CHAPTER 10

STEAM CATAPULTS

10.1 General

The purpose of the steam catapult is to provide a means to safely launch aircraft from carrier decks, day or night, in almost any kind of weather. The steam catapult is designed to launch aircraft with the ship headed into the wind, but has the capabilities to launch aircraft downwind, alongside the pier, or at anchor.

10.2 CAPABILITIES

C-13-0: 74,000 lbs. at 128 knots in 249 ft. Track length: 264 ft. 10" (CV-63, CV-64, CVN-65, CV-67 {3 of 4})

C-13-1: 80,000 lbs. at 140 knots in 309 ft. Track length: 324 ft. 10" (CV-67 {1}, CVN-68, CVN-69, CVN-70, CVN-71)

C-13-2: 80,000 lbs. at 140 knots in 309 ft. Track length: 324 ft. 10" (CVN-72, CVN-73, CVN-74, CVN-75, CVN-76)

NOTE

Primary difference between C-13-1 and C-13-2 is that -2 has 21" diameter power cylinders vice 18".

10.3 CATAPULT SYSTEMS

Each catapult consists of eight major systems:

1. Launching Engine System
2. Steam System
3. Retraction Engine System
4. Drive System
5. Hydraulic System
6. Bridle Tension System
7. Lubrication System
8. Control System

10.3.1 Launching Engine System. The Launching Engine System launches the aircraft, the other seven systems support the launching engine by providing or controlling a functions required for the launching engine to operate properly and efficiently.

The launching engine *(Figure 10-1)* consists of the cylinders, cylinder covers, piston assemblies, sealing strip, grab, shuttle and trough covers. The engine is powered by steam from the ships boilers which is allowed to enter the aft end of the launching engine through the launching valve. This steam then acts on the piston assemblies and projects them forward at an ever accelerating rate. By means of the shuttle assembly, an aircraft can be connected to the catapult hereby projecting it forward as the catapult is fired. At the forward end of the catapult is the water brake assembly which halts the forward motion of the catapult. At this time the aircraft is released from the shuttle with sufficient speed to become airborne.

A most critical factor of the launching engine is that it must be pre-heated to the proper temperature to ensure safe and efficient operation. Installed in the catapult trough is the external preheating system for the launching engine. Finned tubing lies underneath the power cylinders on both sides and in the middle, supplied with steam from the ships boilers, to ensure proper heating of the launching engine prior to operation. Thermal expansion then allows the launching engine cylinders to elongate to the proper operating distance of 7" both rows of cylinders within 1" of each other, to meet the proper operational requirements.

The water brake assembly *(Figure 10-2)*, provides the catapults braking capability. With the forward end of the catapult launching engine cylinders telescoped over the 9 ft. water brake cylinder, the steam piston and spear assembly (middle), is guided forward though the cylinders and halted at the forward end of the catapult by the water brake installation. When the catapult is fired, the spear on the forward part of the piston assembly's guided into the mouth of the water brake cylinder where water pressure resists its entering thereby providing a braking action for the catapult. The water brake cylinder is supplied with fresh water from a 5,000 gallon

tank, located directly below decks in the water brake pump room. This is a recirculating system which eliminates excessive use of fresh water.

The piston and spear assembly *(Figure 10-3)*, moves forward and aft inside the launching engine cylinders, one assembly in each row of power cylinders. As the assembly moves in either direction a steam seal called the sealing strip is lifted from its seat on the cylinder cover and placed back down on its seat by means of the guide and connector on the piston assembly. This action ensures minimum loss of steam pressure during operation. A cylinder cover seal is also mounted on top of the steam piston which prevents steam from escaping over the top of the piston and slowing the forward motion of the piston and spear assembly.

The shuttle assembly *(Figure 10-4)* provides a means of interconnecting both piston and spear assemblies to an aircraft located above the launching engine installation. Numerous teeth (dogs) are located on the shuttle frame and each piston and spear assembly connector to enable both pistons to be connected directly to the shuttle assembly.

Depending upon the type of catapult, cylinder elongation indicator installation varies. Some installations are as shown in *Figure 10-5* with the scale and indicator pointer below decks in the launching valve compartment and others are viewed from the flight deck at the forward end of the catapult track.

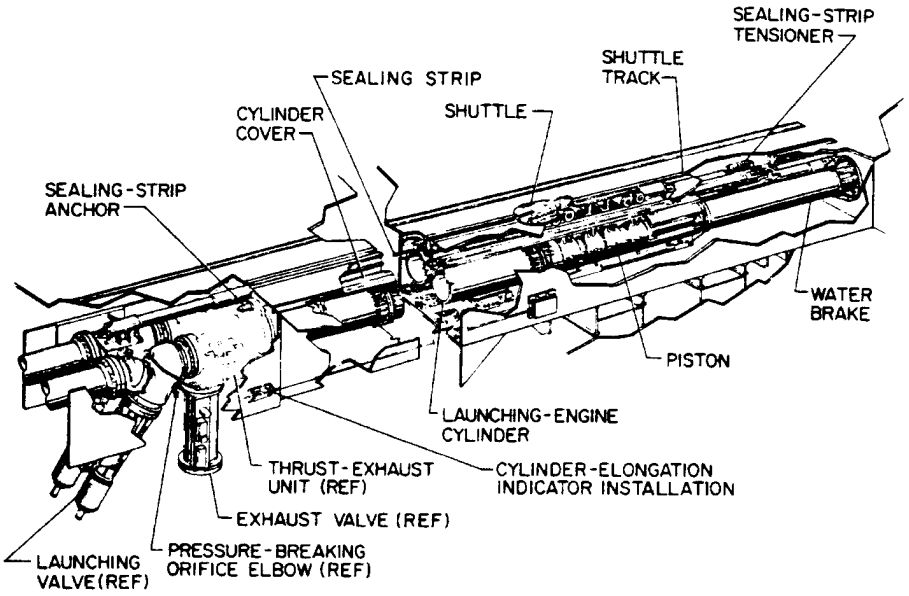
10.3.2 Steam System. The steam system of the catapult, is a wet receiver system *(Figure 10-6)*. This installation enables the catapult to operate with a constant steam pressure. The receiver is filled with water and superheated steam from the ships boilers. With the proper level of water, at the correct operating temperature the wet receiver system allows the catapult a constant acceleration when fired by the action of the steam and water within the steam receiver.

Also shown in *Figure 10-6* are the rotary type launching valves. Their function is to allow steam into the launching engine cylinders. The rotary type valve rotates to open allowing steam into the cylinders firing the catapult.

10.3.3 Retraction Engine System/Drive System. The retraction engine system provides a means of retrieving the shuttle and piston assemblies after the catapult has been fired. The retraction engine also provides the ability to position the shuttle assembly at any point along the catapult track for maintenance purposes or preoperation and postoperation inspections.

The current type of retraction engine in use is the rotary retraction engine *(Figure 10-7)*. This installation is hydraulically operated and works in conjunction with the drive system *(Figure 10-8)* to position the shuttle and spear assembly at any point along the catapult track. As hydraulic fluid enters the manifold assembly it is directed to a drive motor through a series of directional valves. This fluid pressure then rotates the motor in whichever direction desired to drive the grab assembly forward or aft. The hydraulic motor rotates a drum which feeds cable onto and off simultaneously. The cables are guided on and off of the drum by a traverse carriage assembly which is geared to the drum and motor.

The cables are tensioned through means of cable tensioners mounted on the engine which are hydraulically operated and ensure that the proper cable tension is maintained throughout the system during operation. Four separate cables are utilized on the retraction engine, varying in length, two on the aft side of the grab assembly, which are the retract cables and two on the forward side which are the advance cables. These cables are reeved into the system and anchored at one end to the grab and the other end to the retraction engine.



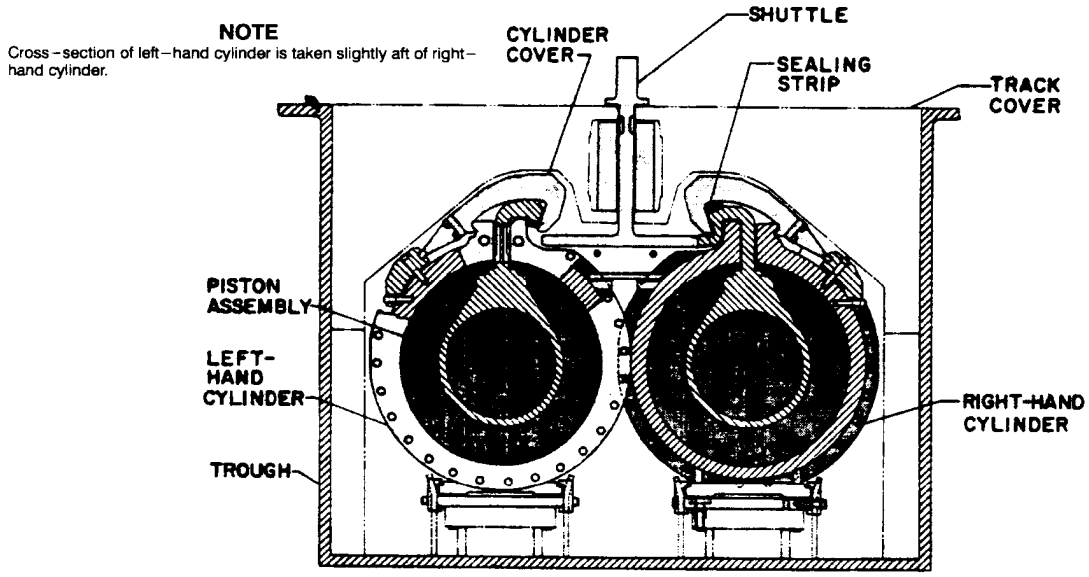


Figure 10-1 the Launching Engine System

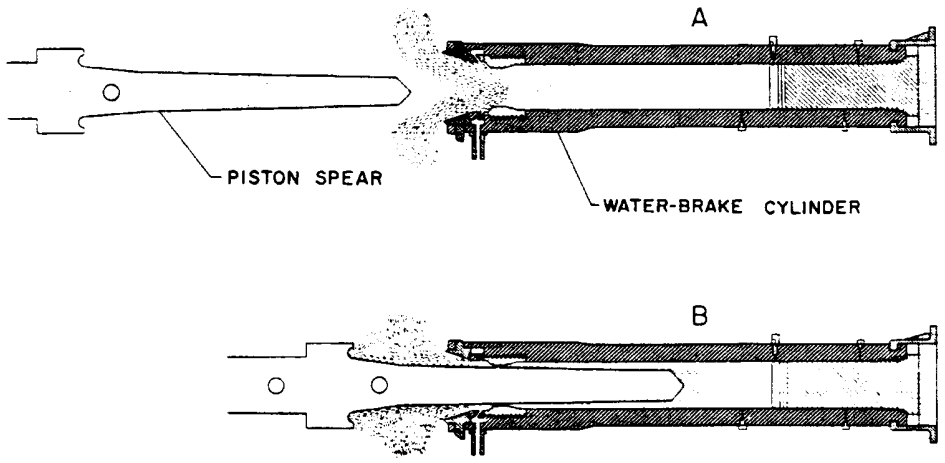


Figure 10-2 Water Brake Assembly

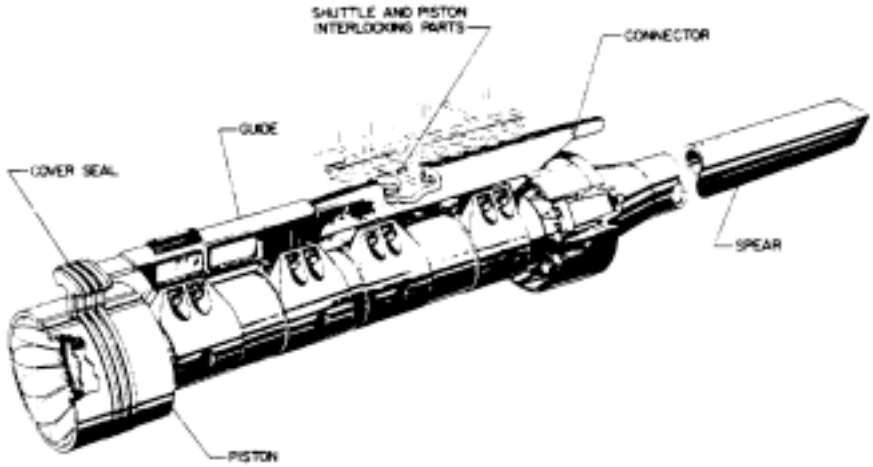


Figure 10-3 Piston and Spear Assembly

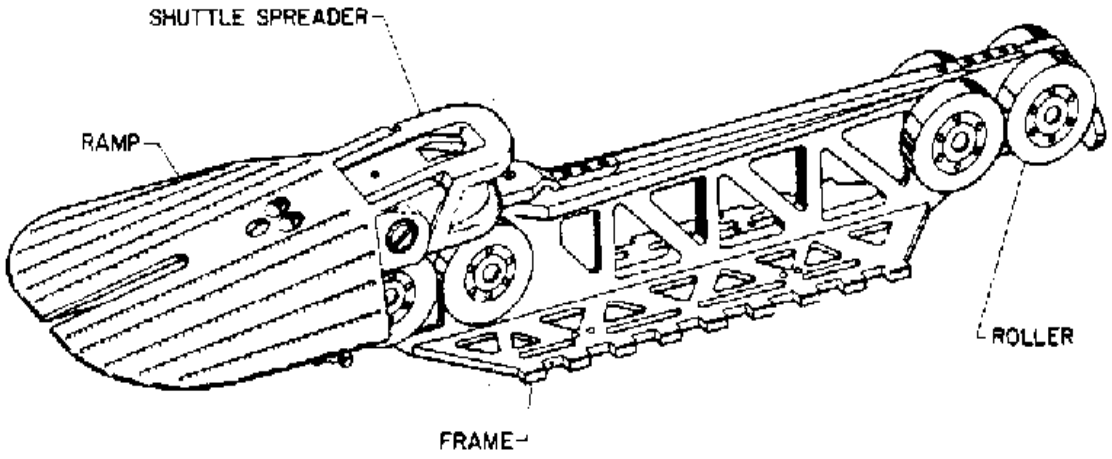


Figure 10-5 Shuttle Assembly

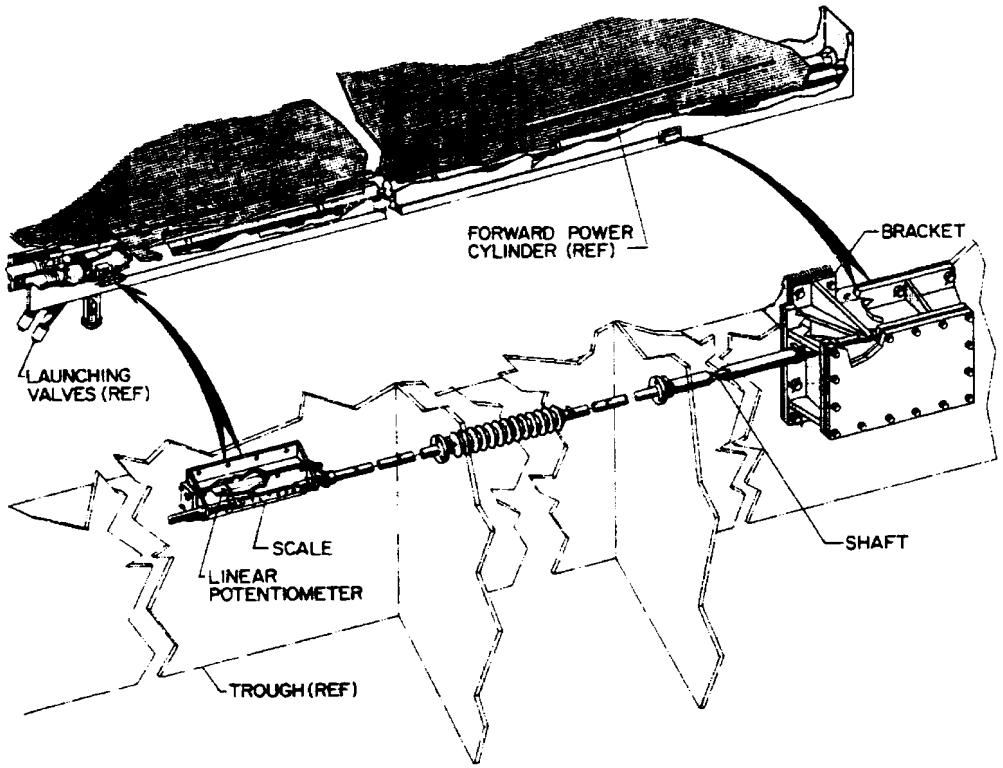


Figure 10-5 Cylinder Elongation Indicator Installation

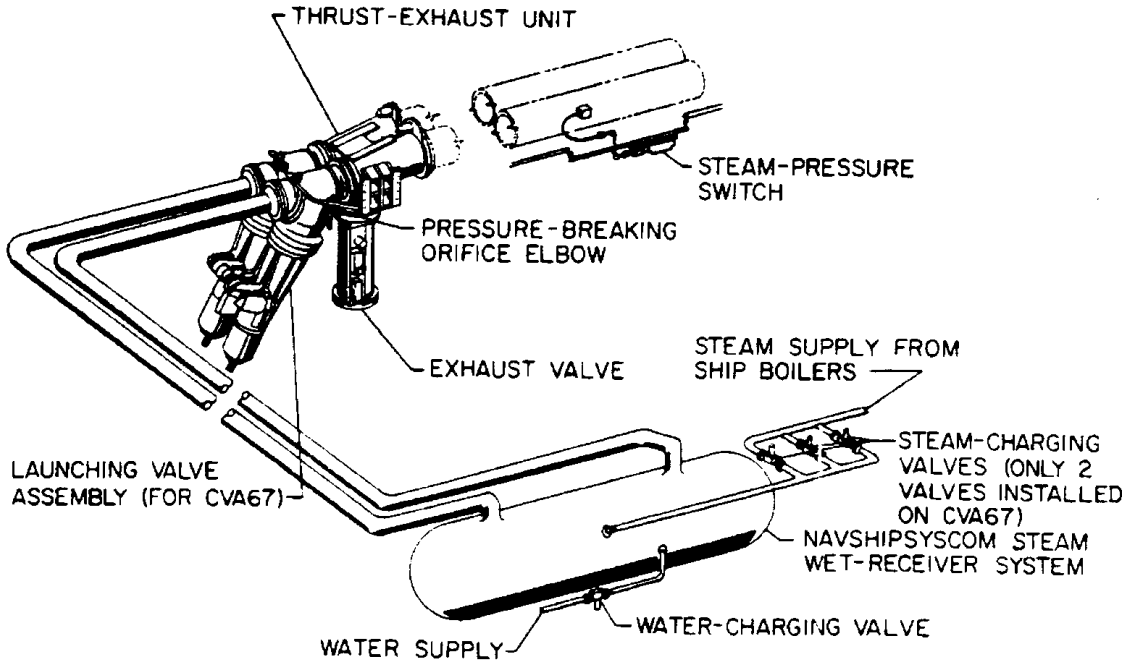


Figure 10-6 Catapult Steam System

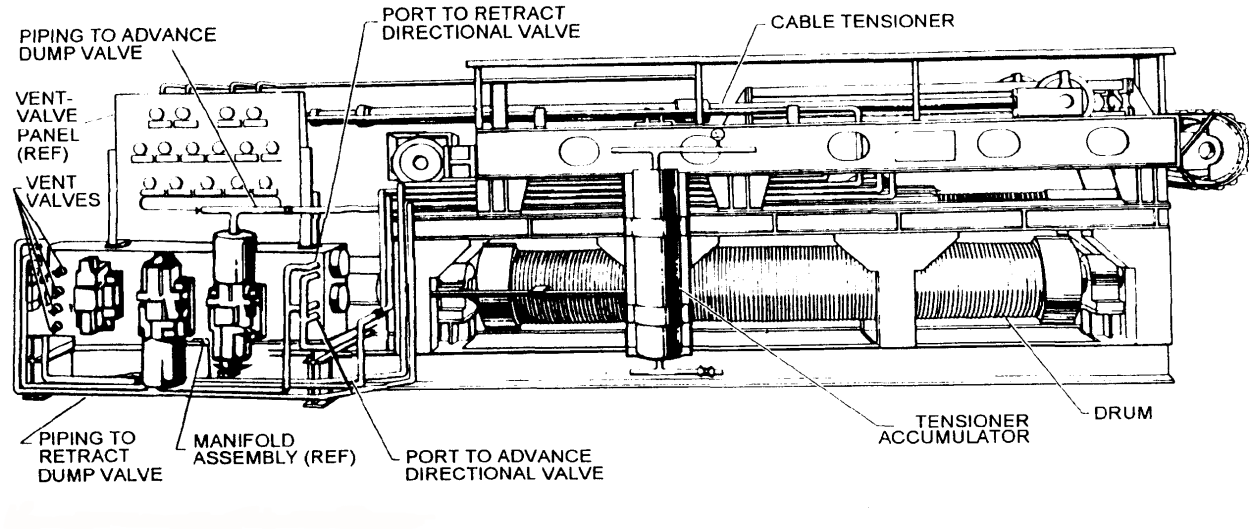


Figure 10-7 Rotary Type Retraction Engine

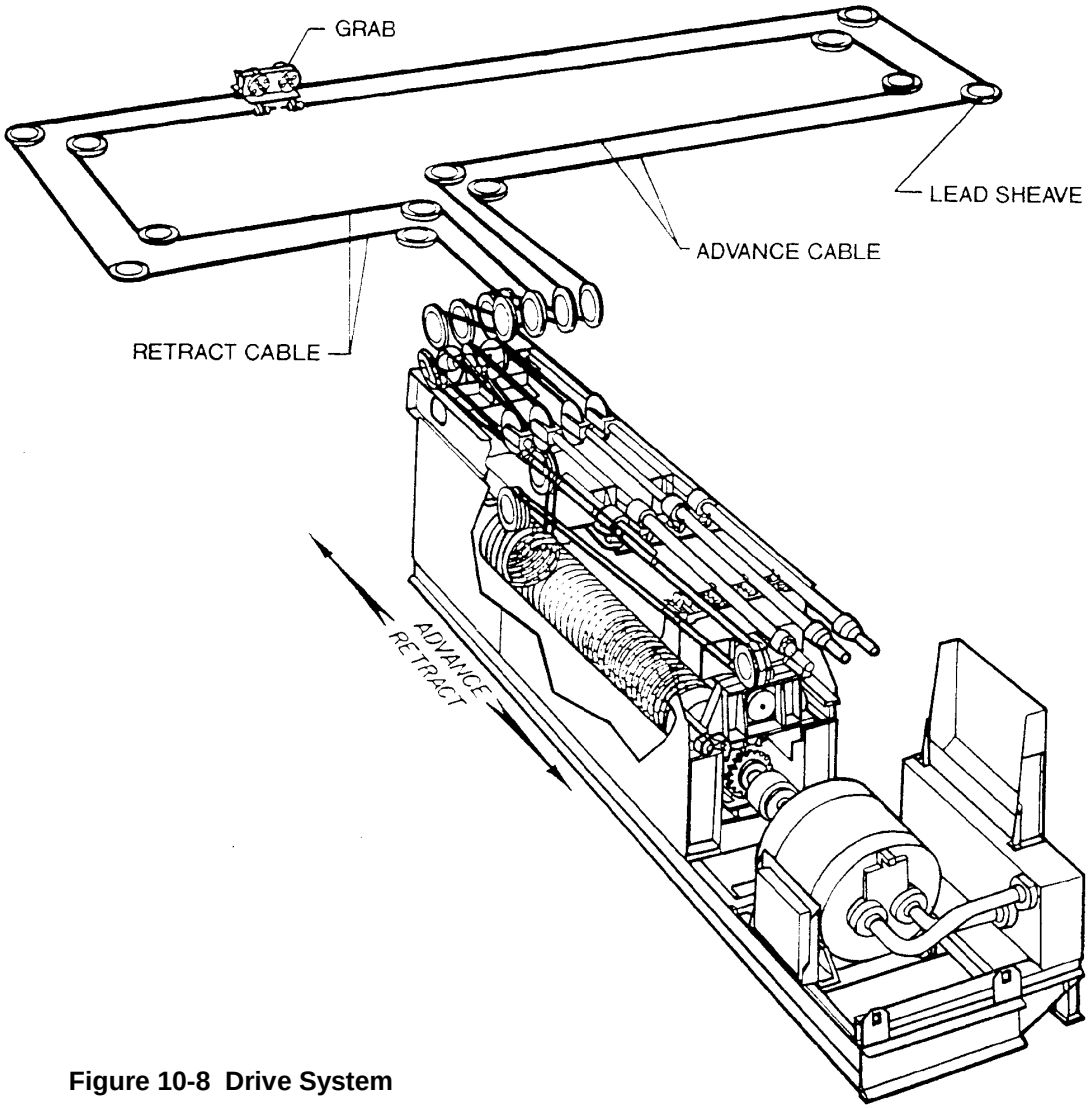


Figure 10-8 Drive System

10.3.4 Hydraulic System. The catapult hydraulic system is the operational center of the catapult. This system is made up of a main storage tank (gravity tank), three main hydraulic pumps, and accumulator, and air storage flask, an auxiliary storage tank, and auxiliary pump, circulating pump, fluid cooler and various control valves and associated piping. *(Figure 10-9)*. This installation provides a means to control the opening and closing of valves which in turn allow the different phases of operation to occur. The system pressure varies with the type of installation, 2500-2750 psi., pressure is maintained in the accumulator assembly which supplies all the various components with medium pressure hydraulic fluid. Due to the flow of the hydraulic fluid through pumps, valves and piping, the fluid heats up and circulates through a fluid cooler to ensure that it is maintained at the proper operational level. This system is a recirculating system with a 1,000 gallon fluid capacity. Replenishment of the system is accomplished by pouring fluid from the flight deck into a inlet down into the storage tank below decks. The fluid passes through several strainers and filters before entering the gravity tank to ensure that the system does not become contaminated.

10.3.5 Bridle Tensioning System. The bridle tensioning system of the catapult consists of a deck tensioner *(Figure 10-10)*, controlling valves, pressure regulator and associated piping. This system is operated hydraulically using a reduced amount of pressure. To launch an aircraft from the catapult it must first be properly tensioned on the catapult. To accomplish this a unit is installed directly below the flight deck in the catapult approach area to apply a force of 4,000 lbs. against the nose gear of an aircraft (depending on the type of aircraft). Once properly positioned on the catapult an aircraft is anchored to the deck by a holdback unit, which varies with the type of aircraft, and then the deck tensioning unit strokes forward to push the shuttle assembly out which applies tension to the aircraft. The bridle tensioning system works in conjunction with the retraction engine and drive systems to allow the grab to be moved forward with the motion of the deck tensioner. Once the deck tensioner is stroked forward pushing against the grab, a latch on the grab releases the shuttle from the grab so the catapult can be fired.

10.3.6 Lubrication System. The catapult lubrication system consist of a storage tank, pump, control valve, metering pumps and injectors, various shutoff and supply valves and associated piping. *(Figure 10-11)* This system provides lubrication oil into the launching engine cylinders during operation to eliminate wear of the components of the launching engine.

The operation of the lubrication system is automatic during operations and can be manually actuated for maintenance purposes. The system storage tank capacity is 220 gallons. The amount of one gallon of oil is used per cycle of the catapult. The lube oil is drawn out of the tank by an electric driven pump which maintains system pressure at approximately 150 psi. Once the entire system has been pressurized, lube oil is supplied to 52 separate metering pumps located along the sides of the catapult trough below the flight deck.

During operation of the catapult each metering pump delivers oil into injector nozzles mounted in the launching engine cylinder covers which spray the inside of the cylinders with lube oil. This occurs when the catapult is in the Retract and Military Power (Standby) phases of operation. Low pressure air is allowed through a solenoid operated pilot valve which shifts the lubrication control valve and directs pressurized hydraulic fluid then forces lube oil out of the metering pumps and into the cylinder cover nozzles. This action provides a sufficient amount of lube oil to be sprayed into the launching engine cylinders for one cycle of the catapult. There are three injector nozzles mounted in each cylinder cover section to provide even distribution of oil into the cylinders. This oil then provides lubrication for the piston and spear assemblies which travel fore and aft inside the launching cylinders.

This system is fully automated during operations and may also be manually actuated as desired by remote pushbuttons located on the catapult control panels.

Replenishment of this system is accomplished by pumping oil from the main ships storage tank, located several decks below the catapult, into the lubrication system storage tank. During this process the oil passes through several strainers and filters to ensure it does not become contaminated. Dirt in the lubrication system could cause clogging of the injector nozzles reducing the capability of the system.

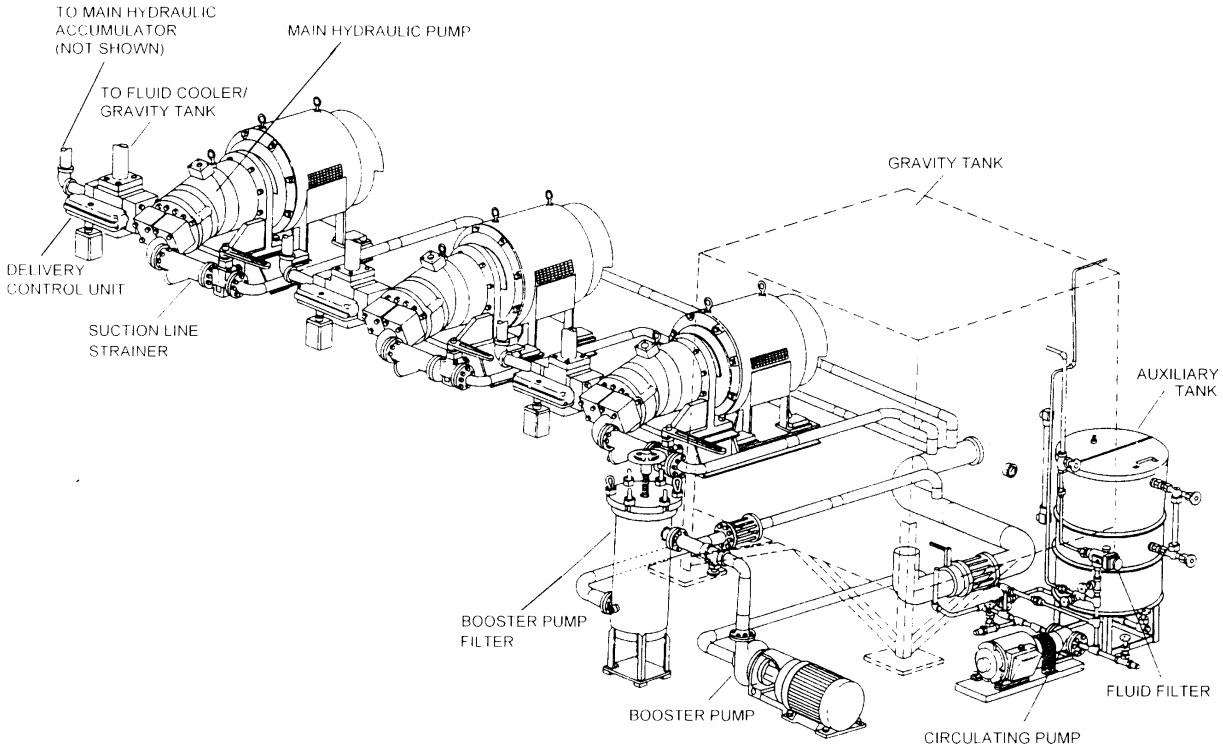


Figure 10-9 Hydraulic System

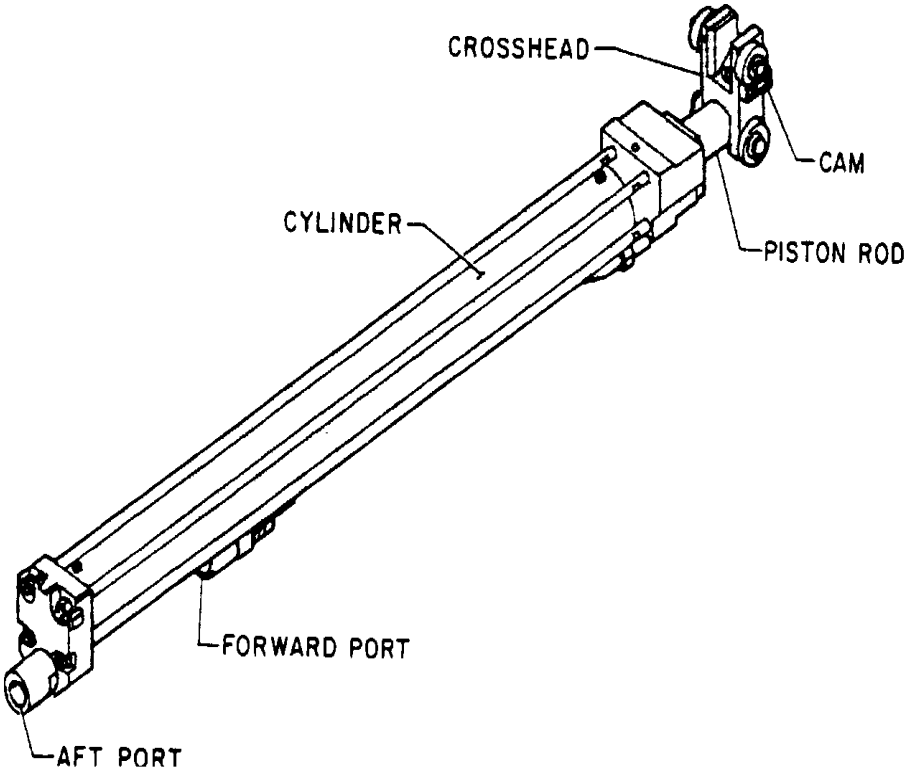


Figure 10-10 Deck Tensioner

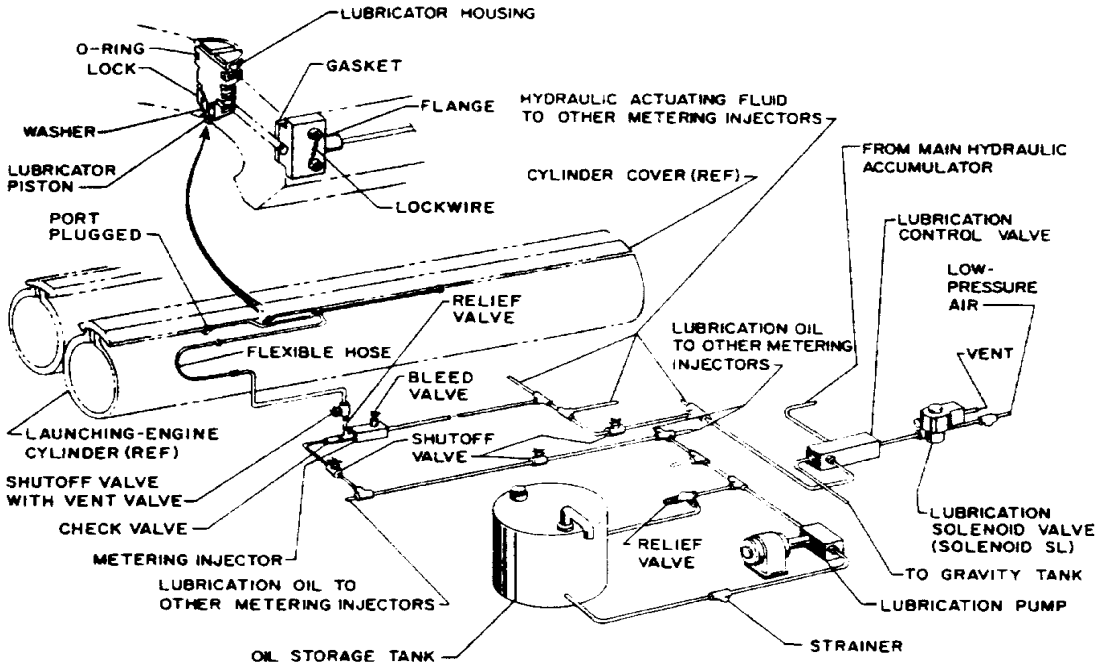


Figure 10-11 Lubrication System

10.3.7 Control System. The catapult control system controls all phases of catapult operation electronically. Depending upon installation and the type of catapult, the control system will vary with each station. The most common control system consists of a main control console (not on board ships with the Integrated Catapult Control Station), charging panel, deck edge control panel and an auxiliary deck panel signal box.

Ships with the newest type C-13-1 and the C-13-2 catapults have the Integrated Catapult Control Station (ICCS). The ICCS incorporates a catapult officers control console, a monitor control console, a central charging panel and an auxiliary deck edge control panel with a deck signal box. All of these items are located in a glass covered vertical movable well in the deck between cats one and two and on the port side of the ship for cats three and four.

On those ships without ICCS, the catapult officer stays on deck and must signal the deck edge operator when to fire the cat. In the ICCS configured ships the catapult officer is in the ICCS deck well and fires the cat himself.

Although somewhat different in appearance and phases of operation, the function of both control systems remains the same.

10.3.7.1 Charging Panel Assembly. The heart of the catapult control system is the charging panel assembly. At this station an operator monitors all the functions of the catapult and ensures all the proper operating pressures, temperatures and conditions are maintained. A console with pressure gauges, indicator lights, charging valves and blowdown valves makes up the charging panel assembly. The status of all the catapult equipment can be observed and controlled at this station. The charging panel assembly shown is a C-13/C-13-1 installation without the ICCS *(Figure 10-12).* The C-13-1 ICCS charging panel consists of four front panel assemblies and eliminates the need for the main control console.

10.3.7.2 Main Control Console. The main control console of non-ICCS catapults *(figure 10-13)*, is the real nerve center of the catapult. The main control console provides a means of controlling the catapult through its various stages of operation. It also indicates the status of the steam and hydraulic systems to the console operator. Although most of the functions of the catapult are controlled at the main control console, actual firing and bridle tensioning are controlled directly from the deck edge station. These two functions may, however, be transferred to the main control console in the event of an emergency condition.

Both the charging panel assembly and the main control console are located below deck near the launching valve enclosure. The operators of these stations establish sound powered phone communication with other station crewmembers during operation.

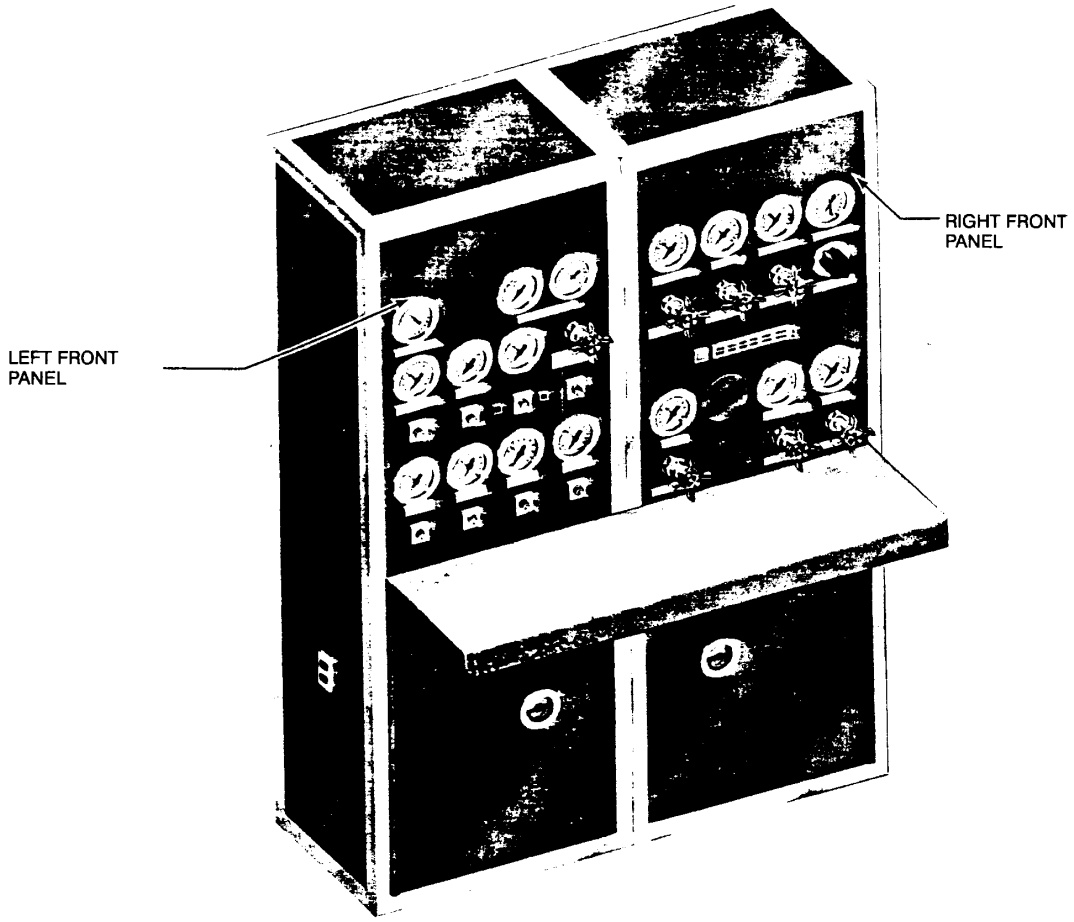


Figure 10-12 C-13/C13-1 Central Charging Panel Installation

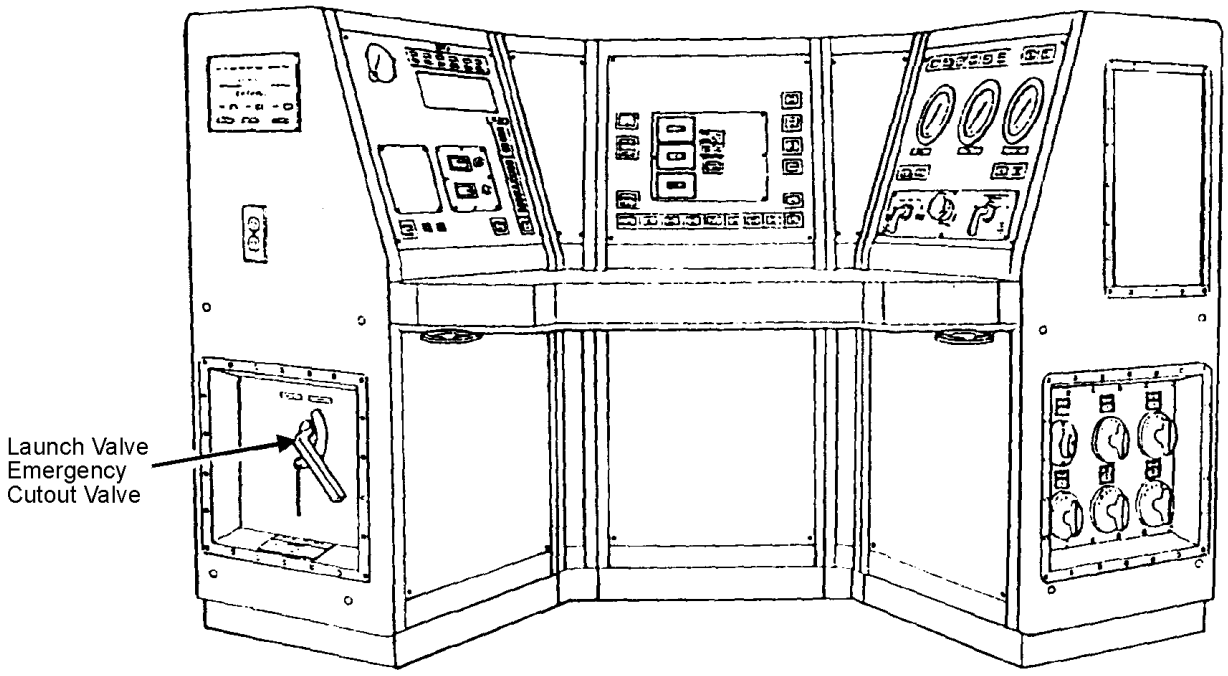


Figure 10-13 Main Control Console

10.3.7.3 Deck Edge Control Panel. The deck edge control panel *(Figure 10-14)*, is located on the catwalk at the edge of the flight deck. The deck edge control panel is used in conjunction with the control console to direct the catapult through a normal launching cycle, (non-ICCS installations). Under emergency conditions, the functions of the deck edge control panel are transferred to the main control console. ICCS installations utilize the deck edge control console as an emergency mode of operation and can also transfer its capabilities to the central charging panel in the event of an emergency.

10.3.7.4 Repeater Panel. The repeater Panel (aux, deck signal light box) is located adjacent to the deck edge station *(Figure 10-15)*. It gives the catapult officer on deck a visual indication of the status of the catapult during operations.

10.3.7.5 Pri-Fly control Panel. The Pri-fly control panel is located in the flight officer's control center. Standby lights and catapult suspend lights on the panel indicated the condition of readiness for each catapult. Catapult suspend switches on the panel permit launchings to be suspended from the control center in an emergency.

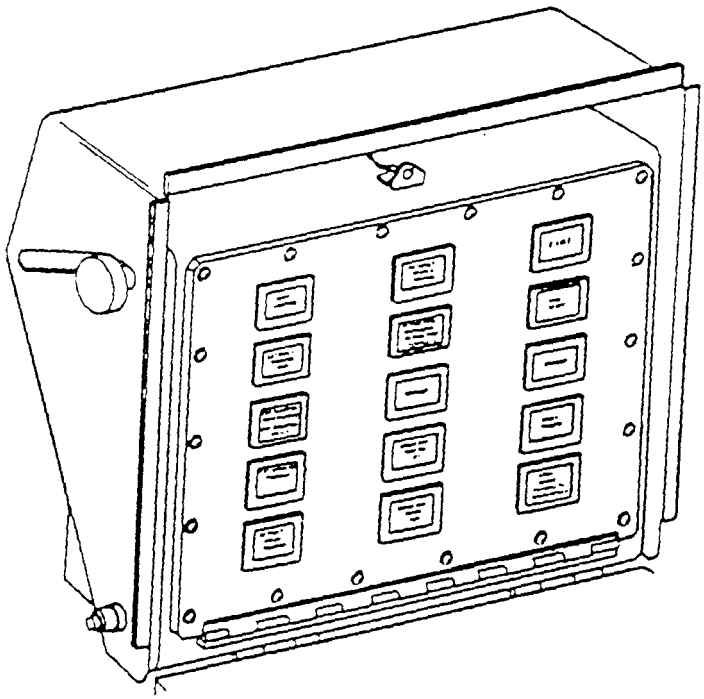


Figure 10-14 Deck Edge Control Panel

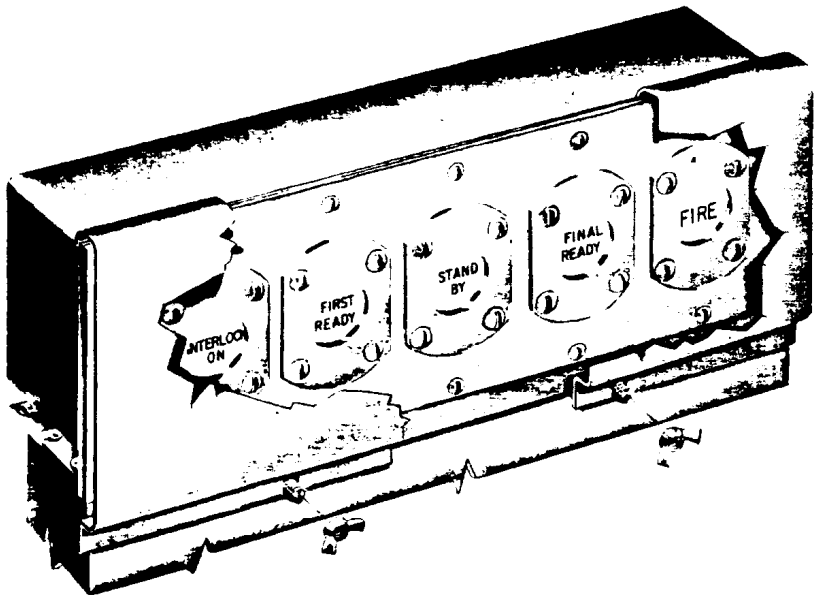


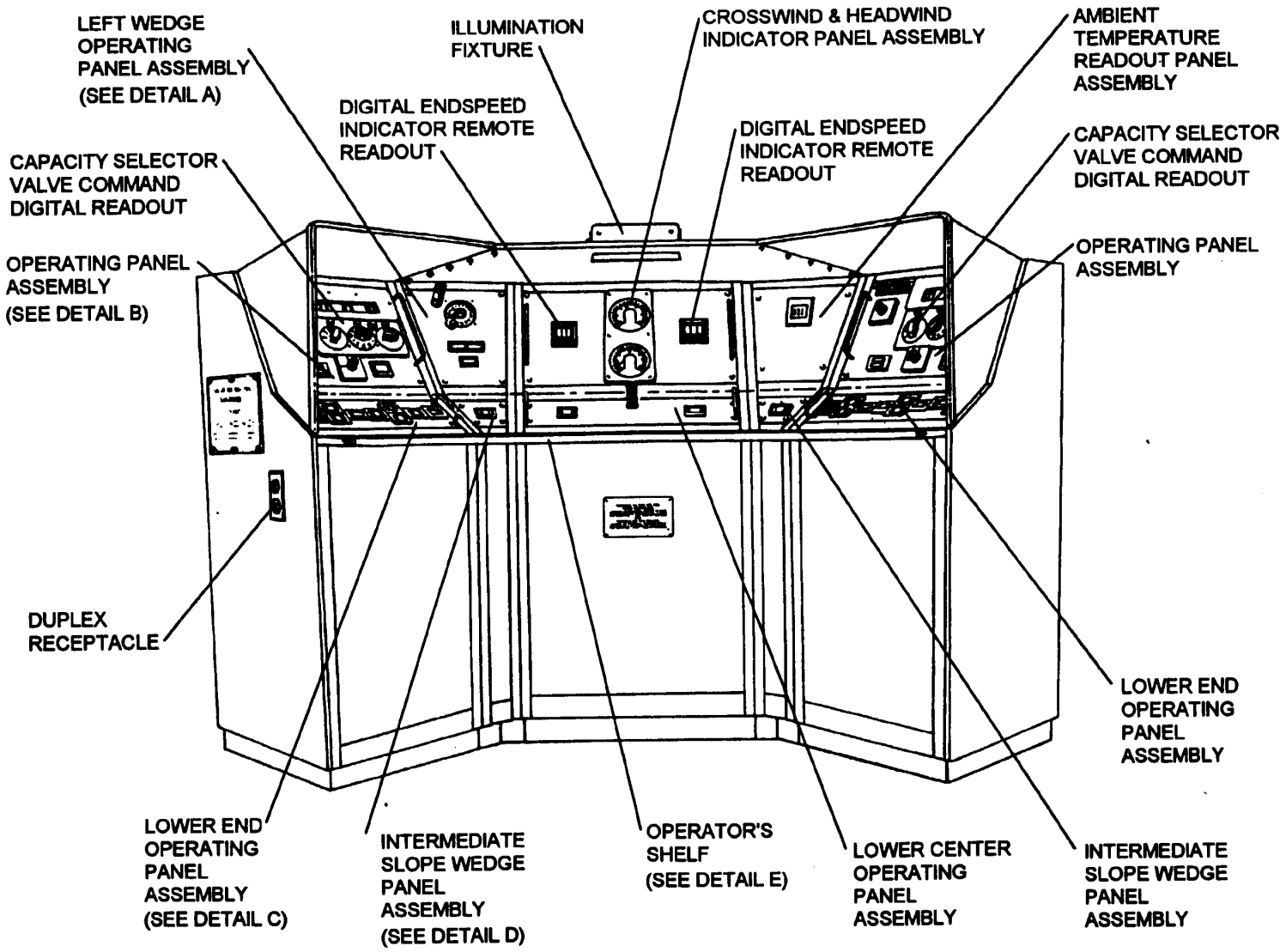
Figure 10-15 Repeater Panel

10.3.7.6 Catapult Officers Control Console. The Catapult Officers Control Console *(Figure 10-16)* is located in the ICCS. The control console provides the launch officer with the necessary controls and information to conduct launching operations on two adjacent catapults. The control assembly is made up of a series of panels. The operating and lower end operating panels contain the controls for capacity selector valve (CSV) setting and the switches and pushbuttons for conducting launching operations. In addition, each operating panel contains a selector switch to energize circuits for conducting either nose tow or bridle/pendant type operations and steam pressure go/no-go lights.

The panels located between the operating panels provide the launching officer with the switches and indicators that apply to both catapults. This includes a 24 hour clock, catapult interlock lights, pri-fly go/no-go lights, wind speed readout indicators, ambient temperature readout, night lighting, push-to-test switches, and a switch for raising/lowering the ICCS cab.

10.3.7. Center Deck Control Station. The Center Deck Control Station is a part of the control system in that it is vital as a visual and communications link between the catapult officer and the main control console (non ICCS). It contains a wind speed and direction indicator, sound powered phone circuits and the controls necessary to mechanically indicate to the main console operator the desired CSV or steam pressure setting. ICCS installations enable the catapult officer to set the desire CSV setting personally.

10.3.7.8 Monitor Control Console. *(Figure 10-17)* Located on the left side of the Main Control Console, it contains status lights for low-pressure air, hydraulic temperature and pressure, lube pressure, and bridle tension pressure; malfunctioning lights (12); and read-outs for end speed and L.V. stroke timer. This console displays the health of all the systems that make up the catapult.


LEFT WEDGE OPERATING PANEL ASSEMBLY (SEE DETAIL A)
ILLUMINATION FIXTURE
CROSSWIND & HEADWIND INDICATOR PANEL ASSEMBLY
AMBIENT TEMPERATURE READOUT PANEL ASSEMBLY
DIGITAL ENDSPEED INDICATOR REMOTE READOUT
DIGITAL ENDSPEED INDICATOR REMOTE READOUT
CAPACITY SELECTOR VALVE COMMAND DIGITAL READOUT
CAPACITY SELECTOR VALVE COMMAND DIGITAL READOUT
OPERATING PANEL ASSEMBLY (SEE DETAIL B)
OPERATING PANEL ASSEMBLY
DUPLEX RECEPTACLE
LOWER END OPERATING PANEL ASSEMBLY
LOWER END OPERATING PANEL ASSEMBLY (SEE DETAIL C)
INTERMEDIATE SLOPE WEDGE PANEL ASSEMBLY (SEE DETAIL D)
OPERATOR'S SHELF (SEE DETAIL E)
LOWER CENTER OPERATING PANEL ASSEMBLY
INTERMEDIATE SLOPE WEDGE PANEL ASSEMBLY

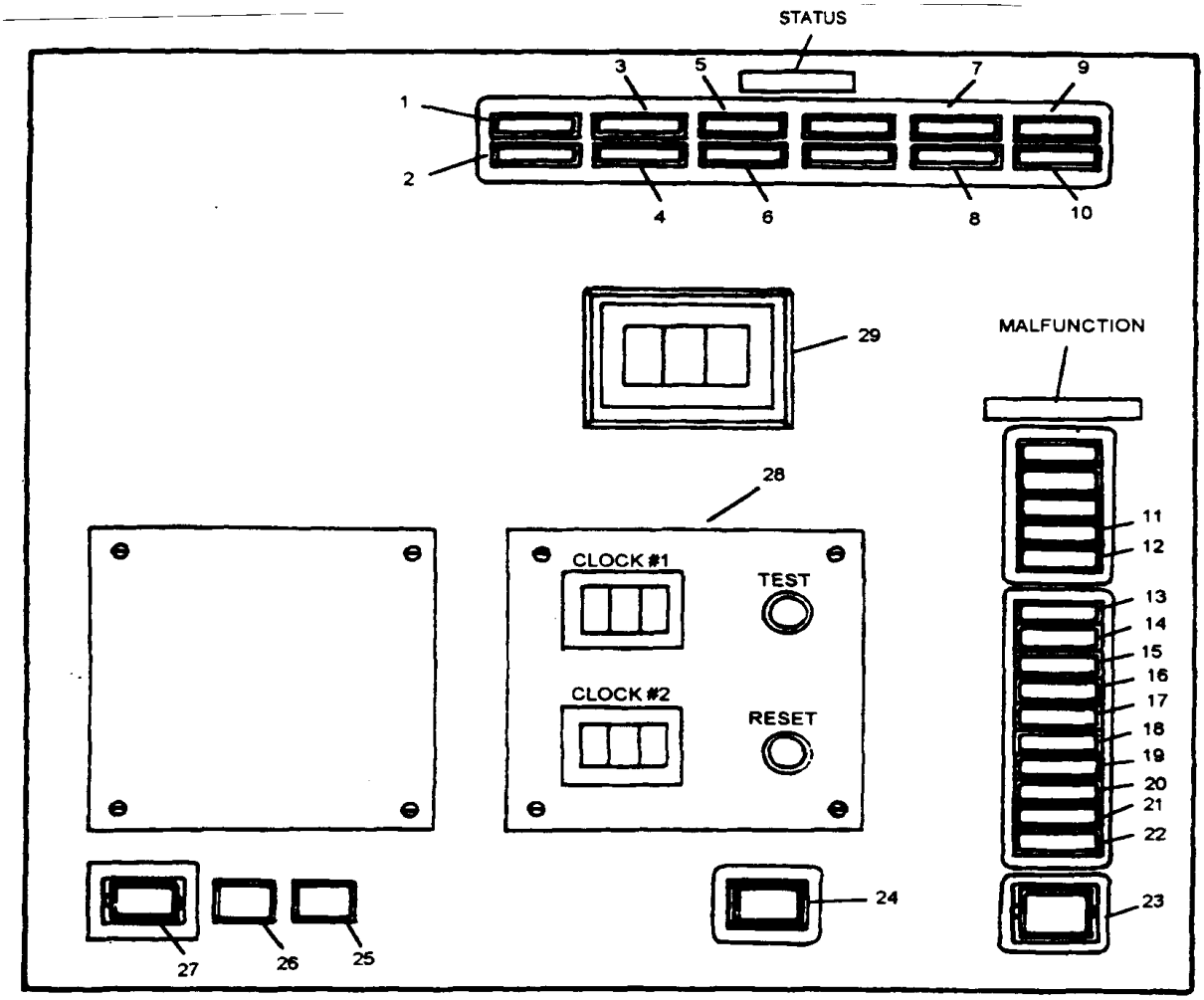


Figure 10-17 Monitor Control Console

STATUS LIGHTS

1. LOW-PRESSURE AIR (RED)
2. LOW-PRESSURE AIR (GREEN)
3. HYDRAULIC FLUID TEMP (RED)
4. HYDRAULIC FLUID TEMP (GREEN)
5. LUBE PUMP PRESSURE (RED)
6. LUBE PUMP PRESSURE (GREEN)
7. HYDRAULIC PRESSURE (RED)
8. HYDRAULIC PRESSURE (GREEN)
9. BRIDAL TENSION PRESSURE (RED)
10. BRIDAL TENSION PRESSURE (GREEN)

MALFUNCTION LIGHTS

11. ACCUMULATOR VALVE POSITION
12. EMERGENCY LAUNCH COMPLETE
13. CSV SETTING
1. FIRE P.B.1.
2. BRIDAL TENSION POSITION
3. EXHAUST VALVE
4. INTERLOCK COMPLETE RELAY
5. SUSPEND RELAY
6. L.V. CUTOUT VALVE
7. HYDRAULIC ACCUMULATOR VOLUME
8. WATER BRAKE PRESSURE
9. LAUNCH VALVE
10. PUSH-TO-TEST
11. BLOW THROUGH NO-LOAD P.B.
12. TIMER RESET FUSE
13. TIMER MOTOR FUSE
14. TIMER POWER ON P.B.
15. L.V.STROKE TIMER READOUTS

29 DIGITAL END SPEED INDICATOR

10.4 PHASES OF OPERATION

The evolution of launching aircraft can be easily divided into the following four areas:

10.4.1 Preparing Aircraft for Launch. The aircraft is spotted just aft of the shuttle at the battery position. After the holdback is installed the aircraft is attached to the shuttle, the bridle tensioner is actuated applying pressure against the grab and moving the shuttle forward to tension the aircraft.

10.4.2 Firing the Catapult. After tensioning, the catapult is fired by opening the launching values and permitting steam to surge into the cylinders. The force of the steam pushes the piston in the cylinder breaking the tension bar. The steam then forces the piston forward, towing the shuttle and aircraft at an ever increasing speed.

10.4.3 Halting the Piston and Shuttle. As the piston approaches the water brake, a switch (launch complete) is actuated by the steam in the cylinders.

This causes the launch valve to close, stopping the flow of steam into the cylinder and the exhaust valve to open and exhaust the spent steam. At about the same time, the retraction engine is set in motion to advance the grab. At the forward end of the shuttle track the grab latches onto the shuttle.

10.4.4 Readying the Catapult for the next aircraft. The retraction engine is reversed and returns the grab, shuttle and pistons to the battery position. The catapult has completed a full cycle and is in position to launch another aircraft.

10.5 MALFUNCTIONS

Slow shot: Incorrect steam pressure or CSV settings; insufficient volume of hydraulic fluid; or binding of launch engine components.

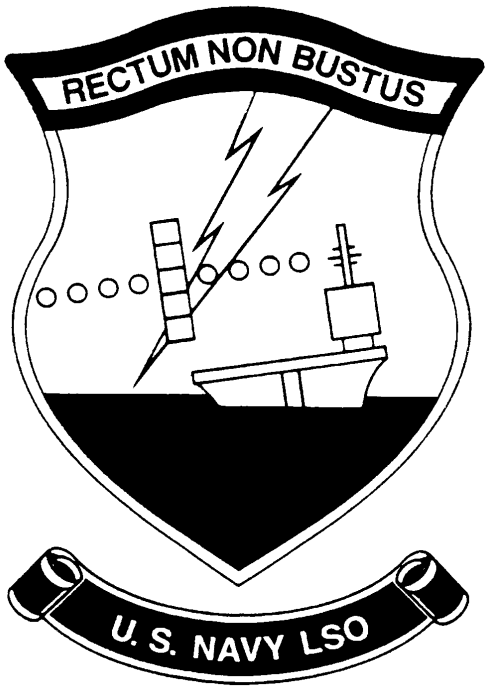
Cold Shot: Launching engine is not sufficiently hot causing the cold steel to sap the strength (expansion) out of the steam.

Runaway Shot: The catapult becomes disconnected from the aircraft at the beginning or during the power stroke. With out the weight of the aircraft, the catapult accelerates, unhindered, forward into the water brakes usually exceeding its stopping power.

10.6 EMERGENCIES

Suspend: The launching sequence is electrically interrupted prior to the fire button being pushed.

Hangfire: Exists when the fire button has been depressed and the catapult fails to fire.



NAME	FULL LOAD DISPLACEMENT (TONS)	FLIGHT DECK DIMENSIONS (a)	CATAPULTS MODEL / NO.	RECOVERY EQUIPMENT (b) (c)		FLOLS
				MODEL / NO. OF ENGINES	NO. OF DECK PENDANTS	
CV-63 KITTY HAWK	75,200	1025 X 237 / 724	C13 / 4 (e)	MK 7 MOD 3 / 4 MK 7 MOD 2 / 1	4	MK6 MOD 3
CV-64 CONSTELLATION	75,200	1025 X 237 / 724	C13 / 4 (e)	MK 7 MOD 3 / 4 MK 7 MOD 2 /1	4	MK6 MOD 3
CVN-65 ENTERPRISE	85,000	1079 X 251 / 754	C13 / 4 (e)	MK 7 MOD 3 / 4 MK 7 MOD 2 / 1	4	MK6 MOD 3
CV-67 KENNEDY	78,000	1029 X 239 / 764	C13 / 3, C13-1 / 1 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-68 NIMITZ	90,579 (d)	1077 X 252 / 786	C13-1 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-69 EISENHOWER	90,579 (d)	1077 X 252 / 786	C13-1 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-70 VINSON	90,579 (d)	1077 X 252 / 786	C13-1 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-71 ROOSEVELT	90,579 (d)	1077 X 252 / 786	C13-1 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-72 LINCOLN	90,579 (d)	1077 X 252 / 786	C13-2 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-73 WASHINGTON	90,579 (d)	1077 X 252 / 786	C13-2 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-74 STENNIS	90,579 (d)	1077 X 252 / 786	C13-2 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-75 TRUMAN	90,579 (d)	1077 X 252 / 786	C13-2 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3
CVN-76 REAGAN	90,579 (d)	1077 X 252 / 786	C13-2 / 4 (f)	MK 7 MOD 3 / 5	4	MK6 MOD 3

(a) Length X width / length angle deck in feet
(b) Pendants and barricades incorporate sheave dampers
(c) All ships have one 24' hydraulic barricade installation
(d) Combat load displacement is 93,026 tons
(e) These catapults are of dry accumulator type
(f) These catapults are of wet accumulator type

Figure A-9 Carrier Dimensional, Launching and Recovery Data