Forward Aux Machinery Room

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Spaces

Where is the Forward Machinery Room?

The ladder leading to the Forward Machinery Room is on Third Deck, right next to First-Class Mess. Going down, the Fourth Deck contains just a stair landing. You can't get to any other rooms on the Fourth Deck because down here, you are below water level. If the ship were to be struck by a torpedo, only a small section of the ship would be destroyed, and since the water would not be able to pass from compartment to compartment, the ship would not be sunk by a single torpedo strike.

Fifth Deck

Electrical Generator

What will we see when we get to Fifth Deck?

Fifth Deck has lots of things to see. On the starboard side of the room, you will find one of the 4 Ships Service Turbo (should be called turbine) Generators (SSTG) which furnish electric power to the entire ship, and you will see the switch board which accompanies this 1,250-kilowatt generator. A single kilowatt per hour is enough energy to light up a small house, and two kilowatts could energize a large house with all-electric appliances. So, this generator is capable of supplying 625 homes with all the electric energy they would need.

Figure 1 SSTG 1

Figure 2 SSTG 1 Air Ejector

Where are the other three generators on the Hornet?

There is another turbine generator in Engine Room 1, another in Boiler Room 3, and another in Boiler Room 4. There are also two emergency diesel generators, each with a production capacity of 1,000kW. With all six generators included, Hornet had a total output capacity of 7,000 kilowatts of electricity. In other words, that's seven megawatts of energy; enough to light up a small city.

I see a tank marked "lube oil filter." What is it for?

That oil is to lubricate the turbine shaft and governor controls of the SSTG generator. The oil drains into a settling tank, and then is pumped into a purifier, cooler, and then a strainer before it cycles again through the generator.

Figure 3 Lube Oil Storage Tank

Degaussing

Down here on Fifth Deck, opposite from the steam generator, what are these 4 large electric motors for?

Three of those machines are motor generators that produce direct current (DC) electricity that power our anti-magnetic degaussing system. The fourth generator is not hooked up to anything. It was a spare backup generator in case one of the others failed.

Figure 4 Degaussing Generator

What in the world is an anti-magnetic degausser?

During the 1940s, it was known that ships would generate an electric field as they traveled through the ocean. During WWII, the Germans had developed **marine mines** that were detonated by sensing the electro-magnetic energy of a passing ship. These explosive mines were creating havoc with our naval fleet. A strong magnetic field would also make the ship easier to target by a torpedo. Our navy developed a way to neutralize this energy by countering it with an opposite field. This anti-magnetic defense system is called a **degausser.**

Where on the ship is this system controlled?

The degaussing control station is found in the Pilot House, on a bulkhead aft of the ship's helm. The gauge displays the electrical current level being applied to the degaussing coils. A higher reading means a stronger electric current is being applied. This electric field needs to be reduced to minimize the ship's detectability, and to reduce the chance of setting off an undersea mine. Periodically, adjustments need to be made to compensate for changes in the ship's heading, local geomagnetic field reading, and proximity to the North or South Pole. Minor adjustments can be made in the Pilot House, but the energy to run and monitor the equipment is done down here.

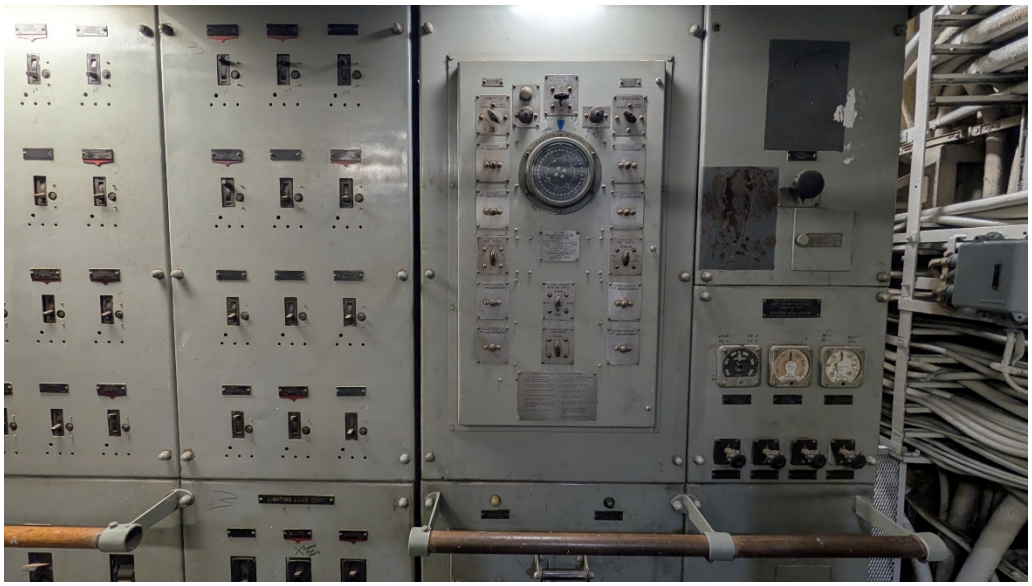

Figure 5 Aux Machinery Degaussing Controls

Did only aircraft carriers need degaussing protection?

All ships with a steel hull and sailing in shallow waters could detonate an undersea mine, and all were subject to destruction. The

only ships that were immune from destruction were the concrete fleet built by the Navy for Merchant Marine supply ships. After the war was over, these obsolete concrete ships were sunk and used for breakwaters.

Bunker C

What are those valves on the portside bulkhead for?

Between this room and the ship's hull, there are large tanks for bunker oil. What you see here is the valve manifold that distributes bunker fuel to our 4 boiler rooms. Each boiler room contains 2 boilers, so in all, there are 8 boilers. The oil needs to be moved from the storage tanks to the service tanks, and then from the service tanks to the boiler rooms. These tanks are all interconnected, so that the oil from any tank can be pumped to any boiler, and the valves you see here are a few of the valves that do this.

Figure 6 Bunker C Manifolds

Is bunker oil used for anything else on the ship?

Bunker oil had no other use than as a fuel for large ships. It is environmentally unfriendly both in the ocean and in the atmosphere. It is a crude bi-product of the petroleum refining industry, and because of this, it is very cheap to buy. The cheap price tag is its only redeeming quality.

Freon

Right next to the down ladder, what is that pump mechanism for?

That pump mechanism is for Freon gas. The gas is compressed to raise the temperature. Then the warm gas goes through a heat exchanger to cool it back to room temperature. Then, the pressure is released, and the temperature drops to below room temperature. This is how all refrigeration units on the ship work. The refrigeration unit in this room is for air conditioning, and for using in the evaporators on the deck below us.

Figure 7 Freon Compressors

If you want to see a clearer model of how a heat exchanger works, check out the air-conditioning unit in Marine Berthing on Second Deck. You will see the Freon gas feed line, the compressor which heats up the gas, and the Freon gas line going into the heat

exchanger warm, and coming out cold on the other end. The refrigeration unit in the Forward Machinery room is for air conditioning, and for using in the evaporators on the deck below us.

Sixth Deck

Evaporators

Detailed Evaporator

This diagram is taken from the USS Oklahoma. It is similar to the Hornet's system except Hornet used a 3-stage evaporator. Just duplicate the 2nd effect evaporator/stage.

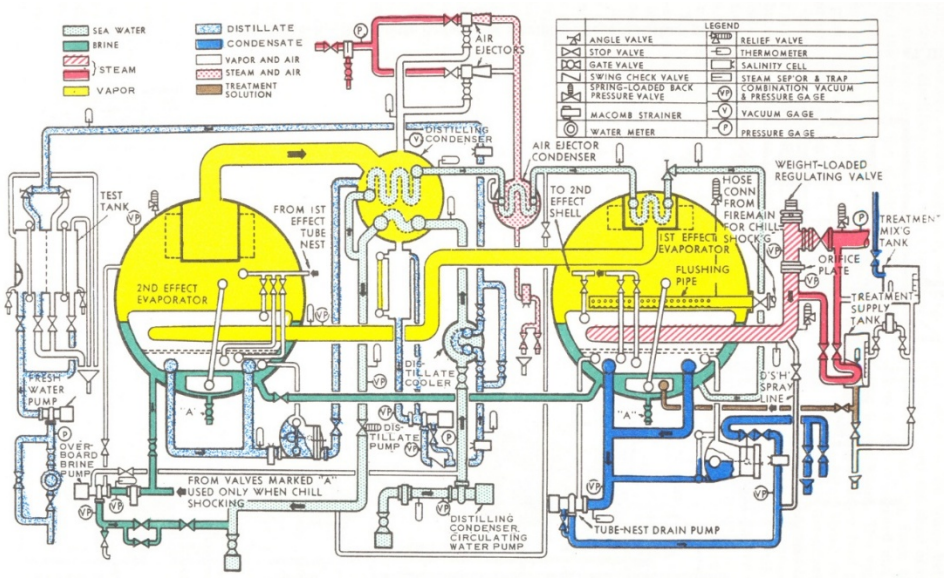

Figure 8 USS Oklahoma City Two shell Double Effect Distilling Unit Diagram

Simplified System

1. Inputs
    a. Steam
    Steam is used for two purposes.
        i. Draw a vacuum in the effector shells. Third stage shell has the highest vacuum which is dependent upon the sea water temperature. Typically, about 28" of vacuum.
        ii. Heat the seawater for boiling.
    b. Seawater
    Seawater is used as the source of the fresh water.
2. Outputs
    a. Brine
    Leftover seawater.
    b. Freshwater
    The end product.

As the seawater passes from stage to stage, it condenses the vapor from the seawater preheats the seawater. It then goes through the heater to heat it to the desired 130°F. Seawater vapor goes through a separator to only allow vapors out. The vapor is condensed and sucked into the next stage by the higher vacuum in the next stage. The leftover seawater, call brine, is also sucked into the next stage. The higher vacuum boils off more vapor. Then the process repeats in the third stage. At this point 5-10% of the fresh water has been removed from the brine and the brine is pumped back overboard while the freshwater is pumped into storage tanks.

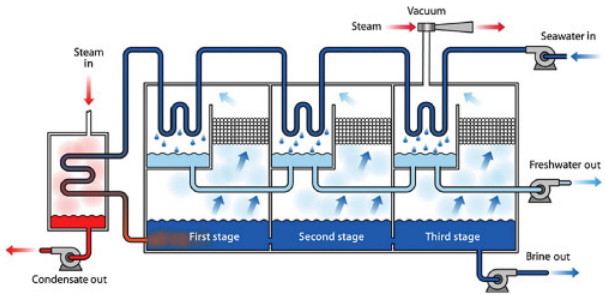

Figure 9 Simplified Evaporator Process

What is an evaporator?

An **evaporator** is a machine that removes all the contaminants from ocean water, and leaves behind only 100% pure water with 0% contamination. The best way to get the salt out of seawater is to distill it. Distillation is the process of boiling water, capturing the water vapor, flushing out the sediment, and condensing the vapor back into water. If the process is done with high temperature, the mechanism is called a **distiller,** but if it is done without high temperature, the mechanism is called an **evaporator.**

What happens if machinery is exposed to salt water?

Salt acts as an electrolyte and accelerates oxidation, which causes the iron to lose electrons and leads to corrosion, which we call **iron oxide** (or rust).

Do we have to desalinate all the water on the ship to avoid corroding all our machinery?

The ship has two water systems: one containing salt water, and the other containing fresh water.

Which systems use salt water?

There are several large pumps which circulate salt water throughout the ship. The pipes that transport this water are made from metals which have very little iron content, like brass, copper, lead, or stainless steel. The salt water is used firefighting, toilet flushing, and all cooling and refrigeration units on the ship. All other water on the ship needs to be desalinated.

Is salt water used for taking showers?

Fresh water is used for showering, but fresh water is in short supply. For this reason, sailors are taught to take a **Navy shower,** which recommends only 15 seconds to wet down, then, shut off the water while you lather up. After that, you turn on the water again to rinse off for 30 seconds. This means that sailors had a total of 45 seconds of water usage. If fresh water supply dropped to 80% of capacity, the showers were switched to using salt water.

How many evaporators does the Hornet have?

The Hornet has 4 main evaporators in two auxiliary machinery spaces. Each evaporator is divided into 3 separate stages, so it looks like each room has 6 evaporators, but in reality, there are only 2. Each of the 3 stages is contained within a dome, which looks very similar to radar dome, so in this room, you will find 3 large domes on the forward bulkhead, and another 3 domes on the after bulkhead. Both Auxiliary Machinery spaces have these evaporators which all four together produce a total of 100,000 gallons of pure water per day.

Figure 10 6th Deck Evaporator Row

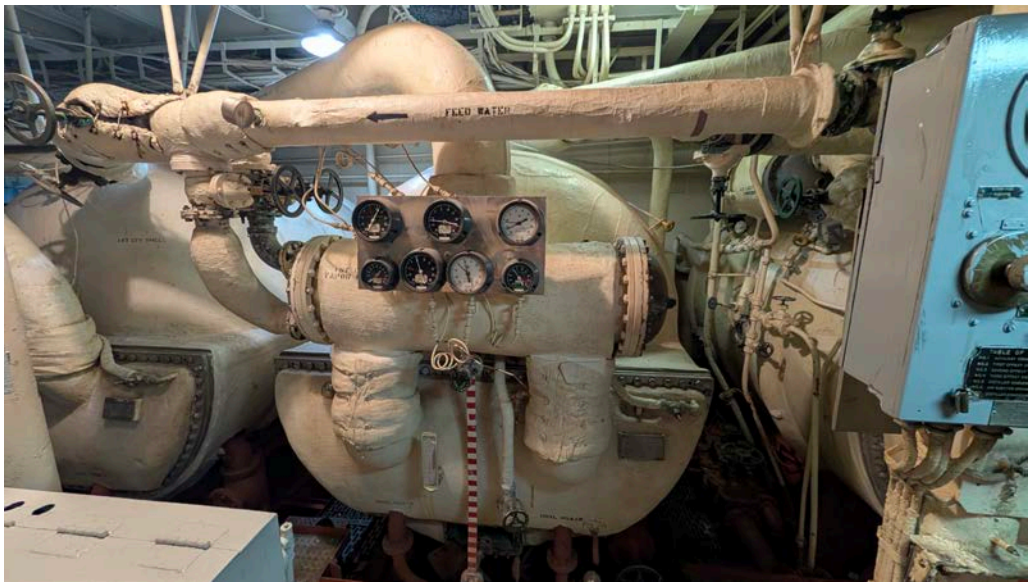

Figure 11 2nd Effect Shell

The Hornet also has a single-stage emergency evaporator located in Boiler Room 3. This water is not 100% mineral free, but is sufficiently pure for drinking, showering, cooking and laundry. This evaporator produces 10,000 gallons per day.

Was the sea water filtered before it begins the evaporation process?

The water was not filtered; however, it did pass through a screen with a 1-inch mesh to keep out large debris. Naval vessels are careful not to take on seawater at within 12 miles of shore, where the ocean may be contaminated by garbage and manmade chemicals.

How can you boil water without high temperature?
The boiling point of water depends upon the pressure the water is under. The lower the pressure is, the lower the boiling point of the water will be. Water will actually vaporize at room temperature if you remove all the air pressure. In cold seas of 28 degrees like north of the Aleutian Islands, the vacuum can be as high as 30" and water boils at about 70 degrees. In hot seas of 90 degrees like the Indian ocean, the vacuum can be as low as 26" and water boils at 115 degrees.

What was the temperature that our evaporator used?
We need to raise the temperature to more than 120^{o}F to kill all the micro-organisms, but if we raise the temperature over 140^{o}F, we get a lot of scale deposits in the evaporator. So, our evaporator should remain in the efficiency range of about 130^{o}F.

If water vaporizes at 212^{o}F at sea level, how do we get it to vaporize at 130^{o}F?
The air pressure is reduced by a method known as the **Bernoulli's Principle.** To imagine how this works, think of a fireman extinguishing a fire. To increase the flow of water to put out the fire, the fireman will tighten the opening of the nozzle, and the compressed water will flow out much faster. Now, if you take a garden hose, and attach one end of it to the fire hose, and expose the other end to the stream of water coming through the nozzle, the tremendous force of the fast-moving water will suck water through the garden hose at a very high speed, and at zero pounds per square inch of air pressure.

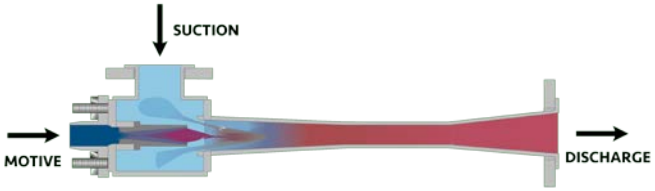

Figure 12 Ejector Cross Section

The motive force can be anything. In dewatering pumps, it is fire main water (sea water) and in the engine room it is typically steam. Suction is the tank that the something is being removed from. In dewatering, it is the room to be dewatered. In a condenser, it is the air in the condenser. Discharge is what you did not want in the tank.

Does the water look like air at this point?
There is very little air inside the dome. The dome is filled with water vapor with a temperature of about 130^{o}F. It resembles the steam in a sauna bath. When this low-temperature steam is chilled in the refrigeration unit at the top of the tank, it is funneled into condensation tubes which is pumped out the bottom of the tank as pure distilled water. To be totally free of impurities, the water will go into the second tank where it will be vaporized again, and then to the third tank where it will complete the total desalination procedure.

Does anything else need to be done to the water?
The water is completely pure now, and it is ready to go to the boiler rooms where it will be turned into steam, then to the engine rooms where it will power the turbines for the engines and generators. After that, the water will go into a heat exchanger where pipes containing the hot steam are passed through tanks of cold ocean water and the steam is cooled and condensed back into clean fresh water.

Is the fresh water ready to be boiled again and turned back into steam?
The water is not yet ready to enter the steam cycle because along the way, it has picked up some contamination. In the boiling process, the water has developed some **dissolved** oxygen molecules which will oxidize in the steam pipes and eventually cause serious corrosion if not removed. To remove these harmful molecules the water needs to pass through the **deaerator.**

Air Compressor

I see a couple of air pumps on the port side of the evaporator room. What are they for?

Those pumps are for compressing low-pressure air for various uses in the forward part of the ship.

They are called **reciprocating piston pumps,** and they work just like an old-fashioned hand-driven bicycle pump. They alternately suck air one side and blow it out the other as a piston slides back and forth inside the cylinder. The air pressure is slowly accumulated in large tanks called accumulators or flasks, and is used on the Hornet for any machinery which needs a sudden burst of energy, namely the elevators, catapults, and arresting gear.

Figure 13 300 PSI Air Compressors

The pressure gauge says that these compressors can only reach 400 psi. Is that enough pressure for the elevator or the catapult?

The elevator has two pressure systems: a low-pressure system for lowering the elevator and a high-pressure system for raising it. The high-pressure compressor can be found in the passageway between Flight Suit Mess and the Catapult Room. It is a modern replacement for the nonfunctioning air compressor below the port catapult room. It can compress the 1200psi that it takes to raise the elevator. The catapult needs 4000psi to launch an airplane, and its pressure comes from thawing out a little of the liquid nitrogen which is stored at -346^{o}F in the O_2N_2 Room.