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# APOLLO

## GUIDANCE AND NAVIGATION

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R-348(Rev. A)
Specification for Procurement
of Apollo Inertial Reference
Integrating Gyro

by


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August 1962

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# SPECIFICATION
# FOR
# PROCUREMENT OF
# APOLLO INERTIAL REFERENCE INTEGRATING GYRO
# INSTRUMENTATION LABORATORY
# MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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SPECIFICATION
FOR
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INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

## 1. SCOPE

### 1.1 Scope of this Specification

This specification establishes the requirements for the procurement of the Inertial Reference Integrating Gyro (MIT/IL C-95799) (hereafter called the IRIG) designed for use in the Apollo Guidance and Navigation System.

## 2. APPLICABLE DOCUMENTS

### 2.1 Specifications for the Production of IRIGs

#### 2.1.1 MIT/IL Specifications

MIT/IL drawing C-95799 and those drawings which are referenced by it and its subassemblies, together with appropriate parts lists and the MC specifications (MIT/IL document E-1091) define the gyro design for this specification. Report R-349, as applicable to the gyro, specifies the Reliability and Quality Control program.

#### 2.1.2 Government Specifications

NASA Quality Assurance Documents 200-1, 200-2 and 200-3.

### 2.2 Conflicting Requirements

In the event of conflict between the requirements of the contract, this specification, and other specifications and drawings cited herein, the requirements of the contract, this specification, and the documents listed in this section, shall govern, in that order.

2.3 Procurement of Applicable Documents

Copies of specifications, standards, drawings, and publications required by the contractor in connection with specific procurement functions should be obtained from MIT/IL.

# 3. REQUIREMENTS

## 3.1 General Requirements

### 3.1.1 Materials

The materials used in fabricating the IRIG shall be in strict accordance with applicable drawings and specifications referenced in section 2.

### 3.1.2 Construction and Assembly

The construction of the IRIG shall be in strict accordance with applicable drawings and specifications referenced in section 2.

### 3.1.3 Workmanship

The fabrication and finish of the IRIG, its assemblies, subassemblies, and parts shall be such as to produce a unit free from any defect that would affect proper functioning in service.

### 3.1.4 Serial Numbers

Each IRIG shall be identified by a serial number assigned by the NASA. Vendors shall request assignment of serial numbers from the procuring activity.

Unauthorized use of NASA serial numbers other than those issued by the NASA is prohibited.

### 3.1.5 Interchangeability

Unless otherwise specified, the IRIG and its component parts shall be physically and functionally interchangeable without selection or fitting within the tolerances of this specification.

3.1.6. Service Life

3.1.6.1 Operating Life

The IRIG design is intended to meet performance specifications for at least 5000 hours of gyro wheel operation, including the manufacturer's turntable testing time of the completed unit.

3.1.6.2 Shelf Life

The IRIG design is intended to have a shelf life at least three years, without operation, at ambient room temperatures after final acceptance at the vendor's plant.

3.1.7 Reliability

This section is inserted to provide for the inclusion of future reliability considerations as they may occur. The present known objective for the reliability of stable drift characteristics of gyros covered in this specification is three years.

3.2 Acceptance Tests

3.2.1 Classification of Acceptance Tests

The Acceptance Tests are to be performed on all IRIG's being submitted for acceptance under the contract. Acceptance Tests shall be performed by the manufacturer and may be witnessed by an MIT/IL Representative, an authorized Representative of MIT/IL, or a NASA Representative. These tests are detailed in paragraph 4.2.

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Acceptance Tests are broken down into two categories as follows: Functional Tests which are designed to measure the functional parameters of the IRIG, and Performance Tests which are designed to measure the basic performance characteristics of the IRIG as a precision instrument.

After initial calibration and balancing the Acceptance Tests shall be made as follows (except as specified in paragraph 4. 2. 3. 4):

I Functional Tests (see paragraph 4. 2. 2)

II Performance Tests (see paragraph 4. 2. 3)

(1) Temperature Stability Test (see paragraph 4. 2. 3. 1)
(2) Float Freedom Test (see paragraph 4. 2. 3. 2)
(3) 3 series of Servo Tests (see paragraph 4. 2. 3. 3)
(4) 24 hour storage at 135°F
(5) 3 series of Servo Tests (see paragraph 4. 2. 3. 3)
(6) Shroud
(7) 3 series of Servo Tests (see paragraph 4. 2. 3. 3)
(8) 24 hour storage at room temperature
(9) 3 series of Servo Tests (see paragraph 4. 2. 3. 3)
(10) Torque-Angle Calibration Tests (see paragraph 4. 2. 3. 4)

3. 2. 2 Functional Requirements

The IRIG shall perform the following functions

3. 2. 2. 1 Thermistor Calibration

The d-c resistance of each thermistor shall be 345 ± 34. 5 ohms at 135°F as measured per MC 25-800, current revision.

3. 2. 2. 2 Ducosyn Resistances

(1) Suspension Circuits: 21 ± 3 ohms
(2) Signal Generator Primary Circuit: 8 ohms ±0. 8 ohms
(3) Signal Generator Secondary Circuits: 65 ohms ± 6 ohms
(4) Torque Generator: 65 ohms /winding ± 6 ohms



[redacted]

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3.2.2.3 Magnetic Suspension Current Phasing

Connected as shown in Fig. 1 with each ducosyn's working capacitors ($C_W$) equal to each other within 1/2%, the S.G. and T.G. suspension currents shall lag the 2.0v source by $45 \pm 3^o$. This measurement shall be made with the signal generator primary disconnected and with the float suspended within the center half of the electrical range of the suspension.

3.2.2.4 Wheel Operation

(1) The spin motor shall be capable of reaching synchronous speed when excited with a voltage of 26.6v maximum.

(2) The spin motor shall reach synchronous speed within 90 seconds maximum after application of normal 28v excitation

(3) The wheel run down time shall be measured, per MC 25-834, once at the beginning and once at the end of each servo test series. The standard deviation ($\sigma_T$) of the run down times to 6000 rpm obtained in these tests must be less than 4.0 seconds. ($n \geqq 8$ for determination of $\sigma_T$).

3.2.2.5 Angle-Voltage Sensitivity

The average ratio of IRIG voltage output to Input Axis (IA) Angle, near null, shall be $11.8 \pm 3.54$ mv/mr.

3.2.2.6 Input Axis Polarity

Rotation in a positive IRIG IA direction should cause the voltage from $S_{1_8}$ to $S_{2_1}$ to have a phase of $0^o \pm 5^o$.

3.2.2.7 Limit of Equivalent Angular Rotation

An angular rotation of $.61^o$ to $.85^o$ about the IRIG IA from S.G. null, shall be sufficient to produce maximum angular displacement of the IRIG float about the Output Axis (OA).

3.2.2.8 Null Voltage Measurements

3.2.2.8.1 Signal Generator: Without compensation, the signal generator null voltage shall not be greater than 4mv. (Signal



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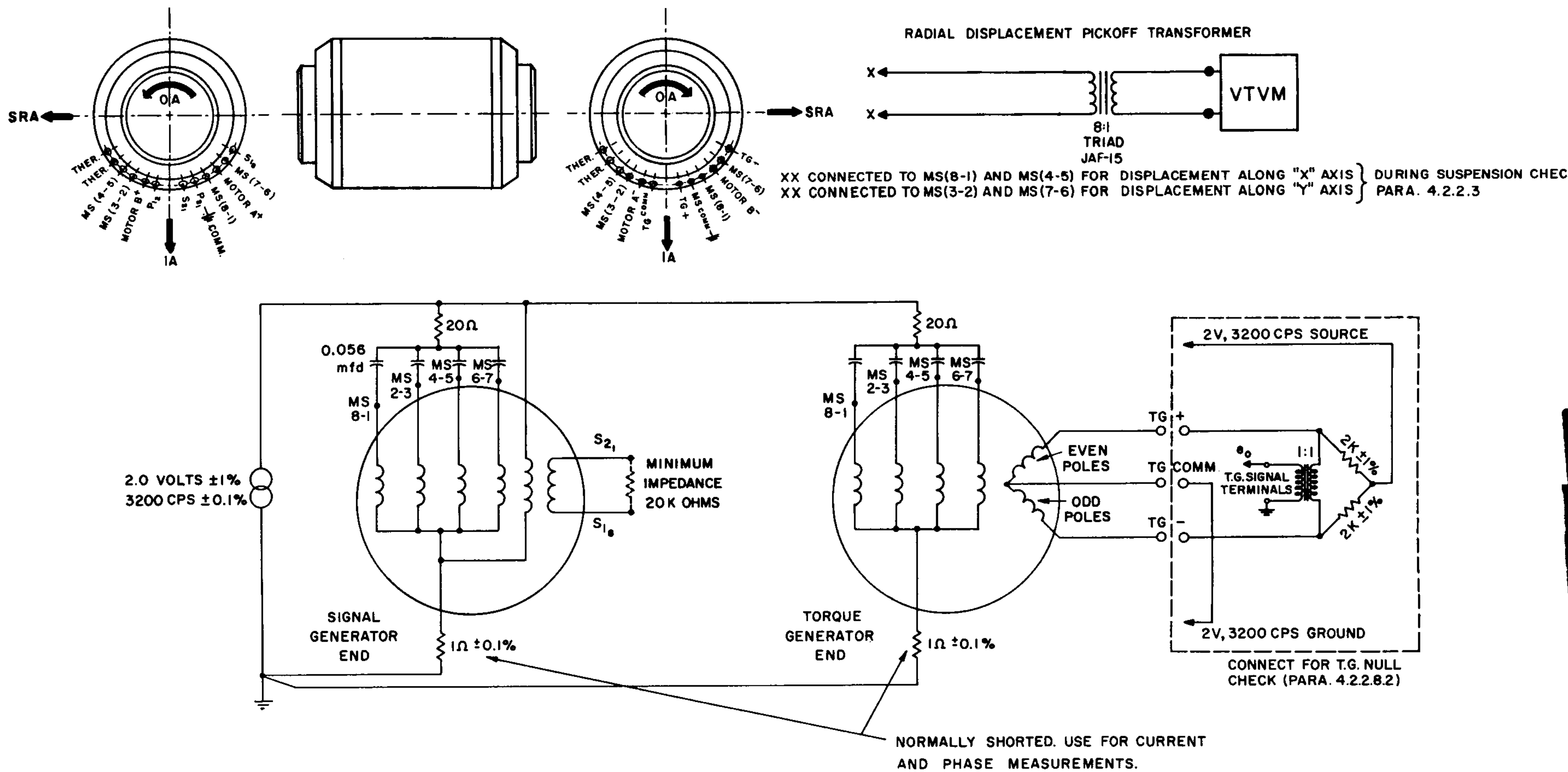


Fig. 1 APOLLO IRIG (ducosyn schematic)

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Generator null is the voltage output when the IRIG wheel is running and when the 3200 cps signal is zero.)

3.2.2.8.2 Torque Generator: The torque generator null when operated as a signal generator shall be within 1/2 mr of the signal generator null.

3.2.2.9 Vibration Requirements

The IRIG shall be capable of withstanding, without damage of any kind, 3 1/2 g rms sinusoidal acceleration along each of its principal axes, sweeping from 100 to 2000 cps.

3.2.3 Performance Tests

3.2.3.1 Temperature Stability Test

At normal excitation and normal operating temperature with the OA up or down, the variation in gyro drift shall not be greater than 5 meru/$^{o}$F when subjected to a temperature cycle of 3$^{o}$F at a rate between 1/2$^{o}$F/minute and 1$^{o}$F/minute.

3.2.3.2 Float Freedom Test

The performance requirements for the Float Freedom Test are as specified in paragraph 4.2.3.2.

3.2.3.3 Drift Rates

(1) With the excitation of 2 v ± 1%, the uncompensated bias drift rate (NBD), shall not be greater than 10 meru at any time.

(2) The acceleration-sensitive drift rate (ADIA) due to 1 g of case acceleration along the positive Input Axis shall not be greater than 15 meru at any time.

(3) The acceleration-sensitive drift rate (ADSRA) due to 1 g of case acceleration along the positive Spin Reference Axis shall not be greater than 15 meru at any time.

(4) The drift rate component proportional to the second power of the case acceleration along any axis shall not be more than 1 meru/$g^2$. (This is inherent in the design, if the wheel is assembled per MC 25-803, and is not a gyro test requirement).



[redacted]

(5) The standard deviation of the ten $1^{o}$ points in any one of the four positions during any of the servo tests shall not exceed 3 meru.

(6) The greatest difference in NBD, ADIA, and ADSRA during all drift performance testing shall not be greater than 5 meru.

3.2.3.4 Torque-Angle Calibration Test

The digital angle scale factor $M\Delta\tau/H$ shall be 0.012 mrad ± 5% and the Command Angle Torque Rate shall be $1.1^{o}$/sec ±10%.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 General

Unless otherwise specified herein, the supplier is responsible for the performance of all inspection requirements prior to submission for MIT/IL or NASA inspection and acceptance. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to MIT/IL or NASA. Inspection records of the examinations and tests shall be kept complete and available to MIT/IL and NASA as specified in the contract or order.

#### 4.1.1 Contractor's Quality Assurance Program

The contractor's quality assurance program shall be conducted in accordance with NASA Quality Assurance Documents 200-1, 200-2 and 200-3 and MIT Report R-349 to the extent specified in the procurement documents.

The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

#### 4.1.2 Special Test Equipment (Test Turntable)

A special test turntable and associated equipment must be provided and must have provisions for operating the IRIG under conditions specified. Adequate meters must be provided to measure excitation levels and operating temperatures. The test

[redacted]

table must have the following:

(1) Suitable mounting to assure that Gyro IA is - or can be adjusted to be - parallel to the test turntable axis within 1 mr (turntable axis wobble ± 0.1 mr).

(2) Provision for testing with the table axis vertical within 1 mr.

(3) Provision for testing with the turntable axis within 1 mr of horizontal and within 5 mr of north.

(4) Servo to keep gyro signal generator output signal inphase component below 2 mv and constant within .5 mv during gyro drift measurement runs.

(5) Angular velocity readout must provide timing signals for 1 degree angle increments with an accuracy of 5 seconds of angle or better for each increment.

(6) Angle increment timing during drift measurement tests must be accurate to 0.1 second time error or better.

(7) Wheel supply must be capable of delivering 15 w starting power.

(8) Table angle readout for ten degree increments shall have an accuracy of 5 seconds of arc or better for each increment.

4.2 Acceptance Tests

4.2.1 Test Conditions

Unless otherwise specified, the test procedures shall be accomplished under the following conditions:

Operating Temperature: Flotation ± 1/2°F and stable within ± 0.1°F.

Flotation shall be 135°F ± 2°F

Vibration: None (see Vibration Test, paragraph 4.2.2.11)

Humidity: Room ambient to 95% relative maximum humidity



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Microsyn Excitation: 2 v ± 1% at 3200 cps±.1%. This voltage is defined as having $0^{o}$ phase.

Suspension Excitation: 2 v ± 1% at 3200 cps±.1%

Spin Motor Excitation: 28 ± 0.28 v, 800 ± 0.08 cps, two phase, A leading B by 90 ● $5^{o}$.

4.2.2 Functional Tests

4.2.2.1 Thermistor Calibration

Before mass balance adjustment, the IRIG thermistors must be calibrated per M.C. #25-800, current revision.

4.2.2.2 Ducosyn Resistance Checks

The d-c resistance of each microsyn circuit must be measured with a suitable 20,000 ohm/volt ohmmeter. The resistances must be within the following limits:

(1) Suspension Circuits: 21 ± 3 ohm at room temperature

(2) S.G. Primary Circuits: 8 ± .8 ohms per leg. at room temperature

(3) S.G. Secondary Circuits: 65 ± 6 ohms at room temperature

(4) T.G.: 65 ± 6 ohms/winding at room temperature

4.2.2.3 Suspension Operation Test

The IRIG is mounted in a precision test turntable and brought up to the Operating Temperature.

Connect the microsyns to the test circuit as shown in Fig. 1.

A voltage pickoff transformer shall be appropriately connected to the test circuit as shown in Fig. 1.



[redacted]

Test each suspension axis in the following manner: Apply an electrical short across one of the suspension capacitors for 90 sec minimum. Remove the short and immediately read the voltage across the secondary of the radial displacement voltage pickoff transformer. Repeat the test for the opposite suspension axis.

The two voltage readings shall be of opposite phase.

The voltage shall decay to a stable reading within the center half of the range between the two readings.

4.2.2.4 Wheel Operation Test

Determine that the spin motor is capable of reaching synchronous speed at reduced voltage, as indicated by a sudden drop in wheel power, by applying a 26.6 v max, 800 ± 0.08 cps, two phase (A leading B) excitation. When this has been determined, remove the excitation and allow the wheel to stop.

To determine the time for the spin motor to reach synchronous speed, a normal excitation of 28 ± 0.28 v is applied. The time required for the spin motor to reach synchronous speed is measured. This time should not exceed 90 sec.

After synchronization at normal excitation, the current level in each phase of the wheel circuit shall be measured and recorded.

The wheel rundown time shall be measured per MC 25-834,

Wheel rundown times will be measured once at the beginning and again at the end of each servo test series. (n = 8)

Record the rundown times.

The standard deviation ($\sigma_T$) of the rundown times to 6000 rpm obtained in those tests must be less than 4.0 sec.

4.2.2.5 Angle-Voltage Sensitivity Test

The turntable servo is disabled, the table axis is vertical, and the gyro is aligned IA parallel to table axis within 1 mr. The changes in the signal generator voltage are measured for approximately ± 1/4 degree of table motion caused by external means within 15 seconds of time. This motion should be such that the gyro signal generator passes through its null and reaches a value nearly equal to its starting value without hitting the gimbal stops. This will permit start and finish voltage readings to be read on the same meter scale. The sum of the meter readings is divided by the actual angle of rotation of the turntable expressed in mr.

This test is performed four times. Two readings in each direction of rotation are obtained. The average ratio of voltage change to angle change is computed.

The average ratio shall be 11.8 ± 3.56 mv/mr.

4.2.2.6 Input Axis Polarity Test

The turntable servo is disabled.

The turntable is rotated about its axis in a manner that drives the gyro gimbal alternately into each stop. A phase-meter is used to determine that the $S_{1_8}$ to $S_{2_1}$ voltage has a $0^\circ \pm 5^\circ$ phase angle when the turntable is rotated in positive IA direction.

The voltage readings are recorded at each stop position.

4.2.2.7 Limit of Equivalent Angular Rotation

The limits of equivalent angular rotation about the IA are computed by dividing the voltage reading at each stop position as obtained in the Input Axis Polarity Test (paragraph 4.2.2.6) by the average ratio of voltage change to angle change as computed in the

[redacted]

Angle Sensitivity Test (paragraph 4.2.2.5). The result shall be from $.61^{o}$ to $.85^{o}$ at each stop.

4.2.2.8 Null Voltage Measurements Test

4.2.2.8.1 Signal Generator: The signal generator is connected to the loading network shown in Fig. 1.

The total rms null for the signal generator is measured using a sinusoidal-rms-calibrated average detecting VTVM.

The null shall not exceed 4 mv.

NOTE: The null may not be improved by loading or parallel input current to the signal generator in the Performance Test. Summation to the signal generator preamplifier output of voltage $90 \pm 5^{o}$ out-of-phase with the microsyn secondary voltage may be used to reduce servo amplifier null, if necessary.

4.2.2.8.2 Torque Generator: The rms voltage at the torque generator signal terminals is measured with the signal generator at null. (See Fig. 1)

The 3200 cps in phase component of the torque generator angular voltage shall not exceed 3 mv.

4.2.2.9 Vibration Test

At operating temperature with the wheel running and microsyns excited, the unit should be subjected to 3-1/2g rms sinusoidal acceleration sweep from 100 to 2000 cps at a constant logarithmic rate in a period of about 1 minute along each of the three principal gyro axes. The IRIG shall be capable of withstanding this test without damage of any kind.

Torque feedback from the signal generator to the torque generator should be supplied during the vibration as required to keep the gyro gimbal clear of its stops. No gyro performance need be measured during this step and temperature and excitations need be only approximately equal to specified values.



[redacted]

4.2.3 Performance Tests

4.2.3.1 Temperature Sensitivity Test

For this test, a continuous analog readout of drift is required. It may be provided by a torque-to-balance loop, previously standardized against the precision test turntable to within 5 meru. The torque-to-balance loop shall be calibrated against earth's rate for nominal torque generator sensitivity.

The Gyro OA is positioned approximately vertical and up. The operating temperature of the IRIG is varied $3^{o}F$ for at least five cycles at a rate of between $1/2^{o}F$/minute and $1^{o}F$/minute as indicated by the thermistors.

The cyclic variation of drift with temperature is observed.

The procedure above is repeated with the Gyro OA vertical and down.

The amplitude of the variation shall not exceed 5 meru/$^{o}F$. If the amplitude exceeds 5 meru/$^{o}F$, the IRIG is unacceptable, and further tests need not be conducted.

4.2.3.2 Float Freedom Test

The gyro shall be at Operating Temperature, mounted on a servo table with table axis vertical, and operated in a torque-to-balance mode as shown in the block diagram in Fig. **2**.

4.2.3.2.1 Test Equipment Requirements:

a. The Float Rate Dummy Director shall be capable of supplying a properly phased 3200 cps ramp voltage output $e_1$ equal to 10 mv/minute ± 0.5% over a continuous voltage range from -50 mv (corresponding to positive float rotation about OA) to 0 mv and from 0 mv to + 50 mv (negative position about OA).

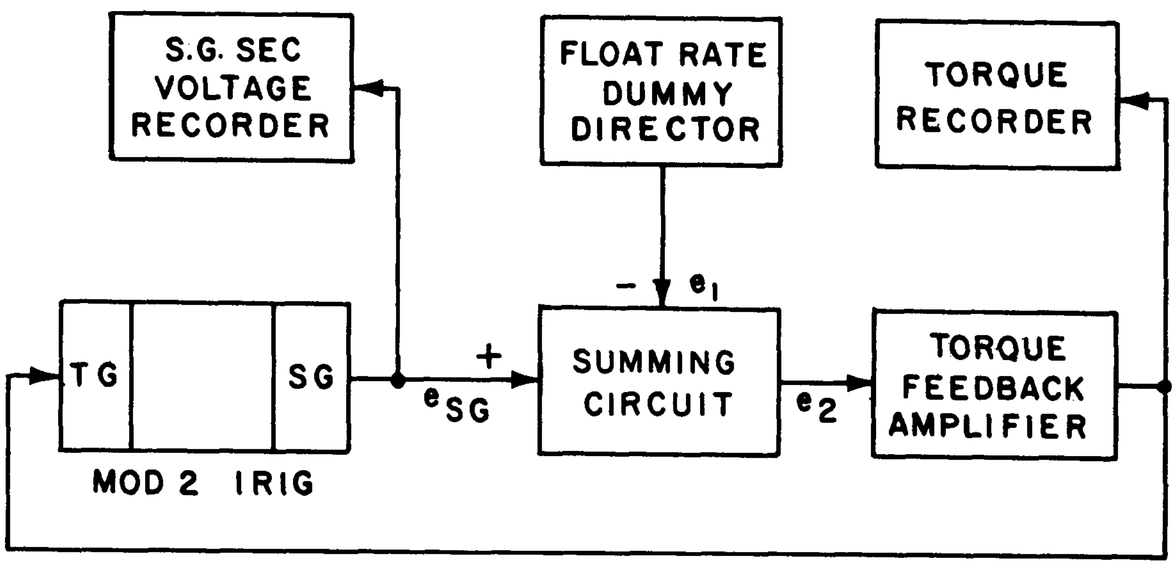


Fig. 2 Torque-to-balance mode block diagram

b. The torque recorder shall have a time constant of 1 sec maximum and shall have no provision for damping adjustment.

4.2.3.2.2 Calibration and Gain Adjustment of the Torque Feedback Amplifier

a. With the gyro positioned OA Vertical up, IA east, wheel off and loop closed, adjust $e_1$ to a phase of $180 \pm 0.5^{\circ}$ with $e_{SG}$ at +50 mv. Set $e_1$ such that $e_{SG}$ is at -50 mv and measure the phase of $e_1$ vs. $e_{SG}$. This phase angle shall be $180 \pm 2^{\circ}$. This procedure constitutes proper phasing as mentioned in paragraph 4.2.3.2.1a.

b. With the gyro positioned as in step a above, measure the loop null voltage $e_2$. Adjust $e_1$ to + 25 mv. After settling occurs, instantaneously switch $e_1$ to 0 mv and measure the time constant for $e_2$ to drop from 20 mv to the null. Adjust the Torque Feedback Amplifier gain until this time is between 10 and 15 sec. All testing in paragraphs 4.2.3.2.3 and 4.2.3.2.4 shall be done at this value of gain.

4.2.3.2.3 OA Vertical Freedom Test: The gyro shall be positioned OA Vertical up, IA east, and shall be normally excited except wheel off.

a. The Dummy Director signal $e_1$ shall be varied according to the schedule in Fig. 3. The float torque shall be continuously recorded throughout the forty minutes of testing. This will result in a torque trace which is shown idealized in Fig. 3. The tape speed shall be approximately 0.4 in./min.

b. Best Straight Lines, L, shall be drawn through the steady-state portions of the torque trace.

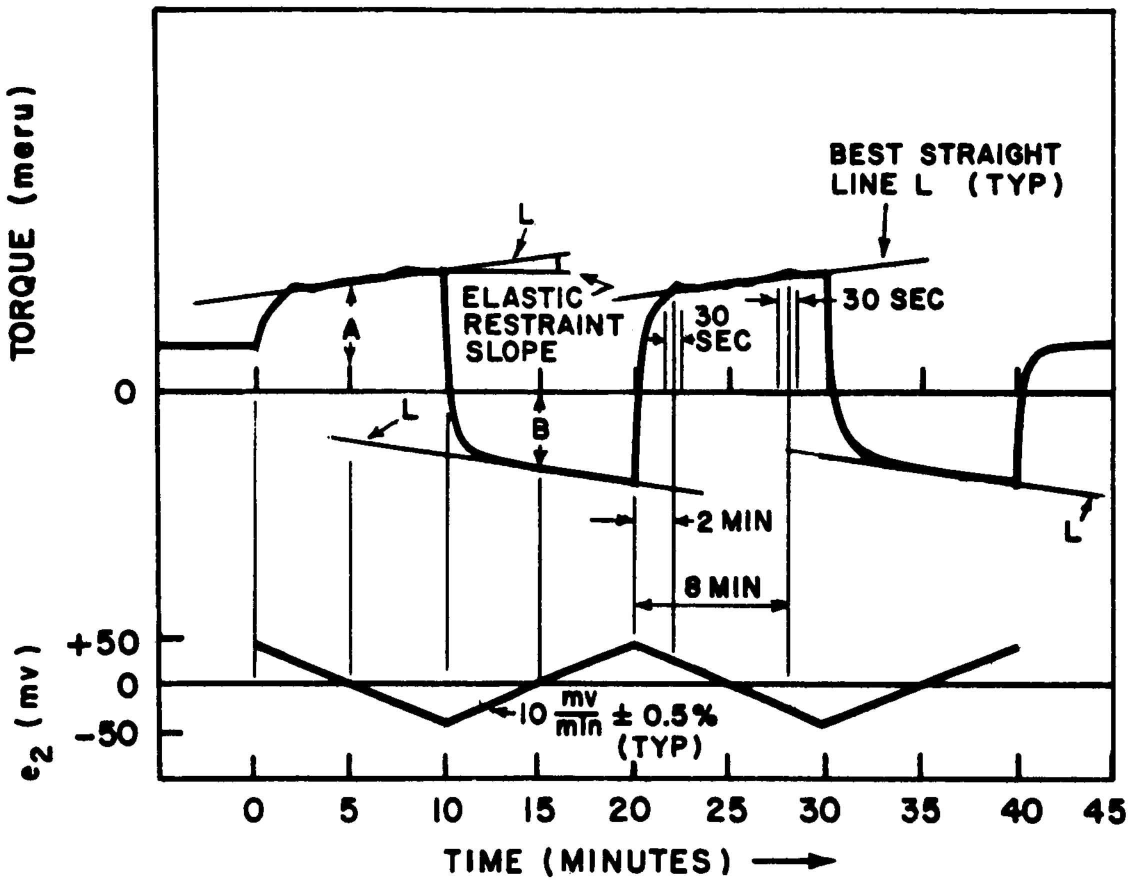


Fig. 3 Continuous Float rotation schedule.

c. Measure the slope of the Best Straight Line for the first direction of float rotation. This Elastic Restraint slope is shown in Fig. 3 and shall not exceed 3 meru/mv.

d. Record the average torque levels A and B (to the Best Straight Line) at $e_1 = 0 \pm 5$ mv during the first cycle of Dummy Direction Voltage. Determine the Fluid Damping Torque, FDT, by calculating the average of the absolute values of A and B. (Refer to Fig. 3.)

$$FDT = \frac{|A| + |B|}{2}$$

FDT shall be 130 ± 25 meru.

e. Observe all spikes and deviations from the Best Straight Line. No more than one spike or deviation may differ by more than 60 meru from its particular Best Straight Line level. The summation of all spikes or deviations greater than 15 meru from the Best Straight Line shall not exceed 90 meru.

f. The Dummy Director signal shall be varied according to the schedule in Fig. 4. This will result in a torque trace which is shown idealized in Fig. 4.

g. Intervals on the torque trace in which the Voltage rate is zero have been labelled C through J in Fig. 4. The average torque levels during the last minute of each of these 2 min intervals shall be algebraically subtracted as follows: C-J, D-I, E-H, and F-G. The absolute value of the difference between any of these terms shall not exceed 20 meru.

4.2.3.2.4 <u>IA Vertical Freedom Test</u>

The gyro shall be positioned IA Vertical up, OA South, and shall be normally excited except wheel off.

Repeat a, b, and e of paragraph 4.2.3.2.3 adhering to the same requirements.

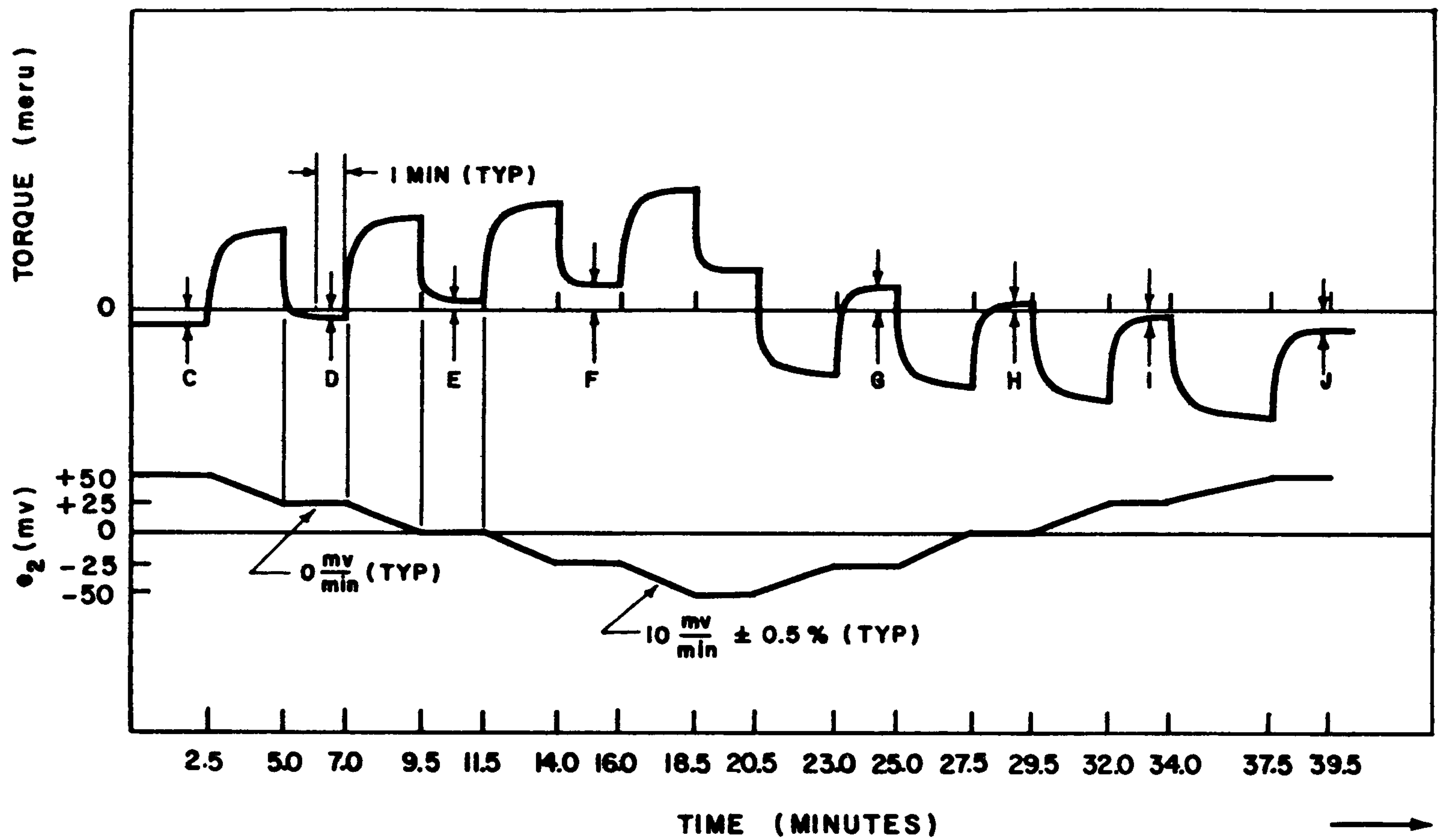


Fig. 4 Interrupted Float rotation schedule.

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NOTE: It is advisable to measure each of the four suspension voltages at some time during the first direction of float rotation in both the OA Vertical and IA Vertical gyro orientations. These voltage levels can be compared with the suspension voltages measured during prolonged deviations on the torque trace. This comparison can be used to distinguish problems due to fluid contamination from those involving pivot-and-jewel clearance, endshake, etc.

4.2.3.3 Drift Tests

4.2.3.3.1 Reduced Excitation Drift with Input Axis Up: With the test turntable axis vertical so that the positive direction of the Gyro IA will be up and at 1 v microsyn excitation, the turntable is allowed to rotate for a time interval during which the turntable should rotate more than $12^{\circ}$.

Measure the total time for the turntable to rotate for the last 10 deg. Divide the total angle by the total time and convert to meru.

NOTE: Note the direction of rotation of the test turntable. When looking down from the top of the test turntable, clockwise rotation will give negative meru values, counterclockwise rotation will give positive meru values of drift with respect to the Earth.

Add algebraically, to the meru value obtained above, +1000 times the sine of test station north latitude. The result of this addition is for the total uncompensated reduced excitation inertial space drift with 1 g of acceleration along the positive direction of the IA and is designated by the symbol Da.

The meru value at each increment of $1^{\circ}$ angle is to be graphically plotted against turntable angle.

4.2.3.3.2 Normal Excitation Drift with Input Axis Up: The



[redacted]

procedure above (paragraph 4. 2. 3. 3. 1) is repeated with normal microsyn excitation of 2 v. The value of the computation is the total uncompensated normal excitation inertial space drift with 1 g of acceleration along the positive direction of the IA and is designated by the symbol Db.

4. 2. 3. 3. 3 Normal Excitation Drift with Spin Reference Axis Up: With the test turntable horizontal, the IRIG is aligned so that the positive direction of Gyro IA is north and the positive direction of the SRA is approximately vertically up. Excitation is the same as in paragraph 4. 2. 3. 3. 2.

Measure the time interval for consecutive $1^{o}$ angle increments of the test turntable for a total of 10 increments.

> NOTE: The test should be started with the SRA approximately $7^{o}$ toward the east away from vertical so that at the end of 12 increments, the SRA will be approximately $5^{o}$ away from vertical to the west.

Measure the total time for the turntable to rotate for the $10^{o}$ increments symmetrically about the vertical. Divide the total angle by the total time and convert to meru.

Observing the note (paragraph 4. 2. 3. 3. 1) for the sign of the meru value obtained above, add algebraically, +1000 times the cosine of the test station north latitude. The result of this addition is the total uncompensated normal excitation inertial space drift with 1g of acceleration along the positive direction of the SRA and is designated by the symbol Dc.

4. 2. 3. 3. 4 Normal Excitation Drift with Spin Reference Axis Down: The procedure above (paragraph 4. 2. 3. 3. 3) is repeated with the IA north but with SRA approximately vertical down and with the test started approximately $7^{o}$ toward the west away from the vertical. The excitation, computations, and plotting are the same as above (paragraph 4. 2. 3. 3. 3). The result is the total uncompensated normal

excitation inertial space drift with 1g of acceleration along the negative direction of the SRA and is designated by the symbol Dd.

4.2.3.3.5 Computation for the Total Acceleration Insensitive Normal Excitation Bias Drift Rate (NBD): The total acceleration insensitive normal excitation bias drift rate is the algebraic average value of Dc and Dd and is designated by the symbol NBD.

$$NBD = \frac{Dc + Dd}{2}$$

4.2.3.3.6 Computation for the Acceleration Sensitive Drift Rate Due to 1g Acceleration Along the Positive Direction of the Input Axis (ADIA): The acceleration sensitive drift rate due to 1g acceleration along the positive direction of the IA is the algebraic subtraction of Db minus NBD and is designated by the symbol ADIA. That is:

$$ADIA = Db - NBD$$

4.2.3.3.7 Computation for the Acceleration Sensitive Drift Rate Due to 1g Acceleration Along the Positive Direction of the Spin Reference Axis (ADSRA): The acceleration sensitive drift rate due to 1g acceleration along the positive direction of the SRA is the algebraic average of the difference between Dc and Dd and is designated by the symbol ADSRA. That is:

$$ADSRA = \frac{Dc - Db}{2}$$

4.2.3.3.8 Computation for Microsyn Excitation Sensitive Drift Rate (RD): The drift rate component which is proportional to the square of the microsyn excitation voltage is $\frac{4}{3}$ times the algebraic difference between the Normal and Reduced Excitation Drift rates (see paragraphs 4.2.3.3.1 and 4.2.3.3.2) and is designated by the symbol RD. That is:

$$RD = \frac{4}{3}(Db - Da)$$

4.2.3.3.9 Computation for Independent Drift Rate (ID): The drift rate component which is independent of microsyn excitation or case acceleration is computed by the formula below and is designated by the symbol Id. That is:

$$ID = NBD - RD$$

4.2.3.3.10 Computation for the Standard Deviation of each Servo Test: The standard deviation of the ten $1^{o}$ drift rate values shall be calculated for each of the twelve servo tests. This computation shall be made by the following method:

$$\sigma_{10} = \sqrt{\frac{\sum_{i=1}^{i=10} (X_i - \overline{X})^2}{N}}$$

where $X_i$ = drift rate at each of the ten $1^{o}$ points.

$\overline{X}$ = average drift rate of the ten $1^{o}$ points.

N = Number of points = 10

The standard deviation $\sigma_{10}$, shall not exceed 3 meru.

4.2.3.4 Command Angle Torque Test

(1) This test shall be performed between the first and second sets of the series of the Performance tests specified in paragraph 3.2.1, section II, items (5), (7) and (9).

(2) (a) The unit is orientated with its input axis parallel to the table axis and vertically up.

(b) The servo loop is closed.

(c) A print is obtained from the forward backward counter of the command pulses for every ten table degrees.

(d) Torque is applied at the positive command angle pulse rate (1600 pps).

(e) This test shall be run for $50^{o}$ and the average of the five prints determined. The five prints shall agree with each other within 16 counts.

(3) Item (2) paragraph 3.2.3.4 is repeated for negative command angle pulse rate (1600 pps) and positive and negative command angle pulse rate of 800 pps.

4.2.3.4.1 Computation of Digital Loop Scale Factor

The digital loop scale factors (SF) in radians/pulse are calculated from the data obtained from the command angle torque tests. Scale factors shall be obtained for the negative and positive command angle torque tests and for both pulse rates. These four numbers shall be supplied with the unit data.

$$SF\pm = \frac{174.533}{R} \mp \frac{4.91343 \times 10^{-2}}{\dot{R}}$$

where R = the average value of pulses obtained from the forward backward counter during the positive command angle torque test.

$\dot{R}$ = the command angle pulse rate (1600 or 800 pps).

The scale factors shall be 0.012 mr/pulse ±5%.

## 5. PREPARATION FOR DELIVERY

### 5.1 Delivery

A tag sheet, equivalent to Fig. 5, shall be packed with each IRIG listing the serial number, vendor, and the following data particular to that unit:

(1) Thermistor resistances at flotation temperature.

(2) Values of suspension capacitors employed during acceptance tests.

(3) Temperature sensitivity.

(4) Total wheel time, average RDT ($A_T$), standard deviation of RDT ($\sigma_T$).

(5) Signal generator and torque generator equivalent IA sensitivities.

(6) Acceleration sensitive drift for 1g of case acceleration with:

(a) Acceleration along the IA. (ADIA)

(b) Acceleration along the SRA. (ADSRA)

(7) Bias Drift (NBD)

(8) The Digital Angle Scale Factor and Command Angle Torque Rate

(9) Date of acceptance tests.

(10) The last 20 hours of dynamometer trace for the wheel in each unit shall be included.

NOTE: When values for (6). (7) and (8) are filled in on the Tag Sheet, the Tag Sheet shall be classified as a CONFIDENTIAL Document.

## 6. NOTES

### 6.1 Description (See Fig. 6)

The IRIG is a single degree of freedom gyro. Three IRIG's mounted on a stable platform maintain a reference for the

DATA SHEET

FOR GYRO MK 45 MOD 2 IRIG

Manufacturer ______________________________ Serial Number ____________

Date of Acceptance Tests ____________________

A. Performance Characteristics

1. Temperature Sensitivity __________ meru/°F.
2. Maximum Float Friction __________ meru.
3. Drift Parameters

a. Before Shrouding

| Date | Test Station | Servo Run No. | NBD | ADSRA | ADIA | RD | ID |
|---|---|---|---|---|---|---|---|
| | | A-1 | | | | | |
| | | A-2 | | | | | |
| | | A-3 | | | | | |
| | | B-1 | | | | | |
| | | B-2 | | | | | |
| | | B-3 | | | | | |

b. After Shrouding

| Date | Test Station | Servo Run No. | NBD | ADSRA | ADIA | RD | ID |
|---|---|---|---|---|---|---|---|
| | | C-1 | | | | | |
| | | C-2 | | | | | |
| | | C-3 | | | | | |
| | | D-1 | | | | | |
| | | D-2 | | | | | |
| | | D-3 | | | | | |

4. Maximum Standard Deviation ($\sigma_{10}$) ____________ meru.

B. Functional Characteristics

1. Thermistor Resistance at Floatation ____________ ohms.
2. S. G. Suspension Capacitor ____________ mfd.
3. T. G. Suspension Capacitor ____________ mfd.
4. S. G. Angle Voltage Sensitivity ____________ mv/mr.
5. Standard Deviation of RDT ($\sigma_T$) ____________ seconds.
6. Total Wheel Time ____________ hours.

Fig. 5

[redacted]

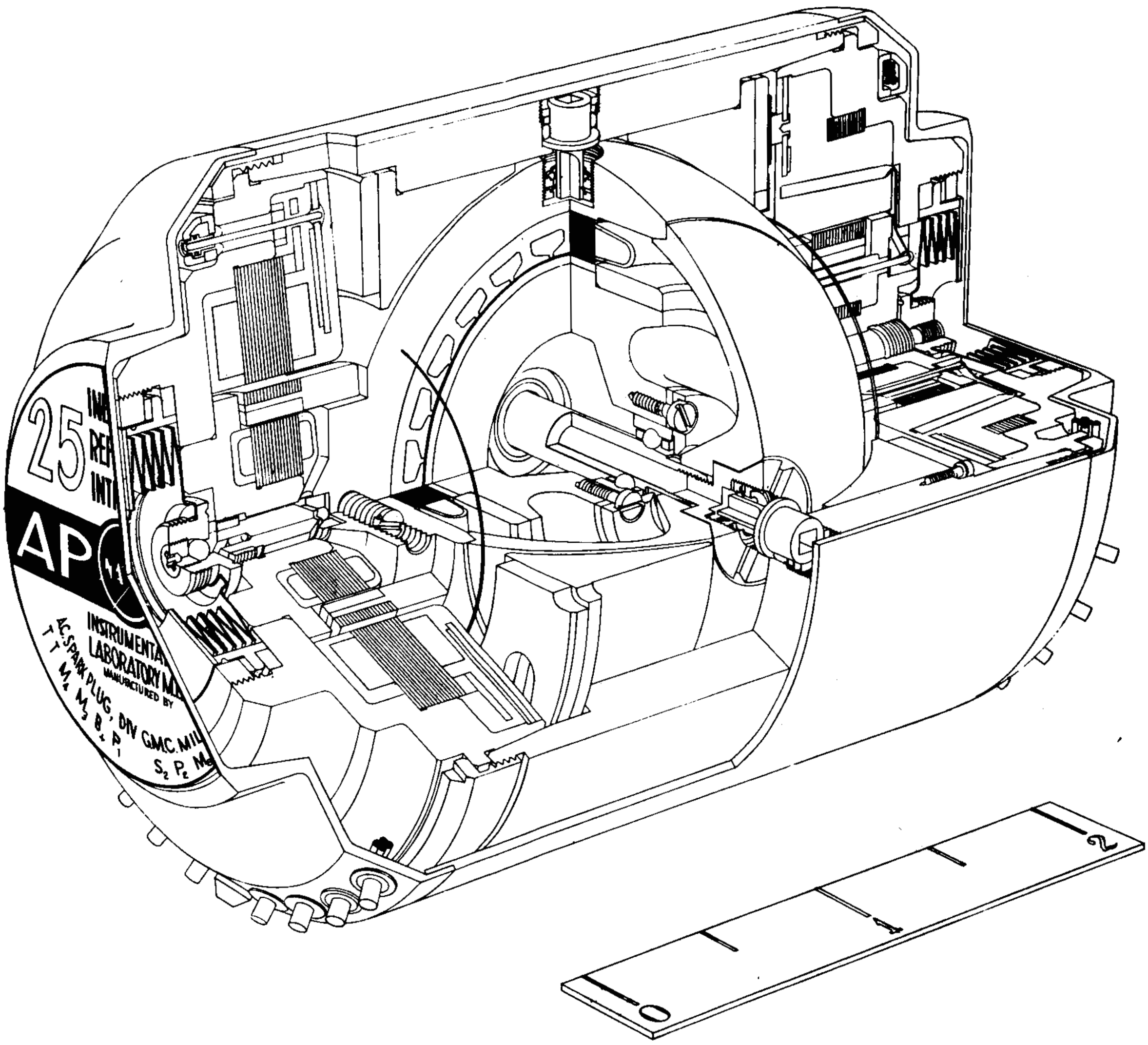


Fig. 6 25 Apollo IRIG(cutaway)



[redacted]

nonrotating, space-oriented axes in the Apollo Guidance and Navigation System. The IRIG contains: a gyro wheel, a floated gimbal in which the wheel is mounted, a microsyn torque generator, and a microsyn signal generator, both generators being mounted on the floated gimbal axis. The spherical gimbal is immersed in a damping fluid of very carefully controlled viscosity, and the float axis is supported by a magnetic suspension at each end of the IRIG case.

6.2 Definitions of Symbols and Abbreviations. (All drift rates in meru with respect to inertial space.)

| | |
|---|---|
| $\sigma_T$ | Standard deviation of Rundown Time (in seconds to 6000 rpm) from $A_T$. |
| $\overline{A}_F$ | Average wheel rundown time (in seconds to 6000 rpm) measured at final float run-in during manufacture. |
| $\overline{A}_T$ | Average wheel rundown time (in seconds to 6000 rpm) measured during acceptance test. |
| ADIA | Acceleration sensitive drift rate due to 1 g of case acceleration along the positive IA Axis. |
| ADSRA | Acceleration sensitive drift rate due to 1 g of case acceleration along the positive SRA Axis. |
| ID | Independent Drift Rate, independent of acceleration and microsyn excitation. |
| RD | Microsyn excitation sensitive drift rate in meru. |
| NBD | Normal excitation total bias drift rate (acceleration insensitive). |
| DNBD | The maximum difference of all NBD values. |
| DADIA | The maximum difference of all ADIA values. |
| DADSRA | The maximum difference of all ADSRA . |
| $\sigma_{10}$ | Standard deviation of the ten $1^\circ$ drift values in a Servo test. |