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North-seeking gyrocompass

Sperry Gyroscope

Great Neck, N. Y. 11020

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NORTH SEEKING GYROCOMPASS
NORTH FINDING MODULE

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THIS REPORT DESCRIBES THE NORTH SEEKING GYROCOMPASS DELIVERED FOR EVALUATION ON THE M113 ARMORED VEHICLE. THE SYSTEM CONSISTS OF A NORTH FINDING MODULE ATTACHED TO A VEHICLE MOUNTED GIMBAL SET AND A SEPARATE CONTROL PANEL/ BATTERY CHARGER. THE GYROCOMPASS SUPPLIES AZIMUTH TO AN ACCURACY OF 2 MILS RMS APPROXIMATELY 2 MINUTES AFTER TURN-ON.

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PREFACE

This report describes the work effort and hardware manufactured under contract No. DAAK 70-78-C-0210 for US Army Engineer Topographic Laboratories, Fort Belvoir, Virginia by Sperry Gyroscope, an operating unit of the Sperry Division of Sperry Corporation, Great Neck, New York 11020. The Contracting Officer's Representative was Mr. Fred Gloeckler, Jr.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

The North Seeking Gyrocompass (NSG) developed for USAETL consists of a North Finding Module (NFM), as developed for the Naval Weapons Center (NWC), China Lake, California, attached to a vehicle mounted gimbal set. The NFM is a battery operated gyrocompass with a LED display that supplies azimuth (heading) information in 2 minutes to an accuracy of 2 mils RMS. The NSG also includes a separable Control Panel/Charger which permits the NFM to be turned on remotely, locks the gimbal set and is used to charge the NSG battery.

INVESTIGATION

The design and development of the NSG consisted of two critical investigations:

a) Design investigation - This task consisted of layout studies to determine the best packaging approach to minimize size and weight. An important requirement was that the NFM used on the NSG would be unchanged from the design developed for NWC. The final design (see Figure 1) consisted of a standard NFM mounted to an intermediate support structure, the "frame". The frame is removable from the gimbal system. It holds a BB557 Nickel-Cadmium battery which operates the NFM in off-vehicle applications. The frame is designed to mount directly onto the night-sight bracket on the GLLD*. Considerable effort was expended in order to provide desired-tilt freedom. The center of gravity and weights of components had to be carefully controlled in order to maintain a natural balance. The NFM has to be nominally level ($\pm$ 3/4°) when mounted on the pendulous gimbal structure. The design investigation also included

*Ground Laser Locator Designator

the placement of viscous dampers on the gimbals. Damping was desired in order to quickly stabilize the NFM in a level position after vehicle motion stops.

b) Gimbal Lock Investigation - On September 20, 1979 a series of tests were conducted on the M-113 with the first of two gimbal sets designed and built for the NSG. The purpose of this test series was to determine whether any accuracy degradation occurred when the NFM was allowed to be free and pendulous while operating. (The concern was that gimbal movements induced by the NFM might in turn degrade NFM perfcrmance.) The data is presented in Tables 1 and 2.

The results of these tests indicated that although the two-mil spec was met, NFM performance (0.5 mil) was degraded to 1.8 mil with the engines on and operating at rated idle (1000 RPM). With a very rought idle (about 400 RPM), caused by a malfunctioning idle adjust in the M-113, the NFM had a tendency to turn off before completing the northing run due to excess movement. When the gimbals were immobilized, this did not happen.

As a result of this investigation, gimbal locks were added to both gimbal systems. These solenoid-controlled gimbal locks are activated remotely by means of a switch on the Control Panel and Charger Assembly.

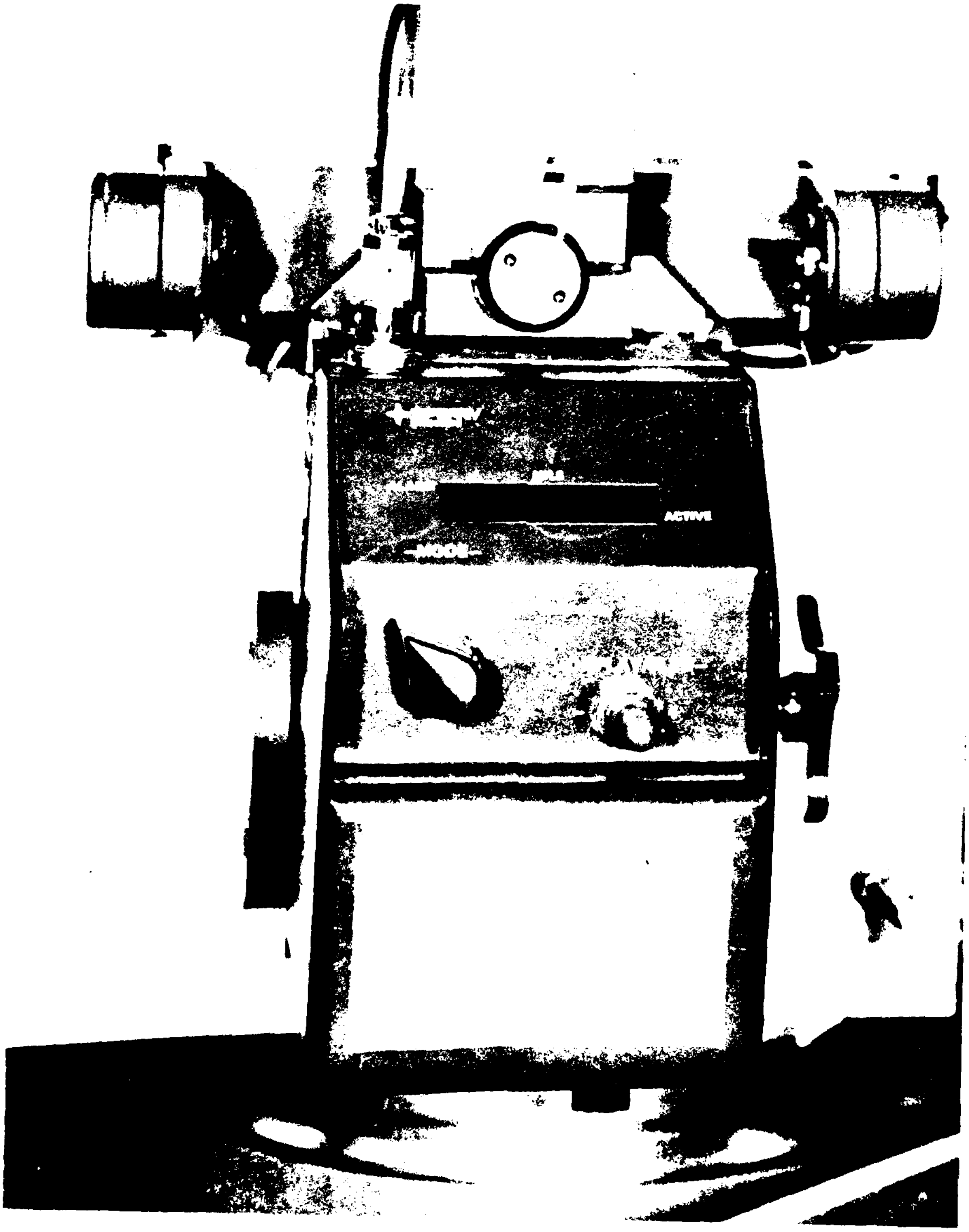


Figure 1. NFM Mounted on NSG Gimbals

TABLE 1. NSG GIMBAL DATA

ENGINE RPM 0	400	700	1000	GIMBAL FREE	LOCKED	AZIMUTH	MEAN	S.D.
X				X		3949.7		
X				X		3949.7	3949.67	.05
X				X		3949.6		
X					X	3949.1		
X					X	3949.3	3948.53	.38
X					X	3948.6		
X					X	3949.1		
X				X		3948.2		
X				X		3947.3	3947.8	.37
X				X		3947.9		
		X			X	3948.7		
		X		X		3948.1		
		X			X	3948.3		
		X		X		3947.9		
		X		X		3948.3		
	X			X		-15 *		
	X				X	3948.1		
			X	X		3947.4		
			X	X		3951.9		
			X	X		3950.9	3949.24	1.82
			X	X		3948.4		
			X	X		3947.6		
	X			X		-15 *		
	X			X		-15 *		
	X			X		-15 *		
X				X		3948.7		
		X			X	3948.3		
		X			X	3948.3		
	X			X		-15 *		

TABLE 2. DATA SUMMARY

NUMBER OF NORTHINGS	OFF	ENGINE 400RPM	400RPM	GIMBAL FREE	LOCKED	MEAN	S.D.
7	X			X		3948.73	.9
4	X				X	3948.53	.38
5		X		X		-15 ALARM*	
1		X			X	3948.1	--
8			X	X		3948.76	1.47
5			X		X	3948.35	.22

* Denotes excess NFM Movement

DISCUSSION

1. Equipment Description

The NSG consists of two main components:

1. The Mounted North-Seeking Module
2. The Control Panel and Charger

The North Seeking Module in turn consists of:

1. North Finding Module
2. Battery Assy
3. Structure (Gimbal System)

The Family Tree of the NSG is shown in Figure 2.

2. North Finding Module

The NFM is the sensor for the NSG. The Sperry North Finding Module is a pendulous gyrocompass used to determine true (geographic) north and grid azimuth. The NFM was designed specifically for the MULE (Modular Universal Laser Equipment) to be mounted on the STTM (Stabilized Target Tracking Module). Figure 3 shows the NFM mounted on the MULE STTM.

The NFM meets all the requirements of the XAS 4536B Critical Item Development Specification for North Finding Module and the North Finding Module ICD (Interface Control Document) 2969.

The Sperry NFM has been designed to fulfill a number of missions requiring medium to high azimuth accuracy. The trade-offs are between accuracy, time and the need for pre-alignment. For applications such as FIST and MULE the requirement is an accuracy of 2 mils RMS in 2 minutes of time with no pre-alignment and with up to $\frac{1}{2}^{\circ}$ mis-level. For survey type of applications, up to 15 minutes of time may be acceptable for a northing. With approximate pre-alignment ($\pm$ 10°) to north, a 10 to 1 improvement in accuracy is possible (i.e. 0.2 mils

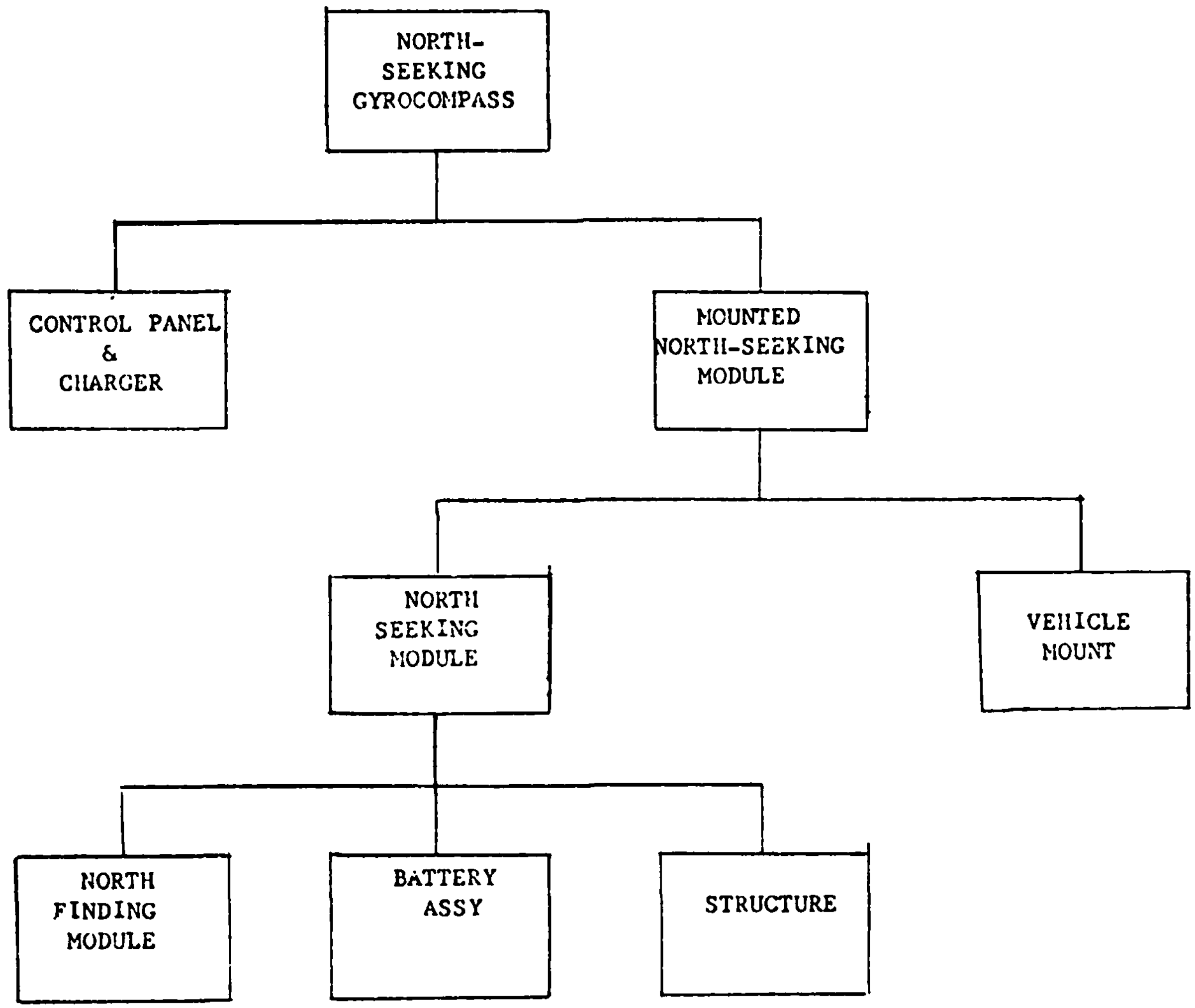


Figure 2. NSG Family Tree

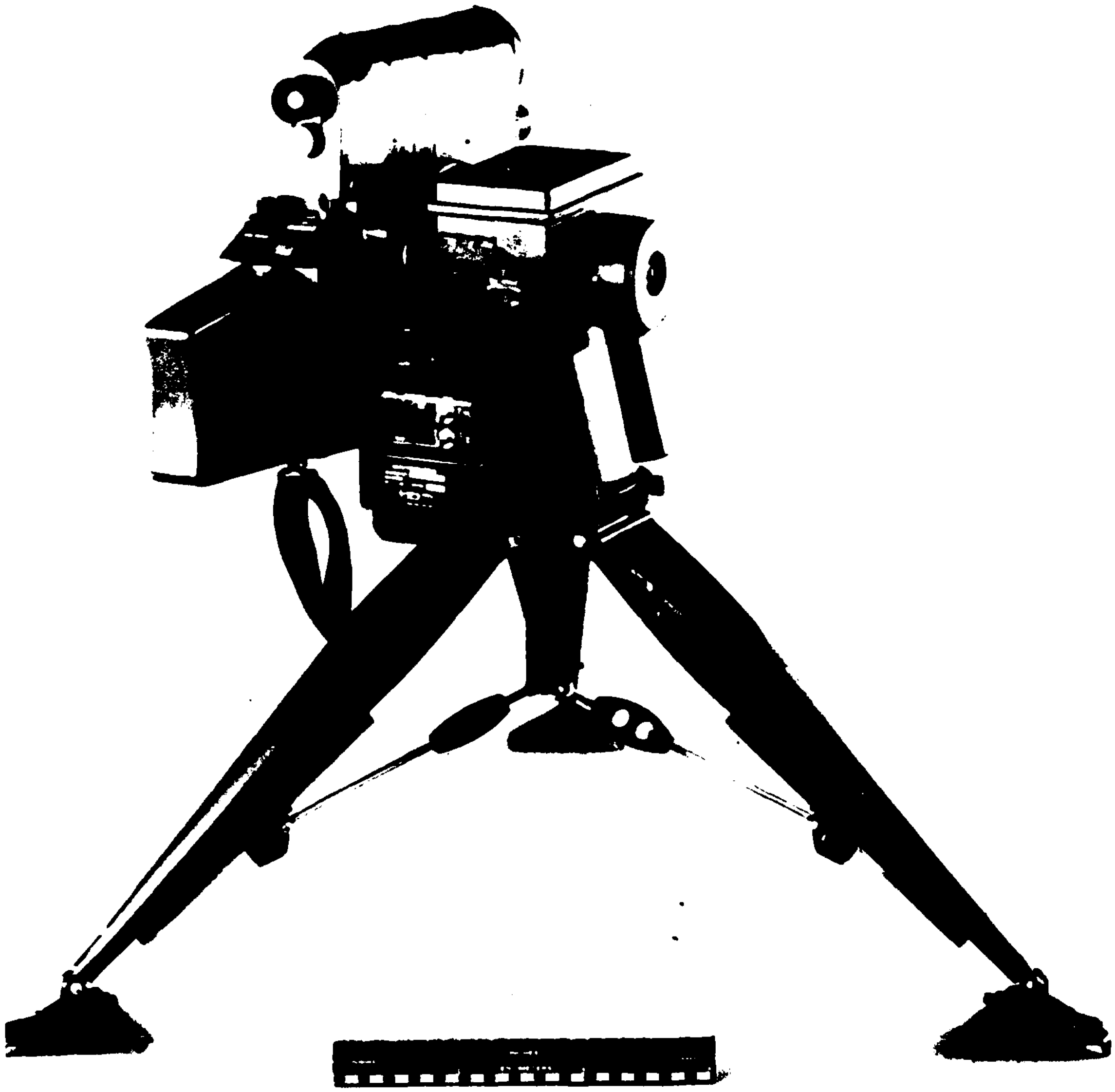


Figure 3. NFM Mounted on MULE STTM

RMS). When the NFM can be pre-levelled within 3 minutes of arc, an azimuth error of less than 2 mils RMS can be achieved within one minute of time. Recognizing that no single mission can afford the starting costs associated with dedicated hardware, Sperry designed the NFM to meet these multi-mission requirements with common hardware, modifying software to meet the mission requirements.

NFM versatility is derived in large part from the exploitation of state-of-the-art microprocessor technology combined with the dependable and proven gyrocompass. True azimuth is obtained from this sensor. Grid convergence, as given on UTM maps, can be inserted and stored in non-volatile memory so that grid azimuth can also be displayed. With this capability, grid convergence (or northing and easting data) can be a pre-mission insertion requiring no further mission procedures.

Operation of the NFM is initiated from the front panel, shown in Figure 4, or by remote turn-on. The front panel consists of a LED display, the five-position MODE switch, and a pressure-activated toggle DISPLAY/SLEW switch.

These two control panel mounted switches initiate the following functions:

MODE SWITCH

POSITION	FUNCTION NAME
1	OFF
2	ON
3	GRID CONV
4	EAST
5	NORTH

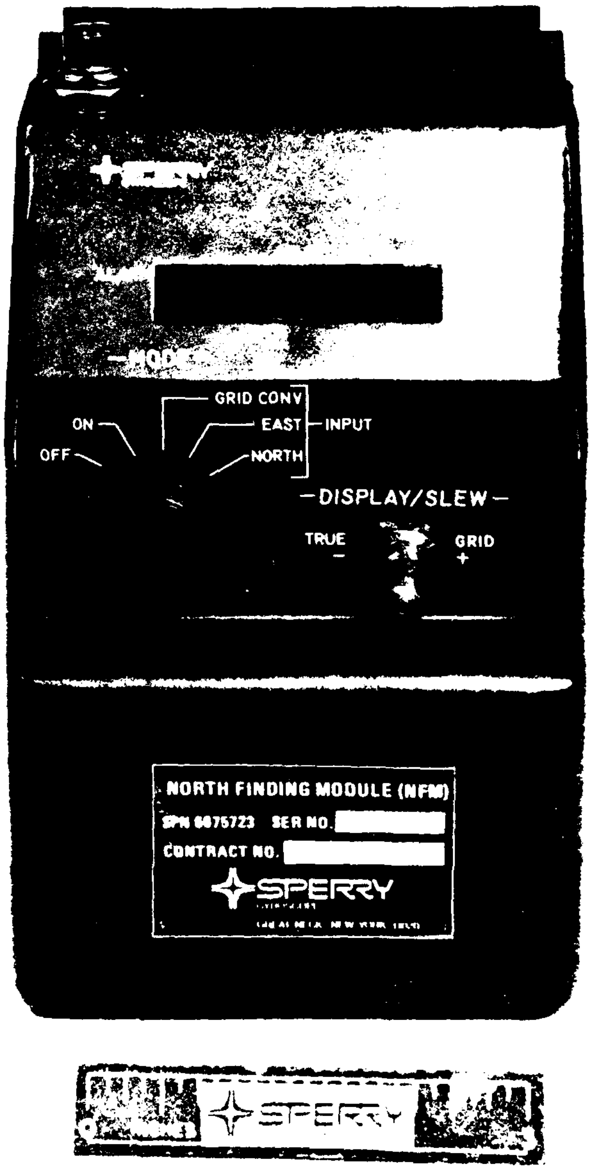


Figure 4. NFM Front Panel

DISPLAY/SLEW SWITCH

1	-TRUE	(True Azimuth)
2	+GRID	(Grid Azimuth)

The NFM connector to which power is applied is also the means by which functions can be remotely initiated. A full explanation of the remote display capability is found on page 16. The functions on the NFM connector are tabulated below.

CONNECTOR PIN

PIN NO.	FUNCTION NAME
A	CLOCK (10V)
B	CLEAR/DATA ENABLE (10V)
C	SERIAL DATA (10V)
D	SEND DATA (20-36V, 40 Ma)
E	FIND NORTH (20-36V, 40 MA)
F	PRIMARY POWER (+19 to +31 VDC)
H	POWER/SIGNAL RETURN AND CASE GND

There are two light emitting diodes (LED) on the front panel, ALARM and ACTIVE. Since the NFM employs continuous built-in test, the ALARM LED is illuminated in the event of a malfunction. The ACTIVE LED is illuminated when the NFM is performing its gyrocompass function to determine azimuth. This serves as a visual indication to the operator that the NFM should not be physically disturbed or mode switched. When this LED turns off, the NFM is available for information call-up or mode change.

Keys consisting of four digit numbers are inserted by the proper sequencing of the MODE switch and the DISPLAY/SLEW switch. These keys convert the NFM from a tactical MULE application to a survey, vehicle, or factory test application. The non-volatile memory will retain the value of key set, even after power to the NFM is removed.

Changes in the MODE switch from OFF to any other position will initiate the mode requested. Change from any position to any other position but OFF will initiate the new mode requested after completion of the mode in progress, provided the NFM has not yet entered the power-down phase. The NFM will power down automatically to zero power when its operational mode is completed. Insertion of data is by means of the INPUT modes on the MODE switch (GRID, CONV, EAST or NORTH) and the DISPLAY/SLEW switch. Values can be most quickly entered by inserting the most significant digit first. Holding the DISPLAY/SLEW switch to + will cause the display to cycle through all 10 ones digits in an increasing direction; then all 10 tens digits; then all 10 hundreds digits and finally to the thousands digits. Release the DISPLAY/SLEW switch at the desired most significant digit. Repeat the above, releasing at the next significant digit. Continue until the correct total value has been inserted. Holding the DISPLAY/SLEW switch to - will have the same effect except in a decreasing direction.

The simplest operating mission of the NFM is the MULE mission. During this mission the operator need only turn the MODE switch from OFF to ON. At the conclusion of its two-minute cycle, the ACTIVE light will extinguish. Toggling the DISPLAY/SLEW switch to TRUE will cause heading to true north to be displayed for 5 seconds.

To determine azimuth with respect to grid north, place a grid convergence value into the NFM either by direct insertion of grid convergence or by allowing the NFM to calculate grid convergence from inserted map values of UTM easting and northing. These values are stored in non-volatile memory, thus allowing the forward observer to insert these values prior to to the start of the mission. A calculated value of grid convergence is distinguished from an inserted value by the fact that the display blinks for the former. Turn the MODE switch from OFF to ON. When the ACTIVE light goes out, the NFM has calculated and stored grid azimuth within it, which will be displayed for 5 seconds when toggling the DISPLAY/SLEW switch to GRID. Toggling to TRUE will give true heading as before.

Midway through a northing (approximately 60 seconds) the ACTIVE LED will blink several times. At this time a preliminary indication of heading can be called up. Accuracy of this value is dependent upon leveling accuracy.

Polar operation (above 66.5° Lat N or S) will be selected automatically with the insertion of the correct northing value.

Although not recommended for tactical operation, a key can be inserted into the NFM to energize the display automatically at the end of the northing cycle. If the key is inserted, the NFM obviously will not pass the 75 ft. dark tunnel test.

Automatic bump detection is included to discount the effects of accidental movement of the tripod or support structure during the operating cycle. This is accomplished by comparing the integration cycles at each internal position of the gyro. If the difference exceeds a pre-set amount, the integration is repeated.

For normal MULE operation under tactical conditions, the display alarm key is not set. The presence of an alarm will be indicated by a four second lighting of the alarm LED. No azimuth information will be displayed.

NFM Remote Data Interface

The NFM has the capability for remote activation and will transmit a serial data signal representing true north. The remote data interface is accomplished by disconnecting the NSG power connector harness on the NFM and replacing it with a Viking Industries VR7/4AG19 connector on an Output Interface Cable. The Output Interface Cable can be up to 1000 feet long.

Electrical interconnections are given on page 13.

The two input signals associated with remote operation are "Find North" which permits the user to remotely reactivate the unit and initiate a north finding cycle, and "Send Data" which transmits data. Send Data and Find North signals will only be recognized when the unit is powered down and the MODE switch is in the ON position. The pulse shape for these signals is given in Figure 5 .

The output signals consist of:

1. Start output which indicates the start of the serial output operation. It occurs before the start of transmission of the sync pulses and the data bits.
2. Eighteen serial data bits, consisting of a data valid bit, sixteen data bits, and a parity bit. The data bits are transmitted synchronously with the serial output sync pulses.
3. Eighteen serial output sync pulses corresponding to the eighteen serial data bits. Each sync pulse occurs within a data bit. These pulses are utilized as "read data bit" commands.

Output signal format and timing are given in Figure 6.

Output Signals Electrical Parameters

Pulse Duration:	Various - See Figure 6
Pulse Amplitude:	+10V (+1V-2V)
Output Source Current:	1 ma
Pulse Rise Time:	3 microseconds
Pulse Fall Time:	3 microseconds

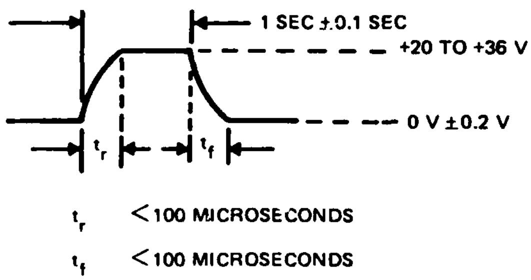


Figure 5. Remote Signal Pulse Shape

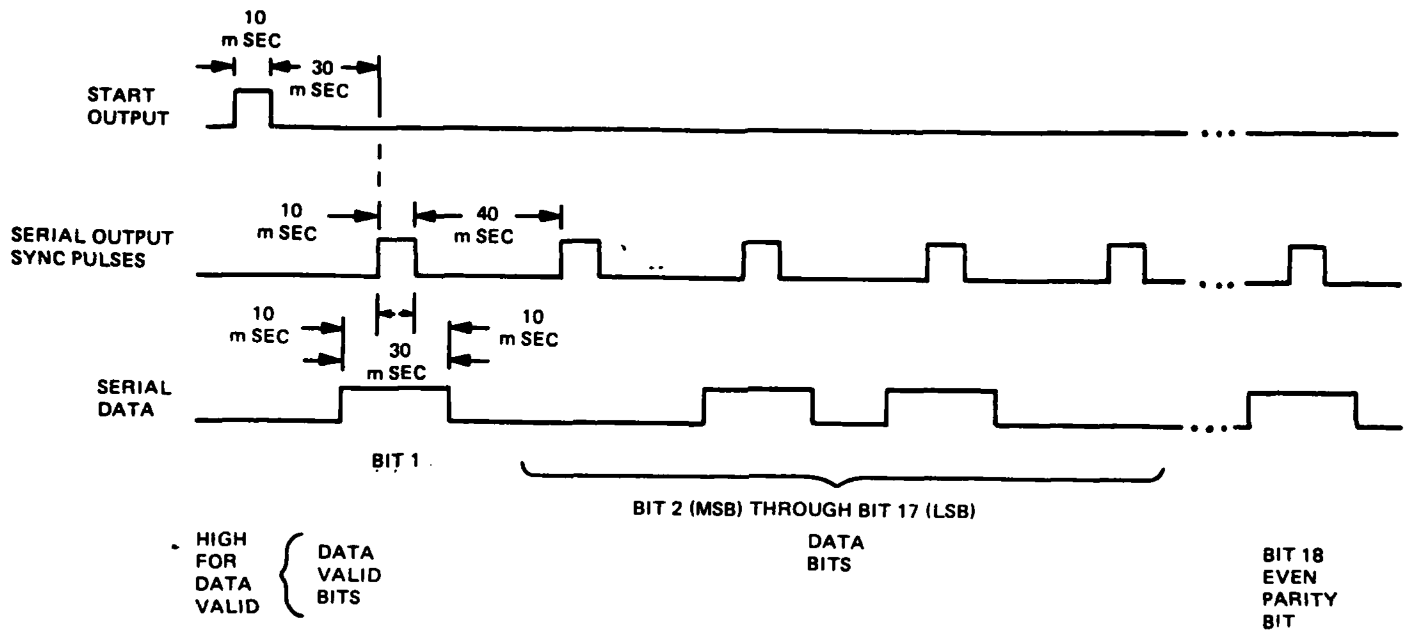


Figure 6. Output Signal Format and Timing

3. Battery Assembly

The battery assembly selected for the NSG mission is the BB 557 rechargeable nickel-cadmium battery pack. This standard 24 volt military battery has a rating of .45 ampere-hours and can provide up to 30 northings on one charge. The NSG is designed to operate either on the vehicle battery or the BB 557. When the NFM and frame are disconnected from the gimbals, the NFM is automatically switched to the BB 557 battery. It is used for off-vehicle applications and for use on the GLLD night sight bracket. The NFM battery is automatically charged when the NSG is connected to the vehicle battery.

The BB 557 battery is readily accessible and can be replaced without difficulty. (See Figure 7.)

4. Structure

The basic structure of the NSG consists of the frame and the gimbal assembly. The frame serves several functions:

(1) It is the intermediate structure to which the NFM is fastened.

(2) The BB 557 battery is secured to the frame.

(3) The frame holds the relay that automatically switches NFM power from the vehicle battery to the NSG battery when vehicle power is disconnected.

(4) The frame is separable from the gimbal structure. It provides the interface to secure the NFM to the GLLD night sight bracket.

(5) The frame provides the pendulosity required to level the NFM.

The gimbal assembly provides the angular freedom required for on-vehicle applications. The NFM is able to perform within specification when misleveled up to $\frac{1}{2}^{\circ}$. A 50% reduction in accuracy may occur when the NFM is misleveled further (up to 0.6°). The gimbals

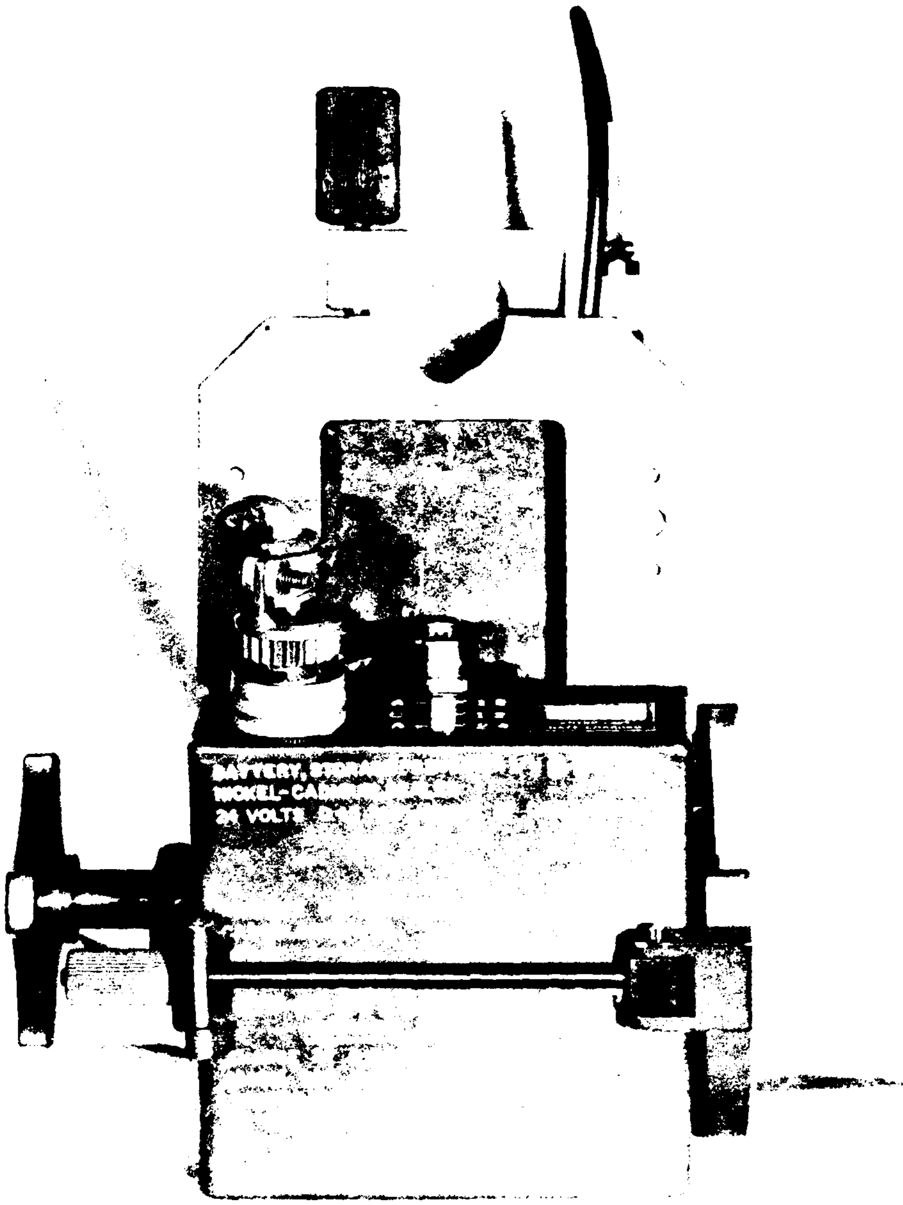


Figure 7. NSG BB-557 Battery Attached to Frame

are designed to maintain the NFM in an acceptable level condition when the vehicle is tilted. They provide for up to $\pm$ 35° freedom in pitch, $\pm$10° freedom in roll when the NSG is mounted to the side walls of a vehicle. The NFM/battery/frame assembly is pendulous. The pendulosity provides the force necessary to overcome bearing friction and maintain the NFM level. Viscous dampers are included on each axis. The dampers use a high viscosity silicone fluid in a .010 inch gap. The viscous shear action quickly settles gimbal motion after the vehicle has stopped.

Solenoid activated gimbal locks have also been included (see Investigations). The purpose of having gimbal locks is to prevent small settling motions in the gimbals during an NFM operating cycle. The gimbal locks are activated remotely by a switch on the control panel/charger assembly. The gimbal locks are not intended to hold the gimbals during vehicle operation. They should be engaged only after the vehicle has stopped and the gimbals are motionless.

5. Vehicle Mount

The NSG module is secured to the vehicle by an intermediate support plate. This plate includes a hinged lock screw that can be used to immobilize the gimbals during normal vehicle operation. The screw must be unlocked for normal NSG operation so that the NFM is level. (See Figure 8.)

6. Control Panel and Charger

The control panel and charger (CP/C) was designed and built specifically for the NSG application. It provides the electrical interface between the vehicle battery and the NFM. It is used to charge the NSG battery, but it serves other useful functions. It monitors the vehicle battery and disconnects that battery when

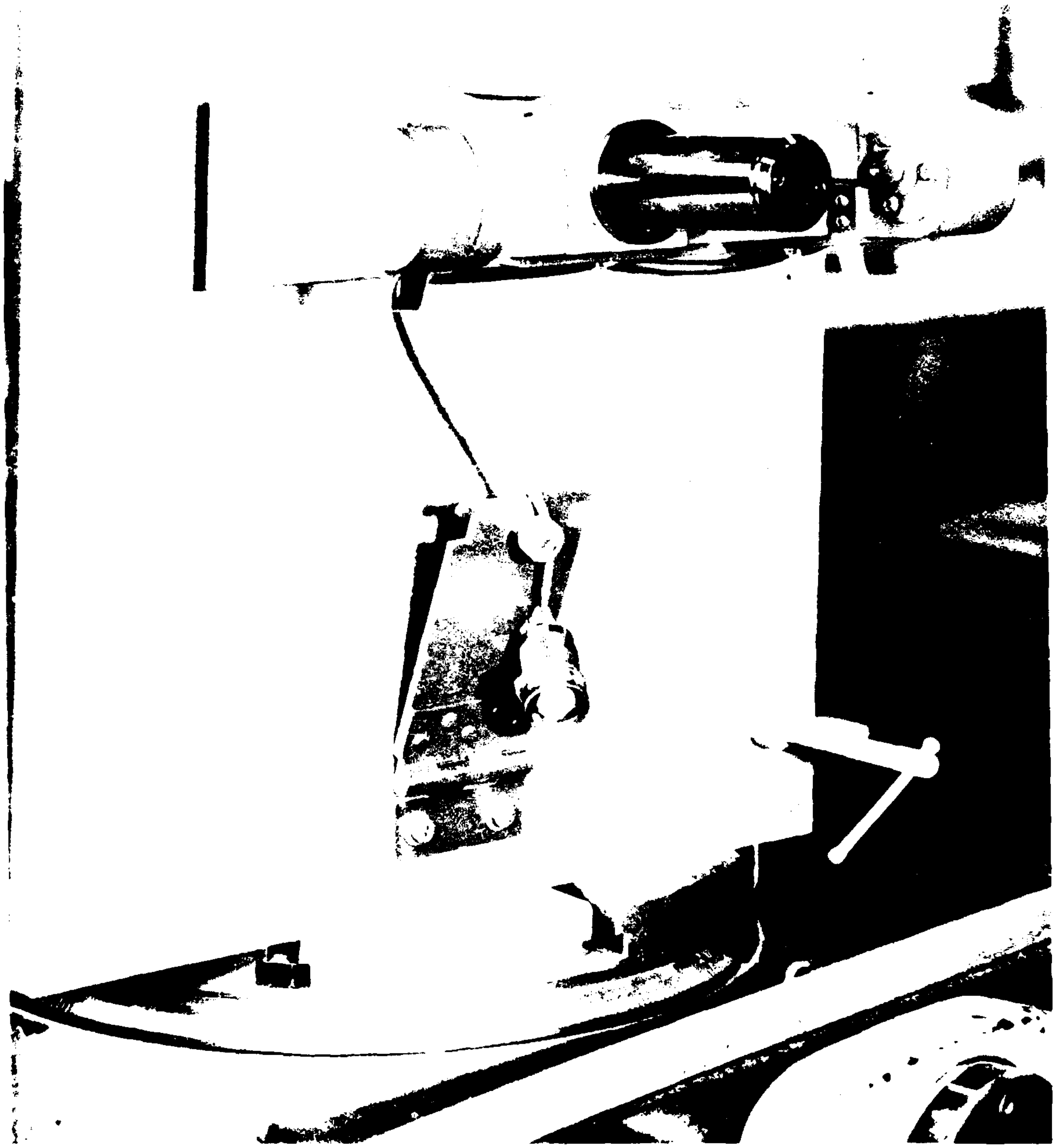


Figure 8. Vehicle Mount with Gimbal Assembly

its voltage drops below prescribed limits (19.5 volts DC). This prevents a condition in which the vehicle battery would become a load on the NSG battery. The CP/C has a booster circuit which charges the 24V NSG battery even when the vehicle battery voltage is down to 20 volts. The schematic of the CP/C is shown in Figure 9.

The CP/C can be located anywhere in the vehicle. After the NFM is turned on, the CP/C can be used to initialize a northing by pressing the FIND NORTH toggle switch. At the end of the northing cycle, the NFM display will be reawakened by pressing the SEND DATA switch. It is recommended that the GIMBAL LOCK switch be turned ON before the NFM is energized. That will assure more accurate heading data.

The CP/C is supplied with a 12-foot cable to connect to the vehicle battery. A 10-foot cable is supplied between the CP/C and the gimbal assembly. The NSG can therefore be activated when the operator is out of the vehicle or almost anywhere in the vehicle.

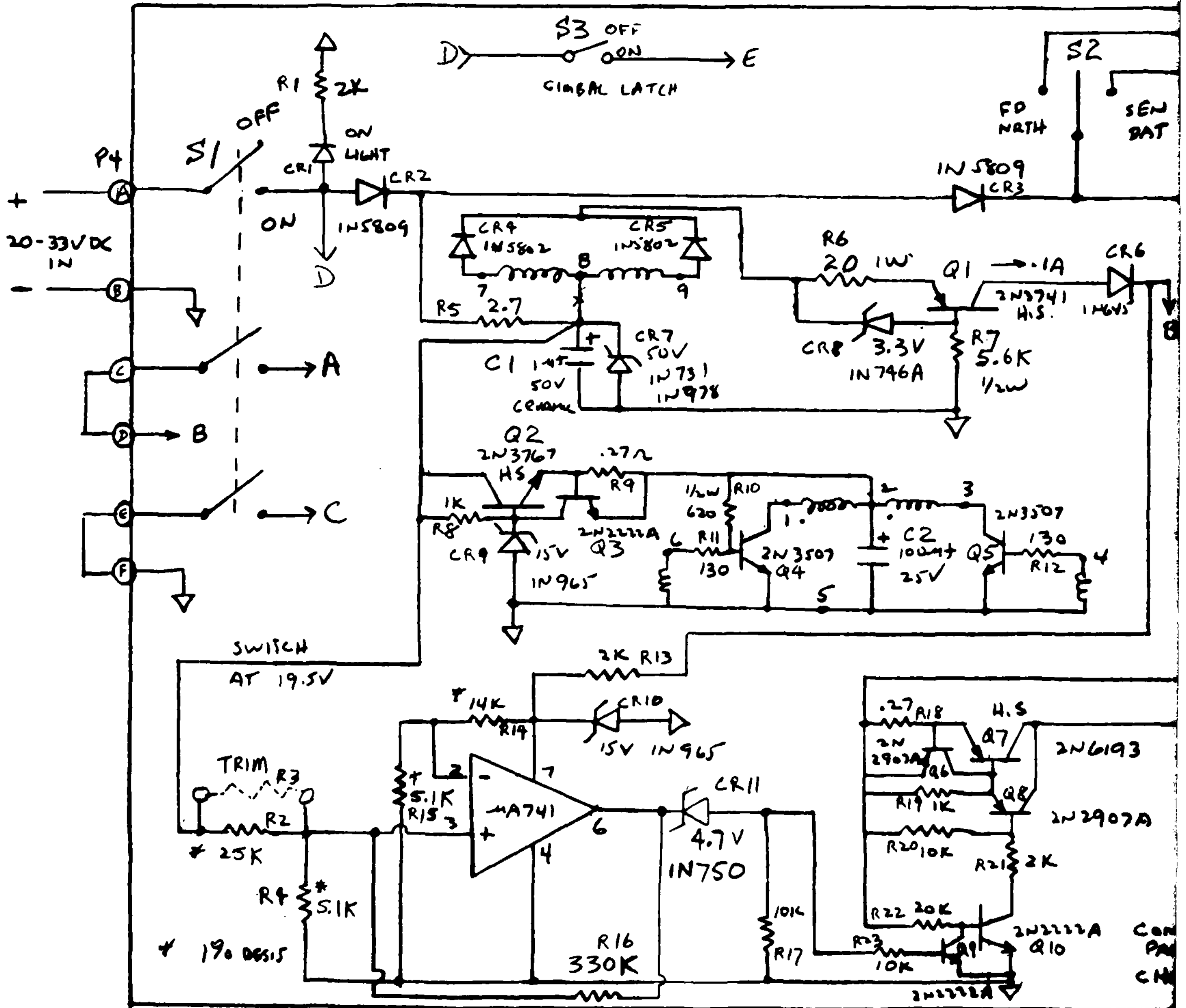
7. Calibration and Alignment

The NSG output is the azimuth of the NFM mounting surface relative to true (geographic) north. In order to align the NFM to the vehicle axis, an Alignment Fixture (AF) has been provided. The alignment method is detailed in Appendix A. The AF contains a poro prism and is calibrated for three angular positions:

1) normal to the NFM mounting surface
2) 60° to the left of the mounting surface
3) 60° to the right of the mounting surface.

This makes it possible to optically align the NSG to the vehicle axis when the NSG is positioned on any vertical surface of the M113 vehicle.

Complete operating and maintenance instructions have been prepared in a manual which is included in Appendix B. The acceptance test requirements for the NFM are presented in Appendix C. The environmental test specification for the NSG gimbal system is presented in Appendix D.


S3 OFF ON
GIMBAL LATCH
S2
FD NRTH
SEN BAT
R1 2K
ON LIGHT
CR1
S1 OFF
ON
P4
CR2
1N5809
1N5809 CR3
+
20-33VDC IN
-
CR4 1N5802
CR5 1N5802
R6 20 1W
Q1 .1A
CR6
2N3741 H.S.
R5 2.7
C1 1μf 50V CERAMIC
CR7 50V 1N731 1N978
CR8 3.3V 1N746A
R7 5.6K 1/2W
Q2 2N3767 HS
.27Ω R9
1K R8
CR9 15V IN965
2N2222A Q3
1/2W R10 620
R11 130
2N3507 Q4
C2 100μf 25V
2N3507 Q5
130 R12
SWITCH AT 19.5V
2K R13
14K R14
CR10 15V IN965
TRIM R3
R2 25K
R4 5.1K
5.1K R15
μA741
CR11 4.7V IN750
10K R17
R16 330K
19% DESIS
.27 R18
H.S. Q7
2N6193
2N 2907A Q6
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Q8 2N2907A
R20 10K
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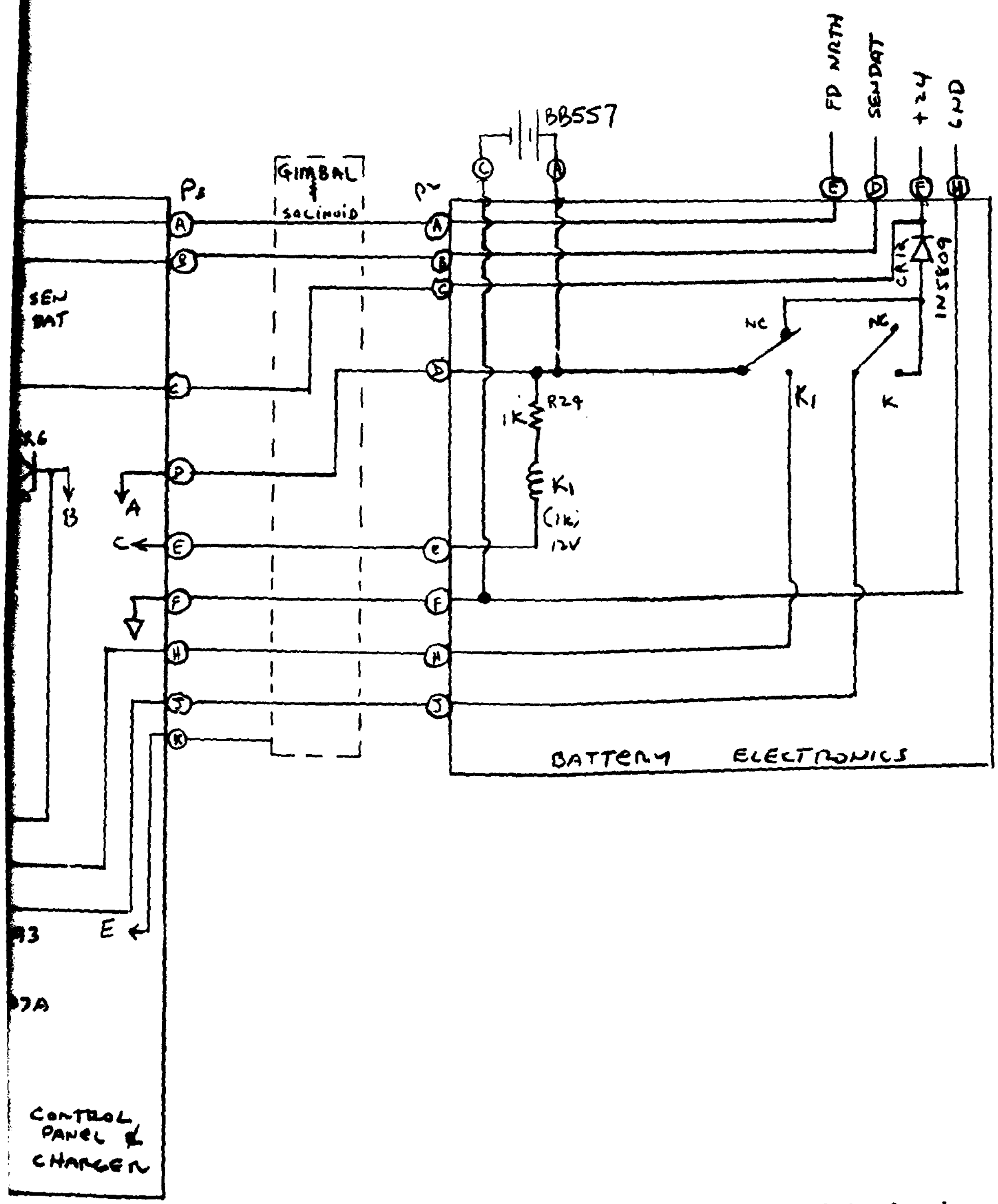

Figure 9. Control Panel and Charger Schematic Diagram

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CONCLUSIONS

1. The NSG was designed to satisfy a variety of missions utilizing the MULE NFM as the sensor.

2. The design of the NSG permits the NFM to be utilized on the M113 (or other vehicle) as well as on a GLLD tripod.

3. The NSG has mission capability using either a vehicle battery or its own rechargeable military battery.

RECOMMENDATIONS

1. The NSG was designed to mount on a vehicle, but it does not have a remote display . It is recommended that a remote display unit be designed for the NSG which would be placed in the driver's compartment. The simplest readout would be a LED display that would repeat the NFM outputs. A more desirable readout would entail the use of a compass card or similar visual display. This would require that the NFM digital serial outputs be converted to an analog signal. The analog signal would, in turn, be used to drive a servo motor attached to a compass card.
2. By including a resolver or an accelerometer on each axis of the gimbal assembly (depending on the desired accuracy), the NSG can be used to provide pitch and roll information.

APPENDIX A

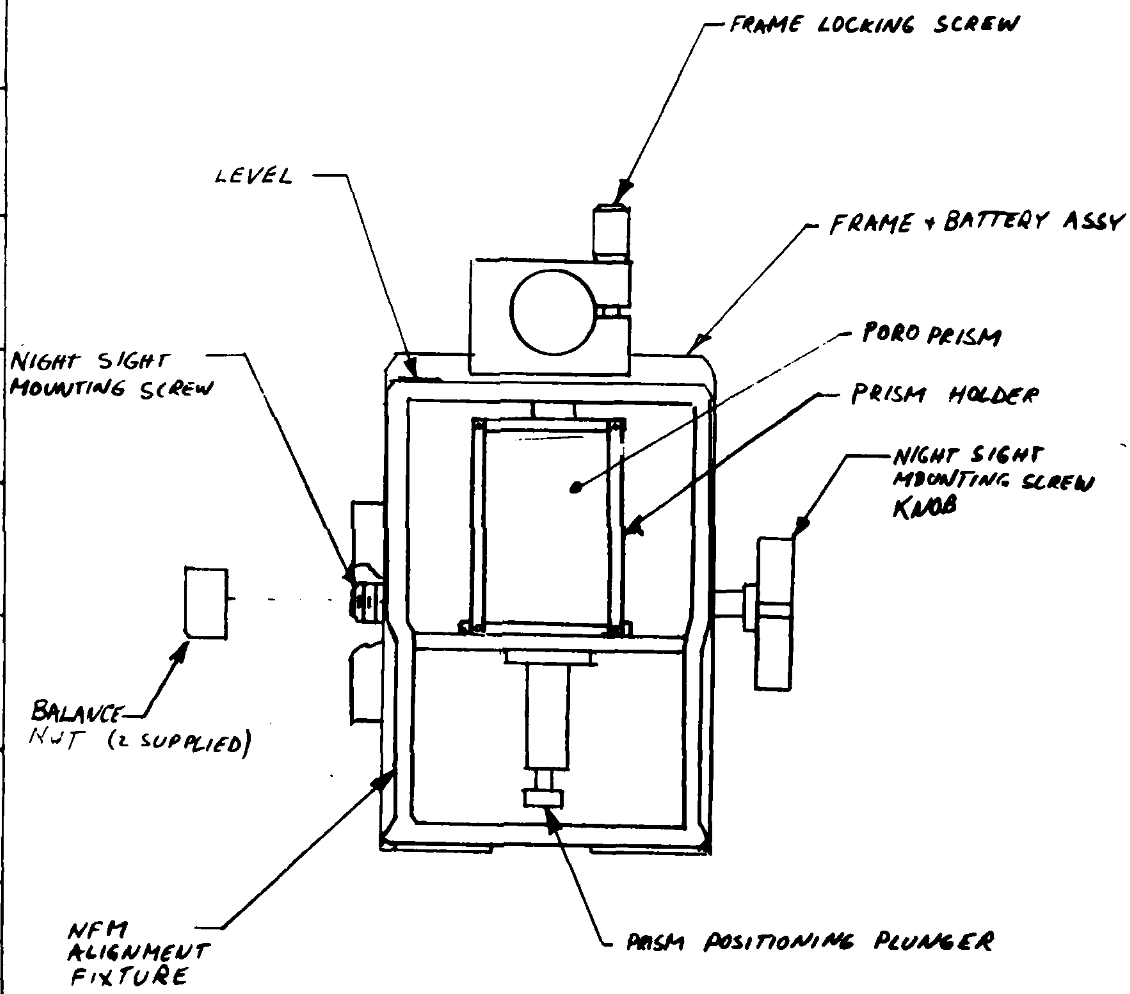
NSG ALIGNMENT INSTRUCTIONS

The NFM Alignment Fixture (AF) consists of a poro prism mounted on NFM alignment pads. The AF is mounted in place of the NFM and is used to align the FIST gimbal pads. For versatility, the fixture can be locked into three pre-calibrated positions. The position of the prism is changed by pulling down fully on the Positioning Plunger (see attached Figure 1), grasping the sides of the prism holder and rotating to the desired position. When the plunger is released it engages and locks into position. The available positions are:

1. Normal to the NFM Mounting Surface
2. 1070.8 MILS Clockwise
3. 1071.3 MILS Counter Clockwise

The orientation is as shown in Figure 2.

When the AF is mounted in the gimbal system the gimbals must be balanced so that the mounting pads are in a vertical plane. The AF is provided with a bubble level. The assembly is adequately leveled when the bubble remains inside the marking ring. Balance the assembly by loosening the Frame Locking Screw and sliding the frame forward until the bubble is centered. If the assembly requires weight on the left, a special Balance Nut is provided. Press in the Night Sight Mounting Screw Knob and engage the nut until the desired balance is achieved.



NFM ALIGNMENT FIXTURE

FIGURE 1

NFM - FIST ALIGNMENT CALIBRATION

(ALL VIEWS LOOKING DOWN ON NFM)

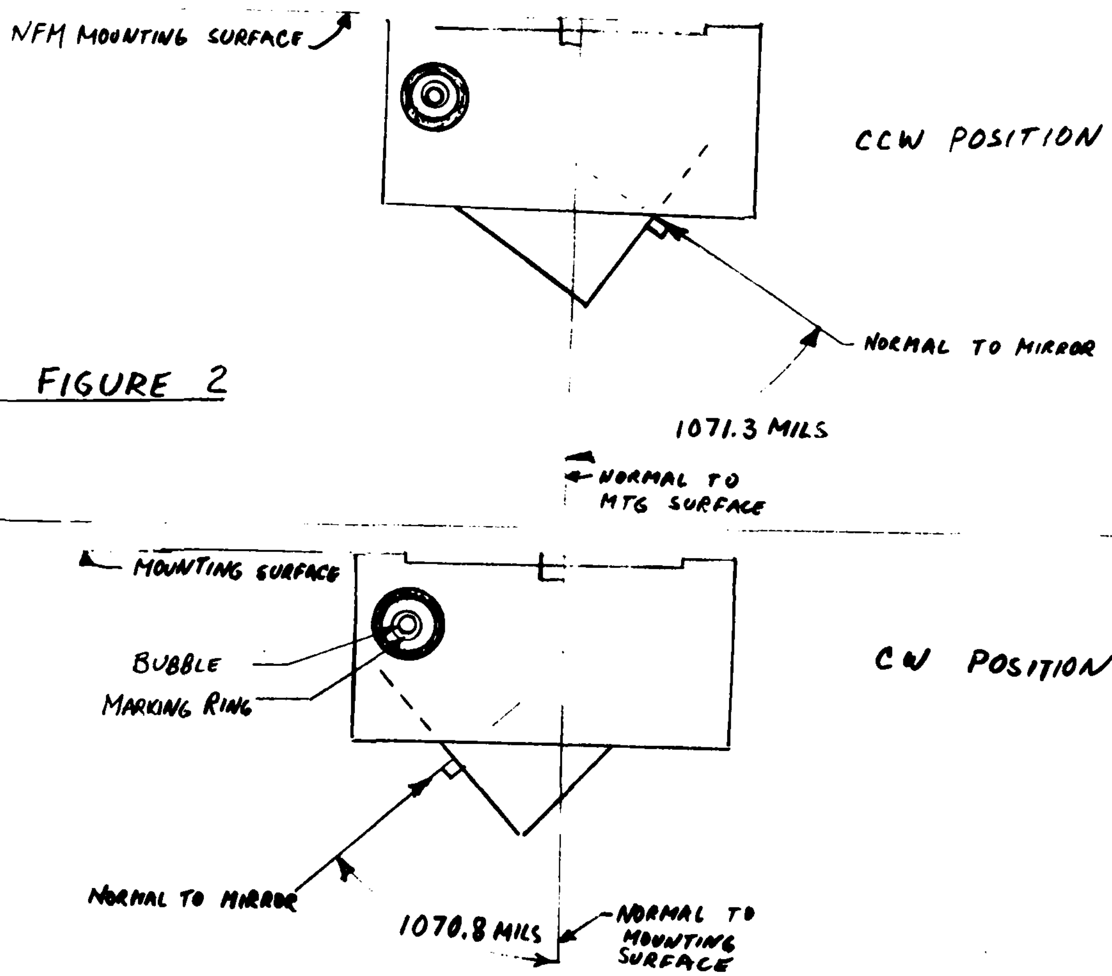


FIGURE 2

- 0° POSITION IS NORMAL TO MOUNTING SURFACE.
- CALIBRATION AND REPEATABILITY WITHIN ± 0.3 MILS.

APPENDIX B

NORTH SEEKING GYROCOMPASS

OPERATING & MAINTENANCE MANUAL

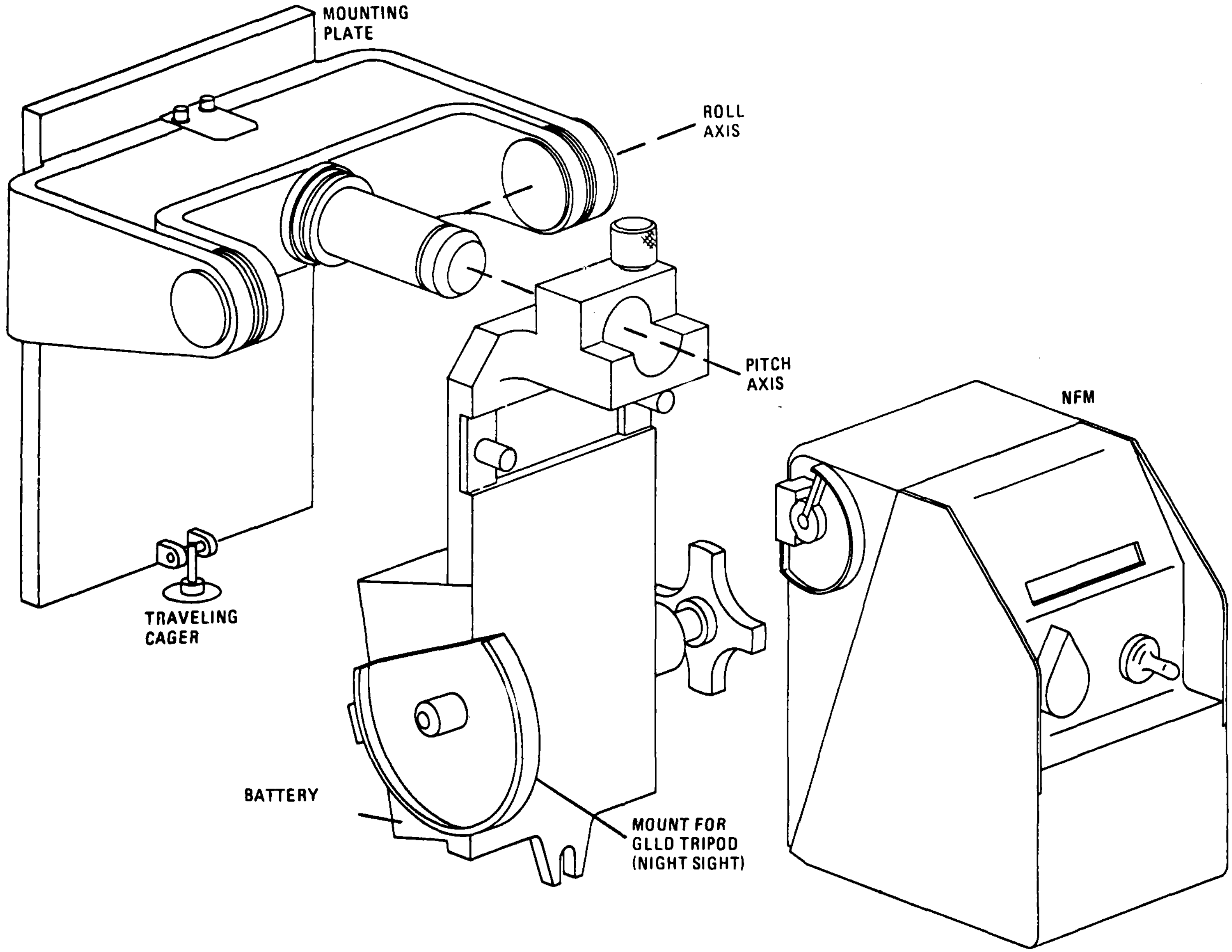
1.0 DESCRIPTION

1.1 GENERAL

The North Seeking Gyrocompass (NSG) provides an azimuth reference for the FIST vehicle, a dismounted Ground Laser Locating Device (GLLD), and a GLLD in its alternate vehicle mount.

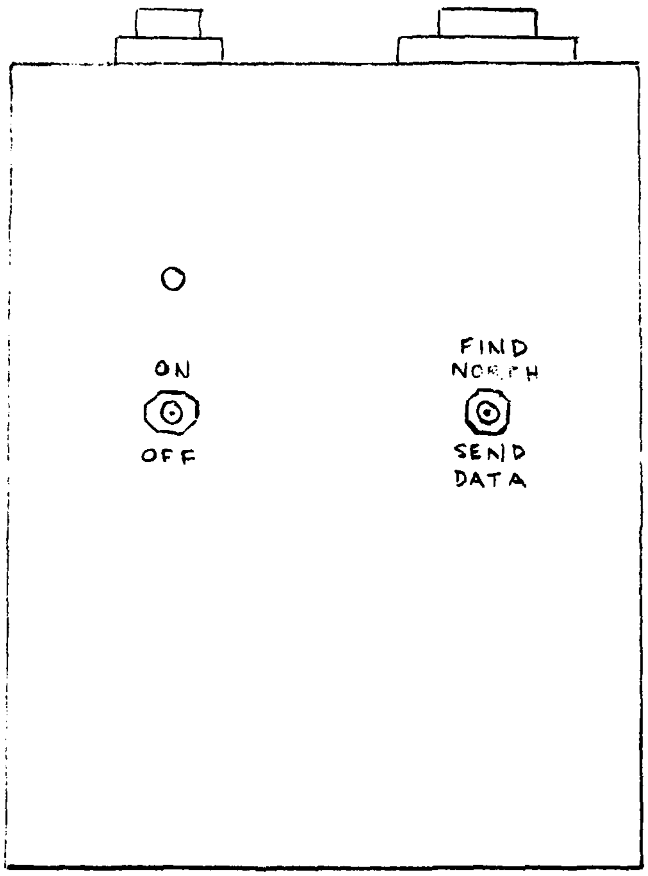
1.2 DESCRIPTION OF EQUIPMENT

The NSG is a North Finding Module (NFM), gimbal mounted for self-levelling which has the capability to rapidly find and display grid or true azimuth. It consists of the NFM which, with a self-contained battery, can be either vehicle or externally mounted. The vehicle complement consists of the gimbals and the control panel and battery charger. An exploded view is shown in figure 1-1. (The control panel and charger are shown in figure 1-2).



EXPLODED VIEW OF NSG

FIGURE 1-1



CONTROL PANEL AND CHARGER
FIGURE 1-2

2.0 INSTALLATION

2.1 FIST VEHICLE USE

The NSG unit shown in figure 1-1 is mounted to a bulk head in the FIST vehicle. The unit, as a pendulous device, levels itself for use. When not in use the NSG is secured via the traveling cager.

2.2 DISMOUNTED GLLD USE

Separating the NSG at the pitch axis allows the use of the North Finding Module with a GLLD.

The mount is designed to attach to a GLLD in place of the Night Sight. The battery is included as part of the mount so as to not require external power.

3.0 OPERATION

3.1 PHYSICAL DESCRIPTION

NSG versatility is derived in large part from the exploitation of state-of-the-art microprocessor technology in conjunction with the tried and true gyrocompass. From this sensor, true azimuth is obtained. Grid Convergence, as given on UTM maps, can be inserted so that grid azimuth can also be obtained.

Operation of the NSG is initiated from the front panel or by remote turn-on at the control panel. The front panel consists of a LED display, the five position MODE switch, and a spring-loaded return to center DISPLAY/SLEW switch.

These two front panel mounted switches initiate the following functions:

MODE SWITCH

Position	Function Name
1	OFF
2	ON
3	GRID CONV
4	EAST
5	NORTH

DISPLAY/SLEW SWITCH

1	-TRUE
2	(not named)
3	+GRID

The control panel consists of two switches, an on-off switch and a mode switch. The on-off switch disconnects M-113 battery power from the NFM. The MODE switch initiates a northing cycle in the FIND NORTH position and displays the previously measured TRUE heading in the SEND DATA position.

Changes in the MODE SWITCH from OFF to any other position will initiate the mode requested. Change from any position to any other position but 'OFF' will initiate the new mode requested after completion of the task in progress, provided the NFM has not yet entered the POWER DOWN phase. The NSG will POWER DOWN automatically when its task is completed. The NSG can be started (from POWER DOWN) (in order of precedence) by requesting SEND DATA or FIND NORTH via the control panel. These requests will only be honored while the NSG is in the POWER DOWN phase.

There are two micro lights on the front panel, ALARM and ACTIVE. Since the NSG employs continuous built-in test, the ALARM is illuminated in the event of malfunction. Section 4 gives the alarm codes and the procedure to be followed in the event ALARM is illuminated.

The second micro light is illuminated when the NFM is performing its gyrocompass for the determination of azimuth ($<$180 sec). This serves as a visual indication to the operator that the NSG should not be physically disturbed or mode switched. When this light is extinguished, the NSG is available for information call-up or mode change.

A North finding cycle is initiated by sending a FIND NORTH signal to the NSG. At the conclusion of the cycle, TRUE NORTH will be transmitted via the output data channel. The NSG can be reactivated for data retrieval by sending a SEND DATA signal to the NSG. The True North previously obtained will be redisplayed. The NSG mode switch must be in any position but OFF (only True North will be displayed).

3.2 OPERATIONAL PROCEDURE IN FIST VEHICLE

The following is a step by step operational procedure to be used for operation of the NSG in a tactical environment. It is assumed that the NSG was leveled and power applied to the unit. It is further assumed that no Grid Convergence is stored in the NSG at this time.

3.2.1 AZIMUTH DETERMINATION WITH RESPECT TO TRUE NORTH

1) Toggle Control Switch to FIND NORTH.

2) When active light goes out ($<$180 sec.) the NSG has calculated and stored within it true heading which will be displayed for 5 seconds when "toggling" the control switch to the SEND DATA position.

COMMENTS:

a) SEND DATA can be performed as many times as desired as long as the NFM MODE switch is in the ON position and is not turned to OFF.

3.2.2 AZIMUTH DETERMINATION WITH RESPECT TO GRID NORTH

1) Place a Grid Convergence into NFM either by direct insertion of Grid Convergence (Section 3.2.2.1) or by allowing NFM to calculate Grid Convergence using grid coordinates (Section 3.2.2.2). Allow the NSG to level itself.

2) Toggle Control Switch to FIND NORTH.

3) When active light goes out ($<$ 180 sec), the NSG has calculated and stored within it grid azimuth which will be displayed for 5 seconds when the DISPLAY/SLEW Swtich is toggled to the right (GRID position).

COMMENTS:

a) DISPLAY/SLEW can be performed as many times as desired as long as the NFM MODE switch is in the ON position and is not turned to OFF.

b) Switching the DISPLAY/SLEW switch to TRUE will give heading values differing from the GRID values by the amount of the Grid Convergence

c) If the Control switch is toggled to SEND DATA True Azimuth will be displayed.

3.2.2.1 INSERTION OF GRID CONVERGENCE

1) Set MODE switch to GRID CONV.

2) Slew desired value in by holding the DISPLAY/SLEW switch until desired value is reached.

3) Allow unit to Power down.

4) Place MODE Switch to the ON position.

COMMENTS:

a) Values can be best inserted left most digit first. Holding the DISPLAY/SLEW switch to + will cause the display to cycle through all ten ones digits in an increasing direction; then all ten tens digits; then all ten hundreds digits and finally to the thousands digits. Release the DISPLAY/SLEW at the desired left most digit.

Repeat the above releasing at the next digit. Combine until the correct total value has been inserted. Holding the DISPLAY/SLEW switch to - will have the same effect except in the decreasing direction.

b) This value of Grid Convergence will remain stored in the NSG until changed, even if the NSG is turned off.

3.2.2.2 GRID CONVERGENCE CALCULATION

NSG accuracy is such that a major source of error may be the Grid Convergence available (to the nearest mil on most military maps) for insertion into the NSG. In order to eliminate this error source, the NSG has the capability of calculating Grid Convergence directly from position data and then utilizing this value for heading determination.

GRID CONVERGENCE CALCULATION PROCEDURE

1) Set MODE switch to EAST
2) Slew in the Easting value as determined from the UTM map. This value should be the whole kilometer East of the NFM location.
3) Set MODE switch to NORTH.
4) Slew in Northing value as determined from the UTM map. This value should be the whole kilometer South of the NFM location.
5) Allow unit to Power down.
6) Return MODE switch to ON position for normal operation.

COMMENTS:

a) Eastings are never negative and are always in the range 110 Km. $\leq$ E $\leq$ 890 Km. Northings are positive in the northern hemisphere and negative in the southern hemisphere. In the northern hemisphere the range from 0° to 80° latitude is 0 to + 8900 Km. In the southern hemisphere 0° to 80° Latitude is the range -9999 Km to -1100 Km.

b) The value of Grid Convergence will remain stored in the NFM through the OFF position and until changed, either by the method of 3.2.2.1 or the method of this sub-section.

3.2.3 POLAR OPERATIONS

For operation above the latitudes of 66.5°, the NSG requires 300 sec to determine azimuth. To place the NSG into this mode a northing value, corresponding to the latitude of operation must be inserted.

POLAR MODE OPERATION

1) Set MODE switch to North
2) Slew in northing value corresponding to the latitude of operation.
3) Allow unit to power down
4) Return MODE switch to ON position and allow NSG to level itself.
5) Toggle Control Switch to FIND NORTH.
6) When ACTIVE light goes out ($<$ 5 min), the heading information is stored in the NFM. It will be displayed for 5 seconds by toggling the control switch to the SEND DATA position.

COMMENTS:

a) The NFM will perform a polar mode determination for any northing greater than +7375 Km or in the range -2621 Km to -1 Km.

b) If Grid North is desired, Easting must be entered as well as Northing and the front panel DISPLAY/SLEW switch must be toggled to the GRID position when the ACTIVE light goes out.

3.3 OPERATIONAL PROCEDURE FOR USE WITH A DISMOUNTED GROUND LASER LOCATING DEVICE (GLLD)

To operate the North Finding Module (NFM) with a dismounted GLLD, it is necessary to separate the North Seeking Module (NSM), (the GLLD tripod mount with the NFM and battery) from the rest of the NSG. A thumb screw at the top of the NSM is loosened, allowing the removal of the NSM from the NSG. The cable from the gimbal mount also must be disconnected.

The NSM can then be attached to the GLLD in place of the night sight. The NSG battery provides power for NSM operation.

The following is a step by step procedure for the operation of the NSM mounted to a GLLD. It is assumed that the unit is leveled and no Grid Convergence is stored in the NFM at this time.

3.3.1 AZIMUTH DETERMINATION WITH RESPECT TO TRUE NORTH

1) Turn MODE switch from OFF to ON.

2) When active light goes out ($<$ 180 sec.), the NSM has calculated and stored within it true heading which will be displayed for 5 seconds when "toggling" the DISPLAY/SLEW switch to the left (TRUE position).

COMMENTS:

a) DISPLAY/SLEW can be performed as many times as desired as long as the NSM MODE switch is in the ON position and is not turned to OFF.

b) Switching the DISPLAY/SLEW switch to GRID will give heading values identical to TRUE since no value of Grid Convergence has been inputted and stored or calculated as yet.

3.3.2 AZIMUTH DETERMINATION WITH RESPECT TO GRID NORTH

1) Place a Grid Convergence into NSM either by direct insertion of Grid Convergence (Section 3.2.2.1) or by allowing NFM to calculate Grid Convergence using grid coordinates (Section 3.2.2.2).

2) Turn MODE switch from OFF to ON.

3) When active light goes out ($<$180 sec), the NSM has calculated and stored within it grid azimuth which will be displayed for 5 seconds when "toggling" the DISPLAY/SLEW switch to the right (GRID position).

COMMENTS:

a) DISPLAY/SLEW can be performed as many times as desired as long as the NFM MODE switch is in the ON position and is not turned to OFF.

b) Switching the DISPLAY/SLEW switch to TRUE will give heading values differing from the GRID values by the amount of the Grid Convergence.

3.4 CONCLUSION

Adherence to the step-by-step procedure will insure that the NFM is setup for automatic operation and outputting of data. If the area of reference changes; i.e., a different UTM map or a different portion of the same UTM map, the Grid Convergence stored in the NFM must be changed to the new value of grid convergence.

4.0 TROUBLESHOOTING

The MTBF of the NSG is such that normally no troubleshooting or repair will be done at the organizational level. The NSG employs an automatic Built-In-Test (BIT) routine which will key the ALARM indicator to illuminate when the DISPLAY switch is toggled. This alarm indicator will be energized for 4 seconds and then be extinguished. The alarm will be energized for any of the malfunctions listed in Table 4-1. (Since a number of these alarms are human or procedural errors, it is recommended that the operator key these alarm codes for corrective actions which he may employ before replacing the NFM). These alarm codes are keyed by turning the Mode switch to GRID CONV and slewing in the number 9999. After 12 seconds the 9999 indicator is extinguished and the NFM powered down. Repeating the mode which gave the original alarm indicator, if the cause of the alarm still exists, the display will indicate the ALARM light and the alarm code.

NFM ALARM CODES - TABLE 4-1

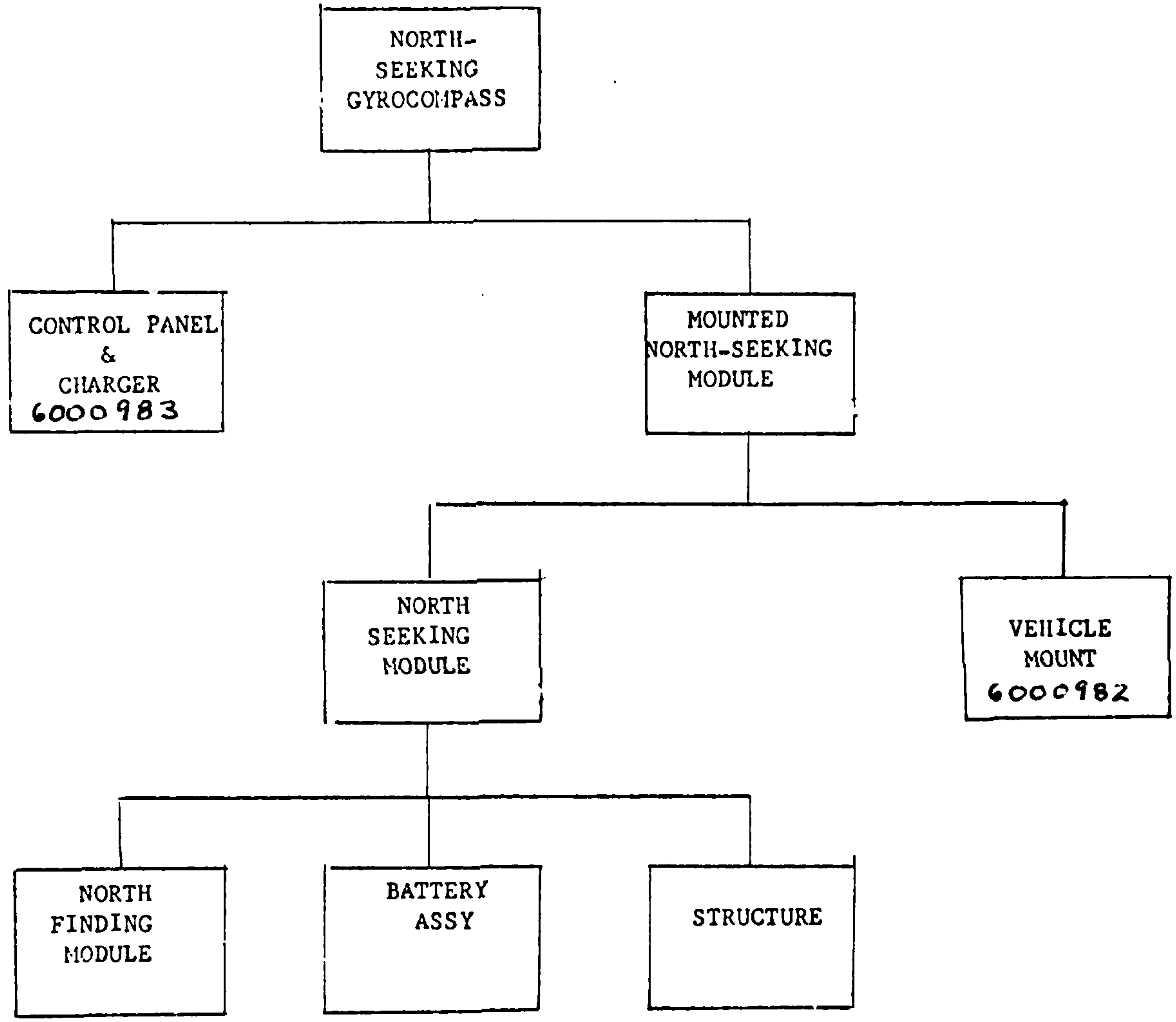
CODE	DEFINITION	RECOMMENDED ACTION
3	GYRO BIAS EXCESSIVE	REPLACE NFM
4	GYRO WHEEL NOT AT SPEED	REPLACE NFM
5	RAM NOT WORKING	REPLACE NFM
6	ROM NOT WORKING	REPLACE NFM
7	EAROM NOT WORKING	REPLACE NFM
8	MODE SWITCH MALFUNCTION	DEFAULTS TO GYRO MODE
9	GYRO TORQUE FEEDBACK NOT WORKING	REPLACE NFM
10	2 POSITIONS NOT ACHIEVED	REPLACE NFM
11	POWER SUPPLY NOT WORKING	REPLACE NFM
12	MPU NOT WORKING	REPLACE NFM
13	ILLEGAL INPUT	CHECK & CORRECT SWITCH SETTING
15	EXCESS TRIPOD MOVEMENT	CHECK TRIPOD CLAMPING/PLACEMENT
18	IMPROPER INITIATION	REPLACE NFM
20	GYRO BIAS DIVERGENT	REPLACE NFM

5.0 REPAIR

No repair work will be performed at the organizational or intermediate level.

6.0 PARTS LIST

The family tree of the NSG given in Figure 6-1 presents the Parts List for the equipment.


NORTH-SEEKING GYROCOMPASS
CONTROL PANEL & CHARGER 6000983
MOUNTED NORTH-SEEKING MODULE
NORTH SEEKING MODULE
VEHICLE MOUNT 6000982
NORTH FINDING MODULE
BATTERY ASSY
STRUCTURE

FAMILY TREE

APPENDIX C

FACTORY ACCEPTANCE TEST PROCEDURE

FOR ENGINEERING MODEL NFM

REV SY

1. SCOPE

This document specifies the procedure for acceptance testing the North Finding Module (NFM) Sperry Part Number (SPN) 1519516.

2. APPLICABLE DOCUMENTS

- Operating and Maintenance Instruction 4222-188818, Revision D, dated Jan 80.
- Development Specification for NFM XAS-4536 B, dated 22 AUGUST 1979.
- North Finding Module Interface Control Document SER 6286. dated 24 August 1979, NWC China Lake, Ca.

3. TEST REQUIREMENTS

3.1 General - Tests shall be conducted under normal ambient conditions within the Gyro Test Facility. Operation of the NFM shall be per the O & M Instructions.

3.1.1 Test Equipment

DC Power Supply, 24 VDC 1 amp

NFM Mounting Bracket SPN 4235-12085-2

Timer capable of one second accuracy

Indexing Table capable of 360° azimuth movement to an accuracy of ± 0.3 MIL (1 MIN.) and $\pm 5^\circ$ roll and pitch movement to an accuracy of $\pm 1^\circ$, settable at 0° to $\pm$ 1. Minute

Interconnecting Cable SPN ____________

Remote Display Unit SPN ____________

3.1.2 Description of Tests

NFM Functional Performance

NFM Repeatability

NFM Accuracy

NFM Mis-level Accuracy

3.2 Size and Weight

3.2.1 Size - Measure the NFM to assure that the nominal dimensions conform to the Outline Drawing shown in Fig. 3 of the ICD.

3.2.2 Weight - Weigh the NFM. Its weight shall be less than 4.0 lbs.

3.3 Inspection

Inspect the NFM to verify that there are no external adjustments visible or available and to locate the following controls and displays.

3.3.1 Mode Switch - (5-position rotary switch with positions for OFF, ON, GRID CONV, EAST, and NORTH.

3.3.2 DISPLAY/SLEW - Toggle Switch (RIGHT, Left, spring return-to-center)

3.3.3 MILS Numeric Display - (4 digit)

3.4 Test Set-up

The test set-up for accuracy measurements consists of an indexing table aligned to true north, checked optically quarterly by star reference. Electrically, the test set up is shown in Figure 1. Mechanically, the test set-up conforms to the mounting pad arrangement shown in Figures 1, 2, and 4 of the ICD.

REV SYM

3.5 NFM Functional Performance

This series of tests verify that the NFM performs functionally as required by the XAS 4536 B specification. Operation of the NFM will be via the front panel of the NFM. Data insertion and NFM operation on this data will be tested.

3.5.1 Set Up

Mount the NFM to the index table utilizing the NFM mounting bracket. Attach the interconnecting cable to the interface connector, located at the top of the NFM. Verify ease of mounting. Set the DC power supply output voltage to 24 VDC, ± 1 VDC. Set the Remote Display Unit to MILS

3.5.2 Cycle Time.

With the NFM mounted on the indexing table, operate the NFM in the ON position of the MODE switch. Verify that the ACTIVE light is extinguished in less than 120 seconds and that the Remote Display Unit reads out a value of azimuth at the same time that the ACTIVE light is extinguished. (In later tests the activation of the Remote Display Unit will constitute the time the NFM requires to find North). Toggle the Display/slew to TRUE. Record the data presented on the Remote Display Unit and the NFM display. The difference shall be ≤ 0.5 Mils.

3.5.3 Insertion of Grid Convergence

Turn the MODE Switch to GRID CONV. Verify that the display increases when the DISPLAY/SLEW is set to + and decreases when the Switch is set to - . Set the value of the display to +11. Allow system to Power Down. Turn the MODE Switch to OFF and then to ON.

When the ACTIVE light is extinguished read out and record the display when toggling the DISPLAY/SLEW switch to TRUE. Read out and record the display when toggling the DISPLAY/SLEW switch to GRID. The difference of the two readings shall be 11 MILS. Record difference. Turn the RDU off and then ON. Activate the SEND DATA SWITCH. Verify that the NFM and the RDU ie-display the same value. Turn the MODE switch to OFF. Turn the MODE switch to GRID CONV. Verify that the display reads 11 MILS. Turn the MODE switch to OFF.

3.5.4 Calculation of Grid Convergence

Turn the MODE switch to EAST. Insert 636 KM EASTING. Turn the MODE switch to NORTH. Insert 4873 KM NORTHING. Turn the MODE switch to GRID CONV. Verify that the calculated Grid Convergence is 21 MILS.

3.5.5 Alarms

Mis-level the NFM by greater than two degrees. Turn the MODE switch to ON. When the active light extinguishes, verify that the ALARM lights when the DISPLAY/SLEW switch is toggled. Verify that no azimuth is displayed. Turn the MODE switch to OFF.

3.6 NFM Time, Accuracy, and Mis-Level

This series of tests verify that the NFM performs within specification for time; accuracy and when in a mis-level condition as required by the XAS 4536B specification. The Remote Display Unit will be used for all time and data readouts, with time measured from turn-on to when the display appears (it was verified previously that the NFM cycle was completed concurrent with the appearance of the display.

3.6.1 Accuracy

Align the NFM reference surface to 0 MILS North azimuth within $\pm$ 1/3 Mil, utilizing the indexing table. Record indexing table heading corresponding to True North. Set the NFM Mode switch to the ON position. After the ACTIVE LED is extinguished, record output reading of the RDU in measured data column. If reading is 63XX, subtract 6400 and record difference in calculated data column. For readings of 00XX enter same number in both measured and calculated data columns. Repeat this cycle seven times, using the FIND North switch in the test set up. Record RDU readings. Calculate the mean and standard deviation of the eight calculated data. The repeatability of the system is the standard deviation of the data from the mean value. This standard deviation shall be $\leq$ 1 mil.

3.6.2 Turntable Accuracy and Time-to-True North

NFM accuracy is verified versus azimuth position. Using the indexing table, rotate the NFM reference surface to 0.0 Mil within $\pm$ 1/3 MIL. At each of 8 azimuth positions positions, 800 mils apart (45°), activate the NFM by means of FIND NORTH. Simultaneously start a clock timer. When the ACTIVE light on the NFM is extinguished, record the time and the RDU reading. Subtract and record the difference between the table azimuth and the RDU reading. The accuracy of the system is the standard deviation of this difference from the mean value of the difference. The Time-to-Find North for each azimuth shall be less than 120 seconds.

3.6.3 Polar Mode

3.6.3.1 Time-True North (Below Arctic Circle)

Insert a Northing of 7374 Km and an Easting of 500 KM by means of the Front Panel. These values are directly below the Arctic Circle. Turn the NFM to OFF and then to ON. Verify that the time is less than 120 sec.

REV

3.6.3.2 Polar Mode Accuracy and Time-to-Time North

Insert a Northing value of 7375 KM by means of the NFM front panel. Turn the NFM to OFF (the NFM now is programmed for operation in latitudes in excess of $\pm 66.5^\circ$). Repeat the procedure of 3.6.2. The Time-to-Find North for each azimuth shall be less than 240 seconds.

3.6.4 Mis-Level Test

This test requires that a test stand capable of very accurate vertical positions be used. If the indexing table used for azimuth accuracy tests is not capable of accurate vertical settings, an alternate test stand can be used. The RDU and external power are required at this stand. If this is the case, mount the NFM on this mis-level test stand. Perform NFM Northings and adjust azimuths until the RDU reads out between 6399.8 and 0000.2 Mils.

Perform a Northing at level, tilted 0.25° up, 0.5° up, level 0.25° down, and 0.5° down. Record the data in measured data column. If the reading is 63XX, subtract 6400 and record difference in calculated data column. For readings of 00XX enter same number in both measured and calculated data columns. Calculate the mean value of the six data items for North in calculated data column. Rotate the NFM to the 1600 MIL ± 0.2 mil azimuth position (EAST). Repeat the above Northing sequence for level, 0.25° left tilt, 0.5° left, level, 0.25° right tilt and 0.5° right. Record the data. For East data subtract 1600 from measured data and record difference in calculated column. Calculate the mean value of the next six data items for East in calculated data column. Compute a standard deviation of the twelve readings from their respective mean value. The standard deviation shall be equal to or less than 1.0 Mil.

3.7 <u>Shipment</u>

The NFM shall be set to 500 KM Easting and 4000 KM Northing at the conclusion of this test. Perform and verify.

Verify that the NFM can be packaged within container Part No. MS 27684-17 with lid Part No. MS 27684-23.

REV SYM

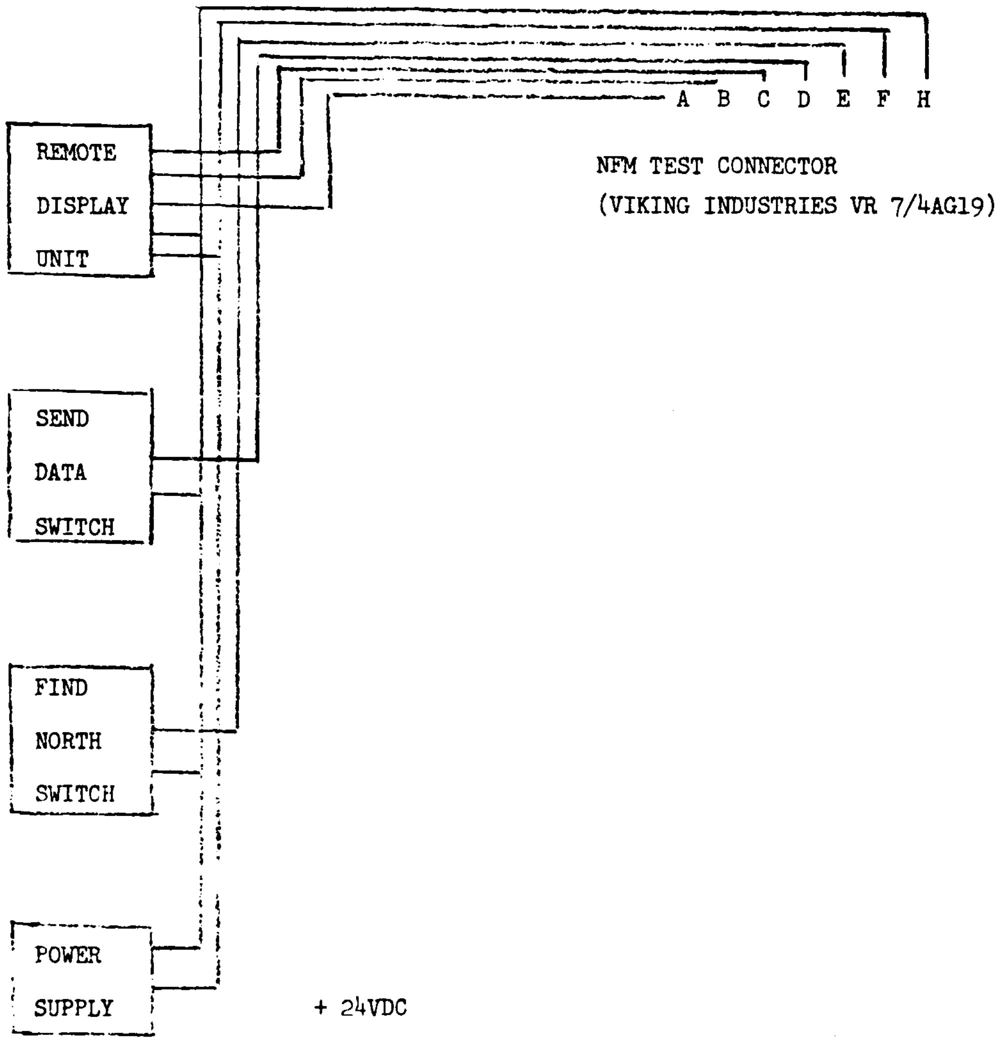


FIGURE 1

REV SYM

4.0 NFM ACCEPTANCE TEST DATA SHEET

T.S. Paragraph		Record Data	Spec
3.2.1	Size Conformity		
3.2.2	Weight		4.0#
3.3	Controls and Display		N/A
3.4	Test Set Up		N/A
3.5.1	Ease of Monitoring		N/A
3.5.2	Cycle Time		$<$ 120 SEC
	RDU Operates		N/A
	RDU Data		
	NFM DATA		
	Difference		$\leq$ 0.5 MIL
3.5.3	Display Increases		N/A
	Display Decreases		N/A
	Grid North		
	True North		
			11 MILS
	Inserted Grid Conv.		11 MILS
	Send Data (verify re-display)		N/A
3.5.4	Calculated Grid Conv.		21 MILS
3.5.5	Alarm Light		N/A

T.S. Paragraph

3.6.1 Accuracy

		Measured Data	Calculated Data
CYCLES	#1	______	______
	#2	______	______
	#3	______	______
	#4	______	______
	#5	______	______
	#6	______	______
	#7	______	______
	#8	______	______
Mean			______
Standard Deviation	(Spec ≤ 1 Mil)		______

ENGINEERING SPECIFICATION	SPERRY GYROSCOPE GREAT NECK, N. Y. 11020	SECURITY NOTATION

REV SYM

3.6.2 Turn Table Accuracy and Time-To-Time North

Index Table		RDU	Time		Error	Spec
0 MILS	-	____		=	____	
			____			≤120 SEC
800 MILS	-	____		=	____	
			____			≤120. SEC
1000 MILS	-	____		=	____	
			____			≤120. SEC
2400 MILS -	-	____		=	____	
			____			≤120. SEC
3200 MILS	-	____		=	____	
			____			≤120 SEC
4000 MILS	-	____		=	____	
			____			≤120 SEC
4800 MILS	-	____		=	____	
			____			≤120. SEC
5000 MILS	-	____		=	____	
			____			≤120. SEC

Mean ____________

Std. Dev. ____________ ≤ 1 MIL

3.6.3.1 Time-to-FIND North (Below Arctic Circle)

	Time	Spec
	____	≤120 Sec

3.6.3.2 Polar Mode Turn Table Accuracy and Time-to-Find North

Index Table		RDU	Time	Error		Spec
0 MILS	-	____		____	=	
			____			≤ 240 Sec
800 MILS	-	____		____	=	
			____			≤ 240 Sec
1600 MILS	-	____		____	=	
			____			≤ 240 Sec
2400 MILS	-	____		____	=	
			____			≤ 240 Sec
3200 MILS	-	____		____	=	
			____			≤ 240 Sec
4000 MILS	-	____		____	=	
			____			≤ 240 Sec
4800 MILS	-	____		____	=	
			____			≤ 240 Sec
5600 MILS	-	____		____	=	
			____			≤ 240 Sec

Mean ____________

Std. Dev. ____________ ≤ 1 MIL

REV SYM

T.S. Paragraph

3.6.4 Mis-Level Test

TILT		MEASURED DATA	CALCULATED DATA
NORTH			
LEVEL		______	______
0.25° UP		______	______
0.5° UP		______	______
LEVEL		______	______
0.25° DOWN		______	______
0.5° DOWN		______	______
	MEAN		______
EAST			
LEVEL		______	______
0.25° LEFT		______	______
0.5° LEFT		______	______
LEVEL		______	______
0.25° RIGHT		______	______
0.5° RIGHT		______	______
	MEAN		______
	Std. Dev. (Spec $\leq$ 1 MIL)		______

SYM

T.S. Paragraph

3.7 Shipment

NORTHING ______________

EASTING ______________

CONTAINER VERIFY __________

APPENDIX D

ENVIRONMENTAL TEST SPECIFICATION FOR

GIMBAL MOUNT

1.0 SCOPE

This document specifies the environmental test of the North Seeking Gyrocompass (NSG) gimbal mount. These tests are in compliance with the Purchase Description, North Seeking Gyrocompass 6 June 1978.

2.0 APPLICABLE DOCUMENTS

- Purchase Description 6 June 1978, North Seeking Gyrocompass (NSG)
- XAS4536 February 17, 1977, Development Specification for North Finding Module.
- North Seeking Gyrocompass Operating and Maintenance Manual.

3.0 REQUIREMENTS

3.1 GENERAL

All tests are to be conducted at the Sperry Gyroscope Company Environmental Test Laboratory using standard calibrated test equipment and the Sperry North Finding Module SPN 6075723, Tested as per Sperry Factory Acceptance Test Procedure 4222-188837, **amended for a 3 minute Northing Cycle.**

3.2 TESTS

3.2.1 Performance tests, which are to be conducted before, during (as specified), and after each test shall consist of a measurement of gimbal position after release from each of its four limit positions.

3.2.2 For each performance test a NFM and battery are to be in place. Roll and pitch angles are to be measured initially. Then the NFM is to be displaced to the left limit and released. Settled roll & pitch are to be measured; then, similarly measured after displacement to the right, forward and rear limits. The five readings of roll or pitch shall have an rms excursion from mean value no greater than 10 arc minutes.

3.3 TEMPERATURE

3.3.1 Test Equipment - Tenney Temperature - Altitude Chamber EV 711.

3.3.2 High Temperature - The NSG gimbal mount shall be subject to the test of Method 501.1, Procedure II of MIL STD 810C with the exceptions noted in paragraph 4.3.1 of the Purchase Description.

3.3.2.1 Set up NSG gimbal mount in the test chamber on a mount sufficiently stable and level to conduct performance tests.

3.3.2.2 Perform the pre-temperature performance test of 3.2.1.

3.3.2.3 Raise the internal chamber temperature to 52°C.

3.3.2.4 Maintain the internal chamber temperature for 6 hours at 52°C.

3.3.2.5 Conduct performance test of 3.2.1.

3.3.2.6 Return the chamber to standard ambient conditions and maintain for one hour.

3.3.2.7 Conduct performance test of 3.2.1.

3.3.3 Low Temperature - The NSG gimbal mount shall be subject to the test of Method 502.1, Procedure I of MIL STD 810C with the exceptions noted in paragraph 4.3.2 of the Purchase Description.

3.3.3.1 Using the same setup as in 3.3.2.1 adjust the temperature chamber to 0°C.

3.3.3.2 Maintain the internal chamber temperature for 12 hours at 0°C.

3.3.3.3 Conduct performance test of 3.2.1.

3.3.3.4 Return the chamber to standard ambient conditions and maintain for one hour.

3.3.3.5 Conduct performance test of 3.2.1.

3.4 VIBRATION

The NSG gimbal mount shall be subject to the test of Method 514.2, Procedure VIII of MIL STD 810C using curve W of Figure 514-2-6 and Time Schedule A for Track Vehicles of Table 514.2-VI.

3.4.1 Test Equipment - MB Model C10 Vibrator.

3.4.2 Mount NSG gimbal mount to allow for proper leveling capability.

3.4.3 Mount the NFM to the gimbal mount and conduct performance test of 3.2.1.

3.4.4 Replace the NFM with an equivalent dummy mass and secure the gimbal with the traveling cager.

3.4.5 Perform vibration sequence curve W of figure 514.2-6, Method 514.2, MIL STD 810 for 15 minutes.

3.4.6 Place NFM back into the gimbal mount. Conduct performance test of 3.2.1.

3.4.7 Repeat 3.4.2 through 3.4.6 for each of the other two orthogonal axis of the gimbal mount.

3.5 SHOCK

The NSG gimbal mount shall be subject to the test of Method 516.2, Procedure I, MIL STD 810C Figure 516.2-1 using 40g for a duration of 11 milliseconds saw tooth pulse.

3.5.1 Test Equipment - AVCO Type SM020 Shaped Pulse Shock Machine.

3.5.2 Mount the NSG gimbal with NFM to a test fixture and conduct a pre-shock performance test of 3.2.1.

3.5.3 Replace the NFM with an equivalent dummy mass and secure the gimbal mount to the Shock Machine. Lock it in place using the traveling cager

3.5.4 Apply three shocks of 40g 11 milliseconds saw tooth pulse.

3.5.5 Repeat 3.5.3 and 3.5.4 for each of the other five orthogonal positions of NSG gimbal mount attitude.

3.5.6 Conduct a post shock performance test of 3.2.1 with the gimbal mount returned to the test fixture of 3.5.2.

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.3.2.2
Condition Pre Temperature

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

REV YM

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.3.2.5

Condition $52^{\circ}C$

	ROLL	PITCH
Initial	______	______
Left Limit	______	______
Right Limit	______	______
Fwd Limit	______	______
Rear Limit	______	______
Mean	______	______
Std. Dev.	______	______

REV 1

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.3.2.7

Condition Post High Temp.

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.3.3.3

Condition $0^{\circ}C$

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.3.3.5
Condition Post Temperature

	ROLL	PITCH
Initial	______	______
Left Limit	______	______
Right Limit	______	______
Fwd Limit	______	______
Rear Limit	______	______
Mean	______	______
Std. Dev.	______	______

REV M

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.4.3

Condition - Pre Vibration

	ROLL	PITCH
Initial	____	____
Left Limit	____	____
Right Limit	____	____
Fwd Limit	____	____
Rear Limit	____	____
Mean	____	____
Std. Dev.	____	____

ENGINEERING SPECIFICATION	SPERRY GYROSCOPE GREAT NECK, N. Y. 11020	SECURITY NOTATION

REV M

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.4.6

Condition Post Vertical Vibration

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

SECURITY NOTATION:

CODE IDENT. NO.	SPEC NO.	REV
56232		
	SHEET	

FORM 633114A 11 2155

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.4.7

Condition Post Lateral Vibration

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.4.7

Condition Post Fore-Aft Vibration

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.5.2

Condition Pre Shock

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.5.2

Condition Post Vertical Shock

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.5.2

Condition Post Lateral Shock

	ROLL	PITCH
Initial		
Left Limit		
Right Limit		
Fwd Limit		
Rear Limit		
Mean		
Std. Dev.		

4.0 NSG GIMBAL MOUNT ENVIRONMENTAL TEST DATA

T.S. Paragraph 3.5.2

Condition Post Fore-Aft Shock

	ROLL	PITCH
Initial	______	______
Left Limit	______	______
Right Limit	______	______
Fwd Limit	______	______
Rear Limit	______	______
Mean	______	______
Std. Dev.	______	______