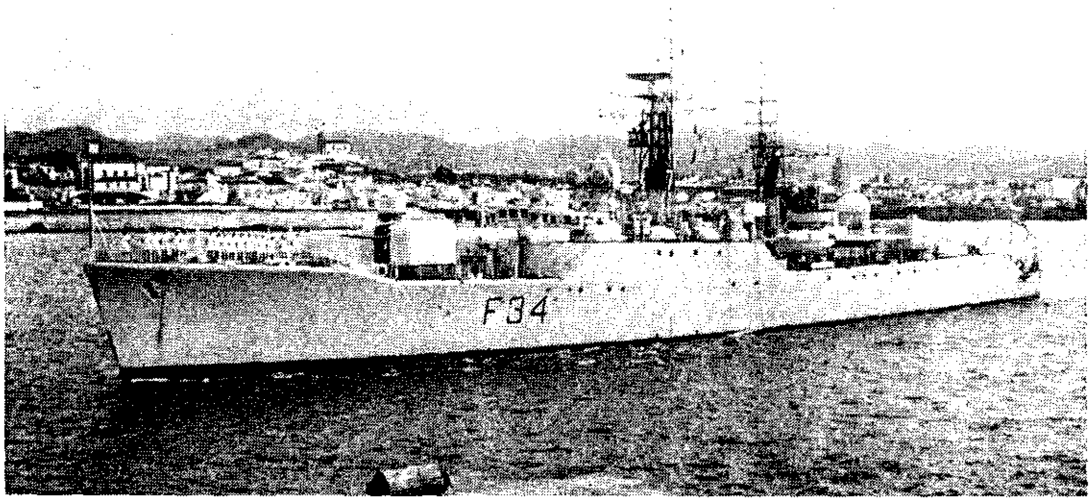

FIG. 5—H.M.S. 'PUMA'

# TYPE 41 FRIGATES

BY

LIEUTENANT-COMMANDER A. N. S. BURNETT, A.M.I.MECH.E., A.M.I.MAR.E.

Four Type 41 A/A frigates have now been built for the Royal Navy—H.M.S. *Puma*, *Lynx*, *Leopard* and *Jaguar*. The first three are in service, and at the time of writing, the *Jaguar*, which is fitted with controllable pitch propellers, has not completed her Acceptance Trials.

The multi-I.C.E. engine and gearbox/clutch arrangement of these ships has presented a number of new problems both to the dockyard and operating staffs.

At present, a number of design defects are interfering with the running of these ships. However, the advantages and disadvantages of this new machinery arrangement are now becoming more clearly defined.

**Main Machinery Arrangement**

The details of the main engines are as follows :—

8—A.S.R.I. 16 V.T.S.
1940 b.h.p. at 920 r.p.m.
4—Napier turbo superchargers (20,000 r.p.m.) on each engine
Boost pressure—5 lb/sq in.
Coolant—Distilled water with a small proportion of ethylene glycol as a corrosion inhibitor
Lubricating oil—O.M.D. 109.

Each engine drives a clutch member in the gearbox through a fluid coupling.

Theoretically, any number of engines can be used on either shaft at any time, but in normal practice either two, three or four engines/shaft are used. One engine/shaft has not been found practicable in H.M.S. *Puma*, owing to rough running of engines (high loads at low r.p.m.) and overheating of the fluid couplings due to high percentage slip.

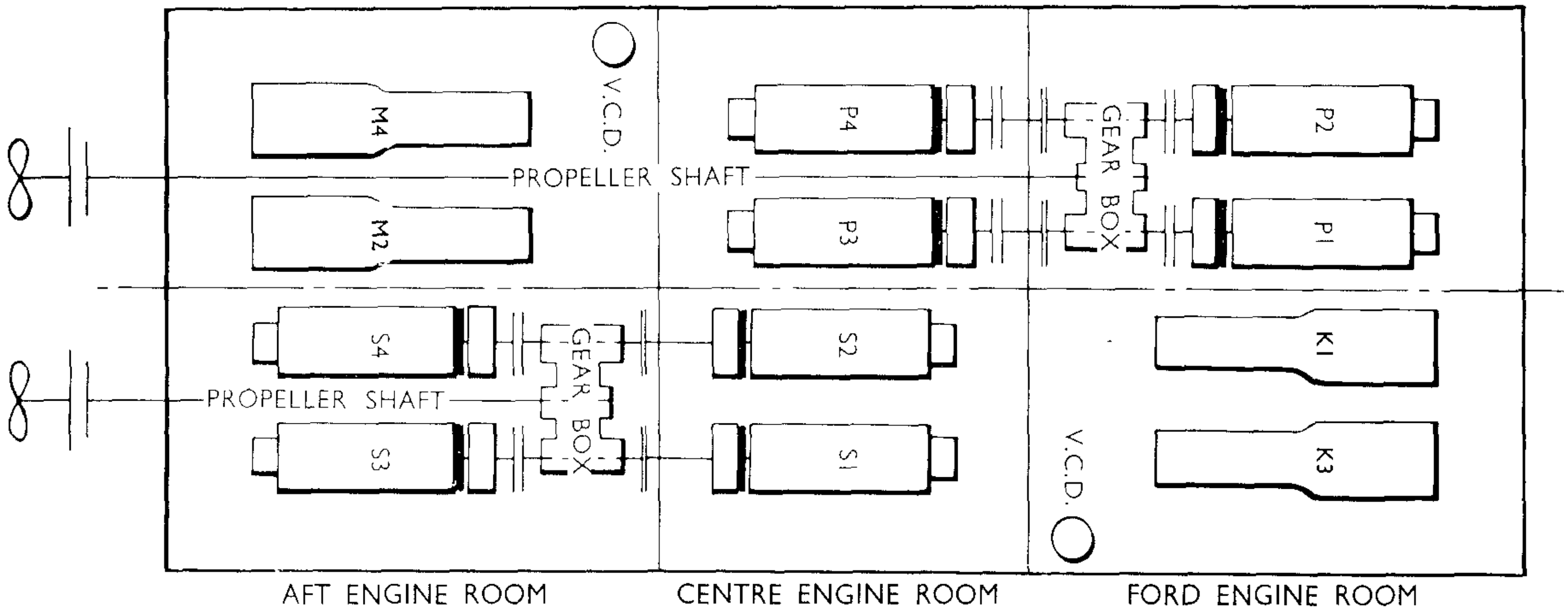


Fig. 1—Main Machinery Layout

Two—four engines/shaft give a speed range of 14—24 knots. Below 14 knots (110 shaft r.p.m.) with two engines/shaft, the formation of carbon deposits in the exhaust systems, and fuel dilution of lubricating oil, prevent low shaft r.p.m. being used for long periods. However, speeds below 110 shaft r.p.m. can be achieved with good engine loading, by using two engines on one shaft and one engine on the other shaft (11—14 knots) or two engines on one shaft and the other shaft trailing (9—11 knots). Neither of these last two arrangements gives full ship manœuvrability in rough weather or when proceeding in close company, but can be used on passage or when proceeding with other ships in 'loose' formation.

When proceeding inside harbours or in fog with two engines/shaft engaged, each shaft can be used alternately, or either shaft can be engaged and disengaged in bursts.

When manœuvring at sea (replenishment or transfer at sea), or entering/leaving harbour, the use of two engines/shaft has been found the most practical combination, for the following reasons :—

(*a*) Sufficient ahead power is available and steerage way remains good when both shafts are trailing (gearbox in neutral)

(*b*) More than sufficient astern power is available

(*c*) It is easier to equalize engine loads with two rather than three or four engines/shaft

(*d*) Slow ahead and slow astern is more practicable with two engines, than with three engines/shaft, as less fuel dilution of lubricating oil will occur, and a lower shaft speed can be obtained.

With an experienced crew, an individual engine takes five minutes to start and to engage to the gearbox. Two engines/shaft and all associated auxiliaries can be made ready for sea in fifteen minutes if required urgently. Normally one hour is allowed to prepare the machinery for sea.

When running at sea, any one engine can be disengaged from the gearbox in under two minutes.

**Main Gearboxes**

The Modern Wheel Drive gearbox is a most ingenious and compact arrangement.

The gear reduction ratio is 4·4 : 1

Each of the four engines on one shaft drives into one gearbox, straight on to one end of each of the four pinion lines, which in turn rotate the main gear-wheel (two pinion shafts are sited on either side of the main gear-wheel). Each pinion line has two clutch members, one on each side of the pinion. The helical gearing on the outside of each clutch unit engages with the similar helical gearing on the outside of the clutch unit on the pinion shaft immediately below or above.

When an engine is not engaged to the gearbox, the stub shaft, leading into the gearbox from that engine, and the external helical gearing of the two clutch units of that engine remain stationary. (The internal elements of the clutch units are however always rotating together with the pinion shafts to which they are splined.) For each engine, one clutch unit is the 'ahead' clutch, and the other the 'astern' clutch. The one connected direct to each engine is called the 'direct' clutch unit, and the one engaging externally above or below it on the other pinion shaft on the same side of the gearbox is the 'indirect' clutch unit.

For P.1 and 2 and S.3 and 4 engines, the ahead clutch is indirect and astern clutch is the direct, and vice versa for P.3 and 4 and S.1 and 2. On running up an engine, the stub shaft of the engine revolves, and in turn it rotates the external

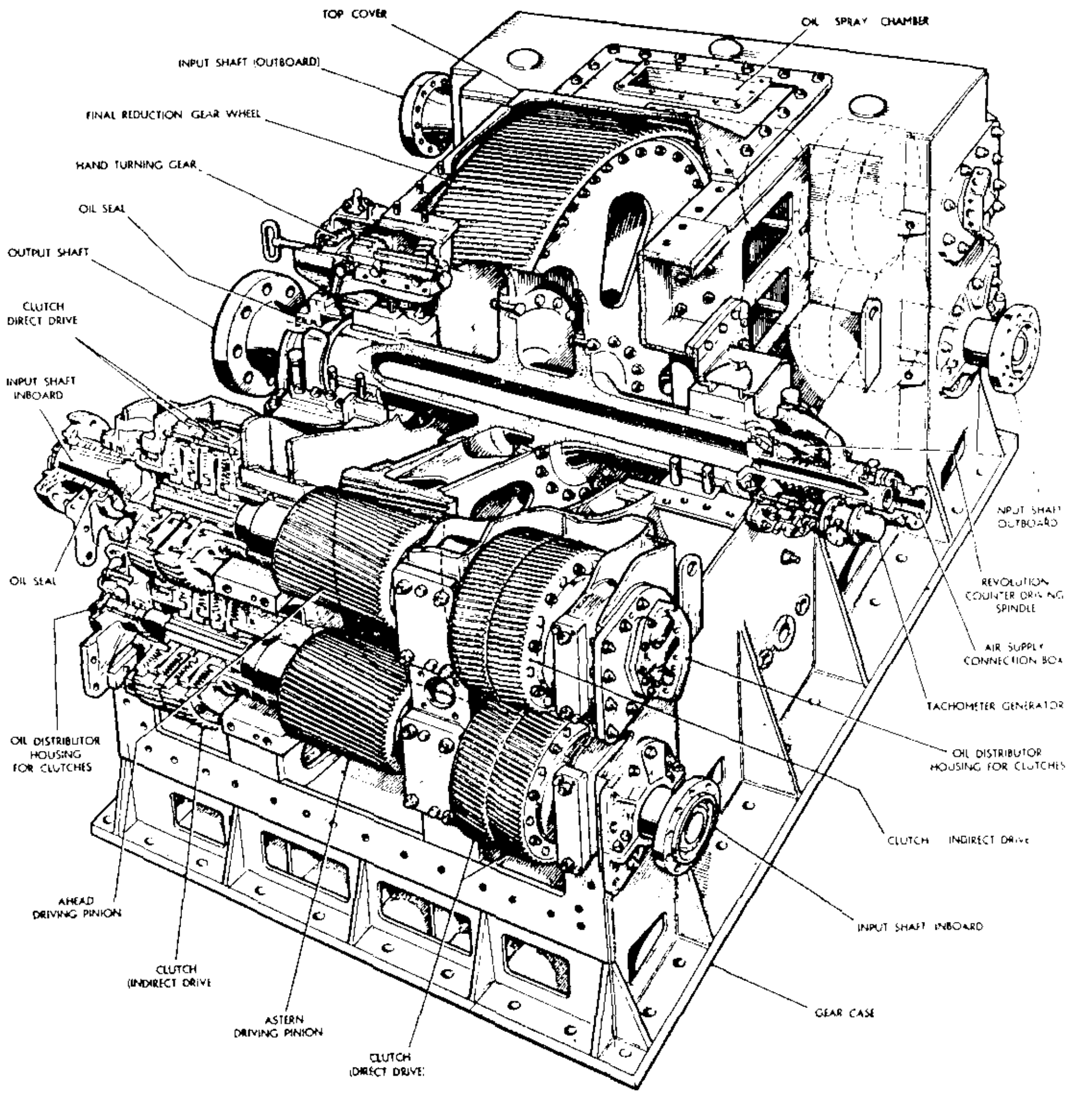


FIG. 2—PORT GEARBOX SHOWING GEARS, SHAFTS AND CLUTCHES

helical gearing of the direct and indirect clutch units. When the ahead clutch is required, oil pressure causes the clutch unit to engage with the helical gearing of that clutch unit of that engine ; the engine will then turn the main gear-wheel ahead via the ahead pinion. If the astern clutch is engaged, the main gear-wheel will be similarly revolved astern by the astern pinion. In order to engage an engine to a gearbox already in use, a separate cock on top of the gearbox is moved and this allows oil pressure to pass to the clutch required. The master gearbox lever controls the supply of oil pressure to all clutch units that are engaged to the gearbox at that time. When the gear lever is in the ahead position, oil pressure is fed to the ahead clutch units, which may be direct or indirect, depending on the engine. On moving the master gearbox lever to astern, the astern clutch members of the engaged engines will engage, and the astern pinion will drive the main gear-wheel. When the lever is moved from ahead to neutral, all clutch units that are engaged will disengage, the engines will idle, and the main gear-wheel will ' trail ' with the propeller shaft. This is achieved by cutting off engaging oil supply to the ahead or astern clutch units ; disengaging oil pressure is however always present on the back of the clutch plates, and this pressure will then

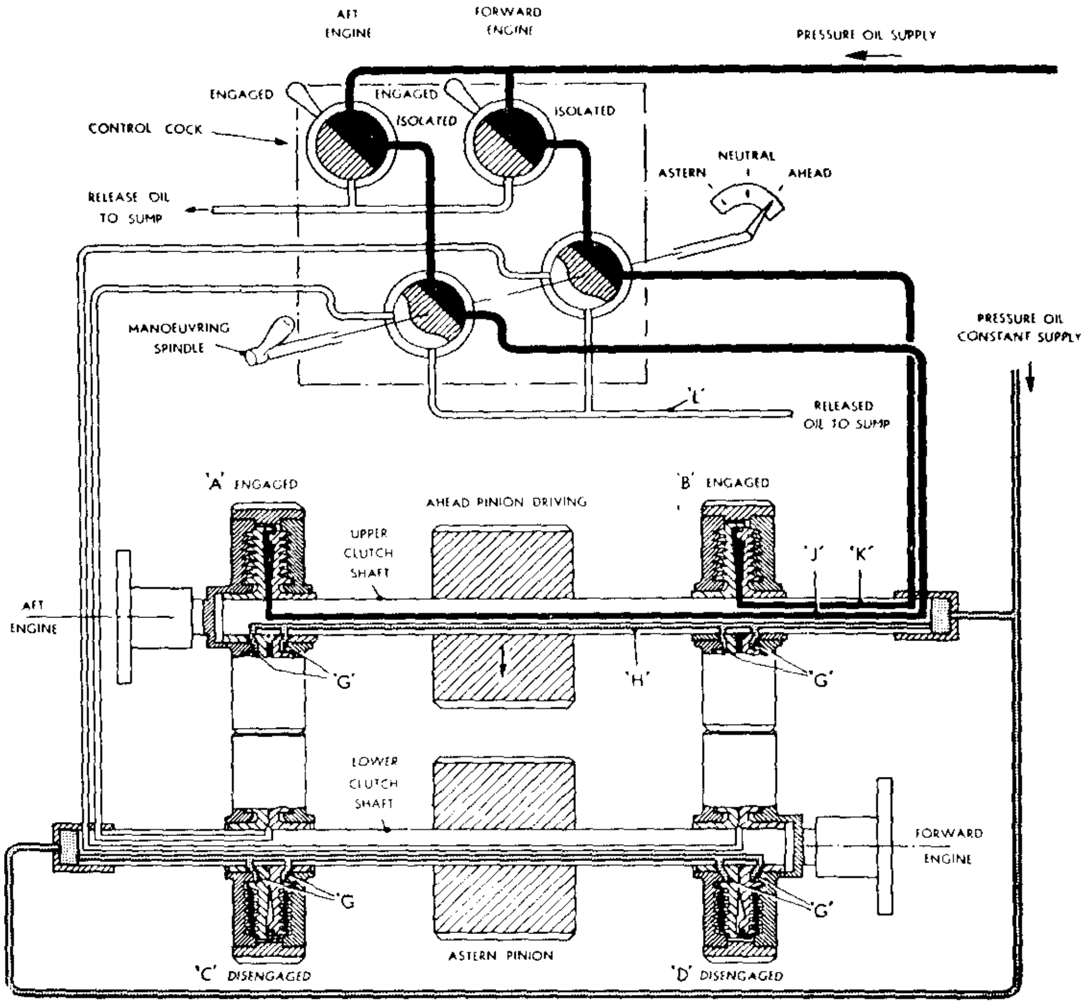


FIG. 3—CLUTCH CONTROL SYSTEM SHOWING DIAGRAMMATICALLY PORT GEAR FOR AHEAD DRIVE

cause the clutch to disengage as soon as the ahead or astern oil pressure has been removed. The effective area behind the clutch plates is smaller than the area in front of the plates, therefore, since engaging and disengaging oil supplies are at the same pressure, there is always a positive force keeping the clutch plates engaged when engagement is selected.

Unfortunately, the ahead clutch members on some engines have the habit of not disengaging immediately when the master gear lever is put from ahead to neutral ; a 'sticky' or 'hanging' clutch virtually never occurs from astern to neutral. A sticky clutch when manœuvering is embarrassing.

The solution to this design problem is now being thoroughly investigated.

O.M. 170 (aero-engine lubricating oil) is used in the gearboxes and is circulated at the rate of 12,000 gall/hr at a pressure of 60 lb/sq in.

**Main Engine Controls**

The four engines on each shaft can either be controlled from the engine control room, situated above the forward engine room, or from the forward engine room (port engines) and the after engine room (starboard engines).

Normally at sea, all the engines are controlled from the E.C.R. which has

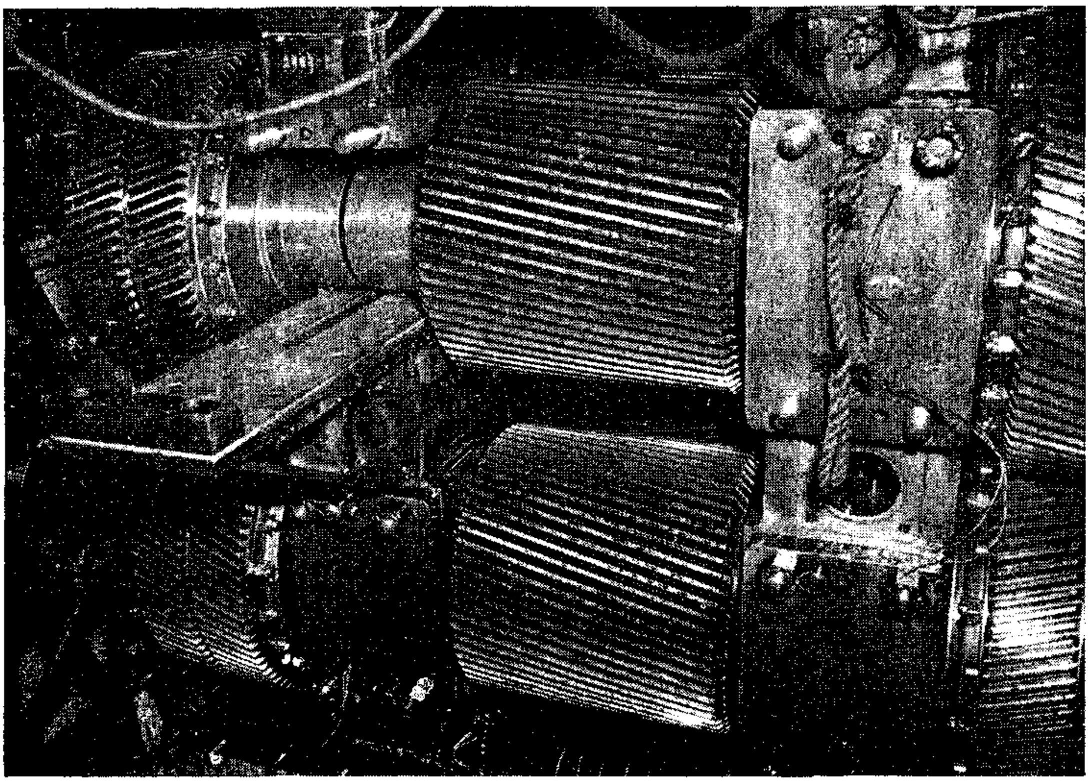

FIG. 4—STARBOARD GEARBOX

direct communication with the Bridge, wheelhouse, steering flat, and all engine rooms.

The governor on each individual engine is moved by means of ' Westinghouse air control system ' from the E.C.R. (primary control), and also by ' Bloctube control ' from the F.E.R. and the A.E.R respectively (secondary control). Both gearbox master clutch levers are operated by Bloctube controls from all positions.

The Westinghouse air system is fed with L.P. air from the starting bottles via a reducing valve. When the engine governor control lever in the E.C.R. is moved the air pressure in the control line, between the E.C.R. and the pneudyne positioner (attached to the engine governor) is altered, the pneudyne positioner takes up a new position and moves the control arm a proportionate amount. When the gear is correctly set, the engine revolutions can be controlled to within 10 r.p.m.

At sea, it is normal to try and balance the driving engines on either shaft so that each engine takes an equal load. This is achieved by moving the individual Westinghouse controls until each engine rack reading (on gauge in E.C.R.) is the same. The engine exhaust temperatures will also be the same, but the distant reading exhaust pyrometers in E.C.R. take 5 to 10 minutes to register any change of temperature at the engine.

**Generators**

Two 360 kW A.S.R.1 6 L.T.S. generators are fitted in both the forward and aft engine rooms adjacent to their respective switchboards. A few ships of this class now have 500 kW A.S.R.1 8 L.T.S. generators. At sea, two generators are normally required, one forward and one aft. In arctic waters, three generators are sometimes required for the extra heating load.

Most working parts and spare gear for the A.S.R.1 generators are interchangeable with main engine spare gear.

### Other Auxiliary Machinery

Two vapour compression distilling plants are fitted in the forward and aft engine rooms respectively ; they each produce between 17 and 20 tons of water per day. Ferric chloride is injected into the sea water in the shell in order to reduce scale formation on the heating coils. Good results have been achieved.

The steering gear, fire and bilge pumps, hull and fire pumps, refrigerating and air conditioning plants are of the normal type and arrangement.

The stabilizers give valuable assistance to all departments as well as to the Gunnery Department. Maintenance, maintenance planning, secretariat work and cooking of meals would all be severely hampered if the stabilizers were not fitted. It also helps to keep the morale of the ships company at a high level.

### Fuel System

The Diesel fuel is stowed in D.B. tanks below the main machinery spaces. These tanks are salt water compensated. In each engine room there is a S.W. gravity tank situated about 12 feet above the tops of the fuel tanks. This tank is kept full of S.W., and the head of water pushes the fuel out of the tank that is in use, to the centrifugal separator suction in the engine rooms. The separator discharges fuel to the ready-use gravity tank. When the D.B. fuel tank is empty, water will appear at the separator, and the fuel supply is then changed over to another fuel tank. The tank is then full of salt water.

When fuel is taken on board, the fuel flows into a gravity tank on the upper deck. From there it flows to the fuel valves on all the D.B. tanks. The fuel valves on the tanks required to be filled are then opened, the salt water inlet from the gravity tank is shut off, and the salt water pipe to the tank is led over the side by means of a fixed pipe and a valve. The fuel head now pushes the salt water out of the tank over the ship's side, and takes its place in the tank. The level of fuel in the tank is ascertained by cocks, from which extend pipes to various heights inside the tanks. When fuel shows from the ' full ' cock, the tank is full of fuel and the fuel valve is shut off.

Thus the ship's draught increases as the fuel is consumed. Also, there is no means of listing the ship by transferring fuel, unless the tanks are emptied altogether. This is rather a laborious process, and cannot be done satisfactorily except by a portable pump.

All engine fuel consumptions are measured by meters situated at each engine and generator.

Theoretically, all the fuel stowed can be used. However, it is difficult to ascertain accurately how much fuel is remaining as the tank level cocks give only a rough guide (to within 25 per cent of each tank), and the meters are not always accurate.

### Maintenance

All I.C.E. machinery requires considerable maintenance and this installation is no exception. The 152 cylinders on the main engines and generators and their associated moving parts require continual maintenance as do the large number of heat exchangers fitted. Thus considerable maintenance effort is required by the E.R. staff in the engine rooms alone. When shore power is not available, 1,000 generator hours are required each month. About 800 main engine hours are used each month.

The normal outside machinery consisting of steering gear, boats, laundry, galley machinery, H.P. and L.P. air-compressors, refrigerating and air conditioning machinery, F.W. and H.W. pumps and stabilizers can be easily maintained by one E.R.A. with the assistance of one E.R.A./Mech. from time to time.

When small defects occur to a main engine or generator at sea, the engine has to be stopped for short periods. This aggravates the planned build-up of running hours and maintenance of other engines.

When three engine/shaft are engaged, very little maintenance can be done on the fourth engine on that shaft, as it is essential to keep one engine/shaft stand-by. One generator is always kept as a stand-by.

One interesting and important maintenance aspect of this I.C.E. installation, is that P.O.M(E)s, L.M(E)s and M(E)s become quickly interested and keen to work alongside, and with, E.R.A.s. The work is interesting and the results are immediate.

Standardization of main engine and generator spare gear is a very great asset.

**Watchkeeping**

Again this provides P.O.M(E)s, L.M(E)s and M(E)s with early responsibility and interesting work. A young M(E) finds himself watchkeeping alone on one or two engines and all its associated auxiliaries on one side of an engine room, (regular visits are made by the E.R.A. in charge of watch or P.O.M(E) on watch). This creates immediate interest.

The P.O.M(E)s get properly employed (i.e. watchkeeping at sea, and day-work in harbour), with interesting work to be done besides normal ship husbandry.

Unlike some steam ships, in which, when only one boiler room or unit is operating, a few ratings become available for maintenance and cleaning, a full watch below must be maintained whenever two or more engines/shaft are in use, as gearboxes must have a watchkeeper and a third engine must always be kept stand-by for immediate use.

**Logistics**

For a small ship, the operating range is large. This advantage brings about several difficulties.

The following list shows the large number of different lubricating oils, chemicals, greases etc., required in reasonably large quantities in order to keep machinery running and maintenance work progressed :—

| | |
|---|---|
| O.M.D. 109 | —Main engines, steering gear, separators, etc. |
| O.M. 100 | —V.C.D. plants |
| O.M. 170 | —Main gearboxes |
| O.M. 70 | —Refrigerating plants |
| O.M. 33, O.M. 13 | —Gunnery |
| O.M. 65 | —H.P. and L.P. air compressors and gunnery |
| Ferric chloride, Caustic soda | —V.C.D. plants |
| Ethylene glycol | —Main engine and generator coolant systems |
| Kerosene | —Cleaning engine air filters |
| Freon | —Refrigerating and air conditioning plants |
| Oxygen, Acetylene | —Welding plant |

| | |
|---|---|
| L.G. 280<br>X.G. 271<br>Belmoline R.B. grease | —Pumps, shaft bearings, etc. |
| Neox oil | —Stabilizers |

A number of these commodities have to be replenished at every port visited. Reasonably large stocks must be held on board, as some of these items are not easily obtainable when on detached duty.

The maintenance work in these ships entails a large amount of repair by replacement, as well as routine examinations at fairly frequent intervals. Unless reasonable stocks of these items are carried, the machinery cannot be kept in good running order and will suffer unnecessary breakdown.

**Running Cycle and Repairs**

This cannot be fully discussed here but, briefly, the engine and generator running hours have to follow certain patterns depending on ship's duty and shore power available, so that major and top overhauls occur at refits, or at pre-determined intermediate periods.

It is obvious that a number of major and top overhauls will occur at each refit and this entails a lot of dockyard work of a specialized variety.

In fact, the refit work in this type of ship requires a large amount of skilled fitting work, a fair amount of coppersmithing work and a little boilermaking and forge work. It will not be easy for the dockyard to balance up this work with other work required in other ships, or to find the necessary lay-apart store facilities required for the engine major and top overhauls.

**Maintenance Planning**

For efficient operation, I.C.E. machinery must be maintained by 'planned maintenance' and this entails a continuous load on the engine room personnel.

There are over 2,000 coloured cards in the Engine Room Department planned maintenance system. One engineer officer, one C.E.R.A. and one E.O.'s writer have to work many hours in order to keep the system operating efficiently and all the records up to date.

In general, the new system of planned maintenance is excellent but the scheme, as laid down, has to be moulded to suit the large number of cards and individual parts of machines and equipment involved.

**Personnel**

A large number of the E.R.A.s as well as M(E)s like the machinery and find the work interesting. There is no doubt, however, that they often have to work very hard and for long hours in order to keep these ships fully operational.

**General**

These ships have good sea-keeping qualities and a good range but are difficult to maintain.

TABLE I

## PART OF THE ORGANIZATION APPERTAINING TO THE AUSTRALIAN COMMONWEALTH NAVAL BOARD

MINISTER FOR THE NAVY

- 1st Naval Member and Chief of Naval Staff. Vice Admiral
- 2nd Naval Member and Chief of Naval Personnel Rear Admiral
- 3rd Naval Member and Chief of Construction. Rear Admiral E
- 4th Naval Member and Supply Member. Commodore S
- Secretary Permanent Head of Department Admin. and Financial Policy

**D.C. of C.**
Deputy Chief of Construction and Director of Technical Planning
(Captain E)

- D.E.E. — Director of Electrical Engineering (Captain L)
- D.M.E. — Director of Marine Engineering (Commander E)
- D.N.C. — Director of Naval Construction (Commander E)
- D.A.M.R. — Director of Air Maintenance and Repair (Captain E)
- D.O.U.W. — Director of Naval Ordnance and Underwater Weapons (Captain)
- D.S.S. — Director of Scientific Services