CHAPTER 4

STEAM-POWERED CATAPULTS

Steam is the principal source of energy and is supplied to the catapults by the ship's boilers. The steam is drawn from the ship's boilers to the catapult wet steam accumulator, where it is stored at the desired pressure. From the wet accumulator, it is directed to the launch valve, and provides the energy to launch aircraft. The most significant differences between the various types of steam catapults are the length and capacity. See table 4-1 for the differences.

Each steam catapult consists of eight major systems:

- Steam System
- Launching Engine System
- Lubrication System
- Bridle Tensioning System
- Hydraulic System
- Retraction Engine System
- Drive System
- Catapult Control System

STEAM SYSTEM

LEARNING OBJECTIVES: Describe the components of the steam system. Describe the function of the steam system.

The catapult steam system (fig. 4-1) consists of the steam wet accumulator, accumulator fill and blowdown valves, trough warm-up system, steam smothering system and the associated valves and piping. The seam system is under the technical cognizance of NAVSEASYSCOM and is operated and maintained by engineering department personnel. An explanation of the steam system major components will provide a better understanding of catapult operations. Figure 4-2 is a simplified schematic of a typical catapult steam piping arrangement. The schematic only shows the piping and valves associated with a single catapult when lined up with the steam plant that normally supplies that catapult. Valves and piping that allow cross connecting of catapults with all steam plants are not shown. Cross connecting provides the capability of operating any catapult from any power plant.

WET ACCUMULATOR WARM-UP

The accumulator warm-up procedure allows valves and piping between the steam plant and the catapult to initially slowly warm up to bring the metal temperatures to operating level. Hot feed water is admitted into the steam accumulator to approximate the low operating level. The launch valve is opened to purge air from the accumulator and steam is slowly admitted into the accumulator feed water to raise the water temperature. When the water temperature reaches approximately 225 degrees, the launch valve is closed and accumulator heating continues. Steam pressure is increased in increments allowing enough time at each increment for the water temperature to increase to a predetermined temperature. This slow increase in temperature and pressure will ensure a thermally stable accumulator when operating parameters are reached.

TROUGH WARM -UP

The trough warm-up procedure allows valves and piping between the steam plant and the catapult to slowly warm -up to bring the metal temperatures to operating level. When steam is directed to a catapult for

Table 4-1.—Steam Catapult Data

Item	C-13-0	C-13-1	C-13-2
Power stroke (in feet)	249-10"	309-8 3/4"	306-9"
blTrack length (in feet)	264-10"	324-10"	324-10"
Weight of shuttle and pistons (in pounds)	6,350	6,350	6,350
Cylinder bore (in inches)	18	18	21
Power stroke displacement (in cubic feet)	910	1,148	1,527

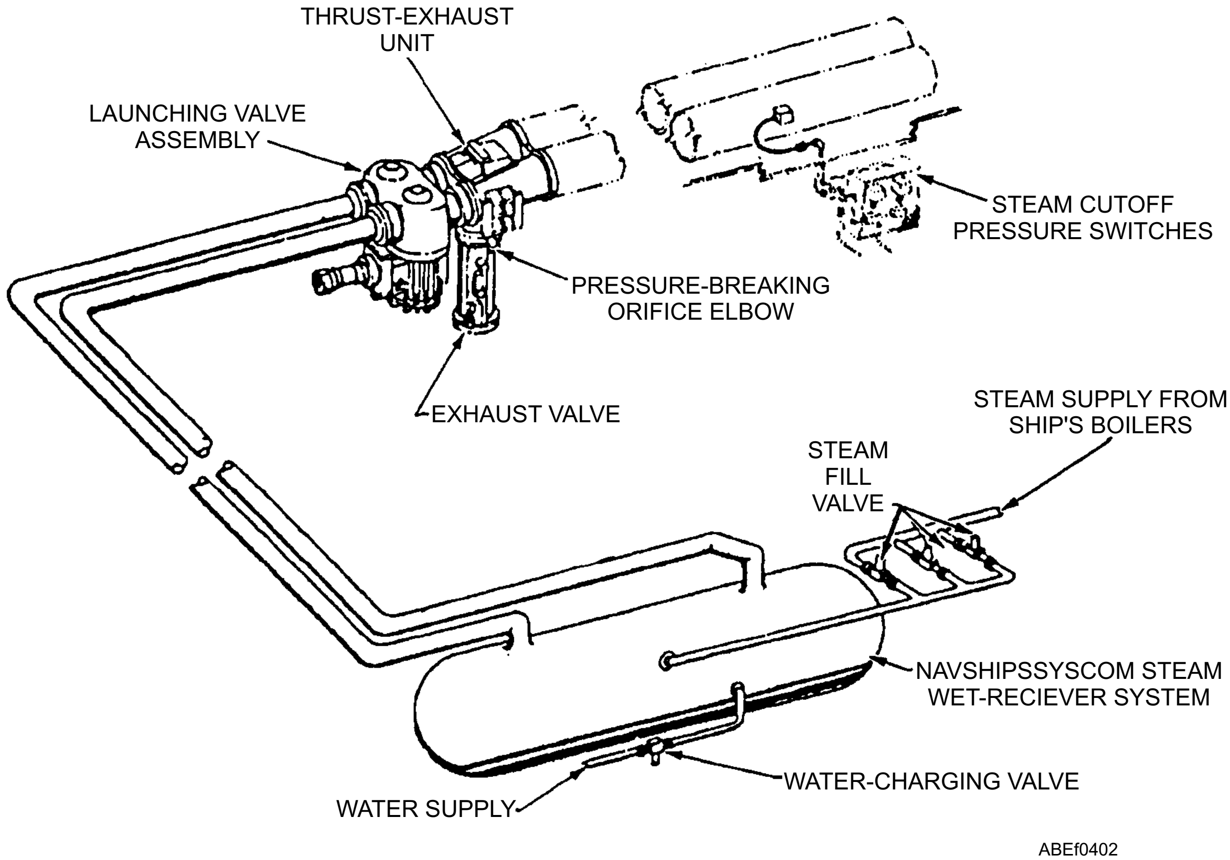


Figure 4-1.—Steam system.

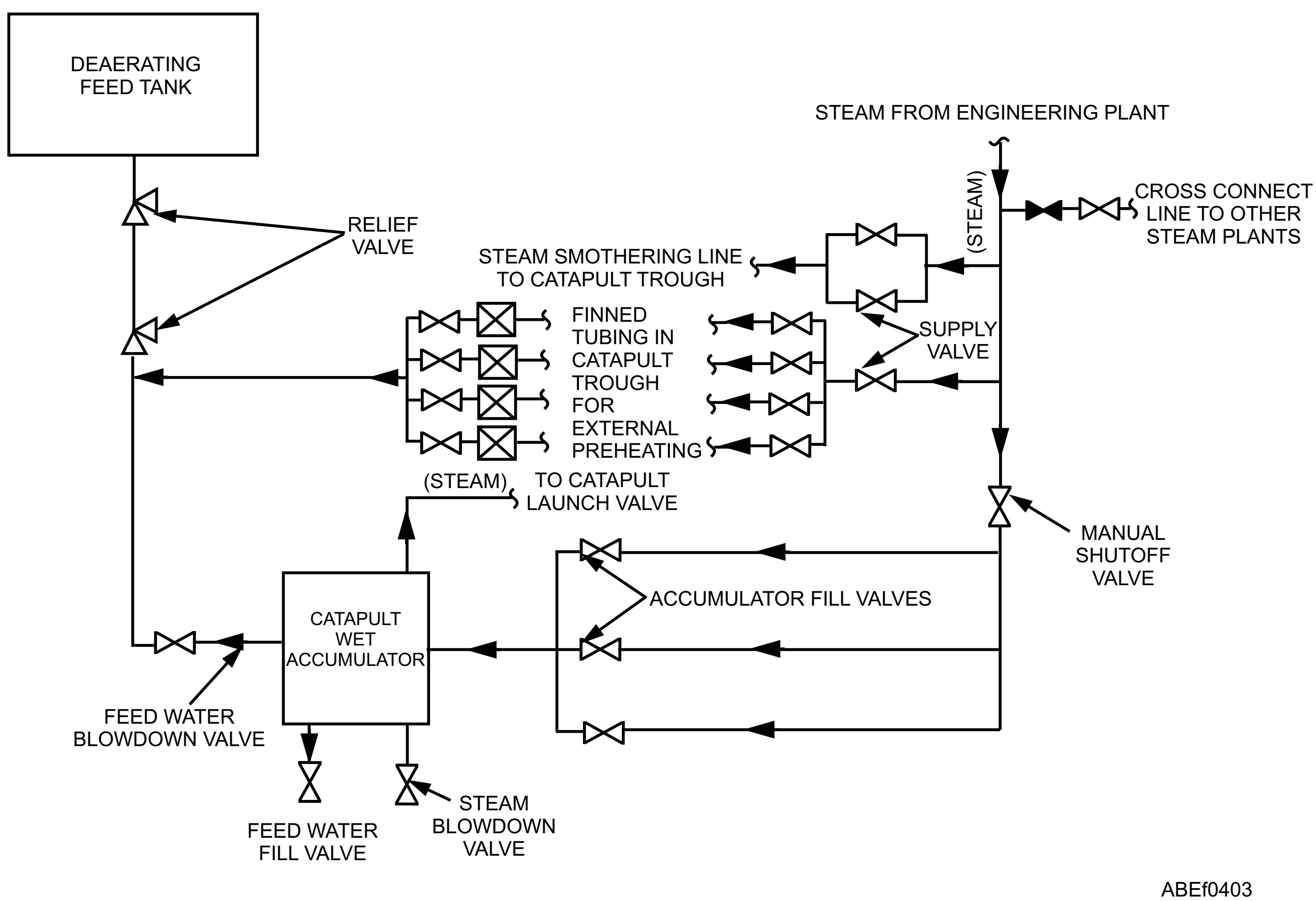


Figure 4-2.—Steam system schematic.

accumulator warm-up, steam is available through a branch line and valves to the trough warm-up system (fig. 4-3). The launching engine cylinders are heated to operating temperature by a pair of trough heaters located below each row of launching engine cylinders. The rough heaters are installed in two sections referred to as the forward and aft legs. Each trough heater consists of a pipe within a larger pipe that is capped at the forward end. Steam is admitted into the inner pipe, them flows through the inner pipe into the outer pipe, heating the outer pipe. Fins installed on the outer pipe provide even radiation of heat to the launching engine cylinders, condensation from each outlet pipe is removed by drains lines which are equipped with fixed orifices. The orifices are sized so that water is removed at a rate that will maintain enough steam flow to heat and maintain the launching engine cylinders at operating temperature, bypass valves are provided around each orifice to remove excess water if required.

STEAM SMOTHERING SYSTEM

The steam smothering system (see fig. 4-3) provides a rapid means of extinguishing a fire in the catapult trough or in the launch valve compartment. The launch valve steam smothering is accomplished by admitting steam into a pair of lines encircling the launch valve area, holes in these lines direct steam to cover the area.

Trough steam smothering is accomplished by admitting main steam into a pipe located between the launching engine cylinders, holes in the pipe direct seam to all of the trough area. Trough steam smothering can be actuated pneumatically by a valve at deckedge or manually by a bypass valve located near the pneumatically operated steam supply valve.

WET ACCUMULATOR OPERATION

The steam accumulator provides a volume of steam under pressure to the launch valve assembly. At operating temperatures, when the launch valve opens and steam is released to the launch engine cylinders, steam pressure within the accumulator drops, when the pressure drop in the accumulator occurs, the steam fill valve open and admit steam into the accumulator by means of a perforated manifold submerged in the water, this will rapidly heat the water back to the operating temperature. Water level will return its pre-established level.

LAUNCHING ENGINE SYSTEM

LEARNING OBJECTIVES: Describe the components of the launching engine system. Describe the function of the launching engine system.

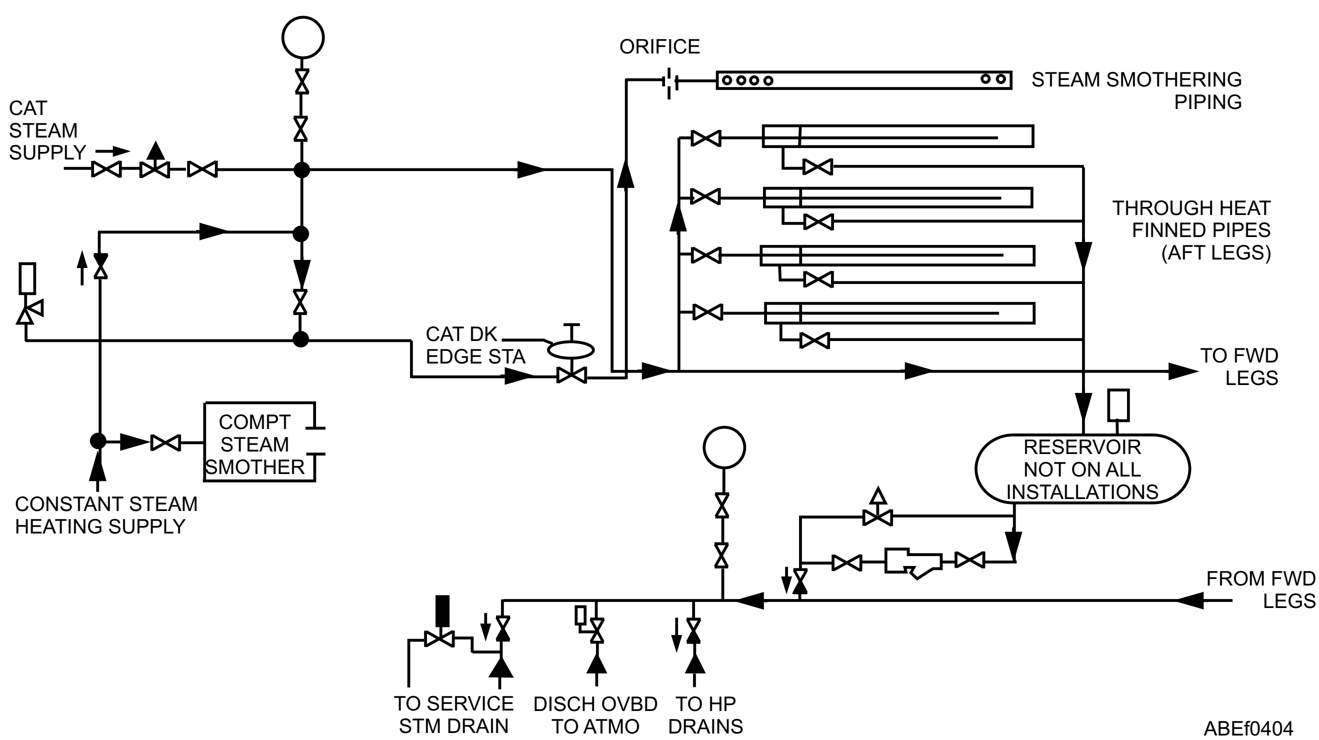


Figure 4-3.—Trough heat and steam smothering.

The launching engine system (fig. 4-4) consists of most of the major components that are used in applying steam to the launching engine pistons during launch operation and stopping the launch engine pistons at the completion of a launch. The major components that comprise the launching engine system are as follows:

- Launch Valve Assembly
- Thrust/Exhaust Unit
- Launch Valve Control Valve
- Exhaust Valve Assembly
- Pressure Breaking Orifice Elbow Assembly
- Keeper Valve
- Launch Valve Hydraulic Lock valve Panel Assembly
- Exhaust Valve Hydraulic Lock Valve
- Launching Engine Cylinders
- Cylinder Covers
- Sealing Strip
- Sealing Strip Tensioner Installation
- Sealing Strip Anchor and Guide
- Launching Engine Pistons
- Shuttle Assembly
- Water Break Installation
- Water break Piping and Pressure Switch Installation
- Steam Cutoff Switch Installation

LAUNCH VALVE ASSEMBLY

The launch valve assembly (fig. 4-5) is located between the two steam lines from the steam accumulator and the thrust/exhaust unit. Its consists mainly of a steam valve assembly, a hydraulic cylinder assembly, an operation control assembly, and the launch valve stroke timer electrical installation. A closed plate and an open plate are located on the operation controls frame and an increment plate is located on the operation controls crosshead. The position of the valve can be determined by the relationship of the increment plate to the closed and open plates.

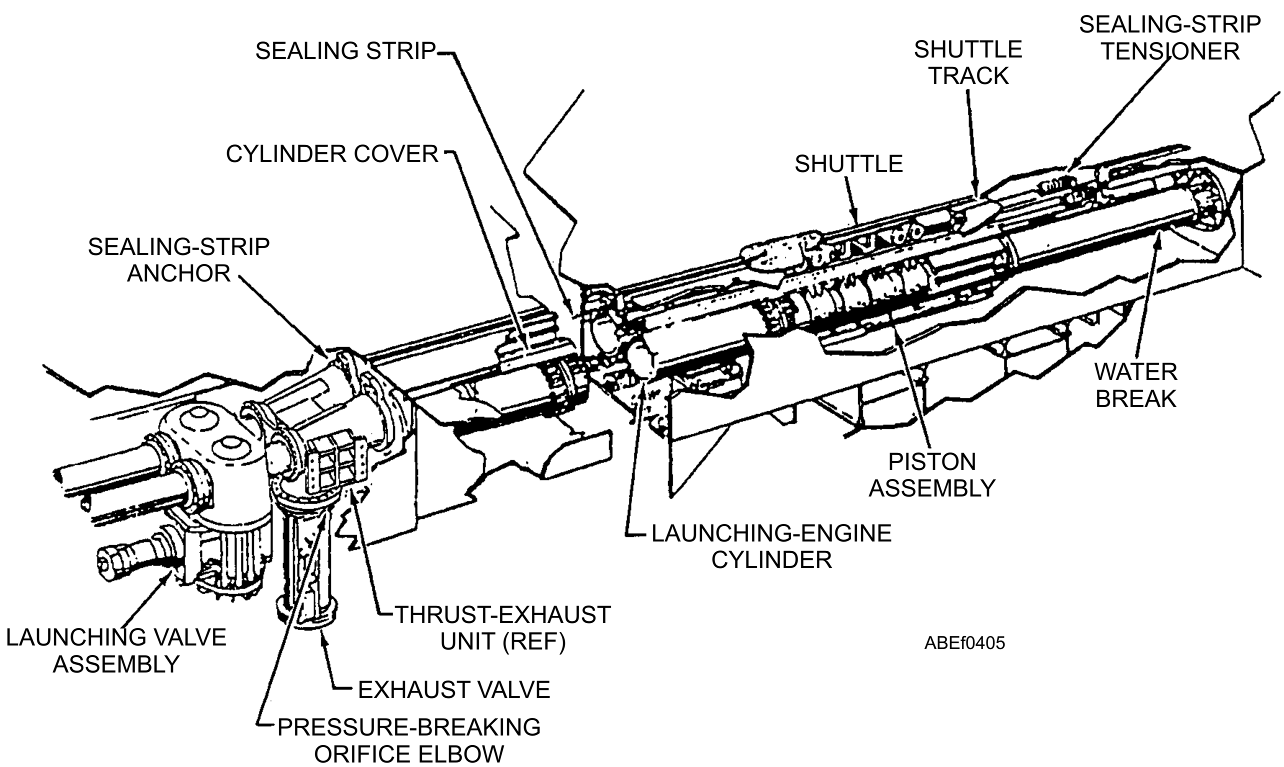


Figure 4-4.—Launching engine system (typical).

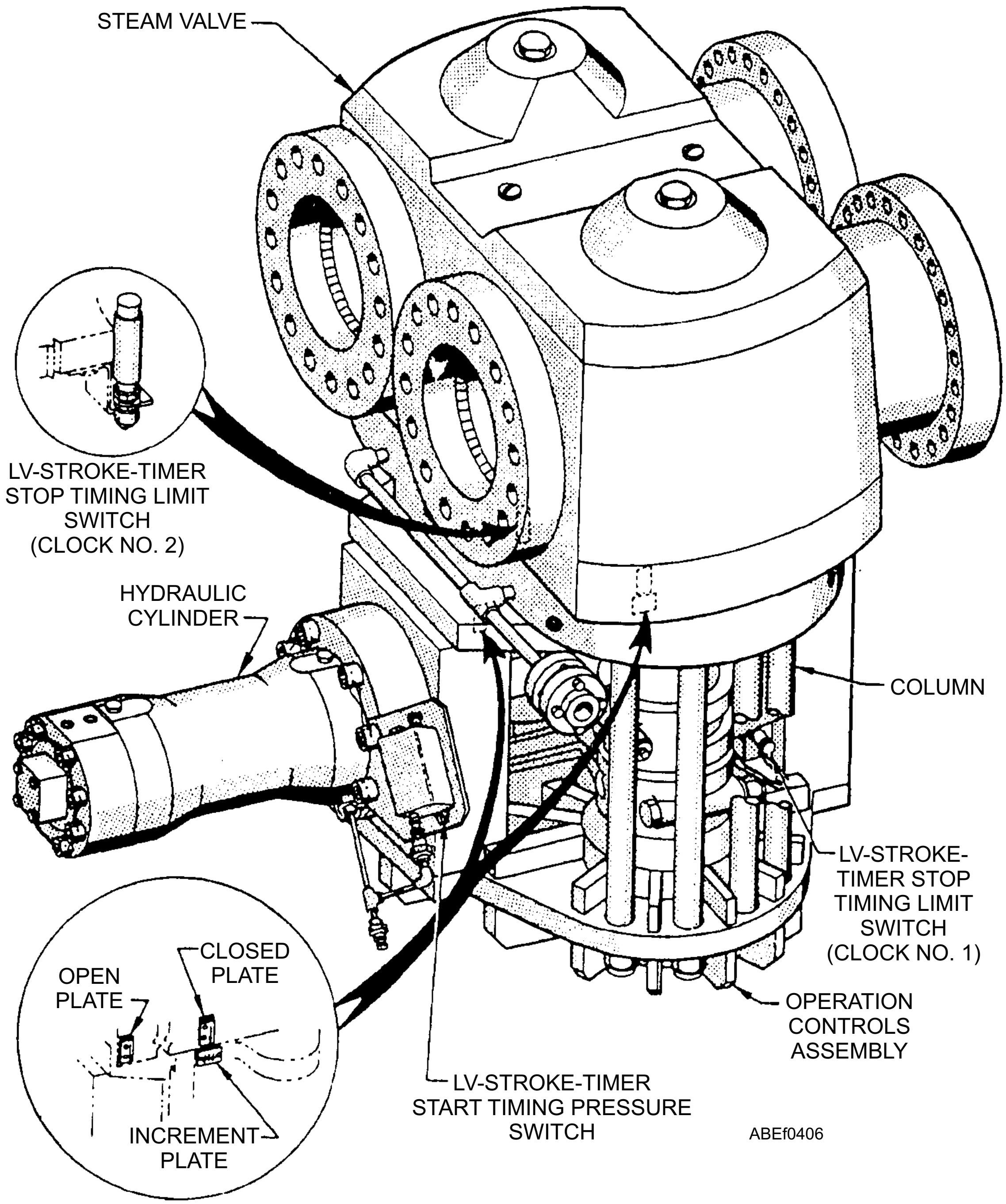


Figure 4-5.—Launch valve assembly (rotary).

STEAM VALVE

The steam valve (fig. 4-6) admits and shuts off the flow of steam to the launching engine cylinders during catapult operations. With the valve in the CLOSED position, two plugs in the valve are in full contact with the valve body seats, providing a tight seal. When the valve is opened, the plugs are moved away from the valve body seats and rotated 90 degrees. In the OPEN position, the circular openings in the plugs are in line with the valve body passages.

OPERATION CONTROLS ASSEMBLY

The operation controls assembly (fig. 4-7) is attached to the bottom of the steam valve assembly. The assembly provides vertical movement needed for seating and unseating the steam valve plugs and rotational movement needed for opening and closing the steam valve. Vertical movement of the plugs is obtained by the action of the lift nuts. Each lift nut has a steep angle thread that mates on each steam valve plug shaft. Each lift nut is connected to the crosshead by a lifter lever and a lifter link. Movement of the crosshead, which is connected to the hydraulic cylinder piston rod, causes the lift nuts to rotate and the plugs to move toward or away from the steam valve body seats. Movement of the crosshead also obtains rotational movement of the plugs. Each plug shaft is connected to the crosshead by a rotator lever and a rotator link. With the steam valve in the CLOSED position, the plugs are fully seated. When the crosshead starts to move to the OPEN position, the lift nuts move the plugs downward, and the links and levers begin to rotate. Due to the geometrical arrangement of the levers, the plugs are moved away from the body seats before rotation begins. As the crosshead stroke approaches the FULL OPEN position, the plugs move toward the valve body seats. When the valve is fully opened, the plugs are not in contact with the body seats, because of the unequal lengths of the links, and the plugs and body parts are in perfect alignment. As the crosshead moves to the CLOSED position, the links and levers rotate the plugs upward to seat the plugs against the seats.

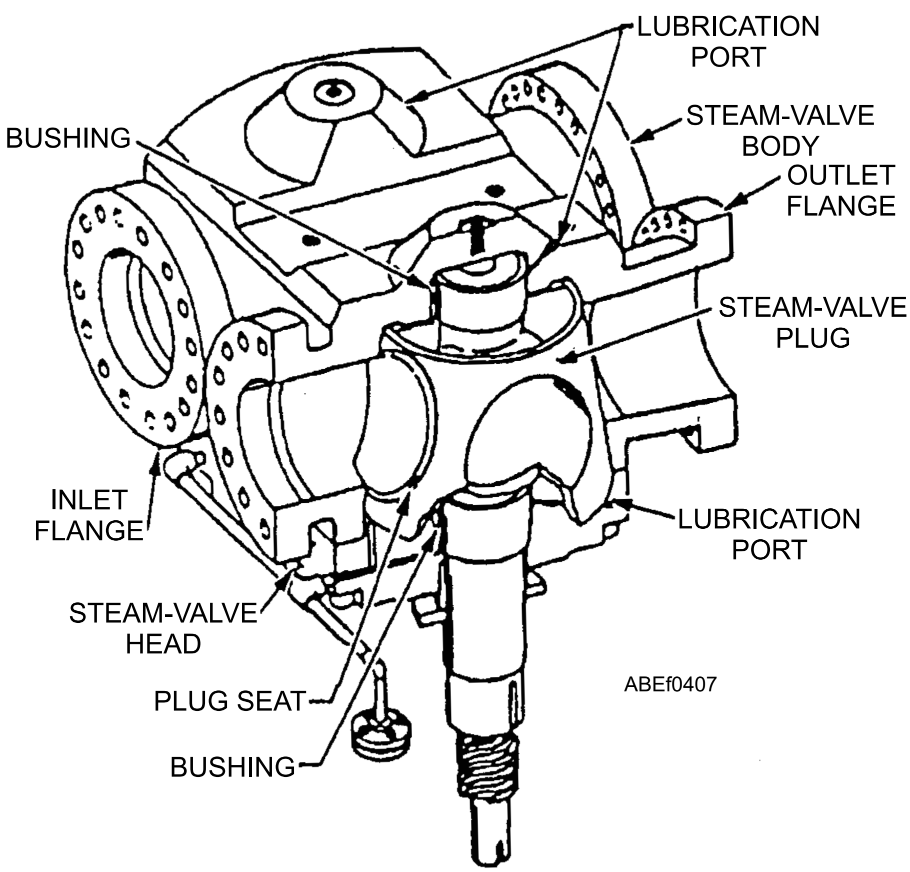


Figure 4-6.—Launching valve steam valve.

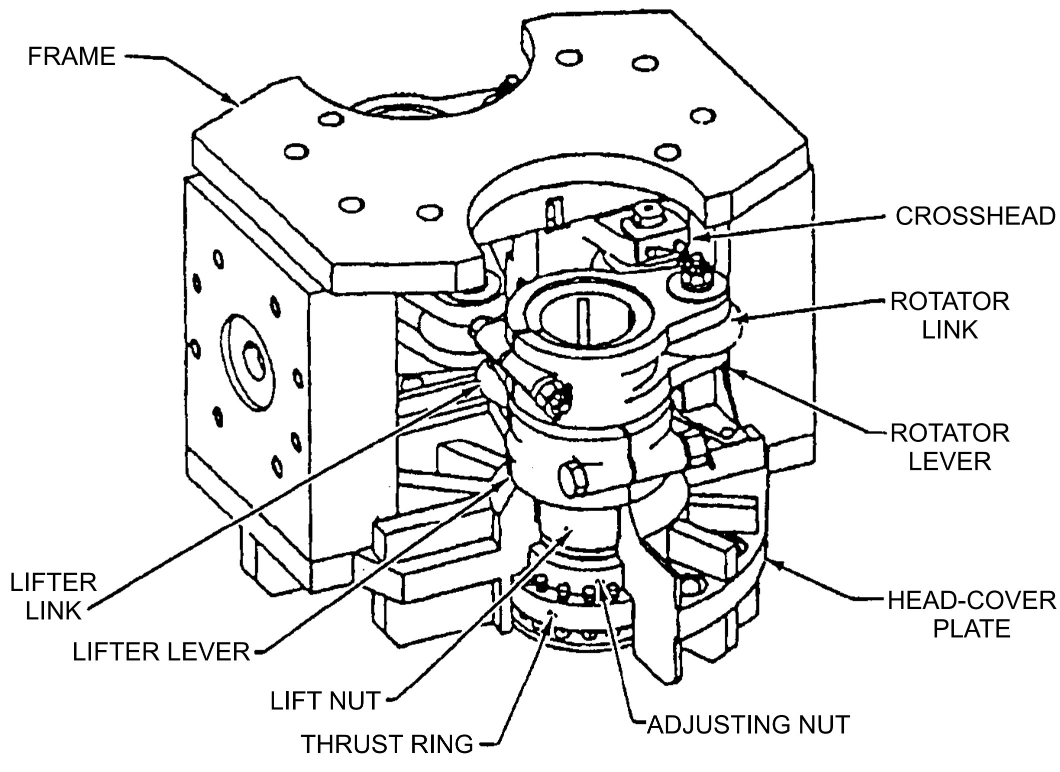


Figure 4-7.—Launch valve operation control assembly.

HYDRAULIC CYLINDER ASSEMBLY

The hydraulic cylinder assembly (fig. 4-8) is connected to the operation control assembly. The hydraulic cylinder assembly is actuated by pressurized hydraulic fluid to open and close the steam valve assembly. When pressurized fluid is applied to port E, the piston moves to the opposite end of the cylinder to open the steam valve. The rate of movement of the piston is faster at the beginning of the stroke, because of

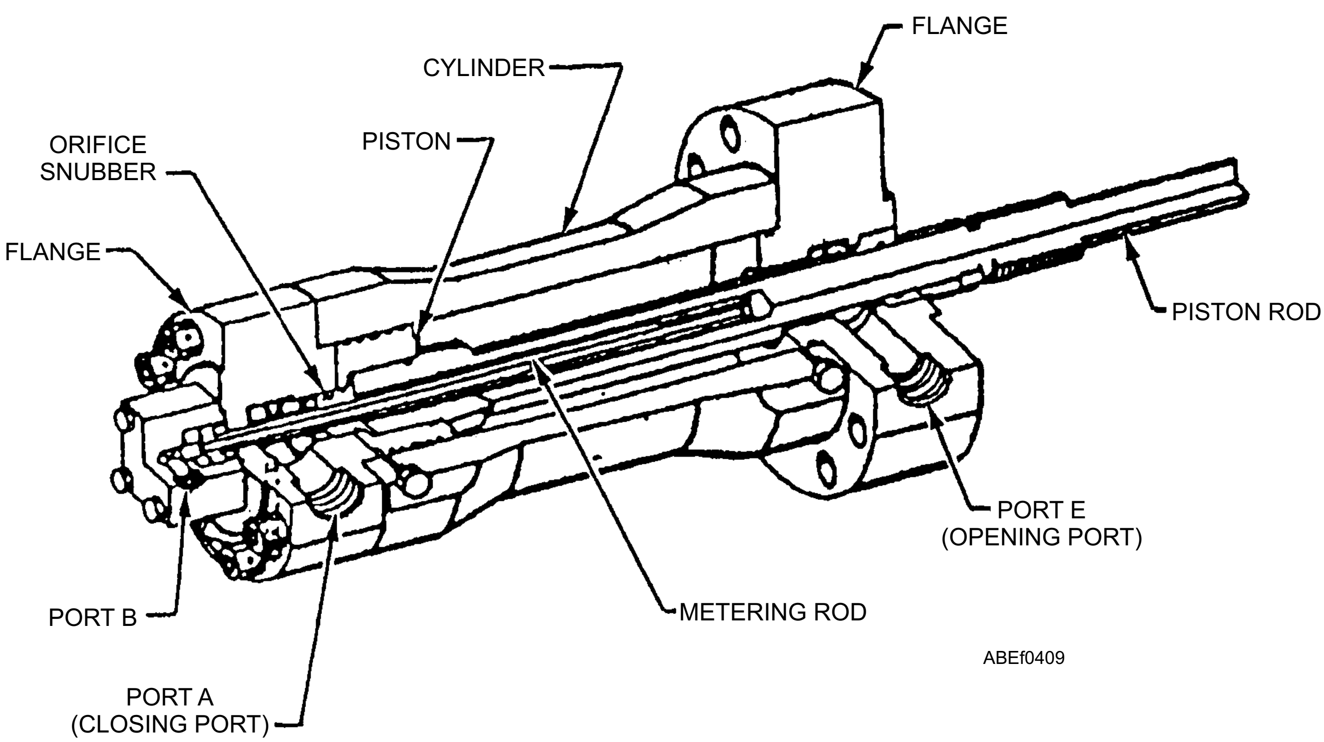


Figure 4-8.—Launch valve hydraulic cylinder.

the effect of the metering rod. At the beginning of the opening stroke, fluid flows out of port A and port B. When the piston has moved approximately 1 inch into the cylinder, the metering rod shuts off the flow of fluid from within the cylinder to port B. At the end of the opening stroke, the orifice snubber controls the escape of fluid from the cylinder, this prevents the moving parts from slamming to a stop and possibly being damaged.

When pressurized fluid is applied to port A, the piston moves toward the opposite end of the cylinder to close the steam valve. At the end of the closing stroke, the tapered end of the piston rod enters the flange. This prevents the moving parts from slamming to a stop and possibly being damaged.

LAUNCH VALVE STROKE TIMER ELECTRICAL SYSTEM

The launch valve stroke timer electrical system (see fig. 4-5) provides a means of measuring the launch valve performance by timing the stroke from fully closed position to the point at which the crosshead has moved 9 inches. When the catapult is fired, fluid pressure from the hydraulic cylinder opening port E actuates the start timing pressure switch. This starts two clocks which measure and displays time in seconds and hundredths of seconds. When the valve opens 3 1/2 inches, a limit switch on the crosshead opens and clock number one stops and display time elapsed. At the 9-inch stroke, a second switch opens, stopping and displaying elapsed time.

The timer clocks are located on the main control console for CV-64, CVN-65, and CV-67 and the central charging panel for CVN-68 through CVN 76. Variations in the launching valve stroke rates may seriously affect catapult performance. The launching valve stroke timers provide a means of detecting differences in the launching valve stroke. Deviations in the launching valve stroke can be detected by comparing current timer readings with previously established timer readings.

THRUST EXHAUST UNIT

The thrust/exhaust units (fig. 4-9) absorbs the thrust of the launch engine pistons and shuttle assembly, connects the launch valve to the power cylinders and to the exhaust valve, anchors the aft end of the launching, engine and prevents aft expansion of the launching engine cylinders.

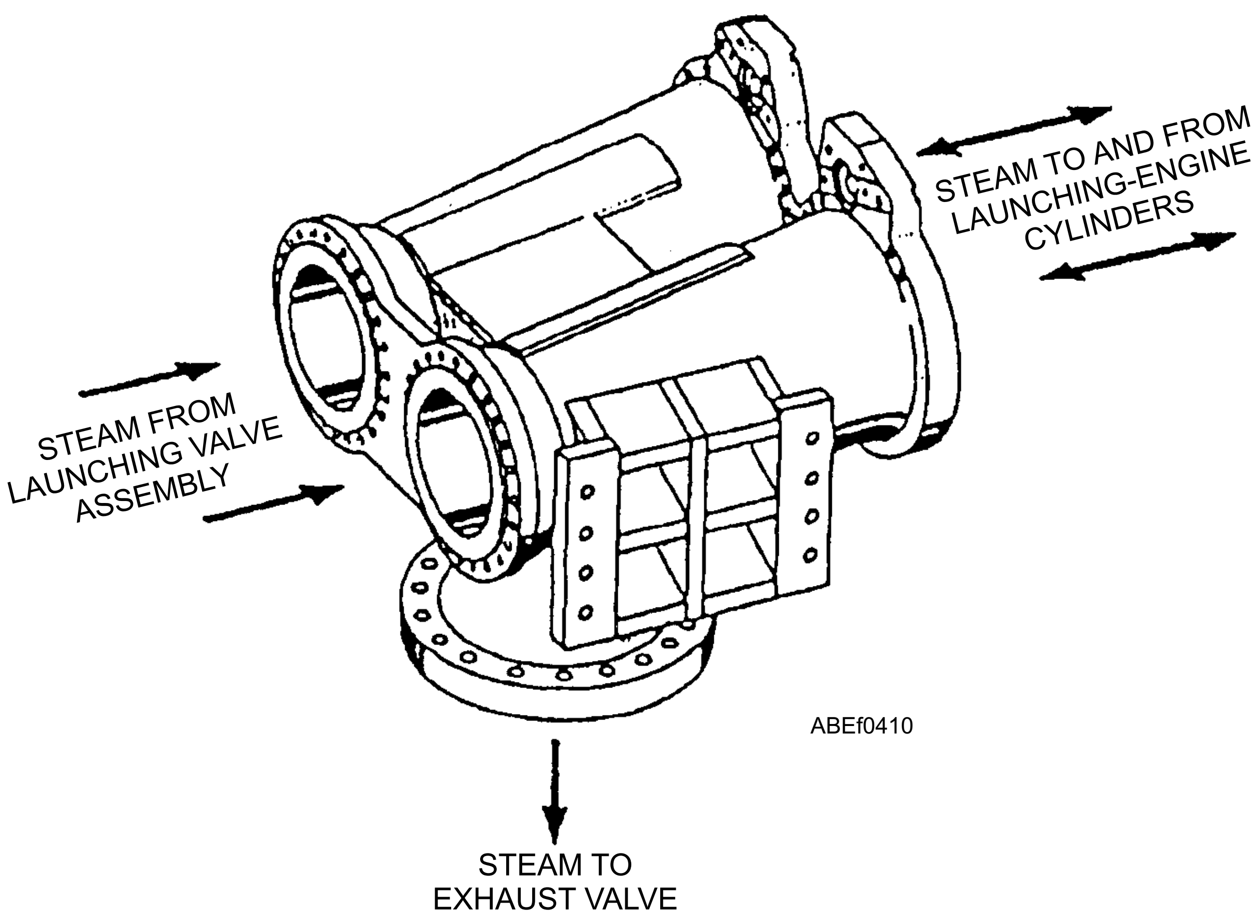


Figure 4-9.—Thrust exhaust unit.

In ships preceding CV-67, a thrust unit anchors the aft end of the launching engine and connects the steam accumulator to the launch valve. An exhaust tee mounted between the launch valve and the aft power cylinders also provides connection to the exhaust valve.

CAPACITY SELECTOR VALVE (CSV)

The CSV (fig. 4-10) provides the means of varying the energy output of the catapult by controlling the opening rate of the launch valve for aircraft of various types and weights. An electric motor unit assembly is used to position the CSV spindle, which meters the flow of fluid from the operating cylinder when the launch valve is opening, changing the valve setting for different capacity launchings. A handwheel is provided to change the valve setting should the automatic control become inoperative. For complete information concerning the CSV assembly, refer to technical manual NAVAIR 51-15ABE-1.

LAUNCH-VALVE CONTROL VALVE

The launching-valve control valve (fig. 4-11) directs pressurized hydraulic fluid to the launch valve hydraulic cylinder to open or close the launch valve. The control valve consists of a valve body enclosed on both ends by glands. A piston within the valve divides the control valve into seven chambers. Piping connects each chamber of the control valve to other components. As the launching valves go through their opening and closing cycles, fluid is being directed to the operating chambers by the action of the sliding piston, lining up the ports and allowing pressurized fluid to enter one chamber while venting the other chamber to gravity. A tailrod is attached to each end of the piston. The tailrods extend through the gland and provide a visual indication of the position of the control valve. Pressurized fluid used to shift the control valve is supplied through the launch valve solenoid-operated hydraulic lock valve.

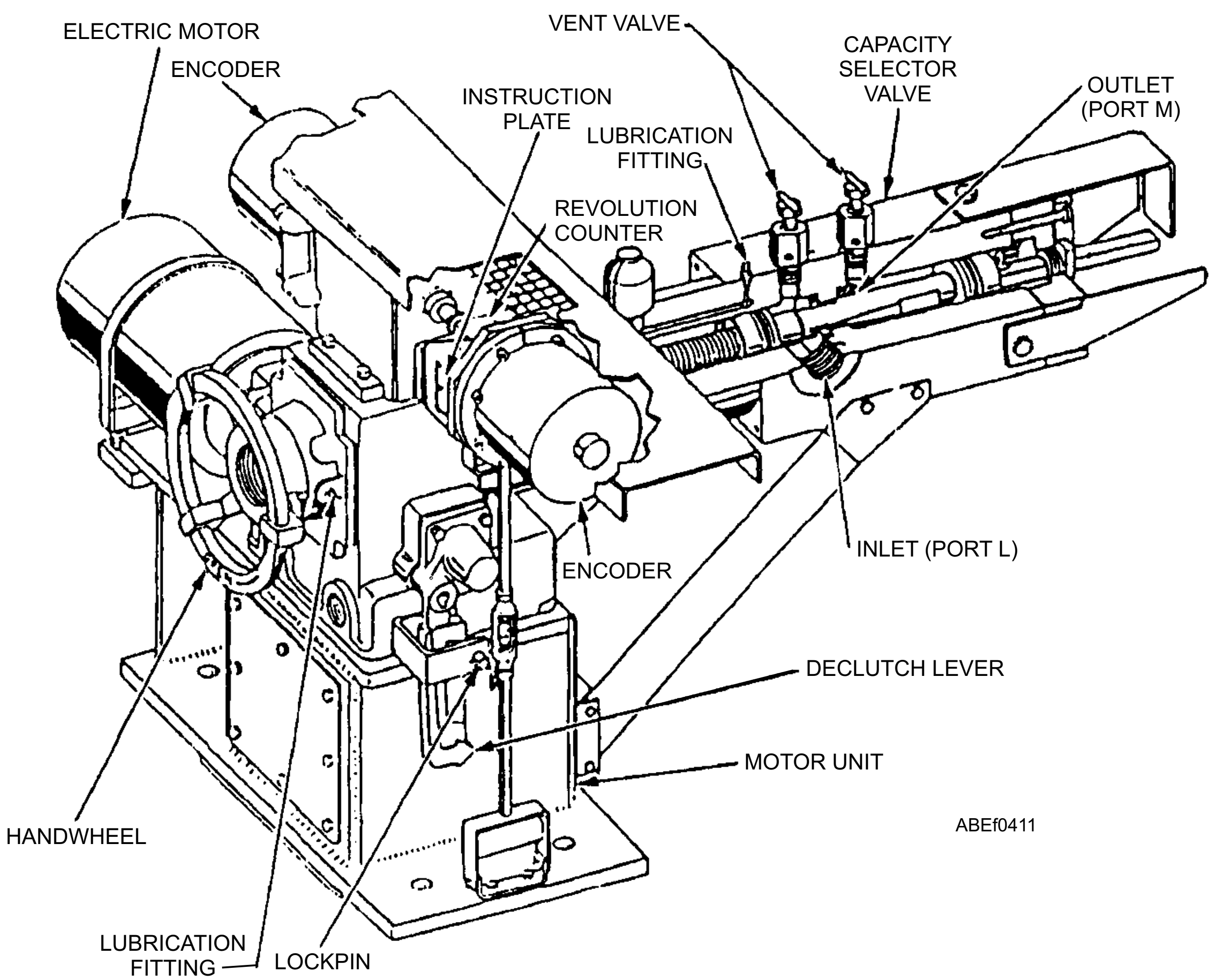


Figure 4-10.—Capacity selector valve assembly.

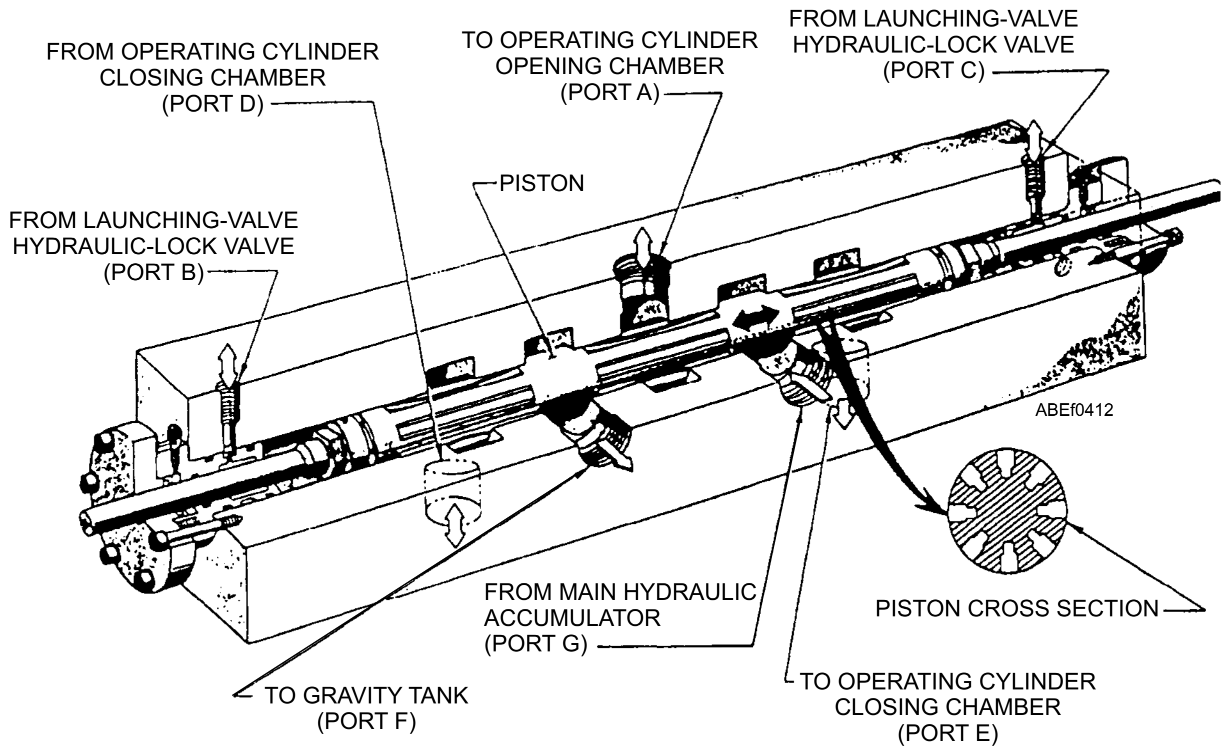


Figure 4-11.—Launch-valve control valve.

BUTTERFLY EXHAUST VALVE

The butterfly exhaust valve (fig. 4-12) provide the means to direct spent steam from the launching engine cylinders overboard after the launch valve closes at the completion of a launch. The exhaust valve is attached to the bottom flange of the thrust/exhaust unit or exhaust tee; it consists primarily of a valve body, a disc, and a hydraulic actuator. Prior to launch, hydraulic pressure is directed from the exhaust valve hydraulic lock valve to the closing port of the hydraulic actuator causing the piston to move downward and the disk within the valve body to move onto its seat. A switch is then actuated that energizes a portion of the electrical circuitry that allows the launch sequence to continue. After a launch, when the launch valve closes, hydraulic pressure is directed from the exhaust valve hydraulic lock valve to the opening port of the hydraulic actuator causing the piston to move upward and the disk within the valve body to move off its seat and release the spent steam overboard. The limit switch is released and allows for a portion of the electrical circuitry necessary to allow retraction of the launching engine pistons.

PRESSURE-BREAKING ORIFICE ELBOW

The pressure-breaking orifice elbow (fig. 4-13) prevents a buildup of steam pressure behind the launching engine pistons when the launch valve is closed. The pressure breaking orifice elbow is attached to a flange on the thrust/exhaust unit or exhaust tee above the exhaust valve assembly and contains an orifice that is large enough to allow the escape of launch valve steam leakage but small enough to have no detrimental effect on catapult performance. Any steam, which may leak through the closed launch valve when the exhaust valve is closed, is permitted to escape through the pressure-breaking orifice. This prevents a build -up of pressure that could cause premature release of an aircraft from its holdback bar restraint.

KEEPER VALVE

The keeper valve (fig. 4-14) prevents the exhaust valve from opening while the launch valve is open. The keeper valve is located in the piping between the launch and exhaust valve lock valves and the closing chamber of the exhaust valve actuator. The valve consists of a block with an internal cylinder containing a movable piston. The keeper valve is actuated by hydraulic fluid from the launch-valve hydraulic lock valve. When the launch valve opens, the piston of the keeper valve shifts and blocks the flow of hydraulic fluid to the exhaust valve hydraulic actuator. This prevents the exhaust valve from opening until the launch valve is closed and the keeper valve piston is shifted.

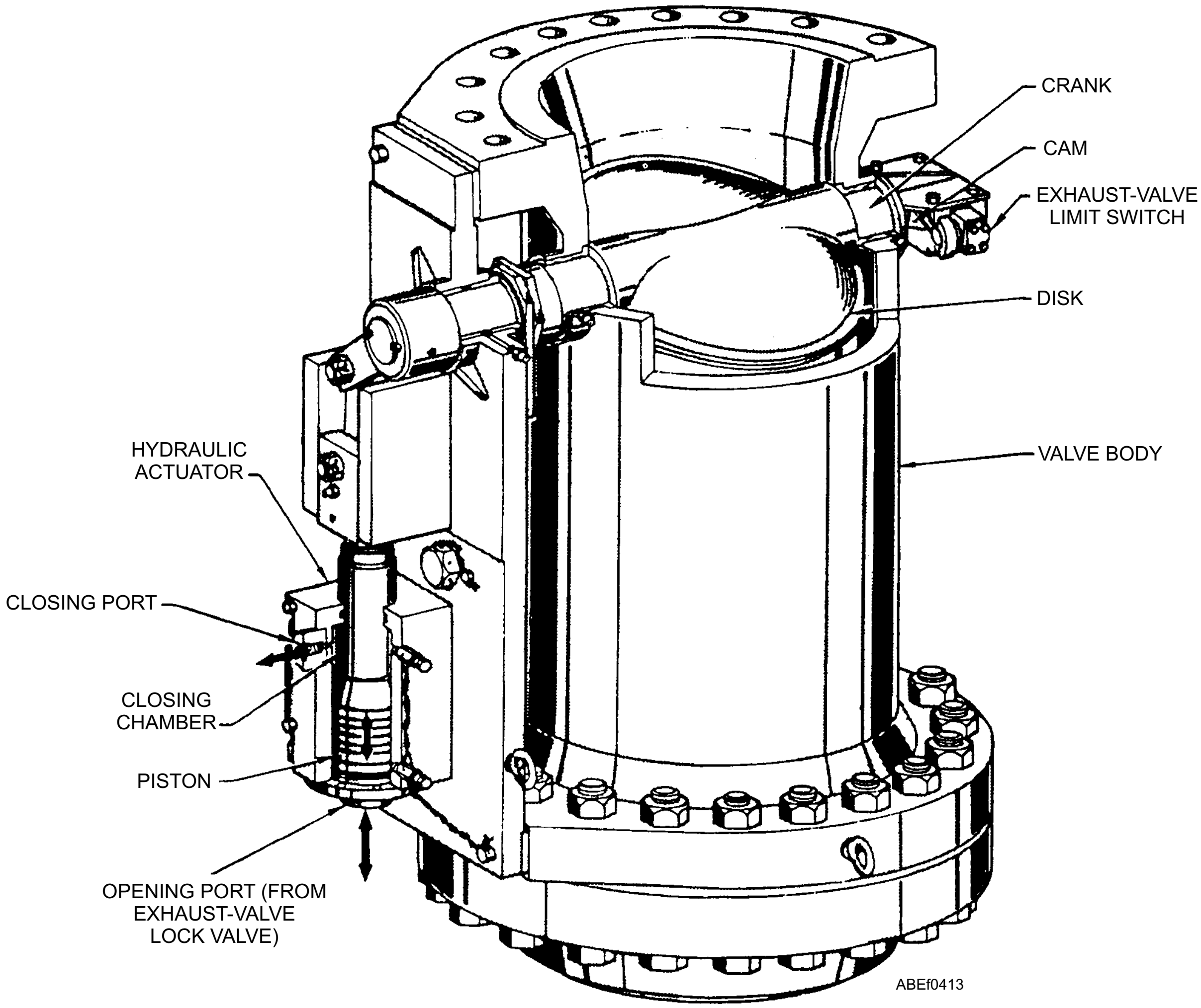


Figure 4-12.—Butterfly exhaust valve.

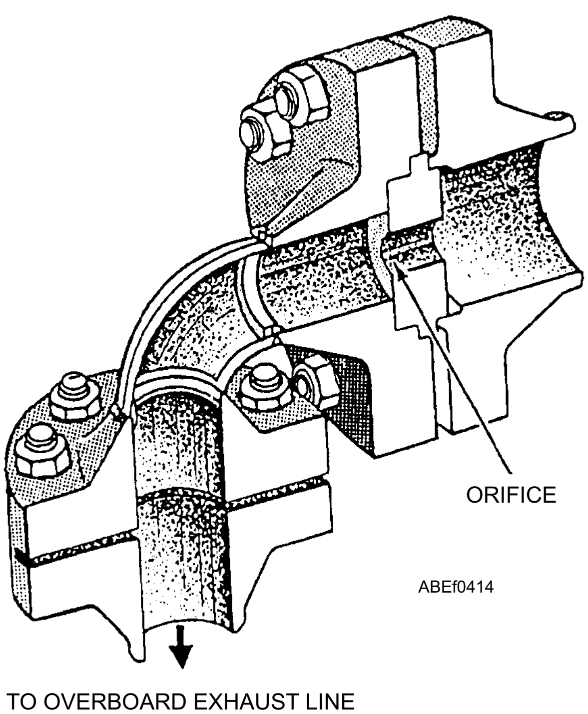


Figure 4-13.—Pressure-breaking orifice elbow.

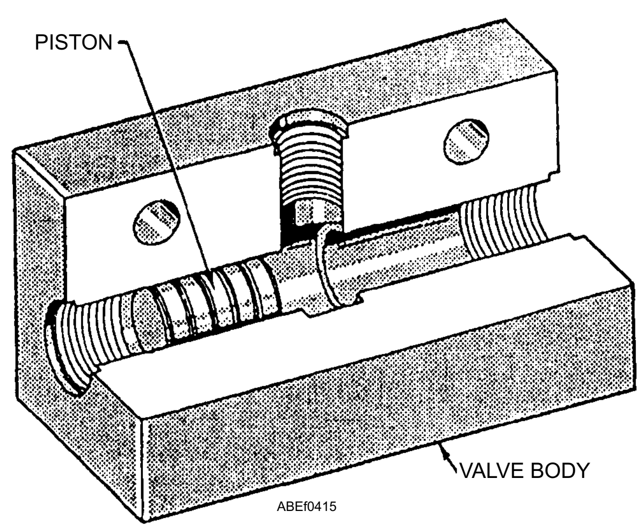


Figure 4-14.—Keeper valve.

HYDRAULIC-LOCK-VALVE PANELS

There are two hydraulic-lock-valve panels, one for the launch valve (fig. 4-15) and one for the exhaust valve (fig. 4-16). The launch-valve hydraulic-lock-valve panel consists of two air-solenoid valves, a hydraulic lock valve with lock positioner, the launch pilot latch solenoid, and piping connections. The launch-valve hydraulic lock valve (fig. 4-17) provides a hydraulic lock to hold the launch-valve control valve in the FIRED position until launch is completed or until the launch-valve emergency cutout valve is placed in the EMERGENCY position, by controlling the flow of fluid to the launch-valve control valve.

The launch pilot latch solenoid controls a plunger that prevents the lock valve from being shifted to the FIRED position unless the catapult control system is in the FINAL READY phase of operation. (A manual lock screw [fig. 4-17] is provided to secure the valve during nonoperational periods.) When the catapult FIRE circuit is energized, the fire air-solenoid valve directs air pressure to shift the lock valve to the fired position. This causes pressurized fluid to be directed from port A through port B to the launching-valve control valve, the keeper valve, and port D via the launch-valve emergency cutout valve. Fluid pressure in port D hydraulically locks the valve in the fired position. When the catapult LAUNCH COMPLETE circuit is energized, the close launch valve air-solenoid directs air pressure to again shift the lock valve, venting port D to gravity and directing pressurized fluid from port A through port C to the launch-valve control valve and closing the launch valves. (During a HANGFIRE condition, port D is vented and port C is pressurized when the launch-valve emergency cutout valve is placed in its EMERGENCY position, ensuring that the launch valves remain closed.)

The exhaust-valve hydraulic-lock-valve panel (see fig. 4-16) consists of the exhaust-valve hydraulic lock valve, two air-solenoid valves, and piping connections.

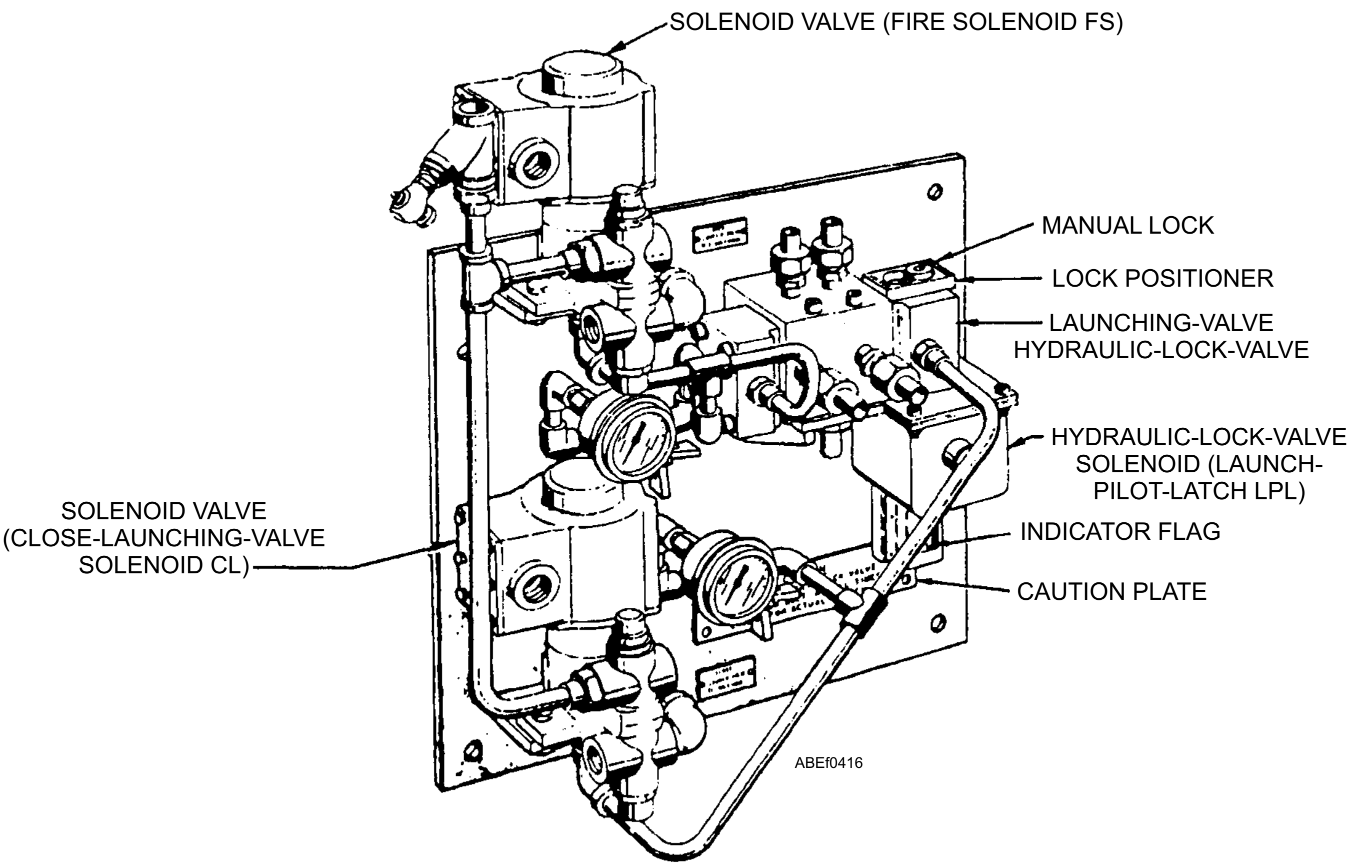


Figure 4-15.—Launch-valve hydraulic-lock-valve panel.

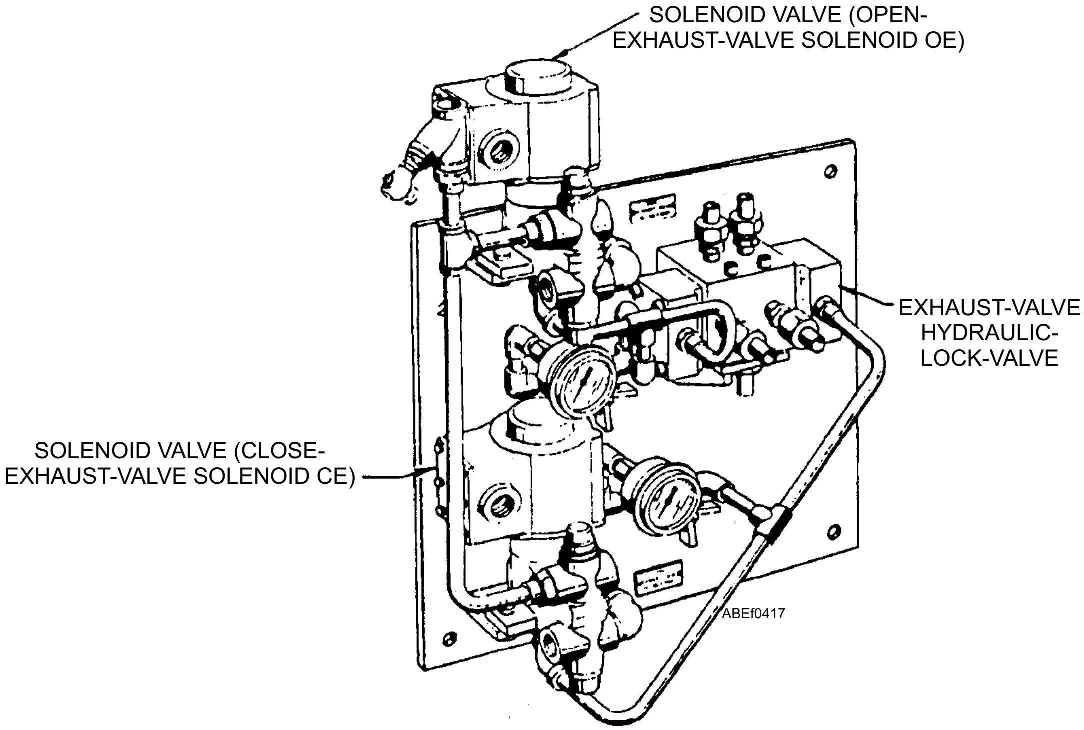


Figure 4-16.—Exhaust-valve hydraulic-lock-valve panel.

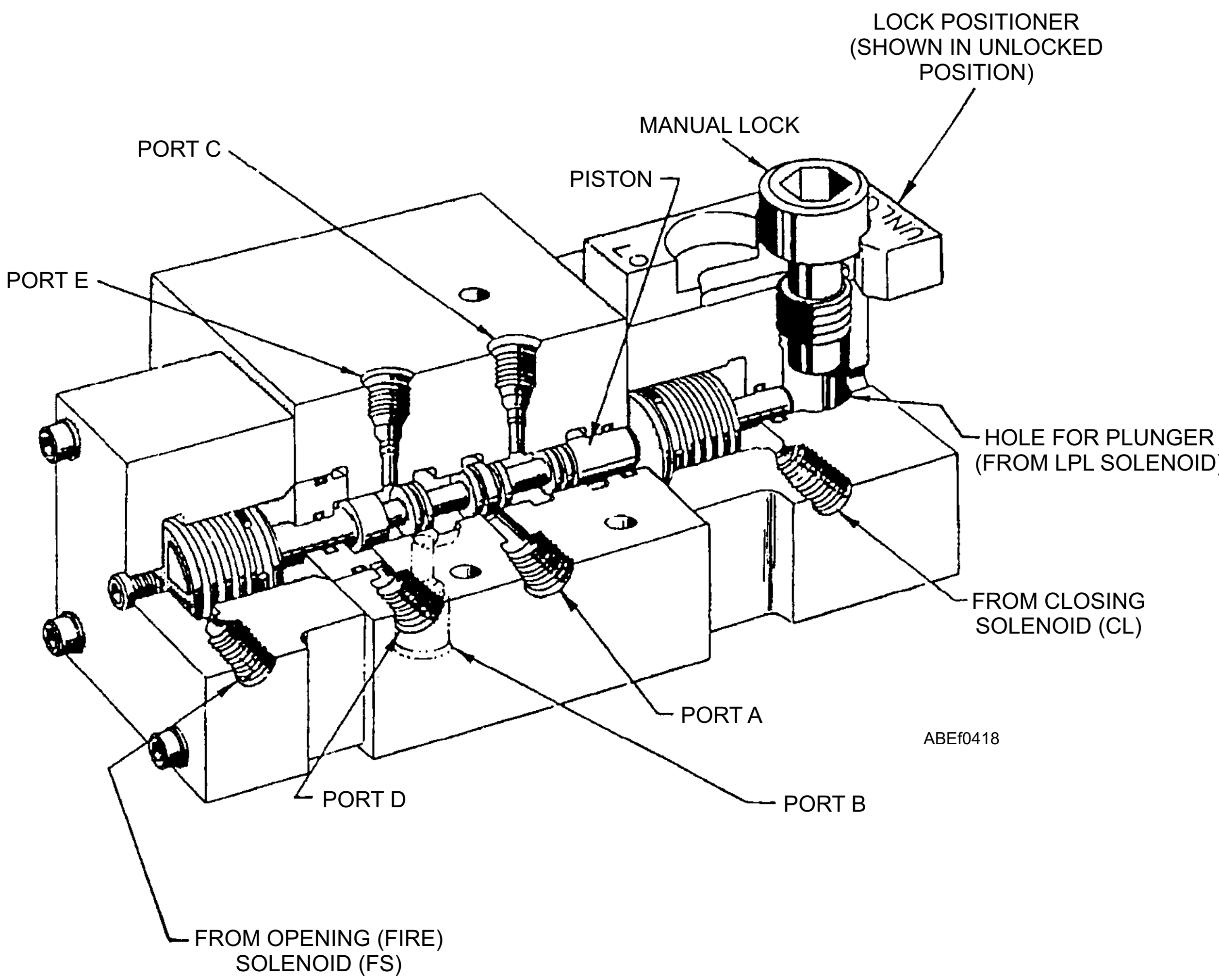


Figure 4-17.—Launch-valve hydraulic lock valve.

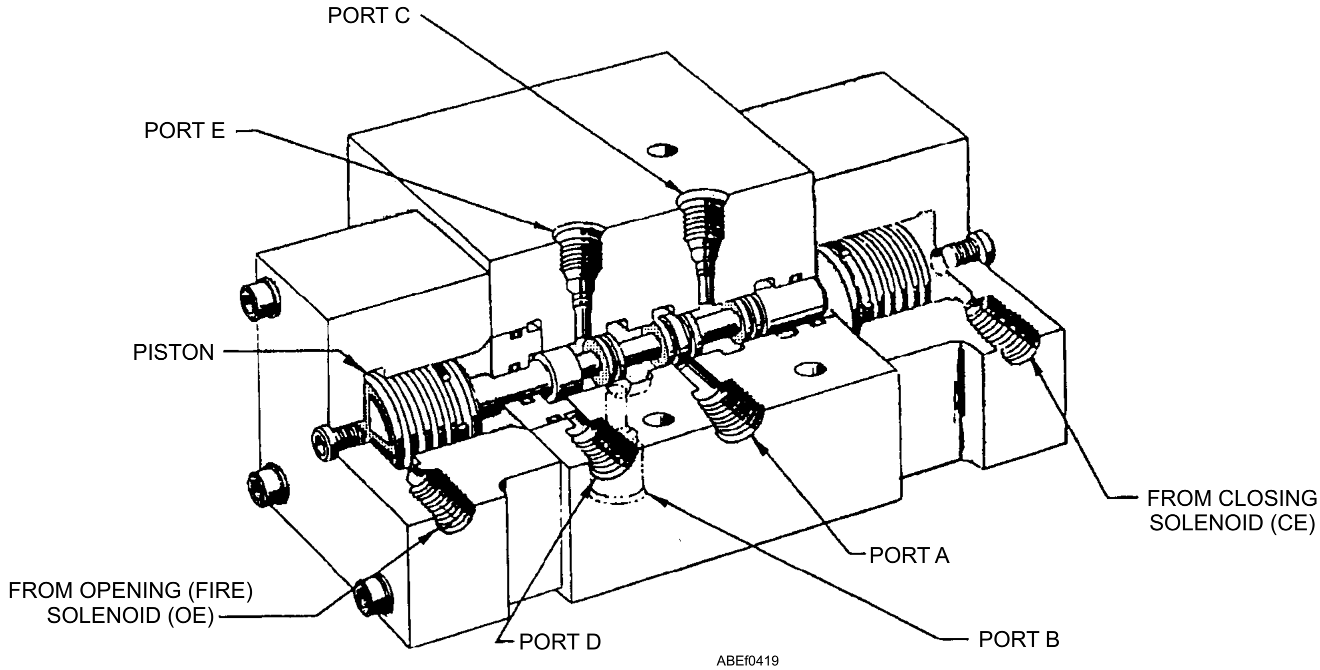
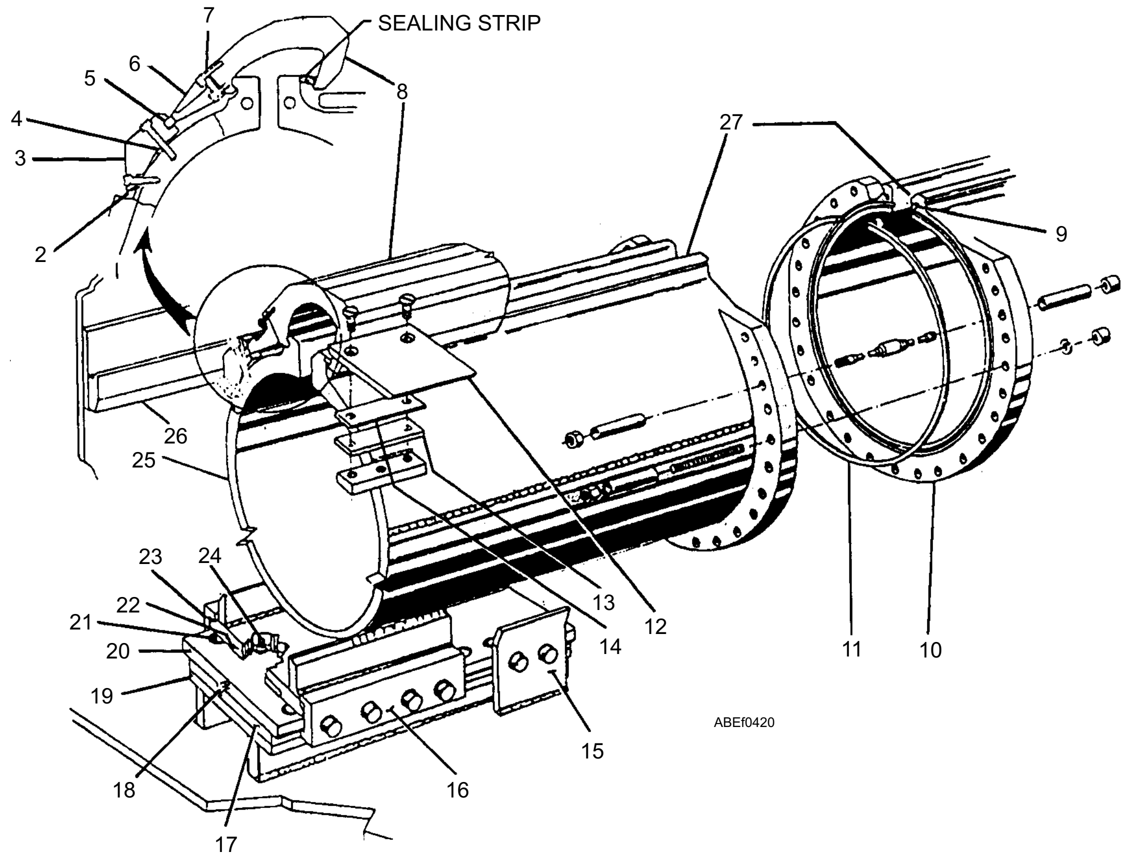


Figure 4-18.—Exhaust-valve hydraulic lock valve.



1. **Thick spacer**
2. **Shim**
3. **Cylinder outer block**
4. **Thin spacer**
5. **Cylinder outer-block spacer**
6. **Cover support bracket**
7. **Shim**
8. **Cylinder cover**
9. **Dowel pin**
10. **Flange**
11. **Aligning ring**
12. **Cable support plate**
13. **Cable support spacer**
14. **Cable support shim**
15. **Guide**
16. **Clamp**
17. **Shim (NAVSHIP)**
18. **Lubrication fitting**
19. **Pad (NAVSHIP)**
20. **Baseplate**
21. **Bolt**
22. **Bearing pad**
23. **Cylinder base**
24. **Screw**
25. **Launching engine cylinder**
26. **Track supporting bar**
27. **Cylinder slot**

Figure 4-19.—Typical Cylinder Section.

The exhaust-valve hydraulic lock valve (fig. 4-18) opens and closes the exhaust valve by controlling the flow of hydraulic fluid to the exhaust-valve actuator. When the exhaust-valve open solenoid is energized, air pressure is directed to the opening side of the lock valve, causing it to shift. This allows fluid to flow from port A, out port B, through the keeper valve, and into the opening chamber of the actuator. Fluid also flows from port D to lock the valve in the OPEN position. When the exhaust-valve closed solenoid is energized, air pressure shifts the lock valve to the closed position, allowing fluid to flow from port A, out port C, and into the closing chamber of the exhaust-valve actuator. The valve is locked in this position by pressure from port A acting on the larger working area of the lock valve piston.

LAUNCHING ENGINE CYLINDERS

Each catapult has two rows of launching engine cylinders (see fig. 4-4) mounted parallel to each other in the catapult trough. Each row of cylinders is made up of sections that are slotted on the top and flanged at each end, with the number of sections determined by the overall length of the catapult. The cylinder sections are bolted together at their flanges (fig. 4-19) by means of long stud bolts, spacers, and nuts. The spacers and long stud bolts are designed to minimize bolt failure due to uneven thermal stress within the cylinders during preheating and operation. Each cylinder is identified by a serial number stamped on the outer surface of its flange.

Base pads are welded in the bottom of the catapult trough at specified intervals to match the bearing pads fastened to the cylinder bases. Shims are then used to properly align each cylinder section, and then the cylinder sections are secured to the trough base pads by bolts and clamps, which prevent the lateral movement of the cylinders while allowing smooth elongation of the cylinders due to thermal expansion. Lubricator fittings are provided for lubrication of the sliding surfaces.

CYLINDER COVERS

The cylinder cover (fig. 4-20) acts as clamps holding the slotted portion of the cylinder in position to prevent radial spreading when steam pressure is applied. Space is provided in the cylinder covers for the sealing strip. Lubrication oil is supplied to the launching engine cylinders through lubrication ports and lubricators in each cover. Cylinder cover support brackets, screwed to the cylinder, hold the cylinder cover in place. Cover seals are used to seal and maintain alignment of each cylinder cover section.

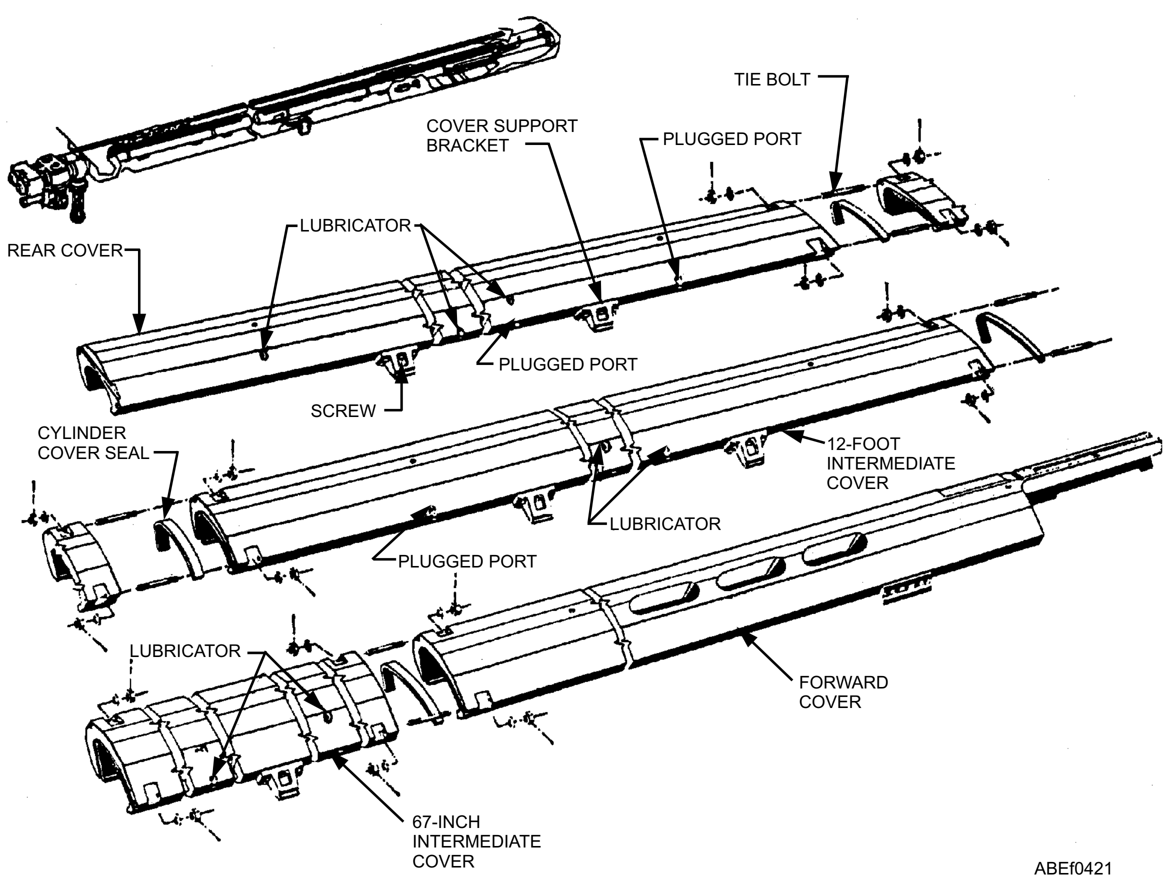


Figure 4-20.—Launching engine cylinder covers.

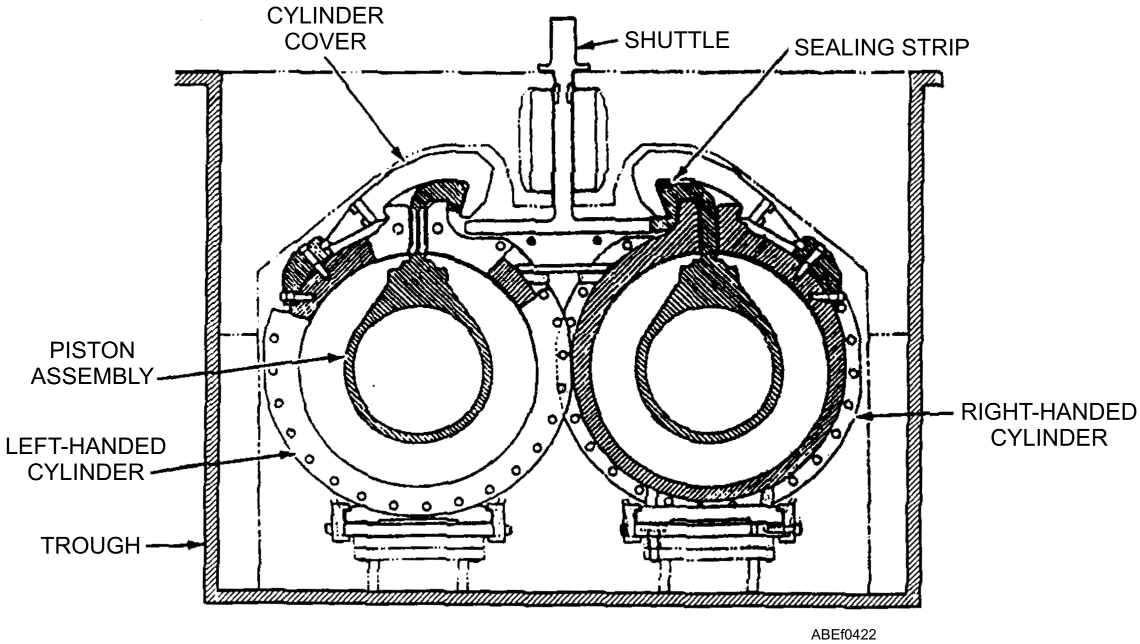


Figure 4-21.—Cross section of launching engine cylinders (typical).

CYLINDER SEALING STRIPS

The sealing strip (fig. 4-21) prevents the loss of steam from the cylinders by sealing the space between the cylinder lip and the cylinder cover. As the steam piston assemblies move through the cylinders, the piston connectors lift the sealing strips and the sealing strip guides reseat them. Action of the sealing strip is shown in figure 4-22. View A shows the strip position forward of the piston assembly. View B shows the connector lifting the strip to permit the piston-shuttle connector to pass under it. View C shows the guide

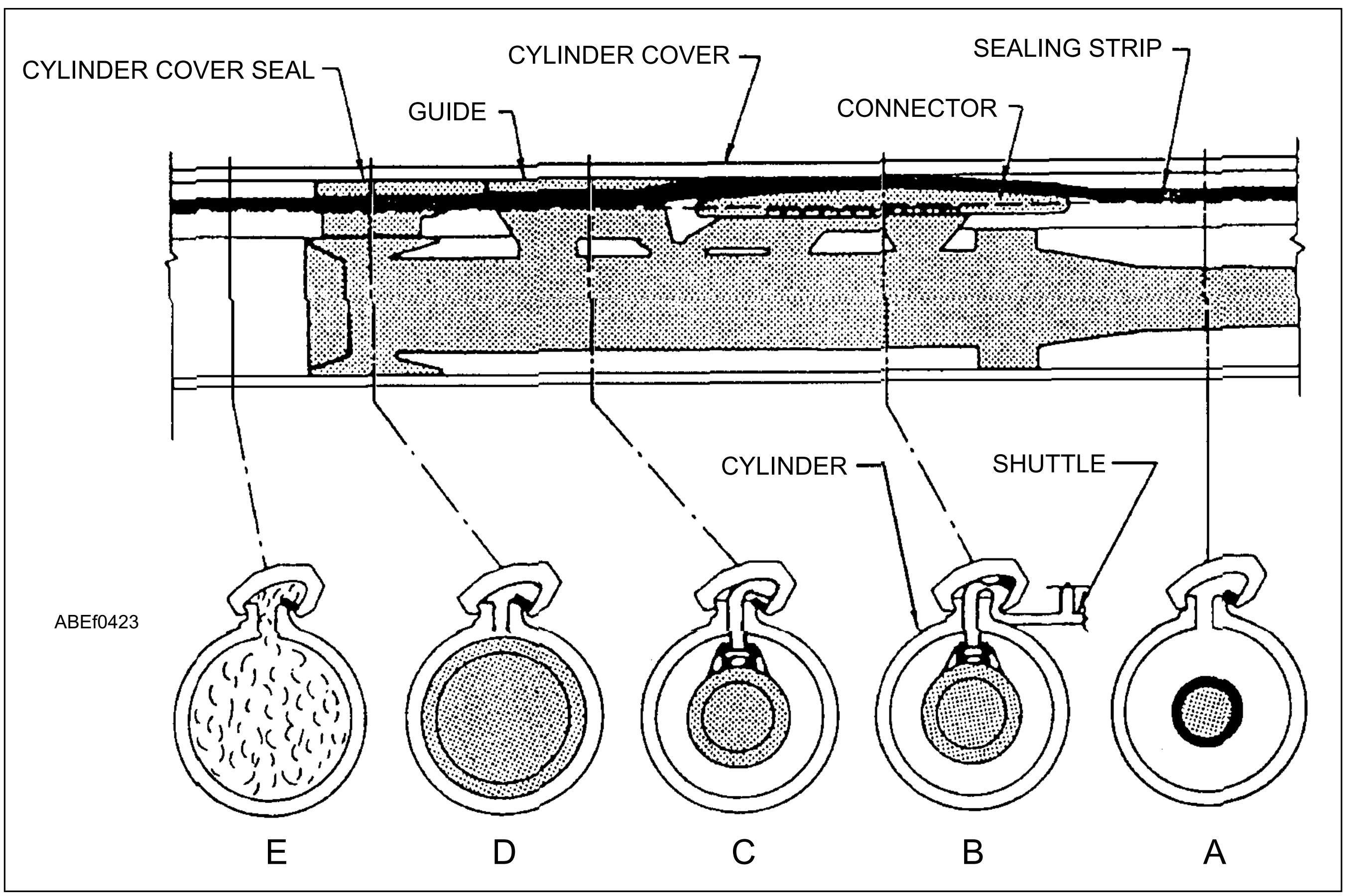


Figure 4-22.—Sealing strip action.

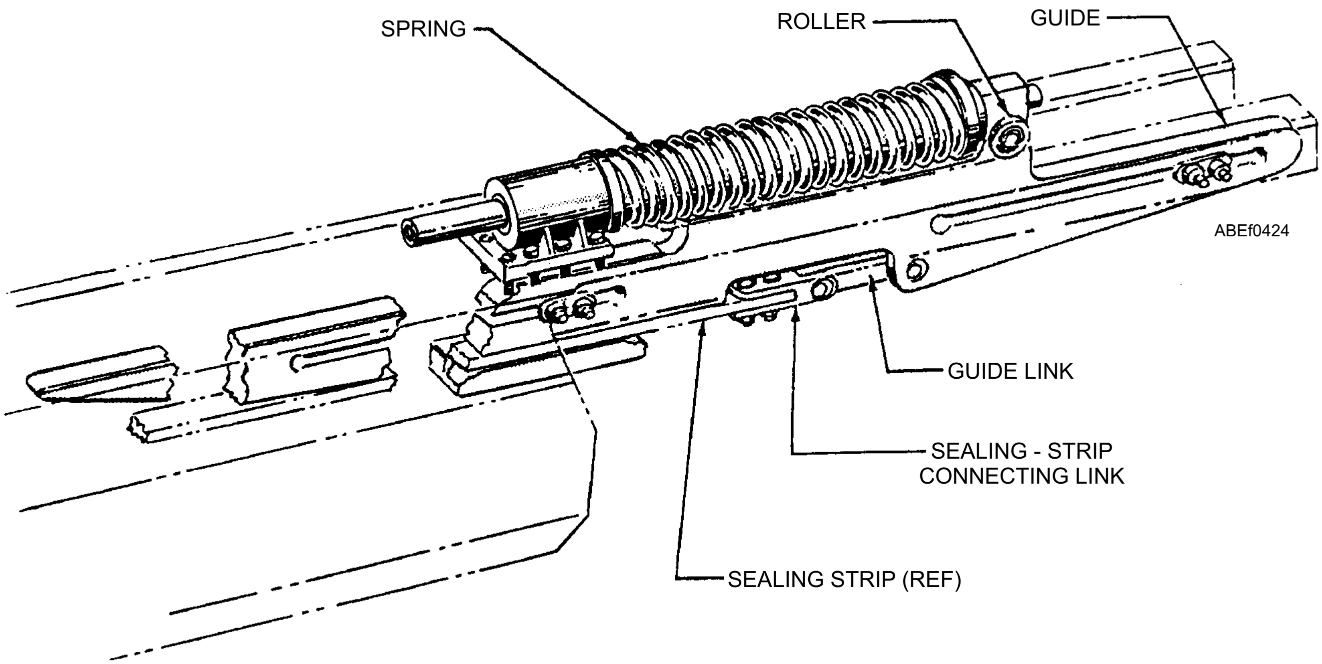


Figure 4-23.—Sealing strip tensioner.

re-laying the strip into its sealing position. View D shows the final step in seating. View E shows the strip fully seated with steam pressure keeping it seated.

SEALING STRIP TENSIONER

The sealing strip tensioner (fig. 4-23) is mounted on the end of the most forward cylinder cover on each cylinder. It applies constant tension to the sealing strip and holds the forward end of the strip in place. The tensioning force applied to the sealing strip is provided by a compressed spring. This force is transmitted to the sealing strip through the tensioner guide, which is free to slide back and forth on rollers.

SEALING STRIP ANCHOR AND GUIDE INSTALLATION

The sealing strip anchor and guide installation (see fig. 4-24) is mounted on the forward flange of each thrust/exhaust unit or exhaust tee. It anchors the after end of the sealing strip by gripping the strip between a

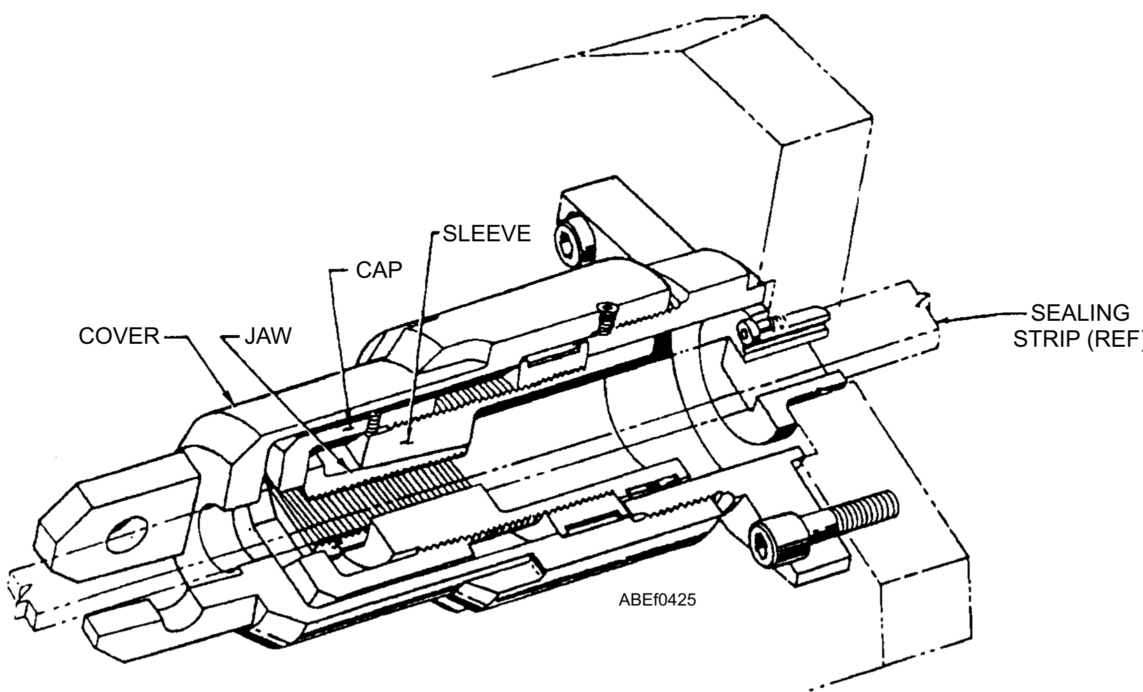


Figure 4-24.—Sealing strip anchor and guide.

set of jaws wedged into a hollow sleeve and held in place by a threaded cap

STEAM PISTON ASSEMBLY

The launching engine piston assembly (see fig. 4-25) consists of left and right hand launching pistons and attaching parts. The launching engine pistons are installed side by side in the launching engine cylinders the shuttle assembly provides the connection for one launching piston to the other along with the connection to the aircraft. The pressurized steam in the launching engine cylinders drives the launching engine steam piston assemblies. They, in turn, drive the shuttle. Component parts of each piston assembly are the steam piston, the barrel, the connector, the strip guide, the piston guide, and the tapered spear

The barrel serves as the chassis for the other components of the assembly. The piston is bolted to the aft end of the barrel; the piston rings installed on the piston seal the space between the piston and the cylinder wall. The cylinder cover segmented seal assembly acts as an extension of the piston into and through the cylinder slot. This seal assembly consists of a housing, three upper seal segments, and six lower seal segments. The upper seal segments press against the cylinder covers, and the lower seal segments press against the sides of the cylinder slot to prevent the loss of steam pressure from behind the steam pistons as the piston assemblies move through the cylinders during the power stroke. The connector and the strip guide are bolted to the top of the barrel. The connector lifts the sealing strip off its seat to permit passage of the shuttle assembly along the cylinder. The strip guide returns the sealing strip to its seat after the connector passes under it, minimizing loss of steam pressure as the piston assembly advances through the power stroke. In addition, the connector has interlocking "dogs," which couple with matching "dogs" on the shuttle assembly to effect the connection between the connectors and the shuttle assembly.

The tapered spear and bronze piston guide are bolted to the forward end of the barrel. The piston guide acts as a bearing surface for the piston assembly and keeps it centered with respect to the cylinder walls. The tapered spear works in conjunction with the water-brake cylinder assemblies to stop the piston assemblies and shuttle at the end of the power stroke.

SHUTTLE ASSEMBLY

The shuttle assembly (see fig. 4-26) carries the forward motion of the pistons to the aircraft by means of a launch bar attached to the aircraft nose gear and connected to the nose gear launch shuttle spreader. The meshing of interlocking “dogs” of the piston assembly connectors and the shuttle frame connect the shuttle and the piston assemblies.

The shuttle is essentially a frame mounted on rollers. Two pairs of rollers fitted with roller bearings

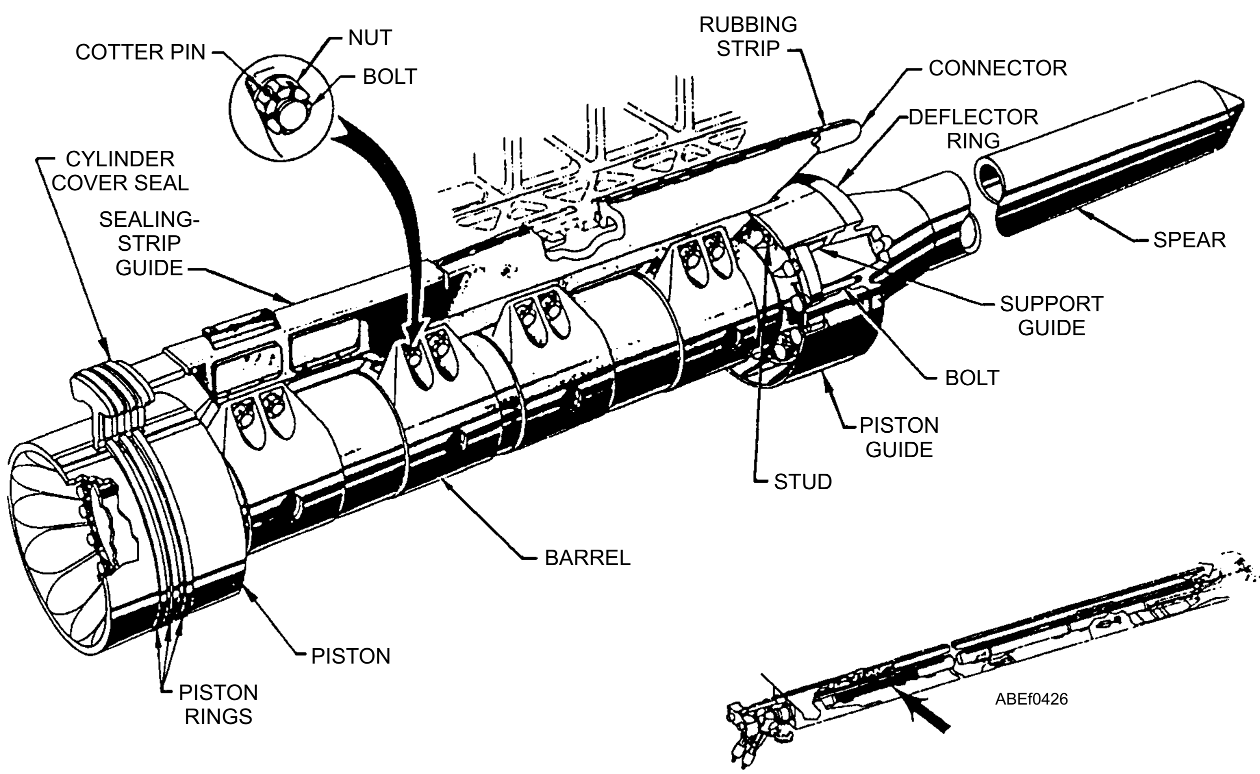


Figure 4-25.—Launching engine steam piston assembly.

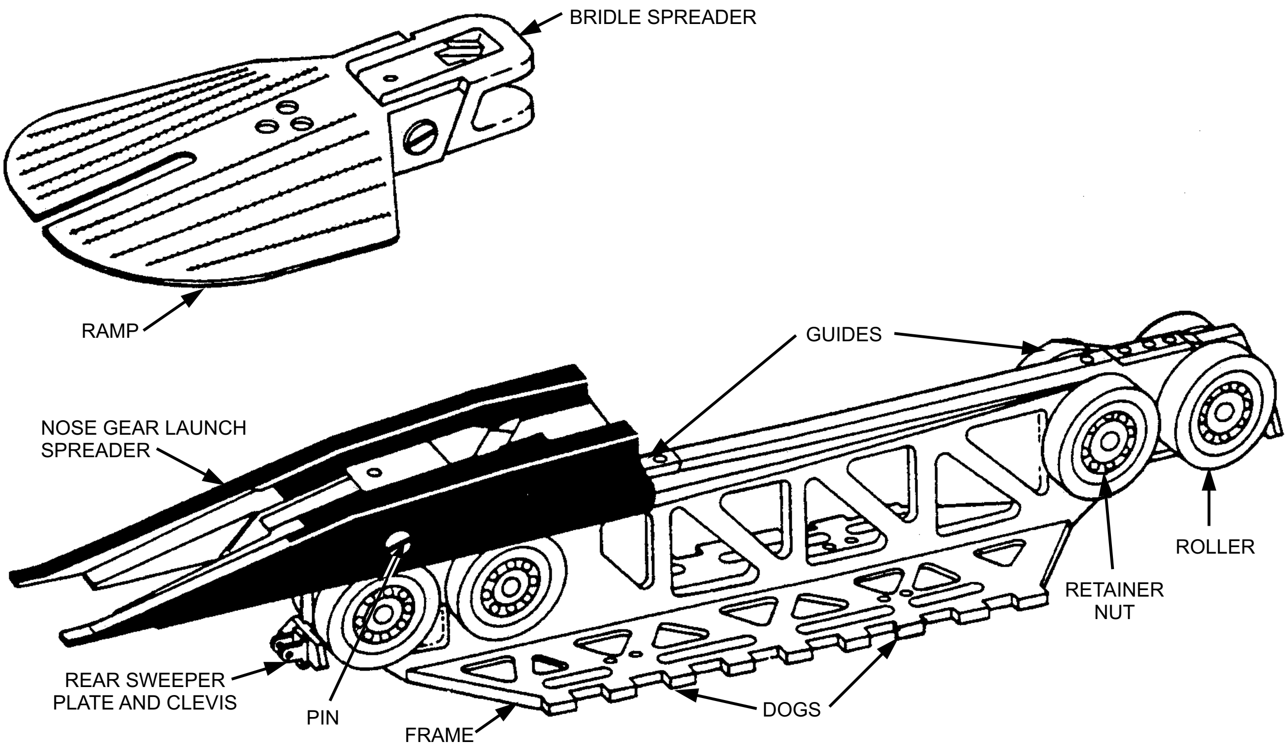


Figure 4-26.—Shuttle assembly.

are installed on hubs mounted at each end of the shuttle frame. The shuttle is installed in a track between and above the launching engine cylinders. The trough covers form the shuttle track, which supports and guides the shuttle.

The bearings of the rollers are lubricated through fittings, which are accessible through the slot in the shuttle track. The shuttle blade is part of the shuttle frame and is the only part that protrudes above the shuttle track. The nose gear launch spreader is attached to the shuttle blade.

WATER-BRAKE CYLINDERS

The water-brake cylinders (fig. 4-27) are installed at the forward end of the launching engine cylinders.

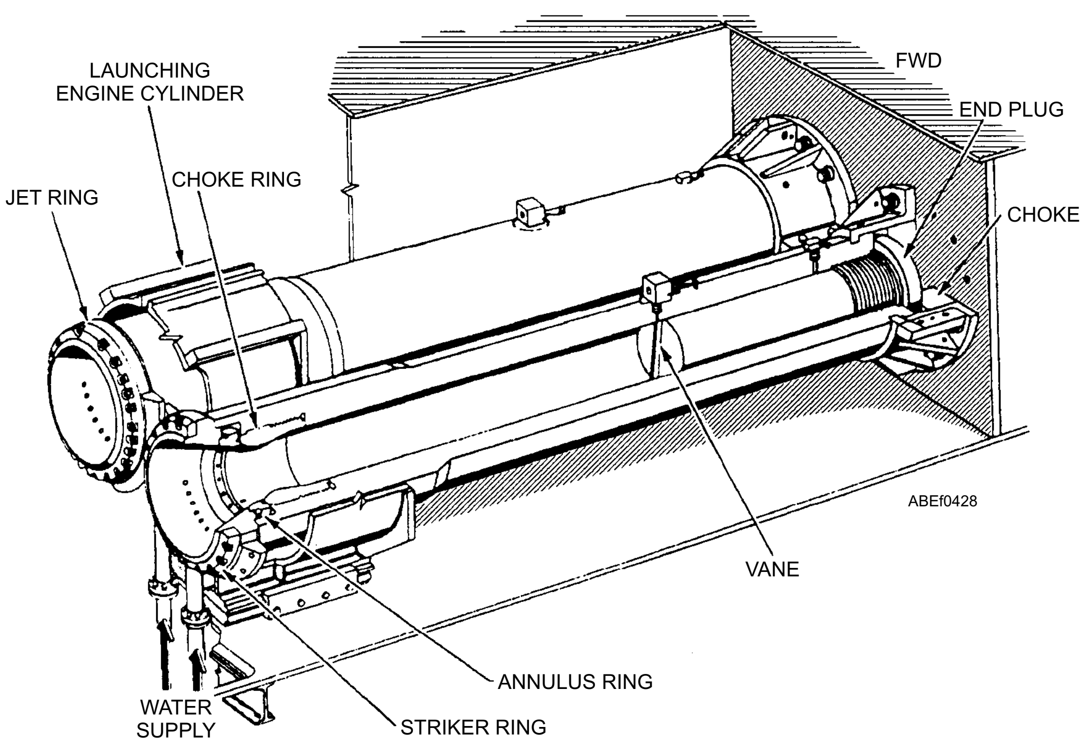


Figure 4-27.—Water-brake cylinder installation.

The water brakes stop the forward motion of the shuttle and pistons at the end of the catapult power stroke. The after end of each water-brake cylinder is supported and aligned by the most forward section of each launching engine cylinder, which telescopes over the after end of the water-brake cylinder. The forward end of each cylinder is anchored in place by an upper bracket and lower support saddle and chock.

The open end of each cylinder holds four rings. They are the choke ring, the annulus ring, the jet ring, and the striker ring.

The choke ring is the innermost ring and is threaded into the water-brake cylinder. The annulus ring has angled holes machined in it to direct pressurized water into the cylinder and forms a vortex (whirlpool) at the open end of the cylinder. The jet ring is bolted to the end of the cylinder and holds the annulus ring in place. The striker ring, the outermost of the four rings, are designed to absorb the impact of any metal-to- contact between the launching engine piston assemblies and the aft end of the water brakes.

WARNING

To prevent damage to the water brakes and piston assembly components, a water-brake pump must be running any time the shuttle and piston assemblies are not fully bottomed in the water brakes.

A vane is keyed to the end plug (see fig. 4-27). Its purpose is to break up the vortex caused by the annulus ring and to create a solid head of water in the cylinder, which is maintained by the continued vortex action at the mouth of the cylinder.

Braking action occurs at the end of the power run when the tapered spear on the piston assembly enters the water brake. Water in the brake is displaced by the spear and forced out the after end of the cylinder between the choke ring and the spear (fig. 4-28). Since the spear is tapered, the space between the choke ring and the spear is gradually decreased as the spear moves into the brake cylinder. This arrangement provides a controlled deceleration and energy absorption, which stops the piston assembly within a distance of about 5 feet without damage to the ship's structure.

WATER-BRAKE TANK

The water-brake tank is installed below the water-brake cylinders to supply water to and reclaim water spillage from the water brakes during operation. It has a minimum capacity of 3,000 gallons of fresh water. Overflow and oil-skimming funnels and bottom drains are provided in the tank to maintain proper water level and to remove excess oil used in the lubrication of the launching engine cylinders.

WATER-BRAKE PUMPS

Water is supplied to the water-brake cylinders by two electric-motor-driven, rotary-vane-type pumps installed in the immediate vicinity of the water-brake tank. They are capable of producing 650 gallons of water per minute at 80 psi. The pumps are electrically interlocked so that if the running pump breaks down,

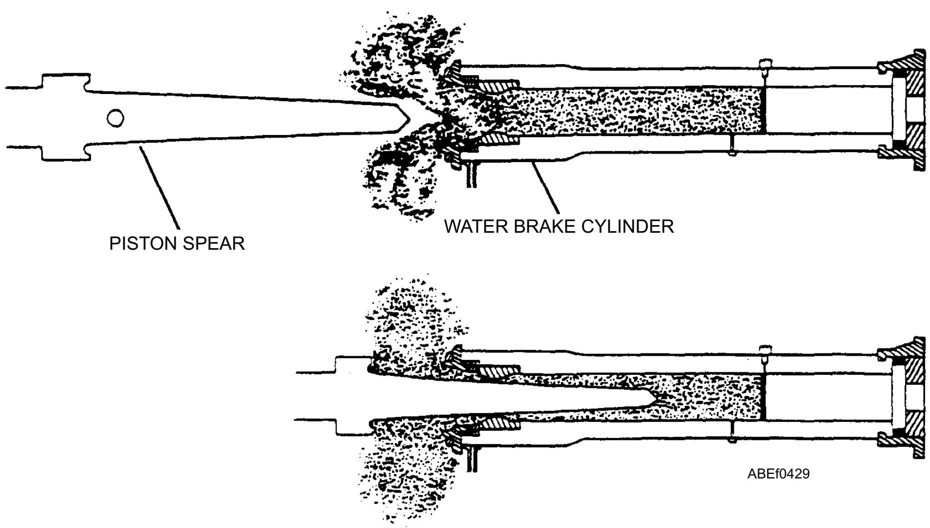


Figure 4-28.—Water brakes.

the alternate pump automatically starts running. A gauge board within the pump room contains gauges for pump suction and discharge pressure and for measuring the water pressure at the connectors (elbow pressure).

WATER-BRAKE WATER SUPPLY PIPING

The suction inlets of the pumps (fig. 4-29) are submerged in the water-brake tanks. The pump discharges each with appropriate valves and a flow-limiting orifice plate, are tied together and connected via flexible hoses to strainer flanges at the bottom of the water supply pipes. Hoses and rigid piping connect the pressure switches to the supply pipes. A pump suction gauge and a pump discharge gauge are located on the gauge panel for each pump. These are in addition to the gauges for the pressure sensing switches. The suction side of the pump consists of an inlet with a gate type shutoff valve, a gauge valve, and a Macomb strainer immediately ahead of the pump inlet. A petcock for venting is mounted at the top of the strainer. The discharge side of each pump includes a flow limiting orifice plate, a check valve, and a gate type shutoff valve. Two discharge lines merge into a single line, which later splits into two lines. High-pressure, flexible hoses lead to and connect to the brake cylinder water supply connectors, which are attached to the water-brake cylinders. A drain valve for the water-brake tank leads to an overboard discharge. Fresh water from the ship's system is added to the tank via fill and shutoff valves in the water-brake pump room.

WATER-BRAKE PRESSURE-SENSING SWITCHES

Two pressure switches are connected to the piping leading from the pumps to the brake cylinders (see fig. 4-29). They usually are installed on the bulkhead adjacent to the tank. The switches are electrically tied in with the main control console/ICCS/CCP to prevent operation in case the pressure falls below normal. Water pressure keeps the switch contacts closed, thus completing a circuit. Should the pressure fall below normal, either one or both of the switches will drop open, breaking the circuit. There are also two pressure gauges in the lines to give a visual indication of the pressure, commonly referred to as "elbow pressure."

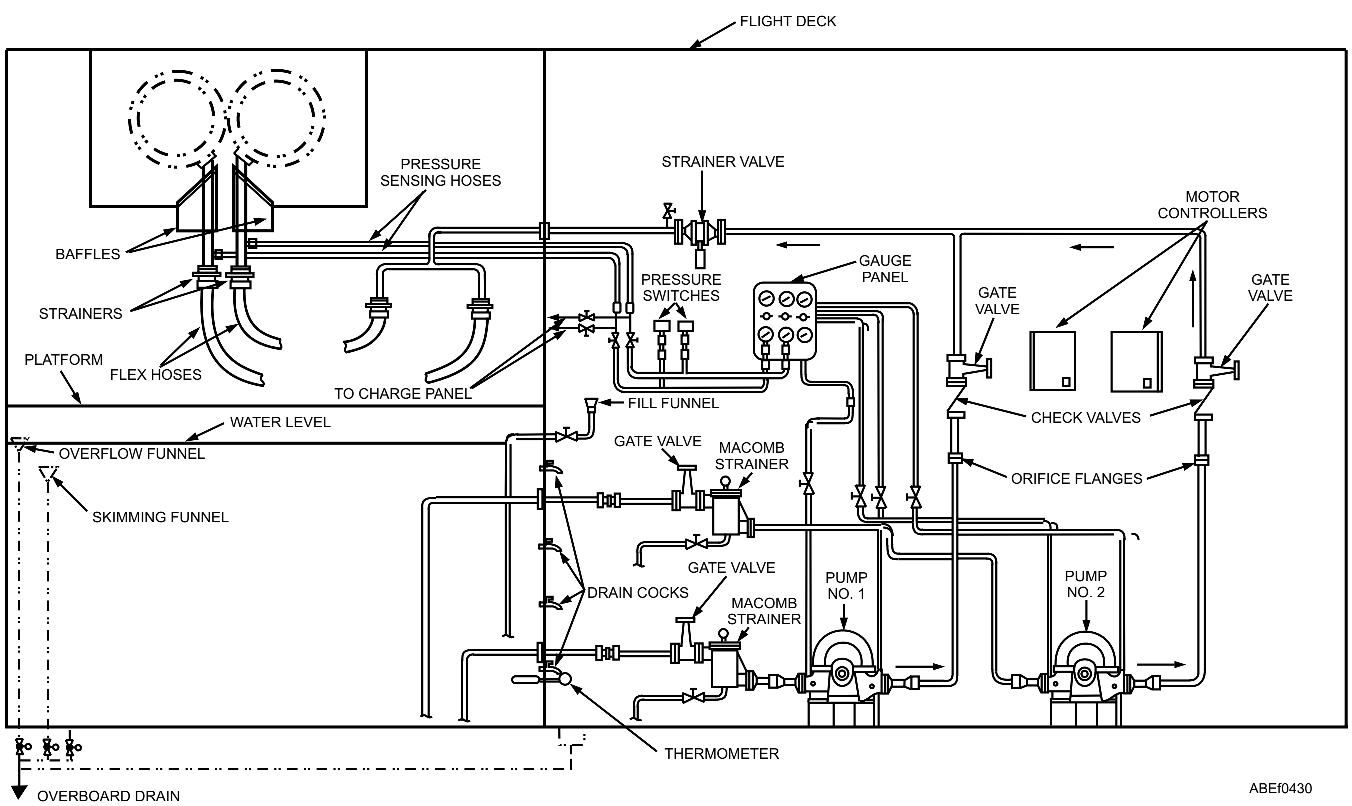


Figure 4-29.—Water-brake piping and pressure switch installation.

STEAM CUTOFF PRESSURE-SWITCH INSTALLATION

The steam cutoff switch installation (fig. 4-30) consists of two pressure switches and associated piping mounted in an intrusion-proof enclosure. The steam cutoff pressure-switch installation is located at a point in the catapult power stroke determined during the catapult certification program. Flexible tubing connects the steam cutoff pressure switch assembly to a port in one of the launching engine cylinders. After the catapult is fired, when the launching engine piston passes the port that is connected to the cutoff switches, steam pressure actuates each switch. This initiates the launch complete phase of operation and the subsequent closing of the launch valve. The pressure switches are preset to close at an increasing pressure of approximately 20 psi and open at decreasing pressure of approximately 10 psi.

CATAPULT TROUGH INSTALLATION

The catapult trough installation (fig. 4-31) provides a means of covering the catapult trough and providing a track within which the shuttle and grab rollers ride. In addition, it covers the launching engine components and seals the launch valve area from fluid spills and debris.

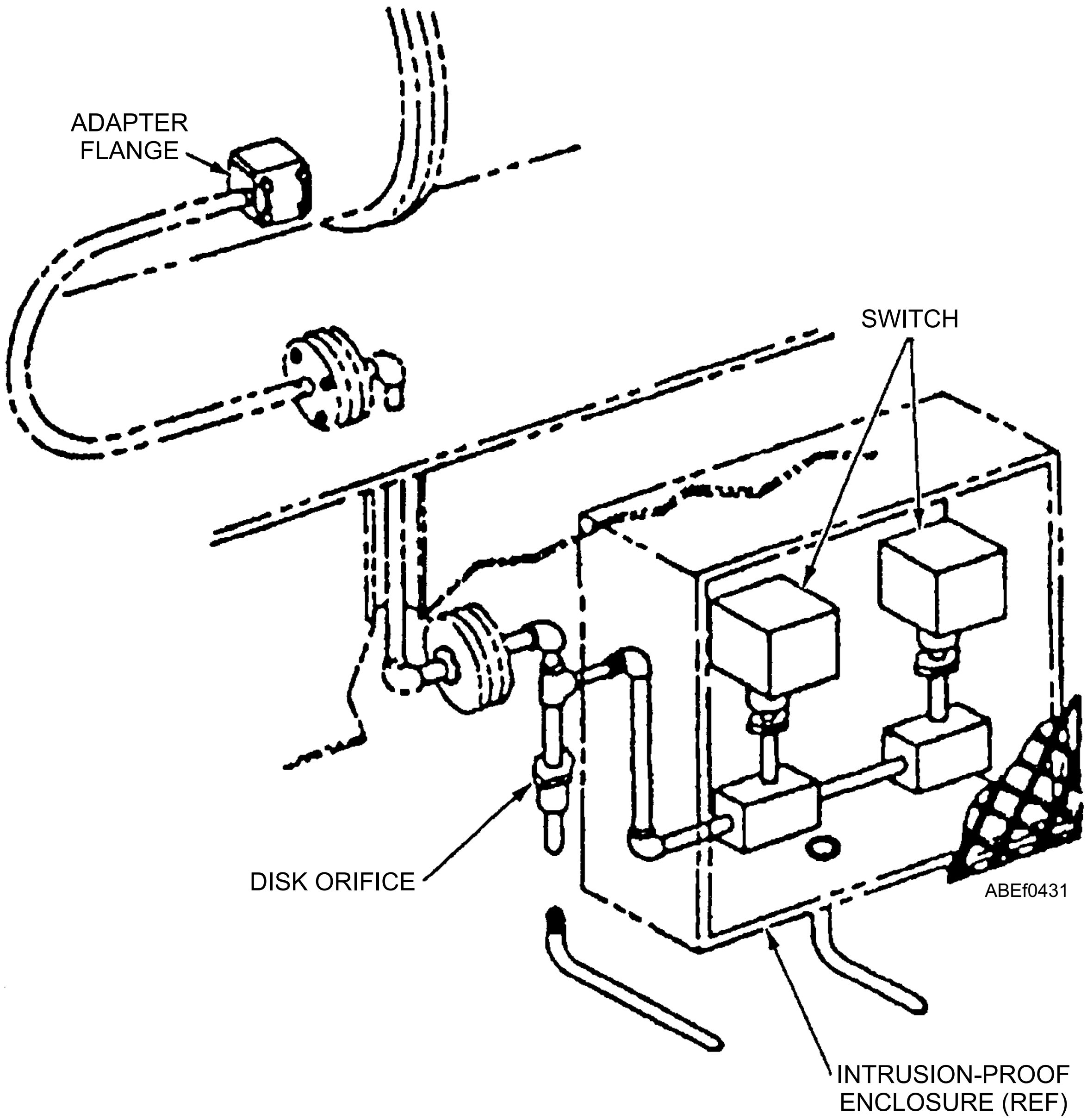


Figure 4-30.—Steam cutoff pressure switches.

Aft Portable Trough Cover

The aft portable cover or Flush Deck Nose Gear Launch (FDNGL) cover, covers the launch valve area and houses the bridle tensioner cylinder and NGL unit. Access covers are provided for the bridle tensioner hydraulic lines.

Shroud and Periphery Drain

On most ships, a shroud and periphery drain assembly is installed directly below the FDNGL cover and on top of the launch valve to further protect the launch valve and its associated piping from corrosion

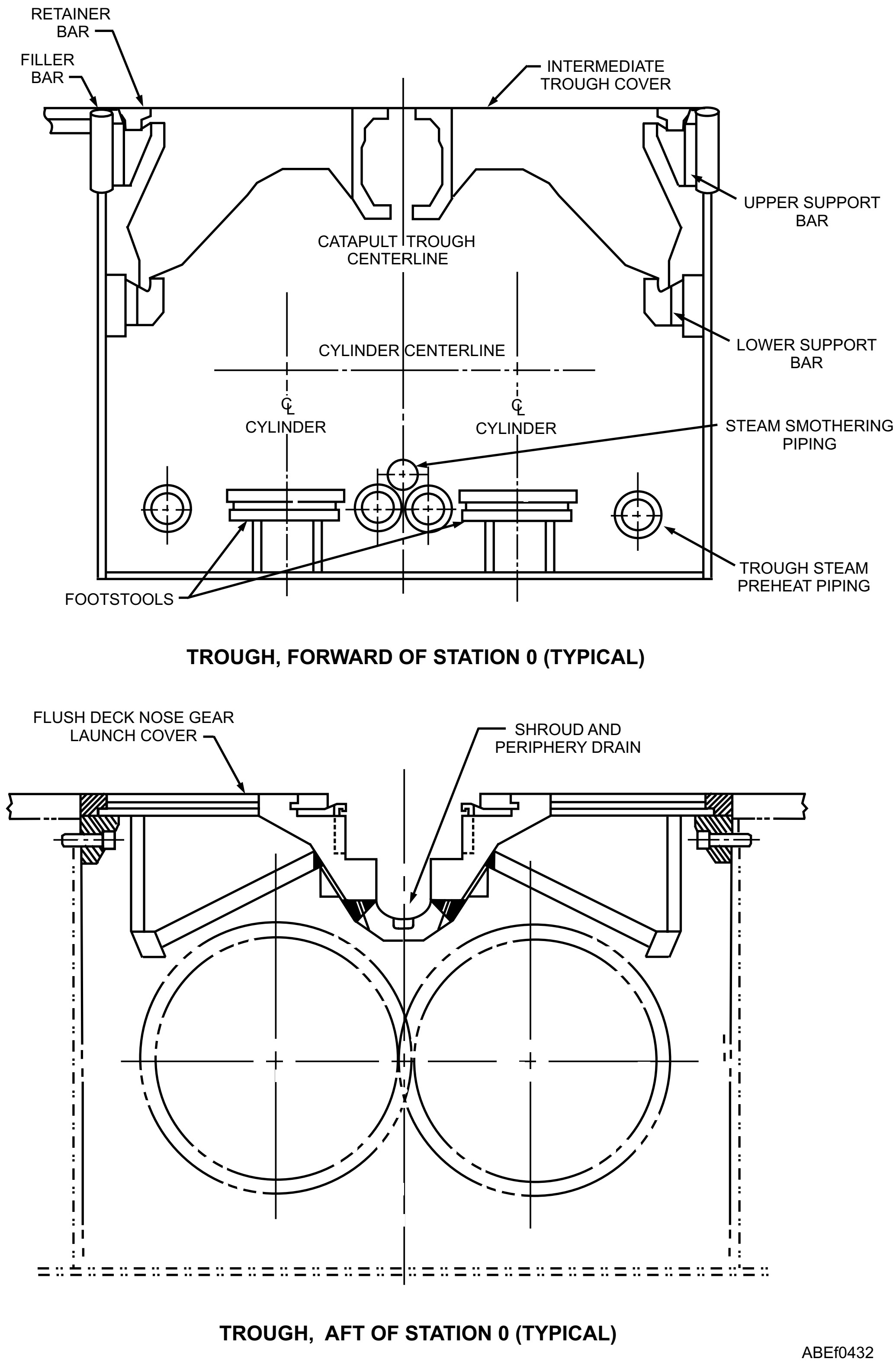


Figure 4-31.—Catapult trough installation.

resulting from water or other fluids leaking past the FDNGL cover.

Intermediate Tough Covers

The intermediate trough covers bridge the catapult trough to provide a smooth continuous flight deck and are manufactured with a track section (channel) which supports and guides the shuttle and grab during catapult operations. All trough covers are designed to withstand a vertical rolling load of 264,000 pounds total (132,000 pounds to each cover) in upward directional force and 100,000 pounds wheel-load in downward directional force. The standard trough covers are made in various lengths.

Forward Trough Covers

The forward trough covers are nothing more than intermediate covers, machined to receive a splash bar to prevent water from splashing up out of the water brake tank when the spears enters the water brakes

Forward Portable Trough Covers

The forward portable trough cover is commonly known as the water brake cover plate. In covers the water brake area and contains access plates to allow for sealing strip tensioner inspection. Slots and attached scales are provided for cylinder expansion indicators.

Upper and Lower Support Bars

The upper and lower support bars are bolted to the catapult trough wall and serve to support and align the trough covers. In addition, the upper support bars provide a means of securing the trough covers in place

Retainer Bars

The retainer bars bolt to and secure the trough covers to the upper support bars

Slots Seals

The slots seals are “T” shaped rubber seals that are installed in the trough cover slots during all non-operation periods. The slot seals aid in maintaining proper catapult cylinder elongation, as well as preventing deck wash, fuel and debris from entering the catapult trough.

Track Slot ButtonS

Track slot buttons (fig. 4-32) are provided to prevent the arresting gear purchase cables from falling into catapult number three’s trough cover slot during recovery operations. Track slot buttons must be removed prior to any catapult operations

Track Slot Button Installation

1. Removed the button from the designated ready storage area and install 12 buttons at 12 feet intervals beginning with the first button 12 feet forward of catapult position.
2. Insert speed wrench in each button latch capscrew and turn one full turn counter-clockwise. This will align the latches with the button.
3. Place the button in the track slot and turn each latch capscrew clockwise until it is fully tightened. Insure each latch turns to a position perpendicular to the track slot.

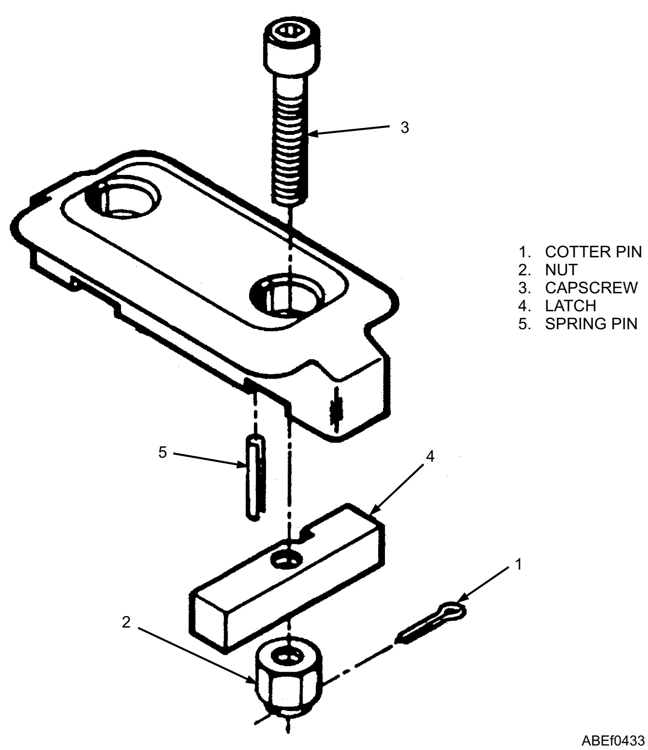


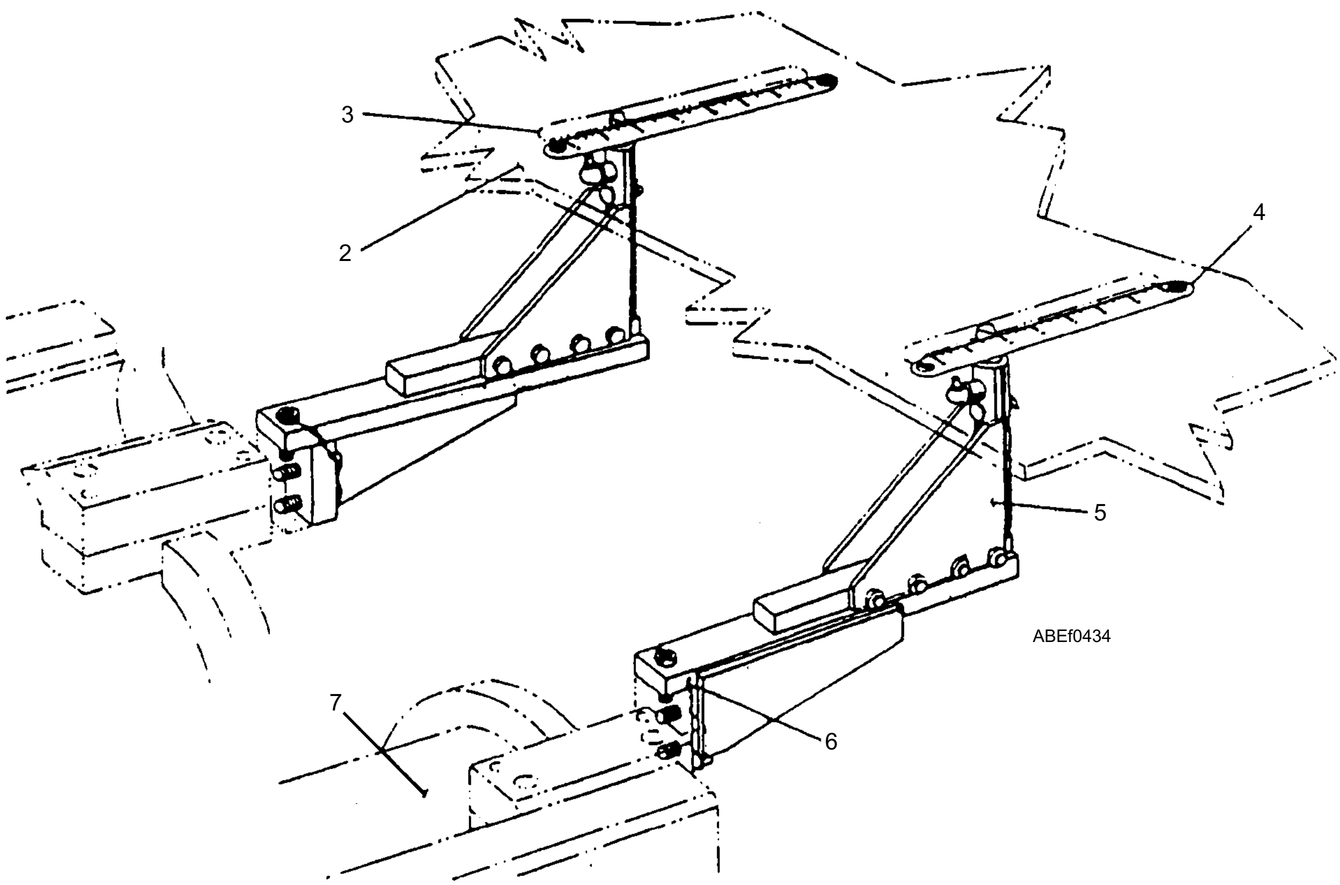
Figure 4-32.—Track slot button.

Track Button Removal

1. Turn the latch capscrew of each button counterclockwise until the latches are aligned with the buttons. The button can then be lifted out of the slot with the speed wrench.
2. Perform a count of the buttons to ensure they have all been removed.
3. Return the buttons to their storage cart and return the cart to their designated storage area.
4. Any missing or damaged button shall be reported to the catapult officer.
5. After the catapult slot has been cleared of buttons, stow the shuttle forward.

Cylinder Expansion Indicator

The cylinder expansion indicators (fig. 4-33) provide a flight deck visual indication of cylinder thermal expansion. There are two expansion indicators, each connected to the forward end of each launching engine cylinder. The indicator support is fastened to the cylinder cover inner male guide, and supports the pointer assembly. The pointers normally extend through slots in the deck, but are spring loaded to prevent damage during deck access cover removal. Recessed in the deck beside each deck slot is a scale with 0.10-inch graduations. The expansion indicators move with the cylinders, and expansion can be measured directly by reading the scale beside the pointer.



1. Inner male guide
2. Deck
3. Slot
4. Scale
5. Pointer assembly
6. Support
7. 9-foot Cylinder

Figure 4-33.—Expansion indicator.

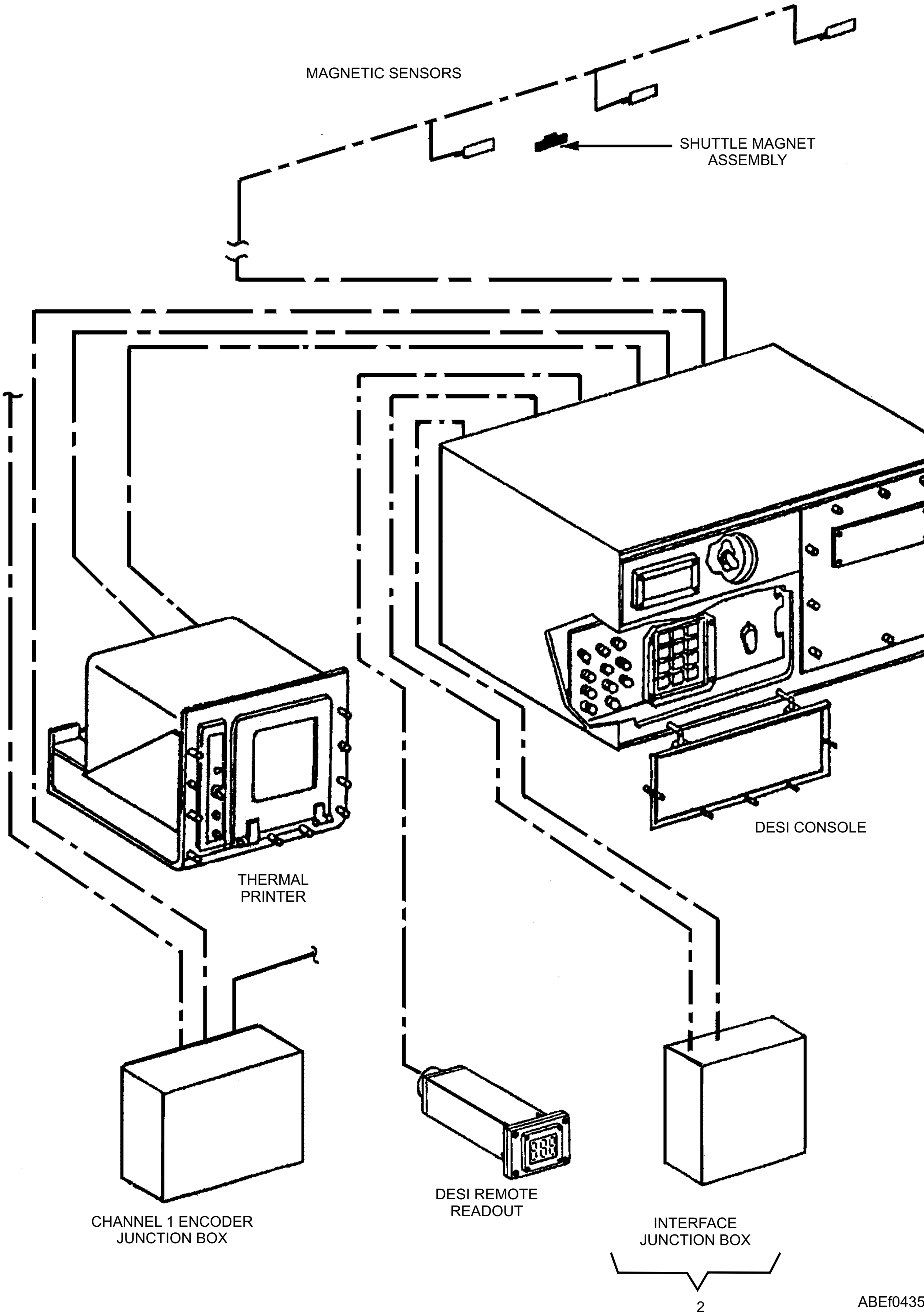


Figure 4-34.—Digital endspeed indicator system.

Digital Endspeed Indicator System

The Digital Endspeed Indicator System (DESI) (fig. 4-34) provides a means for measuring the endspeed of the steam catapult shuttle during operation. The endspeed is measured when a shuttle-mounted magnet passes three magnetic sensors mounted in the catapult track near the water break end. The endspeed is digitally displayed for visual readout on a console assembly. In addition, on CVN-68 through CVN-76, a remote readout is provided in the catapult officer console. A thermal printer permanently records this along with other information such as Capacity Selector Valve (CSV) setting, date, time, and shot count. For more detailed information on the DESI installation, refer to technical manual NAVAIR 51-15ABE-2.

LUBRICATION SYSTEM

LEARNING OBJECTIVES: Describe the components of the lubrication system. Describe the function of the lubrication system.

The lubrication system (fig. 4-35) provides a means of lubricating the launching engine cylinder and sealing strip prior to firing the catapult, by injecting lubricating oil through the cylinder covers with a spray pattern that ensures even lubrication of the cylinder walls before passage of the launching engine pistons. The major components of the lubrication system consists of the following:

LUBE PUMP MOTOR SET

The lube pump motor set delivers lube oil from the lube tank to the lube side of the metering pumps/ injectors. The pump motor is left running continuously during operations.

LUBE STORAGE TANK

The lube storage tank stores lubricating oil for used during operations. The lube oil tank holds approximately 220 gallons and is located in close proximity to the lube pump. The lube oil tank is piped to the ship's lube oil stowage tank, which enables easy and convenient lube oil replenishment.

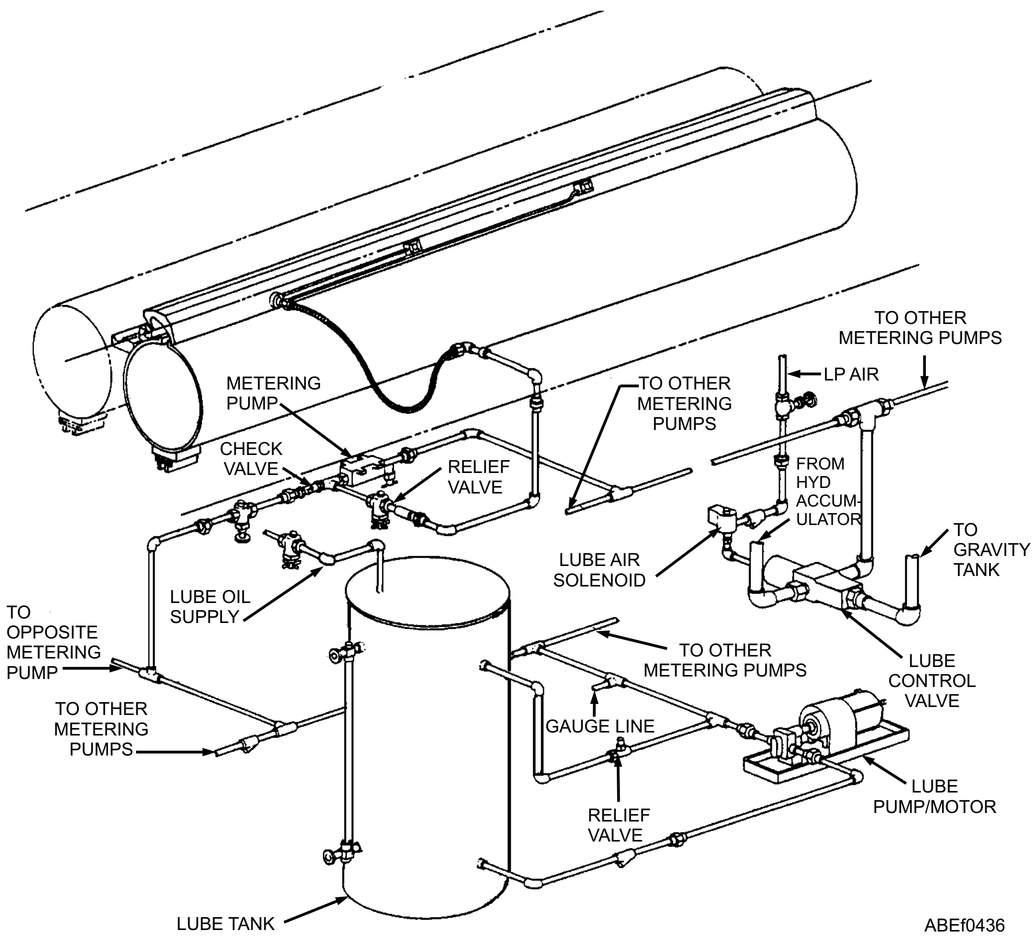


Figure 4-35.—Lubrication system.

AIR-OPERATED LUBE CONTROL VALVE

The lube control valve when actuated, directs accumulator pressure to the high pressure or actuating side of the metering pumps.

AIR-SOLENOID VALVE

The air-solenoid valve, when energized, directs low pressure air to an air cylinder on the lube control valve.

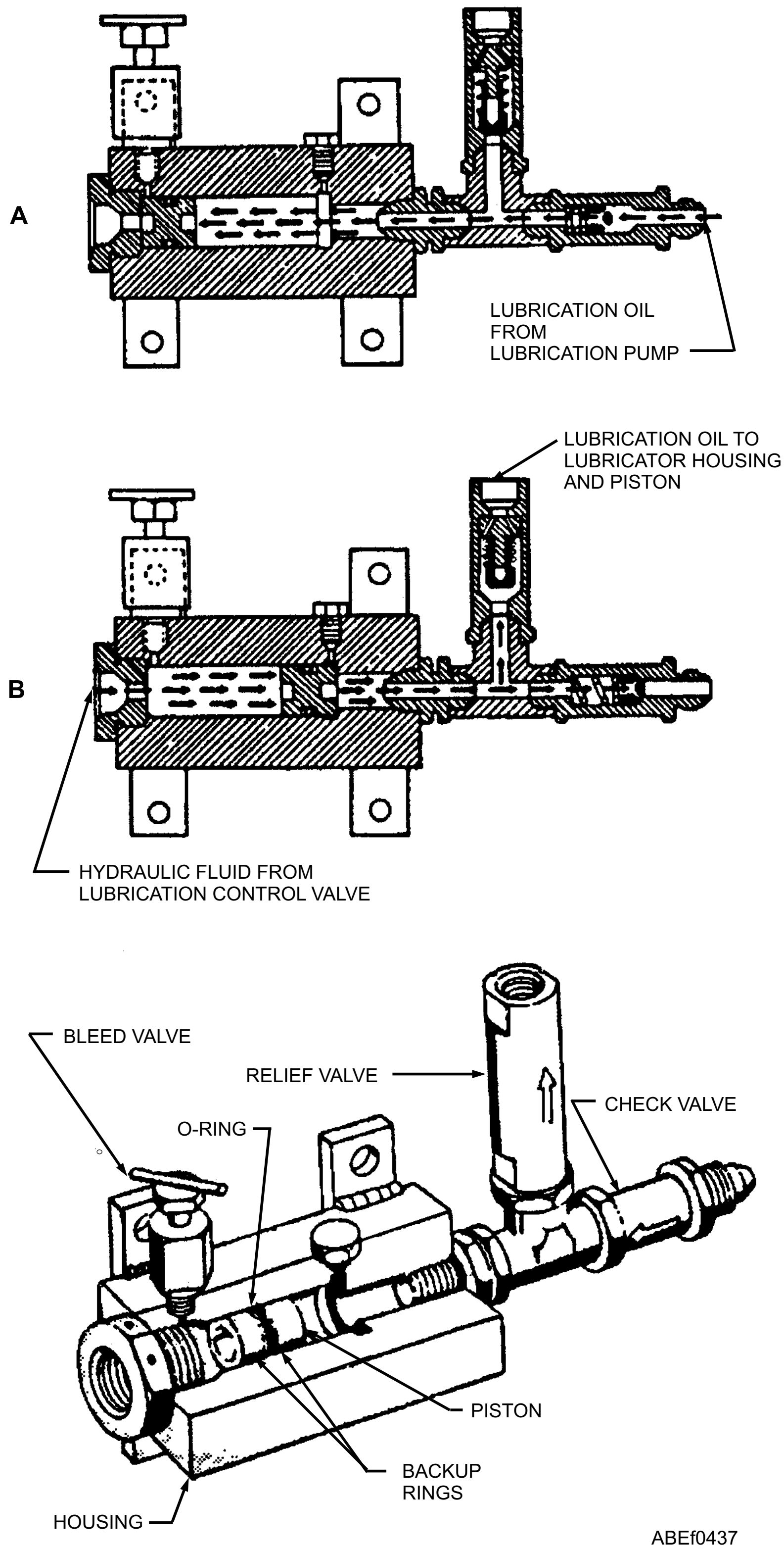


Figure 4-36.—Metering pump.

METERING PUMPS

The metering pumps distribute lubricating oil to the lubricator housing located on the cylinder covers. Each metering pump contains a piston that separates the metering pump into two chambers, a high-pressure hydraulic chamber and a lube oil chamber.

LUBE OIL SYSTEM OPERATIONS

With the lube air solenoid deenergized, accumulator pressure supplied to the lube control valve, acting on the differential area on the control valve piston will keep the control valve shifted to the air chamber side of the control valve. This allows the high-pressure hydraulic side of the metering pumps (fig. 4-36) to be vented through the control valve to the gravity tank. With the lube pump running, the metering pumps will fill with lube oil. When all metering pumps are full, the lube oil pump discharge pressure will increase to the pump relief valve setting (150-165). Pump discharge will now recirculate to the stowage tank while maintaining relief valve setting pressure throughout the lube oil side of the system.

When the lube air solenoid is energized, it directs low pressure air to the air chamber of the lube control valve, overcoming the unbalanced control valve piston. Low pressure air shifts the control valve allowing accumulator hydraulic pressure to be directed to the high-pressure hydraulic side of all the metering pumps (see fig. 4-36). The lube oil in the metering pumps is forced out through a relief valve and to the two injectors in each of the cylinder covers. One lube injector directs lube oil through the open cylinder slot and the other injector is angled to direct lube oil onto the sealing strip.

BRIDLE TENSIONING SYSTEM

LEARNING OBJECTIVES: Describe the components of the bridle tensioning system. Describe the function of the bridle tensioning system.

The bridle tensioning system (fig. 4-37) provides a means of tightly connecting the aircraft to the shuttle prior to firing the catapult. The bridle tensioning system is comprised of components that directly apply a forward force to the shuttle (external tension) and other

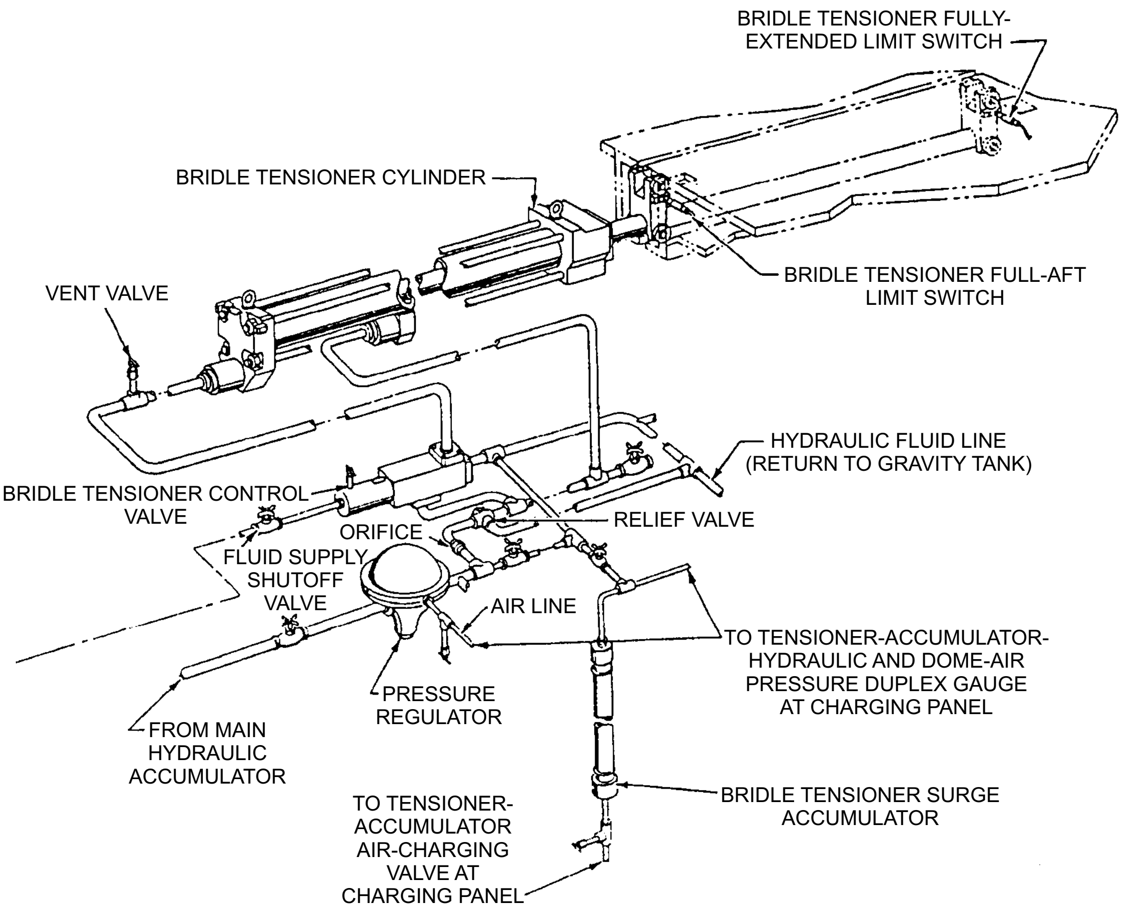


Figure 4-37.—Bridle tensioning system.

components that cause the retraction engine motor to slowly rotate (internal tension). The components of the external tensioning system is comprised of a bridle tensioner pilot valve, a pressure regulator, a tensioner control valve, a tensioner cylinder, a relief valve, and a full aft limit switch.

NOTE

The Mk 2 nose gear launch unit is an integral part of the bridle tensioning system. Its description and operation is discussed later in this manual.

TENSIONER PILOT VALVE

The tensioner pilot valve is located on the retraction engine manifold and is used to actuate the bridle tensioner control valve, internal tensioning inlet, and outlet valve.

PRESSURE REGULATOR

The pressure regulator is used to reduce accumulator pressure to the pressure required for the proper application (4000 plus or minus 250-ft lbs.) through the grab to the shuttle. Reduced pressure from the regulator is directed to the bridle tensioner control valve and to the forward end of the bridle tensioner cylinder.

BRIDLE TENSIONER CONTROL VALVE

The tensioner control valve directs reduced hydraulic pressure from the pressure regulator to the aft end of the tensioner cylinder during the bridle tension phase. At other times the control valve provides a vent to the gravity tank for the aft end of the tensioner cylinder.

BRIDLE TENSIONER CYLINDER

The purpose of the tensioner cylinder is to exert force on the catapult shuttle, via the shuttle grab assembly, to tension the aircraft launching hardware prior to launching. The bridle tensioner cylinder (fig. 4-38) is mounted directly below the nose gear launch (NGL) track and in line with the aft trough covers. The cylinder contains a piston with a rod extending out of the forward end of the cylinder. The end of the rod is fitted with a crosshead containing rollers, which supports and aligns the piston rod within the track formed by the two trough covers. A cam on the crosshead is used to actuate the bridle tensioner full aft limit switch.

RELIEF VALVE

The external tensioning relief valve is set to relieve at 150 psi over the normally required pressure.

BRIDLE TENSIONER FULL AFT LIMIT SWITCH

The full aft limit switch in the bridle tensioning system is located in the aftermost trough cover, and are actuated by a cam on the bridle tensioner piston rod crosshead. The fully aft limit switch, when actuated, allows completion of the RETRACT PERMISSIVE circuit. This prevents retraction of the grab and shuttle

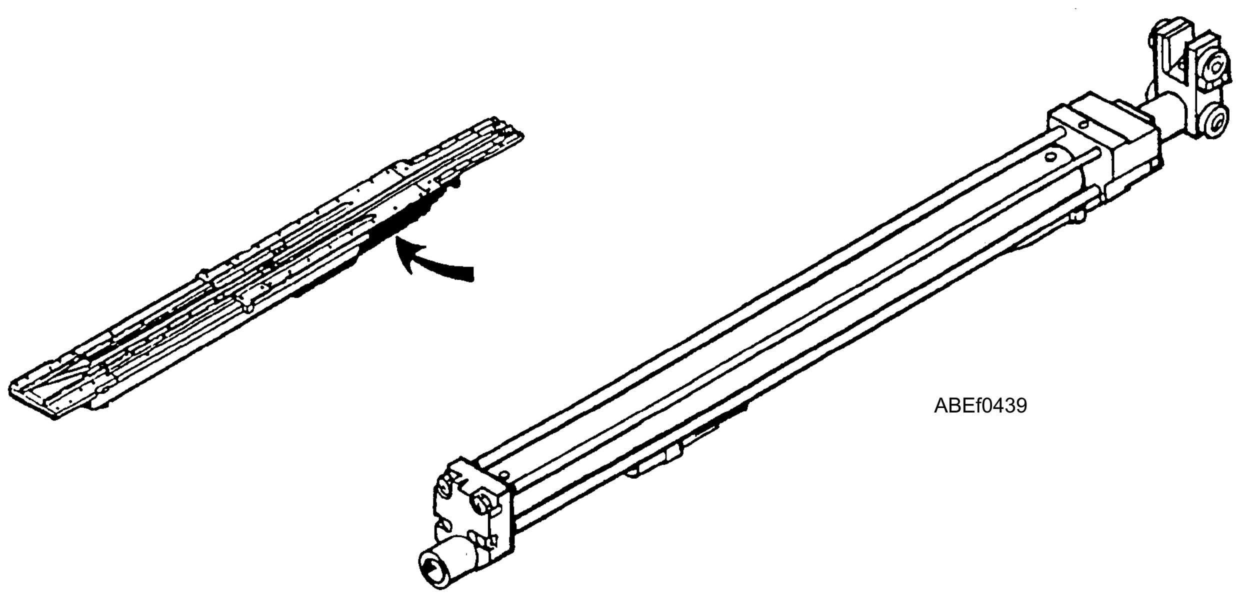


Figure 4-38.—Tensioner cylinder assembly.

into an extended bridle tensioner piston rod. This limit switch is also part of the MANEUVER AFT circuit. This circuit ensures that the tensioner piston rod is fully aft, allowing the grab latch to remain locked to the shuttle in an aircraft-launch-abort situation.

Internal Tensioning Components

The internal tensioning is comprised of components that cause the retraction engine motor to slowly rotate and consists of a pressure regulator, and a inlet and outlet valve.

Pressure Regulator

The pressure regulator is used to reduce accumulator pressure to the pressure required to move the grab and shuttle forward (creep rate) a distance of six feet in 30-50 seconds.

Internal Tensioning Inlet and Outlet Valve

The internal tensioning inlet and outlet valve controls the flow of reduced pressure hydraulic fluid to and from the hydraulic motor and orifice bypass piping during the tensioning phase. When actuated by the bridle tensioner pilot valve, reduced pressure hydraulic fluid flows through the inlet valve to the hydraulic motor and orifice bypass piping. Hydraulic fluid from the motor and bypass piping is routed to the gravity tank through the outlet valve. This enables the hydraulic motor to rotate the drum slowly so that static friction in the retraction engine and drive system is overcome.

Internal Tension Relief Valve

The relief valve is set to relieve at 225 psi over the normal internal tension pressure.

HYDRAULIC SYSTEM

LEARNING OBJECTIVES: Describe the components of the hydraulic system. Describe the function of the hydraulic system.

The hydraulic system (fig. 4-39) supplies pressurized fluid to the hydraulic components of the catapult. The system consists of a main hydraulic accumulator, an air flask, three main hydraulic pumps, a booster pump and filter unit, a gravity tank, a 90 gallon auxiliary tank, and a circulating pump.

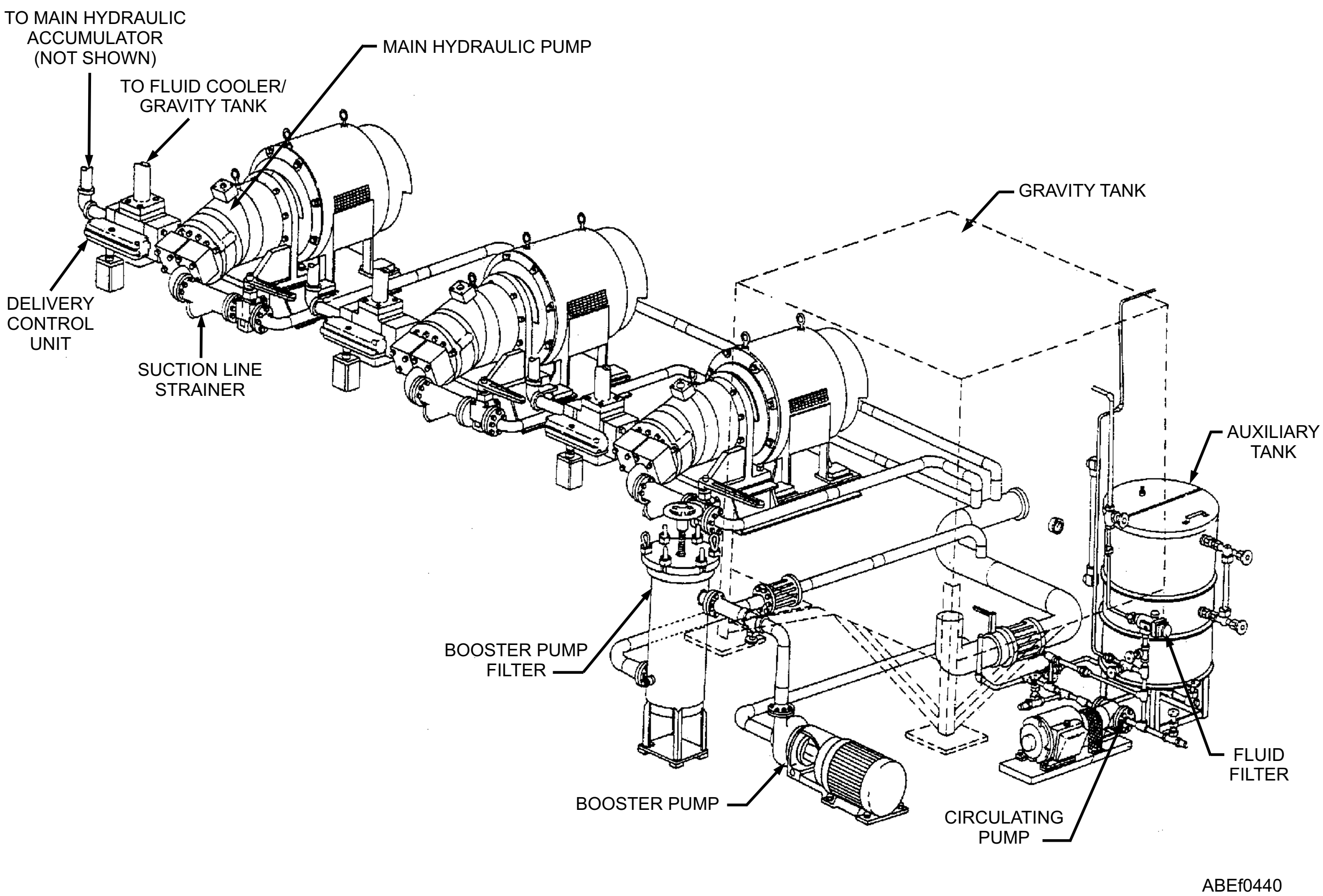


Figure 4-39.—Retraction engine hydraulic system.

HYDRAULIC FLUID

The hydraulic fluid, MIL-H-22072, is 50 percent water, which provides its fire resistance. The remaining 50 percent is composed of a water-soluble polymer, which increases the viscosity of the water, the freezing point depressant, and selected additives that impart lubricant and corrosion protection. The red dye additive provides good visibility for leak detection. With use, the fluid loses water and volatile inhibitors. Water loss is indicated by an increase in the fluid viscosity. Loss of inhibitors is indicated by a change in the pH number of the fluid. (External contamination will also cause a change in pH number.) Normal values for the viscosity and pH number of the unused fluid are as follows:

- Viscosity (fluid temp. 100°F): 185 to 210 SSU
- pH number: 8.8 to 9.8

MAIN HYDRAULIC ACCUMULATOR

The main hydraulic accumulator (fig. 4-40) consists of a vertical cylinder and a floating piston. The piston separates the accumulator into two chambers, a fluid chamber on top and an air chamber on the bottom. The accumulator provides hydraulic fluid under controlled pressure to all hydraulically operated catapult components. The bottom chamber of the accumulator connects by piping to the air flask and the top chamber is connected by piping to the hydraulic system. A stroke control actuator provides the means of controlling main hydraulic pump delivery as required. A volume normal actuator mounted to the top flange provides protection from operating the catapult if the fluid volume is low.

STROKE-CONTROL ACTUATOR

The stroke-control actuator is mounted near the bottom of the main hydraulic accumulator cylinder. The actuator is a lever-operated cam that operates two limit switches. The bottom limit switch controls the operation of the primary pump, and the top limit switch controls the operation of the remaining two pumps. With the accumulator full of fluid, both on stroke cams are in the released position, deenergizing all pump delivery control solenoids. As fluid is used, air pressure raises the accumulator piston and the actuator rod move upward. The on stroke cam for the primary pump actuates first and that pump will deliver fluid to the

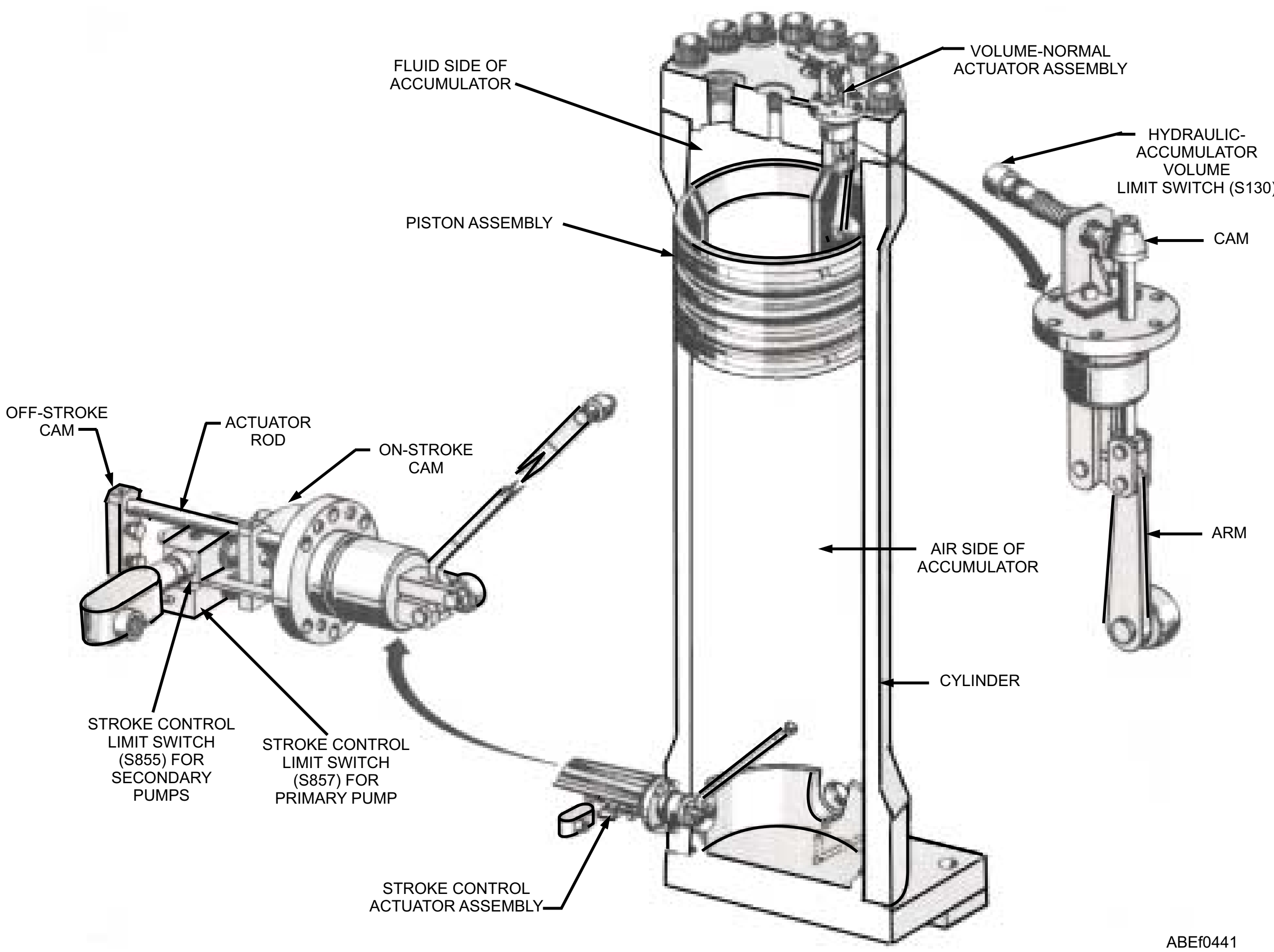


Figure 4-40.—Main hydraulic accumulator.

accumulator. If the system fluid use is in excess of the primary pump output, the accumulator piston will continue to rise causing actuation of the onstroke cam for the other two pumps. The delivery control solenoid of those pumps energizes and all pumps then deliver fluid to the accumulator. As the accumulator fills, the piston move downward reversing the movement of the actuating arm and sequentially opening the circuits to the delivery control solenoids of the three pumps.

VOLUME-NORMAL ACTUATOR

The volume-normal actuator is located in the top of the cylinder (see fig. 4-39). During launching operations, if hydraulic fluid volume in the accumulator becomes dangerously low, the concave top surface on the accumulator piston will come in contact with the arm on the actuator. The arm will rotate and cause the cam to release the limit switch. The limit switch contacts shift, lighting a malfunction light and breaking the circuit to the cat/first ready phase of operation.

AIR FLASK

The air flask (fig. 4-41) is a 70 cubic foot container of compressed air, which is used to maintain nearly constant hydraulic-fluid pressure in the accumulator. As the fluid in the accumulator is used, the air pressure forces the piston upward, displacing the fluid. Because of the large volume of air in the air flask, the pressure change in the accumulator is relatively small.

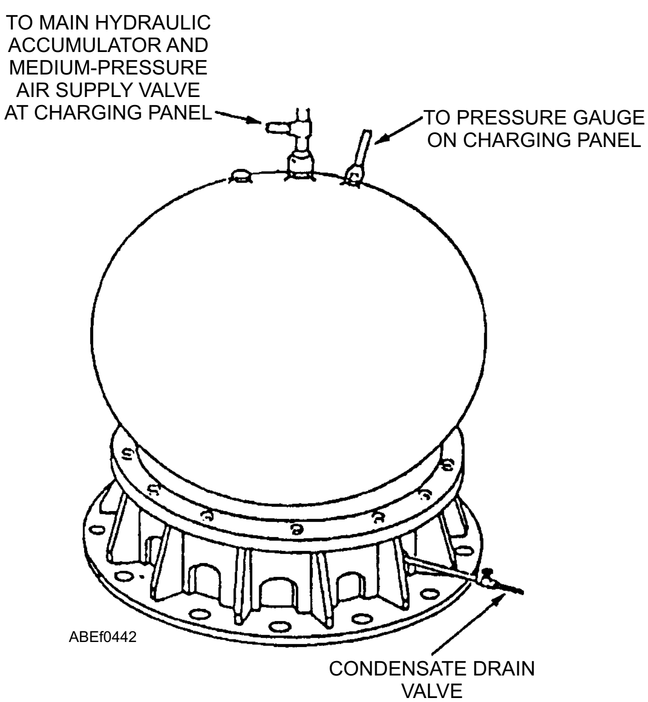


Figure 4-41.—Air flask.

MAIN HYDRAULIC PUMPS

The main hydraulic pumps (see fig. 4-39) deliver hydraulic fluid to the main hydraulic accumulator. The hydraulic pumps are connected in parallel. The intake line to each pump is provided with a strainer. Each pump discharge line is fitted with a delivery control unit, which has a built-in relief valve. When the hydraulic fluid leaves the pumps, the delivery control unit directs it either through a fluid cooler to the gravity tank (pump offstroke), or through the pressure line to the main accumulator. This pressure line is equipped with one-way check valves to prevent the backing up of fluid from the accumulator when the pumps are offstroke.

BOOSTER PUMP AND FILTER UNIT

The booster pump and filter unit (fig. 4-42) consists of a pump and motor assembly and a filter unit installed between the gravity tank and the main hydraulic pumps. The booster pump is operated anytime that a main hydraulic pump is running. During operation the booster pump maintains a positive head of hydraulic pressure at the inlet to the main hydraulic pumps. The filter unit ensures that a clean supply of hydraulic fluid is always available. A means is provided to drain the filter housing to facilitate changing of filter elements. A bypass line, containing a check valve, is installed to permit the main hydraulic pumps to take suction directly from the gravity tank in the event of a clogged filter unit of booster pump failure.

GRAVITY TANK

The gravity tank is the storage reservoir for catapult hydraulic fluid. The tank is made up of internal baffles to minimize fluid surging and foaming. The tank is vented at the top and all low-pressure fluid return lines lead into the top portion of the tank. The tank capacities may vary slightly but the minimum operating tank level with a full hydraulic system and piping is 800 gallons.

AUXILIARY TANK

The auxiliary tank (see fig. 4-39) provides a means to return hydraulic fluid to the gravity tank or replenish with new fluid. The tank consists of a cylindrical shaped container with a top strainer and a lid. A line at the bottom connects to the suction side of the circulating pump. A flexible hose connects the top of the tank to a flight deck fill connection. All new or recycled hydraulic fluid must pass through the auxiliary tank in order to get to the gravity tank.

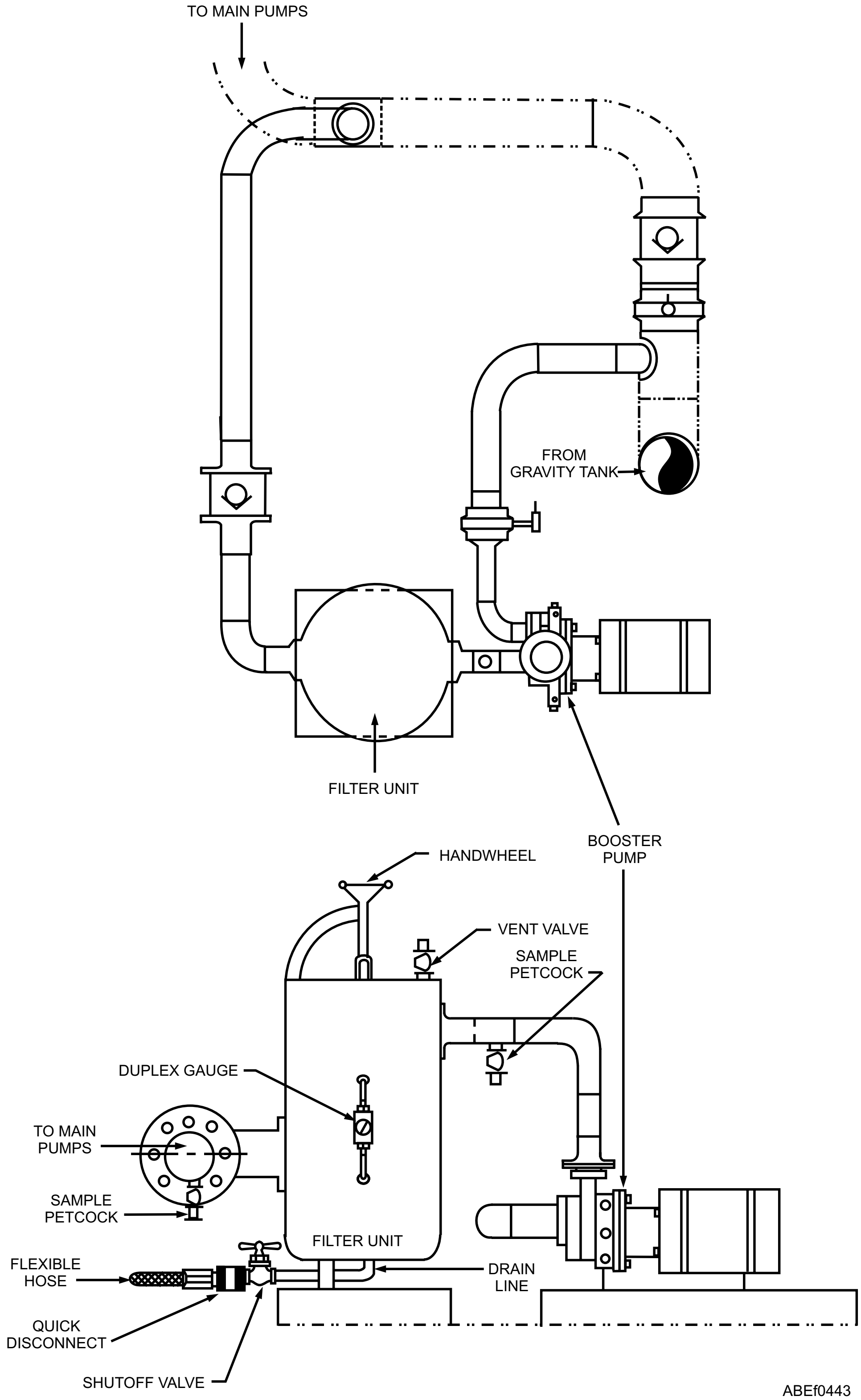


Figure 4-42.—Booster pump and filter installation.

CIRCULATING PUMP

The circulating pump (see fig. 4-39) is utilized to return hydraulic fluid from the auxiliary tank to the gravity tank. The fluid passes through a filter between the discharge side of the circulating pump and the gravity tank. This ensures that all new or recycled hydraulic fluid is filtered prior to entering the gravity tank.

RETRACTION ENGINE AND DRIVE SYSTEMS

LEARNING OBJECTIVES: Describe the components of the retraction engine and drive systems. Describe the function of the retraction engine and drive systems

The retraction engine and drive system (fig. 4-43) consists of the components that are used to return the launching engine pistons and shuttle to the battery position after each launch or to maneuver the grab, whenever necessary

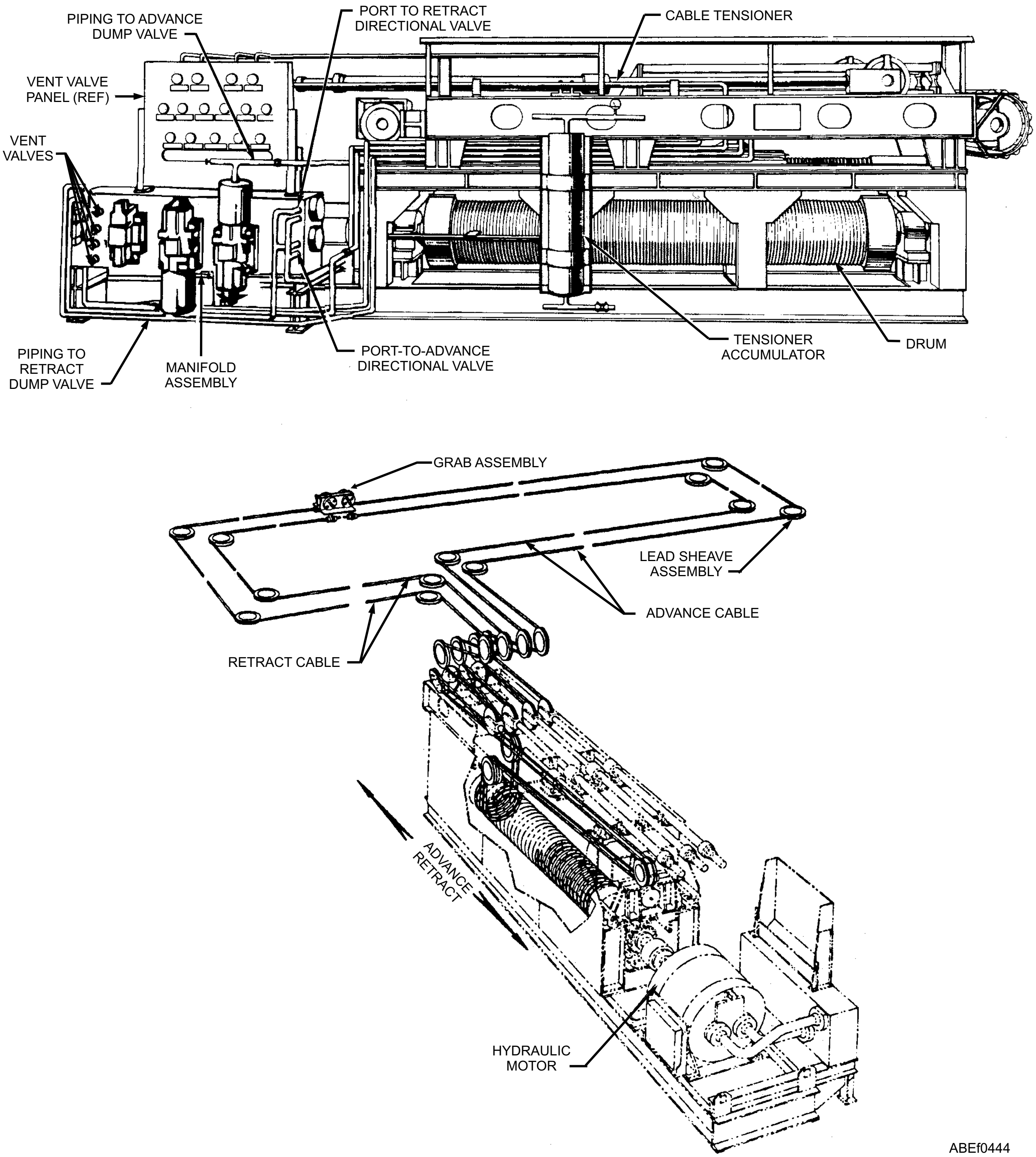


Figure 4-43.—Retraction engine and drive system.

HYDRAULIC MOTOR

The hydraulic motor (see fig. 4-43) is rotated by pressurized fluid from the main hydraulic accumulator. Various directional valves located on the retraction engine manifold control speed and direction of rotation. The hydraulic motor is coupled directly to the drum assembly, causing the drum to rotate in the same direction and speed as the motor.

DRUM ASSEMBLY

The drum is a grooved, cylindrical shaped assembly which winds and unwinds the drive system cables to either advance or retract the grab, based on directional rotation of the hydraulic motor. The drum is directly coupled to the hydraulic motor and is geared to the screw and traverse carriage installation.

SCREW AND TRAVERSE CARRIAGE INSTALLATION

The screw and traverse carriage installation (fig. 4-44) is mounted on the retraction engine frame above the drum and is driven by a gear arrangement connected to the drum. Rotation of the drum causes the traverse carriage to slide along tracks mounted on the engine frame. A sheave and adapter assembly, bolted to the carriage body, acts as a guide for the advance and retract cables as they wind and unwind on and off the drum preventing the cables from becoming tangled. As the carriage assembly moves along the length of the retraction engine, cams mounted on top of the carriage body come in contact with valves and switches mounted within the retraction engine frame. The cams actuate the advance and retract dump valves, advance and retract cutoff limit switches, grab fully aft limit

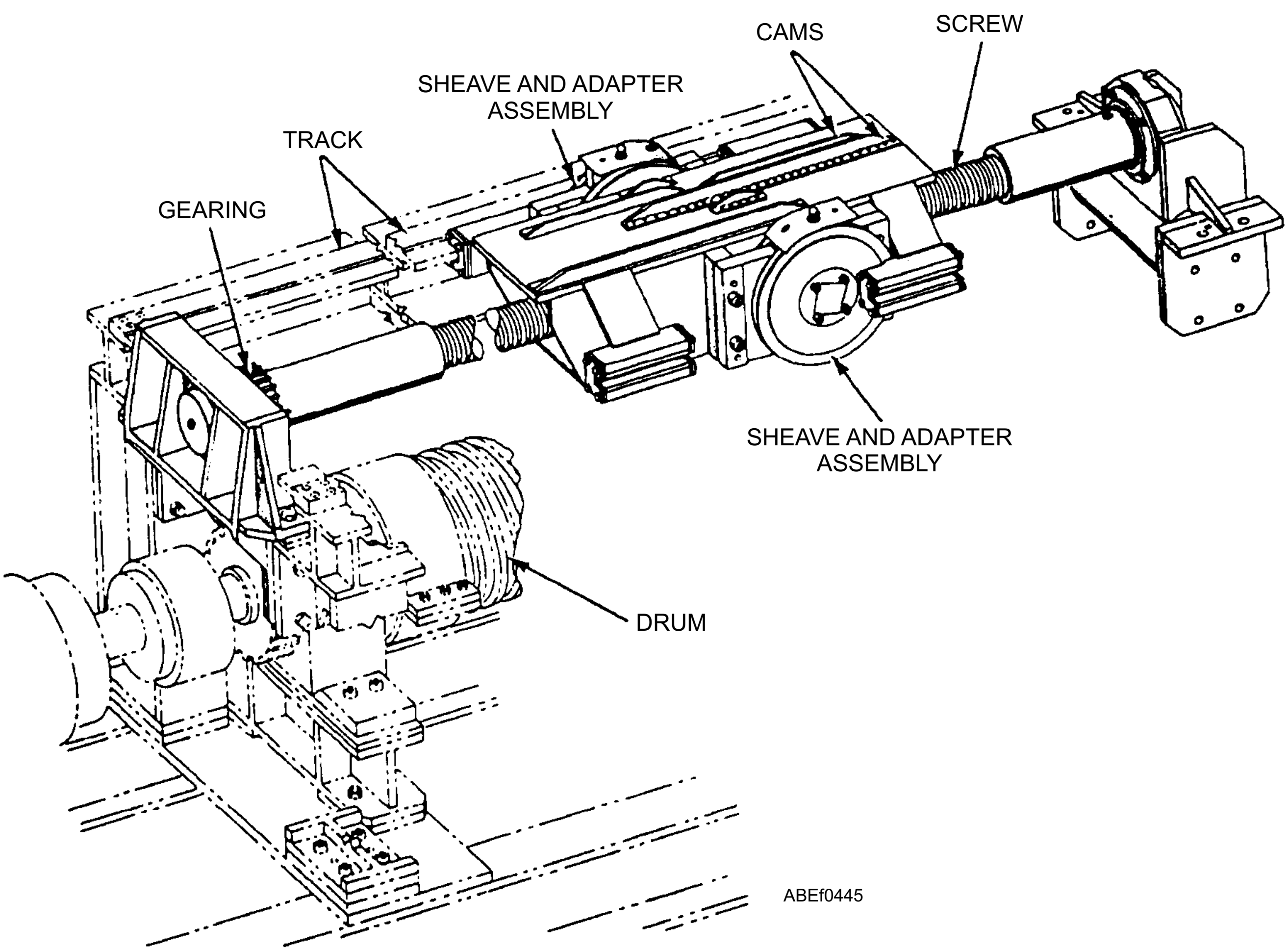


Figure 4-44.—Screw and traverse carriage.

switch, and grab fully advanced limit switch. The cam positions are adjusted for individual installations.

RETRACTION ENGINE MANIFOLD

The retraction engine manifold (fig. 4-45) is mounted on the retraction engine frame and provides internal fluid passages for various control valve functions. The manifold contains the bridle tensioner pilot valve and the internal tensioning inlet and outlet valves for the bridle tensioning system. The manifold also contains the advance and retract pilot valve, retract directional valve, advance directional valve, and maneuvering valve.

ADVANCE AND RETRACT PILOT VALVE

Used to control the advance directional valve and retract directional valve, through the advance dump valve and retract dump valve respectively. When the advance solenoid (SA) is energized, the pilot shifts, directing hydraulic fluid flow through the pilot valve, through the advance dump valve to shift the advance directional valve. When the retract solenoid (SR) is energized, the pilot shifts, directing hydraulic fluid flow through the pilot valve, through the retract dump valve to shift the retract directional valve

RETRACT DIRECTIONAL VALVE

The retract directional valve (see fig. 4-45) controls the hydraulic motor during retract. When actuated by fluid flow from the pilot valve, the retract directional valve piston shifts, directing fluid flow through the directional valve to the hydraulic motor. The fluid returns from the motor and flows through the directional valve to the gravity tank. When the retract directional valve is not actuated, no fluid flow is allowed through the valve. As the traverse carriage nears the end of a retract stroke, a cam mounted on the carriage actuates the retract dump valve. This drains the pressure in the retract directional valve actuating chamber back to the gravity tank through the dump valve. The retract directional valve piston then closes, causing a gradual cutoff of hydraulic fluid from the hydraulic motor, initiating retraction engine braking.

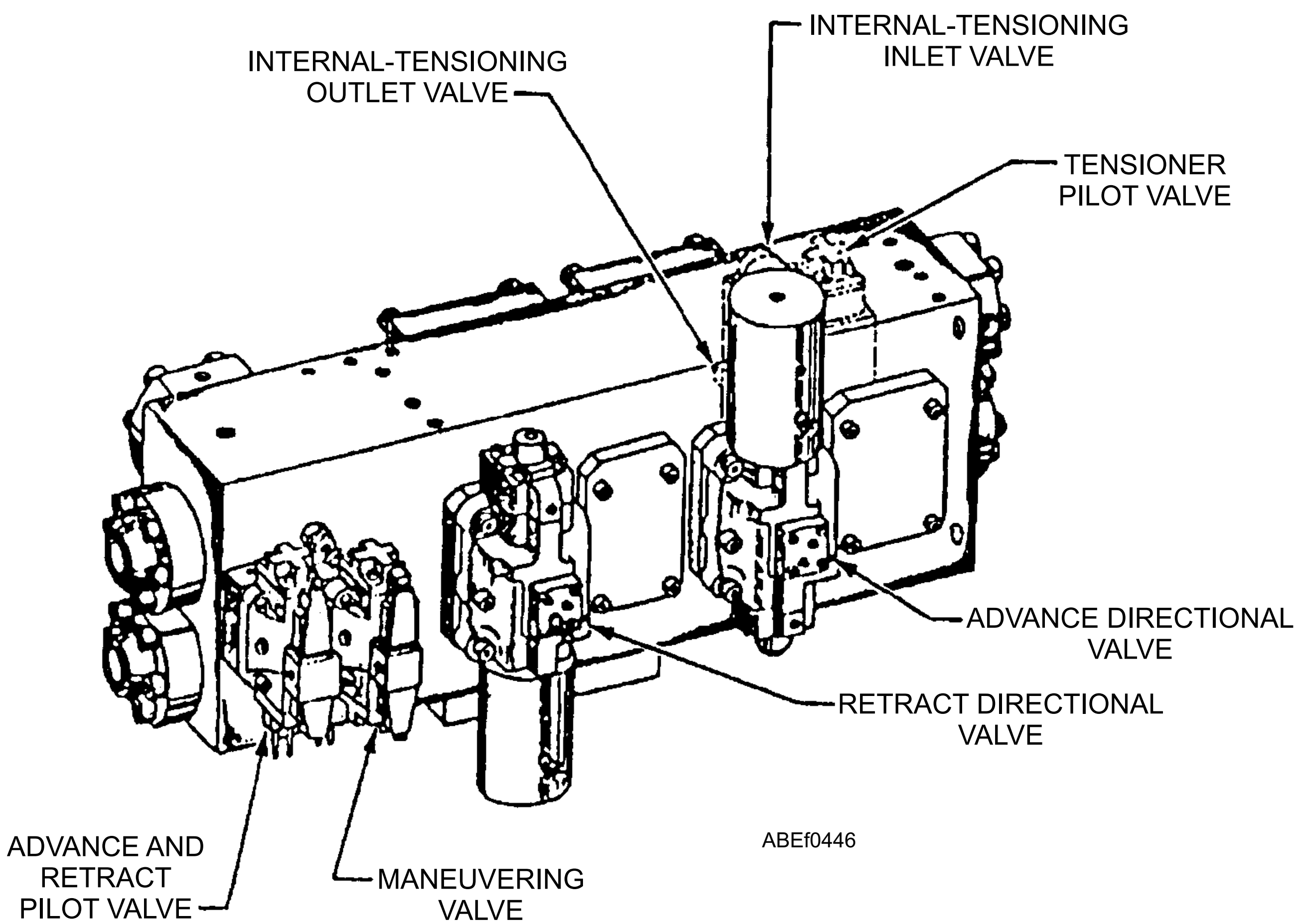


Figure 4-45.—Retraction engine manifold.

ADVANCE DIRECTIONAL VALVE

The advance directional valve (see fig. 4-45) controls the hydraulic motor during advance. When actuated by fluid flow from the pilot valve, the advance directional valve piston shifts, directing fluid flow through the directional valve to the hydraulic motor. The fluid returns from the motor and flows through the directional valve to the gravity tank. When the advance directional valve is not actuated, no fluid flow is allowed through the valve. As the traverse carriage nears the end of an advance stroke, a cam mounted on the carriage actuates the advance dump valve. This drains the pressure in the advance directional valve actuating chamber back to the gravity tank through the dump valve. The advance directional valve piston then closes, causing a gradual cutoff of hydraulic fluid from the hydraulic motor, initiating retraction engine braking.

MANEUVERING VALVE

The maneuvering valve (see fig. 4-45) is mounted on the manifold and is operated by the maneuver forward solenoid (EF) and the maneuver aft solenoid (EA). The maneuvering valve is energized automatically during the latter part of the advance and retract stroke to control the speed of the grab after braking has been completed. Orifices control hydraulic fluid flowing through the valve to and from the hydraulic motor. At times other than during normal operations, the valve can be energized to slowly maneuver the grab, shuttle, and pistons forward or aft for testing or maintenance. A manual override button on the valve can be pushed to maneuver the grab aft in case of power failure and permit disengagement of the aircraft from the shuttle.

DUMP VALVES

The two dump valves (fig. 4-46) are mounted on the retraction engine frame. The valves are actuated by cams mounted on the traverse carriage. When the retraction engine nears the end of the advance stroke, the advance dump valve is actuated. The dump valve closes allowing the pilot-actuating fluid from the advance directional valve to return to the gravity tank, initiating the advance braking stroke. When the

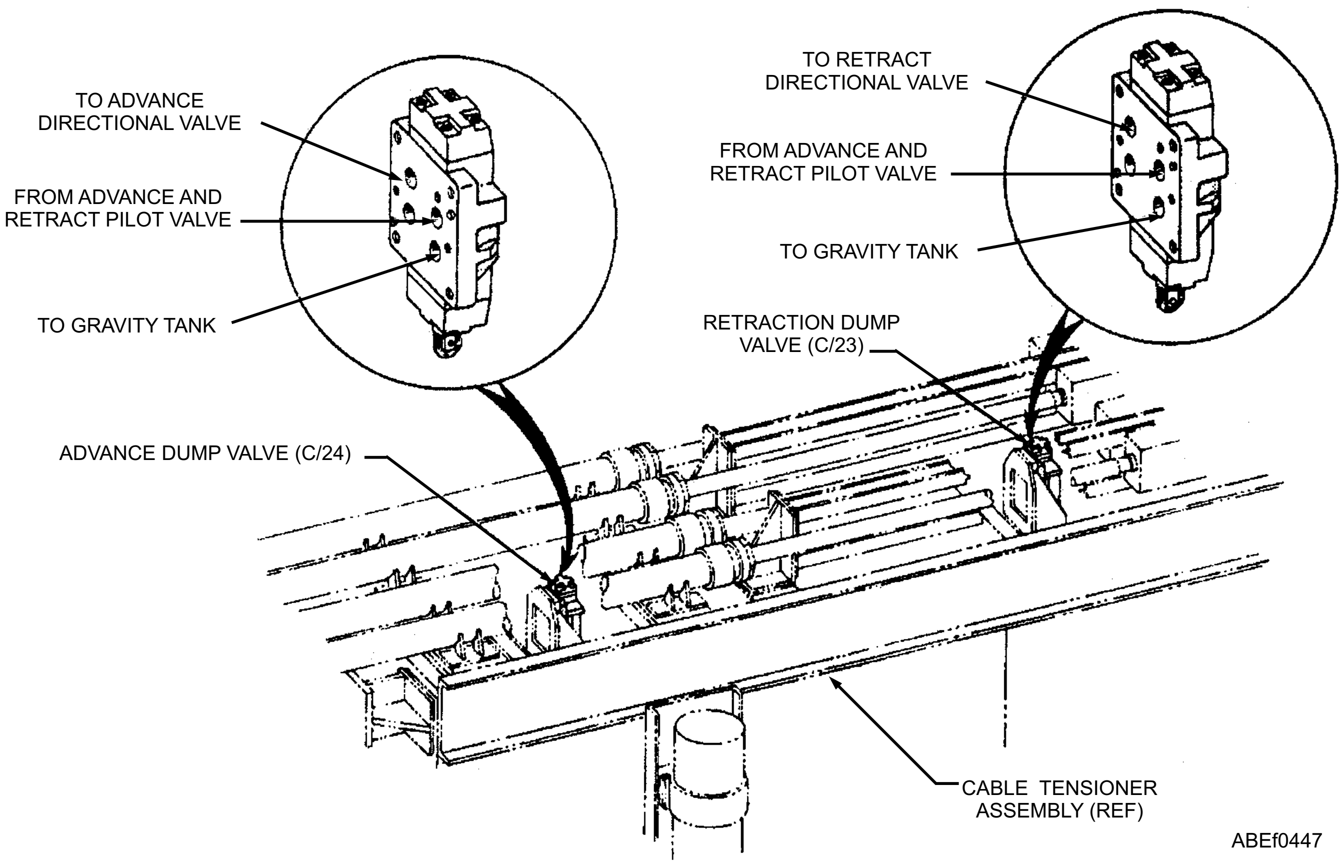


Figure 4-46.—Retraction engine dump valves.

retraction engine nears the end of the retract stroke, the retract dump valve is actuated. The dump valve closes allowing the pilot-actuating fluid from the retract directional valve to return to the gravity tank, initiating the retract braking stroke.

VENT VALVE PANEL

The vent valve panel is located on top of the retraction engine manifold assembly. Vent valves are mounted on the panel and are connected to various points in the retraction engine hydraulic system. These valves are used to bleed (vent) air and air saturated hydraulic fluid from various retraction engine components. A hydraulic fluid reservoir is located at the bottom of the vent valve panel. The reservoir is used to collect vented fluid and provide the outlet to return vented fluid to the hydraulic system.

CABLE TENSIONER ASSEMBLY

The cable tensioner assembly (fig. 4-47) consists of the four cable tensioners required to keep the retraction engine drive system taut. Each cable tensioners consists of a hydraulic cylinder containing a piston with a threaded rod extending from one end and a rod attaching a clevis/sheave from the other end. Fluid under pressure from the cable tensioner accumulator forces the tensioner sheaves toward the cylinders applying tension to the drive system cables. The threaded rods with adjusting nut on the other end of each tensioner provide a stop for sheave stroke when the pressure in the tensioner cylinders is overcome by the braking action which occurs during dump valve actuation.

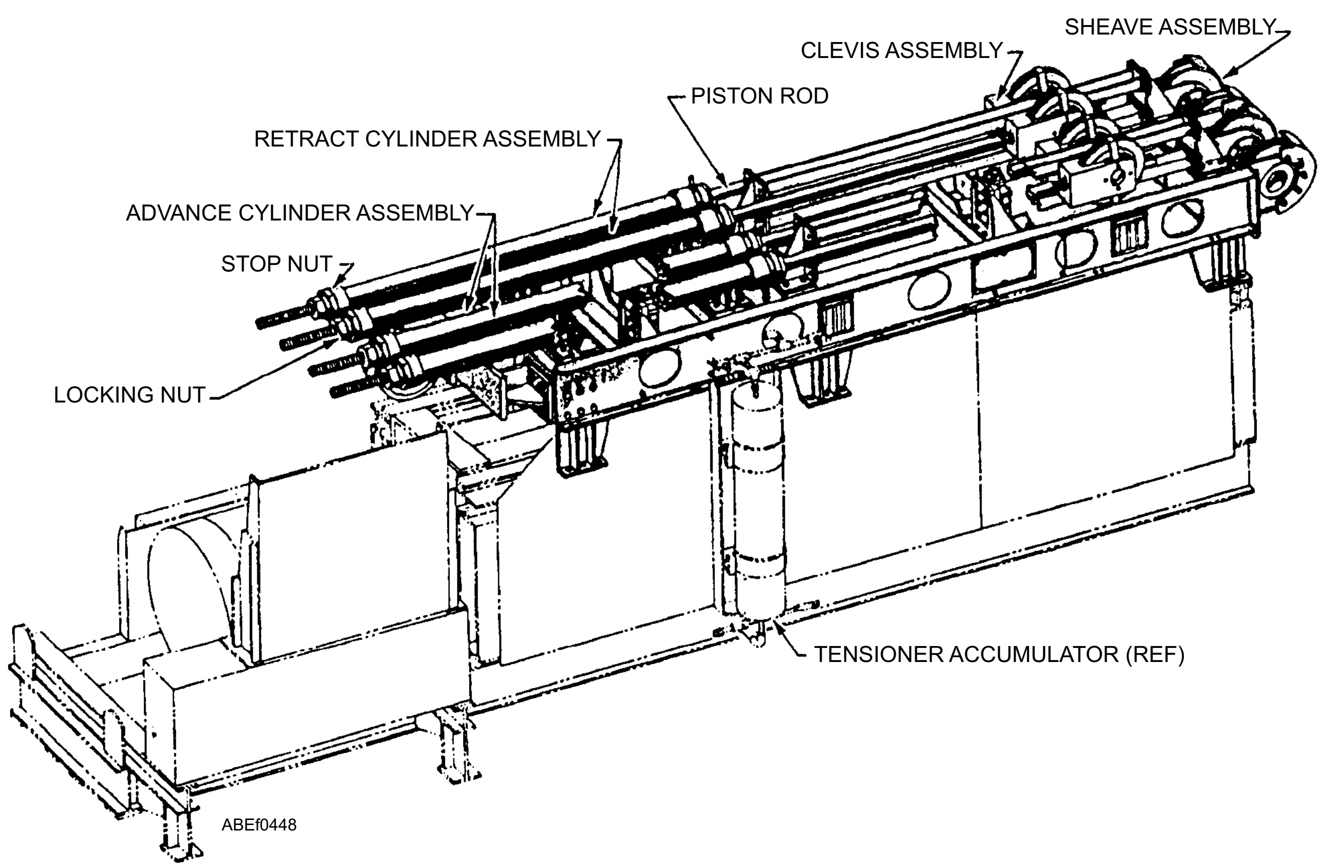


Figure 4-47.—Retraction-engine cable tensioners.

SHEAVES

The sheave assembly (fig. 4-48) is a type of pulley used to guide and change direction of the drive system cables. Sheaves are located on the traverse carriage to feed the cable on and off the drum when the retraction engine is in motion. Fixed sheaves on the retraction engine guide the cables to the fairlead sheaves. The fairlead sheaves are those sheaves that lead the drive system from the retraction engine to the forward and aft ends of the catapult trough.

CABLES

The drive system cables are 9/16-inch wire rope with a swage type fitting on one end for attachment to the grab. Two advance cables and two retract cables attach to the forward and aft end of the grab. The cables are then fairleaded to the retraction engine, around the traverse carriage sheaves and then a predetermined length is wound onto the drum. The drum ends of the cables are held in place by bolted clamps. During retraction engine operation, as the drum rotates, one

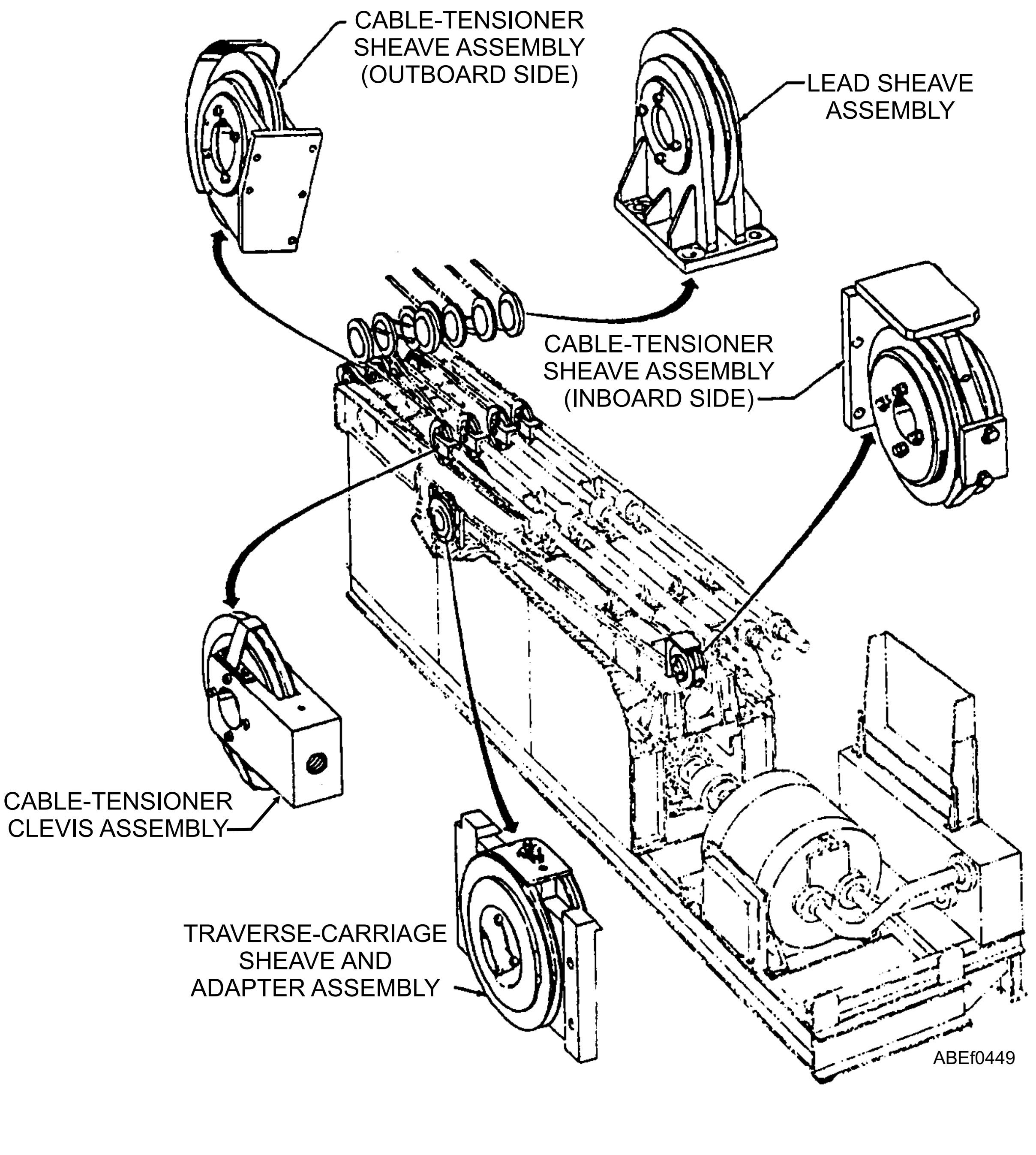
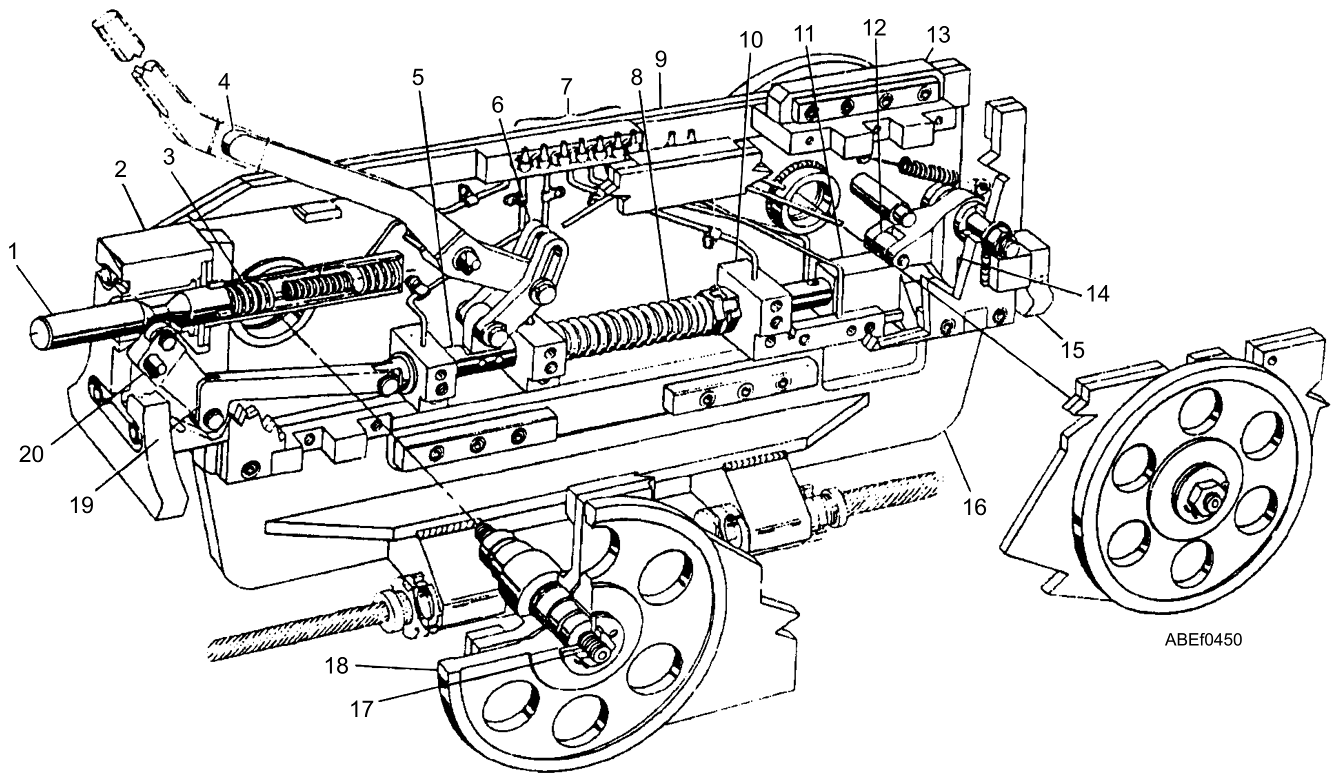


Figure 4-48.—Sheaves.

pair of cables winds onto the drum while towing the grab. The other pair of cables is unwound from the drum by movement of the grab. The traverse carriage moves in proportion with the drum rotation and feed the cables on and off the drum.

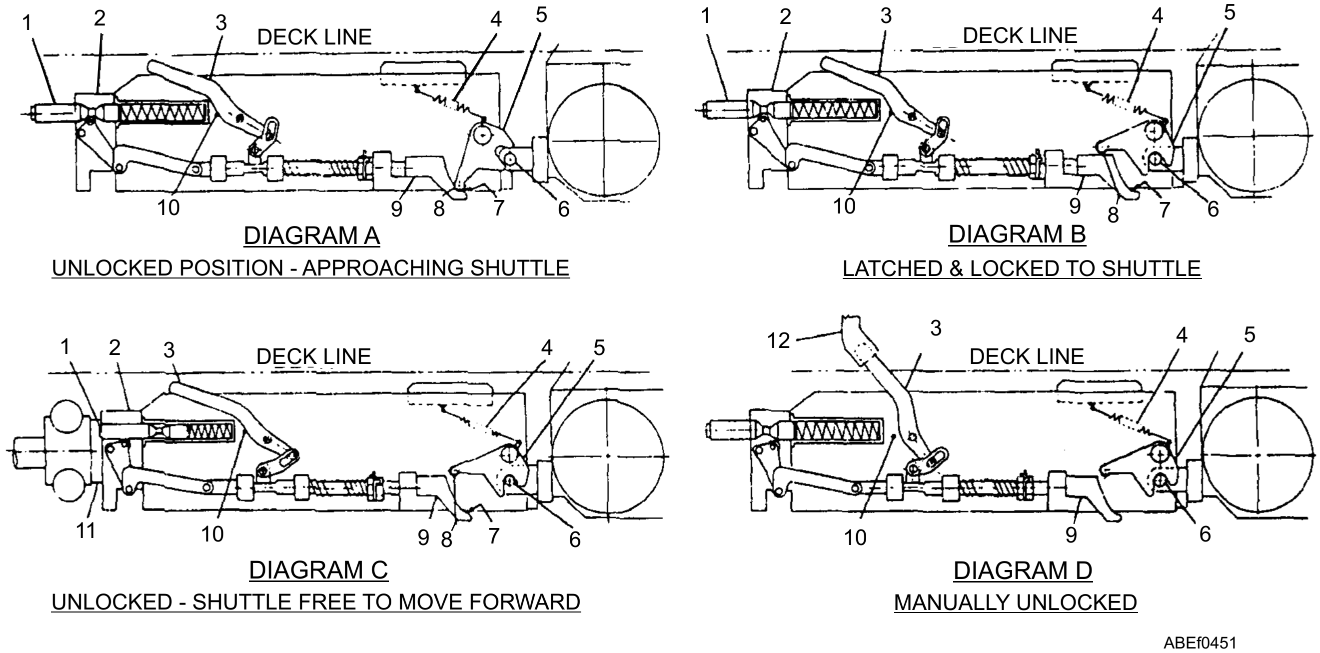
GRAB

The grab (fig. 4-49) is a spring-loaded latch, mounted on a wheel frame and installed within the shuttle track behind the shuttle. The two retract cables are fastened to the aft end of the grab, and the two advance cables to the forward end. After a launch, the grab is pulled forward the length of the shuttle track by the drive system, and automatically latches to the shuttle with a positive-locking device. Diagram A of figure 4-50 shows the grab in the UNLOCKED position, approaching the shuttle. When the grab latch (5) comes in contact with the shuttle clevis pin (6), the latch rotates and the latch cam follower (8) moves out of the cam detent (7) in the lock block (9) and continues upward until it reaches the top surface of the lock block. The spring-loaded lock block then moves under the cam follower, trapping the latch and locking the grab to the shuttle clevis pin, as shown in diagram B. The grab will not release the shuttle until both have been returned to the BATTERY position and the grab unlocking mechanism is actuated by the bridle tensioner. When the bridle-tensioner piston rod moves forward, the bridle-tensioner buffer cap (11) pushes the grab pushrod (1) inward until the buffer cap contacts the grab block (2). When the pushrod is pushed inward, the lock block (9) is pulled from under the latch cam follower and the latch is free to rotate and release the shuttle, as shown in diagram C. When the shuttle and bridle tensioner move away from the grab, the grab remains in the UNLOCKED position, as shown in diagram A. During no-load tests, the grab and shuttle must be unlatched. The grab is manually released from the shuttle, as shown in diagram D. A manual-release disengaging lever (12) is placed over the manual-release arm (3), which is accessible through the track slot, lifted up and pushed forward. This motion pulls the lock block from under the latch cam follower and frees the latch so that the grab and shuttle can be separated.



1. Pushrod	**6. Link**	**11. Block**	**16. Bracket**
2. Block	**7. Lubrication fitting**	**12. Cam follower**	**17. Shaft**
3. Spring	**8. Spring**	**13. Upper tie bracket**	**18. Wheel assembly**
4. Manual-release arm	**9. Plate**	**14. Latch**	**19. Link**
5. Slide shaft	**10. Support**	**15. Buffer plate**	**20. Lever**

Figure 4-49.—Grab.



1. **Pushrod**
2. **Block**
3. **Manual-release arm**
4. **Latch spring**
5. **Grab latch**
6. **Shuttle clevis pin**
7. **Cam detent**
8. **Cam follower**
9. **Lock block**
10. **Manual-release-arm stop**
11. **Bridle-tensioner buffer cap**
12. **Manual-release disengaging lever**

Figure 4-50.—Grab operation sequence.

CATAPULT CONTROL SYSTEMS

LEARNING OBJECTIVES: Describe the components of the catapult control systems. Describe the function of the catapult control systems.

The control system of a steam catapult consists of those panels, lights, and switches that are used to operate a catapult throughout the various operational phases.

ELECTRICAL CONTROL SYSTEM COMPONENTS

The electrical control system for a steam catapult consists of various control panels that govern the operation of the catapult in conjunction with control components of other systems.

Included among the components of the catapult electrical control system are various push buttons, switches, solenoids, relays, circuit breakers, fuses, and lights. The ICCS, CCP, and the main control console is the focal point of all functions of the catapult electrical control systems.

Electrically operated solenoid valves produce mechanical operation of valves throughout the catapult. Buttons actuate some solenoid valves, while others function automatically during catapult operation. Various changes that occur during catapult operation are sensed by limit switches and pressure switches. Operation of these switches actuates lights at various control panels. The following paragraphs briefly describe some of these components. For information on the function and interrelationship of the electrical components in a specific system, study the schematic diagrams in the technical manual for that particular type of catapult.

Solenoids

A solenoid (fig. 4-51) is an electromagnet formed by a conductor wound in a series of loops in the shape of a helix (spiral). Inserted within this spiral or coil are a soft-iron core and a movable plunger. The soft-iron core is pinned or held in position and therefore is not movable. This movable plunger (also soft iron) is held away from the core by a spring in the de-energized position.

When current flows through the conductor, a magnetic field is produced. This field acts in every respect like a permanent magnet having both a north and south pole.

As shown in figure 4-51, the de-energized position of the plunger is partially out of the coil, because of the

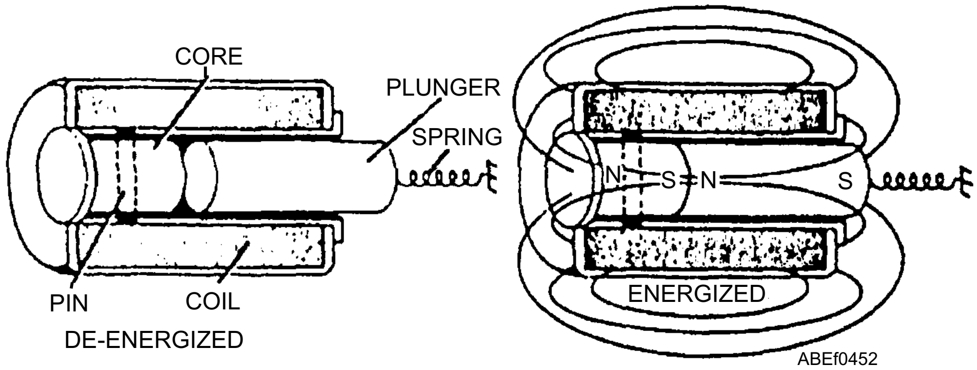


Figure 4-51.—Solenoid.

action of the spring. When voltage is applied, the current through the coil produces a magnetic field, which draws the plunger within the coil, thereby resulting in mechanical motion. When the coil is de-energized, the plunger returns to its normal position by the spring action.

Solenoids are used in steam catapult systems for electrically operating bridle tensioning valves, lubrication valves, engine retraction valves, and relays, and for various other mechanisms where only small movements are required. One of the distinct advantages in the use of solenoids is that a mechanical movement can be accomplished at a considerable distance from the control station. The only link necessary between the control and the solenoid is the electrical wiring for the coil current.

Relays

One of the principal uses of relays is the remote control of circuits. Circuits may be energized by control relays from one or more stations simply by closing a switch. Switches used to energize relays require lightweight wire only, and may thereby eliminate the necessity of running heavy power cable to the various control points. An additional advantage resulting from relay control is the removal of safety hazards, since high-voltage equipment can be switched remotely without danger to the operator.

In general, a relay consists of the following components: a magnetic core and associated coil, the contacts, springs, armature, and the mounting. Figure 4-52 illustrates the fundamental construction of a relay. When the circuit is energized, the flow of current through the coil creates a strong magnetic field, which pulls the armature to a position that closes the contacts. When the coil is energized, it moves the armature to contact C1, which completes the circuit from the common terminal to C1. At the same time, it has opened the circuit to contact C2.

The relay is one of the most dependable electromechanical devices in use; but like any other mechanical or electrical equipment, relays occasionally wear out or become inoperative for one reason or another. Should inspection determine that a relay has exceeded its safe life, the relay should be removed immediately and replaced with one of the same type.

Fuses And Circuit Breakers

The electrical control system is protected from overloading by fuses and circuit breakers.

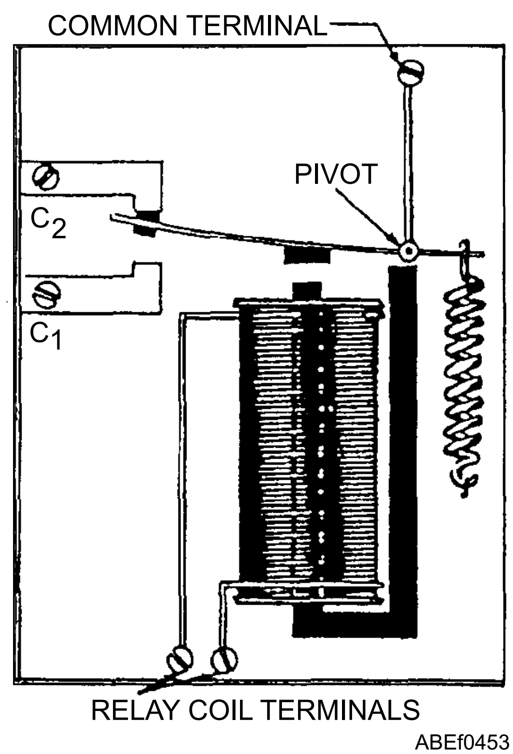


Figure 4-52.—Relay construction.

The fuse is the simplest protective device. A fuse is merely a short length of wire or metal ribbon within a suitable container. This wire or metal ribbon is usually made of an alloy that has a low melting point and is designed to carry a given amount of current indefinitely. A larger current causes the metal to heat and melt, opening the circuit to be protected. In replacing a burned-out fuse, you should be sure that the new fuse is the same size (capacity in amperes) as the original.

The circuit breaker serves the same purpose as the fuse, but it is designed to open the circuit under overload conditions without injury to itself. Thus, the circuit breaker can be used again and again after the overload condition has been corrected.

Limit Switches

Limit switches are used as remote indicators of the position of various components throughout the system. They are actuated mechanically by the movement of the component. Electrical contacts within the switch change the mechanical action to an electrical signal indicated by lights on the various operating panels.

Microswitches

Microswitches serve the same function as limit switches except they are used where a very limited mechanical movement is required (1/16 inch or less). While the term *Microswitch* suggests the function of the switch, it is nothing more than the brand name of the particular type of switch.

PUSH BUTTON CONTROLS

The sequence of operations on the C-13-0, C-13-1, and C-13-2 catapults is controlled by push buttons. The two types of push buttons are the momentary-contact and holding-circuit push buttons. The momentary-contact push button has to be held in the depressed position to keep the particular circuit energized. The maneuver forward and maneuver aft push buttons, are examples. The push button used in a holding circuit stays energized once it is depressed until that particular circuit is de-energized by the normal sequence of operations or one of the suspend switches is actuated. All the push buttons associated with the normal operation of the catapult are incorporated into holding circuits.

CATAPULT CONTROL SYSTEM FOR CVN-68 THROUGH CVN-76 (INTEGRATED CATAPULT CONTROL STATION (ICCS))

The controls for the ICCS are mainly divided between the ICCS at the flight deck level and the Central Charging Panel (CCP) below deck. The ICCS is an enclosure that may be retracted into the deck when not in use. It contains the catapult-officer control console and the monitor control console, and controls the operation of two adjacent catapults. Sound-powered phones and a system of indicator lights link the ICCS to the remote panels for individual catapults. In an emergency, the functions of the ICCS can be transferred to the emergency deckedge control panel or the central charging panel, and the catapult officer can direct operations on the flight deck.

Catapult-Officer Control Console

The catapult-officer control console (fig. 4-53) is used in conjunction with the monitor control console and the central charging panel to direct catapult operations. The control console is of wraparound design for ease of operation and located facing aft in the ICCS. The console is made up of panels containing all of the lights, switches and other controls necessary for the operation of two adjacent catapults. The operating panels and lower end operating panels contain the lights and switches for operation of the associated catapult. The remaining panels located between the operating panels and lower end operating panels provide the launching officer with all of the other information or switches.

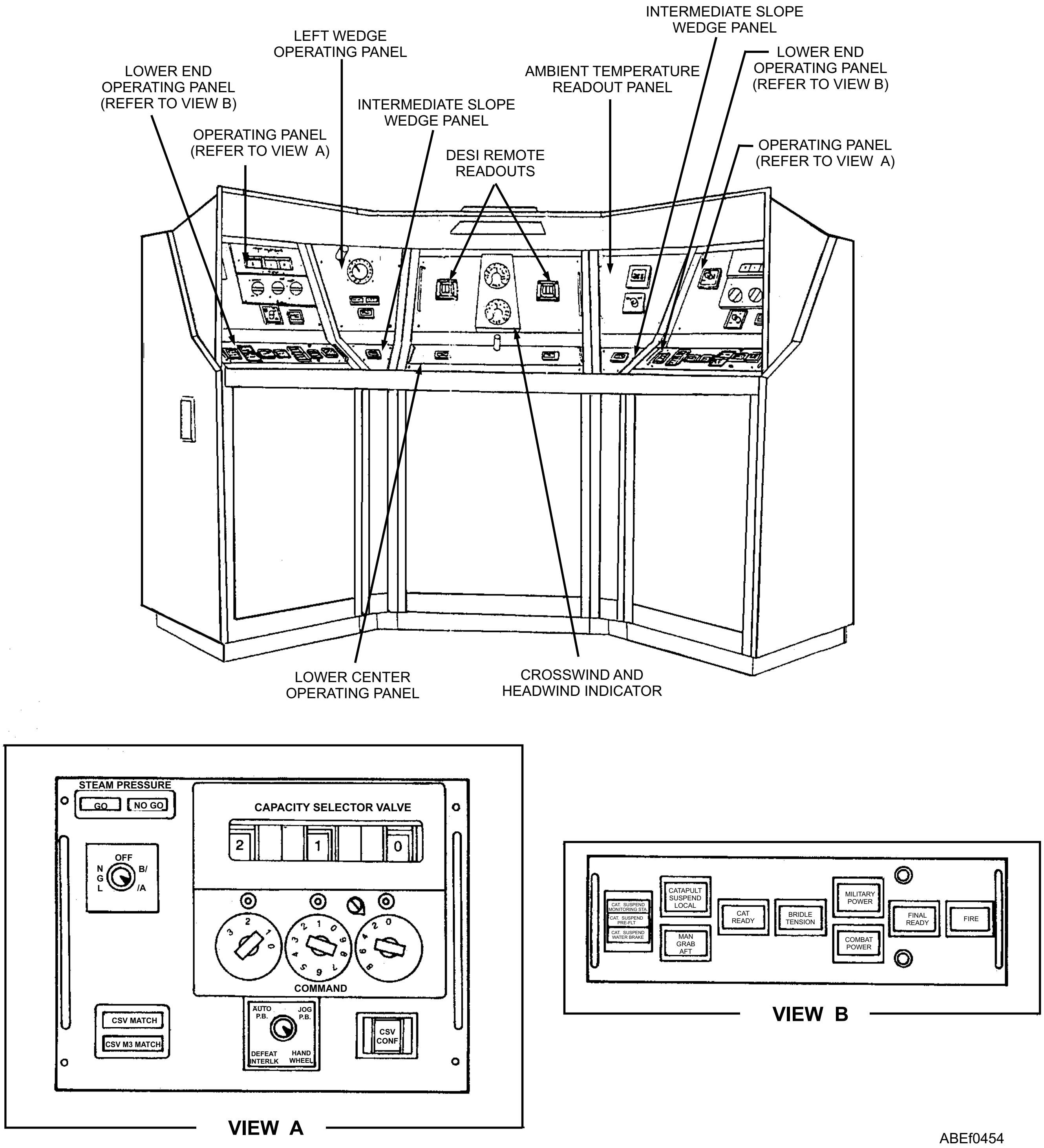


Figure 4-53.—Catapult-officer control console.

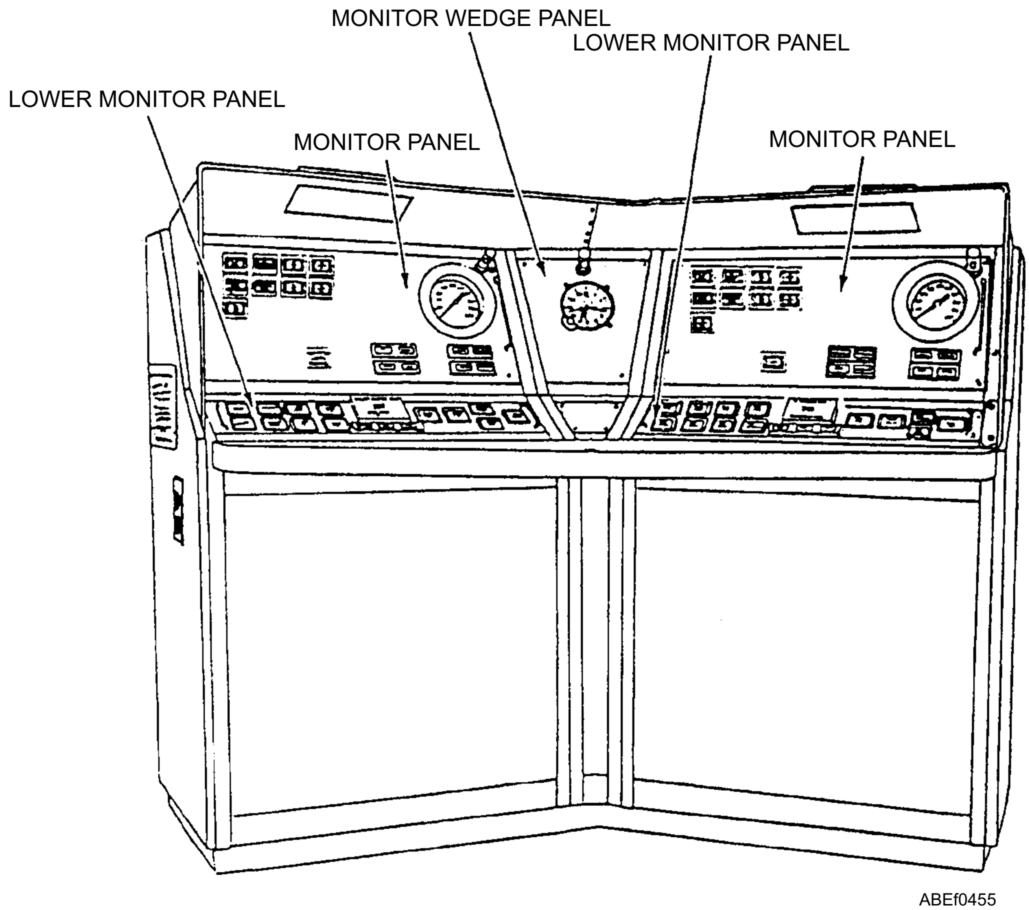


Figure 4-54.—Monitor control console.

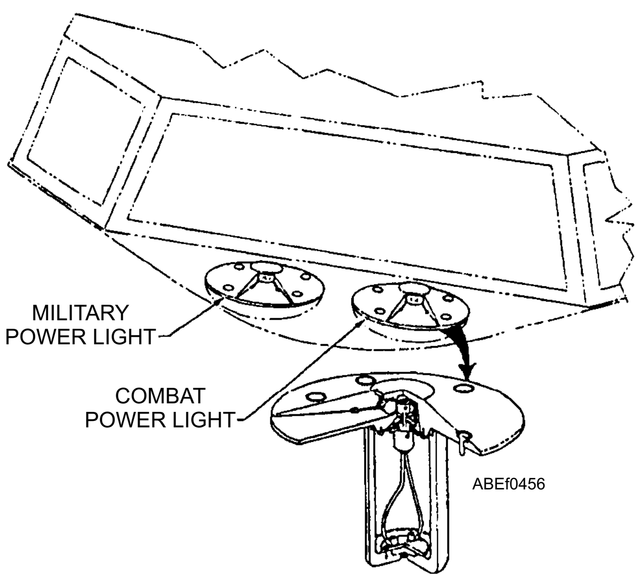


Figure 4-55.—Military and combat power lights (typical).

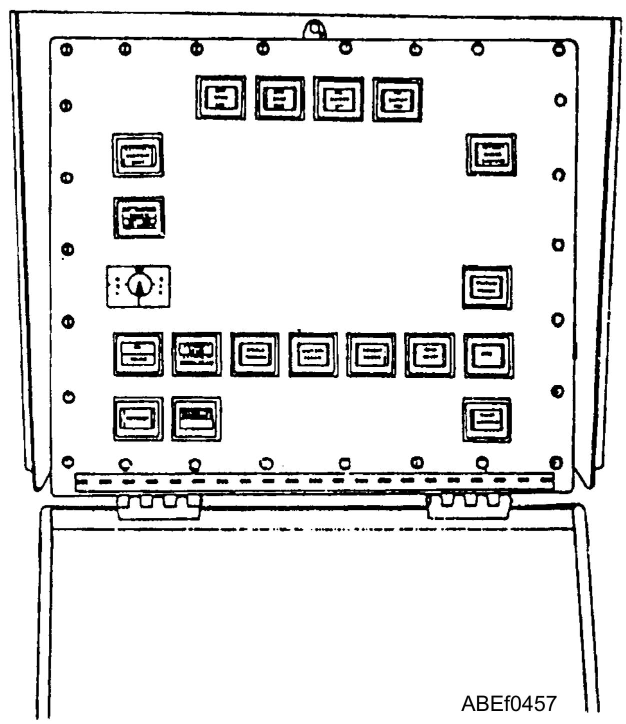


Figure 4-56.—Deckedge control panel.

Monitor Control Console

The monitor control console (fig. 4-54) is used in conjunction with the catapult-officer control console and central charging panel during catapult operations. The control console is of wraparound design and is located facing forward in the ICCS. The console consists of a monitor panel and a lower monitor panel for each of the two adjacent catapults. The center section consists of a wedge panel containing a 24-hour clock. The switches and lights on the monitor panel and lower monitor panel enable the monitor control console operator to keep the launching officer advised of any malfunction occurring on that pair of catapults. During normal operation the green status lights are on. If a malfunction occurs, the green lights go out and the red lights come on. The malfunction lights will indicate red only when a malfunction occurs. A gauge on the monitor panel also indicates steam pressure. In addition to monitoring catapult status, the monitor operator retracts both shuttles and operates the NGL buffer during aircraft abort procedures.

Military Power Lights and Combat Power Lights

Military-power and combat-power lights (fig. 4-55) are located on the deck where they are visible to the pilot when an aircraft is in launch position. The lights are used to signal the pilot when to apply full military power or combat power (afterburner) to aircraft engines during launching operations. These lights are used when operating in the normal (ICCS) mode.

Deckedge Control Panel

The deckedge control panel (fig. 4-56) is located on the bulkhead in the catwalk outboard of the associated catapult. The panel is located such that a clear and unimpeded view of the launching officer and hook up crew is assured. The deckedge control panel is used when launching operation are conducted in the deckedge mode with the launching officer directing operations from the center deck station.

Deckedge Signal Box

The deckedge signal box (fig. 4-57) is located at flight deck level adjacent to the deckedge control panel. Its function is to indicate the readiness of the catapult to the launching officer during operations. The deckedge signal box is only used when operating in the deckedge or central charging panel mode.

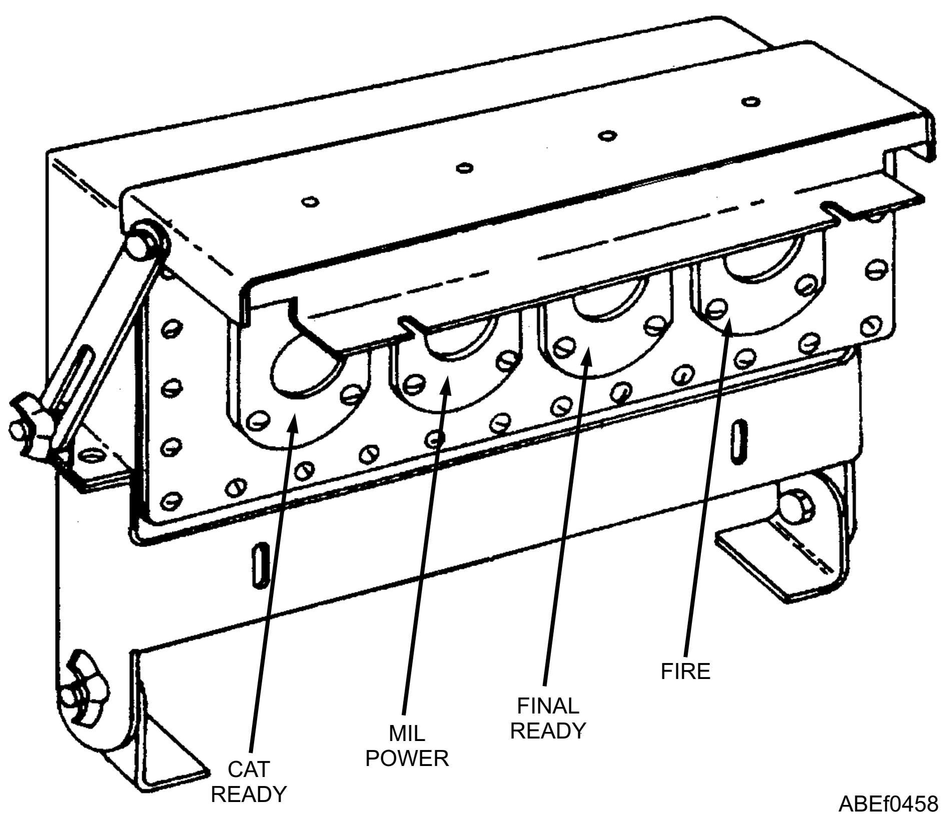


Figure 4-57.—Deckedge signal box.

Deck Catapult-Suspend Light

The deck catapult-suspend light (fig. 4-58) is located on the edge of the flight deck outboard of its associated catapult and in clear view of all topside catapult crew members. The light flashes red during a suspend situation to indicate to personnel on the flight deck that a catapult-suspend situation exists.

Water Brake Control Panel

The water brake control panel (fig. 4-59) is located in the water brake pump room. In the event of an emergency or malfunction of the water brakes, a switch on the panel is used to suspend catapult operations and it further protection for personnel when access to the launching engine cylinders or water brake cylinder is required.

Central Charging Panel

The central charging panel (CCP) (fig. 4-60) provides a single, centralized station from which virtually all below decks catapult functions are accomplished. The CCP consists of left-front panel, left-intermediate-front panel, right-intermediate-front panel, right-front panel, transfer-switch enclosure, and launch-valve-emergency-cutout-valve, which are described in the following paragraphs. The deck-signal-light panel is located inside the central charging panel, below the left-intermediate front panel. Controls on the deck-signal-light panel are used to adjust the intensity of the deck signal lights. The panel enclosure also contains pressure switches, gauge shutoff valves, and other piping components.

LEFT-FRONT PANEL.—The left-front panel contains the switches and pressure gauges for the operation and monitoring of the catapult hydraulic system. The panel contains pressure gauges and OFF-ON switches for the main hydraulic pumps, the booster pump, the circulating pump, and the lubrication pump. Also included are a gravity-tank fluid temperature gauge, three main hydraulic accumulator hydraulic-pressure gauges, an off-on pump delivery control switch, a primary pump selector switch, a retraction-engine suspend switch, a blowdown valve for the retraction-engine hydraulic fluid, and delivery control fuses.

LEFT-INTERMEDIATE-FRONT PANEL.—The left-intermediate-front-panel contains the valves and pressure gauges for charging or blowing down catapult components that require air pressure for their operation. Gauges on the panel indicate the air pressure in the air side of the main hydraulic accumulator, the air flask, the air side of the cable-tensioner accumulator, the low-pressure-air supply, medium-pressure-air supply, and the air side of the tensioner surge accumulator. A dual gauge indicates the air pressure at

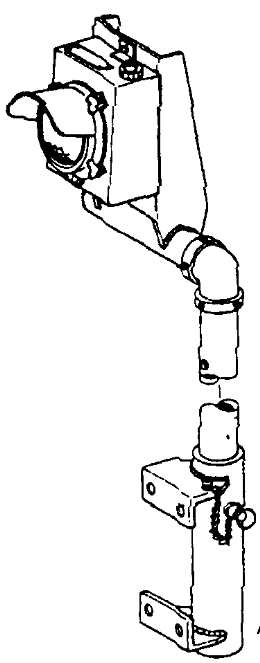


Figure 4-58.—Deck catapult-suspend light.

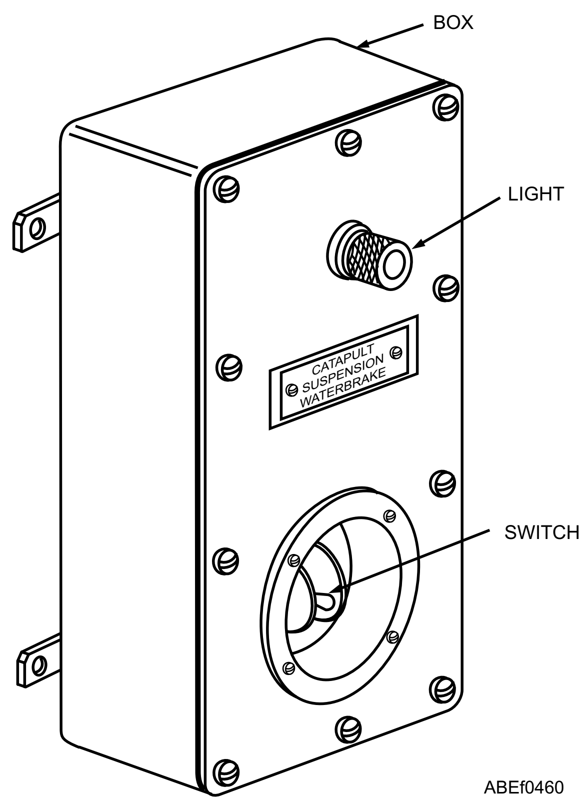


Figure 4-59.—Water brake control panel.

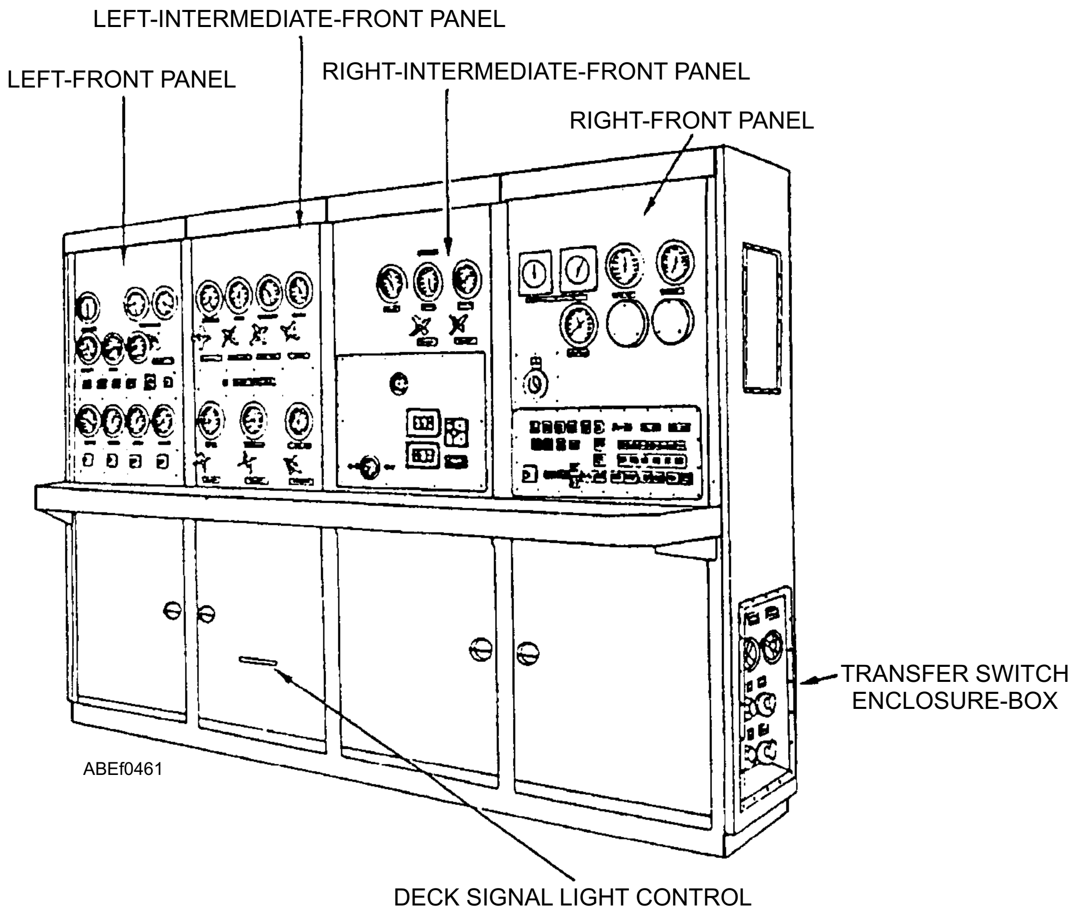


Figure 4-60.—Central charging panel.

the dome of the tensioner regulator and the pressure in the hydraulic fluid side of the tensioner surge accumulator. Valves on the panel are used for charging and blowing down the air flask, the air side of the main hydraulic accumulator, the air side of the cable-tensioner accumulator, the dome of the tensioner regulator, and the air side of the tensioner surge accumulator. There is also a valve to shut off the low-pressure-air supply. A bank of red and green indicator lights on the panel indicates go and no-go indication for various catapult functions.

RIGHT-INTERMEDIATE-FRONT PANEL.—The top portion of the right-intermediate-front panel contains the pressure gauges and valves monitoring, charging, and blowing down the nose gear launch accumulators. The lower portion of the panel contains a 24-hour clock and the CSV setting controls.

RIGHT-FRONT PANEL.—The right-front panel top portion contains the launch valve timer readout, water brake elbow pressure gauges, the wet accumulator pressure gauge, the main power (RC) on/off switch and a panel with the steam fill/blowdown valve selectors. The lower portion of this panel contains lights and switches for operating and monitoring catapult and wet steam accumulator components. The lowest row of lights and switches provide emergency operational capability at the charging panel.

Transfer Switch Enclosure

The transfer switch enclosure is located on the lower right end of the central charging panel. The switch enclosure contains switches that provides a means of transferring catapult control functions for operating in either the deckedge or central charging panel emergency mode. The other switches provide a means of transferring pri-fly, deck signal lights, central control station, and the catapult interlock switch out of the catapult control circuit.

Launch Valve Emergency Cutout Valve

The launch valve emergency cutout valve is located on the lower left end of the central charging panel. The emergency cutout valve provides the central charging panel operator with a positive control to prevent the launch valve from opening during a HANGFIRE condition. When placed in the emergency position, the cutout valve electrically and hydraulically shifts the launch valve control system to the closed position.

Central Junction Box

The central junction box (fig. 4-61) provides a single location for the catapult control system wiring and relays. The terminal board and all wires are clearly marked for easy identification. Relay status lights and a relay tester aid in troubleshooting electrical malfunctions.

CATAPULT CONTROL SYSTEM FOR CV-63, CVN-65, and CV-67

The control system consists of those panels, lights, and switches that are used to operate a catapult throughout the various operational phases. The following is a description of the control system components.

Deckedge Control Panel

The deckedge control panel (figs. 4-62 and 4-63) is located on the bulkhead in the catwalk outboard of the associated catapult. The panel is located such that a clear and unimpeded view of the launching officer and hook up crew is assured. The deckedge control panel contains lights and switches used for catapult control during launching, retraction, and bridle tensioning phases.

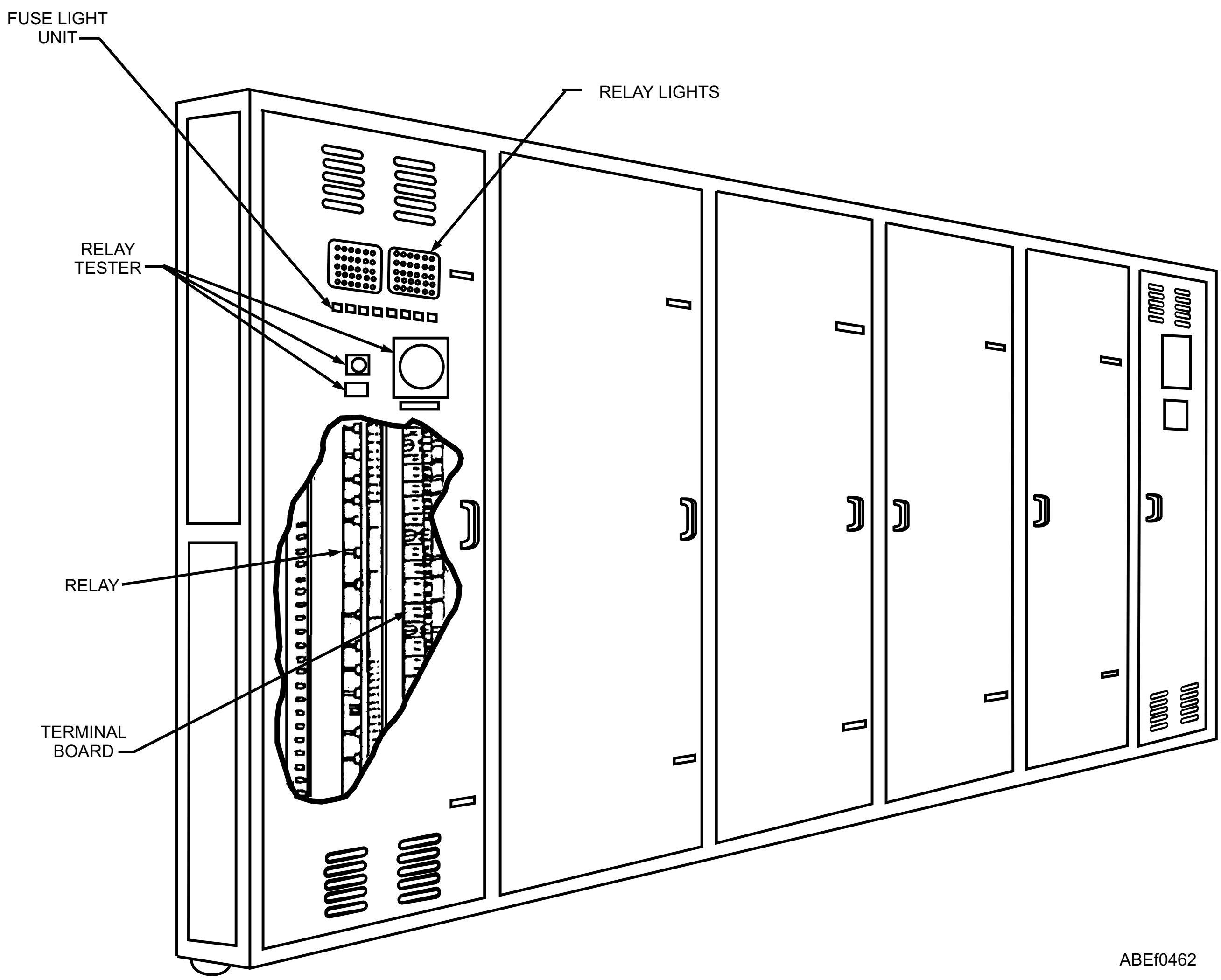


Figure 4-61.—Central junction box.

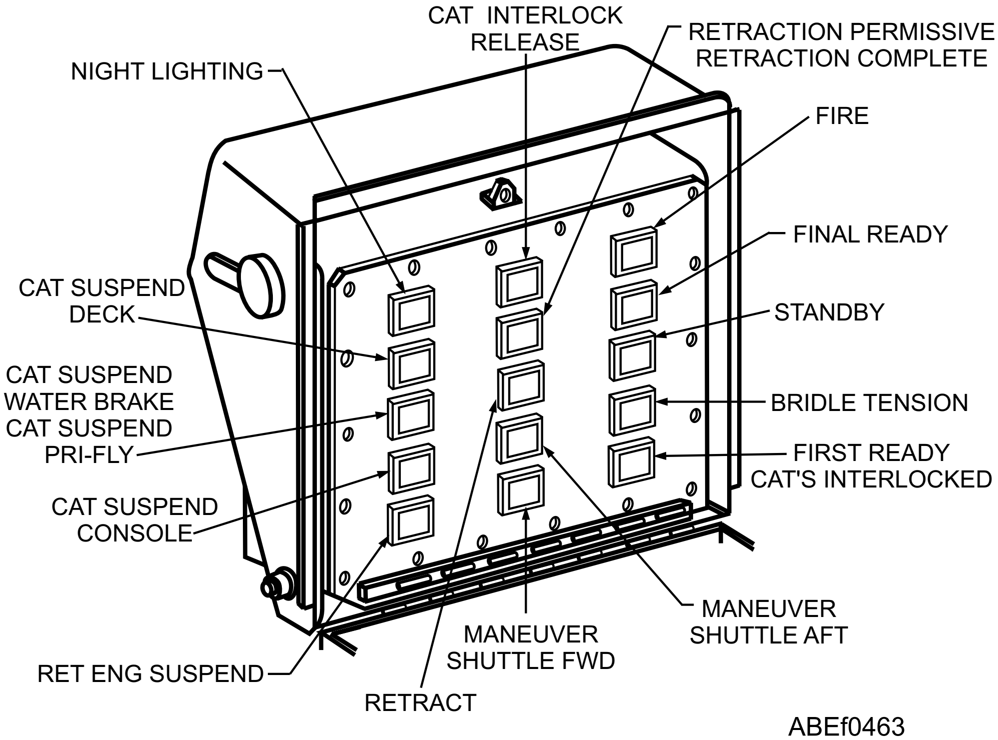


Figure 4-62.—Deckedge control panel (CVN-65 and CV-67).

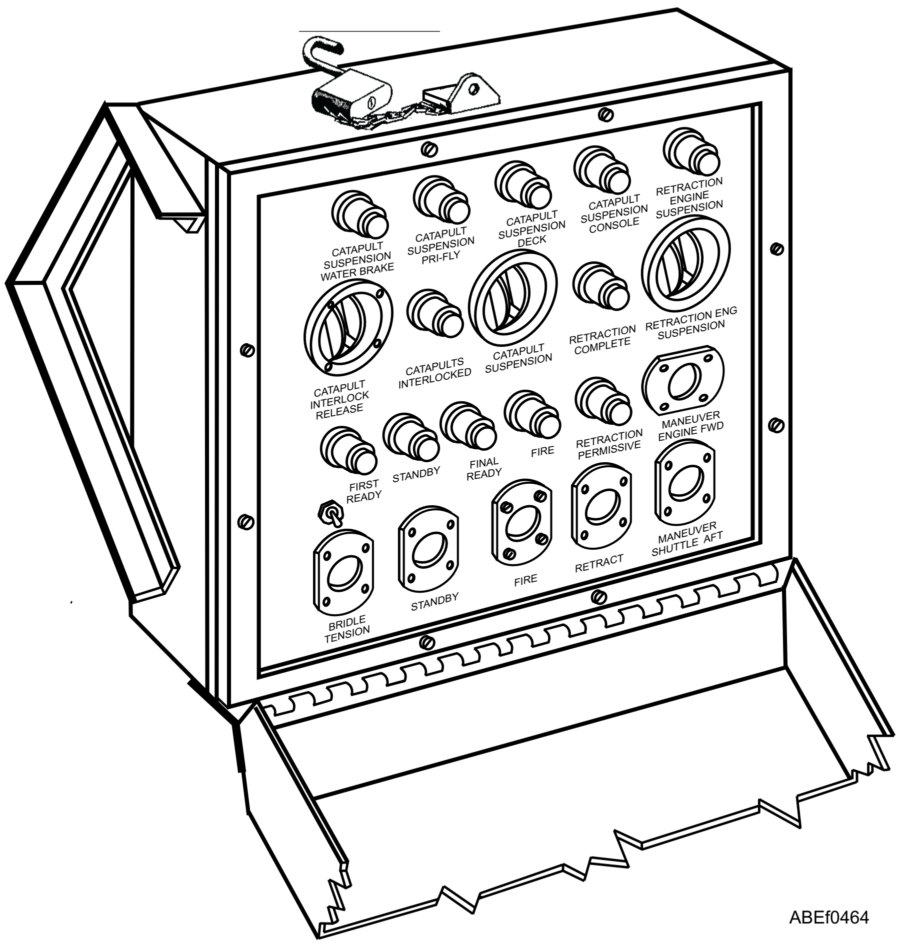


Figure 4-63.—Deckedge control panel (CV-63).

Main Control Console (CVN-65 and CV-67)

The main control console (fig. 4-64) is used in conjunction with the deckedge control panel during catapult operation. The control console consists of a monitor panel, operating panel, steam panel, the launch valve cutout valve, and the transfer switch enclosure.

MONITOR PANEL.—The monitor panel consists of a series of status lights on the top right side for various catapult system pressures. These lights will indicate green for pressure within safe operating limits or red for out-of-limit pressures. Malfunction lights are located down the right side of the panel. These lights will indicate red in the event of a malfunction. The switches that energize these lights will also interrupt the launching sequence. The monitor panel also contains the launch vale stroke timers, and the digital endspeed indicator.

OPERATING PANEL.—The operating panel is used in conjunction with the deckedge panel during launching operations. It contains the lights, push buttons, and switches that are used for catapult control during launching, retraction, and bridle tensioning phases. The operating panel also contains the CSV setting controls.

STEAM CHARGING PANEL.—The steam charging panel contains steam pressure and temperature gauges, status lights, and setting controls. The setting controls provide a means of operating the fill valves automatically or by a manually set air signal. In normal operations, the fill valves are operated in automatic charge. With automatic charge and charge valve selected, the air signal to the fill valves is preset to closely control the opening rates of the fill valves. The manually loading air regulator is used to control the air signal to the blowdown valve and to the fill valves when in manual charge.

Transfer Switch Enclosure

The transfer switch enclosure is located on the lower right side of the main control console. The transfer switch enclosure provides a means of isolating remote panels and switching control to the control console. The transfer switches are rotated from NORMAL to EMERGENCY, as required, to isolate a remote panel that has malfunctioned.

Launch Valve Emergency Cutout Valve

The launch valve emergency cutout valve is located on the lower left side of the main control console. The

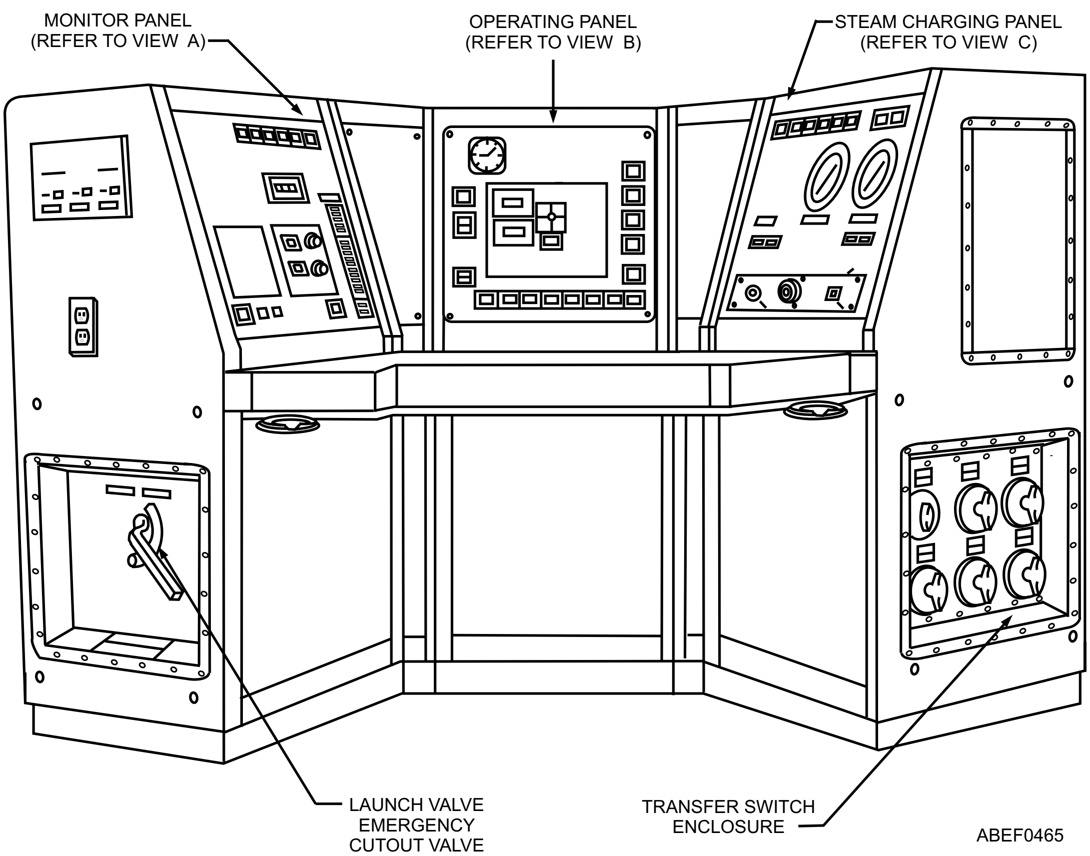


Figure 4-64.—Main control console (CVN-65 and CV-67).

emergency cutout valve provides the console operator a positive control to prevent the launch valve from opening during a HANGFIRE condition. When placed in the emergency position, the cutout valve electrically and hydraulically shifts the launch valve control system to the closed position.

Central Junction Box

The central junction provides a single location for the catapult control system wiring and relays. The terminal board and all wires are clearly marked for easy identification. Relay status lights and a relay tester aid in troubleshooting electrical malfunctions.

Deckedge Signal Box

The deckedge signal box (fig. 4-65) is located at flight deck level adjacent to the deckedge control panel. Its function is to indicate the readiness of the catapult to the launching officer during operations.

Water Brake Control Panel

The water brake control panel (see fig. 4-59) is located in the water brake pump room. In the event of an emergency or malfunction of the water brakes, a switch on the panel is used to suspend catapult operations and it is further protection for personnel when access to the launching engine cylinders or water brake cylinder is required.

Main Control Console (CV-63)

The main control console (fig. 4-66) is used in conjunction with the deckedge control panel during catapult operation. The control console consists of an operating panel, an emergency panel, a malfunction panel, two gauge panels, a launch valve cutout valve, and the transfer switch enclosure.

OPERATING PANEL.—The operating panel is used in conjunction with the deckedge panel during launching operations. It contains the lights, push buttons, and switches that are used for catapult control during the launching sequence.

EMERGENCY PANEL.—The emergency panel contains all the lights, push buttons, and switches are required to provide complete control during the launching, retraction, and bridle tensioning phases.

STEAM GAUGE PANEL.—The steam gauge panel contains a steam pressure gauge, CSV setting controls, digital endspeed indicator and launch valve timer displays.

GAUGE PANEL.—The gauge panel provides a means of monitoring steam and hydraulic temperature and pressures.

MALFUNCTION PANEL.—The malfunction panel contains lights that indicate the status of certain catapult components or systems. The hydraulic pressure and the valve position malfunction lights are

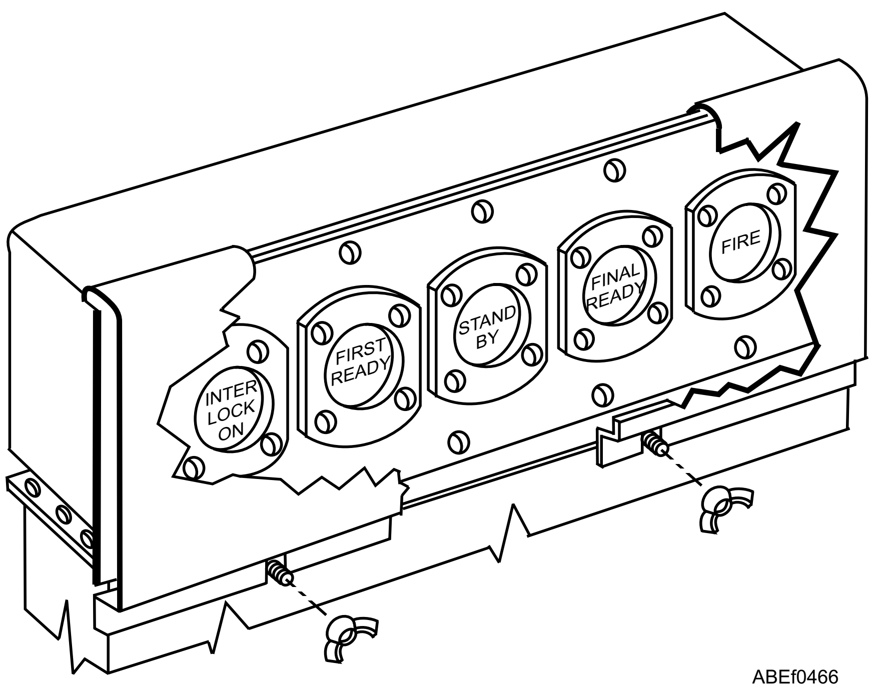


Figure 4-65.—Deckedge signal box.

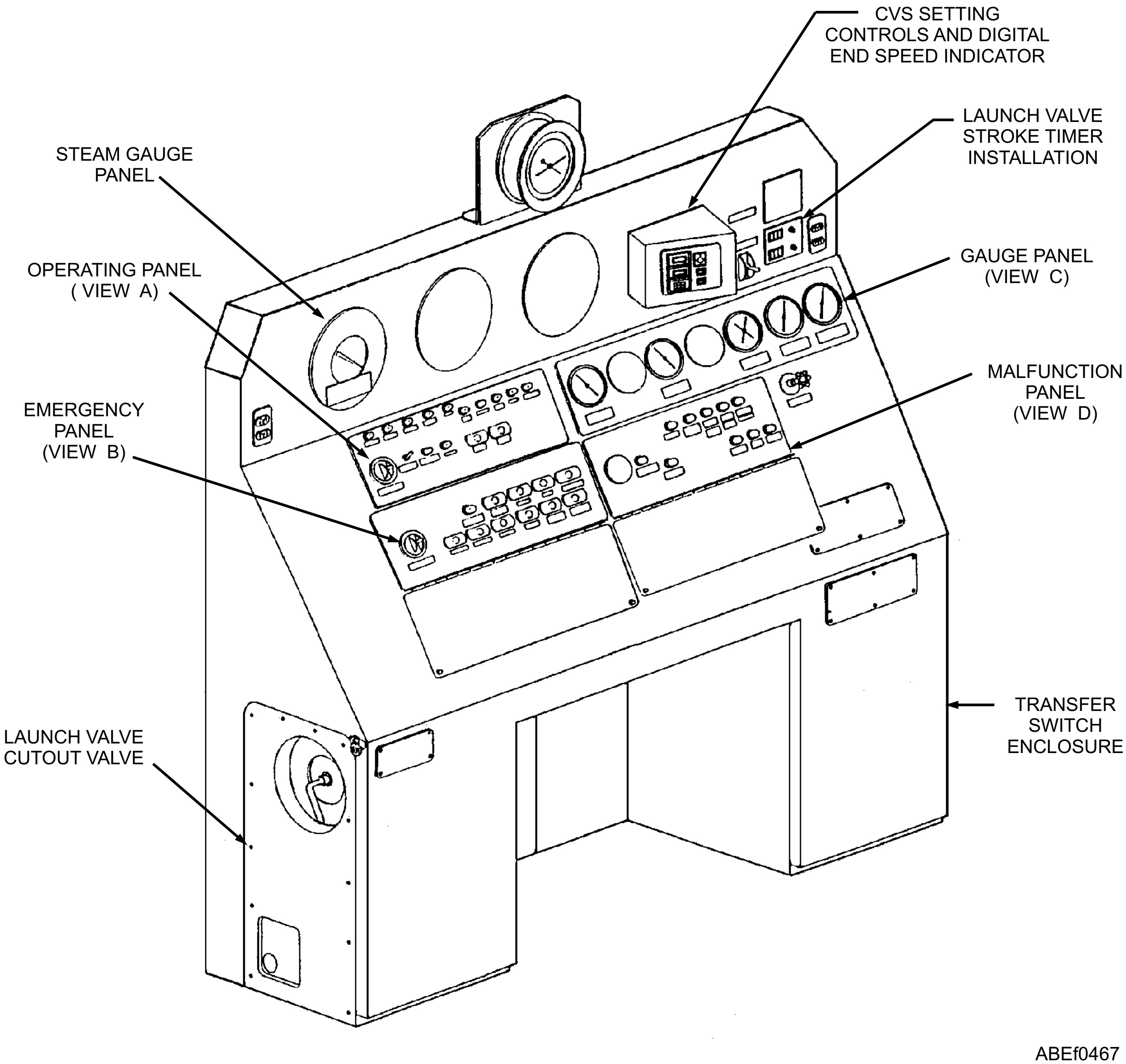


Figure 4-66.—Main control console (CV-63).

red and will illuminate in the event of a malfunction. The blow through no-load light is amber and will illuminate when the blow through circuit is energized. All other lights on this panel are green and will fail to illuminate in the event of a malfunction.

Transfer Switch Enclosure

The transfer switch enclosure is located on the lower right side of the main control console. The transfer switch enclosure provides a means of isolating remote panels and switching control to the control console. The transfer switches are rotated from NORMAL to EMERGENCY, as required, to isolate a remote panel that has malfunctioned.

Launch Valve Emergency Cutout Valve

The launch valve emergency cutout valve is located on the lower left side of the main control console. The emergency cutout valve provides the console operator a positive control to prevent the launch valve from opening during a HANGFIRE condition. When placed in the emergency position, the cutout valve electrically and hydraulically shifts the launch valve control system to the closed position.

Central Charging Panel

The central charging panel (fig. 4-67) provides a single centralized station from which pneumatic and hydraulic systems are controlled and monitored.

LEFT-FRONT PANEL.—The left-front panel contains the switches and pressure gauges for the operation and monitoring of the catapult hydraulic system. The panel contains pressure gauges and OFF-ON switches for the main hydraulic pumps, the booster pump, the circulating pump, and the lubrication pump. Also included are a gravity-tank fluid temperature gauge, three main hydraulic accumulator hydraulic-pressure gauges, an off-on pump delivery control switch, a primary pump selector switch, a retraction-engine suspend switch, a blowdown valve for the retraction-engine hydraulic fluid, and delivery control fuses.

LEFT-INTERMEDIATE-FRONT PANEL.—The left-intermediate-front-panel contains the valves and pressure gauges for charging or blowing down catapult components that require air pressure for their operation. Gauges on the panel indicate the air pressure in the air side of the main hydraulic accumulator, the air flask, the air side of the cable-tensioner accumulator, the low-pressure-air supply, medium-pressure-air supply, and the air side of the tensioner surge accumulator. A dual gauge indicates the air pressure at the dome of the tensioner regulator and the pressure in the hydraulic fluid side of the tensioner surge accumulator. Valves on the panel are used for charging and blowing down the air flask, the air side of the main hydraulic accumulator, the air side of the cable-tensioner accumulator, the dome of the tensioner regulator, and the air side of the tensioner surge accumulator. There is also a valve to shut off the low-pressure-air supply. A bank of red and green indicator lights on the panel indicates go and no-go indication for various catapult functions.

RIGHT-INTERMEDIATE-FRONT PANEL.—The top portion of the right-intermediate-front panel contains the pressure gauges and valves monitoring, charging, and blowing down the nose gear launch accumulators. The right-intermediate-front panel is installed on CVN-65 only.

REVIEW QUESTIONS

Q1. How are the launching engine cylinders heated?

Q2. How is the catapult trough steam smothering actuated?

Q3. What is the purpose of the launch valve steam valve?

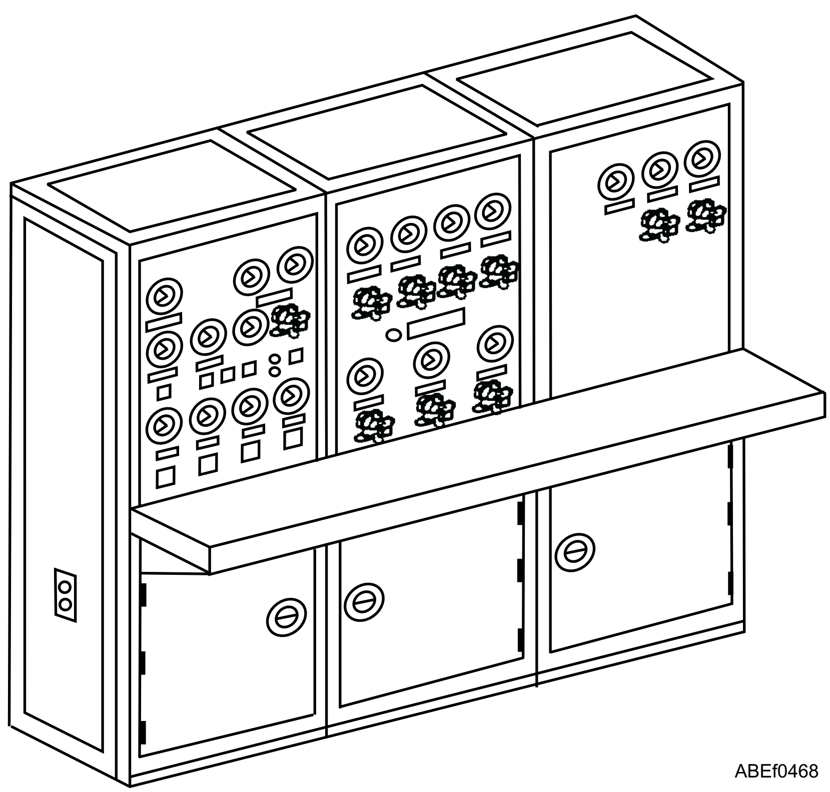


Figure 4-67.—Central charging panel.

Q4. *What provides a means of measuring launch valve performance?*

Q5. *What is the purpose of the keeper valve?*

Q6. *What component transfers the forward motion of the pistons to the aircraft?*

Q7. *What system provides a means of lubricating the launching engine cylinders?*

Q8. *The bridle tensioning system full-aft limit switch is part of what catapult circuit?*

Q9. *The auxiliary tank of the hydraulic system has a capacity of how many gallons?*

Q10. *What is the function of the retraction engine and drive system?*

Q11. *The controls for the ICCS are divided between what panels?*

Q12. *During operation, what indicates the readiness of the catapult to the launching officer?*

OPERATIONS

LEARNING OBJECTIVE: Describe the operation of a steam catapult.

A steam fill-valve system controls the amount of steam from the ship's boilers to the wet-steam accumulator. Steam from the steam accumulator is then released into the launching engine cylinders through the launch valve (the amount of steam used is varied by a capacity selector valve [CSV] assembly that controls the launch valve opening rate).

This surge of steam acts on a set of steam pistons inside the launching engine cylinders. These pistons are connected to a shuttle that is attached to an aircraft. The force of the steam being released from the steam accumulator pushes the pistons forward, towing the shuttle and aircraft at an increasing speed until aircraft take-off is accomplished.

The shuttle and steam pistons are stopped at the end of their "power stroke" as a tapered spear (fig. 4-68) enters a set of water-filled cylinders, forcing the water to be "metered" out of the cylinders as the tapered spear moves into them.

After the shuttle and pistons have been stopped, a grab is advanced forward along the catapult trough covers by means of the retraction engine, and attaches to the shuttle assembly. The retraction engine is then reversed and returns the grab, shuttle, and piston

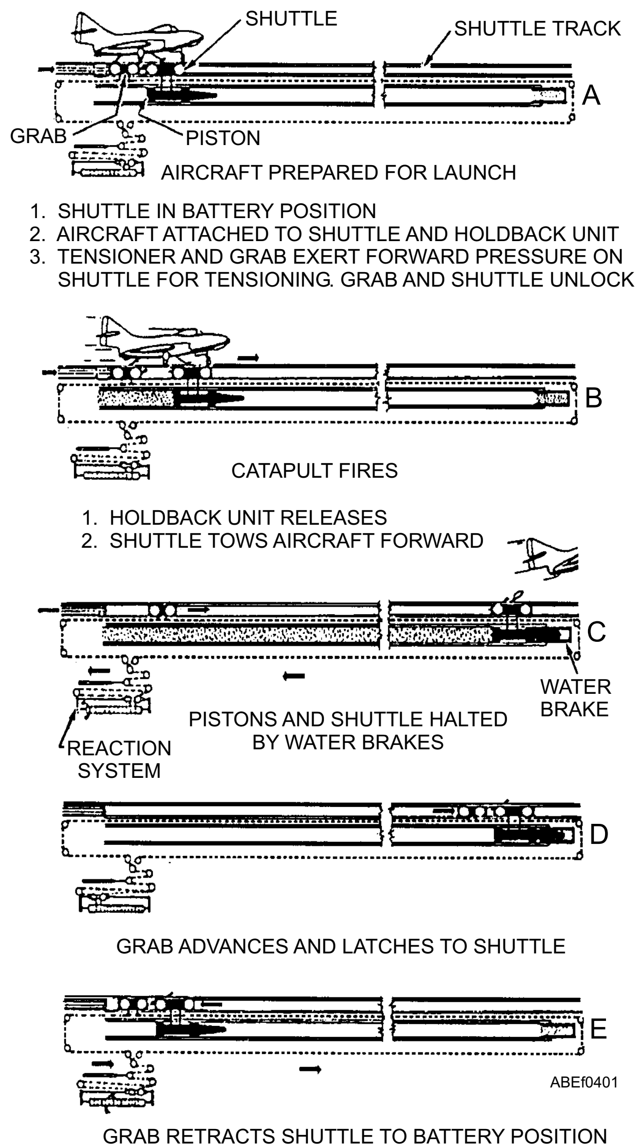


Figure 4-68.—Catapult operation.

assembly to the battery position in preparation for the next aircraft launch.

A integrated catapult control station (ICCS), central charging panel (CCP), main control console, deckedge control panel, retraction engine control/charging panel, and water brake panel are used in conjunction to direct and integrate the catapult electrical and hydraulic systems functions and to control the sequence of operations through a normal catapult launching cycle.

Preliminary functional tests are performed by all operating personnel. These tests consist of at least two no-load launchings, during which the control system is operated through its complete cycle. The functioning of as many component parts of the catapult as possible should be observed by personnel at the various stations during the preliminary functional tests. All malfunctions must be reported to the maintenance officer, catapult officer, or catapult captain.

INTEGRATED CATAPULT CONTROL STATION (ICCS) NO-LOAD LAUNCHING PROCEDURES

No-load launches are conducted during the accomplishment of the preoperational MRCs. No-load launches may also be required for post maintenance catapult checkout.

WARNING

NO-load tests shall be conducted under the supervision of a qualified launching officer. To prevent injury to personnel, safety lines shall be rigged along the deck inboard of the catapult and safety personnel shall be stationed in the catwalk to keep unauthorized personnel clear of the catapult area.

Perform the following steps for no-load test launchings:

1. With the catapult track clear, the safety observer signals the monitor operator to retract.
2. With the grab and shuttle in battery position, the safety observer signals the monitor to maneuver forward a sufficient distance to allow grab/shuttle separation (one to two feet is adequate).
3. With a crewmember manually releasing the grab latch, the safety observer signals the monitor operator to maneuver the grab to the fully aft position.
4. The charging panel operator closes the fluid supply valve to the bridle tensioner pressure regulator and blows off the air pressure in the dome of the bridle tensioner regulator, surge accumulator, and from the dome of the internal tensioning pressure regulator.
5. The launching officer shall set the CSV command setting to the required value and ensure that the CSV is confirmed and that the CSV match lights come on.
6. The charging panel operator shall ensure that the CSV command setting is in the no-load range, and if in agreement with the command setting, depresses the set pushbutton, and ensures that command, position, and mechanical counter all match. If in disagreement with the command setting, the charging panel operator shall not depress the set pushbutton until the setting discrepancy is resolved.
7. The launching officer notifies pri-fly to make a 5MC warning announcement of the impending no load launches.
8. The launching officer depresses the bridle tensioning pushbutton, military power, and final ready pushbuttons.
9. The safety observer shall ensure that the catapult track is clear and all safety personnel are indicating thumbs up and signal the launching officer to fire the catapult.
10. The launching officer shall check for a clear launching area and depress the fire pushbutton.
11. Repeat the above procedures if necessary for subsequent no loads.

INTEGRATED CATAPULT CONTROL STATION (ICCS) LAUNCHING PROCEDURES

Where the ICCS is the primary mode of controlling fixed-wing-aircraft launching operations, the following procedures apply:

As the ship approaches the launch course, the air officer monitors the wind repeater and keeps the launching officer(s) advised of the relative wind velocity. When permission to launch aircraft is received from the bridge, a final check must be made to ensure relative wind is within the limits prescribed in the applicable launching bulletin. This is accomplished before changing the rotating beacon(s) from red to green, which lights the pri-fly "go light" on the catapult officers ICCS console, thereby clearing the launching officer(s) to begin launching.

The following steps must be completed before the launching officer assumes control of the aircraft.

1. Before aircraft tension, the topside safety petty officer performs the following:
    1) Ensures that appropriate jet blast deflectors are raised.
    2) Supervises the attachment of the holdback to aircraft.
    3) Checks the catapult area forward.
    4) Gives the tension signal to the director.

2. The catapult director performs the following:

   1) Checks the catapult area forward.

   2) Ensures that the appropriate jet blast deflectors are raised and that all personnel are clear of the jet blast and prop wash.

   3) Signals the launching officer in the ICCS to take tension, while signaling the pilot to release brakes; the pilot in turn applies power as specified in the *NATOPS Manual* for that type of aircraft.

   4) After the aircraft is tensioned on the catapult, signals the pilot, if required, to raise the aircraft launch bar.

   5) Turns the aircraft over to the ICCS deck signal lights.

3. After tension is taken, the top side safety petty officer performs the following:

   1) Inspects for proper aircraft hookup and alignment.

   2) Ensures that all personnel are clear of the aircraft on the catapult.

   3) Inspects the launch bar to ensure proper engagement with the catapult shuttle after full power application and catapult tensioning are completed.

   4) Signals "thumbs up" to the catapult safety observer with a hand or wand signal if all conditions are satisfactory for launch.

4. The squadron aircraft inspector performs the following:

   1) Makes a final inspection of the aircraft for proper configuration; flaps; trim settings; leaks; and loose panels, doors, or hatches.

   2) Signals "thumbs up" to the catapult safety observer with a hand or wand signal if all conditions are satisfactory for launch.

CAUTION

If there is any doubt in the mind of the topside safety petty officer, director, or squadron aircraft inspector as to satisfactory hookup or aircraft configuration, he or she must so indicate to the catapult safety observer by initiating a crossed arm suspend signal (day) or a horizontal wand movement (night). The catapult safety observer then signals “suspend” to the launching officer in the ICCS.

5. The catapult safety observer performs the following:

   1) Visually checks for proper aircraft hookup and alignment.

   2) Ensures that the appropriate jet blast deflectors are raised and that all personnel are clear of the aircraft, jet blast, and prop wash.

6. The launching officer signals for final turnups by lighting the military power (green) light and the combat power (amber) light, if applicable, in that order. The pilot shall apply full power and afterburner, if applicable, as these lights are illuminated. When the pilot is ready for launch, he or she signifies by saluting the catapult safety observer or, at night, by turning the navigation lights on steady. The pilot ensures that no exterior lights are on before the military power/combat power (afterburner launch) lights are illuminated.

7. The catapult safety observer, after observing the pilot's ready to launch signal performs the following:

   1) Makes a final scan of the aircraft.

   2) Checks for a "thumbs up" signal from the catapult topside safety petty officer and the squadron's aircraft inspector.

   3) Signals "thumbs up" to the launching officer in the ICCS with a hand or green wand signal if all conditions are satisfactory for the launch.

8. Upon receiving the catapult safety observer's "thumbs up" signal and before firing the catapult, the launching officer performs the following:

   1) Checks for a pri-fly go light on his or her console.

   2) Scans the normal area of visibility.

   3) Checks the catapult officer console for satisfactory catapult launch condition.

   4) Checks deck and traffic forward.

   5) Checks deck pitch.

   6) Ensures the catapult safety observer is giving the "thumbs up" signal.

9. After ensuring that all conditions are satisfactory, the launching officer depresses the fire button. If, after coming to full power on the catapult, the pilot desires to stop the launch, he or she does so by shaking the head negatively, rather than by giving the "thumbs down" signal. At the same time, the pilot transmits "suspend, suspend." At night, the visual signal also consists of not turning on the navigation lights. The catapult safety observer signals suspend to the launching officer in the ICCS, using standard hand or wand signals.

NON-INTEGRATED CATAPULT CONTROL STATION (ICCS) NO-LOAD LAUNCHING PROCEDURES

No-load launches are conducted during the accomplishment of the preoperational MRCs. No-Loads launches may also be required for post maintenance catapult checkout.

WARNING

NO-Loads tests shall be conducted under the supervision of a qualified launching officer. To prevent injury to personnel, safety lines shall be rigged along the deck inboard of the catapult and safety personnel shall be stationed in the catwalk to keep unauthorized personnel clear of the catapult area.

Perform the following steps for no-load test launchings:

1. With the catapult track clear, the launching officer signals the deckedge operator to retract.
2. With the grab and shuttle in battery position, the topside safety petty officer signals the deckedge operator to maneuver forward a sufficient distance to allow grab/shuttle separation (one to two feet is adequate).
3. With a crewmember manually releasing the grab latch, the topside petty officer signals the deck edge operator to maneuver the grab to the fully aft position.
4. The retraction engine operator closes the fluid supply valves to the bridle tensioner pressure regulator and the internal tensioning pressure regulator.
5. The launching officer shall set the CSV command setting to the no load value.

WARNING

The main control console operator shall not place the catapult in first ready until the CSV setting has been made, verified and the catapult is ready for no load launches.

6. The console operator shall ensure that the CSV command setting is in the no-load range and depress the set pushbutton. The console operator then ensures that command, position, and mechanical counter all matches and places the catapult in first ready. If in disagreement with the command setting, the console operator shall not depress the set pushbutton and shall leave the catapult in safe until the setting discrepancy is resolved.
7. The launching officer shall ensure that the CSV has been properly set by ensuring a green CSV status light.
8. The launching officer notifies pri-fly to make a 5MC warning announcement of the impending no load launches.
9. The launching officer checks that safety lines are properly rigged and safety personnel are on station. The launching officer then signals the deckedge operator to place the catapult in final ready.
10. The deckedge operator presses the bridle tensioning and standby pushbuttons.
11. The console operator observes the standby light come on, ensures that all conditions are satisfactory and depresses the final ready pushbutton.
12. The deckedge operator observes the final ready light come on and gives the final ready signal.
13. The launching officer shall check for a clear launching area and give the fire signal.
14. The deckedge operator first looks forward and aft to ensure a clear launch area and then presses the fire pushbutton.
15. Repeat the above procedures if necessary for subsequent no loads.

NON-INTEGRATED CATAPULT CONTROL STATION (ICCS) LAUNCHING PROCEDURES

The following steps must be completed before the launching officer assumes control of the aircraft.

1. Before aircraft tension, the topside safety petty officer performs the following:
   1) Ensures that appropriate jet blast deflectors are raised.
   2) Checks the catapult area forward.
   3) Supervises the attachment of the holdback to aircraft.
   4) Gives the tension signal to the director.
2. The catapult director performs the following:
   1) Checks the catapult area forward.
   2) Ensures that the appropriate jet blast deflectors are raised and that all personnel are clear of the jet blast and prop wash.
   3) Signals the deckedge operator to take tension, while signaling the pilot to RELEASE BRAKES; the pilot in turn applies power as specified in the *NATOPS Manual* for that type of aircraft.
3. When the catapult director gives the hand signal that tension is to be taken, the deckedge operator immediately presses the BRIDLE TENSION button and verbally relays the message to the console operator via the sound-powered phone by saying the words TAKING TENSION. Under normal conditions this is the last word spoken until the launch is complete. This is to prevent misunderstanding; for example, misfire, hangfire, fire.
4. Only after correct bridle tension has been applied is control of the aircraft passed, as follows: The director, upon completing bridle tension, immediately passes control of the aircraft by pointing both hands toward the catapult officer.

NOTE

Aircraft to be launched receive a preliminary engine check before being spotted on the catapult; therefore, normal operational procedure is for the catapult officer to go directly into the full power turnup signal after the aircraft has been tensioned.

5. The catapult officer verifies steam pressure readings on the gauges at the center deck panel. The catapult officer observes the first ready signal from the deckedge operator, and acknowledges the signal by holding two fingers overhead, hesitates, and then rotates the hand rapidly for full engine turnup of the aircraft.
6. When the catapult officer starts giving the full power turnup (two-finger) signal, the launching operation proceeds.
7. The deckedge operator, observing the catapult officer's full power turnup signal, immediately presses the standby button. As soon as the standby (green) light comes on at the deckedge panel, he or she holds two fingers overhead. The console operator, observing that the standby (green) light is on at his or her console, immediately checks all gauges and lights. If everything is ok, he or she puts the catapult into final ready condition.
8. When the final ready condition is reached, all final ready (red) lights come on, and the launching operation continues. As soon as the final ready (red) light comes on at the deckedge panel, the deckedge operator immediately holds both hands open above his or her head.
9. With the aircraft at full power, the pilot checks all instruments and gauges. If everything is ok, he or she gets set and indicates ready by turning his or her head slightly toward the catapult officer, executes a right- or left-hand salute, and then positions his or her head against the cockpit headrest. The pilot may refuse to be launched by shaking his or her head negatively, in which case the catapult officer gives the suspension signal.)
10. The launch signal is given only after the catapult has reached final ready and the pilot of the aircraft indicates he or she is ready. The catapult officer ensures that the pilot's head is back against the headrest, checks that the deck is clear forward, and then executes the fire signal. Upon receiving the fire signal, the deckedge operator makes a final check of the flight deck and catwalks. If they are clear, he or she depresses the fire push button.

CAUTION

The deckedge operator must not anticipate the fire signal; if any discrepancy in aircraft hookup is noted or if the deck and catwalks are not clear, he or she must NOT fire but must suspend and notify the catapult officer of the discrepancy.

INTEGRATED CATAPULT CONTROL STATION (ICCS) SUSPEND PROCEDURES

A catapult launch can be halted at any time up until the fire pushbutton has been depressed by actuating a catapult suspend switch. Suspend switches are located at pri-fly, launching officer's console, monitor console, central charging panel, and at the water brake station.

NOTE

If the suspend switch at the water brake station is actuated during catapult operations, breaking tension by energizing maneuver aft cannot occur. If this switch initiated a suspend action, the charging panel operator shall actuate suspend and direct the water brake station to release the water brake suspend.

Actuation of any catapult suspend switch lights a red flashing light mounted at the edge of the flight deck near the battery position for the associated catapult. The operator initiating the suspend must immediately inform the launching officer of the reason for the suspend. The launching officer shall determine the action to be taken for resolution. If the suspend action occurs prior to aircraft hookup, the aircraft shall be held short of the hookup position until the problem has been rectified or the catapult is placed in the down status. If a suspend occurs after an aircraft has been tensioned, the following apply:

1. The safety observer signals suspend to the pilot and other members of the aircraft launching team.
2. The launching officer shall immediately depress the suspend pushbutton.
3. The safety observer shall ensure that the deck suspend light is on and signal the launching officer to maneuver aft.
4. The launching officer depresses and holds the maneuver aft pushbutton until the grab and shuttle are moved fully aft.
5. After the shuttle has moved aft, the safety observer signals the pilot to raise launch bar.
6. For aircraft with NGL selector switch (F/A 18 and S-3):
    1) With the launch bar raised, the safety observer gives the bridle tension signal to the launching officer.
    2) The launching officer depresses the bridle tension pushbutton to position the shuttle forward of the launch bar. When the shuttle has moved forward of the launch bar, the launching officer shall momentarily press the maneuver aft pushbutton.
    3) The safety observer shall step in front of the aircraft and in view of the pilot, give the throttle back signal.
7. For aircraft with manual launch bar (E-2 and C-2):
    1) After the shuttle has moved aft, the safety observer shall ensure that the catapult is in the suspend condition, step in front of the aircraft and in full view of the pilot, give the throttle back signal.
    2) With the aircraft at idle power the safety observer directs the topside safety petty officer to approach the aircraft and manually hold the launch bar high enough to permit shuttle clearance.
    3) With the launch bar held clear, the safety observer gives the bridle tension signal to the launching officer.
    4) The launching officer depresses the bridle tension pushbutton to position the shuttle forward of the launch bar. When the shuttle has moved forward of the launch bar, the launching officer shall momentarily depress the maneuver aft pushbutton.
8. At this time, if the condition that initiated the suspend action has been corrected and the aircraft and catapult are both up, the shuttle may be maneuvered aft, launch bar lowered and the aircraft hooked up to the catapult.

NON-INTEGRATED CATAPULT CONTROL STATION (ICCS) SUSPEND PROCEDURES

A catapult launch can be halted at any time up until the fire pushbutton has been depressed by actuating a catapult suspend switch. Suspend switches are located at pri-fly, deckedge, main control console, and the water brake station.

NOTE

If the suspend switch at the water brake station is actuated during catapult operations, breaking tension by energizing maneuver aft cannot occur. If this switch initiated a suspend action, the main control console operator shall actuate suspend and direct the water brake station to release the water brake suspend.

The operator initiating the suspend must immediately inform the launching officer of the reason for the suspend. The launching officer shall determine the action to be taken for resolution. If the suspend action occurs prior to aircraft hookup, the aircraft shall be held short of the hookup position until the problem has been rectified or the catapult is placed in the down status. If a suspend occurs after an aircraft has been tensioned, the following apply:

1. The launching officer signals suspend to the pilot and other members of the aircraft launching team.
2. The deckedge operator shall immediately actuate the suspend switch and give the suspend signal.
3. The launching officer signals the deckedge operator to maneuver aft.
4. After the shuttle has moved aft, the launching officer signals the pilot to raise launch bar.
5. For aircraft with NGL selector switch (F/A 18 and S-3):
    1) With the launch bar raised, the launching officer gives the bridle tension signal to the deckedge operator.
    2) The deckedge operator depresses the bridle tension pushbutton to position the shuttle forward of the launch bar. When the shuttle has moved forward of the launch bar, the deckedge operator shall momentarily press the maneuver aft pushbutton.
    3) The launching officer shall step in front of the aircraft and in view of the pilot, give the throttle back signal.
6. For aircraft with manual launch bar (E-2 and C-2):
    1) After the shuttle has moved aft, the launching officer shall ensure that the catapult is in the suspend condition, step in front of the aircraft and in full view of the pilot, give the throttle back signal.
    2) With the aircraft at idle power the launching officer directs the topside safety petty officer to approach the aircraft and manually hold the launch bar high enough to permit shuttle clearance.
    3) With the launch bar held clear, the launching officer gives the bridle tension signal to the deckedge operator.
    4) The deckedge operator depresses the bridle tension pushbutton to position the shuttle forward of the launch bar. When the shuttle has moved forward of the launch bar, the deckedge operator shall momentarily depress the maneuver aft pushbutton.
7. At this time, if the condition that initiated the suspend action has been corrected and the aircraft and catapult are both up, the shuttle may be maneuvered aft, launch bar lowered and the aircraft hooked up to the catapult.

INTEGRATED CATAPULT CONTROL STATION (ICCS) HANGFIRE PROCEDURES

In the event the catapult does not fire within 10 seconds after the fire pushbutton is depressed, a hangfire exists. At this time, the launch sequence must be safety stopped and the aircraft removed from the catapult. The actions to be taken and the order in which they are accomplished are paramount to the success of the procedure.

WARNING

If a hangfire occurs, the execution of the hangfire procedure must be accomplished. Even if the cause of the hangfire is quickly determined and can be easily resolved, the actions of all topside crew members and pilot are not known and interrupted firing of the catapult could have catastrophic consequences. The only corrective action authorized is the performance of the hangfire procedure.

1. The launching officer depresses the suspend switch and transmits to the charging panel operator via the monitor operator, "rotate the emergency cutout valve, rotate the emergency cutout valve." The launching officer shall then inform the safety observer of the hangfire condition verbally and by hand signals in daytime or the red wand hangfire signal at night.
2. The safety observer shall remain in the crouched position and shall not take any action toward the removal of the aircraft until the

shuttle has moved aft and assurance is received that the catapult is safe.

3. The charging panel operator shall perform the following actions in exact order:
   1) Depress the suspend pushbutton.
   2) Remove the cotter pin and unscrew the pin from the emergency cutout valve.
   3) Rotate the emergency cutout valve to the emergency position.
   4) Depress and hold the maneuver aft pushbutton for 15 seconds.
   5) Report to the launching officer via the monitor operator that the catapult is safe.
4. The launching officer transmits verbally that the catapult is safe and signals the safety observer a thumbs up in daytime or a red wand signal at night.
5. If the shuttle did not move aft during the preceding steps, the launching officer shall direct the charging panel/retraction engine operator, via the monitor operator, to depress and hold the manual override on the maneuver aft valve for 15 seconds.
6. After receiving assurance that the catapult is safe and observing that the shuttle is aft, the safety observer steps in front of the aircraft and in view of the pilot, gives the throttle back signal. The normal suspend/abort are accomplished for aircraft removal from the catapult.
7. After aircraft removal from the catapult has been accomplished, the launching officer shall set the CSV command to a no-load setting and ensure that CSV confirmed and match lights come on.
8. The emergency cutout valve shall remain in the emergency position until the maintenance officer authorizes rotation of the valve to the normal position.
9. The catapult is placed in a down status until the cause of the hangfire is determined, corrected, and two satisfactory no-load launches accomplished.

NON-INTEGRATED CATAPULT CONTROL STATION (ICCS) HANGFIRE PROCEDURES

In the event the catapult does not fire within 10 seconds after the fire pushbutton is depressed, a hangfire exists. At this time, the launch sequence must be stopped and the aircraft removed from the catapult. The actions to be taken and the order in which they are accomplished are paramount to the success of the procedure.

WARNING

If a hangfire occurs, the execution of the hangfire procedure must be accomplished. Even if the cause of the hangfire is quickly determined and can be easily resolved, the actions of all topside crew members and pilot are not known and interrupted firing of the catapult could have catastrophic consequences. The only corrective action authorized is the performance of the hangfire procedure.

1. The launching officer shall remain in the crouched position and signals in exact order:
   1) Suspend
   2) Hangfire
   3) Maneuver aft
2. The launching officer shall remain in the crouched position and shall not take any action toward the removal of the aircraft until the shuttle has moved aft and assurance is received that the catapult is safe.
3. The deckedge operator depresses the suspend switch and transmits to the main control console operator, “rotate the emergency cutout valve, rotate the emergency cutout valve.”
4. The main control console operator shall perform the following actions in exact order:
   1) Depress the suspend pushbutton.
   2) Remove the cotter pin and unscrew the pin from the emergency cutout valve.
   3) Rotate the emergency cutout valve to the emergency position.
   4) Depress and hold the maneuver aft pushbutton for 15 seconds.
   5) Report verbally to the deckedge operator that the catapult is safe.
5. The deckedge operator upon receiving the assurance from the main control console operator, signals to the launching officer, the hangfire signal followed by thumbs up in daytime or a red wand signal at night.

6. If the shuttle did not move aft during the preceding steps, the deckedge operator shall direct the retraction engine operator to depress and hold the manual override on the maneuver aft valve for 15 seconds.
7. After receiving assurance that the catapult is safe and observing that the shuttle is aft, the launching officer steps in front of the aircraft and in view of the pilot, gives the throttle back signal. The normal suspend/abort are accomplished for aircraft removal from the catapult.
8. After aircraft removal from the catapult has been accomplished, the launching officer shall set the CSV command to a no-load setting.
9. The main control console operator shall depress the set pushbutton.
10. The emergency cutout valve shall remain in the emergency position until the maintenance officer authorizes rotation of the valve to the normal position.
11. The catapult is placed in a down status until the cause of the hangfire is determined, corrected, and two satisfactory no-load launches accomplished.

SAFETY PRECAUTIONS

There are certain safety precautions that must be observed by catapult-operating personnel, maintenance personnel, deck personnel, pilots, and other personnel stationed in the catapult area.

Flight Deck

Bridle (deck) tensioner pressure, as determined by calibration, must be precisely adjusted and maintained at all times. Pressures in excess of those specified may cause premature holdback.

In the event of a malfunction, suspend, or hangfire, the signal for throttle back must NOT be given to the pilot until bridle tension has been released and the launch bar is raised.

When attaching the aircraft to the shuttle, extreme care must be taken so that the launch bar properly engages the shuttle. The catapult officer must ensure that the aircraft is properly tensioned prior to launching.

Precaution should be taken by the pilot not to taxi hard against the holdback unit. This may result in a premature release.

At no time are personnel to walk in front of a tensioned aircraft.

If operation of the catapult is suspended for any reason, bridle tension should be released and the aircraft released from the shuttle.

The shuttle and grab must not be moved along the catapult track until the track slot has been inspected and found to be clear of obstructions and all adjacent areas are clear of loose gear. Using the maneuver forward and aft push buttons, slowly move pistons forward and aft while all sheaves are visually checked to ensure the cables are not sliding over any locked sheaves.

All personnel must be kept out of areas forward of an aircraft positioned on the catapult, and clear of the shuttle track area during a no-load firing. All personnel must be kept clear of the area immediately behind the jet blast deflectors during aircraft turnups and launching.

During night operations, do not attempt to speed up the prelaunch check of catapult components or take unnecessary chances in an effort to maintain rapid aircraft launching intervals. Sufficient time should be taken to double-check each step to prevent accidents due to faulty hookups, misinterpreted signals, and other causes.

ICCS, CCP, Deckedge and/or Main Control Console

Retraction must not be undertaken unless the water brakes are operating properly and the grab and shuttle are latched. During preheating and throughout launching operations, the difference in elongation between the two launching engine cylinders must NOT exceed 1 inch. The catapult must NOT be fired with the shuttle out of BATTERY.

The shuttle must NOT be retracted with steam in accumulators unless the water brakes are functioning.

Do not advance the grab with spears out of the water brakes because possible grab latch damage may result, due to impact. Therefore, use the maneuver forward push button to advance the grab until it engages the shuttle.

Water Brakes

If the water-brake cylinder elbow pressure drops below minimum value the water brakes should be suspended and the CCP/main control console operator notified immediately. The malfunctioning water-brake pump should be secured and the standby pump started.

Do not allow excessive oil to accumulate on top of the water in the water-brake reservoir. Skim off the oil, or remove it by adding fresh water and allowing the oil to flow out the overflow drain.

NOTE

During in-port periods, do not skim the water-brake tanks or allow the water level to reach the overflow pipe. Maintain the water level by use of bottom tank drains. This is to prevent oil from being dumped into harbors.

Retraction Engine

All loose gear and tools must be kept clear of the retraction engine and cable system. Maintain all pressures at predetermined settings.

If any malfunction is observed during the advance of the grab or the retraction of the shuttle and grab, immediately SUSPEND the retract engine and notify the CCP/main console operator. All sheaves must be inspected for freedom of motion before beginning a series of launchings.

General

Operating personnel should wear appropriate protective clothing to prevent burns from steam or from contact with hot metallic surfaces. Earplugs should be worn in areas of high noise level.

The entire hydraulic system must be vented thoroughly and frequently, particularly after extended periods of idleness. Air in the fluid system may cause unpredictable variations in catapult performance and delays in actuation of operating components.

Combustible and volatile fluids and materials must be kept away from heated catapult parts to reduce the hazard of fire and explosion. Adequate ventilation must be provided below flight deck level to prevent the accumulation of explosive vapors.

If a hangfire occurs, personnel must not pass forward of the aircraft until all danger of a delayed launching has passed.

The catapult must NOT be operated with any known broken lockwires, loose or cracked components, major hydraulic leakage, defective reeving, or electrical control malfunction.

During any type of launching, live steam escapes from the track and brake areas. As this steam can cause severe scalding of exposed areas of the body, personnel in the area must avoid contact with it. When the catapult is in operating status, exposed metallic parts, such as track covers, launching and exhaust valves, and steam supply piping, may be hot enough to burn exposed areas of the body on contact. Therefore, operating personnel with duties in these areas should be equipped with appropriate protective clothing.

Aircraft launchings must NOT be made if the required minimum cylinder elongation has not been attained. An exception to this rule may be made under emergency conditions when wind-over-deck requirements have been increased as specified in applicable *Aircraft Launching Bulletins*.

Aircraft must not be launched at weights and wind requirements other than those specified in applicable *Aircraft Launching Bulletins*. Maximum loading of aircraft as specified in the *NATOPS Manual* for each type of aircraft, must be adhered to at all times.

Inspect all pumps and their limit switches and safety valves. Failure of safety devices can result in dangerous overpressures if the pump continues to operate. This condition may result in rupture of hydraulic pneumatic lines and danger to personnel.

SECURING THE CATAPULT

At the completion of aircraft launching operations, the catapult officer shall decide what state of catapult readiness will be maintained. Depending on operational requirements, one of the following readiness conditions will be established:

Ready

The order to maintain the catapult in a READY condition should be given when launching operations are intermittent or when certain conditions make it necessary to keep the catapult in a state of preparedness for launching within seconds after an order is given.

In the READY condition, the catapult is kept in a fully operational status, as between launching cycles.

Standby

If the order for the STANDBY condition of securing is given, it usually comes after the day's launching operations are completed and there is no possibility of additional launching within 12 hours.

The post-launch duties and inspection must be performed according to the MRCs.

Shutdown

The order for SHUTDOWN condition of securing the catapult is given when the catapult is placed out of service for maintenance or when the ship is in port.

Cold Iron

When the catapult will not be required for launching operations for an extended period of time, or the steam system and preheat system must be secured and the components allowed to cool down.

INSPECTIONS AND MALFUNCTIONS

The entire catapult should be kept as clean as possible. It should be wiped down daily to remove excess grease, oil, and dirt. All catapult personnel should be constantly alert for any unusual sound or action of the machinery. Report any unusual condition to the catapult officer for immediate investigation.

Periodic Inspections

Prior to the first launching of each day's operations, execute the PMS preoperational inspection according to the MRCs.

After each day's operation, perform the PMS postoperational inspection according to the MRCs.

Other inspections must be conducted in addition to preoperational and postoperational. These inspections are also accomplished through the use of MRCs.

Prior to conducting an inspection or maintenance on catapult equipment where an injury could occur from careless operation, make sure the following safety precautions have been accomplished in the order indicated:

1. Disconnect the grab from the shuttle and move it fully aft.
2. Close the main steam supply to the steam accumulator.
3. Reduce steam pressure in the steam accumulator to atmospheric pressure.
4. Open the retraction-engine accumulator blowdown valve.
5. Station a safety person at the ICCS, CCP, main control console and deckedge control manning sound-powered telephones to prevent tampering with catapult controls.
6. Station a safety person at the retraction engine and the water-brake tank, manning sound-powered telephones.
7. Tag the steam-smothering valve "out of service."
8. Station a safety person on the flight deck (in the shuttle area) to prevent accidental movement of the shuttle while personnel are in the water-brake tank.

The preceding safety instructions must be strictly followed. Under any conditions when inspection of the water brakes area is undertaken, it is imperative that the control system remain in a SAFE position (exhaust valve open, grab aft).

Malfunctions

This section provides operating personnel with a guide to assist in isolating and correcting causes of malfunctions. During aircraft launch operations, malfunctions may occur that can be rapidly corrected if the cause is correctly determined. In other cases, corrective action may require extensive repairs, and it is important that operating personnel rapidly isolate the cause of the malfunction in order to inform the catapult officer if the catapult must be placed out of service.

When a malfunction occurs, the catapult must be put in a SAFE condition before corrective action is attempted, to prevent accidental launching of aircraft or injury to personnel.

To property correct any malfunction(s) all primary causes should be checked first to quickly isolate the malfunction to a specific system. The secondary causes can then be checked to determine which component(s) within the system caused the malfunction.

All preoperational and post operational inspection procedures that apply to a specific system or station of the catapult are to be conducted and completed by the person or persons assigned the duty. For detailed inspection procedures, the ABE must consult the applicable MRCs or technical manuals.

REVIEW QUESTIONS

Q13. When are no loads conducted?

Q14. A hangfire exists when the catapult does not fire within what amount of time after the fire pushbutton has been pressed?

SUMMARY

We have described functions and operations of the major catapult systems, descriptions of ICCS, central charging panels, main control consoles, and general maintenance procedures. For a more detailed study of the catapult systems and components, see the applicable NAVAIR technical manuals with the latest revisions.