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MILITARY SPECIFICATION

SERVOCOMPONENTS, PRECISION INSTRUMENT, ROTATING, COMMON REQUIREMENTS AND TESTS

GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers common requirements and tests for analog, digital and analog/digital precision instrument rotating servo-components (synchros, electrical resolvers, electrical linear resolvers, transolvers, shaft angle encoders, servomotors, tachometer-generators, servomotor-tachometer- generators, stepping motors, and gearheads). This specification shall be used with the applicable general specification which covers a particular class of servocomponents (e.g. synchros), together with the specification sheet detailing the specific requirement for the individual servocomponent.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specification and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department, Code 93, Lakehurst NJ 08733-5100 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 5990

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SPECIFICATIONS

FEDERAL

J-W-1177	Wire, Magnet, Electrical
QQ-A-250/4	Aluminum Alloy, 2024, Plate and Sheet
QQ-B-637	Brass, Naval, Rod, Wire, Shapes, Forging, and Flat Products with Finished Edges, Bar, Flat Wire, and Strip

SPECIFICATIONS

MILITARY

MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-S-12134	Synchros, Resolvers, and Servo Motors, Packaging of
MIL-W-16878/4	Wire, Electrical, Polytetrafluoroethylene (PTFE) Insulated, 200°C, 600 Volts, Extruded Insulation
MIL-W-16878/6	Wire, Electrical, Polytetrafluoroethylene (PTFE) Insulated, 200°C, 250 Volts, Extruded Insulation
MIL-S-20708	Synchros, General Specification For
MIL-S-22432	Servomotor, General Specification For
MIL-S-22820	Servomotor-Tachometer-Generator AC, General Specification For
MIL-T-22821	Tachometer-Generator AC, General Specification For
MIL-R-23417	Resolver, Electrical, General Specification For
MIL-R-50781	Resolvers, Electrical, Linear, General Specification For
MIL-E-81512	Encoder, Shaft Position to Digital, Contact Type, Altitude Reporting, General Specification For
MIL-B-81793	Bearing, Ball, Precision, for Instrument and Rotating Components
MIL-T-83727	Transolver, General Specification For

STANDARDS

FEDERAL

FED-STD-H28/2	Screw Thread Standards for Federal Services, Section 2, Unified Inch Screw Threads - UN and UNR Thread Forms

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-740(SH)	Airborne and Structureborne Noise Measurement and Acceptance Criteria of Shipboard Equipment

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

ANSI-S1.11-71 (R 1976)	Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, NY 10018.)

NATIONAL BUREAU OF STANDARDS

NBS Handbook 100 Copper Wire Table (International Annealed Copper Standard)

(Application for copies should be addressed to the U.S. Department of Commerce, NBS, Washington, DC 20234.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A582-80	Free Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold Finished
ASTM E18-84	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Test Methods for

(Application for copies should be addressed to the American Society for Testing and Materials. 1901 Race Street, Philadelphia, PA 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Detail requirements. Detail requirements for individual servocomponents shall rank in the following order of precedence:

a. Specification sheet.

b. The general specification for the particular class of servocomponents.

c. This specification.

d. Referenced documents.

3.2 Qualification. Servocomponents furnished under the applicable servocomponent general specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.6 and 6.7).

3.3 First article. When required by the contracting activity, servocompnents shall conform to the requirements specified herein and shall have met the first article inspection specified in 4.7 prior to the regular production on a contract (see 6.3).

3.4 Parts, materials, and processes.

3.4.1 Parts, materials, and processes. Whenever possible, parts and materials shall be selected from those specified herein. If a suitable material is not listed, a material shall be used which will permit the servocomponent to meet all the requirements of this specification. Materials used in the construction or packaging of servocomponents shall not produce corrosive, toxic, or otherwise deleterious fumes or vapors which could precipitate upon or attack parts or personnel. Acceptance or approval of any constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.4.2 Housing rotor shaft. Housing and rotor shaft material shall be corrosion resistant steel conforming to ASTM A 582-80, Type 416 (UNS S14600). The housing is considered to include front and rear end bells, bearing seats, and any other structural supporting parts. The shaft shall have a hardness conforming to ASTM E18-84, appropriate to the servocomponent as follows:

Where the shaft splining is not to be used as a primary pinion such as synchros, resolvers-	20HRC to 32HRC
Where the shaft is designed to be used as the primary pinion such as servomotors-	28HRC to 35HRC

3.4.3 Insulating materials. Insulating materials shall be in accordance with Requirement 11 of MIL-STD-454.

3.4.4 Dissimilar metals. Dissimilar metals shall not be used in intimate contact with each other unless suitably protected against electrolytic corrosion. When it is necessary for any combination of dissimilar metals to be assembled a material compatible with each shall be interposed between them. For classification purposes metals are grouped as follows:

Group 1	Group 2	Group 3	Group 4
Most anodic metals	Aluminum Aluminum alloys Zinc Cadmium Tin Corrosion-resistant steel	Zinc Cadmium Steel Lead Tin Corrosion-resistant steel	Copper and its alloys Nickel and its alloys Chromium Corrosion-resistant steel Gold Silver (Cathodic) Most Cathodic metals

a. Contact between a member of one group and another member of the same group shall be considered as being similar. Contact between a member of one group and member of any other group shall be considered as being dissimilar except for zinc, tin and cadmium as listed in Groups 2 and 3, and corrosion-resistant steel as listed in Groups 2, 3 and 4.

b. All metals not listed in the above grouping shall be considered as being dissimilar not only to each other but also to any member of any group.

c. The above grouping shall not be construed as waiving requirements relating to the corrosion resistance treatment of parts and assemblies. Care shall be exercised in using aluminum alloys against each other or against differing materials.

d. Where reference is made in the above grouping to a certain member in a particular group the reference applies to the metal on the surface of the part such as zinc means zinc casting, zinc electro-plate, zinc hot dip or zinc metal spray.

e. If any corrosion is anticipated between different metals in contact, even though they are similar, the metals shall be assembled in such a manner that the smaller part is cathodic and protected, and the larger part is anodic or corrodible.

f. Certain qualified standard or approved nonstandard parts and attaching hardware have tin or nickel-plate finish. These parts may be mounted on a chassis without additional protection from corrosion.

3.4.5 Electrolytic corrosion protection. Where it is unavoidable that combinations of dissimilar metals be in contact, the following methods or combinations of methods shall be employed unless electrical consideration preclude their use.

a. A material shall be interposed between the metals so as to reduce electrolytic potential differences, such as steel in contact with aluminum should be cadmium plated.

b. An inert material shall be interposed between dissimilar metals to act as an insulating barrier.

c. Corrosion inhibitors shall be applied to the faces of each of the dissimilar metals, such as nickel-plated brass screws in contact with alumminum shall be coated with zinc chromate paste.

d. The contact areas of each of the dissimilar metals shall be coated with an inorganic coating such as aluminum and steel surfaces in contact should be painted.

e. The requirements of 3.4.4e shall apply.

f. The amount of aeration reaching the dissimilar contact areas shall be restricted, such as steel bolts in contact with aluminum should have all contact surfaces sealed with zinc chromate primer or with a vinyl or equivalent film.

g. Any other systems of protection which are designed to alleviate electrolytic corrosion shall be subject to the approval of the procuring activity.

3.4.6 Restricted materials. Flammable or explosive material, magnesium or magnesium alloys, material which can produce toxic or suffocating fumes, cotton, linen, cellulose nitrate, regenerated cellulose, wood (untreated), jute, leather, cork, organic fiberboard, paper and cardboard, hair or wool felts, plastic materials employing paper, cotton, linen or wooden flours as a filler, materials composed of phenolic, mercury or mercuric compounds shall not be used.

3.4.7 Fungus and moisture resistant materials. Materials which are not nutrients for fungi and which are moisture resistant shall be used.

3.4.8 Collector rings. Collector rings, when required, shall be of gold alloy material.

3.4.9 Ball bearings. Ball bearings of the radial thrust type and shall conform to MIL-B-81793, tolerance ABEC-5P or better. Double shielding shall be employed where space permits. Balls, races, retainers, and shields shall be made of corrosion-resistant steel and shall be in accordance with MIL-B-81793.

3.4.10 Lubricants. Lubricants used in servocomponents shall be consistent with the requirements herein in regard to fungus and moisture resistance, corrosion, emission of toxic fumes while enabling the servocomponent to meet all the performance and environmental requirements of this specification.

3.4.11 Threaded parts. All screw threads and tapped holes used in the construction of servocomponents shall be in accordance with FED-STD-H28/2. The number of threads and dimensions shall be those specified for Unified Inch Screw Threads. Unified coarse-threads are preferred, except where definite improvements in design or operating characteristics would be affected by use of Unified fine threads. Servocomponents shall be supplied complete with associated terminal screws and washers, and drive nut and washer, as appropriate.

3.4.12 Soldering. Soldering shall be in accordance with Requirement 5 of MIL-STD-454.

3.4.13 Magnet wire. Magnet wire shall conform to J-W-1177, Class 130 or higher.

3.5 Design and construction.

3.5.1 Termination identification. Winding terminations shall be as specified in the applicable specification sheet. (The identification of terminal screw, solder pin or wire lead types shall be as specified in the applicable general specification.) Terminal identification markings shall be molded permanently into the servocomponent end cap. The design of the end cap shall be such that the material in the terminal recess is below the surface of the female-threaded post. All unused terminal positions should be closed or filled. When thread type terminations are specified, the design of the end cap shall be such that the terminal block shall remain fixed when terminal screws are removed.

3.5.2 Terminal or wire leads strength.

3.5.2.1 Wire leads. Each wire lead terminal shall consist of seven strands of silver-coated copper conductor and shall be 18 inches long minimum or as specified in the applicable specification sheet. For servocomponent frame sizes 05, wire leads shall conform to MIL-W-16878/6, Type ET-30. For servocomponent frame sizes 08, 11 and 15, wire leads shall conform to MIL-W-16878/4, Type E-28. Each wire lead shall be capable, once only, of withstanding a pulling force of one pound in the case of servocomponents size

05, or of two pounds for servocomponents in frame size 08 and larger applied in a manner that both conductor strands and insulation will be subjected to the force. Wire leads shall be anchored so as not to transmit the strain to the internal electrical connections. Each wire lead shall not separate from the housing nor show evidence of insulation or conductor strand damage.

3.5.2.2 Screw-thread terminals. Each screw-thread type terminal shall withstand, once only, a gradual torque of 4.5 pound-inches which shall be maintained for a period of 5 to 10 seconds without evidence of movement or damage to the terminal or surrounding materials. The torque shall be applied clockwise and then counterclockwise about the centerline of the terminal assembly.

3.5.2.3 Solder-pin terminals. Each solder-pin type terminal shall withstand, only once, a gradual 2 pound pulling force which shall be maintained for a period of 5 to 10 seconds without evidence of movement or damage to the terminal or surrounding materials. The force shall be applied in the direction of the terminal axes.

3.5.3 Servocomponent zero marking. The servocomponents housing shall be permanently marked with an index line or arrow adjacent to the rotor shaft to coincide with a permanent mark on the rotor shaft within 10° of exact servocomponent zero as indicated in the applicable specification sheet.

3.6 Performance.

3.6.1 Shaft radial and end play. With a mechanical load on the rotor shaft as specified in the applicable specification sheet, the servocomponent shall meet the shaft radial and end play limts specified therein.

3.6.2 Rotor moment of inertia. When required by the applicable general specification, the moment of inertia of the rotor shall be no greater than that specified in the applicable specification sheet.

3.6.3 Breakaway torque.

3.6.3.1 Mechanical breakaway torque. When required by the applicable general specification, the torque required to turn the rotor shall not exceed the values specified in the applicable specification sheet.

3.6.3.2 Electrical breakaway torque. When required by the applicable general specification, the electrical breakaway torque shall not exceed the values specified in the applicable specification sheet.

3.6.4 Dielectric withstanding voltage. The servocomponent shall withstand the test potentials between application points specified in the applicable general specification. The servocomponent shall display no evidence of insulation breakdown or of internal arcing nor shall winding leakage current exceed 1 milliampere peak. The leakage current limit shall not include the current drawn by the test equipment capacitance. Immediately after meeting this requirement, the servocomponent shall meet the insulation resistance requirement.

3.6.5 Insulation resistance. The insulation resistance at the dc voltage specified and between those application points designated in the applicable general specification for the dielectric withstanding voltage at -55°C or at the standard test condition shall be at least 50 megohms, and at the high ambient temperature specified in the applicable general specification sheet the insulation resistance shall be at least 10 megohms.

3.6.6 Current. The current drawn by each winding designated in the applicable general specification shall be within the limits specified in the applicable specification sheet.

3.6.7 Power. The power consumed by each winding designated in the applicable general specification shall be within the limits specified in the applicable specification sheet.

3.6.8 Impedance. The impedance of each winding designated in the applicable general specification shall be within the limits specified therein.

3.6.9 Temperature rise. The temperature rise of the servocomponent shall not exceed the value specified in the applicable specification sheet.

3.6.10 Variation of brush contact resistance. When required by the applicabale general specification, the change of brush contact resistance over the entire length of travel of the brush on the collector rings shall not be more than 1.0 ohm for servocomponents whose measured rotor resistance is 200 ohms or less and 0.5 percent of measured rotor resistance for servocomponents whose measured rotor resistance is greater than 200 ohms except that resistance variations of less than 25 milliseconds in duration shall be disregarded.

3.6.11 Electromagnetic interference. When required by the applicable general specification the servocomponent shall not exceed the conducted and radiated limits of MIL-STD-461, requirements CE03 and RE02 of Equipment Class IIB.

3.7 Environmental.

3.7.1 Vibration. Servocomponents of frame size 23 and smaller, shall withstand harmonic vibrations of 0.06 inch double amplitude (maximum total excursion) or 15g (pK) whichever is less over the frequency range of 10 to 2000 Hz in each of three mutually perpendicular planes, one of which shall be that of the servocomponent's shaft axis for a period of four hours in each plane. The vibration cycle of 10 to 2000 Hz and return to 10 Hz, shall be traversed in 20 minutes. Servocomponents larger than frame size 23 shall withstand harmonic vibrations at frequencies up to 500 Hz at an accelaration of 10g (pK). Unless otherwise specified in the applicable general specification, while in this environment, the servocomponent shall be energized and its shaft mechanically loaded in accordance with Figure 1 and free to rotate. Subsequently, the servocomponent shall show no evidence of loose or damaged parts and shall then meet the requirements as specified in the applicable general specification.

3.7.2 Shock.

3.7.2.1 Shock, specified pulse. The servocomponent shall withstand 30 impacts at an acceleration of 50g (pK) of 11±1 millisecond time duration, half sine waveform. The servocomponent shall be subjected to five blows in each direction along three mutually perpendicular axes, one of which shall be that of the servocomponent's shaft axis for a total of 30 blows. Unless otherwise specified in the applicable general specification, while in this environment, the servocomponment shall be energized and its shaft mechanically loaded in accordance with Figure 1 and free to rotate. Subsequently, the servocomponent shall show no evidence of loose or damaged parts and shall then meet the requirements of the applicable general specification.

3.7.2.2 Shock, high impact. The servocomponent shall withstand three shock blows from a weight of 400 pounds falling vertically from heights of 1, 3 and 5 feet respectively and three end (back) blows from a weight of 400 pounds swinging on a radius of 5 feet and falling from a vertical height of 1,3 and 5 feet respectively. Unless otherwise specified in the applicable general specification, while in this environment, the servocomponent shall be energized and the shaft mechanically loaded and free to rotate. Subsequently, the servocomponent shall show no evidence of loose or damaged parts and shall then meet the requirements of the applicable general specification.

3.7.3 Altitude. The servocomponent shall operate from sea level to 100,000 feet in combination with any temperature from -55°C to that high temperature specified in the applicable general specification.

3.7.3.1 Altitude low temperature. The servocomponent shall withstand a reduced chamber pressure of 8.27 Torr (approximately equivalent to an altitude of 100,000 feet) after stabilization at an ambient temperature of -55 ± 2°C. While still in this specified environment, the servocomponent shall meet the requirements of the applicable general specification.

3.7.3.2 Altitude high temperature. The servocomponent shall withstand a reduced chamber pressure of 8.27 Torr (approximately equivalent to an altitude of 100,000 feet) after stabilization at a high ambient temperature environment as specified in the applicable general specification. While still in this specified environment, the servocomponent shall meet the requirements of the applicable general specification.

3.7.4 Endurance. The servocomponent shall be energized and either electrically or mechanically loaded or both and either driven or non-driven as specified in the applicable general specification and shall operate or be operated under the applicable conditions specified in 4.10.4 (unless otherwise specified in the applicable general specification). Immediately after meeting this requirement, the servocomponent shall meet the requirements specified in the applicable general specification.

3.7.5 Ambient temperature.

3.7.5.1 Ambient low temperature. The servocomponent shall operate at -55°C and shall meet the requirements specified in the applicable general specification.

3.7.5.2 Ambient high temperature. The servocomponent shall operate at the high ambient temperature specified in the applicable general specification and shall meet the requirements specified herein.

3.7.6 Moisture resistance. The servocomponent shall operate or in storage withstand ten continuous 24 hour high humidity and temperature combination cycles as well as low temperature vibration subcycles. After completion of the final 24 hour recovery period the servocomponent shall meet the requirements as specified in the applicable general specification.

3.7.7 Audible noise, structureborne. When required by the applicable general specification, the structureborne noise generated in the frequency range of 20 Hz to 9,600 Hz, expressed in terms of acceleration dB above a reference acceleration of 0.001 cm/second^2 (9.82 x10^{-5}g) shall not exceed the limiting value or values specified in the applicable specification sheet.

3.7.8 Explosion. When required by the applicable general specification, servocomponents shall operate in the presence of an explosive-gaseous mixture with air without causing an explosion.

3.7.9 Salt atmosphere. When required by the applicable general specification, servocomponents shall withstand atmosphere saturated with salt-ladden moisture. On completion of the salt atmosphere test, there shall be no visual evidence of corrosive buildup anywhere within the servocomponent nor evidence of destructive deterioration.

3.7.10 Identification marking. Servocomponents shall as a minimum be identified by marking conforming to Figure 2 and MIL-STD-130. Markings shall be applied by acid or electric etching, by permanent marking ink or by engraving and shall be read from the terminal end. Irrespective of the method used, the marking shall be applied directly to the servocomponent housing, i.e., the use of a separate nameplate attached to the housing is not permitted. The markings shall be such as to withstand and to remain legible following the environmental requirements specified herein.

3.8 Workmanship. The servocomponent including all parts and accessories shall be manufactured and finished in a thoroughly workmanlike manner. Particular attention shall be paid to neatness and thoroughness of soldering, wiring, marking and plating. All dimensions and tolerances not specified shall be consistent with best engineering practice. Where dimensions and tolerances affect interchangeability, operation, or performance of the servocomponent, they shall be held or limited accordingly. All materials shall be sound, of uniform quality and condition, and free from seams, cracks, and other defects which may adversely affect the strength, endurance, or wear of the part. Any material hammered, filed, or treated in any other manner to conceal defects therein shall be subject to immediate rejection.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. Test equipment and inspection facilities shall be of sufficient accuracy to permit adequate measuring equipment performance appropriate to the tolerances specified for requirements herein and the applicable specification sheet.

4.1.2 Alternate test methods. The use of unspecified alternate test methods is permitted only when one of the following is supported by documentation:

a. The accuracy shall be demonstrated by analysis and calibration.

b. The accuracy shall be demonstrated by subjecting at least five percent of the units under test to both methods with correlation of test data.

4.2 Test conditions.

4.2.1 Standard test conditions. Unless otherwise specified herein, all measurements and tests shall be in accordance with the general requirements section MIL-STD-202.

4.2.2 Temperature conditions of servocomponents under test. Unless otherwise specified in the applicable general specification, all servocomponents shall be tested under one or other of the following temperature conditions. The condition which will apply to each test will be specified in the applicable general specification.

4.2.2.1 Temperature, stabilized non-operating. This is the temperature condition of a servocomponent after it has remained unenergized in an environment of any specified ambient temperature while shielded from stray air currents for a period sufficient for the servocomponent to have attained a stable temperature. This shall be determined by the periodic measurement of the dc resistance of the particular winding specified in the applicable general specification and shall be deemed to have been attained when the resistance of that winding, measured at five-minute intervals, changes by less than one-half percent from the preceding measurement.

4.2.2.2 Temperature, stabilized operating. This is a temperature condition of a servocomponent, mounted on a standard test fixture, in an environment of any specified ambient temperature after the specified test voltages have been applied to the terminals required by the applicable general specification for a period sufficient for the servocomponent to have attained a stable temperature. This shall be determined by the periodic measurement of the dc resistance of the particular winding specified in the applicable general specification and shall be deemed to have been attained when the resistance of that winding, measured at five-minute intervals, changes by less than one-half percent from the preceding measurement. The stabilized operating condition may be assumed to be attained after energization as specified for a period of one hour.

4.2.3 Test power supplies, etc. The following requirements for each type of servocomponent shall be specified in the applicable general specification sheet:

a. Standard test voltage, frequency, waveform and harmonic content.

b. Phase relationship of the test voltages, where appropriate.

c. Special test equipment.

4.3 Mounting fixtures. Unless otherwise specified, each test shall be conducted with the servocomponent mounted on a standard test fixture, see Figures 3 and 4 as applicable.

4.4 Electrical test load condition. The servocomponent under test shall not be electrically loaded unless specified herein or in the applicable general specification.

4.5 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Qualification inspection - the entire process by which products of manufacturers are examined and tested for the purpose of listing on a Qualified Products List (QPL).

b. First article inspection - tests performed on pre-production samples for the purpose of verifying conformance to the operational, functional, and environmental requirements of the specification.

c. Quality conformance inspection - tests performed on production lots for the purpose of verifying conformance to specifications and acceptance of the product.

4.6 Qualification inspection. Qualification inspection shall be performed in accordance with the applicable general specification at a laboratory approved by the qualifying activity.

4.6.1 Qualification sample. A sample shall consist of six servocomponents of the same type for which approval is requested. The sample or samples submitted for qualification approval shall be representative of normal production. Four servocomponents shall be selected for the qualification approval sample and two shall be held in reserve against need as directed by the qualifying activity.

4.6.2 Qualification inspection routine. The sample shall be subjected to the inspection in Table I by the sample number shown for individual units within the sample. Qualification inspection shall include those tests peculiar to that type servocomponent and shall be performed in the sequence listed under the Qualification and Quality Conformance Inspection Table as specified in the applicable general specification.

4.6.3 Assessment of qualification approval test results.

4.6.3.1 Qualification sample failure. A servocomponent shall be regarded as having failed a particular test either if catastrophic physical damage occurs or if the performance of the servocomponent is outside the limits specified in the applicable general specification. The failure of any one servocomponent of the qualification approval sample shall be sufficient cause for withholding qualification.

4.6.3.2 Qualification sample isolated failure. If it is determined by the qualifying activity that a catastrophic failure is considered to be truly isolated in nature, one substituted new servocomponent may be permitted per test sample. This substituted unit must pass all tests to the point of original failure as well as succeeding tests required by the applicable general specification. A second failure shall be cause for rejection of the sample.

4.6.3.3 Degradation of performance. The environmental tests to which servocomponents are subjected impose upon them conditions representing the extremes of those likely to be encountered in service. Therefore, under qualification inspection, some small degradations of performance may occur which would be unlikely to arise in service and would not impair the performance of the equipment. Allowable minor degradations following environmental tests are as specified in the applicable general specification.

4.6.3.4 Major failures during or following environmental tests. On the occurrence of failures beyond those permitted by the applicable general specification, the qualifying authority may, at its discretion, either reject the qualification application or require the substitution of two additional servocomponents if one servocomponent of the qualification sample fails. The two servocomponents shall be submitted to all applicable tests prior to and including the failed test(s). One of the two units shall then be selected to undergo the remaining tests in place of the unit which originally failed. Failure of a second unit (from either the original four or from the two reserve units) shall, in all cases, be cause for formal rejection of the qualification sample.

4.6.3.5 Qualification approval by analogy. When a manufacturer seeks approval at any one time for two or more types of any one class of servocomponent of the same frame size, he may apply for qualification approval on the basis of group submission subject to approval by the qualifying activity. All four units of each type shall be subjected to the full range of quality conformance tests. The types shall then be grouped in the manner specified in the applicable general specification and a full test sample of four units shall be selected from each group. This tests sample shall be subjected to the remaining qualification approval tests (i.e., one sample of four units shall be fully tested as representing each group). Failure of a test sample shall be cause for withholding approval of the group which it represents. Sample substitution shall not be permitted.

4.6.4 Disposition of qualification sample. Servocomponents subjected to qualification inspection shall not be delivered on any contract or order.

4.6.5 Requalification. In order to retain qualification approval, qualification inspection shall be performed every 24 months or as directed by the qualifying activity.

4.7 First article sample inspection. When required by the procuring activity, sample servocomponents shall be subjected to the provisions governing qualification inspection of 4.6, 4.6.1, 4.6.2, and 4.6.4.

4.7.1 First article sample failure. Failure of any servocomponent in any test shall be cause for refusal to grant first article sample approval.

4.8 Quality conformance inspection. The examination and tests comprising quality conformance inspection are classified as specified in Table I and the applicable general specification.

4.8.1 Quality conformance inspection sampling. Statistical sampling and inspection shall be in accordance with MIL-STD-105, Table I, general inspection level II and Table II-A, single sampling plans for normal inspection. The acceptable quality level (AQL) shall be one percent defective for all tests combined.

4.8.2 Quality conformance inspection routine. The minimum of inspection to be verified by the government inspector shall be the applicable tests of Table I and the dimensional and visual requirements as indicated on the outline drawing in the applicable specification sheet.

4.8.3 Quality conformance sample failure. In case of failure, the entire lot shall be rejected. The supplier shall withdraw the lot, correct the deficiencies or screen out the defective units by retest, as applicable and resubmit for inspection.

4.9 Test methods and examinations.

4.9.1 Visual and mechanical examination. The servocomponent shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements of 3.1, 3.4 through 3.4.13, 3.5.1, 3.5.3, 3.7.10 and 3.8.

4.9.2 Shaft radial and end play.

4.9.2.1 Shaft radial play. The servocomponent shall be mounted rigidly with the shaft horizontal. A dial gauge shall be applied to the shaft as close to the bearing face as possible. A load of the value specified in the applicable specification sheet shall be applied perpendicular to the shaft within 1/4 inch of the end of the shaft, and in a horizontal plane, first in one direction and then in the opposite one. The difference between the two dial gauge readings shall be taken as the shaft radial play. The shaft radial play shall not exceed the allowable shaft radial play specified in accordance with 3.6.1.

4.9.2.2 Shaft end play. The servocomponent shall be mounted rigidly with the shaft horizontal. A dial gauge shall be applied to the end of the shaft. A load of the value specified in the applicable specification sheet shall be applied axially to the shaft, first in one direction and then in the opposite one. The difference between the two dial gauge readings shall be taken as the shaft end play. The shaft end play shall not exceed the allowable shaft end play specified in accordance with 3.6.1.

4.9.3 Rotor moment of inertia. The rotor moment of inertia shall be measured by one of the following methods and shall not exceed the value specified in the applicable specification sheet.

4.9.3.1 Moment of inertia by torsional oscillations. The rotor of the servocomponent shall be fixed to an adaptor of the lowest possible inertia (which shall be measured or calculated) and the adaptor and rotor shall be suspended from a steel wire at least 10 feet long, so that the axis of the rotor coincides with that of the suspension wire. The suspended mass shall be protected from air currents and extraneous vibrations which may cause it to sway. The adaptor-rotor assembly shall be twisted so that oscillation occurs about the axis of suspension. The period, t_a, of the oscillation shall be determined. With the same procedure and adaptor being used, the period, t_b, of a body of known inertia shall then be determined. The moment of inertia of the rotor may then be determined from the expression:

$$J_a = \left[(J_b + J_{ad}) \times (t_a)^2/(t_b)^2 \right] - J_{ad}$$

where:

J_a = moment of inertia of rotor in gram-centimeters^2

J_b = moment of inertia of known body in gram-centimeters^2

J_{ad} = calculated moment of inertia of adaptor in gram-centimeters^2

t_a = period of oscillation of rotor plus adaptor, in seconds

t_b = period of oscillation of body of known inertia plus adaptor, in seconds

4.9.3.2 Moment of inertia by trifilar suspension. The rotor of the servocomponent shall be placed in a plate (circular disc or equilateral triangle) so that the axis of rotation of the rotor is perpendicular to the plate and in the exact center of the plate. The weight of the plate shall be approximately equal to the weight of the rotor. Three threads of equal length shall be connected to a flat, level mounting surface and the plate shall be attached to the threads. The threads shall be equidistant and parallel to the axis of rotation. The distance between the mounting surface and the plate shall be greater than twice the radius from the axis of rotation to the threads (see Figure 5). The plate shall be protected from air currents and extraneous vibrations, rotated and the time period measured as the plate oscillates through a small angle about the axis of rotation with and without the rotor in the plate. The rotor moment of inertia can then be calculated using the following formula:

$$I = \frac{Wr^2t^2}{4L} + \frac{W_b r^2}{4L}(t^2 - t_b^{\ 2})$$

Where:

I = rotor moment of inertia in gram-centimeters ^{2}

W = weight of rotor in grams

W_b = weight of plate in grams

t = time period of oscillation of the plate with rotor in seconds

t_b = time period of oscillation of plate without rotor in seconds

L = distance from the plate to the mounting surface in centimeters

r = radius from the axis of rotation to the threads in centimeters

4.9.4 Breakaway torque.

4.9.4.1 Mechanical breakaway torque. With the applicable weight of Figure 6 attached to the dial of Figure 7 (corresponding to the developed torque specified in the applicable specification sheet) and with the dial mounted rigidly on the shaft and hanging free at the start of the test, the housing of the servocomponent shall be rotated through at least three revolutions in each direction at a constant rate between 4 and 6 rev./min. in accordance with 3.6.3.1. The servocomponent shall fail the test if the dial turns one revolution.

4.9.4.2 Electrical breakaway torque. The servocomponent shall be brought to the stabilized operating temperature condition (as specified in the applicable general specification). With the shaft in any initial angular position, voltage applied to the control winding shall be increased slowly from zero. The voltage at which the shaft starts to rotate continuously shall be noted. The test shall be performed three times for each direction of rotation (a total of six measurements). The highest voltage observed shall be recorded as the electrical breakaway torque, and shall meet the requirements of 3.6.3.2.

4.9.5 Dielectric withstanding voltage. The dielectric withstanding voltage test shall be performed in accordance with Method 301 of MIL-STD-202 and the requirements of 3.6.4. The applicable test potentials shall be applied between those points designated. Any dielectric withstanding voltage test that is repeated on the same servocomponent shall be performed with the test potential reduced to 80 percent of the specified value of the initial test. The test potential shall be raised slowly (minimum time 3 seconds) from zero to the specified value. The peak value of the test potential throughout this test shall not exceed 1.5 times the specified rms test potential. The test equipment employed shall be such as to differentiate between winding leakage current and surge discharge current. Following this test, the insulation resistance test shall be performed in accordance with 4.9.6.

4.9.6 Insulation resistance. The insulation resistance shall be measured in accordance with Method 302 of MIL-STD-202 to determine conformance with 3.6.5.

4.9.7 Current. The servocomponent shall be brought to the stabilized operating condition of 4.2.2.2 in the standard test conditions of 4.2.1. The current drawn by each winding shall be measured and shall be in accordance with 3.6.6.

4.9.8 Power. The servocomponent shall be brought to the stabilized operating condition of 4.2.2.2 in the standard test conditions of 4.2.1. The power consumed by each winding shall be measured and shall be in accordance with 3.6.7.

4.9.9. Impedance. The servocomponent shall be brought to the stabilized operating condition of 4.2.2.2 in the standard test conditions of 4.2.1 and while energized at the applicable standard test voltage and frequency specified in the applicable general specification, the impedance of each winding shall be determined and shall be in accordance with 3.6.8.

4.9.9.1 General. Impedance methods of measurements described hereunder are applicable within specified limitations to all types of servocomponents. However, because of the high accuracy attainable with methods described hereunder, measurements lend themselves more to synchros, resolvers, transolvers, and linear resolvers rather than servomotors, where in general, less sophisticated methods are acceptable.

4.9.9.1.1 The Wien-modified Maxwell bridge. Figure 8 shows the circuit diagram of the bridge, together with the appropriate equations necessary for calculating the servocomponent impedances. The following practical points should be noted.

a. The screen connections on the bridge elements should be arranged as shown in Figure 8 so that the capacitance currents to ground are drawn directly from the supply and are not permitted to shunt the elements.

b. The use of a double screen transformer is essential in order to eliminate the effect of stray capacitance and the ground leakage path from the power supply generator or transformer to the ground terminal of the null detector.

c. The resistance of arm R3 should be kept as small as possible in order to minimize frequency variation errors.

d. Magnetic coupling between the power supply transformer and the null detector transformer(s) may cause additional errors. The power supply transformer should be so positioned that, with the bridge in its balanced condition, rotation about its axis causes no significant alteration of null indication.

e. Careful attention should be paid to accuracy in setting up the voltage and frequency of the supply.

f. If a synchro, resolver, or transolver is under test, it should preferably be set to zero within $\pm$ 3 minutes of arc.

g. The accuracy of the bridge components should be within 0.1% of the nominal values.

4.9.9.1.2 The Marshall potentiometer. Figure 9 shows the circuit diagram of the potentiometer while Figure 10 shows the current balancing network, together with the formula for determining servocomponent current. It is evident from the figures that the potentiometer depends for its action on the provision of a current which is in phase-opposition to, and is an intergral multiple of, the servocomponent current. Under balanced conditions, the servocomponent current is given by the ammeter reading divided by the current division ratio, while the applied voltage is given by the voltmeter reading multiplied by a ratio dependent on the taps of transformer T1 from which the voltmeter and servocomponent are supplied. The servocomponent impedance may then be calculated from wattmeter, voltmeter and ammeter readings.

a. The method has the advantages that the meter losses do not have to be taken into account and servocomponent current is not a limiting factor, since the current divider should be designed to be of very low resistance so that power dissipation is small. A suitable value for the first tap (divide by one) is 0.5 ohm, as shown in Figure 10.

b. Transformer T1 should be designed so that the maximum possible load does not significantly affect the voltage ratio between the taps, and in use, the tapping points should be chosen to give large deflections on the voltmeter and wattmeter.

4.9.9.1.3 Incremental induction bridge. Figure 11 shows the circuit diagram and the appropriate equations for calculating servocomponent impedance using the incremental induction bridge. The bridge consists of the unknown (winding under test) and resistors R_a, R_b, and R_c. The value of R_b shall be small compared to the unknown. The current through the unknown causes a voltage drop across R_b. R_h is in the circuit to compensate for the voltage drop across R_b. The setting of the inductance (L) balance control causes the L isolation amplifier to create a current, in phase with the generator, to flow in the standard capacitator (c). The resistance (R) balance control, along with the R_a R_c voltage divider and the isolation amplifiers, cause a current to flow in the standard resistor (G), that is proportional but opposite in phase to the generator voltage. The combination of the L current and the R current is adjusted to create a null on the detector. The resistance and inductance can then be read directly from the dials on the balance control and used to calculate the impedance as shown in Figure 11.

4.9.10 Temperature rise. The servocomponent, mounted on the appropriate standard test fixture, shall be placed in a chamber, the volume of which shall allow between three and five cubic feet of free air space per servocomponent. Servomotors and motor-generators shall have the shaft locked in such a manner that it cannot rotate. The internal ambient temperature of the chamber shall be adjusted to a value within the range 23 $\pm$ 2°C. This value shall be recorded and shall be maintained throughout the test. The dc resistance of that winding designated in the applicable general specification shall be measured and recorded when the servocomponent has attained the stabilized non-operating condition of 4.2.2.1. All windings specified in the applicable general specification shall then be energized at the standard rated voltage and frequency as specified in the applicable general specification and the dc resistance of the designated winding shall be measured when the servocomponent has attained the stabilized operating condition of 4.2.2.2. The methods used for measuring the dc resistance of the designated winding shall not entail disconnection of that winding from the energizing supply while the measurements are taken. (Figure 12 shows a suitable circuit for this purpose.) The temperature rise calculated from the expression which follows shall be in accordance with 3.6.9.

$$\text{Temperature rise, (°C)} = \frac{R_h - R_c}{R_c} \times (234.2 + t_c)$$

where:

R_h = resistance of the designated winding at the final stabilized temperature

R_c = resistance of the designated winding at the starting temperature

t_c = starting temperature

234.2 = 1/0.00427 (0.00427 is the temperature coefficient of resistance of 100 percent conductivity IACS - International Annealed Copper Standard - copper at 0°C).

4.9.11 Variation of brush contact resistance. The servocomponent shall be energized from a source of constant current not to exceed 10 milliamperes and the brush contact resistance variation between collector rings and brushes as exhibited by a change in voltage between each set of rotor winding terminals shall be measured. The rotor shall be turned at 1 rev/m and after the third revolution, the measurement shall be performed through a complete revolution. The variation of brush contact resistance shall be in accordance with 3.6.10. For qualification approval, the variation of brush contact resistance shall be determined by the method described in 4.9.11.1.

4.9.11.1 Method of measurement for variation of brush contact resistance. Figure 13 is a basic bridge circuit. Example shown is for synchro transmitters, receivers, and control transformers. R_1 resistor is adjusted to approximately twice the value of the dc rotor resistance. R_4 resistor is set to 0.5 ohms and will be used for setting the limits on the recorder. R_2 and R_3 resistors are used to balance the bridge. A maximum of 10mA through the rotor winding is recommended unless the applicable specification sheet specifies a lower current value. Balancing the bridge is accomplished by using R_2 and R_3 resistors with a suitable amplification factor set on the dc amplifier and the center scale dc meter. The sensitivity of both instruments is increased as the bridge is being balanced in order to produce a good null. If excessive drifting occurs, the rotor current should be reduced until a steady null is achieved. The sensitivity of the recorder and amplifier are now set at a level that will give a good reference on the tape when the resistance of R_4 is decreased and increased from the 0.5 ohm setting (0.0 to 1.0). After the reference marks have been established on the tape, the rotor is turned by the one rev/m motor with the recorder chart feed set at 5 mm per second.

4.9.12 Electromagnetic interference. When required by the applicable general specification, the servocomponent shall be tested for conducted and radiated electromagnetic interference in accordance with MIL-STD-462 while energized at the standard test voltage on those windings specified in the applicable general specification and under the conditions or electrical or mechanical load also specified therein. The conducted and radiated electromagnetic interference shall not exceed the limits as specified in 3.6.11.

4.9.13 Terminal or wire leads strength.

4.9.13.1 Wire leads. The force shall be applied at the extreme end of the lead and in a downward direction while the servocomponent is held with its shaft vertically upward in the case of servocomponents having leads emerging from the back end of the servocomponent, or while the servocomponent is held with its shaft horizontal in the case of servocomponents having leads emerging from the housing periphery. In the latter case the servocomponent shall be so held that the lead exit is on the under side. For end-emergent leads the servocomponent shall then be turned through an angle of 90 degrees so that the shaft axis is horizontal and while in this position the housing shall be rotated once in each direction, clockwise and counter-clockwise, about the shaft axis through an angle of 360 degrees. For side-emergent leads the servocomponent shall then be turned through an angle of 90 degrees so that the shaft is vertically upward and while in this position, the housing shall be turned once in each direction, clockwise and counter-clockwise about the axis of emergence of the leads (i.e., end over end), through an angle of 360 degrees. The method of applying the force shall be such that the latter is borne by both the conductor strands and the insulation. Wire lead strength shall be in accordance with 3.5.2.1 (see Figure 14).

4.9.13.2 Screw-thread terminals. Each screw-thread terminal shall be tested using 4.5 pound-inch torque in accordance with MIL-STD-202, Method 211, Test Condition E. Screw-thread terminal strength shall be in accordance with 3.5.2.2.

4.9.13.3 Solder-pin terminals. Each solder-pin terminal shall be tested using a gradual two pound pulling force in accordance with MIL-STD-202, Method 211, Test Condition A. Solder-pin terminal strength shall be in accordance with 3.5.2.3.

4.10 Environmental

4.10.1 Vibration. Servocomponents shall be tested in accordance with MIL-STD-202, Method 204. Servocomponents larger than size 23 shall be tested in accordance with requirements of Test Condition A, and servocomponents size 23 and smaller shall be tested in accordance with the requirements of Test Condition B. Throughout the test, the servocomponent shall be rigidly mounted on a test fixture, utilizing standard mounting surfaces, shall be energized and its shaft mechanically loaded and free to rotate as specified in the applicable general specification. Servocomponents shall have an aluminum disc conforming to Figure 1 securely mounted on the shaft utilizing standard hardware. After completion of this test, the servocomponent shall meet the requirements of 3.7.1.

4.10.2 Shock

4.10.2.1 Shock, specified pulse. Servocomponents shall be tested in accordance with MIL-STD-202, Method 213, Test Condition A. The servocomponent shall be securely clamped to a rigid test fixture utilizing normal mounting surfaces which shall be rigidly mounted on the test device. During the test, the servocomponent shall have the disc of Figure 1 mounted on its shaft, with the servocomponent energized as specified in the applicable general specification and the rotor mechanically free to rotate as specified in the applicable general specification. After completion of this test, the servocomponent shall meet the requirements specified in 3.7.2.1.

4.10.2.2 Shock, high impact. Servocomponents shall be tested in accordance with MIL-STD-202, Method 207 and shall be rigidly mounted to the equipment of

Figure 207-4A therein, utilizing normal mounting surfaces. The servocomponent shall have the appropriate dial (see Figure 7) mounted on the shaft and shall be energized. After completion of this test, the servocomponent shall meet the requirements specified in 3.7.2.2.

4.10.3 Altitude.

4.10.3.1 Altitude low temperature. The unenergized servocomponent shall be placed in a test chamber, the internal ambient temperature of which shall be reduced to and controlled at -55 ± 2°C and the servocomponent shall be allowed to attain the stabilized non-operating temperature condition of 4.2.2.1. The servocomponent shall then be energized so as to attain the stabilized operating temperature condition of 4.2.2.2. The pressure in the test chamber shall then be reduced to 8.27 Torr (approximately equivalent to an altitude of 100,000 feet). While still in this specified environment, the servocomponent shall be subjected to and shall meet the requirements as specified in 3.7.3.1.

4.10.3.2 Altitude high temperature. The unenergized servocomponent shall be placed in a test chamber, the internal ambient temperature of which shall be raised to and controlled within ± 2°C of the high ambient temperature specified in the applicable general specification and the servocomponent shall be allowed to attain the stabilized non-operating temperature condition of 4.2.2.1. The servocomponent shall then be energized so as to attain the stabilized operating temperature condition of 4.2.2.2. The pressure in the test chamber shall then be reduced to 8.27 Torr (approximately equivalent to an altitude of 100,000 feet). While still in this specified environment, the servocomponent shall be subjected to and shall meet the requirements as specified in 3.7.3.2.

4.10.4 Endurance. The servocomponent shall be energized and either electrically or mechanically loaded or both and either driven or non-driven as specified in the applicable general specification and shall operate or be operated under the applicable condition shown in Table II unless otherwise specified in the applicable general specificaton. On completion of the endurance test the servocomponent shall be subjected to and shall meet the requirements specified in 3.7.4.

4.10.5 Ambient temperature.

4.10.5.1 Ambient low temperature. The unenergized servocomponent shall be placed in a test chamber and mounted on a test fixture. The chamber temperature shall be lowered to and maintained at -62° ± 2°C. The servocomponent shall be allowed to attain the stabilized non-operating temperature condition of 4.2.2.1 while in this environment. The test chamber temperature shall then be raised to and controlled at -55° ± 2°C for a period of one hour. At the end of this period and while in this environment, the servocomponent shall be energized in accordance with 4.2.3 and having attained the stabilized operating temperature condition of 4.2.2.2, shall then meet the requirements as specified in 3.7.5.1.

4.10.5.2 Ambient high temperature. The unenergized servocomponent shall be placed in a test chamber and mounted on a test fixture. The chamber temperature shall be raised to and maintained within ± 2°C of the high ambient temperature specified in the applicable general specification. The servocomponent shall then be allowed to attain the stabilized non-operating temperature condition of 4.2.2.1. The servocomponent shall be energized in accordance with 4.2.3 and having attained the stabilized operating temperature condition of 4.2.2.2, shall then meet the requirements as specified in 3.7.5.2.

4.10.6 Moisture resistance. The servocomponent shall be tested in accordance with MIL-STD-202, Method 106 and the requirements of 3.7.6. The servocomponent shall be placed in the test chamber with its rotor shaft in a horizontal position. During the test, half of the qualification sample (one servocomponent) shall be energized in accordance with 4.2.3 and the other half shall be unenergized. After completion of the final cycle, the entire sample (two servocomponents) shall be maintained energized at standard test conditions (see 4.2.1) for 24 ± 4 hours. Immediately after the final energization period, the servocomponent shall be subjected to and meet the requirements as specified in 3.7.6.

4.10.7 Audible noise, structureborne. When specified in the applicable specification sheet the servocomponent shall be mounted on the noise test fixture shown in Figure 15 by means of the appropriate standard mounting clamps. A calibrated transducer shall be fitted to the mounting plate successively in each of the positions shown in Figure 16. The surfaces of the transducer and its attachment area shall be coated lightly with a suitable grease. The transducer shall be attached to the mounting plate with a .190-32UNF-2A stud or bolt whose threads shall be coated with a suitable grease engaged at least 1/4 inch deep in the tapped hole in the plate. The torque used in the method of attaching the transducer to the plate shall be 25 + 0, -2.5 in. lb. force. The fixture, complete with servocomponent, shall be suspended as shown in Figure 16 in such a manner that the shaft axis and the top edge of the mounting plate are horizontal to within 5 degrees. With the servocomponent unenergized, the prevailing ambient noise level for the board, one-third octave and narrow bands shall be at least 14 dB below the specified maximum noise limit for the servocomponent in that band or at that frequency. Those windings designated in the applicable general specification shall then be energized as specified therein and the vibration level of the servo-component shall be determined and be recorded for each frequency band. Unless otherwise specified, the one-third octave and narrow band measurements shall be conducted in that axis of the servocomponent for which the maximum broadband vibration level is recorded. The structureborne noise generated in the frequency range of 20 Hz to 9,600 Hz, expressed in terms of acceleration dB above a reference acceleration of 0.001 cm/second^2 (9.8 x 10^{-5}g) shall not exceed the limiting value or values specified in the applicable specification sheet. Broadband structureborne noise, expressed in terms of acceleration dB, shall be measured by means of a calibrated transducer and vibration-level meter which, including cables and accessories, have a frequency response known to within ± 2 dB over the frequency range of 20 Hz to 9,600 Hz. The equipment used shall possess a low response to magnetic, electrical and acoustic fields. No correction for extraneous response shall be permitted in determining the structureborne noise level of a servocomponent. The response of the equipment to extraneous fields shall be at least 14 dB below the maximum noise limits specified for the servocomponent in the applicable specification sheet. One-third octave band structureborne noise shall be measured with the same equipment that is used for the broadband noise measurement but with the addition of one-third octave band filters covering the range 20 Hz to 8,000 Hz. The filters shall have rejection characteristics beyond the band edges at least as good as those required by MIL-STD-740(SH) and ANSI-S1.11-1971(R1966) for octave band filters. The complete system, including cables and accessories, shall have a response known to within ± 2 dB at all band centers within the range. The scanning rate used for the test shall be not less than 5 seconds per band. Narrow-band structureborne noise shall be measured with the same equipment as is used for the broadband noise measurement but with the addition of a vibration-level recorder and a narrow-band analyzer capable of being turned continuously or of being swept through bandcenter frequencies from 20 Hz to 9,600 Hz. The complete system, including cables and accessories, shall have a response known to within ± 2 dB at all band-center frequencies in the range. The scanning or sweeping rate used for the test shall not exceed $(1/2 \times \text{filter width in Hz})^2$ or 200 Hz per second. The servocomponent shall meet the requirements as specified in 3.7.7.

4.10.8 Explosion resistance. For certain specialized requirements servocomponents may be called upon to operate in flammable atmospheres. In view of their light form of construction the servocomponents cannot be made intrinsically explosion-proof, nor can it be ensured, unless size and weight penalties be accepted, that even a servocomponent devoid of moving electrical contacts will be intrinsically safe since its operating surface temperature may well exceed the ignition temperature of the flammable atmosphere. Testing for either 200 or 2,000 hours, dependent upon the degree of acceptable risk and on the nature of the atmosphere, is needed to ascertain the explosion characteristics of a servocomponent. Accordingly, and in view of the probable low incidence of requirements for explosion-proof servocomponents no test for such characteristics is specified in this document. Should a requirement arise it will be the responsibility of the qualifying activity concerned to specify the explosion tests to be performed on a servocomponent to satisfy its requirements. It is recommended, however, that if such a test is invoked, it should be applied to servocomponents which have completed all qualification approval tests other than salt atmosphere, if appropriate, so that the condition of the test servocomponents will approximate to that which is typical after a considerable period of service. The servocomponent shall meet the requirements specified in 3.7.8.

4.10.9 Salt atmosphere. Servocomponents shall be tested in accordance with MIL-STD-202, Method 101, Test Condition B, with a 5 percent salt solution. The servocomponent shall be placed in the test chamber with its shaft horizontal and supported in a manner that provides line contact on material impervious to the effects of salt moisture and permit maximum circulation of the atmosphere about the servocomponent. After completion of the test, the servocomponent shall meet the requirements specified in 3.7.9.

4.11 Inspection of packaging. Sample packages and packs shall be selected and inspected in accordance with MIL-S-12134.

5. PACKAGING

5.1 Packaging and packing. Packaging shall conform to MIL-S-12134. Minimum packing shall be level C unless otherwise specified (see 6.2e).

6. NOTES

6.1 Intended use. Servocomponents covered by this specification are intended for use in military systems for fire control, radar, navigation, guided missiles, and other precision applications.

6.2 Ordering data. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Title, number, and date of the applicable general specification.

c. Title, number, and date of the applicable specification sheet, the complete nomenclature, and the military part number.

d. Whether first article inspection is required (see 3.3).

e. Levels of packaging and packing (see 5.1).

6.3 First article inspection. Information pertaining to first article inspection of products covered by this specification should be obtained from the contracting activity for the specific contracts involved.

6.4 Definitions. Definitions are defined in the applicable general specification.

6.5 Relationship with servocomponent class specifications. This specification consolidates requirements and tests common to eight (8) existing analog and digital and analog/digital precision instrument rotating servocomponent specifications and has been issued for two express purposes:

a. Elimination of multiple revisions or amendments to effect the same changes in individual servocomponent class specifications for the primary purpose of updating those requirements and tests neccessary to align them with other servocomponent class specifications.

b. Provide more meaningful Government and industry participation by highlighting specific design, test, and environmental criteria of latest engineering development that are common to the following specifications:

MIL-S-20708	Synchros, General Specification For
MIL-S-22432	Servomotor, General Specification For
MIL-S-22820	Servomoter-Tachometer-Generator AC, General Specification For
MIL-T-22821	Tachometer-Generator AC, General Specification For
MIL-R-23417	Resolver, Electrical, General Specification For

MIL-R-50781	Resolvers, Electrical, Linear: General Specification For
MIL-E-81512	Encoder, Shaft Position to Digital, Contact Type, Altitude Reporting, General Specification For
MIL-T-83727	Transolver, General Specification For

6.6 International standardization agreements. Certain provisions of this specification are the subject of international standardization agreement reached by the NATO Study Group on Analogue and Digital Servocomponents (AC/301(SG/I)(STG/1)). When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

6.7 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List and information pertaining to qualification of products are listed in the applicable general specification.

Custodians:
  Army - AR
  Navy - AS
  Air Force - 85

Preparing Activity:
  Navy - AS
Project No. 5990-0328

Review activities:
  Army - ER, MI, AV
  Navy - OS, SH, EC
  Air Force - 11, 79, 99
  DSA - ES

User activities:
  Army - ME, AT
  Navy - MC, CG
  Air Force - 14, 19

TABLE I. QUALIFICATION AND QUALITY CONFORMANCE INSPECTION

Test No.	Requirement	Test	Test Method or Examination	Inspection	
				Qualification Sample Nos.	Quality Conformance
1	3.1, 3.4 through 3.4.13, 3.5.1, 3.5.3, 3.7.10 and 3.8.	4.9.1	Visual and mechanical inspection	1, 2, 3, 4	X
2	3.6.1	4.9.2	Shaft radial and end play	1, 2, 3, 4	X
3	3.6.2	4.9.3	Rotor moment of inertia 1/	1, 2	
4	3.5.2	4.9.13	Terminal or wire leads strength	1, 2, 3, 4	
5	3.6.3	4.9.4	Breakaway torque	1, 2, 3, 4	X
6	3.6.4	4.9.5	Dielectric withstanding voltage	1, 2, 3, 4	X
7	3.6.5	4.9.6	Insulation resistance	1, 2, 3, 4	X
8	3.6.6	4.9.7	Current	1, 2, 3, 3	X
9	3.6.7	4.9.8	Power	1, 2, 3, 4	X
10	3.6.8	4.9.9	Impedance	1, 2, 3, 4	
11	3.6.9	4.9.10	Temperature rise	1, 2, 3, 4	
12	3.6.10	4.9.11	Variation of brush contact resistance 1/	1, 2, 3, 4	X
13	3.6.11	4.9.12	Electromagnetic interference 1/	1, 2, 3, 4	
14	3.7.1	4.10.1	Vibration	1, 2, 3, 4	

TABLE I. QUALIFICATION AND QUALITY CONFORMANCE INSPECTION (Cont'd)

Test No.	Requirement	Test	Test Method or Examination	Inspection: Qualification Sample Nos.	Inspection: Quality Conformance
15	3.7.2.1	4.10.2.1	Shock, specified pulse	1, 2, 3, 4	
16	3.7.3.1	4.10.3.1	Altitude, low temperature	1, 2	
17	3.7.3.2	4.10.3.2	Altitude, high temperature	1, 2	
18	3.7.4	4.10.4	Endurance	1, 2	
19	3.7.5.1	4.10.5.1	Ambient low temperature	3, 4	
20	3.7.5.2	4.10.5.2	Ambient high temperature	3, 4	
21	3.7.6	4.10.6	Moisture resistance	3, 4	
22	3.7.2.2	4.10.2.2	Shock high impact	1, 2, 3, 4	
23	3.7.7	4.10.7	Audible noise structure-borne 1/	1, 2, 3, 4	
24	3.7.8	4.10.8	Explosion 1/	1, 2	
25	3.7.9	4.10.9	Salt atmosphere 1/	1, 2	

1/ These tests are special and shall be performed only when required in the applicable general specification.

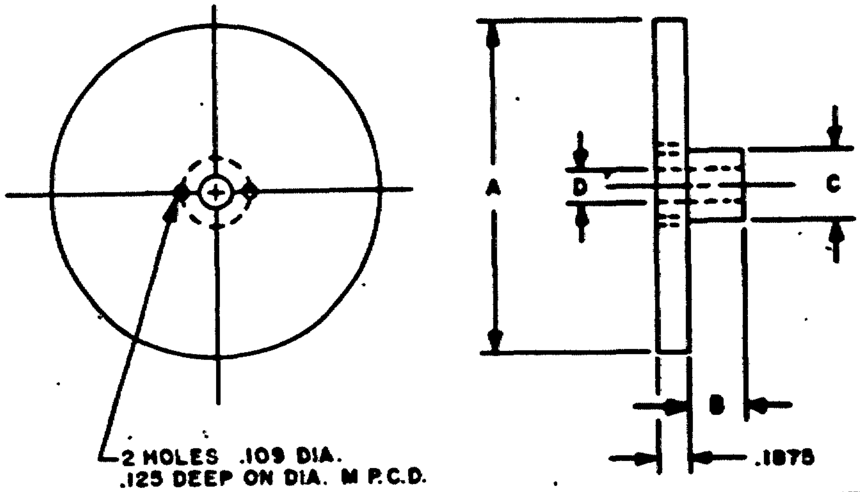
TABLE II. ENDURANCE TEST, TIME SCHEDULE

MIL-S-22432 MIL-S-22820 MIL-T-22821		MIL-S-20708 MIL-R-23417 MIL-R-50781 MIL-T-83727		Shaft Position
Time 2/ (Hours)	Temperature °C	Time 2/ (Hours)	Temperature °C	
64 ± 2	-55 ± 5	64 ± 2	-25 ± 5°	Horizontal
24 ± 2	H	24 ± 2	H	Vertically Upward
24 ± 2	H	24 ± 2	H	45° Upward
24 ± 2	H	24 ± 2	H	45° Downward
24 ± 2	H	24 ± 2	H	Vertically Downward
740 ± 4	15° to 30° (see 4.2.1)	1840 ± 4	15 to 30° (see 4.2.1)	Horizontal
100 ± 3	1/ 100 ± 5°			Horizontal

H is the ambient temperature specified in the applicable general specification.

1/ For MIL-S-22432 and MIL-S-22820, the 100 hrs at 100°C portion of the test shall be performed at maximum power output, as specified in MIL-S-22432 and MIL-S-22820.

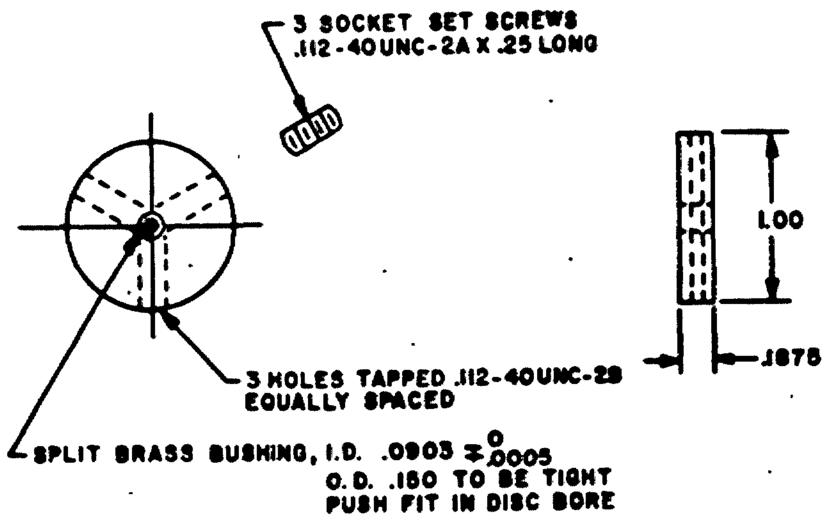
2/ 50% of rotation to be CW and 50% of rotation to be CCW.



SERVO-COMPONENT SIZE	DIMENSIONS				
	A	B	C	D	M*
	INCH	INCH	INCH	INCH	INCH
11, 15, 18	2.0	.1875	.26	.1875	.375
23	2.0	.3125	.60	.2410	.437
31, 37	2.7, 3.3	.3125	.60	.2410	.437

*For mounting with standard drive washer.

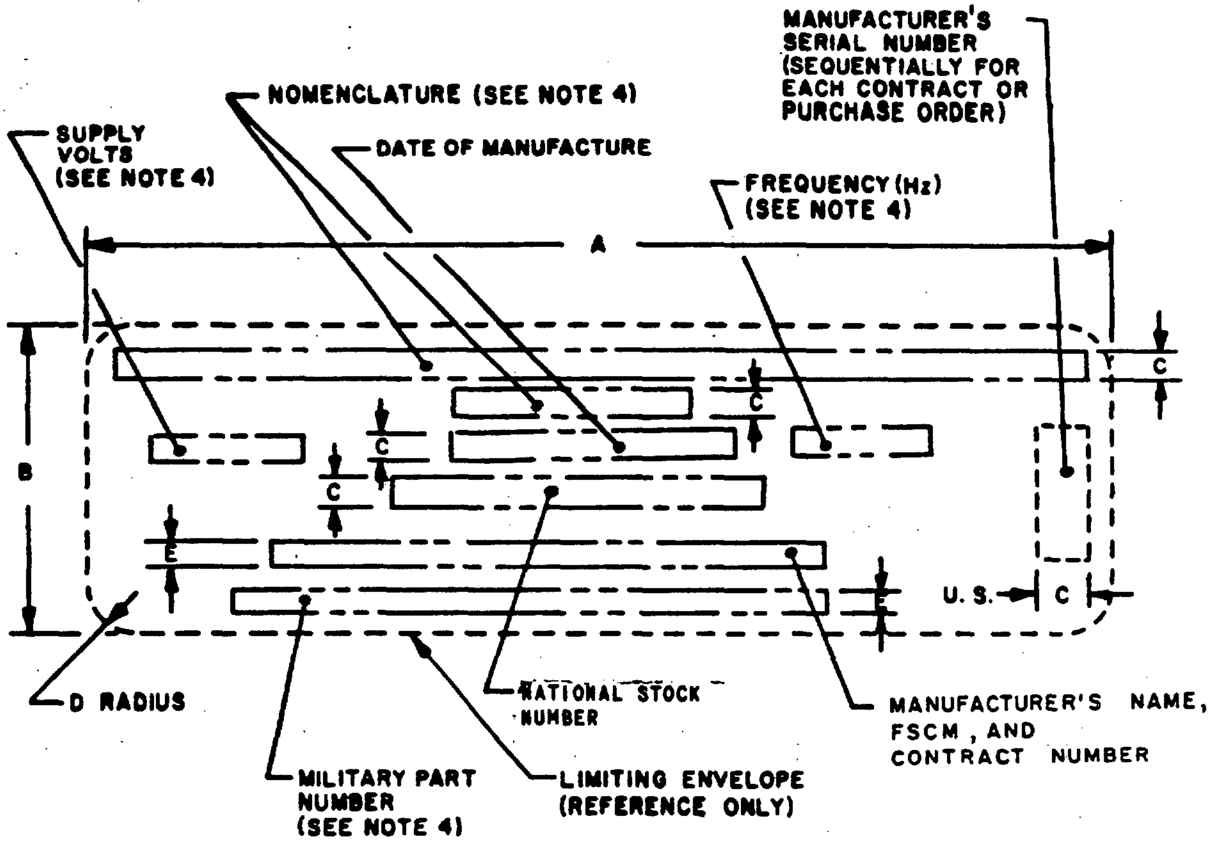
A. Disc for size 11, 15, 18, 23, 31 and 37 Servo-components.



MATERIAL: ALUMINUM ALLOY, QQ-A-250/4.
ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED. TOLERANCES ON DIMENSIONS ARE ±.005.

B. Disc for size 05 & 08 Servo-components

FIGURE 1. Standard disc for loading servocomponent shaft.

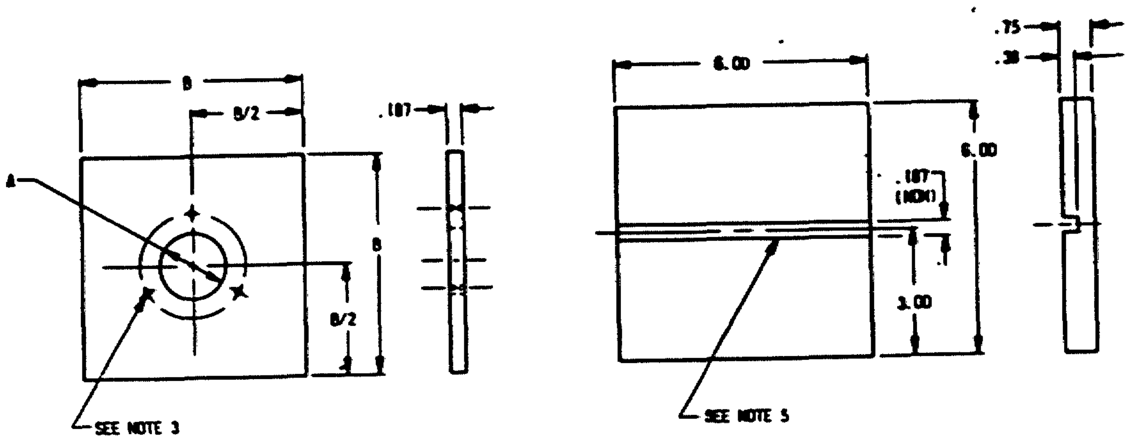


SERVO COMPONENT SIZE	A	B	C	D	E
	in.	in.	in.	in.	in.
05	1-1/2	5/8	1/16	1/8	1/16
08	2-1/4	5/8	1/16	1/8	1/16
11, 15	3	3/4	3/32	1/8	3/32
18, 23, 31, 37	3-5/8	1	3/32	1/4	3/32

NOTES:

1. DIMENSIONS - MINIMUM SIZE IS SHOWN
2. LETTERING - GOTHIC OR FUTURA TYPE CAPITALS WITHOUT SERIFS
3. LEGEND SHALL BE CENTRALLY LOCATED, HORIZONTALLY AND VERTICALLY
4. NOMENCLATURE, MILITARY PART NUMBER, VOLTAGE AND FREQUENCY SHALL BE AS SPECIFIED IN THE APPLICABLE GENERAL SPECIFICATION.

FIGURE 2. Standard marking.



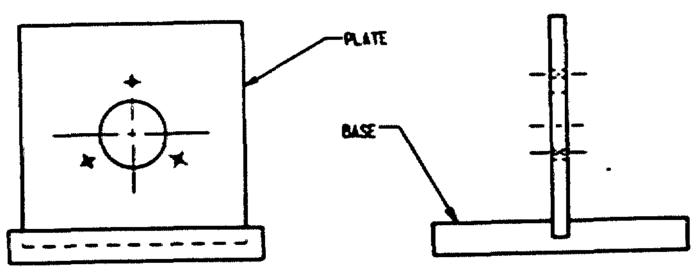
PLATE

MATERIAL: ALUMINUM ALLOY
FINISH: ANODIZE PER MIL-A-8625. TYPE II. CLASS 2 BLACK

BASE

MATERIAL: THERMALLY INSULATING

TABLE OF LETTERED DIMENSIONS		
SIZE	A	B ±.010
05	.381	2.214
08	.506	2.439
11	1.006	3.200
15	1.318	4.300
18	1.568	5.250



NOTES:

1. ALL DIMENSIONS ARE IN INCHES.
2. TOLERANCES: 2 PLACE DECIMALS ±.02
   3 PLACE DECIMALS ±.005
   UNLESS OTHERWISE SPECIFIED.
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE SIMILAR TO MS17183. DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.
5. SLOT IN BASE SHALL BE LIGHT PRESS FIT WITH PLATE.

FIGURE 3. Standard test fixture for servocomponents up to size 18.

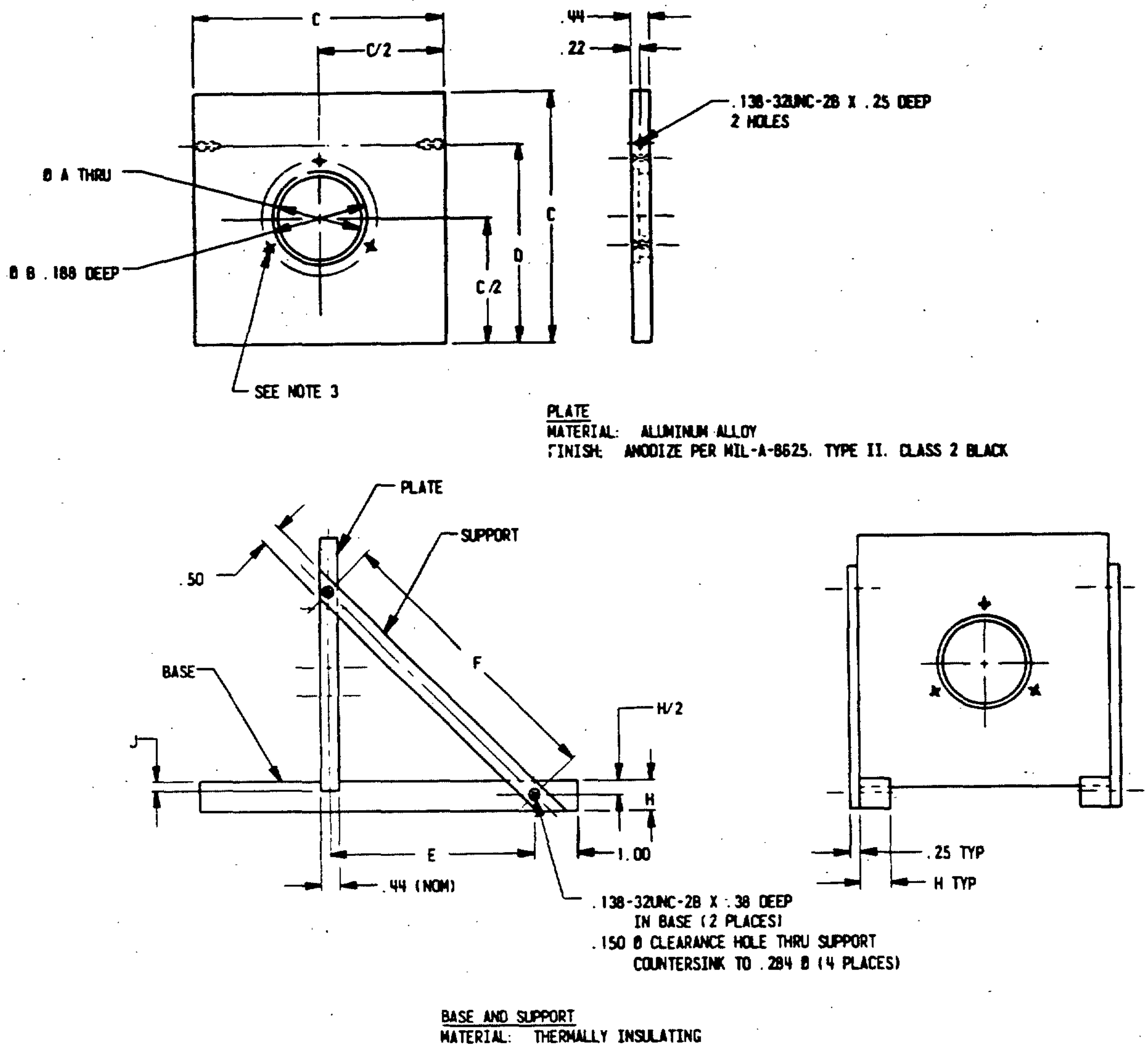


TABLE OF LETTERED DIMENSIONS									
SIZE	A	B	C	D	E	F	G	H	J
23	2.006	2.265	6.00	4.75	4.875	6.892	9.00	.75	.25
31	2.756	3.115	8.25	4.75	4.875	6.892	9.00	.75	.25
37	3.381	3.640	10.12	9.75	10.250	14.495	20.00	2.00	.50

NOTES:

1. ALL DIMENSIONS ARE IN INCHES.
2. TOLERANCES: 2 PLACE DECIMALS ±.02
   3 PLACE DECIMALS ±.005
   UNLESS OTHERWISE SPECIFIED.
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE SIMILAR TO MS17183. DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.

FIGURE 4. Standard test fixture for servocomponents size 23 and larger.

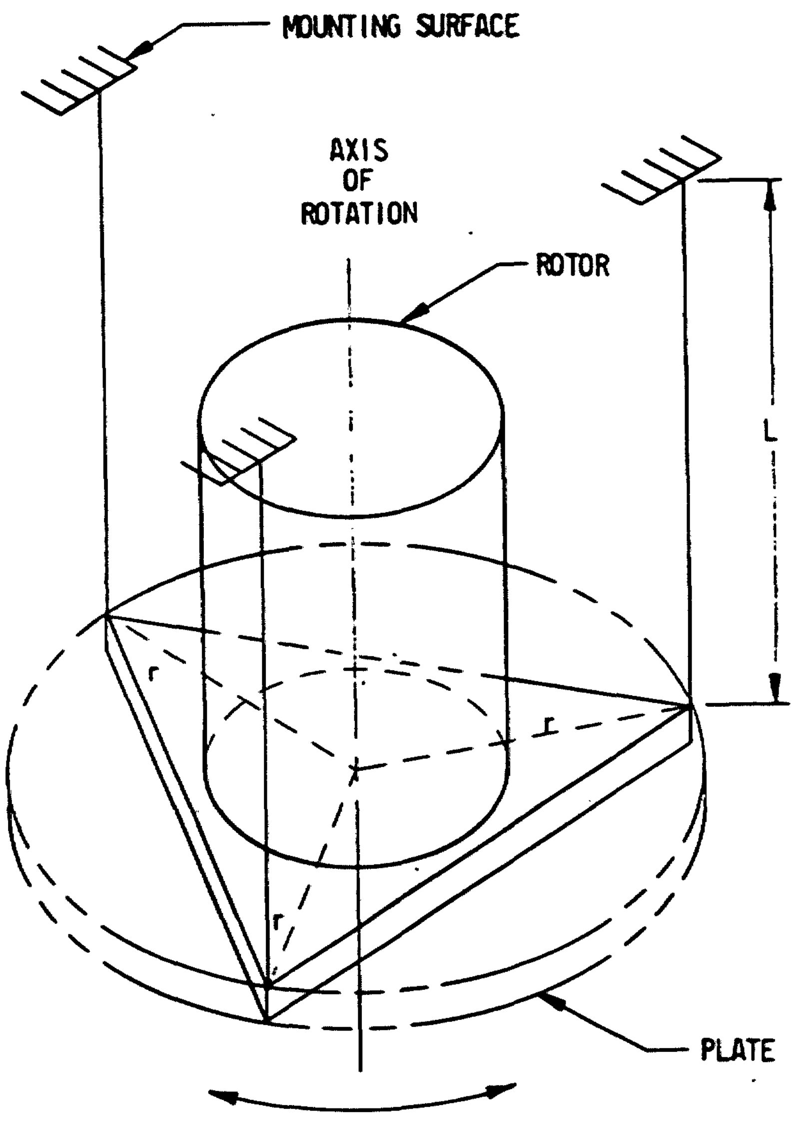
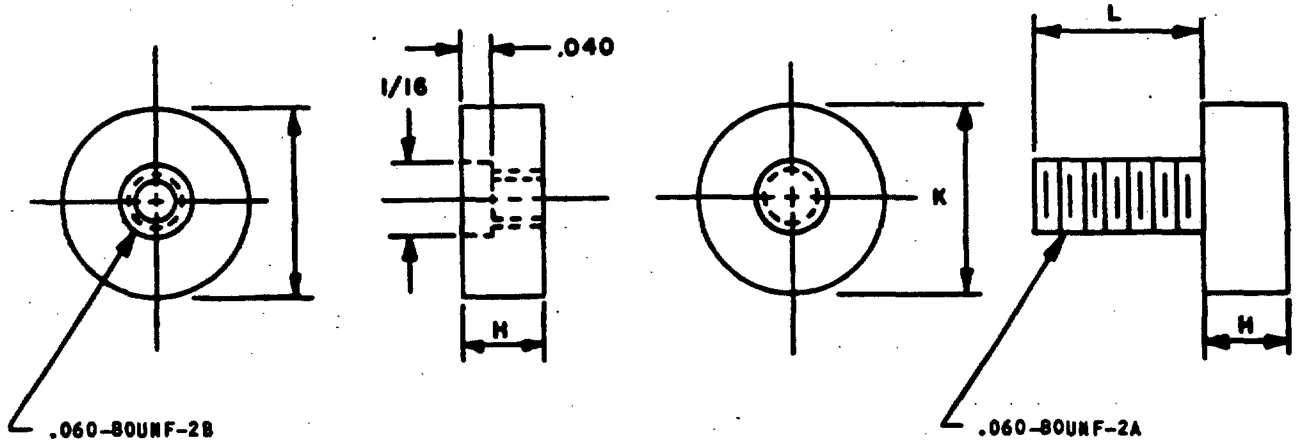


FIGURE 5. ·oment of inertia by trifilar suspension with rotor in place.



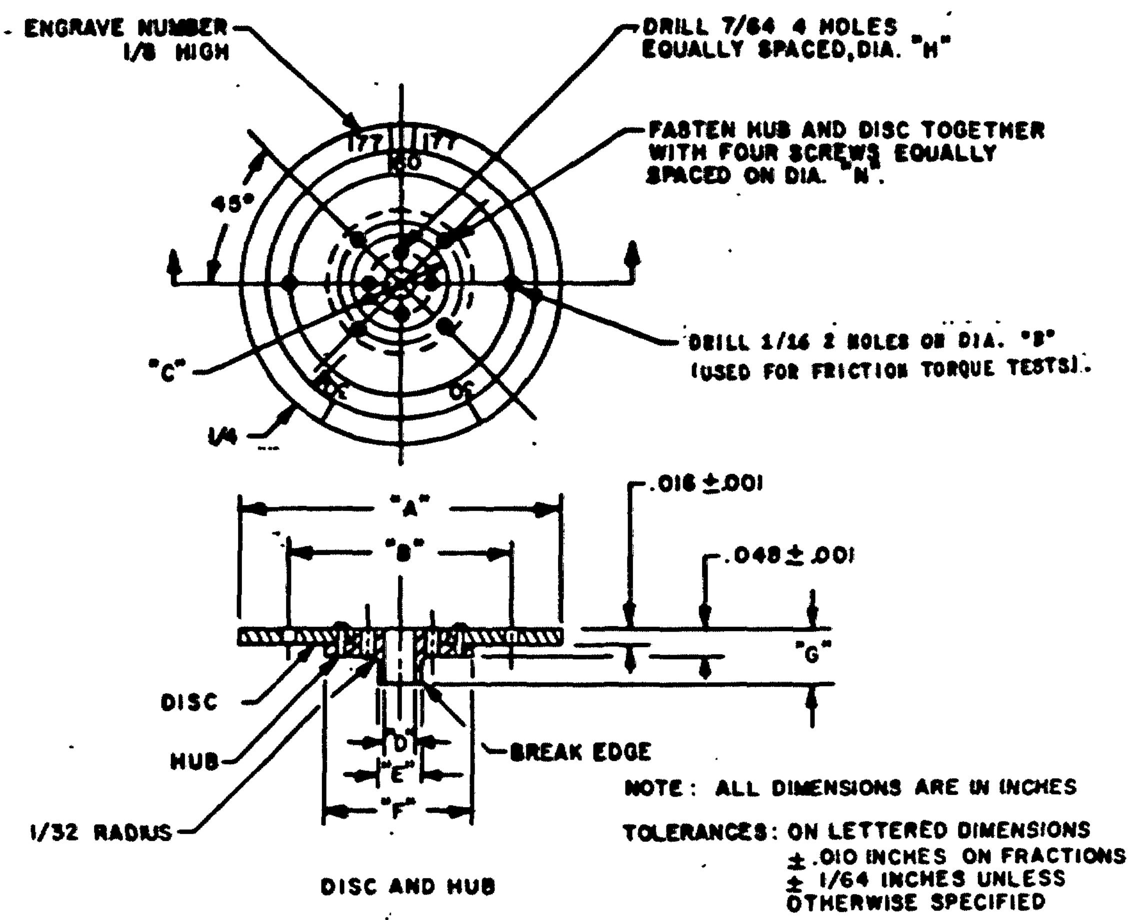
DEVELOPED TORQUE	DIMENSIONS OF MOUNTED DIAL WEIGHTS			WEIGHT ± 3%	MOUNTING RADIUS
	H	K	L		
oz-in	in.	in.	in.	oz.	in.
.02	.062	.262	.078	.033	.600
.03	.062	.325	.078	.050	.600
.04	.157	.242	.171	.067	.600
.05	.150	.267	.171	.083	.600
.06	.125	.324	.141	.1	.600
.07	.125	.346	.141	.117	.600
.08	.125	.373	.141	.133	.600
.09	.236	.288	.250	.150	.600
.10	.236	.300	.250	.166	.600
.20	.351	.350	.250	.333	.600
.50	.180	.597	.203	.500	1.000

NOTE: UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ± 1/64 INCHES
DECIMALS ± .005 INCHES
ANGLES ± 1°

MATERIAL: BRASS, QQ-B-637, ALLOY NO. 462

NOTE: THIS TABLE CONTAINS EXAMPLES OF TORQUE DEVELOPED; OTHER VALUES MAY BE OBTAINED AS REQUIRED.

FIGURE 6. Weights for mechanical breakaway torque tests.



NOTE: ALL DIMENSIONS ARE IN INCHES

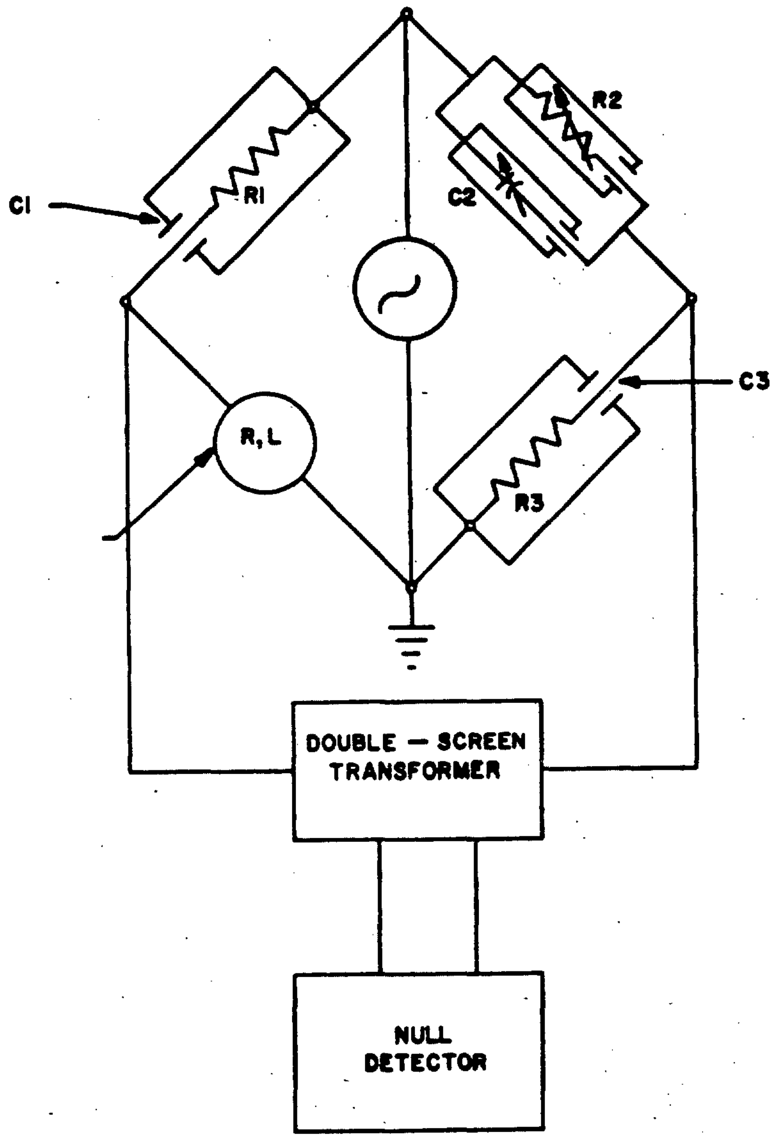
TOLERANCES: ON LETTERED DIMENSIONS ±.010 INCHES ON FRACTIONS ± 1/64 INCHES UNLESS OTHERWISE SPECIFIED

MATERIAL: ALUMINIUM ALLOY, QQ-A-250/4

FINISH: ANODIZE PER MIL-A-8625, TYPE II, CLASS 2 BLACK

	A	B	C	D	E	F	G	H	N
	-	+.002 -.002	+.0004 -.0000	+.005 -.000	+.001 -.000	-	+.005 -.000	-	-
SIZE	in	in	in	in	in	in	in	in	in
05, 08	1.50	1.20	.5625	.1250	.250	.8125	.300	.375	.687
11, 15	1.50	1.20	.5625	.1875	.250	.8125	.300	.375	.687
18	2.00	1.20	.5625	.1875	.250	.8125	.300	.375	.687
23	2.67	2.00	.625	.2410	.3125	.875	.350	.437	.750
31, 37	3.50	2.00	.625	.2410	.3125	.875	.350	.437	.750

FIGURE 7. Dials for mechanical breakaway torque, synchronizing time, and spinning tests.



$$R = \frac{R1\,R3}{R2}\left(1 + w^2 C_2 C_3 R_2 R_3 - 2w^2 R_1 R_3 C_2 C_4\right)$$

$$L = R_1 R_3 C_2 \left(1 - w^2 R_1 R_3 C_2 C_4\right)$$

FIGURE 8. Wien modified Maxwell bridge.

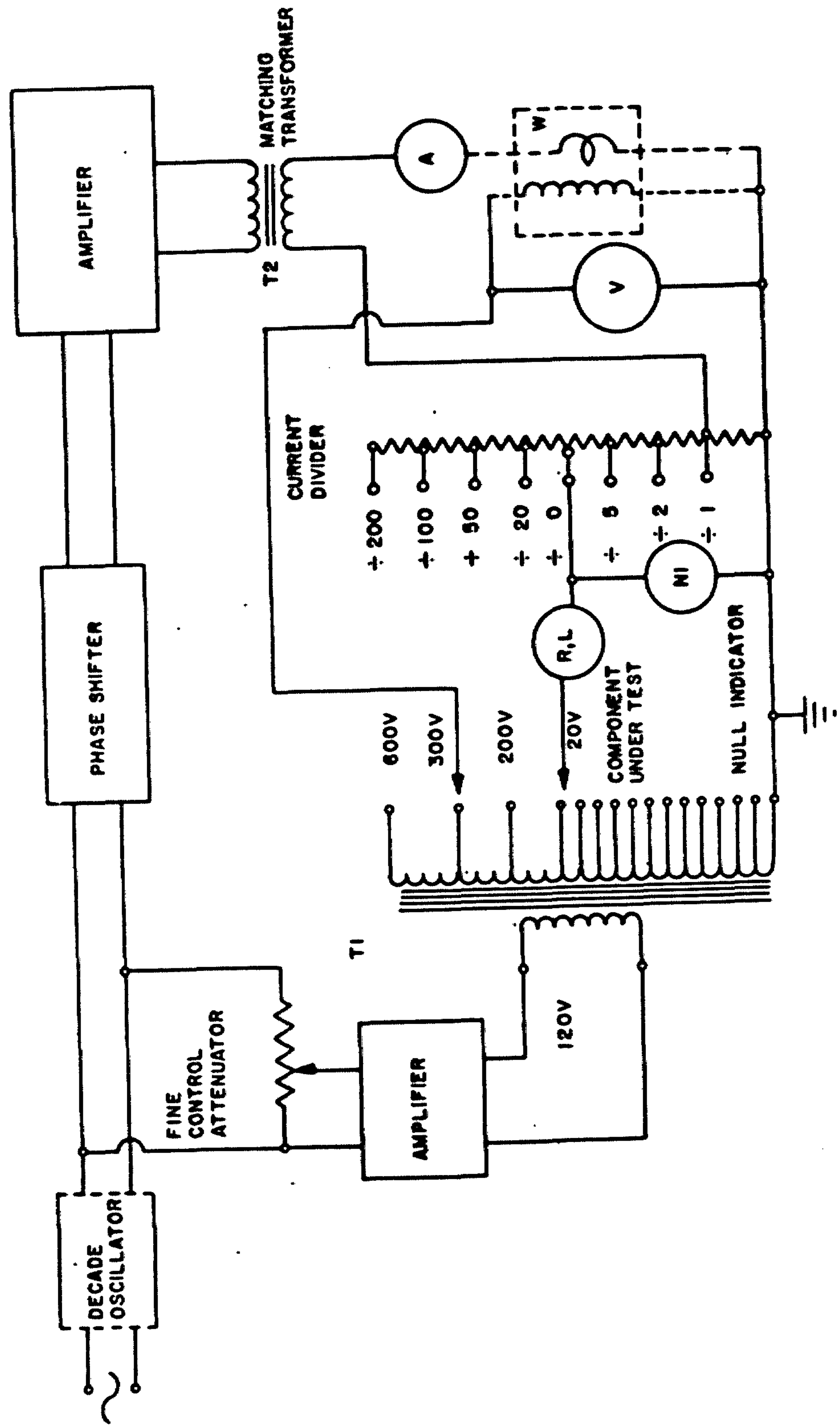
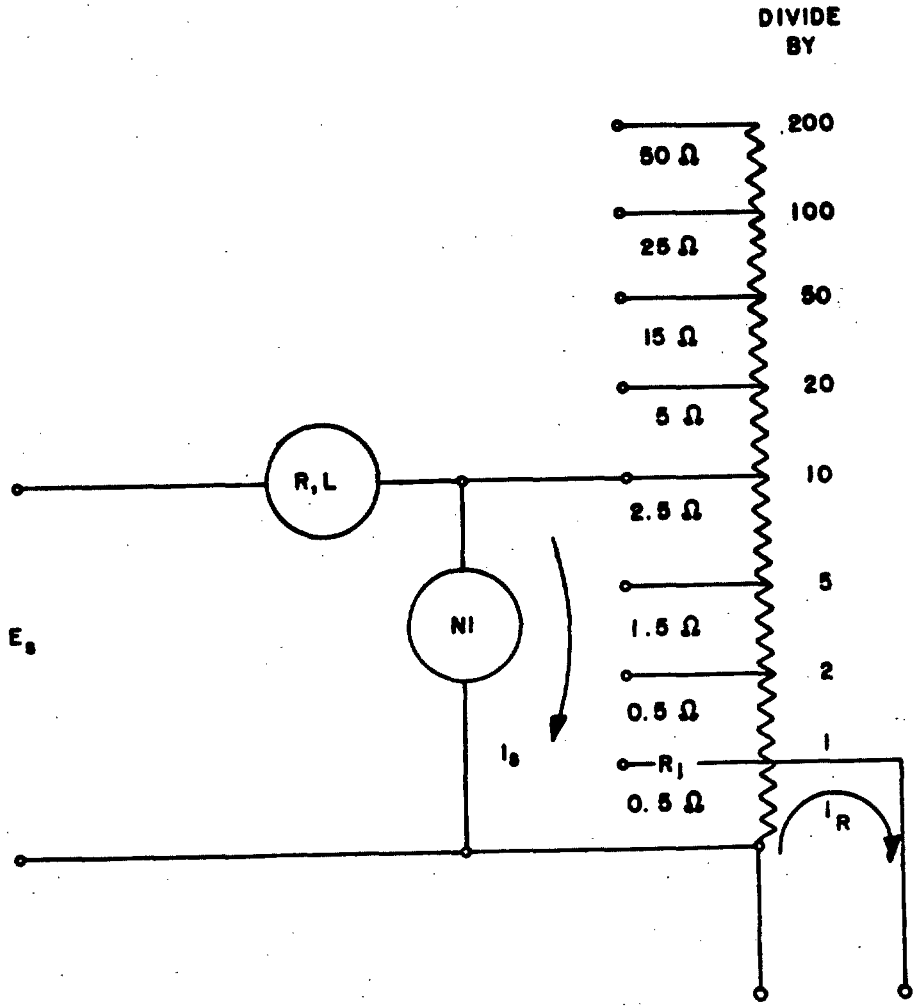


FIGURE 9. Marshall potentiometer.



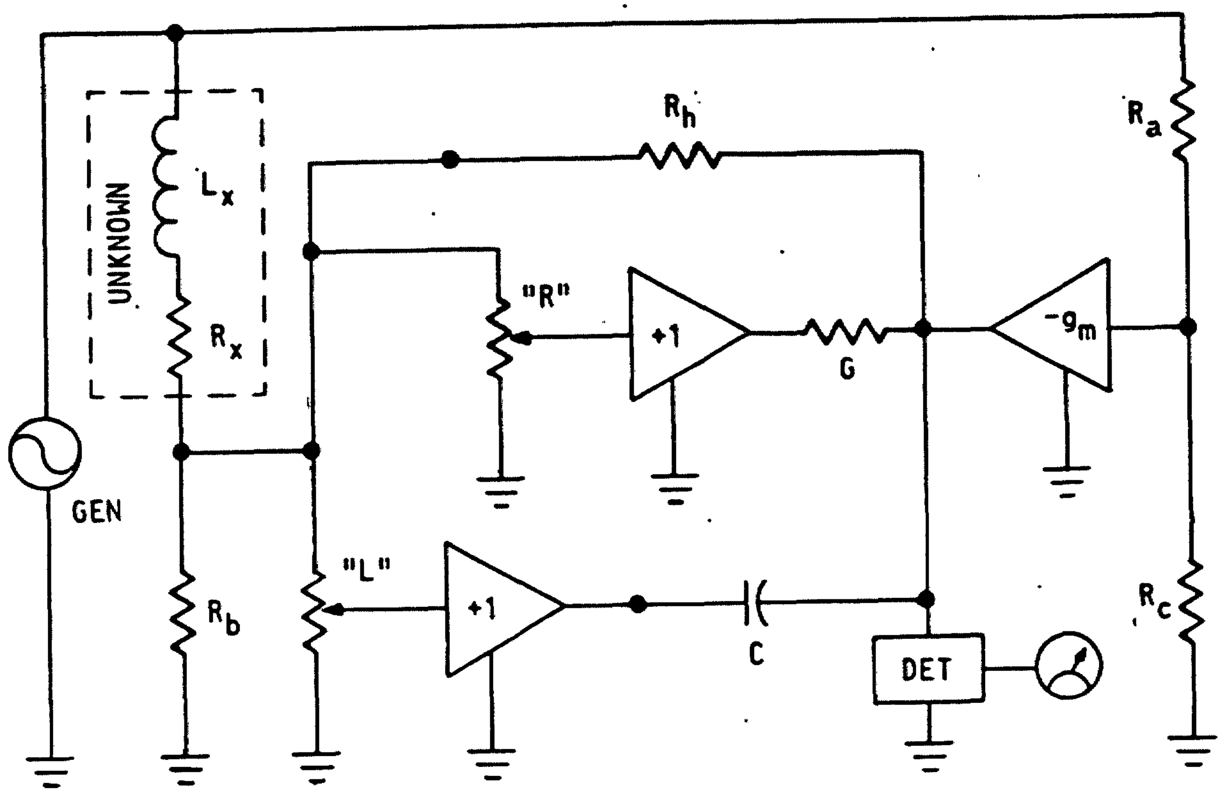
ASSUMING RESISTANCE VALUES AS SHOWN

$I_s (R_1 + 0.5 + 1.5 \text{-----} R_n) - I_R R_1 = 0$

THEREFORE

$$\frac{I_R}{I_s} = \frac{(R_1 + 0.5 + 1.5 \text{-----} R_n)}{R_1}$$

FIGURE 10. Current division circuit of Marshall potentiometer.



C = Standard Capacitor
G = Standard Resistor

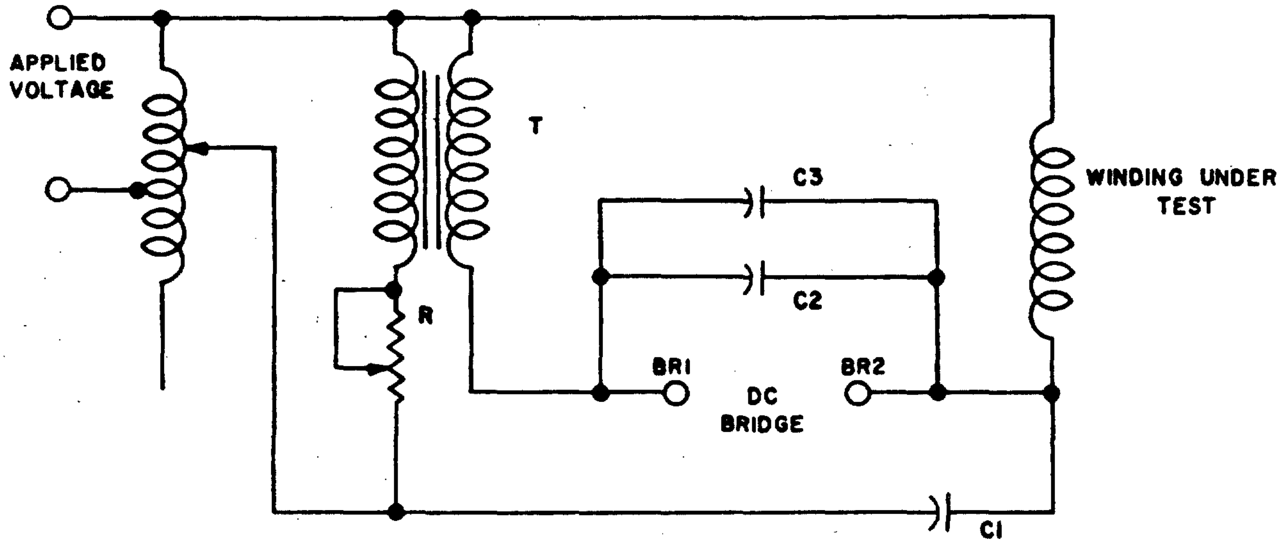
(Values of C and G will be determined by the frequency of the gen voltage.)

Rectangular Impedance is $R + JX_L$ with R read directly from Dial "R" and the X_L calculated from $X_L = 2\pi FL$ with the L read directly from Dial "L".

Polar Impedance is Z at an angle of X. The angle derived from $\tan \emptyset = \frac{R}{X_L}$

Z derived from $Z = \sqrt{R^2 + X_L{}^2}$

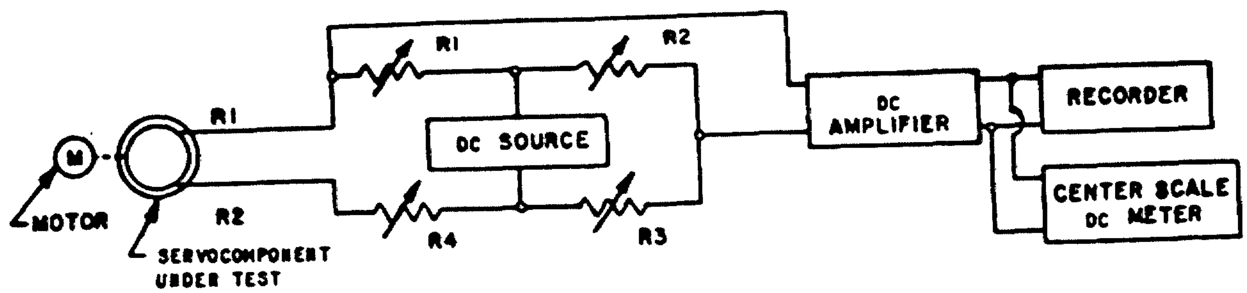
FIGURE 11. Elementary schematic diagram for an incremental induction bridge.



T	1:1 TRANSFORMER RATED AT 250 VA.
R	250 ohms, 100 WATTS VARIABLE RESISTOR
C1, C2, C3,	400 μF, 115 V.A.C. CAPACITORS

THE APPLIED AC TO THE CIRCUIT SHOULD BE ADJUSTED SO THAT THE FULL ENERGIZING VOLTAGE IS APPLIED TO THE WINDING. THE TRANSFORMER T HAS ITS SECONDARY AND PRIMARY WINDINGS CONNECTED SO THAT THE AC VOLTAGE ACROSS THE BRIDGE IS LOW, (LESS THAN 1.5 VOLTS). SUITABLE ADJUSTMENTS CAN BE MADE WITH THE VARIABLE RESISTOR "R". THE BRIDGE IS THEN USED TO MEASURE THE KNOWN RESISTANCE OF THE TRANSFORMER T SECONDARY PLUS THAT OF THE WINDING UNDER TEST.

FIGURE 12. Circuit diagram for temperature rise test.



M - MOTOR, 1 REV/M
R1 - RESISTOR, DECADE, 1K
R2, R3 - RESISTOR, DECADE, 10K
R4 - RESISTOR, DECADE, 10 OHM

NOTE: A CURRENT LIMITING RESISTOR (1K), IF REQUIRED, WOULD BE CONNECTED IN SERIES WITH THE DC SOURCE.

FIGURE 13. Brush contact resistance variation test circuit.

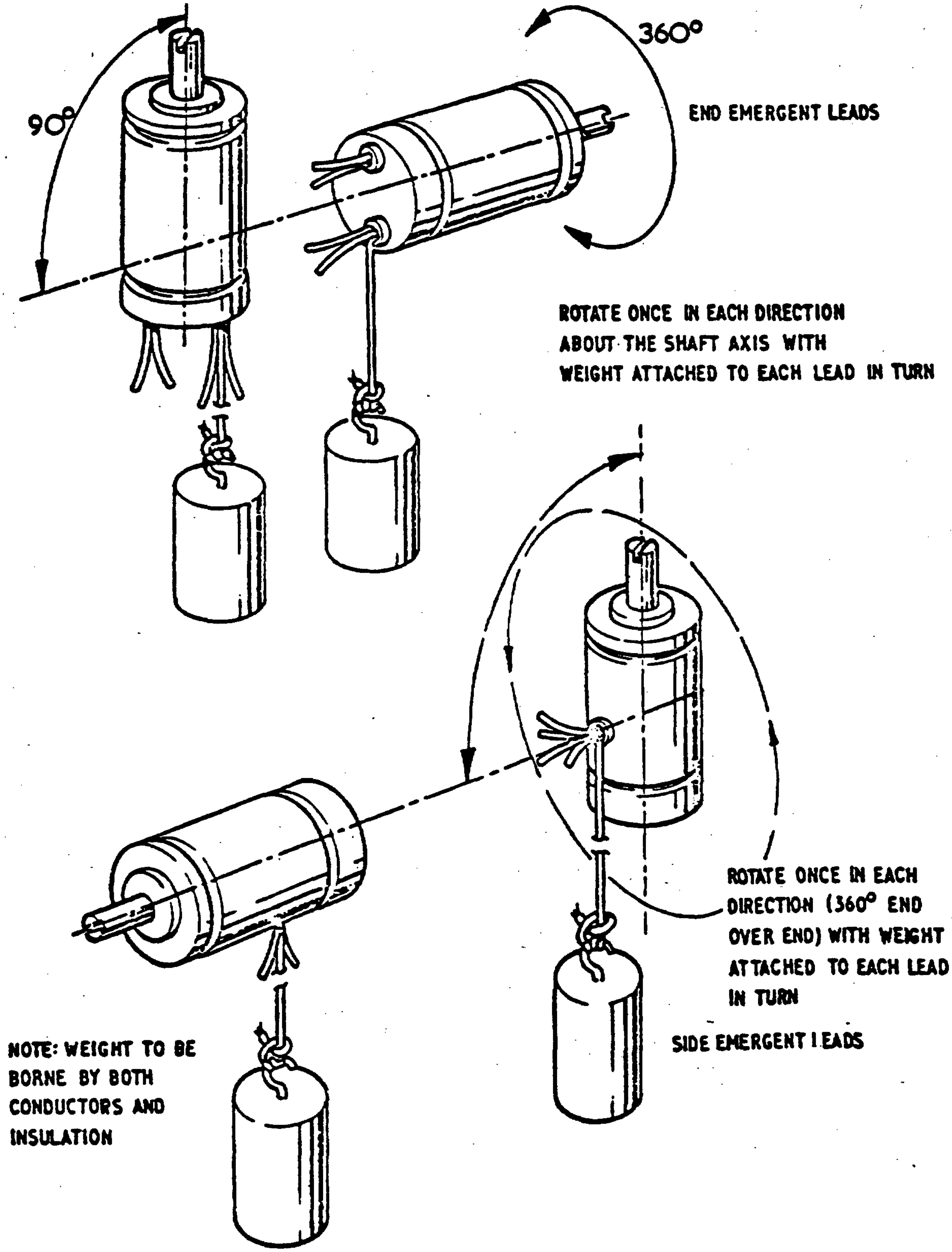


FIGURE 14. Lead wire stress test.

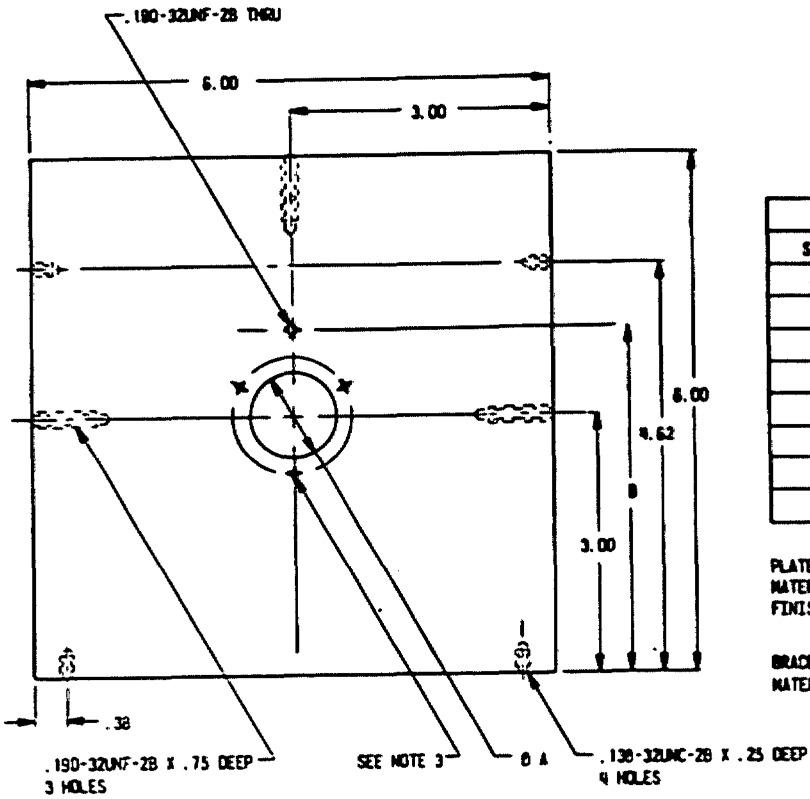
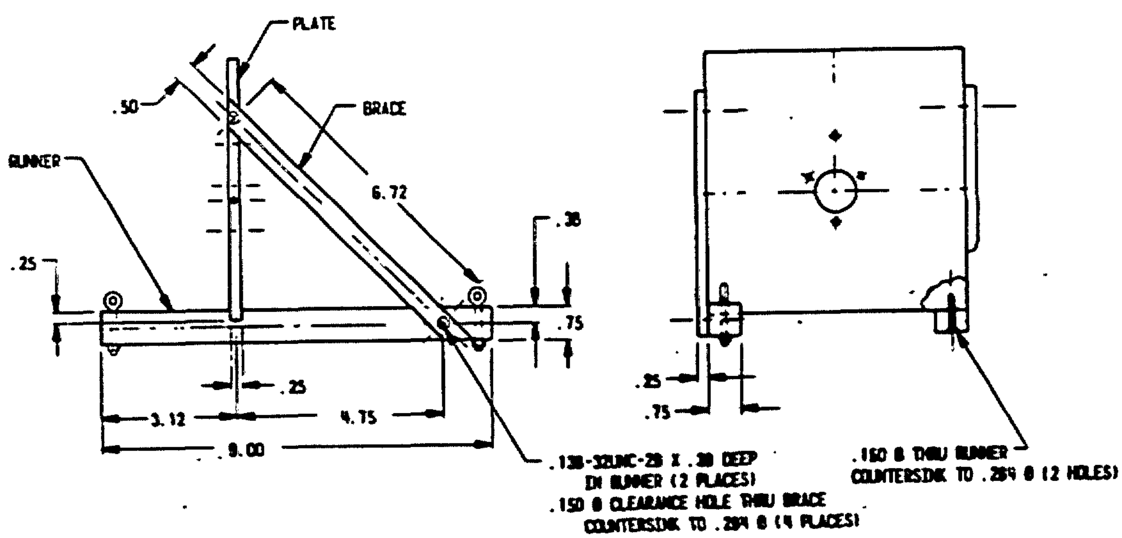


TABLE OF LETTERED DIMENSIONS		
SIZE	A	B
05	.381	3.50
08	.506	3.75
11	1.006	4.00
15	1.318	4.19
18	1.563	4.28
23	2.006	4.81
31	2.756	5.18
37	3.381	5.18

PLATE
MATERIAL: ALUMINUM ALLOY
FINISH: ANODIZE PER MIL-A-8625, TYPE II, CLASS 2 BLACK

BRACE AND RUNNER
MATERIAL: THERMALLY INSULATING



NOTES:

1. ALL DIMENSIONS ARE IN INCHES.
2. TOLERANCES: 2 PLACE DECIMALS ±.02
   3 PLACE DECIMALS ±.005
   UNLESS OTHERWISE SPECIFIED.
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE SIMILAR TO MS17183. DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.

FIGURE 15. Structure-borne noise fixture.

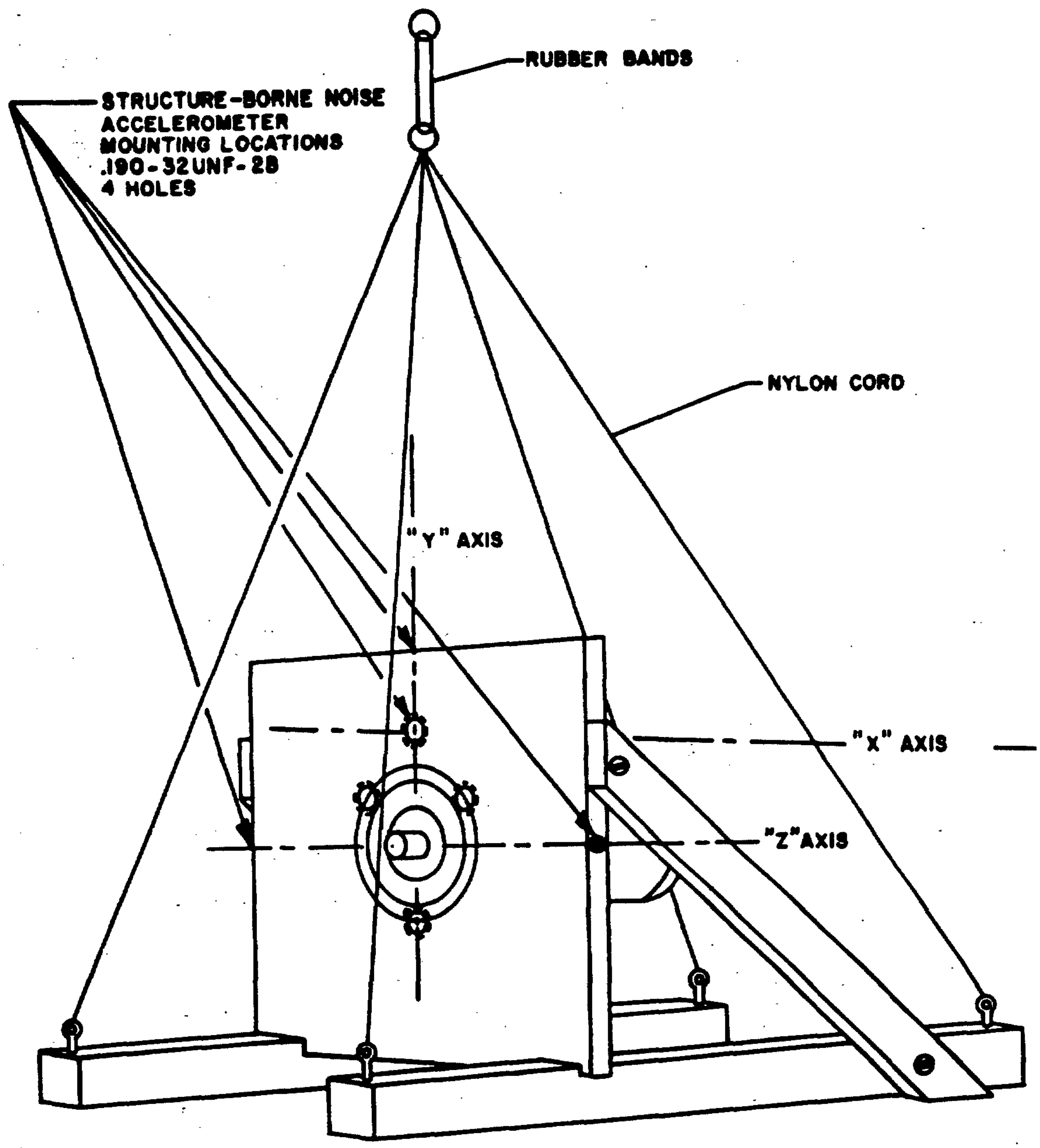


FIGURE 16. Test fixture application for structure-borne noise test.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-S-81963A	Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION *(Mark one)*

☐ VENDOR

☐ USER

☐ MANUFACTURER

☐ OTHER *(Specify)*: ______

b. ADDRESS *(Street, City, State, ZIP Code)*

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

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