WARTIME EXPERIENCE IN A SUBMARINE DEPOT SHIP

by

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In Vol. 1, No. 3 of the "Journal of Naval Engineering" we reproduced Mr. H. E. Skinner's paper covering the provision of depot and repair ships for the Fleet. This article records a user's experience and views of such vessels and gives some idea of the extent to which a submarine depot ship fulfilled her function during the Second World War. Considerable general background is also given on the running of a submarine flotilla from the technical point of view.

The writer's experience includes one year and three months as Flotilla Engineer Officer of the 9th Submarine Flotilla at Dundee, including the starting and functioning of the base, H.M.S. *Ambrose* which grew out of a disused jam factory, for British and Allied submarines and also two years and eight months in the same capacity in the 4th Submarine Flotilla, H.M.S. *Adamant*. It is round the latter period that this article is written and it will explain certain generalizations and references to the repair of surface vessels later in the article if it is pointed out that from April 1942 to April 1943, H.M.S. *Adamant* was mainly employed first as a fleet repair ship and later as destroyer repair ship at Kilindini. During this period the number of submarines dealt with mechanically was small, but the ship retained her function as a submarine depot ship and continued to play her part in the administration of the very scattered and heterogenous 4th Submarine Flotilla.

Function of a Submarine Depot Ship

The function of a submarine depot ship is clearly to maintain a flotilla, numbering normally 12—18 submarines, in all respects efficient between major refits without having recourse to dockyard assistance. It has been an accepted policy prior to the Second World War to give all submarines an intermediate docking every six months and a refit every 18 months. At the intermediate docking it was not intended that a large amount of work should be undertaken —certain routine items were of course necessary, and if there were essential jobs to be done which were beyond the capacity of a depot ship then an intermediate docking period was a convenient time to carry them out. Thus it will be seen that the depot ship was expected to maintain the submarines of the flotilla in fighting trim for a period of 18 months, except for docking.

One important feature, however, distinguishes a submarine depot ship from other types of repair ships. This is the need for accommodation for subm arine crews when the submarines are in harbour. In no other repair vessel does this need arise and it will be appreciated that this consideration seriously complicates the design.

Maintenance of Depot Ship

It is clear that for a depot ship to give her best in maintaining her flotilla she should require little maintenance herself. Complements are divided on paper into ship's staff and repair staffs, and whilst the aim is always to employ personnel on these lines the primary object of the depot ship is to maintain her attached vessels and for this reason it usually happens that the depot ship's maintenance suffers.

Simplicity in depot ship machinery design should therefore be an aim and there is no doubt that steam machinery offers decided advantages in this respect. The main machinery is little used but it was found in H.M.S. *Adamant* that the power was hardly adequate. On all occasions of moving from port to port there was a strong feeling that the vessel was too slow. Her very first trip after commissioning was in a convoy, and it meant steaming at full power pretty well continuously. On occasions when station had been lost to carry out a practice shoot it was difficult to recover station.

Speeds of convoys are not likely to decrease and being of great value a depot ship is almost certain to move in convoy ; it would appear essential therefore that future depot ships should have a greater speed than they have had in the past. It will be argued that greater speed means more space for main machinery at the expense of workshop and accommodation space—here is the catch, for we can ill afford to sacrifice either one or the other.

Auxiliary Machinery

Of auxiliary machinery ; evaporators, generating machinery, and refrigerators are the major items. In *Adamant* the first two were found to be adequate and did not require excessive maintenance. The two 300 kW Diesel generating sets gave good service, and it was often argued that all generators should be Diesel-driven to provide facilities for the training and experience of submarine ratings. There would be advantages in this policy, but it is still felt that steam sets require less maintenance and that this fact should be the major consideration.

The refrigerating machinery was by a manufacturer new to the type of work and the teething troubles in *Adamant*, partly due to poor design and partly to bad workmanship, were considerable. The man-hours spent on maintenance of this vital plant during the first two years of *Adamant's* life were excessive, bearing out the need for simple and easily-maintained depot ship machinery.

Adequacy of equipment is also of great importance. This applies in all departments, e.g., adequate offices for all staff and personnel should be available; if this is not so then offices have to be built, which means that shipwrights and other ratings who should be employed on the maintenance of the depot ship are employed building offices or converting cabins into offices. It will be sufficient to quote two actual cases of many which were necessary in *Adamant*, namely, the building of an adequate staff office easy of access to Captain (Submarine)'s cabin, and the building of an office for the Regulating Chief Stoker.

All deficiencies, in whatever department, e.g. no Asdic workshop, inadequate C.B. office, lack of fitted storage space, etc., necessitated the employment of tradesmen of all kinds on work in the depot ship when they should have been employed in maintaining attached submarines.

Berthing of Submarines

To ensure speedy handling of defects, ease of fuelling, storing, charging batteries etc. it is essential that a submarine be as close to the depot ship as possible—the ideal is that she shall be alongside, but with a large flotilla, this is clearly not possible for all vessels. It has normally been possible to berth a maximum of four submarines adjacent to the depot ship with the others berthed in " trots " as shown in the figure facing page 56.

The fixed cranes with limited radii cannot cover all requirements for these four submarines berthed immediately adjacent to the depot ship. This means that there must be frequent movements of submarines to allow the various lifts

to be made. Such movements are most serious in their effects on the work going on in the submarines, gangways must be lifted, hoses, charging leads etc. broken, and altogether the number of man-hours entailed in each trot movement is excessive.

Experience in *Adamant* led to the firm conviction that the normal fixed type of crane is not suitable for a submarine depot ship. What is required is a travelling crane on either side of the upper deck. Its outside leg should be as far out to the ship's side as possible, in fact the rail could well form the outside of the scuppers, the object being to increase the radius of the jib to a point where it is possible to span two submarines alongside, or at least to reach the centre line of the second vessel for light lifts.

It is appreciated that there are many difficulties in this suggestion, e.g. the travelling racks would be curved, the crane would be difficult to secure on passage, but there is no doubt that the limitations of cranes in submarine depot ships is a very serious hindrance to repair work. When the variety of services to be supplied is considered—fuel, lubricating oil, fresh water, distilled water, torpedoes, victualling stores, spare gear, personal effects, provisions, mines, it will surely be agreed that any improvement in crane services will go a long way to speeding up the preparation of a submarine for her next patrol. It is not suggested that the maximum lift should be increased, in fact experience leads one to think it could be reduced provided, of course, the depot ship's boats can be got in and out by a fixed crane of adequate capacity.

Hand in hand with the requirement for an adequate crane service goes the need for grouping of fittings for the supply of fuel, water etc., to submarines alongside. This was achieved to a certain extent in *Adamant* by the provision of baggage ports. If the cranes could be fitted as in the preceding paragraph the number of positions for these groups of fittings could be reduced to a minimum, handling and storage of the required hoses would be simplified, and the continual complaints against hoses, charging leads etc. being left lying about would be largely eliminated.

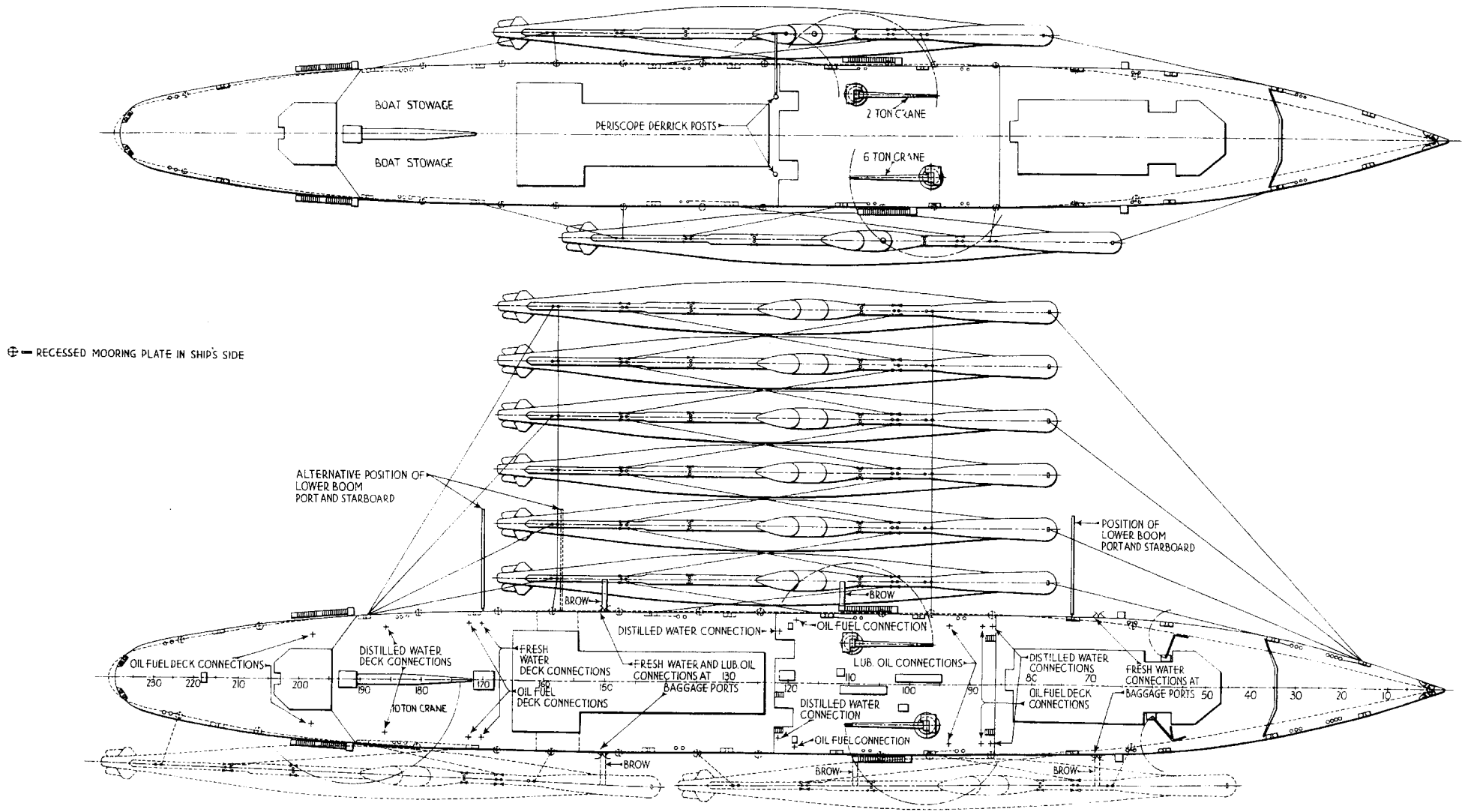
One thing is clear from the above, namely that co-ordination of the requirements of all submarines in the flotilla while they are alongside is of first-rate importance. Experience indicates that the best person to do this co-ordination is the officer who is responsible for the largest number of services, viz., the Engineer Officer of the flotilla. Besides being inefficient from the point of view of preparing a submarine for sea, nothing is more likely to irritate personnel than continual trot movements.

It has frequently happened that berthing alongside was not practicable, either through the numbers of submarines to be serviced at any one time, stress of weather, requirements of the depot ship herself for watering, or fuelling, etc.

Such a situation seriously interferes with refitting work, etc., and the strain on boats becomes considerable ; in fact at times in the 4th Flotilla at Trincomalee it became unbearable. The time wasted in personnel travelling to and fro, transport of defective and repaired items, spare gear, forgotten tools etc. is enormous whilst the " juster " (a rating just about to catch a boat to a submarine or vice-versa) becomes a menace. It is therefore essential that a sufficient number of reliable power boats should be provided.

Personnel

The problems of maintaining a flotilla of submarines brought along their difficulties with personnel just as with all other craft. Dilution amongst artificer and artisan ratings in particular led to grave difficulties in manning workshop machinery and in providing " afloat " repair parties.


BOAT STOWAGE
BOAT STOWAGE
PERISCOPE DERRICK POSTS
2 TON CRANE
6 TON CRANE
⊕ = RECESSED MOORING PLATE IN SHIP'S SIDE
ALTERNATIVE POSITION OF LOWER BOOM PORT AND STARBOARD
POSITION OF LOWER BOOM PORT AND STARBOARD
BROW
BROW
DISTILLED WATER CONNECTION
OIL FUEL CONNECTION
OIL FUEL DECK CONNECTIONS
DISTILLED WATER DECK CONNECTIONS
FRESH WATER DECK CONNECTIONS
FRESH WATER AND LUB. OIL CONNECTIONS AT BAGGAGE PORTS
OIL FUEL DECK CONNECTIONS
10 TON CRANE
LUB. OIL CONNECTIONS
DISTILLED WATER CONNECTIONS
FRESH WATER CONNECTIONS AT BAGGAGE PORTS
OIL FUEL DECK CONNECTIONS
DISTILLED WATER CONNECTION
OIL FUEL CONNECTION
BROW
BROW
BROW
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

The personnel available in a submarine depot ship consist of three categories, ship's staff, repair staff, and submarine spare crews ; there were never enough of these and the general result was that the ship's staff was depleted to boost the repair staff.

Both repair staff and submarine spare crew were theoretically based on the number and types of submarines attached to the flotilla. The repair staff was permanent (up to $2\frac{1}{2}$ to 3 years) but the submarine spare crew ratings were, of course, a varying body both in their actual persons and in the numbers available. Submarine spare crews were depleted as required to keep submarine crews up to full strength and in good health ; this was a prime necessity. Consequently, the manning of workshop machines and plant was usually allotted to personnel of the repair staff as they could be expected to remain and become accustomed to their particular machine or plant. Afloat parties were built up as far as possible with a nucleus of repair staff but backed up as circumstances permitted with submarine spare crew ratings.

It cannot be denied that repair work is greatly expedited if the staff can be trained and kept as specialists both of machines and plant, and even to a lesser extent on fitting work afloat. This fact was recognized by the establishment, during the war, of a nucleus Submarine Repair Force for the whole submarine service, the theory being that all the ratings in the organization were transferable from depot ship to depot ship according to the number of submarines attached. This certainly helped the situation to a great extent but it was not easy to transfer the ratings as required.

The introduction of the Engine Room Mechanic rating was a great help to engineer officers of repair staffs. It was not so necessary to concern oneself with their training as watchkeepers, etc., with a view to them becoming good all round E.R.As. Instead one could put an E.R.M. on a machine (with which in some cases he was already familiar), or to a fitting job or other trade and keep him on the one job for the whole of his time in the ship. This may not be good policy from the point of view of the fleet as a whole but was undoubtedly of value from a repair point of view.

Accommodation

From April, 1942 until the end of 1944 *Adamant* worked in the tropics—Mombassa, Colombo, and Trincomalee ; at the last place she was used purely as a submarine depot ship. It was quickly found that the exacting conditions both in submarines and depot ship increased the need for replacements of personnel and this necessitated a greater number of available personnel. Added to the fact that the ship was attempting to deal with a flotilla larger than she was designed to succour and the continual increase in complements due to radar and other developments the question of adequate accommodation both of officers and ratings soon became critical.

This was partly met by making submarine crews park their kit and clear their mess decks when going on patrol, so that a submarine coming in from patrol could use the space vacated. This was clearly a very undesirable situation quite apart from the normal congestion in wash-places, heads, etc.

The appropriation of an old Chinese river steamer—H.M.S. *Wuchang* did a little towards easing this problem, but it was finally necessary to convert a merchant vessel as an accommodation ship. Whilst giving increased space and providing additional billets for the crews of submarines lying alongside the repair ship this complicated the problem of boat communication, and the amount of time wasted by submarine crews and repair staff ratings going to and from their submarine became excessive.

This problem has yet to be solved. It may be that even bigger depot ships will be required but it will be seen later that as long as one ship is used for both accommodation of personnel and as a workshop, the requirements for the two functions will clash. It may well be that two complementary vessels would be a solution but they would of necessity have to lie in line with one another, bow to bow, with connecting gangways as used for the old hulks forming H.M.S. *Defiance* for example. Objections to such a plan are numerous, *e.g.*, if one is damaged or delayed through defects, etc., or if for any reason they become detached, one is useless without the other. There is no doubt, however, that the clashing of these two requirements makes it difficult to build the ideal submarine depot ship.

Workshops and Workshop Machines

Generally speaking, those submarine depot ships which have been designed as such, and were not conversions, proved to be well equipped and fitted as far as workshops and workshop machines were concerned. Before going into details in this respect it may be as well to point out that although a depot ship may be designed for a specific purpose it invariably happens in practice that she will be required to perform other functions, *e.g.*, *Adamant* at Kilindini in April, 1942, was the only repair ship for some time and she was called upon to maintain the Fleet which consisted of all vessels from battleships and aircraft carriers down to H.D.M.Ls., to say nothing of merchant shipping and fleet auxiliaries.

A small point in the design stage may cause a colossal amount of work on service, *e.g.*, in *Adamant* the oil-fired heating furnace in the Smithery was 6 in. too narrow to take evaporator coils from destroyers—hence the need for descaling and annealing over forges or built-up furnaces, whereas with a furnace giving that extra 6 in. in width they could have been descaled with a fraction of the labour required. It is appreciated that a line has always to be drawn, but the fact that no repair ship ever deals exclusively with the work for which she is designed should be borne in mind when designing a specialized repair ship.

General Arrangement of Workshops in Ship

Water-tight sub-division is recognized as a very important factor in the design of warships, but this can and, in fact, does seriously interfere with the efficient working of a repair ship. In *Adamant** to transport a job from one shop to another frequently meant a long journey up through hatches and along through many bulkheads, *e.g.*, from the Heavy Machine Shop to the Light Machine Shop was up four decks, along and down four decks or two decks if water-tight doors were opened. If it were possible to accept merchant service practice with sliding doors or even bolted plates in bulkheads a great deal of transport of work and stores could be avoided. In addition supervision would be much simplified.

It has been the practice not to supply a fitting shop in a submarine depot ship but to fit benches in each shop and give some limited space for stripping and assembling gear. In *Adamant* the main stripping and assembling space available was directly below the " cargo " hatch in the Heavy Machine Shop. It would be difficult to think of a more inconvenient space for this purpose and in addition two double-bottom oil fuel tank manholes projected up into this space to further spoil its usefulness.

Besides the actual stripping, cleaning, and assembling space required for

* A general arrangement of the ship is shown in the Figure facing page 42 in Vol. 1, No. 3 of the *Journal*.

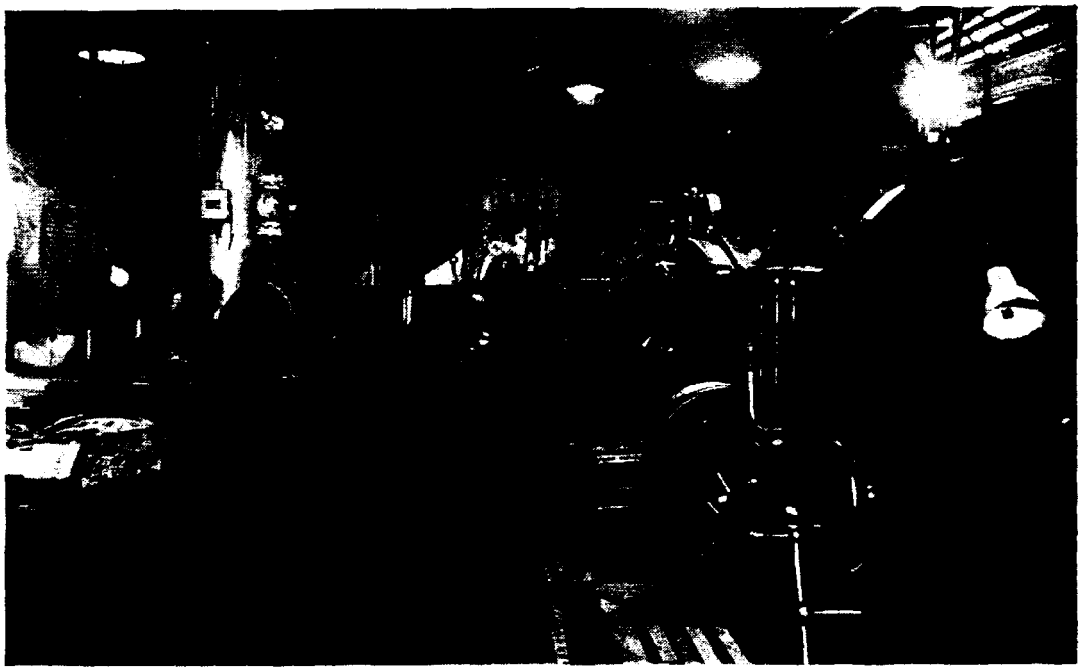


FIG. 2.—HEAVY MACHINE SHOP, STARBOARD SIDE LOOKING FOR'D

many jobs, a very important feature of the work of repairs is the booking-in, progressing, and booking-out of jobs. Without an efficient system no Engineer Officer of a depot ship can keep his finger on the job and be able to form reliable estimates of times when jobs will be completed and vessels ready for sea. Experience shows that if a well-planned " Receipt and Issue " room could be incorporated in a fitting shop where all jobs were received, recorded, and stripped (and " vice versa ") then the flow of work to the various shops could be expedited and easily followed.

An attempt was made in *Adamant* to use an oil fuel working space as a Receipt and Issue Room but it was much too small. It is regretted that it must be recorded that at times jobs were stripped in the Waist much to the disgust of the Commander and the detriment of the wooden decks, besides cluttering up already limited recreation space for the ship's company.

Machine Shops

The complement of machines in the Heavy and Light Machine Shops and E.As. and O.As. Shops was generally adequate. In practice, specialized machines like the gear-planing machine and bevel-gear cutter are little used—they take up a lot of space, much of their work can be done by milling machines and it should be possible to cover the replacement of items that cannot be made in milling machines by provision of extra spares. In addition, a great need was felt for short bed lathes—the incidence of small turning work was very heavy indeed and frequently long bed lathes had to be used for very short work at the expense of longer items like pump spindles, when a short bed lathe could have done the job.

A further boring machine of a size smaller than that fitted in the Heavy Machine Shop in *Adamant* would have been of immense value. Another despised machine is always omitted for some reason—the shaping machine—yet this little machine is invaluable for numerous jobs ; it roughs out material for a milling machine (so extending the life of milling cutters—a very important feature) ; it can be used to true up castings and above all can be operated by

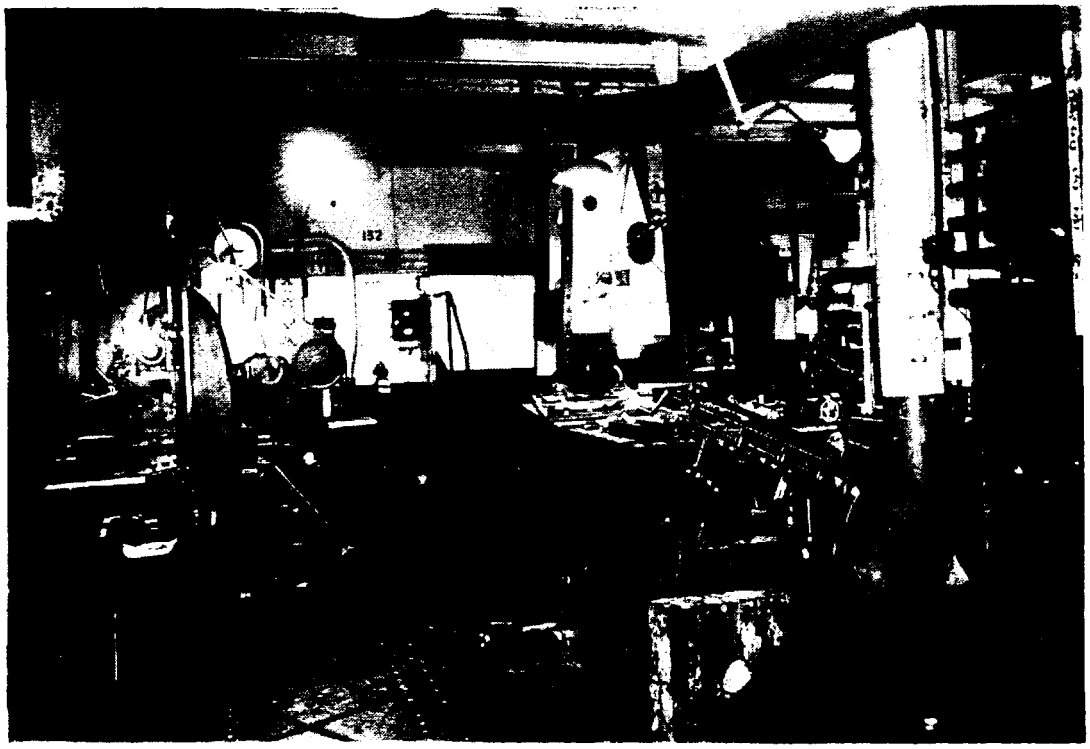


FIG. 3.—HEAVY MACHINE SHOP, MIDSHIPS (FOR'D) LOOKING AFT

an intelligent stoker saving the employment of an E.R.A. on a milling machine. None was fitted in *Adamant* but on arrival in Ceylon one was purchased which proved its worth a hundredfold.

One feature of the Heavy Machine Shop which caused frequent serious interference with work was the siting of the power hammer in the Smith's Shop immediately above. It was impossible to do accurate work on the grinding machines or Kearn's borer when the hammer was in use. This led to frequent arguments as to priority of work and caused undesirable delays in completion of work ; it is a problem which was not solved by the rubber mounting of the hammer but which must be solved in future repair ships.

In the Light Machine Shop, Swift lathes were fitted (believed to be for the first time in the Royal Navy). They proved to be good, thus belying the usual criticism of conservatism, but no provision was made for large-scale cutting of metric threads, a serious handicap when allied submarines (Dutch, Polish, French and later Italian) were attached.

The lifting arrangements provided in the Heavy and Light Machine Shops were generally too heavy and clumsy, and too extensive. The aim in design had obviously been to supply a runway system so that a job could be transported from the bottom of the hatch to every machine. This was not achieved and the result was a heavy and complicated system of runways and travellers which generally speaking was of little use. The number of really heavy jobs met with is small and a temporary rig up was found to be as efficient as the runways in nearly all cases and frequently much more convenient.

The siting of machines was not always good, *e.g.*, sometimes it was not possible to remove the lead screw without lifting the machine and turning it round. It may be argued that this should be a rare occurrence but working at high pressure in wartime it may easily be a necessity and should therefore be an easy job—it could be achieved by careful siting of the machines relative to one another and the bulkheads.

Mention has been made of the nuisance value of the power hammer—besides the vibration it sets up, its noise did not contribute to accurate work in the Heavy Machine Shop below it, especially when added to the normal hammering noises of a smithery. It is for consideration that the smithery be sited at the bottom of a repair ship or if this is not possible, over a store where noise does not adversely affect personnel and workmanship.

The machine shops were generally good but in new design consideration should be given to the following points :—

(i) As many as possible of the obstructions such as ventilation trunks, aerial " lead-ins," D.B. hatch cover, etc., should be removed from the shops. (Some of these can be seen in Fig. 3.)

(ii) Incorporation of the E.As. and O.As. Machine Shop in the Light Machine Shop would improve facilities and space and also allow of more general interchange of artificer ratings on machines—a feature which at times is essential.

(iii) Adequate equipment should be provided for all machines—the scope of some machines was limited by lack of accessories. The supply of accessories would have only meant the expenditure of a mere fraction of the money spent on the machine, but much time and labour can be lost in a depot ship by making accessories. This may be acceptable in a vessel completed in peace time with plenty of time to make and build up stocks of accessories and equipment but for a vessel completed or converted in wartime, as *Adamant* was, it was a great burden to the workshops.

MISCELLANEOUS WORKSHOPS

Smithery and Plate Shop

The Smithery and Plate Shop is by nature a dirty shop and therefore adequate ventilation is essential both for the cleanliness and cooling as the forge and furnace caused great heat. The Shop, in *Adamant*, was generally adequate though an additional forge would have been an asset as blacksmiths worked in the shop as well as boilermakers and engine-smiths.

The two electric hardening and tempering furnaces for tools were situated in this shop and their elements would not stand up to the banging of the power hammer. With spares difficult to obtain, these machines (excellent though they were) could not be used for a large part of their life. They should be sited always in the tool room where in any case they are more handy for the work they are meant to do.

The need to increase the size of the annealing furnace to take destroyer evaporator coils has been mentioned already and a further improvement, complementary to this, would be to fit a plunging bath adjacent.

Handling facilities must be good in this shop—the flanging machine fitted was an excellent machine, but partly due to limited space and poor handling facilities and partly due to the slowness of the machine there was always a tendency for the job to be cold before the machine work necessary on it was completed.

Coppersmith's Shop and Foundry

The interests of the Coppersmith's Shop and Foundry in the same compartment did not clash and each was found to be adequate whilst the plant and equipment supplied were generally good and useful.

FIG. 4.—E.AS. AND O.AS. WORKSHOP FROM PORT TO STARBOARD

Whilst acting as a fleet repair ship at Kilindini, *Adamant* did much large pipe work—the excessive corrosion of all types of circulating water pipes will be familiar to all officers who served in the Eastern Fleet. This emphasized the need for a large lead-melting bath. To use resin was painfully slow in the tropics as it could take as long as four days to set.

It is of interest to note that the Foundry only once had to refuse a job—this was one of 1,100 lb and it was quite impossible to obtain a melt of sufficient weight to cope with this.

Pattern Shop

Though the Pattern shop was able to hold its own, a small circular saw would have been of great use. After several years in service a depot or repair ship builds up a stock of patterns (*e.g.*, for quills) but *Adamant* was confronted with a start from scratch and the Pattern Shop was hard put to it at times. The time saved by a small circular saw would have been invaluable.

Welding and Plumber's Shop

The Welding and Plumber's Shop was a combined shop adjacent to the Coppersmith's Shop and Foundry—in practice by far the larger amount of work done in it was welding. With the growth of welding for all purposes and the improvements in technique and methods it was found that both the staff and facilities were not adequate. This was even clearer when the ship was performing the duties of fleet and destroyer repair ship, which was to be expected. It is significant that the record for the number of hours overtime worked by a single E.R.A. during the period the author was in the ship was held by a welder whose zeal, ability, and improvization earned him an M.B.E. The floor space in this shop was very small indeed and this frequently entailed overflowing into the Smithery on the deck below, a most inconvenient procedure as there was little enough room for the boilermakers, etc. In view of the similarity of the work and the fact that many boilermakers are, in fact,

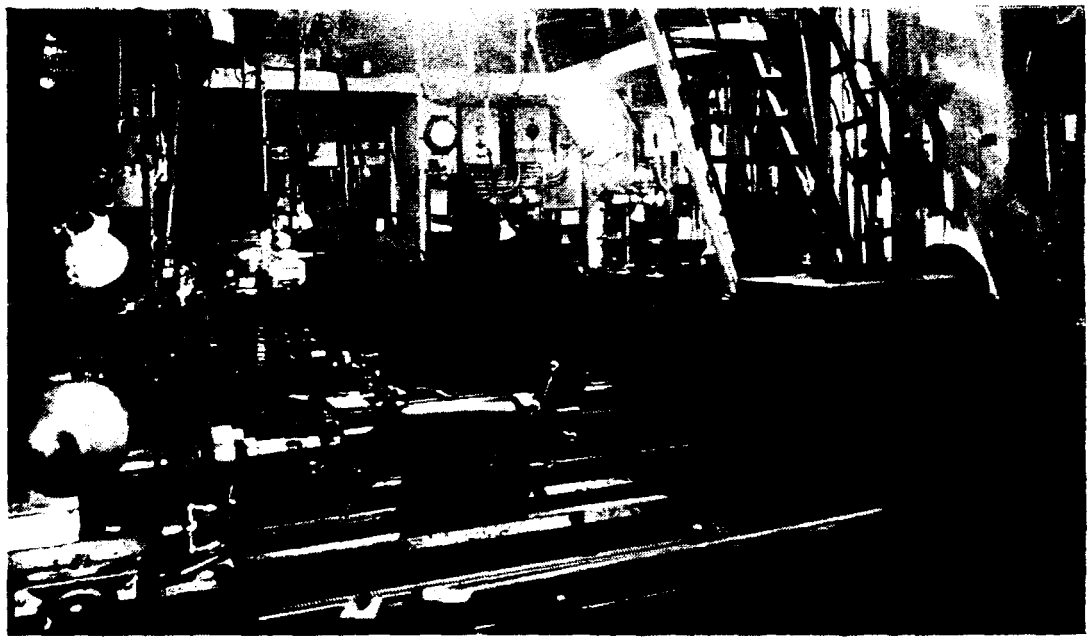


FIG. 5.—E.AS. AND O.AS. WORKSHOP, VIEW FROM STARBOARD TO PORT

welders it is felt that the welding shop and plate shop should be combined with portable screened compartments for welders on small jobs. At least one portable Diesel-driven welding set in addition to a minimum of eight welding points around the vessel are considered to be essential.

Electrical and Ordnance Workshop

The Electrical and Ordnance Workshop was quite inadequate in size—there was insufficient space round the machines and at the benches. In addition it was lined on the bulkheads with branch breakers, etc., and became unbearably hot (Fig. 4 and 5). This not only was physically uncomfortable but the humidity and consequent sweating had a deleterious effect on the work being carried out. The $8\frac{1}{2}$ in. lathe was too big for the shop and above all the shop was in an inaccessible position for heavy work.

With the development of radar and A/S it was soon essential to have more space for electrical work and this was met to a limited degree by sacrificing space in the Gyro Workshop on the upper deck.

There is no doubt that the instruments work, electronics, and other fine electrical work now require a large, well-lighted, air-conditioned, workshop on the upper deck.

This electrical and ordnance workshop was sited most unsuitably for ordnance work ; most of the gun work for submarines was small and light and to have to transport jobs down to this shop was unnecessary labour. A small shop was rigged on the upper deck and found to be of great value, also, by the way, easing the congestion in the main shop.

Motor Boat Workshop

Mention has been made earlier of the great call on boats when running a submarine flotilla, *e.g.*, to visit submarines in dock and transporting personnel and working parties to and fro, H.M.S. *Adamant* had originally nine power boats but the number was increased by the advent of accommodation ships. The small Motor Boat Workshop was found to be inadequate but the problem

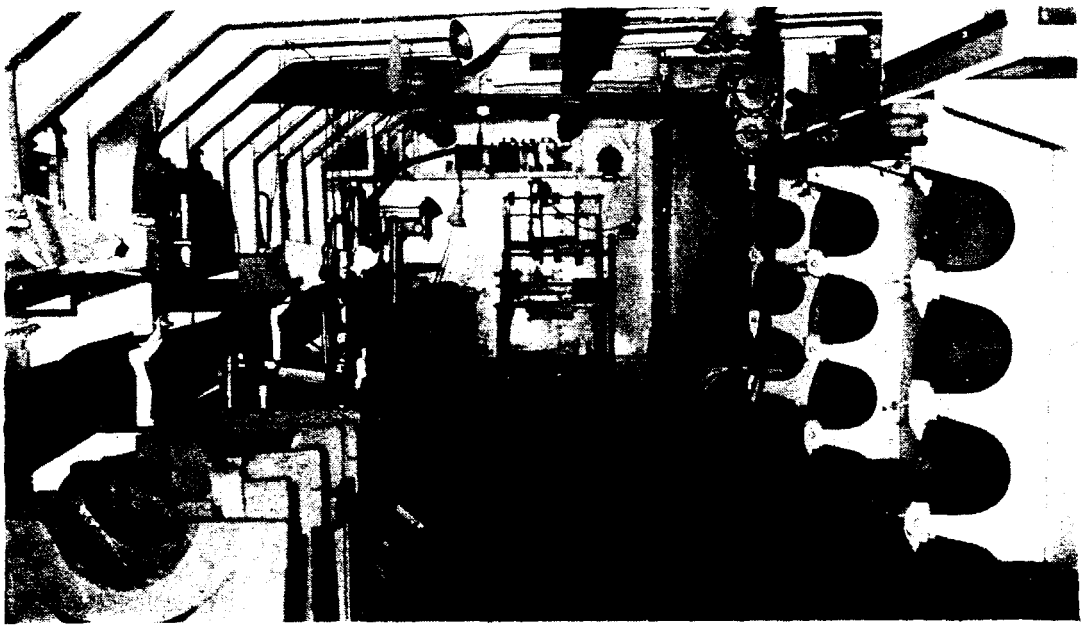


FIG. 6.—PERISCOPE SHOP, VIEW FROM AFT.

was eased by the fact that the flotilla was operating in the tropics and a very large proportion of the work could therefore be done in the open and in the boats themselves.

A submarine depot ship naturally has little sea time and her boats are therefore always running—hence the greater complement of power boats—but in addition it was found that the breakages of " A " brackets and propellers of fast motor boats far outweighed the advantage of their speed. The repair and casting of " A " brackets and " P " brackets for fast motor boats (both of *Adamant* herself and other vessels) almost became a production job.

The motor boat workshop was not within the radius of any crane and this was a major handicap—the provision of the type of crane referred to earlier, if this is practicable, would, of course, surmount this difficulty.

With the present practice of routine maintenance and repair by replacement the need for a large workshop will be largely eliminated. It may be argued that in view of the dependability of a submarine flotilla on boats, this cannot be accepted in this particular class of ship, but with the improved reliability of I.C. engines and the elimination of fast motor boats and petrol-driven engines, it is felt that it can.

Diesel Test House

The Diesel Test House contained the Diesel spray-valve cleaning and testing apparatus as well as pressure-gauge testing apparatus. It was a bit small but was wisely placed high up ; unfortunately this was rather nullified by the absence of large scuttles to give light and air. Above all the ship lacked a Hartridge, or a similar type, fuel pump testing machine and as when the vessel was built we were employing U Class submarines with Paxman engines, this appeared quite incomprehensible. H.M. Dockyard, Chatham, eventually manufactured a machine and this was sent out to *Adamant* at Trincomalee.

A clean, well-lighted shop, high up so that dirt and dust can be excluded, is essential for work on injectors and pressure gauges.

Shipwright's Shop

The Shipwright's Shop was generally satisfactory though it was frequently

found that more bench room was desired—again this was overcome by open-air work, *e.g.*, most of the boat work was done on the boat deck but this could not be accepted in the cooler and wetter climates !

A little more care in siting machines would have helped, *e.g.*, the band saw could only be worked on short lengths of wood because of its site, and the circular saw was limited to fixed depth cuts except by using wood chocks. Adjustable depth of cut would have saved a large amount of time and labour.

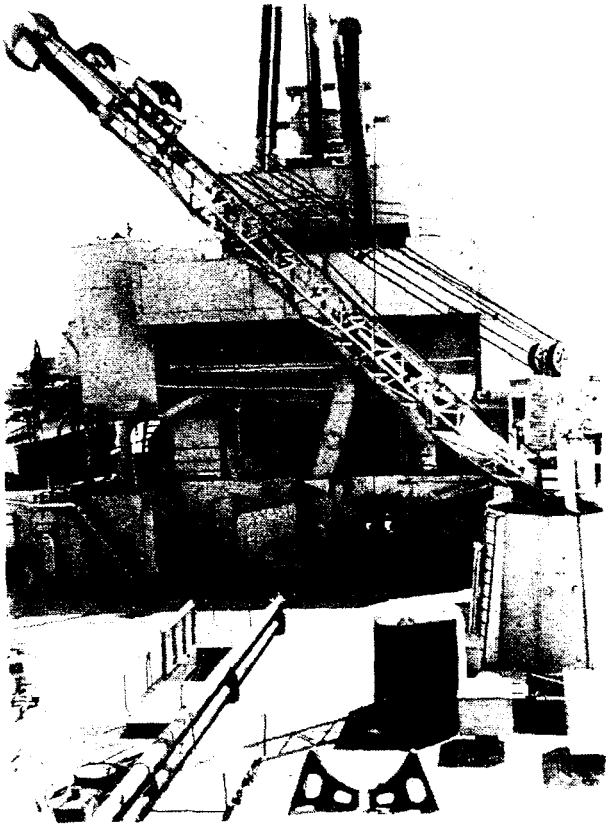


FIG. 7.—6-TON JIB AMIDSHIPS. PERISCOPE DERRICKS SECURED ON CENTRE LINE

Periscope Shop

The Periscope Shop was probably the best shop in *Adamant* (Fig. 6). Even when two additional optical O.As. were added to the complement to deal with the enormous amount of binocular work entailed in maintaining submarines on patrol there was sufficient space for them ; but one criticism must be made of the handling facilities for periscopes ; it was necessary to rig derricks to lift a periscope from a submarine (one port and one starboard) whereas a little longer jib in the cranes or a littler higher siting of them would have allowed them to be used. In actual practice in *Adamant* the 10-ton crane was frequently used and work done on the quarter deck or periscopes transported along the decks on trestles rather than rig derricks which in any case were clumsy in handling such a delicate instrument as a periscope. Fig. 7 shows the periscope derricks dismantled in the secured position.

Before leaving the subject of workshops it is perhaps opportune to draw attention to the saving of manpower, machines, and space that could be achieved by a little combination of shops. There is no reason why the machine tools in the electrical and ordnance workshops should not be sited in the heavy and light machine shops ; the patternmaker's and shipwright's shops be combined ; blacksmiths, engine-smiths and welders all use the smithery and plate shop. It might mean bigger shops but this would be more of an advantage than otherwise and there would undoubtedly be a net saving in space. Problems of personnel of different branches and control are not insoluble—this was proved in *Adamant* where E.As. and O.As. frequently worked in the Heavy Machine Shops ; blacksmiths with the welders, etc., and, moreover, the Engineer Officer must co-ordinate the repair work of the flotilla.

Materials

From the foregoing comments on individual workshops it will be seen that, generally speaking, they were found to be reasonably efficient, but quite inadequate provision had been made for the materials. It is unnecessary to

go into great detail as this was a general failing. Small items were comparatively easy to improvise and build bins and stores for them, though, of course, this meant wasted labour and material ; for storage of adequate quantities of plate, angle, bars of steel, iron, brass, aluminium, and wooden planks and spares it was not so simple. Such things are not easily handled and therefore they must be within the range of a crane—with fixed cranes this limited one to a very small area and it was necessary to build storage space on the upper deck. This took up the already small deck space and was not ideal from a craneage point of view. Some increased storage space for bar and angle was built in the Plate Shop and Smithery but only at the expense of ease of handling of work.

It may be argued that large stocks should not be necessary as the Naval Store Officer is always handy. This certainly was not a fact in the Second World War and had not *Adamant* stocked by all the means at her disposal (fair and foul) on all possible occasions it would have been necessary to refuse work on many occasions. As an example, the writer spent many hours in a car at Kilindini searching for suitable sand to replenish the foundry ! Also, about 25 tons of scrap metal were salvaged from H.M.S. *Resolution* when that vessel was endeavouring to reduce her draught ! Perhaps mention of the various " scrounging " expeditions by the writer and his staff are better omitted, but these instances all serve to illustrate that it is vital that any repair ship must have ample room for storage of materials and that storage must be in accessible places.

Spare Gear

The operation of a flotilla of submarines composed of all types of British submarines plus a variety of Allied ones complicated the spare gear question to a terrifying degree. Again the problem was space and every hole and corner in *Adamant* was utilized to stow spare gear. Such a method of storage is grossly inefficient and wasteful of spare gear for continued handling in difficult spaces always leads to damage. In addition, the preservation and maintenance of spare gear in the tropics is no small problem and, again, adequate space for the handling and storage of the gear is essential. It must not be simply space—the space provided must be fitted with racks, bins, and lifting appliances, simple but ample.

In the supply of spare gear many man-hours were wasted through bad preservation, packing, and marking. This has been recognized by the introduction of P.I.P. and it cannot be too strongly emphasized that this system must be enforced to the limit.

Services

The services to be supplied to a submarine when she is alongside comprise fuel, lubricating oil, fresh water, distilled water, high pressure air, low pressure air, and electric power.

Generally all these are required though high pressure air and electric power less often than the others as a submarine can provide her own. It frequently happens that during repairs, however, it is more convenient to provide either or both these services from the depot ship.

The equipment necessary to supply these services is considerable and the quantity of hose and heavy electric cable required is always a major nuisance on the upper deck. The grouping of the fittings has been referred to on page 56 but in the original design little serious provision was made for stowage of hoses, etc. During building, space for oil fuel and lubricating oil hoses was

made on the upper deck between the periscope and shipwright's workshops, thus slightly reducing the width of these shops. This reduction in space was undesirable but the provision of storage space for hoses was proved to be absolutely invaluable.

There is no doubt that provision on the upper deck should be made for convenient stowage of all the types of equipment likely to be needed on the upper deck.

Docking

The docking of warships was well known to be a major headache during the Second World War. In this respect submarines were no better off than surface vessels—in fact the situation was perhaps more desperate. Silence in approaching the target is an absolute essential in submarine warfare, but *S* and *T* Class propellers had a nasty habit of developing noise if only very slightly chipped or bent and as the *T* Class especially had a very fine-edged propeller very frequent docking was necessary to repair propellers alone. In addition, operations in the Malacca Straits in shallow sandy waters caused rapid wear of " A " bracket bushes. As a consequence, it was not unusual to have to dock a submarine after every patrol and the rule was virtually after every other patrol—this meant on an average once in 12 weeks, twice as often as had been anticipated in peacetime.

Docking was effected in Trincomalee in a small floating dock (A.F.D. XXVI) and as submarines competed with destroyers for the dock the Engineer Officer of the flotilla was involved in endless arguments for priorities. Apart from that problem the dock was berthed about $1\frac{1}{2}$ miles from the depot ship—hence more boat work and more time wasted in travelling to and from the dock. It is considered that there is a case for attaching one small dock to a submarine flotilla for submarine dockings only ; a flotilla of fourteen submarines would keep such a dock continuously occupied under the conditions obtaining in the Far East in 1944.

Conclusion

Sufficient has perhaps been said to give some idea of what a user thought of one of the depot ships designed specially to service submarines. It is thought that this is a fair criticism of the vessel itself and also reflects the feelings of other Engineer Officers of other submarine depot ships one or two of whom have read and kindly criticized this article in its early stages.

Compromise is always a necessity in one of H.M. ships—it will always remain so—but it is very necessary to bear in mind the principal functions of a submarine depot ship namely :—to operate, maintain and repair, and to administer the units of a submarine flotilla away from a major base, and to provide for the well-being of the submarine crews on return from patrol. In this respect *Adamant* was a good compromise.

Whether in a future design all these requirements can in fact be conveniently met in one vessel is very much open to argument. If they can it will be a very large and valuable vessel.

In practice it may not even be advisable with the development of long-range air warfare to have such a large and valuable ship at a forward base. In such a case smaller " mother " ships may be required for advanced bases which could maintain a submarine for two or three patrols after which she would return to the large submarine depot ship for a long rest and bigger repairs.