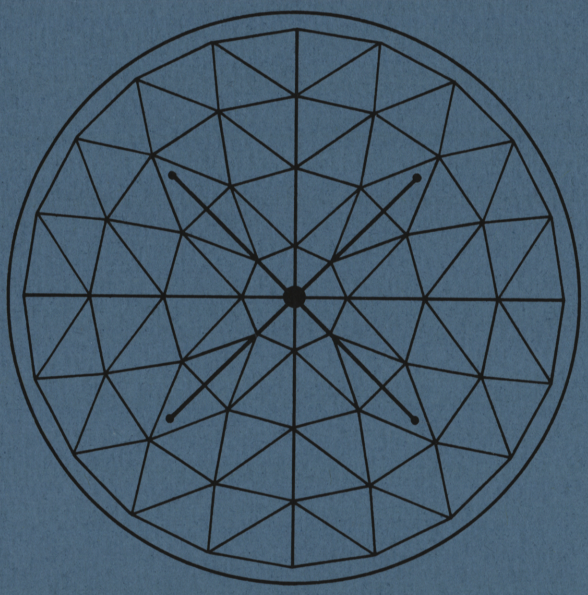


SECTION 6.0

NATIONAL RADIO ASTRONOMY OBSERVATORY
POST OFFICE BOX 2
GREEN BANK, WEST VIRGINIA 24944
TELEPHONE ARBOVALE 456-2011

REPORT NO. H79-7
CONTRACT NO. RAP-79
PAGE ___ OF ___
DATE Nov. 1968

PROJECT: 300 FT. DIA. HOMOLOGY RADIO TELESCOPE

SUBJECT: POSITION REFERENCE PLATFORM APPENDIX-II-

6.0 APPENDIX II

DATA SHEETS

ITEM	DESCRIPTION
A	"KEUFFEL & ESSER" LASER ALIGNMENT SYSTEM
B	"KEARFOTT" VERTICAL SENSING ELEMENT
C	"KEARFOTT" RATE GYRO
D	"KEARFOTT" ACCELEROMETER
E	"INLAND" TORQUE MOTORS
F	"INLAND" DC-AMPLIFIERS
G	"FARRAND" INDUCTOSYN ROTORS & STATORS

PREPARED BY O. R. Heine APPROVED BY _____ SUBMITTED BY S.D.L.

KEUFFEL & ESSER CO.

K&E LASER ALIGNMENT SYSTEM

PRELIMINARY PERFORMANCE SPECIFICATIONS

The following are preliminary performance specifications for the K&E "Laser Alignment System" and "Laser Autocollimating Alignment System." These specifications are based on initial tests, and will be subject to revision as further testing continues.

I. SYSTEM DESCRIPTION

K&E "Laser Alignment System" - consists of one Alignment Laser Instrument, one Power Supply, one Detector Target, and one Read-Out Unit, with necessary lead wires. The Power Supply should be connected to the Laser Instrument, and the Detector Target should be connected to the Read-Out Unit.

K&E "Laser Autocollimating Alignment System" - consists of one Autocollimating Alignment Laser Instrument, one Power Supply, one Detector Target, two Read-Out Units, with necessary lead wires. In use, the Power Supply should be connected to the Laser Instrument, and one of the Read-Out Units should be also connected to the Laser Instrument for measuring autocollimation. The Detector Target should be connected to the second Read-Out Unit for measuring alignment.

Additional separate units of each item are also available.

II. GENERAL - FOR ALIGNMENT AND AUTOCOLLIMATING LASER SYSTEMS

1. Electrical power source - Standard 110/115 volts AC, 60 cps line power.

2. Warm up time - 30 minutes.

3. All mechanical, optical, and electronic components will be manufactured and installed in a workmanship - like manner meeting acceptable standards of precision instruments.

4. Laser instrument barrel - All steel, fully closed and sealed throughout.

   A. Material - Tool steel, chrome plated outside diameter.

   B. Hardness-Rockwell C 54-57.

   C. Outside diameter - precision ground to NAS standard 2.2498 in. Tolerance is +.0000 in. -.0003 in./ft.

D. Length - Alignment Laser barrel about 15 in. overall. Autocollimating Alignment Laser barrel about 18-1/2 in. overall.

E. Finish - 16 microinch, precision ground.

5. The alignment and/or autocollimation optical components are contained wholly within the instrument barrel. The autocollimating output connection emerges from the rear of the instrument barrel.

6. Operating range - the operational range for alignment measurements is 0 to 300 ft. for both laser instruments.

7. Beam diameter -

Alignment Laser:	1/4 in.(+5/16 in. - 1/16) over full 300 ft. range. Minimum diameter is at 120 ft.
Autocollimating Laser:	1/4 in.(+1/4, - 1/16) over full 300 ft. range. Minimum diameter is at 150 ft.

8. Beam Alignment

A. Displacement -- The laser beam emerging from the front objective lens is centered to within $\pm$ .001 in. relative to the mechanical axis of the laser instrument.

B. Angular alignment -- The optical line of sight is the laser beam axis, not the mechanical axis of the instrument. The laser beam is parallel to the mechanical axis of the instrument to within $\pm$ 4 arc seconds.

9. Alignment stability - After warm-up the laser beam drift is less than $\pm$ .0005 in. during a one-hour period in a two-foot enclosed air path.

10. Power - Maximum uniphase laser beam power does not exceed 0.5 milliwatt.

11. After warm-up the effective laser power does not vary more than 10% over a four hour period.

12. Power output is amplitude modulated at a modulation frequency of 10 Kcps. (KHz)

13. Warranty - Laser power output is warranted for one calendar year from date of invoice to be capable of producing the indicated read-out sensitivity over full operational range when used in conjunction with recommended K&E Detector Target and Read-Out Unit.

14. Operating Safety - This Laser System has been designed and manufactured to minimize risk of injury from Laser light. Nevertheless, direct viewing into the oncoming Laser beam should be avoided. It may produce immediate or latent injury to the eye. We recommend that the laser beam not be trained directly into viewers' faces, and that chance spectators should be warned against sighting directly into the oncoming laser beam.

III. AUTOCOLLIMATING LASER INSTRUMENT

1. The Autocollimating Laser is of autocollimating design (not autoreflecting) in that the internal autocollimating sensing unit lies on the focal plane of the objective lens.

2. Autocollimation range - Null reading, over operational range of 0 to 150 ft.

3. The angular alignment of the autocollimation axis is parallel to within ± 2 sec of the mechanical axis of the instrument.

4. The autocollimation scale factor varies less than ± 25% over the full autocollimating distance.

IV. LASER POWER SUPPLY

1. The power supply has automatic voltage regulation and recessed adjustments for current control and modulation control on the front panel.

2. A coaxial cable connects the power supply to the laser instrument.

3. Overall dimensions - 10 in. wide x 8 in. high x 8 in. deep.

V. DETECTOR TARGET

1. The Detector Target is mounted in:

   A. Material - Tool steel, chrome plated.

   B. Hardness Rockwell C 54-57.

   C. Finish - 16 microinch.

   D. Diameter - Precision ground to NAS standard outside diameter overall.

2. Overall length 1-1/8".

3. Alignment - The center of the sensing element is concentric to the outside diameter of the detector target within ± .001 in. The center of the sensing element lies in a plane 1.000 ± .003 in. in front of the rear indexing surface of the Detector Target.

4. A cable connector is provided at the rear center of the Detector Target. Connectors are locked to prevent unwanted rotation.

5. A dust cap with 10 mm (about 3/8") diameter circle scribed on the center of the front face is provided for the Detector Target.

VI. READ-OUT UNIT

1. Read-Out display - Read-out is displayed on two zero-centered flat face meters. One meter reads lateral displacement, "Left" and "Right", directly in thousandths of inch. The other meter reads vertical displacement, "Down" and "Up", to the same sensitivity.

2. Scale range - Scale range is ± .025 in. displacement in each direction, Left, Right, Down or Up, from zero null. If the laser beam falls on the Detector Target beyond .025 in. displacement from its center, the corresponding meter will show full scale deflection to that side.

3. Meter damping time constants - "Fast" - 2 sec; "Slow" 4 sec.

4. Cross coupling - When the Detector Target is displaced either in the horizontal or vertical direction with respect to the laser axis, the remaining axis reading will change less than 10% of the displacement of the first axis.

5. Terminals for connecting up to four separate Detector Targets to each read-out unit are provided at the rear panel. Detector Targets are selected one at a time by a "Selector Switch" on the front panel of the read-out unit.

6. Recessed adjustments for horizontal and vertical Gain Adjust are provided on the front panel. The entire front panel is recessed.

7. Output jacks for driving a strip chart recorder or for servo control devices are provided on the rear panel.

8. Output voltage at jacks is 2 millivolts/.001 in. meter scale deflection, with 700 ohms output impedance.

9. Overall dimensions - About 10 in. wide x 8 in. long x 8 in. deep.

SALES PRICE

K&E COMPLETE
LASER ALIGNMENT SYSTEMS

Effective Nov. 1, 1967

Laser Alignment System - Cat. #71 2600

Consists of:

Alignment Laser with Power Supply		$3500. ea.
Laser Displacement Read-Out Unit		$ 860. ea.
Quad Cell Detector Assembly (Modulated)		$ 375. ea.
	Total	$4735.

Excluding brackets and mounts.

Laser Auto-Collimating Alignment System Cat. #71 2605

Consists of:

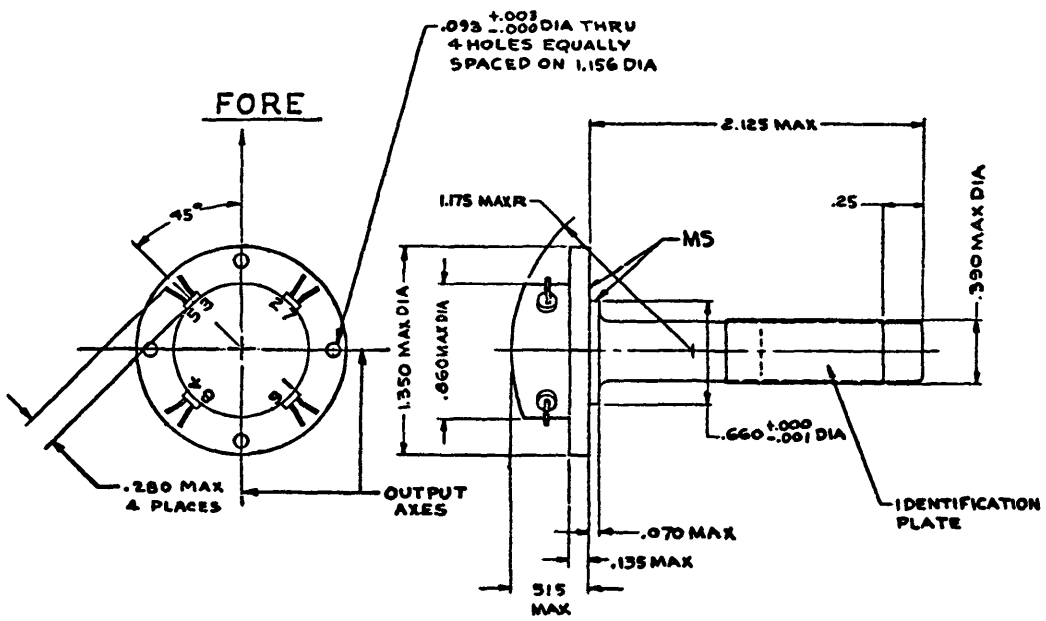
Auto-Collimating Alignment Laser with Power Supply		$4500. ea.
Laser Displacement Read-Out Unit (2 required at $860. each)		$1720.
Quad Cell Detector Assembly (Modulated)		$ 375. ea.
	Total	$6595.

Excluding brackets and mounts.

Laser Tubes covered by 1 year warranty from date of invoice.
Replacement Laser Tube - $595. each.

For further information, contact your local K&E Branch Office.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASE		



NOTES:

1. THE FOLLOWING DOCUMENTS ARE PART OF THIS DRAWING
   - C7C1815002-1 END ITEM
   - C1C1815002-1 PERFORMANCE SPEC

UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES		
DECIMAL TOL	ANGULAR TOL	
2 PLACE ± .03	±0° 30'	
3 PLACE ± .010		
MATERIAL		

DRAWING GRADE	(B)
DR W. Adams	12-4-67
CHK	
ENGR C.C. Jones	12-14-67
APPD JDV	12-15-67

KEARFOTT SYSTEMS DIVISION
WAYNE, NEW JERSEY

ENVELOPE DRAWING VERTICAL SENSING ELEMENT

SIZE	CODE IDENT NO.	
C	14804	C161815002-1

SCALE 2/1 SHEET

3-13-8

3.4.1.1 Resistance. The direct current (DC) resistance of the unit shall be as follows:

Terminal 2 and Case	=	295 ± 20 ohms
Terminals 1 and 5 Terminals 5 and 4 Terminals 4 and 6 Terminals 6 and 3	=	260 ± 25 ohms

3.4.1.2 Current. The unit shall not require in excess of milliamperes (MA) input current.

3.4.1.3 Verticality. The Vertical Sensing Element null position (as determined by monitoring in-phase output) shall occur on each axis with the mounting surface horizontal within a half cone angle of 3 arc minutes (MIN).

3.4.1.4 Null Repeatability. The Vertical Sensing Element null position shall repeat within a half cone angle of 15 arc seconds (SEC).

3.4.1.5 Null Voltage. The Vertical Sensing null voltage shall not exceed 7 millivolts (MV) root mean square (RMS).

3.4.1.6 Output Voltage Phasing. The output voltage between Terminals 1 and 4 shall be at 11 + 5,- 8 DEG with respect to the input voltage when Terminals 3 and 4 are elevated. The output voltage between Terminals 3 and 4 shall be at 11 + 5,- 8 DEG with respect to the input voltage when Terminals 1 and 4 are elevated.

3.4.1.7 Output Voltage. The RMS output voltage of an axis shall be as follows when displaced from the null position about that axis:

A. Displacement: 82 ± 0.16 minutes

B. Output: 180 ± 15 MV

C. *Symmetry: ± 10 MV

Note

*Symmetry is defined as the difference between voltage outputs on the same axis but in opposite displacement directions.

3.4.1.7.1 In addition, the ratio of the output at 58 MIN to the output at 82 ± 0.16 MIN shall be 0.707 to 0.790 in each of the X and Y axes.

3.4.1.8 Angular Freedom. The angular freedom about either axis shall be 1.75 DEG minimum.

3.4.1.9 Cross Axis Bias Sensitivity. (Exclusive of the mounting hole clearance adjustment). The Vertical Sensing Element null position of each sensing axis shall not change by more than half cone angle of 1 arc MIN for a displacement of 45 arc MIN about the other sensing axis.

3.4.1.10 Time Constant. Time constant at 25 DEG C shall be 0.1 to 0.16.

3.4.1.11 Dielectric Strength. The Vertical Sensing Element shall withstand 100 V RMS, 60 Hz for 5 SEC between Terminals 2 and 4. Breakdown is defined as 3 MA of current.

3.4.1.12 Insulation Resistance. The Vertical Sensing Element insulation resistance shall be 100 meghoms minimum between Terminals 2 and 4, tested at a 500 V DC potential at 25 DEG C and 75 percent relative humidity maximum.

3.4.1.13 Orthogonality. The orthogonality of the two Vertical Sensing axes shall be ± 9 arc MIN.

3.4.1.14 Scale Factor Sensitivity to Cross Axis Acceleration. The Vertical Sensing Element scale factor of one sensing axis shall not change by more than [illegible]0 percent of actual output voltage magnitude for a displacement of ± 45 arc MIN about the other sensing axis.

3.4.1.15 Magnetic Sensitivity. The Vertical Sensing Element null position of each axis shall not change by more than a half cone angle of 1 arc MIN per earth's magnetic field.

3.4.1.16 Temperature Change Sensitivity. The Vertical Sensing Element null position shall not change by more than a half cone angle of 1 arc MIN from +25 to -55 DEG C or from +25 to +75 DEG C.

Detail Specification

Vertical Sensing Element

C701815002-1

1. Scope

1.1 General. This specification covers one type of equipment designated as a Vertical Sensing Element, intended for sheltered storage and use.

2. Applicable Documents

2.1 Military Documents. The following documents, of the exact issue shown, form a part of this specification to the extent specified herein:

Specifications

Military

MIL-E-5272C Amend 1	Environmental Testing, Aeronautical and Associated Equipment, General Specification for

Standards

Military

MIL-STD-130C	Identification and Marking of U.S. Military Property

2.2 GP Systems INC., KSD Documents. The following documents of the latest issue in effect form a part of this specification to the extent specified herein:

Drawings

GP Systems INC., KSD

C161815002-1	Envelope Drawing, Vertical Sensing Element.
B360400083-1	Plates, Identification.

3. Requirements

3.1 Qualification. The erection mechanism furnished under this specification shall be a product which has been tested and has passed the inspection tests specified in Section 4.

3.2 Materials.

3.2.1 Materials which are not covered by applicable specifications shall be of the best commercial quality, of the lightest practical weight and entirely suitable for the purpose. Non-flammable material shall be used to the greatest extent practicable in the construction of the erection mechanism.

3.2.2 Fungus Inert Materials. Materials which are not nutrients for fungus shall be used to the greatest extent practicable. Where materials that are nutrients for fungus may be used, such materials shall be treated with a fungicidal agent, or otherwise suitably protected.

3.2.3 Protective Treatment. When materials are used in the construction of the Vertical Sensing Element that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in such a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip or scale with age or extremes of climatic or environmental conditions shall be avoided.

3.3 Design and Construction. The design and construction of the Vertical Sensing Element shall be in accordance with C161815002-1 and MIL-E-5272.

3.3.1 Power Requirements. The Vertical Sensing Element is designed to operate from a 3 volt (V) ± 5 percent, 400 ± 20 Hertz (Hz) single phase power source.

3.4 Performance and Product Characteristics.

3.4.1 Unless otherwise specified, the following specifications apply at 25 degrees centigrade (DEG C). Input Voltage is 3.0 V ± 1 percent, 400 ± 10 Hz.

3.4.1.17 Output Voltage Variation. The coefficient of variation of output voltage with temperature shall be 0.065 percent per 0 DEG C ± 0.006 percent of the value measured at 25 DEG C over the range of -55 to +75 DEG C.

3.4.1.18 Shock. The Vertical Sensing Element will meet the performance specification of 3.4 through 3.4.1.12, inclusive, after being subjected to sinusoidal shock of 25G maximum at a pulse width of 50 milliseconds (MS) (one-half sine wave form input).

3.4.1.19 Vibration. The Vertical Sensing Element will meet the performance specification of 3.4 through 3.4.1.12 inclusive after 2G, 2 to 20 Hz; 2.5G, 20 to 500 Hz input along three major axes.

3.4.1.20 Damping Ratio.

3.4.1.20.1 Damping ratio at -55 DEG C shall be 9 to 11 times critical.

3.4.1.20.2 Damping ratio at +75 DEG C shall be 0.5 to 0.7 times critical.

3.5 Environmental Conditions.

A. Storage: -55 to +75 DEG C

B. Operating: -55 to +75 DEG C

C. Test: 25 ± 5 DEG C

3.5.1 Humidity. The Vertical Sensing Element shall meet the performance requirements as specified in 3.4 at a relative humidity of up to 95 percent at 25 DEG C.

3.6 Dimensions and Weight.

3.6.1 Dimensions. The Vertical Sensing Element shall meet all of the exterior physical dimensions in accordance with C161815002-1

3.6.2 Weight. The Vertical Sensing Element shall have a maximum weight of 60 grams.

3.7 Identification and Marking. The identification and marking shall be in accordance with the requirements of MIL-STD-130. Identification plates shall be in accordance with B360400083-1.

3.8 Service Life. The Vertical Sensing Element shall have a minimum operating life of 10,000 hours and minimum storage life of 4 years.

3.9 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable.

3.10 Maintainability. The detail of the item design shall be such as to minimize maintenance, the use of special tools, support equipment, skills and manpower, and to enhance the ease of maintenance, including inspection, servicing, adjustment and replacement of the item or subassemblies thereof.

3.11 Workmanship. The Vertical Sensing Element, including all parts and accessories, shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies and freedom from burrs and sharp edges.

4. Quality Assurance Provisions

4.1 Examination.

4.1.1 Components. The inspector shall ascertain that prior to assembly all components or subassemblies of the Vertical Sensing Element procured under separate specification or drawing have been inspected, tested and accepted in accordance with their applicable specification or drawing.

4.2 Classification of Tests. The inspection and testing of the Vertical Sensing Element shall be classified as follows:

A. Qualification Tests

B. Acceptance Tests

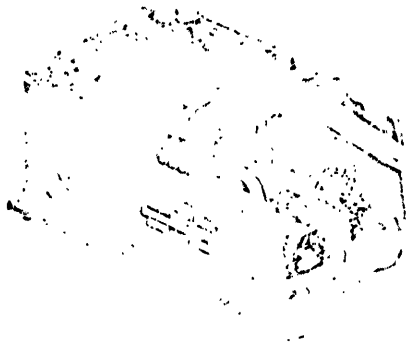
4.2.1 Qualification Tests. Qualification tests to be conducted as deemed necessary by Engineering, or engineering prototypes to assure design conformance with electrical and mechanical characteristics of 3.4 through 3.4.1.19 inclusive.

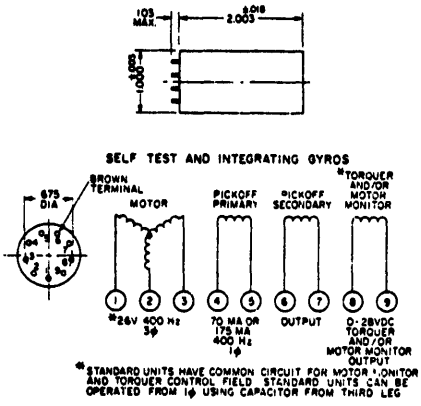
SUBMINIATURE FLUID-FILLED RATE GYROS

■ Minimum number of parts ■ Low hysteresis ■ Excellent null stability ■ Shock and vibration resistant ■ Damping control without heaters ■ Inner sleeve main subassembly ■ Lateral rigidity with exceptional threshold and resolution. Combining high performance, reliability, subminiature size, and minimum weight, these instruments are low-cost because of exclusive design versatility and manufacturing techniques. Basic design simplicity results in minimum null uncertainty, low hysteresis, low acceleration sensitivity, and constant heaterless damping. The basic models consist of: ■ Self-Test-Torquer (C70 2023 & C70 2024 Series) ■ Spin Motor Rotation Detector (C70 2023 Series) ■ Rate Integrating Model (C70 2533 Series) All versions contained within same size envelope configuration; have majority of piece parts common to each; assembled using the same techniques.

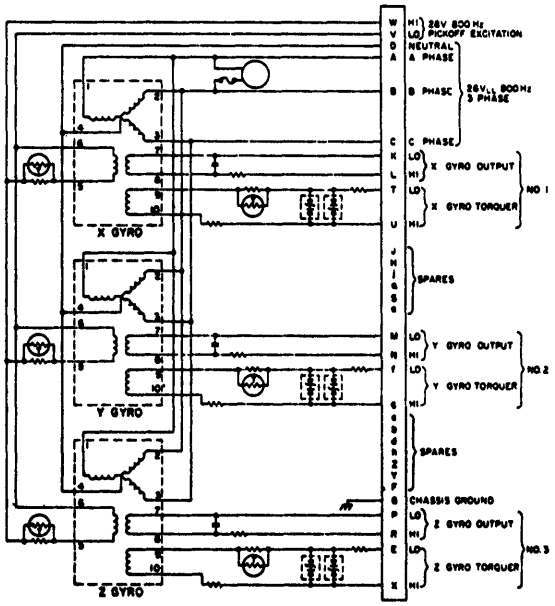
ADVANTAGES

■ Laterally-rigid, low hysteresis, integral torsion bar and bearing assembly ■ Special beryllium-copper torsion bar ■ Bubble-free, flush-through fill ■ Lateral gimbal damping ■ Low-friction gimbal spin-bearing ■ Large pickoff stator-rotor gap lessens lateral gimbal movement error ■ Blisterless plating speeds up perfect-seal soldering ■ Very fine radial balance adjustment. These instruments can be provided in two or three-axis rate sensing packages with temperature compensated pickoff and torquer characteristics.





TYPICAL THREE-RATE-GYRO PACKAGE



SUBMINIATURE FLUID FILLED RATE GYRO CHARACTERISTICS

ALL MODELS	GENERAL	Weight	4.6 ounces
		Mounting	Separate bracket around cylindrical case
		Terminals	Glass feed-through terminals
		External Null Adjustment	Vernier magnetic shunt (sealed at factory)
		Type of Damping	Temperature compensated paddle damper
		Float Support	Ball Bearing
	MOTORS	Type	Hysteresis synchronous
		Excitation	26 volts, 400 or 800 Hz, 3ϕ or 1ϕ with capacitor (higher frequency available)
		Starting Power	3.5 watts
		Running Power	3.0 watts
		Reserve Power	60% minimum
		Synchronous Speed	24,000 rpm
		Angular Momentum	32,000 gm cm²/sec
	PICKOFF	Type	Microsyn
		Excitation	26v or 115v through series choke @ 400 Hz 1ϕ (other frequencies and excitation available)
		Primary Current	175 ma or 70 ma (respectively)
		Phase Shift	0° ±5° with 10K load
	TORQUER	Type	D'Arsonval movement
		Maximum Control Current	100 ma dc
		Torquer Resistance	235 ohms (nominal)
		Torquer Scale Factor	Up to 0.4°/sec/ma
	ENVIRONMENTAL	Shock	100 g's for 5 milliseconds*
		Acceleration	100 g's*
		Vibration (Sinusoidal)	20 g's from 20 to 2,000 Hz*
		Vibration (Random)	0.2 g² per Hz from 20 to 2,000 Hz*
		Temperature Range	−55°C to +85°C
OPTIONAL		SPIN MOTOR ROTATION DETECTOR	
		Output Voltage	0.200 volts zero to peak (typical)
		Output Frequency	1600 Hz
		Wave Form	Modified sinusoidal

*Along three major axes without permanent shift in null or change in performance

RATE GYRO

Rate Range	Up to 400°/sec
Natural Frequency	15 Hz to 150 Hz (depending on rate range)
**Damping	Nominal ±30% from −55°C to +85°C
**Hysteresis	0.02°/sec or 0.05% of full scale, whichever is larger
**Acceleration Sensitivity	0.03°/sec/g or 0.05%/g of full scale, whichever is larger
Threshold and Resolution	Less than 0.005°/sec
RMS Null	Less than 20 mv
Initial Zero Offset	Less than 6 mv or 0.04%/sec whichever is less
**Zero offset shift with temperature	Less than 40 mv
Gimbal Freedom	±2.6° (maximum)
Sensitivity	6 mv/°/sec to 350 mv/°/sec (depending on rate range) Maximum output of standard unit is 8 volts
**Linearity	0.5% of full scale to half scale 2.0% of full scale to full scale

INTEGRATING GYRO

Nominal Gain $\left(\frac{H}{D}\right)$	0.5 to 16 Typical
Gain Variation with Temperature	±30% from −65°C to +.35°C
**Acceleration-Sensitive Drift Rate	100 deg/hr/g (day to day) 3°/hr/g (maximum short term 1 σ)
**Non-Acceleration-Sensitive Drift Rate	100 deg/hr (1 σ) (day to day) 2 deg/hr (maximum short term 1 σ)
Anisoelastic Drift	1 deg/hr/g² maximum (peak g)
Gimbal Freedom	Up to ±2.6 degrees

** Units can be supplied having better performance in these areas. However, since cost may vary considerably, information will be supplied for specific requirements only.

of restraint. Linear unsaturable torque attributable to the pendulous element is balanced by a similarly unsaturable linear torque developed by the gyro's precession. A contributing factor to this accelerometer's overall linearity and accuracy as an integrator is its freedom from an external integration device.

According to prevailing practice, the angular readout of a pendulous integrating gyro accelerometer is preferred in digital form.

BASIC PARAMETERS

The most significant basic parameters for both vertical reference and inertial accelerometers are summarized in the following table. To simplify the basis for comparison and to classify an accelerometer according to possible application, Kearfott spring-restrained and inertial instruments are compared.

To achieve the high degree of accuracy associated with inertial type accelerometers, an instrument of extreme precision is required.

These precision instruments must also be sufficiently rugged and durable to operate under high vibrational, shock, and thermal missile environments without performance degradation. Missile applications also demand small, lightweight instruments. Kearfott inertial accelerometers currently in production adhere to the pendulous force-balance principle. These simple, rugged, and durable devices are capable of the highest accuracy requirements.

	Vertical Reference Type	Inertial Type
Description	Spring-restrained, damped, single-degree-of-freedom, linear. Differential transformer output (AC).	Force-balance, pendulous permanent magnet torquer, one or two degrees of freedom, DC feedback current is linear measure of acceleration.
Threshold	5×10^{-4}g (most DC potentiometer output accelerometers are limited to 10^{-3}g)	3×10^{-7}g (by actual measure)
Linearity	0.05% of full scale	5×10^{-5}g to 1g and less than 0.01% of applied acceleration to higher g's.
Range (Dynamic)	2000	8×10^{7}
Range (Max.)	±1g (adjustable within dynamic range of 2000)	±25g (adjustable upward within limits of amplifier)
Zero Uncertainty (from vertical)	±100 arc seconds	±10 arc seconds
Null (or zero) stability	±50 arc seconds	±5 arc seconds (day to day) ±2 arc seconds (continuous)
Cross axis error	1.0% of applied accelerations	0.005% of applied accelerations.
Undamped natural frequency	9 cps (approx.)	above 300 cps
Damping	5 times critical	0.7 of critical
Output	AC voltage	DC voltage

CHARACTERISTICS OF TYPICAL KEARFOTT PENDULOUS ACCELEROMETERS

TYPE No.	425093-1	326778-1	B2400-01	D2400-01	C70 2401 003	C70 2406 001	C70 2408 000
Range of Measurement**	±5 g	±10 g	±0.035	±8 g	±20 g	±1 g	±0.5 g
Scale Factor (output)	5.0000 ma/g of applied acceleration		0.350 ±.00023 ma/g of applied acceleration	5.0000 ma/g of applied acceleration	4.9475 ma/g of applied acceleration	1 volt/g	2 volts/g
Operating Temperature	Performance optimized within any 20°F range between +50°F and +160°F		75°F ±5°	170°F ±10°F	155°F ±5°F	160°F to 200°F	160°F to 200°F
Linearity	Within 0.02% of applied acceleration	Within ±0.005% of the applied acceleration	0.000035 ma max. at 0.035 g	Within ±0.005% of applied acceleration	0.01% of applied acceleration	+.05% of full scale	+0.1% of full scale
Threshold	Less than 5×10^{-7} g		10^{-7} g	10^{-4} g	5×10^{-7} g	10^{-4} g	10^{-4} g
Zero Stability	±.00005g day to day; Less than ±.00002g over any continuous time interval.		±0.02 milliradian or less	±0.05 milliradian or less	0.00001 g	±.05% of full scale	±.05% of full scale
Vibration	Up to ±5 g peak from 20 to 2000 cps		Up to ±2 g peak from 5 to 2000 cps	Up to ±10 g peak from 0 - 350 cps	Up to ±10g peak to 2000 cps	5 g (10 to 60 cps)	To 30 g
Storage Temp.	−60°F to +170°F		−65°F to +165°F	−45°F to +200°F	−65°F to +200°F	−54°C to +100°C	−54°C to +100°C
Scale Factor Variation	±0.01% randomness		0.01% randomness	.04% maximum, .005% short term (continuous 10 hr. period)	±.01% randomness	—	—
Excitation	2.2 volts, 1600 cps	3.4 volts, 4000 cps*	3.4 volts, 5600 cps	12 volts, 2400 cps	6 volts, 3860 cps	0.067 amp at 38°	6.3 volts, 400 cps
Natural Freq.	120 cps	160 cps	70 - 90 cps	160 cps	220 cps	10 cps (approx.)	12 cps (approx.)
Freq. Response	Flat to 60 cps	Flat to 100 cps	−12 db/octave from 5 cps to 200 cps	Flat to 100 cps	Flat to 250 cps	—	—
Shock	15 g's	30 g's	30 g's	15 g .001 second duration	60 g	15 g	15 g
Weight	7 oz.	2 lbs.	4.5 lbs.	2.07 lbs.	4 ounces	3 ounces	2.8 ounces

* *This unit can also be supplied having a 6 volt excitation.*

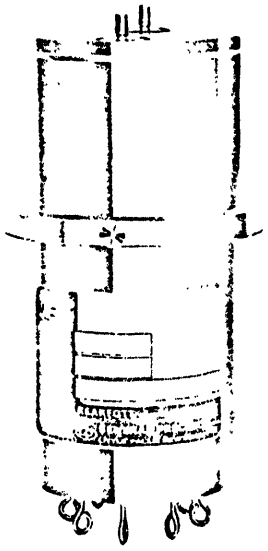
** *Adjustable upward within amplifier limits.*

TYPICAL CHARACTERISTICS OF KEARFOTT NON-PENDULOUS ACCELEROMETER

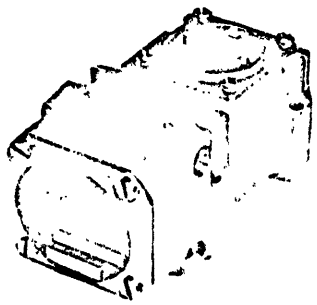
*Input Range: Output Voltage:	±1 g to ±30 g's (unsymmetrical ranges accommodated) to ±10 volts at 400 cps (higher voltages available at higher frequencies)
Output Impedance:	less than 1.5 kilohm (at 400 cps) depending upon output voltage
Excitation Voltage:	6.3 volts and 26 volts at 400 cps (other voltages and frequencies can be provided)
Excitation Power:	Approximately 1 watt
Frequency Response Limits: (cps) (freq. of 90° phase lag): Max. Damping Ratio:	 15 (1 g) 94 (30 g's) 2.5 (1 g) 0.6 (30 g's)
Threshold and Resolution	0.0001 g (max.)
Hysteresis bandwidth:	At 30 g's - 0.08 % full excursion Less than 30 g's - less than 0.08 % full excursion
Input Axis Alignment Error:	0002 radians (max.)
Linearity:	To half scale - 0.3 % full scale To full scale - 1.5 % full scale
Vibration:	To 30 g's up to 2000 cps depending upon range and output voltage
Shock:	To 100 g's depending upon range
Weight:	7 ounces (max.)

*Lower and higher ranges provided on special order

SINGLE AXIS ACCELEROMETERS

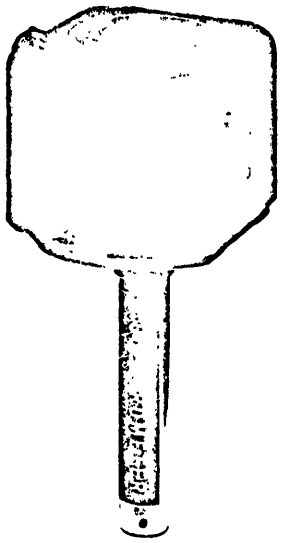


NON-PENDULOUS



PENDULOUS

TWO-AXIS PENDULOUS ACCELEROMETER



TYPE NO.

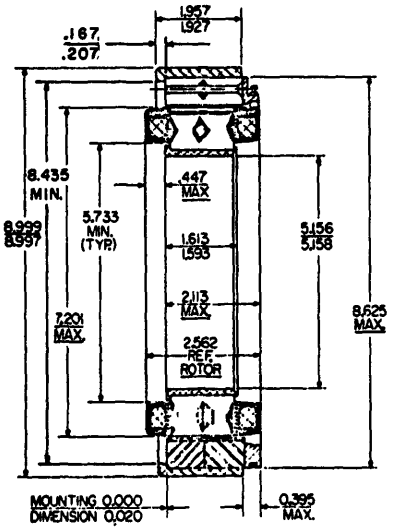
22 lb-ft T-7203

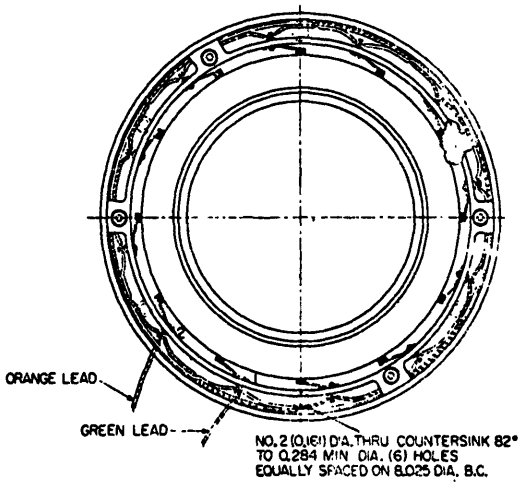
The motor winding constants shown here are typical and are not meant to indicate the complete range available. For information on motor windings not shown please contact your local representative or the factory.

MOTOR SIZE CONSTANTS	UNITS	SYMBOL	VALUE
Peak torque	lb-ft	T_P	22
Motor constant	lb-ft/$\sqrt{watt}$	K_M	1.0
Electrical time constant	milli-sec	T_E	5.0
Mechanical time constant	milli-sec	T_M	14.8
Power input, stalled, at peak torque (25°C)	watts	P_P	525
Viscous damping coefficients: Zero impedance source	lb-ft/rad/sec	F_O	1.26
Infinite impedance source	lb-ft/rad/sec	F_I	0.013
Motor friction torque	lb-ft	T_F	0.20
Ripple torque, average to peak	percent	T_R	4
Ripple cycles per revolution	cycles/rev	—	97
Ultimate temperature rise per watt	deg C	TPR	1.1
Max permissible winding temperature	deg C	—	105
Rotor moment of inertia	lb-ft-sec²	J_M	0.019
Max power rate	lb-ft/sec²	$\dot{P}$	2.5×10^4
Max theoretical acceleration	rad/sec²	α_M	1160
No load speed	rad/sec	ω_{NL}	16
Motor weight	lb	—	18.3

The type T-7203 is a frameless DC permanent magnet torque motor. It is shipped as three unmounted components — rotor, brush ring, and permanent magnet field. When installed, it is required that the structure with which the circumferentially oriented field is in direct contact must be non-magnetic. The rotor-to-field eccentricity should not exceed 0.005 inches. See installation section for detailed installation instructions and specific precautions. Brush life will normally exceed 10^8 revolutions. Rotor hubs and field adapters are supplied to customer specifications.

WINDING CONSTANTS	UNITS	SYMBOL	WINDING DATA FOR MODELS T-7203-A THRU T-7203-H							
			A	B	C	D	E	F	G	H
DC resistance (25°C)	ohms	R_M	0.88	3.35	1.25	5.9	8.6	22.2	34 9	54.7
Volts at peak torque (25°C)	volts	V_P	21.5	41.0	23.7	50.3	66.7	105	132	167
Amps at peak torque	amps	I_P	24.5	12.2	19	8.5	7.75	4.75	3.79	3.05
Torque sensitivity	lb-ft/amp	K_T	0.90	1.81	1.16	2.6	2.84	4.64	5.8	7.22
Back EMF	volts/rad/sec	K_B	1.22	2.47	1.57	3.5	3.85	6.28	7.86	9.78
Inductance	milli-hys.	L_M	5.0	20	8.0	40	48	130	200	310





TYPE NO

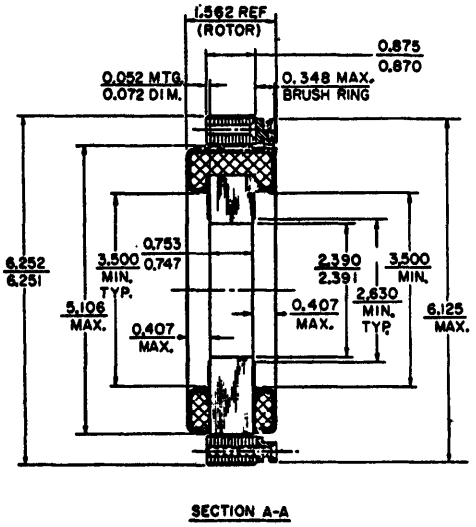
T-5135 4.0 lb-ft

MOTOR SIZE CONSTANTS	UNITS	SYMBOL	VALUE
Peak torque	lb-ft	T_P	4.0
Motor constant	lb-ft/$\sqrt{watt}$	K_M	0.37
Electrical time constant	milli-sec	T_E	3.5
Mechanical time constant	milli-sec	T_M	17.7
Power input, stalled, at peak torque (25°C)	watts	P_P	119
Viscous damping coefficients: Zero impedance source	lb-ft/rad/sec	F_O	0.18
Infinite impedance source	lb-ft/rad/sec	F_I	0.002
Motor friction torque	lb-ft	T_F	0.07
Ripple torque, average to peak	per cent	T_R	5
Ripple cycles per revolution	cycles/rev	—	71
Ultimate temperature rise per watt	deg C	TPR	2.1
Max permissible winding temperature	deg C	—	105
Rotor moment of inertia	lb-ft-sec^2	J_M	3.2×10^{-3}
Max power rate	lb-ft/sec^2	$\dot{P}$	5000
Max theoretical acceleration	rad/sec^2	α_M	1250
No load speed	rad/sec	ω_{NL}	22
Motor weight	lb	—	6.4

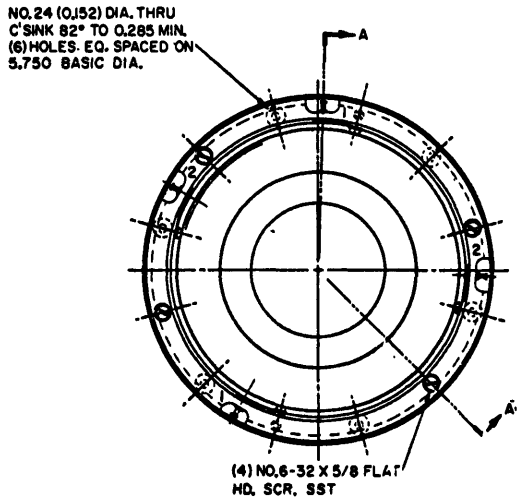
The motor winding constants shown here are typical and are not meant to indicate the complete range available. For information on motor windings not shown please contact your local representative or the factory.

The type T-5135 is a frameless DC permanent magnet torque motor. It is shipped as three unmounted components — rotor, brush ring, and permanent magnet field. When installed, it is required that the structure with which the circumferentially oriented field is in direct contact must be non-magnetic. The rotor-to-field eccentricity should not exceed 0.004 inches. See installation section for detailed installation instructions and specific precautions. Brush life will normally exceed 10^7 revolutions. Rotor hubs and field adapters are supplied to customer specifications.

WINDING CONSTANTS	UNITS	SYMBOL	WINDING DATA FOR MODELS T-5135-A THRU T-5135-H							
			A	B	C	D	E	F	G	H
DC resistance (25°C)	ohms	R_M	0.43	1.0	1.7	6.7	11.1	16.7	42.0	173
Volts at peak torque (25°C)	volts	V_P	7.2	11.1	13.9	28.8	37.0	45.2	71.4	141
Amps at peak torque	amps	I_P	16.7	11.1	8.2	4.3	3.3	2.7	1.7	0.82
Torque sensitivity	lb-ft/amp	K_T	0.24	0.36	0.49	0.94	1.2	1.5	2.4	4.9
Back EMF	volts/rad/sec	K_B	0.33	0.49	0.66	1.3	1.7	2.0	3.2	6.6
Inductance	milli-hys.	L_M	2.0	4.0	6.0	20	40	60	140	620



SECTION A-A



TYPE NO.

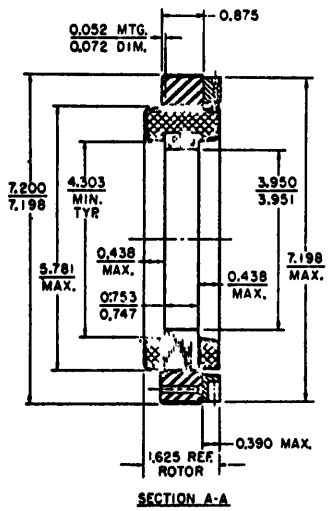
7.0 lb-ft T-5730

The motor winding constants shown here are typical and are not meant to indicate the complete range available. For information on motor windings not shown please contact your local representative or the factory.

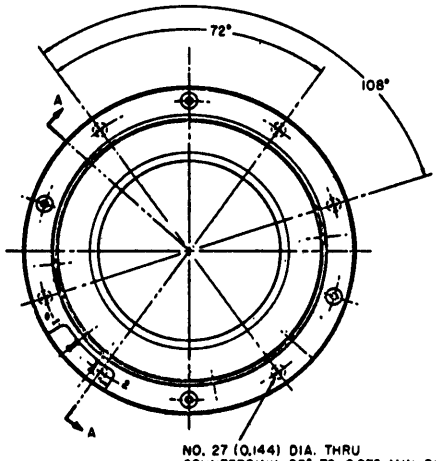
MOTOR SIZE CONSTANTS	UNITS	SYMBOL	VALUE
Peak torque	lb-ft	T_P	7.0
Motor constant	lb-ft/$\sqrt{watt}$	K_M	0.43
Electrical time constant	milli-sec	T_E	2.7
Mechanical time constant	milli-sec	T_M	20
Power input, stalled, at peak torque (25°C)	watts	P_P	260
Viscous damping coefficients: Zero impedance source	lb-ft/rad/sec	F_O	0.26
Infinite impedance source	lb-ft/rad/sec	F_I	0.003
Motor friction torque	lb-ft	T_F	0.07
Ripple torque, average to peak	percent	T_R	4
Ripple cycles per revolution	cycles/rev	—	79
Ultimate temperature rise per watt	deg C	TPR	2.0
Max permissible winding temperature	deg C	—	105
Rotor moment of inertia	lb-ft-sec²	J_M	0.005
Max power rate	lb-ft/sec²	$\dot{P}$	9600
Max theoretical acceleration	rad/sec²	α_M	1400
No load speed	rad/sec	ω_{NL}	27
Motor weight	lb	—	7.25

The type T-5730 is a frameless DC permanent magnet torque motor. It is shipped as three unmounted components — rotor, brush ring, and permanent magnet field. When installed, it is required that the structure with which the circumferentially oriented field is in direct contact must be non-magnetic. The rotor-to-field eccentricity should not exceed 0.004 inches. See installation section for detailed installation instructions and specific precautions. Brush life will normally exceed 10^8 revolutions. Rotor hubs and field adapters are supplied to customer specifications.

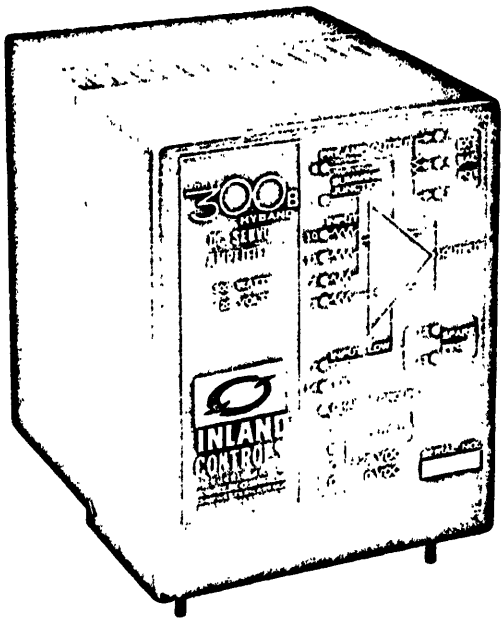
WINDING CONSTANTS	UNITS	SYMBOL	WINDING DATA FOR MODELS T-5730-A THRU T-5730-H							
			A	B	C	D	E	F	G	H
DC resistance (25°C)	ohms	R_M	1.5	3.5	5.4	8.5	13.1	34.4	53.5	139
Volts at peak torque (25°C)	volts	V_P	19.8	30.6	37.8	45.7	57.4	93	113	185
Amps at peak torque	amps	I_P	13.2	8.76	7.0	5.38	4.38	2.7	2.12	1.32
Torque sensitivity	lb-ft/amp	K_T	0.53	0.80	1.0	1.3	1.6	2.6	3.3	5.3
Back EMF	volts/rad/sec	K_B	0.72	1.09	1.36	1.77	2.17	3.53	4.48	7.2
Inductance	milli-hys	L_M	5.0	10	17	27	40	110	170	450



SECTION A-A



NO. 27 (0.144) DIA. THRU
COUNTERSINK 82° TO 0.275 MIN. DIA.
(6) HOLES SPACED AS SHOWN ON
6.600 DIA. B.C.



MODULAR DC AMPLIFIER

MODEL 300

267

Features

- Integral Preamplifier
- Adjustable Open Loop Gain to 10^6 V/V
- Multiple Summing Inputs
- Provision for Servo Compensation Networks
- Current Limiting Adjust from ±7.5 to ±15 Amps.
- All Solid State Silicon Transistor Design
- Low Drift — Less than 10 microvolts/°C

The Model 300B is a high gain, wide bandwidth DC Servo Amplifier designed to drive the INLAND* direct drive DC torque motor. However, it may be used in any servo application requiring up to 300 watts. It has a maximum output of ±15 amps at ±20 volts.

It has an integral heat sink and forced air cooling which will allow operation at an ambient of 50°C. Input power to the amplifier is +28 volts DC. The fan requires 115 volts, 60 cycles. 400 cycle and DC fans are available on special order.

These amplifiers are ideally suited for direct drive servo applications. A DC preamplifier and power amplifier provide high open loop gain and allow maximum versatility for incorporating custom servo compensation networks in the feedback circuit. In order to accommodate feedback control signals, 3 summing inputs are provided. Low input drift of less than 10 microvolts/degree C allows operation from low level signals.

Adjustable current limiting allows matching of the Model 300B to low impedance motor loads for high speed applications without any danger of motor or amplifier damage under any speed or reversing condition.

Special order modifications are available, to provide other output voltage and current combinations.

Inland Motor Corporation of Radford, Virginia is also a subsidiary of Kollmorgen Corporation.

SPECIFICATIONS

OUTPUT POWER	300 watts (nom.)
OUTPUT VOLTAGE (min.) (B+ at 28 V DC)	±20V DC ±10%
OUTPUT CURRENT (adjustable limiting)	±15 amps max. ±7.5 amps min.
OUTPUT IMPEDANCE (max.)	0.1 ohm
INPUT IMPEDANCE (1 non-inverting) (3 inverting)	>5 megohm adj.: up to 1 megohm
INPUT POWER	28 V DC ± 10% at 15 amps max.
FAN POWER	115 volts, 60 cycles, 14 watts
QUIESCENT CURRENT (typ.)	750 ma. (with fan)

LOAD RESISTANCE (min.) (with motor load and output current of 15 amps)

Back EMF Volts	Min. Res. Ohms
0	1.0
7.5	1.5
15	2.0

FREQUENCY RESPONSE (nominal)	A2 (power stage) 3db down 25,000 cps A1 (preamp) GBW 60,000 cps maximum full output frequency 1000 cps
GAIN (adj.)	To 10^6V/V
DRIFT (voltage referred to preamp input)	<10 microvolts/°C
DRIFT (current referred to preamp input)	single ended 0.5 Na./°C differential 0.1 Na/°C
DEAD BAND (referred to power stage input)	±20 mv
OPERATING TEMP. (max.) (0°C min.)	50°C ambient (with integral forced air-cooled heat sink) 95°C baseplate temp (without heat sink assy.)
SIZE (with heat sink assy.) (without heat sink assy.)	5.50" x 5.50" x 4.88" 5.50" x 2.50" x 4.88"
WEIGHT (with heat sink assy.) (without heat sink assy.)	6.0 lbs. 2.5 lbs.

INLAND

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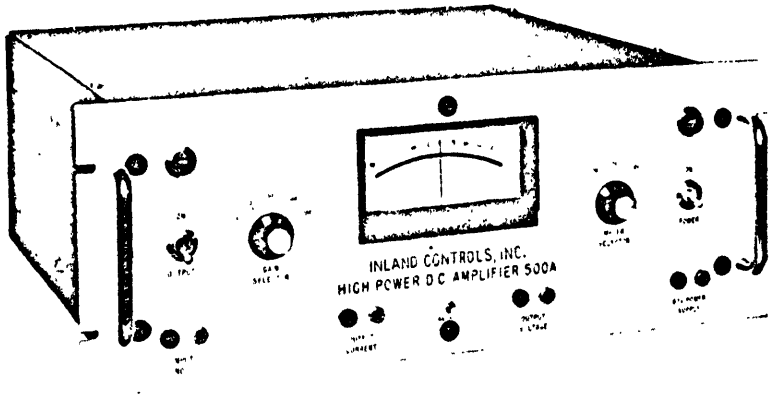
TWX: 710 330-0143

HIGH POWER DC AMPLIFIERS

MODEL 500



SPECIFICATIONS

OUTPUT POWER (max. continuous)	500 watts
OUTPUT VOLTAGE (max.)	±56 VDC
OUTPUT CURRENT (max.)	10 amps
FREQUENCY RESPONSE (3db down)	10 KC for gain of 10 500 cps for gain of 200
DRIFT (referred to input)	0.2 mV/°C
NOISE (referred to input)	1mV (rms)
INPUT IMPEDANCE	50K ohms
OUTPUT IMPEDANCE	0.1 ohm
LOAD RESISTANCE (min.)	5.6 ohms
GAIN (fixed selectable)	10, 20, 50, 100, 200
OPERATING TEMPERATURE	0 to 50°C
LINE VOLTAGE	117 VAC ± 10%, 60 cps
LINE POWER	800VA
SIZE (rack mounting)	7" x 19" x 17 - 1/4" (HWD)
WEIGHT	75 lbs.

Features:

- All solid state circuitry
- Self-contained power supply and preamplifier
- Direct operation from AC line power
- High input impedance — 50K ohms
- Wide bandwidth — up to 10KC
- Linear operation — no switching
- High power output — up to 800 watts

The Model 500A and 800A High Power DC Amplifiers are designed primarily to power INLAND* direct drive DC torque motors. However, they may also be used for the field excitation of rotary amplifiers. Due to their wide bandwidth, these amplifiers have proved themselves very successful in such AC applications as powering shaker tables.

The completely transistorized circuitry of the Model 500A and 800A features linear output, high input impedance, voltage gain, and wide bandwidth that ideally suit these amplifiers for direct drive servo applications. Provisions are made to sum two input signals, as may be required, in order to accommodate a feedback control signal.

The Model 500A and 800A are similar in design and construction except that the Model 800A features higher output voltage and power. The model's numerical designation corresponds to its maximum power output — Model 800A=800 watts; Model 500A=500 watts. These amplifiers include a high-power output stage, a high-gain preamplifier, and a self-contained power supply for operation from 115 VAC,60 cps line power. An over-load circuit protects the amplifiers from accidental short circuits and voltage transients.

Modification to the standard amplifiers can be supplied on special order to accommodate other output voltage and current requirements.

**Inland Motor Corporation is also a subsidiary of Kollmorgen*

MODEL 800

SPECIFICATIONS

OUTPUT POWER (max. continuous)	800 watts
OUTPUT VOLTAGE (max.)	±85 VDC
OUTPUT CURRENT (max.)	9.5 amps
FREQUENCY RESPONSE (3db down)	10KC for gain of 10 500 cps for gain of 200
DRIFT (referred to input)	0.1 mV/°C
NOISE (referred to input)	1mV (rms)
INPUT IMPEDANCE	50K ohms
OUTPUT IMPEDANCE	0.1 ohm
LOAD RESISTANCE (min.)	9 ohms
GAIN (fixed selectable)	10, 20, 50, 100, 200
OPERATING TEMPERATURE	0 to 50°C
LINE VOLTAGE	117 VAC ± 10%, 60 cps
LINE POWER	1200VA
SIZE (rack mounting)	7" x 19" x 17 - 1/4" (HWD)
WEIGHT	75 lbs.

INLAND

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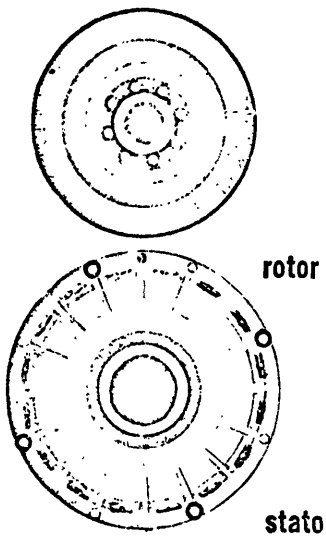
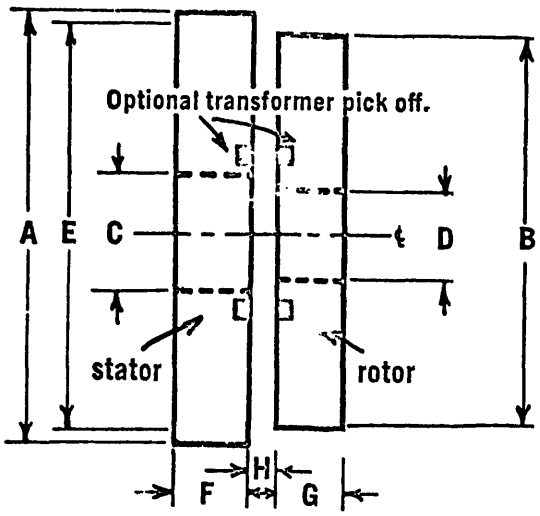
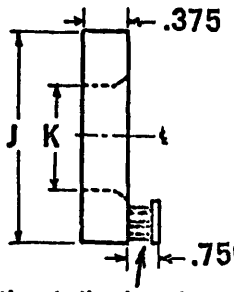


DIAGRAM



SLIP RING ASSY'S



Optional slip-ring pick-off.

SIZE	J	K
7"	4.164	2.250
12"	7.750	5.125

THE DISC MATERIAL AND FINISH OF THE ROTOR AND STATOR IS OPTIONAL

TABLE

INDUCTOSYN DIA	POLES	INSTALL DWG	A	B	C	D	E	F	G	H
2"	256	208547	2.437	1.750	.906	.437	2.000	.125	.125	.003 .004
2"	360	205934	2.500	1.750	.906	.437	2.000	.123	.123	.005 .008
3"	360	206058	3.681	2.706	1.161	.614	3.000	.183	.183	.005 .008
7"	256	206078	7.000	5.750	2.227	1.500	6.150	.312	.312	.005 .015
7"	360	206078	7.000	5.750	2.227	1.500	6.150	.312	.312	.005 .015
7"	720	207100	7.000	5.750	2.227	1.500	6.150	.312	.312	.005 .015
7"	512	207205	7.000	5.750	2.677	1.732	6.150	.312	.312	.005 .010
7"	360	207909	7.000	5.750	4.156	3.438	6.150	.312	.312	.005 .015
7"	360	207885	7.000	5.750	1.375	1.000	6.150	.312	.312	.005 .015
7"	360	208133	6.300	5.650	4.100	4.020	6.150	.393	.393	.004 .006
12"	360	205875	11.890	10.390	4.531	3.156	10.700	.370	.370	.005 .015
12"	720 2000	207103	11.890	10.390	3.750	2.500	10.700	.370	.370	.005 .015
12"	360	206039	11.890	10.390	3.750	2.500	10.700	.370	.370	.005 .015
12"	360-720	208313	11.890	10.390	7.750	6.680	10.700	.370	.370	.005 .015
12"	720-2000	207861	11.890	10.390	7.375	6.000	10.700	.370	.370	.005 .015

FARRAND CONTROLS, INC.
99 Wall St., Valhalla, New York Telephone: (Area code 914) NO 1-2600