REVISION 1

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 420

NAVIGATION SYSTEMS, EQUIPMENT AND AIDS

THIS CHAPTER SUPERSEDES CHAPTER 420 DATED 1 JUNE 1994

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND.

1 SEP 1999

NAVSEA TECHNICAL MANUAL CERTIFICATION SHEET 1 of 1

Certification Applies to: New Manual ☐ Revision ☒ Change ☐

Applicable TMINS/Pub. No. S9086–NZ–STM–010/CH–420R1

Publication Date (Mo, Da, Yr) September 1999

Title: NSTM Chapter 420, Navigation Systems, Equipment and Aids

TMCR/TMSR/Specification No:

CHANGES AND REVISIONS:

Purpose: Side bars in the outside margin indicate changes since the last revision. This chapter was reformatted to support conversion to SGML and electronic distribution. Technical changes requested by the Life Cycle Manager have been incorporated but the chapter has not yet been approved by the Technical Authority.

Equipment Alteration Numbers Incorporated:

TMDER/ACN Numbers Incorporated:

Continue on reverse side or add pages as needed.

CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the above identified document for acquisition compliance, technical coverage, and printing quality. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical manual by the Government, nor relieve the contractor of any responsibility for delivering the technical manual in accordance with the contract requirement.

Authority	Name	Signature	Organization	Code	Date
Acquisition					
Technical	ANTHONY THOMPSON		NAVSEA	PMS307	6/21/93
Printing Release	Digital Media Publishing				

Certification Sheet

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

Chapter/Paragraph Page

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

Chapter/Paragraph Page

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

Chapter/Paragraph Page

TABLE OF CONTENTS - Continued

Chapter/Paragraph Page

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

NOTE

THIS CHAPTER HAS BEEN FORMATTED FROM DOUBLE COLUMN TO SINGLE COLUMN TO SUPPORT THE NSTM DATABASE. THE CONTENT OF THIS CHAPTER HAS NOT BEEN CHANGED.

CHAPTER 420

NAVIGATION SYSTEMS, EQUIPMENT AND AIDS

SECTION 1.
NAVIGATION SYSTEM, GENERAL REQUIREMENTS

420-1.1 ORGANIZATION

420-1.1.1 CHAPTER ORGANIZATION. Organization of this chapter will follow the general guidelines of the Expanded Ship's Work Breakdown Structure (ESWBS) for format.

420-1.1.2 ESWBS SECTIONS. The ESWBS sections covered in this chapter are:

a. Navigation System, General Requirements.

b. Non-Electrical/Electronic Navigation Aids.

c. Electronic Navigation Systems, Radio.

d. Electronic Navigation Systems, Acoustical.

e. Electrical Navigation Systems.

f. Inertial Navigation Systems.

420-1.1.3 REFERENCES.

420-1.1.3.1 Naval Ships' Technical Manuals (NSTM). Other NSTM chapters are used as references within this chapter of the NSTM set.

a. **Chapter 001, General - NSTM Publications Index and User Guide.**

b. **Chapter 090, Inspections, Tests, Records, and Reports.**

c. **Chapter 300, Electric Plant - General.**

d. **Chapter 313, Portable Storage and Dry Batteries.**

e. **Chapter 320, Electric Power Distribution Systems.**

f. **Chapter 583, Boats and Small Craft.**

420-1.1.4 BULLETINS. All available bulletins should be used by shipboard personnel for updates on the systems they are responsible for. The **Navigation Information Bulletin** is a quarterly publication of Strategic Systems Programs, Department of the Navy. It provides timely and reliable information to fleet personnel regarding the operation and maintenance of the Fleet Ballistic Missile Navigation Subsystem.

420-1.2 ADMINISTRATION INFORMATION

420-1.2.1 INTENT. The purpose of this chapter of the NSTM is to provide to the fleet general information about the operation, maintenance, and repair of navigation equipment. The user should supplement this general information by referring to the applicable publications for additional and specific information on the various equipments and systems.

420-1.2.2 RESPONSIBILITY ASSIGNMENTS. Ship's control and navigation equipment is under the cognizance and technical control of the Naval Sea Systems Command (NAVSEA). The responsibility for maintenance of the ship's control and navigation equipment and subsidiary components is dependent on the organization of the ship.

420-1.2.3 TRAINING. Attendance at Navy training courses and study of related publications are suggested as aids in understanding the principles and concepts of navigation systems. Assignment of personnel to the various schools available should be determined through the**Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards** (NAVPERS 18068).

420-1.2.4 QUALIFIED REPAIR PERSONNEL. A qualified maintenance person shall be assigned and responsible, under the appropriate department officer, for maintenance and repair of the ship's control and navigation equipment.

NOTE

A qualified maintenance person is one who has successfully completed formal training at a U.S. Navy Class C school. Authorization for a Navy Enlisted Classification (NEC) code identifying repair qualifications is then assigned to the person.

420-1.2.4.1 Maintenance Responsibility. Ship control and navigation equipment maintenance shall be performed only by qualified and experienced personnel. When possible, the department officer should assign the ship's control and navigation maintenance responsibility to the PO-2 rating level. This is the minimum rating level exhibiting the required skills to perform ship control and navigation equipment maintenance in accordance with NAVPERS 18068.

420-1.2.5 TEST AND REPAIR ACTIVITIES. Ship's control and navigation equipment test and repair activities are at Naval shipyards and most Naval bases and stations with Shore Intermediate Maintenance Activities (SIMA's). In addition, Repair Ships and Tenders, Intermediate Maintenance Activities (IMA's), are equipped to overhaul and repair ship control and navigation systems. The assignment of repair work to the appropriate activity will be made by the Readiness Support Group (RSG). These activities should be utilized by all ships as much as possible for repairs beyond ship's force capabilities.

420-1.2.6 PARTS. NAVSEA designates all repairable assemblies and modules of ship control and navigation equipment serviced by Depots.

420-1.2.6.1 Coordinated Shipboard Allowance List (COSAL). The Coordinated Shipboard Allowance List (COSAL), which contains the Allowance Parts List (APL) for the ship, lists the allowance of parts for ship control and navigation equipment. Ship Parts Control Center (SPCC), Mechanicsburg, PA is the control point for ship

control and navigation equipment repair parts. Identification of current parts and equipment is by a National Stock Number (NSN) from the Federal Supply System. Tenders and repair ships normally carry repair parts in accordance with current requirements.

420-1.2.6.2 Equipment Selection. Where Government specifications or NAVSEA drawings are not specified, equipment shall be U.S. Coast Guard approved or commercial marine grade equipment approved by Naval Sea Systems Command.

420-1.2.7 EQUIPMENT INSTALLATION. In stations having outside vision, indicating equipment having a lubber line or dial indications which are related to the ship fore-and-aft orientation shall be located so that when the observer faces forward to view the indicator, port indications are to the observer's left. Installation of equipment shall be as specified on the applicable Government Installation Control Drawings and Equipment Technical Manual. In the absence of Government Installation Instruction, the Manufacturer Installation Instructions shall be used to install the equipment. Equipment in the Pilot House shall be located so that it will be accessible to operating personnel without interfering with the helmsman and will not obstruct access to windows.

420-1.2.8 RECORDS AND REPORTS. All inspections, repairs, and overhaul actions shall be documented through the Maintenance, Material, and Management System (3M). Detailed procedures for the 3M System are contained in OPNAV 4790.4. Form 4790-2K or the automated 4790-2Q shall be used to report deferred maintenance or completed maintenance which do not result in configuration change. Form 4790-CK shall be used to report a configuration change resulting from a partially completed or completed maintenance action. Inspections, Tests, Records, and Reports are outlined in **NSTM Chapter 090, Inspections, Tests, Records and Reports.**

420-1.2.9 PREVENTIVE MAINTENANCE. Ship control and navigation equipment preventive maintenance shall be in accordance with the 3M System, Maintenance Requirement Cards (MRC's).

420-1.2.9.1 Routine Maintenance. Routine maintenance not covered by the 3M System's, Planned Maintenance System (PMS), shall be performed in accordance with the procedures established in the equipment technical manuals until such time as PMS is developed and installed. Equipment with Built In Test Equipment (BITE) will assist in locating faults. Diagnostic Test Sets (DTS) will further isolate and verify malfunctioning modules. These will aid in the troubleshooting of the systems and equipment.

420-1.2.9.2 Safety Precautions. Safety precautions outlined in **NSTM Chapter 300, Electric Plant - General** shall be followed in all instances, when work is to be performed on equipment and systems.

420-1.2.10 BATTERIES. Batteries shall be installed, handled and tested in accordance with **NSTM Chapter 313, Portable Storage and Dry Batteries.**

420-1.2.11 ELECTRIC POWER DISTRIBUTION PLANT. The electric power distribution plant provides electric power to equipment and provides protection by means of circuit breakers and fuses. Connection and distribution shall be in accordance with **NSTM Chapter 320, Electric Power Distribution Systems.**

420-1.2.12 DATA TRANSMISSION SYSTEMS. When feasible, digital data transmission methods using Local Area Networks (LAN), Integrated Services Digital Networks (ISDN), or Data Multiplexing Systems (DMS) shall be used for the transmission of electrical navigation systems data to user equipment and indicators. At least two

sources of electrical power, normal and alternate, shall be used to ensure continuity of service of the data transfer system. Bit error rate and power margin for fiber optic systems shall be in accordance with MIL-STD-188-111.

420-1.2.13 ACTION CUTOUT SWITCHING. Action cutout switching is installed to permit isolation of equipment in the event of a casualty or malfunction of a portion of the system, thereby permitting the operable portion of the system to function.

420-1.2.14 SYNCHRO SIGNAL CONVERTERS. Synchro Signal Converters are installed where it is necessary to increase the load capacity of a primary transmitter, to isolate electrically a portion of the synchro load of a circuit, or where a conversion to a different speed or frequency is required. Installation of additional synchro signal converters to increase synchro load capacity is accomplished by connecting additional converters in parallel with existing units. Separate synchro signal converters are used to supply control and torque loads during normal system operation. Synchro data transmission systems utilize synchro signal converters in accordance with MIL-C-24105.

420-1.2.14.1 Casualty Operations. For casualty operations, control and torque loads may be switched to a common bus where the resulting electrical characteristics do not overload the circuit or adversely affect the operation of the control receivers. An instruction plate is installed next to the switch to define isolation of non-critical loads when in the casualty configuration.

420-1.2.14.2 Synchro Zeroing. Synchro units in equipment should be zeroed if there is evidence of damage to the equipment or if the operation of the equipment indicates zeroing is necessary. Electrical zeroing of synchro units is accomplished by following the instructions in MIL-HDBK-225.

420-1.2.15 SYNCHRO LOAD TABULATION. For each system utilizing synchros, a complete tabulation of synchro loads in accordance with drawing NAVSHIPS No. 815-1853311, calculated in accordance with DDS 430-2, should be provided on the appropriate isometric cabling diagram for the system. The tabulation is to be based on actual installed equipment. If the tabulation reveals system overloads, deviation from calculated power factor correction, or any condition that exceeded the parameters defined by DDS 430-2, a proposed solution shall be submitted to NAVSEA. If any changes are made to a system, a complete tabulation of the synchro loads shall be recomputed.

420-1.2.16 CABLING AND WIRING DIAGRAMS. The cabling and wiring diagrams shall include all equipment and cables. Cables shall be marked with type, length, and circuit designation. Cabling and wiring diagrams shall be provided for each navigation system described in Section 2, Section 3, Section 5, and Section 6.

SECTION 2.

NON-ELECTRICAL AND NON-ELECTRONIC NAVIGATION AIDS

420-2.1 NON-ELECTRICAL AND NON-ELECTRONIC NAVIGATION AIDS

420-2.1.1 DEFINITION. Non-electrical and non-electronic navigation aids include items such as Alidades, Azimuth Circles, Barometers, Beam Compasses, Binnacles, Chronometers, Clinometers, Magnetic Compasses, Dividers, Heeling and Corrector Magnets and Holder, Keel Trim Indicators, Leadline, Pelorus and Stands, Sextants, Telescopes and Binoculars.

420-2.1.2 MAGNETIC COMPASSES. Magnetic compasses and subsidiary components such as compass binnacles and compass corrector mechanisms are under the cognizance and technical control of Naval Sea Systems Command (NAVSEA Code 06K33).

420-2.1.3 IN-SERVICE ENGINEERING AGENT (ISEA). The Naval Undersea Warfare Center Detachment, Norfolk, is the designated ISEA for all Naval magnetic compasses and associated equipment. All correspondence concerning magnetic compasses should be addressed to:

Officer in Charge
Naval Undersea Warfare Center
Detachment Norfolk
835 Philpotts Road
Suite 100, Code 24211
Norfolk, VA 23513-3199

420-2.1.4 SHIPBOARD RESPONSIBILTITY U.S. Navy Regulations assign responsibility for maintenance, adjustment, and compensation of magnetic compasses to the Ship's Navigator. While the ship is underway, the regulations require the Navigator make frequent checks of the magnetic compass. These checks, when compared with the prime navigator, determine the compass error.

420-2.1.5 INSTALLATION REQUIREMENTS. A direct-reading magnetic compass is installed in the Pilot House, near and readable from the helm station. On ships having a Secondary Conning Station and only one gyro compass system, a magnetic compass is installed at or near the Secondary Conning Station. Direct reading magnetic compass installations include a binnacle stand, hood, corrector system, lighting supply and where required a degaussing compensating coil and control box. Compasses may be mounted on or in the steering console, if the console design is for minimal magnetic effects. If the placement of equipment is too near the compass, excessive or uncorrectable deviations will result. Table 420-2-1 lists the recommended distances at which various equipment should be located to minimize their adverse effect on the compass. The table also provides guidance and serves as an aid to locate possible causes of uncorrectable deviations. If other magnetic equipment is at distances less than recommended, adverse effect might be counteracted by careful adjustment of the compass.

420-2.1.6 TESTS. When first received on board, tests shall be made to decide the operating condition of all direct-reading magnetic compasses. Thereafter, tests should be made any time the compass performance appears faulty. These tests should be performed on all compasses during ship's regular overhaul. Specific instructions for performing the tests, together with space for recording results, will be found under the heading**Tests of Magnetic Compasses** in the front of the **Magnetic Compass Record,** NAVSEA 3120/3.

NOTE

If the compass proves defective or does not meet the minimum requirements, it should be repaired at the earliest opportunity. When services are not available, a defective compass shall be turned in to the nearest supply center, along with a requisition for a replacement.

Table 420-2-1 LOCATION OF MAGNETIC EQUIPMENT [1 2 3]

Magnetic Equipment	Standard Compass	Steering Compass
Alarms, power failure	1.22 (4)	0.91 (3)
Compass compensating coil control boxes	0.46 (1.5)	0.46 (1.5)
Deck plating, magnetic	1.22 (4)	1.22 (4)
Loudspeakers	2.13 (7)	1.22 (4)
Small speakers	3.05 (10)	2.44 (8)
Large bull speakers:	4.57 (15)	3.66 (12)
Fixed position		
Movable position		
Magnetic material, fixed (except deck plating)	3.05 (10)	1.83 (6)
Magnetic material, movable	3.66 (12)	2.44 (8)
Meters, electric (other than repeating or portable types)	0.61 (2)	0.61 (2)
Meters, electric (repeating type)	1.52 (5)	0.91 (3)
Meters, portable	1.52 (5)	0.91 (3)
Motors ac	3.05 (10)	1.83(6)
Below 5 HP	3.66 (12)	2.13 (7)
From 5 to 25 HP	4.27 (14)	2.44 (8)
Above 25 HP		
Motors dc	3.66 (12)	2.13 (7)
Below 5 HP	4.27 (14)	2.44 (8)
From 5 to 25 HP	4.88 (16)	3.05(10)
Above 25 HP		
Pilot House control stands	1.83 (6)	1.22 (4)
Radar equipment: Indicator, Modulators, Repeaters and Transmitters	2.13 (7)	1.83 (6)
Radio equipment:	3.05 (10)	1.83 (6)
Antennas, telescoping	2.13 (7)	1.22 (4)
Receivers and transmitters	2.13 (7)	1.22 (4)
Transmitter remote control station and Radiophone units		
Rheostats, degaussing	3.05 (10)	2.13 (7)
Switches, magnetically controlled	2.44 (8)	1.52 (5)
Switches, Distribution panels and DC circuit breakers	1.83 (6)	1.22 (4)
Synchro indicating and transmitting equipment	0.61 (2)	0.61 (2)
Telephone headsets	2.13 (7)	1.22 (4)
Voltage regulator	2.13 (7)	1.22 (4)
Windshield wipers, electric	1.22 (4)	0.91 (3)

[1.] All measurements are in meters (feet).

[2.] When using the steering compass as a standard compass, the distance shall be as specified for the standard compass. For the transmitter of remote-indicating compasses, limiting distances shall be as specified for the steering compass.

[3.] Steel doors and hatches, and movable steel furniture (including movable steel furniture parts) are considered movable magnetic materials.

420-2.1.6.1 Degaussing Circuits and Compass Coils. On ships equipped with degaussing circuits and compass

coils, residual deviations shall be recorded with Degaussing Off and Degaussing On. A copy of the **Magnetic Compass Table** , NAVSEA 3120/4, shall be posted near the compass to be readily accessible to the Navigator and other personnel concerned with ship navigation.

420-2.1.6.2 Deviation With Latitude. Special attention shall be given to completing all information on the back of the **Magnetic Compass Table** , NAVSEA 3120/4, so that changes of deviation with latitude may be evaluated correctly in terms of Flinders Bar requirements.

420-2.1.6.3 Compass Swing. When making a compass swing, deviations should be recorded both with degaussing off and with degaussing coils energized at the proper currents for heading and degaussing zone.

420-2.1.7 ADJUSTMENTS AND COMPENSATION. Trained personnel, at shipyards, are available to assist with compass adjustment and compensation. These technicians can assist with the investigation of installation problems. Application for assistance should be made by the Commander Officer to the nearest Readiness Support Group utilizing the 3M system.

420-2.1.7.1 Adjustment Instructions. Adjustment instructions are in the **Handbook of Magnetic Compass Adjustment, Publication No. 226,** published by the Defense Mapping Agency, Hydrographic Center, Washington, DC. 20390. Degaussing compensation instructions are in **NSTM Chapter 475, Magnetic Silencing,** and in the degaussing folder carried on each ship equipped with degaussing equipment.

420-2.1.7.2 Residual Deviations. Residual deviations can develop under certain conditions. A properly installed and adjusted compass should not have residual deviations greater than three degrees. When compensated properly, and with degaussing equipment energized, residual deviations should not exceed two degrees from the deviation observed with the degaussing equipment secured. The combined error should never exceed a total of five degrees deviation. If any of the following operations occur, compass should be checked and readjusted:

a. Overhaul.

b. Structural alterations (involving removal, addition, or movement of steel or other magnetic material) in compass vicinity.

c. Electric welding in compass vicinity.

d. Magnetic treatment of ship by deperming or flashing.

e. Mooring on same heading for long periods.

f. Extensive gunfire.

g. Change in setting of compass coil control resistors (changes Degaussing On deviations only - see paragraph 420-2.1.6.1).

h. Installation of major electrical equipment components in compass vicinity.

420-2.1.8 RECORDS AND REPORTS. When adjustments are made to a magnetic compass, or the deviations on all cardinal and inter-cardinal headings are observed, results shall be recorded on**Magnetic Compass Table,** NAVSEA 3120/4. A copy of the latest completed table shall be kept in the envelope attached inside back cover of the**Magnetic Compass Record,** NAVSEA 3120/3.

420-2.1.8.1 Magnetic Compass Record. The **Magnetic Compass Record** , NAVSEA 3120/3, is part of the official ship record. Each volume of the **Magnetic Compass Record** contains a three month supply of the Compass Check Log forms for continuous entries. This is based upon half-hour observations although these may be made at shorter intervals if desired. (If the ship does not operate continuously, the record will be usable for more extended period.) The**Magnetic Compass Record** will accommodate records of both standard and steering magnetic compasses. Latitude and longitude entries may be omitted if such information is classified. The record shall be maintained as an adjunct to the Deck Log that is aboard every ship in commission. The record provides a complete history of each direct-reading and remote-indicating magnetic compass on board. Navy regulations contain requirements for maintaining the record. Disposition of this record shall be made in accordance with instructions for record disposal given in SECNAV INST P5212.5.

420-2.1.8.2 Magnetic Compass Table. Each time a new **Magnetic Compass Table** , NAVSEA 3120/4, is prepared because of compass adjustment (or for any of the reasons outlined above) a duplicate copy of the completed form shall be forwarded to the ISEA (see paragraph 420-2.1.3). A transmittal letter is not required.

420-2.2 SMALL BOAT COMPASSES

420-2.2.1 FIXED AND PORTABLE. Definitions of fixed and portable compasses, as used on small boats and small craft, are as listed below. Small boat compasses may be either a Navy No. 5 compass or an equal size commercial marine boat compass.

420-2.2.1.1 Fixed Compass. A magnetic compass is a fixed compass when mounted on a flat surface and remains with the boat always.

420-2.2.1.2 Portable Compass. A magnetic compass is a portable compass when it can be removed from the small boat for stowage or use on another small craft.

420-2.2.2 SMALL BOAT COMPASS ALLOWANCES. **NSTM Chapter 583, Boats and Small Craft,** identifies the allowances for small boats. The boat check list is requested when a boat is received. The condition of the compass is declared under the heading of Navigation Equipment.

420-2.2.3 ADJUSTMENTS. When first installed, after each overhaul, and after any structural alterations are made to the boat, both fixed and portable Magnetic Compasses shall be adjusted. They shall be adjusted at least once a year.

420-2.2.4 LIGHTING. All Navy No. 5 Magnetic Compasses and commercial compasses used in small boats should be equipped with a lighting fixture.

420-2.2.5 COMPENSATORS. All Navy No. 5 compasses and commercial compasses used in small boats shall have corrector assemblies and quadrantal spheres installed. All compasses issued without such assemblies shall have the missing components installed at the nearest repair facility or returned to the nearest supply depot marked for refurbishing.

420-2.2.6 MAGNETIC COMPASS DEVIATION CARD. A Magnetic Compass Deviation Card is provided with each Navy No. 5 Magnetic Compass and shall be obtained for each commercial compass installed. Compass

deviation should be determined and entered for each thirty degree increment as indicated on the card. It is not necessary to complete the **Magnetic Compass Table** , NAVSEA 3120/4, for compasses used in small boats and small craft.

420-2.3 TIMEPIECES

420-2.3.1 SHIP TIMEPIECES. Ship timepieces include chronometers and clocks. Chronometers indicate accurate navigational time. Clocks, of several types, are in service in specific areas of ships and boats to meet the various timekeeping needs.

420-2.3.2 CHRONOMETERS. Equipment, procedures, and requirements described in the following paragraphs apply to the following types of chronometers:

a. Chronometer, battery-driven, quartz crystal.

b. Chronometer, spring-driven, Size 85, with make-break circuit.

c. Chronometer, spring-driven, Size 85.

d. Chronometer, spring-driven, Size 35.

420-2.3.3 SHIPBOARD RESPONSIBILITY. The Navigator is responsible for chronometer care and custody while the instruments are aboard ship.

420-2.3.4 ALLOWANCES. NAVSEA allowance lists establish quantities of chronometers and gimbals cases carried aboard ship. Ships shall procure their allowance of timepieces from the supply system without reference to NAVSEA.

420-2.3.4.1 Obtaining Allowance. When obtaining allowances of chronometers for new ships or ships being reactivated from reserve fleets, responsible personnel shall requisition the authorized allowances of chronometers from the nearest supply center.

420-2.3.4.2 Damaged or Lost. Damaged chronometers always shall be turned in to the nearest supply center. Only chronometers actually lost shall be surveyed.

420-2.3.5 STOWAGE. When received, navigational timepieces shall be stowed in chronometer lockers provided for that purpose. When there is no provision for chronometer stowage in a chart table, a chronometer locker of the appropriate size shall be located in the navigational area. It shall be located to provide ready access to the chronometers for the purposes of winding, reading, checking battery condition or removal. A key lock shall be maintained to prevent unauthorized entry into the chronometer lockers or chart table compartments. Chronometers shall not be removed unless taken ashore for safekeeping, during extended ship repair, deperming or flashing operations.

420-2.3.5.1 Glass Cover. The glass covers of gimbal cases shall always be closed unless instruments are being wound. This minimizes the effect of rapid temperature changes on the instrument and inhibits entry of dust and moisture. These latter effects are among the most frequent causes of abnormal rates and unexpected errors in

chronometers. If air in the stowage locker is warm and moist, sudden chilling may cause moisture to condense inside the instrument. A single rust spot on a hairspring may cause a timepiece to lose several seconds per day, and this error will increase with additional corrosion.

420-2.3.5.2 Carrying Case. Carrying cases for chronometers are no longer an item of ship allowance. The gimbals case, which is a separate item of allowance, shall be used to transport spring-driven chronometers. Necessary precautions shall be taken to ensure careful handling.

420-2.3.5.3 Gimbal Lock. Gimbals shall be immobilized (locked) during transit of the chronometer to avoid unnecessary rate changes and balance damage. The gimbal lock mechanism, whether used to lock the gimbals or disengaged (during normal chronometer usage) shall be secured to prevent damage.

NOTE

Chronometer rate is defined as the unit amount of time gained or lost, usually in seconds per day. Abnormal or erratic rate changes are cause for chronometer repair or replacement.

420-2.3.5.4 Replacement. A ship requisition is required to obtain replacements. Accounting information for this transaction is in NAVSUP 485, **Supply Afloat Procedures,** published by the Naval Supply Systems Command (NAVSUP).

420-2.3.5.5 New Chronometer. Upon receipt of a new chronometer, the ship shall return the old instrument to the nearest supply center. The equipment shall be packed the same as the new instrument.

420-2.3.5.6 Reason for Replacement. Chronometers shall be replaced if they stop, develop an erratic rate, or become damaged. Necessary replacement instruments shall be obtained from the nearest supply center.

420-2.3.6 RATING. All chronometers aboard ship shall be rated daily. No attempt shall be made to determine errors of less than 0.5 second. **The Navigation Timepiece Rate Book,** NAVSEA 4270, is available for recording errors of timepieces. Requisitions for the rate book shall be directed to the Naval Supply Center at either Norfolk, VA or Oakland, CA.

420-2.3.6.1 Setting. New chronometers are shipped without batteries installed. Ship personnel are required to install batteries and set the chronometer to Greenwich Mean Time (GMT) via an approved time standard. Size 35 or 85 chronometers shall not be set, regulated or adjusted by ship personnel.

420-2.3.6.2 Time Standard. The National Institute of Standards and Technology (NIST), formerly National Bureau of Standards, maintains radio stations WWV and WWVH. These stations transmit time ticks twenty-four hours a day. Signals are on 2.5, 5, 10, 15, 20 and 25 megahertz. Signals on one of these frequencies usually can be received in any part of the world. The telephone number for the time signal is (303) 499-7111. Approved time transmissions for rating timepieces are those of NIST and the Naval Observatory Time Service.

420-2.3.7 QUARTZ CRYSTAL CHRONOMETER. The design of the quartz crystal chronometer does not require periodic overhaul for a minimum specified life of five years without maintenance (other than battery change) and without degradation of performance. The chronometer shall be turned in only if performance is

unsatisfactory. When a quartz crystal is dormant (that is, it has not been excited by an electrical charge for some time), it becomes deactivated. It must then be aged (receive an electrical charge) before the oscillating accuracy becomes stable.

420-2.3.8 BATTERY-DRIVEN QUARTZ CRYSTAL TYPE. The quartz crystal chronometer does not require winding because it is battery powered.

420-2.3.8.1 Batteries. Batteries shall be replaced annually, despite condition. Instructions for battery replacement are on the rear of the chronometer case housing for this type chronometer.

420-2.3.9 SPRING-DRIVEN CHRONOMETER. Chronometers maintain more consistent rates if regularly wound. They shall be wound once every twenty-four hours. To wind a Size 85 chronometer requires about seven half-turns counterclockwise, which is twenty-four hours down from full wind. The Size 35 chronometer requires about twenty-one half-turns clockwise. The end of the winding cycle shall be approached carefully to avoid damage to winding stops.

NOTE

On Size 85 chronometers, after removing the key, the dust plate shall be closed over the winding stem.

420-2.3.9.1 Winding. If wound improperly, the timepieces may suffer possible damage and produce considerable errors. When winding, exercise care to prevent excessive movement or oscillation in gimbals.

420-2.3.9.2 Gimbaled Timepiece. A gimbaled timepiece shall be carefully inverted, wound, and returned to the dial-up position without imparting unnecessary motion to the instrument.

420-2.3.9.3 Maintenance. Spring-driven chronometers require periodic overhaul to prevent costly repairs resulting from dry jewels and other wearing surfaces. Extended operation beyond the date the chronometer is due for overhaul also will result in erratic performance of the instrument. When the chronometer leaves the repair activity, attached to the sloping edge of the bezel under the crystal is a sticker with the next overhaul due date. Ships shall turn in their chronometers as near to this overhaul date as practical.

CAUTION

If a chronometer has been submerged in water, it shall be opened, drained, and immersed in glycerine for at least one hour. The timepiece case shall then be tightly closed with as much glycerine as possible retained over the movement.

420-2.3.9.4 Size 85 Make-Break Circuit Type. Size 85 make-break circuit chronometers are standard size 85 chronometers modified by addition of an electrical contact assembly. The contact assembly can provide an electrical impulse every second (except the 59th second) of every minute. These chronometers are furnished as an item of allowance only to missile carrying ships that are equipped with shipboard time and frequency standards. Procedures for starting them aboard ship are in the **Start Instructions for Chronometers,** NAVSEA 0924-LP-009-1010.

420-2.3.10 CLOCKS. The following paragraphs describe the types of clocks used on ships and boats. Although several types discussed are no longer being issued, they still are in use in older ships and boats. For example: although marine mechanical eight-day clocks have been described as boat, deck, and general purpose types, boat and deck clocks are no longer procured and are surveyed when they become inoperative. The manufacturers of these clocks were The Chelsea Clock Company and Seth Thomas.

420-2.3.10.1 Installation. The following guidelines are provided for clock installation:

a. Power for electrically driven clocks shall be from emergency lighting.

b. Clocks with illuminated dials shall be installed in normally darkened areas (i.e., CIC and plotting spaces).

c. Battery operated clocks shall be installed in non-vital areas (i.e., berthing, messing areas).

d. Twenty four hour clocks shall be installed in communications spaces and security areas.

e. Twelve hour clocks shall be installed in machinery spaces, living and operations areas.

f. Clocks shall be installed where accessible for winding or battery changing and setting.

g. Clocks shall be installed in full view of operating personnel.

420-2.3.10.2 Marine Mechanical Types. Marine mechanical eight-day clocks are designated as a general purpose type. Quartz crystal, battery-powered clocks are replacing mechanical clocks.

420-2.3.10.3 Boat and Deck Clocks. Boat and deck clocks are 12-hour watertight clocks with hour and minute hands. The boat clock has a 101 millimeter (4 inch) diameter dial, and the deck clock a 152 millimeter (6 inch) diameter dial.

420-2.3.10.4 General Purpose Clocks. General purpose clocks are available with 12- and 24-hour dials that are 216 millimeter (8.5 inch) in diameter. Also available are clocks with a 12-hour dial that is 152 millimeter (6 inch) in diameter.

420-2.3.10.5 Winding. Mechanical clocks shall be wound once a week, and set to the correct time. Boat and deck clocks are wound, set and regulated through the back of the movement. General purpose clocks are wound, set and regulated from the dial side of the movement. After winding and setting, the bezel or case shall be secured in place to prevent dust and water from entering the case.

420-2.3.10.6 Mounting. General purpose mechanical clocks are secured to the bulkhead by means of shock mounts. These are attached to the flange of the plastic case, and to welding pads on the bulkhead. These measures provide a secure installation for the clock. All mechanical wall clocks shall be mounted on a vertical plane with the 12- or 24-hour mark at the top.

420-2.3.11 ELECTRIC WALL CLOCKS. An electric wall clock is a 12-hour synchronous motor-driven clock 305 millimeter (12 inches) in diameter. It features controllable internal red illumination using electro-luminescent lighting. To ensure adequate illumination, a built-in transformer provides a maximum voltage of 550 volts to the unit.

CAUTION

Due to the presence of high voltage inside the electric wall clock, care shall be exercised to avoid possible shock during handling.

420-2.3.12 ELECTRONIC WALL CLOCKS. Self illuminated digital clocks may be used provided the numerals are visible to all watchstanders. Digital clocks shall have an internal battery backup supply. The guidelines to ensure visibility can be found in ASTM F-1166.

420-2.4 AUXILIARY NAVIGATIONAL EQUIPMENT

420-2.4.1 AUXILIARY NAVIGATIONAL EQUIPMENT. Auxiliary navigational equipments are sextants, stadimeters, protractors, binoculars, alidades, bearing and azimuth circles, hand-held and installed telescopes and clinometers.

420-2.4.2 PRECAUTIONS. Each of the instruments may be easily damaged. Sextants and stadimeters can become misaligned with rough usage, careless handling, or when dropped to the deck. Installed telescopes and binoculars can fall to the deck if not secured properly to their mountings. Hand-held telescopes and binoculars will be damaged if permitted to become wet by rain or seawater, or if they are damp when stowed. Care also must be taken against placing these instruments where the roll of the ship could cause them to fall to the deck. Cleaning or repairing of these instruments shall be done only by skilled personnel to prevent scratched lenses and prisms, loss of parts, or improper assembly.

420-2.4.3 REPLACEMENT AND REPAIR. Damaged auxiliary navigational equipment, for which a replacement has been issued, shall be shipped to the nearest supply office, at the nearest shipyard, advanced base, SIMA, repair ship, or tender for inspection and repair. If economically repairable, they are repaired and returned to stock.

420-2.4.3.1 Non-repairable. If an instrument is determined by a repair activity to be beyond economical repair, as defined by current instructions of the applicable Inventory Control Point (ICP), it shall be expended. It shall be expended according to current instructions for survey of equipage, unless the ICP gives other instructions to the repair activity.

420-2.4.3.2 Parts, Survey, and Supply. Repair parts for auxiliary navigational equipment are furnished only to tenders, repair ships, SIMA optical repair shops, and shipyards. Repair parts for most standard instruments such as sextants, binoculars, and protractors shall be requisitioned by these repair activities through the ships' parts segment of the Navy Supply System. NAVSO P-3013-2 lists the funding codes for equipage and consumables.

420-2.4.3.3 Surveyed Instruments. Surveyed instruments shall be turned over to a repair activity for disposition. The repair activity shall dismantle the instrument for salvage of usable parts. Disposition of the instruments locally shall be directed by the Commanding Officer of the repair activity.

420-2.4.3.4 Authorization to Issue. Supply activities are authorized to issue to any ship in commission, without reference to NAVSEA, any item of equipage or consumable supplies, navigational equipment for replacement of damaged instruments, or for filling authorized allowances. All requisitions for navigational equipment more than the authorized allowance shall be processed in accordance with NAVSUP 485, **Supply Afloat Procedures** .

420-2.4.4 BEARING AND AZIMUTH CIRCLE. The Bearing and Azimuth Circle is a combined instrument used to:

a. Determine the direction of the sun. The information is used to determine the accuracy of the gyrocompasses or inertial navigation sets and

b. Determine the true or relative angle to a target. The circles are detachable and may be moved to the compass repeater which provides the best viewing angle.

420-2.4.5 BINOCULARS, 7 x 50 POWER. The 7 x 50 power binoculars are provided for each surface and air lookout station. Additionally, binoculars are supplied to the Captain, Executive Officer, Navigator, Officer of the Deck, Junior Officer of the Deck, Signal Shelter, and any additional navigational stations as required. Replacement units are to be provided for immediate use.

420-2.4.6 BINOCULARS, 20 POWER. A 20 power, 120 millimeter aperture binocular of the prismatic stereoscopic type is provided in the Signal Bridge area. A carriage is provided that permits the binocular to be moved in both azimuth and elevation. Additionally a bulkhead bracket or a pedestal on which the carriage may be mounted shall be installed. Installations of the brackets and pedestals shall provide 360-degrees of horizontal visibility.

420-2.4.7 SEXTANT. The sextant is a handheld instrument used by navigators for measuring the angular distance of the sun or stars from the horizon to determine latitude and longitude.

420-2.4.8 STADIMETER. The stadimeter is a handheld unit used to determine the differences of elevation by a means of a telescopic instrument having two horizontal lines through which the marks on a graduated scale are observed. Knowing the height of an object, the distance can be determined.

420-2.4.9 CLINOMETERS. Clinometers can be either bubble-in-tube type or pendulum type. The clinometers shall be capable of indicating:

a. Trim, with an arc of 15° each side of vertical.

b. Heel, with an arc of 20° each side of vertical plus an arc of 60° each side of vertical.

420-2.4.9.1 Installation. Trim clinometers are installed on fore-and-aft bulkheads. Heel clinometers are installed on athwartship bulkheads near the centerline of the ship. One of each type clinometer shall be installed in:

a. Central Control Station.

b. Damage Control Central.

c. Secondary Damage Control Central.

d. Enclosed Operating Station.

e. Propulsion Control Space.

f. Pilot House.

On submarines the trim clinometer shall be installed on the ship control panel. The heel clinometer shall be located next to the ship control panel near the centerline of the ship.

420-2.5 AUDIBLE SHIP SIGNALING DEVICES

420-2.5.1 BELLS AND GONGS. The primary use of a ship's bell is signaling, when the ship is at anchor during periods of restricted visibility. A secondary use of the ship's bell is signaling other ship functions such as a time signal, a boat bell, a fire bell or for other signals.

420-2.5.1.1 Requirements. The exact requirements for signaling, and the fitting of ships with required bells, are contained in the **Convention on International Regulations for Preventing Collisions at Sea,** 1972.

420-2.5.1.2 Sizes. Some ships have a small bell for internal signaling. The location of the bell is either in the weather, on the quarterdeck, or within the ship's envelope, where the sound is transmitted over the ship's general announcing system. The Commanding Officer shall ensure that the small bell is not sounded while the ship is at anchor during periods of restricted visibility.

Table 420-2-2 BELL SIZES

Weight Of Bell Kg (lbs)	Required On
9 (20)	All submarines Power boats 7.6 to 20 meters
14 (30)	Power boats, 20 meters (65 feet) to ship 181 metric tons (200 tons)
27 (60)	Ships, 181 to 563 metric tons (200 to 700 tons)
34 (75)	Ships, 563 to 5443 metric tons (700 to 6000 tons)
91 (200)	Ships over 5443 metric tons (6000 tons)

420-2.5.1.3 Fitting of Ship's Bells. Table 420-2-2 lists requirements for the fitting of ship's bell as specified by the current **Convention on International Regulations for Preventing Collisions at Sea,** 1972. Ships more than 107 meters (350 feet) in length shall be fitted with a gong, in addition to the ship's bell.

420-2.5.1.4 Location. Ship's bells and gongs shall be located as follows:

a. On ships equal to or less than 107 meters (350 feet) in length, bells shall be located on the superstructure at a location convenient to the Pilot House.

b. On ships more than 107 meters (350 feet) in length, bells shall be located on the forward 25 percent of the total ship's length. Gongs shall be located on the after 25 percent of the total ship's length.

420-2.5.2 WHISTLE FREQUENCIES AND RANGE. The fundamental frequency of the whistle signal shall lie within the range of 70 to 700 Hz. Audibility range of the whistle signal shall be determined by those frequencies (which may include the fundamental and one or more higher frequencies) that lie within the 180 to 700 Hz (ñ one percent) range that provide sound pressure levels described in paragraph 420-2.5.2.2.

420-2.5.2.1 Whistle Characteristics. To ensure a variety of whistle characteristics, the fundamental frequency of a whistle shall be between limits defined as:

a. 250 to 700 Hz, for ships less the 75 meters (240 feet) long.

b. 130 to 350 Hz, for ships from 75 to 200 meters (240 to 650 feet) long.

c. 70 to 200 Hz, for ships over 200 meters (650 feet) long.

420-2.5.2.2 Intensity. A whistle shall provide, in the direction of maximum whistle intensity and at a distance of one meter for the whistle, a sound pressure level in at least one 1/3 octave band within the range of 180 to 700 Hz (ñ one percent) of the parameters listed in Table 420-2-3.

420-2.5.2.3 Range. The range of audibility is for information only. It is the approximate range at which a whistle may be heard on its forward axis (90 percent probability) in conditions of still air on board a ship having average background noise level at the listening posts. This shall be assumed to be 68 dB in the octave band centered on 250 Hz and 63 dB in the octave band centered on 500 Hz. Values given can be regarded as typical. However, under conditions of strong wind or high ambient noise level at the listening post, range may be reduced.

Table 420-2-3 INTENSITY LEVEL AND AUDIBILITY RANGE

Ship Length Meters (Feet)	1/2 Octave Band Level at One Meter *	Audibility Range in Kilometers (Nautical Miles)
200 (650) or more	143	3.70 (2)
75 to 200 (240 to 650)	138	2.78 (1.5)
20 to 75 (66 to 240)	130	1.85
Less than 20 (66)	120	.93 (0.5)

*dB referred to 2 x 10 -5 Pascals

NOTE

In practice, the range at which a whistle may be heard is variable, and depends on weather conditions.

420-2.5.2.4 Directional Properties. Sound pressure level of a directional whistle shall not be more than four dB below sound pressure level on the axis at any direction in the horizontal plane within 45° of the axis. The sound

pressure level at any other direction in the horizontal plane shall not be more than 10 dB below the sound pressure level on the axis. The range in any direction, therefore, will be at least half the range on the forward axis. The sound pressure level shall be measured in that 1/3 octave band that determines the audibility range.

420-2.5.2.5 Location. When a directional whistle is to be used as the only whistle on a ship, it shall be installed with its maximum intensity directed straight ahead. A whistle shall be placed on a ship as high as practicable, to reduce interception of the emitted sound by obstructions, and to minimize risk of hearing damage to personnel. The sound pressure level of the ship's own signal at listening posts shall not exceed 110 dB(A), and as far as practicable, should not exceed 100 dB(A).

420-2.5.2.6 Combined Whistle Systems. If the sound field of a single whistle, or one of several whistles, is likely to have a zone of greatly reduced signal level because of obstructions, a combined whistle system shall be fitted to overcome this reduction. As defined in **Convention on International Regulations for Preventing Collisions at Sea,** 1972, a combined whistle system shall be regarded as a single whistle.

420-2.5.2.7 Location. The whistles of a combined system shall be located not more than 100 meters (330 feet) apart and rigged to be sounded simultaneously. The frequency of one whistle shall differ from those of the others by at least 10 Hz. If whistles are more than 100 meters (330 feet) apart, they shall not be considered a combined system. They shall be arranged so they cannot be sounded simultaneously.

SECTION 3.

ELECTRONIC NAVIGATION SYSTEMS, RADIO

420-3.1 RADIO NAVIGATION SYSTEMS

420-3.1.1 GENERAL. Radio navigation systems include:

a. Ground Based Radio Navigation
   1. OMEGA
   2. LORAN

b. Space Based Radio Navigation
   1. Navy Navigation Satellite (TRANSIT)
   2. Global Positioning System (GPS)

c. Direction Finders
   1. TACAN
   2. Collision Avoidance System

The radio navigation systems in conjunction with other shipboard systems will provide precise ship's position at any time.

420-3.2 GROUND BASED RADIO NAVIGATION

420-3.2.1 OMEGA SYSTEM. The OMEGA system is a worldwide all weather radio navigation system. The OMEGA system provides a means of determining own-ship's position from measurements of phase differences

of transmitted OMEGA signals. The OMEGA systems transmit three narrow-band Very Low Frequency signals (10.2, 11.33 and 13.6 kHz). The narrowband signals allow for tracking in high noise conditions. OMEGA has a typical accuracy of 1.8 to 7.4 km (1 to 4 NM). There are eight stations located throughout the world; locations are: Norway, Liberia, Hawaii, North Dakota, La Reunion, Argentina, Trinidad, and Japan. The system provides for automatic synchronization and tracking of all OMEGA stations. OMEGA provides worldwide navigation with coverage up to 14,824 km (8,000 NM per station).

420-3.2.1.1 Installation. Installation consists of an antenna and receiver. The installation may be commercial or military equipment. Military receiver types are: AN/BRN-7, AN/SRN-17, AN/SRN-12 and AN/SRN-25.

420-3.2.1.2 Commercial Equipment. For capabilities, operation, and maintenance of on board commercial equipment, refer to the applicable equipment technical manuals.

420-3.2.2 AN/BRN-7 AND AN/SRN-17. The AN/BRN-7 and AN/SRN-17 receiver sets are the same except for minor differences. See Table 420-3-1. The receiver set consists of an antenna, interconnect group, receiver computer group, and control indicator.

Table 420-3-1 AN/BRN-7 - AN/SRN-17 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA	152 x 152 x 3m (6 x 6 x 125)	4 (9)	N/A
INTER-CONNECT GROUP	229 x 229 x 279 (9 x 9 x 11)	15 (33)	65
RECEIVER COMPUTER	305 x 330 x 584 (12 x 13 x 23)	31 (68)	200
CONTROL INDICATOR	229 x 229 x 279 (9 x 9 x 11)	7 (16)	65

420-3.2.2.1 Antenna. The antenna consists of the element and coupling box. The element is a ten foot rod connected to the coupling box which receives the OMEGA signals. The coupling box contains an impedance matching circuit and a lightning arrestor. The coupling box couples the OMEGA signals to the receiver via a coaxial cable. (The AN/BRN-7 will normally use a floating wire antenna.)

420-3.2.2.2 Interconnect Group. The interconnect group provides a means of interfacing the AN/BRN-7 and AN/SRN-17 to the ship's power (115V, 400 Hz), ship's prime navigator for ship's heading (synchro) and ship's underwater log for ship's speed (synchro). The interconnect group also amplifies and conditions the received OMEGA signals and passes them to the receiver computer group.

420-3.2.2.3 Receiver Computer Group. The receiver computer group processes the received OMEGA signals, ship's heading, and ship's speed into useful data for display on the control indicator. When no OMEGA signals are available the system will use ship's heading and ship's speed to dead reckon. The receiver computer group has Built-In Test (BIT). (The AN/BRN-7 also has an antenna switching matrix.)

420-3.2.2.4 Control Indicator. The control indicator provides the interface between the operator and the equipment. The controls allow the operator to manually initialize and deenergize the system, insert updated data, select operating mode, and select specific data to display. The requested information will be displayed on the information display. Navigation information available for display is present or waypoint position (latitude and longitude), range and bearing.

420-3.2.2.5 Maintenance. Regular maintenance involves quarterly inspections, cleaning and performance test. All maintenance should be accomplished in accordance with the ship's Planned Maintenance System and the equipment technical manual.

420-3.2.2.6 Test Set. A test set is provided as part of the system to aid in trouble shooting the OMEGA system. Fault isolation of the OMEGA set is accomplished by control of the diagnostic functions of the receiver computer. The test set is capable of confirming BIT malfunction indications and isolating the fault to a replaceable assembly in the receiver computer.

420-3.2.3 AN/SRN-12. The AN/SRN-12 consists of an antenna and a receiver. See Table 420-3-2.

Table 420-3-2 AN/SRN-12 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA	152 x 152 x 3m (6 x 6 x 125)	5 (10)	N/A
RECEIVER	610 x 584 x 483 (24 x 23 x 19)	56 (123)	130

420-3.2.3.1 Antenna. The antenna consists of the element and coupling box. The element is a ten foot rod connected to the coupling box which receives the OMEGA signals. The coupling box contains an impedance matching circuit and a lightning arrestor. The coupling box couples the OMEGA signals to the receiver via a coaxial cable.

420-3.2.3.2 Receiver. The receiver synchronizes and tracks the received OMEGA signals (any four selected stations), maintains tracking, and computes the Lines-of-Position (LOP). The LOP are displayed on an indicator and plotted on a graphic recorder. The AN/SRN-12 has an accuracy of 1 to 2 NM. A built in scope is provided to monitor the OMEGA signals and is also used for trouble shooting. A battery backup is provided to maintain synchronization during power outages of not greater than ten minutes. The receiver requires 115 Vac, 60 Hz power.

420-3.2.3.3 Maintenance. The AN/SRN-12 maintenance concept is hands-off maintenance. It is designed for minimal preventative maintenance. Periodic inspections for loose, missing, or broken parts and cleaning and operational test are required. Corrective maintenance is limited to fault isolation, assembly or component replacement and retesting.

420-3.2.4 AN/SRN-25 (MX1105/1157). The AN/SRN-25 is an integrated navigation system capable of receiving signals from OMEGA, TRANSIT (see paragraph 420-3.2.6) and GPS (see paragraph 420-3.2.3.3) for com-

puting ship's position. This capability reduces the time between satellite fixes and consequently reduces dependence on dead reckoning. The OMEGA section of the AN/SRN-25 consists of an antenna and console. See Table 420-3-3.

Table 420-3-3 AN/SRN-25 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA	152 dia x 2.4m	4	N/A
OMEGA	(6 x 96)	(9)	
CONSOLE	356 x 432 x 432 (14 x 17 x 17)	39 (175)	175

420-3.2.4.1 Antenna Equipment. The antenna equipment consists of an element and preamplifier. The element is an 8-foot rod connected to the preamplifier. The preamplifier provides mounting for the assembly. The preamplifier is a factory sealed unit. The antenna and preamplifier assembly receives the OMEGA signals, amplifies the signals and sends the amplified signals to the console.

420-3.2.4.2 Console. The console processes the OMEGA signals and calculates ship's position at fixed intervals or when selected by the operator. When operating in the OMEGA mode: between fixes ship's heading and ship's speed are summed with OMEGA derived drift and set corrections for dead-reckoning (NAV2); there is no capability to update the dead-reckoning of NAV1 or GPS. A battery backup is provided to maintain operation for about ten minutes in case of power failure. The console keyboard permits the operator to input data and select navigation data. Data is displayed on a cathode ray tube. Standard OMEGA outputs are:

a. Latitude (degrees, minutes, thousandths of a minute).

b. Longitude (degrees, minutes, thousandths of a minute).

c. Greenwich Mean Time of fix (hours, minutes, seconds).

d. Greenwich Mean Time date (day, month, year).

e. Speed (knots).

f. Heading (degrees).

g. Set and drift correction.

h. No Fix Code.

420-3.2.5 NAV1. NAV1 is a TRANSIT satellite navigation capable of producing accurate satellite position fixes. NAV1 combines ship's speed and heading with a drift and set correction. The heading and speed information can be manually inserted or can be provided by the ship's underwater log and ship's prime navigator.

420-3.2.5.1 Navigators. The AN/SRN-25 has three separate navigators that operate simultaneously. Each navigator can be selected via the keyboard. They are:

a. NAV1 - Integrated TRANSIT Satellite.

b. NAV2 - Integrated TRANSIT Satellite/OMEGA.

c. GPS - Integrated GPS Satellite/TRANSIT satellite.

420-3.2.5.1.1 Dead Reckoning Between Satellite Fixes. For dead reckoning between satellite fixes, speed, heading, and set and drift are normally required. For operation of these modes consult the equipment technical manual.

a. Speed and heading can be provided as follows:
   1. Manually (keyboard).
   2. Automatically (speed and heading interface module).
   3. Externally (navigation computer).

b. Set and drift is available from:
   1. GPS satellite fixes.
   2. TRANSIT satellite fixes.
   3. OMEGA (NAV2 only).
   4. Manually (keyboard).

c. Outputs from dead reckoning are:
   1. Latitude (degrees, minutes, thousandths of a minute).
   2. Longitude (degrees, minutes, thousandths of a minute).
   3. Dead-reckoning time since last position fix.
      (a) DRT - TRANSIT.
      (b) ODRT - OMEGA.
      (c) GDRT - GPS.
   4. Greenwich Mean Time (hours, minutes, seconds).
   5. Speed (knots).
   6. Heading (degrees).
   7. Set and drift.

420-3.2.5.2 Optional Equipment. The following optional equipment is available:

a. Printer - provides an automatic printout of the ship’s route at selected intervals and after each fix.

b. Remote computer - provides another means of supplying ship’s heading and ship’s speed to the console.

c. Remote video display - provides a display of navigational data to areas needing or desiring the data.

d. External alarm - provides an external alarm when any of the following exists:
   1. Internal circuit failure.
   2. Speed or heading error.
   3. Main power failure.
   4. Excessive temperature of the console.

420-3.2.5.3 Maintenance. The AN/SRN-25 maintenance consists of periodic inspections for loose, missing, or broken parts, cleaning of air filter and case, checking batteries and other maintenance in accordance with the ship's Planned Maintenance System. The AN/SRN-25 automatically self tests every 128 minutes.

420-3.2.6 LORAN SYSTEM. The LORAN system provides a means of determining own-ship's position by discrimination of pulse repetition frequency between LORAN chains. A LORAN chain consists of a master transmitter and two or more slave transmitters located about 600 miles apart generally along coastal areas. Pulses are transmitted at a fixed frequency of 100 kHz, the individual RF cycles within each pulse are matched to provide high resolution and accuracy. LORAN provides wide area coverage of 1200 to 1500 miles. LORAN is maintained by the U.S. Coast Guard.

420-3.2.6.1 Installation. Installation consists of an antenna and receiver. The installation may be commercial or military equipment.

420-3.2.6.2 Commercial Equipment. For operation, capabilities and maintenance of on board commercial equipment refer to the applicable equipment technical manuals. Commercial receiver type is Trimble Model 50 and Model 100.

420-3.2.6.3 Model 50 and Model 100. The model 50 and model 100 are the same except for minor differences. The model 100 automatically corrects latitude/longitude calculations for propagation delay in the LORAN signal when it travels over land. The model 50 calculates latitude/longitude assuming the LORAN signal is transmitted entirely over water. The accuracy for the model 100 is typically within 150 yards, the model 50 will vary with location up to as much as two miles. Equipment characteristics are shown in Table 420-3-4.

Table 420-3-4 TRIMBLE MODEL 50 AND 100 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA	2.44m (8 Ft)	UNK	N/A
RECEIVER	UNK	UNK	18

420-3.2.6.4 Antenna. The antenna consists of an element and coupler. The element is an eight foot fiberglass whip attached to the coupler. The coupler provides an impedance matching network and couples the LORAN signals to the receiver via a coaxial cable.

420-3.2.6.5 Receiver. The receiver processes the received LORAN signals in to latitude and longitude to be displayed on the receiver display panel. Latitude and longitude are displayed in degrees, minutes and hundredths of minutes.

420-3.2.6.6 Receiver. The receiver is capable of storing up to 100 waypoint. The following waypoint operations/functions are available:

a. Course to destination.

b. Speed over ground.

c. Cross track error (right or left of a great circle course).

d. Steer (graphic display of cross track error).

e. Speed toward destination.

f. Distance made good (between waypoints).

g. Speed made good (between waypoints).

420-3.2.6.7 Maintenance. Regular maintenance involves keeping the display clean and ensuring all connectors are tight on a monthly basis. All maintenance shall be accomplished in accordance with the Ship's Planned Maintenance System and the equipment technical manual.

420-3.3 SPACE BASED RADIO NAVIGATION

420-3.3.1 NAVY NAVIGATION SATELLITE SYSTEM. The Navy navigation system (TRANSIT) provides a means of determining own-ship's position and Universal Coordinated Time (UTC) by measuring satellite position and from satellite messages. TRANSIT consists of six satellites in a circular polar orbit at an altitude of 1075 km (600m). TRANSIT is a worldwide all weather Very High Frequency (150 and 400 MHz) system. The satellites have an orbital period of approximately 107 minutes, permitting the user to obtain a fix about every 30 minutes. Ship's position can be calculated within 32 meters and UTC within one (1) second. TRANSIT is maintained by the Navy Astronautics Group, Point Mugu, California, with tracking stations in Maine, Minnesota, and Hawaii. Space Track Messages are issued to inform users on satellite status.

420-3.3.1.1 Installation. Installation consists of an antenna and receiver. The installation may be commercial or military equipment. The military receiver types are AN/SRN-25 and AN/WRN-5.

420-3.3.1.2 Commercial Equipment. For capabilities, operation and maintenance of on board commercial equipment refer to the applicable technical manual.

420-3.3.2 AN/SRN-25 (MX1105/1157). The AN/SRN-25 is an integrated navigation system capable of receiving signals from OMEGA (see paragraph 420-3.2.1), TRANSIT, and GPS (see paragraph 420-3.2.3.3) for computing ship's position. This capability reduces the time between satellite fixes and consequently reduces dependence on dead reckoning. The TRANSIT section of the AN/SRN-25 consists of an antenna and console. See Table 420-3-5.

Table 420-3-5 AN/SRN-25 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA TRANSIT	1m dia x 1.2m (38.3 x 45.6)	23 (50)	N/A
CONSOLE	356 x 432 x 432 (14 x 17 x 17)	39 (175)	175

420-3.3.2.1 Antenna Equipment. The antenna equipment consists of a dual channel antenna and preamplifier. The preamplifier is a factory sealed unit and provides mounting for the assembly. The antenna/preamplifier assembly receives the TRANSIT signals, amplifies the signals and sends the amplified signals to the console.

420-3.3.2.2 Console. The console can be configured to be either a single channel or dual channel receiver. The console processes the TRANSIT signals, calculates ship's position within 37 m (dual channel), calculates when it will see the satellite again, and provides Greenwich Mean Time within one second. Ship's position calculations utilize satellite information, ship's speed, ship's heading, ship's position, time and antenna height. A dual channel receiver corrects for ionospheric distortion of the satellite signals, providing maximum navigation accuracy. A battery backup is provided to maintain operation for about ten minutes in case of power failure. The console keyboard permits the operator to input data and select navigation data. Data is displayed on a cathode ray tube. Standard TRANSIT outputs are:

a. Dead-reckoning time.

b. Latitude (degrees, minutes, thousandths of a minute).

c. Longitude (degrees, minutes, thousandths of a minute).

d. Greenwich Mean Time of fix (hours, minutes, seconds).

e. Speed (knots).

f. Heading (degrees).

g. Drift and set correction.

420-3.3.2.3 Navigators. The AN/SRN-25 has three separate navigators that operate simultaneously. Each navigator can be selected via the keyboard. They are:

a. NAV1 - Integrated TRANSIT Satellite.

b. NAV2 - Integrated TRANSIT Satellite/OMEGA.

c. GPS - Integrated GPS Satellite/TRANSIT satellite.

420-3.3.2.3.1 Dead Reckoning Between Satellite Fixes. For dead reckoning between satellite fixes, speed, heading, and set and drift are normally required. For operation of these modes consult the equipment technical manual.

a. Speed and heading can be provided as follows:
   1. Manually (keyboard).
   2. Automatically (speed and heading interface module).
   3. External (navigation computer).

b. Set and drift is available from:
   1. GPS satellite fixes.
   2. TRANSIT satellite fixes.
   3. OMEGA (NAV2 only).
   4. Manually (keyboard).

c. Outputs from dead reckoning are:
   1. Latitude (degrees, minutes, thousandths of a minute).
   2. Longitude (degrees, minutes, thousandths of a minute).
   3. Dead-reckoning time since last position fix

(a) DRT- TRANSIT.
(b) ODRT- OMEGA.
(c) GDRT- GPS.

4. Greenwich Mean Time (hours, minutes, seconds).
5. Speed (knots).
6. Heading (degrees).
7. Set and drift.

420-3.3.2.4 Optional Equipment. The following optional equipment is available:

a. Printer - provides an automatic printout of the ship's route at selected intervals and after each fix.

b. Remote computer - provides another means of supplying ship's heading and ship's speed to the console.

c. Remote video display - provides a display of navigational data to areas needing or desiring the data.

d. External alarm - provides an external alarm when any of the following exists:
1. Internal circuit failure.
2. Speed or heading error.
3. Main power failure.
4. Excessive temperature of the console.

420-3.3.2.5 Maintenance. The AN/SRN-25 maintenance consists of periodic inspections for loose, missing, or broken parts, cleaning of air filter and case, checking batteries, and other maintenance in accordance with the ship's Planned Maintenance System. The AN/SRN-25 automatically self tests every 128 minutes.

420-3.3.3 AN/WRN-5. The AN/WRN-5 consists of an antenna, preamplifier, radio receiver, remote video display (optional), and teleprinter (optional). See Table 420-3-6. The AN/WRN-5 has two basic versions: the AN/WRN-5()1 for submarines and the AN/WRN-5()2 for surface ships.

420-3.3.3.1 Antenna Installation. The antenna installation consists of the element and antenna group assembly (preamplifier) for surface ships and preamplifier mounted within 50 feet of the element for submarines.

420-3.3.3.2 Preamplifier. The preamplifier is a two channel unit operating at 150 MHz and 400 MHz. Power to the preamplifier is provided by the receiver via coaxial cable.

420-3.3.3.3 Radio Receiver. The radio receiver receives the satellite signals and processes the signals to obtain position information, which is monitored on video displays. Ship's speed and heading are interfaced with the receiver to provide dead reckoning between satellite fixes. An NTDS interface provides a means of digital communication with the AN/WSN-5 Inertial Navigation Set. Normal mode of operation is the dead reckoning display mode. The major components of the receiver are the operational keyboard, XDUP, tape transport, status indicators and video display.

Table 420-3-6 AN/WRN-5 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
RADIO RCVR	762 x 483 x 305 (30 x 19 x 12)	68 (150)	400
PREAMPLIFIER	127 x 254 x 330 (5 x 10 x 13)	6 (13)	1
VIDEO REMOTE DISPLAY	356 x 254 x 229 (14 x 10 x 9)	6.4 (14)	20
ANTENNA	1016 x 965 dia (40 x 38 dia)	4.5 (10)	N/A
ANTENNA GROUP	152 x 330 dia (6 x 13 dia)	11.3 (25)	N/A

420-3.3.3.4 Operational Keyboard. The operational keyboard provides a means for the operator to interface with the AN/WRN-5. Operations may include equipment initialization, position update, mode selection.

420-3.3.4 XDUP. The XDUP is an integrated circuit, 16K magnetic core memory, general purpose digital computer. The XDUP controls all operations of the receiver. Such operations include control search of satellites, decode and process satellite messages, prepare data for display, interpret keyboard inputs and decode front panel switch information.

420-3.3.4.1 Tape Transport. The tape transport is for loading the OPNAV program from magnetic tape into core memory. The tape transport is also used to record selected data.

420-3.3.4.2 Status Indicators. The status indicators provide a visual indication of the current status of the receiver. Indicators include frequency lock (150 MHz and 400 MHz), BIT sync, Message sync, satellite fix in progress and system error.

420-3.3.4.3 Video Display. The video display provides a visual indication of the computer input/output information and data. In the normal mode of operation the video display provides the following information:

a. GMT (hours, minutes, seconds).

b. Latitude (degree, minutes, hundredths of minutes).

c. Longitude (degree, minutes, hundredths of minutes).

d. Speed.

e. Heading.

420-3.3.4.4 Maintenance. Maintenance consists of regular cleaning of the air filter and tape transport heads and performance tests to evaluate equipment performance. All maintenance should be accomplished in accordance with the ship’s Planned Maintenance System and the equipment technical manual.

420-3.3.5 GLOBAL POSITIONING SYSTEM. The Global Positioning System (GPS) provides a means of determining precise own-ship's position, velocity, and GPS system time by measurement of range to the satellites (pseudo-range) and from satellite messages. GPS consists of eighteen (18) operational satellites and six (6) standby satellites in 12 hour orbits at an altitude of 20,183km (10,898m). GPS is a world wide all weather L Band (1227.6 and 1575.42 MHz) system. The signals are modulated with two codes: P Code (1227.6MHz) which provides for precision measurement and C/A Code (1575.46 MHz) which provides for lock-on. Six satellites are available at all times permitting 3 dimensional position within 10 meters, velocity accuracy within 0.1 meter, and GPS system time within 10 nanoseconds. GPS has a high resistance to jamming. GPS is maintained by the Joint Project Office, U.S. Air Force, Los Angeles, California.

420-3.3.5.1 GPS System Time. GPS system time differs from Universal Coordinated Time (UTC), which must be adjusted for leap seconds at periodic end-of-the-year intervals. GPS system time is not adjusted in order to maintain continuous availability of the satellites for navigation purposes. GPS system time and UTC time are maintained within 100 microseconds. Differences between GPS system time and UTC time are published regularly for those who desire to use GPS system time as a time standard.

420-3.3.5.2 Satellites. The GPS satellites provide navigational data to the navigation sets. The satellite constellation configuration provides world wide continuous coverage. Data messages from the satellites provide the navigation set information about the satellites for translation into navigation data.

420-3.3.5.3 Ground Control System. The ground control system tracks, monitors and controls the satellites' orbit. The ground control consists of a Master Control Station (MCS), and Monitor Stations (MS). The MCS and a MS are located in Colorado Springs, Colorado at the Combined Space Operations Center. Four additional MS's are located outside the continental United States at Hawaii, Diego Garcia Island, Ascension Island and Kwajalein Island in the Marshall Islands. The MS's collect satellite tracking data from all satellites. This data, combined with environmental data, is encrypted and transmitted to the MCS. The MCS uses the data to generate new space vehicle position tables and clock offset updates. The updates are transmitted to the respective satellites once every 24 hours. The MCS also performs satellite health and housekeeping functions.

420-3.3.5.4 Installation. Installation consists of an antenna and receiver. The installation may be commercial or military equipment. The military navigation set is the AN/WRN-6 and AN/SRN-25.

420-3.3.5.5 Commercial Equipment. For capabilities, operation and maintenance of on board commercial equipment refer to the applicable equipment technical manuals.

420-3.3.5.6 Navigation Set. The navigation set (AN/WRN-6) consists of an antenna, antenna amplifier, receiver, and indicator control. See Table 420-3-7. Using the navigation signals from the satellites, the navigation set measures the pseudo-ranges (ranges uncorrected for user clock bias) and pseudo-range rates with respect to the satellites. The navigation set converts this information into three-dimensional position, velocity and system time. This position solution is in World Geodetic System (WGS-72) coordinates, an earth-centered, earth-fixed coordinate system, which can be converted to any of 41 designated reference systems. The navigation set can operate as a stand-alone navigation aid or can be interfaced with other navigation equipment to provide the best possible navigation solution.

Table 420-3-7 AN/WRN-6 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
RADIO	313 x 469 x 369 (12 x 19 x 15)	32 (70)	150
INDICATOR CONTROL	244 x 146 x 152 (10 x 6 x 6)	4 (8)	27
ANTENNA	393 dia x 209h (16 x 8)	9 (20)	N/A
ANTENNA AMPLIFIER	225 x 109 x 51 (12 x 4 x 2)	1 (2)	4

420-3.3.5.7 Antenna. The antenna receives the signals from the satellites in all directions including overhead. The housing of the antenna serves as a ground plane for the antenna and can also serve as a housing for the antenna amplifier.

420-3.3.5.8 Antenna Amplifier. The antenna amplifier provides initial signal processing of the GPS satellite signals. The received signals are split and converted into intermediate frequencies, further amplified and sent to the receiver via coaxial cable. Power to the amplifier is provided by the receiver via the coaxial cable.

420-3.3.5.9 Receiver. The receiver processes the intermediate frequencies from the antenna amplifier, data from ship's prime navigator (roll, pitch, heading) and ship's underwater log (speed) into useful navigational data which can be displayed on the indicator control and can also be provided to other systems on the ship. Data exchange with other equipment is via an NTDS interface. The receiver can support two indicator control units. Input and output connectors are on the rear of the receiver. Battery backup is provided to save critical memory when ship's power is lost.

420-3.3.5.10 Indicator Control. The indicator control provides the operator with the capability to control the navigation set, input data and observe navigation generated outputs. The indicator control contains operating controls, a data entry keyboard and a four-line alphanumeric cathode ray tube. Output information available is as follows:

a. Latitude

b. Longitude

c. Altitude and Depth

d. Time

e. Waypoints

f. Bearing to waypoint

g. Slant range to waypoint

h. Ground track

i. Heading

j. Speed

k. Magnetic variation

l. Grid convergence factor

m. Elevation angle

n. Number of satellites tracked

o. Figure of merit (Dilution of Precision)

p. Almanac age

q. Number of satellites declared bad by set

420-3.3.5.11 Maintenance. Maintenance of the GPS consists of changing the battery in the radio at least once every six months and normal ship's Planned Maintenance System.

420-3.3.6 AN/SRN-25 (MX1105/1157). The AN/SRN-25 is an integrated navigation system capable of receiving signals from OMEGA (see paragraph 420-3.2.1), TRANSIT (see paragraph 420-3.3.1), and GPS for computing ship's position. This capability reduces the time between satellite fixes and consequently reduces dependency on dead reckoning. The GPS section will calculate a three dimensional position when four or more satellites are available. The GPS section of the AN/SRN-25 consists of an antenna and console. See Table 420-3-8.

420-3.3.6.1 Antenna Equipment. The antenna equipment consists of an antenna and preamplifier. The preamplifier is a factory sealed unit and provides mounting for the assembly. The antenna and preamplifier assembly receives the GPS signals (two channel C/A), amplifies the signals, converts the signals to intermediate frequencies and sends the signals to the console.

420-3.3.6.2 Console. The console processes the GPS signals, calculates ship's position independent of dead reckoning and provides Greenwich Mean Time within one second. A position fix will be calculated once every 1.2 seconds as long as sufficient satellites are available. A battery backup is provided to maintain operation for about ten minutes in case of power failure. The console keyboard permits the operator to input data and select navigation data. Data is displayed on a cathode ray tube. Standard GPS outputs are:

a. Satellite Fix information.

b. Alert messages (normally not displayed).

c. Latitude (degrees, minutes, thousandths of a minute).

d. Longitude (degrees, minutes, thousandths of a minute).

e. Greenwich Mean Time of fix (hours, minutes, seconds).

f. Speed (knots).

g. Heading (degrees, tenths of a degree).

h. Speed over ground (knots).

i. Course over ground (degrees, tenths of a degree).

Other GPS displays are available. Consult the equipment technical manual for access and an explanation of the displays.

Table 420-3-8 AN/SRN-25 EQUIPMENT CHARACTERISTICS

UNIT	SIZE l x w x h mm (in.)	WEIGHT Kg (Lbs)	POWER (Watts)
ANTENNA	208 dia x 375	3	N/A
GPS	(8.2 x 14.8)	(6)	
CONSOLE	356 x 432 x 432	39	175
	(14 x 17 x 17)	(175)	

420-3.3.6.3 Modes of Operation. The console has the capability of two modes of operation for GPS. The modes are altitude hold and clock hold.

420-3.3.6.4 Altitude Hold. In the altitude hold mode the antenna height is used in the fix calculation. A horizontal fix position is obtained for both latitude and longitude. Antenna height is from sea level to the top of the antenna. Ship's movement should not affect the fix results. The console automatically operates in the mode.

420-3.3.6.5 Clock Mode. The clock mode requires an external frequency standard. In the clock mode the console will calculate fixes with only two satellites.

420-3.3.6.6 Navigators. The AN/SRN-25 has three separate navigators that operate simultaneously. Each navigator can be selected via the keyboard. They are:

a. NAV1 - Integrated TRANSIT Satellite.

b. NAV2 - Integrated TRANSIT Satellite/OMEGA.

c. GPS - Integrated GPS Satellite/TRANSIT satellite.

420-3.3.6.6.1 Dead Reckoning Between Satellite Fixes. For dead reckoning between satellite fixes, speed, heading, and set and drift are normally required. For operation of these modes consult the equipment technical manual.

a. Speed and heading can be provided as follows:
   1. Manually (keyboard).
   2. Automatically (speed and heading interface module).
   3. External (navigation computer).

b. Set and drift is available from:
   1. GPS satellite fixes.
   2. TRANSIT satellite fixes.
   3. OMEGA (NAV2 only).
   4. Manually (keyboard).

c. Outputs from dead reckoning are:
   1. Latitude (degrees, minutes, thousandths of a minute).
   2. Longitude (degrees, minutes, thousandths of a minute).
   3. Dead-reckoning time since last position fix.

(a) DRT - TRANSIT.
(b) ODRT - OMEGA.
(c) GDRT - GPS.

4. Greenwich Mean Time (hours, minutes, seconds).
5. Speed (knots).
6. Heading (degrees).
7. Set and drift.

420-3.3.6.7 Optional Equipment. The following optional equipment are available:

a. Printer - provides an automatic printout of the ship's route at selected intervals and after each fix.

b. Remote computer - provides another means of supplying ship's heading and ship's speed to the console.

c. Remote video display - provides a display of navigational data to areas needing or desiring the data.

d. External alarm - provides an external alarm when any of the following exists:
   1. Internal circuit failure.
   2. Speed or heading error.
   3. Main power failure.
   4. Excessive temperature of the console.

420-3.3.6.8 Maintenance. The AN/SRN-25 maintenance consists of periodic inspections for loose, missing, or broken parts, cleaning of air filter and case, checking batteries and other maintenance in accordance with the ship's Planned Maintenance System. The AN/SRN-25 automatically self tests every 128 minutes.

420-3.4 DIRECTION FINDERS

420-3.4.1 TACAN SYSTEM. The AN/URN-25 Tacan set provides a means of transmitting information that will allow an aircraft to find range and bearing to the ship.

420-3.4.2 Collision Avoidance System. The Collision Avoidance System (CAS) provides a means of rapid and accurate assessment of potential collisions. The CAS is interfaced with the ship's radars, prime navigator, and the underwater log. The CAS processes the signals and generates potential collision situations in relation to tracked targets. CAS provides the following information:

a. Own ship (heading and speed).

b. Selected target.

c. Range.

d. Bearing.

e. Speed.

f. Course.

g. Closest Point of Approach (CPA).

h. Time to CPA.

SECTION 4.

ELECTRONIC NAVIGATION SYSTEMS, ACOUSTICAL

420-4.1 ACOUSTICAL ELECTRONIC NAVIGATION SYSTEMS

420-4.1.1 The acoustical electronic navigation systems consist of a Sonar Sounding Set (AN/UQN-4A) and a Channel Finder System (AN/WQN-1(V)).

420-4.2 DEPTH DETERMINING SYSTEM

420-4.2.1 GENERAL. This system provides a means of indicating water depth determined by acoustical methods.

420-4.2.2 DEPTH DETERMINING SYSTEM INSTALLATION. The location of the Sonar Sounding Set Transceiver is in the Chart Room. Remote Sonar Sounding Set Depth Indicators may be located in the Pilot House or CIC. The location of the Sonar Sounding Set Transducer is in a trunk. The transducer is supplied with a cable and connector, assembled and tested to assure watertight integrity. The cable length is 21.3 meters (70 feet) and may restrict the location of its junction box.

420-4.3 CHANNEL FINDER SYSTEM

420-4.3.1 The Channel Finder System automatically obtains and monitors navigation channel parameters. The Channel Finder System consists of two basic AN/WQN-1(V) sonar sets connected on a master/slave configuration with a total of eight hull mounted transducers. Each set consists of a control unit, a main electronic unit, a junction box, four remote electronic units, and four transducers.

SECTION 5.

ELECTRICAL NAVIGATION SYSTEMS

420-5.1 ELECTRICAL NAVIGATION SYSTEMS

420-5.1.1 Electrical navigation systems include items such as gyrocompass systems, synchro signal transmitters, magnetic compasses, underwater log systems, plotting systems, and depth detector systems.

420-5.2 GYROCOMPASS EQUIPMENT

420-5.2.1 GYROCOMPASS SYSTEMS. The gyrocompass provides a means of determining own-ship's heading, roll, and pitch of the ship. Gyrocompass systems include the MK 19, MK 23, MK 27 and AN/WSN-2. The gyrocompass system transmits information to weapons control, sonar, radar, degaussing, depth control, dead reckoning, and other such equipment or systems as required. Components of the gyrocompass systems include: gyrocompass control cabinets, power supply, and ship's heading, roll and pitch indicators (analog and digital), synchro signal amplifiers, and synchro signal converters.

420-5.2.2 GYROCOMPASS INSTALLATIONS. Gyrocompass systems are installed aboard warships (submarines and DD types and larger), amphibious warfare ships (LSD and larger), auxiliary ships (longer than 91 meters (300 feet)), patrol ships (FF types and larger), and mine warfare ships.

420-5.2.2.1 Two Gyrocompass System. When two gyrocompass systems are installed in ships, two course indicators shall be installed in the Pilot House, in the steering console, and each gyro room. Each indicator shall be connected directly to the respective gyrocompass transmitter. Indicators in the gyro rooms shall be connected directly to the opposite gyrocompass. All other indicators shall be connected through synchro signal amplifiers or synchro signal converters.

420-5.2.2.2 Gyrocompass Mounting. Each gyrocompass shall be ideally installed on the ship's centerline. At a minimum, the gyrocompass shall be mounted with lubber line forward and near the ship's centerline. No steam or water lines shall pass over or near the gyrocompass. Sufficient clearance shall be provided for adequate ventilation, and access for alignment and maintenance.

420-5.2.3 GYROCOMPASS SERVICE RECORD BOOK. The Gyrocompass Service Record Book is provided with each gyrocompass to provide a chronological history of inspections, repairs, and overhauls. The instructions for maintaining the Gyrocompass Service Record Book are in the front of the book. MRC actions should not be recorded in the Gyrocompass Service Record Book. Repair or replacement of parts resulting from such maintenance, however, should be recorded in the Gyrocompass Service Record Book. This information will aid with future repairs to the gyrocompass. The Gyrocompass Service Record Book remains with the master gyrocompass throughout its service life. When the compass is removed from the ship, its Gyrocompass Service Record Book accompanies it.

420-5.2.4 OVERHAUL. Gyrocompasses requiring major overhaul (complete disassembly, rebalancing, or alignment) should be referred to Qualified Depot or Repair Activity.

420-5.2.5 HEADING INDICATORS. Heading indicators display own-ship's heading information received from the ship's gyrocompass system. The indicators may be either synchro-servo or digital indicators. The indicator may be single (1X) or a combined single and thirty-six (1X, 36X) speeds. Thirty-six speed indicators are used for precise readings. Digital indicators provide a three digit solid state readout of ship's heading with a range of 000 to 359 degrees in one degree increments. Single and thirty-six (1X, 36X) speed indicators are provided in areas such as:

a. AFT Steering - each trickwheel
b. AFT Steering - emergency steering
c. Pilot House - Ship Control Console
d. Pilot House -
   (OOD) single dial bearing
   (OOD) steering
e. Bridge Wings - Pelorus
f. Auxiliary Conning Station (CV and CVN)
g. Gyro Room
h. Ship Control Station - Outboard Position (submarine)

i. Ship Control Station - Inboard Position (submarine) Single (1X) speed indicators are provided in areas such as:

j. Pilot House - Chart Table

k. Pilot House - CO Chair

l. CIC - Command Table

m. CIC - Surface OPS Area

n. CIC - Subsurface OPS Area

o. CIC - DRT

p. Sonar Control - Sonar Supervisor

q. Air Ops Center - Air Ops Officer

r. Tactical Air Control Center - Tactical Air Officer

s. CCA Room - CCA Officer

t. Helo Direction Center - Helo Director

u. Flight Control Station - Air Officer

v. Helo Control Station - Helo Officer

w. Surface and Sky Lookouts

x. Remote Conning Stations

y. CO Tactical Plot - DRT

z. Central Control Station - EOOW

aa. Balloon Inflation Room

ab. Flag Plot - DRT

ac. Flag Bridge - Flag Chair

ad. Chart Room - Chart Table

ae. Meteorological Room

af. Debark Control Center (Debark Officer)

ag. Staterooms, Sea Cabins
Flag
CO
Navigators

ah. Command and Control Center - Command Area (submarine)

ai. Command and Control Center - Plot Area (submarine)

aj. Missile Control Room (submarine)

ak. Sonar Control Room (submarine)

al. Integrated Radio Room (submarine)

am. CO Stateroom (submarine)

an. Wardroom (submarine)

ao. Officer's Study (submarine)

420-5.2.6 MAGNETIC BEARING CONTROL. A magnetic bearing control unit is installed in aircraft carriers to provide capability of correcting ship heading signals to the heading indicator in the CCA Room. The unit provides the capability to include angled deck heading and magnetic variation. The heading indicator in the CCA room is viewable by all console operators.

420-5.2.7 UNINTERRUPTIBLE POWER SUPPLY (UPS). Each gyrocompass system should be provided with a UPS that shall provide electrical power during a loss of ship's power. The capacity of the UPS shall allow each gyrocompass to provide true ship's heading to indicators in Aft Steering and Pilot House ship control console for 30 minutes. An alarm shall be provided from each gyrocompass to alert the IC technician in each gyro room, when the gyrocompass is operating from the UPS. Gyrocompass system fault alarms are provided in the Pilot House Ship Control Console, CIC weapons control area, Optical Landing System Equipment Room, Landing Signal Officer's Platform, Flight and Helo Control Station, CCA Room, Helicopter Direction Center, and Sonar Control.

420-5.2.8 MK19 GYROCOMPASS. The MK19 Gyrocompass seeks and continuously indicates the meridian and the zenith, thus serving as a reference for measurement of the ship's roll, pitch and heading. The MK19 Gyrocompass furnishes precise synchro roll, pitch and heading data for use in navigation, as well as for stabilizing surveillance and fire control devices. The MK19 Gyrocompass consists of four major components: master compass, control cabinet, failure annunciator, and power supply.

420-5.2.8.1 Master Compass. The principle component of the master compass is the sensitive element which is the North-seeking and vertical-indicating element of the compass. The North-seeking or meridian gyro and the East-seeking or the slave (components of the element) are mounted on the phantom assembly. The azimuth phantom defines the meridian, and the roll and pitch defines the zenith. The master compass includes supporting structures known as the gimbal, the frame, and the binnacle. The compass element is gimbaled in the binnacle and has freedom of ± 60 degrees about the roll axis and ± 40 degrees about the pitch axis.

420-5.2.8.2 Control Cabinet. The control cabinet contains the voltage regulator, dc power supply, computers, amplifiers, and other assemblies required for operating and indicating the condition of the gyrocompass. The operating switches or controls, indicator and alarm lamps, and indicator fuses are located at the top. These parts are on a recessed panel to avoid injury to personnel, damage to the controls, or accidental change of setting.

420-5.2.8.3 Mode of Operation. The MK19 Gyrocompass provides for three modes of operation: Normal, Directional Gyro, and High Latitude. For operation and use of these modes consult the MK19 Gyrocompass technical manual.

420-5.2.8.4 Output Signals. The MK19 Gyrocompass provides the following output signals: Heading (1X, 36X synchro), Roll and Pitch (2X, 36X synchro). The Heading data is provided on two different busses: Normal and Critical. To prevent overload of the Static Power Supply when operating on battery the normal buss is disconnected and only those indicators on the critical buss remain operational.

420-5.2.8.5 Failure Annunciator. The failure annunciator is a remote visual indicator, usually located on the Bridge, to give a remote alarm signal whenever there is an alarm signal on the control cabinet. The failure

annunciator contains two red lamps that are lighted when the system is operating properly and are flashing whenever there is a malfunction. The COMPASS OPERATION alarm lamp will flash when there is a malfunction in the compass control system, DC power supply, follow-up amplifier, or static power supply. The SHIP'S 400 Hz SUPPLY alarm lamp will flash when there is a malfunction in the ship's 400 Hertz power supply or voltage regulator.

420-5.2.8.6 Static Power Supply. The static power supply provides a 115 volt, 400 hertz, 3-phase ac power supply from either a 115 volt, 400 hertz, 3-phase source or from 120 volt dc source, such as batteries. The static power supply provides the power necessary for the operation of the master compass, control cabinet, failure annunciator, and for charging the batteries for the static power supply. Any other shipboard equipment must be provided power from the ship's power supply. In the event of ship's power loss the static power supply will continue to operate from the stowage batteries until power is restored or the batteries are discharged.

420-5.2.8.7 Maintenance. Maintenance of the MK19 consists of periodic test and checks, inspections, cleaning, and lubrication. Periodic test and checks that need to be made are operational checks that need to be performed by the watch. General cleaning and inspection should be done on a daily or weekly basis depending on circumstances. Lubrication should be done when the equipment is idle and monthly or quarterly, depending on the component. All maintenance should be done in accordance with the ship's Planned Maintenance System.

420-5.2.9 MK23 GYROCOMPASS SYSTEM. The MK23 Gyrocompass seeks and continuously indicates the meridian or true North. The MK23 Gyrocompass is capable of withstanding severe operating conditions in small boats, amphibious vehicles, surface vessels, and submarines. The MK23 Gyrocompass consists of seven major units: master unit, control cabinet, alarm control, visual alarm indicator, power supply control, and power supply unit.

420-5.2.10 MASTER UNIT. The master unit consists of a shock mounted, oil filled binnacle and the compass element. The compass element is the North-seeking component of the compass. The compass element is gimballed in the binnacle and has 45-degree freedom about the roll and pitch. The sensitive element, a part of the compass element, has 65-degree freedom about its horizontal axis.

420-5.2.10.1 Control Cabinet. The control cabinet contains all the controls, amplifiers, power supplies and networks necessary for the operation of the MK23 Gyrocompass system. The control circuits are contained in eight plug-in modules. The control cabinet also contains a test panel consisting of a series of jacks and potentiometers used during trouble shooting and calibration. The front panel contains the manual controls and indicators used during normal operation of the gyrocompass.

420-5.2.10.2 Alarm Control Unit. The alarm control unit contains all the components necessary to activate an alarm when the gyrocompass system becomes inoperative. The alarm control unit receives alarm signals from the control cabinet and activates an alarm indicator when any of the components fail.

420-5.2.10.3 Visual Alarm Indicator. The visual alarm indicator is used in place of bells to indicate a failure where an audible alarm is undesirable. The visual alarm indicator is activated by the alarm control unit.

420-5.2.10.4 Speed Unit. The speed unit is used to produce an electrical signal proportional to the speed of the ship. Speed data may be developed from synchro speed data received from the ship's underwater log system or may be manually set by an operator.

420-5.2.10.5 Power Supply Unit. The power supply unit contains a static inverter and battery charger. The static inverter is a standby power supply which produces a single-phase, 115 Vac, 400 Hz output when the ship's power fails. The battery charger will continuously charge the batteries during normal operation. Charging rates are selectable by internal jumper. Charging rates are selected based on the batteries used.

420-5.2.10.6 Power Supply Control Unit. The power supply control unit monitors the voltage and frequency of the ship's power source. If the voltage falls below 105 Vac, or the frequency falls below 380 Hz, the power supply control unit will shift the power supply unit to emergency operation. The power supply control unit will also cut off all nonvital loads.

420-5.2.10.7 Modes of Operation. The MK23 Gyrocompass system provides for two modes of operation: Normal and Directional. For operation and use of the modes consult the MK23 technical manual.

420-5.2.10.8 Output Signals. The MK23 provides Heading 1X and 36X synchro data.

420-5.2.10.9 Maintenance. Maintenance of the MK23 consists of adjustments, alignment and replacement of the equipment and limited emergency repair in the binnacle. Adjustments are confined to the control cabinet. When an adjustment has to be made to the system other adjustments may have to be considered. For this reason all test and adjustments should be in sequence.

420-5.2.11 MK27 GYROCOMPASS. The MK27 Gyrocompass is primarily a direct reading compass. The MK27 Gyrocompass seeks and continuously indicates the meridian or true North. The MK27 Gyrocompass consists of the master compass, electronic control, and power converter. Optional equipment includes switching unit and speed compensator. The MK27 Gyrocompass can be configured to provide heading information to remote areas with a step transmitter, 1X or 36X synchro data or a combination of these units.

420-5.2.11.1 Master Compass. The master compass consists of a shock mounted, fluid filled binnacle which contains the sensitive element. The sensitive element is the North-seeking element. A viewing window is provided on the aft of the master compass to view the compass card.

420-5.2.11.2 Electronic Control. The electronic control contains the control panel power supply, servo amplifiers latitude corrector, alarm and other circuits necessary for the operation of the MK27 Gyrocompass.

420-5.2.11.3 Power Converter. The power converter adapts the MK27 Gyrocompass to the ship's 115 Vac, 60 Hz or 400 Hz power. The power converter supplies 24 Vdc to the gyrocompass system.

420-5.2.11.4 Switching Unit. The switching unit provides a means of driving two 70 volt step-by-step repeaters from the gyrocompass system 400 Hz power. The switching unit is optional.

420-5.2.11.5 Speed Corrector. The speed corrector is used to provide speed correction to the master compass to correct errors associated to ship speed. The speed corrector provides a signal proportional to ship's speed and the cosine of the ship's course.

420-5.2.11.6 Maintenance. Maintenance of the MK27 Gyrocompass system is limited to troubleshooting by shipboard personnel using the test jack on the electronic control, replacement of major components and periodic inspections. Periodic maintenance shall be in accordance with the ship's Planned Maintenance System.

420-5.2.12 AN/WSN-2 GYROCOMPASS. The AN/WSN-2 Gyrocompass seeks and continuously indicates the meridian and the zenith. The AN/WSN-2 provides precise output signals for ship's heading, roll and pitch. The AN/WSN-2 consists of five major components: inertial measuring unit, control indicator, control power supply, amplifier synchro signal, and battery set.

420-5.2.12.1 Inertial Measuring Unit. The inertial measuring unit contains the sensitive element (North-seeking element), gimbal assembly, the electronics necessary to maintain the gimbal assembly, and associated electronics necessary to interface with the control, computing and processing functions. The inertial measuring unit also contains Built-In Test Equipment (BITE).

420-5.2.12.2 Control Indicator. The control indicator contains all the operator controls and indicators required for the operation, evaluation and monitoring of the AN/WSN-2 Gyrocompass. The control indicator also contains BITE.

420-5.2.12.3 Control Power Supply. The control power supply contains all the control, computing, processing, analog and digital conversion, input and output interface, and power supply for the AN/WSN-2 Gyrocompass. The control power supply also contains built-in BITE.

420-5.2.12.4 Amplifier Synchro Signal. The amplifier synchro signal contains four synchro buffer amplifiers. The buffer amplifiers provide voltage and power levels for Heading, Roll and Pitch output. The amplifier synchro signal also contains an inverter which converts the battery output to the proper levels for the amplifier. The inverter also contains built-in BITE.

420-5.2.12.5 Battery Set. The battery set contains the batteries, isolation diodes, fuses and sensing circuits. The battery set contains 60 lead acid batteries connected in series and parallel to provide 24Vdc output. The battery set will provide 30 minutes operation when ship's power is lost.

420-5.2.12.6 Output Signals. The AN/WSN-2 provides the following output signals: Heading vital and nonvital (1X, 36X 400 Hz synchro), Roll and Pitch (2X, 36X 400 Hz synchro) and remote alarm.

420-5.2.12.7 Shipboard Maintenance. The gyrocompass features modular construction with a high degree of accessibility to minimize maintenance and repair times. In addition, built-in test and computer-directed test programs isolate malfunctions, greatly reducing trouble-shooting requirements. Self-calibration routines allow replacement of inertial instruments without need for adjustment. No scheduled or preventative maintenance is required. A fault indicator matrix is provided in Table 420-5-1.

420-5.2.12.8 Alarm Indicators. The alarm indicator provides MALFUNCTION SUMMARY ALARM and ON BATTERY indications.

420-5.2.12.9 Modes of Operation. The AN/WSN-2 Gyrocompass provides for two modes of operation: Navigation and Directional. For operation and use of the modes consult the AN/WSN-2 technical manual.

420-5.3 SYNCHRO SIGNAL TRANSMITTERS

420-5.3.1 SYNCHRO SIGNAL AMPLIFIERS. Synchro signal amplifiers are installed where it is necessary to increase synchro load capacity, isolate synchro loads, convert to a different synchro speed or output frequency. Synchro signal amplifiers can be paralleled to increase load capacity.

420-5.3.2 SYNCHRO SIGNAL CONVERTER. Synchro signal converters are used to increase the capacity of a synchro signal transmission system, converting 60 Hz to 400 Hz synchro transmission, 400 Hz to 60 Hz synchro transmission, convert relative bearing signals to true bearing signals, convert to a different synchro speed or output frequency, and to isolate reflected oscillations from the input synchro bus. Synchro signal amplifiers can be paralleled to increase load capacity.

Table 420-5-1 AN/WSN-2FAULT INDICATOR MATRIX

MAINTENANCE ITEM	FAULT INDICATOR					
	DS6	**DS5**	**DS4**	**DS3**	**DS2**	**DS1**
PROM	U	U	U	U	U	L
A/D MUX	U	U	U	U	L	U
DISPLAY I/O	U	U	U	L	U	U
A/D CONVERTER	U	U	U	L	L	U
IMU I/O	U	U	U	L	L	L
RAM	U	U	L	U	U	U
HEADING CONVERTER (1X)	U	U	L	U	L	L
HEADING CONVERTER (36X)	U	U	L	U	U	U
DISCRETE I/O	U	SEE NOTE 1				
PROCESSOR	L	L	L	L	L	L
LEGEND:	U = UNLATCHED L = LATCHED					

NOTE 1: XXXXX INDICATOR 6 INDICATES DISCRETE I/O FAILURE REGARDLESS OF WHAT OTHER INDICATORS LATCHED, EXCEPT IN CASE OF PROCESSOR FAILURE, WHEN ALL INDICATORS ARE LATCHED.

420-5.4 MAGNETIC COMPASS

420-5.4.1 DIGITAL MAGNETIC COMPASS. This system provides the capability of transmitting magnetic North detected by electronic sensors to remote displays. A display from a digital magnetic compass should be installed near and readable from the primary steering station. The remote displays should be lighted and provide a direction of turn indication. In Pilot Houses with a Ship's Control Console, the remote display is to be part of the Console.

420-5.5 UNDERWATER LOG SYSTEMS

420-5.5.1 UNDERWATER LOG SYSTEMS. The underwater log system provides a means for measuring and displaying the speed of the ship and the distance traveled through the water. The underwater log system provides information to the various weapons and navigational systems as required. The underwater log system provides speed in knots and distance in nautical miles. Two types of underwater log systems are currently available, Electro-magnetic and Doppler.

420-5.5.2 ELECTRO-MAGNETIC LOG SYSTEM INSTALLATION. The electro-magnetic log system consists of a rodmeter, sea valve and hoist, and indicator-transmitter. Remote indicators for speed and distance are included as required.

420-5.5.2.1 Rodmeters. The rodmeter is a sensing device which develops a signal voltage proportional to the speed of the ship with respect to the water. The rodmeters are located to ensure they are free of hull induced disturbances including the effects of the boundary layer, or turbulence caused by appendages or sea discharge lines. Rodmeters are available in various lengths, .71, 1.2, 1.8 and 2.5 meters (28, 46, 72 and 100 inch). There is an additional flush mounted model. These rodmeters project through a sea valve into the water with the sensing element at least 635 millimeters (25 inches) clear of the ship's hull. The flush mounted sensor is mounted so that no protuberances, inlets, outlets or other flow disturbing elements will affect the water flow across the face of the sensor. Interconnecting cables between rodmeters and associated electronics shall not exceed 45 meters (150 feet) in length.

420-5.5.2.2 Sea Valve and Hoist. A sea valve is mounted in the hull of the ship and provides a watertight support through which the rodmeter protrudes. The sea valve also seals the hull when the rodmeter is retracted. The hoist raises and lowers the rodmeter through the sea valve. The hoist can be operated from the indicator-transmitter or the hoist control panel. A manually operated hoist is available.

420-5.5.2.3 Submarine Installation. Rodmeter housing and valves, which penetrate the pressure hull of submarines shall be in accordance with Level 1 Submarine Material Certification requirements.

420-5.5.2.4 Indicator-Transmitter. The indicator-transmitter contains all the electronics required to convert the rodmeter signal to a speed display, compute and display distance traveled, provide power supplies and controls for the rodmeter hoist, and provide outputs for remote indicators.

420-5.5.2.5 Electro-Magnetic Log Output. The electro-magnetic log outputs are 60 Hz synchro signals scaled at 40 and 100 knots per revolution and 400 Hz signals scaled at 10, 40 and 100 knots per revolution. A resettable distance counter is provided on the front of the indicator-transmitter. Distance output is a 60 Hz synchro signal scaled at 360 revolutions per nautical mile.

420-5.5.2.6 System Calibration. Calibration of the electro-magnetic log system is necessary after initial installation and partial calibration should be made upon replacement of the rodmeter. Detailed instructions are provided in the electro-magnetic log technical manual. Minor variations in rodmeter sensitivity will result in variations to speed indications when utilizing different rodmeters in one common installation and when switching from one rodmeter to another.

420-5.5.2.7 Electro-Magnetic Log Dummy Log. By means of the remote dummy log control unit, speeds can be set on the indicator-transmitter from a remote location or at the indicator-transmitter. The electro-magnetic log makes it possible to use the underwater log system as a dummy log in certain situations, for example, the ship is operating in shallow water and the rodmeter must be retracted to prevent its damage, or the rodmeter has been damaged. Remote dummy log control units are installed at locations such as the central control station, the ship's control console or the main engineering control station. A red light on the remote control unit tells the operator that the log has been switched to dummy log operation. While watching the speed indicator, speed can be set by means of an increase-decrease switch. The system may be switched to dummy log operation only at the indicator-transmitter.

420-5.5.2.8 Electro-Magnetic Log Speed Indicators. Remote speed indicators for the electro-magnetic log system display own ship's speed through the water from information received from the underwater log system. The indicators may be either synchro or digital. Ship speed indicators are provided in areas such as:

a. Pilot House
    1. Conning Officer
    2. Captain's Chair
    3. Chart Table
    4. Ship Control Console
b. Chart Room (Chart Table)
c. CIC
    1. Surface Operations Area
    2. Subsurface Operations Area
    3. Command Table
    4. DRT
d. Air Operations (Air OPS Officer)
e. Tactical Air Operations Center (Tactical Air Officer)
f. CCA Room (CCA Officer)
g. Helo Direction Center (Helo Director)
h. Sonar Control (Sonar Supervisor)
i. Balloon Inflation Room
j. Flag Plot (DRT)
k. Flag Bridge (Flag's Chair)
l. Flight Control Station (Air Officer)
m. Helo Control Station (Helo Officer)
n. Meteorological Room
o. Central Control Station
p. CO Tactical Plot (DRT)
q. Depart Control Center (Debark Officer)
r. Remote Conning Stations
s. Staterooms
    1. Captain
    2. Flag Officer
    3. Navigation
t. Sea Cabins
u. Command and Control Center (Command Area and Plot Area) (submarine)
v. Missile Control Room (submarine)

w. Sonar Control Room (submarine)

x. Integrated Radio Room (submarine)

y. CO Stateroom (submarine)

z. Wardroom (submarine)

aa. Officer's Study (submarine)

A remote indicator of distance traveled shall be provided at the Chart Room chart table.

420-5.5.2.9 Rodmeter Cleaning. The rodmeter should be removed and cleaned approximately every six months. Use steel wool or fine sandpaper to clean the sensor face. Guidance for removal and replacement of the rodmeter is provided in the electro-magnetic log technical manual. Cleaning may also be done by divers without removal of the rodmeter.

420-5.5.2.10 Electro-Magnetic Log Maintenance. The electro-magnetic log is designed to be reliable and trouble free. All major maintenance and repair should be performed by manufacturer's field service representatives, shipyards, tenders, or Intermediate Maintenance Activities (IMA's). The majority of the electronic components are plug-in modules and are replaced completely rather than repaired aboard. Routine maintenance should be in accordance with the ship's Planned Maintenance System.

420-5.5.2.11 Electro-Magnetic Log Voltage Simulator (ELVS). The MK 1 MOD 0 ELVS is primarily used to align and troubleshoot the indicator-transmitter by using it as a comparison standard to determine if the electromagnetic log system electronics have degraded in operation. It allows the technician to simulate the electromagnetic log rodmeter output in the first stages of the electronic circuitry of the indicator-transmitter. This signal provides a means of troubleshooting the coupling transformer, preamplifier and amplifier circuitry that are not exercised by the Test Input Potentiometer. The ELVS is used for aid in troubleshooting for location of a malfunction, and performing operational checks during initial installation. The ELVS also verifies the adjustment range and smoothness of operation of each intermediate potentiometer. It is not to be used as a substitute for a calibrated measured mile.

420-5.5.2.12 Doppler Speed Log System. The doppler speed log system provides accurate indication of ship's speed, distance traveled, and water depth. The doppler log system consists of the transducer, transducer electronics, and main display unit.

420-5.5.2.13 Transducer. The transducer transmits and receives beams of acoustic energy in either two or three directions. Echoes of the transmitted beam are also received by the transducer. The transducer can be mounted through the hull of the ship through a sea chest with a gate valve and is removable from within the ship without dry docking or the use of divers. Removal of the transducer does not impair the watertight integrity of the hull. The transducer is located where the hull is flat or horizontal and no appreciable aeration or sweepdown exist.

420-5.5.2.14 Transducer Electronics. The transducer electronics contains the transmitter for driving the transducer and receivers for amplifying the received echoes.

420-5.5.2.15 Main Electronics Unit. The main electronics unit contains circuits for generating the transmit signals and for calculating the fore and aft speed of the ship through the water from the received echo. In waters

sufficiently shallow to permit reliable receipt of echoes from the bottom, the system will reference the speed to the bottom. In deep water the system will detect reflection from the water mass, and the speed will be referenced to the water mass.

420-5.5.2.16 Main Display Unit. The main contains the controls and displays for operation of the doppler log system.

420-5.5.2.17 Doppler Log Output. The doppler log system provides a digital output for ship's speed fore and aft (16 bit), distance traveled (200 pulses-per-nautical-mile), distance traveled (100 pulses-per-nautical-mile), system status (8 bit), and depth (16 bit).

420-5.5.2.18 System Calibration. There are no system adjustments or calibrations required, after initial installation.

420-5.5.2.19 Transducer Cleaning. The transducer should be removed and cleaned at least once every twelve months. Use mild detergent and a soft brush to remove any marine growth or deposits from the transducer.

420-5.5.2.20 Doppler Log Maintenance. The doppler log system is designed to operate with a minimum of required maintenance or repair. No adjustments or calibrations are required beyond ensuring correct transducer alignment. Routine and corrective maintenance should be in accordance with the ship's Planned Maintenance System (PMS) or the doppler log technical manual if PMS has not been established for the doppler log.

420-5.6 PLOTTING EQUIPMENT.

420-5.6.1 PLOTTING SYSTEMS. Plotting systems provide a means of indicating the ship's position in latitude and longitude on an appropriate chart or on mechanical dials. Plotting systems also record on appropriate charts the ship's travel relative to a fixed starting point. When properly set, the dead reckoning equipment continuously indicates the ship's latitude and longitude by computing mechanically the distance traveled by the ship and the ship's course. The distance traveled is computed from the input received from the underwater log and the gyrocompass.

420-5.6.2 PLOTTING SYSTEM EQUIPMENT. Plotting system equipment consists of dead reckoning analyzer or dead reckoning analyzer indicator, dead reckoning tracer and ASW plotting tables. ASW plotting systems receive data to plot target position about own-ship's position from range and bearing information from weapons control, sonar, and radar systems. Most commonly used dead reckoning tracers and ASW plotting systems used by the Navy are as follows:

a. DRT Mk 6 - Dead Reckoning
   Mod 4 B/C Tracer

b. DDRT Mk 6 - Digital Dead
   Mod 4 D/E Reckoning Tracer

c. DDRT Mk 6 - Digital Dead
   Mod 5 Reckoning Tracer

d. Mk NC-2 Mod 0 - ASW Plotting System

e. Mk NC-2 - ASW Plotting
Mod 1/1A System

f. Mk NC-2 - ASW Plotting
Mod 2A System

g. PT 512/S Tactical - ASW Plotting
Display Plotter System

420-5.6.2.1 Dead Reckoning Analyzer. The dead reckoning analyzer receives ship's distance information from the underwater log and ship's heading information from the gyrocompass. These inputs are combined to determine and indicate the total distance and the overall distance traveled in a North-South and East-West direction by the ship from any given point. Displays include Own-Ship's Heading, Total Miles, Miles North, and Miles East.

420-5.6.2.2 Dead Reckoning Analyzer Indicator. The dead reckoning analyzer indicator is a hybrid analog/digital computer which continuously computes, transmits and displays navigation information. Displays include Own-Ship's Speed, Heading, Latitude, Longitude, Own-Ship's Distance, distance North-South and East-West, Velocity North-South and East-West. The dead reckoning analyzer indicator is capable of driving four dead reckoning tracers.

420-5.6.2.3 Dead Reckoning Tracer. The dead reckoning tracer consists of mechanical and electro-mechanical assemblies to graphically record own-ship track and latitude and longitude. The dead reckoning tracer receives distance North-South and East-West from a dead reckoning analyzer or dead reckoning analyzer indicator for plotting own-ship's track and compute latitude and longitude. The glass cover of the compartment is an auxiliary plotting surface for manually plotting own-ship's track and a target position and movement with respect to own-ship. Two light shield assemblies, one on each side of the compartment, provide illumination for the chart board. Plotting scales available are:

a. 200 yards per inch for emergency tracking.

b. 0.10 NM per inch to 99.99 NM per inch (variable in 0.01 - NM per inch increments).

420-5.6.2.4 Chart Board. The chart board is the recessed surface of the dead reckoning case. Ship's movements are plotted on a chart inserted between the plot surface and the range-bearing projector. A pencil assembly attached to the range-bearing assembly will plot the ship's movement on the chart. Plots are made at predetermined intervals as determined by a mechanical clock.

420-5.6.2.5 Auxiliary Plot. The auxiliary plot is the large glass surface hinged to the dead reckoning case. The auxiliary plot is used to plot ship's course and ranges and bearings of targets obtained from points along own-ship's course. Plots are accomplished using the range-bearing projector and a universal drafting machine.

420-5.6.2.6 Digital Dead Reckoning Tracer. The digital dead reckoning tracer consists of mechanical and electro-mechanical assemblies to graphically record own-ship track and latitude and longitude. The digital dead reckoning tracer receives Own-Ship's Distance North-South and East-West for the ship's tactical computer. The glass cover of the compartment is an auxiliary plotting surface for manually plotting own-ship's track and a target position and movement with respect to own-ship. Two light shield assemblies, one on each side of the compartment, provide illumination for the chart board. Plotting scales available are:

a. 200 yards per inch for emergency tracking.

b. 0.10 NM per inch to 99.99 NM per inch (variable in 0.01 - NM per inch increments).

420-5.6.2.7 Chart Board. The chart board is the recessed surface of the dead reckoning case. Ship's movements are plotted on a chart inserted between the plot surface and the range-bearing projector. A pencil assembly attached to the range-bearing assembly will plot the ship's movement on the chart. Plots are made at predetermined intervals as determined by a mechanical clock.

420-5.6.2.8 Auxiliary Plot. The auxiliary plot is the large glass surface hinged to the dead reckoning case. The auxiliary plot is used to plot ship's course ranges and bearings of targets obtained from points along own-ship's course. Plots are accomplished using the range-bearing projector and a universal drafting machine.

420-5.6.2.9 ASW Plotting Tables. ASW plotting tables calculate latitude and longitude, plot own ship's position and four targets relative to ship's position. Targets can be stationary, moving, underwater, surface, or airborne. The ASW plotting tables are used during ASW operations, tactical situation, and as aids to navigation. ASW plotting tables can be operated automatically or manually. In the automatic mode the ASW plotting table receives ship's distance North-South and East-West from a dead reckoning analyzer or dead reckoning analyzer indicator. Target information is provided by various target acquisition systems. In the manual mode own-ship's course, own-ship's speed, and relative target information is inserted from controls on the ASW plotting table.

420-5.6.2.10 Plotting System Maintenance. All plotting system equipment should be inspected at least once a quarter for loose, missing, or damaged parts. Cleaning should be accomplished on an as needed basis to remove dust and loose dirt from the glass surface and inside the plotting equipment. Other inspections and test should be accomplished in accordance with the ship's Planned Maintenance System.

420-5.7 DEPTH DETECTOR SYSTEMS

420-5.7.1 DEPTH INDICATOR SYSTEM. This system provides submarines with a means of determining and transmitting depth information. Depth information is provided to Weapons Control, Ship Control, and displays throughout the ship. The system is capable of indicating depth equal to twice the submarine's operating depth.

420-5.7.1.1 Installation. The installation consists of at least three pressure transducers, associated electronics, and indicators. The pressure transducers are in accordance with MIL-P-24212 and the contract or order.

420-5.7.1.2 Transducers. The pressure transducers are located near a point on the ship's keel directly under the crown of the sail. Each transducer is provided with a valve to allow isolation from the sea chest and from the other transducers. An automatic air bleed system is provided for each transducer.

420-5.7.1.3 Electronics. The depth detector electronics are installed in a dry, ventilated, and well lighted space. They consist of signal conditioners, converters, and microprocessors necessary to calculate the depth of the submarine and provide digital depth signals to equipment and indicators. Numeric depth indicators are located in Command and Control Center (Command Area, Plot Area), Ship's Control Panel, Ballast Control Panel, Missile Control Room, Sonar Control Room, Integrated Radio Room, CO Stateroom, Wardroom, and Officer's Study.

SECTION 6.

INERTIAL NAVIGATION SYSTEMS

420-6.1 SHIP'S INERTIAL NAVIGATION SYSTEMS

420-6.1.1 GENERAL. The ship's inertial navigation system provides a means of determining and transmitting ship's heading, roll, pitch, latitude, longitude, vertical velocity, velocity north and east, and ground speed. This information is transmitted to various ship's equipment and indicators, weapons control, naval tactical data systems, and alignment of aircraft navigation systems. Inertial navigation systems include the AN/WSN-1 and AN/WSN-5.

420-6.1.2 INSTALLATION. Inertial navigation systems are installed onboard submarines and surface ships with aircraft capabilities. The installation shall consist of an inertial navigation set. The inertial navigation set is provided with a battery backup, which shall provide electrical power during a loss of ship's power. Inertial navigation system fault alarms shall be provided in areas such as:

a. Pilot House (ship control console).

b. CIC (weapons control area).

c. Optical Landing System Equipment Room.

d. Landing Signal Officer's Platform.

e. Flight and Helo Control Station.

f. CCA Room.

g. Helicopter Direction Center.

h. Sonar Control.

Ship heading indicator requirements shall be in accordance with Section 5.

420-6.1.3 INERTIAL NAVIGATION SYSTEM MOUNTING. Each inertial navigation set shall be ideally located on the ship's centerline. At a minimum, the inertial navigation set shall be mounted with a lubber line forward and near the ship's centerline. No steam or water lines shall pass over or near the inertial navigation set. Sufficient clearances shall be provided for adequate clearance, ventilation, and access for alignment and maintenance.

420-6.2 AN/WSN-1 INERTIAL NAVIGATION SYSTEM

420-6.2.1 GENERAL. The AN/WSN-1 Inertial Navigation System (INS) provides continuously updated attitude (roll and pitch), heading, velocity (north and south) and position (latitude and longitude) to ship's subsystems. The AN/WSN-1 operates under all at-sea conditions and at all latitudes while providing accurate output data for 30 hours without a reset. The AN/WSN-1 consists of three major assemblies. The assemblies are:

a. Navigation Control Console (NCC) (1 ea).

b. Inertial Measuring Unit (IMU) (2 ea).

c. Blower Assembly (2 ea).

420-6.2.2 MODES OF OPERATION. The AN/WSN-1 has four modes of alignment: cage, self align, slave align, navigate.

a. Cage - The cage mode provides coarse platform alignment. The IMU is coarse aligned to the ship about the roll and pitch axes and to either an operator inserted heading angle or to the heading angle of the other INS channel.

b. Self Align - The self align mode provides fine IMU platform alignment to local vertical and geographic north, and compensates gyro drift rates. Electro-Magnetic (EM) log velocity is used as a reference for all at-sea alignments.

c. Slave Align - The slave align mode enhances fine alignment and gyro drift rate estimates by using velocity and heading from the other INS channel.

d. Navigate - The navigate mode provides accurate latitude, longitude, north velocity, east velocity, total velocity, roll, pitch, and heading for long time intervals without the need for external position information.

420-6.2.3 SUBMODES OF OPERATION. The AN/WSN-1 has three submodes of operation: Undamp, Polar, and Test. The AN/WSN-1 is normally operated with all submodes in normal.

a. Undamp - The operator may enable or inhibit the damping of oscillations using EM log velocity as a reference. During normal operations the computer estimates EM log bias, EM log scale factor errors, ocean current, and side slip co-efficient whenever ship speed or heading changes occur. The Undamp Mode is used when the ship is expected to undergo high speed maneuvers resulting in large EM log errors.

b. Polar - The Polar display may be enabled or disabled by the operator at any latitude. When operating in the polar display submode, the standard Navy transverse coordinate system is used. (The transverse north pole is located at the intersection of the 180th meridian and equator.) The Polar mode selection initiates position displays in the Navy Transverse Coordinate System.

c. Test - The test mode provides the capability for measuring velocity meter biases, gyro scale factor errors, and gyro misalignments during dockside operation.

420-6.2.4 NAVIGATION CONTROL CONSOLE. The Navigation Control Console is comprised of two identical channels. Each channel contains a control panel, test panel, power supplies and signal processing electronics. The control panel contains all displays, controls, and indicators for system operation. A keyboard is included for manual control of commands and the input and output of data. The NCC provides the interface between the AN/WSN-1 INS and the ship's computer and switchboard complex. All input and output signals are processed by the NCC electronics.

420-6.2.4.1 Operation. During operation, the NCC electronics performs all the coding and decoding of signals for proper communications between the AN/WSN-1 and the computer. The roll, pitch, and azimuth resolver outputs from the IMU are converted to synchro output signals within the NCC prior to being routed to the other ship subsystems. The NCC electronics provides Built-In Test Equipment (BITE) that automatically and continuously informs the computer of the NCC operational status.

420-6.2.5 INERTIAL MEASURING UNIT. The Inertial Measuring Unit (IMU) consists of a three-gimbal platform, electronics, inertial instruments, a housing and environmental controls. The IMU produces functions of roll, pitch, heading, and velocity for use by the other ship subsystems. This unit is a precision assembly and is mounted within the Electrical Equipment Mounting Base which maintains accurate alignment between the unit

and the ship. The IMU platform is externally gimballed with the following inward axis sequence: outer roll (limited freedom), pitch (limited freedom) and azimuth (unlimited). The IMU is cooled with ship's ambient air by an air-to-exchange temperature control system.

420-6.2.6 BLOWER UNIT. A blower assembly supplies ambient air for cooling the IMU equipment. The Blower Assembly provides 125 CFM (nominal) over the range of 20 to 149 degrees F and has self-contained shock mounts. Sound deadening material is designed internal to the case to reduce the emitted noise level. The output air flow is ducted to the IMU housing through a flexible hose.

420-6.2.7 EMERGENCY SYSTEM OPERATION. The NCC contains a battery which will provide power to the INS in case of ship's 400 Hz power failure. Transfer to battery will be automatic and will maintain operation for approximately 3 seconds. If power is restored prior to battery failure the system will automatically restore to ship's 400 Hz power.

420-6.2.8 OUTPUTS. The AN/WSN-1 INS provides the following outputs:

a. Alarm status signal.

b. Output data request discrete.

c. Input data request discrete.

d. Digital data to computer (19 detected lines).

e. Synchro Reference (115 V, 400 Hz).
   1. Simulated synchros
      Azimuth (1X, 36X)
      Roll (1X, 36X)
      Pitch (1X, 36X).
   2. Double Sideband Suppressed Carrier (90 Vac, 400 Hz)
      Azimuth (1X & 36X synchro)
      Roll (2X, 36X synchro)
      Pitch (2X, 36X synchro).

420-6.3 AN/WSN-5 INERTIAL NAVIGATION SET

420-6.3.1 GENERAL. The AN/WSN-5 inertial navigation set seeks and continuously indicates the meridian and the zenith, thus serving as a reference for measuring the ship's roll, pitch, heading and velocity north and east. Ship's position can be updated automatically by NAVSAT/NAVSTAR or manually from the keyboard. The AN/WSN-5 consists of five major assemblies in an electrical cabinet. The assemblies are:

a. Control-indicator.

b. Control-power supply.

c. Battery set.

d. Synchro signal amplifier.

e. Inertial measuring unit.

420-6.3.2 MODES OF OPERATION. The AN/WSN-5 has two modes of operation: NAV and Polar.

a. NAV - used when operating between 85 degrees north and 85 degrees south, the output is geographical.

b. Polar - used when operating above 85 degrees north or 85 degrees south, the output is transverse coordinate.

420-6.3.3 ELECTRICAL CABINET. The electrical cabinet provides mechanical and electrical interface between the major assemblies, EMI filters and cable interconnects for all cabling to external equipment.

420-6.3.4 CONTROL-INDICATOR. The control-indicator contains all the operator controls and indicators necessary for equipment operation and maintenance.

420-6.3.5 CONTROL-POWER SUPPLY. The control-power supply contains a three phase power supply, battery charger and Built-In Test Equipment (BITE). The control power supply also contains a digital computer consisting of:

a. Processor - 24 bit parallel digital computer.

b. Memory - PROM contains instructions and constants used by the processor. RAM used for temporary storage for variable data generated by the processor.

c. Analog to digital converter - converts analog inputs to the AN/WSN-5 into digital values.

d. Input-output circuits - provides outputs for the on-off control of external functions by the processor and input of internal status to the processor.

e. Display input-output circuits - provides serial communications between the computer and displays and indicator lights.

f. True heading converters - generates 1X and 36X resolver format of true heading.

g. External input-output circuits - provides serial and parallel digital communications to ship’s equipment.

h. ARINC - NAV data, roll, pitch, time, NAVSAT, and equipment status.

i. NTDS (parallel) - Julian Day, latitude, longitude, antenna correction, iterations, elevation angle.

j. High speed serial - GMT, roll, pitch, heading, latitude, longitude.

k. Digital to analog - synchro velocity outputs.

420-6.3.6 BATTERY SET. The battery set provides battery power to the three-phase power supply in the control-power supply when ship’s power is lost. The battery set consists of 60 sealed lead acid batteries connected to provide 24 volts for approximately 30 minutes. A sensing circuit is incorporated to monitor for high and low voltages and temperatures. Outputs of the sensing circuit are sent to the BITE in the control-power supply.

420-6.3.7 SYNCHRO SIGNAL AMPLIFIER. The synchro signal amplifier contains four synchro buffer amplifiers for driving ship’s synchro loads and an inverter.

420-6.3.8 BUFFER AMPLIFIER. The buffer amplifiers provide voltage and power levels necessary to provide the following outputs:

a. Heading (1X, 36X 400Hz).

b. Roll and Pitch (2X, 36X 400Hz).

c. Velocity North (1X, 10X 400Hz).

d. Velocity East (1X, 10X 400Hz).

420-6.3.8.1 Inverters. The inverter converts battery output to provide DC levels for the synchro signal amplifiers, AC power for vital heading, velocity synchro reference and fans. The inverter also contains BITE.

420-6.3.9 INERTIAL MEASURING UNIT. The inertial measuring unit consists of two gyroscopes and three accelerometers mounted on a gimbal set. The inertial measuring unit also contains electronics to maintain the gimbal assembly, electronics to interface with the control, processing and computing functions of the control-power supply. The inertial measuring unit has freedom of ± 60 degrees about the roll axis and ± 45 degrees about the pitch axis.

420-6.3.10 SUPPORTING FUNCTIONS. The AN/WSN-5 has eleven accessory functions to support its primary navigation capabilities as follows:

a. Data display and keyboard control - manual data entry capability.

b. Local and remote alarm - when equipment outputs are not reliable.

c. Local alert and alarm display - when operator action required.

d. Built-In Test Equipment - fault location.

e. Teletypewriter digital communication - provide hard copy printout of system performance, status and inputs.

f. NAVSAT/NAVSTAR - digital and analog communications.

g. External computer - NTDS parallel digital input/output and output only channels.

h. External computer - serial digital communications.

i. Automatic and manual position reset - reset position, velocity, gyro drift, pitch, roll, heading outputs.

j. ARINC - slave align, auto performance comparison, NAVSAT/NAVSTAR position reset.

k. Manual and EM log reference - EM log reasonableness test, automatic at-sea calibration of EM log.

420-6.3.11 AN/WSN-5 INPUTS. For start up and normal operation the AN/WSN-5 requires the following:

a. 115vac, 400Hz, 3 Phase - primary power, synchro excitation.

b. EM log - synchro data and reference.

420-6.3.12 MAINTENANCE. Maintenance is in accordance with the ship's Planned Maintenance System (PMS). When system is first installed maintenance will be in accordance with the equipment technical manual until PMS is installed.

420-6.3.13 SHIP'S AIRCRAFT INERTIAL ALIGNMENT SYSTEM. The ships aircraft inertial alignment system provides a means to erect and align the aircraft inertial navigation systems from shipboard references.

420-6.3.14 INSTALLATION. The installation consists of an alignment console in accordance with MIL-C-23174, a distribution system in accordance with NAVSHIPS Drawing No. 815-2482586 and alignment outlets in accordance with NAVSHIPS Drawing No. 815-2482977 and a digital data radio link AN/SRC-40.

420-6.3.14.1 Alignment Outlets. Alignment outlets shall be installed at each catapult, each aircraft servicing station on the flight deck, and port and starboard in each hanger bay. A fused junction box shall be provided for each alignment outlet. The fused junction box should be located in an interior passage protected from the weather, near to its associated alignment outlet.

420-6.3.15 INPUTS. Inputs to the ship's aircraft inertial alignment system are:

a. Ship's heading - inertial navigation system or gyrocompass (1X, 400Hz).

b. Ship's velocity North and East - inertial navigation system primary (100 knots per revolution, 1X, 400Hz).

c. Ship's velocity North and East - dead-reckoning system secondary (1X, 400Hz).

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.