RMS Empress of Britain 1931

Owners: Canadian Pacific Steamships Ltd

Builders: John Brown, Clydebank

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1. Overview of machinery spaces

1.1. Boiler rooms

The ship is (or was) a quadruple screw Canadian Pacific liner fitted with two Scotch fire-tube boilers at 200lb/in^2, one Johnson water-tube boiler and eight Yarrow 5-drum water-tube boilers, operating at 425lb/in^2, 725°F superheated. In SI units this converts to 13.8bar saturated (198°C) for the Scotch boilers, and 29bar, 385°C superheated. At 29bar the saturated temperature is 234°C, so the boilers operate at 151°C superheat.
The boilers are arranged in 2 boiler rooms, one forward and one aft, separated by oil fuel tanks.
In the forward boiler room are the 2 Scotch boilers, the Johnson boiler and two Yarrow boilers. In the aft boiler room are the remaining 6 Yarrow boilers. A profile and plan of the boiler rooms is shown at Figure 15

1.2. Oil bunkers

The boiler oil fuel bunkers are arranged between the forward and after boiler rooms, and comprise 4 storage and 4 settling tanks. The latter separate oil from water and other solids by gravity, and are regularly sludged to remove the water prior to it being pumped to the boiler oil-firing apparatus. The oil-firing or burner pumps are arranged between each pair of Yarrow boilers.

1.3. Diesel fuel bunkers

Diesel fuel for the generators is stored in double bottom tanks under the generator room. The fuel from these tanks is drawn via the diesel transfer pumps located midships and discharged into service tanks on the forward bulkhead of the diesel generator room (aft of the after boiler room). There does not seem to be a diesel purifier on the ship drawings, so presumably the reasonably clean diesel fuel was passed to settling tanks to drain off the water – probably the two tanks shown on the port outboard side – before being pumped to the service tanks. From there filtration would clean the fuel of any other solid impurities prior to injection into the cylinders.

1.4. Propulsion engines

The propulsion system differs from the older vessels in this series as the turbines are arranged for triple expansion in each turbine set. The turbine sets each comprise an hp (high pressure), ip (intermediate pressure) and lp (low pressure) turbine working each shaft. Astern turbines are fitted on the inner two shafts only, the outer shafts being only for ahead running. The reason for this is that 2/3 of the vessel's propulsive power is provided by the inner sets of turbines working together, with 1/3 of the power delivered by the two wing turbine sets operating together.
The vessel is innovative in that she is designed for transatlantic service on all four shafts at maximum power in the winter months, and for summer cruising on the inner turbine sets, with the propellers removed from the outboard shafts. The cruising speed of 18knots is achieved at about half the consumption of all 4 shafts running together, a very economical design.
The ship has a very comprehensive redundant system for running the turbines together or in isolation, but the normal triple-expansion arrangement will be described below.

1.5. Main steam piping (Figure 1)

Each bank of three boilers in the after boiler room supply a steam line (two lines in all) and two steam lines from the forward boiler room carrying the combined output of the three forward boilers.
Steam from these four main steam pipes passes through the diesel generator room and enters the forward engineroom via bulkhead stop valves operated by Brown's engines and governors from the turbines, which shut off the steam supply in the event of turbine overspeed.
From the stop valves, the outer steam pipes pass to the two turbine sets in the forward engineroom, the inner two pipes pass through the forward engineroom to the bulkhead stops on the after

engineroom bulkhead. From the stop valves on both the forward and after engineroom bulkheads, the steam passes to the turbine manoeuvring valves in each section.
From the manoeuvring valves the steam passes through each turbine stage and finally exits to the condensers from the lp turbine exhausts.
This exhaust steam from the low-pressure turbines is directed to the four vacuum condensers, situated under each of the four turbine sets, where it is condensed into feed water and pumped back into the boilers.
Manoeuvring from ahead to astern is carried out solely using the forward engineroom ahead and astern turbines, with the wing turbines – which do not have astern turbines fitted - used for working up to full speed on North Atlantic service. The turbines may be isolated in case of breakdown.
For cruising operations in the summer months, the outboard engines are not used, the shafts having their propellers removed to reduce drag. This results in a significant reduction in fuel consumption at the expense of unnecessary speed, the latter only being required on the North Atlantic run.
Regulating valves, driven by worm and quadrant gear via spindles operated from the starting and manoeuvring platform, admit steam to the engines as required by the telegraph orders.

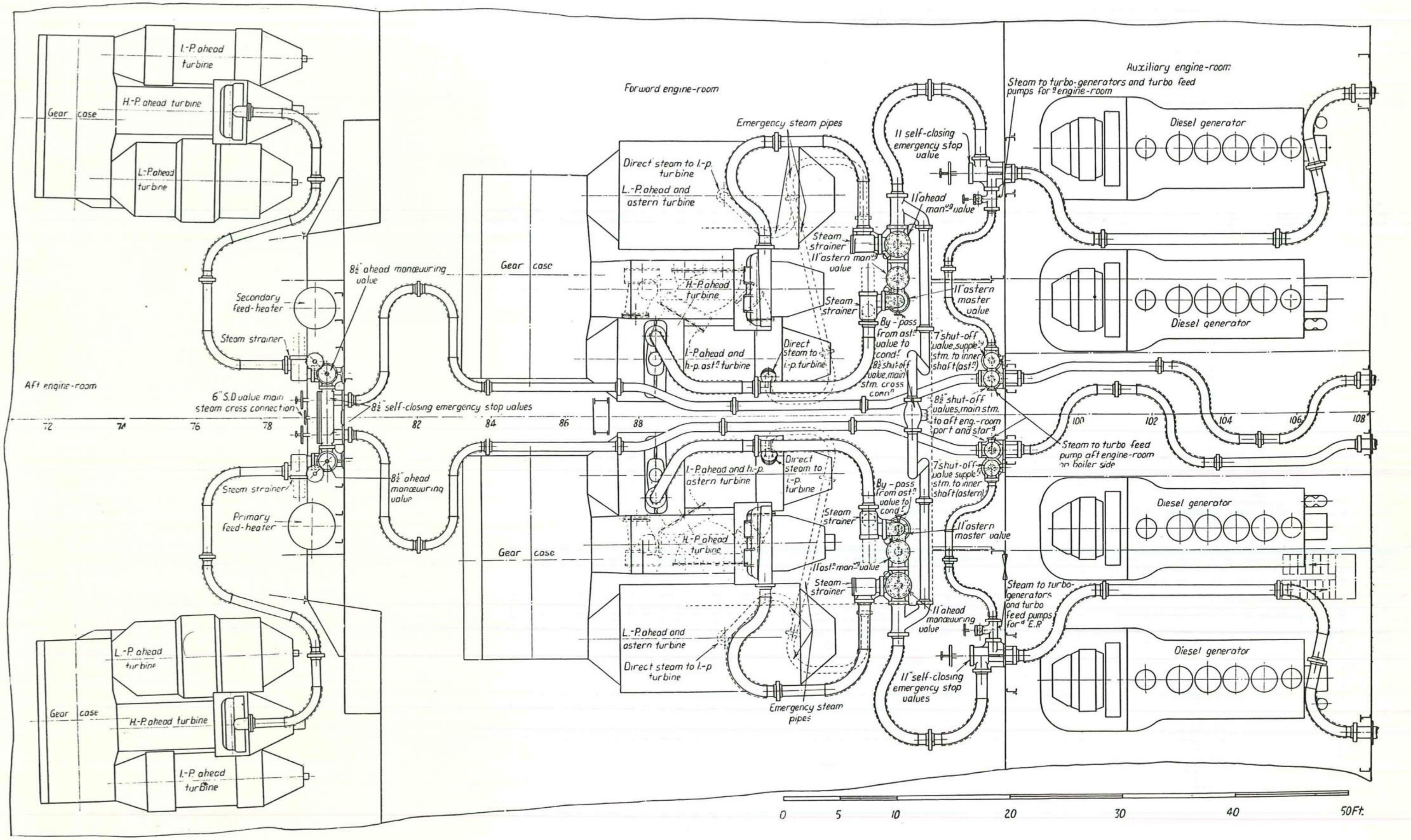

Figure 1 Plan of steam piping in enginerooms

1.6. Gearboxes

Unlike the previous two turbine-driven ships, which were direct drive owing to the slower speed of the turbines with low-pressure saturated steam, this vessel has single reduction gearing via four gearboxes, one for each shaft, to cope with the speed of the turbines under superheated high pressure steam conditions.

1.7. Electrical power generation

i. Emergency generating sets

The vessel is fitted with two emergency diesel generators of 75kW each for emergency lighting, wireless telegraphy as well as some power circuits. These machines could be used for cold starting, providing the emergency switchboard has a connection for the FD fans, but with main diesel generators available, this is unlikely. We will use them here to get lighting and low power services running so that shore power can be disconnected.

The generators, when running under loss of main power, have a charging capability for the main and 'panic' battery banks. Under normal power the battery banks are charged from the main system.

The generators are electric start, so the engineers would start these machines and put them on the board, after which the shore power breaker can be opened.

Once the engines are started and put on the board, the various circuits required for starting the main generators are energised, up to the capacity of the emergency switchboard.

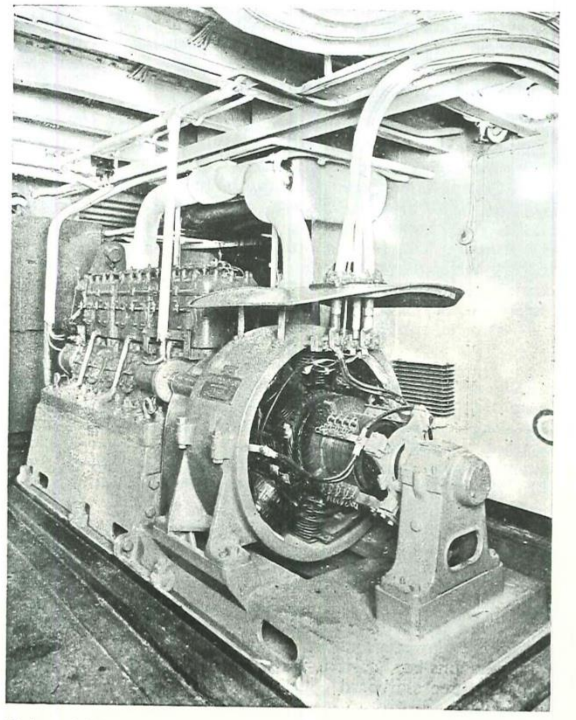

Figure 2 Emergency Generator set

ii. Emergency Switchboard

Attached to this board are the emergency distribution circuits. On this age of ship these are generally confined to –

- Emergency lighting (throughout the ship)
- Transition lighting (stairways, control panels and operating stations)
- Wireless telegraphy
- Small power (probably ventilation fans for accommodation and other hotel services)
- Battery charging (main and "panic" banks)

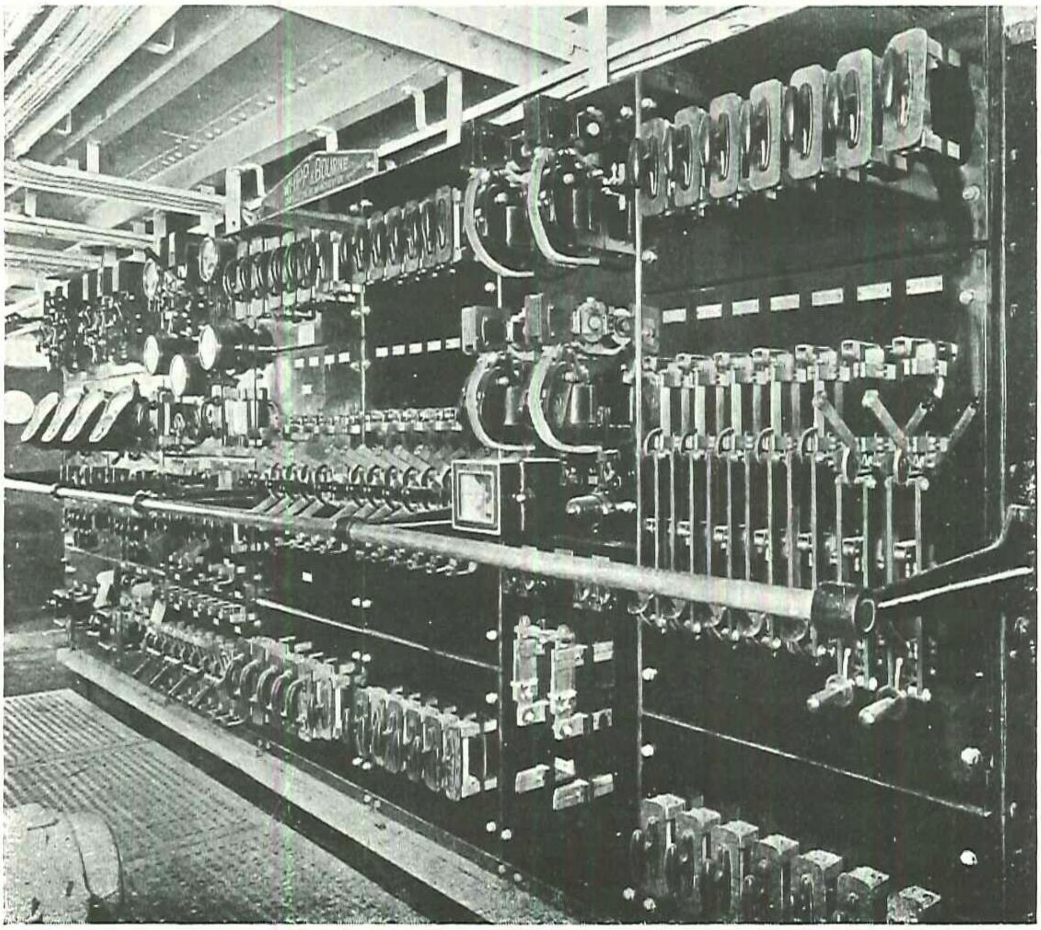

Figure 3 Emergency Switchboard

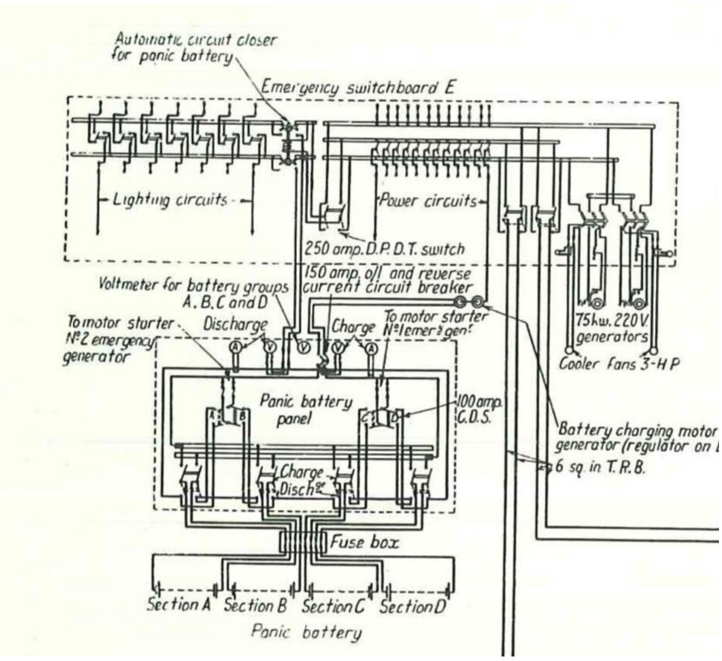

Figure 4 Emergency distribution system

iii. Main Diesel generating sets

The vessel is fitted with four 450kW 225Vdc diesel generators situated in the generator room between the after boiler room and the forward engineroom. These are large crosshead type engines, single-acting and with blast (air) injection, as opposed to the modern methods of fuel injection. A photo of one of the engines is shown below

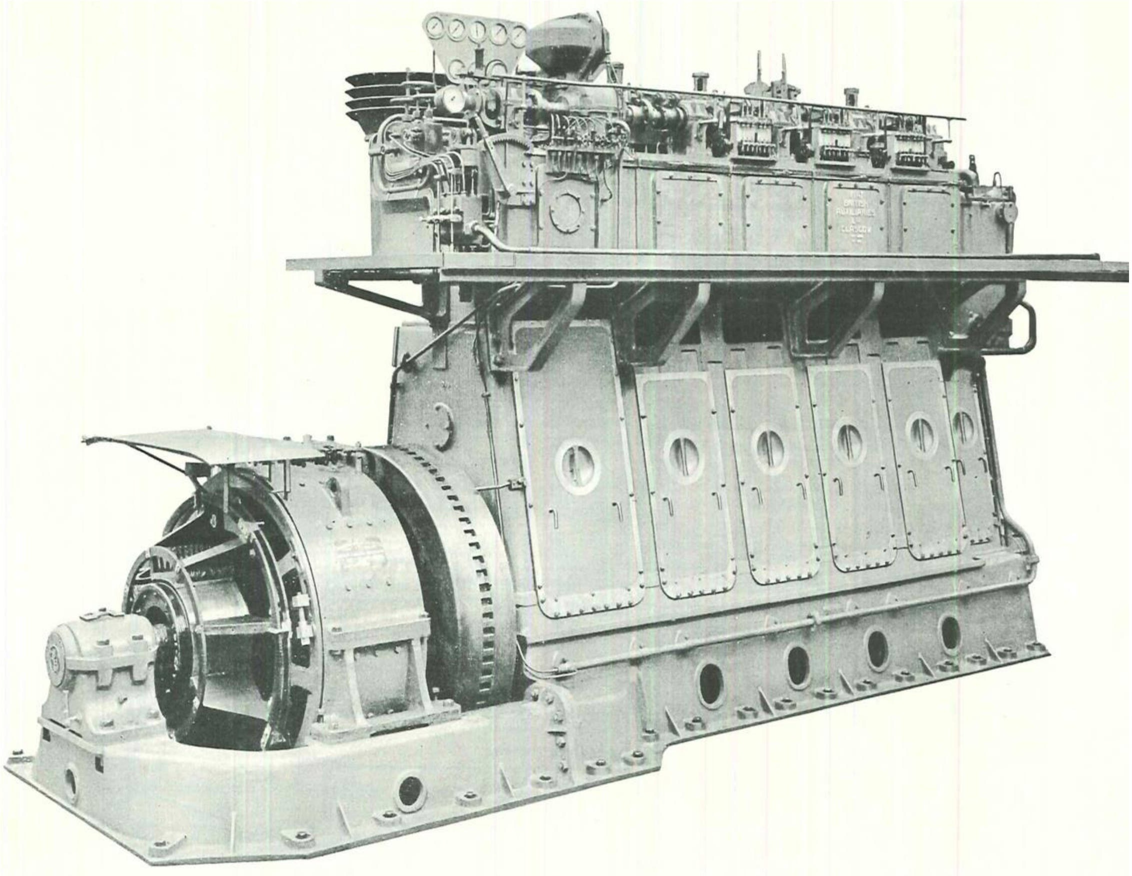

Figure 5 One of the diesel generating sets

iv. Turbo-Generator sets

In addition, there are two single-reduction geared turbo-generators driven by BTH steam turbine prime movers at 6000rev/min, each of 800kW 225Vdc. These sets are situated on turbine flats, one either side of the forward engineroom bulkhead, arranged longitudinally. The main and auxiliary switchboards are situated in a switchboard room on E Deck, above the diesel generator room.
Steam at a pressure of 375lb/in^2 and 700F is fed to the turbines and exhaust steam is directed in port or at start up to the auxiliary condensers. At sea the exhaust steam is directed to the feed heaters 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 3.4MWdc, with adequate stand-by redundancy.
Without knowing the actual full load of the vessel, the redundancy could be 2x100%, i.e. one turbine and two diesels (1.25MW) or 4 diesels (1.8MW) or two turbines (1.6MW). This sounds a reasonable load for such a ship, but the arrangement could be any permutations depending on the load. Whilst cruising on the centre shafts, the propulsion load would be less and therefore the electrical load would also be less, though if air conditioning was fitted for summer cruising, the additional load could take up the reserve.

2. Starting the main diesel generating sets

Unlike the other ships in the series, the fitting of main diesel generating sets only requires sufficient starting air to get the main power up and running, so there is no need to start firing boilers at this stage using the emergency sets. If starting air is not available, the auxiliary starting air compressor is started off the emergency supply and the starting air bottles charged up. The main diesels are fitted with an engine-driven seawater cooling pump for the jackets and oil coolers; not really a good idea as seawater is highly corrosive, especially so at the running temperature of a diesel. Nowadays engines are cooled by a central fresh water system, which is in turn cooled by raw seawater.
The engines are therefore self-contained, with the fuel supply being gravity fed from the diesel oil service tanks mounted on the generator room forward bulkhead. Once the engine turns over on air and fires, the cooling and lube oil systems start as they are also engine-driven. A compressor on one end of the engine shaft generates compressed air for the blast injection. The scavenge air compressor

(an early method of increasing the combustion air pressure prior to the advent of turbo-charging) is mounted on the other end to balance the forces and reduce vibration.
Main power is then available and the main breakers are closed onto the main switchboard.
At this stage, all the power required for starting the ship is available, with a turbo-generator being started once steam is available. As the main switchboard seems to be split with a turbo-generator and two diesels on each side of the board (see Figure 7), we will only start two diesels (port inner and outer) to give us 900kW of power available. Below is a section through the diesel engine space showing the arrangement of the engines 4 abreast, diesel tanks, air compressor and diesel transfer pumps. Of interest are the spare crankshaft and armature, probably carried for when the ship is cruising far from her home ports.

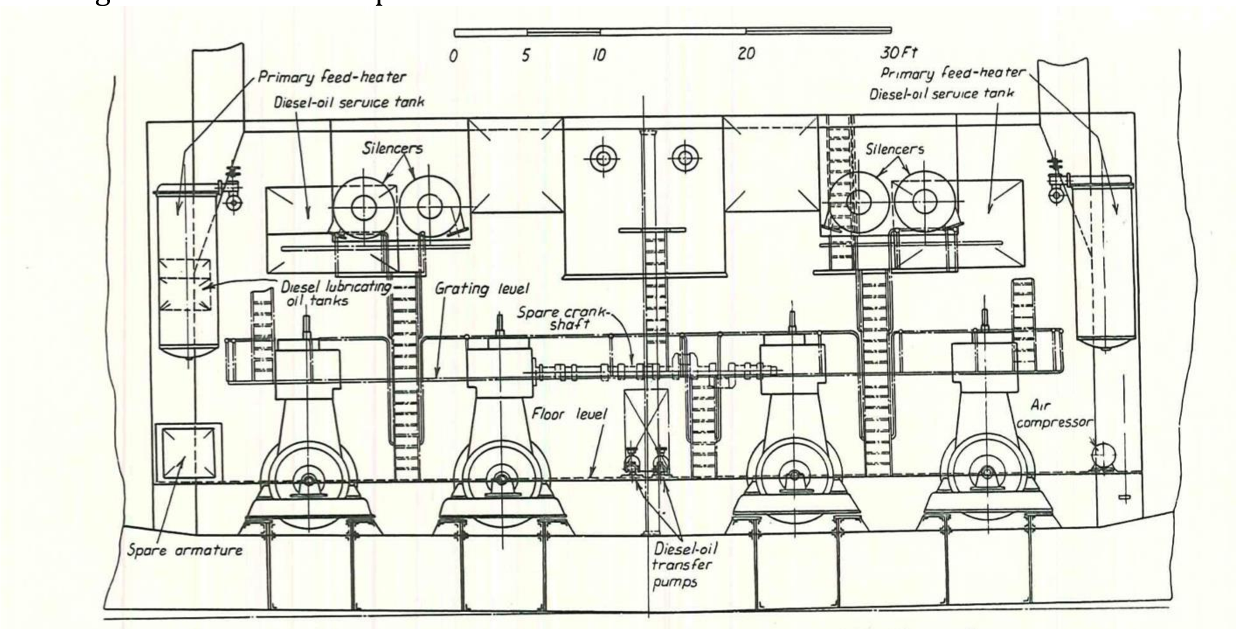

Figure 6 Section through Auxiliary ER, looking Forward

1.8. Main switchboard distribution

The main switchboard is divided into sections in order to distribute the power to the various areas of the ship. Most of the auxiliaries are electric drive and the breakers for these can be seen on the board. On Direct Current the breakers for the generators (all six are shown on the diagram) can be put straight on to the board (with the shunt field regulator wound right down) - there is no need to synchronise as with an alternating current system. The shunt field regulator is then wound up to share the load with the other generators on the board. The board has two sections split by a bus-tie breaker, which bears out the 2x100% redundancy in that a turbine generator is seen on each side, paired with two diesel generators.
Of interest is the size of the Shore Power at 1,000A, corresponding to 225kW, and the 1500A Galley breakers corresponding to 337.5kW – quite a large galley load as expected on a passenger ship of this size. If AC power had been available in 1931, the electrical current load with a 3-phase 440V 60Hz supply would have been considerably less, as the required power would result in a much lower current and therefore a much reduced cable size and volt drop. For the same galley power of 337.5kW on an AC supply, the current would be around 553A, approximately 37% of the dc current shown.
An interesting note in a 1927 marine engineering book states, “There is no foreseeable future for alternating current in ships”. Fortunately, marine engineers are forever endeavouring to achieve greater power and economy from the machinery they design, have ignored that statement and alternating current is now the standard in ships.

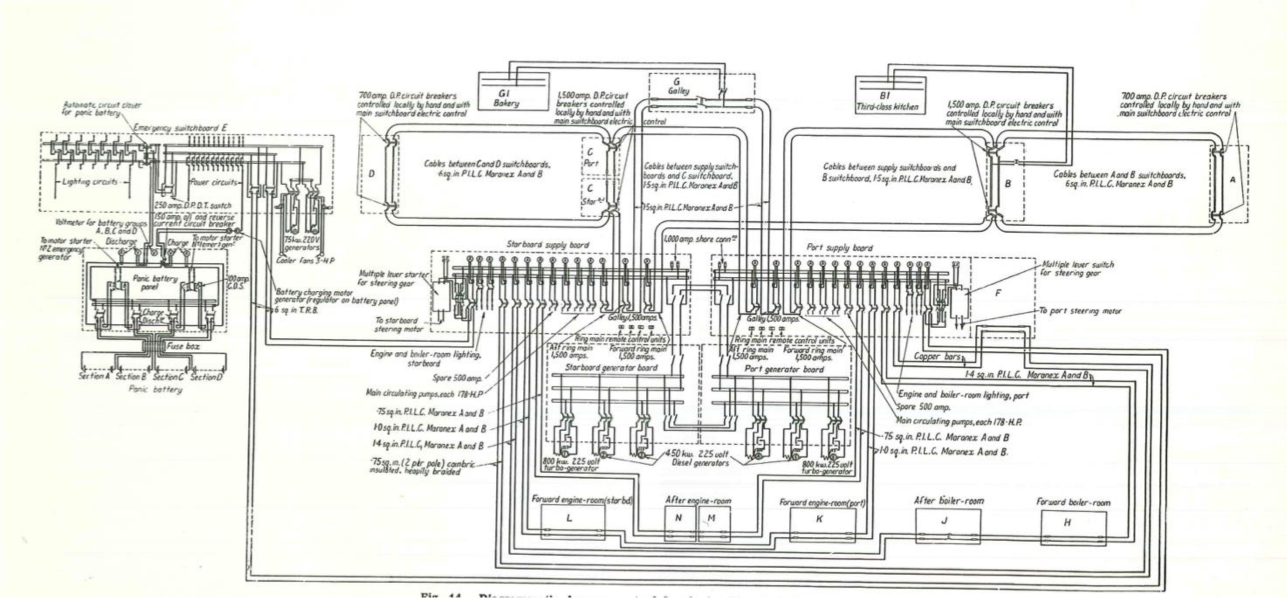

Figure 7 Main switchboard distribution

3. Firing up the boilers

We how have power available for the engineers start the forced draught fans from the main switchboard.

Once the air is established the firemen start an oil-fuel unit (electric drive) and light up the boilers, assuming there is sufficient water level. If there isn't sufficient level, there are two sets of electrically driven auxiliary feed pumps in the forward boiler room, which can be used to establish a level in all the required boilers. It is likely that there is also an electric "cold-start" feed pump in the engineroom, but this is not shown on the drawings.

Once lit, dampers adjust the boiler draft and the fires start to heat the water in the water-tube boilers. Water-tube boilers are much more efficient and faster starting than fire-tube, but would still take around 7-10 hours to raise steam to manoeuvring pressure from cold. Firing boilers is carried out in stages to avoid thermal shock to the tubes and boiler drums, with the superheater starting valve open, along with the vents on top of the drums to dispel any air. Additionally the main stop on the first boiler (usually furthest away, so in the forward boiler room) is open in order to drain the main steam lines as pressure is raised.

As the pressure rises and steam is issuing from the steam drum vents they are closed, with the superheater starting valve left open to ensure a steam path through the superheater banks to avoid damaging the tubes.

As steam is raised on the boiler which has its main stop valve open, the drains along the whole length of the main steam lines to the enginerooms are opened up to drain any condensate, as liquid entering the turbine machinery can cause damage.

Once steam is raised and up to sufficient pressure to start a turbo generator (around 375lb/in^2) at the main stops, the bulkhead stop valves to the main steam lines in the enginerooms are opened to drain condensate from the lines serving the turbo-generators. The remaining main stop valves of the boilers required to start a turbo-generator are cracked open to the main steam pipe and the piping and valve drains opened to clear the lines of condensate, which can damage reciprocating and turbine machinery.

4. Main condensers and seawater circulating pumps

Once steam is raised and is used, it has to be returned to the boilers via the feed system. It is not very clear from the simplified feed drawing in the book how the feed system actually works regarding the exhausts from the turbo main feed pumps (TMFP) or the exhausts from the turbo-generators. It can be reasonably assumed however, that the auxiliary condenser situated on the starboard side of the forward boiler room is both too far away and not large enough to handle either of the exhausts from this machinery as in the earlier ships in this series, so the main condensers will need to be put into service.

As a more modern ship, the main seawater circulating pumps are electric drive, and there are 3 sets of 2 of these fitted,

- one pair either side of the forward engineroom thrust blocks
- one pair either side of the forward engineroom underneath the turbo-generators
- one pair inboard of the centre shafting in the after engineroom.

The main circulating pumps for the inner shaft turbines are started and supply seawater to the condensers under each turbine set, with the discharge sent overboard. At the same time, and to achieve the vacuum in the condenser by removing air and other non-condensables, there are steam driven air ejectors fitted to all four turbine sets, the forward engine room sets placed either side of the forward end of the turbines, the after set inboard of the centre shafts in the after engineroom, serving the two wing turbine condensers. These ejectors use steam through a venturi arrangement to create a vacuum in the condensers.

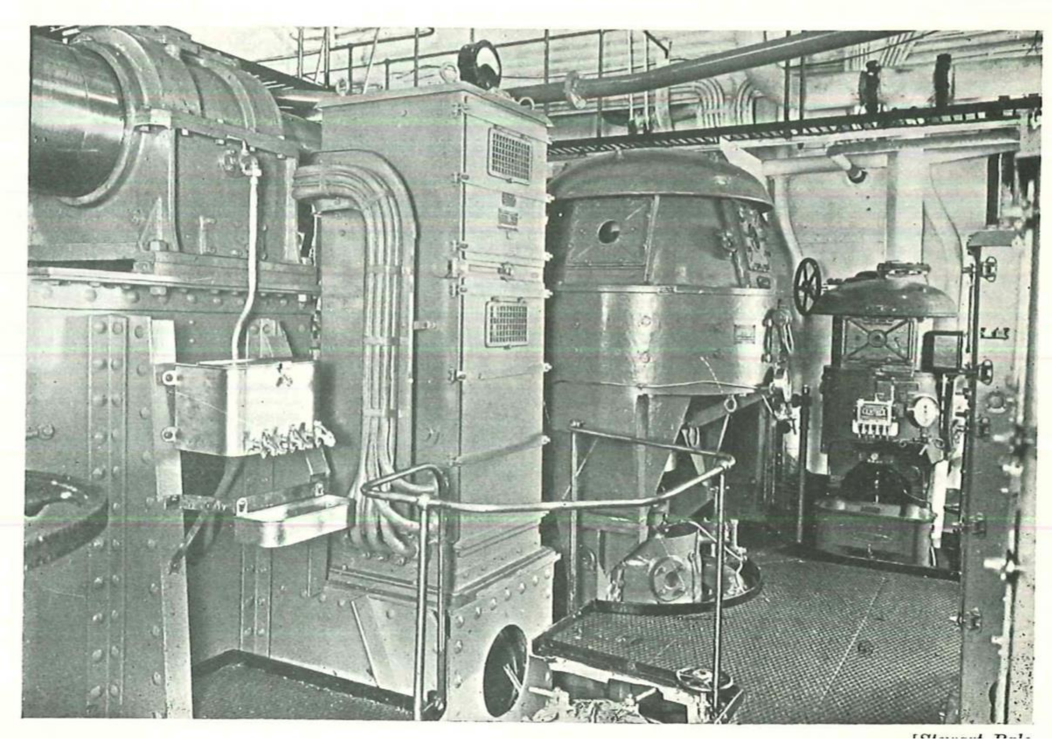

Figure 8 One of the main SW circulating pumps and its starter (aft ER)

5. Starting a turbo-generator

We are now ready to start a turbo-generator and will start the port turbo-generator, to serve with the two portside diesel already on the board in accordance with the electrical schematic.
The exhaust from the turbine is opened to the main condensers. As the turbo-generators are in the forward engineroom, it is likely that the condensers under the inner shaft turbines are used, not the after engineroom condensers, though there may be bypass lines. The seawater passing through these condensers condenses the exhaust steam into water, thereby dropping its pressure and creating a vacuum. Without this the turbine would trip on high exhaust backpressure, as the exhaust steam has nowhere to go.
The turbine bearings are lubricated with oil, so the stand-by LO pump is started and lubricating and control oil pressures established. The control oil is used to shut down the turbine in the event of LO pressure failure by holding open the control valve whilst the pressure is maintained. Once the turbine is running, a shaft-driven pump maintains the oil pressure. The oil system is supplied with oil coolers and filters to maintain the temperature and cleanliness within normal limits.
With all the lines drained to the turbine, the stop valve is opened and the control valve drained through. Steam is now available right up to the turbine inlet, and opening the throttle valve will allow the turbine to turn, slowly gathering speed until it as full revolutions. The turbine sets incorporate single-reduction gearing to reduce the electrical generator end speed to suit the supply voltage.
The turbine control valve should now allow itself to stay open unaided, held by the governor oil supply from the control oil system. Speed control is therefore automatic via the governor and the throttle valve. Usually the turbine trip is now tested, by closing off the control oil to the throttle valve; loss of control oil pressure should trip the valve. Once proved, the system is reset and in operation.
Once up to speed, the generator main switchboard breaker is closed and the shunt field regulator adjusted to share the load with the two diesels. There is now 1.7MW of power available for getting the ship underway.
As we are now consuming steam, we will also need to start the main feed pumps to supply the boilers with feed water as required. The steam that is consumed by the turbo-generator is being condensed as above into the condenser hotwell, and the condensate extraction pumps (called “Pervac” pumps in the drawings) under the condensers are started in order to maintain the correct condenser hotwell water level. The feedwater and condensate system is explained below.

6. The Feedwater and Condensate System (Figure 9)

The feed and condensate system is designed to extract the maximum energy from the steam and return the heated feed back to the boilers at the maximum design temperature.

Steam from the condensers that has condensed into the hotwells under the condensers is returned to the boilers via two feed heaters using the sets of condensate pumps (called “Pervac” pumps on the drawing) located in a well below the tanktop and outboard of the lp turbines. These pumps deliver the condensate via the *Drains Coolers* located at the forward end of the engineroom between the Forced LO pumps and their starters on the forward bulkhead. These drains coolers are fed with exhaust steam from the Primary Feed Heaters, mounted outboard in each diesel generator room, and this exhaust heats the feedwater passing through the shell and tube heating elements.

From the outlet of the drains coolers the feed water is passed to the suction of the *Turbo Main Feed Pumps* (TMFP), which are arranged in two sets of two pumps, outboard at the forward end of the engineroom.

The TMFP then delivers the feed in series through the Primary and Secondary Feed Heaters before delivery to the boiler feed control valves. The secondary heaters are also situated outboard in the diesel generator room, forward of the primary units.

The *Secondary Heater* is heated by bled steam from a turbine stage at 110lb/in^2(a), 140F superheat and exhausts to the Primary Heater, along with some auxiliary drains.

The *Primary Heater* is also fed from a turbine stage at 30lb/in^2(a) as well as the exhaust from the Secondary Heater mentioned above, and exhausts to the Drains Cooler as above, which in turn drains to the feed tanks mounted either side on the forward bulkhead. Appropriate recirculating piping is supplied to return feed water back to the hotwell depending on boiler load conditions.

Of special note in the feed arrangements for the forward engineroom (the after engineroom is similar) are the Scotch boilers. These have a set of feed pumps that draw from the Auxiliary Feed Tank and discharge through the Auxiliary Feed Heater, termed “Greasy Exhaust Heater” in the feed diagram. Auxiliary drains go to this tank via the Auxiliary Condenser. From the heater, the water is directed to the Scotch boilers, and the “clean steam” so generated is delivered at 200lb/in^2 to a turbine stage. A line from this clean steam pipe also leads to the auxiliary drains cooler, which supplies the heating medium for the feed heater, whose drains are returned to the Auxiliary Feed Tank. All this equipment is situated outboard of the starboard Scotch boiler in the forward boiler room. One can’t help wondering what these contaminated drains do to the internals of the Scotch boilers, but it is assumed that there is some kind of Observation Tank and filter to separate any oily drains.

With everything up and running, steam is raised on all the boilers required for leaving port.

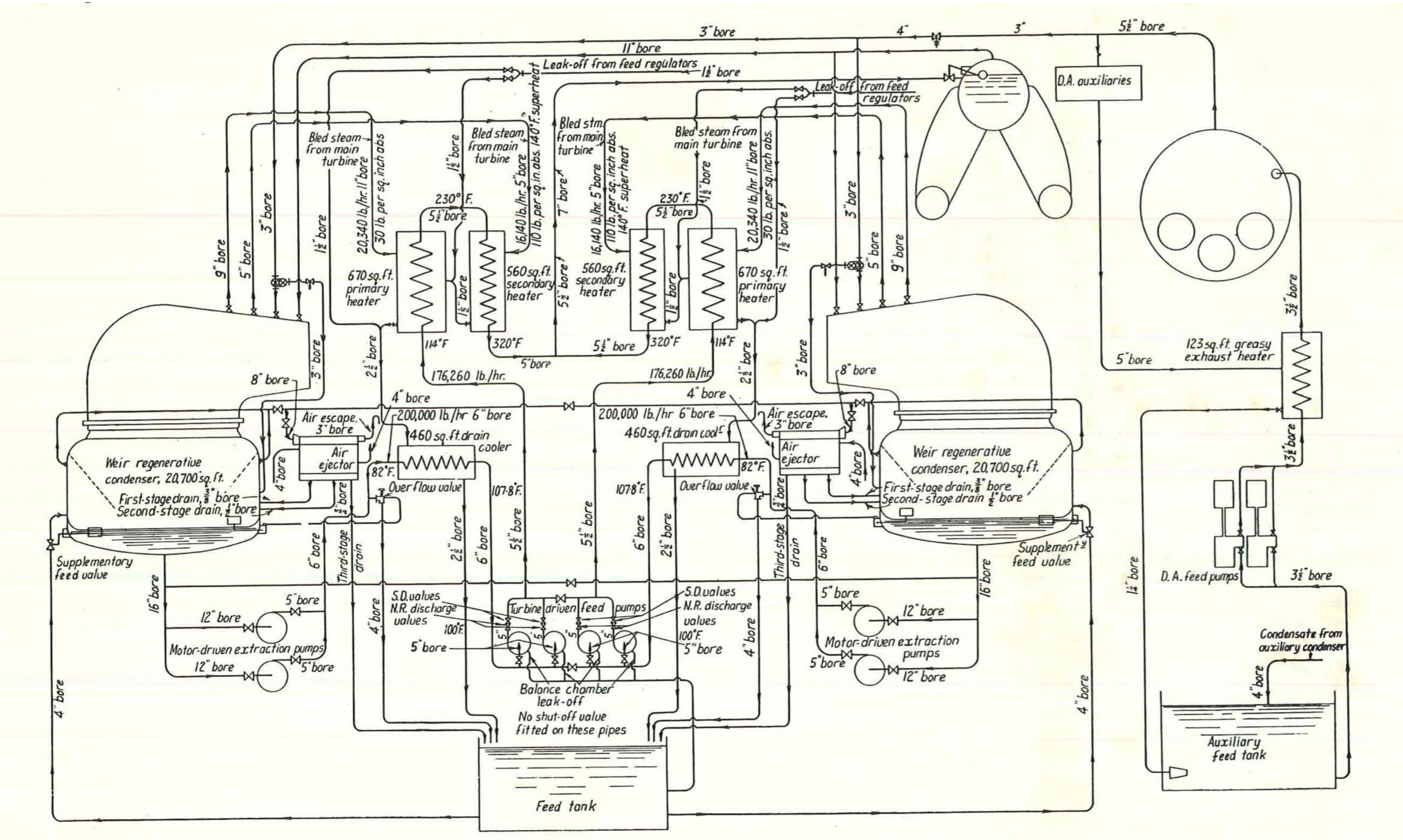

Figure 9 The feedwater and condensate system

7. Starting main engines

We now have more than enough power for firing all the boilers necessary for starting the main engines and getting the enginerooms ready for sea.
First we have to get the propulsion exhaust steam and feed systems arranged in a similar way to that of the generators, with each turbine set more or less similar. As the turbine sets are triple expansion, steam passes through each of the hp, ip and lp stages and exhausts to the main condensers underneath the turbines. For manoeuvring out of port, only the forward engineroom sets are used, as they have astern turbines configured in the set. The wing shaft turbines are ahead capable only, and are therefore used to work up to full speed on a transatlantic passage, and would be kept warmed through on "steam spinning" until required. For cruising the outer shafts have the propellers removed, so the turbines are not used for this period, though the rotors will be turned regularly on the turning gear to avoid sag.

1.9. Main engines (forward engineroom)

By this time the engineers (we assume we are not doing this on our own) will have engaged the electric turning gear motors on all four shafts, as well as starting the turbine motor-driven forced lube oil pumps arranged in sets of three pumps forward of each of the two forward engineroom turbine sets. The oil filters and coolers are arranged aft of the pumps.

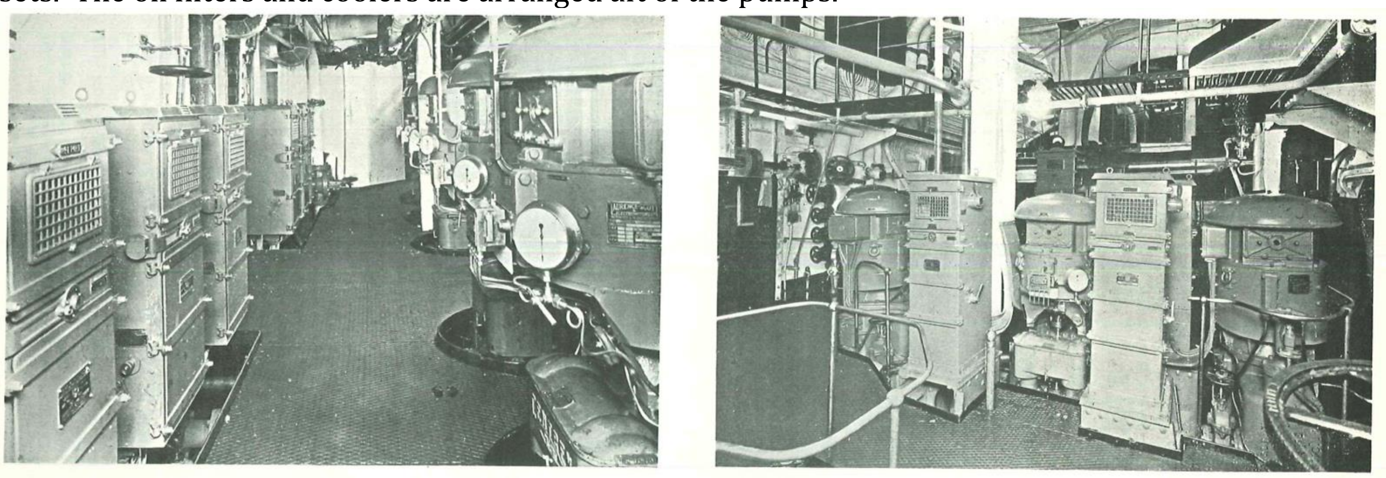

Figure 10 The Forced LO Pumps in the Forward (L) and After (R) enginerooms

The engines are kept turning until required for use, whence the gear is withdrawn to avoid damage to it in the event of starting a turbine with it engaged. Gland steam is assumed to have been fitted (no mention in the Engineer & Shipbuilder reprint) and will be started up to extract leakage steam from the turbine shaft glands, and condense it back to the hotwell drains. At this stage the turning gear is removed and the engines turned on "steam spinning" ahead and astern to ensure all condensate is drained and the turbines are ready for manoeuvring.
The turbines are kept warmed through ready for manoeuvring and working up to speed on passage, with manoeuvring steam admitted to the hp turbines with the drains full open until proved clear. In series, the exhaust steam from hp turbine exhausts via the ip turbines and into the lp turbine sets. At first the main steam bulkhead stop valves are cracked open until everything is warmed through, whence they can be fully opened.
Once the turbine drains are emitting steam, we can call the bridge and ask if the propellers are clear for a slow turn ahead and astern on both inner shafts. Once this is given, the turbine manoeuvring valves are set to the ahead position (with the astern isolator closed) and the main steam regulating control valve cracked open at the starting platform at the forward end of the turbine room. Each engine turns ahead at low revs. After a few turns of the shafts ahead the regulating valve is closed and the astern isolator opened to allow steam to the astern turbines on each shaft. Again the regulating valve is cracked open and the astern hp turbine turns, with its exhaust to the ip astern turbine and the ip exhaust to the lp astern turbines. The shafts turn astern for a few revs at low speed.

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

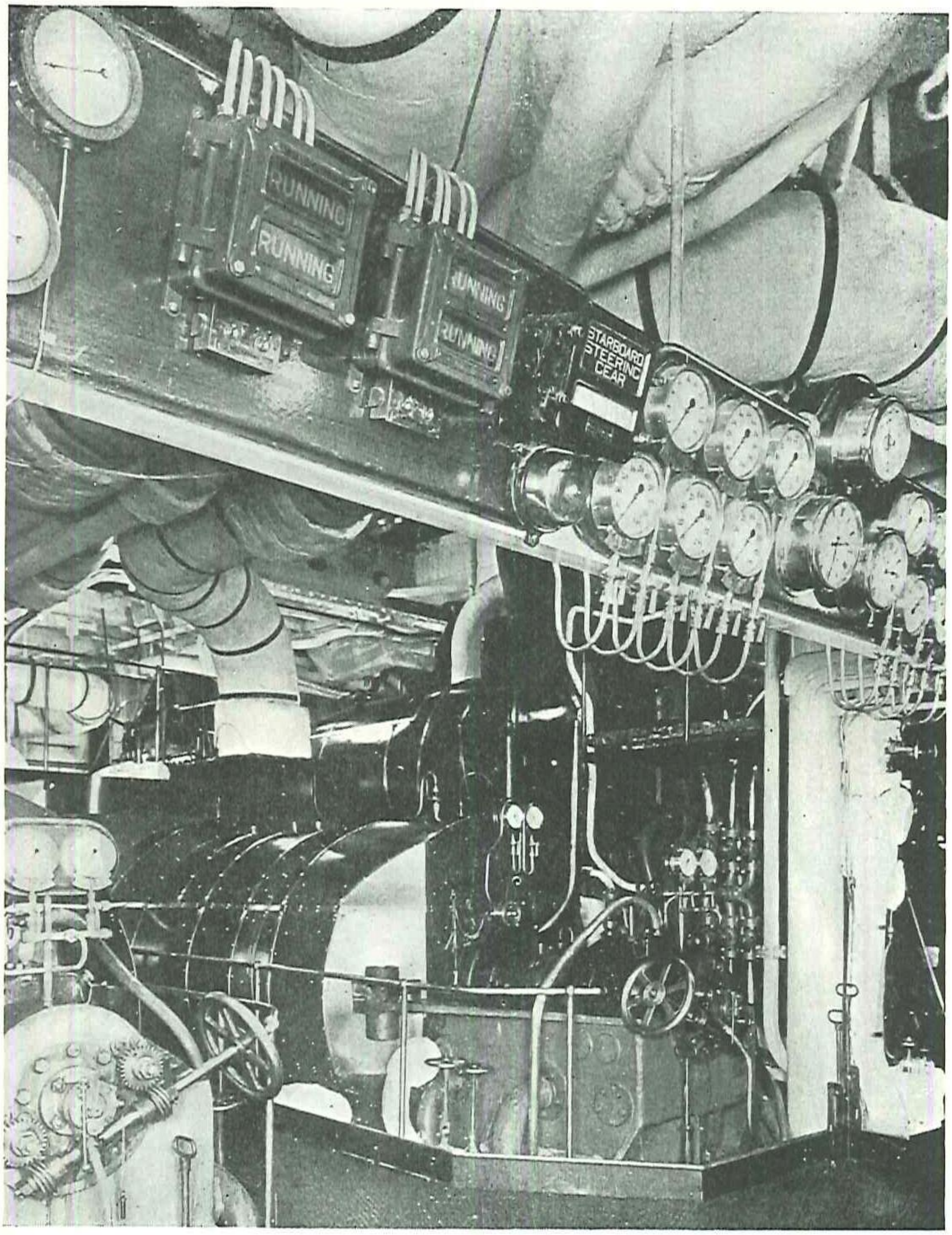

Figure 11 Gauge panel at the forward end of the turbines

8. Getting under way

In response to the bridge signals on the engineroom telegraphs, the ahead/astern turbine sets are manoeuvred accordingly as above and the ship departs her berth and heads for the open sea.

1.10. High-pressure and intermediate-pressure turbines

Once the ship is up to full ahead, and prior to full away, the steam is now passing from the boilers to the main steam lines, through the hp turbines, into the lp turbines, then the lp turbines and finally exhausting to the condensers, from where it is returned to the boilers as above in a closed feed cycle. On transatlantic service, the after engineroom is now engaged and the outboard turbines and feed system put into service. Full power can now be worked up once <u>full away</u> is rung on the telegraphs.

1.11. The Starting Platforms

The main engines and some of the auxiliaries such as the steering gear are started from the Starting Platforms, of which there are one for each engineroom.

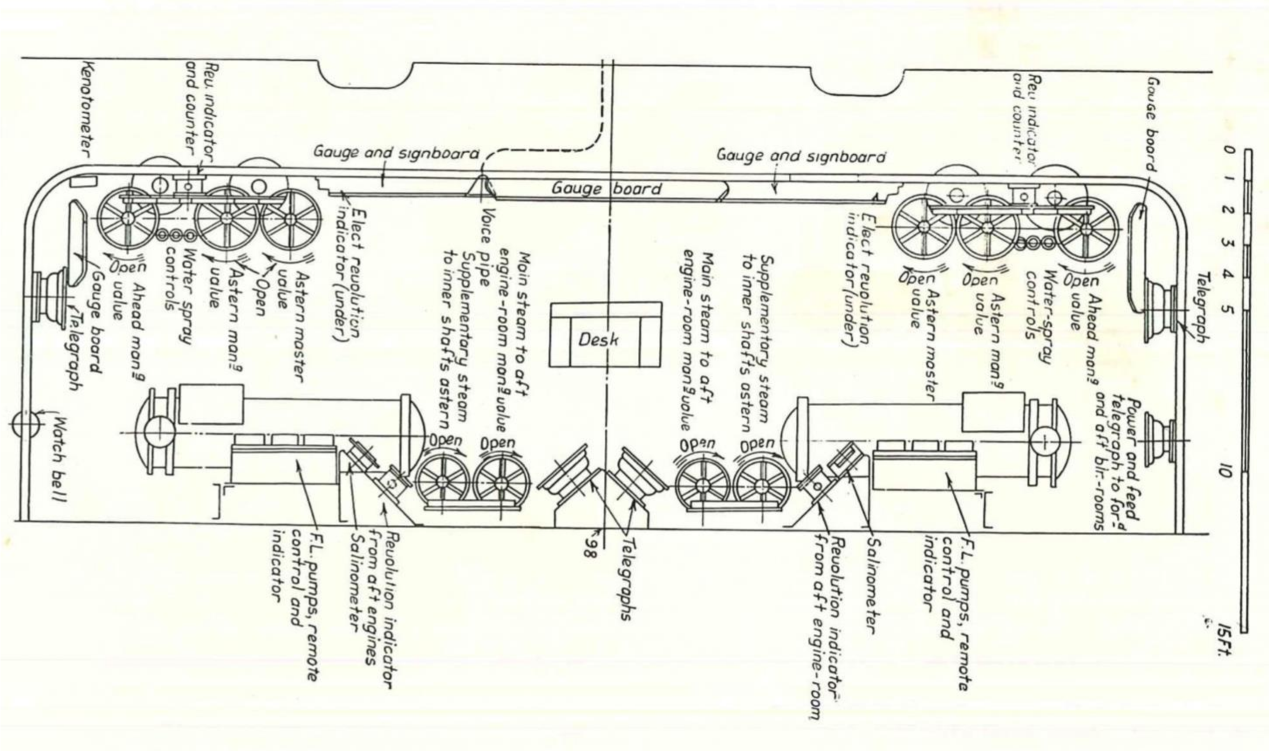

Figure 12 The forward ER starting platform

At the after end of the platform are the turbine manoeuvring valves, where the engineers stand facing the engines – looking aft. The three main wheels shown are the Astern Master Valve (sometimes called the Astern Isolator), which physically stops astern steam being applied if the ahead wheel is open. Next is the Astern Manoeuvring Valve which, providing the Master Valve is open, applies steam to the astern turbines. The outboard wheel is the Ahead Manoeuvring Valve, which turns the ahead turbines. Once Full Away rings off stand-by, the ahead valve is gradually opened up until the turbines are at full speed ahead. Various telegraphs are also shown for both engines and boilerooms.

The Water Spray Controls shown are for manually spraying water into the condenser to force the water level and improve the vacuum when manoeuvring.

On the forward bulkhead are the isolators for the after engineroom steam system, and the Forced LO control panels above the drains coolers, shown in the photo below.

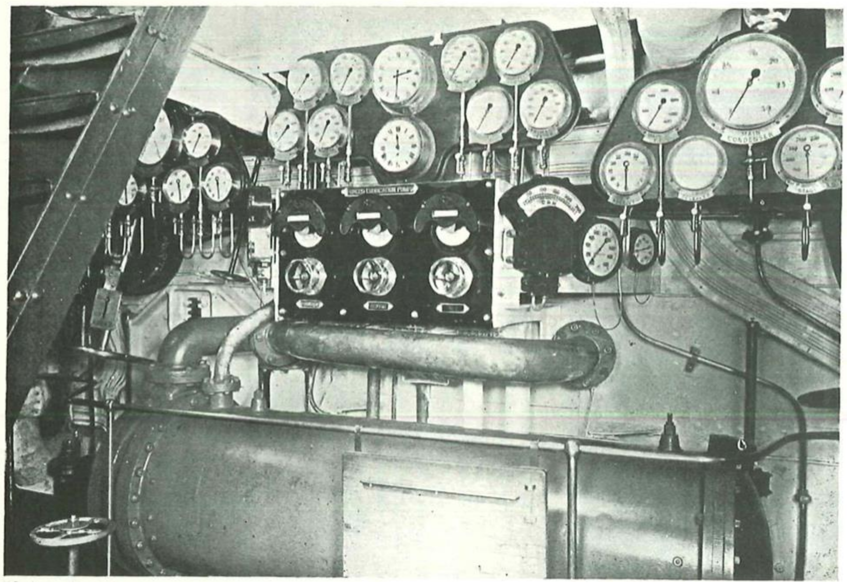

Figure 13 Speed regulators and ammeters for FL Pumps

1.12. After engineroom starting platform

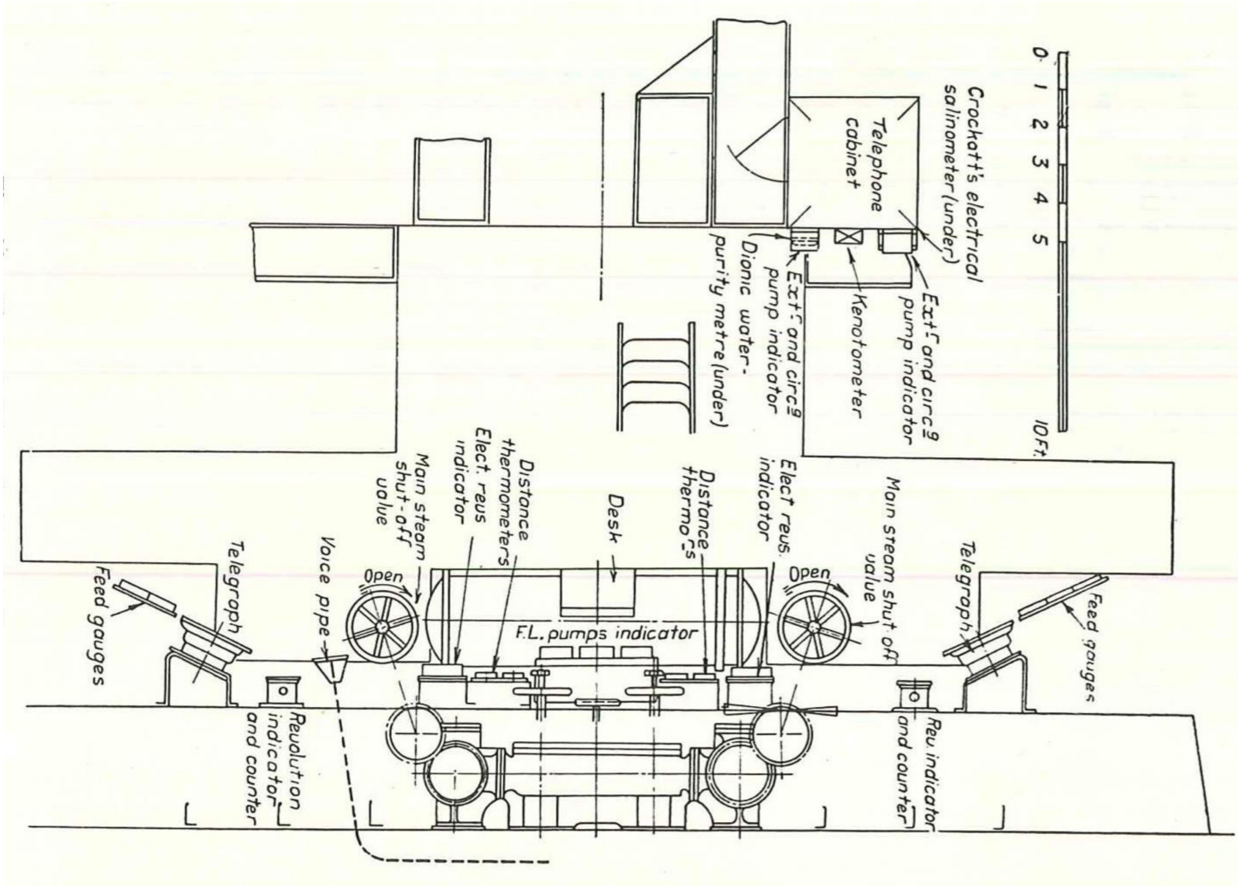

Figure 14 Aft ER Starting Platform

As the after engineroom turbines are not used during manoeuvring, the controls here are much simplified. A voice pipe from the forward starting platform relays orders as required to the after personnel. As the after engineroom handles the outboard engines – which do not have astern running – the engines are brought up to speed once full away is rung, but opening the main steam shutoff valves either side of the drains cooler. Telegraphs, revolution counters, feed gauges and a FL Pump panel similar to the forward station are provided.

PLATES FROM THE PUBLICATION "OCEAN LINERS OF THE PAST, EMPRESS OF BRITAIN (1931)

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

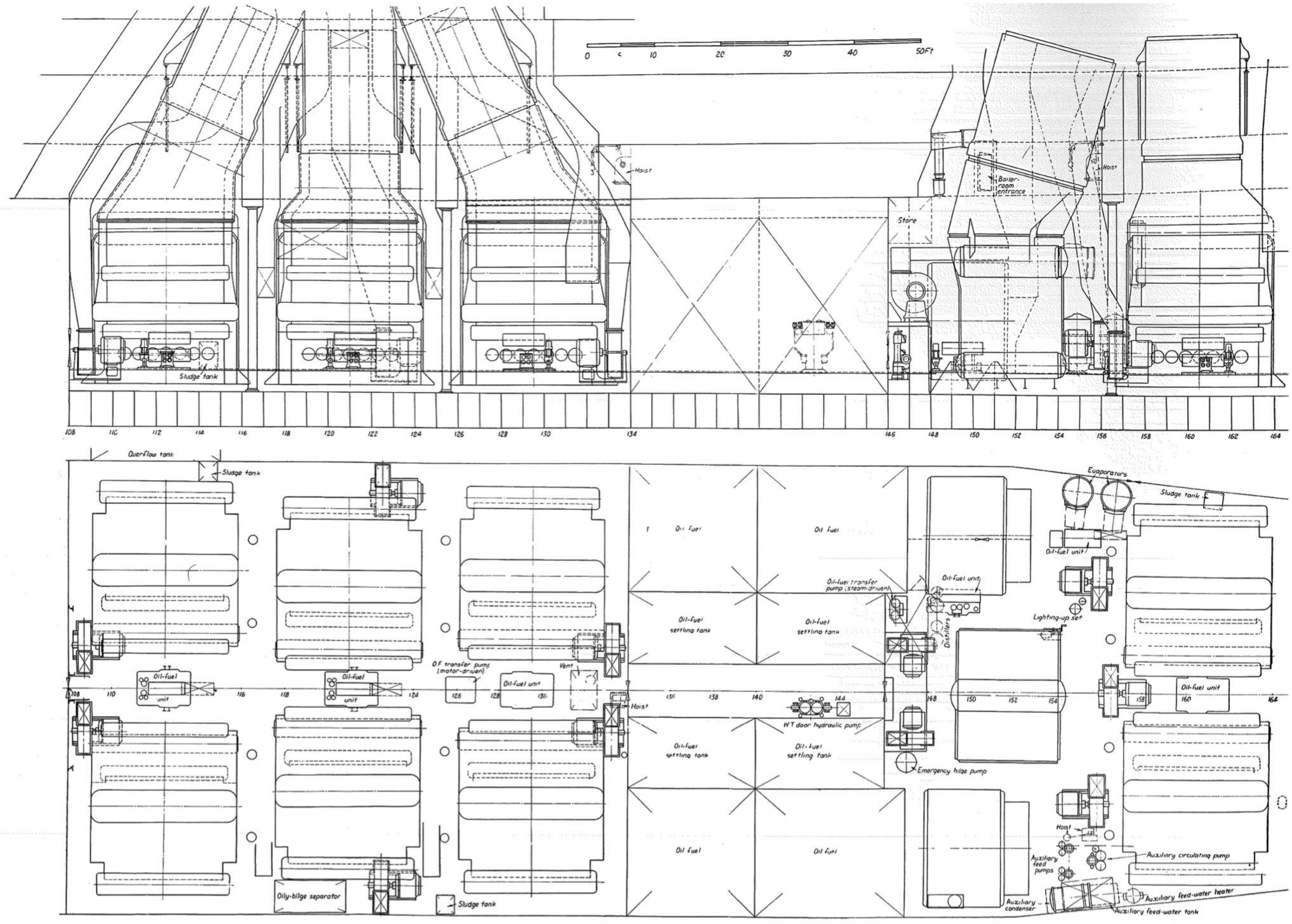

Figure 15 Elevation and Plan of Boiler Rooms up to the ER bulkhead

9. Profile and Plan of Boiler Rooms

On the view in Figure 15 can be seen the extent of the forward and aft boiler rooms. The Yarrow boilers are installed 6 in the after boiler room, and the remaining 2 in the forward boiler room. Also shown in the forward boiler room are the two Scotch boilers either side of the innovative Johnson boiler in the centre.

1.13. Uptakes

The uptakes can clearly be seen, illustrating that the forward two funnels on this vessel served the boilers with the aft funnel serving as a ventilation shaft and engine hatch over the enginerooms.

1.14. Fuel oil tanks

Between the two boiler rooms are the boiler fuel oil tanks, consisting of four storage tanks and four settling tanks, with an access way between. Situated in the access way are the watertight door hydraulic pumps.

1.15. Oil fuel units

Between each pair of Yarrow boilers can be seen an oil-fuel unit. There is also one unit inboard of the port Scotch boiler which serves the two boilers. Either this unit or more likely the one shown adjacent to the evaporators on the port side would supply the Johnson boiler.
These units contain supply pumps, which draw from the settling tanks, then pass the fuel through strainers and filters to clean it before supplying it to the boiler burners.

1.16. Other auxiliary units

The Scotch boilers are used to evaporate raw feed water, the steam produced being passed to an intermediate stage of the main turbines. In the forward boiler room can be seen two evaporators to make feedwater from seawater, and also a distiller for producing feed water from condensed steam and/or fresh water. An auxiliary condenser, pumps and feed tank for serving the Scotch boilers is shown on the starboard side.
In the aft boiler room is an Oily Water Separator, used to clean bilge water before discharge overboard. These were early units which made a token attempt to clean the water, compared to the strict regulations nowadays on marine pollution as published by the MARPOL guide which limits overboard discharges to 15ppm oil in water.

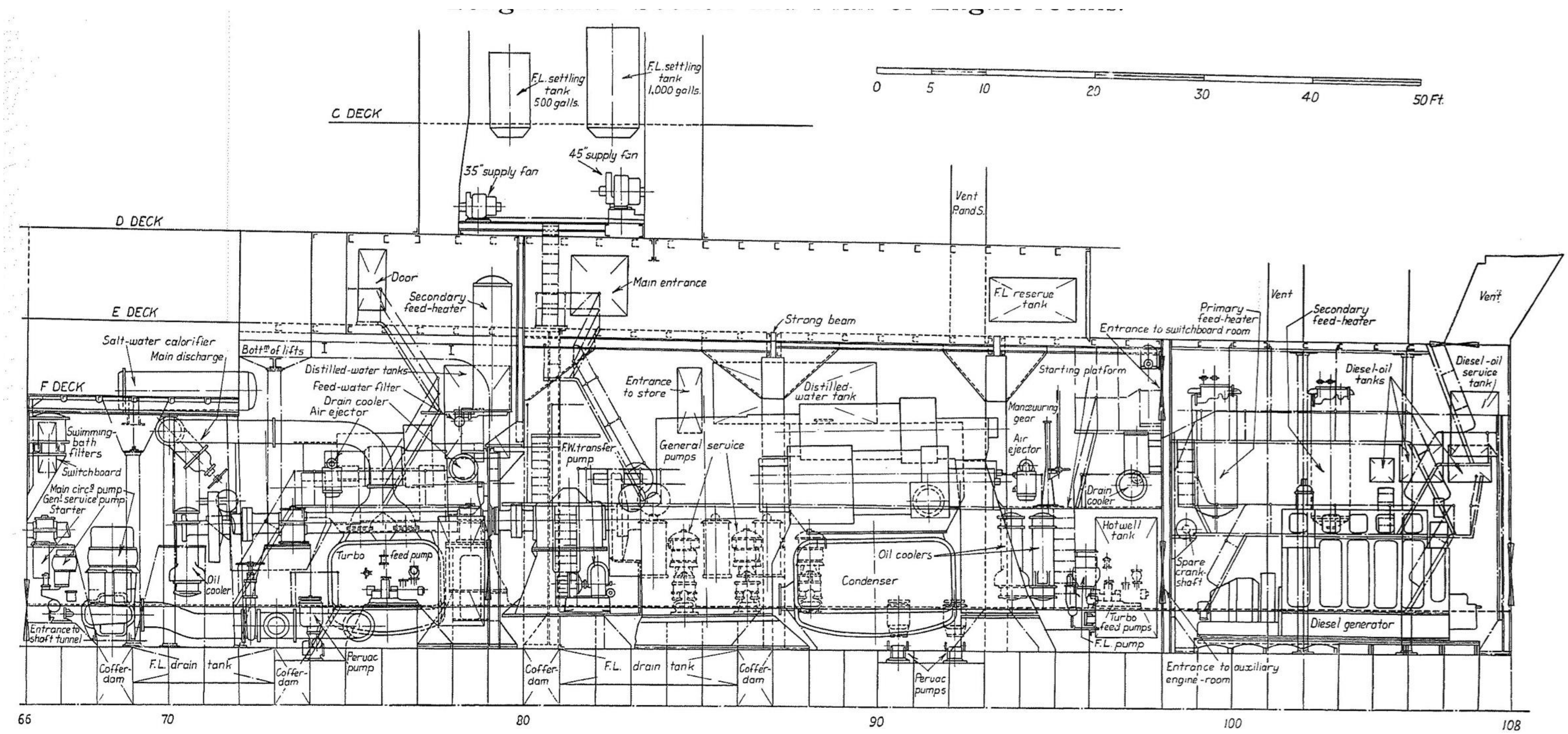

Figure 16 Elevation of Enginerooms

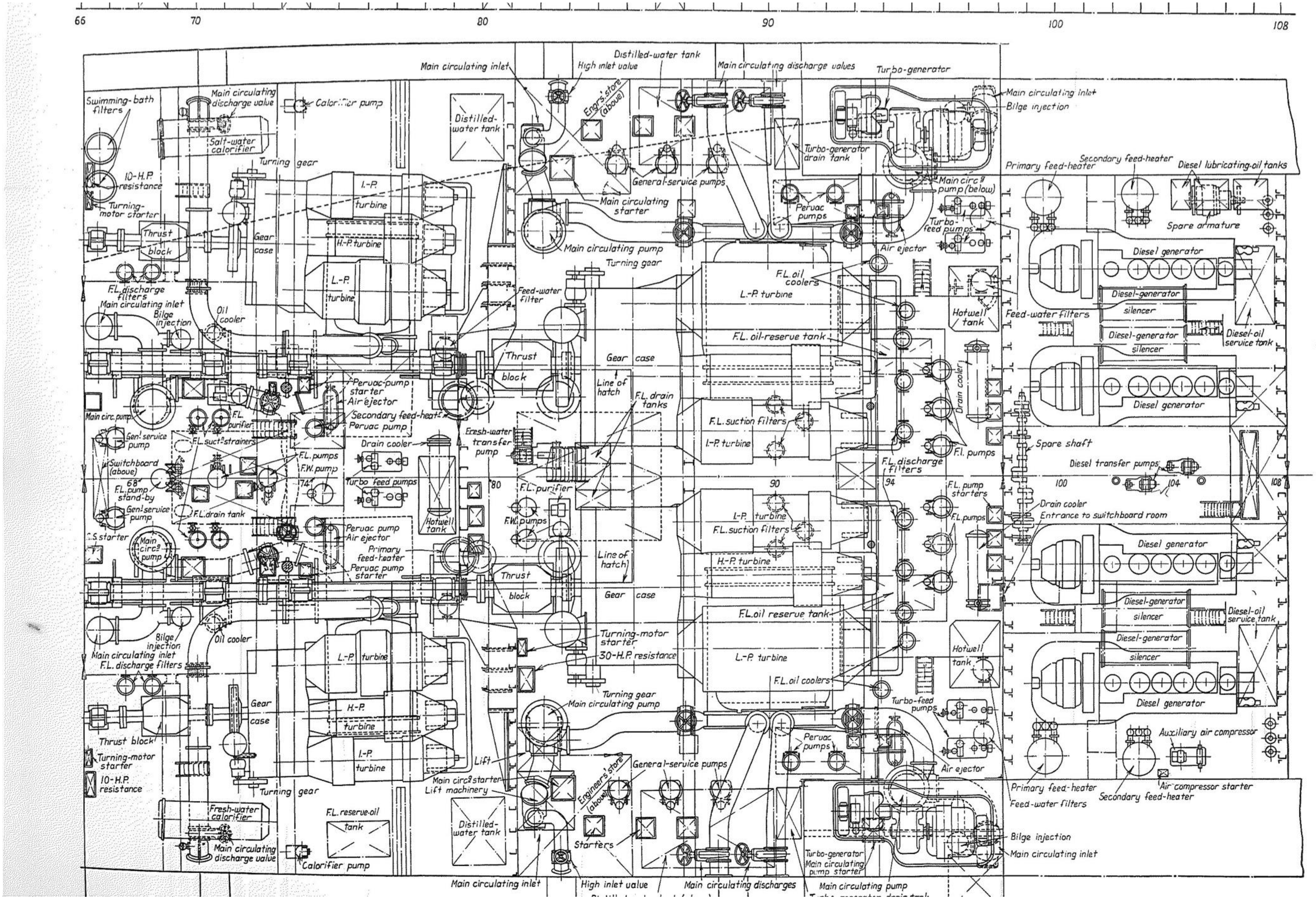

Figure 17 Plan of Enginerooms

10. Elevation and Plan of enginerooms

The views in Figure 16 and *Error! Reference source not found.* show the forward and after enginerooms.

1.17. Diesel generator room

Starting at the forward end of the Diesel Generator Room are the diesel service tanks (treated fuel from the settling tanks located between the two boiler rooms) plus some other smaller day tanks. These supply clean fuel for the engines.
Next are the engines themselves, with the Primary and Secondary Feed Heaters shown.
Note the spare generator crankshaft, which in modern ships is not a capital spare item. In 1931 perhaps even on a transatlantic voyage, the steam engineers didn't trust a diesel generator; this is often the case with steam engineers even today!

1.18. Forward engineroom

Passing through the door at the after end of the diesel generator room, we enter the forward engineroom.
On the forward bulkheads can be seen the feedwater tanks (called Hotwell tanks on the drawing), the Forced LO pumps and their attendant oil coolers.
Above is the starting platform, the drains coolers (against the forward bulkhead), air ejectors and the entrance to the switchboard room over the diesel generator room. Also shown is a manoeuvring gear stand and above this space the forced LO gravity tank which supplies LO by gravity if the forced LO pumps fail, timed to give enough LO for the turbines to run down.
Moving aft, the turbine sets, condensers, "Pervac Pumps" situated in a well, three General Service pumps and a distilled water header tank are shown.
Under the turbines in the double bottom are the Forced Lube drain tanks, and cofferdams.
The turbine thrust blocks are shown, as are the centre shaftlines exiting through the watertight bulkhead into the after engineroom.
Above the machinery can be seen ventilation fans for the enginerooms.

1.19. After engineroom

In this room are the wing turbines, condensers and auxiliaries for the turbine operation.
Starting at the forward bulkhead, the inner shafts can be seen exiting through the bulkhead and passing through the space.
On the centreline is the hotwell tank (feed tank), Drains Cooler and Feedwater Filters. Outboard are two distilled water tanks, one on each side. Either side of the centreline are the Primary and Secondary Feed Heaters for the after feed system.
Moving aft are the outer shaft wing turbines, on the centreline are the TMFP for the after feed system and between the inner shafts are the steam air ejectors, the "Pervac" pumps (condensate pumps) and a Fresh Water pump.
Aft of these and still within the inner shafts are the Forced Lube pumps mounted on the FL tank on the centreline, the two main seawater circulating pumps and two general service pumps. Above is a switchboard.
Mounted outboard of the engineroom are two calorifiers for heating domestic water and two swimming pool filtration units on the port after bulkhead.
From this area, the four shafts exit to the shaft tunnels.

1.20. Shafting and propellers

The two inner propulsion shafts are arranged in the shaft tunnels and exit the ship via the stern tubes. There are several intermediate bearings (Plummer Blocks) along the length of the shafting, which are splash lubricated.
The outer pair of shafts exit the hull in pods which are supported by shaft brackets to the hull structure.


Figure 18 Shaft tunnel of a large liner