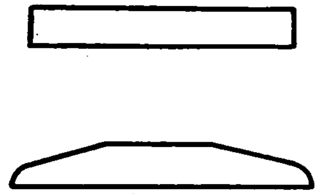
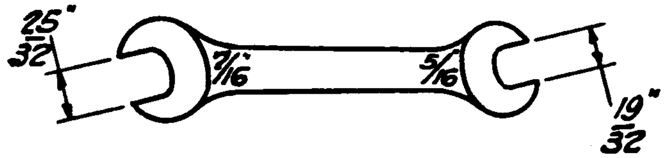
Hanging Bar for Piston Rod
Dwg. № 18178-8



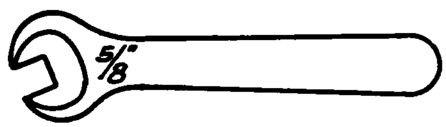
For H.P. & M.P.

For L.P.

Double Head Wrench for General Use on Wrench Board

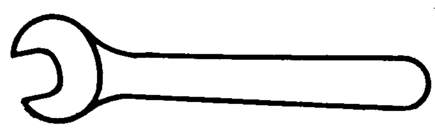


Set Screw Wrench on Wrench Board



Std. Wrenches for General Use on Wrench Board

2"	Wrench -	3 1/8"	Opening
1 7/8"	"	2 15/16"	"
1 3/4"	"	2 3/4"	"
1 5/8"	"	2 9/16"	"
1 1/2"	"	2 3/8"	"
1 3/8"	"	2 3/16"	"
1 1/4"	"	2"	"
1 1/8"	"	1 13/16"	"
1"	"	1 5/8"	"
7/8"	"	1 7/16"	"
3/4"	"	1 1/4"	"
5/8"	"	1 1/16"	"
1/2"	"	7/8"	"
3/8"	"	11/16"	"
1/4"	"	1/2"	"



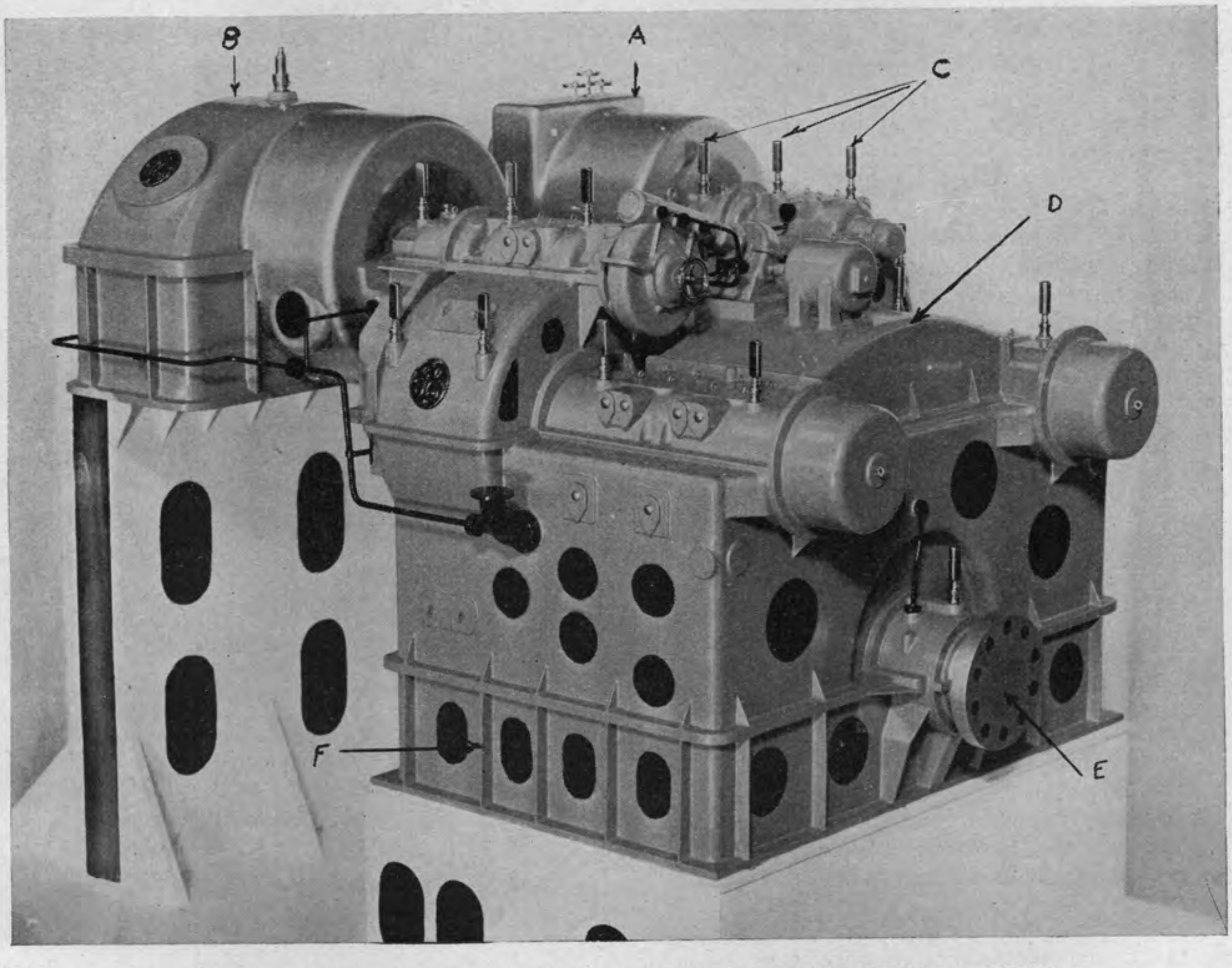
STEAM TURBINES

PRINCIPLE

In order to understand the principle upon which the steam turbine operates, let us first consider the water wheel. In the old type water wheel, the water was piped to the top of a wooden wheel containing blades or buckets. The water filled the buckets and thus turned the wheel, causing the water to spill when the buckets reached the bottom. This is known as an overshot water wheel and is shown in the sketch on the following page.

A wheel built to make use of water flowing from a higher level, or under greater pressure, uses a nozzle directing a stream of water at high velocity against the buckets. As there was a great deal of splashing from this type, the buckets are made with a curving surface, such as is shown in the sketch. This is known as a Pelton wheel.

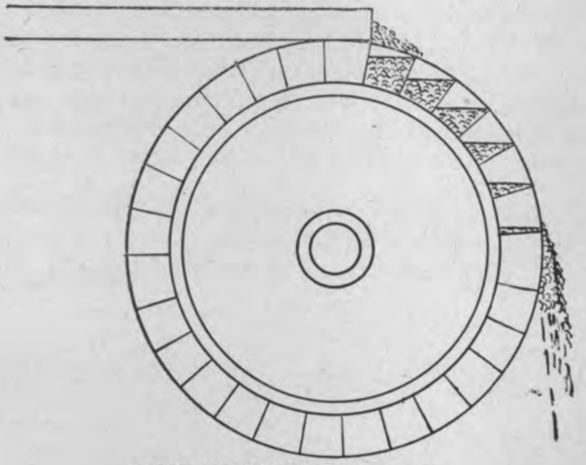
Steam turbines use blades shaped very much like those of the water wheel. Instead of using a jet of water, steam is directed against the



MODEL OF G-E CROSS-COMPOUND GEARED MARINE STEAM TURBINE

A–H.P. TURBINE
B–L.P. TURBINE
C–BEARING THERMOMETERS
D–REDUCTION GEAR CASING
E–PROPELLER (LINE) SHAFT COUPLING
F–LUBE-OIL SUMP

blades by a nozzle. The nozzle is so designed that it converts the pressure of the steam into velocity. The steam is usually directed from the side of the wheel against the curved blades.



OVERSHOT WATERWHEEL

TYPES OF TURBINES

Impulse Turbines–Several nozzles are used to direct and give velocity to the steam. The blades convert the velocity of the steam into a rotary motion. This type of turbine is known as an impulse turbine due to the fact that most of the velocity of the steam is converted into rotary motion by the impact or impulse force of the steam on the blades.

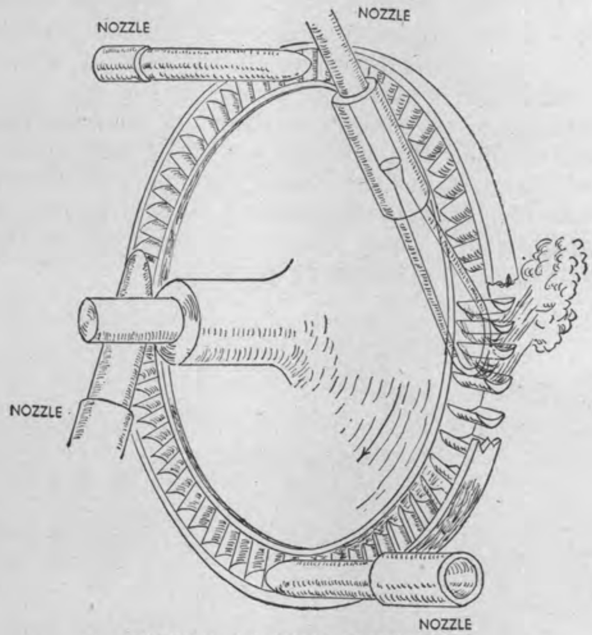
PELTON WHEEL

A sketch of the impulse turbine is shown.

The sketch is a single impulse wheel with four nozzles. In the nozzles, steam expands and its pressure is converted to velocity so that the steam leaving the nozzles strikes the plates at high velocity causing the wheel to rotate.

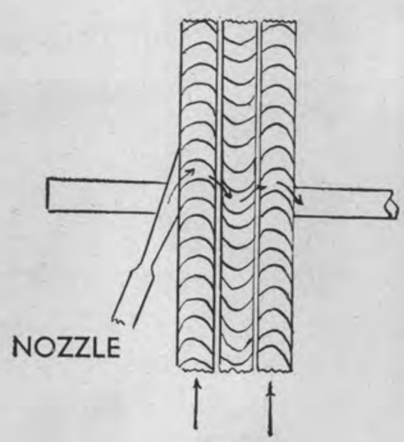
The impulse turbine is built in single stages, as the one described, or in multi-stage, having two or more simple turbines on the same shaft.

The second sketch shows the position of nozzle, moving blades, stationary blades and the second row of moving blades in a Curtis stage of an impulse turbine. The steam is expanded in the nozzle, gives up part of its energy in pushing the row of blades (A), is redirected in the second row of moving blades by the stationary row of blades (B). The steam gives



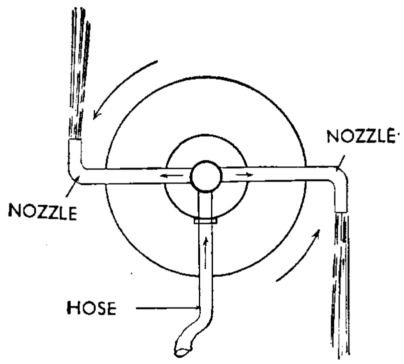
SIMPLE IMPULSE TURBINE

up more of its velocity in the row of moving blades (C). The stationary row of blades is used to reverse the direction of the steam flow.



Reaction Turbines–Another type of turbine is shown as the reaction turbine. The third sketch represents a lawn sprinkler using the reaction principle to cause it to rotate. The water is led to the sprinkler through a hose.

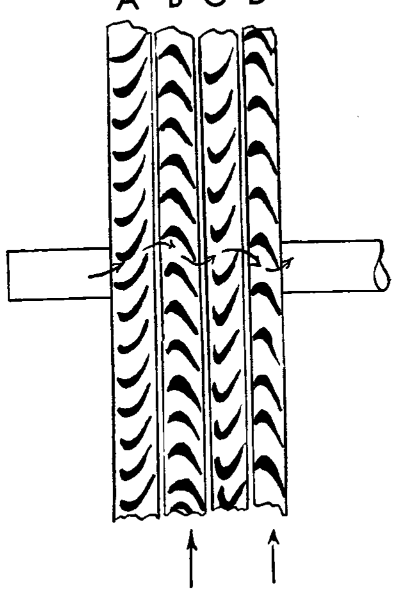
The water flows up the vertical pipe into the two horizontal bent arms which end in nozzles. The water is discharged from each nozzle at an



REACTION

increased velocity, and as it leaves, reacts or kicks back on the nozzle, giving a rotating motion to the arms in an opposite direction to the stream of water. It is this reaction force alone that causes rotation of the sprinkler.

The reaction turbine uses a set of stationary



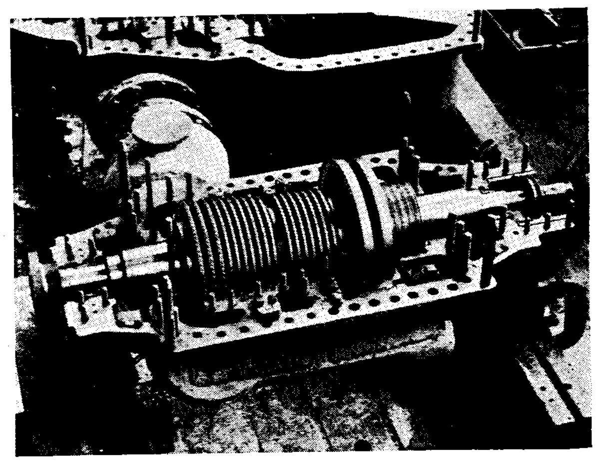
REACTION

curved blades or vanes which direct the steam into a set of blades mounted on a wheel or drum. The steam expands in these blades, leaving at a higher velocity than that at which it entered, thus kicking the blades around in a rotary path. A reaction turbine contains many rows of stationary and moving blades, each set being known as a stage and the steam being expanded slightly in each row.

The fourth sketch shows the blading of a reaction turbine showing two stages. The steam enters the stationary blades (A) which direct it into the first row of moving blades (B). The steam pressure is decreased and the velocity slightly increased in the stationary blades. Thus some impulse is used in this turbine. In the moving blades the steam expands, increases in velocity in leaving and tends to turn the blades by reaction. A second row of stationary blades (C) redirects steam into the second row of moving blades (D), etc., where the action is repeated.

Neither the impulse nor the reaction turbine is caused to rotate by one principle alone, but the impulse turbine has a small amount of reaction involved, and the reaction turbine, a small amount of impulse involved.

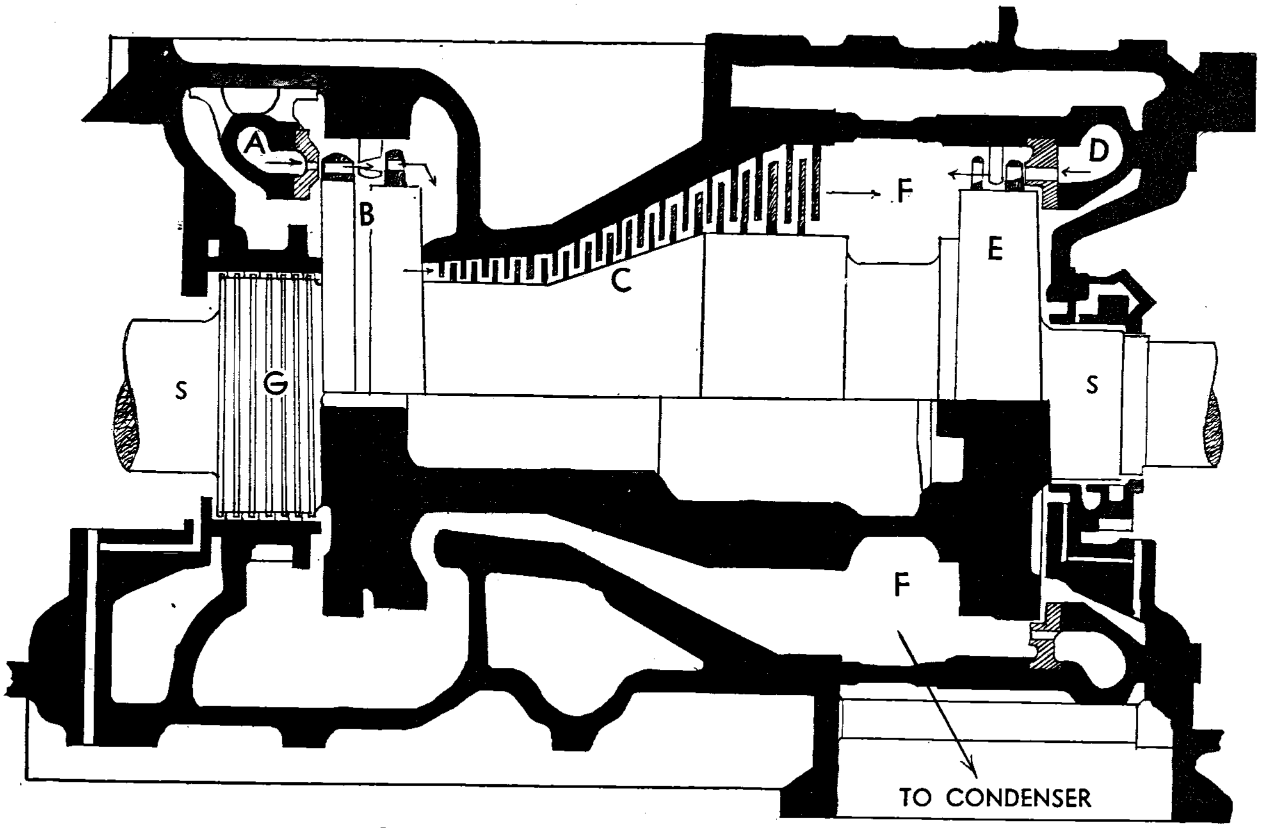
Some turbines consist of one rotor in one casing, in which case it is known as a complete expansion turbine. However, to reduce the size



WESTINGHOUSE TURBINE WITH TOP HALF OF CASING REMOVED

of the plant where higher pressures are used, the turbine is compounded; that is, after the steam passes through one turbine, it is led to another turbine. The first turbine is known as the high pressure and the second as the low pressure. In most cases, the two turbines are placed side by side and are referred to as a cross-compound unit. There are some installations where expansion of the steam is done in three turbines, this being known as a triple-expansion turbine.

The sketch shows a complete expansion turbine which has been used in marine practice. The turbine blading is partly of the impulse, and partly of the reaction type. The steam en-



COMPLETE IMPULSE-REACTION TURBINE

ters the nozzle chamber (A) and passes through nozzles where it expands somewhat and increases velocity. It then passes through a Curtis stage at (B) consisting of two rows of moving blades separated by a row of stationary blades. After passing through these blades, the steam passes through 21 moving rows of reaction blading (C), together with the same number of stationary blades. The exhaust is taken from (F) and passes to the condenser. This action of the steam drives the rotor shaft (S) in the ahead direction.

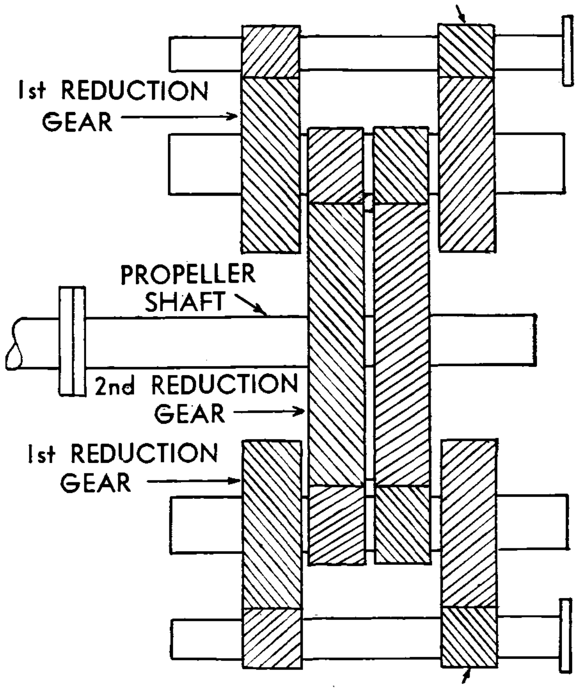
Turbines have the distinct disadvantage in that they cannot run backwards. Because it is necessary for vessels to maneuver astern as well as ahead, there is installed a separate turbine of low power for running astern. It operates under high steam pressure, and is located in the same casing of a complete expansion turbine, or in the low pressure casing of a compounded unit.

Because it is imperative that steam is not admitted to the astern turbine while steam is on the ahead, or vice versa, some type of guarding mechanism is supplied at the throttle valves so that while one is open, the other cannot be opened.

In the sketch of the complete expansion turbine the astern turbine (E) consists of a Curtis stage and takes steam from the nozzle chamber (D). The steam pressure is supplied to (D) when running astern as supplied to (A) when running ahead. Marine turbines have comparatively little backing power.

REDUCTION GEARS

There is a great deal of theory attached to the design and construction of a steam turbine, which will not be gone into at this time. However, it might be said that for theoretical reasons, it is impossible to get any form of efficiency from a slow speed turbine unless of tremendous size. So in marine practice, where the saving of space and weight is an asset, turbines are small in size and operate at very high speed, 2,500 to 6,000 R.P.M. This high speed is contrary to the requirements of a propeller for good efficiency. A propeller must turn at relatively low speeds (80-100) R.P.M., therefore, the high speed of the turbines must be reduced to the low speed of the propeller. This is done in one of two ways; either mechanically with reduction gears, or electrically. The electric method is known as turbo-electric, and in this system the turbine is directly connected to a generator and the high speed generator drives a synchronous or induction motor at low speed, which in turn drives the propeller. In the majority of installations, the speed reduction is effected mechanically, or with reduction gears.



DOUBLE REDUCTION GEARS

There is a small pinion on the turbine shaft which meshes with a larger gear to effect one speed reduction. If the speed is still sufficiently high to necessitate further reduction, there is a pinion on the shaft of this gear which meshes with another larger gear to effect a second reduction. This latter type, known as double reduction gears, is very frequently used.

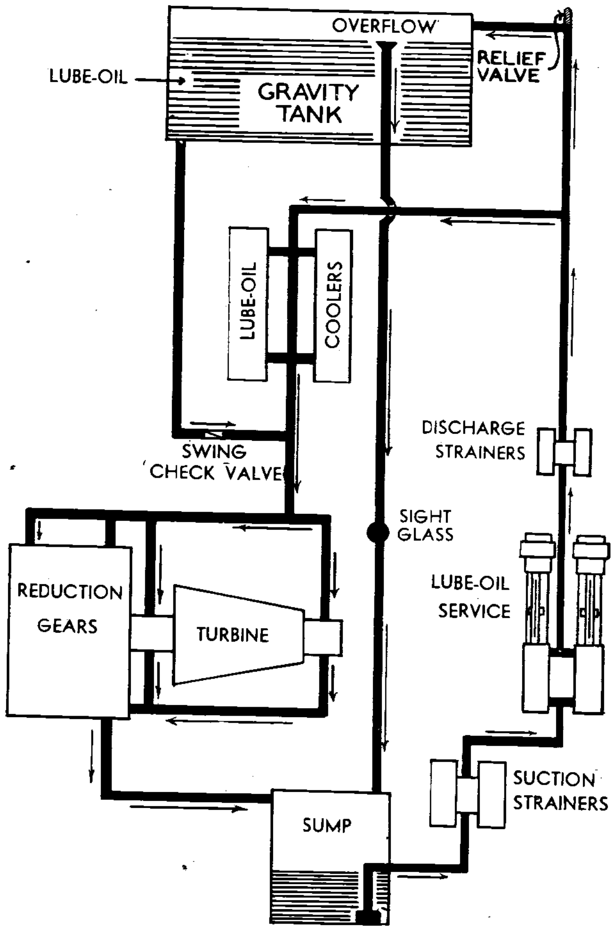
The sketch shown is an arrangement of one type of double-reduction gear. Gear teeth are not cut straight across the gear, but are either cut spirally, known as helical gear teeth, or are cut at opposing angles, known as herringbone gear teeth.

SHAFT PACKING

When the rotor extends through the end of the turbine casing, steam is prevented from leaking out and air from leaking into the casing by glands. These consist of labyrinth packing which consists of a series of rows of metallic strips through which the steam is throttled several times to greatly reduce the leakage pressure. Carbon rings around the shaft and water seals are also used.

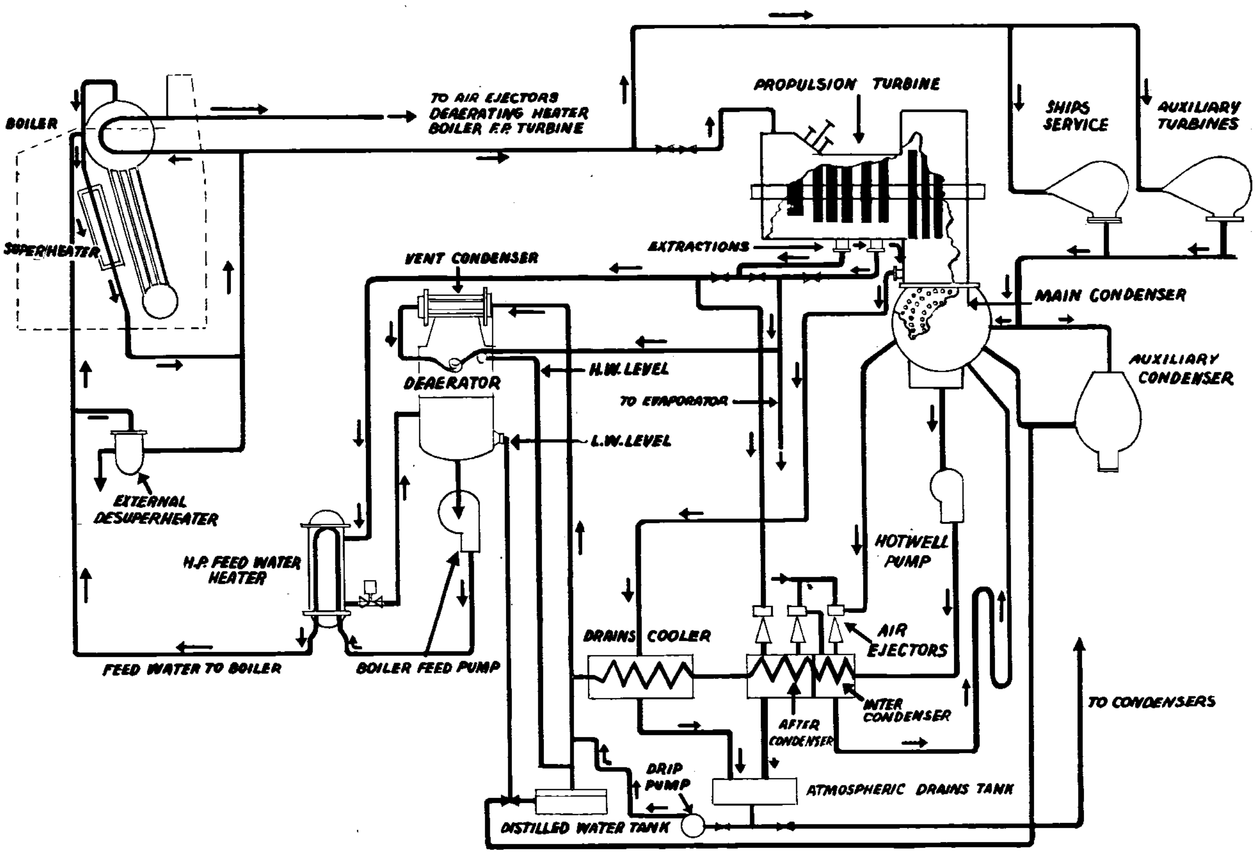
SPEED GOVERNOR

Every turbine has a maximum safe speed limit which must not be exceeded, otherwise the blade wheels may explode from the excessive centrifugal force set up and destroy the turbine.



TURBINE LUBE-OIL PRESSURE SYSTEM

To limit the speed to a safe R.P.M., an automatic speed governor is installed on every turbine installation. It is a vitally important piece of equipment and must not be tampered with. One type of governor uses revolving weights which swing out by centrifugal force from a center shaft as the speed of the turbine increases. As the weights swing out they act on a series of levers and rods which close in on the steam governor valve, which limits the steam entering the turbine and so the speed.



MODERN TURBINE STEAM AND WATER CYCLE

This modern installation is typical of those used on the T-2 tankers and is similar to that used on Victory and C-type ships. The boilers operate at 450 lbs. per square inch and the steam temperature at the turbine throttle valve is about 750° F. The high efficiency of the steam generating plant is dependent in part upon the high temperature of the feedwater as it enters the boiler.

The method of feedwater heating shown here consists of bleeding high temperature steam from various extraction points on the turbine and using this steam to heat the feedwater for the boiler. Such a system is capable of more than a 10 per cent saving in fuel consumption because the steam used to heat the feedwater has already been used to turn the turbine and move the ship.

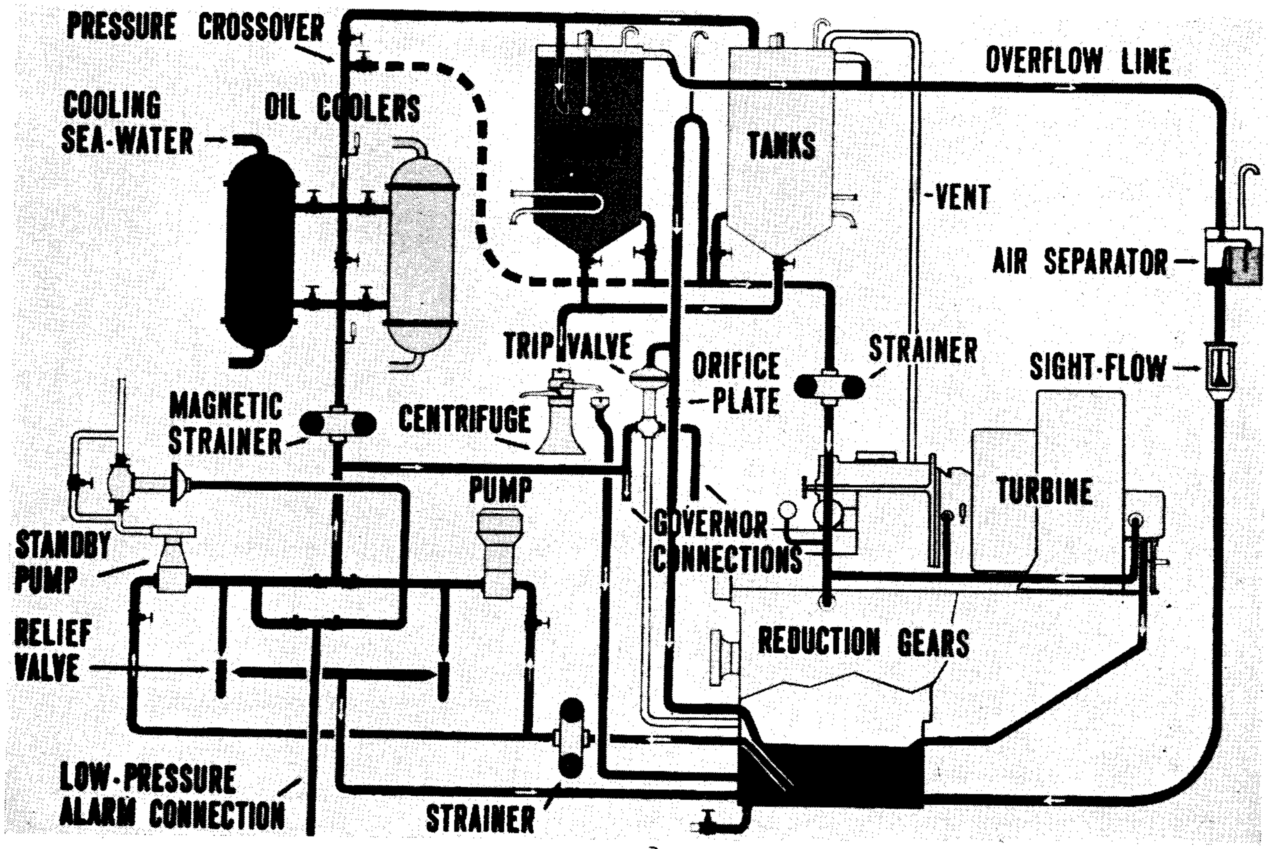
As with all turbine propulsion plants the proper amount of vacuum must be maintained in the main condenser if full efficiency and power is to be realized. Any loss of vacuum causes the turbine rotor to slow down even though the same amount of steam is entering the turbine.

LUBRICATION

The lubrication of turbines is usually accomplished by the circulation of oil under pressure. The oil is taken from a sump tank and through suction strainers by a lube-oil service pump. The sump tank is equipped with a float to show the level of the oil in the tank. The suction strainers are used to remove any solid particles that might damage the pump. Suction strainers are installed in duplicate, or are duplex, so one may be in service while the other is cleaned.

At least two lube service pumps are installed in the system. Thus, one is a stand-by pump, while the other is in service. The lube-oil service pump discharges through duplex discharge strainers of fine mesh, where any foreign solid matter which passed through the suction strainers is removed.

The oil then flows through lube-oil coolers where heat is removed from the oil by passing over coils through which sea water is circulated. The circulating water is usually taken from the discharge of the sanitary pump, although a pump to be used just for this purpose may be installed.



TURBINE LUBRICATION—GRAVITY TYPE SYSTEM

From the lube-oil coolers the oil flows to each of the bearings of the turbine and to the reduction gears. The amount of oil supplied to the bearings must be sufficient to cool as well as lubricate them. The oil supplied to the reduction gears flows to the gear shaft bearings and between the gear teeth. From the turbine bearings the oil drains out to the gear casing where the oil from the gears and the bearings drains to the sump tank to be used over again.

Some of the oil pumped from the sump is discharged through a relief valve into the lube-oil service tank, thus keeping the service tank full, the excess overflowing through the overflow line, passing down to the sump tank by way of a sight glass where the flow of oil can be observed.

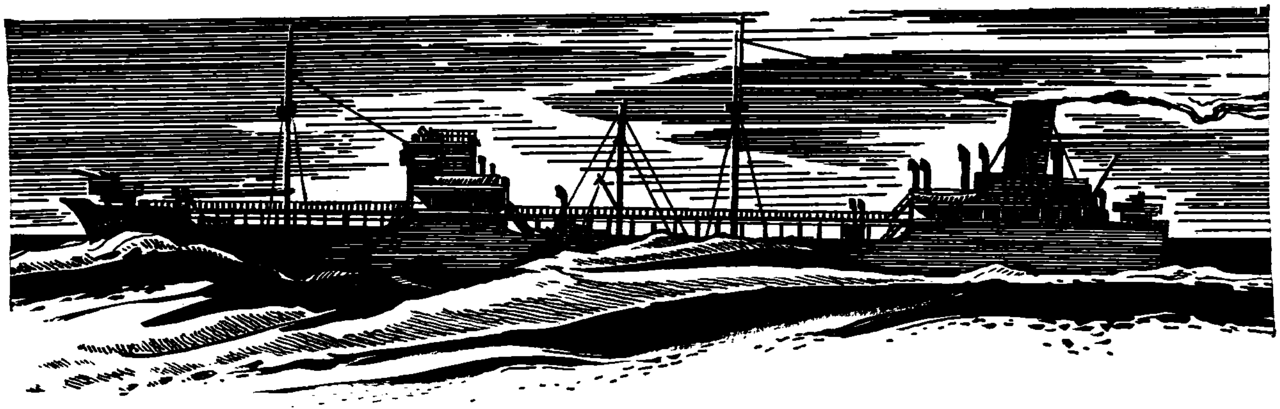
A connection is made from the lube-oil service tank to the bearings and gears through a swing check valve that is kept closed by the oil pressure of the service pump. If this pressure should fail, the oil in the service tank would flow to the bearings to supply the necessary lubrication, until the turbine can be stopped. A low pressure alarm is installed to give warning should the oil pressure fall below a safe limit.

Pressure gages are installed on each bearing and on the lines to the gears to show the pressure of oil supplied to them.

Thermometers are installed at various points of the system to show the temperature of the oil entering the cooler, leaving the cooler, and the oil leaving each bearing.

The operating temperatures of the bearings can not be definitely stated, but in most cases should never exceed 130° F., and should never be carried below 90° F. A rise in bearing temperature above normal definitely indicates trouble, which should, of course, be found and remedied immediately.

Water, sludge, and sediment which accumulate in the oil are removed by a centrifugal oil purifier, called a centrifuge. At frequent intervals, the oil is taken from the service or sump tank, and passed through the centrifuge, from which the cleaned oil returns to the sump tank.



REMEMBER—A WIPED BEARING MAY STOP YOUR SHIP

DUTIES OF AN OILER

At sea the main engine usually turns at a steady speed although in convoys the speed will quite often be varied from time to time. The oiler makes regular rounds usually every half hour feeling all of the various bearings on the main engine and oiling them. He also must swab the piston rods and valve stems. He also feels of the thrust bearing and travels down the shaft alley feeling and oiling the spring bearings and feeling the stern gland and looking to see if sea water is running through. In between his regular rounds the oiler checks the engine room auxiliaries, refrigerating system and steering engine. He should know how to stop the main engine should it become necessary and the engineer were absent.

It is the oiler's duty to learn everything possible in connection with the operation of the vessel's power plant, because when opportunity comes for advancement he will be able to qualify for the position of watch engineer.

All oilers should thoroughly understand the operation of the different types of lubricating oil pressure and gravity systems for turbine lubrication.

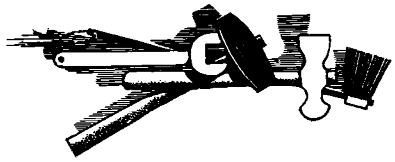
The actual oiling of the machinery takes up but little of the oiler's time. However, he should have the plant under his constant surveillance.

The oiler's watch at sea is of four hours, with eight hours off in between. In port on some vessels, his duties consist of day work, while on other vessels his watch is eight hours long, with sixteen hours off in-between.

During his watch, the oiler is probably called upon to do one or all of the following. Pump out the bilges, pump up fresh water or ballast tanks, keep an eye on the water level in the boilers and on the fireman, take temperatures of the stack, sea water, filter box, and feedwater for entrance into the logbook, keep oil wiped up off the floor plates and gratings, and on some ships he has a station to keep clean.

In port his work consists mainly of oiling the auxiliaries, and in assisting in the maintenance and repair of the plant. He may be called upon to oil and watch the cargo winches during the night if the cargo is being worked at that time.

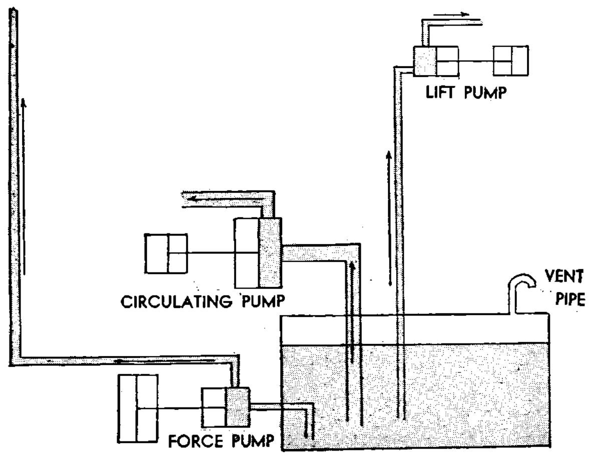
His is a responsible job; his negligence may result in damage to machinery to the extent of thousands of dollars.



PUMPS

A pump, in the ordinary acceptance of the term, is a machine for the transferring of liquids.

All pumps are generally classed under the three purposes for which they may be used. The sketch below shows that pumps are classed according to their purpose, and according to their position with the fluid supply.



CLASSES OF PUMPS

Pumps are used to transfer fluids from one place to another, but for clarity, it will be assumed that water is the liquid being pumped throughout this discussion.

If the pump is located at a distance above the liquid supply it is termed a lift pump. The distance that the pump is above the liquid supply is termed the "lift" of the pump. Some pumps have very little lift, and are used to discharge large quantities of water under little pressure. In this case, the pump is classed as a circulating pump.

Where a pump is to be used for discharging smaller volumes against high head pressures, it is classed as a force pump.

First, consideration is given to the lift pump. Pumps of this class, being located some distance above the liquid supply, demand more consideration on the suction side than on the discharge side.

In order to understand the operation of this class of pump, the theory of vacuum and atmospheric pressure must be understood. First of all, there is no such thing as a drawing force, or sucking force as is ordinarily imagined. Flow of fluids is never caused by one pulling from the other, but always caused by one under a higher pressure pushing against the one with the lower pressure.

Atmospheric pressure is 14.7 pounds per square inch and the pressure of perfect vacuum is 0 pounds per square inch. It is impossible to obtain a perfect vacuum. Therefore, it is impossible to reduce pressure down to 0 pounds per square inch, and whenever the pressure is reduced below atmospheric pressure, but above a perfect vacuum, this is known as a partial vacuum. The pressure being above 0 pounds per square inch, then this partial vacuum has a small pressure, but a pressure nevertheless.

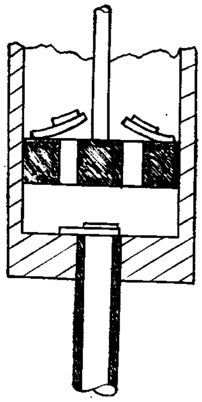
Now, the mercurial barometer operates under the fact the atmospheric pressure at sea level is capable of holding up a column of mercury approximately 30″, and when the pressure rises, or falls, the column of mercury rises and falls. If water were substituted for the mercury, the water, being much lighter than mercury, could be held up by atmospheric pressure to a distance of 34′. This is only true if the water used is absolutely pure, and assuming that a perfect vacuum is maintained at the top of the column, and that there is no friction involved between the water and pipe.

The lift pump, when it begins operating, does not draw the water into the pump chamber, because, as has just been explained, this is not possible. The pump plunger, however, pumps the air out of its chamber, and displaces the air in the suction line, thereby reducing the pressure in the suction line below that of the atmosphere, causing the atmospheric pressure, acting on the surface of the water through the vent pipe, to push the water up through the suction pipe into the pump chamber, where it may be acted on by the pump plunger, and discharged.

Any pump, in order to lift water must be able to pump air. All pumps can not pump air, and those that can are capable of displacing anything in the pump chamber, and are known as positive displacement pumps.

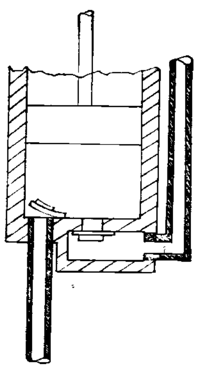
RECIPROCATING PUMPS

Simplex Type–All reciprocating pumps consist of a cylinder in which a close fitting plunger is moved back and forth. A simple type known as a lift pump is shown. This consists of a cylinder and plunger with a suction valve



LIFT PUMP

at the bottom of the cylinder and a valve in the plunger. The illustration shows the plunger on the down stroke, the suction valve is shown closed, the plunger valves are open, permitting air in the cylinder to flow above the plunger as it moves down. On the upward stroke, the plunger valves close, and the suction valve opens, permitting air in the suction line to flow



FORCE PUMP

into the cylinder. After a few strokes the air pressure in the cylinder and suction line are reduced sufficiently to allow the atmospheric pressure to force the water from the supply up the suction line into the cylinder. From here on the pump continues the same action, but moves water instead of air. This type of pump is used for lifting water only. Practically, water can be raised about 25 feet with a lift pump.

A simple sketch of a force pump is shown in the accompanying drawing. Water is forced up into the pump cylinder by atmospheric pressure as the pump reduces the pressure in the cylinder and suction line. Instead of admitting air or water to the top of the plunger through a valve, on the down stroke it forces the water or air through the discharge valve. The height to which the water may be forced depends upon the power applied to the plunger. Both pumps described are single acting pumps as they move water out of the cylinder only on every other stroke of the plunger.

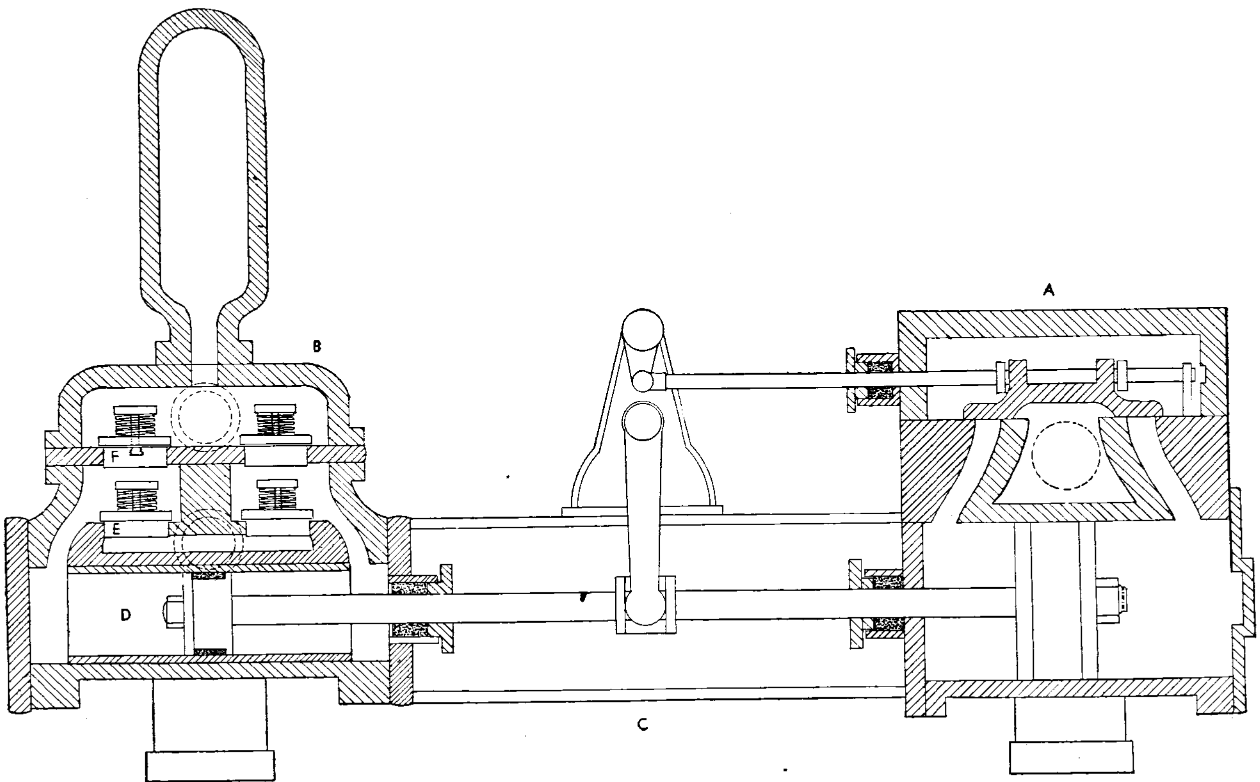
The type of pump generally used on board vessels is a double acting pump which works the same as the force pump described, although not necessarily a force pump, except that a suction and discharge valve is provided at each end of the cylinder. Thus, while the plunger is forcing water out a discharge valve at one end of the cylinder, water is forced in the other end through the suction valve by atmospheric pressure.

The valves are not usually arranged as shown in the simple sketch but are as shown in the drawing of a double acting reciprocating pump. (A) is the steam end of the pump, (B) the water end. Suction (E) and discharge decks (F) are provided above the cylinder and the suction and discharge valves are placed on these decks. The discharge deck is placed above the suction deck, a suction chamber is between the suction deck and the cylinder. The ends of the cylinder are connected by ports to the space above the suction valves and are separated by a division plate. (C) is the pump frame between the steam and water ends.

Duplex Type–The pumps which we have spoken of so far are known as simplex pumps, due to one pump cylinder being used. The discharge from this type is irregular due to the plunger reversing its direction after each stroke. For this reason a pump having two cylinders was developed, one plunger starting stroke before the other plunger has finished its stroke. This action gives a much smoother discharge than is possible with the simplex pump.

The duplex pump requires twice the number of valves used in a simplex pump, that is, at least four suction valves and four discharge valves.

In the steam reciprocating pump, the plunger is driven directly by a steam piston through a piston rod. Steam is admitted to first one end of the steam cylinder and then to the other, moving the steam piston back and forth. The



DOUBLE ACTING RECIPROCATING STEAM PUMP

A–STEAM END
B–WATER END
C–PUMP FRAME
D–PUMP CYLINDER
E–SUCTION VALVES
F–DISCHARGE VALVES

admission of steam is controlled by a slide valve, opening ports to the cylinder for steam to flow through.

The valve is controlled in a different way in the simplex pump than in the duplex pump. In the duplex pump the slide valve for one cylinder is controlled by the piston rod of the other cylinder. Thus as one piston nears the end of its stroke it causes the slide valve of the other cylinder to slide on its seat, opening ports, admitting steam, thus starting the other piston on its stroke.

For best results, in the simplex pump an auxiliary valve is controlled by the piston rod, which admits steam to one side of an auxiliary piston in the steam chest, which in moving in a cylinder, slides the main slide valve in the proper direction to admit steam to the cylinder, starting the piston on a new stroke.

Starting Reciprocating Pumps–In starting a reciprocating pump the following operations should be followed.

1. Make sure pump is clear and free to operate.
2. Open proper discharge valve.
3. Open proper suction valve.
4. Open cylinder and steam chest drains.
5. Open exhaust valve.
6. Crack steam valve, starting pump.
7. Close drains.
8. Regulate speed.
9. Lubricate.

CENTRIFUGAL PUMPS

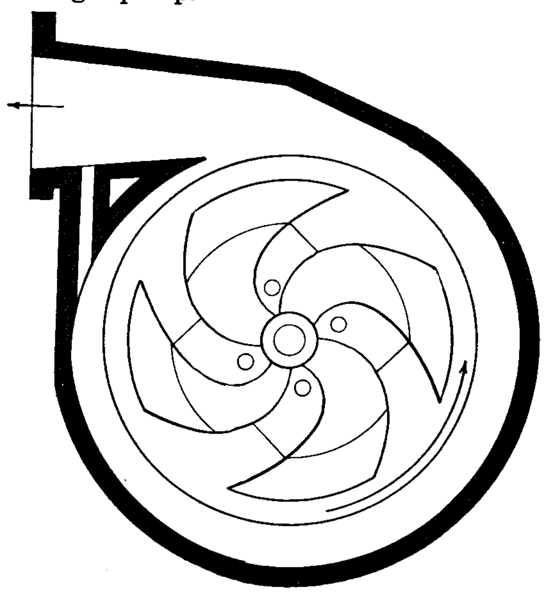
If a pail partly filled with water is whirled in a circle, the water will stay in the bottom of the pail, in fact, the water will tend to force itself through the bottom of the pail. This action is due to what is known as centrifugal force. Centrifugal force is a force set up by whirling a body in a circle, which tends to cause that body to fly off at a tangent to the circle.

Mud guards are used around wheels because of the mud and water being thrown off the wheels due to centrifugal force.

A centrifugal pump is a pump that causes the flow of a liquid due to this force. It consists essentially of a motor or impeller which is rotated at high speed inside a casing. The water enters the center of the impeller, is rotated rapidly, and is thrown from the ends of the impeller blades at high speed due to centrifugal force. This high velocity, imparted to the liquid by the impeller, can not be used for pumping, but must be changed into pressure. This is done in one of two ways. In one case, the shape of the casing is such that, as the casing nears the discharge opening, its area becomes larger and larger, or the casing cross section has a spiral shape. This shape of the casing is called volute. This volute-shaped casing causes the liquid to slow down and build up static pressure. Thus when the liquid leaves the casing, it leaves under a pressure.

In the other case, when the water is thrown from the blades of the impeller at high speed, it is caused to flow through vanes, which are attached to rings called diffusion rings. It also changes the high velocity into pressure.

Centrifugal pumps are usually divided into two classes according to the manner in which the velocity of the water is changed into pressure. If the volute shape of the casing is used, the pump is termed a volute centrifugal pump; whereas, if diffusion rings, containing diffusion vanes are used, the pump is termed a turbine centrifugal pump.



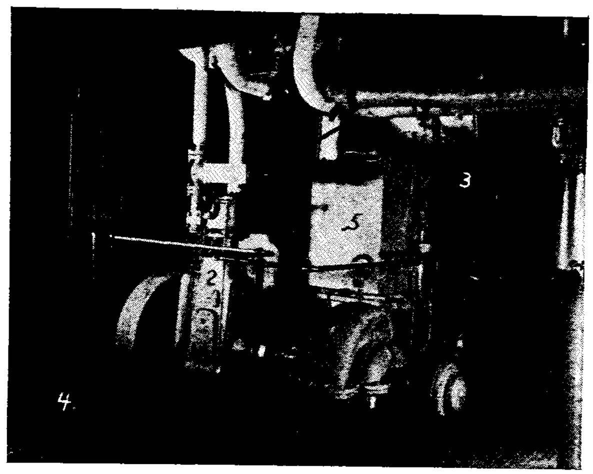
VOLUTE CENTRIFUGAL PUMP

If there is only one impeller contained in the casing, the pump is known as a single-stage pump. A single-stage centrifugal pump of the volute type class is shown in the accompanying drawing.

The impeller turns in the direction of the arrow. The liquid entering the center of the rotating impeller is thrown outwards by centrifugal force at high velocity. The walls of the casing form a spiral-shaped chamber which increases in area as the discharge outlet is approached. This spiral shape of the casing is called the volute. The purpose of the volute is to collect the liquid which is thrown out by the impeller blades at high velocity and, by the increase in area, reduce the velocity and increase the pressure.

In some installations, where the discharge pressure obtained is not sufficient, there may be more than one impeller contained in a casing. The first impeller discharges directly into the center of the second impeller, etc., each succeeding impeller building up more pressure. These are known as multi-stage centrifugal pumps and consist of more than one impeller connected in series. This type is used for boiler feed pumps.

In other installations, where a tremendous



CENTRIFUGAL MAIN CIRCULATING PUMP

The above picture shows centrifugal type circulating pump (1), driven by a single cylinder reciprocating steam engine (2). The pump takes its suction from the sea through the main injection valve (4), and discharges into the cooling water side of the main condenser (3).

The steam control valve to the engine is equipped with an extension rod to the topside, as is the main injection valve. This permits stopping the main circulator and closing the main injection from outside the engine room in an emergency.

The engine cylinder drain valves are also visible. (5) is the observation tank for examining the returning condensate from the fuel oil heaters for presence of fuel oil. (6) is the feed and filter tank.

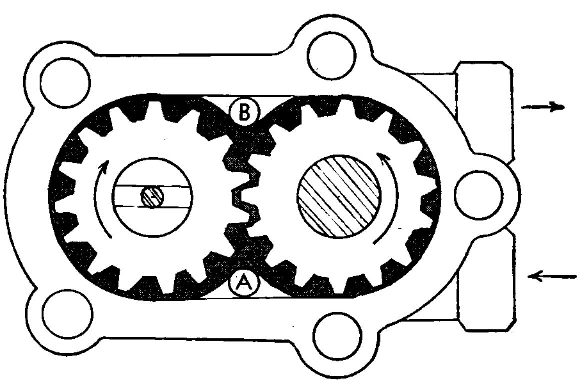
volume of liquid is required, such as some fire pumps, in order to reduce the size of the pump, more than one impeller is inclosed in a casing, all of them taking suction from the same suction line, and all of them discharging into a common discharge line. These are pumps in parallel, and with little effect on the pressure, are capable of discharging large quantities of liquid.

By themselves, centrifugal pumps of both classes have the disadvantage of being unable to displace air and reduce the prèssure in the suction line below that of the atmosphere. They are therefore unable to lift water from a level below the pump suction. They are the only type of pump which are not positive displacement pumps.

ROTARY PUMPS

Where a service requires the lifting of small volumes of liquids, and the delivering of it with an even flow against an appreciable head pressure, rotary pumps of the positive displacement type have, to a large extent, replaced reciprocating pumps. Their pumping action is accomplished by rotating gears, screws, or tumblers inside a casing.

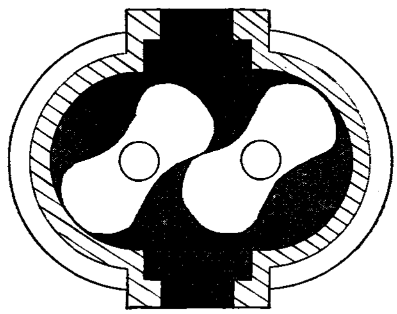
There are many types and designs of rotary pumps, the most common being the gear and screw pump. A gear pump is shown here.



GEAR PUMP

Gear Type–The gear pump usually consists of two gears, meshing together, caused to rotate within a close fitting casing. One of the gears is turned by an engine or motor, and in turn, rotates the second gear. The liquid enters at the bottom of the pump at (A), is carried between the gear teeth of each gear around the inside of the casing, and when the teeth mesh the liquid is displaced and forced out through a discharge opening, (B).

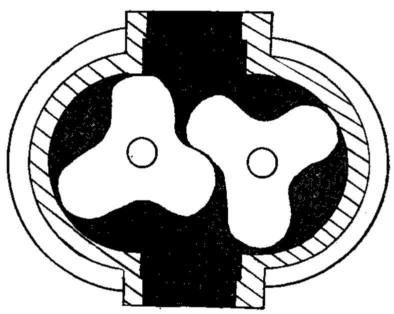
Another form of this pump uses two rotors with lobes on each rotor. The two rotors mesh together. The lobes act in the same way as the gear teeth, carrying the liquid around the inside of the casing, displacing the liquid when a lobe on one rotor meshes between two of the lobes of the other rotor. This type of rotary pump must have meshing gears on the same shafts, or timing chains to keep the lobes of both rotors spaced so that they mesh at the



TWO LOBE CYCLOIDAL PUMP

center of the pump. In the drawing of the lobe type pump, known as a cycloidal pump, the liquid enters at the bottom and is discharged at the top as indicated by the arrows.

These pumps may contain rotors of two or three lobes, and these lobes engage with a rolling motion.



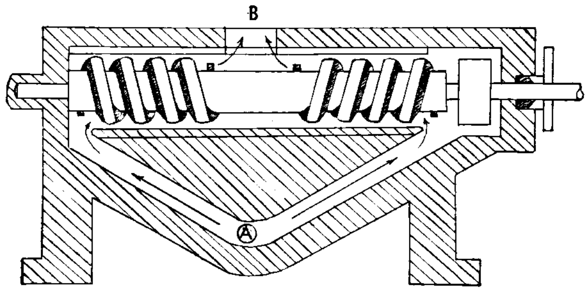
THREE LOBE CYCLOIDAL PUMP

Screw Type–Screw pumps are rotary pumps using rotating screws to create the pumping effect. They consist of two shafts, each shaft carrying a left and right-hand screw. One shaft is driven by the power unit, and imparts its motion to the other shaft through a set of gears. These gears also act as timing gears.

The screws must be contained in a close fitting casing. The liquid enters the pump at the bottom, and floods the casing. The ends of the threads cut into the liquid, trapping quantities of it into the spaces between the threads. The meshing of the threads prevents the escape of liquid from these spaces.

The threads, being right and left-handed, move the liquid from either end towards the center of the shafts, where it is discharged from the outlet to the line.

The accompanying sketch shows the rotating parts of the screw pump enclosed in the tight fitting casing. It shows the liquid inlet at the bottom, and the discharge outlet at the top. The



SCREW PUMP

arrows showing the flow of the liquid through the pump denote that the liquid enters at the ends of the threads and is discharged at the center.

This is an excellent type of pump for services such as the fuel oil service pump.

Rotary pumps of the gear and screw types should not be used for pumping liquids containing abrasives such as sand, grit, etc., because any wear of the pump parts will materially reduce the efficiency of the pumps.

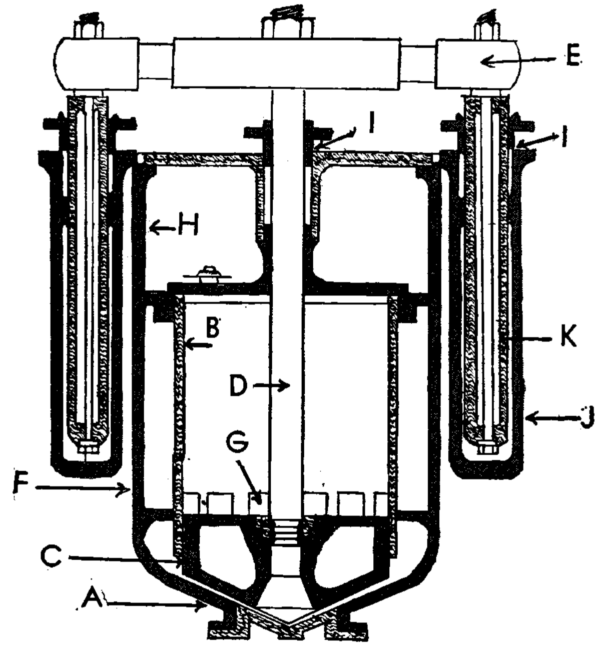
AIR PUMPS AND VACUUM

A certain amount of air and non-condensable vapor unavoidably enters the condenser. As the condenser operates at a pressure below atmospheric pressure, this air is also at a pressure below the atmosphere; and in order to remove it, some apparatus must be furnished that will compress this air to above atmospheric pressure.

There are two mechanisms in general use for removing this air; one called an air pump and the other an air ejector.

Air pumps are divided into two general classes: wet and dry. A wet air pump handles both air and condensate. A dry air pump handles air only, with a separate pump handling condensate.

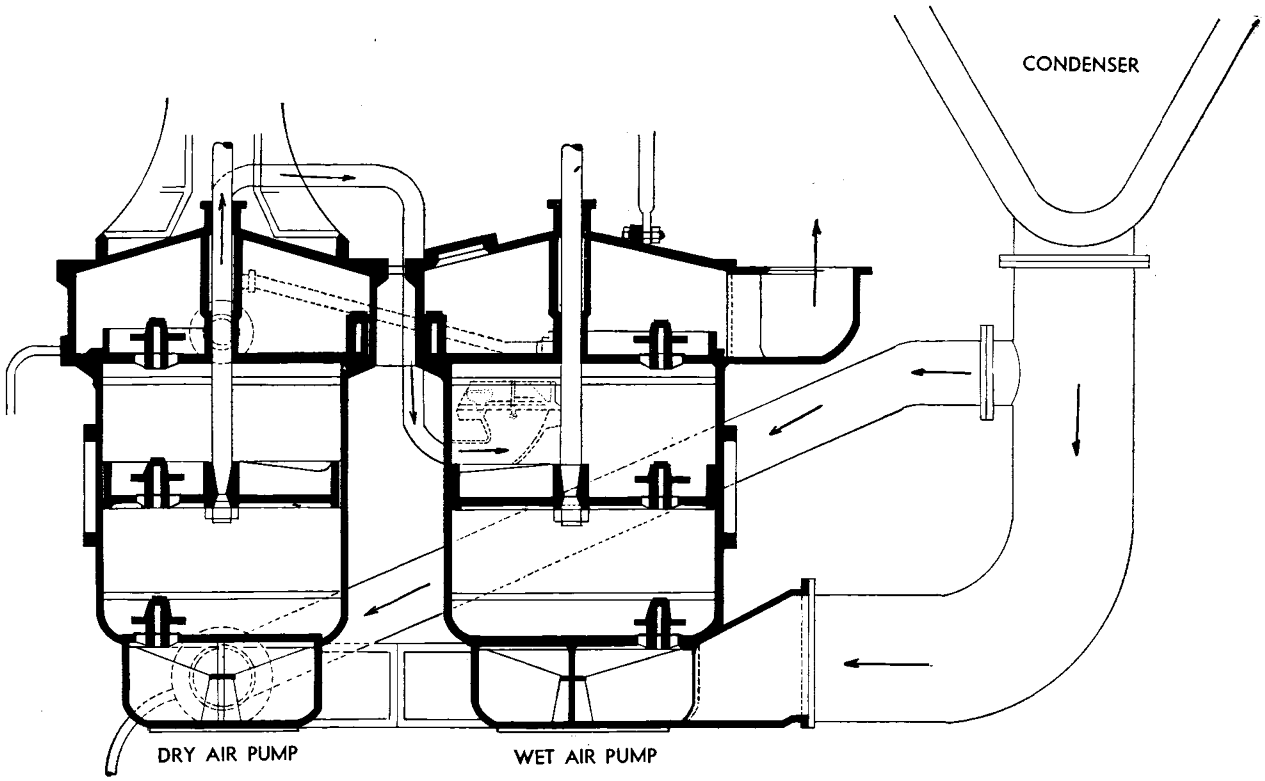
Dependent Air Pump–In marine practice, the wet air pump is more commonly used than the dry. The common method of driving the pump is to attach it to the L.P. crosshead of the main engine, of the reciprocating type. The Edwards air pump is in general use and a sketch of this type is shown. In this particular pump all valves are dispensed with, except those for the discharge. The air and water, or condensate, which collects in the base of the pump is displaced and forced into the pump cylinder by the descending plunger. It is then caught above the plunger when it makes an up-stroke and is discharged through the discharge valves.



EDWARDS DEPENDENT AIR AND CONDENSATE PUMP WITH ATTACHED BILGE PUMPS

A–AIR PUMP BODY
B–AIR PUMP LINER
C–AIR PUMP BUCKET
D–AIR PUMP ROD
E–CROSSHEAD
F–INLET CONNECTION FROM MAIN CONDENSER
G–AIR PUMP SUCTION PORTS
H–DISCHARGE VALVES
I–STUFFING BOXES
J–BILGE PUMP CYLINDER

Independent Air Pump–This type, formerly used with turbine installations, has largely been replaced with air ejectors and condensate pumps as a means of removing air and condensate from main condensers. Independent air pumps consist of two pumps, one for removing the condensate and the other for air. In the cross-section view the wet air pump removes the condensate from the condenser and discharges it out of the top of the pump to the feed and filter tank as shown by the arrows. The dry air pump takes its suction higher up on the main condenser thereby taking only air. The air is dis-



INDEPENDENT AIR AND CONDENSATE PUMP

charged out of the top of the pump to the engine room. To provide a liquid seal for the dry air pump plunger, a small amount of water is injected at the bottom end of the pump.

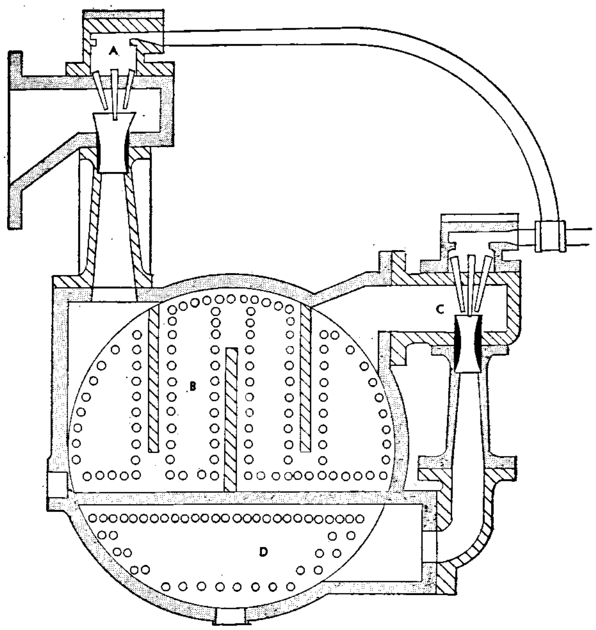
Independent air pumps are driven by their own steam cylinders being entirely independent of the main engine.

AIR EJECTOR

The steam jet air ejector, because of its small space, weight, and economy of operation and maintenance, has replaced the reciprocating air pump on practically all turbine-driven vessels, and in some cases is used with reciprocating engine installations.

An ejector consists essentially of a steam nozzle discharging a jet of steam at high velocity across a suction chamber. The air and non-condensable vapors enter the suction chamber, are entrained by the jet of steam, and discharged into a compression tube where the velocity is reduced and the pressure increased before discharging.

This is known as a single-stage air ejector, but, since it is necessary to discharge the air into the atmosphere, the required discharge



TWO STAGE AIR EJECTOR

pressure cannot be economically obtained by the use of just one set of steam nozzles.

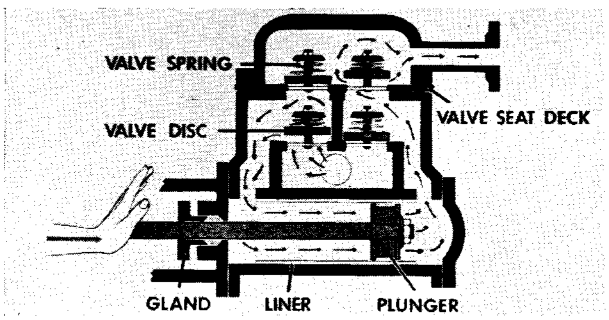
To attain higher vacuums, and for increased economy, air ejectors are usually built with two or more jets in series. They are known as multi-stage ejectors.

A two-stage air ejector is shown in the accompanying sketch.

The first-stage nozzles (A) at the top of the sketch take their suction from the main condenser and discharge into a chamber known as an intercondenser (B) where a portion of the steam vapors are condensed. The second-stage nozzles (C) pull the remaining air and steam vapors out of the intercondenser and discharge them into the after condenser (D) where all vapors are condensed. The cooling water for the inter and aftercondensers is fresh water condensate from the main condenser condensate pump. The inter and aftercondensers may be of the jet or surface type. All of the condensate returns to the feed system.

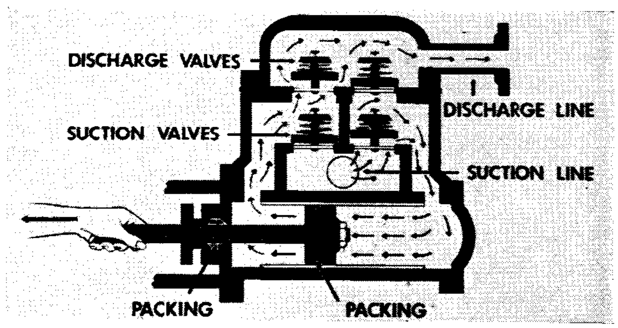
When air ejectors are used, the condensate formed in the main condenser is removed by a separate pump which may be either of the reciprocating or centrifugal type. The pump discharges the condensate through the inter and aftercondenser to the open type deaerating feedwater heater. (See steam and water cycle on page 86.)

LIQUID END DOUBLE ACTING PUMP

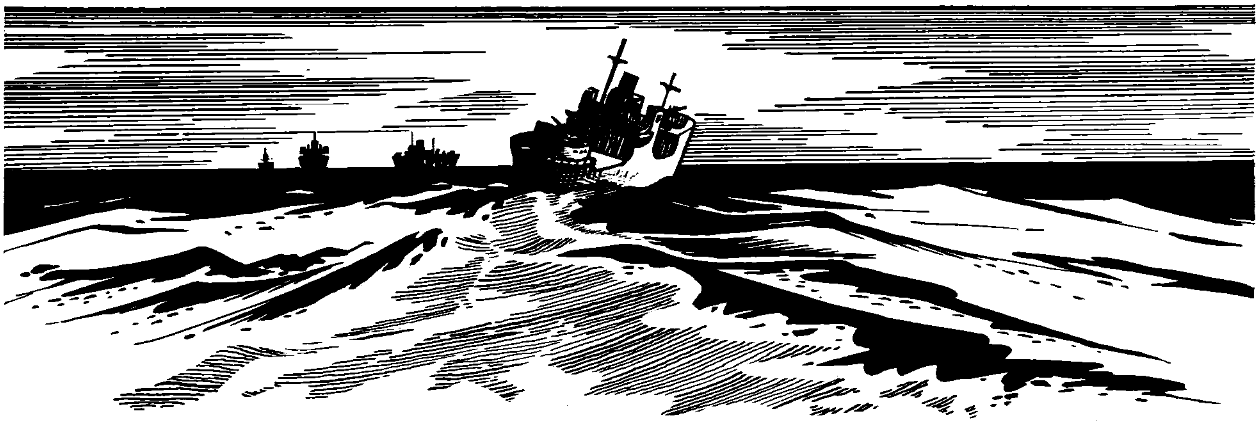


The arrows indicate the flow of liquid as the plunger is moved forward. A partial vacuum is created behind the plunger. Atmospheric pressure is now sufficient to force the liquid through the suction valves, filling the spaces behind the plunger. At the same time liquid is pushed through the discharge valves by the plunger. This discharge pressure aids the springs in holding the suction valves closed and forces the discharge valve open.

By following the arrows the reader can see that on the return stroke the same cycle of events takes place. The hand shown on the piston rod is representative of the steam cylinder which transmits power through the piston rod to the liquid plunger. Each stroke of a double acting pump is a power stroke and the result is a steady, unbroken flow.



U. S. Maritime Service Training Aids Unit Charts



REMEMBER—BILGE WATER OIL SLICK CAN BE TRAILED

PUMPING SYSTEMS

For the ship's safety and operation the following pumping systems are needed. The pumps are usually located in the engine room.

Bilge System–Into the engine room bilges flows the cooling water discharging from the main bearings, guides and thrust bearing. Sea water also enters the bilge from the stern gland.

To remove this water and discharge it overboard, a pump known as the bilge pump is used. It is an independent pump usually of the steam reciprocating type. The pump takes its suction through a pipe line from wells in the forward and after ends of the engine room bilge. The fireroom bilge is likewise equipped. Around the open end of the suctions is placed a strainer in the form of a perforated steel plate, to prevent rags, etc., from entering the pipe. These are sometimes known as rose boxes. If the bilge pump refuses to remove the water, look at the rose boxes to see if they are not plugged.

Many reciprocating main engines have what are known as bilge rams on the side of the dependent air pump. These act as bilge pumps when the main engine is operating, the regular bilge pump being kept for port use.

Do not pump bilge water overboard except at authorized times. You may leave a trail of oil behind your ship that the enemy can follow.

Ballast System–When a ship is running without cargo it rides high in the water. Should heavy seas blow up, it will be necessary to bring the ship down further in the water in order to handle it. This is done by pumping sea water through pipe lines into the empty fuel oil storage tanks in the double bottoms. This is known as ballast. The pump for this purpose is known as the ballast pump. On the suction and discharge sides of the pump are valve manifolds, which are simply several valves in one body. Each valve wheel has a name plate, upon which is stamped the particular tank that the pump is sucking from and discharging into. By opening and closing the different valves, ballast may be pumped from any one tank to any other.

Valve manifolds are also used with other pumps, such as the fuel oil transfer pump.

Sanitary System–To supply sea water for the various toilets aboard ship a steam pump known as the sanitary pump is provided. It takes its suction directly from the sea and is usually controlled by an automatic pressure regulator so that the pressure in the sanitary line remains constant no matter how much water is being used.

Do not flush toilets in daytime. You may give away the location of your ship to the enemy.

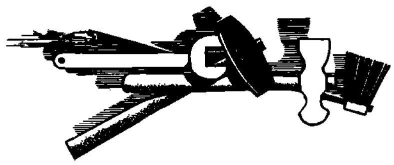
The cooling water for the refrigerating machine is quite often taken from this line.

Fresh Water System–For washing purposes, fresh water is pumped from the fresh water storage tanks through pipe lines to the lavatories in the crew's quarters and to the showers in the washrooms.

Water for drinking and cooking is pumped from the domestic tanks to the galley and drinking fountains. In some ships a gravity tank is provided on the boat deck, in which case the drinking water would be pumped from the domestic tanks to the gravity tank, from where it would run by gravity to the galley and fountains.

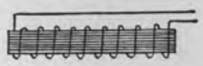
Fire Main–For fire fighting purposes a special pump known as the fire pump is provided. It takes its suction from the sea and discharges it through the fire line the length of the ship. Convenient fire hose connections are located along the fire line to permit a fire at any point in the ship being reached by the fire hose.

Fire pumps must be ready for instant service and the method of starting up should be thoroughly understood by the engine room crew.



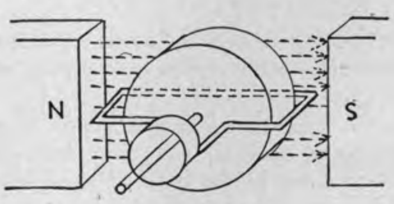
ELECTRICITY

For many years American ships have been equipped with electric lights. Prior to that, oil lamps were used for running lights and illumination in crew's quarters, engine and firerooms. Electricity for these lights and to operate electric motors is produced in an electric generator which is driven by a steam engine, either reciprocating or turbine.



ELECTRO-MAGNET

The electricity produced flows to all parts of the ship requiring light and power, through copper cables in much the same manner as water flows through pipes. There is nothing complicated about the principle of electricity if it is compared with a liquid. If water is pumped through a pipe line under pressure, the amount of pressure in lbs. per sq. in. is determined by looking at the pressure gage. The pressure of electricity is known as volts and is determined by looking at the voltmeter on the switchboard.



ARMATURE

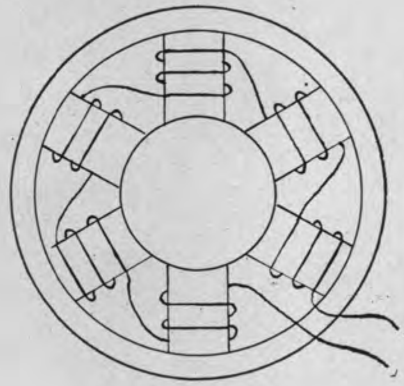
The rate of flow of a liquid may be spoken of in gallons per minute. The rate of flow of electricity is known as amperes and is determined by looking at the ammeter on the switchboard.

To find the amount of work being done by an electric current, multiply the volts by the amperes. This results in watts. A thousand watts is a kilowatt, known as K.W. On the name plate of generators is stamped the maximum K.W. capacity of the generator. This should not be exceeded.

Electricity, if allowed to flow through the human body, can easily be fatal even though the voltage is low. The amount of amperes has the greatest effect on the body. When working around electricity take every safety precaution.

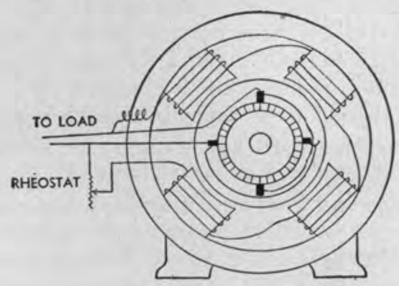
GENERATORS

Electricity is generated by the cutting of magnetic lines of force by wires in a closed circuit. The magnetic lines of force are created by field poles, which are really electro-magnets. An electro-magnet consists of an iron core with a coil of wire around it, electricity passing through the wires of the coil.

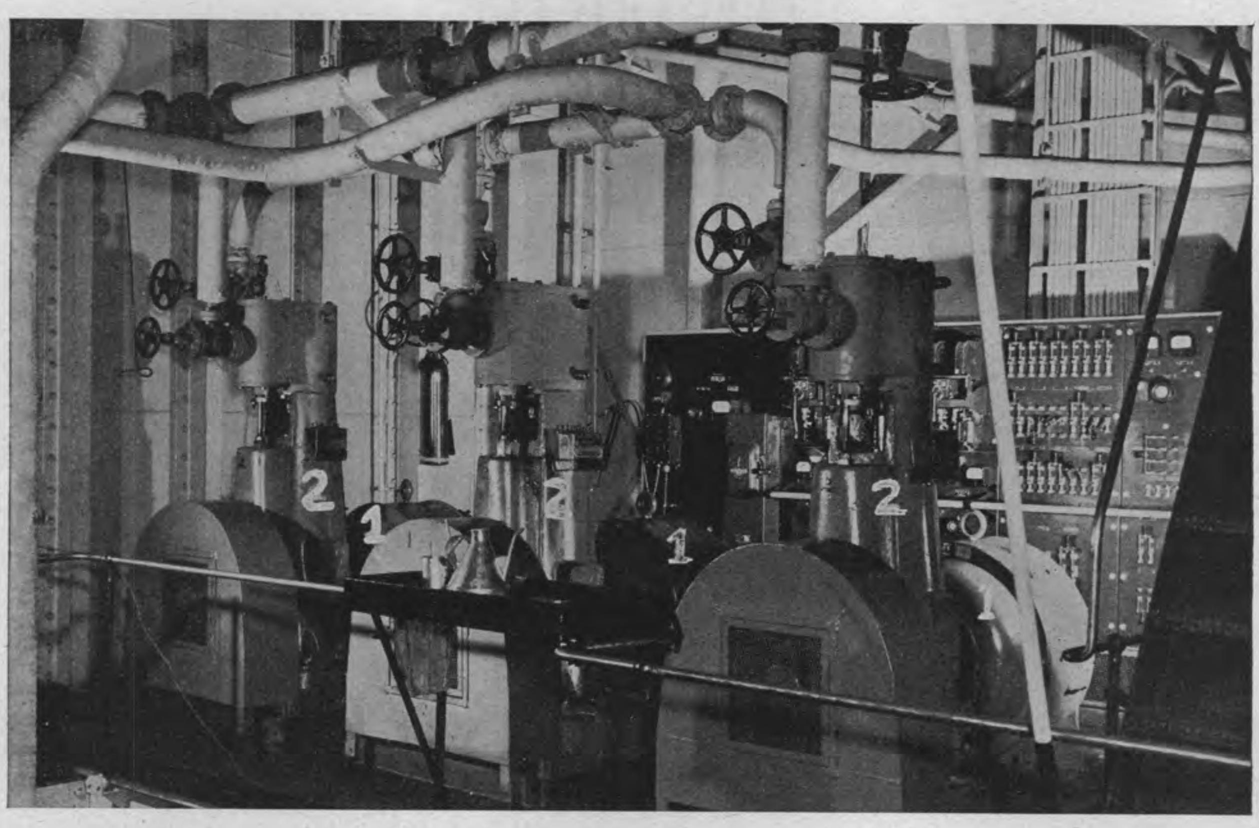


FIELD POLES

The wires which cut the magnetic lines of force are wound on the armature of the generator. The armature is connected to the engine or turbine and is rotated between the field poles, which are stationary. As the electricity is generated in the wires of the rotating element, it must be taken from it. To do this, carbon brushes bear against a commutator to which the armature windings are connected. The commutator consists of copper segments, each one insulated from the next one, and also insulated from the armature shaft. Each coil has one end connected to one segment and the other end to a segment on the opposite side of the commutator. The brushes which bear against the commutator are arranged so that one of them will connect one end of the coil to the outside circuit, thus making a complete circuit. The brushes connect



GENERATOR



GENERATORS AS INSTALLED ON LIBERTY SHIP

The above picture shows three 110 volt, 20 K. W., D. C. generators (1), driven by single cylinder reciprocating steam engines (2). The switchboard is visible aft of the generators with cables leading up from it to the various parts of the ship.

It is most important that the oiler be thoroughly familiar with the lubrication of the steam engine. The lubrication of the main bearings, crankpin bearings, crosshead bearings, guides, eccentric and valve gear bearings is automatic, being supplied by an oil pump located in the oil sump in the base of the engine frame. The pump is operated from the crosshead by a rod or chain drive from the crankshaft. The oil discharges upward through a pipe line to a gravity sight feed oil box seen on the side of the engine just below the cylinder. From here the oil flows by gravity through needle type regulating valves to each bearing. A glass window in the side of the box enables the oiler to see whether or not oil is flowing to each bearing. The level of the lubricating oil in the sump is determined by looking at the gage glass in the side of the engine base. Oil should be added from time to time to keep the proper level.

The generator shaft bearing may be either of the ring oiled type or a sealed ball bearing requiring little attention except to feel it each round.

The piston rod and valve stem are swabbed with cylinder oil each round. The packing should be kept from leaking as the escaping steam tends to travel down the valve stem and piston rod into the crankcase where it mixes with the lubricating oil, forming an emulsion. This emulsion is not a proper lubricant.

As generators must operate at a constant speed no matter what the load, a speed governor, usually of the wheel or shaft type, is provided on the engine. This type governor regulates the length of the valve travel thereby controlling the amount of steam entering the cylinder.

In the picture may also be seen the steam and exhaust valves, the larger valve wheel being the steam. Cylinder relief valves are also visible. The engine balance wheels are covered with a guard to prevent injury to crew members in event of being thrown against them.

The generator commutator must be kept dry and clean. Lubricating oil should never be used on it. To clean the commutator the generator is revolved slowly with the brushes removed, holding a clean dry rag or very fine grade of sandpaper on it.

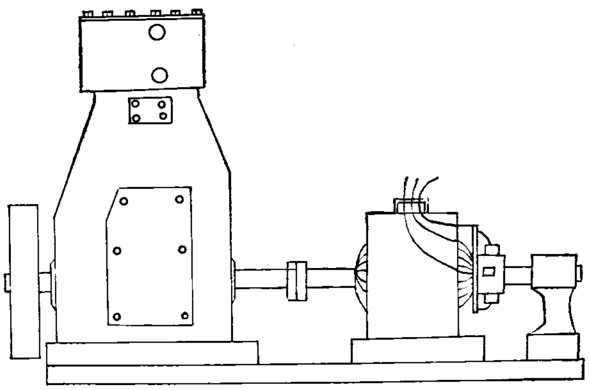
When checking a generator, as when checking any other auxiliary machinery, any unusual noise or sound should be noted and reported at once to the engineer.

to a main switch on the switchboard, from which electrical circuits lead to the lights and motors on the ship.

A complete circuit is necessary for electrical current to flow. Therefore when no electricity is being used, there is no flow of electrical current. When lights are on or motors started, the circuit is completed and electricity flows through the circuit.

As a flow of electricity is necessary for an electro-magnet to work, and as field poles are electro-magnets, electricity from the armature is led to the field coils. This creates magnetic lines of force between two poles.

When starting up a generator, the necessary magnetism is provided by that held by the iron cores of the field poles. This magnetism is known as residual magnetism.



ENGINE GENERATOR.

From the main switch, the lines carry the electricity to a circuit breaker. The circuit breaker is a device which automatically opens the whole circuit in case of an overload. Thus the circuit breaker is a protective device for preventing the overloading of the generator. An overloaded generator will heat up, causing burned insulation and short circuits.

Lines from the circuit breaker connect to switches that control the individual lighting and power circuits of the ship. These lines are heavy copper bars and are known as busses or bus bars. The individual circuit switches are equipped with fuses, which melt if too much load is applied to that circuit. Thus the fuses are a protective device for preventing too high a load on any one circuit.

If the circuit breaker opens, some of the load (lights and motors) must be reduced, and the circuit breaker may then be closed by moving the handle back to closed position. If a fuse melts, or blows out, as it is called, a new fuse is placed in position after some lights or motors are shut off. In some types of fuses the fuse may be taken apart and a new fuse link put in place of the melted one.

The switchboard also has a voltmeter and an ammeter installed on it. The voltmeter is to show the voltage of electricity generated. In marine practice this is kept at around 120 volts. The voltage is controlled by the number of magnetic lines of force cut by the armature windings. This in turn depends upon the speed of the armature, and the current flowing through the field coils. As the speed of the armature is kept constant by the governor of the engine or turbine, the voltage must be controlled by the amount of current flowing in the field coils.

In practice the voltage is controlled by a rheostat located on the switchboard. The control wheel is turned one way to increase the voltage and the other way to decrease the voltage. The rheostat controls the amount of current flowing through the field coils, thus controlling the voltage.

The ammeter shows the amount of current that is being used by the lights and motors of the ship. The current is measured in amperes, the amount depending upon the size and number of lights and motors in use.

PROPER METHOD OF CHANGING OVER GENERATORS

Generators are ordinarily started and stopped by the engineer but it is well for the oiler and watertender to understand the procedure. They may be called upon to assist at any time.

When a ship has two generators, one is in service while the other stands by. At regular intervals, probably once a week, the stand-by is started up and the in-service one shut down for a week. This is known as changing over the generators.

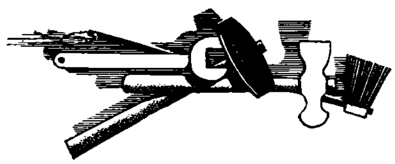
To start a generator the following procedure should be followed:

1. Make sure circuit breaker and main switch on the switchboard are in the open position.
2. Make sure generator is clear by revolving it one revolution by hand.
3. Check commutator to make sure brushes are in place.
4. Check lubricating oil level in engine.
5. Open cylinder and steam chest drains.
6. Open exhaust valve.
7. Crack steam valve, allowing engine to run slowly until warmed up.

8. Check lubrication.
9. When engine is warmed sufficiently, bring up to full speed.
10. Close drains.
11. Adjust rheostat to bring voltage up to a few volts above the bus voltage.
12. Throw in circuit breaker.
13. Throw in main switch.

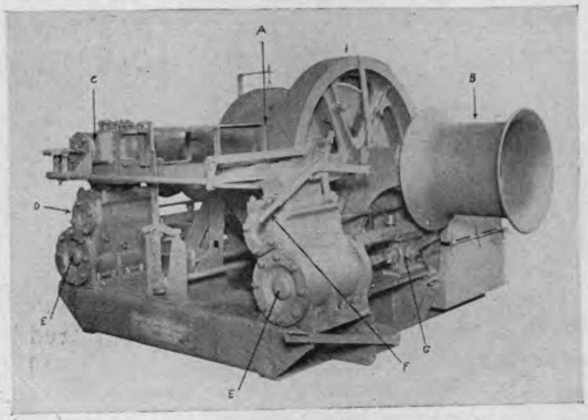
The following procedure should be followed when shutting down a generator:

1. Take most of the load off the machine.
2. Trip the circuit breaker.
3. Pull out the main switch.
4. Close steam valve to engine.
5. When machine stops close exhaust.
6. Open drains.



DECK MACHINERY

To lift cargo aboard and ashore, pull in the mooring lines and raise the ship's anchors, machinery is required. As it is usually located on the open deck, it is known as deck machinery. These include cargo winches, capstans and anchor windlass, which may be driven by steam engines or electric motors.



STEAM CARGO WINCH

A–DRUM
B–NIGGER HEAD
C–DIFFERENTIAL VALVE
D–STEAM CHEST
E–CYLINDER
F–DIFFERENTIAL VALVE CONTROL LEVER
G–CROSSHEAD

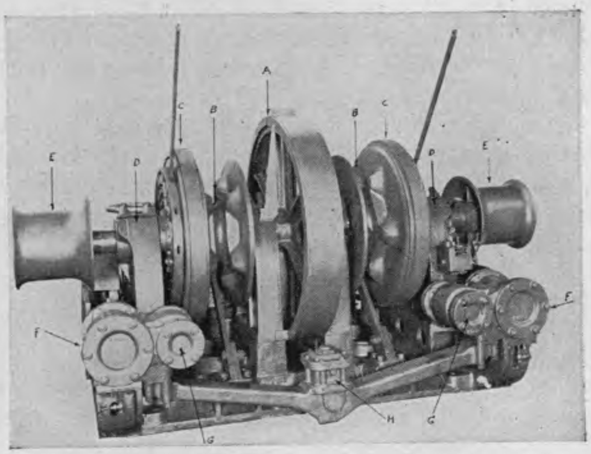
CARGO WINCH

Steam winches consist of two steam engines connected to the same crankshaft. The two cranks are at 90 degrees so that the winch will always start no matter what position it is. The crankshaft is connected to a drum by means of reduction gearing. Wire is wound on the drum, which turns at a much slower speed than the crankshaft. The other end of the wire is carried up a cargo boom and is used to transfer cargo from the hold to the dock or vice-versa. A brake is usually fitted to the drum of the winch, controlled by a foot lever so that the winch may be held with a load on it when the steam is shut off. Steam to cargo winches is controlled by an operating lever which moves a differential valve, working in the same manner as described on reversing engines. The winch is thus reversible, the differential valve controlling the speed and direction of rotation of the drum.

A warping winch is supplied on the after deck for handling mooring lines. The winch is built on the same plan as the cargo winches but two nigger heads or gypsies are secured on the same shaft as the drum and geared down from the speed of the crankshaft. The cargo winches usually have one gypsy on the outboard side. The nigger heads are used to wind the mooring lines around so that as the heads are rotated the lines are drawn in.

The warping winch is usually made reversible, operated by a lever and differential valve. In some types a double reduction of speed is accomplished by another set of gears which may be brought into use by moving a lever. This reduces the speed of the nigger heads.

Electric winches are driven by an electric motor. The speed of the motor is reduced by gearing and the drum turns at a slower speed. The speed of the motor is controlled by a resistance box and handle.

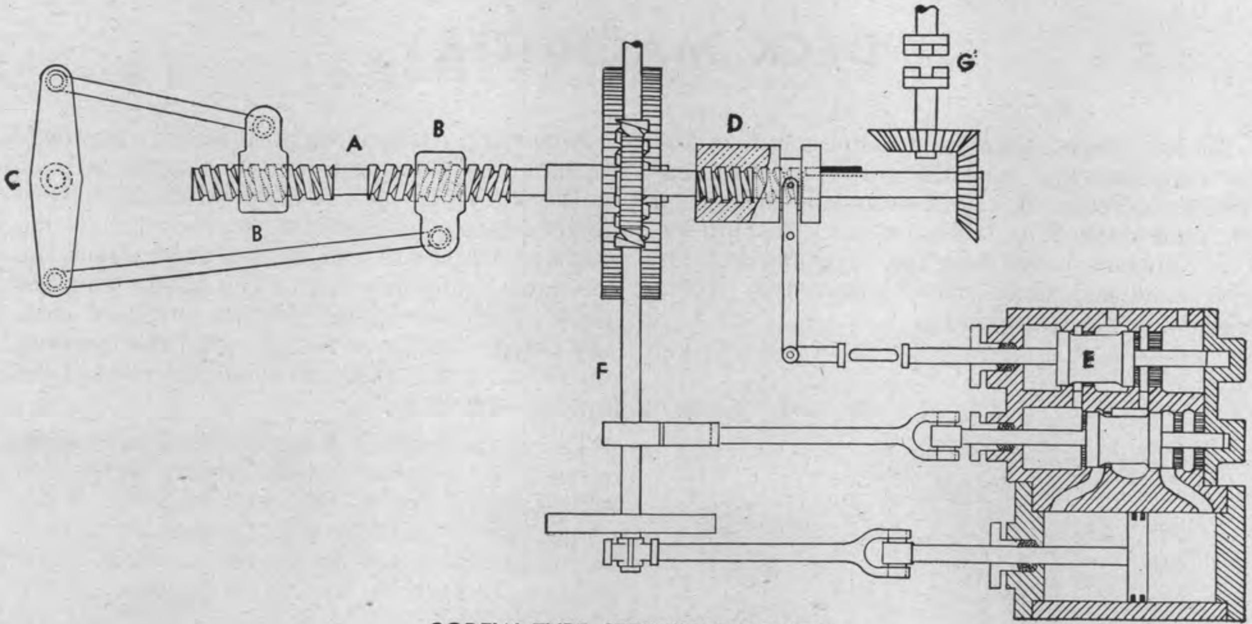


ANCHOR WINDLASS

A–SPEED REDUCING GEAR
B–WILDCAT
C–BRAKE
D–BEARINGS
E–NIGGER HEAD
F–CYLINDER
G–STEAM CHEST
H–DIFFERENTIAL VALVE

ANCHOR WINDLASS

On the forecastle head an anchor windlass is situated for the purpose of hoisting anchors and handling mooring lines. The anchor windlass consists of two reciprocating engines connected



SCREW TYPE STEERING ENGINE

to the same crankshaft, as in cargo winches. The rotation of the crankshaft is communicated by gears to two wildcats into which the anchor chain fits. The dogs on the wildcats keep the chain from slipping. Each wildcat is held on its shaft by a clutch which may be slacked off entirely or tightened up so that either or both chains and anchors may be hoisted.

The wildcats are run much slower than the crankshaft due to the number of speed reducing gears used between the crankshaft and the wildcat shaft. Each wildcat is supplied with a brake, actuated by a hand wheel, so that when it is not secured to the shaft, the brake may be used to prevent its turning.

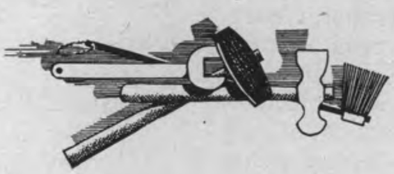
Nigger heads are secured to the ends of a higher speed shaft, thus turning faster than the wildcats. The nigger heads run whenever the windlass is turned over. They are used for handling mooring lines.

The windlass is the most powerful of the deck machines because not only may it be required to lift both anchors at the same time, but when the vessel is riding at anchor there are times when the full strain of the anchors and chains pull directly on the windlass. Being in the extreme bow of the vessel, it sometimes takes the brunt of the seas coming over in rough weather.

LUBRICATION

The various bearings of the winch and windlass steam engines are oiled by hand, the oil being squirted into brass oil cups filled with horse hair. The piston rods and valve stems have to be swabbed the same as any steam engine.

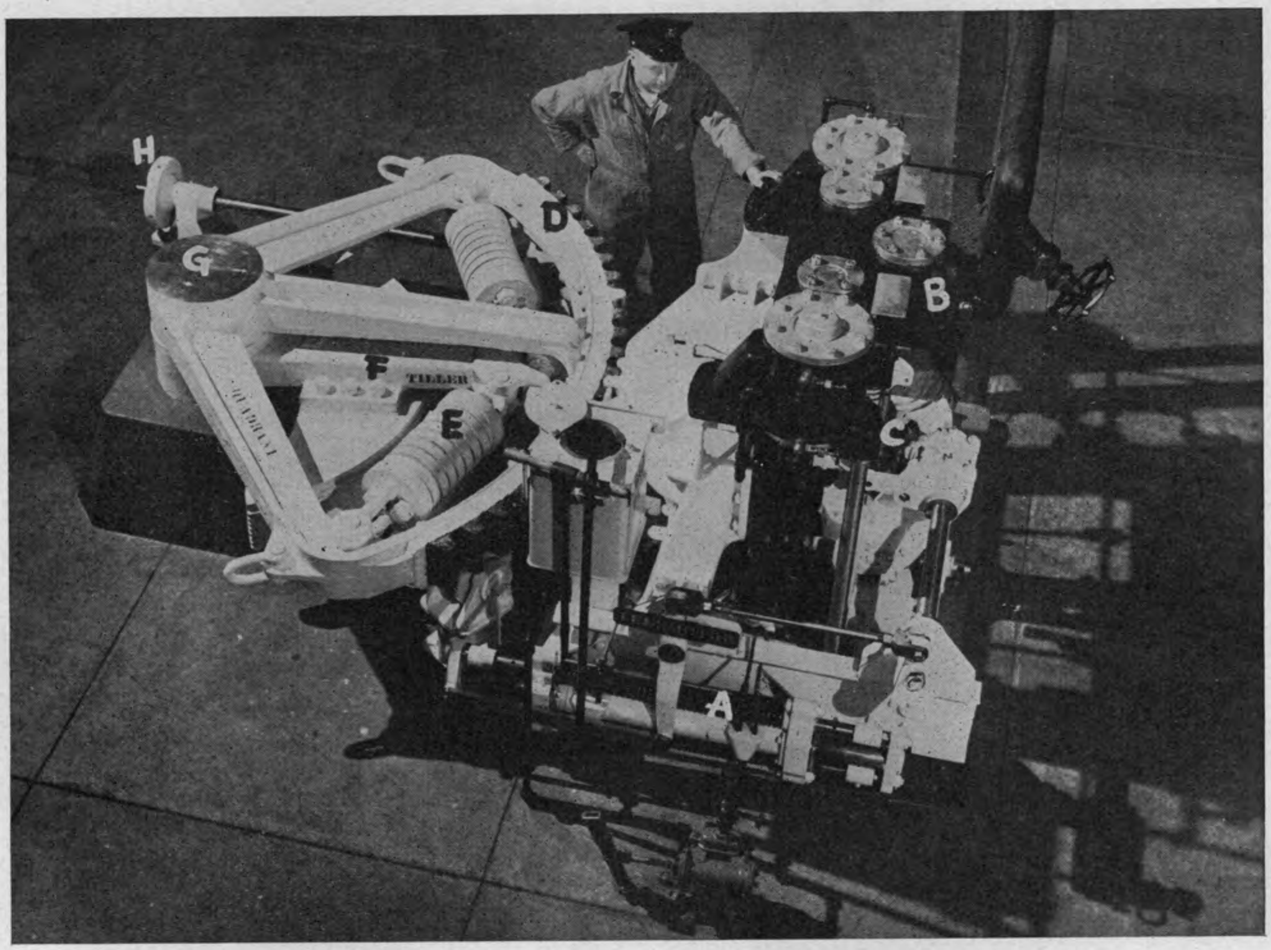
The winch and windlass bearings are generally lubricated by grease from grease cups on each bearing.



STEERING ENGINES

All vessels need a form of control with which to steer the ship. This consists of a rudder at the stern of the vessel, the rudder being moved by some mechanical device.

At present the two devices generally used are the steam engine, and the hydraulic ram. The steam engine usually consists of two cylinders with cranks 90 degrees apart, so that the engine will start from any position when steam is admitted to the cylinders. The steam to the valve chests is controlled by a differential valve, as explained under reversing engines, to allow the steering engine to run in either direction. The crankshaft of the engine is attached by gears, quadrants or screws to the rudder post so that when the engine turns, the rudder is moved to turn the heading of the ship to port or starboard.



QUADRANT TYPE STEERING ENGINE

A–TELEMOTOR
B–DIFFERENTIAL VALVE
C–FOLLOW-UP GEAR
D–QUADRANT
E–SPRING
F–TILLER ARM
G–RUDDER POST
H–HAND BRAKE

In this illustration pinion and quadrant gears are painted to afford photographic contrast.

The differential valve is controlled from the bridge of the ship by the steering wheel. This is usually done in one of two ways; by gears and shafting reaching from the bridge to the steering engine or by telemotor.

A sketch of a screw-type steering engine is given on page 104.

SCREW-TYPE STEERING ENGINE

The steam is admitted to the cylinder through the differential valve (E) which is controlled by steering wheel shaft (G). As the crankshaft (F) revolves, the worm also revolves, turning the large worm gear on the right- and left-hand screw shaft (A). The traveling nuts (B) move together or apart, depending on which way the engine is turning, and through connecting rods turn the rudder post (C).

In order for the steering engine to stop and hold the rudder when the steering wheel is stopped, the follow-up gear (D) is provided. This pushes the differential valve to the closed position, stopping the engine as soon as the man at the steering wheel stops turning it.

QUADRANT TYPE STEERING ENGINE

A very popular type on medium sized cargo vessels, consisting of a vertical two-cylinder steam engine with cranks set at 90° apart to permit starting of the engine at any point. A worm on the crankshaft meshes with a worm wheel upon a vertical shaft, upon which is a gear that meshes with the quadrant. The quadrant is connected through coil springs to the tiller arm. The springs take up some of the shock of the seas pounding against the rudder. As the engine operates in one direction or the other, the quadrant swings in an arc turning the rudder post and rudder.

The engine bearings are hand-oiled, having wick-feed gravity boxes.

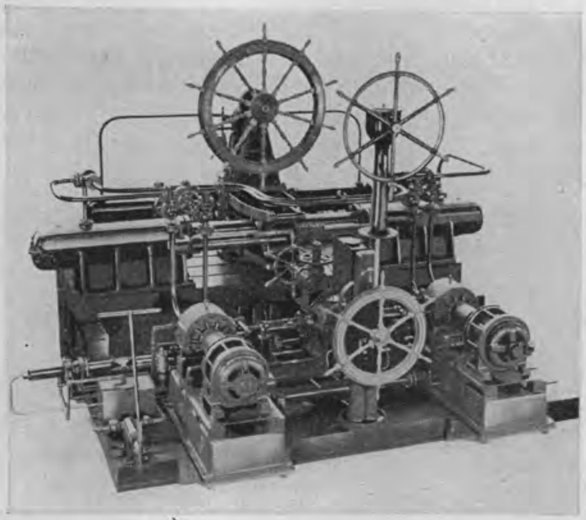
The engine has a differential valve and follow-up gear the same as the screw type.

To lock the rudder in the event of one or more of the gears carrying away, a hand brake with control wheel is provided.

Steam steering engines usually exhaust direct to the main condenser instead of into the auxiliary exhaust line. In this manner there is no fluctuating back pressure for the engine to work against.

ELECTRO-HYDRAULIC TYPE STEERING ENGINE

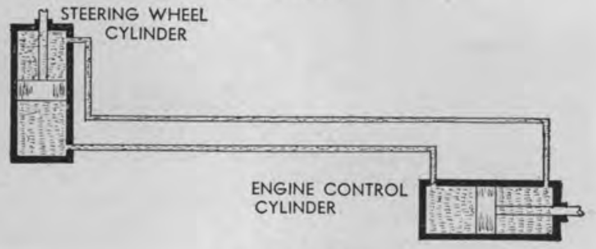
In fast, modern ships this type is predominant. A typical installation is shown in the illustration. It consists of an electric motor driven reversible pump which forces light oil into either end of a hydraulic ram. As the ram moves, it swings the tiller arm and rudder. By reversing the direction of the pump, the movement of the ram is reversed and so the rudder.



ELECTRO-HYDRAULIC STEERING GEAR

TELEMOTOR

The sketch shows the principle of the hydraulic telemotor. It consists of two cylinders connected by pipes. Each cylinder contains a close-fitting piston. The cylinders and piping are filled with a mixture of glycerine and water, or with a light oil. When one piston is moved it moves the other piston through the medium of the oil or glycerine mixture.



TELEMOTOR

One piston is attached to the steering wheel on the bridge, the other being attached to the differential valve by links, and lever arrangement. Thus, as the wheel on the bridge is turned, the piston in the steering engine room moves the differential valve, admitting steam to the engine.

PIPING SYSTEMS

The various pipe lines are the blood vessels of the power plant, for through them flow the vapors and liquids that are the life blood of the ship.

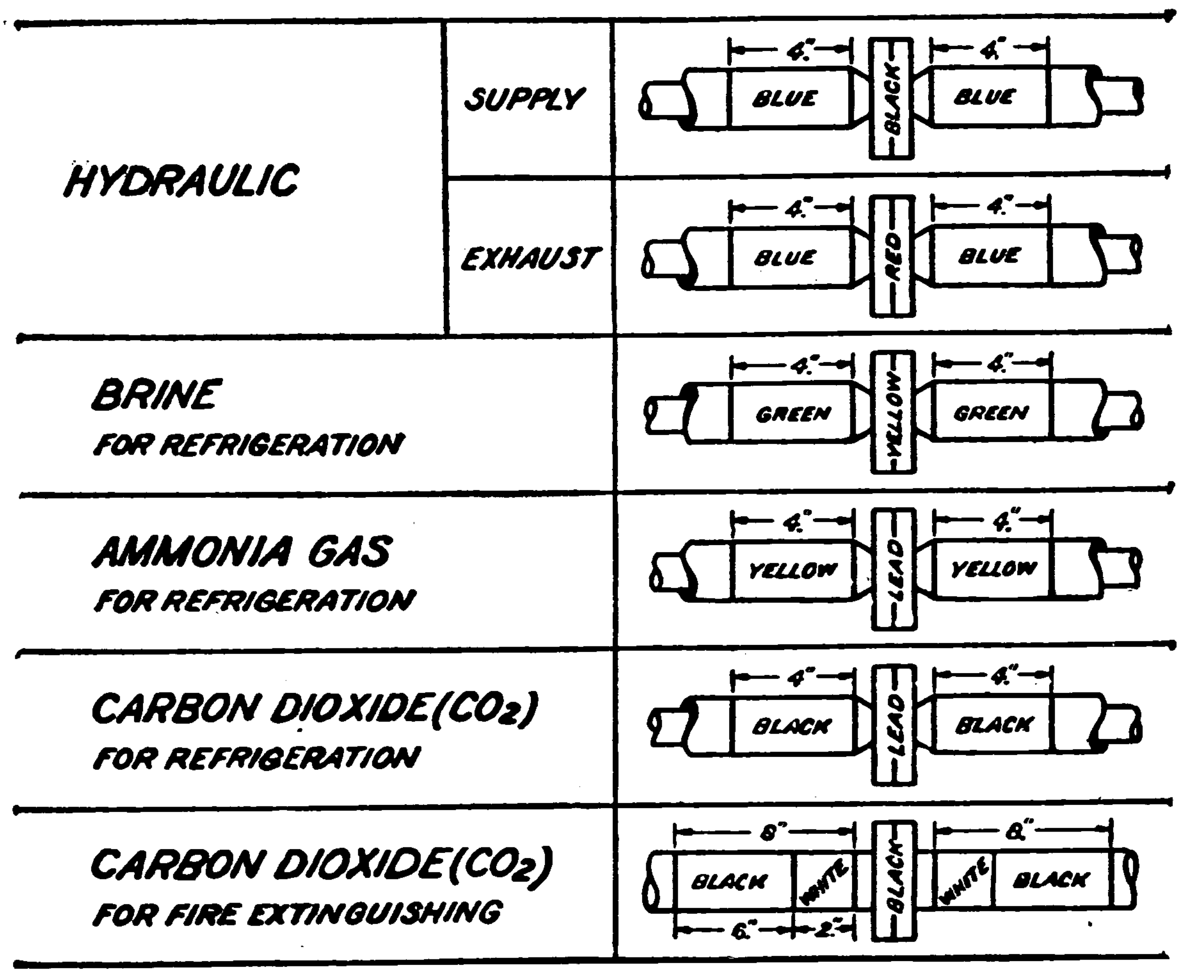
MATERIALS

Main Steam Line–The main steam line that conveys the steam from the boilers to the main engine is made of copper or steel, depending on the pressure and temperature to be carried. The piping is made up in sections for convenient handling, being joined usually by bolted flanges, although with modern methods a certain proportion of the joints are fusion welded.

Auxiliary Steam and Exhaust Lines are also made of copper or steel and joined together in the same manner, excepting some of the smaller sized piping, which may be joined by threaded connections.

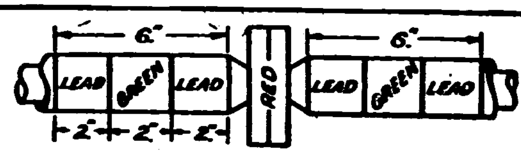
Allowances for expansion and contraction of the piping due to temperature changes must be made, either by a slip joint or an expansion loop. Piping must also be supported by hangers at sufficient points to prevent strain on the piping.

Around the outside of all steam piping is placed asbestos insulation, usually covered with sewed canvas, to hold the heat inside the pipe line.

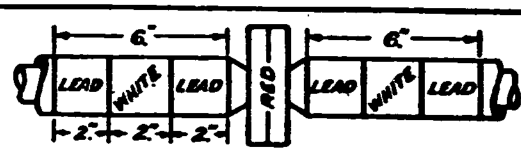


PIPE LINE IDENTIFICATION MARKINGS

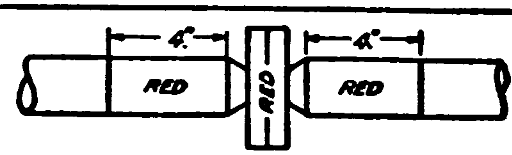
HOT WATER



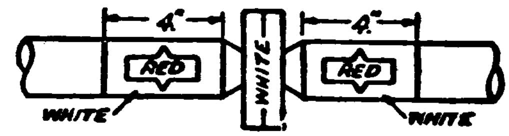
REFRIGERATED WATER



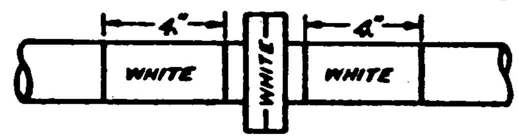
FIRE MAIN



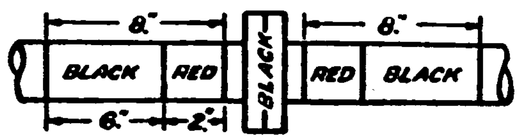
FLOODING
FOR TANKS AND COMPARTMENTS



MAIN & AUXILIARY DRAINS, SCUPPERS, FLOOR & OTHER DRAINS, AIR ESCAPES & SOUNDING TUBES

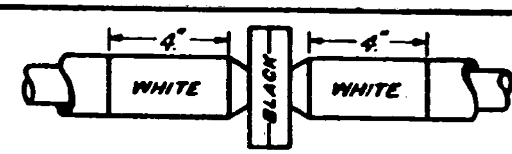


AIR WATER EJECTION

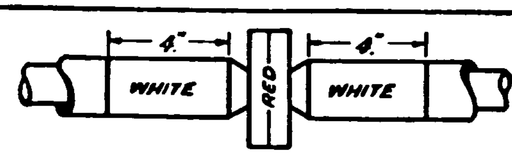


STEAM

SUPPLY

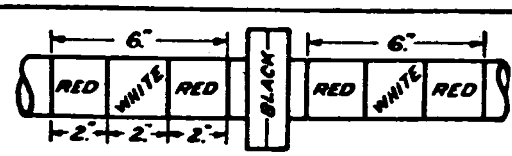


EXHAUST

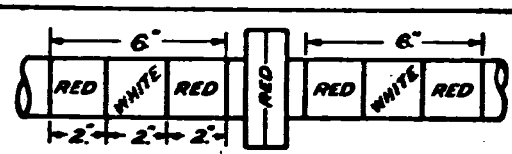


FUEL OIL

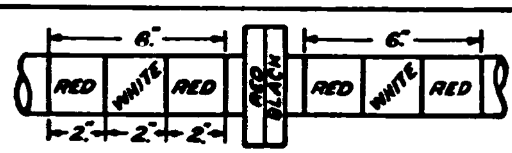
SUCTION

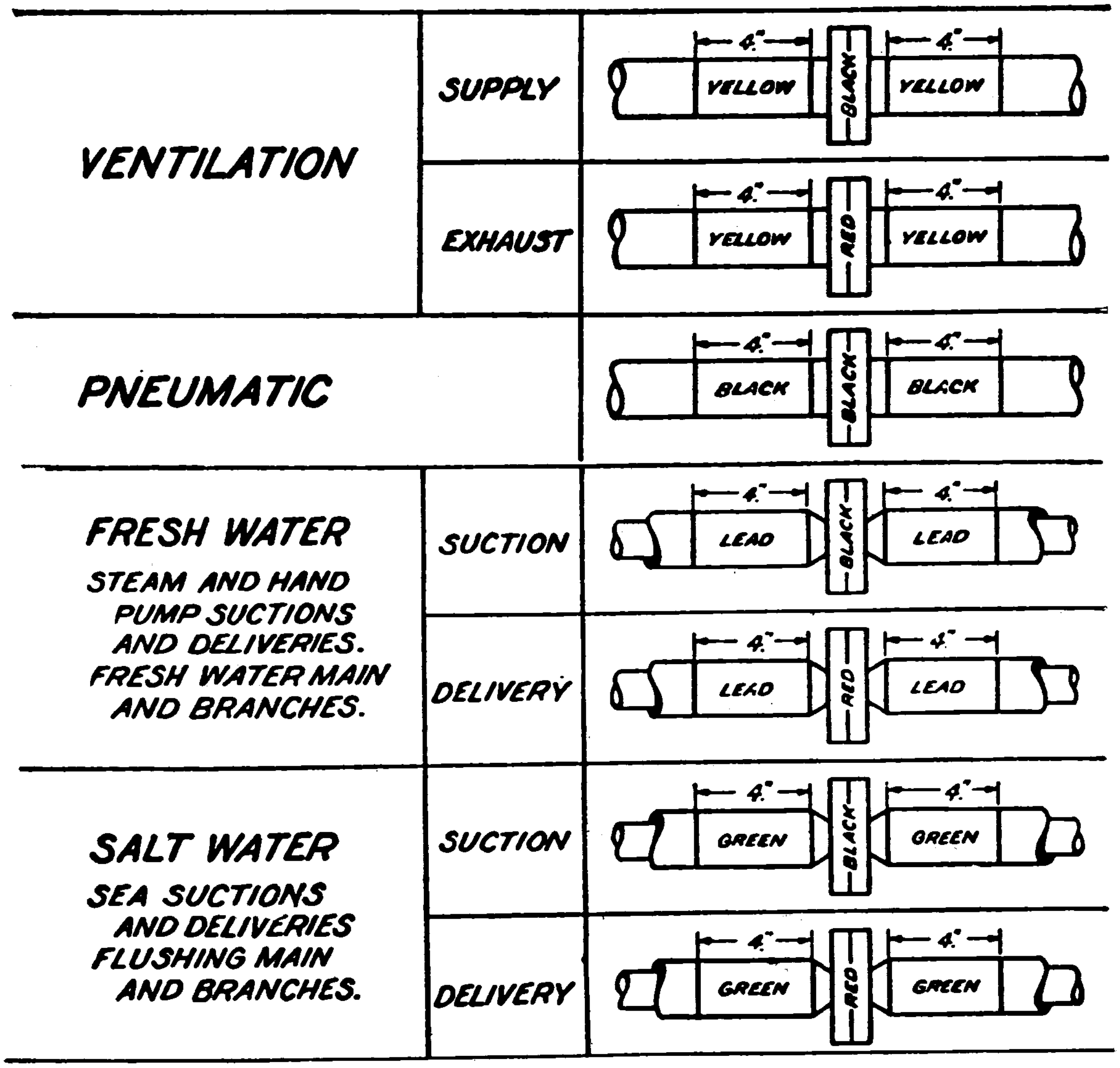


DELIVERY



COMMON SUCTION AND DELIVERY





Fresh Water Piping–Piping carrying fresh water should preferably be made of copper or brass to resist corrosion, although galvanized steel pipe is sometimes used.

Salt Water Service–For salt water service brass or copper piping should always be used, as corrosion is severe on steel piping.

Cold water pipes are usually covered with from ½ inch to 1 inch of cattle hair felt to prevent condensation forming on the outside of the pipe.

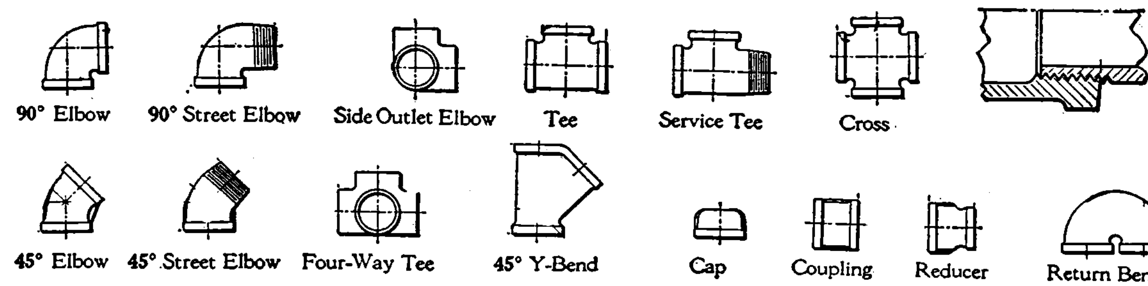
Fuel Oil and Refrigeration–For fuel oil and refrigeration, steel pipe is used.

IDENTIFICATION MARKINGS

In order that the various pipe lines carrying different substances may be readily identified throughout the ship, a system of markings is used at intervals along the pipe lines. Some shipping companies use their own systems. The standard marking system used on most ships today is listed.

PIPE FITTINGS

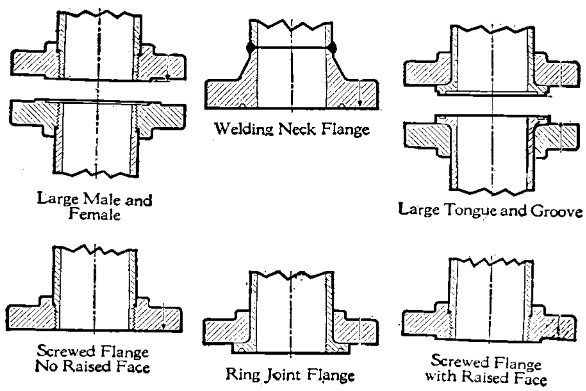
Pipe is made in three wall thicknesses—standard, extra heavy, and double extra heavy. When a pipe line is installed, the straight sections of pipe must be joined together. One method is with threaded fittings of which several types are shown. The type to use depends on the combination of piping and angles to be joined. The material of the fittings should in most cases be the same as the pipe.



STANDARD PIPE FITTINGS

Another method of connecting sections of pipe is with flanged joints, several different types of which are shown.

A gasket is placed between the faces of the flanges, after which the flanges are pulled tightly together with bolts.



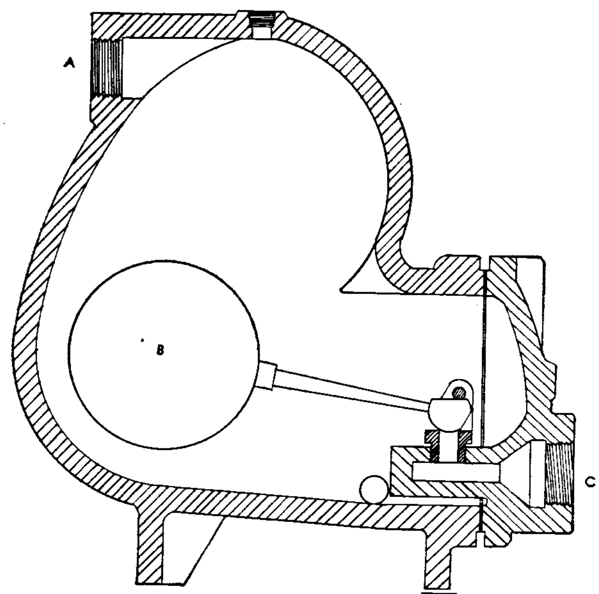
PIPE FLANGES

STEAM TRAP

When steam travels through pipe lines for any distance, condensation will occur. When steam is admitted to a cold line, condensation is great. To automatically remove the condensate, steam traps are used.

There are several types of traps, the cross-section sketch being a trap of the float type. From a low point in the steam line a small pipe line connects to the inlet opening (A) of the trap. The condensate and steam under pressure enter the chamber. As the condensate gradually fills the chamber, the copper float (B) rises and through the float lever opens the valve. The pressure forces the condensate through the valve opening and out the discharge (C) to the hotwell. As the condensate leaves, the float drops, closing the valve before the condensate level drops below it, preventing the steam from leaving.

Steam traps are also used in the drains from feedwater heaters, fuel oil heaters and in connection with any apparatus where it is desired to automatically remove condensate without wasting steam.

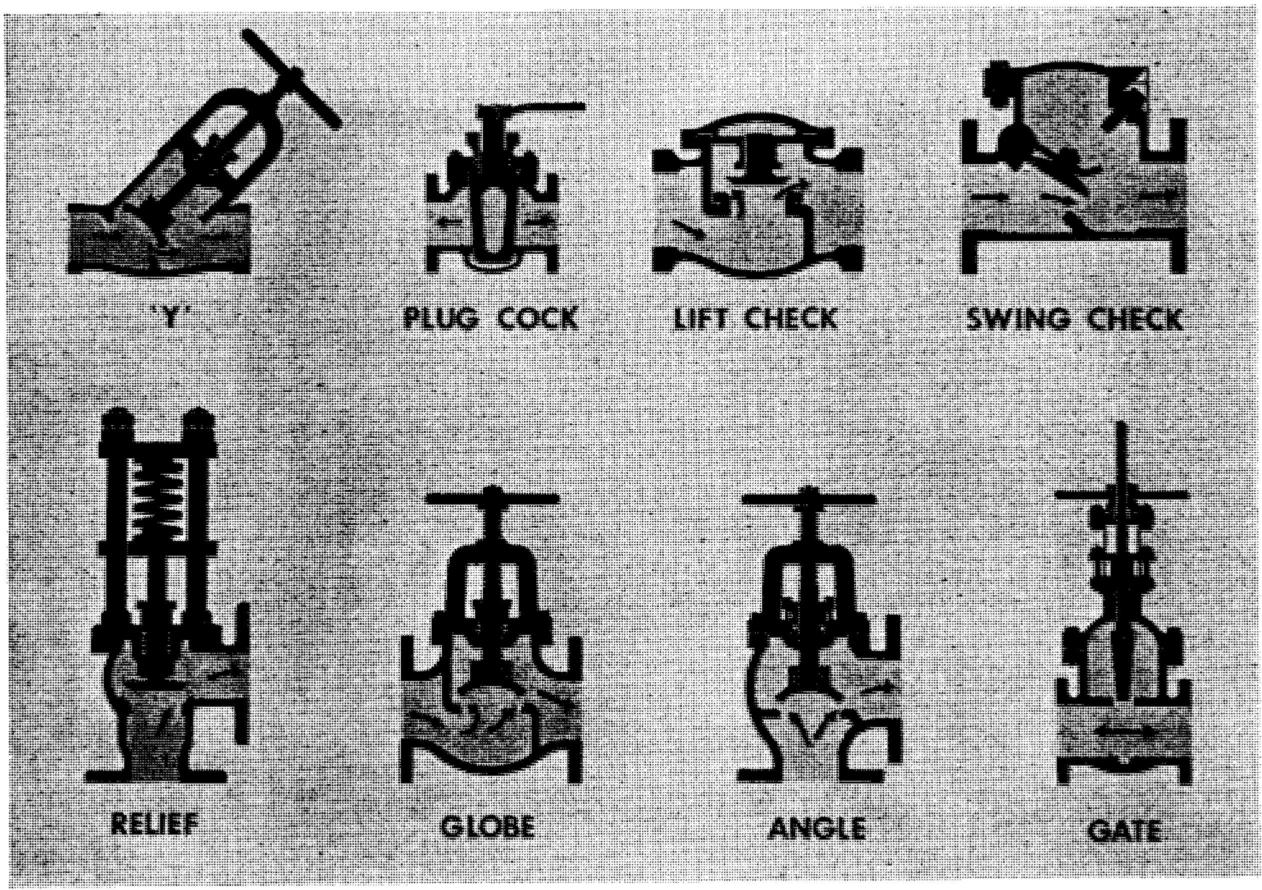


STEAM TRAP

VALVES

Valves are used to control the flow of fluids. There are many types of valves, but they are usually one of the following: globe, angle, gate, check, or cock. The working pressure and the kind of service determines the material, weight, size, and design of the valve to be used.

The **globe valve** is used to control passage of steam, water, etc. It is made up of a body, bonnet, seat and valve disc, stem, stuffing box and hand wheel. The seat may be either flat or beveled; if beveled, usually to 45°. The valve disc is fastened to the stem, which is threaded and turns in similar threads in the bonnet. The body of the valve is usually of cast steel or



U. S. Maritime Service Training Aids Unit Chart

TYPES OF VALVES

The arrows indicate the direction of flow in the more common types of valves used in ship's piping. The check valves and relief valve shown are classified as automatic valves. The globe, angle and "Y" type valves are used where it is desirable to adjust the rate of flow. The gate valve should be either completely open or completely closed, otherwise chattering will result in excessive wear. The gate valve is used where a minimum amount of turbulence is desired since it offers very little resistance to flow. The gate valve shown has a rising stem which indicates at a glance whether the valve is open or closed.

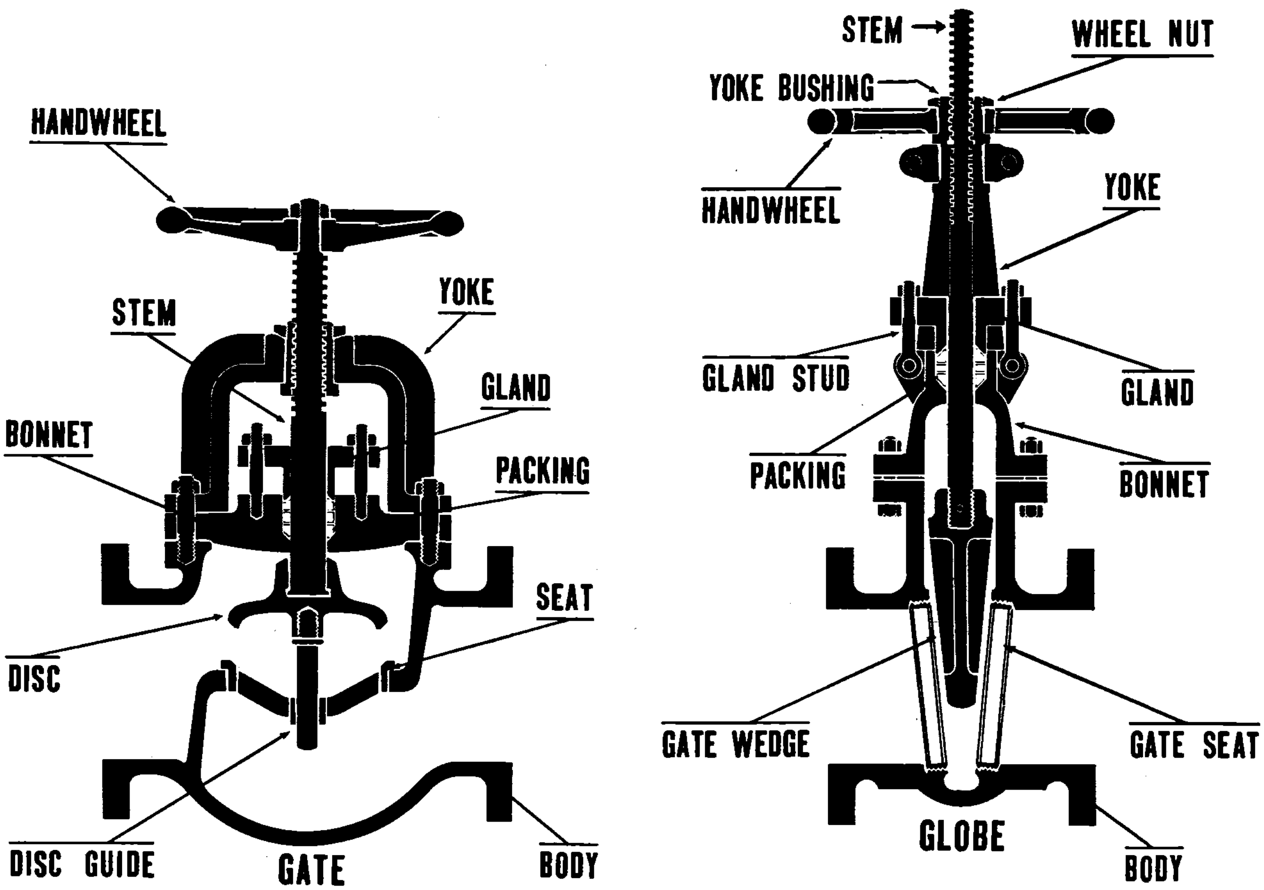
brass. The valve and seat are usually of composition, and if the valve is very large it has a renewable seat, usually screwed into the body casting. On most valves, two inches and over, the threaded part of the bonnet through which the stem passes will be outside or in the form of a yoke. This keeps the threads away from the action of the steam. The yoke is part of the bonnet, the stuffing box being beneath the yoke.

The **angle valve** uses the same type of seat and valve disc as the globe valve, the difference being that it is used to connect pipes that meet at a right angle. The construction and materials used in the angle valve are the same as those in the globe valve, the only difference being the design. One advantage of the angle valve over the globe is that it offers less resistance to flow.

Check valves are valves that permit fluids to pass through them in one direction only, and are designed to close automatically whenever the flow of the fluid is reversed. They are made in different forms, as, vertical, horizontal and angle check valves. They are also made in swing check valves, where the valve disc is hinged and closes the seat while still at a slight angle, and globe check valves, where a globe type valve disc is provided with guides above and below the seat to keep the disc from tilting sidewise.

Adjustable check valves are of the same type generally as the globe check valve, but the amount that the valve can lift is governed by a stem and hand wheel. These are used frequently as the feed check valve on boilers.

A **cock** is a valve which is capable of being



U. S. Maritime Service Training Aids Unit Chart

VALVE PARTS

quickly opened or closed. Probably the most familiar type is the pet-cock.

Blowoff valves on boilers are usually of the straightway type such as gate or "Y" valves, or of special design. Angle valves are also used for this purpose. These types of valves do not trap sediment.

Gate valves are made either as single gate valves which receive pressure on one side only, or as double gate valves, which may receive pressure on either side. Some forms of double gate valves close off the fluid passage with a solid wedge, others with a box wedge, and others with sectional gates having either parallel or wedge-shaped seats.

Gate valves are advantageous where little resistance to the flow of the liquid is desired, as they leave an unobstructed passage when fully open. Therefore, they are largely used on water and exhaust steam connections. When throttled, that is, when only partly open, they are hard to regulate and often chatter. In all gate valves, the discs rise into the upper part of the bonnet and leave a straight passage for the flow.

One type of gate valve has the gate threaded, and the gate screws up the stem, the hand wheel remaining at the same distance from the bonnet whether the valve is open or closed. On larger gate valves a yoke is used, the stem being threaded and fitted to threads on the hand wheel. When open, the stem extends through the wheel. This type is advantageous as the threads may be properly lubricated and also do not come in contact with the steam. Gate valves should be installed in a vertical position with the hand wheel on top, if possible.

REFRIGERATION

On American ships fresh meat, vegetables and fruits are an everyday fare for the crew even though the ship be traveling a long distance in warm climate. This is made possible by mechanical refrigeration which keeps the meat frozen in the meat box until just before it is to be cooked. The fruits and vegetables are kept in a separate box where the temperature is kept above freezing but cold enough to preserve them until used.

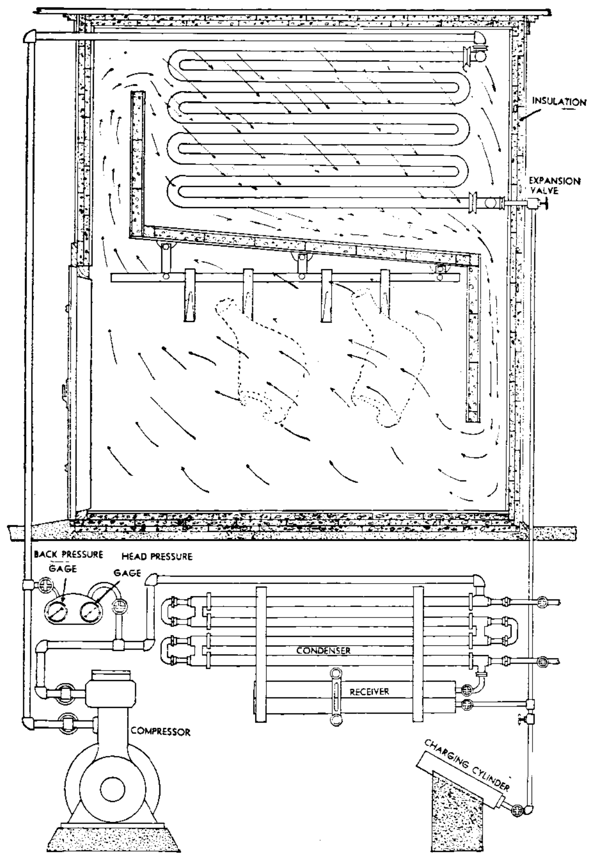
Mechanical refrigeration depends upon heat for operation. A typical modern refrigeration system is shown in the sketch.

In the upper part of the meat box is a steel pipe coil into which liquid, either ammonia, freon, or CO_2 is allowed to expand into a gas. When this occurs, heat from the surrounding air in the box is absorbed by the gas in the coil. The heat travels with the gas through the pipe line out of the box to the suction side of the compressor. This leaves the box cold. The arrows in the box indicate how the cold air around the coil settles down to the bottom of the box and the warmer air around the meat rises up to be cooled.

This particular system is for freon so that type will be discussed. Upon returning to the compressor, the freon gas is compressed by a piston in a cylinder which is driven by either a steam engine or electric motor. From here the compressed gas travels to the condenser, where the heat is taken out of the gas by sea water on the same principle as a steam condenser. With the heat removed, the gas returns to a liquid in which form it drops down to the receiver, which is a tank for storage. The liquid freon passes from the receiver up the pipe line to the expansion valve, through which it passes to become once again a gas in the box coil. By regulating the expansion valve, the amount of freon entering the coil is determined, which in turn regulates the temperature of the meat box.

The side walls, roof and floor of the box are insulated to keep the outside heat out and the inside cold in.

Two pressure gages are provided just above the compressor. One shows the pressure of the freon gas returning to the compressor usually around 5 to 10 pounds. The other shows the discharge pressure of the gas leaving the compressor usually around 90 pounds. These pressures vary according to the temperature of the cooling water flowing through the condenser. The hotter the cooling water, the higher the discharge pressure and vice-versa.

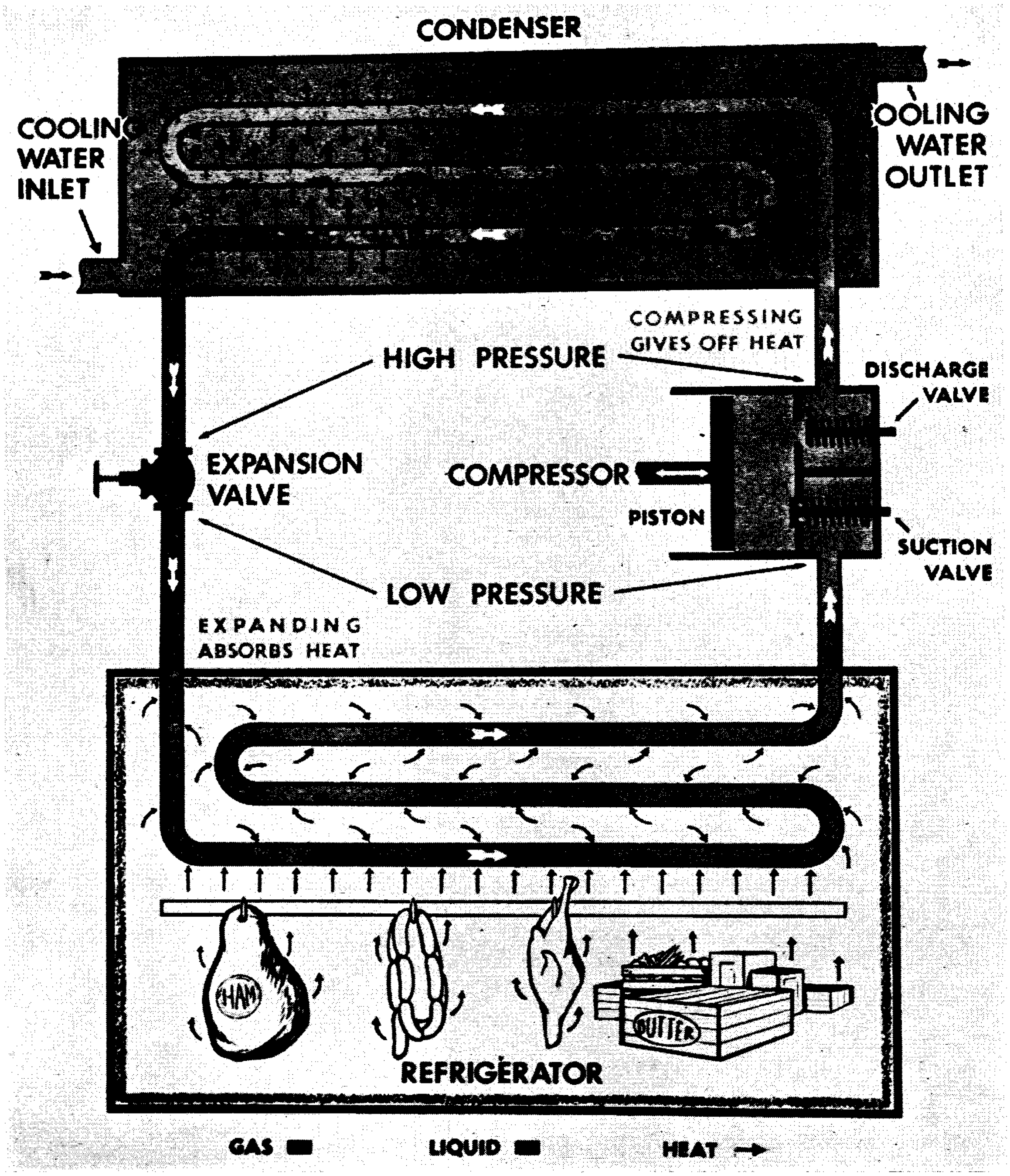


FREON REFRIGERATION SYSTEM

When more freon is needed in the system it is put in from the charging cylinder shown.

Previously, ammonia was widely used as the liquid for refrigeration aboard ship, but today practically all new ships are equipped with freon systems. Freon is an odorless, harmless substance, except to the eyes upon close contact. Ammonia is highly injurious to humans, if trapped in a confined space.

When checking the refrigerating system the oiler should note the suction and discharge pres-



U. S. Maritime Service Training Aids Unit Chart

MECHANICAL REFRIGERATION

sures. An excessively high discharge pressure is a good indication that the cooling water to the condenser has stopped flowing. This can be serious if the pressure should continue to build up until an explosion results. Relief valves are installed as a safeguard against excess pressure, but should not be depended upon. The oiler should definitely determine that the cooling water is flowing properly at each visit.

The oiler should check the lubrication of the compressor, and listen for any unusual sounds. Notify the engineer of anything unusual.

SAFETY PRECAUTIONS

Working around marine power plants, members of the crew must observe a few safety precautions if they are to escape injury.

The following rules should be thoroughly memorized and lived up to at all times:

Keep a close watch on the water level in the boilers.

Always use a torch when lighting an oil burner.

When blowing down the gage glass, look away from the glass until gage glass drain valve is closed. The glass may break and pieces fly in your eyes.

In passing up and down ladders and along gratings, keep one hand on guard rail at all times. Do not try to carry an object requiring both hands. Remember the ship may roll or pitch unexpectedly, causing you to fall to the deck or into the moving engine. The old saying, "one hand for the ship and one for yourself," is a good one.

Always use safety goggles to protect the eyes when working around flying particles, such as chipping paint or using an emery wheel. Remember you can't see with a glass eye.

When working with tools do not lay them on the gratings. The ship may roll or someone walking along the grating may accidentally kick them off, injuring the man below by striking him on the head. Put tools away when leaving the job.

When oil is spilled, wipe it up immediately. There is nothing that can cause as quick a fall as to step on an oily steel deck plate.

Always keep your arms bare and fingers free of rings when around machinery.

Never enter any kind of an empty tank or boiler until all safety precautions have been taken.

Do not smoke in unauthorized places.

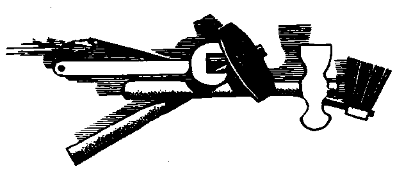
Do not fool or tamper with the machinery.

Notify the engineer of any unusual occurrence, or of anything of which you are in doubt.

Keep your mind on your job.

Know where the emergency escape ladders are. **Practice using these emergency ladders frequently.**

REMEMBER–CONSTANT VIGILANCE IS THE PRICE OF SAFETY.



GLOSSARY OF ENGINE ROOM TERMS

Air Cock. A valve placed on the highest point of a boiler. Opened to allow air to escape from boiler when filling or getting up steam. Also opened to allow air to enter boiler when draining.

Air Compressor. A power-driven pump by which air is placed under pressure and usually delivered to a storage tank.

Air Ejector. The unit by which air and uncondensed gases are removed from the condenser, leaving a vacuum. Generally operated by a steam jet. Usually used with power plants having turbine-type engines.

Air Register. A part of an oil burner. By adjusting the air register the amount of air entering the furnace to mix with the oil is controlled.

Appurtenance. (Boiler)—Any equipment used with or attached to a boiler.

Auxiliary. (Auxiliary feed—auxiliary steam lines)—A duplicate, generally of smaller capacity, which can be used as a substitute or used to assist.

Atmosphere Valve. A valve by which the auxiliary exhaust steam can be released to the atmosphere instead of going to the condenser. Used in the event the condenser is inoperative such as when the ship is in drydock.

Alley Well (Tunnel Well). A deep recess at the after end of the shaft tunnel where water trickling through the stern tube collects to be pumped out by the bilge pump.

Back Pressure. The pressure of the auxiliary exhaust steam. Usually about 15 lbs. per square inch.

Auxiliary Steam Stop Valve. A stop valve placed directly on top of each boiler to cut off the flow of steam from that boiler through the auxiliary steam line.

Baffle, Gas Passage. A wall or partition of heat-resisting material between the boiler tubes to conduct the flow of gases along a definite path among the boiler tubes from the furnace to the stack.

Baffle, Water. A steel plate placed in the water and steam drum of boilers to direct and improve water circulation and prevent water splashing over into the dry pipe.

Ballast Pump. A large pump located in the engine room to transfer water ballast either from one tank to another tank, or from one tank overboard. Ballast tanks are usually filled by flooding from the sea.

Boiler. A pressure vessel used to convert water to steam by applying heat. General types: Firetube or Scotch boiler in which water surrounds tubes and firebox. Watertube in which water is carried in tubes which are surrounded by hot gases.

Blowdown. The difference, in lbs. per square inch, between the pressure at which a safety valve opens and the pressure at which the valve reseats, generally expressed as a percentage of the lifting pressure.

Blowdown Ring. A notched ring held in place by a setscrew which extends through the safety valve body. The amount of blowdown can be adjusted by this ring:

turn ring right—raises it and shortens blowdown.

turn ring left—lowers it and lengthens blowdown.

Blow Valves. Used to remove sludge, scum, and to reduce salinity.

Bottom blow—A valve used for blowing sludge, mud, scale etc. from the lowest portion of the boiler.

Surface blow—(Not required where pressure exceeds 350 lbs. per square inch.) Attached at normal water level of boiler to a pipe or pan which collects scum, grease etc. Used for blowing scum or grease from surface of water.

Blower. A power-driven fan by which air is supplied, under a slight pressure, to a furnace.

Bulkhead. A wall or partition on a ship; may or may not be watertight.

Bulkhead Deck. The deck which connects to any watertight bulkhead forming a watertight compartment.

Brickwork. The brick lining of a furnace made up of firebrick, refractory and insulating material forming walls which add to the efficiency of furnace operation.

Bulkhead Stop Valve. A valve located on the engine room side of the bulkhead separating engine and fireroom. Used to control flow of steam in main line.

Bilge. That portion of a ship's compartment between hull plates and floor plates or between tank tops and floor plates.

Bilge Pump. Any pump having the necessary connections to bilges and water bottoms (suction strainer, pipes, mudboxes, basket strainers, manifold etc.) may be attached directly to air pump beam of the main engine or may be an independently powered pump such as the sanitary, ballast, general service or fire pump.

Circulating Pump, Condenser. A pump of large capacity used for the purpose of pumping sea water through the tubes of the condenser, thus cooling the tubes so that the exhaust steam will be condensed. This sudden reduction of volume creates a vacuum which reduces back pressure.

Combustion Chamber. A large space provided in a boiler to allow room for complete combustion to take place. Generally found in Scotch boilers, as the furnace in a watertube boiler is usually large enough to allow for complete combustion.

Condensate. This is the name given to condensed exhaust steam; it is distilled water.

Condenser, Steam. A unit in which the exhaust steam from the power plant is condensed into water so as to perform two purposes: First, it reduces the back pressure on the machinery, and second, it makes possible the use of the water over again as feedwater.

Crown Sheet, Boiler. The top sheet of the combustion chamber. Usually found in marine installations using Scotch boilers.

Dampers, Uptake. A pivoted metal plate placed in the uptake or stack of a boiler for regulating draft or closing the stack or uptake. In boilers using oil for fuel, dampers are secured in the open position while the boilers are in use.

Desuperheaters, Steam. A unit by which the superheat is removed from the steam, generally consisting of a series of pipes submerged in the water in the boiler drum through which the superheated steam passes. Desuperheaters are used to protect superheaters by maintaining circulation. Also to supply steam to auxiliaries.

Draft, Stack. The flow of the hot gases from the boiler and the flow of air into the furnaces. **NATURAL DRAFT** is the natural flow of the cooler air into the furnaces without the aid of any mechanism; **FORCED DRAFT** is when the air is forced into the furnaces under a slight pressure; and **INDUCED DRAFT** is when the pressure in the stack is reduced to speed up the flow of air.

Dry Pipe. A perforated pipe running lengthwise in the top of the steam space of the boiler through which the steam must pass before leaving the boiler. The steam in passing through the small holes in the pipe loses most of its moisture particles which otherwise would be carried over from the boiler.

Economizer, Boiler. A feedwater heater located in the boiler uptakes which receives its heat from the waste gases from the boiler as they pass on their way to the stack.

Evaporators. Units in which sea water is evaporated so as to obtain distilled water or fresh water for boiler feeding, etc.

Feed and Filter Tank. Generally referred to as the Hotwell (see Hotwell). A tank into which the condensate pump discharges the condensate and in which the feedwater passes through filtering material to remove oil and grease. The filtering material generally is made up of loofa sponges.

Feedwater Heaters. A heater through which the feedwater passes between the feed pump and the boiler in which the feedwater is heated by the heat contained in the auxiliary exhaust steam. Some of the auxiliary exhaust steam instead of flowing to the condenser, is led to the heater. **BACK PRESSURE** is the pressure of this exhaust steam in the feedwater heater, and is the pressure against which the auxiliary machinery must operate. The **BACK PRESSURE VALVE** is a valve which admits the auxiliary exhaust steam to the condenser, and is the valve by which the **BACK PRESSURE** can be regulated.

Feed Pumps. Pumps which take suction from the feed and filter tank or the reserve feed tanks and discharge the feedwater into the boilers under pressure above boiler pressure. Generally a vertical, simplex, double-acting, reciprocating steam pump, although some vessels now use centrifugal pumps, or electric driven triplex pumps.

Feedwater, Boiler. Water which is used to make steam in the boilers. Between the feed tank and the boiler, the water is known as **FEEDWATER;** between the boiler and the machinery as **LIVE STEAM;** between the machinery and the condenser as **EXHAUST STEAM;** and between the condenser and the feed tank as **CONDENSATE.**

FEEDLINE CHECK VALVES. Valves placed in the feedwater line just before the boiler through which the water may pass in one direction only—toward the boiler. Any flow from the boiler causes the valve to close.

Feedline Stop Valve. A valve placed between the feed check valve and the boiler, attached directly to the boiler shell to cut off the flow of water in either direction. Both the feed stop and the feed check valves are required by law.

Fire Pump. A pump of large capacity for supplying sea water to the fire mains. Also has, as a rule, a bilge suction connection and a ballast suction connection.

Flareback, Furnace. A dangerous explosion in a boiler furnace due to the ignition of accumulated gases from the fuel. Caused by lighting fires without a torch, leaky burners, etc. Can cause extensive damage to the boiler and result in the death of the fireroom personnel.

Floor Plates. Steel plates which form the decking of the engine room and fireroom.

Foaming, Boiler. The creation of bubbles or froth on the surface of boiler water, caused generally by impurities in the boiler water. Causes water to be carried over from the boiler into the steam lines.

Fresh Water Pump. A pump by which fresh water is delivered from the tanks to wash bowls, showers, etc., for washing purposes.

Furnace, External. A place in which the fuel is burned to produce the heat necessary to evaporate water into steam in the boiler. External furnaces are outside of the boiler shell and generally form part of the boiler setting. Most watertube boilers have external furnaces.

Furnace, Internal. A space within the boiler shell in which the fuel is burned to produce the heat necessary to evaporate water into steam in the boiler.

Fusible Plug. A safety device used in a boiler to warn the operator of dangerously low water. The plug has a hole which tapers to a small diameter and the water side taper is filled with banca tin 99.3% pure. This tin melts before low water harms the boiler. There are two types—waterside and fireside and they are named because of the way they go in. Example: Waterside plug goes in from the waterside of crown sheet or tube.

Gag, Safety Valve. A horseshoe shaped **clamp** for locking a safety valve closed. Used during annual Hydrostatic test, often referred to as a clamp.

Generators, Electric. Machines which generate electricity for use on shipboard, driven by some type of power unit.

Governor, Speed Control.. A device by which the speed of a piece of machinery is regulated.

Handholes. Openings for cleaning boiler. When large enough to permit passage of a man are referred to as manholes. Special plates are used to seal these holes and great care must be used when closing and tightening.

Hotwell. The name sometimes given to the feed and filter tank. It is also the name given to the reservoir at the bottom of the condenser from which the condensate pump takes its suction.

Hydrostatic Test. A test put on a boiler with water under a pressure from 1¼ to 1½ times the safe allowable working pressure of the boiler. Put on by the boiler inspectors, and, while under this pressure, the boiler is inspected for ruptures and leaks.

Ice Machine. The name given to the compressor in the refrigerating system. Driven by some type of power unit.

Injector, Boiler Feedwater. A jet pump by which a jet of steam is used to force feedwater to the boiler. Simple in design, delicate in construction, the injector has been replaced by other types of pumps.

Lance, Hand, Air or Steam. A unit by which a jet of air or steam is directed into tubes of a boiler for removing soot. Operated by hand. Several safety precautions must be observed when using steam lance.

Manifold, Valve. A casting into which a number of pipe lines are led, each pipe opening controlled by a valve.

Main Steam Stop Valve. A valve connected directly to the top of the boiler shell which controls the flow of the steam from the boiler to the main steam line, which supplies only the steam to operate the main engines.

Manhole, Boiler. Generally an elliptical hole to allow the passage of a man's body so that the boiler can be entered for inspection, overhaul, or repairs. Covered from the inside with a plate known as a manhole cover, which is secured from the outside by dogs.

Muddrum, Boiler. A small drum or header located at the lowest point of the boiler into which sediment, sludge, and other impurities of the boiler water precipitate, and from which they are removed by the bottom blowdown valve.

Pressure Gage, Boiler. A gage by which the steam pressure in the boiler is registered. The pipe which connects this gage to the steam space of the boiler is fitted with a valve directly connected to the boiler shell.

Priming, Boiler. An action taking place in a boiler which causes water to be carried over into the steam lines.

Propeller, Screw. A device which, when rotated, causes a vessel to move through the water. Often referred to as the wheel or screw.

Reduction Gears, Speed. Due to the fact that some main engines, such as turbines, are most efficient at high speeds, and that the propeller is most efficient at fairly low speeds, the use of gears to reduce speed of screw is necessary.

Refractory, Furnace. Plastic and molded heat-retarding and insulating material used mostly for furnace linings.

Reducing Valve. A valve by which a varying high steam pressure can be automatically reduced to a constant low pressure.

Retarders. Flat, twisted strips of steel usually found in the tubes of firetube boilers, feed heaters, etc. to slow down the flow of the heating agent, so that there is time for more heat to pass through the tube.

Safety Valves, Boiler. Spring loaded valves which are set to open at the safe working pressure of the boiler. Used to relieve excess pressure in the boiler so that the boiler will not explode.

Salinometer Cock. A small cock or valve by which a sample of boiler water can be taken from the boiler for test as to acidity, alkalinity, or salinity.

Sanitary Pump. A pump which delivers sea water to the "heads" for sanitary purposes.

Saturated Steam. See **Steam.**

Scale, Incrustation. Formations on the plates and tubes of boilers due to the impurities in the boiler water.

Skin Valve, Sea Cock. A valve at the skin or side of the vessel; generally refers to the one on the blowdown lines used to prevent sea water from backing up to the boilers.

Soot Blowers. Mechanical devices attached to the boiler casing through which a steam jet is directed against the surface for removing soot deposits.

Spring Bearings, Main Line Bearings. Those bearings which support the weight of the main propeller shaft between the thrust bearing and the stern tube. They also tend to maintain the alignment of the shaft.

Staybolts, Boiler. Solid and drilled stays which are used to support the combustion chambers in boilers.

Steam. Steam is an invisible vapor produced by the rapid evaporation of water when heat is applied. **SATURATED STEAM** is steam in direct contact with the water from which it was formed and has the same temperature as the water. It may contain a light amount of moisture in which case it is known as **WET SATURATED STEAM**, or it may be 100% dry in which case it is known as **DRY SATURATED STEAM.** If this steam is led to a separate unit known as a superheater, which is placed in the path of the hot gases, its temperature is increased above that of the water from which it is formed, and it is then called **SUPERHEATED STEAM.**

Steam Generators. Steam generators is the name given to the combination of the boiler, superheaters, economizers, air preheaters, desuperheaters etc.

Steering Engine. Due to its large area, it is impracticable to move the rudder by hand; instead, the rudder is turned by a power-driven unit which is known as the steering engine.

Stern Gland. The stern gland is a packing gland at the inside end of the stern tube which prevents excessive flow of sea water in through the stern tube. This gland should never be tightened so much that there is no trickle of water through the stern tube, except in port, because this water trickle supplies lubrication to the stern tube.

Stern Tube. The tube or bearing through which that part of the propeller shaft (tail shaft) which contains the propeller passes through the stern of the vessel, generally lined with lignum vitae.

Superheaters, Steam. Units generally consisting of a number of tubes through which saturated steam passes, and over which the hot gases of combustion of the boiler pass so that the steam may be heated to a higher temperature.

Superheated Steam. See **Steam.**

Surface Blow. See **Blowdown Valves.**

Tail Shaft. The last portion of the propeller shaft, which passes through the stern tube, and onto which the propeller is fastened.

Telltale Holes, Staybolt. Small holes drilled in the ends of staybolts so that if the staybolt breaks or cracks, the steam and water will escape through the hole to the outside of the supported space to give warning of the break.

Throttle Valve, Main Engine. The valve by which the speed of the engine may be regulated by controlling the supply of steam flowing to the engine.

Thrust Bearing, Main Shaft. A bearing on the main shaft to prevent endwise movement of the shaft, so that the thrust of the propeller is transmitted along the shaft to the thrust bearing which transfers the thrust to the hull of the vessel.

Trap, Steam. A unit for allowing passage of condensate but preventing passage of steam.

Try Cocks, Boiler Water Level. Three small valves or cocks connected directly to the boiler shell at the water level so that the accuracy of the gage glass can be checked. One is located above, one at, and the other below the normal steaming water level (approximately).

Turning Gear, Jacking Gear. A unit which when engaged may be used for slow turning of the engine or preventing the engine from rolling over accidentally. Never engaged while steam is on main engine.

Uptakes, Furnace. Passages through which the gases of combustion, on leaving the boiler, are led to the stack.

Water Level Gage. A means by which the water level in the boiler is visible to the operating personnel, generally consisting of a glass tube for low pressure boilers, and a special non-shatterable glass gage for high pressure boilers.

Wet Air Pump. When the condensate and the air are both removed from the condenser by the same pump, the pump is known as a wet air pump. This system does not maintain as high a vacuum in the condenser as when the two pumps are used.