CHAPTER 8

HYDRAULICS AND PNEUMATICS IN MISSILE SYSTEMS

INTRODUCTION

You have been using hydraulic, electrohydraulic, and pneumatic power to operate different equipments almost from the day you entered the Navy. Deck equipment for loading and unloading, and equipment for raising, lowering, or otherwise moving heavy objects such as anchors, use hydraulic power. Your basic military texts (Seaman, NavPers 10120-E; Basic Military Requirements, NavPers 10054-C; Military Requirements for Petty Officer 3/2, NavPers 10056-C) did not tell you how these equipments were powered. But now you need to understand the power behind the machine. Look at the quals on hydraulics and pneumatics. Note that all of the knowledge factors are required of the E-4 and E-5. Much of this information that you need may be found in Fluid Power, NavPers 16193-B. We will try to show how fluid power is used in missile systems. The preceding chapter told how fluid power is actuated through servomechanisms. Wherever you need a large force, controllable by a small force, hydraulic power can fill the need. It is the chief source of power for operating equipment and machinery used by the GM ratings. Keeping the hydraulic systems in peak operating condition is a major part of the GMM's work. The more you understand about how hydraulic systems work the better able you will be to keep them working.

HYDRAULIC TERMS COMMONLY USED BY GMMs

The terms defined may be used as an introduction to the subject of hydraulics, and for later reference. These terms may have more than one meaning, but we will give only the meaning which applies to hydraulic systems.

ACCUMULATOR. - A device for storing hydraulic fluid under pressure. It is usually a spherical or hemispherical hollow object (fig. 8-1) with diaphragms, bladders, valves, and other accessories to control the fluid. Its purpose is to store enough fluid at, or close to, the working pressure of the system to meet short demands for excess fluid. It also smoothes out surges and pulsations in the hydraulic system, and meets low-capacity demands without operating the high-capacity pump (except intermittently to charge the accumulator).

AIR BREATHER. - A device which allows air to enter or leave a hydraulic tank as the oil level changes. An air filter is normally installed in the breather. See figure 8-8.

ANNEALING. - Method of softening pipe and tubing so that it can be bent or formed more easily. Only copper tubing is annealed. The process is also used to restore flexibility to tubing to prevent splitting or cracking.

BAFFLES. - Plates or partial plates which extend into hydraulic tanks to reduce sloshing and foaming and to aid in cooling the fluid.

BUFFER. - A mechanism used to retard moving equipment or bring it to a smooth stop. See figure 8-2. It is not necessarily a hydraulic device, but may be pneumatic or mechanical. In the buffer illustrated, forcing the fluid through the deceleration grooves causes the slow down.

CAB UNIT. - Combination A-end and B-end. The A-end and B-end are located in the same housing and are separated by a valve plate (fig. 7-16).

CAVITATION. - Partial vacuum in hydraulic fluid caused by lack of full volume of fluid at the pump intake. Collapse of such cavities produces very large impulsive pressures that may cause considerable mechanical damage to neighboring solid surfaces.

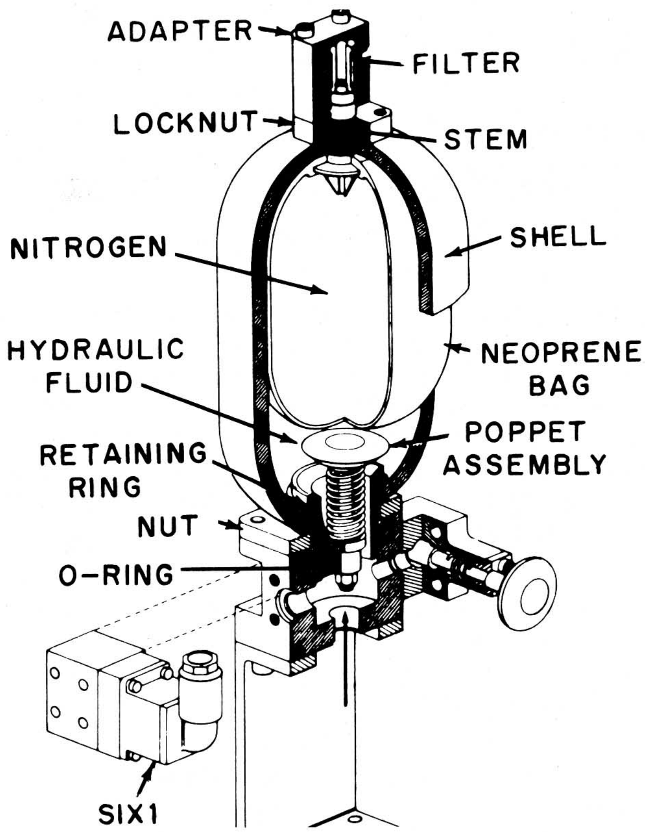

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Figure 8-1.—Bag type amcumulator.

CONTROL FLUID. - (Control pressure). Hydraulic fluid, other than transmission fluid, under pressure and used to control the operation of the hydraulic power unit.

CYLINDER AND PISTON. - A linear motion device for converting fluid energy into mechanical energy (fig. 8- 3).

DASHPOT. - A device to cushion the last portion of the stroke and prevent metal-to-metal contact of pistons and plungers when they reach the ends of travel (fig. 8-4).

DRAIN LINES. - Lines that return hydraulic fluid to the sump, supply, or header tanks.

DRAIN PLUG. - Plug used to drain hydraulic fluid from a hydraulic system or tank. See figure 8-8B.

FILTER. - A device for removal of dirt, sludge, and lint from a hydraulic fluid where the resistance to motion of such solids is in a tortuous path. (Compare with Strainer.) Filters are installed at various points in the hydraulic system. See figure 8-5. The one shown has a single element of the "micronic" type, constructed of a pleated cellulose material, to be discarded when clogged.

FITTINGS. - Devices used to interconnect hydraulic pipes and tubing. Fittings may be screwed, flanged, or compression type. See Fluid Power, NavPers 16193-B, and chapter 12 for different types and uses of each.

FIRE POINT. - The temperature at which a substance, if ignited, will burn for at least 5 seconds. The fire point is always higher than the flash point.

FLASH POINT. - The temperature at which a fluid (such as gasoline) gives off sufficient vapor to form a flammable mixture with air.

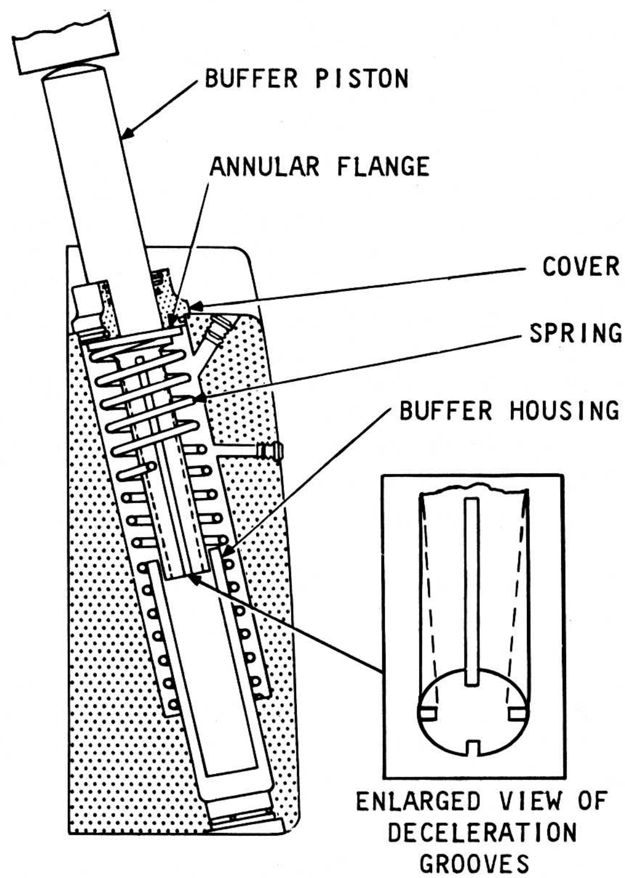

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Figure 8-2.—Hydraulic buffer.

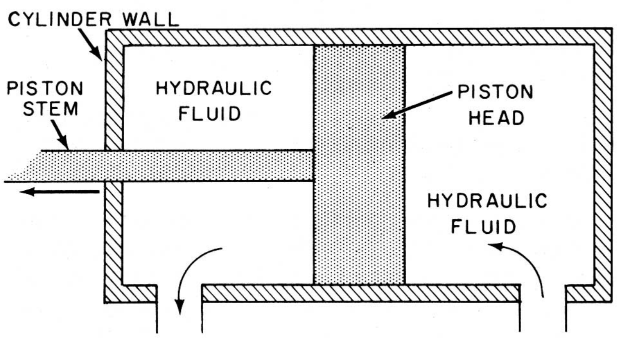

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Figure 8-3. — Cylinder and piston.

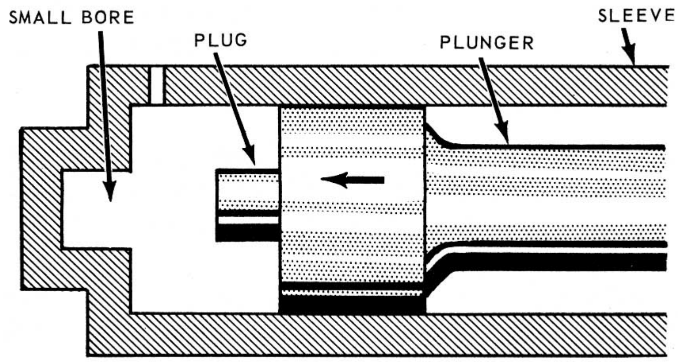

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Figure 8-4. — Dashpot.

FLOW RATE. - The number of units of volume of fluid passing through any channel in one unit of time. See Volume of Flow.

FLUID LEVEL GAUGE (GAGE). - An instrument which indicates the fluid level in a hydraulic system.. Sometimes called Tank Window. Refer to figure 8-8.

GASKET. - Material placed between mating surfaces of hydraulic fittings (flanges, etc.) to increase tightness of the seal.

GPM (GALLONS PER MINUTE). - The normal way of measuring the volume of flow rate in a hydraulic system.

HEAD OF FLUID. - Hydraulic fluid in a system that is maintained above the power drive level.

HOSE. - Flexible hydraulic lines.

HYDRODYNAMICS. - Study of liquids in motion.

HYDROSTATICS. - Study of liquids at rest, particularly regarding pressure and equilibrium.

INHIBITORS (OR ADDITIVES). - Chemicals added, during the manufacturing process, to hydraulic fluid to improve its ability to retard corrosion and foaming and to resist oxidation.

JIC SYMBOLS. - Graphic symbols for fluid power, used on hydraulic schematic diagrams. These symbols were originated by a Joint Industrial Conference of manufacturers of commercial hydraulic equipment. They are now included in MIL-STD-17B-2.

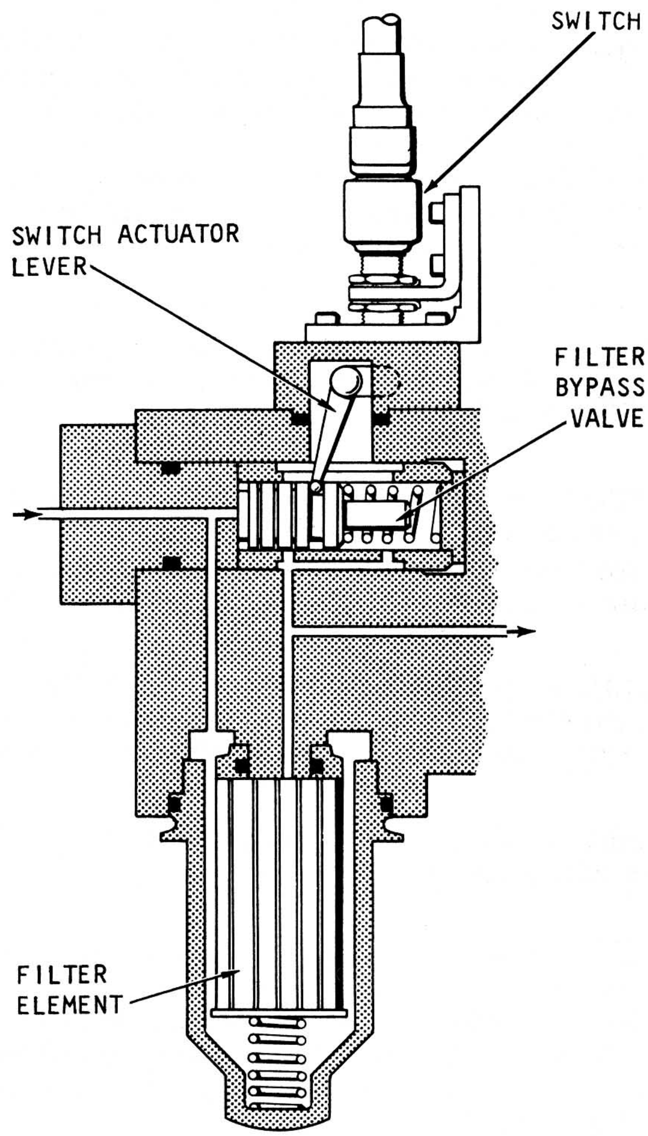

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Figure 8-5. — Filter.

ORIFICE. - An opening of relatively small size in a fluid passageway that controls or limits the rate of flow; a restriction. See figure 8-9D.

OXIDATION. - Chemical change in hydraulic fluid caused by oxygen which combines with the fluid during high temperature operation.

PACKING. - Hydraulic seal to prevent leakage around a moving part) such as a piston rod.

PASCAL'S LAW. - This law states that pressure applied anywhere to a body of confined fluid is transmitted undiminished to every portion of the surface of the containing vessel. This transmission of pressure through a fluid is the principle on which all hydraulic operation is based.

PASSAGE. - A machined hole or channel which lies in or passes through a hydraulic component and acts as a conductor of hydraulic fluid.

PICKLING. - A method of removing scale from the inner surfaces of piping and tubing. It is described in Fluid Power, NavPers 16193-B.

PISTON, CYLINDER OR BUFFER. - The moving part of a hydraulic cylinder or buffer. See figures 8-2 and 8-3.

PISTON, PUMP OR MOTOR. - The mechanical component of a pump or motor. The piston works in a cylinder and either moves the hydraulic fluid or is moved by it. Refer to figure 8-3.

PORT. - Opening in a surface of a component, usually where hydraulic fluid enters or leaves the mechanism" such as a valve, piston, or pump.

POUR POINT. - Lowest temperature at which a liquid will pour or flow.

PSI. - Pounds per square inch (pressure).

PUMP. - A device which converts mechanical energy to hydraulic energy. Following are short definitions of several kinds of pumps used in hydraulic systems.

Constant Delivery Pump. - A pump that delivers a fixed volume of fluid in a given time.

Axial Piston Or Parallel Piston Pump. - A pump in which the pistons rotate on a shaft in such a way that the pistons are driven back and forth in their cylinders in a direction parallel to the shaft. See figure 7-15.

Gear Pump. - A constant delivery pump with two or more intermeshing gears acting as the pump rotor (fig. 8-6).

Positive Displacement Pump. - A pump that discharges the fluid in volumes separated by a period of no discharge. A definite volume of liquid is delivered for each cycle. Pump types such as axial piston, gear, and vane may be considered to be several separate positive displacement pumps combined in one unit to smooth surges caused by periods of no discharge.

Rotary Pump. - A pump with rotor which carries the fluid from intake to discharge on a curved path. Vane and gear pumps (fig. 8-6) are classified as rotary pumps.

Variable Delivery Pump. - A pump that delivers a variable volume of fluid without changing the speed of rotation of the source of power..

REPLENISHING FLUID. - (Also called Supercharge Fluid.) Fluid that is used to replace any volume loss in power drive transmission lines (lines between A-end and B-end).

RESTRICTION. - (Also called Choke or Orifice.) A device which produces a deliberate pressure drop in a line or passage by means of a reduced cross-sectional area (fig. 8-9D).

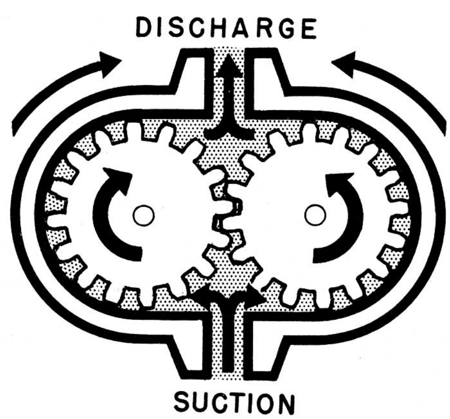

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Figure 8-6. — Gear pump.

SEAL. - A part or assembly of parts used to prevent leakage of hydraulic fluid. Compare with Gasket and Packing.

SERVO FLUID. - Control pressure fluid in the hydraulic portion of the servosystem.

SLUDGE. - Gummy deposit caused by hydraulic fluid breakdown, mainly due to oxidation.

STRAINER. - A device for removal of dirt, sludge, and lint from fluid wherein the resistance to motion of such solids is in a straight line, as when pouring fluid into the system. A strainer is sometimes called a screen (fig. 8-7). It may be simply a funnel with a 200-mesh wire screen fitted in it.

STROKE PISTON. - Normally, a hydraulically controlled piston that controls the output of an axial piston variable delivery pump (fig. 7-15).

SURGE. - A transient rise of hydraulic pressure in a hydraulic system.

TANK. - Container for the hydraulic fluid in the system. Several types are described below and illustrated in figure 8-8.

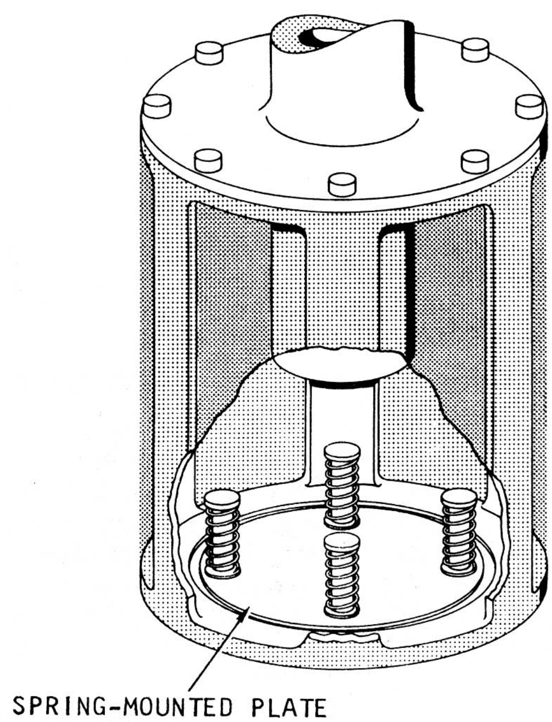

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Figure 8-7. — Pump intake strainer (screen).

Expansion Tank (Header Tank). - This tank, located above the hydraulic system, provides space to allow for expansion and contraction of the hydraulic fluid in the system due to temperature changes. It also maintains a head of fluid to prevent entry of air into the system.

Reservoir. - (Also called Supply Tank.) The power drive tank used to maintain a supply of working fluid which may be drawn from as needed.

Sump Tank. - A tank usually enclosed within a power drive reservoir or supply tank to ensure available space for drainage from the receiver regulator.

TILT PLATE (OR TILT BOX). - The plate which is suspended by two trunnions and is moved by the stroke piston(s) to control the output of a variable delivery radial piston pump (fig. 7-14).

TRANSMISSION FLUID. - Hydraulic fluid located in the lines between the A-end and the B-end.

TUBING. - Copper, brass, or steel hydraulic lines. It is common practice to call small hydraulic lines tubing and large lines piping. However, there is no official distinction made.

VALVE. - A device for controlling flow rate, flow direction, or flow pressure. Some types of valves commonly used in hydraulic systems are described below. Numerous variations are designed for specific applications.

Valve Block. - Several closely associated valves can be organized into a valve block so they can be more readily controlled, and coordinated. Many combinations are possible.

Bypass Valve. - A valve used to let a volume of fluid bypass a hydraulic component (fig. 8-5).

Check Valve. - A device which permits hydraulic fluid to flow in one direction only (fig. 8-9A).

Directional Control Valve. - A valve which directs the flow or passage of fluid in a hydraulic system (fig. 8-9B).

Dump Valve. - A valve which, when actuated, dumps hydraulic fluid trapped in an accumulator system. It is normally manually operated. (See fig. 8-9C). The fluid is returned to the supply tank.

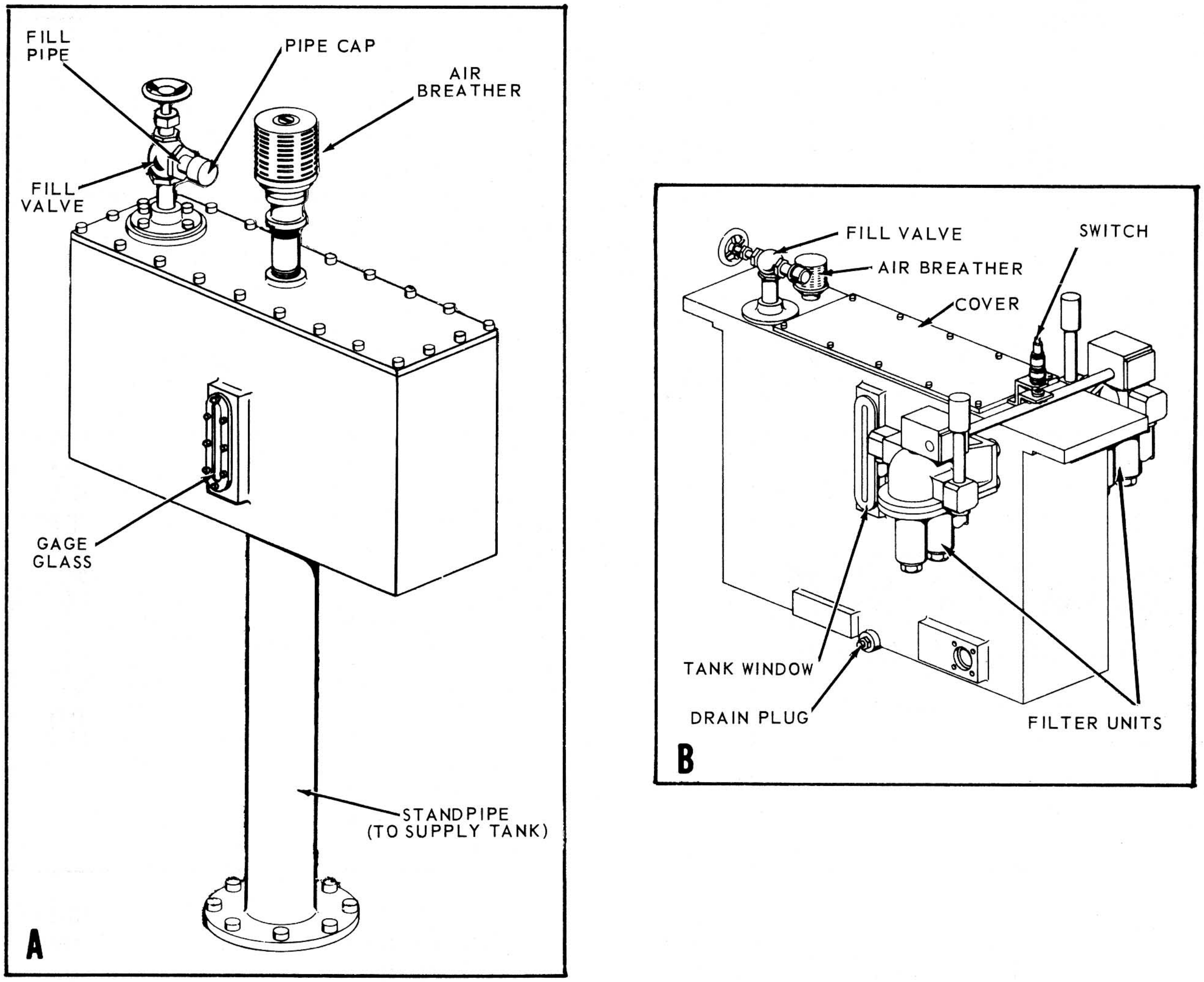

Figure 8-8. — Types of hydraulic fluid tanks in missile systems: A. Expansion (header) tank; B. Reservoir (supply tank). 83.178

Flow Control Valve. - This valve maintains a preset rate of flow regardless of pressure variations at the inlet or outlet (fig. 8-9D).

Gate Valve. - A manually operated valve that controls the flow of fluid by means of wedge (gate) which can be moved up or down across the line of flow. It is usually operated by a hand- wheel.

Globe Valve.-A manually operated valve that controls the flow of fluid by means of a plug, ball, or disk, which may be raised from or lowered into the valve seat.

Pilot Valve. - A valve that controls the action of another valve.

Poppet Valve. - A valve in the hydraulic end of a bag accumulator (fig. 8-1). It prevents the synthetic bag (containing the pressurized gas) from extending into the hydraulic manifold when there is no (or very little) hydraulic fluid in the accumulator flask. See fig. 8-9E.

Relief Valve.-A valve which limits the maximum pressure applied to the portion of a hydraulic system to which it is connected. If the

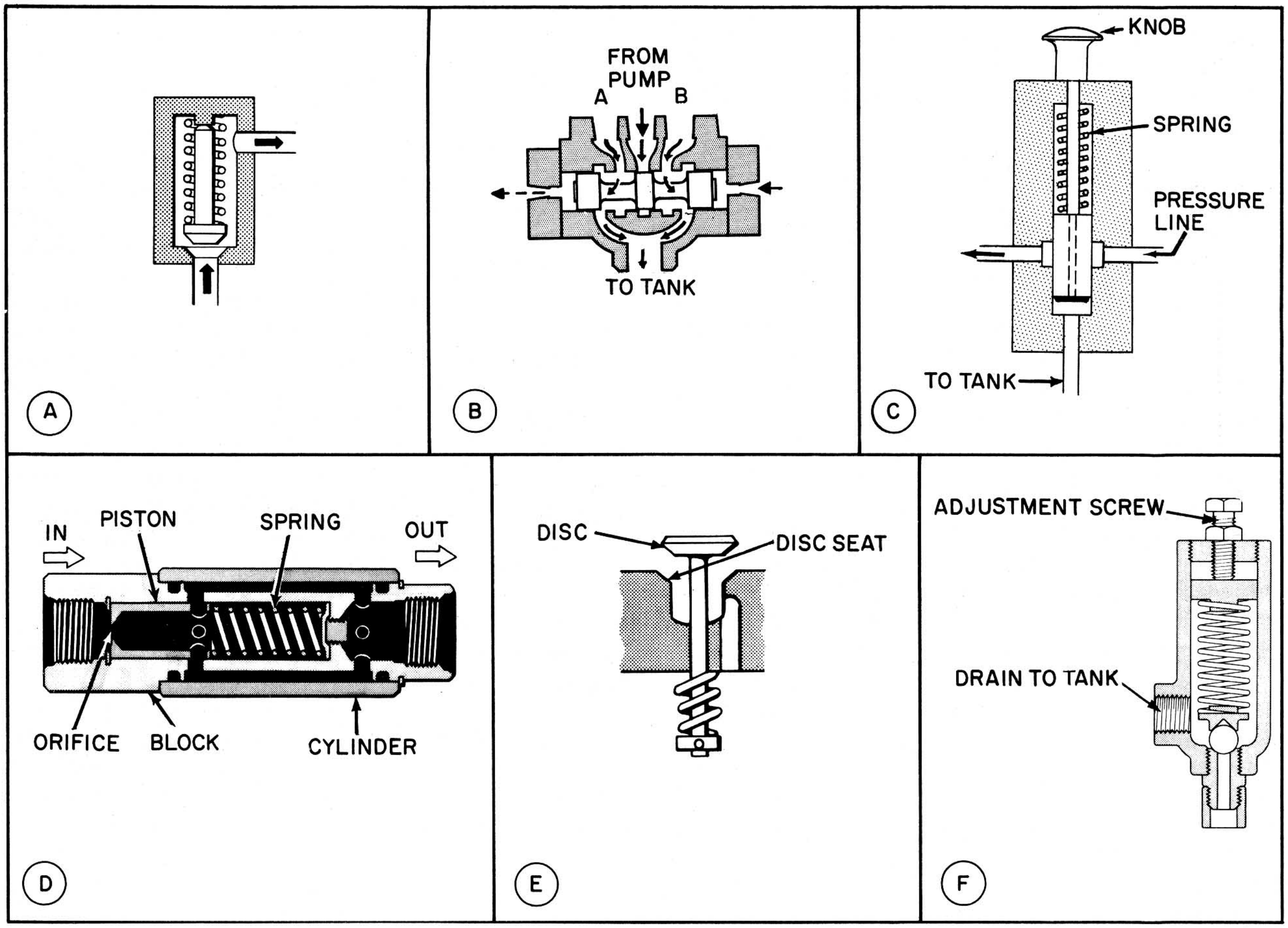

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Figure 8-9.—Some common types of valves: A. Check valve; B. Directional control valve; C. Dump valve; D. Flow control valve; E. Poppet valve; F. Simple relief valve.

pressure exceeds this limit, the valve opens and releases some of the hydraulic fluid. Figure 8-9F shows a simple relief valve.

Servo Valve. - Also called Pilot Valve or Control Valve. This valve is in the hydraulic portion of a servosystem that is normally controlled by an electrical error signal and that originates the hydraulic control signal.

Unloading Valve. - A valve used in accumulator power drives. It directs pump output to the accumulator or tank, in accordance with system demand. Fluid in excess of pressure requirements is returned to the tank.

VELOCITY. - Rate or speed at which fluid is moving at a given point in a hydraulic system.

VENT (Verb). - To remove air from a hydraulic system.

VENT (Noun). - A threaded plug or needle valve used to remove air from a hydraulic system.

VISCOSITY.-Measure of a hydraulic fluid's resistance to flow. Temperature affects the viscosity of hydraulic fluids.

VISCOSITY INDEX (V.I.). - Rate at which the viscosity of a fluid changes with the temperature.

VOLUME. - Quantity of hydraulic fluid.

VOLUME OF FLOW. - The quantity of fluid, usually measured in gallons per minute (GPM) that passes a given point in the hydraulic system in a given time.

LAUNCHER POWER DRIVES

Chapter 7 discussed the launcher power drives from the standpoint of electrical and electronic action required. The hydraulic components were given only incidental mention, with the exception of the operation of the A-end and B-end. This chapter will emphasize the work of the hydraulic parts of the power drives.

MAIN COMPONENTS OF POWER DRIVE SERVOLOOP

As described and illustrated in chapter 7, you know that there are two separate systems for moving the launcher; one power drive system moves the launcher in train, another system moves it in elevation (or depression). Each one has a prime mover (which is an electric motor) an A-end hydraulic pump, a B-end, mechanical shafting and gearing, and means of transmitting signals received. The operation of the A-end and the B-end was described in the preceding chapter and in Fluid Power, NavPers 16193-B, so there is no need to repeat it here.

Electric Motor

The electric motor not only drives the A-end but also the replenishing pump, the control pressure pump, and the sump pump and oscillator. Since the speed of the A-end is much less than that of the electric motor, it is necessary to use reduction gears between them. (Basic Machines, NavPers 10624-A, explains how reduction gears work.) Reduction gears are also used between the electric motor and the pumps it operates.

A-end and B-end Response Linkage

The response is the quantitative output resulting from the input. If the response is linear, the output is the same quantity as the input.

The transmission lines between the A-end and the B-end are the hydraulic lines that carry the hydraulic fluid, and the valves and gears that control the quantity of flow. Pipes, tubing, and passages (defined at the beginning of the chapter) form part of the transmission lines.

Components of Components

Each of the main components of a hydraulic system is made up of many parts, similar in many respects in different systems. A supply of hydraulic fluid is required; the tank containing it may be called a reservoir or a supply tank. See figure 8-8B. As the system operates, the fluid becomes heated and expands. An expansion tank receives overflow of fluid so that pressure does not build up in the lines. See figure 8-8A. Leakage can drain into a sump tank. Filters are located at several points. Filters have to be cleaned when they become clogged; follow the instructions in the applicable OP when you need to do this. Some filters have a replaceable filter unit that is discarded when it becomes clogged. If it is not possible to take care of the filter at the time, the filter assembly valve block will bypass fluid around the filter element to the system to prevent starving the system of fluid. When this occurs a filter bypass switch actuated by the bypass valve will close, to complete a circuit to a filter clogged indicator light on the control panel. The trouble should be remedied as soon as possible, for unfiltered fluid can cause further trouble such as scored valves which, then must be removed and repaired or replaced.

The definitions at the beginning of the chapter listed and illustrated several kinds of valves and briefly gave the function of each type. This is far from a complete list; many more are described in Fluid Power, NavPers 16193-B. Some of them operate automatically, as when pressure reaches a certain point; others are operated manually. The operating power maybe hydraulic, pneumatic, or electrical which may use mechanical devices to actuate the valve. A spring- actuated valve is an example of use of a mechanical device to open or close a valve. The successful operation of any hydraulic system is dependent on its valves. You need to learn the location and use of each valve in the system on which you work. Whenever a hydraulic system is not operating properly, one of the first things to do is to check the valves involved. You need to learn how to dismantle, clean, and reassemble valves. Some general instruction on the installation and maintenance of valves may be found in Fluid Power, NavPers 16193-B, but you need the appropriate OP for your equipment for directly applicable instructions.

When reading chapter 5 you may have noticed how many of the launching system components are operated hydraulically- magazine rail latch, positioner, hoist, speed reducer, retractable rail, power-off brake, and many more. To be operated hydraulically, each part must be connected to pipes or lines that carry the hydraulic fluid. That means there are a great many connecting lines behind the scene. You can see why you need to know types and uses of pipes, fittings, seals, and gaskets. Replacement of gaskets and seals or sections of pipe are frequent assignments for the GMM.

Gear Pumps

The dual gear pump (fig. 8-10) is operated by the electric motor. It draws hydraulic fluid from the supply tank and supplies both servo and supercharge pressure fluids. A dual gear pump actually consists of two gear pumps in one housing. The gears differ in width, which allows for difference in fluid volume, although both are driven at the same speed. It is also called an auxiliary gear pump, and it ports the hydraulic fluid to the control mechanism.

Control Mechanism

The control mechanism is not actually a part of the power drive itself but is directly related to its operation. It governs the operation of the CAB unit. It uses the pressure fluid ported to it by the gear pump. The servo pressure is used to shift valves, release the power-off brake, and position the stroking pistons. The supercharge pressure is used to replenish fluid lost through slippage and leakage and to supply the main relief valve. The control mechanism is mechanically linked to the A-end and the B-end and continually receives indications of tilt angle and B-end motion. When the control assembly receives a signal (from the computer) ordering the driven equipment to a new position, it establishes the difference between the existing position of the equipment and the ordered position.

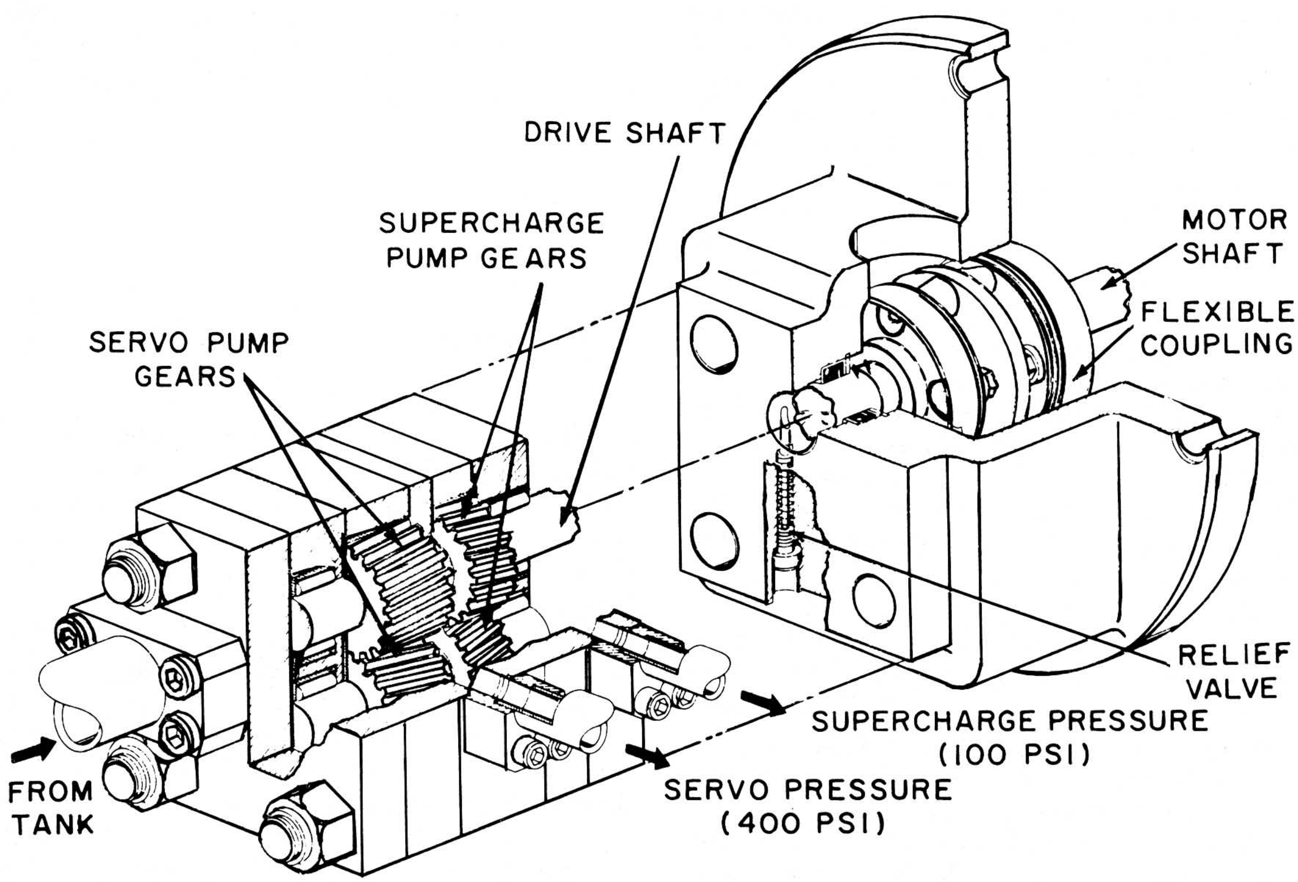

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Figure 8-10. — Dual gear pump on typical CAB power drive.

This error is then translated into valve movement. Regulated pressure fluid is ported to the stroking pistons. This moves the A-end tilt plate to the desired angle. The A-end then supplies pressure fluid to the B-end, which drives the equipment to the ordered position.

Control assemblies are generally mounted on top of the power drive, but may be mounted on the side.

Main Relief Valve

This valve is connected to the two lines between the A-end and the B-end (fig. 7-15). It is a compound valve designed to prevent excessive pressure in the high pressure line or A-end discharge line. When the pressure in one line exceeds the preset limit, the valve ports the excess to the other, or low pressure, line.

Power-Off Brake

The power-off brake, an associated component of the CAB unit, secures driven equipment against pitch and roll of the ship when the system is inactive, holds and secures the equipment in event of a power failure, and provides a manual means of operation (handcrank or air motor) for emergency operation, or installation and maintenance procedures. The brake usually is located adjacent to the B-end, fig. 8-11, and mounted to a geared speed reducer coupled to the B-end drive shaft. The brake shaft is driven by the speed reducer' shaft before the gear train increases the torque.

Figure 8-12 shows a cut-away of a typical power-off brake. Principal components of the brake assembly are the brake shaft, friction disc, disc housing, the worm and worm wheel, the worm shaft and clutch assembly, brake release piston, and the brake housing.

One end of the brake shaft is geared to the B-end output shaft. The other end, as shown in fig. 8-12, is splined to the inner discs. These inner friction discs alternate with the outer friction disc, and the outer disc are splined to the disc housing.

Since the disc housing is fastened to the worm wheel and can only be turned through handcrank operation, the outer friction disc are classed as stationary (whereas the inner friction discs rotate with the brake shaft).

Braking occurs when the spring-loaded pressure plate presses the rotating discs into contact with the stationary discs. Since the brake shaft has a positive gear-drive relationship with the B-end output shaft, this action also holds associated driven equipment.

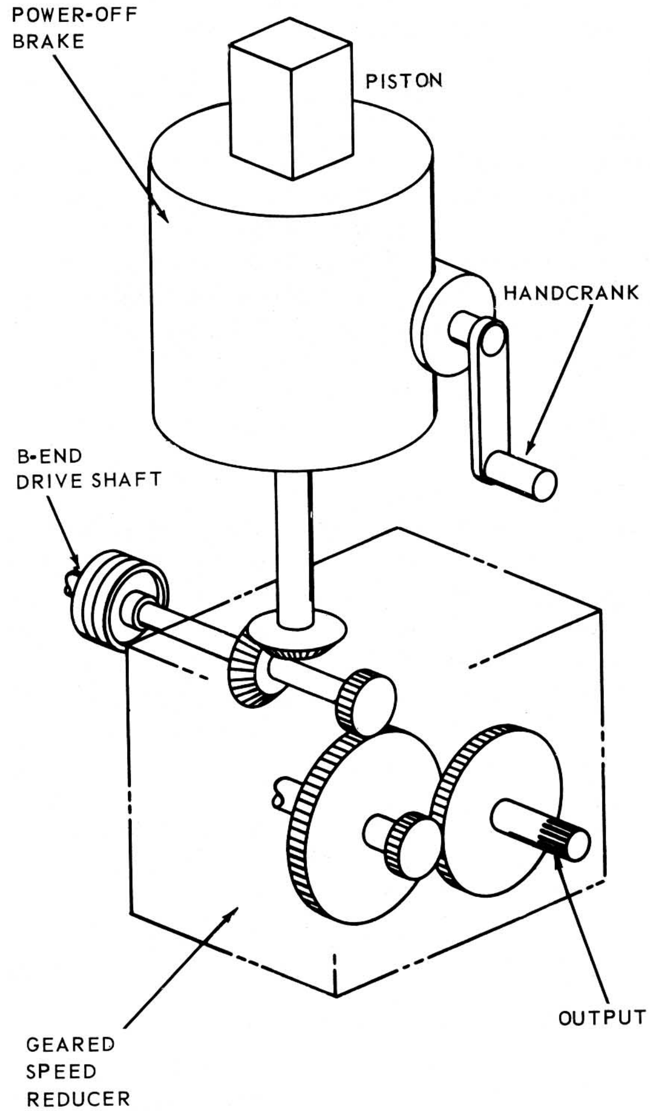

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Figure 8-11. — Power-off brake location.

During normal CAB unit operation (B-end rotating), hydraulic pressure is ported to the power-off brake and acts on a brake-release piston which is attached to the pressure plate through a connecting rod. The subsequent force exerted by the piston compresses the pressure springs. This action releases the friction discs to permit free rotation of the brake shaft.

When the CAB unit is shut down, the resultant pressure drop to the release piston allows the spring-loaded pressure plate to force the friction disc into braking engagement.

Whenever the brake is set, the worm wheel is connected (through disc contact) to the brake shaft. Consequently, the brake shaft can be turned only by handcrank rotation of the worm.

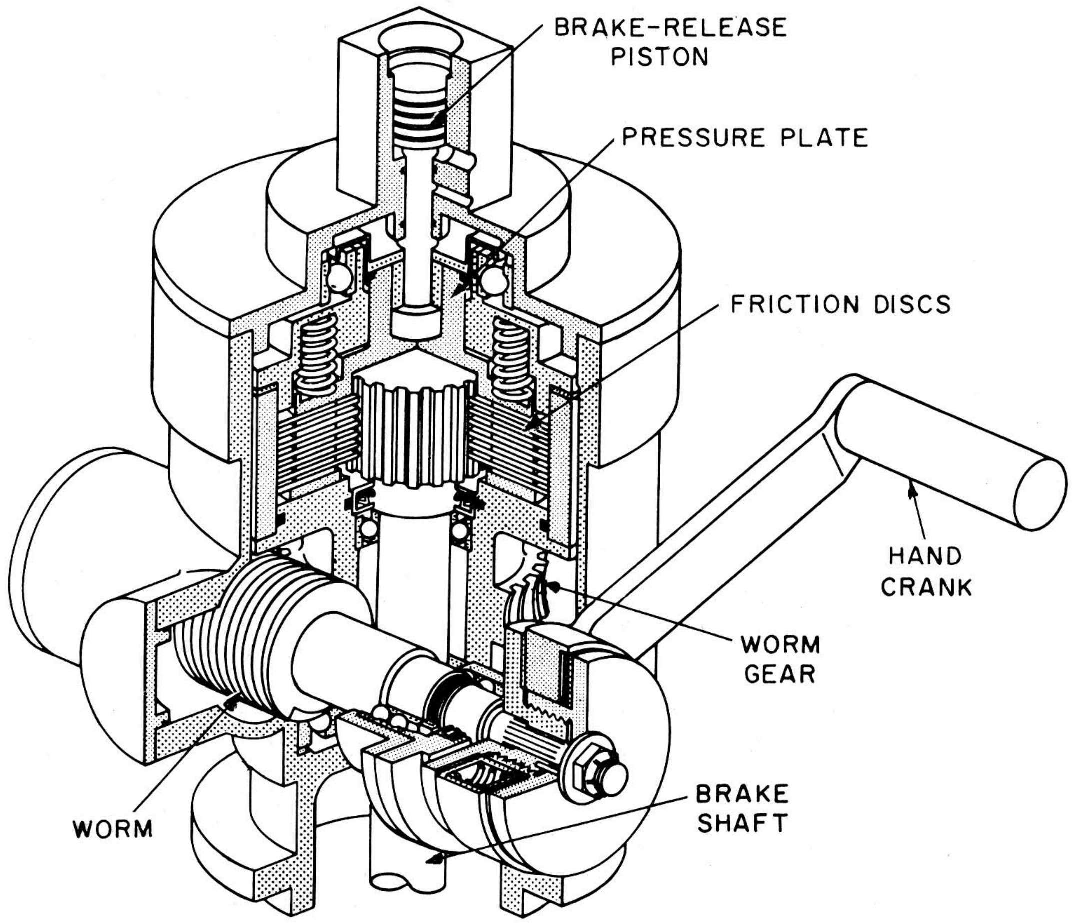

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Figure 8-12.— Power-off brake (typical).

The worm is the mechanical counterpart of the hydraulic check valve. Both transfer motion in one direction but not in the reverse direction. The worm self-locks in one direction of motion because of the low helix angle of the worm thread.

Most power-off brakes are designed with a manual drive input to which a handcrank or air motor may be attached for emergency operation, or for installation and maintenance procedures. The train and elevation system have separate power-off brakes. The brakes differ somewhat in different applications. The number of friction discs varies with different mods but they function in the same manner.

LAUNCHER RECEIVER-REGULATORS, TRAIN AND ELEVATION

A receiver-regulator is a component of a gun mount or launcher power drive that receives order signals from a remote or local station, compares these signals with the train and elevation positions of the launcher (or gun), and generates error signals to control the movements of the power drives to correct the launcher position. Most of the receiver regulators used with launchers are similar in design and operation.

In normal operation, remote orders are supplied by the assigned fire control system. The principal function of the receiver-regulator and the servo amplifier is to convert electrical order signals into hydraulically powered movements. These movements control the velocity, acceleration, deceleration, and position of the launcher carriage and guide arms. The B-end output of the train system .drives the launcher carriage, while the B-end output of the elevation system drives the launcher guide. When the launcher is synchronized to the director orders, the missile is ready to be fired.

The launcher receiver-regulators (train and elevation) are part of the basic power drive servoloops, each of which also includes a hydraulic pump (A-end), hydraulic motor (B-end), and the A-end and B-end response linkage.

The receiver-regulator is mounted on a stand, directly over the A- and B-ends (CAB unit). In outward appearance, the receiver-regulator is a metal box with connections to other units, and a dial (fig. 8-13). The inside is packed with

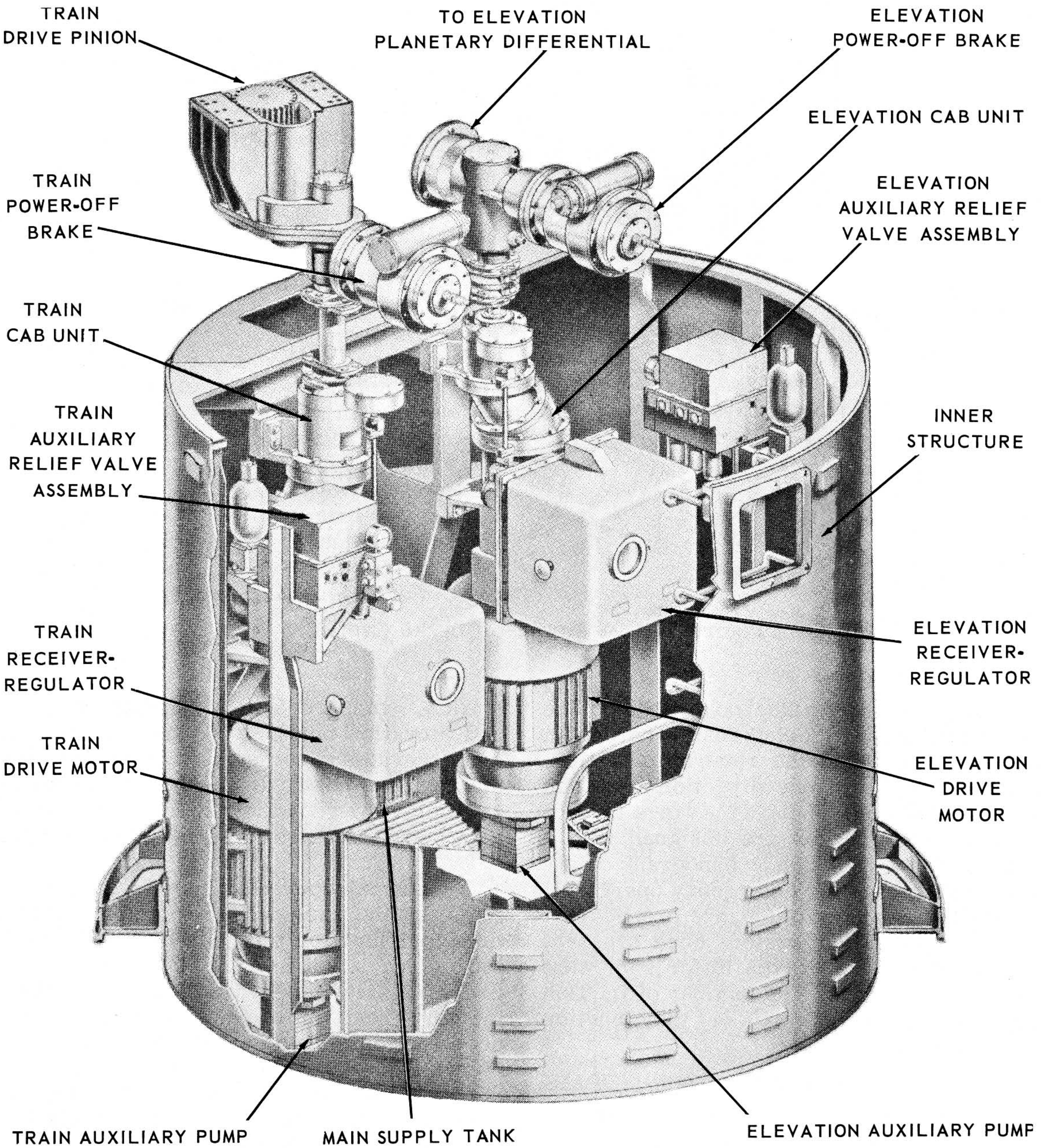

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Figure 8-13.—Train and elevation power drives, Mk 13 Mod 0 launching system (Tartar).

an assortment of complex equipments. In figure 8-14, locate the parts described in the next few paragraphs. These components are connected to components outside the receiver-regulator to perform their functions. The operation is intricate and we will give only briefly the work of the main components.

Main Valve Block

The main valve block of the receiver regulator contains the components (valves, pistons, switches) that are used by the primary, velocity, integration, and stroke servosystems. Only a few of the parts (there are about twenty valves, etc.) are visible in figure 8-14. The dither transformer (TPTD2) is mounted on top of the valve block along with its adjustment, the dither potentiometer (RATD4), which controls the amplitude of the dither input. The stroke control and integration actuating levers, not seen in figure 8-14, are mounted on the right-hand end of the valve block. The primary electrohydraulic servovalve (BCTD1) converts the amplified primary electrical error signal to a hydraulic signal.

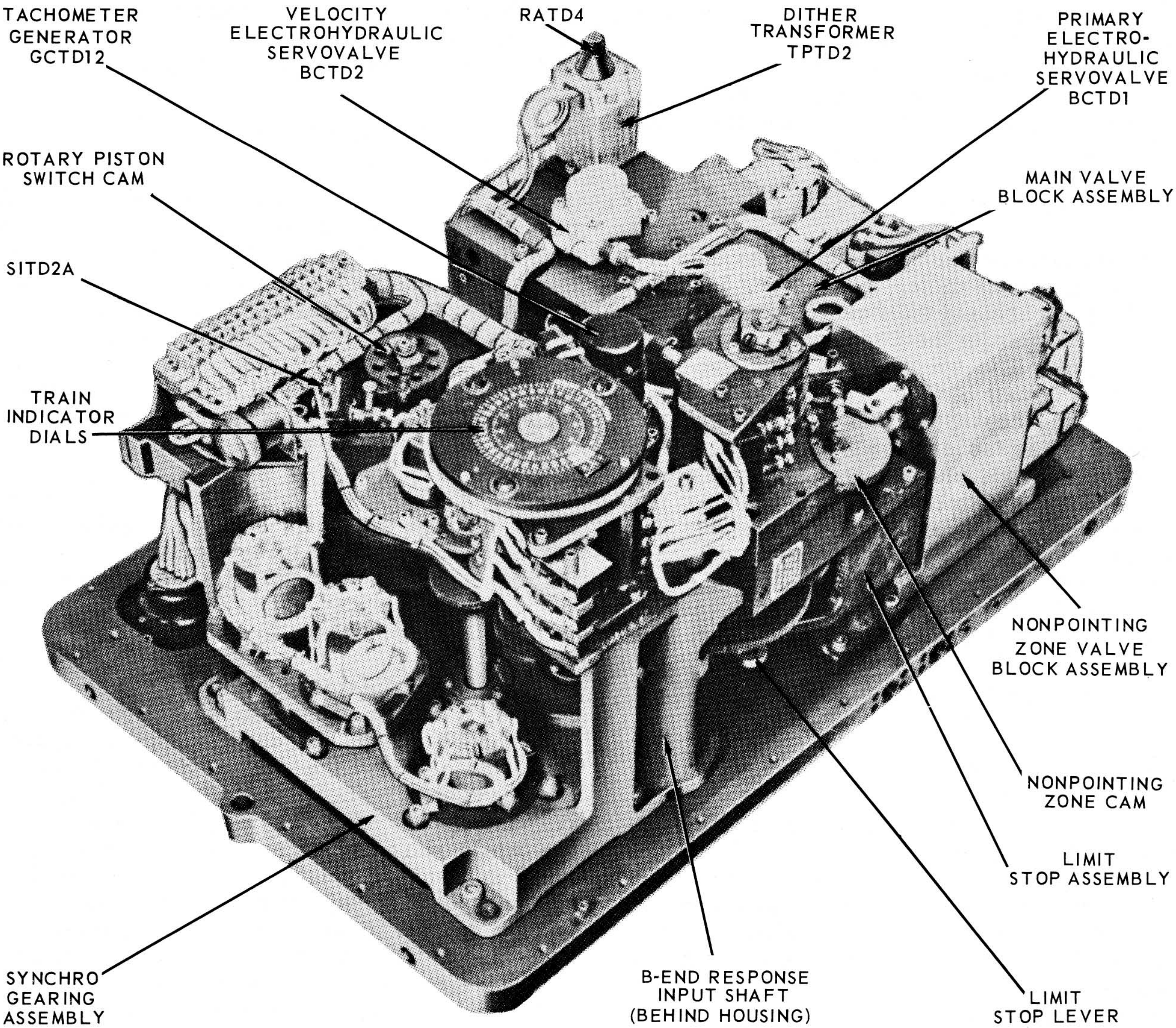

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Figure 8-14.—Train receiver regulator, Mk 5 launcher, Mk 10 launching system (Terrier).

The velocity electrohydraulic servovalve (BCTD2) converts the amplified electrical velocity and integration signal to a hydraulic signal.

Rotary Piston

The rotary piston is located below the rotary piston switch cam. It consists of a cylinder, piston vane, piston stop, piston cam, two response gears, and a switch cam with its associated switch. Two hydraulic fluid ports lead to the piston cylinder which is divided into two hydraulic chambers by the piston vane and piston stop. If the pressure is equal in both chambers, the piston vane remains stationary. If the pressure is unequal, the cam moves toward the lower side. This moves the rotor shaft which is connected to the rotors of the 1-speed and 36-speed control transmitter (CX). The indicator dials show what movement has taken place.

Synchro Gearing Assembly

The synchro assembly (fig. 8-14) mounts five synchros, the tachometer generator, indicator dials, the switches and their cams, a transformer, and the gearing from the B-end response and the stroke piston. The synchros receive the order signal (electrical) and transmit the launcher position to the control panels and the fire control system. The tachometer generator transmits a launcher speed (velocity) signal for test purposes. The transformer steps down the a-c voltage for dial illumination. The indicator dial indicates the launcher position and is driven by the B-end response. The switch cams are driven by the B-end response and are used to actuate the switches that indicate the launcher train position. Although train and elevation synchro assemblies appear identical, there are differences.

Limit-Stop System

The train limit-stop system includes the limit-stop assembly, the nonpointing zone valve block, and a part of the A-end response assembly. This system acts as a safety device to stop launcher movement whenever it is necessary for safe or proper operation. The elevation limit-stop assembly is similar to the train limit-stop assembly except that it has a gear and rack (instead of a nonpointing zone cam). The cams must be designed and cut for each ship so the missiles will not be pointed into any part of the ship's structure.

Non-Pointing Zone Valve Block

This is also known as the tracking cutout valve block. It contains nonpointing zone pistons and their associated valves and solenoids. The limit stop actuating shaft leads through the base of the valve block and connects to the servovalve linkage. Each piston is controlled by one of the nonpointing zone solenoid valves; the train valve block has two and the elevation valve block has three.

The nonpointing zone components prevent the launcher with loaded guide arms from training or elevating into any part of the ship's structure, stopping the train power drive if necessary and introducing an elevation order that elevates the launcher above the nonpointing zone.

A-End Response Assembly

Figure 8-14 does not show the lead-in for the A-end response assembly but does show components to which it transmits. The movement of the A-end tilt plate is transmitted to the limit stop assembly and the train limit stop valve. The A-end response also positions the sleeve of the stroke control servovalve and a switch cam. When it is not necessary to operate the limit-stop systems, transmission of launcher position and launcher velocity continue.

The shaft of the A-end response assembly leads through an opening in the regulator base plate, approximately in the center of the regulator, inboard of the limit-stop assembly.

B-End Response Assembly

The approximate location of the B-end response input shaft is shown in figure 8-14. It extends through an opening in the regulator base plate near the lower center section of the regulator. The lower gear of the B-end response input shaft drives the synchro gearing while the upper gear of this shaft drives the limit-stop assembly. When the B-end rotates, it drives the launcher, through a gear reduction unit, at the speed and in the direction determined by the error signal. A mechanical B-end response signal is fed back to the CTB stator in the receiver regulator. This response signal cancels the order signal when the order has been satisfied. The B-end response is often referred to as "position."

OTHER POWER DRIVES IN LAUNCHING SYSTEMS

Not all the hydraulic systems in the launching system belong to the A-end- B-end type. Hydraulic power for operation of the launching system is not furnished by one big hydraulic system, but by several independent systems. Several of these systems are of the accumulator type. The main components of the accumulator type are: (1) electric motor; (2) gear pump; (3) control valve block; (4) accumulator; and (5) accumulator charging valve and pressure gage. See figure 8-15. Of course, it also has to have a supply tank for the hydraulic fluid. An important difference between the accumulator type and the CAB type described previously is in the use of accumulator flasks, such as the one shown in figure 8-1, to keep a supply

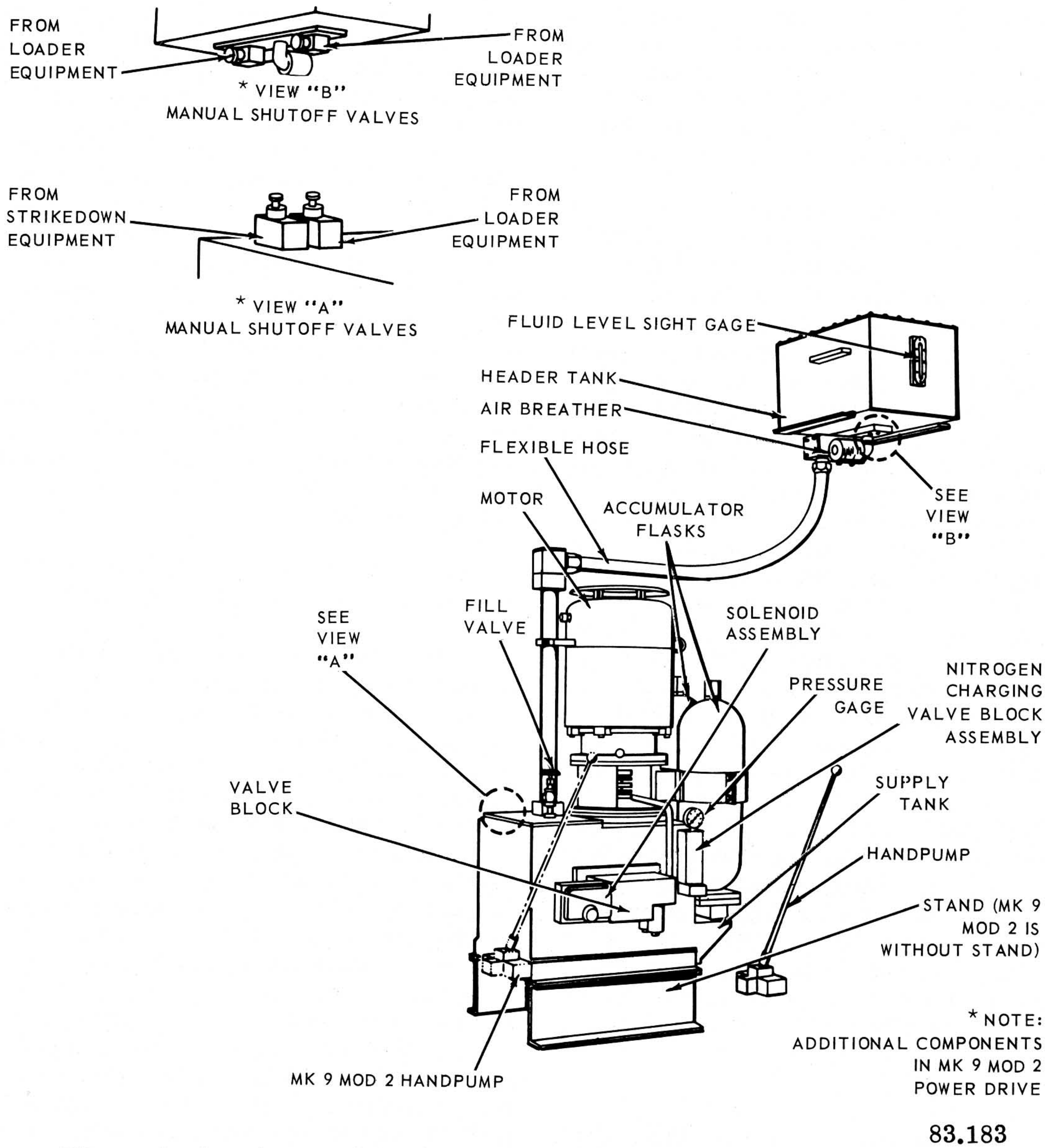


Figure 8-15.—Accumulator type power drive system for loader (Terrier).

of hydraulic fluid ready for instant use at the desired pressure. Most systems have two or more such accumulator flasks. The accumulators are pressurized with nitrogen. The bladder inside the flask is charged with nitrogen through the nitrogen charging assembly (fig. 8-15). Nitrogen is used because it is not a fire hazard where oils are used.

On Terrier systems, the loader has two types of power drives, a CAB type which operates the loader chain, and an accumulator power drive, which is in the strikedown area and provides power for the spanning rail, blast doors, floating tracks, tilting rail, and other loader components. The magazine power drive is also of the accumulator type. It supplies the power to the ready service rings, tray shifts, hoist drive, load status recorder, magazine doors, and, in the Mk 10 Mod 7, to the lower ready-service ring under inter-ring transfer conditions.

The guide arm components on the Mk 5 launcher (used in the Mk 10 launching system) are operated by an accumulator type hydraulic system. Its electric motor is sometimes called "launcher rails motor" on electrical diagrams. Older mods of the accumulator had manually operated shutoff or dump valves, but Mk 5 Mod 3, and later launchers, have solenoid operated dump valves for the accumulators. Functionally, the different mods are the same and use the same major components.

A load status recorder was mentioned above. There is a load status recorder for each ready service ring in the magazine. It shows what type of missile is loaded in each space in the ready service ring. If a missile is moved from a tray, the change is shown on the recorder (also called an indicator). No personnel are stationed in the magazine so these indications on a recorder in the magazine are of no use is anyone. The information must be displayed where it will be of use; this is on the control panels. "Load status" indication is not shown as such on any panel except through the various circuits which may, in turn, indicate loaded, empty, or dud stations on the circular light patterns on the panels (EP2 and EP4, EP5). See figure 5-17. The load status recorder is operated hydraulically and mechanically but the information is sent to the panels through electrical relays.

POWER DRIVES FOR SMALLER LAUNCHING SYSTEMS

"One-armed" launchers such as the Mk 13 and the Mk 22 (Tartar) might be considered "smaller" launchers. They use hydraulic power for the same operations as the largest launching systems although they do not need as many systems nor such large ones. The power supply for the magazine of the Mk 13 system uses one A-end hydraulic pump to drive two B-end hydraulic motors. One B-end drives the ready service ring and the other drives the hoist chain, but not simultaneously. The train and elevation systems on the launcher each have an A-end and a B-end type power drive to train and elevate the launcher, but share one header tank, which is mounted in the stand. (The header tank for the magazine power supply is also mounted in the stand.) In the Mk 22 launching system, the train power drive system also drives the hoist and operates the associated latches and pawls. The train system and the hoist system have separate controls and separate gear reducers but one power drive system. During hoisting operations the training mechanism is latched, and vice versa.

The Mk 13 (Tartar) system has an additional power system to operate the launcher guide arm and the blast door. The header tank is a part of the guide arm; the main tank is a part of the base ring, and the other components are mounted to the underside of the base ring weldment. There is an electric motor which drives the rotary gear pump, the control valve block and three accumulator flasks, a solenoid valve assembly, and a plunger. The rotary gear pump is submerged in the main tank.

HYDRAULIC POWER IN STRIKEDOWN, MATE, AND LOADING OPERATIONS

The same power system is used for loading a missile on the launcher and for returning it to the ready service ring. Automatic unloading in just a matter of reversing the steps (Each installation has charts posted at the control panel, listing each step.) However, if the missile is to be struck down to any other area, such as testing and checkout areas, other power systems are involved. Periodic tests are required for all is just a matter of reversing the steps in the loading process. (Each installation has charts posted at the control panel, listing each step.) However, if the missile is to be struck down to any other area, such as testing and checkout areas, other power systems are involved. Periodic tests are required for all missiles and, for these, the missile must be unmated from the booster (except Tartar and Standard) (MR). This work is done in the strikedown and checkout area. This area has been identified in several illustrations.. See figures 5-1, 5-4, 5-8, and 5-11. The location with relation to the rest of the launching system varies with the weapon system and the ship, but it is as close as possible to the ready service rings. (The Tartar systems do not have such an area as the weapons are checked out on the launcher arm.)

As you can see in figure 5-4, a missile brought up from the magazine (ready service ring) can be sent to the strike down and checkout area instead of to the launcher. Step control must be used for this operation. The loader trunk sections extend into the strikedown area (fig. 5-11). Here the strikedown car receives the weapon. The hoists, cranes, checkout car, booster cart, and other equipment in the strikedown area are operated from ship's power source which can be either electric, pneumatic, or hydraulic.

The checkout mode is also used for removing missiles from the ship. Terrier and Talos rounds must be unmated and the missiles and boosters transferred separately.

When received by the ship, Terrier, Standard (ER) and Talos missiles and boosters are in separate containers, except when transferred by Fast system, in which case they are not containerized. They are moved to the strikedown and checkout area by a hydraulically operated elevator where they are handled with the aid of the checkout car and the booster cart.

Chapter 14 will tell you more about your work in this area. This will include missile replenishment, missile mating and unmating, and preparing missiles for tests.

PNEUMATIC POWER

Although hydraulic power is used for moving most of the parts of a missile launching system, from positioning heavy missile launchers to nudging tiny valves to open or close, there are some items that use pressurized air for power. Connections to the ship's pressurized air system are available in some of the spaces, especially where testing and checkout are to be done. Cylinders of compressed air may be used in some instances.

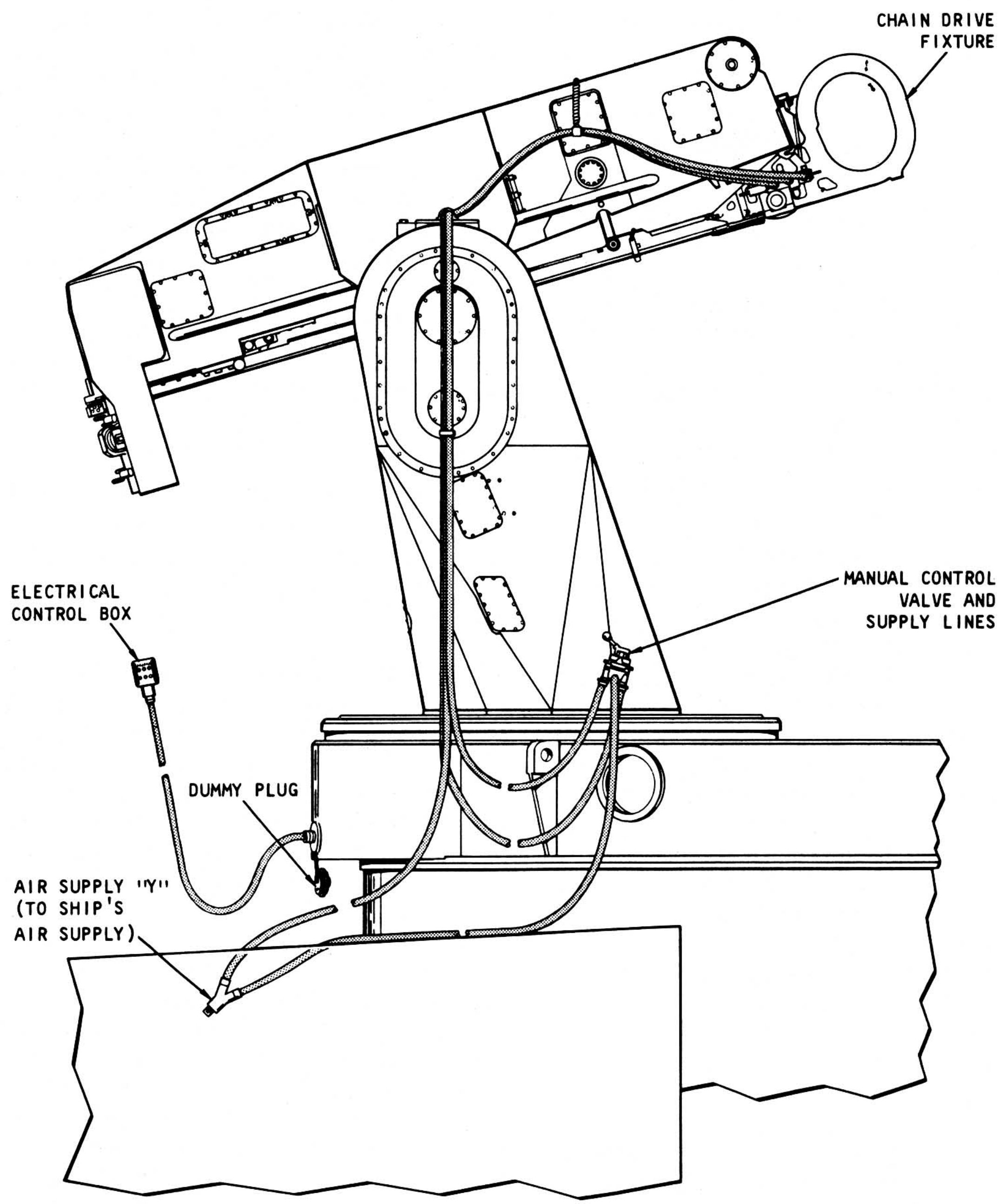
AIR OPERATED POWER UNIT

When Tartar missiles are struck down to the magazine for replenishment or are off-loaded, the launcher is used but auxiliary equipment is needed. The strikedown gear used (fig. 8-16) with the Tartar missile consists of an air-driven chain fixture, a manual control valve (portable), and an electrical control box. The electrical control box is a hand-held, portable apparatus that permits the launcher captain to be on deck in full view of the launcher while controlling the launcher by means of the pushbuttons and switches on the control box. It is used for positioning the launcher during strikedown, checkout, or E-section removal. Illustrations may be seen in the OP. The strikedown gear is removed and stowed when not in use.

The power for the unit is supplied by the ship's compressed air system. Flexible hoses are used to make the connection to the ship's supply.

The compressed air is not used directly in the same form in which it is stored but is converted to mechanical energy. The potential energy in the compressed air is changed to mechanical energy through an air motor, located adjacent to the chain drive, where it drives a gear train. An air motor, when coupled to an electric generator, may also be used to supply the electrical energy to drive a hydraulic system.. Figure 8-17 A is a sketch of a basic pneumatic system. The air is led from the compressed air flask or the ship's supply line, through a pressure reducer, then to the air motor or air turbine. On the Tartar strikedown unit shown in figure 8-16, the pressure regulator reduces the air pressure to 20 psi.

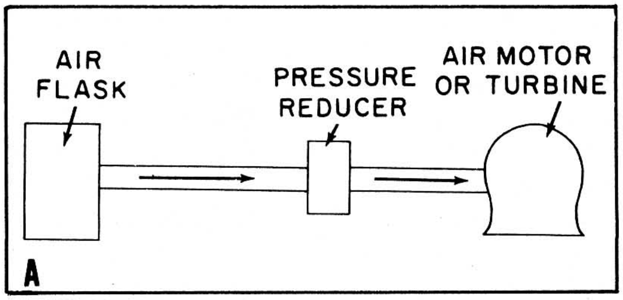
The air motor shown in figure 8-17B works on the principle of differential areas. (This is not the one used in the Tartar system.) The motor consists of a rotor with freely sliding vanes mounted in recesses around its outer edge. The rotor is eccentrically mounted in its housing as shown in the figure. When the rotor is in motion the vanes tend to slide outward due to centrifugal force. The distance they can. slide is limited by the eccentricity of the rotor housing. When the compressed air is ported into the inlet, its pressure is exerted equally in all directions. Since area "A" is greater than area "B", the rotor will turn counterclockwise. Each vane in turn assumes #1 and #2 positions and the rotor turns continuously. The potential energy in the compressed air is thus converted into kinetic energy. The air at reduced pressure is exhausted to the outside. The shaft of the motor is directly coupled through gearing to the unit it is to drive (in fig. 8-16, the chain drive unit).

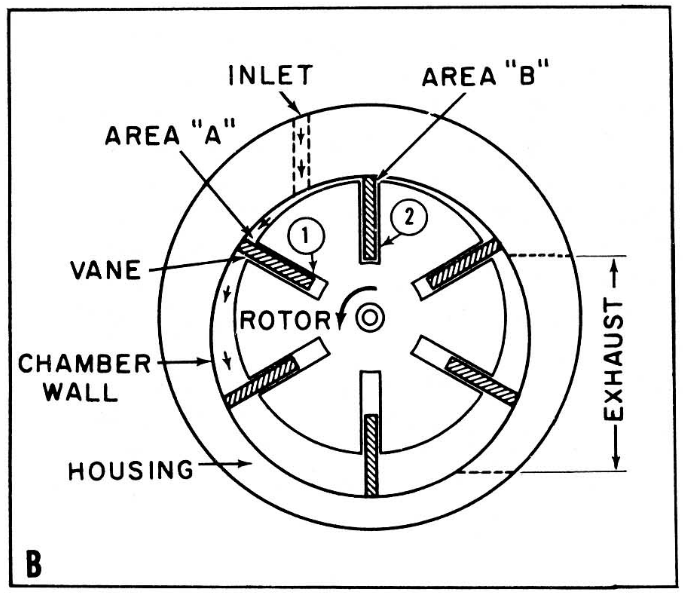


94.72
Figure 8-16.—Strikedown gear attached to Tartar launcher (Mk 13 Mod 0 system).

DUD JETTISON DEVICES

There are several methods of disposing of dud missiles. Most often the missile is returned to the magazine to be checked out, tested later, and defective parts replaced. When it is necessary to rid the ship of a dud missile, the launcher is used with the dud jettisoning unit. The Talos system uses an emergency igniter injector on the launcher (fig. 5-23), but other systems have a jettisoning unit that pushes the missile overboard without firing it. The Terrier systems and the Tartar Mk 11 system use dud jettison units that are hydro-pneumatic systems powered by compressed air from the ship's high pressure air supply. The Mk 13 launching system (Tartar) uses compressed nitrogen from an accumulator. The installation arrangements vary





33.42:.43
Figure 8-17.— Pneumatic power: A. Basic pneumatic system; B. Air motor.

for the different Terrier mods but the operating principles are the same. The deck location of the dud ejector is shown in figure 6-5. and in several of the illustrations in chapter 5. The major portion of the dud ejector is below deck when not in use (not extended). The launcher holding the dud missile is trained and elevated to align with the dud ejector. The dud jettison unit is operated from the dud jettison control panel (fig. 6-5) when orders have been received to use it. The compressed air is used directly, without conversion to electrical energy; that is, it is a static system.

PNEUMATIC OPERATED HANDLING EQUIPMENT

The cranes and hoists used to handle missiles on deck and below deck are under the cognizance of Naval Ships Systems Command. Descriptions of these equipments may be found in NAVSHIPS publications. You will be using cranes and hoists in handling missiles during replenishment and in off-loading. Some of them are operated by the ship's compressed air supply. Guided missile handling equipment such as missile skids, handling dolly, transfer dolly, handling attachments, storage cradles, hoisting slings, and similar machines are described and illustrated in OP 2173, volumes 1 and 2, Handling Equipment for Ammunition and Explosives.

Apart from the cargo handling gear listed above, the strikedown car, booster cart, receiving stand, and transfer car are used for missile checkout. The installations vary on different ships. You are responsible for safe attachment of the missile or booster, and you operate the equipment, but other personnel are responsible for the maintenance and repair of the equipment. All Talos, Terrier and Standard (ER) missiles must be unmated (separating the booster from the missile) each time they are checked out, and mated again for return to the ready service ring. (Talos missiles and boosters are stowed separately except those that are in the ready service.) The electrically operated checkout car in the Mk 10 launching system is used to receive missiles and boosters from the strikedown elevator and to move these components to the loader rail. A movable platform on the car is used for missile and booster mating/unmating operations. Not all the handling equipment is power operated. The transfer car and some of the handling hoists for the Tartar missiles are operated by hand power. On a CV A you will have an elevator to move the missiles to the checkout room.

PNEUMATIC TEST SETS

Testing of missiles aboard ship is done at prescribed intervals, according to the appropriate OP for the equipment. Special test sets have been developed for each type missile. The Guided

Missile Test Set (GMTS) programs the missile through a simulated flight sequence, comparing missile response to known standards. A missile systems test is made up of a number of individual tests. The test set is in the checkout room.. Chapter 14 has an illustration (fig. 14-23) of a missile with connections to the test set. There are electrical, hydraulic, electronic, and pneumatic connections to be made (which you do) ~ There is also a pneumatic test set that is used to test certain internal components of missiles. It uses high pressure air but controls it and reduces it to the pressure needed.

Example of the carrying out of the tests will be given in chapter 14. As a GMM 3 or 2, you will prepare the test setups, making the connections to the power source and to the proper component of the missile.

MAINTENANCE OF PNEUMATIC SYSTEMS

In general the same periodic inspection and precautions required for hydraulic systems are also valid for maintenance of pneumatic equipment. The micronic filter elements of a pneumatic system must also be inspected for cleanliness and replaced at regular intervals. Pneumatic units which become contaminated cannot be flushed as can hydraulic systems but must often be disassembled and cleaned as described in the appropriate maintenance publications.

Leaks in air or nitrogen systems can usually be found with the aid of a soap solution applied to the joints. The presence of a leak is revealed by the formation of bubbles. Tightening of connections or replacement of O-rings usually takes care of the leakage problems. A bit of dirt in a valve may require dismantling of the valve to clear it.

HYDRAULIC PNEUMATIC POWER USED INSIDE MISSILE

CONTROLLER DEVICES

In earlier chapters, statements were made about control surfaces moving a certain way upon signal, and about other movements in the missile. There has to be some power to cause these movements. Hydraulic power is used for many of them. It should be remembered that hydraulic fluid contains no energy in itself. It merely provides a means for transferring energy within a mechanism. Since, for all practical purposes, hydraulic fluid is incompressible, it can be used to transfer energy with negligible losses.

Since hydraulic fluid normally moves through a closed system, several methods have been devised for moving it. Axial piston and rotary hydraulic pumps, driven by turbines, are commonly used in guided missiles. The hydraulic pumps are of the same types as those used in the launching systems, though not of the same size. The principles of a simple hydraulic system are shown in figure 8-18. The reservoir or sump acts as a storage tank for the hydraulic fluid. A motor or other prime mover is connected directly to the hydraulic pump. The relief valve ports excessive pressure to the sump.

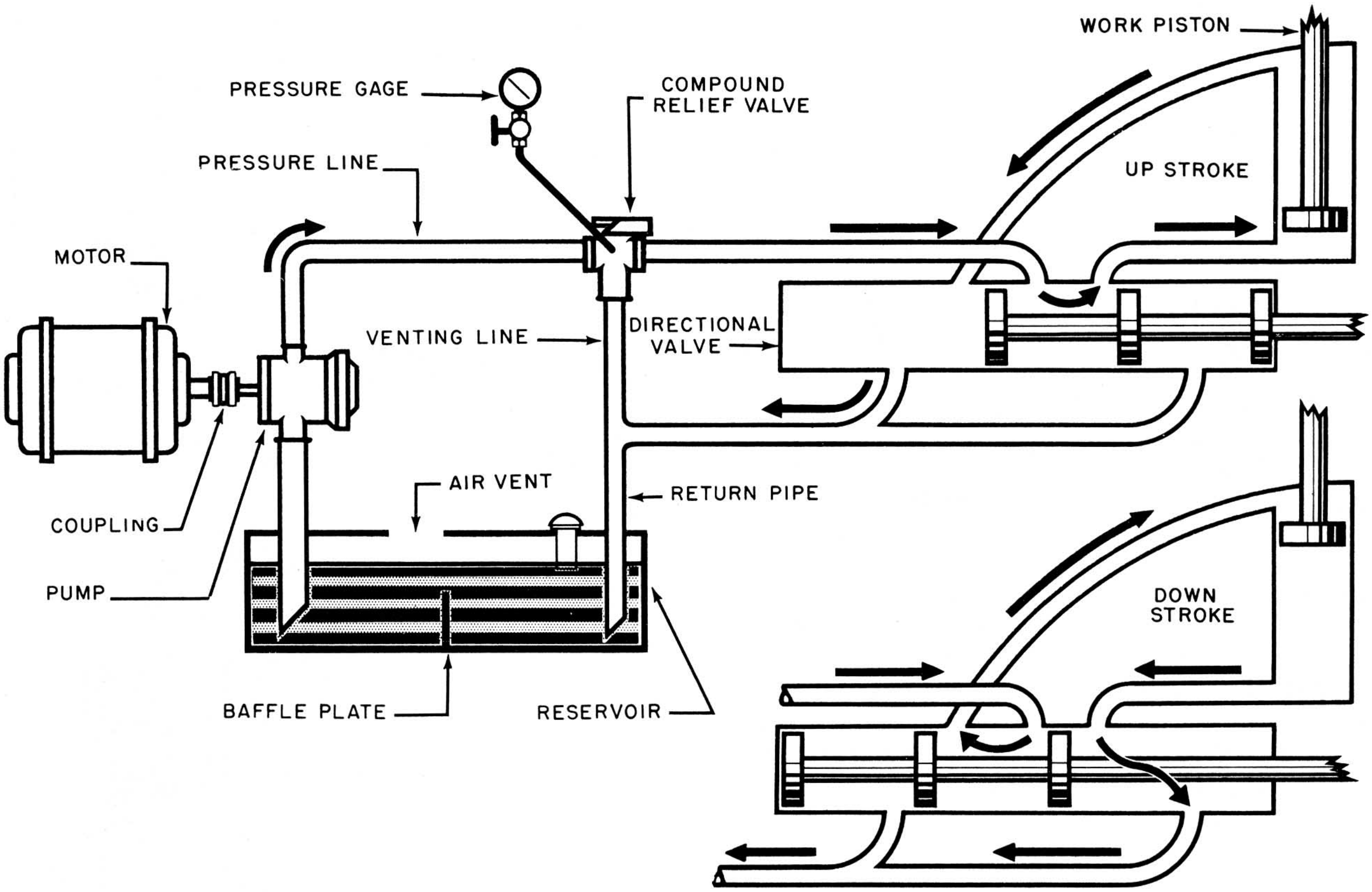
ENERGY CONVERSION

To cause the work piston to move up, we must position the directional valve as shown in the upper portion of the figure. This permits the oil to exert pressure against the bottom of the work piston, causing an upward movement. The oil on the top side of the work piston is returned to the sump as shown.

The lower portion of the figure shows how we can cause the work piston to move down. In this case, we must move the directional valve to the left so that the oil will be forced to take a path leading to the top of the work piston. This will cause the work piston to move down. The oil on its lower side will pass back to the sump.

In both cases the controlling factor was the position of the directional valve. In the operation described, the hydraulic fluid, which has no energy of its own, merely translated rotary motion of the motor to linear motion at the work piston. This is one form of energy conversion unit used in the auxiliary power supply (APS) of missiles to provide a source of power to the many devices required for successful flight of the missile. The APS is in addition to the main missile engine (propellant) required for thrust.

Early mods of the Terrier missile used compressed air cylinders as the source of power, but these limited the range and also gave a slow reaction due to the time it takes to compress the air in the actuator to a pressure sufficient to move it. Hydraulic power



5.71
Figure 8-18. — Transfer of power in a simple hydraulic system.

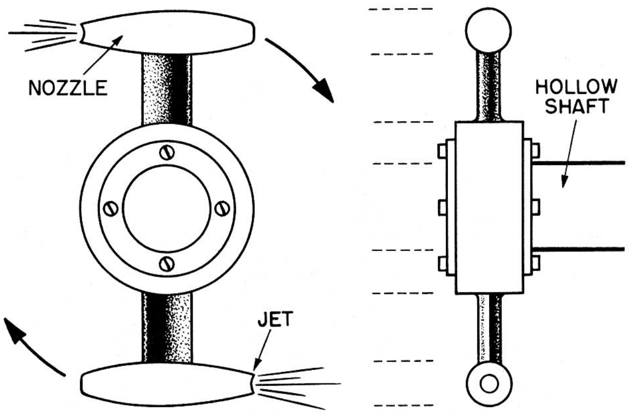
will produce a faster reaction on an actuator. as hydraulic fluid transmits the power almost instantly.

Turbines

Turbines may be driven by air or by hot gas. Both Terrier and Tartar missiles use auxiliary hot-gas systems. The Terrier and Tartar missiles have two hot-gas generators. each with its package of solid propellant. The hot gas exhaust from one is fed to the missile's turbohydraulic system and the other goes to the turboelectric system. They are placed in the aft section, near the tail, which is controlled by the hydraulic system. The Talos missile uses an air-driven hydraulic pump that makes use of air taken in through the diffuser section in the missile nose.

AIR TURBINES. - One type of air turbine is the pinwheel turbine shown in figure 8-19. This turbine is a mechanical jet similar in principle to a garden sprinkler. Compressed air is led into the pin wheel hub through the hollow shaft. It eventually passes through the diametrically opposed nozzles where its velocity is increased. The reaction to the exhaust causes a rotation of the pinwheel just as the reaction to the ejection of exhaust gases causes thrust in the main propulsion system. As with the air motor, the shaft of the air turbine is coupled to another device- usually an electric generator.

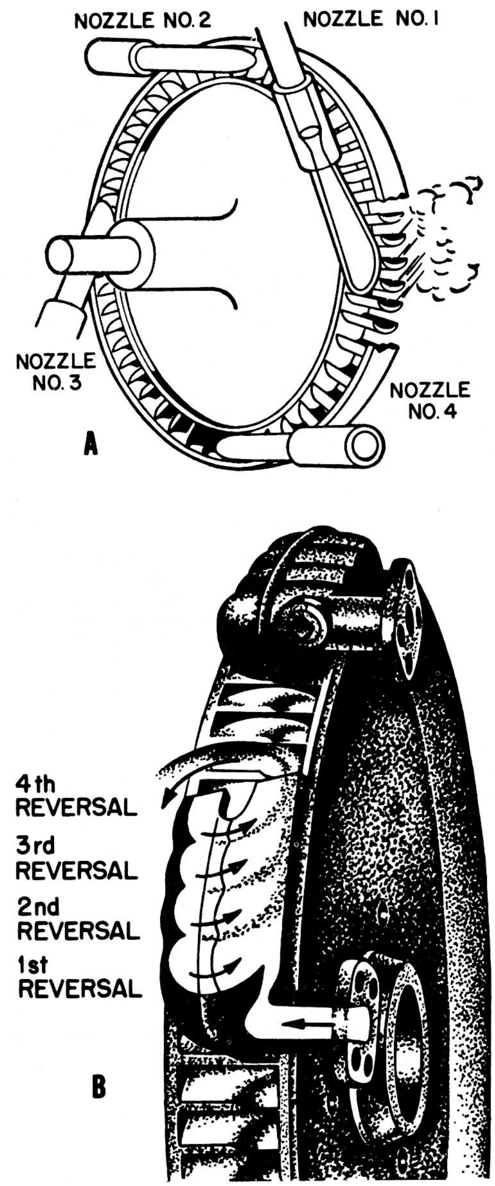
HOT GAS OR COMPRESSED AIR TURBINES. - Hot gas turbines are used in dynamic systems in which the energy source is solid or liquid fuel. These turbines may also be used to convert the potential energy in compressed air to kinetic energy. One type of turbine found in these systems is the Terry turbine, shown in figure 8-20B. The turbine wheel is a solid piece of steel having semicircular recesses (buckets) milled into its



33.44
Figure 8-19.—Air-operated pinwheel turbine.

periphery. Mounted on the casing around the wheel are four nozzles spaced 900 apart. Within the casing are a series of stationary semicircular reversing chambers. The products of combustion are led through a gas manifold ring and pass through the nozzles. The gases then impinge at high velocity on the buckets. In passing through the buckets the direction of flow is reversed 180 degrees. The gases are then caught by a semicircular reversing chamber in the casing, where they are again reversed 1800 and returned to the wheel. The process is repeated five times through a 900 arc of the turbine housing, after which the gases are exhausted. Reversing the hot gases several times gives a multiple-stage effect, thereby using more of the potential energy in the gases.

Another type of turbine is the single-stage impulse turbine shown in figure 8-20A. In this turbine the gases expelled through the nozzles are not reversed in direction, but make only one pass through the turbine blades. You will find variations on the turbines discussed, but their basic principles of operation will remain the same. Both Terrier and Tartar use this type in their APS systems.

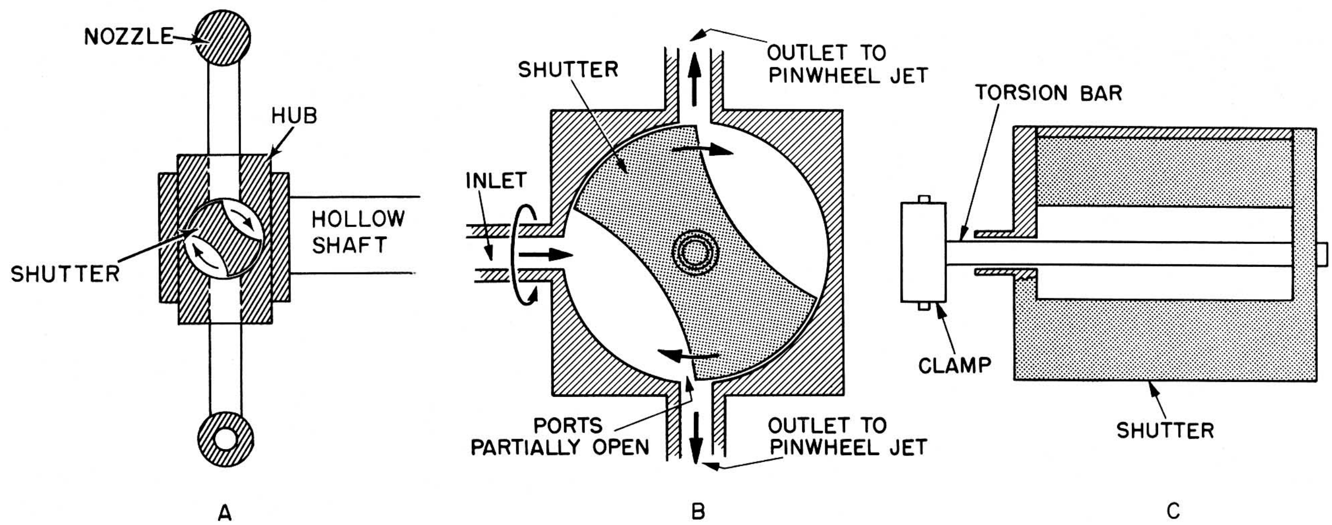


33.46:.45
Figure 8-20.—Turbines used in auxiliary power supply (APS) A. Impulse turbine; B. Terry turbine.

Governors

As mentioned earlier, turbines are often coupled to an a-c or d-c electric generator. To provide a constant electrical output, a governor is commonly used to control turbine speed within very close tolerances. One type which may be used is the moving shutter governor, which controls the speed of the pinwheel turbine.

MOVING SHUTTER GOVERNOR. - The moving shutter governor is mounted in the hub of the pinwheel turbine, as shown in figure 8-21A and 8-21B. Compressed air entering the turbine through the hollow shaft must pass through the



33.47
Figure 8-21.—Moving shutter governor.

governor before it can pass through the jet nozzles. The governor consists of a shutter secured to a torsion bar (fig. 8-21C). As the turbine rotates, centrifugal force causes the shutter to attempt to align itself in the plane of turbine rotation. In figure 8-21B the shutter tends to turn clockwise and block the flow of air to the nozzles. The torsion bar restrains the shutter from blocking the outlets. As turbine speed approaches a specified limit, the force on the shutter begins to overcome the restraint of the torsion bar, thus permitting the shutter to turn clockwise and partially block the outlets to maintain speed at the specified limit. If turbine speed decreases, the torsion bar overcomes the centrifugal force, and the shutter moves counterclockwise to uncover the outlets. Thus the moving shutter governor continuously controls turbine speed by metering the airflow to the nozzles.

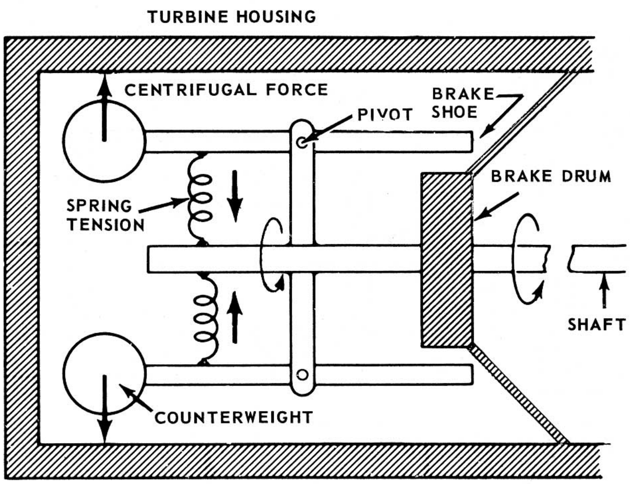
FLYBALL GOVERNOR. - A very common type of turbine governor is the flyball governor shown in figure 8-22. The coiled springs provide a restraining force on a pair of pivoted counterweights mounted on the turbine shaft. When shaft speed reaches design speed, centrifugal force overcomes spring tension. The counterweights pivot, causing the brake shoes to bear on the brake drum. When design speed is exceeded, the centrifugal force and the braking action increase. At decreasing speeds the centrifugal force lessens, and the braking action decreases. Thus a constant turbine speed is maintained.

Another type of flyball governor controls turbine speed by metering the flow of air or hot gases to the turbine. Its springs and counterweights are coupled to a valve on the input side of the turbine. Centrifugal force causes the weights to open and close the valve, thereby controlling turbine speed directly.

Miscellaneous Devices

Devices other than those described in this chapter are found in many APS systems. For example, air systems may include dehydrators which prevent moisture from reaching system components. Hydraulic systems contain devices for bleeding off entrapped air. (Entrapped air in hydraulic lines can cause serious problems. System failure often results because of the compressibility of air.) Sight gauges are often provided for indicating pressure and fluid levels. Speed reduction gears are often found between high speed turbines and the machinery they drive. The technical manuals concerning the missile you are working with will describe the applicable APS system in detail.

Certain auxiliary devices are included in all APS systems to aid in smooth and safe operation. These devices include check valves, starting valves, reducer valves, filters, and various types of flow regulators.



33.48
Figure 8-22.—Flyball governor.

One of the simplest devices for restricting or regulating flow is a fixed orifice or restriction in the hydraulic line. A more complex device is an adjustable orifice restrictor, such as a needle valve.

ADVANTAGES AND DISADVANTAGES

The disadvantages of compressed air power for movement of control surfaces of missiles were mentioned earlier. Hot gas APS systems took the place of the compressed air systems. All of them actuated a hydraulic system to cause the movement of control surfaces as required for missile flight. A disadvantage of the hydraulic system is that it is bulky and heavy. This offsets the advantages of smooth, speedy response. The new missiles are being equipped with all-electric systems to replace the hydraulic components.

MAINTENANCE OF HYDRAULIC AND PNEUMATIC EQUIPMENT

The maintenance and repair of hydraulic and pneumatic units in missiles and in missile test equipments pose no special problems if the instructions given in the appropriate maintenance publications are followed closely. However, there are two general precautions of importance which apply to work with fluid systems. The first of these is the need for cleanliness of work areas, tools, and related equipment. The second (but not second in importance) is the need for constant observance of safe work practices.

The need for cleanliness results from the fact that the moving parts of hydraulic and pneumatic devices are machined to very close tolerances and must be perfectly free of foreign matter. The smallest impurity in these systems can damage the precision components, impair the operation of the overall system, and cause missile failure.

PERIODIC INSPECTION

To prevent impurities from entering missile fluid systems, inspections are made of hydraulic and pneumatic equipments at regular intervals. Both the units which supply fluids for testing the missile and those which charge it prior to actual flight are closely inspected.

At intervals specified by technical manuals, and as summarized and codified in the 3-M system, the input and output filters of missile hydraulic systems should be removed and examined. The filters are usually of the micronic type mentioned earlier in this course. The elements in these filters cannot be cleaned. If there are signs of excessive impurities, they must be replaced.

SYSTEM FLUSHING

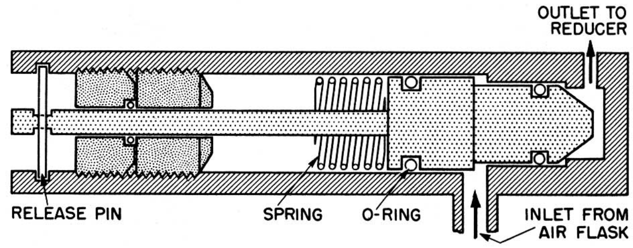
Flushing of test equipment pumping systems is performed to remove any contamination which might be present. This is always done both after the initial fluid system installation, and following any major repair in which the principal connections have been broken and remade. When the initial system installation has been completed and given an electrical checkout, or when repairs have been completed, the equipment is turned on and the hydraulic fluid is allowed to circulate for a specified period of time.

The equipment is then turned off an the fluid is removed from the system and discarded. The input filters are then replaced and the reservoir refilled with the proper fluid. When the reservoir is filled to the correct level, the system is then ready to supply oil to the missile for testing purposes or for charging the system for flight.

If hydraulic components within the missile become contaminated, they must be removed and reworked in a repair shop. This type of repair is done only at a major shore repair station-not aboard ship. A unit, such as shown in figure 4-33, is removed in its entirety and is replaced with a new unit.

HYDRAULIC TROUBLESHOOTING

Except for the electrohydraulic components, most troubleshooting in hydraulic systems is accomplished by visual means. The most frequent cause of trouble is leakage caused by poor connections or faulty O-rings. When a connection shows evidence of leaking, tightening will usually stop the loss of fluid. When the leak results from a bad O-ring, it may be necessary to disassemble the unit and replace the ring. If a leak cannot be repaired by one of these methods, the faulty section is usually replaced.



33.53
Figure 8-23. — Starting valve.

CARE OF PNEUMATIC EQUIPMENT

As in the case of hydraulic components in the missile faulty pneumatic components may be removed in their entirety and sent to a repair facility.

VALVES

Many types of hydraulic valves are described and illustrated in Fluid Power, NavPers 16193-B plus general instructions and cautions for installing and maintaining such valves. That material will not be repeated here as the basic text should be readily available to you.

Pneumatic systems use many of the same type valves as those used in hydraulic systems, but there are some that are special for use with air systems, either compressed or free air.

Starting Valves

Starting valves are commonly used in pneumatic systems. These valves provide a positive block on the discharge (output) side of the air flask. Many of these are designed to be opened by retracting a pin, either by hand or electrically. Retraction of the pin permits air to pass from the flask, thus starting operation of the pneumatic system. Figure 8-23 shows the operation of a starting valve. When the pin is released, inlet pressure acting on the valve shoulder causes piston movement to the left. The function of the spring is merely to absorb the shock of the rapid piston movement.

Relief and Safety Valves

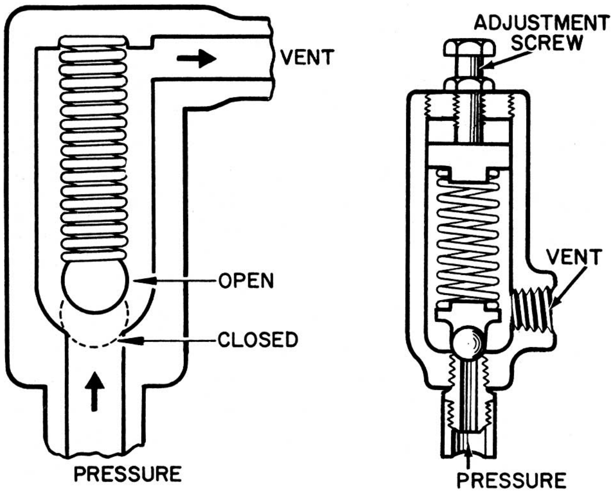
Relief valves and safety valves (fig. 8-24) are used in all closed systems. Their function is to prevent excessive pressures from rupturing hydraulic and air lines, or damaging machinery. Most of these are spring-loaded valves in which spring compression is set according to the maximum allowable pressure in the system. If pressure becomes excessive, the spring is compressed and the excess pressure is vented to the atmosphere. An adjusting screw is normally provided to set the spring pressure.

Although safety and relief valves operate on the same principle, their function is slightly different.. Relief valves are usually small in comparison to safety valves, and are designed to relieve occasional excess pressures during normal operating conditions. Safety valves are designed for emergency or breakdown, and can take care of the entire load.

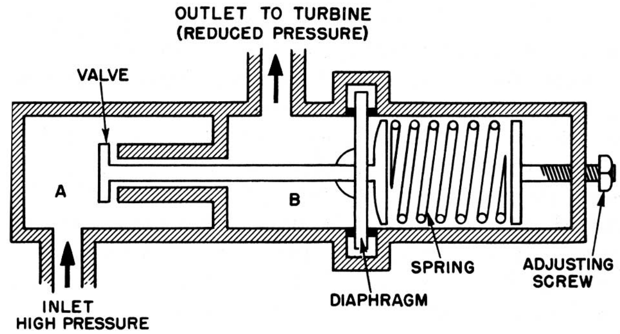
Air Pressure Reducer Valve

It is usually necessary to reduce air flask pressure (about 3000 psi) to a much lower operating level.

In the reducer valve shown in figure 8-25 pressure is reduced to 300 psi prior to reaching the turbine. To start with, assume that atmospheric pressure exists in chambers A and B before the starting valve is opened. At this time, the spring pressure against the diaphragm holds the reducer valve open. At the instant the starting valve is opened, air at 3000 psi rushes into chamber A and passes through the valve into chamber B. The pressure in chamber B immediately begins building up from atmospheric pressure. When it exceeds 300 psi it is sufficient to overcome spring tension; thus the diaphragm moves to the right, compressing the spring, and the valve closes. Note that the spring tension is set by the adjusting screw so that pressure in chamber B must exceed 300 psi to move the diaphragm to the right, permitting the valve to close. If the pressure in chamber B drops below 300 psi,



33.54
Figure 8-24. — Relief of safety valves.



33.55
Figure 8-25. — Air pressure reducer valve.

spring pressure pushes the diaphragm to the left, causing the valve to crack open, admitting air to chamber B. When the pressure in chamber B is exactly 300 psi, a point of balance is reached wherein the valve will remain open just enough to permit constant pressure in chamber B. Although it may appear that the spring pressure would be insufficient to overcome the high pressure in chamber A to open the valve, the valve is designed so that even a relatively low spring pressure will crack it against 3000 psi in chamber A.

This valve will maintain a constant outlet pressure of 300 psi as long as the inlet pressure exceeds 300 psi.

Although pneumatic systems have been designed for missile control systems, none is in use. The valves described above are types that may be used in other applications, as in a pneumatic-electric control system. The illustrations of the basic parts of each type can help you when you have to dismantle and clean a valve. You need to have the parts drawing that will show all the parts, not just the main parts as in these sketches but, if you understand how the valve operates, it will help you to put it together correctly.

A pneumatic valve that you need to know is the PRP valve in the sprinkling system in the magazines. (It will be described in detail in chapter 10 and illustrated in fig. 10-35).

SAFETY

Safety is everybody's job. Awareness of danger, knowledge of how to avoid it, and constant vigilance are the three basic requirements for the prevention of accidents while you are working on or operating a launching system.

Safety is both a result and a reflection of good training. The crews of missile launching systems may be trained so that every man thoroughly knows how to do his job; however, the crew still cannot be considered well trained unless every man is safety conscious. Safe working habits must be impressed upon every crewman through proper instructions, constant drills, and continuous supervision. Carelessness, cockiness, and lack of training have led to disaster while working with all types of ordnance equipment and material.

Each piece of ordnance equipment has a specific list of safety precautions to be observed during operation and/or maintenance. Study these thoroughly before attempting to operate or repair any piece of equipment with which you are not familiar.

Hydraulic systems operate under hydraulic pressures ranging from approximately 100 psi to 2,000 psi. Some pneumatic systems operate in approximately the same range of pressures as hydraulics. These pressures are dangerous and can be hazardous to personnel.

The following safety rules are but a few of the many that must be observed when operating or working on hydraulic or pneumatic systems.

Never disconnect hydraulic lines or disassemble hydraulic equipment when the hydraulic system power motor is running.

Never disconnect hydraulic lines or disassemble hydraulic equipment until the accumulators have been manually dumped to tank.

Never manually actuate switches, solenoids, relays, or valves on hydraulic systems under pressure unless you are competent and qualified to perform these actions.

Report hydraulic leaks immediately so that they may be repaired at the first opportunity.

If clothing becomes drenched with hydraulic fluid, immediately change into dry clothing for hydraulic fluid is injurious to health when in prolonged contact with skin. It is also a fire hazard. Immediately wipe up all spilled fluid.

Do not direct a high-pressure air jet at any part of the human body; this may be fatal.

Safety precautions must be observed when performing maintenance, testing, and operating ordnance hydraulic and pneumatic equipment. The high pressure liquid or air can cause major injuries to your face, hands, and other parts of the body by jets of air or liquid escaping from valves or pipe connections which are highly pressurized.

Don't think that once you have learned all applicable safety precautions you can sit back and take things easy. Review them periodically, particularly those for jobs seldom performed. Try to improve upon any rules in effect. Safety is everyone's responsibility, not just those who drew up the regulations. Most accidents are caused by men who are so familiar with their job they think they can take short cuts; by men who don 't know the applicable precautions; by practical jokers; or, in the majority of instances, by plain carelessness.