MIL-HDBK-224 (NAVY)
27 September 1968

Superseding
OP 1755 (Change 1)
8 February 1960
OP 1755 (First Revision)
29 April 1958

MILITARY STANDARDIZATION HANDBOOK
PRECISION COMPONENTS

FSC 5990

DEPARTMENT OF THE NAVY

WASHINGTON, D. C. 20360

MIL-HDBK-224 (NAVY)
27 September 1968
PRECISION COMPONENTS

1. This standardization handbook has been approved by the Department of the Navy and supersedes Ordnance Pamphlet 1755 (First Revision) dated 29 April 1958 and change 1 dated 8 February 1960. This edition includes many components which have been developed during the interim. Others have been removed. Synchros are now covered in MIL-HDBK-214 and MIL-STD-710.

2. This publication was approved on 27 Sept. 1968 for printing and inclusion in the military standardization handbook series.

3. This document provides engineering and technical data on precision components recommended for new design as well as on components procured for maintenance of existing equipments. The handbook is not intended to be referenced in purchase specifications except for informational purposes, nor shall it supersede any specification requirements. Detailed specification requirements may be obtained from the procuring agency.

4. It is the intention of the Engineering Division to maintain the contents of this handbook current with the state-of-component art. Page and Figure numbering has been related to the various chapters so that each area of interest may be updated as the need arises. Your interest and assistance is solicited. Recommendations, corrections, additions or deletions regarding the material in this handbook should be addressed to Commander, Naval Air Systems Command, Engineering Division, Technical Support Branch, Components Section (AIR-52022), Washington, D. C. 20360.

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE.

The purpose of this handbook is to provide the engineer with technical reference data on precision components for new design, and on components required for maintenance of existing equipments. Precision components for new design are listed in WR-40. Procurement requirements for the various components are specified in corresponding specifications.

1.2 NOMENCLATURE.

Nomenclature is assigned by the Department of the Navy. The nomenclature consists of the item name followed by a type designation including a modification letter and a part number. All precision components having the same nomenclature are mechanically and electrically interchangeable for all military applications.

1.3 REFERENCED DOCUMENTS.

Applicable documentation is referenced for each precision component which covers the general requirements applicable and describes the technical requirements for procurement and the procedures by which it will be determined that the requirements have been met. The unique requirements for each component type are given in specification sheets which are identified by the general specification number with a suffix consisting of a slant (/) and a number. (e.g. MIL-S-22820/1, etc.)

Items are identified by a military part number. The purpose of such identification is to preclude the possibility of awarding more than one Federal Stock Number (FSN) to items which are interchangeable. Thus all items which have a military part number will be given the same FSN. This part number is made up of the specification number preceded by an M. Dash numbers indicate differences provided by the specification. (e.g. M22820/16-1).

WR-40 combines available information on resolvers, servomotors, tachometer generators, and servomotor-tachometer generators. Standard hardware is listed in MIL-HDBK-214 and MIL-HDBK-225.

Standard synchros for new design and for maintenance of existing equipments are listed in MIL-HDBK-214. MIL-STD-710 establishes requirements for the selection of synchros for use in military equipments.

General information, fundamentals, and theory of resolvers is contained in MIL-HDBK-218.

CHAPTER 2

AMPLIFIERS

The amplifiers described in this chapter consist mainly of packaged servo system amplifiers.

AMPLIFIER, RESOLVER

MK 74 MOD 0

CHARACTERISTICS

Number of channels	2	
Input voltage range	0.25 to 14	V
Input frequency	400	Hz
Power supply:		
Plate supply voltage	150	V
Plate supply power	10.0	watts
Filament supply voltage	6.3	V
Filament supply power	9.5	watts
Rotor output/amplifier input	1	
Ambient temperature range	-55 to +75	degrees C
Effect of input voltage, frequency, and ambient temperature change:		
Time phase shift between input and rotor output,		
varying input from 0.25 to 14.0 V rms	±0.2'	
varying frequency from 380 to 420 Hz	±1.0'	
varying ambient temperature from -55 to 75°C	±1.0'	
Rotor output amplitude variation,		
varying input from 0.25 to 14.0 V rms	±0.0003	
varying frequency from 380 to 420 Hz	±0.0002	
varying ambient temperature from -55 to 75°C	±0.001	
Weight	15.0	oz
Volume	14	cu. in

REFERENCES

Specification, development	NAVORD OS 6477	
Installation drawing	WP Dwg	1349030
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

For use with MK 4 MOD 0 Resolver.

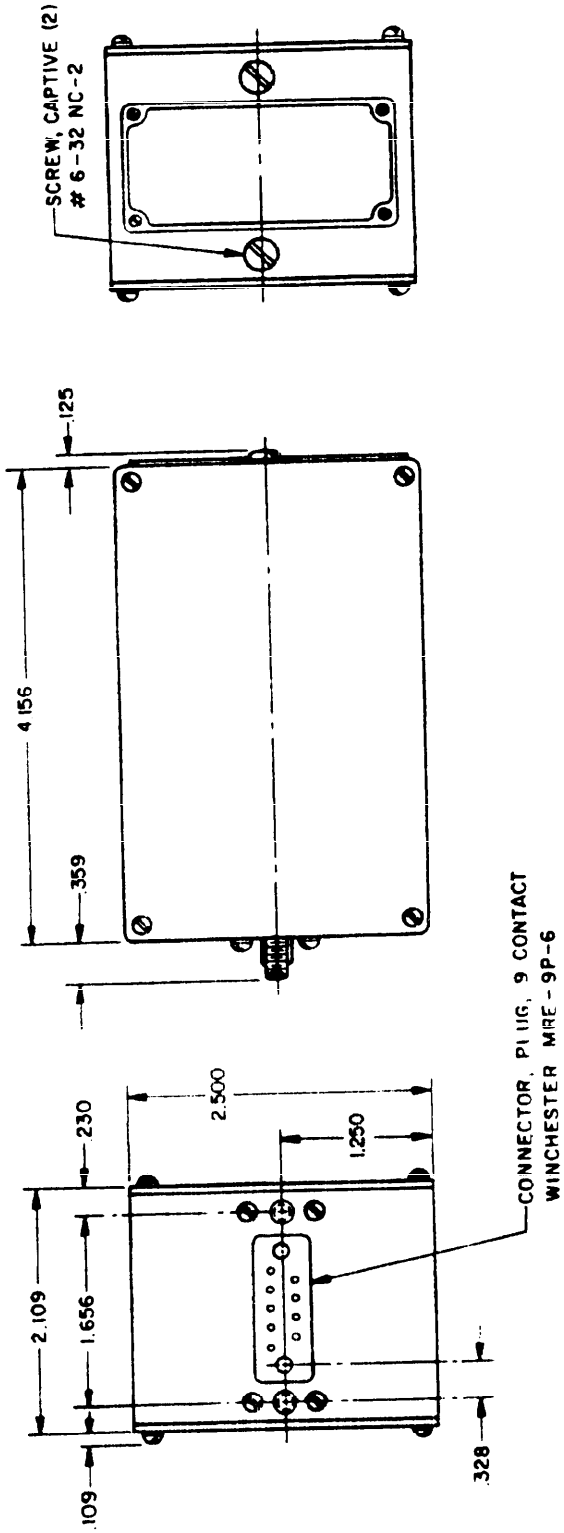


Figure 2.1. MK 74 MOD 0

AMPLIFIER, RESOLVER

M81258/1-1

ELECTRICAL CHARACTERISTICS

D.C. power supply		
Output voltage	±58	V
Ripple (peak to peak, max)	3	mV
Power input	1.82	watts
Output voltage (open loop, nominal)	20	V rms
Gain (at 20°C)	3500	
Input voltage range (closed loop)	0-26	V rms
Input voltage range (open loop)	0-60	mV rms
Frequency (closed loop)	5-35	kHz
Frequency (open loop)	285-515	Hz
Input impedance (open loop)	390,000	ohms
Phase shift (at resonance)	180	degrees
Internal noise (max)	1	mV rms
Warm-up time (max)	1.5	second

MECHANICAL CHARACTERISTICS

Operating temperature range	-55 to +85	degrees C
Nonoperating temperature range	-62 to +125	degrees C

External connections

Pin		
	A	resolver excitation
	B	input
	C	signal ground
	D	power ground
	E	d.c. power supply
	F	spare

Weight (max)	10.5	oz
MTBF	1000	hours

REFERENCES

Specification	MIL-A-81258/1(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

For use with MK 4 MOD 1 Resolver

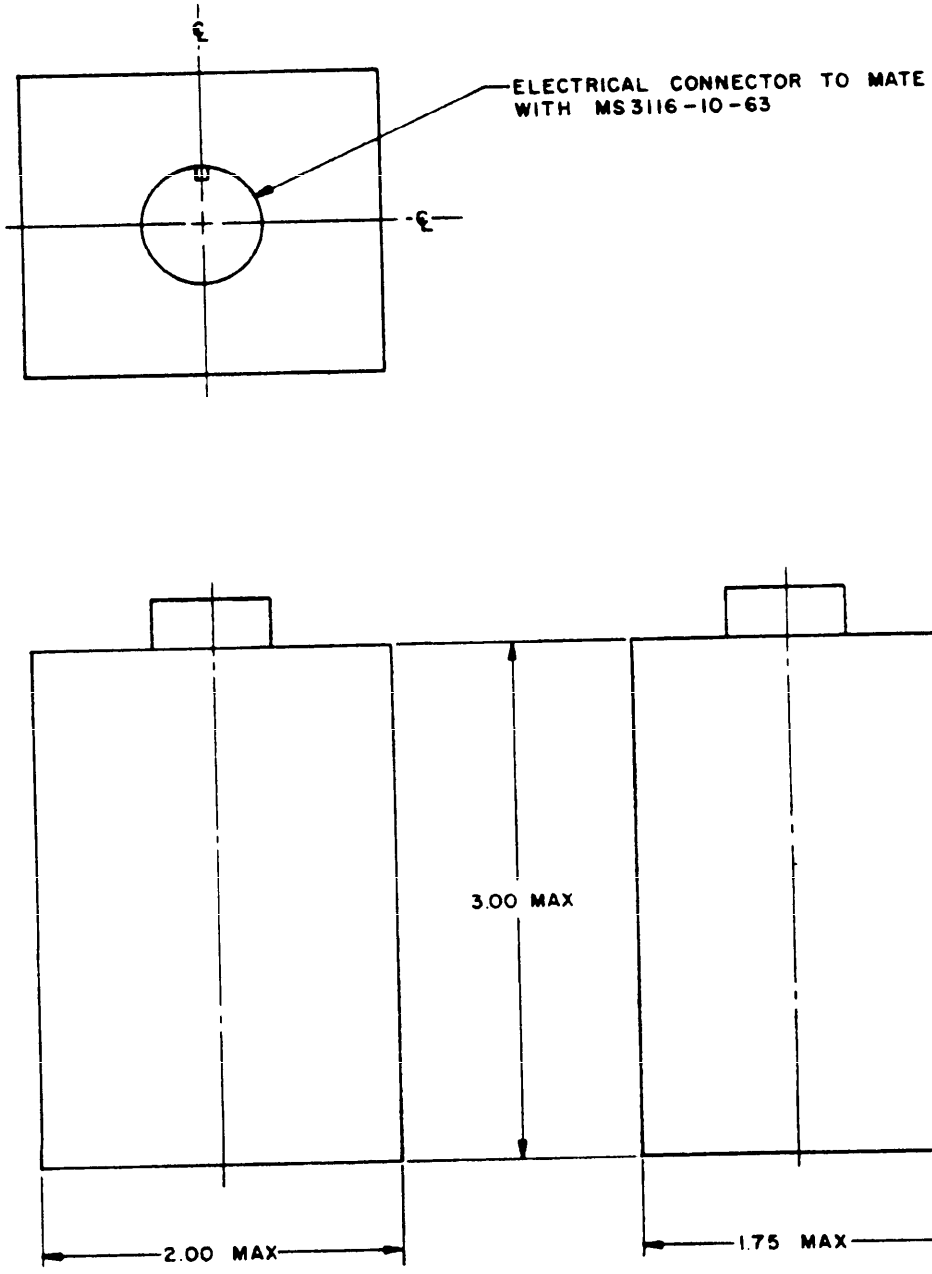


Figure 2.2. Part No. M81258/1-1

AMPLIFIER, SERVOMOTOR

MICROELECTRONIC 2 WATTS

ELECTRICAL CHARACTERISTICS

Voltage gain	200	
Input		
Voltage (max)	60	V rms
Impedance		
Input	5-15	k ohms
Output	30-500	ohms
Output		
Voltage (min)	36 ± 2	V rms
Frequency	dc to 10	kHz
Power (min)	2	watts
Power supply voltage	28	Vdc
Power supply (max-no damage)		Vdc
Phase shift	0- ±15	degrees
Servomotor load option No. 1	500 ohms end to end ac impedance 50 ohms end to end dc resistance	
Servomotor load option No. 2	575 ohms end to end ac impedance 100 ohms end to end dc resistance	

MECHANICAL CHARACTERISTICS

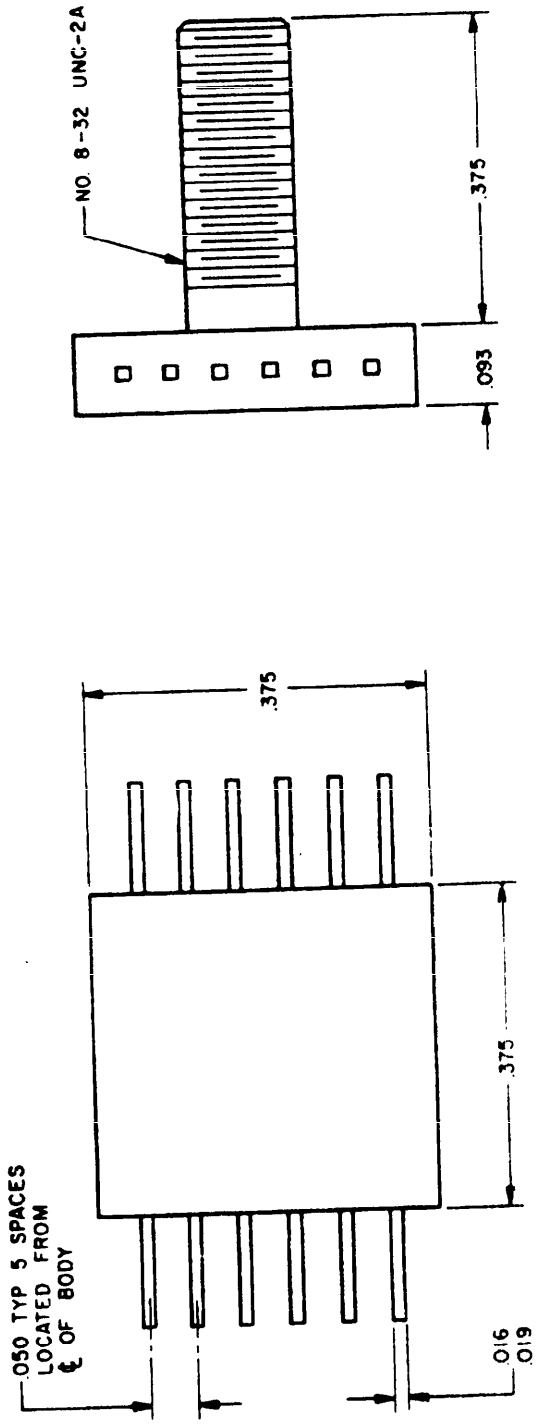
Ambient temperature range	-55 to +100	degrees C
Size	.375 by .375	in
Weight (max)		

REFERENCES

Specification
Installation drawing
Federal Stock Number (FSN)
Qualified Products List (QPL)

NOTES

Developed under contract NOw 61-1053.
Available with voltage gains up to 1000.
Several choices of feedback ratios are offered on external leads to accommodate the characteristics of the motor used.



THIS AMPLIFIER IS HERMETICALLY SEALED IN A FLAT PACKAGE MOUNTED ON A HEAT-SINK STUD.

Figure 2.3. 2 Watts

AMPLIFIER, SERVOMOTOR

3.5 WATTS

ELECTRICAL CHARACTERISTICS

Voltage gain	425	V/V
Input voltage (max)	60	V rms
Impedance		
Input (small signal)	22	k ohms
(large signal)	9	k ohms
Output (max)	150	ohms
Output		
Voltage (min)	36	V rms
Frequency	400	Hz
Power (min)	3.5	watts
Power supply voltage	28	V dc
Power supply (max - no damage)	80	V dc
Phase shift	90	degrees

MECHANICAL CHARACTERISTICS

Operating temperature range (mounting base)	-55 to +105	degrees C
Size	1.14 x 1.23 x 3.15	in.
Volume	3.6	cu in.

External connections

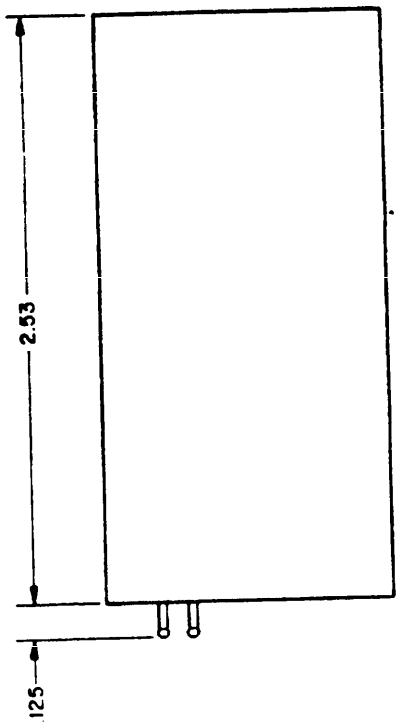
Pin 1 output (90 -)	Pin 5 tach. input
2 output (90 +)	6 signal input
3 power ground	7 +28 V dc
4 signal ground	

Weight	4.5	oz
Construction type	Wire weld-encapsulated	

NOTES

Developed by NAFI

Output terminals may be continuously shorted without incurring amplifier damage.



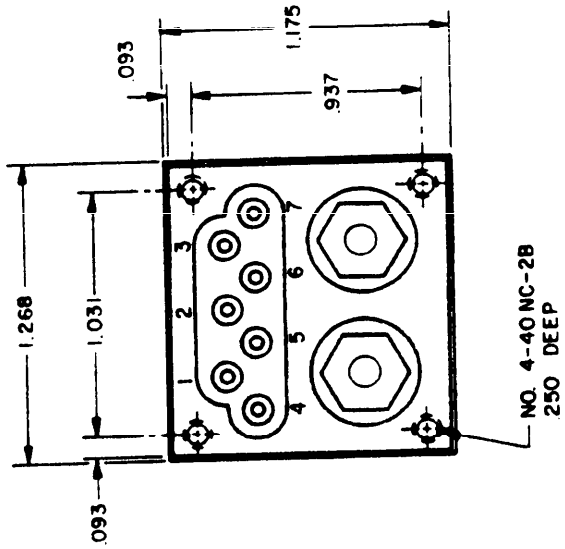


Figure 2.4. 3.5 Watts

AMPLIFIER, SERVOMOTOR

MICROELECTRONIC 6 WATTS

ELECTRICAL CHARACTERISTICS (T_c = 25°C)

Gain, signal input (min)	500	
Impedance		
Signal input	10 ± 2	k ohms
Output (nominal)	20	ohms
Input current		
Quiescent (nominal)	120	mA
At saturation (nominal)	800	mA
Output voltage, at saturation (min)	36	V
Phase shift	±15	degrees
Efficiency, full load (min)	50	percent
Absolute maximum ratings		
Input voltage (differential)	30	V rms
Load current	1	A
Power out (resistive load of 50 ohms)	50	watts
Power input to amplifier	75	watts
V_B+ and V_B-	35	V
Power dissipated in amplifier @ T_c = 100°C	25	watts

MECHANICAL CHARACTERISTICS

Ambient temperature range (using specified heat sink)	-55 to +100	degrees C
Size and configuration		per dwg

External connections

Pin 1 input #1	Pin 6 not used
2 ground #1	7 ground #2
3 output #1	8 input #2
4 V_B+	9 V_B-
5 output #2	

Weight

NOTES

Developed under contract NOw 63-0477.

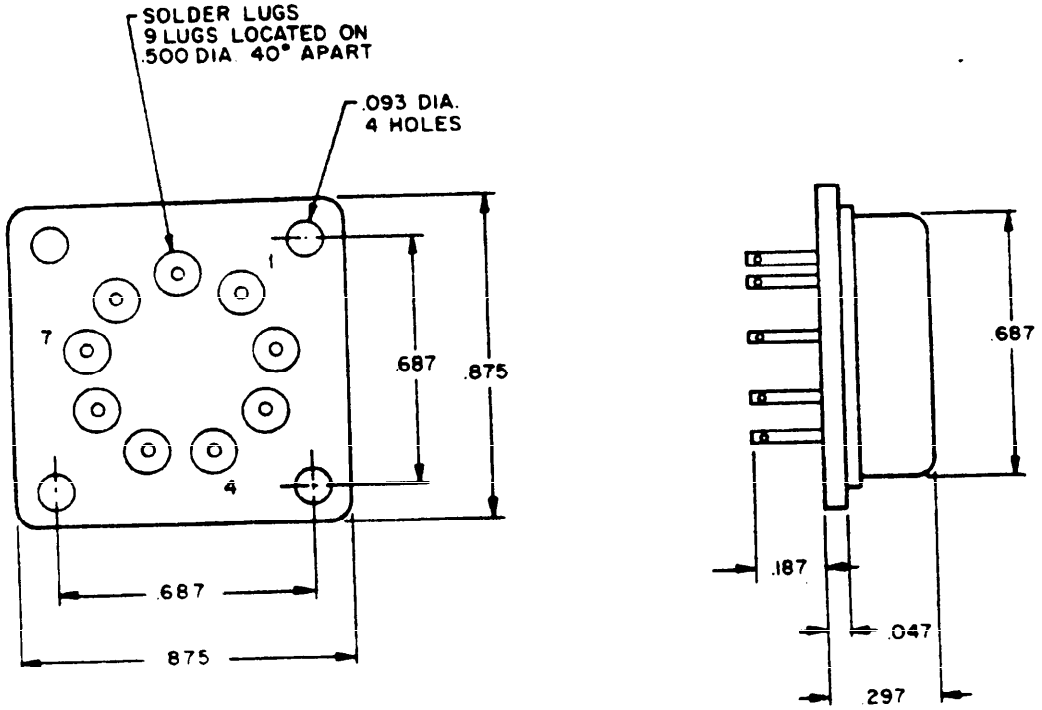


Figure 2.5. 6 Watts

AMPLIFIER, SERVOMOTOR

TYPE 2, CLASS 3, 28 V. D.C., 10 WATTS

M81307/1-1

ELECTRICAL CHARACTERISTICS

Gain		
Signal input	1400	
Tachometer input	35	
Input current (max)		
Quiescent	100	mA
At saturation	715	mA
Shorted output	1000	mA
Impedance		
Signal input	22	k ohms
Tachometer input	29	k ohms
Output (max)	40	ohms
Output voltage		
At saturation	40	V
Noise (max)	0.5	V
Phase shift	90	degrees
Amplifier bandwidth		
Lower limit (max)	300	Hz
Upper limit (min)	500	Hz
Harmonic voltage rejection ratio @1200 Hz	18	db
Full load efficiency (min)	50	percent

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +120	degrees C
Size and configuration		per dwg

External connections

Lug No. 1	compensation input
2	signal input
3	tachometer input
4	tachometer ground
5	signal ground
6	+28 V. d.c.
7	output
8	power ground
9	output
10	spare

Weight (max)	1.0	lb

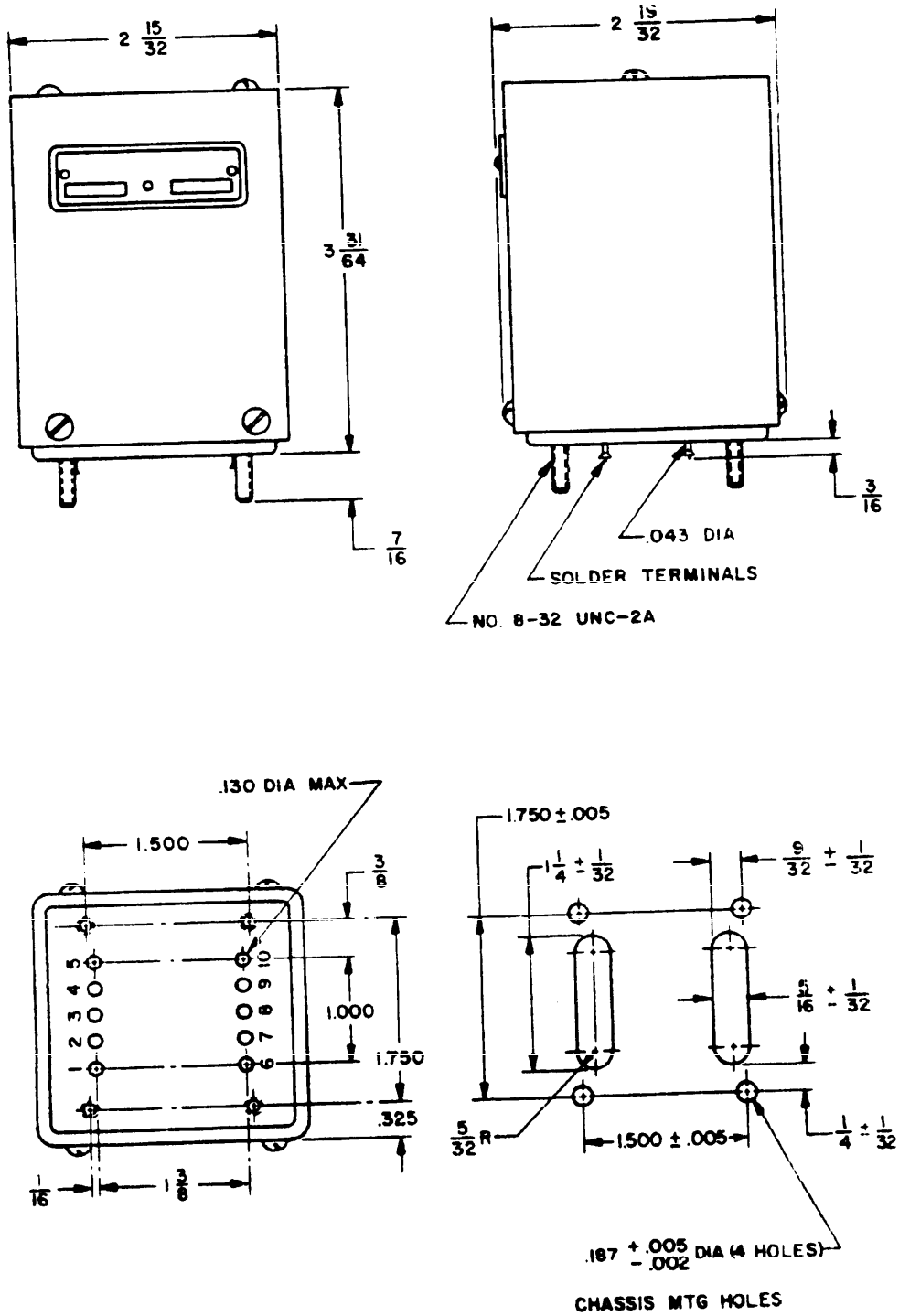


Figure 2.6. Part No. M81307/1-1

M81307/1-1 (Continued)

REFERENCES

Specification.	MIL-A-81307/1(WP)
Installation drawing.	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Developed by NAFI.

AMPLIFIER, SERVOMOTOR, MODULE

TYPE 2, CLASS 3, 28V DC 10 WATTS

ELECTRICAL CHARACTERISTICS

Gain		
Signal input	1	V/V
Input current (max)		
Quiescent	0	mA
At saturation	450	mA
Shorted output	530	mA
Impedance		
Output (max)	100	ohms
Output voltage		
At saturation	36	V
Noise (max)	0.5	V
Phase shift	0	degrees
Full load efficiency (min)	55	percent

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +120	degrees C
Size and configuration		per dwg
External connections		
Lug No. 1	input 1	
2	input 2	
3	output 1	
4	output 2	
5	power ground	
Weight (max)	2.7	oz

NOTES

Developed by NAFI
Must be driven by the 3.5 Watt servomotor amplifier, or equivalent. May be powered from M81338/1-1, 0.7 ampere power supply.

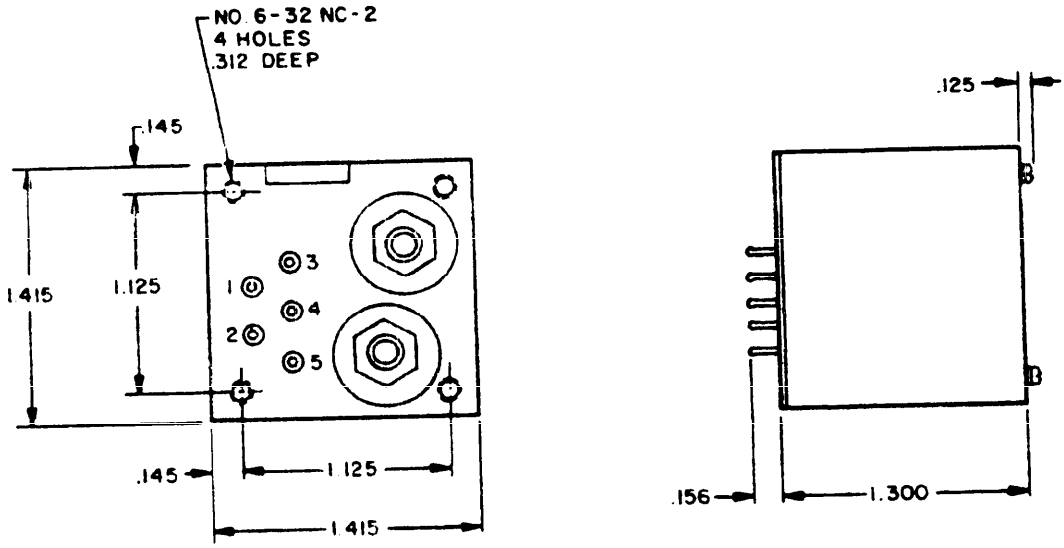


Figure 2.7. 10 Watts

AMPLIFIER, SERVOMOTOR

TYPE 2, CLASS 2, 28 V. D.C., 30 WATTS

M81307/2-1

ELECTRICAL CHARACTERISTICS

Gain		
Signal input	1400	
Tachometer input	35	
Input current (max)		
Quiescent	100	mA
At saturation	715	mA
Shorted output	1000	mA
Impedance		
Signal input	22	k ohms
Tachometer input	29	k ohms
Output (max)	40	ohms
Output voltage		
At saturation	40	V
Noise (max)	0.5	V
Phase shift	90	degrees
Amplifier bandwidth		
Lower limit (max)	300	Hz
Upper limit (min)	500	Hz
Harmonic voltage rejection ratio @ 1200 Hz	18	db
Full load efficiency (min)	50	percent

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +115	degrees C
Size and configuration		per dwg
External connections		
Lug No. 1	output	
2	output	
3	signal input	
4	signal input	
5	+28 V. d.c.	
Weight (max)	5.0	oz

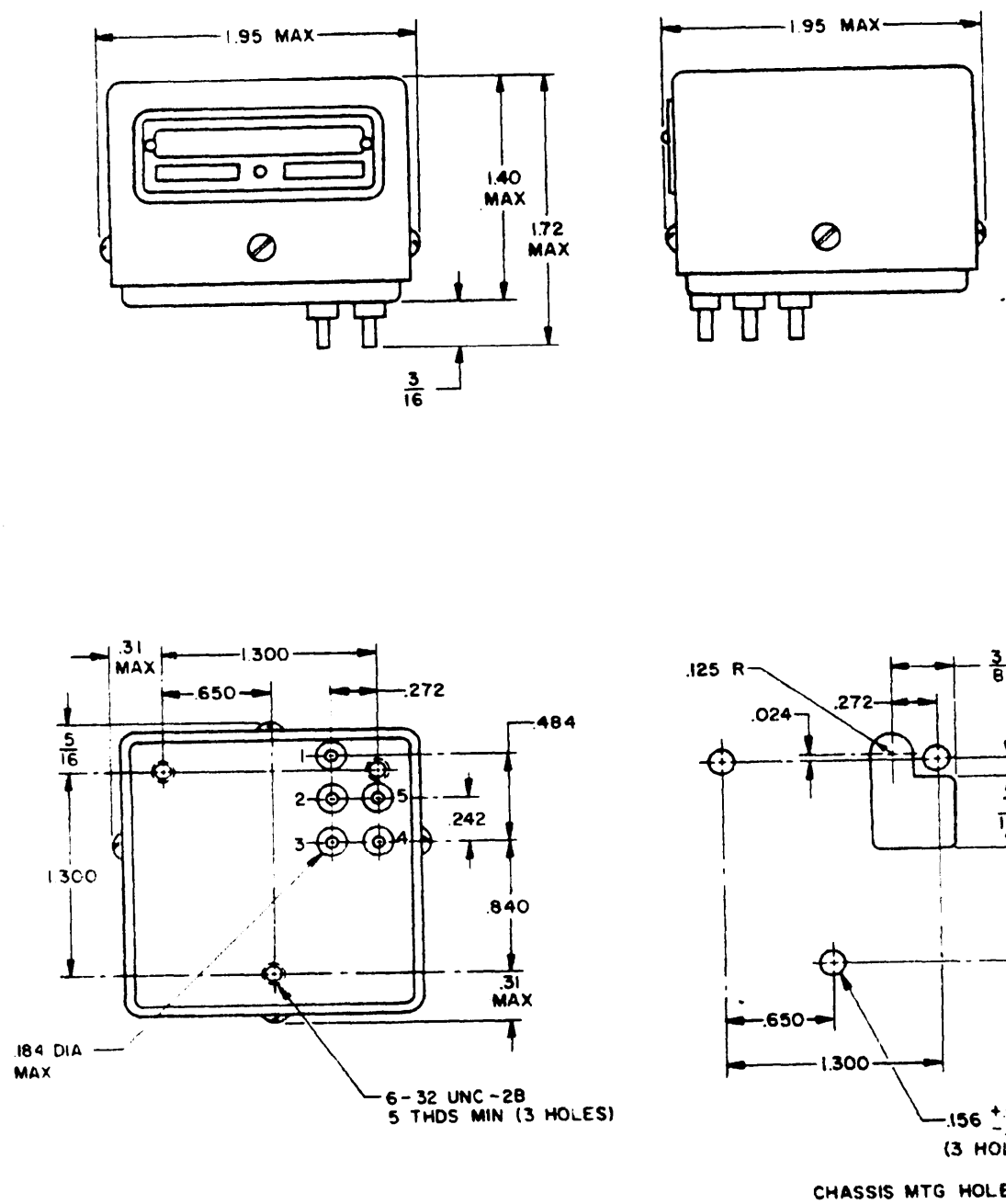


Figure 2.8. Part No. M81307/2-1

M81307/2-1 (Continued)

REFERENCES

Specification	MIL-A-81307/2(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Must operate in conjunction with M81307/1-1, 10 watt servomotor amplifier. May be powered from M81338/2-1, 2.0 ampere power supply.

Developed by NAFI.

AMPLIFIER, PARAPHASE, THIN FILM

ELECTRICAL CHARACTERISTICS

Input		
Frequency	10 to 100	kHz
Amplitude	2 ± .2	V rms
Output		
Rise time (t_r) (max) (with 2 ±.2 Vrms sine wave)	3	μsec
Fall time (t_f) (max) (with 2 ±.2 V rms sine wave)	1.5	μsec
(t_r and t_f are specified from 10% to 90% levels)		
Pulse width (with 2V sine wave, 20 kHz @ 25°C @ 50% level)	25 ±1	μsec

The rms max voltage of the algebraic sum of the outputs is 1 V rms @ 125°C @ 10 kHz.
Typically, it is .15 V rms @ 25°C @ 20 kHz.

Output Vce (sat), at -55°C	.5	V
Supply voltage	6	V

MECHANICAL CHARACTERISTICS

Operating temperature range	-55 to +125	degrees C
Size and configuration		per dwg

External connections

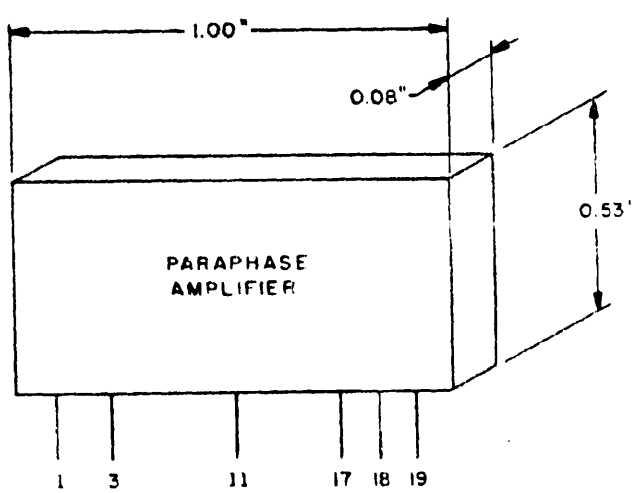
Pin 1 input
3 external capacitor if required (see note)
11 ground
17 output #1
18 output #2
19 B+

Pins 2, 4 thru 10, and 12 thru 16 not used

Weight

NOTES

For use at frequencies lower than 10 kHz an external .01 μfd capacitor can be connected across pins 1 and 3.



PIN IDENTIFICATION

Figure 2.9. Paraphase Amplifier

AMPLIFIER, 60 MHz IF

MULTI-STAGE MICROCIRCUIT

ELECTRICAL CHARACTERISTICS

Gain variation (max)	3db (40 to 80 MHz)	
Gain (nominal) Vcc = 4.6V @ I_t =20 mA	60	db
Impedance		
Input	50	ohms
Output	50	ohms
Power dissipation (nominal)	200	m watts
Power supply voltage	40 to 10	V
Power supply current	20 to 50	mA

MECHANICAL CHARACTERISTICS

Size and configuration . . . . . Flat package 1/4 x 1/8 in

External connections

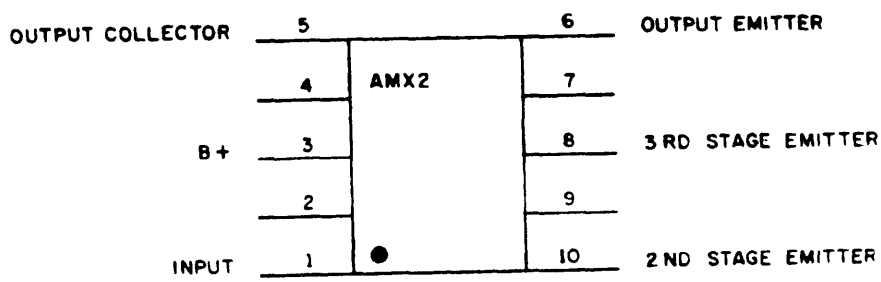
Lead	1	input
	2	no connection
*	3	B+
	4	no connection
*	5	output collector (ac ground)
	6	output emitter
	7	no connection
	8	3rd stage emitter
	9	no connection
	10	2nd stage emitter

Package bottom is ground terminal

NOTES

Developed under contract NO$_w$-65-0483-f.

* .002 μf capacitor to ground



IDENTIFICATION OF PACKAGE LEADS

Figure 2.10. 60 MHz IF Amplifier

CHAPTER 3

CONVERTERS, STATIC, SOLID-STATE

The converters described in this chapter are of the analog to digital and digital to analog type using integrated circuits to the maximum extent possible consistent with the state-of-the-art.

CONVERTER, DIGITAL – SYNCHRO

ELECTRICAL CHARACTERISTICS

Input		
Number of channels	1	
Digital data	11 bit parallel binary	
Digital address	4 bit parallel binary	
Analog reference	26V or 115V ac, 400 Hz	
Analog reference loading (min)	20,000	ohms
Conversion time (max)	30	μsec
Updating rate	data indefinitely stored	
Output		
Number of channels	up to 16, modular in groups of 2	
Output level (nom)	11.8 or 90	V
Output loading for 11.8V synchros (min)	100 ohms line-line	
for 90V synchros (min)	4000 ohms line-line	
Power 115V line-neutral	3Ø, 400 Hz	
Power drain	90	watts
Resolution	11	bits
Accuracy	±1	LSB

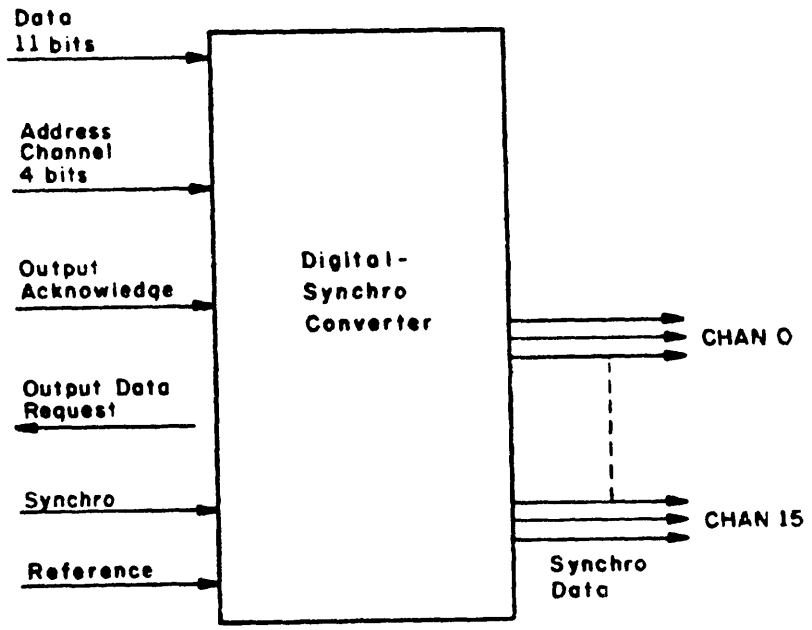
MECHANICAL CHARACTERISTICS

Ambient operating temperature (from 0 to 30,000 ft)	-55 to +71	degrees C
Weight	86	lbs
MTBF	10,000	hours

NOTES

This equipment interfaces with the NTDS family of computers and can be made to interface with similar equipment with different logic levels by substituting the appropriate interface card.
This equipment contains a Go/No-Go self test.

Developed under contract N600(19)62471.
Final report available from DDC, AD No. 800 381.



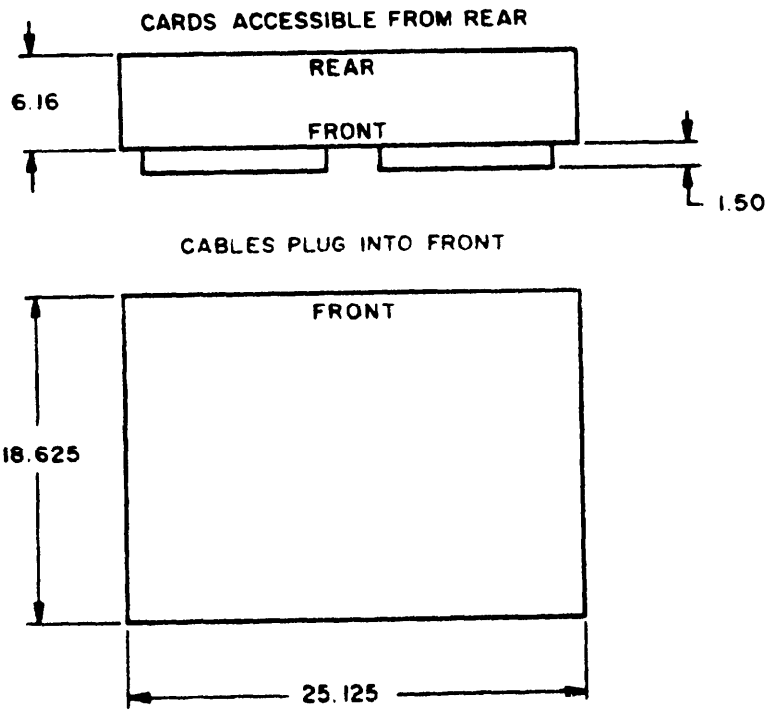


Figure 3.1. Digital – Synchro Converter

CONVERTER, SYNCHRO – DIGITAL

ELECTRICAL CHARACTERISTICS

Input		
Number of channels	Up to 32, modular in groups of 2	
Digital address	5 bit parallel binary	
Analog reference	26V or 115V ac, 400 Hz	
Analog reference loading (min)	20,000	ohms
Conversion time (max)	100	μsec
Synchro data	11.8V or 90V line-line, 3 wire	
Source loading	Synchro loading not heavier than equivalent 5000 ohm line-line load with ±2% unbalance	
Slewing rate-will track synchros rotating at up to 20 rpm with no degradation of accuracy.		
Output		
Number of channels	1	
Data	11 bit parallel binary	
Power	115V line-neutral, 3Ø, 400 Hz	
Power drain	30	watts
Resolution	11	bits
Accuracy	±1	LSB

MECHANICAL CHARACTERISTICS

Ambient operating temperature (from 0 to 30,000 ft)	−55 to +71	degrees C
Weight	105	lbs
MTBF	10,000	hours

NOTES

This equipment interfaces with the NTDS family of computers and can be made to interface with similar equipment with different logic levels by substituting the appropriate interface card.
This equipment contains a Go/No-Go self test.

Developed under contract N600(19)62471.
Final report available from DDC, AD No. 800 381.

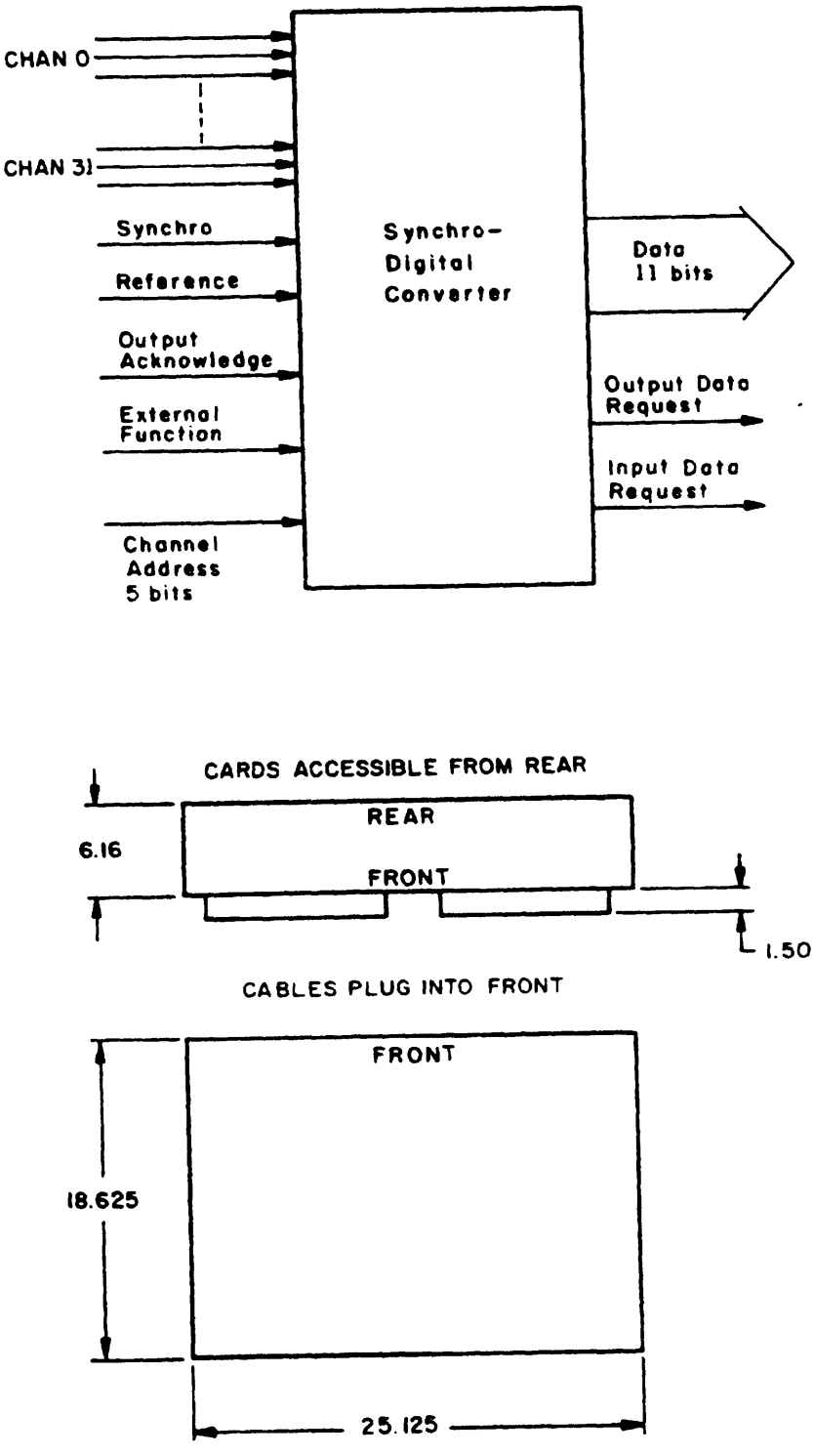


Figure 3.2. Synchro – Digital Converter

CONVERTER, DIGITAL-ANALOG

ELECTRICAL CHARACTERISTICS

Input		
Number of channels	1	
Digital input word		
For synchro conversion	13 bits, parallel, binary	
For AC conversion	12 bits, parallel, binary	
For DC conversion	12 bits, parallel, binary	
Address	4 bits, parallel, binary	
External reference		
Synchro and AC, 400 Hz	26	Vrms
DC	+10	V
Conversion time (max)	30	μsec
Updating rate	DC to 33 KC; digital storage of each channel	
Output		
Number of channels	up to 16, any type	
Synchro inputs	3 wire, type CX transmitter equiv., will drive up to 100 ohms, line-to-line, equiv. to std. 11.8V, 400 Hz, 3 wire synchro control transformer	
AC, 400 Hz (will drive a 5 K ohm resistive load)	26	V
DC (will drive up to a 10 K ohm resistive load)	±10	V
Power	115V line-neutral	3 φ, 400 Hz
Power drain	40	watts
Resolution		
Synchro	13 bits	
AC	11 bits plus sign	
DC	11 bits plus sign	
Accuracy (synchro, AC and DC)	±2	LSB
Controls	INPUT ACKNOWLEDGE and EXTERNAL FUNCTION per A-New 1830 Avionic Computer	

MECHANICAL CHARACTERISTICS

Environmental requirements	Designed to meet MIL-E-5400, Class 2	
Weight	26	lbs
Volume	1350	cu in.
Dimensions (including handles)	17-1/4 x 10-1/4 x 7-5/8	in.

NOTES

This equipment interfaces with the A-New 1830 Avionics Computer and can be made to interface with other digital computers by substituting an appropriate interface module.

Each channel is capable of handling any analog signal via the insertion of proper input/output modules.

This equipment contains a Go/No-Go self test.

Developed under contract N600(19)64558.

Final report available from DDC, AD No. 831 813.

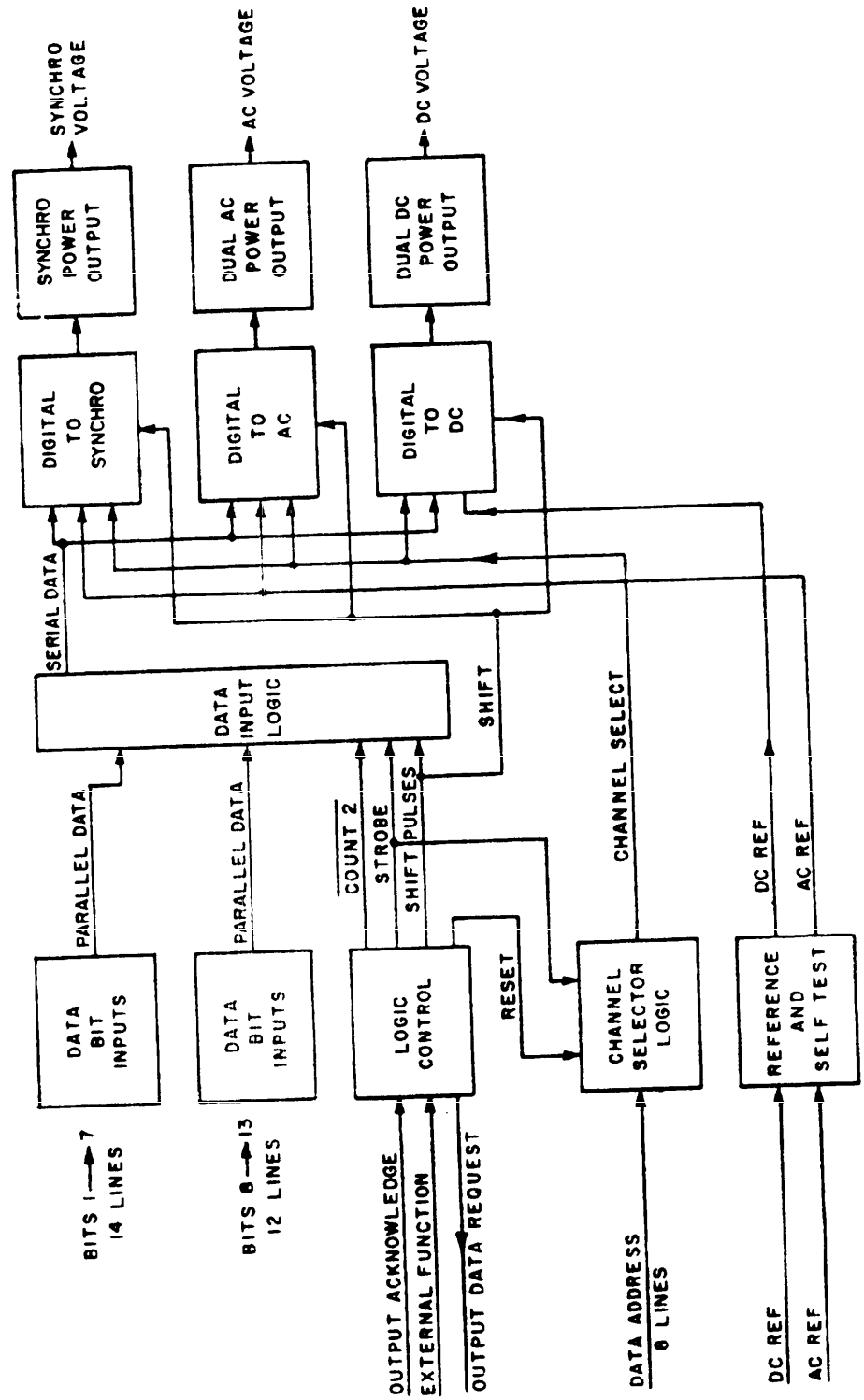


Figure 3.3. Digital - Analog Converter

CONVERTER, ANALOG-DIGITAL

ELECTRICAL CHARACTERISTICS

Input		
Number of channels	up to 16, any type	
Synchro	3 wire, type CX transmitters, 400 Hz, 11.8 Vrms	
AC	2 wire, 400 Hz, 26 V, in phase with synchro ref.	
DC	1 wire, potentiometer type transducer. Single range of 10V. Ratio of input impedance to signal is infinite.	
Address	4 bits, parallel, binary	
Controls	OUTPUT ACKNOWLEDGE, EXTERNAL FUNCTION, INPUT ACKNOWLEDGE per A-New 1830 Avionics Computer	
External reference		
Synchro and AC, 400 Hz	26	Vrms
DC	+10	V
Conversion time (max)	100	μsec
Staleness	None	
Output		
Number of channels	1	
Digital output data word		
For synchro conversion	13 bits, parallel, binary	
For AC conversion	12 bits, parallel, binary	
For DC conversion	12 bits, parallel, binary	
Control words	OUTPUT DATA REQUEST and INPUT DATA REQUEST per A-New 1830 Avionics Computer	
Power	115 V line-neutral, 3φ, 400 Hz	
Power drain	40	watts
Resolution		
Synchro	13 bits	
AC	11 bits plus sign	
DC	11 bits plus sign	
Accuracy (synchro, AC and DC)	±2	LSB

MECHANICAL CHARACTERISTICS

Environmental requirements	Designed to meet MIL-E-5400, Class 2	
Weight	22	lbs
Volume	1350	cu in.
Dimensions (including handles)	17-1/4 x 10-1/4 x 7-5/8	in.

NOTES

This equipment interfaces with the A-New 1830 Avionics computer and can be made to interface with other digital computers by substituting an appropriate interface module.

A "rate correction" circuit corrects for "staleness" in synchro information signals.

Each channel is capable of handling any analog signal via the insertion of proper input/output modules.

This equipment contains a Go/No-Go self test.

Developed under contract N600(19)64558.

Final report available from DDC, AD No. 831 813.

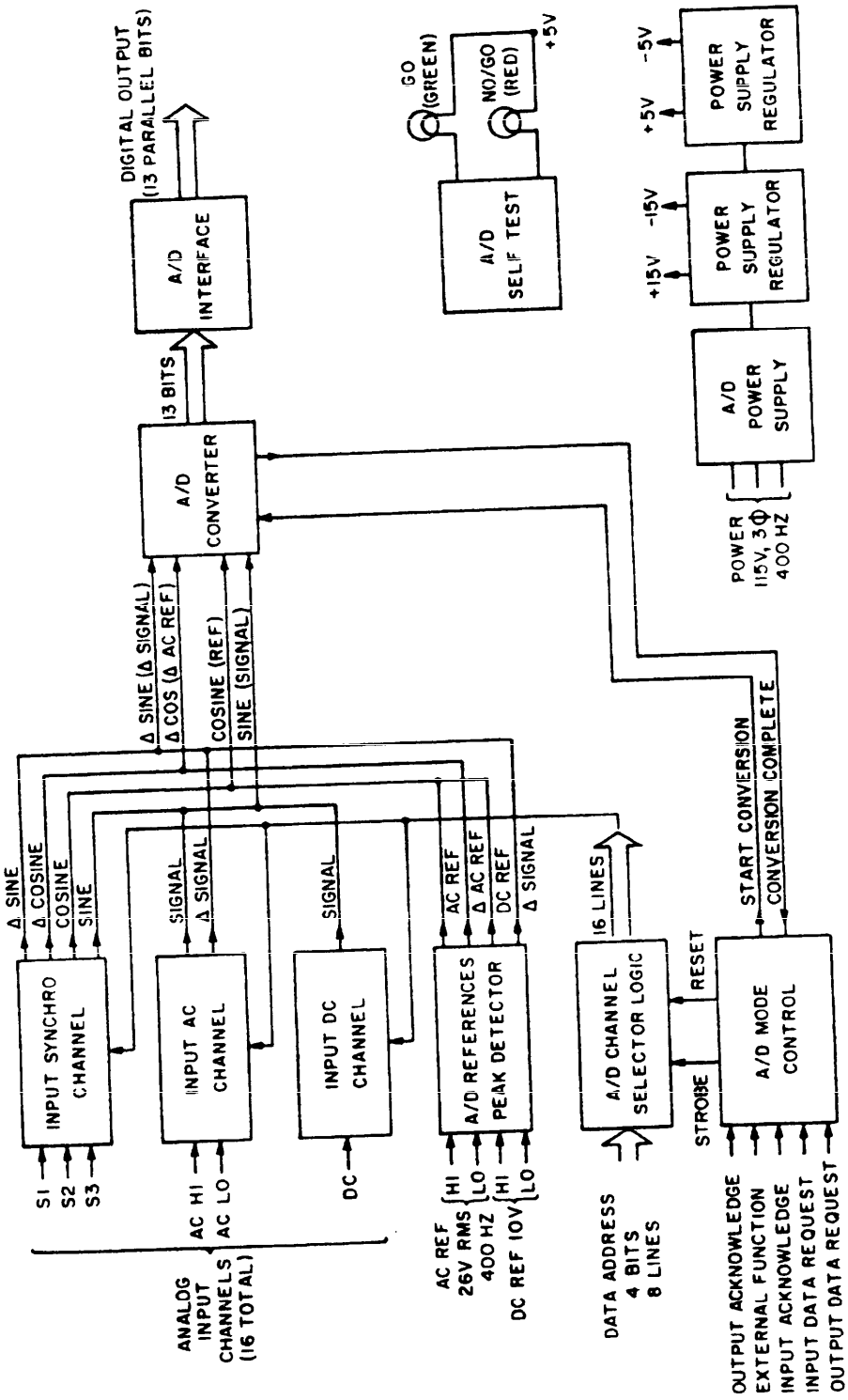


Figure 3.4. Analog-Digital Converter

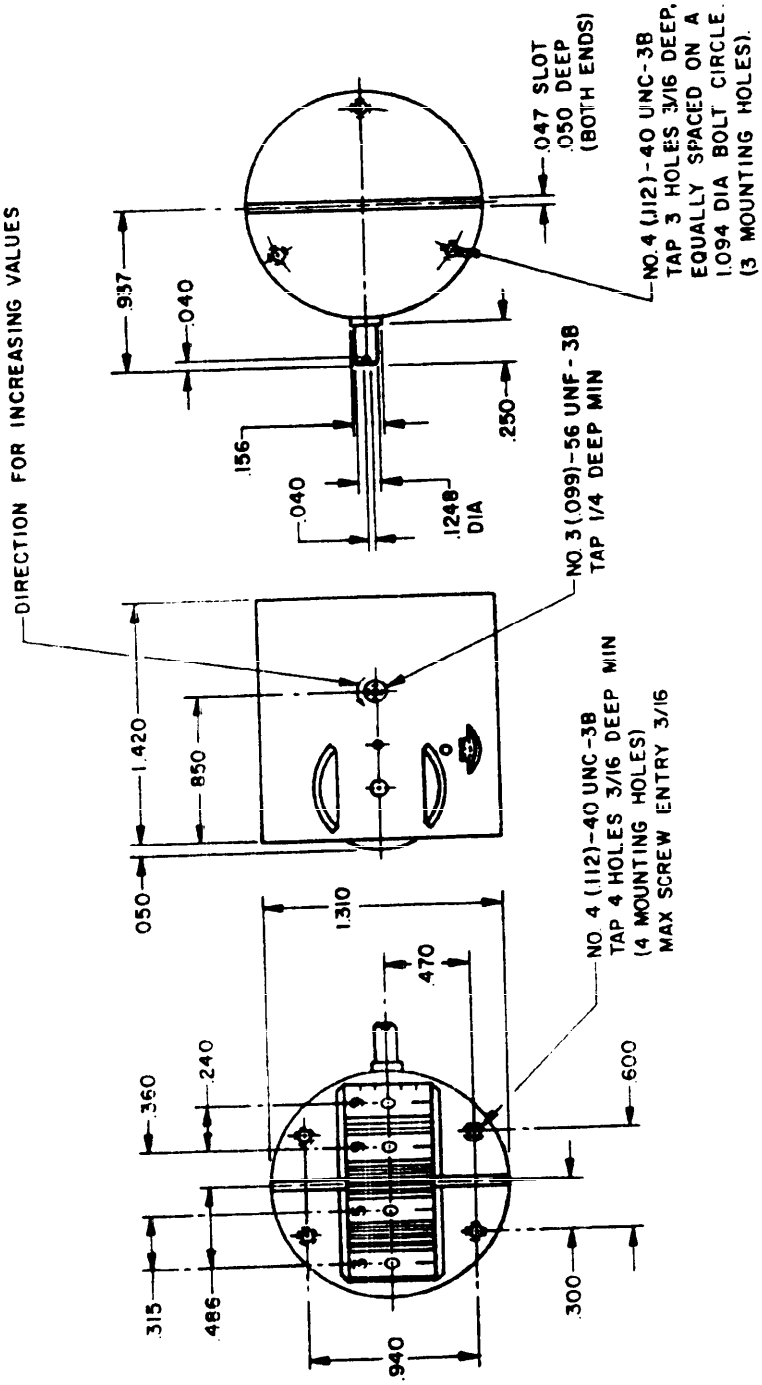


Figure 4.1. MK 2 MOD 0

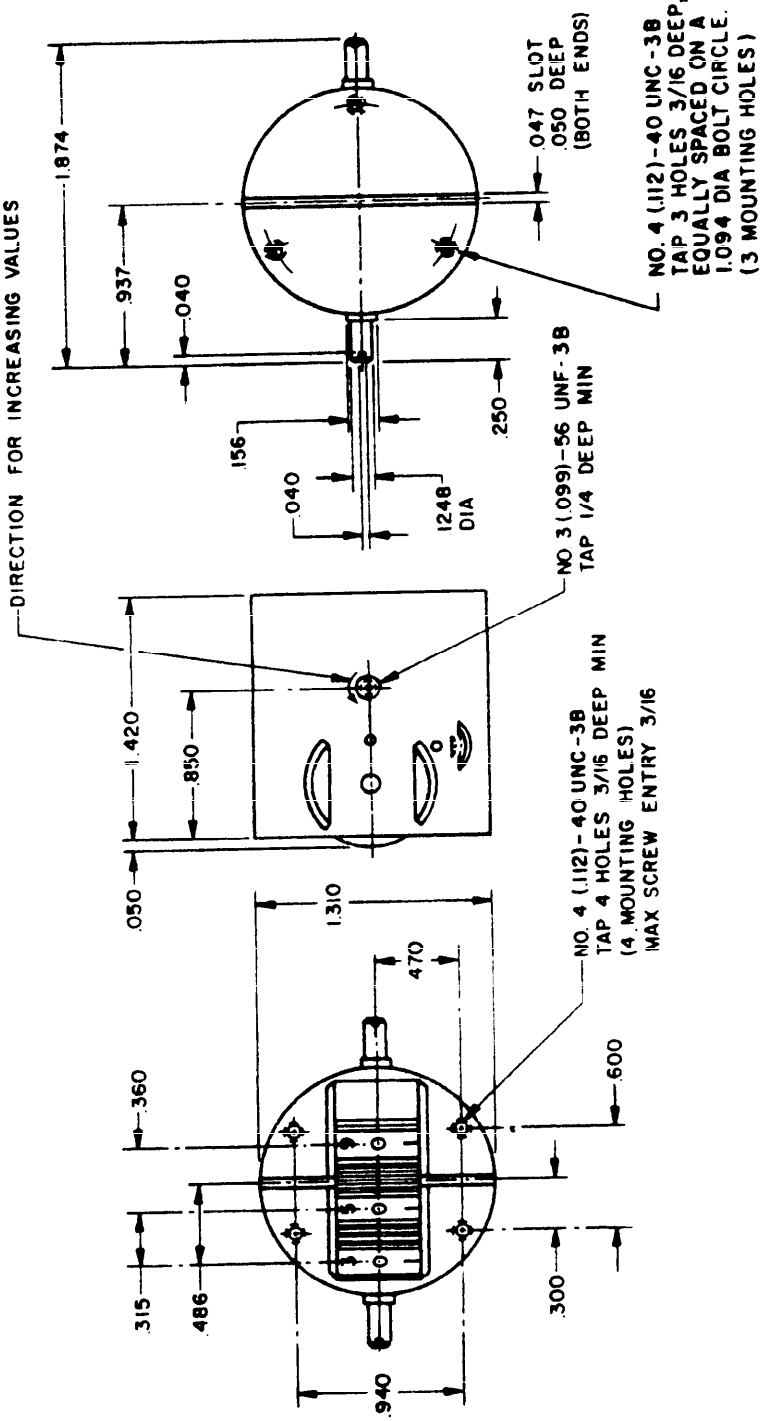
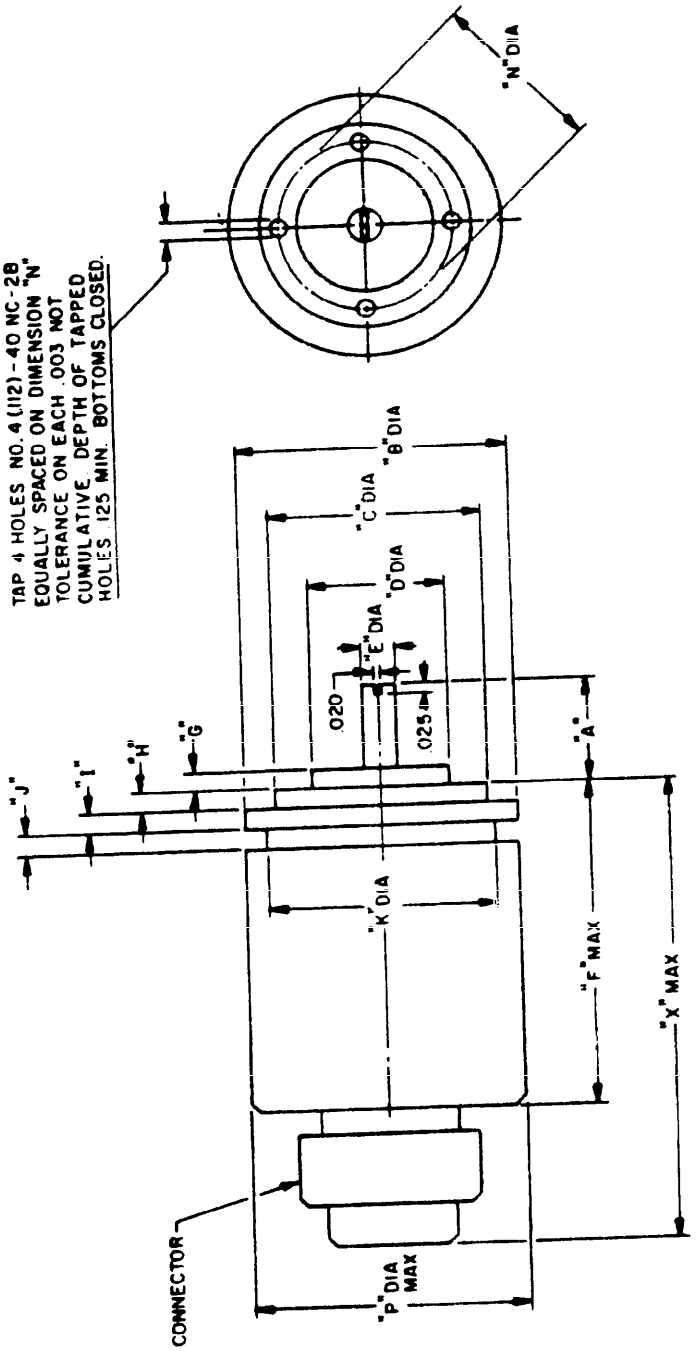


Figure 4.2. MK 3 MOD 0

CHAPTER 5

ENCODERS, SHAFT ANGLE TO DIGITAL

The encoders described in this chapter are of the brush type (MIL-E-81050) and brushless type (MIL-E-81321). A compilation of both types of encoders has been published and is available from DDC, AD No. 486 041. Development and evaluation of encoders which will ultimately be listed as preferred items is underway. Microelectronic circuits are used in these encoders to the maximum extent possible consistent with the state-of-the-art.



SIZE	A ±.010	B $^{.000}_{-.005}$	C $^{.0000}_{+.0005}$	D $^{.0000}_{+.0005}$	E $^{.0000}_{+.0005}$	F MAX	G ±.005	H ±.005	I ±.005	J ±.005	K $^{.000}_{-.005}$	N ±.003	P MAX	X MAX
11	.500	1.062	1.0000	.6250	.1247		.062	.062	.093	.062	.975	.812	1.062	
15	.540	1.437	1.3120	.8750	.1872		.040	.132	.093	.078	1.312	1.100	1.437	
18	.540	1.750	1.5620	.9375	.1872		.040	.132	.093	.078	1.625	1.250	1.750	
23	.625	2.250	2.0000	.9375	.2495		.062	.200	.125	.100	2.062	1.500	2.250	

Figure 5.1. Proposed Encoder Frame Sizes

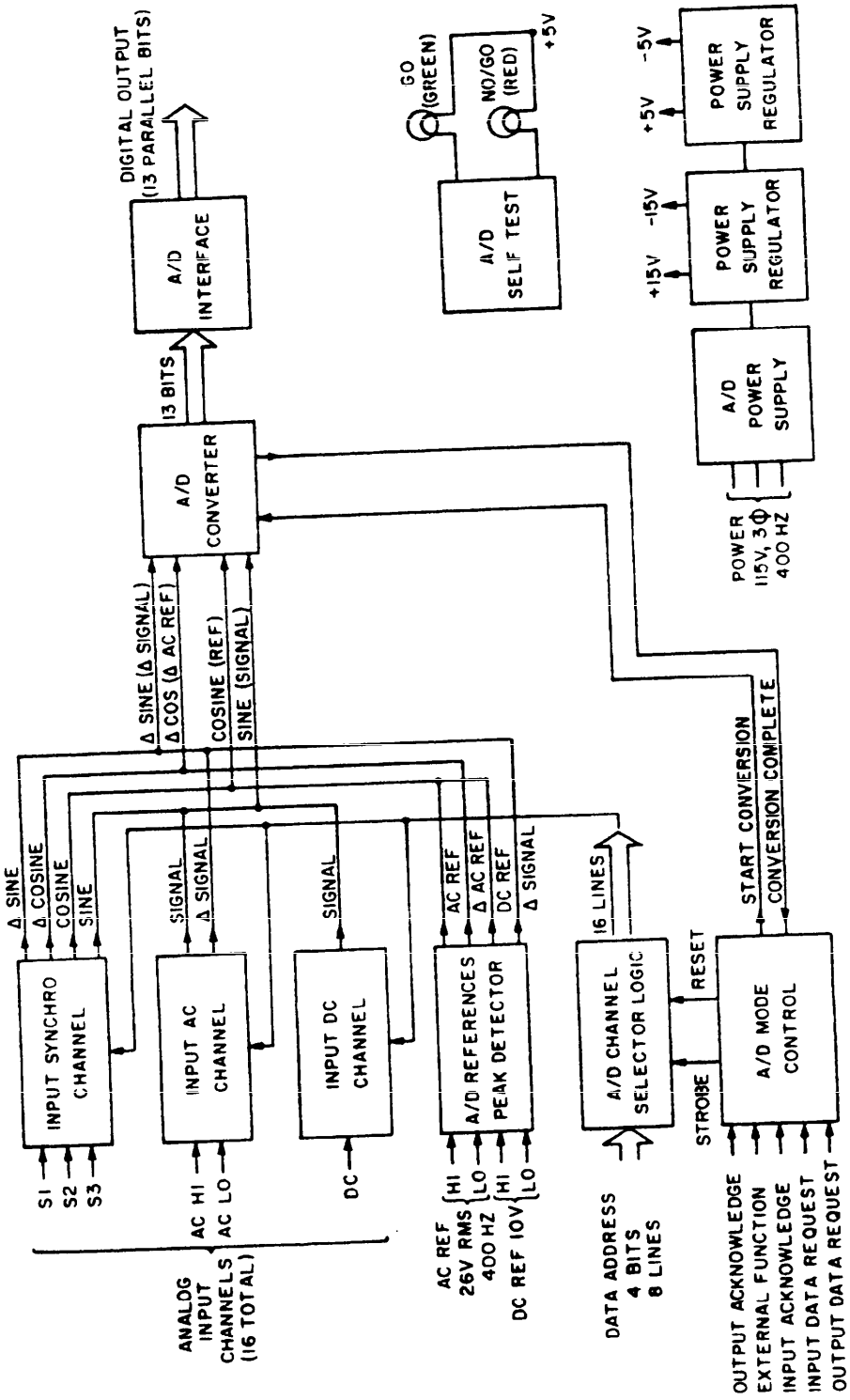


Figure 3.4. Analog-Digital Converter

CHAPTER 4

COUNTERS

The counters described in this chapter have been designed for specific purposes for which known commercial counters are not suitable.

COUNTER

MK 2 MOD 0

CHARACTERISTICS

Range of indication	0-360	degrees
Shaft speed ratio: 1 turn of shaft CCW	1	degree
Maximum allowable input shaft speed	1800	rpm
Finish of dial background		dull black
Finish of numerals		engraved aluminum
Finish of counter face		dull black
Weight	4.4	oz

REFERENCES

Installation drawing	WP Dwg	675005
General arrangement drawing	WP Dwg	675020

NOTES

The purpose of this instrument is to receive a mechanical shaft rotation and to indicate the total angle rotated in degrees and tenths of degrees from 0 to 359.9 degrees and return to zero.

One revolution of input shaft equals one revolution of decimal drum.

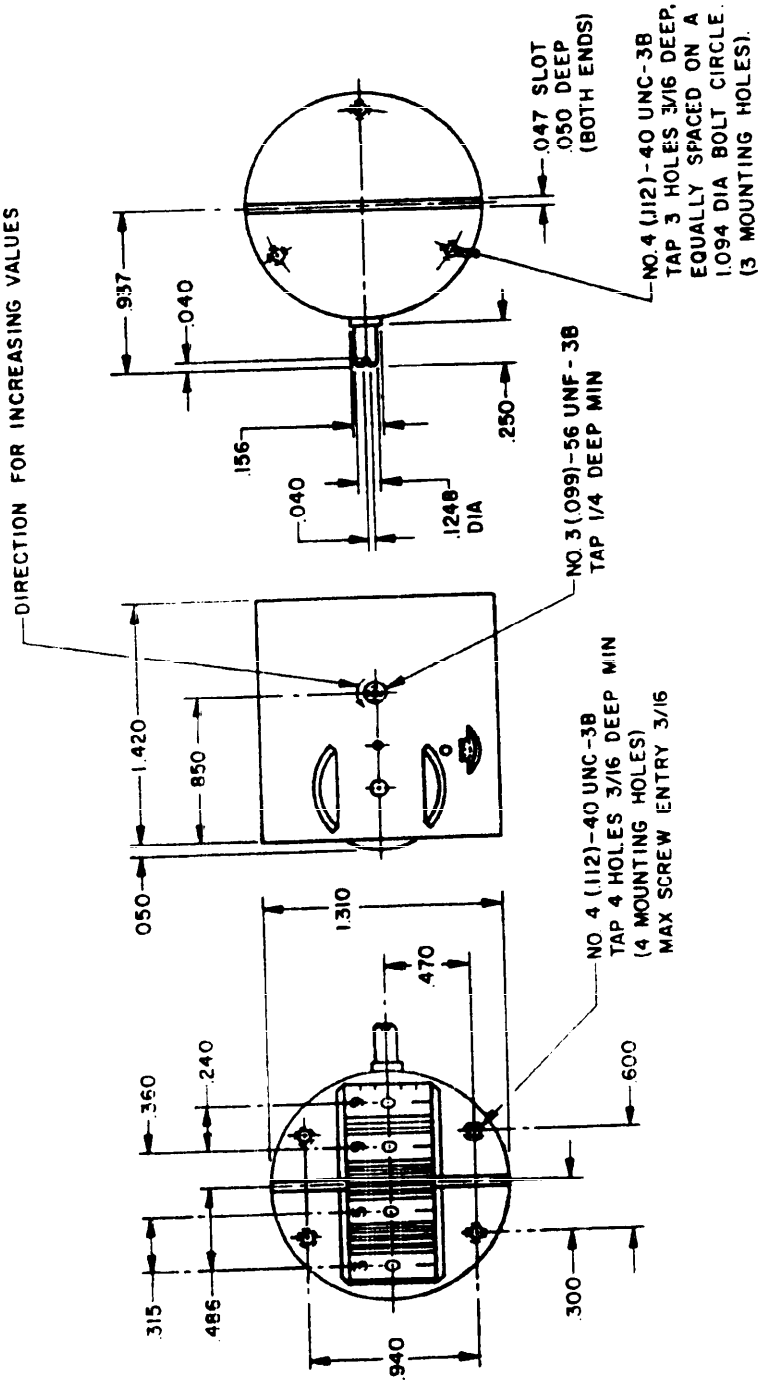


Figure 4.1. MK 2 MOD 0

COUNTER

MK 3 MOD 0

CHARACTERISTICS

Range of indication	0-360	degrees
Shaft speed ratio: 1 turn of shaft CCW	10	degrees
Maximum allowable input shaft speed	1800	rpm
Finish of dial background		dull black
Finish of numerals		engraved aluminum
Finish of counter face		dull black
Weight	4.2	oz

REFERENCES

Installation drawing	WP Dwg	675022
General arrangement drawing	WP Dwg	675030

NOTES

The purpose of this instrument is to receive a mechanical shaft rotation and to indicate the total angle rotated in degrees from 0 to 359 degrees and return to zero.

One revolution of input shaft equals one revolution of unit drum.

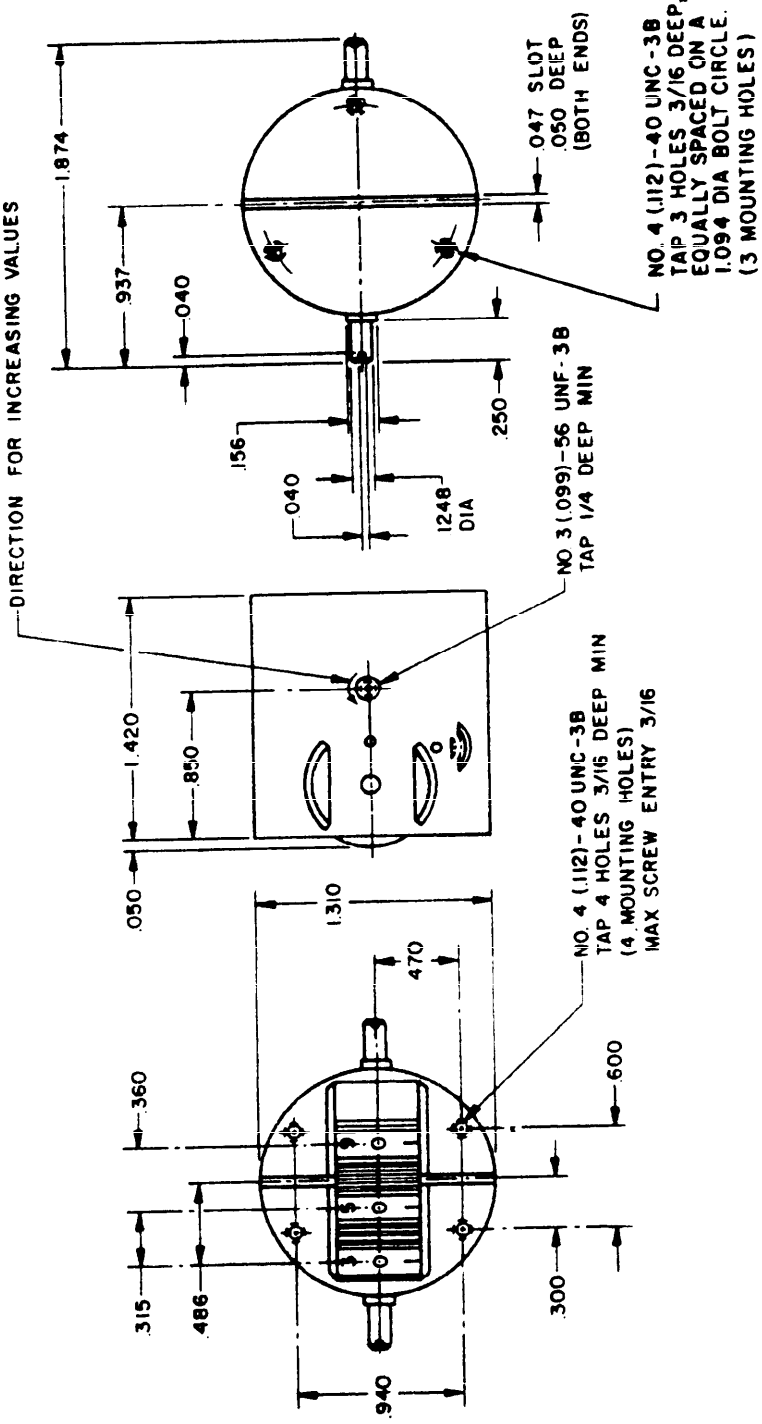
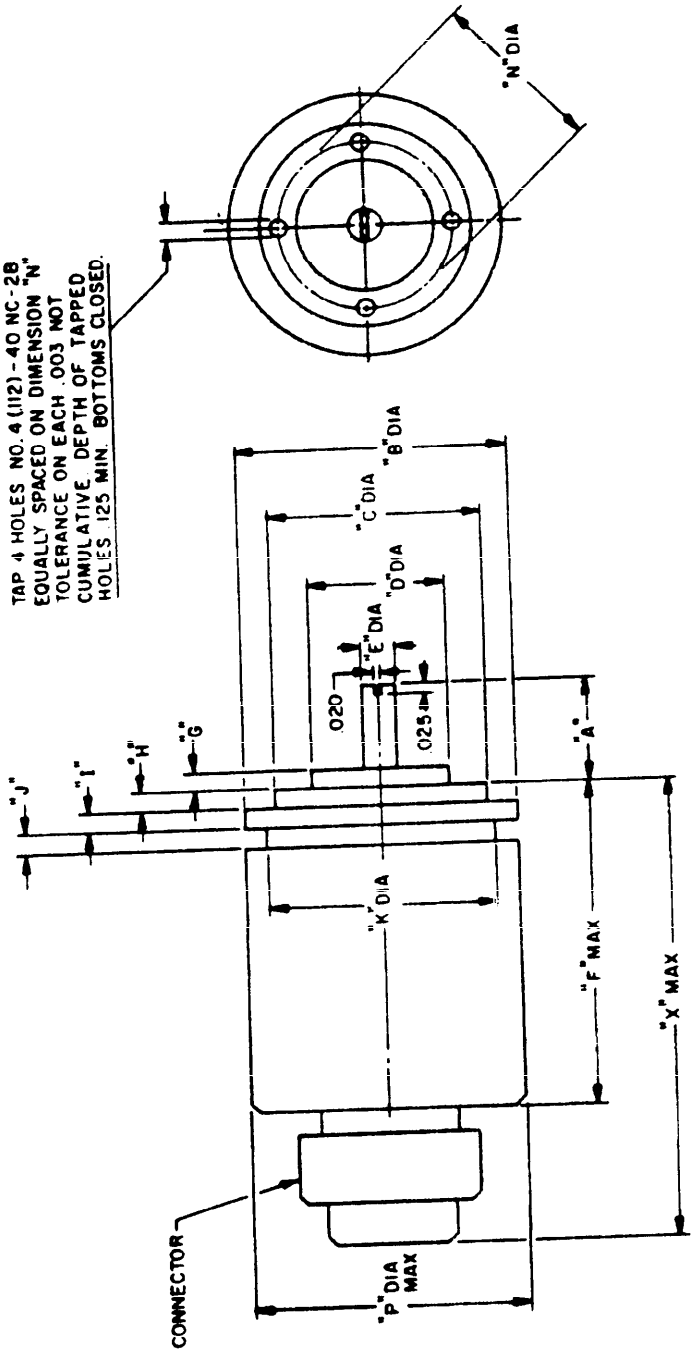


Figure 4.2. MK 3 MOD 0

CHAPTER 5

ENCODERS, SHAFT ANGLE TO DIGITAL

The encoders described in this chapter are of the brush type (MIL-E-81050) and brushless type (MIL-E-81321). A compilation of both types of encoders has been published and is available from DDC, AD No. 486 041. Development and evaluation of encoders which will ultimately be listed as preferred items is underway. Microelectronic circuits are used in these encoders to the maximum extent possible consistent with the state-of-the-art.



SIZE	A ±.010	B $^{.000}_{-.005}$	C $^{+.0000}_{-.0005}$	D $^{+.0000}_{-.0005}$	E $^{+.0000}_{-.0005}$	F MAX	G ±.005	H ±.005	I ±.005	J ±.005	K $^{.000}_{-.005}$	N ±.003	P MAX	X MAX
11	.500	1.062	1.0000	.6250	.1247		.062	.062	.093	.062	.975	.812	1.062	
15	.540	1.437	1.3120	.8750	.1872		.040	.132	.093	.078	1.312	1.100	1.437	
18	.540	1.750	1.5620	.9375	.1872		.040	.132	.093	.078	1.625	1.250	1.750	
23	.625	2.250	2.0000	.9375	.2495		.062	.200	.125	.100	2.062	1.500	2.250	

Figure 5.1. Proposed Encoder Frame Sizes

ENCODER, OPTICAL

SIZE 11 – 2^{13} SINGLE TURN

ELECTRICAL CHARACTERISTICS

Interrogation input impedance	500	ohms
Interrogation waveform		
Rise time (max) 10% to 90% level	.5	μsec
Pulse duration	25 μsec (max)	2 μsec (min)
Interrogating level	-.5 ± .5	V
Noninterrogating level	-4.5 ± .5	V
Power supply voltage	-5	V
Power supply current	350	mA
Logical "one" output level	-1.1 Vdc or more positive	
Logical "zero" output level	-4.0 Vdc or more negative	
Interrogation (max)	20,000	Hz
Conversion time	32	μsec

MECHANICAL CHARACTERISTICS

Weight	4.5	oz
Code	Natural Binary-parallel	
Total count	$2^{13} = 8,192$	in one turn
Function	Angular position	
Resolution	2^{13}	in one turn
Starting torque (max)	.1	oz in.
Running torque (max)	.03	oz in.
Running speed (max)	20	rpm
Slew speed (max)	2000	rpm
Ambient temperature range (sea level)	-55 to +80	degrees C
Ambient temperature range (50,000 ft)	-55 to +55	degrees C
MTBF	10,000	hours
Termination	13 Wires	
Accuracy	±1	quantum

NOTES

Developed under contract N600(19)62042.

Can also be supplied with B- ground and all voltages given above five volts more positive.

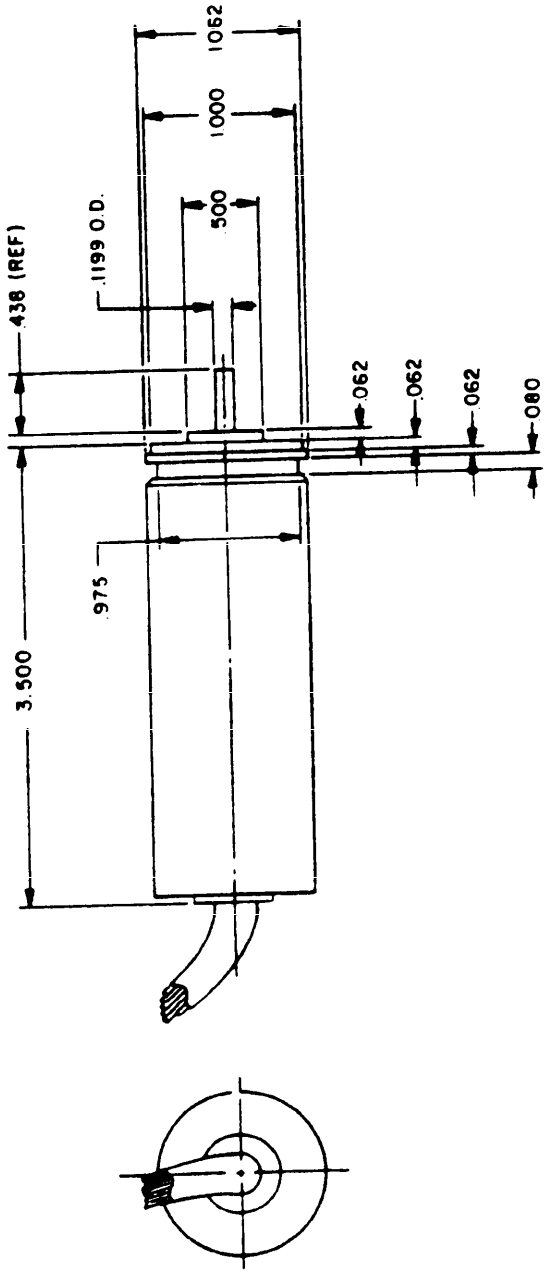


Figure 5.2. Optical Encoder Size 11 – 2^{13} Single Turn

ENCODER, OPTICAL

SIZE 18 – 2^{15} MULTITURN

ELECTRICAL CHARACTERISTICS

Interrogation levels		
Before interrogate	20 μ sec pulse, negative level	
During interrogate	ground ± 1.5 V	
After interrogate	negative level	
Rise and fall time (max)	3	μ sec
Output voltage levels (per Naval Tactical Data System Technical Note 233A with output load conditions of not less than 3,300 ohms to −13.5 V and 200,000 ohms to ground)		
Binary zero	open circuit > 300K	
Binary one	−1.5 to +1.5	V
Output current, per bit	4	mA
Power required	−19.5 to −20.5 V at less than 17.5 mA	
Conversion time (max)	15	μ sec

MECHANICAL CHARACTERISTICS

Weight	8	oz
Code	Natural Binary-parallel	
Total count	2^{15} = 32,768 for 64 turns	
Function	Angular position	
Resolution	2^9 in one turn	
Starting torque (max)	.5	oz in.
Running torque (max)	.05	oz in.
Running speed (continuous)	0 to 1280	rpm
Slew speed (max)	2000	rpm
Ambient temperature range (sea level)	−55 to + 85	degrees C
Moment of inertia	.07	oz in.^{2}
Operational life	40,000 hours or 10^8 revolutions	
Termination	18 wires	
Accuracy	±1	least significant bit

NOTES

Developed under contract NOw 63-0817-F.
An output gating function is included such that all output lines are disabled except during interrogate time. This allows many encoders to be connected to one interface input buffer and gated merely by interrogating the selected encoder.

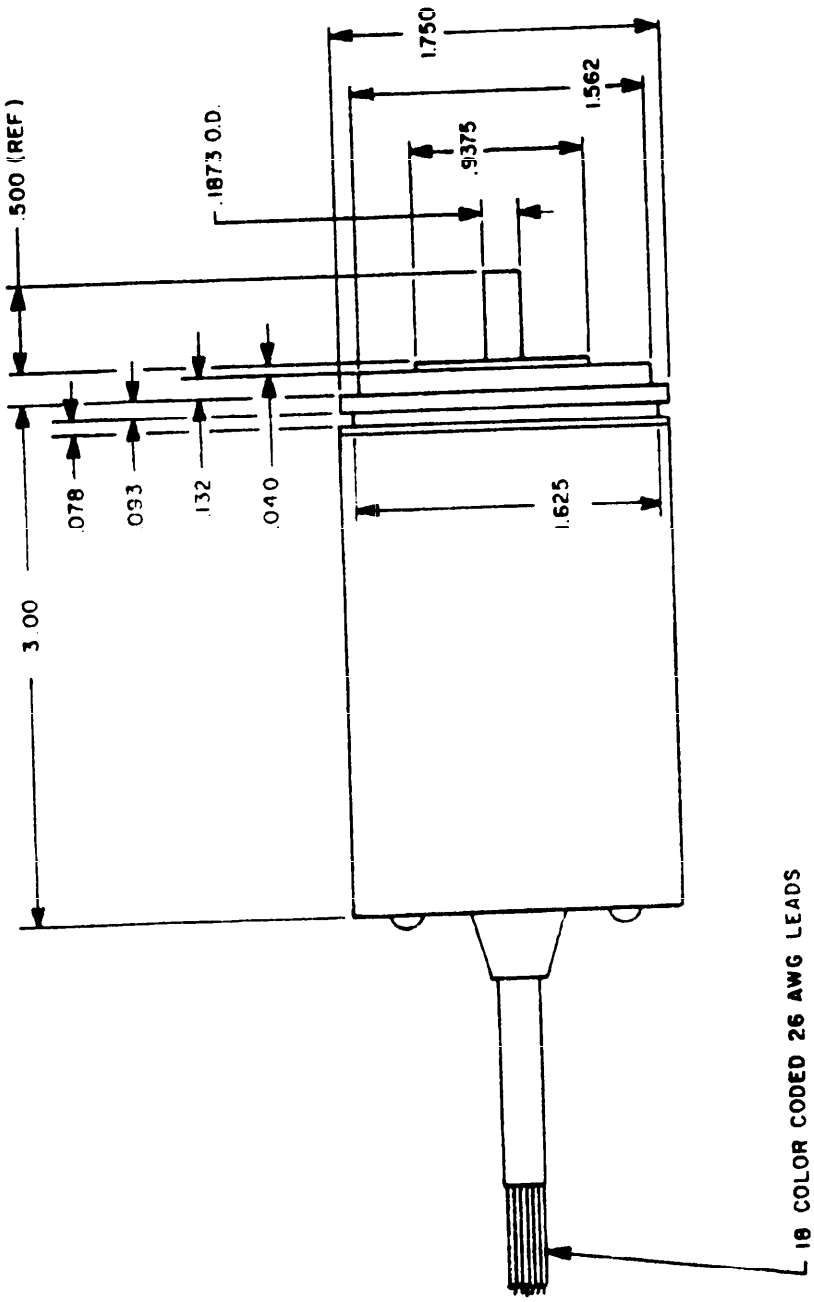


Figure 5.3. Optical Encoder Size 18 - 2[15] Multiturn

CHAPTER 6

GYROS

GYROSCOPE, RATE INTEGRATING

MB1168/1

CHARACTERISTICS

Spin motor		
Type	synchronous, hysteresis	
Winding configuration	3 phase	
Rated excitation		
start	10.5 ±1.0	V
run	9.0 ±1.5	V
Frequency	400	Hz
Note: Spin motor, pickoff, torquer and heater excitations shall be supplied from same frequency source.		
Angular velocity	12,000	rpm
Rotor angular momentum	2.0×10^4	gm-cm²/sec
Run-up time (max)	15	sec
Power consumption (max)	3.0	watts
	0.5	power factor ±0.1

Pickoff		
Type	four pole, variable reluctance microsyn	
Rated excitation	0-100	mA
Impedance		
primary	9.9 + j5.0	ohms
secondary	2130 + j4520	ohms
Null voltage (max)	10	mVrms
Phase shift	67	degrees
Scale factor	26.5	mv/mr
Linearity error (max)	5	percent
at input angles of 0, ±1, ±2, and ±3 degrees		

Torquer		
Type	four pole, variable reluctance microsyn	
Reference winding excitation	0-170	mA
Control winding excitation	0-145	mA
Command rate scale factor,	0.1000	mr/sec/ma²
up to ±5000 ma² inputs	.189	percent
Torquer linearity error,		
at ±5000 ma² input	2250	mr/sec
Maximum command rate		
Impedance		
reference winding	130 + j282	ohms
control winding	188 + j302	ohms

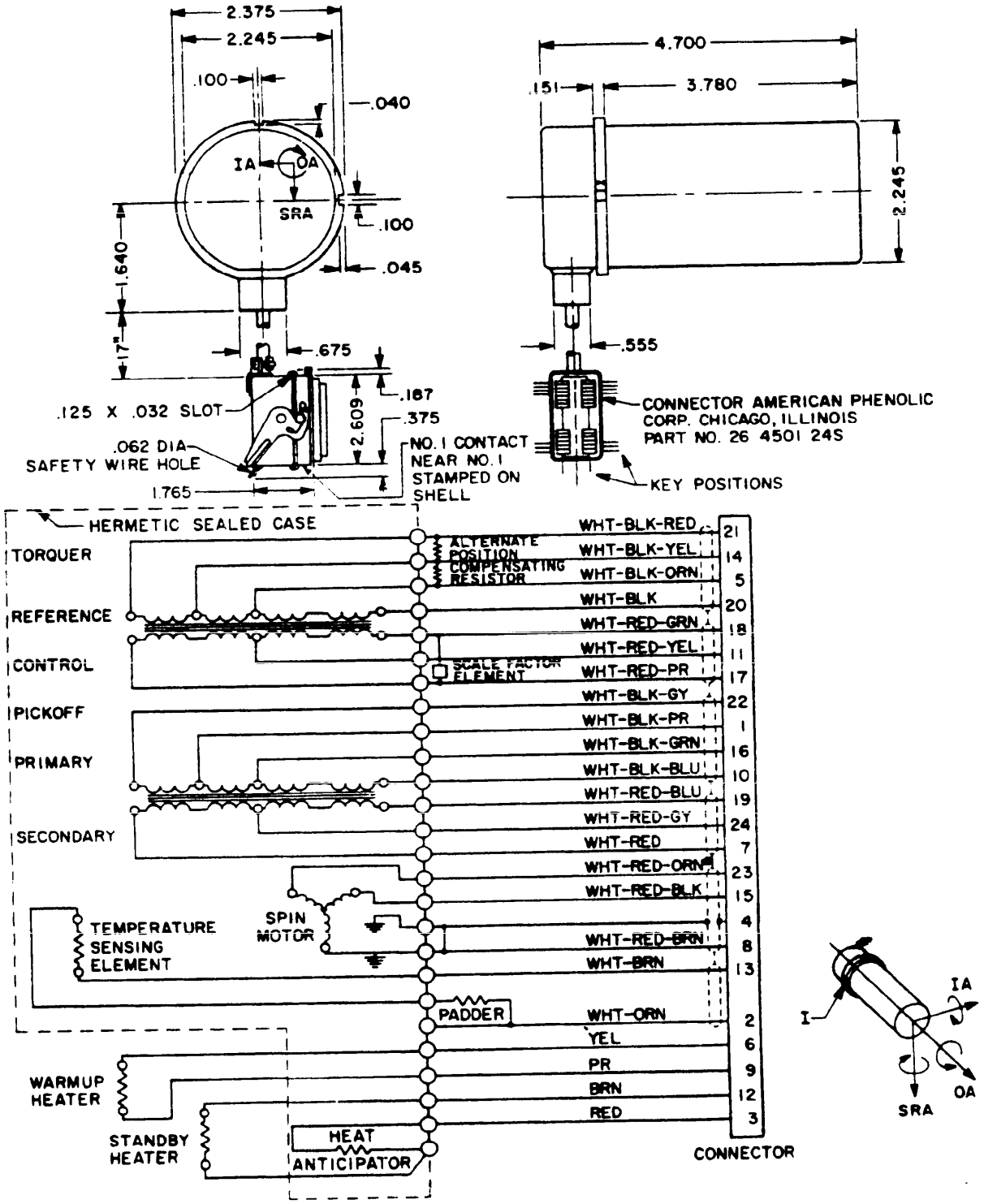


Figure 6.1. Part No. M81168/1

M81168/1 (Continued)

Temperature Sensor		
Type	resistance alloy wire	
Scale factor	1.5	ohms/°F
Operating temperature resistance	780	ohms
Induced voltage (max)	3.0	mVrms
Operating temperature	165	degrees F
Heaters		
Power		
Warm-up heater (min)	75	watts
Standby heater	101	watts
Gyro Unit		
Gyro scale factor	25	mv/mr
Input angular freedom (min)	6.5	degrees
Characteristic time (max)	3.0	msec
Axis alignment:	OA orthogonal to mounting flange surface within 1 milliradian. IA aligned within ±0.5 degree maximum of the IRA notch when pickoff is at null.	
Acceleration insensitive drift (max)	60	deg/hr
Acceleration sensitive drift (max res.)	45	deg/hr
Day to day stability (max)	20	deg/hr
Ambient temperature	-40 to +165	degrees F
Operating life (min)	2000	hours

REFERENCES

Specification	MIL-G-81168/1A(OS)
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Same as M81168/2, except /2 has 185° F operating temperature.
Used in AN/SPG-49 and AN/SPW-2 series for TALOS.

GYROSCOPE, RATE INTEGRATING

M81168/2

CHARACTERISTICS

Spin motor		
Type	synchronous, hysteresis	
Winding configuration	3 phase	
Rated excitation		
start	10.5 ± 1.0	V
run	9.0 ± 1.5	V
Frequency	400	Hz
Note: Spin motor, pickoff, torquer and heater excitations shall be supplied from same frequency source.		
Angular velocity	12,000	rpm
Rotor angular momentum	2.0×10^4	gm-cm^2/sec
Run-up time (max)	15	sec
Power consumption (max)	3.0	watts
	0.5	power factor ±0.1
Pickoff		
Type	four pole, variable reluctance microsyn	
Rated excitation	0-100	mA
Impedance		
primary	10.0 + j5.0	ohms
secondary	2080 + j4520	ohms
Null voltage (max)	10	mVrms
Phase shift	67	degrees
Scale factor	26.5	mv/mr
Linearity error (max)	5	percent
at input angles of 0, ±1, ±2, and ±3 degrees.		
Torquer		
Type	four pole, variable reluctance microsyn	
Reference winding excitation	0-170	mA
Control winding excitation	0-145	mA
Command rate scale factor, up to ±5000 ma^2 inputs	0.1000	mr/sec/ma^2
Torquer linearity error, at ±5000 ma^2 input	.189	percent
Maximum command rate	2250	mr/sec
Impedance		
reference winding	130 + j282	ohms
control winding	188 ± j302	ohms
Temperature Sensor		
Type	resistance alloy wire	

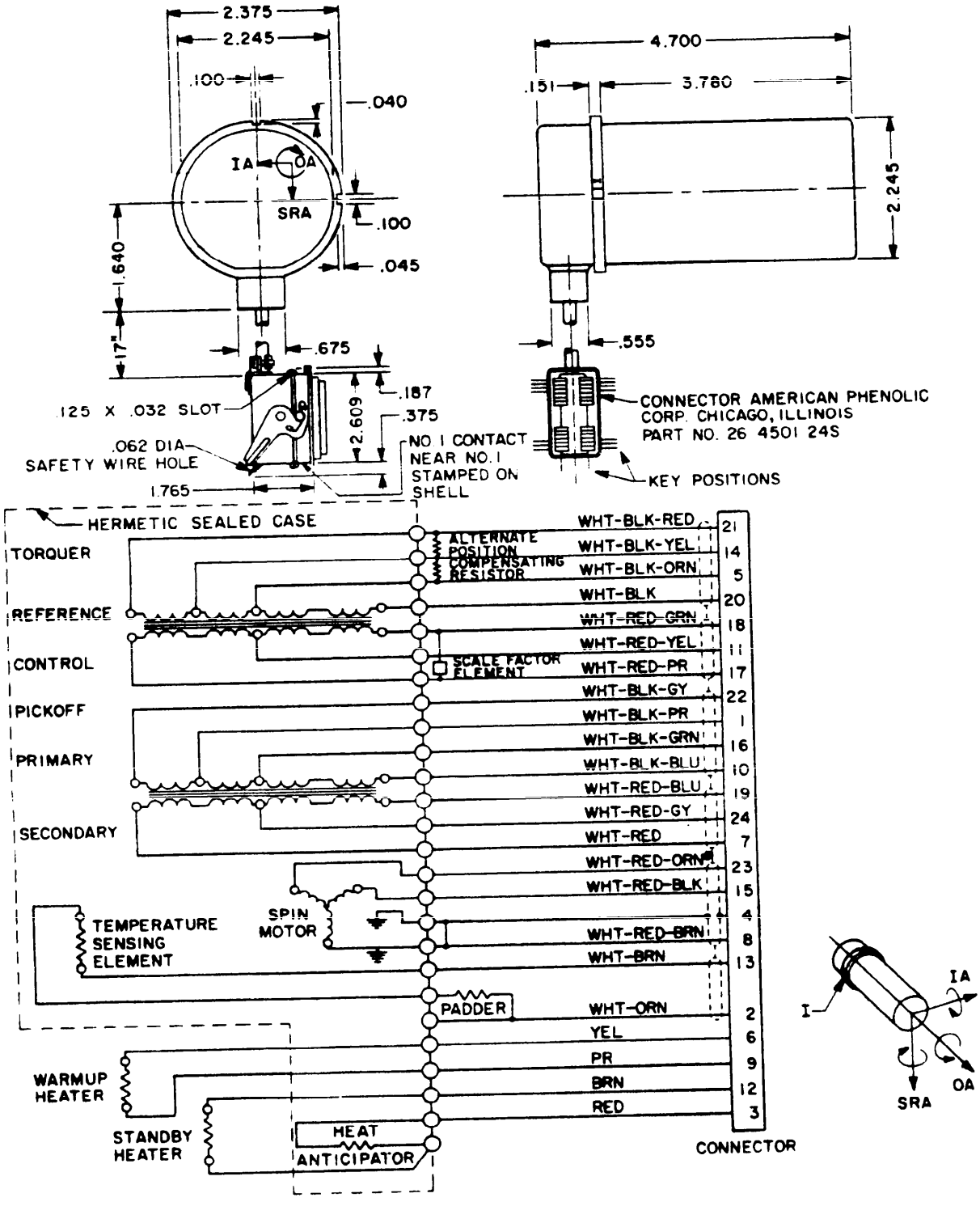


Figure 6.2 Part No. M81168/2

M81168/2 Continued)

Scale factor	1.5	ohms/°F
Operating temperature resistance	780	ohms
Induced voltage (max)	3.0	mVrms
Operating temperature	185	degrees F

Heaters

Power

Warm-up heater (min)	75	watts
Standby heater	101	watts

Gyro Unit

Gyro scale factor	25	mv/mr
Input angular freedom (min)	6.5	degrees
Characteristic time (max)	3.0	msec
Axis Alignment:	OA orthogonal to mounting flange surface within 1 milliradian. IA aligned within ±0.5 degree maximum of the IRA notch when pickoff is at null.	
Acceleration insensitive drift (max)	60	deg/hr
Acceleration sensitive drift (max res.)	45	deg/hr
Day to day stability (max)	20	deg/hr
Ambient temperature	-40 to +165	degrees F
Operating life (min)	2000	hours

REFERENCES

Specification . . . . . MIL-G-81168/2A(OS)

Federal Stock Number (FSN) . . . . . .

Qualified Products List (QPL) . . . . . .

NOTES

Same as M81168/1, except /1 has 165°F operating temperature.
Used in AN/SPW-2 Series for TALOS.

GYROSCOPE, RATE INTEGRATING

M81168/3

CHARACTERISTICS

Spin motor		
Type	synchronous, hysteresis	
Winding configuration	3 phase	
Rated excitation		
start	10.5 ± 1.0	V
run	9.0 ± 1.5	V
Frequency	400	Hz
Note: Spin motor, pickoff, torquer and heater excitations shall be supplied from same frequency source.		
Angular velocity	12,000	rpm
Rotor angular momentum	2.0×10^4	gm-cm²/sec
Run-up time (max)	15	sec
Power consumption (max)	3.0	watts
	0.5	power factor ±0.1

Pickoff		
Type	four pole, variable reluctance microsyn	
Rated excitation	0-100	mA
Impedance		
primary	10.3 + j5.0	ohms
secondary	2170 + j4520	ohms
Null voltage (max)	10	mVrms
Phase shift	67	degrees
Scale factor	26.5	mv/mr
Linearity Error (max)	5	percent
at input angles of 0, ±1, ±2, and ±3 degrees.		

Torquer		
Type	four pole, variable reluctance microsyn	
Reference winding excitation	0-145	mA
Control winding excitation	0-145	mA
Command rate scale factor	0.1000	mr/sec/ma²
up to ±5000 ma² inputs	.189	percent
Torquer linearity error,		
at ±5000 ma² input	2250	mr/sec
Maximum command rate		
Impedance		
reference winding	136 ± j584	ohms
control winding	196 + j302	ohms

Temperature Sensor	
Type	resistance alloy wire

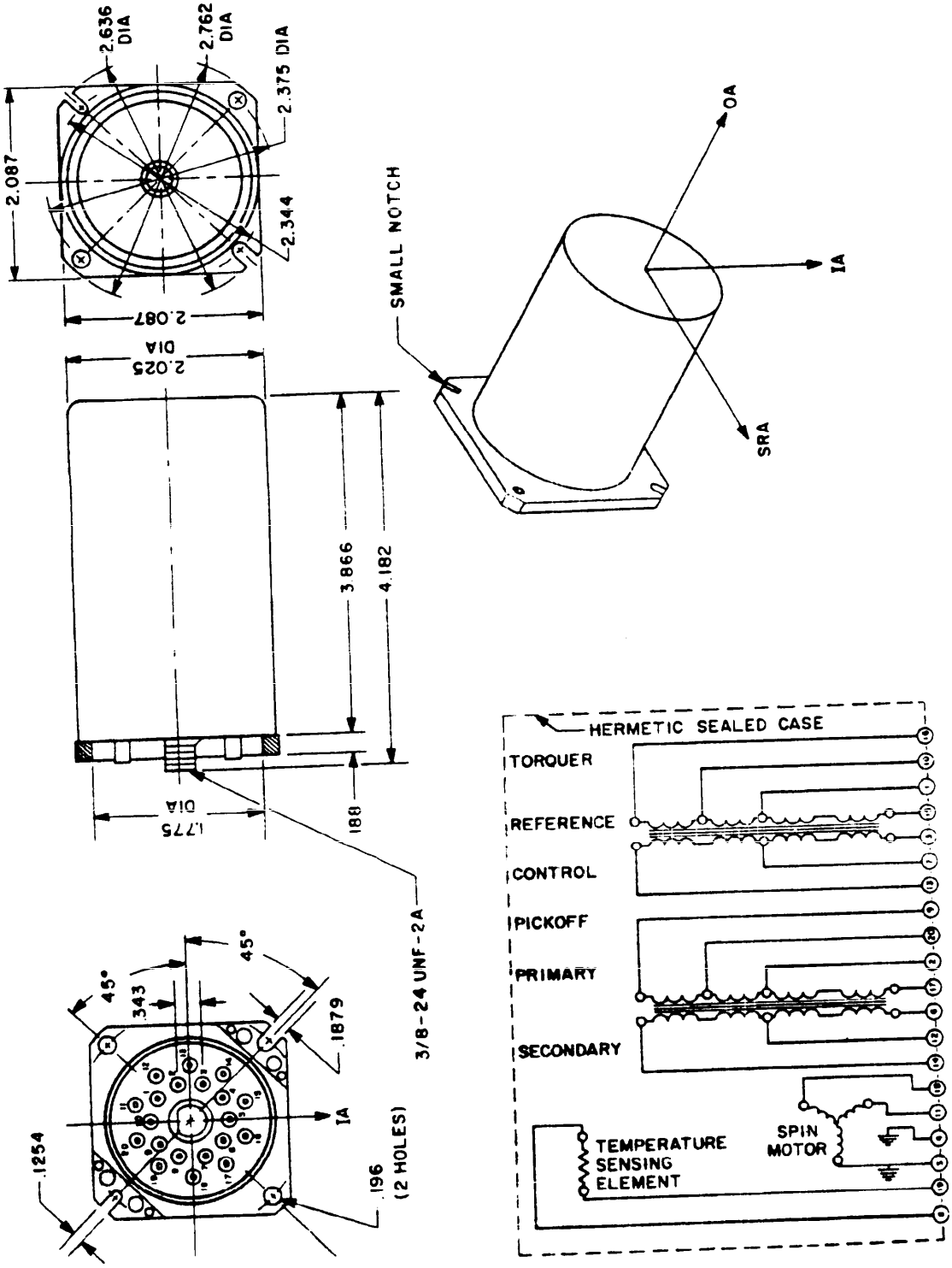


Figure 6.3 Part No. MX1168/3

M81168/3 (Continued)

Scale factor	1.44	ohms/°F
Operating temperature resistance	750	ohms
Induced voltage (max)	3.0	mVrms
Operating temperature	190	degrees F

Gyro Unit

Gyro scale factor	30	mv/mr
Input angular freedom (min)	7.0	degrees
Characteristic time (max)	3.0	msec
Axis alignment:	OA orthogonal to mounting flange surface within 1 milliradian. IA located 45° CW, and SRA located 45° CCW from centerline of notches (viewed from terminal end).	
Acceleration insensitive drift (max)	975	deg/hr
Acceleration sensitive drift, mass unbalance	40	deg/hr
Day to day stability (max)	20	deg/hr
Ambient temperature	-65 to +190	degrees F
Operating life (min)	2000	hours

REFERENCES

Specification . . . . . MIL-G-81168/3A(OS)

Federal Stock Number (FSN) . . . . . .

Qualified Products List (QPL) . . . . . .

NOTES

Used in AN/SPG-51 Series for TARTAR.
Does not incorporate heaters.

GYROSCOPE, RATE INTEGRATING

M81168/4

CHARACTERISTICS

Spin motor		
Type	synchronous, hysteresis	
Winding configuration	3 phase	
Rated excitation		
start	10.5 ± 1.0	V
run	9.0 ± 1.5	V
Frequency	400	Hz
Note: Spin motor, pickoff, torquer and heater excitations shall be supplied from same frequency source.		
Angular velocity	12,000	rpm
Rotor angular momentum	2.0 x 10^4	gm-cm²/sec
Run-up time (max)	15	sec
Power consumption (max)	3.0	watts
	0.5	power factor ±0.1
Pickoff		
Type	four pole, variable reluctance microsyn	
Rated excitation	0-100	mA
Impedance		
primary	10.3 + j5.0	ohms
secondary	2170 + j4500	ohms
Null voltage (max)	10	mVrms
Phase shift	67	degrees
Scale factor	26.5	mV/mr
Linearity error (max)	1	percent
at input angles of 0, ±1, ±2, and ±3 degrees.		
Torquer		
Type	four pole, variable reluctance microsyn	
Reference winding excitation	0-150	mA
Control winding excitation	0-150	mA
Command rate scale factor,	0.1000	mr/sec/ma²
up to ±5000 ma² inputs	.283	percent
Torquer linearity error,		
at ±5000 ma² input	1500	mr/sec
Maximum command rate		
Impedance		
reference winding	136 + j280	ohms
control winding	196 + j300	ohms
Temperature Sensor		
Type	resistance alloy wire	

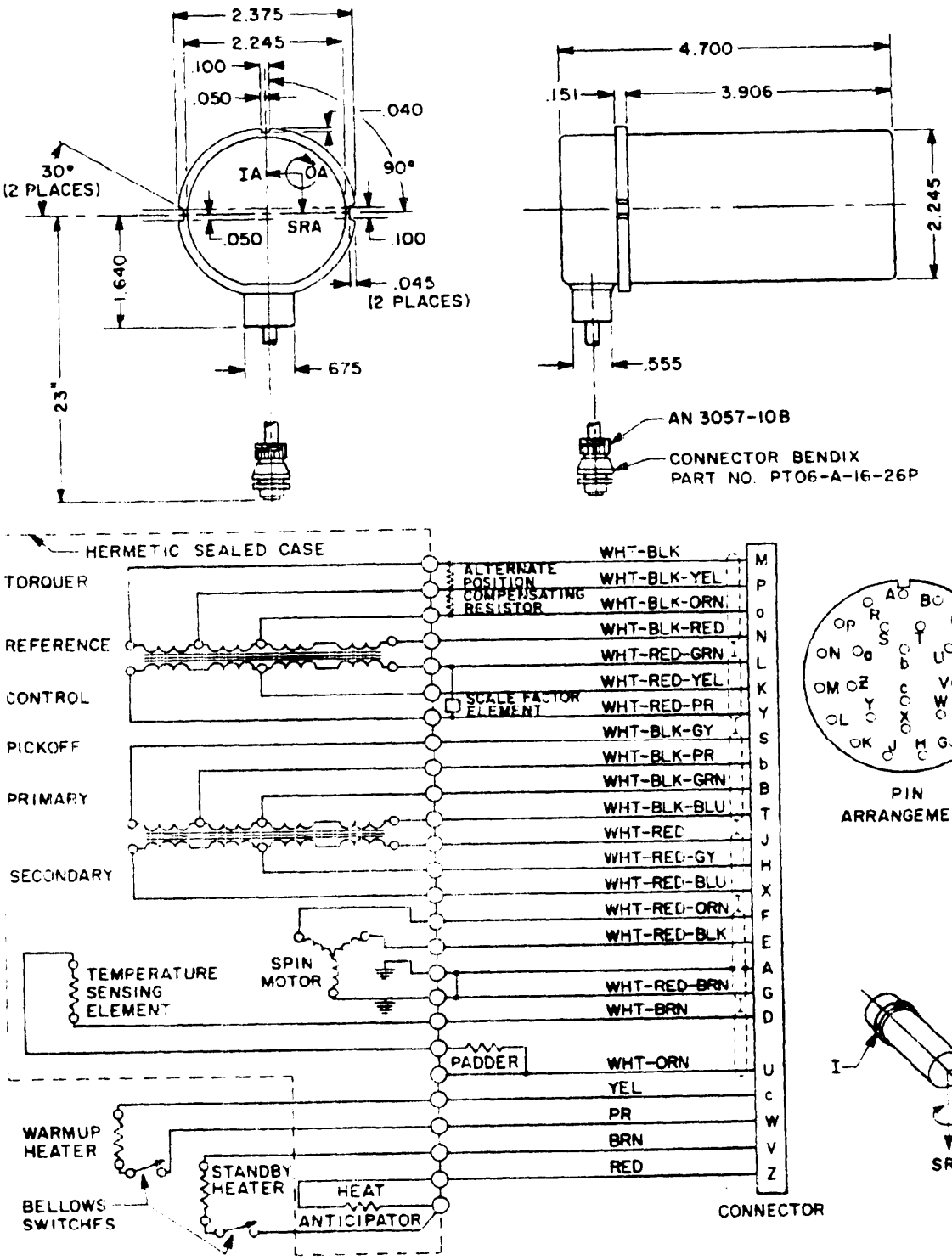


Figure 6.4. Part No. M81168/4

M81168/4 (Continued)

Scale factor	1.65	ohms/°F
Operating temperature resistance	780	ohms
Induced voltage (max)	3.0	mVrms
Operating temperature	190	degrees F
Over temperature sensor, bellows switch		
Open	815	ohms
Close (min)	785	ohms

Heaters

Power		
Warm-up heater (min)	75	watts
Standby heater	101	watts

Gyro Unit

Gyro scale factor	35.5	mv/mr
Input angular freedom (min)	6.0	degrees
Characteristic time (max)	3.0	msec
Axis alignment:	IA shall lie in plane of mounting flange surface within ±1 milliradian. IA aligned within ±0.5 milliradian maximum of the IRA notch when pickoff is at null.	
Acceleration insensitive drift (max)	60	deg/hr
Acceleration sensitive drift (max res.)	45	deg/hr
Day to day stability (max)	20	deg/hr
Ambient temperature (operating)	+65 to +165	degrees F
Operating life (min)	2000	hours

REFERENCES

Specification . . . . . MIL-G-81168/4A(OS)

Federal Stock Number (FSN) . . . . . .

Qualified Products List (QPL) . . . . . .

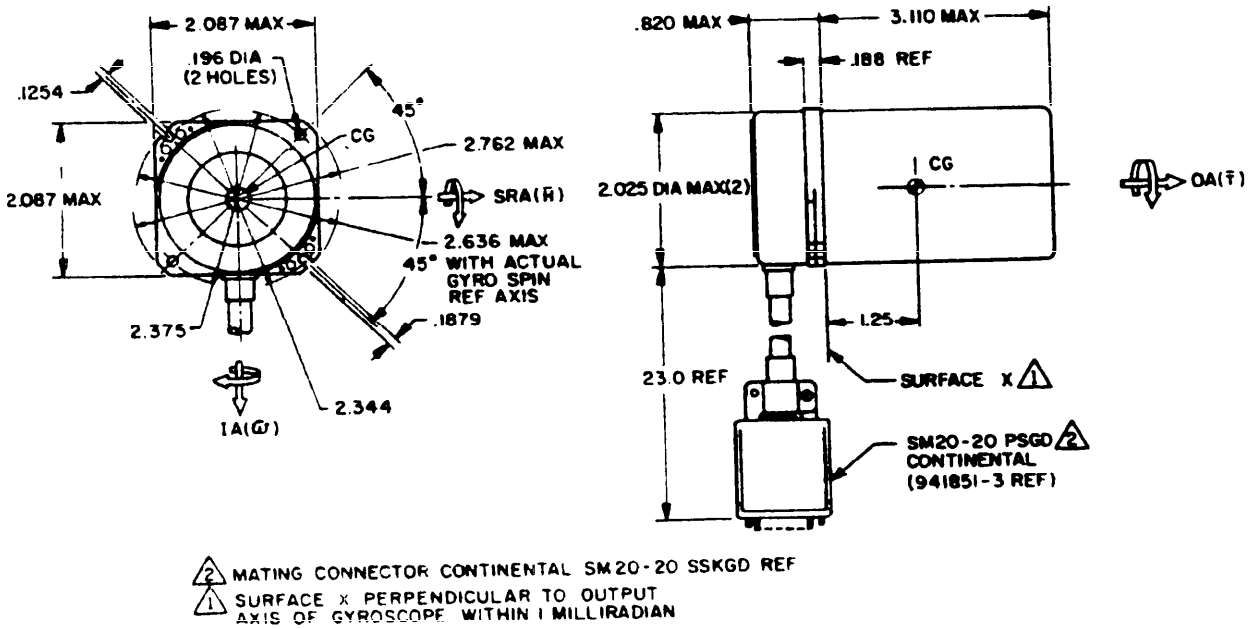
NOTES

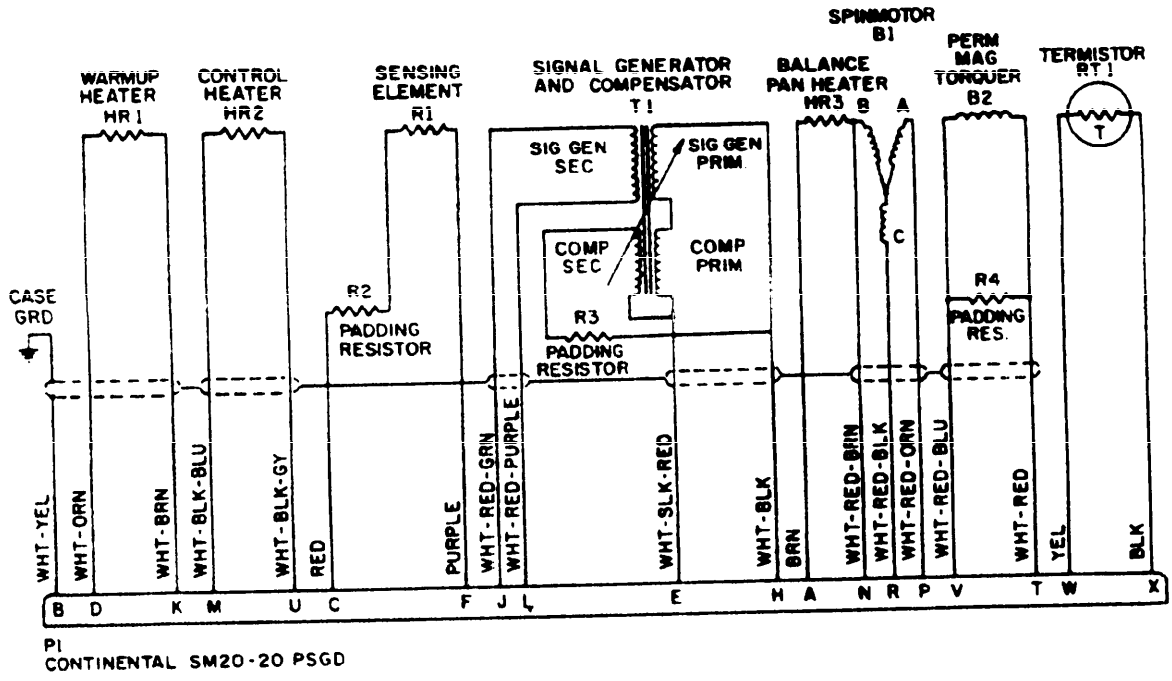
Used in AN/SPG-Q5, Q5A and AN/SPG-55A, 55B for TERRIER.

GYROSCOPE, INTEGRATING, DGG258A
(CERAMIC GAS-BEARING SPINMOTOR)

CHARACTERISTICS

Spin motor		
Type	synchronous (ceramic gas-bearing similar to GG159 gyro)	
Winding configuration	3 phase	
Impedance (phase)	43 + j85	ohms
Synchronous speed	24,000	rpm
Rotor angular momentum	3.5×10^4	gm-cm^2/sec
Run-up time (max)	3.5	sec
Power consumption (max)	6	watts
g-capability, 20-1000Hz	15	g
Pickoff (signal generator)		
Type	dualsyn (used on GG87), 16 pole stator, 8 pole rotor	
Impedance		
primary	52 + j18.1	ohms
secondary	1105 + j1005	ohms
Null voltage (max)	9.4	mVrms
Sensitivity	26	mv/mr
Linearity error (max) at input angles up to ± 3 degrees	1	percent
Torquer		
Type	four pole, permanent magnet and moving coil	
Impedance (dc resist.)	193	ohms
Sensitivity	11.4	mr/sec/ma
Command rate sensitivity	2175	deg/hr/ma
Secondary sensor		
Type	thermal resistor	
Temperature coefficient	5.9	ohms/°F
Operating temperature resistance	1400	ohms
Power rating @ 100°C	1/8	watt
Gimbal assembly		
Construction	ceramic	
Case assembly		
Construction	integral, one-piece	
Balance capsule		
Construction	microvernier, eutectic alloy	





SCHEMATIC DIAGRAM

Figure 6.5. **DGG258A**

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP15

ELECTRICAL CHARACTERISTICS

	SINGLE TURN	TEN TURN	
Resistance (max total)	150,000	350,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @40°C ambient	2.0	3.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS

Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES

Specification	MIL-R-81106/5(WP)	MIL-R-81106/6(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/16(WP) and /17(WP) are similar to MIL-R-81106/5(WP) and /6(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

MIL-R-81106/23(WP) is similar to MIL-R-81106/5(WP) except that the output function is non-linear.

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP18

ELECTRICAL CHARACTERISTICS	SINGLE TURN	TEN TURN	
Resistance (max total)	200,000	400,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @ 40°C ambient	3.0	4.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS			
Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	±80	±80	ppm
Weight			oz

REFERENCES		
Specification	MIL-R-81106/7(WP)	MIL-R-81106/8(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/18(WP) and /19(WP) are similar to MIL-R-81106/7(WP) and /8(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP20

ELECTRICAL CHARACTERISTICS	SINGLE TURN	TEN TURN	
Resistance (max total)	250,000	500,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @ 40°C ambient	4.0	5.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS			
Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	–65 to +125	–65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+ 80	+ 80	ppm
Weight			oz

REFERENCES		
Specification	MIL-R-81106/9(WP)	MIL-R-81106/10(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/20(WP) and /21(WP) are similar to MIL-R-81106/9(WP) and /10(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP30 (SINGLE TURN)

ELECTRICAL CHARACTERISTICS

Resistance (max total)	325,000	ohms
Voltage, working, continuous (max)	250	V
Power rating @40°C ambient	6.0	watts
Resistance tolerance		
Standard	±5	percent
Minimum	±1	percent
Function, output	linear	
Linearity tolerance		
Standard	±1	percent
Minimum	±0.025	percent
Electrical rotation	350	degrees
Electrical noise (max)	100	ohms

MECHANICAL CHARACTERISTICS

Mechanical rotation	continuous	degrees
Torque, starting (max)	1.5	oz-in
Single section	1.25	oz-in
Each additional section	500,000	cycles
Rotational life	-65 to +125	degrees C
Ambient temperature range		
Temperature coefficient of resistance element (Nichrome wire)	+80	ppm
Weight		oz

REFERENCES

Specification	MIL-R-81106/11(WP)
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

MIL-R-81106/22(WP) is similar to MIL-R-81106/11(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

CHAPTER 8

POWER SUPPLIES

The power supplies described in this chapter have been designed to meet specific requirements of fire control systems or components.

POWER SUPPLY

MK 47 MOD 1

ELECTRICAL CHARACTERISTICS

Input		
Voltage	25.0 to 29.5	V d.c.
Current	14.0	amps
Output		
Voltage, 3 phase 3 wire	115	V
Phase BC	115	V
Phase AB	115	V
Phase CA	400	Hz
Frequency	ACB	
Phase rotation		
Rating	30 to 100	VA
Three phase	0 to 50	VA
Single phase		
Total VA not to exceed 100, except for 5 minute period with 150% overload	0.4 to 0.8	
Load power factor (reactive)	10	percent
Harmonic content, total (max)		

MECHANICAL CHARACTERISTICS

Weight (max)	19.5	lb

REFERENCES

Installation drawing	WP Dwg	675139
General arrangement drawing	WP Dwg	675142
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

POWER SUPPLY

TYPE 2, CLASS 2,28V, 0.7 AMP

M81338/1-1

ELECTRICAL CHARACTERISTICS

Input		
Frequency	380 to 420	Hz
Voltage	103 to 124 or 24 to 28	V
Output		
Voltage DC	27.44 to 28.56	V
Current	0 to 0.7	A
Ripple, peak to peak (max)	25	mV
Impedance, at 800 Hz (max)	2	ohms

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +100	degrees C
Size and configuration		per dwg
External connections		
Lug No. 1	+28 v d.c. output	
2	115 v 400 cps input	
3	26 v 400 cps input	
4	input ground	
5	no connection	
6	output ground	
7	no connection	
Weight (max)	1.8	lb

REFERENCES

Specification	MIL-P-81338/1(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

POWER SUPPLY
TYPE 2, CLASS 2,28V, 2.0 AMP
M81338/2-1

ELECTRICAL CHARACTERISTICS

Input		
Frequency	380 to 420 103 to 124	Hz V
Voltage	or 24 to 28	
Output		
Voltage d.c.	27.44 to 28.56	V
Current	0 to 2.0	A
Ripple, peak to peak (max)	25	mV
Impedance, at 800 Hz (max)	2	ohms

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +85	degrees C
Size and configuration	per dwg	
Extemal connections		
Lug No. 1	+28 v d.c. output	
2	115 v 400 cps input	
3	26 v 400 cps input	
4	input ground	
5	no connection	
6	output ground	
7	no connection	
Weight (max)	3.0	lb

REFERENCES

Specification	MIL-P-81338/2(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

DGG258A (Continued)

Normal excitations		
Spin motor, per phase @ 400 Hz		
start	36	V
run	28	V
Torque generator	0 ± 150	mA dc
Operating and control heaters	0 to 115	V, ac or dc
Primary sensor (max)	20	mA
Heaters		
Operating temperature impedances		
Warm-up heater	42	ohms
Control heater	133	ohms
Gyro Unit		
Gyro transfer function	19.5	mv/mr
Input axis freedom (min)	±7.0	degrees
Time constant	.004	sec
Input axis alignment	3.5	min
Fixed torque	-13	deg/hr
Mass unbalance	3.3	deg/hr
Damping	57,000	D-cm/rad-sec
Ambient temperature		degrees F
Operating life (min)		hours
Weight (gyro plus cable)	1.35	lb

REFERENCES

Specification

Federal Stock Number (FSN)

Qualified Products List (QPL)

NOTES

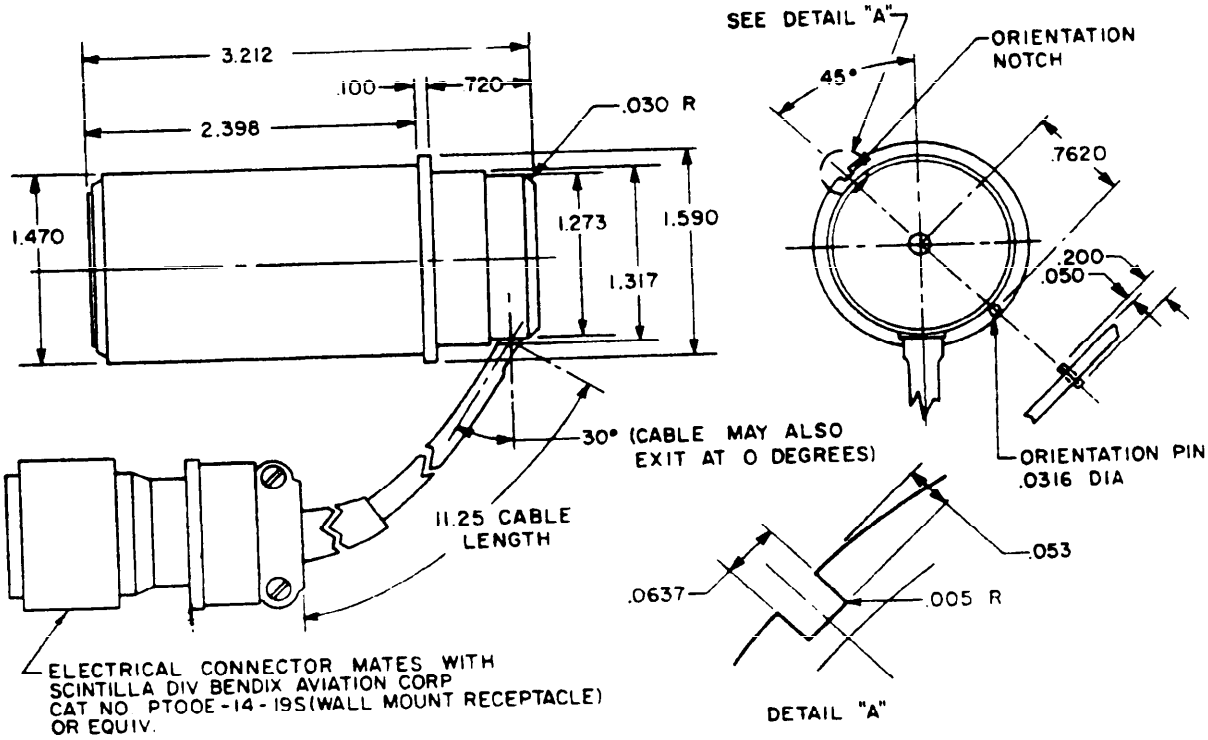
Developed under contract NOw 63-0830C
Mechanically interchangeable with the GG14M (used in the MK 73 MOD I Director for Tartar). Interchangeable with M81168/3.

GYROSCOPE, RATE INTEGRATING

GG 250 A-11

CHARACTERISTICS

Spin motor		
Type	Synchronous	
Winding configuration	2 phase	
Rated excitation (900 Hz)	6.5 ±.5	V
Rated current	280 – 430	mA
Impedance		
Phase	5.4 + j 14.8	ohms
Total	20 ± 3	ohms
Run-up time (max)	30	sec
Gimbal		
Anisoelasticity (max)	.00045	deg/sec/g^2
Signal generator		
Type		AC moving coil
Rated excitation (900 Hz)	29.5 ± .5	V
Impedance, primary	229 + j 325 to 391 + j 444	
Power consumption (max)	1.5	watts
Resistance (moving coil)	340 ± 50	ohms
Torque generator		
Type		d'Arsonval
Resistance	283 – 1250	ohms
Temperature regulator (if heater is used)		
Types (optional)	either a temperature sensor or a thermostatic device	
Resistance (if sensor is selected)	780	ohms
Heater (use is optional)		
Power source (400 Hz)	115	V
Power (max)	175	watts
Resistance (min) @ 22°C	50	ohms
Gyro unit		
Gyro scale factor (over range 0 to ± 90 deg/sec)		
1350 ohm series torquer resistor	1	Vdc/deg/sec
500 ohm series torquer resistor	0.5	Vdc/deg/sec
Linearity error (max)		
0 – 5 deg/sec angular rate	.02 deg/sec or 1% of true rate, whichever is greater	
5 – 60 deg/sec angular rate	1% of true rate	
60 – 90 deg/sec angular rate	2% of true rate	



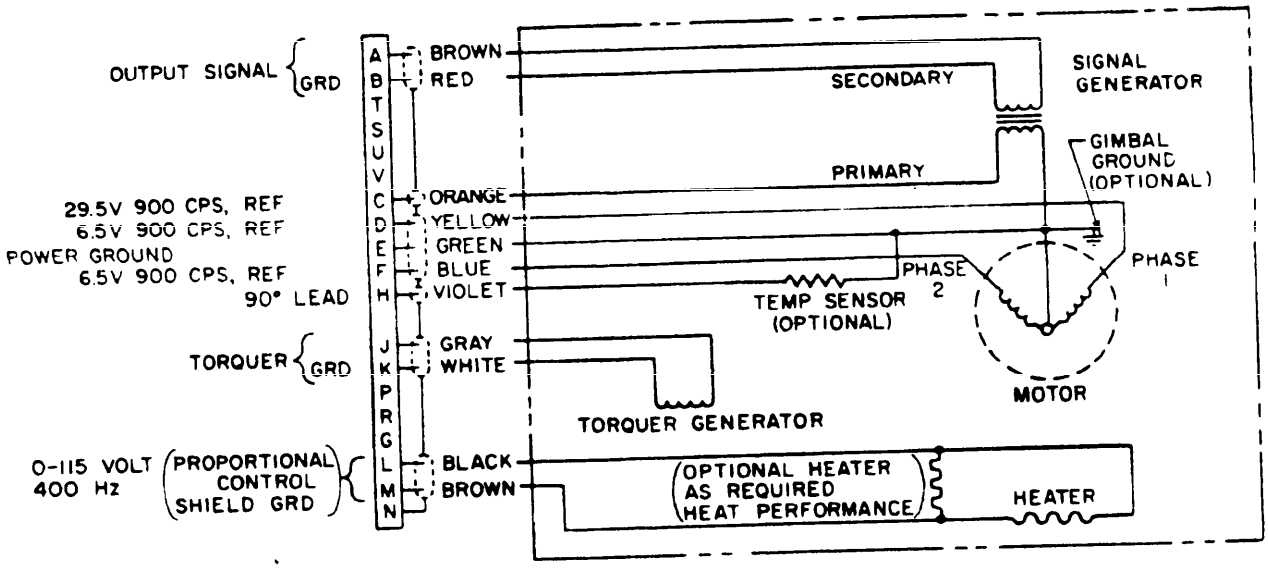


Figure 6.6. GG 250 A-11

GG 250 A-11 (Continued)

Zero rate uncertainty, in ea. of 6 gyro positions (max)	±.02	deg/sec
Cross-coupling (max)	±1% of full input rate	
Hysteresis (max)	.02	deg/sec
Operating life (min)	2000	hours
Storage life (min) @ –62 to +95°C	5	years
Weight (excluding cable and connector)	210	grams

REFERENCES

Specification	MIL-R-23750
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Used in AN/APG-59 and AN/APQ-72/100 radar sets.

CHAPTER 7

POTENTIOMETERS (VARIABLE RESISTORS)

The precision, wirewound or non-wirewound, long life, low noise potentiometers (variable resistors) described in this chapter have special requirements on rotational life, electrical noise, and temperature coefficient of resistance. They incorporate movable electrical contacts of a precious metal, lubricated to minimize wear and signal noise, a resistance element of Nichrome Alloy or better, and are (a) either single or ten turn (b) linear or non-linear function and (c) single-section or multisection (ganged).

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP09

ELECTRICAL CHARACTERISTICS	SINGLE TURN	TEN TURN	
Resistance (max total)	100,000	125,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @ 40°C ambient	1.25	2.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS			
Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	0.50	1.0	oz-in
Each additional section	0.35	1.0	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES

Specification	MIL-R-81106/1(WP)	MIL-R-81106/2(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/12(WP) and /13(WP) are similar to MIL-R-81106/1(WP) and /2(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

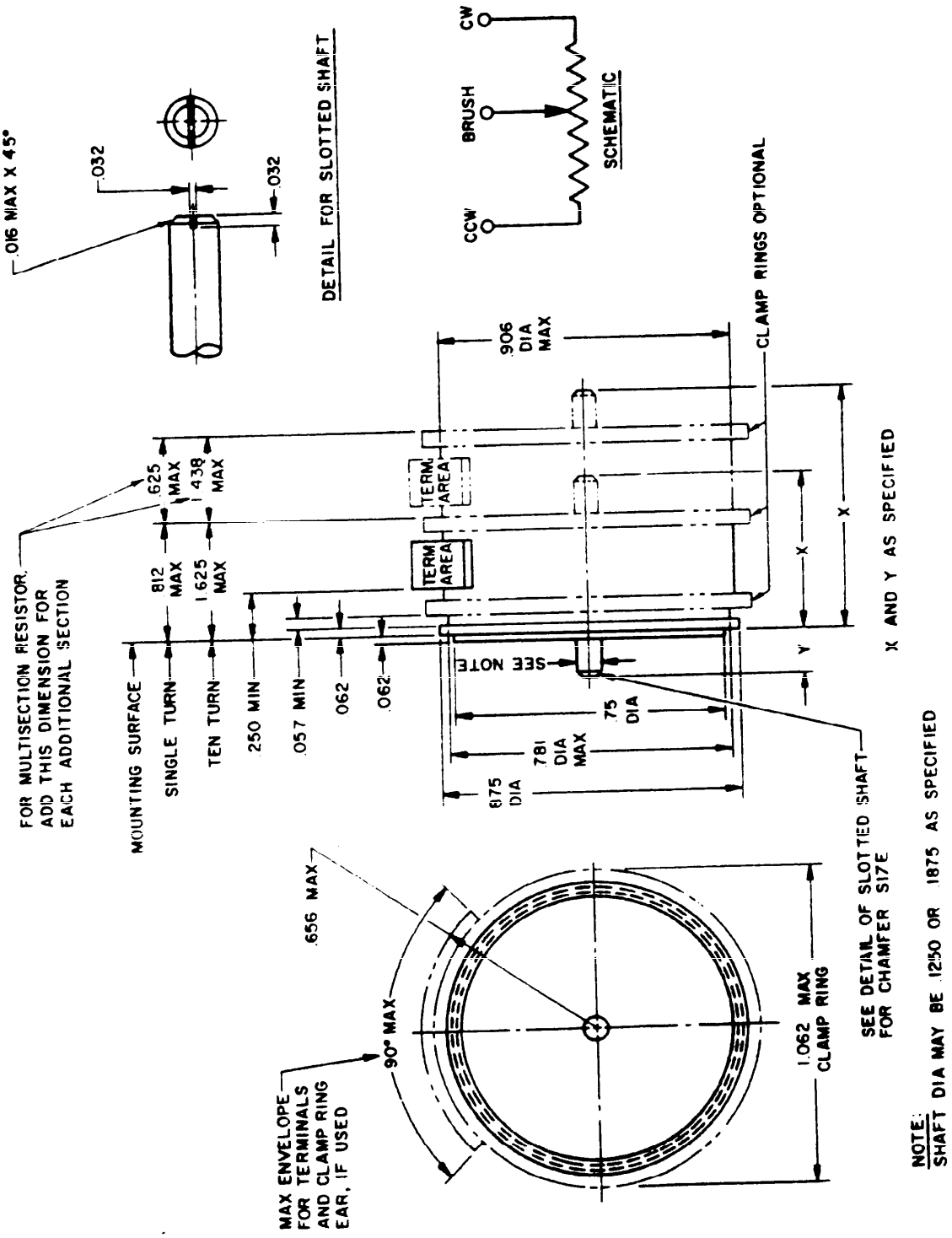


Figure 7.1. Style RRP09

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP11

ELECTRICAL CHARACTERISTICS	SINGLE TURN	TEN TURN	
Resistance (max total)	125,000	200,000	ohms
Voltage, working, continous (max)	250	500	V
Power rating @ 40°C ambient	1.5	2.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	± 0.025	± 0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS			
Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
single section	0.75	1.25	oz-in
Each additional section	0.50	1.25	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES

Specification	MIL-R-81106/3(WP)	MIL-R-81106/4(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/14(WP) and /15(WP) are similar to MIL-R-81106/3(WP) and /4(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

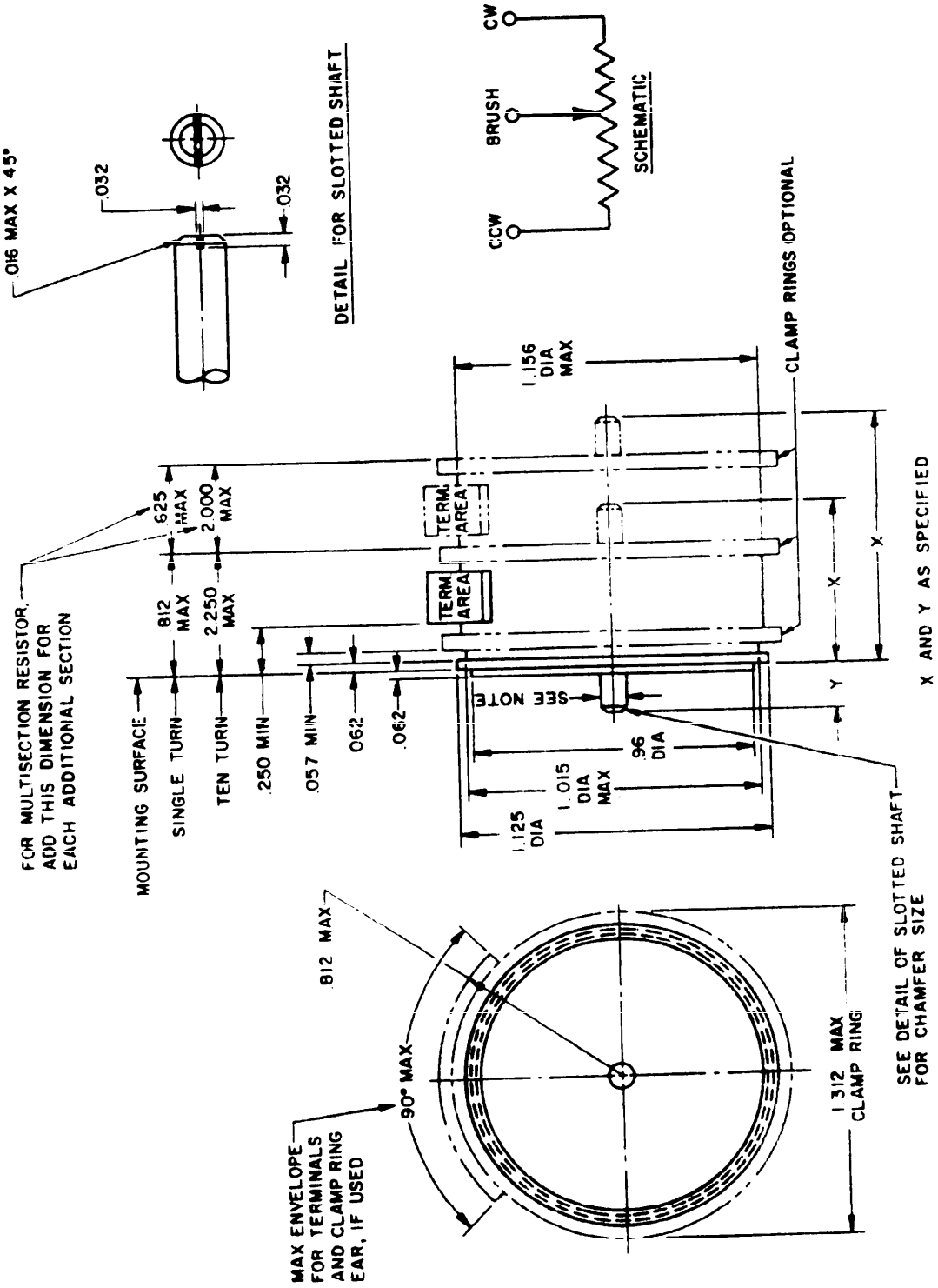


Figure 7.2. Style RRP11

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP15

ELECTRICAL CHARACTERISTICS

	SINGLE TURN	TEN TURN	
Resistance (max total)	150,000	350,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @40°C ambient	2.0	3.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS

Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES

Specification	MIL-R-81106/5(WP)	MIL-R-81106/6(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/16(WP) and /17(WP) are similar to MIL-R-81106/5(WP) and /6(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

MIL-R-81106/23(WP) is similar to MIL-R-81106/5(WP) except that the output function is non-linear.

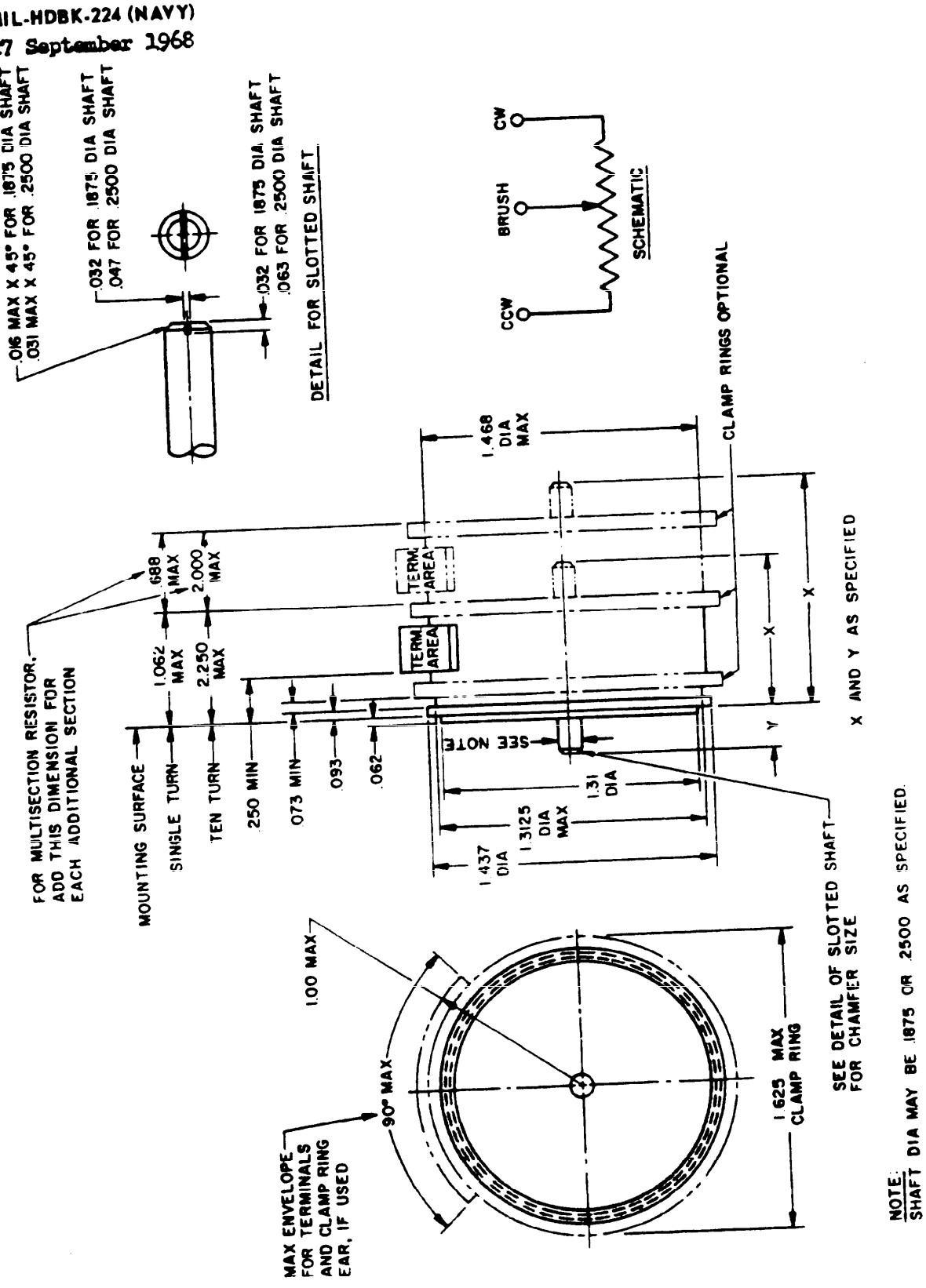


Figure 7.3. Style RRP15

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP18

ELECTRICAL CHARACTERISTICS	SINGLE TURN	TEN TURN	
Resistance (max total)	200,000	400,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @ 40°C ambient	3.0	4.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS			
Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	–65 to +125	–65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES		
Specification	MIL-R-81106/7(WP)	MIL-R-81106/8(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/18(WP) and /19(WP) are similar to MIL-R-81106/7(WP) and /8(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

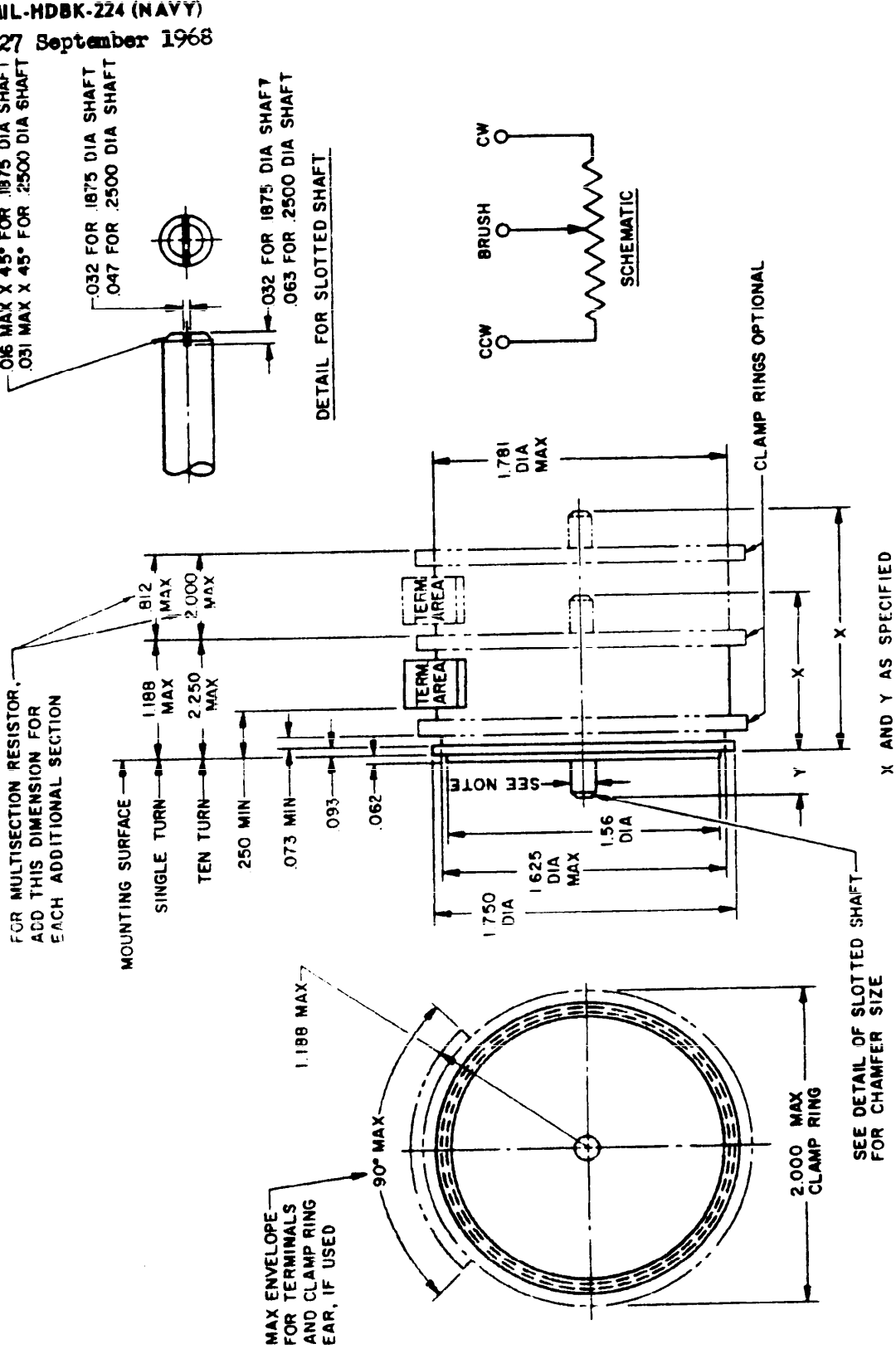


Figure 7.4. Style RRP18

NOTE:
SHAFT DIA MAY BE .1875 OR .2500 AS SPECIFIED.

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP20

ELECTRICAL CHARACTERISTICS

	SINGLE TURN	TEN TURN	
Resistance (max total)	250,000	500,000	ohms
Voltage, working, continuous (max)	250	500	V
Power rating @ 40°C ambient	4.0	5.0	watts
Resistance tolerance			
Standard	±5	±5	percent
Minimum	±1	±1	percent
Function, output	linear	linear	
Linearity tolerance			
Standard	±1	±1	percent
Minimum	±0.025	±0.025	percent
Electrical rotation	350	3600	degrees
Electrical noise (max)	100	100	ohms

MECHANICAL CHARACTERISTICS

Mechanical rotation	cont.	3600	degrees
Torque, starting (max)			
Single section	1.0	1.5	oz-in
Each additional section	0.75	1.5	oz-in
Rotational life	500,000	200,000	cycles
Ambient temperature range	-65 to +125	-65 to +125	degrees C
Temperature coefficient of resistance element (Nichrome wire)	+80	+80	ppm
Weight			oz

REFERENCES

Specification	MIL-R-81106/9(WP)	MIL-R-81106/10(WP)
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

MIL-R-81106/20(WP) and /21(WP) are similar to MIL-R-81106/9(WP) and /10(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

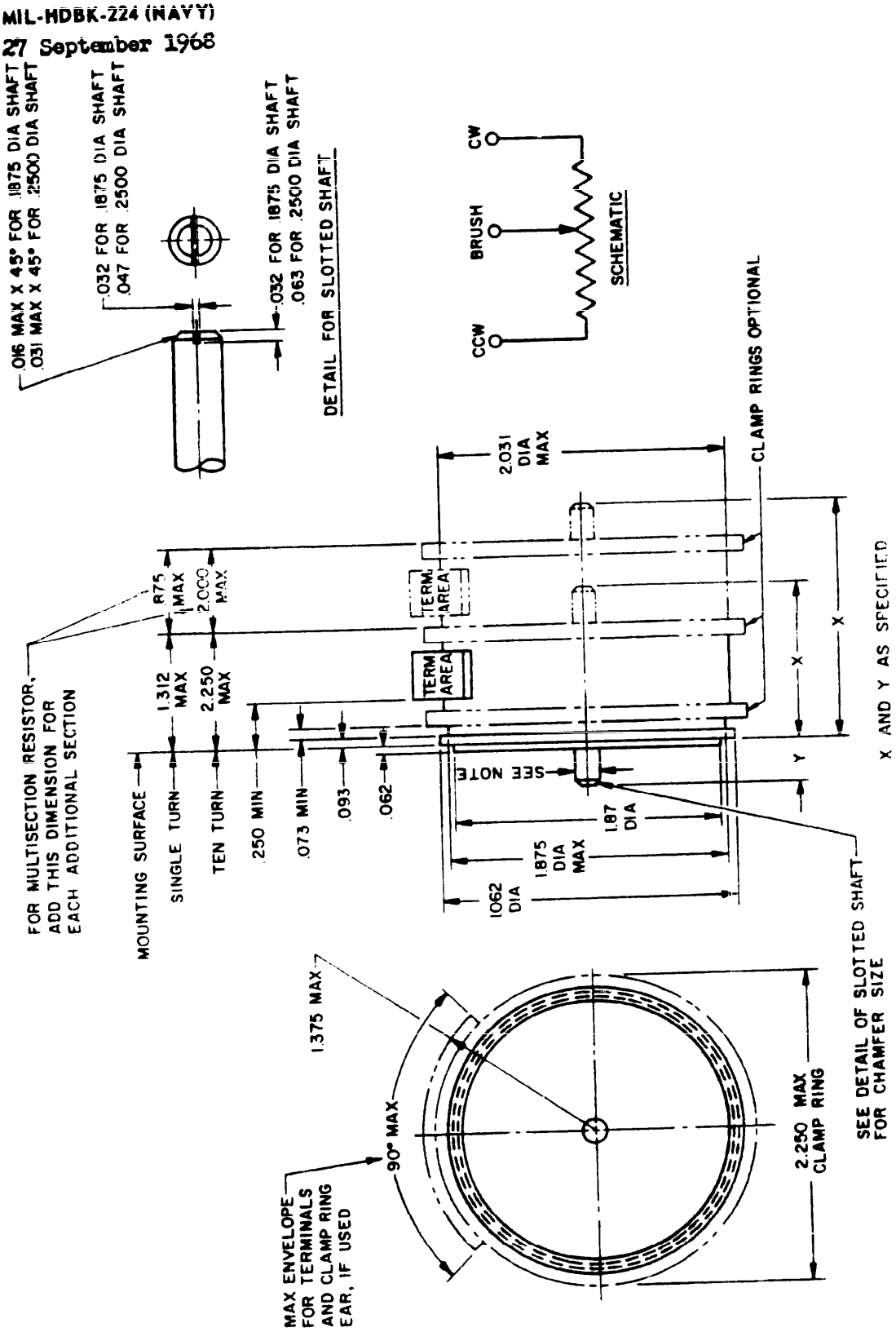


Figure 7.5. Style RRP20

NOTE:
SHAFT DIA MAY BE .1875 OR .2500 AS SPECIFIED.

RESISTOR, VARIABLE, WIREWOUND
PRECISION, LONG LIFE, LOW NOISE
STYLE RRP30 (SINGLE TURN)

ELECTRICAL CHARACTERISTICS

Resistance (max total)	325,000	ohms
Voltage, working, continuous (max)	250	V
Power rating @40°C ambient	6.0	watts
Resistance tolerance		
Standard	±5	percent
Minimum	±1	percent
Function, output	linear	
Linearity tolerance		
Standard	±1	percent
Minimum	±0.025	percent
Electrical rotation	350	degrees
Electrical noise (max)	100	ohms

MECHANICAL CHARACTERISTICS

Mechanical rotation	continuous	degrees
Torque, starting (max)		
Single section	1.5	oz-in
Each additional section	1.25	oz-in
Rotational life	500,000	cycles
Ambient temperature range	-65 to +125	degrees C
Temperature coefficient of resistance		
element (Nichrome wire)	+80	ppm
Weight		oz

REFERENCES

Specification	MIL-R-81106/11(WP)
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

MIL-R-81106/22(WP) is similar to MIL-R-81106/11(WP) except that the resistance element material is precious metal wire having a temperature coefficient of +240 ppm.

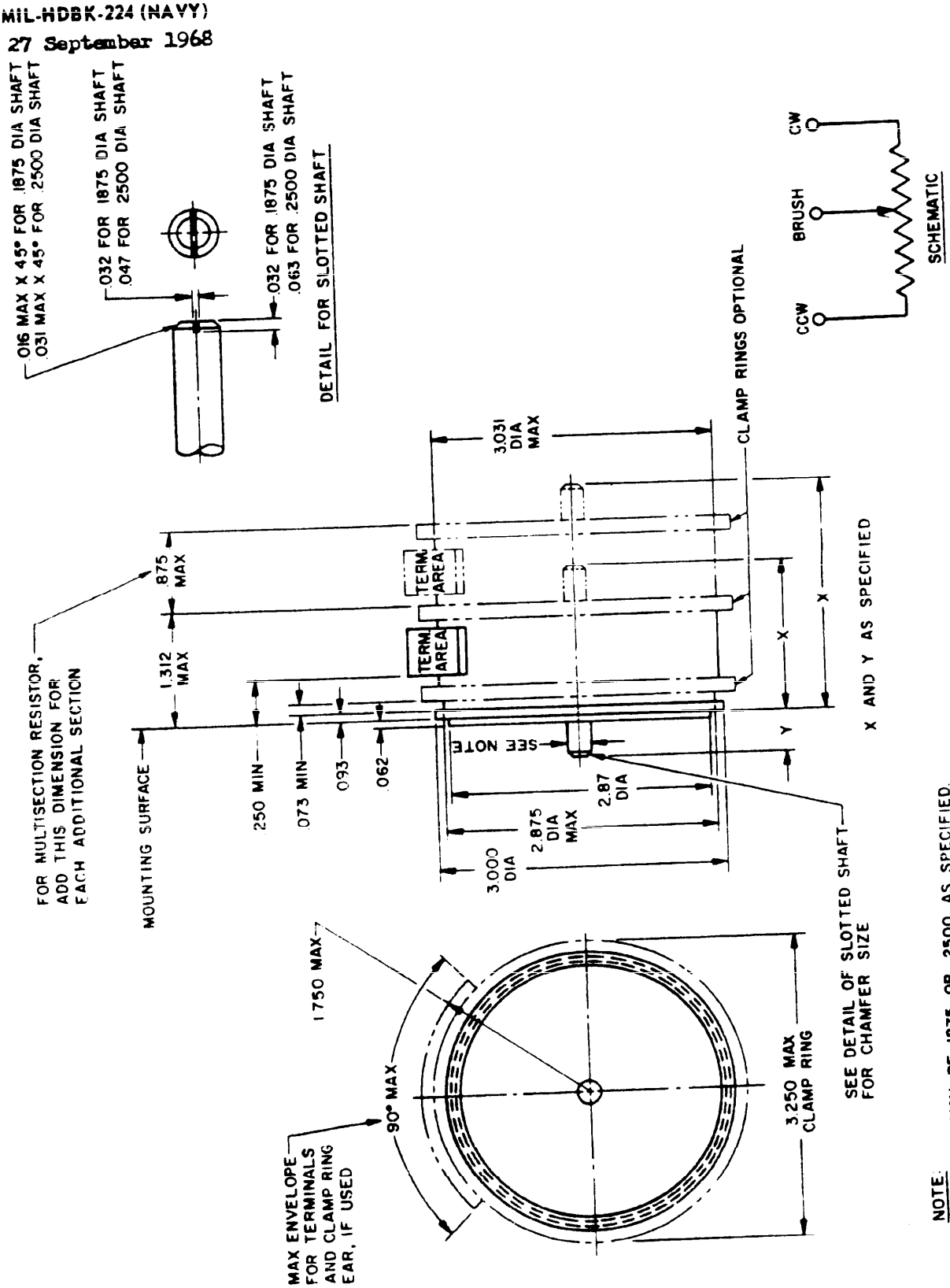


Figure 7.6. Style RRP30 (Single Turn)

NOTE:
SHAFT DIA MAY BE .1875 OR .2500 AS SPECIFIED.

CHAPTER 8

POWER SUPPLIES

The power supplies described in this chapter have been designed to meet specific requirements of fire control systems or components.

POWER SUPPLY

MK 47 MOD 1

ELECTRICAL CHARACTERISTICS

Input		
Voltage	25.0 to 29.5	V d.c.
Current	14.0	amps
Output		
Voltage, 3 phase 3 wire	115	V
Phase BC	115	V
Phase AB	115	V
Phase CA	400	Hz
Frequency	ACB	
Phase rotation		
Rating	30 to 100	VA
Three phase	0 to 50	VA
Single phase		
Total VA not to exceed 100, except for 5 minute period with 150% overload	0.4 to 0.8	
Load power factor (reactive)	10	percent
Harmonic content, total (max)		

MECHANICAL CHARACTERISTICS

Weight (max)	19.5	lb

REFERENCES

Installation drawing	WP Dwg	675139
General arrangement drawing	WP Dwg	675142
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

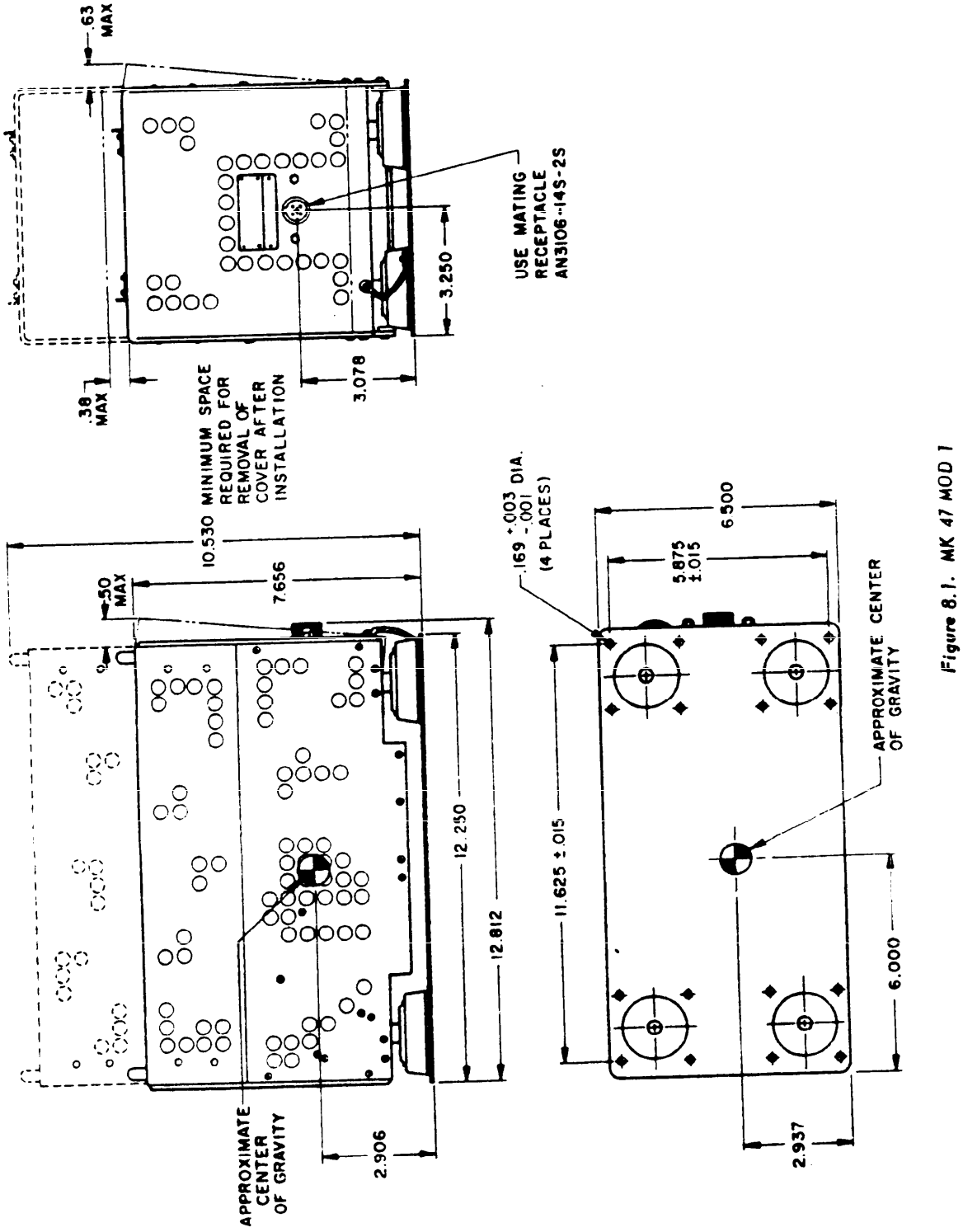


Figure 8.1. MK 47 MOD 1

POWER SUPPLY

TYPE 2, CLASS 2,28V, 0.7 AMP

M81338/1-1

ELECTRICAL CHARACTERISTICS

Input		
Frequency	380 to 420	Hz
Voltage	103 to 124 or 24 to 28	V
Output		
Voltage DC	27.44 to 28.56	V
Current	0 to 0.7	A
Ripple, peak to peak (max)	25	mV
Impedance, at 800 Hz (max)	2	ohms

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +100	degrees C
Size and configuration		per dwg
External connections		
Lug No. 1	+28 v d.c. output	
2	115 v 400 cps input	
3	26 v 400 cps input	
4	input ground	
5	no connection	
6	output ground	
7	no connection	
Weight (max)	1.8	lb

REFERENCES

Specification	MIL-P-81338/1(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

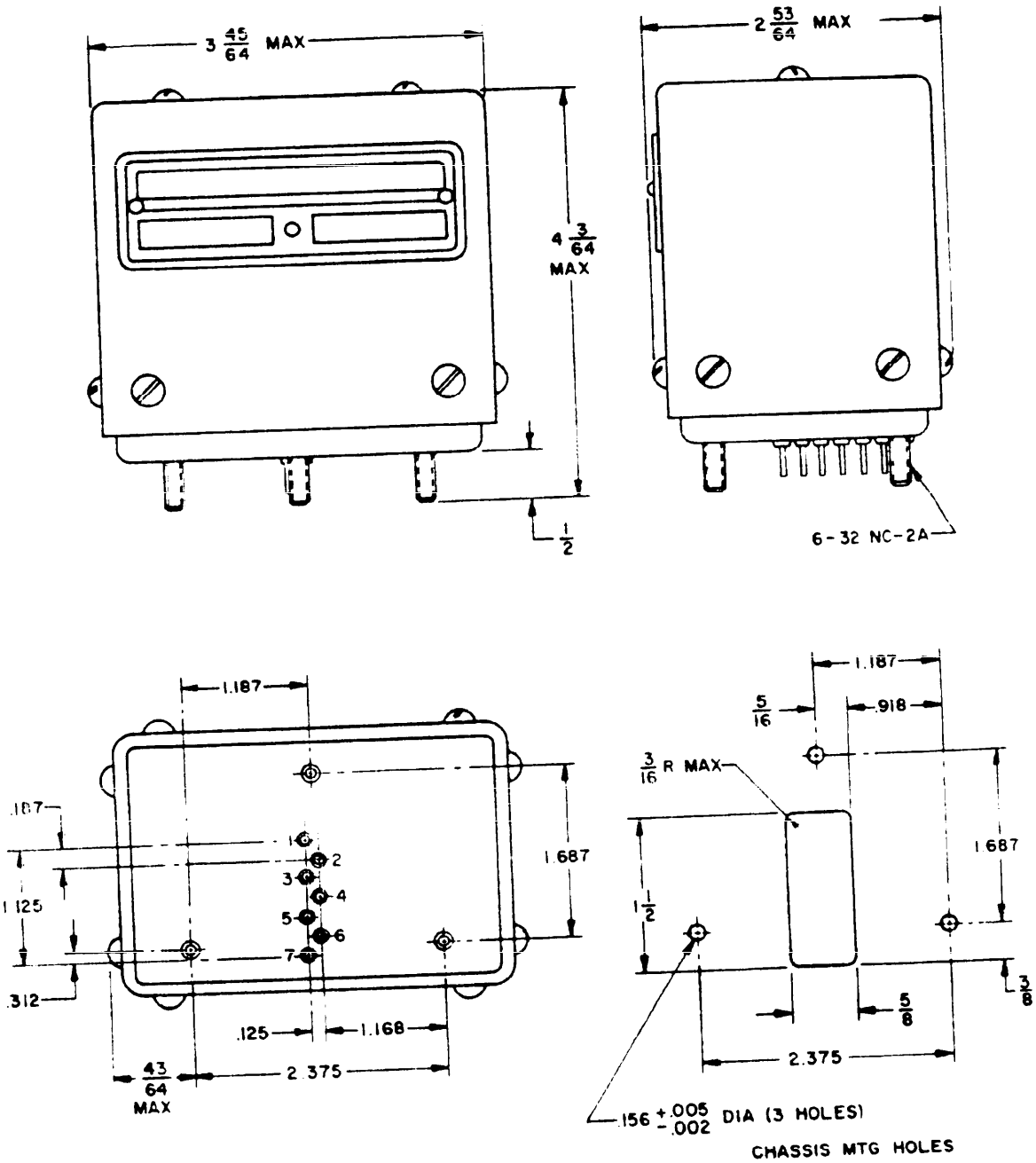


Figure 8.2. Part No. M81338/1-1

POWER SUPPLY
TYPE 2, CLASS 2,28V, 2.0 AMP
MB1338/2-1

ELECTRICAL CHARACTERISTICS

Input		
Frequency	380 to 420	Hz
Voltage	103 to 124 or 24 to 28	V
Output		
Voltage d.c.	27.44 to 28.56	V
Current	0 to 2.0	A
Ripple, peak to peak (max)	25	mV
Impedance, at 800 Hz (max)	2	ohms

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +85	degrees C
Size and configuration	per dwg	
External connections		
Lug No. 1	+28 v d.c. output	
2	115 v 400 cps input	
3	26 v 400 cps input	
4	input ground	
5	no connection	
6	output ground	
7	no connection	
Weight (max)	3.0	lb

REFERENCES

Specification	MIL-P-81338/2(WP)
Installation drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

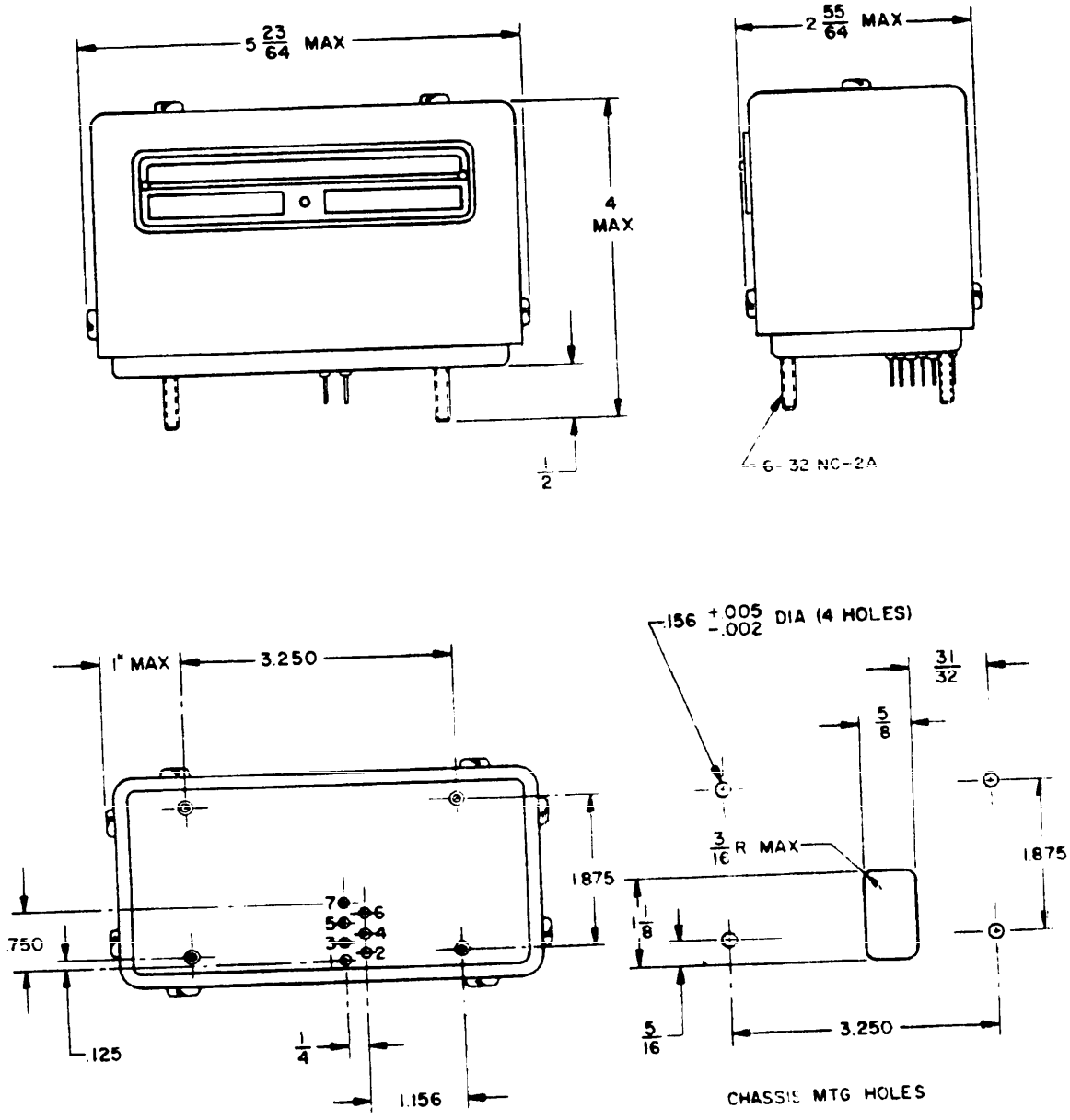


Figure 8.3. Part No. M81338/2-1

POWER SUPPLY

MODULES, 25 WATTS

ELECTRICAL CHARACTERISTICS

Input		
Frequency (3 phase)	400	Hz
Voltage	112-124	V
Output		
Voltage dc range by a series of modules (adjustment over 10% range of each module)	10 to 100	V
DC power	0 to approx 25	watts
Short circuit current (approx)	140% full load current	
Temperature coefficient of output voltage (max)	.005%	per degree C
Ripple and noise (max)	1	mVrms
Load regulation (no load-full load and full load - no load) max	10	mVrms
Transient recovery time (time required to recover from full load current change to within 10 mV of nominal output voltage) max	1 00	μsec
Transient line voltage, 100 msec, line-neutral (max)	192	Vrms

MECHANICAL CHARACTERISTICS

Ambient temperature range (mounting base)	-55 to +120	degrees C
Size and configuration		per dwg

External connections

Pin 1 - output
2 - remote sensing
3 + remote sensing
4 + output sensing
5 spare
6 T101-3(Ø1)
7 T101-9(Ø2)
8 T101-15(Ø3)
9 T101-16(comm.)

Weight

NOTES

NAFI designation PP-4436(XAN-1)/U.

BUWEPS drawing No. 64A49D1.

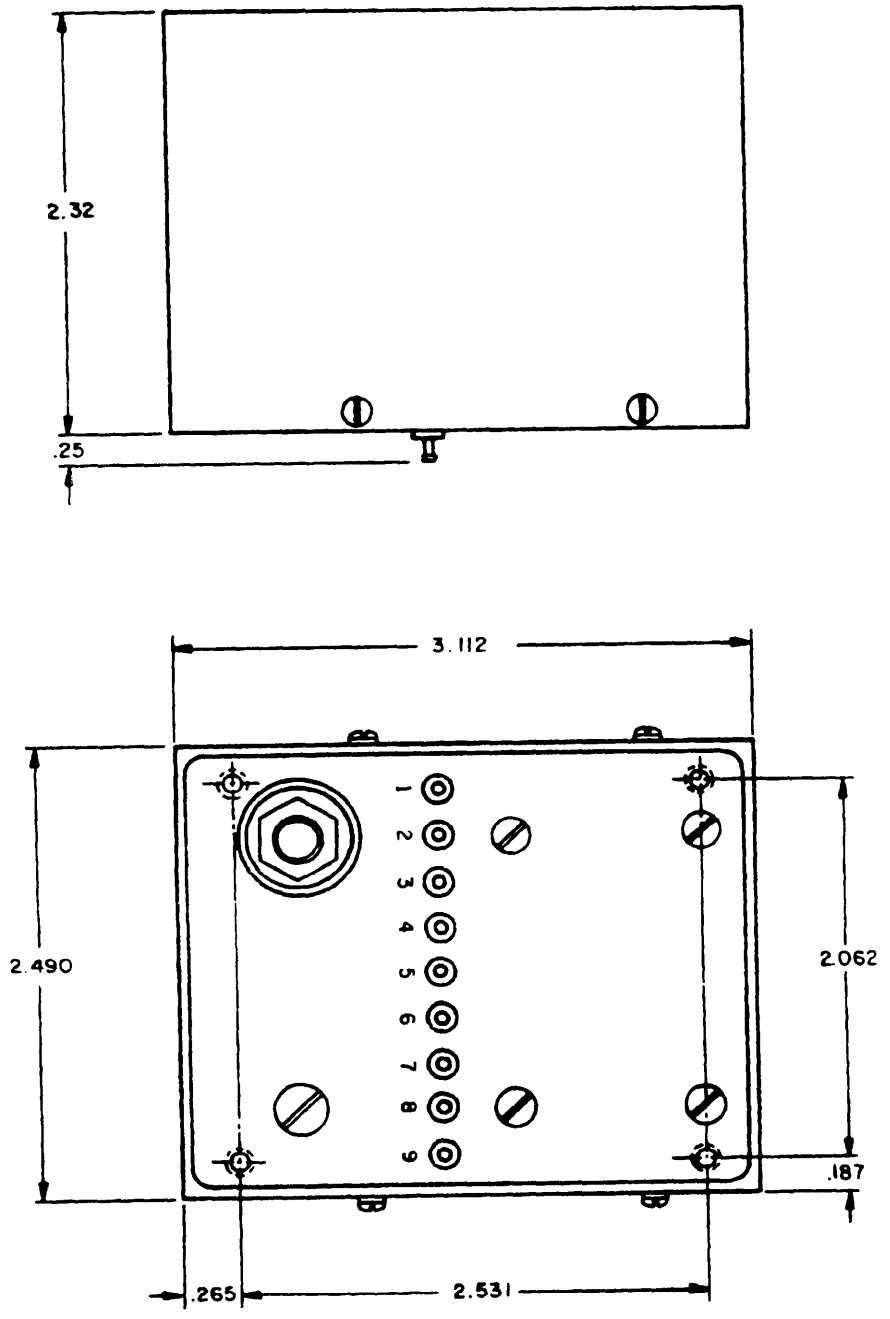


Figure 8.4. 25 Watts

CHAPTER 9

RELAYS

The relays described in this chapter are high-reliability, hermetically sealed (crystal case) units for MK 47, MK 118, and MK 119 computers.

SERVOMOTOR

TYPE 26V-08SM4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage	26	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)	.75	V
Minimum starting (max)		
Current (at stall)	245	mA
Reference phase	178	mA
Control phase (series)	318	mA
Control phase (parallel)	3.6	watts
Power input/phase (max)	.58	
Power factor/phase		
Effective resistance	366	ohms
Control phase (series)	92	ohms
Control phase (parallel)		

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.30	oz-in
Rotor moment of inertia	.20	gm-cm^2
Theoretical acceleration (at stall)	106.000	rad/sec^2
Power output (max)	.4	watts
Temperature rise	85	degrees C
Ambient temperature range	-55 to +125	degrees C
Weight	2.0	oz

REFERENCES

Specification	MIL-S-22432/30B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

SERVOMOTOR

TYPE 26V-08SM4b

ELECTRICAL CHARACTERISTICS (DESIGN)

Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1	V
Current (at stall)		
Reference phase	160	mA
Control phase (series)	118	mA
Control phase (parallel)	210	mA
Power input/phase (max)	2.8	watts
Power factor/phase	.7	
Effective resistance		
Reference phase	260	ohms
Control phase (series)	505	ohms
Control phase (parallel)	126	ohms

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	9800	rpm
Stall torque (min) at 23°C	.3	oz-in.
Rotor moment of inertia	.2	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	106,000	rad/sec^2
Power output (max)		watts
Temperature rise	75	degrees C
Ambient temperature range	-55 to + 125	degrees C
Weight	1.5	oz

REFERENCES

Specification		MIL-S-22432/
Installation drawing	WP Dwg	2571620
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Developed under contract NOw 64-0584-f.

SERVOMOTOR

MK 14 MOD 2

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	53	mA
Control phase (series)	53	mA
Control phase (parallel)	106	mA
Power input/phase (max)	3.5	watts
Power factor/phase	.575	
Effective resistance		
Reference phase	3800	ohms
Control phase (series)	3800	ohms
Control phase (parallel)	950	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min)	0.63	oz-in
Rotor moment of inertia	1.07	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	41,500	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	4.5	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	988714
General arrangement drawing	WP Dwg	988713
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

SERVOMOTOR

TYPE 11SM4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)	3	V
Current (at stall)		
Reference phase	105	mA
Control phase (series)	105	mA
Control phase (parallel)	196	mA
Power input/phase (max)	6.5	watts
Power factor/phase	.54	
Effective resistance		
Reference phase (series)	2168	ohms
Control phase (parallel)	2168	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	1.00	oz-in
Rotor moment of inertia	1.1	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	66,000	rad/sec^2
Power output (max)	1.1	watts
Temperature rise	125	degrees C
Ambient temperature range	-55 to +125	degrees C
Weight	4.6	oz

REFERENCES

Specification	MIL-S-22432/17B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

Formerly MK 14 MOD 4

SERVOMOTOR

TYPE 11SM4c

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	.75	V
Current (at stall)		
Reference phase	63	mA
Control phase (series)	200	mA
Control phase (parallel)	366	mA
Power input/phase (max)	3.7	watts
Power factor/phase	.50	
Effective resistance		
Reference phase	4020	ohms
Control phase	395	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.65	oz-in
Rotor moment of inertia	.8	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	57,000	rad/sec^2
Power output (max)	.8	watts
Temperature rise	65	degrees C
Ambient temperature range	-55 to +125	degrees C
Weight	4.5	oz

REFERENCES

Specification	MIL-S-22432/31B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

SERVOMOTOR

TYPE 11SM4d

ELECTRICAL CHARACTERISTICS (DESIGN)

Frequency	400	Hz
Voltage	115	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)	1	V
Minimum starting (max)		
Current (at stall)	50	mA
Reference phase	150	mA
Control phase (series)	290	mA
Control phase (parallel)	2.8	watts
Power input/phase (max)	.50	
Power factor phase		
Effective resistance	5100	ohms
Reference phase	494	ohms
Control phase (series)	124	ohms
Control phase (parallel)		

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	9800	rpm
Stall torque (min) at 25°C	.33	oz-in.
Rotor moment of inertia	.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	80,000	rad/sec^2
Power output (max)		watts
Temperature rise	65	degrees C
Ambient temperature range	-55 to + 125	degrees C
Weight	4.0	oz

REFERENCES

Specification	WP Dwg	MIL-S-22432/ 2571650
Installation drawing		
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Developed under contract NOw 64-0584-f.

SERVOMOTOR

MK 7 MOD 0

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	110	mA
Control phase (parallel)	220	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	2200	ohms
Control phase (parallel)	550	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	8.0	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	675027
General arrangement drawing	WP Dwg	675025
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

SERVOMOTOR

MK 7 MOD 1

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	110	mA
Control phase (parallel)	220	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	2200	ohms
Control phase (parallel)	550	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	gm-cm^2
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	8.0	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	675069
General arrangement drawing	WP Dwg	675068
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Same as MK 7 MOD 0 except for spline.

SERVOMOTOR

MK 7 MOD 2

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	230	V
Control phase (parallel)	115	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	54	mA
Control phase (parallel)	110	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	8800	ohms
Control phase (parallel)	2200	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	7.3	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	982126
General arrangement drawing	WP Dwg	982127
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

SERVOMOTOR

MK 7 MOD 4

ELECTRICAL CHARACTERISTICS @ 26°C

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	180	mA
Control phase (series)	180	mA
Control phase (parallel)	360	mA
Power input/phase (max)	8.9	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1480	ohms
Control phase (series)	1480	ohms
Control phase (parallel)	370	ohms

MECHANICAL CHARACTERISTICS @ 26 °C

No load speed (min)	5000	rpm
Stall torque (min)	2.0	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	42,600	rad/sec^2
Power output (max)		watts
Ambient temperature range	to +125	degrees C
Weight	7.0	oz

REFERENCES

Specification		
Installation drawing	WP Dwg	1359522
General arrangement drawing	WP Dwg	1359519
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

RELAY, HERMETICALLY SEALED

SPDT 26.5 V COIL

INACTIVE FOR NEW DESIGN

ELECTRICAL CHARACTERISTICS

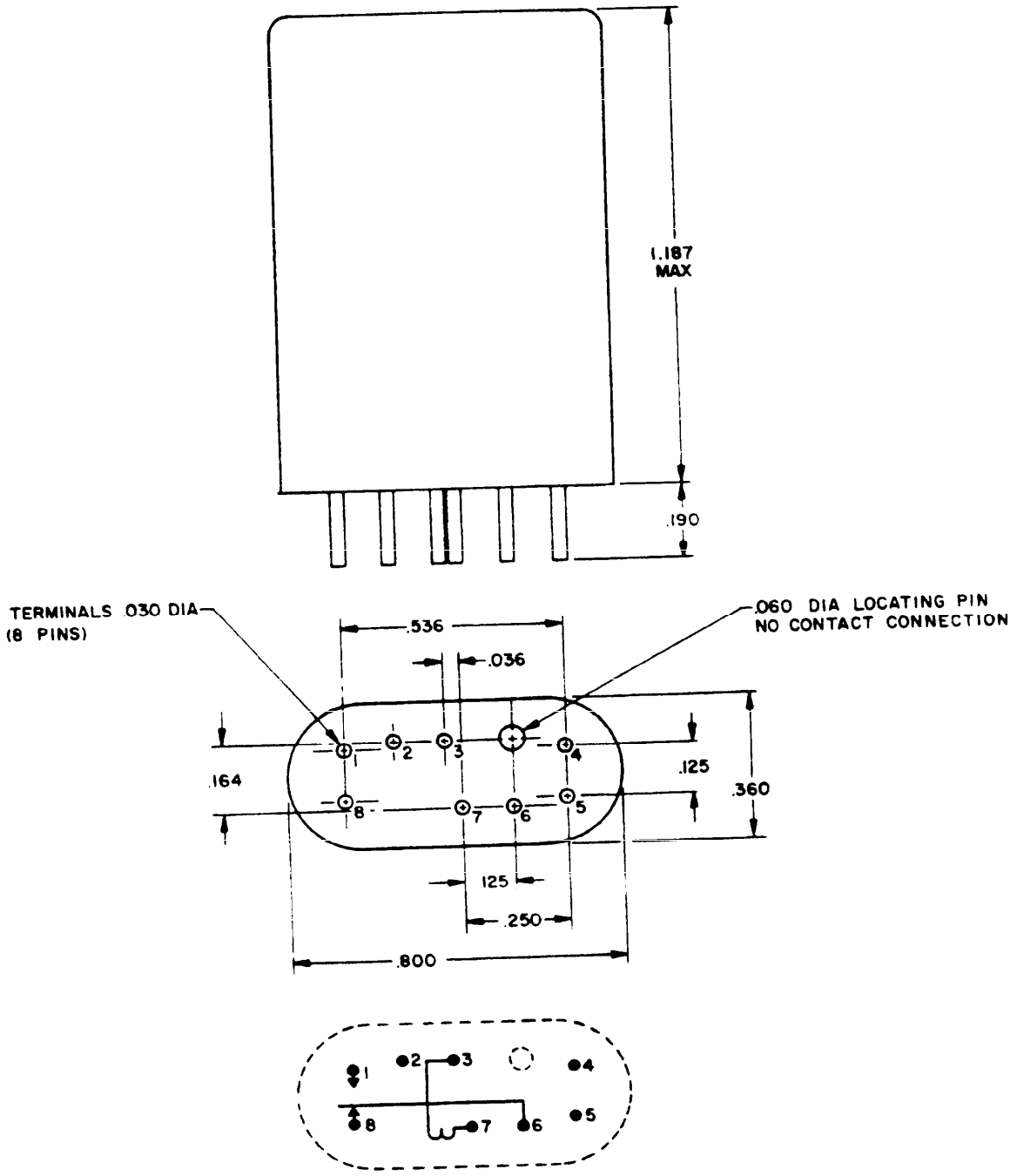
Contact arrangement	SPDT	
Contact rating	28 d.c., 115 a.c.	V
Voltage	2	A
Current	.05	ohms
Resistance/contact (max)		
Coil		
Voltage d.c.		
Nominal (rated)	26.5	V
Pull-in	19.2	V
Drop-out	10.0	V
Power sensitivity	144	mw
Resistance	2556	ohms
Time		
Operate	9	ms
Release	5	ms
Dielectric		
Between terminals & case (sea level)	1000	V rms
Between terminals (sea level)		V rms
Between terminals (80,000 ft)		V rms
Insulation resistance (@25°C)		meg ohms

ENVIRONMENTAL CHARACTERISTICS

Operating temperature range	-55 to +85	degrees C
Shock g's/time duration	40/11	g's/ms
Vibration 50 cps to 500 cps	20	g's
Life-No. of operations (nominal)	100,000	

MECHANICAL CHARACTERISTICS

Size & configuration	per dwg	
Terminals	pin plug	
Mounting	plug	
Weight (max)		oz



TERMINAL DIAGRAM

Figure 9.1. SPDT 24 5 V Coil

SPDT 26.5 V COIL (Continued)

REFERENCES

Specification		MIL-R-5757
Installation drawing	WP Dwg	1226344
Federal Stock Number (FSN)		5945-543-8214
Qualified Products List (QPL)		

NOTES

Coil is current calibrated.
Used on computers MK 47 MOD 8 and 9
MK 118 MOD 0, 1 and 2
MK 119 MOD 0, 1, 3, and 4

RELAY, HERMETICALLY SEALED

DPDT 39.4 V COIL

ELECTRICAL CHARACTERISTICS

Contact arrangement	DPDT	
Contact rating (resistive load)		
Voltage	50 d.c., 115 a.c.	V
Current	2	A
Resistance/contact (max)	.05	ohms
Coil		
Voltage d.c.		
Nominal (rated)	39.4	V
Pull-in	26.7	V
Drop-out	13.8	V
Power sensitivity	387	mw
Resistance	1840	ohms
Time		
Operate	5	ms
Release	5	ms
Dielectric		
Between terminals and case (sea level)	1000	V rms
Between terminals (sea level)	750	V rms
Between terminals (80,000 ft)		V rms
Insulation resistance (@25°C)	1000	meg ohms

ENVIRONMENTAL CHARACTERISTICS

Operating temperature range		degrees C
Shock g's/time duration		g's/ms
Vibration 10 cps to 2000 cps		g's
Life-No. of operations (nominal)	100,000	

MECHANICAL CHARACTERISTICS

Size and configuration	per dwg	
Terminals	pin plug	
Mounting	flange	
Weight (max)		oz

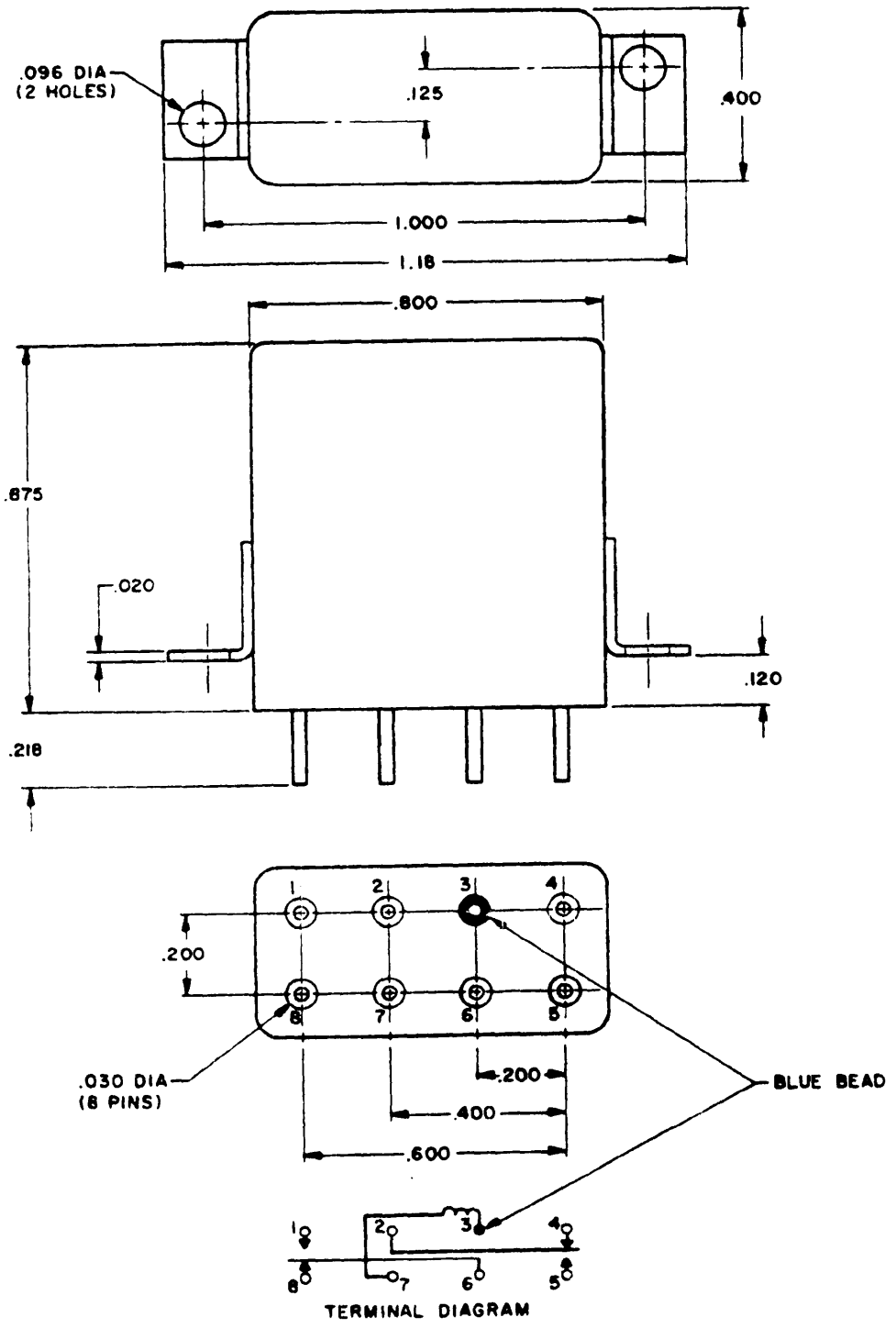


Figure 9.2. DPDT 39.4 V Coil

DPDT 39.4 V COIL (Continued)

REFERENCES

Specification		MIL-R-5757
Installation drawing	WP Dwg	2324701
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Used on computers MK 119 MOD 3 and 4

CHAPTER 10

RESOLVERS

The resolvers described in this chapter are of the inductive type. These instruments are designed to operate on a single variable input voltage and to produce two voltages; one voltage is equal to the product of the input voltage and the sine of the angle of shaft rotation from electrical zero, and one voltage is equal to the product of the input voltage and the cosine of the angle of shaft rotation from electrical zero. In general, these instruments require the use of amplifiers for isolation and for compensation.

RESOLVER, ELECTRICAL

TYPE 15R11W4a

ELECTRICAL CHARACTERISTICS

	stator	
Excitation winding	400	Hz
Frequency	26	V
Input voltage (max)	14	mA
Primary current (nom)	0.044	watts
Primary power (nom)		
Impedance		
Zro	200 + J1200	ohms
Zso	225 + J1050	ohms
Zrs	285 + J125	ohms
Zco	275 + J1100	ohms
Transformation ratio, rotor/stator	0.98	
Phase shift (nominal)	8.5	degrees
Null voltage		
Fundamental	8	mV (rms)
Total	15	mV (rms)
Function error (max)	±0.1	percent
Shift of resolver zero		
with voltage	± 1.0	minutes
with frequency	± 0.5	minutes

MECHANICAL CHARACTERISTICS

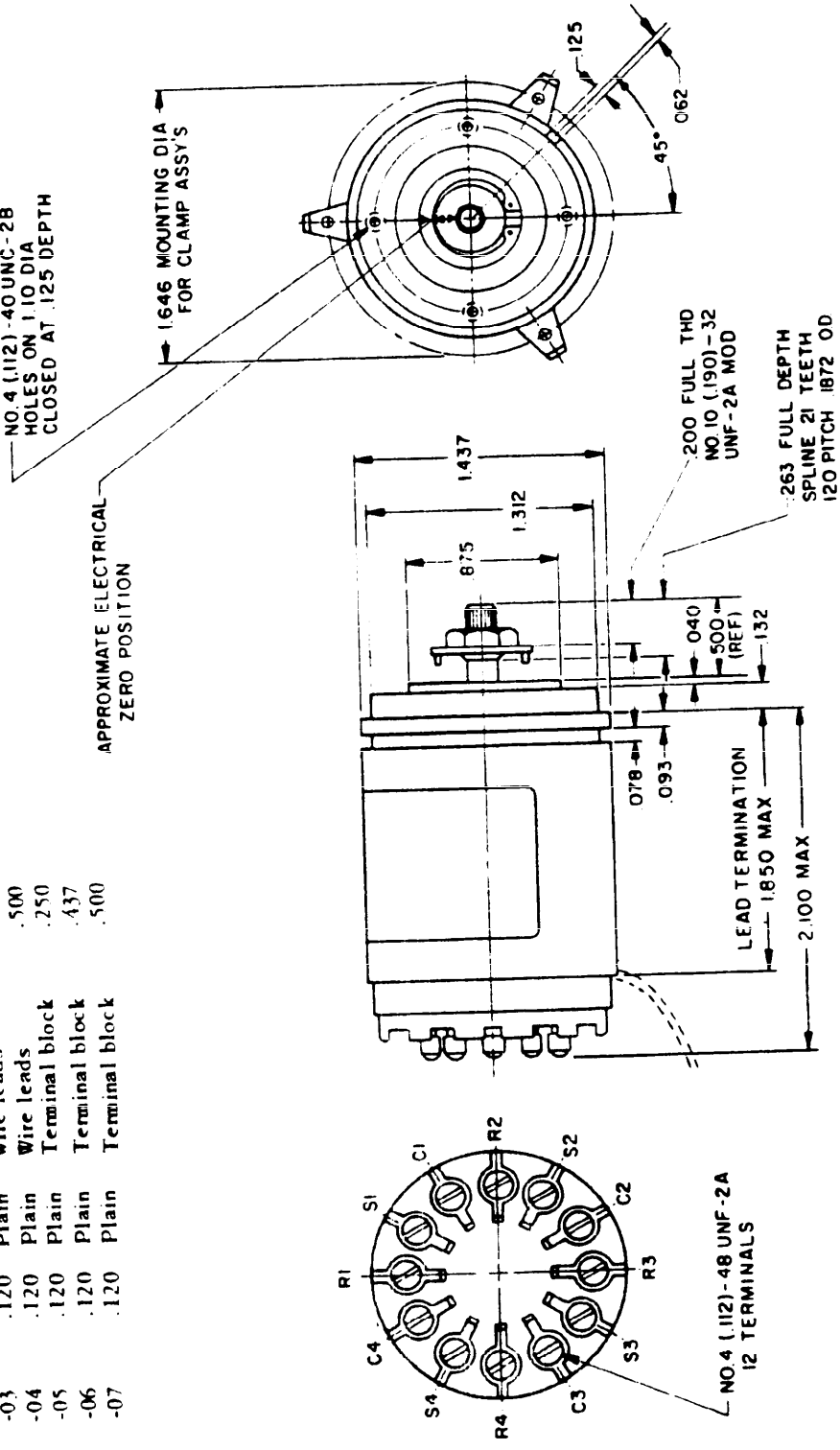
Friction torque (max)	0.15	oz-in
Ambient temperature range	-55 to +125	degrees C
Weight		oz

REFERENCES

Specification	MIL-R-23417/26
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Preferred version of the MK 4 MOD 0 (MIL-R-23417/6A (OS)).



Dash No.	Shaft Dia.	Shaft Style	Termination	Shaft Length (REF)
-01	.187	Spline	Terminal block	.500
-02	.120	Plain	Wire leads	.250
-03	.120	Plain	Wire leads	.437
-04	.120	Plain	Wire leads	.500
-05	.120	Plain	Terminal block	.250
-06	.120	Plain	Terminal block	.437
-07	.120	Plain	Terminal block	.500

Figure 10.1. Type 15R11W4a

RESOLVER, ELECTRICAL

TYPE 15R26W4a

ELECTRICAL CHARACTERISTICS

Excitation winding	stator	
Frequency	400	Hz
Input voltage (max)	26	V
Primary current (nom)	5.7	mA
Primary power (nom)	0.015	watts
Impedance		
Zro	450 + J2800	ohms
Zso	470 + J2545	ohms
Zrs	710 + J250	ohms
Zco	640 - J2700	ohms
Transformation ratio, rotor/stator	0.98	
Phase shift (nominal)	8.5	degrees
Null voltage		
Fundamental	8	mV (rms)
Total	15	mV (rms)
Function error (max)	±0.1	percent
Shift of resolver zero		
with voltage	±1	minutes
with frequency	±0.5	minutes

MECHANICAL CHARACTERISTICS

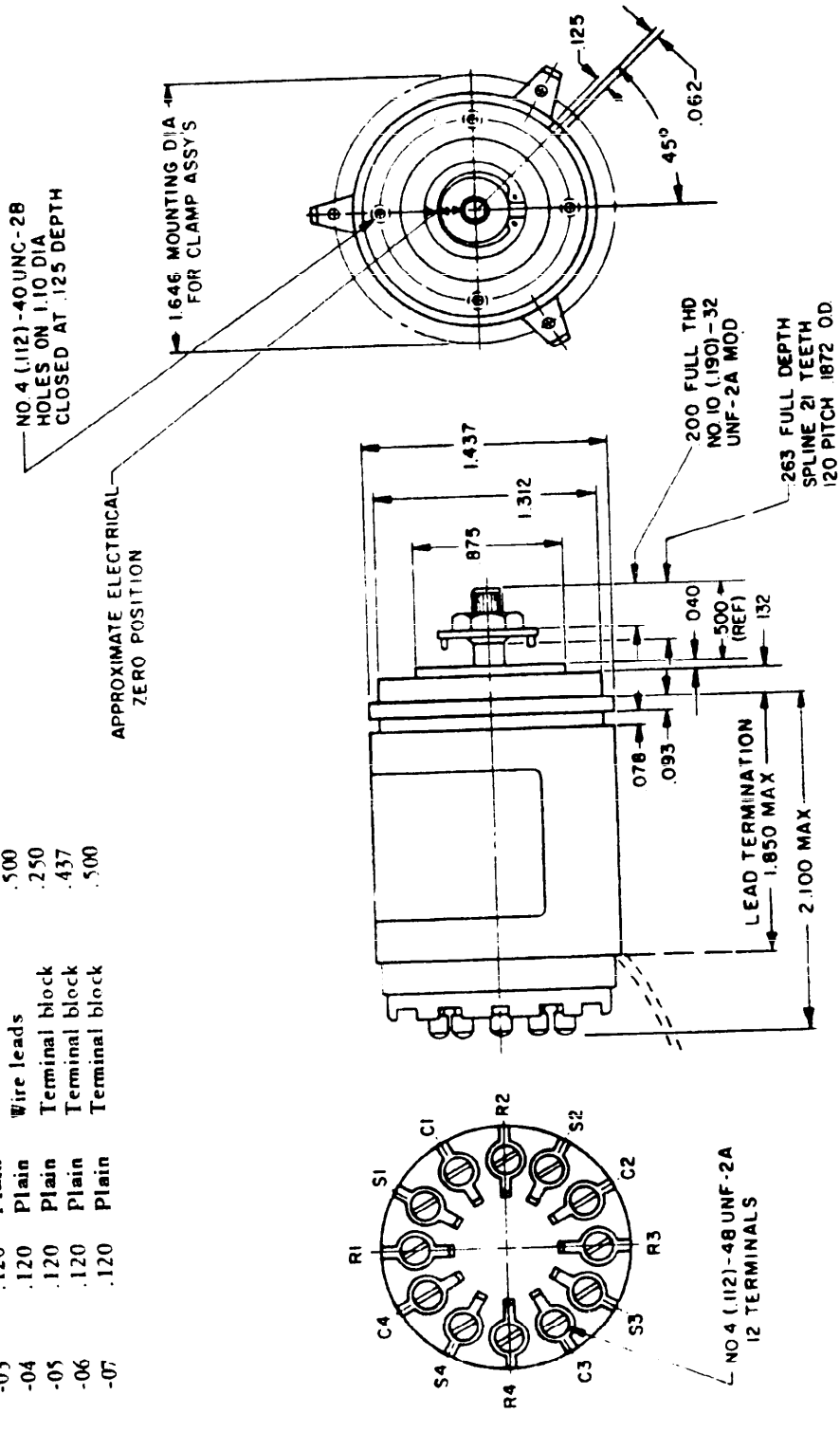
Friction torque (max)	0.15	oz-in
Ambient temperature range	-55 to +125	degrees C
Weight		oz

REFERENCES

Specification	MIL-R-23417/27
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Preferred version of the MK 4 MOD 1 (MIL-R-23417/8A (OS)).



Dash No.	Shaft Dia.	Shaft Style	Termination	Shaft Length (REF)
-01	.187	Spline	Terminal block	.500
-02	.120	Plain	Wire leads	.250
-03	.120	Plain	Wire leads	.437
-04	.120	Plain	Wire leads	.500
-05	.120	Plain	Terminal block	.250
-06	.120	Plain	Terminal block	.437
-07	.120	Plain	Terminal block	.500

Figure 10.2. Type 15R26W4a

RESOLVER, ELECTRICAL

TYPE 23R32W4a

ELECTRICAL CHARACTERISTICS

Excitation winding	stator	
Frequency	400	Hz
Input voltage (max)	130	V
Primary current (nom)	19	mA
Primary power (nom)	.078	watts
DC resistance		
Stator	97	ohms
Rotor	172	ohms
Compensator	200	ohms
Transformation ratio, output/input	.98	
Phase shift (output/input)	1.9	degrees
Null voltage		
Fundamental	20	mV (rms)
Total	30	mV (rms)
Function error	± 0.05	percent
Shift of resolver zero		
with voltage	±1.0	minutes
with frequency	±0.5	minutes

MECHANICAL CHARACTERISTICS

Friction torque (max)	0.2	oz-in
Temperature rise (max)	20	degrees C
Weight		oz

REFERENCES

Specification	MIL-R-23417/17
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

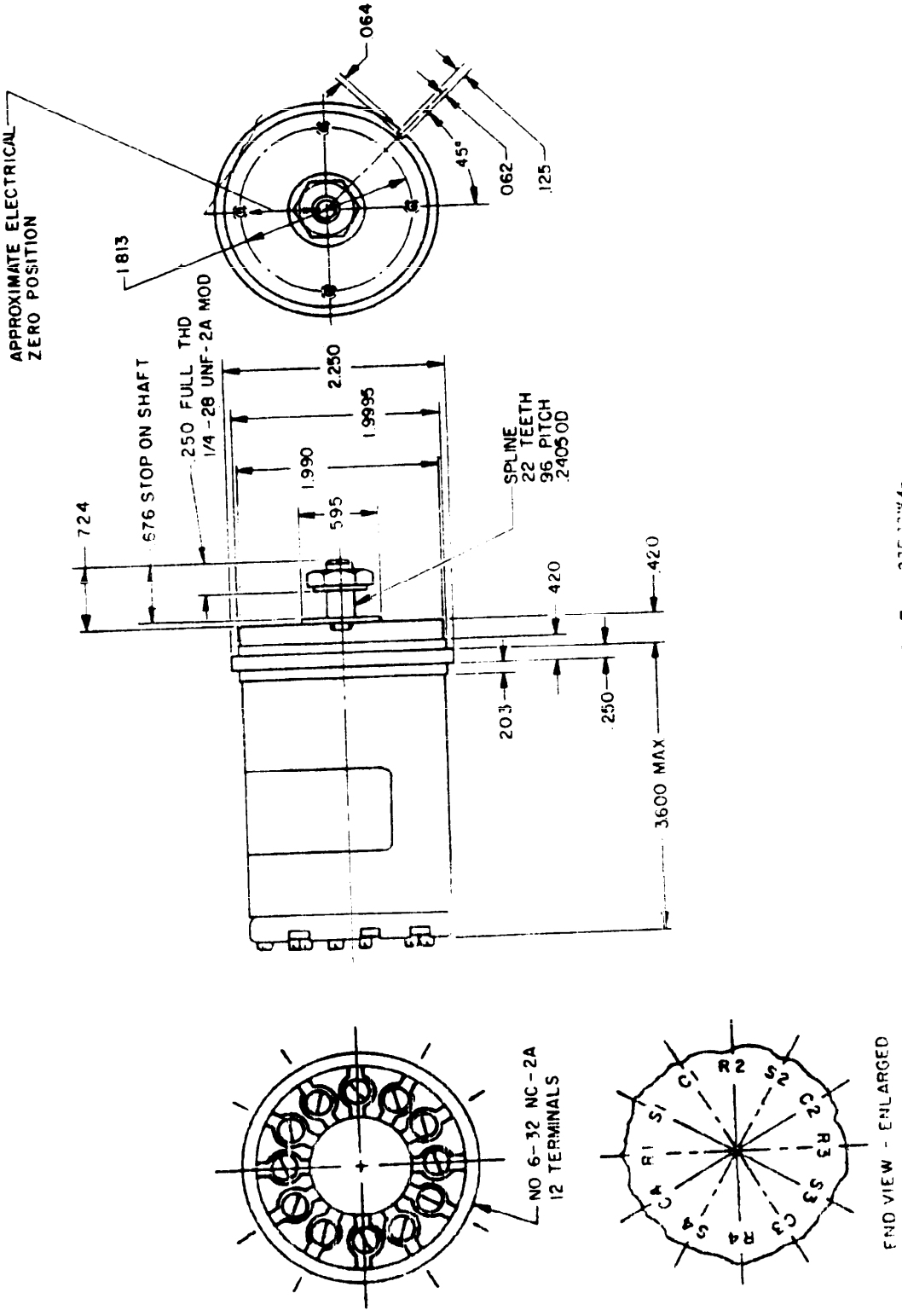


Figure 10.3. Type 23E32W4a

RESOLVER, ELECTRICAL

TYPE 23R58N4a

ELECTRICAL CHARACTERISTICS

Excitation winding	Stator	
Frequency	400	Hz
Input voltage (max)	100	V
Primary current (nom)	8.5	mA
Primary power (nom)	.063	watts
DC resistance		
Stator	130	ohms
Rotor	230	ohms
Impedance, Zso	870 + J5790	ohms
Transformation ratio, output/input	.975	
Phase shift (output/input)	1.2	degrees
Null voltage		
Fundamental	20	mV (rms)
Total	30	mV (rms)
Function error	±.05	percent
Shift of resolver zero		
with voltage	±1.0	minutes
with frequency	±0.5	minutes

MECHANICAL CHARACTERISTICS

Friction torque (max)	0.2	oz-in
Temperature rise (max)	20	degrees C
Weight		oz

REFERENCES

Specification	MIL-R-23417/19
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

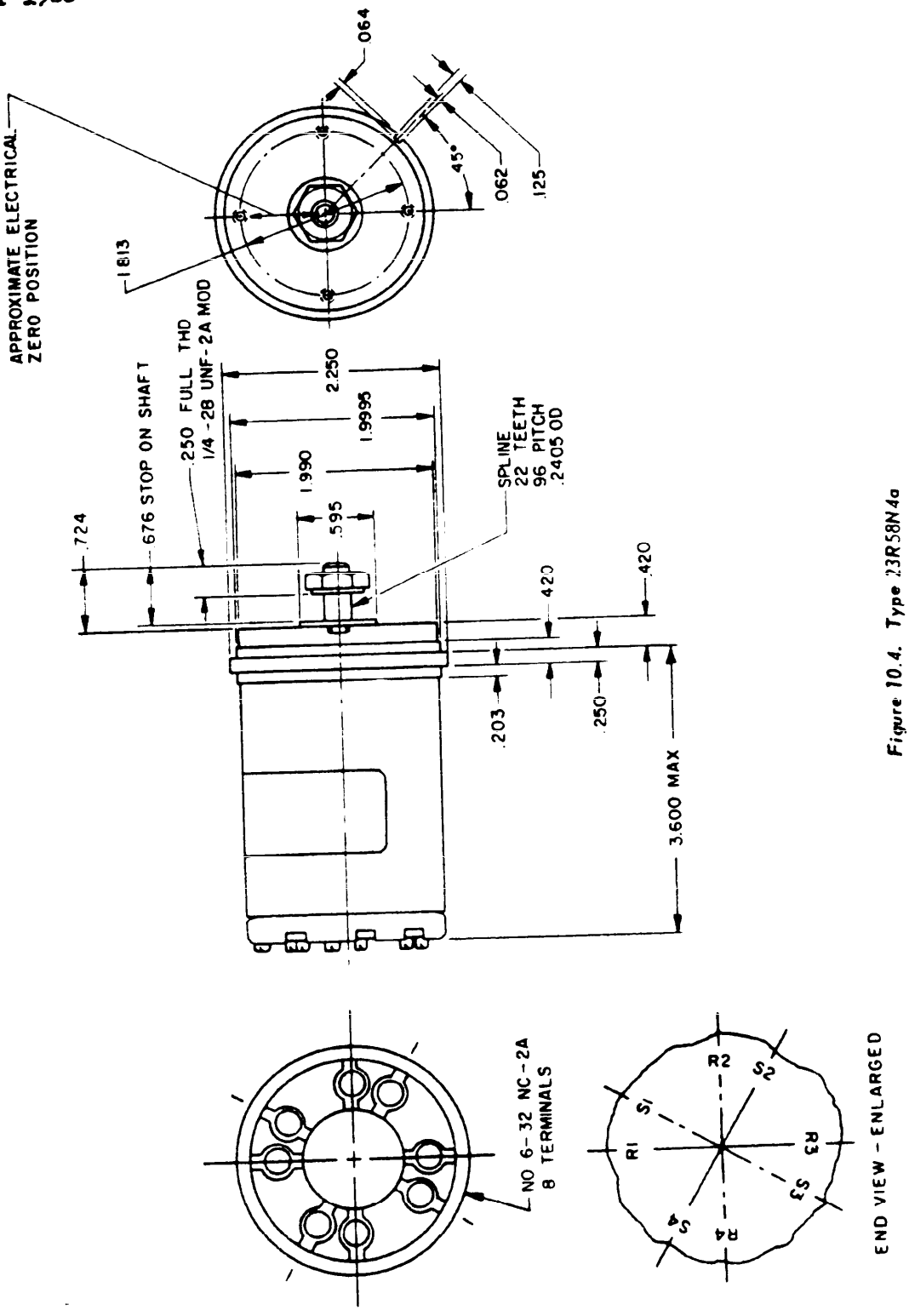


Figure 10.4. Type 23R58N4a

RESOLVER, ELECTRICAL

TYPE 23R58W4a

ELECTRICAL CHARACTERISTICS

Excitation winding	stator	
Frequency	400	Hz
Input voltage (max)	100	V
Primary current (nom)	8.5	mA
Primary power (nom)	.047	watts
DC resistance		
Stator	205	ohms
Rotor	45	ohms
Compensator	53	ohms
Transformation ratio, output/input	.298	
Phase shift (output/input)	1.9	degrees
Null voltage		
Fundamental	10	mV (rms)
Total	15	mV (rms)
Function error	±.05	percent
Shift of resolver zero		
with voltage	± 1.0	minutes
with frequency	± 0.5	minutes

MECHANICAL CHARACTERISTICS

Friction torque (max)	0.2	oz-in
Temperature rise (max)	20	degrees C
Weight		oz

REFERENCES

Specification	MIL-R-23417/20
Installation drawing	
General Arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

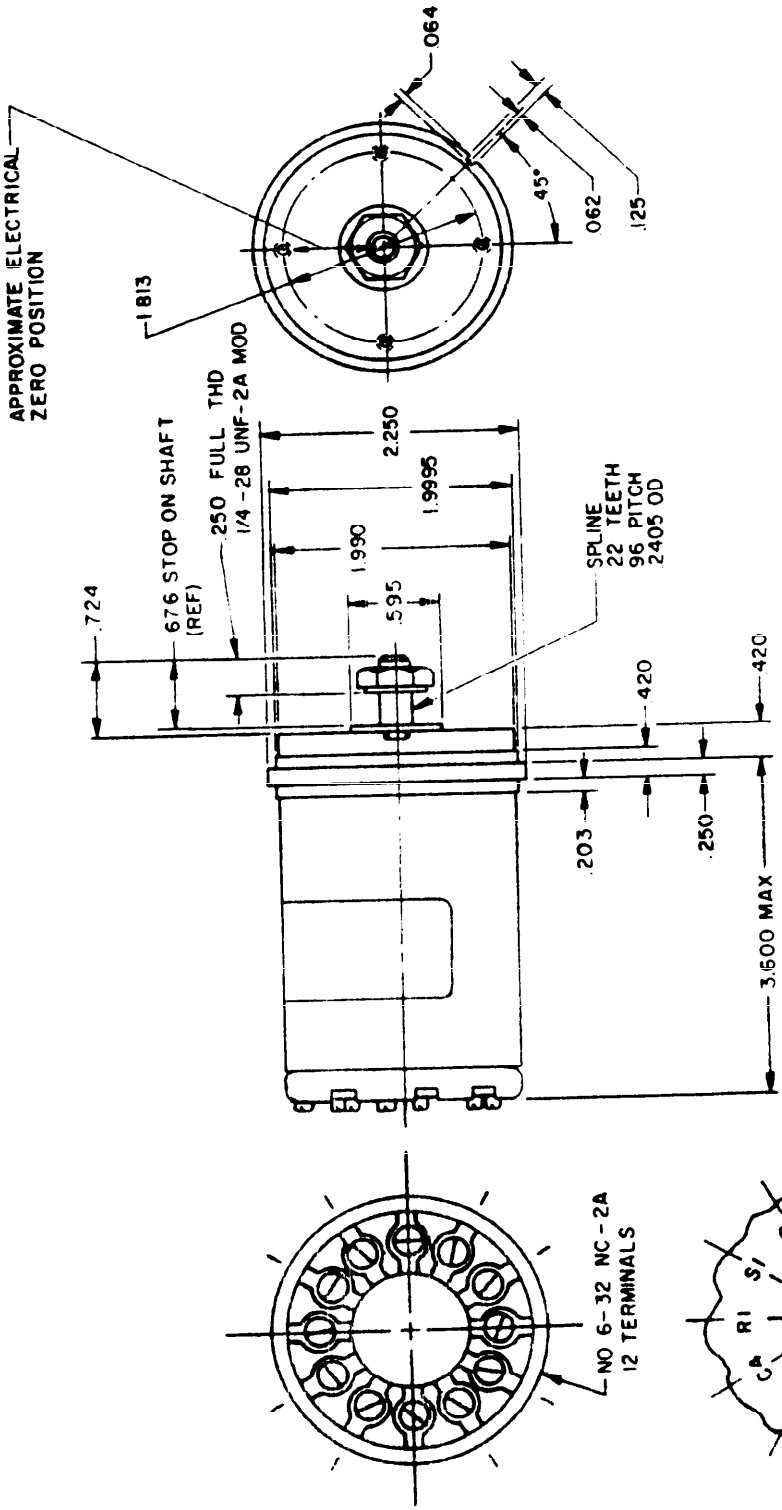


Figure 10.5. Type 23R58W4a

RESOLVER, ELECTRICAL, AND AMPLIFIER

MK 4 MOD 1

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Rotor output voltage	26	Vrms
Inputs	3/channel - 2 channels	
Input impedance	500 kohms shunted with 5 pf	
Power supply		
Voltage	-55	V
Current	38	mA
Ripple	.2% of nominal	
Impedance	25 ohm resistor in series with 10 mH inductor	
Transient	5% above nominal	
Transformation ratio		
At 400 Hz input to rotor at max	1 ± .0014 ± j.0014	
0-200 kHz	2	
Total output noise (max)	1	mVrms
Harmonic distortion (max)	.1	percent
Upper cutoff frequency (3db), max	35	kHz
Max transient input, 1 sec, 400Hz	52	Vrms

MECHANICAL CHARACTERISTICS

Weight	9.75	oz

NOTES

Developed under contract N600(19)60560.
This integrated unit contains dual hybrid monolithic amplifiers trimmed to its associated computing resolver.

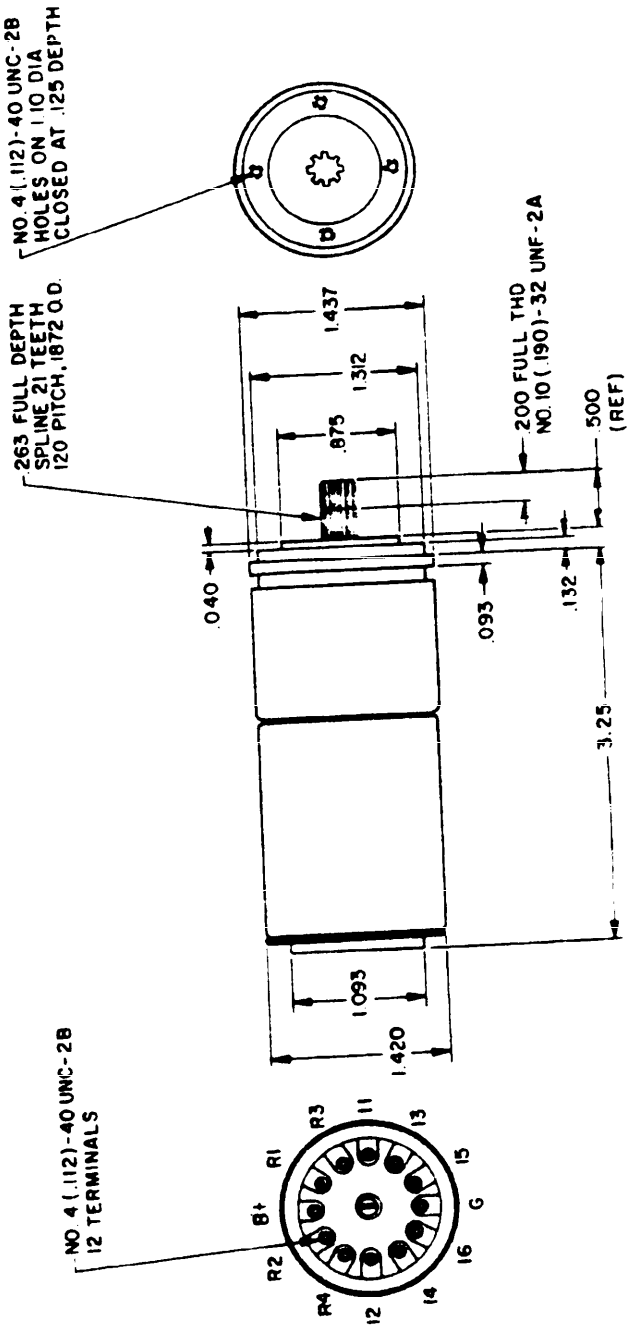


Figure 10.6. Resolver and Amplifier, MK 4 MOD 1

CHAPTER 11

SERVO GEARHEADS

A compilation of Servo Gearheads is being prepared

CHAPTER 12

SERVOMOTORS

The motors described in this chapter are precision grade machines designed for servo use and for special purposes.

SERVOMOTOR

TYPE 26V-05SM4a

ELECTRICAL CHARACTERISTICS (DESIGN)

Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1	V
Current (at stall)		
Reference phase	90	mA
Control phase (series)	65	mA
Control phase (parallel)	125	mA
Power input/phase (max)	2.0	watts
Power factor/phase	.78	
Effective resistance		
Reference phase	392	ohms
Control phase (series)	765	ohms
Control phase (parallel)	191.2	ohms

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	9500	rpm
Stall torque (min) at 23°C	.075	oz-in.
Rotor moment of inertia	.03	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	160,000	rad/sec^2
Power output (max)		watts
Temperature rise (max)	50	degrees C
Ambient temperature range	-55 to + 125	degrees C
Weight	.75	oz

REFERENCES

Specification	MIL-S-22432/
Installation drawing	WP Dwg 2571715
General Arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Developed under contract NOw 64-0583-f.

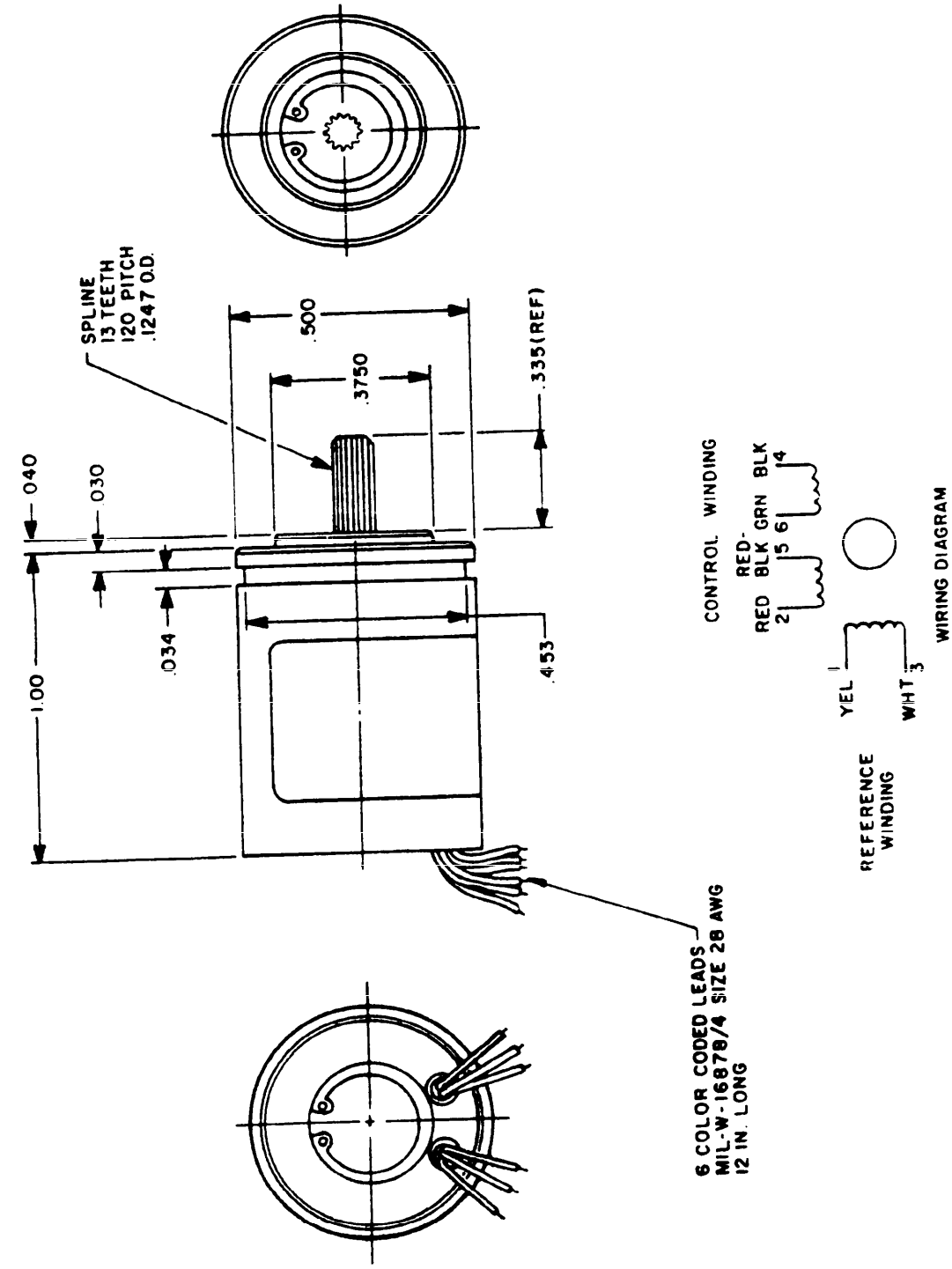


Figure 12.1. Type 26V-055M4a

SERVOMOTOR

TYPE 26V-08SM4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	.75	V
Current (at stall)		
Reference phase	245	mA
Control phase (series)	178	mA
Control phase (parallel)	318	mA
Power input/phase (max)	3.6	watts
Power factor/phase	.58	
Effective resistance		
Control phase (series)	366	ohms
Control phase (parallel)	92	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.30	oz-in
Rotor moment of inertia	.20	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	106,000	rad/sec^2
Power output (max)	.4	watts
Temperature rise	85	degrees C
Ambient temperature range	-55 to +125	degrees C
Weight	2.0	oz

REFERENCES

Specification	MIL-S-22432/30B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

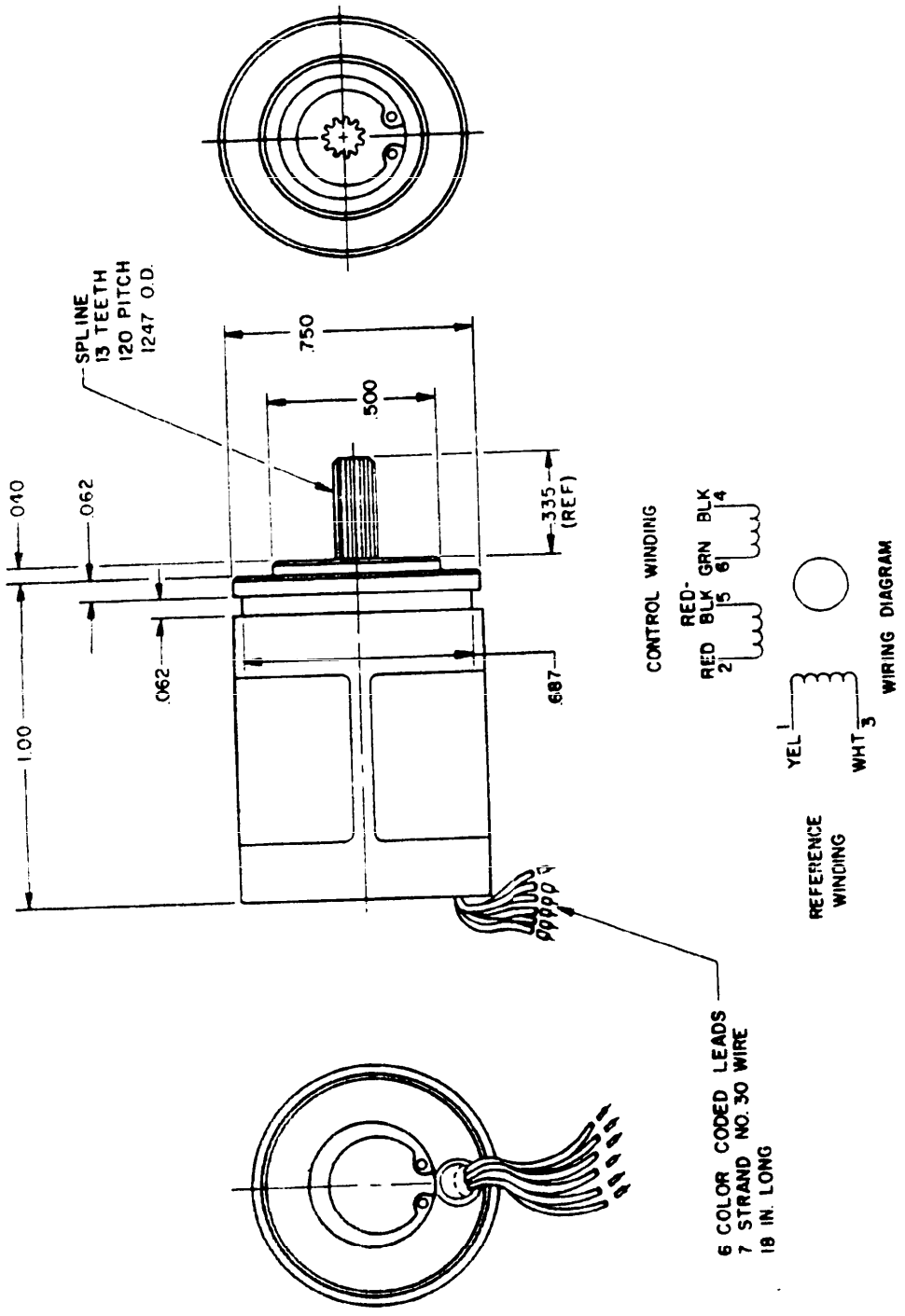


Figure 12.2. Type 26V-08SM4a

SERVOMOTOR

TYPE 26V-08SM4b

ELECTRICAL CHARACTERISTICS (DESIGN)

Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1	V
Current (at stall)		
Reference phase	160	mA
Control phase (series)	118	mA
Control phase (parallel)	210	mA
Power input/phase (max)	2.8	watts
Power factor/phase	.7	
Effective resistance		
Reference phase	260	ohms
Control phase (series)	505	ohms
Control phase (parallel)	126	ohms

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	9800	rpm
Stall torque (min) at 23°C	.3	oz-in.
Rotor moment of inertia	.2	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	106,000	rad/sec^2
Power output (max)		watts
Temperature rise	75	degrees C
Ambient temperature range	−55 to + 125	degrees C
Weight	1.5	oz

REFERENCES

Specification		MIL-S-22432/
Installation drawing	WP Dwg	2571620
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Developed under contract NOw 64-0584-f.

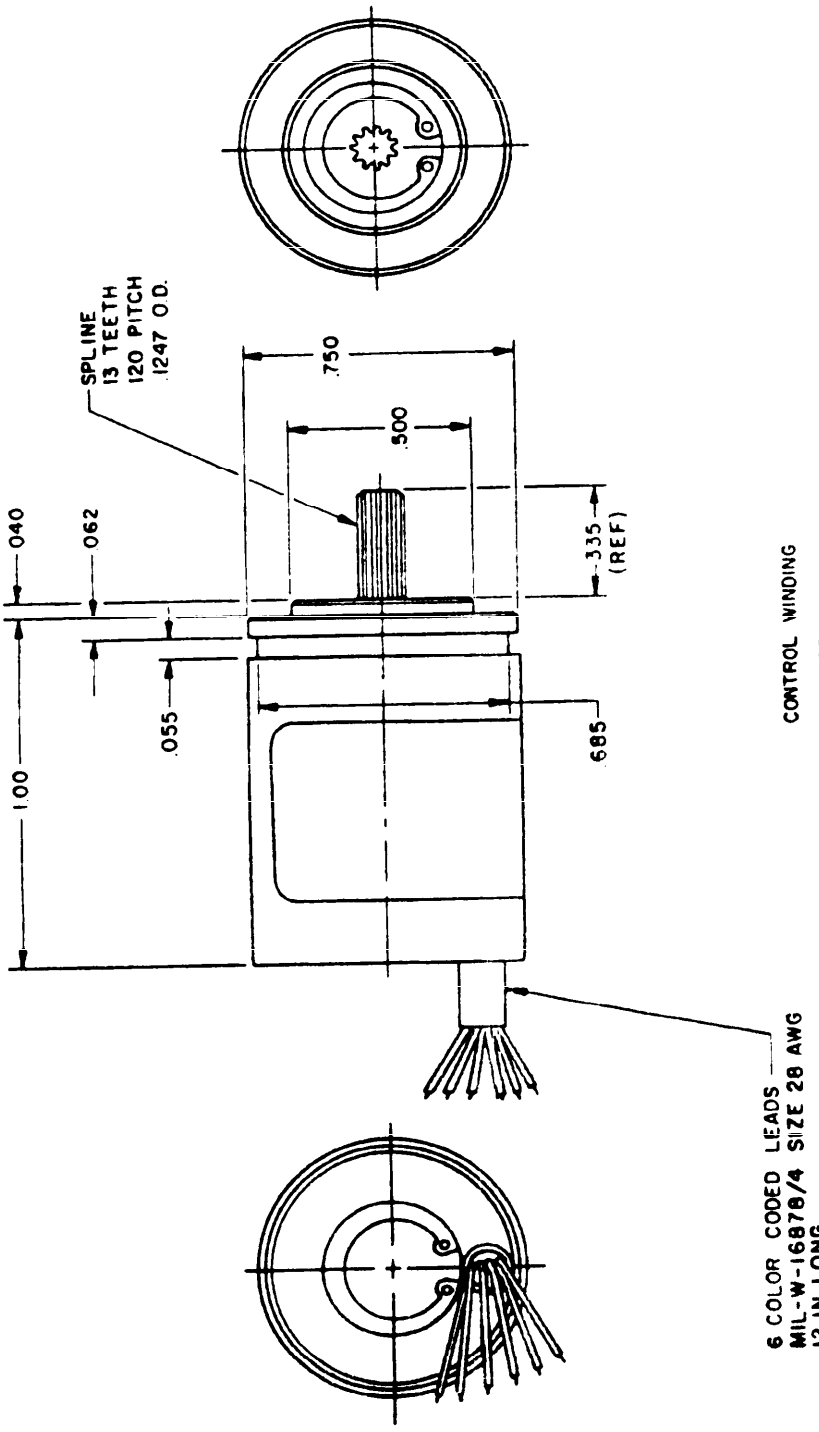


Figure 12.3. Type 26V-08SM4b

SERVOMOTOR TACHOMETER GENERATOR

TYPE 11SM-DG4a

ELECTRICAL CHARACTERISTICS, Servomotor Section		
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1.0	V
Current (at stall)		
Reference phase	62	mA
Control phase (series)	197	mA
Energizing	41-52	mA
Power input/phase (max)	3.7	watts
Power factor/phase	.52	
Impedance		
Reference phase	1070 + j 1760	ohms
Control phase (series)	106 + j 173	ohms
Output	800	ohms
MECHANICAL CHARACTERISTICS, Servomotor Section		
No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.60	oz-in.
Rotor moment of inertia	1.3	gm-cm^2
Theoretical acceleration (at stall)	32,600	rad/sec^2
Ambient temperature range	−55 to +125	degrees C
Weight	6.5	oz
ELECTRICAL CHARACTERISTICS, Tachometer Generator Section		
In-phase speed sensitive TR	.0143	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (max)	±.5	percent
Zero-speed output voltages		
Total (max)	12	mV
Fundamental (max)	8	mV
Output gradient	.55	v/1000 rpm
Temperature sensitivity (over range −55 to 125°C)		
In-phase speed sensitive TR (min)	.0098	
Phase shift (max)	15	degrees
Zero-speed output		
Total (max)	22	mV
Fundamental (max)	15	mV

TYPE 11SM-DG4a (Continued)

REFERENCES

Specification	MIL-S-22820/32(AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

TYPE 11SM-IN4a

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1.0	V
Current (at stall)		
Reference phase	62	mA
Control phase (series)	197	mA
Energizing	83	mA
Power input/phase (max)	3.7	watts
Power factor/phase	0.52	
Impedance		
Reference phase	1070 + j 1760	ohms
Control phase (series)	106 + j 173	ohms
Output	2800 + j 5500	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.60	oz-in.
Rotor moment of inertia	7.5	gm-cm^2
Theoretical acceleration (at stall)	6,000	rad/sec^2
Ambient temperature range	−55 to +125	degrees C
Weight	8.5	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

In-phase speed sensitive TR	.07150	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (500 to 3600 rpm)	±.07	percent
Axis error voltages		
In-phase (max)	±4	mV
Quadrature-phase (max)	+7	mV
Zero-speed output voltage, total (max)	15	mV
Position error voltages		
In-phase (max)	5	mV
Quadrature-phase (max)	10	mV
Output gradient	2.75	v/1000 rpm

TYPE 11SM-IN4a (Continued)

Temperature sensitivity (over range −55 to 125°C)		
In-phase speed sensitive TR		value measured at 23°C
Phase shift		value measured at 23°C
In-phase axis error voltage (max)	8	mV
Zero-speed output, total (max)	20	mV
In-phase position error voltage (max)	5	mV
Frequency sensitivity (over range 380 to 420 Hz)		
In-phase speed sensitive TR		value measured at 400 Hz
Phase shift		value measured at 400 Hz
Zero-speed output voltage, total (max)	20	mV
Voltage sensitity (over range 115 V ±10%)		
In-phase speed sensitive TR		value measured at 115 V
Phase shift		value measured at 115 V

REFERENCES

Specification	MIL-S-22820/33 (AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

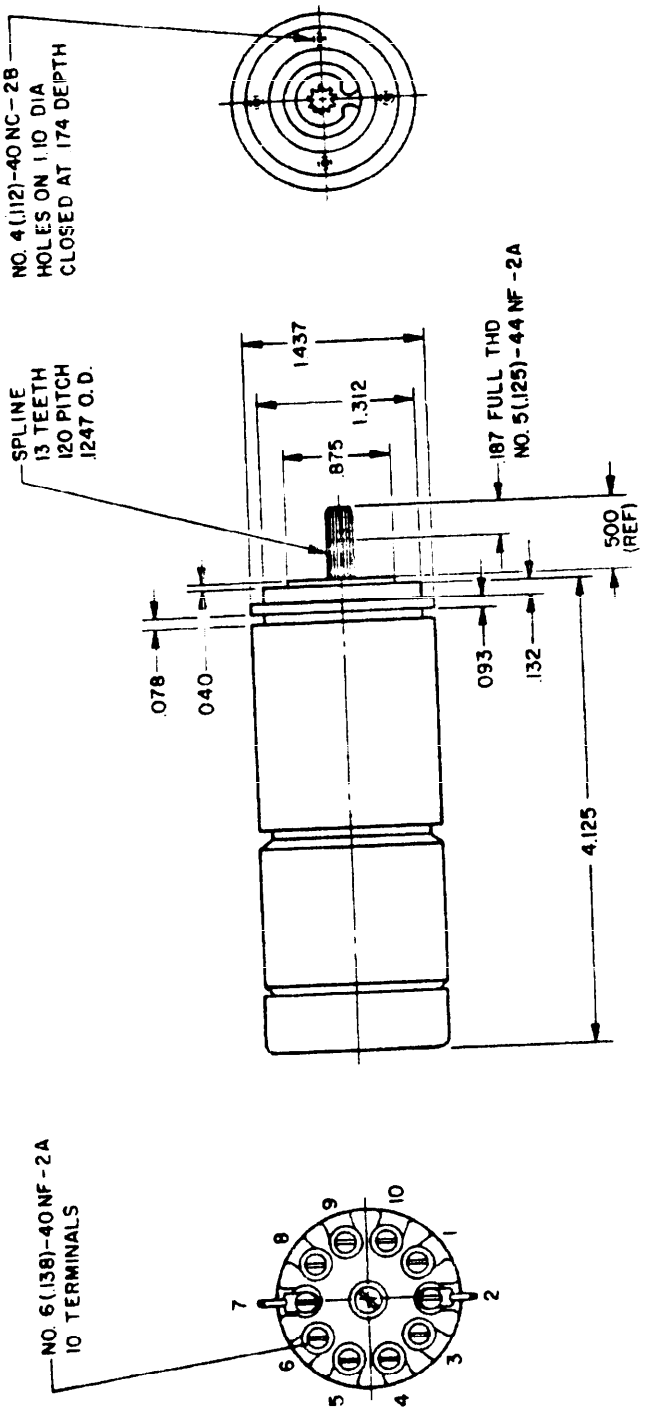


Figure 13.5. MK 11 MOD 0

SERVOMOTOR

MK 7 MOD 0

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	110	mA
Control phase (parallel)	220	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	2200	ohms
Control phase (parallel)	550	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	8.0	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	675027
General arrangement drawing	WP Dwg	675025
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

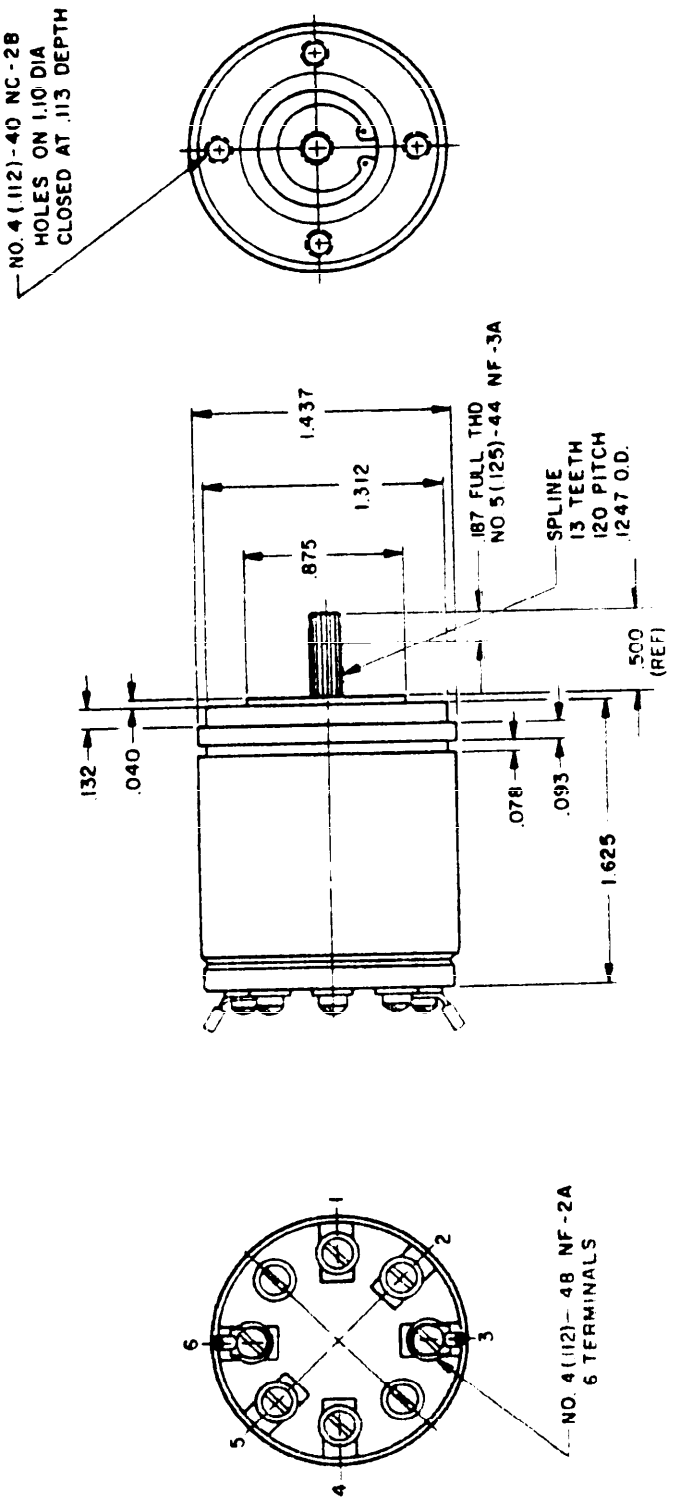


Figure 12.8. MK 7 MOD 0

SERVOMOTOR

MK 7 MOD 1

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	110	mA
Control phase (parallel)	220	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	2200	ohms
Control phase (parallel)	550	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	gm-cm^2
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	8.0	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	675069
General arrangement drawing	WP Dwg	675068
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Same as MK 7 MOD 0 except for spline.

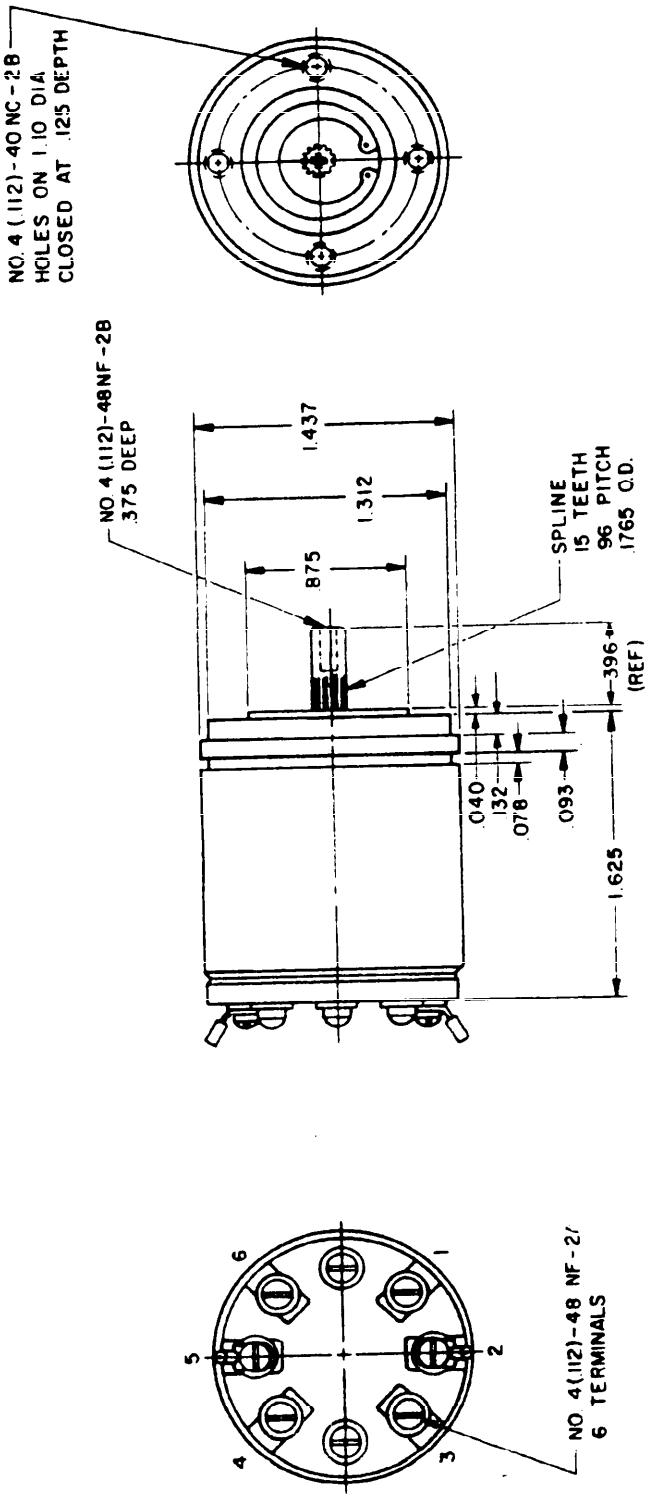


Figure 12.9. MK 7 MOD 1

SERVOMOTOR

MK 7 MOD 2

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	230	V
Control phase (parallel)	115	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	54	mA
Control phase (parallel)	110	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	8800	ohms
Control phase (parallel)	2200	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	31,000	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	7.3	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	982126
General arrangement drawing	WP Dwg	982127
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

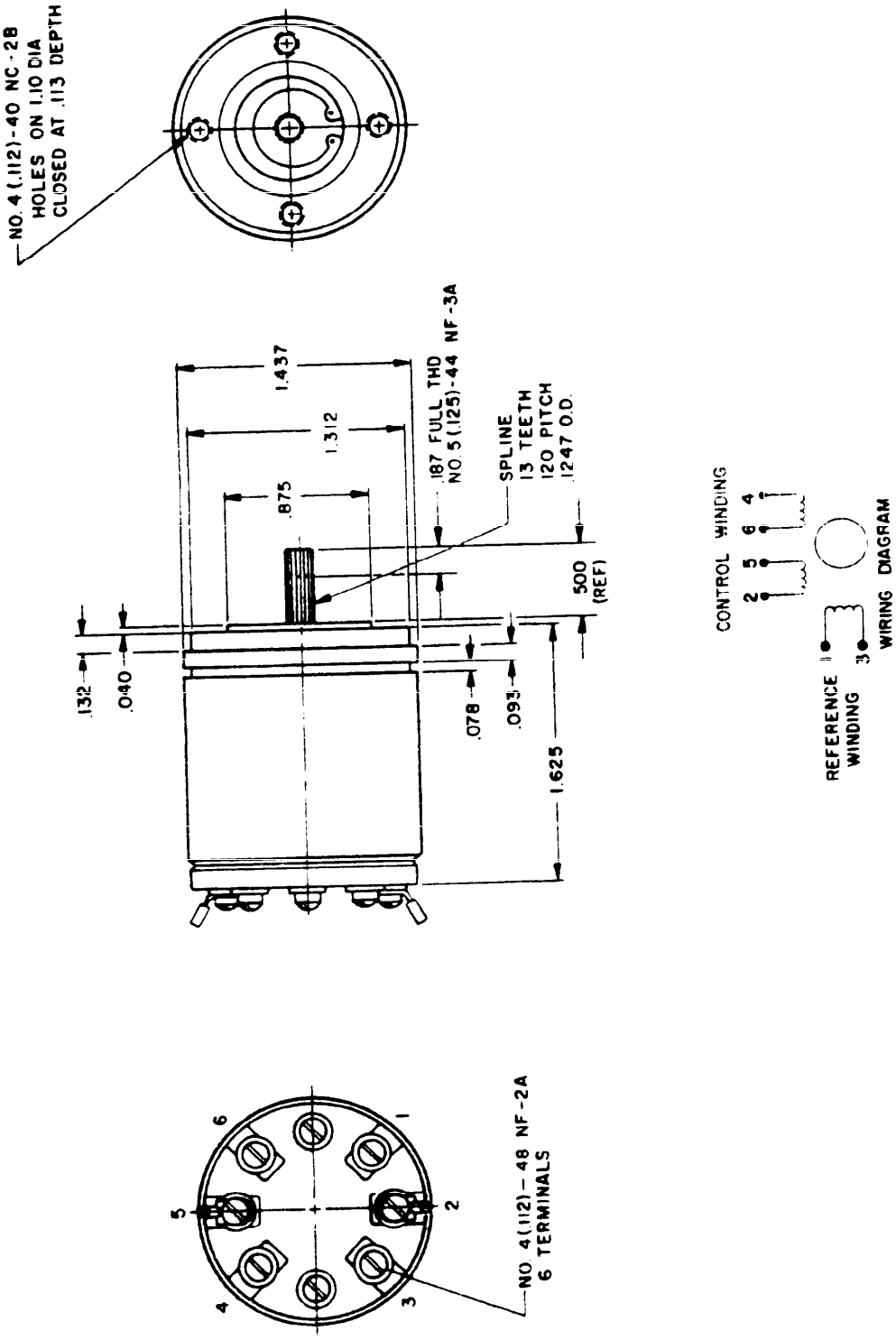


Figure 12.10. MK 7 MOD 2

SERVOMOTOR

MK 7 MOD 4

ELECTRICAL CHARACTERISTICS @ 26°C

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	180	mA
Control phase (series)	180	mA
Control phase (parallel)	360	mA
Power input/phase (max)	8.9	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1480	ohms
Control phase (series)	1480	ohms
Control phase (parallel)	370	ohms

MECHANICAL CHARACTERISTICS @ 26°C

No load speed (min)	5000	rpm
Stall torque (min)	2.0	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	42,600	rad/sec^2
Power output (max)		watts
Ambient temperature range	to +125	degrees C
Weight	7.0	oz

REFERENCES

Specification		
Installation drawing	WP Dwg	1359522
General arrangement drawing	WP Dwg	1359519
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

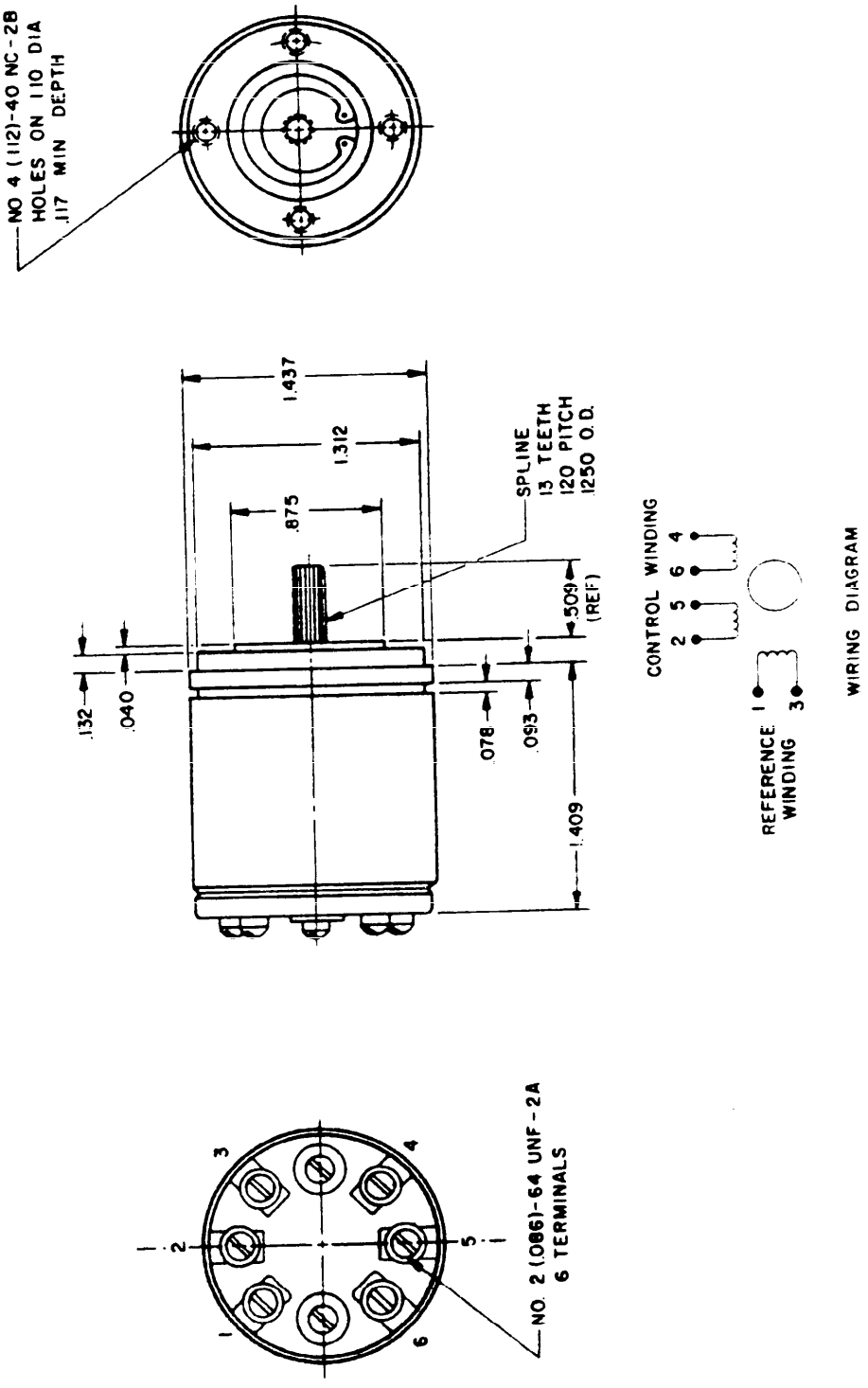


Figure 12.11. MK 7 MOD 4

SERVOMOTOR

MK 7 MOD 5

ELECTRICAL CHARACTERISTICS @ 26°C

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	180	mA
Control phase (series)	180	mA
Control phase (parallel)	360	mA
Power input/phase (max)	8.9	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1480	ohms
Control phase (series)	1480	ohms
Control phase (parallel)	370	ohms

MECHANICAL CHARACTERISTICS @ 26° C

No load speed (min)	5000	rpm
Stall torque (min)	2.0	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	42,600	rad/sec^2
Power output (max)		watts
Ambient temperature range	to +125	degrees C
Weight	7.0	oz

REFERENCES

Specification		
Installation drawing	WP Dwg	1473970
General arrangement drawing	WP Dwg	1359521
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

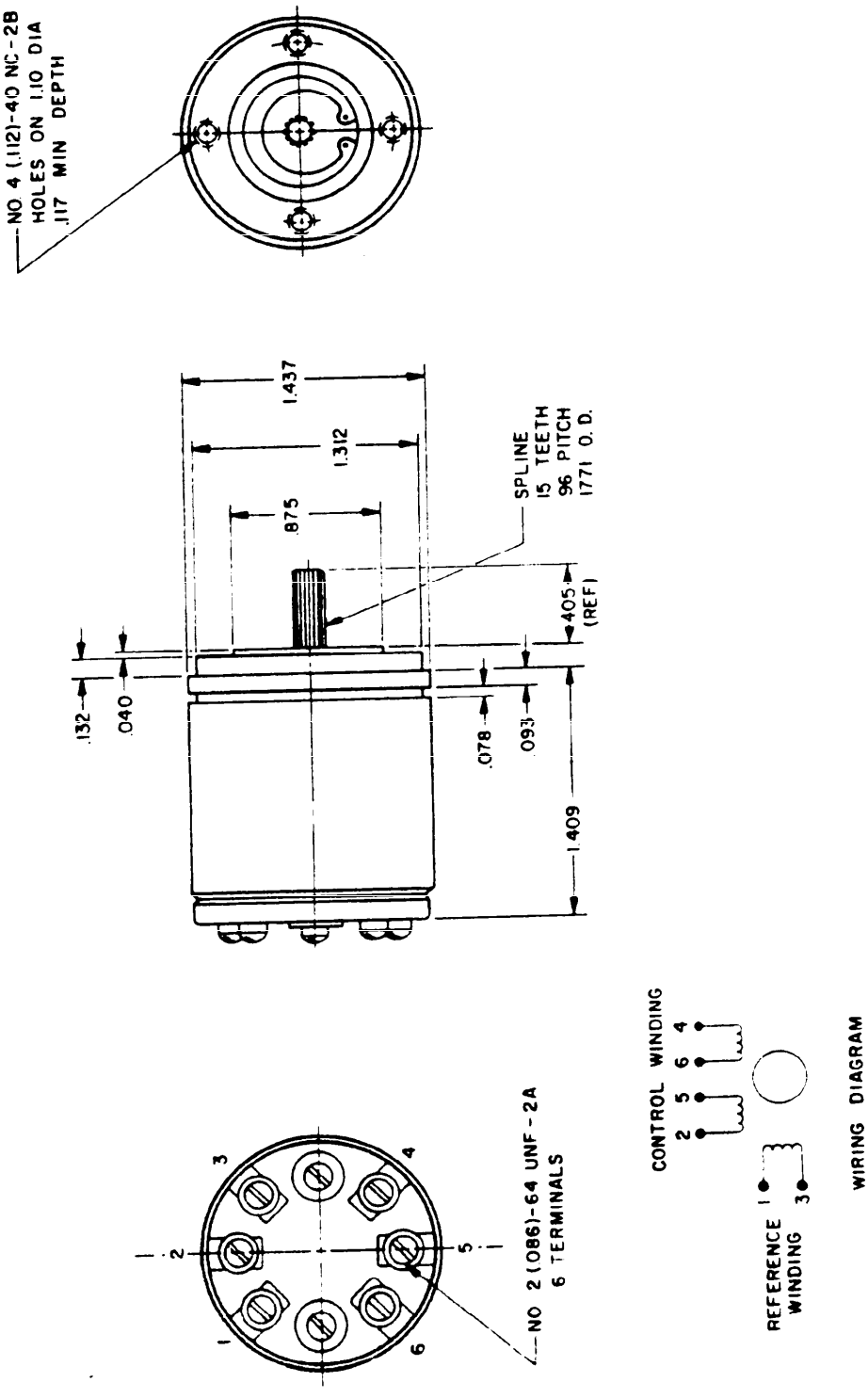


Figure 12.12. MK 7 MOD 5

SERVOMOTOR

MK 7 MOD 6

ELECTRICAL CHARACTERISTICS @ 26°C

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	230	V
Control phase (parallel)	115	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	180	mA
Control phase (series)	90	mA
Control phase (parallel)	180	mA
Power input/phase (max)	8.9	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1480	ohms
Control phase (series)	5020	ohms
Control phase (parallel)	1480	ohms

MECHANICAL CHARACTERISTICS @ 26°C

No load speed (min)	4800	rpm
Stall torque (min)	2.35	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	70,500	rad/sec^2
Power output (max)		watts
Ambient temperature range	to +125	degrees C
Weight	7.0	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	1473969
General arrangement drawing	WP Dwg	1473971
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

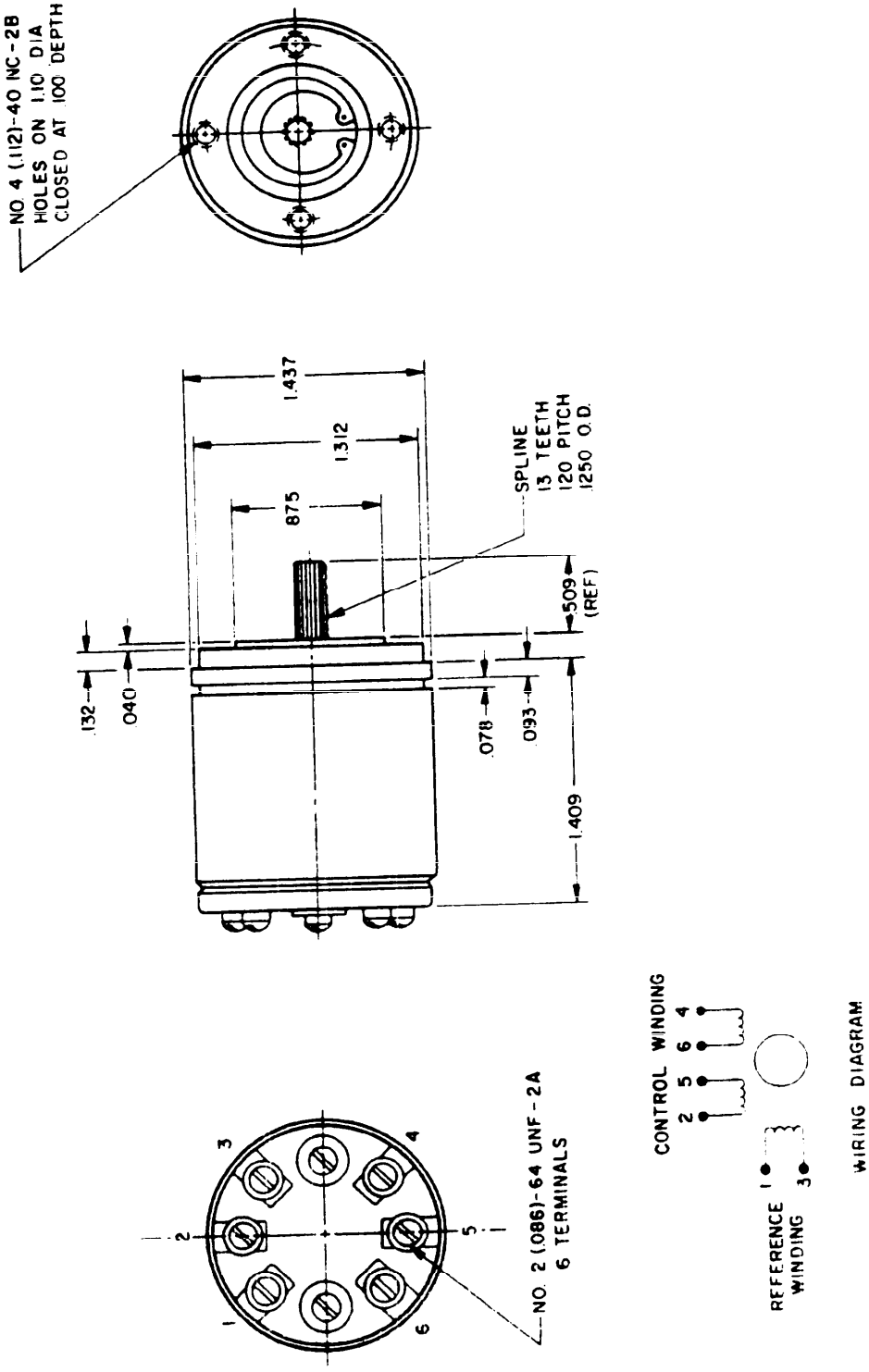


Figure 12.13. MK 7 MOD 6

SERVOMOTOR

MK 7 MOD 7

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)	3	V
Current (at stall)		
Reference phase	114	mA
Control phase (series)	114	mA
Control phase (parallel)	210	mA
Power input/phase (max)	6.2	watts
Power factor/phase	.47	
Effective resistance		
Control phase (series)	2340	ohms
Control phase (parallel)	585	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	5,000	rpm
Stall torque (min) at 23° C	1.35	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	29,000	rad/sec^2
Power output (nom)	1.18	watts
Temperature rise (max)	85	degrees C
Weight	8.0	oz

REFERENCES

Specification		MIL-S-22432/6A
Installation drawing	WP Dwg	2094887
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

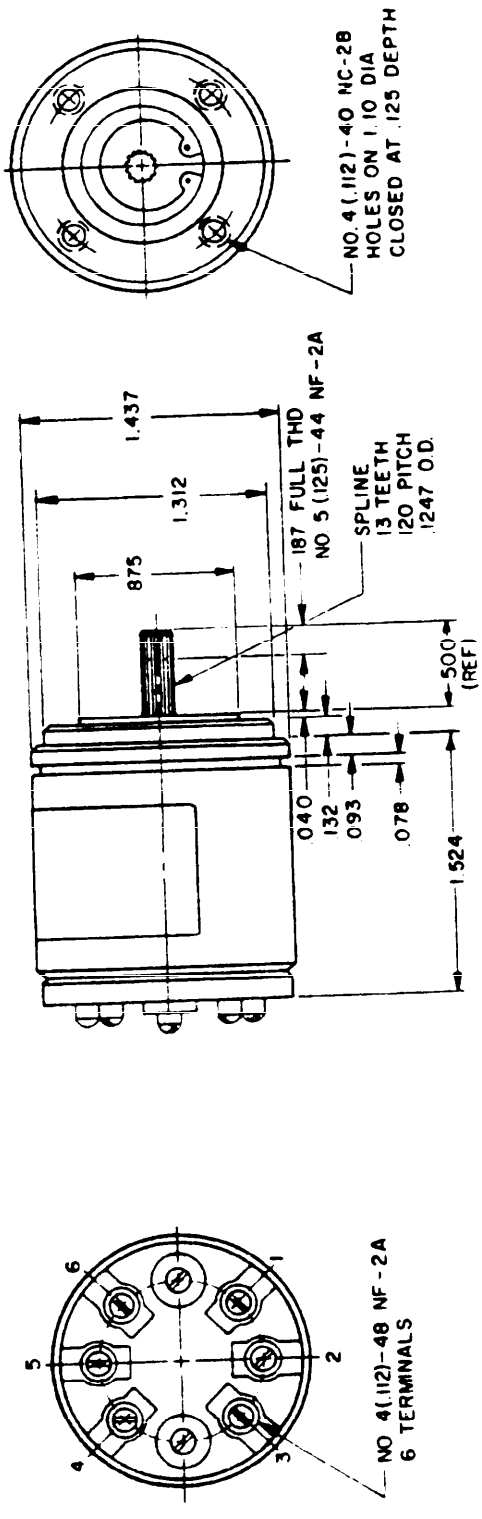


Figure 12.14. MK 7 MOD 7

SERVOMOTOR

TYPE 15SM4c

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)	3	V
Current (at stall)		
Reference phase	114	mA
Control phase (series)	114	mA
Control phase (parallel)	210	mA
Power input/phase (max)	6.2	watts
Power factor/phase	.47	
Effective resistance		
Control phase (series)	2340	ohms
Control phase (parallel)	585	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	5000	rpm
Stall torque (min) at 23° C	1.35	oz-in
Rotor moment of inertia	3.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	29,000	rad/sec^2
Power output (max)	1.18	watts
Temperature rise	85	degrees C
Ambient temperature range	-55 to +125	degrees C
Weight	8.0	oz

REFERENCES

Specification	MIL-S-22432/7C
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

Formerly MK 7 Mod 8.

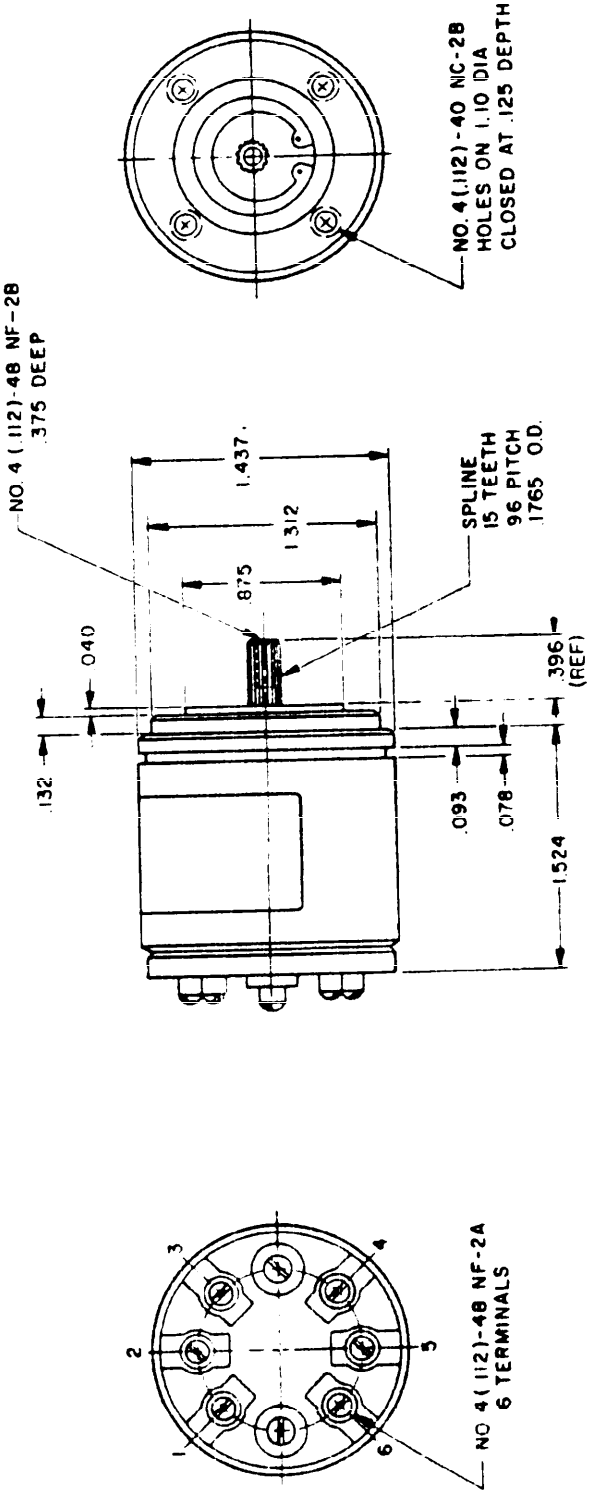


Figure 12.15. Type 15SM4c

SERVOMOTOR

TYPE 15SM4d

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage	115	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)	.75	V
Minimum starting (max)		
Current (at stall)	117	mA
Reference phase	368	mA
Control phase (series)	680	mA
Control phase (parallel)	6.8	watts
Power input/phase (max)	.49	
Power factor/phase		
Effective resistance	2200	ohms
Reference phase	216	ohms
Control phase (series)		

MECHANICAL CHARACTERISTICS

No load speed (min)	6200	rpm
Stall torque (min) at 23° C	1.20	oz-in
Rotor moment of inertia	.8	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	105,000	rad/sec^2
Power output (max)	.8	watts
Temperature rise	65	degrees C
Ambient temperature range	−55 to +125	degrees C
Weight	7.3	oz

REFERENCES

Specification	MIL-S-22432/32B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	Yes

NOTES

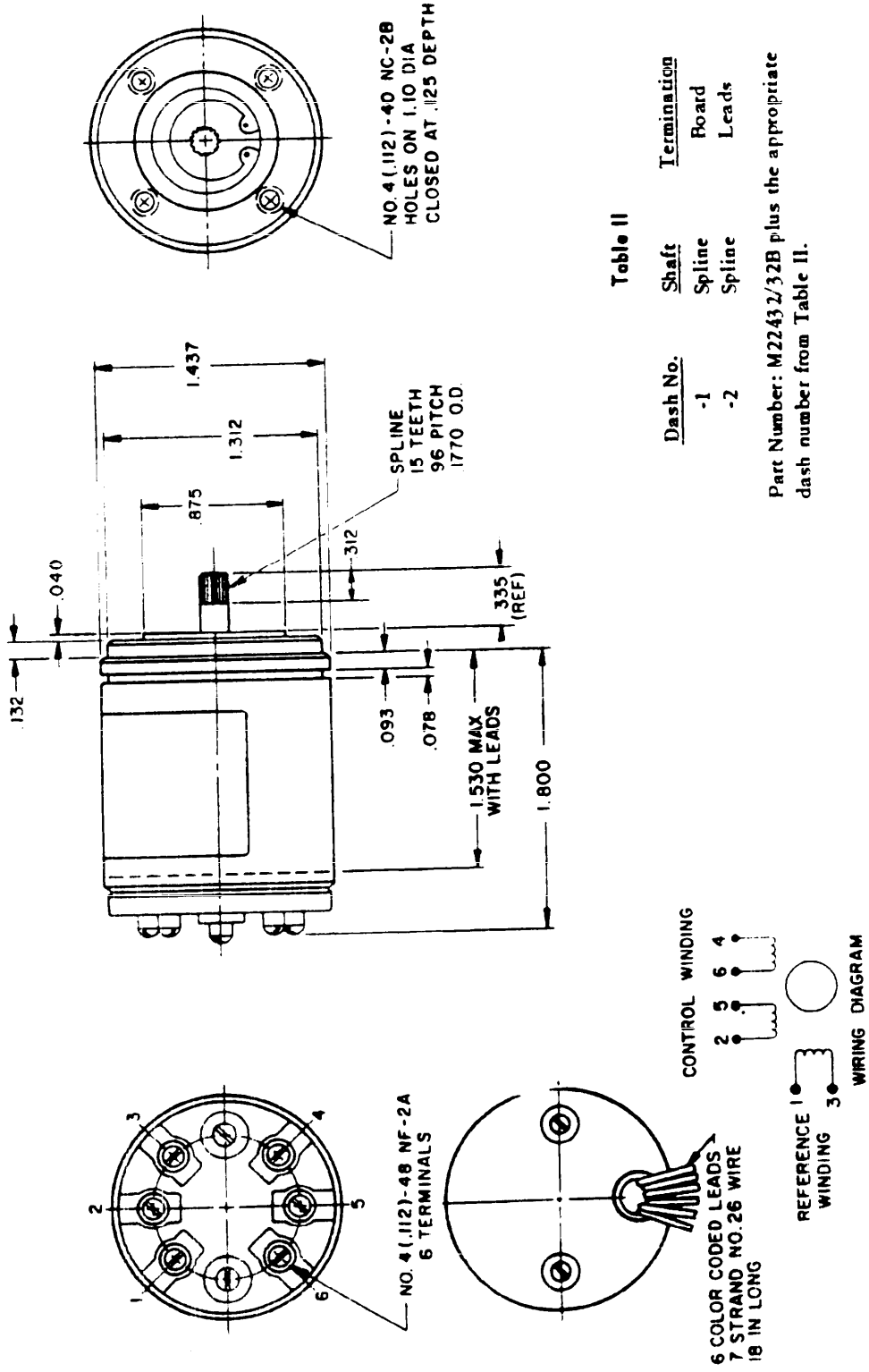


Table II

Dash No.	Shaft	Termination
-1	Spline	Board
-2	Spline	Leads

Part Number: M22432/32B plus the appropriate dash number from Table II.

Figure 12.16. Type 15SM4d

SERVOMOTOR

MK 8 MOD 0

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	180	mA
Control phase (series)	180	mA
Control phase (parallel)	360	mA
Power input/phase (max)	9.1	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1460	ohms
Control phase (series)	1460	ohms
Control phase (parallel)	365	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	2.35	oz-in
Rotor moment of inertia	4.0	gm-cm^2
Theoretical acceleration (at stall)	39,700	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	12.2	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	675029
General arrangement drawing	WP Dwg	675033
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

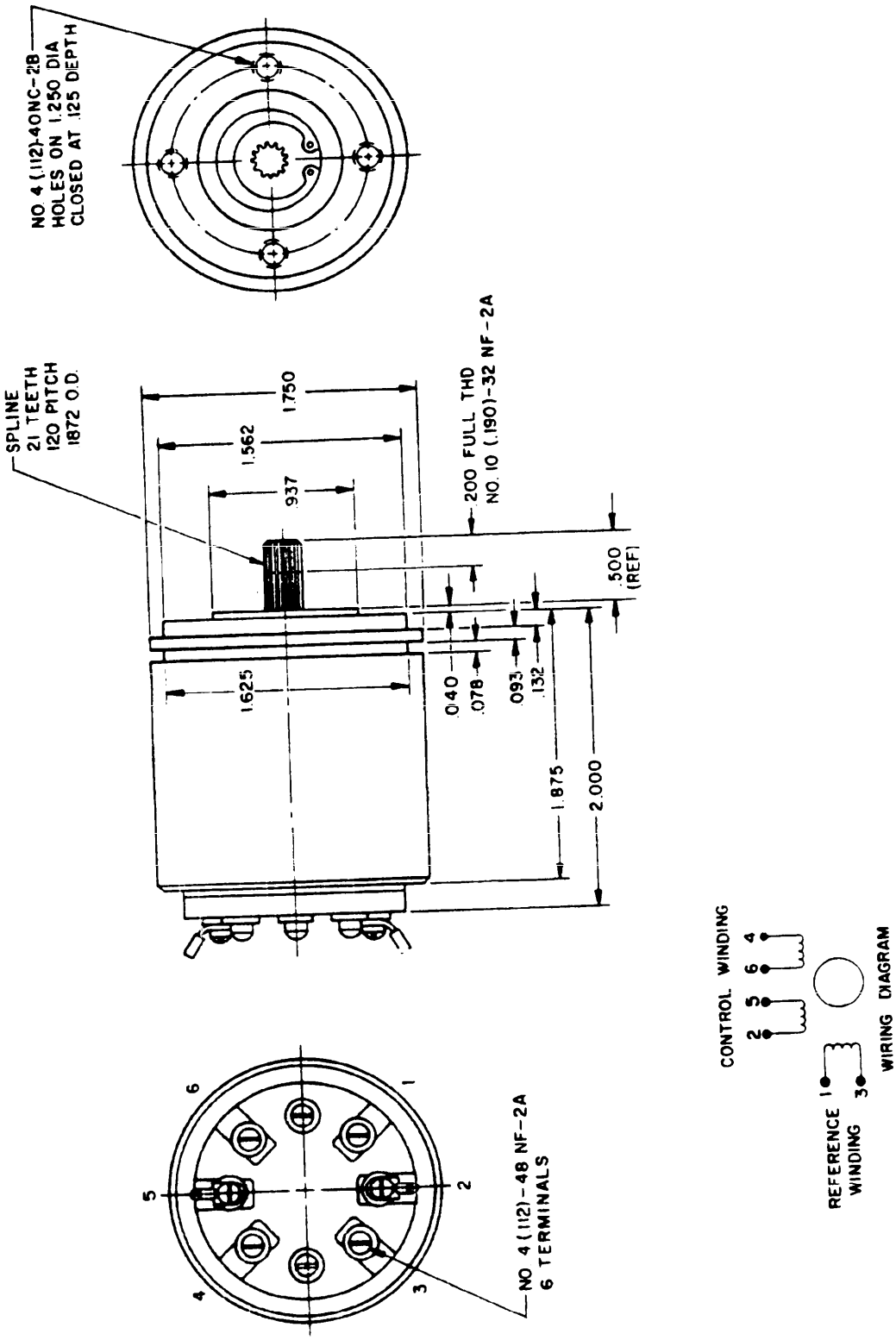


Figure 12.17. MK 8 MOD 0

SERVOMOTOR

MK 8 MOD 2

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	300	V
Control phase (parallel)	150	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	183	mA
Control phase (series)	67	mA
Control phase (parallel)	134	mA
Power input/phase (max)	9.6	watts
Power factor/phase	.43	
Effective resistance		
Reference phase	1464	ohms
Control phase (series)	9400	ohms
Control phase (parallel)	2500	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min)	2.35	oz-in
Rotor moment of inertia	4.0	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	39,700	rad/sec^2
Power output (max)		watts
Ambient temperature range		degrees C
Weight	13.2	oz

REFERENCES

Specification		MIL-S-17087
Installation drawing	WP Dwg	982128
General arrangement drawing	WP Dwg	982129
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

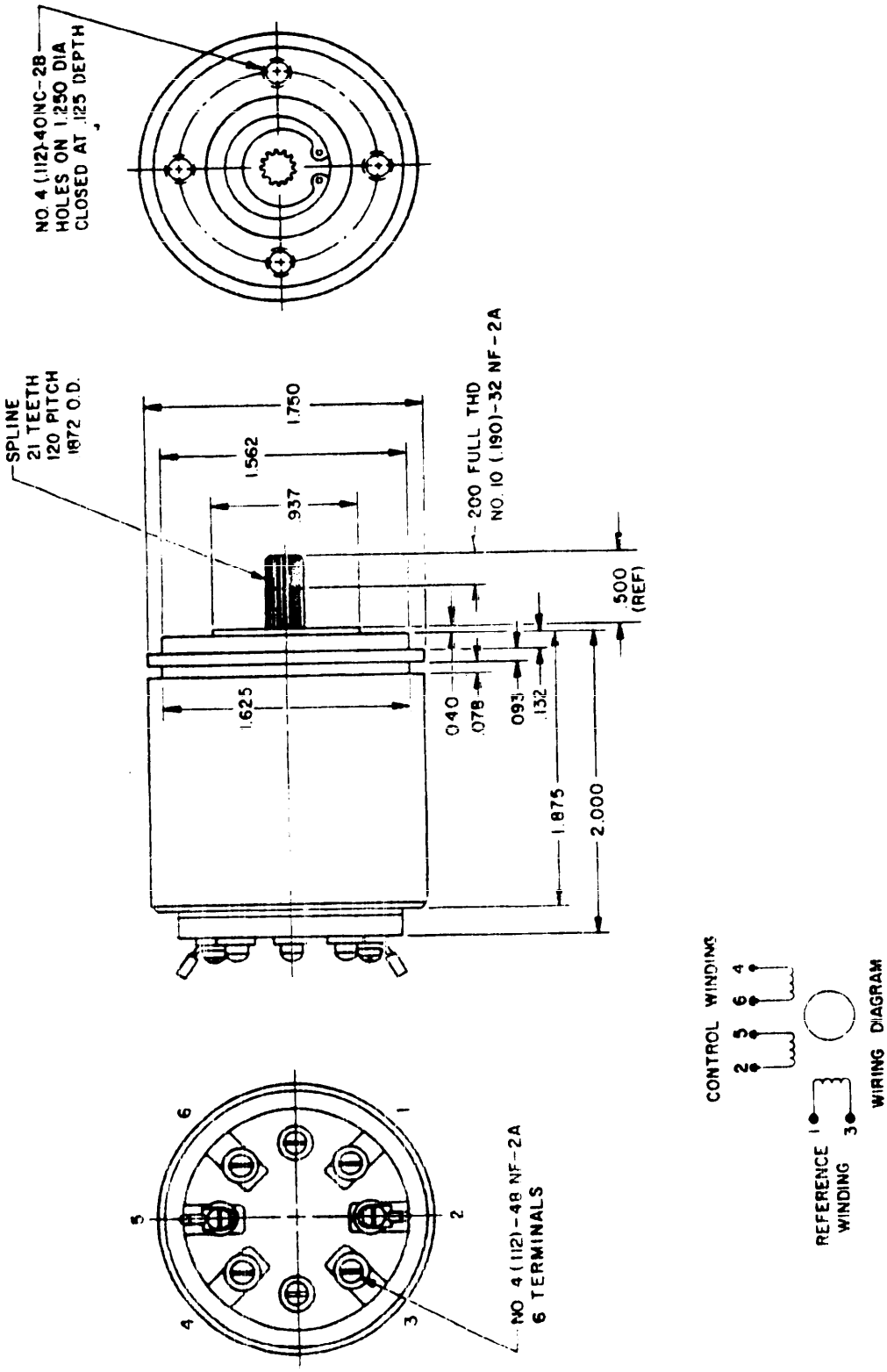


Figure 12.18. MK 8 MOD 2

SERVOMOTOR

TYPE 18SM4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)	3	V
Current (at stall)		
Reference phase	275	mA
Control phase (series)	275	mA
Control phase (parallel)	506	mA
Power input/phase (max)	14	watts
Power factor/phase	.44	
Effective resistance		
Control phase (series)	1017	ohms
Control phase (parallel)	254	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	5000	rpm
Stall torque (min) at 23° C	3.5	oz-in
Rotor moment of inertia	4.0	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	71,000	rad/sec^2
Power output (max)	3.3	watts
Ambient temperature range	-55 to +125	degrees C
Weight	12.0	oz

REFERENCES

Specification	MIL-S-22432/11A
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 8 MOD 3
Maximum temperature rise 100°C.

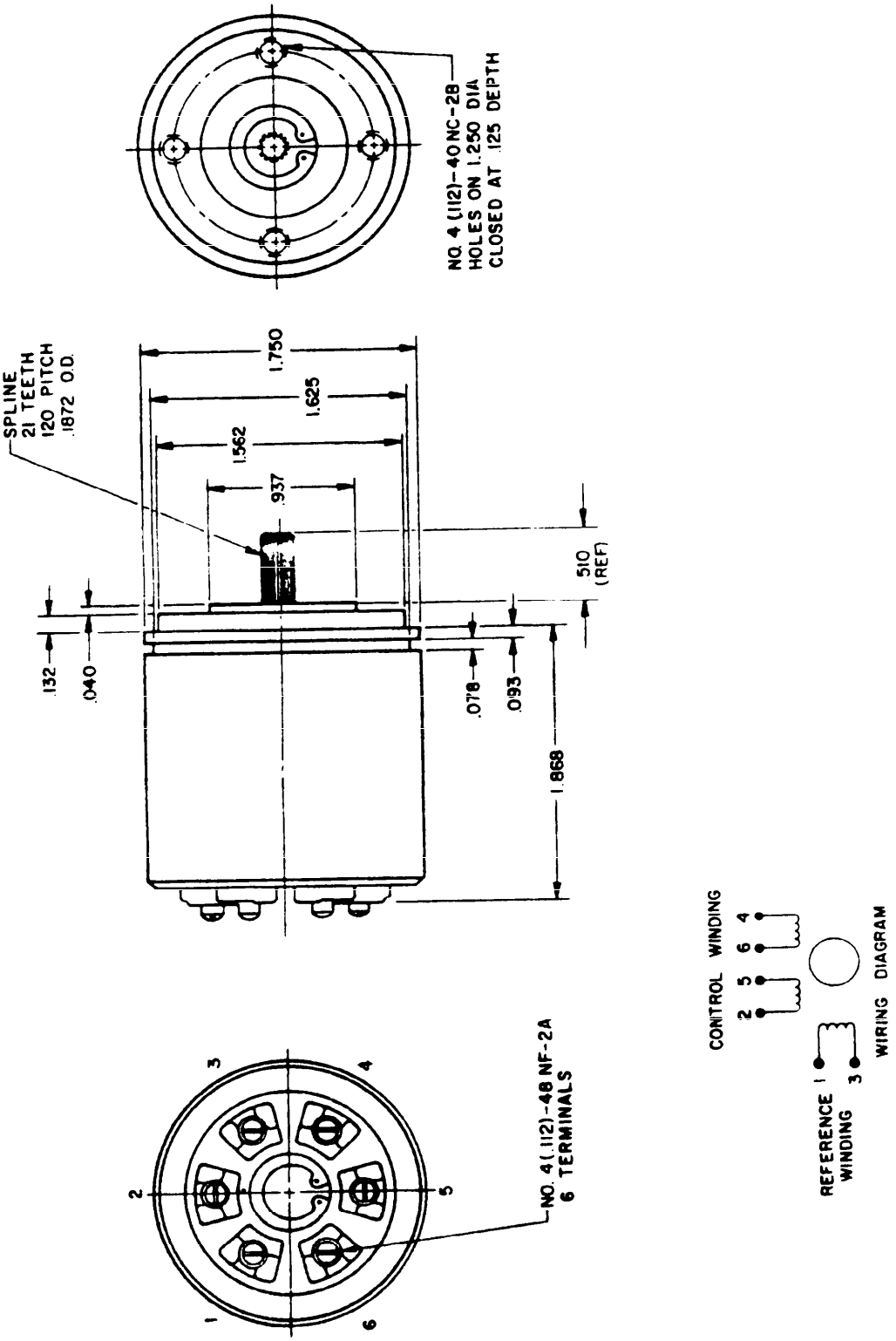


Figure 12.19. Type 18S14a

SERVOMOTOR

TYPE 18SM4c

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)	3	V
Current (at stall)		
Reference phase	200	mA
Control phase (series)	200	mA
Control phase (parallel)	350	mA
Power input/phase (max)	9.1	watts
Power factor/phase	.42	
Effective resistance		
Control phase (series)	1525	ohms
Control phase (parallel)	380	ohms

MECHANICAL CHARACTERISTICS

No load speed (min)	4800	rpm
Stall torque (min) at 23°C	2.20	oz-in
Rotor moment of inertia	4.0	gm-cm^2
Theoretical acceleration (at stall)	42,000	rad/sec^2
Power output (max)	2.25	watts
Temperature rise (max)	85	degrees C
Ambient temperature range	-55 to +100	degrees C
Weight	13.5	oz

REFERENCES

Specification	MIL-S-22432/9B
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 8 MOD 1

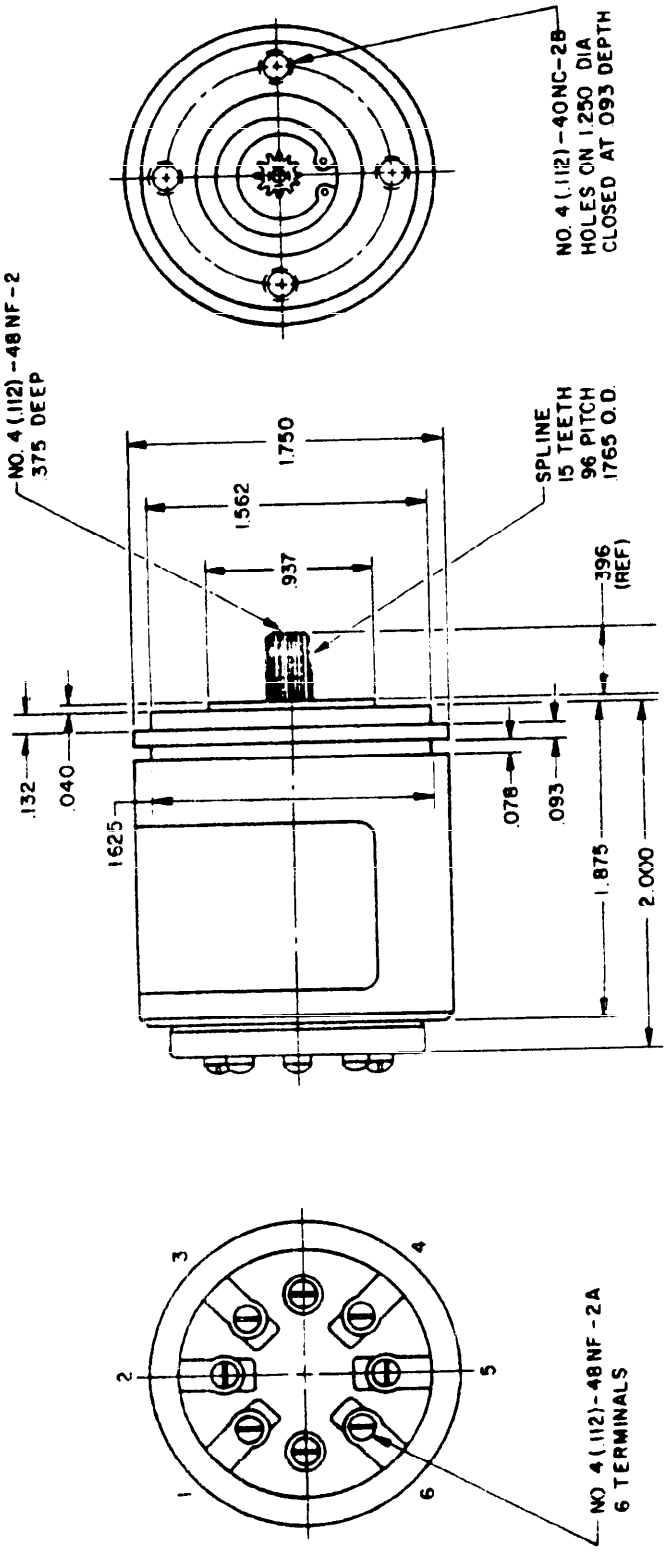


Figure 12.20. Type 18SM4c

SERVOMOTOR

TYPE 18SM4d

ELECTRICAL CHARACTERSITICS (DESIGN)

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1	V
Current (at stall)		
Reference phase	500	mA
Control phase (series)	1500	mA
Control phase (parallel)	2400	mA
Power input/phase (max)	25	watts
Power factor/phase	.47	
Effective resistance		
Reference phase	660	ohms
Control phase (series)	66	ohms
Control phase (parallel)	16.5	ohms

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	4500	rpm
Stall torque (min) at 23°C	5.0	oz-in.
Rotor moment of inertia.	7.0	gm-cm^2
Theoretical acceleration (at stall)	51,000	rad/sec^2
Power output (max)		watts
Temperature rise (max).	85	degrees C
Ambient temperature range	-55 to + 100	degrees C
Weight	20	oz

REFERENCES

Specification		MIL-S-22432/
Installation drawing	WP dwg	2571670
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Developed under contract NOw64-0584-f.

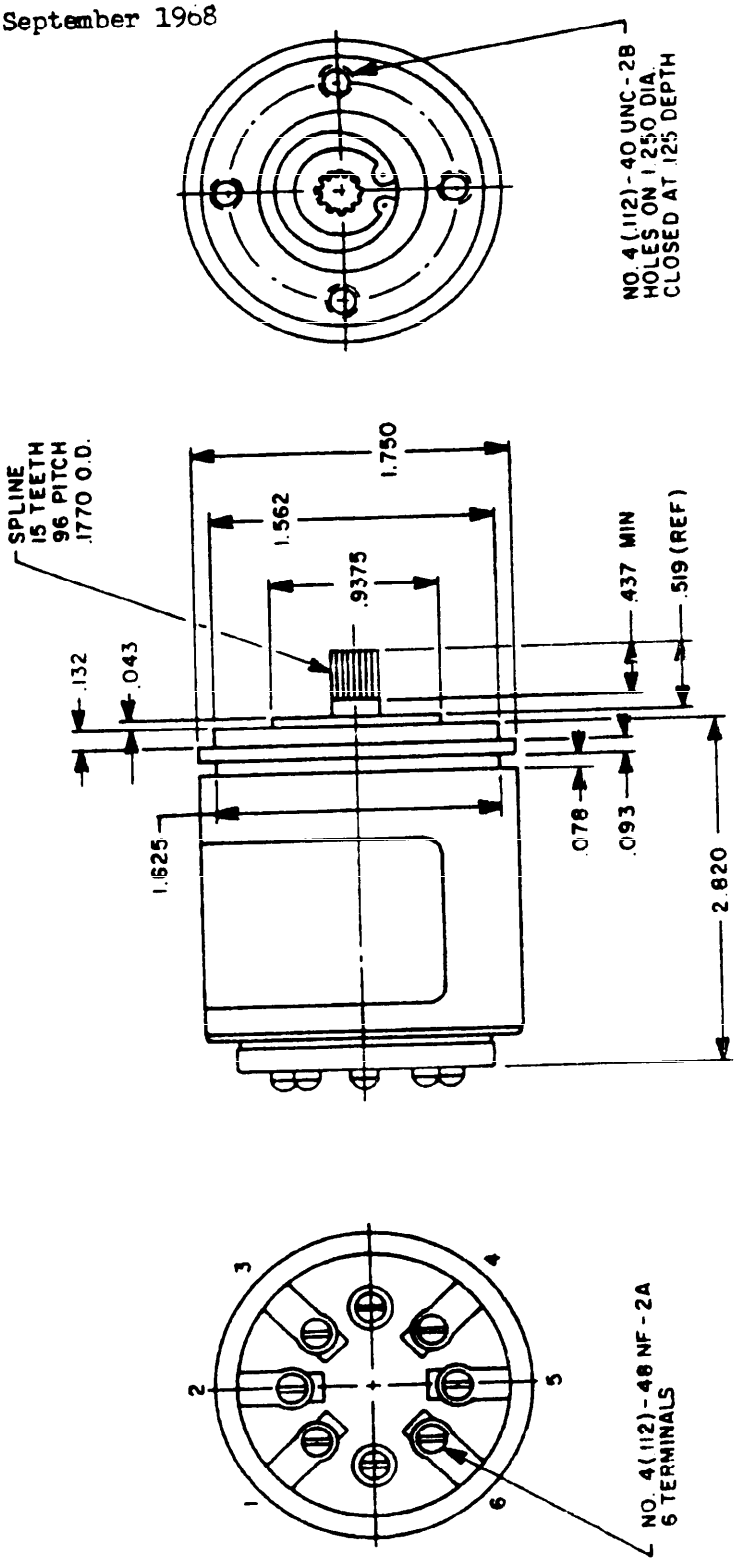


Figure 12.21. Type 18SM4d

SERVOMOTOR

TYPE 23SM4a

ELECTRICAL CHARACTERISTICS (DESIGN)

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1	V
Current (at stall)		
Reference phase	720	mA
Control phase (series)	2000	mA
Control phase (parallel)	3600	mA
Power input/phase (max)	30	watts
Power factor/phase	.45	
Effective resistance		
Reference phase	440	ohms
Control phase (series)	50	ohms
Control phase (parallel)	12.5	ohms

MECHANICAL CHARACTERISTICS (DESIGN)

No load speed (min)	3200	rpm
Stall torque (min) at 23°C	10.0	oz-in.
Rotor moment of inertia	20	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	35,000	rad/sec^2
Power output (max)	120	watts
Temperature rise (max)		degrees C
Ambient temperature range	-55 to + 100	degrees C
Weight	36	oz

REFERENCES

Specification	MIL-S-22432/
Installation drawing	2571690
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Developed under contract NOw 64-0583f.

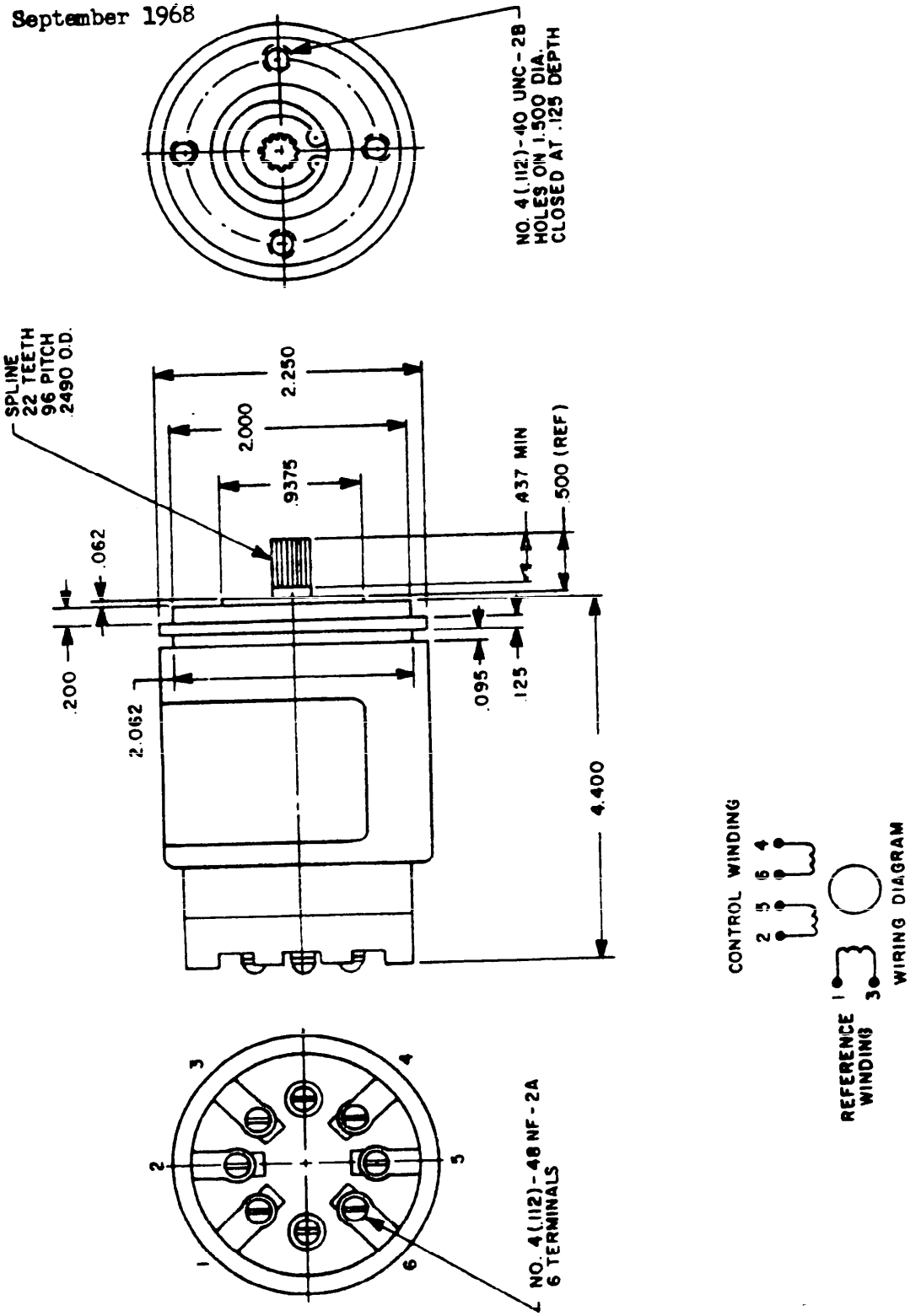


Figure 12.22. Type 23SM4a

CHAPTER 13

SERVOMOTOR TACHOMETER GENERATORS

The instruments described in this chapter are designed for two classes of applications, one applied where the absolute value of generated voltage is not required to be free of temperature effects, and one applied where the absolute value of generated voltage must be independent of ambient temperature. The attainment of a high ratio between generated voltage and the value of fundamental component of output voltage at zero speed has been a major objective.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 26V-08SM-DG4a

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	.75	V
Current (at stall)		
Reference phase	245	mA
Control phase (series)	178	mA
Energizing	70	mA
Power input/phase (max)	3.6	watts
Power factor/phase	.58	
Impedance		
Reference phase	67 + j 95	ohms
Control phase (series)	122 + j 171	ohms
Output	1100	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.30	oz-in.
Rotor moment of inertia	.7	gm-cm^2
Theoretical acceleration (at stall)	30,000	rad/sec^2
Ambient temperature range	−55 to + 125	degrees C
Weight	2.5	oz

ELECTERICAL CHARACTERISTICS, Tachometer Generator Section

In-phase speed sensitive TR	.041	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (max)	±0.5	percent
Zero-speed output voltages		
Total (max)	12	
Fundamental (max)	10	
Output gradient	.40	V/1000 rpm
Temperature sensitivity (over range −55 to 125°C)		
In-phase speed-sensitive TR	Not less than 70% of value measured at 23°C	
Phase shift	value measured at 23° C	

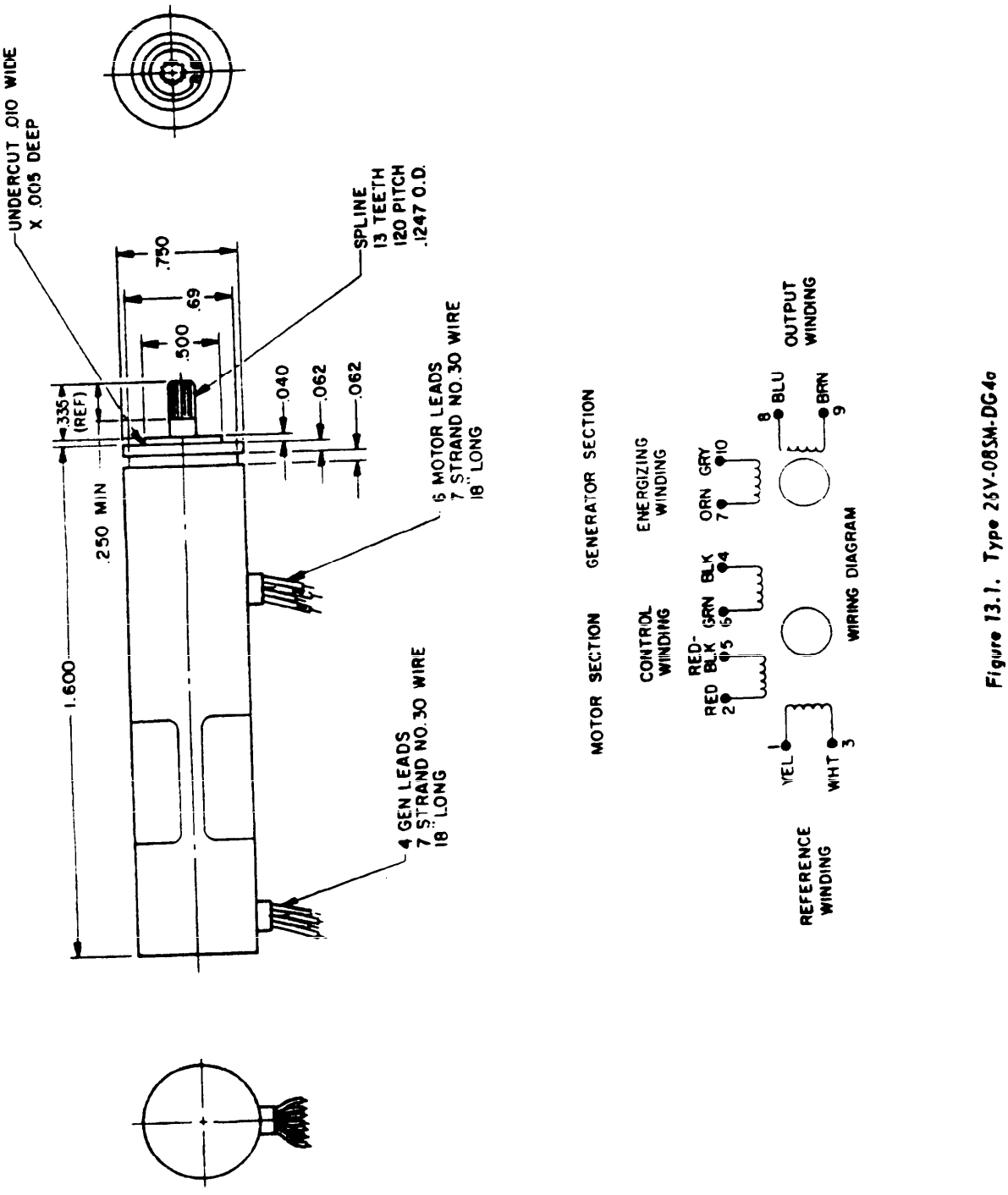


Figure 13.1. Type 26V-08SM-DG4a

TYPE 26V-08SM-DG4a (Continued)

Zero-speed output		
Total (max)	18	mV
Fundamental (max)	15	mV

REFERENCES

Specification	MIL-S-22820/30(AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

TYPE 26V-08SM-IN4a

ELECTRICAL CHARACTERISTICS, Servomotor Section

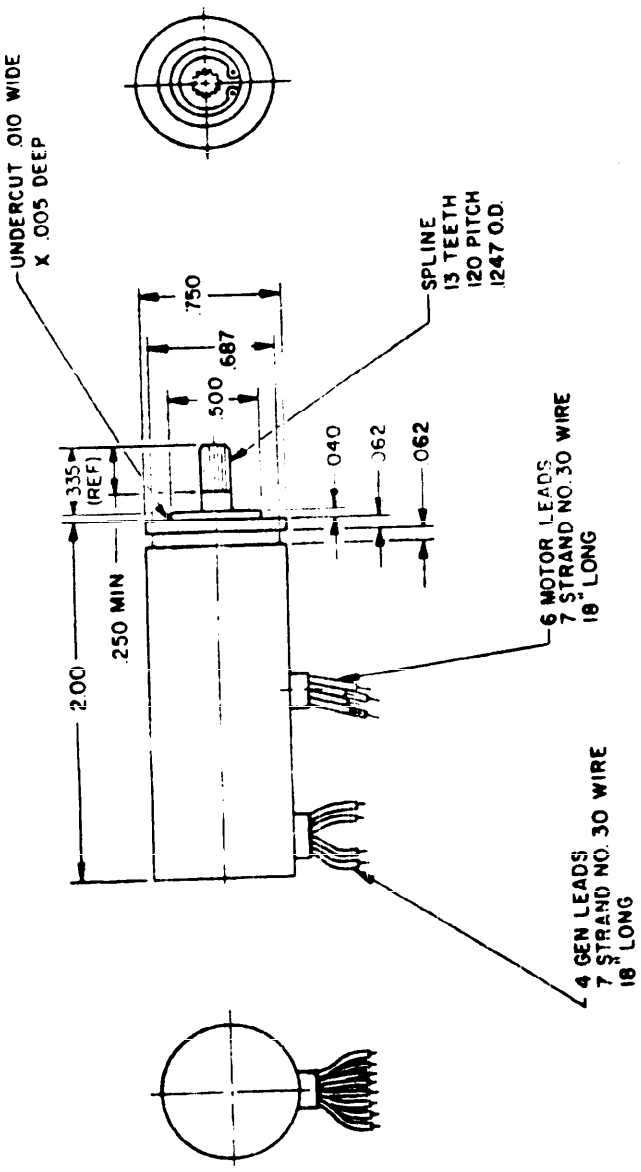
Frequency	400	Hz
Voltage		
Reference phase	26	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	.75	V
Current (at stall)		
Reference phase	245	mA
Control phase (series)	178	mA
Energizing	79	mA
Power input/phase (max)	3.6	watts
Power factor/phase	.58	
Impedance		
Reference phase	67 + j 95	ohms
Control phase (series)	122 + j 171	ohms
Output	2200 + j 1900	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.30	oz-in.
Rotor moment of inertia	1.6	gm-cm^2
Theoretical acceleration (at stall)	13,000	rad/sec^2
Ambient temperature range	−55 to + 125	degrees C
Weight	2.5	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

In-phase speed sensitive TR	.0580	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (500 to 3600 rpm)	± .07	percent
Axis error voltages		
In-phase (max)	±5	mV
Quadrature-phase (max)	±7	mV
Zero-speed output voltage, total (max)	15	mV
Position error voltages		
In-phase (max)	5	mV
Quadrature-phase (max)	10	mV
Output gradient	.50	v/1000 rpm



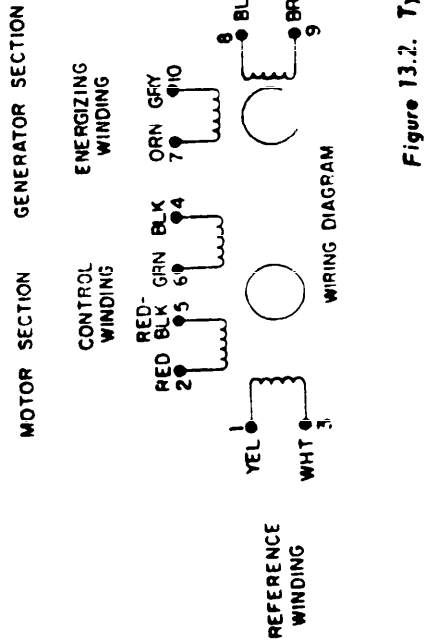


Figure 13.2. Type 26V-08SM-IN4a

TYPE 26V-08SM-IN4a (Continued)

Temperature sensitivity (over range – 55 to 125°C)		
In-phase speed sensitive TR		value measured at 23°C
Phase shift		value measured at 23°C
In-phase axis error voltage	±10	mV
Zero-speed output, total (max)	20	mV
In-phase position error voltage (max)	8	mV
Frequency sensitivity (over range 380 to 420 Hz)		
In-phase speed sensitive TR		value measured at 400 Hz
Phase shift		value measured at 400 Hz
Zero-speed output voltage, total (max)	20	mV
Voltage sensitivity (over range 26V ±10%)		
In-phase speed sensitive TR		value measured at 26V
Phase shift		value measured at 26V

REFERENCES

Specification	MIL-S-22820/31(AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

TYPE 11SM-DG4a

ELECTRICAL CHARACTERISTICS, Servomotor Section		
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1.0	V
Current (at stall)		
Reference phase	62	mA
Control phase (series)	197	mA
Energizing	41-52	mA
Power input/phase (max)	3.7	watts
Power factor/phase	.52	
Impedance		
Reference phase	1070 + j 1760	ohms
Control phase (series)	106 + j 173	ohms
Output	800	ohms
MECHANICAL CHARACTERISTICS, Servomotor Section		
No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.60	oz-in.
Rotor moment of inertia	1.3	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	32,600	rad/sec^2
Ambient temperature range	-55 to +125	degrees C
Weight	6.5	oz
ELECTRICAL CHARACTERISTICS, Tachometer Generator Section		
In-phase speed sensitive TR	.0143	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (max)	±.5	percent
Zero-speed output voltages		
Total (max)	12	mV
Fundamental (max)	8	mV
Output gradient	.55	v/1000 rpm
Temperature sensitivity (over range -55 to 125°C)		
In-phase speed sensitive TR (min)	.0098	
Phase shift (max)	15	degrees
Zero-speed output		
Total (max)	22	mV
Fundamental (max)	15	mV

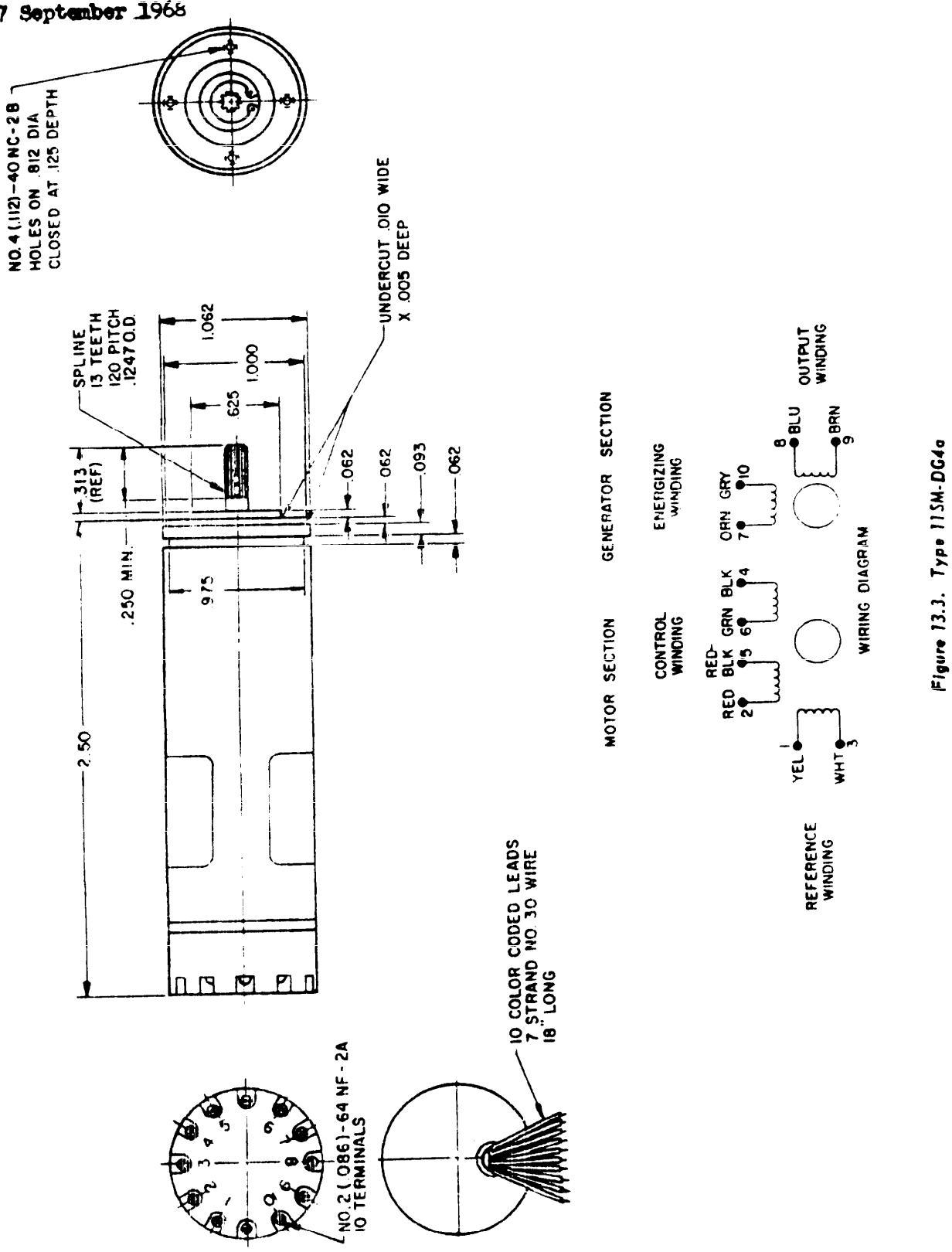


Figure 13.3. Type 11SM-DG4a

TYPE 11SM-DG4a (Continued)

REFERENCES

Specification	MIL-S-22820/32(AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

TYPE 11SM-IN4a

ELECTRICAL CHARACTERISTICS, Servomotor Section

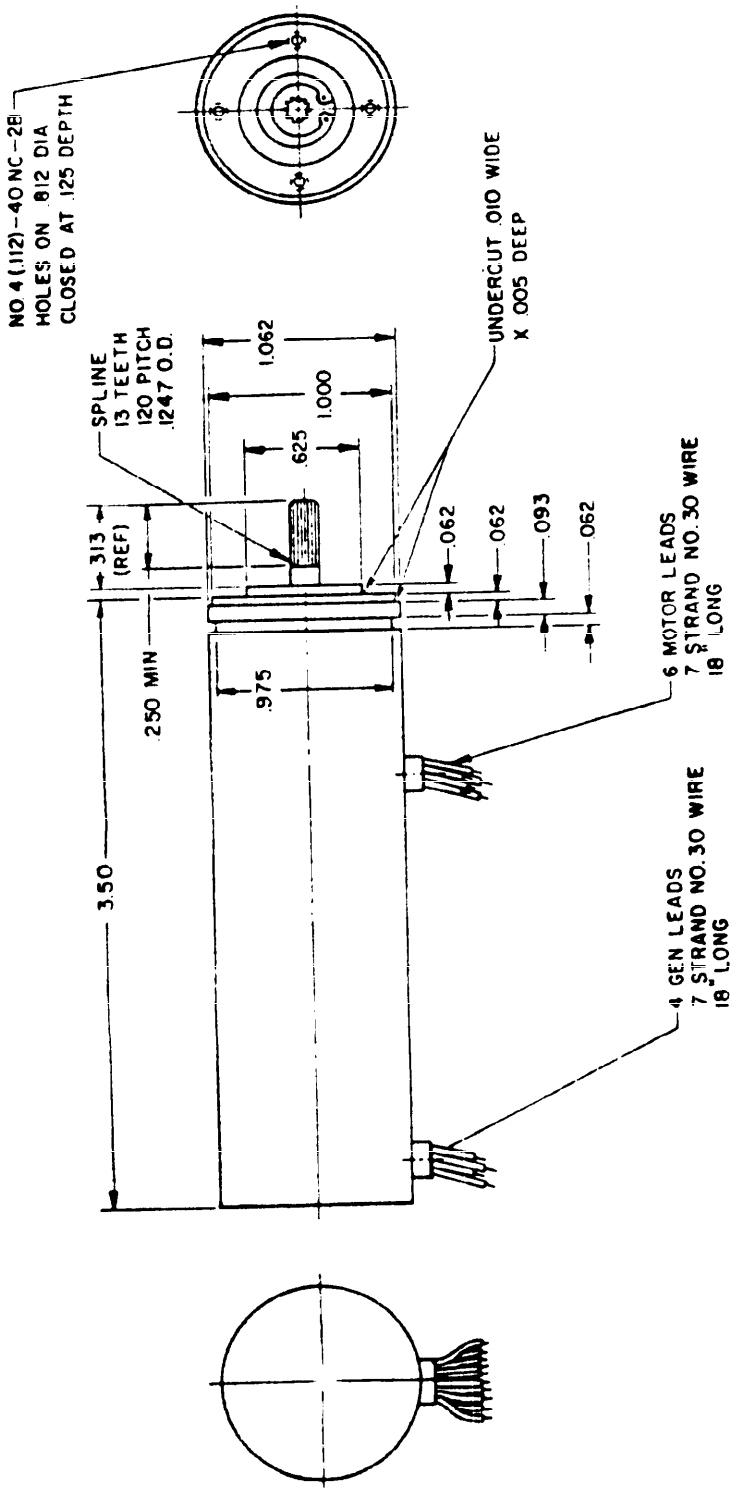
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1.0	V
Current (at stall)		
Reference phase	62	mA
Control phase (series)	197	mA
Energizing	83	mA
Power input/phase (max)	3.7	watts
Power factor/phase	0.52	
Impedance		
Reference phase	1070 + j 1760	ohms
Control phase (series)	106 + j 173	ohms
Output	2800 + j 5500	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6200	rpm
Stall torque (min) at 23°C	.60	oz-in.
Rotor moment of inertia	7.5	gm-cm^2
Theoretical acceleration (at stall)	6,000	rad/sec^2
Ambient temperature range	−55 to +125	degrees C
Weight	8.5	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

In-phase speed sensitive TR	.07150	
Phase shift (500 to 3600 rpm)	0	degrees
Linearity (500 to 3600 rpm)	±.07	percent
Axis error voltages		
In-phase (max)	±4	mV
Quadrature-phase (max)	+7	mV
Zero-speed output voltage, total (max)	15	mV
Position error voltages		
In-phase (max)	5	mV
Quadrature-phase (max)	10	mV
Output gradient	2.75	v/1000 rpm



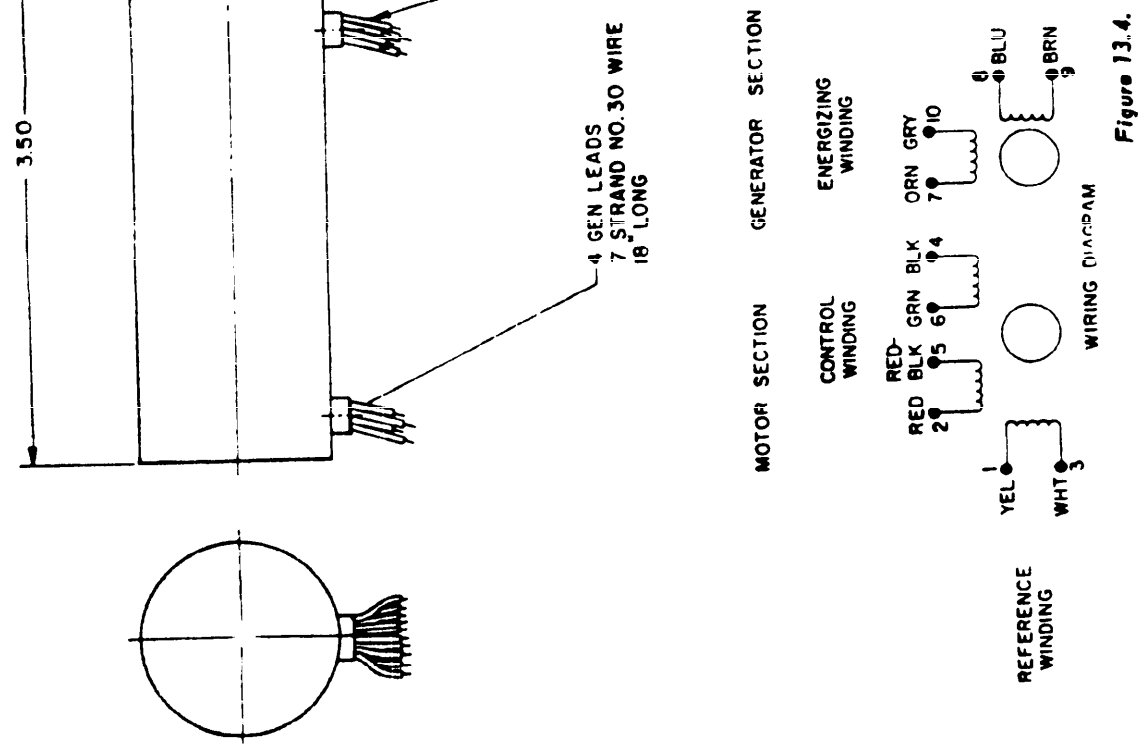


Figure 13.4. Type 11SM-1N4a

TYPE 11SM-IN4a (Continued)

Temperature sensitivity (over range −55 to 125°C)		
In-phase speed sensitive TR		value measured at 23°C
Phase shift		value measured at 23°C
In-phase axis error voltage (max)	8	mV
Zero-speed output, total (max)	20	mV
In-phase position error voltage (max)	5	mV
Frequency sensitivity (over range 380 to 420 Hz)		
In-phase speed sensitive TR		value measured at 400 Hz
Phase shift		value measured at 400 Hz
Zero-speed output voltage, total (max)	20	mV
Voltage sensitity (over range 115 V ±10%)		
In-phase speed sensitive TR		value measured at 115 V
Phase shift		value measured at 115 V

REFERENCES

Specification	MIL-S-22820/33 (AS)
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

MK 11 MOD 0

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	64	mA
Control phase (series)	63	mA
Control phase (parallel)	120	mA
Power input/phase (max)	5.2	watts
Power factor/phase	.70	
Effective resistance		
Reference phase	2520	ohms
Control phase (series)	2620	ohms
Control phase (parallel)	655	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6000	rpm
Stall torque (min)	.65	oz-in
Rotor moment of inertia	4.4	gm-cm^2
Theoretical acceleration (at stall)	11,200	rad/sec^2
Ambient temperature range	-65 to +225	degrees F
Weight	16	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator input		
Frequency	400	Hz
Voltage	115	V
Current	69	mA
Power factor	.66	
Power input (excitation)	5.2	watts
Power input (heater)	21.5	watts
Impedance		
R	1100	ohms
X	1260	ohms
Z	1670	ohms
Effective resistance	2530	ohms

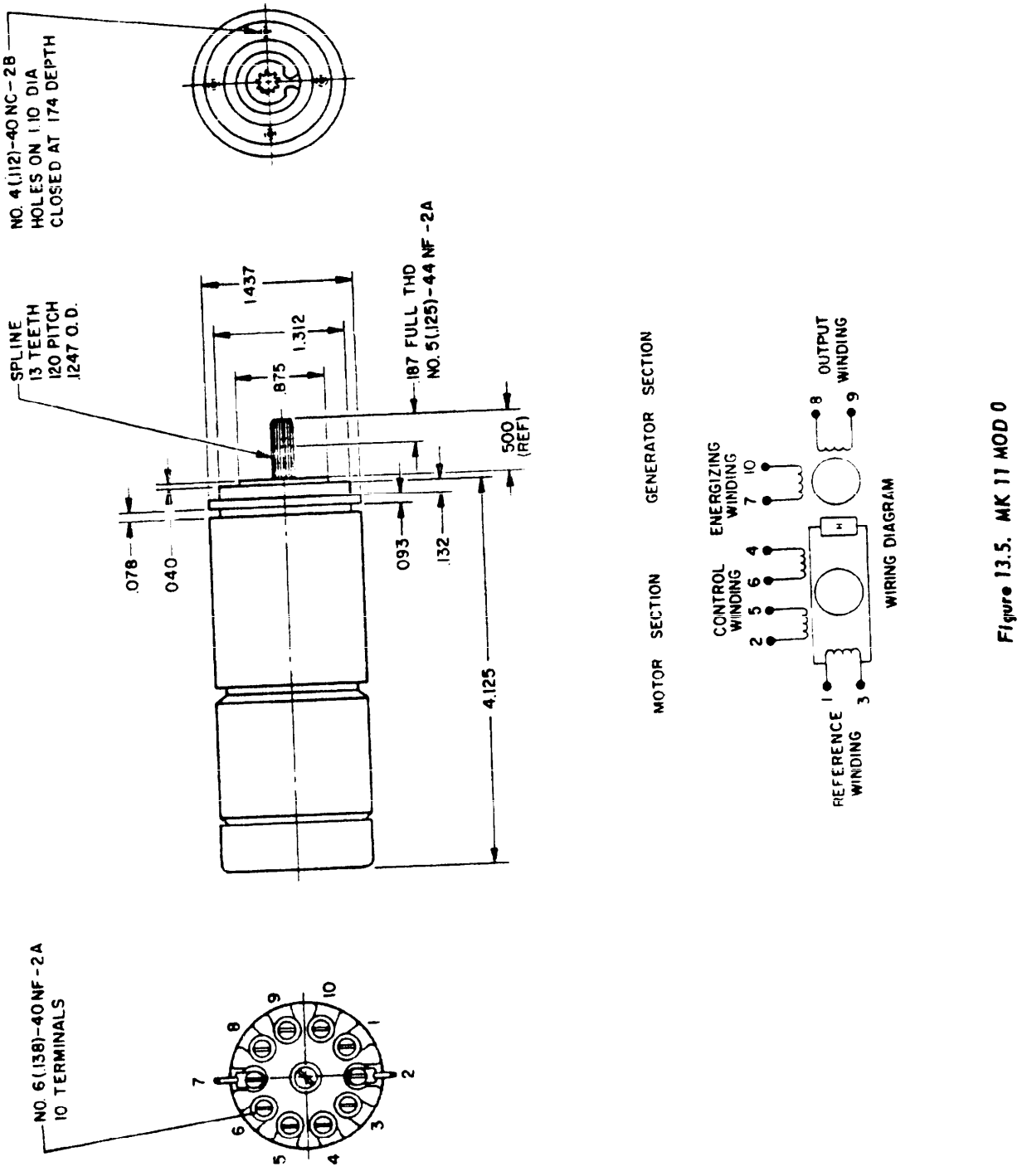


Figure 13.5. MK 11 MOD 0

MK 11 MOD 0 (Continued)

Generator Output

Output voltage gradient (Volts/1000 rpm)	2.75	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 5000 rpm	0.50 leading	degrees
Null voltage		
Total (max)	15	mV-rms
Fundamental	10	mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification		MIL-S-22820/
Installation drawing	WP Dwg	675072
General arrangement drawing	WP Dwg	675071
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Heater compensated.

SERVOMOTOR TACHOMETER GENERATOR

MK 11 MOD 1

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	225	V
Control phase (parallel)	112.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	64	mA
Control phase (series)	25	mA
Control phase (parallel)	50	mA
Power input/phase (max)	5.6	watts
Power factor/phase	.72	
Effective resistance		
Reference phase	2520	ohms
Control phase (series)	9000	ohms
Control phase (parallel)	2250	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	6000	rpm
Stall torque (min)	.65	oz-in
Rotor moment of inertia	4.4	gm-cm^2
Theoretical acceleration (at stall)	11,200	rad/sec^2
Ambient temperature range	-65 to +225	degrees F
Weight	16	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	69	mA
Power factor	.66	
Power input (excitation)	5.2	watts
Power input (heater)	21.5	watts
Impedance		
R	1100	ohms
X	1260	ohms
Z	1670	ohms
Effective resistance	2530	ohms

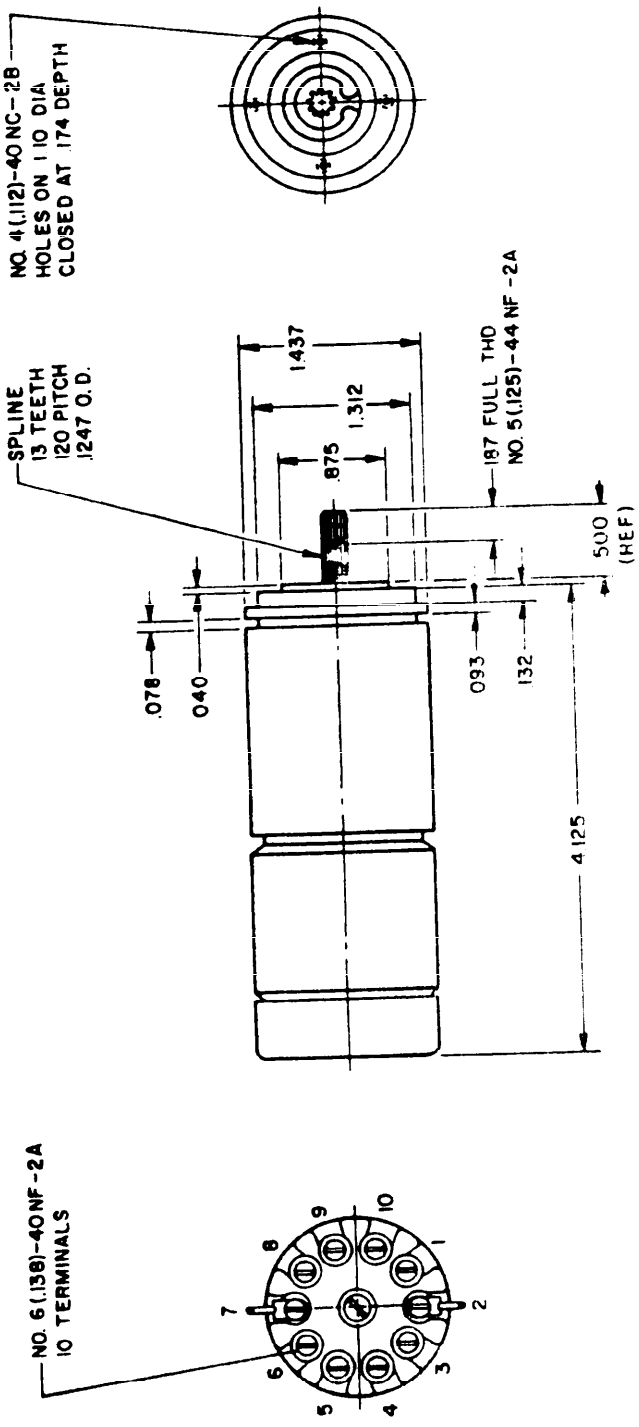


Figure 13.6. MK 11 MOD 1

MK 11 MOD 1 (Continued)

Generator Output

Output voltage gradient (Volts/1000 rpm)	2.75	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 5000 rpm	0.50 leading	degrees
Null voltage		
Total (max)	15	mV-rms
Fundamental	10	mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification		MIL-S-22820
Installation drawing	WP Dwg	988704
General arrangement drawing	WP Dwg	988703
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Same as MK 11 Mod 0 except for motor control winding voltages, and impedance. Generator section identical to MK 11 Mod 0.

SERVOMOTOR TACHOMETER GENERATOR

MK 12 MOD 0

ELECTRICAL CHARACTERISTICS, Servomotor Section

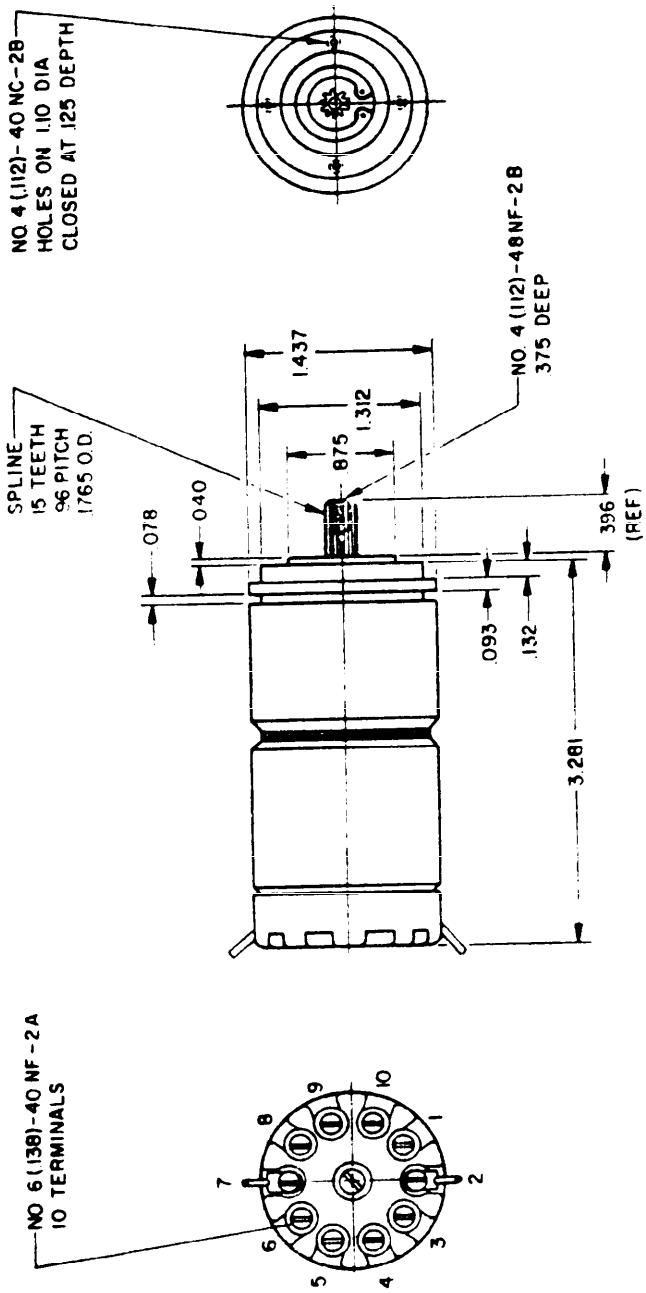
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	115	V
Control phase (parallel)	57.5	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	110	mA
Control phase (parallel)	220	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	2200	ohms
Control phase (parallel)	550	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	5.26	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	19,500	rad/sec^2
Ambient temperature range		degrees C
Weight	14	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	73	mA
Power factor	.64	
Power input	5.4	watts
Impedance		
R	1012	ohms
X	1210	ohms
Z	1575	ohms
Effective resistance	2440	ohms



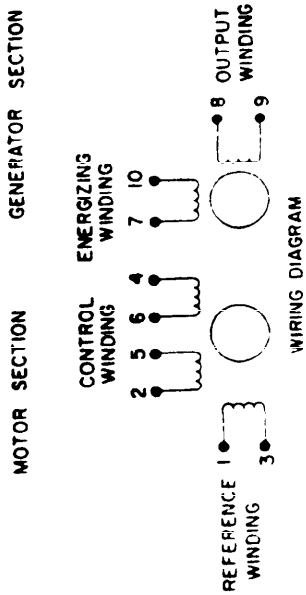


Figure 13.7. MK 12 MOD 0

MK 12 MOD 0 (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	3.2	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 5000 rpm	4.5 lagging	degrees
Null voltage		
Total (max)	13	mV-rms
Fundamental	8	mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification	MIL-S-17806
Installation drawing	WP Dwg 675074
General arrangement drawing	WP Dwg 675073
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

SERVOMOTOR TACHOMETER GENERATOR

MK 12 MOD 1

ELECTRICAL CHARACTERISTICS, Servomotor Section

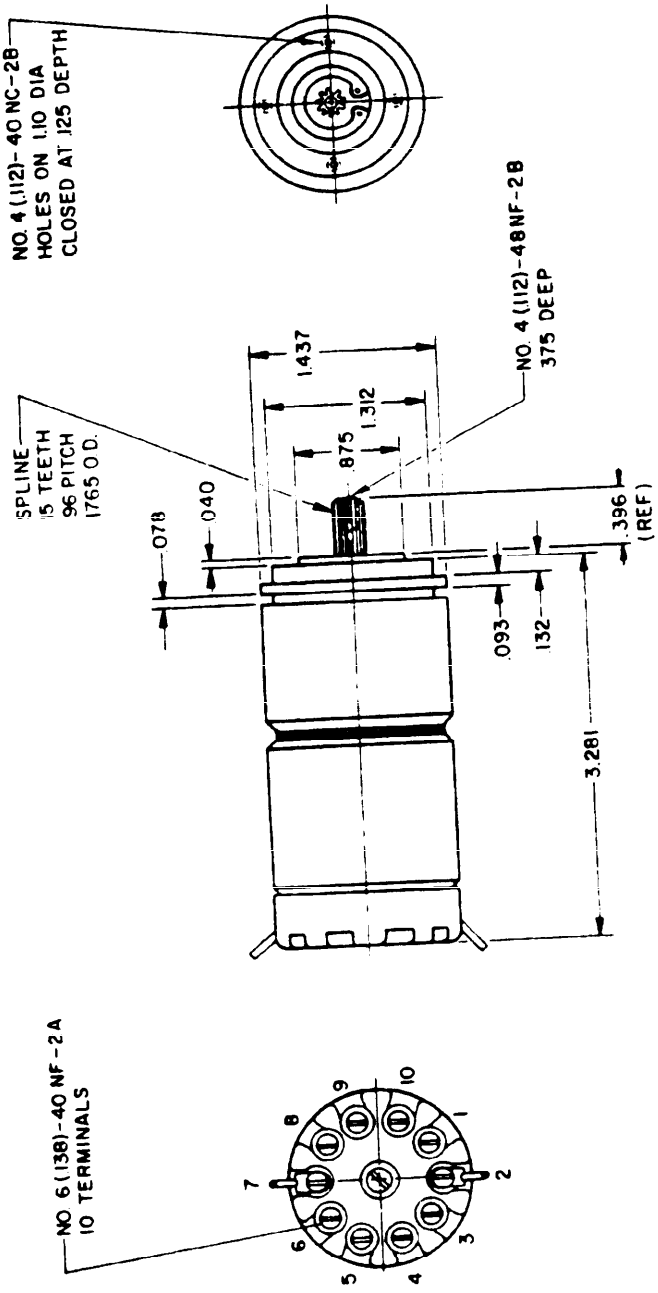
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	230	V
Control phase (parallel)	115	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	110	mA
Control phase (series)	54	mA
Control phase (parallel)	110	mA
Power input/phase (max)	6.1	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	2200	ohms
Control phase (series)	8800	ohms
Control phase (parallel)	2200	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	5.26	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	19,500	rad/sec^2
Ambient temperature range		degrees C
Weight	14	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	73	mA
Power factor	.64	
Power input	5.4	watts
Impedance		
R	1012	ohms
X	1210	ohms
Z	1575	ohms
Effective resistance	2440	ohms



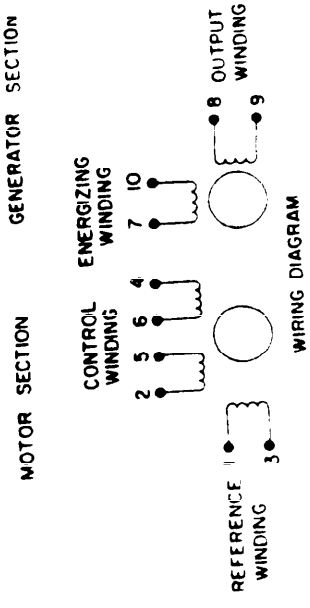


Figure 13.8. MK 12 MOD 1

MK 12 MOD 1 (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	3.2	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 5000 rpm	4.5 lagging	degrees
Null voltage		
Total (max)	13	mV-rms
Fundamental	8	mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification		MIL-S-17806
Installation drawing	WP Dwg	988697
General arrangement drawing	WP Dwg	988698
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Same as MK 12 Mod 0 except for motor control winding voltages and impedance. Generator section identical to MK 12 Mod 0.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 15SM-DG4

ELECTRICAL CHARACTERISTICS, Servo Motor Section

Frequency	400	Hz
Voltage	115	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)	1.0	V
Minimum Starting (max)		
Current (at stall)	89	mA
Reference phase	288	mA
Control phase (series)		mA
Control phase (parallel)	6.1	watts
Power Input/phase (max)	.60	
Power factor/phase		
Effective resistance		ohms
Reference phase		ohms
Control phase (series)		ohms
Control phase (parallel)		

MECHANICAL CHARACTERISTICS, Servo Motor Section

No-load speed (min)	6000	rpm
Stall torque (min)	1.20	oz-in
Rotor moment of inertia	8.5	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	9950	rad/sec^2
Ambient temperature range	-55 to +175	degrees C
Weight	14.0	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	44	mA
Power factor	.67	
Power	3.4	watts
Impedance	1785	ohms
R	1965	ohms
X	2650	ohms
Z	3950	ohms
Effective resistance		

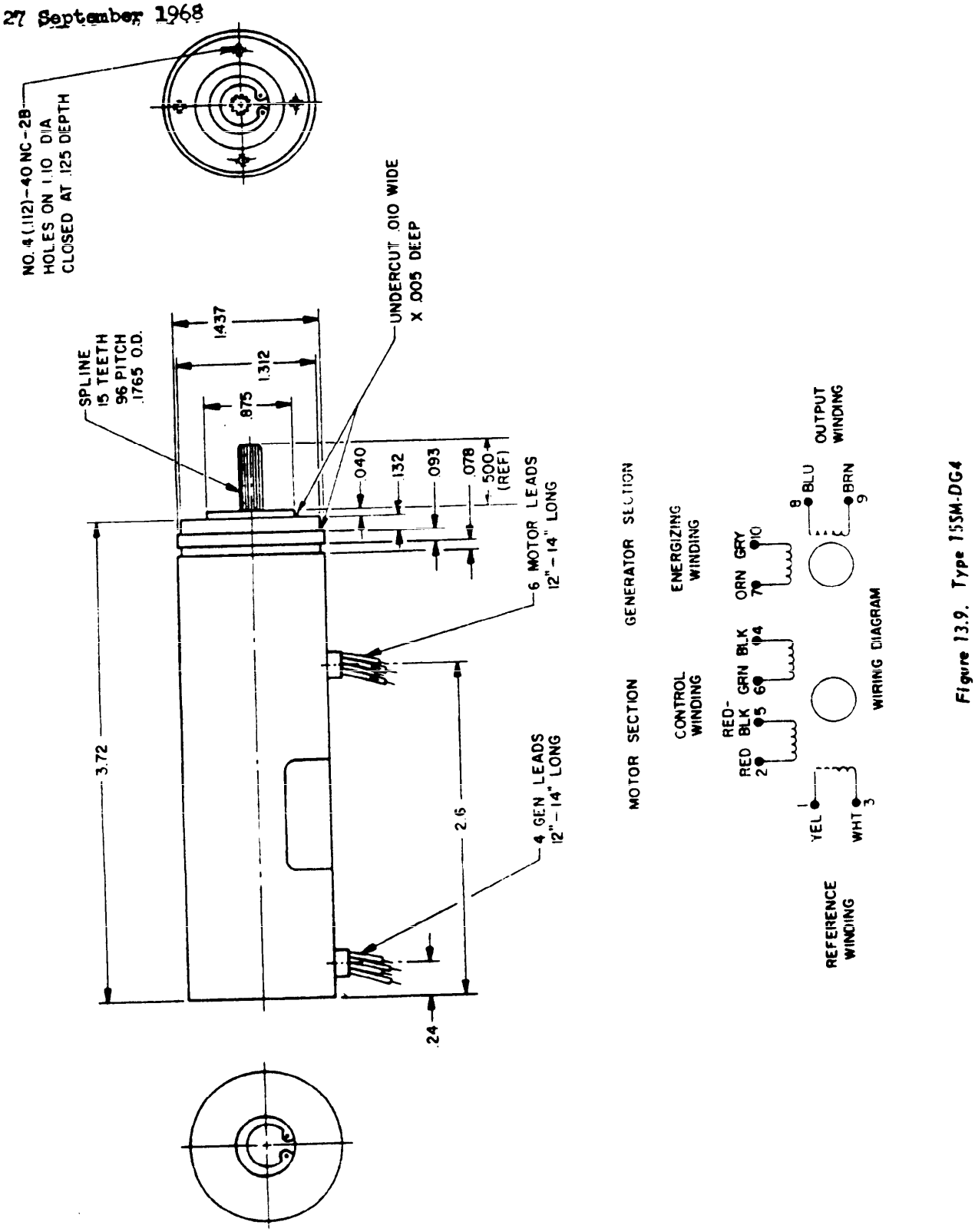


Figure 13.9. Type 15SM-DG4

TYPE 15SM-DG4 (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	2.75	
Output impedance		ohms
Max speed for linear output (.3%)	6000	rpm
Phase shift at 3600 rpm	5	degrees
Null voltage		
Total (max)	10	mV-rms
Fundamental	10	mV-rms
In phase component (max)	5	mV-rms
Quadrature component (max)	8	mV-rms
Variation of in phase component (max)	5	mV-rms

REFERENCES

Specification	MIL-S-22820/
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Developed under contract NOw 62-1093-f.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 15TGSM4d

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage	115	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)		V
Minimum starting (max)		
Current (at stall)	110	mA
Reference phase	355	mA
Control phase (series)	710	mA
Control phase (parallel)	6.1	watts
Power Input/phase (max)	.49	
Power factor phase		
Effective resistance	2200	ohms
Reference phase	212	ohms
Control phase (series)	53	ohms
Control phase (parallel)		

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	1.45	oz-in
Rotor moment of inertia	5.26	gm-cm^2
Theoretical acceleration (at stall)	19.500	rad/sec^2
Ambient temperature range		degrees C
Weight	14	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input	400	Hz
Frequency	115	V
Voltage	73	mA
Current	.64	
Power factor	5.4	watts
Power input		
Impedance	1012	ohms
R	1210	ohms
X	1575	ohms
Z	2440	ohms
Effective resistance		

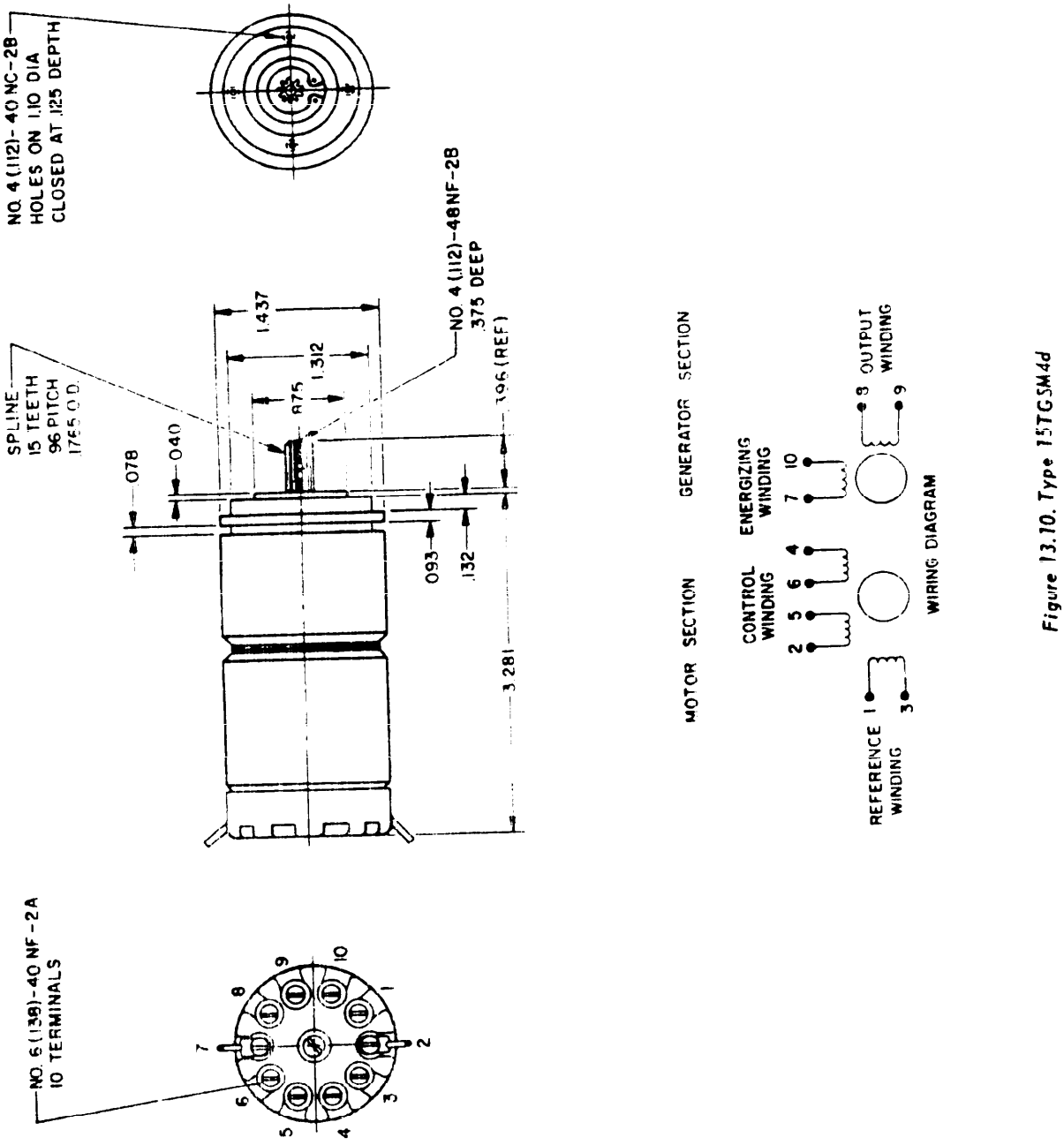


Figure 13.10. Type 15TGSM4d

TYPE 15TGSM4d (Continued)

Generator Output

Output voltage gradient	3.2	
(volts/1000 rpm)	2200	ohms
Output impedance	5500	rpm
Max speed for linear output	4.5 lagging	degrees
Phase shift at 5000 rpm		
Null voltage	13	mV-rms
Total (max)	8	mV-rms
Fundamental		mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		

REFERENCES

Specification		MIL-S-22820
Installation drawing	WP Dwg	2030641
General arrangement drawing		
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Formerly MK 12 Mod 2. Same as MK 12 Mod 0 except for motor control winding voltages and impedance. Generator section identical to MK 12 Mod 0.

SERVOMOTOR TACHOMETER GENERATOR

MK 16 MOD 0

ELECTRICAL CHARACTERISTICS, Servomotor Section

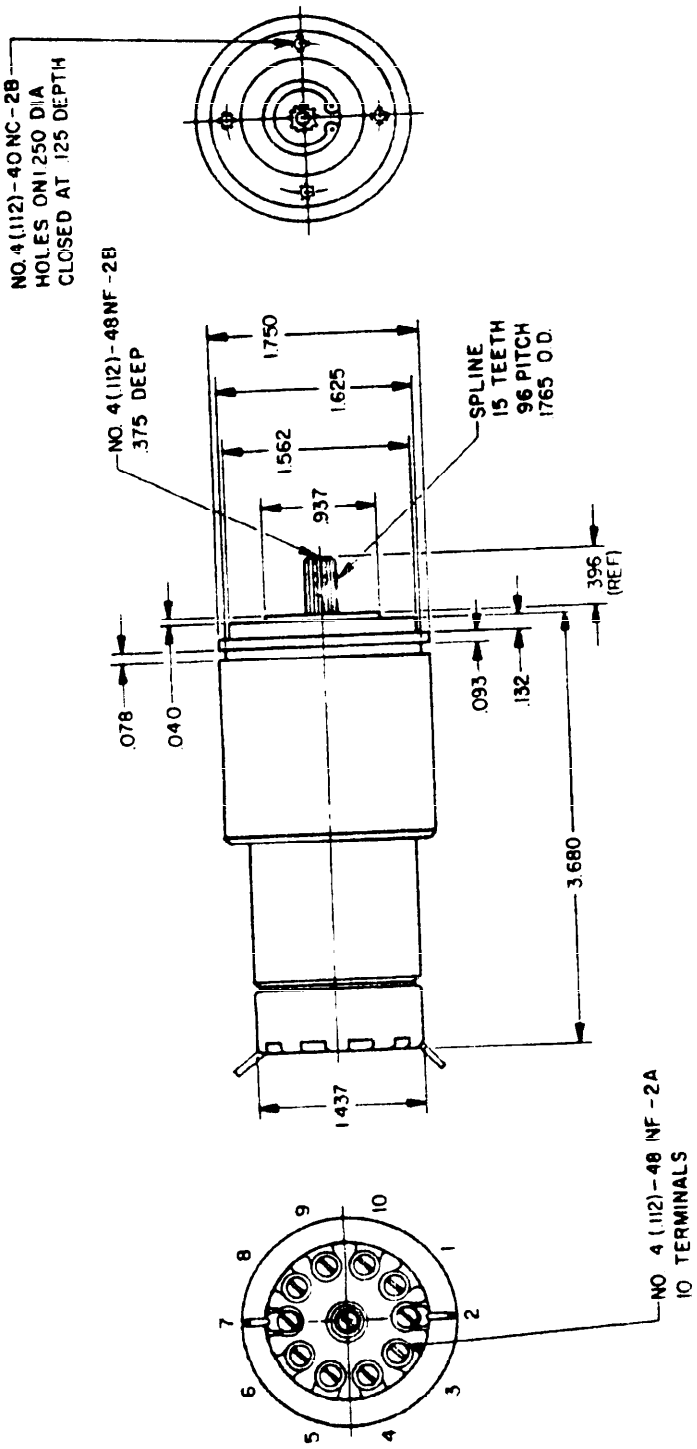
Frequency	400	Hz
Voltage	115	V
Reference phase	115	V
Control phase (series)	57.5	V
Control phase (parallel)		V
Minimum starting (max)		
Current (at stall)	183	mA
Reference phase	183	mA
Control phase (series)	366	mA
Control phase (parallel)	9.2	watts
Power input/phase (max)	.43	
Power factor/phase		
Effective resistance	1460	ohms
Reference phase	1460	ohms
Control phase (series)	365	ohms
Control phase (parallel)		

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	2.35	oz-in
Rotor moment of inertia	5.73	gm-cm^2
Theoretical acceleration (at stall)	29,000	rad/sec^2
Ambient temperature range		degrees C
Weight	19	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input	400	Hz
Frequency	115	V
Voltage	73	mA
Current	.64	
Power factor	5.4	watts
Power input		
Impedance	1012	ohms
R	1210	ohms
X	1575	ohms
Z	2440	ohms
Effective resistance		



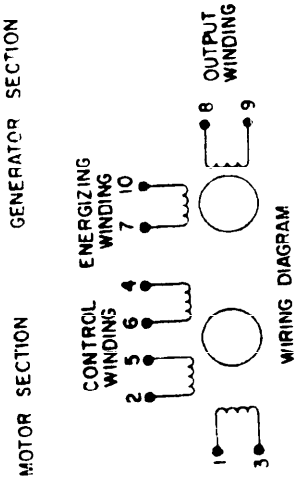


Figure 13.11. MK 16 MOD 0

MK 16 MOD 0 (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	3.2	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 5000 rpm	4.5 lagging	degrees
Null voltage		
Total (max)	13	mV-rms
Fundamental	8	mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification		MIL-S-17806
Installation drawing	WP Dwg	979402
General arrangement drawing	WP Dwg	675092
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Generator section identical to MK 12 Mod 0.

SERVOMOTOR TACHOMETER GENERATOR

MK 16 MOD 1

ELECTRICAL CHARACTERISTICS, Servomotor Section

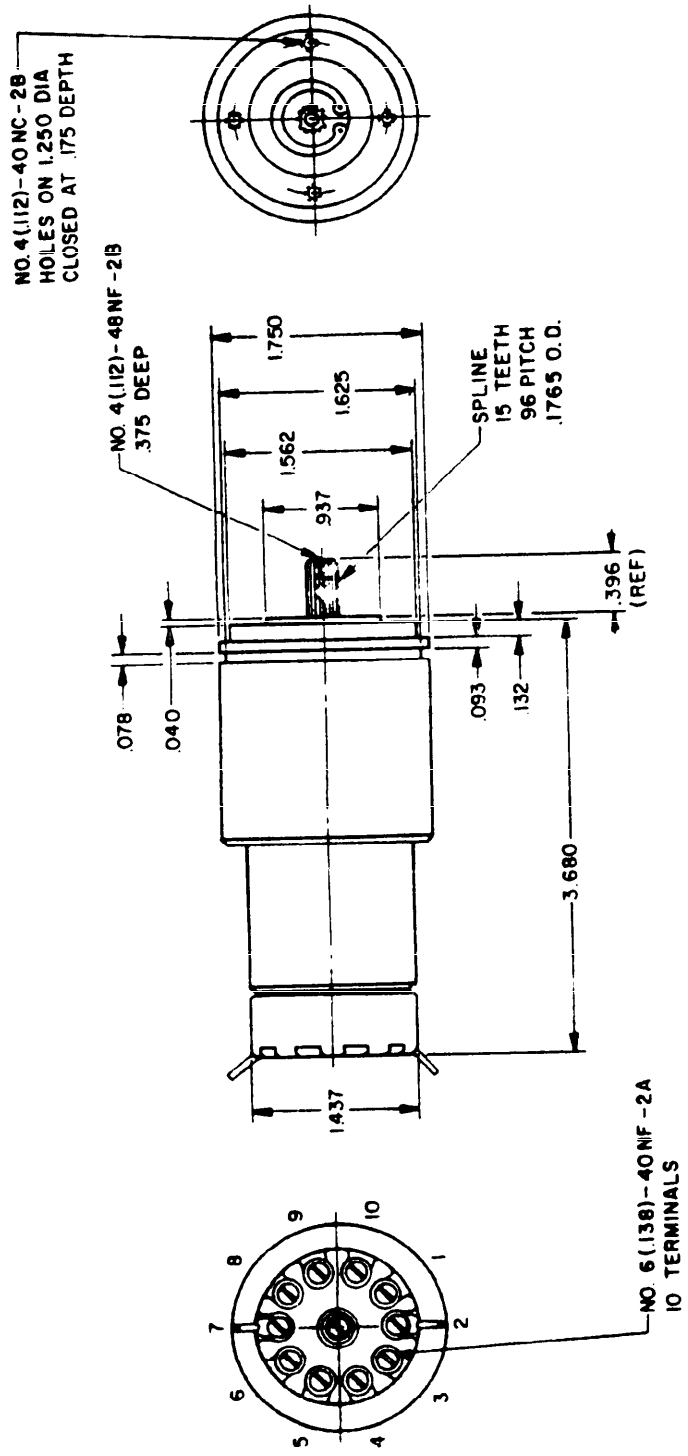
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	300	V
Control phase (parallel)	150	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	183	mA
Control phase (series)	67	mA
Control phase (parallel)	134	mA
Power input/phase (max)	9.6	watts
Power factor/phase	.48	
Effective resistance		
Reference phase	1460	ohms
Control phase (series)	9400	ohms
Control phase (parallel)	2500	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	2.35	oz-in
Rotor moment of inertia	5.73	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	29,000	rad/sec^2
Ambient temperature range		degrees C
Weight	20	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	73	mA
Power factor	.64	
Power input	5.4	watts
Impedance		
R	1012	ohms
X	1310	ohms
Z	1575	ohms
Effective resistance	2440	ohms



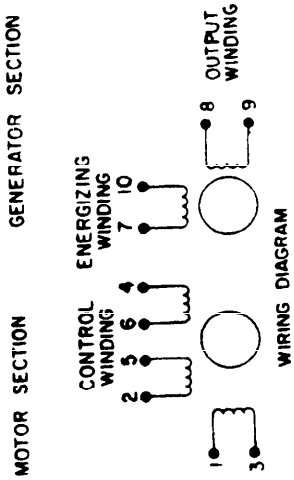


Figure 13.12. MK 16 MOD 1

MK 16 MOD 1 (Continued)

Generator Output

Output voltage gradient	3.2	
(volts/1000 rpm)	2200	ohms
Output Impedance	5500	rpm
Max speed for linear output	4.5 lagging	degrees
Phase shift at 5000 rpm		
Null voltage	13	mV-rms
Total (max)	8	mV-rms
Fundamental		mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		

REFERENCES

Specification		MIL-S-17806
Installation drawing	WP Dwg	988699
General arrangement drawing	WP Dwg	988700
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Same as MK 16 Mod 0 except for motor control winding voltages and impedance.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 18SM-15TG4

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)		V
Current (at stall)		
Reference phase	241	mA
Control phase (series)	77	mA
Control phase (parallel)	1540	mA
Power input/phase (max)	13.6	watts
Power factor/phase	.49	
Effective resistance		
Reference phase	1000	ohms
Control phase (series)	95	ohms
Control phase (parallel)	24	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min)	3.5	oz-in
Rotor moment of inertia	5.73	gm-cm^2
Theoretical acceleration (at stall)	43,100	rad/sec^2
Ambient temperature range		degrees C
Weight	20	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current	73	mA
Power factor	.64	
Power input	5.4	watts
Impedance		
R	1012	ohms
X	1210	ohms
Z	1575	ohms
Effective resistance	2440	ohms

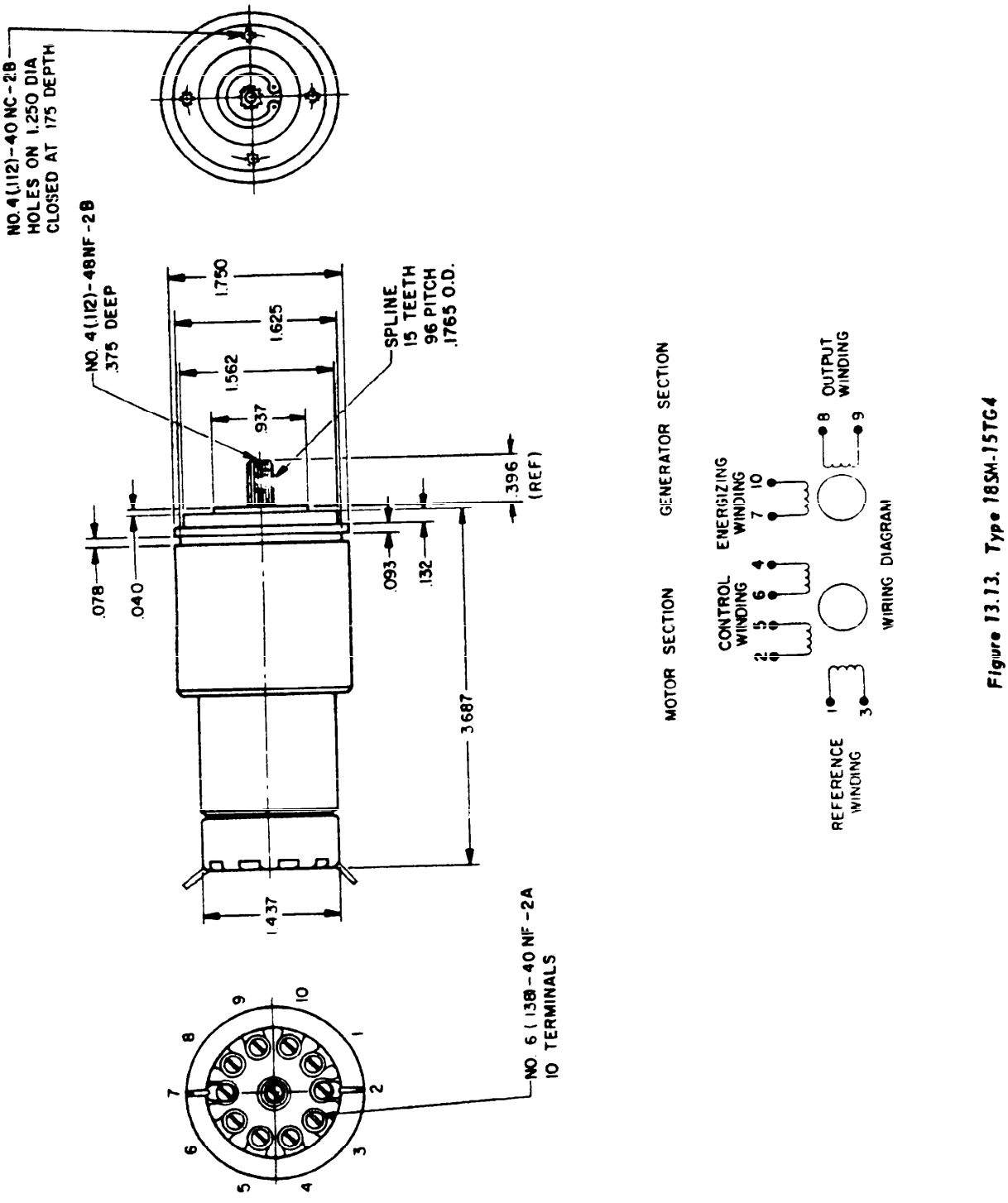


Figure 13.13. Type 18SM-15TG4

TYPE 18SM-15TG4 (Continued)

Generator Output

Output voltage gradient (Volts/1000 rpm)	3.2	
Output impedance	2200	ohms
Max speed for linear output	5500	rpm
Phase shift at 3000 rpm	5 lagging	degrees
Null voltage		
Total (max)		mV-rms
Fundamental		mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification		MIL-S-17806
Installation drawing	WP Dwg	2009128
General arrangement drawing	WP Dwg	
Federal Stock Number (FSN)		
Qualified Products List (QPL)		

NOTES

Formerly MK 16 MOD 2. Same as MK 16 MOD 0 except for motor control winding voltages and impedance.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 18SM-RG4d

ELECTRICAL CHARACTERISTICS, Servomotor Section

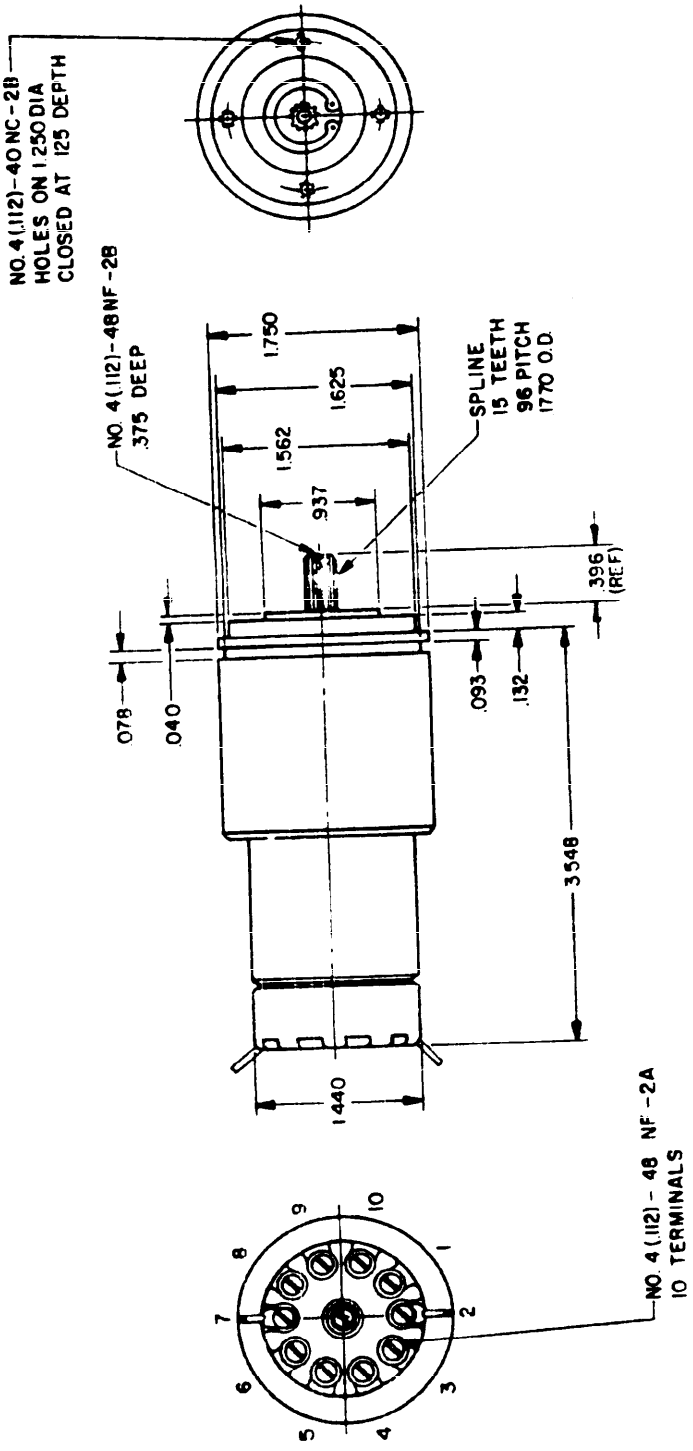
Frequency	400	Hz
Voltage		
Reference phase	115	V
Control phase (series)	36	V
Control phase (parallel)	18	V
Minimum starting (max)	1.0	V
Current (at stall) (max)		
Reference phase	200	mA
Control phase (series)	634	mA
Control phase (parallel)	1170	mA
Power input/phase (max)	9.1	watts
Power factor/phase	.42	
Effective resistance		
Control phase (series)	125	ohms
Control phase (parallel)	36	ohms

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	4500	rpm
Stall torque (min) at 23° C	2.20	oz-in
Rotor moment of inertia	5.73	gm/cm^2
Theoretical acceleration (at stall)	29,000	rad/sec^2
Ambient temperature range	-55 to +100	degrees C
Weight	21	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input		
Frequency	400	Hz
Voltage	115	V
Current (max)	78	mA
Power factor	.63	
Power input	5.6	watts
Impedance		
Energizing winding	1035 +j1276	ohms
Output winding (max)	3000	ohms
Output winding (min)	2500	ohms
Effective resistance, energizing winding	2645	ohms



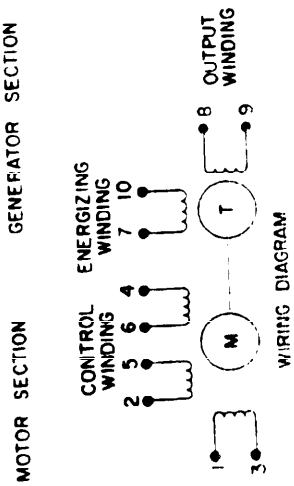


Figure 13.14. Type 18SM-RG4d

TYPE 18SM-RG4d (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	3.1	
In-phase speed sensitive TR	.08056	
Phase shift at 3000 rpm	4.5 lagging	degrees
In-phase linearity	±0.8	percent
In-phase axis error	±8	mV
Null voltage		
Total (max)	13	mV-rms
Fundamental	10	mV-rms

REFERENCES

Specification	MIL-S-22820/7A
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 16 MOD 3 (WP Dwg 2009026). Physical dimensions the same as MK 16 MOD 0. Generator section identical to MK 16 MOD 0.

SERVOMOTOR TACHOMETER GENERATOR

TYPE 18SM-RG6

ELECTRICAL CHARACTERISTICS, Servomotor Section

Frequency	60	Hz
Voltage	115	V
Reference phase	36	V
Control phase (series)	18	V
Control phase (parallel)		V
Minimum starting (max)		
Current (at stall)	125	mA
Reference phase	390	mA
Control phase (series)	780	mA
Control phase (parallel)	9.9	watts
Power input/phase (max)	.80	
Power factor/phase		
Effective Resistance	1430	ohms
Reference phase	140	ohms
Control phase (series)	35	ohms
Control phase (parallel		

MECHANICAL CHARACTERISTICS, Servomotor Section

No load speed (min)	2900	rpm
Stall torque (min)	3.0	oz-in
Rotor moment of inertia	5.73	$gm\text{-}cm^2$
Theoretical acceleration (at stall)	38,000	rad/sec^2
Ambient temperature range		degrees C
Weight	20	oz

ELECTRICAL CHARACTERISTICS, Tachometer Generator Section

Generator Input	60	Hz
Frequency	115	V
Voltage	10	mA
Current	.91	
Power factor	10.5	watts
Power Input		
Impedance	1160	ohms
R	500	ohms
X	1275	ohms
Z	1390	ohms
Effective resistance		

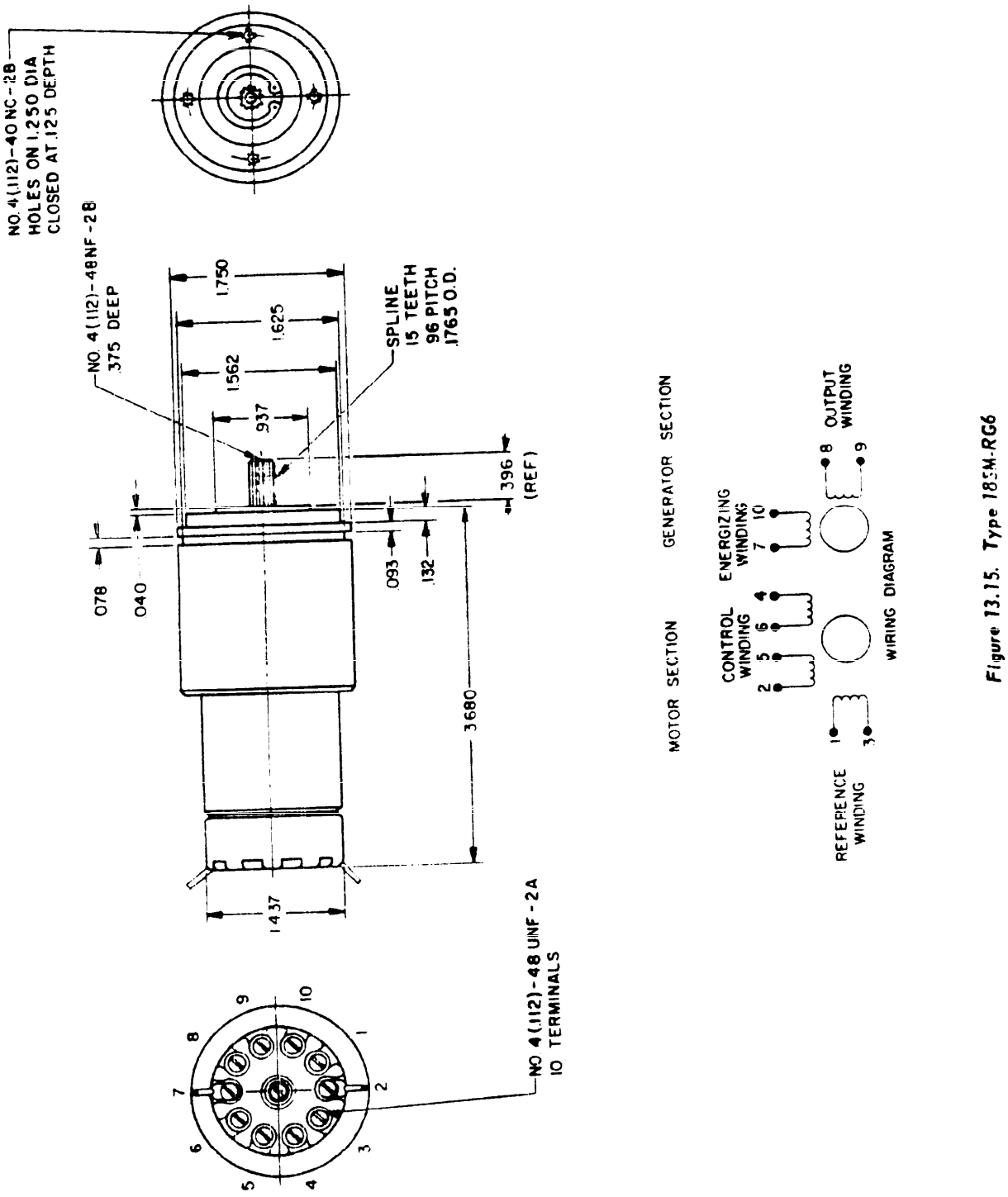


Figure 13.15. Type 18SM-RG6

TYPE 18SM-RG6 (Continued)

Generator Output

Output voltage gradient (volts/1000 rpm)	1.1	
Output impedance	1900	ohms
Max speed for linear output	3000	rpm
Phase shift at 1800 rpm	75 ± 7 leading	degrees
Null voltage		
Total (max)	20	mV-rms
Fundamental		mV-rms
In phase component (max)		mV-rms
Quadrature component (max)		mV-rms
Variation of in phase component (max)		mV-rms

REFERENCES

Specification	MIL-S-22820
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 31 MOD 1 (WP Dwg 2094897)
Physical dimensions the same as MK 16 Mod 0

CHAPTER 14

SERVTORQS

The instruments described in this chapter are self-contained, remote angular positioning and tracking devices for converting input synchro data into an accurate shaft position. They will perform, in both 60 Hz and 400 Hz systems, the functions of conventional instrument servo mechanisms and synchro torque receivers. The response is faster, the torque gradient is much greater, and the weight is less than equivalent size torque receivers. They require signal level power only from synchro driver and are relatively insensitive to frequency and voltage changes (50 Hz to 440 Hz, and 10 percent variation in voltage).

SERVTORQ

SIZE 23 (2.5/5.3)

ELECTRICAL CHARACTERISTICS (TYPICAL)

Frequency range	50 to 440	Hz
Voltage		
Primary, ± 10%	115	V
Signal input.	90	V
Primary current	70	mA
Primary power	8	watts
Peak torque	3.5	oz-in.
Torque gradient		
at 60 Hz	2.5	oz-in./deg
at 400 Hz	5.3	oz-in./deg
Accuracy		
Dynamic, at 20 rpm	30	min
Static	15	min
Input impedance		
at 60 Hz	4,600	ohms
at 400 Hz	24,500	ohms
Synchronizing time	0.2	sec

MECHANICAL CHARACTERISTICS

Temperature rise	20	degrees C
Ambient temperature	-55 to +100	degrees C
Weight	23	oz

NOTES

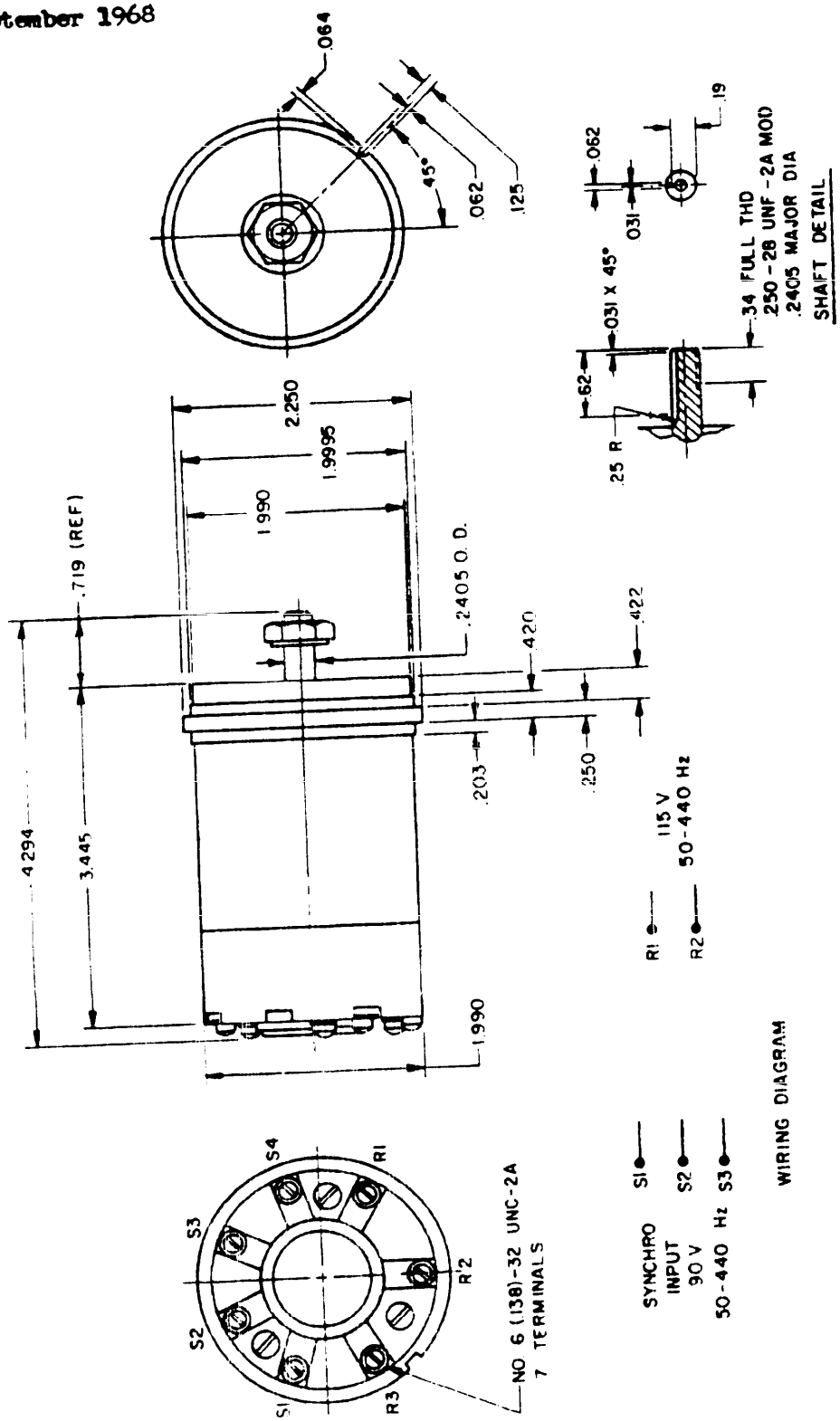


Figure 14.1. Servtorq Size 23 (2.5/5.3)

SERVTORQ

SIZE 23 (10/25)

ELECTRICAL CHARACTERISTICS (TYPICAL)

Frequency range	50 to 440	Hz
Voltage		
Primary, ±10%	115	V
Signal input	90	V
Primary current		
Peak	240	mA
Quiescent	50	mA
Primary power		
Peak	30	watts
Quiescent	7.5	watts
Peak torque	10	oz-in.
Torque gradient		
at 60 Hz	10	oz-in./deg
at 400 Hz	25	oz-in./deg
Accuracy, over ambient temp. range	±10	min
Input impedance		
at 60 Hz	4,600	ohms
at 400 Hz	24,500	ohms
Small signal natural frequency		
Zero load inertia	300	rad/sec
100 gm-cm^2 load inertia	200	rad/sec
Small signal damping factor		
Zero load inertia	0.7	
100 gm-cm^2 load inertia	0.5	
Velocity constant		
at 60 Hz	8,000	
at 400 Hz	15,000	

MECHANICAL CHARACTERISTICS

Temperature rise	20	degrees C
Ambient temperature	−55 to + 100	degrees C
Weight	23	oz

NOTES

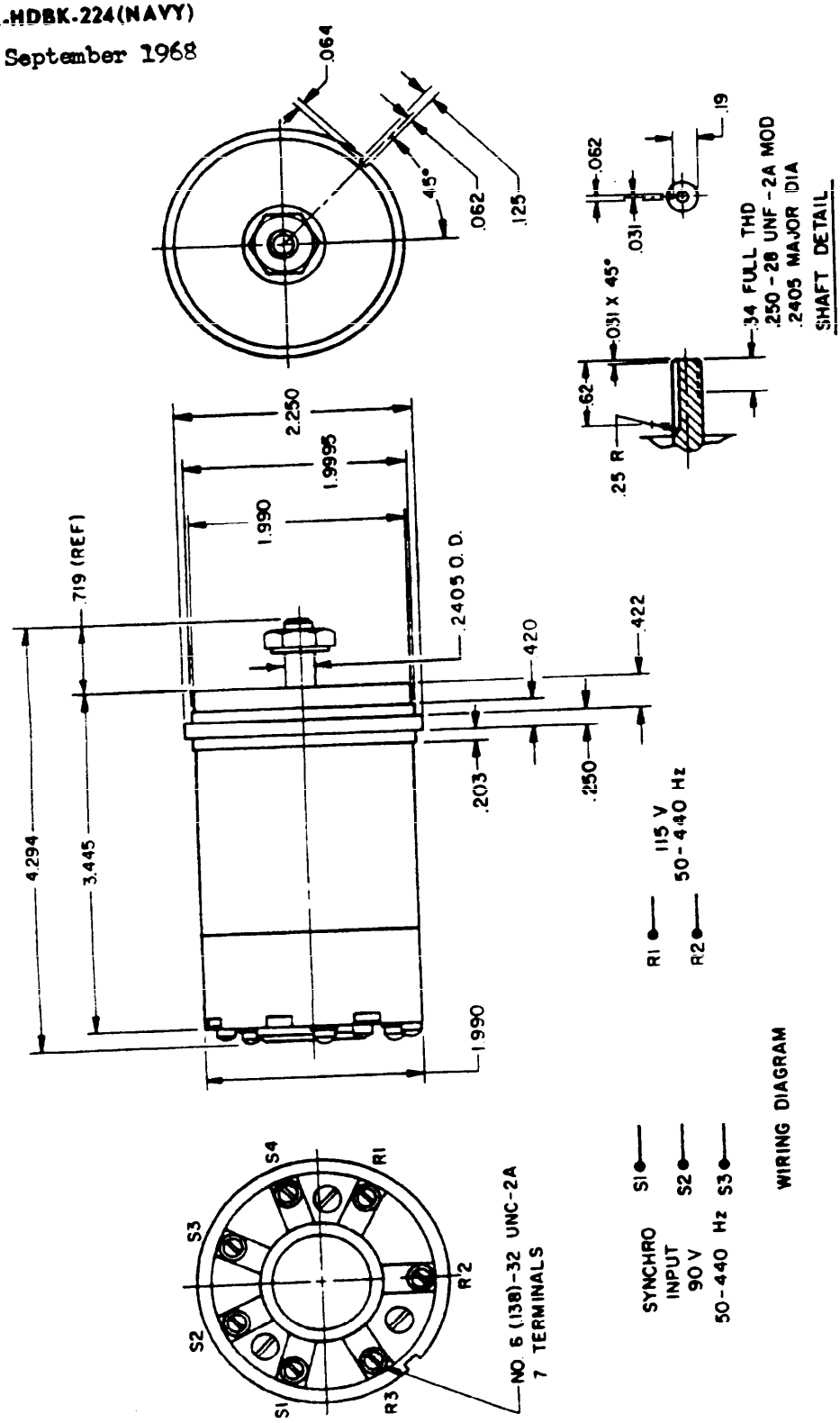


Figure 14.2. Servtorq Size 23 (10/25)

CHAPTER 15

STEPPER MOTORS

A compilation of stepper motors is being prepared

CHAPTER 16

STATIC RESOLVERS (STABILIZATION COMPUTER)

The static resolvers described in this chapter are of the solid-state type using integrated circuits to the maximum extent possible consistent with the state-of-the-art. This equipment is of the digital computational type used for advanced fire control systems.

RESOLVER, STATIC

ELECTRICAL CHARACTERISTICS

Frequency (operating)	1.5	MHz
Input-output voltage levels, binary "one"	0 ±1.5	V
binary "zero"	-13.5, +3.5 or -4.0	V
Input current, binary "one," per gate	3	mA
binary "zero" (-10V), per gate	0	mA
Output current, binary "one"	4 (15 mA, max)	mA
binary "zero" (-10V)	.5	mA
Rise-fall time transition slope (max), per μsec	5	V
Transition time (max) at the 10% - 90% levels	6	μsec
Power input (max) (115Vac, 1Ø, 400 Hz)	52	watts

Function

Platform stabilization - transformation of X, Y and Z target information to azimuth and elevation angles after correcting for ship's roll, pitch and heading.

Radar data conversion - transformation of radar range, azimuth, and elevation to X, Y, and Z information after correcting for ship's roll, pitch and heading.

Both of the above in sequence.

Capacity

Two platforms, two radars, or one platform and one radar simultaneously.

Speed per conversion	500	μsec
Input accuracy (maintained)	15	bits

MECHANICAL CHARACTERISTICS

Temperature range	-20 to +85	degrees C
Weight	46	lbs
MTBF	3500	hr

NOTES

Developed under contract NOw 63-0826-f.

Input and output voltage levels and other characteristics are compatible with the Naval Tactical Data System (NTDS). Operational and test mode controls, as well as visual register display are available on the front panel.

For list of drawings refer to Drawing 1001-DL2492980, Final report AD No. 472118. Request for copies of above should be addressed to NAVAIR, AIR-52022.

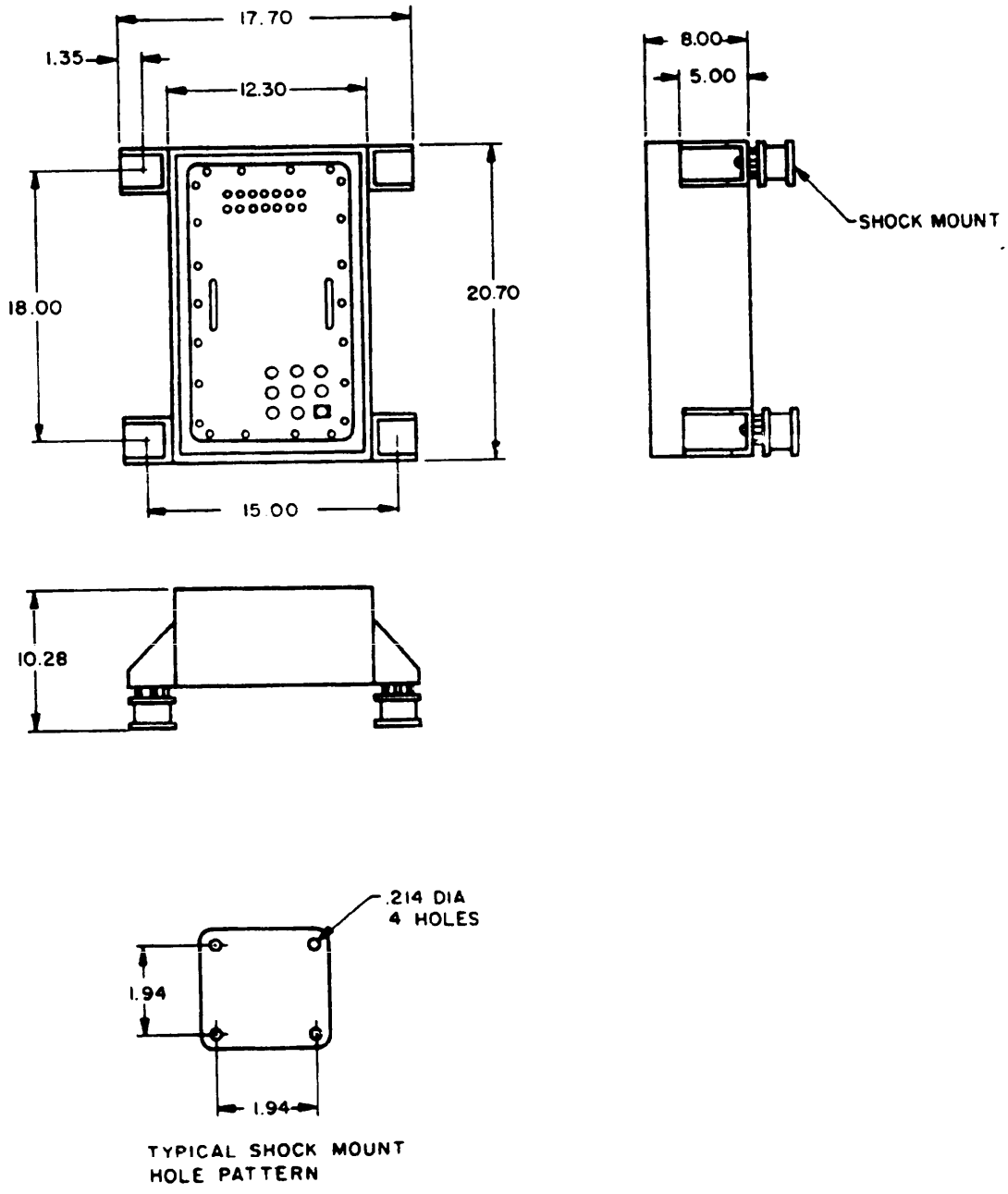


Figure 16.1. Static Resolver

CHAPTER 17

SWITCH, SILICON PNPN, RF DESENSITIZED

The switch described in this chapter is of the PNPN, RF desensitized, four-layer structure type modified to include an RC filter which attenuates RF signals introduced between the gate and cathode leads. Between the resistor and the gate lead is a diffused zener junction which breaks down at eight volts. This extra junction rectifies RF signals between gate and cathode, and places on the emitter junction a reverse bias which must be overcome before the RF signal can fire the switch. In normal DC operation, the gate voltage is raised slightly above the zener breakdown voltage, sending sufficient current through the emitter to fire the switch.

SWITCH, SILICON PNPN, RF DESENSITIZED

ELECTRICAL CHARACTERISTICS

Range of protection		
Anode, dc to 29 MHz	±100	V
Gate, 100 kHz to 29 MHz	+.5	mA
Gate firing signal (max), at 10V	.5	Adc
Current handling ability	10	A
for 5 msec	60	pf
Interlead capacitance (approx), between any two leads		

MECHANICAL CHARACTERISTICS

Temperature range		
Operating	−65 to +80	degrees C
Storage	−65 to +15	degrees C
Size	TO-5 can	
Weight (approx.)	1	gram

NOTES

This device is intended to replace the conventional PNPN switch in circuits which may be exposed to unwanted radio-frequency energy.

Additional details may be obtained from U. S. Naval Ordnance Laboratory, Silver Spring, Maryland.

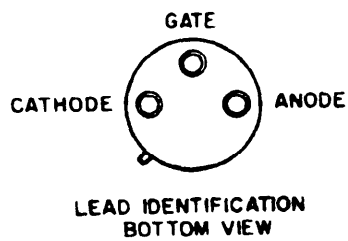


Figure 17.1. RF Desensitized PNPN Switch

CHAPTER 18

SYNCHROS

Engineering and technical data on standard synchros recommended for new design as well as on synchros procured for maintenance of existing equipments is contained in MIL-HDBK-214, "SYNCHROS." The requirements for the selection of synchros for use in military equipments are established by MIL-STD-710, "SYNCHROS, 60 AND 400 CYCLE."

CHAPTER 19

TACHOMETER GENERATORS

The instruments described in this chapter are designed for two classes of applications, one applied where the absolute value of generated voltage is not required to be free of temperature effects, and one applied where the absolute value of generated voltage must be independent of ambient temperature. The attainment of a high ratio between generated voltage and the value of fundamental component of output voltage at zero speed has been a major objective.

TACHOMETER GENERATOR

TYPE 11TG4

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage	115	V
Current (max)	55	mA
Power (max)	4.7	watts
Power factor		
Effective resistance		ohms
Impedance		
Energizing winding		ohms
Output winding		ohms
In-phase speed sensitive TR		
Phase shift at 3600 rpm (380 to 420 Hz)	2.0(Lag.)	degrees
Max speed for linear output (0.2%)	7200	rpm
Null voltage		
Total (max)	15	mV-rms
Fundamental		mV-rms
Output voltage variation		
(−55 to +175°C range)	±0.5	percent
(380 to 420 Hz range) (max)	0.4	percent
Input/output voltage ratio variation		
(105 to 125 V range)	±0.5	percent
Output voltage gradient (V/1000 rpm)	2.75	

MECHANICAL CHARACTERISTICS

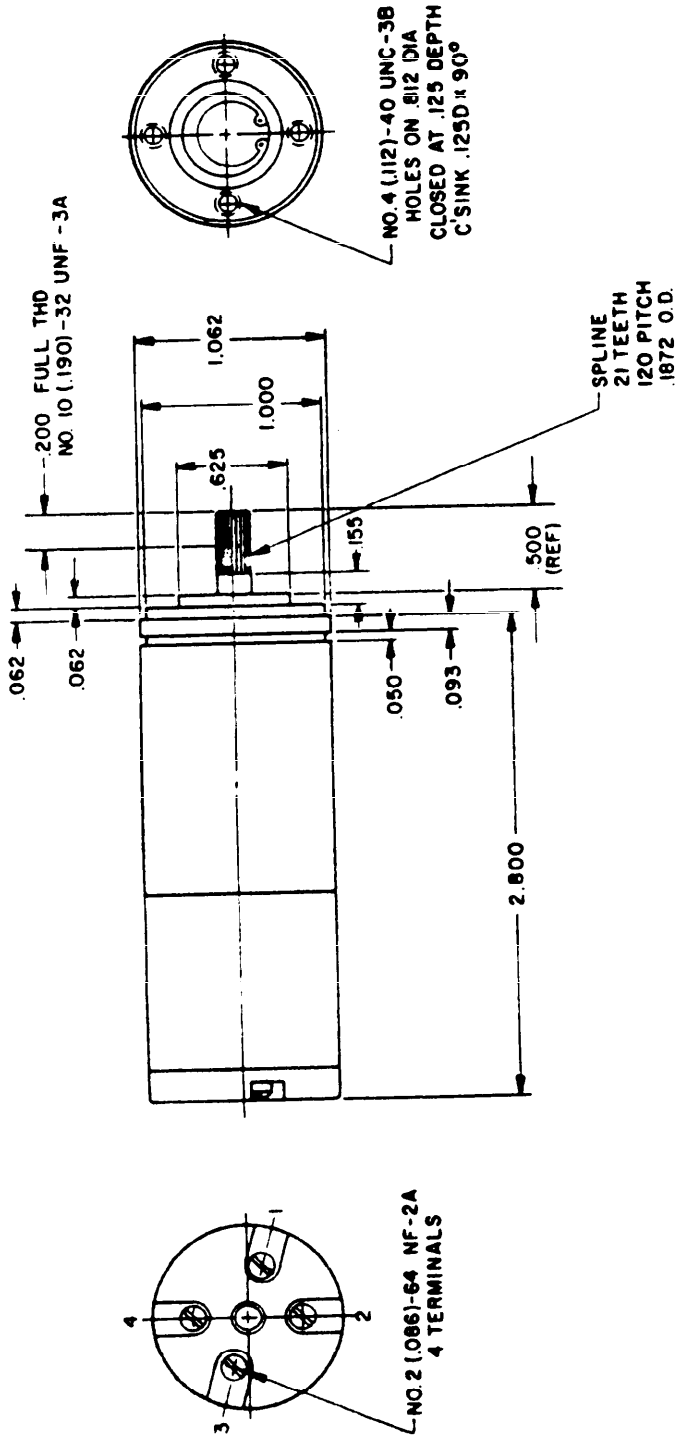
Friction torque (max)	.032	oz-in
Speed range	0 to 7200	rpm
Rotor moment of inertia	5.5	gm-cm^2
Ambient temperature range	−55 to +175	degrees C
Weight	7.0	oz

REFERENCES

Specification	MIL-T-22821
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Developed under contract N600(19)57244.



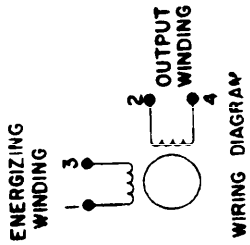


Figure 19.1. Type 11TG4

TACHOMETER GENERATOR

TYPE 15IH4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage	115	V
Current (max)	260	mA
Heater winding	86	mA
Energizing winding		
Power (max)	30	watts
Heater winding	6.5	watts
Energizing winding		
Impedance	2500	ohms
Zso	53.2	degrees
Φso	.0717	
In-phase speed sensitive TR	0	degrees
Phase shift	0.5	percent
In-phase linearity	±8	mV
In-phase axis error (max)		
Zero speed output voltages	13	mV-rms
Total (max)	10	mV-rms
Fundamental (max)		
Voltage sensitivity (energizing winding)	0.5	percent
Linearity, 115V ±10% range, (max)		
In-phase TR (No greater than 1% of value at 115V ±1%)		
Temperature sensitivity (−55 to +100°C range)	0.5	percent
In-phase linearity (max)		
In-phase TR (No greater than ±7% of value at 23 ±2°C)	1.8 ±.5	degrees
Phase shift at 75°C	2.75	
Output voltage gradient (V/1000 rpm)		

MECHANICAL CHARACTERISTICS

Speed range	0 to 3600	rpm
Rotor moment of inertia	2.1	gm-cm^2
Ambient temperature range	−55 to +100	degrees C
Weight	9.4	oz

REFERENCES

Specification	MIL-T-22821/1
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 2 MOD 0

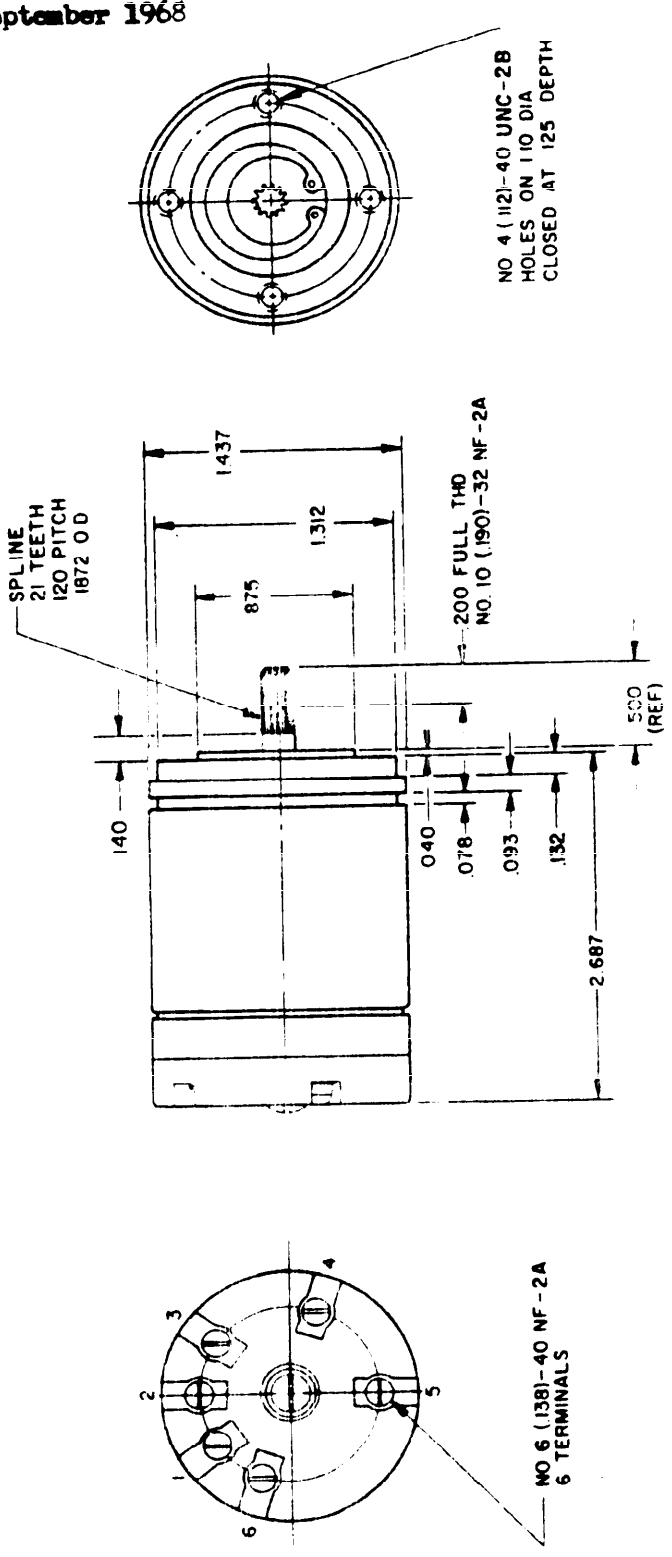


Figure 19-2. Type 15IH4a

TACHOMETER GENERATOR

TYPE 15IN4a

ELECTRICAL CHARACTERISTICS

Frequency	400	Hz
Voltage	115	V
Current (max)	76	mA
Power (max)	5.49	watts
Power factor	.64	
Effective resistance	2440	ohms
Impedance		
Energizing winding	1746	ohms
Output winding	34	ohms
In-phase speed sensitive TR	.0836	
Phase shift	7.0 (Lag.)	degrees
In-phase linearity (max)	5.0	percent
In-phase axis error (max)	±8	mV
Zero speed output voltages		
Total (max)	12	mV-rms
Fundamental (max)	8	mV-rms
Voltage sensitivity (energizing winding)		
Linearity, 115V ±10% range (max)	0.5	percent
In-phase TR (No greater than 1% of value at 115V ±1%)		
Temperature sensitivity (−55 to +100°C range)		
In-phase linearity (max)	0.5	percent
In-phase TR (No greater than ±7% of value at 23 ±2°C)		
Phase shift at 75°C	7 ±1	degrees
Output voltage gradient (V/1000 rpm)	3.2	

MECHANICAL CHARACTERISTICS

Speed range	0 to 3600	rpm
Rotor moment of inertia	2.1	gm-cm^2
Ambient temperature range	−55 to +100	degrees C
Weight	7.5	oz

REFERENCES

Specification	MIL-T-22821/2
Installation drawing	
General arrangement drawing	
Federal Stock Number (FSN)	
Qualified Products List (QPL)	

NOTES

Formerly MK 1 MOD 1

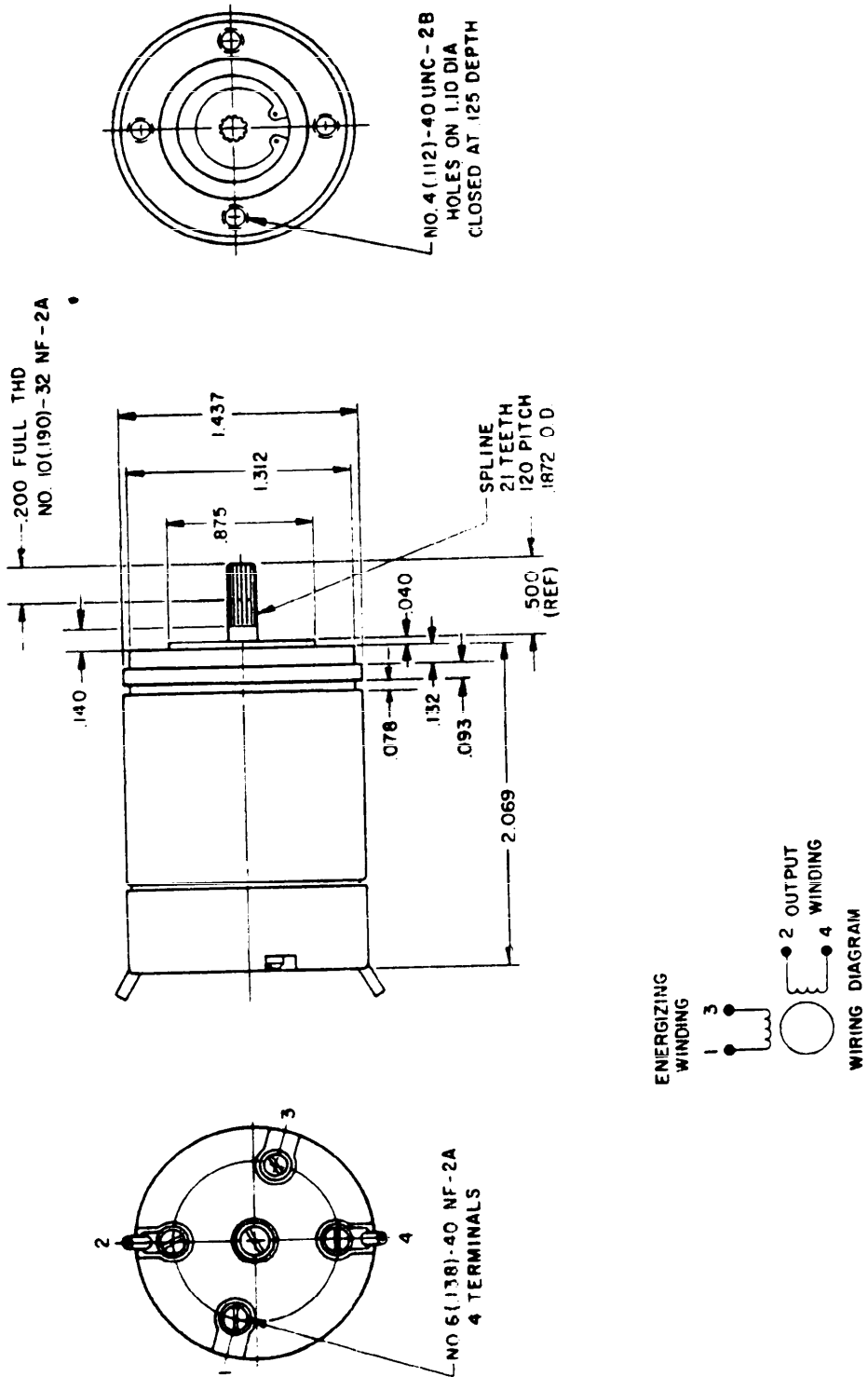


Figure 19-3. Type 15IN4a

CHAPTER 20

TOOLS, HARDWARE, AND MOUNTING METHODS

To facilitate mounting precision rotating components, several items of hardware have been developed. The various mounting methods and the manner in which items of hardware are used are described in MIL-HDBK-214, "SYNCHROS," MIL-HDBK-225, "SYNCHROS, DESCRIPTION AND OPERATION," and MIL-HDBK-218, "APPLICATIONS OF ELECTRICAL RESOLVERS."

Preparing activity:
Navy – AS
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NOTICE OF CANCELLATION

INCH-POUND

MIL-HDBK-224(NAVY)
NOTICE 1
22 APRIL 1991

MILITARY STANDARDIZATION HANDBOOK

PRECISION COMPONENTS

MIL-HDBK-224(NAVY), dated 27 September 1968, is hereby canceled without replacement.

Preparing Activity:
Navy - AS

(Project 5990-N400)

AMSC - N/A

FSC 5990

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