IEEE Specification Format for Single-Degree-of-Freedom Spring-Restrained Rate Gyros

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Acknowledgment

The Institute wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge and have conducted experimental work on which many of the IEEE publications are based.

This Specification Format and the Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros (IEEE Standards Publication No. 293) represent a group effort on a large scale. They were generated as projects of the Gyro and Accelerometer Panel from May of 1962 to November of 1967. The Gyro and Accelerometer Panel (GAP) affiliated with the IEEE in May of 1965 and is now a part of the IEEE Aerospace and Electronic Systems Group. A total of 238 individuals attended 30 GAP meetings while these documents were in preparation. Fifty-one individuals attended six meetings or more and provided 61 percent of the total attendance of 916. These people are listed here.

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Introduction

This Specification Format has been prepared as a *guide* for the preparation of a single-degree-of-freedom spring-restrained rate gyro specification. Prepared by the Gyro and Accelerometer Panel of the Aerospace Electronic Systems Group of the Institute of Electrical and Electronics Engineers, this format provides a common meeting ground of terminology and practice for manufacturers and users.

Two other documents, Aerospace Industries Association EETC Report No. 5 (Revision A), "Standard Gyro Terminology,"* and IEEE Standards Publication No. 293, "Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros," have been utilized in the preparation of this format. This format will be limited to conventional single-degree-of-freedom spring-restrained rate gyros. A model equation is given in paragraph 6.3 for reference, and is to be included in a specification only to the extent necessary.

Table 1, on this page, lists various rate gyro design features for which this format is applicable. The table is not intended to make any suggestion regarding the selection of particular design features that might restrict the free choice of manufacturers.

Blank spaces are provided in the Specification Format for the insertion of specific values. Brackets are used to designate possible alternates. Boxed information is intended for explanatory purposes. Figures 1, 2, and 3 are to be used as a guide for the preparation of specific figures or drawings.

The user is cautioned not to *overspecify.* Only those parameters that are required to guarantee proper instrument performance in the intended usage should be controlled.

* Available from: National Standards Association, Inc.
1321 Fourteenth Street N.W.
Washington. D.C. 20005

Table 1—Rate Gyro Design Features

Pickoff	Spin Motor	Damping Regulation	Self-Test Torquer	Rotor Rotation Detector
1. Variable reluctance (microsyn)	1. Ac synchronous hysteresis (3-phase, 2-phase)	1. Self-compensating	1. Variable reluctance	1. Pulse
2. Potentiometer	2. Ac induction (squirrel cage rotor) (3-phase, 2-phase)	2. Controlled temperature (heater controlled)	2. Dc permanent magnet	2. Near sinusoidal
3. Switch	3. Dc (with governor)	3. Uncompensated		
4. Other (optical, capacitance)				

NOTE — The intent of this table is to indicate configurations of a spring-restrained rate gyro for which this specification format is applicable. The features may be employed in any combination.

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SPECIFICATION COVER SHEET

RATE GYRO, _____ DEGREES PER SECOND

Specification No. _____

Date

Procuring Firm or Organization Data

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IEEE Specification Format for Single-Degree-of-Freedom Spring-Restrained Rate Gyros

1. Scope

This specification defines the requirements for a single-degree-of-freedom spring-restrained rate gyro for [aircraft, missile, spacecraft,_____] applications. The rate gyro shall be capable of providing [(dc, ac) voltage outputs proportional to angular rate inputs up to_____ degrees per second, a switch closure(s) at angular rates (exceeding, less than)_____ (+, –, ±)_____ degrees per second].

2. Applicable Documents

The following documents of the issue in effect on date of invitation for bid or request for proposal form a part of the specification to the extent specified herein. In the event of any conflict between the requirements of this document and the listed documents, the requirements of this document shall govern.

2.1 Specifications

2.1.1 Government

2.1.2 Industry/Technical

2.1.3 Company

2.2 Standards

2.2.1 Government

2.2.2 Industry/Technical

2.2.2.1

Aerospace Industries Association, EETC Report No. 5 (Revision A), “Standard Gyro Terminology,” June 1965.

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2.2.2.2

IEEE Standards Publication No. 293, “Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros.”

2.2.3 Company

2.3 Drawings

2.3.1 Government

2.3.2 Industry/Technical

2.3.3 Company

2.4 Bulletins

2.4.1 Government

2.4.2 Industry/Technical

2.4.3 Company

2.5 Other Publications

Other applicable documents should be listed under the appropriate paragraph.

3. Requirements

3.1 Description

The major components of the rate gyro herein specified are a [variable reluctance (microsyn), potentiometer, switch,_____] pickoff, a rotor, a [hysteresis synchronous, induction, direct current,_____] spin motor, and [self-compensated, controlled temperature, uncompensated] damping. The elastic restraint is accomplished by a mechanical spring. A [variable reluctance (microsyn), direct-current permanent magnet,_____] torquer and a rotor rotation detector are included as self-test features. See Figure 1.

Self-test features may or may not be required.

3.2 General Requirements

3.2.1 Precedence

In the event of conflict among the purchase agreement, this specification, and other documents referred to herein, the order of precedence shall be as follows:

a) purchase agreement,
b) this specification and its applicable drawings (see paragraphs 3.4.2, 3.4.6, and 3.5.1),
c) other applicable documents (see Section 2.).

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3.2.2 Definitions

The following documents define terminology used in this specification, and the test techniques that will be utilized to determine unit compliance.

3.2.2.1 : Standard Gyro Terminology, Aerospace Industries Association EETC Report No. 5 (Revision A).

3.2.2.2 : Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros, IEEE Standards Publication No. 293.

3.3 Performance

The tolerances include a summation of manufacturing and test errors, and environmental effects. Any exceptions due to environmental effects are listed under paragraph 3.6.3.1.

3.3.1 Input Limits

± _____ °/s.

The positive and negative input limits need not be equal.

3.3.1.1 Limit Stops

The output angle shall be mechanically limited to an input limit value of ± _____ °/s.

A tolerance may be specified if necessary. The positive and negative limit stops need not be equal.

3.3.1.2 Mechanical Overload

The rate gyro shall perform within specification after an angular rate of _____ °/s has been applied about the _____ [axis, axes] for _____ seconds a total of _____ times. The rate gyro shall perform within specification after an angular acceleration of _____ $°/S^2$ has been applied about the _____ [axis, axes] for _____ seconds, a total of _____ times.

3.3.2 Gyro Scale Factor

_____ ± _____ V/(°/s).

3.3.3 Natural Frequency

[_____ ± _____ hertz, not less than _____ hertz].

3.3.4 Damping Ratio

_____ ± _____.

Acceptable limits are sometimes specified graphically.

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3.3.5 Run-Up Time

_____ seconds max to _____ percent of full speed.

Sometimes minimum run-down time is also specified.

3.3.6 Warm-Up Time

_____ seconds max.

3.3.7 Self-Test Torquer

Scale Factor: _____ ± _____ (°/s)/mA.

For a variable reluctance torquer, the scale factor shall be _____ ± _____ (°/s)/mA^2.

Continuous Torquing Rate at _____ °C Ambient: _____ °/s max.
Composite Error: _____ percent max of the max continuous torquing rate.

Sometimes nonlinear torquers are specified, in which case a table defining output versus input should be supplied.

3.3.8 Rotor Rotation Detector

Peak Output: _____ ± _____ volts (at rated speed).
Repetition Rate: _____ times rotor speed.
Pulse Width: _____ seconds at _____ volts (at rated speed).

For the pulse output type.

Total Output: _____ volts root mean square minimum (at rated speed).
Fundamental Signal: (Sinusoidal) _____ percent of total output.
Fundamental Frequency: _____ times rotor speed.

For near sinusoidal output type. Other types of Rotor Rotation Detectors should be specified in accordance with their characteristics.

3.3.9 Rate Switch

Switch Operation, increasing rate: normally [open, closed] contacts shall [close, open] at ± _____ ± _____ °/s within _____ seconds.
Switch Operation, decreasing rate: switch shall return to normal at ± _____ ± _____ °/s within _____ seconds.

This requirement is based on use as an erection cutout. Other uses may require a different form of specification. The rate switch may be the sole gyro output or an additional output. Sometimes contact bounce requirements are specified.

3.3.10 Composite Error

0 to _____ °/s: _____ percent max of the output range.

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_____ °/s to input limits: _____ percent max of the output range.

3.3.11 Threshold

_____ °/s max.

3.3.12 Resolution

_____ °/s max.

3.3.13 Hysteresis Error

_____ °/s max.

3.3.14 Zero Offset

_____ max.

3.3.15 Acceleration-Sensitive Drift Rate

_____ (°/s)/g max.
_____ (°/s)/g_2, max.

3.3.16 Output Noise

_____ °/s peak-to-peak max at frequencies _____ hertz to _____ hertz.

Sometimes referred to as “signal modulation.” Usually specified at zero input rates. Other input may be specified.

3.3.17 Rate Sensitivity About the Spin Reference Axis

At zero rate input to the Input Reference Axis (IRA): _____ (°/s)/(°/s) max.

A function of the misalignment of the actual Spin Axis (SA) with respect to the Spin Reference Axis (SRA).

At _____ °/s input to the IPA: _____ (°/s)/(°/s) max.

A function of the misalignment of the actual SA with respect to the SRA and of gimbal output angle.

3.3.18 Rate Sensitivity About the Output Axis

_____ (°/s)/(°/s) max.

Due to the actual SA not being perpendicular to the Output Axis (OA) as defined by the axis alignment provisions. Not usually specified, but added for consideration.

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3.3.19 Angular Acceleration Sensitivity About the Output Axis

_____ (°/s)/(rad/^{2}) max.

> A function of gimbal moment of inertia and of rotor angular momentum. Numerically equal to gimbal moment of inertia divided by rotor angular momentum.

3.3.20 Reference Constants

These constants are for reference only. They are not specified independently because they may vary within the framework of the specification and also because they are difficult or impossible to measure independently in a complete gyro. Nominal values are listed.

Rotor Angular Momentum: _____ g · cm^2/S.
Rotor Speed: _____ r/min.
Gimbal Output Angles at Input Limits: ± _____ degree.

> The positive and negative output angles need not be equal.

Gimbal Moment of Inertia: _____ g · cm^2.
Elastic Restraint Coefficient: _____ dyn · cm/rad.
Damping Coefficient: _____ dyn · cm · s/rad.

3.3.21 Polarity

Shall conform to [Drawing No. _____, Figure 1], [Outline Drawing No. _____, Figure 2], [Schematic Drawing No. _____, Figure 3].

3.3.21.1 Pickoff

The voltage from the pickoff secondary line-to-return shall be [in-, out-of-] phase, within the pickoff phase shift, with the voltage from the pickoff primary line-to-return for positive input rates.

> For direct-current pickoffs this shall read: The voltage (or resistance) from the pickoff signal line to the pickoff excitation line shall decrease for positive input rates.

3.3.21.2 Rotor

The rotor shall rotate in the direction indicated by the SRA for [ac excitation phase sequence, phase _____ leads phase _____ leads phase _____; dc positive voltage, spin motor line-to-return].

3.3.21.3 Self-Test Torquer

A positive rate indication shall result when the voltage from the control line-to-return is [positive, negative].

> For a variable reluctance torquer this shall read: A positive rate indication shall result when the voltage from the control line-to-return has the [same, opposite] [polarity, phase] as the voltage from the pattern line-to-return.

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3.3.22 Life

3.3.22.1 Storage

_____ months.

3.3.22.2 Operating

_____ hours.

> Some gyro applications have a “ready, nonoperating” environment that may differ from the above requirement and deserve separate listing.

3.4 Mechanical

3.4.1 Exterior Surfaces

All exterior surfaces must withstand the environment herein specified and the handling expected in the normal course of operation, testing, and maintenance without deterioration that causes nonconformance to this specification.

> Additional requirements controlling surface finish, workmanship, processing, etc., may be designated by the procuring agency.

3.4.2 Outline and Mounting Dimensions

Shall conform to [Drawing No. _____, Figure 2].

3.4.3 Gyro Axes

The IRA and the SRA are determined from the axis alignment provisions on the gyro case.

3.4.4 Weight

_____ [ounce, pound, gram, kilogram] max.

> When accessories, such as cable, connector, or choke, are to be included in the weight, the specification shall so state.

3.4.5 Seal

The gyro shall be sealed so that no fluid leakage is detectable under _____ power magnification.

> For gas-filled gyro, specify allowable leak rate.

3.4.6 Identification of Product

The gyro shall be identified on the surface indicated in [Drawing No. _____, Figure 2]. Identification shall include:

Rate Gyro _____ °/s,
Specification Number,
Unit Serial Number,

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Axis Identification Marking as shown in [Drawing No. _____, Figure 2],
Manufacturer's Name or Symbol.

3.5 Electrical

Transient conditions of electric excitation may need to be specified.

3.5.1 Schematic

The electric circuits shall be connected as shown in [Drawing No. _____, Figure 3].

3.5.2 Circuit Excitations and Impedances

3.5.2.1 Spin Motor

Excitation, line-to-line: _____ ± _____ volts [ac, dc] _____ ± _____ hertz [_____ phase, _____].

Specify waveshape if other than sinusoidal.

Starting Current: _____ mA max.

Starting power may be specified.

Running Current: _____ mA max.
Running Power: _____ watts max.

Power factor may be specified.

Phase-Splitting Capacitor: _____ ± _____ μF.
Overvoltage: _____ percent for _____ seconds max.

3.5.2.2 Pickoff

Excitation: _____ ± _____ [volts, mA] [ac, dc] _____ hertz [± _____ hertz, phase-locked with spin motor excitation].
Harmonics: _____ percent max of fundamental.

Specify waveshape if other than sinusoidal.

Primary Impedance: The impedance of the primary winding as measured with the secondary winding [open-circuited, connected to the load impedance specified below] shall be _____ ± _____ ohms [+, –] *j* _____ ± _____ ohms when measured at _____ hertz and at _____ ± _____ °C.

If a series inductance (choke) is to be used, both the inductance and minimum *Q* at nominal excitation frequency and current shall be specified.

Secondary Impedance: The impedance of the secondary winding as measured with the primary winding [open-circuited, short-circuited] shall be _____ ± _____ ohms [+, –] *j* _____ ± _____ ohms when measured at _____ hertz and at _____ ± _____ °C.
Load Impedance: _____ ± _____ ohms [+, –] *j* _____ ± _____ ohms.

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Carrier Phase Shift, primary to secondary voltage: _____ ± _____ degrees, at _____ °/s input rate and above.
Electrical Null: _____ mV [root-mean-square, peak-to-peak] max.

> For alternating-current pickoffs the electrical null is composed primarily of harmonics, noise, and quadrature (voltage at the fundamental frequency but 90 degrees out-of-phase with the signal output for large signals). It occurs when the in-phase signal is at or near zero and therefore does not necessarily occur at zero rate.

3.5.2.3 Temperature Control

Warm-Up Heater Excitation: _____ ± volts [ac, dc] _____ hertz.
Warm-Up Heater Power: _____ watts max.
Maintenance Heater Excitation: _____ ± _____ volts [ac, dc] _____ hertz.
Maintenance Heater Power: _____ watts max.

> If a temperature sensor is used, its characteristics shall be specified.

3.5.2.4 Self-Test Torquer

Torquer Winding Impedance: _____ ± _____ ohms + *j* _____ ± _____ ohms at _____ hertz, at room temperature.

> For a variable reluctance torquer, specify excitation-winding current or voltage. Open-circuited impedances of both windings should be specified at room temperature.

3.5.2.5 Rotor Rotation Detector

Impedance: _____ ohms, max when measured at _____ hertz.
Load: _____ ohms minimum.

> The rotation detector in some gyros is also a self-test torquer winding.

3.5.2.6 Rate Switch

Contacts shall be rated at _____ amperes [inductive, noninductive].

> It is sometimes necessary to specify additional parameters such as contact bounce, contact resistance, minimum make-break cycles. etc.

3.5.3 Insulation Resistance

The insulation resistance between isolated electric circuits and between the gyro case and circuits isolated from the gyro case shall not be less than _____ megohms measured at _____ ± _____ volts direct current applied for _____ ± _____ seconds.

3.5.4 Dielectric Strength

The leakage current shall not exceed _____ mA when _____ ± _____ volts root mean square, _____ hertz is applied between isolated electric circuits and between the gyro case and electric circuits isolated from the gyro case for _____ ± _____ seconds.

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3.5.5 Radio Noise Interference

In accordance with _____.

> In the United States, a common Standard is MIL-STD-461.

3.6 Environmental

> This paragraph contains environmental requirements only. Test procedures that are to be used, including required combinations of environments, are covered in paragraph 4.6.

3.6.1 Storage

The gyro shall conform to all requirements of this specification after exposure to any combination of the following environments while packaged per Section 5 for the time specified in paragraph 3.3.22.1.

> The procuring organization shall list the applicable environments from paragraph 3.6.4 and specify the limits for each based on the storage conditions expected.

3.6.2 Transportation

The gyro shall conform to all requirements of this specification after exposure to any combination of the following environments while packaged per Section 5..

> The procuring organization shall list the applicable environments from paragraph 3.6.4 and specify the limits for each based on the transportation conditions expected.

3.6.3 Operational

> In order to properly specify the environmental requirements for a gyro, three different sets of environments and/or environmental limits may need to be described. A guide for the selection of the environments most often included in each of the three sets can be obtained by referring to the table at the end of IEEE Standards Publication No. 293, “Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros.”

3.6.3.1 Operating Environment

The gyro shall conform to all requirements of this specification during exposure to any combination of the following environments (except during exposure to _____ where the deviations to this specification are given below).

> Where degraded performance is to be allowed, include the parenthetical phrase in paragraph 3.6.3.1 and list in the blank space those environments for which degraded performance is allowed. The procuring agency shall list the applicable environments from paragraph 3.6.4 and specify the limits for each, based on the conditions expected when the gyro is in use. For those environments where degraded performance is allowed, specify the performance deviation in the paragraph that specifies the environment.

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3.6.3.2 Survival Environment, Operating

The gyro shall conform to all requirements of this specification after the operating gyro has been exposed to any combination of the following environments.

> The procuring organization shall list the applicable environments from paragraph 3.6.4 and specify the limits for each based on the conditions expected when the gyro is operating but not in use.

3.6.3.3 Survival Environment, Nonoperating

The gyro shall conform to all requirements of this specification after the nonoperating gyro has been exposed to any combination of the following environments.

> The procuring organization shall list the applicable environments from paragraph 3.6.4 and specify the limits for each based on the conditions expected when the gyro is not operating.

3.6.4 Environments

> This list is intended as an aid to the selection of the applicable environments under paragraphs 3.6.1, 3.6.2, and 3.6.3 above. A paragraph 3.6.4 in this form would not be included in a final specifications.

3.6.4.1 Temperature

_____ °C to _____ °C.

3.6.4.2 Vibration

Sinusoidal: _____ in double amplitude (DA) _____ to _____ hertz; _____ *g* peak, _____ to _____ hertz. Sweep rate shall be _____ minutes per octave (continuous). Exposure shall be _____ minutes per axis.

> Axes shall be defined.

When available, supply the specific vibration versus frequency for the application.

If exposure to random vibration is required, power spectral density, bandwidth, peak acceleration level, and duration shall be specified.

3.6.4.3 Mechanical Shock

_____ *g* peak, _____ waveshape, _____ ms, _____ shock(s) per axis.

> Axes and direction of shock shall be defined.

3.6.4.4 Thermal Shock

_____ °C to _____ °C within _____ seconds.

> If exposure to cyclic conditions is required, temperature limits for each level, dwell times, and sequence shall be specified.

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3.6.4.5 Pressure

_____ [torr, inHg, lbf/in^2, N/m^2] to _____ [torr, inHg, lbf/in^2, N/m^2].

3.6.4.6 Linear Acceleration

_____ *g*, _____ minutes.

Axes and direction shall be defined.

3.6.4.7 Fungus

Specify fungi organisms, length of exposure, temperature and humidity conditions during exposure.

3.6.4.8 Humidity

_____ percent relative humidity for _____ hours obtained from steam or distilled water having a pH value of _____ ±_____.

3.6.4.9 Salt Spray

_____ percent salt solution for _____ hours.

3.6.4.10 Acoustical Noise

_____ dB _____ to _____ hertz. Exposure shall be _____ minutes.

When available, supply the specific decibel versus frequency for the application. Sweep rate may be specified as _____ minutes per octave (continuous).

3.6.4.11 Thermal Radiation

_____ W/cm^2 of radiation of wavelength from _____ to _____ μm. Exposure shall be _____ minutes.

3.6.4.12 Air Currents

_____ [ft/s, m/s] at _____ °C for _____ minutes.

Axes and direction of air flow shall be defined.

3.6.4.13 Nuclear Radiation

_____ rads with an exposure rate of _____ rads per second and/or combinations of _____ particles at a fluence of _____ per square centimeter with energy greater than _____ MeV.

3.6.4.14 Magnetic Fields

_____ [gauss, milliteslas].

Axes and direction of field shall be defined. If exposure to fields resulting from alternating current is desired, specify intensity versus frequency.

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3.6.4.15 Sand and Dust

_____ [g/ft^3, g/m^3], at a velocity of _____ ± _____ [ft/min, m/s] for _____ hours. Relative humidity not to exceed _____ percent at any time.

Specify particle size, shape, and chemical analysis.

3.6.4.16 Sunshine

_____ ± _____ [W/ft^2, W/m^2] of wavelength _____ to _____μm for _____ hours.

Describe distribution of power density versus wave-length.

3.6.4.17 Rain

Rainfall of _____ ± _____ [in/h, mm/h] consisting of droplets having a minimum diameter of _____ mm for _____ minutes.

3.7 Reliability

3.7.1 Reliability Program

The reliability program required shall be in accordance with _____.

In the United States, a common Standard is MIL-STD-785.

3.7.2 Mean Time Between Failure (MTBF)

It shall be demonstrated that the MTBF lower _____ percent confidence limit shall be a minimum of _____ hours.

4. Quality Assurance Provisions

4.1 Classification of Tests

The inspection and testing of the rate gyro shall be classified as follows:

a) Acceptance Tests: Acceptance tests are those tests accomplished on gyroscopes submitted for acceptance under contract,
b) Qualification Tests (Preproduction Tests): Qualification tests are those tests accomplished on samples submitted for qualification as a satisfactory product,
c) Reliability Tests: Reliability tests are those tests accomplished on production units to demonstrate the level of reliability and to assure the ability to maintain, with certain confidence, the assessed reliability.

4.2 Acceptance Tests

Acceptance tests shall consist of the following:

a) Individual Tests,
b) Sampling Tests.

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4.2.1 Individual Tests

Each rate gyro shall be subjected to the following tests described under paragraph 4.6.

> The list of individual tests shall be specified by the procuring organization based on individual requirements. The number or type of individual tests specified is at the discretion of the procuring organization. Those tests that are usually specified as individual tests are listed. A run-in period under specified conditions may be required before beginning individual tests.

a) Paragraph 4.6.1 Examination of the Product (Mechanical),
b) Paragraph 4.6.2 Impedance Tests,
c) Paragraph 4.6.4 Insulation Resistance,
d) Paragraph 4.6.6 Polarity,
e) Paragraph 4.6.7 Electrical Null,
f) Paragraph 4.6.8 Output Noise (Signal Modulation),
g) Paragraph 4.6.9 Run-Up Time,
h) Paragraph 4.6.10 Rotor Rotation Detector,
i) Paragraph 4.6.11 Power Consumption and Current Starting and Running,
j) Paragraph 4.6.12 Run-Down Time,
k) Paragraph 4.6.13 Rate Transfer Characteristic Test Series,
l) Paragraph 4.6.14 Limit Stops,
m) Paragraph 4.6.15 Pickoff Phase Shift,
n) Paragraph 4.6.16 Switching Rate,
o) Paragraph 4.6.17 Self-Test Torquer,
p) Paragraph 4.6.18 Acceleration-Sensitive Drift Rate,
q) Paragraph 4.6.19 Rate Sensitivity About Spin Reference Axis,
r) Paragraph 4.6.22 Dynamic Response Test Series.

> There are other individual tests that are not generally specified but that may be included under individual tests based on specific application.

4.2.2 Sampling Plans and Tests

4.2.2.1 Sampling Plans

> This section is intended to designate a sampling plan if required. Sampling plans are up to the discretion of the procuring organization based upon usage, size of contract, individual requirements, etc.

Gyros selected per _____ shall be subjected to the tests specified in paragraph 4.2.2.2 as described in paragraph 4.6.

> In the United States, selection according to MIL-STD-105 is common.

4.2.2.2 Sample Tests

> The procuring organization shall specify from paragraph 4.6 those tests that shall be performed on gyros selected by paragraph 4.2.2.1 above. Those tests that are usually specified for sample tests are listed below. Sampling plan units may be used for delivery unless the procuring organization specifies life tests or other destruction-type tests under the sampling plan.

a) Individual Tests listed in paragraph 4.2.1,
b) Paragraph 4.6.23 Warm-Up Time,

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c) Paragraph 4.6.24.1 Low Temperature,
d) Paragraph 4.6.24.2 High Temperature,
e) Paragraph 4.6.24.3 Excitation Voltage and Frequency Variation,
f) Paragraph 4.6.24.10.2 Operating Life.

Other tests may be added as required.

4.2.2.3 Rejection and Retest

When one (1) item selected from a production run fails to meet the specification, the procuring organization shall be immediately notified of the failure and at the discretion of the procuring organization no items still on hand or later produced shall be accepted until the extent and cause of failure are determined. After corrections have been made, all necessary tests shall be repeated. For operational and production reasons, individual tests may be continued pending the investigation of a sampling plan failure.

Other requirements suitable to an individual contract may be substituted for the above.

4.2.2.4 Defects in Items Already Accepted

The investigation of a test failure could indicate that defects may exist in items already accepted. If so, the manufacturer shall fully advise the procuring organization of defects likely to be found and of methods for correcting them.

4.3 Qualification Tests

4.3.1 Qualification Test Samples

A preproduction sample of _____ rate gyros manufactured in accordance with the requirements of this specification shall be subjected to qualification tests specified herein at an activity designated by the procuring organization.

If the product is later modified in any way, the modified form shall be subjected to and pass those qualification tests designated by the procuring organization.

The qualification test samples shall be identified with the manufacturer's own part number and any other information required by the procuring organization.

4.3.2 Qualification Tests

The procuring organization shall specify from paragraph 4.6 those tests, or combination of tests, that shall be performed on gyros submitted for qualification.

4.4 Reliability Tests

4.4.1 Run-In

Each gyro shall be subjected to a run-in period of _____ hours under the following conditions.

Specify environment and operating conditions.

Consideration shall be given to not compromising the useful operating life by excessive test time during run-in.

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4.4.2 Demonstration Testing

The MTBF requirements of paragraph 3.7.2 shall be demonstrated by testing _____ units for _____ hours minimum each, and a minimum time of _____ hours combined.

Stress-level tests shall be in accordance with _____.

> In the United States, testing in accordance with MIL-STD-781 is common.
> Other methods of demonstration testing may be selected at the discretion of the procuring organization. A demonstration test plan shall be prepared to define test conditions, failures, types of tests, etc.

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4.5 Test Conditions and Equipment

The procuring organization shall specify from Section 3. of IEEE Standards Publication No. 293, "Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros," the nominal test conditions and test equipment required. The conditions shall apply to all tests unless otherwise specified. When a test condition is specified, the complete test condition shall be detailed in this specification. The test equipment required shall also be listed by name and model, part number, or performance requirement.

4.6 Test Methods

Instructions for performing specified tests in this section are detailed in Section 4. of IEEE Standards Publication No. 293, "Test Procedure for Single-Degree-of-Freedom Spring-Restrained Rate Gyros." When a test is specified, the complete test method shall be detailed in this specification, including requirements to be met after test to determine satisfactory performance. A test should not be listed in paragraph 4.6 unless a requirement exists in Section 3. of this specification.

4.6.1 Examination of Product (Mechanical)

4.6.2 Impedance Tests

4.6.3 Dielectric Tests

4.6.4 Insulation Resistance

4.6.5 Leak

4.6.6 Polarity

4.6.7 Electrical Null

4.6.8 Output Noise (Signal Modulation)

4.6.9 Run-Up Time

4.6.10 Rotor Rotation Detector

4.6.11 Power Consumption and Current Starting and Running

4.6.12 Run-Down Time

4.6.13 Rate Transfer Characteristic Test Series

4.6.13.1 Gyro Scale Factor

4.6.13.2 Composite Error

4.6.13.3 Hysteresis Error

4.6.13.4 Zero Offset

4.6.13.5 Threshold

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4.6.13.6 Resolution

4.6.14 Limit Stops

4.6.15 Pickoff Phase Shift

4.6.16 Switching Rate

4.6.17 Self-Test Torquer

4.6.18 Acceleration-Sensitive Drift Rate

4.6.19 Rate Sensitivity About Spin Reference Axis

4.6.20 Rate Sensitivity About Output Axis

4.6.21 Angular Acceleration Sensitivity about the Output Axis

4.6.22 Dynamic Response Test Series

4.6.22.1 Natural Frequency

4.6.22.2 Damping Ratio

4.6.23 Warm-Up Time

4.6.24 Environmental Test Series

4.6.24.1 Low Temperature

4.6.24.2 High Temperature

4.6.24.3 Excitation Voltage and Frequency Variation

4.6.24.4 Mechanical Shock

4.6.24.5 Thermal Shock

4.6.24.6 High Altitude

4.6.24.7 Vibration

4.6.24.8 Acceleration

4.6.24.9 Mechanical Overload

4.6.24.10 Life

4.6.24.10.1 Storage

4.6.24.10.2 Operating

4.6.24.11 Fungus

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4.6.24.12 Humidity

4.6.24.13 Salt Spray

4.6.24.14 Acoustical Noise

4.6.24.15 Thermal Radiation

4.6.24.16 Air Currents

4.6.24.17 High Pressure

4.6.24.18 Nuclear Radiation

4.6.24.19 Magnetic Fields

4.6.24.20 Radio Noise

4.6.24.21 Sand and Dust

4.6.24.22 Sunshine

4.6.24.23 Rain

Specific applications may require specific special tests.

4.7 Test Data Submittal

The format for all test data organization and the method of submittal shall be specified.

5. Preparation For Delivery

Give detailed procedures for: 1) preservation and packaging, 2) packing, and 3) marking of shipping containers. A common United States specification covering preservation and packaging is MIL-P-116. Other organizations use different supporting documents.

6. Notes

6.1 Intended Use

Description of application if it is considered necessary or helpful.

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6.2 Ordering Data

Procuring documents should specify the following:

a) title, number, and date of this specification,
b) level of packaging and packing desired,
c) whether sampling plan tests are to be conducted,
d) number of preproduction samples to be submitted for qualification testing.

6.3 Model Equation

The model equation of a single-degree-of-freedom gyro is defined as a series that mathematically relates the output of a gyro to the several inputs applied to the gyro. The assumed model equation for a spring-restrained rate gyro when each term has the dimensions of angular velocity and angles are assumed to be small is:

$$\frac{J}{H}\ddot{\theta}_0 + \frac{C}{H}\dot{\theta}_0 + \frac{K_r}{H}\theta_0$$

$= \varphi_i$ (effect of case rotation about the IRA)
$- \varphi_s(\theta_0 + \epsilon_0)$ (effect of case rotation about the SRA)
$+ {}_0\epsilon_s - (J/H)_0$ (effect of case rotation about the axis perpendicular to the IRA and SRA)
$+ D_0$ (acceleration-insensitive drift rate)
$+ D_{1i}$, $a_i + D_{1s}$, a_s (acceleration-sensitive drift rate)
$+ D_2 a_i a_s$ (acceleration-squared-sensitive drift rate)
$+ K_t i$ (command rate)

where

J = Gimbal output axis moment of inertia.
θ_0 = Gimbal angle displacement about the output axis with respect to the case.
C = Damping coefficient for gimbal angular velocity with respect to case.
K_t, = Elastic restraint coefficient, for gimbal angular displacements with respect to case.
H = Angular momentum.
φ_i = Case angular displacement about the IRA.
φ_s = Case angular displacement about the SRA.
φ_0 = Case angular displacement about the axis perpendicular to the IRA and SRA.
D_0 = Acceleration-insensitive drift rate coefficient (zero offset).
D_{1i} = Acceleration-sensitive drift rate coefficient associated with acceleration along the IA.
D_{1s} = Acceleration-sensitive drift rate coefficient associated with acceleration along the SA.
a_i = Linear acceleration along the IA.
a_s = Linear acceleration along the SA.
D_2 = IA to SA acceleration-squared-sensitive drift rate coefficient.
K_t = Command rate scale factor.
i = Torquer command current.
ϵ_0 = Misalignment angle between the plane containing SRA and the axis perpendicular to IRA and SRA, and the plane containing SA and the axis perpendicular to IRA and SRA, when ${}_i = {}_0 = {}_s = 0$. It is approximately equal to $[D_0 - (K_r/H + {}_s)\,\theta_0]1/{}_s$.
ϵ_s = Misalignment angle between the plane containing SA and the axis perpendicular to IRA and SRA, and the plane containing SA and OA. It is approximately equal to $[(K_s/H)\theta_0 - D_0]1/{}_0$.
$-(\theta_0 + \epsilon_0)$ ≅ The rate sensitivity about the SRA as specified in paragraph 3.3.17.
$+\epsilon_s$ ≅ The rate sensitivity about the OA as specified in paragraph 3.3.18.
$-J/H$ = The angular acceleration sensitivity about the OA as specified in paragraph 3.3.19.

Neglecting all error terms, the model equation for an ideal gyro becomes:

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$$\frac{J}{H}\ddot{\theta}_0 + \frac{C}{H}\dot{\theta}_0 + \frac{K_r}{H}\theta_0 = \dot{\varphi}_i.$$

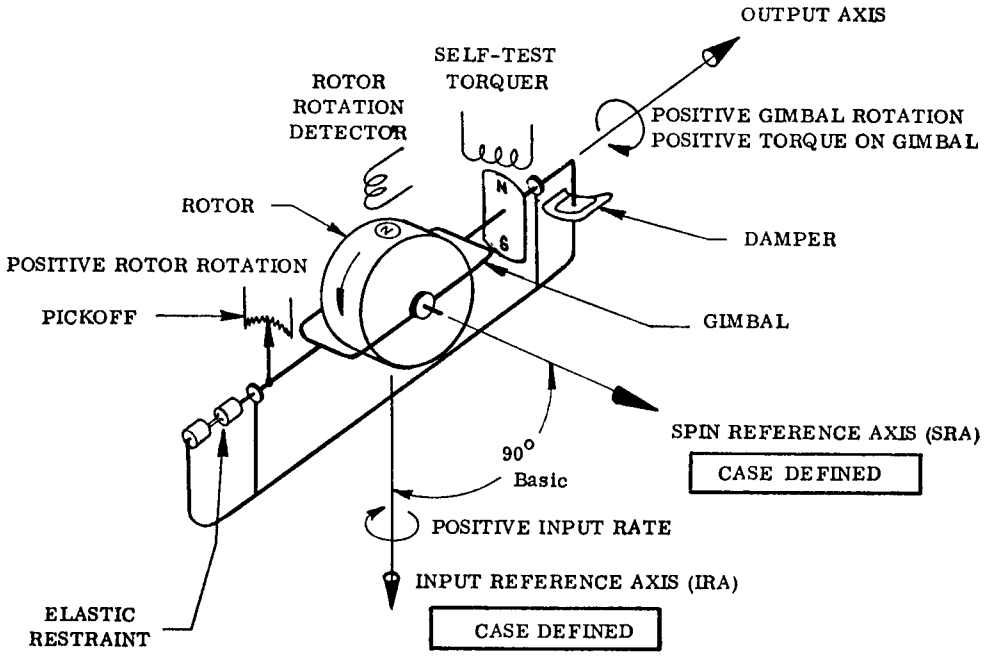

Figure 1—Mechanical schematic, typical rate gyro.

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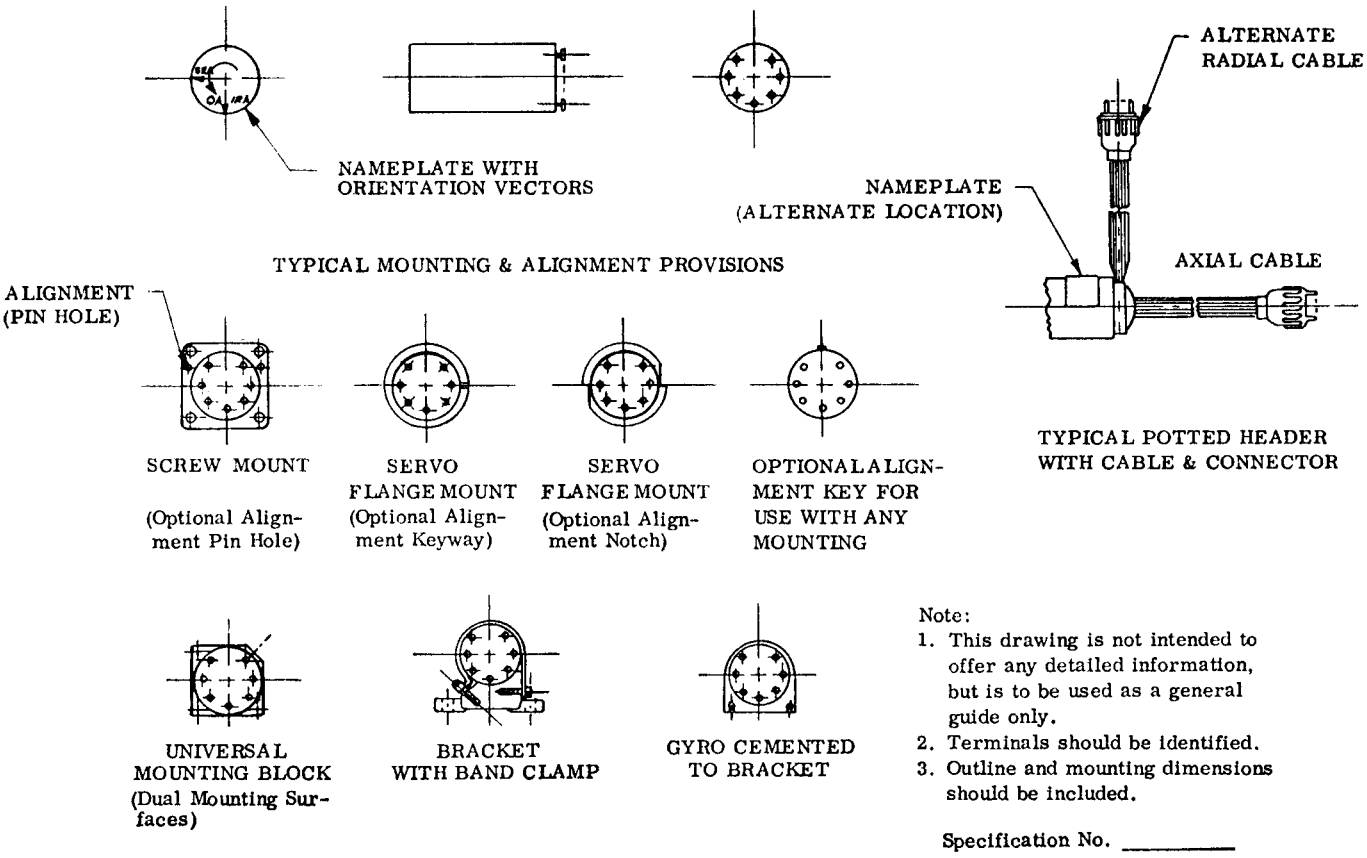

Figure 2—Outline, typical basic rate gyro.

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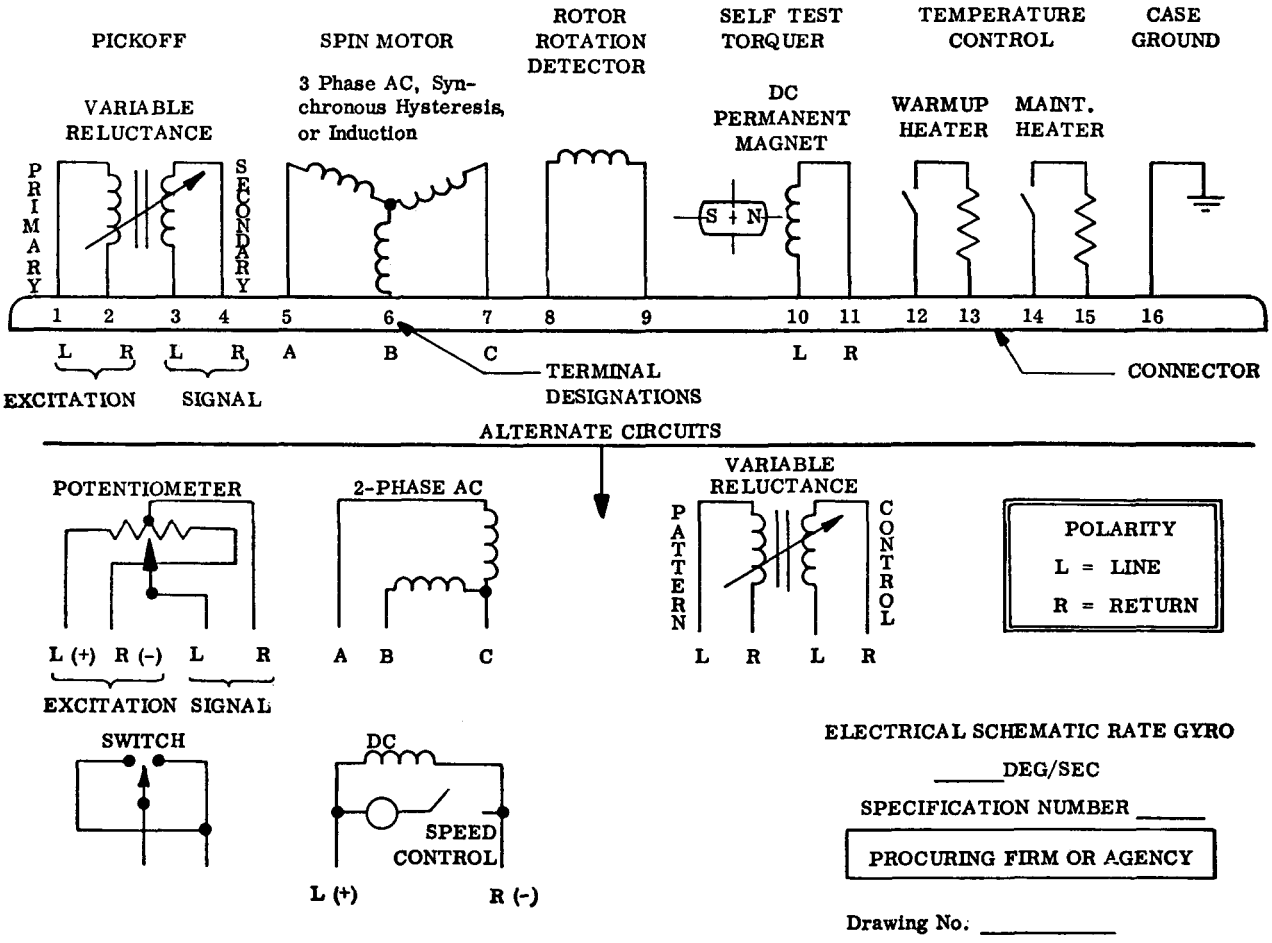

Figure 3—Electrical schematic, rate gyro.

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