IMPROVED LEANDER CLASS FRIGATES

BY

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Introduction

During 1960 and 1961, increased efforts were made to correct some features of the machinery installation in *Whitby* and *Rothesay* Class frigates which were not as reliable as they should be, and by early 1961 sufficient running experience had been gained to indicate the items which required to be modified in later designs. By this time seven *Leander* Class frigates had been ordered, which were virtually repeats of the *Rothesays* as regards machinery, and later in 1961 another three were ordered to the same design, making ten in all. This continuation of the Type 12 New Construction programme clearly warranted correction of known shortcomings if design weaknesses were not to be perpetuated. It was, however, essential that there should be no break in the flow of orders for new *Leander* Class frigates, and in order to catch the next batch of orders in 1962 only a limited amount of redesign was possible. In addition other divisions within the Ship Department were heavily committed, and could not undertake extensive redesign of the ship. In particular the Naval Construction Division wished to limit the drawing work load, already large because of weapon changes, and required all connections to the machinery compartments to be kept the same unless a change was vital. This precluded any alteration to the position of the blower downtakes, ventilation trunks, uptakes and so on. So far as the Marine Engineering Division was concerned the short time available prevented the use of any machine which was not already existing or in service, except that machines being developed for ships already building could be used, for example, the 450 kW Diesel alternators for the Assault Ship.

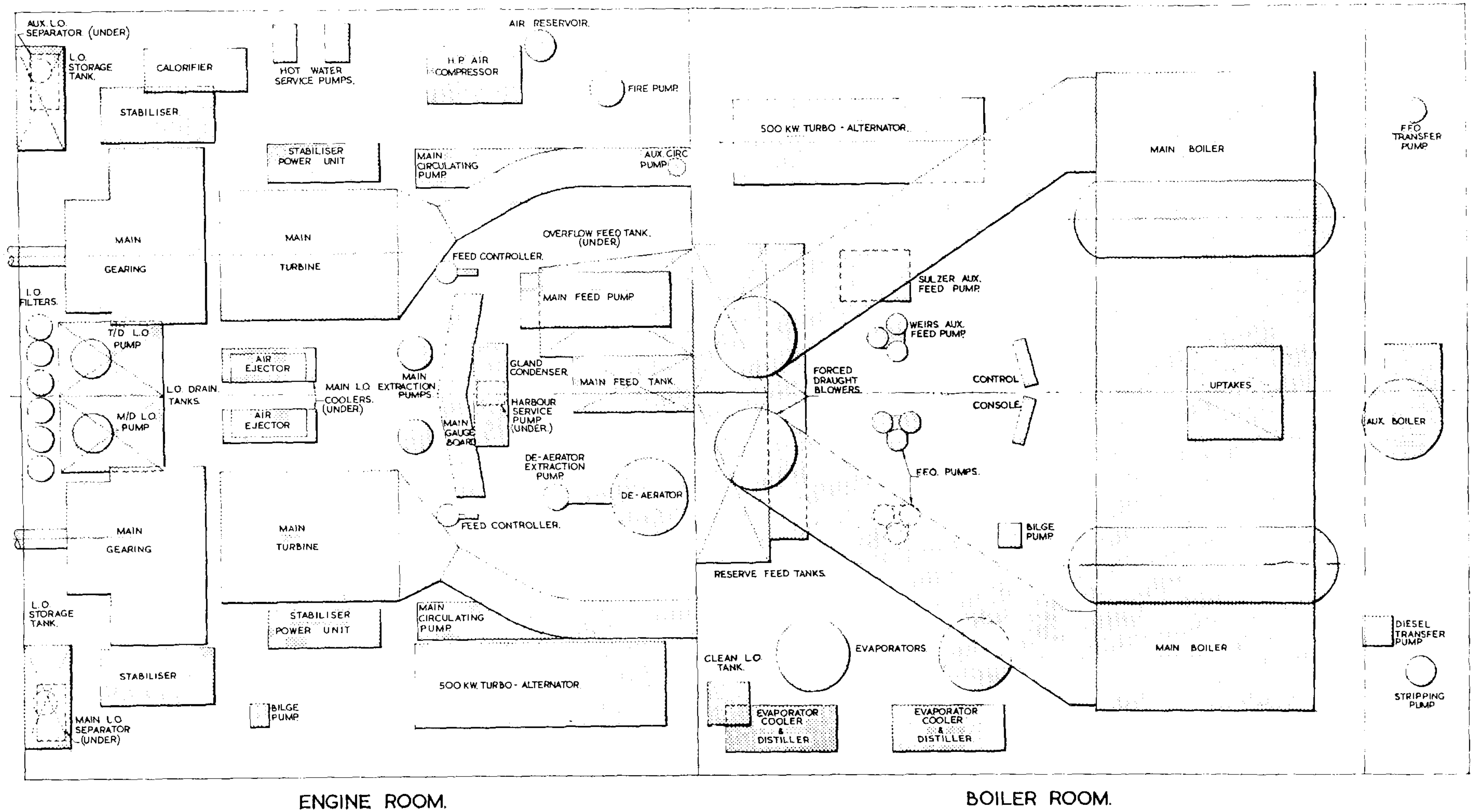

FIG. 1—LEANDER CLASS MACHINERY LAYOUT

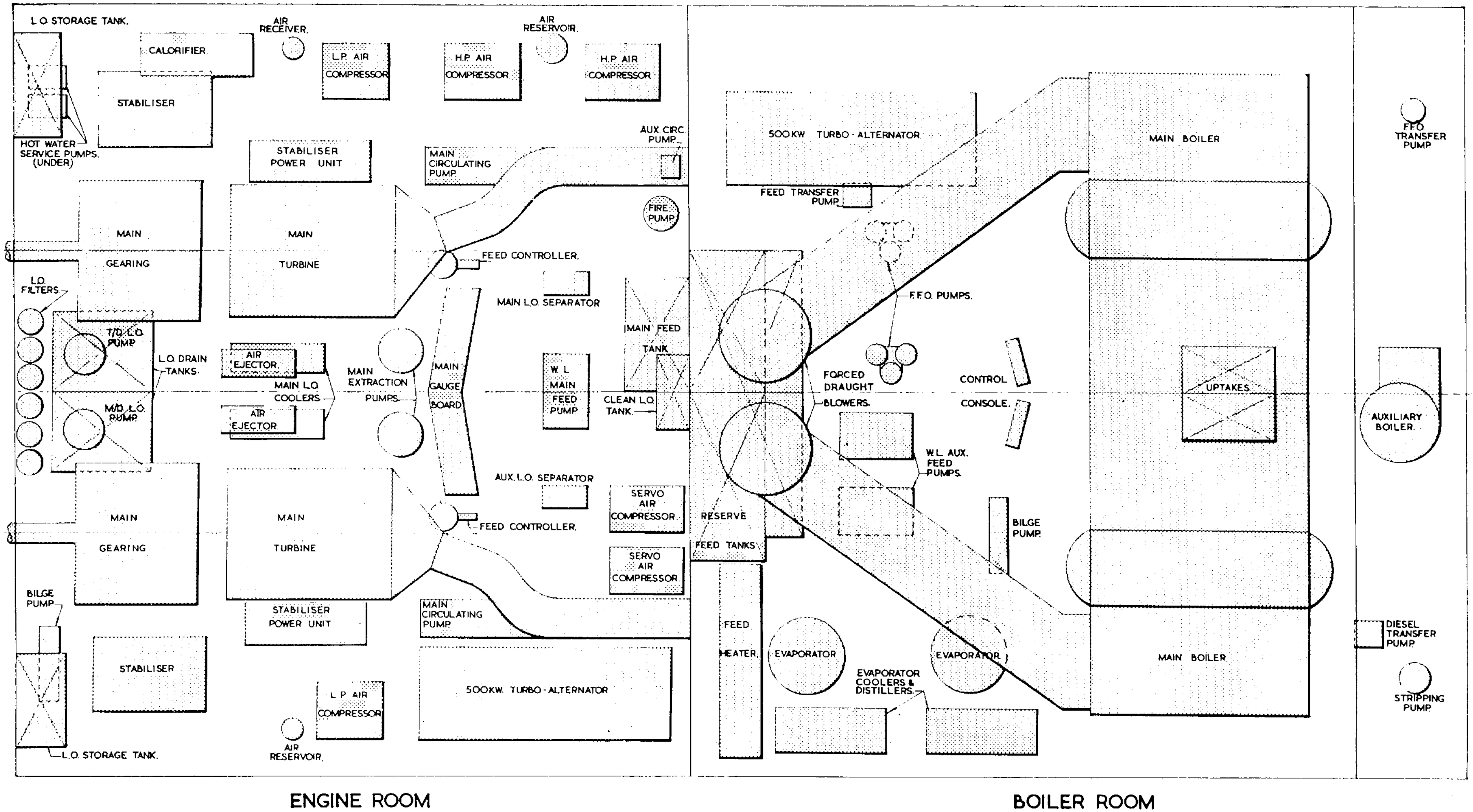

FIG. 2—Y.136 IMPROVED LEANDER CLASS MACHINERY LAYOUT

The limitations described above naturally imposed some considerable restriction on this redesign, but it must be remembered that this is not a new design of ship, only an 'improved' version of an existing design. All the defects which had come to light in previous ships were considered both from S.2022 records and from discussions and meetings with numerous engineer officers of running ships, so if the reader's pet hate has not been dealt with, there has been a good reason why it could not be done. The remainder of the article describes each change made in the new *Leanders*, which are known on their drawings as 'Y.136 *Leanders*' and from their specification as '1962-63 *Leander* Class'. Y.136 is the Yarrow-Admiralty Research Department contract reference under which the new specification was written. FIG. 1 shows the machinery layout in the original *Leanders*, and FIG. 2 that in the 'Y.136 *Leanders*'.

Feed Heater

The deaerator and its extraction pump together with the complex feed system associated with them had given trouble, and required excessive maintenance. The degree of deaeration which a deaerator provides is no longer considered necessary where the steam pressure is as low as 550 lb/sq in., and a simple surface feed heater has been fitted instead. Reference to FIG. 2 shows that this has been fitted in the boiler room where the switchboard was in *Whitby* and *Rothesay* Classes. It is a very cramped position, and it is recognized that repair will be a refit task. However, little trouble has been experienced with pressure feed heaters in service. There is room to remove the end cover and plug a burst tube and the heater can, of course, be by-passed in the event of serious damage.

Feed System

The feed systems in modern ships are necessarily complicated, and the deaerator makes them more so. The system was carefully examined to see what could be done to prevent unnecessary complexity, and to shorten runs of piping. The feed heater could only be fitted in the one position, and the main and auxiliary feed pumps have been positioned so far as possible to obtain a smooth flow, with short runs of piping to suit the fixed position of the feed heater. The main feed pump is on the centre line, and the two auxiliary feed pumps are on the starboard side near the feed heater in the position occupied by the F.F.O. pumps in earlier ships. The feed water flows from the condensers, through the extraction pumps and air ejectors, through the main feed pump (or one of the auxiliary pumps at powers below 50 per cent), up to the feed heater, and on to the boilers. By referring to FIG. 2 it will be seen that this involves very little doubling back or weaving from side to side.

Modern practice is to dispense with the overflow feed tank and to fit a main feed tank only, all drains being arranged to run under gravity to the main feed tank, or if low down in the ship to be pressurized. This has been done in these ships, and one tank of the combined capacity of the previous main and overflow tanks has been fitted. The tank is fitted with a baffle to keep hot water under it with a minimum possibility of absorbing air, and all connections to the tank are carefully designed and specified to maintain partially deaerated hot water available for any sudden calls due to power fluctuations. The make up connections are sited high up under the baffle. All water is removed via the float controllers, and sprayed high up into the main or turbo alternator condensers, where it is deaerated. In the event of the feed tank becoming excessively hot, the feed heater drain can be diverted directly to the main and T/G condensers.

The system is designed to operate as a closed feed system when auxiliary steaming by fitting closed feed controllers to the turbo alternators. The system then operates in exactly the same way as the main system, with make up water being sprayed into the turbo alternator condensers for deaeration. This was considered to be a desirable feature in its own right, and additionally to provide a degree of deaeration in harbour now that the deaerator has been removed. When the main extraction pumps are in use, the T/G extraction pumps (which are designed with a smaller discharge head) do not operate in parallel, but deliver the T/G condensate to the feed tank via their own feed controllers.

Extraction Pumps

The original extraction pumps were driven by geared turbines to improve their efficiency although this made them more complicated. The maintenance load was heavy, and, unfortunately, the machines were unreliable, mainly due to repeated thrust failures. A small reduction in overall plant efficiency has been accepted, and direct drive units are being fitted in these ships. They are practically identical with those fitted in G.M. destroyers, and are known to be reliable units. Maintenance is of course greatly reduced. The original units were pressure governed because of the requirements of the deaerator, and the new units are able to employ a simple speed governor. Consideration was given to making at least one unit motor driven to save complexity of steam pipes, control gear, and maintenance, but the electric power available is limited, and it was eventually decided to retain two steam driven units.

Main and Auxiliary Feed Pumps

The original pumps fitted had several disadvantages. The Weirs Y.100 main feed pump was large and its lubrication system was troublesome in many respects. The Weirs reciprocating auxiliary pump suffered from heavy ring wear especially on hot feed, required a lot of maintenance, and its specified output was inadequate. The Sulzer auxiliary pump required a complete redesign to improve reliability, and its specified output was also inadequate. Experience in service had shown that adequate stand-by feed pump capacity was vital to ensure boiler safety, and various schemes were investigated all with a minimum requirement of 100 per cent stand-by capacity, so that if the main feed pump failed, the P.O.M.(E) would have plenty of water available to protect the boilers. The final solution reached was to provide a 100 per cent water lubricated Weirs main feed pump (T.W.L.35) in the engine room, and two 50 per cent water lubricated Weirs auxiliary feed pumps (T.W.L.20) in the boiler room in place of the existing pumps. These water lubricated units have been used in the merchant service and two units have been tried in *Blackwood* Class frigates. They have not been trouble free, but the failures which have occurred have all been taken into account in the design of these units, and in particular in the installation of the water lubrication arrangements integrated into the feed system in these ships. The pumps are small, robust, quiet and cheaper than the units they replace. They have very few moving parts, and all these parts can be replaced with spares in a short time by ships staff without outside assistance. Most ships have used their main pump under all conditions because of the unreliability and small output of their auxiliaries, and a reliable 50 per cent auxiliary unit will be more economical. Their steam consumption, size for size, is comparable with the original Y.100 main feed pump.

Air Ejectors and Gland Evacuation

All auxiliaries except the turbo alternators will be fitted with carbon glands in accordance with current practice, and will be arranged for, but not with, gland evacuation. The gland vapour condenser has been dispensed with, and the main engine glands are dealt with by a combined air ejector and gland vapour condenser, which is the same unit as is fitted in G.P. frigates. The turbo alternators deal with their own glands as in earlier ships. The boiler room combined drain cooler and gland vapour condenser becomes a simple drain

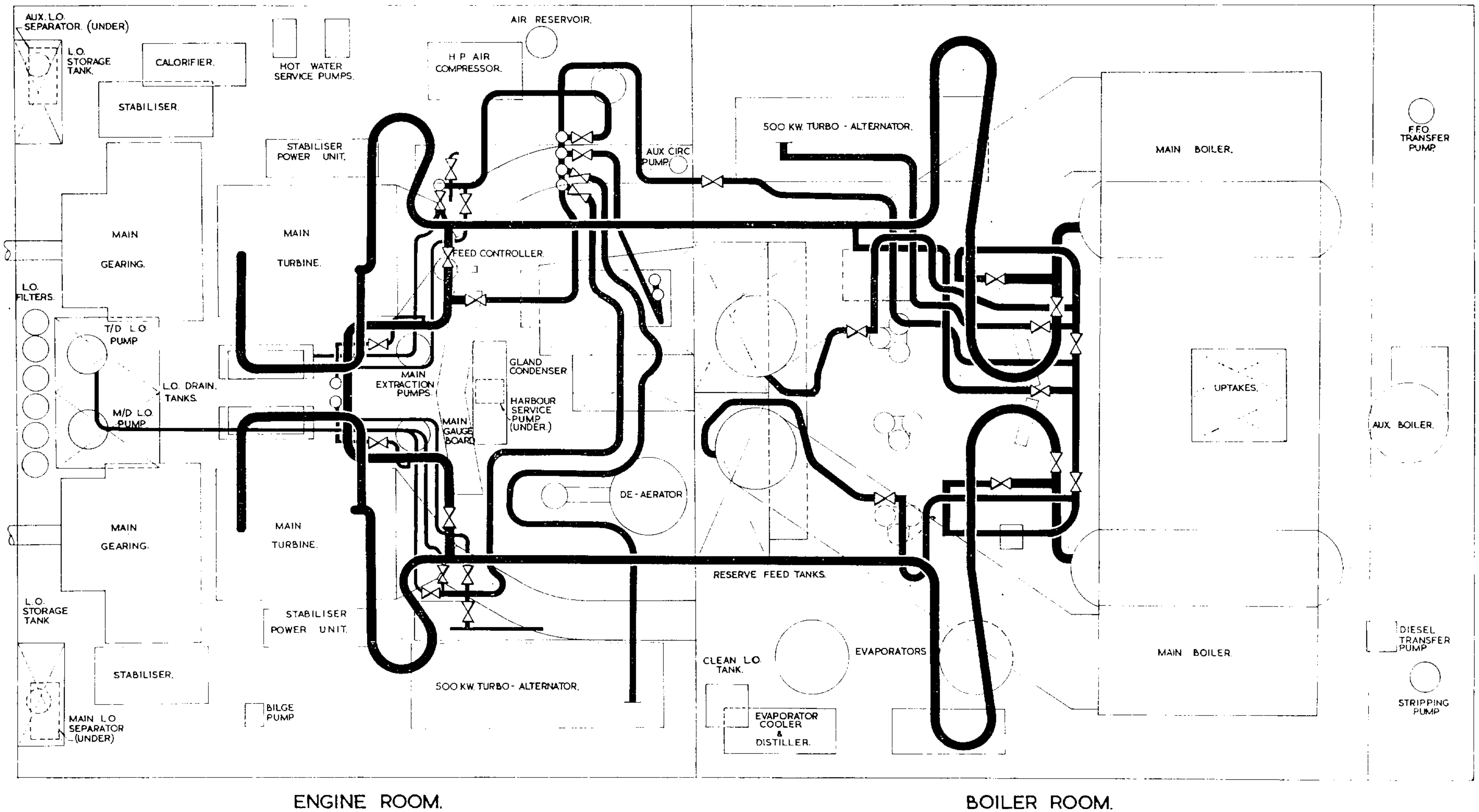

FIG. 3—LEANDER CLASS SUPERHEATED STEAM SYSTEMS

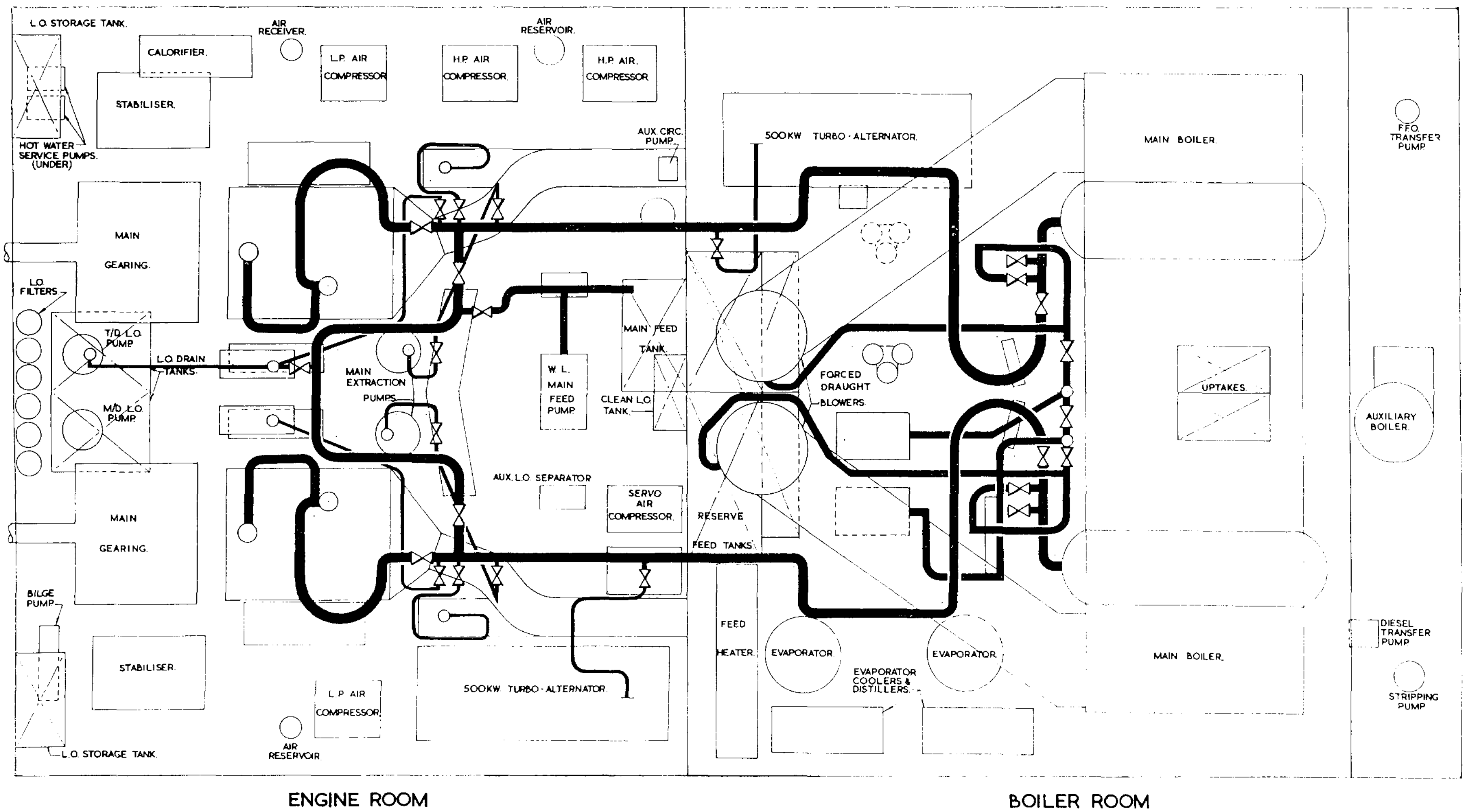

FIG. 4—Y.136 IMPROVED LEANDER CLASS SUPERHEATED STEAM SYSTEMS

cooler. Very little development has been required to fit carbon glands to all auxiliaries because most of the turbines already had carbon gland versions in use in other applications.

Superheated Steam System

The superheated steam systems were carefully studied to eliminate known defects, and with a view to simplification if at all possible. It was found that cross-connections between systems generally lead to vulnerable points where one failure, be it action damage or defect, may cause the whole plant to be put out of action. A single system, such as the auxiliary superheated steam system in *Leanders* is also very vulnerable because failure may put all engine room or all boiler room auxiliaries out of action, and damage to the bulkhead valve between engine room and boiler room will put all auxiliaries out of action. This leads to the conclusion that two systems are required, each one supplying one side of the ship, with the minimum of cross-connections, and further that there is no advantage in separating main and auxiliary superheated steam systems. Taking into account the 'lagged' size of pipes, every effort should be made to have as few pipes as possible if the deckhead is going to be visible at all. The original system fitted in *Leanders* is shown in FIG. 3 and that fitted in Y.136 *Leanders* in FIG. 4. It will be seen at once that there is a marked reduction of actual pipework brought about by the amalgamation of the main and auxiliary superheated systems, and also by a general tightening up of the pipework design. The pipe design has been optimized as far as possible so that the pipes are operating only a little below the permitted stress limit. The stresses in the multi-anchor arrangements have been rigorously checked for all operating and dismantling procedures; this extensive stress programme was carried out on a digital computer at Yarrow-Admiralty Research Department and involved hundreds of hours of computer operation. Without the use of a computer the improvements could not have been realized.

The number of valves in the system has also been reduced, partly by the amalgamation of main and auxiliary systems, and partly by using valves in the boiler room range as guard valves, instead of fitting additional valves. Allowing for the replacement of one auxiliary saturated feed pump by a superheated one, the new system has five less valves to maintain. There were originally 28 valves, so the saving is about 18 per cent.

The new system allows all the operational flexibility of the old. The only disadvantage is that when auxiliary in harbour, steam must be admitted up one or other side of the engine room up to the main engine guard valve, whereas in the old system steam could be confined to the boiler room. However, this class of ship is expected to shut down to Diesel alternators in harbour, and not to remain flashed up for more than a very small percentage of time at normal notice.

It has been necessary to introduce the main engine guard valves referred to above to provide positive shut off of steam from the main engines, and to maintain two valves between engines and steam. It will also be noted that if the ship has to be auxiliary in harbour with the starboard boiler and boiler room turbo alternator out of commission, then steam must be flooded right round the system to enable the port boiler to supply the engine room turbo alternator. It has been accepted that under these double-fault conditions steam will be up to the main stop of the non-steaming starboard boiler.

Saturated Steam System

The design of the system has not been altered but it has been restressed as a multi-anchor system using the computer at Yarrow-Admiralty Research Department, and considerably cleaned up as a result. The engine room range has been re-run via a more direct route with considerable saving of pipe.

The reducing valves providing the L.P. saturated steam have been a constant source of trouble, and a heavy maintenance liability. They have therefore been replaced by a servo air operated design, which should provide a reliable source of L.P. steam at constant pressure. This in its turn should improve the quality and output of the evaporators when running on live steam.

Exhaust Steam System

The auxiliary exhaust system has had to be completely redesigned due to the introduction of the feed heater. At the same time the Arca exhaust pressure control system has been replaced by a servo air operated system, and the control point has been placed where the evaporators take off the range in order to provide a really steady pressure for the element steam. It was also planned to take the gland steam reservoir supply from adjacent to the control point, but it was found that the gland steam control valves had been tested satisfactorily over a wide range of supply pressures, and so the lead was taken from a point in the engine room, thus saving considerable pipe run, and a bulkhead penetration. It was also considered possible that the supply could have been taken from the exhaust rejection leads to the condensers just before the gland steam control valves, which would have been a very neat arrangement. However, doubt was felt about the conditions close to the rejection valves when the system was rejecting at full bore to the condenser, from a nominal 10 lb/sq in. to, say, 28 inches of vacuum. It was felt that there might well be a vacuum close to the rejection valve, and one ship of the class is being instrumented so that conditions may be observed on trials. If conditions are favourable, the exhaust system could be further simplified in later ships of the class, or the information used in a new design of ship.

Turbo Alternators

The installed electrical power has been increased to match the load which has crept up in each succeeding class, and a further increase was desirable for these ships, but unfortunately the existing sets have reached the limit of their development, and a bigger plant could not be fitted in the available space. Some improvements have been made to improve reliability. A closed feed controller has been fitted to improve the operation of the extraction pump, and also to fit in with the harbour state of the whole plant, giving a closed feed system as described under 'Feed System' above. The make-up water is sprayed into the condenser to provide deaeration in the harbour condition, and the air ejector is condensate cooled to eliminate a possible source of feed contamination. The extraction pump has been redesigned to deal with the heavier duty, and to eliminate the instability encountered in earlier designs.

Diesel Alternators

The original concept of the Diesel generator exclusively for emergency needs has changed, and it is now recognized that Diesels are required primarily for harbour use, and that this will adequately cover the salvage duty for which they were originally fitted. Time has shown that hopes of world-wide availability of adequate shore power have not been fulfilled, and ships must be self-sufficient while maintaining in harbour. At the same time power requirements have risen, and in order to meet the duty with adequate reserve, that is one set spare, 450 kW sets are being fitted. Fortunately developments in the Diesel world have kept pace with growing demands, and the sets remain more or less the same physical size as the 230 kW machines originally fitted in the *Whitby* Class.

Turbo Blowers

The original blowers suffered from several inherent defects, which have been the subject of modifications. When these are complete throughout the Fleet, it is confidently expected that the machines will give good service. However, the accessibility for maintenance will remain poor. Accessibility in *Leanders* is much improved compared with previous classes and in this redesign the blowers have been moved forward six inches from the bulkhead, with further improvement. Horizontal blowers would have been preferred, but the necessary modifications to the ship's structure could not be undertaken, although the Y.100 blower itself could have been turned into the horizontal position without any great difficulty. Several features have been redesigned, including:

A new method of securing the impeller

New oil sealing arrangements

An improved thrust bearing

An additional motor-driven lubricating oil pump with automatic cut-in facilities.

Servo Air

Although full automatic boiler control is not fitted, servo air has been introduced to carry out some limited functions and it is being supplied by two standard machines discharging into a reservoir. One machine will comfortably manage the full duty, with the second on stand-by. In addition reduced H.P. air can be used. The functions being carried out using servo air are:

(*a*) *Boiler feed regulators.* A.E.I. three element control is being used instead of the Copes fitted in earlier ships.

(*b*) *L.P. saturated steam control.* It is hoped to achieve a really steady steam pressure in these ships.

(*c*) *Exhaust steam control.* Servo air systems have shown themselves to be ideal for this application, and if evaporators are to be run safely on exhaust steam, a really steady pressure is essential. The system is quite complicated, with one make-up and four rejections.

(*d*) *Stripping pump control.* This was previously supplied by reduced H.P. air, but is an ideal application for servo air.

(*e*) *Stand-by to auxiliary boiler atomization.* The boiler has its own small air compressor, and stand-by is by reduced H.P. air in earlier ships. The requirement is relatively large, requiring frequent running of the H.P. air compressor, which is not an automatic starting machine. Servo air is normally kept for servo applications only, but in this special case it is used as a stand-by for the boiler atomization for which it is clearly much more suitable than the H.P. air compressor.

H.P. Air

The demand for air has been growing in the last few years until it has reached the point where it is desirable, if not essential, to fit a second H.P. air compressor to keep the ship operational in the event of defects on the first plant. The machine fitted in earlier ships is not in the new standard range, and so two smaller machines from the standard range have replaced it in the new design, bringing the installed capacity up from 50 to 80 cu. ft of free air per minute. One advantage of the smaller machine is the reduced starting load which should make it easier to pump up air bottles without any danger of overloading the Diesel alternator in harbour.

Fuel System

The *Leander* system had only one service tank, which meant that there could be no settling time. The tank has been divided into two with an individual lead to each fuel pump. Stand-by arrangements for suction direct from storage tanks have also been improved. The system has also been looked at in detail in connection with the bilge investigation mentioned later, with the result that some pipes have been re-run, and some valves have been removed by making others into three-ported valves instead of two. The F.F.O. pumps have been resited on the port side to fall in line with modifications to the feed system.

The Diesel watchkeeper has been given a small electric pump instead of the handpump to pump up his ready-use tanks.

Boilers

The original *Whitby* Class boilers have been improved in detail in the *Leander* Class, but have remained difficult to clean externally. The design is tailored to fit the hull, and this has inevitably led to a compromise between saving of space and access for maintenance. In the Y.136 *Leander* Class several features have been included to improve accessibility, and to overcome some of the problems which have been shown up by operating experience with the original boilers. Some examples of the improvements are:

(*a*) The superheater headers have been moved apart allowing good access to the tube roots, and some access into the nest.

(*b*) A space of about eighteen inches has been provided between the superheater bank and the generator rows to allow access for cleaning the superheater, and the tube roots of the generator rows.

(*c*) The casings are all welded except for a few access doors.

(*d*) The dampers have been arranged athwartships, and are controlled by a single lever between the boilers. This should eliminate most of the problems previously encountered such as rod gearing backlash and seizing in the bushes, and also eliminates the need for the interlocks between the two passes.

(*e*) The economizer headers are tubular and have no handhole doors. Stubs are welded to them during manufacture, and the tubes are strength welded to the stubs as opposed to the light seal weld previously employed. The risk of a leaking element is greatly reduced, but if a leak does occur, it is plugged from the outside.

Gearing

The gearing elements have not been changed, but cruising turbines are not fitted and the remainder of the cruising train has been eliminated. The turning gear now drives onto one of the secondary pinions, and the box has been redesigned and stiffened. Access to the stabilizers has been considerably improved as a result.

Tachometers on Auxiliaries

Electric distant reading tachometers have been found to be more reliable in service than direct drive mechanical, and they are accurate enough for general use. In addition large easily visible dial faces can be used, and placed where they can be seen. These have therefore been fitted where possible. The alternators retain a direct drive tachometer, and the Diesels have been given an 'hours' run' counter. The main engine tachometers have not been altered.

Lubricating Oil Renovating Systems

The reduction in the number of geared auxiliaries has made the provision of a continuous renovating system an unnecessary complication. However, oil cleanliness remains as important as ever, and also filling and draining of large auxiliaries such as turbo alternators presents a difficult problem if it has to be done by hand. The new design therefore retains the facility for piped supply and drain to each auxiliary that needs it, together with the header and drain tanks and the purifier. Each auxiliary can be topped up as required with piped clean oil, and any water or dirt in the bottom of the sump can be drained off at any time, and the oil reclaimed for further use. Whenever an auxiliary is stopped the complete charge can be drained and purified and replaced with a minimum of effort. In addition it is hoped that improved filters will be fitted to all auxiliaries that require them.

The main engine system remains unchanged, and cross-connections are provided so that either purifier can be used on the main system. There should be no excuse in future for non-compliance with B.R. 3000, Article 2006.

Workshop Machinery

The Universal Machine Tool (Small) has been criticized chiefly because of its inadequate lathe facilities. The other facilities provided can either be achieved with a reasonable sized lathe with suitable attachments, or are so seldom used that they may perhaps be regarded as an unnecessary luxury in a small ship. The UMT is also very expensive, and it has therefore been replaced by a 11⅜-inch swing lathe with attachments, a 3½-inch precision lathe, and an assortment of other small items similar to those provided before.

Twelfth Scale Mock-Up of Main Machinery Spaces

Two models were made by Yarrow-Admiralty Research Department to facilitate the design. A model of the complete main machinery compartments (engine room and boiler room) was used in the layout of the machinery items, and in the design of the steam and feed systems in particular, and other items in the upper half of the spaces. Two main lessons emerged from this model:

(*a*) The congestion at the upper levels, which is all too well appreciated by those at sea, is most obvious in a model progressed to the degree which this one was. In future work a similar amount of effort must be put in at the model stage if a satisfactory layout is to be achieved. Once again it became apparent that anyone can put machines down in what look like wide open spaces, but it takes an expert to put the pipes in afterwards and still be able to get at the machines at all.

(*b*) It has been said that models are required so that higher management can understand what is perfectly clear to the draughtsmen on the job. In this case, particularly on steam pipe work, the men on the job used the model extensively to see what could be done before putting it in on the detailed drawings, and the value of the model was felt at all levels. The leading main machinery contractor also finds the model invaluable for production of detailed layout drawings. It is hoped to get the model corrected to the 'as fitted' state finally, and then it can be used for instructional purposes when no longer required by the leading main machinery contractor.

Bilge Investigation

A second model was made to facilitate an investigation into the congestion in the bilge area. This model was built up to about 12 feet from the keel, and included all the major systems in this area. Time and available effort did not permit the smaller bore systems to be included which would have been desirable. The main lessons learnt from this model were:

(*a*) The minor longitudinal stiffeners stand out as being difficult to maintain due to their small size and closeness together. The space between them, although a significant proportion of the machinery space volume, is narrow and inaccessible, and cannot be used by the machinery designer.

(*b*) A detailed look at the major systems in the bilge area led to close questioning of the worth of each pipe and valve. As a result several pipes and valves were removed altogether. Some pipes were rerouted, and some valves were redesigned so that a 3-way cock replaced two or more straight through cocks or valves. Overall, these alterations will make the bilge area a little more accessible, but no startling improvement has been made.

(*c*) A first look at the bilge model reveals a great number of feed pipes, which are mainly at the mid-level of the machinery spaces. These pipes were difficult to route, and in any design will take up a lot of space. The layout was carefully examined to reduce the feed pipes to a minimum as discussed under the feed system, and it is apparent that a lot of effort will be required in future designs to obtain an acceptable arrangement.

(*d*) It is not possible to investigate the lower areas of the machinery spaces in one model of the whole space because it is difficult to get into the congested lower areas when all the ventilation and steam pipes are on top. In some ways the bilge model is more impressive than the complete model, because it focuses attention on pipe runs and gives a better idea of the problems of system design which are usually more intractable than those of designing the disposal and support of machines and equipment.

Conclusions

The aim has been to produce a machinery installation which will eliminate known faults in earlier classes so far as possible, and particularly to improve reliability and maintainability. Some new equipments have been used, but in nearly all cases these are either existing machines already in use in other applications, or slight modifications to suit this application. The machines that were used in the original *Leanders*, and which have been retained, have been modified to eliminate weak points. The whole project has been regarded as consolidation rather than a great step forward.

Acknowledgments

The Y.136 *Leander* Class Specification was written in the very short time of about nine months to the requirements of the D.M.E. Ship and Specialist Sections by the Yarrow-Admiralty Research Department. The new design was produced to a fixed programme and the flow of ships has not been interrupted. D.N.C. and D.E.E. Ship Sections have co-operated fully in vetting the new items where their departments are affected, and in catering for alterations necessarily imposed upon their parts of the ship and equipment. Without this teamwork by all concerned the task could not have been done.