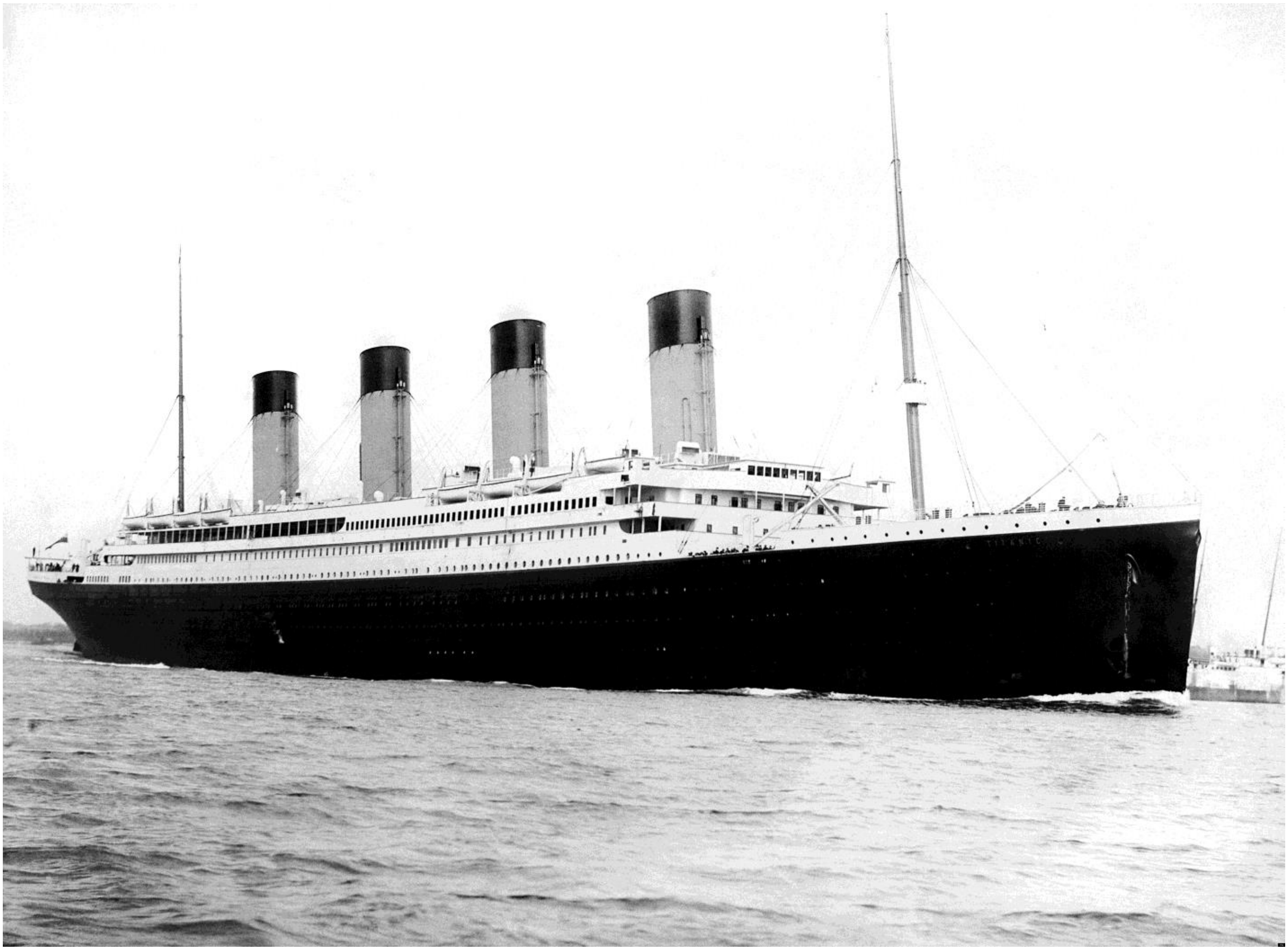


RMS Olympic 1910
RMS Titanic 1911

Owners: White Star Line Ltd

Builders: Harland & Wolff, Belfast

Cold Starting

Starting RMS Titanic
(From cold)

Table of Contents

1 Foreword

This document is almost primarily about the machinery and systems of the two sister ships Olympic and Titanic, with appropriate notes concerning the sinking of the latter. Otherwise the two ships were basically identical in their engineering systems. In reality Titanic would only have been started from cold when she left the shipyard on trials, whereas the Olympic would have been shut down several times in her lifetime under dry-dock conditions. Both would require shore power to start up, though as the boilers were natural rather than forced draft, it could be possible to raise sufficient steam to start a generator without first starting a stokehold fan.

2 Overview of machinery spaces

2.1 Boiler rooms

Both ships were triple screw White Star liners fitted with 5 single-ended and 24 double-ended boilers, operating at 215lb/in2. These boilers are 5 abreast in 6 boiler rooms, except in No6 Boiler Room (the foremost one) where the fine lines of the ship only allow 4 abreast.

No1 Boiler Room, forward of the reciprocating engineroom houses the single ended boilers used for hotel services and auxiliary supplies in port. The double-ended boilers are fired for transatlantic passages up to full speed and primarily used for main propulsion.

Stokehold fans provide ventilation for the stokeholds, and for cold starting these are started using the shore supply. Where no shore supply is available (we are assuming that it is) the single-ended boilers may be fired on natural draft on cold-start, with the ventilators turned into the wind. Once under way the vessel operates on induced and natural draft in the same way as a steam locomotive, via large ventilators visible on the upper decks, with the stokehold fans supplying primary and secondary air to the stokeholds. (See Figure 20).

The hot gases rising up the flue, drawing air in via the fire and draft doors, form induced draft. The fires drawing air in from the stokehold form natural draft – aided by the stokehold fans. Air forced into the furnaces via fans and a trunked system is forced draft (predominantly used by Cunard in their vessels).

2.2 Coal bunkers

Coal bunkers are provided facing the furnaces in each boiler room to enable a ready supply of coal for the trimmers and firemen to stoke the boilers.

Ash chutes are provided to discharge ash from the furnace bottoms overboard at regular intervals to keep the stokehold clear of ash whilst at sea. In port ash hoists are used to dispose of the ash to shore facilities.

2.3 Main steam piping

The main steam pipes run the length of the boiler rooms into the reciprocating engineroom for distribution to the engines and auxiliaries.

2.4 Propulsion engine rooms

There are two triple-expansion reciprocating engines situated in the reciprocating engineroom, aft of Boiler Room No1. Steam from the main steam piping is admitted to the reciprocating engines which, whilst manoeuvring in port, exhaust direct to the vacuum main condenser. Once Full Away on Passage, large changeover valves redirect the exhaust steam from the reciprocating engines into the low-pressure turbine situated in the turbine engineroom aft of the main engineroom, separated by a watertight bulkhead.

Exhaust steam from the turbine is directed to the vacuum condensers where it is condensed into water (termed condensate) and pumped back into the boilers.

2.5 Electrical power generation

2.5.1 Main generating sets

Note: *The term dynamo has gone out of usage in recent years in favour of the terms "AC Generator" and "DC Generator". The term "alternator" is now confined mainly to automotive use. The term "Dynamo" has been used in this publication as it was the term used in the extract from The Shipbuilder used for guidance.*

The vessel is fitted with four 400kW main dynamos driven by steam reciprocating prime movers. Reduced steam at a pressure of 185lb/in2 (12.75 bar) is fed to the engines and exhaust steam is directed - in port or at start up - to the auxiliary condenser. At sea the dynamo exhaust steam is directed to the surface feed heater to extract the remaining energy from the exhaust steam and deliver it to the feed heating system. This configuration gives a total installed power of 1.6MW dc, with three sets covering the full steaming load and one in stand-by. (See Figure 22)

Emergency generating sets

These are termed Emergency/Auxiliary Generating Sets but as they are steam driven, are not able to be cold-started without a steam supply. There are two of these sets, situated above the waterline on a flat within the engine casing on the Shelter or D Deck, each of 30kWdc output power. To give a certain amount of redundancy, they are fed by separate steam pipes from three of the boiler rooms (see Figure 3).

With the ship on shore power we will be using these two machines to start up the ship's lighting systems in order to disconnect the shore power as soon as possible.

This start-up routine assumes the emergency sets as the quickest method of getting off shore power and on to ship's power, but it could be that the engineers would cut out this stage and just start the main generating sets, though the time taken would probably be a lot longer as more boilers would be required.

3 Going on board

The ship is in the water and has been coaled up before we arrive. This is fortunate for us because coaling ship is a filthy process and normally considered a "whole ship" activity, where everyone – including the Captain – is involved. We have escaped this however (as has probably the Captain), and can go on board in relative cleanliness in order to help start up the ship.

The ship is berthed port side to, which gives us access to the engineers' entrance on the Upper Deck (E Deck). We go up the gangway and enter the engineer's alleyway, doing a U-turn on entry to go down the stairs to the cabin flat on the Middle Deck (F Deck) deck below.

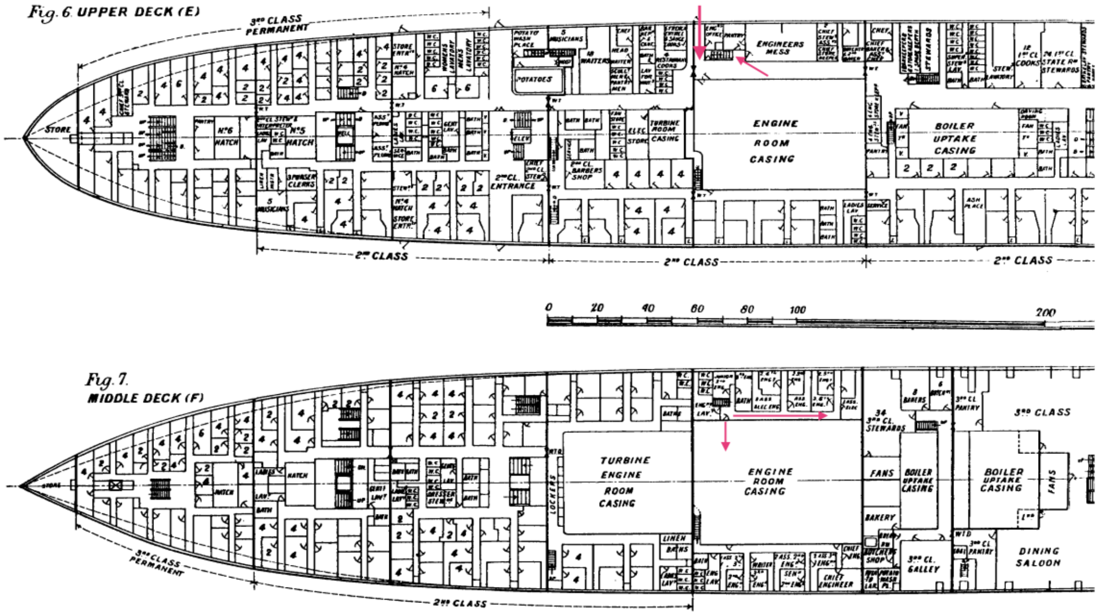


Figure 1: Entry into the Engineers' Accommodation

We walk forward on F Deck to the forward engineers' cabins where we stow our gear and get changed for the task ahead. Our working clothing consists of a white boilersuit (which marks us out as the ship's engineers), a pair of stout boots (known as "steaming bats") and our 2nd best caps ("steaming bonnet") in case we meet a senior engineer, who may bring us up on not being correctly dressed. Our steaming bonnets are the ones with a plastic top, liberally stained with grease, oil and coal dust. Our best caps are kept for when in the passenger accommodation in uniform, though as juniors we won't be allowed there too often – we know our place…

Note: *Depending on the company in those days, passenger ship officers were allowed "on decks" (mixing with the passengers) in accordance with their rank. In Cunard, only the Chief and Second Engineers were considered Senior Engineers and allowed to mix with the passengers. In liners other than transatlantic ones, the 3rd Engineer often had his own table in both 1st and 2nd Class. Juniors generally were "off decks" four hours before their watch, Seniors two hours before their watch. Readers nowadays will probably have more idea than the writer on what is the norm on passenger and cruise vessels in the 21st century.*

Once changed, we walk aft again and enter the Reciprocating Engineroom by the port after door at about the level of the main engine cylinder tops. There is an immediate smell of paint, oil and coal dust in the air, and a hint of sulphur from when the boilers were fired – rather like a visit to an engine shed on a preserved railway. We take a moment to look around the space, which houses both the propulsion engines, refrigerating machinery, auxiliary condenser and its attendant pumps (which we will need later) and various other pumps, heaters, filters and miscellaneous equipment. It's a bit dim down here and quite chilly (we are in England after all) as the ship has been dead for some time. The lights are only the emergency circuit lamps at the moment, which illuminate the stairways and control centres only throughout the machinery spaces of the ship. Once we get an auxiliary dynamo on the board it will brighten considerably. And once we light a boiler or two it will get a bit warmer…

Our first task therefore is to gather a Leading Fireman plus a handful of firemen (sometimes called Stokers) and trimmers in order to get them to start firing the number of boilers required.

***Note**: The **Leading Fireman** directs the stokehold crew in their duties, keeps an eye on the fires, observes the orders on the stokehold telegraphs and generally cracks the whip over the stokehold crew. These are hard men: tough, probably violent, hard drinking, hard working, uneducated and often difficult to handle. The **Fireman's** job is to keep the furnaces stoked with coal, trim the fires for efficient burning of fuel, draw fires for cleaning, and obey the orders of the Leading Fireman. They are respectful of the engineers however, which is a relief – some scary guys here, and there are hundreds of them! They don't mess with the Leading Fireman either, who is harder than they are. The **Trimmers** are similar and are the lowest grade of engineroom crew. They may aspire to being firemen and even Lead Fireman over the years. Their job is to shovel coal and ash and help out with oiling round the machinery – coal from the bunkers is shovelled to the stokehold floor, ash from the ash pits is shovelled to the ash chutes and lifts. It's a hard, backbreaking, hot and dirty job for sure, though their watches of 4-on, 8-off are better than the deck crew who do 6-on, 6-off. They are also better paid and get better food than the sailors, who are still steeped in sailing ship days. The Engineers are also better paid than the Deck Officers, have better food (unless the deck officers are eating in the passenger accommodation like the Captain may do) and have watches of 4-on, 8-off. The Deck Officers tend to work RN watches (WSL officers all had a Master's Ticket in Sail), which include Dog Watches of two hours each in order to cycle the times they are on watch.*

These ships carried 24 engineers, 6 electrical engineers, two boilermakers, a plumber and the Chief Engineer's Writer (Clerk). For a complete listing and the duties of the engineers, see Titanic's engineering staff by Dr Denis Griffiths.

In modern ships, the 2nd Engineer takes the 4-8, the 3rd Engineer the 12-4 and the Chief Engineer the 8-12, though his watch is delegated by him to the 4th Engineer as it is within normal daylight hours.

For the Olympic and Titanic there were many engineers required to work what was essentially a manual ship; a Google search will come up with tables of all the ranks. You and I are relatively junior – I am an Assistant-Third and you are a Fiver (one of many), so you call me "Third" or "Sir" if you want to be sycophantic… First names were not often used in those days, the hierarchy being fairly rigid. You would never *call the 2nd or Chief Engineer by their first names – God forbid!*

4 Lighting up the boilers

With the lights on shore power so we don't have to use torches, the firemen are set to work in the required boiler rooms to lay fires in sufficient boilers to provide enough steam for the dynamos.

This is easier said than done – first the trimmers start chipping away at the bunker to release the coal so that they can shovel it into wheelbarrows and deliver it to the stokehold in front of the grates. Meanwhile the firemen are "coaling the bars" in order to give a bed of coal that won't burn through once it's lit. This will take some time, and already we are getting coal dust up our noses, and on our hands and faces. We will grab hold of an electrician and send him up to start a stokehold fan off the shore supply. We can't start too many of these as they are quite high consumption and shore power is normally quite limited.

Once the bars are coaled and the stokehold fan is keeping the dust down a bit, pieces of wood are put on a shovel and launched into the middle of the firebed, along with twists of newspaper to get the fire to hold long enough to light the coal. This requires some expertise, so we watch what they are doing, without getting in the way. An elbow in the face from one of these guys "accidentally on purpose" will not improve our day. Once the kindling is laid, an oily rag (plenty of those to hand) or cotton waste is placed on a shovel, some paraffin is poured on it and a match lights it up. Once it is burning nicely, the fireman hefts the shovel and throws the burning rag right onto his pile of kindling, which will start to burn almost immediately. Deftly, he slings a couple of shovels-full of coal onto the burning kindling without disturbing it (you or I would probably put the fire out with a clumsily launched shovel full). Allowing the air to enter the underside of the grate using the dampers, the flame is fed with air through the coal bed. Once the pile of coal has lit, it will in turn light the coal adjacent to it until eventually the whole bed is starting to light up. If the fire burns through in any particular place, the draft will blow through the hole in the bed, thereby starving the rest of the bed, so the firemen have to keep an eye out for this and deposit coal on the places where the fire looks as if it will burn through. This is skilled work, but these men are the pick of the fleet in such a prestigious liner. As are you and I incidentally…

The boiler room is starting to smell of smoke and sulphurous products of combustion – rather nice to steam engineers like us. It's getting quite warm in here, so we'll stay until the pressure gauge starts to move. First though we will climb up the ladders to the top of the boilers and open the stop valves in Boiler Room 1. This will allow a passage from the boilers to the main bulkhead stop valves on the watertight bulkhead aft of us, and allow us to bring up the lines to temperature by draining them in this space. From the drawing in Figure 3 you will see that the boilers in this room can feed through the bulkhead stops and thence to the emergency dynamos (magenta line), and can also feed the main generating sets via the green lines. This means that we can get both emergency and main generating sets going on just the boilers in this No 1 Boiler Room. For main propulsion we will need more, which will be started up later.

Once lit, the dampers adjust the boiler draft and the fires start to heat the water in the fire-tube boilers.

Note: Water-tube boilers are much more efficient and faster starting than fire-tube, but weren't well tried and proven in the early part of the century. It would take around 7 – 12 hours to warm through and start to raise sufficient steam. Raising steam too quickly in a cold boiler can lead to thermal stress which is not good for the boiler longevity and could even cause cracking and rupture, especially on riveted boilers.

No1 boiler room was used in port as it is closest to the enginerooms and can feed steam to both the emergency and the main dynamos. For main propulsion at sea the main double-ended boilers are used, with the fires in Boiler Room 1 drawn and re-laid ready for lighting in the next port. Owing to short port turnarounds, the main boilers would remain lit with fires banked ready for a (reasonably) quick start without using too much coal.

Once we have a main dynamo going, the number of boilers required for sailing are also laid and lit, and we will get back to this later.

We can now leave the "cosy" boiler room and exit back through the watertight door into the reciprocating engine room - still a bit chilly in here. We will check out the auxiliary condenser and its equipment ready for starting the dynamos once the boilers are up to pressure.

The emergency dynamos are available for starting with a steam pressure of 185lb/in2, so this will take some hours to achieve. We'll go for a cup of tea first, and put our feet up out of sight of the other engineers, or maybe even turn in for a few hours.

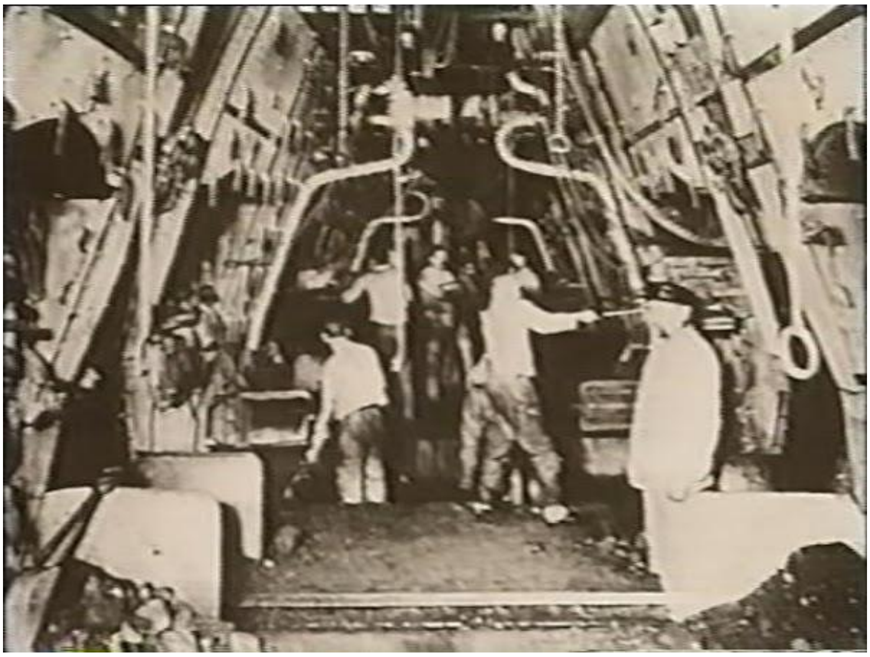


Figure 2: Our "cosy" stokehold

After some hours raising steam the Leading Fireman tells us that we have around 190lb/in2 in the lines. As the bulkhead stops are open to the steam from Boiler Room 1, we can check the various drains in the spaces and make sure that any condensate lying in the lines is drained. Any water in the lines can severely damage steam engines, so we need to make sure they are clear of water. The drains incorporate steam traps with a bypass line. The bypass is opened manually to check if there is water in the line and, once steam is issuing from it, it can be closed and the drains routed through steam traps. These are automatic devices that periodically drain any collected water from the lines. Once up to temperature, a well-lagged steam pipe will not have any water in it at all.

Note on the sinking:

Whilst the single ended boilers in Boiler room No1 were normally used in port, at the time of the sinking these boilers were not lit, so must have been shut down on sailing from the last port (Queenstown).

4.1 Steam line redundancy

All ships need a certain amount of redundancy in their systems to cope with emergency conditions. For redundancy in main steam lines (Figure 3) –

The main dynamos, refrigeration machinery and auxiliary pumps (termed "the auxiliaries") were fed from a steam main connected to –

- Starboard outer pair of boilers in Boiler Room 4
- Port outer pair of boilers in Boiler Room 2
- All five single-ended boilers in Boiler Room 1

The main dynamos were fed exclusively from a steam main connected to –

- Port outer pair of boilers in Boiler Room 2
- All five single-ended boilers in Boiler Room 1 (the line used for electrical power in port)

The emergency dynamos were connected to –

- All five boilers in Boiler Room 5
- All five boilers in Boiler Room 3
- All five boilers in Boiler Room 2
- An auxiliary line from the main steam lines feeding the reciprocating engines in the engineroom

The emergency engines were run regularly to keep the steam lines warmed through in case of emergency – probably for an hour or so each day.

Note on the sinking:

As the vessel started to plunge by the head, to conserve steam and keep the lights on as long as possible, the main dynamos would have been fed from the furthest aft steam line, that from Boiler Room 2 above. Once Boiler Room 5 fires were drawn owing to water ingress, the steam from the boilers would start to decay, and the isolation from them to the main steam lines and the line to the emergency dynamos would have been shut off.

As each boiler room flooded and was shut down, the lines from each boiler would be isolated. The steam reserve in boiler rooms 3 and 2 (Boiler Room 1 was not fired at the time according to the enquiry) would have supplied both the main and emergency dynamos, and as the latter had a smaller steam consumption it is likely that the main dynamos would have been shut down and the auxiliaries used to conserve what steam was left in the boiler drums. This is borne out by the auxiliary seawater overboard starting up and flooding one of the lifeboats being lowered on the starboard side; by that time the engineers would have known that the main engines would never run again, so their primary duty was to conserve steam and keep the lights on as long as possible.

Boiler Room 2 was the furthest aft and would have been supplying steam until the end, the auxiliary seawater pump and air pump fed from the port outer pair of boilers, and the emergency dynamos from all five boilers, though more probably the remaining three in order to separate the auxiliary pumps from the emergency dynamos.

For an illustration of the steam lines, on the next page is the general layout, Copyright Sam Halpern, from the Titanic site -http://www.titanicology.com/Titanica/TitanicsPrimeMover.htm where a fuller description of the steam system may be found.

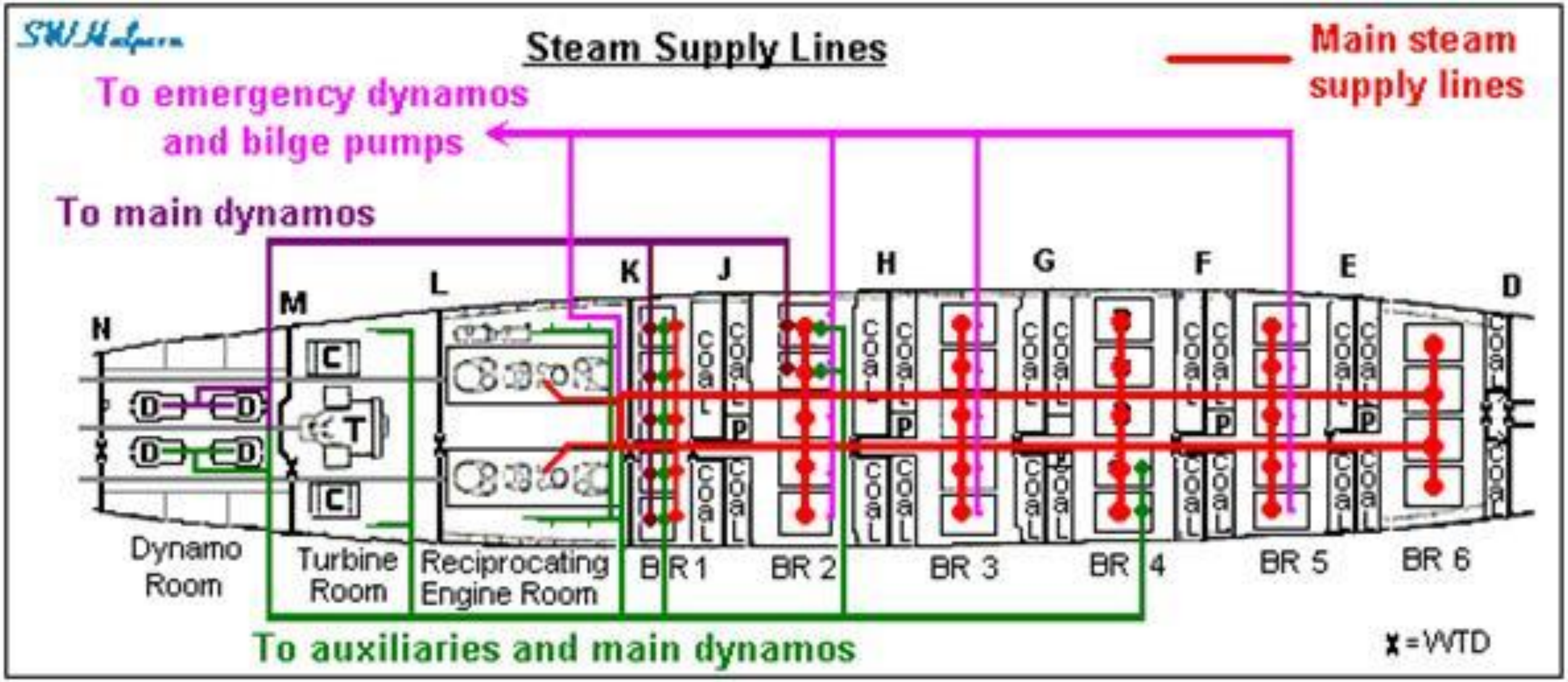


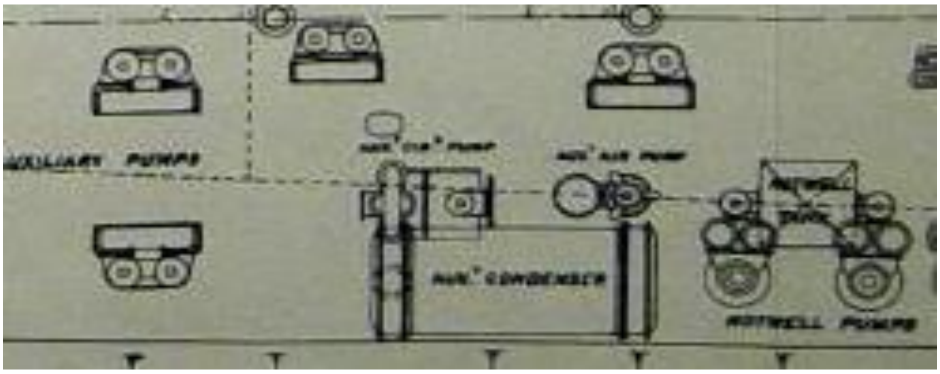
Figure 3 Steam line redundancy © Sam Halpern

5 Starting the dynamos

5.1 Auxiliary seawater pump and condenser

In order to start an emergency dynamo, the exhaust steam from the engines needs to be directed to the auxiliary condenser. The seawater passing through this condenser condenses the exhaust steam into water (termed “well condensate”), thereby drawing a vacuum owing to the drop in pressure. Without this the engine would trip on high exhaust backpressure, as the exhaust steam otherwise has nowhere else to go (some ships had an atmospheric blow-off, but this is wasteful of steam, coal and water and was not fitted to the Olympic class). In addition the condenser is fitted with an auxiliary air pump (or vacuum pump) to augment the vacuum by removing non-condensables such as air, in order to drop the exhaust steam pressure further (air will expand and reduce the vacuum).

The auxiliary seawater pump is steam driven and situated under the auxiliary condenser on the starboard side of the main engineroom. (See Figure 25) and the extract below –



Here we are on the starboard side of the engineroom against the ship’s side. The Auxiliary Seawater Pump is on the after end of the condenser, with the Auxiliary Air Pump at the forward end.

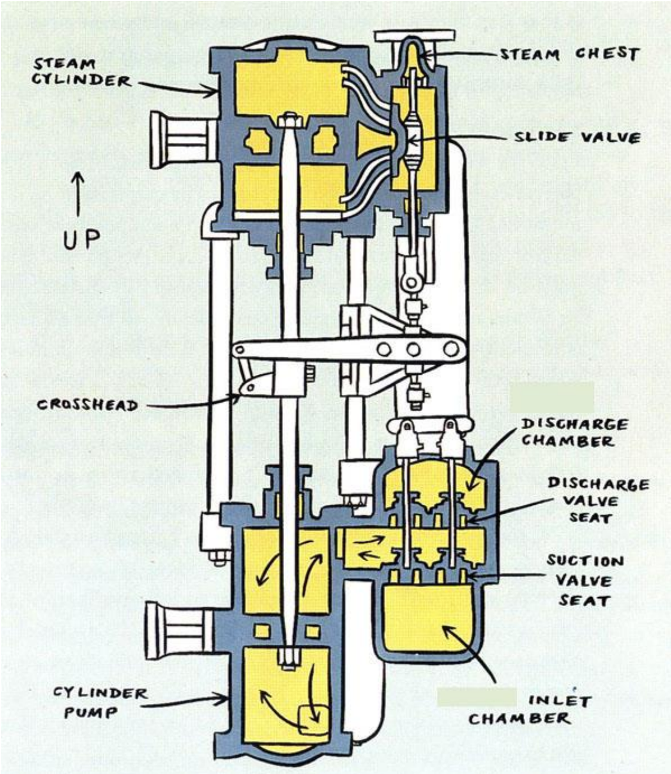


Figure 4: Typical Steam Reciprocating Pump

In the drawing above, the steam cylinder is at the top, and the "bucket pump" at the bottom. The steam side is double acting, in that steam is alternately admitted from the steam chest above and below the piston by the slide valve. The piston moves up and down, as does the bucket pump in the lower section, the arrows showing the direction of the water from suction to discharge. The inlet is connected to the sea suction valve on the ship's side, with the discharge going to the condenser inlet. After passing through the condenser tubes and condensing the steam, the water is passed to overboard, taking the heat with it. A temperature rise of some 8-10C across the condenser is normal.

We locate the seawater induction and overboard valves on the ship's side, and open them along with the condenser inlet and outlet valves. Under the steam cylinders of the pump are the drain valves, and we open these to drain any water out of the cylinder. With the drains still open, we crack open the steam valve to the pump steam chest and steam is admitted to the pump cylinders. The pump starts to move up and down, still with the drains open until only steam issues from them, whence we close them. Gradually opening the steam valve further, the pump starts to gain speed until it is up to its working speed, which we can control with the inlet valve. The pump now circulates seawater through the auxiliary condenser tubes to overboard. We check the condenser inlet and outlet pressures to make sure there is no blockage in the condenser tubes.

In the same way the auxiliary air pump is started in order to draw non-condensables from the condenser steam side and improve the vacuum. We are now ready to start an emergency dynamo

***Note on the sinking**: As mentioned earlier, this is the seawater overboard that nearly filled one of the lifeboats on the starboard side aft. It was started up when the engineers realised that the main engines would never run again, and that they had to conserve steam.*

There are many of these pumps in the engineroom for the various services required to operate the machinery, which will be started up in much the same way.

5.2 Starting an emergency dynamo

We now have to get to the emergency dynamo room, which is situated aft above the turbine room. It's quite a climb, but the room is accessible from the ladders going up to D Deck above the turbine room. The turbine room is quiet and chilly, but we'll warm up climbing the ladders up through F, E and D deck. We go through the door into the dynamo room, which is forward of the 2nd Class Pantry, though with no access to it to nick a few pastries…

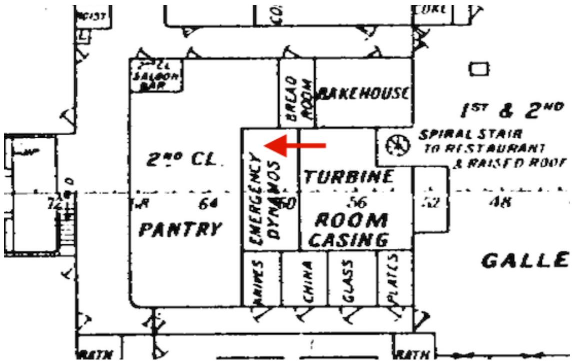


Figure 5: Emergency dynamo room

The steam lines for these engines comes from the lines from the various boiler rooms as in Figure 3, but we are using the one that comes from the reciprocating engineroom as we have drained it at the bottom before we started in order to get the auxiliary seawater pump going. The engines don't use a great deal of steam, so on the boilers we have running, we can get 60kW of power, enough to light 600 100W bulbs or 1000 60W bulbs. We don't need all these lights, so – providing we can connect to the main system, we can take over from shore power, with the stokehold fan running off the emergency sets – it's less than 30kW so we have a dynamo to spare. Once we have more boilers on line we can start a main dynamo.

As with the seawater pump, we start with all the drains open, and make sure the exhaust valve is open to the auxiliary condenser line. Prior to starting we have to "oil round" – which means filling all the oil reservoirs for the cranks and main bearings of the engine (this machine doesn't have its own lube oil pump, so has to run attended in order to avoid it seizing up). Once that's done, we crack open the steam control valve, and steam is admitted to the reciprocating engine, with the exhaust being drawn to the auxiliary condenser by vacuum as soon as the steam comes in contact with the cold condenser coils. We gradually open the steam valve until the engine has warmed through, the drains are running clear of water and the machine is running at its rated speed of 380rev/min under the governor. The emergency switchboard is within a section on the main switchboard, so once the engine is stable we can leave a Junior and his oiler here to look after it and go back down to the main switchboard where the main breaker for the emergency dynamo is situated. This means we have to go all the way back down to the turbine room plates, and exit through the after watertight door into the main dynamo room on the starboard side forward.

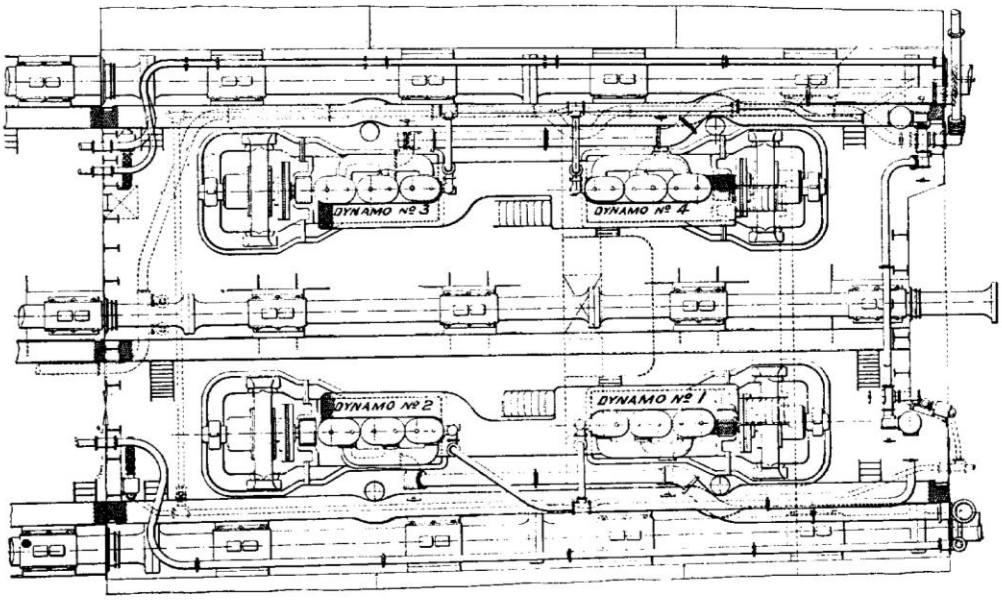


Figure 6: Main electricity generating set room

Another cold, damp room, with the sound of dripping water into the bilge, but we will be starting the machines up in this room shortly and things will begin to change.

The switchboard is located at the forward end of this room, overlooking the dynamo sets, so we climb the ladders to the switchboard – note that the three propulsion shafts pass through this room – you can spot them in the drawings.

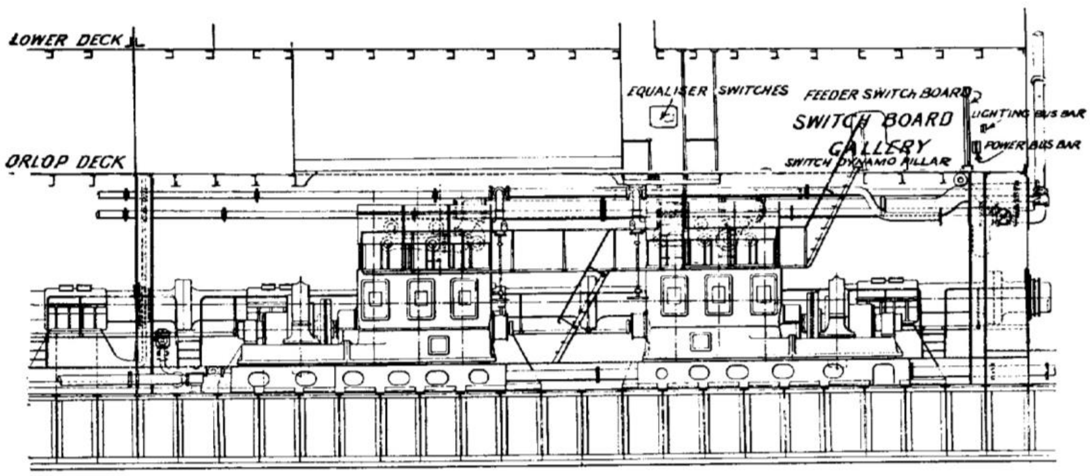


Figure 7: Main dynamo room showing switchboard

The vessel is still on shore power, so we close the emergency dynamo breaker onto the Emergency Board. Even if other dynamos are on the board, with Direct Current no synchronisation is required, hence dynamos can be added to the main switchboard at any given time. On closing the breaker, the voltmeter lamps will light dimly and show a small voltage. Using the shunt field regulator (also called the exciter), we turn up the voltage until it shows full mains voltage of 100V. Up above in the emergency dynamo room, the increased load of lighting and the stokehold fan will cause the dynamo governor to admit more steam to the cylinders to maintain the engine speed.

We now have 30kW of power available – 60kW if we start both dynamos - and can start to get main power on. We can now disconnect the shore power by simply opening the breaker; we don't want to pay for any more shore power than we have to – Shipping Companies are a mean bunch.

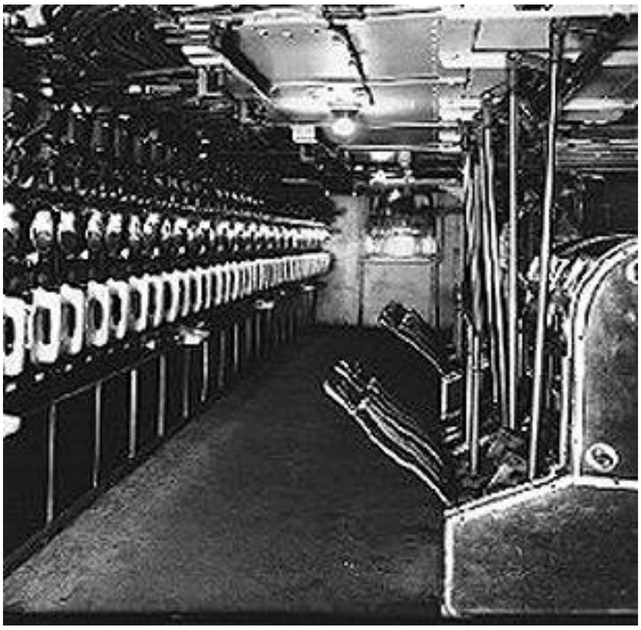


Figure 8: Main switchboard and dynamo breakers

Note on the sinking:

The lights would have stayed on providing an emergency dynamo was running, which is likely to have been the case as there were no batteries fitted for emergency lighting on Titanic, though Olympic may have been retrofitted after the accident. Looking at the angle of the waterline at the point where the lights went out – just prior to breaking in two – it is very close to the suction for the auxiliary condenser seawater pump above.

With an emergency dynamo and the seawater and air pumps running on the volume of steam left in the boilers that remained un-flooded, there would have been little or no reason for any of the engineering staff to remain below, apart from perhaps the Chief Engineer and a couple of volunteers to swing isolation valves, reset breakers etc. None of the boilers would have been stoked at this point, as the fires would have been drawn and the stokers sent up on deck, and indeed many of the stokers survived the sinking. One or more of the witnesses stated that most of the engineers – including the Second, Farquharson - were seen on deck prior to the sinking, though none survived.

As the seawater induction for the auxiliary seawater pump was still under the water, the steam lines fracturing when the ship broke in two would have blown off the steam to the dynamo and the lights would have died. Some survivors reported that they saw the lamps glow before going out, commensurate with the dynamo running down. With the ship at such an angle, any engineers left below would not have physically been able to save themselves even if they wanted to.

5.3 Starting the main dynamos

We now have the emergency sets supplying power for a short while until we get the main sets going. As we are consuming steam, we will also be able to start a main feed pump to supply the boilers with feed water as required, described later under the feed system. For the moment there is enough volume of steam in the boilers to drive the emergency set for the time it will take us to set up a main unit, and the exhaust from the auxiliary condenser will drain into one of the feed tanks, so no need to start a feed pump at this stage.

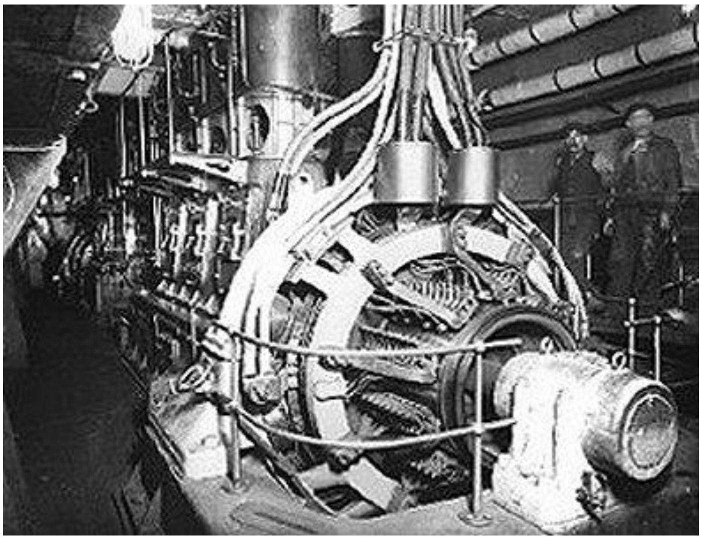


Figure 9: Main dynamos in the ship

The dynamos are forced lube, closed crankcase type, and we will assume that on these engine the LO pump is engine driven as there is no evidence to the contrary. There will be a hand pump located on the side of each engine which we crank until LO pressure shows on the gauges. Once the engine is started and runs up to speed, the engine driven pump will maintain the oil pressure to the bearings. A failure of the LO system will act on the steam control valve and governor, and shut down the engine. These engines will therefore run relatively unattended.

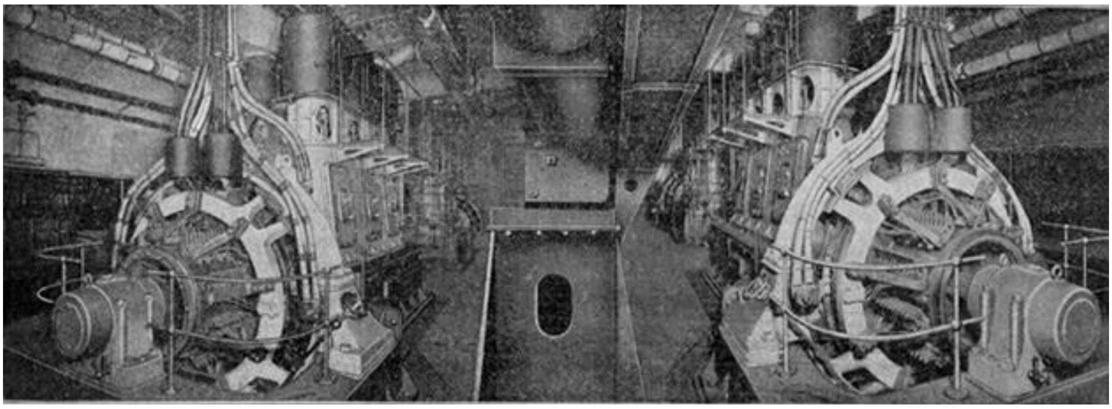


Figure 10: View looking forward in the main dynamo room

After warming through the steam lines from forward, and opening the engine exhaust to the auxiliary condenser, we crack open the steam control valve to the first engine, which will start to move, with water and steam issuing from the cylinder drains. Running slowly at first to warm the machine through thoroughly, we gradually shut the drains and open the control valve until the governor takes over. Providing the LO pressure is maintained, the control valve will stay open.

We go to the second dynamo and start it up in the same way, running up to a speed of 325rev/min. It is not known how many dynamos would run on the auxiliary condenser, but as the reference work states this was the condition in port, it was likely to be able to run at least two. Without an electrical single line diagram or load estimate, we have to rely on experience, and 800kW on this ship should be enough to get things going. If not, we can always start another one.

Going back up to the switchboard flat, the breaker is closed for the first dynamo and the shunt field regulator adjusted to give mains voltage. Once the dynamo is taking the load, the breaker(s) for the emergency dynamo(s) are opened and the emergency set(s) shut down, though kept warmed through for immediate start on failure of the main sets. (See Figure 24)

We can now put the other dynamo(s) on the board as required. We are up and running and can connect other feeders via the main switchboard distribution (see Figure 23).

As you can see, this is quite a long job compared to a modern diesel powered ship (though steamships still take some time). A blackout on a modern motorship can be restored within a few minutes, though cold starting takes longer depending on dynamo warming through requirements.

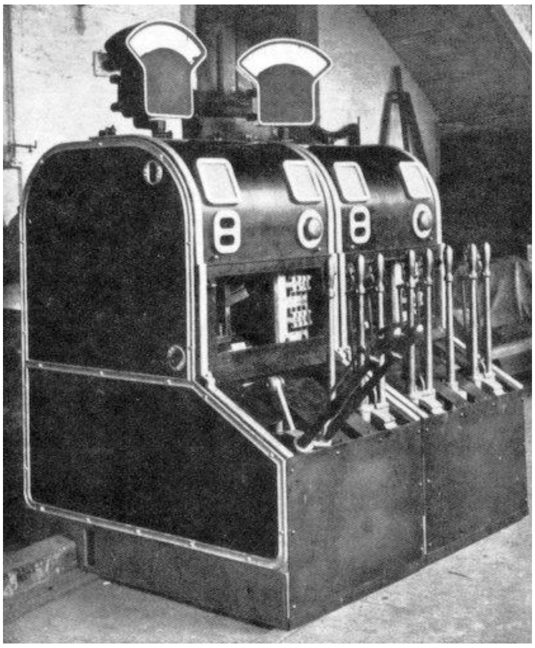


Figure 11: Dynamo switchgear

The picture in Figure 11 above shows an individual circuit breaker, voltmeter and ammeter for two of the main generating sets (nowadays these are incorporated in the switchboard), whereby the main breakers may be closed or opened as required. Load is shared with other sets using the ammeters so that all sets are equally loaded.

5.4 The feed system

We are now starting to use a fair bit of steam, the firemen and trimmers are responding by bending their backs in No 1 Boiler Room and by this time all the required boilers have been lit and are up to pressure, with their stop valves open to the main steam lines. We need to start getting some water into the boilers!

Referring to the drawing © Sam Halpern at Figure 19, we can use an extract of this to show the method of pumping water from the feed tanks to the boilers.

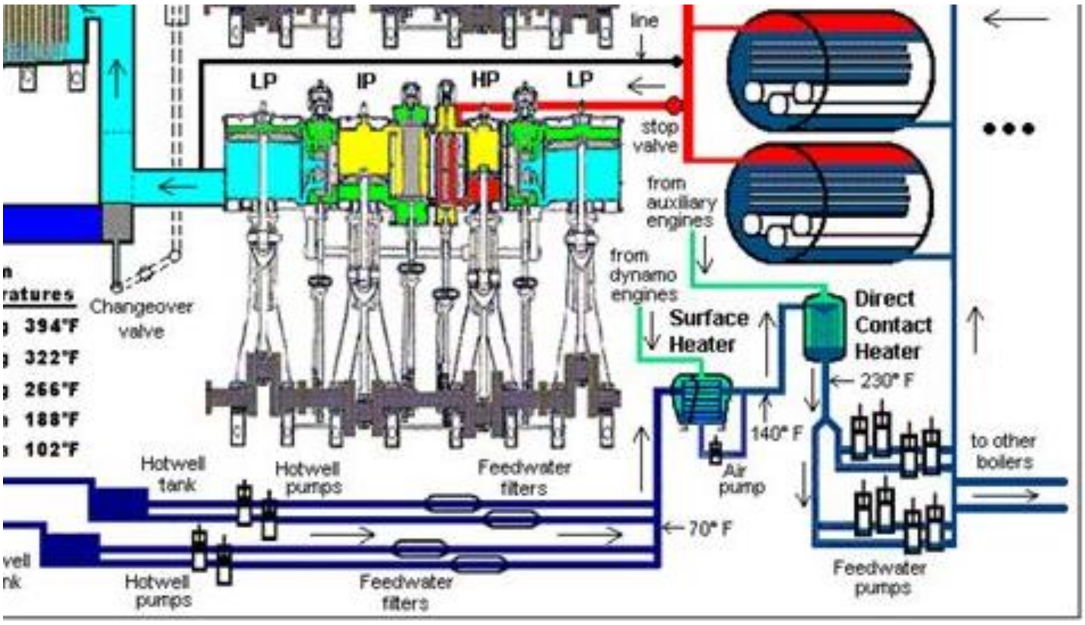


Figure 12: Extract of feed system © Sam Halpern

At the bottom of the drawing in Figure 12 can be seen the **hotwell tanks** that the auxiliary condenser is currently draining into. The Hotwell Pumps draw water from these tanks, pass it through the **feedwater filters** to remove any grease or dirt that can contaminate boiler tubes, then through the **Surface Heater** and into the **Contact Feed Heater** situated high up in the engineroom forward. The working of these heaters is explained later in the main feed system.

From the Contact Heater the water is drawn by the Boiler Feed Pumps under gravity and pumped into the main and auxiliary feed lines going to each boiler throughout the ship. These are all steam pumps similar to the ones we have started earlier, so we start the hotwell pumps first in order to get a level in the contact heater in order to give a head for the boiler feed pumps to draw on. Once this is established, one or more feed pumps can be started and water can start being admitted to the boilers. In the Olympic class ships this was a purely manual operation – there is no mention of any automatic feed regulators in the paucity of engineering detail available on these ships. The firemen in each stokehold are responsible under the engineers to keep the boiler water at the right levels, and the engineers in the engineroom will tend the hotwell and feed pumps, hotwell tank levels and other aspects of the feed system during their watch.

Currently we only have a couple of auxiliary pumps running plus the exhaust from the main dynamos, which we can switch to warming the feed water once we start up the main propulsion systems. This will mean pumping relatively cold water to the boilers as we are using very little steam at this stage, so we can "force" the contact heater using live steam from the main steam lines (see 7.2); this is wasteful of live steam, so we don't want to do this for too long.

6 Starting main engines

We now have power for firing all the boilers necessary for starting the main engines and getting the engineroom ready for sea. We can sit back (relatively speaking) until the end of our watch, and come back down below again to get the engineroom ready for standby leaving port.

During our time off watch, most probably boiler rooms 6 and 5 would come on line first as they are the furthest forward, No 6 being opened to the main steam lines for warming through back to the main stops, No 5 open to the emergency dynamo independent line (see Figure 3) "just in case". Steam is raised on these boilers with the main stop valves open such that the whole system is taken up to pressure, with all the main steam line drain valves open one to two turns right back to the engineroom bulkhead stops. This same principle applies to steam systems today. Further boiler stop valves are cracked open once up to pressure until all the boilers required for leaving port are up to pressure and banked ready for manoeuvring.

We are now going back down below again for our next watch, and the scene is a lot different from when we left. We come down from above No 5 Boiler room via the doors higher in the ship. A blast of hot air hits us as we walk across the gratings and take the ladders down to the stokehold floor.

Figure 13: Above the boilers by the uptakes

The stokehold is hot and coal dust fills the air as usual. Sweating firemen and trimmers are clearing ash from one of the furnaces as we pass, whilst others are shovelling coal into other furnaces on these double-ended boilers. There is a device that only permits one fire door to be open at a time on each end of these furnaces, so that the draft doesn't blow out into the stokehold, along with flaming chunks of coal and hot cinders.

A trimmer dumps a load of coal from his barrow as we pass by, taking time to wipe the sweat off his brow with cotton waste and knuckle his forehead in recognition of two officers passing by.

Once the boilers are getting near the required steam pressure, the fires will be damped to avoid blowing the safeties and wasting coal until required for manoeuvring of the main engines. The firemen can rest awhile before the onslaught of a transatlantic passage at full speed is visited on them.

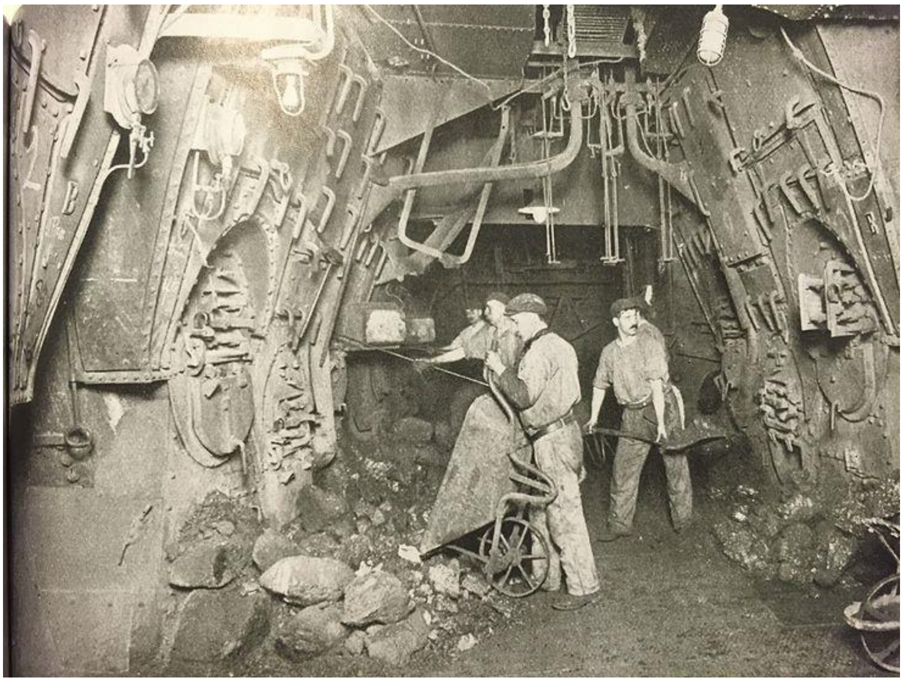


Figure 14: A trimmer with his barrow

We pass through the watertight doors of each boiler room on our way to the engineroom. As we pass through the last door at the aft end of Boiler Room 1 the heat and dust diminish somewhat as the engineroom fans are on to avoid the dust and heat blowing into the engineroom. There is no evidence to suggest it, but this last door was probably closed most of the time (or had a heavy curtain over it), though the other ones forward would have been open to allow passage for the stokehold crews coming on and off watch. The spiral staircase at the forward end of the ship plus the “Firemen’s Corridor” were there to avoid these rough specimens of humanity from coming into contact with the more genteel members of society of the period, who were not much interested in “how the other half lived” or if they even lived at all; a form of insouciance that was common at the time.

6.1 Main seawater pumps

First we have to get the exhaust steam system arranged in a similar way to that of the dynamos but, in the case of the propulsion system, the auxiliary condenser is nowhere near big enough to handle the exhaust from the main engines and turbine.

Off we go aft into the turbine room again, where we can take a moment to pass round the equipment to the port outboard side.

This space is full of some massive items of machinery; not least are the two condensers fitted outboard, and the central turbine. Climbing over the thrust blocks of the reciprocating engines and passing under the huge changeover valves on the forward bulkhead, we squeeze round the port main condenser into the space holding the two main seawater circulating pumps that serve it.

In the bottom plating of the ship are the large seawater induction openings, with gratings to stop marine life being drawn in once the pumps are operational. These can be seen on the drawing below, along with the large seawater induction valve, which we will now start to swing open for each pump, one aft and one forward in the space. The pumps, like everything else in this room are large; they are horizontal centrifugal pumps as opposed to the vertical ones we have started so far, and they are driven by compound steam engines working on a crankshaft to translate the reciprocating into rotational motion.

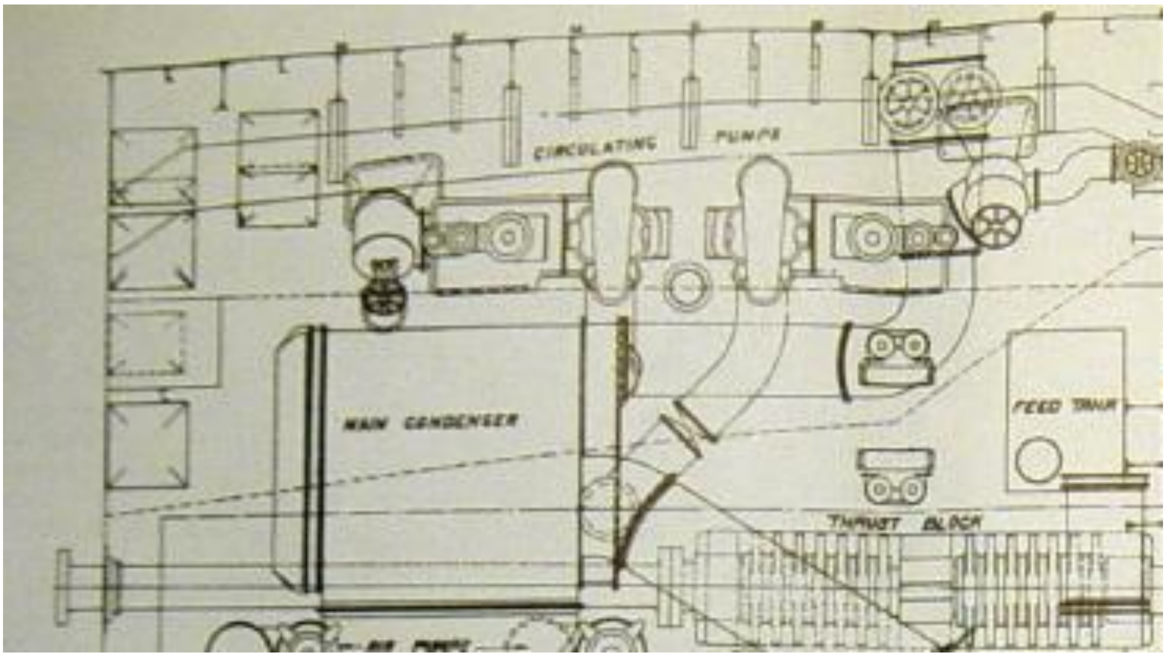


Figure 15: The main seawater pumps

Whilst opening the forward pump inlet valve, we will also open the two massive seawater discharge valves from the condenser, shown outboard of the inlet valves of the forward pump.

Starting the compound engines is the same as the other reciprocating engines; open the exhausts to the contact feed heater, drain the lines from the engineroom, open the cylinder drain cocks and crack open the main steam valve. Once the drains are clear of water we admit more steam until the pump starts to turn the crankshaft and thence the pumps themselves. As the pump gathers speed the seawater pressure gauge on the pumps and the condenser discharge start to show the differential pressure across the condenser. If this is too high a differential, it means the tubes are becoming blocked with weed, shellfish, the odd Coke can (was Coke around then in cans?) and bits of mashed fish. We assume that the differential is satisfactory as the ship has just been towed out of dry-dock where the tubes were thoroughly cleaned.

The exhaust from these pumps will condense in the contact feed heater and mix with the feed water drawn by the boiler feed pumps, which will increase the temperature of the feed to the boilers. We are starting to get a bit more bang for our buck; and the less coal our men have to shovel, the better.

Going across to the starboard side, we start the pumps on that side in the same way, also exhausting to the contact feed heater.

***Note**: The condenser overboard discharges are the large discharge that can be seen on any steamship up to the present day.*

As a guide, the amount of seawater required to condense the steam is 50 to 80 times the steam flow. With the reciprocating engines running at 75 revolutions per minute and 24 double-ended boilers on line, a supply rate of just over 260lbs of steam per minute per boiler would be produced, *or 260x24x60=374400lbs/hr. The amount of seawater would therefore be 50 to 80 times this amount, 8,300 to 13,300t/hr – very large pumps and in our case around 2,100 to 3,300t/hr each.*

The four pumps share this large volume in order to reduce the size of the machinery. Turbine ships of the period had pumps even bigger than this at some 5,000t/hr delivery.

6.2 Main air pumps (dual system)

The air pumps (called vacuum pumps these days) evacuate air and water from the condensers, with the air pumps extracting non-condensables and helping the vacuum in so doing. This improves the exhaust flow through the engines and also extracts the maximum energy from the steam. They are situated in the turbine room by the condensers and are of course steam driven. We start these in the usual way, and leave them to help draw a vacuum on the condensers (once steam from the main engines condenses}, usually around 28.5in with an atmospheric pressure of 30in. In modern day parlance these dual air-water pumps would be termed vacuum pumps and condensate pumps respectively.

In Figure 25 they can be seen inboard of the two condensers in the turbine room. Condensate from the waterside of the pumps is returned to the condenser or to the feed tank against the forward bulkhead in order to maintain the condenser level, with air being ejected to atmosphere. From these tanks the water runs to the hotwell tanks under the hotwell pumps either side in the main engineroom; these are the ones we got going earlier. We line up the valves on these air pumps and set them going, with their exhausts again going to the contact feed heater. We are finished in here and can leave the engineers in charge of the room to take over.

6.3 Main Dynamo exhaust change over

Now that the steam and feed system is up and running, we can extract the energy from the main dynamo engine exhaust by redirecting the steam to the surface shell-and-tube feed water heater shell, through the tubes of which the feedwater from the hotwell tank passes via the hotwell pumps on its way to the main feed pumps. This imparts heat to the feed water to avoid wasting the energy from the dynamo exhaust, which as the ship starts to get going is becoming quite considerable as the dynamos load up. Burning and turning…

By this time other engineers are starting up the hotel services systems, including the refrigerating plant. The refrigerating plant is used to chill the cold and cool rooms where the provisions, vegetables, meat, fish and dairy products are stored. Again the exhausts from these engines go to the contact feed heater.

6.4 Main engines

By this time the engineers whose station is in the reciprocating engineroom will have engaged the steam turning gear on both engines, and are oiling round the main, connecting and crosshead bearings and guides, as well as starting the forced lube oil pumps (steam driven of course) for the main bearings. Titanic's engines are open crankcase, so oil is also directed to oil pots by skilled oilers when the engine is running. The cylinder oil pots are also filled and set up to admit cylinder oil in a controlled amount. After turning the engine, the turning gear is taken out to avoid damage when the engine starts. We'll watch what they are doing to get the main engines ready for sea, and give a hand where necessary.

At first the main steam bulkhead stop valves on the forward engineroom bulkhead are cracked open until everything is warmed through, whence they can be fully opened. From the main stops on the forward bulkhead, the steam lines are warmed through in the usual way – water can damage the main engines, which is not a good career move for the aspiring future Chief Engineer. With all steam cylinder, valve chest and line drains open, the main steam throttle valves are cracked open, which admits steam to the engines via the slide valves. At this point the engine does not turn, and we wait a while until things warm through. The exhausts from both engines are open via the large changeover valves we saw in the turbine room earlier, direct to the condensers.

Once the cylinder drains are emitting steam, we can call the bridge and ask if the propellers are clear for a slow turn ahead and astern. Once this is given, the slide valves are put into the AHEAD position via the steam driven reversing engine, which sets the reversing gear to the full ahead position. The main steam valve control valve is then cracked open further. The engine will start to turn ahead at low revs, but the engineer is ready to shut off the throttle if the engine speeds up too quickly. After a few turns ahead the control valve is closed and the reversing gear set to astern position using the steam reversing engine. Again the throttle valve is cracked open and the engine is turned astern for a few revs at low speed.

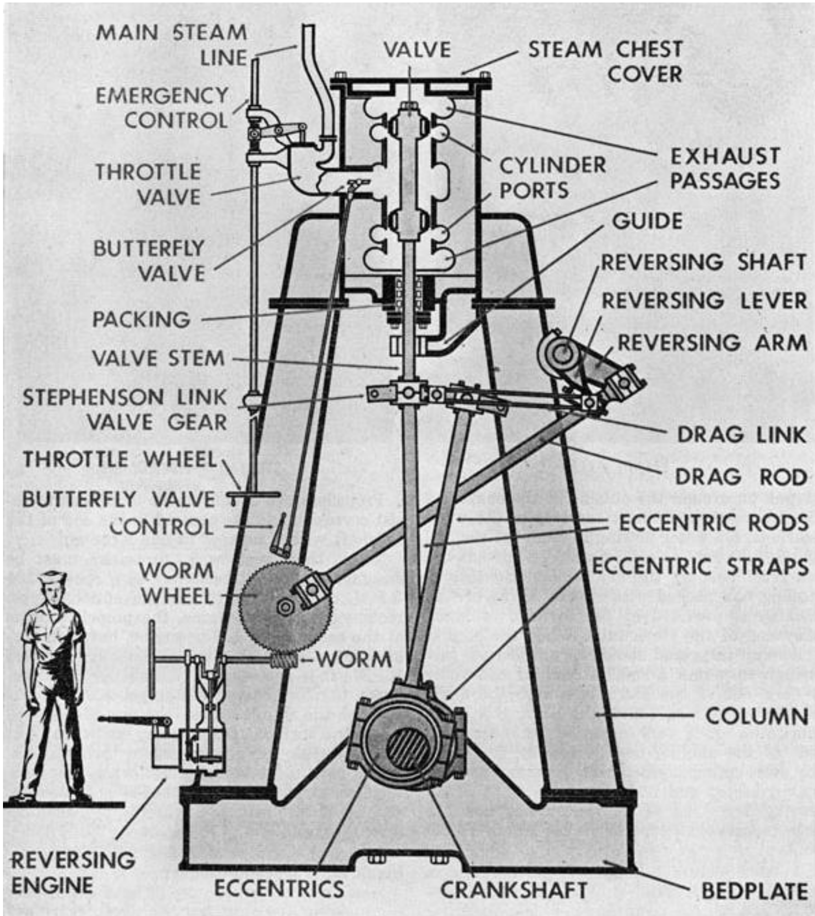


Figure 16: Reversing engine and gear (Wiki)

In the above drawing, the small steam-reversing engine moves the link gear from ahead to astern and vice versa via a crank and worm. On small engines the links are moved by hand, but on large engines the link gear is heavy and is therefore moved via a small steam engine.

We are about ready to go, and test the communications between the engineroom, boiler rooms and bridge that we are ready for sea service. Around the same time an engineer is dispatched to the steering engine room to warm through the steam steering engines and test the rudder from midships to 30 degrees port, back to 30 degrees starboard then returning to midships. Clocks are synchronised between bridge and engineroom.

7 The Feedwater and Condensate system

Before Standby is rung on the telegraphs we can take a look at what's happening in the feedwater system. Referring to the drawing in Figure 19:

Condensate from the bottom well of the condensers is pumped via the waterside of the dual pumps into the feed tanks on the forward bulkhead of the condenser room. From there it drains to the hotwell tanks either side in the forward engine room.

The hotwell pumps draw from these tanks and pump the feedwater through two feed heaters, after first sending it through filters to remove oil, grease and other impurities.

7.1 Surface feed heater

The first is a shell and tube surface feed heater, where the feedwater passes through the tubes. As mentioned above, the exhaust steam from the main dynamos at about 5psia passes through the shell of this heater, and imparts its energy to the feedwater, raising it from around 70°F to 140°F (21°C to 60°C), the exhaust condensate from the shell being pumped into the feed downstream of the heater by a mono air pump.

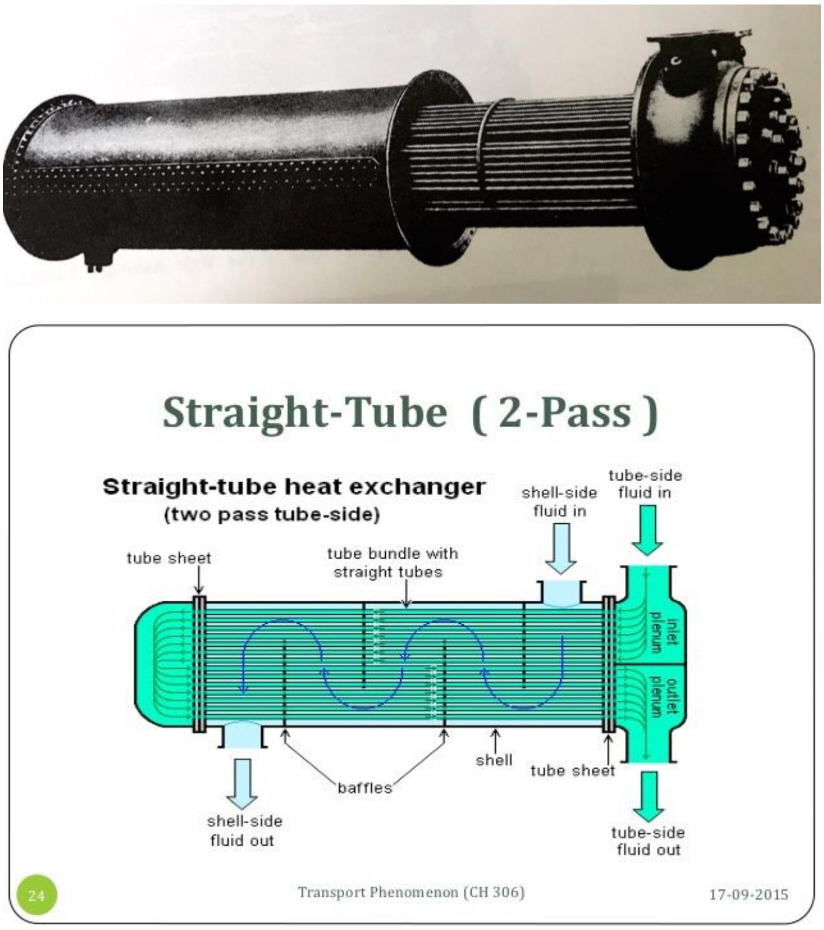


Figure 17: Surface shell and tube feed heater

7.2 Contact feed heater (deaerator)

The 2nd of the two feed heaters is a contact heater where the feedwater comes into direct contact with exhaust steam from the many engineroom auxiliary pumps and refrigeration units. It is situated high in the engineroom on D Deck and acts as a deaerator once the air vent at the top of the heater is opened up to the main condenser to extract non-condensable gases (CO2 and O2), which can cause corrosion problems in the boilers. This exhaust steam input condenses in the feedwater stream – thereby adding it directly into the feedwater - and raises the temperature of the feed water from 140°F to 230°F (60°C to 110°C). At low load it may be necessary to use live steam into the heater, depending on the energy available from the auxiliaries. This live steam comes from the main steam lines within the engineroom.

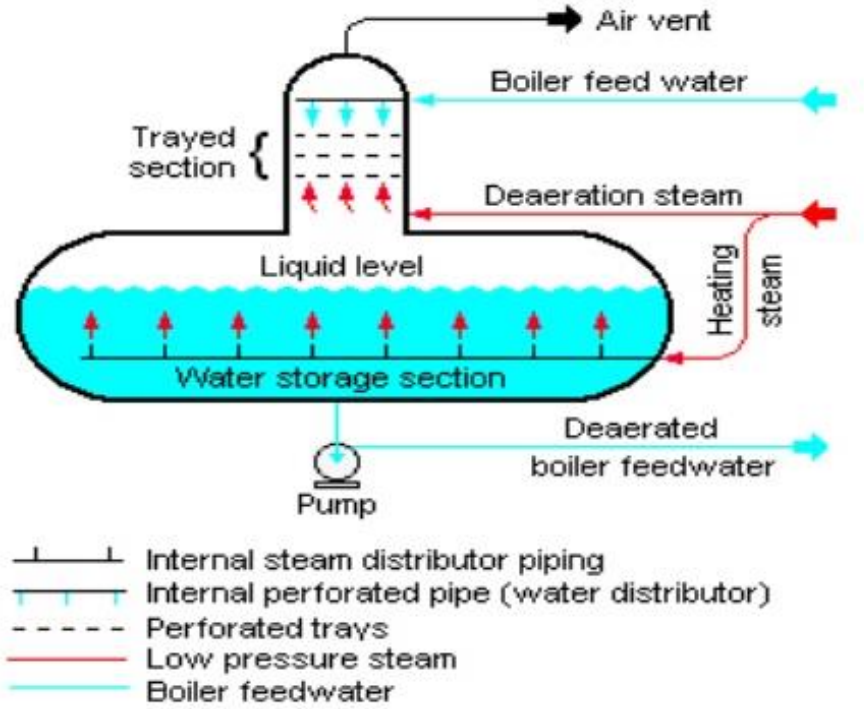


Figure 18: Contact feed heater or deaerator (Wiki)

The feed heater above shows the live heating steam and exhaust steam combining in the vessel, such that it mixes with the feed water entering at the top. The vessel is high up in the engineroom in order to give a better head (NPSH) for the feed pumps. Whilst the picture shows a horizontal vessel for clarity, these ships had vertical vessels operating on the same priciple.

7.3 Boiler Feed Pumps

From the contact heater the feed water is then extracted under gravity by the steam-driven main feed pumps and sent to the boilers as required. Titanic did not have automatically operating feed control valves, so this was a manual operation. The height of the contact heater ensures that there is sufficient positive suction head for the main feed pumps that feed the boilers. In Figure 19 is a schematic of the propulsion steam, feed and condensate system described above, © Sam Halpern.

All is now ready to go, with the stokers bending their backs to raise steam on all the boilers required for leaving port.

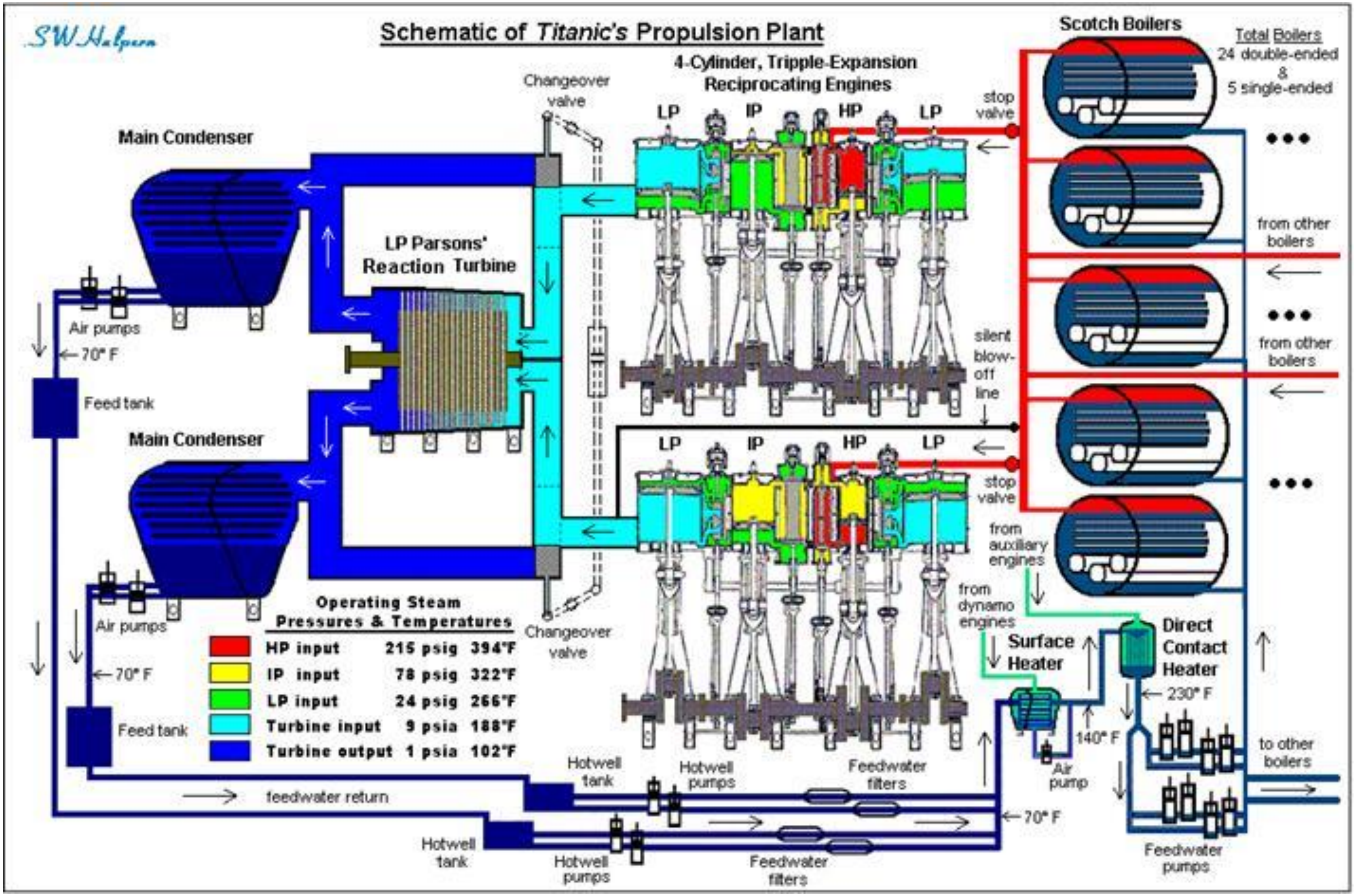


Figure 19 Propulsion steam, feed and condensate system, © Sam Halpern

8 Getting under way

8.1 Manoeuvring main reciprocating engines

We are back down below again for another watch, this time in the reciprocating engine room. Your job is on the Starboard Main Engine throttles, situated inboard of the engine in the middle. You are probably a bit overawed by the responsibility for driving these large items of machinery, but fear not, you are not on your own. The Chief Engineer is obligingly breathing down your neck as an aid to concentration. Try not to look him in the eye. Alongside you is a Junior Engineer whose task is to answer the telegraph and fill in the Movement Book. Oilers and greasers are about on the engine middles and tops making sure everything is lubricated, and engineers are standing by to observe any signs of overheating, odd noises or smells. Even with the advanced electronic watchkeeping devices in this day and age, these three senses are not easily replicated by automation.

The telegraphs ring! Standby Main Engines. The Junior enters this and the time in the Movement Book. You wipe your hands on your boilersuit and try not to fondle the reversing engine control overmuch.

Your telegraph rings again – makes you jump: Dead Slow Ahead. As the reversing gear is in the mid (stop) position, you move the reversing engine lever to ahead. The steam cylinder whirrs up and down, and the reversing gear moves across to the full ahead position with no “cut off”*. You crack open the throttle (all the drains are open, lots of people around the check them out) and the main engine starts to turn ahead with a satisfying hissing sound (these things are quite quiet compared to their diesel engine cousins). You watch the revolution counter to make sure the engine does not exceed the required speed, adjusting the throttle valve accordingly. The engine responds to your commands most satisfyingly.

The bells ring again – STOP! Shutting off the throttle, the engine comes slowly to a halt. You don’t know what the next command will be, so leave the reversing gear in the ahead position.

Jangle jangle! Slow Astern! You move the reversing engine lever to astern, the engine huffs away and moves the reversing gear into the full astern position with no “cut off”*. Opening the throttle – there is a pointer on it, which shows the approximate revs – you move this pointer to the Slow Ahead point and observe the revolutions on the rev counter, making alterations as necessary. The engine runs smoothly astern with a little vibration felt (propellers are not so efficient astern as they are ahead).

The bells ring – STOP! You swing the throttle smartly closed and the engine comes to a halt.

As the vessel departs the berth, the engines are used to help the tugs move the ship in the right direction. At these speeds the rudder is of little use, as it needs a fair bit of water past it in order to react to helm orders. You carry on answering the telegraph orders as the ship clears the port.

As the ship clears the pilot station, the pilot shakes hands with the Captain and returns to the pilot boat, and once clear, the telegraphs ring again Full Ahead on both main engines. We are still on standby, so this is a manoeuvring full ahead at lower revs than those required on passage, about 50%. The ship has a long way to go until Southampton Roads and the Isle of Wight are cleared, and we have yet to stop at Cherbourg and Queenstown in Ireland.

Fast forward to leaving Queenstown and heading for the open sea. We are not quite finished yet – we have one more job to do in the turbine room. Leaving the watchkeeping engineers at the throttles, we go aft through the watertight door into the turbine room.

Note on "cut-off": *For a full explanation, try Wikipedia or similar site ([Steam engine cut-off]).*

Steam is admitted to a steam reciprocating engine cylinder via a shuttle or inlet valve, which controls both the amount of steam and the direction of the engine, both being achieved via the reversing gear. The latter changes the aspect of the inlet valve to match the horsepower needed to drive the engines at their maximum efficiency, using the expansion of steam rather than using steam for the whole of the piston stroke. When starting the engines from rest, no cut-off is used, as maximum torque is required to overcome the mass of the ship at rest. This means that the reversing gear is hard over in the ahead (or astern) position. Once the ship gathers way the load on the engines reduces, so to save steam the reversing gear is wound back to cut off the admission of steam at a certain percentage of full valve travel. This way the steam admitted is allowed to expand to do work on the piston. E.g. a 25% cut-off means that steam is cut off at 25% stroke, with the remaining 75% being under expansion of the steam. In heavy weather the load on the propellers and therefore the engines will increase, and may result in the engine revs dropping, as there is insufficient steam pressure to handle the load. Under these circumstances the cut off is increased to allow steam later in the stroke to increase the torque. This is analogous to a car requiring more accelerator to maintain speed when it reaches a hill.

8.2 Starting the Low-pressure turbine

With the ship up to 50% power or more ahead, and prior to full away, the low-pressure turbine is warmed through, with its exhaust directed to the two condensers. At the moment the main engines are still exhausting direct to the condensers, so we operate the huge changeover valves (themselves steam engine driven as they are so big – see Figure 25) - to direct the exhaust steam from the reciprocating engines to the low-pressure turbine, on the shaft of which is the centre propeller. The turbine will work up to speed, governed by the exhaust steam pressure (the turbine also has an over speed device which works on the changeover valves to avoid damaging the turbine if it overspeeds for any reason).

The main engine exhausts are now driving the low-pressure turbine and full power can be worked up once full away is rung on the telegraphs. This novel method of propulsion is quadruple expansion, with triple expansion through the reciprocating engines, and the final 4th expansion through the turbine. It was considered to be an economical method in such a big ship and indeed by the end of her life, the Olympic was performing better than she had when new, with a much lower fuel consumption than the Mauretania (turbine driven) which was a much smaller ship, and only a few knots slower than Mauretania; quite a price to pay for an extra 48 miles per day.

The bridge now takes us off standby by ringing down "Full Away on Passage" normally signalled by ringing the telegraphs from Full Ahead to Half Ahead and back to Full Ahead again. The Junior assiduously notes "FAOP" and the time in the Movement Book, and his job is done; the Chief Engineer departs to work out the amount of coal used from standby to FAOP and write it up in the Company Abstract.

The new watch are coming down below, going through the boiler rooms which are now a miasma of coal dust, intense heat, white hot furnaces and the constant back-breaking labour of feeding enough coal into the gaping maws of the furnaces to keep the ship at full sea revolutions. There is coal strewn about the stokehold floor despite the trimmers' efforts to keep it clear, ash is being hosed down into the ash chutes, one furnace on each boiler is being drawn and cleaned of ash and clinker at the end of the watch, with the bars coaled ready for the new watch to light up – a continuous routine for the whole of the passage across the Atlantic. Not for the faint-hearted.

Meanwhile up top the moneyed classes are sitting down to dinner to the strains of the ship's orchestra, waiters are flitting noiselessly about, tending to the passengers' every need, under the watchful eye of the headwaiter. Cooks are beavering away in the huge galleys, producing meals for over 2000 people 24 hours a day, bakers baking bread, confectioners producing glorious works of art in pastry, cream and chocolate. Even higher up, as the ship sails into the setting sun, the watchkeeping officers on the bridge are checking the ship's course, ensuring the steaming lights are lit, that the lookouts are awake, and sipping a mug of hot chocolate – or "kai" in naval parlance; most if not all are commissioned officers in the Royal Naval Reserve, as is the Captain, which is the reason most of these ships flew the Blue Ensign instead of the Red Ensign.

All is peaceful as night falls; a young lady pauses to admire her reflection in a dining saloon mirror, unaware that on the other side of the decorated bulkhead are the uptakes from the boilers where, down below in the Dante's Inferno of the boiler rooms, teams of sweating men are pouring coal on the furnaces. But no one above has any interest in that, and it's doubtful even if they understand what makes this leviathan pass through the water at such a breath-taking speed - it just does, right? But we know better…

We are also done, it's the end of our watch again, and we've been down below on a coal-burner for over 12 hours, and it's time to go to bed before having to get up again 8 hours later and continue our watch over the machinery of this great ship. In the case of Olympic, she served for 24 years and a World War with hardly a hitch, and got more efficient as she got older. By the time of her retirement, Olympic had completed 257 round trips across the Atlantic, transporting 430,000 passengers on her commercial voyages, travelling 1.8 million miles.

Her two sisters were not so lucky as we all know.

RIP Titanic and Britannic, both of which are still with us in their watery graves.

PLATES FROM THE PUBLICATION "OCEAN LINERS OF THE PAST, OLYMPIC & TITANIC (1911)

(With notes to explain the various items of equipment fitted)

Elevation of boiler rooms

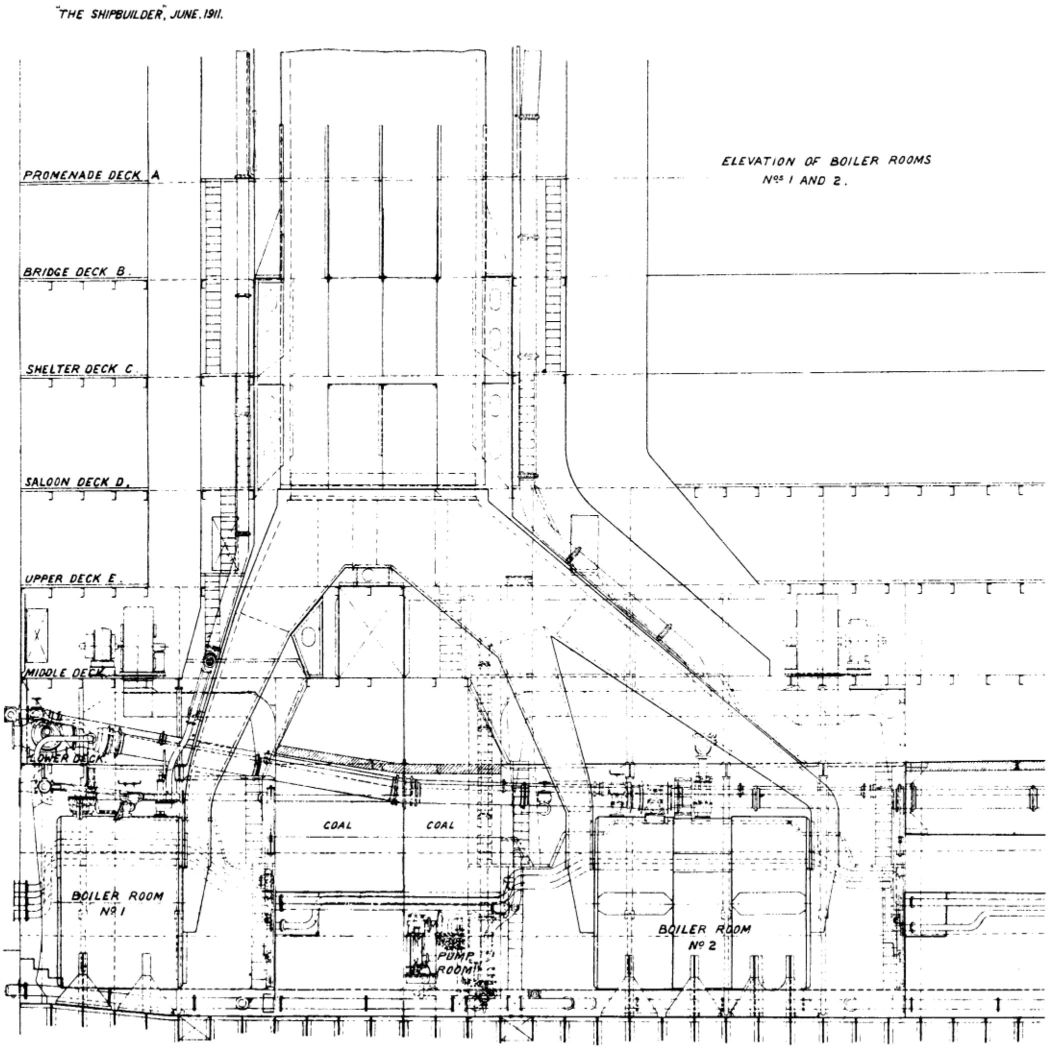


Figure 20 Boiler Rooms 1 & 2

Here you can see the No 1 Boiler Room single-ended boilers with the coal bunker forward, opposite the furnaces.

Also shown is the main steam pipe that is routed throughout the ship from No6 Boiler Room (foremost) to the engineroom.

On the deck above can be seen the Sirocco fans that are used for ventilation of the stokeholds. The boilers themselves are fired on "Natural Draft", with the stokehold pressurised by the fans. Where the combustion air is ducted via trunking into the boiler furnace, this is termed "Forced Draft", as employed on Cunard vessels of the era.

Electrical Generating Room

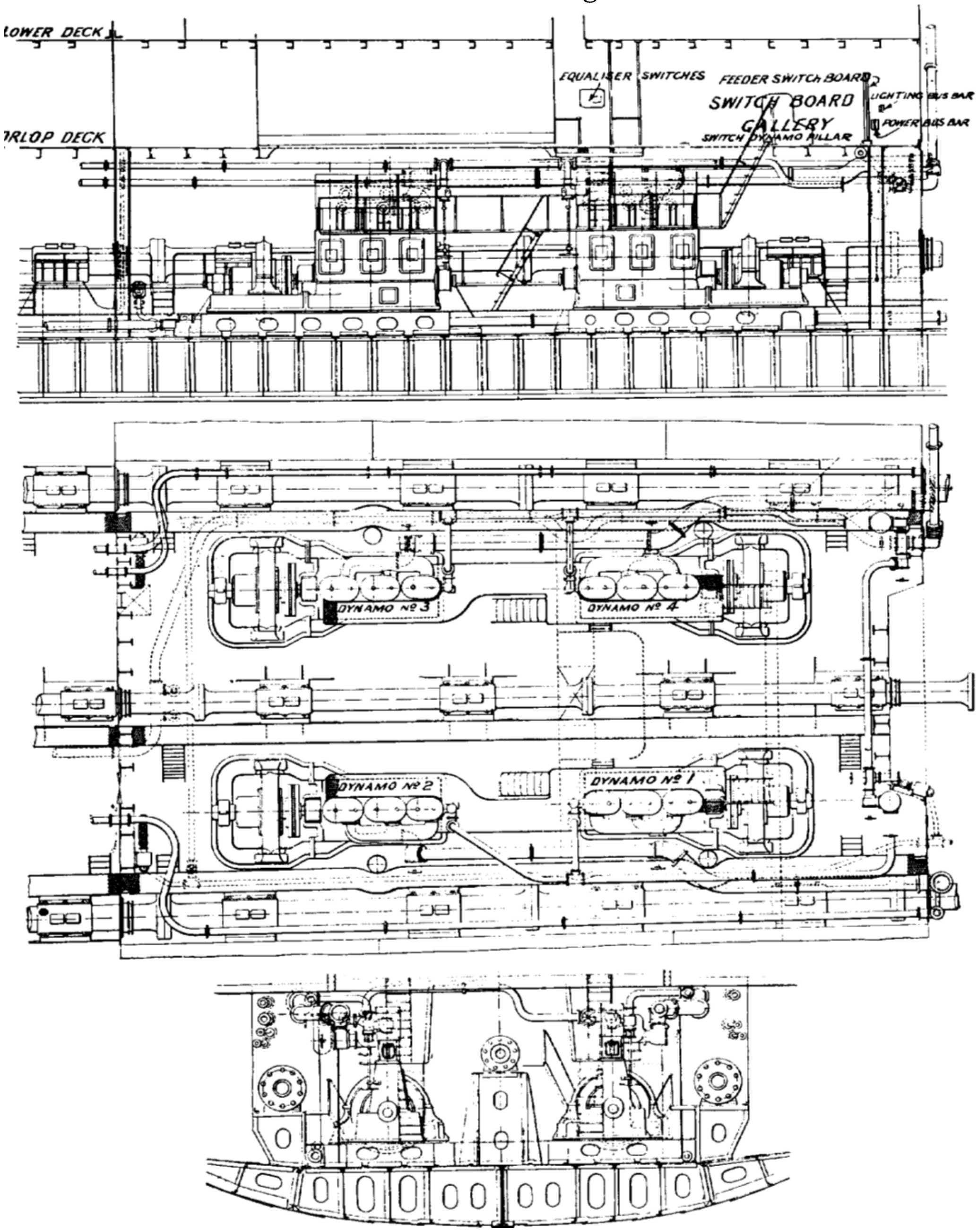


Figure 21 Electrical Generating Room

This view shows the main dynamo room with the 4 x 400kW dynamo sets. You can see the three propeller shafts passing through this room in the views.

In the profile view you can see the main switchboard gallery above the sets. Engineers and electricians on watch can see from there down to the dynamos below.

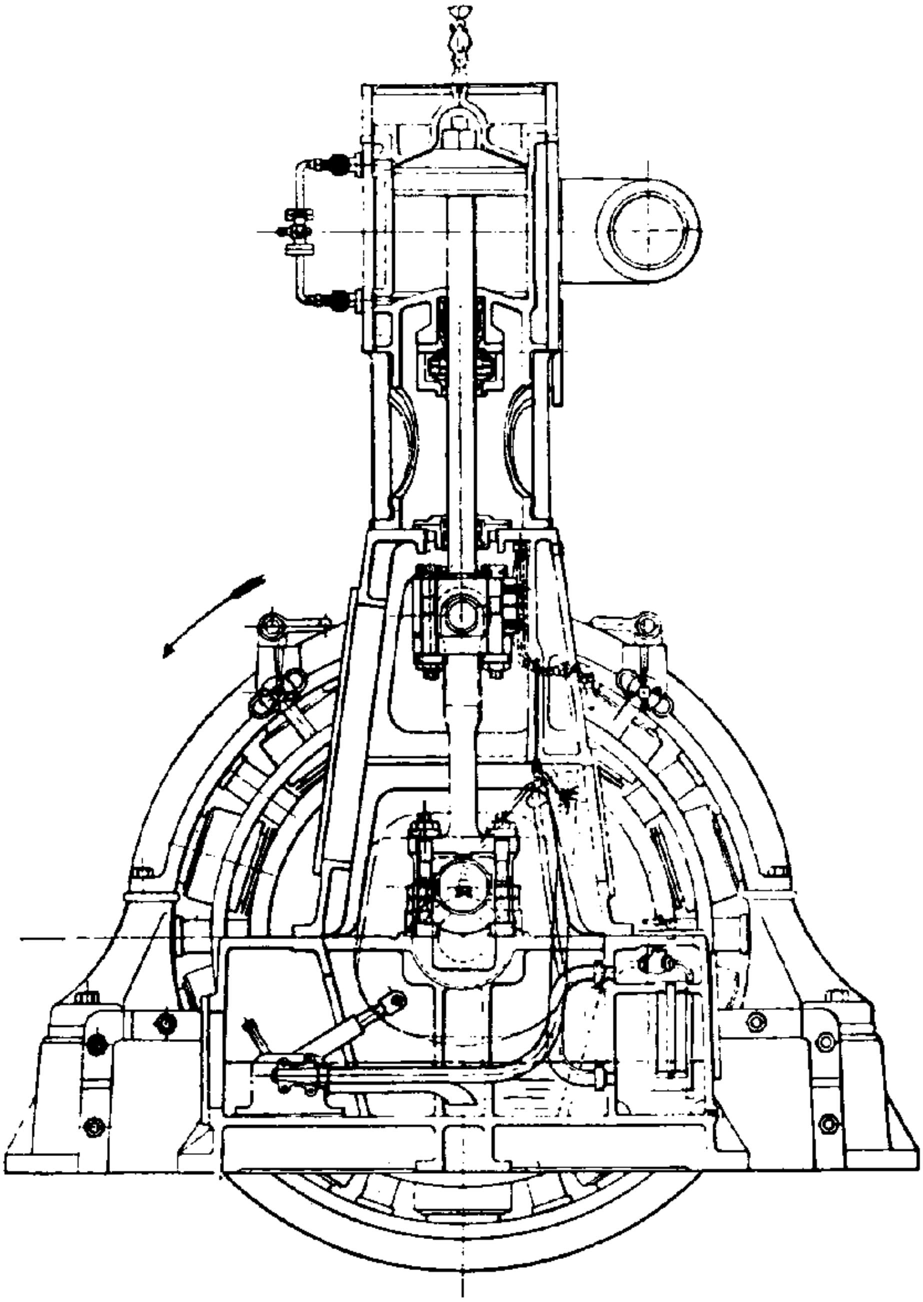


Figure 22 Sectional View of Main Dynamo Set

This is a compound reciprocating crosshead type engine driven DC dynamo of 400kW. The emergency sets are similar though smaller. They are closed crankcase machines with forced lubrication from an engine-driven pump.

Main switchboard in the electrical shop

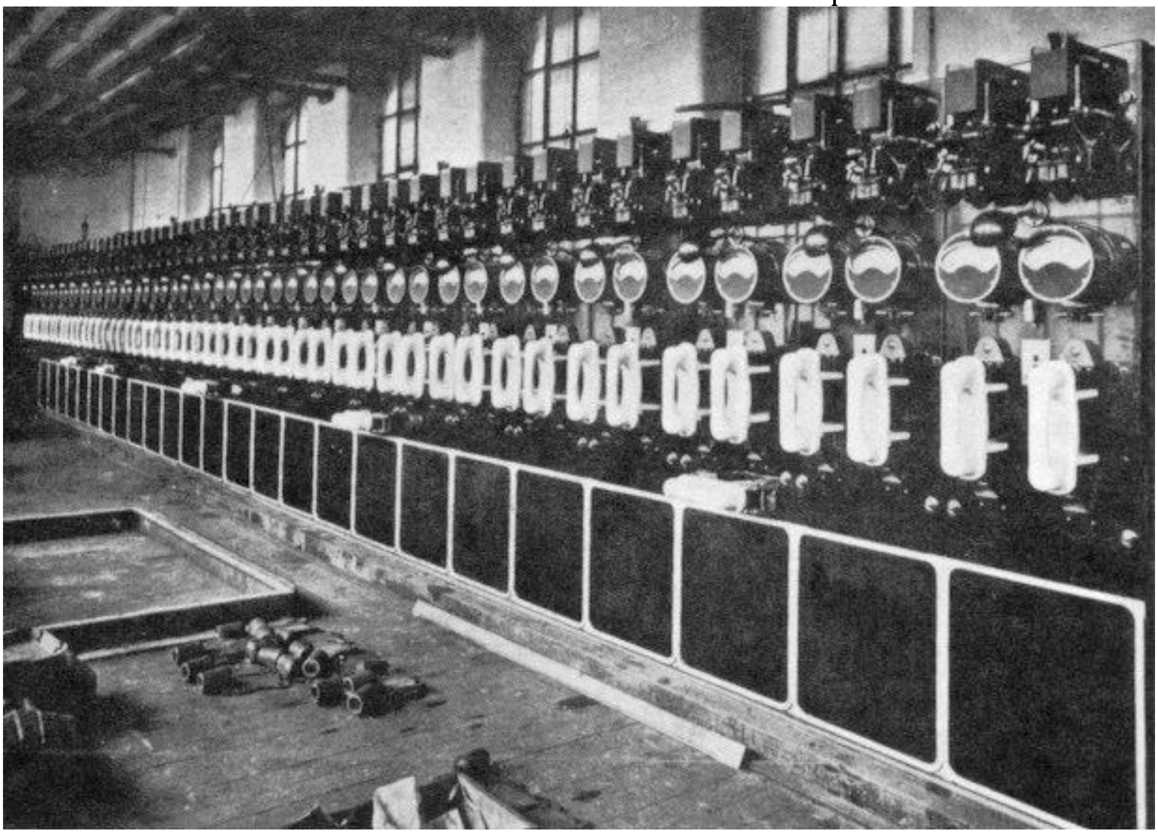


Figure 23: Main Distribution Switchboard

This view of the main switchboard in the assembly shop shows the extent of the electrical distribution around the ship.

At the top are the breakers, under them the voltmeters and ammeters, and below them the large porcelain fuses.

Main Dynamo Control Panel and Breakers

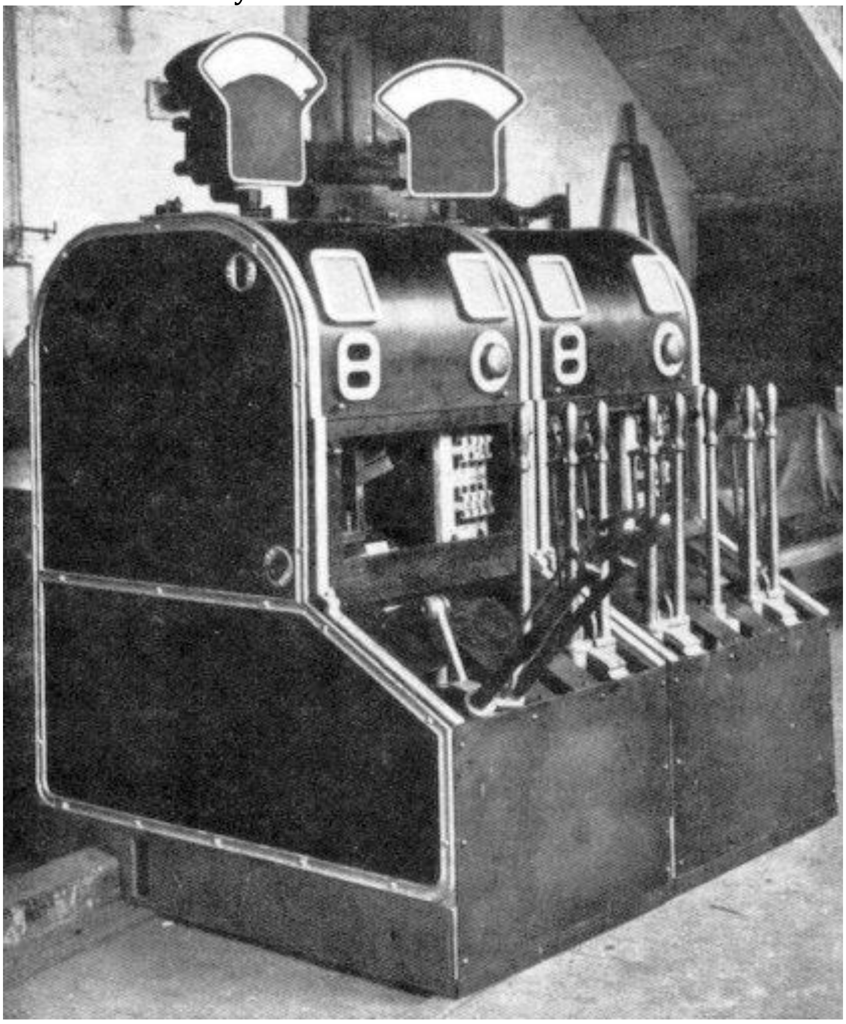


Figure 24 Main Dynamo Breaker Control Panel

Unlike more modern ac and dc switchboards, which have the dynamo breakers integrated with the switchboard, Titanic's dynamos had their own control panel and breaker switches. The shunt field regulators for increasing and decreasing the voltage and loads are on this panel, which serves two of the main dynamo sets.

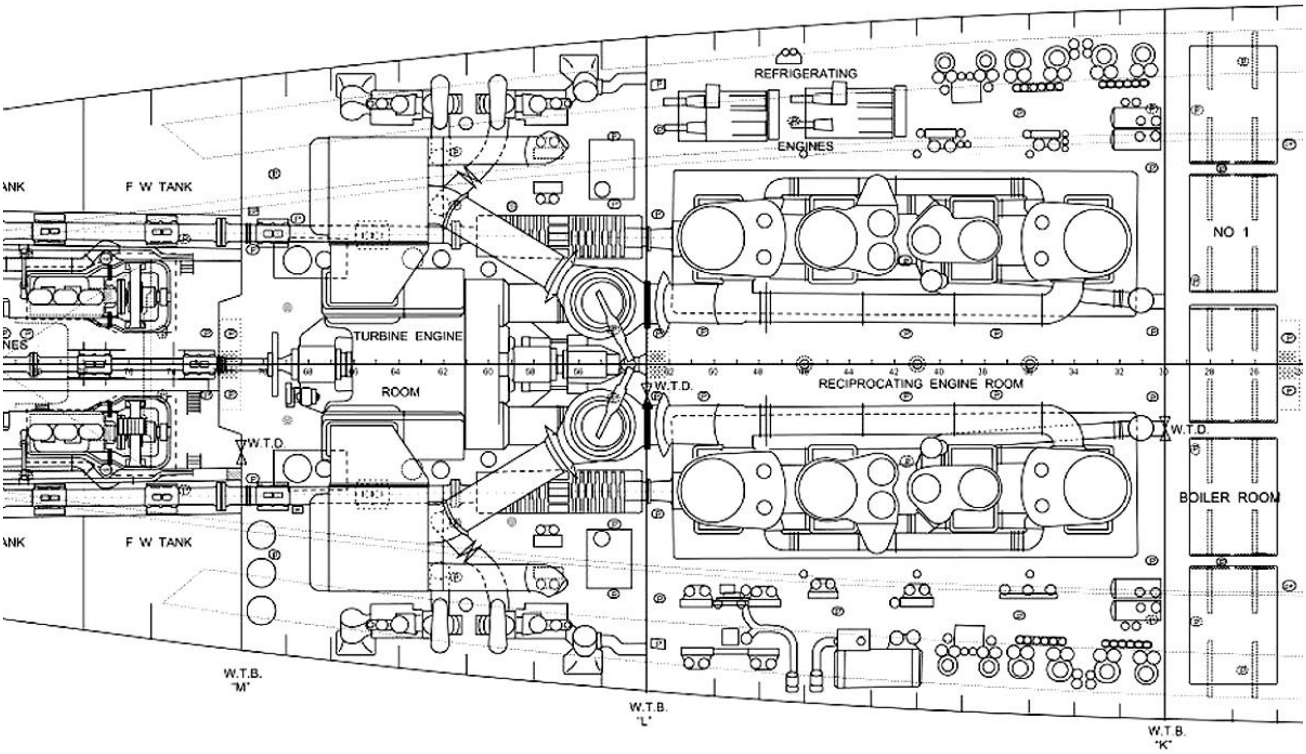


Figure 25 Main and Turbine Engine Rooms

Zoom in to see this picture more clearly.
In the main engineroom can be seen:

1. The two reciprocating main engines arranged port and starboard, with the steam lines coming through the watertight bulkhead aft of No1 Boiler Room
2. The auxiliary condenser with the auxiliary seawater circulating pump situated below it
3. The hotwells and hotwell pumps that transfer the feed water to the feed heaters via the filters, seen against the forward bulkhead port and starboard
4. The auxiliary air pump that creates a vacuum on the auxiliary condenser
5. The main feed pumps that draw from the contact feed heater above the engineroom and discharge to the boiler feed lines and thence to the boilers
6. Auxiliary pumps such as forced lube oil, bilge, ballast, fire and general service
7. Refrigeration machinery on the port side outboard

In the turbine room can be seen:

1. The low pressure turbine driving the centre propulsion shaft and propeller
2. The huge changeover valves to divert exhaust steam from the main engines to either the condensers direct, or via the low-pressure turbine. The arms shown on top of the valves are part of the steam driven machinery that operates them as they cannot be shifted manually
3. The main condensers either side of the turbine
4. The main seawater circulating pumps outboard on both sides
5. Condenser feedwater tanks
6. Dual water-air pumps (condensate and vacuum pumps)