REVISION 1

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 565

SURFACE SHIP STABILIZING SYSTEMS

THIS CHAPTER SUPERSEDES CHAPTER 565 DATED 31 MARCH 1993

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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–TD–STM–010/CH–565R1

Publication Date (Mo, Da, Yr) September 1999

Title: NSTM Chapter 565, Surface Ship Stabilizing Systems

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

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Authority	Name	Signature	Organization	Code	Date
Acquisition					
Technical	LOUIS W. NELSON		NAVSEA	05J1	3/31/93
Printing Release	Digital Media Publishing				

Certification Sheet

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NOTE

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

CHAPTER 565

SURFACE SHIP STABILIZING SYSTEMS

SECTION 1.

INTRODUCTION

565-1.1 STABILITY

565-1.1.1 DESCRIPTION. A ship designer must consider two kinds of stability: static and dynamic. Static stability is the ship's ability to resist heeling caused by off-center weights. Dynamic stability is a part of the overall seakeeping ability of a ship. Motions that effect dynamic stability include roll, pitch, heave, sway, surge and yaw (Figure 565-1-1). Since the amplitudes of sway, surge and yaw are usually small, they do not appreciably affect seakeeping.

565-1.1.1.1 Dynamic stability has a major effect on both ship operation and crew performance. Large roll, pitch and heave motions increase the loads experienced by equipment and can make the performance of missions such as aircraft launch and recovery, underway replenishment, and weapons operations difficult or even impossible. Excessive motions can also make it difficult for the crew to perform their day-to-day routine securing tools from rolling about in the work space and while trying to maintain their balance. Even normal ship motions can cause seasickness. Seasickness reduces the effectiveness of the crew. In the least severe cases, seasickness symptoms include drowsiness and distraction. At worst, seasickness can totally incapacitate susceptible members of the crew. To reduce these effects, stabilization systems to counter ship roll have been developed.

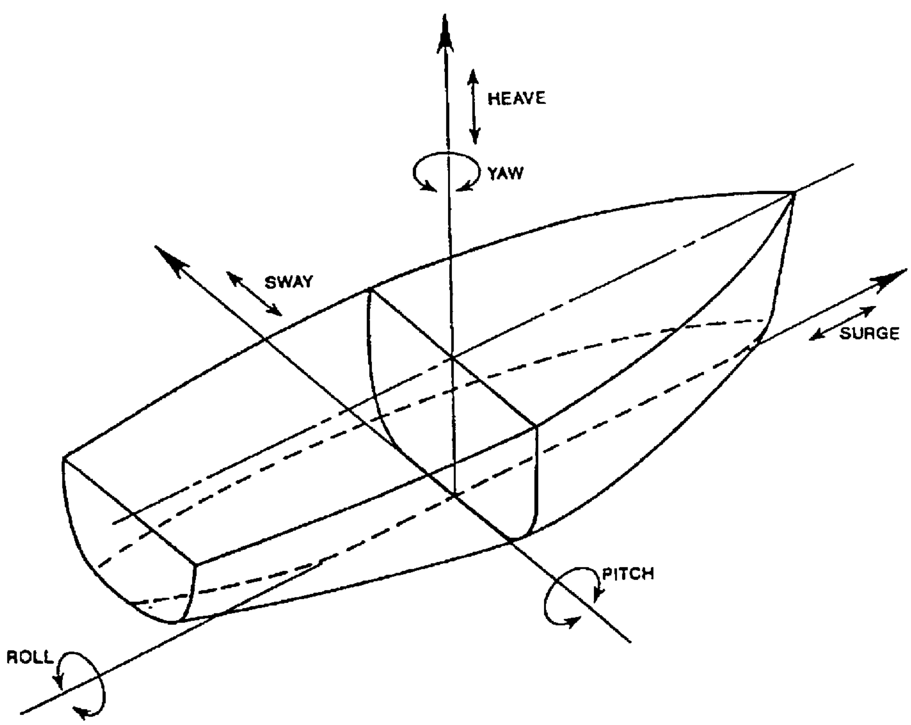

Figure 565-1-1 Ship Motions

565-1.1.1.2 Many factors, both physical and mechanical, contribute to ship motions. These include the static stability of the ship, ship size, ship heading and speed, wave height, and wave period.

565-1.1.2 WAVE MOTION. Waves contribute most to ship roll. Therefore, a brief discussion of waves follows. The wind creates waves at sea. Waves are the visible evidence of passing energy. Energy contained in a wave varies directly with the square of the wave height and directly with the wave length. The period of a wave is the time required for one complete wave (crest and trough) to pass a given point. The period of a wave relates directly to the wave length, because for a specific depth of water all waves of a given length travel at the same speed. Every sea state consists of many individual wave patterns of varying height, length, and direction. These wave patterns interact with each other to produce more complex waves of varying height and shape. Usually there is a dominant pattern that sets the overall wave length and period encountered by a ship. A statistical average called the significant wave height (the average of the top one-third of the highest waves) provides a measure of the energy contained in sea waves of irregular height.

565-1.1.2.1 When a ship is moving through a given wave pattern, the speed and course of the ship alter the apparent period of the waves. For instance, if a ship is going directly into the waves, the speed of the ship adds to the speed of the wave, and the time between waves decreases. Conversely, if the ship is travelling with the waves the time between waves increases. The frequency at which the waves meet the ship is called the encounter frequency. Roll, pitch and heave amplitudes are related to the encounter frequency and the significant wave height of the sea state in which a ship is operating.

565-1.2 SHIP ROLLING.

565-1.2.1 Of all the ship motions, roll has the most effect on crew and ship functions. Every ship has a natural roll period that is a function of its hull form, displacement, and center of gravity. As the wave encounter frequency approaches a ship’s natural roll frequency, the rolling motion of the ship increases dramatically with wave height, particularly in very large waves. As the two frequencies diverge, the rolling motion decreases rapidly. This effect is largest when the natural roll frequency of a ship is shorter than the wave encounter frequency. Ships that have high static stability tend to have very short roll periods (high natural frequencies). These ships will tend to roll more over a wider range of wave encounter frequencies than will ships that are less stiff. Therefore, ships must be designed with both minimum and maximum ranges of static stability to ensure both safety and mission effectiveness.

565-1.2.2 When rolling becomes extreme, the captain of a ship has two possible options to reduce rolling. He may alter course to reduce the amount of heeling energy imparted to the ship (which also changes the encounter frequency) or, he may alter speed to change the encounter frequency so that it is farther from the natural roll period of the ship. Both measures can be employed together. Although these measures are effective at reducing roll, they may degrade or negate mission effectiveness. Consequently, most ships employ some type of roll reduction equipment. More effective systems are employed where roll reduction is critical such as on aviation-capable ships and warships requiring a stable platform for weapons operations.

565-1.2.3 Pitch and heave control are generally impractical on displacement ships, and would require massive control surfaces. An exception to this rule is the small waterplane area twin hull (SWATH) ship that has less longitudinal stability than conventional hull forms. This ship has sufficient space between the hulls for large control surfaces.

565-1.3 ROLL REDUCTION.

565-1.3.1 GENERAL. There are two main categories of roll reduction systems. They are classified as passive systems and active systems. Only one type of each system is currently in use on U. S. Navy ships. The passive system currently used is the bilge keel. The active system is installed on the OLIVER HAZARD PERRY class frigates (FFG 7). These ships are fitted with an automatic fin stabilizer system (FSS) manufactured by Brown Brothers and Company, Limited, of Edinburgh, Scotland. Almost all of the information presented in this NSTM chapter is directly related to this fin stabilizer system. Following, however, is a brief discussion of bilge keels, rudder roll stabilization and a general discussion of active fin stabilizer systems.

565-1.3.2 PASSIVE SYSTEMS. Passive systems are designed to resist rolling without input from a control system or a power source. Their ability to resist rolling is induced by the motion of the ship itself. However, due to additional hull drag generated by external hull appendages, increased propulsive power is required.

565-1.3.2.1 Bilge Keels. Bilge keels are the most common type of passive anti-rolling device used on ships (Figure 565-1-2). They may be used with other anti-rolling systems. Bilge keels are from one-quarter to one-half of the length of the ship, and they are very narrow, seldom more than four feet wide. Bilge keels must be aligned with the flow of water past the hull in order to minimize drag. Bilge keels are attached to the hull at the turn of the bilge to maximize their distance from the center of roll. They generally do not protrude beyond the maximum beam of the ship, thereby minimizing possible damage from pier pilings or other vessels along side.

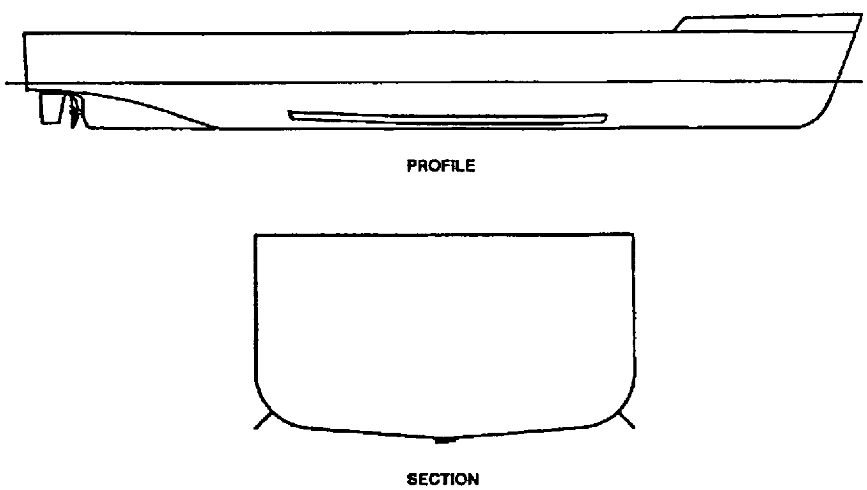

Figure 565-1-2 Bilge Keels.

565-1.3.2.1.1 Bilge keels do not generate much lift. Therefore, roll reduction by this means, that is, opposing the roll force with lift force, is secondary. Instead, bilge keels resist rolling with the hydrodynamic drag caused by their large flat area which is perpendicular to the direction of roll. Bilge keels are equally effective when the ship is stopped because of their large area and because they derive their restoring force from the roll itself, not from the forward motion of the ship. Properly designed bilge keels can reduce rolling by up to 35 percent.

565-1.3.3 ACTIVE SYSTEMS. Active systems require motion sensors, control systems, and power input to function. Besides their direct power requirements, active systems also induce additional propulsion loads through increased drag caused by hull appendages.

565-1.3.3.1 Rudder Roll Stabilization. The steering gear of the ARLEIGH BURKE class destroyer (DDG 51) has been designed to accommodate the requirements of rudder roll stabilization. A rudder roll stabilization system is capable of providing stabilization in a manner similar to that of active fin stabilizers. Instead of sending signals to separate fin actuators, the rudder roll stabilizing control unit produces signals that augment the autopilot signals to the steering gear. These control signals cause the hydraulic power unit to respond with the necessary speed to quickly cycle the rudders to positions that counter roll forces. Rudder roll stabilizing does not require additional ship volume nor does it increase the ship's displacement. Rudder roll stabilizing systems can reduce rolling by as much as 50 percent. Like active fin stabilizers, rudder roll stabilizing is ineffective at slow speed or at stop. This form of roll reduction is not yet operational.

565-1.3.3.2 Active Fin Stabilizers. Active fin stabilizers are the most common type of active stabilization systems. A pair of fin stabilizer units are installed on the FFG 7 class ships. These types of units can, however, be installed in multiple pairs as on some Royal Navy ships. The control unit for active fin stabilizers receives input signals from either the ship's gyrocompass and speed log, or from an independent accelerometer, and sends a signal to the hydraulic power unit to position the fin at the appropriate angle to counter the roll sensed by the roll sensor. Since the ship is constantly in motion, the fin angle will constantly be changing.

565-1.3.3.2.1 The fins are an airfoil section. As the angle of the fins change, lift forces of varying amplitudes are generated which oppose the roll forces. The fins rotate in opposite directions in order to balance the restoring forces. Figure 565-1-3 depicts this action. Active fin stabilizer systems can provide roll reduction of up to 90 percent at cruising speeds, but are ineffective when the ship is stopped or at low speed. An active fin stabilizer system weighs approximately one percent of the ship's load displacement and requires a dedicated volume in the hull. Ship resistance increases slightly when the fins are in operation.

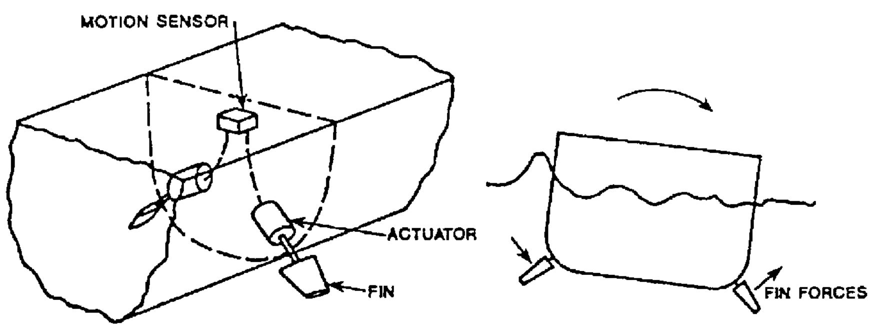

Figure 565-1-3 Active Fin Stabilizer System.

565-1.3.3.2.2 Two other control sensors determine fin position and ship speed. The fin position sensors are similar to rudder angle indicators and provide feedback information to the control system. A connection to the ship's speed log provides speed information. In FFG 7 class ships, the FSS is not operational below 6.5 knots. Below this speed the fins do not generate sufficient lift force to affect the rolling. At higher speeds (25 to 35 knots) the maximum allowable fin angle must be reduced. This is because the lift force increases with the square of the ship's speed. The maximum fin angle is therefore reduced to prevent over controlling and over-stressing the shafting and actuator gear.

SECTION 2.

SAFETY PRECAUTIONS

565-2.1 INTRODUCTION

565-2.1.1 Safety precautions are included in this NSTM chapter to remind the reader to exercise caution when operating, maintaining, or overhauling the equipment. Specific warnings and cautions are presented in the fin stabilizer technical manual in the appropriate sections. In order to properly understand the operating principles of the fin stabilizer system, read the technical manual thoroughly. Safety instructions have been developed to prevent injury to personnel or damage to the equipment.

565-2.2 ELECTROMAGNETIC RADIATION

565-2.2.1 There are no personnel hazards due to electromagnetic radiation from the equipment. However, electromagnetic interference may be the cause of spurious failures in the starboard local control unit power supply on FFG 7 class ships.

565-2.3 HAZARDS TO DIVERS

565-2.3.1 FINS. Ensure that no divers are in the vicinity of the fins when the fin stabilizer system is being operated. Before operating fins, alert the Command Duty Officer and Quarterdeck so that dive teams performing other work under the ship can be notified. See Volume II, Part 1, paragraph 1-6.5 of the FFG 7 fin stabilizer system technical manual for more details.

565-2.3.2 AIR EMISSION SYSTEM. If the air emission system is to be operated while divers are in the vicinity, alert the dive team leader so that divers are not startled by the noise.

565-2.3.3 STEAM EMISSION. If the air emission system is to be cleaned by steam, inform the dive team leader so that the divers are not at risk of being scalded. See Volume II, Part 1, paragraph 1-6.6 of the FFG 7 fin stabilizer system technical manual for more detail.

565-2.4 SYSTEM HAZARDS

565-2.4.1 MAIN POWER. The electric motors on the hydraulic power unit are powered by 440 Vac, 3 phase electrical power. Only qualified personnel shall work on the motor controllers. Before opening the controllers, the supply power must be isolated at the main control panel. The 440 Vac power source can be lethal. Exercise extreme caution in this area.

565-2.4.2 CONTROL SYSTEM POWER. The central control unit and the local control unit are powered by 115 Vac. Before work is undertaken on these units, the power must be isolated at the main control panel. 115 Vac power may be lethal. Common injuries due to contact with 115 Vac power include burns and cuts or abrasions incurred by reactive withdrawal of hands from within the control unit enclosures.

565-2.4.3 ROTATING MACHINERY. The hydraulic pump is coupled to the electric motor with a flexible coupling which is normally shielded by a cover. In the event that the cover has been removed, exercise caution around the rotating shaft.

565-2.4.4 HIGH PRESSURE FLUID. The fin stabilizer system is actuated by high pressure hydraulic fluid. If it is required to open a valve to atmosphere, open the valve slowly to avoid a sudden rush of fluid. When the equipment is stopped, allow a minute for the servo and charge pressure to decay before opening a valve to the atmosphere.

565-2.4.4.1 The hydraulic fluid used in the FSS is flammable. Take necessary precautions in the event of spillage. Extinguish all smoking materials, have a fire extinguisher on hand and do not allow the fluid to come in contact with a hot surface. The flashpoint of the fluid is 325° F.

565-2.4.5 HYDRAULIC ACTUATOR. The hydraulic actuators exert great force against the tillers. Ensure that all body limbs are clear of the system when operating or testing.

565-2.5 OPERATIONAL SAFETY SUMMARY

565-2.5.1 When going astern, the FSS must be deactivated and the fins positioned at zero degrees inclination. This action is required to prevent extreme overhauling forces from stressing the machinery.

565-2.5.2 When the ship's speed is below 6.5 knots, the fins will not be cycling even though the system is energized. However, as the speed of the ship increases beyond 6.5 knots, the fin subsystem will activate automatically. One can determine if the system in energized by the sound of the motor and hydraulic pump. If these components are not making any sound, the system is deenergized. Always exercise caution around this equipment whether the system is energized or not so as to avoid personnel injury. The fin stabilizer system can be energized remotely from the bridge or central control station.

565-2.5.3 See Volume II, paragraph 1-6.4 for precautions to be taken during watchkeeping activities.

565-2.6 MAINTENANCE SAFETY SUMMARY

565-2.6.1 Before performing any maintenance work involving electrical components, hydraulic lines or moving parts, tag out the equipment in accordance with ship's tag out directives.

565-2.6.2 After maintenance or repairs, ensure that all personnel are clear of the equipment before it is energized. If it is necessary to remove any of the standard electronic modules (SEM's) deenergize the system and allow the dc voltages to decay before removal. Do not touch the edge connectors of the SEM's because static discharge may damage the components. Do not use excessive force when reinstalling the SEM's.

565-2.6.3 Maintenance work involving steam emission or rotation of the fins must not be conducted if divers are in the vicinity. Always check on the status of divers before conducting this type of maintenance.

565-2.6.4 When in drydock or coming along side, be advised that the fins can be damaged by staging or by a roll that exposes the fins.

SECTION 3.
CONDITIONS OF READINESS

565-3.1 INTRODUCTION

565-3.1.1 This section describes the operational requirements of the fin stabilizer system with respect to the conditions of readiness of the ship.

565-3.2 WATCH CONDITION

565-3.2.1 OVERVIEW. In watch condition, normal operational instructions apply to the FSS. Personnel requirements are very low since the system is fully automatic and self-regulating once in operation. Only one man, either at the bridge control unit or at the central control station is necessary to monitor the performance of the fins while attending to other duties. Additional crew requirements are only in the event that maintenance is required.

565-3.2.2 GENERAL QUARTERS CONDITION If possible, the fin stabilizer system should be kept operational during general quarters condition. The fin stabilizer system requires no additional monitoring during this condition.

565-3.3 EMERGENCY CONDITION

565-3.3.1 There are no further manpower requirements for the fin stabilizer system during emergency conditions.

565-3.4 HELICOPTER OPERATIONS

565-3.4.1 During helicopter operations, operate the system in TEST MODE 02 (faults suppressed).

SECTION 4.
EQUIPMENT DESCRIPTION

565-4.1 SYSTEM DESCRIPTION

565-4.1.1 Fin stabilizer systems are designed to reduce ship roll to the maximum extent possible when a ship is underway in a seaway. Roll reduction on FFG 7 class ships is accomplished by a pair of non-retractable, controllable fins which generate lift as water flows over their air foil shaped surface. The fin stabilizer system electronically processes the ship's speed, roll angle, and roll acceleration signals and calculates the fin angle required to counteract the roll. Standard electronic modules (SEM's) in the control system are used to generate an error signal for the hydraulic pump to position the fins at the appropriate angle to counter the measured roll. The SEM's are also instrumental in providing the trouble shooting diagnostic capabilities of the system.

565-4.1.2 The following subsystem descriptions are applicable to the FSS on the FFG 7 class ships. Three subsystems comprise this fin stabilizer system. They are the fin subsystem, the hydraulic subsystem (mechanical), and the control subsystem. Figure 565-4-1 is a block diagram showing the individual subsystems and their connections to each other and to other ship systems.

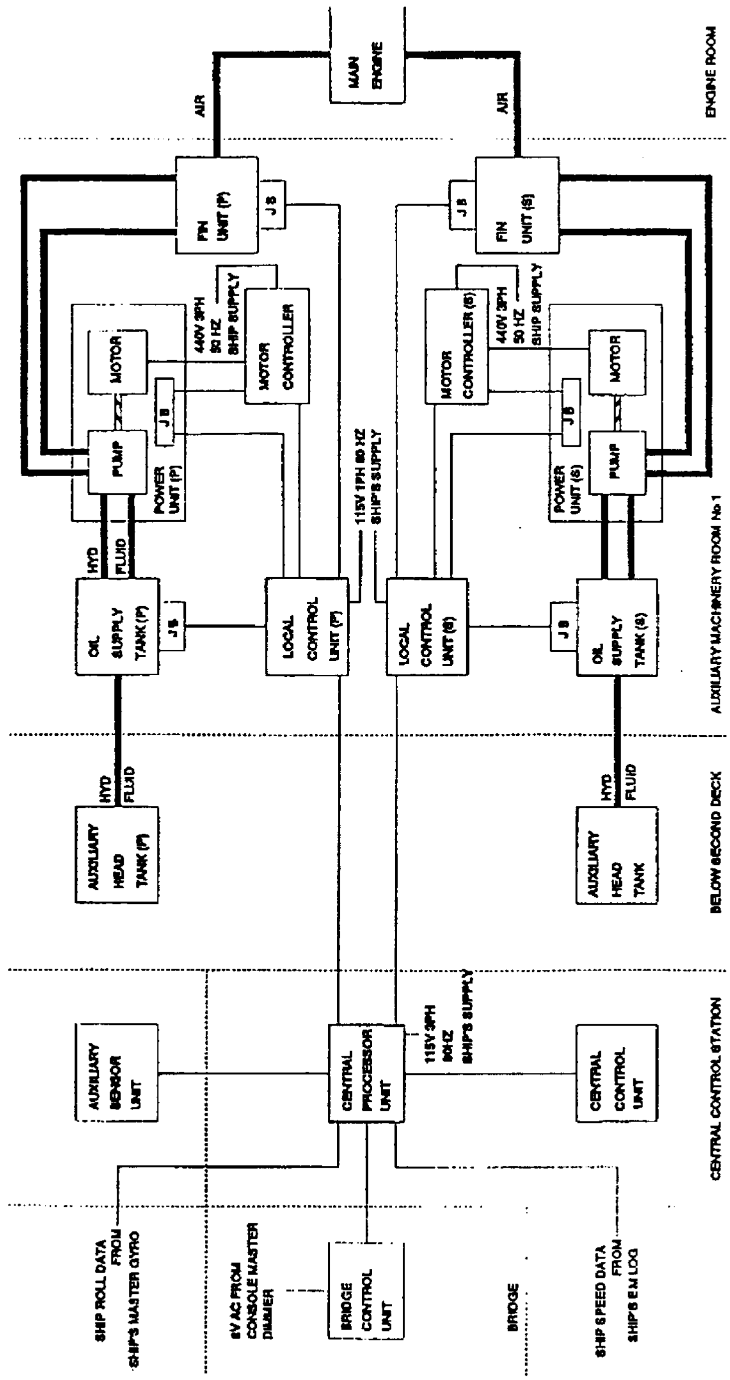

Figure 565-4-1 Fin Stabilizer System Block Diagram

565-4.2 MECHANICAL SYSTEMS

565-4.2.1 FIN SUBSYSTEM. The fin subsystem is an integral unit which is welded into the hull. It consists of the fin and shaft assembly, the finshaft bearings, the tiller, and the support structure. Also associated with the fin subsystem is the air emission system and the lubrication systems. Figure 565-4-2 shows an exploded view of the FFG 7 fin subsystem.

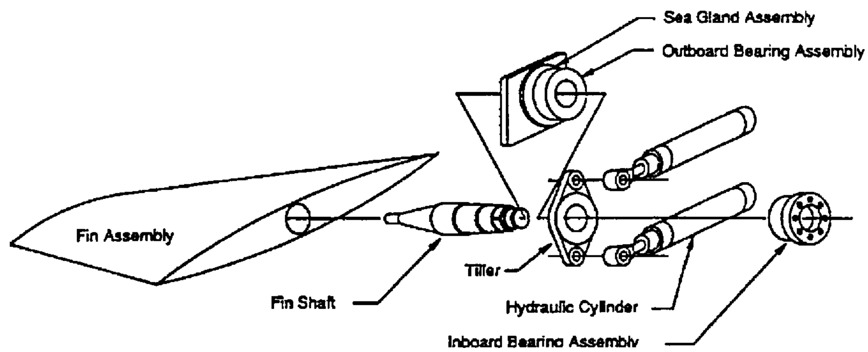

Figure 565-4-2 Fin Subsystem

565-4.2.1.1 Fin and Finshaft Assembly. The fin and finshaft assembly consist of a welded, hollow structure similar to a rudder and a high tensile steel shaft. The finshaft passes through a tapered casting inside the fin and is secured to the fin by a nut on the threaded outboard end of the finshaft. The mid-section of the shaft is fitted with a bearing sleeve made of Stellite. The bearing sleeve is shrunk fit onto the finshaft. The upper, or inboard end of the shaft is machined to fit the tiller halves and the components of the inboard tapered roller bearing. The inboard bearing is housed in the bridge piece of the support structure. The tiller is split and is keyed and clamped (bolted) to the shaft. The tiller arm extremities are attached via spherical bearings to the rod ends of the hydraulic actuators.

565-4.2.1.2 Outboard Bearing. The original configuration of the outboard bearing consists of a housing fitted with a solid, cast Stellite bushing. It is imperative that this bearing configuration be lubricated in accordance with the system maintenance requirements. If the bearing is not lubricated, and the fin stabilizer system is operated for any length of time, it is likely that the finshaft sleeve will fail. NAVSEA Code 05J3 has determined that local heat build-up causes the finshaft sleeve to crack along its entire length. Once this failure mode has occurred, a direct path for seawater to enter the ship is established. Continued operation in this condition may cause extra damage to the bushing and the finshaft. Repair requires drydocking for fin and finshaft assembly removal and is very expensive.

565-4.2.1.2.1 Bearing Sleeve. Because of the potential for finshaft sleeve failure discussed above, NAVSEA Code 05J3, has initiated a program to modify the outboard bearing configuration. An immediate replacement for the cast Stellite finshaft sleeve is a sleeve fabricated from a carbon steel forging, weld-clad with a thin layer of Stellite on the sleeve surface. The carbon steel forging is more ductile than the cast Stellite sleeve and so is less apt to fail. This intermediate configuration also requires lubrication. During the investigation of the sleeve cracking problem, NAVSEA Code 05J3 determined that the grease specified in the maintenance documentation was not ideal. Subsequently, a new grease was identified and a class advisory was issued to the FFG 7 class ships advising them of the changeout. The old grease was MIL-G-23549. The new grease is MIL-G-24139. To improve the operational reliability of the FSS, the lubricant should be changed in accordance with the class advisory.

565-4.2.1.2.2 Composite Bushings. A new outboard bearing configuration consisting of the weld-clad finshaft sleeve and a self-lubricated, seawater cooled, composite bushing is being evaluated and may already be installed on some FFG 7 class ships. This configuration requires no lubrication, thereby reducing maintenance time and expense. Reduced lubrication requirements also reduce the environmental impact.

565-4.2.1.3 Finshaft Seals. The original configuration of the finshaft assembly uses two sets of seals on the finshaft sleeve. Two outboard facing lip-seals prevent ingress of seawater into the outboard bearing. A stack of nonmetallic, aramid fiber packing rings serve as the sea gland on the inboard side of the sleeve. The inboard seals require lubrication. If the fin stabilizer system is configured with a composite bushing, the outboard lip seals are removed to allow for seawater to enter the bearing clearance. In this case, the inboard packing still requires lubrication. NAVSEA Code 05J3 is evaluating a non-lubricated face seal to replace the packing rings.

565-4.2.1.4 Air Emission System. The fin stabilizer system is designed to emit small air bubbles from the leading edge of the fin to reduce cavitation noise. Masker system air, generated by the compressor bleeds on the propulsion gas turbine, is delivered to the fin cavity via a hose assembly bolted to the air emission system manifold on top of the finshaft. This port can also be used for steam cleaning the tiny orifices at the leading edge and tip of the fin.

565-4.2.1.5 Lubrication System. The lubrication system consists of either one or two grease pump or supply canisters mounted on the forward stool of the support structure. Positive pressure is maintained on the grease by a spring loaded follower plate in the canister. During lubrication maintenance, the grease is hand-pumped, one port at a time, through cartridge valves mounted in two manifolds. One manifold, with 12 ports, supplies the outboard bearing and gland assembly. The other manifold, with six ports, supplies the actuator bearings.

565-4.2.1.5.1 During lubrication maintenance, only one cartridge valve shall be open at a time. Each grease port shall receive three complete pump strokes before securing the valve and proceeding to the next valve port. At the conclusion of the lubrication maintenance, one valve shall remain open to ensure that the safety rupture disc on the grease pump is not ruptured if the pump handle is inadvertently activated. If the rupture disc ruptures and a replacement is not readily available, a temporary rupture disc can be fabricated from the side of a soda pop can. This is only a temporary repair. The grease cannister should be properly maintained as soon as possible.

565-4.2.1.5.2 Grease Operating Pressure. The grease pumps are fitted with a pressure gauge. Normal pressures while lubricating the fin stabilizer system should not exceed 1000 psi. If the pressure exceeds this value, check the lubrication lines for crimping. If the pressure exceeds 2000 psi, the rupture disc should rupture.

565-4.2.1.6 Additional Components on the Fin Subsystem. In addition to the components called out above, the following additional components are mounted on the fin subsystem:

a. the hydraulic distribution manifold

b. the hydraulic actuators (tilting cylinders)

c. the overtravel, mechanical lock and overpressure switches.

These components are described in detail in the appropriate section of the FSS technical manual. Figure 565-4-3 is a top view of the fin subsystem depicting the location of these components.

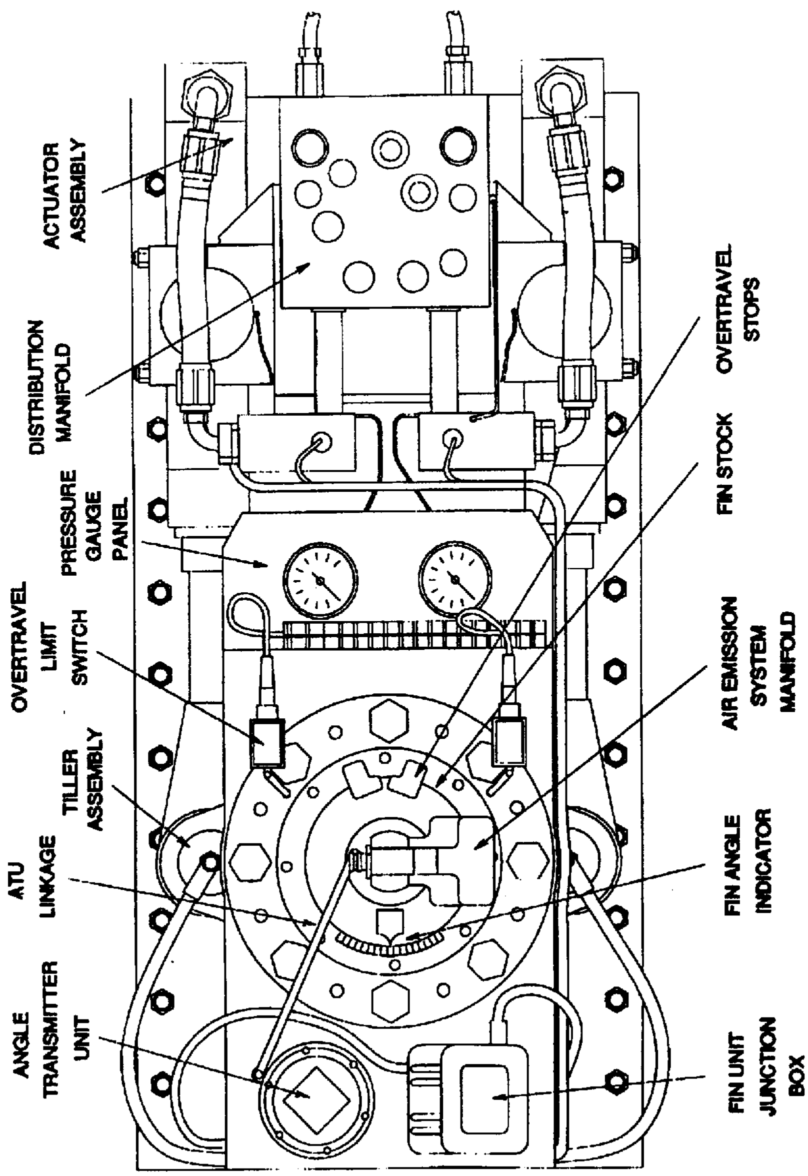

Figure 565-4-3 Top View of Fin Subassembly

565-4.2.2 HYDRAULIC SUBSYSTEM. The hydraulic power unit (HPU) consists of a variable displacement hydraulic pump driven by a 50 horsepower electric motor, hydraulic oil tanks, hydraulic oil filters, relief valves, the hydraulic actuators (tilting cylinders) and fault sensors. There are two HPU’s, one each for the port and starboard fin stabilizer units.

565-4.2.2.1 Main Hydraulic Pump. The variable delivery hydraulic pump delivers hydraulic fluid to the actuators via the pump bypass cylinder blocking (PBCB) valve and the acoustic filters. The pump is continuously rated for 3500 psi at 1200 rpm. Its maximum working pressure is 3000 psi. The variable output of the pump is governed by the position of the swash plate which is controlled by the control cylinders and the servo valve.

565-4.2.2.2 Pump Servo Valve. The servo valve is a 2-stage, jet pipe type valve driven by a low voltage dc signal. This valve controls the flow of hydraulic fluid to the control cylinders which position the swash plate.

565-4.2.2.3 Control Cylinders. The control cylinder assembly is mounted on the right hand side of the pump just behind the swash plate potentiometer. Two spring centered rams in the assembly bear on the swash plate hanger through a knuckle. The springs tend to keep the swashplate angle at zero when there is no command.

565-4.2.2.4 Swash Plate Angle Potentiometer. The swash plate angle potentiometer is a single turn, dc potentiometer. The potentiometer is coupled to the swash plate trunnion in such a way that when the swash plate moves, the potentiometer moves through the same angle. The output from the potentiometer serves to cancel the signal to the servo valve controlling the pump swash plate cylinders.

565-4.2.2.5 Swash Plate Angle Indicator. The swash plate angle indicator is mounted to the pump on the opposite side of the potentiometer and provides a visual indication of the swash plate angle.

565-4.2.2.6 Pump Valve Block. The pump valve block is mounted on top of the pump and contains a number of hydraulic relief, check and shuttle valves. The hydraulic system pressure relief valves are set to relieve at 3500 ± 50 psi while the servo system relief valve will relieve at 800 ± 10 psi. The charge system will relieve at 175 ± 10 psi.

565-4.2.2.7 Replenishment Pump. The replenishment pump is close coupled to the rear end of the main hydraulic pump and contains two pumping units in one pump case, the charge pump and the servo pump. The pump has a common suction line and two delivery lines. One delivery circuit. line is for the charge circuit, the other is for the servo

565-4.2.2.8 Filter Assemblies. The filter assemblies for the charge and servo supplies are located on either side of the pump. The filters are rated for 10 and 25 microns respectively and are capable of withstanding 1500 psi. The filters are fitted with an integral bypass valve and pop-up clogging indicators. MOD 3 FSS filters are fitted with electronic differential pressure switches. When these switches are activated by a clogged filter, the FSS is automatically shut down and the operator is alerted by a fault alarm.

565-4.2.2.9 Pump Bypass Cylinder Blocking (PBCB) Valve Assembly. Hydraulic fluid to the actuators is directed through the PBCB valve. When the PBCB valve solenoid valve is not energized, hydraulic fluid is bypassed back to the pump, the fluid is blocked from the actuators and the actuators are blocked from each other. When the solenoid valve is energized, fluid is directed from the pump through the acoustic filters, to the actuators via the distribution manifold.

565-4.2.2.10 Acoustic Filters. The acoustic filters are located in the lower soleplate under the HPU and are connected to the PBCB valve through flexible hoses. Their function is to attenuate fluid borne noise generated by the pump. They are fitted with drain and vent plugs.

565-4.2.2.11 Distribution Manifold. The distribution manifold is located on the fin subsystem between the two actuators. The distribution manifold contains several system valves. They are:

a. system blocking valves - block the flow of hydraulic fluid to the actuators

b. bypass valve - bypasses flow back to the pump

c. safety relief valves - limit system pressure build-up to 4500 psi

d. fin centering valves - used to port the flow of hydraulic fluid from the fin centering pump to the actuators for manual centering or manipulation of the fins

e. pressure gauge valve - when open, ports hydraulic flow to the pressure gauges for indication.

565-4.2.2.12 Actuator Assemblies. The actuators are trunnion mounted, heavy duty, double acting cylinders. Figure 565-4-4 shows a typical actuator unit.

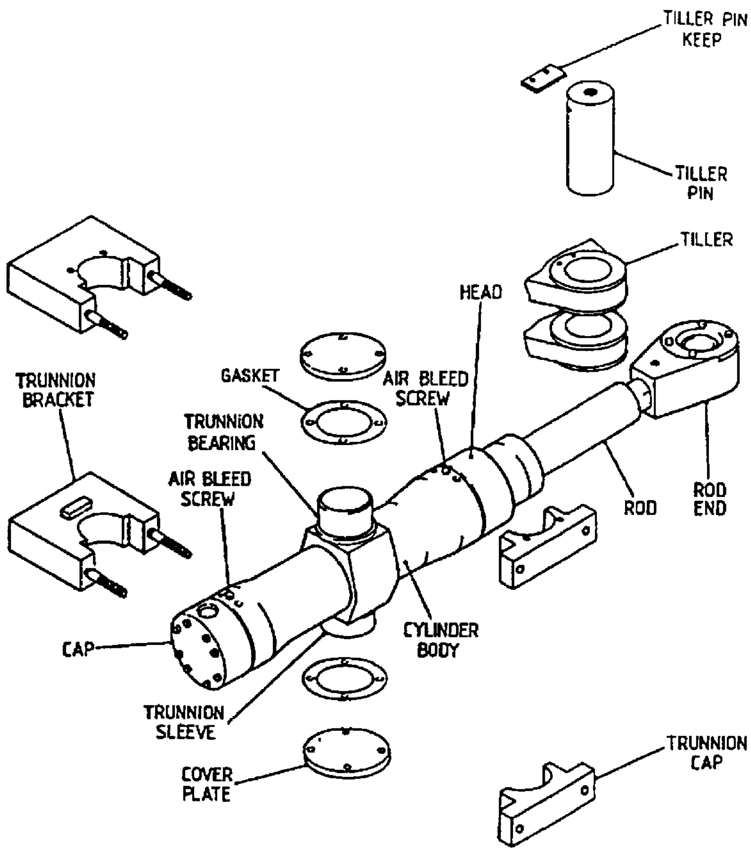

Figure 565-4-4 Actuator Assembly

565-4.2.2.13 Hydraulic Fluid Tanks. There are three hydraulic fluid tanks associated with the FSS.

565-4.2.2.13.1 The main supply tank is integrally welded with the ship's hull. This arrangement allows for the fluid to be cooled by the flow of seawater across the hull. Fluid is drawn from this tank through a large suction strainer. Return fluid is through the self-test unit. The supply tank houses the following alarm sensors:

a. fluid level (low oil) switch

b. low temperature (cold oil) switch

c. high temperature (overtemp) switch.

565-4.2.2.13.2 The auxiliary head tanks are located in the overhead of the compartment above AMR-1. They are connected to the supply tanks via hydraulic piping and serve to maintain a positive head on the hydraulic system as well as acting as an expansion tank in the event of overheating.

565-4.2.2.13.3 The hydraulic oil storage tank is located in AMR-1 and holds a volume of clean replenishment oil for the system. The tank can also be used to store hydraulic oil that has been drained from the system for maintenance purposes.

565-4.2.2.14 Accumulator. A bladder type accumulator is mounted on the pump or motor coupling guard. The accumulator discharge is pumped to the pump valve block and is used to provide backup fluid for the charge system. The accumulator is rated for 1.2 gallons at 5000 psi with full flow characteristics. The accumulator is precharged with nitrogen to 100 ± 10 psi.

565-4.2.2.15 Self-Test Unit. The self-test unit is located in the return line from the main hydraulic pump and is used to measure the fluid flow rate and temperature. The self-test unit contains a filter pop-up indicator, a flow meter, a thermometer, a flow control valve and a cooling control valve. Operation of the self-test unit is clearly defined in the FSS technical manual. Figure 565-4-5 shows the configuration of a self test unit.

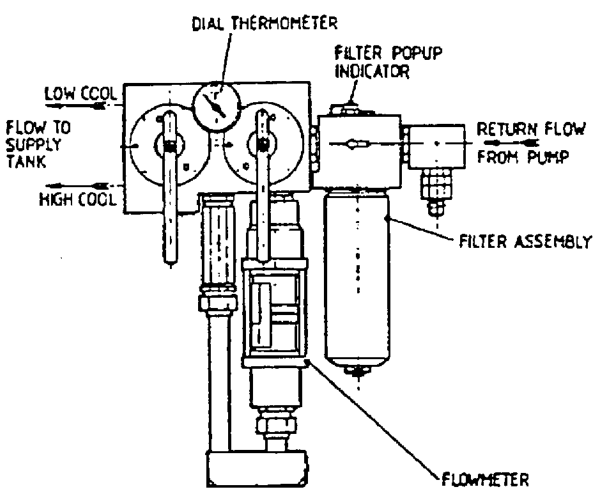

Figure 565-4-5 Self-Test Unit.

565-4.2.2.16 Electric Motor. The electric motor is a totally enclosed, fan cooled, squirrel cage, induction motor operating from a 440 Vac, three phase, 60 hertz supply. The motor is continuously rated at 50 horsepower and is capable of meeting the system duty cycle which can peak at a maximum of 139 horsepower.

565-4.2.2.17 Motor Controller. The motor controller is in a watertight enclosure, is across the line starting and is capable of meeting the power requirements of the motor. Figure 565-4-6 shows the cover of the motor controller.

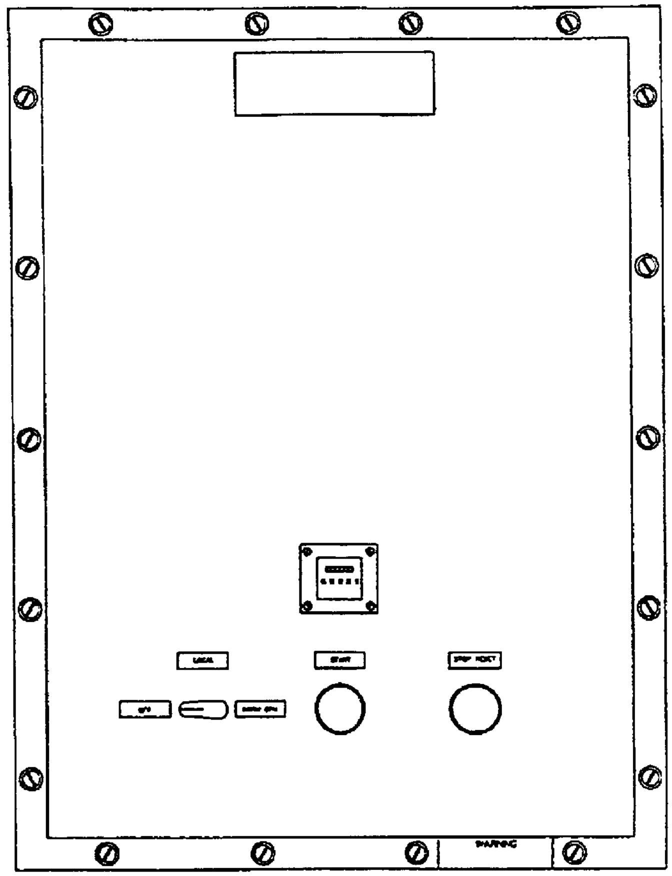

Figure 565-4-6 Motor Controller

565-4.3 ELECTRICAL CONTROL SUBSYSTEM

565-4.3.1 SUBSYSTEM DESCRIPTION. There is one electrical control system per ship. This system consists of a digital processor, various control units, control panels, signal transmission lines and related equipment (Figure 565-4-7). The control unit provides fin positioning command signals to the hydraulic subsystems.

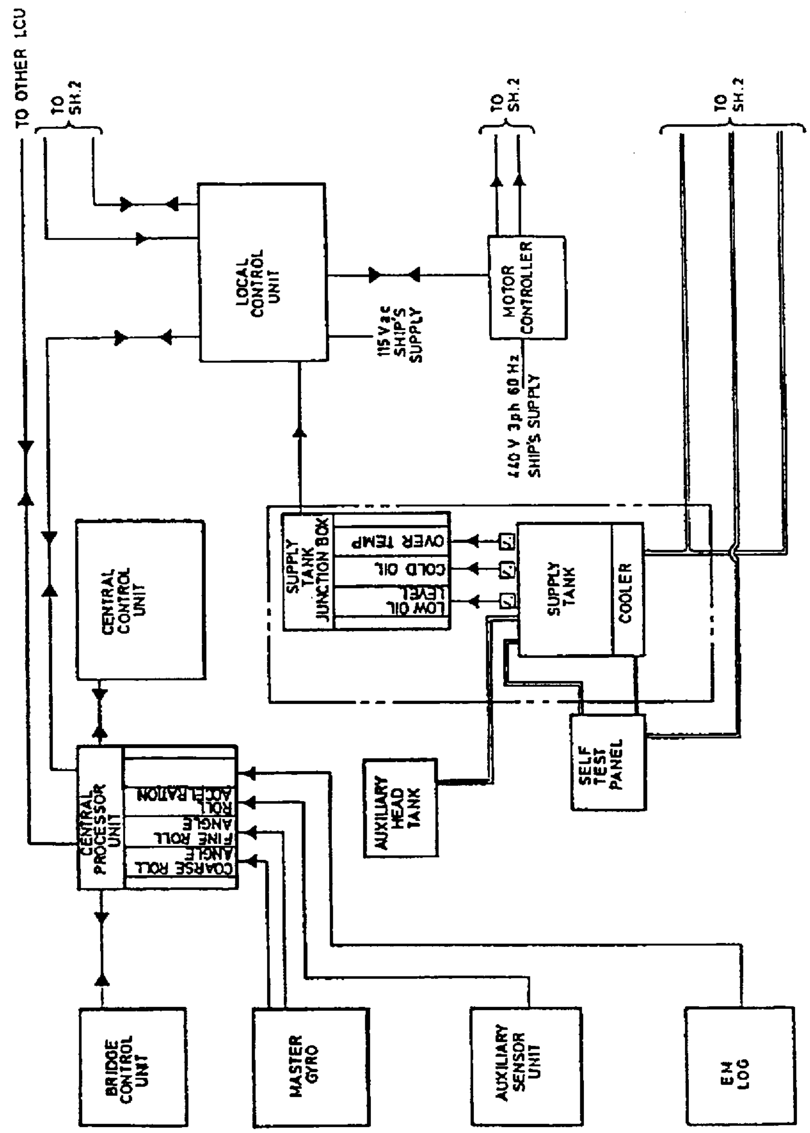

Figure 565-4-7 Control System Block Diagram (Sheet 1 of 2)

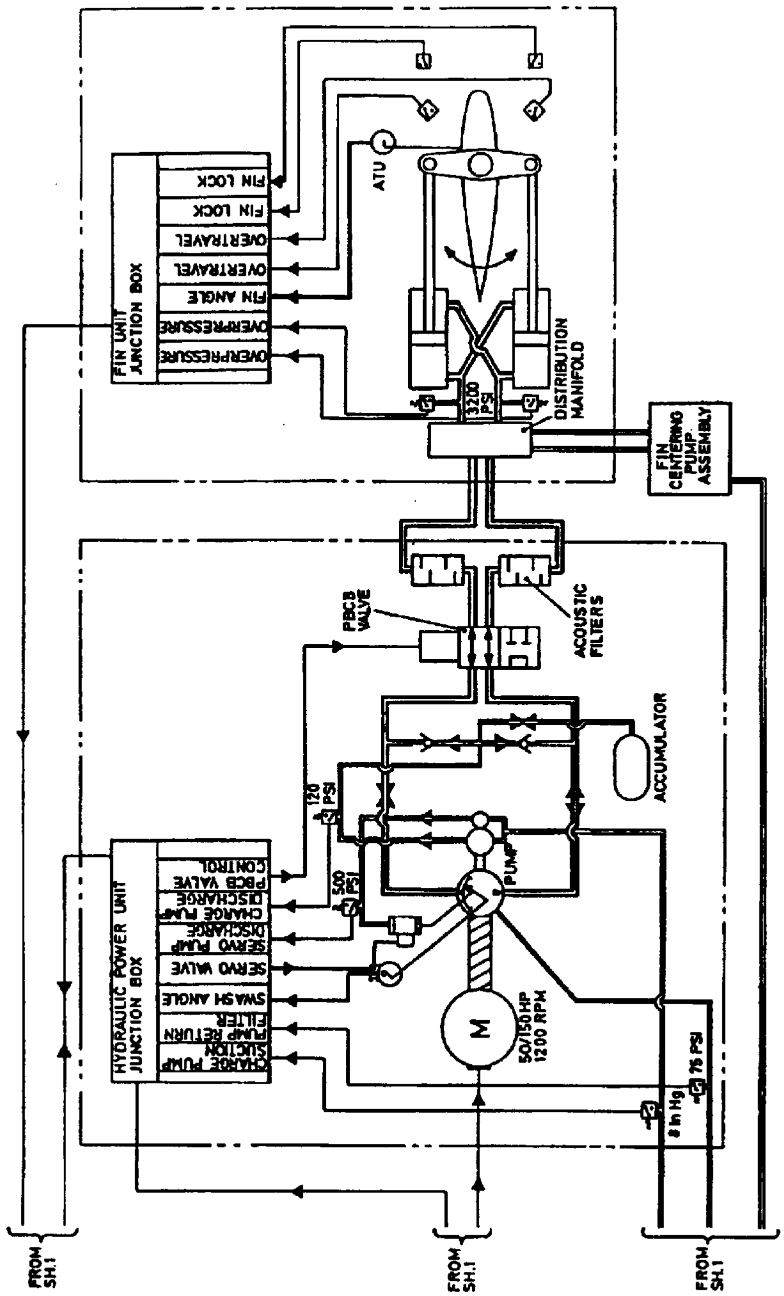

Figure 565-4-7 Control System Block Diagram (Sheet 2 of 2)

565-4.3.2 BRIDGE CONTROL UNIT (BCU). The BCU (Figure 565-4-8) is a panel-mounted unit, suitable for mounting in a console. The BCU is located on the bridge. This unit has all the controls necessary for startup, shutdown and control of the fin stabilizer. The controls and indications provided on the BCU are described in detail in the FSS technical manual.

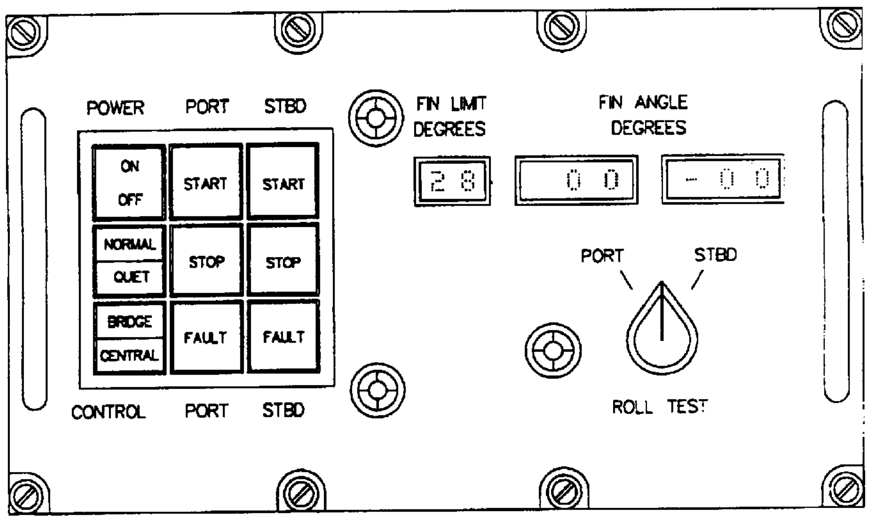

Figure 565-4-8 Bridge Control Unit.

565-4.3.3 CENTRAL CONTROL UNIT (CCU). The bulkhead mounted CCU contains various controls and indicators (Figure 565-4-9). This unit also has all of the controls necessary for start-up, shutdown, and control of the fin stabilizers. The Operator Control Module (OCM) is a removable, plug-in module housed in the CCU. Although the OCM is not exactly the same as the BCU, it can be used as a replacement for the BCU if necessary. The controls and indicators housed in the CCU are described in the FSS technical manual.

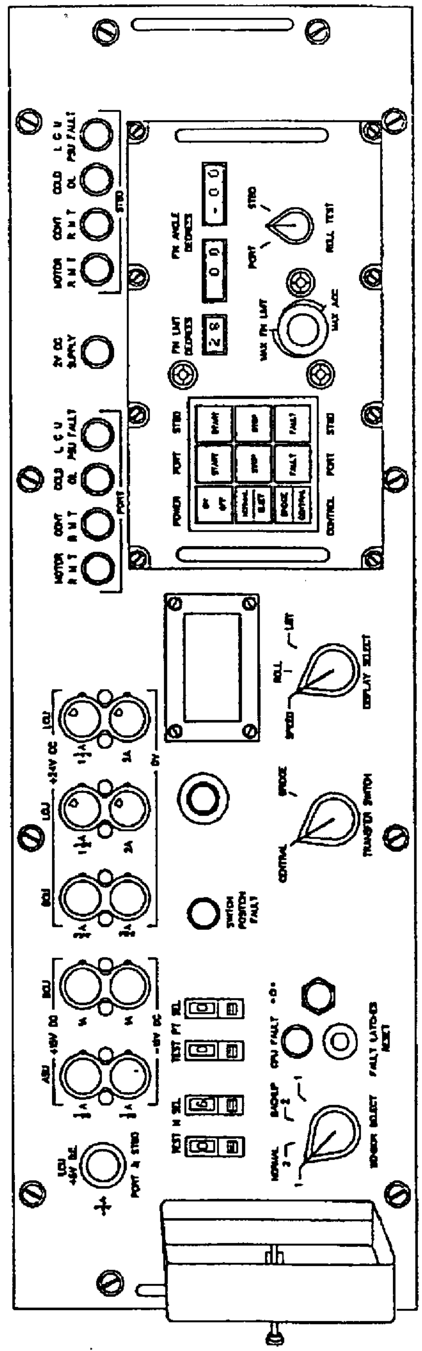

Figure 565-4-9 Central Control Unit

565-4.3.4 CENTRAL PROCESSOR UNIT (CPU). The CPU is a bulkhead mounted unit (Figure 565-4-10) that accepts data from remote sensors and receives information from, and sends information to, the other control units. This is the main controlling link in the stabilizer system. The controls and indications housed in the CPU are described in the FSS technical manual.

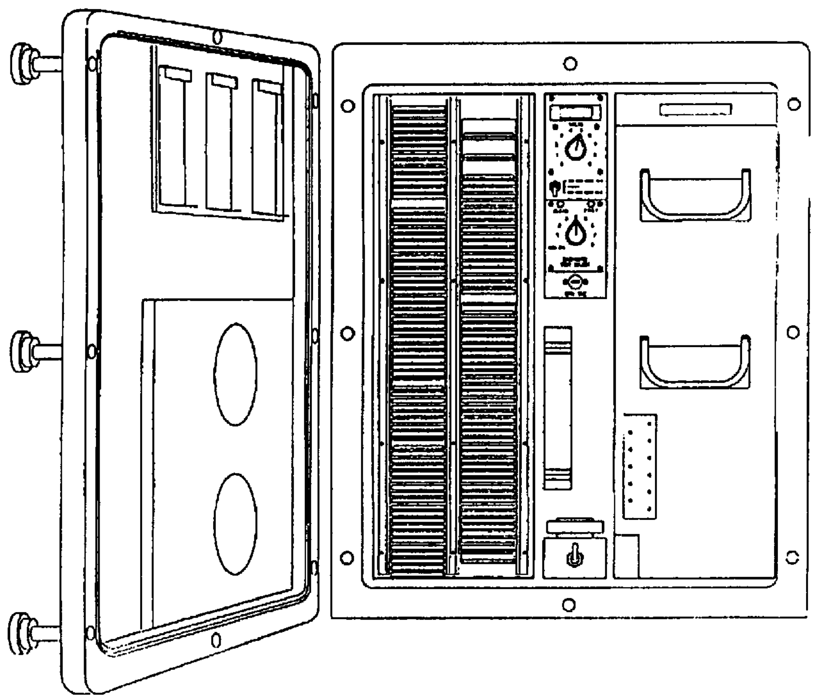

Figure 565-4-10 Central Processor Unit

565-4.3.5 LOCAL CONTROL UNIT (LCU). There are two bulkhead mounted LCU's (Figure 565-4-11). Each LCU connects one motor controller, fin unit, and oil supply tank. The LCU displays the status of fault sensors, controls the operation of the electro-hydraulic servo valve that moves the fin, and provides test points for system checks. The controls and indicators housed in this unit are described in the FSS technical manual.

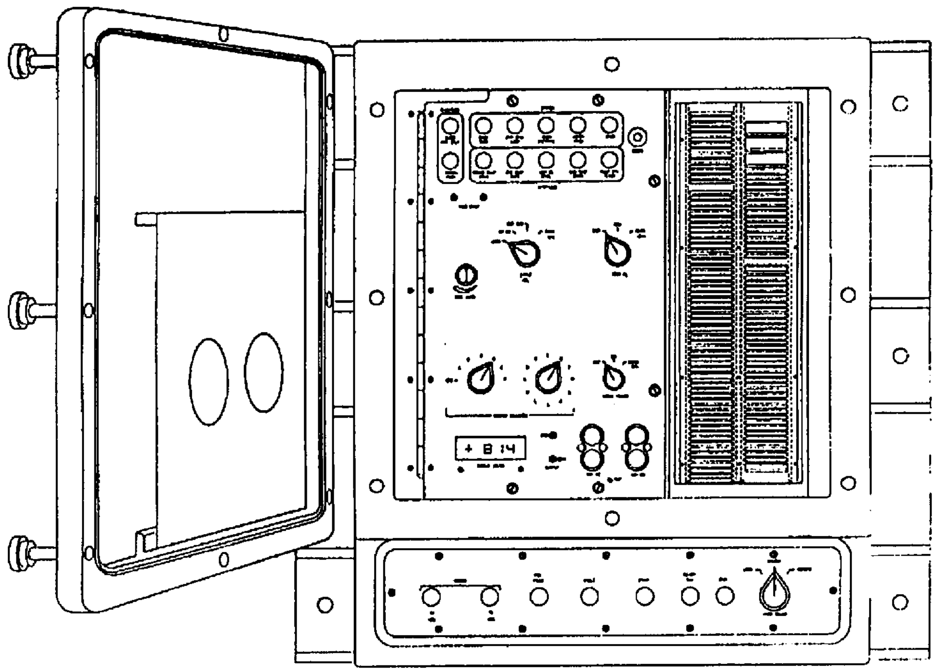

Figure 565-4-11 Local Control Unit

565-4.3.6 ANGLE TRANSMITTER UNIT (ATU). One ATU (Figure 565-4-12) is mounted on each of the two fin assemblies. The ATU is mechanically coupled to the fin shaft by an adjustable linkage. The ATU produces an electrical signal for the angle of fin rotation.

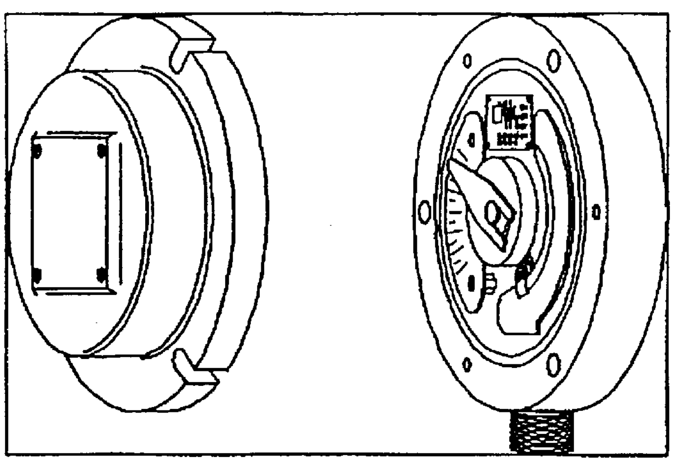

Figure 565-4-12 Angle Transmitter Unit.

565-4.3.7 AUXILIARY SENSOR UNIT (ASU). The ASU is bulkhead mounted close to the ship's axis of roll and provides a roll acceleration signal to the CPU (Figure 565-4-13).

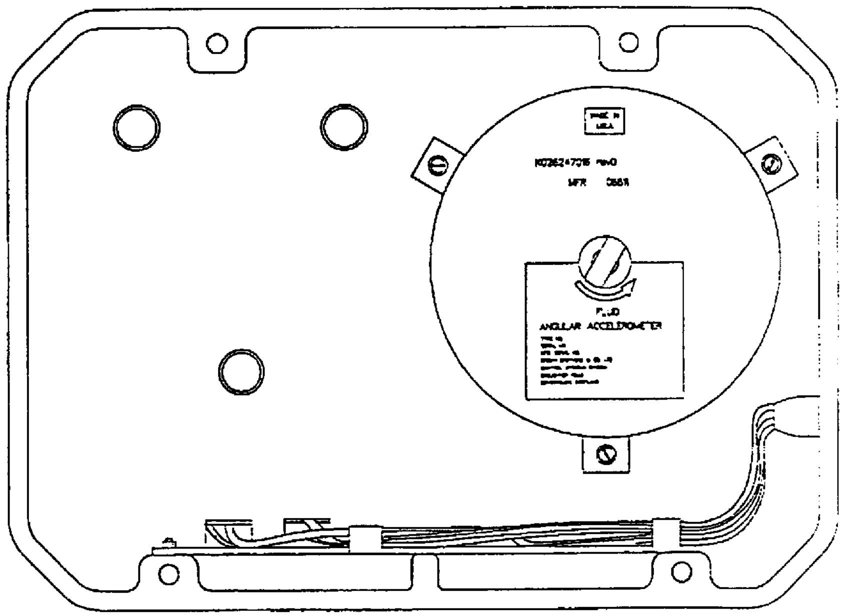

Figure 565-4-13 Auxiliary Sensor Unit.

565-4.3.8 FAULT SENSORS. The hydraulic subsystem and the fin subsystem support various fault sensors (Figure 565-4-14). These are used to measure oil level, oil temperature, hydraulic pressure, electric motor current and fin shaft overtravel.

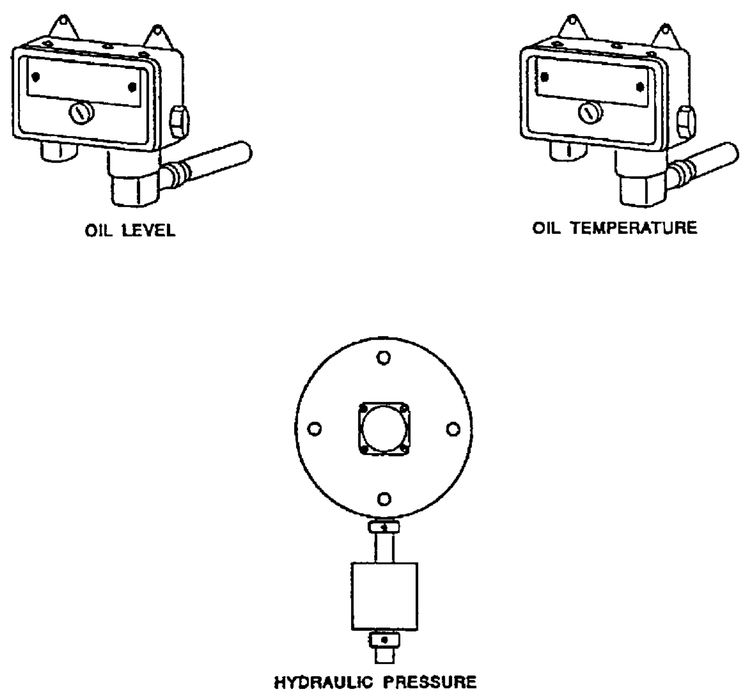

Figure 565-4-14 Fault Sensors.

565-4.3.9 MASTER GYRO AND ELECTROMAGNETIC (EM) LOG. The master gyro determines the roll angle of the ship. The fin stabilizer control system calculates roll velocity and roll acceleration from the change in roll angle. The EM log determines ship speed. The fin stabilizer control system calculates the fin angle required to counter roll based on ship speed.

SECTION 5.
FIN STABILIZER OPERATION

565-5.1 FIN STABILIZATION

565-5.1.1 FIN MOTION. Fin stabilizers work by imposing a force that opposes the inertial forces of the rolling hull. This is a damping force. If the ship is rolling towards the starboard side, the starboard fin will be angled up while the port fin will be angled down. Similarly, if the ship is rolling to port, the starboard fin will be angled down while the port fin will be angled up. This concept is depicted in Figure 565-5-1.

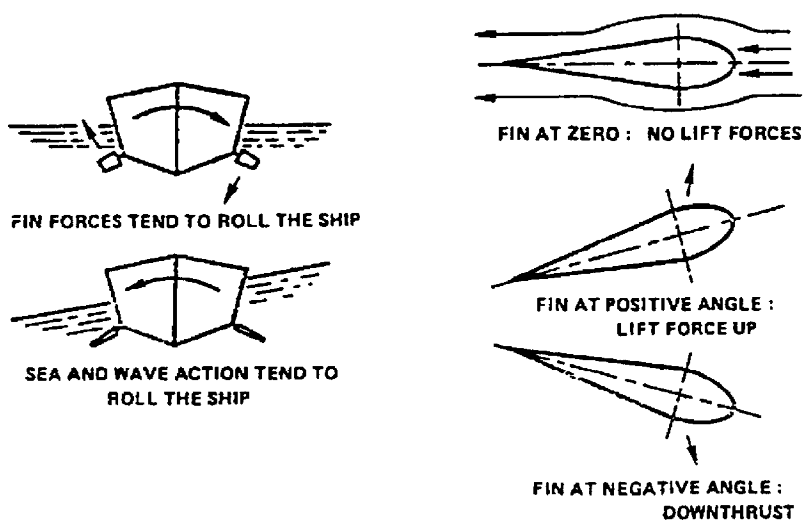

Figure 565-5-1 Fin Operation

565-5.1.1.1 The fins are positioned with hydraulic actuators. The FFG 7 class FSS uses a double-tiller arrangement with two hydraulic cylinders (Figure 565-5-2). A hydraulic power unit (HPU), driven by an electric motor, provides hydraulic power. Solenoid-operated flow control valves direct the flow of hydraulic fluid to the actuators.

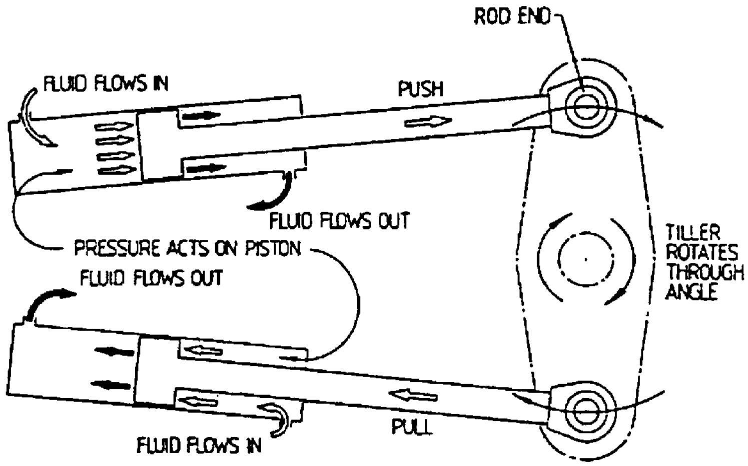

Figure 565-5-2 Actuators and Finshaft Rotation

565-5.1.1.2 The motion of the fins must be exactly one-quarter of a roll period out of phase with the roll of the ship. In addition, the amount of force generated must be carefully regulated. If these conditions are not met, the fin stabilizer system may cause an increase in the roll amplitude. Therefore, an effective fin stabilizer system requires a sophisticated control system. Figure 565-5-3 provides a graphic representation of typical fin performance.

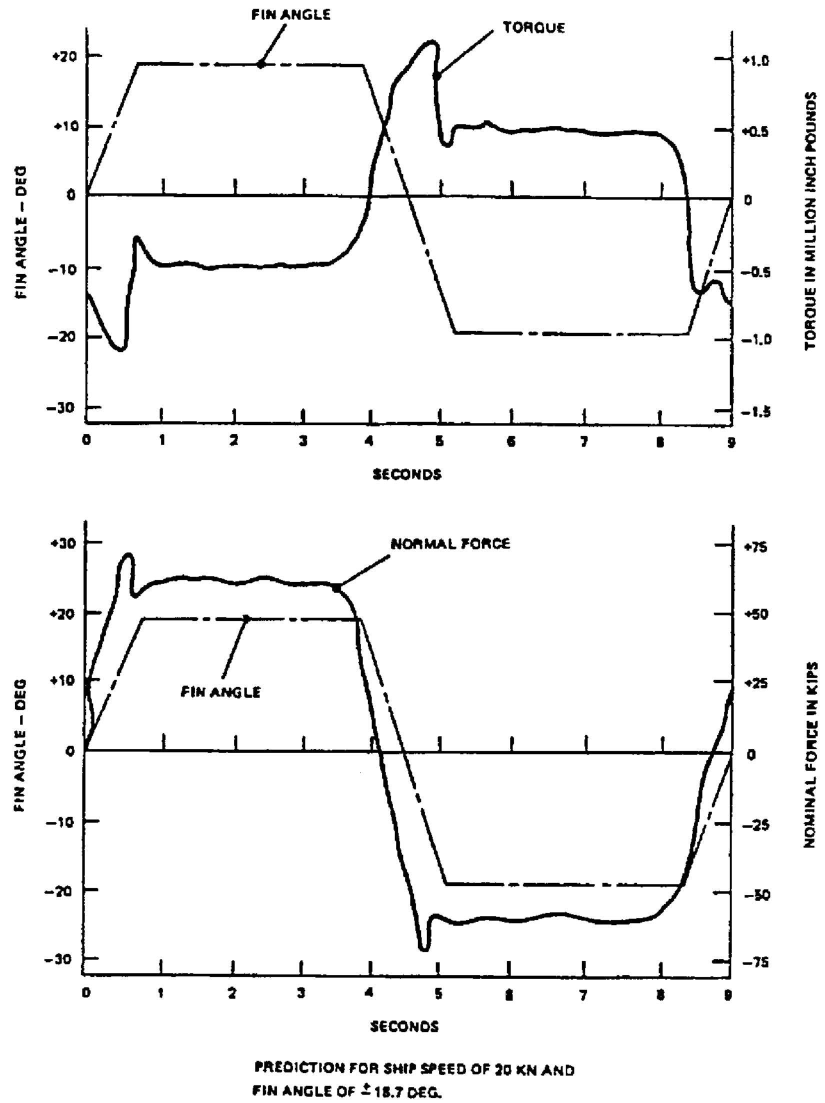

Figure 565-5-3 Typical Fin Performance

565-5.2 CONTROL SYSTEM

565-5.2.1 SENSORS. The FFG 7 class fin stabilizer system obtains roll information from two sources. The primary source for MOD 1 systems is the master gyroscope, a component of the gyrocompass system. From this source, the control system (CPU) extracts position and calculates roll acceleration and rate. By combining these output signals with the speed signal from the EM log, the fin angle required to counteract the roll is calculated. The secondary source for MOD 1 systems, normally the backup source, is the ASU. For MOD 3 systems, the ASU is the primary source while the gyro input is the backup source. The ASU contains an accelerometer and is located near the centerline (center of roll) of the ship. This accelerometer senses acceleration and sends signals to the CPU. The CPU uses this signal as described above; to generate an input to the hydraulic pump to move the fins in the proper direction and amplitude to counter the roll. These sensors can be used alone or in combination to provide information to the CPU.

565-5.2.2 OPERATION. In normal operation, the CPU is continuously monitoring the ship's rolling movement and sends demand signals to the LCU's which control the actual mechanical movement of the fins. The LCU monitors the fin angle from signals produced by the angle transmitter unit and monitors the pump swash plate angle from the pump-mounted potentiometer. The angle transmitter unit is attached to the inboard end of the finshaft via a mechanical linkage.

565-5.2.2.1 When the LCU receives a fin angle demand from the CPU, it compares the required fin angle with the existing fin angle and generates an error signal. The error signal is in effect a demand for hydraulic pump delivery. By controlling the current to the servo valve, and monitoring the ever changing fin angle and swashplate angle, the fin is rotated in the direction required to counteract the roll. The fin will continue to move until the error between the demanded fin angle signal and the actual fin angle signal is zero. The fin angle demand will only change if the ship's speed is in excess of 6.5 knots. Below this speed, there is no fin angle demand regardless of roll amplitude.

565-5.2.2.2 In addition to controlling the fin position, the LCU routes the START/STOP and Pump Bypass Cylinder Blocking (PBCB) valve ON/OFF signals to the motor controller. It also monitors other safety switches and will shut down the motor if predetermined safe levels are being exceeded. The other sensors and safety switches monitored include sensors for motor voltage and current, hydraulic oil pressure and temperature, and over-travel switches. In the event of a safety level being exceeded, a general fault indicator will illuminate on the LCU, the OCM and the BCU. Additional indicators are found on the LCU only which identify the activated sensor to facilitate fault isolation.

565-5.2.2.3 On the command to start, which comes from either the OCM or the BCU, the signal is routed to the motor controllers via the CPU and the LCU, and the pump motors start. In the LCU, the START pulse initiates a five second delay before the PBCB valve energizes which allows the motor to run up to speed without load, and the various auxiliary pressures to come up to their working values before there is any demand on the pump.

565-5.2.2.4 During operation, the fin angles are displayed on digital readouts on the BCU and OCM so that the operator knows the precise angle of the fins at all times. In addition, the operator has control over the fin limit via the MAX FIN LIMIT/MAX AGC control knob and the NORMAL/QUIET pushbutton. A roll test can be conducted by manipulating the ROLL TEST switch and the audible alarm on the CCU can be silenced by pressing the FAULT/SILENT pushbutton.

565-5.2.2.5 On the command to stop, the CPU sends a zero fin angle demand signal to the LCU in order to center the fins. After a three second delay to allow the fins to center, the CPU shuts the motors down and the LCU's lock the fin actuators by de-energizing the PBCB valves.

565-5.3 MANUAL OPERATION

565-5.3.1 MANUAL OPERATION MODES. The fin subsystem can be operated manually if required. During manual operation, the fin can be positioned with the local control unit or, in the event that the control system is non-operational, with the fin centering pump. Several different types of system failures dictate either manual control (from the LCU) or complete manual operation. If the main control system fails through loss of sensors, control units or communications, the FSS is not effective for roll stabilization. The fins can be returned to the centered position using the normal hydraulic actuators and power units through the LCU. If the hydraulic power unit (HPU) or main hydraulic piping fails, the fin must be moved to the center position manually by using the fin centering pump and the appropriate valves on the distribution manifold. Figure 565-5-4 is a cut-a-way schematic of the distribution manifold. Figure 565-5-5 is a second level functional diagram of the FSS.

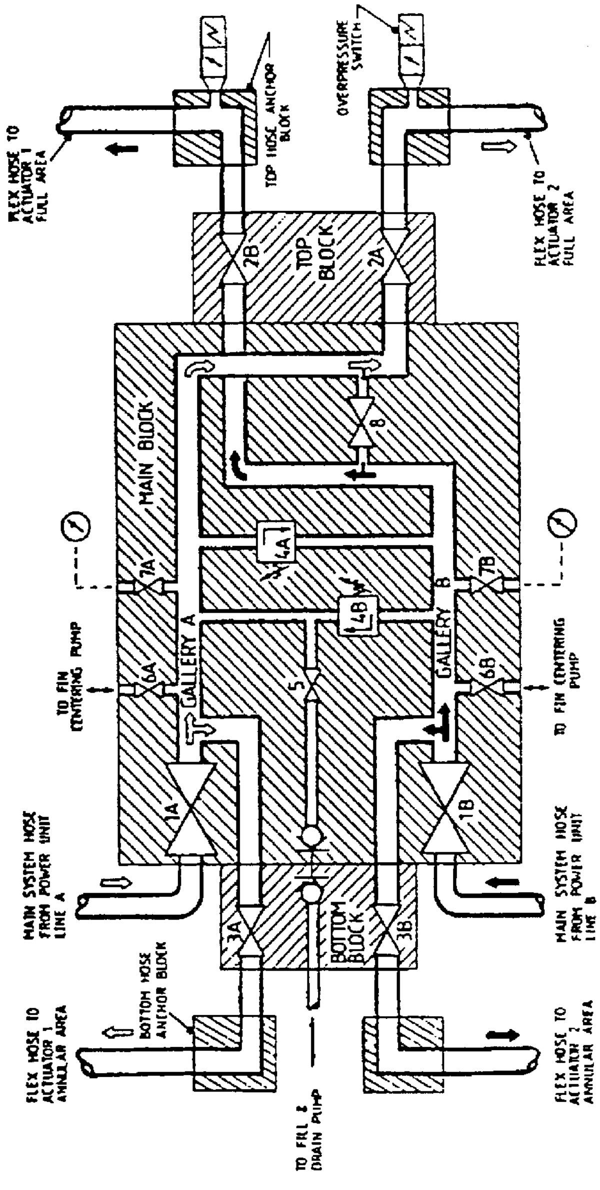

Figure 565-5-4 Distribution Manifold Schematic

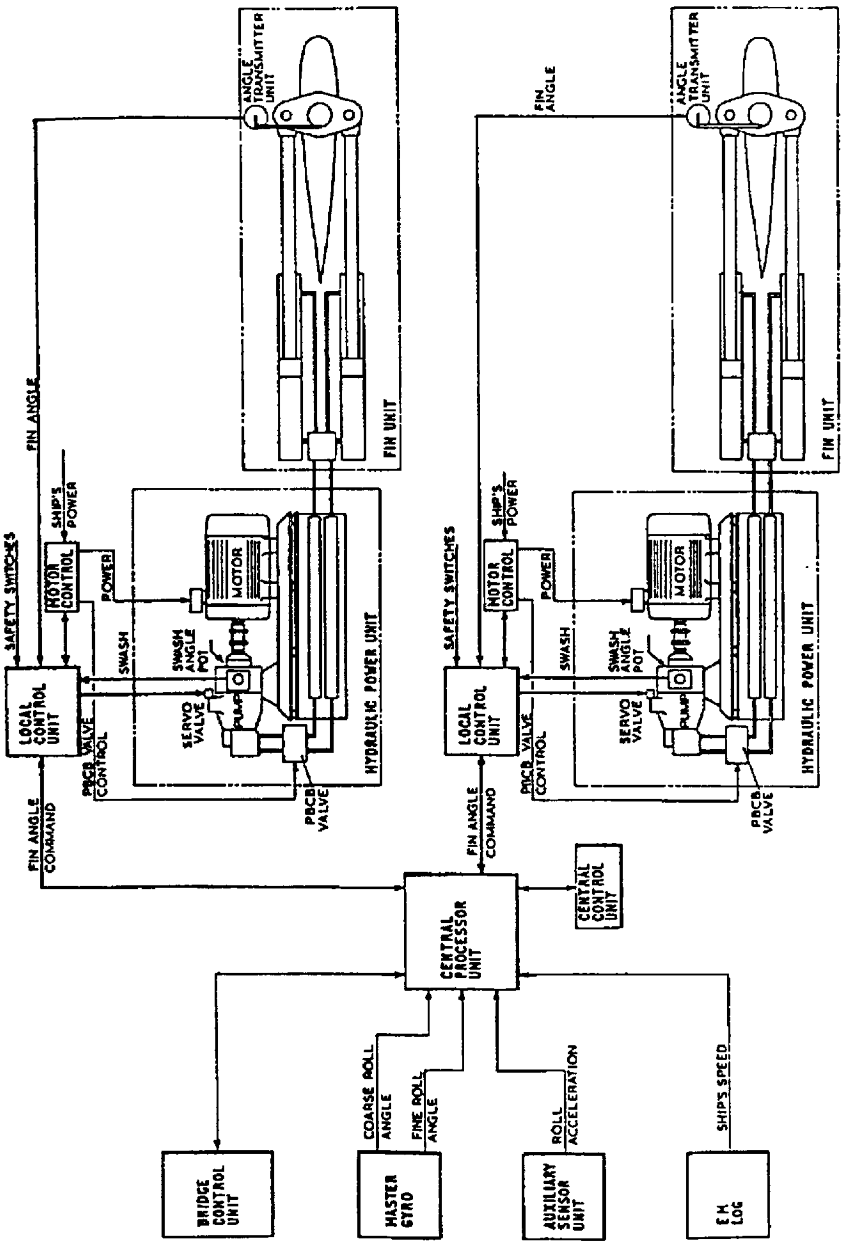

Figure 565-5-5 Second Level Functional Diagram

565-5.3.2 FIN CENTERING PUMP. Upon failure of the HPU, the operator can use the fin centering pump to center the fins. This pump is located next to the outboard fin actuator on the hull structure. The manual operation takes several minutes. If at all possible, the ship should be slowed or stopped during the manual centering operation. Reducing the speed of the ship minimizes the forces on the fin.

565-5.3.3 FIN LOCK. After the fin has been manually centered, it must be positively locked so that hydraulic leakage will not allow the fin to move out of the centered position. The fin lock consists of a block of steel that is pivoted to the fin subsystem support structure. When in the locked position, the block is held in place by a pin and the fin lock limit switches are activated. If the fin lock limit switches are activated, the FSS can not be inadvertently energized.

SECTION 6.

EQUIPMENT INSPECTION AND TROUBLESHOOTING

565-6.1 INTRODUCTION

565-6.1.1 SCOPE. This section contains requirements, instructions, and information needed for inspection and troubleshooting of the fin stabilizer system developed for use on FFG 7 class frigates. It includes only general information considered essential to inspection and troubleshooting. More detailed information may be found in the fin stabilizer technical manual, S9565-AA-MMO-000, **Maintenance Manual for Fin Stabilizer System** .

565-6.1.1.1 Equipment Inspection. Proper inspection will ensure that the equipment functions properly in all modes, will detect obvious deficiencies, and will ensure that all adjustments critical to safe and reliable operation of the equipment has been accomplished.

565-6.1.2 SAFETY PRECAUTIONS. Observe safety precautions during inspection and troubleshooting to prevent injury to personnel, damage to equipment, or both.

565-6.1.3 MAINTENANCE REQUIREMENT CARDS (MRC'S). Carry out inspections according to the procedures detailed in the MRC's. Enter any observed deficiencies into the Work Center Work List (WCWL)/Job Sequence Number (JSN) Log.

565-6.2 INSPECTION AND TROUBLESHOOTING

565-6.2.1 GENERAL. Minimize repair time by using logical inspection and troubleshooting techniques. Use the methods in the following paragraphs to identify defective areas or parts before disassembling equipment. Complete all required equipment repairs and adjustments before beginning inspection. Personnel performing inspection and troubleshooting shall be thoroughly familiar with the equipment and its function.

565-6.2.2 INSPECTION CRITERIA. Inspect the functional condition of all components before, during, and after operation. Perform inspection by sight, sound, touch, measurement and with instrumentation. Read the technical manual, S9565-AA-MMO-000, **Maintenance Manual for Fin Stabilizer System** , for specific inspection and troubleshooting techniques.

565-6.2.3 HYDRAULIC SUBSYSTEMS. Inspect and troubleshoot the hydraulic subsystem for:

a. leaks

b. loose connections

c. damaged hoses and fittings

d. correct pressure

e. dirty filters.

565-6.2.4 ELECTRICAL SUBSYSTEMS. Inspect and troubleshoot electrical subsystems and components observing the following paragraphs. For additional inspection and troubleshooting information, see **NSTM Chapter 300, Electric Plant - General** .

WARNING

Inspection of electrical systems and components shall be performed by qualified personnel. Systems and components shall be de-energized and ″DANGER″ tagged according to tag out procedures before inspections as required by PMS or when prudence dictates.

565-6.2.4.1 Inspect and test motors for:

a. loose connections

b. insulation resistance

c. lubrication

d. current phase balance

e. correct voltage

f. noise and vibration

g. overheating.

565-6.2.4.2 Inspect and test controllers for:

a. blown fuses

b. incorrect settings of overloads

c. dirty, worn, or bent contacts on switches and contactors

d. loose electrical and mechanical connections

e. sluggish operation of switches and relays

f. burned out indicators.

565-6.2.4.3 Inspect and test sensors for:

a. physical damage

b. open circuits or shorts

c. current draw

d. proper output.

565-6.2.5 MECHANICAL SUBSYSTEMS. Inspect for:

a. broken or cracked welds

b. loose or missing bolts

c. misalignment

d. noise and vibration

e. water leaks and cracks on the inboard edge of the finshaft sleeve.

SECTION 7.
MAINTENANCE

565-7.1 MAINTENANCE REQUIREMENTS

565-7.1.1 GENERAL. The following paragraphs contain the information for scheduled inspection and maintenance, and preventive maintenance, for the subsystems and components of the fin stabilizer system. Refer to the technical manual, S9565-AA-MMO-010, **Maintenance Manual for Fin Stabilizer System** , for more information.

565-7.1.2 SAFETY PRECAUTIONS. Only qualified and trained personnel shall perform maintenance on the various systems and components of the fin stabilizer. Observe safety precautions during maintenance to prevent injury to personnel, damage to equipment, or both.

565-7.1.3 PMS DOCUMENTATION. The Planned Maintenance System (PMS) documentation gives the required preventive maintenance schedule. OPNAVINST 4790.4 describes the PMS system. This document also covers departmental and work center record keeping, the Maintenance Index Page (MIP) No. 5651 **Stabilizing Fins, and the Maintenance Requirement Cards** .

565-7.2 DAILY MAINTENANCE

565-7.2.1 Perform the following maintenance daily:

a. inspect hydraulic fluid level

b. inspect for hydraulic fluid leaks

c. observe fluid temperature

d. inspect for water leaks at the finshaft outboard bearing

e. lubricate daily while operational

f. observe status of hydraulic filter bypass indicators.

565-7.3 WEEKLY MAINTENANCE

565-7.3.1 Perform the following maintenance weekly:

a. Inspect and charge lubrication reservoirs.

565-7.4 MONTHLY MAINTENANCE

565-7.4.1 Perform the following maintenance monthly:

a. Inspect a hydraulic fluid sample for contamination
b. Inspect accumulator charge pressure.

565-7.5 QUARTERLY MAINTENANCE

565-7.5.1 Perform the following maintenance quarterly:

a. Clean air emission system
b. Inspect angle transmitter unit (ATU) linkage and alignment
c. Inspect equipment mounting for loose or worn parts
d. Inspect filters.

565-7.6 SEMI-ANNUAL MAINTENANCE

565-7.6.1 Perform the following maintenance semi-annually:

a. Chemically inspect hydraulic fluid sample
b. Inspect indicator lights for proper operation
c. Perform functional checks on electrical units and controllers
d. Inspect sensors for proper operation
e. Lubricate fin shaft inboard bearing.

565-7.7 OTHER MAINTENANCE

565-7.7.1 Conduct other maintenance in accordance with the maintenance requirements of the system and the Class Maintenance Plan.

565-7.8 GENERAL MAINTENANCE AND TESTING

565-7.8.1 MAINTENANCE REQUIREMENTS. Maintenance activities for fin stabilizer systems include preventive and corrective maintenance. Preventive maintenance is performed to keep the system in good operating condition and to minimize the risk of having an operational failure. Corrective maintenance is the troubleshooting and repair work done to correct a problem with the system. The fin stabilizer system has a formal preventive maintenance plan which is part of the Planned Maintenance System (PMS). The specific maintenance procedures and scheduling requirements are outlined in the MRC's. Recommended maintenance requirements are also found in the technical manuals for the system. This section of the NSTM provides an overview of recommended maintenance practices that should be applied to most fin stabilizer systems.

565-7.8.2 PRECAUTIONS. Significant problems can be avoided if the following precautions are taken while performing any maintenance procedure on the system.

a. Safety - All safety guidelines should be followed at all times.

b. Avoiding contamination - Whenever the hydraulic system is opened to the atmosphere, small particles in the air and any dirt near the opening can enter the system. These contaminants readily travel throughout the hydraulic system and accelerate wear on the components. This contamination can be avoided by cleaning around the area of a filler cap or fitting before opening it, and by capping or covering the opening if it is to be exposed to atmosphere for any length of time.

c. Proper fluids, lubricants, and other components - Most fluids and lubricants have special properties and are not always compatible with fluids or lubricants conforming to different military specifications. The MRC's identify the correct fluids, lubricants, cleaners, and equipment for performing each maintenance action. These requirements should always be followed unless it is known with certainty that a substitution can be made.

565-7.8.3 MAINTENANCE GUIDELINES. The MRCs provide preventive maintenance instructions and schedule requirements for the fin stabilizer system. The following visual inspections should be performed on the equipment to identify any potential problems.

a. The oil level in each of the supply tanks, the head tanks, and the storage tank should be within the proper limits. The oil level in the supply tanks may fluctuate during operations. This is considered normal as long as the fluid level returns to the proper level.

b. The temperature gages should show readings within the normal operating temperatures. Most systems operate between 60 and 135° F.

c. The main, servo, and replenishment pressures should be checked to verify that the readings are not above the specified limits. Consult the technical manual for the proper pressure readings.

d. Check the system piping and components for signs of external leakage. Some oil leakage past the cylinder rod packing is allowed, but it should not exceed approximately 1/2 pint during a 24 hour period.

e. The oil filters should not have the pressure drop indicator showing that the filter element is clogged. When this occurs, the filter element must be changed immediately.

f. Linkages should be intact. Components should not be bent or broken.

g. There should not be any excessive noise or vibration in the system.

h. The foundation fasteners should be checked to make sure that none are loose.

i. There should not be any unauthorized equipment stored in or on the fin stabilizer equipment.

565-7.9 HYDRAULIC FLUID CLEANLINESS

565-7.9.1 CLEANLINESS REQUIREMENTS. The cleanliness, or lack of contamination, of the hydraulic system is extremely important in maintaining the fin stabilizer system. Any extraneous material that is present in the hydraulic system can be considered a contaminant. Fin stabilizer systems are required to have a fluid cleanliness level of NAS 1638 Class 9. For particles in the 5 to 15 micron size range, the number of particles allowed can be in accordance with NAS 1638 Class 10 requirements. The water content of the hydraulic fluid in any system should not exceed 0.5 percent. The acceptable neutralization number is 0.06.

565-7.9.1.1 Fluid cleanliness can be controlled by preventing contaminants from entering the system, proper filtration, and periodic fluid sampling. **NSTM Chapter 556, Hydraulic Equipment Power Transmission and Control** , provides a detailed explanation of fluid cleanliness.

565-7.9.2 SOURCES OF CONTAMINATION. The majority of fluid contamination in a system results from normal operation. When the surfaces of close-fitting components slide relative to each other, small fragments of metal are worn away. Debris such as paint, metal chips, and welding slag can be introduced into the system during installation or repair work. Small particles in the air and any dirt near an opening in the hydraulic system can easily enter the system during maintenance. These metal fragments and debris can be carried by the fluid throughout the system. The particles can get into the clearances of the moving parts and accelerate wear.

565-7.9.2.1 Water from condensation in the hydraulic fluid tanks is another source of contamination. Water dilutes the hydraulic fluid and accelerates the formation of rust. Air entrained in the hydraulic fluid is another contaminant. Air can enter the system through improperly fitted suction and return line flanges, the shaft seals of the pumps, and the cylinder packings. Air in the hydraulic fluid causes changes in the system response, the positioning accuracy of the cylinders, increases the noise level, and can cause the pump to cavitate.

565-7.9.3 HOSE INSTALLATION. Hoses are removed from the fin stabilizer system periodically for hydrodynamic testing at a shore facility. Testing is performed in accordance with S6430-AE-TED-010, **Technical Directive for Flexible Piping Devices, Flexible Hose Assemblies** . The hoses should be cleaned and capped when they are returned to the ship, otherwise they should not be accepted. Prior to installation, the cleanliness of each hose should be checked to ensure that there is no debris within the hose assembly. The procedure is simple. Moisten a lint-free cloth with hydraulic fluid. Attach a piece of wire that is longer than the hose length to the cloth. Pull the cloth through the hose with the wire. If a black film, rubber particles, or any type of gummy substance is seen on the cloth, the hose must be flushed before it is installed. The cloth test should be repeated after the hose has been flushed, capped, and returned to the ship. The hose should only be installed if it is clean. Contaminants in the hose from the hose cutting process and from the glue used on the hose fittings can easily enter the pump and damage the pump's internal components.

565-7.9.4 FLUID SAMPLING. Fluid sampling should be performed whenever fluid contamination is suspected or as required by the MRC's. Fluid samples should be taken from the main lines that connect the pump ports to the cylinders. The circulating fluid in these lines provides a representative sample of the fluid that is being pumped. Some systems have been equipped with vent and test valves in the hydraulic lines for obtaining fluid samples. Other systems require the use of pressure gauge ports.

565-7.9.4.1 Pressure Gauge Port Sampling. When pressure gage ports are used to obtain a fluid sample, the following procedure should be followed.

a. Operate the power unit until the normal operating temperature is reached. The power unit should be operating while the sample is taken.
b. Clean around the area where the sample will be taken. Dirt or dust particles that enter the fluid sample bottle will lead to inaccurate contamination readings.
c. Ensure that the sample bottle is completely clean and completely air dry. Any moisture in the bottle will be considered water contamination of the system.
d. Close the valve for the pressure gauge line, disconnect the gauge, open the valve and allow a pint or quart of fluid to drain into a bucket. Once some of the fluid has drained, fill the sample bottle.
e. Close the valve, reconnect the pressure gauge, and re-open the valve.

565-7.9.4.2 Vent and Test Valve Sampling. If vent and test valves are installed in the system, these valves can be used to collect fluid samples by attaching the portable hose assembly to the valve. Allow a pint to quart of fluid to drain into a bucket to eliminate any particles or fluid that may have settled from getting into the sample. After enough fluid has drained, fill a clean, dry sample bottle with fluid.

565-7.9.4.3 Visual Inspection. After obtaining the fluid sample, allow the sample to settle for at least one hour, then examine the fluid. A cloudy or milky appearance indicates fluid emulsification (oil, water or air contamination). A layer of clean water beneath the fluid or milky-appearing strings within the fluid are signs of water contamination. Granules or darkness seen at the bottom of the sample when it is held up to a light are signs of particulate contamination.

565-7.9.4.4 Fluid Analysis. An analysis of the hydraulic fluid contamination by a naval test facility is required in accordance with PMS or whenever one of the following conditions exist:

a. immediately before overhaul
b. immediately before the first sea trials following an overhaul
c. immediately after sea trials following an overhaul
d. after repairs have been accomplished on the hydraulic system or on hydraulic components that required the hydraulic system to be opened.
e. when reliability is in doubt.

565-7.9.4.4.1 Whenever a fluid sample is taken, the sample should be marked with the ship's name and date, the sample point, and the approximate length of time the system was in operation before sampling.

565-7.10 REMOVING FLUID CONTAMINANTS

565-7.10.1 FILTERS AND STRAINERS. Fin stabilizer systems use filters conforming to MIL-F-24402, **Filters, (Hydraulic), Filter Elements (High Efficiency), and Filter Differential Pressure Indicators, General Specification For** or MIL-F-24702, **Filter Elements, Hydraulic, Disposable, General Specification For** . The filter elements are not cleanable. They should be disposed and replaced when the indicator shows evidence of a clogged filter or when required by the MRC. If the filter clogs more than semi-annually, the hydraulic system should be evaluated to determine the cause and eliminate the source of the contamination. Strainers, suction strainers, and breathers are located at the fill connections of the fluid tanks and at other locations to prevent large particles from entering the system. The strainers should be cleaned when dirt can be seen.

565-7.10.2 PORTABLE FILTRATION CARTS. When the contamination level of the fluid is higher than normal but there has not been a major failure that resulted in massive contamination of the system, the hydraulic fluid can be filtered by a portable filtration cart (also called a filter buggy or filtering rig, National Stock Number 4330-01-044-7992). Systems with sediment or particle contamination that can be detected by visual examination of the fluid sample should be filtered with the filtration cart.

1. Check that the fluid level in the supply tank is at the proper level for normal operation.
2. Connect the filtration cart to the supply tank.
   a. If the tank has quick-disconnect fittings, connect the portable filter suction hose to the lower quick-disconnect fitting. Connect the filter discharge to the upper quick-disconnect fitting.
   b. If the tank is not fitted with quick-disconnect fittings, put the suction hose as close to the bottom of the reservoir as possible. Put the filter buggy return hose in the top of the reservoir, keeping the hoses as far apart as possible.
3. Open the quick-disconnect shut-off valves if the quick-disconnects were used to connect the hoses.
4. Energize the portable filter unit and start the hydraulic pumps. Allow the fluid to circulate for one hour. Cycle the fin once every five minutes to prevent heat build-up.
5. Check that the hydraulic fluid level has not dropped below the low level mark. The fluid level will fluctuate when the fin is cycled.
6. Obtain a sample of hydraulic fluid for analysis.
7. Stop the filter unit and stop the hydraulic pump.
8. Check that the quick-disconnect shut-off valves are closed, if they are part of the configuration.
9. Disconnect or remove the hoses from the tank.
10. Return equipment to readiness condition.

565-7.10.2.1 More information on filtering rigs can be found in **NSTM Chapter 556** .

565-7.10.3 FLUSHING PROCEDURES. The fin stabilizer hydraulic system seldom requires flushing. System or component flushing may be required only as a result of one or more of the following conditions:

a. installation of a new system during ship construction or an alteration that results in the replacement of many system components
b. catastrophic failure of a system component that results in major contamination of the hydraulic system
c. major contamination of the hydraulic fluid from an external source
d. major system repair that involves pipe welding, brazing or drilling operations.

565-7.10.4 INSTALLATION OR MAJOR ALTERATION. The hydraulic system, as well as the remaining fin stabilizer components, are installed during the ship construction. The shipbuilder assumes responsibility for hydraulic system cleanliness and any appropriate system or component flushing necessary. The responsible shipyard may use its own NAVSEA-approved flushing procedures or may use those procedures provided in MIL-STD-419, **Cleaning, Protecting, and Testing Piping, Tubing, and Fittings for Hydraulic Power Transmission Equipment** . Major system alterations, especially those calling for piping rip-out and the installation of new piping runs, may require flushing those portions of the piping system affected. In most cases, total system flushing should not be necessary. Pipe segments and piping adapters should be flushed individually in a qualified shore facility. The clean components should then be capped in accordance with MIL-STD-419 and transported to the ship for installation. New pumps, valves, and other assembled hydraulic components may not require flushing if proper cleanliness standards, verification methods and transportation requirements have been specified during the procurement of the components. After completing installation of the system aboard ship, hydraulic fluid sampling should be performed. If extreme contamination is not present, hydraulic system filters may be used to filter the hydraulic fluid by circulating the fluid through the piping using the system pumps and valves. Repeated sampling may be necessary until the hydraulic fluid meets the fluid cleanliness requirements specified for the system. (Cleanliness requirements vary with the component manufacturer's specifications for the equipment. The equipment requiring the lowest particle count limits determines the overall system cleanliness.) When flushing is completed, the filter elements should be replaced to ensure full capacity.

565-7.10.5 CATASTROPHIC FAILURE OF SYSTEM COMPONENTS. A catastrophic component failure most likely will result within rotating hydraulic equipment, such as pumps. High fluid temperature, improper hydraulic fluid, excessive water in the hydraulic fluid and externally-introduced contamination, may all contribute to an extremely high wear rate, causing a considerable volume of large metallic particles to be generated and released into the system. A failure such as this requires careful examination of the entire fin stabilizer hydraulic system to determine the extent of the damage; not only to the primary component of failure, but also to ancillary components. After repairing and replacing the failed component(s) as well as isolating and correcting the cause of failure, system flushing should be performed. If possible, system components should be removed from the ship and cleaned and flushed within an approved shipyard facility. If a suitable facility is not available, the fin stabilizer hydraulic system may be flushed in accordance with **NSTM Chapter 556, Hydraulic Equipment Power Transmission and Control** and as detailed in MIL-STD-419. The fin stabilizer hydraulic system is not a looped circuit. The piston in the hydraulic cylinder presents a barrier to the fluid. Thus, the fluid leaving the pump and the fluid returning are different. Therefore, flushing the hydraulic system can be performed only through sections of the piping at any one time. For best flushing results, the individual piping sections may be isolated in accordance with their service duty. The recommended piping sections are:

a. high-pressure

b. suction and return-line

c. control and emergency pump

d. gauge.

565-7.10.6 HIGH-PRESSURE PIPING. As stated, component flushing should be performed in a qualified shore facility, if possible. If this method is not available, flushing may be performed in accordance with MIL-STD-419. Piping should be disconnected at the pump and at the cylinder. The connecting piping may now be flushed using an external flushing pump and jumper hoses connected to establish a loop. Valves and pumps should be cleaned in the ship's hydraulic shop through disassembly, careful cleaning and reassembly. Individual component maintenance procedure information, found in the relevant technical manual, should be observed. After full reassembly of the system, further sampling and fluid filtration should be performed.

565-7.10.7 SUCTION AND RETURN-LINE PIPING. Hydraulic system supply tanks should be drained and cleaned prior to any flushing of the attached piping. Suction strainers within the tanks should be cleaned prior to refilling the tanks with fluid. Suction and return-line piping should be disconnected from the supply tank and the system pump and then looped with a jumper hose similarly to the high-pressure piping described above. Components such as heat exchangers and shut-off valves may be left in the loop and flushed at the same time. Flushing this loop in the reverse flow direction may be helpful in inducing more particles to dislodge from cavities within the components. However, if a suction filter is present, the internal filter element should be removed to prevent the element from collapsing. A new element should be installed when the flushing is complete.

565-7.10.7.1 Gauge Piping. Since all of the gauge piping is dead-ended and fluid in these lines is essentially static, flushing these lines may be unnecessary. If the presence of contamination is suspected, the gauge lines may be flushed individually similarly to the high pressure piping described above.

565-7.10.8 EXTERNAL SOURCE CONTAMINATION. The results of contamination introduced from an external source may be similar to those of a catastrophic component failure. Indeed, a catastrophic component failure may result from such a contamination. System flushing, therefore, should be performed similarly to the procedures described in the previous section. Depending on the type of the contamination, all of the system hydraulic fluid should be drained and filtered using an external filtration system. A chemical contamination that results in degradation or break-down of the fluid requires discarding and replacing the fluid. Disposal of the contaminated fluid shall be in accordance with local, state and federal laws or the fluid should be retained in containers for shore disposal.

565-7.10.9 PIPE WELDING, BRAZING OR MECHANICAL REPAIR. The pipe section designated for welding, brazing, drilling or any other repair procedure shall be disconnected from the remainder of the system prior to any work being performed. When the repair or modification has been completed, the piping section should be cleaned and hydrostatically tested using the procedures for cleaning and pickling detailed in MIL-STD-419.

565-7.11 LUBRICATION

565-7.11.1 FIN UNIT. All moving components of the fin unit require lubrication. Each unit has a lubrication chart posted that identifies where the equipment must be greased. The chart can also be found in the system technical manual. Grease fittings are provided at several locations in the system so that disassembly of the equipment is usually not needed. MIL-G-24139, **Grease, Multipurpose, Quiet Service** is the proper grease for the unit and should be applied through the grease fittings.

565-7.11.2 FIN BEARINGS. Proper lubrication of the fin bearings is important to system operation.

565-7.12 PUMP TESTS

565-7.12.1 GENERAL. Pump tests are performed to determine whether the pump is operating properly and the pump settings or adjustments are correct. Pump test procedures are outlined in the MRC's. Equipment manuals for the pumps describe in detail the porting, rotation, output, and other features that affect operation. These manuals should be used as references if needed when conducting pump tests. Safety precautions should always be followed. The fluid level in the pump case should be checked to ensure it is full after any maintenance is performed on the system which requires the system to be opened.

565-7.13 REPORTING FAILURES

565-7.13.1 CASUALTY REPORTS. Casualties in the fin stabilizer system should be reported using the lowest level Allowance Parts List (APL) number of the part that actually failed, rather than the overall APL number of the fin stabilizer system. If possible, the National Stock Number (NSN) of the failed part should also be reported.

565-7.13.2 4790-2K. In the event of a failure, the operating conditions at the time of the failure should be recorded with as much detail as possible on a Form 4790-2K. This information can assist the technical teams in the troubleshooting and repair of the failed components.

565-7.14 OVERHAUL

565-7.14.1 GENERAL. When the ship is in an overhaul period or a similar industrial activity environment where the system will not be in operation for a week or longer because the ship is dry-docked, the fin stabilizer system must be protected from potential damage. Dirt and moisture are the two biggest enemies.

565-7.14.2 MACHINERY PROTECTION. Components, especially the piston rods of the cylinders which are not painted may become pitted or show signs of corrosion if not protected. To protect the fin unit, apply a medium coat of MIL-G-23549, **Grease, General Purpose** to the piston rod surface. Drape the fin units and power units with a canvas cover. If additional guards or shields are needed, metal or wooden materials plus canvas can be used for the topping cover.

565-7.14.3 ELECTRICAL EQUIPMENT PROTECTION. The following steps should be taken to protect the electrical equipment during an overhaul period.

1. Follow all safety precautions.
2. Install a drying agent and protective covering.
   a. Open the access door or remove the panel cover.

WARNING

Consider all electrical leads to be energized until positively proven they are de-energized.

   b. Test the unit with a multimeter to ensure circuits are de-energized.

WARNING

High-voltage, high capacitance components may contain voltages dangerous to life.

   c. Discharge high-voltage, high-capacitance components to electrical ground, if applicable.
   d. Install fishpaper such as MIL-I-695, **Insulation, Electrical, Paper (Slot-cell)** between accessible contact surfaces.

e. Install silica-gel packets conforming to MIL-D-3716, Desiccants, Activated for Dynamic Dehumidification in the controller case at a rate of 1/2-pound for each cubic foot of space. Count the number of packets installed and note this number on a tag. Attach the tag inside of the case.

f. Close the access door or reinstall the panel cover.

g. Install plastic or herculite covering, if required. Seal the openings with pressure-sensitive tape.

3. If the ship is waterborne, the system should be operated at least once a month by personnel who are familiar with fin stabilizer system operating procedures.

a. Remove the canvas covering from the fin unit and power unit.

b. Clean the grease from the piston rod surface.

WARNING

Exercise extreme caution in the vicinity of the operating equipment.

c. Start the power unit in accordance with operating procedures.

d. Engage the local control unit for the fin unit.

e. Cycle the fin.

f. Disengage local control unit. Stop the power unit.

g. Apply a medium coat of grease to the piston rod.

h. Reinstall the canvas cover.

i. Repeat the procedure so that each fin is operated.

4. If the ship is waterborne and no electrical power is available to operate the power units, the system should still be operated on a monthly basis by using the hand pump.

a. Remove the canvas covering from the fin unit.

b. Clean the grease from the piston rod surface.

WARNING

Exercise extreme caution in the vicinity of the operating equipment.

c. Line up the hydraulic system in accordance with the standard operating procedures.

d. Operate the hand pump in accordance with the standard operating procedures and cycle the fin. Return the fin to neutral position.

e. Return the hydraulic system to readiness condition.

f. Remove the coupling cover from the main power unit.

g. Rotate the pump shaft several revolution by hand.

h. Reinstall the main pump coupling cover.

i. Apply a medium coat of grease to the piston rod surface.

j. Reinstall the canvas cover.

k. Repeat the procedure so that each fin is operated.

5. Measure the insulation resistance for motors that have not been operated in the past 90 days.

a. Open the motor controller access cover.

NOTE

Existing wiring configurations of indicating lamps or electrical interlocks on some controllers, provide a low voltage feedback circuit at auxiliary contacts when the power sources are de-energized. Be sure to de-energize the power supplies to the motor controller and tag ″OUT OF SERVICE.″ Remove the tape and covering from the controller, if required.

WARNING

Consider all electrical leads to be energized until it is positively proven that they are de-energized.

b. Test with a multimeter to ensure that the circuits are de-energized.

c. Measure the insulation resistance between the ship hull and the power leads on the motor. The minimum insulation resistance is 0.5 megohms for ac motors.

d. Close the motor controller access cover and reseal it if necessary.

e. Remove the safety tag and energize the power supplies.

6. Once the overhaul period has ended, the system must be prepared for use.

a. Remove the cover from the fin unit and power unit.

b. Clean the grease from the piston rod surface.

c. Remove the protective covering and drying agents from the electrical components.

d. Open the access doors or remove the access panels.

e. Remove the note tag and the silica-gel packets. Be sure to check that the number of packets removed is not less than the number recorded on the tag.

f. Remove the fishpaper from the contacts if it was installed.

g. Close the access door or reinstall the access cover.

h. Remove the safety tag from the circuit.

SECTION 8.
REPAIR

565-8.1 INTRODUCTION

565-8.1.1 Certain repair must be carried out when shore based or alongside a tender. These include repair of the fin, fin shaft, tiller, and fin shaft bearings, and calibration of instruments and sensors. Other repairs may be made while under way.

565-8.2 PROCEDURES

565-8.2.1 PREVENTIVE MAINTENANCE. Preventive maintenance will reduce or eliminate failures in the fin stabilizer system. Follow the instructions of maintenance requirement cards and technical manuals when making repairs.

565-8.2.2 SAFETY. Observe all safety precautions when making repairs to prevent injury to personnel, damage to equipment, or both.

565-8.3 FIN STABILIZER

565-8.3.1 Repairs to the stabilizer fins, fin shafts, and fin bearings shall not be made while underway, or without tender based or shore based facilities.

565-8.4 HYDRAULIC SYSTEMS

565-8.4.1 FILTERS, HOSES AND FITTINGS. Filters, hoses, and fittings may crack or rupture. Repair by replacing the failed component. Follow maintenance requirements when cleaning and refilling the hydraulic system.

565-8.4.2 HYDRAULIC SYSTEM COMPONENTS. Usually repair failure of sensors, valves, and similar parts by replacing the part. Seals and packings in hydraulic cylinders can be replaced. Some seals and bearings in hydraulic valves can be replaced.

565-8.4.2.1 Pump. Replace hydraulic pumps when they fail. External leaks may be repaired by replacing seals. Cleanliness is very important when working on hydraulic pumps.

565-8.5 ELECTRICAL

WARNING

To prevent injury or death, de-energize the electrical power and tag it ″OUT OF SERVICE″ in accordance with ship's procedures before making repairs.

565-8.5.1 MOTOR. Remove the motor from the pump and disassemble and repair the motor in accordance with **NSTM Chapter 300, Electric Plant - General** .

565-8.5.2 CONTROL SUBSYSTEM. Repair or replace parts in accordance with the maintenance manual. When it is cost effective, automatically replace, instead of repair, any part that does not operate properly.

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.