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CONTENTS

CHAPTER 6

HYDRAULICS IN MISSILE LAUNCHING SYSTEMS

INTRODUCTION

In the process of passing from striker to GMM 3 and then to GMM 2, you have learned the theory of hydraulics as applied to missile launching systems. You have learned how to operate the hydraulically powered handling equipment and missile launching machinery, and how to drain and refill the hydraulic systems. You know how to look for leaks, check pressure, check fluid level, charge accumulators, and disassemble, inspect, clean, and lubricate hydraulic equipment

Every missile launching system in current use is operated in part by hydraulic power. The network of piping required to carry the oil, and the valves to direct, restrict, relieve, or shut off the flow afford numerous places for trouble to develop. Constant inspection and maintenance are necessary to keep the systems operating smoothly. You know from experience that the trouble spot is sometimes hard to locate. To advance to GMM 1 or GMM C, you need to become more expert in troubleshooting hydraulic systems and learn to test, adjust repair, and overhaul them. Overhaul of the whole system is done at shipyards.

Hydraulic power drives have been used in the Navy for many years to train and elevate guns and when launchers were needed for rockets and missiles, power drives were adapted for them. The principal advantage of hydraulic power drives is their ability to move large loads smoothly and quickly. A disadvantage is the need for constant maintenance. Strict adherence to the instructions in the maintenance publications and the Maintenance Requirement Cards (MRCs) will help the equipment to retain its design characteristics of power, speed, and control, and will help to eliminate extensive repairs and costly replacement. Correct casualty analysis can be made only by someone with a thorough knowledge of how the equipment operates. When trouble develops, reach first for the OP - not for your wrench.

Hydraulic systems can actuate mechanisms almost instantaneously, with almost 100 percent efficiency; but leakage or foreign matter can make the whole system in operative. Daily checks on leakage, and constant vigilance against entrance of foreign matter, are very important parts of hydraulic system maintenance. You have learned many of the basic types of repairs, such as replacing pipes and pipe sections, fittings, gaskets, and valves; cleaning or replacing filters; venting the system of air; and replacing broken or defective mechanical parts. Now you need to learn how to adjust all parts of the hydraulic system, and to overhaul and repair any part. To qualify for GMM C you must be able to plan and supervise the repair and maintenance program. Since many parts of a launching system are operated by hydraulic power, many components are involved. There is not just one power drive unit to be maintained, but several, each with attached electrical, electronic, mechanical, and/or pneumatic components. You have to interpret the application of basic hydraulic principles in each system.

This chapter will expand on the information given in the preceding text, *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199 and will give information on the more technical aspects of maintenance and alignment. The safety factors will be mentioned briefly in connection with the work, but a more complete treatment will be given in chapter 12. Emphasis will be given to your responsibility in planning, implementing, and supervising maintenance and repair work, in inspection of work done by others, and testing before and after work is done on equipment. Alignment of components of a launching system is a precise operation that requires both knowledge and skill. The information in this chapter will tie in with that of the preceding chapter.

HYDRAULIC POWER IN MISSILE SYSTEMS

Hydraulic power drives are used in missile systems to load and unload missiles from a magazine stowage area to the launcher guide arm, to position missile launchers in train and elevation for firing, to load and off load missiles from ship to ship or from ship to shore, and in some systems to jettison unwanted missiles. Hydraulics are also used in the missile themselves to control the missile flight attitude through movement of missile control surfaces (wings). This chapter will explain hydraulics in launching systems so we'll not discuss hydraulics in missiles. How hydraulic systems control the missile's flight path is explained in GMM 3&2, NT 10199.

HANDLING EQUIPMENT

The use of handling equipment in loading, strikedown, strikeup, and offloading was described in chapter 2, but little was said about the source of power for the equipments used. Figure 2-17 showed hand lift trucks used to move the Asroc missile in its container. Two trucks are required. The Mk 41 has a hydraulically operated lifting arm, located at the front of the truck, to raise or lower the container. Closing the pressure-release valve and operating the hydraulic pump handle raises the lifting arm. It is lowered by opening the pressure-release valve. The Mk 42 uses a screw jack, operated by a ratchet wrench, to raise or lower the lifting arm. The Mk 41 hand lift trucks are being replaced by the Mk 42.

Transfer dollies of different mods, but similar in construction and operation are used for transferring missiles. The framework and shock absorbers protect the missile against accidental impact, and the hydraulic or hydraulic-mechanical brakes make control positive. They are called "dead-man" brakes. Some dollies are designed for use with a particular missile, and others, such as Weapon Component Transfer Dolly Mk 6 Mod 0, are adaptable to several types (Terrier missile, Terrier booster, or Tartar, in this instance). This type of transfer dolly is used for transfer at sea, and to move the missile about on deck.

Other hydraulically operated handling equipment includes ready service cranes, transfer cranes, and hydraulic booms. The strikedown elevator and hatch in the Mk 10 launching system are hydraulically operated by the loader accumulator power drive. The ship's elevators also are operated by electrohydraulic power. Hydraulic fluid provides the "muscle" for much of the moving machinery aboard ship. The electrical system activates and controls the hydraulic system.

HYDRAULICS IN THE FEEDER SYSTEM

The feeder system of a typical missile launching system includes the magazine, loader (rammer), assembler, and strikedown equipment. Tartar missiles do not require assembly areas, and have no strikedown area for checkout or repair. Otherwise, we can consider Mk 10(Terrier) as a typical launching system. What components are operated by hydraulic power?

The loader accumulator power units are located in the strikedown and checkout area and supply hydraulic power to:

1. Spanning rails and blast doors.
2. Retractable rails.
3. Floating rails on tracks.
4. Loader positioner.

Magazine Accumulator Power System

Each magazine accumulator power system has four accumulators, and supplies hydraulic fluid for operating:

1. Ready service drive motor.
2. Tray-shift mechanism.
3. Magazine hoist.
4. Magazine doors.

The ready service ring may be rotated in either direction by the hydraulic motor. The tray-shift mechanism, used to transfer a missile either from the ready service ring to the hoist, or the reverse, is moved by extending a hydraulically operated piston rod. The magazine doors are hydraulically opened upward, and may be locked open or closed by means of latches which are operated hydraulically. The hoist has a hydraulic drive unit with upper drive transmission, lower drive transmission, and drive shafts. The accumulator power supply system consists of an electric motor, piston pump, supply tank, header tank, control valve block, and four accumulators.

The location of each of the power units varies somewhat with the mark and mod of the system, and the ships on which they are installed. The Mk 10 Mod 7 system is installed forward on the 01 level of DLG-26 class ships and it has three ready service rings instead of the usual two. Mods 3 and 4 are installed aft and athwartship from each other on CV A-63 class ships, which imposes a different placement of the ready service rings (and their power units). It is not so much the location of the different units that you need to memorize, as the action and interaction of the different components in the system.

Magazines with two sides, A and B, which include all Talos and Terrier, have two magazine accumulator systems, one for each side, to supply power to the magazine components. Figure 6-1 shows the location of components in the Mk 10 Mod 7 system. The accumulator flasks are not shown in this illustration; the high pressure accumulator pump is inside the fluid-filled supply tank, and is therefore not visible. This system has one header tank common to both A and B sides.

The supply tank holds the hydraulic fluid, the motor driven pump produces the hydraulic pressure, the valves in the valve block regulate system pressures, and the accumulator flasks store energy, absorb hydraulic shocks, and prevent excessive pressure fluctuations. A solenoid assembly, attached to the valve block, actuates the dump valve to dump pressure fluid to the tank when the system is deactivated.

Systems that require a large volume of pressure fluid usually make use of a parallel piston pump instead of a gear pump. In addition, all power drives have an auxiliary pump, which may be power-driven or manually operated. This is used to provide a limited supply of hydraulic fluid for emergency operation. During maintenance or installation, the hand pump is used.

Several types of valves and a parallel piston pump were illustrated and described in *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199. Not all power drives have all the associated valves in one valve block but may have several separate assemblies. The valves control the volume of fluid, the direction of flow, and the pressures at which the system operates.

Figure 6-2 is a schematic of the magazine accumulator system used in the Mk 10 Mod 0 Terrier system. The accumulator flasks, one of which is shown with the internal bladder and the poppet valve, are charged with nitrogen through nitrogen valves. The pressure required varies with the temperature; refer to the data chart on the charging valve block when checking the pressure. This is one of the daily maintenance procedures; use the MRC cards if you have them aboard, and if not, use OP 2351, vol. 1. Be sure you have the latest revision.

Checking the fluid level in the header tank is another daily maintenance job. The system must be shut down before you do this. Most header tanks have a sight gauge through which you can see the fluid level. Use the MRC (or the OP) for step-by-step instructions.

The electric motor to operate the pump (inside the supply tank) is coupled to the pump through a mounting flange. The pump draws the hydraulic fluid through the intake screen and discharges the fluid under pressure to the valve block. From the valve block, the pressurized fluid is passed through the filter elements and the filter bypass valve to the unloading and starting valves. If the filters are clogged and the fluid must pass through the filter bypass valve, a light on the EP-2 panel comes on, showing that the filters must be replaced. In an emergency it is possible to continue operating the power drive when the filters are clogged, but in practice sessions you would stop the operation and replace the filters. For practice in servicing filters (fig. 6-3), remove the 12 filter elements from the multielement filter assembly, inspect the elements, replace them, and reassemble the unit. Follow the MRC instructions (or the OP). This assembly filters the pressure fluid passing from

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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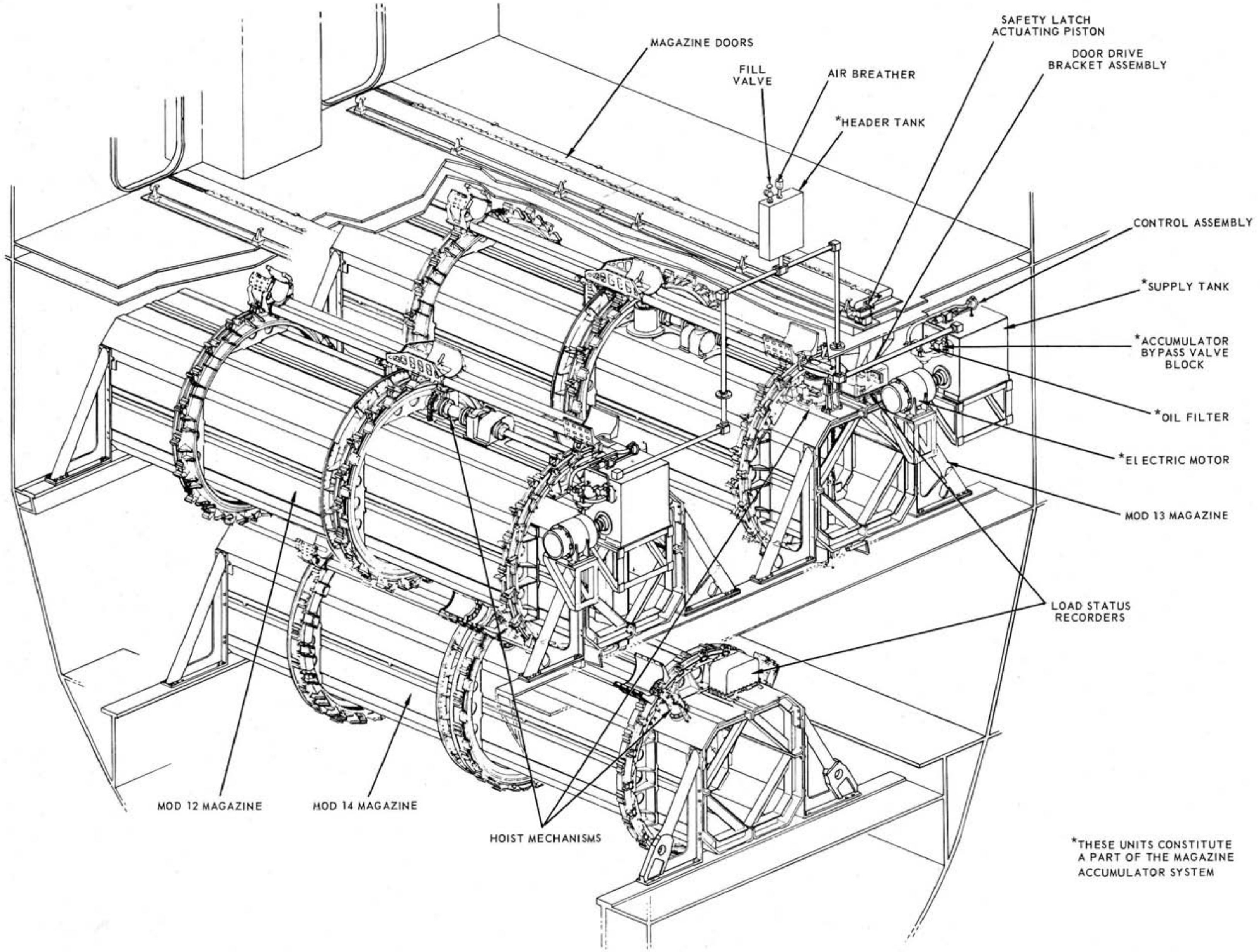

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Figure 6-1.—Guided Missile Magazine, Mk 10 Mod 7 launching system; location of magazine accumulator components.

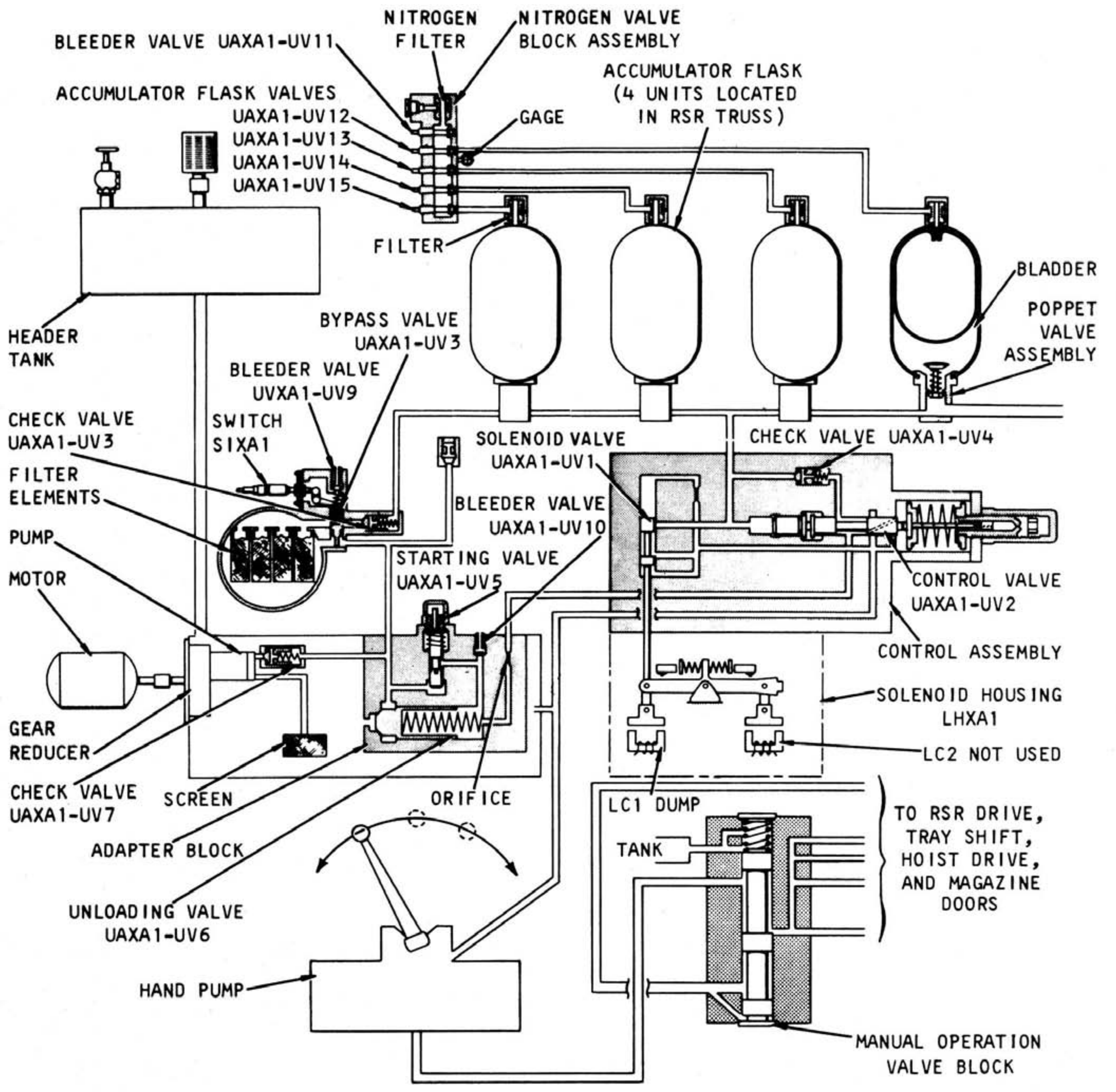

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Figure 6-2.—Hydraulic schematic of Power Drive Mk 64 Mod 0.

the adapter block to the accumulator flask assembly. It is mounted on the side of the supply tank.

The pressure fluid passes around the unloading valve, which is operated by the control valve, and goes on to the starting valve. The check valve allows the fluid to go in only one direction. The control valve maintains the pressure between the set limits (for example, 1300 to 1500 psi), by control of the unloading valve opening or closing It as needed to keep the pressure within limits. Excess pressure fluid is ported to the tank, Pressurized fluid passes through the check valve into the accumulator flasks, where

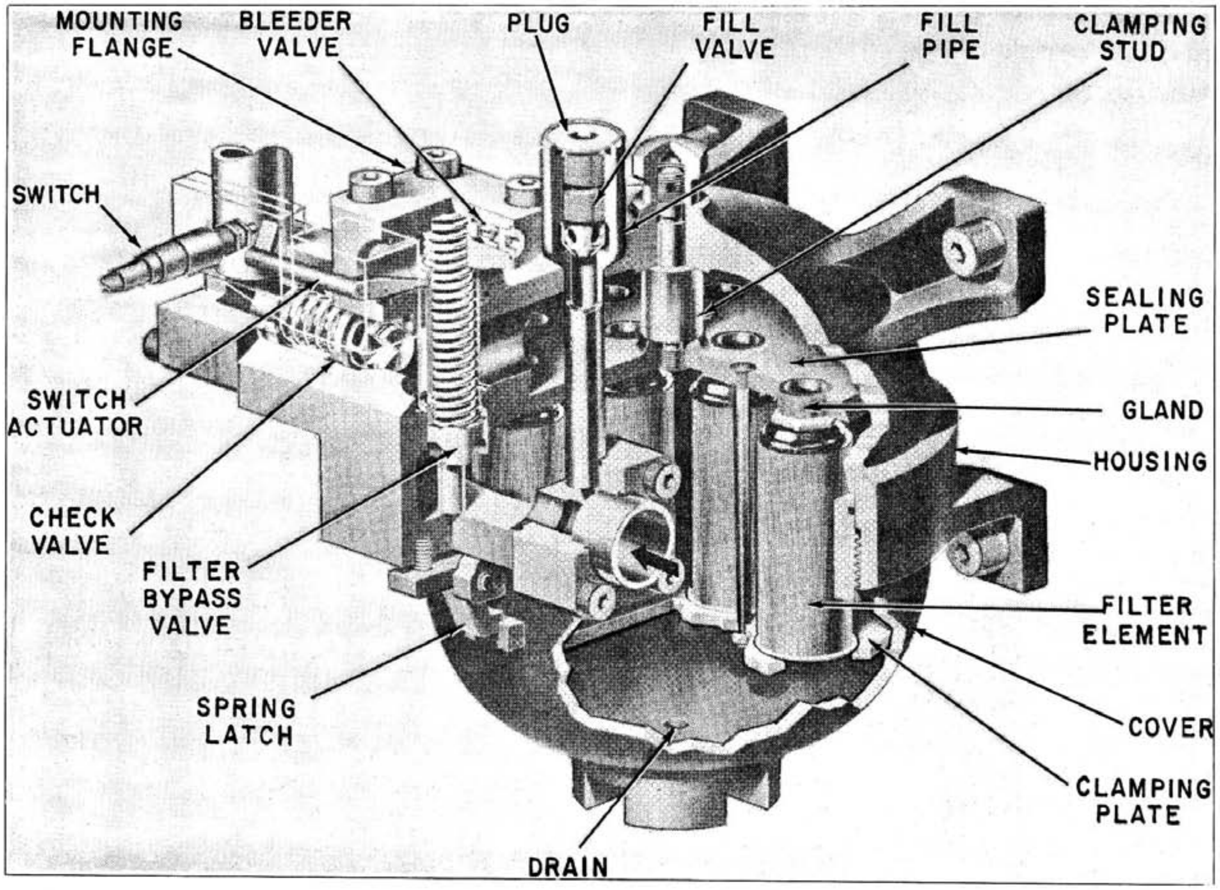

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Figure 6-3.—Multiple element hydraulic filter assembly.

some is stored to maintain a steady pressure in the system.

The connection of the hand pump to the system is also shown in figure 6-2.

TRAY SHIFT MECHANISM. - The tray shift mechanism is located at the top of the ready service ring truss at station 1, the transfer station. Its operating power comes from the magazine accumulator power system. The saddles on the tray, which hold the missile, also are operated by hydraulic power from the same source. On Mk 10 Mods 7 and 8 systems, there is an inter-ring transfer system to transfer missiles from one ready service ring to another. Hydraulic power is received from the magazine accumulator power system via piping, controlled by selector valves, solenoid valves, check valves, pilot valves, and interlock valves, actuated by electrical signals. Figure 6-4 shows the valve block for the tray shift mechanism at station 1 (the transfer station). The operating cylinder with its piston and orifice rod does the actual positioning of the tray.

The detented solenoid LHDA1 (fig. 6-4) is attached to the side of the valve block. There are two switches, but only one is shown (SIDA2). Tray shift latch-operating valves UVDA5 and UVDA4 actuate the switches. Selector valves UVDA6 and UVDA7 can port the hydraulic fluid in either direction, depending on where the fluid enters. Solenoid valve UVDA2 controls the direction of fluid flow to pilot valve UVDA3, and connects by a plunger rod to LHDA1. The pilot valve controls the direction of operation of the latch-operating valves. UVDA9 and UVDA10 are simple plunger check valves that permit leakage to return to the tank. UVDA1 is

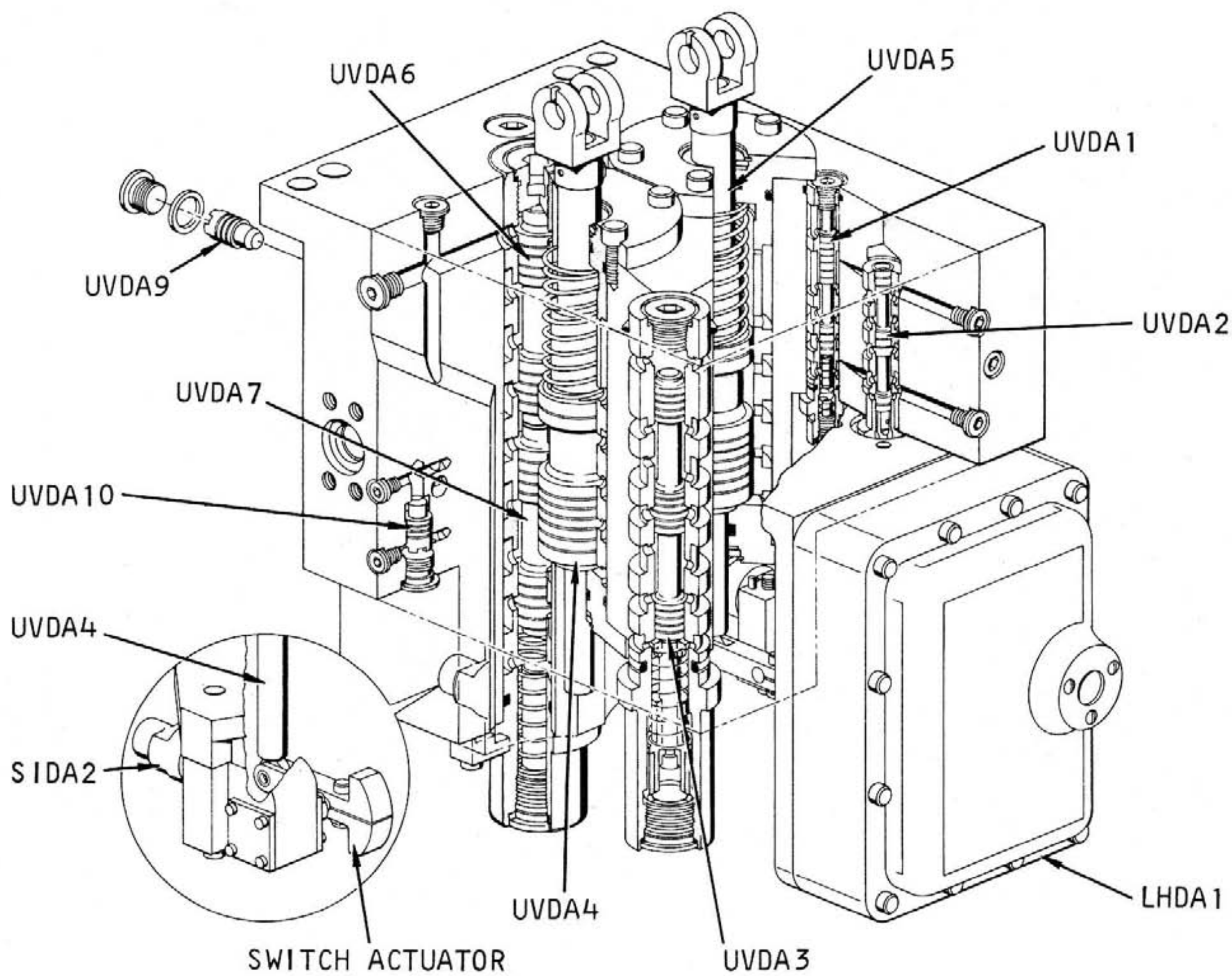

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Figure 6-4.—Station 1 tray shift control in Mk 10 Mod 7 launching system.

an interlock valve that prevents movement until the required conditions are met.

HOIST MECHANISMS. - The location of the hoist mechanisms was pointed out in figure 6-1. These, too, operate on hydraulic power from the magazine accumulator power system. The function of the hoist mechanism is to raise missiles from the ready service ring to the loader, or to return them during unloading. Figure 6-5 shows the mechanisms of the A-side hoist. The telescoping columns that raise or lower the missile are driven by chains and gearing. The hydraulic motor (B-end) drives the gearing. The upper drive is a gearbox driven by the intermediate drive shaft from the lower drive. The hoist heads contact the shoes (forward or aft) that support the missile round in the tray. The probe on the aft hoist head aligns the head with the loader trunk in the hoist-raised position. The head of the aft shoe hoist is more elaborate than the forward one.

The hydraulic control valve block is mounted on the wall of the lower transmission housing, and two detented solenoids are mounted on top of the valve block (fig. 6-5). It contains a metering valve to regulate the flow of oil, an orifice valve to control speed of the B-end by size of the orifice, a pressure-off valve to shunt pressure to the power-off brake, a selector valve to control direction of the B-end movement, a sequence selector valve to pull the appropriate latch in the hoist drive assembly, an interlock valve to prevent movement before all conditions are ready, and two solenoid valves to control the flow of fluid to the sequence selector valve. The power-off brake is used during maintenance or installation or if the pressure falls below 900 psi (normal, 1500 psi).

MAGAZINE DOORS.- The location of the magazine doors in relation to the ready service

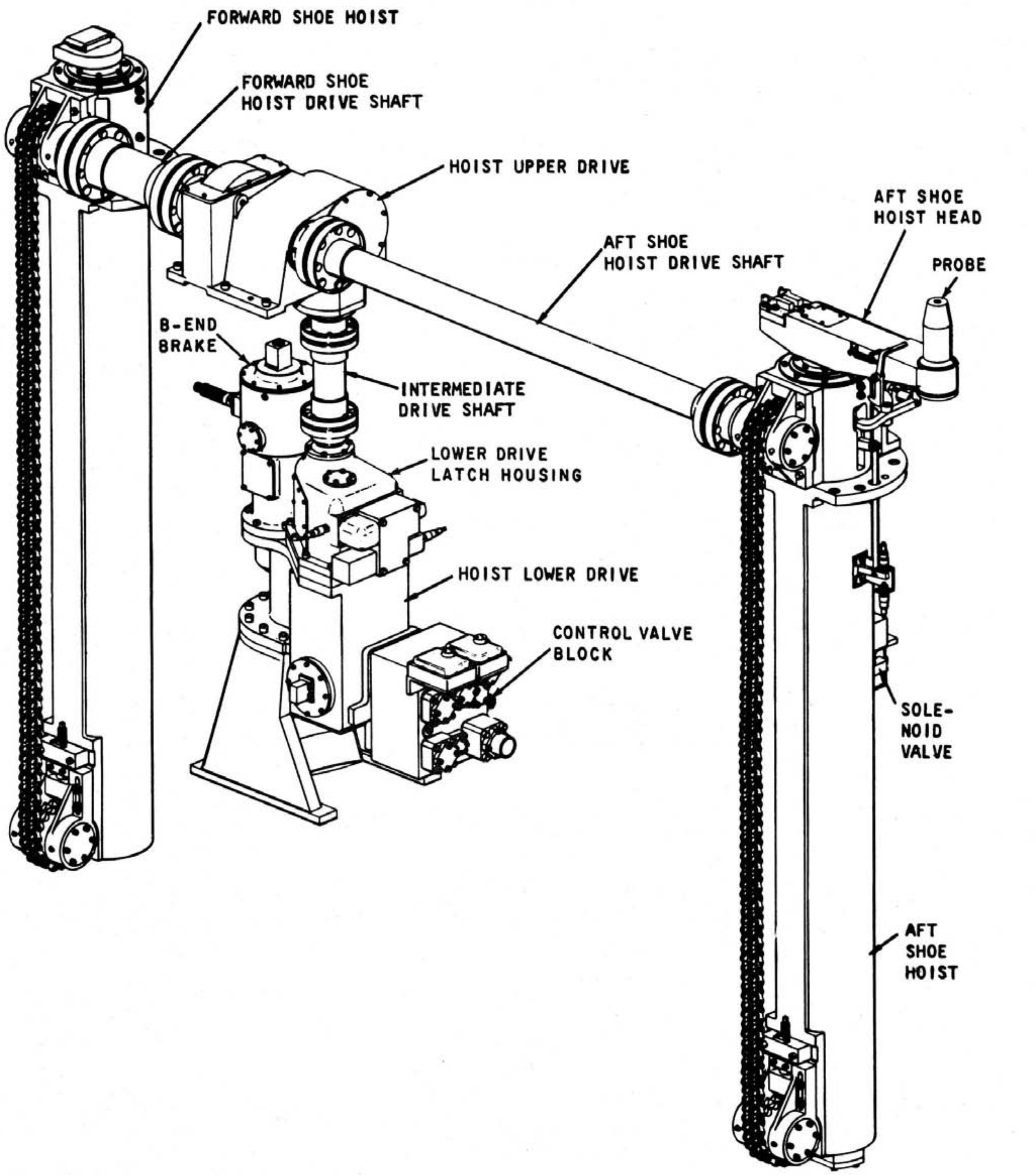

Figure 6-5.—Hoist mechanism for "A" side, Mk 10 Mod 7 launching system.

rings was shown in figure 6-1. The safety latch assembly, which resembles a giant zipper, maybe seen in figure 6-6. At the right-hand end, the safety latch actuating piston is shown, and below the door drive bracket assembly. The door drive bracket assembly includes all the components for operating the magazine doors: the switch, the door operating piston assembly, the latch control valve, the door-open and the door-closed latch, and the solenoid valve. There is a door-closed latch at each end of the doors. Electrical and hydraulic interlocks assure that the blast doors are closed and the hoist is down and latched before the doors can be opened, and that the hoist is down and latched before the doors can be closed. The hydraulic operation is through the piston assembly. It contains a directional valve and a metering valve in addition to the piston. The solenoid valve block assembly is attached to the piston block assembly. The latch control valve block is fastened behind the piston guide. The door-open latch valve block is fastened to one of the webs of the door drive bracket. The hydraulic fluid to operate these valves and pistons comes from the magazine accumulator power system.

The opening and closing of doors may seem like a minor item, but it is very important. The magazine doors are flame tight and watertight. They must never be open when the blast doors are open. All the parts, valves, switches, pistons, etc., must act in sequence. Failure of any part can disrupt the whole series of actions. If that happens, you need to get out the hydraulic schematics and the electrical drawings and trace the cause of the failure. It might be a clogged valve or a broken switch, or the pressure in the magazine accumulator might be too low. You would shut down the magazine accumulator system while locating the trouble.

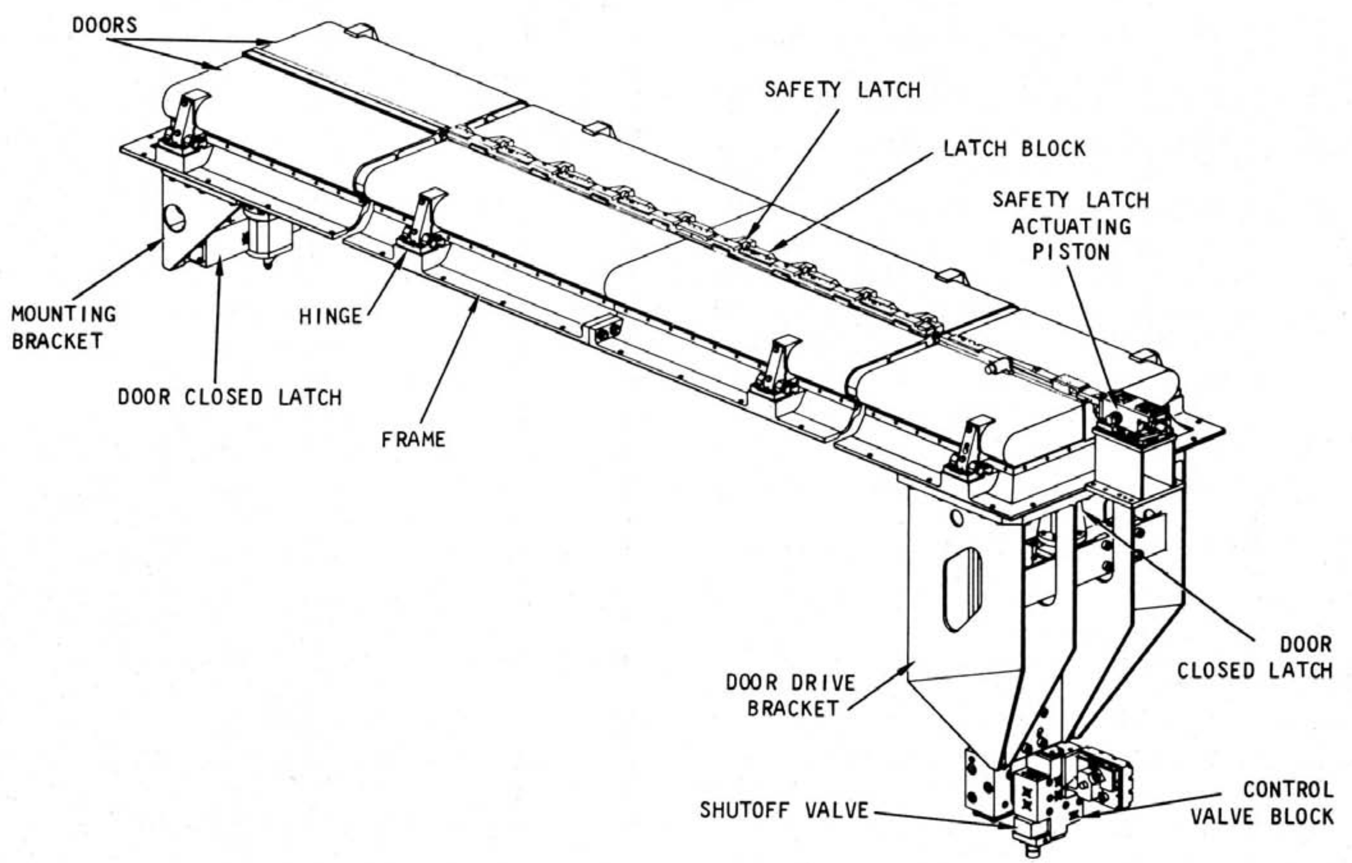

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Figure 6-6.—Magazine door assembly.

Loader Components

The loader, figure 6-7, consists of similar A-side and B-side assemblies that engage, support, and move missiles between the assembly area and the launcher, or between the assembly area and the strikedown/checkout area. Major components of the loader are the loader trunk, the tilting rail (in the Mod 5 system), the blast doors and spanning rail, the loader chain and pawl, the loader power drive. The loader has a loader horn that sounds when the system is in the unload launcher mode to warn personnel of impending movement of the missile back to the assembly area.

LOADER POWER DRIVES.- There are two accumulator-type power drives, one for the A-side and one for the B-side. Each power drive includes a tank to hold the hydraulic fluid, a motor-driven pump to develop hydraulic pressure, a series of valves to regulate system pressure, and two accumulator flasks to store energy, absorb hydraulic shocks, and prevent excessive pressure fluctuations. These components operate in the same manner as the magazine accumulator power system.

The accumulator power drive furnishes hydraulic power to operate the spanning rail, the blast door latches, the retractable rails, the floating track piston assemblies, the loader pawl positioner, the interlock valve block, the tilting rail, and the NAVSHIPS strike down checkout gear.

A second power system, a combined A-end, B-end (CAB) power unit, is located near the aft end of the loader trunk. It develops hydraulic pressure and transforms it into rotary mechanical motion to drive the loader chain.

The CAB power drive also has a power-off brake assembly. This is used to halt moving equipment, to secure driven equipment against roll and pitch when the equipment is inactive, to halt and secure equipment if there is a power failure, and to provide a means of manual operation (by hand crank) for maintenance procedures, installation, or emergency operation. A small auxiliary gear pump, driven by the same electric motor that drives the A-end, supplies the necessary hydraulic pressure for the control mechanism that controls the A-end tilt plate, and therefore the speed and direction of rotation of the B-end. The auxiliary gear pump produces 400 to 500 psi servo pressure to operate the control components of the CAB units, and delivers 100 psi (supercharge pressure) from another set of gears to replenish fluid losses from slippage and leakage.

LOADER TRUNK.-The loader trunk is made up of sections that are mounted to the overhead bulkhead. The number of sections varies with the mod of the system. The Mk 10 Mod 0 Terrier launching system has eight sections; Mods 5 and 7 have six loader trunk sections and tilting rail; Mod 8 has 12 sections. There are some differences in the trunk sections of different mods, but they are sometimes interchanged by making slight modifications. Figure 6-8 shows a trunk section made for the Mk 8 Mod 11 loader.

A number of the hydraulically operated components of the loader are mounted in the loader trunk sections. Only the control panels, the power drives, and the tilting rail control are not mounted in the loader trunk assembly. The cross-section view in figure 6-7 shows the channels or tracks in which the forward and after shoes and the chain can slide.

TILTING RAIL.-In mods that have a tilting rail, many of the moving or movable components of the loader are attached to or move in the tilting rail. Figure 6-9 shows the location of the important components on the tilting rail and the operating piston. The tilting rail takes the place of about four and half loader trunk sections in the assembly area. The trunnion supports are mounted in the ship's overhead over the magazine doors. The tilting rail receives the missile round from the hoist, moves it to the assembly area for wing and fin assembly, then tilts to the angle necessary to match the launcher load angle. The operating piston (fig. 6-9) is the unit that elevates or lowers it. Hydraulic power is obtained from the CAB power unit, which is connected at the power drive input. A hydraulic transfer pin (inside the trunnion) distributes the hydraulic fluid to the floating track piston assemblies, the positioner piston and interlock valve block, and the rail-loaded indicator assemblies, through the adapter block mounted on the trunnion (fig. 6-9) neatly

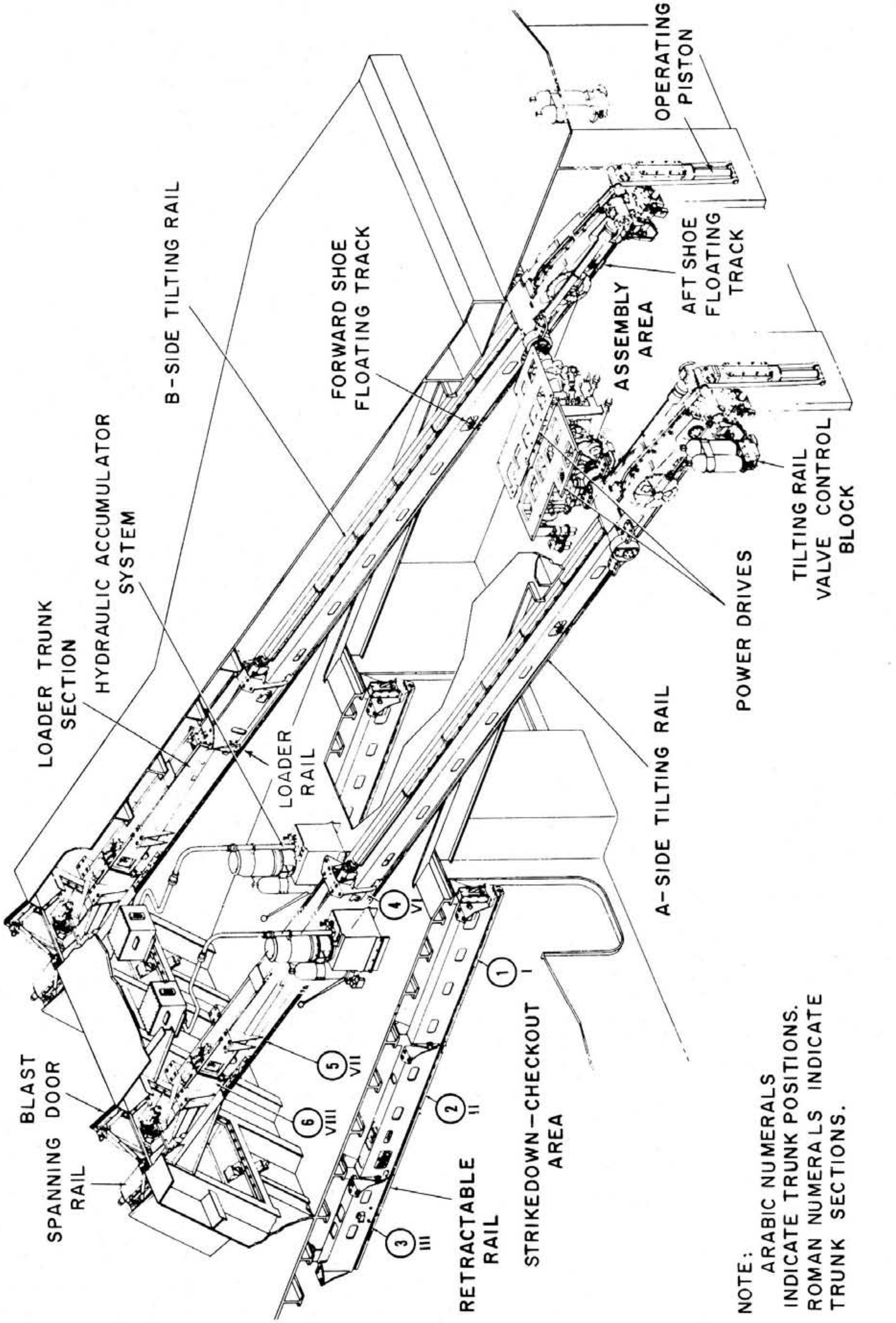

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Figure 6-7.—General arrangement of Loader Mk 5 system.

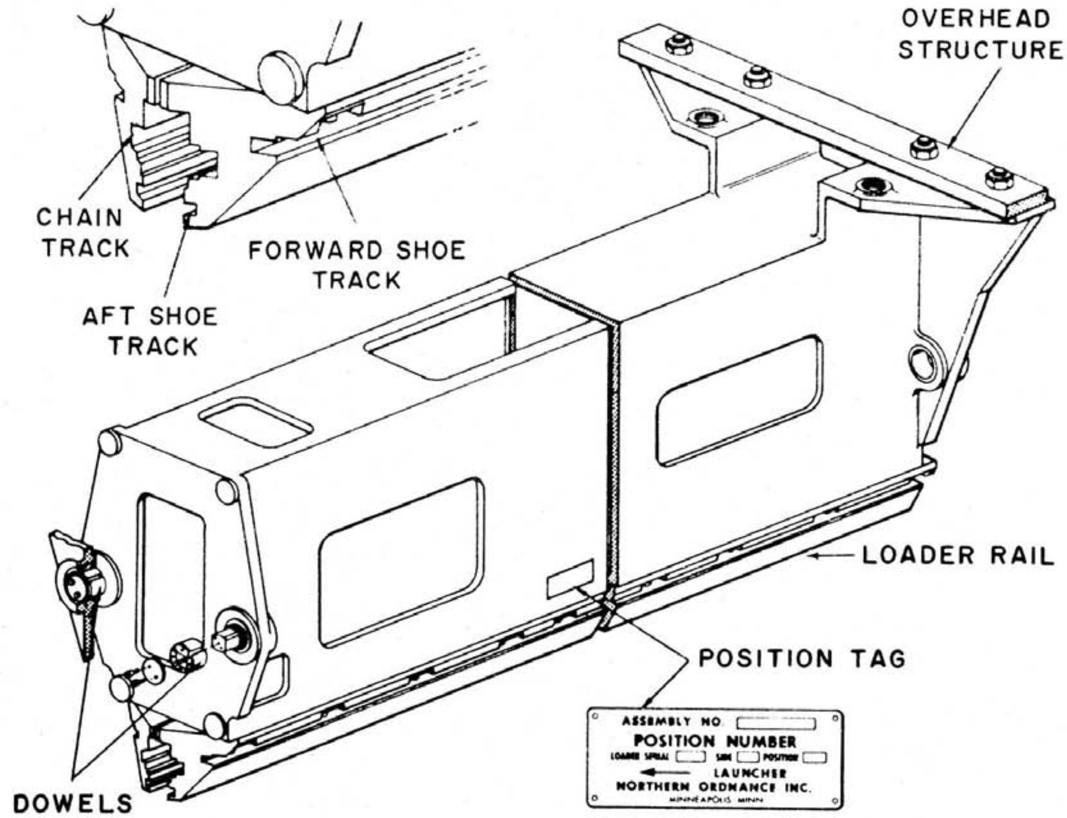

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Figure 6-8.—Loader trunk section II.

buckles and folds the links of the chain to prepare the chain for stowage. Mods 1 and 13 of the Mk 8 loader do not have a chain stacker. The chain links are different in the different mods, and there are differences in the chain sprocket gear reduction and chain track housing. You need the OP for your launching system to study the operational details.

FLOATING TRACKS. - The location of the floating tracks may be seen in figures 6-7 and 6-9. In mods that do not have a tilting rail, the floating tracks are attached to the loader trunk in the same positions. The aft floating track assembly catches the aft booster shoe in its slide track, and the forward floating track assembly does the same for the forward booster shoe. They are piston operated by hydraulic fluid from the blast door power unit. The loader positioner moves the loading pawl forward about three inches, enough to slide the booster shoes out of the hoist head and into the floating track rails. The floating tracks hydraulically align the booster shoes with the track grooves of the fixed loader rail.

RETRACTABLE RAILS. - The retractable rails are used to allow the booster shoes to engage or disengage from the loader rail. They are used during strikedown and checkout (or strike-up) operations, when the rounds are raised or lowered from the loader rail. When the retractable rail segments are open, they align with the tracks of the fixed loader rail to make a continuous track. The hydraulic controls for the retractable rails are mounted in the loader trunk. An interlock switch prevents operation of the loader when the rails are open. The valves are typical solenoid, pilot, directional, interlock, latch (open and close), and check valves. An operating piston and linkages transfer the movement to the movable parts of the rails.

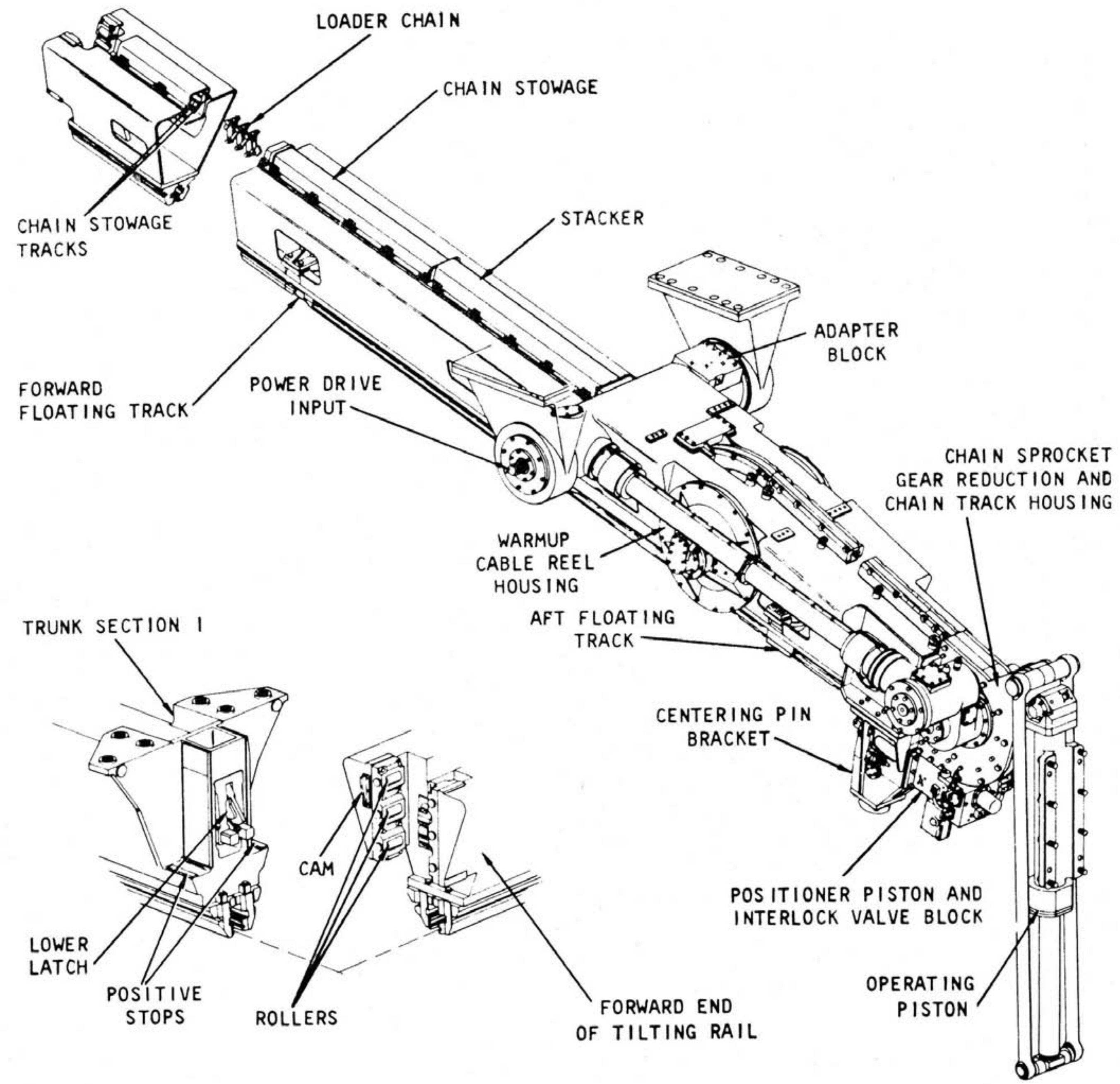

Figure 6-9.—Tilting rail and operating piston.

SPANNING RAILS AND BLAST DOORS.- When extended, the spanning rails bridge the gap between the loader rail and the guide arm rail. The spanning rail is attached at one end to the loader rail and at the other to the blast doors. The power piston that operates the spanning rail and the blast doors is mounted in the loader trunk and the hydraulic fluid is supplied by the loader accumulator. The spanning rail opens the doors as it extends, and closes them as it retracts. The spanning rail and blast doors function automatically during automatic control in load or unload cycles, but they can also be operated in step control. The blast doors are closed except during the brief time while a missile is passing through, either on its way to the launcher, or returning for unloading. Interlocks keep the doors closed at all other times.

In the Talos launching system, rails attached to the magazine doors are called spanner rails. They allow the hoist to travel to or from the loader. They form an extension of the magazine hoist rails. The rails that bridge the gap between the loader rail and the launcher guide arm rails are called the span track.

In the Tartar launching systems, the rails attached to the blast doors are called spanning rails. Tartar launching systems do not have a loader system like Terrier and Talos launching systems. Missiles are carried from the magazine to the launcher guide arm by a rammer type roller chain hoist. In the Mk 11 system it is stowed in the launcher guide arm.

HYDRAULICALLY OPERATED LAUNCHER COMPONENTS

Although launchers contain parts that are not operated hydraulically, the interconnection with hydraulic power makes it impossible to consider them apart. All missile launching systems have a fixed stand - a steel weldment on the deck, which mounts the carriage. The carriage is rotatable horizontally, to position the launcher in train. Most of the launcher components are mounted in or on the carriage. It supports the trunnion tube which holds the guides (or guide).

Guide and Guide Arms

After a missile has been brought from the magazine by the hoist, and wings and fins have been assembled to it (Terrier and Talos missiles), it is placed on the launcher; to be more exact, on the launcher guide arm. Terrier and Talos launchers have two guide arms, as does the Tartar launcher in the Mk 11 system, but the Mk 13 and Mk 22 Tartar launching systems have only one guide on the launcher. The guide arm supports the missile during the last stage of weapon handling, arming the weapon and holding it until it is launched. It contains arming devices, aft shoe latch, launcher contactor, forward restraining latch, and firing contacts. The arming device arms the missile booster by extending and winding the arming tool by means of hydraulically operated pistons.

The aft shoe latch mechanism has a piston-operated latch and associated linkage. When the missile is positioned on the guide arm (by the loader), the latch is hydraulically extended against the aft booster shoe to keep the missile from moving to the rear. The aft shoe latch (fig. 6-10) may be called a positioner, a positioner spade, an aft lug latch, aft motion latch, or reverse motion latch. In some launchers the aft shoe latch is locked by a detent that is hydraulically interlocked to prevent accidental retraction of the latch due to ship's motion and guide arm movements.

The forward restraining latch prevents forward movement of the missile, which might otherwise be caused by launcher depression or by ship's motion. It also holds the fired missile on the launcher until the booster has developed enough thrust to overcome the force of gravity plus the force of the adjustable spring that is part of the restraining mechanism.

The launcher contactor is hydraulically extended to apply warmup power to the missile before it is fired. On the Tartar systems, the contactor extends from the rear of the launcher into the stern of the missile.

Two booster firing contacts and two ground contacts are located in the forward section of the guide arm, one of each on each side of the arming device. They provide a double firing circuit for the booster.

The hydraulic power to move the components in the guide arm is provided by the guide arm accumulator power drive, located in the trunnion support or carriage (fig. 6-11). It supplies hydraulic fluid for both the A and B guide arm components.

Carriage-Mounted Hydraulic Parts

The parts described in the paragraphs under this heading apply specifically to the Terrier carriage mounting, but other systems employ similar ones. The location and some details may differ.

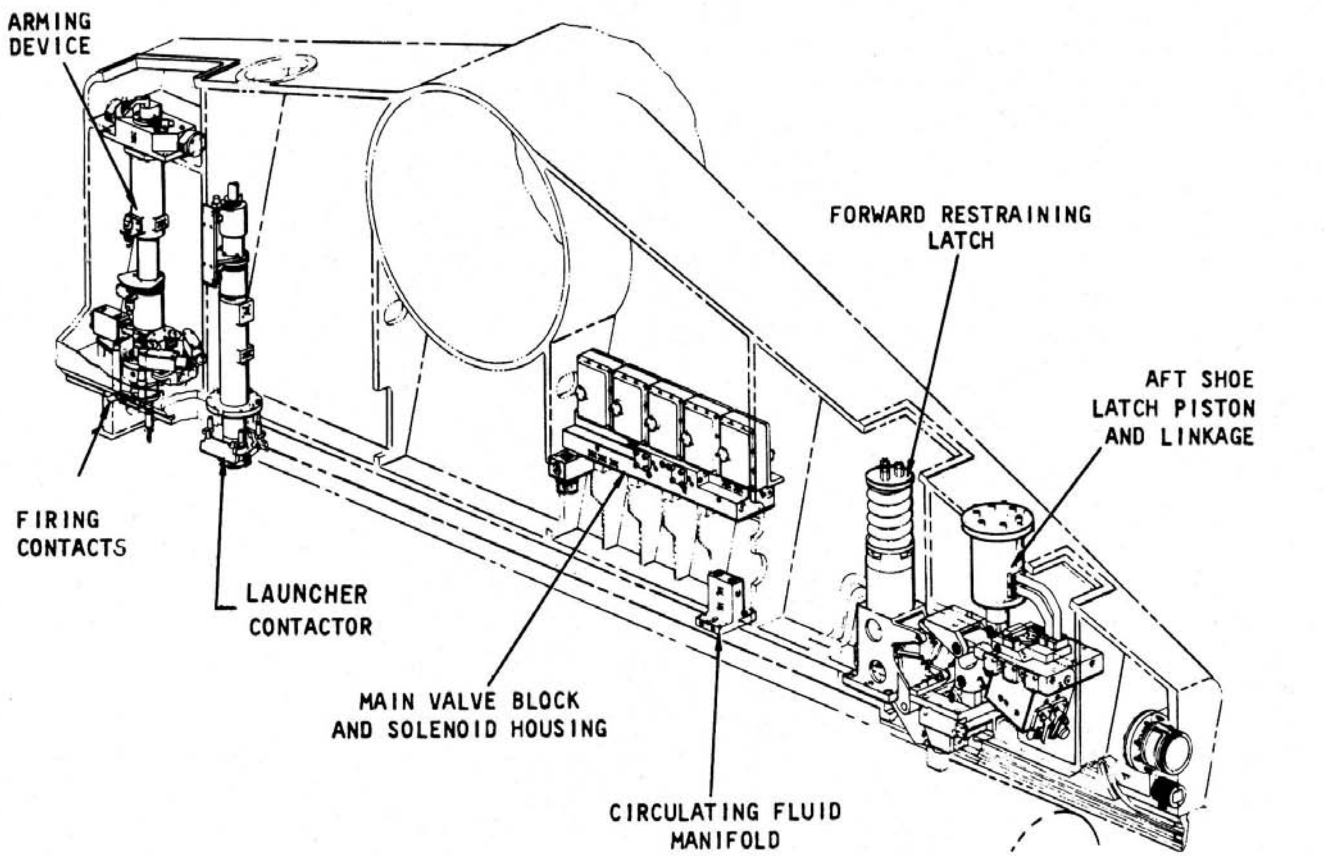

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Figure 6-10.—Guide arm components, Mk 10 launching system; general arrangement.

HYDRAULIC BREAKS. - The elevation brake is located on the reduction gear housing, which is mounted to the upper center of the carriage, below the trunnion tube. The train brake is mounted to the bottom of the carriage. Train and elevation brakes are hydraulically operated, spring-loaded, friction-disc type. During power-off conditions they remain set, preventing movement of the launcher.

TRAIN AND ELEVATION LATCHES - The elevation latch is a hydraulically operated steel pin, located below the reduction gear housing. When the latch is extended, it secures the launcher in the "Load" position. The train latch is mounted to the bottom of the carriage. It functions in the same way as the elevation latch. The elevation latch-control valve block houses the solenoids and valves which control the elevation latch. It is located below the reduction gear housing. A hand pump, mounted to the left side of the carriage, provides a means of operating the guide arms and the components of the train and elevation latches during maintenance operations or during power failure.

REDUCTION GEAR ASSEMBLY. - The train reduction-gear assembly is located within a housing mounted to the bottom of the carriage. The gears transmit the output of the hydraulic motor, at the required speed, to the pinion gear. The elevation reduction-gear assembly, enclosed in a housing, is mounted to the upper center of the carriage, below the trunnion tube. The elevation pinion gear is meshed with the elevation arc gear and is driven by the reduction-gear assembly. The train drive pinion meshes with the training circle and causes the launcher carriage to rotate in train. The elevation drive pinion causes the elevation arc to rotate the trunnion tube which causes the guide arms to elevate or depress.

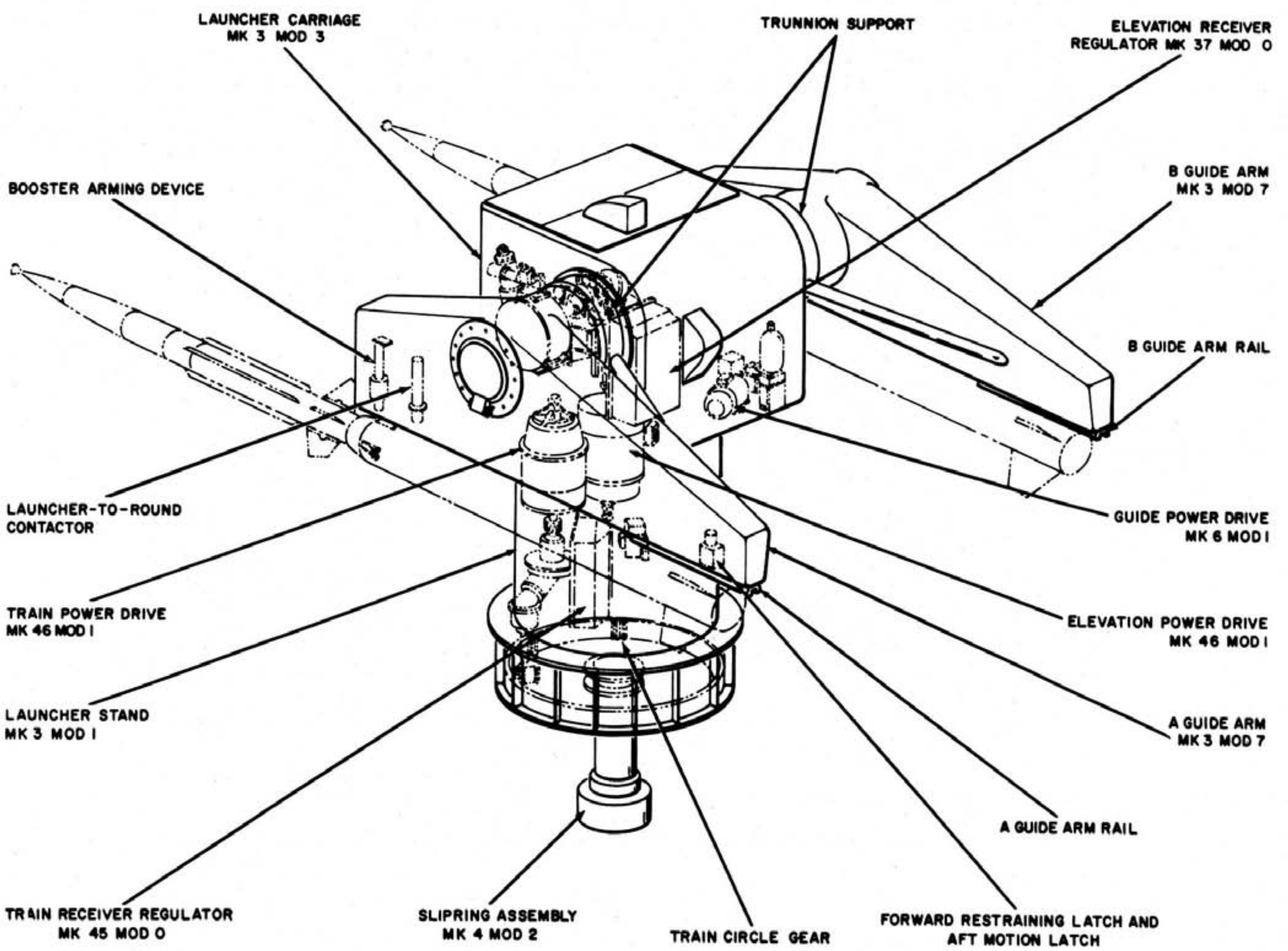

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Figure 6-11.—Guided Missile Launcher Mk 5 Mod 8.

POSITIONING VALVES. - The elevation positioning valve is located below the elevation arc, and the train positioning valve is mounted to the bottom of the carriage. These valves are spring loaded and mechanically operated to ensure that the launcher is in the proper position before porting fluid to extend the securing latches (train or elevation). They actuate interlock switches when the launcher is in the "Load" position.

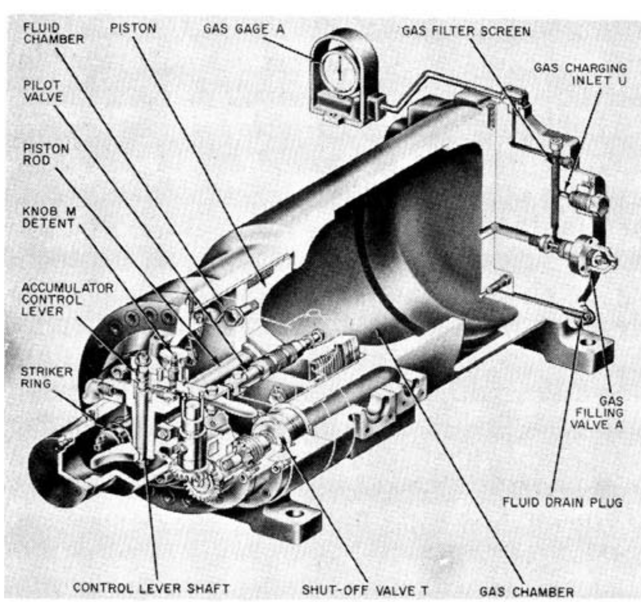
BUFFERS.-A buffer is anything that serves to deaden a shock or bear the brunt of a collision. Buffers are also used to slow down movement to avoid a violent shock or stop. Ordnance equipment uses hydraulic and pneumatic buffers, as well as spring buffers. Train and elevation buffers are used to slow down the training or elevating movement of the launcher to prevent a jerking halt. The elevation and depression buffers, mounted on each side of the trunnion tube, buff the movements of the trunnion tube and thus prevent excessive stress on the missile when the guide arms reach the elevation or depression limits. An accumulator furnishes a supply of hydraulic fluid for buffer operation.

Accumulators

Accumulators in hydraulic systems permit the use of smaller pumps than would be required if no accumulator were present. The fluid stored under pressure in the accumulator can assist fluids in motion to accomplish work when the demands of the hydraulic system require more fluid than the pump can supply. Accumulators may be used in hydraulic systems to supply fluid to compensate for leakage in closed or pressure-regulated circuits, as an emergency source of power for short periods, to operate secondary hydraulic systems, and as an auxiliary source of energy in intermittent duty systems.

Two basic types of accumulators are used in launching systems: bag and piston. The piston type is used with NAVSHIPS missile handling equipments and is shown in figure 6-12. The bag type was shown in figure 6-2 in the magazine accumulator system, and a cutaway view is shown in figure 6-13A.

Nitrogen is used to pressurize both types. The outside of the bag type is a metal shell; the bag, of neoprene, is inside, and contains the nitrogen. The bladder will fill approximately three-fourths of the inside area of the cylinder when the hydraulic pump forces oil into the flask. A spring-loaded poppet valve at the bottom of the flask prevents the bladder expanding down into the manifold if there is no hydraulic fluid in the flask.



33.183.3(94A)
Figure 6-12.—Piston type hydraulic accumulator, cutaway view.

The flask is mounted on a manifold (fig. 6-13A), and the valve block and gage (fig. 6-13B) are mounted nearby. The location of the gage and the type of nitrogen valve assembly will differ on accumulators of special ordnance systems. The nitrogen valve assembly (fig. 6-13B) controls the compressed nitrogen. It has one valve for each flask, a bleeder valve, a nitrogen fill cap, and a porous bronze filter. A pressure gage is mounted on top of the valve block.

PISTON ACCUMULATORS perform the same functions as the bag type, although constructed differently. The steel cylinder is divided into two chambers by a movable piston (fig. 6-1), one side for the hydraulic fluid, and the other for the nitrogen.

The cylinder head of the hydraulic fluid chamber has a manifold through which the flow of fluid is automatically controlled by a pilot valve, whether in charging or discharging the accumulator. The pilot valve (fig. 6-12) is actuated by the piston rod through a linkage operated by cams in a control housing. The housing includes a manually operated shutoff valve by which the accumulator pressure can be cut out of the power drive system when the drive is not in operation, or if the accumulator fails.

The facilities for admitting nitrogen under pressure are at the other end of the accumulator cylinder. These include a gas filling valve, gas charging inlet, and gas pressure gage. The arrangement of these may vary from that shown in figure 6-12.

ACCUMULATOR OPERATION. - An accumulator of either type is located in the hydraulic power system in such a way as to apply force in the pump discharge line, and to be charged with hydraulic fluid after loss of volume from the accumulator has occurred.

An accumulator valve block, containing a control valve and check valves, maintains the desired operating pressure in the accumulator by controlling the output of the hydraulic pump. The control valve is adjusted to limit the maximum pressure in the accumulator; and is designed to control the minimum pressure. (Typical accumulator pressure is 1300-1500 psi.) When the accumulator is being charged, fluid from the pump flows through check valve 1 (fig. 6-14), around the lower land of the control valve, and

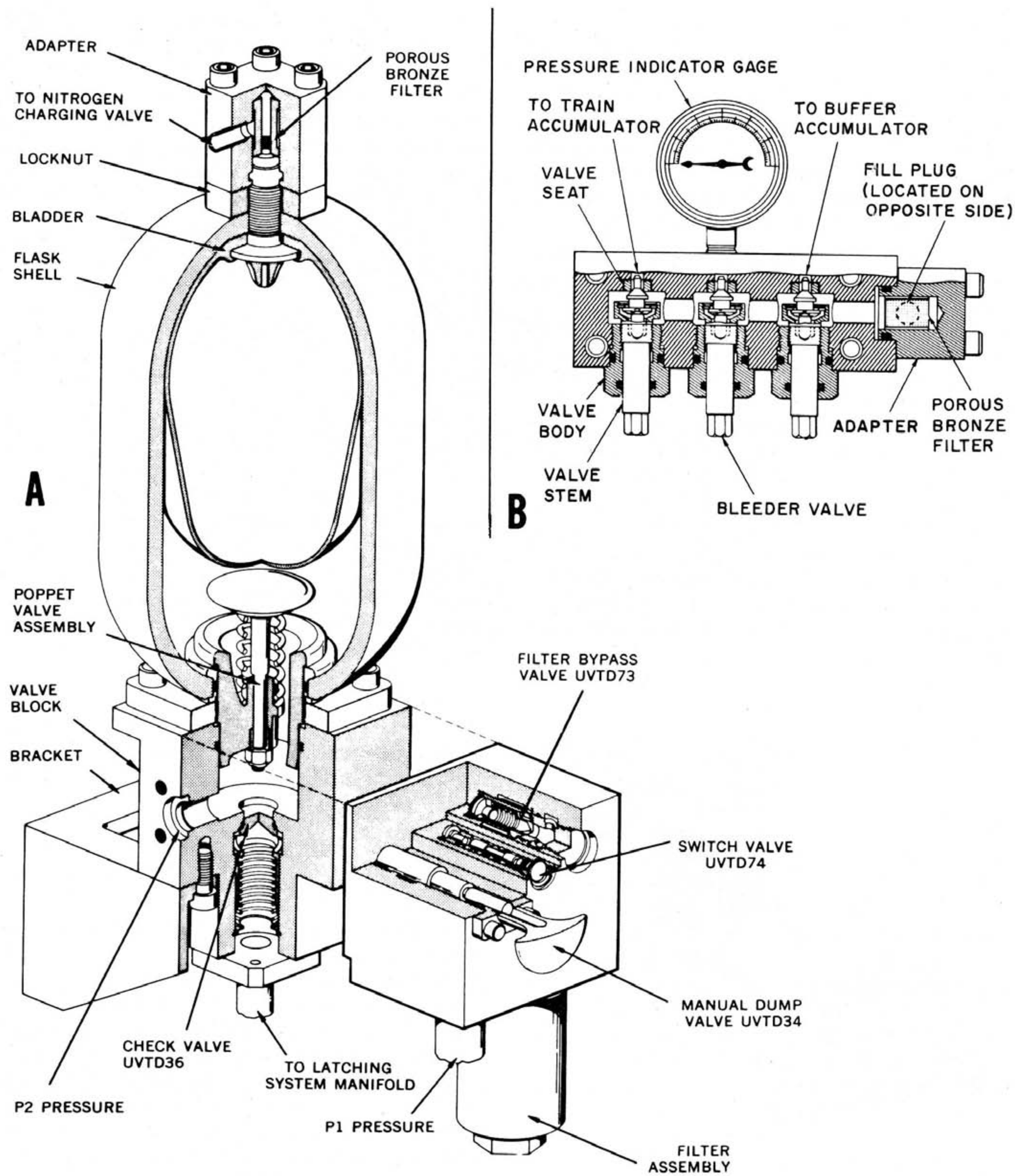


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Figure 6-13.—Hydraulic accumulators: A. Bag type accumulator, cutaway view; B. Nitrogen valve block assembly.

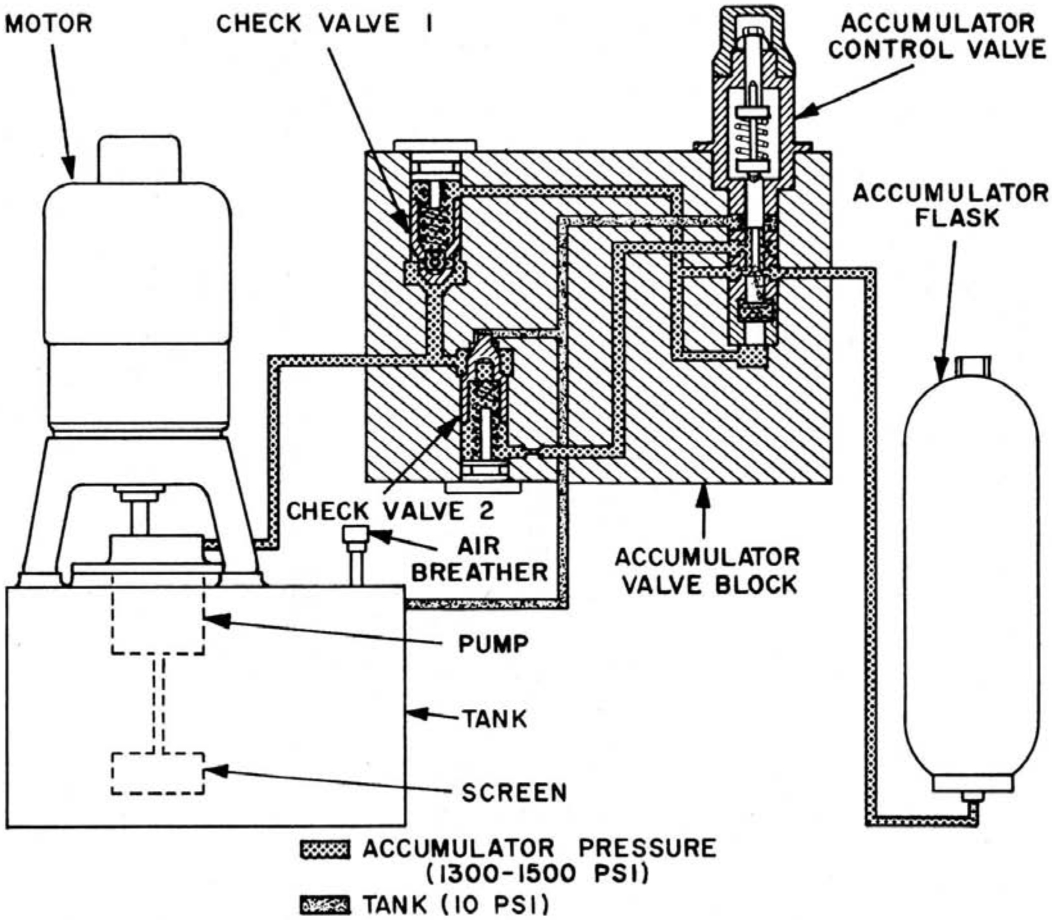

Figure 6-14.—Schematic, accumulator unit, charging cycle.

into the accumulator. When the accumulator becomes fully charged, the pump output is ported through check valve 2 to the tank.

The control valve has a spring and seat, a two-land plunger, and a piston. The piston is larger in diameter than the lower land of the plunger, against which it bears. A cross-port in the lower land of the plunger ensures equal pressure on each end of the lower land chamber. Accumulator pressure is always available at the bottom of the piston. As the charging cycle begins, the spring holds down the plunger and piston, and the hydraulic fluid passes into the accumulator. As the accumulator fills, the piston and the plunger are pushed upward, compressing the spring. When the spring is compressed enough, flow to the accumulator is blocked off and check valve 2 lifts and vents the pump output to the tank. When the accumulator pressure drops to the minimum set for it, the charging cycle is repeated.

Power Drives

As noted in the preceding paragraphs, each launching system has several power drives. To distinguish them, the location or use of the power drive is included as part of the name, as hoist power drive. The train and elevation power drives on the launcher are the ones most often referred to simply as the "power drives" of the launching system. They are two separate electro-hydraulic systems which control the movements of the launcher in train and elevation (fig. 6-15).

The function of the power drives is to make the launcher position correspond to the ordered positions (orders from fire control, under normal, automatic operation) with the least

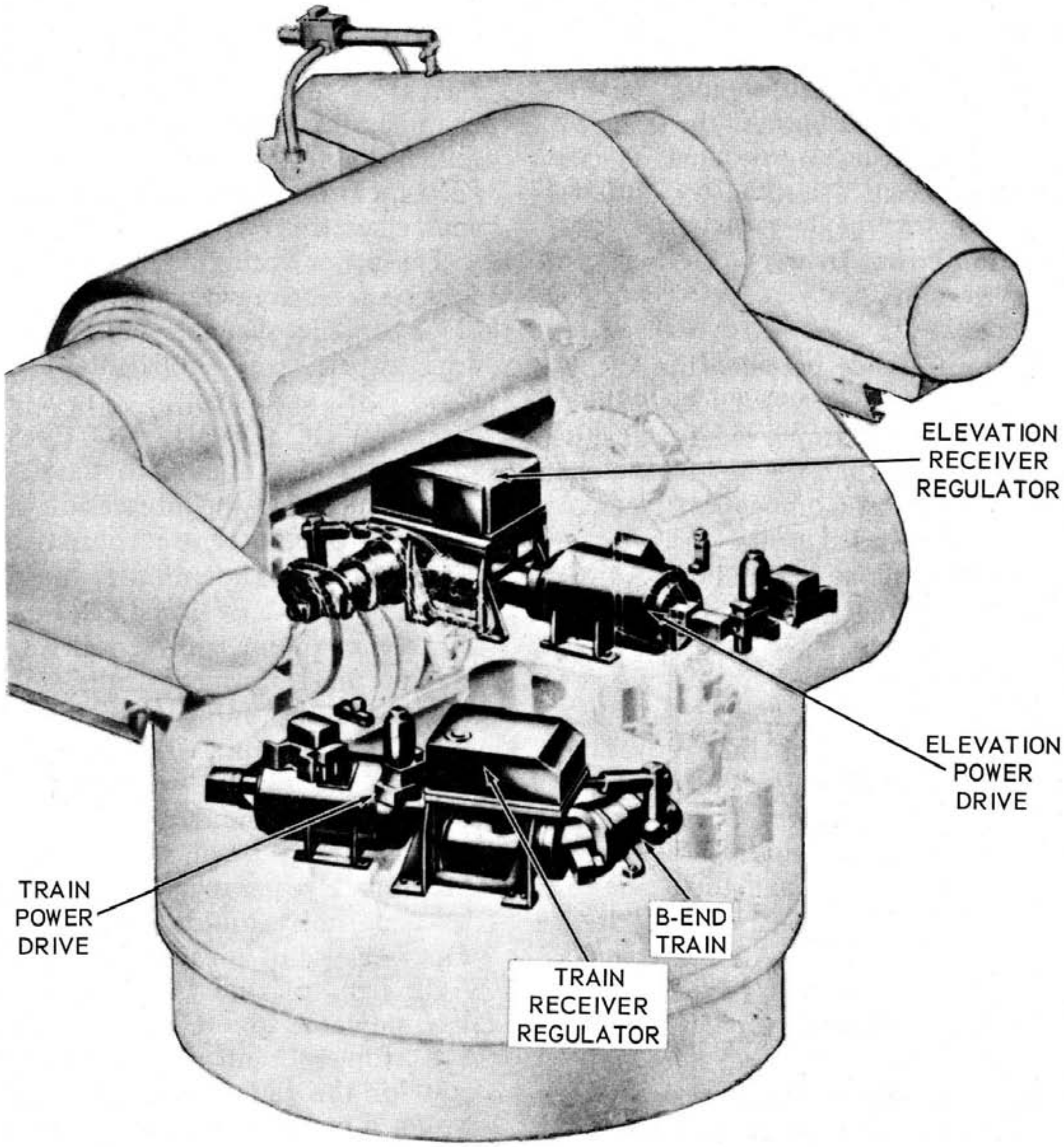

Figure 6-15.—Train and Elevation Power Drive Mk 50 Mod 1 (Talos).

possible error at all tlInes. The design of the train and elevation power drives is very similar, but they are not interchangeable.

The electric power for the power drive is supplied from the ship's power supply through the power panel.

The power unit consists of an electric motor, an A-end hydraulic pump, an enclosed gear train, a stroke control assembly or control cylinder, a transfer valve, and the B-end motor. The receiver-regulator is located with these components, and is functionally a part of the power drive. How they operate together is descnbed later in this chapter.

The train and elevation power drive controls of the GMLS Mk 13 are located off-mount but the power drives are mounted inside the stand in the inner structure. The magazine power drives are also located in the inner structure of the stand. The ready service ring is in the outer structure of the stand. The location of components of the train and elevation power drives of the Mk 13 launching system is shown in *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199.

That text also illustrates a number of devices used in hydraulic systems, such as various types of valves, buffer, dashpot, filter, strainer, and gear pump. Differences in the number of power units used by the "one-armed" Mk 13 and the larger launching systems (Terrier and Talos) were also pointed out.

Train and Elevation Power Drives of Mk 22 Tartar System

The overriding difference between the Mk 22 and other missile launching systems is its small size. It handles Tartar and Improved Tartar missiles, but fewer of them than the Mk 11 and the Mk 13 launching systems. Compact arrangement of components necessitated some changes in placement of parts, and some combination of functions. The Train Power Drive Mk 67 Mod 0 also drives the hoist. It has a shift and clutch mechanism that enables it to drive the launcher or the hoist. In the mk 22, it is the launcher that moves to a position above the missile to be loaded; the ready service ring doesn't rotate. The elevation power drive elevates and depresses the launcher guide. The major components of the train/hoist and the elevation power drives are the same: an electric drive motor, a hydraulic system, a CAB unit, and a drive train. The hydraulic systems have the same type of auxiliary pump, auxiliary relief valve assembly; and accumulator assembly; they differ only in capacity. The train/hoist power drive has a speed reducer and a lubrication pump that are not duplicated in the elevation power drive. Both systems use a common supply tank and common header tank.

The main supply tank, which holds about 110 gallons of fluid, is integral with the skirt adapter assembly (fig. 6-16). This is not to be confused with the main tank of the launcher guide power unit, which is fastened on the under side of the base ring and protrudes above it. That tank holds only about 20 gallons of hydraulic fluid. The location of the launcher guide power unit is also shown in figure 6-16, as are other launcher components. The train/hoist and elevation header tank is mounted in the base ring adjacent to the train/hoist power-off brake. The header tank for the launcher guide power unit is in the front end of the guide arm. A header tank provides a head of fluid to prevent entrance of air into hydraulic lines, which would cause erratic behavior of the hydraulic components. It also serves as an expansion and heat dissipation chamber for returning fluids. A strainer in the return-flow pipe strains out solid particles to keep them from getting into the servo and supercharge systems.

The major components of the train and elevation power drives are: (1) electric drive motors,(2) hydraulic systems, (3) CAB units, and (4)drive trains.

ELECTRIC DRIVE MOTORS. - These provide mechanical inputs to the CAB units, auxiliary pumps, and the lubrication pump. They are mounted on the center column of the carriage (fig. 6-17). The motors are activated by switching on the EP-l and EP-2 panels. The train lubrication pump is driven directly by the electric motor. It furnishes lubricant to the speed reducer. If the pump fails, the pressure in the discharge line drops. The lowered pressure, deactuates the switch, stops the motor and prevents motor burnout. An excess of pressure in the CAB unit also will stop the electric motor by actuating a pressure-cutout switch. When either the train/hoist motor or the elevation motor stops because of pressure cutout, the All Motors STOP light on the BP-2 panel starts blinking. This indicates to the operator why the motors have stopped, and warns him that he should look for the cause of the pressure buildup and correct it before restarting the motors.

HYDRAULIC SYSTEMS. - The main components are an auxiliary pump, an auxiliary-relief-valve assembly, and an accumulator assembly. The train/hoist and the elevation hydraulic systems are identical except in capacity. The train/hoist system is the larger one; it supplies power for operation of the train and the hoist systems. The pumps are of the type described in *Fluid Power*, NAVPERS 16193 as gear pumps; they may have helical or spur gears or a combination. The pumps operate the power-off brake, the receiver-regulator, the CAB unit, and the main relief valve of the CAB unit. The train/hoist system also operates the hoist selector valve block assembly, and the hoist control assembly. The relief valve block contains filters.

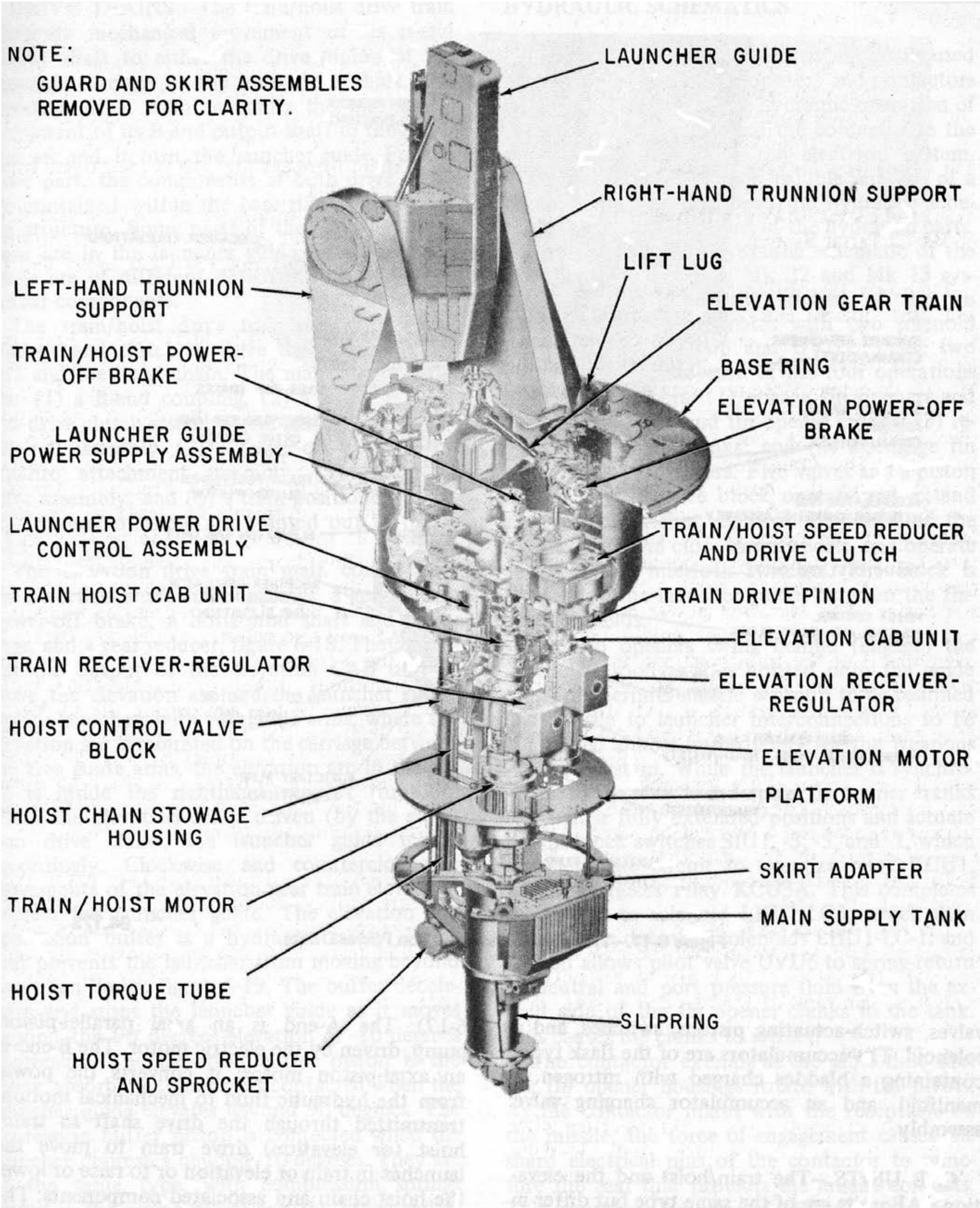

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Figure 6-16.—Guided Missile Launcher Mk 123, Mod 0 (Mk 22 Launching System for Tartar missile).

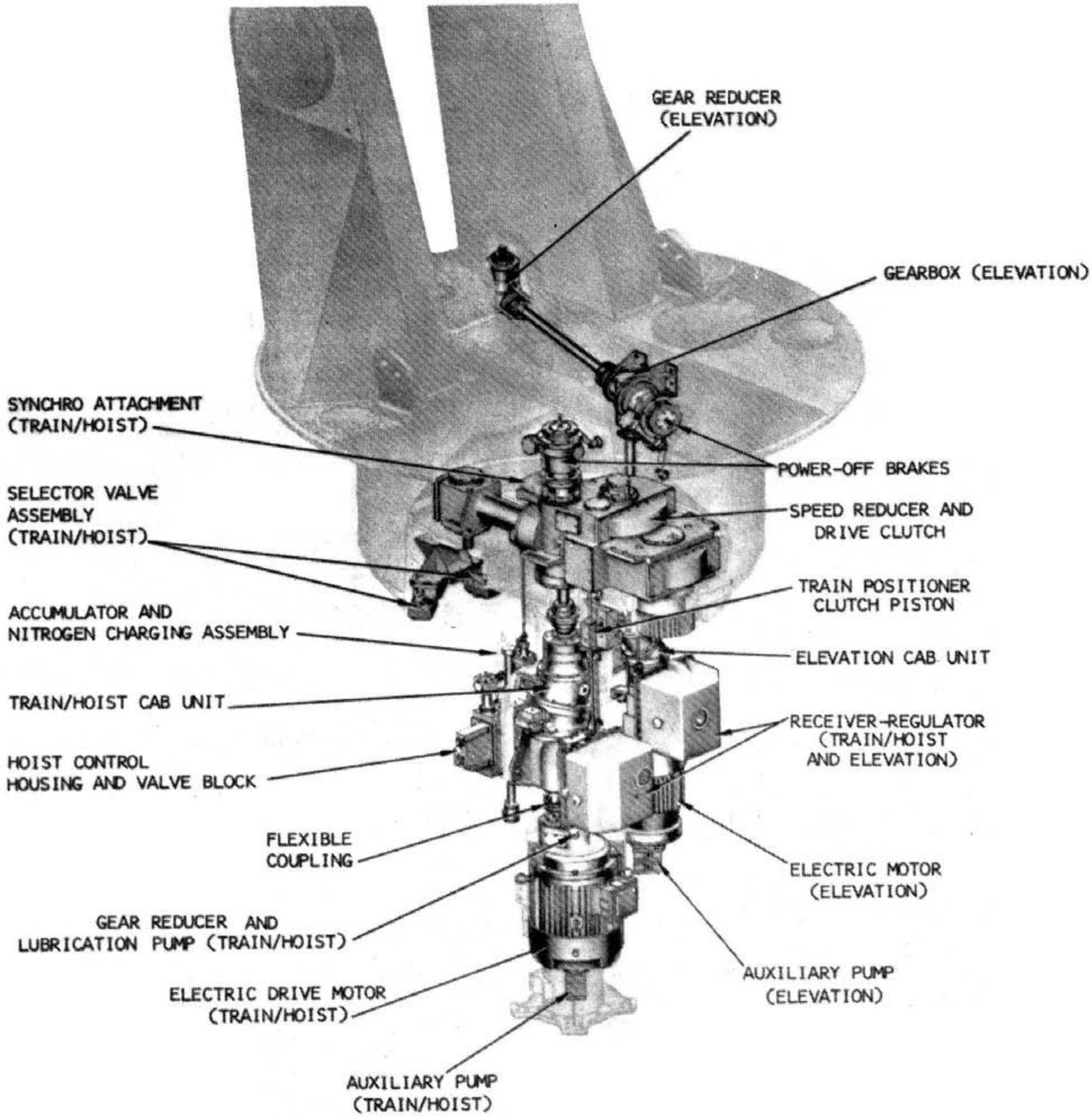

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Figure 6-17.—Train/Hoist and Elevation Power Drives.

valves, switch-actuating pistons, switches, and a solenoid. The accumulators are of the flask type, containing a bladder charged with nitrogen, a manifold, and an accumulator charging valve assembly.

CAB UNITS. - The train/hoist and the elevation CAB units are of the same type but differ in size and output. They are mounted on the center column of the rotating structure (fig. 6-17). The A-end is an axial parallel-piston pump, driven by the electric motor. The B-end is an axial piston motor; It converts the power from the hydraulic fluid to mechanical motion, transmitted through the drive shaft to train/hoist (or elevation) drive train to move the launcher in train or elevation or to raise or lower the hoist chain and associated components. The operation of CAB units is described in *Fluid Power*, NAVPERS 16193.

DRIVE TRAINS. - The train/hoist drive train transmits mechanical movement of its B-end output shaft to either the drive pinion of the launcher carriage or the hoist drive shaft. The elevation drive train transmits the mechanical movement of its B-end output shaft to the elevation arc and, in turn, the launcher guide. For the most part, the components of both drive trains are contained within the base ring of the rotating structure. Some parts of the elevation drive train are in the launcher guide. The two drive trains are of different design but contain some similar components.

The train/hoist drive train uses a common gearbox and clutch to drive the rotating structure and the hoist chain. The main components are: (1) a B-end coupling, (2) a speed reducer and drive clutch assembly and associated retractable-rail assembly, (3) a power-off brake, (4) a synchro attachment assembly, (5) a selector valve assembly, and (6) a train-positioner assembly. Several of these are pointed out in figure 6-15.

The elevation drive train main components are a vertical shaft and couplings, a gear box, a power-off brake, a horizontal shaft and couplings, and a gear reducer, figure 6-18. They transmit the output of the elevation CAB unit to move the elevation arc and the launcher guide. Unlike launchers with two guide arms, where the elevation arc is mounted on the carriage between the two guide arms, the elevation arc in the Mk 22 is inside the right-hand support trunnion. When the elevation arc is driven (by the elevation drive train), the launcher guide moves accordingly. Clockwise and counter-clockwise movements of the elevation gear train elevate or depress the launcher guide. The elevation and depression buffer is a hydraulic safety device that prevents the launcher from moving beyond its design limits, figure 6-19. The buffer decelerates and stops the launcher guide as it moves beyond the 90 degrees elevation or -10 degrees depression. The elevation buffer piston is the shock absorbing component contacted when the launcher guide elevates beyond 90 degrees. The depression buffer piston is contacted when the launcher depresses beyond -10 degrees. They are of the same type, with compression springs seated in the piston recess and the other end in the sleeve.

HYDRAULIC SCHEMATICS

Chapter four shows the electrical circuits used in step operation of fin openers and contactors in the Mk 13 system. The hydraulic operation of the fin opener cranks and the contactor to the missile is actuated by the electrical system. When you are performing trouble analysis of a component, you also need the hydraulic schematic to trace the actions of the hydraulic parts. Figure 6-20 shows a hydraulic schematic of the fin opener assembly in Mk 22 and Mk 13 systems. Primary hydraulic control of the fin opener assembly originates with two solenoid operated valves UVU6 and UVU7. These two pilot valves initiate each of the four operations of the fin openers: (1) engage fin openers and contact or; (2) extend fin opener cranks; (3) retract fin opener cranks; and (4) disengage fin openers and contactors. Five valves and a piston in the control valve block operate and extend and retract latches, control the speed of the pivots, open and close various ports, and operate some of the interlock switches. The block is located on the launcher guide, between the fin-opener shields.

The fin openers swing behind (engage) the missile as soon as it is hoisted onto the guide rail. This permits missile warmup to be resumed and missile to launcher interconnections t be completed almost immediately for the Weapons Control System. While the launcher is synchronizing to the remote order, the fin opener cranks reach their fully extended positions and actuate the interlock switches SIU1, -3, -5, and -7, which complete the circuit to energize relay KCU1, which energizes relay KCU3A. This completes the circuit to solenoid LHU1-LC3, which then releases the detent of solenoids LHU1-LC-1, and -2, and allows pilot valve UVU6 to spring-return to neutral and port pressure fluid from the extend side of the fm opener cranks to the tank. This causes the cranks to retract.

The contactor extends at the same time that the fm opener housings rotate with the pivots. As the contactor mates with the receptacle on the missile, the force of engagement causes the sharp electrical pins of the contactor to puncture the seal that protects the missile contacts. This requires a pressure of 450 to 500 pounds. The contactor remains in position until the

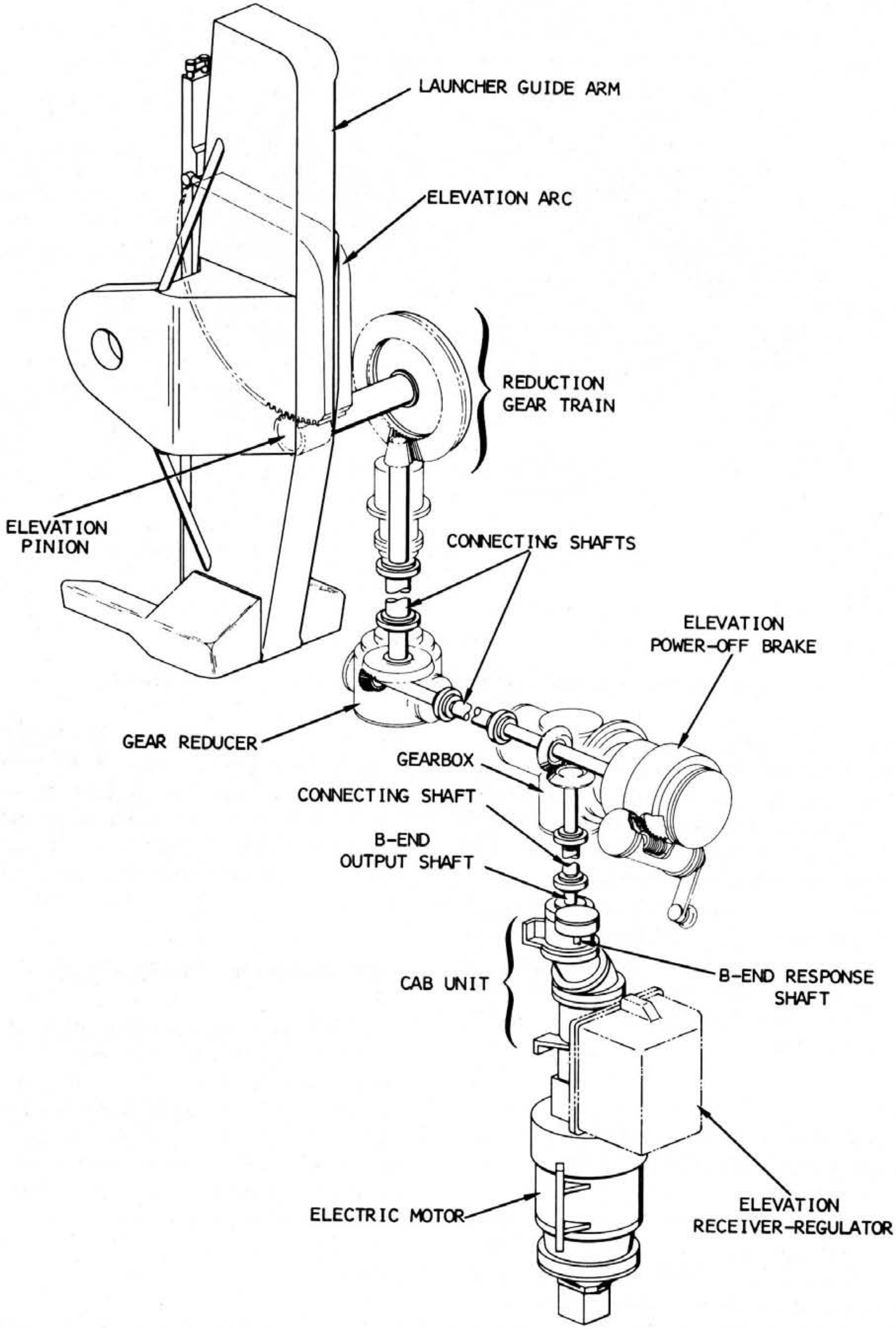

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Figure 6-18.—Elevation Drive: Mechanical Schematic.

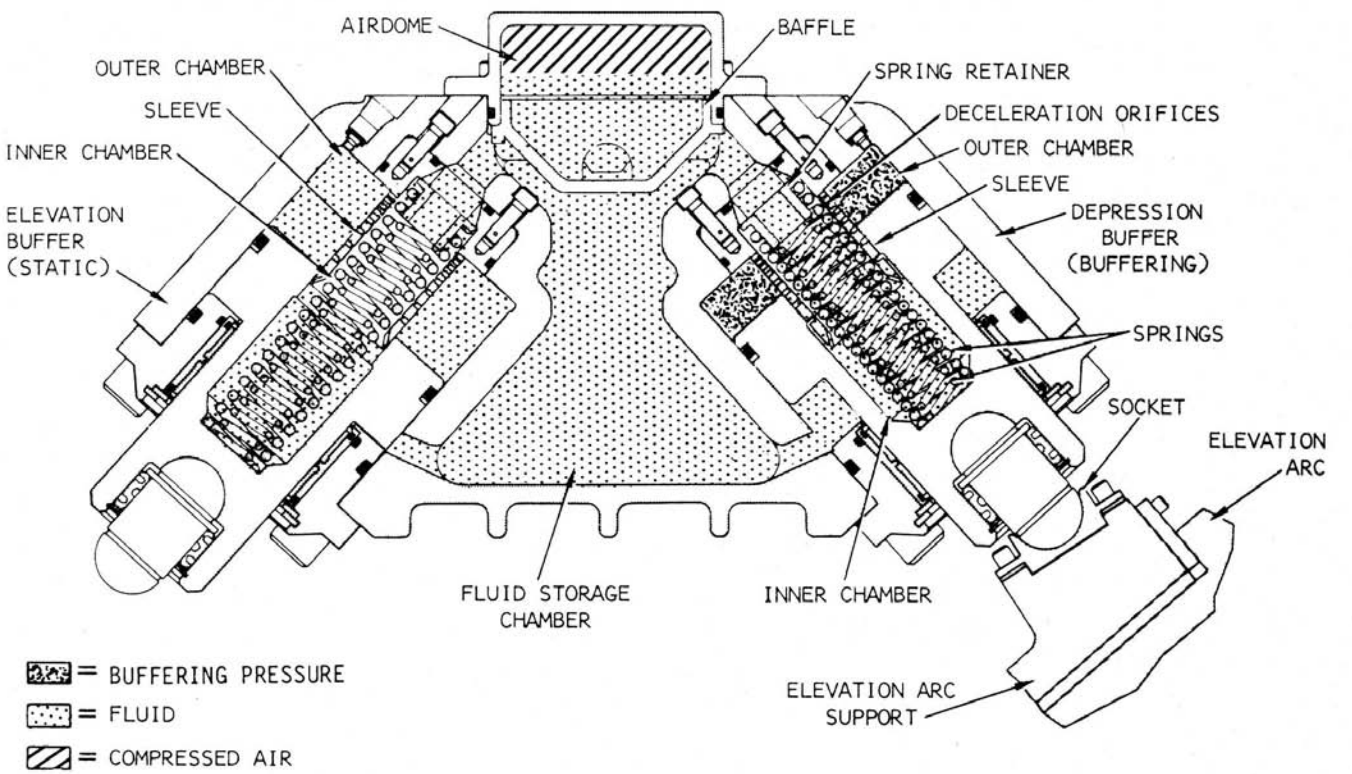

Figure 6-19.—Elevation and Depression Buffers: Hydraulic Schematic.

order to fire is received.

This small sample of a hydraulic schematic shows how electric and hydraulic schematics must be considered together. The electric components start the action; the hydraulic components carry out the electrical orders.

Study the OP and follow through on hydraulic schematics so you will understand the flow of hydraulic power through the system and its translation into mechanical movement. This knowledge will be invaluable to you in trouble-shooting the system.

ADJUSTMENT AND REPAIR OF HYDRAULIC SYSTEMS

To tell in detail how to adjust and repair hydraulic systems used in missile launching systems would require several large volumes. To work on any system, you need the drawings for that system as installed on your ship, and the applicable OPs and ODs. The types of valves used in the power drive for the ready-service ring may be the same as those in the power drive for the train or elevation system on the launcher, but their numbers or other designations and the locations would differ. In a general course like this, we cannot name the particular valve to adjust.

SHIPBOARD MAINTENANCE

Initial adjustments were made at the time of installation. Later adjustments aboard ship should be undertaken only after competent personnel have determined that adjustment is necessary. Brake valves, replenishing pump relief valves, and the control pressure pump are some components of a drive system that are adjusted whenever necessary.

Filters

The indicating lights on the control panels pinpoint some troubles, such as clogged filters.

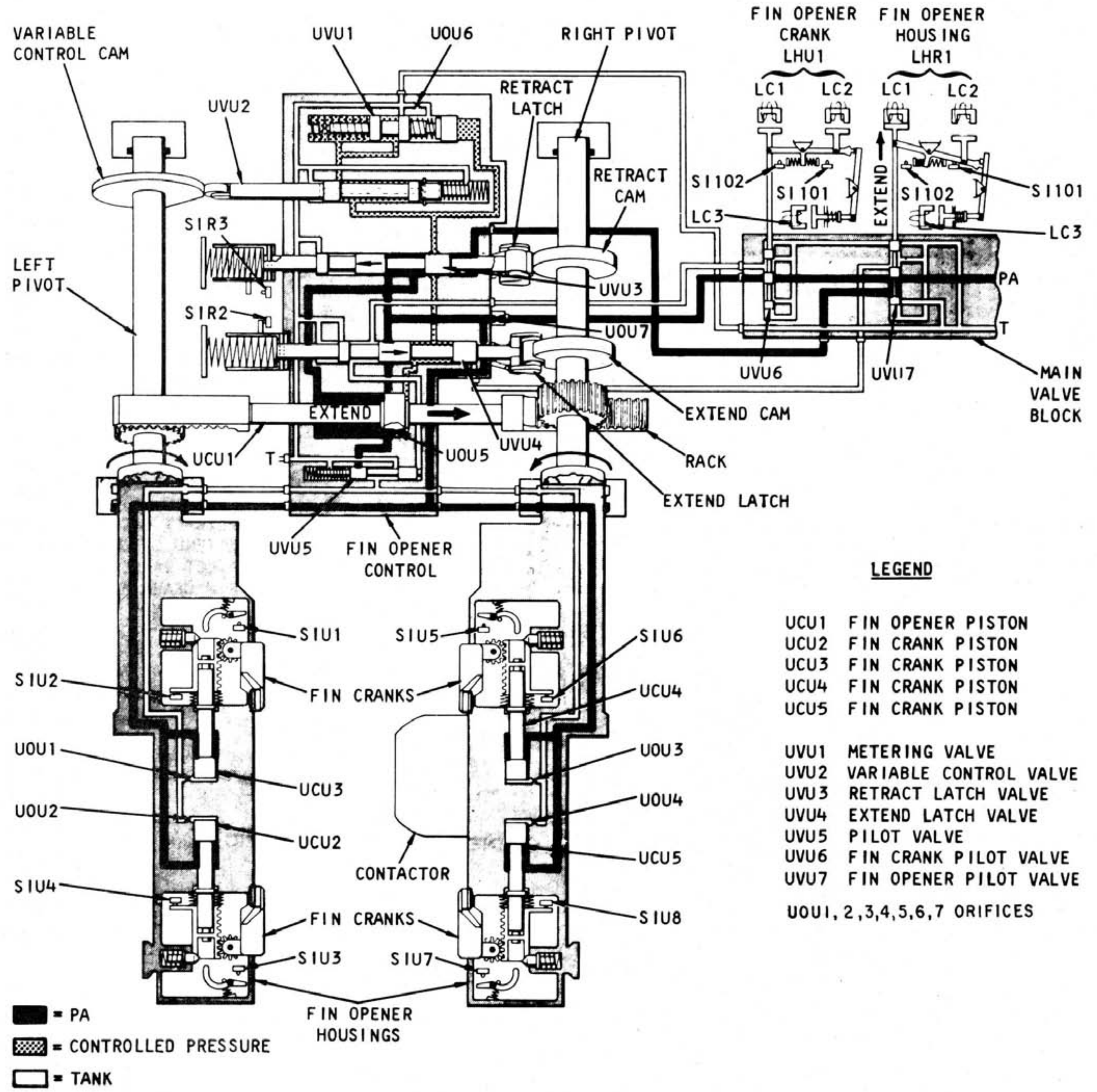

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Figure 6-20.—Hydraulic schematic; fin openers and contactor extended (engaged); Tartar Mk 13 and Mk 22.

Let us use as, an example the power drive in the Mk 10 Mod 0 launching system for the Terrier. This is the power drive used to operate the ready-service ring, the tray shift mechanism, the magazine doors, and the magazine hoist mechanism. The oil filter assembly is mounted on the supply tank, above the electric drive motor. The assembly contains twelve micronic filter elements which filter out any foreign particles of 10-micron size or larger before the oil is pumped to the magazine components. When the filters become cogged and the filter bypass valve opens, a clogged-filter switch mechanism illuminates a light on the EP-2 panel, indicating that the filter news changing. After the filters have been changed, the filter assembly is filled with oil through the filler plug on the filter, which forces out air that was in the filters and keeps air out of the system.

Some power drives use disposable, cartridge type filters. These require no maintenance except replacement of the cartridge, as in the system above. If the filter element has to be cleaned, follow the instructions for the type of filter and observe the safety precautions for the cleaning method and materials used.

Full-flow types filter all the oil that passes through the pumps. Such filters may have a relief valve to allow bypassing of the oil if the filter element is clogged. A bypass filter is one which filters only a portion of the oil passing through the pump. Figure 6-21 is an example of a bypass filter. More correctly, it is called a proportional flow filter. It consists of a cylinder containing a filter element made up of a number of packs of perforated paper discs. Spring action

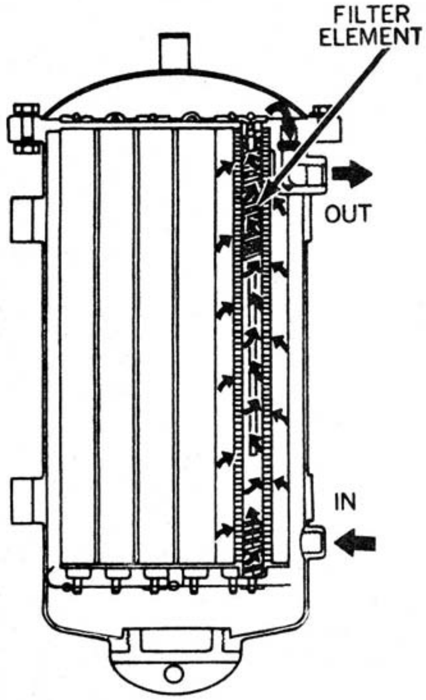

Figure 6-21.—Auxiliary bypass filter.

maintains a uniform pressure on each of the packs. Oil passes from the outside of the pack, where the foreign matter is deposited, to the center passage, and through the outlet at the head of the filter.

To clean this type of filter, lift the head, with the filter packs attached, from the body of the filter. Connect a low pressure air supply to the oil outlet of the system. This allows the air to blow back through the element. When a white foam appears along the entire length of the pack, it is clean.

If you remember to observe the rules for keeping contaminants out of hydraulic systems, the filters will seldom need cleaning. Keep the containers of hydraulic fluid tightly closed except when actually transferring the fluid. Strain the fluid into the hydraulic system, even though you are pouring from a freshly opened can. Keep all openings on the hydraulic system closed so water, dust, dirt, or any other contaminant cannot get in. Even with the greatest care, however, it is not possible to keep out every bit of foreign matter. Also, bits of metal wear off during operation of pumps, gears, valves, and other parts of the hydraulic system. Therefore, filters are installed at numerous places in the system to catch all those bits. The MRCs and the OPs on maintenance tell you how often each filter is to be checked as a matter of routine. By regular frequent checking of filters, and replacement, you can greatly reduce the down time of hydraulic systems. Testing of samples of hydraulic fluid taken from the accumulator supply tanks detects deterioration of the fluid. Use the MRC instructions for obtaining the samples.

A typical micronic type filter unit is shown in figure 6-22. It consists of a single element filter assembly, a filter bypass valve, a switch valve, a filter clogged switch, and switch actuator. If the filter element starts to clog, it retards the flow of hydraulic fluid and causes a pressure differential on the opposite ends of switch valve UV-1 (fig. 6-22). When the pressure differential reaches a preset setting, the higher pressure at the input end of switch valve UV-1, causes the valve to shift to the right against the spring end of the valve which opens a pressure port to the switch actuator. When this occurs, a Filter Clogged light (red lamp) begins to blink on one

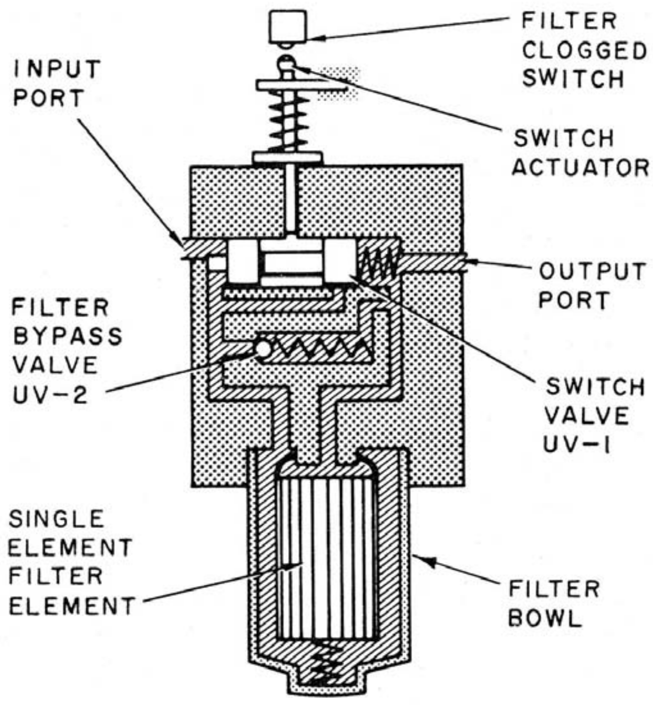

Figure 6-22.—Filter unit.

or more of the control panels. When the lamp blinks, the launcher captain at the EP-2 panel must determine the location of the clogged filter and take appropriate maintenance action according to ship's doctrine. As long as the filter remains clogged and the pressure differential reaches a preset setting above that regulated by the filter bypass valve UV-2 an valve spring (fig. 6-22), the bypass valve will open and port hydraulic fluid around the filter element and flow directly into the system through one output port. The replaceable filter element is a treated cellulose paper formed in vertical convolutions which catch and hold dirt and other solid particles. (Some filter elements are made of other fibrous material or of metal discs and rods which can be cleaned and reused if a new filter element is not available, or it may be set aside to be cleaned later and placed in storage for reuse. They need to be thoroughly dry before reuse.)

Before you change a filter element, turn off the hydraulic system and release the system pressure.

WARNING: Be sure that system pressure is relieved before disassembling or removing hydraulic components. High system pressure can cause serious injury to personnel.

Arrange to catch hydraulic fluid that will spill from the bottom of the filter unit when the bowl is removed. Unscrew and remove the filter bowl, then pull the filter element off the head. Install a new or properly cleaned filter element and an O-ring, seating them firmly on the filter head. Examine the O-ring in the filter bowl; replace if it is faulty. Coat the external threads of the filter head with petrolatum and reassemble the filter bowl to the head. Install the safety wire. If the filter continues to clog, the hydraulic system may need to be drained, flushed, and refilled.

Valves

The daily and weekly operational checkouts may reveal need for adjusting one or more valves. Types of valves used in hydraulic systems are described and illustrated in *Fluid Power* NAVTRA-16193 and some general instructions for installation and maintenance are given. See also the illustrations and descriptions in chapter 8 of this text, and in the preceding text, *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199-Be.

Numerous valves, simple and compound, are used in the hydraulic components of missile launching systems, and in the missiles. Note the number and variety of valves in that small segment of a launching system shown in figure 6-20. The same principles of operation apply to all, regardless of complexity, but the components and their method of assembly may differ. Whenever a valve has to be disassembled, be sure to get the drawing showing all the parts and the order of assembly. The automatic valves, such as regulators, relief valves, and safety valves, should not be disturbed except at over haul, unless found faulty. Foreign matter in the valve seat, scoring and grooving of parts, or plugging of openings may cause the valve to stick or fail to close completely. The usual remedy for such conditions, as in fact for practically all serious valve troubles, is to dismantle the valve, thoroughly clean all parts, replace those that are damaged, and reassemble. You may have done this with the simpler valves, or under supervision. Maintenance of compound relief valves is fundamentally the same as that of simpler types. You can generally tell that a compound relief valve is not functioning properly because it will overheat, and will operate sluggishly or erratically, or at the wrong pressure. The valve will usually clean itself if you start the pump and back off the adjustment screw on the pilot valve a little by turning it counterclockwise so that the pressure control spring responds to a lower pressure. The adjustment screw should never be removed completely while the system is under pressure. (Some instructions require complete release of system pressure before adjusting: check the instructions for your launching system.) After a flow of liquid has cleaned the valve, carefully reset the adjustment screw, using a pressure gage. The relief valve should be set to open at about 25 percent more than the maximum normal operating pressure.

CHECK VALVES require little attention overlong periods of time. Leakage may be caused by a tiny particle of foreign matter between the checking device (ball, cone, or poppet) and its seat. It will be necessary to remove the valve and disassemble it completely for cleaning. Remember the warning about high pressure systems - shut off power and release the pressure before removing any part from the hydraulic system.

If no scratches are found on the valve seat or the checking device, wash all parts in clean hydraulic fluid of the same type as used in the system. Inspect the housing and the checking device for evidence of corrosion. A slightly rough surface can be smoothed by buffing. Replace the valve if there is corrosion or excessive roughness. A cone type check valve may have a tendency to lean to one side, in which case the movable part may dig into the soft aluminum body of the housing and stick there.

Remember that the arrow on the housing must point in the direction of the flow of liquid through the valve. Before removing a check valve from a line, mark the adjacent structure, indicating the direction in which the arrow points. When installing the check valve, grip the wrench flats of the check valve at the end to which the connecting tubing is being installed. Do not grip the opposite end. This will prevent the possibility of distorting the valve body, which would cause the valve to leak.

When a valve has to be disassembled for cleaning and replacement of broken or worn parts, such as a broken spring, deteriorated O-ring, or scored valve plunger, it is important that the correct parts be used, and that they are assembled in the proper order. The MRC gives all the steps in order. The OP with the illustrated parts breakdown (IPB) identifies every part by name and stock number. A neat, orderly workbench is essential so parts can be laid out in order. A dust-free area helps in keeping dirt out of the valve when reassembling.

Through constant use, working parts may become worn, springs may be weakened or cracked, and O-ring and backup rings may become deteriorated. Vibrations can cause metal parts to crystallize and crack. However, keeping dirt, moisture, and air out of the hydraulic system is the best preventive of trouble. Daily inspections will detect leaks that can be corrected by simple tightening; daily checking of pressures and fluid levels can detect other troubles before they become major ones.

Valves are not disassembled as a routine maintenance procedure; they are disassembled only if they are not functioning properly.

Pumps

As a rule the pumps in hydraulic power drive systems require little maintenance other than proper lubrication and a clean hydraulic system to operate in. Signs of trouble are overheating, unusual noise, or failure to deliver the designed output. A frequent cause of noise is failure of oil to reach the pump. The oil level in the reservoir may be low, or there may be clogged lines or filters. Since the pump depends on the hydraulic fluid for lubrication, failure of the supply will soon cause the pump to heat up and will probably cause its parts to bind.

Another cause of abnormal noise is poor alignment between a pump and its driving mechanism. This condition will cause worn parts and possible leakage, reducing the pump's efficiency. Correcting the misalignment can be a major repair job, but the trouble will not correct itself-it will get worse.

Pounding or rattling noises in axial piston pumps may be unavoidable because of a partial vacuum produced in the active system during high speed operation or under heavy loads. The noise should stop when the load is reduced. If it does not, bleed air from the system at the vents.

Hydraulic systems which perform satisfactorily and show no evidence of sludge, corrosion, etc., should not be opened. Cover plates should be kept tightly secured, and should not be opened without good reason.

Use special care when you reassemble a rotary gear type pump. The rotors operate in a pump casing or body. End plates enclose the rotors on each side. When tightening the screws that hold the sections together, use only moderate force. Make them just tight enough to allow free movement of the rotor with no leakage.

The routine inspection, lubrication, checking of fluid level and pressure are tasks for the GMM 3 and GMM 2. They use the MRCs for instructions, and check off each job on the work schedule after completion. Your job is to supervise and check the work, and make sure it is done at the intervals scheduled, whether daily, weekly, or otherwise.

Motors

Hydraulic motors are activated by receiving fluid flow from the power pump. This fluid, under pressure, forces the motor pistons away from the flow source, thus resulting in a rotation of the motor drive shaft. The pressure buildup in the high pressure line between the pump and motor will be in direct proportion to the mechanical output or work required of the motor. The motor speed will vary directly with the amount of fluid pumped to the motor. The direction of rotation can be instantly reversed without harming the motor. The direction of flow is controlled by a selector valve.

A fixed displacement hydraulic motor may be used with a variable displacement hydraulic pump. A radial piston motor is usually used with a radial piston pump, and an axial piston motor with an axial piston pump. See *Fluid Power*, NAVTRA 16193 for descriptions.

Hydraulic motors are self lubricating; daily inspection for leakage is usually all the maintenance needed. If the motor must be removed for overhaul or corrective maintenance, be sure to plug all openings of connecting pipes so no dirt will get into the system. Use a lifting device to transfer the motor to the workbench. Figure 6-23 illustrates a typical hydraulic piston-type motor. Disassemble the parts carefully to avoid marring or scratching smooth surfaces. This is especially necessary where the fit must be exact to prevent oil leakage, as at oil seals. Follow the disassembly and reassembly instructions in the OP for the power system. The correct order makes the work easier, and is less likely to result in damage to parts by excessive use of force.

When removing the roller bearings, take care that the rollers do not fall out. As you remove each part, carefully place it on a cloth or paper-covered space in the order of removal. There are several small parts that can easily be lost. Do not throw away a part until you have a replacement part for it. You may need it for comparison, even though the stock number for the new part is the same as the old. A flaw or defect in a part may not be visible until after the part is cleaned. Inspect each part after you have cleaned it. Do not leave bare parts exposed any longer than necessary without the protection of a coat of oil. Rust can develop quickly and mar the polished surface of a precision-fitted part.

On some later modes of B-end motors, a hydraulic equalizing valve is mounted on each side. These valves were set when the power driveways tested. If the motor is removed, or replaced, adjustment can be made so that exactly equal pressures can be developed in each B-end motor high pressure line. Gages can be mounted on the B-end motor when pressure tests are to be made. The snubber and fittings that accommodate the gages are located beside the equalizing valves.

Troubleshooting

When scheduled maintenance or system testing (DSOT) reveals a fault, system trouble-shooting procedures begins. The use of trouble-shooting charts and procedures contained in PMS/SMS system manuals (OPs) isolates the fault. After finding and isolating the fault, system manuals direct the maintenance personnel to the appropriate instructions for correcting the malfunctions. Corrective maintenance instructions consist of either Corrective Maintenance Cards (CMCs) or a volume of the system OPs for corrective maintenance. System OPs have

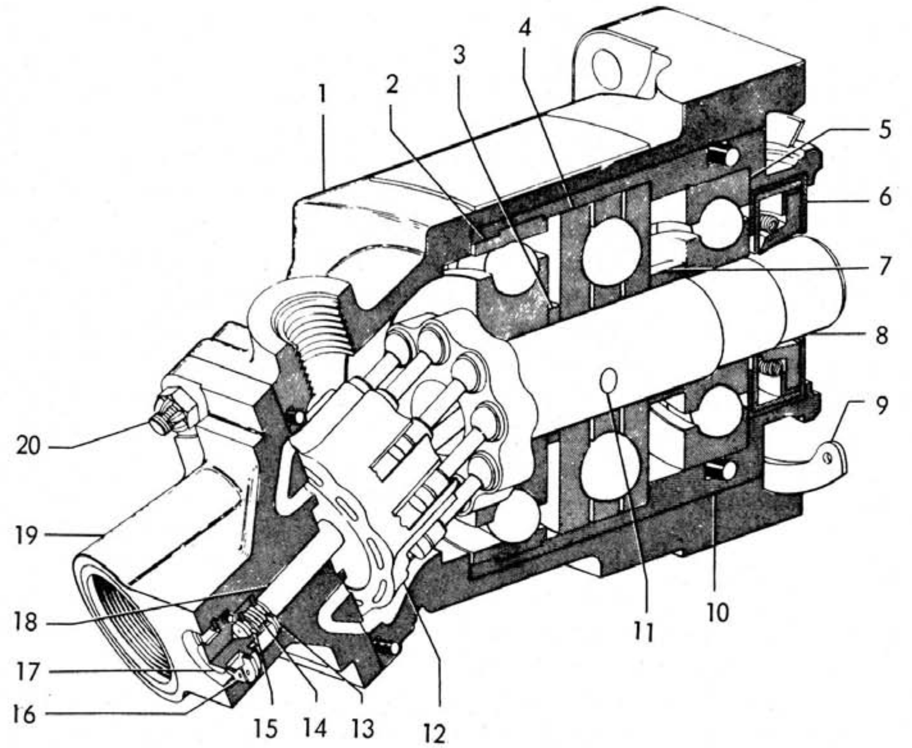

Figure 6-23.—Typical hydraulic motor, piston type.

volumes which contain detailed instructions for the performance of nonscheduled maintenance within the capabilities of ship's personnel using shipboard facilities. These instructions are for the alignment, adjustment, repair, and replacement of parts and components. Other volumes contain detailed instructions for maintenance that require the facilities of a shipyard or depot. These instructions cover dismantling, repair, replacement, and alignment of major assemblies and subassemblies.

ADJUSTMENT AND REPAIR AT A NAVY YARD OR REPAIR TENDER

Given careful daily maintenance and inspection, hydraulic systems can be used for long periods of time without major repairs. Break-downs can occur, however, in spite of the best care you can give. Size and weight of some components make repair. aboard ship difficult or impossible; alignment of such components may require the facilities of a shipyard or a repair tender. Attempts by unskilled personnel to overhaul or repair components can result in serious damage to costly equipment, and possible personnel injury. Before disassembling any part, be sure you can put it together again, correctly, and understand how it should operate. The illustrated parts drawings are essential for the less experienced men, and help even the most experienced men to check themselves on reassembly.

Alignment of large components may require yard or tender facilities. Critical adjustments may need to be deferred yard or tender work. Train and elevation power drive units are not normally removed or installed by ship personnel. While it is possible for shipboard personnel to remove the train or elevation power unit, it is recommended that such removal be accomplished during major overhaul. If the power unit has to be removed before yard or tender facilities are available, it is better to remove it by disassembling than to try to remove it as a unit when adequate handling facilities are not available.

Realigning a launcher rail is a task of considerable proportions. Arrange for tender or yard assistance, if possible. Do not readjust the launcher rail unless it is absolutely necessary.

Removal of excessive backlash in train and elevation drives is best reserved for overhaul. Excessive backlash causes misalignment between the launcher and the weapons system; insufficient backlash causes galling and binding.

Repair and overhaul of train and elevation gear boxes are tasks for tender and shipyard personnel. Although ship personnel can remove, disassemble, and reassemble the gear boxes, getting the proper alignment and backlash within the gear box, and properly aligning the gearbox to the sector gear or training circle, wouldn't be possible with the equipment normally available on board.

Lest these paragraphs give the impression that few adjustment and repair jobs are done aboard ship, look over the list of maintenance procedures for the system now assigned to you. There are several maintenance manuals that list the tests, repairs, alignments, adjustments, and servicing of a launching system that are done on shipboard. While this list includes such minor items as changing a light bulb, there are many complicated adjustments, such as interlock switch actuation adjustments.

RECEIVER-REGULATORS

Receiver-regulators are located on the launcher with the power drive units (figs. 6-11 and 6-18). The two control systems - train system and elevation system - consist of similar electric, hydraulic, and mechanical equipment. Each system receives its own order signals; the train system receives train order signals through its receiver-regulator, and the elevation system receives elevation order signals through the elevation receiver-regulator. During normal (automatic) operation, the train and elevation systems convert electrical signals received from a remotely located computer into hydraulic movements. These hydraulic movements control the velocity, acceleration, and position of the launcher carriage and the guides or guide arms.

Basically, the power drive consists of a CAB unit and a receiver-regulator. The CAB unit is composed of a B-end (hydraulic motor) and an A-end (hydraulic pump): The B-end converts fluid flow into mechanical motion. The output shaft of the B-end drives the launcher through reduction gears. Therefore the speed and direction of launcher movement is determined by the speed and direction of the B-end output.

The A-end is the hydraulic pump that supplies pressure fluid to the B-end. The fluid flow supplied by the A-end determines the speed of the B-end, while the direction of fluid flow from the A-end to the B-end governs the direction of the B-end rotation.

The A-end output is determined by two stroking pistons controlled by the receiver-regulator. These pistons "stroke" the A-end tilt plate, and thus regulate both the quantity and the direction of fluid flow from the A-end. The A-end is driven at a nearly constant speed by a unidirectional electric motor. The receiver-regulator controls the hydraulic fluid ported to the stroking pistons, and thereby regulates the CAB unit operation. The regulator components position the A-end tilt late so the B-end output is in accordance with the electrical signal input order to the receiver-regulator. The position signals are sent from the computer to both the train and elevation systems. Synchro transmitters (CX) at the computer initiate the signal voltages; synchro receivers (CT) in the receiver-regulators receive the signals.

Figure 6-24 is a simple sketch of the synchro control system components, showing how they interact. A signal voltage (primary or position signal), transmitted by CX to CT, indicates the desired position of the launcher. The CT acts as a differential, combining the actual position of the driven equipment indicated by the mechanical responses with the ordered position. Two other systems, not discussed here, can control the tilt of the A-end plate and therefore the position of the launcher. A velocity system improves the synchronizing capabilities of the launcher; the integration system improves the accuracy of the launcher.

The CT output is a signal voltage proportional to the B-end error. The B-end error is the difference between the ordered position of the driven equipment (launcher) and its actual position. The CT output is transmitted to the amplifier, where it is amplified and sent back to the

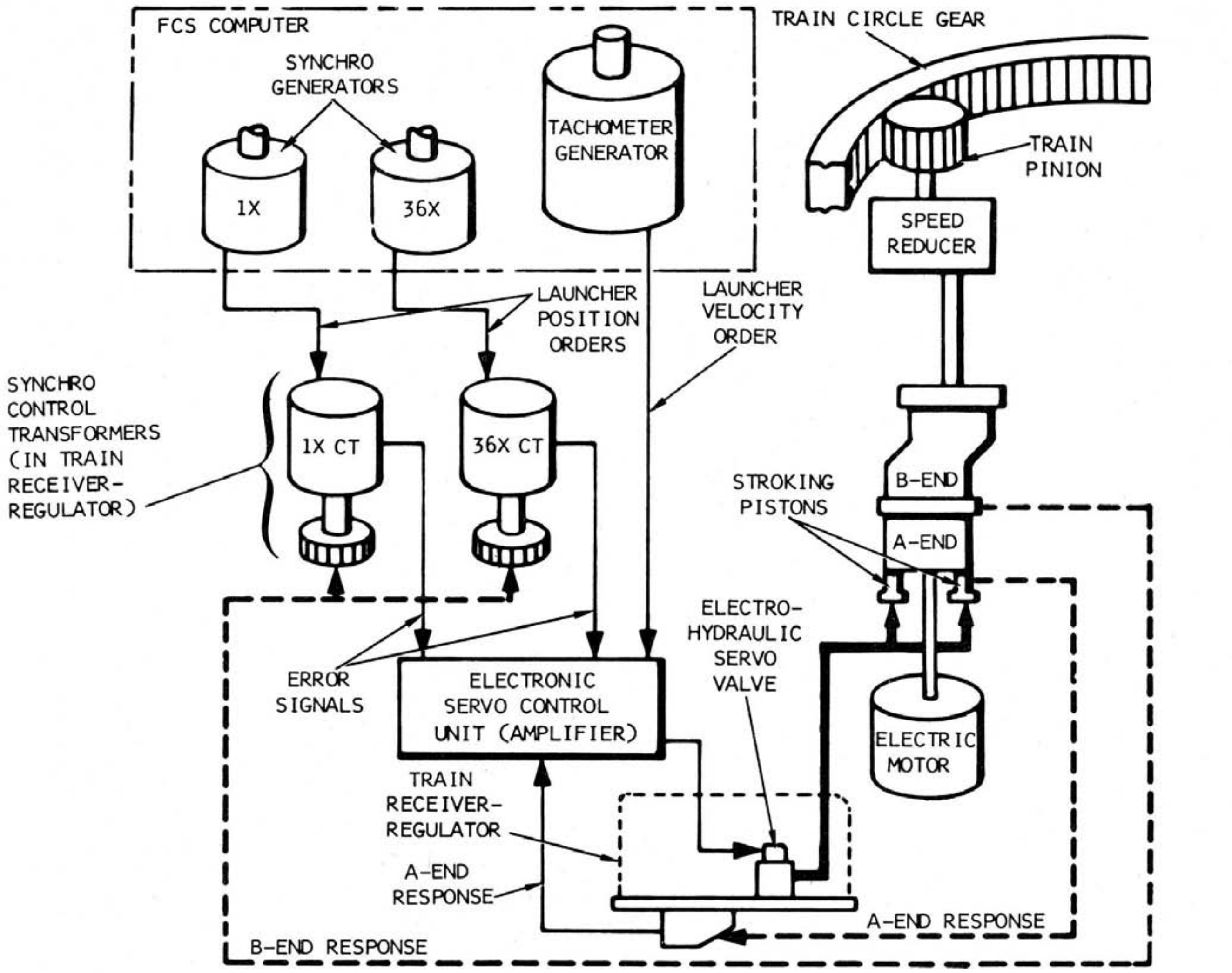

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Figure 6-24.—Launcher synchro control system and amplifier.

receiver-regulator. There it drives an electrohydraulic servo valve which transforms the amplified electrical input into a proportional hydraulic movement, and moves the launcher to the position ordered. If the target is moving, the position of the launcher has to be corrected with each new signal from the computer.

To enable the launcher to be positioned more accurately, the train and elevation synchro control systems have CXs and CTs in pairs. Each pair consists of a coarse synchro called 1X (one-speed) and a fine synchro called 36X (36-speed).The CXs are located at the computer and the CTs are at the receiver-regulator. The rotor movement of the 1X coincides with the launcher movement, while the rotor of the 36X CT will move 36 degrees for every degree of launcher movement. As long as the system is on automatic operation, the launcher is moved in train and elevation on signal from the computer. In local operation, the launcher is moved by moving the train and elevation dials as ordered by the Weapons Control Station. (On some systems the dials cannot be changed manually.) Figure 6-25 shows the train and elevation local control dials, 1-speed and 36-speed, on the EP-3 panel for the Mk 5 launcher (Terrier). The train and elevation error indicator meters (fig. 6-25) show how much adjustment is needed. The local control knobs, one for train and one for elevation, are used to make the adjustment. Behind the face of the EP-2 panel are the synchro control

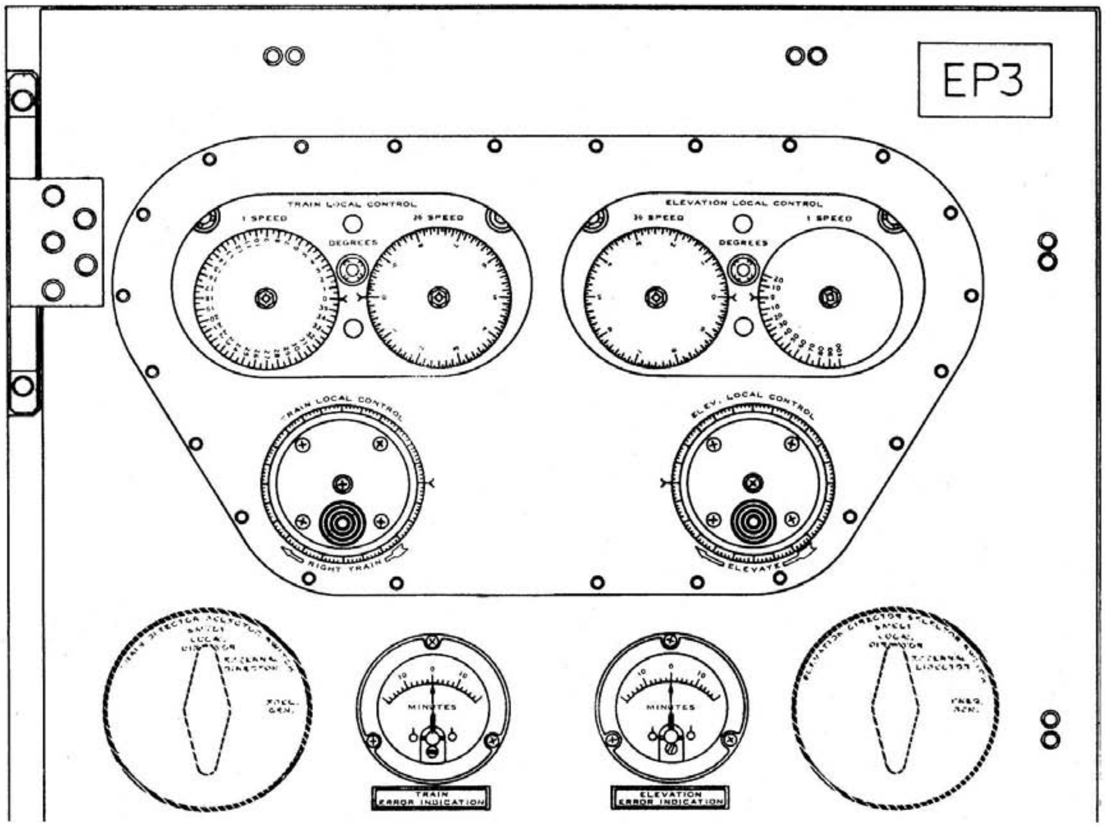

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Figure 6-25.—Train and elevation dials, local control station, EP-3 panel, Launcher Mk 5 (Terrier).

transmitters, tachometer generators, gear trains, and flywheels (one set for train and one for elevation) to transmit the motion to adjust the position of the launcher. For adjustments of less than 4.8 degrees, the 36-speed dial is used. For larger changes, the 1-speed dial is adjusted first to bring the launcher position to within 4 to 5 degrees of the ordered position. Then the fine adjustment is made with the 36-speed dial. LOCAL control may be used to stow weapons, exercise the launcher (without loading a weapon), and to purge the hydraulic system of air during maintenance or in an emergency. LOCAL control cannot be used for loading and firing. This simple statement points out the absolute necessity for keeping the system in perfect operating condition. The failure of one small part can inactivate the whole launching system. You must learn to repair hydraulic, electric, and mechanical parts of the system. The ability to locate the trouble quickly and surely is very valuable.

Synchro systems are discussed in the preceding chapter and also in the preceding course, *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199 and in *Basic Electricity*, NAVTRA 10086. These all emphasize the electrical aspects of the operation.

TARTAR RECEIVER-REGULATORS

The following description of Tartar receiver-regulators are those used with GMLS Mk 13 and Mk 22. The receiver-regulator is mounted less than 2 inches from the main supply tank. The heating and cooling of the hydraulic fluid tends to create a vacuum in the receiver-regulator cases, which causes air from the main supply tank to be sucked into the receiver-regulator cases. The air breather on the main supply tank allows salt or humid air to enter the tank. This air would cause damage if it reached the receiver-regulator parts. To prevent this, an expansion chamber with a quantity of inert gas is connected to the top of the main supply tank.

The receiver-regulator cases port through this chamber in such a way that only the inert gas can ever enter the receiver-regulator cases when a vacuum is created.

Remote train and elevation order signals originate in the missile fire control system. Order signals may also originate in the control transmitters within the launching system (EP-3 panel). These signals are used in the LOCAL control mode of operation, which is used primarily for daily workout or routine maintenance.

The receiver-regulators on the Mk 116 launcher of the Missile Launching System Mk 13 are different from preceding models in sever always. The Mk 116 launcher uses an amplifier (electronic servo control unit) which electrically performs many of the functions that were previously performed hydraulically by other types of receiver-regulators. A modified synchro system is used, with the B-end response positioning the synchro rotors. There is no rotary piston response. Only one modified electrohydraulic servovalve is used. Both chambers of the electro-hydraulic servovalve plunger are utilized, and each chamber is directly connected to the A-end stroking piston. The two stroking pistons have equal areasfor hydraulic pressure to act upon.

The A-end response is transmitted electrically by a potentionmenter to the amplifier and mechanically to the limit stop and automatic tracking cutout systems. A modified limit stop system is used to mechanically return the electrohydraulic servovalve, and thus the A-end, to neutral.

The automatic tracking cutout system uses the limit stop system to stop the power drive. There are no hydraulic velocity and integration systems in the regulator. However, a velocity signal is electrically applied to the amplifier.

Guided Missile Launching System Mk 13 Mods 1, 2, and 3 use Launcher Mk 126 Mod 1, and a number of changes have been made in the associated equipment. The principal change in the train and elevation systems is the redesign of the electronic servo control units. Minor modifications have also been made in the train and elevation drive motors, the servo and supercharge hydraulic systems, and the receiver-regulators.

The Mk 48 Mod 1 train receiver-regulator is the same as the Mk 48 Mod 0 receiver-regulator except for the synchro gear, the stroke response assembly, and the automatic tracking cutout valve block assemblines. The Mk 49 Mod 1 elevation receiver-regulator differs from the Mk 49 Mod 0 regulator in the same way.

The modified stroke response assembly includes an electrical connector to facilitate replacement of the stroke response potentiometer. A resistor has been added to the synchro gear assemblies, which is wired to the tachometer generator. The automatic tracking cutout valve block assembly has been mounted with rollers above and below the limit stop actuating cam to prevent binding.

Some of the check valves that arc on the auxiliary relief valve assembly in the Mk 13 Mod 0 have been relocated on the header tank cover in the Mods 1,2, and 3.

The train and elevation auxiliary pumps in the Mk 13 Mods 1, 2, and 3 furnish supercharge pressure at approximately 150 psi instead of 100 psi as in the Mod 0. The servo pressure remains the same, approximately 525 psi at 3 gallons per minute (gpm).

The only changes in the CAB units (hydraulic transmission) involve the safety relief valves. They are compound valves mounted on the valve plate between the A-end pump and the B-end motor. The assembly consists of the valve block, six valves, and two orifices. The valves serve to limit maximum pressure buildup in the high-pressure output line of the A-end pump and prevent cavitation by porting hydraulic fluid to the low pressure (suction) line of the A-end pump. (This compensates for fluid lost through slippage and leakage.)

The train and elevation amplifiers are identical, and share a common power supply in a transistorized Electronic Servo Control Unit which is mounted in the EP-2 control panel. Thirteen printed circuit cards in a rack on top of the main chassis plug into 13 female receptacles in the back of the compartment.Each of the amplifiers (train and elevation) requires an identical set of six printed circuits, one card for each of six primary stages in the functioning of the amplifier.

Figure 6-26 is a block diagram of the six stages, each representing a printed circuit card, of an amplifier. The electronic servoamplifier is

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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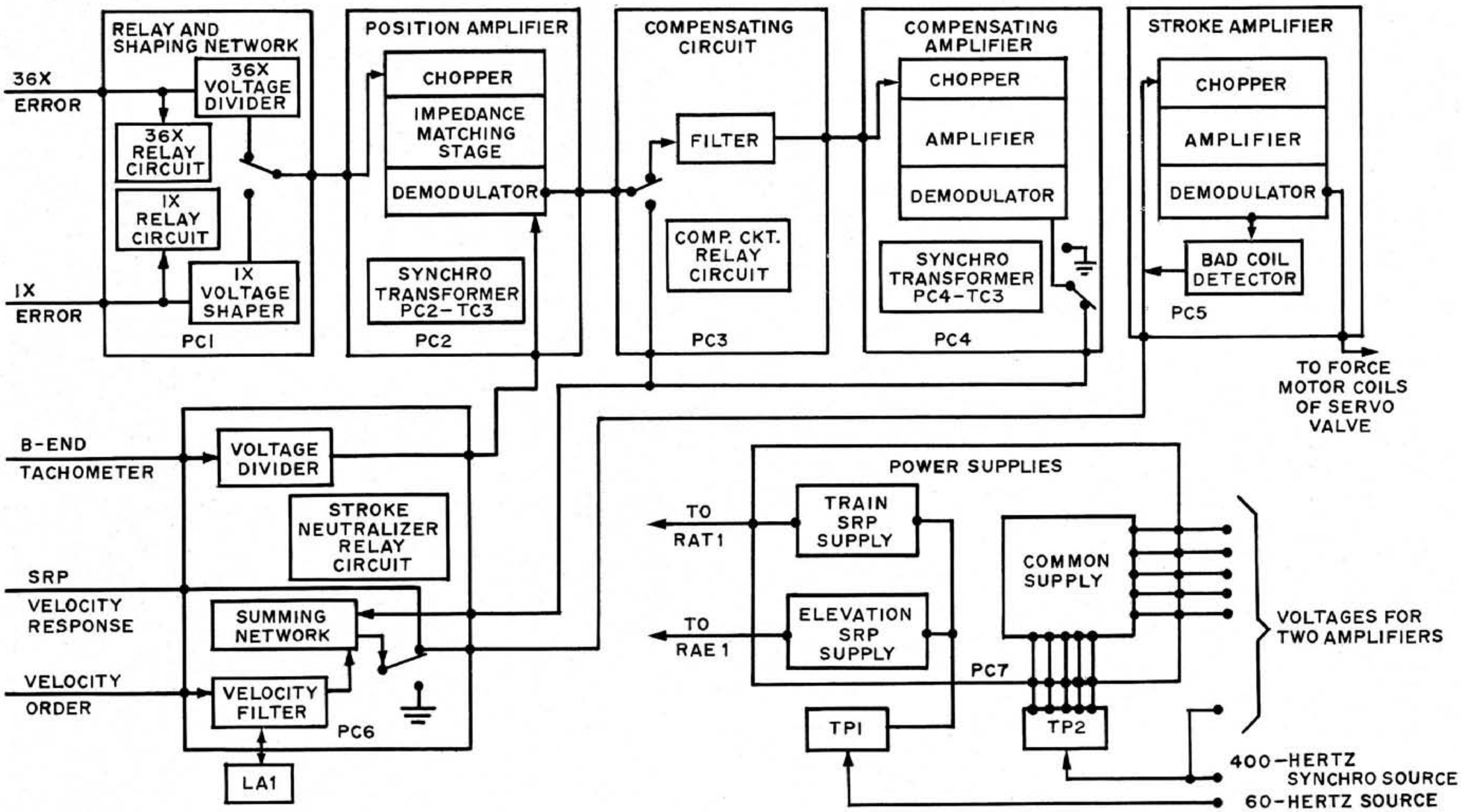

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Figure 6-26.—Amplifier Circuit Cards, Functional Diagram.

one of the components of the servomechanism that keeps the launcher synchronized until the missile leaves the guide rail. The receiver-regulators are the error detectors in the system, comparing the remote orders (from the launcher computer in the fire control system) with the actual launcher position. The amplifier processes the error. The processed position error becomes the velocity required of the launcher to correct the position error. It is one of the inputs to the velocity controller, which detects any difference between the order velocity and the launcher velocity and makes it a control order to the stroking pistons. The electrical order comes from the electronic servoamplifier to the electro-hydraulic servo valve, which converts the order into hydraulic orders and admits hydraulic pressure to the stroking pistons according to the orders. The CAB unit supplies the response information to complete the servo loop, sending position information to the receiver-regulators.

TERRIER RECEIVER-REGULATORS

The receiver-regulators are mounted to the center of the launcher carriage, directly above the CAB units. Servo pressure at 400 psi is supplied to the receiver-regulator valves and pistons. There are two major servo systems in the receiver-regulators: the power drive and the velocity drive systems.

The signal for moving the launcher to the correct train and elevation position for dud jettisoning comes from a fixed synchro in the EP-2 panel. There is a switch for each launcher arm, A and B. Air motors provide a means of training or elevating the launcher for maintenance.

Figure 6-27 shows a receiver-regulator with the cover removed, and some of the main components are named. It contains a multitude of components, here grouped into seven logical sections to simplify location and identification:

1. The main valve block (including the electrohydraulic servovalves).
2. The nonpointing zone valve block.
3. The limit stop assembly.
4. The B-end response.
5. The synchros and their accompanying gearing.
6. The rotary piston assembly.
7. The A-end response assembly.

Between the limit stop assembly and the elevation indicator dials are two B-end response gears. One of the B-end response gears drives the synchro gearing assembly and the other gear drives the limit stop assembly. The B-end response shaft that drives the gears leads through an opening in the regulator base plate. The B-end tachometer is driven by the limit stop gearing.

The synchro gearing assembly includes five visible synchros with the gearing immediately below them, and indicator dials. The dials are visible through the window in the cover of the receiver-regulator.

The A-end response shaft leads into the receiver-regulator through an opening in the base plate, and is not visible in figure 6-27. The rotary piston assembly is attached to the inboard side of the main valve block and lies below the rotary switch cam.

Except for minor differences, the train receiver-regulator is identical to the elevation regulator. The train rotary piston cam has a slightly different contour than the elevation rotary piston cam, but it operates similarly. The contour is different because of the different acceleration and velocity specifications in train.

The nonpointing zone components of the train and elevation receiver-regulators prevent the launcher guide arms from training or elevating into any part of the ship's structure. The train limit stop does not have a gear and rack as does the elevation limit stop assembly, but contains a nonpointing zone cam. The cam may be halted by pistons in the nonpointing zone valve block. By means of the gear and rack, the power drive can elevate the launcher arm above the nonpointing zone.

The train B-end response assembly differs from the elevation B-end response assembly in design because of mounting position. The train B-end response is coupled to the train gear reduction.

Receiver-regulators used with early models of the Mk 5 launcher (also Mk 7 launchers for Talos) use torque motors and rotary valves instead of electro hydraulic servovalves. The torque motors are controlled by conventional tube

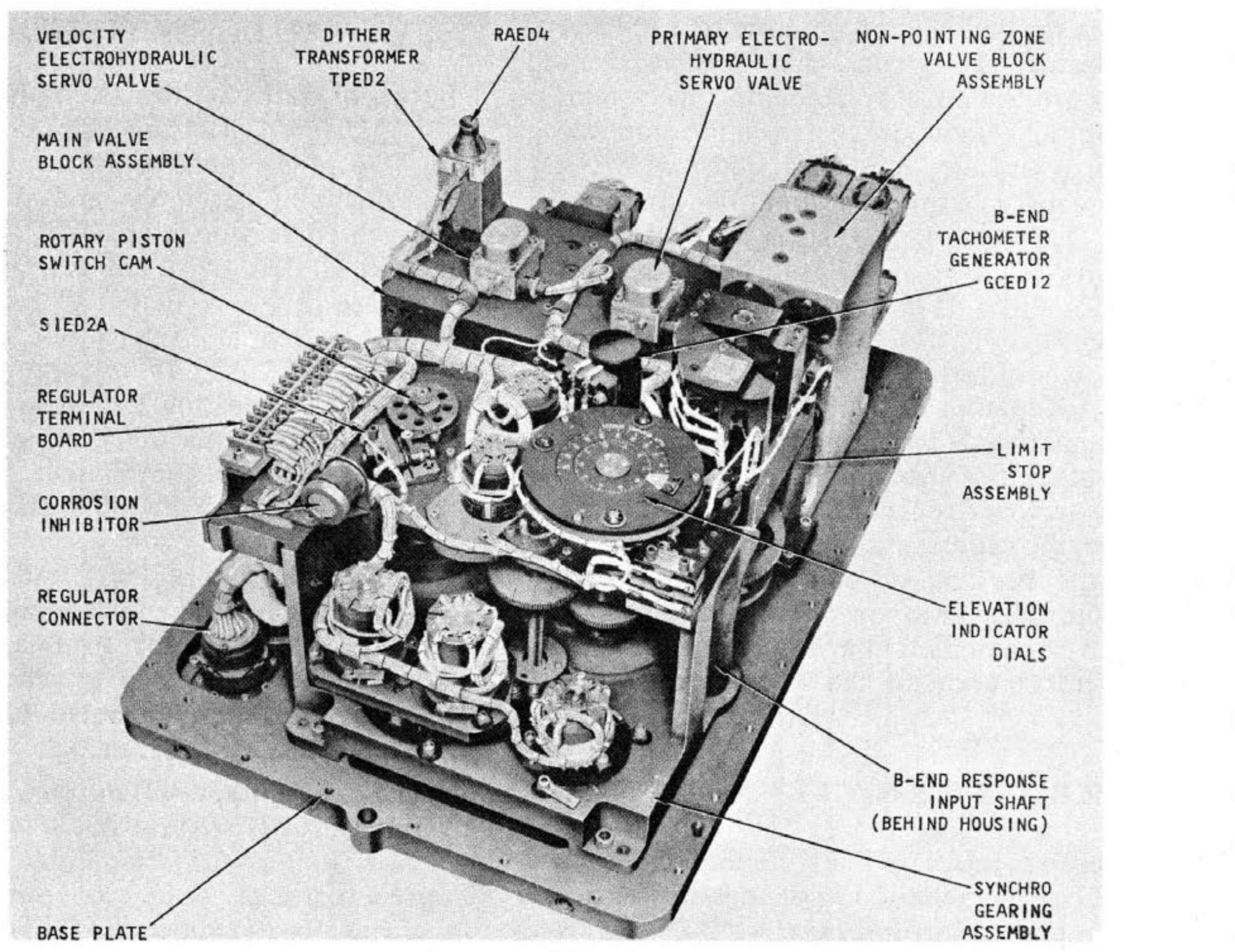

Figure 6-27.—Elevation receiver-regulator, Mk 5 launcher; cover removed.

amplifiers instead of magnetic amplifiers. The function of the electrohydraulic servovalve is to convert an electrical signal from the train (or elevation) primary amplifier into a proportional hydraulic order. It does this with a minimum of friction and negligible time delay. Figure 6-28 is a cutaway view of an electrohydraulic servovalve. There are four ports in the base of the valve. One port supplies hydraulic fluid at 400 psi to the servovalve, one port leads to the tank, and a third port supplies control pressure from the servovalve to the rotary piston neutralizing valve. The fourth port is blocked off and not used.

The hydraulic pressure ordered by the electrical input is applied to the end of the servovalve plunger and positions it. The plunger position results in the output of control pressure, proportional to the electrical input, which is sent through the control port.

The force motor (fig. 6-28) consists of two permanent magnets, two pole pieces, two coils and a reed. One end of the reed is centered in the air gap between the two pole pieces and the other end is centered between two nozzles in the mixing chamber. The reed is the armature of the magnetic circuit and is polarity conscious. The force motor transforms the electrical input, a differential current, into a proportional force on the motor reed. The hydraulic amplifier converts the reed movements into corresponding differential pressures. The differential pressures cause the plunger to shift. A decreasing order signal causes a shift to the left; an increasing order signal causes a shift to the right.

Adjustment can be made on the adjustment

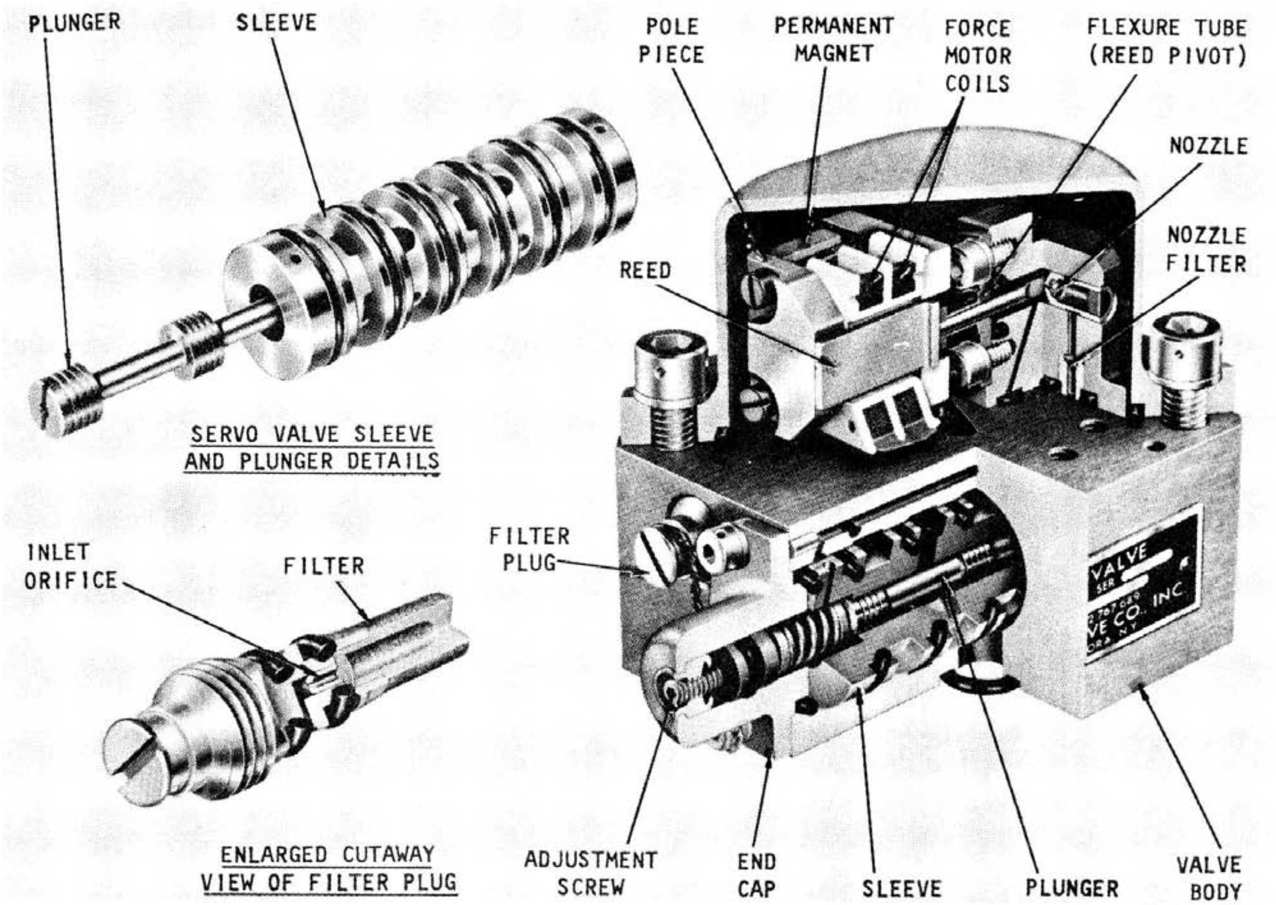

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Figure 6-28.—Electrohydraulic servovalve cutaway view.

screw (fig. 6-28). The filters may need to be cleaned, or the whole valve may need to be disassembled, cleaned, and reassembled. Servovalves are used in several of the hydraulic systems, and you need to be able to maintain and repair them.

TALOS RECEIVER-REGULATORS

There are many similarities between the Mk 7 and the Mk 12 launching systems, and in many cases the equipments are identical. The basic principles of hydraulics and electricity apply to both systems. Equipments that are the same are the Area 1 accumulator, the mechanical and hydraulic aspects of the loader (except the power drive), and the mechanical and hydraulic aspects of the span track and the blast doors.

The receiver-regulators used with the Mk 7 and Mod 0 launcher and Mk 50 Mods 0 and 1 power drives make use of torque motors and rotary valves. On the Mod 2 power drives, electrohydraulic servovalves are used. The primary (position) and the velocity electrohydraulic servovalves for train and for elevation are in the receiver-regulators. Magnetic amplifiers are located on the EP2 panel. These amplify the train and elevation electrical signals so the signals are strong enough to tilt the A-end plate and thus start movement of the hydraulic fluid which will move the launcher in the direction and amount ordered.

Local train and elevation orders are transmitted by the local order synchro transmitters mounted in the internal director section of Test Panel Mk 203 Mod 0, the EP-3 panel. The transmitters are positioned by operation of the controls on the EP-3 panel to set the train and elevation indicator dials on the face of the panel to the positions ordered. There are fine and coarse dials for train and elevation on the control panel and also on the receiver-regulators. Remote control is in the form of electrical signals from the fire control computer that processes the information from a radar antenna mount. Two channels of control signals are fed to the train and elevation drives. One is a position order and the other is a velocity order. The synchro transmitter in the computer transmits a position order to the IXCT in the receiver regulator of the launcher. The stator of this CT is geared to the B-end of the hydraulic transmission. If the launcher is not positioned at the same bearing as the transmitted order, a voltage is developed on the rotor of the CT to represent launcher position error (angular difference between actual launcher position and the ordered launcher position). This error voltage is placed on the input terminals of the magnetic amplifier in the EP-2 panel. The error signal, amplified, is sent back to the receiver regulator, which then applies tilt to the A-end of the hydraulic transmission. The amount of tilt of the A-end governs the speed of the B-end. A gear reduction unit reduces the speed before it is applied to the drive pinion to drive the carriage. As the carriage rotates to the ordered position, the error reduces until it is zero.

When the situation is continually changing, as when the radar is tracking a moving target, the launcher must keep moving to follow the error signal, which could make it rough. A smooth operation of the launcher is made possible by the use of the velocity channel as an additional means of stroking the A-end. The velocity order is also received from the computer. The signal is amplified in the EP-2 panel, and sent t the receiver regulator, which causes a proportional tilt in the A-end. The electrohydraulic servovalve is part of the receiver regulator. It converts the electrical signal into hydraulic actuation.

A third system for power drive control is the integration system. It differs from primary and velocity control in that it is initiated within the receiver regulator. It is used only when the launcher is within one degree of synchronization and it prevents the launcher from hunting back and forth over the synchronization point. The integration system detects a small primary error through the displacement of primary stroke valve UVTD2 and responds to it by putting a movement on the stroke control lever through the velocity piston. Movement of UVTD2 acts on one end of a lever-arm linkage and the other end is pivot-mounted to a stationary point on the regulator valve block. As an example of how an integration signal is developed, a small increasing order through the primary system will be discussed.

The small downward displacement of UVTD2, figure 6-29 will cause a proportional downward displacement of integrator control valve UVTD7. UVTD7 supplies control pressure through neutralizing valve UVTD20 to the integration piston UCTD8. Any movement of UVTD7 from its neutral, position will cause a pressure change in the chamber above, UCTD8. Due to the decrease in pressure at the top of UCTD8, the integration piston starts to move up. The final position of UCTD8 represents the volume of fluid that has flowed to or from UVTD7. This volume is a measure of the sum of the primary error for each unit of time that the error existed.

The movement of UCTD8 generates an electrical signal through RATD5, (fig. 6-29), the integration potentiometer. The integration signal is amplified by the velocity amplifier and applied to the primary system to the stroke control level through the velocity system. The velocity potentiometer develops a response signal through RATD4 to electrically cancel the integration signal.

The integration system is cut out when large error signals are applied to the power drive servo system.

The train and elevation limit stop systems are located in the receiver regulators. Their function is to stop movement of the launcher and/or guide arms when moving into a fixed limit or nonpointing zone, or when a power failure occurs.

INDICATING EQUIPMENT

The position of the launcher must be known to the man who presses the firing key, the man who must make the decision whether to fire, and the men who position the launcher. The information must be presented simultaneously to all of them. The indicating lights are on the

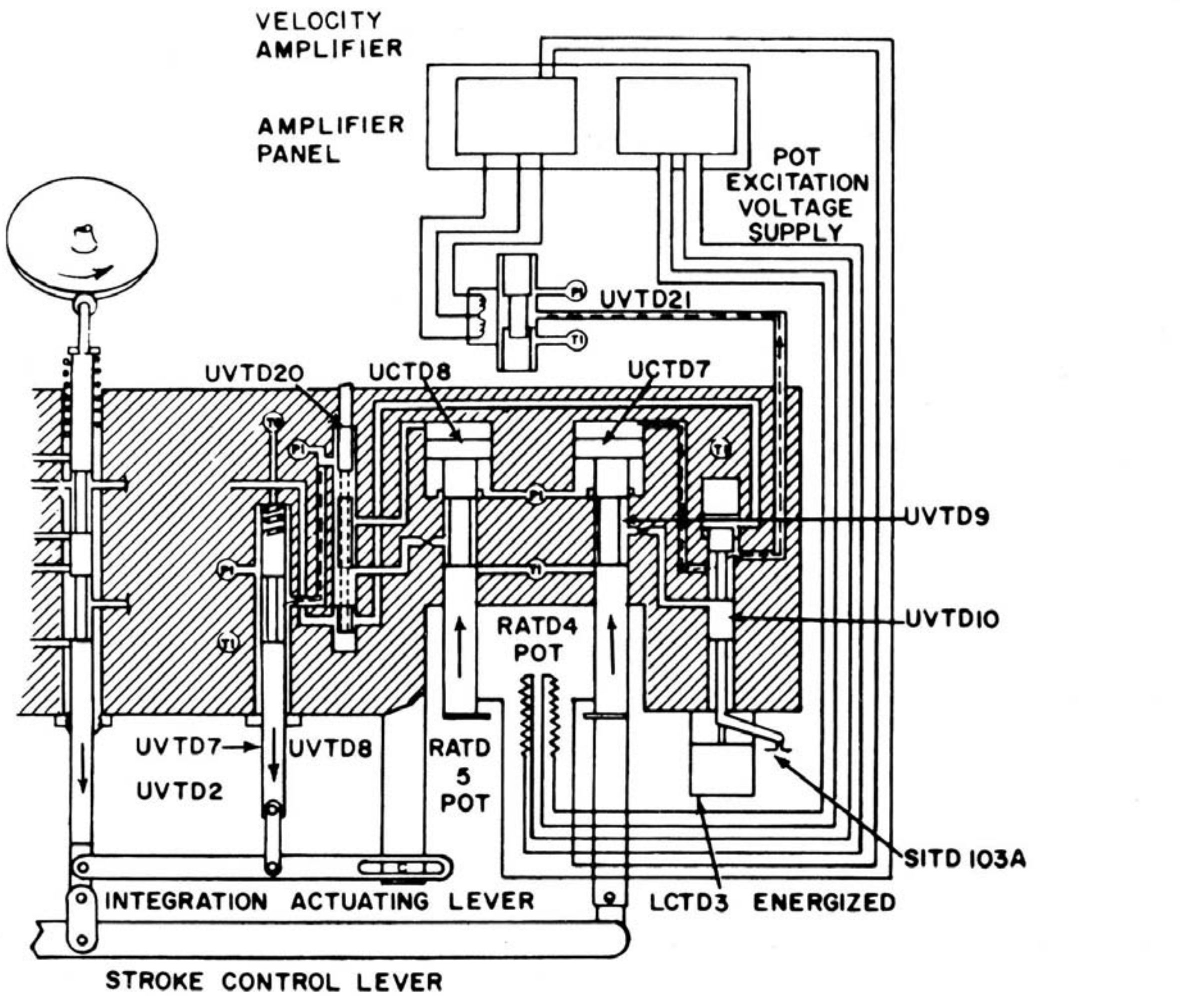

Figure 6-29.—Increasing order operation of the integration system.

launcher captain's control panel, in the weapons control station, and on the bridge. Train and elevation position and order dials on the launcher captain's control panel indicate the actual train and elevation positions and the ordered positions. (These dials cannot be changed manually.) Launcher elevation is shown in minutes of elevation arc, and train is shown in degrees. When the observed position and the ordered position match, the launcher is in firing position and the TRAIN IN SYNC and ELEVATION IN SYNC lights illuminate. When all parts of the missile and the launcher are ready, the READY-TO-FIRE window on the panel lights up. The missile may not be fired until all lights show that everything is in readiness.

Within the weapons system are numerous equipments called indicators, all designed to supply information to the operators. The train position indicator and the elevation position indicator are two of these. All the panels in the launching system, manned and unmanned, are indicating panels. Numerous panels and consoles in the Weapons Direction System (WDS) provide indications of weapons system conditions to the operators. Among those of interest to the GMM are the Weapon Assignment Console (WAC), Director Assignment Console (DAC), Target Selection and Tracking Console, master control panel, casualty weapons direction panel, casualty firing panel, missile status indicator panel, and control indicator panel. Some of these are in the Combat Information Center (CIC) and some are in the Weapons Control Station (WCS). Intersystem communication between the Weapons Direction Equipment and the guided missile launching system transmits orders to the control panels in the launching system and feedback from the launching system is transmitted back to the Weapons Control Station to indicate the carrying out of the order. For example, a load-select order is transmitted to the EP-2 panel as a light indication that shifts from flashing to steady when the EP-2 panel operator positions the A or B Selector switch to match the position ordered. This switch continuously feeds back an indication of the switch position to Weapons Control. Information on missile status (Armed/Safe, or Unsafe) is sent through the EP-2 panel to Weapons Control. Firing status is transmitted to Weapons Control as Missile Ready, Missile Firing, Dud, etc.

What happens if the launcher and missile are in readiness, but one or more of the necessary indicator lights are not on? The actual cause of this failure may be merely a burned out light bulb on the panel, but you don't actually know what is wrong until you check and find the trouble. Know-how acquired through daily checkouts should help you locate the trouble quickly and surely. In a combat situation, loss of even a short time can be critical. Your knowledge of launching system checkout can be the saving factor.

In addition to automatic equipment, sound-powered telephone circuits provide rapid interchange of information between missile system stations. These circuits are independent of electrical power from ship supply and can therefore continue to function when other systems fail.

TESTING AND MAINTENANCE

Each system has some provision for continuing operation if part of the system is inactivated by casualty. In the Terrier system it is called casualty mode of operation. Duplicate control panels and consoles are ready to be placed in operation in emergency, and ways of bypassing some controls are provided. The OP for the system describes casualty operation of the Terrier system.

Other missile systems have an auxiliary mode or emergency mode. In the Tartar system, Step control can be used for emergency if the automatic circuitry is inoperative. Manual operation is used for maintenance, checking, and installation, as well as for emergency. The Talos system has auxiliary mode in step control. The purpose<;>f these "extra" methods of firing is not to avoid making repairs on the system, but for use in an emergency in a combat situation. Train your men in the use of them so they will know what can be used in an emergency. Manual operation is strictly for maintenance, repair, and exercise.

SHIPBOARD RECEIVER-REGULATOR ADJUSTMENTS

The components of receiver-regulators are not fragile, but adjustments are precise and delicate, and therefore maintenance must be performed with care by trained, competent men. Improper care and maintenance procedures can destroy critical adjustments which require extensive realignment. Misalignment or binding of the various mechanisms can cause erratic launcher movement. The real cause of the trouble may be difficult to locate, so make a careful study of the problem before attempting to make any adjustment or repair.

Shipboard maintenance of receiver regulators includes replacement and adjustment of electro-hydraulic servovalves, velocity and integration potentiometers, and input synchro control transformers. One man operates the panel while another performs adjustments. Telephone com-munication between them is essential.

To replace an electrohydraulic servovalve, deactivate the system and dump fluid pressure from the regulator by draining the system to the level of the main supply tank. Then loosen the capscrews which secure the servovalve to the top of the main valve block in the receiver-regulator, and disconnect the cable plug. Replace with a new servovalve, tighten the capscrews, and reconnect the cable plug. A dowel pin in the base of the servovalve assures that the valve is positioned correctly.

After the servovalve is positioned, it is ready for adjustment. The servovalve spool position is adjusted by means of the adjustment setscrew (fig. 6-28). To adjust the primary electrohydraulic servovalves, energize the primary system but leave the velocity system deenergized. Adjust the primary electrohydraulic servovalve for zero difference current. Use the adjustment setscrew to adjust the valve spool. The difference current can be checked at the amplifier test points (fig. 6-30, 10A and 10B on the test points). Be sure the meter switch is turned to TRAIN PRIMARY when testing the train servovalve, and to ELEV PRIMARY when testing the elevation servovalve.

The adjustment of the velocity electrohydraulic servovalves is made in a similar manner. Activate the velocity system but not the primary system. Make sure the velocity potentiometer is adjusted to zero volts from the amplifier test point 8B to ground. With the setscrew (fig. 6-28) adjust the servovalve spool to zero difference current at velocity test points 10A and 10B (fig. 6-30). Turn the meter switch to TRAIN VELOCITY and the train test switch to 10 when checking the train velocity valve. To check the difference current on the elevation velocity servovalve, be sure to turn the meter switch to ELEVATION VELOCITY and the elevation test switch to 10.

When an operational check shows faulty operation of a potentiometer, it should be replaced and adjusted. There are four potentiometers ill the amplifier assembly shown in figure 6-30, two integration potentiometers, and two for train and elevation velocity. A volt meter is needed to make the adjustment of the potentiometer arm to zero volts before beginning removal or testing of any part. Deenergize the velocity system. Follow the instructions in the OP for your weapon system.

The position of the launcher, compared to the position indicated on the receiver-regulator dials must be checked at regular intervals. If there is any difference between the actual position of the launcher and the dial indication, adjustment must be made to the vernier on the regulator B-end responsible shaft. If the B-end vernier is adjusted, the launcher load order synchros will also require adjustment. Refer to your OP for the methods of doing this. Shut off power to the system when replacing any parts. Careful readjustment is necessary whenever a new part is placed in the system.

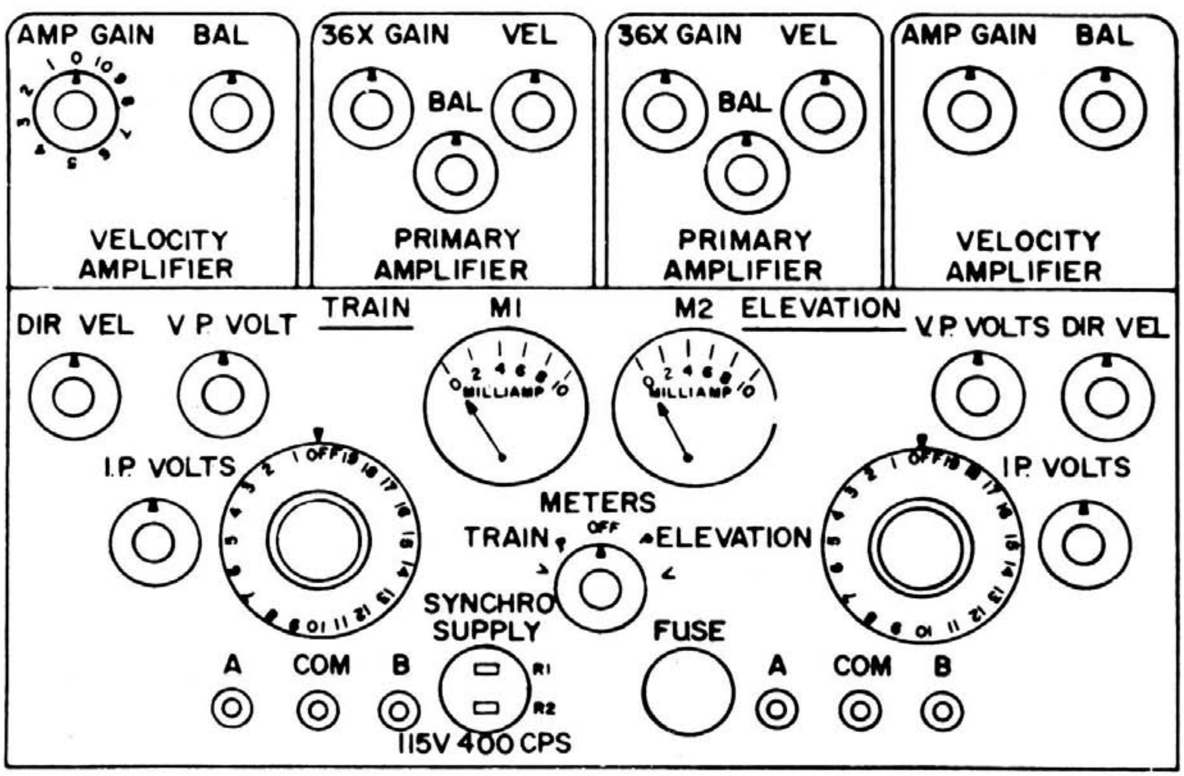

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Figure 6-30.—Front panel of amplifier.

MAINTENANCE OF RECEIVER-REGULATORS

Quarterly, or after each 360 hours of operation, secure the launcher intrain and elevation, and remove the housing cover of the receiver-regulator (train and elevation receiver-regulators receive the same maintenance). With the lubricant specified for your equipment, lubricate the rotary piston switch bearings, pivots, and rollers; A-end stroke response switch arm, bearings, pivots, and rollers; main valve block bearings, adjustable gears, and pinions; blind zone cutout gearing bearings, pivots, and rollers; blind zone cutout gearing brake block linkage and bearings; and all synchro gearing and bearings except those located within the synchros.

Remove the fluid power transmission fitting protective cap on the A-end stroke response and lubricate the fitting with a hand gun containing the prescribed fluid mixture. Check and refill, or add the specified corrosion inhibitor if required, at the synchro gearing assembly level.

Plan to adjust the power drive interlock switches at the same time, so the receiver-regulator covers do not have to be removed oftener than necessary. Most of the interlock switches are adjusted at the receiver-regulator. When possible, interlock switches are adjusted with the power off. Turn off power at the power panel.

Switch actuation is checked by a continuity indication at the nearest terminal. Switch lead termination between switches is sometimes common so that one lead must be disconnected. Because of the complexity of the wiring, the disconnected lead should be tagged and, after adjustment, reconnected immediately.

Communication must be established between the manual operator and the person or persons performing the switch adjustment. You will need to have the drawings showing the location of the switches for your power drive system, the OP, and a check sheet listing each switch so you can record your tests: Some of the interlocking switches can be checked with the power off and a 1.5-volt test lamp connected to the switch terminals in the regulator.

Train and elevation blind zones are fixed on the individual installations and are permanently recorded. You need a copy of the record when checking the stop positions of the launcher in train and elevation. Compare the train and elevation stop positions with the recorded limits. The air drive motor is used to move the launcher slowly in train and elevation for testing. Listen for the click of the solenoid that indicates actuation, and record the B-end position at that time. Use the OP for complete instructions.

Adjustment of the various interlock switches of the train and elevation power drives requires familiarity with the operation of the associated control circuitry and the actuating mechanisms. Equipment required includes a continuity checker with a self-contained, power supply and a regulated and adjustable hydraulic fluid supply with a pressure gage.

Some special tools are used in adjustment and maintenance of parts of receiver-regulators. The correct tools make the work easier; they are a necessity for exacting adjustments. Follow through on the care of the tools. See that they are put back in their proper places, in undamaged condition. If a tool becomes damaged during use, do not put it back on the tool rack or in the tool kit, but recondition it or replace it.

WARNING: Make sure that power to the power drive system is shut off prior to removing receiver-regulator covers or auxiliary relief and brake control valve switch and solenoid housings for switch adjustments, unless switch adjustment requires power operation. Remove the safety switch handles from the power and control panels. Keep all panel doors and solenoid housing covers secured at all times except when being serviced. Do not position any SOLENOID by hand unless specifically ordered to do so.

Maintain the schedule of lubrication setup for your equipment and use the lubricants specified on the lubrication chart. An atomizer is used where very light lubrication is needed yet all parts must be reached by the oil. Do not over-lubricate or use the wrong type of lubricant.

Equipment adjustments should be made only when actually required. When switches, relays, solenoids, etc., malfunction, do not attempt to repair them. Replace the faulty unit with a functional one, replace and tighten all screws, nuts, etc., and then test-operate to be sure it functions properly in place. Make adjustments then if necessary, following OP instructions.

TROUBLE ANALYSIS

The response (or lack of it) of the launcher to signals from the weapons control station or the control panel is an indication of the condition of the system. In the daily exercise of the launcher, watch for any erratic movement. Trace the cause, and make the necessary adjustment or repair. Then test the adjustment or repair by again operating the launcher. Leakage in the hydraulic system can be located by visual inspection. Noisy operation may be due to lack of circulating hydraulic oil, either because of insufficient oil or blockage of the supply. Air in the hydraulic system also causes noisy operation. Overheating of any part is usually due to lack of lubrication. The remedies for these troubles are fairly simple.

When the launcher makes erratic response to the order signal, the trouble may be more difficult to locate and adjust. If the launcher will move in only one direction, look for trouble in the valves in the B-end and A-end. An improperly adjusted pilot valve in the A-end may permit the launcher to override the control signal. If the launcher moves several degrees beyond the ordered position (or stops before reaching the ordered position), the synchros are not properly adjusted to null. If the launcher is slow in responding to the control signal, the control pump filters may be clogged, the torque motor coils may be improperly adjusted, the oil level may be too low, the control pressure relief valve may be improperly set, the B-end relief valves may be improperly set, or there may be a defective part.

WARNING: Make sure that power to the power drive system is shut off before removing receiver-regulator covers or making any adjustments.

MISSILE CONTROL COMPONENTS AND SYSTEMS

Guidance and control are sometimes spoken of as if they were one and the same. They are two parts of the problem of getting the missile to the selected target after it is fired. The main reason for controlling a missile in flight is to gain increased accuracy for missiles with extended ranges.

A missile guidance system keeps the missile on the proper flight path from launcher to target, in accordance with signals received from a control point. The missile control system keeps the missile in the proper flight attitude. Together, the guidance and control components of any guided missile determine the proper flight path to hit the target, and control the missile so that it follows this determined path. Missiles accomplish this "path control" by the processes of tracking, computing, directing and steering. The first three processes of path control are performed by the guidance system, steering is done by the control system.

GMM 3&2, NT 10199, described the external control surfaces of guided missiles such as wings and fins and explained the effects of natural forces acting upon them and how the missile compensates for them. The remainder of this chapter explains the characteristics of some of the numerous mechanical, hydraulic, and pneumatic systems used to control the steering components to maintain a stable missile flight. We will deal with the general principles, rather than the actual design of any specific missile.

Types of Control Systems

Missile control signals may come from inside the missile, from an outside source, or from both. Regardless of which method of control is used, some source of power must be produced to control the steering surfaces of the missile. This power is initially produced within the missile by hot gases, compressed or high pressure air, or by electrical means. The power is transmitted from the supply source to the movable steering controls by pneumatic, electrical, or mechanical means, or by using a hydraulic transfer system in conjunction with the sources mentioned above.

Before getting into the details of specific types of control, let us first take a general look at several possible controllers and compare some of their advantages and disadvantages.

A pneumatic system which depends on tanks of compressed air is obviously limited in range. Since air or any other gas is compressible, the movement of a pneumatic actuator is slow due to the time it takes to compress the air in the actuator to a pressure sufficient to move it. Hydraulic fluid is practically incompressible and will produce a faster reaction on an actuator, especially when the actuator must move against large forces. Thus, large, high speed missiles (Talos) are controlled by hydraulic actuators.

Very few missiles have been designed which do not have some part of their control systems operating by electricity. The use of an all electric control system would place all the equipment, except the propulsion unit, within the electrical field. This would simplify manufacture, assembly, and maintenance. Also, it would be easier to transmit information or power to all parts of the missile by wires, rather than by hydraulic or pneumatic tubing.

An all mechanical control system in a missile is not very probable. In an all mechanical system, error information would be transferred from a mechanical sensor by some mechanical means such as a gear train, cable, rotating or sliding shaft, or chain linkage. This linkage would then connect to the correcting devices such as control surfaces.

The major disadvantages of a mechanical control system are that too much power would be required to move the necessary (and heavy) gear trains and linkages, and the installation of an all mechanical system would be extremely difficult in the small spaces of a missile.

To gain advantages and offset disadvantages of the different types of control, combinations are used, such as pneumatic-electric, hydraulic-electric, hydraulic-mechanical, or others.

Missile Control Servosystem

A missile control subsystem is a servomechanism. A servomechanism takes an order and carries it out. In carrying out the order, it determines the type and amount of difference between what should be done and what is being done. Having determined this difference, the servomechanism then goes ahead to change what is being done to what should he done. To perform these functions, a servomechanism must be able to:

1. Accept an order which defines the result desired.
2. Evaluate the existing conditions.
3. Compare the desired result with the existing conditions, obtaining a difference between the two.
4. Issue an order based on the difference so as to change the existing conditions to the desired result.
5. Carry out the order.

For a servomechanism to meet the requirements just stated, it must be made up of two systems - an error detecting system and a controlling system. The load, which is actually the output of the servo, can be considered part of the controller.

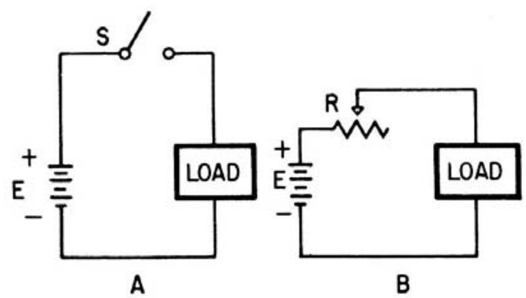
By means of servo systems, some property of a load is made to conform to a desired condition. The property under control is usually the position, the rate of rotation, or the acceleration of the load. The system may be composed of electrical, mechanical, hydraulic, pneumatic, or thermal units, or of various combinations of these units. The load device may be anyone of an unlimited variety; a missile control surface, the output shaft of an electric motor, and a radar tracking antenna are a few typical example.

Discontinuous and Continuous Control

The simplest form of control can be illustrated by the elementary circuit shown in figure 6-31A. The circuit contains a source of power, a switch, or controlling device; and an unspecified load. The elements are connected in series. When the switch is closed, energy flows to the load and performs useful work; when the switch is opened, the energy source is disconnected from the load. Thus, the flow of energy is either zero or a finite value determined by the resistance of the circuit. Operation of this general type is called DISCONTINUOUS CONTROL.

In figure 6-31 B, the circuit is modified by substitution of a rheostat for the switch; and the circuit now provides CONTINUOUS CONTROL.

By displacing the rheostat contact, the circuit resistance is varied continuously over a limited range of values. The energy expended in the load is then varied over a corresponding range rather than byintermittent, or on-off action as in discontinuous control. Both these simple examples represent a fundamental property of control systems in general: the energy required to control the system is small compared with the quantity of energy delivered to the load.



33.60
Figure 6-31.—Elementary control circuit: A. Discontinuous control; B. Continuous control.

Open- and Closed- Loop Servosystems

In the examples given above, the power source is controlled directly by manual adjustment of a switch or of a rheostat. In more complicated servo systems, control signals are applied to the power device by the action of an electrical or a mechanical device rather than by manual means.

Automatic servosystems can be divided into two basic types: open-loop and closed-loop systems. The essential features of each are indicated by the block diagrams in figure 6-32.

In both systems, an input signal must be applied which represents in some way the desired condition of the load.

In the open-loop system shown in figure 6-32A, the input signal is applied to a controller. The controller positions the load in accordance with the input. The characteristic property of open-loop operation is that the action of the controller is entirely independent of the output.

The operation of the closed-loop system (fig. 6-32B) involves the use of followup. The output as well as the input determines the action of the controller. The system contains the open-loop components plus two elements which are added to provide the followup function. The output position is measured and a followup signal proportional to the output is fed back for comparison with the input value. The resultant is a signal which is proportional to the difference between input and output. Thus, the system operation is dependent on input and output rather than on input alone.

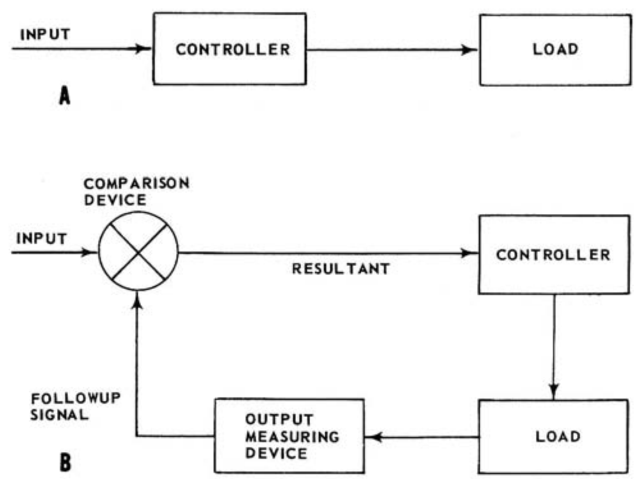


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Figure 6-32.—Basic types of automatic servosystems: A. Open-loop; B. Closed-loop.

Of the two basic types, closed-loop control (also called followup control) is by far the more widely used, particularly in applications where speed and precision of control are required. The superior accuracy of the closed-loop system results from the followup function which is not present in open-loop systems. The closed-loop device goes into operation automatically to correct any discrepancy between the desired output and the actual load position, responding to random disturbances of the load as well as to changes in the input signal.

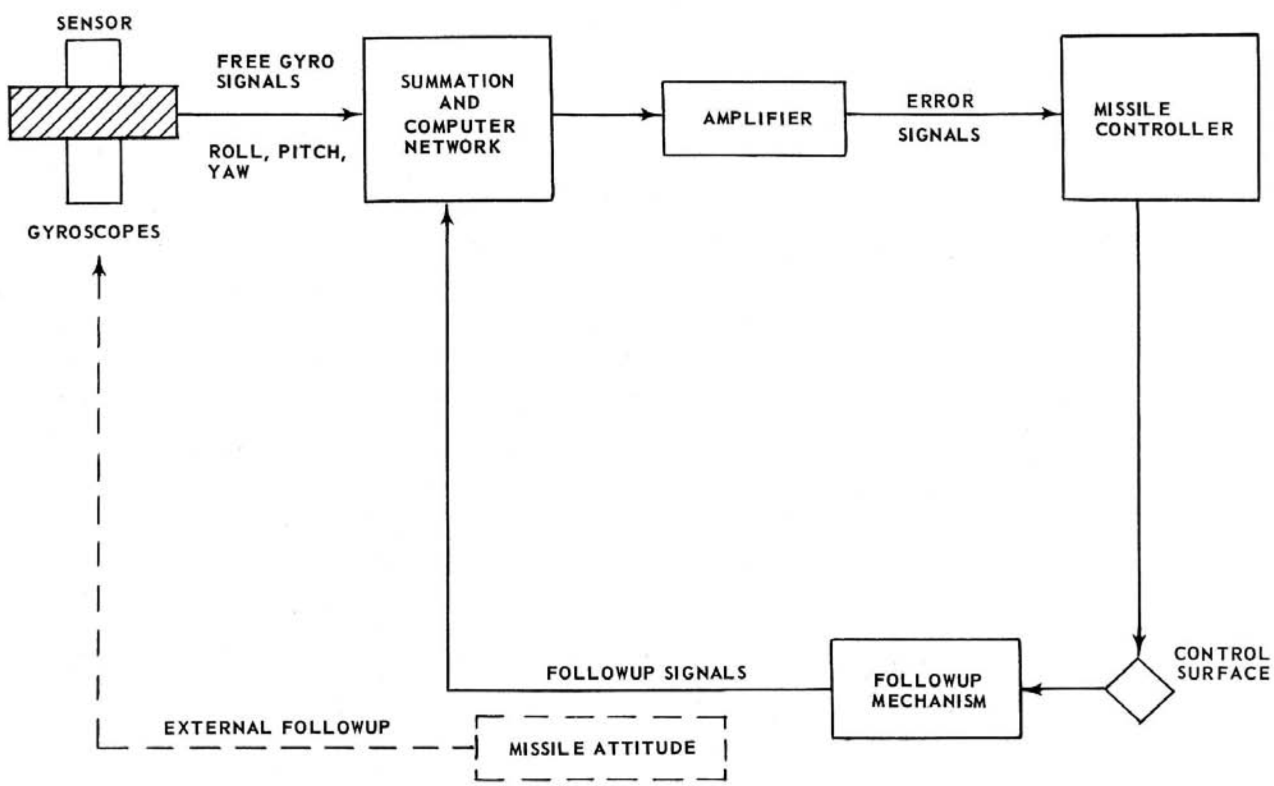
Controllable Factors

The missile control system is actually a closed-loop servomechanism in itself. It is able to detect roll, pitch, and yaw. and it is able to position the movable control surfaces in accordance with this attitude information. It is very important that you understand that the control surfaces are not positioned, on the basis of attitude information alone. It is again pointed out that movement information, guidance signals, and control surface position information are continuously analyzed in the computer network. The correction signals are continuously generated on the basis of all this information.

Overall Operation

Before studying the individual components of the missile control system, let us take a brief look at the operation of the system as a whole. Figure 6-33 shows the basic missile control system in block diagram form. Free gyroscopes provide physical (spatial) references from which missile attitude can be determined. For any particular missile attitude, free gyro signals are sent from the gyroscopes to the computer network of the missile. These signals are proportional to the amount of roll, pitch, and yaw at any given instant. After these signals have been compared with other information (for example, guidance signals), correction signals result. The correction signals are orders to the controller to position the control surfaces. The purpose of the amplifier is to build the weak correction signals up to sufficient strength to cause actuation of the controller As in any closed-loop servosystem, followup information plays an important role. A followup mechanism continuously measures the positions of the control surfaces and relays signals back to the computer network.

EXTERNAL FOLLOWUP.-In addition to the internal followup which is actually measured by a mechanism, we can think of the missile's movement detecting devices as providing an external followup feature. The fact that the gyroscopes continuously detect changing missile attitude introduces the idea of external followup.



33.62

Figure 6-33.—Basic missile control system.

This is represented by the dotted line in figure 6-33.

Components of Missile Control Systems

Figure 6-33 have named parts of a missile control system and some of the components have been discussed. The components may be grouped according to their functions. They cannot be strictly compartmentalized as they must work together and there is overlapping. Devices for detecting missile movement may be called error-sensing devices. The amount and direction of error must be measured by a fixed standard; reference devices provide the signal for comparison. Correction-computing devices compute the amount and direction of correction needed and correction devices carry out the orders to correct any deviation. Power output devices amplify the error signal, but the prime purpose is to build up a small computer output signal to a value great enough to operate the controls. The use of feedback loops provides for smooth operation of the controls.

Do not confuse the missile control system with the weapons control system. The weapons direction system and the fire control systems and their related components comprise the weapons control system. These shipboard equipments control all weapons aboard, including guns, missile s, and torpedoes. The missile control systems are in the missile, and may receive direction from shipboard equipment.

CONTROLLER AND ACTUATOR UNITS

A controller unit in a missile control system responds to an error signal from a sensor. There are several types of controller units, and each type has some feature that makes it better suited for use in a particular missile system.

Solenoids

A solenoid consists of a coil of wire wound around a nonmagnetic hollow tube; a moveable soft iron core is placed in the tube. When a magnetic field is created around the coil by current flow through the winding, the core will center itself in the coil. This makes the solenoid useful in remote control applications since the core can be mechanically connected to valve mechanisms, switch arms, and other regulating devices. Two solenoids can be arranged to give double action in certain applications.

Transfer Valves

Figure 6-34 shows an application in which two solenoids are used to operate a hydraulic transfer valve. The object is to move the actuator which is mechanically linked to a control surface or comparable device.

The pressurized hydraulic fluid, after it leaves the accumulator, is applied to the transfer valve shown in figure 6-34B. The valve is automatically operated by the response of the solenoids to electrical signals generated by the missile computer network.

If solenoid #1 in the figure is energized, it will cause the valve spool to move to the left. This will permit pressurized fluid to be ported to the

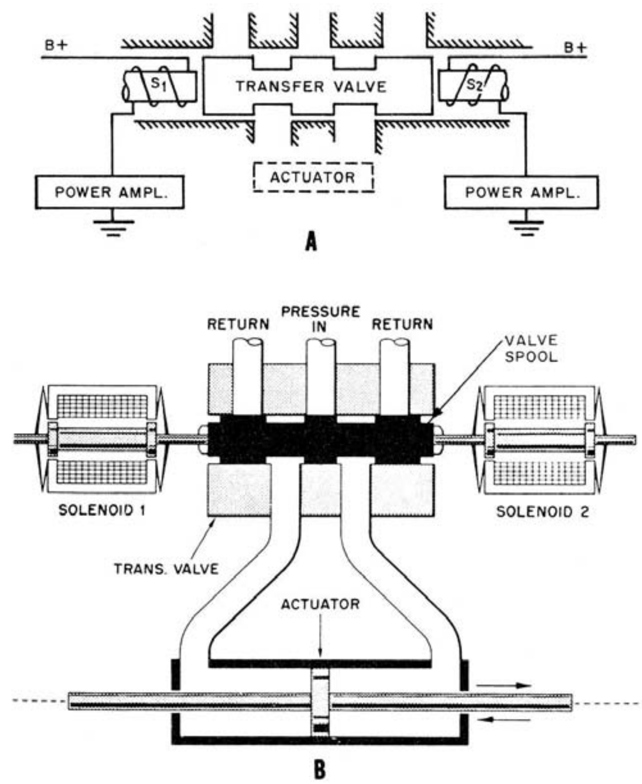


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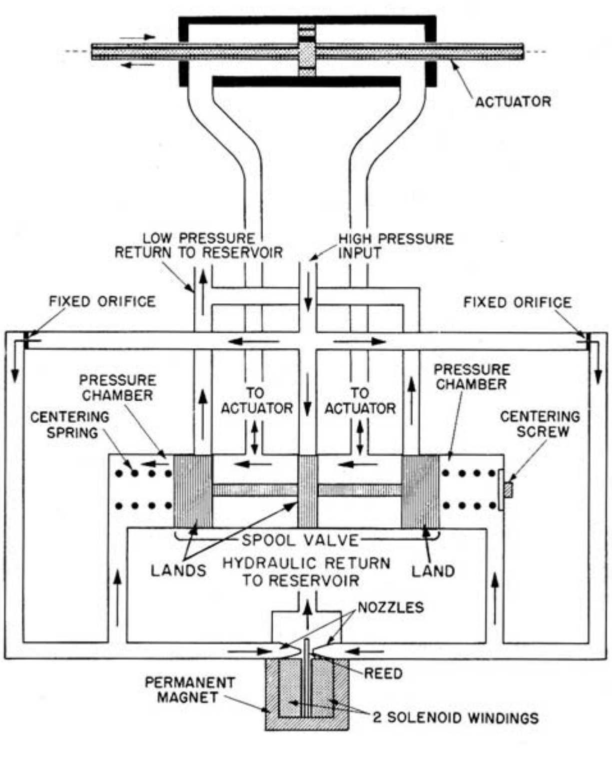
Figure 6-34.—Transfer valve: A. Closed position (schematic); B. Hydraulic transfer valve and actuator.

right-hand side of the actuator and cause its movement to the left. If solenoid #2 is energized, the valve spool will move to the right, causing actuator movement to the right in the same manner. When neither coil is energized, the valve is closed (fig. 6-34A).

The transfer valve just described has one disadvantage in that it operates in an on-off manner. This means that it provides positive movement of the control surfaces, either full up or full down, full right or full left. A finer control is usually more desirable in missile systems. The servovalve (fig. 6-35) provides this control. With neither of the windings energized (or a balanced current flowing through both), the magnetic reed is centered as shown (fig. 6-35). In this condition, high pressure hydraulic fluid from the input line cannot pass to the actuator since the center land of the spool valve blocks the inlet port. The pressurized fluid flows through the alternate routes, through the two restrictors (fixed orifice), passes through the two nozzles, and returns to the sump without causing



33.185

Figure 6-35.—Servovalve.

any movement of the actuator. If the right-hand solenoid is energized, the magnetic reed will move to the right, blocking off the flow of high pressure fluid through the right-hand nozzle. Pressure will build up in the right pressure chamber. This will move the valve to the left. In moving left, the center land will open the high pressure inlet and permit fluid flow directly to the right-hand side of the actuator. At the same time, the left-hand land of the spool will open the low pressure return line and permit flow to the sump from the left-hand side of the actuator. This process will cause actuator movement to the left. By energizing the left-hand solenoid, the reed will move to the left, and the entire process will be reversed, the actuator then being moved to the right. The actuator can be used to physically position a control surface.

Relays

Relays are used for remote control of heavy-current circuits. The relay coil may be designed to operate on very small signal values, such as the output of a sensor. The relay contacts can be designed to carry heavy currents.

Figure 6-36A shows a relay designed for controlling heavy load currents. When the coil is energized, the armature is pulled down against the core. This action pulls the moving contact against the stationary contact, and closes the high current circuit. The relay contacts will stay closed as long as the magnetic pull of the coil is strong enough to overcome the pull of the spring.

The relay just described has a fixed core. However, some relays resemble a solenoid in that part of the core is a moveable plunger. The moving contacts are attached to the plunger, but are electrically insulated from it.

Figure 6-36B shows a form of relay that can be used in a pneumatic control system. Two air pressure lines are connected to the air input ports. The relay operates when its arm is displaced by air pressure. A modified design of this type relay might be used in a hydraulic-electric system, in which case the diaphragm would be moved by hydraulic fluid pressure.

The actuator unit is the device that converts the error detected by the sensor into mechanical motion to operate the appropriate control

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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device that will correct the error or compensate for it. The actuator must be able to respond rapidly, with a minimum time lag between detection of error and movement of the flight control surfaces or other control device. At the same time, it must produce an output proportional to the error signal and powerful enough to handle the load. Figure 6-34B shows a double-acting piston-type hydraulic actuator in which hydraulic fluid under pressure can be applied to either side of the piston. The piston is mechanically connected to the load.

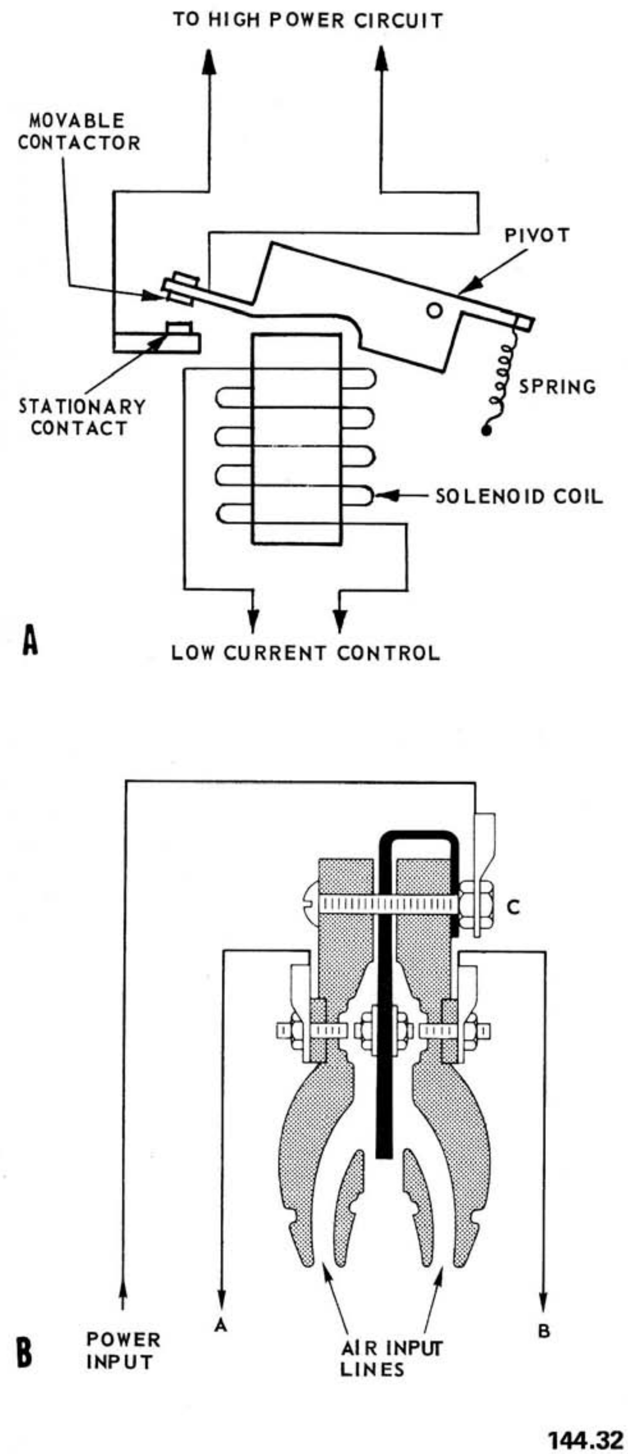

Figure 6-36.—Some types of relays in missiles: A. Low current relay; B. Air-actuated relay.

PRINCIPAL TYPES

Actuating units use one or more of three energy transfer methods: hydraulic, pneumatic, or electrical. Each of these has certain advantages, as well as certain design problems, mentioned earlier in this chapter. Control devices make use of more than one method of energy transfer but are classified according to the major one used. Combinations are hydraulic-electric, and pneumatic-electric. Mechanical linkages are used to some extent by all of them.

Hydraulic Actuators

Pascal's Law states that whenever a pressure is applied to a confined liquid, that pressure is transferred undiminished in all directions throughout the liquid, regardless of the shape of the confining system.

This principle has been used for years in such familiar applications as hydraulic door stops, hydraulic lifts at automobile service stations, hydraulic brakes, and automatic transmissions.

Generally, hydraulic transfer units are quite simple in design and construction. One advantage of a hydraulic system is that it eliminates complex gear, lever, and pulley arrangements. Also, the reaction time of a hydraulic system is relatively short, because there is little slack or lost motion. A hydraulic system does, however, have a slight efficiency loss due to friction.

HYDRAULIC - ELECTRIC CONTROL DEVICES. - The hydraulic-electric method of actuating movable control surfaces has been used more than any other type of system. As previously mentioned, the most important advantages of this type of system are the high speed of response and the large forces available when using hydraulic actuators.

You have studied several of the components shown in the simplified block diagram of a hydraulic-electric controller (fig. 6-37). This

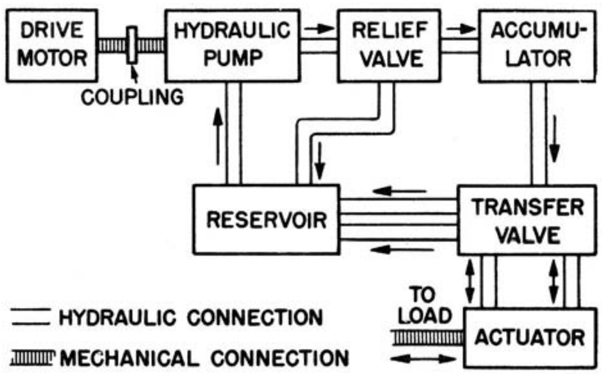

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Figure 6-37.—Basic hydraulic controller.

system is comprised of (1) a RESERVOIR which contains the supply of hydraulic fluid, (2) a MOTOR and a PUMP to move the fluid through the system, (3) a RELIEF VALVE to prevent excessive pressures in the system, (4) an ACCUMULATOR which acts as an auxiliary storage space for fluid under pressure and as a damping mechanism which smoothes out pressure surges within the system, and (5) a TRANSFER VALVE which controls the flow of fluid to the actuator.

Most of these components of the system have been covered in the preceding pages. The theory of hydraulic piston displacement is explained in *Fluid Power*, NAVTRA 16193 and hydraulic pumps are also illustrated and explained. Pumps used in missile systems generally fall into two categories-gear and piston.They are usually driven by an electric motor within the missile.,

Electric Actuators

The electric actuators used to control the deflection of control surfaces are replacing many of the hydraulic systems now used in some missiles. Figure 6-38 shows a mechanical schematic of an actuator used in the Standard Missile. The missile has four actuators and, since the operation of each is identical, only one will be discussed.

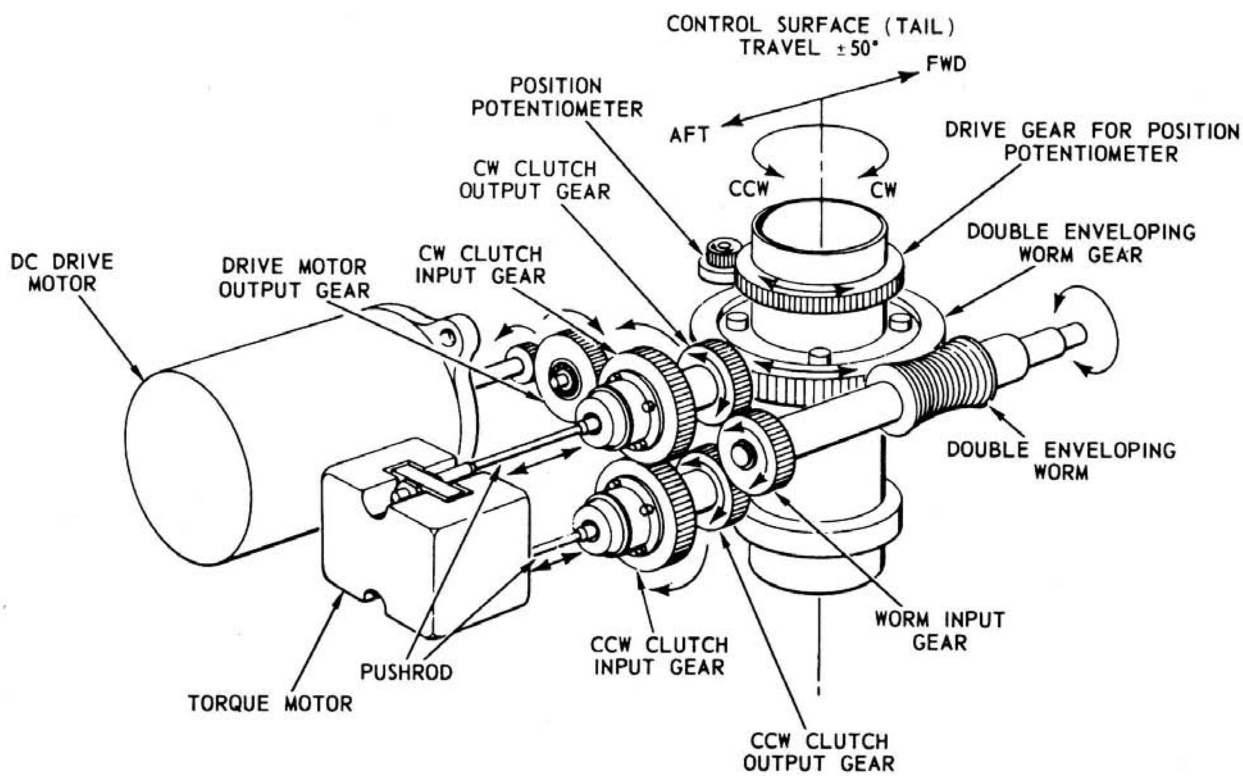

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Figure 6-38.—(U) Electric Tail Actuator, Mechanical Schematic Diagram.

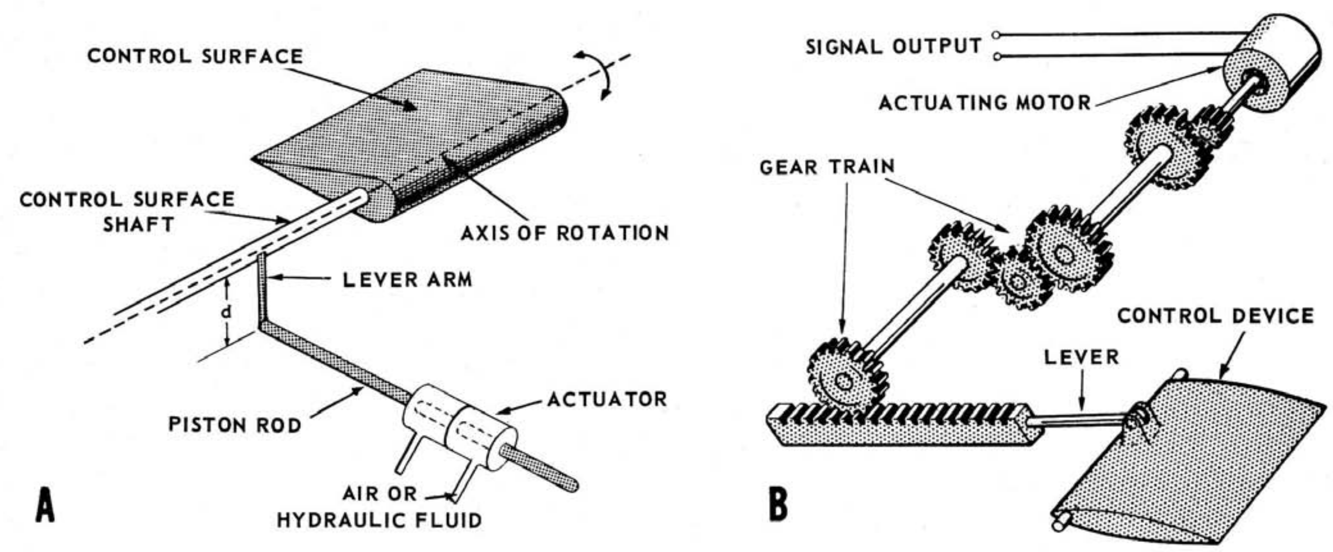

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Figure 6-39.—Mechanical linkages: A. Actuator and load linked by lever arm; B. Gear train type of mechanical linkage.

The drive motor (fig. 6-38) runs continually (after missile activation) in the same direction so that the drive motor output gear, and the CW and CCW clutch input ears rotate continually in the direction indicated by the arrows. Either clutch output gear rotates in the direction of the corresponding clutch input gear when the clutch is engaged; either clutch output gear is free to turn in either direction when the corresponding clutch is disengaged. Since only one clutch can be engaged at a given time, one of the clutch output gears is always free to turn in either direction. Either clutch is engaged when the corresponding pushrod is advanced forward into the clutch by the torque motor in response to the output of the missile control system.

Prior to the missile control system activation, the torque motor receives no input from the system, consequently both clutches are disengaged and neither clutch output gear rotates. After system activation, one of the two coils in the torque motor is energized, (depending on the signal output from the control system) resulting in the engagement of one of the clutches. When the CW clutch is engaged, the CW output gear rotates in the direction of the CW clutch input gear rotation, and drives the worm input gear to cause CW rotation of the control surface. When the CCW clutch is engaged, the control surface rotates CCW.

Mechanical Linkage

We have discussed the various control systems, but have not discussed in detail the mechanical means of linking the flight control surfaces to the actuator. In addition to providing a coupling means, the linkage may also be used to amplify either the force applied or the speed of movement.

A mechanical linkage between an actuator and a load is shown in figure 6-34A. The distance d on the drawing represents the distance from the control surface shaft to the point where the force is applied. The control surface moves because force exerted by the piston is applied at a distance from the axis of rotation, and thus produces a torque. Other mechanical linkages may consist of an arrangement of gears, levers, or cables (fig. 6-39B).

A number of mechanical systems may be grouped together to form a combination system.

This system uses levers, cables, pulleys, and a hydraulic actuator. However, a system using this kind of control is not suited for high speed missiles.

SUMMARY

This chapter explained the hydraulic systems used in some missiles and missile launchers. The hydraulic principles are the same in all of them; in application of the principles they differ only in details. Each hydraulic power drive has an A-end pump and a B-end motor; some systems use a radial piston type, and other systems use axial piston types or parallel piston types. All are started. by an electric motor, which may vary in size, manufacture, and other details.

Methods of maintenance and repair of filters, valves, pumps, and motors common to all the system are given. Within the limitations of the facilities available, a GMM 1 or C should be able to repair and maintain most parts of a hydraulic system. The size rather than the complexity of the component may be the determining factor. With an understanding of how the parts work together and the aid of parts lists and illustrations, checkoff lists, MRCs, and maintenance OPs and ODs, the GMM 1 or C can adjust and repair the most complex parts and train his men in the maintenance of the system. Although the present day trend is to replace malfunctioning units with new ones, avoiding time-consuming disassembly and repair, the new unit must operate correctly when in place. It may require delicate adjustment after installation. To do this you need to know how it operates, so you can understand how to adjust it.

Since so much of the launching system is dependent on the interaction of electric and hydraulic components, testing of the system operation will be discussed further in a later chapter.

CHAPTER 7

PNEUMATIC EQUIPMENT AND COMPONENTS

Air, pressurized and unpressurized, is used in many ways in connection with guided missile systems-in the missiles themselves, in the control system, in the launching system, and in tools and equipment. The effects of air on missile flight were discussed as part of the fire control story in the preceding course. As a GMM 3 and GMM 2 you learned the types of missile air frame construction, characteristics of various missile configurations, and influence of missile shapes, wings, and fins on the effects of the air stream, wind, air pockets, etc, This information will not be discussed further here: refresh your memory when necessary by reviewing the preceding course in this series, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199.

The use of pressurized air in the launching system and handling equipment will be covered in this chapter. The dud-jettisoning equipment, described in chapter 4, is one example of a pneumatic component that you have learned to operate, test functionally, disassemble, inspect, clean, and lubricate. Your knowledge of this component must now be expanded to include overhaul, repair and adjustment of the equipment, and planning and supervising the maintenance and repair program for the equipment.

The parts of equipments that are pneumatic are intricately connected to electrical and hydraulic components, so it is difficult to discuss the pneumatic features separately.

Compressed air is supplied to various systems by high pressure, medium pressure, or low pressure air compressors in the ship's engineering department. Compressed air outlets are located in the spaces where needed, such as checkout and repair spaces. Low pressure is 150 PSI or less; medium pressure is 150 to 1000 PSI; pressures above 1000 PSI are classed as high pressure. Reducing valves reduce higher pressure to a lower pressure for a specific system. Compressed air has many uses aboard a modem Navy ship, such as for operating pneumatic tools and handling equipment, charging and firing torpedoes, operating the dud-jettisoning unit, and other parts of the missile launching system. On most ships the air is dried. If you require dry compressed air, as for blowing out or drying out electrical components, check to be sure that the air at the outlet is dried. Use only rubber or insulating hose in portable air lines for blowing out electrical equipment. Also, pressure must be low, not over 30 PSI on motors and generators up to 50 horsepower or 50 kilowatts.

PNEUMATIC COMPONENTS USED WITH AND/OR IN MISSILE SYSTEMS

In the descriptions of the weapons systems in this course and in the preceding course, mention has been made of various pneumatic components. Of these, the dud-jettison unit was described and illustrated with the most detail.

TOOLS

The tools operated by compressed air are old friends of yours from your Seaman days. Your chief concern with them is to see that your men use them properly and observe safety precautions. Be sure the tools are returned in good condition to their proper place. Any defects in a tool should be, corrected before it. is placed on the tool board, or in a locker or other storage place. *Tools and Their Uses*, NAVTRA 10085, describes and illustrates the pneumatic hand tools commonly used in the Navy, and gives the safety precautions to observe when using them. Even at low pressures, an air hose should never be pointed at anyone. The pressurized air can do serious bodily harm. Two air hoses on automatic rewind reels are conveniently located just inside each access door in the space where the missiles are unpacked.

Pneumatic Wrenches (Decanning Tools)

Wherever missile components are received in packaged form, usually in gasketed metal barrels or cans, special tools are provided for opening or for closing the cans. It is important to prevent damage to the sealing edge of the cans so they can be re-used for protected packaging of components. Even though the component being repackaged is a damaged, malfunctioning, or nonfunctioning part being returned to a depot for repair, it is important to protect it by proper packaging, which in most cases means placing it in a gasket-sealed metal can with desiccant, and cushioning or blocking material. A portable pneumatic impact wrench used for installing or removing nuts and bolts is described and illustrated in *Tools and Their Uses*, NAVTRA 10085. Use only the equipment and tools authorized for the job; consult the OP and/or the MRC.

AIR DRIVEN HANDLING EQUIPMENT.

Power for operating missile handling equipment may be electric, hydraulic, pneumatic, or a combination such as electro hydraulic. Chapter 2 mentions some pneumatic-powered equipment used during replenishment. The power used varies with the ship installation more often than with the type of missile handled. Some typical air-operated equipments are described. On all components of an air system, the inlet and outlet parts of all valves and air motors must be plugged or covered until installed and during repairs. It is important that dirt, metal chips, filings, and other extraneous material be kept from getting into the system. Under no circumstances should water be allowed to get into the system. All tubing and flexible hose must be clean and free from scale or other foreign matter. Whenever equipment appears to be malfunctioning, it should be shut down and the cause investigated. Before dismantling any part of the air system, make sure that the part is shut off from pressure; allow trapped pressure to escape gradually. Keep grease and oil off air hoses and outlets.

Bi-Rail Trolley Hoists

Cruisers of the CG-10 class have three pneumatically operated bi-rail trolley hoists (one forward and two aft in the Talos launching systems), and CGN-9 class ships have two of them. Bi-rail trolley hoists provide for athwartship transfer of Talos innerbodies at the second, deck between the receiving stand and the elevator, and in the warhead magazine. While in the hoist, the innerbody can be rotated 360 degrees in azimuth and locked in any azimuth position.

Bridge Cranes

The trolley hoists travel on air-driven bi-rail overhead bridge cranes. The trolley hoist can be moved onto the bi-rail section of the bridge crane and secured. When not in motion, the bridge crane and trolley hoist will automatically lock in position.

Receiving Stands

Two pneumatic-powered receiving stands are provided on the second deck of CG-10 and CGN-9 class cruisers for each of the Talos launching systems. The stands hold the innerbody or the warhead during transfer to the mating area. They move athwartship between the strikedown hatch and birail trolley hoist. The innerbody is supported in, the receiving stand ring assembly and can be tilted or rotated to the position necessary for mating to the missile, from vertical to horizontal. Handling adapters are provided for handling warheads.

Telescoping Warhead Hoists

On CGN-9 and CG-10 class ships, two telescoping warhead hoists in the forward and after deckhouses travel on overhead bi-rail tracks from the checkout area to the warhead strikedown hatch on the main deck. They are air-operated, telescopic guided, vertical lifting and lowering, trolley-type devices. The telescopic guides stabilize the hoist and prevent swinging with the ship's motion. The load can be rotated from the horizontal to the vertical position. Adapters make it usable for handling standard and exercise heads and tactical or exercise innerbodies. It is used for removing or installing innerbodies and warheads, specifically for hoisting and lowering Talos components. The hoist in the magazine for spare Talos components also uses telescopic guides for stabilization against ship's motion.

Similar equipment is used on DLGs and other ships. Figure 7-1 shows use of handling equipment for a Terrier warhead on a CVA. The warhead is received in its container at one of the aircraft elevator receiving areas, and is moved by forklift truck across the hangar deck and positioned in front of either the port or starboard bridge crane. The outer container is removed and the warhead, in its inner container, is attached to the bridge crane with the aid of an adapter, and is lowered to the strikedown area, where it is secured to the tilt table. The tilt table is turned to the vertical position and the container is lifted off (with the hoist), so the warhead can be inspected before it is placed in warhead stowage. After the warhead has passed inspection, it is returned to the container and sealed, and taken to the warhead magazine, where it is secured against movement.

Chain Drive Fixture

An air-driven chain drive fixture with a manual air control vale, and a strike down hand control box, is used for strike down and for offloading Tartar missiles. The chain drive fixture is used with GMLS Mk 13 and Mk 22. Figure 7-2 shows the missile handling equipment attached to a launcher. The launcher captain, using local control operation, positions the launcher to a convenient position to attach the missile handling equipment.

The chain fixture is attached manually to the front of the launcher when preparing for strikedown or offloading. When the latch lever (fig.7-3) is pushed, the quick release pins can be inserted to attach the fixture to the launcher guide. The latch engages a block on top of the retractable rail. The chain drive fixture is easier to install if the launcher guide arm is depressed in LOCAL TEST.

Inside the fixture housing, or attached to it, are a chain, an air motor, a chain drive sprocket and gears, a pressure regulator, and an air throttle valve (fig. 7-3). The strikedown chain pulls the missile onto the launcher guide during strikedown, or controls the missile during offloading. There are four cams in the chain which actuate linkages to the throttle valve and interlock switch S1N2. The stop cam stops the air motor (through linkage to the air throttle valve) when the chain is fully retracted. The air motor shaft drives a simple gear train which drives the chain drive sprocket.

The PRESSURE REGULATOR reduces air pressure in the extend cycle of the chain. It is mounted in parallel with a check valve in the air line between the throttle valve and the air motor (fig. 7-3). The regulator is factory adjusted to a static pressure of 20-22 PSI, which must not be changed.

The AIR THROTTLE VALVE regulates the speed of the air motor and determines its direction of rotation. Two inlets are connected to the manual control valve (fig. 7-2) and one to the ship's air supply. Two outlets connect to the air motor and two others port exhaust air to the atmosphere. Cams on the chain shift the valve through linkages to open or close air inlets or outlets and thus control the speed of the air motor and chain.

The MANUAL CONTROL VALVE (fig. 7-2) ports air pressure to the air throttle valve to shift it to retract or extend the strikedown chain. The position of the control handle on the manual control valve for "retract" or "extend" has to be determined by trial (for each ship installation) and then marked. When not in operation, the plunger is centered to "neutral" by a double acting spring.

The HAND CONTROL BOX (fig. 7-2) positions the launcher in train and elevation for strikedown, checkout, or missile component removal. It is operated by the launcher captain and enables him to be on deck where he can

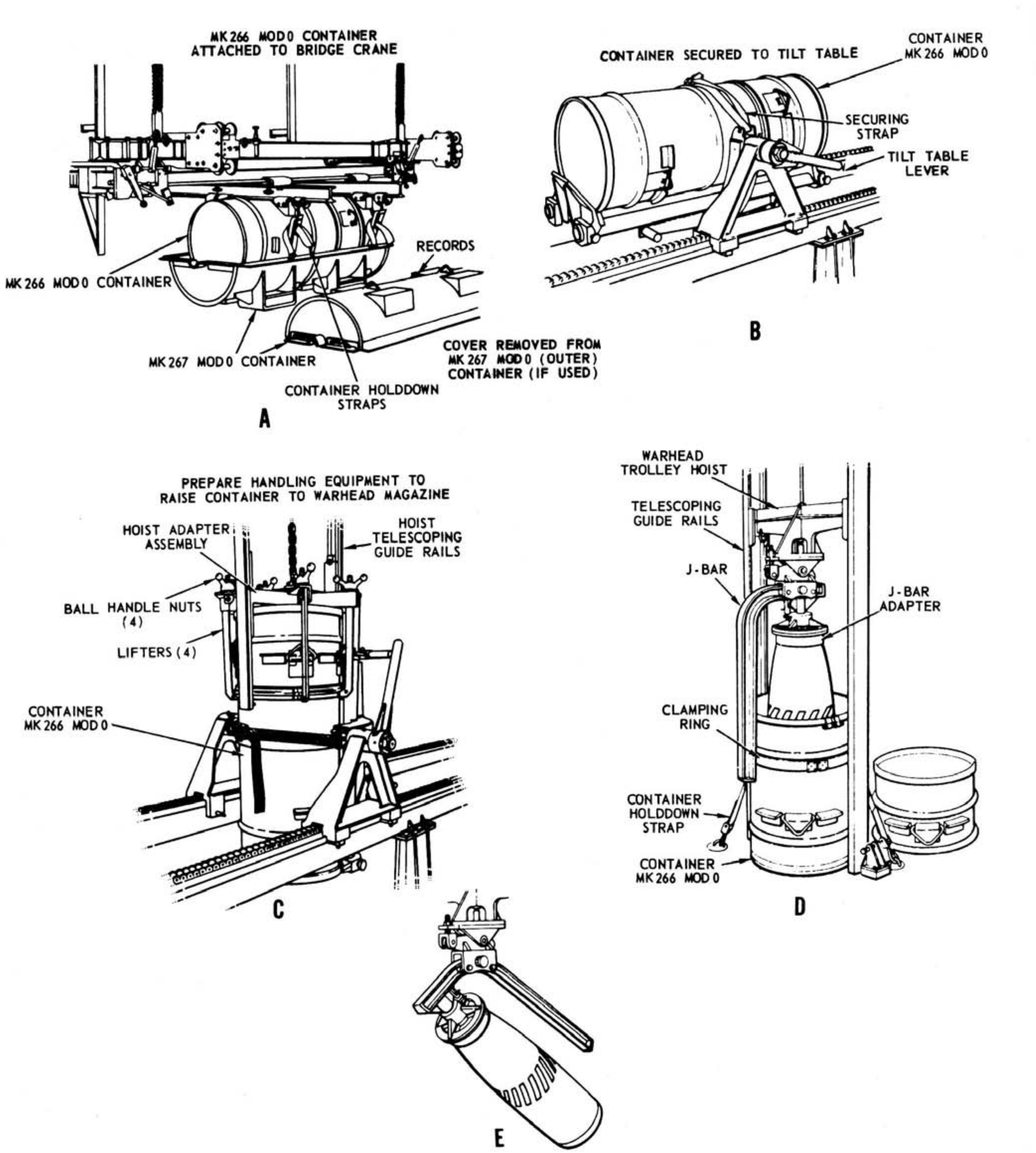

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Figure 7-1.—Decanning a Terrier warhead: A. Warhead in container attached to bridge crane; B. Warhead in inner container secured to tilt table in checkout area; C. Preparing handling equipment to raise container off warhead; D. Upper part of container removed, J-bar attached; E. Warhead held by J-bar in horizontal position for receipt inspection (aft end).

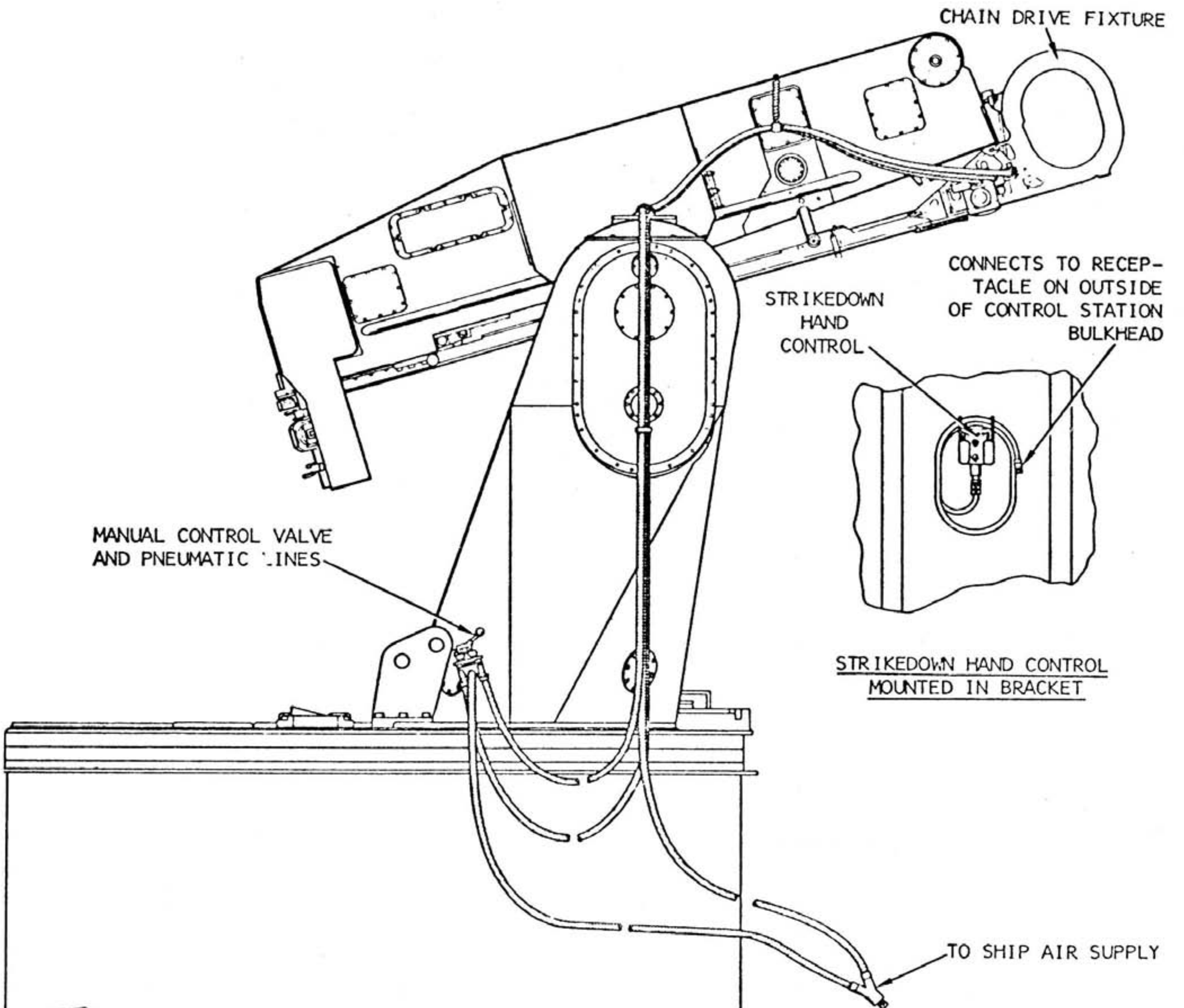

Figure 7-2.—Strikedown Gear.

have a full view of the launcher and the operations. To position the launcher for mounting the strikedown gear and chain drive fixture, the EP2 panel operator and the launcher captain follow the procedure as for checkout operation. The launcher is trained to a convenient position by local control, and the guide is lowered to zero degrees elevation. The Firing Safety switch. handle must be removed from the EP2 panel before anyone is permitted to begin mounting the strikedown gear to the launcher. This is to make certain that the launcher cannot be started while someone is working on it. When the fixture is attached and air line hoses connected (two hoses between the throttle valve and the manual control valve, one between the throttle valve and the ship's supply "Y", and another between the manual control valve and the ship's

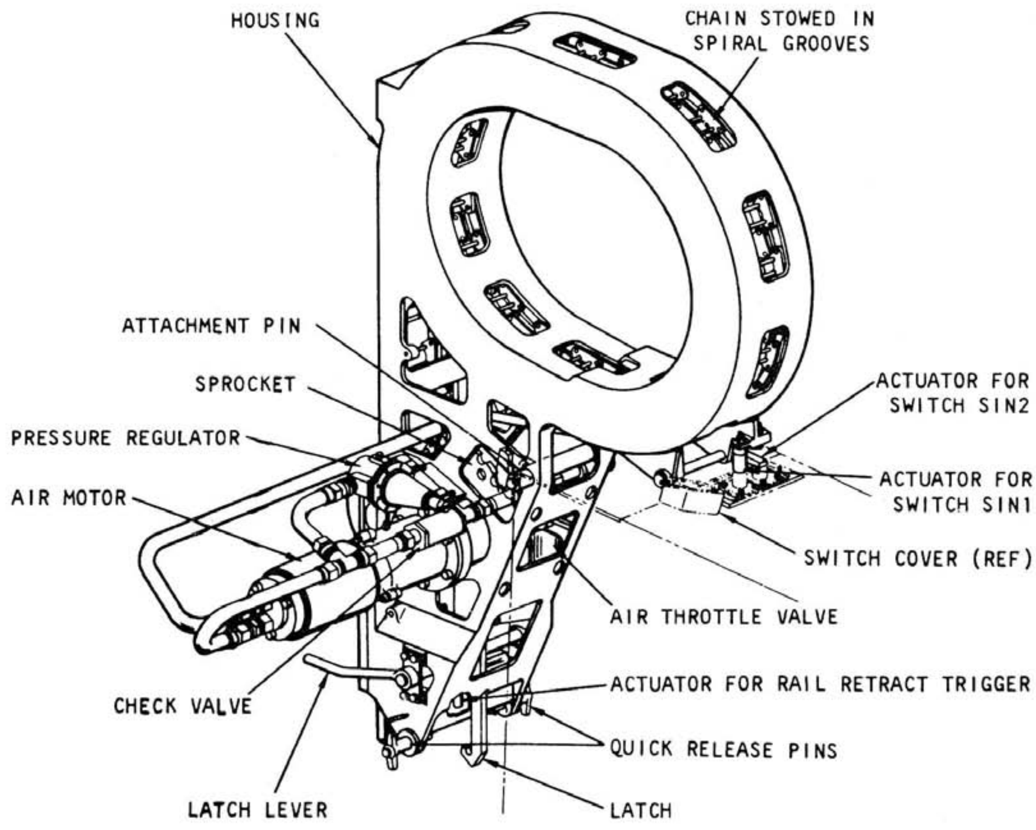

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Figure 7-3.—Chain drive fixture, strikedown gear, Guided Missile Launching System Mk 13 and Mk 22.

supply "Y"), then the Firing Safety switch handle can be returned to the EP- 2 panel and the system reactivated.

Consult the publication for the Mk 13 launching system, OP 2665, or complete description of the steps in strikedown, offloading, checkout, and deactivation. OP 3 15 is the publication to consult regarding the M 22 Tartar system.

PNEUMATIC COMPONENTS OF LAUNCHING SYSTEMS

In addition to the handling equipments described above, and the dud-jettisoning units described in a previous chapter, pressurized air is used in several other parts of the launching system: in the missiles, the test equipment, and the control systems. Frequently, electric and hydraulic components are closely related to the air-powered parts to actuate and control a system.

Train and Elevation Air Drive Motor

Air motors have been mentioned in connection with the missile component handling crane, monorail overhead air hoist, receiving stands, deck fixtures, and chain drive fixture. They are also used to train and elevate missile launchers in manual control. The air drive motors used on the Mk 10 launching system are described below. In case of a power loss, the air motors may be used in conjunction with hand pumps and hand cranks to perform essential operations with the launching system. For example, the loader chain can be retracted by use of a hand crank. A hand pump can be used to furnish hydraulic fluid directly to a component inactivated by a power loss. The blast doors, for example, can be closed by this means in an emergency. Manually controlled air motors are attached to the power-off brakes of the train and elevation systems. If manual operation is to be used, the power for the side (A-side or B-side) is turned off at the EP-1 panel. Figure 7-4 shows the location of the air drive motor in relation to the power-off brake. The location is similar for train and elevation systems. The air motor drive is used during power failure or during installation and maintenance procedures.

When the air motors are to be used, the power system must be off, either through power failure or turned off. The air motors drive the associated gear reduction. The air pressure to operate the air motors is supplied from the ship's air lines, using 100 PSI. No electrical control is used. An air control valve assembly (fig. 7-5) controls the flow of air to the train and elevation air motors. The assembly is fastened to the left side of the base ring, above the train power-off brake (fig. 7-4). The valve assembly has two identical sections (fig. 7-6); one section controls the elevation air motor, and the other the train air motor.

CAUTION: When operating the launcher with the air motors, normal safety interlocks are bypassed. Use extreme caution; specifically, never move the launcher if the blast doors are open, and never open or close the blast doors by use of the hand pump if the launcher has been moved off the stow position with the air motors.

The train section of the train control valve assembly (fig. 7-5) consists principally of a control handle, air control valve, and check valve. The control handle, employed as a first class lever, operates the air control valve. If the handle is moved up and down, air is ported through one of the two outlet ports to the train air motor. The outlet port through which the air is supplied determines the direction of rotation of the air motor.

The air control valve is linked to the control handle at the upper end. The lower end of the valve is attached to a bottle spring that holds the valve at neutral until displaced by the control handle. With the valve at neutral, the two output ports of the train air motor are closed. The check valve prevents passage of air from the supply source to the center chamber of the control valve unless the check valve plunger is unseated.

When the control handle is moved, it forces the train control valve plunger off neutral which unseats the train check valve plunger and allows air to flow through the central chamber of one of the two outlet ports of the air motor.

The elevation air motor operates in the same way as the train air motor.

Before using either the train or elevation air motors, be sure train and elevation latches are retracted. In manual operation, they are retracted by use of the hand pump, and power drives must be off.

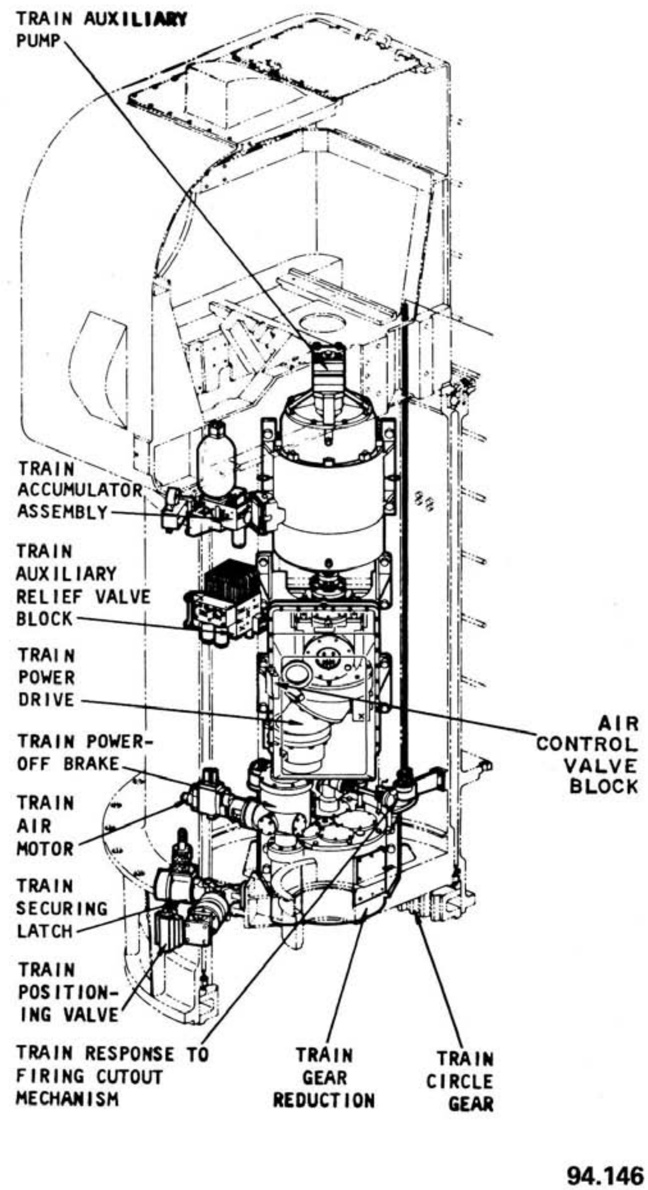

Figure 7-4.—Train system, general arrangement of components.

If lubrication is scheduled, follow instructions in system OPs and MR cards and review safety precautions for manual operation. When you are making use of the air motors, you will also use the handpumps for hydraulic actuation of components, and handcranks for mechanical actuation. Be sure automatic power is off in each case.

Although we have illustrated and discussed the use of air motors only in the Terrier Mk 10 launching systems, similar air motors are used in the Talos and some Tartar launching systems. For manual operation of train and elevation power drives in the Mk 13 Tartar system, a handcrank is attached to the splined end of the worm shaft of the power-off brake assembly.

Asroc Loading Fixture

Before Asroc missiles can be loaded into the Mk 10 Mods 7 and 8 launching systems, they must be placed in adapters. The loading fixture has three major components: the stowing mechanism, the drive assembly, and the chain assembly (fig. 7-7). The stowing mechanism is mounted to the loader trunk in the strikedown- checkout area. It consists of two mounting brackets, a worm, a gear quadrant, four supporting arms, and an extended-retracted latch mechanism. A special handcrank is needed to crank the fixture down from stowed. position. The latch mechanism serves to lock the latch pin on the drive in either the drive-retracted or the drive-extended position, and to actuate the interlock switch SINB6 or SINB7 to indicate in the loader electrical circuits either the retracted or the extended position of the drive assembly. The latch handle has two positions, LATCHED and UNLATCHED. It is positioned manually.

The loading fixture drive assembly is mounted on the chain stowage housing (fig. 7-7). It consists of a manual control valve, an interlock valve (not shown in fig. 7-7), a throttling valve, an air motor, a speed reducer and chain drive sprocket assembly, a chain stowage housing, and chain-retracted interlock switch SINB8.

The manual control valve (fig. 7-7) is a three-position valve spring-loaded to OFF, EXTEND, and RETRACT. The throttling valve is a three-land. three-position valve. It is initially shifted

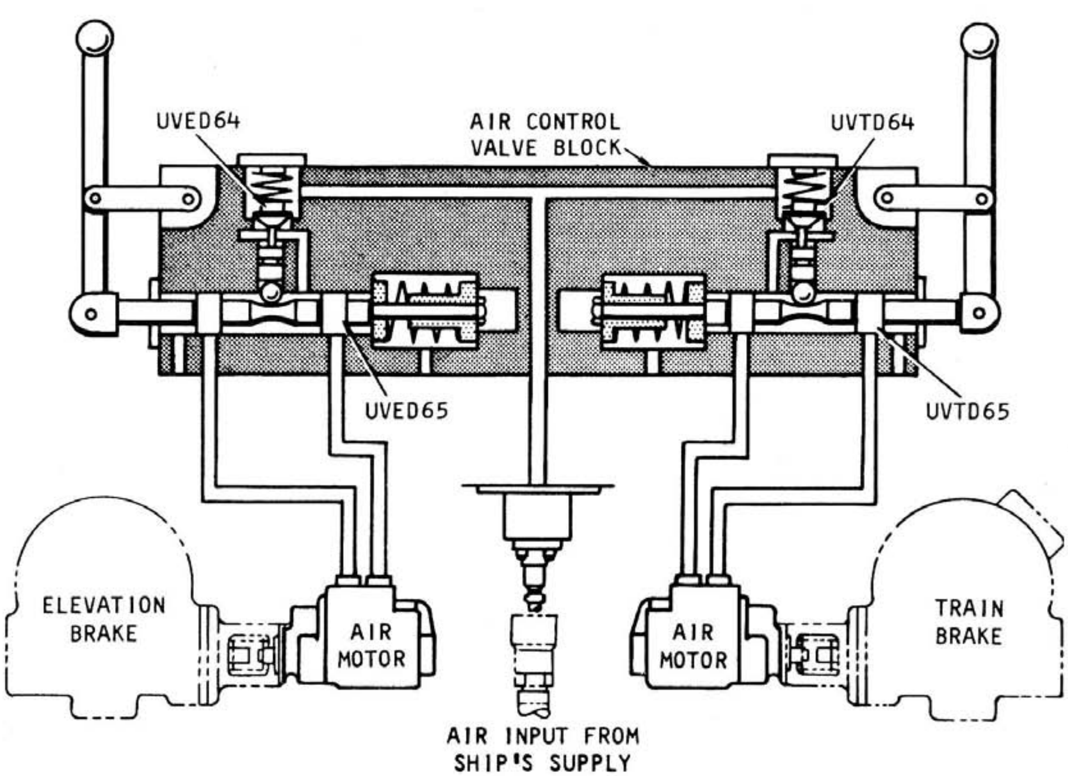

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Figure 7-5.—Air control valve assembly.

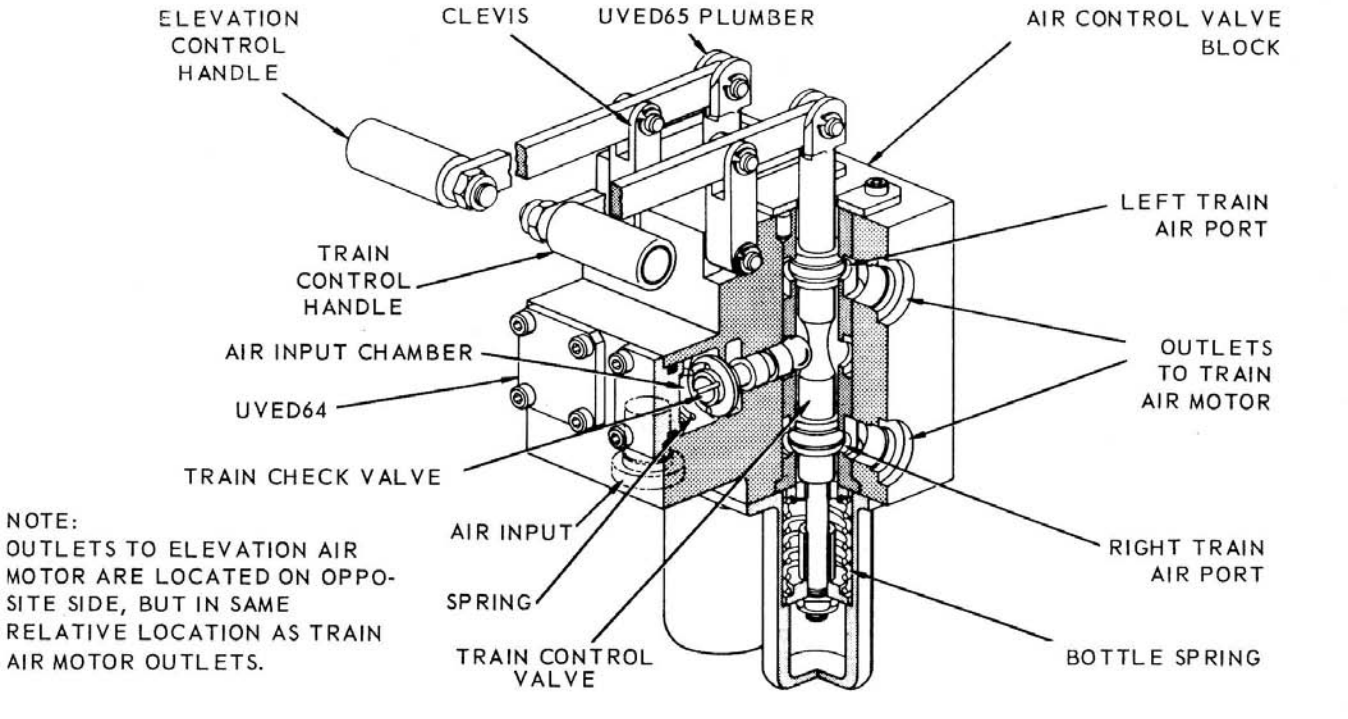

Figure 7-6.—Schematic of air motor drive.

by air pressure. It is returned to neutral and held there by spring-loaded linkages. The reversible air motor drives the chain drive sprocket through a worm and worm gear speed reducer.

The J-shaped chain stowage housing (fig. 7-7) serves as a mounting base for the drive assembly. The retracting chain is drawn into the housing by the drive sprocket, and as it passes around the sprocket section it enters the stacking section where the chain is folded link-on-link to stow it. The chain assembly is a rammer-type roller chain and pawl.

The throttling valve is between the manual air control valve and the air motor in the pneumatic circuit (fig. 7-8). The chain-extended cam or the chain-retracted can return it to neutral after it is activated by the air motor. The loading fixture pawl is pivoted to the end of the chain. The interlock valve is in the pneumatic circuit between the ship's air supply and the control valve. It is actuated by a cam that is shifted when the Asroc adapter contacts it.

LOADING THE ADAPTER. - The first step is to crank the loading fixture to the loading position, called No. 1 Stop position, and to extend the pawl cam pins. This is done manually.

Next, bring an empty Asroc adapter to the strikedown area. Be sure it is the proper type of adapter (fitted for torpedo or for depth charge). When the empty adapter rests in position on the loading fixture, the system is shut down to protect personnel working in the area. The snubbers in the adapter are in closed position, the arming tool socket and safety key mechanism is at reset position, the restraining latch is set at LATCHED, and the adapter contains no umbilical cable.

To prepare the adapter to receive the missile, he snubbers must be opened. The restraining latch and snubber release is turned to UNLOCKED with a special wrench. Torsion bars opens the snubbers when (the latch is released; personnel must stand clear of snubbers, as they open quickly and forcefully. The restraining

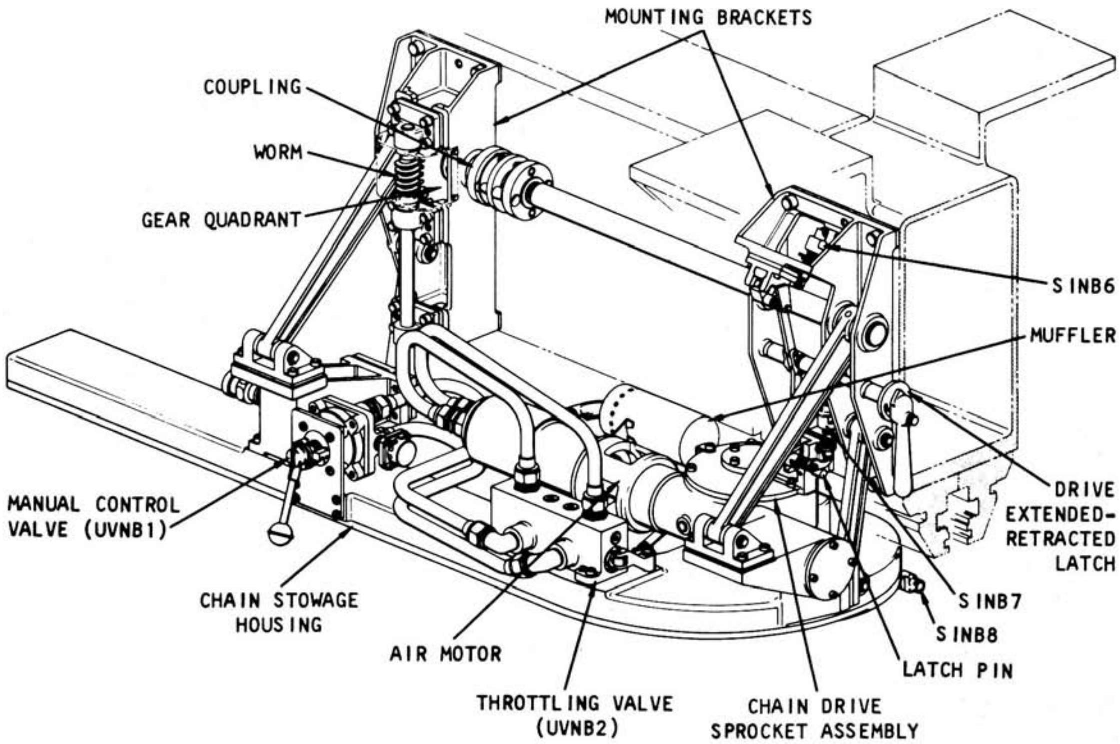

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Figure 7-7.—Adapter loading fixture assembly (for Asroc).

latch pawls are then retracted out of the way of the aft shoe of the Asroc. The cover over the U-shaped channel of the cantilever beam of the adapter is removed, and the umbilical cable is strung in the channel, the connectors are plugged in, and the cover is replaced. Then the Asroc missile is placed under the adapter and aligned to engage the shoes with the adapter and the fixture pawls. The strikedown car is then moved to the stowed position and secured.

The Asroc is now moved to its final position on the adapter by the fixture chain, powered by the air motor. Position the manual control valve (fig. 7-8) to EXTEND. This opens a port to the left side of the throttling valve so air pressure (ship's air supply at 100 PSI) passes through the left chamber of the throttling valve to the air motor. The pressure buildup opens the port to furnish a greater volume of air to the motor.

When the Asroc aft shoe nears its position behind the pawls of the restraining latch, the chain-extended cam on the fixture chain actuates the roller on the throttle valve actuator and shifts the throttling valve to neutral. This cuts the air supply to the air motor, decelerating it. When the Asroc aft shoe contacts the stop block on the Asroc adapter, the air motor is forced to stop, and the operator releases the manual control valve to OFF.

The Asroc is secured in the adapter by resetting and locking the restraining latch, pumping (with a hydraulic hand pump} the snubbers closed and locking them, and plugging the connector into the socket in the missile. The fixture chain and pawl are retracted by use of the air motor, the reverse of extending. When the chain and pawl are retracted, the fixture is ready to load another adapter or, if no more missiles are to be loaded, to be stowed. The Asroc, attached to the adapter, is struck down to the magazine.

Always remove the special tool (pump handle, cam wrench, or other tool) after using it, before proceeding with the next step.

If Asroc missiles are to be off-loaded, they are separated from their adapters with the aid of the loading fixture.

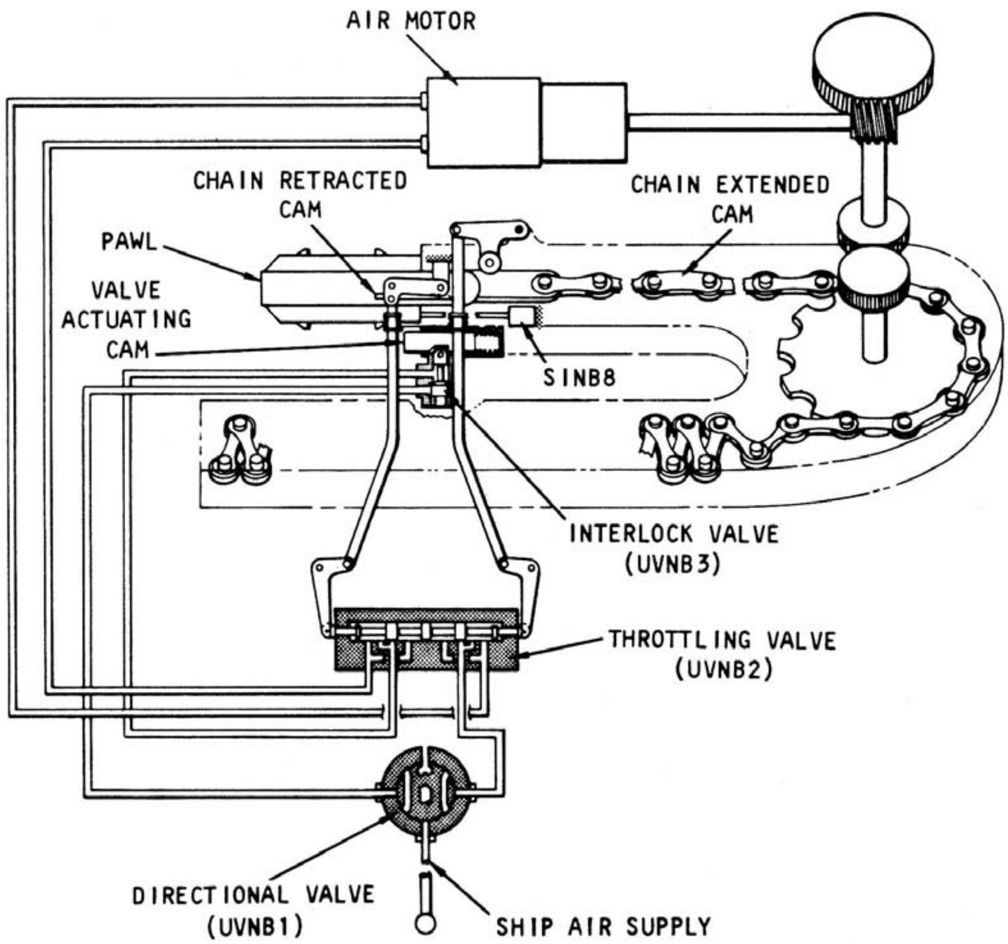

Figure 7-8.—Loading fixture (for Asroc) pneumatic schematic.

Ejectors and Dud-Jettisoning Equipment

Chapter 4 described and illustrated methods of jettisoning dud missiles in Tartar, Terrier, and Talos systems. In the Terrier/Asroc system, Mk 10 Mods 7 and 8, the same jettisoning equipment is used for all types of missiles loaded. The three main components of the jettison unit are the A-side ejector, the B-side ejector, and the control panel. A manually operated shut-off valve on the panel shuts off the 4500-PSI air supply to the jettison controls. The positioner air supply valve admits (or shuts off) air at 100 PSI from the ship's air supply to the A and B positioner control valves. The 4500-PSI air supply is used to charge the air chamber (fig. 7-9) and to operate the firing valve. The air pressure gage is usually set at 3500 PSI, and the panel operator cuts off the air supply when this pressure is reached. He does this by moving the operating lever of the Charge and Fire Control valve to the READY position. (Although there are some differences in control panels for different systems, the one shown in figure 4-3 is typical, and can be referred to for location of. parts.) The B ejector controls are on the right-hand side of the panel, and duplicate controls are on the left-hand side for the A ejector. Each side had four indicating lights, a positioner control valve, a charge and fire control valve, and a pressure gage. The shutoff valve and the positioner air supply valve control both sides.

OPERATING THE DUD-JETTISONING EQUIPMENT. - Figure 7-9 shows the location of some of the valves and other components, on the

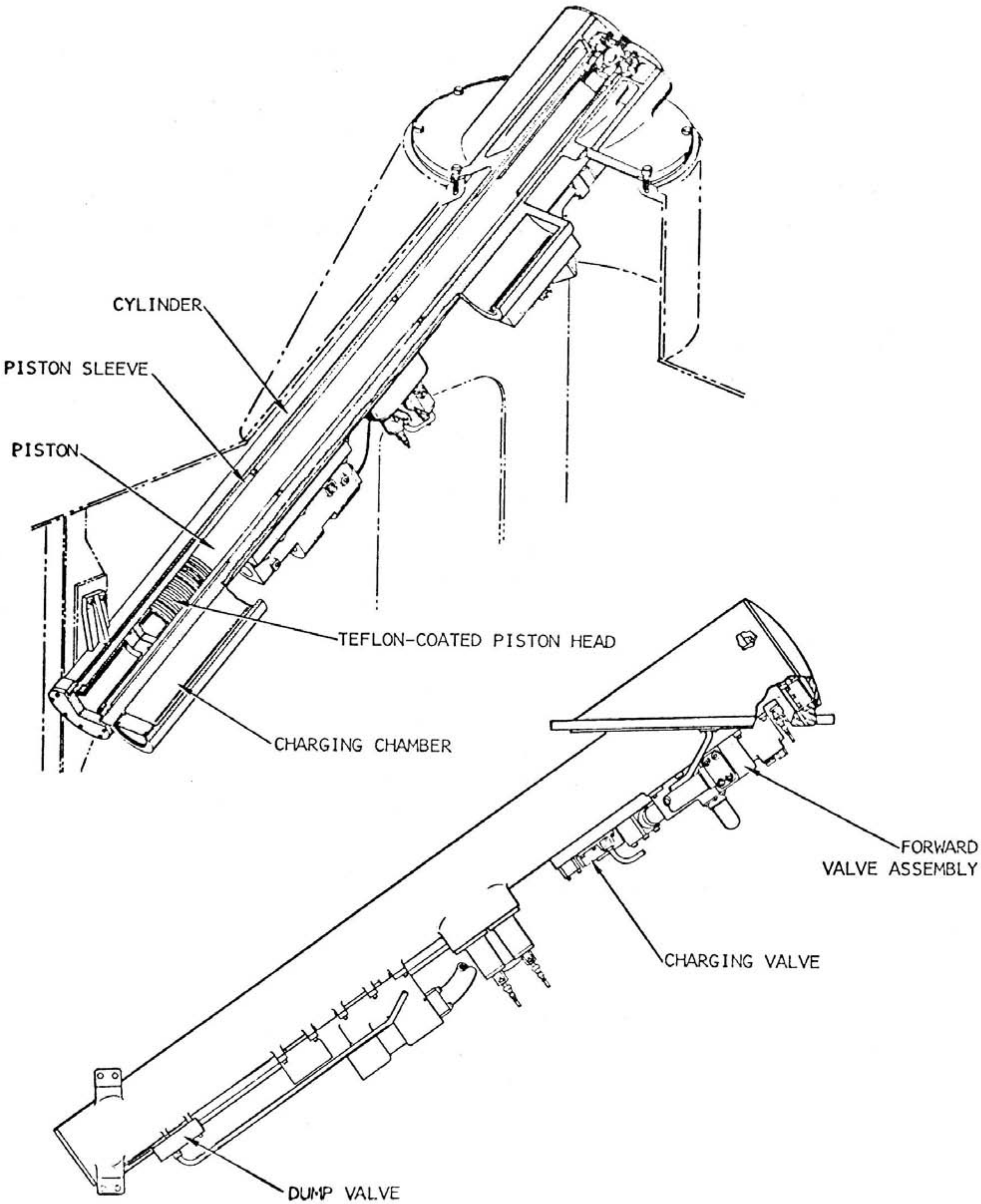

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Figure 7-9.—Dud Jettison Ejector.

cylinder weldment that are actuated when you move levers on the control panel. The dud jettison order synchros, of which there are eight for each unit, are mounted in a housing in the EP-2 panel. The rotors of the dud jettison order synchros are adjusted and fixed at predetermined positions so they train and elevate the launchers to preset dud-jettison positions when the launcher captain turns the switch to DUD JETTISON on the EP-2 panel. The dud jettison normal relay (KCB1) and associated electrical circuitry must be energized before the ejector will move to position I. (Position II is not used with Mk 10 Mod 7 launching system.) Position II was used for small booster missiles (BW-1) which have been phased out.

When the operator stationed at the dud jettison panel is signaled that everything is ready at the EP-2 panel, he executes the steps listed on the instruction plate on his panel. First, he turns the Positioner Air Supply Valve to OPEN, which directs 100 PSI air to the Positioner Control Valves. Since only Position I is to be used, the Positioner Control Valve (in the upper right-hand corner of the panel) is turned to POSITION I. The dump valves (fig. 7-9) then port 100 PSI air pressure to the rear of the ejector sleeve which causes the sleeve to move forward about 24 inches. Meanwhile, 4500 PSI air is going to the Charge and Fire Control valve, which you set at CHARGE. Air is ported to the firing safety valve (not shown), the charging valve (fig. 7-9), and both ends of the firing valve which is in the forward assembly.

When the indicating needle on the pressure gage reaches the stationary needle (which was preset), move the lever of the Charge and Fire Control Valve to READY. This shuts off the 4500-PSI air supply so the pressure will not go higher.

Check all the indicating lights on the panel and the pressure gage to be sure everything is in readiness, and observe the inclinometer which is adjacent to the control panel. If the roll of the ship is more than 20 degrees, the weapon must be ejected only on the down roll in the direction the weapon is pointing.

Now move the Charge and Fire Control lever to JETTISON AND OFF. The lines to the firing safety valve, the charging value, and the spring-loaded end of the firing valve are vented to atmosphere. Charging pressure is vented from the firing valve to the check valve and the shuttle valve in the forward valve assembly. This supplies air to both forward and rear ends of the ejector piston and to the plungers and the check valve in the rear valve assembly. As the piston moves forward, the pan at the front contacts the booster. The resistance causes an immediate pressure buildup behind the piston, which causes the control valve in the rear valve assembly to open and send air behind the piston to force the missile overboard. The rate of piston movement is controlled by orifices and the position of the control valve. In practice sessions, when you are not using a missile, the control valve assures that the piston will move at about the same rate as if loaded.

Anti-Icing Systems

Anti-icing systems keep vital areas of the launching system ice-free during freezing conditions. The anti-icing fluid is circulated by a motor independent of the rest of the launching system. Air bladders in the heat exchanger tank (fig. 7-10) maintain a constant head of pressure on the anti-icing fluid, compensating for expansion and contraction of the fluid under varying temperature conditions. The heat exchanger tank and components shown in figure 7-10 is of the type used in the Mk 10 launching system, and a similar one is used in the Talos launching system, while that shown in figure 7-11 is used in the Mk 13 launching system. The principles of operation are the same. The same special tool, air-charger-and-gaging assembly, is used to check the air pressure in each bladder and to charge it to the correct amount. The frequency of checking and charging the air bladders will depend a great deal on the temperatures in which the ship is operating.

USE OF SHIP'S AIR SUPPLY

The source of compressed air used in the equipments described is the ship's compressed air supply. The succeeding paragraphs describe the use of compressed air in equipments and systems that you will use, other than the missile launching systems.

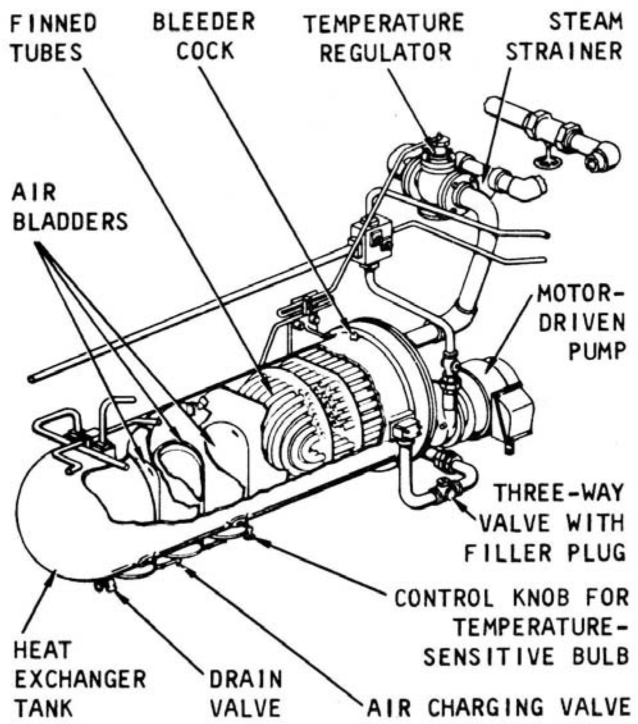

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Figure 7-10. Major components of anti-icing system.

Ship's air supply is used for testing and servicing missiles, and for the launching systems. Each missile must be checked as soon as possible after being brought aboard. The pneumatic tests are only a part of the tests used on the missile and the launching system. A great many of the tests are electrical to check the transmission of signals. The ship's compressed air supply lines are the source of compressed air used for all the tests of missiles as well as of launching system components. However, at present, no pneumatic tests of missile components are performed aboard ship. Air is used for charging air bladders, though compressed nitrogen is used for accumulators. Keep safety rules in mind when using compressed air and see that your men observe the rules.

THERMO-PNEUMATIC CONTROL SYSTEMS

A thermo-pneumatic control system is designed to actuate a magazine's fire suppression system in response to either a rapid rate of rise in temperature or a slow rise to a fixed temperature in a protected space. The automatic thermo-pneumatic system is installed as an adjunct to a hydraulic control wet or dry type magazine sprinkling system or a independent carbon dioxide (CO_2) system. Some missile magazines also use a water injection system containing a compression tank which supplies fresh water under air pressure as part of a fire suppression system. The procedures for testing, operating, and maintaining magazine fire suppression systems are explained in GMM 3/2, NT 10199, and chapter 8 of this text.

Pneumatic Components

The pneumatic operated components of a CO_2 system are heat sensing devices and pneumatic control heads. For a sprinkling system, they are heat sensing devices and pneumatic release pilot (PRP) valve.

The heat sensing devices detect temperature increases and transmit pneumatic pressure changes to a PRP valve or CO_2 pneumatic control heads.

A pneumatic control head reacts to pneumatic pressure from a heat sensing device by opening a discharge head and releasing liquid CO_2 from a supply cylinder. A control head consists of an air chamber and a diaphragm. When pressure in the control head chamber increases, the diaphragm expands and trips a lever that releases a trigger mechanism which activates the CO_2 fire suppression system.

The PRP valve, figure 7-12, connects pneumatically to a heat sensing device. In addition to a diaphragm, the PRP valve contains a lever, a spring mechanism, and a compensating vent. The diaphragm expands in response to sudden pressure changes and moves a lever to release a spring mechanism which opens the PRP valve. Salt water from the ship's fire main flows through the PRP valve and opens the sprinkling system main control valve which admits fire main supply water to sprinkle the magazine. The compensating vent functions to leak-off normal temperature fluctuations within the pneumatic piping system and heat sensing device to prevent inadvertent tripping to the PRP valve. The compensating vent is calibrated and adjusted at the

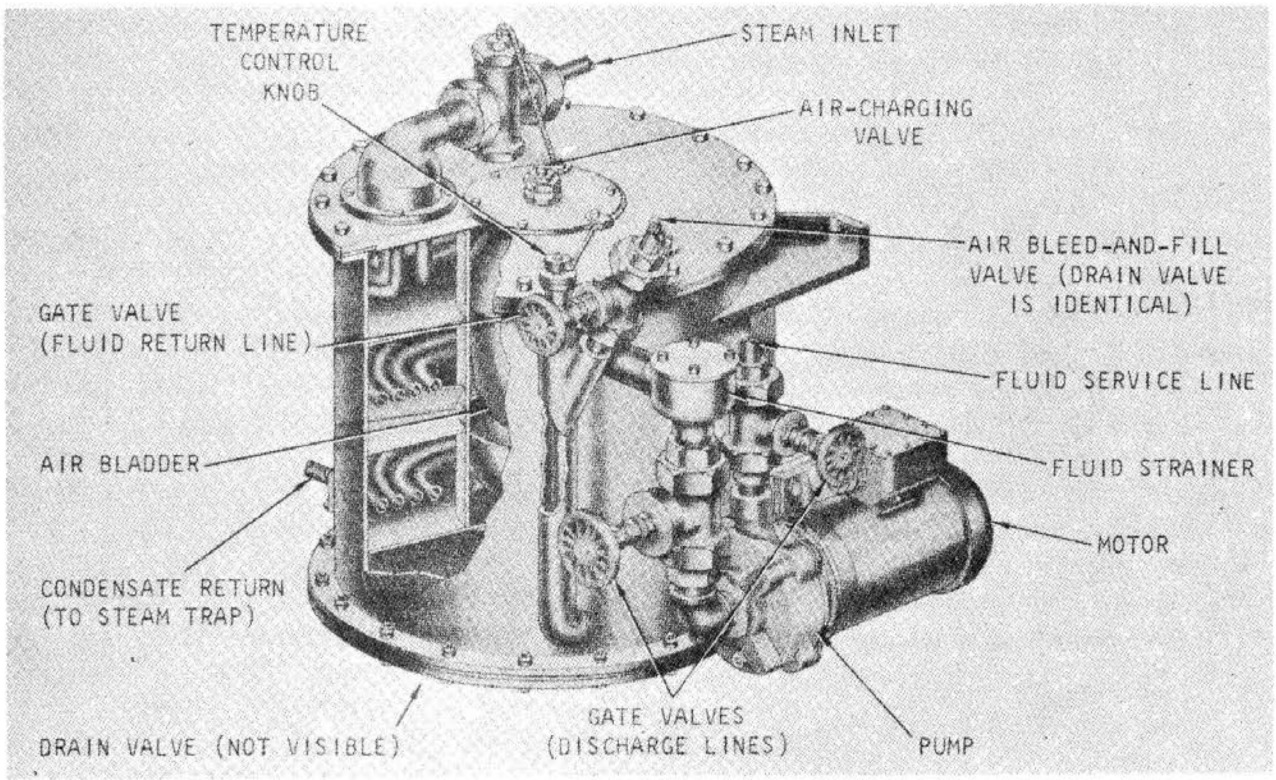

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Figure 7-11.—Anti-icing heater tank, Mk 13 launching system (Tartar).

factory. No adjustments should be undertaken by ship's force.

Pneumatic Control Circuits

The majority of systems installed on board ships consist of separate "rate of rise" and "fixed temperature" circuits. The "rate of rise" circuit uses a Heat Actuated Device (HAD) as sensing devices, and the "fixed temperature" circuit uses Fixed Temperature Units (FTU's) as sensing devices. A recent modification to some of the pneumatic control systems has been the replacement of HAD's and FTU's by Heat Sensing Devices (HSD's). The HSD combines the functions of the HAD and the FTU.

The "rate of rise" circuit is the primary circuit in most control systems. The operation of the "rate of rise" circuit is based on the following principles:

(a) Air expands when heated.

(b) Pressure is created when air expands in a closed system.

(c) Pressure can be converted to mechanical energy.

A differential pressure of at least 8 ounces per square inch across the release diaphragm is necessary to trip the PRP valve. A heat sensing device creates pneumatic pressure in two ways. First, a rapid temperature increase in a missile magazine heats and expands air in a bellows to increase air pressure. Second, a fusible slug melts and releases a spring which collapses the bellows producing a sudden increase in pressure in the pneumatic lines leading to the PRP valve or the CO_2 control heads. The pressure is converted to mechanical action by the expansion of a diaphragm. When the diaphragm expands, it releases a spring mechanism which opens a valve in the sprinkling system or shifts a plunger in the CO_2 system, thus activating a magazine's fire suppression system. Figure 7-13 shows the pneumatic control components of a CO_2 system.

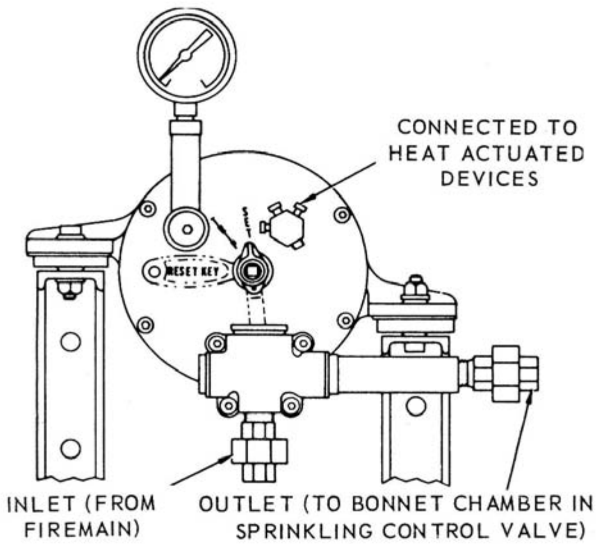

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Figure 7-12.—Pneumatically released pilot valve (PRP) used with heat-sensing devices in sprinkler systems.

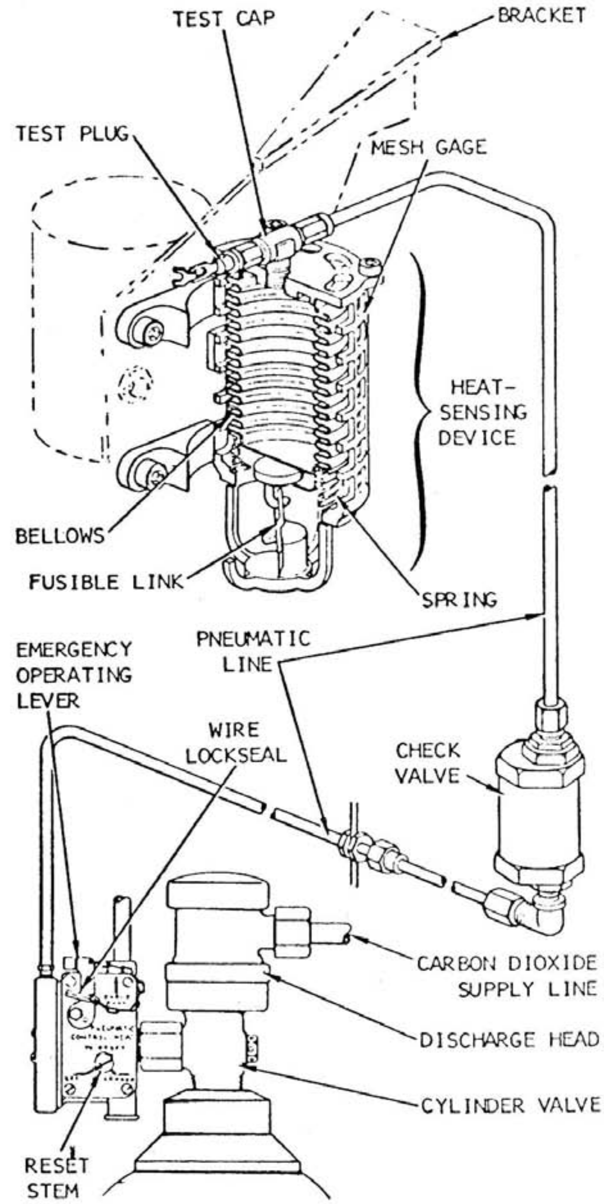

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Figure 7-13.—Carbon Dioxide System: Pneumatic Components.

Charging Flasks, Bladders, and Accumulators

Figure 7-14 shows the charging and gaging assembly used for air-charging and gaging the anti-icing bladders in the Mk 10 launching system. The bladder pressure for the anti-icing system on the Mk 10 launching system is 10 PSI. Check the requirement for the system you have aboard. The pressure should be checked monthly.

Compressed air is also used in the compression tank for the water injection system in the Mk 11 and Mk 13 launching systems described in the next chapter.

Accumulators in the hydraulic system of the missiles and the launchers are pressurized with nitrogen. When the missile is mated in the checkout area, the pressure in the accumulators must be checked and more nitrogen added if necessary.

PNEUMATICS IN MISSILES

The 3- T missiles (Terrier, Talos, and Tartar) all use air taken in through the missile nose to operate parts of the missile internal system. Figure 7-15 shows a cutaway view of the nose section of a Terrier BT -3 missile. The probe shield is a protective covering to prevent entrance of dust and moisture. The shield is blown away by air pressure against its face when the missile is launched. The nose orifice admits air to the transducer. The gas pressure transducer is a variable-reluctance device that senses total air pressure (static pressure plus pressure caused by missile velocity) and converts it: to a voltage which regulates the servo gain in the roll and

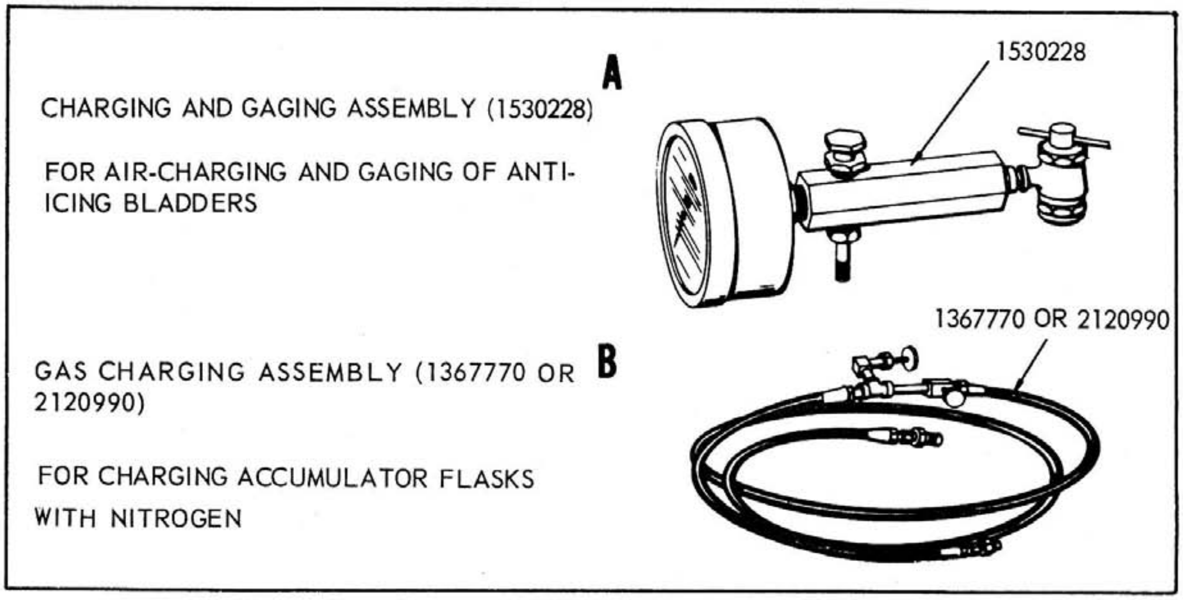

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Figure 7-14.—Charging assemblies: A. Charging and gaging assembly for anti-icing bladders; B. Nitrogen charging assembly.

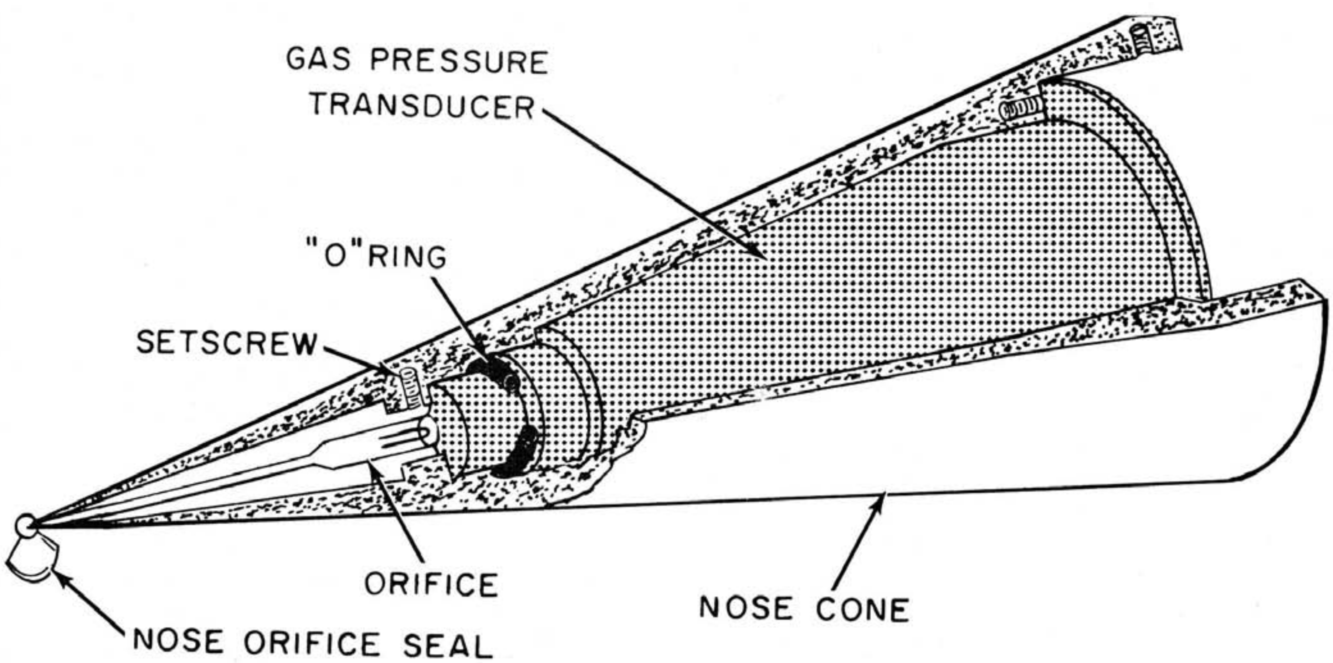

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Figure 7-15.—Nose section of Terrier BT-3 missile; cutaway view.

steering systems to compensate for changes in the control surface effectiveness caused by changes in missile velocity and altitude. The potentiometers associated with the gas pressure transducer are located in the signal control package. Changes in the ram and static air pressure are signaled to the signal control package to effect changes in the missile attitude.

The Terrier HT-3 missile has similar parts with slightly different names. The nose section is called the radome section, and it has a ram pressure probe that supplies the pressure transducer With ram air pressure. The transducer, in turn, supplies an electrical output that drives the servometer. As the servometer turns, it positions the ganged potentiometers as a function of missile ram pressure. The potentiometers act as fractional multipliers for various signals in the guidance computer so that the steering system gain is correctly controlled for variations in air density and missile velocity. The same technique is used in Tartar missiles.

The Talos missile has a more extensive air intake system because it must also take in air for operation of the ramjet engine in the propulsion system. An air-turbine-driven fuel pump delivers fuel from the tank. Ram air enters the diffuser, which is an annular passageway (leading to the combustor) where the supersonic low pressure air is converted to a low-velocity, high-pressure airstream. In the combustor, fuel is sprayed into the airstream and the air/fuel mixture is ignited by a spark ignition unit (spark plug). The hot exhaust gases develop thrust in passing through the exit nozzle to speed the missile on its way.

As in the other missiles, the control surfaces (wings, fins) are moved by hydraulic power. But hydraulic pressure is developed by the ram air turbine. Before the missile is in flight and the ram air turbine is operating, hydraulic pressure is built up by a high-pressure nitrogen pressurization system.

OVERHAUL, REPAIR, TESTING, AND ADJUSTMENT

The GMM 1 must be able to test, overhaul, repair, and adjust the pneumatic components of missile handling and dud-jettisoning equipment; the GMM C must be able to plan, implement. and supervise the maintenance and repair program for the pneumatic equipment. The Naval Ordnance Systems Command has contracted for technical services to assist naval personnel in the proper assembly, installation, inspection, test, repair, servicing, modification, maintenance, and operation of guided missiles, missile targets, and associated special test and handling equipment (NAVORD INST. 4350.5A). However, for fleet self-sufficiency and to conserve funds, GMMs are expected to be able to take care of their weapon systems and request help only in unusual circumstances.

WARNING: Always deenergize equipment before attempting any repairs. Exhaust air from lines or pipes in or to the equipment.

In any pneumatic system, loss of air pressure is the most common failure. Checking with the pressure gage can give you proof of the loss of pressure; slow or weak action is a symptom of pressure loss.

CAUTION: Plug all lines, openings, and connections during disassembly and assembly so no dirt, dust, water, or other foreign matter can get into the system.

Plan the job before attempting any overhaul. This planning should include obtaining the proper tools, checking availability of repair parts, study of the equipment and illustrations, review of safety measures pertinent to the type of machinery involved, and allocation of sufficient personnel to complete the overhaul in the allotted repair time. A well planned project will result in better, quicker, and safer results.

AIR MOTORS

Whenever any repair or maintenance is required on the train or elevation system of launcher, the air motors are used for moving the launcher. They are also used if the automatic system for operating the launchers is disabled. Air motors, therefore. must be kept in operating condition by proper maintenance, repair, and overhaul. Solenoid-operated control valves, which have identical components it hydraulic or pneumatic control, must actuate on signal. All O-rings and gaskets should be replaced With new ones whenever the valve is overhauled. The caution to "remove gaskets carefully," is intended chiefly as a caution against scratching or gouging the seat for the gasket. Take the valve to a dirt-free area to disassemble, clean, replace parts, and reassemble. Do not use waste for cleaning; use clean, lint-free rags. Be sure to secure all power to the launcher before removing any parts.

WARNING: Position the main power circuit breaker and the train and elevation air drive motor manual control valves at OFF. Place warning tags on these controls.

To remove the air drive motor, disconnect two air lines. Plug lines to prevent entrance of dirt or foreign particles.

Air motors used in Talos, Tartar, and Terrier launching systems are of similar construction. Obtain and study the maintenance instructions for those on your equipment before attempting repair work on them.

Assembly is the reverse of disassembly. Do not disassemble any more than necessary. Careful alignment and snug fit are important; frequent disassembly tends to destroy these. If replacement of the head gaskets or the rear gasket is necessary, scribe the cylinder and cylinder-to-rear housing for alignment on reassembly. Make alignment scribe marks on the head, distributor, and drive shaft before disassembling these parts from the head. These scribe marks are important because rotation of the distributor by 180 degrees changes motor rotation to the opposite direction.

Use new gaskets and new cover plate screws when reassembling, and replace any pitted or worn balls, and worn oil seal.

AIR LUBRICATORS

Air lubricators (fig. 7-16) are of the Micro Fog type which convert the oil to a vapor which is carried along with the air to give internal lubrication to the air drive motors. One lubricator supplies oil vapor to the train and elevation air drive motors; the other supplies the guide pneumatic cylinders. Do not disturb the factory adjustment of the lubricators unless you are positive a malfunction is caused by lubricator maladjustment. The oil level may be seen through a sight glass on the lubricators; if the level falls to the lower third, replenish the oil (check NAVORD drawing for correct type). Remember to secure all power to the launcher before doing this.

The air-driven chain drive fixture used with the Mk 13 launching system for strikedown, described earlier in this chapter, also has an air lubricator in the air supply line to the air motor, air throttle valve, and manual air control valve components. Although not always mentioned, other air motors also have air lubricators to supply air that lubricates.

The air lubricators, which provide a fine mist of oil to the air motors, sometimes need cleaning or adjustment. Check the fluid level monthly and replenish with the proper grade of oil if the level falls to the lower third of the sight glass on the lubricator. Check the applicable drawing for your equipment. For example, NAVORD Dwg 1600594 (for Guided Missile Launcher Mk 5 Mod 3) directs that train and elevation air motors need to have their reservoirs filled after 4 hours of operation.

Symptoms of maladjustment are:

1. Oil accumulation in the guide (or near the lubricators).
2. Noisy air drive.
3. Sticking pneumatic cylinders causing jerky piston operation, binding, or slamming.
4. Loss of power in air drive motors.
5. Lubricator has to be filled too often.
6. Lubricator needs no oil after extended launcher operation.

Each air lubricator has an oil feed adjusting screw (fig. 7-16) by which you can adjust the drip to 8 to 10 drops per minute (this vanes for lubricators in different systems). The position of the plate under the sight feed dome should be checked; remove the clamp ring and the sight feed dome. The bottom horizontal plate in the sight cavity should have the cast arrow pointing to position B for full air flow to the air motor and the lubricators. Adjust the plate with a screwdriver if it is not in position B. Type "B" lubricators have a bypass screw for adjusting the air flow (fig. 7-16B).

Operate the equipment to check the success of the adjustment. Several adjustments may be necessary before you achieve good results. Although air lubricators are of rather simple construction, adjustments must be made with care. They are NAVSHIP equipment if installed on ship's air lines.

Air control valves may require adjustment or overhaul. Any time a control valve is disassembled, all O-ring and backup seals should be replaced.

PNEUMATIC TEST SET TS-1165/DSM

Pneumatic Test Set T8-1.165/DSM is used for depot testing of the BT-3 and BT-3A Terrier missiles. Figure 7-17 A shows the exterior of the test set and figure 7-17B shows the pneumatic circuit. Depot MSTs are performed with regulated air to operate the auxiliary power supply turbines. The air is furnished through the TS-1165/DSM. Aboard ship, the MST is performed with external hydraulic power, supplied by the HD-259/DSM pumping unit. External electrical power is furnished by the Guided Missile Test Missile Test Set AN/DSM-54(V)C2. Both depot and shipboard checkouts use pneumatic pressure to actuate the missile ram pressure system. On shipboard, a gas pressure actuator is used (fig. 7-18), but a pneumatic test is not conducted.

The pneumatic test set weighs 200 pounds and is housed in an aluminum cabinet 24 inches square and 27 inches high. On the top panel are five gages and three indicator lamps for monitoring operation. The meter indicators and light on the front panel (fig. 7-17 A) are part of the automatic safety mechanisms. They are mounted on an individual chassis and may be removed easily for servicing. All controls except one manual shutoff valve for each channel (fig. 7-17B) are electrically operated. The test set can be operated from the panel or from a remote source. If can be controlled automatically by the use of the program tape of the AN/DSM-54(V)C2.

Ensure that all air lines and electrical connectors are securely attached t the proper ports and connectors at the top of the pneumatic test set, including a hydraulic pressure switch. Apply pressure from an external source of clean, dry air, either a compressor or a tank (600 to 1000 PSI).

WARNING: Make SURE that output hoses are SECURELY connected and ends tied down to prevent whipping.

The pneumatic test set accepts high pressure air and directs it through tubing into one of two separate channels which supply pneumatic power to the turbohydraulic and turboelectric systems of the BT-3 or BT-3A Terrier. The two channels can be used simultaneously and controlled independently. The principal elements of each channel are the manual valve for complete shutoff and a dome type regulator with high flow capability (fig. 7-17B). The controlling pressure applied to the dome is passed through a low-volume regulator capable of precise control. The dome is exposed to continuous compensation in either increasing or decreasing direction at a level preset manually prior to test operations.

When the turboelectric supply channel is opened by means of the manual control, pressurized air is applied to the pilot regulator and to the principal dome regulator; however, the valve in the latter remains closed as long as there is no pressure in the dome. The pilot regulator stabilizes the pressure but is prevented from influencing the dome by a solenoid shutoff valve. Air flow will begin when the solenoid is energized. The regulated air of the pilot valve will then enter the dome and establish a large flow through this channel at an outlet pressure determined by the preset conditions of the pilot valve. Flow will continue to the limit of the source and variations of input pressure and external demand will be compensated so that the output pressure will remain constant, within working limits. A pressure gage connected into the channel continuously monitors the output pressure, and a temperature gage indicates the temperature of the regulated air.

Deenergizing the solenoid valve between the pilot regulator and the dome stops the air flow between them but does not stop the flow through the main channel, as a certain amount of air is trapped in the dome. Another solenoid valve must be opened to permit the dome to release the trapped air. A check valve senses the reduced pressure and simultaneously dumps any retained air from the output tube unless it has already been dissipated. The exhaust vent is open at all times except when a regulated flow is required. The vent closes and the line from the pilot regulator to the dome opens when both solenoids are energized.

The second channel (turbohydraulic supply) functions the same way but has an additional pilot regulator and solenoid (fig. 7-17B), so two preset dome pressure levels are available, electrically selected by means of the solenoid valves.

The only pneumatic element common to both channels is a pressure gage indicating the source pressure.

Note (fig. 7-17B) the capped ports for calibration, one in the main supply line and one in each channel. Calibration of the test set is necessary each time before use. Follow the instructions supplied with the test set, or in the applicable OP.

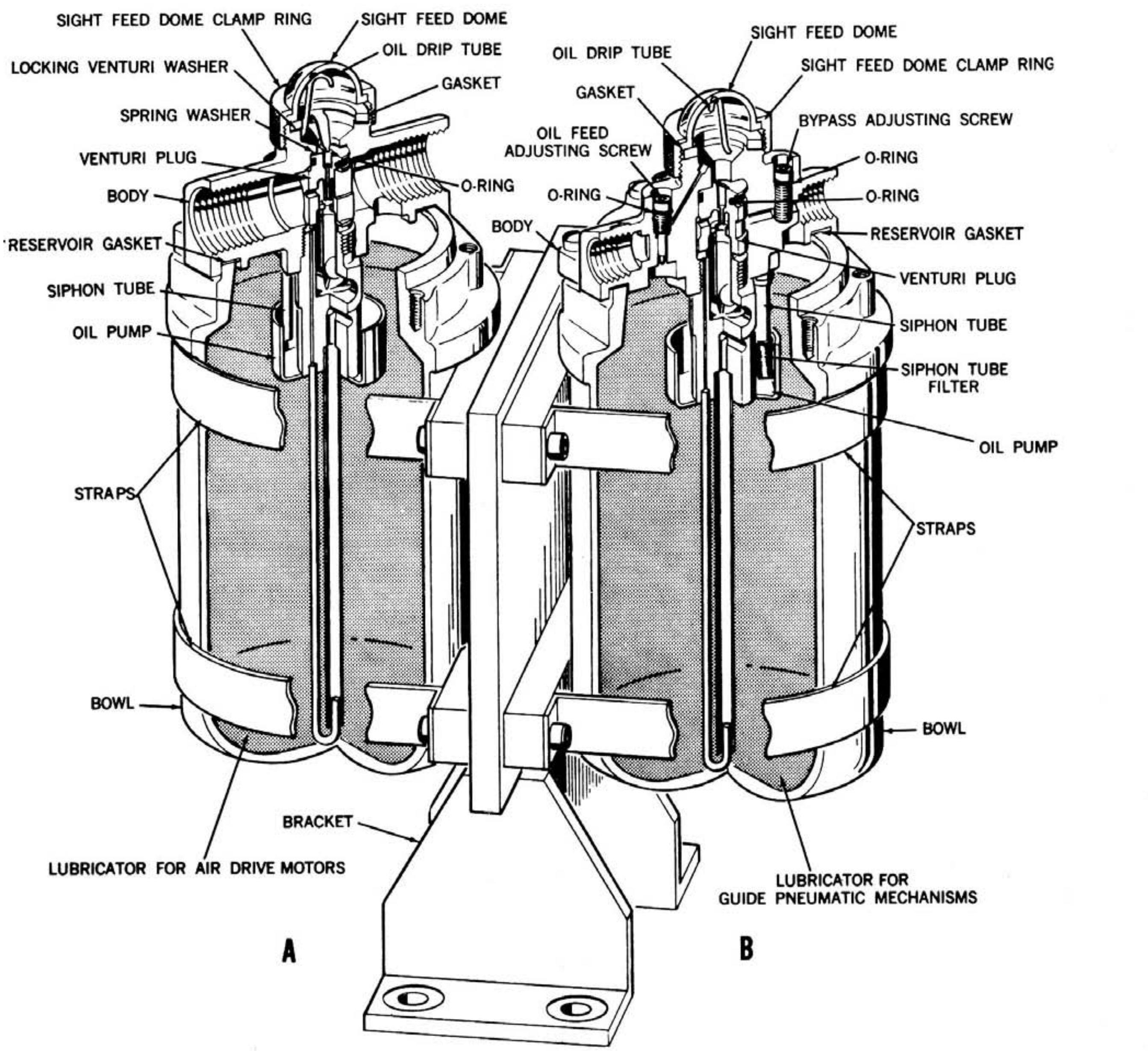

Figure 7-16.—Air lubricators, cutaway view; types A and B.

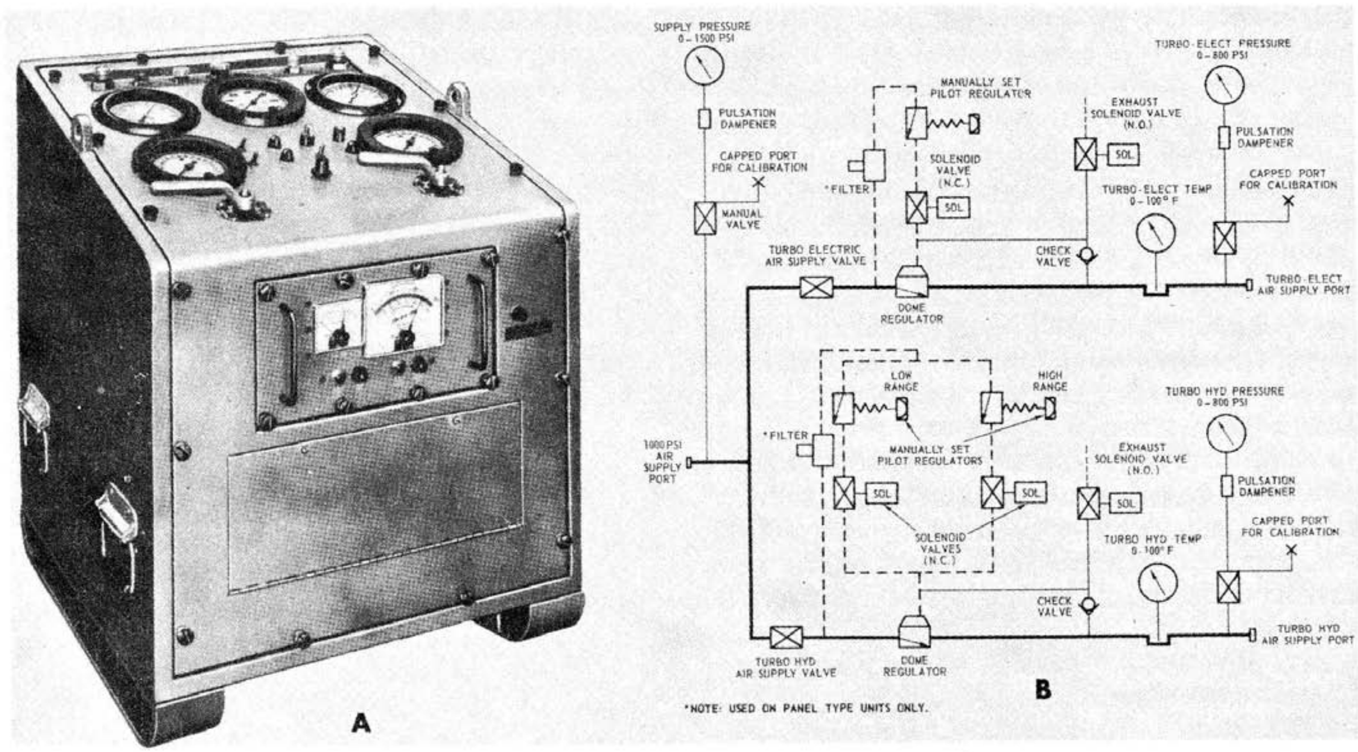

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Figure 7-17.—Pneumatic testing of missile: A. Guided Missile Pneumatic Test Set TS-1165/DSM; B. Pneumatic circuit diagram.

WARNING: All depot MSTs are performed on missiles with a live sustainer. This necessitates that the missile be grounded at all times. Observe all safety precautions.

For a pneumatic MST, the missile is assembled without the warhead section, S & A device, and fuze booster. A tactical test spacer (fig. 7-18A) is used in place of the warhead section, and a station test cable is used to connect the TDD and the electronic section. Present type depots perform only pneumatic MSTs. The sustainer is not electrically or mechanically armed, but is propulsive with the sustainer igniter squibs electrically grounded. There is no electrical connection between the test equipment and the sustainer igniter squib.

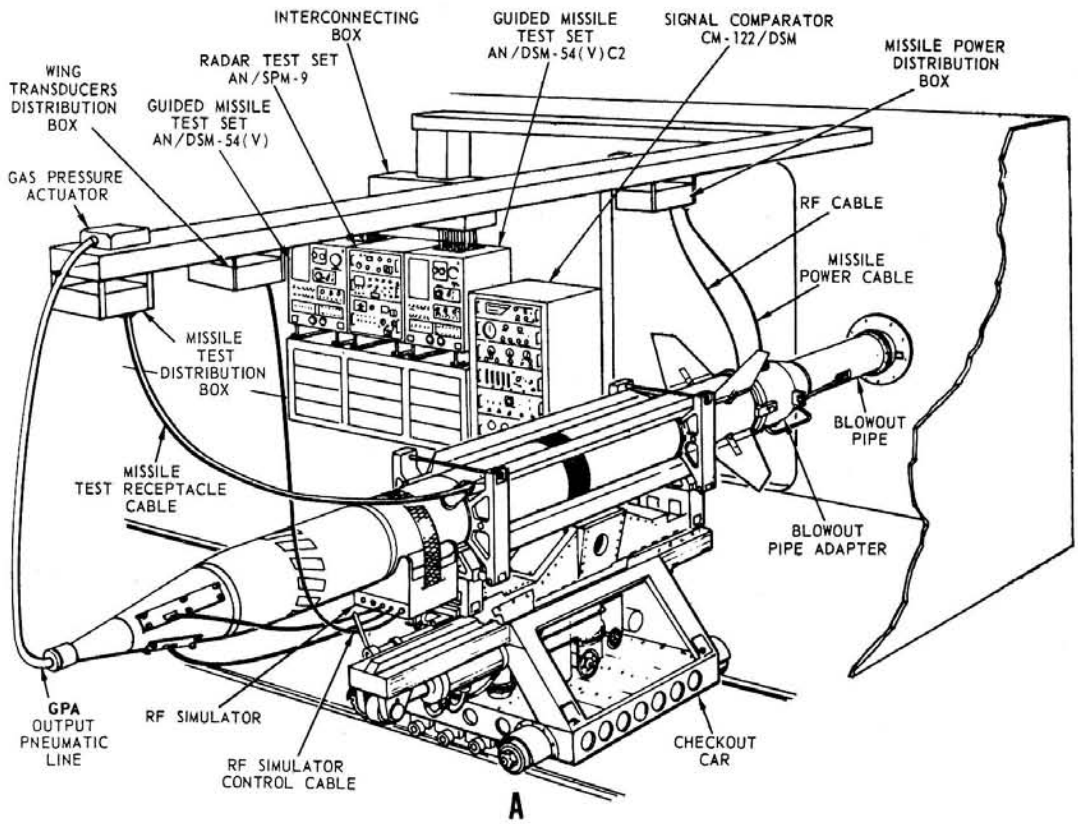
All-up type depots, which have special steel lined, reinforced concrete test cells where the missile is tested, perform electronic MSTs on completely assembled missiles with live sustainer, warhead, S & A device, and fuze booster.

Testing Aboard Ship

Pneumatic Test Set T8-1165/DSM is not used aboard ship to test missiles. Note its absence in figure 7-18B. However, Guided Missile Test Set AN/DSM-54(V)C2 is used, as at depots, to program the electronic test. The test set is connected to some pneumatic lines as well as to cabling, but no pneumatic test is performed.

On shipboard, checkout is performed with the missile completely assembled, with a warhead, S & A device, and fuze booster installed. The missile is brought to the. checkout area on the checkout car (fig. 7-18B), the booster is removed from it and is returned to the magazine for the duration of the test. The missile, on the checkout car, is moved to the blowout port and connected to it with the blowout pipe adapter.

The connections for missile testing aboard ship are sketched in figure 7-18B. The need for the blowout pipe has been discussed in previous chapters. The nose probe shield is removed from



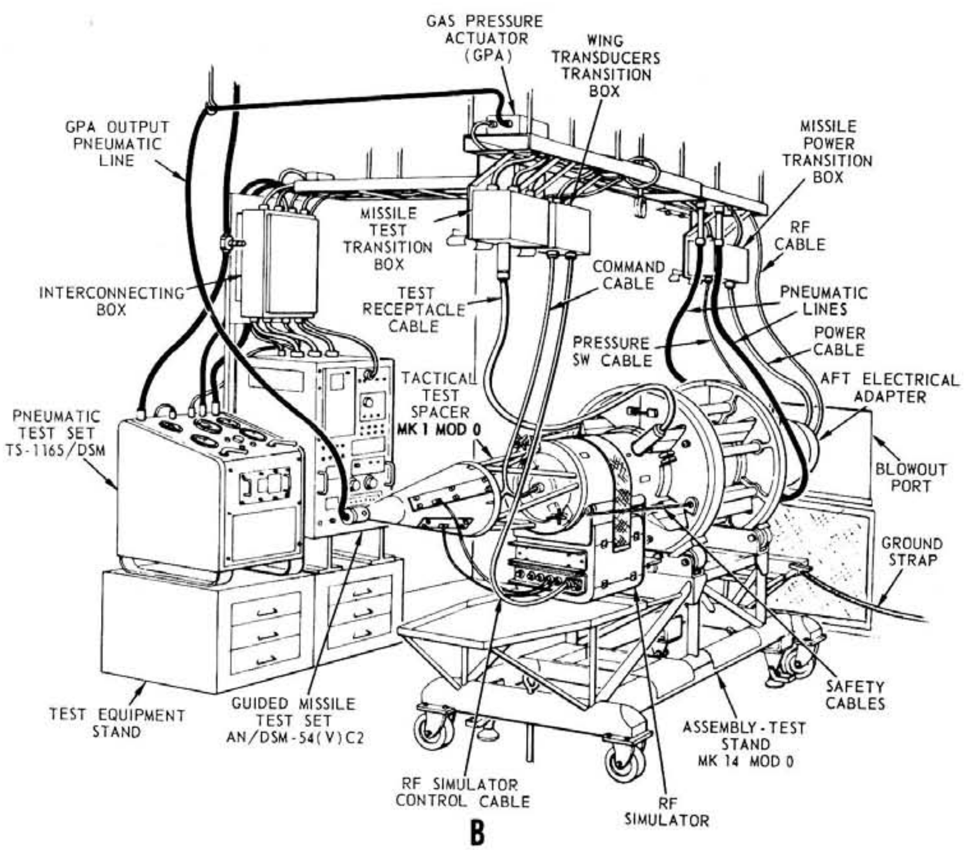


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Figure 7-18.—Missile Systems Test: A. Typical shipboard MST station installation; B. Typical depot MST station installation (present type).

the nose section of the Terrier for attachment of the gas pressure actuator air hose. To expose the missile test receptacle so the test receptacle cable can be attached, remove the forward end cover from dorsal fin No. 1, and then remove the test receptacle cover. A removal tool is required for this.

Full information on the equipment, pneumatic lines, and cables used at the individual shipboard test stations may be found in NAVORD OP 3119, *Terrier Guided Missile Test Stations*. Chapter 10 also gives some instructions for conducting the MST aboard ship, but the OP is needed for complete step-by-step procedures.

At the. end of the test, the Missile Test Set gives a GO or NO-GO indication of the missile flight readiness. If the test is NO-GO, Fault Location Lamps will illuminate on the test set, indicating the package which was found faulty during the test. With the aid of the fault location chart, it will usually be possible to determine the trouble.

After a successful test (GO indication), the missile can be restored to its previous condition by disconnecting all test connections, removing the TDD and nose section (to be reinstalled prior to flight), removal of the exercise head, if used, and reinstallation of the warhead, replacing the S & A device. Then the booster can be brought back for re-mating to the missile, and the round can be returned to the magazine.

If the test gives a NO-GO indication, fault isolation and troubleshooting procedures must be followed. There are different procedures for depot and for shipboard fault isolation. There are 13 FAULT LOCATION lamps on the test set. If any of the tests on a package fails, the associated lamp light. The lamps are interlocked so there will not be multiple lamps illuminated for the same fault. If several lamps light, it is almost always an indication that there were several failures.

A missile package or component that has been found defective should be replaced with an identical spare component. After replacement, the MST should be repeated to verify missile flight-readiness. Severe damage to missiles will result if the MST rules are not observed between tests. The troubleshooting between tests must be held to a definite minimum. The use of pressurized air is restricted to 6 minutes at low pressure (150 PSI) or 1 minute at high pressure (450 PSI) on aft section hydraulics. Other minimums are established for application of electrical power.

REPAIRS ABOARD SHIP

The pneumatic equipment used with missile launching systems is repaired on board ship to the extent of the ability of the men aboard and the repair parts available. Test sets, used by the FTs for testing the missile, may have to be returned to a depot or facility for repair and adjustment.

SUMMARY

Pressurized air is used to some extent in all the missile launching systems studied, but hydraulic and electric power are used to a greater extent. The air drive motors and air lubricators described are used in the Terrier and Talos systems for training and elevating launchers when there is a power failure, and also for maintenance and repair work. On Tartar launching systems, a pneumatic hand drive can be attached to the manual drive mechanism for moving the launcher.

The kind and number of handling equipments that are air operated vary with the installation. Some typical ones are described and illustrated. You are expected to maintain the ship's equipment that you use, but major repairs and overhaul are performed by other rates.

The pneumatic machinery that is part of the launching system, such as the receiving stand used with the Talos, and the chain drive fixture attached for loading the Tartar, are your responsibility. You must be able to maintain them in operating condition.

The use of Pneumatic Test Set TS-1165/DSM in checkout of Terrier missiles at depots, and shipboard testing without it were discussed. GMMs usually do not conduct the checkout alone, but should be prepared to do so.

CHAPTER 8

AMMUNITION AND MAGAZINES

INTRODUCTION

The preceding course in this series, *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199 gave you basic information on explosives their nature, history, classification, characteristics, and service use, along with some definitions of terms used in relation to explosives. Nearly every part of a missile round contains one or more types of explosives, selected to produce the desired effect. A fuze must contain sensitive explosives, yet not so sensitive that it cannot be handled (carefully) with safety. Boosters contain propellant charges that produce a steady thrust. Warheads contain high explosives for quick and devastating detonation.

The use of a special pyrotechnic item - the flash signal on exercise heads - and the purpose of self-destruct devices in missiles, were explained briefly in the above text.

The payload of a missile is in the warhead. The above text also described the different types of warheads that might be used in missiles. Advantages of certain types were given. Advances in the construction of shaped charges have increased their destructiveness. The continuous-rod type of warhead is used in some terrier, Talos, and Tartar missile warheads.

Nuclear warheads can be used in certain mods of Terrier and Talos missiles, Details of nuclear warhead construction are beyond the security classification of this course, but information on the destructive effects of nuclear weapons is available in unclassified publications. You are not required to know the scientific explanation of how nuclear reactions occur, but because some missiles are stowed with the nuclear warhead installed, you should know how to handle and stow them so there won't be an accidental reaction. A nuclear warhead also contains a considerable quantity of conventional explosives, usually several kinds which include both fast-burning and slow-burning propellants and high explosives. The safety rules for explosives therefore apply also to nuclear missiles.

All the current missiles fired from shipboard launching systems use solid propellants of the fast-burning type for boosters. Slow-burning propellants are used for the sustainers, which continue to accelerate the missiles after booster burnout. The Tartar has both the booster and sustainer in a single-stage dual-thrust rocket motor (DTRM). The Talos is the only one with a liquid fuel sustainer. It has a ramjet engine that uses JP-5 jet fuel (kerosene). The ramjet engine takes over after the booster has burned out and dropped off.

This chapter will go into more detail on the tests and inspections to be made of missiles and missile components before stowage, during stowage, and just before use. Since GMMs are now responsible for the nuclear warheads installed in their missiles, your duties and responsibilities with regard to the nuclear components will be expanded upon. You will have more responsibility for reports on tests, condition of missiles and missile components, and accounting for quantities on hand or parts needed. This chapter will give you information on reports needed.

On shipboard, your missile stowage spaces are well regulated and protected. At shore stations, the situation may be far different, especially at advanced bases. Your quals require you to know how to stow missiles at shore bases. Chapter 2 gave you some information on the subject of stowage at shore bases, and chapter 11 will tell you where to find additional information. This chapter makes only brief references to the subject. OP5, Volume 1, Ammunition and Explosives Ashore, is a compendium of rules for depot or other shore station ammunition regulations. Be sure to study the latest revision.

SAFETY OBLIGATIONS

Supervisory personnel are responsible for ensuring that all safety precautions related to handling, stowage, and use of all types of ammunition and explosive ordnance with which a vessel is supplied are strictly observed in all handling and stowage areas under their cognizance.

Explosives are intended to be destructive. While some are more dangerous than others, all explosives must be treated with respect. Since familiarity with any work, no matter how dangerous, is apt to lead to carelessness, all personnel who supervise work in connection with the inspection and use of explosives shall:

1. Exercise the utmost care that all regulations and instructions are observed.

2. Carefully instruct those under them and frequently warn them of the necessity of using the utmost care in the performance of their work. No relaxation of vigilance should be permitted.

3. Explain to their subordinates the characteristics of the ammunition, explosives, and other dangerous materials; the equipment, the precautions to be observed; and the hazards of fire, explosion, and other catastrophes which the safety precautions are intended to prevent.

Supervisors are required to maintain high standards of good housekeeping in ordnance spaces. Everything that is not in its place or is not in the safest condition increases the probability of an accident. All ammunition, missiles and their complementary items shall be protected from extremes of temperature, humidity, vibration, electromagnetic or magnetic fields, and radiological exposure. Observe the permissible maximum stowage temperatures for all ordnance as prescribed by NAVORDSYSCOM. Moisture and heat may cause some explosives to deteriorate and become dangerous.

In each weapon space where missiles are stored or handled or where missile equipment is operated, such safety orders as apply should be posted in conspicuous places. Conditions not covered by these safety instructions may arise which, in the opinion of the supervisor, may render missile stowage or missile handling unsafe. The supervisor may at any time use such additional safety instructions as he may deem necessary.

RF RADIATION

The most sensitive explosives are used in fuzes and igniters. Electric igniters, VT fuzes, detonators, and electrically fired rocket motors must be protected from radiofrequency emissions. None of these units may be exposed within 10 feet of any operating electronic transmitting equipment, including antennas and antenna leads. The minimum distance varies with the power output of the transmitters. Warning signs are required to be posted at the foot of all ladders or other access to all towers, masts, and superstructures which are subjected to hazardous levels of radiation, and also in the radio transmitter room. If the transmitting apparatus is part of authorized test equipment, or is part of the weapons system, follow the special instructions concerning its operation.

Naval Ordnance Systems Command carries on the Hazards of Electromagnetic Radiation to Ordnance (HERO) program to promote the safety of our weapons against rf radiation. The broader program, under the direction of the Chief of Naval Operations, has the code name RAD HAZ. It investigates the effects of electromagnetic radiation on ordnance, personnel, and volatile flammable materials. Protection of personnel against such radiation is now required on all ships. RF radiation causes damage to body tissue, which becomes heated by absorbing wave energy. The damage may be done before you feel any sensation of heat. The harmful effects may result from irradiation of the whole body, of the eyes, or of the reproductive organs. Eye damage is the most frequently noted health hazard. Do not permit your men to work where they can be harmed by rf radiation.

Technical Manual, Radio Frequency Hazards to Ordnance, Personnel, and Fuel, OP 3565, is the official HERO publication. It prescribes the operating procedures and precautions to avoid rf radiation damage to ordnance, personnel., and fuels. This manual supersedes all previous publications on rf hazards, and parts of manuals or publications dealing with this hazard, including NAVSHIPS and NAVORD publications. Many tests were conducted to determine for each weapon and/or component if it was HERO Safe, HERO Unsafe, or HERO Susceptible ordnance. The situation also makes a difference. RF radiation is most likely to damage ordnance during assembly, disassembly, loading or unloading, and handling in rf electromagnetic fields. The rf energy may enter through a hole or crack in the ordnance item, through firing leads, wires, contact with metal of tools or handling equipment, or exposed wires or contacts. A wooden or a plastic container is no protection against rf energy. Metal enclosures serve as a shield.

The technical manual cited above contains lists of explosive items and missile components that are HERO Safe, HERO Susceptible, and HERO Unsafe. However, items that are HERO Safe when completely assembled may be HERO Unsafe when tests are being conducted that require additional electrical connections, or when being assembled or disassembled, or when in a disassembled condition. Any time there are exposed wire leads from electroexplosive devices such as squibs, primers, and blasting caps, or unshielded flash signals, igniters, tracking flares, etc., there is a HERO Unsafe condition. Unshielded rocket motors, warheads, and exercise heads are HERO Unsafe. HERO Unsafe ordnance must not be permitted on flight or weather decks at any time. Testing, assembly, and disassembly of ordnance should be done below decks if at all possible. When it must be done on deck, be sure that all radiation equipment is secured.

Each ship should prepare a HERO Bill based on the information contained in OP 3565, just as each ship has a FIRE Bill. This would coordinate radar and radio control with the work being done in the ordnance department. Preparing the bill is the responsibility of the Commanding Officer who may designate a HERO officer. The great increase in the use of electronic equipment and the increase in transmitter output powers has brought an equivalent increase in the amount of radiation. The use of guidance radars brings more radiation to deck areas. It is only in recent years that the hazards have been investigated. The cause of many formerly unexplained explosions and duds was revealed to be from electromagnetic radiation.

SAFETY CHECKS

Before handling any component containing explosives, inspect the safety device to be sure it is in the SAFE position. If it is not, the unit must be made safe by experienced personnel. In most instances, the "experienced personnel" means you.

Be sure the airframe of the missile is well grounded electrically at all times. Check the grounding when the missile or a component is on the elevator, transfer cart, or other handling equipment during replenishment, stowage, inspection, mating, or unmating. The checkoff sheets for each operation list grounding as one of the steps (remember this when you prepare checkoff sheets); check each ground for correctness and firmness of attachment before you let your men proceed with the operation.

Be sure that the rocket motor case is grounded during all handling operations. Before connecting igniters in rocket motors, check firing leads for stray or induced voltages and for static charges. Inspect the igniter to see that the case and safety switch are not damaged. Any damage on these items is cause for rejection.

SPECIAL DANGERS OF DIFFERENT EXPLOSIVES

Black powder has been called the most dangerous of all explosives. It must be protected against heat, moisture, sparks, rf radiation, and friction. Only very small quantities are used in modern naval ordnance in fuzes, igniters, tracking flares, and primers. Largest quantities are contained in impulse charges.

The cast propellants used in rocket motors and sustainers must be protected against heat, moisture, and physical damage from dropping, abrading, etc. A crack in the cast propellant can cause failure of the missile because it prevents continuity of the burning rate. Powdered or crumbled propellant is more dangerous than the undamaged material. Dragging boxes over smokeless powder grains or broken propellant on concrete decks or docks has caused fires. Powder grains that have fallen into cracks and crevices are believed to have been the cause of many fires. The explosive ordnance disposal (EOD) team should be called immediately if powder is spilled or more propellant is broken. Work must be suspended until the spilled or broken explosive has been collected and placed in water-filled containers. Report all accidents or incidents to NAVORDSYCOM according to NAVORDINST 8025.1 (latest revision).

Some of the high explosives used in warheads look very much like harmless chunks of clay or pieces of rock. Scraping, striking, or dropping them can cause them to explode. Some high explosives cause dermatitis when handled with bare hands; some give off poisonous gas when they burn; one type leaves a white, powdery residue that is poisonous; and another type leaves a residue that is explosive if moved even a little. A drop of as little as 5 inches can cause PETN to explode; TETRYL has a drop sensitivity of 12 inches. These are high explosives used in warheads. The EOD team is trained in procedures to follow in emergencies with explosives; untrained personnel should not move damaged explosives.

TNT is now seldom used alone, but it is a major ingredient in several of the high explosives. Heat and sunlight deteriorate and darken it, and cause an exudation that is extremely dangerous if mixed with or absorbed by organic matter, such as wood. Any explosive containing TNT must not be stored on wood or linoleum decks. The exudate may appear as an oil liquid, or it may be sticky and viscous. It may collect in detonator wells on a warhead. Exudates must be. removed as soon as observed at inspection.

TNT is practically insoluble in water; the exudates can be washed off with hot water, this. is the preferred method to be used. NEVER use steel scrapers, soap, lye, or other alkaline solutions to remove exudate. Even a small amount of caustic soda or potash will sensitize the TNT and cause it to explode if heated to 160° F. Carbon tetrachloride, acetone, alcohol, and trichloro-ethylene will dissolve exudate. The first named should not be used because of its toxic fumes; the third named could cause further exudation after a period of time; the last named is the solvent most likely to be available to you. Be sure to have adequate ventilation when using any solvent.

Missile boosters are usually propellants, which tend to burn rather than detonate, though they may detonate if confined during burning. Propellants, jet thrust units, flash powders, and pyrotechnic powders all belong to this fire hazard class.

A rocket motor that has been dropped must not be fired. It must be returned to the depot, or disposed of according to instructions in: the OP or instructions from the commanding officer.

Never use any power tools on the rocket motor. Never apply heat to the motor, or to any of its associated components.

In case of a rocket motor misfire, wait at least 30 minutes, and make sure the firing circuits are open, before you approach the rocket.

Missiles not expended in live runs must be safed at the first opportunity in accordance with the instructions for the missile.

The tracking flares used on exercise heads contain black powder and magnesium, or a mixture of barium nitrate and aluminum. The dangers of black powder have already been mentioned. The magnesium powder is a fire and explosion hazard. In the air, a spark can cause an explosion. In contact with water, magnesium powder can burn violently. Metal fume fever is caused by magnesium oxide. If particles of magnesium get into a wound in the skin, gas gangrene may result. Because of all these hazards, tracking flares and flash signals must be handled with great care. They must be stored in the pyrotechnic locker. Moisture must be kept away from them, as well as heat and sparks. Rough handling, or movement in storage must be avoided. Check all missile electrical connections for NO-VOLTAGE before installation of the flash signal charge in the missile. Figure 8-1 shows a cross sectional view of a flash signal kit.

The self-destruct charge contains Composition B and Tetryl, both of them high explosives, contacted by two explosive leads. The explosive leads are detonated by an electric primer. The primer leads must be shorted at all times until just before firing. Handle and store these charges as high explosives. Always check the visual indicators for SAFE condition of the unit prior to installation.

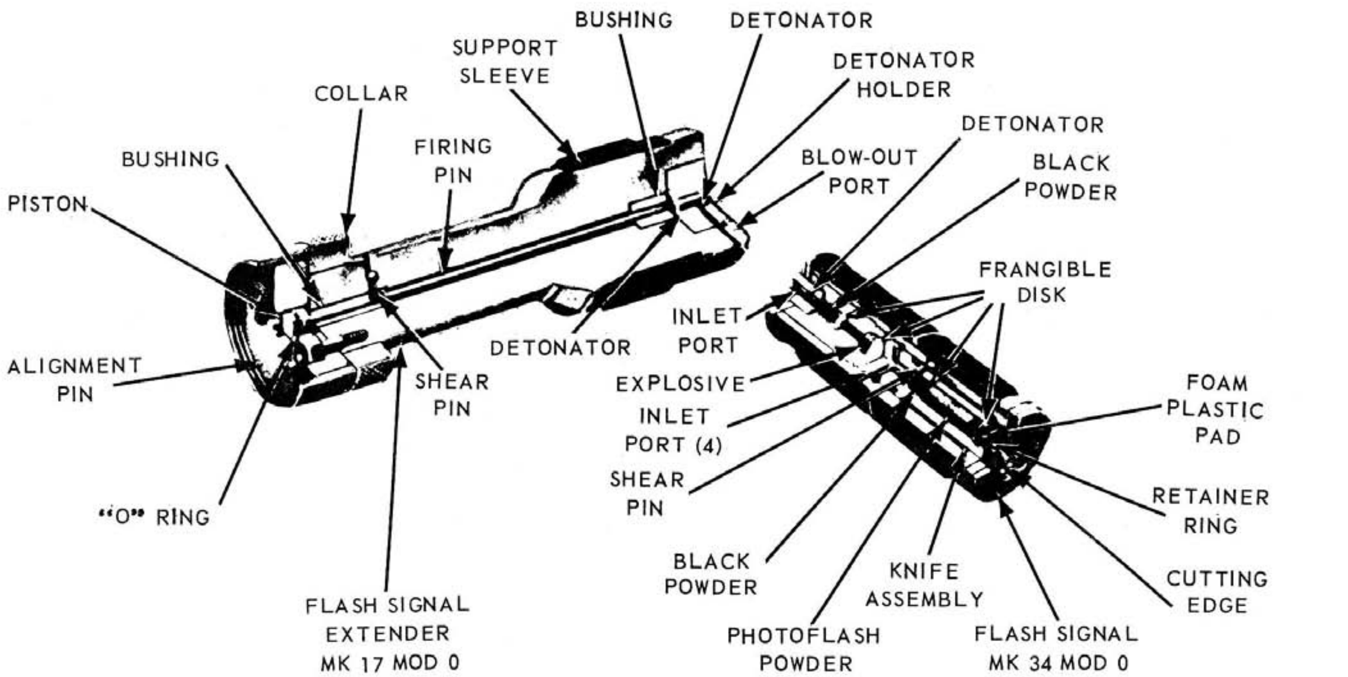

Figure 8-1.—Flash Signal Kit for Tartar missile exercise head.

NUCLEAR WARHEAD WEAPONS

With the exception of the nuclear hazard, there is little difference between the safety aspects of nuclear weapons and conventional weapons. These are the hazards of high explosives, propellants, detonators, igniters, flash signals, self-destruct devices, arming devices, mechanical and electrical hazards. These components surround the warhead or are attached to it.

The hazard of radioactivity is always present where there is a nuclear warhead. However, the hazard is minimal because of the many safe-guards included in the nuclear warhead. Improper handling can, of course, increase the hazard. As long as the seal of the nuclear container remains unbroken, the radioactive material does not escape. However, if by some mischance, the seal of the nuclear container is broken and finely powdered radioactive material escapes into the air, personnel must immediately evacuate the area. Decontamination teams wearing OBAs are sent to decontaminate the area. The radioactive particles do the most damage inside the body, and they are very easily inhaled or ingested. These tiny particles spread rapidly through the air, and get into all crannies and crevices and settle on everything. If the accident happens while the missile is on the launcher, above decks, much of the radioactive material will be carried away into the atmosphere, but if it occurs in the magazine or other space below decks, the ventilation system would quickly carry the contamination to other parts of the ship. That is why the instructions tell you to hold your breath, turn off the ventilation system, get out of the space, and close it.

If two sub-critical masses of active material from nuclear warheads are brought too close together (less than 3 feet), the entire mass can go critical, and personnel in the vicinity will receive massive does of radiation. When the active material is in the warhead and the warhead is in the missile, the necessary 3-foot spacing is automatically provided.

The greatest danger is probably that of accidental detonation of the explosives in the warhead, which could result in a partial nuclear detonation. (It is believed that an accidental full-scale nuclear detonation is an impossibility.) Even if only one detonator is exploded, some nuclear material may be spread in the vicinity of the detonation. Therefore, extreme care must be used not to activate any fuzing or firing device. Take care not to subject detonators to undue bending or twisting, and NEVER drop them. The nuclear material may burn, spreading contamination in the immediate vicinity. In a nuclear accident, the radiation resulting is the same as from a nuclear warshot. In a partial detonation, the noticeable effect may be so slight (just a puff) that it is overlooked, but the deadly radiation is present just the same. Any personnel in the area must report to the medical department. One of the insidious things about nuclear radiation is the fact that you cannot feel it (except massive doses that are quickly fatal). You cannot see it, taste it, smell it, and its deadly results may be long in developing. Though the men may protest that they feel fine, see to it that all the men who were in the area are monitored and report to the medical department. Since there no longer is a requirement for continuous monitoring of weapons spaces on shipboard, the monitoring done by the medical department forms the only record of the radiation.

INSPECTION AND TEST OF EXPLOSIVE COMPONENTS

The testing of explosive components aboard ship is naturally very limited. Explosive items never tested on shipboard are S&A units, fuzes, flash units or tracers, and boosters. The electrical circuits are tested for continuity, but great care must be used to make all connections correctly and not actuate any explosive. The men of the Fire Control Technician (FT) rating are responsible for most of the testing of components of the missile, as well as the functional resting of the weapons system. An FTC acts as the coordinator of weapons system tests. The GMMs position and prepare the missiles for testing. They install or remove adaption kits, arming and fuzing devices, and replace defective or malfunctioning components or modules. They must know the methods of testing missile propellants, boosters, and sustainers. (Note: Boosters are not tested aboard ship.)

INSPECTION

The inspections to be made upon receipt of the missiles and missile components at replenishment were discussed in chapter 2. Missiles are delivered to the firing ship in assembled condition; inspect of the components was performed at the facility that assembled the missile. If the missile is delivered in a container, you inspect it only for evidence of damage from rough handling or water. After unpackaging for stowage (or if it is received in the unpackaged state), you can inspect the exterior more closely for evidence of rough handling, water damage, mildew or other fungus growth, and broken or missing parts. Parts that are unpackaged before stowing, such as wing and fin assemblies, are inspected when unpackaged. Check the position of safety switches to make sure the missile is not armed. Check the humidity indicator if there is one. If the humidity is too high (the OP for the component lists the humidity limits and heat limits), unpackage the component and inspect for damage. Heat damage is seldom visible; the missile's record provides the evidence of over-exposure to heat and cold. Dispose of damaged components as directed by your officer. If the, component is still usable, repackage it with fresh desiccant and packaging materials as necessary. Packaging to make a waterproof container must be done according to precise packaging instructions and with the prescribed materials.

Damaged explosives must be disposed of in accordance with orders. Some have to be packaged carefully and sent back to the facility; others are thrown overboard. Call your officer to decide what is to be done. The quals require a GMMC to know enough about the explosive components to recognize dangerous changes and know what should be done in each condition. See OP 4, Vol. 2, *Ammunition Afloat*, for general rules on disposition of explosives, and the applicable missile OP for specific rules.

Nuclear Warhead Inspection

When a nuclear warhead is received aboard in a container, it is given receipt inspection. The outer container is removed before transfer to the checkout area, where the inner container is removed. Remove the records from the outer container. Inspect the seals, and if there is evidence of tampering, notify the security officer. Check the humidity indicator on the package. If it shows humidity in excess of 40 percent, a thorough check must be made (after you have finished unpacking the warhead) for mildew or other fungus or other evidence of moisture damage. Fungus growth or corrosion can be removed; it is not a cause for rejection of the warhead. Superficial scratches or abrasions on the warhead are not a cause for rejection, but dents or deformation are.

WARNING: If the safety switch actuator is in the ARMED position, rotate it back to SAFE with a large screwdriver. Submit an incident report to NAVORDSYSCOM.

The Battery Power Supply may come packaged separately and may be stowed that way, or an administrative decision may be made to install it in the warhead. A monitor test follows battery installation. The warhead may be placed in temporary storage until it is installed in the missile, or it may be placed in the warhead magazine, encased in the inner container.

When performing any work involving a nuclear warhead, obey the 2-man rule-always have two qualified men present. They must be familiar with the Navy SWOPS that spell out the details of caring for nuclear weapons. Great care must always be used not to bump or drop the warhead. That means all handling equipment must be in safe operating condition, and that you have enough men to do the work safely. Check the operation of the handling equipment before using it.

Storage inspection and monitor tests of stowed nuclear warhead or warheads assembled into the missile are performed according to the Navy SWOP for the missile. For example, Navy SWOP W45.21-1 gives the instructions for Terrier missiles. The frequency of inspection varies for the different warheads the Navy has; but all are given a receipt inspection, an inspection when removed from a missile, and another prior to being offloaded. A defective power supply battery may be removed but no other disassembly of the warhead on shipboard is authorized.

DISPOSAL OF EXPLOSIVES

As has been mentioned several times, you do not jettison a missile unless it is absolutely necessary for the safety of the ship and men. If it is a dud, you return it to the magazine until you can return it to a depot for refurbishing. In case of a misfire in which the APS are expended, the aft section of the missile must be replaced. This is done at a depot. To prevent damage to the roll free gyro, it must be recaged. After waiting the required time (minimum of 15 minutes for Terrier) after the misfire, apply external power for at least one minute to ensure caging of the gyro. Return the missile to the magazine as a dud. Enter the facts in the missile log - that a misfire occurred, that the APS were expended on the launcher, and the condition of the gyro caging mechanism. Shipboard replacement of the APS components is not permitted. Shipboard replacement of aft section components is limited to those items for which spares are provided.

Boosters and Sustainers

Rust and corrosion may be removed from boosters and sustainers with fine sandpaper; but emery cloth or a wire brush should never be used, as they cause static electricity that could fire the igniter. If a booster or a sustainer is dropped, set it aside and notify NAVORDSYSCOM and ask for instructions for its disposition. Boosters and sustainers should be grounded at all times during handling, maintenance, assembly, and disassembly.

Should any indication of abnormal deterioration of boosters or sustainers be noted (such as exudate or excessive corrosion), notify NAVORDSYSCOM promptly.

Other Explosive Missile Components

Other explosive components of missiles are igniters, self-destruct components, safe and arming devices, fuze booster, flash signal charge, APS igniter, APS gas generator, and the warhead. Do not try to clean corrosion from an igniter because static electricity could ignite it. Do not disassemble it. Do not stow it in the vicinity of electrical discharge or radio wave radiations. If an arming device does not function properly, make no attempt to repair it but notify NAVORDSYSCOM of the malfunction.

Any S & A device that has been dropped 5 feet or more (when packaged), or is suspected of having been dropped, should be repacked and instruction for disposition requested from NAVORDSYSCOM. Any unit found in the armed condition must be disposed of in accordance with established procedures and a full report of the incident sent to NAVORDSYSCOM, and the S & A log sheet forwarded to Naval Ordnance Laboratory, Corona, California.

The fuze booster screws on to the aft end of the S &.A device. Do not attempt to clean it and do not test or disassemble it; inspect it for visual damage.

The flash signal used in exercise heads is a pyrotechnic item and must be handled and stowed as such. The destructor charge and the APS igniter are high explosives, and the APS gas generator is classed as a fire hazard. The gases produced are toxic and may be explosive if confined.

MISSILE COMPONENT IDENTIFICATION

Navy guided missiles, as with other ammunition, are classified as service (tactical) missiles and nonservice missiles. Tactical missiles, or rounds, are fully functional and fully explosive loaded rounds. Nonservice missiles may be further segregated into practice (exercise) rounds, training (training or inert operational) rounds, and dummy (dummy or shape) rounds. Each type of nonservice missile carries an identifying ammunition color code.

The external surfaces of all Navy guided missiles (service rounds), except radomes and antenna items, are painted white. White has no identification color coding significance when used on guided missiles. Three significant color coding colors - yellow, brown, and blue - are used on guided missiles and their components. The three colors are applied to the external surface of guided missiles to indicate explosive hazards and uses.

Color Code Interpretation

Yellow identifies high explosives and indicates the presence of an explosive which is either:

(a) sufficient to cause the ammunition to function as a high explosive, or

(b) particularly hazardous to the user.

Brown identifies rocket motors and indicates the presence of an explosive which is either:

(a) sufficient to cause the ammunition to function as a low explosive, or,

(b) particularly hazardous to user.

Light Blue identifies ammunition used for training or firing practice. Blue painted items may have a yellow or brown band painted on them to indicate explosive hazards or may be an overall blue color without bands indicating a training item that is nonexplosive loaded. Any missile with external surfaces painted all blue is a fully inert training item.

Light Green identifies smoke or marker ammunition.

Missile and Component Markings

Guided missiles that contain compressed gas components fitted with an explosive squib are classified, for the purpose of explosive color coding, as being particularly hazardous to the user and are so indicated by a brown band on the component and on the external surface of the missile section in which the gas flask is contained. Figure 8-2 illustrates color coding for a typical missile configuration.

Guided missile warheads and their associated fuze mechanisms may be loaded and configured for service (tactical) or nonservice use. Some large surface-to-air missiles have more than one explosive type warhead while practice warheads for all missiles may be inert loaded with an in-flight destructor charge installed or completely nonexplosive loaded. Service tactical warheads for all missiles are painted overall white. Training heads may be either overall white or blue. A high explosive warhead painted overall white has a solid yellow band no greater than three inches wide painted around the warhead.

Warheads fitted with pyrotechnic components to indicate fuze activation are painted with a one inch light green band adjacent to a one inch brown or yellow band, figure 8-2. Training warheads

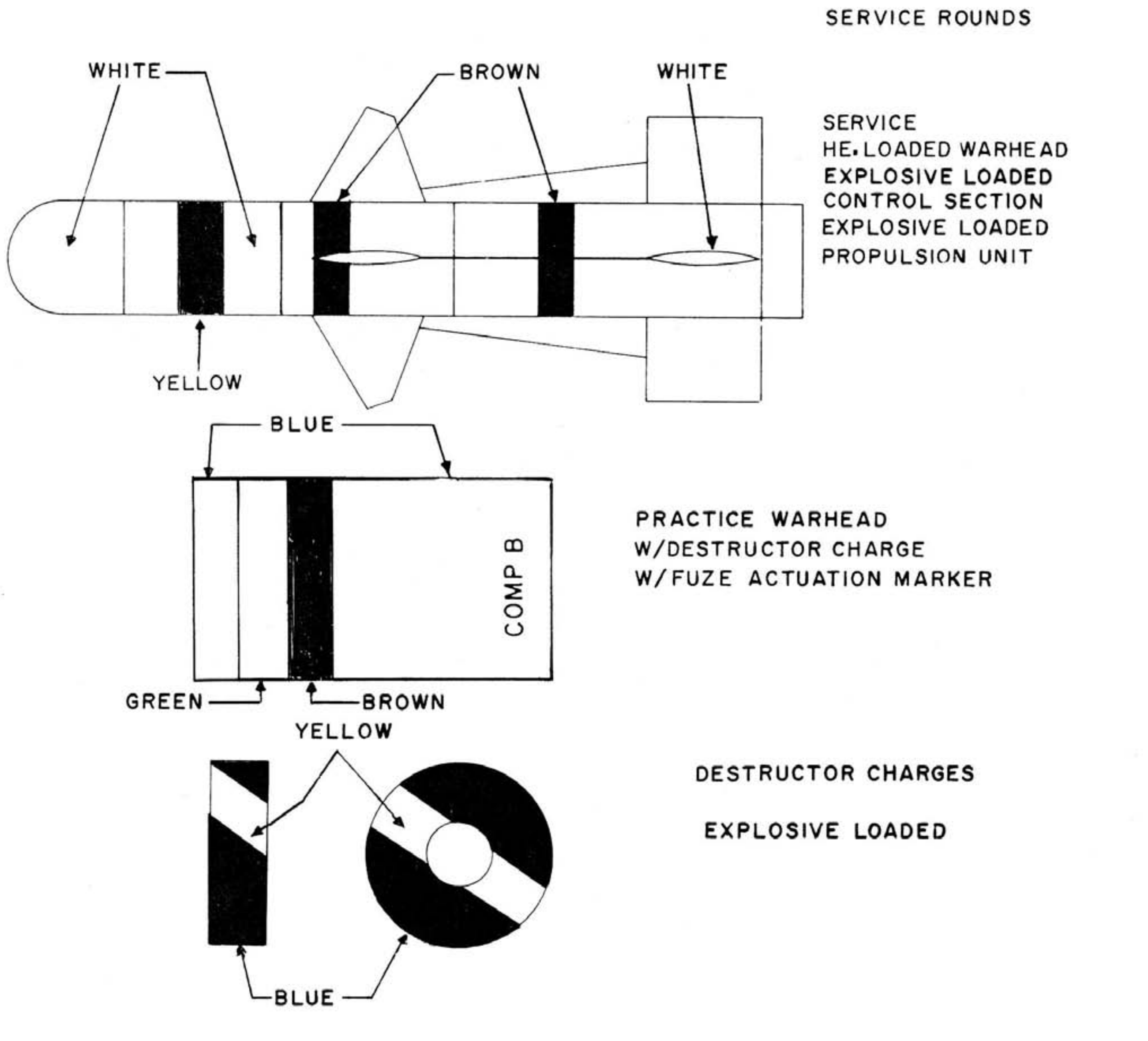

Figure 8-2.—Typical guided missile component painting.

with an explosive destructor charge installed are marked with the symbol COMPB in yellow letters as illustrated in figure 8-2.

Miscellaneous Explosive Devices

Miscellaneous missile explosive devices encompass all independent explosive or pyrotechnic devices that are not components of the missile fuze and warhead or the propellant units and igniters. Items specifically included under this grouping are: in-flight destructor charges, safe arming devices, auxiliary power units, and arming and firing devices. These devices follow the ammunition color coding requirements. Explosive components containing high explosive or having sufficient explosive to function as a high explosive are painted yellow overall or with a yellow band. Explosive components containing explosive amounts sufficient to cause the explosive to function as low explosive or deemed to be particularly hazardous to the user are painted brown or with a brown band.

Training items nonexplosively loaded are painted blue overall or with a blue band.

Practice items may be explosively loaded and have a yellow or brown band painted over the blue overall back ground color, figure 8-2. Anti-submarine rockets (ASROC) used with some Terrier weapon systems are painted gray overall and carry the same ammunition color code specified for guided missiles. Blue is used as an overall color for totally inert training and handling ASROC weapons. Guided missile and rocket designations and ammunition color coding for missile and rocket components are explained and illustrated in Identification of Ammunition, OP 2238.

TESTING

As mentioned before, you do not test propellants, boosters, fuzing and firing units, or sustainers aboard ship. No tests are authorized for these munitions aboard ship. While components are in storage, periodic inspections are made to ensure that the containers are preserving the contents effectively, and that the component has not exceeded its storage life. Storage life of assembled ASROC missiles, for example, is 30 months. Periodically, stored ASROC missiles must be returned to an AD or ASW facility for inspection and replenishment of components. The missile is considered to be in a packaged and preserved condition when stored either in a container or in the launcher magazine. The ASROC Depth Charge, with its nuclear warhead, is also stored in the launcher magazine. Any testing or inspection is done according to the Navy SWOP 44.341, whose classification is higher than that of this publication.

MISSILE MAGAZINES

Surface-to-air guided missiles Terrier, Tartar, Talos and Standard are ready service complete rounds of ammunition. The complete missile represents a mixture of mechanical, electrical, and electronic equipment hazards plus hazards due to several different explosive components. Because of the nature of guided missiles, requirements for their stowage aboard ship differ from the conventional ammunition magazine requirements. Surface launched missile magazines are usually located above the ship's water line. Missile magazines are constructed so that each missile is segregated from one another in cells or trays for easy handling and maximum protection against fire and shock. Missile magazines contain the necessary electric, hydraulic, and pneumatic power operated equipment to stow, select, and deliver a missile from. the magazine to the launcher rail for firing. The location and general arrangement of the various types of missile magazines differ with the type of missile and the type of ship in which the missile system is installed. In some missile magazines, restraining gear is provided to prevent movement of an inadvertently ignited missile motor while the missile is stowed in a cell. Special care is taken with the magazine vent systems to ensure that magazine pressures do not build up to a dangerous level if a missile rocket motor is accidentally ignited. A plenum chamber and vent is provided in Tartar magazines and a relief port for Terrier and Talos magazines which vents the exhaust gases from an accidentally ignited missile to the atmosphere.

In some missile magazines flame barriers are installed between each cell to make them a separate, enclosed compartment open only at the top through which a missile passes during loading and unloading. Figure 8-3 shows this type arrangement used in a Tartar magazine of a Mk 11 GMLS. Missile magazines also contain fire fighting equipment which frequently consists of built in sprinkler systems, water injection systems, carbon dioxide (CO_2) systems, portable dry powder extinguishers, or a combination of these systems.

Missile magazine access doors, flame tight blast doors, and compartment doors should be kept closed at all times except when they must be open to permit passage of missiles, missile components, or personnel. Special emphasis is placed on this requirement during periods of weapon assembly, disassembly, system testing, system firing, or other operations involving missile movements, The same precautions observed in magazine areas must also be observed in all areas of a missile system where weapons are handled or tested.

Explosive and Flammable Components

Combustive missile components are classified under three major categories as follows:

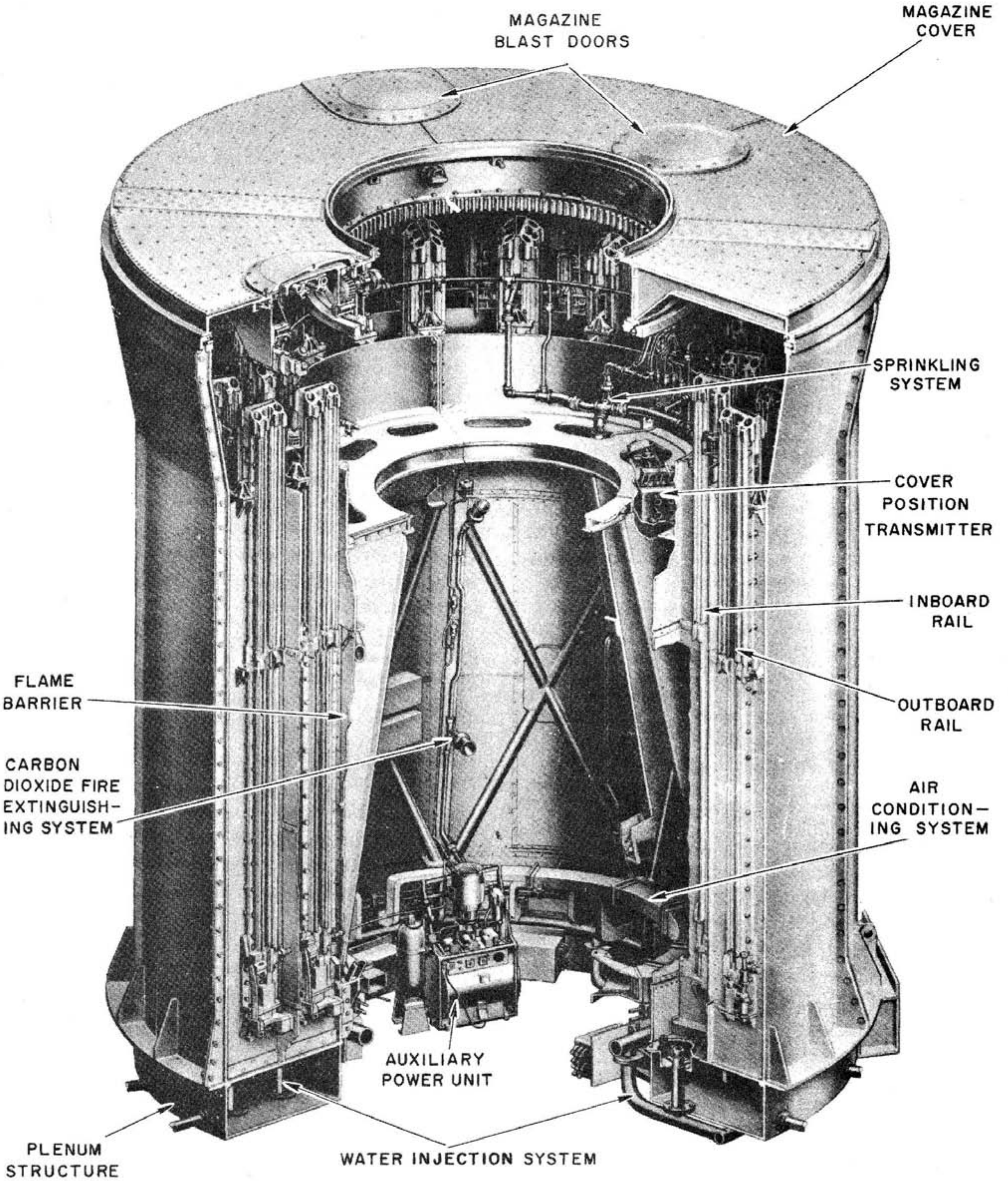

Figure 8-3.—Guided missile magazine.

1. Class" A" is the maximum hazard category which includes items that explode violently when contacted by sparks or flame, or when subject to excessive heat or shock. Items such as the missile warhead and fuze booster are considered Class "A" explosives. All Class "A" explosive components must be handled carefully to prevent their being dropped or otherwise damaged by shock. They must also be protected from intense heat and sparks.

2. Class B is the Flammable Hazard category which includes items that are subject to rapid combustion rather than detonation. The hazards created by Class B explosives are fire, heat, and noxious gases. Missile components such as flash signals, auxiliary power supply, rocket motors and igniters are examples of Class "B" hazards.

3. Class C is the Minimum Hazard category which includes items containing only limited quantities of explosive/flammable materials and are therefore considered insufficiently hazardous to be classified as Class A or B. A typical example of a Class C items are the APS igniter and S and A device.

Missile Component Stowage

Wings, fins, warheads, fuze boosters, fuzes, exercise heads and missile spare parts for Terrier and Talos missiles are stowed in appropriate sections of the missile house. The wings and fins are placed in the racks in the launching system assembly area. Warheads, fuze booster, fuzes, and exercise heads are stowed in racks, bins, and stalls inside the warhead magazine. Nonexplosive complementary components (except wings and fins) are stowed in the missile component storeroom.

Magazine Safety Precautions

Specific safety precautions relating to shipboard stowage of guided missiles are presented in launcher system OPs and in Chapter 4 of OP 4, Vol 2. Listed below are some of the general safety precautions applicable to all missile magazine areas.

1. All magazines shall be kept scrupulously clean and dry at all times. Nothing shall be stored in magazines except missile rounds and the necessary magazine equipment. It is imperative that no oily rags, waste, or other foreign material susceptible to spontaneous combustion be stowed in the magazines.

2. To minimize environmental hazards, the missile magazine is temperature and humidity controlled. It is imperative that the temperature and humidity control systems operate at all times. Inspect missile magazines daily to verify that proper humidity and temperature exist.

3. Personnel must remove all matches, lighters, or any other fire making or spark making devices from their persons before entering a magazine space.

4. Blowout discs and hatches are provided as safety measures to relieve pressure in the magazine in case of rocket motor ignition. The discs and hatches should be inspected periodically to make sure they are operable. They should be clearly marked to show their locations. Personnel should stand clear of the hatch area and the area directly beneath the hoods where the discs are ejected.

5. In the event of accidental ignition of a booster or sustainer in the magazine, stand clear of the magazine until exhaust gases have been completely vented. The gases are toxic and lethal if inhaled in sufficient amounts. A minimum waiting period of 10 minutes after burnout is recommended before approaching the area without wearing special equipment.

6. Precautions should be taken to ensure that heat detectors as well as the sprinkler and CO_2 heads are not covered, damaged, or subjected to any environment that might falsely activate them or impair their utility. Because of the suffocation hazard represented by CO_2 in a closed area, all personnel should disable the CO_2 system before entering a magazine area.

7. If a magazine has been flooded with carbon dioxide, allow 15 minutes for all burning substances to cool down below their ignition temperatures, then thoroughly ventilate the area for an addition 15 minutes to make certain that all portions of the magazine area contain only fresh air. If it is necessary to enter the installation before it is thoroughly ventilated, use a fresh air mask or other type of self contained breathing apparatus.

ORGANIZATION AND ADMINISTRATION OF SAFETY PROGRAMS

In accordance with the Navy policy of conserving manpower and material, all naval activities are required to conduct effective and continuous accident prevention programs. The organization and administration of a safety program applicable to a missile system is the responsibility of the leading gunner's mate within the system. The safety program must be in accordance with local instructions and based on information contained in United States Navy Ordnance Safety Precautions, OP 3347. Adopt work methods which do not expose personnel unnecessarily to injury or occupational health hazards. Post instructions on appropriate safety precautions in appropriate places. Review these signs and instructions frequently and do not allow them to become. rusty, faded, or covered with dirt or dust. Appropriate safety posters and signs may be obtained through the ship's supply department. Give the new men assigned to a missile system safety indoctrination as soon as they report for duty. A supervisor of a missile system should delegate authority to his subordinate petty officers to assist him in training and monitoring a safety program. A supervisor should also include a follow up program which inquires as quickly and as thoroughly as possible into circumstances of accidents and reports of unsafe practices and takes proper action or makes recommendations. When new safety directives and precautions are issued, it is the responsibility of the supervisor to correctly interpret their application to his men.

Organize a formal safety training session for new men and explain each safety subject in detail. The results of unsafe acts are usually the most dramatic and easiest remembered.

Magazine Firefighting Equipment

GMM 3/2, NT 10199, describes the types of missile magazine fire fighting equipment presently installed on board Naval ships. Since fire and explosions are the chief dangers in a magazine where missiles and their explosive components are stowed, prevention of conditions that can cause fire and explosions and the means of fighting fire if it occurs are included in every missile magazine. During the daily inspection of missile magazines examine them carefully for cleanliness, ventilation, temperature, and the general condition of the missiles stowed in the magazine. The temperature and the moisture content of the magazine's atmosphere must be constantly watched. Temperatures are read daily and the maximum and minimum readings recorded in a magazine temperature record book. A magazine sprinkling system has to be inspected and tested monthly. Magazine flooding control systems, quenching systems and installed missile handling equipment must also be inspected for security, safety, and operation periodically.

Missile Magazine Hazards

Most missile magazines contain automatically controlled missile handling equipments which can be hazardous to personnel if safety precautions are not observed. Hazards from moving equipment within the magazine areas can be eliminated by removing or positioning safety switches from a controlling station which stops all equipments within a magazine area. Other hazards such as a suffocation hazard from a CO_2 firefighting system can also be safed by securing valves which feed the system.

Safety instructions posted near the entrance of magazines are very effective if they are easily understood and can easily be complied with. Some standard safety warnings such as: "Suffocation Hazard Secure CO_2 System Before Entering Magazine Areas" and "Danger To Prevent Magazine Motor Activation, Remove Safety Switches From Control Panels" point out the potential danger but do not give instructions about the methods of eliminating the dangers. Where safety methods are not fully explained, the launcher supervisor should instruct all personnel who have access to magazine spaces the proper procedures taken before entering these spaces.

Additional instructions may be posted near the warning signs (figure 8-4) which give information on the location and actions taken to safe a magazine area. Instructions can be made up to read as follows: Suffocation Hazard. Before entering magazine area close the two shut-off valves that serve the carbon dioxide (CO_2)

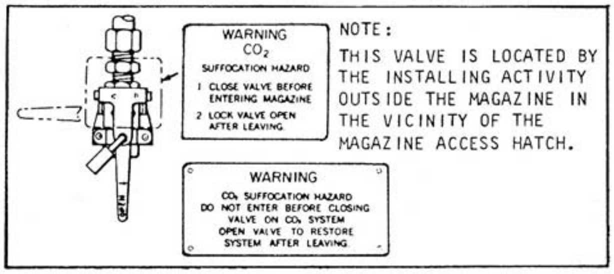

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Figure 8-4.—Additional safety instructions.

system. These valves are located outside the launching system structure in compartment 3-75-4-L. They are normally locked in the open position, accordingly, unlock and close both valves and lock in closed position before entering magazine area.

Safety During Tests and Maintenance

In missile magazines that have both CO_2 and sprinkling systems installed, the control units used to activate these systems could be the same type. An example illustrated and explained in GMM 3&2, NT 10199, is the magazine fire-fighting system used with the Mk 13 GMLS. In this system two control circuits, one for CO_2 and the other for sprinkling systems, are activated by identical heat sensing devices.

A common hazard of a heat sensing device is its method of operation. It is activated by a fusible slug which melts at a predetermined temperature. This action causes a mechanical action to take place which activates either the CO_2 system or the sprinkling system. If a heat sensing device is located too near an operating electric motor or hydraulic unit, the fusible slug could melt from the excessive heat emitted from the units and accidentally activate one of the systems. Because of this hazard, the slugs are checked periodically to ensure their condition. Fusible slugs come in many types which melt at different temperatures. In the Mk 13 GMLS two types are used, one which melts at 174°F for the sprinkling circuit and one which melts at 158°F for the CO_2 circuit. Since all heat sensing devices are identical (except for their fusible slugs), extreme caution must be observed when conducting maintenance on these units. If an inspection reveals that a slug must be replaced, a maintenance requirement card (MRC) will explain all the steps necessary to perform this task and also lists the safety precautions related to the task. A launcher supervisor should research the MR card to ensure that the required actions listed include all additional safety requirements for entering a magazine area. The supervisor should also ensure that all safety instructions are understood by the personnel performing the task. Most MR cards include a statement to observe all standard safety precautions. A standard safety precaution is one that pertains to all types of magazines and is not listed as a specific instruction on the MR card for the maintenance action being performed. An example of a standard magazine safety precaution would be to ensure that no matches, or other flame producing apparatus, are taken into the magazine while it contains explosives. In cases where similarity of systems may cause confusion, the launcher supervisor must take all the necessary additional precautions to ensure personnel safety even though they are not listed on a MR card.

Installing Fusible Slug

Before installing a fusible slug in the heat sensing device of a sprinkling or carbon dioxide system, both systems should be secured regardless of which system is being maintained. When a damaged fusible slug is removed from a heat sensing device, it releases a compressed spring that forces a bellows to collapse. This action causes a sudden pressure change in the heat sensing device. The pressure change causes a mechanical action to take place which actuates either a control head of a CO_2 system or a PRP valve for the sprinkling system, (both systems are explained and illustrated in GMM 3&2, NT 10199). To prevent accidental activation of either system, they both must be secured prior to removing a fusible slug from any heat sensing device.

To secure the carbon dioxide system, disconnect the control heads from the supply cylinders and close off all valves that serve the carbon dioxide system. Also secure all firemain water pressure valves that serve the sprinkling system and install a sprinkling system test casting into the sprinkling system salt water control valve. When either a PRP valve or a CO_2 control head is activated, its position is shown by an indicator on either unit, see figure 8-5. An activated condition of a PRP valve is shown as the trip position, and for the CO_2 control head, a released position. The position of the control mechanisms is a very important factor when performing a maintenance action. In normal operation the position indicator on a CO_2 control head will move when the bellows of a heat sensing device collapses to produce a sudden pressure increase in the pneumatic lines leading to the CO_2 control heads. The pressure differential causes a diaphragm mechanism to trip an actuating lever which releases a compressed spring. The spring shifts a plunger in the control head mechanism and opens a pilot seat in the cylinder valve, figure 8-6. Liquid carbon dioxide flows through the pilot seat to the upper chamber of the discharge heads, forcing the piston down and opening the control cylinder valve. Opening the cylinder valve releases liquid carbon dioxide from the supply cylinders through shut off valves and into the magazine area where a gaseous snow is produced which quickly reduces temperature and extinguishes fires. During maintenance, the closing off of the shutoff valves prevents carbon dioxide from entering the magazine.

Even though all known precautions are taken, there is still a possibility that a condition could exist which might cause accidental activation of either system. When a new fusible slug is installed in a sensing device as shown in figure 8-7, the bellows must be expanded by a special tool. This tool, called a pull rod, is attached to a section called the collet. When the pull rod is pulled out, the bellows attached to the collet is reset in a position to collapse when a fusible slug melts. The fusible slug holds the extended collet in place, and the collet holds the reset bellows. Resetting the bellows does not automatically reset the tripping mechanism of either the CO_2 control head or the PRP valve, they must be reset manually.

Before reactivating the CO_2 system, check to see if the visual indicator on the control heads is

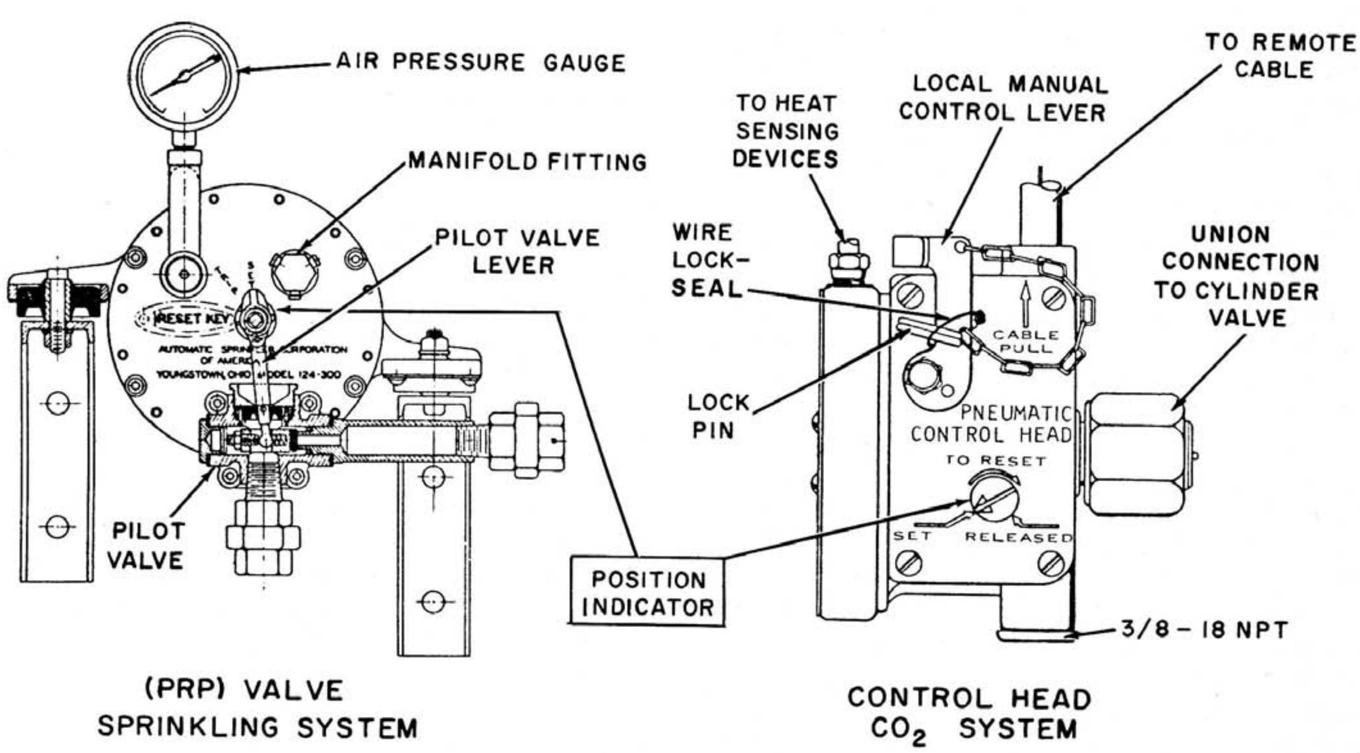

Figure 8-5.—Automatic control devices.

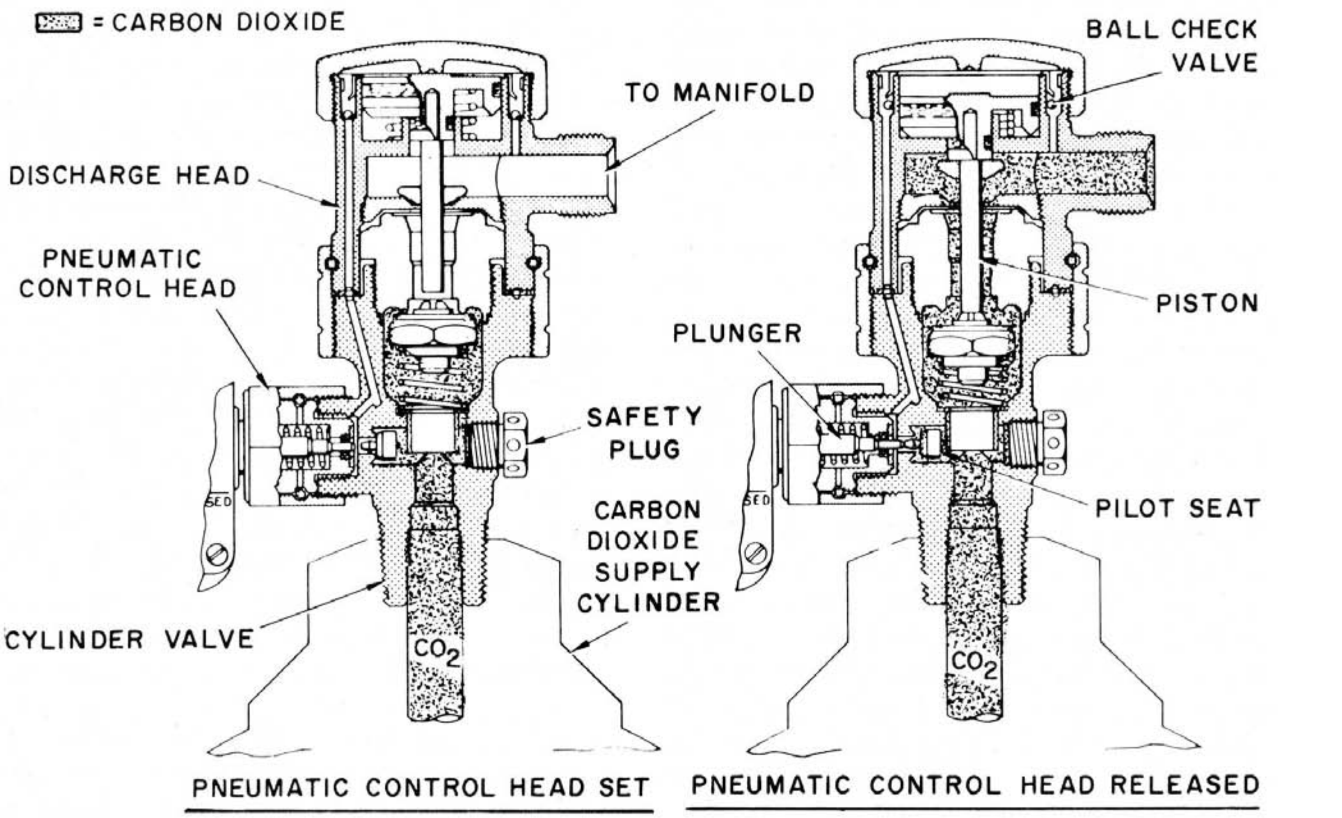

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Figure 8-6.—Cylinder valve, pneumatic control head, and discharge head.

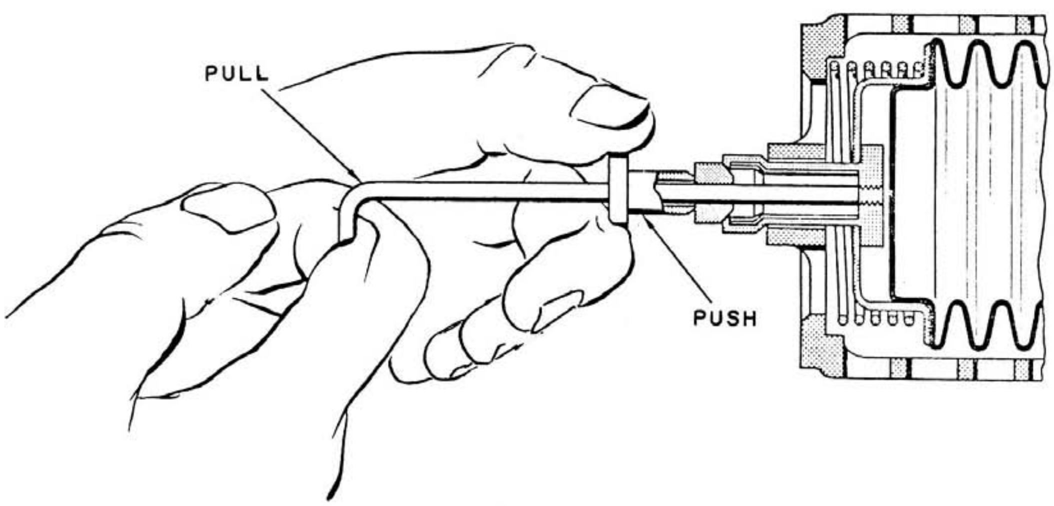

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Figure 8-7.—Installing fusible slug in heat sensing device

in the SET position, figure 8-5. To reset the tripping mechanism on the control head, turn the stem on the visual indicator clockwise with a screwdriver from the released position to the SET position. Slight resistance will be met just before the stem locks.

Before reactivating the sprinkling system, check to see if the visual indicator on the PRP valve is in the SET position. To reset the tripping mechanism of a PRP valve, use a special key to turn the reset mechanism on the front of the valve clockwise from the TRIP position to the SET position, figure 8-5.

OTHER PROTECTIVE DEVICES

All means used to maintain the missiles in the best condition help to prevent accidents. The air-conditioning and ventilation systems installed in the magazine certainly may be considered protective devices in this sense. The heavy construction of the magazines gives protection against blast and fire from accidental ignition of a missile. The blast doors on the magazine provide protection against the blast and exhaust when a missile is fired from the launcher; safety switches prevent firing of the missile until the blast door is closed. Flametight doors are installed between Terrier and Talos magazines and the assembly rooms so the blast and flame from an accidental ignition in the magazine cannot spread to the assembly area. There is no assembly or wing and fin assembly area in the Tartar magazine, but there is a flame tight hatch in the base of the magazine to keep flame and blast from getting into parts of the ship beneath the magazine.

As previously stated in chapter 7 of this text, a blowout pipe is connected to a Terrier missile in the checkout area during missile testing aboard ship. The missile, secured in the checkout stand (car), is positioned in front of the blowout pipe. A blowout pipe adapter is securely attached to both the missile and bulkhead to which the blowout pipe is attached, figure 8-8. If there is an accidental ignition of a missile sustainer motor during checkout, the blowout pipe adapter performs the major function of restraining the missile. The blowout pipe has a water cooling system which injects water into the pipe through a ring about the adapter. Water injection is done automatically by means of a pressure probe downstream in the pipe if missile ignition should occur. With proper operation of the cooling system, the blowout pipe will safely vector the exhaust gas flow to atmosphere.

There are several alarm systems installed in missile magazines which warn personnel of danger to themselves and also alert them to take preventive or corrective action to protect the missiles stowed in magazines. A high temperature alarm, for example, lets personnel know that the magazine is too warm, either because the air conditioning is not operating, or a possible fire. When alarm systems are activated, personnel must investigate and correct the problem before any damage is done to the missiles. There are other types of alarm systems used in a missile magazine which indicate either CO_2 or sprinkling system activation, a radiation hazard, a security violation, and other alarm systems which warn personnel when handling equipment is activated or when missiles are being moved. Missile magazine alarm systems are explained in GMM 3/2, NT 10199.

Plenum Chambers

All Tartar missile magazines have a plenum chamber arrangement which carries off gases and exhaust fumes from an accidentally ignited missile in the magazine. The plenum chamber is in the base of the magazine, beneath the missile. Each cell of a Tartar magazine has a blow-in plate assembly which gives way under pressure when a rocket motor is accidentally ignited and permits high pressure exhaust gases to escape to the atmosphere through the plenum ducts. Figure 8-9 shows a magazine base structure of a Tartar missile magazine used with the Mk 22 GMLS. All missile magazines also have some type of blowout plate which gives way and vents high pressure exhaust that escapes upward in a magazine.

Magazine Anti-Icing System

A major difference between a standard ship-board magazine and a missile magazine is the location aboard ship. Most standard magazines are located below deck and are not subject to outside weather conditions. Missile magazines, because of their function, are located adjacent to or below their launchers. In some GMLS, missiles such as Tartar are loaded directly from their magazine onto launcher guide arms for. firing. Others, such as Talos and Terrier must pass through an assembly area prior to loading

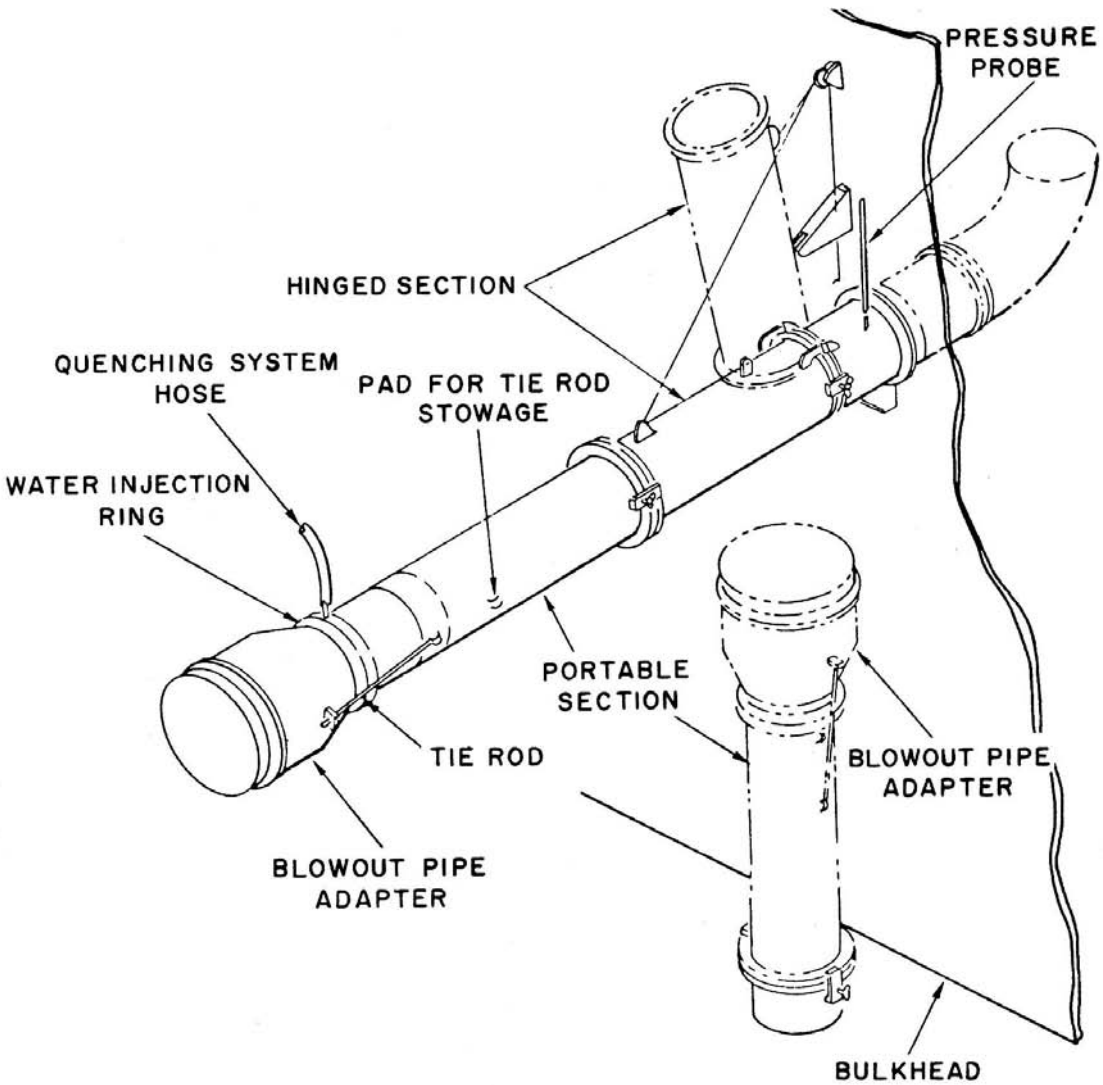

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Figure 8-8.—Typical blowout pipe installation.

onto the launcher guide arm. Both systems have a type of blast door or magazine door between the launcher and the missile stowage area which must be opened for loading and closed during firing. These doors and other exposed areas of a launcher and magazine must have an anti-icing system. to prevent ice from accumulating on exterior surfaces during cold weather operations. Heated anti-icing fluid pumped through a closed piping system warms designated areas to keep them free of ice which could interfere with missile loading operations or prevent the function of a safety device. Some of the areas of a Tartar system serviced by an anti-icing system are shown in figure 8-10. These areas - the blast door, blowout plates, magazine cover, and magazine base ring - are considered necessary for both safety and system operation. Since the magazine areas of Talos and Terrier are located within the ship's structure, they have no openings requiring passage of missiles onto a weather deck area. Only the blast doors from the assembly area to the launcher guide arm require anti-icing system

The location of the components for an anti-icing system vary with the type of missile system in which it is installed. All anti-icing systems contain a heat exchanger, a motor driven pump, steam supply lines, valves, and manifolds and supply lines to distribute the

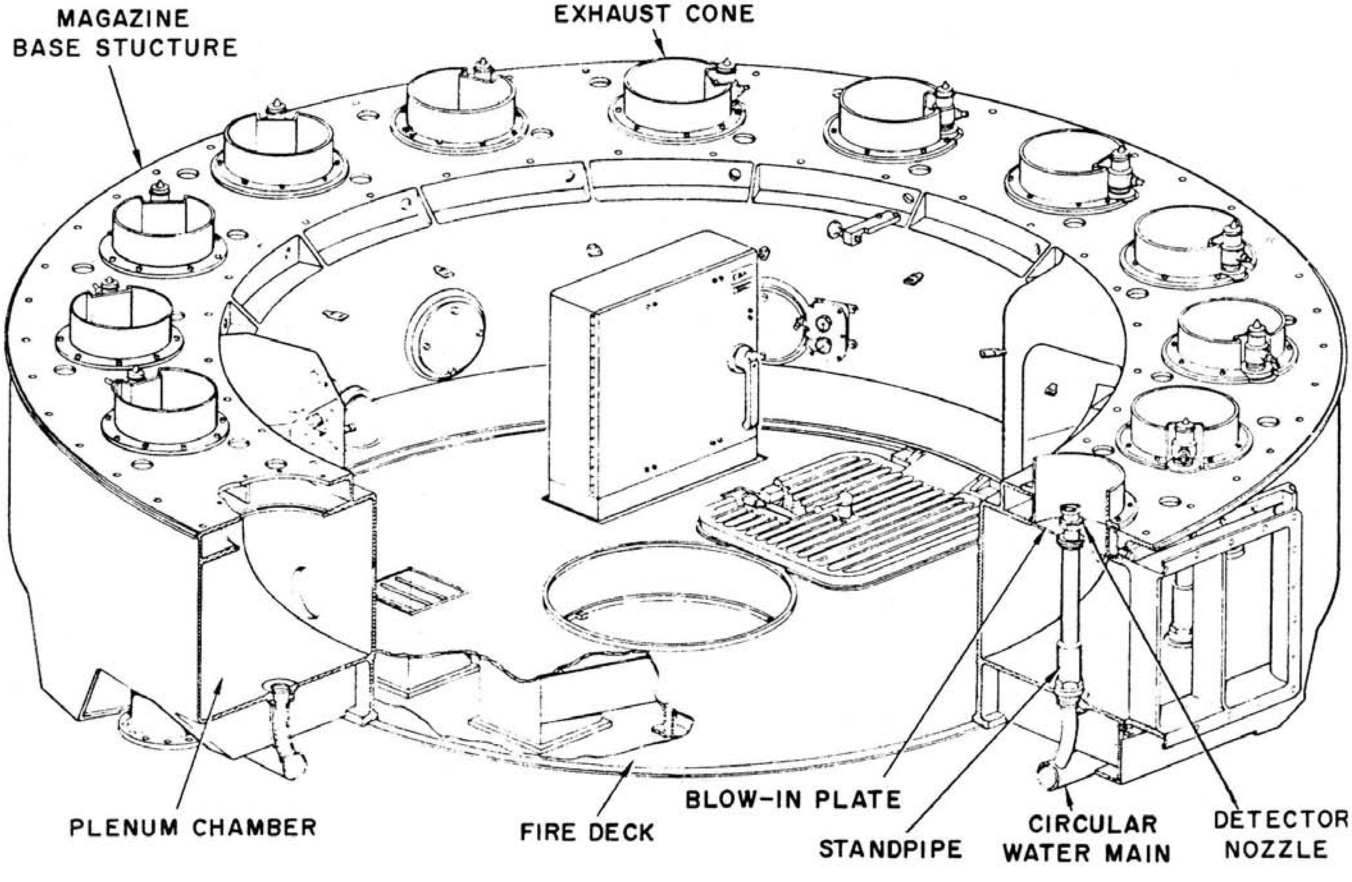

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Figure 8-9.—Magazine base.

heated fluid. The heat exchanger is a tank which heats and stores the anti-icing fluid which is made up of a 1 to 1 mixture of distilled water and ethylene glycol. The motor driven centrifugal pump circulates the heated fluid through the system. Fluid in the system is heated by ship's stream in the heat exchanger and recirculated throughout the system by a network of piping and flexible hoses. A temperature control unit (thermostat) is installed on the heater tank and is set at a temperature which is adequate to prevent icing.

Ventilating System

A missile magazine ventilating system cools the missiles stored in cells or racks with air provided by a ship's air conditioning system. Air enters and leaves the magazine area through ducts and circulates throughout the magazine to maintain the proper stowage temperature. The humidity at which missiles and their components are stored is a very important factor and if not properly controlled, may cause serious deterioration of some types of explosives and also cause rust, corrosion, and fungus growth on both exterior and interior components of a missile. Air conditioning systems are adjusted automatically to maintain the optimum moisture content of the air within a magazine area.

Missile components that are packed in shipping containers contain a quantity of desiccant and are packaged in sealed moisture proof paper or sealed in a pressurized container and have a humidity indicator placed where it can be read without opening the container. When a missile is assembled into a complete round, the components that make up the round are no longer kept dry by a desiccant unit. For this reason the humidity of the air within a magazine

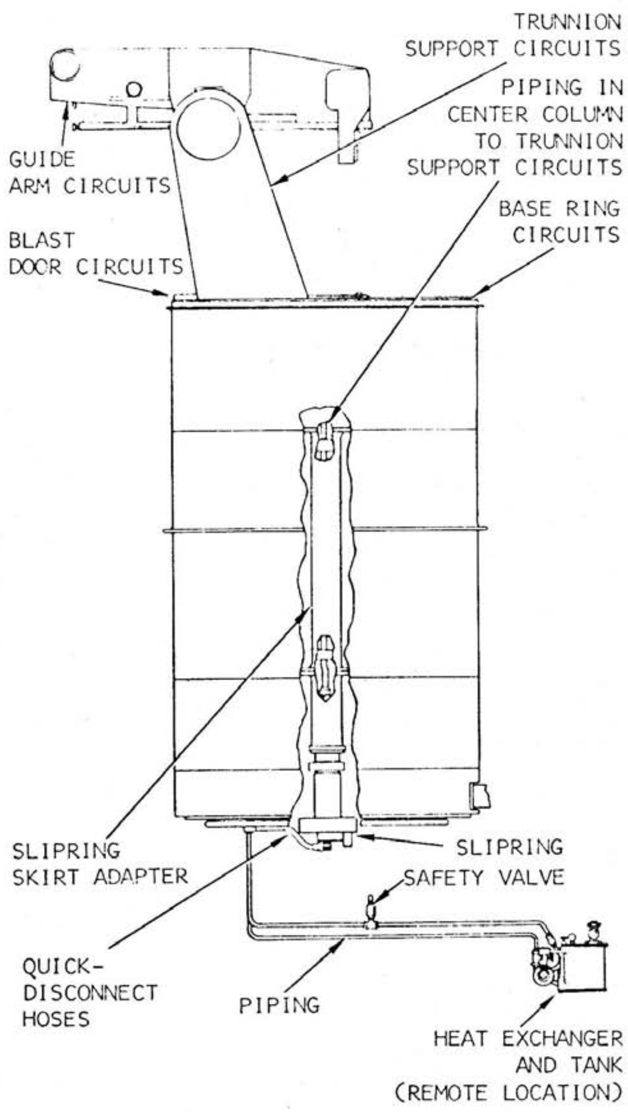

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Figure 8-10.—Anti-icing system arrangement.

area is automatically regulated by the air conditioning unit that serves the magazine. These units are maintained by personnel in the engineering and hull ratings and require no test or maintenance by the GMM.

If moisture is found on missiles, bulkheads, or machinery within a missile magazine, it should be called to the attention of personnel maintaining the air conditioning units. The humidity of the air in the magazine can. be checked to determine the efficiency of the air conditioning system feeding the missile magazine area. Keeping the air filters clean in an air conditioning system helps maintain the proper temperature and humidity level.

MAGAZINE INSPECTION RECORDS AND REPORTS

The missile magazines that are part of the missile launching system are in use every day for some part of the training, maintenance, and repair operations. The magazines can be inspected during the course of daily work. Before anyone enters the launcher magazine, be sure to inactivate it and remove the switch handle from the control panel so no one can activate any of its machinery while someone is within.

On the missiles look for leakage of hydraulic oil, lubricants, or rocket fuel, and report leakages for repair.

Daily inspection trips must be scheduled to the magazines for spare components, as these are not opened except to obtain a spare component. The magazines are kept locked. Teach your men what to look for when they inspect the magazine. Every day inspect the general condition of the magazine-cleanliness, ventilation, dryness, (note any signs of dampness or "sweating"), lighting, presence of unauthorized tools and gear, temperature, presence of any odors indicating decomposition of explosives, escape of, gases, or other indication of anything amiss. Find the source of any odor and remedy the trouble. You may need the assistance of the Explosive Ordnance Disposal Team. With modern, air-conditioned magazines, explosives usually remain in good condition for a long time.

Detonators, of course, should not be in the same magazine with rocket boosters, propellants, etc., unless they are in an assembled warhead in a missile. Little pools of exudate may form in detonator wells, from which they must be removed with the greatest care. This exudate is extremely sensitive, and removal should not be delayed. A sample of the exudate must be sent for analysis. See OP 4, Volume 2, Ammunition Afloat, for instruction.

Notice the condition of the containers. There must be no open or damaged containers, no spilled powder or broken propellant grains, and no dust, dirt, trash, or combustible materials about. Containers should be neatly stacked and fastened down so there is no shifting, slipping; or rolling about. Remove damaged containers to another compartment for repair.

If there are windows or ventilation openings, be sure that sun and rain are kept out and that the screening is intact. In an air conditioned magazine, the ventilation openings are secured except for blow-out purposes during General Quarters, or for emergency use. Be sure the lights are working and that there are no shorts to cause sparks. The door must be flametight: if it is even slightly sprung, have it repaired at once. The fire extinguishers, firehose, and water buckets should be in ready condition, neatly placed in convenient locations...

A checkoff sheet listing all the items to be checked in the magazine area is a practical necessity. Depending on how often the weapons officer wants the report turned in, it may contain spaces for the daily checking for a week or for a month.

Magazine temperature records and magazine logs are maintained by each command for every magazine and ready service locker aboard ship and selected magazines ashore. On shore stations a representative number of magazines in each group, containing representative quantities of each type of explosive material, are inspected each day with different magazines within the respective groups being inspected on successive work days until all magazines have been inspected. Frequency of inspections ashore may be varied on the basis of prevailing outside temperatures. The date and hour of each inspection shall be noted and recorded in a magazine inspection log over the signature of the person who makes the inspection. Substandard or abnormal conditions shall be reported promptly to the supervisor in charge for correction and the conditions observed noted in the log. When conditions are satisfactory and normal, this also shall be noted in the log by the entry "normal". Magazine inspection logs ashore may be destroyed when one year old. Magazine inspections ashore shall be made during daylight hours when there is sufficient light to assure that any existing substandard conditions can be seen and reported. Magazines are inspected to determine if repairs are needed, to make sure that the safety regulations, particularly those with regard to cleanliness and elimination of fire hazards, are being observed and to ascertain that materials are not deteriorating into an unsafe condition and that they are stored in an orderly, approved manner as specified in NAVORD OP 5, Vol 1, Ammunition and Explosives Ashore.

Aboard ships, daily entries of temperatures are recorded on magazine temperature cards, department record magazine logs, and the ship's official deck log and serve to document the magazine inspection records. Identification of the magazines that experienced maximum and minimum temperatures since the previous inspection plus a notation of any abnormal physical conditions observed completes the report. If no abnormal conditions are observed, the notation of "conditions normal" should be made. Whenever abnormal conditions in magazines or missiles are discovered and recorded, the facts shall be reported in person to the commanding officer or command duty officer and further relayed to ensure that all personnel concerned are officially notified so that the necessary corrective action may be initiated promptly.

Inventory Record of Small Arms and Pyrotechnics

Small arms are issued to you and your men for guard duty, and must be strictly accounted for on an individual basis. You will not have stores of small arms in your care, nor will you have stocks of small arms ammunition. These will be issued to you as required, and you are accountable for them. NAVORDINST 8370.1 gives the instructions for reporting lost, stolen, and recovered small arms. A letter report is required in each instance.

The special pyrotechnic items on missiles, the tracking flares and flash units, are issued to each ship in the quantity designated by the ship's COSAL. The quantity is determined by the number and kinds of missiles on the ship and the mission of the ship. If a lengthy training cruise is scheduled for the ship, more pyrotechnic items will be needed than for a tactical mission. When the ship was loaded and outfitted, the quantity of each item had to be checked against the COSAL, and the amount entered on the ammunition inventory. When any item is used, it must be deleted from the inventory. The number of items in the pyrotechnic locker should always match the number listed in the inventory.

Other Navy pyrotechnic items that are not used on missiles are not part of your inventory, but you must know how to stow them and how to use them correctly and safely. Containers of pyrotechnic items that show signs of dampness or moisture must be opened. If there is evidence of moisture on the pyrotechnics, a report must be made to NAVORDSYSCOM, and instructions requested for disposition of the damaged articles, which must be segregated from all other items.

Gunner's Mate M (Missiles) 3&2, NAVTRA 10199, contains material on pyrotechnics with illustrations and diagrams to supplement the text. *Ammunition Afloat*, OP 4, vol. 2, gives the official rules for care and maintenance, surveillance, stowage, and disposal of various types of pyrotechnics. Be sure to get the latest revision of this volume; rules have been made more precise and stringent because of recent disasters caused by mishandling of pyrotechnics.

Ammunition Records and Reports

Due to ammunition's essentiality to naval operations, and because of its high cost and other unique logistic characteristics, ammunition status is under careful and continuous study at the highest echelons of the defense establishment, as well as by operational and logistics commanders. It is vital that an accurate and prompt method of reporting ammunition stock status be available to commanders of naval forces. For this reason commanding officers of ships and shore activities are responsible for submitting reports regarding all receipts, transfers, expenditures, and quantities of all ammunition components within their command.

A quarterly ammunition report is made to Navy Ships Parts Control Center (SPCC), Mechanicsburg, Pennsylvania, so that an accurate inventory of assets and expenditures of expendable ordnance items throughout the Naval service can be maintained. A quarterly ammunition report includes all conventional expendable ordnance material, including gun-type, bombs, rockets, ASW weapons, guided missiles, military chemicals, mines, torpedoes, demolition and pyrotechnic materials assigned a four digit NALC (Navy Ammunition Logistics Code) in accordance with NAVORD OD 16135, and excludes nuclear ordnance. The frequency of ammunition assets and expenditures report made to fleet commanders and other command authority is outlined in COMSERVLANTINST 8015.1 (Series) and COMSERVPACINST 8015.5 (Series) as appropriate. Most ships report monthly to Commander Service Forces Atlantic or Pacific who will in turn report to SPCC. These reports, when processed by SPCC, provide Naval Ordnance Systems Command with information concerning expenditure rates, ammunition availability; and facts from which fleet requirements can be determined.

There are numerous other reports that have to be made periodically concerning ammunition afloat and ashore. These reports include complete ammunition identification data, including lot number, mark, and modification numbers and NAL codes of all ammunition and components. Some of the information required in these reports are;

1. Available stowage space of the activity.
2. Types and numbers of missiles used for training.
3. Performance of ordnance equipment.
4. Performance of pyrotechnics and other ammunition components used.

Reports on Missiles

Ships reporting complete rounds of surface to air missiles in accordance with OD 16135 must in addition to reporting receipts; issues, and expenditures include reclassifications and reconfigurations due to installation of alternate or exercise missile components. Some missiles can be reclassified from a service round to an exercise round by exchanging a missile warhead for an exercise head. A missile's NALC code number will change when the missile is fitted with an exercise head. OD 16135 lists a Terrier missile with a warhead as NALC-1600, and a Terrier missile with an exercise head as NALC 1601. If a missile is received aboard as a service missile and previously reported with a NALC 1600 number indicating a warhead shot and is reconfigured as an exercise round, the missile is then reported with a NALC 1601 number indicating an exercise shot. The warhead removed from the service missile must also be reported with its own NALC identification. In addition activities reporting surface to air missiles or boosters must include a serial number for each missile or booster being reported.

Emergency (message) Expenditure Reports are made according to instructions promulgated by the fleet commander, area commander, or other authority. NAVORDINST 8025.1 "Accidents and incidents involving nonnuclear explosive ordnance, materials, and devices; report of," establishes regulations that apply to all ships and stations regarding such reports. (See chapter 11.) It defines and differentiates between an explosive accident and an explosive incident. When a nuclear component is involved, special reports are made and special rules apply (OPNAVINST 8110.16C or later revision).

LIMITATIONS IMPOSED BY NUCLEAR WARHEADS

If you have missiles or depth charges with nuclear warheads, the storage conditions must meet the requirements for the nuclear component. For specific information on the temperature and humidity limitations for certain nuclear weapons, general information on storage requirements for nuclear components, and the storage limitations of the missiles and depth charges you have aboard, consult the Navy SWOPs for those weapons. The classified publications custodian in your division has charge of those publications. Navy SWOP 35-49 gives the instructions for preparing report form NAVORD 8110/10, "Nuclear Weapons Information Report," and NAVORD Form 8110/11, "Nuclear Weapons Inspection Summary;" while Navy SWOP 5-8 tells about NAVORD Form 8110/14, "Special Weapons Unsatisfactory Report." Until the new forms are available, Navy activities may use NAVORD Form 2795 (6-60) to report material discrepancies. If the material is in dangerous condition, Emergency URs are sent to the Naval Ammunition Depot, McAlester, Okla. 74501, plus copies to NAVORDSYSCOM, ORD-0822, Washington, D.C. 20360.

Items received in damaged condition are reported on DD Form 6, "Report of Damaged or Improper Shipment."

The Inspection Summary is sent each month the other reports are sent when there are changes to report.

Missiles containing war reserve nuclear warheads are never loaded on the launcher except when actual firing is anticipated. Dummy, practice, or exercise warheads are used for all other purposes (training, maintenance, checkout, exercise). Dummy warheads have merely the outward appearance of the real thing.. A mockup not only has the outside appearance, but it can be assembled and disassembled. A training warhead is an elaborate mockup. There are six categories, according to the extent each uses live or dummy components.

Training weapons are of several categories, depending on the completeness of the weapon. If you are going to use it only for practice in putting a missile into the magazine and bringing it up to the launcher, the size, weight, and conformation of a real missile are all that are needed.

All Navy and Marine activities having custody of training weapons, component assemblies, or test and handling equipment associated with nuclear ordnance must make semiannual reports. NAVORD Form 8110/2, "Modernization Status Report, Training Weapons and Test and Handling Equipment," is the report form to be used for this. It is explained in Navy SWOP 40-13.

SUMMARY

Missiles, to be of any value in defensive war, must be completely assembled and ready to go on very brief notice. This assemblage of extremely dangerous and powerful components makes necessary meticulous adherence to safety rules and highly effective fire fighting and protective systems. You are expected to have learned the qualities of different explosives as a GMM 3 and 2. Now you are expected to supervise the handling of explosive components and assembled missiles, and to enforce the safety regulations.

Considerable attention is given to the types of protection included in the magazines and other parts of the launching system. You not only must know how to operate these systems, but you must be able to repair them, test them, and keep them operating efficiently.

The problems created by having missiles with nuclear warheads in the same magazine with missiles with conventional explosives is not treated to any extent because of security classification.

As soon as you know what weapons you have aboard, find out the special precautions that apply. You and your men have to handle and stow the assembled missiles that contain the nuclear warheads. You therefore must know what to do in emergencies, and you must know all special rules for handling and stowage, such as humidity and temperature limits, and what to do in case of an accident or incident. One of the most frequent criticisms found in reports of investigations of explosive accidents or incidents is that no one seemed to know just what to do and precious time was lost in getting organized to take effective action. This indicates strongly that more organized drill is necessary so someone is ready to take the lead and the men know just what to do.

CHAPTER 9

BALLISTICS, FIRE CONTROL, AND ALIGNMENT

INTRODUCTION

If you looked up the definition of ballistics in the older dictionary-not very old, at that-you would find that missiles are not included in the definition. A 1958 definition of ballistics says that it is "the science which studies the laws governing the motion of projectiles shot from artillery or firearms, or (ballistics of bombs) of bombs dropped from aircraft." Later definitions include missiles.

The science of ballistics studies the effects of various factors on the speed, course, range, and other behavior of the projectile, bomb, or missile. The factors include initial velocity, force of gravity, atmospheric conditions (wind, moisture, clouds, etc.), earth's rotation, earth's curvature, and drift. Ever since the invention of guns, men have studied how to use them with greater accuracy. The pioneer hunter learned from trial and error how to allow for the wind and how to "lead" his target. The scientific principles as they applied to projectiles shot from guns were formulated and applied long before the era of guided missiles. In *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199, you learned how ballistic principles apply to guided missiles. The effects of gravity, air density, wind, coriolis effect, stabilization (of the ship and the missile), trunnion tilt, and parallax on the trajectory of a guided missile were explained and illustrated. The missile design is planned to take advantage of these effects as much as possible, or to offset their disadvantages.

The principles of missile flight as affected by missile aerodynamics also were explained in the preceding course. The density of air decreases as the altitude increases. This reduces the air pressure and the drag on the missile passing through it. The layers of the atmosphere were defined as the troposphere, the stratosphere, and the ionosphere. The ionosphere begins about 25 miles above the surface of the earth. The air particles in it are ionized by the ultraviolet rays from the sun and to a less extent by the charged particles from the sun. The low air density at this height makes increases in speed possible; the effects of ionization on missile electronic systems and nuclear material are still being studied.

Most long-range missile flights will be made in the stratosphere, which extends between the troposphere (the layer of air next to the earth's surface) and the ionosphere. The constant temperature and lack of winds are advantageous to missile flight, but the low temperature and the lack of oxygen are disadvantageous. By carrying out flights in the stratosphere, the advantages of low drag, high speed, low fuel consumption, and greater range are obtained. The shape of the missile and the shape and arrangement of the fins are designed to take advantage of the lift of air, and also to provide stability to the missile. Fixed fins contribute primarily to stability; control is achieved by movable fins. Design and arrangement of fins differ for subsonic and supersonic missiles.

The speed of missiles is often stated as a Mach number, which represents the ratio of the speed of the missile to the speed of sound in the surrounding atmosphere. At subsonic speeds, the Mach number is less than one, as 0.80; at supersonic speeds it is greater than one, as 1:31. Talos and Terrier have a speed in the range of Mach 2.5; Tartar speed in Mach 2; Asroc speed is Mach 1.

All the principles of missile flight are important in missile fire control. You need the background knowledge given you in the preceding course, and barely touched on here, to help you understand how the weapons system operates and enable you to see why certain things must be done in certain ways in the operation and maintenance of the system.

EQUIPMENT OF A MISSILE WEAPONS SYSTEM

A missile weapons system consists of a weapons direction system, one or more fire control systems, the launching system, and the missiles. The weapons direction system and the fire control systems and their related equipments comprise the weapons control system. The system described in this section is installed aboard the DLG-9 class frigates. It consists of a weapons direction system, two Terrier missile fire control systems (Mk 76), a Mk 10 guided missile launching system, and BT and HT missiles. However, for the sake of clarity and to conserve space, we have generally limited our discussion to one fire control system. On the basis of their fundamentals of operation, fire control systems may be divided into two main classes: linear rate and relative rate. Figure 9-1 illustrates the equipments in the groups of equipments, and the two basic methods of solving the fire control problem.

LINEAR RATE SYSTEMS

Linear rate systems are used for both surface and air targets, for gun and missile systems Linear rate systems measure changes in target position in knots, like the surface fire control systems used in main battery installations. Because it has both magnitude and direction, relative target motion is a VECTOR quantity. And, like any vector, it can be separated into two or more components.

In figure 9-1B (1) relative target motion has been separated into three components. The component along the line of sight is range rate (dR). The component at right angles to the LOS in a horizontal plane is the linear bearing rate (RdBS). And the component at right angles to the LOS in a vertical plane is the linear elevation rate (RdE).

The director measures target range, bearing, and elevation, and transmits their values to the computer. The computer solves the vector problem and calculates the future position of the target at the end of the missile's time of flight, allowing for the effect of relative motion during the time the missile is in the air. It then determines from the predicted target position how the missile launcher must be positioned for the missile to hit the target, allowing for wind, gravity, drift, and initial missile velocity.

The computer solves the problem continuously and continuous orders are sent to the guns or missiles. The rates are calculated in the computer from three groups of inputs:

1. Ship motion inputs of own ship's course and speed.
2. Target motion inputs of target course and speed; in an AA problem, target speed is resolved into two components-horizontal speed and rate of climb (vertical speed).
3. Target position inputs of target elevation, bearing, and range.

Three rates are computed relative to the LOS: in the LOS (range), across it in the horizontal plane (bearing), and perpendicular to it in the vertical plane (elevation). These rates are based on the position of the LOS at the instant of their computation. The velocity of the LOS is not used directly to determine the rates. This is a disadvantage of the system. However, when aided tracking is used by the director, the velocity of the LOS furnishes a check on rate accuracy. (The linear rates are converted to angular rates for aided tracking.) The calculated linear rates correspond to the computer's coordinate system.

Relative Rate

Many publications use the term relative rate rather than angular rate. For our purposes the two terms have the same meaning.

There are many different types of relative rate directors used in the Navy. One common feature is that they use gyros to measure the angular tracking rate.

The lead-computing sight determines changes in target position by measuring the ANGULAR VELOCITY of the line of sight. (If you keep your finger pointed at a moving airplane, the rate at which your arm and finger move to follow the plane's flight is a rough measure of the angular velocity of your line of sight.) Angular rate systems measure this angular velocity, and correct for time of flight and curvature of trajectory. As the director operator keeps his sights on the target, and introduces range, the equipment automatically computes the elevation and bearing lead angles required to compensate for target motion. The launchers are then automatically and continuously moved through these angles.

Figure 9-1B (2) shows how this method works. Here the target is flying a circular course about the gun, so that elevation is the only problem we need to worry about. (The same procedure would be used if the plane were flying in a horizontal circular course.)

The range is such that the time of flight to any position on the target course is three seconds, and the target is changing its elevation it the rate of 5° per second. During the three seconds of projectile flight, the target elevation will increase by 15°. If the gun is fired at this future position (that is, with a 15° lead angle), the times of flight of the projectile and target will be equal, and the projectile will strike the target.

The major difference then, between the linear rate and angular rate systems, is that the former measures components of target motion linearly In three planes, and the latter measures the angular velocity of the line of sight, to predict changes in target position.

SEARCH RADARS

Outside the weapon system but supplying the target data needed for its use are the search radars (fig. 9-1). The search radars look for and detect targets on the surface of the sea, and in the air. These radars keep a large volume of space about the ship under constant surveillance, and they stand watch in all kinds of weather. Their beams can penetrate fog, rain, snow, and the dark of night, as they constantly sweep the sky and earth's surface in their search for the enemy. When a target is found, the radars measure its position with respect to own ship or some other reference point. To determine a target's position, we must know its range, bearing, and, in the case of an air target, its elevation. Search radars can usually give all three of these coordinates, but some radars specialize. Some radars are designed to search for aircraft and others for objects on the surface of the sea. Air search radars are used primarily to detect aircraft and missiles. Surface search radars are used mostly for detecting targets on the surface of the sea. Most of the low-flying aircraft are detected by surface search radars. FC radars can pick out prominent shore targets such as a tower, a high mountain peak, or protruding rocks.

In the typical weapons systems shown in figure 9-1, there are three search radars: the AN/SPS-10, AN/SPS-39, and AN/SPS-37. Working together as a group of detecting equipments, these three radar sets can cover all the sky and surface about a ship.

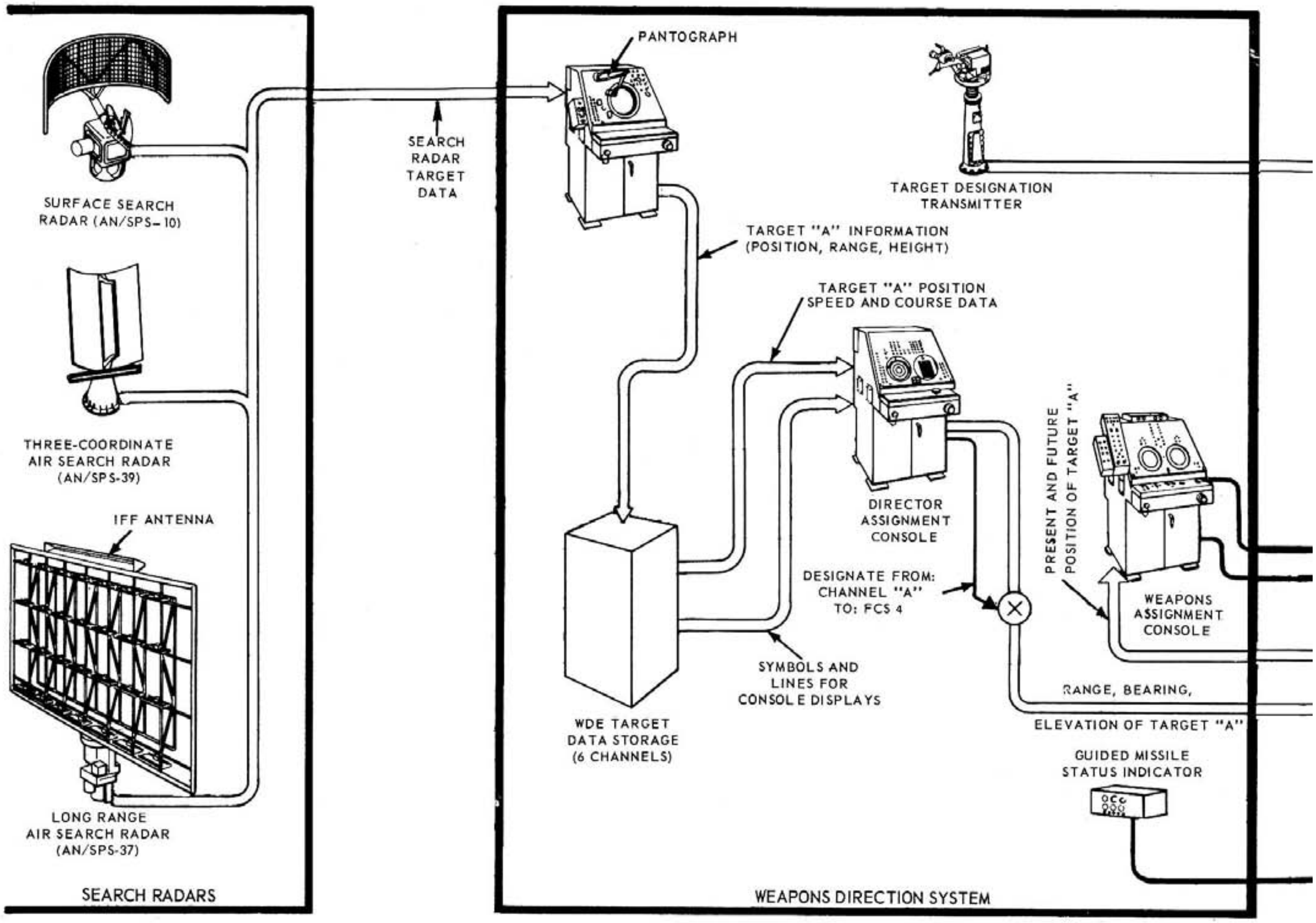
AN/SPS-10

The AN/SPS-10 is a surface search radar. It detects surface targets in excess of 15 miles. The radar transmits a beam that looks like a fan set edgewise on the surface of the sea. The beam is rotated continuously through 360 degrees. The spread of the fan is about 22 degrees, and therefore the radar can pick up air targets. But its primary purpose is to detect targets on the surface and to keep them under constant observation

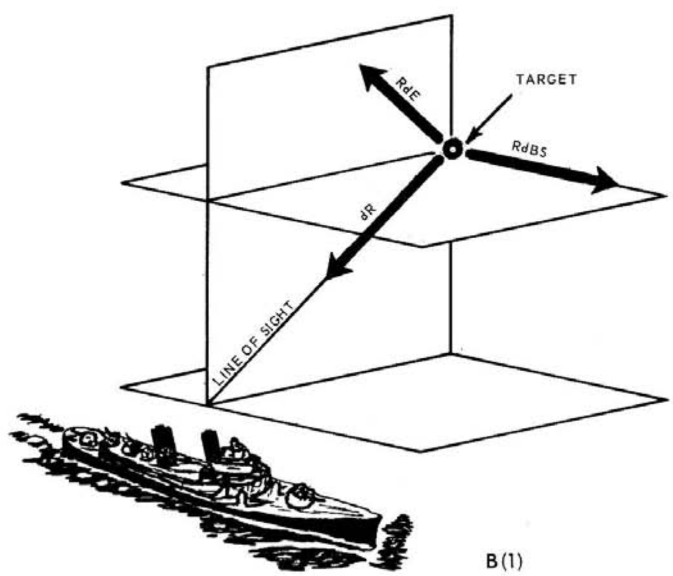
You can classify the AN/SPS-10 as a two coordinate radar. It can measure only the range and bearing of targets. To find the position of any object on a plane (and that is what the surface of the earth or sea is usually considered to be), all you need is range and bearing. But to find the position of an object in the air you must have three pieces of information-range, bearing, and elevation.

AN/SPS-39

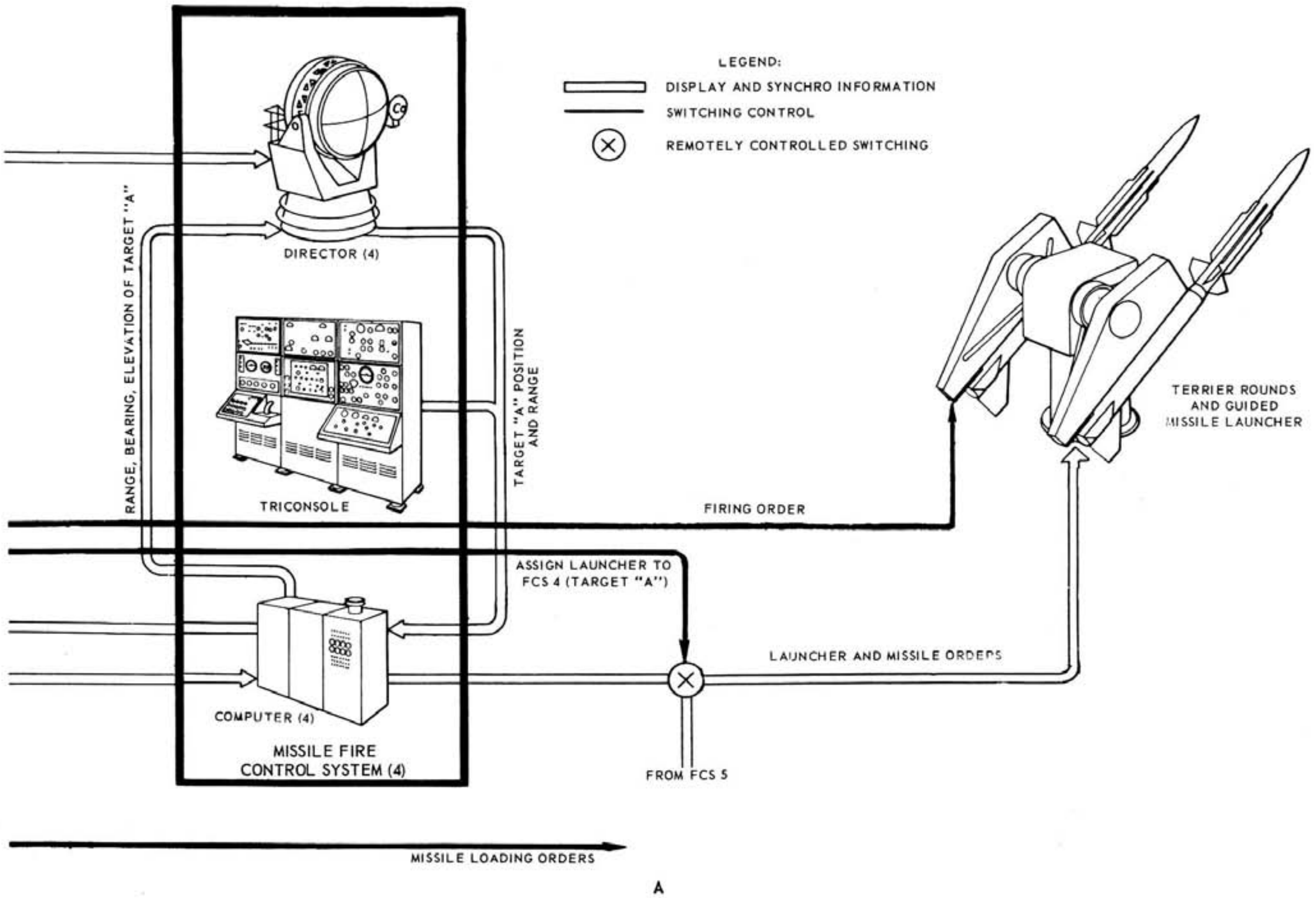
Radar Set AN/SPS-39 is an air search radar; it can measure the elevation, as well as range and


PANTOGRAPH
SEARCH RADAR TARGET DATA
SURFACE SEARCH RADAR (AN/SPS-10)
TARGET DESIGNATION TRANSMITTER
TARGET "A" INFORMATION (POSITION, RANGE, HEIGHT)
TARGET "A" POSITION SPEED AND COURSE DATA
THREE-COORDINATE AIR SEARCH RADAR (AN/SPS-39)
PRESENT AND FUTURE POSITION OF TARGET "A"
IFF ANTENNA
DIRECTOR ASSIGNMENT CONSOLE
DESIGNATE FROM: CHANNEL "A" TO: FCS 4
WEAPONS ASSIGNMENT CONSOLE
SYMBOLS AND LINES FOR CONSOLE DISPLAYS
RANGE, BEARING,
ELEVATION OF TARGET "A"
WDE TARGET DATA STORAGE (6 CHANNELS)
GUIDED MISSILE STATUS INDICATOR
LONG RANGE AIR SEARCH RADAR (AN/SPS-37)
SEARCH RADARS
WEAPONS DIRECTION SYSTEM

A


TARGET
RdE
RdBS
dR
LINE OF SIGHT

B(1)



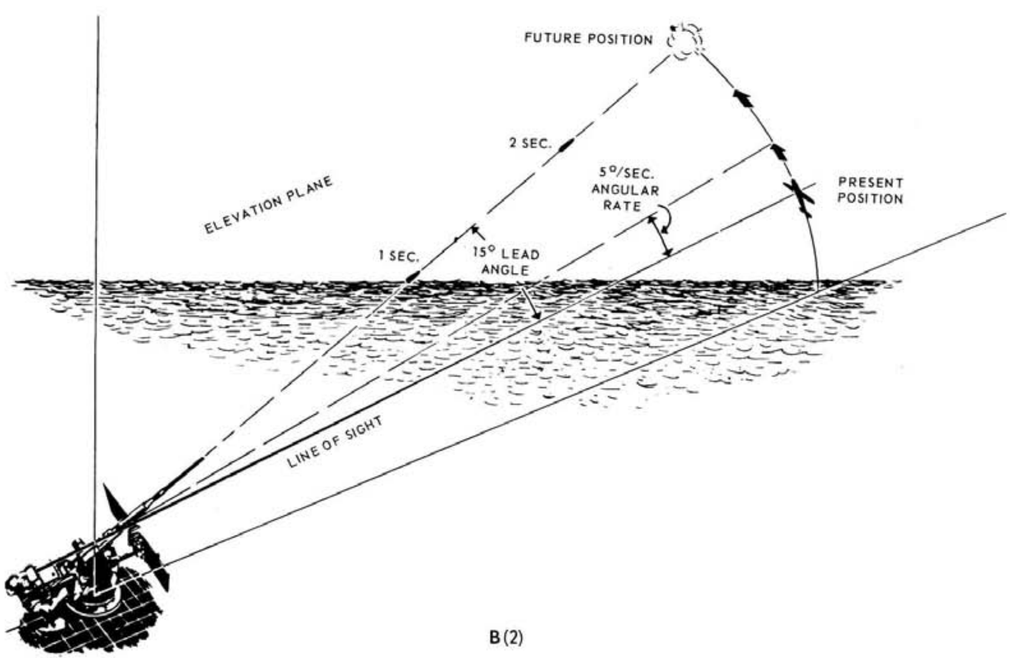


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Figure 9-1.—Typical missile weapons system. A. Components of the system, by groups; B. Using the components to solve the fire control problem; (1) Linear rate method; (2) Relative (angular) rate method.

bearing, of air targets. The set can pick up aircraft at an altitude in excess of 35,000 feet out to a range in excess of 100 miles. This radar transmits a narrow, pencil-shaped beam and scans it up and down as the antenna rotates.

AN/SPS-37

Compared with gun weapons systems, missile weapons systems are petty "slow on the draw." It takes almost a minute to select and then load missiles on a launcher. Even the trigger action is slow. Once the firing key is closed, it takes slightly over a second for-a missile to leave the launcher. So the more warning a ship has of the approach of an enemy, the more time there is to prepare the missile battery for action. Another radar, the AN/SPS-37, gives this advance preparation time. It is a long range radar. Like the AN/SPS-10, it has a fan beam and can measure only the range and bearing of air and surface targets.

IDENTIFICATION OF FRIEND OR FOE (IFF). - Look at the top of the AN/SPS-37's antenna (figure 9-1). The small antenna you see there is for the Identification of Friend or Foe (IFF) equipment. In modern warfare the identification of friend or enemy is very important. A missile cannot tell an enemy target from a friendly one. Therefore, we must make sure that we launch a weapon at a curious or unaware friend. How can we identify a target that may be several hundred miles from our ship? The answer is: IFF equipment. The equipment consists of two major units-a challenging unit and a transponder. The challenging unit is aboard ship arid electronically asks the question, "Are you a friend or foe?" The transponder is located on board friendly ships and aircraft and answers the question put by the challenging unit. The challenging unit sends out a pulse of low-power radio energy toward the target. If the target is friendly it will transmit back a series of coded pulses. If there is no answer to the challenge, the target is classified as hostile.

Target Designation Transmitter (TDT)

Optical device called target designation transmitters (fig. 9-1) are used as supplementary target detection equipment. Their use is limited to short-range, visible targets. The speed of missiles and jet aircraft is so great that such targets must be engaged while they are still well beyond the range of our present optical instruments.

Summary on Search Radars

To summarize, you can see that search radars, in conjunction with IFF equipment, search for targets, find them, and. then identify them. As a hunter, you perform these same basic functions when you hunt for game. Your eyes probe the underbrush and other parts of the landscape in search of prey. When you sight some animal or bird, you fix your eyes on it and measure its position with respect to you, and then you identify it "Is this animal or bird in season?" you ask yourself. If it is, you raise your gun and prepare to fire; if it is not, you resume your search for legal game.

A basic idea to keep in mind is that the equipments in a weapons system simply extend man's senses and capabilities. Radar extends his vision by hundreds of miles and gives him the added capability of seeing in the dark, and in other conditions of poor visibility. The IFF equipment enables him to tell whether a target is friendly or not.

Target echoes and IFF pulses are sent from the radars through a radar switchboard to consoles in the weapons control system. Target position and range information follow a similar path. In figure, 9-1. all this information is labeled "search radar target data."

GMLS CAPABILITIES

Guided missile launching systems are capable of stowing, selecting, loading, and launching missiles which can be used against air, surface, shore, and underwater targets. The 3Ts, (Terrier, Talos and Tartar) are the three missile systems now found aboard ships. These systems have undergone many changes since their inception. A Standard missile has been developed which will be employed with either the Terrier (Standard extended range (ER) missile) or the Tartar (Standard medium range (MR) missile) missile systems. The ASROC missile has also been adapted for use with some Terrier systems.

A brief description of the capabilities of the three missile system follows.

A Terrier/ASROC GMLS system provides the fleet with a tactical air, shore, surface, and underwater defense. The Terrier missile used for air, surface, and shore defense can maintain a firing rate of two missiles every 30 seconds when launched from a dual arm launcher. When the launcher is in the ASW mode of operation, two ASROC missiles can be loaded simultaneously. They can only be fired singly with the B side firing first and can maintain a firing rate of approximately 80 seconds.

The Terrier missile is a guided weapon with a solid fuel rocket motor and sustainer. The missile uses either a beamriding (BT) or a semiactive homing (HT) guidance system.

The ASROC missile is a solid fuel, rocket propelled ballistic weapon with either a torpedo or a depth charge configuration. Both weapons are fired from the same dual arm missile launcher in which a Terrier weapon is launched in quick succession (a salvo) and an ASROC weapon launched singly. To make an ASROC missile compatible with a Terrier launching system, the ASROC missile must be equipped with an adapter rail mechanism so that the ASROC can be handled by the same equipment as the Terrier missiles. Both missiles have the capability of carrying either a conventional or nuclear warhead.

A Tartar/Standard GMLS provides the fleet with a tactical weapon for use against air and surface targets. Tartar/Standard missiles are launched from either a single or dual arm launcher with a load-to-fire rate of approximately 8 seconds for Tartar missiles and 10 seconds for Standard missiles.

The Tartar/Standard (MR) missiles are supersonic surface to air missiles with a solid fuel dual thrust rocket motor. They are guided by a semi-active homing system.

A Talos GMLS provides the fleet with a tactical weapon for use against air targets. The Talos missile booster combination is a ramjet propelled supersonic missile with a solid propellant rocket booster. The missile uses a beam riding control system during midcourse flight and a homing guidance system during the terminal phase of flight. Talos can carry either a nuclear warhead or a conventional warhead.

Modes of Operation

Based on information received from a ship's weapon system, a GMLS controls the movements and performance of each missile selected prior to missile firing. Target selection determines the missile type, whether a single or multi missile firing is desirable, and when to load a missile onto the launcher guide arm for firing. Missiles within a launching system can be assigned a code letter according to their purpose and design. An X, Y, or Z select code circuit can be used to identify each type of missile within a system. Missiles can be coded by their configuration, (whether they are used against surface, air or under water targets,) and also by the type of warheads they employ against a target. The coding circuit will provide a selected missile with the initial flight guidance prior to launch. The type of target selected, which would be the most threatening target, determines the mode of operation of a launcher system and also determines the type of target data received by a system. Figure 9-2 shows the flow and processing of target data through a Terrier weapons system and the inputs to the launching system. Most weapon systems operate in three basic modes of operation: surface, underwater, and air.

Surface and Shore Targets

During surface operations in a Terrier weapon system, the controlling Missile Fire Control System (MFCS) tracks the target in range and bearing while the radar guidance beam is programmed to a small elevation angle above the target. The MFCS receives designation orders, acquires targets, and tracks surface targets. Target tracking data from the fire control director, missile performance characteristics, and own ship's motion are computed to generate launcher train and elevation orders for an optimum firing position. When the launcher is assigned to a MFCS, it trains and elevates to synchronize to a computed position which aims the Terrier missile toward the correct capture point depending on the type of missile selected. The fire control systems computer continuously corrects the launcher aim point as the ship and target maneuver.

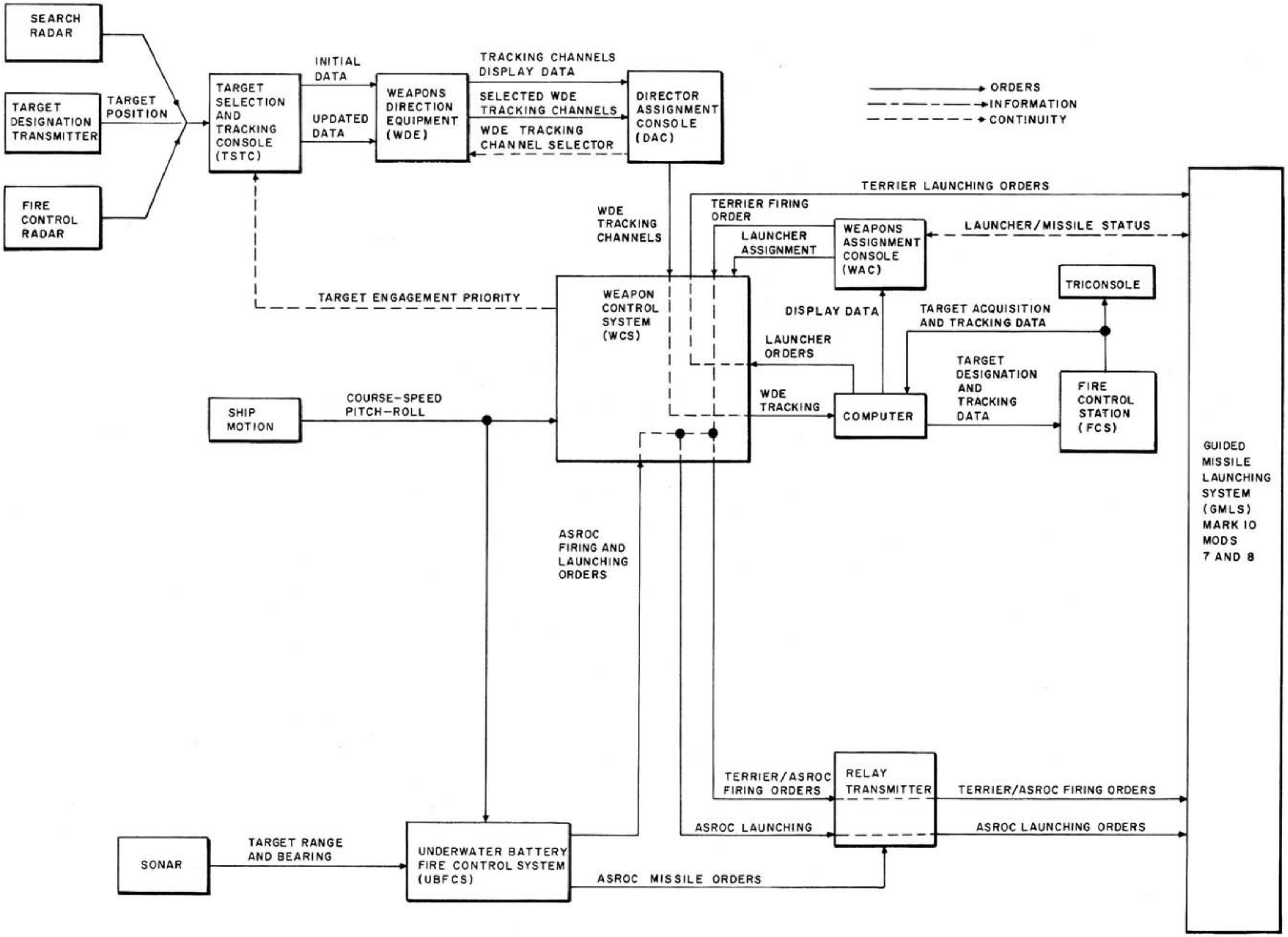

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Figure 9-2.—Flow and Processing of Target Data Through Terrier Weapons System.

For a shore target, a Terrier missile system follows a procedure similar to engagement of surface targets but the targets are not tracked. The missile is launched at a preselected point, and the missile warhead is detonated at a preselected height above the target. During shore firing operations, the MFCS radar director remains fixed in bearing as the ship holds a steady course. When launched, the missile follows the guidance beam toward the shore target, and the MFCS computer programs the beam down to the burst height as the missile-to-target range decreases to zero. Figure 9-3 illustrates a surface and shore fire control problem.

Underwater Targets

When underwater targets are encountered and identified as hostile, the ship's Underwater Battery Fire Control System (UBFCS) orders the Terrier missile system into an Antisubmarine Warfare (ASW) operation. When targets are to be engaged by ASROC missiles, the UBFCS controls the attack problem and the Weapon Direction System (WDS) implements the order for the launcher to shift to an ASROC mode. The UBFCS continues tracking the underwater target and continuously corrects the launcher aim point as the target and ship maneuver. When all indications are correct and the ASROC missile is launched, UBFCS designates a position is space where the Gun Fire Control System (GFCS) radar can acquire the ASROC missile and track it to its water entry point. This information is used by the UBFCS to evaluate the probable success of the firing. If the missile has a torpedo payload, a parachute deploys which slows the payload to a safe water entry velocity. The parachute detaches from the payload upon water impact. The torpedo sinks to a preset initial search depth and starts on a target search program. If the missile has a depth charge payload, the payload continues its trajectory to the water entry point and detonates at a preset depth.

Airborne Targets

Since GMLS are the ship's primary defense against air targets, we will discuss in some detail the components used during antiaircraft operations starting with a ship's weapons control system.

THE WEAPONS CONTROL SYSTEM

A weapons control system is comprised of two major subsystems: (1) a Weapons Direction System, and (2) one or more Fire Control Systems. The weapons control system contains equipment that makes decisions on its own or aids officers in making appropriate decisions. Information about targets is visually displayed and stored, and this displayed and stored information provides the basis for decision making. Commands are transmitted between equipments in the weapons control system and to units in other systems. Information is passed back and forth between equipments and individuals over data transmission circuits that are a part of the weapons control system. Computing equipment calculates lead angles which are sent to the launcher to aim it in the proper direction. Also, orders are sent to the missiles before they are launched. After the missiles are in flight, information is sent to them to direct their flight to the target.

The Weapons Control System serves the gun batteries as well as the missile batteries. A gun battery consists of a group of gun mounts of similar size, ballistic characteristics, and ammunition requirements. A missile battery has two or more missile launchers. Traditionally, the largest caliber of guns on board is the main battery, but the term "Main battery" may mean the weapon of the greatest potential effect, and therefore the missile battery may be the main battery.

Weapons Direction System

The typical missile weapons system shown in figure 9-1 includes Weapons Direction Equipment Mk 3. The WDS is made up of two groups of equipment: (1) Weapons Direction Equipment (WDE), and (2) related (ancillary or auxiliary) equipment.

WEAPONS DIRECTION EQUIPMENT. - This term is the one in current use. The same equipment has been called Designation Equipment

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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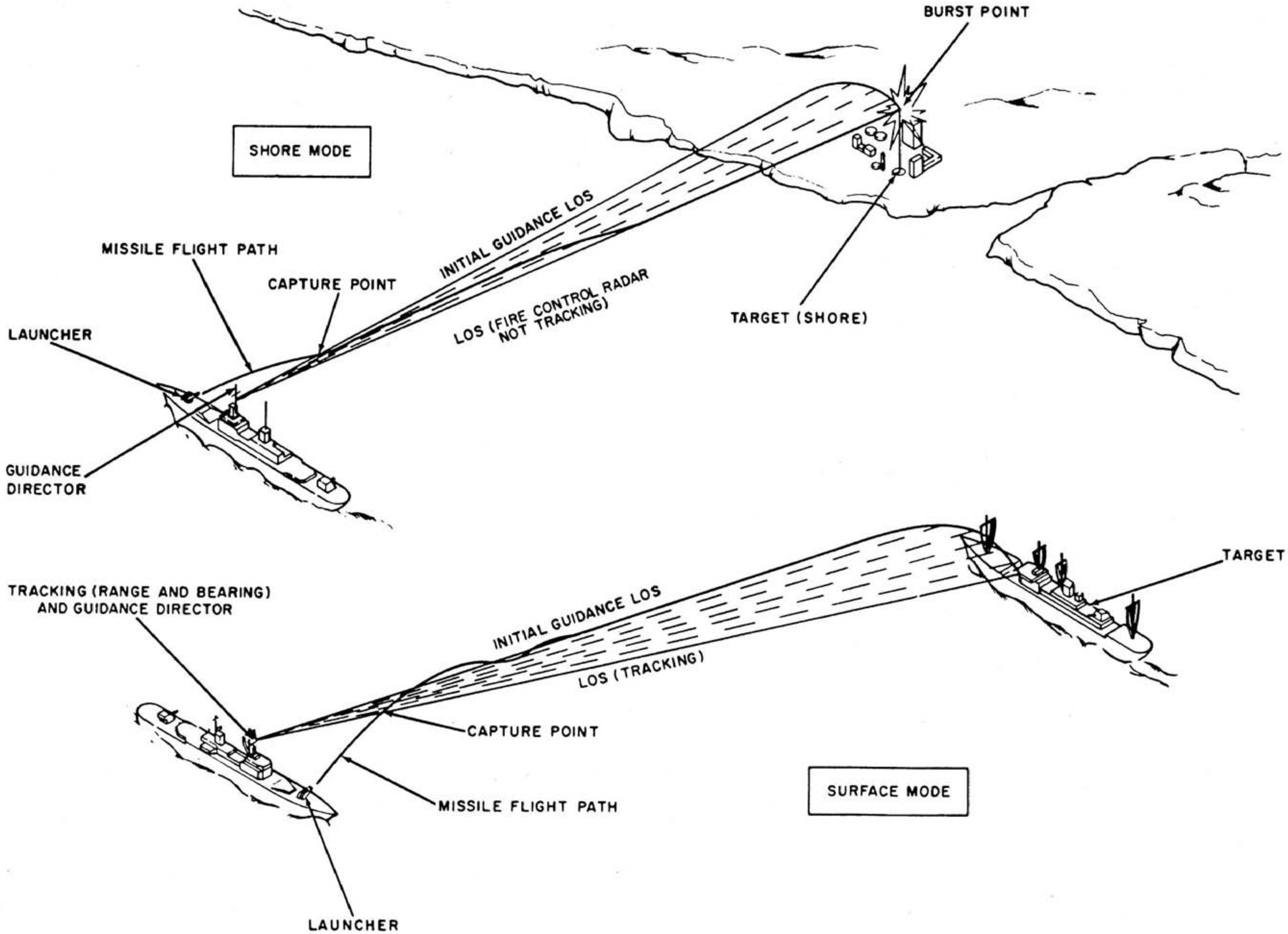

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Figure 9-3.—(U) Basic Fire Control Problem, Y Surface and Shore Modes.

(DE) or Target Designation Equipment (TDE), and you will find these terms still in use. In the system illustrated in figure 9-1, it is called Designation Equipment Mk 9. It consists primarily of three Target Selection and Tracking Consoles (TSTC), a Director Assignment Console (DAC) a Weapons Assignment Console (WAC), and a Guided Missile Status Indicator. The last two equipments are especially of interest to you because they originate many of the instructions sent to the launching system. They also receive much information in return.

The WDE, as a whole, selects targets from the video and target position information supplied by the search radars. This target information is electronically displayed on cathode-ray tubes in the various consoles. Selected search radar targets are manually tracked to determine course and speed. The WDE provides for the assignment of missile fire control radars to track the most threatening of these targets. Equipment is provided to assign the launcher to one of the missile fire control computers. Other equipment is used to let the launching system know what type of Terrier missile is to be launched. Also, a firing key is provided in the Designation Equipment to start the launching process. In short, the Designation Equipment coordinates and monitors the activities of the entire missile weapons system.

Target Selection and Tracking Console (TSTC). - The three TSTCs in our typical weapon system (fig. 9-1) can all be used for selecting and tracking targets. One TSTC is located in the Combat Information Center (CIC), and is normally used to select targets for tracking. The other two consoles are part of the Weapons Control Station, and they track the targets selected by the TSTC in CIC. All the consoles are wired in parallel; therefore, both functions (selection and tracking) can be performed by any console or combination of consoles. In figure 9-1 you can see the general outlines of a TSTC. Figure 9-4 shows the panel face.

The principal indicator on each console is a Planned Position Indicator (PPI). You studied this radar indicator in Basic Electronics, NAVTRA 10087 so we won't describe how it works. The cathode-ray tube displays the bearing and range of every target detected by a selected search radar. A control on each console can select a particular search radar to use as a target data source. The normal source is the AN/SPS-39.

The personnel in CIC and Weapons Control need this picture to evaluate the combat situation. Evaluation is concerned with answering the following questions:

1. What does the target intend to do? Is he going to make a run on the ship or simply stay at long range and observe?
2. How threatening to our ship's safety is the target? If it becomes obvious that his intent is to attack, how much time does our ship have to launch a counterattack? This raises another question.
3. What weapon shall the ship use to counter an attack?
4. What kind of weapons does the target carry?

Many other factors are involved in evaluating a target situation, but these sample questions should give you some idea of what the term "evaluate" means. The target selection and tracking consoles aid in the evaluation process by determining which targets to track, and then keeping them tracked. Each target assigned its own tracking and storage channel. The channels are lettered A through F. When a target has been selected for tracking and has been assigned a channel, the appropriate letter is electronically painted on the PPI-scope. Look at figure 9-5A. It shows a view of the air and sea space around your ship as seen from a position directly above it. Figure 9-5B is the TSTC display scope and it shows a symbolic reproduction of the actual combat picture. As the real targets maneuver, their electronic counterparts (blips) follow the same motions. Search radar target tracking consists of making the letter symbol associated with a target continuously follow the target blip. The operator uses the pantograph (fig. 9-4) as you would a gun sight. He lines up the pantograph ring sight with a target - let's say target A. Then he presses a button to measure the position of target A. This position information is put into a computer. The operator keeps his sight over the target for several seconds while he continually presses the tracking button. Meanwhile, the

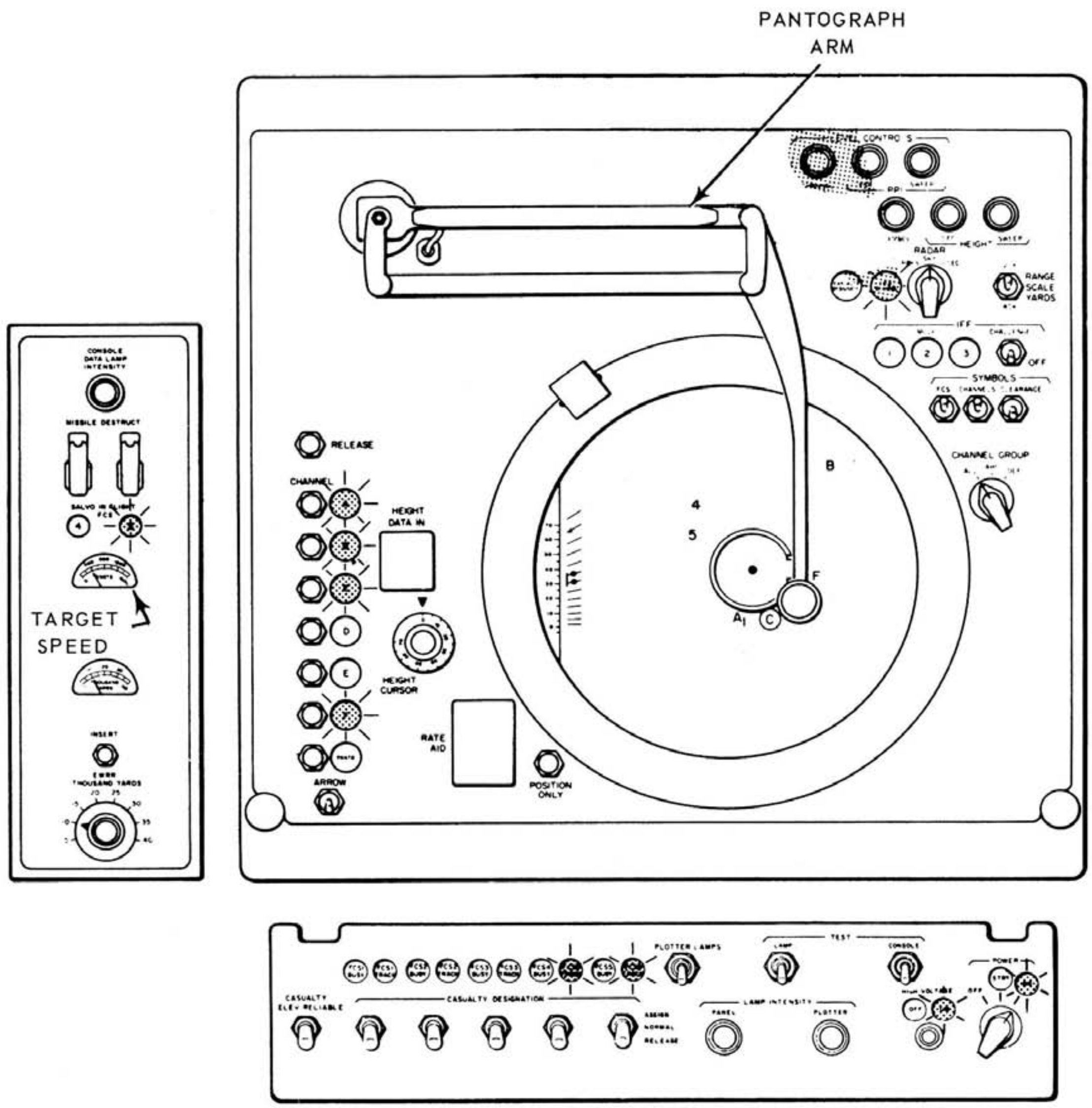

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Figure 9-4.—Panel face of target selection and tracking console (TSTC), Mk 9 Mod 0 Designation Equipment.

computer associated with target A is calculating the target's speed and course. When the computer has the correct course and speed of target A, the letter symbol, which is driven by the computer, will follow the target blip without the operator of. the console moving the pantograph. Target position, course, speed, and elevation are stored in the A channel computer for use by the TSTC and the DAC operators.

Search radar targets are tracked with the aid of pantograph arms, one on each TSTC. You can see a general outline of the arm in figure 9-SB. The arm is essentially a link between the search radars and the weapons control system. We can illustrate this point by showing, in a brief and general explanation, what happens when we start the WDE tracking process. You should have a general ideal of what is going on in Weapons Control so you can understand how you fit into the "big picture."

The weapons officer tells the operator of the tracking TSTC which target to follow. The operator places the pantograph arm, which has a ring sight, over the selected target blip. He then presses various buttons which open up a tracking channel. Assume that channel A is selected (for

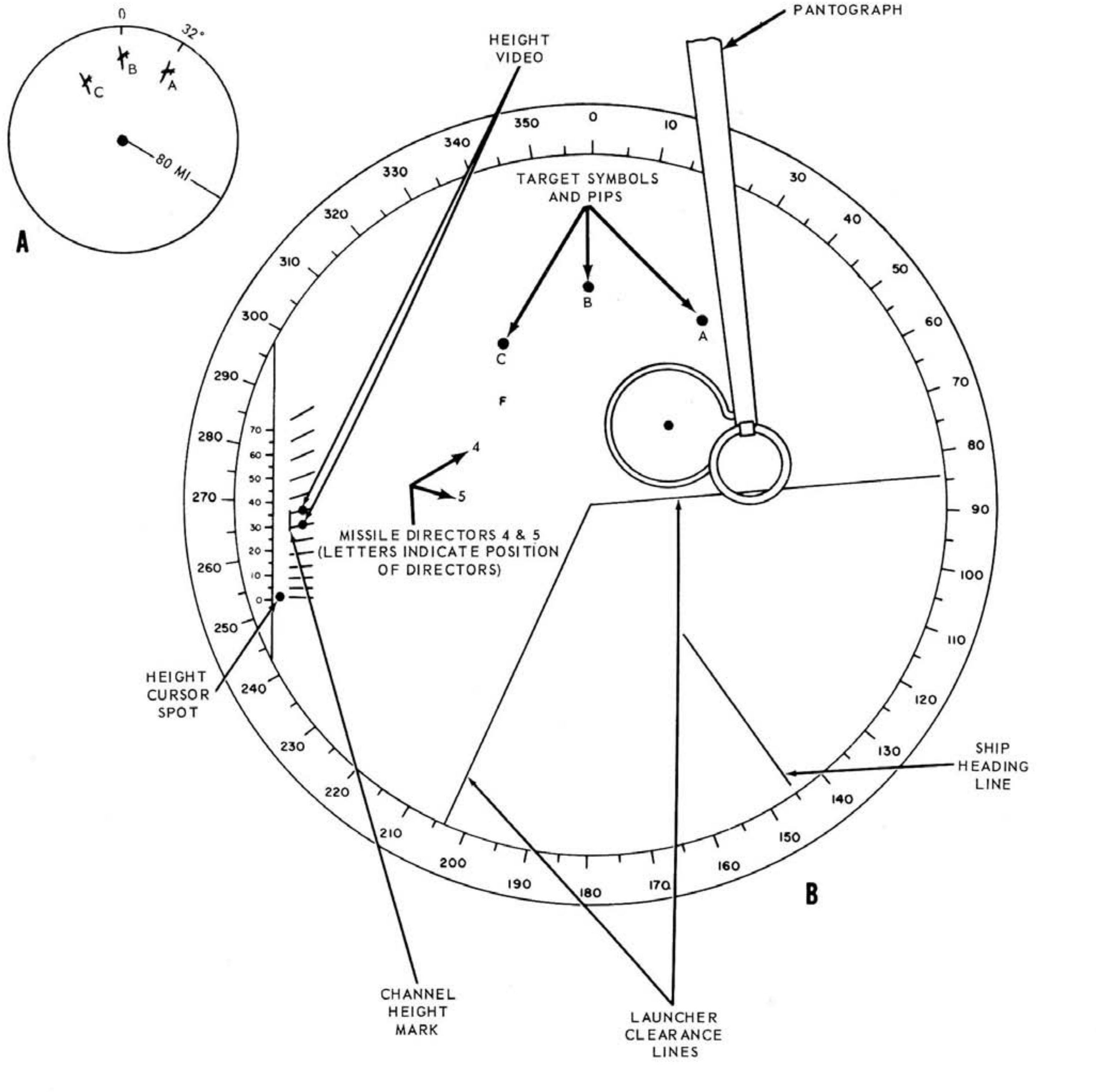

Figure 9-5.—How the combat picture looks on the TSTC display: A. Targets A, B, and C; B. Display scope, Target Selection and Tracking Console.

target A). Target position and rate information are placed in the channel computer and storage unit, and stored. Also, if information about the height (elevation) of the target is available, this information is put into storage.

Let's follow this target through the weapons control system as the information passes from one equipment to another. We have already described the first leg where a selected target was passed from a search radar to tracking and storage channel A via the pantograph arm on one of the TSTCs. Target range, bearing, course, and speed are now stored in the A channel of the WDE Data Storage Unit (shown as a large box in fig. 9-1). Coming out of this unit is a line marked "Target A position. speed, and course data." The line ends at another piece of equipment in the WDE called the Director Assignment Console.

Director Assignment Console (DAC). - The Director Assignment Console (fig. 9-6) is located in the Weapons Control Station and is used to display target fife control information. Despite the console's name, its primary purpose is to assign a missile or gun fire control system rather than only a director to a particular target. The console contains two cathode-ray tube displays (fig. 9-6). The tube on the left shows the bearing and range of each target being tracked by the target selection and tracking console operators. Pushbutton controls are used by the console operator to assign fire control systems to targets and for releasing the systems after the targets are destroyed or if some other target becomes more threatening. Indicator lamps show the status of the fire control systems. For example, the track light shows that a fire control system is already tracking target A; the FCS NON-OP light indicates that its associated fire control system has a casualty in it and is therefore inoperative; the IND light indicates that some other designation source, such as a Target Designation Transmitter, is designating to a fire control system.

The multipurpose display on the right of the panel face (fig. 9-6) shows the target elevation and speed of any targets that are in tracking channels. This target information is determined by the tracking channel computers in the WDE target data storage unit (fig. 9-1). The DAC operator can tell from the information displayed on the multipurpose plot (vertical line) how much time he has to assign a fire control director to a target before the target reaches a range at which it can release its weapons. He can also determine from. the display how long a fire control system will be busy tracking a target and guiding a missile to it (horizontal line).

You can get a closeup view of the DAC displays in figure 9-7. You can learn quite a bit about a target by looking at these displays. The PPI tells us that target A is bearing 025°, and is about 75,000 yards from the ship. Missile fire control director 4 (symbolized by the numeral 4) is positioned at bearing 258° and its radar range measuring unit is sitting at 35,000 yards. As director 4 changes its train position, the numeral 4 will move correspondingly. Now figure out where director 5 is positioned in bearing and range. Notice the target course line extending from target A toward the center of the scope. The course line indicates that target A is heading for the ship.

The multipurpose display indicates how fast target A is traveling. It is making about 750 knots, and is flying at 35,000 feet. The multipurpose display also provides information about the length of time a director will be used to track and control missiles during the engagement.

According to the display in figure 9-7 target A is in position to launch an attack against the ship. Since he is within missile range (or soon will be), and beyond gun range, the DAC operator assigns a missile fire control system to engage the enemy. Assume that FCS 5 is busy controlling a missile salvo against another target. This means that all units in FCS 5 are at work; therefore, FCS 4 must be assigned to this target. The DAC operator assigns FCS 4 to target A by pressing appropriate control switches on the console. A selector switch in the missile FC switchboard automatically turns, connecting target A position information (as determined by the channel A tracking computer and storage unit) to the missile fire control computer in FCS 4.

The missile fire control computer (fig. 9-1) associated with director 4 changes the target A position information from tracking channel A into synchro signals that are proportional to the range, bearing, and elevation of target A. These target A position signals are then sent to the director's range, bearing, and elevation servos. The director slews onto the target, searches for it, and when it has found the target, begins to track it. Now the director and its radar accurately measure target A's position and range, and send this information down to the fire control computer. At about this time, the fire control system signals the DAC that it is tracking target A (the FCS 4 track light comes on), and the tracking channel A lights on the TSTC and DAC begin to flash, indicating that target A is being tracked by FCS 4.

The TSTC operator disconnects tracking channel A from the fire control system because

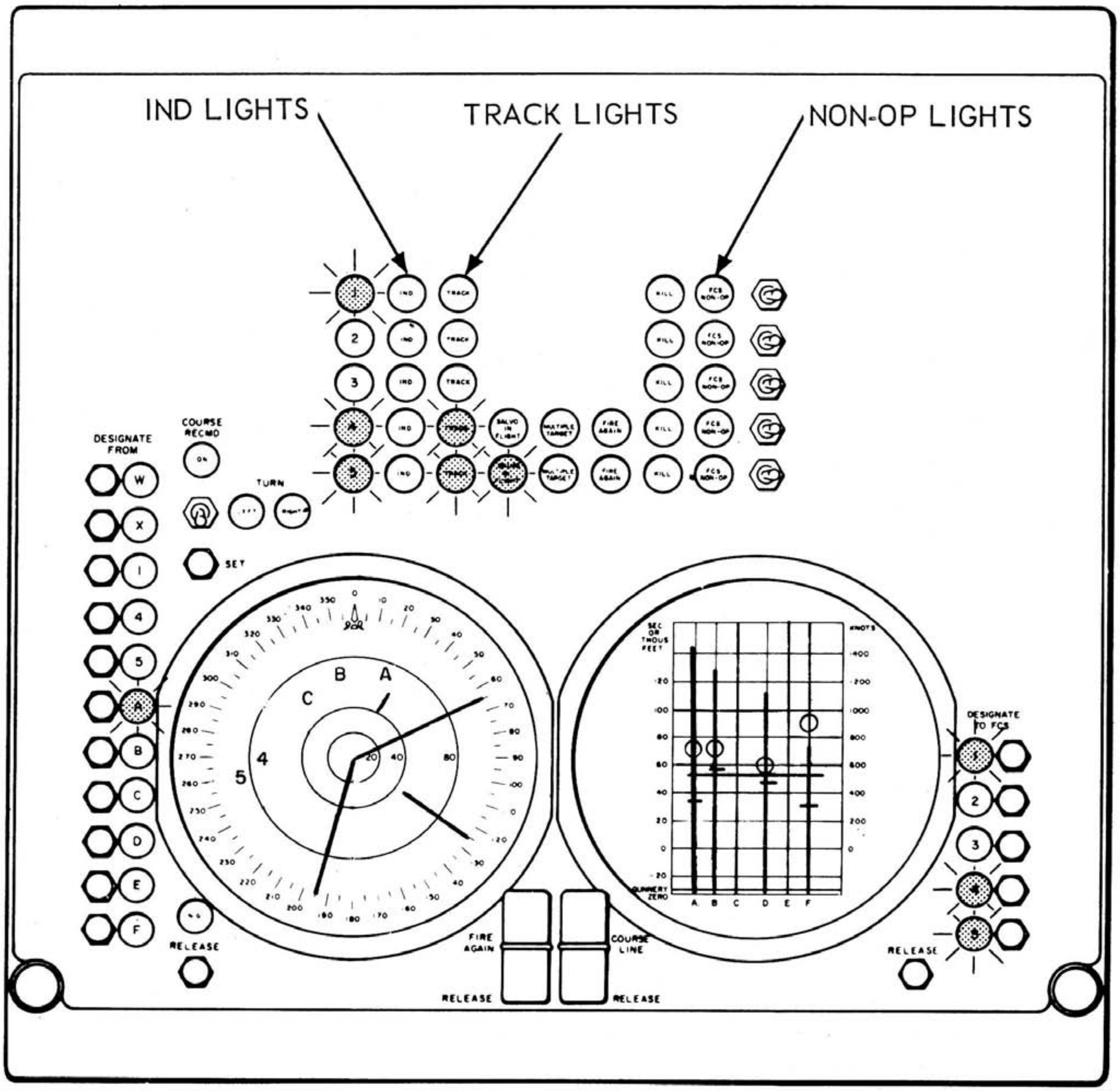

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Figure 9-6.—Panel face of Director Assignment Console (DAC).

there is no further need for it since the fire control system now has the target.

So far in this discussion, target A has been detected by a search radar, identified as a hostile target, selected out of a group of three targets, tracked by the TSTC operator to get a rough idea of the target's position and motion, passed on to a fire control system which then picked up target A. As the director and its radar track the target, they continuously and precisely measure target A's position and range. This very accurate information is sent to the computer, which predicts where the target will be some time in the future. The computer also makes up launcher train and elevation orders as well as information for use by the missile when it is in

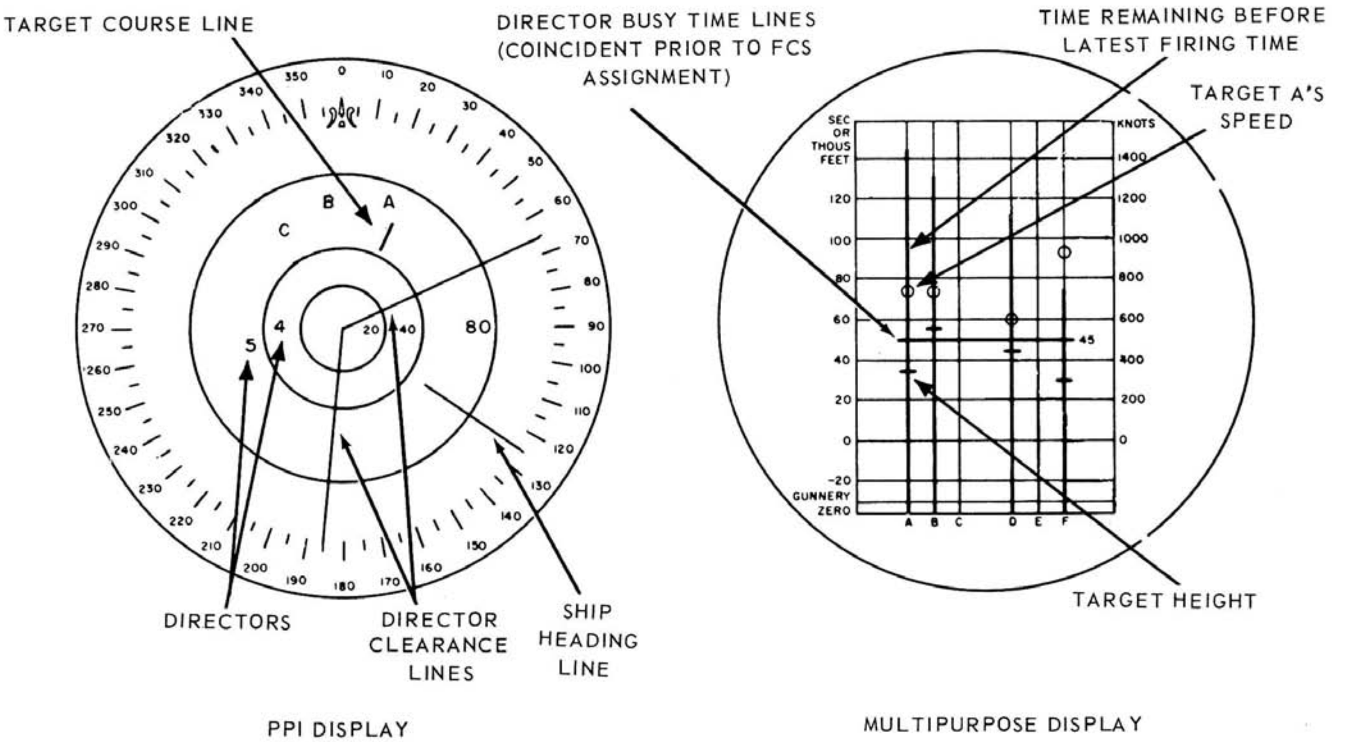

Figure 9-7.—Tactical displays on Director Assignment Console (DAC).

flight. We'll talk more about the fire control system later. But for the present, let us return to target A and take a look at the next step in its progress toward destruction.

Since our typical missile weapons systems has only one launching system, it must be shared with the two missile fire control systems. The operator of the next equipment we will discuss, the Weapons Assignment Console, has control of connecting the launcher with a selected fire control system, in this case, FCS 4.

Weapons Assignment Console (WAC). - Each of the PPI displays on the Weapons Assignment Console (WAC) presents target position information from a fire control system assigned to track a target. The PPI-scope on the left in figure 9-8 shows the target being tracked by radar set and director 4; the indicator on the right shows information about the target being tracked by system No. 5. A summary of conditions at the launching system also appears on the console. The last step in the evaluation process take place at the WAC. The WAC operator makes a final evaluation of the target in terms of: (l) Is the direction of the missile launcher clear of obstructions, such as the ship's superstructure? (2) Is the target within the range and altitude capability of Terrier type missiles? (3) Is the launcher synchronized with the computer order signals?

Each PPI (fig. 9-9) is a plot of range against bearing, with own-ship position at the center. The small circle at the center of the scope represents the minimum effective range of the missile. There is no point in firing a missile at a target within this range; you won't hit it.

Launcher clearance lines represent the unclear area (because of ship superstructure or equipment) for the launcher, where it may not be trained (or elevated) for firing. Notice the tiny circle near the inside edge of the bearing scale at about 028°, at right PPI. This circle represents the position of the launcher. As the launcher trains, the circle moves to a position corresponding to launcher bearing. If the launcher were positioned between the V-shaped clearance

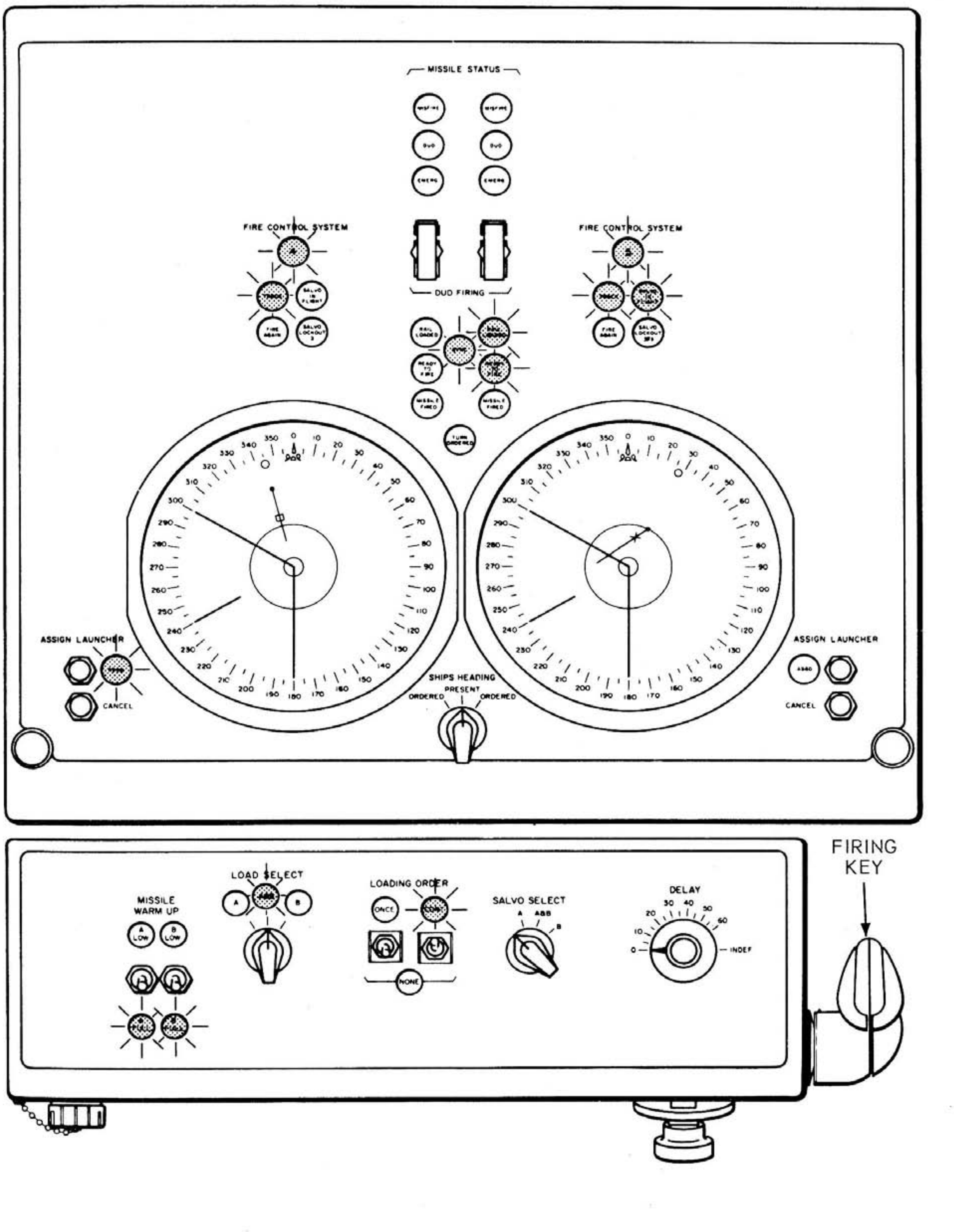

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Figure 9-8.—Panel face of Weapons Assignment Console (WAC).

lines, launching a missile would be prevented by the firing cutout cam and the automatic tracking cutout system.

To assign the launcher to one of the fire control systems, the operator of the console presses the appropriate pushbutton marked "ASSIGN LAUNCHER" (fig. 9-8). If the launcher is prepared for remote operation, it automatically synchronizes with the train and elevation orders transmitted from the assigned missile fire control computer. As soon as the launcher is synchronized with the order signals, the light labeled "SYNC" comes on.

When the fire control system has been assigned by the DAC operator to track a target, and the radar is automatically tracking the target, additional indications appear on the PPI display as shown in figure 9-9. An outer contour circle appears on the scope of interest. The outer contour represents the maximum capabilities of the Terrier missile; the inner contour circle represents the minimum area, which is too close to the ship for the missile to strike. A square appears for FCS 4 and a cross for FCS 5. These. geometrical figures represent target position at the time a missile would intercept it, if the missile were fired now. Notice that the square is outside the outer contour circle in the illustration. The WAC operator can see from the display that the missile is not capable of hitting this particular target because it is beyond the capabilities of the missile. If the target is headed toward the ship, firing the missile can be delayed until the target is within range; the computer will calculate the time accurately and speedily.

Two columns of lamps at the center of the WAC, just above the two display scopes (fig. 9-8), indicate missile status for the A and B rails of the launcher. These lamps are lighted by events that happen at the launcher. For instance, the RAIL LOADED lamp comes on when a missile is on the associated launcher rail. The SYNC lamp lights when the launcher is synchronized with the launcher train and elevation orders

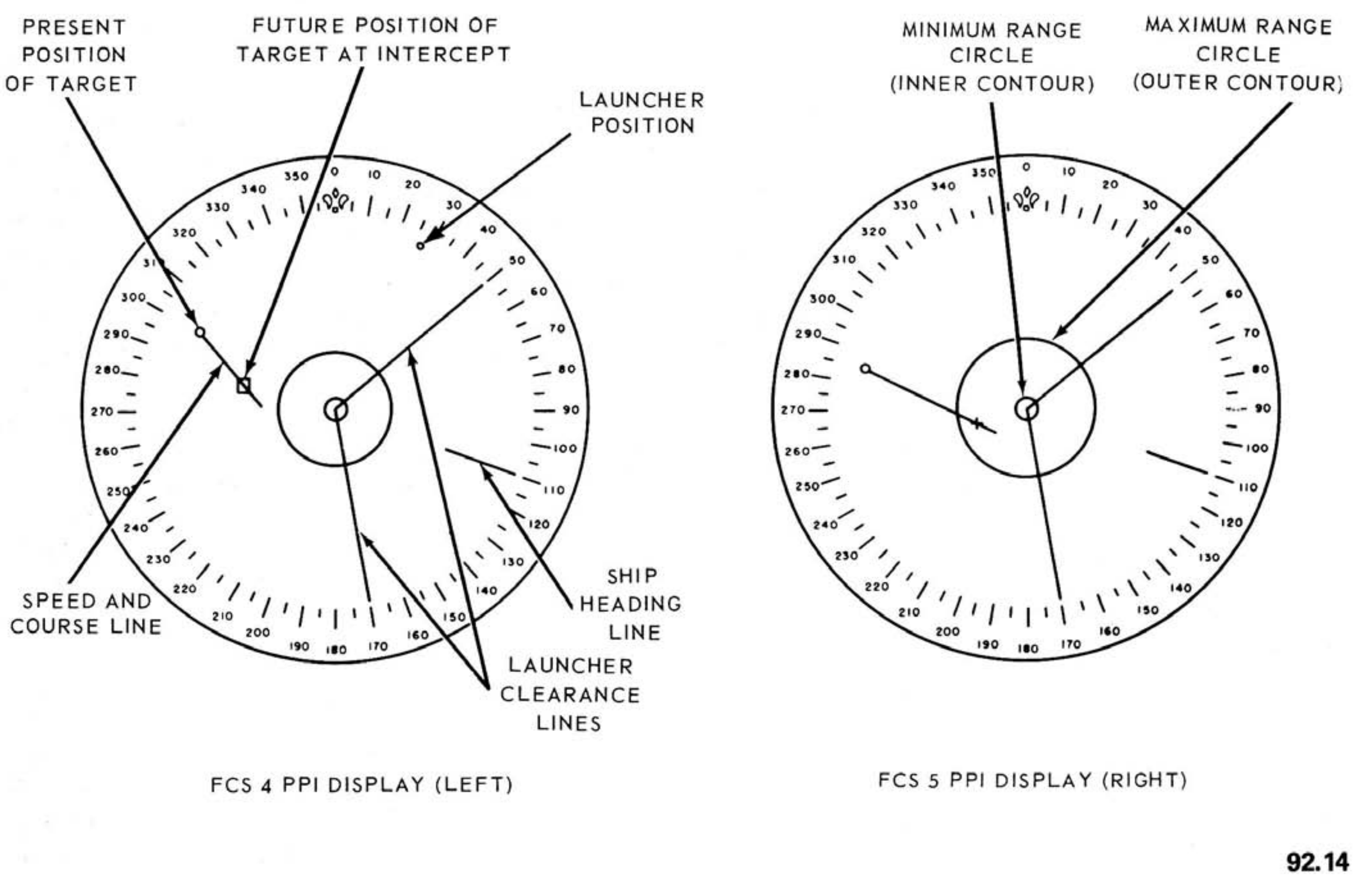

Figure 9-9.—Weapons assignment console (WAC) combat picture.

from the missile fire control computer. The READY TO FIRE lamp indicates that firing circuit interlocks are closed, the rail is loaded, the blast doors are closed, the firing zone is clear, the contactor is extended, the launcher is synchronized with computer orders, and the missile has received at least 20 seconds of warmup power and is ready to be fired. The weapons control officer makes the decision to fire when the READY TO FIRE lamp is on, and tells the WAC operator to close the firing key.

The MISSILE FIRED lamp is lighted after the missile has left the rail; this lamp remains on until both missiles have been fired, or the launcher has been released from the fire control system to which it was assigned.

The MISFIRE lamp is lighted when an attempt is made to fire a missile, the firing current flows through the booster squib, but the booster propellant does not ignite. A misfire is a dangerous failure. The DUD lamp lights when an attempt is made to fire but the firing current fails to flow through the booster squibs. Below each DUD lamp is an EMERG (emergency) lamp and a DUD FIRING switch. When the DUD FIRING switch is operated, it bypasses the normal firing circuits to the missile and connects firing current directly to the booster squibs. The EMERG lamp indicates that emergency firing circuits are energized.

The missile status information described above is also displayed on the Launcher Captain's panel (EP2). See figure 9-10.

Now let's shift Our attention to the group of five lamps that are above each PPI (fig. 9-8). The group on the left is associated with FCS 4 and the group on the right with FCS 5. When the director receives an assignment, the lamp at the top of the group lights. The TRACK lamp lights when the director starts to track an assigned target. The SALVO IN FLIGHT lamp is lighted during the time interval between launch and target intercept. When the DAC operator orders another salvo fired at the same target, the FIRE AGAIN lamp flashes. When two salvos have been fired at a target, the SALVO LOCKOUT 3RD lamp lights, which indicates that the director is not available for another assignment until the salvos already in flight have reached their target. The fire control systems can control a maximum of four missiles (two 2-missile salvos). Therefore, a third salvo (one or two missiles) cannot be fired.

At the lower left-hand corner of the main panel (fig. 9-8) are two pushbuttons and one lamp. The ASSIGN LAUNCHER pushbutton is used to assign the launcher to FCS 4. The ASSIGN (ASGD) lamp, alongside the pushbutton, lights to indicate that connection has been made between fire control system and the launcher. Also, on the EP2 panel (fig. 9-10) in the launching system, the LAUNCHER ASSIGNED lamp lights. As soon as two missiles have been fired and the firing key is released, assignment of the launcher to the fire control system is canceled automatically. When only one missile. is fired in the first salvo, launcher assignment is not canceled. If the WAC operator decides not to fire at a target after the launcher has been assigned, he may break the assignment by manually pressing the CANCEL pushbutton. When the assignment is canceled, the ASGD lamp goes out and so does the corresponding lamp on the EP2 panel.

The rectangular shaped panel at the bottom of the main display panel (fig. 9-8) is called the control-indicator auxiliary. It contains switches that send orders to the launching system concerning missile handling and firing. With the exception of the DELAY knob, you are familiar with all the functions in the launching system that are ordered by the controls on this panel.

The position of the LOAD SELECT switch indicates to the launching system personnel which launcher rails are to be loaded. You can see in figure 9-8 that the order is to load both A and B arms of the launcher. The LOAD A & B light just above the load select switch is burning, and this indicates that the launcher captain has acknowledged the order.

LOADING ORDER switches send orders to the launching system personnel to load the rails once, continuously, or not at all. The lamp associated with the operated switch shows the WAC operator that his order has been received and acknowledged. It does not mean, as you know, that the load order has been carried out. If you will look up at the main display panel, you can see that the B rail is loaded but the A rail is empty at this time. The RAIL LOADED lights are lit when the missiles are actually on the launcher and their shoes make contact with the interlock switches. This is positive proof

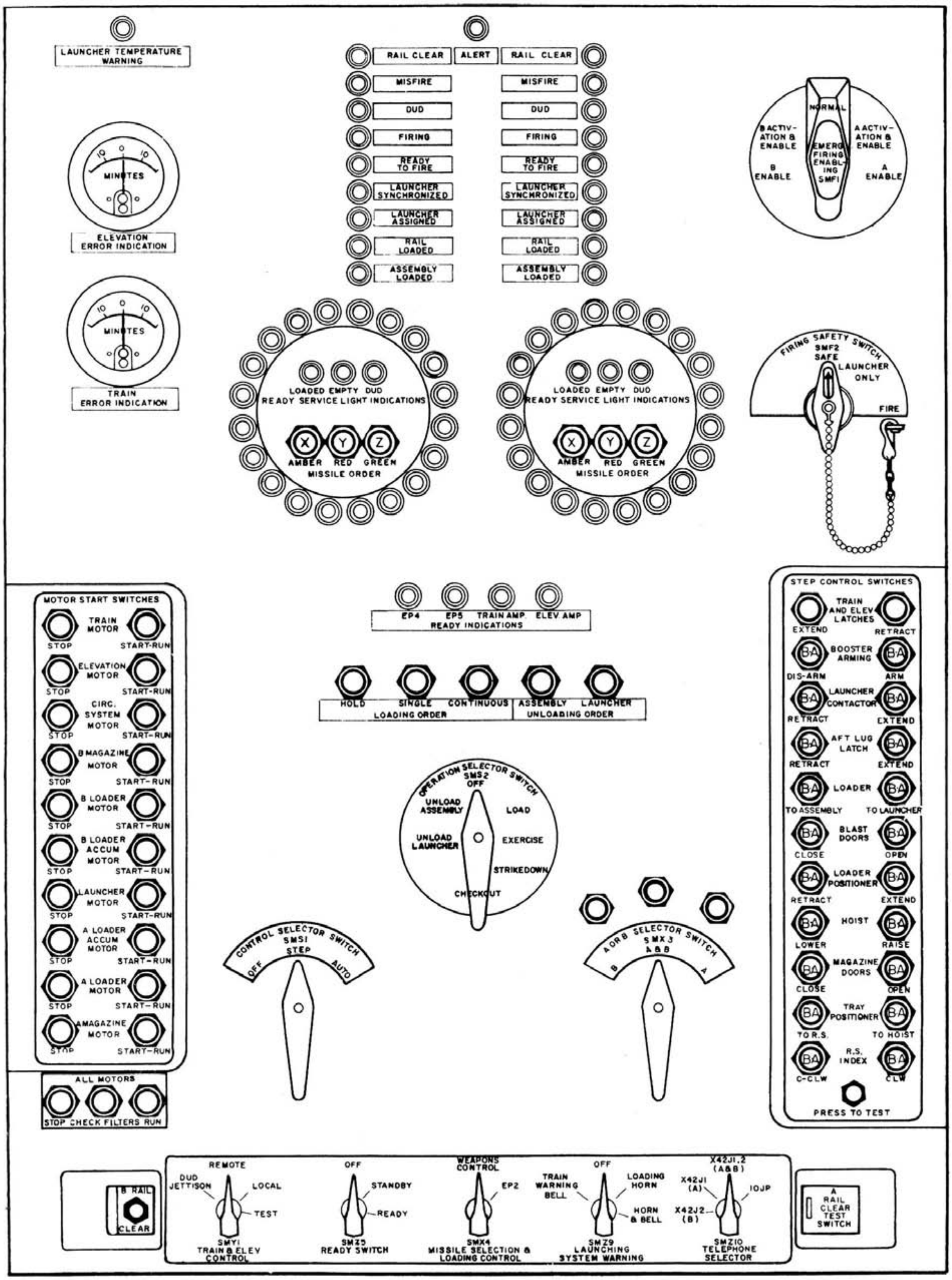

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Figure 9-10.—Launcher captain's panel (EP2), Mk 190 Mod 1.

that they are on the launcher and in firing position. No human opinion enters, into the picture.

The SALVO SELECT switch selects the rail or rails from which a missile is to be fired. When the switch is put in the position shown in figure 9-8, the missile officer wants a single missile fired at the target. He does not particularly care whether it leaves the A or the B rail. But he wants to make sure that one of them goes. If the A rail missile is ready first, and it normally is, that's fine. But if you get a NO-GO on the missile intended for rail A. then you load rail B. The salvo select switch (fig. 9-8) is positioned so a missile can be launched from the A arm only, the B arm only, or from the A and B arms (in succession, not simultaneously).

Operation of the DELAY control sends a synchro signal to the missile fire control computer to advance the fire control problem solution by whatever delay is selected. The term "delay" refers to the loading time of the launching system. If the approximate loading time of your system is forty seconds and you want to see what the fire control problem will look like 40 seconds from now, you turn the DELAY knob to 40 seconds. The computer uses this information to advance the present fire control problem by 40 seconds. Information about this future problem is sent back to the PPI-scope and the future position symbol will move to the position where the target will be 40 seconds from now. Being able to look into the future helps the WAC operator to evaluate more effectively.

Missiles must be warmed up before they are launched For Terrier missiles the minimum warmup time is 20 seconds. When MISSILE WARMUP switches are placed at the FULL position, warmup power is applied to the missile through the launcher-to-missile contactor, which mates with the warmup pad on the booster, and the FULL lamps light. Switches may be left in this position for a maximum of 15 minutes. If the missile is not fired during this period, the LOW lamps flash. This indicates that the operator should place the switches in the LOW position, which removes warmup power from the missiles so they can cool off.

When the DAC operator assigns a target to a fire control system, the BUSY lamp for the FCS (indicated by the FCS number) lights up on the WAC. Figure 9-8 shows that both fire control systems have been assigned a target. The lamp remains lighted until the assignment is canceled. The operator can tell if the fire control radar is automatically tracking the designated target because the TRACK lamp lights.

When the missile clears the launcher rail, the missile FC computer is notified by a SALVO IN FLIGHT signal from the launching system. The computer transmits the salvo-in-flight signal to the WAC SALVO IN FLIGHT lamp, which then lights. It remains on until the missile intercepts the target, or until its flight time runs out.

In case the DAC operator orders a second salvo to be fired against the same target, the FIRE AGAIN lamp begins flashing. When the second salvo is fired, the FIRE AGAIN lamp goes out, and the SALVO IN FLIGHT and the SALVO LOCKOUT 3RD lamps light. Interlock circuits prevent firing a third salvo and the lighted lamp shows that the lockout circuitry is working properly; the third salvo is automatically locked out, and overload of the missile system is prevented.

The TURN ORDERED lamp, before the SYNC lamp, is lighted from the pilot house when the captain or officer of the deck orders a change in ship's course. It is important that the WAC operator know of a proposed course change since it changes the area of launcher clearance. When the TURN ORDERED lamp lights, the operator can see what course change has been ordered by changing the SHIPS HEADING switch from PRESENT to either ORDERED position. All presentations on the WAC rotate to the proposed course. Target position may then be observed in relation to the new clear area.

Guided Missile Status Indicator. - Another unit in the Weapons Direction Equipment (fig. 9-1) that is closely associated with the launching system is the guided missile status indicator. Figure 9-11 shows the indicator's panel face. The indicator is mounted on a bulkhead in the Weapons Control Station. The primary function of the indicator is to order the type of missile to be loaded and to indicate the type and status of the missiles which have been selected for loading. Having ordered a particular type of missile, the indicator provides a means for checking that the launching system has elected the right type

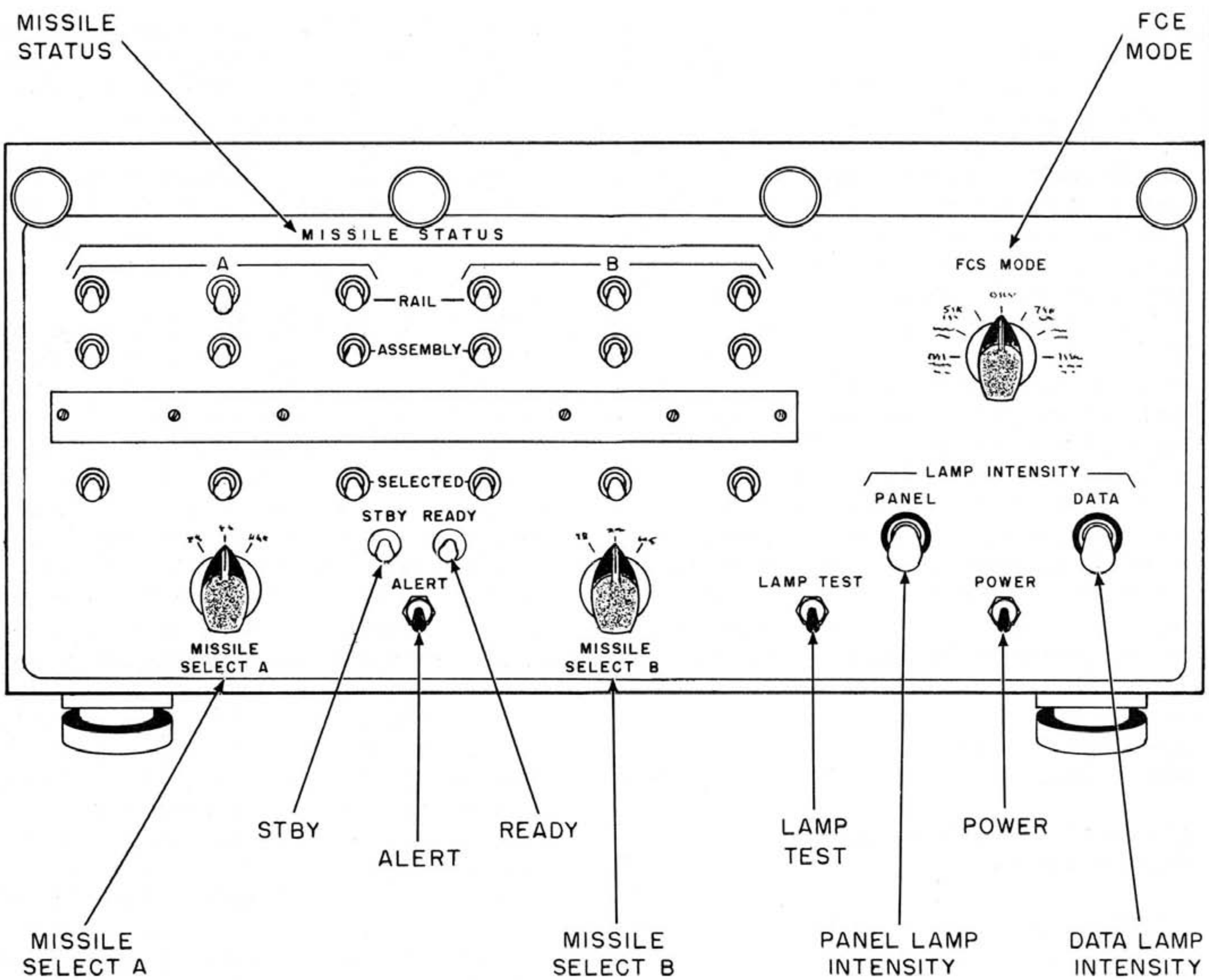

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Figure 9-11.—Guided Missile Status Indicator in the Weapons Control Station.

for loading, and, by watching lights, the WAC operator (who is usually the missile officer) can watch the progress of selected missiles as they pass from the magazine to the launcher arm during the loading process. At any time, he can tell where each missile is in the launching system. Also, the unit can provide signals to the fire control switchboard to order special modes of missile director operation.

As you read the next few paragraphs, refer to figure 9-11. There are two MISSILE SELECT switches on the lower part of the panel, one for rail A and one for rail B. The switches have three positions and provide for ordering any of three types of missiles- BT, HT, or BT(N). To order a BT -3 missile, the switch for the desired rail is turned to the BT position. This sends a signal to the ready-service ring and it rotates to bring the nearest BT round to the load position. For BT-3A(N) or HT-3 missiles, the switch is set to the BTN - or HT position, respectively. A spring-loaded stop prevents accidental selection of a BT-(N) missile.

Directly above each switch are three columns of lamps which indicate missile status for each rail. Each vertical set of three lamps indicates a missile type. Each row of lamps shows the location of the missile during the loading process.

For example, if rail A is to be loaded with a BT missile, the switch is turned to that position. The three lamps above left are all marked BT. The lamp in the bottom row indicates the type of missile selected; the lamp in the middle row indicates that loading has started and the missile has reached the assembly area. When the lamp lights in the top row it indicates that the missile is on the launcher rail. Thus, the progress of the missile through the launching system can be followed from the Weapons Control Station.

The FCS MODE switch on the right hand side of the panel indicates to be fire control system when the missile fire control systems are to be used in a special type of operation. The switch has seven positions: BOTH 1-DIR SURF, 1-DIR SHORE, 2-DIR SHORE, NORM, 2-DIR SURF, 1-DIR SURF FCS 4, 1-DIR SURF FCS 5. For normal antiaircraft operation, the switch is left at NORM position. To engage a surface target, the switch is set at SURF, and for beach bombardment, at SHORE, the position depending on whether one or two directors are to be used. The lights and switches below the MODE switches are used to control the intensity of panel lighting and lamps, and to turn on the panel power.

GUIDED MISSILE FIRE CONTROL SYSTEM MK 76

Included in our representative missile weapon system are two missile fire control systems (no. 4 and no. 5). Each system consists of a Radar Set AN/SPG-55 (Fire Control Technicians pronounce it "speegee fifty-five.") and one Computer Mk 119. Since the systems are physically and functionally identical, we will describe only one system - number 4.

Radar Set AN/SPG-55

In general, the principal purpose of the Radar Set AN/SPG-55 (fig. 9-1) is to introduce into the computer the target's position and rate of motion in terms of range, bearing, and elevation (in the case of air targets), and to control the flight of the missiles. To do all these, the radar set must be able to find (search), to get on (acquire), and to track targets. The radar must be able to control all types of Terrier missiles. This presents a challenge to the radar set because, as you know, some Terriers are beam-riding missiles and others are semi-active homing missiles. However, the AN/SPG-55 can handle all Terrier types, but not simultaneously.

The radar has four radar transmitter: (1) track, (2) capture (3) guidance, and (4) an illumination transmitter. It also has two antennas: a main antenna (the large one in fig. 9-1), and the small capture antenna (fig. 9-12).

TRACK TRANSMITTER. - The track transmitter generates a very narrow beam which is used to search for, acquire, and then to track a target (fig. 9-12). Earlier you learn that the radar set is assigned (designated) a selected target by the DAC operator. Initially the targets were picked up by the search radars. There may be one, two, or many targets. The search radars measured their range and bearing, and, depending on the radar, the elevation. The search radar target information is fairly accurate, but it is not accurate enough to solve the fire control problem. Fire control radars are precise measuring devices. Target range and bearing measured by a fire control radar are extremely accurate. But these radars suffer from lack of power. They can detect targets only at relatively short ranges. Search radars are much more powerful than fire control radars.

To measure angles accurately, the track beam must be narrow. When the radar has the designated target in the track beam, and set automatically starts to follow the target and to measure its range and position. This information is transmitted over synchro circuits to the fire control computer.

CAPTURE TRANSMITTER. - The capture transmitter produces a wide, cone-shaped beam (fig. 9-12) for controlling the first moments of controlled flight of the beam-riding Terrier missiles. The capture beam is transmitted from the small antenna you see alongside the main antenna in figure 9-1. The capture problem and beam-riding guidance techniques were discussed in the preceding course. *Gunner's Mate M (Missiles) 3 & 2*, NAVTRA 10199, so we will not dwell on these subjects here. The basic capture holds for both Talos and Terrier beam rides. You might keep in mind that Talos beam riders

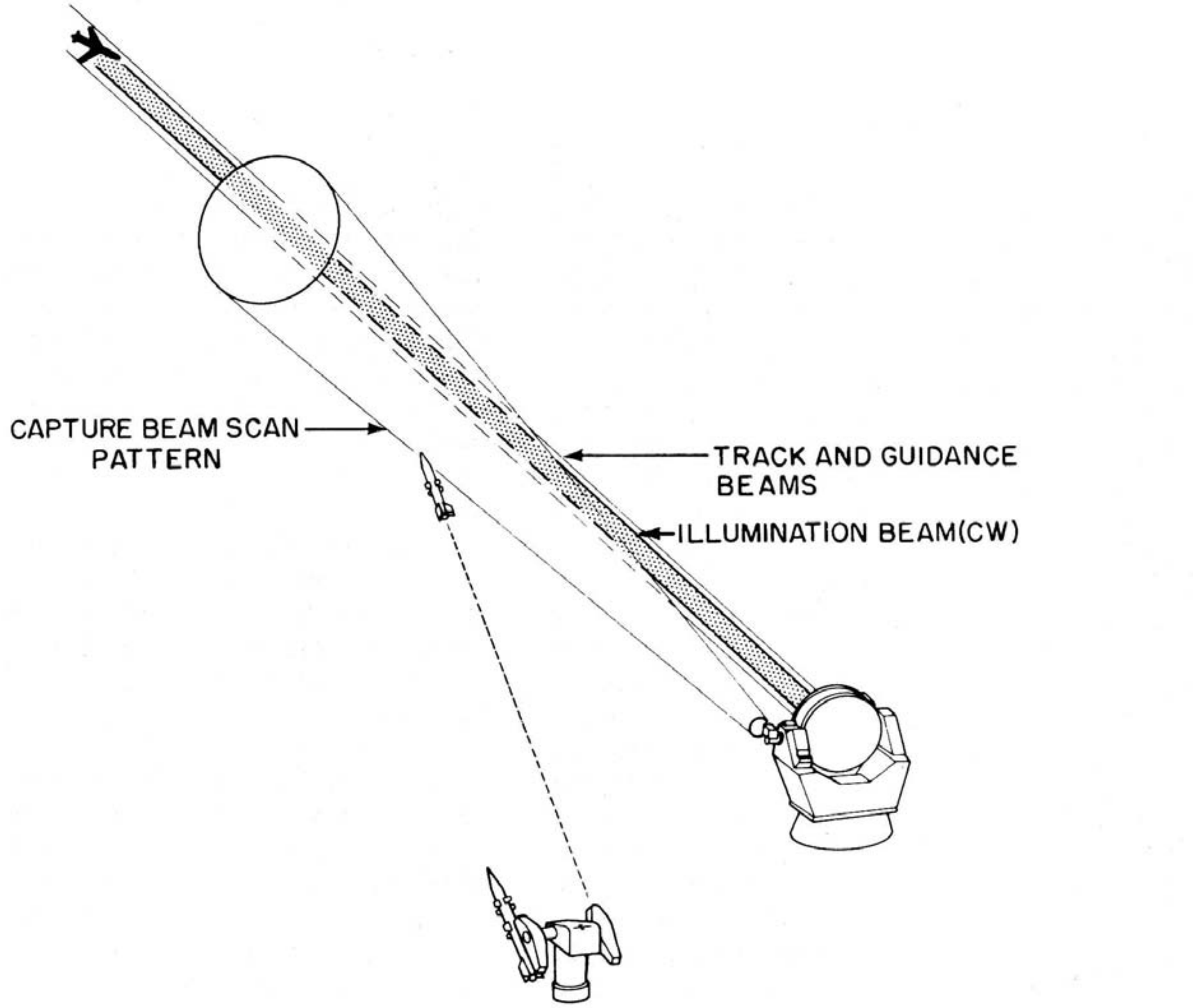

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Figure 9-12.—Missile fire control radar.

are launched into a stationary capture beam from a momentarily stationary launcher. Then the beam is moved. Terrier beam riders are launched on the fly, so to speak. Both the capture beam and the missile launcher are moving at the moment of missile launch.

GUIDANCE TRANSMITTER. The guidance transmitter also generates a cone shaped beam (fig. 9-10) but it is much smaller than the capture beam. The small guidance beam enables the mile to fly a tighter course to the target. The large capture beam ensures that the radar set grabs the missile. Once the radar set has the missile in its electromagnetic grip, the missile puts itself into the small guidance beam and follows this beam to the target. The track, capture, and guidance beams are all coincident. Where one beam goes, they all go. As the track beam follows the target, the capture and guidance beams are dragged along.

ILLUMINATOR TRANSMITTER.-The flight sequence of the HT 3 missile is different, from that of the beam-rider Terrier. Homing Terriers carry a small radar receiver which picks up radar energy reflected from the target and homes in on this energy. The illuminator transmitter on the AN/SPG-55 generates a very narrow beam of radar energy. This beam is smaller than the tracking beam (fig. 9-12). After booster drop-off, and after the missile's guidance system is cut in, the homing missile seeker head receives r-f energy from the illumination beam that has bounced off the target.

The Mk 119 Computer

The computer is the "brains" of a fire control system; the Mk 119 is no exception. It makes the calculations that point the launcher in the right direction to put a beam-riding missile in the capture beam or to place a homing missile on its proper course. In other words, the computer solves the fire control problem. The solutions take the form of continuous outputs which control the movements of the launcher in train and elevation and introduce preflight information into beam-rider and homing missiles before they are launched. The lead angle information is called launcher orders; the missile preflight information is called missile orders.

There is a direct tie-in between the launching system and the missile fire control computers just as there is between the launching system and the Weapons Assignment Console in the Weapons Direction Equipment. Therefore, we need to consider the functions of Computer Mk 119. The reason for this emphasis on computer function is that many of the outputs of the computer flow through your launcher circuitry. You should know where the data comes from and the important part it plays in the operation of the missile system as a whole. Another reason is that you are expected to test computer outputs where they enter your launching system and also to see if the outputs get into the "birds." Remember that the outputs pass through the launcher-to-missile contactor.

LAUNCHER ORDERS. - There are two sections in the computer that generate launcher orders: the HT section and the BT section. The HT launcher order section determines the train and elevation angles which aim the launcher at a point in space so that the missile can intercept the target. The HT missile is not guided during the boosted phase of its flight. Consequently, the missile trajectory is affected by the forces of gravity and wind. Several other forces affect the missile's flight path at launch. As the missile leaves the launcher, its angular velocity will impart some motion to the missile, and a part of the straight line (linear) motion of the launcher will be added to the missile's motion. Corrections for all these ballistic factors are made in the HT launcher order section. Also, an additional elevation spot is added to the launcher elevation order so the missile will fly an up-and-over trajectory. The increased elevation spot is intended to put the missile above its intended target so it can swoop down on it. The beam-rider elevation launcher order does not have this increased elevation spot because the beam-rider. trajectory is along the line of sight. The beam-riding launcher section generates launcher orders that aim the launcher so the missile can intercept the capture beam. The orders contain corrections for wind, gravity, and the effects of launcher angular and linear motion on the missile.

Either homing or beam-riding launcher orders are fed from the computer to the missile through the launching system circuits. Switches in the fire control switchboard determine which set of launcher orders is passed on to the launcher.

MISSILE ORDERS. - While missiles are on the launcher, waiting to be fired, they receive pre-flight orders which are stored in the missile for later use in flight. BT missiles receive two orders proximity fuze setting (sometimes referred to as fuze time delay), and launcher cross traverse (often called missile roll order).

BT Missile Orders. - Figure 9-13 shows the general path of BT missile orders. They originate in the missile fire control computer and flow through the missile fire control switchboard to the launching system. Within the launching system, they flow through the launching system control circuits to the launcher-top round contactor (fig. 9-13) into the booster, and finally end up in the missile itself.

FUZE DELAY TIME determines when the warhead will detonate. This preflight order sets the proximity fuze (in the warhead) so it will detonate at a distance from the target calculated to get maximum destructive effect. The best distance to get maximum destructive effect from the warhead depends principally on the target size. Large targets, because the proximity fuze will detect them earlier (the large target has more reflecting area for electromagnetic waves),

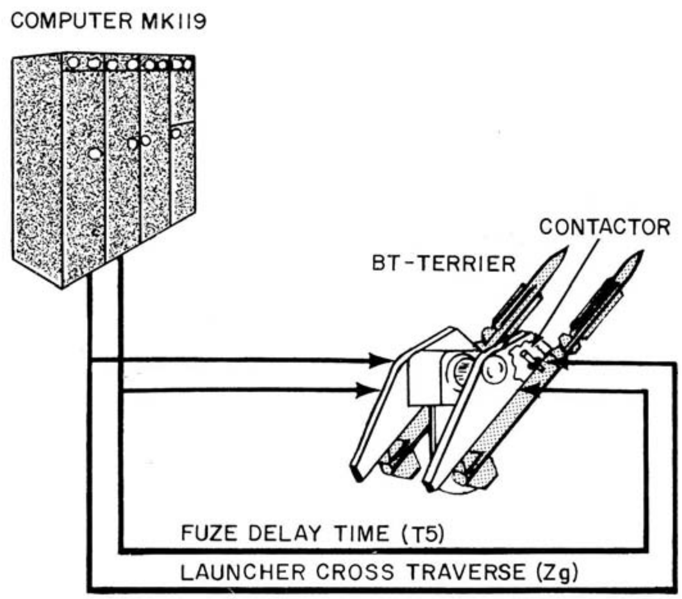

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Figure 9-13.—BT missile orders from fire control computer.

require relatively greater delay than do smaller targets. The effect of fuze delay time is illustrated in figure 9-14.

MISSILE ROLL ORDER is stored in the missile to provide a vertical reference. This order compensates for the roll of the missile while it is on the launcher (due to the roll and pitch of the ship). The missile roll gyro (fig. 9-15A) provides a reference system for guidance and roll stabilization. Before launch and during the boost phase of flight, the roll gyro is caged (locked). Therefore, the missile cannot tell which way is up. The fire control computer provides this vertical reference in the form of missile roll order. At the end of the boost period (about four seconds), the roll gyro is uncaged by a servomechanism device, the missile roll stabilizes, and its vertical reference is the reference that was supplied prior to launching. The net effect of missile roll order is to align the vertical axis of the missile guidance reference system with the guidance beam reference system.

The Terrier HT missile (fig. 9-15B) is a homing type missile. It also has a roll gyro for stabilization.

HT Missile orders. - Figure 9-16 shows the general path of HT missile orders. Preflight orders for the HT missiles are:

(1) Sweep selector signal
(2) N orders
(3) Seeker head orders
(4) Launcher cross traverse (roll order) orders

Like BT missile orders, the missile fire control computer is the common source of these pre- flight orders. All of these orders follow the same general path described for BT missile orders. Sweep Selector Signal. The HT missile looks for the target in much the same way that you would look for a program on the radio if you did not know on what station it was. You would probably start sweeping the turning knob from one end of the dial to the other while you listened for some identifying sound from the program. The HT missile seeker (fig. 9-15B) uses similar search technique. The seeker circuits (called a speed gate) sweep a narrow band of Doppler frequencies (fig. 9-17) that represent a narrow range of target speeds. To shorten the search time, the missile fire control computer determines where in the speed range the seeker should look. This sweep selection information is sent from the fire control computer to the missile before it is launched. Essentially, the sweep selector signal tells the missile receiver circuits to look for the target Doppler signal on the low end of the dial or the high end, depending on target speed. The Doppler frequency of a particular target, once acquired, should change very little unless the target executes violent evasive maneuvers which would change the missile-target range rate.

The Tartar missile also uses this method of seeking the target.

N Order. - For maximum maneuverability, the I missile is aimed and launched in such an attitude that it ascends to a high altitude and then plunges downward to intercept the target. This is sometimes called a hyperbolic trajectory. (No guided missile in current use follows a hyperbolic trajectory.) At target acquisition, however, the missile would normally perform a sharp turning maneuver and proceed in a straight line to intercept the target (fig. 9-18). Such a maneuver

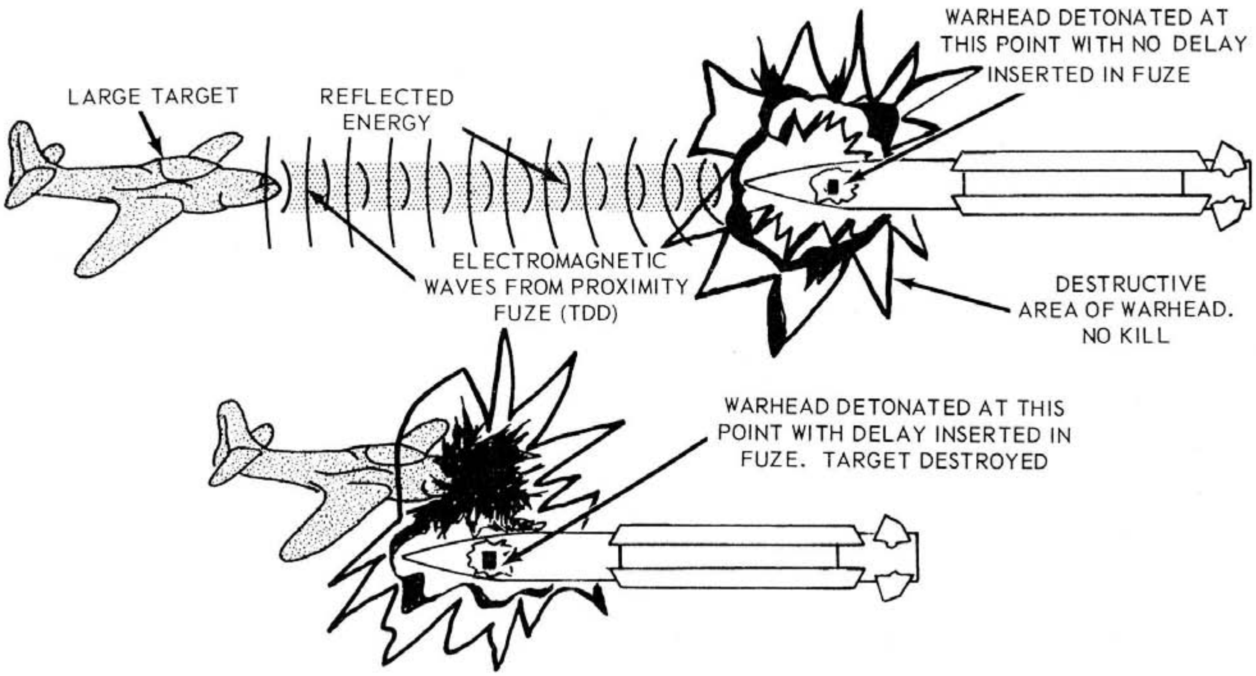

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Figure 9-14.—Effectiveness of warhead detonation: Above without fuze delay time; Below fuze delay time (T5) brings missile nearer target.

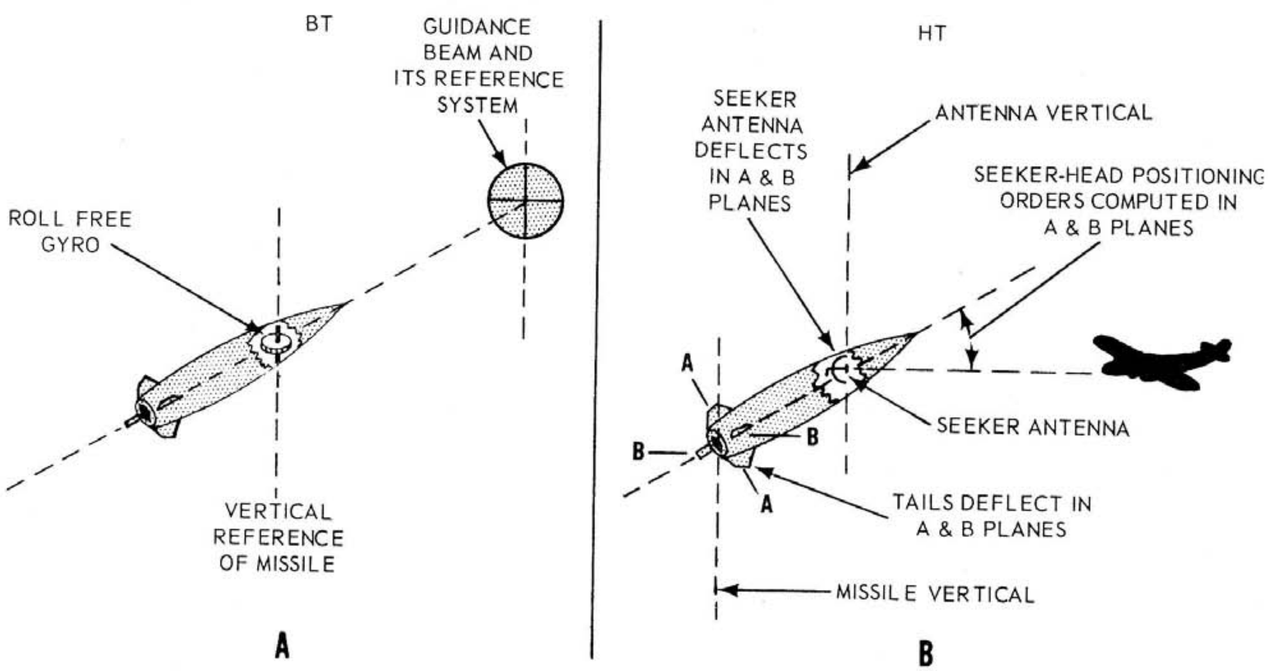

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Figure 9-15.—Missile roll order (cross-traverse): A. Terrier BT missile; B. Terrier HT missile.

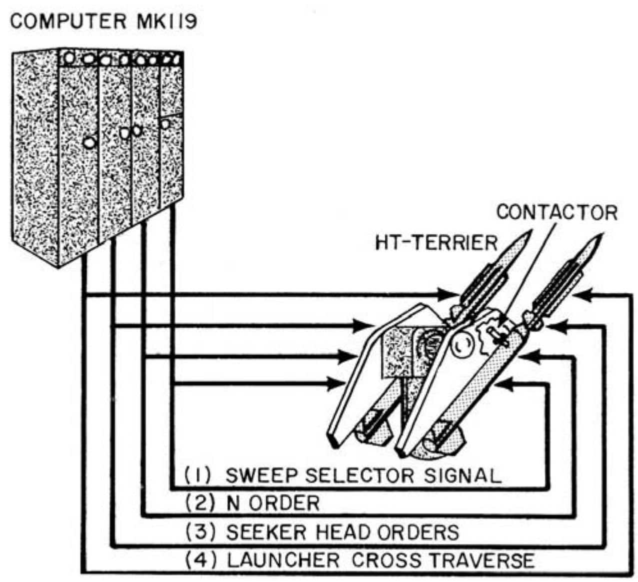

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Figure 9-16.—HT missile preflight orders.

would -cause a large loss in the velocity because of extreme control surface aerodynamic drag; and further loss of velocity because a large portion of the missile flight would occur in the denser air (with increased drag) of lower altitudes. So, to prevent straight-line intercept at target acquisition, the missile is made to turn gradually (fig. 9-18) toward the direction of target interception, thereby greatly conserving the boost velocity for the terminal phase of the missile flight and thus increasing the kill probability. The amount of turn required of the missile is calculated by the computer on shipboard and transmitted to the missile's guidance and control system, where it is stored until the homing phase. This type of missile: maneuver is also called proportional navigation, a type of homing guidance.

The rate at which the missile turns toward the intercept point for a given error signal from the seeker head is determined by a function called the variable navigation order, N.

Seeker Head Orders. - The homing Terrier missile is launched toward a point in space so it can intercept the target. The fire control computer predicts where the target will be with respect to the missile at booster burnout. This information is transmitted to and stored in the missile while it is on the launcher (fig. 9-19). The target position information is used later to position the seeker on the target. From launch until booster separation, the missile follows a ballistic trajectory. Except for maintaining the control surfaces streamlined, the missile steering system is inactive during the boost phase. Before launch and until a short time after booster separation, the seeker head is aligned with the fore and aft axis of the missile (fig. 9-15B). At booster separation, the missile is roll stabilized, for the missile must know which way is UP so it can determine the position of the target. Before launch, vertical reference information is put into the missile gyro system. Before the missile is launched, the fire control computer "tells" the missile where to look at booster dropoff. This prelaunch order is called seeker head order.

Missile Roll Orders.-Proper operation of the HT missile steering system depends on the correct missile roll attitude relative to the vertical position of the missile's roll gyro. (See part B of fig. 9-15). The vertical position of the roll gyro is established just before the missile is launched. Like the BT missile (or any guided missile for that matter), the HT missile must know which way is up if it is to be properly guided. The missile is launched in the correct flight attitude, but ship's motion is imparted to the missile at launch. So, while on the launcher, the missile is supplied with synchro information indicating roll error due to ship roll and pitch. At launch, the missile stores the existing roll error for later use. After booster separation, the roll stabilization system in the missile establishes and maintains correct roll attitude. The stored roll error signal causes the missile to rotate to the correct roll position.

Missile roll orders originate in the missile fire control computers and flow to the missile fire control switchboard. Automatic switching connects the launcher roll order circuits to either of the computers, depending on which fire control system your launcher is assigned to. Missile roll orders flow through the roll order switch and out the switchboard, then through the ship's wiring and connection boxes which are between the missile computer room and the launching

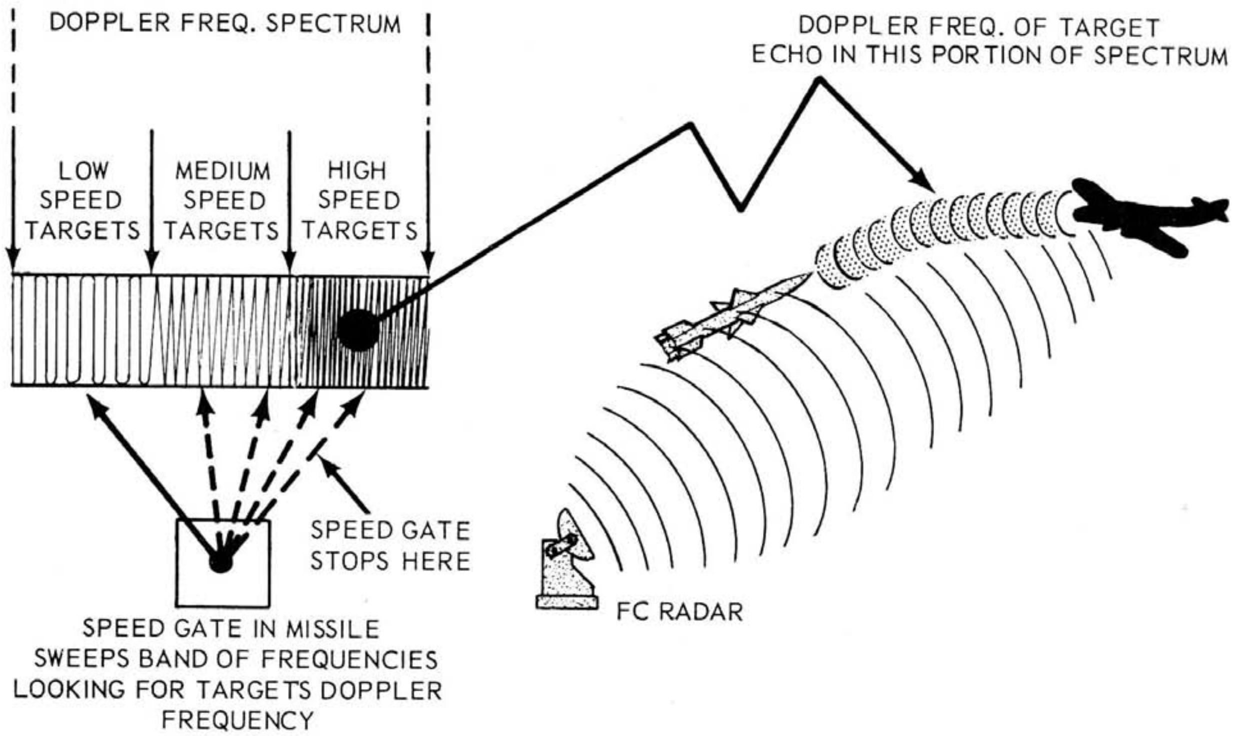

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Figure 9-17.—Sweep selection signal, used for homing missiles.

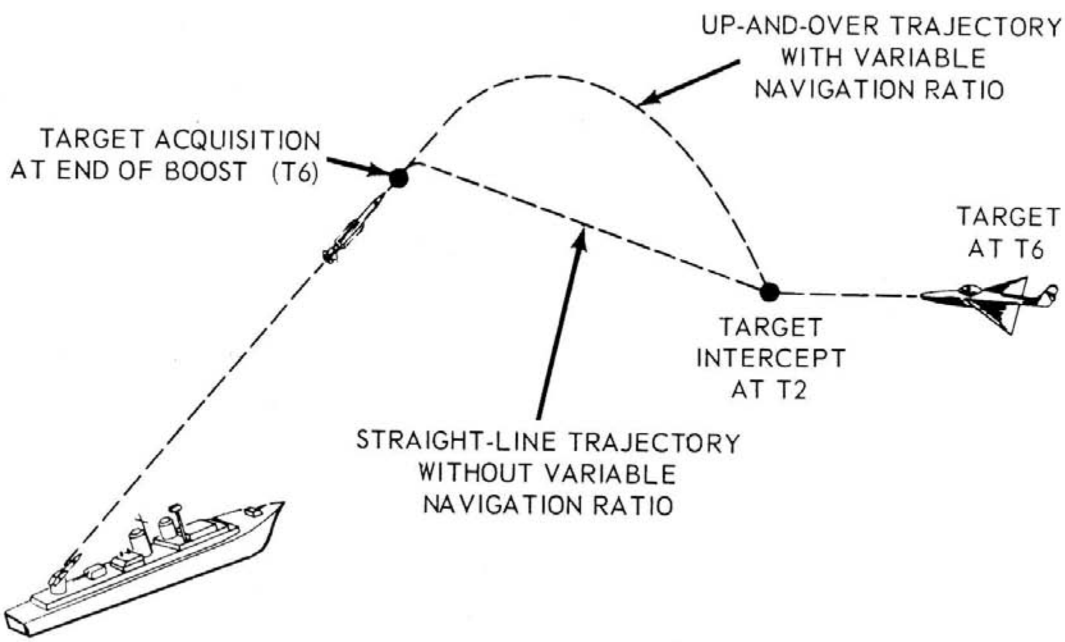

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Figure 9-18.—N order to missile.

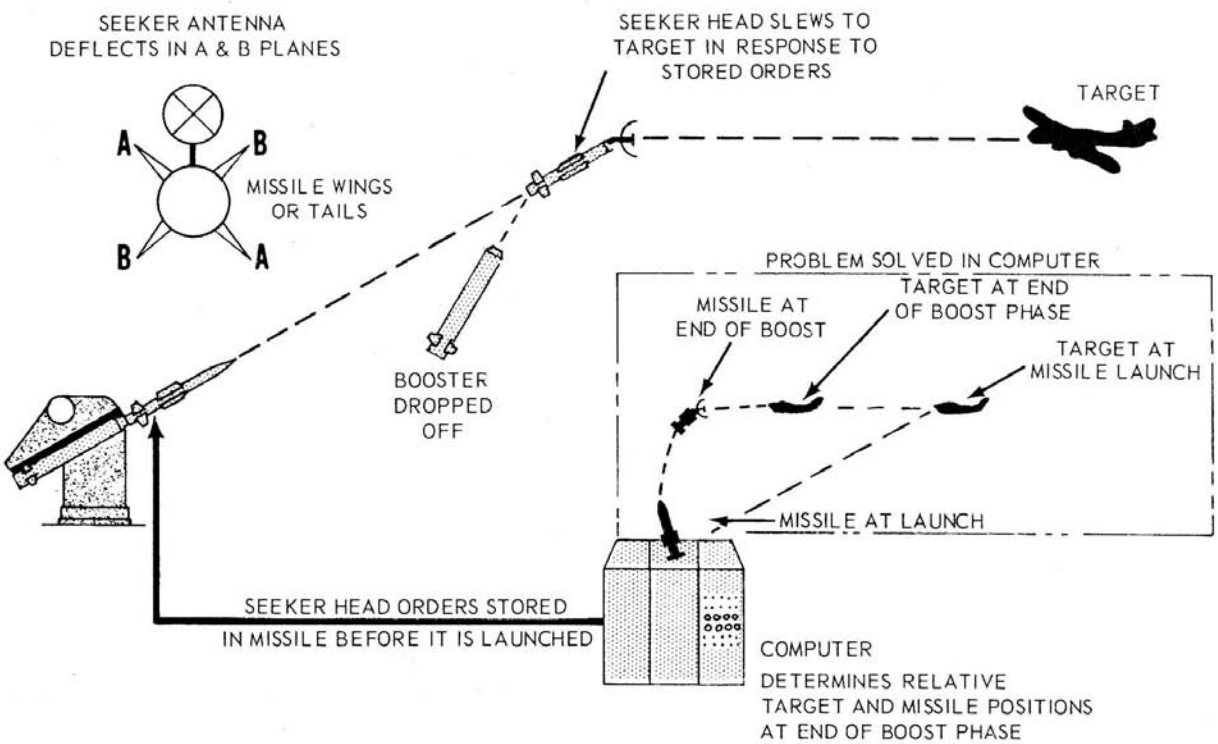

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Figure 9-19.—Seeker-head order to missile.

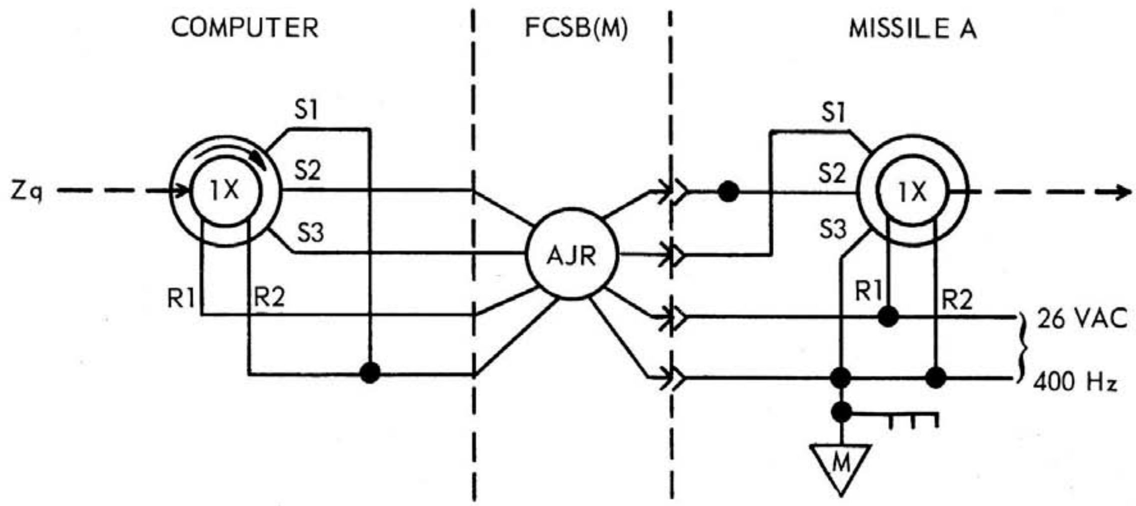
system. The launching system control circuits connect the missile roll order to the launcher, through the launcher-to-round contactor and booster pad, and then to the missile roll corrector. Figure 9-20 shows a one-function diagram of a missile roll order.

One of the many test in the Daily System Operability Test (DSOT) is to check for missile roll order. If the missile on test is not receiving the missile roll order (shown on the appropriate dial), you have to locate the point of trouble. Ask the Fire Control Technician in the missile computer room if roll order signals are coming but of the switchboard (fig. 9-20). If they are, then you know the trouble is in the circuits for which you are responsible, and you have to break out your one-function diagrams and begin troubleshooting.

The Director

As indicated in figure 9-1, there may be more than one director in the missile fire control system. A target is assigned to the director by the operator of the Director Assignment Console (DAC), and the director then begins tracking that target. When it has acquired the target, it goes into automatic tracking. It operates the TRACKING MODE switch, and this places the computer in the TRACKING mode. As soon as the computer has reached a solution, the symbols for target present position, target course line, point of intercept circle, outer range limit ellipse, and launcher bearing circle appear on the display scope of the WAC (fig. 9-9).

When the DAC operator is assured that the director is tracking the target satisfactorily, he releases the channel, and can assign it to another target if necessary. The launcher orders, missile roll orders, radar-phasing orders, and display data are now all valid. As soon as the WAC operator determines that range, clearance, and missile capability data are favorable, he assigns a launcher to the fire control system. The fire control switchboard connects the launcher to the computer. The computer determines the time to intercept for the weapons control system. The LAUNCHER ASSIGNED lamp lights on the



94.102

Figure 9-20.—One-function diagram of missile roll order for missile on A arm of launcher.

WAC, and at the director the CODE SELECT and ASSIGNED lamps light, and the warning bell sounds on the radar test set.

The code select circuits are enabled, the launcher slews to comply with the computer orders, and the missile receives correct roll orders and the DIRECTOR SELECTED signal, setting the missile code for the director selected. The launcher is now synchronized and ready to fire as soon as the weapons control officer gives the word and the WAC operator presses the firing key.

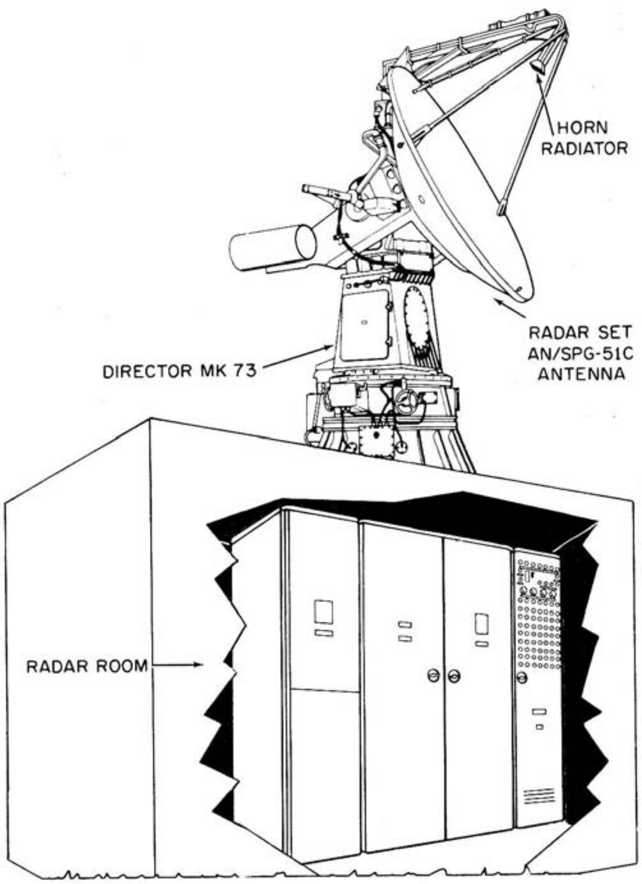
The director is also called the radar set. A gun director may contain a radar and/or optics for tracking and ranging. A missile director depends on the radar for tracking and is unmanned, though there is an operator in the radar control room, chiefly to monitor the equipment. The radar not only tracks the target, continuously transmitting target position to the computer, but it also transmits beams to control the missile (beam-riding or semiactive homing, or combination) and to guide it to its target.

The part of the director or radar set that is above deck is called the antenna group (fig. 9-21) and consists of a pedestal on which are mounted the antenna and the electrical and mechanical components required to stabilize and position the antenna. Inside the mechanical structure are the transmitting, receiving, and associated microwave circuits, and the gyroscopes needed to space-stabilize the antenna. The control and power group of the radar set is located below decks in the radar room.

Missile fire power is closely related to director activity. A missile director must stay on a target throughout missile flight to provide the necessary guidance. The assigned target time (director activity) of each director depends upon target range, therefore a ship's missile target handling capacity depends upon the amount of missile directors for each missile system installed.

Stable Element

Stabilization of missiles in flight has been mentioned several times in the discussion of missile orders, missile roll orders, and seeker head orders. All gun and missile systems must have means to correct for ship's roll and pitch; gyroscopes or stable elements are used by the ship, the missiles, and the fire control systems. The radar set shown in figure 9-21 uses Computer Mk 118 Mod 0 and associated stable elements. The gyros in the mechanical structure of the antenna group space-stabilize the antenna to compensate for the roll and pitch of the ship. Several installations of gun fire systems have Stable Element Mk 6 Mod 1 in the gunnery plotting room, and a Stable Element Control Panel, used to start and to monitor the stable element, in the missile plotting room. Under



141.82(141B)
Figure 9-21.—Fire Control System Mk 74: Radar AN/SPG-51C, Director Mk 73, and radar room with consoles.

certain conditions, target assignment and target position data may be transferred between the missile system and the gunnery system. The stable element measures the level and crosslevel angles caused by the variation in the position of the deck of the ship with respect to the horizontal. These angles are used to keep the line of sight of the director positioned automatically on the target while the ship rolls and pitches.

The principles of gyros and their use in missiles were described in the preceding course, Gunner's Mate M (Missiles) 3&2, NAVTRA 10199. Because the spin axis of a gyro is fixed in space, the gyro can provide stabilized reference planes from which various angles, lines, and motions in the fire control problem can be measured. The gyro in the stable element measures the amount of roll and pitch of the ship and sends correction angles to the computer.

A gyro that measures the rate of change is called a rate gyro. A single-degree-of-freedom gyro is used extensively in fire control systems both as a computing device and a stabilizing device. It can detect and measure an angular rate of change of position of an object. In fire control, we are most concerned with the angular rate of change of position of the target. The director-radar tracks the target, measuring the target's position and changes of position. The term relative rate is sometimes used instead of angular rate. The speed of the target plus change of trajectory due to ballistic factors must be measured to determine target position at a given moment.

ALIGNING THE MISSILE BATTERIES

Alignment may be considered as of two types-alignment of all parts of a component so it functions correctly and smoothly, and alignment of all the components of a weapons system so they function properly as a whole system. Most of the paragraphs and sections on alignment that you find scattered through OPs are of the first type-how to adjust and align the parts of a component. If the weapons system has been manufactured and installed properly, and it is functioning as intended, it is best not to tamper with it. Adjustments may need to be made to correct for wear or damage.

The alignment of all the components of a guided missile weapons system is done originally by the shipbuilder. Refinements and readjustments may be necessary as the system is "worn in." Some of these realignments are made on the shakedown cruise.

SOURCES OF ALIGNMENT INFORMATION

The basic text on alignment is OP 762 (Second Revision) Alignment of Ordnance Installations Aboard Ship. Although gun battery alignment is explained in the most detail, the basic principles and techniques of battery alignment are applicable to missile battery alignment.

Many of the procedures can be carried out only at a shipyard, but ship's personnel must work with shipyard personnel to do the job. On ship-board, the men from several ratings must cooperate to check the alignment of the missile systems and to make any adjustments. The quals require the GMM 1 & C to assist the fire control officer in the alignment of missile batteries. You learned about fire control principles in the course for GMM 3 & 2.

OP 2456, Battery Alignment, has a separate volume for each type of ship. For example, volume 8 is Battery Alignment, DLG Type. Ships. The description of procedures is written for guns, but the same methods are used for missile systems. ODs give specific instructions and drawings for each installation; these usually describe procedures to be used during installation of the weapons system and alignment after completion of installation and before the ship is seaborne. All information on the installation and alignment is kept on board to be used for reference when realigning or adjusting. The Publications Requirement List. names all the publications that should be aboard. OD 17425, for example, lists all the publications placed on guided missile frigates, DLG 26 class. From this list you can select the publications you need to study to do your part in aligning the weapons system. The ODs are revised from time to time, so be sure you have the latest one.

Alignment and adjustment of the components of a weapons system must be made with exacting care. Before attempting to do any of this work, make a check list that you can follow, and make yourself thoroughly familiar with the procedures to be followed. Since you will not be operating alone, work it out with the men who will be at different stations.

SYSTEM ALIGNMENT

Alignment work done while the ship is afloat consists principally of tests and adjustments required for keeping the weapon system in readiness to deliver with the maximum effectiveness. Realignment is necessary because the ship's hull is a flexible structure and is subject to small but significant changes in shape when it leaves the drydock. These changes in hull shape can cause appreciable changes in the alignment of a battery. The details of the alignment procedures afloat are considerably different from drydock alignment because the ship is in motion and the instruments and references on shore cannot be used.

System alignment requires orienting and adjusting the several components to each other so they function properly as a whole. No alignment work should ever be undertaken without first making careful tests to make certain that adjustment is necessary. Before changing any adjustment, make a careful analysis to determine alignment errors and calculate the adjustments necessary. An incorrect or unnecessary adjustment can cause serious trouble in the system.

Shipyard Alignment

Before any alignment can be done on a new ship, a reference frame must be established. First, a reference point is selected from which measurements are made. Then a reference direction and a reference plane are selected. These three references are the reference frame (fig. 9-22). Directions are expressed with respect to the reference frame. The horizontal plane is the one most commonly used, and the ship's deck is nominally the horizontal plane. When the ship is afloat, the deck cannot be used as the horizontal reference plane because of the constant movement of the ship. Bench marks are set and tram readings are made while the ship. is in drydock, and these are used as references when the ship is afloat.

During the construction of a ship, one or more base plates (fig. 9-23) are installed within the hull of the ship. These plates are referenced to a similar plate mounted on a fixed ground installation. The plates are leveled as accurately as possible before the ship is launched. An imaginary base plane is figured from the averaged readings taken from the base plates. The fire control reference plane is parallel to the construction base plane and is the reference from which all system elements are aligned. A. vertical plane perpendicular to the fire control reference plane and lying along the ship's centerline is the zero train reference for all system elements.

Zero train position is established during original alignment in the drydock.

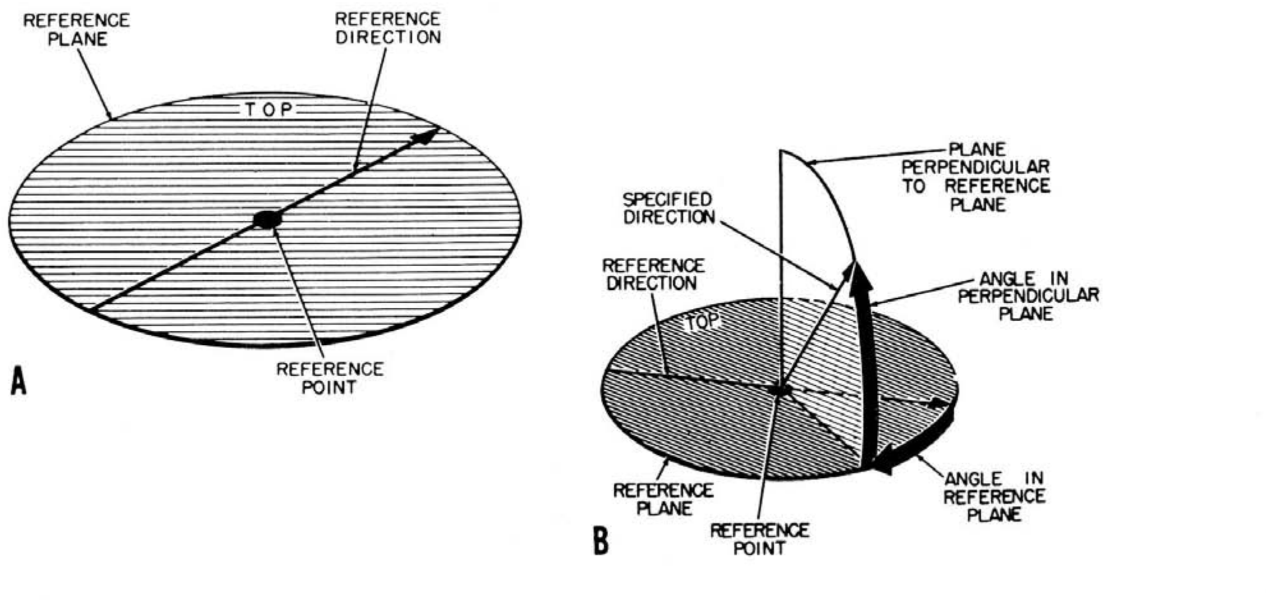


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Figure 9-22.—Reference frames: A. Representation of reference frame; B. Expressing direction with respect to reference frame.

After battery alignment in train, comes alignment in elevation. The purpose of alignment in elevation is to set all elements so that when they are positioned in elevation with their pointing lines parallel to the reference plane (vertical parallax zero), the elevating dials of the elements will read zero and the elevation synchros will be at electrical zero.

So that guns and launchers can be realigned to the same position, bench marks and tram readings are provided.

BENCH MARK. - For purposes of checking director's zero train at sea, a bench mark and bench-mark reading are established. The bench mark usually is a small brass plate with crosslines etched on it. This plate (fig. 9-23) is welded to a secure part of the ship within vision of the director's sights. After zero director train has been established and the dials set, train the director and put the cross wires of the boresight or telescope on the bench mark, and read the train angle-read dials. This is the bench-mark reading which should be recorded, and which will remain the same until such time as new drydock data are obtained. The same telescope must be used for obtaining all settings and readings. The launcher is trained to position its rails parallel to the zero train reference plane and the train indicators are adjusted to the indicated zero train. Then the launcher is elevated to position its rails parallel to its roller path plane and all elevation indicators are adjusted to indicate zero elevation. The maximum amount of deviation permitted for each element is shown in figure 9-23.

TRAM READINGS. - A reference point for each turret, mount, or launcher must be established to check the accuracy of launcher or gun train dials at sea. The original tram readings are taken after zero mount or launcher train has been established and the dials set. However, unlike bench-mark readings, which never change, tram readings will change each time response is broken and any alignment correction is made to the mount or launcher. New tram readings must be taken and recorded after making any alignment correction between mount or launcher and director.

Shipboard Alignment Requirement

The alignment requirements for a weapons system include internal alignment of each of the components and system alignment of the different components or elements with each other.

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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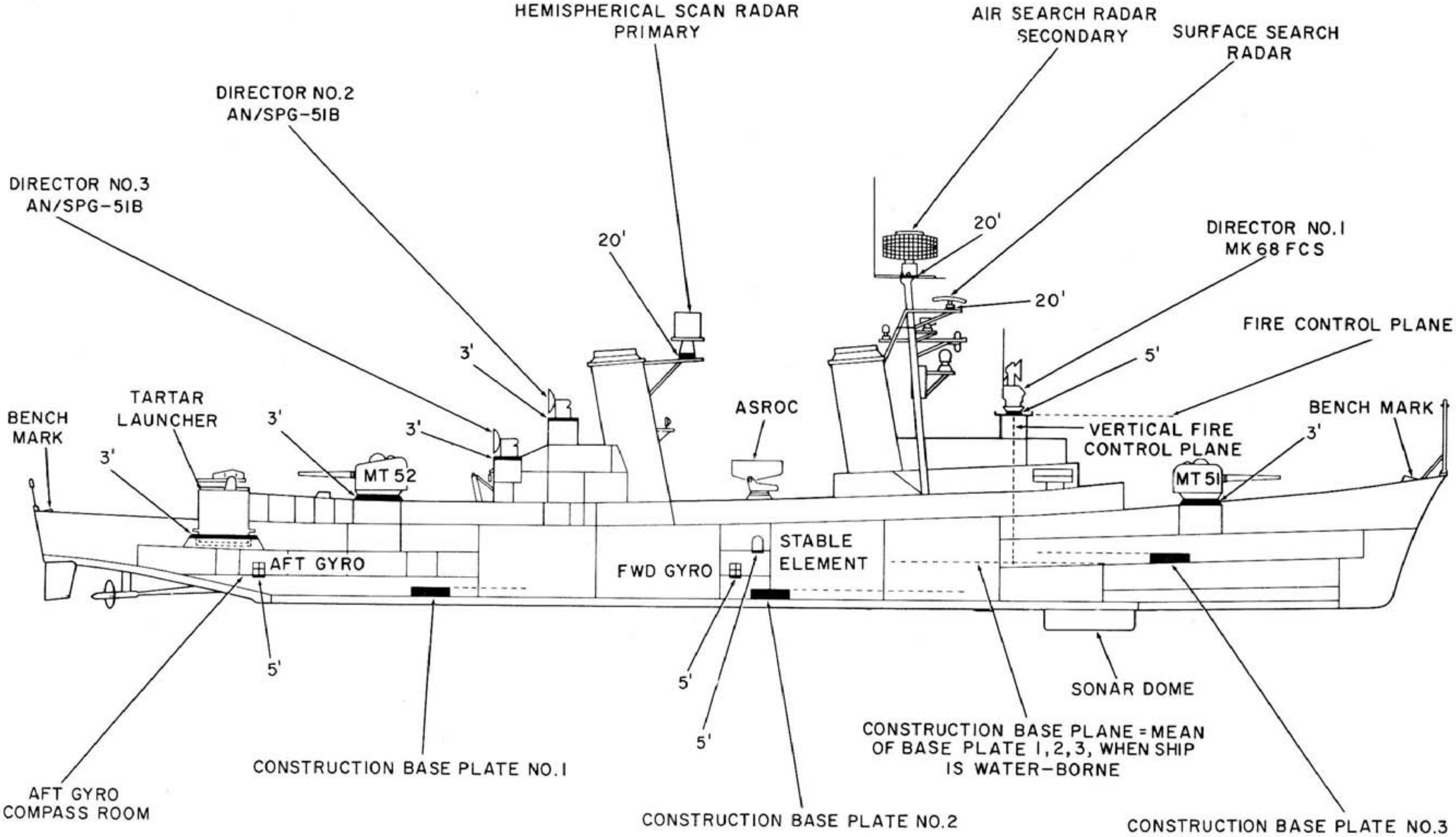

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Figure 9-23.—Mechanical Foundation Tolerances.

The internal alignment of an ordnance element is established at manufacture. A high degree of machining and fitting structural parts assures good internal alignment. If any basic alignment is necessary because of faulty manufacture, overhaul at a navy yard usually is necessary. Each director should be internally aligned with the ship's references (fig. 9-22). All parts of the weapons system are aligned to the reference while the ship is being outfitted or in dry dock, and the whole system is tested. When the ship is afloat, the operation of the system must be rechecked. If there are serious distortions, the ship is returned to the shipyard for adjustments.

The launchers and guns must be aligned to the directors in tin and elevation.

Alignment work done while the ship is afloat consists principally of tests and adjustments required for keeping the ship's ordnance equipment in readiness to deliver fire of maximum effectiveness.

We will not describe all the procedures of battery alignment that apply to the many different types of ships. However, if you understand the following procedures, which are based chiefly on procedures given for the Tartar system on DDG-2 class ships, you shouldn't have much difficulty on any other type of ship

On DDG-2 class ships, Gun Fire Control System Mk 68 is aligned first, and Missile Fire Control System Mk 74 is aligned to it. The Gun Fire Control Director Mk 68 is the reference director and the Missile Fire Control Director Mk 73 is aligned to it in train and elevation. Director Mk 68 is used to determine the alignment condition of all rotating elements with the exception of the missile launcher and the gyrocompass, which are aligned to Director Mk 73. The work of aligning the directors is not done by GMMs, but that work must be completed before the launchers can be aligned. Your alignment checks should be done soon after the directors have been aligned.

We should mention here a preliminary check which must be made before any alignment afloat work is undertaken. This is the transmission check. Synchro and dial errors corrected at this point will keep you from compounding the errors, or introducing errors to correct for errors in the ensuing alignment procedures. (Of course, these errors, even if initially undetected, would be revealed before you completed your alignment work. But by then you would be faced with the task of redoing one or more of the alignment phases.)

Do not proceed with synchro alignment unless the preliminary check shows a misalignment. If the synchro is close to zero, make only the fine adjustment. Be sure to use a power source of correct frequency and voltage since damage will result otherwise. Do not keep the synchro units energized any longer than necessary. If a synchro feels hot when touched, deenergize it and allow it to cool.

ALIGNMENT OF LAUNCHER

Precise alignment of the launcher requires extreme accuracy in the performance of alignment checks and adjustments. The manual train and elevation features of the Mk 11 launching system make checking very difficult when there is motion of the ship. It is suggested that the checks be made with the ship moored to a pier or at anchor in a calm sea. If the safety warnings are heeded, the checks and tests can be made without damage to the equipment or injury to personnel.

When ready to proceed with launcher and gyrocompass alignment, man the launcher and the gyrocompass, and establish telephone communications on the JCT phone circuit.

Alignment in Train

The train alignment check provided an accurate method or determining the degree of parallelism between the zero train lines of all elements of the system. When the director is trained to any point and the launcher dial pointers are matched with zero settings, the director and launcher lines of sight are parallel in train.

Since the ship is now afloat, it is impracticable to use multiple targets to obtain parallelism between the launcher and director. However, if the lines of sight of both director and launcher are aligned on a target at infinite range, for all practical purposes they will be parallel. This method, commonly called "shooting the moon," is the most accurate method of train alignment afloat. It is also called alignment on a celestial body.

When train alignment is performed simultaneously for several equipments, the train dial readings from all stations should be transmitted to a central station (such as the missile plotting room) for systematic recording. The recorders at the individual elements should cross check all readings to eliminate possible errors in recording the readings. Rotation of the earth and ship motion may cause the line of sight to drift from the target, but this drift is not detrimental as long as the line of sight is on the target when the reading is taken.

Install Boresight Telescope Mk 75 (modified) in Launcher Mk 8 (fig. 9-24) on the stationary guide, and insert a T-lug in the front guide of the B-rail. The T -lug prevents the front guide from tripping, and thus prevents personnel injury. Install the peepsight on the forward end of the guide arm.

Be sure the launcher is not energized when it is being manned for alignment and test purposes. Gear all unnecessary personnel from the area. An observer is stationed inside the launcher to read the train and elevation dials.

BENCH MARKING THE LAUNCHER. - The boresight operator should have the bench mark in his field of vision. The launcher is manually trained until the vertical crosshair of the borescope coincides with the vertical index on the bench mark. This should be done several times, training to the right and to the left of the bench mark to check on the first alignment. Do the same for elevation.

CORRECTING TRAIN ALIGNMENT ERRORS. - Before attempting to correct the error of equipments, carefully analyze the results of the train alignment check. Generally, a small deviation from zero (say, 2') is acceptable. A careful analysis of the launching system is required to determine whether the misalignment is caused by the components of the launching system or those of the fire control system. Misalignment within the launching system may cause serious casualties in the equipment. To isolate the cause of any misalignment, check the operation of the launching equipment to the fixed mechanical positions of STOW, DUD JET A, DUD JET B, LOAD, and TRANSFER. If the launching system operates correctly in those positions in train and elevation, the trouble is in the fire control system. Emergency adjustment can be made at the computer. Afterward, a transmission check must be made between the computer and the launcher. The launcher train dials should indicate launcher train order plus the correction applied. The results should be recorded in the Battery Alignment Log.

To correct the train dial, which is in the train receiver-regulator under the launcher shield, deenergize the launcher. Locate the adjustable (vernier) coupling on the B-end response shaft of the receiver-regulator, loosen the lockscrew of the coupling, and adjust the coupling to correct the train response dials by the amount of the TRAIN dial error. In other words, make the train dial reading equal director train dial reading when both are on target and in manual operation. Tighten the lockscrew on the adjustable coupling and recheck according to the previously described procedure. Continue to make adjustments until the error is within the allowable tolerance.

Elevation Alignment

The launcher is aligned in elevation to the director. It is elevated in manual control to bring its rails into position parallel to its roller path

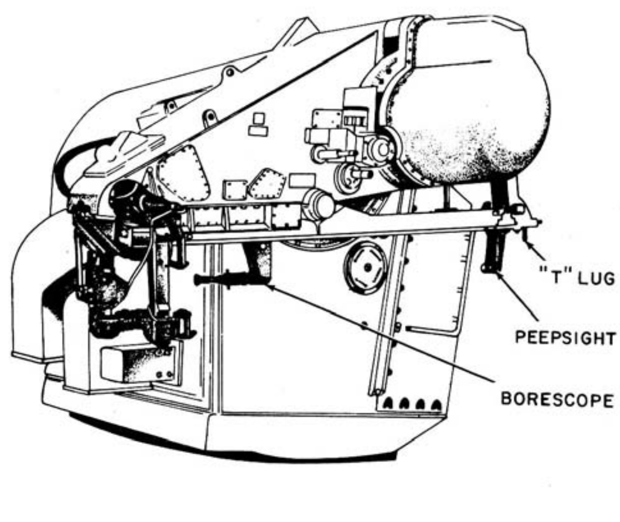


Figure 9-24.—Boresight Telescope Mk 75 installed in Mk 8 launcher.

plane (at a point of known inclination) within 3' of arc. All elevation indicators are adjusted to indicate zero elevation.

The Mk 75 boresight telescope is installed on the stationary guide as for train alignment (fig. 9-24). The T-lug is inserted in the front guide of the launcher B rail. The peepsight assembly is installed on the forward end of the guide arm at a point about 5/8 inch from the rear of the front guide.

The launcher must not be energized for alignment or test; set the safety switch on the EP3 panel to SAFE and remove the handle. The train and elevation securing pins are released by turning the clamp screws, using handcranks. When the securing pins are fully retracted, they are locked in that position with the clamp screws. The train and elevation latches also have to be released, and hydraulic pressure is needed for. that. Energize the launcher elevation motor and retract the latches by depressing the latch retract buttons. Then deenergize the launcher. Hydraulic pressure is maintained by use of the hydraulic hand pump.

The launcher is then moved manually with the aid of a large crescent wrench. When the line of sight through the boresight is parallel to the director line of sight, release the hand drive. The man at the elevation receiver inside the launcher shield gives the elevation readings as the launcher is being moved. When the man at the director calls "mark," the dials should be at zero.

ELEVATION HORIZON CHECK. - The elevation horizon check provides an accurate method of determining elevation alignment errors between elements under normal operating conditions and a method of determining the relative inclination between the roller paths of the reference and nonreference elements while the ship is afloat. The aft missile director (no. 3, fig. 9-23) is used as the reference element for the Mk 11. Tartar missile launcher and he Mk 19 gyrocompass.

The horizon check is conducted by comparing the dial readings at the director and at the launcher as they are aimed at a series of points on the horizon. The ship should be underway, on a steady course, with a ship's speed of between 5 and 10 knots. A clear, clam day with a well-defined horizon is necessary.

The borescope should be installed in the launcher as for train and elevation check. All stations participating in the check should be manned.

Since the various elements of the missile battery are installed at different heights about the waterline, the dip angles of the elements will differ. The dip angle is the angle by which the line of sight of an element must be depressed before the horizontal to place the line of sight on the horizon. Figure 9-25 illustrates dip angles and dip differences. The dip angle is given in minutes and the height (H) is the height in feet of the element optics above the waterline at mean ship draft. The angle is computed by the formula:

$$\text{dip angle} = .98\sqrt{H}$$

Before the elevation horizon check is begun, record the dip angle of each element.

The director is trained to a suitable bearing and depressed to below 0° elevation. Each element that is being checked is trained to the same bearing and then depressed to the horizon. Then the director is positioned so the line of sight is on the horizon. As the line of sight approaches the horizon, the operator calls "Standby," to alert the operators at the other stations. When the line of sight is exactly on the horizon, he calls out "Mark." The operators of the elements being checked correct their elevation until the line of sight is exactly on the horizon. When all are aligned, the elevation dial readings are recorded.

These readings are taken throughout the full arc of launcher train, with readings at every 15° of bearing. All data are recorded on worksheets and the information is then plotted on graph paper for analysis.

There should always be a difference between the launcher and director elevation reading due to the difference in height of these elements aboard ship. The director, being higher, must always depress further to sight on the horizon than the launcher. This angle of depression onto the horizon is called "dip angle." The difference between dip angle of the director and dip angle of the launcher is called "dip difference." When the launcher and director are properly aligned in elevation, the zero axis of the horizon check curve should be above the zero axis of the graph by the amount of dip difference. If the zero axis of the horizon check curve fails at any other point on the graph, an elevation alignment error exists. This error is positive (high) when the zero axis of the curve is above the value of the dip difference, and negative (low) when below the value of dip difference.

To compute dip angle and dip difference consult ship's plans to obtain the height of the elements above the waterline. Enter table 9-1 at this height to obtain the dip angle to horizon. Subtract the dip angle of the launcher from the dip angle of the reference director. The difference is dip difference. It should be constant at all bearings.

All elevation readings are in minutes. On those elements having response dials graduated in degrees and minutes, the dial reading must be transposed to minutes, with 2000' representing zero elevation.

Generally, an error of ±3' is acceptable. Small errors may be the result of incorrect readings. For this and other reasons, it is better policy to do no adjusting of the dials unless large errors are found, after several readings have been taken that definitely indicate that adjustment is needed.

Since most missile system elements do not have roller path tilt correctors or leveling rings, no adjustments can be made to correct for errors in roller path tilt aboard ship. When roller path tilt errors are found to be excessive, correction is accomplished at a shipyard.

FIRING STOP MECHANISMS

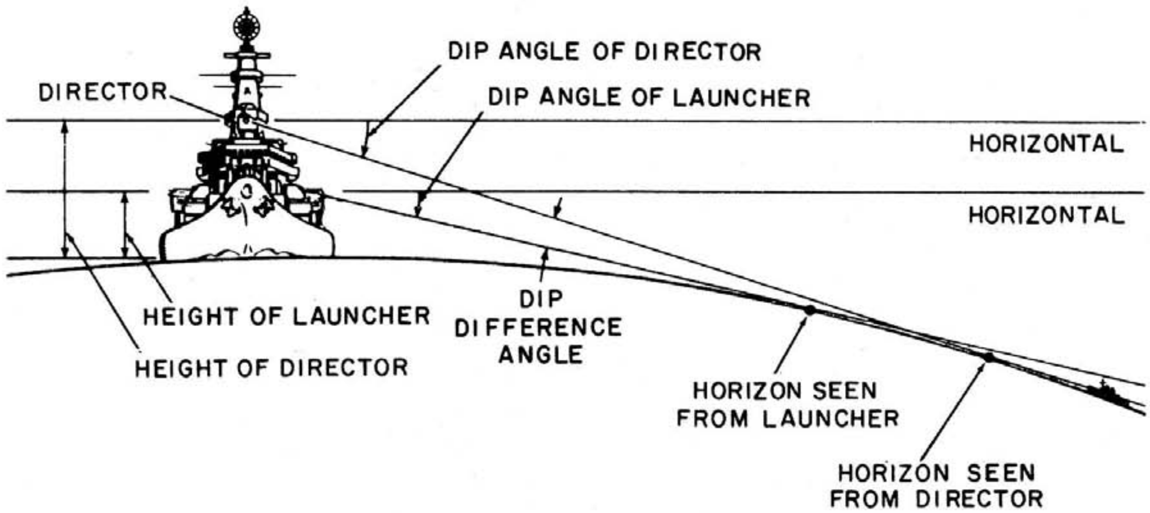
It's hard to overemphasize the importance of checking the firing stop mechanisms after making the original alignment, after doing any work or repair on the launchers that would disturb the firing stop mechanism, or in the course of routine checkups. Every casualty from ships firing into their own superstructures testifies to the seriousness of ANY misalignment. of the firing stop mechanisms Equally important: In EVERY case these casualties could have been prevented. They resulted from negligence on the part of the ship's personnel; or cams were cut improperly and in some cases misaligned; or the firing stop mechanisms were inoperative through lack of preventive maintenance.

As you remember, firing stop mechanisms are designed to interrupt electrical firing circuits and firing mechanism linkages whenever guns and launchers are trained or elevated to a position where firing the guns or launchers would endanger personnel or damage the ship. They should not be confused with the depression stop cams that are used occasionally to limit the movement of some guns and launchers to a safe zone of fire, or with train or elevation limit stops. Firing stop mechanisms do NOT interface with the free movement of the gun or launcher.

The Naval Ordnance Systems Command has issued definite instructions for the guidance of

Table 9-1.–Dip of the Sea Horizon

Height, ft	Dip	Angle	Height, ft	Dip	Angle
	'	"		'	"
1	0	59	27	5	06
2	1	23	28	5	11
3	1	42	29	5	17
4	1	58	30	5	22
5	2	11	31	5	27
6	2	24	32	5	33
7	2	36	33	5	38
8	2	46	34	5	43
9	2	56	35	5	48
10	3	06	36	5	53
11	3	15	37	5	58
12	3	24	38	6	02
13	3	32	39	6	07
14	3	40	40	6	12
15	3	48	45	6	36
16	3	55	50	6	56
17	4	02	55	7	16
18	4	09	60	7	35
19	4	16	65	7	54
20	4	23	70	8	12
21	4	29	75	8	29
22	4	36	80	8	46
23	4	42	85	9	02
24	4	48	90	9	18
25	4	54	95	9	33
26	5	00	100	9	48



92.48

Figure 9-25.—Dip angle and dip difference.

the personnel responsible for plotting, cutting, installing, and checking firing cutout cams and mechanisms. These regulations apply strictly in all cases. In addition, special instructions govern particular installations.

The computations for the missile's trajectory and for the necessary safety clearances relative to the ship's structures and equipments are complicated and extensive. A high degree of precision and skill are required to make these computations, and to prepare and install the cutout cams in the launchers. The computations are now done with the electronic computers at the Naval Weapons Laboratory, and the cutout data prepared for the requesting ship. NWL also prepares the cutout cams and assists in installing and adjusting the cams. This was formerly done by the shipbuilding activities. OD 16581, "Method for Determining Pointing and Firing Cutout Zones for Shipboard Guided Missile Launching Systems," is the instruction followed. When a new cam is installed, it is essential that the two train reference points be reestablished. These are the train B-end stopped position and the non pointing zone cam arrested position. The nonpointing zone switches must be rest accordingly. NWL personnel will assist you in this.

The firing interrupter cams are plotted, scribed, and cut during the final stages of the initial installation or overhaul period and after I all installation and alterations to the topside, superstructure, masts, and rigging are completed.

New firing interrupter switch operating cams must be scribed, cut, and installed whenever changes in the topside arrangement of the ship affect existing areas of fire.

Procedures for scribing and matching the firing interrupter cams are given in the applicable OD. Performance of the cams should be checked before each firing, monthly, and whenever new cams are installed.

The Tartar system actually has four interrelated systems to ensure safe operation of the launcher. These are the (1 and 2) limit-stop system for train and elevation; (3) the automatic-pointing-cutout system; and (4) the automatic-firing-cutout system. The nonfiring zones are identical with the nonpointing zones. The train and elevation systems are physically and mechanically separate but are electrically connected through the automatic-pointing-cutout system and the automatic-firing-cutout system. The components of these systems - cams, levers, switches, brakes, etc. - are in the train and elevation receiver regulators. The pointing cutout system prevents movement of the launcher into zones in which firing would be hazardous. The firing cutout system opens the firing circuits so the missile cannot fire when the launcher is in a nonpointing zone or the strikedown gear is attached to the launcher. The train and elevation limit-stops restrict launcher movement under certain conditions. When activated, the limit-stop system neutralizes the associated power drive, thus limiting the movement of the launcher. The limit-stop cam controls the deceleration rate of the launcher power drive. Train and elevation require different rates of deceleration, and consequently their cams differ in contour. The actuating cams are identical. When the launcher approaches a nonpointing zone, they start the limit-stop system.

CAM ALIGNMENT

An adjustment screw is secured to the bottom of each limit-stop cam. To aid in alignment, scribe lines are scored into the cams. The position-plus-lead cam stacks, which indicate to the automatic-pointing-cutout and automatic-firing-cutout systems, have a vernier that permits simultaneous adjustment of all the cams in the stack, and each cam can be adjusted to a vernier in its base.

Firing interrupter cams, limit-stop cams, and associated shafts, switches, and components are present by the manufacturer and the installing activity. These cams do not require routine adjustment. They should be checked periodically and should be reset only if they are not within plus or minus 1° of actual launcher settings.

When the launcher is operated in TEST, the firing cutout system is checked. You will need checkout sheets for your system to indicate which lights will activate on the test panel for each condition.

RADAR ALIGNMENT

All elements of the guided missile battery are aligned in the same manner as a conventional weapons battery. There is, however, one additional step that must be accomplished before commencing the battery physical alignment. That is the alignment of the radar reference beam and the optical boresight telescope of the radar antenna. This is accomplished by use of a shore tower approximately 100 feet high and at least 1300 feet from the ship, on which is located an optical target and a tunable radar transmitter.

In some missile systems, the radar beam is used as the reference for this alignment. The radar beam is trained and elevated to the tunable transmitter and electrically aligned. The boresight telescope is then adjusted to the optical target and locked in place. In other missile systems the boresight telescope is the reference. The boresight telescope is trained and elevated to the optical target on the tower and then the radar beam is aligned to the tunable transmitter. This is the most critical alignment because in both cases the boresight telescope, after aligning, becomes the only reference line of sight for the director.

The above is drydock alignment, performed by shipyard personnel, perhaps assisted by FTs. When the ship is afloat, the radar reference beam is again checked (by FTs). While at the pier, the shore towers are used. At sea, all guided missile ships will use bow and/or stem towers, installed in accordance with current NAVORD instructions. Each tower will contain an optical boresight target, a capture antenna, and a track and guidance antenna.

In discussing the alignment of guided missile radar systems, we talked about the alignment of the reference beam to the boresight telescope. But there is more to guided missile radar beam alignment (collimation) than that. In some of our guided missile radar systems we have as many as four different radar beam: track, capture, guidance, and illumination. These must all be collimated to their own zero positions (beam zero indication) and to the reference beam. In some guided missile radar systems the guidance beam is used as the reference beam while in others the track beam is used. Whatever beam is. used, the problem is the same; all the other beams must be collimated to the reference beam. The role of the GMM in aligning the radars to the missile is to prepare the missile for testing, and to cooperate with the FTs who conduct the tests.

SONAR-TO-RADAR ALIGNMENT CHECKOUT

The sonar alignment check is performed to assure that the AN/SQS-23 sonar is accurate to the degree required by the ASROC weapon system. This check is accomplished by comparing sonar range and bearing with radar range and bearing of a surface target or a snorkeling submarine.

This check should be made monthly or whenever a target ship is available. Because the complete checkout requires considerable time, the entire check may be divided into sections so that at least one section of the check can be accomplished when a target ship is available. A different section of the check should be made each time. Fewer than the recommended bearing readings may be taken for each run when scheduled operations do not allow sufficient time for the complete check.

Selection of a fire control director to be used in this alignment check varies from one class of ship to another. In general, however, the director nearest the sonar transducer should be used. If the horizontal distance between the selected director and the sonar transducer exceeds 20 yards, compensation must be made for horizontal parallax.

The sonar alignment check consists of simultaneous sonar and radar determination of range and relative bearing of a target ship while both the target ship and own ship are on a parallel course at the same speed and at a predetermined range.

It is best to perform dial alignment in calm weather and sea conditions, with good visibility, while the ship is (1) underway in company with another ship to serve as a target at selected ranges, (2) anchored in quiet water, (3) moored to a buoy, or (4) tied up to a dock. A celestial body may also be used as a target.

General Requirements

Certain general requirements must be met before conducting the sonar alignment check.

1. The selected fire control director foundation must be in aliment with the first foundation machined, as specified in sections S78-1-f of General Specifications for Ships of the United States Navy.
2. Sonar AN/SQS-23 must be electronically adjusted and aligned as detailed in NAVSHIPS 93612. Technical Manual for Sonar Detecting Ranging Set AN/SQS-23. An improved version is the AN/SQS-26.
3. The sonar foundation must be in alignment with the first foundation machined in accordance with standard alignment procedures.
4. An operating area of open water at least 5 miles square with the least 40 to 50 fathom depth must be available (for submerged targets).
5. A surface (or submarine) target must be provided.
6. One man must be at each of the following stations to perform the tasks indicated.

a. One man at the selected fire-control director to optically sight the director on the target ship.

b. One man at the radar console to operate the radar and to read target range and relative bearing.

c. One man at the pelorus to make visual relative bearing checks of the target.

d. One man at the sonar indicator to act as data-taking coordinator and to receive and record data.

e. One man at the sonar indicator to operate the sonar and to read target range and relative bearing.

f. One man (ASW or sonar officer) to act as overall sonar alignment coordinate (in direct communications with the bridge).

Note that none of these stations is operated by a GMM. Your part in the alignment is that of aligning the launcher to the fire control director and other parts of the system before alignment to the sonar is begun.

WARNING: While equipment is energized, stay away from the front of the radar antenna.

FINAL ALIGNMENT ADJUSTMENT PROCEDURES

The success of missile flight will depend to a great extent upon the mechanical and electrical alignment of the system. Since guided missiles are used at relatively long ranges, the accuracy with which target angles and range are measured becomes increasingly important. A pointing error of 1/2 a mil at 30,000 yards will result in a miss distance of 45 feet at the target. The same pointing error at a range of 90,000 yards will result in a miss distance of 135 feet at the target.

If any error corrections were made to train or to elevation receiver-regulator dials, new alignment readings must be established. Obtain the detailed instructions for your launching system and follow them with care.

Upon completion of the train check and the horizon check, the elements of the system are rechecked on their respective benchmarks and new dial readings are recorded in the ship's battery alignment and smooth fire control logs.

Although both of the above tests can and should be conducted by ship's force, it is well to remember that any adjustment to either the train or elevation response requires an adjustment also to the load, stow, dud jettison, and transfer position synchros and cams. These adjustments are extremely critical and difficult to make. So before any adjusting is done to the system by ship's force it would be wise to ask for technical assistance from a repair facility.

FINAL OPERATIONAL CHECK

Modern ordnance installations are operated almost exclusively in automatic control, except under certain special conditions or in emergencies. Therefore, it is particularly important for an installation to be aligned accurately for automatic operation. If the alignment methods described in this chapter are employed so that the dials of each element are aligned accurately with the pointing line and the synchros are aligned with the dials, a good alignment should be obtained. However, it is advisable to check the results under conditions which approximate those under which the equipment will be operated.

Perform the check with the installation in automatic control, and with he parallax equipment functioning. A boresight telescope will be necessary.

If possible, select various targets at different bearings and at ranges which will be approximately equal to mean battle range for the equipment. For antiaircraft installations, try to use air targets which are at an elevation angle near 45°. The target should produce a slow bearing rate, so that accurate tracking is not difficult.

Train and elevate the director to track a target as accurately as possible, particularly in train. If the director trainer cannot stay on the target continuously, he should inform the operators at the weapons by telephone when he is on, by calling "Mark." The operator at each weapon observes the target through the sight telescope or the boresight, and makes a note of any train error present when the director is on the target. This is done for targets at various bearings, some moving to the right and some moving to the left. In this check, some small error is to be expected because there is always some lag and lost motion in the followup servomechanisms. However, the error observed when tracking to the left should be essentially equal to that observed when tracking to the right, and should be in the opposite direction. If the errors do not change direction when the direction of tracking is changed, or if they are considerably larger for one tracking direction than the other, a misalignment is indicated. This can be corrected by adjusting the train synchros; but before any adjustment is changed, a careful analysis should be made to be certain that the error is not caused by some other factor, For example, a misalignment of the sight telescope could cause an error. This should be corrected by boresighting the telescope-not by adjusting the synchros. In this case, adjusting the synchros would bring the sight telescope on, but would result in firing errors. If, after careful analysis, an adjustment is made to the synchros, a check should be made to see whether or not a corresponding adjustment must be made to the dials or any other part of the equipment.

SUMMARY

To operate and maintain launching systems effectively, you must know the relationship of the missile and the launching system to each other. Just as important, you must know their relationship to the rest of the weapon system. This "need to know" about the relationship of each part of a weapon system to the other parts of the system is clearly demonstrated by the Daily System Operability Test (DSOT). This daily test is designed to check the overall readiness and effectiveness of the entire weapon system. The DSOT will reveal almost any kind of trouble that may arise, especially in the interchange of information between systems and equipments in the weapon system. Although the entire test requires only about thirty minutes, the men of the associated ratings in each subsystem monitor the test, standing ready to find and correct the cause of any failure.

You can see that every component in a weapon system is linked directly or indirectly to the others and so are the operators and maintainers of the equipments. You must think and act in terms of the weapon system as a whole. What you do and what your equipment does affect the operation of the system as a unit.

Alignment of the Tartar system is given more coverage here than other systems. Although there are many areas of similarity, the alignment of each weapon system is specific for the ship on which it is installed. Data for your installation must be used when making any adjustments or alignments. The admonition stands: Don't tamper with it if it is working all right.

CHAPTER 10

MAINTAIN, REPAIR, ADJUST, TEST, OVERHAUL

If all the subjects listed in the title of this chapter were discussed only in this chapter, it would comprise about ninety percent of the book. The programs in each of these phases are the topics of this chapter. The administration of the programs is covered in the succeeding chapter.

The preceding course, which you have completed, defined preventive and corrective maintenance and maintenance levels - organizational maintenance (on shipboard), intermediate maintenance (tender), and depot or yard maintenance. Organizational maintenance includes operational and technical maintenance.

Operational maintenance consists of on-the-job inspection, cleaning, servicing, lubrication, adjustment, and preservation of components and assemblies. It also includes the replacement of minor parts when this does not require special skills, or necessitate alignment or adjustment as a result of the replacement.

Technical maintenance is limited normally to replacing unserviceable parts, assemblies, and subassemblies, followed by aligning, testing, and adjusting the equipment.

Tender/yard or depot maintenance involves major overhaul or complete rebuilding of the principal subassemblies, assemblies, or the total equipment.

In performing any type of maintenance, a GMM must use knowledge and skills of two types: First, he must have specific information relating to the particular equipment he is to maintain or repair. Second, he must possess and use certain general skills and knowledge which apply to many kinds of equipment.

The specific information required consists of detailed step-by-step procedures approved for a specific piece of equipment. This information is almost always found in classified publications prepared by the Naval Ordnance Systems Command or by a vendor of the equipment under contract to NAVORDSYSCOM.

You have acquired the general maintenance skills and information in progressing to your present rate. The procedures generally follow the practical factors which you must complete as part of your qualifications for advancement in rating. Procedures in soldering, use of basic handtools, performance of basic electrical measurements with devices such as voltmeters, ammeters, and ohmmeters, are examples of some of the general skills in maintenance.

Now that you are preparing for GMM 1 or GMM C, you must be prepared to teach the basic skills to lower rated men and at the same time, increase your knowledge and skill so you can take care of advanced work on the weapons system. You need to learn more about the over-all and continuing plan of maintenance and the administration of the plan.

The technical duties include the maintenance of specialized test equipment as well as the assembly, adjustment, maintenance, and testing of missile launching components. The manuals written for each missile system and for each series of test equipments provide the equipment details and the approved procedures for .repair and maintenance.

NAVORDSYSCOM PROGRAM FOR MAINTENANCE OF WEAPON SYSTEMS

Planned maintenance for a ship's weapon system has progressed from the division level to a Navy wide Planned Maintenance System

(PMS). The PM system includes all components of a ship's weapon system and provides a scheduled maintenance program which detail all necessary tests, cleaning, inspection, and lubrication of specific types of ordnance equipment for a specific type of ship. The procedures for a maintenance program for a GMLS are performed at the departmental organizational level and area part of a PMS for a Surface Missile System (SMS). The PMS/SMS concept involves Daily System Operability Tests (DSOT) and supple-mental system tests and maintenance procedures. The system tests determine the overall operability of a system whereas scheduled maintenance is performed on individual equipments of a system to detect possible trouble areas and to maintain a high degree of readiness. General guidelines for implementing PMS are contained in OPNAV 43P2, Maintenance and Material Management (3M) Manual.

Daily System Operability Tests (DSOTs) are used to give the weapons system a quick run-through each day. If any part does not function as it should, corrective maintenance is applied. The schedules of routine maintenance established for each equipment are performed on the days assigned to each according to the plan. By conscientious performance of scheduled maintenance, minor difficulties can be discovered and corrected before they become serious. No comparative figures are available at present, but it is anticipated that the 3-M system will reduce the number of breakdowns and the amount of downtime for missile systems.

The 3-M system does for the entire weapons system what earlier systems of maintenance did for components of weapons and for weapons. *Military Requirements for PO 1 & C*, NAVTRA 10057 contains a chapter that discusses the 3-M system from the standpoint of the responsibility of a PO 1 and C, that is, the managerial aspects of 3-M.

RESPONSIBILITIES OF GMM IN THE MAINTENANCE PLAN

A study of the quals on maintenance shows that the GMM 1 must be able to "overhaul, repair, and adjust, . . . , test and adjust, . . . , perform authorized maintenance,. . . , record system performance," while the GMM C must be able to "Plan, implement, and supervise the maintenance and repair program." Two exceptions to this division of responsibility are concerned with the indicator and receiver-regulator equipment in the power drive system. In those systems, it is the chief who must test, adjust, overhaul, and repair. Note that nearly all the "Knowledge Factors" are on the GMM 3 and 2 level, with the exception of principles of receiver-regulators, functions of fire control systems and equipment, and administrative and supply procedures.

The GMM 1 is expected to have knowledge of basic layout geometry for drawings and sketches, to be able to prepare freehand sketches, and to read and interpret diagrams and service instructions. The preceding course explained in some detail the use of different types of ordnance drawings in your work. Drawings of electrical, electronic, mechanical, and hydraulic systems are included. No additional requirements are stated for the GMM C he needs to be able to teach the use of drawings and sketches and their interpretation.

The decision whether to repair or replace a component often has to be made by you. This requires a knowledge of the equipment that is both detailed and broad in scope. Knowledge of the supplies or replacements available is indispensable. Before discarding any part, be sure there is a replacement aboard.

The success of any planned maintenance program depends to a very large extent on cooperation at the working level. Help your men to understand how their day-by-day work of lubrication, cleaning, and similar routine upkeep helps to prevent costly and time-consuming breakdowns and the consequent hard repair work.

The work of the PO 1 and C in administering the 3-M system of maintenance and the Maintenance Data Collection System (MDCS) are described in Military Requirements for PO 1 and C, NAVTRA 10057. Planning the daily work of maintenance by his men (and himself) to carryout the ship's plan is the responsibility of the GMM 1 and C.

STEPS IN MAINTENANCE PROCEDURE

Maintenance procedures include visual inspection, tests, lubrication, equipment operation, performance tests, and cleaning parts. Preventive maintenance involves four major types of activity:

1. Periodic cleaning
2. Periodic lubrication
3. Periodic inspection
4. Periodic performance checks

Corrective maintenance is generally performed in three phases: (1) troubleshooting, (2) removal and replacement of parts, and (3) alignment and adjustment. There may be overlapping between corrective and preventive maintenance; there is no sharp dividing line.

VISUAL INSPECTION

All components, including explosives, receive frequent visual inspection. Although it is of limited value in detecting some types of weapons system troubles, it is the first method used in trying to find the source of trouble or potential trouble. Do not let it become a casual inspection. Normal ship vibration will cause screws and lugs to work loose; a good visual inspection will locate loosened ones. Loose terminal lugs and screws are a common source of trouble. Loose mounting bolts can be the cause of misalignment.

Cables should be inspected for looseness or damage at places where they enter equipment or at any other point in the cable run. Cables showing signs of damage or abuse should be either rerouted or protected. Particular attention should be given to the coaxial cable, which is easily damaged by dents or sharp bends.

Look for signs of overheating and faulty insulation. When these signs appear, the equipment may be blackened around the area of over-heating. Check the condition of tubes and tube sockets. Sometimes the shock of gunfire loosens tubes in the sockets. The light bulbs on control panels may be loosened by vibration.

Inspect junction boxes and other unit covers to see that they are properly dogged down. Tighten all retaining bolts and dogs evenly and firmly, alternating between diametrically opposite bolts or dogs.

Visual inspection discovers leaks in hydraulic systems, dents and similar damage in pipes, tanks, and other components. The efficient operation of any hydraulic system depends to a great extent on the effectiveness of the seals in keeping air and dirt out of the system and keeping the fluid in it. Fluid leakage can be discovered by visual inspection, though the accumulation of leaked fluid may be some distance from the leak and you have to trace it to its source. Do not "sell short" this simplest of troubleshooting methods; it can save much time and testing in locating troubles with your equipment.

CLEANING OF PARTS

One of the most important rules of preventive maintenance is "Keep it clean," and you have been reminded of this many times in your Navy career. Many of the equipments are highly machined and have close tolerances. Dirt, dust, or other foreign substances can cause the equipment to operate erratically. Grit can cause excessive wear of parts of a mechanism and can make it inaccurate. Moisture can cause corrosion, and this can cause inaccuracies in operation. Excessive grease or the wrong kind can hamper operation.

Scheduling of routine cleaning is part of your responsibility. In the 3-M as in previous systems of maintenance, the intervals of cleaning are based on normal conditions. If you have a situation other than normal, such as an extreme amount of dust, more frequent cleaning may be necessary. Prepare your daily and weekly schedules in accordance with the 3-M system and modify it to take care of any special situations on your ship. As each job is completed, check it off.

As supervisor and instructor of the men doing the cleaning of equipment, be sure that all safety precautions are observed. With any kind of solvent cleaner, ventilation is necessary to carry away fumes. Heat, fire, and sparks must be kept away from solvent cleaners. The Navy has tested many types of cleaners to find the best in effectiveness AND safety. Use the ones recommended in the OP for the equipment. Use the cleaners as sparingly as possible. Aside from cost savings, there are several reasons for this. Fumes will be less, reducing the health hazard; danger of fire is lessened; the solvent will not run into parts where it can do damage, as in electrical parts and skin exposure is lessened, reducing the hazard of dermatitis. Because cleaners are used so frequently, the tendency to become careless with them needs to be held in check. The occurrence of a fatality from solvent fumes has heightened the stress on the need for ventilation when using solvents. Close the container of solvent when it is not in use, even though you must open it again in a few minutes. It is very easy for a container to be knocked over (as in the case of the fatality mentioned); besides, evaporation is continuous while the cover is off. A small amount of solvent on a clean, lintless cloth is the best way for cleaning small or delicate parts. Federal Specification P-D-680 Type I or O-T-634, Type II are the solvents most commonly used on mechanical parts to remove oil and grease (and dust, etc. embedded in it). Alcohol is used for cleaning cork and rubber parts. Always check the OP for the right type of cleaner to be used. OD 3000 describes the different types of solvents and cleaning compounds.

Arrange the layout of work so you have adequate working space, good lighting, and good ventilation. Planning the layout and the work sequence will do much to expedite the work, making it easier, and reducing mistakes and hazards.

LUBRICATION

You know the importance of lubrication in the maintenance of all equipment. You are acquainted with lubrication charts and have used them in your maintenance work. As a GMM 1 and C you will prepare checkoff schedules from lubrication charts, OPs, on-mount instructions, or other sources, and supervise the work of lubrication. The types of lubricants and types of lubricating tools were discussed in the preceding course of this series, and in OD 3000.

The parts of the launching system especially subject to corrosion are those that are entirely above deck and constantly exposed to sea spray and water. Maintain the paint on all painted surfaces and a protective coating of lubrication on unpainted surfaces. Flush, clean, and relubricate any bearing surfaces that have been flooded with salt water. Be sure to use the correct lubricant for the part being lubricated and for the weather conditions. Some cold weather lubricants must be used very sparingly to avoid "freezing" of parts. The lubrication charts, which have a NAVORD drawing number, show all points requiring lubrication, give access locations, designate the required lubricants, and tell you how often to lubricate at each point.

Caution against over lubrication is especially important where electrical components are concerned. Oil and grease must be kept off insulation of cables, and other electrical parts. They cause switches and solenoids to malfunction, and will ruin motor armatures.

An excess of lubricant in gear housings can be a source of trouble. When the oil heats up during operation of the unit, it expands, and it may seep out and into parts where it will cause damage. Always check the oil level during maintenance, and do not add oil above the indicated oil level.

Other cautions in regard to lubrication are concerned with cleanliness. If there is dirt, lint, or gummy substance at the area to be lubricated, clean the area before adding fresh lubricant. When grease-lubricated bearings or bearing surfaces are disassembled, all the old grease must be removed and the bearings and housing washed with solvent before fresh grease is applied. The lubricating tool (grease gun, grease pump, oiler, etc.) also must be clean. Wipe it clean before using it and also wipe the point of application on the unit being lubricated. Before opening an enclosed unit, especially one that is gasketted to keep out dust and moisture, wipe the outside of the container. Do the work in a clean area, and place clean parts on a clean cloth or paper. Just a few grains of grit in a delicate instrument can be ruinous.

Maybe you already are observing all these cautions; see that the cautions are observed by the men who are helping you and are learning from you.

Several grease guns should be available for use by your group so each one can be used for a different type of grease. If you have only one grease gun, you have to clean it thoroughly every time you have to use a different type of grease. Do not mix different types of lubricants. To reach some parts for lubrication, such as all parts of the training circle of the launcher, the train drive pinion, and elevation drive pinion, the launcher must be moved from its stowed position. Take great care to avoid injury to personnel. The air motor is used to move the launcher and the trunnion tube. NEVER use automatic movement to train or elevate the launcher during servicing, or to move the trunnion tube. Be sure to return the trunnion tube and launcher to stow position, using the air motor, after completing the maintenance work.

Hydraulic systems need checking of fluid level at different points in the system. On some components, such as the ASROC adapter buffer used with the Terrier launching system, the fluid level may be noted through a viewing indicator. Hoist the adapter to the loader rail to inspect. If the level is too high, loosen the plug at the bottom of the reservoir and drain enough fluid to bring it down to the required level. A dip-stick inserted through the fill port is used to check the hydraulic fluid level in sumps. The fluid level in the train buffer should be maintained at the height of the filler plug. Oil level plugs mark the filling level on train and elevation gear boxes and hydraulic brakes. ALL hydraulic fluid MUST be strained into the hydraulic system through a 10 micron filter, even though it is being poured from a freshly opened can. Call upon your experience to impress on your men that the need for such care is not mere fussiness. You know the trouble just a little dirt in the hydraulic system can cause.

TESTS

It is hardly an exaggeration to say that at any given moment, some part of a weapons system is undergoing test. The processes of maintenance, testing, repairing, and operational checkout are continuous. The formal planned maintenance programs, from the Satterwhite system, then PRISM and IMP, and now the 3-M system, all were established to prevent forgetting some components in the maintenance and test programs. Other ratings perform some of the tests, on the missile itself, on the fire control system, and the weapons direction equipment. The ship's maintenance plan for the weapons system includes all of them. When you plan the assignments of your work week, you must coordinate the jobs with those in other units of the weapons system, and avoid interference in the performance of the work. The FTs test the missile and you and your men test the launching system. On some missiles you will prepare the battery for installation. On any missile system, you and your men will move the missile into position where the FTs can conduct the tests on it. Cooperation in planning and performance are essential for successful testing of a system. An understanding of the relationship among the parts of the system and the place of each in the whole is needed for intelligent cooperation. The types of tests and frequency of tests are subject to change. The analysis of results with the 3-M system will reveal need for greater frequency of some tests and less testing in other cases. Always check the latest MRC.

Daily Tests

Some tests and maintenance work must be performed every day. We'll use the Tartar system as an example. Daily preventive maintenance and a daily operational checkout are required for the Tartar system. A more comprehensive weekly operational checkout, plus monthly preventive maintenance, and prefiring and post-firing checkouts are required. Each day, in addition to the inspection for leaks, etc., checking of pressure, cleaning, and lubrication, certain tests must be made. Daily operation of the launching system perfects the training of the crew and also keeps the lubricants distributed on all bearing surfaces. A Tartar training missile is used. A safety watch is posted topside near the launcher and the EP-2 control panel is manned. The system is cycled three or four times in Step control and then in Automatic. The EXERCISE switch on the EP-l panel is set so the missiles do not receive actual warmup; the system then acts as if the missiles were on warmup.

The launcher captain stationed at the EP-1 control panel watches the cycling of the launching system. If any part does not perform in the cycle, it is rechecked in Step control. The action may be too slow, or it may not take place at all. Then a careful check must be made to locate the cause of the trouble. You may need to get the wiring diagrams.

Part of the daily testing is testing the firing circuits. Four tests are involved: (1) normal firing and misfire; (2) normal firing resulting in a dud; (3) firing of a dud; and (4) emergency firing. During practice operation, tests 1 and 2 are performed daily; tests 3 and 4 are performed periodically.

The Tartar training missile is hoisted onto the launcher. Be sure the EXERCISE switch is set on the EP-1 panel during the entire checking of the firing circuits. The checking is done in cooperation with Weapons Control. Each man should have a checklist that tells him the things to do (buttons to push) at his station, and indicating lights to observe for each step.

Weekly Tests

A weekly schedule for testing, checking, servicing, and lubricating launcher components is listed on maintenance index page for a designated GMLS and contains a list of all Maintenance Requirements Cards (MRCs) applicable to the system. Each MRC contains step-by-step instructions for performing the weekly task and, where applicable, shows a lubrication chart for the component scheduled for maintenance. A lubrication chart shows the points requiring lubrication, the frequency of lubrication, and the type of lubrication. If the recommended lubricant is not available, a tested substitute with the same characteristics may be used. Substitute oils and lubricants are listed in OD 3000. Local environmental conditions may require the use of special lubricants such as cold-weather lubricant. Always cycle the equipment after lubrication. This distributes the lubricant and forces out any excess. Clean up any excess, and clean up your grease guns and other applicators after use, before you stow them.

HYDRAULIC CHECKS. - Checking hydraulic fluid levels can be a daily or weekly maintenance requirement. Fluid levels may be checked by a sight gage or a dip stick. Most header tanks have some type of sight gage for quick easy fluid checking where main supply tanks contain a dipstick mechanism. In most GMLS a main supply tank contains an oil fill and drain valve while most header tanks contain only a fill valve or fill cap.

CHECKING ACCUMULATOR PRESSURE. - In most missile jettison systems air and/or nitrogen pressures are checked daily. In other accumulator assemblies weekly checking is the rule. The correct pressure of each nitrogen accumulator system varies with the ambient temperature, A table of temperature-pressure requirements may be mounted near a nitrogen accumulator charging assembly. This table lists the required nitrogen pressure for a given temperature recorded on a centigrade thermometer attached to the nitrogen charging valve block assembly. If a table is not attached to the charging assembly, a temperature pressure tabulation chart will be included on the MRC for the system being maintained. If a launching system has been in operation prior to a maintenance requirement, wait about 2 hours before checking an accumulator system. The waiting period should allow the system to cool so that thermometer gage readings represent normal ambient temperatures.

Checking Fire Protection Systems

All missile magazines have either a salt water or a oil operated hydraulic sprinkling system actuated by an automatic (thermo-pneumatic) control system. Sprinkling systems are tested monthly to ensure proper operation. Tartar missile magazines also have a water injection system which is used to diffuse the exhaust flame resulting from rocket motor ignition in the magazine. Water injection systems are not tested but are checked periodically to ensure that the fresh water and air pressure used within the system are at their required levels. Built in carbon dioxide systems installed in missile magazines are tested in accordance with current ship's policy.

Monthly Tests

Certain tests and checks of the weapons system are regularly scheduled to be performed once a month (or every 30 days). The Terrier missile must be checked at 3-month intervals for the first three checks, and every 6 months thereafter (current regulations; subject to change). The battery of the Talos missile must be removed each month and replaced with a new or reconditioned battery. The battery is not tested before removal; experience indicates that the battery is likely to need changing and we want to be absolutely sure the missile has a good power source.

A number of the monthly tests are checks on the operation of related parts of the weapons system, with the GMM 1 and C cooperating. You may be placed at the Launcher Captain's Control Panel to observe and report the indications at your panel. Monthly tests on the Mk 13 system repeat the daily and weekly tests, but with additional procedures. The lubricating job includes many additional places to lubricate. Testing the sprinkling system adds several procedures, including air testing of pneumatic lines for tightness and operability of the heat sensing devices, air testing for unobstructed flow between the sprinkling control valve and the sprinkling heads, flushing the associated firemains, cleaning the salt water strainers and the drain hole, giving the system an operational test, and checking the operation of all the valves. Review chapter 8 for these operations.

Testing the carbon dioxide system in the magazine was described in chapter 8. The monthly testing includes inspection to discover any breaks in the tubing or other leakage. The supply piping is air-tested for tightness, and the operation of the system activation alarms are tested. The supply of CO_2 is cut off during the tests by disconnecting the control and discharge heads and capping the connections to the supply tanks. These are precautions to prevent the escape of CO_2 while working in the launching system. Compressed air is used to test the operation of the system, connecting the ship's air supply to the carbon dioxide lines with an adapter. If the air pressure gage shows even a slight drop in pressure, the leak must be found and repaired. A drop in pressure could prevent the operation of the alarm system when it is needed to warn of a fire.

The control heads are checked with the use of a pneumatic hand pump and an air gage. Remember the warnings about the suffocation danger from CO_2 and see that the supply cannot be turned on accidentally. Connect or disconnect lines, .control heads, and discharge heads in the order given on the MRC or your check sheet so there is no outflow of carbon dioxide at anytime while anyone is working in the launching system.

Other monthly checks and maintenance procedures include cleaning of the steam strainer and fluid strainer and checking the bladder pressure in the anti-icing system, and checking the operation of interlock switches. Solenoid switch operation is checked quarterly. Among the interlock switches that are tested (whether for actuation or continuity) are numerous sensitive switches, single-element switches, paired switch elements, micro switches, and rotary switches. The table of interlock switch actuation adjustments for the Mk 13 launching system consists of 22 pages in the OP. The switches must be actuated and checked in the correct sequence; you can see that check sheets are a necessity for checking and adjustment of the interlock switches.

Some interlock switches require quarterly checking or adjustment; ship policy decides the adjustment period for others. This is likely to be the case when part of the system is under NAVSHIPS control, as in sprinkling systems.

Periodic Tests

Some tests are scheduled to be made every 3 months, or every 6 months, or yearly. Refer to the OP for your missile system for a listing and description. Other tests are listed as "unscheduled." They are made when there are indications that maintenance or testing is needed. Your experience and judgment are needed to decide. "Clean hydraulic filters," is an example of a periodic or unscheduled job. Noisy or erratic operation of hydraulic components may be an indication that the filters need cleaning, so you schedule the job to be done as soon as possible (immediately).

WARNING: Be sure that system pressure is relieved before disassembling or removing hydraulic components. High system pressure can cause serious injury to personnel.

Quarterly Tests

A series of tests that is usually scheduled to be performed quarterly is timing of operations. For the launching system to operate properly, the components must act within the time limits set for each, a matter of seconds. A stop watch is needed for testing certain operations. An electric timer is used at the EP-2 panel. On the Tartar Mk 13 launching system, use a 60-second, 115-volt, a-c timer with a special, self-contained 24-volt, d-c rectifier. You will need the wiring diagram to make the proper connections. Each timing operation is repeated two or three times and the time is recorded. If the average is not within the limits needed for that action, you must search for the cause of the trouble and correct it. The tests are conducted with all the motors running (except where indicated otherwise) in STEP control, Figure 10-1 illustrates a test circuit used to time the operation of a Tartar system. Timing relay KCZ2 is connected into the circuit being tested by two excitation leads. The contacts of KCZ2 control the start and stop action of the timing mechanism. The following are some of the timing tests made on a Tartar launching system; similar tests are made on other GMLS.

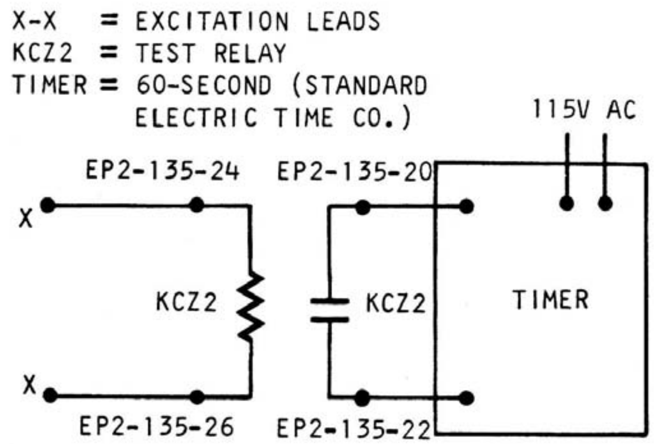


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Figure 10-1.—KCZ2 and timer circuit, used in timing of operations.

1. Check and record the time that it takes to index between stations on both inner and outer rings of the ready service ring.
2. Check and record the time that it takes to extend and retract both the inner and outer hoist retractable rails.
3. Check and record the time that it takes to open and close the blast door.
4. Check and record the time that it takes to raise and lower the hoist chain under the designated conditions with the chain shifter at either the inner or outer ring (depending on which ring the Tartar training missile is stowed in).
5. Check and record the time that it takes to extend and retract the electrical contactor and fin opener housings.
6. Check and record the time that it takes to extend and retract the fin opener cranks.
7. Check and record the time it takes to arm and disarm a Tartar training missile.
8. Check and record the time it takes to extend the launcher retractable rail when it is empty.
9. Using a stop watch, check and record the time that it takes to retract the jettison piston (test circuitry and electric timer not used).
10. Check and record the time it takes to load a missile (1) from the initiation of a single load order until the fins are unfolded and the fin opener cranks are retracted, (2) from the initiation of a single load order until the next missile in the magazine is ready to hoist, (3) from activation of the system to AUTO until the launcher is loaded and synchronized to the load order, and (4) from activation of the system in AUTO until the launcher is loaded, synchronized, and ignition of a simulated missile is indicated.
11. Check and record the time that it takes to unload a missile from the launcher.
12. Check and record the effective time delays imposed by the time delay relays that remounted within the EP-l and EP-2 panels. In addition to the electric timer and a stop watch, a jumper is needed. Figure 10-2 shows how to wire up a time delay relay for testing purposes.

All these tests require careful attention to detail - connecting to the right circuit, exact time, particular sequence of steps, and careful recordkeeping. They cannot be done hurriedly. Schedule them for a time when they are not likely to be interrupted.

LAUNCHER SHIPBOARD PERFORMANCE TEST

Launcher performance tests determine whether launcher equipment functions satisfactorily under various operating conditions.

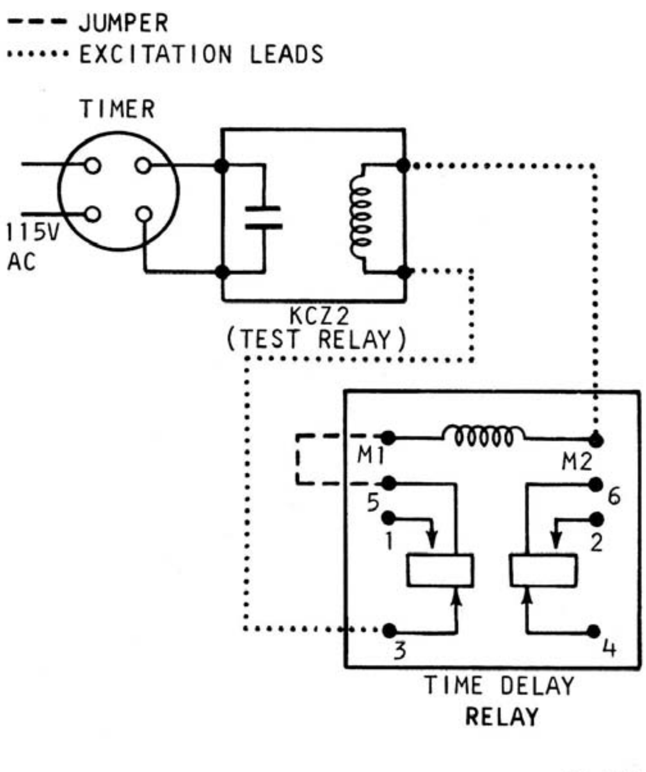

Figure 10-2.—Circuit for testing time delay relay.

Most launcher performance tests are conducted quarterly, but an existing condition (a suspected malfunction) may require that certain performance tests be conducted more frequently. Regardless of the frequency of performance tests, personnel conducting these tests must be familiar with both the testing procedures and the test equipment used. The test equipment is used to control and record the performance of the launcher power drives while they are being controlled by the launcher test panel. The responses that are recorded represent instantaneously the error position and velocity of the power drive unit under test. Most shipboard launcher systems have a test panel (EP3 Panel) which contains all the necessary test receptacles and test jacks for connecting the different test cables, leads, and jumpers to the test equipment required for a given performance test. Switches, pushbuttons, and control knobs used to control the launcher test equipment are located on the face of the test panel. A local director (internal director) is mounted within the test panel which enables the launcher to be positioned in train and elevation in local control or in a test mode of operation. A dummy director (external director), an error recorder, two limiter and demodulator units, and a frequency generator are used in conjunction with the EP-3 test panel when conducting launcher performance tests.

Some of the older GMLS do not have an EP3 test panel. These systems have separate local control panels, test panel, and system simulator panels for testing components.

DUMMY DIRECTOR AND ERROR RECORDER

Dummy directors and error recorders are used for routine shipboard dynamic testing of synchro controlled follow up systems such as train and elevation power drives for missile launchers. Their purposes are to simulate a command synchro signal, normally sent to the missile launcher power drive servo system by the missile fire control system, and to record the error between the selected input signal and the actual output response of the power drive servosystem under test. The information obtained is used for analysis of a launcher's electro-hydraulic control system and launcher power drives.

Dummy directors have been in use for many years, beginning with Mk 1. The one presently used with the Tartar and Terrier missile systems is the Mk 6 Mods 0 and 1. Figure 10-3 shows the control panel of the Mod 0. It was designed primarily for shipboard testing of guided missile launching systems. It does not replace test equipment used for laboratory, factory, shipyard, and installation tests. The records of installation tests are retained on board the ship, and the first record made with the dummy director and error recorder aboard the ship is kept for comparison with subsequent tests by the same test equipment. Each major unit of a ship's weapon system controlled by a synchro system and positioned by an electro-hydraulic power drive has a separate weapon system publication (OD) which lists all the individual shipboard tests conducted at the time of initial installation. Each major unit, a launcher, a gun mount, a rocket launcher, etc, is subject to a complete set of performance tests as detailed in an Installation Test Instruction OD for each unit installed. The results of all tests are recorded or added as an appendix in a shipboard copy of the OD for future reference. Any information obtained from a routine shipboard performance test could result in detection of a significant performance deterioration of a launcher component and can warn of impending failure which could result in the need for corrective maintenance, repair, or overhaul.

Dummy Director Mk 6

Dummy Director Mk 6 Mod 0 weighs 78 pounds. It is housed in a portable, aluminum case approximately 19 inches long, 16 inches wide, and 12 inches high. It requires 1-ampere, 115-volt, 400-hertz a-c power for operation, and it accommodates either 400-hertz or 60-hertz synchro signals. All power is supplied from the launching system test panel via cable stored in the case. An auxiliary power conversion unit is required for 60 to 400 hertz conversion if the system to be tested is limited to 60-hertz power supply. The principal components of the dummy director are:

1. A main servodrive, with transistor and potentiometer control. It drives two synchro transmitters for 1- and 36-speed order signals, together with a 36-speed synchro control transformer for error detection purposes. It also drives a d-c tachometer for generation of a signal velocity order required for certain power drives.
2. An auxiliary servodrive, with similar transistor and potentiometer control, for generation

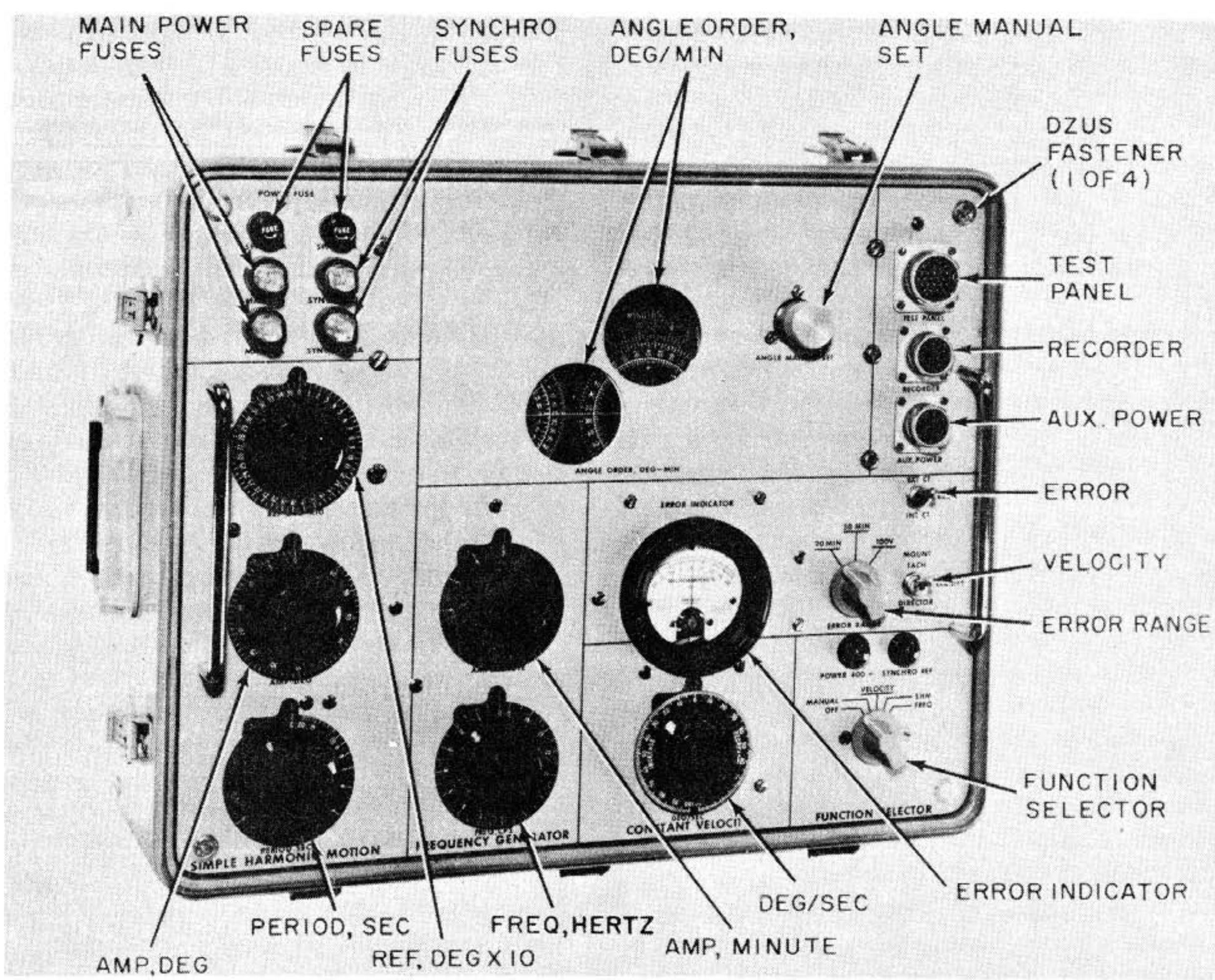

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Figure 10-3.—Dummy Director Mk 6 Mod 0, control panel.

of oscillating signals for simple harmonic motion control of the main servodrive for frequency generation.

All manual controls, indicators, and connectors are located on the control panel (fig. 10-3) for the following operations. These tests are made for train and for elevation.

MANUAL OPERATION. - During manual operation, the servo drives are disengaged from the synchro gear train, which permits the operator to position the output synchro rotors to any selected angle from where the particular test may begin. The manually set output signal is stationary, enabling the power drive under test to synchronize with the dummy director output. DO NOT, under any conditions, turn the knob on the 1X dial by hand.

CONSTANT VELOCITY OPERATION. - Constant velocity test signals are used to drive the unit under test at a constant speed. The velocity may be adjusted from 0 to 100 degrees per second in either direction. An oscillograph is used to make the test traces. (See chapter 5.)

SIMPLE HARMONIC MOTION OPERATION. - Simple harmonic motion test signals provide a sinusoidal input signal to the power drive under test. The sinusoidal signal causes the driven unit to oscillate about a present reference point, which is adjustable through 360 degrees. The period of oscillation is adjustable from 4.5 to 18 seconds, and the amplitude of the oscillation is adjustable to a maximum of 60 degrees at a period of 9 seconds and longer and up to 10 degrees at a period of 2 seconds.

FREQUENCY GENERATION OPERATION. - Frequency generation operation of the dummy director produces a sinusoidal signal of 0 to 12 minutes amplitude which is superimposed on the 36-speed synchro output signal. During frequency generation operation, the output command synchro transmitters of the dummy director are positioned automatically at a 10-degree electrical zero position. The frequency of the frequency generation signal is adjustable from approximately 0 hertz to 18 hertz.

The frequency generator components are mounted to the frequency generator chassis, which has a removable cover. A connecting cable is provided for connecting the generator to the EP-3 panel. Open and closed views of the frequency generator are shown in figure 10-4. It is used to test the frequency generator are shown in figure 10-4. It is used to test the frequency response characteristics of the launcher train and elevation systems.

Dummy Director Mk 1

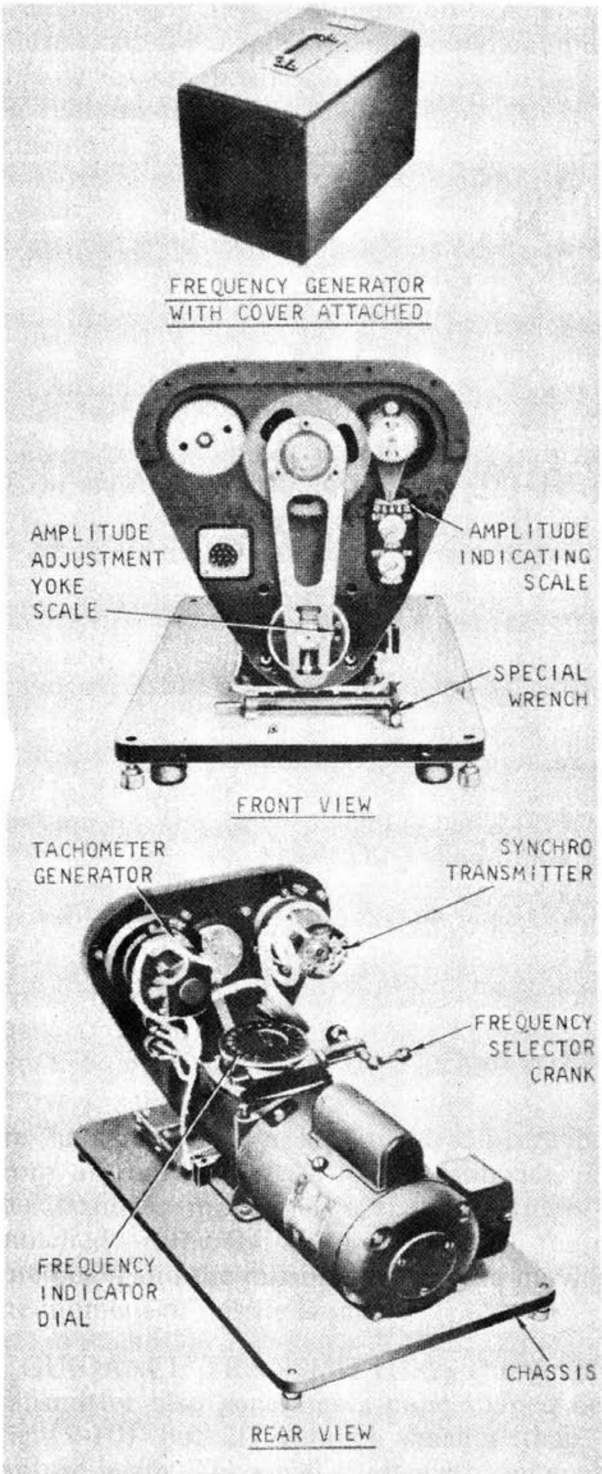
The launcher power drives for the Talos launching system are tested with Dummy Director Mk 1 Mod 6. Two portable units are used, one to test the elevation power drive and the other for the train drive. The dummy director produces 1- and 36-speed, 400-hertz synchro signals for position orders and a 1-volt-per-degree-per-second (open circuit at l-speed) velocity order proportional to the velocity of the generated signal. The dummy directors are plugged into the rear of the control test panel to activate them. For a detailed description of the unit, refer to OD 17398, Operating Instruction for Dummy Director Mk 1 Mod 6.

Error Recorder For Talos System

A dual channel oscillograph is used to record error traces of the Talos weapon system. Three types of error traces are taken with it: B-end error traces, velocity traces, and position traces. Two different traces can be taken at the same time. This allows corresponding trace results to be compared. Calibrate the oscillograph before using it; follow the instructions in the OP on maintenance and testing of the launcher system. Some error traces were shown in chapter 5, along with some instructions on reading test traces, and description of an oscillograph.

Error Recorder Mk 12 Mods 0 and 1

Error Recorder Mk 12 Mods 0 and 1 (fig. 10-5) is housed in a portable, aluminum case approximately 21 inches long, 15 inches wide, and 21 inches high. It weighs 76 pounds. It requires 1.6-ampere, 115-volt, 60-hertz a-c power which is normally supplied from the launching



94.163
Figure 10-4.—Frequency generator, enclosed and interior views.

system test panel via the dummy director. The principal component of the error recorder is a modified commercial Brush Instrument Company Recorder Mark III, which provides the immediately visible, permanent chart recording son two channels. It includes integral amplifiers for a pen deflection of 1-mm per 10-millivolts of input signal, up to 100 hertz. Simple adjustment and chart speed controls are located on the front panel (fig. 10-5), which also permit convenient change of chart paper. In addition to the two chart-recording pens, the recorder includes two event-marker pens, individually operated through remote control circuits. The recorder may also be used for time recordings of various launching system sequence operations.

The error recorder must be calibrated to zero position in relation to launcher zero train and elevation, and requires a warmup time of 15 minutes to provide an accurate error trace. (The time requirement may vary with the mod; observe the requirement stated in your instructions.) An error trace may be recorded of the launcher velocity, acceleration and deceleration, hunt, and ability of the launcher to follow static, constant velocity, or simple harmonic motion signals. These traces can be compared to those at installation.

The error recorder is connected by cable to the dummy director when in use, and the dummy director is connected to the launcher EP-3 control panel. The receptacles for connecting the dummy director, the two limiter and demodulator units, and frequency generator to the EP-3 control panel are on the lower part of the EP-3 panel, adjacent to the test jacks.

All required cabling for electrical interconnection of test instrumentation and connection of instrumentation to the test panel EP3 of missile launching systems control is provided with the test equipment. The special cables are designed with proper conductors, length, insulation, and connectors for optimum performance of equipment. Only the approved cabling should be used in the test instrumentation set up. Figure 10-6 illustrates the set up between the test panel EP3 and the test equipment used with a Talos missile launcher system. Only one dummy director is used at any one time, either for train or for elevation system testing.

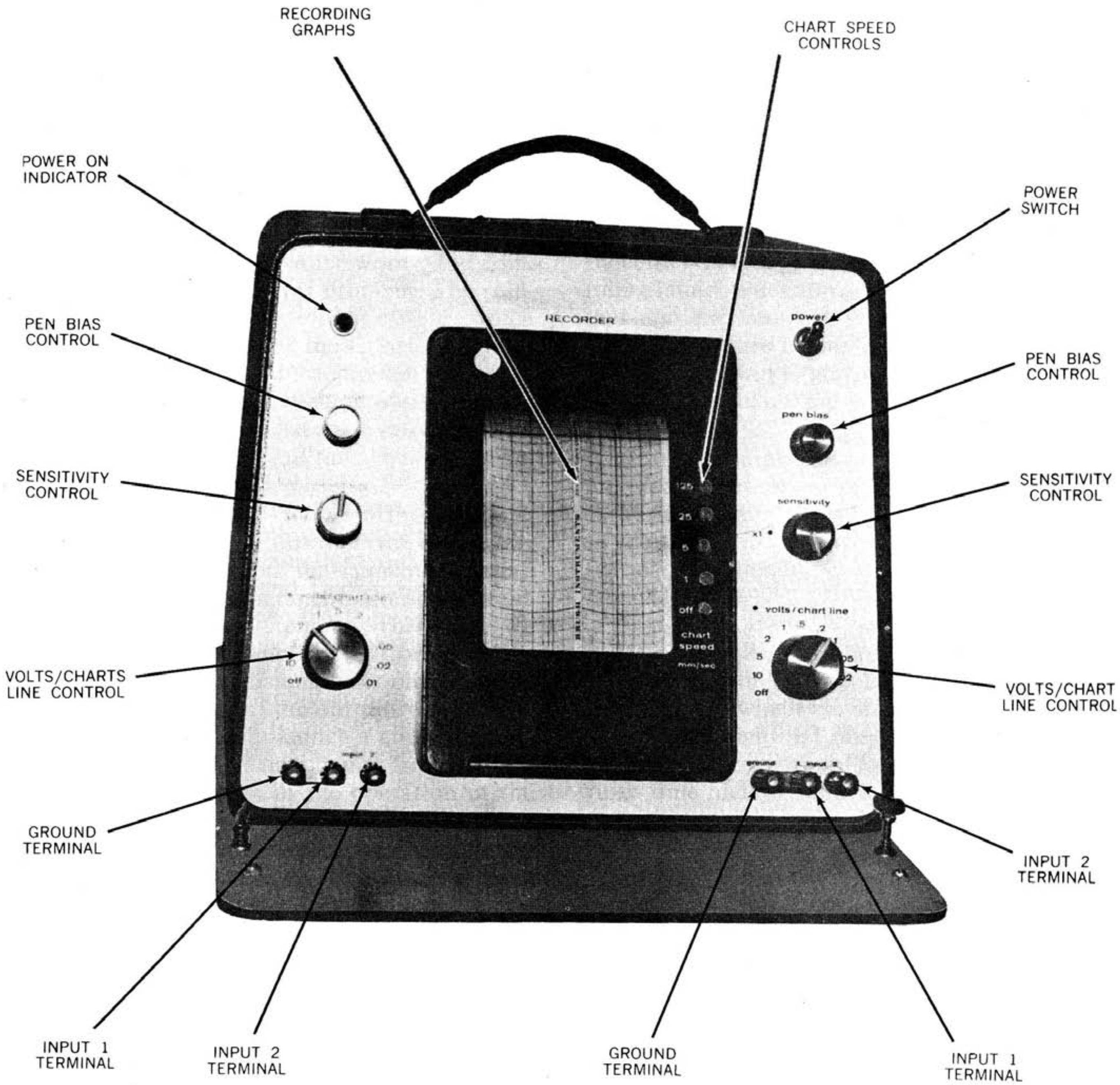


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Figure 10-5.—Error Recorder Mk 12, control panel.

Types of Tests and Test Procedures

Launcher systems having scheduled performance tests should have an associated Maintenance Requirements Card (MRC) for each power drive unit within a system which explains the step-by-steps procedure and also illustrates for reference purposes a sample trace of each test conducted.

In the Talos GMLS a performance test of the launcher train power drive is conducted quarterly and requires four hours to perform. The MR card consists of 38 pages with nine tests conducted in sequence. The tests listed on the

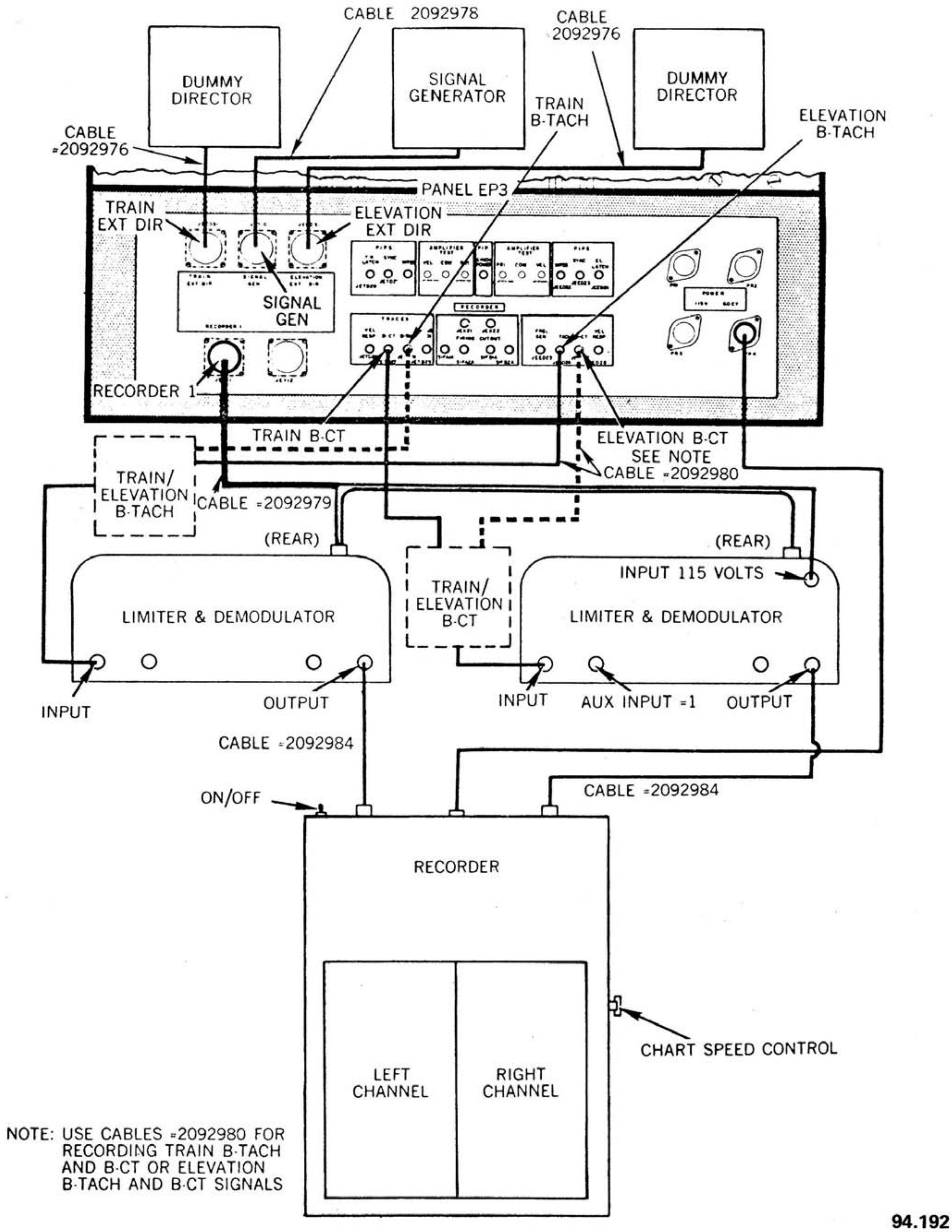

Figure 10-6.—Launcher Test Equipment Set Up.

MR card accomplish the following; (I) check amplifier balance, (2) test train power drive accuracy, (3) record train power drive velocity and acceleration rates, (4) check launcher synchronizing time, (5) calculate launcher travel distance and maximum deceleration rate between synchro and main power failure points and actual launcher stop points. The sequence in which the launcher train power drive is tested and some of the sample test traces are shown in figure 10-7.

MISSILE SIMULATOR

The use of simulators for training in all phases of missile handling, launcher operation, firing, and securing has been developed to a high degree. A missile simulator combines in one piece of equipment the functions of the several equipment attached to the test panel EP3 in a missile launching systems. The Tartar missile simulator is placed in the training missile, as is the Terrier simulator. Since you will be training lower rated men in the operation of the launching system you need to become familiar with the operation of the missile simulator you have aboard ship. Missile Simulator SM-161/DSM, used to check the Tartar missile launching system aboard ship is installed in the Tartar Training missile (TSAM), occupying the space normally occupied by the auxiliary power supply (AS). The missile simulator test panel is located just under the missile skin and is accessible by a hinged cover. All electrical connections from the launcher to the missile simulator are made through the DTRM firing contacts on the skin of the DTRM, and through the missile-to-launcher contactor on the aft end of the tail cone. The missile simulator furnishes electrical loads equivalent to those in a tactical missile and provides indicators and test jacks as a means of checking the launcher firing control circuits.

Guided Missile Simulator SM-75A/DSM is used in Terrier Guided Missile Training Round Mk 14 Mod 0 (BT-3) or Mk 18 Mod 0 (BW-1). Guided Missile Simulator SM-159B/DSM is also used with those training rounds and, in addition, is used with Training Round Mk 43 Mod 0 (BT-3A/F/, BT-3B/F/), Mk 44 Mod 0 (BT-3A/N/, BT-3B/N/), or Mk 45 Mod 0 (HT-3) (HT-3A). The simulator provides the electrical responses and loads equivalent to the missiles, thus allowing realistic loading and firing drills.

Operational Cycle

Operation of the missile simulator is through the launcher control console. The operator at the launcher control console operates the push-buttons and switches in the sequence required for the test. being made, and the man at the simulator test panel watches the indicating lights that show if the proper response is taking place. He has a checklist, of course, and maintains communication with the console operator.

There are many possible combinations of situations that can beset into the simulator. The operator of the control panel operates the switches manually.

Before attempting to teach with the simulator, have clearly in your mind the steps you will take and what will happen each time. Since the orders must come from the attack console, coordinate your lesson with the men who will send the orders to your launching system. Manual operations are required at both stations. The men who are being trained are stationed at the control panels in the same manner as for an actual firing. The indicator lights show what has been simulated. The abbreviations used on the face of the launcher panel and missile simulator are explained in the OP, as are the code symbols used to indicate weapon system units and fire control symbols.

Maintenance of Simulator

It is part of your job to keep the simulator in operating condition. As long as the simulator operates satisfactorily, do not open it for cleaning and inspection. Lubrication is usually performed at the factory, and is not required on shipboard under normal conditions. Periodically clean and inspect the exterior only. Panel lamps may require replacement. If the simulator becomes inoperative, inspect the interior for security of the switches on the front panels, for loose or damaged connectors, broken or loose switch wafer wire connections, evidence of overheating, excessive wear, or corrosion of electrical parts, cracked or damaged O-rings, and damaged wiring. Before opening the unit, be fairly certain

Gene Slover's US Navy Pages

Phil Hays' Talos Missile Page

Table of Contents

PROCEDURE (continued)

Test Sequence	Test
1	Check magnetic amplifier balance
2	Train accuracy
	a. Simple harmonic motion
	b. Static condition
	c. Constant velocity
3	Train velocity and acceleration rates
4	Synchronized indicator checks
	a. Static error
	b. Time delay
	c. Synchronizing time to static signal of 5°, 10°, 20°, 45°, 90°
5	Synchronizing to harmonic motion
	a. 60°
	b. 90° right train
	c. 120°
	d. 90° left train
6	Return to load
7	Synchro power failure
8	Main power failure
9	Frequency response

Train Power Drive Test Relationship Summary

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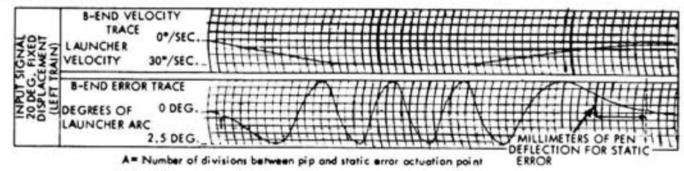
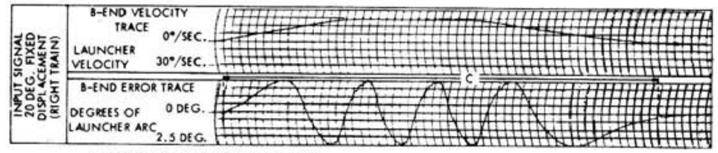
PROCEDURE (continued)



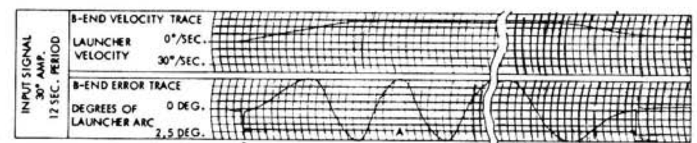
A = Number of divisions between pip and static error actuation point
B = 0.04 second per division
A x B = time delay (seconds)

Train Synchronized Indicator—Time Delay Sample Trace



C = Number of time divisions between pips
D = 0.04 second per division
C x D = synchronizing time (seconds)

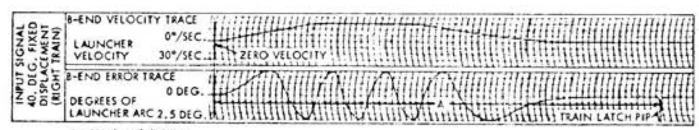
Train Synchronized Indicator—Synchronizing Time Sample Trace



A = Number of time divisions between pips
B = 0.04 second per division
A x B = Synchronizing time (seconds)

1 TIME DIVISION
* SYNCHRONIZATION LOST
** SYNCHRONIZED

Harmonic Motion—Synchronizing Time Sample Trace



A = Number of divisions
B = 0.04 second per division
A x B = Synchronizing Time (seconds)

Return-to-Load Sample Trace

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94.193

Figure 10-7.—Test sequence and sample traces.

that the trouble is in the simulator. Failure of lamps and dials on the attack console, the simulator panel, and the LCCP are the most common indications of malfunctions.

WARNING: Do not attempt repair of a simulator panel until the panel has been deenergized.

Before removing any part, make a sketch of its position and wire connections to ensure its correct replacement. All wires have marked sleeves at each terminal end. The dummy steering power section is removed from the trainer missile before inspecting or cleaning the internal components of the simulator. A soft, clean cloth and a brush are used for cleaning the interior of the simulator. After cleaning and correcting any obvious faults, such as a loose wire, return the simulator to the dummy missile.

When the cause of the trouble is not obvious, make resistance checks of the circuits in the simulator. All power is removed from the missile simulator and the missile is disconnected from the launcher. A Simpson 260 or similar multimeter and it General Radio 1800A a-c vacuum tube voltmeter are used. Use the access jacks on the front of the simulator panel.

Use troubleshooting charts or wiring diagrams of the simulator. When you have located the remedy in the appropriate chart, follow the instructions for repair, adjustment, and/or replacement. Repairs other than those described in the OP should be done at an authorized repair station. Synchro alignment, for example, is done at a repair depot.

During the dynamic testing of the simulator, it is in the trainer missile on the launcher and is receiving stimulus voltages from the weapons system. A correct voltage reading .on the front panel of the simulator indicates that the simulator and the weapons system are functioning properly in the test. The voltages for each test point are listed in the OP.

Corrective maintenance must be done by persons familiar with the theory of operation and the method of operation of the simulator.

Weapon Electrical Simulator

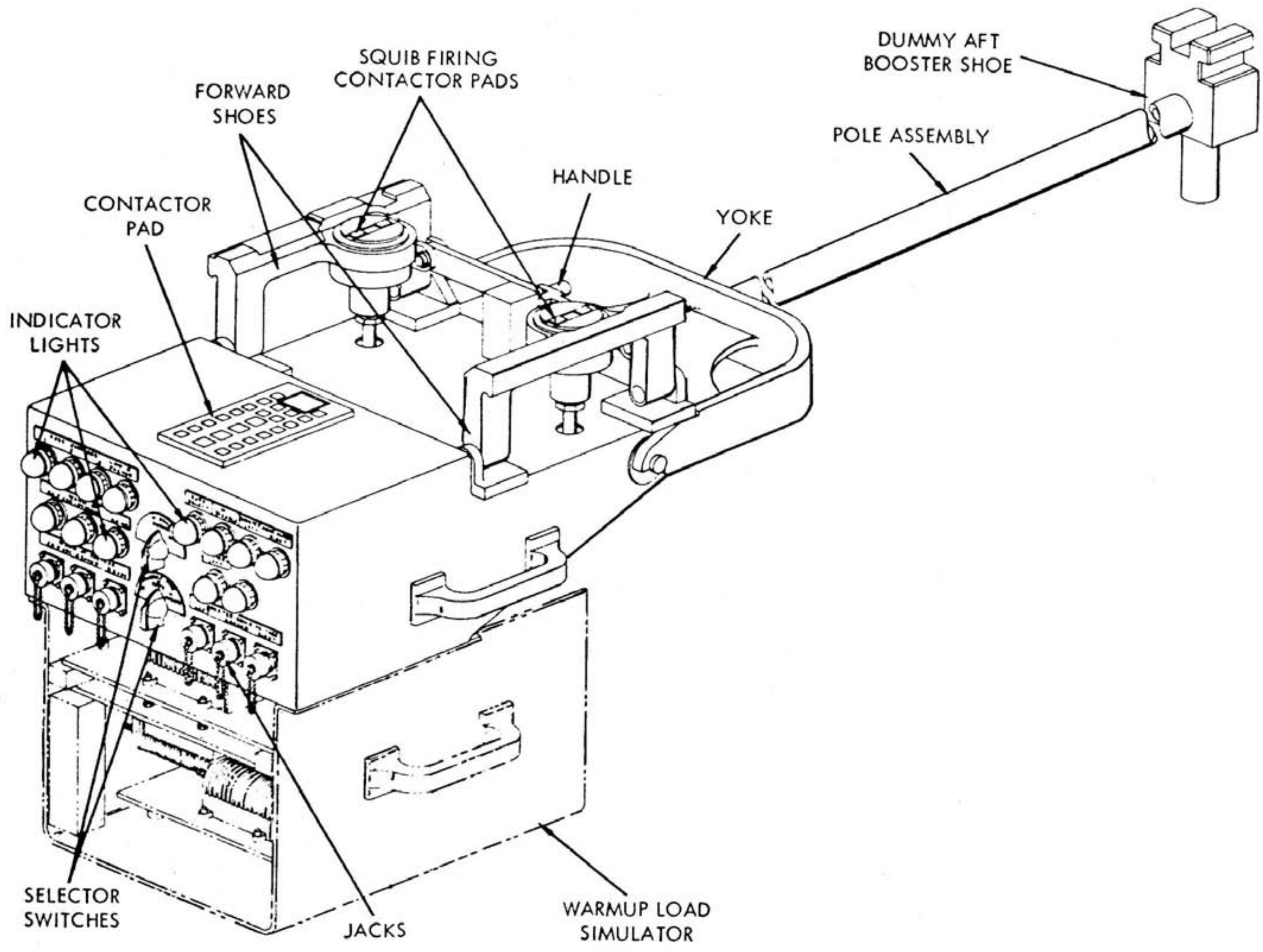
The simulator used with the Talos GMLS simulates the electrical functions of an S or a W type Talos missile. The primary purpose of the simulator is to allow realistic warmup, power changeover, and firing drills by providing electrical circuits that furnish responses equivalent to those of an operational missile. It also serves as a test unit for checking the operation of the launcher warmup and firing circuits. In addition, the simulator gives all rail loaded indications at launcher Areas 1 and 2, it latches to the guide arm, and it engages the loader in the same manner as a missile. Forward and aft shoes, figure 10-8, similar to those on an operational missile, permit the simulator to be attached to the loader or launcher rail.

When the simulator is attached to the rail, the electrical warmup contactor in Area 1, or at the launcher, can be extended and mated with the contact pad on top of weapon simulator, figure 10-8. This pad is identical to the contact pad on a service missile. The contactor conducts warmup power as well as all input and output signals to and from the simulator, except for booster-squib voltages. Booster-squib ignition voltages are provided by two sets of contacts mounted on the forward simulator shoes, figure 10-8.

During warmup, power change-over, and firing phases of a drill, circuits within the simulator simulate or monitor the operation of missile warmup, power change over, and firing circuits. Indicator lights on the front panel display sequence and indications of voltages. A warmup load simulator, an accessory unit of the weapon simulator, can be used to simulate the loads that an operational missile would normally impose on the launcher during firing. In addition to indicator lights, the front panel of the weapon simulator contains all the necessary switches and plug in jacks necessary for a weapons electrical simulation test.

TRAINING MISSILES

The use of a trainer missile provides several kinds of training in addition to checking out shipboard launching systems. This includes training of missile handling crews in assembly techniques, packaging and transfer operations, checkout methods, launcher loading, and operation of the launcher firing sequence. The trainer is stowed in the missile magazine along with the other missiles; when it is to be used for checkout, it is brought up and loaded on the launcher.



94.194

Figure 10-8.—Weapon Electrical Simulator.

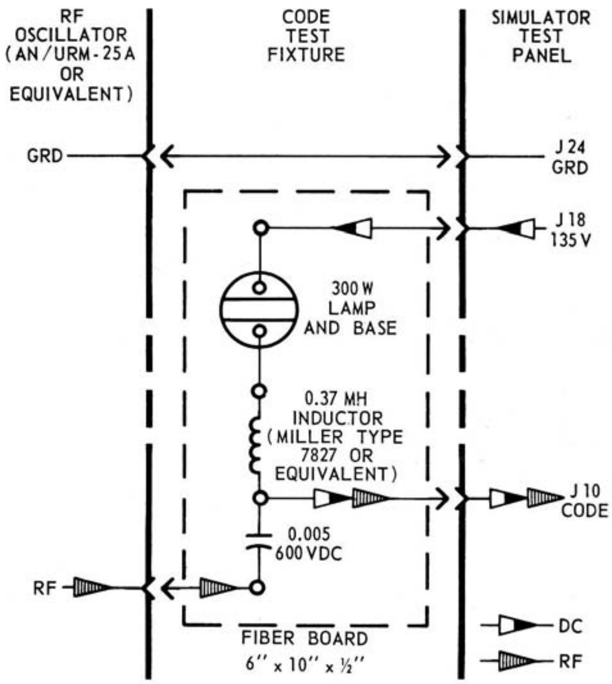
The trainer missile is used with a code test fixture and RF oscillator to check the operation of the code comparator and associated weapon control ready-to-fire indicating circuits. The conductors from the code test fixture and the RF oscillator are connected to the simulator test panel in the trainer missile. The RF oscillator is ship's equipment, but the code test fixture is constructed from materials at hand. Figure 10-9 shows a schematic of a code select circuit. In the Tartar systems the missiles are checked out on the launcher, and therefore it is necessary to have the launcher trained and elevated to a position that is most convenient for the operator of the simulator panel.

WARNING: Be sure all personnel are cleared from the launcher area before energizing launcher circuits. A safety observer must be on deck, and in communication with the launcher control station.

Study the description of circuit action in the OP with the drawings before you. This type of follow-through will be very helpful in trouble-shooting.

Training Missiles Used With Simulators

Training missiles with dummy simulators or no simulators at all are used for practice in



94.164

Figure 10-9.—Launcher system code select circuit check; schematic.

handling of missiles; but when any circuitry is involved, a real simulator must be connected. The simulator is electrically connected to the trainer via booster and missile power receptacles, shown on the left end of the simulator in figure 10-10.

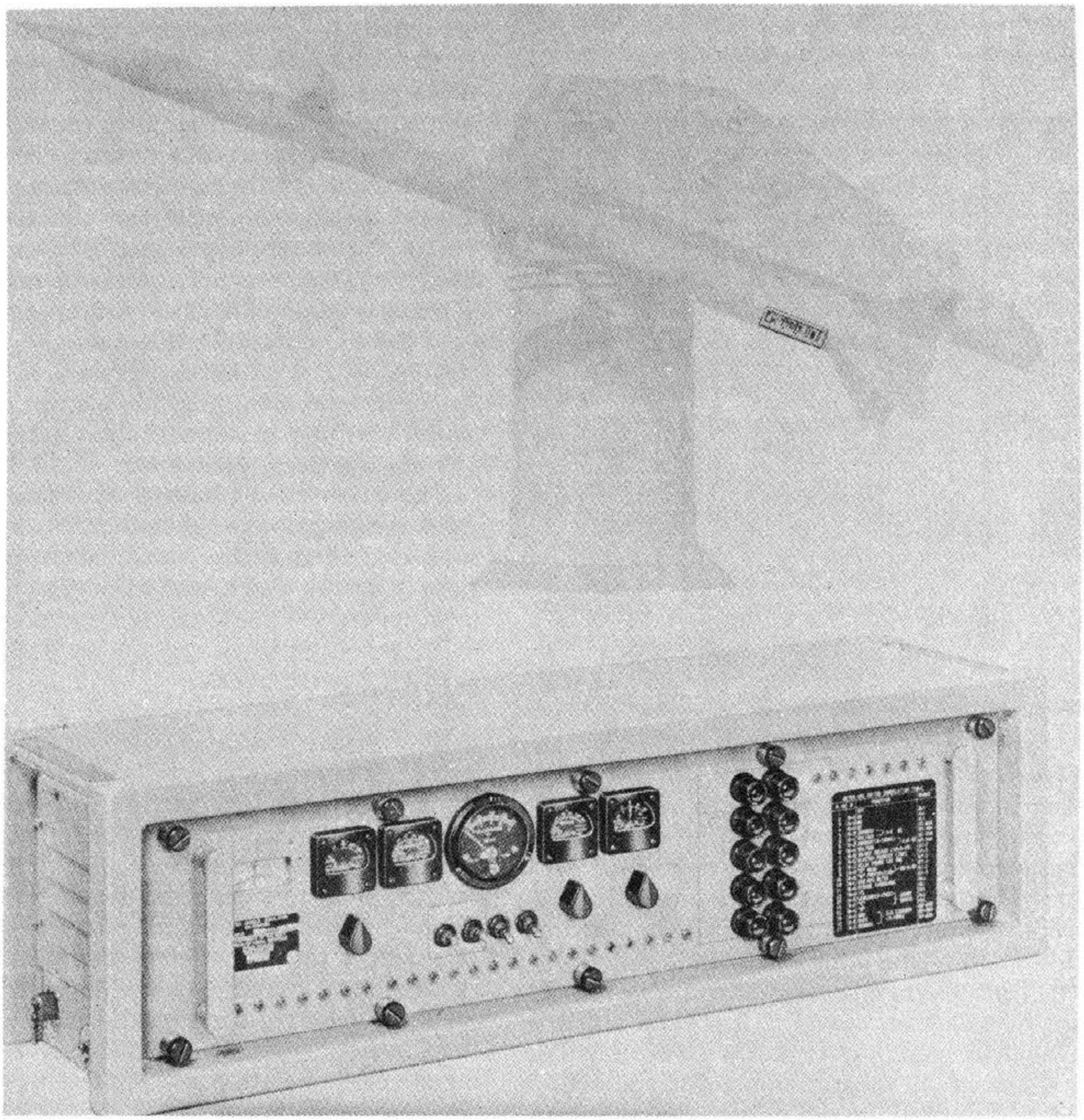
Two Terrier training rounds and two Asroc training rounds are provided for each Mk 10 Mod 7 or 8 launching system. The guided missile simulator used in these training rounds is described in OP 2258, Guided Missile Simulator. OP 2905, Guided missile Simulators SM-75A/DSM and SM-159B/DSM, gives the instructions for use of the simulators for the Terrier missiles stowed in the Mk 10 Mods launching systems. There are variations in them to accommodate the different Terrier missile types, and changes have been made to improve the simulators, so be sure you have the latest revision of the OP.

The launching system is cycled through all its operations, using a training missile in place of an active missile. For testing the firing circuits, a Terrier training missile with the simulator installed is used, loaded on the launcher rail. It is tested for normal firing, A- and B-side, misfire, and dud firing. The launcher electrical contactor is mated to the trainer electrical contactor. During the warmup, power changeover, and firing phases of the training drill; circuits in the simulator represent or monitor the missile operations. All the input and output signals, except the booster squib ignition voltages, are conducted through the electrical contactor. Figure 10-10 shows the panel face of the Simulator SM-159B/DSM and its location on the missile when it is on the launcher. Automatic control is used for training drills; the observer of the simulator panel has a dangerous position because of launcher movement, and he must be constantly alert. All other personnel must be cleared from the launcher area.

The steps of operation will vary with the missile being tested and type of firing being simulated. Follow the steps exactly as given in the OP or the check sheets for the test you remaking.

SONAR SIMULATOR

The primary target detection unit of the Asroc Weapon System is Sonar Detecting-Ranging Set AN/SQS-26. The sonar detects and tracks submarine targets and provides target location data to the fire control group. For training use, a target must be simulated. Sonar Target Signal Simulator SM-170/SQS-26 is used to supply a signal similar to a submarine target. It simulates course, speed, depth, range, and own-ship course. Simulated sonar echoes are transmitted from a maneuverable artificial target. The operation of this equipment is not the responsibility of the GMM. The Sonarmen check out the sonar target signal simulator, but the GMMs check the Asroc weapons that they have in the Mk 10 launching system. The Asroc training missiles are made to resemble the rocket-thrown torpedo and the rocket-thrown depth charge forms. All forms of Asroc are used for ASW, and must therefore be checked out with the aid of sonarmen. The sonar target signal simulator is Unit 5 in Fire Control System Mk 114 Mods 9 and 12. The operator of this panel sets the problem. He sets in the target bearing, course, range, and speed, and own ship's speed. Other fire control units proceed to solve the



94.165

Figure 10-10.—Missile Simulator SM-159B/DSM, and location on missile on launcher.

problem and transmit orders to the missile and. the launching system. The GMMs man the launcher panels. When the decision is made to fire either a torpedo or a depth charge, the correct form of training missile is brought up from the magazine by the launcher captain, and is loaded on the launcher arm.

TESTING THE MISSILE

Although maintenance of the missiles consists largely of removing a defective component or part and replacing it with a new one, frequent checking and testing of missiles is necessary to detect any faulty component. The development of replaceable modules was one step in the reduction of missile testing aboard ship. The missile NO-TEST-aboard-ship programs are working toward the elimination of missile checkouts aboard tactical ships. The Tartar program has been completed and missile shipboard checkout equipment is being removed. The Terrier program is being worked on at present. The Guided Missile Surveillance Program monitors, measures, identifies, and interprets factors that influence missile readiness and reliability. The Missile Systems Test Monitoring Program utilizes analog data to validate missile checkout results. These data are analyzed to detect missile problems that may not be recognized or detected by missile checkout equipment. Some missiles aboard tactical ships were found to be in a failure condition that had not been disclosed by shipboard tests. These programs are carried on by the Naval Fleet Missile Systems Analysis and Evaluation Group with headquarters at Corona, Calif.

Until the NO-TEST program is perfected, missiles will be tested aboard ship to a limited degree.

Missile Systems Test (MST)

Several mods of Guided Missile Test Sets (GMTS) are in use. AN/DSM-60 (TATTE) is used to test the Talos; AN/DSM-54(V) is used with the Terrier; and the AN/DSM-55 and AN/DSM-55(V)B are used with the Tartar. Each of these has type modifications. These sets are connected to the missile by the GMM, but the tests of the missile may be conducted by Fire Control Technicians. At depots a pneumatic test set, the TS-1165/DSM, is also used with Terrier and Tartar missiles, but on shipboard only the electronic system is checked. External hydraulic power is used, supplied by the HD-259/DSM hydraulic pumping unit.

The AN/DSM-54(V) consists of four functional sections: (1) program section, (2) missile stimulator section, (3) evaluation and indication section, and (4) power supply section.

The Guided Missile Test Set applies a series of tape-controlled electrical stimuli to activate the missile guidance system. Missile functions and conditions simulated include warmup, launch, boost phase guidance, search, target acquisition, and intercept. Selected steering signals are applied to the missile. Missile responses to these signals are monitored at various points in the missile and compared to the tolerance limits within the missile test set. At the end of the test the GMTS will show a green GO light if the missile is functionally flight-ready and a red NO-GO light if it is not. One or more FAULT LOCATION lights will indicate the location of the trouble when the missile tests NO-GO

If the light is red, continue the tests to pin-point the trouble and correct it if you can. If the light is green, the GMMs return the missile to the magazine.

Because of different test requirements, different punched program tapes are installed in the missile test sets: for depot or for shipboard tests, for tactical missiles, for missiles with an exercise head, for testing the forward assembly only, and other specific conditions. The missile systems test is performed in approximately three minutes.

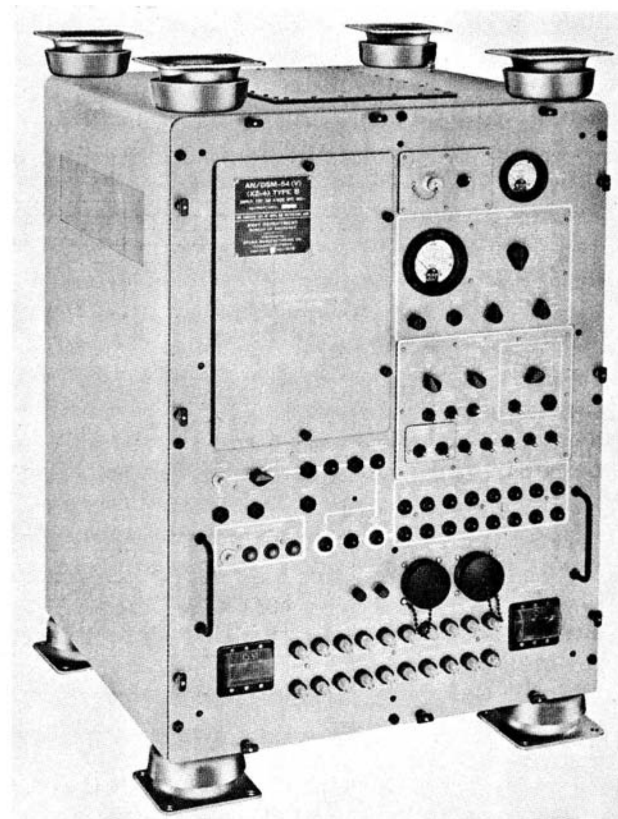
Before the test set is connected to the missile, the set performs an automatic check of its own evaluation and interlock circuitry, as well as the critical power supply voltages. The result of this self-check is displayed by indicator lights on the control panel, which show whether the test set is in condition for conducting the missile test. The self-test is initiated by pressing the OPERATE button on the test set. If any of the ready lights do not go on, the self-test has failed. When making the external connections of the test set to the missile, make sure that the missile is grounded at all times. Set the sustainer igniter arming mechanism to CHECK. After the completion of the test and after the GYRO CAGED lamp is illuminated, place the sustainer igniter arming mechanism on SAFE, and remove the connections from the missile.

WARNING: The test set will not remove power from the missile unless the gyro is caged.

The tests are performed on completely assembled missiles except for the warhead section, S&A device, and fuze booster. During tests, a warhead spacer is used in place of the warhead section between the forward end of the electronic section and the after end of the Target Detection Device (TDD). (On shipboard, the missile is tested completely assembled. The only preparation needed is separation of the missile and booster before attaching cables and hoses.) A through cable for connecting the TDD and the electronic section is provided as part of the station installation to supply S&A launch-latch bypass and for powering the TDD and missile nose sections.

SIMILARITIES AND DIFFERENCES IN TEST SETS. - The AN/DSM-54 and AN/DSM-55 test sets are fully enclosed and housed in an aluminum enclosure. The -54 sets (fig. 10-11) weight approximately 266 pounds and the -55 sets about 275 pounds. They are placed in the checkout area but can be moved if necessary. The hydraulic pumping unit, HD-259/DSM, is placed nearby. The AN/DSM-60 (TATTE) test set, used for testing the Talos missile, includes four cabinets of equipment, each of which contains several subassemblies. These cabinets and the auxiliary equipment are installed in the missile checkout area (fig. 10-12). The -60 test set is a composite of the -18, -18A, -18B, and -18C capabilities.

All of them require a power supply, an altitude simulator, a telemetric data recording set, meters and tools. Special tools and maintenance equipment are supplied with each set for servicing the module.



94.106
Figure 10-11.—Guided Missile Test Set AN/DSM-54V; pictorial view.

WARNING: When power is on, high voltages are present in the GMTS. Use caution when performing inspection, adjustments, voltage measurements, and maintenance. High voltage (300 v-d-c) is present at test points. Do not service or adjust alone. Another person capable of rendering aid should be present.

PREPARATION FOR MISSILE CHECKOUT

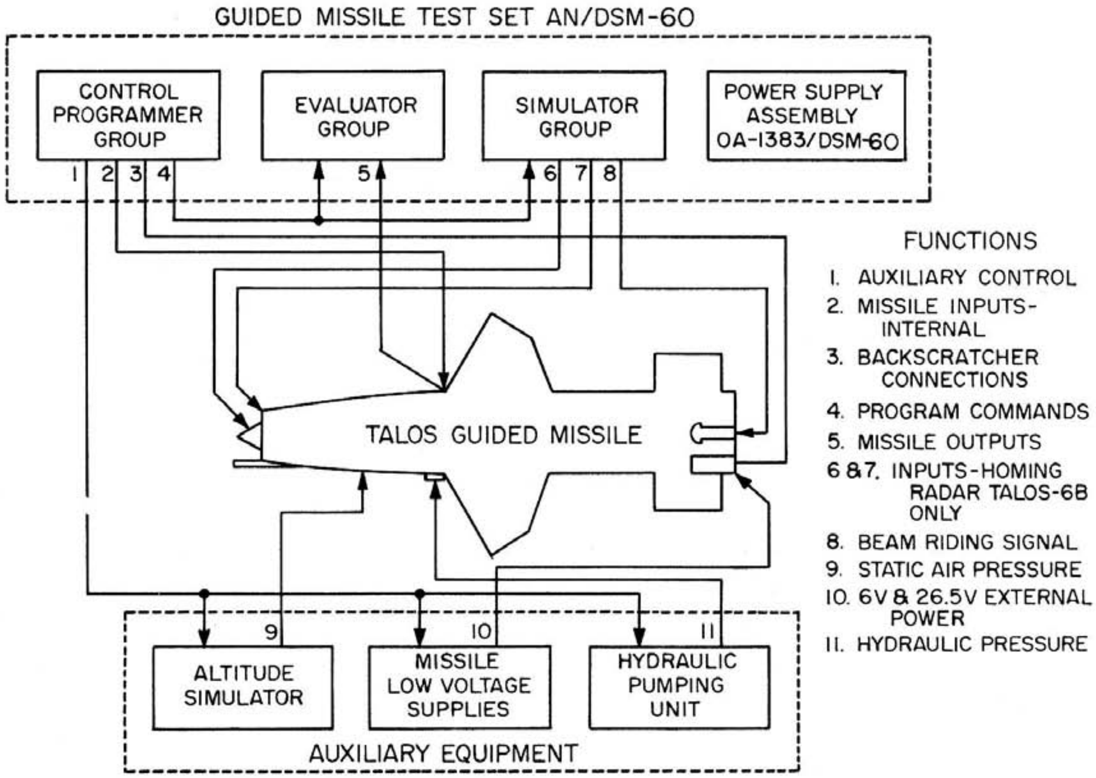
Figure 7-18A illustrates the test set AN/DSM-54(V) connected for depot testing, and figure 7-18B shows it ready for shipboard testing. Configuration 2 (C2) of the test set is shown in these illustrations.

Terrier

The AN/DSM-54(V) is adaptable for testing any of the current Terrier missiles. Each set can be changed quickly to test any of the Terrier missiles and to operate on either X band or C band frequency.

NOTE: If the same 400-hertz voltage source is used for both the AN/DSM-54(V) and the HD-259/DSM, it is necessary to start the HD-259 first in order to prevent damage to the DSM-54(V).

After the equipment has been warmed up for at least 30 minutes, check all power supplies of the AN/DSM-54(V) for proper operation. If the power supplies are operating properly, check and, if necessary, adjust the missile stimulator section of the AN/DSM-54(V). Radar Test Set AN/SPM-9 is used to check Pulsed Radio Frequency, Frequency Modulation, Amplitude Modulation, Radio Frequency, Pulse Width, Pulse Coding, and R-F Power Out. The function generator section of the DSM-54 set is adjusted



94.107

Figure 10-12.—Talos missile checkout equipment; functional relationship of units.

for proper output of Roll (both LO and HIGH), Rate (LO and HIGH), and Acceleration. These adjustments are critical and require a highly accurate differential voltmeter. They may be made by other ratings, but you need to know how.

The test results are recorded by either Telemetric Data Recording Set AN/SKH-l or Telemetric Data Receiving, Recording, and Scoring Set AN/SKQ-l. These sets record on special photosensitive paper housed in the magazine of the oscillograph. The photosensitive paper is developed under fluorescent light. The developed recording may be analyzed and annotated. Future recordings are compared with it.

To prepare the HD-2S9/DSM, check the level the hydraulic fluid in the reservoir, as indicated in the sight glass on its front panel (fig. 10-13). If the level is low (below MIN), fill the reservoir to the proper level. Check the condition of the hydraulic lines running to the missile. Connect the supply lines to the return line by use of an adapter, and connect the unit to a source of 115-volt, 3-phase 400-hertz power.

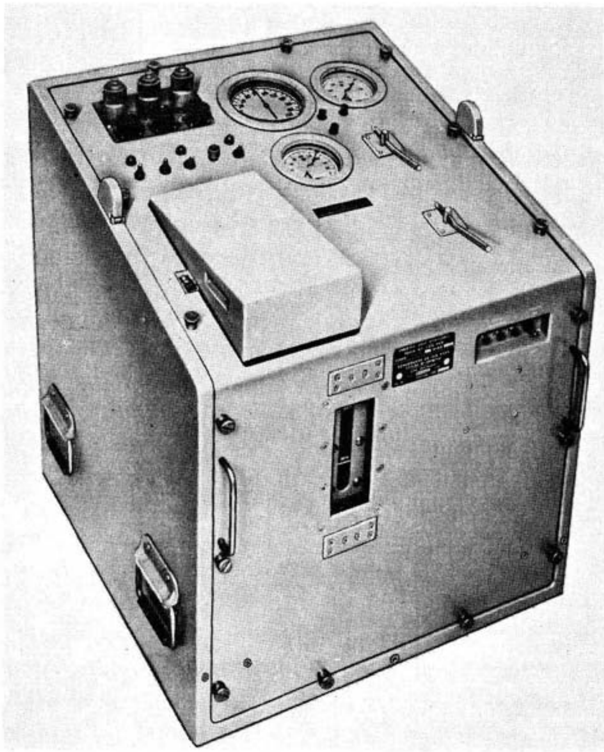
Set the BYPASS valves to the OPEN position. Set the VALVE switch to the CLOSED position and the OSCILLATOR switch to the OFF position. Turn the MOTOR switch to ON. Note whether the motor starts and the indicator lights illuminate. The supply pressure gage should read about 100 psi.

Then close the supply bypass valve. Check to see that the supply pressure gage reads approximately 1000 psi, and that the temperature reading is normal. Place the return bypass in its closed position; the return pressure gage shouldered about 125 psi.

When all these conditions are met, the unit is ready to be connected to the missile for automatic test. During the missile test, the unit is remotely controlled by the AN/DSM-54(V)

Tartar

The basic test philosophy of the DSM-54 test set applies also to the DSM-55(V) - to perform a test, as nearly automatic as possible, to assure that the Tartar will function as it should. Three



94.108
Figure 10-13.—Hydraulic Fluid Pumping Unit HD-259/DSM.

modes of operation are provided in the DSM-55(V): a missile systems test (MST) for use on the assembled missile, an electronic ("E") test for use on the electronic section by itself, and a manual mode which permits the operator to test any missile response at will.

There are five stages in the operating sequence of the test set: (1) before use, (2) standby, (3) during use, (4) after use, and (5) "secure." In the "before use" stage, the operator makes at least one pretest checkout every 24 hours of operation. The drop cables need not be attached to the missile, but the operator should assure that all test set circuitry is functioning, that the tape (in the test set) advances smoothly, that power supply voltages are available, and that all indicator lamps are functioning properly. The test set is ready to operate when all the indicator lamps and the READY lamp illuminate.

With the main circuit breaker on, depressing the POWER ON button places the test set on "standby." This allows all filament and plate voltages to come up to required levels. A 30-minute warmup is sufficient. The blower cooling the klystron should operate at all times to avoid damage to the klystron. Turn off the power immediately if the klystron blower is not operating. The blower that cools the chassis should begin operating immediately if the ambient temperature is over 35°F. After the test, the set is returned to STAND-BY by pressing the reset button. To secure the test set, place the main circuit breaker in the OFF position. This removes all power from the test set and the missile.

PREPARATION FOR USE (PRETEST CHECKOUT). - Follow the steps below to check the test set before it is to be used to test a missile.

1. Make sure that all captive screws on the control panel are tight.
2. Check all drop cables for proper connection to transition boxes.
3. Assure that no cables are connected to a missile.
4. Place Missile Circuit Breaker in OFF position.
5. Place Main Circuit Breaker in ON position.
6. Depress POWER ON button. See that the klystron blower starts immediately, and that the blower cooling the chassis starts when the ambient temperature is over 35°.
7. See that the POWER light is on. The tape index light should be on. If it is not, press the reset button and wait for the tape to rewind. At index, the lamp will go on.
8. Allow 30 minutes for the system to warmup.
9. See that all fuse lamps are out. If one is on, it means that the fuse is open and must be replaced. Spare fuses are available on the back of the microwave access door.
10. Set test function switch to MST.
11. Press the OPERATE button. During the next 15 seconds, the self-test will be run and the ready lamp should light along with all the active fault locator lamps.
12. Press the TEST START button. All lamps except "power" and "test in progress" should go out.

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13. The "test-in-progress" lamp will remain lit during an MST. The test will be completed in about 4 minutes. The "test-in-progress" lamp will then go out, and the tape will rewind.

14. Four minutes are required to rewind the tape. At the end of that time, the tape index lamp will illuminate.

15. See that the NO-GO and "Aft Mating" lamps come on. Since no missile was connected, an overall NO-GO should result at this point.

16. Press the reset button.

17. The pretest is now complete. If no missiles are to be tested with the next few hours, press the POWER OFF button.

There is no shipboard testing of Tartar missiles. All testing equipment for Tartar missiles has been removed from ships. Tartar GMLS are in a No-Test program which requires only missile stowage maintenance prior to missile firing. (Test set DSM 55 is used at shore stations only.)

Talos

Like the Terrier, Talos missiles should be given initial checkout and servicing as soon as possible after replenishment. Thereafter, check-out is accomplished periodically. Initial mating of the missile and booster includes installing the antenna lenses, matching the missile codes with those of the guidance radars, connecting the explosive lead to the warhead-booster assembly or electrically connecting the thermal-battery assembly. This routine is also followed in emergency operations, instead of the complete missile checkout.

PREPARATION OF THE TALOS MISSILE FOR CHECKOUT. - Preparatory steps for Talos missile routine checkout are as follows:

1. Select the round to be tested, remove it from the magazine, and transfer it to the check-out area.

2. By means of the ready service crane, transfer the round to the missile and booster dollies, and secure the round to the dollies.

3. Unmate the booster from the missile and return the booster to the magazine.

4. Remove the missile antenna lenses.

TALOS MISSILE CHECKOUT. - Talos missile checkout is accomplished by conducting a Tactical Missile Test (TMT), using the equipment previously described, and following instructions for the use of these equipments as contained in the applicable OPs. In general, the following steps are necessary.

1. Disconnect the flexible explosive lead (in Guided Missile Mk 11 Mod 2) or disconnect the thermal battery assembly (in Guided Missile Mk 11 Mod 4).

2. Check the nitrogen pressure in the inner-body assembly if the missile is Mk 11 Mod 4.

3. Make surveillance checks for fuel and hydraulic fluid leaks.

4. Match the codes and radio frequency to the guidance radars.

5. Conduct a "GO", "NO-GO" tactical missile test.

6. Perform missile maintenance as necessary.

7. Service the missile as necessary.

8. Test the innerbody assembly (if missile is Mk 11 Mod 4) by means of NAVORD Adapter Receptacle supplied with Test Set AK T-3074.

9. Reconnect the flexible explosive lead (in Mk 11 Mod 2) or reconnect the thermal-battery assembly (in Mk 11 Mod 4).

The TMT is also called the missile Operability Test (MOT), in fact, this term is replacing the earlier one.

When the above steps are completed, the missile and booster are remated in the checkout station, the antenna lenses are reinstalled, and the round is returned to the magazine. Subsequent to the initial checkout described above, periodic checkouts will be the same, except that it will not be necessary to again match the codes and radio frequency to the guidance radars unless the radar's code and frequency have been changed. If the TMT indicates NO-GO for the Talos and the fault has been indicated by means of the monitoring panel, replacement or adjustment of faulty components and modules should be accomplished.

Repair of missiles and boosters is limited to replacement of readily replaceable components, such as electronic packages, inner-body assemblies, booster shoes, and other items which do not require extensive disassembly operations, servicing, and adjustment procedures. The original versions of missile incorporate the large size electronics packaging which require the assistance of handling equipment. Since the checkout compartments each stow one set of replaceable spare parts, the units may be taken from these areas and replaced during lull periods.

When the test is completed, reconnect the flexible explosive lead (Mk 11 Mod 2) or the thermal battery assembly (Mk 11 Mod 4). Remate the missile and booster in the checkout area, reinstall the antenna lenses, and return the round to the magazine. After the initial test, step 4 can be omitted unless the radars' code and frequency have been changed.

In the test equipment checkout and missile warmup period, the test set runs through two self-check sequences. The results of the tests are indicated in GO/NO GO fashion on the test panels. If any element covered by the test is found faulty, a TATTE failure lockout command stops the test.

The self-check portion of the overall test is at the beginning of the test tape, or a special tape may be provided which contains only the self-check portion. With the special tape, the self-check of the test equipment can be performed without doing the missile operability test (MOT).

OP 2900 (Volume 3), Guided Missile Test Set AN/DSM-60, Operation and Maintenance (U:C), contains the complete instructions for the use of the technicians who conduct the missile tests. If you need to help with the tests refer to that text.

OWN SHIP'S MAINTENANCE PROGRAM

The development of planned systems for maintenance of ordnance and ship's equipment was discussed in the preceding course and in earlier chapters of this text, and also in your military requirements courses. Each ship develops its own Current Ships Maintenance Project (CSMP) file which is used for planning and coordinating the ship's maintenance workload. The CSMP file is made up of deferred action report form 4790/2K for those maintenance actions which have been deferred because of a requirement for technical skills or special equipment not available on board ship. This information is also used for analyzing maintenance and logistic support problems; and, in addition, the CSMP makes it possible to record and report the need to delay an accomplishment of a required maintenance and can indicate the principal reason for the delay. The 3-M System of maintenance and material management, its purpose, organization, and procedures for shipboard use and the forms which make up the CSMP are explained in chapter 11 of this test.

SLOW-RUN-THROUGH (SRT)

Because all parts of the missile system must work together, testing of the complete system must be done before it is put into use, and at intervals thereafter. Shipbuilders and naval shipyards are given general and detailed specifications for installing the equipments and for checkout procedures after installation. The systems test after installation on shipboard is called the slow-run-through (SRT). Detail requirements for the SRT are established by the NAVSHIPSYSCOM. The SRT must demonstrate the satisfactory operation of the complete shipboard weapons installation, including supporting and auxiliary subsystems.

An SRT may also be necessary after a ship has undergone overhaul or conversion and after new or major alteration to the weapons system. Sometimes it is necessary after a minor alteration because of alignment problems. In that case the necessity for an SRT is determined by the type commander, NAVSHIPSYSCOM, and the shipyard. Any deficiencies revealed during the SRT must be corrected by the installing activity. The ship's personnel assist in conducting the SRT.

Testing of advanced ASW system installations, surface-to-surface, and surface-to-air missile installations begins with replenishment-at-sea and proceeds through all phases of strike-down, stowage, checkout, disassembly, servicing, checkout servicing, assembly, handling, and simulated launch. For ASW systems (Asroc), an actual or simulated sonar contact is introduced into the overall weapon system and checked through the underwater fire control system. On other systems, an actual or simulated output from the ship's search radars is introduced into the overall missile system and checked through the weapons direction equipment, the missile fire control system, and the ready service feeder and launcher system. The feeder and launcher systems thereby receive orders that result in a missile being rammed on the launcher and the launcher trained and elevated to the position indicated by the initial input. Each magazine, launcher feeder, checkout, and strikedown system must be tested.

In addition to testing the weapons system, all supporting services and auxiliary subsystems must be tested. These include all associated lighting, air conditioning, humidity control, security alarms, sprinkling, damage control facilities, air sampler alarms, communications, and other utilities contributing to the effectiveness of the weapons system installation. Accurate time cycles must be recorded for parts of the system where the speed is part of the operational effectiveness.

When an SRT is being conducted on your ship, as a petty officer you will be assigned responsibility for checking the operation of parts of the ship's equipment and keeping the records of the operation. As a GMM 1 or C you will supervise the operation of parts of the launching system and the recording of results of the tests. The response of the launcher to train and elevation orders must be noted with care, and adjustment made if necessary. The correctness of the firing cutout cam is demonstrated by the launcher movement; the cam must prevent launcher movement into an area where the ship's structure or personnel would be endangered. Since there are differences in each installation, detailed instructions are prepared for each ship. From these instructions the tasks are apportioned among the ship's and contractor's personnel.

ORDALTS

Of course you know what an ORDALT is - you have worked with an on them a number of years in your Navy career. They are NAVORD authorized alterations to ordnance equipment, made to improve the existing ordnance. Many of the changes are made to improve the safety features of the equipment; others are changes to increase the accuracy or reliability of the equipment. Some are required and must be performed before the equipment is used again. Others are optional and mayor may not be performed before the equipment is used again. SHIPALTS are of NAVSHIPS cognizance and may be associated either with ORDALTS or alterations to equipment belonging to the NAVSHIPSYSCOM, but supervised by the weapons department. NAVALTS are handled as ORDALTS or SHIPALTS, as appropriate.

The program for accomplishing ORDALTS is described in the next chapter. The most essential changes must be made first; priority is assigned by the ship's Ordnance Accomplishment Requirement (OAR).

An ORDALT Instruction states the specific conditions of applicability of the ORDALT and the method by which it is to be accomplished. If it affects only a few units, the serial numbers of the equipments affected are given. All necessary drawings, sketches, etc., are included as part of the instructions. ORDALT kits should be ordered through normal supply channels. Authorization for accomplishment of ORDALTS on nonexpendable ordnance in accordance with NAVORD INSTRUCTION 8000.2, "Nonexpendable ordnance."

After the alteration has been made on the equipment, the ORDALT number must be stamped on the ORDALT plate on the equipment, if it has one. If it does not have an ORDALT plate, order one from Supply, inscribe the number of the completed ORDALT, and attach it to the equipment, if permissible. Guided missiles and torpedoes are examples of ordnance where it is not permissible to attach ORDALT plates.

As a GMM 1 and C you have more responsibility for getting the ORDALT promptly and precisely accomplished. Authorization for ORDALT accomplishment is by a specific work directive (letter, project order, allotment, etc.), and the current ORDALT are listed by number, name, and brief description in NAVORD ORDALT 00, in numerical order. Cancelled, completed, superseded, or disapproved OrdAlts are listed by number only. Keep informed on what changes are required for your equipment so you can plan to get the work accomplished on schedule. In some activities delay in

ORDALT accomplishment has seriously hindered and hampered the ship's mission. This is especially true when the ORDALT is intended to remove a safety hazard and the equipment may not be used until the ORDALT is performed.

Many of the ORDALT that apply to guided missile systems contain classified information and therefore are held by the publications custodian. Maintain the required security status when using them.

An ORDALT is not necessarily a complicated, lengthy alteration; some require only a few minutes to complete. The important thing is to schedule them for a definite time so they will be done at that time and not forgotten.

OVERHAUL

The quals require you to be able to overhaul mechanical, electrical, electronic, hydraulic, and pneumatic systems of the missile launching system.

That seems to include just about everything, and at first glance appears a well-nigh impossible requirement. However, the overhaul must be within the ship's capability as well as yours. Before you undertake an overhaul job, be sure you have the necessary equipment and facilities. Usually the OP for the equipment will state definitely whether it can be repaired or over-hauled aboard ship. Many electronic components are replaced rather than repaired aboard ship, and spares are carried in supply. In your daily practice session with the equipment you learn to make many repairs and adjustments, but in a combat situation it may be impractical to attempt repair of a sophisticated electronic unit.

The forms to be used in requesting and in reporting overhaul actions are discussed in the next chapter.

SUMMARY

This chapter covers the bare bones of the testing and maintenance program for the launching system, the missiles, and the operation of the weapons system. The systematic routine testing, inspection, and maintenance are discussed first for the launching system. The operability tests can be performed only with the assistance of other ratings. The system must be kept in operating condition, and therefore the Daily Systems Operability Test (DSOT) is necessary.

The missile must also be checked out frequently. The explosive components of course cannot be tested, but the reaction of the missile's electric, electronic, hydraulic, pneumatic, and mechanical parts to signals or commands are tested regularly with the aid of FTs. Although plans are being worked out so that missiles will not have to be tested aboard ship, shipboard testing of missiles will be continued according to schedule until such time as the NO-TEST system is ready.

CHAPTER 11

ADMINISTRATION AND SUPPLY

To be an effective petty officer you must have a certain amount of administrative ability. Some of this may be natural aptitude, but much can be learned. Administrative ability is an important part of leadership. It includes the arts of organization, management, and human relations. A good administrator can grasp the overall plan, fill in details of the plan, determine his place in it, and carry out his part of it with the help of his men. A course which you have completed, *Military Requirements for Petty Officer 3 & 2*, NAVTRA 10056 discusses at some length the qualities you need to become a leader. More emphasis is placed on the planning responsibilities of the petty officer in *Military Requirements for Petty Officer 1 & C*, NAVTRA 10057. It devotes a whole chapter to administrative duties, and in related chapters discusses them in particular areas or fields. Keeping records and making reports are important parts of those duties.

This chapter deals almost entirely with the paperwork required in the performance of your administrative duties in regard to maintenance, repair, supplies to perform the maintenance and repair, reports on performance of the weapons system, reports on tests on tests made, planning of work, and recordkeeping. The automatic data equipment must have data put into it before it can do any computing. Your reports and records furnish the necessary data.

ADMINISTRATIVE REQUIREMENTS

In every chapter, something has been said about the role of the GMM 1 and GMM C as a supervisor, teacher, planner, and executive or administrator. The quals require you to "Plan, implement, and supervise;" "Coordinate and direct;" "Organize and administer;" "Implement plans;" "Prepare plans," etc. To perform adequately as a GMM 1 and GMM C, you must have wide practical and technical knowledge of the equipments used in your rate, and experience in performing the physical work involved in operation and maintenance of the launching system. This background must be teamed with the ability to see the overall picture or plan, and the ability to direct the activities of the men to achieve the objective of the plan. You have to be able to interpret directives, rules, forms, plans, and instructions, and explain then clearly to the men.

The GMM 1 and GMM C has the responsibility for many of the reports required of the weapons department. As a GMM 3 and GMM 2, you have filled out many of the simpler forms, such as those used in recording magazine inspections, maintenance performed, and other data cards. You need to check these for accuracy and completeness when your men prepare them.

The reports must be accurate and must be promptly made and promptly sent. Computers cannot come up with the correct answers if the inputs are wrong. Your reports are the input.

In addition to knowing the requirements for your launching system and the missiles, you also need to have some acquaintance with the supply system. You need to know how and where to order parts, what you can order, and what to do with the replaced parts.

Your quals require you to know the regulations concerning accountability and procurement, maintenance, stowage, and transmission of classified records, reports, and publications. Since much of the written material in your department is classified. you need to institute a constant check on the proper keeping of the material.

Personal qualifications related to administrative ability are discussed in chapter 1 of this text and in your military requirements text.

STANDARD NAVY MAINTENANCE AND MATERIAL MANAGEMENT SYSTEM

Each shipboard Guided Missile Weapon System maintenance program is part of the Standard Navy Maintenance and Material Management (3-M) Planned Maintenance System for Surface Missile Systems (PMS/SMS). SMS documentation, in conjunction with OPNAV 43P2 (3-M) Manual and the associated equipment publications for a specific system, constitutes the basis for an effective PMS/SMS maintenance program. The ship's Weapon System publications for a type of weapon system installed aboard on a specific class ship describe the relationship of the system/equipment documentation to OPNAV 43P2 and amplify instructions for implementing shipboard management procedures in consonance with the 3-M Planned Maintenance System.

OPNAV 43P2 is the authority and basic guide governing maintenance management within the Cruiser-Destroyer Force. It provides management with information required for efficient and economical utilization of all available resources. Technical details necessary for making repairs to SMS equipments are not included in OPNAV 43P2. OPNAV 43P2 delineates those procedures required for implementation of the PMS system and the Maintenance Data Collection System (MDCS).

The 3-C system encompasses all maintenance and material functions performed on ships and aircraft of the operating forces. These functions are performed within two levels of maintenance which are defined as (1) organizational maintenance at the ship level and (2) intermediate maintenance performed in tenders, repair ships, and all repair activities ashore except for shipyards and overhaul and repair (OR) facilities. Uniform procedures and systems are applied to the following functions performed within the operating forces.

1. Maintenance planning, scheduling, and control procedures.
2. Maintenance production and material usage data reporting.
3. Supply accounting and budgetary support systems and procedures.

The primary objective of the 3-M system is to improve material readiness of the fleet through improvements in management and material functions. To attain this objective, the 3-M system employs three' basic functional subdivisions which include the Planned Maintenance Subsystem (PMS), the Maintenance and Material Data Collection Subsystem (MDCS) and the Manhour Accounting System. All of these subdivisions are explained in detail in Military Requirements For PO 3&2, NAVTRA 10056, and Military Requirements For PO 1 &C, NAVTRA 10057.

PLANNED MAINTENANCE FOR SURFACE MISSILE SYSTEMS

The PMS/SMS maintenance program was initiated by the Navy Ordnance Systems Command to improve fleet maintenance documentation for surface missile systems and for the individual equipments of these missile systems. The concept underlying PMS/SMS arose from a background of fleet operational experience with surface missile systems and the difficulties encountered in their operation and maintenance. Early attempts to alleviate these difficulties led to' the development of a daily system test designed to determine overall system operability in the normal modes of) operation. Through developmental experience with this test, it became apparent that all system functional circuits could not be checked by a single daily test. By examining functional circuits within the system, and by determining the importance of each circuit to system operation, system versus equipment level maintenance requirements could be established.

Integrated Testing

While it is recognized that improvements in hardware design can now and will in the future improve reliability and decrease down time, a more immediate gain can be realized through improvements in testing and trouble-shooting techniques. PMS/SMS was devised to ensure optimum missile system material readiness through an integrated, test-based maintenance program. One of the key points in the PMS/SMS maintenance program is the establishment of a management plan for missile system maintenance. The required frequency of each system test, equipment test, and servicing procedure for the missile weapon system has been established. Different type surface missile ships are now able to integrate system level operational/maintenance tests with individual equipment level tests and servicing procedures.

PMS/SMS Maintenance Management

A Planned Maintenance System (PMS) is directed toward preventive, rather than corrective maintenance. PMS maintenance documentation is developed by critically examining all routine preventive maintenance tasks so as to determine actual maintenance requirements deemed necessary, who should perform the tasks, and the proper periodicity of accomplishment. When all of these questions are answered, a specific maintenance procedure is developed for a specific component of a system and placed on a Maintenance Requirement Card (MRC). MRCs prescribe minimum maintenance requirements capable of accomplishment by shipboard personnel, which will maintain equipment operation within design standards and meet established readiness criteria.

A PMS/SMS maintenance system in addition to routine preventive maintenance include system operational tests supported by fault isolation documentation and special corrective maintenance procedures. System/equipment level tests and corrective maintenance servicing procedures are found on MR cards in the same manner as for PMS. Corrective alignment/ adjustment and or repair/replacement procedures are performed only when a problem has been isolated as a result of system or equipment maintenance test failure. Within PMS/SMS, a test is defined as a standard procedure to determine if the current operational status of a specific system (equipment) function is within the desired tolerance limitation' characteristics. When fault indications are observed during the test process, test related fault directories and or data reduction analysis procedures are used to ensure a logical follow through from the system equipment fault indication to the most appropriate troubleshooting document. The relationship of system level to equipment level documentation used in implementing an integrated maintenance program for PMS/SMS is outlined in specific technical PMS/SMS manuals.

Equipment OPs

A PMS/SMS equipment Ordnance Publication (OP) contains all the technical information pertaining to major components of a shipboard surface missile system. These publications consist of five volumes; (Volume 1) describes the major component (a launcher, a radar, a director) and explains the operating functions; (Volume 2) gives detailed instructions for performing scheduled maintenance actions; (Volume 3) provides the necessary documents for trouble isolation; (Volume 4) provides the necessary instructions for corrective maintenance actions; and (Volume 5) includes a complete indexed listing of parts for identification and replacement purposes and a list of special tools and accessories. Detailed instructions on the use of the contents in this publication are provided as necessary in the introduction of each chapter. Volume 2 and Volume 4 of most equipment OPs have been deleted from the manual structure and have been superseded by the PMS/SMS MRC cards and PMS/SMS Corrective Maintenance Card (CMC) sets. These two volumes should not be eliminated from the manual structure until adequate scheduled and corrective maintenance card coverage is instituted in shipboard launcher spaces and applicable corrective maintenance material has been installed in the group work spaces in accordance with implementation instructions contained in the SMS corrective maintenance manual. Premature destruction of these two volumes could result in inadequate documentation aboard ship for equipment maintenance, therefore launcher supervisors shall ensure that scheduled and corrective maintenance card coverage is adequate and that the card sets are satisfactorily distributed to all launcher spaces.

System OPs

A PMS/SMS system OP describes the physical, functional, operational, and maintenance aspects of a specific Guided Missile Weapon System onboard a specific type ship. An example of a system OP is NAVORD OP 3472 (PMS/SMS) for Tartar Guided Missile Weapon System DDG 2 through 24 class ships. System OPs are used by personnel responsible for operation and maintenance of a weapon system and by personnel concerned with training personnel. System OPs have eight volumes; Volume 1 is entitled Description and Operation. Volume 2 describes general and specific safety precautions to be observed for ensuring the safety of personnel responsible for the operation and maintenance of a weapon system. Volume 3 describes the weapon system General Quarters (GQ) duty stations and recommended personnel assignments and operating procedures within these stations under normal and casualty conditions. Volume 4 contains a functional description of a weapon system with emphasis on analyses of major system functions involved in Fire Control System (FCS) assignment, target tracking, computations of missile orders, and evaluations of Daily System Operability Tests (DSOT). Volume 5 explains system PMS as applicable to a specific system ensuring an adequate frequency of system tests to verify continued satisfactory performance of the system. Volume 6 explains Weapon System Maintenance Tests, test fault directory, and other essential data to ensure effective testing and isolation of malfunctions to a specific functional area of a system. Volume 7 contains troubleshooting and alignment documentation necessary to quickly isolate malfunctions and misalignments to a particular equipment or circuit within the equipment. Appropriate descriptions and references are provided to ensure effective use of all troubleshooting and battery alignment material. Volume 8 contains System Functional Diagrams (SFDs) and sketches which functionally present the system interconnecting circuits for weapons control, fire control, missile firing and system support equipment.

MAINTENANCE LEVEL RESPONSIBILITIES

The Navy has prescribed three levels of maintenance accomplishment; (1) organizational (ship), (2) intermediate (tender/repair facilities), and (3) depot (Navy/civilian shipyards). The authority for conducting maintenance management within the respective areas of their responsibility belongs to each CO, squadron commander, and force commander. Organizational maintenance applies to maintenance functions normally performed on a day-to-day basis by an operating ship. System or equipment maintenance within each department aboard ship is generally accomplished by personnel assigned to that particular department. Organizational level work can generally be grouped into the following categories.

1. Scheduled testing
2. Preventive maintenance
3. Corrective maintenance
4. Equipment modifications through installation of applicable SHIPALTs, ORDALTS, field changes and so forth.
5. Necessary record keeping and submittal of records peculiar to organizational level maintenance.

Intermediate maintenance applies to maintenance functions normally performed by tenders. The primary purpose of the intermediate level maintenance activity is to support and supplement the work of organizational maintenance activities as follows:

1. Repair and test of components and items requiring shop/equipment facilities and/or skills not available in organizational level activities.
2. Installation of SHIPALTS and field changes beyond the capability of organizational level activities.
3. Record keeping and reporting peculiar to intermediate level maintenance.

Depot maintenance applies to the maintenance functions performed by shipyards and other shore activities (installation of ORDALTS). The technical aspects and quality of depot level maintenance is under management control of the cognizant systems commander.

Lowest Level Maintenance

Determination of types of maintenance performed at each level is governed primarily by the availability and distribution of maintenance personnel, equipment, parts, and facilities. It is a common function to ensure that the distribution of equipment and facilities is continually reviewed for the purpose of increasing the amount of maintenance activities that can be performed at the lowest level consistent with available personnel skills and an acceptable quality of work.

PMS/SMS Tools and Documentation

In addition to the maintenance documentation previously defined, PMS/SMS also requires the use of special tools and documentation for maintenance accomplishment. These include OPNAV 43P2, OPNAV 43P1, cycle schedules, quarterly schedules, weekly schedules, maintenance requirement cards, and associated hardware. A chapter on the 3-M system is contained in Military Requirements for PO 3&2 (NAVTRA 10056-C) and discusses the principal components of the system and illustrates the various forms required for carrying out and recording maintenance actions. Complete details of the entire 3-M system are contained in the 3-M manual, OPNAV 43P2.

Work Center Manual

The work center manual (43P1) is that portion of the master PMS manual (43P2) which contain the Maintenance Index Pages (MIPs) applicable to a specific maintenance group. It is designed to provide ready reference within the maintenance group and is used by the maintenance group supervisor in preparing his weekly schedule.

Scheduling Maintenance

Each ship has a long range schedule which includes all the maintenance work to be done between overhauls. It is displayed on a schedule display board, and consists of the Cycle Schedule and two quarterly schedule forms (the current quarter and the succeeding quarter). Maintenance requirements are scheduled by weeks and are determined from the Cycle Schedule. There are spaces for each maintenance group (gunnery, etc.). The quarterly schedule is prepared by the department head, the division officers, and the maintenance group supervisors. The latter prepares the weekly schedule from it, in which he assigns specific jobs to personnel by name. The weekly schedule is posted in the work area of the maintenance group. The printed form, OPNAV Form 4700-6, is made of plastic and is written on with a pencil. It is cleaned with a soft rubber eraser and is used over and over.

The numbers in the daily columns are the maintenance requirement numbers that appear at the top of the maintenance requirement cards. The man who is assigned to do the work pulls the MRCs from the set as he needs them to perform each job. As each job is finished, he places an X on the weekly schedule after the number of the completed job. Any work that is not completed at the end of the week is circled and is rescheduled for the next week or another time. The petty officer who is the maintenance group supervisor reschedules all the circled items. He also fills in the column on "Outstanding repairs," in which he explains why some work was not or could not. be completed. Possible reasons are lack of qualified men, shortage of repair parts, etc. At the end of each week he also updates the quarterly schedule by marking on it the jobs that were completed during the week, and circling those that were not completed. At the end of the quarter, the quarterly schedule is filed in the maintenance records. Your officer prepares the quarterly schedules from the cycle schedule and the Planned Maintenance Subsystem Manual, and you assist him. The schedules are posted (quarterly schedule and subsequent quarterly schedule); and unfinished jobs are transferred to the schedule for the subsequent quarter. The PO also supervises, assists, and teaches the men as they do the maintenance work; and he checks the completed work. Do not "gun deck," the records, and do not give your O.K. to unacceptable work.

SHIP ARMAMENT INVENTORY LIST

The Ship Armament Inventory List (SAIL) is a reporting system which furnishes NAVORD and all commands concerned with a master armament configuration listing of installed shipboard nonexpendable ordnance equipment together with pertinent Ordnance Alterations (ORDALTS) status. SAIL is produced on data processing equipment and includes the ordnance equipment listed in the Ordnance Systems Patterns portion of Index of Alterations to Ordnance Equipment (ORDALT OO). The SAIL program supersedes the formerly used Ordnance Inventory/Ordalt Status Listing, which it greatly resembles.

Each ship has on board two copies of SAIL supplies by NAVORDSYSCOM. A sample copy of SAIL is shown in figure 11-1. Prior to a scheduled overhaul availability, this list should ~ be reviewed and all changes in armament and ORDALT completion status that have taken place since the last printing of the listing should be annotated on one copy of the list. This corrected copy should be marked "PRIOR TO OVERHAUL REPORT" and submitted to reach NAVORDSYSCOM (ORD 041B3) on the first of that month 7 months prior to a scheduled yard overhaul. After submitting these corrections, NO corrections to the SAIL should be forwarded until completion of the yard availability. Complete instructions for correctly annotating SAIL can be found in NAVORD INST 8000.1.

SAIL Distribution.

a. The Naval Ordnance Systems Command normally will distribute copies of SAIL to:

Naval Shipyard/SUPSHIPS/INDMAN (as appropriate)
Ship/Station/Command
ESO
SPCC
NAVWPNSERVO
Type commander
NAVPLANTREP
NSMSES (SMS ships only)
NUWRES (ASW ships only)

b. The SAILS distribution schedule will be as follows:

EVENT	
Construction/ Conversion construction/	12 months prior end-of conversion End of conversion/ fitting-out
Regular Overhaul (ROH)	6 months prior to commencement 2 months after completion
Post Shakedown Availability (PSA)	2 months after completion
Significant Change	2 months after receipt of report

Within 10 days following completion of shipyard overhaul, the ship shall annotate the SAIL to indicate all corrections, additions, and deletions, mark the report "OVERHAUL COMPLETION REPORT", and forward one copy to NAVORDSYSCOM. Upon receipt of this verified and corrected copy, NAVORDSYSCOM processes the corrections, and a new revised SAIL is distributed as indicated above.

Any changes in reportable ordnance equipment installed aboard, or the accomplished of an ORDALT which takes place at times other than as specified above, should be reported when occurring using Ship Armament Inventory List (SAIL) Change Report, NAVORD Form 8000/2 figure 11-2. This report is required because NOSC NAVORDSYSTEM must have, at all times, an up-to-date listing of inventory and ORDALT status for each ship. No revised SAILS ate produced, except as provided above, unless NAVORDSYSCOM considers that the changes are of such significance as to render the latest SAIL obsolete.

For purpose of current reference, ships and activities should keep their latest copy of SAIL marked up to date and destroy the previous one.

OAR PROGRAM

The ORDALT Accomplishment Requirement (OAR) is a list issued by NAVORDSYSCOM on NAVORD Form 8000/3 (figure 11-3) about 6

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
Table of Contents

LSR / EXPANDED SAIL
LOGISTICS SUPPORT REQUIREMENTS (CATALOG NO 0D0040)
VESSEL NAME: KNOX SQDRN/DIV: 112

REASON FOR ISSUE: SPECIAL REQUEST TYCOM: COMCRUDESPAC TYPE/HULL: DE 1052 CIP: 1052 UIC: 54047

AVAILABILITY DATE: 10/08/69 TO 01/18/70 O/H YARD: LBECH REPORT DATE: 09/10/70 NAVSHIP TYPE DESK 423

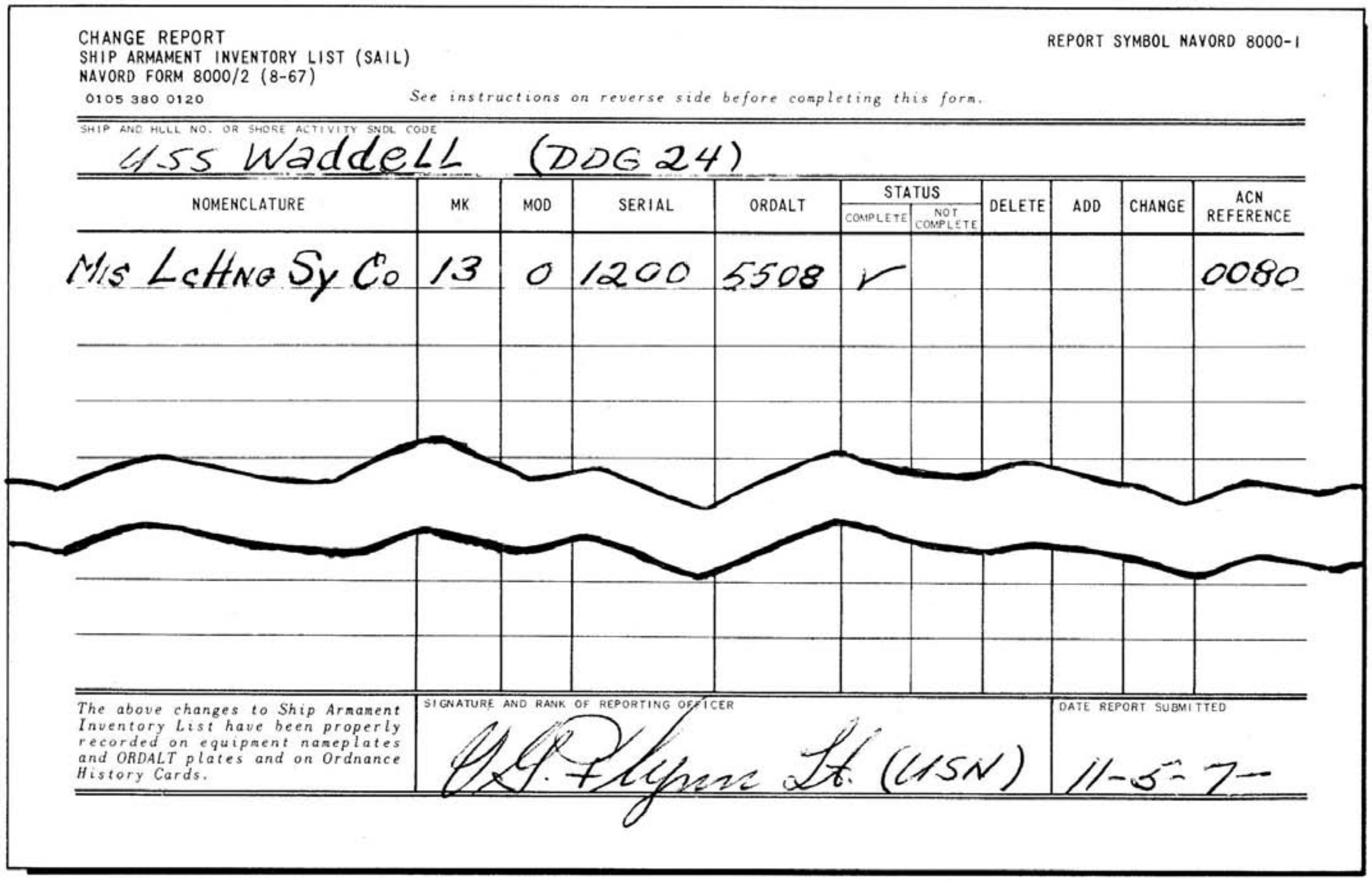
CAN	SYS/EQ NOMENCLATURE	CODE	MARK	MOD	SERIAL	P	LOC	EIC	APL	LD/SK	DWG NO	FSN	ORDALT DATA NUMBR	R	C	S	K	COMPL DATE
870													6888			00	%	70-07
880	TELESCOPE	8185	100	1	51			G11K700	49401989									
880												4N12405937041	3867			00	%	69-02
900	DYNAMIC TESTER	2595	2	3	54			G1R3000	49402528	2324850								
910	ERROR RECORDER	3095	7	1	192			G1RA000	49402010	LD412565								
920	TEST SET	8195	346	3	147				49402717		2438177							
930		612	14	6	02-01													
930													6653			00	P	70-02
930													6654			00	P	70-02
930												2A49251347728	6791			00	P	
930													7024			00	P	69-03
930													7063			00	P	69-03
930													7115			00	P	
930												2A12901685649	7200			00	P	
1000	MISC FIRE CONTROL EQ	678	-	-	-													
1010	BEARING/RANGE INDICA	1645	7	4	165													
1020	DUMMY DIRECTOR	2585	3	8	132			JY41000	49402156	LD272568		2J49317708439						
1030	ERROR RECORDER	3095	6	5	173				49400582									
1040	INDICATOR PANEL	4925	5	29	653				49401604	LD281226								

PAGE
6

TOTALS: SYSTEMS: 10 EQUIP: 69 ORDALTS: 125 COMPLETE: 96 INCOMPLETE: 29 ITEMS: 204

63.12

Figure 11-1.—Ship Armament Inventory List (SAIL).



CHANGE REPORT
SHIP ARMAMENT INVENTORY LIST (SAIL)
NAVORD FORM 8000/2 (8-67)
0105 380 0120

REPORT SYMBOL NAVORD 8000-1

See instructions on reverse side before completing this form.

SHIP AND HULL NO. OR SHORE ACTIVITY SNDL CODE: USS Waddell (DDG 24)

NOMENCLATURE	MK	MOD	SERIAL	ORDALT	STATUS COMPLETE	STATUS NOT COMPLETE	DELETE	ADD	CHANGE	ACN REFERENCE
M/S LcHNG Sy Co	13	0	1200	5508	✓					0080

The above changes to Ship Armament Inventory List have been properly recorded on equipment nameplates and ORDALT plates and on Ordnance History Cards.

SIGNATURE AND RANK OF REPORTING OFFICER: O.G. Flynn Lt. (USN)

DATE REPORT SUBMITTED: 11-5-7-

180.121

Figure 11-2.–SAIL Change Report, NAVORD Form 8000/2.

months prior to overhaul of a ship. It lists all outstanding ORDALTS for the ship is order of priority of accomplishment and shows the estimated man-hours for accomplishment of each ORDALT, and the total estimated cost for the ship. The ship receives one copy, which must be given a thorough review and a report then submitted within two weeks to NAVORD NAVSHIP the overhauling activity, and SPCC. This report must list all the ORDALTS completed after the "Prior to Overhaul" SAIL was submitted, all ORDALTS that should be on the OAR list but are not, all ORDALTS that are on the OAR list, but are not applicable, and a list of all applicable ORDALT material on board. Upon receipt of this report, and appropriate offices will amend the OAR, requisition material, and plan to accomplish as much of the required ORDALT work as is possible within the limitations of time and available funds.

Further details on OAR can be found in NAVORD INST 8000.2 and 8000.6.

SHIPYARD AND TENDER AVAILABILITY

The preceding chapter described the weapon system CSMP. The petty officers of the division prepare and maintain the records so they are ready for the engineering department and the commanding officer when they prepare the work requests for the whole ship and submit them for review for yard or tender availability. Within ten days after completion of overhaul, the shipyard, or overhauling activity, submits a report to NAVORD and NAVSHIP of the ORDALTS they have accomplished and the total cost. A revised SAIL, reflecting this report and the ship's annotated SAIL "OVERHAUL COMPLETION REPORT", is then issued by NAVORD and sent to the ship.

O A R — ORDALT ACCOMPLISHMENT REQUIREMENT

OVERHAUL OR BUILDING YARD	OVERHAUL OR COMPLETION DATE	TYPE COMMANDER	VESSEL NAME OR ACTIVITY	TYPE	HULL #
BOSTON	6-15-65	CRUDESLANT	DEWEY	DLG	14

			SYSTEM				EQUIPMENT				ESTIMATED		EXPENDED
ITEM	ORDALT	SHIPALT	NOMENCLATURE	MARK	MOD	SERIAL	NOMENCLATURE	MARK	MOD	SERIAL	CONTRACT SERVICE ENGINEER MAN HOURS	INDUSTRIAL ACTIVITY MAN HOURS	INDUSTRIAL ACTIVITY MAN HOURS
1	5233		Guided Missile Launching System	10	0-6	23	Dud Jettison Interlock	108	0	14		10	

APPROPRIATION	APPROVED FUNDS	ORIGINALLY PREPARED	REVISED DATE	PAGE	TOTALS		
61192/6823/64	4475	7/63			MAN HOURS	10	
					DOLLARS	4475	

63.13

Figure 11-3.—OrdAlt Accomplishment Requirement (OAR), NAVORD Form 8000/3.

The records must be as complete and up to date as you can make them. If you forget to record an item that needs to be repaired at a navy yard, there won't be another chance for 2 years or more. However, essential repairs, that is, repairs necessary for the safe and reliable operation of the ship to carry out her military mission, will be taken care of.

Work Requests

Each division must write up its work requests in time to be included in the ship's repair or overhaul requests. The petty officers in each division are most familiar with the repair, alteration, and overhaul needs and therefore are the logical ones to prepare the requests. It may not be possible to include all your requests in the ship's scheduled repair and overhaul time, or your request may be returned with the notation that you and you men should perform the work aboard ship.

OPNAV Form 4790/2K (Work Request Form) is used to request assistance to complete a maintenance action. Work requests are prepared from the information contained on the shipboard copy of a deferred action form which makes up the department CSMP. Procedures for preparing internal Work Requests are outlined in the 3-M Manual, OPNAV 43P2. Appropriate blocks on four sheets of form 4790/2K are filled in, to record the need for outside assistance.

Variations, however, from this standard number of copies may be required by certain repair activities. OPNAV Form 4790/2K is a single sheet, multipurpose form printed on NCR (no carbon required) paper. The 4790/2K is used to report certain completed maintenance actions, deferred maintenance actions and the requirement for maintenance assistance (Work Request). Form 4790/2K differs only in the required information appropriate for each type of maintenance action. Each maintenance action requires a different type of maintenance action code system to be recorded in data element block on form 4790/2K. Special instructions for documentation of 4790/2K are contained in 43P2. Three Maintenance Action blocks (Comp, Defer, Work Req) located in the upper right corner of 4790/2K, are used to designate the purpose of the form.

Supplemental Form 4790/2L

OPNAV Form 4790/2L provides a supplemental form for voluntary submission of maintenance-related comments, questions or information which cannot be accommodated by the 4790/2K. If drawings or sketches are required for a work request, form 4790/2L is used to record the required drawings and sketches and all other additional data about blueprints, technical manuals, plans, etc., required to accomplish the work request. When using 4790/2L for overflow information about a work request, be sure to check appropriate continuation sheet block and that the ship's job control number is the same as the one used on the work request form 4790/2K. Form 4790/2L is also used as a DMCS feedback form for voluntary submission of maintenance-related information. Voluntary submittal of maintainer's observations and remarks is encouraged. Those who are willing to take the time and trouble to document such information can provide valuable assistance to the commands responsible for more effective support of fleet equipment.

The information furnished on 4790/2L might assist technical, supply, or other support personnel in understanding or evaluating a maintenance problem related to a routine maintenance action. Such information may be submitted in the form of sketches, narrative comment above previous maintenance experiences, or about operational circumstances surrounding a required maintenance action or a previously reported equipment failure. Form 4790/2L is also used as a MDCS feedback form for reporting certain special maintenance data. The mandatory use of 4790/2L will be initiated only after review and approval of a special maintenance plan by the Chief of Naval Material. Form 4790/2L is fully described and discussed in the 3-M Manual 43P2.

Technical Assistance

Assistance for field services may be obtained when technical difficulties are beyond the repair capabilities of a ship. Certain field activities of the Navy have technical personnel assigned to them and some Service Forces have system engineering specialists assigned directly to Force Commanders. These engineers are specialists in particular equipments which makes their availability limited. Emergency request for technical assistance may be made by message or telephone to the nearest activity having a specialist but a written request for assistance must follow. Maintenance assistance received from MOTU, Tech Rep or NOSSO contact personnel or other activity which does not normally require documentation of maintenance actions will be documented on a single sheet of form 4790/2K and submitted as a work request. The document is originated by the requesting work center in accordance with procedures outlined in OPNAV 43P2.

The objective of NAVORDSYSCOM is to ensure that all ordnance units attain the maximum degree of self reliance in operation, utilization, and maintenance. Special assistance is provided to fleet personnel who serve these objectives by providing special assistance through different levels of maintenance assistance by Contact Service Engineers (Tech Rep), Mobile Technical Units (MOTUS) and Naval Ordnance System Support Office (NAVORDSYSUPPOs).

Contact Service Engineers are specially trained contractor engineers and technicians trained to handle specific equipments. These personnel are available on an "as required" basis either by special assignment to activities or service commands, or by a specific request to NAVORDSYSCOM. Special Ordnance and Type

Commander (TYCOM) instructions are issued periodically to cover these services.

Mobile Technical Units (MOTUs) are specifically selected and trained groups of military personnel assigned to and made available by Commander Service Force Pacific and his counterpart, Service Force Atlantic. These groups normally are made available for assistance in the maintenance of newly installed equipment, but may be called upon in an emergency. There are other forms of external assistance given to ships when requested, such as contractor representative personnel assigned by NOSSO for special projects.

Once the assistance has been rendered, or it has been found that the equipment cannot be repaired or deficiencies in its operation can not be eliminated without extensive work and time, a maintenance action report (4790/2K) is prepared and used by the ship as a reference to prepare job requests when the ship is assigned an upkeep or yard availability. Requests for technical assistance during regular overhaul to augment the technical capability of an activity will be specifically directed to NAVORDSYSUPPO Atlantic or Pacific in accordance with NAVORD INST 4350.4. In the event of an emergency request, the appropriate NAVORDSYSUPPO will be advised, by telephone or message, of the scope and nature of the request. Listed below are the major services provided by NOSSO organizations.

1. Liaison, single point of contact for ordnance
2. Fleet support engineering
3. Tech assists (MOTU Backup)
4. Pre-deployment reviews (PDR)
5. Configuration (Verifications and up date)
6. Special assist teams

a. Technical (system and or equipment)
b. Torpedo
c. Logistics
d. Test equipment
e. Publications (tech data and documentation)

7. Ordnance technical training support
8. Tests and trails on new construction/ modernized surface ships.

ASSISTANCE TEAMS

Navy Ship Missile System Engineering Station (NSMSES) provides a program of timely and competent assistance to the commanding officer of each guided missile ship in achievement of a stable level of weapon system operational readiness on a continuing basis. The Ship Qualification Trials (SQT) are conducted in order that surface missile/UNREP systems may be adequately checked out and proofed after completion of new construction, conversion, or overhaul and prior to overseas deployment. A Ships Qualification Assistance Team (SQAT) is provided by NSMSES to assist a ship's crew in achieving or demonstrating a set of program objectives for a given surface missile/UNREP system during a SQT period. A SQAT team will normally report to the ship's commanding officer after completion of fitting-out of new construction and upon completion of conversion/overhaul for other ships. The primary objective of SQAT is to demonstrate weapon system performance as operated and maintained by ship's personnel. Assistance is provided to each ship in direct support of this objective as follows:

(1) A test program to demonstrate, on a step-by-step basis, the operability and capability of the weapon system(s) in the at-sea environment and the competence of the ship's force to maintain and operate them.

(2) A team to assist and instruct the ship's force in the conduct of the test program. The conduct of system maintenance tests, including the Daily System Operability Test (DSOT) must conform to the PMS/SMS discipline.

(3) Training materials, documentation, logistic support and special technical assistance required in support of the test program.

During a SQT period the leading GMM of a system has the responsibility of following all of the training requirements provided by a SQAT team. He also helps in the identification of system problems and the collection of technical information required for corrective action. NSMESESINST 8820.1 B lists the sequence of events for an orderly accomplishment of the

SQT program and indicates action responsibility for each event. The listed objectives of the SQT program may be varied as required to meet the constraints imposed by each ship's material, personnel, logistics, and operational situation.

Prior to a SQT period each GMM 1 in charge of a missile launcher should look over the checklist contained in 8820.1 B for the SQT program to ensure that all maintenance and training requirements have been accomplished. One of the maintenance management requirements for SQT is to ensure that each launcher has an updated MRC deck and if not, a Feedback Report (OPNAV 4790/7A) has been submitted. The SQT period for each ship is scheduled by the ship's operational commander and terminates upon satisfactory completion of a SQT program. A Modified Ships Qualification Trial (MSQT) or a SQT is conducted on a yearly basis and schedule arrangements are made between NSMSES and the operational commander prior to overseas deployment if no conversion or overhaul maintenance has been conducted within a yearly period.

FEEDBACK REPORT

The Planned Maintenance Subsystem (PMS) feedback report is utilized to submit recommended modifications and revisions to PMS documentation and to request certain additional or replacement software and hardware. In addition, PMS feedback form OPNAV 4790/7 A may be used to suggest changes to technical manuals and to report or inquire about other matters in connection with PMS. This form provides a direct line of communication, via TYCOM, between the maintenance man and the Navy Material Command. When using this form, check the appropriate box in the discrepancy section and write out a description of the discrepancy, giving as much detail as possible. Instructions for making out the form are found in 3-M Manual, OPNAV 43P2.

RECORDS OF MATERIAL USAGE AND JOB DATA

In addition to the maintenance action information collected on the OPNAV Forms 4790/2K and 4790/2L, the MDCS requires certain specific information pertaining to the availability and usage of parts and material. This information is collected on two basic Supply System documents, NAVSUP Form 1250 and DD Form 1348, which are completed as appropriate for each maintenance action.

Accurate documentation of material usage and cost data on various maintenance transactions requires the joint effort of maintenance and supply personnel. The maintenance man will initiate documentation for transactions involving requests for material from supply, returning material to supply and reporting "usage only" for items obtain outside the normal supply channels. The Single Line Item Requisition System Document, DD Form 1348, will be used by ships having mechanical (automated) supply records or nonmechanized ships which use DD 1348 as an internal issue document. In nonmechanized ships the Single Line Item Consumption/Management Document, NAVSUP Form 1250 is used. These forms will be completed by supply department personnel from information provided by maintenance personnel either verbally or in skeletonized format on the applicable document.

Supply personnel are expected to assist maintenance personnel whenever difficult or unusual documentation problems arise. The same applies to issues of materials which do not directly involve a maintenance action (minor consumables) and are not reported in the MDC system. These forms are explained and illustrated in Military Requirements for PO 3&2, NAVTRA 10056.

SUPPLIES FOR MAINTENANCE AND REPAIR

The fact that there are supplies on your own ship and on tender/repair ships has been mentioned several times. Here we will give a run-down on the supply system, beginning with top agency.

RESPONSIBILITY OF THE GMM

You have dealt with supplies in one capacity or another since you first joined the Navy. As you advance in your rating, you will take a more active part in assisting your division officer and the supply officer in estimating material needs and planning for replenishment. A review of the supply chapter in *Military Requirements for Petty Officer 3 & 2*, NAVTRA 10056 and study of the supply chapter in *Military Requirements for Petty Officer 1 & C*, NAVTRA 10057, should be helpful. A word of caution is in order here. The spread of automation in many phases of supply, the consolidation of all armed forces supply systems into one Defense Supply Agency (DSA), and cost reduction programs all work together to cause rapid changes in the supply system. Members of the supply department can help you keep abreast of the changes as they affect you. Navy Training Courses are revised every two or three years, but the supply system changes cannot wait that long; the supply department receives the directives on the changes as they occur.

SOURCES OF SUPPLY

The original source of supply is of course the manufacturer of the item, but you seldom have direct contact with the original source. Supplies are purchased in huge quantities and stockpiled at various locations where they will be more readily available to the ultimate users.

Defense Supply Agency (DSA)

The consolidation of supply and service functions between and amount the military departments was begun several years ago. The DSA acts as the centralized policy making and monitoring agency sitting on top of the whole single manager concept. It has been assigned management and operational control of a number of defense supply agencies and centers. Supply agencies will be transferred to DSA as the consolidation is carried forward.

DSA publications and directives, under the overall policies of the Secretary of Defense, provide information and direction to all defense agencies that receive support from, or supply support to DSA. These publications include catalogs, stock lists, price lists, manuals, handbooks, and information bulletins. The numbering system, along with other information on these publications, is given in SECNAVINST 5215.13A.

Having one supply system for all defense agencies is expected to save the government many millions of dollars each year. As a taxpayer, that should interest you. As a PO you have a part in implementing the system. Learn enough about it so you can order supplies intelligently. Every incorrect or ambiguous order causes extra correspondence, incorrect shipments, aggravating delays, confusion, and annoyance; and it piles up costs. Ever more important, repair of weapons and weapon components is delayed, which could be critical.

Ship's Parts Control Center

The statement that all supply activities are consolidated under DSA does not mean that all supply depots except one are being abolished. Supplies must be located in a number of areas so they are available quickly. This is a matter of logistics. Logistics is the art of having what you need, where and when you need it. It is the function of the overall supply system which supports the using activity with the necessary equipment and parts.

The supply of ordnance material is coordinated through the Ship's Parts Control Center (SPCC), Mechanicsburg, Pa. This office is operated under management control of NAVSUP. The Electronics Supply Office (ESO), Great Lakes, Illinois, is the inventory control point for electronic materials. SPCC and ESO are responsible for control inventories, procurement, and distribution. They also maintain records, catalogs (NAVORD lists), and stock levels, and regulate the flow of material throughout the Navy distribution system, but do not maintain stocks of repair parts and equipments. The limited application of guided missiles and related test and handling equipment does not justify the positioning of spare parts throughout the distributive system to the same extent as other ordnance material. For the same reason, range and depth of guided missile material has generally been restricted to cover specific program requirements.

At the present time, there has been no obligation established for "Not-carried" items, and such demands are to be forwarded to the Ship's Parts Control Center, Mechanicsburg, Pa.

Inventory Control Points

NAVORD material cognizance assignments are reviewed each year and cognizance of standardized items is transferred to Inventory Control Points (ICPs) by the Stock Coordination Review Group. The Aviation Supply Office (ASO) has cognizance of "2V" material; the Electronics Supply Office (ESO) has control of electronics equipments for the Navy.

Guided Missile Material Responsibility

The Naval Ordnance Systems Command has primary responsibilities for guided missiles within the Navy. NAVSHIPS is responsible for jointly developing, with NAVORDSYSCOM, system installation design. In addition, NAVSHIPS is responsible for specific portions of the system. Naval Supply Systems Command (NAVSUPSYSCOM) and Naval Material Common (NAVMATCOM) obtain the materials and place them at the various supply depots, from which they may be obtained by the operating units.

Guided Missile Support Facilities

The Navy Ordnance Systems Command is establishing guided missile support facilities at various coastal and tidewater depots. These facilities are being provided with the necessary special test equipment and skilled personnel to assemble, check out, modify, maintain, and prepare for issue various NAVORDSYSCOM guided missile material, scheduled for service use. This material includes requirements for the U.S. Marine Corps, as well as for the fleet and naval air stations. In addition, these facilities will support ammunition type components such as warheads, fuzes, and rocket motors for Sparrow and Bullpup missiles. Guided missile facilities at depots, unlike conventional ammunition facilities, require 'considerable special-purpose electronic and hydraulic test equipment, and special tools and handling equipment. These guided missile support facilities are specially designed to maintain substantial numbers of specific types of guided missiles in a ready-for-issue condition for ship allowances, fleet training, and NAVORDSYSCOM evaluation. The facilities also have capabilities for off-loading fleet missile in conjunction with vessel shipyard overhauls, for accomplishing minor maintenance, and for performing ORDALTS on missiles in stock.

The primary distribution points for guided missile material in the ordnance segment of the Navy supply system are NSC Norfolk, Va., for all ordnance guided missile material on the East Coast, and OSD, NSC Oakland, Calif., for all ordnance guided missile material on the West Coast.

BUDGETING AND FUNDING

Each of the Services is responsible for its own budget estimates. They submit their estimates of their needs and these are reviewed jointly by the Bureau of the Budget and the Department of Defense. Each Service must be prepared to justify, with facts and figures, every item in its budget. The information on which budget estimates are based must be submitted by the using agencies of each Service.

Your Part in Budgeting and Funding

The paragraph above describes very sketchily the top level activities in budgeting and funding. Although you play no direct part in the budgeting and funding process, you do have a part at the ship's (or activity's) division level. The cost of operating your division is included in the final estimate. Economical use of materials .can reduce costs a surprising amount; excellent care of material helps to keep expenses down. The budget has to' include replacement costs of equipment. You are aware that careless use can ruin a piece of expensive electronic equipment in almost no time. Carelessness or ignorance can destroy in a flash a weapon costing many thousands of dollars, or even a million dollars. The cost must be covered by the budget allowances and is paid for by taxes, yours as well as others.

At each level of the organization, an estimate of the operating requirements is necessary. Your reports furnish the needed information to the division officer so he can estimate the needs of his division. The assignment of weapon capabilities is made by high-level planning groups. You cannot guess what the requirements will be. But you can keep down the day-to-day operating costs in your division, and the sometimes startling costs of carelessness and ignorance in weapon handling, maintenance, etc.

COSAL AND WHAT IT MEANS

The Coordinated Shipboard Allowance List (COSAL) was explained and illustrated in your Military Requirements text, cited above. As a GMM 1n the Weapons Department the part of the COSAL that concerns your work is the section that lists the guided missile launching systems and the tools and repair parts allowed for their maintenance. The type and quantity of repair parts allotted a ship was determined by studies of requirements in the past. Each ship has a COSAL prepared just for it and the ship is stocked accordingly.

The parts of the COSAL prepared by Ship's Parts Control Center SPCC) cover hull, mechanical, electrical, and ordnance equipment. The Electronics Supply Office (ESO) prepares the part on electronics equipment; Aviation Supply Office (ASO) deals with aviation equipment, and Naval Ship Engineering Center (NavShips) prepares the COSAL for portable communication, radiac, and sonar equipment, and electronic and electric test equipment allowance.

The stock numbers given in COSAL listings are Federal Stock Numbers (FSNs). The Federal Supply Classification system and the numbering system were explained in *Military Requirements for Petty Officer 3 & 2*, NAVTRA 10056. Review it to refresh your memory.

The COSAL does not include ship's store stocks, resale clothing, bulk fuels, subsistence items, expendable ordnance, or repair parts for aircraft. These items are covered by separate outfitting and load lists.

Ordnance Segment of COSAL

The ordnance segment of the COSAL is an allowance list of ordnance equipments, equipage, and supporting repair parts and other materials, tailored to the individual ship. As each active ship with ordnance installations undergoes overhaul, it is supplied with a new ordnance segment of the COSAL. All active fleet, new construction, and major conversion ships with installed armament receive an ordnance segment of the COSAL. Only the items listed will be placed on board, in the quantity listed.

The ordnance section of the COSAL is made up of an introduction and three separate parts. The introduction is prepared by the Ship's Parts Control Center (SPCC) and gives complete information on the use of the COSAL. Study this introduction carefully before using the COSAL.

Allowance requirements for nuclear weapons, guided missiles, and certain FBM equipments are included in special supplements to the COSAL. The supplement consists of an index of all major training items, test and handling equipment, tools, and consumables within the nuclear weapons program; an Allowance Parts List (APL) of all authorized repair parts within the equivalent war reserve weapons or components and test equipment listed in the index (above); and a stock number sequence list of authorized onboard allowances for all equipments and repair parts listed. The supply department does not have cognizance over war reserve nuclear components; the weapons officer must take the responsibility for those. The tools, test equipment, etc., are obtained through the supply department.

The page numbers of the ordnance part of the COSAL are preceded by Z.

Sections A and B of the index cross-reference each other. Knowing how to use the index is an important part of knowing how to use the COSAL to locate an item. Practice is the best way to become familiar with using the index.

Records and Reports for COSAL

The COSAL does not generate any additional reports or records but simplifies your record keeping. It gives you the Federal Stock Number for most of the items you have to order, and saves much looking up of those numbers, It lists the items your ship is allotted, so you will not order something you may not have. For example, you might like to study the OPs for the Talos, but if your ship does not have Talos capabilities, the books will not be sent to you. When you need a repair part, the COSAL gives you the correct stock number for ordering it, so you will get the correct part. It gives you the correct name for the part and tells where it is used, which gives you another method of checking that you are ordering the right part. If the supply department on the ship has it in stock, the COSAL also gives you that information.

The COSAL for each ship is prepared by the Inventory Control Point (ICP), which also stocks the ship with the listed equipments and repair parts, either at outfitting of a new or a converted ship or just before overhaul. Minor revisions to the COSAL are made as pen-and-ink changes on the ship's copy. More extensive revisions or additions are distributed as changes.

How to order Supplies According to COSAL

Part 1 of the COSAL lists your equipment and its major components, and gives the component identification numbers (application code). The identification number acts as a page number for a more compete breakdown of the components in Part II.

Part II is the Allowance Parts List of repair parts needed to support the items in Part I. The Federal Stock Number for each item is given in Part II.

Part III of the COSAL is the final authorized on-board allowance quantity of a repair part. This part of the COSAL is of more use to the storekeeper than to you. It is here that the total allowance of parts which may be common not only to the ordnance section of the COSAL but other departments as well, are added together. That is, your section of the COSAL may permit you an allowance of three particular limit switches. The engineer's COSAL may show their allowance to be six of the same switchers. Part III of the COSAL will show a total of nine of these switches, giving their applications.

Procurement of Material

Procurement is the act of getting or obtaining something. As a rule your supply officer will procure the material for you, provided you furnish him with the necessary information. The COSAL tells you what material is authorized. You must know what forms to use and the procedure for initiating procurement action. Material may be procured by: (1) requisition, (2) purchase, (3) transfer, and (4) manufacture.

The requisition method is the one you will use most often. Use NAVSUP Form 1250 or DD 1348 to obtain your supplies and repair parts from the ship's storeroom. A supply of the forms is usually kept in the weapons office. While you are in the weapons office, check the COSAL to find out if the part you want is stocked, and copy the Federal Stock Number on the form. If it is customary on your ship to list the price, look it up and enter it on the form.

When you have filled in the information on supply form, take it to your department head for his signature, then take it to the storekeeper. The storekeeper will double-check your information, and if the item requested is in stock, he will issue it to you. He retains the form as authorization for the supply department to requisition the same item from supply ashore to bring the ship's allowance up to full condition again.

It is good practice to maintain a file in the weapons office of all material requisitioned from supply. Record the request or requisition numbers. These numbers are assigned by the supply department and entered on the supply form. The number is especially helpful when tracing a part that was requisitioned from an activity other than your ship, such as a shore activity. The requisition number is necessary to start a tracer through the supply system to locate your material if it is unnecessarily long in coming.

If you are unable to determine the Federal Stock Number of a repair part that you need, use NAVSUP Form 302 to requisition it, and give all the descriptive information that you can. This information will include nomenclature, identification taken from the nameplate, drawings, or any source that will help identify the item.

The 302 form is shown in PO 3/2 NAVTRA 10056.

When you have used a repair part that was stocked in your department, do not put off ordering a replacement for the part.

In-Excess Requisitions

Sometimes it is necessary to request material above the quantity shown for the item on the COSAL. Your department must give reasons sufficient to justify the need in excess of the allowance and the supply department prepares the in-excess requisition.

In-excess requisitions are required for all of the following materials:

1. Equipage not on the ship's COSAL.
2. Equipage on the COSAL but requested in greater quantities than allowed.
3. Nonstandard consumable supplies.
4. Repair parts not listed with quantities on the ship's allowance, for which a requirement can be justified.

Approval of an in-excess requisition does not constitute a change of or addition to the COSAL. If replacement of the in-excess articles is required, additional approval is required.

Issuing Procedures

Procedures for issuing supplies vary on different ships. Approval by the man maintaining the Departmental Budget Record may be required on some ships. Clearance with the supply department is required before proceeding to the stockroom with the approved requisition form. Be sure that each man drawing material is instructed to check that each item is received in correct quantity and the price is listed correctly for the material actually received.

Disposition of Repair Items

In the basic repair cycle of the distribution system, all items fall within two general classifications. These classifications are "Expendable" and "Nonexpendable" items. The expendable items are disposed of in accordance with applicable current instructions. The nonexpendable items, which are classified by Material Control Codes G, H, 0 (formerly "X" fraction code), on the allowance list are rated as repairable. The user returns them to the supply system when he requisitions replacements. Vessels operating outside the continental United States will normally off-load such failed components at the first opportunity. Once back in the supply supply system, these failed or damaged items are reported to SPCC as available for repair.

The primary distribution points have a list of items requiring fast repair. These items are returned to the contractor or a qualified repair center immediately upon being turned in. Repairable items not appearing on this list will be accumulated at the distribution point pending disposition instructions from SPCC.

STUDIES TO IMPROVE REPAIR SUPPLIES

The Planned Maintenance Subsystem is providing means to correct failings in the supply system for repair parts. Military Essentiality Coding (MEC) is a method of determining just what repair parts are likely to be required. Some equipments and components on shipboard are more essential than others for the performance of the ship's mission. The failure of a search radar, for example, is more serious than the failure of laundry equipment (in relation to the ship's mission). MEC assigns code numbers that indicate the criticality of the equipment. Computerized analysis of all reports reveals how essential each repair part is, how many parts will be needed in stock, and other data on supply. Study is continuing on MEC to summarize data from reports and thus reveal actual needs for repair parts and avoid overstocking or understocking. You can help in this program by supplying information regarding items needed or not needed.

The MEC on the Allowance Parts List (APL) and on the Stock Number Sequence List (SNSL) uses codes I and 3. Code I is given to parts whose failure would have a major effect on the dependence/operation of the component. Code 3 is assigned to parts whose failure would have little effect on the dependence/operation of the component.

The MEC is given in the COSAL Index as V-Vital, or NV-Nonvital. Equipment is classed as V if its failure could reduce the ship's capability to perform its mission. If the ship's mission would not be adversely affected, the equipment is classed as NV.

SOURCES OF ORDNANCE IDENTIFICATION

In addition to the COSAL, there are several other places to search when trying to identify an item (which may be an old model not given in new lists, or for other reason is difficult to identify exactly).

One of the most important sources of identification is the information on nameplates. This may include the manufacturer's name, make or model number, size, voltage, and the like. Identification publications such as manufacturers' technical manuals may help you in identifying an item.

The 2-digit cognizance symbol that precedes the Federal Stock Number indicates the command, agency, or office that has control over the supply and distribution of the material. Two-digit dual cognizance symbols replace the former one-letter symbols used.

Cognizance symbols are assigned to different groups of material. Cognizance symbol "21" material includes, among other things, guided missile launchers (less airborne), torpedo launchers, rocket launchers, selected fire control and optical equipments under the design control of NAVORDSYSCOM, and other major ordnance equipment.

Cognizance symbols "2T", "4T", and "8T" are expendable ordnance and include missiles; signals, underwater sound; related inert and explosive components, and selected support or test equipments for the above items. Torpedoes; mines, and underwater ordnance are "6T". The condition of ordnance material is also designated by code letters which are used in stock recording and reporting procedure for the ammunition segment of the ordnance supply system. A numeric code was formerly used. The changeover calls for the use of a new Ammunition Class X, new alphabetic condition codes, and MILSTRIP routing identifiers to be used in place of station reporting numbers (e.g., N35 for SPCC, N24 for 4T NAVORDSYSCOM, etc.). The new designation Ammunition Class W identifies items for which end action disposal has been authorized.

Illustrated Parts Breakdown of Ordnance Equipment (IPB) is a publication prepared by SPCC. Each IPB is published for one particular type or piece of equipment, and describes and illustrates the relationship of all assemblies and parts comprising the equipment. IPB 0000 is an index of all IPBs.

NMDL

The Navy Management Data List (NMDL) provides information necessary for good management of the item. It is not practical to include such items as price, unit of issue, and cognizance symbol in the Federal Supply Catalog or in the COSAL since these items are subject to frequent change. -Therefore, these items, along with other information, are listed in the NMDL. Basically, you will use this publication to determine the price, unit of issue, cognizance symbol, and material control code (if applicable) for FSNs you have located in the COSAL. All Navy-interest FSNs are listed in the NMDL.

You will continue to use the SPCC Ammunition Index of Navy Ammunition, Navy Stock List of Forms and Publications, and certain ICP specialized supplements.

The NMDL is expected to eliminate a great deal of searching for correct stock numbers to identify items, and to simplify requisitioning. It will extend the utility of the COSAL by providing updated stock numbers and reference numbers.

Other Supply References

General purpose items are described and illustrated in the Illustrated Shipboard Shopping Guide (ISSG).

Part numbers are cross-referenced in the Master Cross-Reference List (MCRL). Another publication that is frequently used with the MCRL is the Federal Supply Code for Manufacturers. It consists of two volumes and lists all commercial firms manufacturing material for DOD. Each manufacturer is identified by a 5-digit number. One volume lists the manufacturers in alphabetic order and identifies them to the code number. The other volume is a numerical listing by code number, and identifies the manufacturer. Frequently, different parts manufactured by different manufacturers will be identified by the same part number. When this occurs, the FSCM helps you identify and obtain the correct part. If you have any question on supply, the answer can probably be found in the NAVSUP Manual, and someone in the supply department will know about it or can find it.

Ordering Publications

Cognizance symbol "I" designates printed material such as standardized forms, handbooks, instructions, and training publications. They are listed in NAVSUP Publication 2002, "Navy Stock List of Formers and Publications, Cognizance Symbol I." The initial commissioning allowance is sent without requisitioning. Other recommended publications, classified as Category II, may be requisitioned from Forms & Publications Stock Point, U. S. Naval Supply Center, Norfolk, Virginia, or Oakland, California.

Except where indicated otherwise, order OPs and changes from the Naval Supply Depot, Philadelphia, Pa. Use a MILSTRIP form. Changes are automatically supplied, but if you are missing any, write, "include changes 1, 2, and 3" in the "Remarks" section of MILSTRIP on which you order the OP by stock number.

Whoever is appointed the publications custodian has the responsibility for ordering publications that are needed and keeping changes inserted. He also is responsible for the security of the publications.

HOW TO PREPARE REQUISITIONS

The uses of NAVSUP Form 1250 and NAVSUP Form 302 were discussed earlier, and you have studied about them in Military Requirements for Petty Officer 3 & 2, NAVTRA 10056. These forms are used for procuring items from the supply department aboard ship. The use of data processing equipment has brought into use the requisitioning procedure called MILSTRIP.

Military Standard Requisitioning and Issue Procedures

MILSTRIP is a procedure used to requisition all items of general stores and repair parts. It uses codes for a large part of the information on the card form. MILSTRIP has been extended to include all items of supply except supplies specifically excluded.

NAVSTRIP was an interim method used by the Navy during the development of the MILSTRIP procedures. The same form DD Form 1348, was used. This may be a single-page form, or 4-part, or 6-part form. Supply personnel usually complete the forms but you need to give the information for the parts to be requisitioned. Your military requirements texts discuss the use of the form in connection with supply and with the 3-M system.

PRIORITY SYSTEM

The Uniform Material Movement and Issue Priority System (UMMIPS) forms an integral and essential part of supply support functions by providing a common basis for determining the relative importance of material movement and issue transactions. Priority designators are from 01 (highest) for the most important through 15 (lowest) for the least important. Figure 11-4 shows the two elements that are required to assign a priority designator to any request. The first of these elements is the force/activity designator (F / AD). An F / AD is assigned to each ship by higher authority (normally by or via TYCOM). Its purpose is to rate the ship according to its military or mission importance. The second element, Urgency of Need Designator (UND) is explained on figure 11-4.

When you are requisitioning material, you merely tell the supply officer when you need the material. The supply officer will then assign a tentative priority code. When the assigned priorities are 01 through 03, the commanding officer must personally review the requisition. All other priorities may be reviewed by someone assigned in writing by the commanding officer.

WEAPONS DEPARTMENT REPORTS

OPNAVINST 5214.1C contains a consolidated list of required recurring reports from operating forces of the Navy to Navy headquarters organizations. These reports are made by ship's department heads via commanding officers from information received from petty

Urgency of need designator (condensed description)	Force/activity designator I	II	III	IV	V	Supply Activity Processing Time	PLUS Standard delivery time for delivery to: CONUS	Alaska, Hawaii, Caribbean, South America, North Atlantic	Northern Europe Mediterranean Africa	Western Pacific
	Priority designator									
Designator A Emergency material requirements for primary weapons and equipment for immediate use without which the force/activity concerned is unable to perform its mission. To eliminate a work stoppage at intermediate maintenance activities on primary weapons or equipments of customers.	Ø1	Ø2	Ø3			3 days	3 days	4 days	4 days	5 days
				Ø7	Ø8					
Designator B Immediate material requirements for immediate use or for known requirements in the immediate future, the lack of which impairs the operational capability of the force/activity concerned. Preclude anticipated work stoppage on mission essential equipment. Replace allowance list material required to support mission essential equipment.	Ø4	Ø5	Ø6			4 days	6 days	4 days	4 days	5 days
				Ø9	1Ø					
Designator C Material requirements to meet scheduled deployments. Material needed to repair/replace administrative or collateral equipment or systems not immediately essential to operational mission. Material required for scheduled maintenance or material required for routine stock replenishment.	11	12	13	14	15	13 days	13 days	38 days	43 days	53 days

Standard Delivery Date is obtained by adding the supply activity processing time AND standard delivery time to the requisition date.

10.66

Figure 11-4.—Priority Designators and Standard Delivery Dates.

officers of different divisions of a ship. The information necessary for these reports comes from equipment logs, missile logs, supply records and the ship's CSMP. An example of a required report is the SMS Firing Report which is submitted after each test firing of guided missiles against surface or air targets. A firing report is sent within four working days following the firing to U. S. Navy Fleet Missile Systems Analysis and Evaluation Group (FMSAEG), Corona, California.

Missile Firing Report

For each surface-launched missile firing test, ships have been required to prepare a one-page firing report NAVORD form 8821/8. To collect data for the form, most ships have devised observer data sheets. Since similar data are contained in both the firing report and data sheets, a new report form is now provided which combines the two into one report. Report symbols assigned to the reporting requirements are NAVORD 8810-6, Surface-Launched Missile Firing Reports and NAVORD 8810, Electromagnetic Interference (EMI) Report. The data required on firing reports are of extreme importance to the Naval Ordnance System Command Headquarters (NAVORD), and the information provided by the Fleet will be under constant review to ensure that the maximum degree of missile system performance is achieved. To be successful in this endeavor, the reporting and evaluating of data must be a joint effort. The information supplied to a department head by leading petty officers must be accurate and up-to-date. The firing reports which may be filled in by hand consist of three separate forms, depending upon the type missile fired. The Talos system used from 8810/6A, the Point Defense system uses form 8810/6B and the Terrier/ Tartar/Standard systems use form 8810/6C. All data indicating performance of the weapon system during the missile firing, including film, magnetic tapes, paper records, operations recorder, target plots, and logs for the expended missile and their components are sent with the missile firing reports. Instructions for completion of forms 8810/6 are contained in NAVORDINST 8810.7. Weapons exercises, conducted aboard ship for training purposes, checking out the weapons system, and qualifying and grading the ship and an operating unit, are described in FXP-3 series (Ship Exercises). When your ship is preparing to engage in firing exercises, make yourself familiar with the plan and your place in it. Team work and cooperation are essential to successful performance in firing exercises.

Commanding Officer's Narrative Report (CONAR)

Despite the large amounts of statistical data accumulated from the MDC system, there remains a vital need for the comprehensive assessment of the surface missile systems and associated equipment as an integrated part of a ship's defense capability. The Commanding Officer's Narrative Report provides an opportunity to comment on the missile system as a whole, and to make such recommendations as desired for improved operation of the system. Problems of quality control or poor design of parts, suggestions for better utilization of equipment or manpower, and changes in test design should be reported routinely on the PMS feedback report, OPNAV 4790/7 A, or, if desired, in a Narrative Report. To the extent that this report is used to define problems, it is an "exception" report intended to uncover problems of more than a routine nature. It may be used to evaluate, compare, or to simply report problems encountered. The CO Narrative Report is submitted to Naval Ships Missile System Engineering Station (NAVSHIPMISYSENGSTA) within 15 working days after each calendar quarter. A guide for preparing the CONAR report is contained in NAVORDINST 8810.5.

A CO Narrative Report is divided into sections covering equipments which effect a guided missile or a SMS weapon system operational capability. A section of this report is used to facilitate the exchange of information among missile systems which may have the same or similar problems. This section can be used by missile launcher system personnel as a reference to solve a maintenance problem. Each problem area of a missile system is divided into separate sections which explain the casualty, the findings, the remedy, and the probably cause. Since most types of missile weapon systems installed aboard a particular class of ship are physically and the functionally the same, the remedy of a casualty of one ship could also be the remedy of a casualty of a ship in the same class. For this reason all inputs related to casualties and maintenance problems for a given launcher system should originate from a missile launcher system petty officer whose knowledge and personal judgment are essential for improving and maintaining surface missile launching systems.

Upon receipt of a CONAR, the missile system engineering station takes the following actions:

(1) Distributes copies of CONAR to prescribed NAVORD activities.

(2) Enters in-service engineering problems into the Deficiency Corrective Action Program (DCAP) system in accordance with SMSINST 8810.1A.

(3) Reviews those areas of responsibility of the CONAR and provide a CONAR reply wherein those problems, other than in-service engineering problems, are discussed, indicating action intended, when appropriate. Problems relating to personnel are referred to the Bureau of Naval Personnel for possible comment.

DCAP

The DCAP is the vehicle for monitoring and controlling the actions necessary to respond to feedback information received from fleet and shore activities. All data elements and information reported via the formalized 3-M reporting system and by CONAR from all sources are processed to establish the in-service engineering responsibilities and authority necessary to solve and correct a problem. The CONAR provides the primary periodic feedback channel for all SMS problems and deficiencies. Acknowledgment of all reported problems and deficiencies is vital to the success of the CONAR and will be continued; however, DCAP reporting will be restricted to progress on in-service engineering problems only. The DCAP system will:

(1) Provide one central clearing house for SMS in-service engineering problems and establish communication channels for the expeditious flow of problem information.

(2) Provide continually updated information on the status of in-service engineering problems and provide follow-up action. Problems will not be terminated until the final solution has been accomplished in all affected ships or stations, incorporated into production as required, and all technical data and records have been made.

(3) Inform all levels of management, through a series of reports, of all SMS in-service engineering problems, actions planned or underway, and interim or final solutions. An in-service engineering problem is concerned with all engineering actions that are required to ensure the SMS equipments continue to be suitable for their intended service use. In-service engineering does not include within its scope actions which would significantly after specified operational or performance characteristics, which would alter the configuration or interface requirements, or would compromise the reliability or safety of SMS equipments.

GUIDED MISSILE SERVICE RECORD

Once a missile had been received at the firing activity, all tests and work done on the missile (a complete history of the missile) must be conscientiously recorded on the Guided Missile Service Record (GMSR), NAVORD Form 8800/2 (NAVORDINST 8800.1). It is not used to report missile equipment failures. Missile test results are reported on this form.

This record is usually prepared in triplicate by printing with a ballpoint pen. This eliminates the need for transcribing to other forms. All servicing operations as well as the results of periodic and preflight tests, including firing of guided missiles, are recorded on this form.

The original is submitted monthly to Naval Fleet Missile Systems Analysis and Evaluation Group, Corona, California. The first copy is placed in the missile log and the second copy is placed in a file aboard ship for future reference. The second copy is retained aboard ship even after the missile has been fired and the missile log sent to Corona. No report is required for periods when no servicing to testing was done.

The information on the GMSR is coded and automatically processed after it is received at Corona, and the results summarized. The summaries may be used in connection with factory acceptance and rework information, waivers and deviations, quality evaluation laboratory data, and flight performance data to:

1. Predict potential failures.
2. Identify factors adversely affecting reliability and serviceability.
3. Determine the quality level of guided missiles in stockpile.
4. Recommend to the Naval Ordnance Systems Command.

a. Improvement in the design or production and quality control procedures for guided missiles.

b. Appropriate action to correct material defects, dispose of defective material, and revise handling, storing, servicing, and firing procedures.

The importance of the GMSR and its numerous uses makes completeness and accuracy of reporting essential. Whether you or pas of another rating will have prime responsibility for the report depends on the local situation.

In Terrier systems which have ASROC capabilities, an additional log is used for identification and transactions of ASROC weapons. NAVORD form 8540/3 is used to record all information about ASROC weapons. and includes mark, modification and serial numbers, and ammunition lot numbers (if required) for each component that makes up an assembled weapon. Each ASROC is identified by an assembly identification number (AIN) for either a Rocket Thrown Torpedo (RTT) or Depth Charge (RTDC). When a missile is expended by firing, the log is sent to NWS, Seal Beach, California.

SMS EQUIPMENT STATUS LOG

All ships of the operating fleets equipped with surface missile systems shall complete the original and one copy of the Nonexpendable SMS Equipment Status Log, NAVORD Form 8810/2, figure 11-5, for each equipment listed in NAVORDINST 8810.3B. The originals of each week's data shall be forwarded within seven working days after completion to NWS, Seal Beach, Corona, California. The log may be filled in by hand. The yellow copy of 8810/2 will be retained by the ship as' its equipment rough log; no other log is required. The information recorded on 8810/2 shall' not repeat any maintenance action details that are normally reported on maintenance action from 4790/2K. Use as many 8810/2 forms as) necessary to record all information for a seven-day period. Continue entries for the next day on the same sheet if space is available. Make at least one entry at the beginning of every day. This entry should show at least the date, time, and ~ode in appropriate columns (fig. 11-5). A final daily entry should show at least the date, time, status code, and signature of the person completing the form. Procedures for completing 8810[2 are explained in NAVORDINST 8810.2A. The security classification of 8810/2 when filled in will depend upon the content in the Remarks section. If there are no classified remarks, then the form is unclassified and does not need to be marked. Examples of entries which may or may not classify 8810/2 are:

a. Statement that a missile was fired is unclassified.

b. Statement of a missile firing with results of firing is Confidential

c. Specific missile frequencies are Secret.

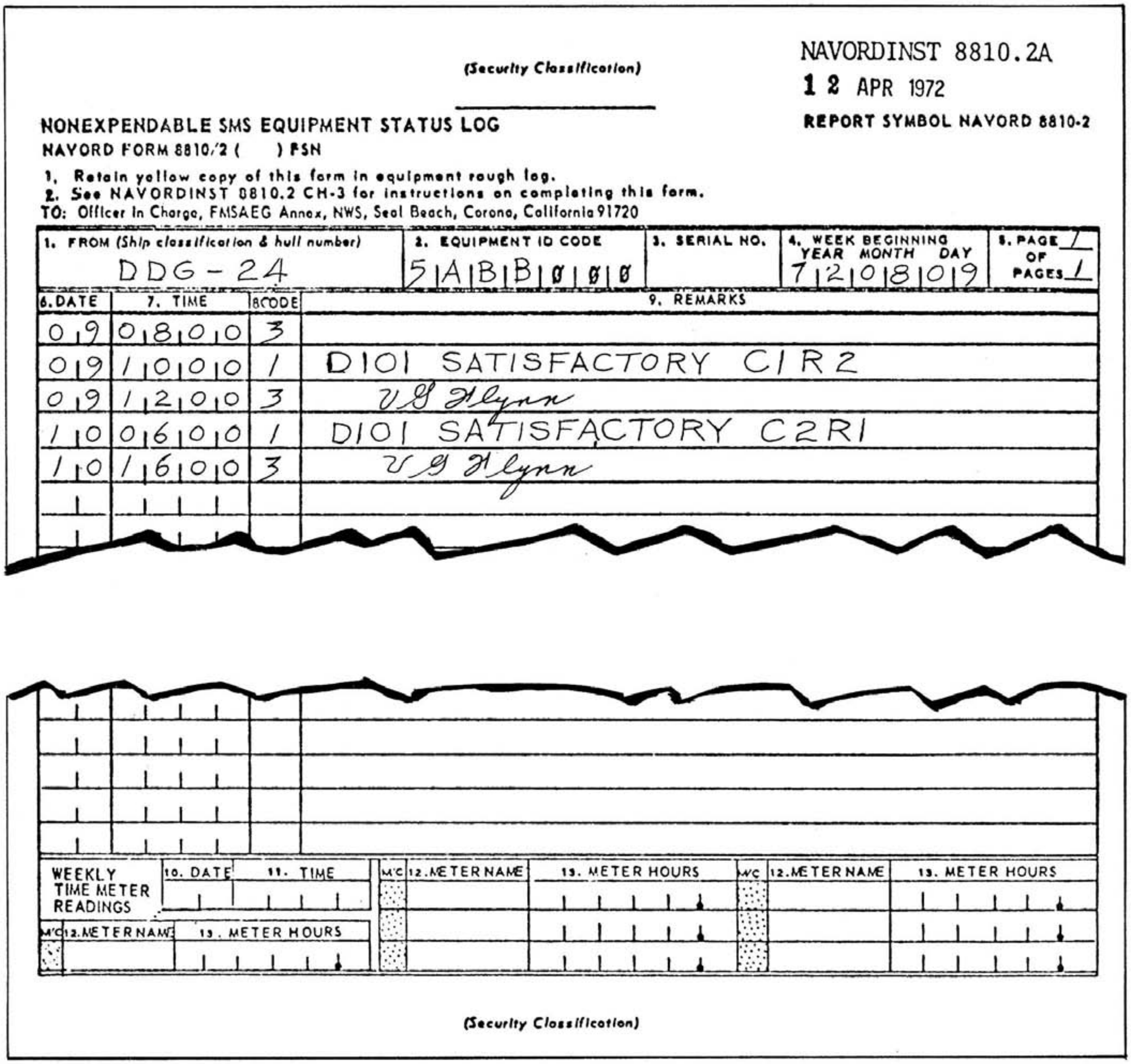
d. Routine operations of the equipment, such as DSOTs, tracking operations, loading operations, or system testing are unclassified.

For the appropriate downgrading statement when 8810/2 is classified, see Navy Security Manual 5510.1C.

NUCLEAR REPORTS AND INSPECTIONS

All nuclear material is subject to the control of Defense Nuclear Agency (DNA). Personnel assigned to work with nuclear weapons must receive special training in the handling, stowage, and accounting methods peculiar to nuclear weapons. Prior to such training they must possess at least a Secret clearance based 011 a background investigation. If you work in a GMLS that has nuclear weapons, a series of special publications is issued by the Joint Atomic Weapon Publications System and are used as reference publications for maintenance, tests, storage requirements, and identifications of all nuclear weapons used by all services. In addition a series of Navy Special Weapons Ordnance Publications (SWOPs) for Navy nuclear weapons and their related equipments for each type nuclear weapon used with shipboard GMLS is also issued. The SWOPs take precedence over all other technical publications where conflicting information is present. Since all the procedures in SWOPs are mandatory, it is important that all shipboard activities expedite the processing and routing of message/speedletter changes, interim and permanent changes to SWOPs to ensure prompt updating of affected publications. Each type of nuclear weapon and its related components and their test equipments are assigned a separate publication number series applicable to the Navy's Nuclear Weapon Program. For example SWOP 30.19 series is applicable to Talos and SWOP 45.21 series is applicable to Terrier. The requirements for the SWOP documents are determined by the individual commands in accordance with their nuclear weapons capabilities. An Index to Joint Atomic Weapons Publications used for multiple service purposes is listed in SWOP 0-1; a Navy supplement SWOP 0-1B lists all publications applicable for Navy use only.

Chapter 8 of this text mentioned some of the reports required for nuclear material. All nuclear weapons, handling equipments, and record and reports are subject to special inspection in accordance with OPNAVINST 05040.6 (series).



(Security Classification)

NAVORDINST 8810.2A
12 APR 1972

REPORT SYMBOL NAVORD 8810-2

NONEXPENDABLE SMS EQUIPMENT STATUS LOG
NAVORD FORM 8810/2 ( ) FSN

1. Retain yellow copy of this form in equipment rough log.
2. See NAVORDINST 8810.2 CH-3 for instructions on completing this form.

TO: Officer in Charge, FMSAEG Annex, NWS, Seal Beach, Corona, California 91720

1. FROM (Ship classification & hull number): DDG-24
2. EQUIPMENT ID CODE: 5ABBØØØ
3. SERIAL NO.:
4. WEEK BEGINNING YEAR MONTH DAY: 72 08 09
5. PAGE 1 OF PAGES 1

6. DATE	7. TIME	8. CODE	9. REMARKS
09	0800	3	
09	1000	1	D101 SATISFACTORY C1R2
09	1200	3	V G Flynn
10	0600	1	D101 SATISFACTORY C2R1
10	1600	3	V G Flynn

WEEKLY TIME METER READINGS — 10. DATE, 11. TIME, M/C, 12. METER NAME, 13. METER HOURS

(Security Classification)

94.166

Figure 11-5.—Nonexpendable SMS Equipment Status Log Report, NAVORD Form 8810/2.

The type of inspection required for any activity having nuclear capabilities depends upon the type installation and type weapons.

Navy Technical Proficiency Inspection (NTPI)

This inspection is performed once a year by Navy inspectors. The inspection teams are sent aboard ship from Nuclear Weapons Training Centers. Instructions are issued by fleet commanders; these differ for east and west coast fleets. The NTPI determines the capabilities of the Navy activities for storing, testing, assembling, maintaining, handling, and loading nuclear weapons or nuclear missiles. When the NTPI team is to come aboard, obtain the current instruction and study it so you will know what is expected of you and your men.

Inspectors are provided from the Nuclear

Weapons Training Centers, Atlantic or Pacific, by the appropriate fleet training commands for all fleet inspections. The inspectors are usually officers and chiefs who are skilled in nuclear weapons handling. When practicable, NTPIs of fleet units are conducted in conjunction with, and as part of, operational readiness inspections (ORI) or other major readiness exercises.

NTPls are graded in accordance with applicable directives of fleet commanders in chief and NAVORDSYSCOM. Inspection reports are made in accordance with applicable directives of fleet commanders and NAVORD and include all the inspector's comments, recommendations and discrepancies noted. They are appended to the chief inspector's report.

NTPI Guides

With the vast numbers of different nuclear capable units operating in ,the fleet today and their many levels of responsibilities, it is apparent that some sort of guide should be made available delineating the items that are to be inspected. Therefore, a guide for each of the many different types of activities is published and used in the conducting of inspections. The action required for items listed in the guide is governed by the requirements of the governing directives (SWOPs, OPs, Inst, etc.), in force at the time of the inspection, rather than the working or apparent intent of the item. Although the guide is comprehensive, inspections are not limited to only those items listed in the guide. This is particularly true for items concerning new requirements not in existence at the time the guide was published. Consult your NTPI guide often to make sure you have not overlooked any items. Although the scope of coverage of an NTPI differs for almost every activity, all matters directly related to the processing, handling, testing, inspecting, maintaining and storing of nuclear weapons, and all matters and procedures involved in the administration of a nuclear unit are included in every NTPI. Following are some of the items checked by an NTPI.

Housekeeping - Is the area clean, free from tripping or slipping hazards; the lighting sufficient, the noise level low, fire equipment inspected and maintained periodically, first aid and decontamination facilities properly identified and readily available?

Safety Precautions - Are they posted and are personnel familiar with them?

Emergency Equipment - Is it readily available, properly stowed, and in good condition?

Check Sheets - Are they up to date and do they include all manual changes and contain all applicable notes, cautions, and warnings?

Tool Safety and Discipline - Are all tools clean, in good condition, and used properly?

Two-Man Rule - Is the two-man rule enforced, with personnel who are equally knowledgeable with respect to the task being performed?

Use of Toxic and Hazardous Liquids or Materials - Are containers labeled properly for identification? Are they stowed properly?

Test and Handling Equipment - Records and labeling are checked for proper calibration, maintenance, and repair.

Is the personnel reliability program being implemented? Are the records of such personnel maintained properly and are medical and supervisory personnel provided observation of such personnel?

Is the intrusion alarm system being operated and maintained in accordance with existing instructions?

Local Instructions of the activity being inspected are carefully read and checked for current information and accuracy. Are personnel aware of them and are they being adhered to? Many discrepancies are noted in this area when these instructions are not reviewed and updated periodically.

Are Navy SWOPs, OPs, and ODs, maintained up to date in accordance with current allowance lists? Are subcustody procedures in effect sufficient to allow a rapid complete inventory?

Is the emergency destruction bill current and are personnel assignments reviewed to insure accuracy? Is the emergency recall bill exercised periodically?

Are personnel allowances adequate in view of the responsibilities and workload imposed?

Does the pass and badge system comply with current directives?

Are reports properly submitted?

Accident/Incident Drills - Are performed by the inspected organization and observed by the NTPI team. Accident/incident drills demonstrate initial procedures performed by local station personnel with the aid of the local EOD team, if one is available. These drills are designed to check:

Medical, fire fighting, guard force, and EOD procedures.

On-scene survivors and on-scene commander's procedures.

Hot line procedures.

EOD equipment

Completion Inspection Report

At the completion of the NTPI, a rough draft report is prepared. A copy of this report is given to the activity and a critique is conducted. All discrepancies and comments are read to the technicians and supervisors and they are given an opportunity to dispute them. The final smooth report is issued about 2 weeks later, after a thorough check for accuracy and veracity. This report is submitted to the appropriate activities in the chain of command.

Upon completion of the inspection, the Commander, Naval Ordnance Systems Command makes a report directly to the Chief of Naval Operations, with a copy to the Fleet Commander in Chief, certifying the readiness of the facility. This report contains the following information:

A statement that all safety (nuclear and explosive) technical and security criteria have been met, or a statement listing the deviations from those criteria with the justification for waiver; and a statement as to whether the facility is ready to perform its assigned mission.

NUCLEAR WEAPONS ACCEPTANCE INSPECTION

A nuclear weapons acceptance inspection (NWAI) is conducted on all prospective Navy nuclear weapons activities by Navy inspectors. This inspection determines the readiness of the activity to perform technical, administrative, and logistical procedures directly related to their nuclear weapons capabilities. This could be a newly constructed ship, a ship just recently operational after an extended yard period during which a large number of personnel were transferred, or a newly constructed shore site. Each activity is inspected for each of its capabilities and must receive a grade of satisfactory before it is considered operational for any capability. A regularly scheduled NTPI can serve as a NWAI for an operational activity achieving a new capability in addition to those it already holds.

TECHNICAL STANDARDIZATION INSPECTION (TSI)

This inspection is performed by personnel from Field Command, Defense Nuclear Agency (DNA). The schedule of inspections is published, so you wit) be aware of the approximate date when your activity will be inspected. During the TSI, you and your men will be expected to assemble a nuclear warhead into a missile under the observance of the inspection team. In addition to judging your capability in the handling and care of missiles with nuclear warheads, all the records, reports, publications, training programs, and team organizations will be inspected. As a guide to the inspectors, DNA Technical Letter 25-1 lists the points to be inspected. This list can also be a valuable guide to you for checking yourself and for training your men. The TSI also determines the status of maintenance of/your nuclear missiles.

PERSONNEL REPORTS

As you advance in your rating, your responsibilities increase not only in care and operation of equipment, but toward personnel of your group. Many of these responsibilities are defined in *Military requirements for Petty Officer 1 & C*, NAVPERS 10057. Group and individual training records, drill records, and records of instruction are described and illustrated. All these are records that you must keep when you are placed in charge of men. Their chances for advancement could hinge on the accuracy and completeness of your reports and records. Do not fail to enter on the record every test or qualification passed by a man. The best way to be sure it is done is to make the entry at the time, not later, "when you have more time." It is too easy to forget things that are put off. Also, do not give a man a passing mark if he does not actually qualify. The lives of many men may depend on the knowledge and skill of one; require your men to KNOW their jobs.

Personnel Injuries

Any time a man sustains a personal injury, a report must be made. The medical department prepares the medical report, but the weapons department must explain the circumstances that caused the injury. If a casualty is caused by an explosive accident or incident, it is reported according to the message format given in NAVORDINST 8025.1 shown in figure 11-6. The same format is used for reporting explosive accidents and incidents without personnel casualties. The messages may be supplemented with written descriptions, photographs, diagrams, etc. The purpose is to determine by what means the accident could have been avoided and to issue instructions to correct the conditions that caused the accident or incident. In item 9 (fig. 1.1-6), note the attention given to electromagnetic radiation. Analysis of reports supplied much of the information included in OP 3565, Technical Manual Radio Frequency Hazards to Ordnance, Personnel, and Fuel.

Supervisor's Report of Injury, NAVEXOS Form 180, is an administrative report about any type of injury sustained by military personnel. The information given on these reports is analyzed by the Coordinator of Safety Programs to discover the causes and frequency of different types of accidents.

SECURITY

Commanding officers are responsible for establishing security orientation, education, and training programs for all personnel assigned. OPNAVINST 5510.1 (series) provided the necessary minimum requirements for implementing these programs.

The central aim of the security education program is to make all personnel "security-minded". To achieve this, a continuing training program must be in use at all levels of the command, with emphasis by the senior petty officers to their subordinates.

Effective security also requires that the handling, accountability, procurement, stowage and transmission of classified records, reports, and publications be managed in an efficient manner. Good classification management practices are important in obtaining effective security control. If security needs are to be met, constant attention must be given to the way in which classified material is handled. With confidential and secret publications and material in daily use in a GML system, the responsibility for safeguarding classified material lies with each person who handles the material. In addition to this general responsibility each leading petty officer should establish organizational responsibilities for the control of classified material. A simple effective control system can provide a readily available accurate accounting system for classified documents. A guide for handling and control of classified material is OPNAVINST 5510.49 (series).

A petty officer can be designated as the custodian of classified publications within a missile system. His duties would be to keep a record of all classified publications assigned to that missile system so that every copy of each classified publication is accounted for without fail. The accounting procedures can be kept simple by eliminating unnecessary procedures so that the custodian can concentrate on the essential aspects of the accounting process at all stages in the handling of classified publications. In a missile system handling a very small quantity of classified material, you may find that a card system or log book is sufficient for effective control procedures;

With a card or log book system of accounting, each piece of classified material to be controlled is recorded on a card or log book. When a publication is issued, the person receiving the item should sign for it and, when returned, the custodian should record the date the item was returned and sign the control accounting form (card or log book) which is retained and used as an inventory file for classified material. When material is checked out for study purposes, a time limit should be set so that an up-to-date inventory can be maintained; this prevents a wild scramble when an inventory report is required for an inspection. Material used for study purposes are sometimes passed from one person to another without concern for safeguarding. A quarterly verification of a custodian's records, made by a leading petty officer, will assist the custodian by giving adequate attention to the essential aspects of control. Security-mindedness

NAVORDINST 8025.1A
3 Nov 1969

MESSAGE FORMAT

From: (Activity Submitting Report)

To: COMNAVORDSYSCOM
SPCC Mechanicsburg

Info: CNO (Include CNO and designate OP-98 and OP-41D in message text for all accidents, incidents and malfunctions other than minor malfunctions)
NAVORDSYSUPPOLANT/PAC (As appropriate on all ORD Items)
NWL Dahlgren
NAVSAFECEN NORVA
CHAIN OF COMMAND (As appropriate - include service force cdr)
COMNAVAIRSYSCOM (On accidents, incidents involving NAVAIR Items at non-aviation activities)
Appropriate Information Addressees from enclosure (2)

____________ Report, (Report Symbol NAVMAT 8020-2) (Insert Explosive Accident, Explosive Incident, Ordnance Malfunction, or Defective Ordnance, as appropriate, on subject line).

1. Complete Nomenclature of item including MK and Mod and Logistic (DOD) Code or Federal Stock Number.

2. Complete Round Lot Number or serial No. (Include lot numbers of major components, i.e., fuze, powder charge, motor, etc., as applicable).

3. Description of occurrence including date, time, and place of the occurrence, launching or firing equipment and conditions of firing, launching, etc.

4. Number and extent of casualties (Specify military, civilian, contractor or other).

5. Descriptions of damage to equipment or property (Government or private).

6. Number involved out of total fired or being processed during the run, exercise or batch.

7. Weight of explosive involved - actual or estimated.

8. Number of rounds remaining on hand from the lot involved (Include whether malfunctioned round or remaining fragments are available).

9. Describe any exposure to climatic or electromagnetic environmental conditions, if applicable.

10. Comments, as appropriate, (Include cause, known or probable, effect on launcher or gun capability, adequacy of operating instructions and safety precautions, local action being taken to preclude recurrence, request for assistance, recommendations, etc.)

11. Statement whether or not investigation will be conducted in accordance with the JAG Manual.

94.195

Figure 11-6.—Message format.

by leading petty officers is impressed upon all personnel when constant attention is given to .the way classified material is handled.

Security Orientation, Education, and Training Program

The security orientation, education, and training program of each GML system must include all personnel entrusted with classified information regardless of their position, rank, or grade. Persons being assigned to duties requiring access to classified information, prior to being granted access, must be indoctrinated on the security aspects and responsibilities of their assignment. A security training program should be designed to include the following:

1. Familiarize all personnel with the security requirements with which they have to comply for proper performance of their duties and assignments.
2. Remind all personnel of their responsibility for assuring that classified information is effectively safeguarded at all times.
3. Ensure willing, conscientious compliance with security regulations, procedures, and practices.
4. Advise all personnel of the hazards of disclosure of classified information to persons not authorized to receive it. Classified information can slip into conversations through carelessness.
5. Bring to the attention of all personnel the disciplinary action, outlined in OPNAV 5510.1 series, that may result from violation of security regulations.

Periodic briefings must be held by all commands for personnel having access to classified information. These briefings should include special emphasis on the subjects discussed in chapter 3 of the Security Manual, OPNAVINST 5510.1. The Security Manual also provides the necessary information for debriefing personnel who have had their security access to classified information terminated.

INVENTORIES AND SURVEYS

The supply officer is required to maintain a Controlled Equipage Custody Card (NAVSUP form 306) for each item of controlled equipment aboard. He prepares these cards in duplicate, turning over the copy to the responsible department head and maintaining the original in his safe. The allowance quantity shown on the copy signed by the weapons officer pertains to equipage used by the weapons department only. Controlled equipage for a GML system consists of selected items which require increased management control afloat due to their high cost, their vulnerability to pilferage, or, their essentiality to the ship's mission.

On some missile ships the weapons officer may delegate the leading petty officer of a GML system as custodian of the controlled equipage within his launcher system. The custodian may be required to sign a subcustody card which is a duplicate of the 306 form signed by the weapons officer. On ships that have more than one GML system controlled equipage, such as test equipment, usually have serial numbers assigned which are used as a means of identification and should be entered on the subcustody cards. When controlled equipage passes from one launcher system to another or from one petty officer to another, the new custodian should sign a copy of the custody card. A record is also kept on a custody card for all non-signature items issued to a department and serve as accountability cards for inventory and expenditure purposes.

All items of controlled equipage must be inventoried during March of each year. Inventories are also required when the ship is commissioned, inactivated, or reactivated; any upon relief of the head of department for those items in the department concerned.

In those instances when it is not feasible to stow missile system components in supply department spaces, the supply officer must be authorized by the commanding officer to stow such material in spaces belonging to the weapons department. When this type stowage is authorized, the weapons officer designates in writing a custodian whose major responsibility is to report to the supply department an accurate record of issues of all items under his custody so that the supply department can take prompt replenishment actions. It is required that a quarterly inventory be made of material stowed in weapons spaces. The inventory of such items is to be conducted jointly by the custodian and a supply department representative.

SURVEY OF ORDNANCE MATERIAL

In official Navy publications a survey is regarded as a means of establishing the reason for deterioration or loss of government property. If material is missing, a survey is a means of finding what happened to it. It material is damaged, a survey will uncover how the damage occurred, who was responsible, and what should now be done with the material. The end result of a survey is to provide a method of expending the surveyed material from the books.

Anyone who is aware of a material condition that requires a survey may initiate action. Survey requests are normally started by the head of the department having custody of the material in question.

The originator requests a survey in ROUGH on a Survey Request Report and Expenditure form. The request must include the following:

1. Description and condition of the material.
2. Cause of loss, damage, etc.
3. Responsibility for cause or condition (if it can be determined).
4. Recommended disposition of material and action to be taken in regard to cause and responsibility.

As the initial request is forwarded via the department head and the supply officer, additional helpful information is added.

The purpose of this initial request is to provide all the data available to assist the commanding officer (or his delegate) in determining the type or survey, if any, to be ordered.

The type of survey to the conducted may be either FORMAL or INFORMAL.

Formal Survey

A formal survey is required at all times when it appears that responsibility for lost or damaged material may be placed on a person or persons in the naval service.

In most cases, a formal survey is conducted by one officer: However in the case of surveying equipage where custodial signature is required, and when so directed by the CO, a survey board of three officers (no one of whom is from the department having control of the material) conducts the survey.

The following members may not serve on a survey board:

1. Commanding officer
2. Officer on whose records the material being surveyed is carried, for example, the Weapons Officer
3. Officer who is charged with the physical custody of the material being surveyed, for example, the Missile Officer.

When controlled equipage is surveyed, it must be recorded on the custody record card 306. Failure to do so may mean that the expenditure will not be posted to the cards (306), and the custodian will be held accountable for material that is long gone.

Informal Survey

As a rule, the information survey is held for routine matters where it appears that no disciplinary action is required. The distinguishing feature of the informal survey is that the CO appoints the head of department having custody of the material to be surveyed as the surveying officer.

After the findings have been made by the surveying officer, board, or head of department, a full report is submitted to the commanding officer for review. The supply officer and/or appropriate department head takes the final action in expending the material from the books.

Ordnance repair parts worn out or damaged in use are not surveyed when replaced by a new part, except upon order of the CO or higher authority. Repair parts lost or damaged in storage are surveyed when a notation of the survey must be included on the request for replacement. NAVORDSYSCOM requires formal survey for ordnance equipage requiring custody signature, when such equipage is missing, damaged, or worn beyond economical repair.

Repair kits are listed as one-line items and are replaced by complete kits, even though not all items in the kit were used up.

Some unserviceable items must be repaired by the manufacturers under the warranty provisions of their contract. The handling of such items and other repairable items is described in SPCC Field Instruction P4440.83. Many of the items discussed in this instruction are part of the Terrier/Tartar/Talos systems. Refer to this instruction for information regarding the disposition of any parts of those weapon systems.

Inspection

Material being inventoried or surveyed must be inspected. It will not suffice to copy from the custody cards or a previous inventory-you must sight each item and determine its condition. You may have men assisting you in the work but you are responsible for the accuracy of the report you turn in.

Costs

Every department aboard ship is given a budget for each quarter, representing the money available to procure the materials it needs. Careful management of supplies is a major part of keeping within your budget. Wastefulness uses up the funds without increasing the fighting effectiveness of the Navy.

You may be required to keep some of the budget records for the department. There is no standardized form for the budget record, but it should show the cost of the materials requisitioned, with each requisition number and the date. Be sure the materials were actually received and the requisition was not canceled or modified.

MANAGEMENT OF ORDNANCE STOWAGE AREA

The chapter on handling and stowing of missiles repeated several times the admonition about stowing of explosive components of missiles and nonexplosive items. Where to stow the assembled missiles is no problem - you know they must be placed in the magazines that are a part of the launching system, where they are locked in position.

MISSILES

Every missile received above is identified on the bill of lading or shipping document by name, mark, mod, lot number, serial number, manufacturer's name or initials, and/or other identifying information. Each missile received must have the information concerning it entered on the missile log. After it has been loaded into the missile magazine, the location of the missile is marked on the log and the type identification is inserted on the launcher panel. Prior to loading, you have checked the launcher magazine for operability of equipment, temperature control, humidity control, fire fighting equipment, and general cleanliness.

Only qualified men may be assigned to operate the handling equipment and the launching system for transferring the missiles to the magazines. Safety personnel are placed at strategic locations to enforce safety regulations. Due to the many hazards connected with the, handling of ammunition and missiles, no factor may be overlooked in setting up the organization for replenishment and carrying out the work. The petty officer in immediate charge of the handling and stowing operations must be thoroughly familiar with the operations. He must brief his men on the safety regulations and instruct them in what they must do. It is the duty of the leading petty officers to be with the men under their supervision, and to ensure that all safety precautions and procedures are strictly observed.

The guided missile officer is responsible for maintaining the allowance, accounting, stowage, safety, and custody of all classified components and publications of guided missiles. He initiates the requisitions for guided missiles, repair parts, tools, and handling and test equipment as established by the COSAL.

The commanding officer of the ship is responsible for the care, surveillance, testing, inspection, and overhaul of ammunition. During regular yard overhaul, he may request overhaul and inspection of the ship's ammunition supply. Guided missiles are overhauled at specified installations. Missiles must be returned to depots at specified intervals, current instructions for the missiles you have aboard tell you when and where to ship your missiles for this periodic inspection and overhaul.

When missile components are stowed in ship's magazines, they require the same care as ammunition.

ORDNANCE MATERIALS

Missile ordnance materials include rocket motors, igniters, fuzes, warheads, and in some cases, boosters or auxiliary rockets. All of these units are potentially dangerous; each unit must be handled in accordance with the procedures authorized for it. The precautions in chapter 12 are in addition to the detailed directions given in the manuals for particular missiles.

All safety devices in ordnance units must be used exactly as designated. These devices must be kept in order and operative at all times. Changes, modifications, or additions to ordnance items may be made only upon explicit direction from the bureau concerned. No explosive assemblies may be used in any way or in any appliance except those designated by the proper authority.

SUMMARY

Standard reporting forms are discussed but emphasis is placed on the use of new reporting forms which can be processed by machines. It is essential to consider the operation of a weapon system as a unit, for no single part can serve as a means of defense. The GMM must coordinate his work with other ratings that specialize in other parts of the weapons system. Training plans must include all personnel who work with any part of the weapon system, and plans of the different departments and divisions must dovetail nicely. Your training sessions on components of the launching system prepare your men to do their share in the operation of the weapon system.

The day-to-day condition of the weapon system components and the work done to keep them in operating condition require a reporting system from which the fact can be quickly extracted and summarized for conclusions. The use of data processing machines will make the facts quickly available to the planning echelons of the: Navy and the Defense Department. At the same time, the amount of work required to write the reports at the petty officer level will be reduced. Reports will still be required from the POs at frequent intervals on every phase of work, but the method of reporting will be simplified as) much as possible for machine pickoff.

This chapter brings together the story of how you are supplied with missiles and spare parts to maintain them. The entire supply system is undergoing extensive change. You must keep abreast of these changes, not as a professional supply man, but sufficiently so you can order supplies intelligently.

One of the important areas of endeavor is that of reducing costs. This is not to be achieved by having fewer missiles and therefore less firepower, but by less waste in the use of expendable supplies and better maintenance of nonexpendable ordnance. It cannot be relegated to one corner of the ship's system; the idea of cost reduction must permeate all areas and phases.

Carefully kept inventory lists are a necessity. They show not only what you have on hand but what has been used, and thus are a valuable source of information in planning future supply allocations.

CHAPTER 12

SAFETY

This chapter is a summation of safety rules concerning mechanical, electrical and electronic, hydraulic, and pneumatic equipment; and explosives, radiation, gases, vapors, chemicals, and fire safety precautions. Some of these rules and warnings have been given in applicable chapters of this book, but they can bear repetition.

All your life you have been reminded to be careful, and have been cautioned about accidents that may happen if you do not heed the warning. No doubt you have ignored some of the warnings, out as you matured you came to realize the necessity for safety rules. An infraction that might cause only a minor mishap at one time could result in a disaster another time. The chance is not worth the risk. If you are reckless about your own safety, you have no right to endanger others.

A PO 1 or C has a responsibility for impressing on lower rated men the need for the safety rules, and he must be firm in enforcing them. Frequent reminders should be given even at the risk of nagging. Nearly all accidents are caused by an infraction of safety rules, whether through ignorance of the rules, or carelessness, or recklessness. The Military Requirements necessitate a knowledge of safety rules at all levels; but at E-6 or E-7 levels, for which you are trying, supervision and teaching are also required. The GMM quals expect you to interpret safety instructions and directives, to carryon a safety program in your area, and to enforce the rules. Don't forget that a good example is the first step.

ACCIDENT PREVENTION PROGRAMS

The overall directives for safety programs are issued by OPNAV or other high level authority. Interpretation of the directives takes the form of specific instructions and directives. The application takes place on shipboard and at shore stations. You have responsibility to interpret the directives to your men, to promote the program, and to enforce rules. Safety posters, magazines, films, and other educational materials are supplied by the Navy to help get across the safety program.

NAVORDSYSCOM is increasing its efforts to achieve the goal of reduction in accidents. The measures that must be taken are:

1. Plan every job operation with adequate safety precautions and instructions.
2. Assure that supervisors, when issuing work assignments, provide specific instructions on safe working practices and procedures directly related to hazards and risks incident to the assigned job.
3. Include supervisory indoctrination and specialist training to make sure that well-developed safety training is included in each such program in accordance with approved training procedures.
4. Review activity programs for employee development in safety.
5. Continue to emphasize accident prevention through activity and poster publicity. Material is available from the Commander, Naval Ordnance Systems Command Headquarters.

Personnel failure was determined to be the chief cause of accidents, whether through unawareness of the safety precautions required for the assigned task or indifference toward hazards and risks normal to the job. Past experience indicates that accidents can be significantly reduced by thorough instruction in safe working conditions and procedures, and giving information regarding the hazards and risks of the job.

Young people, who have the most to lose by accidents, are normally the most reckless. You have to keep reminding them of the hazards and the possible consequences to themselves and their shipmates.

SAFETY AROUND MACHINERY

Probably the first safety precaution given you dealt with mechanical things such as moving machinery, ladders, a swinging boom, and similar objects. The first rate training manual that you studied, Seaman, NAVTRA 10120, contains many safety rules that apply to working with and around machinery. Each text on military requirements reviews the rules and adds others. At the time you were striking for E-3 you were expected to remember those rules and apply them. Now that you are trying for E-6 or E-7, you have supervisory responsibility. The primary objective of the Navy supervisor is to operate with maximum efficiency and safety. Accidents reduce efficiency and increase costs. Practice with training aids that can be manipulated is suggested as a prime means in learning how to handle machinery with safety. A picture showing how the equipment operates helps to orient the learner to what happens when the machine works, but operating a model fixes the motion in mind. When you are planning a lesson on safe operation of equipment, use every means available to impress the lessons on the senses. Many films and slides are available on safety subjects. Select those most appropriate to your lesson to intensify your instruction. Closely supervised operation of the machinery is the next step in learning safe and proper operation.

You may have to instruct some of your men in the safe use of common tools in a safe and efficient manner. He needs to know this before he is ready to handle the far more complicated equipment used by a GMM. Take time to teach any of your men who are deficient in tool skill. See Tools and Their Uses, NAVTRA 10085, for material to review and self-study.

HANDLING AND STOWAGE

You have already qualified as an E-5 in supervising crews in the safe and proper procedures for transferring, handling, and stowing missile components. Now you will work with your officer in planning the handling and stowing operations. The safety of handling and stowing can be greatly bettered by good advance planning. Find out what is coming aboard, and plan how to take care of all the items. Decide who will be stationed at each position to handle the missiles and missile components. Have a practice session the day before the loading is to take place. If you are new on the ship, find out the location of all the storage spaces you will need to use, and the means of reaching them.

On Shipboard

When any explosives are to be handled (and all missiles are explosives and combinations of explosives), firefighting equipment must be readied on the deck. Check the operating condition of the equipment, and make sure that each man knows his responsibility and that he knows how to operate the equipment. It means that you have trained your en in methods of fighting fires in explosives.

The handling equipment also must be checked out before use. Examine the trolley, conveyors, tracks, dollies, and other handling equipment you will use. Before raising any missile or component off the deck, bench, or launcher, check the security of the lifting attachment by raising the component about 2 inches. This way, it will not have far to fall. You know the 5-foot-l-foot rule: if dropped 1 foot or more, an unpackaged explosive is considered unsafe and must be returned to the depot; a packaged explosive, if dropped 5 feet or more, is considered unsafe and must be returned to 'the depot. It is discussed in chapter 2 of this text and is mentioned several times in chapter 8.

It is difficult "to separate explosives safety rules from safety rules for handling equipment since what you are handling consists chiefly of explosives.

Ammunition handling equipment is operated and controlled by electric, hydraulic, pneumatic, and mechanical components or a combination of these. Thus all safety rules for each type of equipment apply in all steps of ammunition handling. The handling equipment used with the Tartar system is a good example of a multi type missile handling system. This system employs pneumatic equipment (missile strike down fixture), electrical equipment (deck control box), mechanical equipment (missile handling dolly) and hydraulic equipment (launcher train and elevation systems). At least one hour before replenishment, prepare and examine all handling equipment to be used and operate all equipment in all steps of missile handling. Some shipboard missile handling equipment is under the cognizance of NAVSHIPS. All safety instructions and precautions for this equipment are issued by NAVSHIPS under the guidelines set up by NAVORDSYSCOM.

Safety devices should be inspected frequently to ensure they are operative. Warn personnel if any safety device is inoperative, and restore it to operating condition as soon as possible. Some safety devices may seem to be a "bother," but it is far better to be bothered or inconvenienced a little than crippled.

Safety at Shore Stations

If you are studying to make E-7, you need to know the methods of handling and stowing missiles ashore. Although some of the handling equipment is the same, shore stations make much use of motorized equipment. Forklift trucks are used to a much greater extent than on shipboard. Proper balance of loads and securing the loads are important factors in the safe operation of forklift trucks. The manufacturer's handbook gives the instructions for his equipment. A compendium of information on about fifteen different models is given in OP 2173 (Volume 1), Handling Equipment for Ammunition and Explosives Mobile Equipment. Missile handling equipment for particular missiles is covered in one chapter, and safety precautions are consolidated in appendix A. The handling equipment described for missiles is chiefly for transfer-at-sea use. Some of the forklift trucks described are large enough to handle Talos missiles. Although forklifts are not used on highways, driving rules apply. In addition, extra care is required because of the cargo. The speed limit usually is 5 miles per hour. Never permit other persons to ride on the equipment. Watch for low or narrow clearance areas, and be sure your equipment can pass through safely. Avoid bumps or sharp objects, drive around them. Guided missiles are extremely sensitive to shocks and jars.

Volume 2 of OP 2173 describes nonmobile handling" equipment such as pallets, hoisting slings, cradles, skids, strongbacks, dollies, carriers, and stands. With the use of the stream system for shipboard handling, few of these find shipboard use, but many of them are needed for handling components at shore bases where missiles are assembled, disassembled, repaired, and stored. One safety rule that applies to all-be sure that the missile or component is securely attached. The points of attachment are marked on the containers or on the missile skin.

Duty at a shore base may involve you in packaging and shipping of missiles and components. If the shipment crosses state lines, the rules of the Interstate Commerce Commission (ICC) apply, whether Navy vehicles or public carriers are used. OP 2165, Navy Ordnance Shipping Handbook, reviews rules for different types of explosives and different means of transportation. References are given so you can get the latest rules that apply to your particular activity. Discoveries of new types of explosives make new rules necessary for safe transportation. Drivers of vehicles also must be checked on their qualifications and on safety rules. OP 2239, Driver's Handbook, Ammunition, Explosives, and Dangerous Articles, sets forth the regulations.

The safety record of NAVORDSYSCOM in driving of vehicles has been better than most; let's make it better still.

OP 5, Volume 1, Ammunition Ashore, Handling, Stowing, and Shipping, is the overall text on this subject. Be sure you get the latest revision with all the changes. There have been some changes in almost every chapter of that book; the chapter on pyrotechnics is nearly a complete change from the old rules. The chapter on chemical munitions needed some additions; so have chapters on flammable liquids, flammable solids, corrosive liquids, compressed gases, and toxic chemicals. New materials have necessitated additional rules for handling and stowing those materials.

The handling equipment is not described in OP 5, but some motor truck specifications are given. Since the ICC shipping rules are constantly revised, it is best to get the shipping regulations directly when needed. The Navy Shipping Guide gives. the Navy regulations for truck shipments.

The rules for handling and stowing specific missiles are given in the OPs for those missiles. For example, OP 2979, Volume 6, Terrier/ Tartar Shipping and Handling System, describes factory-to-firing sequence, with instructions for depot operations, depot loadout, transfer to dockside, shipboard operations, transfer at sea operations, return of missiles to depots, and other phases of the entire sequence for the HT-3 missile. Volume 5 does the same for the BT-3 and BT-3A missiles.

MOVING MACHINERY

One of the most frequently repeated warning is that about launcher movement or other moving parts of the launching equipment. No one may be m the area covered by the movement of the launcher or gun turret, and to make sure that no one is there, a loud warning bell is rung and a safety observer looks over the area. It took a grisly accident to show the need for this rule. A man thought the shadow of a gun turret provided a good place to take a snooze. While he slept, the turret was activated; his head was crushed before the moving mount could be stopped. To prevent a repetition of such a casualty, you are reminded over and over to make sure that no one is in the path of moving machinery, whether it is a launcher, a crane or boom, or other powered equipment.

To make sure that no one starts the launching system while someone is working on it, set the safety switch on the EP-2 panel to SAFE and remove the switch handle. If you give the switch handle to the person who is working on the system, you can be sure no one can activate it. That takes care of the men working on the system; you still have to look out for any man who might be where he has no business, like the man in the story above.

ELECTRICAL AND ELECTRONIC SAFETY PRECAUTIONS

Volumes have been written about electrical and electronic safety, yet accidents continue to happen. More often than not, the victim of such an accident is a person who should have known the dangers of electricity, such as an electrician making repairs. Certainly an electrician is aware of the dangers of electricity, so why does he fall a victim to it? Perhaps the answer is in the old saying, "Familiarity breeds contempt." Men become careless when they work with electricity every day.

What can you do about this attitude? You can keep reminding your men of "the safety rules that must be observed in each operation. Watch your men to see that they are observing the safety rules. Check to be sure that all electrical tools are in good repair and that the end of the ground wire within the tool is connected to the. tool's metal housing. The other end must be connected to ground. The grounded type plugs and receptacles, which must be used, automatically make this connection.

Missile components must be protected against stray voltages by adequate grounding during all phases of handling, assembling, disassembling, and testing. Attach the ground straps where indicated on the containers and the missiles.

GENERAL SAFETY RULES

The following general safety precautions are applicable during all phases of maintenance and operation.

KEEP AWAY FROM LIVE CIRCUITS. - Remove all power from the equipment when conducting operations requiring no power. Under certain conditions, capacitors may retain a high voltage charge after the equipment is turned off. To avoid the possibility of electrical shock, discharge circuits before touching them.

USE SAFE TEST EQUIPMENT. - All electrical test equipment using 115-v-a-c line power is provided with a means of grounding the chassis systems through the power cable. Be sure the proper power cable is used. Do not use damaged power cables or test leads. Damaged test leads should be replaced, not repaired.

DO NOT SERVICE OR ADJUST ALONE. - Under no circumstances should personnel perform servicing or maintenance of the equipment without the immediate presence of another person capable of rendering aid.

RESUSCITATION. - Personnel working with or near high voltages should be familiar with the methods of artificial respiration. Standard First Aid Training Course, NAVTRA 10081, describes the accepted method of mouth-to-mouth resuscitation. Charts illustrating and describing the method should be posted at a number of places on the ship. EVERYONE needs to know it. There isn't time to look it up after there has been an accident. Resuscitation should be started in seconds after an accident. After 3 minutes, the chances of revival decrease rapidly.

Safety Precautions to Observe When Testing

Do not attempt cleaning operation until all power is removed from the Guided Missile Test Set (GMTS).

Turn GMTS power off and remove tape readers before attempting lubrication.

High voltage (+ 300 v-d-c) is present at test points. Use only an insulated portable multimeter and proceed with caution.

Use caution when performing inspection, adjustments, voltage measurement, and maintenance. High voltages are present in the GMTS and the Missile Electrical System Test Set (MESTS).

Voltages up to +950 v-d-c are present in the microwave power supply chassis. Use caution when taking voltage measurements.

Remove power from the test set before attempting to remove any part of the set.

Chassis protective interlock circuits are bypassed when the BATTLESHORT switch is on. UNSAFE lamps on the panel indicate this unsafe status.

Any cabinet, chassis, or cabling damage found during inspection must be corrected before power is applied to the GMTS.

Be careful not only of what you touch with your hands, but what you touch with any part of your body. Be sure you do not brush against energized equipment, or lean against it.

Safety Around Electronic Equipment

In nearly every accident, investigation shows that it could have been prevented by observing the safety practices and procedures in chapter 9670 of the NAVSHIPS Technical Manual, and the applicable schematics, wiring diagrams, and precautions contained in the equipment manual.

Although such protective devices as interlocks, cutout switches, and circuit breakers are built into modern electronic equipment, personnel can still receive severe bums and lethal shocks under many conditions. One source of danger sometimes neglected by repairmen" with serious results is the multiple power inputs of electronic equipment. All sources of power must be turned off, including that from other equipment such as synchros and remote control circuits. For example, turning off the antenna safety switch will deenergize the antenna, but it may not turn off the antenna synchro voltages from the ship's compass or stable elements. Moreover, rescue of a victim shocked by the power input from a remote source is often hampered because of the time required to find the power source so that it can be turned off.

Another source of trouble is failure to realize that removing a unit from its normal location and energizing it while outside its normal enclosure may eliminate the protection given by built-in safety features. In such cases, special precautions are necessary to avoid accidents.

Personnel working on electronic equipment and circuits should take the time required to make the operation safe. Schematics and wiring diagrams of the entire system should be carefully studied in advance and note taken of all circuits which must be deenergized in addition to the main power supply. Electronic equipment usually has more than one source of power; all sources must be deenergized before equipment is serviced. A circuit should not be worked on with the primary power applied unless absolutely necessary. In those cases where such a procedure is necessary, the repairman should stand on approved rubber matting and keep one hand free at all times, either behind him or in his pocket.

One-hundred-fifteen volt power is not a low, relatively harmless voltage; only voltages below 30 can be considered safe. Many accidents have occurred in the Navy from 115-volt power because people often regard it as harmless and ignore safety measures.

Most of the hazards which confront the

electronics repairman are the result of careless maintenance practices or failure to observe the required precautions. The following common sense safety precautions should be observed at all times:

1. Use one hand when turning switches on or off. Keep the doors to switch and fuse boxes closed, except when working inside or replacing fuses. Use a fuse puller to remove cartridge fuses, after first checking the circuit to make certain it is dead.

2. Never work on energized circuits unless absolutely necessary. Always take time to lock out, or blockout, the switch and tag it. Locks for this purpose should be readily available; if a lock cannot be obtained, remove the fuse and tag it.

3. All supply switches or cutout switches from which power can possible be fed should be secured in the open position and tagged. The tag should read: "DANGER Shock Hazard. Do not change position of switch except by direction of ___________" (the person making, or directly in charge of, repairs).

4. Never short out, tamper with, or block open an interlock switch.

5. Inform remote stations of the circuit on which work is being performed.

6. Keep clear of exposed equipment; if necessary to work on it, use only one hand as much as possible.

7. Keep clothing, hands, and feet dry if at all possible. If work must be done in wet or damp locations, use a dry platform or wooden stool to sit or stand on, and place an approved rubber mat or other nonconductive material on top of the wood. Use insulated tools and insulated flashlights of the molded types when working on exposed parts.

8. Do not remove hot tubes from their sockets with bare hands. Use asbestos gloves or a tube puller.

9. Use a shorting stick to discharge all high voltage capacitors.

10. Be aware of nearby high-voltage lines or circuits. Use rubber gloves where applicable and stand on approved rubber matting (MIL-M-15562). Not all so-called rubber mats are good insulators.

11. Do not work on high-voltage equipment alone; a safety observer, qualified in first aid for electrical shock, should be present at all times. He should also know the circuits and switches controlling the equipment and should be given instructions to pull the switch immediately in case of accident.

12. Avoid reaching into enclosures except when absolutely necessary. In such case, use rubber blankets to prevent accidental contact with the enclosure.

13. Check circuits with a meter, never with bare fingers, and avoid touching any of the metallic surfaces of the test prods. When measuring voltages over 600 volts, do not hold the test prods.

14. Turn off the power before connecting alligator clips to any circuit.

15. Make certain that the equipment is properly grounded. Ground all test equipment to the equipment under test.

16. Solvents should be used to the minimum extent possible for routine cleaning. Solvents should not be used on hot equipment due to the increased fire or toxicity hazard. See NAVSHIPS Technical Manual, chapter 9600 or chapter 9030, for instructions and safety precautions applicable to cleaning solvents.

Electrical Power Tools

1. See that all power tool cables are so located that they will not be a tripping hazard.

2. Make sure that all electrically powered tools are properly grounded. Refer to chapter 9600 in NAVSHIPS Technical Manual for information on grounding tools and equipment.

3. Wear goggles when doing work where flying particles may strike the eyes.

4. Make certain that all dangerous moving parts of the tools are guarded.

5. Instruct all operators in the correct use of power tools, the hazards present, and the safety practices to be observed.

6. When work is completed, disconnect the tool and stow in it the assigned location.

Soldering Irons

The quals requiring knowledge and experience with soldering irons and soldering techniques are listed as requirements for the E-4, but we will list a few rules for review.

1. Always assume that a soldering iron is hot.
2. Never rest an iron anywhere but on a rack designed for that purpose.
3. Do not exert lateral pressures on pencil soldering irons. Grasp them lightly and avoid breakdown of internal insulation.
4. Do not use excessive solder because the drippings may cause bums. When excess solder collects on the iron, remove it with a rag. Do not remove solder by swinging the iron.
5. Make sure that the plug on the soldering iron cord is in good condition.
6. Hold small soldering jobs with pliers or clamps to prevent burns.
7. When cleaning an iron, place the cleaning rag on a suitable surface and wipe the iron across it. Do not hold the rag in the hand.

Rescue of Shock Victims

Prompt rescue is essential to survival in case of electrical shock. However, to avoid becoming another victim, the rescuer must first shut off the voltage or, if this is not immediately possible, he must observe the following precaution in freeing the victim from the live conductor.

1. Stand on dry insulating material and use a dry board, belt, clothing or other nonconducting material to free the victim.
2. Pull victim free of shock source by the heels of his shoes or by slack in his clothing.

Two types of injuries require prompt first aid. In case of severe electrical shock, the victim's breathing may be paralyzed and heart beat stopped; immediate artificial respiration and external heart massage may be necessary. An accident with tools may also cause dangerous bleeding which must be controlled at once. These first aid measures are described in publications issued by the Bureau of Medicine and Surgery and by the Red Cross. NAVSHIPS Technical Manual also illustrates and describes external heart massage and mouth-to-mouth artificial respiration. All personnel concerned with electronic equipment should be familiar with these first aid techniques.

HYDRAULIC FLUID AND EQUIPMENT

The hazards of hydraulics will be discussed in two phases, that is, dangers from the liquid itself, and danger from its power when it is used in machines or missiles. As you know, it does not have power of itself, but transmits power imparted to it.

HAZARDS OF HYDRAULIC FLUID

Many different combinations of materials have been tried in the search for an ideal hydraulic fluid. Water-based fluids are highly fire-resistant but are apt to cause corrosion. Petroleum base liquids are the most widely used hydraulic fluids. However, they are flammable under normal conditions and can become dangerously explosive when subjected to high pressures and there is a source of flame or high temperatures. Do not mix fire-resistant hydraulic fluids with petroleum-base hydraulic oils.

In recent years, nonflammable synthetic liquids have been developed for use in hydraulic systems where fire hazards exist. Special seals are required that will not be deteriorated by the chemicals in the hydraulic fluid.

Never permit high-pressure air to be in direct contact with petroleum base liquids in a closed system because of the danger of ignition. If gas pressure is needed, nitrogen or some other inert gas should be used.

Do not let other mixtures get into the hydraulic system, as when flushing it. Do not use diesel oil for flushing a hydraulic system; small amounts clinging to the pipes would contaminate the new supply of hydraulic fluid and could make it more flammable or explosive.

Most hydraulic fluids are free of toxic materials, but some of the fire-resistant liquids are toxic. If you spill hydraulic fluid on your skin, wash it off; some types cause skin irritation and rash. If your clothes become saturated with hydraulic fluid, change into clean clothes with no delay. Some of the toxic materials can be absorbed through the skin. Containers of hydraulic fluid of a toxic type should have a label indicating this. The label should say: DANGER, TOXIC, CONTAINS (name of substance), A VOID INHALING, SWALLOWING, OR CONTACT WITH SKIN. The toxic symbol is brown on white, with a skull in the circle.

High -Pressure Hazards

When servicing hydraulic driving gear, keep in mind that you are dealing with powerful forces. I t is the pressure transmitted by the fluid that operates the machinery. With a pressure of a ton per square inch behind it, a jet of liquid from a hydraulic pipe can cause painful damage. This could happen if there were a break in a pipe. You have been told over and over that pressure must _always be released before working on a hydraulic system, so you should not be guilty of trying to crack a pipe connection or a valve without first releasing the pressure. Pressure- regulating valves and pressure-reducing valves adjust the pressures to the desired values. Relief valves, simple or compound, drop the pressure. Dumping or unloading a system is useful for stopping the hydraulic mechanism at some point in the operating cycle without shutting off the power.

Be sure to bleed the hydraulic system to reduce accumulator pressure before breaking any hydraulic connections or servicing the ready-service ring or the hoist.

HAZARDS OF HYDRAULIC EQUIPMENT

Explosions have occurred in high pressure hydraulic systems as a result of compression-ignition of petroleum oil in contact with air. The compression-ignition (diesel action) depends on the presence of air and oil, the operating temperature, and the speed of rise in pressure. The quick release of oil under high pressure into a closed part of a system can produce the high temperature and pressure conditions that cause this type of explosion. Air-oil accumulators and air flasks used to charge accumulators are the components that present the greatest explosion hazard in the system. Accumulators and air flasks retain pressure after the pumps are shut down.

Because of this danger, nitrogen is used instead of air in the flasks in missile systems. If there are any air flasks still in use in your system, be sure to observe the following precautions:

1. Keep oil out of the air side of accumulators, and keep air out of the hydraulic oil system.

2. Prevent sudden release of high pressure into dead end parts of a system.

Whether nitrogen or air flasks are used, the temperature of the hydraulic fluid is a critical factor. A maximum of 190 degrees F is commonly given. At high temperatures the fluid decomposes and these chemical changes cause formation of sludge, separation of components of the fluid, and other changes that affect the operation of the hydraulic system. An electric spark in the vicinity of overheated equipment can cause combustion. Immediately mop up any spilled fluid, and wipe off leaks. Repair any leak as soon as possible; shut down the equipment first.

NEVER charge a nitrogen flask with oxygen or compressed air. A mixture of hydraulic fluid and oxygen is extremely explosive.

Clogged filters should be removed as soon as possible. Critical components of a hydraulic system may be damaged if the system is operated when the fluid is not being filtered. Shut down the system before attempting to remove a filter and replace with a good one. Wait for the hydraulic pressure to decay before proceeding.

Before attempting to repair a leak, shut down the system, release the fluid pressure before disconnecting any pressure line; release gaseous nitrogen and hydraulic fluid pressure before disconnecting the accumulator. Be sure the appropriate shutoff valves are closed on the associated main supply tank or the header tank.

In opening a hydraulic system to make repairs, some air is likely to become entrapped. After reassembling all parts, thoroughly bleed the system before placing it in operation.

The hydraulic power drives that operate the different parts of the launching system are very powerful. Before going into any area where you could be injured by moving machinery (launcher area, magazine, loader, spanning rail, blast doors, retractable rails, floating tracks, loader positioner, strikedown gear), set the safety switch on the associated panel to SAFE, and take the switch handle with you. Then no one can start the equipment inadvertently.

If the maintenance requires power on, station a man at the EP2 panel and another safety man at the EP1 panel (circuit breakers), establish phone communication with the two safety men, t and work with extreme caution. There is very little space and a person could easily be crushed by moving machinery.

Blast doors and magazine doors open and close with sudden force. Do not place any part of the body in the opening of either.

Each time before equipment is moved (except at General Quarters), sound the train warning bell and get an "all clear" signal before training or elevating the launcher. Likewise, sound the loading horn before moving any of the feeder components, *each time* before equipment is to be moved. Do not enter the magazine during any loading or unloading operation.

Do not enter the train circle when the launcher train motor is running.

Do not depend on a switch alone to remove power from equipment. If the equipment is wired to a secondary power distribution system by a power cable, separate the cable from the receptacle before attempting repairs. If permanently wired in, remove the main fuses and open the power switch. Attach a warning tag to the switch so no one will close the switch while repairs are in progress.

HYDRAULICS IN MISSILES

In missile testing, the hydraulic fluid becomes heated. It is imperative that the missile be allowed to cool before attempting to bleed or disconnect a hydraulic line.

Smoking is prohibited in the immediate area while filling or maintaining the pumping unit. Any spilled fluid must be wiped up immediately.

Remove all power from the missile before connecting the pumping unit servo oscillator cable to the missile for making the test. Failure to do so will result in damage to the missile and to the pumping unit.

Prior to installation of the replacement hot-gas generator (hydraulic), check to make sure that the squib is shorted.

The turbine, gearbox, and hydraulic pump for the missile are combined in a single unit that may be replaced. Before disconnecting any hydraulic line or connection, the missile hydraulic system must be bled.

Follow the steps of the procedure exactly so as to avoid deforming the hydraulic tube (high pressure or low pressure) or damaging the seal.

Leakage of hydraulic oil may contaminate harnesses (electrical) and connectors. It may be removed with aliphatic naphtha, but this must be done in a well-ventilated and fireproof (restricted) area.

PNEUMATIC EQUIPMENT

Compressed air is used as the power source in a number of your operations, though not to the extent that hydraulic power is used. The source is the compressor plant of the ship, from where the compressed air is led by piping to many parts of the ship. NAVSHIPS Technical Manual, chapter 9490, describes the ship's compressor equipment and its uses. Other rates have responsibility for care and maintenance of the system, but users must know how to use the air at the outlets. You have used the low-pressure lines for operating pneumatic tools; the chipping hammer is probably the first pneumatic-powered tool that you used in the Navy.

SAFETY WHEN USING LOW-PRESSURE AIR

The usual working pressure is 100 psi, but repair ships and tenders use 125 psi: In some ships low-pressure air is supplied through reducing valves from a higher pressure system. The low-pressure system can be used for many purposes, including operation of pneumatic tools, cleaning electrical machinery, cleaning CO_2 indicator systems, charging pump air chambers, and operating parts of the missile launching system. Even at low pressures, an air hose should never be pointed at anyone. The pressurized air can cause serious bodily damage. Make sure that output hoses are securely connected to the tool or other equipment to be operated by compressed air.

Pneumatic Tools and Handling Equipment

Before operating a pneumatic drill, inspect the air hose and check for any leaks or damage. Blow air through the air hose to free it of any foreign material before connecting it to the drill. Keep the air hose clean and free from lubricants.

Chipping hammers should not be operated without safety goggles. All persons in the imediate vicinity should also wear goggles. Never point the chipping hammer toward a person; the tool might be accidentally ejected and could seriously injure personnel or damage equipment. Disconnect the hose from the tool if you have to lay it down temporarily.

The same safety rules apply to the use of the pneumatic impact wrench.

The pneumatic handling equipment is usually under NAVSHIPS cognizance and NAVSHIPS publications give the instructions for use of the equipment. Air-operated chain hoists are sometimes used to replenish missiles. The Tartar loading fixture is air operated.

Air Motors

In manual operation of launchers, air motors are used instead of the hydraulic power drives. The normal safety interlocks are bypassed. Use extreme caution; specifically, never move the launcher if the blast doors are open, and never open or close the blast doors by use of the handpumps if, the launcher has been moved off the stow position by air motors. Be sure the power system is off before using the air motors.

SAFETY IN THE USE OF HIGH PRESSURE COMPRESSED AIR

The highest pressures are used in the dud-jettison units. In the Mk 108 Mod 0 dud-jettison unit, air trapped by the underside of the piston at the end of the jettison stroke is nearly 15,000 psi. This charge returns the ejector to the position it had before jettison. Air from the 10o-psi ship's supply line passes to the positioner valve, but the pressure admitted at the charging valve is 3500 psi. The charging chamber acts as. a temporary storage for the pressurized air. The high pressure air is passed to both sides of the firing valve. Air can be vented from the chamber by a bleeder valve if the jettisoning operation is to be stopped.

Operation with such high pressures makes it essential that all tubing and flexible hoses be inspected periodically for weak points. Flexible hose should be replaced, regardless of condition, at expiration date (labeled at installation). Release pressure before disconnecting any high pressure lines.

Do not direct a high pressure air jet at any part of the human body; to do so may be fatal. Keep your face clear of any air outlet, air flask, or hose.

Do not use compressed air to clean air breathers. Compressed air is not effective as a cleaner.

Before unscrewing any of the filter plugs on the dud-jettison panel, close the manual shutoff valve, and be sure that the pneumatic lines leading to the dud ejectors are vented.

Before applying air pressure, be sure that all air connectors are secure; a loose air connection is dangerous.

The missile air flask is charged in the checkout area before mating of a Terrier or Talos missile. Permit only one man in the checkout area during charging of the air flask. Remain behind protective shields while charging the air flask, and for 5 minutes after charging. Do not charge or top-off more than one missile air flask at one time in the same checkout compartment. Never exceed the maximum stabilized air pressure of 3750 psi. Refer to the manufacturer's table of flask pressures and read the pressure from the air supply high pressure outlet gage, not the missile air flask gage. Discontinue checkout during rough seas. Bleed off air pressure before disconnecting the supply line. If it is necessary to remove the plug from the air fill valve, be sure that the air fill valve does not unscrew.

Be very sure you do not use compressed air where pressurized nitrogen should be used.

Immediately report any leak to the safety officer or the officer in charge of operations.

Inspect threads of couplings before mating. Make sure they are free of dirt, oil, and physical defects. Do not use light oils, benzene, or kerosene as cleaning or lubricating agents in a high pressure air system. These oils vaporize easily and form a highly explosive mixture with compressed air. Do not use oil on gages associated with pneumatic systems, and do not use oil gages on an air system.

Do not kink a high pressure line or hose, nor strike a fitting or an air line that is under: pressure. Do not attempt to loosen or tighten any high pressure connection while the system is under pressure.

PRESSURIZING AIR FLASKS, TANKS, AND BLADDERS

Some uses of compressed air in missiles and launching systems were mentioned in chapter 7. Depot testing of missiles with a pneumatic test set is briefly described. High pressure air is used for that test. Before energizing the equipment, make sure that all hoses are connected firmly both to the test set and to the missile. The hoses require replacement at stated intervals, and oftener if found defective. Inspect them each time before using.

Be sure that there is no oil or grease near high pressure air lines or fittings. High-pressure air and petroleum make an explosive combination.

Be careful not to come into contact with any of the compressor or discharge pipes as they operate at a temperature of around 200°F. Be careful not to get in the path of high pressure air; it is extremely dangerous.

Before applying air pressure to the missile, be sure all the connections are tight and the air hoses are attached to rigid supports.

Do not remove air supply lines to the missile while air supply is pressurized. Shut off the air supply at the test station and bleed pressure from the lines before removing the line from the missile. Do not strike a fitting or an air line that is under high pressure.

Do not attempt to loosen or tighten any high-pressure connection while the system is under pressure. Personnel must be thoroughly trained and checked out on a high pressure system before being authorized to operate the system.

Anti-icing systems use an air bladder to provide pressure for the hot water tank. It is charged to 10 PSI and not over 12 PSI. While servicing or troubleshooting the anti-icing system, be sure the launching system cannot be activated.

USE OF AIR PRESSURE GAGES

Gages used to measure pressure are described and illustrated in Basic Machines, NAVTRA 10624, and in Fluid Power, NAVTRA 16193.

Dropping a gage may permanently damage the calibrated units. When gages are not in use they should be stowed in a dry place.

Do not use oil on gages associated with pneumatic systems. Keep the gages clean at all times. Do not use an oil gage on air systems.

Carefully observe sequence of operations as outlined in the procedures to prevent damage to low-pressure gages, controls, and connections.

Keep pressures within safe range by frequent checks of the gages. Don't let the pressure become dangerously high before you do something about it. Relieve the pressure by means of a relief valve or switch and then look for the cause of the trouble and remove it. Do not open or close the valves rapidly, unless authorized to do so.

Use no oil when calibrating gages. Even a minute amount of oil is an explosion hazard in a high pressure air system.

On equipments where there is an installed air pressure gage, as in the dud ejector, be sure all air supply is closed off before attempting to remove any part of the equipment, such as the filters. Close the manual shutoff valve on the jettison panel, and be sure all air lines leading to the ejector are vented.

AMMUNITION AND EXPLOSIVES SAFETY

Because of the dangerous nature of munitions, you have been reminded of safety precautions with regard to explosives throughout your Navy career You should know the cautions and warnings quite thoroughly by now, and remind those with you of the rules.

HAZARD CLASSIFICATIONS

The hazard classification of each type of explosive has been determined through tests at firing ranges, research activities, and manufacturing establishments. The combinations of explosives used in missiles have also been tested. Shipboard, you will not be concerned with meeting the regulations of the Interstate Commerce Commission (ICC) for shipment of explosives, but at a depot, you must make yourself familiar with the ICC regulations on shipment of missiles and missile components. The color code painted on the ammunition indicates its hazard classification. The specific hazard classifications and stowage compatibility are provided in OP 5, Ammunition Ashore, and OP 1631 Ammunition Hazard Classifications, Dimensions, and Weights. Be sure you have the latest revision. OP 2165, Navy Ordnance Shipping Handbook, gives instructions for packing and marking specific items. As new items are tested, instructions are issued to cover them.

Shipboard you check the condition of the magazine where the missiles and missile components are to be stored; at a shore base you check the buildings that are to be used. Different types of structures are used for munitions of different hazard classification. The distance between buildings, distance from occupied dwellings or offices, distance from roads or streets, and other specifications must be met. If you have duty at a shore base, you need to study the regulations that apply to the explosive components that you have to stow. There are many of them, but they are necessary because of the dangerous character of the materials being handled.

STOWAGE FOR SPECIAL TYPES OF EXPLOSIVES

The assembled missiles are stowed in the missile magazine of the launching system, as you know. The extra components, or spares, are stored in magazines and lockers according to their hazard classification. Throughout the text you have been reminded where to stow or not to stow.

PYROTECHNICS

One of the most frequent reminders concerns the stowage of flash signals and flares. All pyrotechnic items are easily actuated, and must be so in order to serve their purpose, but that also makes them very dangerous. While the quantity of explosives they contain is small, they are a terrible fire hazard. When handling any pyrotechnic items, grasp them securely to avoid dropping them. Do not disturb the actuating mechanism, whether it is a tear tape, a wire, or other device.

The flash signals used on missiles are treated as pyrotechnic ammunition. Like fireworks, they are easily set off and will quickly ignite other flammables nearby. Precautions are as follows:

1. Dissipate static electrical charges before they are able to reach pyrotechnics. Sparkproof shoes, tools, and other safety items should be used when working with pyrotechnics. The flash signals used on missiles are treated as pyrotechnic ammunition. Like fireworks, they are easily set off and will quickly ignite other flammables nearby. Precautions are as follows:

1. Dissipate static electrical charges before they are able to reach pyrotechnics. Sparkproof shoes, tools, and other safety items should be used when working with pyrotechnics.
2. Stow in a dry environment at all times. Moisture quickly deteriorates these munitions, rendering them completely unserviceable.
3. Stow pyrotechnic items well away from all sources of radio energy emissions such as from radar and antenna lead-in.
4. Always have readily available sufficient and proper firefighting equipment.

BOOSTERS. - To the inexperienced eye, boosters are inoffensive looking items. Nothing could be farther from the truth; they are deadly.

1. Never jar, drop, bump, or otherwise subject boosters to shock. They are sensitive to both shock and friction.
2. Never use nails to secure covers on boxes containing boosters - use screws on wooden boxes.

FUZES. - Fuzes contain delicate mechanisms and sensitive explosives.

1. Any fuze from which the safety pin has been removed must be considered armed. No exceptions are considered.
2. A fuze dropped from a height of 5 feet or more (when packaged) must not be installed. Set it aside and dispose of it as instructed. This may involve destruction or sending it back to the factory or depot. When not packaged, a drop of 1 foot or more is sufficient to require return or, if armed, disposition in deep water.

INERT MUNITIONS. - Inert munitions include such things as wings and fins, and dummy or training missiles. The weight and mass of inert ammunition require care in handling to avoid accidents. The weight can crush a man if it falls on him. Edges of wings and fins can inflict cuts. Dents or bends can cause erratic flight of the missile.

Exercise heads without the destruct charge can be stored as inert items. When the destruct charge is assembled into it, it must be handled as class A explosive, the same as a warhead.

Liquid Propellants and Fuels

The Talos missile uses a ramjet liquid fuel which is put in at the depot. This fuel is JP-5; it is flammable and its vapors form explosive mixtures with air. It is moderately skin irritating but its main danger comes from accidentally swallowing some of the fuel. Do not induce vomiting if fuel is swallowed accidentally, except on medical direction. Clothing contaminated by the fuel should be promptly removed, and the skin washed with soap and water as soon as possible.

The fire danger comes from fuel spills, fuel in storage, or burning fuel streams. Wipe up fuel spills promptly; sand and dirt will absorb spills. Do not allow accumulation of oily rags, waste, or papers.

Do not inhale vapors of the fuel. If the area is poorly ventilated have canister type gas masks or respirators at hand.

Shipboard you are provided with only enough JP-5 fuel to top off the tanks. Handle it with the same care as larger quantities store in a cool place, free of combustibles. Take care not to spill it on yourself or on the deck. Promptly clean up spills. Wear goggles or a face shield if fuel splashing is likely to occur. Wear non- sparking or static-conductive type shoes. Do not permit open flames or spark-making equipment in fuel-handling areas. This includes smoking paraphernalia (matches, lighters).

Be sure the missile is grounded to prevent static buildup.

Hydraulic fluid, fuel, or other flammables must not be stored in or near any space where explosive components will be stored or handled.

S&A Device

Every missile has an S&A device. In the assembled missile it is attached to the center of the warhead or the exercise head. The spare S&A devices are stored in the fuze and detonator locker or magazine, each one packaged in its container. Do not subject it to rough handling. An S&A device that has been dropped 5 feet or more (in its container) must not be used. Do not use an S&A device that has been dropped 1 foot or more when out of its container. Repackage the dropped unit and request disposition instructions from NAVORDSYSCOM.

Do not test or disassemble an S&A device.

Make certain that the S&A device is in SAFE condition (fig. 12-1). If it is found to be ARMED, it must be disposed of according to instructions from NAVORDSYSCOM (disposed of in deep water).

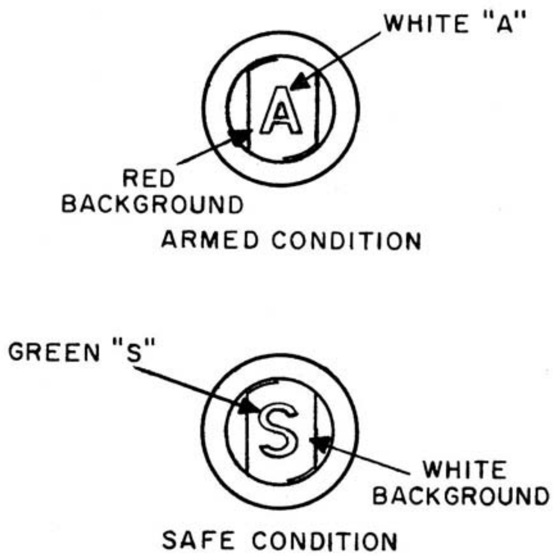
Do not attempt to force the arming mechanism into position, or tamper with it. Do not install a damaged S&A device.

The S&A device is connected to the warhead booster by a flexible explosive lead, similar to "primacord" in construction. It has an explosive-filled cup at either end for attachment. It should be handled and stored as a high explosive. Do not kink or strike the explosive lead, or try to stretch it to fit, or force it in any way.

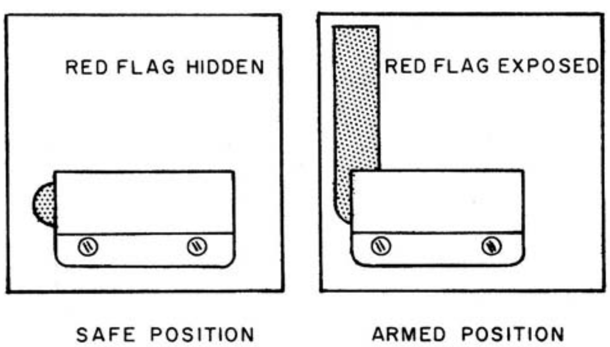
Igniters

The igniter assembly is supported in the center of the headcap of the booster by an arming ring. It contains the ignition charge (black powder) and two ignition element diverters. In the armed condition, the squibs may be activated by electrical signals sent through contacts on the forward launching shoes of the booster. Figure 12-2 shows the ARMED and SAFE positions which you observe. Do not tamper with the arming mechanism. Handle it as a high explosive. Spare igniters are stored (in their containers) in the fuze and detonator locker. They are not tested aboard ship.

Verify that the booster arming device is in the SAFE position during all handling operations, and that the igniter assembly is in the non":



94.168
Figure 12-1.—Indicator window of S&A device; ARMED and SAFE conditions.



94.169
Figure 12-2.—Igniter arm-disarm mechanism flags, SAFE and ARMED positions.

propulsive state when the booster is not mated to the missile.

Do not attempt to remove a defective igniter from a booster; request disposition instructions from NAVORDSYSCOM.

Do not apply heat to any part of the igniter assembly (welding, brazing, soldering, etc.).

Do not approach a misfire for at least 20 minutes. This time varies for different missiles; follow ship's doctrine.

INCREASE IN HAZARD THROUGH DETERIORATION

Explosives deteriorate because of moisture, heat, sun, cold (freezing), and age. The degree of damage varies with the type of explosive. To the above factors, physical damage may be added, Powdered propellant, for example, is much more dangerous than pressed propellant. It will catch, fire much more readily. It can explode. A crack in a propellant grain can cause uneven burning or it might cause it to explode instead of burn. Its behavior becomes unpredictable. That's why you must not use a booster that has been dropped. The same thing may happen to the; high explosive in the warhead; its behavior cannot be depended on. The shock of the fall can set off some of the very sensitive high explosives. A drop of only a few inches can trigger a detonator, or a fuze. Be very careful not to drop or bump any of these sensitive explosives.

Even with the best conditions, smokeless powder deteriorates with age. Its behavior becomes unpredictable. Therefore, age limits are set for missiles; the missiles are returned to a depot or factory after the expiration date.

Temperature limits are set for each type of missile. Exposure to excessive temperatures affects the explosives in the missile. Missiles exposed to excessive temperatures must not be used, but must be returned to the depot or factory for reworking. Exposure to a hot sun is one way in which missiles become overheated. This is more likely to occur on shore stations; than on shipboard, where you promptly strike down the missiles and missile components as they are delivered on the ship. Storage problems are compounded at an advance base. These are discussed in OP 4, Volume Ammunition Ashore, Advanced Bases. Instructions are included for stowage of pyrotechnics, fuzes, primers, igniters, boosters, detonators, tracers, and other components. If missiles have to be stored at such a base, they need to be given the same protection as bombs, rockets, and torpedoes. The problems will vary with the climate of the region, the shelters and the transportation available, and other local factors.

The temperature and humidity limits for nuclear warheads are clearly defined in the Navy SWOP for each Mark and Mod. If there are nuclear warheads in any of your missiles, study the applicable SWOP and follow the regulations prescribed.

Excessive vibration can break down an explosive so it becomes dangerous. Cushioning of explosive components in containers, and blocking and bracing of containers are two methods used to reduce vibration. In overland transportation, such protection is especially necessary, but prevention of unrestrained movement is also necessary on shipboard. The missiles are secured in the trays in the ready service ring. The spare components must be securely stowed in their magazines so they cannot roll about.

SAFE TRANSPORTATION OF EXPLOSIVES

The Navy's safety record in transportation of explosives has been good; let's make it even better.

The rules for transportation of explosives and other dangerous articles are made by the Interstate Commerce Commission (ICC). The regulations are known as Agent T.C. George's Tariff (latest edition), and apply to shipments via common carriers (barges, trucks, trailers, railroad cars, boats, etc.). When you return missiles or components to be utilized, at least part of the way, and therefore ICC regulations apply, as well as Navy shipping regulations. Transportation by freight, express, or the Coast Guard (CG 108) is covered by the rules. The shipment of explosives in any form by mail is forbidden. The regulations are very comprehensive and specific. OP 5 (Volume 1), Ammunition and Explosives Ashore, Safety and Security Regulations gives thorough coverage to the rules.

Safety in transportation of explosives begins with the proper packaging. When you are preparing components for shipment, use the container designed or designated for each item and use the cushioning and blocking material made to fit the item and the container. It is not so much the quantity of cushioning used, as the fit and design of it. It is important to prevent movement of the item inside the container. A small amount of cushioning and bracing, snugly fitted, is more effective than quantities of loose material that can shift about.

During the packaging operation, safety precautions must be observed. Firefighting equipment should be at the ready. The smoking lamp is out. Handling equipment must be in safe condition. Nonsparking tools are to be used, and no spark- or heat-producing operation, such as welding, may be carried on in the space. As a general rule, metal containers should be kept grounded. Check the grounding requirements for the components you are packaging. In no case should a ground strap lie across, or be attached to, an umbilical connector of an assembly containing an explosive component. A warhead container must be grounded before inserting the warhead, and the warhead must be grounded while it is outside the container. Only authorized personnel may be in the area where the work is being done.

Motors must also be grounded during handling and packing operations. The container must be grounded before inserting the rocket (missile) motor (or opening and removing it). Do not get behind the motor, where you would be in the path of the blast in case of an accidental ignition.

Do not bring power lights or power cords near the motor. Use a safety flashlight to inspect the motor.

When packaging a nuclear warhead, follow the instructions in the applicable Navy SWOP. Mark the container in accordance with the SWOP. Containers of conventional explosives are marked according to ICC rules, This includes the hazard classification and the nomenclature.

Before closing a container, make sure that the explosive component is in the SAFE condition.

If you believe an explosive component is in hazardous condition and should not be shipped, get the approval of your officer to dispose of it in deep water, without delay.

If the container is a wooden one, use only nonsparking tools for driving the nails or inserting the screws for closing the container, and be very careful to drive the nails into the container only. If packing lists must be attached by nailing, use tacks that do not penetrate through the wood container.

The applicable OP gives the detailed packaging procedure for each type of component. If the item is to be shipped by common carrier, the packaging must meet ICC standards as well as Navy standards. Pyrotechnics, for example, must be specially packaged to keep out moisture. One method used by manufacturers is to package the items in corrugated board cartons and seal out moisture with a paraffin dip. A number of cartons then are placed in an outer container of wood. Metal-lined wooden boxes may be used when there are no facilities for sealing the inner boxes.

Shipment

Whatever method of shipping is used, always make sure that the handling equipment is checked out just prior to use. Supervise the men closely and be sure there is no rough handling or dropping of any component. Do not neglect to follow up on any dropped item; the damage may not be visible to the naked eye, but it can be serious, even critical.

SHIPMENT BY COMMON CARRIER. - Many missiles and missile components are transported by truck, trailer, and/or railroad car. The components must be blocked and braced so they will not move about during transit. The quantity and type of material to be used has been computed by ICC to give a margin of safety. Follow the instructions laid down for the shipment of your packages or containers, even though the amount of blocking and bracing may seen excessive to you. It has to be strong enough to take care of contingencies that may occur.

Explosive items must not be left untended on the pier, dock, or loading platform and must not be left overnight.

The driver of the truck or other vehicle hauling the explosives must read and sign the safety instructions before he starts on his trip. He must know what to do in case of accident, breakdown, fire, or other emergency.

SAFE DISPOSAL OF DAMAGED EXPLOSIVES

Missiles deteriorate with age, and suffer damage from moisture, heat, shock, rough handling, or malfunction of components. Before the missile reaches a dangerous stage from deterioration, you package it in its container and return it to a depot for rework. Missiles damaged by rough handling, or by failure of a component, as in a dud, are also returned to the depot. Only if the missile is endangering the ship, as in a misfire that might explode on the launcher, is a missile jettisoned. No rule of thumb can be given; the danger has to be assessed on the spot and the decision made by the officer.

If the stability and compatibility of ammunition or an explosive is not known, it shall be given separate stowage, and instructions for Its disposal requested.

The preferred method of disposal of dangerous explosives is by dumping at sea, in deep water. If the material is not heavy enough, it must be weighted so it will not rise to the surface after dumping.

For routine disposal, authorization must be obtained from NAVORDSYSCOM. Explosive Ordnance Disposal (EOD) personnel and qualified graduates of the explosive Ordnance Disposal School may be called on in an emergency and, if no one is available, immediate disposal must be made by the commander and other ship's personnel. You can't wait for someone to tell you what to do in an emergency situation.

SAFETY FEATURES OF MISSILES

Most fuzes contain one or more safety features designed to prevent premature firing. When set at SAFE and packaged in containers, they are protected against stray radiation, but dropping them is always a hazard. Fuzes, primers, tracers, boosters, and detonators are all explosive hazards; they are sensitive to shock, friction, and heat. They must be handled with care at all times, and cushioned and supported against shock.

The arming plug is not added to the missile until it is in the assembly area preparatory to firing, and only one missile is armed.

The safing devices provided for explosive actuating circuits and components are designated by different terms: safety switch, arming plug, shorting clip, shorting plug, safing and arming device, etc. The purpose of each is to prevent the electrical impulse from reaching the explosive before time.

Grounding wires or straps are other safing devices used on explosives containers and on explosive components while removing or packaging components and during tests and maintenance operations.

The safety devices on nuclear warheads are multiple. They are described in the Navy SWOPs applicable to each type.

RADIATION

Radiation dangers are of several kinds. Nuclear radiation is probably the most feared, but there is also radio-frequency (RF) or electromagnetic radiation. Electromagnetic radiation ay be further classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-rays, and gamma rays. Cosmic radiation is a mixture, not completely identified.

NUCLEAR RADIATION

With so many of our missiles carrying nuclear warheads, many of our ship's crews live with nuclear dangers. The multiple safety devices on each weapon make accidental detonation almost impossible, but there is always the chance of human errors. The accidents that have occurred have been due to carelessness or neglect by the men handling the weapons. Neglect in checking of handling equipment has been a prominent cause of incidents. Improper procedure in removing or installing a warhead is another common cause of incidents. There has never been an accidental full scale nuclear detonation but there have been many cases of incidents. Each one is investigated and reported. When you read the reports of the investigations (your publications custodian will have them), you can readily see that observation of simple safety rules would have prevented almost all of them.

A bulletin published quarterly, Nuclear Weapons Safety, discusses various aspects of nuclear safety, safety of particular weapons, results of NTPIs and NWAIs, and analysis of incidents. Most of the issues are classified Secret. They can give you valuable information to aid your safety program, and your plans for drilling your men in safe procedures.

Detection and Measurement

The instruments used to detect and measure nuclear radiation are called Radiac instruments, meaning Radioactivity, Detection, Identification and Computation. Different types of instruments are used for different purposes. Those used to measure radiation after a nuclear attack or an accident are survey instruments. On nuclear submarines, installed equipment monitors the air continuously. Continuous monitoring of nuclear weapons storage spaces on surface ships is no longer required. Portable radiac instruments are used in the shops, assembly or checkout areas, and storage areas when anyone is working in the area. The instructions for operating the monitor are packed in the carrying case with it. Since many ships have no GMTs aboard, you will need to learn how to operate the instrument. The IC/T2-PA is a portable meter that can be plugged into an, 115-V a-c, 60-hertz outlet. It has an audible alarm that is triggered by the presence of radioactive particles in the air. Monitoring of individuals who are believed to have received some radiation is done in the medical department.

The medical department also keeps records of the amounts of radiation received by individuals. Decontamination of the ship is done by Hull Technicians and under their supervision. Control of day-to-day contamination in the missile spaces is your responsibility. Minor spills of nuclear material can be wiped up with absorbent paper and the wipes placed in the can for contaminated waste, which is later disposed of at sea. The waste may not be burned, as fire does not destroy radioactivity. Wear protective gloves while cleaning up. Other personnel should be sent out of the area until the cleanup is finished and the radioactivity is reduced to a safe level.

In case of a major spill evacuate the area, close it off, and send for the decontamination team. They will wear protective clothing and OBAs.

Protection Against nuclear Radiation

The use of protective clothing and of shelters, and the methods of decontamination are described in Basic Military Requirements, NAVTRA 10054, with regard to nuclear attacks, where there are massive quantities of radiation.

However, the same care must be exercised when the quantities of radiation are much smaller, as in a slight incident with a nuclear warhead. Constant association with the deadly nuclear giant may make you careless and complacent. Don't forget that the danger is always there, even though surrounded by numerous safeguards. Prevention is the best protection.

Peacetime Safety Rules

Fear of nuclear radiation from nuclear weapons is worldwide; every nuclear warhead is viewed as a potential cause of another Hiroshima. The need for extreme caution in peacetime operations with nuclear missiles is obvious. Safety rules were developed by all the services and were written into the Navy SWOPS and the check lists and the MRCs for each missile and nuclear weapon. The standards set up by OPNAV to be applied in all the studies setting up the safety rules were:

(1) There will be positive measures to prevent weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield.

(2) There will be positive measures to prevent deliberate arming, launching, firing, or releasing except upon execution of emergency war orders or when directed by competent authority.

(3) There will be positive measures to prevent inadvertent arming, launching, firing or releasing.

(4) There will be positive measures to ensure adequate security.

These criteria were observed in preparing the nuclear weapons peacetime safety rules. It was also recognized that information to the public is of great importance to allay fears. Definite rules and procedures have been established for the informational angles in case of an accident or incident. OPNAVINST 8110.16 gives those instructions. The most recent revision consolidates a number of instructions and documents on nuclear accidents and incidents. Your CO is responsible for preparing releases in case of an accident or incident, but you should be aware of what is required.

RF OR ELECTROMAGNETIC RADIATION

Chapter 8 told about the studies made under the HERO and RAD HAZ programs to discover the dangers of RF radiation to people, explosives, and fuel. The tests and studies are being continued, and any changes in the rules will be published as changes to the basic OP 3565. NAVORD has the responsibility for making the changes.

Ordnance Protection

Sources of RF radiation are the communication equipment and the radars. The majority of the ordnance systems tested have proven to be HERO SAFE and HERO RELIABLE if just a few general precautions are followed. An assembled Tartar or Talos missile is HERO SAFE, but HERO UNSAFE when being tested disassembled. Radar transmitters must be silenced during operations when missiles are HERO UNSAFE. If within the distance limits, radar transmitters on other ships must also be silenced. The minimum safe distance for a particular radar may be looked up in OP 3565, (Technical Manual Radio Frequency Hazards To Ordnance, Personnel, and Fuel). Greater stand- off distance is required for ships with large amounts of transmitting equipment, such as command ships, and communication ships.

Avoid touching any exposed firing contact, wiring, or other exposed circuitry with the hand or any metal object or structure such as a metal steering hook, or screwdriver.

To prevent accidental touching of electrical connector pins, cover the connectors with non-metallic caps.

Do not expose internal wiring or firing circuits by unnecessary disassembly.

Electrically insulate all steering hooks or loading hooks used with loading cranes, booms, burtoning wires, etc. Use nonconductive rope, strain insulators, or similar material.

When handling missiles with nuclear warheads, follow the SWOP checklist exactly.

HERO UNSAFE ordnance, such as flash signals, igniters, tracking flares, unshielded rocket motors, warheads, and exercise heads, should not be stored in the same space with exposed electronic transmitting apparatus or with any exposed antenna or transmission line. Transport all HERO UNSAFE ordnance in completely enclosed metal cases whenever possible. Unshielded items are not permitted on the weather deck or the flight deck. As far as possible all handling should be below decks.

A missile that is HERO SAFE in the assembled state, becomes HERO UNSAFE or HERO SUSCEPTIBLE in different stages of disassembly.

The auxiliary power supply (APS) of a Tartar missile may be ignited by RF radiation when it is undergoing test or disassembly on the launcher. Stay at least three feet from the APS ports when standing in direct line with them.

Personnel Protection

The Bureau of Medicine and Surgery has established safe limits of RF radiation to humans based on the power density of the radiation beam and the exposure time of the human body in the radiation field. The nonthermal effects on the body are still being studied.

The Naval Ship Systems Command has the responsibility for determining the hazardous shipboard areas and ensuring that the RF radiation hazard to personnel is minimal, or nonexistent. All hazardous areas are posted with warning signs, and the ship's intercommunication system is used to warn personnel when the radars are operating. Observe the warning signs and avoid centering those areas. Some of these areas will be permanently marked, and others temporarily.

Fuel Hazards

Volatile fuel-air mixtures are most likely to occur near aircraft fuel vents, open fuel inlets during over-the-wing fueling, and spilled gasoline. Obviously, the most danger of fuel ignition by RF radiation is on aircraft carriers. The danger of fueling with IP-S (which you use to top off the liquid fuel container of the Talos missile) is not considered significant. The use of nonsparking equipment reduces any hazard.

OTHER RADIATION HAZARDS

You are bombarded with cosmic rays whenever you are in the open air. Whether this is good or harmful has not been proven. It is known that overexposure to the sun is harmful. Frequent suntans can cause skin cancer.

Overexposure to X-rays is a cause of cancer. Early experimenters with X-rays did not know this and many of them succumbed to cancer. Doctors now are careful not to u an excess of X-rays. Each man's medical record lists the dates when X-rays were taken, so there is no duplication or overexposure. The technicians who take the X-rays must step behind a lead curtain to protect themselves while they are taking the X-rays.

Luminescent paints that contain radium emit rays constantly. There is no record that anyone wearing a wrist watch with a radium dial received enough radiation to be harmed; the workers who painted the dials were the ones who died of bone cancer.

GASES, VAPORS, AND TOXIC MATERIALS

There are so many poisonous and toxic materials all around us, maybe we sometimes wonder how we manage to escape. We will review only those that are a particular hazard in association with military life.

CARBON DIOXIDE

The use of carbon dioxide as a fire extinguisher in missile magazines makes it an ever present hazard. The dangers were discussed in chapters 8 and 10. The use of CO_2 extinguishers, portable and installed, was discussed in Basic Military Requirements, NAVTRA 10054, in connection with damage control on shipboard. No mention is made in that text of the CO_2 installations in missile magazines. Although CO_2 is not toxic, it displaces air and kills by suffocation. Since it has no odor, a man can be overcome before he realizes what is happening to him. The warning system attached to the missile magazine CO_2 system must always be in operating condition. If the warning system indicates that the CO_2 system has been activated, do not enter the magazine until it has been thoroughly ventilated. If it is necessary to enter the magazine before it is completely free of CO_2, be sure to wear an OBA or an airline mask. A filter mask may not be used, as it does not filter out the CO_2. Do not use a canister type gas mask. Always have a person posted outside the magazine to render assistance.

Before anyone is allowed to go into a magazine with a CO_2 installation, make sure the supply of CO_2 is shut off. Disconnect the control and discharge heads and cap the connection to the supply tanks, before entering the magazine. Just closing the valves is not enough; they can be opened accidentally. Be sure the CO_2 supply cannot be turned on while anyone is in the magazine. Immediate application of artificial respiration is necessary for anyone overcome. The standby observer must be qualified to give artificial respiration. Brain damage results if the brain is without oxygen for even a few minutes; therefore speedy resuscitation is necessary.

CARBON MONOXIDE

Carbon monoxide (CO) is odorless and colorless but its effects are deadly. It results from smoldering fires, exhaust gases, or whenever carbon burns. As little as 9 parts of gas in 10,000 parts of air will cause nausea and headache, and slightly larger amounts will cause death. It may cause headache before unconsciousness comes, but in most instances the person becomes drowsy and then unconscious. One symptom that distinguishes carbon monoxide poisoning from other types is the bright cherry-red color it often causes in the skin, lips, and the eyes and inner edge of the eyelids. Death results quickly. Before entering any space that has been closed, ventilate it, or check the air for gases, or wear an OBA or an airline mask if you must enter the space. Remove a victim to fresh air before giving artificial respiration, but it must be done quickly. Methods of artificial respiration are described in Standard First Aid Training Course, NAVTRA 10081.

EXHAUSTS FROM MISSILES

The exhaust from missiles is a double threat-from heat and from the noxious quality of the gases. The APS gas generator is classed as a fire hazard and the gases produced are toxic and may be explosive if confined.

The blowout pipe in the checkout area must be connected to the missile during checkout. If there is an accidental ignition, the exhaust is ported out through the blowout pipe.

The deck area near a launcher must be cleared before a missile is to be fired.

At all times, personnel should keep clear of the exhaust cone of a missile motor.

Keep clear of the exhaust vent of a missile magazine. If you have to pass the vent, do so quickly.

The blast doors must not be opened when there is a missile on the launcher.

MISSILE FUELS

At present none of the missiles you handle use "exotic" missile fuels. The precautions for solid missile propellants and the liquid fuel used for the Talos missile have been reviewed. The prepackaged liquid fuel used in the Bullpup missile would be a fire' hazard if a leak developed. If you have these missiles aboard, follow the rules for handling as given in the OP for the missile.

OXYGEN, HYDROGEN, NITROGEN, AND OTHER GASES

Although oxygen, nitrogen, and some carbon dioxide make up the air you breathe the safety precautions are concerned chiefly with compressed gases obtained either from ship's lines or from tanks. For stowage purposes, ALL compressed gases of ANY type are classed as dangerous materials.

So much injury and damage can be and has been caused by mistaking one gas cylinder for another that a national program has been established to make it almost impossible to confuse cylinders. The identifying features include the color code for painting the cylinders, the name of the gas stenciled along two sides of the cylinder, two identifying decals placed on the shoulder of the cylinder, and a code letter (X for oxygen). With all these ways of identifying the contents of a cylinder, there should be no excuse for making a mistake.

OXYGEN. - Because oxygen makes explosive combinations with many substances, especially the hydrocarbons such as oils, fuels, and greases, compressed oxygen is not supplied to missile Spaces.

NITROGEN. - Compressed nitrogen in cylinders is one of the expendable materials supplied for your work. Where ship's nitrogen is available, nitrogen in cylinders is not supplied.

Although nitrogen is not toxic, it can asphyxiate you if it replaces all the oxygen in the air. It is an inert gas and does not support combustion. The rules for safe handling and stowage of cylinders of compressed gases apply.

If a nitrogen tank must be disconnected for repairs, as in the dud jettison device, be sure it is vented to the open air before you disconnect any lines.

HYDROGEN. - Hydrogen is classed as a fuel gas; the cylinders are painted yellow with a brown band at the shoulder. It is highly flammable, and will explode if it is mixed with air (5 to 75% by volume) and contacts red hot metal, sparks, or flames. It is used for underwater welding and cutting operations, and for inflating barrage balloons. Liquid hydrogen is used for fuel in some missiles. Normally, there will be no hydrogen storage cylinders in missile spaces.

WAR GASES

The different gases used against the enemy are discussed under NBC warfare in your military texts as chemical warfare. Some are intended to be deadly and others are merely incapacitating. All major nations have arsenals of these agents. Since World War I, fear of reprisal has prevented the use of fatal agents or those producing permanent disability. The use of materials that disable temporarily has increased.

G Agents

Gases that affect the nerves are called "G" gases. There are several kinds, all deadly in a short time. As part of your disaster control training, you need to recognize the symptoms they cause, as they cannot be detected with any certainty by the senses. They can be detected with a special chemical kit, but this is of doubtful value because it would delay donning of a protective mask.

CHEMICALS

Some chemicals are dangerous in themselves and others become dangerous when they contact other materials. Some may not be stored near flammable materials. For stowage purposes, they are classified as safe, semisafe, and dangerous (NAVSHIPS Technical Manual). The semisafe materials are considered safe unless the container is opened or there is leakage. Many of the acids are included in the category - they are safe unless spilled, and are not explosive or highly flammable. Trichloroethylene, which you use for cleaning, is classed as semisafe.

Dangerous chemicals include all the compressed gases and materials involving considerable fire hazard or having other dangerous characteristics, whether in containers or not. Electrolytes, both the acid and the caustic types, and many of the cleaning compounds, such as methanol, Stoddard solvent, and toluene, are listed as dangerous.

Naked lights and spark-emitting devices must not be used in compartments containing semisafe or dangerous materials. Sodium igniters must not be fought with water; therefore stowage spaces for sodium igniters must not be equipped with sprinkling systems. Other ammunitions that must not contact water are white phosphorus, smoke pots, torpedo torch pot, and flash signals. An OBA must be worn when smoke-producing chemicals or munitions are in a fire.

OTHER TOXIC MATERIALS

Many mixtures, compounds, gases, and chemicals that you use or come in contact with rather frequently are unsafe if improperly used. Among these are batteries, cleaning solvents,' epoxy compounds and their solvents, vinyl resin adhesives, and certain chemicals. Many of these materials are used in repair and maintenance work.

A few materials are so dangerous, chiefly to human life, that they are not permitted aboard ship. These are: DDT xylene emulsion, hydrocyanic acid gas, methyl bromide, and carbon tetrachloride.

Broken fluorescent lights present an additional danger of poisoning. The mercury vapor sealed into the lights is poisonous to breathe. Dust from the coating on the interior of the lights is poisonous to inhale, and is also dangerous if it gets into cuts or abrasions. A number of fatalities have been traced to cuts received while disposing of broken fluorescent lights. Place the defunct fluorescent tube in the empty container which held the replacement. Do not break it up.

BIOLOGICAL AND CHEMICAL WARHEADS

These warheads are not carried aboard ship except by special authorization from NAVORDSYSCOM or higher authority, and then they are accompanied by trained personnel. However, you must know how to protect yourself against such attacks by the enemy, or possible accidental rupture and spilling of those on board. They are built in a very rugged way and careful handling will prevent accidents with them. If you have any of these special warheads aboard, you will be given special training in detection and decontamination techniques, and handling of emergency equipment.

If any biological or chemical agents are spilled or released don a protective mask immediately and move upwind from the source. The VX nerve agents are absorbed primarily through the skin, and a mask is therefore not effective against those deadly agents.

Self-protection and first aid methods for each type of BW/CW agents are given in brief in Basic Military Requirements, NAVTRA 10054 and more fully in Disaster Control (Afloat and Ashore), NAVTRA 10899 and in Standard First Aid Training Course, NAVTRA 10081-B. In your shipboard training exercises, you will probably have to give first aid drills for simulated attacks with different types of gases.

FIRES

Fire at sea is a dreaded catastrophe. You have received training and drill in fire prevention and fire fighting since you came aboard. Now it is up to you to organize and administer a safety program applicable particularly to your missile system. Preventing and fighting fires is a big part of that program.

Some of the worst holocausts on shipboard started in the ammunition or explosives. The sprinkler systems in the magazines usually can take care of the stocks in the magazines (if they are turned on soon enough). Careless handling and transportation of explosive components is a frequent cause of explosions and fires. You learned about the use of different types of fire fighting equipment in Basic Military Requirements, NAVTRA 10054 and which was best for Class A, B, or C fires.

FIRES IN EXPLOSIVES

When the missiles are assembled and stowed in the magazine, they are protected against fire by automatic sprinkling systems, water injection systems, and carbon dioxide flooding systems, When the missiles are partially disassembled in the checkout area, you have to depend on portable extinguishers and fire hoses. On the launcher, you again have to depend on these two methods, and you may have, in addition, foam and fog nozzles.

If the missile contains a nuclear warhead, extraordinary efforts must be made to prevent detonation. Keep away any nonessential personnel and make every effort to cool the missile to a temperature below the detonation point (below 300°F). Foam spread over the entire weapon will radiate heat away from it and protect the weapon from nearby flames (if the weapon itself is not in the fire). Do not break the blanket of foam with streams of water. When fighting fire involving explosives, seeks as much cover as possible and do not expose yourself unnecessarily to intense heat, flying fragments, and possible explosions.

All personnel who have helped with the fire fighting or have been in the area must be monitored for contamination. Any who have received nuclear contamination must go through the decontamination showers. Eating, chewing, drinking, and smoking must be forbidden in the area. where contamination may be present. A decontamination team may be called to decontaminate the area. Any missile, nuclear or conventional, that has been in a fire must be returned to a depot.

If the fire or accident with a nuclear warhead is below decks, it is extremely important to prevent the spread of nuclear contamination to other spaces. Close the ventilation system immediately and turn off any fans in the space. You will need to hold drills so your men will know what to do in case of a fire or accident. Study the Navy SWOPs for the latest rules on what to do when a nuclear component is involved. OBAs are required for any firefighting, rescue, or salvage operations below decks in case of accident or incident with nuclear warheads.

Each ship must train teams for nuclear, biological, and chemical monitoring and decontamination. They perform in case of attacks or accidents. Special teams may be called aboard to assist and direct the shipboard teams. The widely publicized episodes in which nuclear weapons were accidentally dropped over foreign soil show the extent of responsibility and involvement Of our government. At the same time, it showed how safe the weapons are - there was no detonation although the weapons were dropped from a considerable height. However, our government is still paying damages for the one that broke open and spilled nuclear material on the farms and gardens of the area.

For nuclear accidents aboard a ship there are two broad areas of responsibility. One is responsibility for the action taken by the ship and the other is the responsibility of the appropriate commander ashore.

ELECTRICAL FIRES

General cleanliness of the work area and of the electrical and electronic apparatus is essential for prevention of electrical fires. Oil, grease, and carbon dust can be ignited by electrical arcing. Electrical and electronic equipment should be kept absolutely clean of all such deposits. Wiping rags and other flammable waste material must always be kept in tightly closed metal containers, which must be emptied at the end of the day's work. Containers holding paints, varnishes, cleaners, or other volatile solvents should be kept tightly closed when not in actual use. They must be stored in a separate compartment or locker.

In case of electrical fire, deenergize the circuit and then use the CO_2 fire extinguisher, directing it at the base of the flames. Never use carbon tetrachloride for fire fighting since it changes to phosgene (a poisonous gas) upon contact with hot metal. The application of water to electrical fires is dangerous. Foam type fire extinguishers should not be used on electrical fires as the foam is electrically conductive.

When selenium rectifiers burn out, fumes of selenium dioxide are liberated. These fumes are poisonous and should not be breathed. Deenergize the equipment immediately and ventilate the space. Do not attempt to remove the rectifier until it has cooled; a burn from a hot rectifier might result in the absorption of some of the selenium compound, with serious results.

When using the fire extinguisher, do not allow the tip to touch the electrical panel or energized equipment. The "snow" that forms on the tip should not be touched; it will burn the skin.

SUMMARY

This chapter brings together the safety precautions of all the chapters and adds some that did not fit into any particular place in the text. I t is not possible to write rules that will cover all the situations that might occur on a ship or ashore in connection with missiles and their launching equipment. The introduction of nuclear weapons added much to be learned about the effects of nuclear detonations and the best methods to circumvent or remedy the bad effects. The public disaster aspects are covered in other texts. Since GMMs are responsible for handling missiles with nuclear warheads, they must know the safety rules to avoid nuclear accidents or incidents. Much of the necessary information is beyond the scope of this text, and may be found only in the Navy SWOPS. Study them carefully and apply the rules with meticulous exactness.

Zeal in observation of safety rules should be unflagging. Don't let the desire to be popular, with your men mislead you to be lax in enforcing the rules. Temporary thoughtlessness or impatience will give way to the clear appreciation of the need for adhering to the rules at all times.

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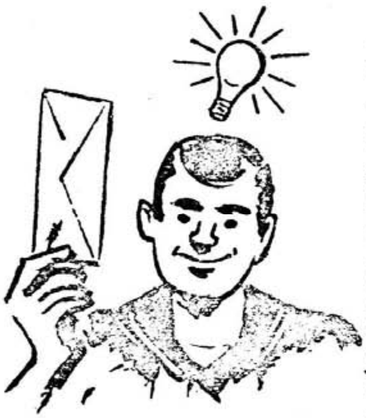

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