive dot	OHL 4 places	UAI	3/8/73
842-100-202	C	2116	Trans. Sapphire Ct.		None		2/28/73
842-100-106	C	2115	Trans. Assembled		None		2/23/73
842-100-104-1/2	B	2104	Wafer Ni Coated		None		2/15/73

IN PROCESS INSPECTION SUMMARY

Contract No.	Supplier	Item Description	Assembly/Dwg. No.	Rev.	Serial No.
NAS8 26846	GTE Labs	PBM-8G Beam Steerer	842-100-604	A	001

Part/Dwg. No.	Rev.	MCR No.	Item Description	Characteristic	Deviations	Disposition Rewk/Acc,UAI	Date
842-100-103-1-2	B	2103	Wafer, Lapped		None		1/25/73
842-100-102-1-2	B	2102	Wafers		None		1/25/73
842-100-101-1-2	B	2101	Blank, Piezzo		None		1/25/73

DATA PACKAGE

APPENDIX D-2

SHIPPING DOCUMENT (COPY)

FORM DD 250

PBM-8G BEAM STEERER

SERIAL NO. 001

SERIAL NO. 003

MATERIAL INSPECTION AND RECEIVING REPORT	1. PROC. INSTRUMENT IDEN (CONTRACT) NAS8-26846 MDD S/A6	(ORDER) NO.	6. INVOICE NO. DATE	7. PAGE 1 OF 1 / 8. ACCEPTANCE POINT D
2. SHIPMENT NO. TW0001	3. DATE SHIPPED 73APR04	4. B/L TCN R	5. DISCOUNT TERMS	

9. PRIME CONTRACTOR CODE 03042

GTE Laboratories Incorporated
40 Sylvan Road
Waltham Ma 02154

10. ADMINISTERED BY CODE S2202A

DCASR - Boston
666 Summer Street
Boston, Ma 02210

11. SHIPPED FROM *(If other than 9)* CODE 03042 FOB: D

SEE BLOCK 9

12. PAYMENT WILL BE MADE BY CODE

Financial Management Office
National Aeronatics & Space Administration
George C. Marshall Space Flight Center
Attention: A&TS-FIN-AG
Marshall Space Flight Center, Alabama 35812

13. SHIPPED TO CODE

National Aeronatics & Space Administration
George C. Marshall Spcae Flight Center
Huntsville, Alabama 35812

14. MARKED FOR CODE

Accountable Property Officer
Bldg 4471
DCN: 1-1-40-11519

15. ITEM NO.	16. STOCK/PART NO. DESCRIPTION *(Indicate number of shipping containers - type of container - container number.)*	17. QUANTITY SHIP/REC'D *	18. UNIT	19. UNIT PRICE	20. AMOUNT
	Beam Steerer S/N001 Per GTE DWG. 842-100-604	1	EA.	NSP	NSP
	" " " S/N003 " "	1	EA.	NSP	NSP
	Connector Receptacle NB4E14-18SNS	1	EA.	NSP	NSP
	" " NB4E8-98SNS	1	EA.	NSP	NSP
	Drawing Package	1	EA.	NSP	NSP

21. PROCUREMENT QUALITY ASSURANCE

A. ORIGIN

☐ PQA ☐ ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

DATE SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE

B. DESTINATION

☐ PQA ☐ ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

DATE SIGNATURE OF AUTH GOVT REP

TYPED NAME AND TITLE

22. RECEIVER'S USE

Quantities shown in column 17 were received in apparent good condition except as noted.

DATE RECEIVED SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE

* If quantity received by the Government is the same as quantity shipped, indicate by (✔) mark, if different, enter actual quantity received below quantity shipped and encircle.

23. CONTRACTOR USE ONLY

APPENDIX E

MANUFACTURING DRAWINGS AND TEST PROCEDURES

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-000-000

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

MANUFACTURING DRAWINGS

AND

TEST PROCEDURES

PBM-8G BEAM STEERER

CONTRACT NAS8-26846

GTE LABORATORIES

MARCH 1973

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
MANUFACTURING DRAWINGS AND TEST PROCEDURES		

DRAWN BY R.L.

DATE 3/30/73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-000-000

Page 1 of 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-000-000

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

CONTENTS

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

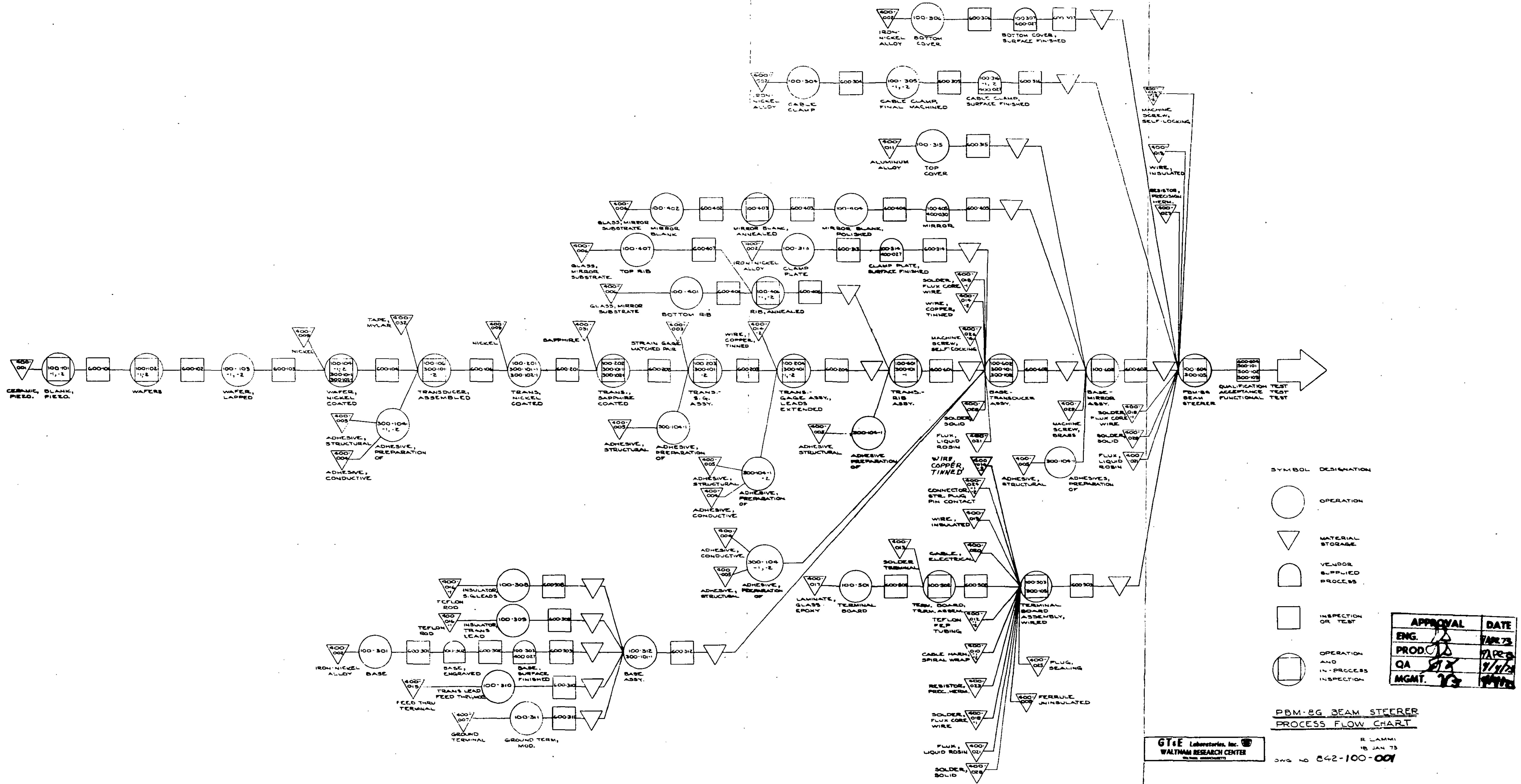
NAME	MATERIAL	PROJECT NO.
MANUFACTURING DRAWINGS AND TEST PROCEDURES		

DRAWN BY R.L.

DATE 3/30/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-000-000


CERAMIC, PIEZO.
BLANK, PIEZO.
WAFERS
WAFER, LAPPED
WAFER, NICKEL COATED
TRANSDUCER, ASSEMBLED
TRANS., NICKEL COATED
TRANS., SAPPHIRE COATED
TRANS.- S.G. ASSY.
TRANS.- GAGE ASSY., LEADS EXTENDED
TRANS.- RIB ASSY.
BASE-TRANSDUCER ASSY.
BASE-MIRROR ASSY.
PBM-8G BEAM STEERER
QUALIFICATION TEST
ACCEPTANCE TEST
FUNCTIONAL TEST
TAPE, MYLAR
NICKEL
SAPPHIRE
STRAIN GAGE, MATCHED PAIR
WIRE, COPPER, TINNED
ADHESIVE, STRUCTURAL
ADHESIVE, CONDUCTIVE
ADHESIVE, PREPARATION OF
GLASS, MIRROR SUBSTRATE
MIRROR BLANK
MIRROR BLANK, ANNEALED
MIRROR BLANK, POLISHED
MIRROR
TOP RIB
BOTTOM RIB
RIB, ANNEALED
IRON-NICKEL ALLOY
CLAMP PLATE
CLAMP PLATE, SURFACE FINISHED
BOTTOM COVER
BOTTOM COVER, SURFACE FINISHED
CABLE CLAMP
CABLE CLAMP, FINAL MACHINED
CABLE CLAMP, SURFACE FINISHED
ALUMINUM ALLOY
TOP COVER
MACHINE SCREW, SELF-LOCKING
WIRE, INSULATED
RESISTOR, PRECISION, HERM.
SOLDER, FLUX CORE WIRE
SOLDER, SOLID
FLUX, LIQUID ROSIN
MACHINE SCREW, BRASS
CONNECTOR, STR. PLUG PIN CONTACT
CABLE, ELECTRICAL
SOLDER TERMINAL
LAMINATE, GLASS EPOXY
TERMINAL BOARD
TERM. BOARD, TERM. ASSEM.
TERMINAL BOARD ASSEMBLY, WIRED
TEFLON FEP TUBING
CABLE HARN. SPIRAL WRAP
RESISTOR, PREC. HERM.
PLUG, SEALING
FERRULE, UNINSULATED
TEFLON ROD
INSULATOR S.G. LEADS
INSULATOR TRANS LEAD
BASE
BASE, ENGRAVED
BASE, SURFACE FINISHED
TRANS LEAD FEED THRU, MOD.
FEED THRU TERMINAL
GROUND TERMINAL
GROUND TERM, MOD.
BASE ASSY.
SYMBOL DESIGNATION
OPERATION
MATERIAL STORAGE
VENDOR SUPPLIED PROCESS
INSPECTION OR TEST
OPERATION AND IN-PROCESS INSPECTION
APPROVAL
DATE
ENG.
PROD.
QA
MGMT.
GT&E Laboratories, Inc.
WALTHAM RESEARCH CENTER
PBM-8G BEAM STEERER
PROCESS FLOW CHART
R. LAMMI
18 JAN 73
DWG NO 842-100-001

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1

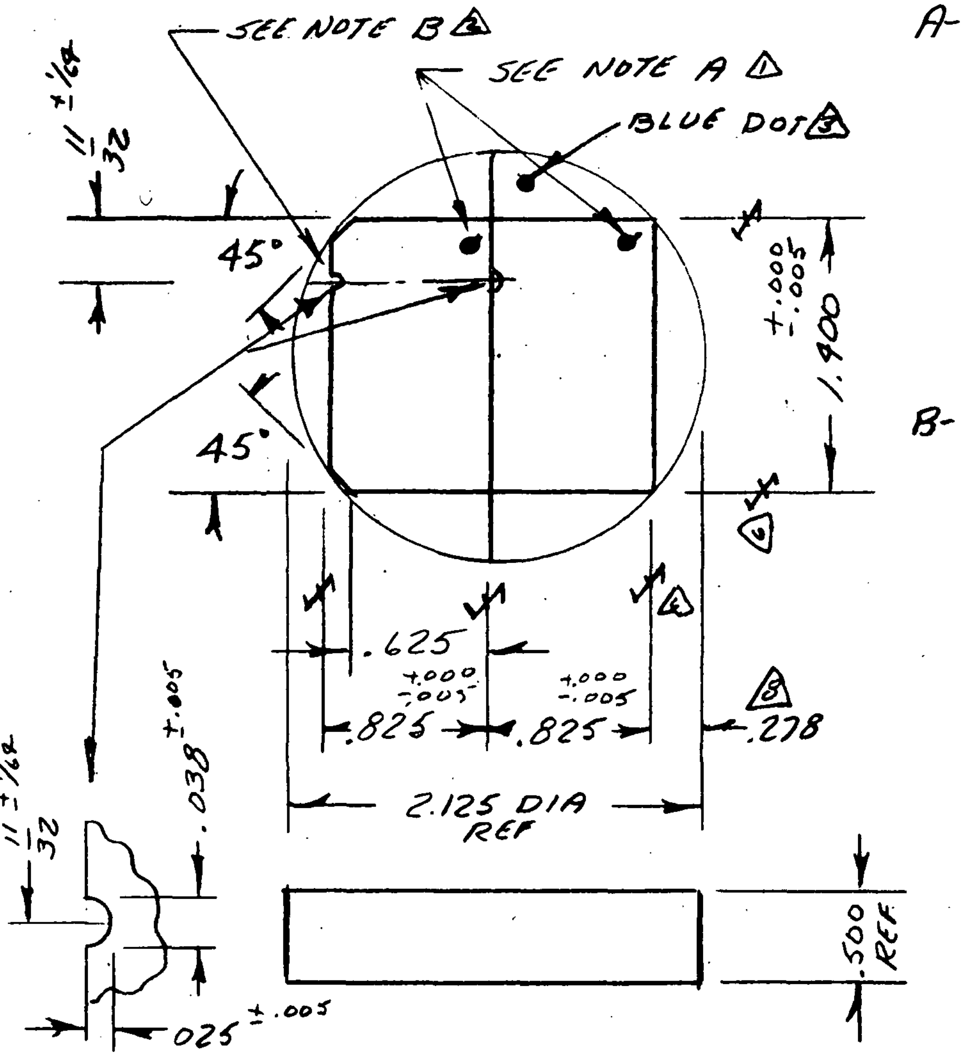
DO NOT SCALE DRAWING

812-100-101-B
PAGE 1 OF 2

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

REVISIONS

- A- (1) CHANGED SCRATCH MARKS TO RED LACQUERED DOTS
- (2) ADDED NOTCH NOTE B 1-19-72
- B- (3) ADDED BLUE DOT NOTE
- (4) PART NO. WAS DWG NO
- (5) NEXT ASSEMBLY 842-100-102 B WAS 842-100-100
- (6) ADDED SQUARE & PARALLEL "✗" TO 1.400 & .825 DIM
- (7) ADDED .001 PER INCH TO SQ. AND PARALLEL NOTE
- (8) ADDED CHORD DIMEN
- (9) ADDED PAGE 2 OF 2 ON PAGE 2 2-25-72



APPROVAL	DATE
ENG.	2/29/72
PROD.	2/29/72
QA	2/29/72
MGMT.	2/29/72

(4) PART. NO.	PIECE CHARACTERISTIC	USE
842-100-101-1	(2) 45° CORNERS (2) 90° CORNERS	TOP
842-100-101-2	(4) 90° CORNERS	BOTTOM

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN .001 PER INCH - ALL DIMENSIONS ARE IN INCHES UNLESS SPECIFIED OTHERWISE

(5) NEXT ASSEMBLY 842-100-102

NAME	MATERIAL	PROJECT NO.
BLANK, PIEZOELECTRIC	CERAMIC DWG 842-400-001	

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-101-B PAGE 1 OF 2
DATE 1-3-72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-100-101-B
Page 2 of 2

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

CAUTION: THIS MATERIAL IS CAPABLE OF GENERATING VOLTAGES SUFFICIENT TO SHOCK WHEN HEATED. BEFORE HANDLING SHORT ELECTRODE SURFACES TOGETHER TO DISCHARGE.

NOTES:

A. Mark each piece with two red lacquer dots in upper right-hand corner as shown on same side as blue dot.

B. Notch each piece (101-1 & 101-2) as shown in relation to red polarity dot markings.

C. When mounting for cutting or grinding the temperature of the ceramic shall not exceed 175°C (350°F).

D. In all machining operations use unrecirculated kerosene, as coolant, directed at leading edge of wheel.

E. In all cutting or grinding operations, using a wheel peripheral velocity of at least 1000 in/sec, the product (depth of cut in inches) x (table feed in inches per minute) shall not exceed 0.4. In no case shall cut be made deeper than 0.2 inches. Examples of acceptable values are:

   1. Depth of cut = .002 inches, table feed = 180 inches/min.
   2. Depth of cut = 0.2 inches, table feed = 2 inches/min.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
BLANK, PIEZOELECTRIC	As noted	

DRAWN BY W. GANNON

DATE 1-4-72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-100-101-B PAGE 2 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1

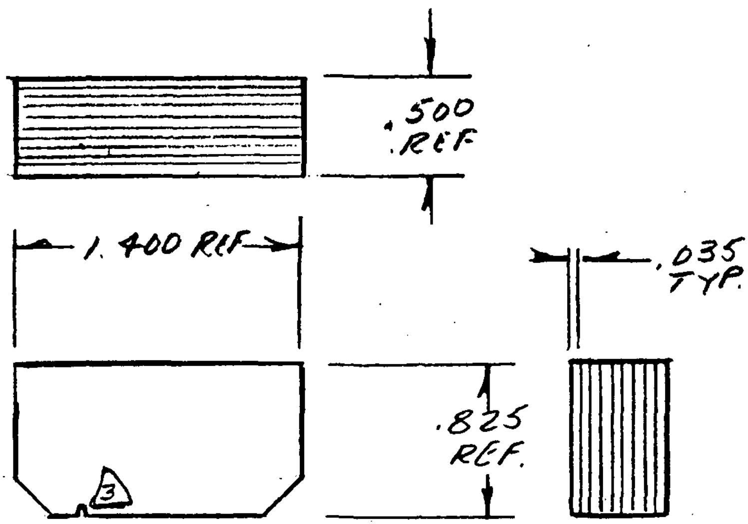
DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

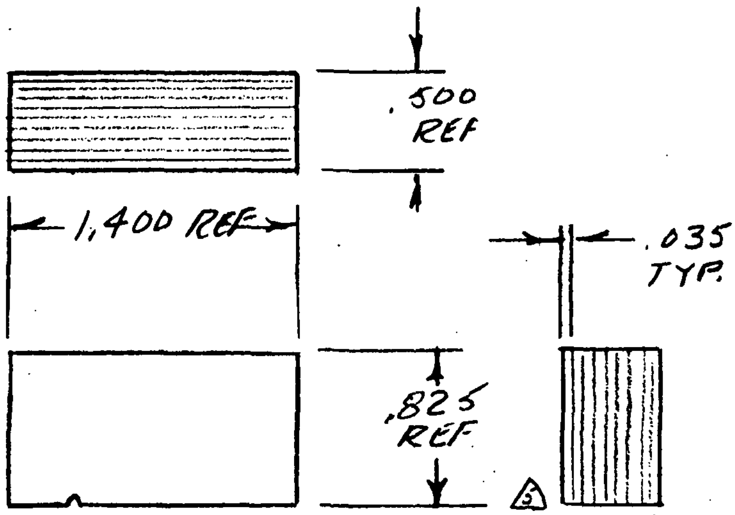
REVISIONS

A-
(1) CHANGE NOTE E FROM "PRESERVE --- DIAGONAL" TO "FINISHED ---"
(2) DELETE NOTE F ON SHEET 2
(3) ADDED NOTCH
(4) DELETE SCRATCH MARKS
1-19-72

B
(5) WORD PART WAS DWG
(6) NEXT ASSEMBLY 842-100-103 WAS 842-100-100
(7) TITLE WAFERS WAS PIEZO ELECTRIC WAFERS TOP & BOTTOM
(8) ADDED PAGE 2 OF 2 ON PAGE 2



MAT'L: PIEZOELECTRIC BLANK
(5) PART 842-100-101-1



APPROVAL	DATE
ENG. [signature]	2/29/72
PROD. [signature]	2/29/72
QA [signature]	2/29/72
MGMT. [signature]	2/29/72

MAT'L: PIEZOELECTRIC BLANK PART 842-100-101-2

(5) PART NO	PIECE CHARACTERISTICS	USE
842-100-102-1	(2) 45° CORNERS (2) 90° CORNERS	TOP
842-100-102-2	(4) 90° CORNERS	BOTTOM

ALL SURFACES MARKED "f" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN
ALL DIMENSIONS ARE IN INCHES UNLESS SPECIFIED OTHERWISE

NEXT ASSEMBLY (6) 842-100-103

NAME	MATERIAL	PROJECT NO.
(7) WAFERS	AS NOTED	[signature]

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-102 B PAGE 1 OF 2
DATE 1-3-72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

CAUTION: THIS MATERIAL, WHEN HEATED, IS CAPABLE OF GENERATING VOLTAGES SUFFICIENT TO SHOCK. BEFORE HANDLING SHORT ELECTRODED SURFACES TOGETHER TO DISCHARGE.

NOTES:

A. Dimensions shown are for finished wafers sliced from blanks.

B. When mounting for cutting or grinding the temperature of the ceramic shall not exceed 350°F (176°C).

C. All machining operations shall use unrecirculated kerosene, as coolant, directed at leading edge of wheel.

D. In all cutting or grinding operations, using a wheel peripheral velocity of at least 1000 in/sec, the product of depth of cut in inches and table feed in inches per minute shall not exceed 0.4. In no case shall a cut be made deeper than 0.2 inches. Examples of acceptable values are:

1. Depth of cut = .002 inches, table feed = 180 inches/min.
2. Depth of cut - 0.2 inches, table feed = 2 inches/min.

E. Finished pieces shall have no cracks and no chips on surface or edges larger than .020.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
WAFERS	As noted	

DRAWN BY L GANNON

DATE 1-3-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-102 · B
PAGE 2 OF 2 (B)

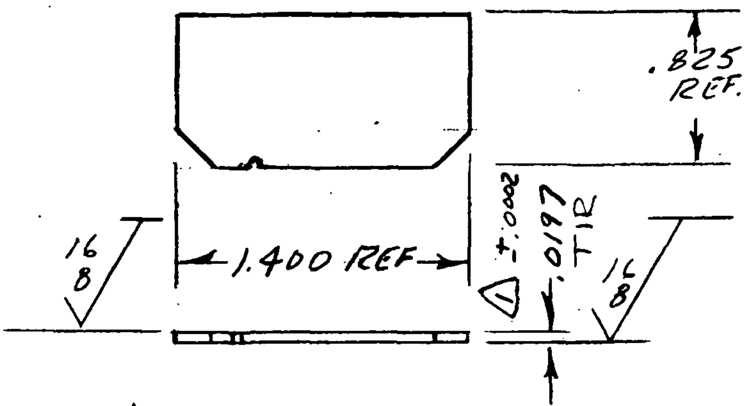
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1

DO NOT SCALE DRAWING

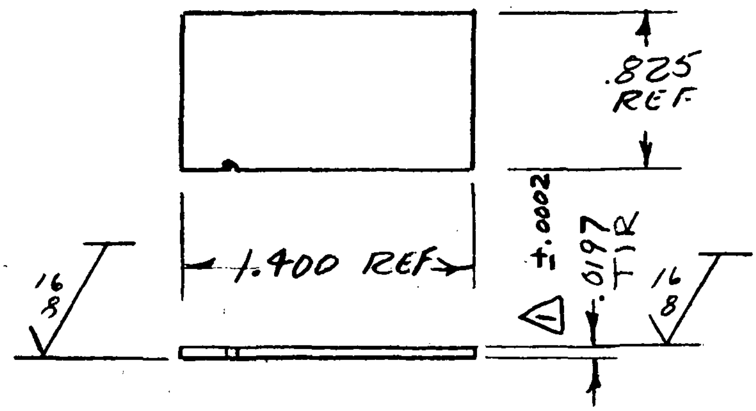
REVISIONS

A	△1 .0197 ±.0002 TIR WAS .0199 +.0000 -.0003 TIR WG. 2-11-72
B	△2 NEXT ASSY. -104 WAS 100 △3 NAME "TOP & BOTTOM" REMOVED △4 177°C WAS 175°C

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



MAT'L: PIEZOELECTRIC WAFER DWG 842-100-102-1



APPROVAL	DATE
ENG.	2/29/72
PROD.	2/29/72
QA	2/29/72
MGMT.	2/29/72

MAT'L: PIEZOELECTRIC WAFER DWG 842-100-102-2

DWG. NO.	PIECE CHARACTERISTICS	USE
842-100-103-1	(2) 45° CORNERS (2) 90° CORNERS	TOP
842-100-103-2	(4) 90° CORNERS	BOTTOM

ALL SURFACES MARKED "ƒ" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN ALL DIMENSIONS ARE IN INCHES UNLESS SPECIFIED OTHERWISE

NEXT ASSEMBLY △2 842-100-104

NAME	MATERIAL	PROJECT NO.
WAFER, LAPPED △3	AS NOTED	

DRAWN BY W. GANNON DATE 1-10-72	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-103-B PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES:

A. Blanks to be finished on both sides by lapping with alumina compound (9 micron) to give specified surface finish.

B. When mounting for lapping the temperature of the ceramic shall not exceed 350° F (177°C). ⚠4

C. Inspect all pieces with a magnification of no less than 10 power, using back lighting. Pieces are unacceptable under any of the following conditions:

1. cracks
2. holes or inclusions greater than .005 below the surface.

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN
All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY
842-100-104

NAME	MATERIAL	PROJECT NO.
WAFER, LAPPED	As noted	

DRAWN BY W GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-103-B Page 2 of 2
DATE 1-10-72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	FULL

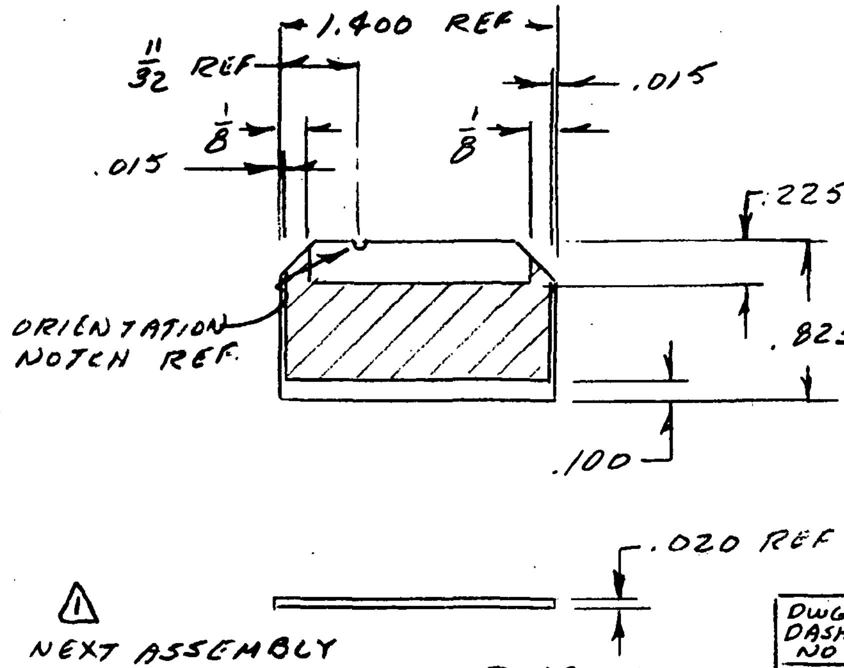
DO NOT SCALE DRAWING

842-100-104 B
PAGE 1 OF 1

REVISIONS

A	ON DWG 1 ONLY (1) ADDED NEXT ASSY. NO (2) ADDED "DEPOSIT FILM" NOTE 3-28-72 WG
B	(3) REARANGED NAME (4) NEXT ASSY WAS -105 14 JUL 72

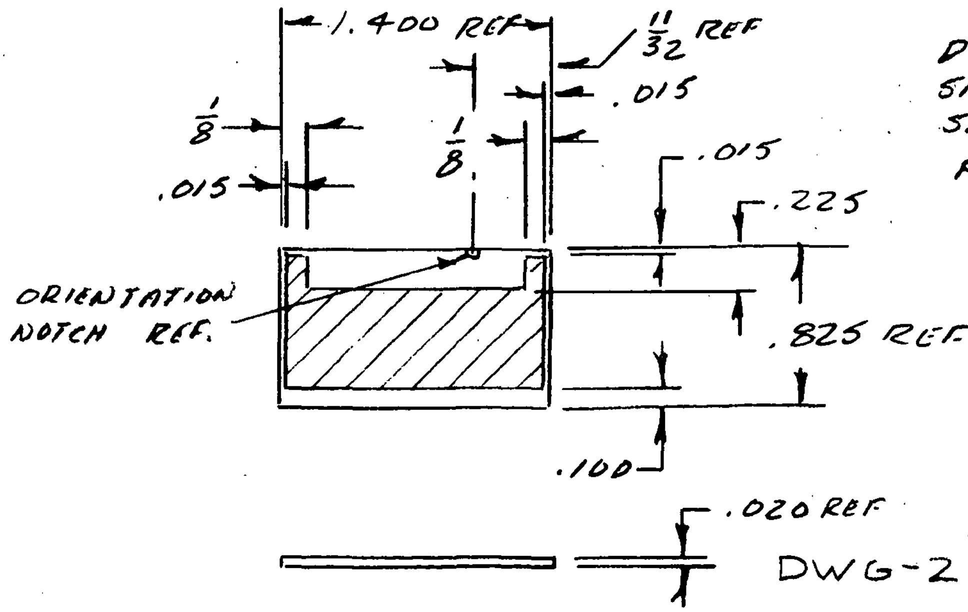
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



(2) DEPOSIT FILM IN SHADED AREA AS SPECIFIED ON PCD 842-300-102-1

(1) NEXT ASSEMBLY 842-100-106

DWG DASH NO	DWG. NO	PIECE CHARACTERISTICS
-1	842-100-103	(2)45° CORNERS (2)90° CORNERS
-2	842-100-103	(4)90° CORNERS



DEPOSIT FILM IN SHADED AREA AS SPECIFIED ON PCD 842-300-102-1

APPROVAL		DATE
ENG.	[signature]	2/29/72
PROD.	[signature]	2/29/72
QA	CDH	2/29/72
MGMT.	[signature]	2/29/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY (4) 842-100-106

NAME	MATERIAL	PROJECT NO.
WAFER, NICKEL COATED (3)	SEE TABLE	

DRAWN BY W. GANNON

DATE 2-1-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-104 B
PAGE 1 OF 1

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

PARTS LIST

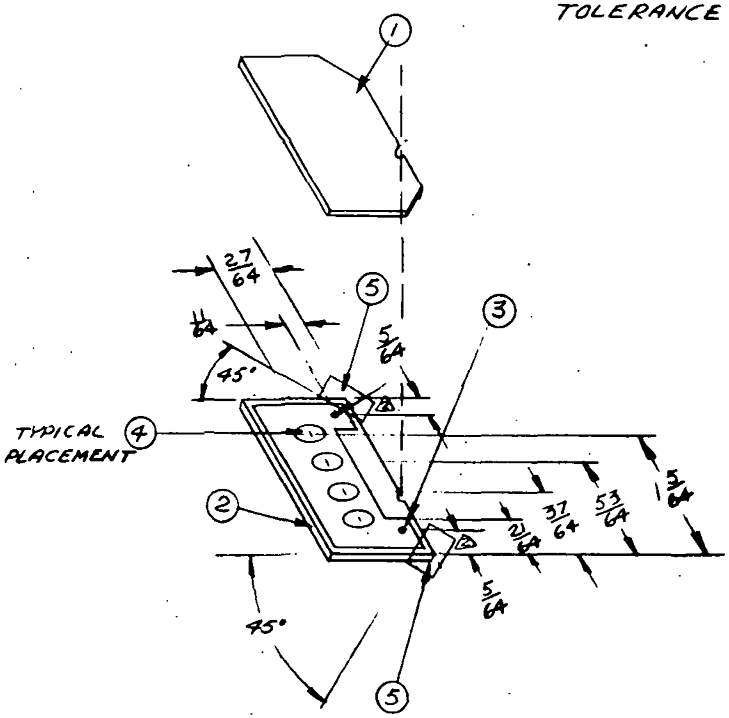
ITEM NO.	ITEM	PART NO.
1	WAFER, NICKEL COATED	842-100-104-1
2	" " "	842-100-104-2
3	ADHESIVE, PREPARATION OF (CONDUCTIVE)	842-300-104-2
4	" " " (STRUCTURAL)	842-300-104-1
5	TAPE, MYLAR®	842-400-032

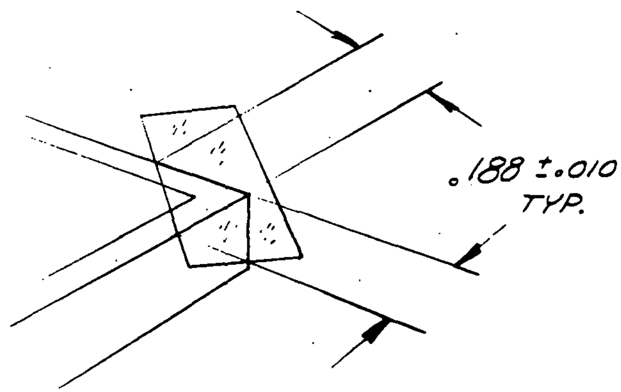
842-100-106C
PAGE 1 OF 2

REVISIONS

A	⚠ ADDED NOTES 6,7,8. ⚠ REMOVED LEADS
B	⚠ PAGE 1 OF 3 WAS 1 OF 2
C	⚠ CN 1030 REDRAWN 'B' SIZE ADDED NOTE 2 2.7.73 EGAR

TOLERANCE ON ADHESIVE DROP LOCATION ± 1/32 (4)





TYPICAL DETAIL AT (5)
NO SCALE

APPROVAL		DATE
ENG.	[signature]	13 FEB 73
PROD.	[signature]	13 FEB 73
QA	[signature]	2/13/73
MGMT.	[signature]	2/13/73

NEXT ASSEMBLY
842-100-201

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME	MATERIAL	PROJECT NO.
TRANSDUCER, ASSEMBLED	AS NOTED	842

DRAWN BY EGAR (GANNON)
DATE 2.7.73

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-106C
PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-100-106-C

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES

1. Clean wafers, Items 1 and 2, and a dropper that makes 36 ± 4 drops of water per milliliter, per 842-300-101-2. Handle wafers in subsequent steps with tweezers cleaned in the same manner.

4 2. Cut two pieces of tape, Item 5, 3/8 x 1/4" and place one across each of two corners of wafer, Item 2, positioned as shown. Burnish the tape onto the wafer to seal the nickel coat from contamination during subsequent adhesive application.

3. Place a 3/64 diameter dot of conductive adhesive, Item 3, in each of 2 positions on wafer, Item 2, as shown.

4. Place wafer, Item 2 on a flat level surface. With the dropper at a height of 1/4 to 1/2" above the wafer, place one drop of structural adhesive, Item 4, at each of 4 locations as shown. Let the adhesive volatiles evaporate for 5 to 10 minutes.

5. With the dropper at a height of 1/4 to 1/2" above the wafer, place a second drop of structural adhesive as in Note 4 at each of the same 4 locations shown in the figure. Let the adhesive volatiles evaporate in open air at room temperature for 1 to 1 1/4 hours.

6. Position wafer, Item 1, on wafer, Item 2, in such a way that the notches are aligned and the square corners are flush. Press parts together with a uniform pressure of 115 ± 10 lb./sq. in. and cure adhesive under pressure at 150° ± 5°C (302° ± 9°F) for 2 hours. Parts shall begin cure cycle at room temperature and reach cure temperature in no less than 15 minutes.

1 7. After completion of cure, parts are to be inspected for the following conditions:
   a) No cracks are to appear on either surface when examined under a minimum magnification of 30 power.
   b) All positions along each edge are to show evidence of excess adhesive flow-out.
   Parts not conforming to both a) and b) shall be rejected.

1 8. Remove tape from the corners of the part. Remove residual adhesive from the edges of the part by stroking the edge on #320 silicon carbide abrasive paper. Do not remove more than .002" of ceramic from each edge.

1 9. Remove any excess adhesive from surface of the part by lapping on #600 silicon carbide abrasive paper. Transducer thickness must not be reduced below .0390.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise

NAME	MATERIAL	PROJECT NO.
TRANSDUCER, ASSEMBLED		

DRAWN BY J. Schlafer

DATE 1/30/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-106-C

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1

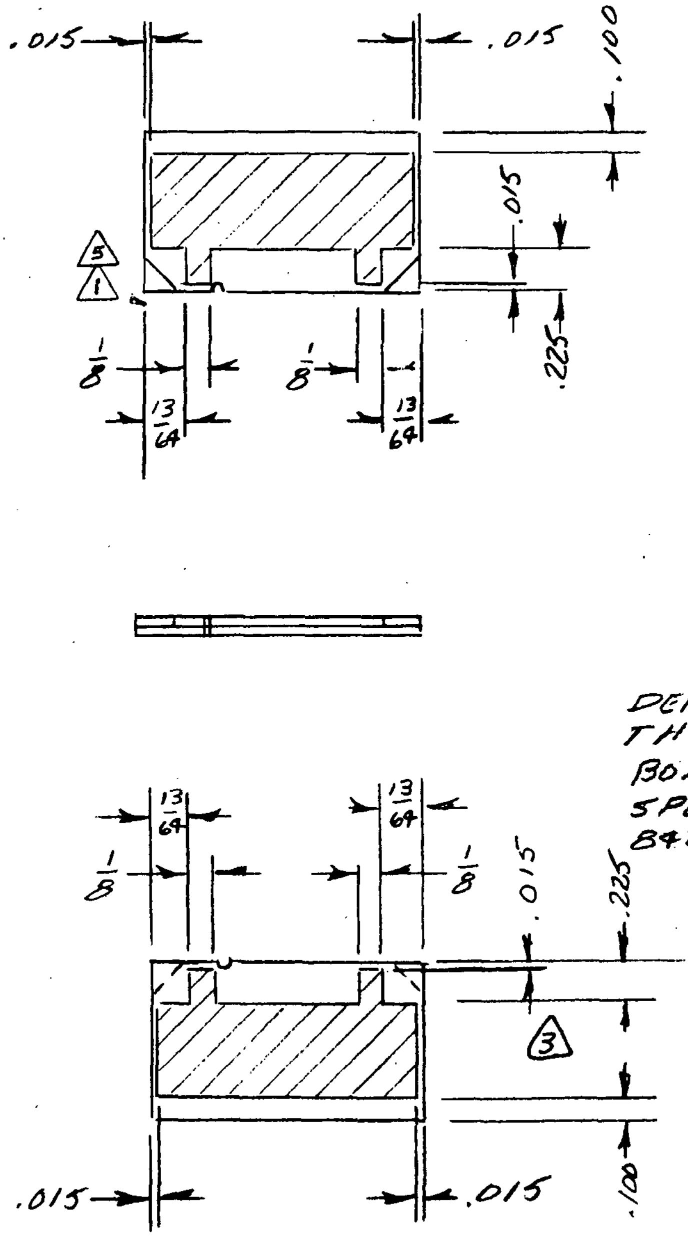
DO NOT SCALE DRAWING

842-100-201-C
PAGE 1 OF 1

REVISIONS

A	△1 ADDED LEADS AT CORNER (2 PLACES) 3-22-72 W.G.
B	△2 MATERIAL WAS 842-100-105; △3 ADDED DIMEN. OF NICKEL DEPOSIT ON LOWER VIEW; △4 ADDED WORD "NICKEL" TO DEPOSITION NOTE 3-22-72 WG
C	△5 REMOVED "REV" △1; △6 NAME WAS SANDWICH 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



△4 DEPOSIT NICKEL FILM ON THE SHADED AREA OF BOTH SURFACES AS SPECIFIED ON PCD 842-300-102-1

APPROVAL	DATE
ENG.	2/29/72
PROD. SP	2/29/72
QA EDH	2/29/72
MGMT.	2/29/72

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-202

NAME	MATERIAL	PROJECT NO.
TRANSDUCER, NICKEL COATED △6	842-100-106 △2	

DRAWN BY W. GANNON
DATE 2-1-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

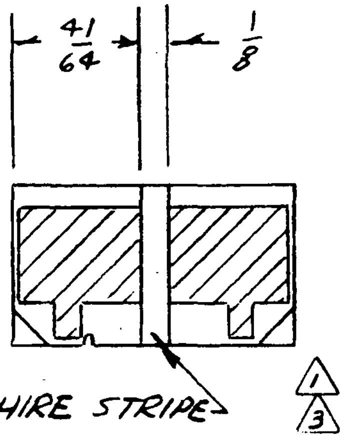
842-100-201C
PAGE 1 OF 1

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1
DO NOT SCALE DRAWING			

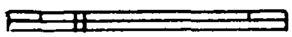
842-100-202-C
PAGE 1 of 1

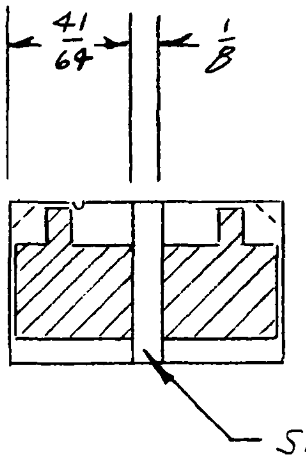
	REVISIONS
A	(1) ADDED LEADS AT CORNER (2 PLACES 3-22-72 WG
B	(2) MATERIAL WAS 842-100-105 3-28-72 WG
C	(3) REMOVED "REV (1)" (4) NAME WAS SANDWICH 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



DEPOSIT SAPPHIRE STRIPE
IN INDICATED AREA ON BOTH
SURFACES AS SPECIFIED ON
842 - 300 - 102 - 2





SAPPHIRE
STRIPE

APPROVAL		DATE
ENG.	[signature]	2/29/72
PROD.	[signature]	2/29/72
QA	EDH	2/29/72
MGMT.	VJ	2/29/72

NEXT ASSEMBLY
842-100-203

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
TRANSDUCER, SAPPHIRE COATED (4)	842-100-201 (2)	

DRAWN BY W. GANNON
DATE 2-1-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-202 C
PAGE 1 OF 1

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-203E
PAGE 1 OF 3

PARTS LIST

ITEM NO.	ITEM	PART NO.
1	TRANSDUCER, SAPPHIRE COATED	842-100-202
2	STRAIN GAGE, MATCHED PAIR	842-400-003
3	ADHESIVE, PREPARATION OF (STRUCTURAL)	842-300-104-1

REVISIONS

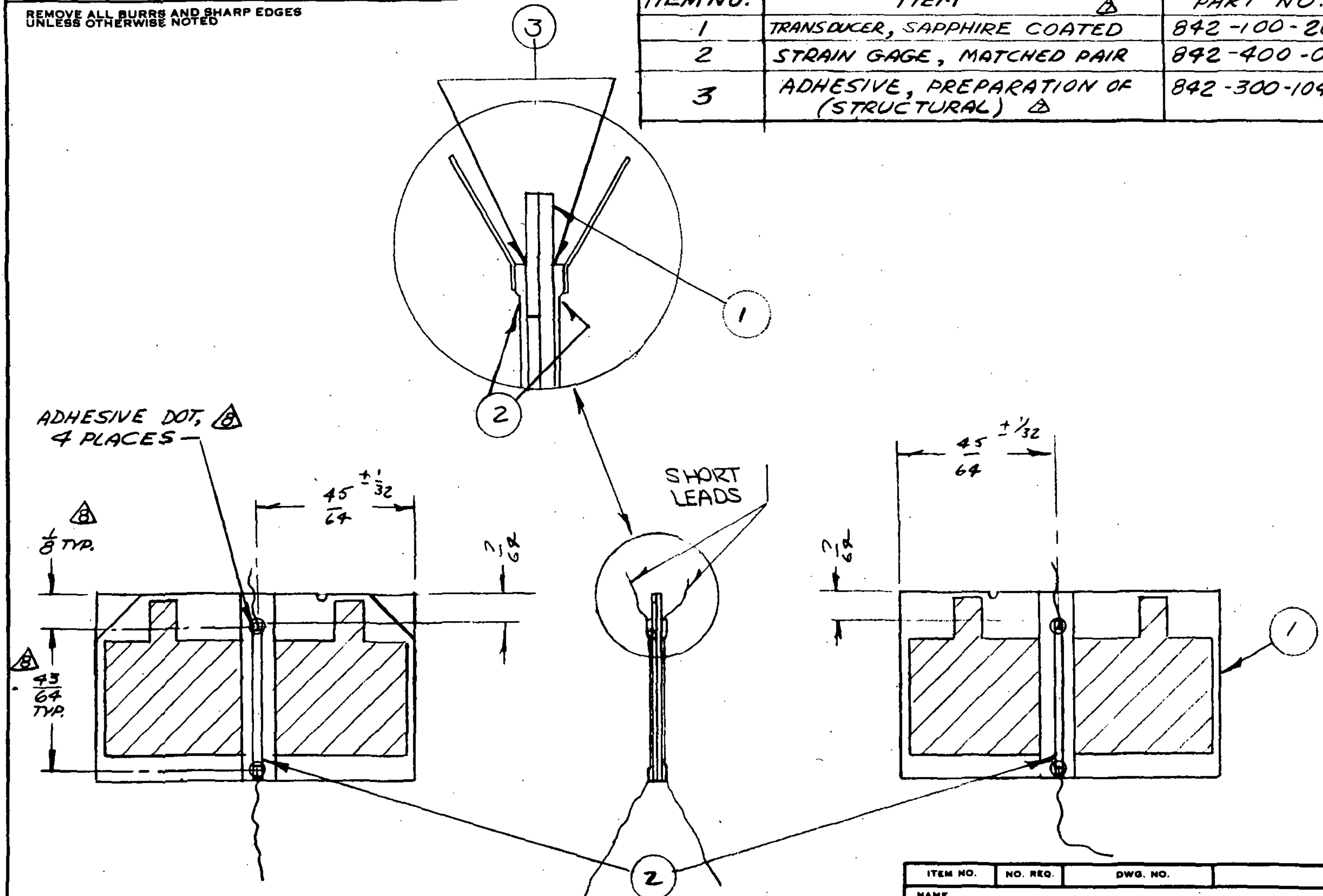
A - Note 5. Time was 2H. Note 6, Add I.R. Caution. Note 9. Was 35 ±4 LB. 10 MAR 72

B - -400-005 was -300-101-1. Notes 4.3, 4.4 & 4.5 were 4.5, 4.3 & 4.4. Reprocess was Reject. 12 July 72

C - CN 1031. Item 1 was sandwich, " 3 was struct. adhesive. Note 4.2 was 2 sec. 2-7-73 EGAR

D - CN 1042. Added adhesive dot dimensions. 3-13-73 EGAR

E - CN 1046. Rewrote notes 8 thru 11. 3-15-73 R.L.



APPROVAL		DATE
ENG.		4 MAY 72
PROD.		4 MAY 72
QA		5/4/72
MGMT.		3/28/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-204

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: TRANSDUCER - STRAIN GAGE ASSEMBLY

MATERIAL: AS NOTED

PROJECT NO.

DRAWN BY W. GANNON

DATE 3-22-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-203E
PAGE 1 OF 3

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-100-203 E

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES:

1. Clean transducer, Item 1, as per 842-300-101-2, and inspect for cleanliness on the aluminum oxide area.

2. Cut one lead on each of the strain gages, Item 2, to 1/4" length.

3. Clean strain gage pair, Item 3, as per 842-300-101-2, but do not use cleanliness test. Gages should be held vertically by the extremity of the long lead while cleaning.

4 4. Coat the gages by dipping in structural adhesive, Item 3, as follows:

   4.1 Suspend the gage vertically from the long lead.

7 4.2 Lower the gage into the adhesive until the adhesive just covers the top solder pad (lead attachment point) and then withdraw the gage in a smooth uniform motion. This step must be completed in less than 1.5 seconds.

   4.3 Dip the lower lead into acetone, USP grade, to within 1/64" of the lower solder pad for no more than 5 seconds to strip the adhesive from this lead.

5 4.4 Let the adhesive dry on the gage from 5 to 10 minutes.

   4.5 Repeat Notes 4.2 thru 4.4 a second and third time.

1 5. After Note 4 gages must be inspected per Note 6 and applied as per Notes 7 thru 9 within 20 minutes.

2 6. Inspect the bottom surface of the gage (opposite side from the lead attachment point) at 7 times magnification using specularly reflected light having low infrared output (to avoid curing adhesive). Reprocess gages not having the following characteristics:

   6.1 The adhesive layer shall be of such a thickness that it is visible as a light yellow coating along the entire length of the gage.

   6.2 The coating shall be uniform with no uncoated areas or bubbles.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
TRANSDUCER-STRAIN GAGE ASSEMBLY		

DRAWN BY J. Schlafer

DATE 1/30/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-203E

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

6.3 The coating shall have no imbedded or adhering foreign particles.

7. Place a 1/32 diameter dot of structural adhesive, Item 3, on the transducer at the point at which the center of the strain gage solder pads will lie when the strain gage is positioned as in the figure (2 places each side). Let the adhesive dry for 5 minutes.

9 8. Grasp the gage by one or both of the leads and guide it into position on the transducer as shown in the figure. Place one gage on each side. Touch the gage lightly in 3 places to tack it to the transducer.

9 9. Place the transducer with gages between two 3/32 rubber pads of Shore A hardness 31 ± 3 whose faces have been protected from adhering to the gage with two sheets of .001 to .003" teflon film on each side. Clamp this assembly between rigid plates at 30 ± 10 lb/sq. in.

9 10. Place the clamped assembly in an oven at 142° ± 4°F (61° ± 2.2°C) for 30 minutes. After 30 minutes remove the transducer-gage assembly and two inner sheets of teflon from the clamp and rubber pads and cure at the above temperature for 16 to 24 hours.

9 11. After completion of cure inspect the assembly for the following characteristics:

11.1 The gage shall be positioned as shown.

11.2 The gage shall have lead attachment points on the side away from the transducer.

11.3 The gage leads shall not be nicked or crushed.

11.4 The adhesive pressed out from between the gage and the transducer shall be visible on both sides of the gage along its entire length.

11.5 The resistance measured between the strain gage and the nickel electrode on the transducer shall be greater than $2(10)^7$ ohms.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
TRANSDUCER-STRAIN GAGE ASSEMBLY		

DRAWN BY J. Schlafer

DATE 3/15/73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

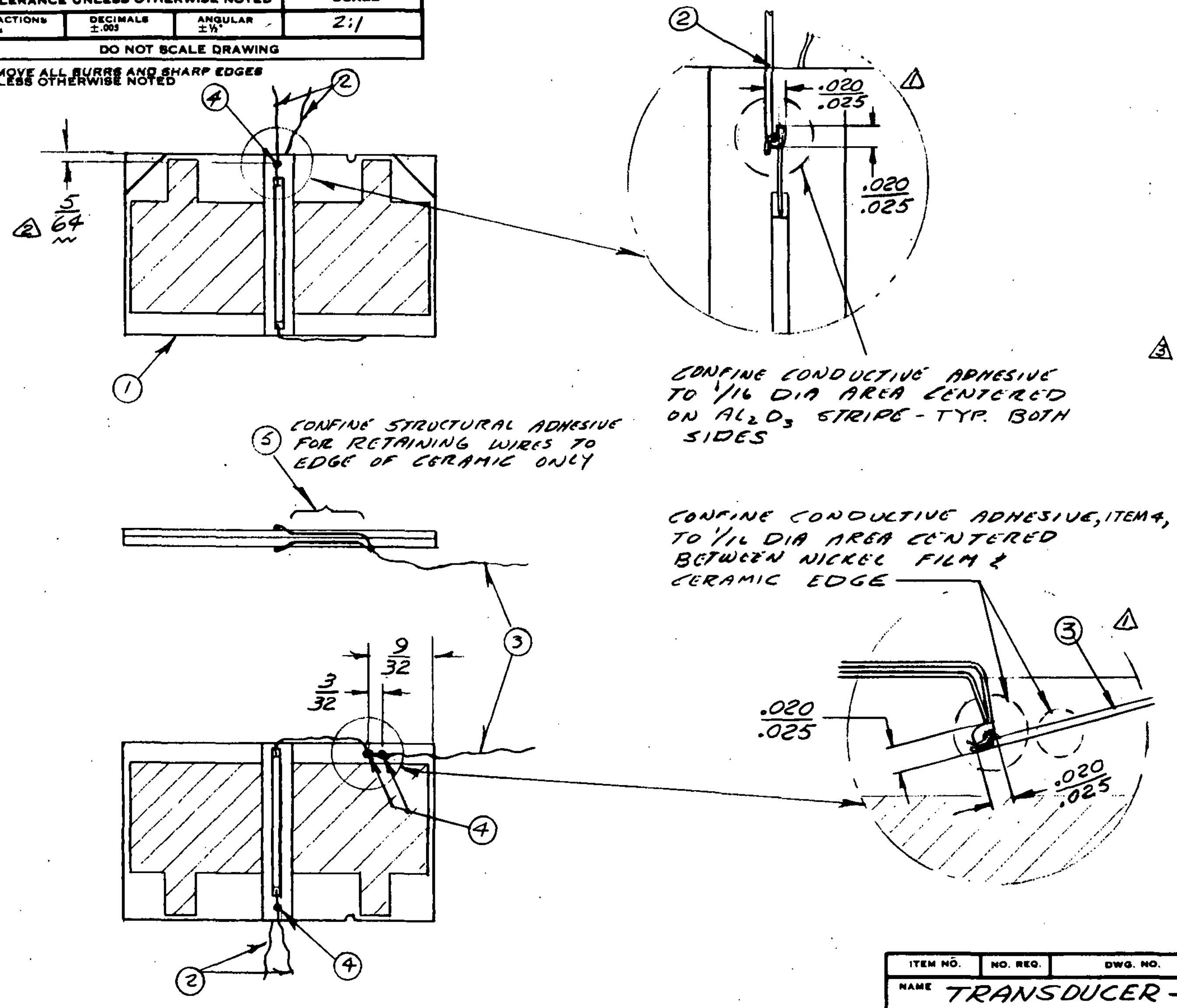
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

REVISIONS

A CN 1032
1. REDRAW DETAILS
2. 5/64 WAS 3/64
3. PARTS LIST AND NOTES REWRITTEN.
EGAR 2-8-73



PARTS LIST			
ITEM NO.	QTY.	DESCRIPTION	PART NO.
1	1	TRANSDUCER-STRAIN GAGE ASSY.	842-100-203
2	2	WIRE, COPPER, TINNED (1 1/2")	842-400-014-2
3	1	WIRE, COPPER, TINNED (3")	842-400-014-2
4	AR	ADHESIVE, PREPARATION OF (CONDUCTIVE)	842-300-104-2
5	AR	ADHESIVE, PREPARATION OF (STRUCTURAL)	842-300-104-1

APPROVAL		DATE
ENG.	[illegible]	15 FEB 73
PROD.	[illegible]	15 FEB 73
QA	[illegible]	2/13/73
MGMT.	[illegible]	2/28/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-601

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: TRANSDUCER - GAGE ASSEMBLY, LEADS EXTENDED

MATERIAL: AS NOTED

PROJECT NO.

DRAWN BY W. GANNON

DATE 3-28-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES:

1. Cut two 1 1/2" lengths and one 3" length of tinned copper wire per Items 2 & 3. Form a 180° hook on one end of each wire, as shown in the details.

2. Clean the wires on the hooked end for a length of at least 1/2" as per 842-300-101-1.

3. Train the pair of gage leads on the un-notched side of the transducer, Item 1, to lay along the edge of the transducer to within 9/32 of the corner. At this point bend the leads over the edge so they lie flat on the transducer surface.

4. Clean the transducer as per 842-300-101-2.

5. Use structural adhesive, Item 5, to retain the gage leads along the transducer edge.

6. Position the hooked ends of the wires, Items 2 and 3, on the transducer as shown in the details. Loop the gage lead at each position through the hook on the wire. Slightly scrape a small area of the strain gage lead at the hook to obtain bright metal free of adhesive or corrosion.

7. Prepare conductive adhesive, Item 4. Apply adhesive with a clean applicator to join wire and strain gage leads, and to bond both to the transducer, as shown. Make an additional application of conductive adhesive to bond the wire to the transducer 3/32" from the point at which the two gage leads join the wire. This is for strain relief.

8. Cure the adhesive for at least 1 hour at 150°F (65°C) $\pm$ 5%.

9. Cut off free end of strain gage leads flush to the surface of the conductive adhesive bond.

10. Measure each gage resistance to an accuracy of $\pm$ 0.1 ohm. Resistance shall be 48.0 $\pm$ 1.0 ohm. Resistance from either gage to nickel electrode shall be greater than $2(10)^7$ ohms.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
TRANSDUCER-GAGE ASSEMBLY, LEADS EXTENDED		

DRAWN BY J. Schlafer

DATE 2/1/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

TOLERANCE UNLESS OTHERWISE NOTED	SCALE
FRACTIONS / DECIMALS / ANGULAR	3:1
DO NOT SCALE DRAWING	

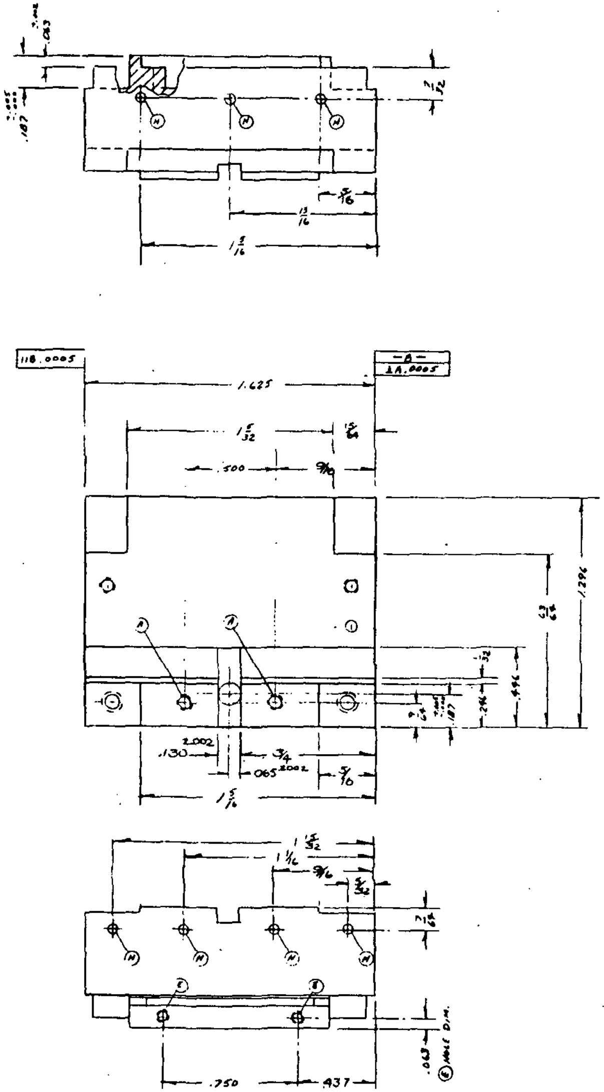
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

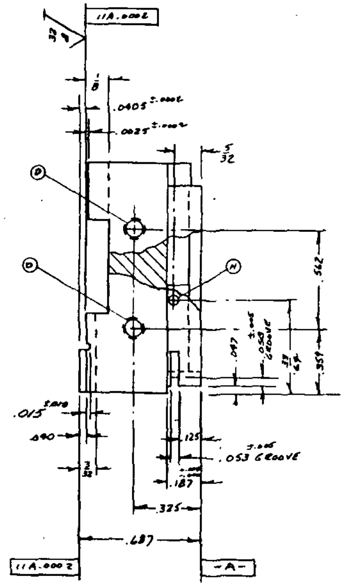
842-100-301

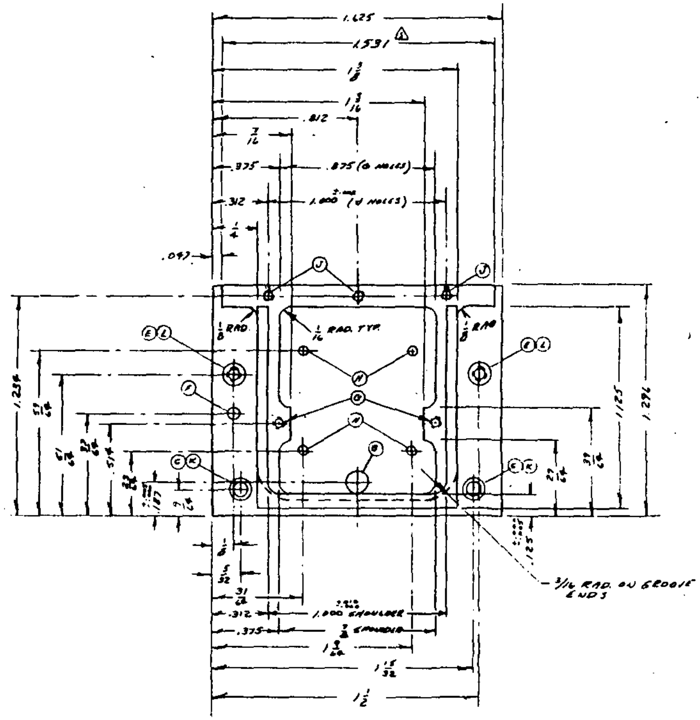
REVISIONS

A △ 1.531 REF TO .047 SHOULDER

HOLE LEGEND		
HOLE	NO. REQ	DESCRIPTION
A	2	DR. & TAP #1-72 NF-2B x 1/8 DP
B	1	DR. .125 [illegible] THRU
C	2	DR. .070 [illegible] DIA THRU
D	4	DR. & TAP BOTH SIDES #5-40 NC-2B x 1/2 DP.
E	4	DR. & TAP THRU #2-56 NC-2B
F	1	DR 1/16 DIA. THRU
G	2	DR. #56 (.046) x 1/8 DP. & TAP 0-80 NF2-B x 3/32 DP.
H	13	DR. 3/64 BLEEDER HOLE BREAK INTO TAPPED HOLE
I	—	—
J	3	DR. #56 (.046) x 1/4 DP. & TAP #0-80 NF2-B x 3/32 DP
K	2	DR. .0935 [illegible] DIA. x .480 DP.
L	2	DR. .125 DIA x .046 DP.







ALL SURFACES MARKED TO BE SQUARE, PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH 2000 [illegible]

NEXT ASSEMBLY 842-100-302

APPROVAL	DATE
ENG	
PROG	
QA	
MGMT.	

NAME: BASE

MATERIAL: AS PER DWG 842-400-002

DRAWN BY W. CANNON

DATE 3-22-72

842-100-301-A

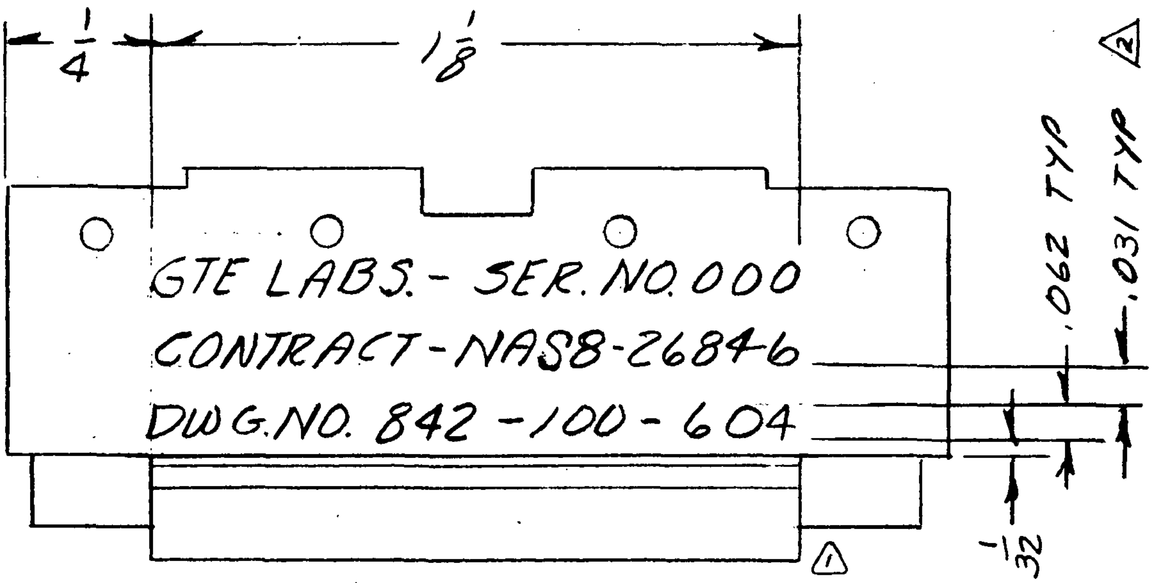
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	3:1
DO NOT SCALE DRAWING			

842-100-302 B

REVISIONS	
A	(1) WAS 842-100-603 14 JUL 72
B	CN 1047 (2) WAS .062 3-16-73

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES-
LETTERING TO BE ENGRAVED 1/16 GOTHIC NORMAL TYPE X .007 $^{+.003}_{-.002}$ DEEP & SPACED AS SHOWN. SEE PRODUCTION ORDER FOR SEQUENTIAL SERIAL NUMBERING



APPROVAL	DATE
ENG.	6 APR 72
PROD.	6 APR 72
QA	4/6/72
MGMT.	4/6/72

ALL SURFACES MARKED "X" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-303

NAME: BASE, ENGRAVED

MATERIAL: AS PER DWG 842-100-301

PROJECT NO.

DRAWN BY: W. GANNON

DATE: 3-31-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-302 B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

DO NOT SCALE DRAWING

842-100-303-A

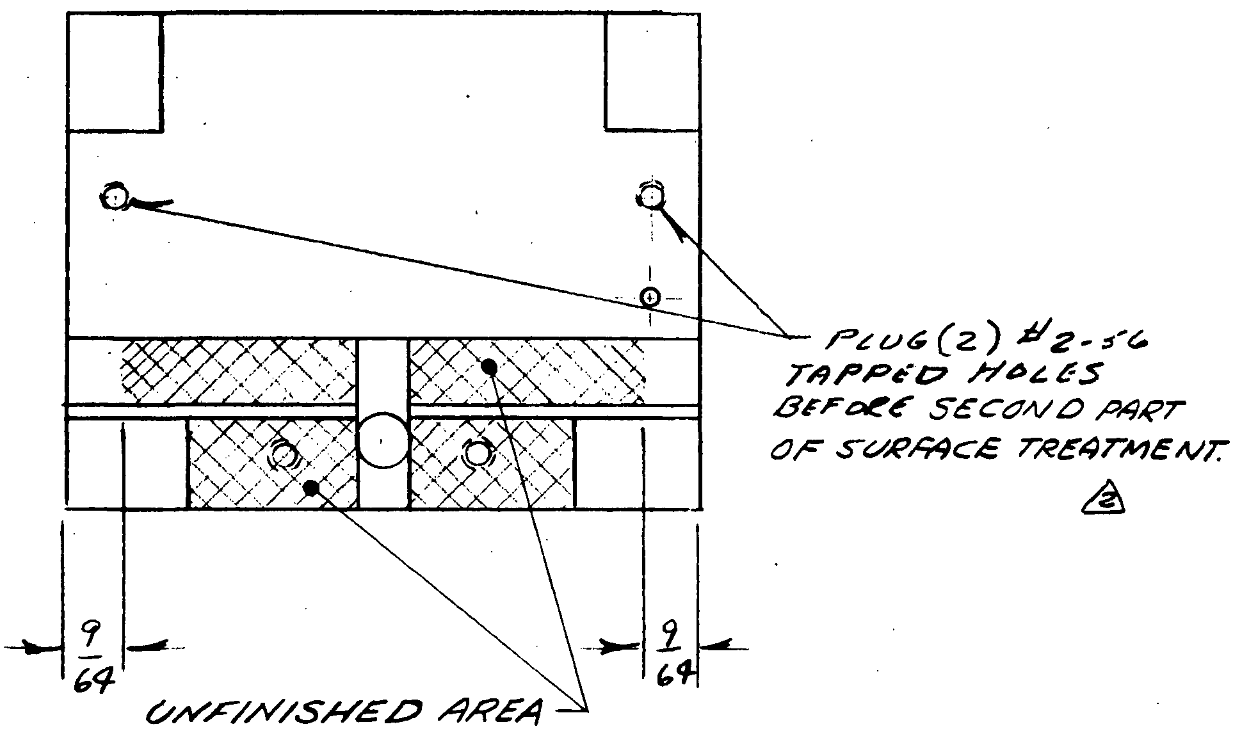
REVISIONS

A	1	NOTE-WAS SPEC Q-C320 FOR FIN.
	2	SURFACE TREATM. WAS PLATING
	3	NAME-WAS SURFACE FINISH BASE
	4	-302 WAS 301

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTE

FINISH SURFACE OF PART 842-100-302 AS PER DWG. 842-400-027. MASK AREA SHOWN AS CROSS HATCHED FOR SECOND PART OF SURFACE FINISHING. (1)



13 APR 72
13 APR 72
13/4/72
4/13/72

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-312

NAME	MATERIAL (4)	PROJECT NO.
BASE, SURFACE FINISHED (3)	AS PER DWG 842-100-302	

DRAWN BY W. GANNON

DATE 3-27-72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-100-303-A

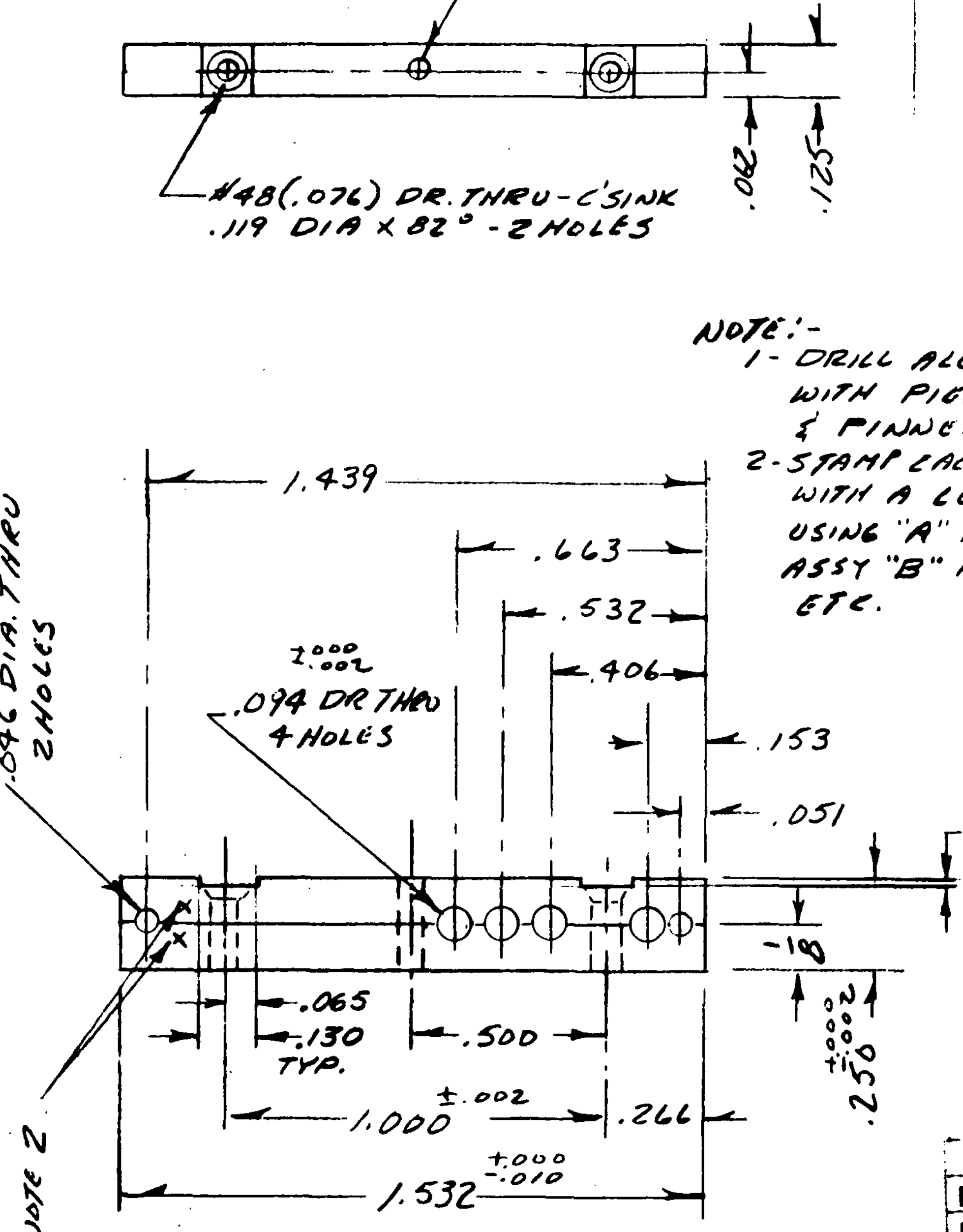
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1
DO NOT SCALE DRAWING			

842-100-304-A

REVISIONS

A CN1033 △ ADDED SLOTS EGAR 2-8-73

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



NOTE:-
1- DRILL ALL OTHER HOLES WITH PIECES ASSEMBLED & PINNED
2- STAMP EACH PIECE OF ASSY WITH A LETTER IDENTIFICATION USING "A" FOR THE FIRST ASSY "B" FOR THE SECOND ETC.

PIECES TO REMAIN ASSEMBLED AFTER FABRICATION

APPROVAL	DATE
ENG.	7 APR 72
PROD.	7 APR 72
QA	4/7/72
MGMT.	4/13/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-305

NAME: CABLE CLAMP

MATERIAL: AS PER 842-400-002

PROJECT NO.

DRAWN BY W. GANNON

DATE 4-5-72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-100-304-A

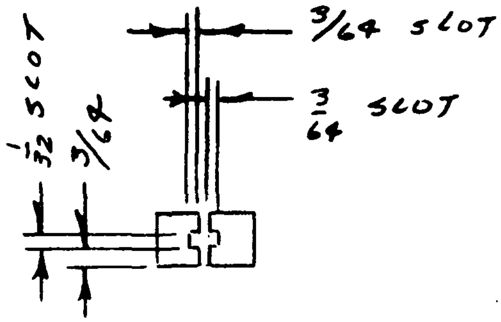
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

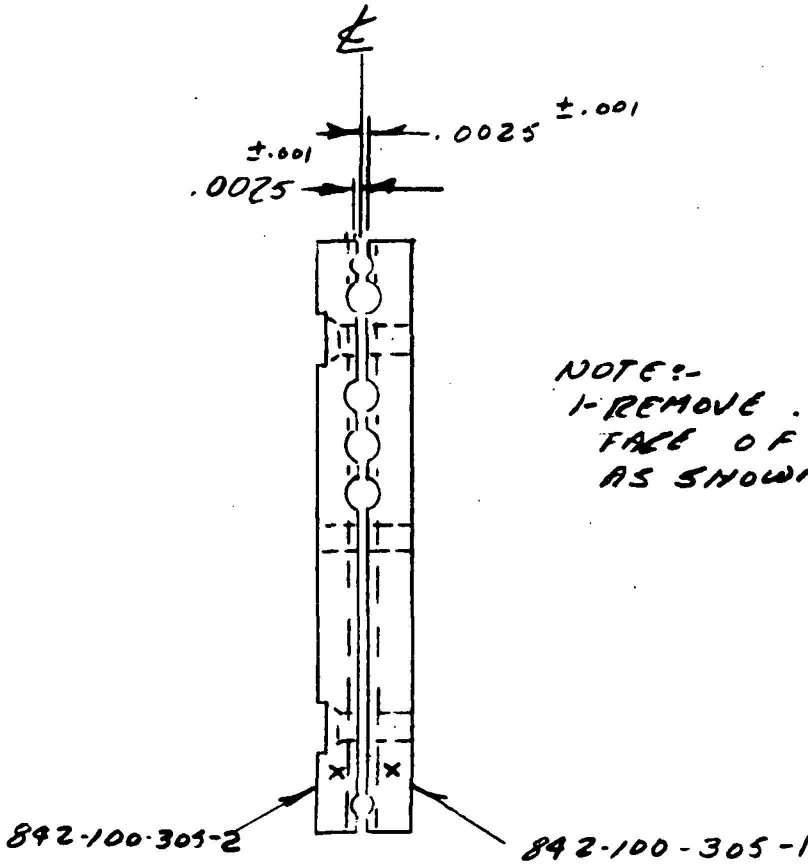
DO NOT SCALE DRAWING

842-100-305-A

REVISIONS	
A	△1 -316 WAS -307 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED





NOTE:-
1- REMOVE .0025 ±.001 FROM INNER FACE OF EACH PIECE AS SHOWN

APPROVAL		DATE
ENG.	[signature]	7APR72
PROD.	[signature]	7APR72
QA	[signature]	4/7/72
MGMT.	[signature]	4/13/72

ALL SURFACES MARKED "√" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-316 △1

NAME	MATERIAL	PROJECT NO.
CABLE CLAMP, FINAL MACHINED	AS PER DWG 842-100-304	

DRAWN BY W. GARDNER
DATE 4-7-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-305-A

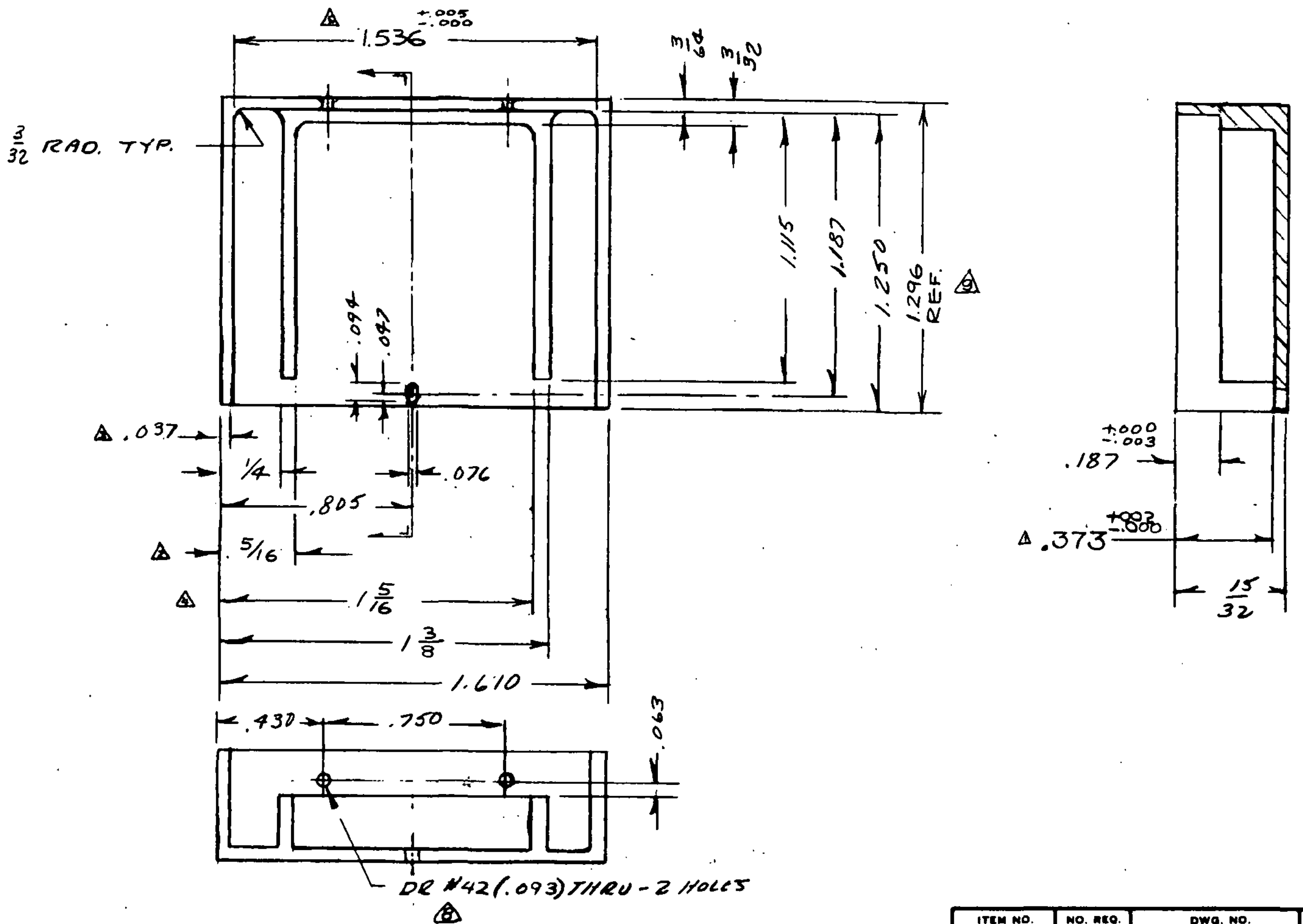
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.003	ANGULAR ±1/2°	2:1
DO NOT SCALE DRAWING			

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-306-C

REVISIONS

A	⚠ .373 DIM. WAS 13/32 REDUCED SHOULDER HGT. FLUSH TO TOP ⚠2 5/16 WAS .305 ⚠3 .037 WAS .030 ⚠4 1 5/16 WAS 1.000 ±.002 TO 5/16 SHOULDER ⚠5 1.536 +.005 -.000 WAS 1.581 ±.005 REF. TO L.H. EDGE 11 MAY 72
B	⚠6 NEXT ASSY WAS -307-3 ⚠7 MATERIAL WAS 842-100-002
C	CN1034 ⚠8 WAS #50 (.070) ⚠9 ADDED FOR REF. 2.8.73



APPROVAL		DATE
ENG.		21 Apr 72
PROD.		21 Apr 72
QA		4/25/72
MGMT.		4/25/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-307

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: BOTTOM COVER	MATERIAL: AS PER. 842-400-002	PROJECT NO.
DRAWN BY: W. GANNON DATE: 3-28-72	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-306-C

R.B.

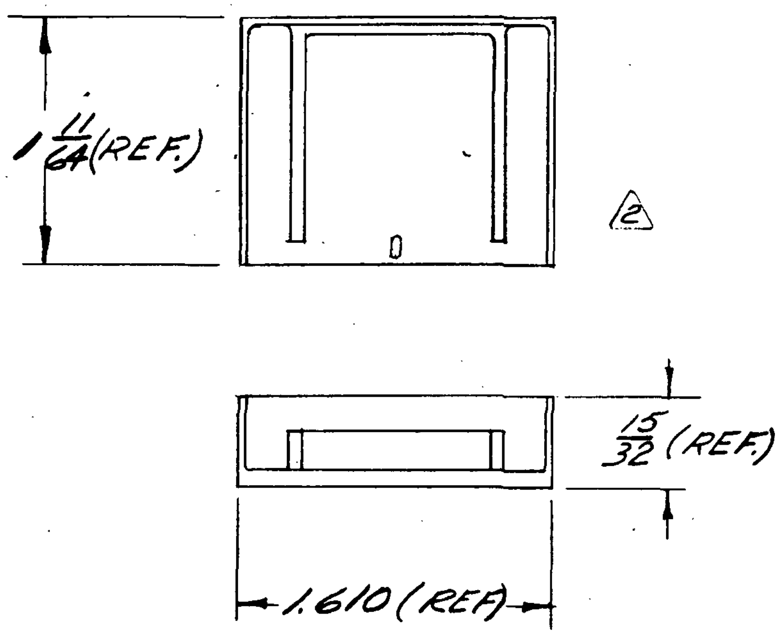
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	FULL

DO NOT SCALE DRAWING

842-100-307-A

REVISIONS	
A	(1) REMOVE TABLE (2) ADDED PICTURE & REF. DIM. (3) NAME WAS SURFACE FINISH (4) ADDED NEXT ASSY NO. (5) FINISH SPEC. WAS QC-320 CHROME PLATE 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



NOTE
FINISH EXTERIOR SURFACE
OF PART 842-100-306 AS
PER DWG. 842-400-027 (5)

APPROVAL		DATE
ENG.	[signature]	7 APR 72
PROD.	[signature]	7 APR 72
QA	[signature]	4/7/72
MGMT.	[signature]	4/13/72

ALL SURFACES MARKED "✗" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY (4)
842-100-604

NAME	MATERIAL	PROJECT NO.
BOTTOM COVER, SURFACE FINISHED (3)	842-100-306	

DRAWN BY W. GANNIN
DATE 3-27-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-307-A

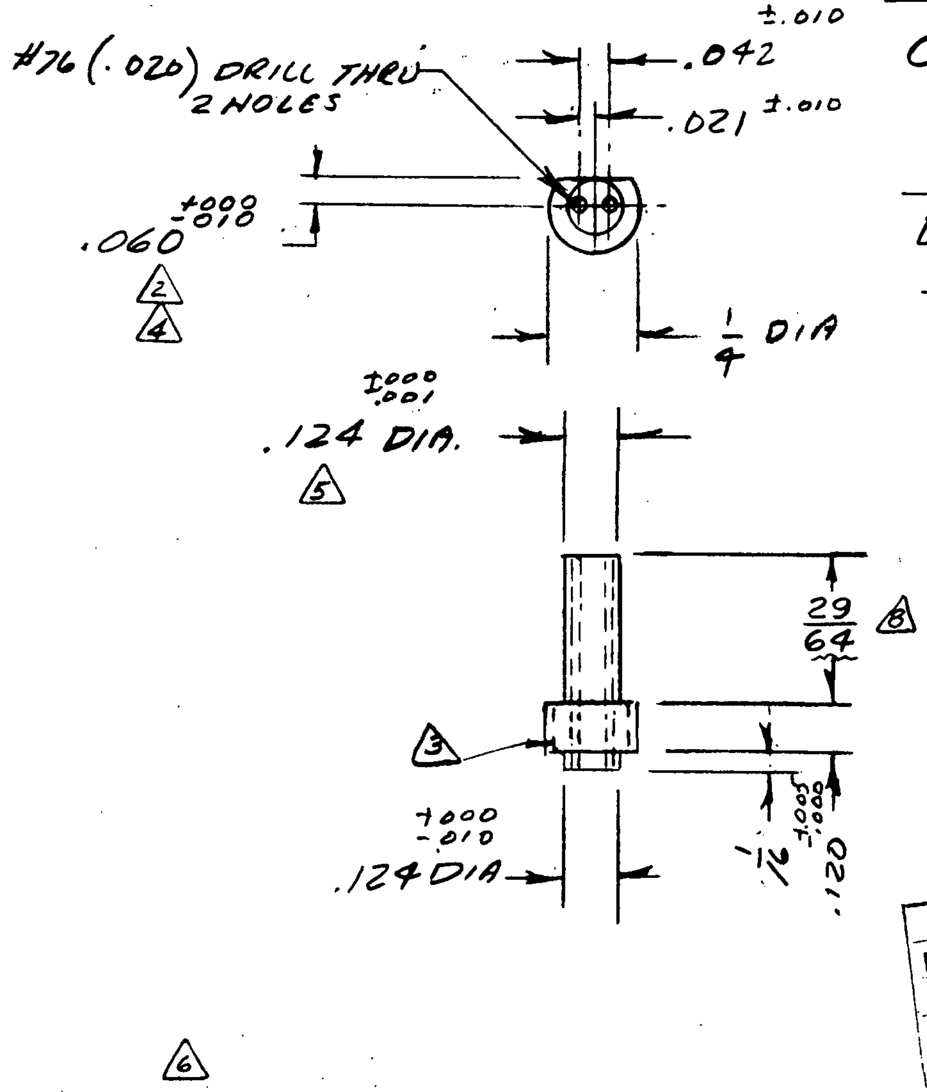
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

DO NOT SCALE DRAWING

842-100-308-D

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

	REVISIONS
A-	1 NEXT ASSY. WAS 842-100-310 3-28-72 WG
B-	2 .062 +.000 -.010 WAS .062 3 INSERTED EDGE LINE OF FLAT FACE ON LOWER VIEW 4-12-72 WG
C	4 .060 WAS .062 5 .124 WAS .125 6 REMOVE MAT: SPEC. TEFLON ROD MIL P19468A 7 ADDED MAT: DWG. NO. 14JUL72
D	CN 1035 EGAR 2-8-73 8 WAS 27/64



APPROVAL	DATE
ENG.	22MAR72
PROD.	3/13/72
QA EDH	3/23/72
MGMT.	3/23/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY
1 842-100-312

NAME	MATERIAL	PROJECT NO.
INSULATOR, STRAIN GAGE LEADS	AS PER 7 842-400-016	

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-100-308-D
DATE 2-17-72		

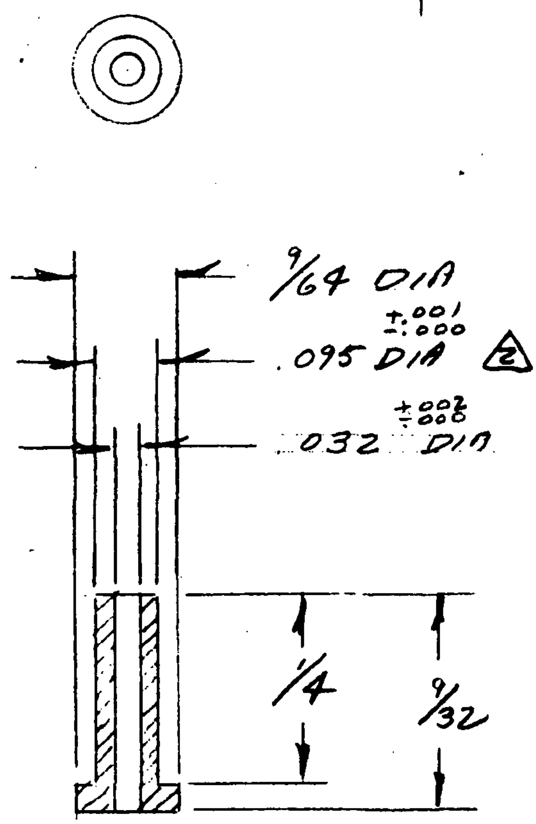
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	4:1

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

842-100-309C

	REVISIONS
A-	(1) NEXT ASSY NO WAS 842-100-310 3-28-72 WG
B-	(2) .095 +.001 -.000 WAS .0934 +.000 -.001 DIA 4-12-72 WG
C	(3) REMOVED MAT. MIL-P-1948-8A (4) ADDED MAT. NO. 14 JUL 72



(3)

APPROVAL	DATE
ENG.	22 MAR 72
PROD.	3/23/72
QA	3/23/72
MGMT.	3/23/72

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
(1) 842-100-312

NAME: INSULATOR, TRANSDUCER LEAD

MATERIAL (4): AS PER DWG 842-400-016

PROJECT NO.

DRAWN BY: W. GANDON

DATE: 2-18-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-309C

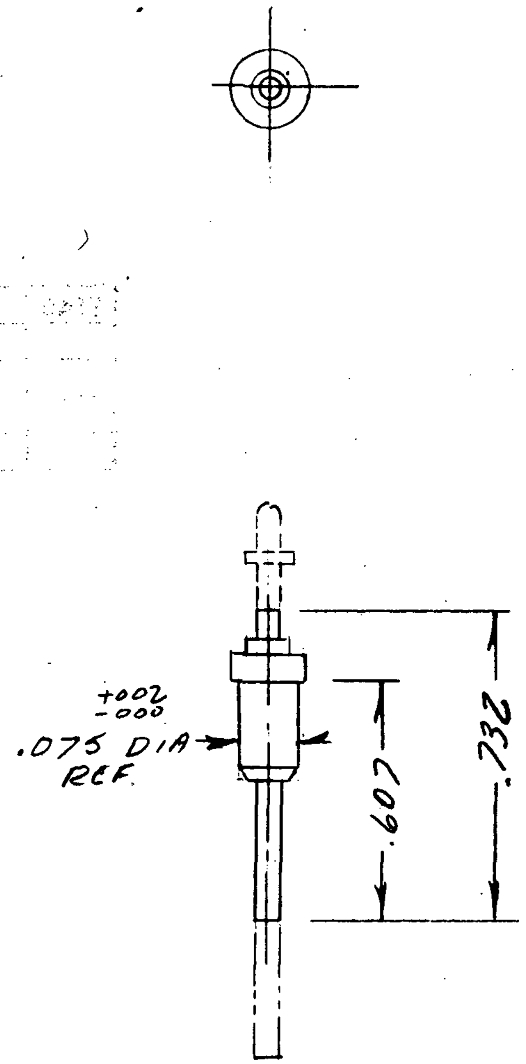
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE

DO NOT SCALE DRAWING

842-100-310-B

	REVISIONS
A-	△1 NEXT ASSY. NO WAS 842-100-310 3-28-72 WG
B 14 JUL 72	△2 NAME WAS "INSULATOR" △3 ADDED REMOVED PORTION IN DASH LINE

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



APPROVAL	DATE
ENG.	22 MAR 72
PRE	3/23/72
QA EDH	3/23/72
MGMT. VB	3/23/72

ALL SURFACES MARKED "ƒ" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
△1 842-100-312

NAME TRANSDUCER LEAD FEED-THRU, MODIFIED

MATERIAL AS PER DWG 842-400-015

PROJECT NO.

DRAWN BY W. GANNON

DATE 2-15-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

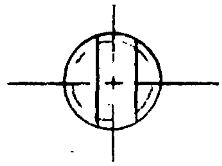
842-100-310-B

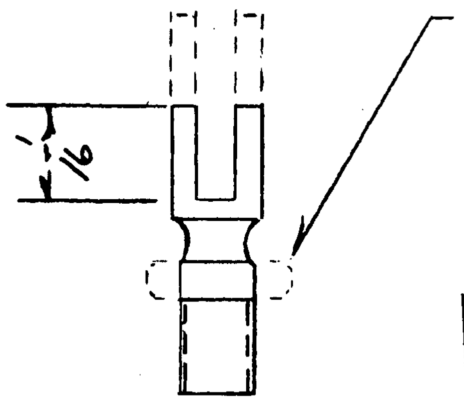
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	8:1
DO NOT SCALE DRAWING			

842-100-311-B

	REVISIONS
A-	⚠1 NEXT ASSY NO WAS 842-100-310 3-28-72 WG
B	⚠2 NAME ADDED "MODIFICATION" 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED





APPROVAL	DATE
ENG. [signature]	22 MAR 72
PROD. [signature]	3/23/72
QA EDH	3/23/72
MGMT. [signature]	3/23/72

ALL SURFACES MARKED "f" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
⚠1 842-100-312

NAME	MATERIAL	PROJECT NO.
GROUND TERMINAL, MODIFIED ⚠2	AS PER DWG 842-400-007	

DRAWN BY W. GANNON

DATE 3-18-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-311-B

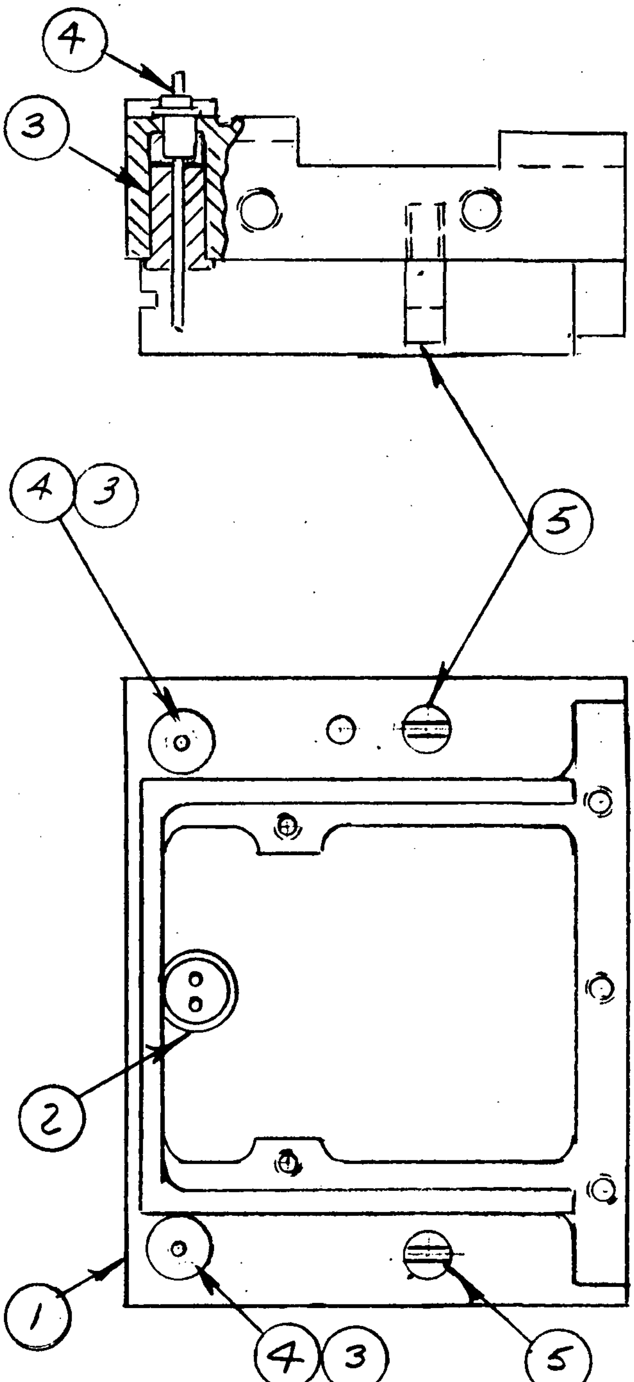
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

DO NOT SCALE DRAWING

842-100-312
PAGE 1 OF 2

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



PARTS LIST		
ITEM NO.	NO. REQ	PART NO
1	1	842-100-303
2	1	842-100-308
3	2	842-100-309
4	2	842-100-310
5	2	842-100-311

APPROVAL		DATE
ENG.	[signature]	9 FEB 73
PROD	[signature]	9 FEB 73
QA	[signature]	2/9/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-602

NAME: BASE ASSEMBLY

MATERIAL: AS NOTED

PROJECT NO.

DRAWN BY: W. GAWNIAN

DATE: 3-31-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-312
PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/4°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES:

1. Clean all parts as per 842-300-101-1, paragraphs 1.2.1 thru 1.2.8. Air dry parts at 100°C for 15 minutes after cleaning. Subsequent to cleaning handle all parts with clean tools or gloved hands.

2. Items shall be assembled in the order shown on the parts list.

3. Items 2 thru 4 shall be inserted to seat on shoulders as shown in figure.

4. Item 5 shall be inserted such that no spreading of the slotted section occurs and tightened to a torque of 1.2 inch-pounds.

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
BASE ASSEMBLY		

DRAWN BY RB

DATE 4/20/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

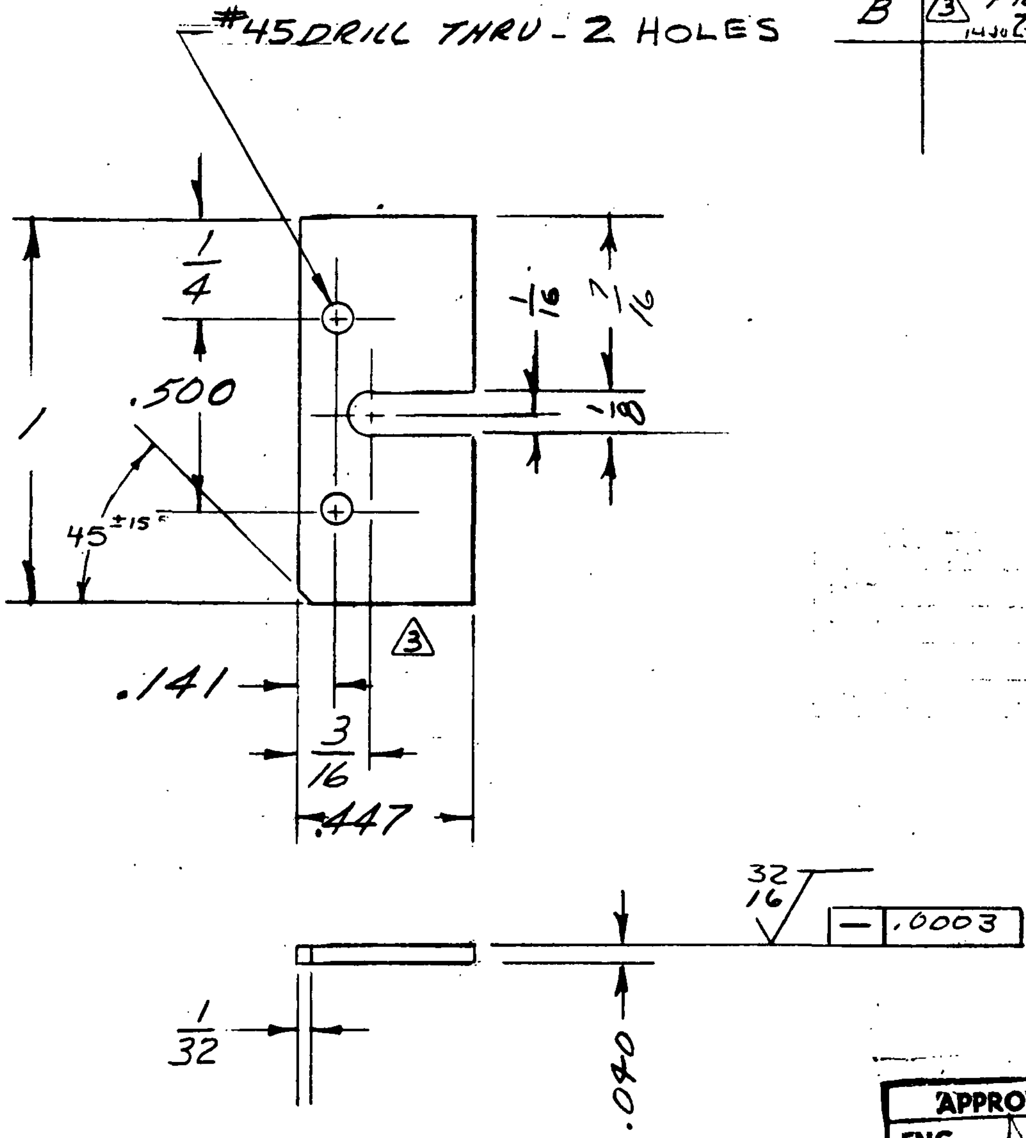
DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

(1) 842-100-313-B

REVISIONS

A	(1) DWG. NO WAS 842-100-304 (2) NEXT ASSY NO WAS 842-100-401 3-28-72 WG
B	(3) PICTURE BROUGHT TO SCALE 14JUN72



MAT'L:-
IRON-NICKEL ALLOY PER DWG 842-400-002

APPROVAL	DATE
ENG. [signature]	23 MAR 72
PROD. [signature]	3/23/72
QA [signature]	3/23/72
MGMT [signature]	3/23/72

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY (2) 842-100-314

NAME	MATERIAL	PROJECT NO.
CLAMP PLATE	SEE NOTE	

DRAWN BY W GANNON
DATE 2-17-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-313-B (1)

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1

DO NOT SCALE DRAWING

842-100-314 A

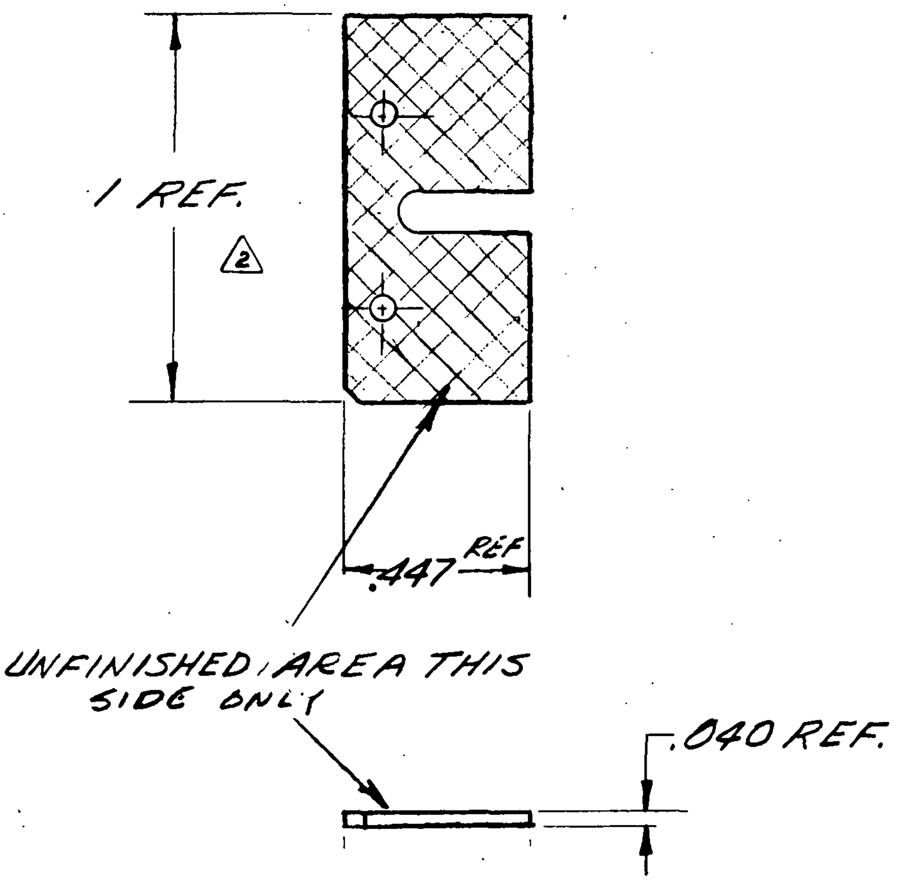
REVISIONS

A	(1) FIN: WAS MIL. QC 320 (2) ADDED REF. DIM. (3) NAME WAS REARRANGED 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTE

1-FINISH SURFACE OF PART 842-100-313 AS PER DWG. 842-400-027 MASK AREAS SHOWN AS CROSS HATCHED (1) FOR SECOND PART OF SURFACE FINISHING



APPROVAL	DATE
	13Apr72
PROD.	13Apr72
QA	4/13/72
MGMT.	4/13/72

ALL SURFACES MARKED "x" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-602

NAME (3)	MATERIAL	PROJECT NO.
CLAMP PLATE, SURFACE FINISHED	AS PER DWG 842-100-313	

DRAWN BY W. GANNON

DATE 3-27-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

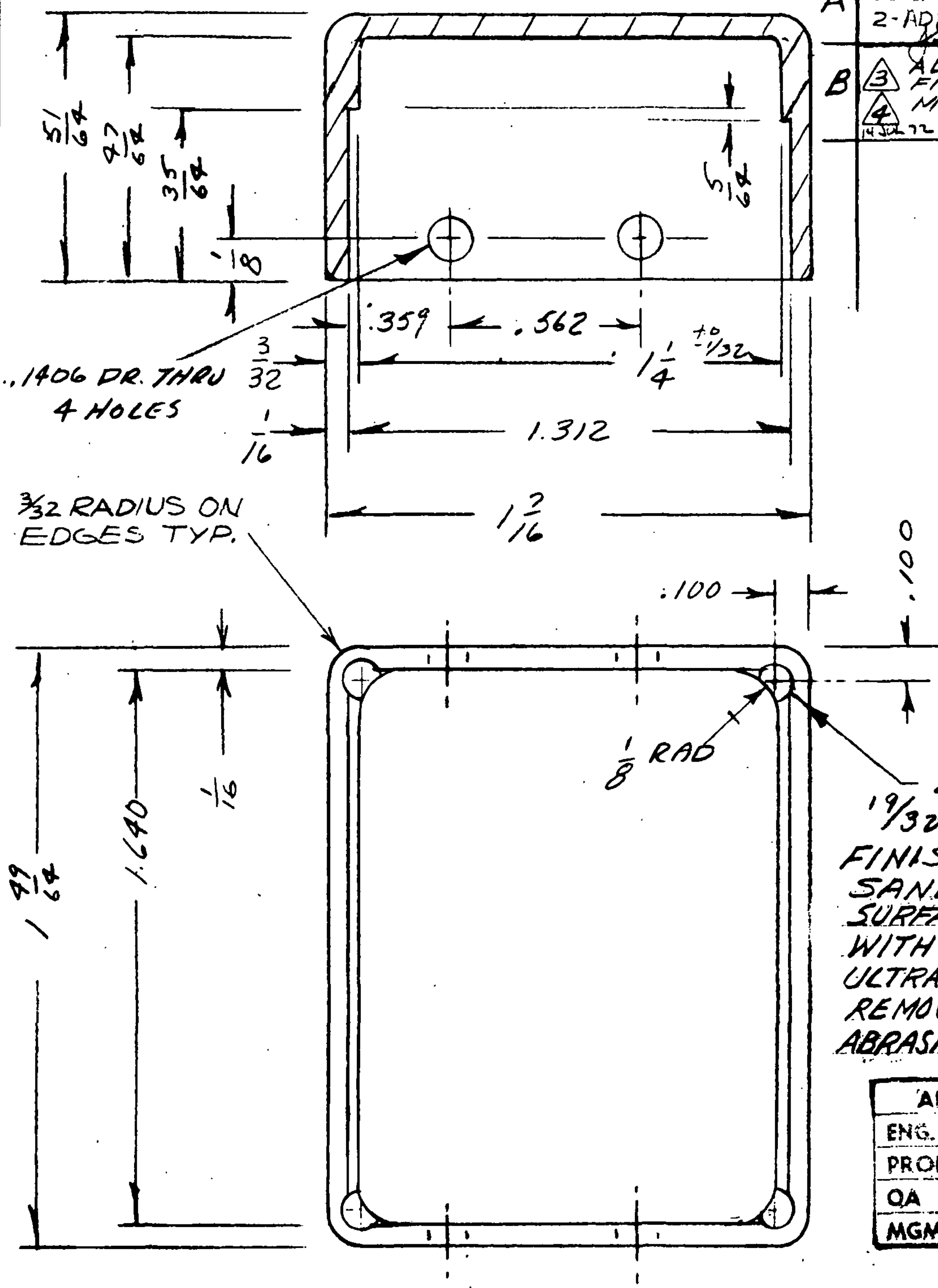
842-100-314-A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1
DO NOT SCALE DRAWING			

842-100-315-B
PAGE 1 OF 1

REVISIONS	
A	1- REMOVE HIDDEN LINES 2- ADD NOTE - 3/32 RADIUS 11 MAY 72
B	(3) ADDED DETAIL TO FIN. NOTE (4) MAT: WAS 2024 T4 ALUMINUM 14 JUL 72

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



FINISH (3)
SAND BLAST ENTIRE SURFACE AND CLEAN WITH ACETONE IN ULTRASONIC BATH TO REMOVE ALL TRACES OF ABRASIVE PARTICLES

APPROVAL	DATE
ENG.	21 Apr 72
PROD.	21 Apr 72
QA	4/25/72
MGMT.	4/25/72

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-603

NAME	MATERIAL (4)	PROJECT NO.
TOP COVER	AS PER DWG 842-400-011	

DRAWN BY W. GANNON
DATE 2-18-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-315-B
PAGE 1 OF 1

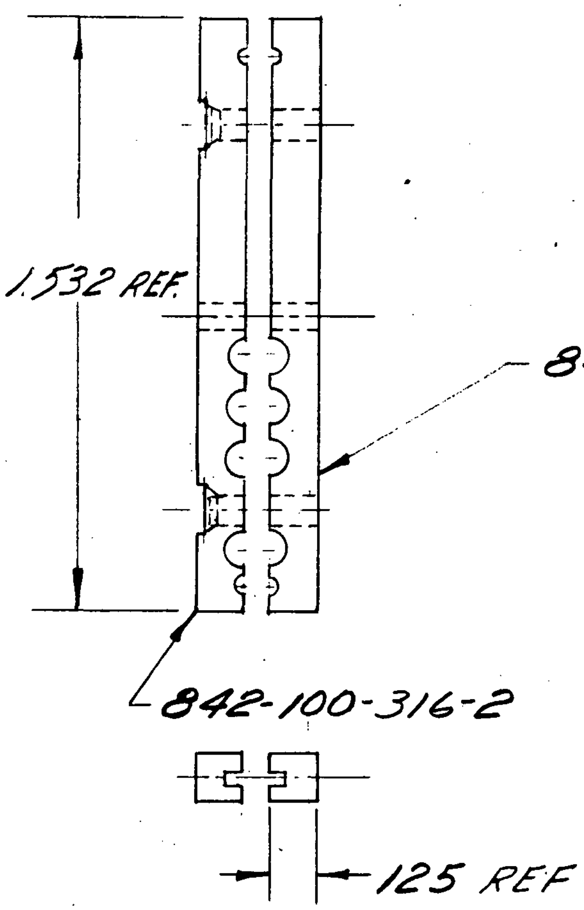
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE

842-100-316

DO NOT SCALE DRAWING

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



NOTE
FINISH ENTIRE SURFACE
OF PART 842-100-305
AS PER 842 400 027

APPROVAL	DATE
ENG.	9FEB73
PROD.	9FEB73
QA	2/9/73
MGMT.	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
342-100-604

NAME
CABLE CLAMP, SURFACE FINISHED

MATERIAL
AS PER DWG
842-100-305

PROJECT NO.

DRAWN BY RB Kosten

DATE 7-14-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-316

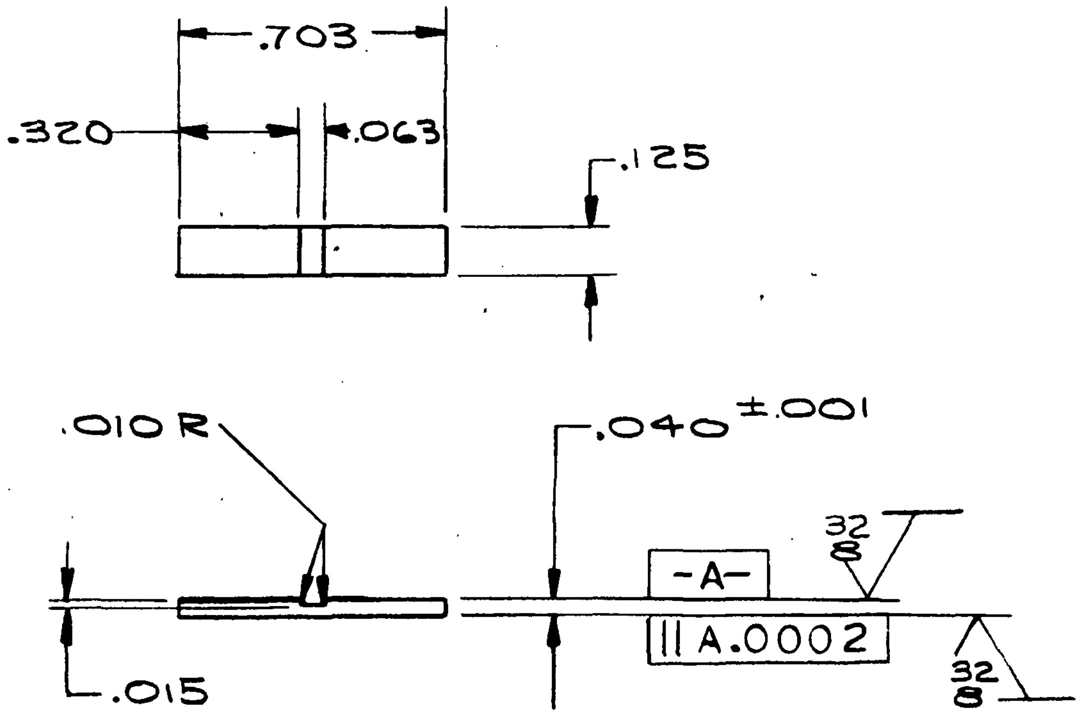
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-401B

REVISIONS	
B	REDRAWN CN 1045



NOTES

1. CHIPS SHALL BE NO LARGER THAN 1/64

2. MATL: AS PER 842-400-006

APPROVAL		DATE
ENG	[signature]	4 Apr 73
PROD	[signature]	4 Apr 73
QA	[signature]	3/30/73
MGMT	[signature]	3/30/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-406-1

NAME	MATERIAL	PROJECT NO.
BOTTOM RIB	NOTE 2	

DRAWN BY BOUDROT

DATE 22 MAR 72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

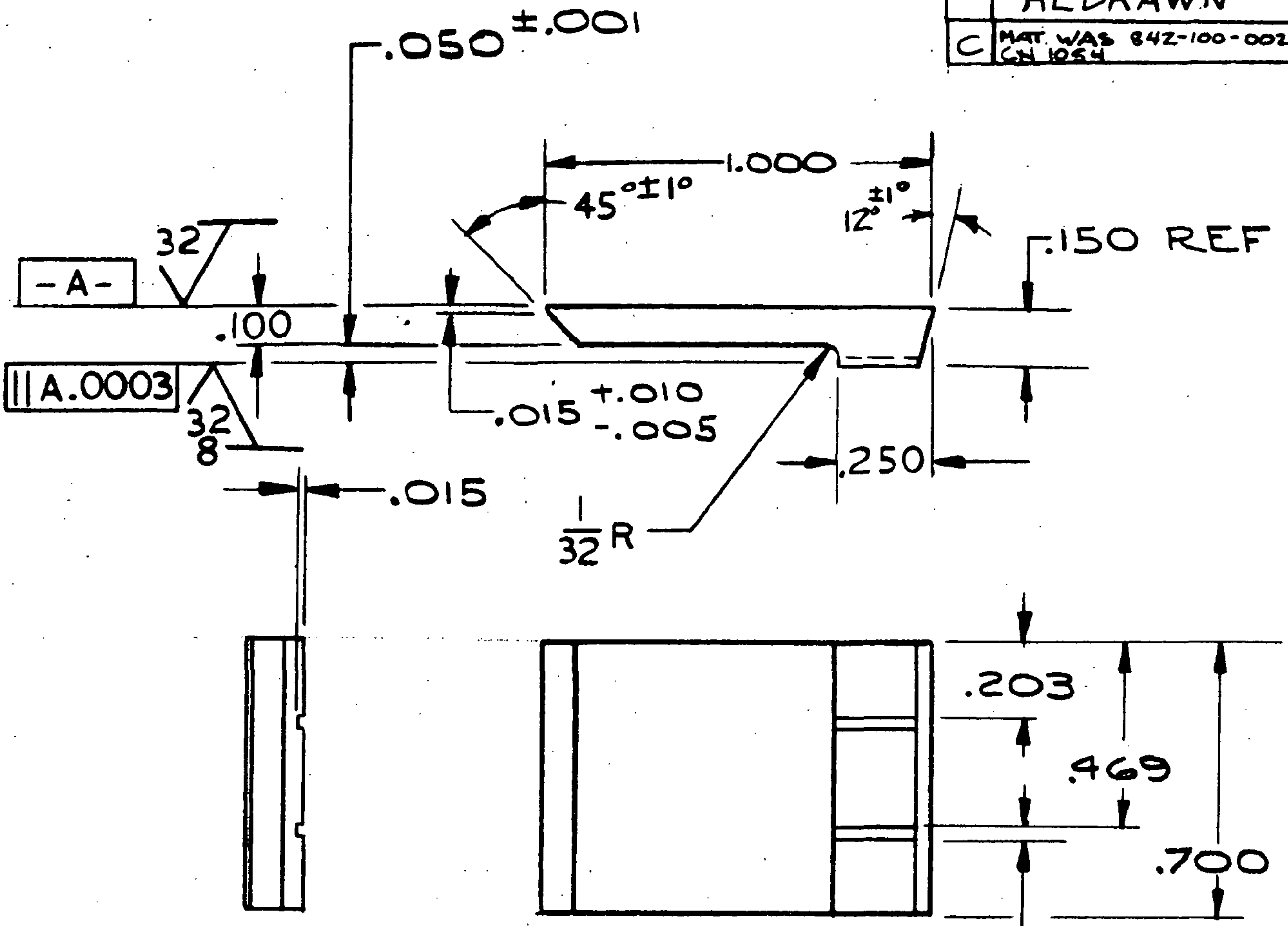
842-100-401B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2X
DO NOT SCALE DRAWING			

842-100-402C

REVISIONS	
B	CN 1044 REDRAWN
C	MAT. WAS 842-100-002 CN 1054

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



APPROVAL	DATE
ENG. [signature]	4/2/73
PROD. [signature]	4/2/73
QA [signature]	3/30/73
MGMT. [signature]	3/30/73

NOTE

1. FINISHED PART MUST HAVE NO CHIPS WITH A MAXIMUM DIMENSION GREATER THAN .020 AND NO CRACKS

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-403

NAME	MATERIAL	PROJECT NO.
MIRROR, BLANK	842-400-006	

DRAWN BY Boudreau

DATE 3/26/73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-100-402C

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

842-100-403 - B

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

	REVISIONS
A	1 ADDED PICTURE 2 NAME CHANGED 14 JUL 72
B	3 CN1044 CHANGED PROFILE DELETE 3 SLOTS 3·26·73 EGAR

NOTES:

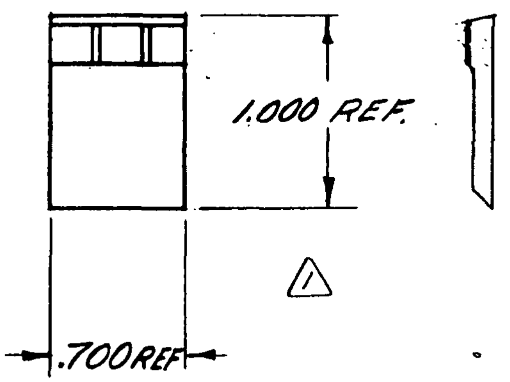
1. This part is to be annealed according to the following annealing schedule. The temperatures given are measured in air within 1/2 inch of the part surface.

1.1 Arrange parts in furnace to obtain minimum temperature gradient across surfaces and raise temperature to 465 $\pm$ 10°C in no less than 1 hour.

1.2 Soak part in annealing furnace at 465 $\pm$ 10°C for at least 1 hour, then lower the temperature at a rate no greater than 3.0°C per hour to 385 $\pm$ 10°C.

1.3 From 385°C lower the temperature at a rate no greater than 7.2°C per hour to 332 $\pm$ 10°C.

1.4 From 332°C lower the temperature at a rate no greater than 90°C per hour to room temperature.



APPROVAL	DATE
ENG. [signature]	2/25/72
PROD. [signature]	2/29/72
QA [signature]	2/29/72
MGMT. [signature]	2/29/72

NEXT ASSEMBLY
842-100-404

ALL SURFACES MARKED " " TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
MIRROR BLANK, ANNEALED 2	842-100-402	[signatures]

DRAWN BY JS

DATE 2/22/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-403 - B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

842-100-404 - B

REVISIONS	
A	△1 ADDED NOTE 2. △2 ADDED PICTURE △3 NAME CHANGED
B	△4 CN 1044 CORRECTED PROFILE DELETED 3 SLOTS. 3-26-73 EGAR

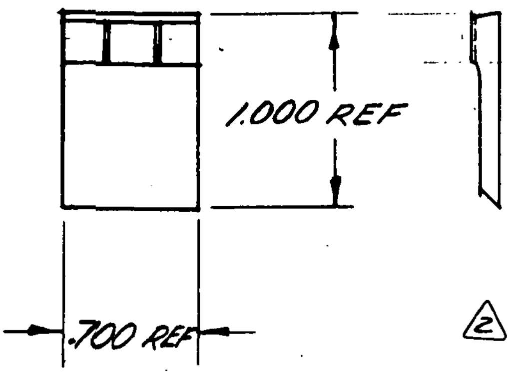
REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES:

1. Polish 0.7 x 1.0 surface such that the peak-to-peak deviations from a flat plane do not exceed 3.6 microinches (λ/6.5 at helium wavelength 587.6 nm).

2. CLEAN PART BY SOAKING IN CONCENTRATED SULFURIC ACID TO DIGEST ALL TRACES OF POLISHING COMPOUND. NEUTRALIZE ACID IN DILUTE SODIUM HYDROXIDE SOLUTION AND RINSE IN RUNNING WATER. △1

3. SURFACE FINISH SCRATCH AND DIG TO BE 60-40 AS PER MIL-0-13830



APPROVAL	DATE
ENG. [signature]	2/29/72
PROD. [signature]	2/29/72
QA [signature]	2/29/72
MGMT. [signature]	2/29/72

NEXT ASSEMBLY
842-100-405

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
[illegible], MIRROR BLANK, POLISHED △3	842-100-403	[initials]

DRAWN BY JS

DATE 2/22/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-404 - B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2:1
DO NOT SCALE DRAWING			

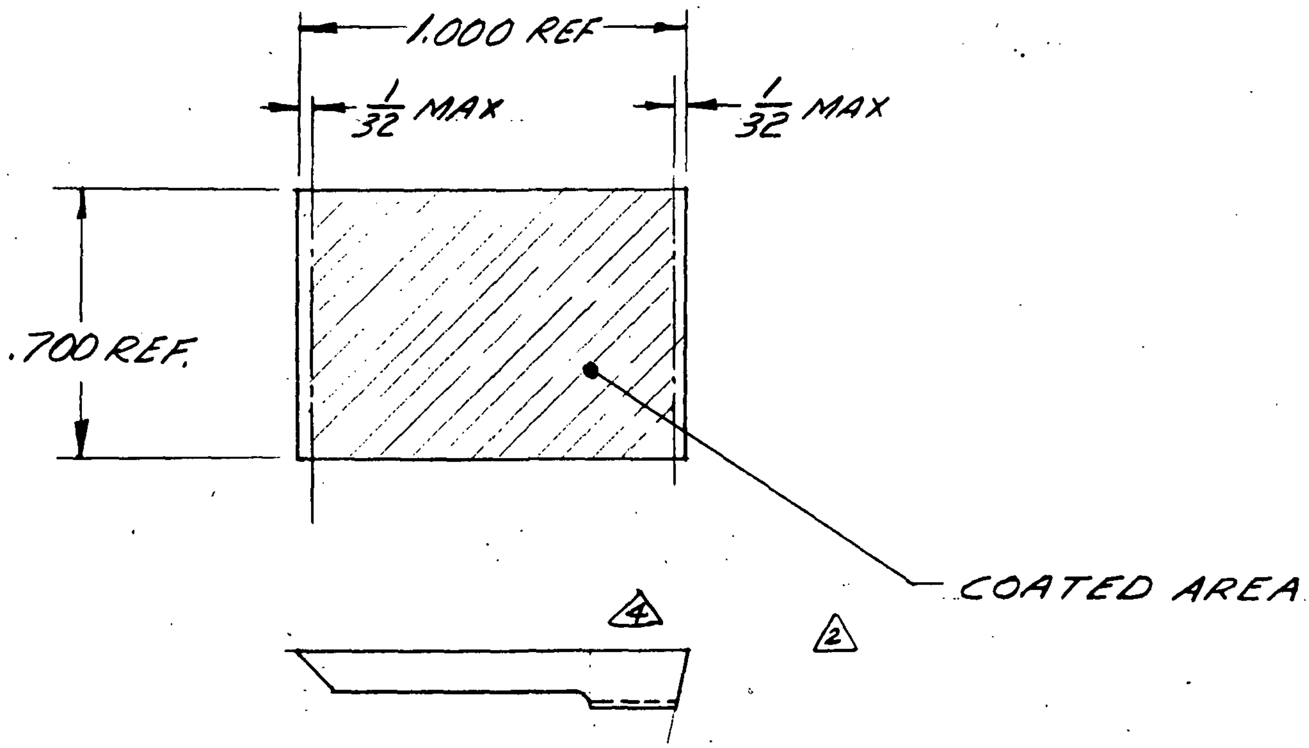
842-100-405 - B

REVISIONS	
A	1 ADDED VIEW
	2 NAME CHANGE
	3 WAS PROTEC. SILVER 14 JUL 72
B	4 CN 1044 CORRECTED PROFILE 3·26·73 EGAR

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES:

1. Mirror substrate to be coated with a REFLECTIVE (3) layer as per 842-400-030.



APPROVAL	DATE
ENG. JS	2/29/72
PROD. SR	2/29/72
QA EDH	2/29/72
MGMT. VB	2/29/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY 842-100-603

NAME	MATERIAL	PROJECT NO.
(2) MIRROR	842-100-404	JS EDH VB SR

DRAWN BY JS

DATE 2/22/72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-100-405 - B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1
DO NOT SCALE DRAWING			

842-100-406-B

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

	REVISIONS
A	(1) ADD FIG. (2) WAS ANNEALING MIRROR BACKUP PLATE 14 JUL 72
B	CN 1045 ADDED -2

NOTES

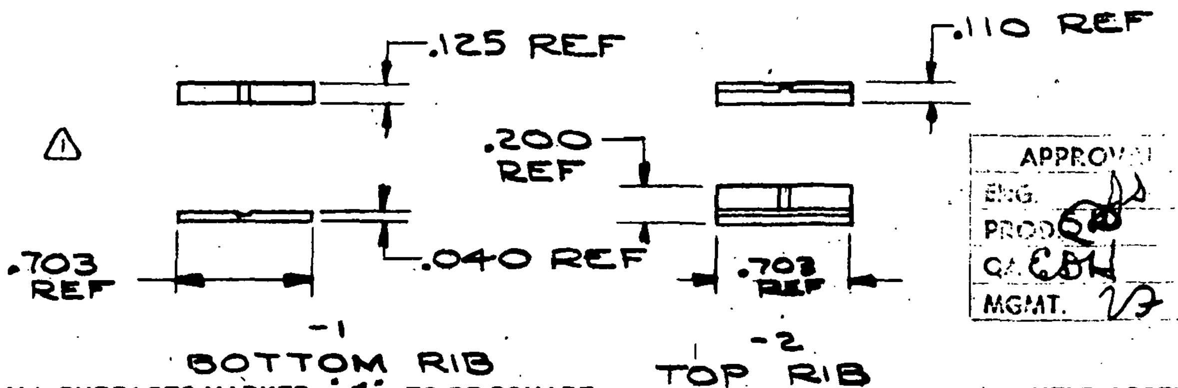
1. This part is to be annealed according to the following annealing schedule. The temperatures given are measured in air within 1/2 inch of the part surface.

1.1 Arrange parts in furnace to obtain minimum temperature gradient across surfaces and raise temperature to 465 $\pm$ 10°C in no less than 1 hour.

1.2 Soak part in annealing furnace at 465 $\pm$ 10°C for at least 1 hour, then lower the temperature at a rate no greater than 3.0°C per hour to 385 $\pm$ 10°C.

1.3 From 385°C lower the temperature at a rate no greater than 7.2°C per hour to 332 $\pm$ 10°C.

1.4 From 332°C lower the temperature at a rate no greater than 90°C per hour to room temperature.



APPROVAL		DATE
ENG.	[signature]	3/9/72
PROD.	[signature]	3/9/72
QA	CBH	3/9/72
MGMT.	[signature]	3/9/72

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-601

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
RIB, ANNEALED (2)	842-100-401 842-100-407	

DRAWN BY RB

DATE 3/8/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

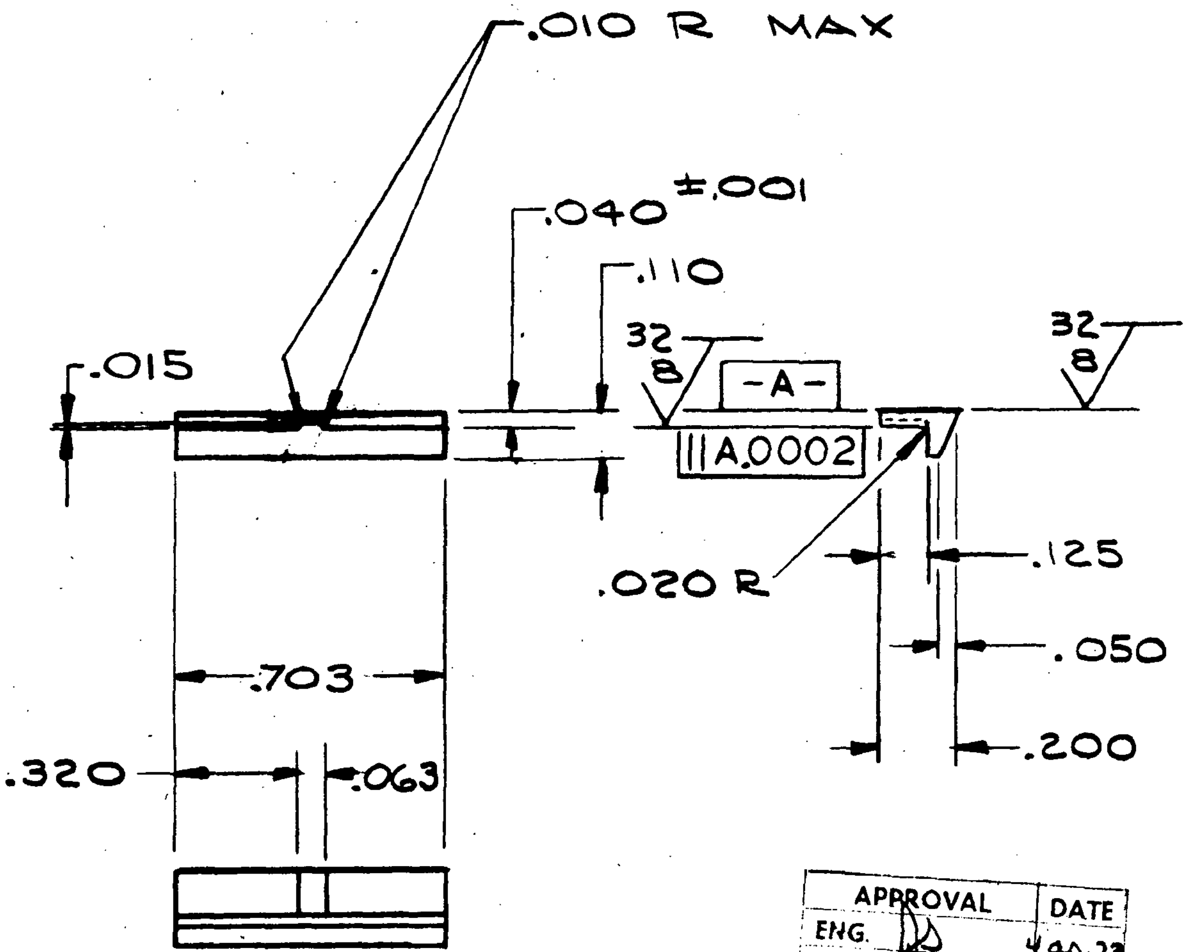
842-100-406-B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE
DO NOT SCALE DRAWING			

842-100-407

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



APPROVAL	DATE
ENG.	4/2/73
PROD.	4/2/73
QA	3/30/73
MGMT.	3/30/73

NOTE

1. CHIP SHALL BE NO LARGER THAN $\frac{1}{64}$
2. MATL: AS PER 842-400-006

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-406-2

NAME	MATERIAL	PROJECT NO.
TOP RIB	NOTE 2	

DRAWN BY BOUDROT

DATE 22 MAR 73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-407

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	3:1

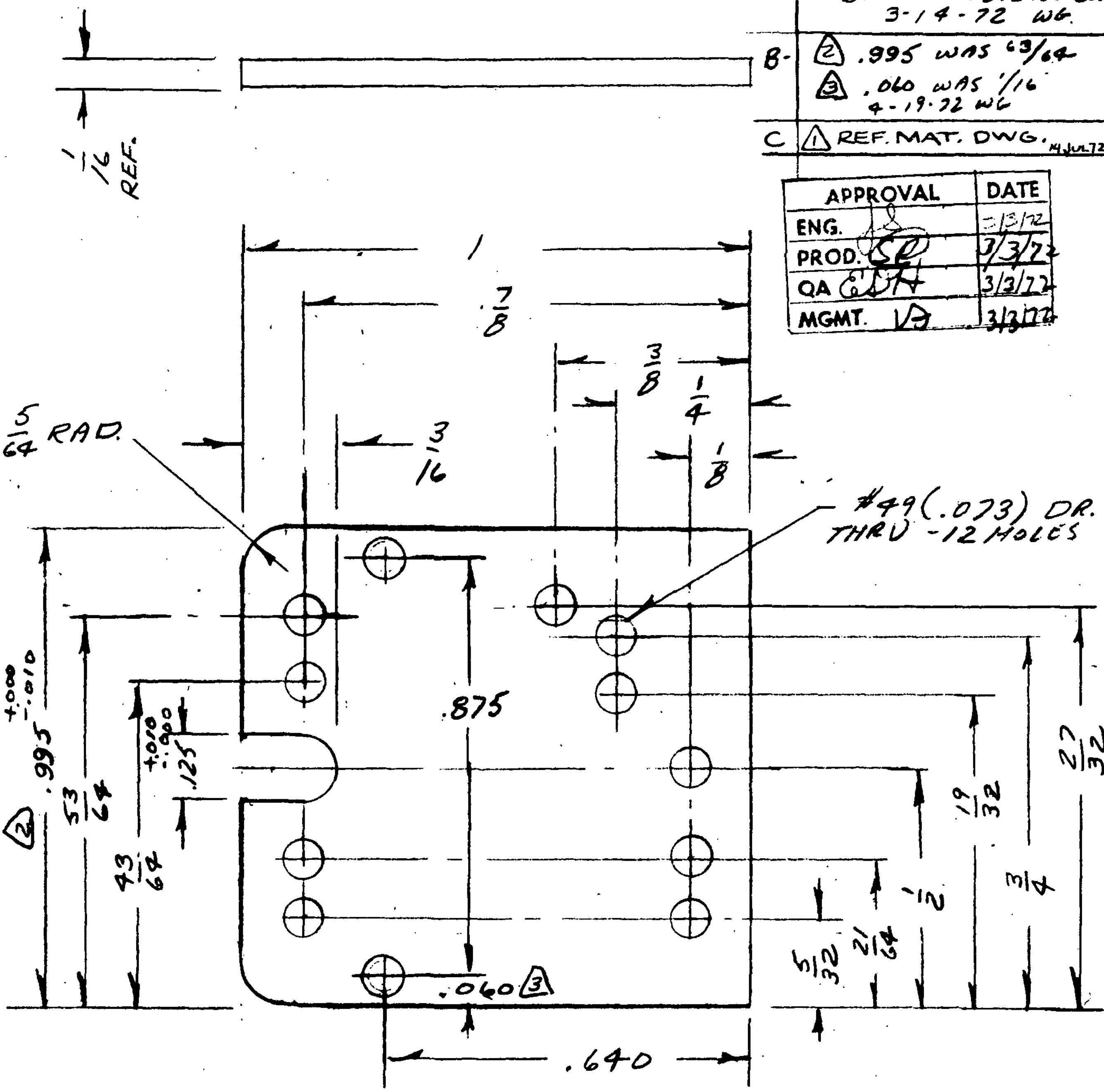
DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

842-100-501-C

REVISIONS	
A	△ REDESIGN TO INTERFACE WITH CHANGES ON BASE DWG 842-100-301 3-14-72 WG
B	△2 .995 WAS 63/64 △3 .060 WAS 1/16 4-19-72 WG
C	△1 REF. MAT. DWG. 14 JUL 72

APPROVAL		DATE
ENG.		3/3/72
PROD.		3/3/72
QA		3/3/72
MGMT.		3/3/72



ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-502

NAME	MATERIAL △4	PROJECT NO.
TERMINAL BOARD	AS PER 842-400-017	

DRAWN BY W. GANNON

DATE 2-2-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

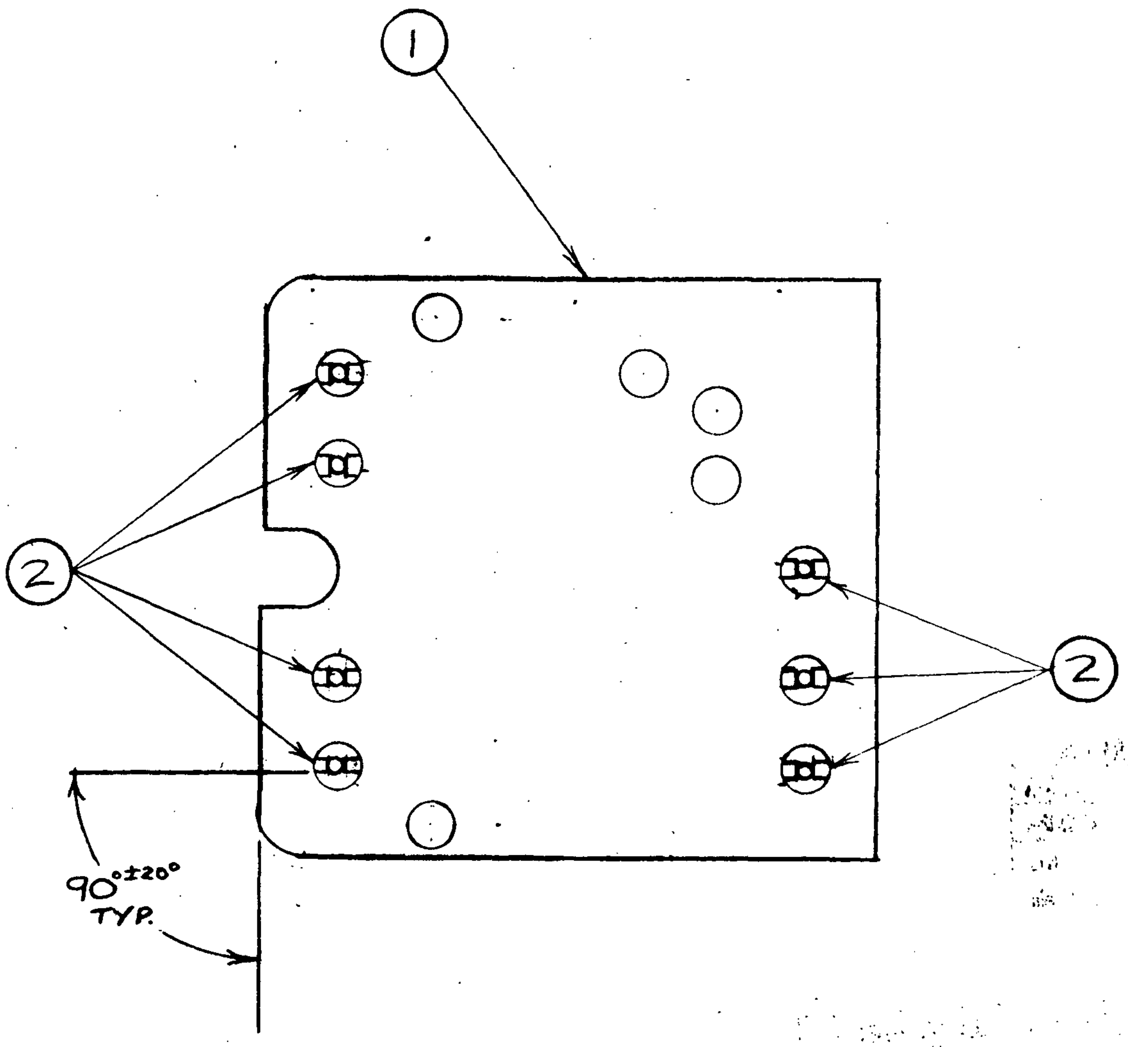
842-100-501-C

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	3:1
DO NOT SCALE DRAWING			

842-100-502
PAGE 1 OF 2

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



ITEM NO.	QUAN REQD	PART NO.	DESCRIPTION
2	7	842-400-013	SOLDER TERMINAL
1	1	842-100-501	TERMINAL BOARD

PARTS LIST

APPROVAL	DATE
ENG.	7FEB73
PROD.	7FEB73
QA	2/9/73
MGMT.	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-503

NAME: TERMINAL BOARD, TERMINALS ASSEMBLED

MATERIAL: AS NOTED

PROJECT NO.

DRAWN BY: W. GANNON

DATE: 2-2-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-502
PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

Notes

1. Swaging tools:
   Anvil - Cambion part #6412
   Rolling punch - Cambion part #6617
   These tools can be used with any Cambion 3800 series swagers or equivalent. (Available from Cambridge Thermionic Corp.)

2. Adjustments:
   Install anvil and rolling punch in swager and align in vertical direction.

   Bring punch down until it just touches anvil.

   Adjust anvil by screwing into plate so that the clearance between the shoulders of the anvil and punch, with punch ram fully extended, is .070 ± .002 inches.

   Lock anvil with set screw. Raise punch.

3. Place solder terminal, forked end down, in anvil and locate in appropriate hole of epoxy board. Before swaging orient each terminal as shown in drawing.

4. Swage terminal by lowering punch to the full extension of the ram.

5. Inspect terminal and reject those not conforming to the following:

5.1 Rotation of the terminals shall not be possible using only unaided finger pressure.

5.2 The swaged end of the terminal shall not be cracked.

5.3 Orientation shall be as in figure.

5.4 The board shall show no evidence of delamination around the terminals as indicated by white spots or lines.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME TERMINAL BOARD, TERMINALS ASSEMBLED	MATERIAL	PROJECT NO.
DRAWN BY JS DATE 7/13/72	GTE LABORATORIES INCORPORATED BAYSIDE RESEARCH CENTER	842-100-502 Page 2 of 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ± 1/64	DECIMALS ± .005	ANGULAR ± 1/2°	~
DO NOT SCALE DRAWING			

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-503 B PAGE 1 OF	
	REVISIONS
A	CN1049 3.27.73 REDRAWN EGAR
B	FIG. B CHANGE L FIG. C CHANGE L CN 1055

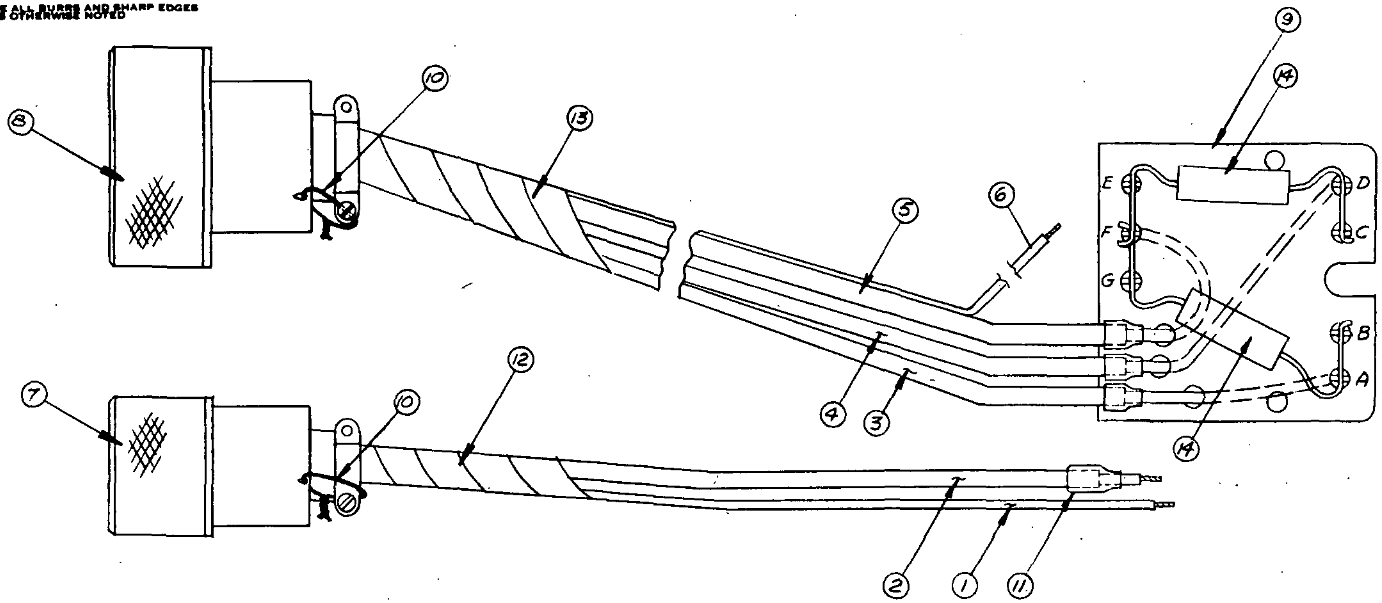


FIGURE A

SEE PAGE 2

18	1 1/4"	TEFLON® FEP TUBING	842-400-012-2
17	11	PLUG, SEALING	842-400-025
16	12"	WIRE, INSULATED	842-400-019
15	4	FERRULE, UNINSULATED	842-400-008
14	2	RESISTOR, PRECISION HERMETIC	842-400-023-1
13	9"	CABLE HARNESS, SPIRAL WRAP	842-400-010-2
12	9"	" " , " "	842-400-010-1
11	1"	TEFLON® FEP TUBING	842-400-012-1
10	A/R	WIRE, COPPER, TINNED	842-400-014-3
9	1	TERMINAL BOARD, TERMINALS ASSEMBLED	842-100-502
8	1	CONNECTOR, STRAIGHT PLUG PINS	842-400-024-1
7	1	" , " " "	842-400-024-2
6	11 5/8"	WIRE, INSULATED	842-400-019
5	11 7/16"	CABLE, ELECTRICAL	842-400-020
4	11 21/32"	" , "	" " "
3	11 1/16"	" , "	" " "
2	12 1/16"	" , "	" " "
1	11 5/8"	WIRE, INSULATED	842-400-019
ITEM NO.	QTY.	ITEM	DWG. NO.

- PARTS LIST -

APPROVAL		DATE
ENG		4/1?/73
PROD		4/1?/73
QA		3/30/73
MGMT	VJ	3/30/73

NEXT ASSEMBLY

842-100-603

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION
NAME: TERMINAL BOARD ASSEMBLY, WIRED	MATERIAL	PROJECT NO.	
DRAWN BY: EGAR	GTE LABORATORIES INCORPORATED	842-100-503B	
DATE: 3.27.73	BAYSIDE RESEARCH CENTER	PAGE 1 OF 6	

TOLERANCE UNLESS OTHERWISE NOTED

FRACTIONS	DECIMALS	ANGULAR	SCALE
± 1/64	±.005	± 1/2°	~

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

CABLE ITEM	QUAN.	LENGTH L	LENGTH S
2	1	12 5/16"	1 5/16"
3	1	12 1/4"	1 1/4"
4	1	12 1/2"	1 1/2"
5	1	12 1/8"	1 1/8"

842-100-503 B
PAGE 2 OF 6

REVISIONS

A CN 1049 REDRAWN 3·27·73 EGAR

B FIG. B CHANGE L, FIG. C CHANGE L, CN 1053

FIGURE B CABLE PREPARATION

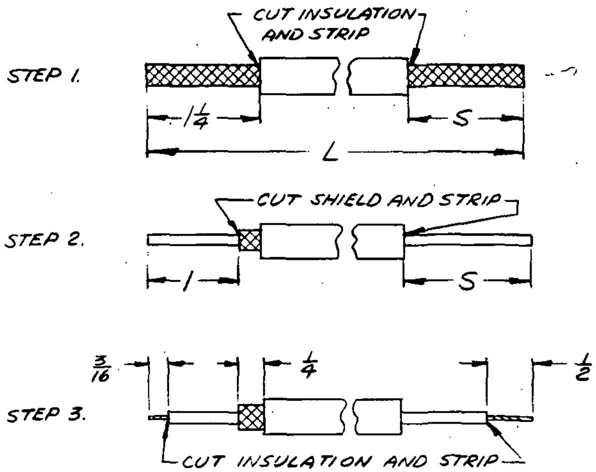
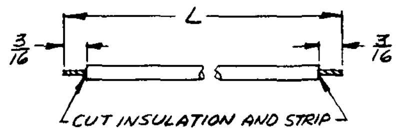
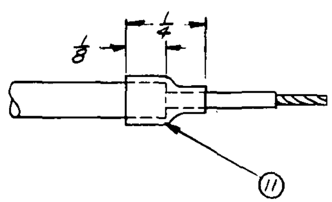


FIGURE C WIRE PREPARATION



WIRE ITEM	QUAN.	LENGTH L
1	1	11 1/4"
6	1	11 3/4"
16	4	3"

FIGURE D SHIELD INSULATION



ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

FIGURE E FERRULE-CABLE ASSEMBLY

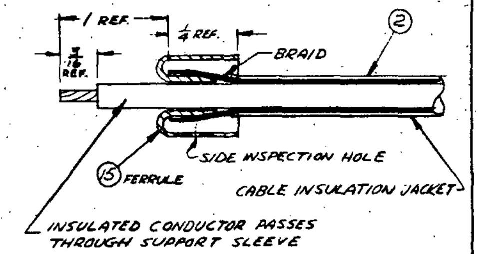


FIGURE F FERRULE-WIRE INSERTION

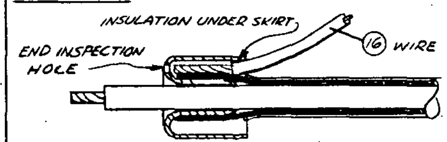


FIGURE G FERRULE INSULATION

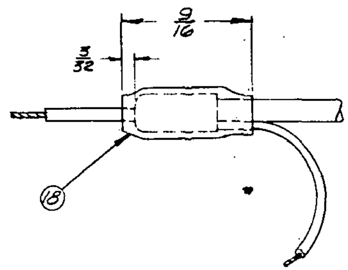
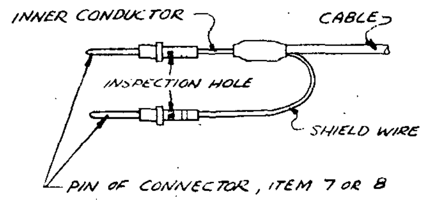
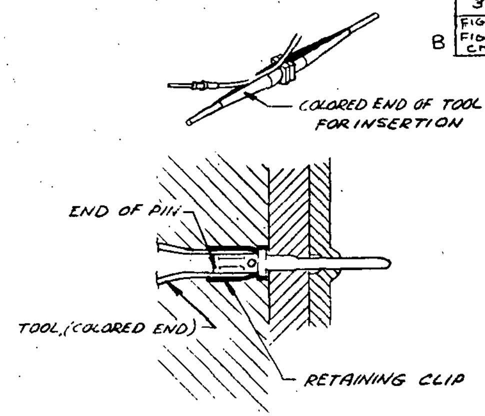


FIGURE H CABLE-PIN ASSEMBLY



NEXT ASSEMBLY

FIGURE J. PIN INSERTION



ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: TERMINAL BOARD ASSEMBLY, WIRED

MATERIAL

PROJECT NO.

DRAWN BY EGAR

DATE 3·28·73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-503 B
PAGE 2 OF 6

NOTES:

1. Cut and strip per Soldering Procedure 842-300-105, paragraph 3.2, one length each of electrical cable Items 2,3,4, and 5 as in Figure B and one length each of insulated wire Items 1 and 6 as in Figure C.

2. Tin the bare conductors on each end of the leads prepared in Note 1 per 842-300-105, Paragraph 3.2.

3. Cut four 1/4 inch lengths of Teflon FEP tubing, Item 11, and fit on the unshielded end of cable Items 2,3,4 and 5 as in Figure D. Apply heated air at a temperature of 325°F to 375°F to shrink tubing onto cable.

4. Insert cable Items 3,4, and 5 into holes in terminal board, Item 9, and pass tinned leads up through terminals A, D, and F, respectively as in Figure A. Pull leads through terminals until insulation is adjacent to rear of terminal. Bend upper portion of lead through 90° and cut flush with terminal diameter as in 842-300-105, Figure 1. Shrunk teflon tubing, Item 11, shall lie fully inside the edge of the terminal board.

5. Mount two resistors, Item 14, onto terminal board, Item 9, as in Figure A. Follow component preparation and mounting procedures specified in 842-300-105. Trim leads flush with terminal diameter.

6. Solder leads to terminals A, D, and F in Figure A as per 842-300-105.

7. Cut and strip per 842-300-105, paragraph 3.2, 4 lengths of insulated wire, Item 16, as in Figure C.

8. Tin the bare conductors on each end of the wire prepared in Note 7 per 842-300-105, paragraph 3.2.

9. Insert a ferrule, Item 15, on the end opposite Item 11 of the cable, Item 2, as in Figure E. The braid shall enter the annular opening of the ferrule and be visible through the side inspection hole.

10. Insert a wire, Item 16, into the ferrule annulus such that it is visible through the end inspection hole, as in Figure F. Wire insulation shall be under the ferrule skirt.

11. Crimp the ferrule on the conductors using Crimp tool #595000 with die insert 45062-3, available from AMP Incorporated, Harrisburg, Pa., Crimp tool shall be used, maintained, and inspected per AMP Sheet IS1662.

12. Repeat steps 9 through 11 for cable Items 3, 4 and 5.

13. Cut four 9/16 inch lengths of teflon FEP tubing, Item 18, and fit over the ferrule on Items 2, 3, 4, and 5 as in Figure G. Apply heated air at a temperature of 325°F to 375°F to shrink tubing onto ferrule.

14. Insert Cable, Item 2, into a pin of connector, Item 7, as per Figure H. Pins are included with the connector. The insulation shall abut the pin and the conductor shall be visible through the inspection hole.

15. Set crimp tool M22520/1-01 with turret M22520/1-02, available from ITT Cannon Electric, Los Angeles, California, for size 20 pins and No. 18 wire. Insert the pins and crimp. The crimp tool shall be used and gaged as per ITT Tool Bulletin No. 24.

16. Repeat steps 14 and 15 for cable Items 3, 4 and 5 using pins of connector Item 8.

17. Repeat steps 14 and 15 for shield wire on Items 2, 3, 4, and 5 and insulated wire Items 1 and 6. The crimp tool shall be set for size 20 pins and No. 22 wire.

18. Place the back shell of the connector, Item 7, over the cable and wire Items 1 and 2. Place the back shell of the connector, Item 8, over the cable and wire Items 3, 4, 5, and 6.

19. The pins are to be inserted into the pin positions of the connectors, Items 7 and 8 as shown in Table I.

TABLE I

CABLE/ WIRE ITEM	CONDUCTOR	PIN POSITION	CONNECTOR ITEM
1	INNER	B	7
2	INNER	A	
	SHIELD	C	
3	INNER	B	8
	SHIELD	R	
4	INNER	K	
	SHIELD	S	
5	INNER	A	
	SHIELD	U	
6	INNER	F	

An insertion/removal tool is supplied with the connectors and should be used in the following manner to insert the pins as shown in Figure J:

19.1 Hold the colored half of the insertion/removal tool between the thumb and forefinger and lay the wire to be inserted along the slot, leaving about 1/2" of wire protruding. Then snap the wire into the tool.

19.2 Pull the wire back through the tool until the tip of tool seats against shoulder.

19.3 Holding the connector with the rear insert facing you . . . slowly push the contact straight into the connector insert cavity.

19.4 A firm stop will be evident when the contact positively seats in the connector insert cavity. A slight click can be heard as the tines of the metal retaining clip snaps into place behind the contact shoulder. Then let go of the wire and pull out the tool.

20. If it should be necessary to remove a pin from the connector it should be done as follows:

20.1 With the rear insert toward you, snap the white end of the tool over the wire of the contact to be removed.

20.2 Slowly slide the tool along the wire into the insert cavity until it engages the contact rear and a positive resistance is felt. At this time, the contact retaining clip is in the unlock position.

20.3 Press the wire of the contact to be removed against the serrations of the plastic tool and pull both the tool and the contact-wire assembly out of the connector.

21. Fill all unused insert holes in connector, Item 8, with sealing plugs, Item 17.

22. Assemble the back shells to the connectors. First thread the coupling nut while holding the connector until the teeth of the connector engage in the back shell. Then tighten further by holding the clamp. Tighten the cable clamp over the cables and wires.

23. Secure the coupling nut of the connector, Item 8, with two wires, Item 10, thru the small holes in the coupling nut nearest the screw heads. Thread the wires thru the holes in the screw heads and twist ends together and cut off excess wire. Connector Item 7 does not have holes in the screw heads. Loosen the cable clamp and run one wire thru a small hole in the coupling nut and under the clamp and twist ends together and cut off excess wire. Retighten the clamp.

24. Wrap Items 1 and 2 together with a 9 inch length of cable harnessing, Item 12.

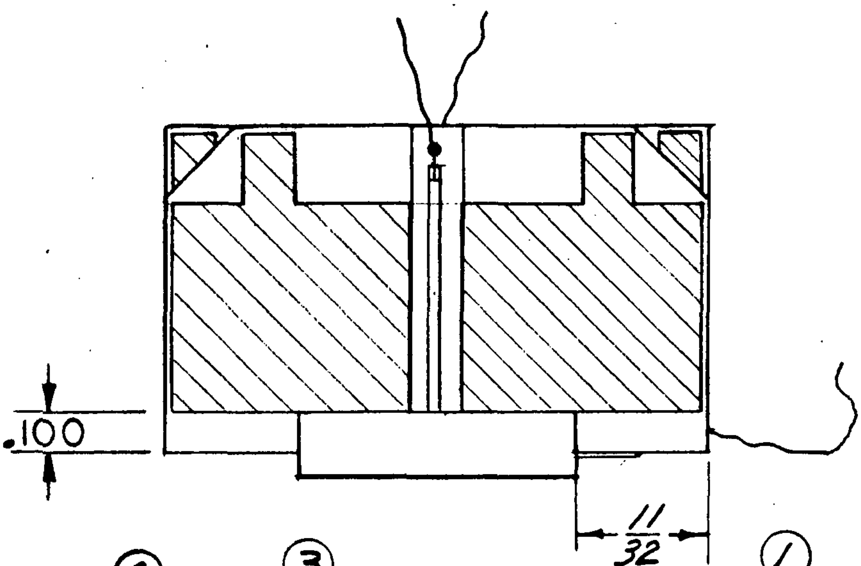
25. Wrap Items 3, 4, 5, and 6 together with a 9 inch length of cable harnessing, Item 13.

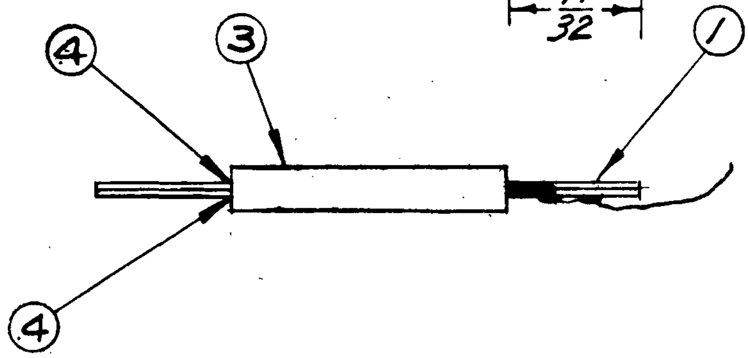
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE

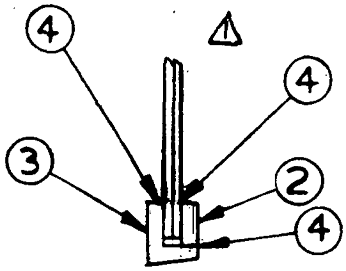
DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

REVISIONS	
A	CN1045 ⚠ ADDED VIEW







SIDE VIEW

APPROVAL		DATE
ENG.	[signature]	13 Jul 72
PROD.	[signature]	13 Jul 72
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ITEM NO	QUAN. REQ'D	PART NO	DESCRIPTION
4	SEE NOTES	842-300-104-1	ADHESIVE, PREPARATION OF (STRUCTURAL)
3	1	842-100-406-2	RIB, ANNEALED (TOP RIB)
2	1	842-100-406-1	RIB, ANNEALED (BOTTOM RIB)
1	1	842-100-204	TRANSDUCER-GAGE ASSY, LEADS EXTENDED

PART LIST

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY 842-100-602

NAME: TRANSDUCER-RIB ASSEMBLY

MATERIAL: SEE PARTS LIST

PROJECT NO.

DRAWN BY RBK

DATE 7-12-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-100-601A

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

NOTES:

1. Clean the top and bottom annealed ribs, Items 3 and 2, as per 842-300-101-1.
2. Clean the transducer-gage leads extended assembly, Item 1, on both sides in the area to which the top and bottom ribs will be attached, as shown in the figure. To clean, rub gently with a clean cotton swab affixed to a wooden stick and moistened in acetone, USP grade. Repeat cleaning with three separate swabs.
3. Using an 000 artist brush, or a microliter syringe, distribute about 3 microliters of structural adhesive, Item 4, on each half of the slotted surface of the top and bottom ribs. Apply about 3 microliters of structural adhesive to the surface perpendicular to the slotted surface on the top rib over the area which it mates with the bottom rib on assembly. The adhesive should cover the designated areas in a thin, bubble-free layer. Allow the adhesive to dry on the parts for 50 to 60 minutes.
4. Mount the top and bottom ribs on the transducer positioned over the strain gage as shown. Press the ribs against each other momentarily such that all air bubbles are expressed along the area where they mate. Press the ribs against the transducer with a uniform pressure of 7 to 10 lb/sq. inch for 5 to 8 minutes. Check rib alignment. Cure adhesive for 3 hours at 145°F to 155°F while maintaining the above clamping pressure.
5. After returning to room temperature inspect the assembly for the following characteristics.

   5.1 The ribs shall be positioned as shown in the figure and be parallel with the long edge of the transducer to within .010.

   5.2 There shall be no bubbles or unbonded areas with a maximum dimension larger than .025 in the adhesive film between the rib and the transducer as seen through the top of the rib after wetting with 2 propanol.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
TRANSDUCER-RIB ASSEMBLY		

DRAWN BY J.S.

DATE 3/13/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-100-601A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	2 : 1

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

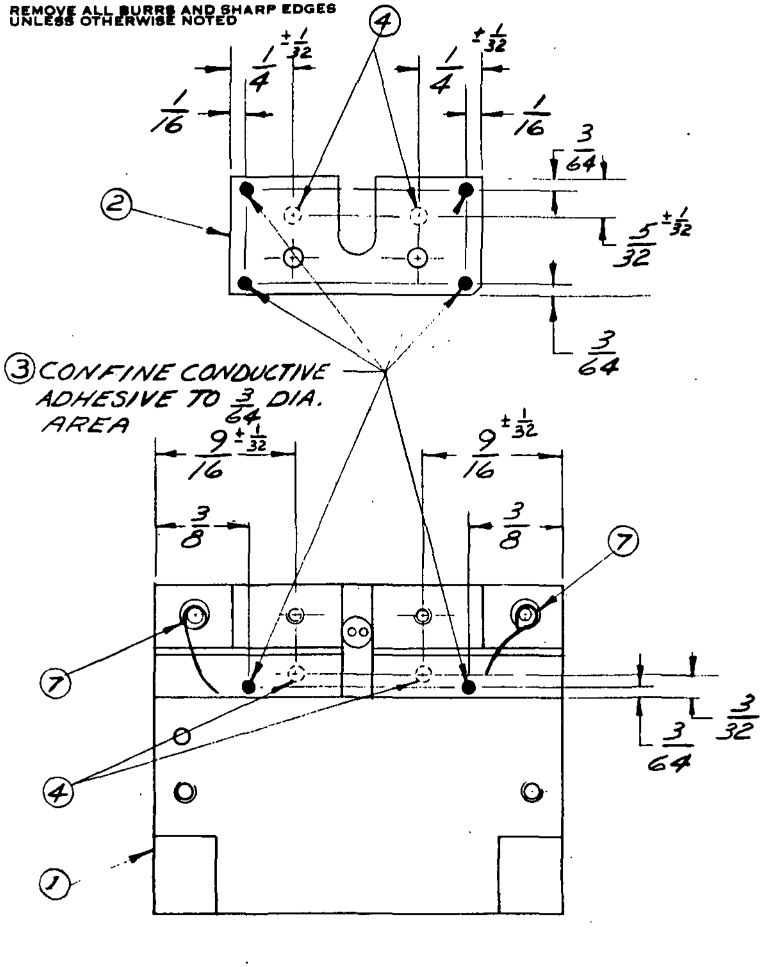


FIGURE I ③

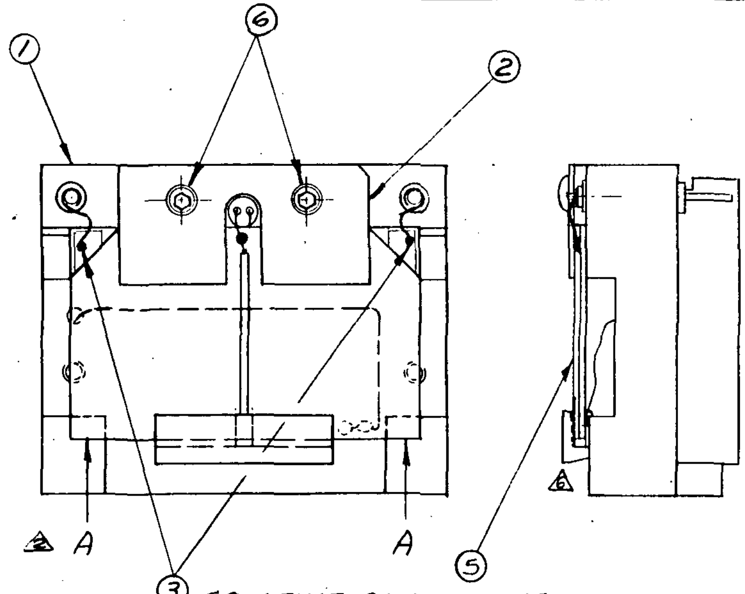


FIGURE II ③

842-100-602D

	REVISIONS
A	CN 1036 ① REWORK PARTS LIST ② ADDED 'A' DETAIL ③ I WAS (a) II WAS (b) ④ RETYPE NOTES EGAR 2-9-73
B	CN 1043 ⑤ ADDED NOTE 10.5
C	CN 1045 ⑥ CORRECTED RIB PROFILE AND POSITION 3-26-73 EGAR
D	CN 1052 ⑦ ADDED NOTE 12 3-30-73 R.L.

ITEM No	QUAN. REQ'D.	PART NO.	DESCRIPTION
7	1"	842-400-0142	WIRE, COPPER, TINNED
6	2	842-400 0264	MACHINE SCREW, SELF LOCKING
5	1	842-100-601	TRANSDUCER-RIB ASSEMBLY
4	AR	842-300-104-1	ADHESIVE, PREPARATION OF (STRUCTURAL)
3	AR	842-300-104-2	" " " (CONDUCTIVE)
2	1	842-100 314	CLAMP PLATE, SURFACE FINISHED
1	1	842-100-312	BASE ASSEMBLY

PART LIST

APPROVAL		DATE
ENG.	[signature]	13 Jul 72
PROD.	[signature]	13 Jul 72
QA	[signature]	2/9/73
MGMT.	[signature]	3/28/73

NEXT ASSEMBLY 842-100-603

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: BASE-TRANSDUCER ASSEMBLY

MATERIAL: SEE PART LIST

PROJECT NO.

DRAWN BY RKK

DATE 7-12-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-602D

PAGE 1 OF 4

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES

1. Cut two (2) 1/2" lengths of wire, Item 7. Solder one per 842-300-105 to each of the feed thru terminals on the base assembly, Item 1, as shown in Figure I.

2. Fit the transducer-rib assembly, Item 5, to the base assembly, Item 1. At the same time bend the three strain gage lead extentions to pass through the holes in the base as shown in Figure II. After fitting, disassemble the parts.

3. Clean the base assembly and the clamp plate, Item 2, as per 842-300-101-1 not more than 1 hour before use.

4. Clean transducer-rib assembly, Item 5, as per 842-300-101-2. Apply cleanliness test only to those areas of the transducer which will be bonded to the base and clamp plate, and to the corners, which will receive conductive adhesive, Item 3, in Figure II.

5. Place a 3/64 diameter dot of conductive adhesive, Item 3, on the clamp plate in each of four (4) locations and on the base assembly in each of two (2) locations as shown in Figure I.

6. Place the base and the clamp plate on a level surface with the unfinished side of the clamp plate up. Hold a dropper calibrated to give 36 ± 4 drops of water per milliliter at a height of 1/4 to 1/2" above the part. Place one drop of structural adhesive, Item 4, at each of the locations shown in Figure I. The adhesive is expected to flow out and cover most of the flat area to which it is applied. Let the adhesive volatiles evaporate for 50 to 60 minutes.

7. Orient the transducer-rib assembly on the base as in Figure II. Thread the two gage lead extensions through the holes in the teflon insulator bushing and thread the single gage lead extension near the ribs through the hole in the base. Place the clamp plate on the base with the adhesive side down and secure loosely with two screws, Item 6. Position the transducer-rib assembly in such a way that it is banked against the step to which the clamp plate is attached and the strain gage is centered in the slot in the clamp plate. Make sure that the gage extention lead is not trapped between the transducer and the base at any point. Secure the assembly by tightening the screws to a torque of 2.3" lbs.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
BASE-TRANSDUCER ASSEMBLY		

DRAWN BY J.S.

DATE 2/7/73

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BAYSIDE RESEARCH CENTER

8. Form a .025 dia. loop 7/32 from the terminal in the wire installed in Note 1. Do not touch the wire with bare hands. Position the loop against the transducer-rib assembly in the center of the triangular cutout, as in Figure II, leaving a slight bow in the wire between the loop and the terminal. The free end of the wire beyond the loop may be used to hold the loop in position. Place a dot of conductive adhesive, Item 3, over the loop and work the adhesive around the wire to obtain complete wetting of the wire loop and the portion of the transducer directly below it. Use no more conductive adhesive than necessary to cover the loop. In no case shall the conductive adhesive extend beyond the nickel coated area in the triangle.

6 9. Check that the transducer-rib assembly is banked against the base and positioned laterally. Insert a 2.7 mil shim between the transducer-rib assembly and the base at the two points marked "A" in Figure II. Retighten the screws, Item 6, if necessary, to a torque of 2.3 inch-pounds. Apply a vertical force of .22 pound (100 grams) to the rib and cure the adhesive at 150° ± 9°F (65° ± 5°C) for 16 to 20 hours.

10. After the base transducer assembly has returned to room temperature inspect and reject any assembly not meeting the following:

10.1 The transducer-rib assembly shall abut the step on the base under the clamp plate with a gap no greater than .007 and the strain gage shall be centered in the clamp plate slot to ± 1/64.

10.2 The resistance between the feed thru terminals to which the wire is attached shall be less than 40 ohms.

10.3 The resistance between the upper and lower nickel electrode coatings on the transducer-rib assembly shall be less than 30 ohms.

10.4 The resistance of each strain gage shall be 49.0 ± 1.0 ohms and the resistance between either gage and ground shall be greater than 10^7 ohms with all leads isolated from the base.

5 10.5 After the 2.7 mil shims have been removed, the space at points "A" shall be .0025 $^{+.0005}_{-.0000}$.

11. Cut off excess lead beyond Item 3 in Figure II with sharp blade.

All dimensions are in inches unless specified otherwise.

842-100-602D
Page 3 of 4

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

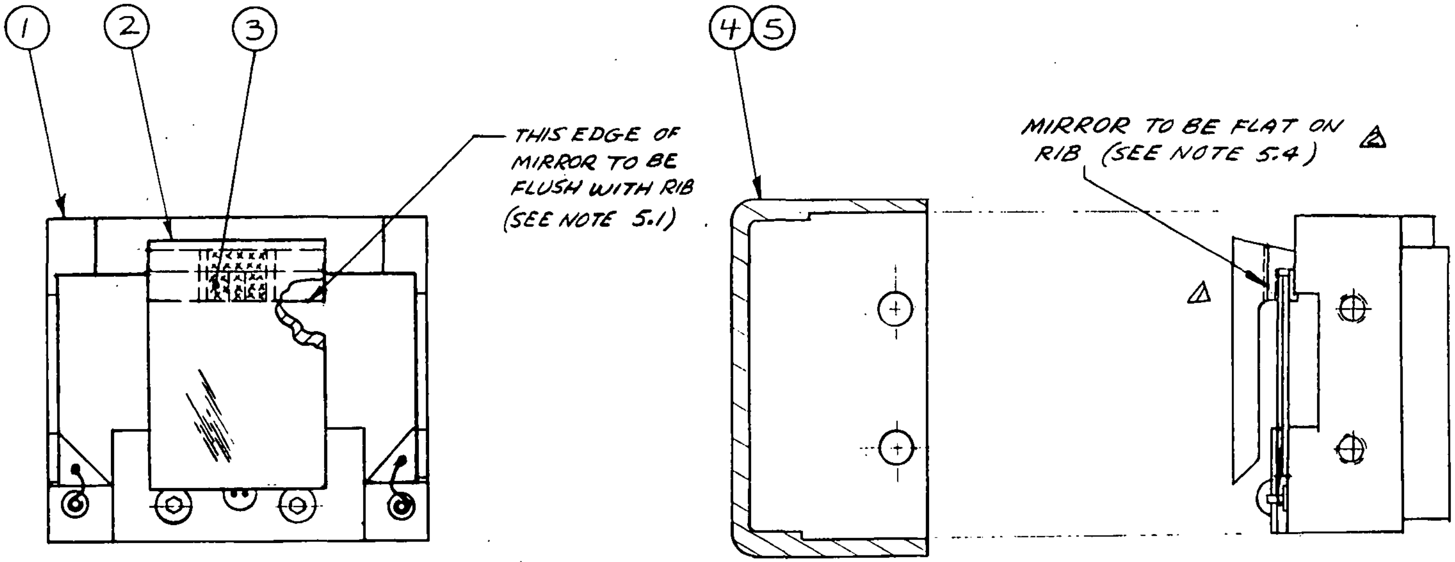
△7 12. Apply 390 ± 10 Vrms at 60 Hz between either feed thru terminal and the base. Monitor the current through a series resistor of about 10K ohms using an oscilloscope. No spiking should be noted on the current waveform which would indicate arcing on the assembly.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	~
DO NOT SCALE DRAWING			

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-603 B
PAGE 1 OF 3

	REVISIONS
A	CN1044, CN1045 △ CORRECTED MIRROR AND RIB PROFILE 3-26-73 EGAR
B	CN1050 △ ADDED NOTE REF. 5.4 3-28-73 EGAR



ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION
5	4	842-400-029	MACHINE SCREW, BRASS
4	1	842-100-315	TOP COVER
3	AR	842-300-1041	ADHESIVE, PREPARATION OF (STRUCTURAL)
2	1	842-100-405	MIRROR
1	1	842-100-602	BASE-TRANSDUCER ASSY.

APPROVAL	DATE
ENG.	9 FEB 73
PROD.	9 FEB 73
QA	2/9/73
MGMT.	2/28/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY
842-100-604

NAME: BASE-MIRROR ASSEMBLY

MATERIAL: SEE PARTS LIST

PROJECT NO.

DRAWN BY W. GANNON

DATE 2-18-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-603 B
PAGE 1 OF 3

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-100-603B

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES:

1. Fit the mirror, Item 2, to the rib on the base - transducer assembly, Item 1, as shown. The free end of the mirror should be supported by shims such that the mirror and rib mating surfaces are parallel. Use caution so that the shims do not abrade the strain gage.

△ 2. Clean the central area between the two slots on the uncoated side of the mirror and clean the rib on the top of the base-transducer assembly as follows:

   2.1 Wipe the area to be cleaned with a cotton swab affixed to a wooden stick and moistened with trichloroethylene USP grade.

   2.2 Repeat step 2.1 using a fresh swab moistened in acetone, USP grade.

   2.3 Repeat step 2.1 using a fresh swab moistened in 2 propanol isopropyl alcohol, A.C.S. purity.

△ 3. Using a calibrated syringe (available from Hamilton Co.) or 000 artist brush apply 5 microliters of structural adhesive Item 3 to each of the two central mounting pads on the mirror back, as shown. Allow the adhesive to dry on the part for 50 to 60 minutes.

4. Mount the mirror on the rib, supporting the free end with the shim height determined in Note 1. Protect the mirror surface with lens tissue and place △ a 7 oz. ± 10% (200g) weight in the center of the mirror. Check that the mirror and rib edges are flush as shown and place assembly in an oven at 60° ± 5°C (140° ± 9°F). Remove the weight from the mirror after 30 minutes. Continue to cure the assembly for 16 hours.

5. After the assembly has returned to room temperature remove the shims and inspect the assembly for the following characteristics:

   5.1 The mirror shall be positioned as shown and flush with the long edge of the rib within ± .007.

   5.2 The mirror must be able to withstand a force of 7.0 oz. (200g) applied on the mirror centerline perpendicular to the mirror surface 1/8" in from the free end.

   5.3 The mirror surface shall not deviate from a true plane by more than 80 nanometers peak-to-peak (λ/8 at 633 nm) measured as per 842-500-103, △ paragraph 6.3.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
BASE - MIRROR ASSEMBLY		

DRAWN BY J.S.

DATE 2/7/73

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842-100-603B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

⚠2 5.4 The mirror must be flat on the rib allowing no more than .0005 gap between them.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
BASE - MIRROR ASSEMBLY.		

DRAWN BY J.S.

DATE 2/7/73

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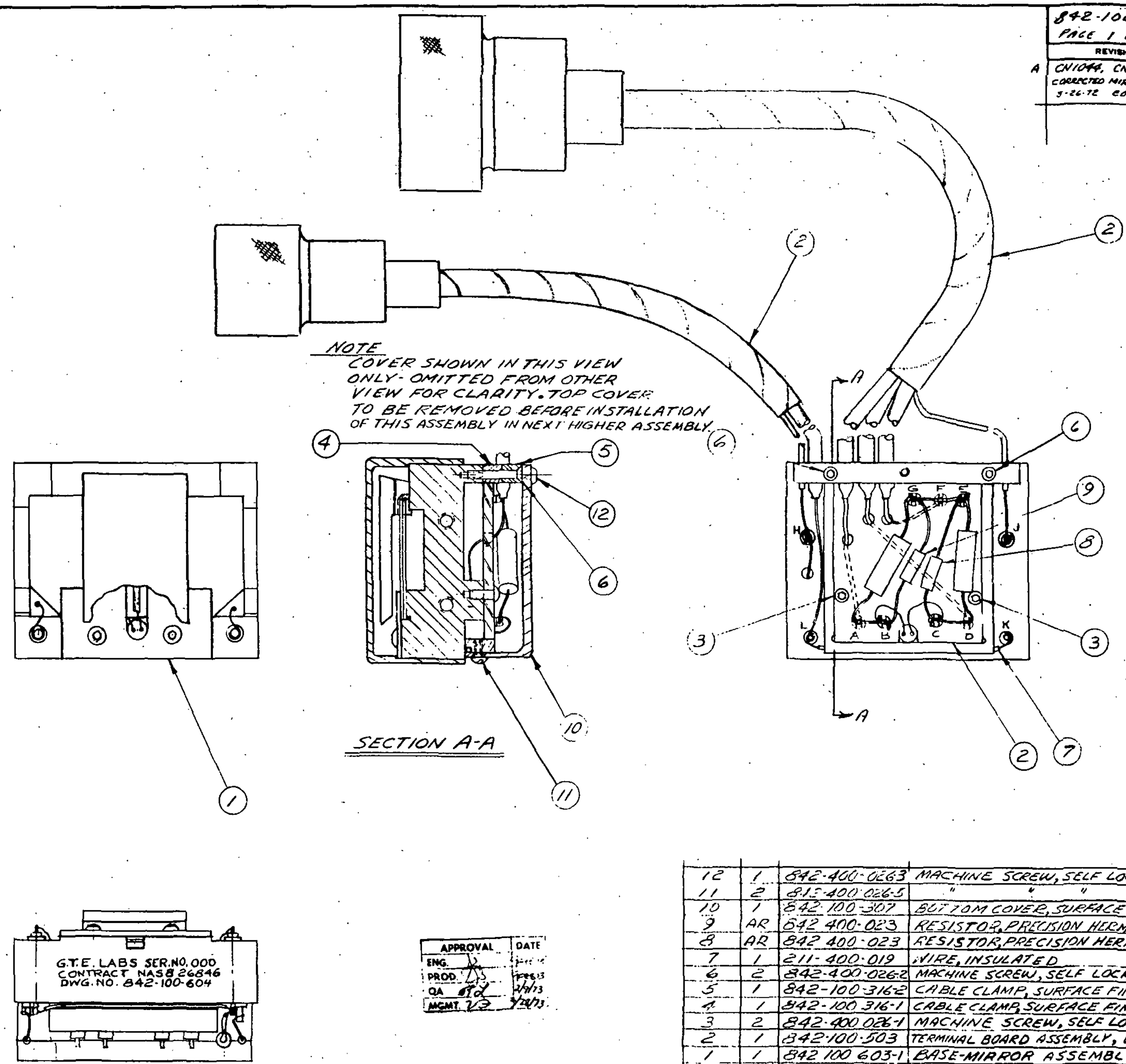
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±½°	2:1
DO NOT SCALE DRAWING			

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

842-100-604 A
PAGE 1 OF 4

	REVISIONS
A	CN1044, CN1045 CORRECTED MIRROR PROFILE 5-26-72 EGAR



APPROVAL	DATE
ENG.	
PROD.	2/9/73
QA	2/9/73
MGMT.	2/12/73

12	1	842-400-0263	MACHINE SCREW, SELF LOCKING
11	2	842-400-026-5	" " " "
10	1	842-100-307	BOTTOM COVER, SURFACE FINISHED
9	AR	842 400-023	RESISTOR, PRECISION HERMETIC
8	AR	842 400-023	RESISTOR, PRECISION HERMETIC
7	1	211-400-019	WIRE, INSULATED
6	2	842-400-026-2	MACHINE SCREW, SELF LOCKING
5	1	842-100-316-2	CABLE CLAMP, SURFACE FINISHED
4	1	842-100 316-1	CABLE CLAMP, SURFACE FINISHED
3	2	842-400 026-1	MACHINE SCREW, SELF LOCKING
2	1	842-100-503	TERMINAL BOARD ASSEMBLY, WIRED
1	1	842 100 603-1	BASE-MIRROR ASSEMBLY
ITEM	QUAN REQD	PART NO.	DESCRIPTION

PART LIST

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: PBM-8G BEAM STEERER
MATERIAL: SEE PART LIST
PROJECT NO.

DRAWN BY W GANNON
DATE 2-28-72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-100-604A
PAGE 1 OF 4

FILE ATU

ALL SURFACES MARKED "✓" TO BE SQUARE, PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

NOTES

1. Install terminal board assembly, Item 2, in the base-mirror assembly, Item 1, by inserting the terminal board in the base recess and securing it with two (2) self-locking screws, Item 3. Tighten the screws to 1.3 in.-lb. torque.

2. Insert both cables of Item 2 in the cable clamps, Item 4 and 5, and attach them to the base with two (2) self-locking screws, Item 6. Tighten the screws to 1.3 in.-lb. torque.

3. Cut a 1 9/16 length of insulated wire, Item 7, and strip the insulation back 5/32 on each end. Tin the wire on each end per 842-300-105. Install wire in slot in base between feed thru terminals K and L as shown. Connect Item 7 to terminals K and L. Connect the long lead from the small cable of Item 2 to terminal L. Solder the wires to the terminals as per 842-300-105.

4. Connect the short lead from the small cable of Item 2 and the #36 AWG lead from the transducer to the ground lug H. Connect the small diameter lead from the large cable of Item 2 to the ground lug J. Solder these connections per 842-300-105.

5. Connect the two #32 AWG leads fed through the teflon insulating bushing each to its own nearest terminal B and C on the terminal board, leaving enough slack for a 1/8 dowel to fit between the wire exit from the bushing and the terminal. Solder both connections per 842-300-105.

6. Trim the bridge by adding shunting resistors, Items 8 and 9, using the following procedure:

   6.1 Apply 2.000 ± 0.001 volts to the bridge between terminals F and J with F as the positive terminal.

   6.2 Read the voltage between terminals B and C and note the polarity.

   6.3 Use Table I on page 4 to determine trim resistor values R_{T1} and R_{T2} which are to be used for Items 8 and 9.

   6.4 Using resistors conforming to 842-400-023, connect a resistor with the value R_{T1} between terminals B and G if B was negative in Step 6.2 or, between terminals C and E if C was negative in Step 6.2.

   6.5 Using resistors conforming to 842-400-023, connect a resistor with the value R_{T2} between terminals B and G if B was positive in Step 6.2 or,

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NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

between terminals C and E if C was positive in Step 6.2.

6.6 Solder connections made to terminals B, C, E and G as per 842-300-105.

6.7 Apply 2.000 ± 0.001 volts between terminals F and J and read the voltage between terminals A and D. This unit shall be acceptable only if this voltage is not greater than 0.61 millivolts.

7. Install the bottom cover, Item 10, and secure with two (2) self-locking screws, Item 11, and one (1) self-locking screw, Item 12. Tighten Item 11 first, to a torque of 3.8 in.-lb., and then Item 12 to a torque of 1.3 in.-lb.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

TABLE I

VALUES FOR BRIDGE TRIM RESISTORS

INITIAL UNBALANCE MILLIVOLTS		TRIM RESISTORS		MAXIMUM UNBALANCE AFTER TRIM - MILLIVOLTS
FROM	TO	R_{T1} KILOHMS	R_{T2} KILOHMS	
0	0.52	None*	None*	0.52
0.52	1.55	24.3	None*	0.53
1.55	2.59	12.1	None*	0.53
2.59	3.70	8.06	None*	0.61
3.70	4.68	2	3.01	0.61
4.68	5.72	3.01	8.06	0.59
5.72	6.76	3.01	12.1	0.57
6.76	7.79	3.01	24.3	0.57
7.79	8.87	3.01	None*	0.61
8.87	9.91	2	8.06	0.61
9.91	10.95	2	12.1	0.59
10.95	11.98	2	24.3	0.59
11.98	13.04	2	None*	0.60

*Use no Resistor

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME PBM-8G BEAM STEERER

MATERIAL

PROJECT NO.

DRAWN BY JS

DATE 7/14/72

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TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

Process Control Drawing

1. Cleaning Procedure, 842-300-101-1.

1.1 Materials

1.1.1 Trichloroethylene, USP grade

1.1.2 Acetone, USP grade

1.1.3 2 propanol isopropyl alcohol, A.C.S. purity

1.1.4 Rack-glass or metal, holding the parts to be cleaned separate from each other.

1.1.5 Container - glass or metal adequate in size to hold the rack of parts with at least 1/2" clearance around the edges.

1.1.6 Ultrasonic cleaning tank - Branson Ultrasonic, Inc. Model AP-25B or equivalent.

1.1.7 Hot plate with adequate power to heat container of solvent to the boiling point.

1.1.8 Lint-free gloves.

1.1.9 Tweezers, cleaned as per 842-300-101-1.

1.2 Cleaning

1.2.1 Place parts to be cleaned in the cleaning rack.

1.2.2 Fill container with enough trichloroethylene such that parts will be completely submerged.

1.2.3 Place rack of parts into container of trichloroethylene.

1.2.4 Place container of trichloroethylene on hotplate and bring to a boil for 5 minutes.

1.2.5 Transfer container immediately to Ultrasonic cleaning tank. The level of the acoustic coupling medium in the tank should be above the top of the part in the container. Clean ultrasonically for 10 minutes.

1.2.6 Remove rack of parts from container of trichloroethylene before shutting off Ultrasonic cleaner. Shut off Ultrasonic cleaner. Let parts air dry.

1.2.7 Remove container from Ultrasonic cleaning tank and discard contents. Rinse container with acetone.

APPROVAL	DATE
ENG. [illegible]	2/29/72
PROD [illegible]	2/29/72
QA EDH	2/29/72
MGMT [illegible]	2/29/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
CLEANING PROCEDURE		

DRAWN BY RB
DATE 2/15/72

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1.2.8 Repeat 1.2.2 through 1.2.7 using acetone in place of trichloroethylene.

1.2.9 Fill container to 1/10 of its total volume with propanol.

1.2.10 Place container of propanol on hotplate.

1.2.11 Place rack containing parts in container such that the lower extremity of the parts is approximately one inch above the surface. of the propanol. All parts of the rack should be below the top edge of the container.

1.2.12 Bring the propanol to a boil and allow vapors to condense on the parts for 5 minutes.

1.2.13 Raise rack of parts and suspend two inches above the top of the container for one minute.

1.2.14 Remove rack of parts completely from propanol vapors and air dry at 100°C for 15 minutes. Cool to room temperature.

1.3 Test for cleanliness as per section 3.

1.4 Store parts in rack in air tight enclosure. Parts must be used in the processing step calling out this cleaning procedure within 24 hours of cleaning.

2. Cleaning Procedure, 842-300-101-2.

2.1 Materials

2.1.1 Trichloroethylene, USP grade.

2.1.2 Acetone, USP grade.

2.1.3 2 Propanol isopropyl alcohol, A.C.S. purity.

2.1.4 Rack - glass or metal holding the parts to be cleaned separate from each other.

2.1.5 Container - glass or metal adequate in size to hold the rack of parts with at least 1/2 inch clearance around the edges.

2.1.6 Hot plate with adequate power to heat container of solvent to the boiling point.

2.1.7 Tweezers, cleaned as per 842-300-101-1.

2.2 Cleaning

2.2.1 Place parts to be cleaned in the cleaning rack.

2.2.2 Fill the container 10 percent of its volume with trichloroethylene.

2.2.3 Place the rack of parts in the container of trichloroethylene such that the lower extremity of the parts are approximately one inch above the fluid surface. All parts of the rack should be below the top edge of the container.

2.2.4 Bring the trichloroethylene to a boil and allow vapors to condense on the parts for 5 minutes.

2.2.5 Raise the rack of parts and suspend two inches above the top of the container for one minute.

2.2.6 Remove the rack of parts completely from the trichloroethylene vapors and air dry.

2.2.7 Discard solvent and rinse container with propanol.

2.2.8 Repeat 2.2.1 through 2.2.7 using acetone in place of trichloroethylene

2.2.9 Repeat 2.2.1 through 2.2.7 using propanol in place of trichloroethylene.

2.3 Test for cleanliness as per section 3.

2.4 Store parts in rack in air tight enclosure. Parts must be used in the processing step calling out this cleaning procedure within 24 hours of cleaning.

3. Cleanliness test.

3.1 Materials

3.1.1 Deionized water.

3.1.2 Glass container, 500 ml, cleaned internally as per 842-300-101-1, or -2.

3.1.3 Tweezers or holding fixture, cleaned as per 842-300-101-1, or -2.

3.1.4 Absorbent towel.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

3.1.5 Rack, glass or metal, holding parts separately, cleaned as per 842-300-101-1, or -2.

3.2 Test procedure.

3.2.1 Fill glass container with 400 ml of deionized water.

3.2.2 Grasp part with tweezers or holding fixture near an extremity and hold with the long dimension vertical.

3.2.3 Immerse the part completely in the container of deionized water, withdraw and touch the lowest extremity to an absorbent towel to remove excess accumulated water.

3.2.4 Using specularly reflected light observe the water remaining on the part in the designated areas and inspect for the following characteristics:

3.2.4.1 The water shall form a thin uniform layer covering the entire surface of interest.

3.2.3.2 The film shall show no breaks or discontinuities until it becomes thin enough that evaporation causes local drying.

3.2.4.3 As the water film becomes thinner and dry areas appear the film edge at these points shall show no noticeable curvature (i.e., it should appear as a "feather edge") when examined by the unaided eye.

3.2.5 Any parts not exhibiting all of the characteristics of 3.2.4 shall be recleaned and tested.

3.2.6 Parts exhibiting all of the characteristics of 3.2.4 shall be placed in the rack or holding fixture, air dryed at 100°C for 15 minutes, and cooled to room temperature.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME CLEANING PROCEDURE	MATERIAL	PROJECT NO.

DRAWN BY RB

DATE 2/15/72

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BAYSIDE RESEARCH CENTER

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-300-102

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

APPROVAL		DATE
ENG.	[signature]	7FEB73
PROD	[signature]	7FEB73
QA	[signature]	2/9/73
MGMT.	[signature]	2/20/73

Process Control Drawing

Process 842-300-102-1, Nickel

1.1 Clean per 842-300-101-1.

1.2 Deposit a film of 842-400-009 nickel by vacuum evaporation in the areas shown on the detail drawing referencing this document, to obtain the characteristics specified in 1.3.

1.3 Characteristics.

1.3.1 Adhesion
Place the sticky surface of mylar tape, 842-400-032 over a portion of the coated surface. Press the tape firmly against the coated surface. Pull the tape down over the edges of the element and then slowly remove the tape. A visual inspection shall be made of the tested area to assure that the films have not been removed from the substrate material.

1.3.2 Resistivity
The resistance of the nickel film shall be less than 40 ohm when measured by 1/16 inch diameter contact pads (2) on each of the 1/8 inch film extension tabs, using a V-O-M, Simpson 269 or equivalent.

Process 842-300-102-2, Sapphire

2.1 Clean per 842-300-101-2.

2.2 Deposit a film of 842-400-031sapphire by vacuum evaporation in the area shown on the detailed drawing referencing this document, to obtain the characteristics specified in 2.3.
Note: A film thickness test sample, a microscope slide with a mask over approximately one half of the surface, shall be included in each deposition lot, located in the center of the batch or located symetrically with the lot in the chamber.

2.3.1 Adhesion
Sec. 1.3.1.

2.3.2 Film Thickness
The thickness of the film shall be measured on the test sample only, and shall be between 1.0 and 1.3 micrometers (40 to 52 μ inch).

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NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
FILM, DEPOSITION OF		

DRAWN BY RB

DATE 2/9/73

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842-300-102

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

1. 842-300-104-1, BR610 structural adhesive

1.1 Materials

1.1.1 Adhesive kit as per 842-400-005 received within one year prior to preparation and stored at a temperature between 15°C and 30°C.

1.2 Preparation Procedure

Disregard any preparation information included with adhesive as purchased.

1.2.1 Remove and discard brushes from caps of 1/2 oz. bottles.

1.2.2 Clean mixing bottle and cap, and 1/2 oz. bottles, exclusive of caps, as per 842-300-101-1, Section 1.2.9 through 1.2.14.

1.2.3 Pour part B completely into mixing bottle, then add all of part A.

1.2.4 Immediately cap mixing bottle and shake vigorously for fifteen seconds.

1.2.5 Allow mixture to stand two hours at room temperature.

1.2.6 Install pouring nozzle and fill eleven 1/2 oz. bottles to within 3/8 inch of top with adhesive mix. Cap bottles immediately.

1.3 Labeling

1.3.1 Label bottles of mixed adhesive with the following information:

1.3.1.1 Part number 842-300-104-1.

1.3.1.2 Date of mixing per 842-300-104-1.

APPROVAL		DATE
ENG.	[signature]	3/22/72
PROD.	[signature]	3/22/72
QA	EDH	3/22/72
MGMT.	[signature]	3/23/72

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
ADHESIVE, Preparation of		

DRAWN BY RB

DATE 3/14/72

GTE LABORATORIES INCORPORATED
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1.3.1.3 Material Condition Report (MCR) number for this kit.

1.4 Storage

1.4.1 Store bottles of mixed adhesive at +2°C or below within 8 hours of mixing, except for that quantity which is to be used immediately.

1.4.1.1 Adhesive stored between +2° and -17°C shall be discarded 6 months after mixing.

1.4.1.2 Adhesive stored below -17°C shall be discarded 12 months after mixing.

1.5 Handling

1.5.1 Adhesive removed from refrigeration and intended for use shall be marked with the date of removal and discarded after 10 days. Adhesive not to be re-refrigerated.

1.5.2 After removing from refrigeration adhesive shall be allowed to reach room temperature before opening container.

1.5.3 When not in use adhesive is to be kept in tightly capped container at room temperature.

1.6 Curing

Adhesive is to be cured according to the schedule given in the drawing referencing this document.

2. 842-300-104-2, Eccobond 56C conductive adhesive

2.1 Materials and Equipment

2.1.1 Adhesive kit as per 842-400-004 containing 56C resin and catalist 9. The date indicating end of useful life, as marked on container of silver resin, shall not have expired. Components shall have been stored at a temperature between 15°C and 30°C.

2.1.2 Toluene, USP grade

2.1.3 Balance with a sensitivity of at least 10 milligrams.

2.1.4 Glass or metal container for weighing and mixing components.

2.1.5 Glass or metal spatula for mixing components.

2.1.6 Wire applicator .010 to .025 inch in diameter.

2.1.7 Standard dropper measuring 20 ± 2 drops of water per millimeter.

2.2 Preparation Procedure

Disregard any preparation information included with adhesive as purchased.

2.2.1 Clean the mixing container, spatula, wire applicator, and standard dropper exclusive of bulb as per 842-300-101-1, Section 1.2.1 through 1.2.8.

2.2.2 Weigh out 2.9 ± 0.1 grams of 56C resin using the spatula and container.

2.2.3 Add 2 drops of catalist 9 to the 56C resin and mix very thoroughly with the spatula.

2.2.4 Add from3 to 10 drops of toluene, mixing thoroughly after every three or less drops, to obtain a smooth creamy adhesive mixture. The mixture should be of such consistency that it may be easily applied in controlled quantities with the wire applicator and thoroughly wets the surfaces to which it is applied. Add the smallest amount of toluene possible to obtain the proper adhesive consistency.

2.3 Handling

2.3.1 Useful life - the adhesive mixed according to section 2.2 shall be discarded one hour after mixing.

2.3.2 Consistency maintenance - should the consistency of the adhesive change within the one hour life of the mixture, more toluene may be added with the total quantity in the mixture not to exceed 10 drops.

2.4 Curing

Adhesive is to be cured according to the schedule given in the drawing referencing this document.

842-300-104
Page 4 of 4

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

1. SCOPE

This process specification includes all details necessary to permit connections to be made from wire and/or component leads to bifurcated terminals, by means of solder, in a repeatably reliable manner.

2. EQUIPMENT & SUPPLIES

Only those tools, equipment, and chemicals specified herein shall be used.

2.1 Soldering Iron

Weller 60 watt soldering station W-TCP,1/16" screwdriver tip (600°F) PTA6.

2.2 Pliers

Lindstrom chain nose 36-154 or equivalent.
Lindstrom flush-cut diagonals 36-2385 or equivalent.

2.3 Tweezers

Dumont OC or equivalent.

2.4 Stripper, thermal

Stripall TWC-1
Bench fixture TBM

2.5 Solvent

Trichlorotrifluoroethane 99.8% pure.

2.6 Solder

Solder, Flux Core Wire, per 842-400-018.
Solder, Solid, per 842-400-028.

2.7 Flux

Flux, Liquid Rosin, per 842-400-021.

2.8 Solder Pot

Solder tinning receptical with a volume of at least 20 cc. and capable of temperature control to within $\pm$ 15°F at 600°F.

2.9 Gloves

Fabric gloves of cotton or nylon.

All dimensions are in inches unless specified otherwise.

APPROVAL		DATE
ENG.	[signature]	20Feb73
PROD.	[signature]	20Feb73
QA	[signature]	3/19/73
MGMT.	VJ	3/20/73

NEXT ASSEMBLY

3. PREPARATION FOR SOLDERING

3.1 Environmental Conditions

The soldering area shall have a controlled environment which limits entry of contamination. The area shall be controlled at least as follows:

Temperature	65°F to 75°F
Relative Humidity	60% RH, maximum
Light on Work Surface	100 ft. candle, minimum

3.2 Conductor Preparation

3.2.1 The insulation shall be stripped from wire end as required using the tool specified in 2.4.

3.2.2 The wire strands and insulation shall be examined for damage. Wire with damaged insulation or strands shall not be used.

3.2.3 The lay of wire shall be restored using gloved hand.

3.2.4 The end of the wire shall be tinned within 1/16" of insulation, as specified in 3.5.

3.3 Terminal Preparation

Terminals shall be examined and cleaned, when necessary, as specified in 3.6.

3.4 Component Preparation

3.4.1 Component leads shall be cut to size as required and tinned as specified in 3.5.

3.5 Tinning

3.5.1 Prepare a Solder bath with solder pot and solid solder specified in 2.6. The temperature of the solder shall remain between 525°F and 575°F during all tinning operations.

3.5.2 Place flux per 2.7 in a suitable container to allow for complete immersion of wire area to be tinned. Do not mix used flux with unused material. Discard flux after it becomes cloudy with use or age.

3.5.3 Clean wire or component lead as specified in 3.6. Thoroughly dry wire before applying flux.

3.5.4 Apply flux by dipping wire or lead into container to within 1/16" of insulation. No flux shall be allowed to pass under the insulation.

3.5.5 Tin to within 1/16" of insulation by dipping wire into solder bath.

3.5.6 After tinning the wire surface shall have a shiny appearance and the lay of the stranded wire shall be visible.

3.5.7 Clean the flux from the part as specified in 3.6.

3.6 Cleaning Procedure

3.6.1 Terminals, wire, and component leads shall be cleaned by a three step process, employing three separate containers of the solvent at its boiling point. The containers shall be labeled from 1 to 3 and the item to be cleaned shall be held in each container for no less than 5 seconds, starting with container 1 and progressing to container 2 and then to container 3.

3.6.2 When a contamination induced color change is noted in the solvent in any container, this solvent shall be discarded and the solvent in the container adjacent and higher in number shall be transferred to the container (e.g., the solvent in container 3 shall be transferred to container 2) and fresh solvent introduced into the highest number container.

4. ATTACHMENT OF CONDUCTORS

4.1 Bifurcated Terminals

4.1.1 Bottom route shall be connected as shown in Figure 1. Conductors shall not extend beyond the diameter of the base.

4.1.2 Side route shall be connected as shown in Figure 2. The conductor shall enter the mounting slot perpendicular to the posts. When more than one conductor is connected to a terminal, the direction of bend of each additional conductor shall alternate. Conductors shall not extend beyond the diameter of the base, except on a side thru route.

All dimensions are in inches unless specified otherwise.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	~

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

842-300-105 A

	REVISIONS
A	REDRAWN CN 1038 PORTIONS DELETED. EGAR 3·6·73

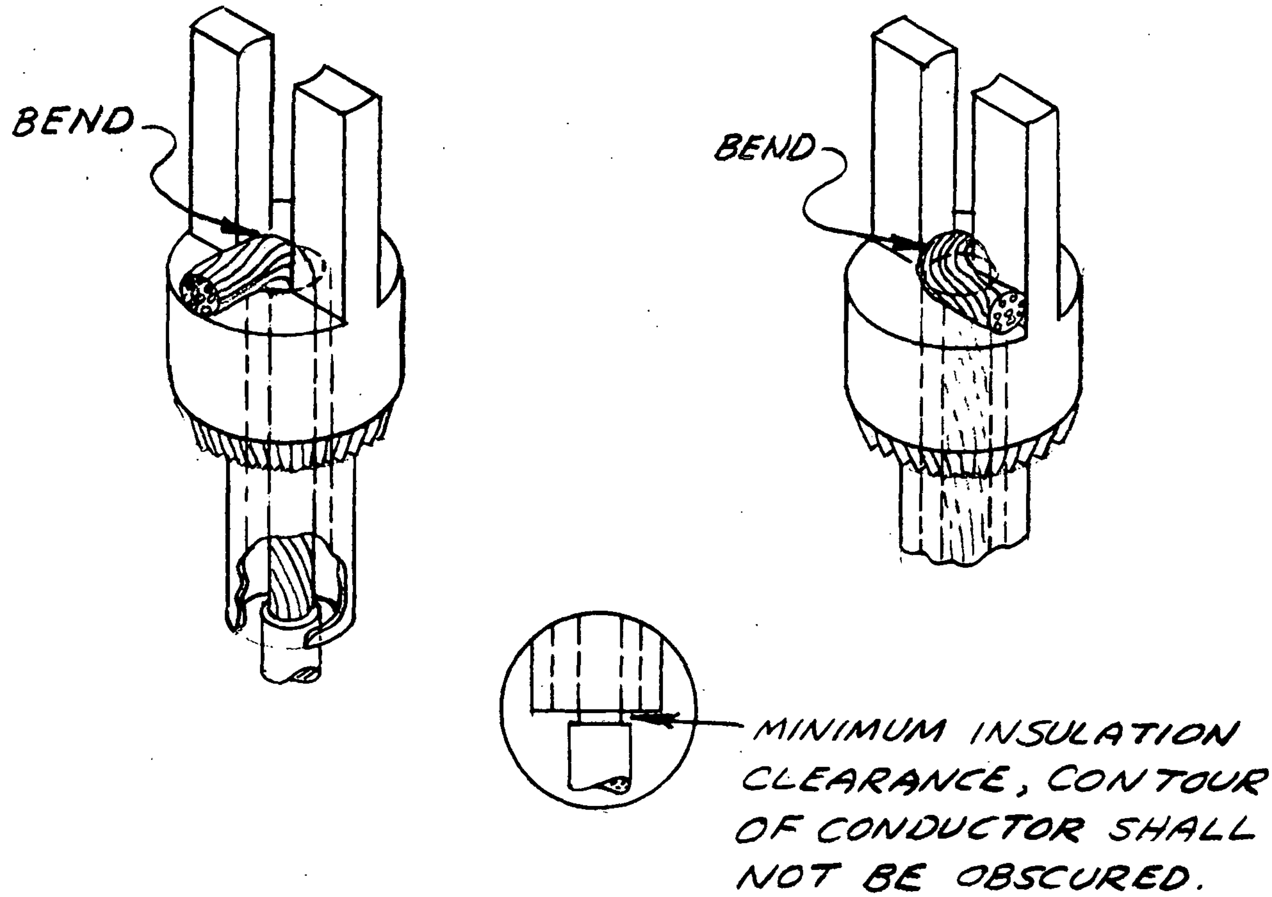

FIGURE 1

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
SOLDERING PROCEDURE		

DRAWN BY EGAR

DATE 3·6·73

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BAYSIDE RESEARCH CENTER

842-300-105A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	~
DO NOT SCALE DRAWING			

842-300-105A

	REVISIONS
A	CN1038 – REDRAWN 3·7·73 EGAR

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

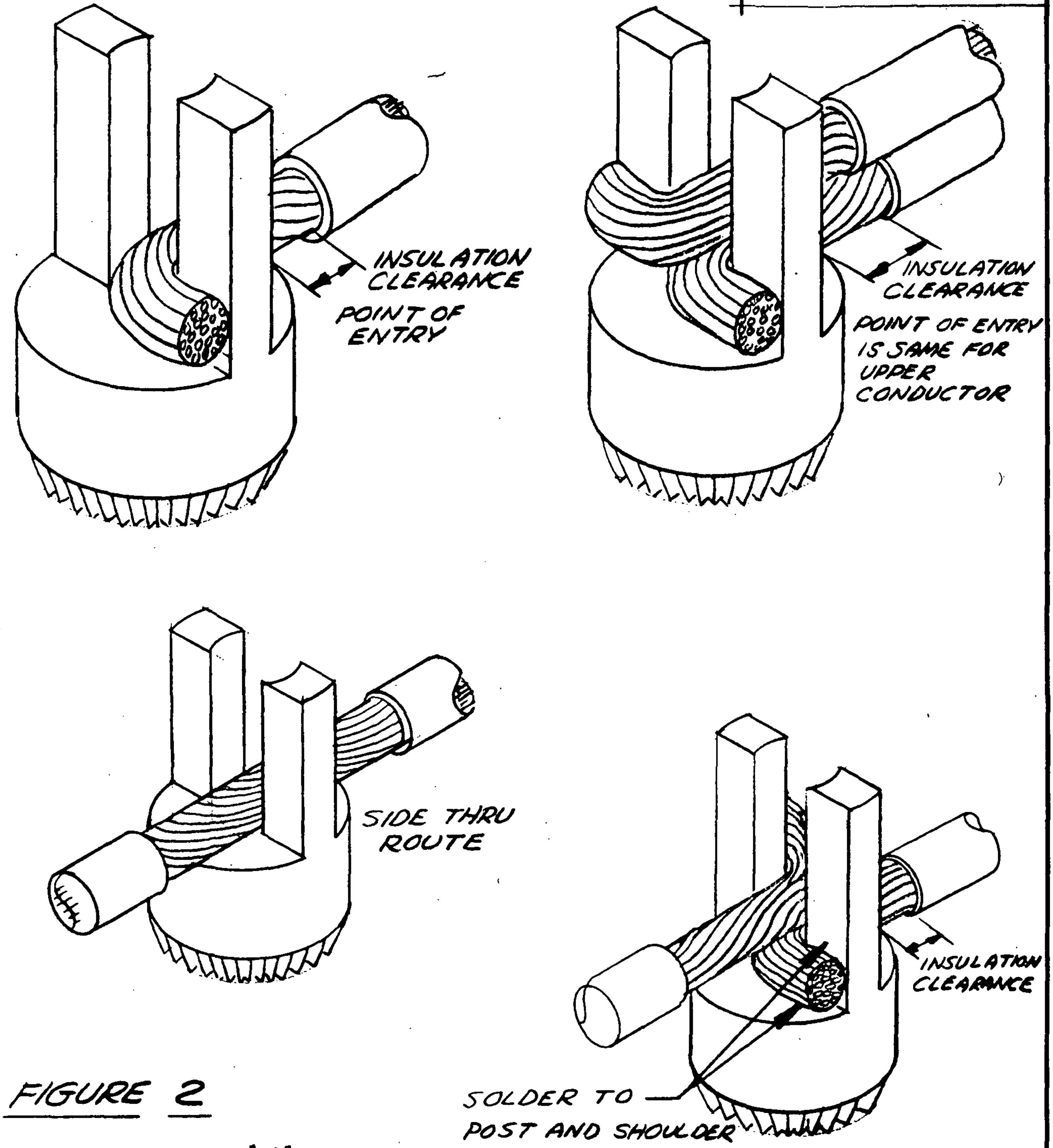


FIGURE 2

ALL SURFACES MARKED "√" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
SOLDERING PROCEDURE		

DRAWN BY EGAR

DATE 3·7·73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-300-105A

4.1.3 When both routes are required, the bottom route shall be installed first as shown in Figure 1, then the side route as shown in Figure 2.

4.1.4 The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation. Routing of conductors shall not permit shorting between adjacent conductors.

4.2 Component Mounting

All components shall be mounted parallel to and in contact with the mounting surface, with component identification marking visible and readable from the same direction.

5. SOLDERING OF TERMINALS

Using good workmanship and proper procedure, solder terminals to obtain the characteristics listed herein. The soldering iron shall be as specified in 2.1 and the solder shall be flux core solder as specified in 2.6.

5.1 There shall be no relative motion between conductors and the terminal during soldering and while the solder is solidifying.

5.2 A concave fillet of solder shall be formed between the terminal and each side of the conductor.

5.3 The contour of the conductor shall be visible after soldering.

5.4 Terminals with more than one wire shall have each wire in contact with and soldered to the terminal.

5.5 After the solder has solidified and cooled, flux and residue shall be carefully removed from each solder connection as specified in 3.6.

6. QUALITY ASSURANCE

6.1 Inspection

6.1.1 The minimum magnification for normal inspection of wires shall be as follows:

Awg	Wire Size Dia. in Mils	Magnification Power
24	20	10
29	11	20
36	5	45

6.1.2 Inspection of solder joints shall be made at 30 power.

6.1.3 Parts and conductors shall not be moved and/or physically disturbed to aid in inspection.

6.2 Acceptance Criteria

An Acceptable solder connection will be characterized by:

6.2.1 Clean, smooth, undisturbed surface.

6.2.2 Concave fillet between conductor and termination.

6.2.3 Contour of conductor visible.

6.2.4 Complete wetting.

6.3 Inspection Criteria

Soldering inspection shall be conducted using form 842-300-105 (last page) which lists the characteristics for which each assembly shall be reviewed.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-300-105A

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOLDERING INSPECTION

842-300-105

WO __________ Dwg # __________ Date __________

Qty __________ Inspector __________

Check each item examined during inspection

Conductors		Connections		Components	
nicked strands		wrapping		location	
burnt insulation		flux residue		type	
imbedded insulation		contaminants		mounting	
birdcaging/tinning		stress relief		orientation	
insulation clearance		service loops		polarity marking	
		terminal contact		damage	
Soldered Joints		**Assembly**		**Notes:**	
excess		conformal coat			
insufficient		lacing			
disturbed		locking devices			
rosin					
dewetting					
pitted or porous					
fillets					
cracked					

ALL SURFACES MARKED ✓ TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
SOLDERING PROCEDURE		

DRAWN BY J.S.

DATE 2/14/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

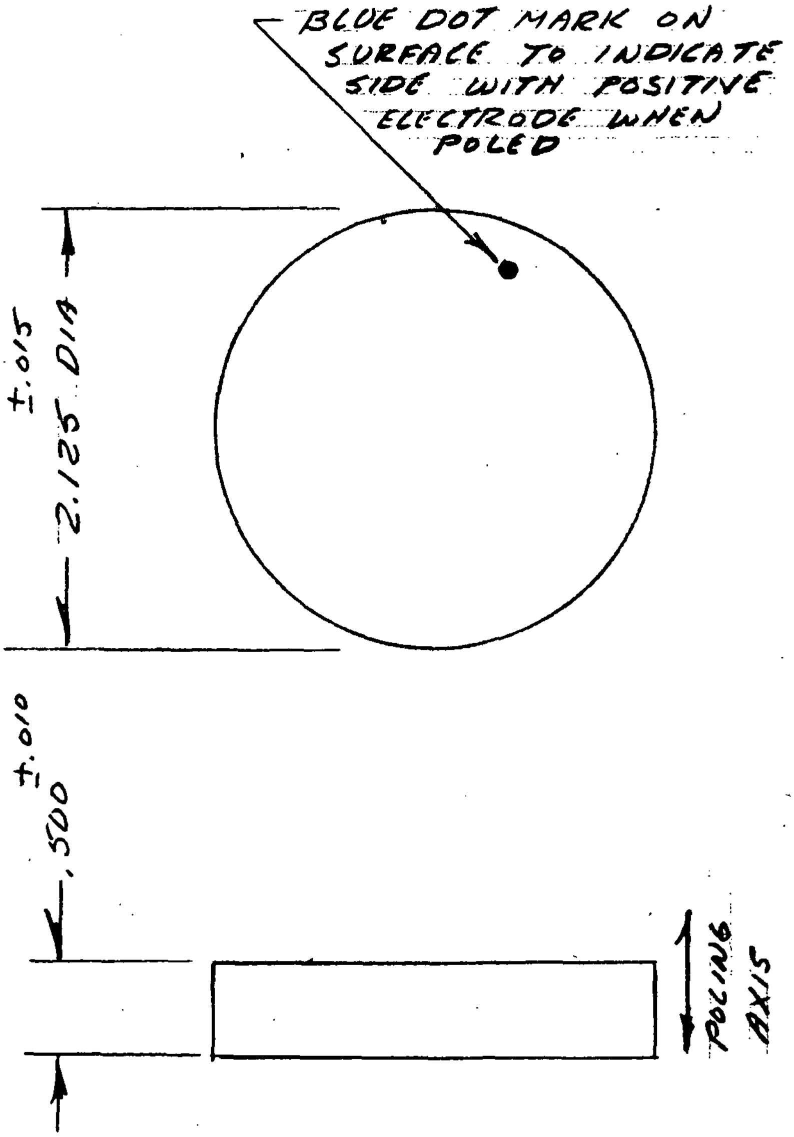
842-300-105A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	1:1
DO NOT SCALE DRAWING			

842-400-001A
PAGE 1 OF 2

REVISIONS
A — CN 1042 △ WAS 2100

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



APPROVAL		DATE
ENG.		20FEB73
PROD.		20FEB73
QA		2/19/73
MGMT.		2/20/73

ALL SURFACES MARKED "X" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN
ALL DIMEN. IN INCHES UNLESS SPECIFIED OTHERWISE

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
CERAMIC, PIEZOELECTRIC	AS NOTED	

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-001A PAGE 1 OF 2
DATE 10-6-71		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

APPROVAL	DATE
ENG.	
PROD.	
QA	
MGMT.	

SOURCE CONTROL DRAWING

Requirements

A. Piezoelectric ceramic material to be supplied in disks as per drawing.

B. The disk shall have the following characteristics measured at 78°F, 1 kHz drive frequency and maximum electric field strength of 10^3 V/m, where applicable:

1. Capacitance C	2000 pF ± 7%	△1
2. Maximum dissipation factor	.006	
3. Minimum planar coupling factor	-0.50	
4. Minimum density	$7.0(10)^3$ kg/m^3	

C. Additional characteristics of the piezoelectric ceramic material shall be

1. Minimum Curie point temperature 315°C
2. Minimum a.c. depoling field 10^6 V rms/m
3. Thermal expansion coefficient from 0°C to 50°C, after first heating:
    a. Perpendicular to poling direction $(38 \pm 3)(10)^{-7}$ in/in/deg C
    b. Parallel to poling direction $(17 \pm 3)(10)^{-7}$ in/in/deg C

D. Vendor shall supply certified test data, for the lots from which this material is supplied on purchase orders referencing this document, for the characteristics listed in B1 through B4.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Vernitron Corporation Piezoelectric Division 232 Forbes Road Bedford, Ohio 44146	Piezoelectric ceramic PZT-4 Part No. 34500-4	Transducer wafers

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
CERAMIC, PIEZOELECTRIC	As noted	

DRAWN BY W. Gannon
DATE 10.5.71

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

TOLERANCE UNLESS OTHERWISE NOTED			SCALE	842-400-002
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°		
DO NOT SCALE DRAWING				REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

Requirements

A. Metal to be an iron-nickel alloy containing 42 $\pm$ 1 percent nickel with the balance iron. Mill analysis to be supplied verifying percentage nickel.

B. The thermal expansion coefficient shall be $(47.0 \pm 1.5)\ (10)^{-7}$ inches/inch/deg. C average over the temperature range 25°C - 150°C.

Suggested Sources of Supply	
Vendor	Vendors Item Ident. No.
Universal-Cyclops Speciality Steel Division of Cyclops Corp. 650 Washington Road Pittsburgh, Pa. 15228	Uniseal 42
Wilbur B. Driver Co. 1875 McCarter Highway Newark, N. J. 07104	NIromet 42

APPROVAL		DATE
ENG.	[signature]	20 FEB 73
PROD.	[signature]	20 FEB 73
QA	[signature]	3/19/73
MGMT.	[signature]	3/20/73

ALL SURFACES MARKED "✗" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

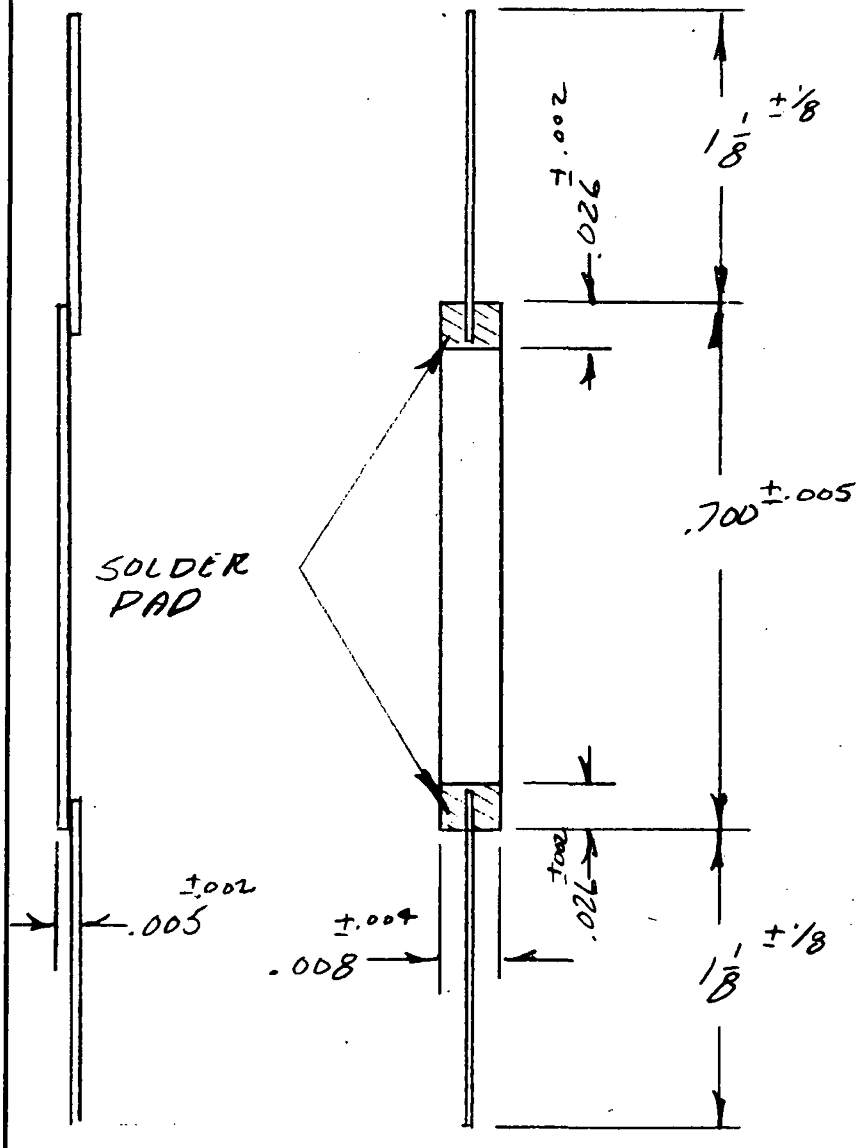
NAME	MATERIAL	PROJECT NO.
IRON-NICKEL ALLOY	As noted	[signatures]

DRAWN BY W Garnson	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-002
DATE 7 October 1971		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE
DO NOT SCALE DRAWING			

REVISIONS	
A	△ .0010 ± 10% OHM-CM WAS .0015 ± 10% OHM-CM CO 842-1002

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



APPROVAL	DATE
ENG. [signature]	20FEB73
PROD. [signature]	20FEB73
QA [signature]	2/19/73
MGMT. [signature]	2/20/73

SOURCE CONTROL DWG

NEXT ASSEMBLY

ALL SURFACES MARKED "✗" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN
ALL DIMEN. IN INCHES UNLESS SPECIFIED OTHERWISE

NAME	MATERIAL	PROJECT NO.
STRAIN GAGE, MATCHED PAIR	AS NOTED	[signature]

DRAWN BY W GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED	842-400-003-A
DATE 1-5-72	BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements

A. Gages shall be fabricated of doped germanium with a bulk resistivity of .001 ± 10% OHM-CM. (1)

B. Gage factor shall lie between 40 and 50 and within a lot shall not vary more than ± 2 at 72°F over strain levels of ± 500 $(10)^{-6}$ in/in.

C. Gold plated silver leads .002 inches nominal diameter shall be bonded to the gage ends by plating and soldering to achieve ohmic contacts.

D. Gages to be supplied in matched pairs as follows;

1. Pairs shall be from the same lot (gage factor ± 2)
2. Resistance; 50Ω ± 1Ω @ 78°F
3. Resistance difference between elements of pair; ± 0.1Ω
4. Each gage container shall be marked with the gage resistance at 78°F and at 32°F to 0.1% accuracy
5. Each gage container shall be marked with the lot number

E. Vendor shall supply certified test data, for the lot(s) from which material is supplied on purchase orders referencing this document, verifying requirement B.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Kulite Semiconductor Products, Inc. 1038 Hoyt Avenue Ridgefield, New Jersey 07657	Semiconductor Strain Gage Matched Pair PKP-50-700 (2)	Strain gages on piezoelectric transducer

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
STRAIN GAGE, MATCHED PAIR	As noted	JS

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED	842-400-003 -A
DATE 1-4-72	BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	Page 2 of 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

842-400-004

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

APPROVAL	DATE
ENG.	20 FEB 73
PROD.	20 FEB 73
QA	2/19/73
MGMT.	2/20/73

SOURCE CONTROL DRAWING

Requirements

A. Adhesive shall be a two component, non-flowing, smooth, silver-filled paste formulation.

B. Full cure should be achieved in 30 minutes at 150°F and result in the following typical properties:

Temperature range of use	-100°F to + 350°F
Minimum lap shear strength at 70°F	700 psi
Maximum volume resistivity at 70°F	$2.5(10)^{-4}$ ohm-cm
Maximum thermal expansion	$21(10)^{-6}$ in/in/°F

C. Pot life should be at least 3/4 hours at 70°F for the mixed components.

D. Shelf life should be at least 6 months at 70°F for the unmixed components. Each container shall be marked to indicate the expiration of useful life.

Only the item described on this drawing when procured from the vendor listed herein is approved by GTE Laboratories Incorporated, Bayside, New York 11360, for use in the applications specified herein. A substitute item shall not be used without the prior testing and approval of GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

Approved Source of Supply		
Vendor	Vendors Item Ident. No.	Application
Emerson & Cuming, Inc. 59 Walpole Street Canton, Mass. 02021	Conductive epoxy Eccobond 56-C with Catalist 9	Attaching leads to ceramic transducer and strain gage

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherside

NAME	MATERIAL	PROJECT NO.
ADHESIVE, CONDUCTIVE	As noted	

DRAWN BY W. GANNON

DATE 5 OCT. 71

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-400-004

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

842-400-005

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Adhesive to be a solvent-thinned, unfilled, epoxy compound specifically formulated for use as a strain gage adhesive in transducer applications.

Cure Temperature Requirements

A. Adhesive shall be capable of being fully cured using any of the following time and temperature cure proceedures as maximum requirements:

30 minutes at 400°F
1 hour at 350°F
2 hours at 275°F
5 hours at 200°F

APPROVAL	DATE
ENG. [signature]	20FEB73
PROD. [signature]	20FEB73
QA [signature]	2/19/73
MGMT. [signature]	2/20/73

Environmental Requirements

A. Operating temperature range shall extend from -100°C to +275°C and it shall have an elongation capability of at least 1 percent within this temperature range.

Form of Supply

A. Adhesive to be supplied in a concentrated two component form, Part A and Part B, totaling 3 ounces and consisting of the unmixed components, a mixing bottle and twelve 1/2 ounce bottles.

Physical Specifications

A. Pot life at 75°F shall be at least one week after mixing components.

B. Shelf life at 75°F shall be at least six months for the unmixed components. Each container shall be marked to indicate the expiration of useful life.

Only the item described on this drawing when procured from the vendor listed hereon is approved by GTE Laboratories Incorporated, Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without prior testing and approval of GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

Approved Source of Supply		
Vendor	Vendors Item Ident. No.	Application
William T. Bean, Inc. 18915 Grand River Ave. Detroit, Mich. 48223	Adhesive BR-610-2C Concentrated (3 oz.) Cat. No. A-16101C	Assembly of PBM-8G Beam Steerer

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
ADHESIVE, STRUCTURAL	As noted	[signatures]

DRAWN BY [signature]	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-005
DATE 5 Oct. 71		

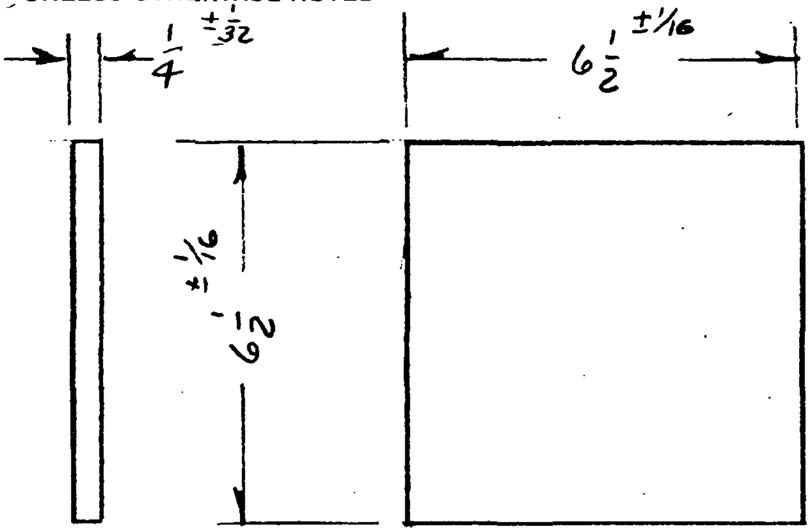
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE
DO NOT SCALE DRAWING			

842-400-006

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING



APPROVAL		DATE
ENG.	JS	20 FEB 73
PROD	JS	20 FEB 73
QA	[illegible]	2/19/73
MGMT.	[illegible]	2/20/73

Requirements

A. Material to be supplied in blanks as per drawing.

B. Thermal expansion coefficient shall be $(39.5 \pm 1.0)\ (10)^{-7}$ inches/inch/deg C average over the temperature range 25 - 100°C. Test data verifying the expansion coefficient for the lot from which this material is supplied shall accompany each shipment.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

Approved Souce of Supply		
Vendor	Vendors Item Ident. No.	Applications
Corning Glass Works Houghton Park Corning, N. Y. 14830	Corning 9741	Mirror substrate

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN
ALL DIMEN. IN INCHES UNLESS SPECIFIED OTHERWISE

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
GLASS, MIRROR SUBSTRATE	As noted	

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-006 PAGE 1 OF 1
DATE 7 October 1971		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DWG. A—

REVISIONS

⚠ CHANGED VENDORS ITEM IDENT. NO. 12-13-71 Stan Rich CO 842-1001

Requirements

A. Grounding terminal; see page 2.

B. Terminal material: brsss per QQ-B-626, composition 22; half hard.

C. Terminal finish: plating, bright tin per MIL-T-10727.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

Approved Source of Supply

Vendor	Vendors Item Ident. No.	Application
U. S. Terminals Inc. 7502 Camargo Road Cincinnati, Ohio 45243	⚠ M3-461 - A (SEE REQUIREMENT C)	PBM-8G base

APPROVAL		DATE
ENG.	[signature]	20 Feb 73
PROD.	[signature]	20 Feb 73
QA	[signature]	3/19/73
MGMT.	[signature]	3/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
Ground Terminal		SP

DRAWN BY W. GANNON

DATE 1-10-72

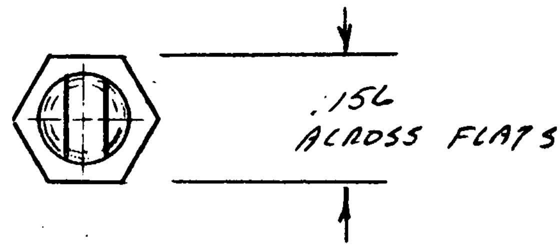
GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

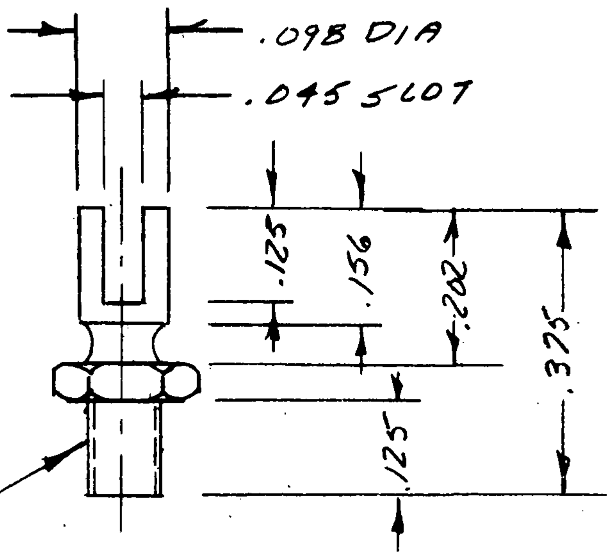
842-400-007-A
PAGE 2 OF 2

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



APPROVAL	DATE
ENG.	20FEB73
PROD.	20FEB73
QA	2/19/73
MGMT.	2/20/73



ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
GROUND TERMINAL		SP

DRAWN BY W. GANNON	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-007-A PAGE 2 OF 2
DATE 1-10-72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

A	Revision A ⚠1 Add prefix 2- S. Reich 4-11-72
B	Revision B ⚠2 Change to next size ferrule

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements:

A. Ferrule, uninsulated: see figure Page 2.

B. Material: brass as per MIL-C-50

C. Finish: tin plate as per MIL-T-10727

D. Color: natural

E. To fit primary insulation diameter range 0.045 - 0.065 in ⚠2

Only the items described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
American Pamcor Inc. 80 West Street Englewood, N.J. 07631	Ferrule uninsulated natural color 2-323930-3 ⚠1	GROUND TERMINAL

APPROVAL		DATE
ENG.	[signature]	3/27/72
PROD	SP	3/27/72
QA	[signature]	3/27/72
MGMT	[signature]	3/27/72

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise

NAME	MATERIAL	PROJECT NO.
FERRULE, UNINSULATED		

DRAWN BY SR

DATE 3/23/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

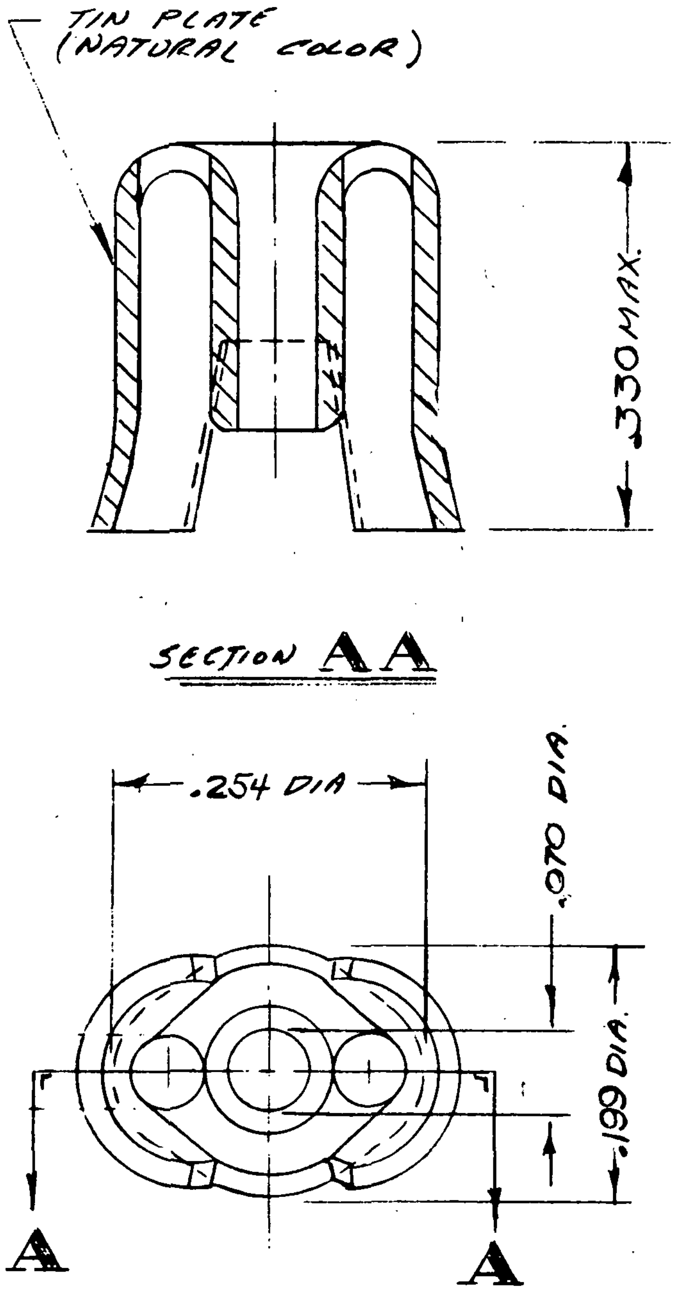
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.008	ANGULAR ±1/2°	8:1

DO NOT SCALE DRAWING

842-400-008B
PAGE 2 OF 2

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FERRULE, UNINSULATED		

DRAWN BY W. GANNON

DATE 3-23-72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-400-008B
PAGE 2 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-009

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

General Requirements

Material conforming to this specification shall be nickel of 99.99% purity or greater. It shall be supplied in wire or rod form as required in sizes specified on the purchase order referencing this drawing.

SUGGESTED SOURCES OF SUPPLY

Vendor

Materials Research Corp.
Route 303
Orangeburg, New York 10962
(914) 359-4200

Consolidated Reactive Metals Inc.
116 Hoyt Avenue
Mamaroneck, N.Y. 01543
(914) 698-2300

APPROVAL		DATE
ENG.	[signature]	6 FEB 73
PROD.	[signature]	16 FEB 73
QA	[signature]	2/15/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
NICKEL		

DRAWN BY J.S.

DATE 2/14/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-009
Page 1 of 1

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-010

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Item supplied to be spiral wrap cable for flexible harnesses

B. Material: TFE teflon, natural state, to meet Federal Specifications AMS3651B for standard wall teflon tubing

C. Vendor shall supply certificate indicating compliance with Federal Specification AMS3651B.

D. Form of supply: as per table in lengths indicated on purchase order. Part number is drawing number plus appropriate dash no.

ITEM DASH NO.	VENDOR ITEM IDENT. NO.	NOMINAL SIZE	PITCH	OUTSIDE DIAMETER	WALL THICKNESS
-1	500-5001	1/8	1/4	0.125	0.030
-2	500-5002	3/16	1/4	0.187	0.030
-3	500-5003	1/4	3/8	0.250	0.030

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Transcon Manufacturing Co. Box 20825 Dallas, Texas 75220	See dash number above	Cable harness

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	JD	20 Feb 73
PROD	JS	20 Feb 73
QA	RR	2/19/73
MGMT.	VF	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
CABLE HARNESS, SPIRAL WRAP		

DRAWN BY JS

DATE 7/12/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-010

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/4°	
DO NOT SCALE DRAWING			

842-400-011

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

Requirements

Material to be supplied shall be aluminum alloy as specified in the Table. Form of supply shall be as required and shall be specified on the purchase order referencing this drawing.

Drawing Dash No.	Type #	Percentage Allow Composition					Temper
		Cu	Mn	Mg	Si	Cr	
-1	2024	3.8-4.9	0.3 - 0.9	1.2-1.8	-	-	T4
-2	6061	0.15-0.40	-	0.8-1.2	0.4-0.8	0.15-0.35	T6

Suggested Source of Supply

Vendor	Vendors Item Identification Number
Aluminum Company of America 200 Park Avenue New York, New York 10017 Reynolds Metals Company 6601 W. Broad Street Richmond, Virginia 23218	See Type Number in Table

APPROVAL	DATE
ENG. [signature]	16FEB73
PROD. [signature]	16FEB73
QA [signature]	2/15/73
MGMT. [signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
ALUMINUM ALLOY		

DRAWN BY J.S.

DATE 2/14/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-011

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-012A
Page 1 of 1

REVISIONS	
A	CN1051 ADDED -2

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

Heat shrinkable modified teflon-FEP tubing with continuous service temperature of 400°F.

Shrink temperature

Tubing shall completely shrink to recovered I.D. when exposed to 350°F.

Form of supply

Straight lengths.

Part # is the drawing number plus appropriate dash number.

Dash No.	Expanded Diameter	Recovered Diameter	Wall Thickness	Wall Tolerance
-1	.092	.072	.009	.002
-2	.180	.143	.010	.003

APPROVED SOURCE OF SUPPLY

Vendor	Vendors Item Ident. No.	Application
Penntube Plastics Co. Inc. Div. of Pennsylvania Fluorocabon Madison Ave. & Holly St. Clifton Heights, PA.	Penntube 11-SMT 14	-1 Insulation for shield
	" 11-SMT 8	-2 Insulation for ferrule

Only the item described on this drawing when procured from the vendor listed hereon is approved by GTE Laboratories Incorporated, Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without prior testing and approval of GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL	DATE
ENG. [signature]	2 Feb 73
PROD. [signature]	2 Feb 73
QA [signature]	2/19/73
MGMT. [signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
Teflon FEP Tubing		

DRAWN BY W. [signature]	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-012 A Page 1 of 1
DATE 10-5-71		

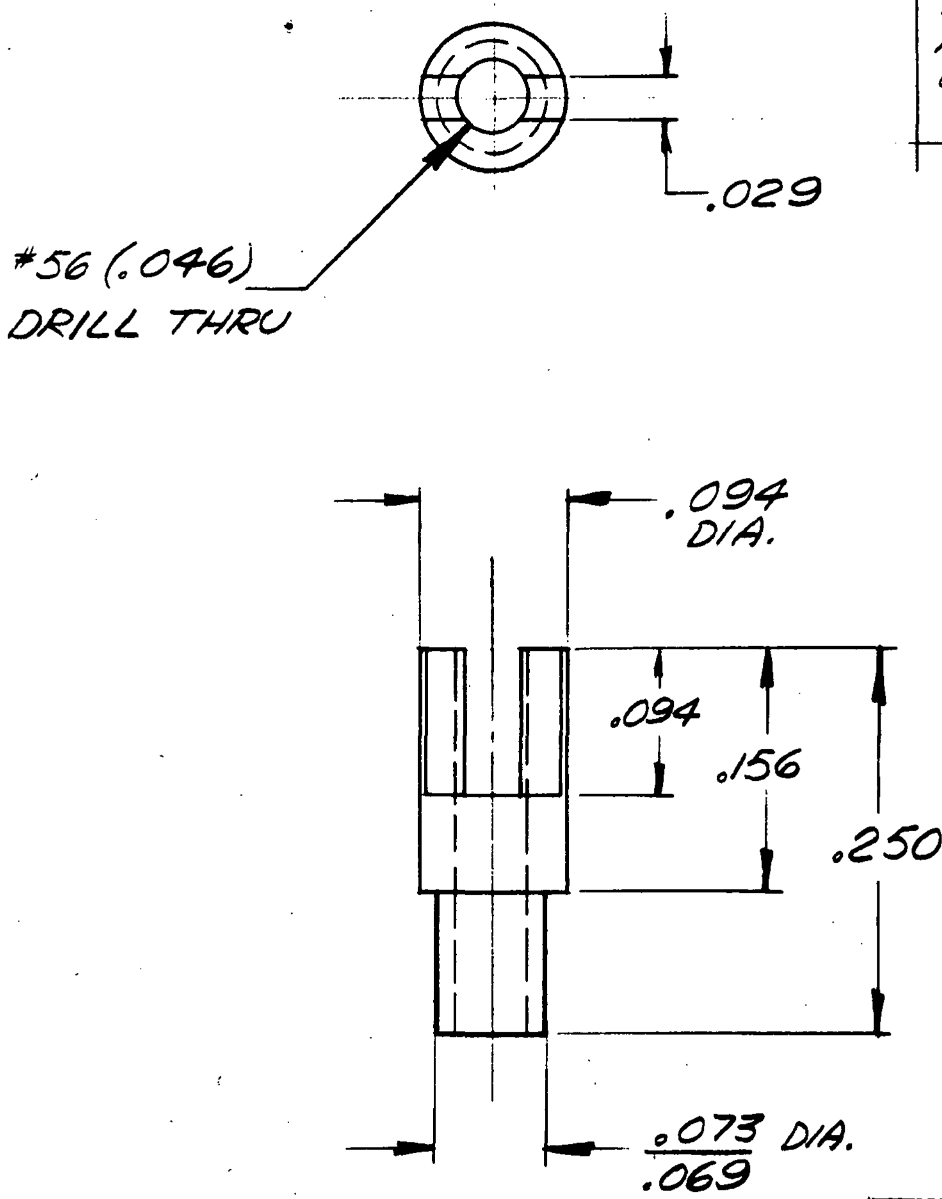
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	8:1

DO NOT SCALE DRAWING

842-400-013A
PAGE 1 OF 2

	REVISIONS
A	CN 1037 REDRAWN 8:1 TOP AND FRONT VIEW CORRECTED. EGAR 3-6-73

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED



APPROVAL		DATE
ENG.	[signature]	7 MAR 73
PROD.	[signature]	7 MAR 73
QA	[signature]	3/7/73
MGMT.	[signature]	3/12/73

ALL SURFACES MARKED "ƒ" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN ALL DIMEN. IN INCHES UNLESS SPECIFIED OTHERWISE

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
SOLDER TERMINAL		[signature]

DRAWN BY W. GANNON DATE 10-5-71	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-013A PAGE 1 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements

A. Solder terminal; forked; thru hole; mounting diameter .071

B. Terminal material: brass as per ASTM-B135

C. Terminal finish: .0005 electro solder plate over .000050 copper plate, as per MIL-F-14072

Only the item described on this drawing when procured from the vendor listed hereon is approved by GTE Laboratories Incorporated, Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without prior testing and approval of GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

Approved Source of Supply

Vendor	Vendors Item Ident. No.	Application
Cambridge Thermionic Corp. 445 Concord Ave. Cambridge, Mass. 02138	1941-2-05	PBM-8G Terminal Board

APPROVAL		DATE
ENG.	JS	20 Feb 73
PROD.	JS	20 Feb 73
QA	RL	2/19/73
MGMT.	VB	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
Solder Terminal		SE

DRAWN BY D. GANNON DATE 10-5-71	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-013 A Page 2 of 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-014A

REVISIONS	
A	CN1052 Added -3 3/29/73 R.L.

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

Requirements

A. Material to be solid, soft drawn, tinned copper wire conforming to Federal Specification QQ-W-343 Type S.

B. Form of supply: Spools

C. Vendor shall supply certificate indicating compliance with Federal Specification QQ-W-343 Type S.

D. Wire size shall be as indicated in table. Part number is the drawing number plus the appropriate dash number.

Item Dash No.	Wire Size AWG
-1	36
-2	32
-3	24

SUGGESTED SOURCES OF SUPPLY

VENDOR	DASH NO.	VENDOR ITEM IDENT. NO.	APPLICATION
Standard Wire & Cable Co.	-1	302-4	Electrical
40 Townsend Road	-2	302-6	Connectors
Attleboro, Mass. 02703	-3	302-10	
Dearborn Wire and Cable Co.	-1	936	
9299 Evenhouse Drive	-2	932	
Rosemont, Illinois 60018	-3	924	

APPROVAL		DATE
ENG.	[signature]	12 Jul 72
PROD.	[signature]	2 Jul 72
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
WIRE, COPPER, TINNED		

DRAWN BY RB

DATE 5/31/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-014A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-015

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

Source Control Drawing

Requirements

A. Feed thru terminal; see page 2.

B. Terminal material; brass per QQ-B-626, composition 22; half hard.

C. Terminal finish; Electroplate .0003 inch min. per M259 with solder per MIL-F-14072.

D. TEFLON INSULATOR PER MIL-M-14077-A

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Sealectro Corp. 225 Hoyt St. Mamaroneck, N.Y.	FT-MM-47-TUR	DRIVE SIG. FEED THRU

APPROVAL		DATE
ENG.	[signature]	20Feb73
PROD.	[signature]	20Feb73
QA	[signature]	3/14/73
MGMT.	[signature]	3/20/73

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FEED THRU TERMINAL		

DRAWN BY W. Gannon

DATE 1/10/72

GTE LABORATORIES INCORPORATED

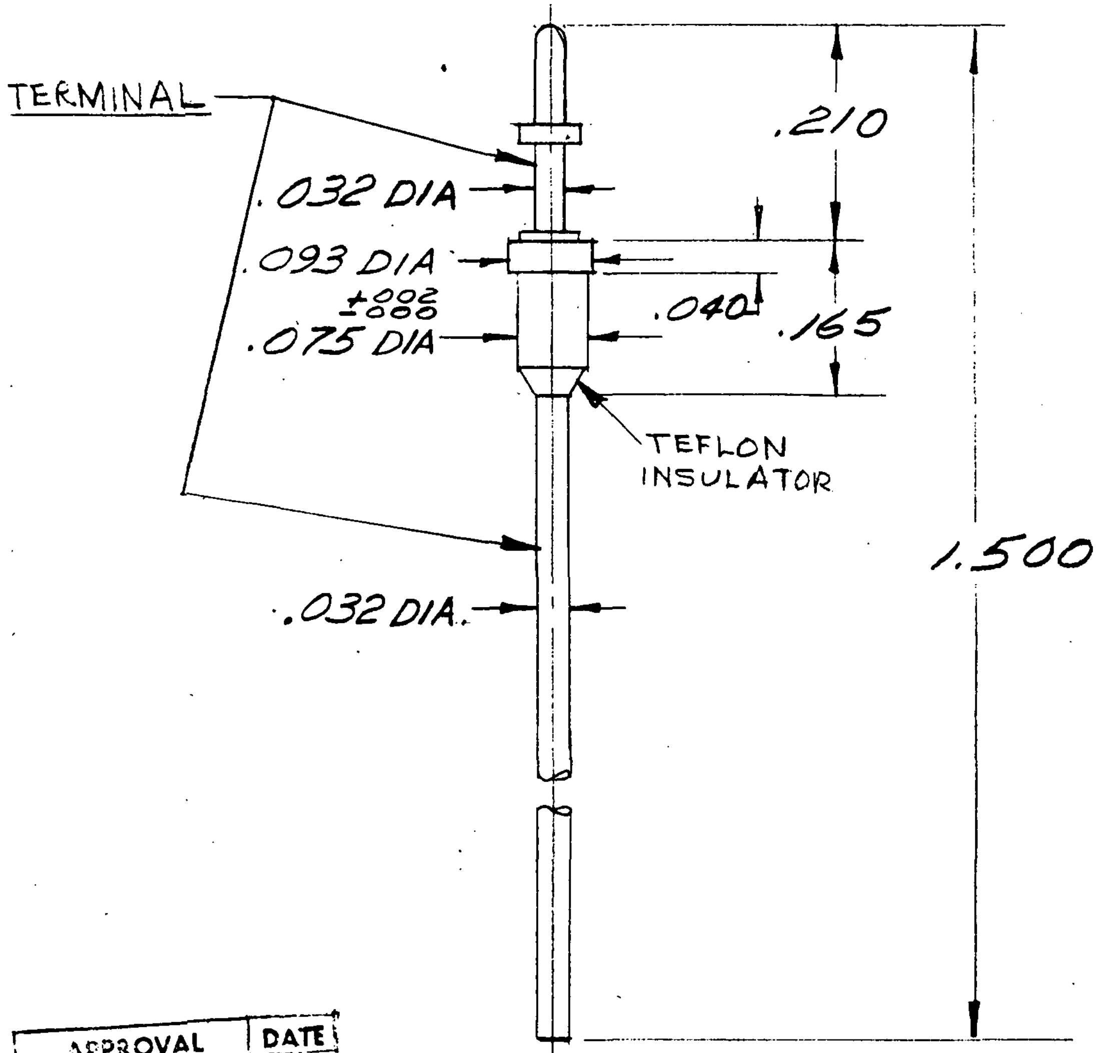
BAYSIDE RESEARCH CENTER

842-400-015

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	5:1
DO NOT SCALE DRAWING			

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED



APPROVAL		DATE
ENG.		20 FEB 73
PROD		20 FEB 73
QA		2/19/73
MGMT		2/20/73

ALL SURFACES MARKED "ƒ" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME: FEED THRU TERMINAL

MATERIAL: PER REQUIREMENTS

PROJECT NO.

DRAWN BY: RBK

DATE: 2-16-72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-015
PAGE 2 OF 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-016

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Material to be PTFE extruded teflon rod as per MIL-P-19468A

B. Vendor shall supply certificate indicating compliance with MIL-P-19468A

C. Form of supply as per table. Part number is the drawing number plus the appropriate dash number.

ITEM DASH NO.	DIAMETER (INCHES)	LENGTH (INCHES)
1	0.25	As specified on purchase order

APPROVED SOURCE OF SUPPLY

VENDOR	VENDOR ITEM IDENT. NO.	APPLICATION
DBL Plastics 43-38 36th Street Long Island City, N. Y.		Insulator

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	20 Feb 73
PROD.	[signature]	20 Feb 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
TEFLON ROD		

DRAWN BY JS

DATE 7/12/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-016

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-017

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements

A. Terminal board, glass epoxy laminate .063 ± .003 in. thick.

B. Material: To meet MIL-P-18177

C. Form of supply - sheet 36" x 48" x 1/16"

D. Vendor shall supply certification indicating compliance with MIL-P-18177.

APPROVED SOURCE OF SUPPLY

Vendor	Vendor Item Identification No.	Application
Synthane Taylor Valley Forge, Pa. 19481	GEE 500	Terminal board

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	12 Jul 72
PROD.	[signature]	12 Jul 72
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
LAMINATE, GLASS EPOXY		

DRAWN BY RB	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-017
DATE 5/31/72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-018A

REVISIONS
A CN1041 Composition was 60/40 Core was 66 Size was .031 New Vendor Number.

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Solder supplied shall conform to Federal Specification QQ-S-571 for flux cored solders.

B. Solder shall have an alloy composition of 63% tin - 37% lead.

C. Solder flux core size shall be such that the volume flux-to-solder ratio is 58.

D. Flux shall be a non-corrosive activated rosin type.

E. Vendor shall supply certificate indicating compliance with Federal Specification QQ-S-571.

F. Form of supply: Spools of wire of such diameter as indicated in the table. Part number is the drawing number plus the appropriate dash number.

Item Dash No.	Wire Size Diameter-in inches
-1	.029

Approved Source of Supply

Vendor	Vendor Item Identification No.	Application
Kester Solder Company 4201 Wrightwood Avenue Chicago, Illinois 60639	#SN63WR[illegible]AP2	Soldering

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL	DATE
ENG. [illegible]	12 Jul 72
PROD. [illegible]	12 Jul 72
QA [illegible]	2/19/73
MGMT. [illegible]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "√" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
SOLDER, FLUX CORE WIRE		

DRAWN BY RB

DATE 5/31/72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-400-018A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-019

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

Source Control Drawing

Requirements

A. Wire, electrical supplied to the following specifications:

1. Nickel plated stranded copper.
2. Insulation FEP teflon with liquid H outside coating.

B. Additional specifications:

1. Size; 24 19/36 NPC
2. Color; clear (vendor's designation), or transparent brown (actual)
3. Type; .0095X/0
4. MSFC Spec. 40M395 13A/7

C. Vendor shall supply certified data, for the lots from which this material is supplied on purchase orders referencing this document, for the characteristics listed under Requirements.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Haveg Industries, Inc. Winooski, Vermont	Wire, electrical Part No. W6N24N	PBM-8G

APPROVAL		DATE
ENG.	[signature]	20 Feb 73
PROD.	[signature]	20 Feb 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME: WIRE, INSULATED

MATERIAL: As noted

PROJECT NO. 2-15-72 2/15/72

DRAWN BY A.C.

DATE 2/8/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-019

TOLERANCE UNLESS OTHERWISE NOTED			SCALE	842-400-020
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°		
DO NOT SCALE DRAWING				REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

Source Control Drawing

Requirements

A. Cable, electrical supplied to the following specifications:

1. Center conductor nickel plated copper.
1.1 Basic wire insulation FEP teflon with polymide coating.
2. Nickel plated shield braid.
2.1 FEP teflon jacket insulation.

B. Additional specifications:

1. Size; 20 009 x 19/32 NPC; I.C. NPC; TE.
2. Color; clear.
3. Shield style -N.
4. Jacket style -B.
5. MSFC Spec. 40M 395 26A/5.

C. Vendor shall supply certified data, for the lots from which this material is supplied on purchase orders referencing this document, for the characteristics listed under Requirements.

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Bayside, New York 11360, for use in the application specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA, Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDORS ITEM IDENT. NO.	APPLICATION
Haveg Industries Inc. Winooski, Vermont	Cable, Electrical Part No. V6N20 N1NB	PBM-8G

APPROVAL		DATE
ENG.	[signature]	20 Feb 73
PROD.	[signature]	20 Feb 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise

NAME	MATERIAL	PROJECT NO.
CABLE, ELECTRICAL	As noted	2-1573 VB 2/17/72

DRAWN BY A.C.

DATE 2/8/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-020

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	

DO NOT SCALE DRAWING

842-400-021

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

Material supplied shall be a non-corrosive liquid rosin soldering flux conforming to MIL-F-14256, Type A, except that the copper mirror test (par. 3.5) is not required, and that the resistivity of water extract (par. 3.2.6) shall be at least 45,000 ohm-centimeters.

APPROVED SOURCE OF SUPPLY		
Vendor	Vendor Item Identification No.	Application
Kester Solder Co. 4201 Wrightwood Ave. Chicago, Illinois 60639	Kester Soldering Flux 1544	Tinning and Soldering

Only the items described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	12 Jul 72
PROD.	[signature]	12 Jul 72
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
FLUX, LIQUID ROSIN		

DRAWN BY RB	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-021
DATE 5/31/72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/4°	
DO NOT SCALE DRAWING			

842-400-022A

REVISIONS	
A	CN 1039 Re-wrote requirements.

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements

A. Potting compound shall chemically cure to an amber color and conform to NASA specification MSFC-SPEC-393-A.

B. Temperature range of application: -70°F to +300°F.

C. Working life after mixing: Time to 250 poises, 1 hr. @ 75°F.
Time to 2500 poises, 5 hrs. @ 75°F.

D. Cure time to 70 Shore A hardness: 7 days @ 75°F
6 hrs. @ 180°F

E. A primer for metals shall be specifically formulated for use with the above potting compound.

F. Each container shall be labeled with date of manufacture. Shelf life in unmixed components shall be at least 6 months after date of manufacture when stored below 80°F.

APPROVAL		DATE
ENG.	[signature]	20FEB73
PROD.	[signature]	20FEB73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

G. Vendor shall supply certificate indicating compliance with MSFC-SPEC-393-A.

H. Form of supply: Both potting compound and primer are supplied in two part units to be mixed as required.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDOR ITEM IDENTIFICATION NO.	APPLICATION
Products Research & Chemical Corp., 410-416 Jersey Avenue Gloucester City, N.J. 08030	PRC-1538 Amber PR-420	Potting Connectors Primer

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Waltham, Mass. 02154, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

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NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
POTTING COMPOUND, AMBER		

DRAWN BY J.S.
DATE 2/14/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-022A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-023

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Resistors supplied shall be of type RNR, hermetic seal, to meet requirements of MIL-R-55182-C

B. Vendor shall supply certificate indicating compliance with MIL-R-55182-C.

Part number is the drawing number plus appropriate dash number.

DASH NO.	MILITARY PART NO.	DESCRIPTION
-1	RNR 60E50R0BP	50Ω 0.1% 1/8W hermetic seal
-2	RNR 55E2432 DS	24.3kΩ .5% 1/10W hermetic seal
-3	RNR 55E1212DS	12.1kΩ .5% 1/10W hermetic seal
-4	RNR 55E8061DS	8.06kΩ .5% 1/10W hermetic seal
-5	RNR 55E3011DS	3.01kΩ .5% 1/10W hermetic seal
-6	RNR 55E2001DS	2kΩ .5% 1/10W hermetic seal

APPROVED SOURCE OF SUPPLY

VENDOR	VENDOR ITEM IDENT. NO.	APPLICATION
Mepco/Electra Inc. Morristown, N. J. 07960	See above table	

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	JS	2 Feb 73
PROD.	JS	2 Feb 73
QA	[illegible]	2/14/73
MGMT.		

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NAME RESISTOR , PRECISION HERMETIC	MATERIAL	PROJECT NO.

DRAWN BY JS

DATE 7/12/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-023

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-024

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Connector: electrical, miniature circular, environment resisting, straight plug, pin

B. Vendor shall supply certificate indicating compliance with MSFC Specification 40M39569B

C. Form of supply as per table. Part number is the drawing number plus the appropriate dash number.

ITEM DASH NO.	NASA PART NO.	DESCRIPTION
-1	NB 6E14-18 PNS	plug, straight crimp contact,environmental
-2	NB 6E8-98 PNS	plug, straight crimp contact,environmental

APPROVED SOURCE OF SUPPLY

VENDOR	VENDOR ITEM IDENT. NO.	APPLICATION
ITT/Cannon Electric %Comptronic Assoc.,370 Old County Road, Garden City, N.Y. 11530	As in table	Cable connector
Deutch Electric Components 640 Fulton Street, Suite 7 Farmingdale, L.I.,N.Y. 11735	As in table	Cable connector

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL	DATE
ENG.	20 Feb 73
PROD.	20 Feb 73
QA NEXT ASSEMBLY	2/19/73
MGMT.	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
CONNECTOR, STRAIGHT PLUG,PIN CONTACT		

DRAWN BY JS

DATE 7/12/72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-400-024

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-025

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

General: Plug, sealing, grommet, electrical connector; for #20 pin

Specification: To meet MSFC Specification 40M39569B

APPROVED SOURCE OF SUPPLY

VENDOR	NASA ITEM IDENTIFICATION #	APPLICATION
ITT/Cannon 666 Dyer Road Santa Ana, Calif. 92072	NB-GSP-20	Connector sealing plug
Deutch Electric Components Municipal Airport Banning, Calif. 92220		

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	20 Feb 73
PROD.	[signature]	20 Feb 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
PLUG, SEALING		

DRAWN BY JS

DATE 7/12/72

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-025

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-026

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

Requirements

A self-locking maching screw is to be supplied conforming to the following requirements:

A. Screw material shall be AISI4037 Steel of at least 170,000 psi tensile strength tempered to hardness of Rockwell "C" scale 38-43.

B. The screw shall be slotted at the threaded end and fitted with an insert of blue KEL-F (3M Company) material. The slot shall be .020 ± .003" in width and the insert shall begin not further than one (1) thread back from the screw tip and extend the length of at least three (3) threads.

C. The screw shall be finished with black oxide coating conforming to MIL-C-13924B.

D. Threads shall be Class 3A fit.

E. Screw thread, length, and head type shall be as specified in the table. The dash number of the drawing indicates the row of the table for that screw.

DWG. DASH #	THREAD	LENGTH	HEAD TYPE	NUMBER PER ASSY.	FASTENER FOR
-1	0-80	1/8	Cap Head Socket	2	Term. Board
-2	0-80	3/8	Flat Head Socket	2	Cable Clamp
-3	0-80	7/16	Button " "	1	Bottom Cover
-4	1-72	1/8	" " "	2	Clamp Plate
-5	2-56	1/8	" " "	2	Bottom Cover

F. A certificate certifying compliance with all of the above requirements shall accompany all items delivered on purchase orders referencing this document.

APPROVAL		DATE
ENG.	[signature]	16FEB73
PROD.	[signature]	16FEB73
QA	[signature]	2/15/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
MACHINE SCREW, SELF-LOCKING		

DRAWN BY J.S.

DATE 2/14/73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-400-026

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-026

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

APPROVED SOURCE OF SUPPLY		
VENDOR	DASH #	VENDOR ITEM IDENTIFICATION #
Long-Lok Fasteners Corp. 10630 Chester Road Cincinnati, Ohio 45215 (513) 772-1880	-1 -2 -3 -4 -5	LL66U00J2 LL66J00J6 LL66B00J7 LL66B12J2 LL66B26J2

Only the items described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Waltham, Mass. 02154, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise

NAME	MATERIAL	PROJECT NO.
MACHINE SCREW, SELF-LOCKING		

DRAWN BY	J.S.
DATE	2/14/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-026
Page 2 of 2

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-027

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

1. SCOPE

This specification defines the requirements for surface coating of high nickel alloy parts for corrosion protection and low optical reflectivity.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in affect on the date of the order referencing this specification form a part of the specification to the extent cited herein.

Specifications

MIL-C-26074 Coatings, Electroless nickel, Requirements for

MIL-P-14538 Plating, Black chromium (Electrodeposited)

APPROVAL	DATE
ENG.	19 MAR 73
PROJ.	19 MAR 73
QA	3/16/73
MGMT.	3/20/73

3. REQUIREMENTS

3.1 Basis metal. Unless otherwise specified the metal parts to be coated under this specification will be an iron-nickel alloy consisting of 45 to 50 percent nickel.

3.2 Precoating Operations. Parts as supplied shall not require nor be subjected to stress - relief heat treatment, shot peening, or embrittlement relief.

3.3 Coating. Two coatings shall be applied to each of the parts supplied as specified.

3.3.1 Electroless nickel. A coating of electroless nickel shall be applied in accordance with MIL-C-26074, Class 1, Grade B (0.0005 minimum thickness). Nickel shall have a non-specular satin finish.

3.3.2 Black chromium. A coating of black chromium shall be applied in accordance with MIL-P-14538 to give a black low reflectivity finish.

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME: SURFACE FINISH

MATERIAL

PROJECT NO.

DRAWN BY J.S.

DATE 3/16/73

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842-400-027

3.4 Coating sequence. Coatings and masking are to be applied in the following sequence.

3.4.1 Electroless nickel coat all surfaces on parts as per 3.3.1.

3.4.2 Mask parts where specified on part drawings referencing this specification.

3.4.3 Black Chromium coat masked parts as per 3.3.2.

3.4.4 Preservative. No supplementary preservative treatment shall be applied.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein and in referenced documents. The buyer or the Government reserves the right to perform any of the inspections set forth in this or referenced specifications where such inspections are deemed necessary to insure supplies and services conform to prescribed requirements.

4.2 Inspection. Except where otherwise specified, inspection shall be in accordance with the provisions of MIL-C-26074 and MIL-P-14538.

4.3 Test specimens. Except when otherwise specified, all destructive testing of adhesion, thickness, or other coating properties shall be performed on test specimens cleaned and coated concurrently with the parts represented. The test specimens shall be strips approximately 1 x 3 x 0.04 inch and supplied with the lot to be coated.

4.4 Embrittlement relief. No embrittlement relief testing is to be performed.

Suggested Sources of Supply

American Electroplating Co.
7 Harvard Street
Cambridge, Mass. 02138

Vernon Plating Works, Inc.
33-18 57th Street
Woodside, N.Y. 11377

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-028A

	REVISIONS
A	CN1040 Composition was 60/40

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SOURCE CONTROL DRAWING

General Requirements

A. Solder supplied shall conform to Federal Specification QQ-S-571, Type S for solid solder.

B. Solder shall have an alloy composition of 63% tin - 37% lead.

C. Vendor shall supply certificate indicating compliance with FederalSpecification QQ-S-571, Type S.

D. Form of supply: bars or spooled solid wire as required.

APPROVED SOURCE OF SUPPLY

Vendor	Vendor Item Identification No.	Application
Kester Solder Company 4201 Wrightwood Ave. Chicago, Illinois 60639	63/37 solid solder wire or bar	Tinning

Only the item described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Bayside, New York 11360, for use in the applications specified hereon. A substitute item shall not be used without the prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	12 Jul 72
PROD.	[signature]	12 Jul 72
QA	[signature]	2/9/73
MGMT.	[signature]	2/20/73

NEXT ASSEMBLY

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NAME	MATERIAL	PROJECT NO.
SOLDER, SOLID		

DRAWN BY RB	GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK	842-400-028A
DATE 5/31/72		

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-029

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

General Requirements

The size and length of a slotted round head brass machine screw is specified in the following table:

DWG. DASH #	THREAD	LENGTH IN INCHES	CLASS OF FIT
-1	5-40	1/4	2

Suggested Source of Supply

Lehigh Metal Products Corp.
134 Alewife Brook Parkway
Cambridge, Mass. 02140

McMaster-Carr Supply Company
2828 North Paulina Street
P.O. Box 4355
Chicago, Illinois 60680

APPROVAL		DATE
ENG.	[signature]	20 FEB 73
PROD.	[signature]	20 FEB 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
MACHINE SCREW, BRASS		

DRAWN BY J.S.

DATE 2/15/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-029

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-400-030

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

1.0 SCOPE

1.1 Scope. This specification covers a mirror coating process consisting of a deposited silver reflective film overlaid with a transparent dielectric protective film applied on the surface of optical elements.

2.0 APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of the purchase order referencing this document, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

L-T-90	Tape, Pressure-sensitive, adhesive, (Cellophane and Cellulose Acetate).
CCC-C-271	Cheesecloth, Bleached and Unbleached.

Military

MIL-0-13830	Optical Components for Fire Control Instruments; General Specification Governing the Manufacture Assembly and Inspection of

STANDARDS

Military

MIL-STD-1241A	Optical Terms and Definitions

APPROVAL	DATE
ENG. [signature]	20 Feb 73
PROD. [signature]	20 Feb 73
QA [signature]	2/19/73
MGMT. [signature]	2/20/73

3.0 REQUIREMENTS

3.1 Qualification. Coatings furnished under this specification shall be a product which has been tested, and passed the qualification tests specified in 4.2 and has been approved by General Telephone & Electronics Laboratories or NASA-Marshall Space Flight Center (herein referred to as GTEL or NASA).

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

All dimensions are in inches unless otherwise specified.

NAME: MIRROR COATING SPECIFICATION

MATERIAL

PROJECT NO.

DRAWN BY: J.S.

DATE: 2/15/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-030

3.2 Optical terms and definitions. Reference shall be made to MIL-STD-1241 to define optical terms used.

3.3 Optical elements. The processor is responsible for maintaining the quality of the optical elements used as backing for a front surface mirrored finish.

3.4 Coating Process. The coating process producing the front surface mirror finish shall cause no impairment to the optical element. Optical elements shall not be rejected because of fine hair lines, scratches, digs or stains which are made more visible by the coating process.

3.4.1 Silver Film. The deposited film shall be of high quality silver. There shall be no visible discontinuities or blemishes that adversely affect the field of view as seen with the eye.

3.4.2 Protective Film. The front surface silver film shall be protected by a film of high quality dielectric material. The film shall be free from holes, foreign matter, and perceptible variations in density.

3.5 Reflectance. The finished coated surface shall have 98% or more specular reflectance at an incidence angle of 45° ± 5° when measured with randomly polarized light at 905 ± 5 nm.

3.6 Coated area. The optical element shall be coated over that portion of the surface area indicated on the drawing referencing this specification.

3.7 Temperature influence. The coated surface shall show no signs of deterioration or removal of films after being subjected to ambient temperature of -100°F and also + 160°F.

3.8 Hardness. The coated surface shall show no signs of deterioration such as streaks or hairline scratches as defined in MIL-O-13830 after being hand rubbed with a dry cloth.

3.9 Adherence. No part of the silver or protective films shall be removed when cellulose tape is pressed against the coated surface and slowly removed.

3.10 Humidity. The coated surface shall show no evidence of corrosion, pitting or loss of reflectivity per 3.5 when exposed to a relative humidity of 95 to 100% at 120°F ± 4°F for a period of 24 hours.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. The processor is responsible for performance of all inspection requirements specified herein. He may use his own facility or any commercial laboratory acceptable to GTEL or NASA.

4.1.1 GTEL and/or NASA reserves the right to witness or perform any of the inspections set forth herein where it is deemed necessary to assure conformance to the prescribed requirements.

4.1.2 The processor shall notify GTEL and/or NASA 7 days prior to the start of any testing (4.2 or 4.3).

4.2 Qualification Tests

Three samples shall be processed to meet the requirements of paragraphs 3.3 thru 3.10 inclusive.

4.2.1 Acceptance. The samples shall be examined in accordance with Table 1.

Table 1. Classification of Defects

	Requirement	Test Procedure
Silver Film	3.4.1	4.4.1
Protective Film	3.4.2	4.4.1
Reflectance	3.5	4.4.2
Coated Area	3.6	4.4.1
Adherence	3.9	4.4.5

4.2.2 Environmental

The samples shall be exposed to the environments of paragraphs 4.4.3, 4.4.4, and 4.4.6. Subsequent to each environment the samples shall be examined in accordance with Table 1.

4.2.3 Approval

Sample units and the test results and environmental test report shall be submitted to GTEL or NASA for approval.

4.3 Acceptance

Items for delivery shall be examined in accordance with Table 1.

4.4 Test Methods and Procedures

4.4.1 Coating Process

Use a visual inspection and procedures set forth in MIL-0-13830 to determine compliance with requirements 3.4.1, 3.4.2, and 3.6.

4.4.2 Reflectance

The reflectance of the finished mirror shall be measured by a spectrophotometer or equivalent instrumentation at 900-910 nm.

4.4.3 Temperature Influence

The element shall be exposed to ambient temperatures of -100 and + 160°F for a period of 120 hours and 1 hour respectively. A visual inspection shall be made after the element is returned to standard ambient temperature (+60° to 90°F) to determine compliance with the requirement 3.7.

4.4.4 Hardness

This test shall be performed using a pad of clean dry laundered cheesecloth, conforming to CCC-C-271, approximately 3/8" diameter and approximately 1/2" thick. Bearing with a minimum force of one pound on the protected clean surface of the element, rub a minimum of 50 strokes across the surface in straight lines or circular motions. Subsequent to this procedure the protective coating must meet the requirements of 3.8.

4.4.5 Adherence

Place the sticky surface of cellulose tape, conforming to L-T-90, over a portion of the coated surface. Press the tape firmly against the coated surface. Pull the tape down over the edges of the element and then slowly remove the tape. A visual inspection shall be made of the tested area to assure that the films have not been removed from the substrate material to determine compliance with 3.9.

Edges not forming a part of the reflecting surface shall not be considered when inspection is being performed.

4.4.6 Humidity

The coated elements shall be exposed for a period of 24 hours in a thermostatically controlled humidity chamber having a relative humidity of between 95 and 100% of 120° ± 4°F. The elements shall be removed from the chamber and dried with lens tissue or soft cloth, then inspected to determine compliance with the requirements of 3.10.

5.0 PREPARATION FOR DELIVERY

5.1 Packing

Each completed item shall be individually **wrapped** in tissue and placed in a plastic container.

5.2 Packaging

Boxes shall be packaged in a shipping container capable of being shipped by common carrier.

5.3 Marking

Shipping container shall be marked with the destination shown on the purchase order, purchase order number, part number, and quantity.

6.0 NOTES

6.1 Test data developed by a processor prior to receipt of this document may be acceptable in lieu of Qualification Testing. Such data should be submitted to GTEL or NASA for review.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/4°	
DO NOT SCALE DRAWING			

842-400-031

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

SPECIFICATION CONTROL DRAWING

General Requirements

Material conforming to this specification shall be water white sapphire (aluminum oxide) single crystal or poly-crystaline rod. Length and diameter of rod shall be as specified on purchase order referencing this drawing.

SUGGESTED SOURCES OF SUPPLY

Union Carbide Corporation
Crystal Products Department
P.O. Box 112
Bedford, Mass. 01730

Tyco Saphikon Division
16 Hickory Drive
Waltham, Mass. 02154

APPROVAL		DATE
ENG.	JS	20 Feb 73
PROD.	JS	20 Feb 73
QA	GQ	2/19/73
MGMT.	VB	2/20/73

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NEXT ASSEMBLY

All dimensions are in inches unless specified otherwise.

NAME	MATERIAL	PROJECT NO.
SAPPHIRE (ALUMINUM OXIDE)		

DRAWN BY J.S.

DATE 2/19/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-031

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/4°	
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842-400-032

REVISIONS

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SOURCE CONTROL DRAWING

General Requirements

Material conforming to this specification shall have the following characteristics:

A. Tape material shall be Mylar (DuPont) .001 to .003" thick and 1/2" wide.

B. The tape shall have pressure sensitive adhesive on one side which does not decompose at temperatures up to 200°F.

APPROVED SOURCE OF SUPPLY

VENDOR	VENDOR IDENTIFICATION NUMBER
William T. Bean, Inc. 18915 Grand River Avenue Detroit, Michigan 48223	H20702

Only the items described in this drawing when procured from the vendor listed hereon is approved by GTE Laboratories, Inc., Waltham, Mass. 02154, for use in the applications specified hereon. A substitute item shall not be used without prior testing and approval by GTE Laboratories or by NASA Marshall Space Flight Center, Huntsville, Alabama 35812.

APPROVAL		DATE
ENG.	[signature]	2 FEB 73
PROD.	[signature]	20 FEB 73
QA	[signature]	2/19/73
MGMT.	[signature]	2/20/73

ALL SURFACES MARKED "✓" TO BE SQUARE
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WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
TAPE, MYLAR		

DRAWN BY J.S.

DATE 2/19/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-400-032

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-101B

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

	REVISIONS
A	Renumbered paragraphs, Deleted Pyrotechnic Shock, Modified Altitude.
B	CN1048 Rewrote

QUALIFICATION TEST PROCEDURE

BEAM STEERER

Approval — Date

Engineering John Schlaffer 4 Apr 73

Production John Schlaffer 4 Apr 73

Quality Assurance R. Lambin 4 Apr. 73

Management V J Fowler 4 Apr. 73

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

842-100-604

NAME	MATERIAL	PROJECT NO.
QUALIFICATION TEST PROCEDURE, BEAM STEERER		

DRAWN BY W. Gannon

DATE 1/6/72

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

842-500-101B

1. SCOPE

1.1 This procedure describes the qualification tests to be performed on an Optical Beam Steerer, Drawing number 842-100-604.

1.2 The Beam Steerer has the following physical characteristics; Weight - approximately 8 oz., Volume - approximately 1 3/4 x 1 1/2 x 1 1/4 inches, Connections - two 1 foot long 1/4 inch diameter cables attached.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of this procedure form a part of this procedure to the extent specified herein:

MIL-C-45662 Calibration System Requirements
842-100-604 PBM-8G Beam Steerer, GTE Labs.
842-500-103 Functional Test Procedure, Beam Steerer, GTE Labs.

3. ENVIRONMENT

3.1 Ambient conditions shall be considered to be 23°C ± 5°C, 45% to 75% relative humidity, and 30 ± 2 inches Hg.

3.2 All times indicated shall be considered minimums.

3.3 Environmental values for test requirements are minimums and deviations (including tolerances) shall be in a direction away from ambient.

4. SELECTION OF UNITS

The unit(s) selected for qualification testing shall be qualification models produced in accordance with Drawing 842-100-604. The testing of these units is to insure qualification of the design and production practices, and the adequacy of quality control procedures.

5. FUNCTIONAL TESTS

Functional tests (electrical, optical and/or operational), when specified, shall be performed by the manufacturer in accordance with Functional Test Procedure 842-500-103. References in parenthesis below cite the paragraph number in the test procedure. All functional tests shall be performed at ambient conditions unless otherwide specified.

5.1 Strain Gage Bridge Unbalance (6.1).

5.2 Strain Gage Angular Sensitivity (Amplified) (6.2.1).

5.3 Deflection Sensing Error (6.2.2).

5.4 Mirror Flatness Deviation (6.3).

5.5 Resonance Frequency (6.4).

5.6 Mirror Deflection (6.5).

5.7 Mirror Reflectivity (6.6).

6. QUALIFICATION TESTS

6.1 Temperature, Operating

The unit shall be exposed to the following environment for the time shown. Measurements as specified shall be taken at the operating temperature and data recorded.

6.1.1 -5°C (+23°F) for 60 minutes.

6.1.1.1 Test for strain gage bridge unbalance, per paragraph 5.1.

6.1.1.2 Test for strain gage angular sensitivity per paragraph 5.2.

6.1.1.3 Test for the mirror flatness deviation per paragraph 5.4.

6.1.2 +45°C (+113°F) for 60 minutes.

6.1.2.1 Test for strain gage bridge unbalance, per paragraph 5.1.

6.1.2.2 Test for strain gage angular sensitivity per paragraph 5.2.

6.1.2.3 Test for mirror flatness deviation per paragraph 5.4.

6.2 Temperature

The unit shall be exposed to the following environment for the times shown.

6.2.1 +60°C (+140°F) for 6 hours.

6.2.2 Ambient for 30 minutes.

6.2.3 -30°C (-22°F) for 6 hours.

6.2.4 Ambient for 30 minutes.

6.2.5 Test for strain gage bridge unbalance, per paragraph 5.1.

6.2.6 Test for strain gage angular sensitivity per paragraph 5.2.

6.3 Altitude

6.3.1 Hi Vacuum

The unit shall be spectrometrically examined at room ambient, in a pressure of no more than 1×10^{-8} Torr and the outgassing products and partial pressures shall be identified and recorded.

6.3.1.1 Pump down shall continue for at least an additional 24 hours at which time the tests shall be repeated, and all values, including pressure, shall be recorded.

6.3.2 Vacuum

The unit shall be exposed to a pressure of 1×10^{-6} Torr at 120°F for 30 minutes.

6.4 Humidity

6.4.1 The unit shall be exposed to 95% relative humidity at +30°C (+86°F) for 24 hours. No operating test will be made during the environment.

6.4.2 Dry the unit thoroughly using unheated low pressure air.

6.4.3 Test per paragraphs 5.1 through 5.7 inclusive.

6.5 Vibration and Acoustic Noise

The unit shall be exposed to the following environment for the duration shown in each of three axes.

6.5.1 Sinusoidal Sweep at one octive per minute each axis.

Frequency Range (Hz)	Amplitude
5 - 14	0.5 in (peak-to-peak)
14 - 400	5.0 g (0-peak)
400 - 2000	7.5 g (0-peak)

All resonant peaks shall be recorded.

6.5.2 Random, Broad Band. Four minutes each axis (Figure 1).

Flat 20 to 80 Hz at 0.05 g^2/Hz

Roll off below 125 Hz at 5.5 db/octave

Flat 125 to 560 Hz at 0.1 g^2/Hz.

Roll off above 560 Hz at 3.5 db/octave.

Flat 1000 to 2000 Hz at 0.05 g^2/Hz.

Overall: 12.7 g (rms).

6.5.3 Random, Narrow Band. Sweep one octive per minute (Figure 1).

.25 g^2/Hz narrow band sweep between 180 and 2000 Hz with overall value of 3.53 g (rms) and an equivalent bandwidth of 50 Hz.

6.5.4 Acoustic Noise.

The unit shall be exposed to the environment shown in Figure 2 for 3 minutes.

6.5.5 Test per paragraphs 5.1 through 5.7 inclusive.

6.6 Acceleration

The unit shall be exposed to the following environment for the times shown.

6.6.1 Linear

8 g for one minute in each axis.

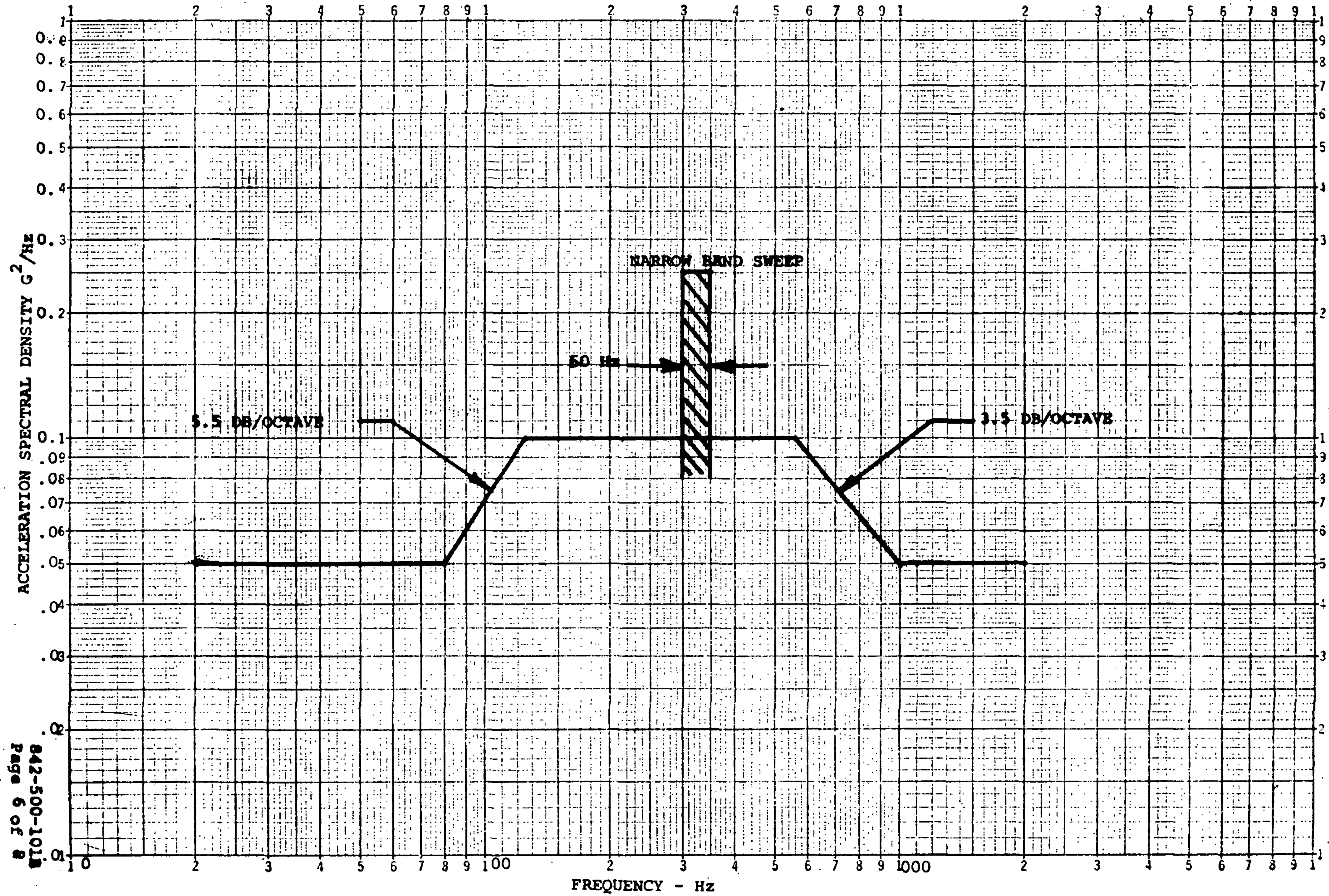

FIGURE 1

RANDOM VIBRATION

842-500-101B

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-101B

REVISIONS

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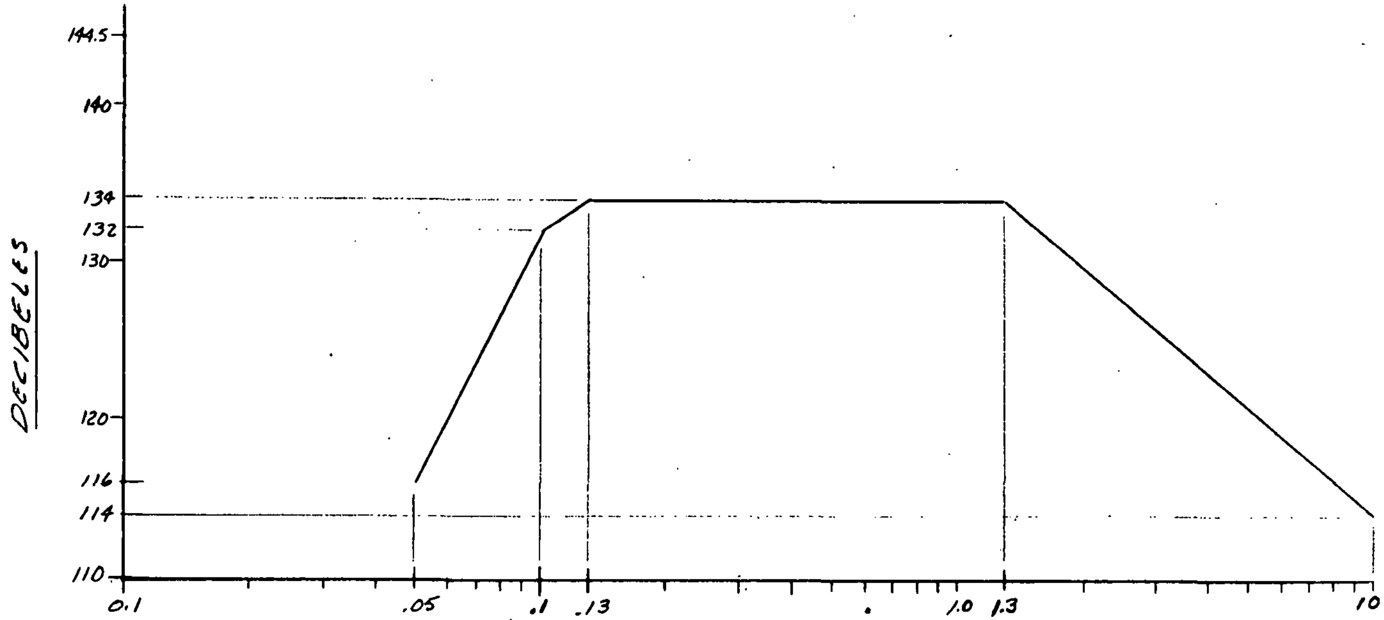

DB REFERENCE LEVEL
0.0002 DYNES/CM²

APPROVAL	DATE
ENG	20 Feb 73
PROD.	20 Feb 73
QA	2/22/73
MGMT.	2/28/73

ITEM NO.	NO. REQ.	DWG. NO.	DESCRIPTION

NAME: ACOUSTIC LEVEL VS FREQUENCY FIGURE 2

MATERIAL

PROJECT NO.

ALL SURFACES MARKED "ƒ" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

DRAWN BY W. GANNON

DATE 3·22·72

GENERAL TELEPHONE & ELECTRONICS LABORATORIES INCORPORATED
BAYSIDE LABORATORIES, BAYSIDE 60, NEW YORK

842-500-101B
PAGE 7 OF 8

6.6.2 Half Sine (shock)

20 g for 11 msec, one shock in each axis.

6.6.3 Test per paragraphs 5.1 through 5.7 inclusive.

7. QUALITY ASSURANCE PROVISIONS

7.1 The equipment used shall be under calibration control in accordance with MIL-C-45662.

7.2 All tests shall be witnessed by a Quality Assurance/Reliability representative of the manufacturer.

7.3 The testing facility shall submit a report containing the following information as a minimum:

7.3.1 Tests performed referencing paragraphs of this procedure.

7.3.2 Serial number of units tested.

7.3.3 A list of the test equipment used and their last calibration dates.

7.3.4 Date of each test.

7.3.5 Visual evidence of damage after each test.

7.3.6 Signature of person performing the test.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-102

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
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ACCEPTANCE TEST PROCEDURE

BEAM STEERER

Approval Date

Engineering John Schlafer 4 Apr 73

Production John Schlafer 4 Apr 73

Quality Assurance R Lamm 4 Apr. 73

Management V Fowler 4 Apr. 73

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
ACCEPTANCE TEST PROCEDURE, BEAM STEERER		

DRAWN BY J. Schlafer

DATE 3/23/73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-500-102

1. SCOPE

This procedure describes the acceptance tests to be performed on an optical beam steerer, Drawing number 842-100-604.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of this procedure form a part of this procedure to the extent specified herein:

MIL-C-45662 Calibration System Requirements
842-500-101 Qualification Test Procedure: GTE Labs.
842-500-103 Functional Test Procedure: GTE Labs.

3. SELECTION OF UNITS

All prototype and flight models manufactured in accordance with a qualified design shall be subject to acceptance testing. The design shall have been qualified through testing of a qualification test model in accordance with GTE Qualification Test Procedure 842-500-101.

4. ENVIRONMENT

Ambient conditions shall be considered to be 23°C ± 5°C, 45% to 75% RH and 30" Hg ± 2" Hg.

5. ACCEPTANCE TESTS

Acceptance tests consist of a series of functional tests as described in the Functional Test Procedure 842-500-103 performed after environmental tests described here and in the Qualification Test Procedure 842-500-101 in the sequence listed herein. Table I lists the paragraph numbers of the tests to be performed. Measurements are to be taken after each environmental test checked off in the table and data recorded in a log book initiated for the unit under test. Unless specified otherwise, measurements are to be taken under ambient conditions of paragraph 4.

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FUNCTIONAL TEST FROM 842-500-103		ACCEPTANCE TEST PARAGRAPH NUMBER			
PAR.	TEST	5.1.1 LOW TEMP.	5.1.2 HIGH TEMP.	5.2 VIBRA-TION	5.3 ACCELERA-TION
6.1	Strain Gage Bridge Unbalance	X	X	X	X
6.2.1	Strain Gage Angular Sensitivity (Amplified)	X	X		X
6.2.2	Deflection Sensing Error	X	X		X
6.3	Mirror Flatness Deviation	X	X	X	X
6.4	Resonance Frequency			X	X
6.5	Mirror Deflection			X	X
6.6	Mirror Reflectivity				X

TABLE I

ACCEPTANCE TESTS

5.1 Operating Temperature

Measurements are to be made at the operating temperatures.

5.1.1 +5°C (+41°F) for 60 minutes.

5.1.2 +35°C (+95°F) for 60 minutes.

5.2 Vibration

5.2.1 Sinusoidal vibration in accordance with paragraph 6.5.1 of 842-500-101.

5.2.2 Random vibration in accordance with paragraph 6.5.2 of 842-500-101.

5.3 Acceleration in accordance with paragraph 6.7.1 of 842-500-101. Measurements are to be made at least 45 minutes after the test.

6. QUALITY ASSURANCE PROVISIONS

6.1 The equipment used shall be under calibration control in accordance with MIL-C-45662.

6.2 All tests shall be witnessed by a Quality Assurance/Reliability representative of the manufacturer.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-103 A

REVISIONS

A	CN 1053 △ Corrected Table I

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FUNCTIONAL TEST PROCEDURE

BEAM STEERER

Approval Date

Engineering John Schlafer 4 Apr 73

Production John Schlafer 4 Apr 73

Quality Assurance R. Lammi 4 Apr. 73

Management V Fowler 4 Apr. 73

ALL SURFACES MARKED "✗" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FUNCTIONAL TEST PROCEDURE, BEAM STEERER		

DRAWN BY J. Schlafer

DATE 3/2/73

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BAYSIDE RESEARCH CENTER

842-500-103 A

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-103 A

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE NOTED

1. SCOPE

This procedure describes the functional tests to be performed on an optical beam steerer, Drawing 842-100-604.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of this procedure form a part of this procedure to the extent specified herein:

MIL-C-45662 Calibration Systems Requirements.

APPROVAL	DATE
ENG.	15 MAR 73
PROD.	16 MAR 73
QA	3/13/73
MGMT.	3/15/73

3. ENVIRONMENT

Ambient conditions shall be considered to be 23°C ± 5°C, 45% to 75% RH and 30" Hg ± 2" Hg.

4. EQUIPMENT

4.1 Electronic Autocollimator. This instrument optically detects mirror angular position and provides a voltage step or pulse output when the mirror passes through perpendicularity to the instrument axis. This voltage step or pulse must make a total transition in less than 20 arc sec. of mirror deflection and have a phase shift of less than 45° at 16 $(10)^4$ positive transitions per second. The instrument is used as a null indicator to signify when the beam steerer passes through an angle and need not be linear through the transition region.

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NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FUNCTIONAL TEST PROCEDURE, BEAM STEERER		

DRAWN BY J. Schlafer

DATE 3/2/73

GTE LABORATORIES INCORPORATED

BAYSIDE RESEARCH CENTER

4.2 Calibrated Wedges. These are optical deviation wedges whose deviation angle has been calibrated to an accuracy of ± 0.6 arc sec. Three wedges are required with nominal deviation angles of:

α = 4 arc min. (nominal)
β = 12 arc min. (nominal)
γ = 10 arc sec. (nominal)

4.3 Orientation Adjustment. The beam steerer is to be mounted on a platform which will allow angular orientation about the deflection axis with control of 0.5 arc sec.

4.4 Differential Amplifier. This amplifies the bridge output voltage and must have the following minimum characteristics:

Gain	150 ± 10
Bandwidth to 3 dB points	dc to 150 KHz
Linearity over output voltage range ± 1 volt	0.01 per cent error
Offset voltage drift vs. temp. referred to input	1.0μV°C
Noise referred to the input	2μVrms
Common mode rejection ratio	10,000

4.5 Transducer Drive Source. This must be capable of driving the beam steerer transducer with sine and triangular waveforms at a variable level from zero up to 1000 Vp-p from 1 to 100 Hz. It shall have a dc offset of less than 10V.

4.6 Bridge power supply. This shall supply a current of at least 50 mA at 2V and allow the voltage to be maintained at 2.000 ± .001V throughout a test sequence. The noise shall be less than 0.5 mVp-p.

4.7 Variable reference voltage. This is a d.c. reference voltage against which the amplified strain gage voltage is compared. It must be variable from + 1.2 to -1.2V and have a noise and spurious signal level less than 1 mVp-p. The voltage control shall be fine enough to allow setting to 0.2 mV.

4.8 Digital Voltmeter. This instrument must be capable of measuring the variable reference voltage to an accuracy of 0.1 mV out of 1.0V.

4.9 Differential Comparator. The voltage from the bridge differential amplifier is compared with the reference voltage by the differential comparator. When the varying bridge voltage passes through a value equal to the reference voltage the comparator output is a voltage step. The comparator should have the following characteristics:

Response time to saturated output with 10 mv step input	< 200 ns
Input voltage differential to drive output over full voltage range	0.2 mv

4.10 Dual Beam Oscilloscope. The oscilloscope indicates when proper adjustments have been made to achieve time coincidence of the signals from the electronic autocollimator and the differential comparator. The oscilloscope should have the following minimum characteristics:

Bandwidth	d.c. to 200 KHz
Sweep Speed	to 10 μs/cm
Synchronization	triggering from either input

4.11 Temperature Controlled Chamber. The beam steerer is placed inside the chamber when measurements are to be made at other than room temperature. The chamber must be constructed with a high optical quality window so that the beam steerer mirror can be monitored by the electronic autocollimator. Temperature shall be maintained at ± 1°C for any temperature set between -30°C to +50°C.

4.12 Thermocouple for temperature range of -30°C to +50°C.

4.13 Monochomatic Parallel Light Interferometer (Twyman-Green or equivalent).

4.14 Oscilloscope with a vertical sensitivity of at least 50 mv per division.

4.15 Signal Source having the following characteristics:

Sine wave output	0 - 10 Vrms Variable
Frequency Range	200 - 1500 Hz continuously variable
Input Impedance	600Ω or less.

4.16 Drive source capable of supplying a sinewave signal from 0 to 360 Vrms at 100 Hz.

4.17 A.C. Digital Voltmeter of ± 0.5% accuracy.

4.18 Stroboscope capable of operating at 100 flashes per second.

4.19 Optical Spectrometer for measurement of mirror reflectance.

4.20 Frequency Counter with a minimum range of 10 - 2000 Hz and 0.5% accuracy.

4.21 Autocollimator having a calibrated range of 60 arc minutes.

5. DIFFERENTIAL AMPLIFIER GAIN CALIBRATION

The voltage gain of the differential amplifier 4.4, used to amplify the strain gage bridge output shall be calibrated in the following manner. Measurements as specified shall be taken and data recorded.

5.1 Connect the differential input leads of the amplifier across a fixed resistance bridge consisting of three (3) 51.0 ± 0.5 ohm resistors, and one (1) 49.0 ± 0.5 ohm resistor, as shown in Figure 1. Apply 2.0 volts to the bridge.

5.2 Measure the differential amplifier output voltage, V1, and the differential input voltage, V2, to ± 0.05% with the digital voltmeter, 4.8. Record the gain, G = V1/V2, on the Linearity Test Data Schedule, Figure 4.

5.3 Measure the differential amplifier temperature to ± 1°C with a thermocouple, 4.12, and record it on the Linearity Test Data Schedule.

6. FUNCTIONAL TESTS

The following functional tests are described herein to be performed as required by acceptance or qualification testing. The data is to be recorded in a manner prescribed by such testing. Parameters shall fall within the limits given in Table I unless otherwise specified. The order of testing of each unit need not follow the order of tests listed herein.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-500-103
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REVISIONS

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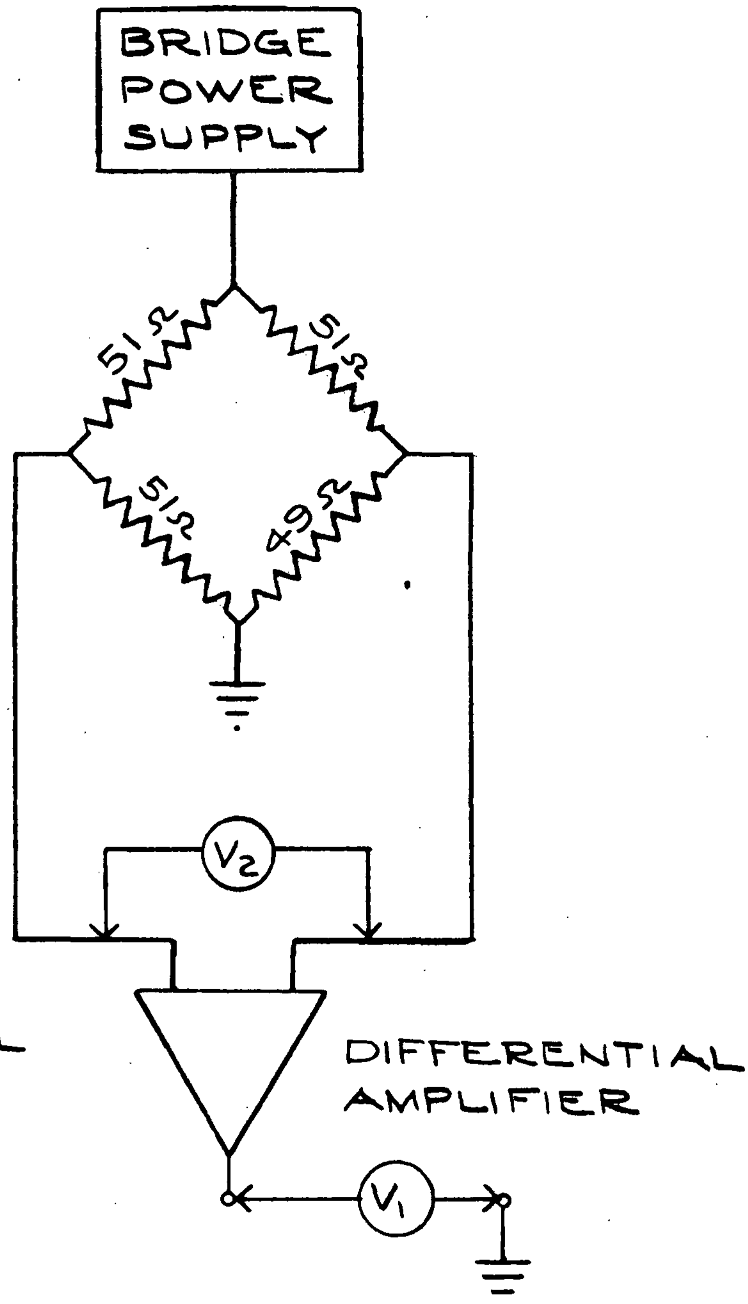

DIFFERENTIAL AMPLIFIER GAIN CALIBRATION

FIGURE 1

ALL SURFACES MARKED "√" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FUNCTIONAL TEST PROCEDURE, BEAM STEERER		

DRAWN BY Boudreault

DATE 27 FEB 73

GTE LABORATORIES INCORPORATED
BAYSIDE RESEARCH CENTER

842-500-103A

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Table I
FUNCTIONAL TEST LIMITS

PAR	TEST	LIMITS	
6.1	Strain Gage Bridge Unbalance	± .055 mV	
6.2.1	Strain Gage Angular Sensitivity (Amplified)	0.765 to 0.935 mV/Arc Sec.	
6.2.2	Deflection Sensing Error	< 0.1%	⚠1
6.3	Mirror Flatness Deviation	< 4.2 μ in.	⚠1
6.4	Resonance Frequency	1120 to 1270 Hz	
6.5	Mirror Deflection	17 to 23 Arc Min.	
6.6	Mirror Reflectivity	≥ 97%	

6.1 <u>Strain Gage Bridge Unbalance</u>

With the voltage as specified below applied to the strain gage bridge and no deflection drive voltage the bridge unbalance shall be determined. Measurements as specified shall be taken and data recorded.

6.1.1 Orient the beam steerer such that the mirror surface is in a vertical plane. Ground the transducer drive lead, No. 2 in Figure 2. Connect a constant voltage supply of +2.000 ± 0.001 volts between the bridge supply lead No. 5 and bridge ground No. 1. Let the bridge stabilize for 10 minutes before making measurements.

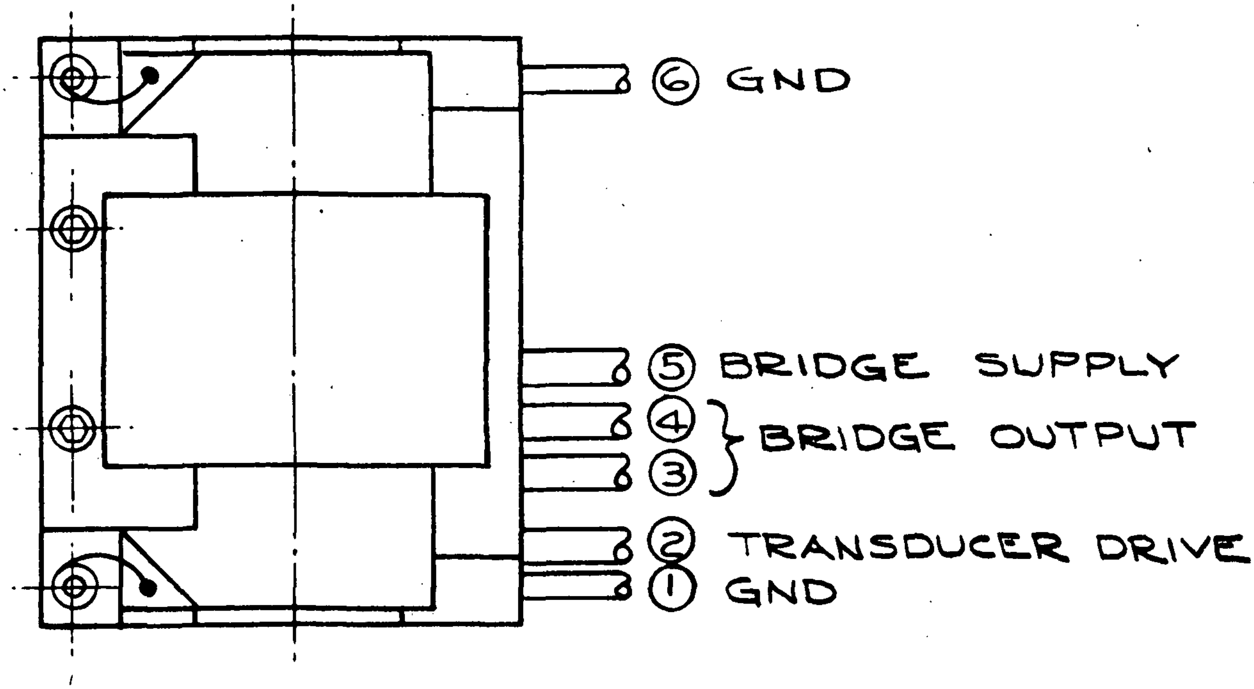
6.1.2 Measure and record the voltage and polarity across the bridge output leads, No. 3 and No. 4 to ± 0.02 millivolts.

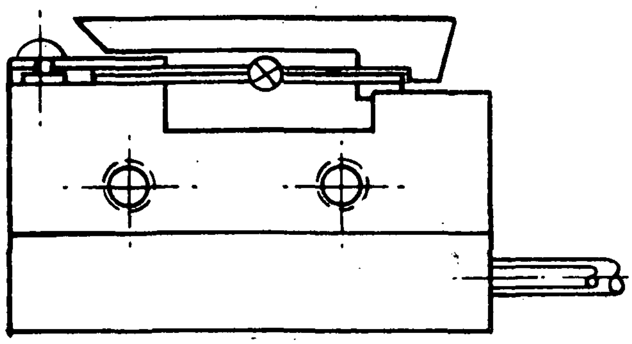
TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	NONE
DO NOT SCALE DRAWING			

842-500-103
A

REVISIONS

REMOVE ALL BURRS AND SHARP EDGES
UNLESS OTHERWISE NOTED





BEAM
STEERER
LEADS

FIGURE 2

NOTE:

SEE 842-100-503 FOR CONNECTOR PIN LETTERS CORRESPONDING TO LEAD NUMBERS

ALL SURFACES MARKED "✓" TO BE SQUARE
PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC
WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
FUNCTIONAL TEST PROCEDURE, BEAM STEERER		

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842-500-103 A

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6.1.3 Measure and record the beam steerer base temperature to ± 1°C with a thermocouple, 4.12.

6.2 Strain Gage Angular Sensitivity and Deflection Sensing Error

The amplified strain gage bridge output as a function of mirror angular deflection is to be measured and a proportionality factor K (mv/arc sec.) derived. The amplified bridge output is measured at various discrete mirror deflection angles, equal to angles generated by a set of calibrated optical deviation wedges, while the beam steerer is being driven with the specified voltage waveform and frequency. The value of K is calculated as a least square fit to the data plotted as amplified bridge voltage vs. deflection angle. The maximum deviation (ε_{max}) of deflection from a line with this slope is then determined.

6.2.1 Angular Sensitivity Measurement

6.2.1.1 Assemble and arrange the equipment described in 4.1 thru 4.10 as shown in Figure 3. Calibrate the differential amplifier, 4.4, as per paragraph 5. Mount the beam steerer rigidly on the orientation adjustment mechanism, 4.3 and position it such that the mirror is perpendicular to the axis of the autocollimator, 4.1 with no wedges present. If measurements are to be made at other than room temperature, the beam steerer must be placed inside the temperature controlled chamber, 4.11.

6.2.1.2 Turn on all electronic equipment. Apply a triangular voltage waveform of 1000 Vp-p at 10 Hz to the beam steerer transducer from the transducer drive source, 4.5. Apply 2.000 ± 0.001V to the beam steerer bridge from the bridge power supply, 4.6. Wait 15 minutes after equipment turn-on before making measurements.

6.2.1.3 Trigger the dual beam oscilloscope 4.10, from the autocollimator step signal generated when the mirror passed through perpendicularity to the autocollimator axis. With the variable reference voltage, 4.7, set at zero, adjust the beam steerer angular orientation about an axis parallel to the deflection axis so that the step signal from the differential comparator, 4.9, is coincident with the autocollimator signal on the oscilloscope.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

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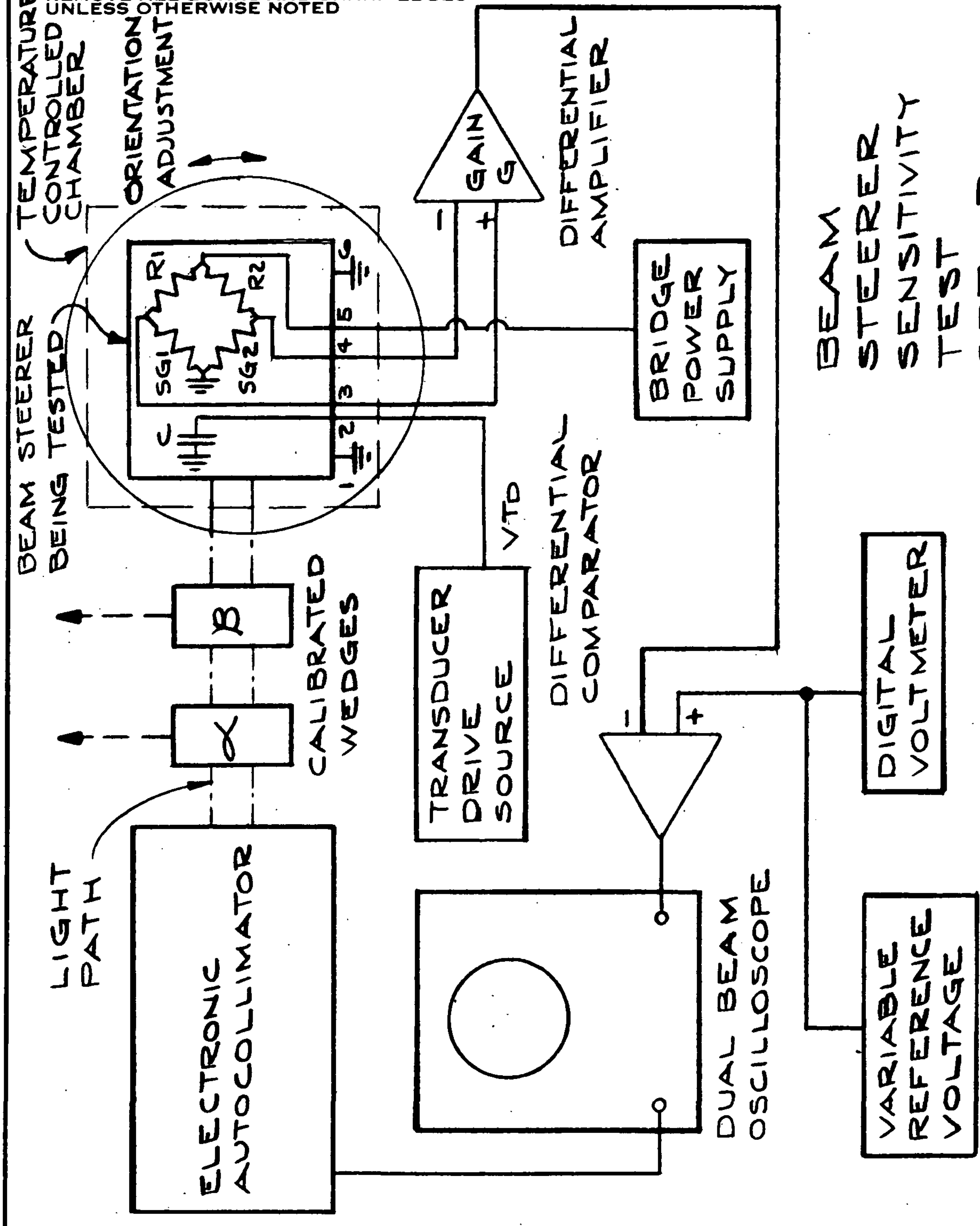

BEAM STEERER SENSITIVITY TEST SET-UP

FIGURE 3

ALL SURFACES MARKED "✓" TO BE SQUARE PARALLEL & PERPENDICULAR TO EACH OTHER & CONCENTRIC WITH AXIS TO WITHIN

NEXT ASSEMBLY

NAME FUNCTIONAL TEST PROCEDURE BEAM STEERER	MATERIAL	PROJECT NO.
DRAWN BY Boudrot	GTE LABORATORIES INCORPORATED	842-500-103 A
DATE 27 FEB 73	BAYSIDE RESEARCH CENTER	PAGE 10 OF 15

6.2.1.4 Insert the calibrated wedge γ, 4.2, into the optical path between the autocollimator and beam steerer such that its plane of deviation is parallel to the beam steerer deflection plane. Adjust the oscilloscope sweep speed such that wedge γ shifts the comparator step signal 7 to 10 major divisions on the screen. This sweep speed is to be used on all subsequent measurements.

6.2.1.5 Record the values of the calibrated wedges α and β, 4.2, on the Linearity Test Data Schedule, Figure 4. Complete the Arc Sec column of the schedule. Insert wedges α and β into the optical path, as in 6.2.1.4, in the sequence given in the Wedges column of the Schedule. Adjust the reference voltage to bring the comparator step into coincidence with the autocollimator signal for each wedge setting, and record the value as read on the digital voltmeter, 4.8, in mV in the V_{SG} (Ø) column on the Linearity Test Data Schedule. At check points, where no wedges are inserted, the measurements shall be repeated if the reference voltage setting is greater than ± 0.3 mV with a differential amplifier, 4.4, nominal gain of 150, as determined in 5.

6.2.1.6 Record the following additional information on the Linearity Test Data Schedule:

Model
Serial #
G (amplifier gain) as per 5.2
B (differential amplifier bandwidth) in Hz.
f (transducer drive frequency) in Hz.
T (beam steerer ambient temperature) in °C.
T_A (differential amplifier temperature) in °C.
By (person performing test).
Date
Witness (quality assurance or government)

6.2.1.7 Calculate the slope, K (mV/arc sec) of the straight line passing through zero which forms the best least square fit to the data plotted as V_{SG} vs Ø. Record the value of K on the Linearity Test Data Schedule.

LINEARITY TEST DATA SCHEDULE, BEAM STEERER DEFLECTION

MODEL: ________ SERIAL NO. ________

α = ________ arc sec β = ________ arc sec

Ø				
Wedges	Arc Sec	V_{SG} (Ø) mV	δV_{SG} (Ø) mV	ε (Ø) Percent
0	REF. 0	CHECK PT.*		
α				
$\beta - \alpha$				
β				
$\beta + \alpha$				
0	REF. 0	CHECK PT.*		
$-\alpha$				
$-(\beta-\alpha)$				
$-\beta$				
$-(\beta+\alpha)$				
0	REF. 0	CHECK PT.*		

K = ________ mV/arc sec ε max ________ percent

COMMENTS: ________

G = ________ (differential amplifier gain)

B = ________ Hz (differential amplifier bandwidth)

f = ________ Hz (transducer drive frequency)

T = ________ °C (beam steerer ambient)

T_A = ________ °C (differential amplifier temperature)

K = Strain Gage Ang. Sensitivity (Least square fit)

$\delta V_{SG}(Ø) = KØ - V_{SG}(Ø)$ (Deviation from linear)

$\varepsilon(Ø) = \frac{\delta V_{SG}(Ø)}{2 V_{SG}(\alpha+\beta)} \times 100$ (Percent Relative Error)

*MAX ALLOWABLE V_{SG} (0) = 0.3 mV FOR G~150

LARGER VALUE INDICATES NEED FOR IMPROVED MEASUREMENT STABILITY OR LONGER WARMUP.

BY: ________

DATE: ________

WITNESS: ________

FIGURE 4
FUNCTIONAL TEST PROCEDURE, BEAM STEERER

842-500-103 A
Page 12 of 15

6.2.2 Deflection Sensing Error

6.2.2.1 Using the data gathered in 6.2.1 for each angular value of the wedge settings, calculate the deviation of the amplified strain gage bridge output δV_{SG} (Ø) from a line of slope K using,

$$V_{SG}(\emptyset) = K\emptyset - V_{SG}(\emptyset)$$

6.2.2.2 For each angular value calculate the percent relative error from linearity ε(Ø) of V_{SG}(Ø) from,

$$\epsilon(\phi) = \frac{\delta V_{SG}(\emptyset)}{2V_{SG}(\alpha + \beta)} \times 100$$

Enter the values for ε (Ø) on the Linearity Test Data Schedule opposite the appropriate angle.

6.2.2.3 Determine the largest ε(Ø) percent error from linearity and enter the value in the location labeled "ε max." on the Linearity Test Data Schedule.

6.3 Mirror Flatness Deviation

The peak-to-peak deviation of the mirror surface from a true plane is to be determined using non-contacting interferometric means.

6.3.1 Observe the mirror surface through a monochromatic parallel light interferometer (Twyman-Green or equivalent), 4.13. Adjust the instrument such that a set of fringes are observed which are nominally parallel to the long edge of the mirror. Calibrate the measurement apparatus utilizing the fact that the distance between two adjacent fringes is one half the wavelength of the interferometer source. Measure the peak-to-peak deviation of each fringe from a straight line passing through its end points and record the maximum value observed in microinches.

6.3.2 Orient the fringes to be nominally parallel to the short edge of the mirror and calibrate the measurement apparatus, as in 6.3.1. Measure the peak-to-peak deviation of each fringe from a straight line passing through its end points and record the maximum value observed in microinches.

6.4 Resonance Frequency

The first mechanical resonance frequency of the beam steerer transducer shall be measured according to the following procedure.

6.4.1 Connect the bridge differential amplifier, 4.4, and bridge power supply, 4.6, to the beam steerer and apply 2.0 volts to the bridge.

Monitor the output of the differential amplifier with an oscilloscope, 4.1.4, having a vertical sensitivity of at least 50 mV per division.

6.4.2 Connect the transducer to a signal source, 4.15, having the following characteristics:

Sine Wave Output	0 - 10 Vrms variable
Frequency Range	200 - 1500 Hz continuously variable
Input Impedance	600Ω or less.

With the frequency set at 200 Hz increase the drive voltage from zero until the output bridge differential amplifier is 300 mV peak-to-peak, as monitored on the oscilloscope. Slowly increase the drive frequency and reduce the drive voltage, as required, to maintain the differential amplifier output at 300 mVp-p. Hold that frequency setting at which the differential amplifier output peaks and begins to decrease with increasing frequency. Measure and record this frequency with a frequency counter, 4.20, to an accuracy of ± 1%.

6.5 Mirror Deflection

The peak mirror deflection is to be measured using an a.c. drive signal.

6.5.1 Connect the beam steerer transducer to a drive source, 4.5, capable of supplying a sinewave signal from 0 to 360 Vrms at 100 Hz. Monitor the drive voltage with an a.c. digital voltmeter to an accuracy of ± 0.5%.

6.5.2 Observe the mirror deflection with an autocollimator, 4.21, having a calibrated range of at least 60 arc minutes. The light source for the autocollimator shall be a stroboscope, 4.18, capable of operating at 100 flashes per second.

6.5.3 Set the drive source at 100 Hz and bring the voltage up from zero to 353 Vrms. Adjust the stroboscope flash rate to be slightly asynchronous with the drive signal such that the return image in the autocollimator can be observed swinging slowly across the reticle. Determine the peak-to-peak deflection of the mirror and record this numerically as ± (1/2 peak-to-peak deflection) arc minutes.

6.6 Mirror Reflectivity

The absolute mirror reflectivity shall be determined at 45° angle of incidence over the wave length band specified using an optical spectrometer or equivalent method.

6.6.1 Clean the beam steerer mirror with fresh lens tissue and alcohol to remove any surface contamination.

6.6.2 Calibrate the spectrometer over the specified wavelength band with the mirror removed such that 100% transmission is recorded.

6.6.3 Insert the mirror to be measured at 45° ± 5° angle of incidence and scan the specified wavelength band. Note the minimum single reflection reflectivity in this band and record this value in percent.

7. QUALITY ASSURANCE PROVISIONS

7.1 The equipment used shall be under calibration control in accordance with MIL-C-45662.

7.2 All tests shall be witnessed by the Quality Assurance Section.

TOLERANCE UNLESS OTHERWISE NOTED			SCALE
FRACTIONS ±1/64	DECIMALS ±.005	ANGULAR ±1/2°	
DO NOT SCALE DRAWING			

842-600-000

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INSPECTION INSTRUCTIONS

NOTES:

1. Points of inspection during parts manufacture and assembly are indicated on the Process Flow Chart, 842-100-001.

2. Specific inspection instructions which are not given on the part drawing or associated notes are to be generated prior to fabrication of flight hardware. Each instruction shall be numbered in the series 842-600-XXX with the last three digits corresponding to the last three digits of the manufacturing drawing to which it refers.

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NEXT ASSEMBLY

NAME	MATERIAL	PROJECT NO.
INSPECTION INSTRUCTIONS		

DRAWN BY R. Lammi

DATE 4/4/73

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842-600-000

ZONE	LTR	DESCRIPTION	DATE	APPROVED

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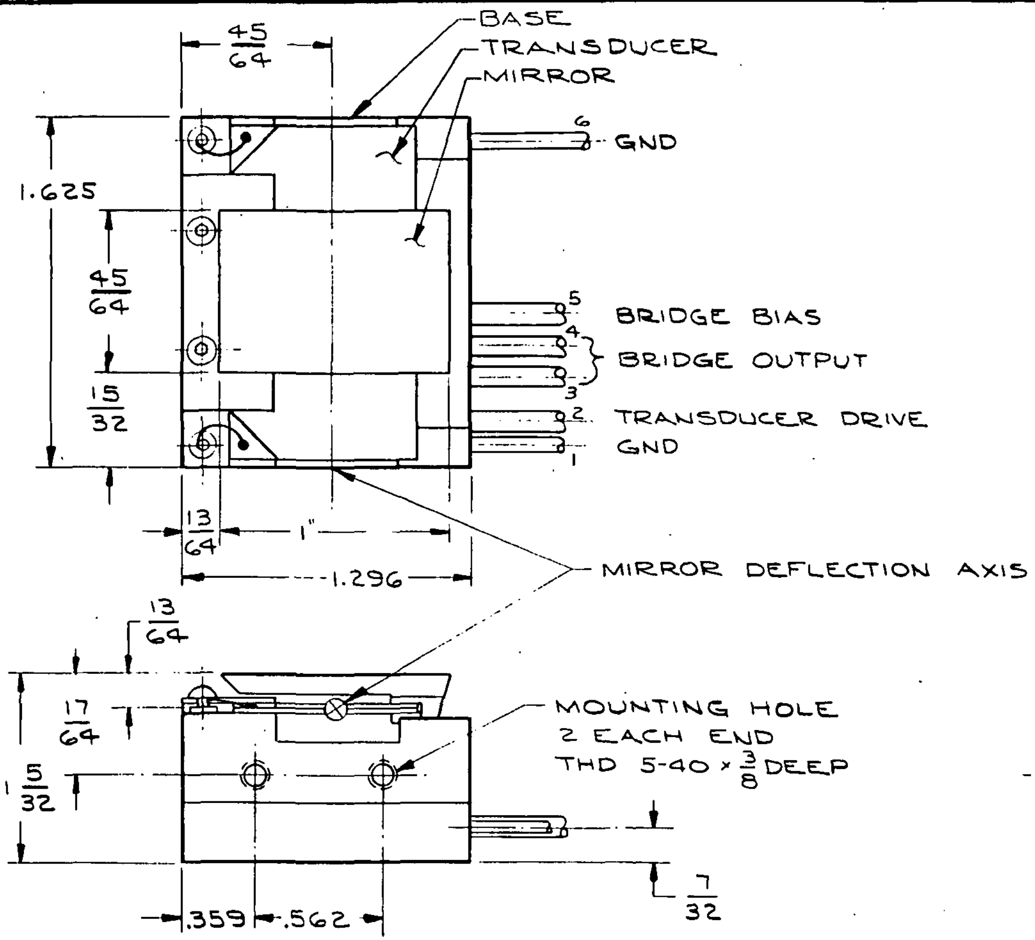

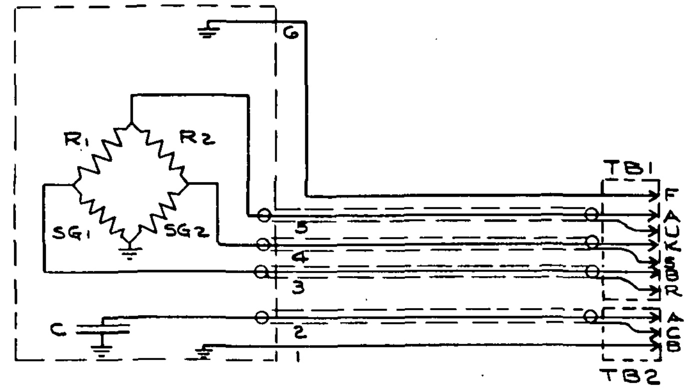

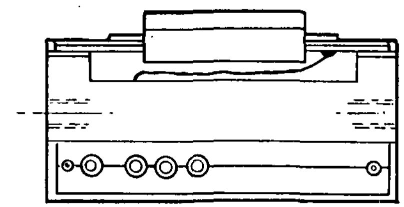

UNLESS OTHERWISE NOTED DIM. ARE IN INCHES. TOLERANCES .XX ± 1/64 .XXX ± .005 ANGLES ± 1/2°	DR Boudrot DATE 2-23-73	GTE LABORATORIES INCORPORATED WALTHAM RESEARCH CENTER WALTHAM, MASSACHUSETTS
	CHK 23 Feb 73	
	APPD 23 Feb 73	TITLE MOUNTING DIMENSIONS PBM-8G BEAM STEERER
MATERIAL	APPD	SIZE B · CODE IDENT. · DWG NO. 842-700-001
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