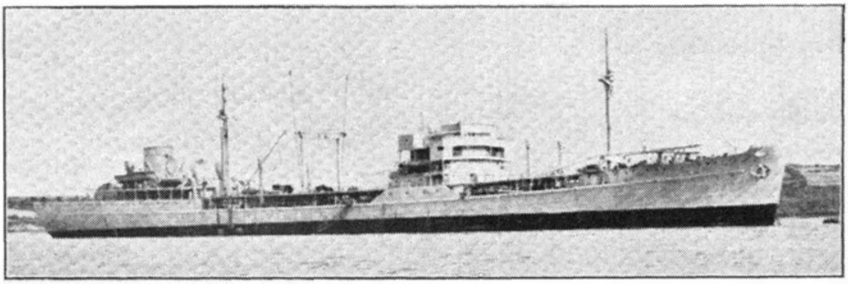

H.M.S. NORTHMARK

by

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Engineer-in-Chief's Department

The writer was recently afforded an opportunity of attending sea trials and passage in one of the enemy's supply ships, *Northmark*. Owned by the German Navy, the *Nordmark*, ex *Westernald* (sister ship to *Dittenmarken*, now *Southmark*, operating under the U.S. flag in American waters) was constructed under Hitler's orders as a cargo ship but was actually intended and did function as a fast fleet tanker, armament supply store ship and victualling ship to German raiding battleships.

The following registration particulars are of interest :—

Displacement	22,000 tons
Speed	21 knots
Length overall	584 ft.
Beam	78.23 ft.
Loaded draught	30.5 ft.
Shaft horse power	22,000 (twin screws)
Revolutions per minute	120

The ship served in northern waters for a long time and is admirably heated throughout. Short periods of service were done in the tropics, however, and no reason is apparent why she should not prove equally efficient under these conditions. Good accommodation appears everywhere and excellent amenities were provided for the German crew, including sick bay, operating room, laundry, cinema projector, canteen, workshops and bakery.

The original German arrangement for fuelling at sea was with two approximate 6-in. hoses and one approximate 4-in. hose (lubricating oil) over the stern. The deck space is clear and open ; admirably suited for handling hoses and wires. Over the centre well deck an additional deck has been fitted, joining the forward and aft superstructures. Hoses are handled along the length of this deck. The trough method was not used by the Germans but presumably could be with alterations to the derricks.

The full power trial referred to later in this narrative was the first attempt in British hands ; from information gleaned on board, the last previous occasion was when ship was chased by H.M.S. *Rodney* during the war and succeeded in escaping owing to her extremely low silhouette.

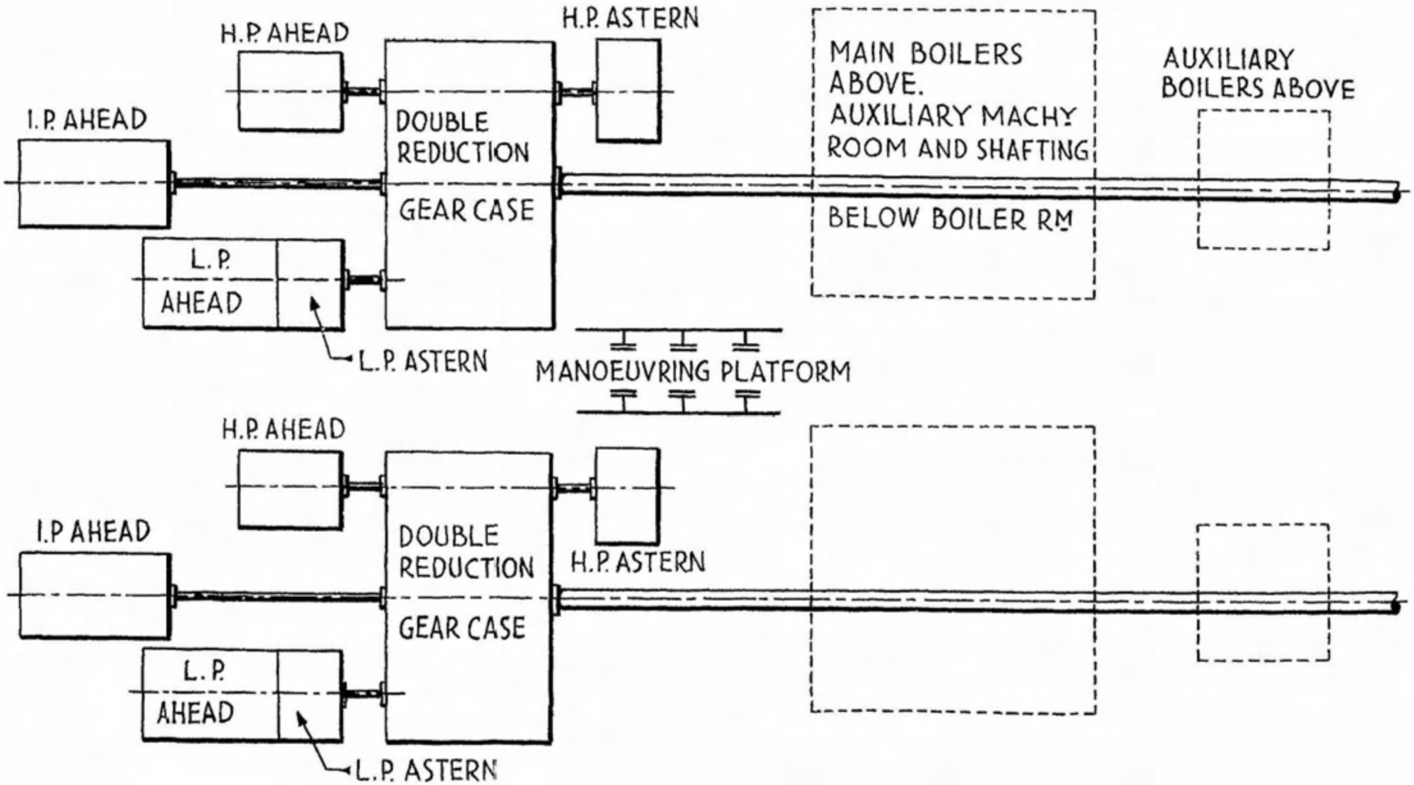

H.P. AHEAD
H.P. ASTERN
I.P. AHEAD
DOUBLE REDUCTION GEAR CASE
L.P. AHEAD
L.P. ASTERN
MAIN BOILERS ABOVE.
AUXILIARY MACHY ROOM AND SHAFTING BELOW BOILER RM
AUXILIARY BOILERS ABOVE
MANOEUVRING PLATFORM
H.P. AHEAD
I.P AHEAD
DOUBLE REDUCTION GEAR CASE
H.P. ASTERN
L.P. AHEAD
L.P. ASTERN

Fig 2.

It is the scope of this article to refer in particular to the machinery, which deserves attention in respect of its novel advanced design and very interesting arrangement.

The ship was designed and used for the following purposes :—

(*a*) Supplying bunker oil and Diesel oil at sea from the stern.

(*b*) Oiling ships alongside and over the bows in harbour.

(*c*) Supplying armament stores, shells, bombs, etc., also torpedoes and victualling stores.

The cargo provision rooms contained enough food for 5,000 men for 30 days.

The cargo capacity is 10,000 tons of boiler fuel oil (or Diesel oil), and 300 tons of lubricating oil. 4 in. No. 250 ton oil fuel transfer pumps are fitted in two pump rooms situated in the hold of the ship. The layout of fuelling and discharge pipes is on normal lines. The main deckline is approximately 11 in. diameter with original discharge hoses of about 6 in. diameter. Space is fitted forward and aft of fuel cargo for carrying Fleet stores, while the armament store space is in the centre. Ship can carry 1,000 tons of armament stores and up to 100 torpedoes.

The condition of the ship is good and serviceable, and the machinery in excellent running condition. Certain stores, fittings, etc., either of specialist manufacture or German origin, are, however, in short supply.

Machinery arrangement

The machinery arrangement consists of two units, each developing 11,000 S.H.P. at 120 revs. per minute, and consisting of a Wagner, Deshimag high-pressure boiler in connection with a set of turbines in series made by the same firm. Each set has one H.P., I.P. and L.P. turbine, which are placed one beside the other. A H.P. astern turbine is on the non-condenser side of the gearing and works through the H.P. pinion. In addition, the L.P. astern turbine is in the exhaust space aft of the L.P. ahead turbine. Abaft the condenser is the main gearing of the double reduction type connected to the various turbine rotors by pinions through flexible couplings. Both sets are in the same engine room.

The manoeuvring control consists of a valve for each of the nozzle groups 1, 2 and 3, of the ahead turbine which are operated by means of a camshaft. In addition there are two bypass valves which are operated by a separate handwheel when changing over from cruising to full speed.

The turbines are of the impulse type. The casings of the H.P. and I.P. ahead and H.P. astern turbines are of molybdenum cast steel and those of the L.P. ahead and astern of cast steel. The rotors are of chrome nickel steel and blading of non-rusting Krupp steel. The H.P. nozzles are held in a special nozzle box made of heat-resisting cast steel ; others are held in grooves in the turbine housing. The main steam pipes and connecting pipes between the turbines are not corrugated but have large generous bends, all in a vertical direction, easily accommodated in the lofty machinery spaces.

Turbines are fitted with labyrinth glands, the leak off steam being led through a common pipe to a gland condenser. The gland sealing steam is regulated by an Arca regulator.

Safety devices

In order to prevent damage to the various parts of the main turbines, a trip valve is fitted to each main engine before the manoeuvring valve. This is automatically shut if :—

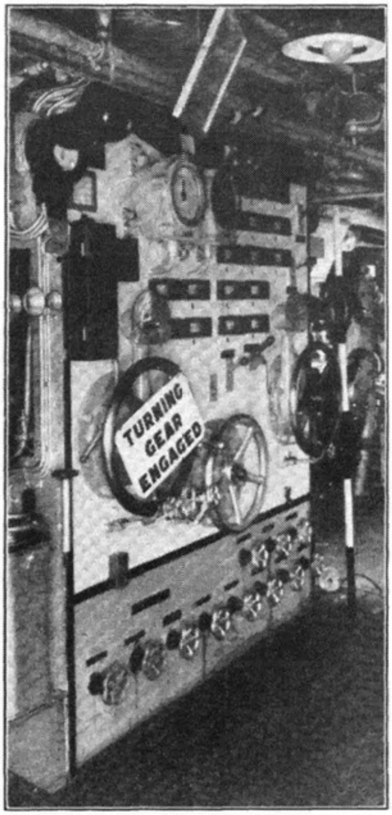


FIG. 3—MANOEUVRING POSITION.

(i) Revolutions increase excessively due to breakage of shaft, or shearing of coupling teeth, etc.

(ii) There is an excessive pressure rise in turbine due to damage.

(iii) Axial position of turbine alters to such an extent that blades are in danger.

(iv) Vacuum is lost due to various causes. The trip gear operated at 70 per cent. vacuum.

(v) Main lubricating oil system fails.

An indicator lamp gives a warning before the trip valve closes due to causes (i) or (ii).

The gear case is fabricated and the gearing of the double reduction type, wheels and pinions being fitted with double helical teeth. The material of these items seems to be in accordance with usual British Admiralty practice. There are three pinions, two intermediate wheels with their intermediate pinions and one main gear wheel. The H.P. and I.P. pinions mesh with the same intermediate wheel whereas the L.P. pinion meshes with the second intermediate wheel. The turning engines can only be engaged when the main engines are shut down. Under such conditions the manoeuvring valve hand wheels are locked by oil pressure.

Fabricated condensers of the surface type are slung under the L.P. turbine in the usual manner. Tubes are of aluminium brass and tube plates of Muntz metal. Thicker tubes are fitted at the top nearer the L.P. turbine with the idea of resisting the action of the steam. The circulating water has reverse flow with the inlet and outlet at the same end.

The emergency steaming gear has the object of keeping the ship under way in case of damage to the H.P. and I.P. turbines by passing steam (reduced in pressure and cooled) direct to the L.P. turbine, the H.P. and I.P. being uncoupled and locked.

The lay-out of machinery is illustrated in Fig. 2.

A feature of the machinery arrangement is the group pump made by the main machinery contractors and fitted to each unit. This is a combined main feed pump, circulating pump, feed supply pump and extraction pump, driven by one turbine and situated at the forward end of each main turbine beside the condenser. For each main engine unit there is one turbine driven standby feed and feed supply pump for harbour use. The feed supply pump sucks water from the feed heater and discharges to the standby feed pump and thence to the boiler. The standby is a two-stage and the feed supply a single-stage centrifugal pump.

The forced lubrication system follows the usual practice. A standby electric oil pump with automatic cut-in device is fitted for the lubrication of each set of main engines and its group pump.

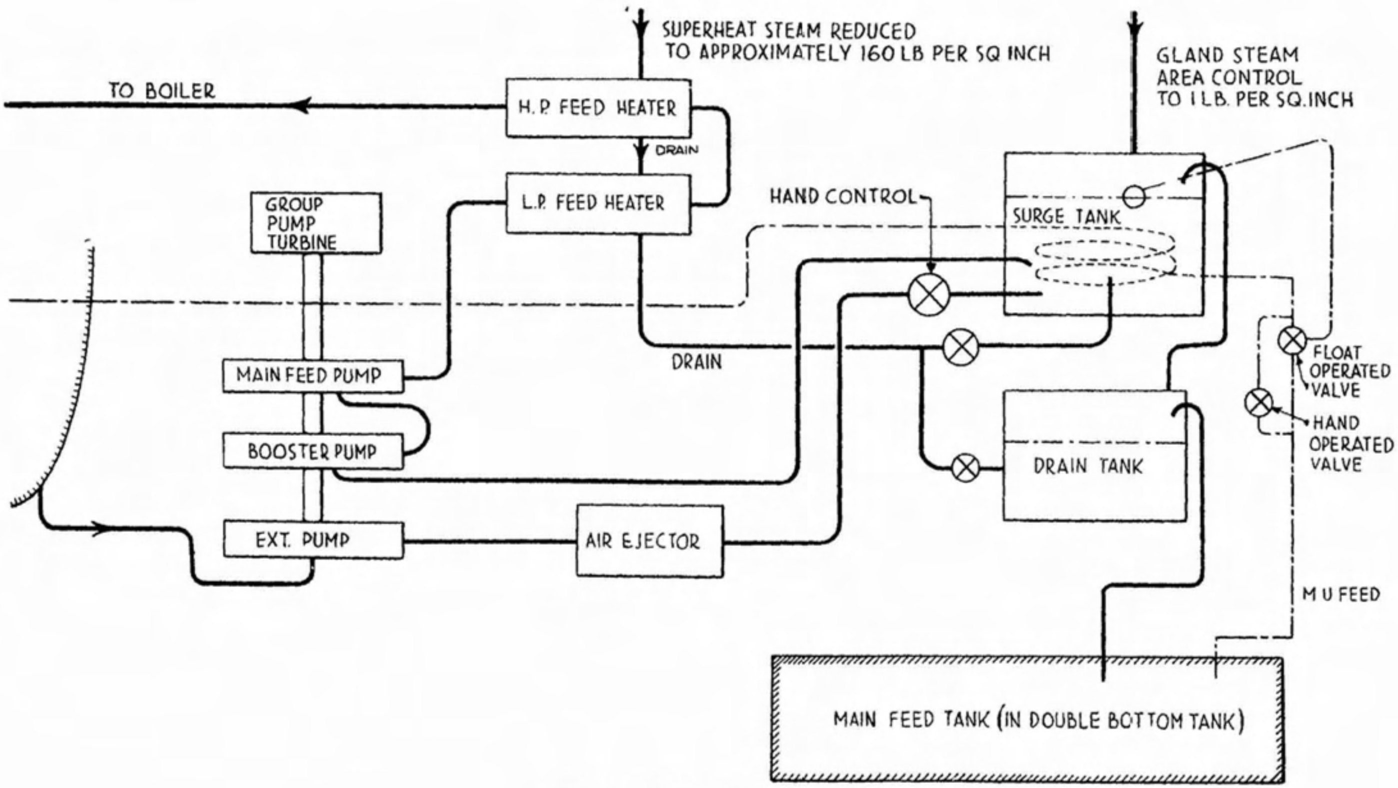


FIG. 4.—CLOSED FEED SYSTEM

Closed feed system

The arrangement of closed feed system is shown in Fig. 4.

The condensate is taken by the extraction pump and passes through condensate cooled air ejector to a surge tank where the temperature is raised by the feed heater drain and gland steam, thence to booster and main feed pump through H.P. and L.P. feed heaters to feed regulator. Condenser level is regulated by hand control valve on surge tank.

Make up feed is obtained by another hand-operated valve and sucked to the condenser after going through a two turn coil in the surge tank. A float operated valve is fitted for this purpose but it is not reliable for manoeuvring.

Auxiliary machinery

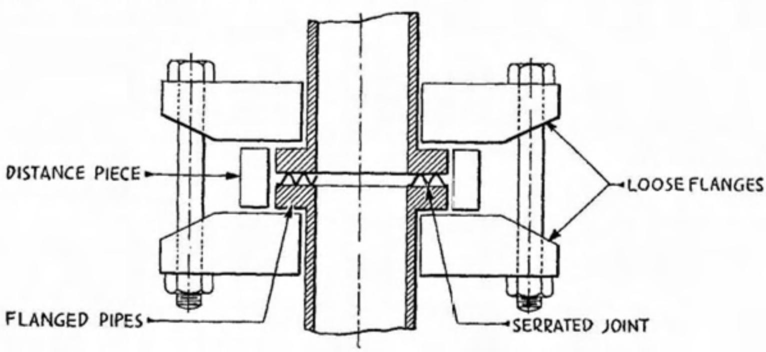
Electrical power is supplied by 2 in No. turbo-generators 200 K.W. Brown-Boveri 230 volts D.C., 2 in No. 200 K.W. Diesel generators with airless injection and air starting. There is also one Diesel harbour generator. The turbines have automatic nozzle regulation and are designed to work on superheated steam. Their use, therefore, necessitates the main boilers being alight.

The ship was never intended as a harbour vessel and indiscriminate use of the Diesel engines leads to fast wearing under harbour loads. Replacement of spares is not easy and an additional turbo-generator to work on saturated steam from the auxiliary boilers under harbour conditions would be more economical.

The cargo oil pumps of horizontal reciprocating type are of Worthington design. Together with residue transfer and bilge pumps they are situated in the hold between the cargo oil tanks. Compressors are fitted in the auxiliary machinery compartment aft of the engine room for Diesel starting air. There is also a combined compressor and auxiliary lighting set in the upper deck compartment for charging torpedoes and supplying auxiliary lighting driven by a 32 K.W. Diesel driven Junkers engine. A number of CO_2 refrigerating machines exist for ship's domestic use. There are in addition 4 CO_2 plants, each of 60,000 B.T.Us. capacity aft, and 5 in No. similar sets forward for the cargo provision rooms.

The machinery compartments are very lofty and spacious, giving a good impression. They are clean and all pipes have coloured bands for identification. All fittings are of robust construction. The auxiliary engine room is underneath the boiler room and is well laid out. All tends to infer that watchkeeping is relatively comfortable. From a machinery point of view it would appear that a good job has resulted, but it is evident that the designer had little restrictions as regards machinery weight and space.

There is almost a complete absence of steam leaks and the design of joint fitted throughout the ship is as follows :—



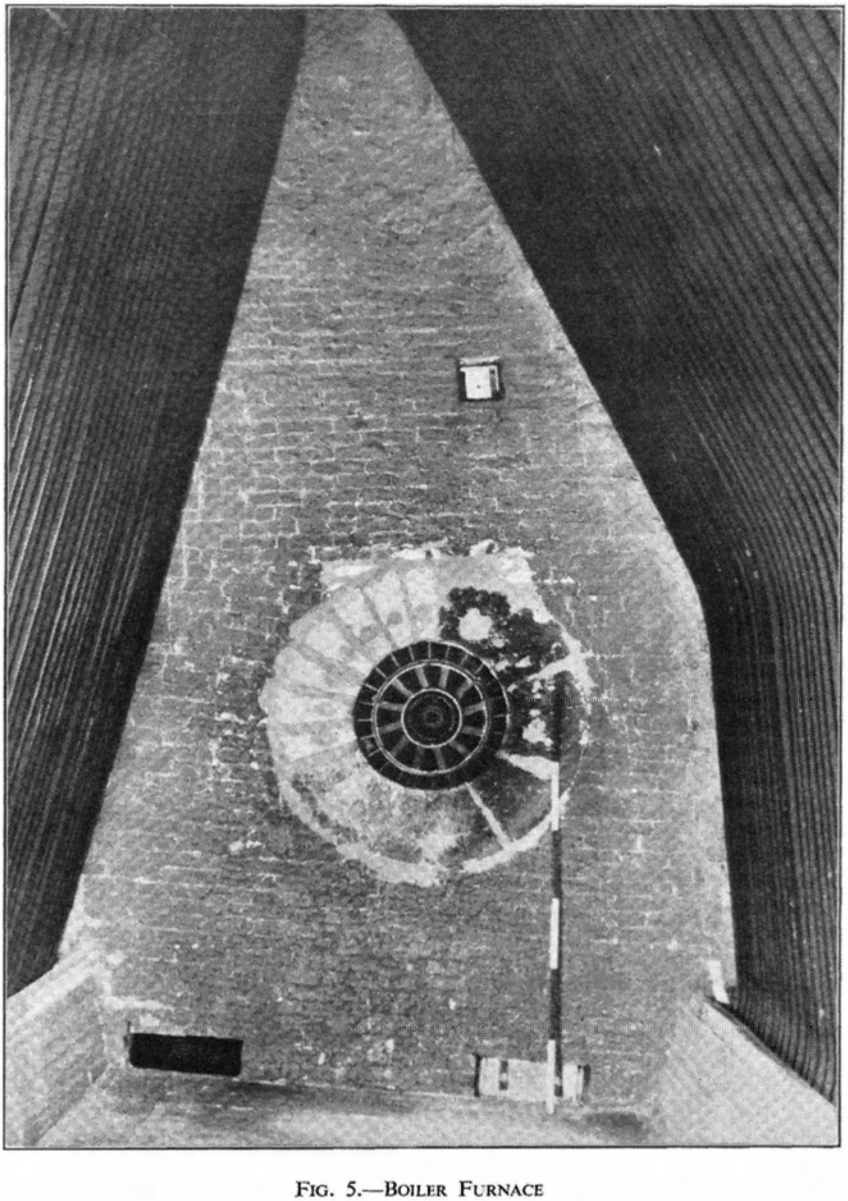


FIG. 5.—BOILER FURNACE

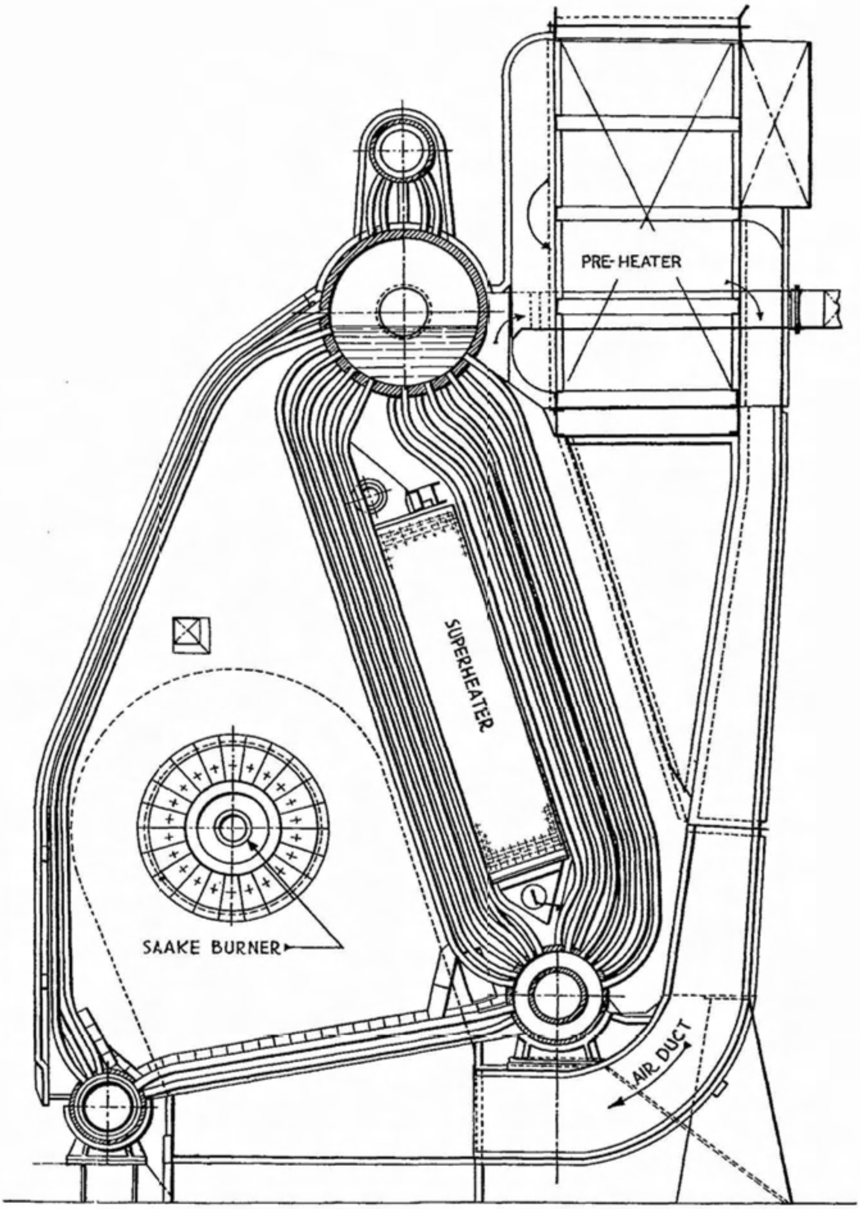


Fig. 6.—Boiler

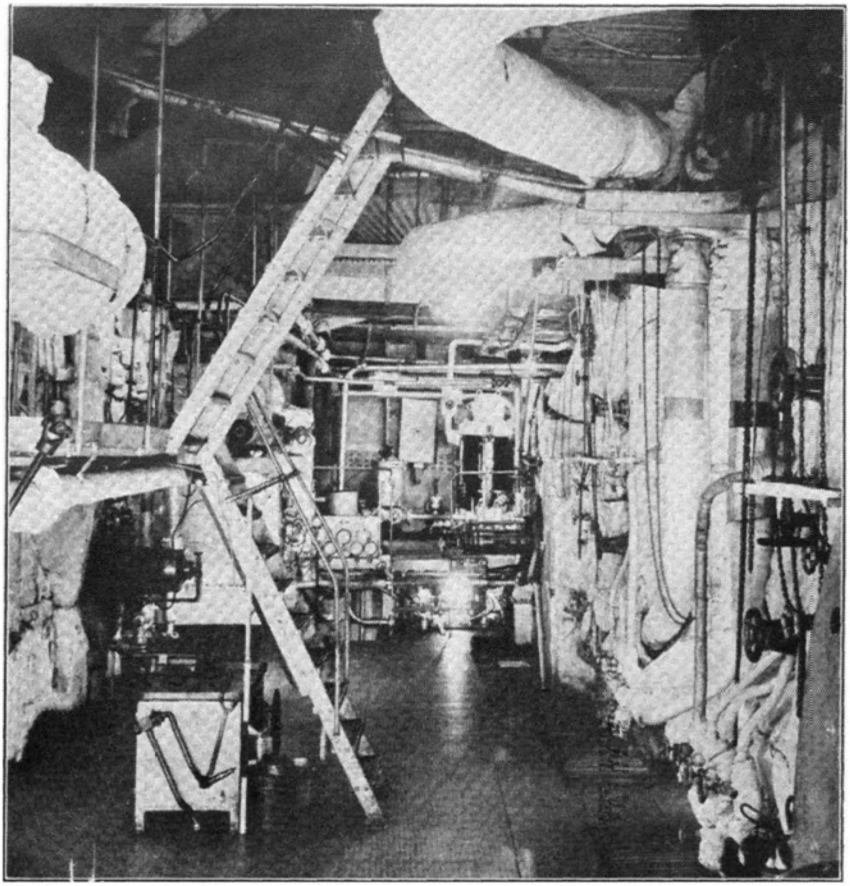


FIG. 7.—BOILER ROOM

Boilers

Two main high-pressure double-ended water-tube type boilers are fitted in the boiler room with pre-heaters and superheaters (Fig. 6). According to information obtained on board each is designed to conform to the following data :—

Normal working pressure at superheater	648 lbs./sq. in.
Steam temperature at outlet from superheater ...	815° F.
Working efficiency of boiler at full power	85%
Quantity of water evaporated per lb. of fuel oil ...	13.1 lbs.
Quantity of water evaporated per hour	101,200 lbs.
Sprayer fan air pressure	33.4 ins. of water
Temperature of combustion air on entering	554° F.
Pressure of combustion	6 ins. of water

Above the upper drum there is a steam collector which is provided with a flange at each end one to carry the stop valve and the other to carry the safety valve.

The superheater is in two parts, each half being capable of withdrawal towards its end of the boiler.

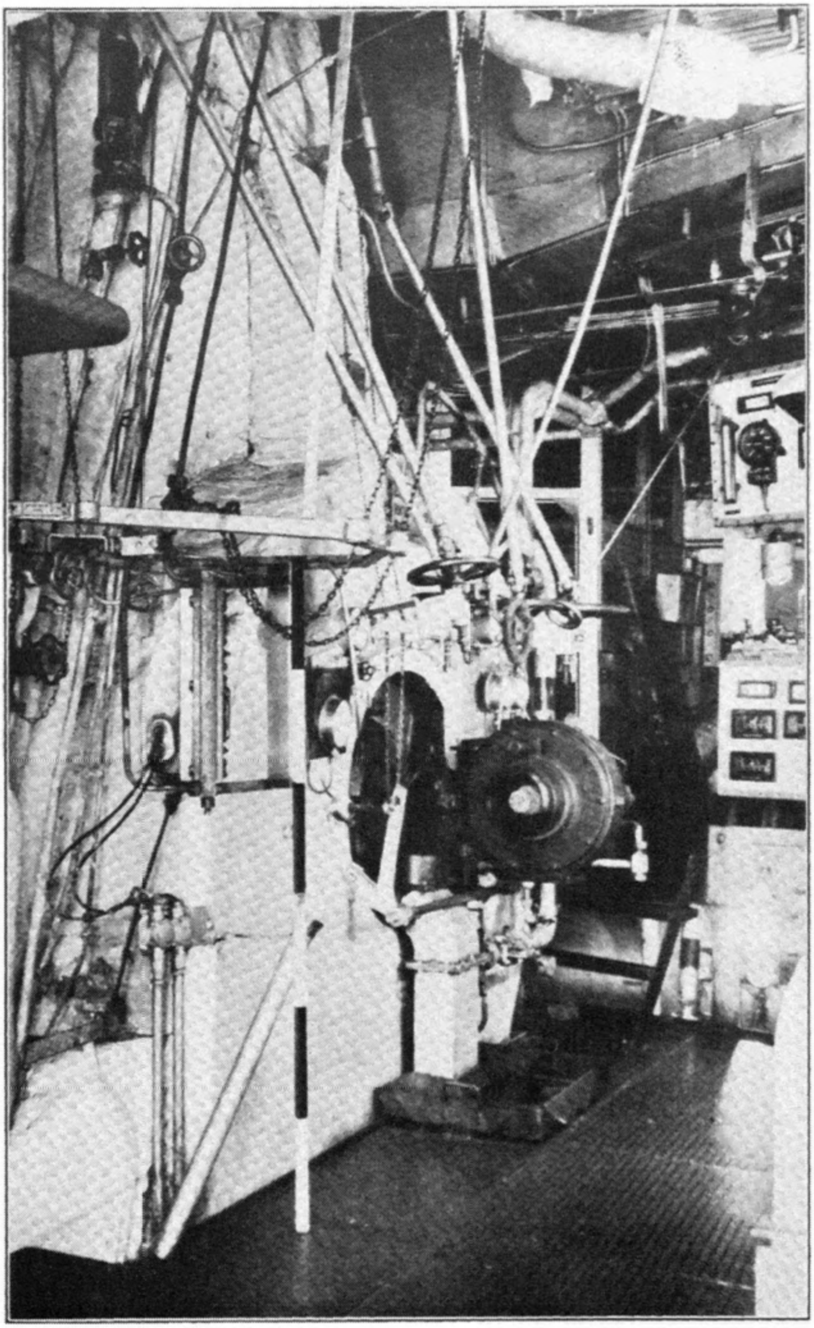


Fig. 8.—Boiler room showing Saake Burner swung back

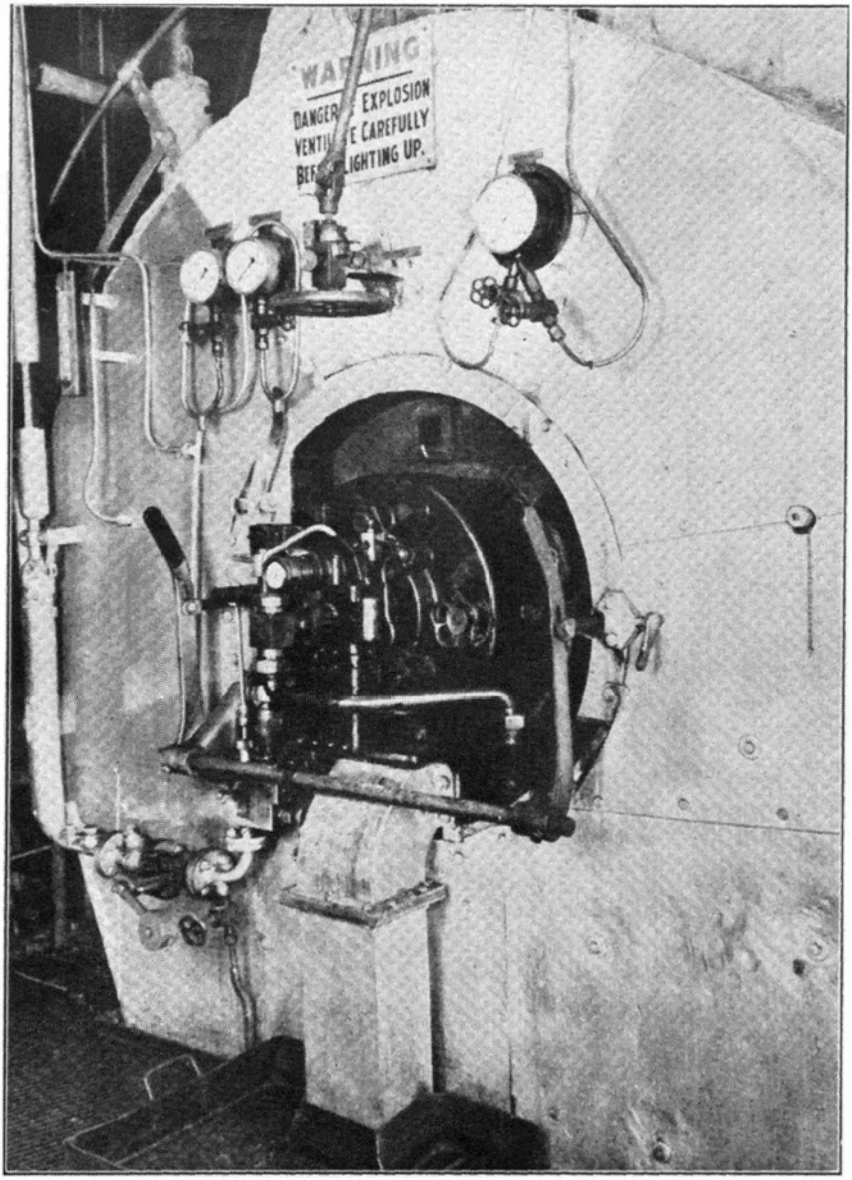


FIG. 9.—SAAKE BURNER

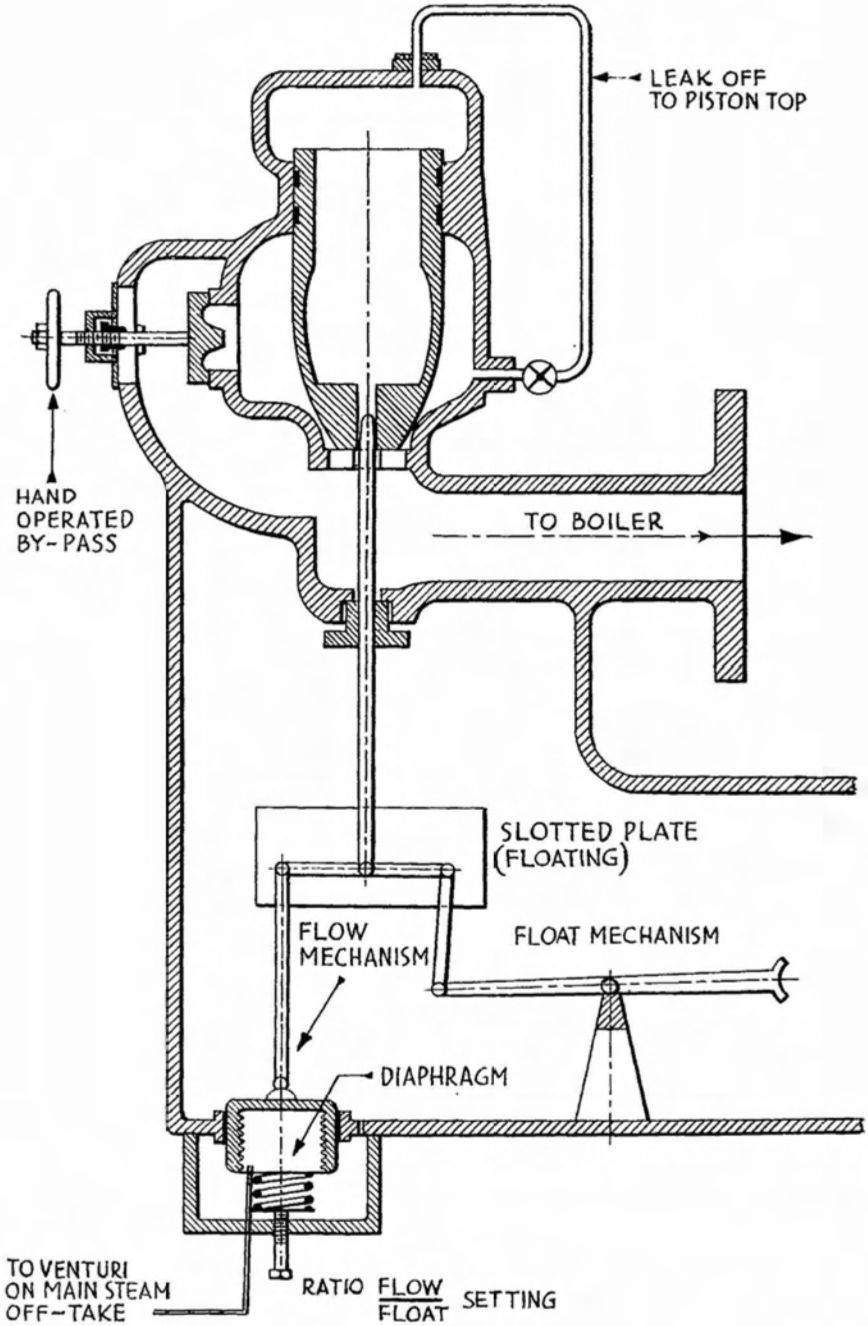


FIG. 10.—AUTOMATIC FEED REGULATOR

The boilers are bricked in the usual manner and to increase the resistance of the surface to heat a mixture of heavy oil containing powdered glass had been smeared on the brickwork.

Access to the furnace is obtained by swinging out the outer part and taking out the inner cone of the Saacke burner fitted one to each end of the boiler. Each burner is supplied with primary air to assist the atomising of, and to impart swirling motion to, the oil fuel. Pre-heated secondary air is supplied through casing ducts for combustion in the furnace. The air is sucked out of the boiler room by the turbo boiler fan and passed through trunking into the air preheater. After passing over the heater tubes it passes through another trunking to the inboard side wall and ends of the boiler casing and thence through the burner into the furnace.

There are two in number forced draught fans for supplying the secondary air to the furnaces, and two in number oil fuel pumps and primary air fans for the Saacke burners. Each sprayer is capable of burning 3,960 lbs. of fuel per hour and this can be regulated to 1/10th of that capacity. A specially electrically driven sprayer fan is used for lighting up.

Steam jet soot blowers are fitted at each end and can be operated from the boiler-room platform. There are also hand soot blowers which make it possible to clean the boiler whenever necessary.

Uptakes are of the usual design, both boilers have a common funnel, divided the whole of its length by a partition so that virtually each boiler has its own uptake. Many devices are fitted in the boiler room, including funnel gas sampling apparatus, CO_2 measuring sets, water level indicators at floor plate level, and oil fuel flow indicators.

To provide saturated steam for auxiliary and domestic purposes two single unit Wagner type water tube boilers are provided, each evaporates 20,000 lbs. of water per hour at 200 lbs./sq. in. Both are fitted with preheaters and lead into a common funnel, which, in turn, is enclosed in the oval outer casing of the main funnel. The services supplied by these boilers are as follows : Winches, capstans, ship's heating, oil fuel tank heating, gland steam system and cargo pumps.

The main and auxiliary boiler saturated steam pipes are cross-connected through a reducing valve ; there is no separate superheated auxiliary steam range.

Automatic feed regulator

The automatic feed regulator is of interest and is shown diagrammatically in Fig. 10. These automatic feed regulators are fitted with flow control and a hand-operated bypass, a venturi nozzle being connected to the diaphragm and a link mechanism couples this to the movement from the float, the sum of the two movements being transmitted to the needle, which controls the movement of the check itself. The latter is of the rather curious shape indicated, presumably so that with constant W.L. flow through valve is approximately equal to the steam evaporated. The port regulator was out of action, due to some defect presumably, but starboard worked perfectly the whole trip with very little trace (if any) of hunting. Manoeuvring was not, however, severe enough to constitute any real test. The spring tension on the diaphragm affects its movement for a given change in pressure.

Full power trial

A full power trial was carried out with the machinery in units. The number of records taken were few, but the salient figures are given below. Full credit must be given to the engine and boiler room staff in that for both trials they were the only personnel available for taking these records under conditions of difficulty. Most of the instruments were of continental manufacture with metric dimensions and quantities and some allowance must be made on this account.

NOTE.—In some instances it will be noted that a design figure under full-power conditions has been quoted beside the trial figures recorded.

	Port	*Starboard*	*Design*
Boiler Pressure, lbs./sq. in.	600	575-600	
Throttle steam, lbs./sq. in.	550	510	
H.P. nozzle pressure, lbs./sq. in. ...	500	500	553
H.P. nozzle temperature, ° F. ...	770	800	737
I.P. nozzle pressure, lbs/sq. in. ...	205	210	205
I.P. nozzle temperature, ° F.... ...	620	625	577
L.P. nozzle pressure, lbs./sq. in. ...	40	47	44
L.P. nozzle temperature, ° F. ...	390	300	350
Vacuum	29	28	
Circulating water inlet temperature, ° F.	50	50	18° difference
Circulating water outlet temperature, ° F.	67	69	
R.P.M.	124	124	
Closed exhaust, lbs./sq. in.	19	20	
Sea water temperature, ° F.	50		
Air temperature, ° F.	38		
Superheater temperature, ° F. ...	825	850	815
Forced draught fans, inches of water	4½	3.0	
Sprayer fan, inches of water ...	18-24	—	
Uptake temperature	660 average		
Temperature of air entering furnace	465	554	
Sprayer fan, revs. per minute ...	5,000	4,000	

During the whole of the trial there were no signs of pulsation of the main boilers. The burning of oil fuel and control of combustion at the Saacke burners was excellent. A clear funnel was maintained and there were no signs of carbon deposits on the brickwork cones or the sprayer bowls of the burners.

Difficulties

Local overheating of the casing of the main boilers occurred in some positions. Full boiler pressure of 635 lbs. per sq. in. could not be maintained by reason of defective pilot valves of the main safety valves. The port main boiler automatic feed regulator failed to function and hand control of feed water to this boiler was necessary. The feed water consumption was rather high, the loss being attributed to :—

(*a*) Defective packing of port and starboard group pumps, feed pumps.

(*b*) Overflowing of feed water into bilges from port overflow tank.

(*c*) Defective safety valves.

Trouble was experienced with the port and starboard turbo-sprayer fans and oil fuel pumps when steaming at 124 r.p.m. In each case the opening of the full-power nozzles failed to increase the revolutions of the turbines, the fuel pumps being defective. The motor-driven sprayer fan and oil fuel pumps were used during the period of making good defects to the fuel pumps of the turbo sprayer fan.

It was observed that communication by telephone from Bridge to Engine Room and Boiler Room to Engine Room was impossible owing to noise interference.

One objectionable feature was that at full power sulphur fumes were very strong in the vicinity of the Stoker Petty Officer's position in the boiler room.

A satisfactory trial

After 2 hours at 124 r.p.m. machinery was worked down to the speed ordered to complete the passage in schedule time. The fuel consumptions from the flow meters recorded during the full power trial worked out at approximately 200 tons per day, showing a speed of about 20.5 knots and a horse-power of 20,500 on the graphs. In general the machinery worked excellently, easily responding to increase or decrease of power required. The minimum attention required to the boilers was remarkable when compared with conditions, say, in a boiler room of a cruiser. Slight adjustment of the air flaps to alter the burner flame and alteration of oil fuel by-pass on individual burners was the only operation required at the boiler.

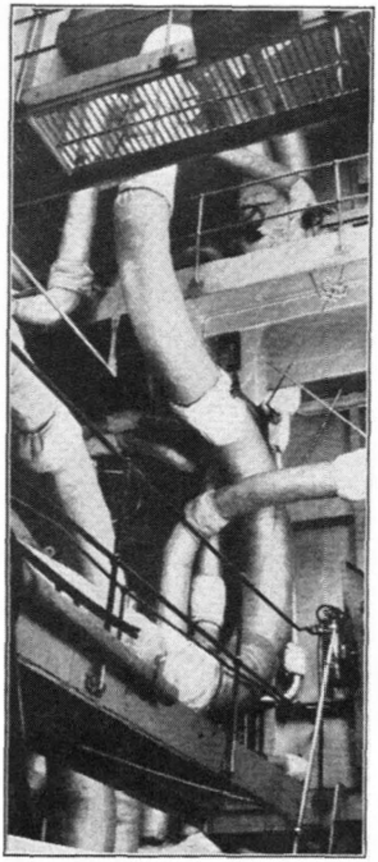


FIG. 11.—VIEW OF MAIN STEAM PIPES LOOKING UPWARDS

Temperature conditions in the machinery spaces were very comfortable, which was attributed to the large sized compartments facilitating free radiation. Both engine and boiler rooms are under natural supply conditions, large exhaust fans being fitted on the main deck with trunking right to the bottom of the engine room.