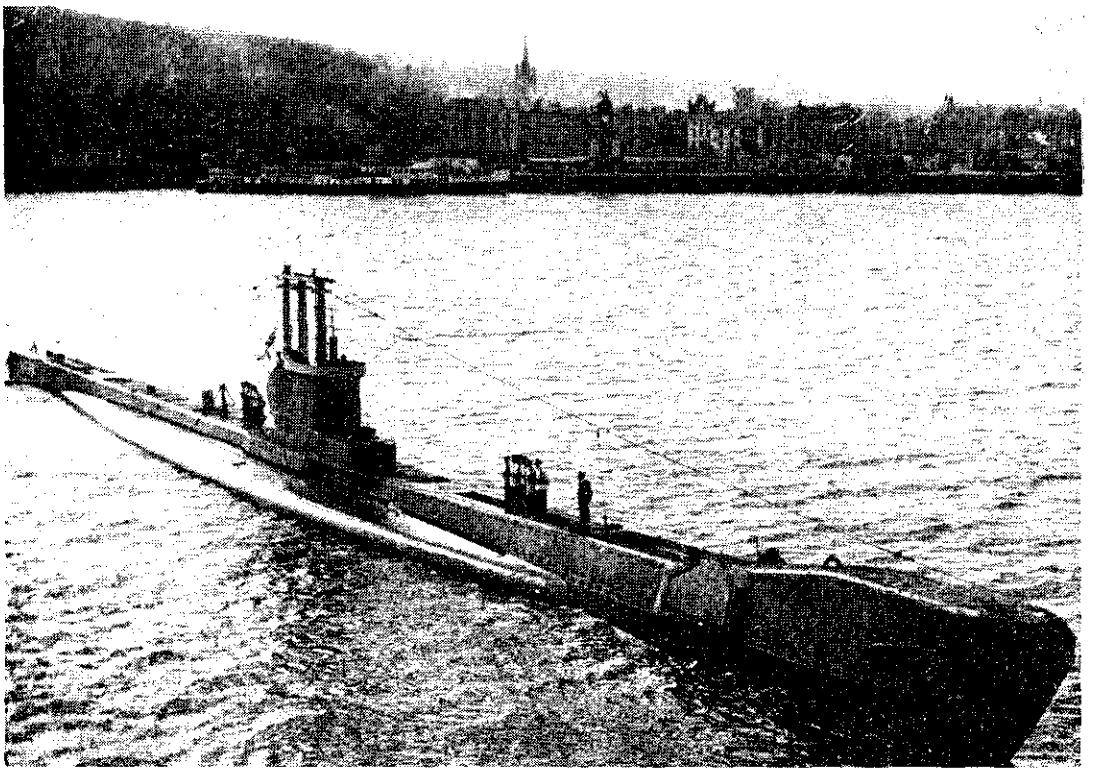


AN "A" CLASS SUBMARINE OFF ROTHESAY

SERVICE IN SUBMARINES

This article has been written for those who know little of submarines and their contents. No submarine engineer officer will learn anything at all by reading the lines which follow: the author has cravenly resisted Editorial efforts to persuade him to put his name to his work because he fears the ridicule of his fellow submariners. However, in the days before he first went to Blockhouse, the writer would have welcomed the chance of reading an article such as this, which is his reason for writing it.

Almost every country in the world has a submarine fleet of a sort, and a glance at *Janes* will show that nearly all types of existing submarines are similar to each other in size, shape, and performance. These three factors have changed little over the last thirty years. A typical operational submarine is about 250 feet long with a maximum diving depth of 400 feet, a submerged speed of 8, and a surface speed of 15 knots. Some coastal patrol types are a little smaller, some ocean cruisers a little bigger. But the shape, size and speed of the U.S.S. *Nautilus* is much the same as that of the *River* Class, built in the U.K. during the 1920s. Recent attempts to streamline the superstructure have radically altered the appearance of the modern submarine as seen by the shore observer—but the basic hull shape and length to beam ratio have not changed.

The typical submarine, then, consists of a cigar-shaped pressure hull of 15 feet diameter extending the full length of the vessel, a light metal casing superimposed on the cigar to streamline periscope supports, conning tower and external piping, and a light metal system of external buoyancy tanks. The casing and tanks are open to the sea and are thus pressure balanced when submerged. The conning tower is a vertical pressure-tight tube fitted on top

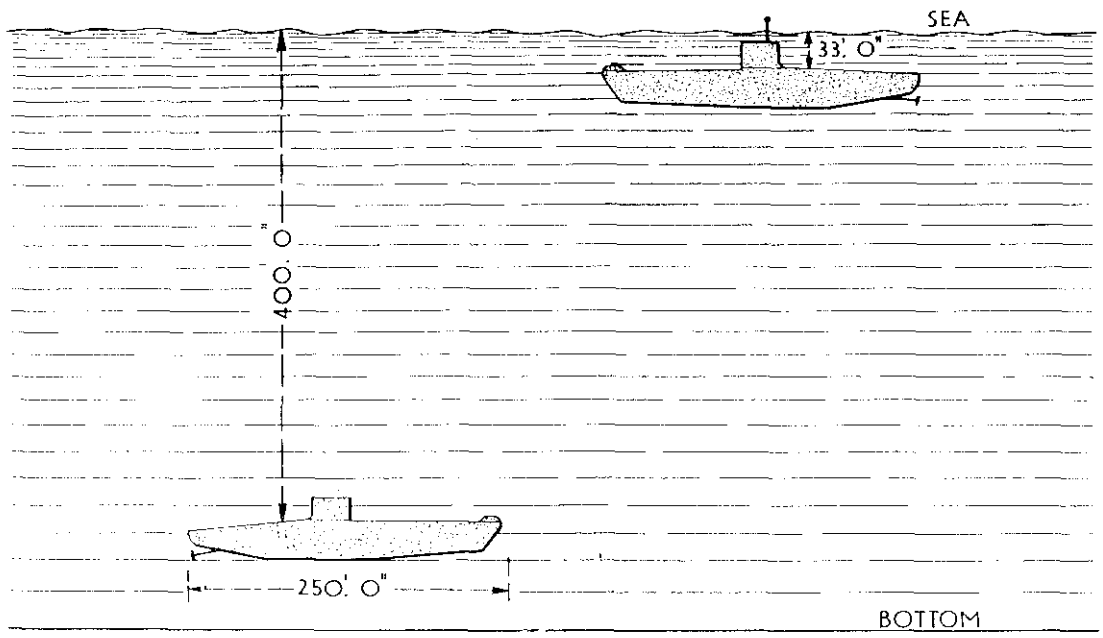


FIG. 1

of the control room, the real use of which is to enable the Captain to have a quick look round when surfacing, before bringing the whole submarine into view. FIG. 1 shows how small is a submarine's range in depth, and how very close to the surface she must come to use her periscope. The unsupported length of periscope is severely limited by the rigidity needed for clear vision. The view through a periscope even at 8 knots, is badly blurred by the vibration of the optical tube.

Depth keeping is extremely difficult when using the periscope with, say, a six feet swell running. The swell may either lift the bow and make the superstructure break surface, or force the bow down and drive the submarine below periscope depth. In the first case the vessel's presence is revealed, and in the second the Captain goes 'blind' until the periscope depth is regained. Ideal submarining weather is a force 3 wind, to provide a few white horses to hide periscope 'feather', yet not enough swell to make depth keeping difficult at slow speeds. Changes in depth, even in emergency, are rarely carried out at angles greater than 8°–10°. The Americans have tried operating at 30° bow up or down, with the crew strap-hanging, but the tactical advantages of this are doubtful, and such behaviour is obviously unpopular with the ship's company.

The typical submarine has four modes of propulsion :—

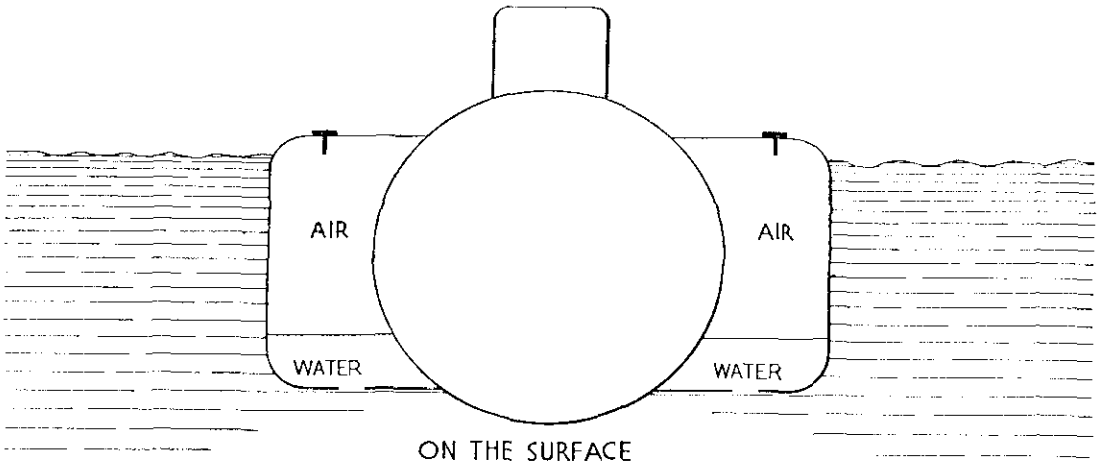
(1) Surfaced, on main Diesel engines.

(2) Snorting, at periscope depth on main Diesel engines.

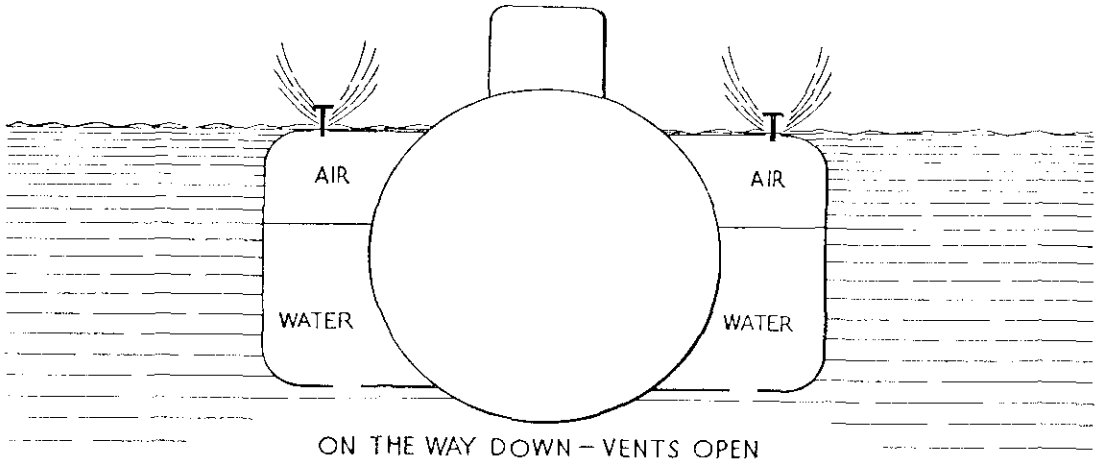
(3) Submerged, at any feasible depth on electric battery and motors.

(4) Surfaced, on battery and motors, when manœuvring.

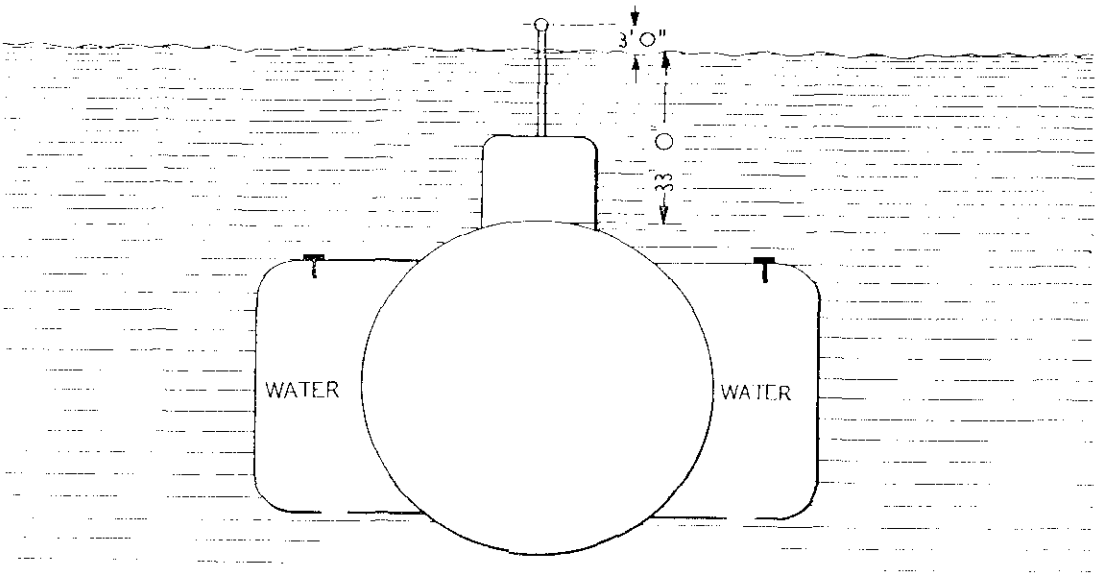
Most submarines are direct drive : United States Naval vessels and our modern 'T' class are Diesel electric and can manœuvre on main Diesel engines. Most submarine Diesels are non-reversing. The voyage to the patrol area is usually carried out in modes (1) or (2) above, changing temporarily to (3) when wishing to become invisible. Hydrophone detection of a submarine surfaced or snorting on main engines is easy, but battery capacity is limited to a little over 100 miles at economical speed. A submarine on the surface has about one sixth



ON THE SURFACE



ON THE WAY DOWN – VENTS OPEN



SUBMERGED AT PERISCOPE DEPTH – VENTS SHUT

FIG. 2

reserve of buoyancy, rather better than an iceberg, and when snorting or truly submerged she is neutrally buoyant.

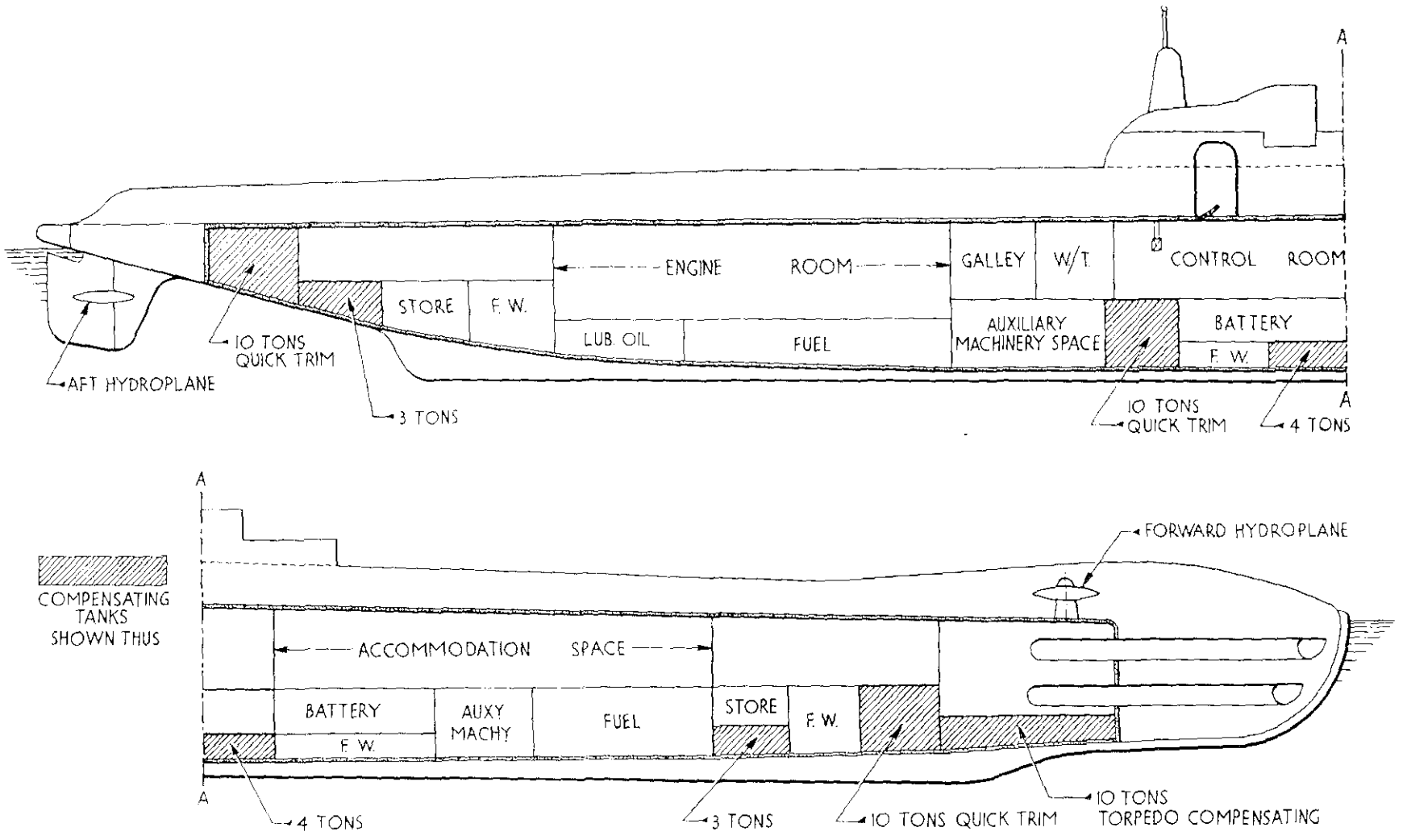
Positive surface buoyancy is gained entirely by the buoyancy tanks external to the pressure hull. These are open to the sea at the bottom and shut off from atmosphere at the top, by vent valves. (FIG. 2). The submarine is submerged simply by opening the vents until the external tanks are completely full of water. If the internal weights of the vessel have been correctly adjusted, she will then be neutrally buoyant and can be forced down to whatever depth is required by her own speed and the water pressure on her hydroplanes. She has a pair of these forward and another pair aft. Internal weights, fuel, machinery, spare torpedoes, stores and men are allowed for in the design, and ballast is added along the keel to ensure that with the 'normal' weight distribution the vessel will be in trim when submerged. Deviations from this 'normal' distribution must be compensated for before diving, or the submarine will either plummet to the bottom or stay wallowing obstinately on the surface when the vents are opened. Fortunately, by a peculiar quirk of British submarining, the First Lieutenant, and not the Engineer Officer, would be called on to explain either of these embarrassing states of affairs to the Commanding Officer.

External buoyancy tanks are not used to achieve this compensation, but only to perform the acts of submerging and surfacing : never for adjustment of trim when submerged. Compensation is done by varying the quantities of water in internal tanks spaced throughout the pressure hull. These tanks are of two main types, 'quick' and 'slow' trimming. Sea-water is flooded into or pumped from the slow trim tanks in accordance with the First Lieutenant's calculations before attempting to submerge, and adjustments are made on the quick trim tanks for any errors in these calculations which may be revealed by the behaviour of the submarine on submerging. To lighten the submarine rapidly, without actually surfacing, water can be blown from the quick trim tanks by H.P. air, instead of being pumped out.

Adjustment of the quantities of water in the compensating tanks must be done within fine limits, ten gallons being the usual unit of alteration. Perfection of trim is especially necessary as the small endurance of the electric battery demands that the speed of the submarine be kept always to the minimum, making depth-keeping difficult, because the hydrodynamic forces on the hydroplanes are correspondingly lessened. Except when in contact with the enemy, a submarine rarely travels submerged (i.e. not snorting) at more than two or three knots, but circles slowly in her patrol area.

Longitudinal stability submerged is of course harder to maintain than transverse, unlike a surface ship. The change of moment due to one well-fed stoker moving two hundred feet from his mess aft to the 'spud' stowage forward is considerable and will certainly be noticed at low speeds by the officer of the watch. He will correct the resultant bow down angle by pumping water from a forward quick trimming tank to an after one. The raising of a periscope increases the displacement of the submarine without any increase in weight, and must be allowed for, at very low speed, by flooding water into a quick trimming tank, or the submarine will rise to the surface. A bow salvo of torpedoes weighing ten tons may be fired at periscope depth in the space of a few seconds. Immediate compensation is vital if the submarine's bow is not to break surface. This is done automatically by the firing gear, which admits sea water at depth pressure to a compensating tank under the tubes, through a valve whose period of opening is hydrostatically controlled.

The action of going deeper compresses the pressure hull and reduces the displacement. This must be allowed for by pumping or blowing out about 100 gallons of water for every 100 feet of depth. Similarly, water must be flooded



SECTIONAL ELEVATION OF A TYPICAL SUBMARINE

in when decreasing the depth of submergence. If no correction is applied, a diving submarine accelerates towards the bottom, while a rising one rushes to the surface like an expanding bubble. The art of keeping the submarine neutrally buoyant when submerged is one of the most fascinating known to the writer, and requires as constant attention as that of working a sailing boat to windward.

After about 12 hours cut off from any supply of fresh air, the atmosphere in the submarine must be freshened. This can be done chemically, or by raising the snort mast, or by surfacing and opening the conning tower hatches. If the Captain decides to surface, the vent valves in the external buoyancy tanks are checked shut, a final look round is taken through the periscope and the order is then given to blow the external tanks. Sufficient H.P. air is admitted to the tanks to bring the submarine awash, the Captain opens the conning tower top hatch and goes on to the bridge. If all is well, the submarine is brought to full buoyancy by an L.P. air compressor taking suction down the conning tower. This conserves the precious H.P. air in the storage bottles. If on the other hand the Captain decides it is healthier down below, he shouts down the voicepipe the order to open the main vents, and descends smartly through the conning tower.

Details of the machinery on board, with hints on refitting and maintenance planning, though obviously valuable, are outside the scope of this article. Below is a skeleton list of the chief items of machinery on board, in what seems to me their order of relative importance. The methods of running, maintenance and refitting are left to the handbooks and to the discretion of the individual Engineer Officer.

Two 50 h.p. air compressors (0–4000 lb/sq in).
Two main Diesel engines of 1500 h.p. each.
Two 10 h.p. hydraulic pumps– ' Imo ' type now becoming universal. Some reciprocating Vickers are still fitted.
One 25 h.p. multi-stage centrifugal F. and B. pump.
Ten torpedo tubes and firing gear.
One Areton refrigerator.
One L.P. rotary air compressor.
Two Areton air-conditioning plants each of 50,000 B.Th.U./hr.
Two 15 galls/hr vapour compression distillers.

To maintain and operate this machinery the Engineer Officer has a Chief E.R.A. and 4 E.R.A.s, a C.P.O.S.M. or P.O.S.M. and a dozen or so L.S.M. and S.M. Three of the E.R.A.s work and watchkeep in the engine room, the fourth or ' outside ' E.R.A. maintains all the systems and machinery outside the engine room. He may have the junior engine room E.R.A. with him as a ' makee-learn ' and will have also one L.S.M. and a S.M. The efficiency of this team is of the greatest importance, and the operational efficiency of the submarine can depend upon it. He is in charge of the steering gear, periscopes, hydroplanes, and the hydraulic and H.P. air systems by which the vessel surfaces and submerges. He is thus, in many of his duties, directly responsible to the First Lieutenant, who is the diving officer.

The outside E.R.A. is normally allowed to work his party and his routines with as much freedom as possible, and the C.E.R.A. seldom interferes. Should he fail in his duties, the effect is usually obvious to the entire ship's company.

In any ship it is vital that the Engineering and Executive sides should work in concord : it is doubly important that this be so in a submarine. When tempers are strained in a destroyer, it is usually possible to ease them by taking a hot bath or a stroll in the cool air of the upper deck. Neither of these amenities is available in the confined space of a submarine. Only the Captain has a

cabin—though this may be no more than a thick walled 40 gallon oil drum, and at best will be little bigger than his bunk.

Since the First Lieutenant is concerned so continually with the 'outside systems', I believe it most important that the Engineer Officer should master this aspect of his own duties before he tries to become a Diesel engine tuner. It may sometimes happen that a quick decision on some technical point of the hydroplane or H.P. air circuits may save the ship—the same is very rarely true of the main engines. There has long been an idea, outside the Submarine Service, that the Engineer Officer of a submarine is just a Diesel engine driver. This is entirely untrue. All the auxiliaries affecting the main engines are in one compartment—the engine room. At 'special sea dutymen' and during diving and surfacing, the C.E.R.A.s place is in the engine room: he will usually have a senior E.R.A. there also, as his lieutenant. The outside E.R.A. will be in the control room at the 'panel', the collection of hydraulic and H.P. air valves which operate the main vents and H.P. air blows to the external and internal tanks. If an emergency arises anywhere else, from the bowcap of a torpedo tube jamming to the galley ventilation failing, the Engineer Officer should be the most competent and readily available man to deal with it. It is stated in Queen's Regulations that he is ultimately the technical adviser of the Captain and this is equally true of practical technicalities in a submarine. The C.E.R.A. often cannot leave the engine room, or the outside E.R.A. the panel, the E.O. is the only man who is free to go around *doing* things in a crisis. The responsibility of the submarine engineer officer is certainly as great as that of any other, in peacetime at any rate.

If there is a need to be a good practical engineer in a submarine there is a need also to be a good officer. Some of the reasons for this have already been stated. Anyone who wants to settle its truth finally is recommended to go to sea for a week's exercise in a submarine, return to base, spend two days storing for a second week at sea, and at the same time fit in divisions, defaulters, and drinking with all one's thirsty shore-based chums. Everyone in a submarine is very, very, nearly treading on someone else's toes all the time as he does his particular duty, and only a really expert team can avoid an occasional clash.

Even if, by great forbearance and toleration, life on board is happy enough, the Engineer Officer's responsibilities do not of course end when the submarine returns to its base. The Senior Engineer of the Depot Ship or base will come aboard, anxious to find out how his new type of periscope gland, and your stock of gin, have stood up to the conditions met during your last exercise. If a rush job must be done in the base workshops, it may be necessary to bargain with him as to which operations can be done by your E.R.As, so that his staff doesn't do all the overtime, knowing (as you think you do) that your staff has been slaving away 24 hours a day for weeks while his has loafed around making rabbits.

At sea in peacetime the Engineer Officer cannot officially keep a watch either dived or on the surface. He should therefore help out the executive side of the team, who are in three watches, in every way he can. Any non-submariner who thinks he knows how easy three watches can be, should try keeping them on a submarine's bridge in bad weather on a shipping lane, with no cup of cocoa to warm him because it is too rough to allow anyone up, and a gremlin on the periscope standards squirting a hose down his neck.

The organization and disposition of the Submarine fleet is at present straightforward and simple. There are submarine squadrons of a dozen boats based on Malta, Portsmouth and Rothesay, smaller ones in the Far East and Halifax, Nova Scotia, and a dozen or so refitting.

On joining the Submarine Service, the E.O. undergoes a four month course at Fort Blockhouse, and then joins a depot ship for a few months until a vacancy occurs in a boat. By the time he joins his first submarine he thinks he has forgotten all he learnt at Blockhouse except for the 'war-cries' but his training class cramming usually comes back quickly when he finds he now has to answer his own questions, since there is no one else to do so, except his departmental juniors and a trio of executive officers, all of whom seem to know a surprising amount about engineering.

Finally I recommend submarining to any one who wants a job which is often exhilarating and completely satisfying, always down to earth and invariably carried out in conditions of appalling squalor.