NAVAL ENGINEERING REVIEW

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PRINCIPAL CONTENTS

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FRONT COVER ILLUSTRATION

The Westland Sea King is the Royal Navy's newest and most advanced anti-submarine search and strike helicopter. Fitted with an integrated sonar and search radar weapon system and an automatic flight control system, the Sea King is capable of operation by day or night and from either ship or shore bases.

The aircraft is capable of carrying four MK44 torpedoes or four MK11 depth charges. The former being used in the normal role of the Sea King. (See article on page 17.)

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General Secretary's Notes and Comments

This issue of the *Naval Engineering Review* celebrates the Centenary of the Royal Naval Engineers' Benevolent Society which was born in 1872 out of a desire for justice by the newly-introduced corps of Engine Room Artificers. These men, ostensibly brought into the Royal Navy as mechanics to assist the junior engineers with repair and maintenance work, and given the rate of Chief Petty Officer on entry, soon found that they were in fact taking over all the functions of junior engineers, including charge of watches in the engine rooms. They were nevertheless, in those early days, treated with scorn by all and sundry as being "oily rags". Living in the same mess as other CPOs, they were expected to take their turn at mess chores and preparing their own food, etc. Their shore leave was under the jurisdiction of the Master at Arms. No avenue of promotion whatever was open to them.

Their counterparts, who chose to join the rapidly growing steam-driven merchant navy, were far more fortunate both as regards pay and conditions, though they came from the same source. Any attempt by the ERAs to gain some improvement in their lot was looked upon as insubordination by the die-hard officers of the time, many of whom were not even convinced that steam was a necessity in the Navy, or at best, was an inconvenience which had to be tolerated.

Progress by the Society towards improvement for the corps was slow in the early days, with much prejudice to overcome. For many years they met and carried out their business in a cloak and dagger atmosphere for fear of reprisals. Enlisting the aid of the Trades Unions, to one of which most of its members already belonged, their most effective early ploy was to discourage any further entry of Artificers. This was not difficult as most men who considered leaving the engineering workshops or shipyards to go to sea had little hesitation in preferring the conditions offered by the merchant service.

Eventually, having scraped the bottom of the barrel of possible recruits and having even tried using Chief Stokers as Artificers, the Admiralty conceded some improvements. These included higher pay (though still not equal to the MN) separate messes for ERAs with messmen to attend them and the privilege of employing hammock men.

The Society also successfully enlisted the aid of the technical press, various Members of Parliament and other influential persons and professional bodies in its fight for a better understanding by the Admiralty and the country as a whole, of the value of the work being done by ERAs. Nor was the general press overlooked, and many "letters to the editor" were written over the years by the Secretaries and committee members of the Society's branches. First the rate of Chief ERA was introduced, though still carrying the rate of CPO and then, in 1899, the first Warrant Officers, or Artificer Engineers, as they became known.

Though the position achieved by Artificers has never reached the level for which the Society has aimed, much of its efforts over the last half of the 100 years of its existence has been concentrated on preventing a decline in the conditions which had been achieved in the first 50 or so years. At about the time that the Society celebrated its Jubilee in 1922, although the Mate(E) scheme had been introduced and the promotion prospects for ERAs began to improve slowly towards its present level, there was an air of disillusionment amongst our corps. The brave new world which they had thought would come after they had more than proved their worth in the Great War, was not coming after all. Though the Society, through some of its leading members, was very active on the Jerram Committee and was instrumental in helping other lower deck Societies to form and present their cases, the general feeling among Artificers was that such improvements as had been achieved benefited the rest of the Navy and tended only to whittle down the "lead" which Artificers had formerly held over the rest.

There grew up at this stage a not-inconsiderable "anti-Society" faction which one remembers quite well as a junior member at the time. This phase lasted until after World War II. One wonders, in retrospect, at the strength of this antagonism against the Society and who could have been fostering it, if it *was* being actively encouraged by anybody. Many were the arguments in the ERAs' Messes and accusations by some that the Society's officers were feathering their own nests and achieving nothing. It was alleged that as a corps we might have fared better without the Society and that Authority singled us out for detrimental treatment in order to teach a lesson to those who thought they could influence that august body, the Admiralty, by "political" means. There certainly did seem to be "someone up there" who had it in for Artificers and was determined to cut them down to size.

During this period, which lasted about 30 years and encompassed, it so happened, the whole of my 26 years of service, the position of Artificers was gradually whittled down. Starting in October 1925 with the introduction of the 5th class Leading rate Artificer and the loss of gilt buttons on the uniform of Apprentices through, at the end of World War II, the gradual implementation of the policy of abolition of separate Artificers' messes and culminating in the new pay code for the Services which destroyed the large differential in pay over other CPOs previously enjoyed by Artificers. Added to this the Chief Artificer found himself linked incontrovertibly, for status, allowances and pension, to the Army staff sergeant whilst those in the other Services carrying similar responsibility to himself were Warrant Officers at least. Most Chief Artificers (myself included) far from receiving the big surge forward in pay which everyone else was welcoming, found themselves "marking time" on their existing pay for some years while the new scales caught up with them.

It was at this stage, towards the end of my Service career that I started the campaign for the introduction of a Warrant Officer rank similar to that of the other armed forces. In February 1951 I made a Representation in writing through my Captain for the introduction of such a rank, to be held by all Chief Artificers and Chief Mechanicians and a selected number of CPOs of other branches. This campaign was continued by the Society, to whom I reported my action. Shortly after retiring from the Service, I became General Secretary of the Society. I continued and expanded a policy which my predecessor had just started before having to resign because of indifferent health, of creating and maintaining a dialogue with as many of those in authority as could be contacted. Whoever was "up there" who had it in for Artificers had to be shown that notwithstanding the rough treatment they had received, they were still amongst the most loyal and hardworking of Her Majesty's Forces. That working, as they did, to a great extent entirely unsupervised, their goal was always a more efficient fighting service. All they wanted was a fair place in it, commensurate with their true worth. Also, that the Society, which attempted to speak on their behalf, far from being a subversive body was dedicated to the same Objects—an efficient and happy branch in a more effective Navy.

Regular visits to the Apprentices' Training Establishments have been made in order to ensure so far as possible that standards were not being lowered as a matter of expediency in the light of the difficulty which persisted over the years, in obtaining sufficient recruits of the right calibre to become good Artificers and Engineer Officers. Whatever else may be said, there is no doubt that those "up there" no longer consider the Society a subversive body which must be suppressed. It is recognised as a valuable avenue of communication. With communication comes better understanding on both sides which, whilst not yet perfect because the participants are not perfect, is nevertheless a great improvement on the former situation.

Apart from the major issue of the Fleet Chief, of which everyone is aware, it may not be generally appreciated that the Society is responsible for, or had a hand in, the following:

(a) the issue of a meaningful Discharge Certificate showing an Artificer's full qualifications and experience.

(b) The introduction of a tender to HMS *Caledonia* for the purpose of improving the training of Apprentices.

(c) The introduction of ONC courses for Apprentices.

(d) The restoration of gilt buttons to the uniforms of Apprentices. This may seem a small thing, but it should be considered in the light of the fact that the actual proposal at the time was for Apprentices and all Artificers below Petty Officer rate to be put into "square rig", as was actually done in the case of Writers, Cooks, etc. By emphatic representation the Admiralty were persuaded that such a step in the case of Apprentices and Artificers would entirely kill the recruiting situation which was already in a critical position, and that in fact what was needed was to restore the buttons lost in 1925, which might give recruitment a fillip.

(e) It is unlikely that the accommodation at Caledonia would have been improved without continued pressure on behalf of the Society. That this accommodation would no longer be used by Apprentices a few years from now could not have been foreseen when the matter was being pressed, many years ago.

This list is not intended to be exhaustive, but by mentioning some of the principal items it indicates the kind of activities and achievements of the Society other than the provision of cash benefits and the production of this journal.

The Society now enters the second century of its existence stronger in membership in spite of a shrinking Navy and pledged to uphold and improve the standards, status and conditions of Artificers and those promoted therefrom. One of its immediate aims, from which we shall not falter, is to continue to press the claim for Warrant Officer status for every Chief Artificer.

In many ways the naval Artificer of today is a very different fish from his predecessors of previous decades. This is true of all branches, but of none is it more so than in the Engine Room (Marine Engineering) branch. The function and duties of the modern MEA are far removed from those of the ERA of 20 or even 10 years ago. Paradoxically, it is in the nuclear submarines that among the most modern ships, much of the old role for MEAs remains.

Though training syllabuses and methods may change, and change they must, to keep in step with future requirements, one thing is unalterable . . . the need for a sufficiency of top quality recruits to HMS *Fisgard*. Only those of the right calibre can come through this training successfully. To lower the standard of entry or to scrape too often the bottom of the barrel, is no solution to the problem of insufficient numbers. This only makes the training task harder for both trainer and trainee. A high failure rate is not the only penalty. Too high a proportion of those who only just scrape a pass mark leaves a very watery mixture after the cream has been skimmed off by way of Upper Yardmen and S/D List officer promotions. Since the residue is expected to bear the heat and burden of the day and be the backbone of any ship or station, it is obviously essential that barrel scraping must not be resorted to.

As I have said over and over again, the best answer to this situation is to increase the rate of re-engagement. Every Artificer who re-engages to complete time for pension is worth at least two new recruits. Allowing for drop-outs, failures and those promoted to the ward room, only about one in two new entrants comes through to the end of 12 years, as an Artificer. If he then re-engages we can have a fair expectation of his services for another 10 years or possibly even longer. Ten years of maturity, experience, of maximum advantage to the Service. It is only common sense therefore, that every inducement should be given to Artificers to re-engage to age 40. This is not merely a matter of a re-engaging gratuity. Those who reach this position must be able to see some improvement ahead for themselves. These men have no fear of the outside world, even in the present depressed state of the labour market. They can, and do, obtain really good jobs without difficulty, whether leaving the service at age 30 or 40. (It is a slightly different story at 45.)

At the present time the inducement to become a Chief Artificer is too small in comparison with the additional responsibility. Becoming a Chief Artificer is, to an Artificer (who is already a CPO of several years standing) equivalent to any other CPO becoming a Fleet Chief, yet the Chief Artificer is still only a CPO with a comparatively small pay differential over the Artificers for whom he may be responsible.

If they wish to keep Artificers, having trained them, the MOD must give them sufficient inducement. To advertise proudly, as is done, that these men can earn up to £2,000 per year, cuts little ice when:

(a) only the selected, older men who are willing to serve until they are 45, can become Warrant Officers.
(b) Very few ex-Chief Artificers in civilian life are earning less than £2,000 p.a. and many are receiving very much more.

It merely only shows how little real understanding of the situation exists in the corridors of power.

Senior officers of the Engineering Branch with whom I discuss these matters nearly all endorse my views. They are the ones who can best evaluate the situation and know the worth of Artificers. The trouble seems to be that there are still those at the top in decision making positions who are bogged down with the idea that the most important quality for promotion is "Leadership". What merits recognition in the Navy of today is the ability to keep an important piece of ironmongery functioning perfectly and the resourcefulness and experience to get it, or its replacement, working again quickly if it fails or is destroyed. The man who is doing this is the Artificer or Chief Artificer, very often without supervision or control of any other officer. This is not intended to denigrate the role of Engineer officers. Their professional qualifications, experience and managerial capabilities are obviously necessary and have their important place in the scheme of things, but they would be the first to agree that there is no substitute for the Artificer or fully trained Mechanician, without whom the Navy would soon become as useless as scrap iron.

A fully trained Artificer or Mechanician, after a few years of experience and having passed professional qualifying examinations and tests, is a CPO. After about 5 or 6 more years and having passed further examinations and been recommended, he may go on to promotion to Chief Artificer or Chief Mechanician, carrying considerably more responsibility. By what kind of logic can it be denied that he does not merit the rate of Fleet Chief with its higher pay, allowances and pension? At present he remains a CPO and can only become a Warrant Officer if he is further recommended and is willing to serve in the Navy until he is 45 years old or more. The Army and RAF have no such stipulation for their Warrant Officer rank.

The Fleet Chief rate as introduced, seems to have been based on the assumption that special jobs would have to be found, where they did not already exist, in order to "accommodate" the new rating. It is our contention and always has been, that this is not necessary in the case of Chief Artificers/Mechanicians. In some cases a

(continued on page 52)

A CENTURY AGO. . .

. . .Snippets from the 1870 era

HMS 'SULTAN'

The Sultan, armour-plated ship, which was disabled through the giving-out of its boilers at the critical moment when our relations with Russia might have led to hostilities at any moment, is now in a fair way of being soon added to the effective strength of the Navy. Launched at Chatham on the 31st May, 1870, and provided by the Messrs Penn, of Greenwich, with a pair of horizontal trunk surface condensing engines, she was long regarded as the crack ship in the service, and was selected by the Duke of Edinburgh when required to make up his sea time in the Mediterranean; and though she is now surpassed, as regards size, thickness of armour, and power of guns, by many of our modern iron clads, she continues one of the most formidable and seaworthy cruisers in the Navy. She is protected with 9-inch armour, mounts eight 18-ton and four 12-ton guns, and has realised over 14 knots per hour on the measured mile. Owing also to her cellular method of construction, she is enabled to carry weights exceeding the weight of her hull to the extent of 900 tons. At the end of her last commission she was found to be in such a state of dilapidation as regards her hull and boilers that she was despatched to Portsmouth for extensive repairs, the Duke of Edinburgh taking over the command of the Black Prince. But while all the necessary repairs and renovations have been made, the opportunity afforded by the refit has been taken advantage of to provide the ship with all the modern appliances and engines of war, so that when next she hoists the pendant she will be a more powerful and efficient cruiser than when she was first commissioned. As a matter of course, all the defective rivets in the bilge, keel, and rudder have been taken out and replaced, the whole of the plating has been scraped, chipped, and renovated, and the fittings to the cables, anchors, rigging, and masts have been thoroughly examined. The whole of the store-rooms, shell-rooms, and magazines have been completely refitted and altered, to suit the requirements of the improved projectiles, which are somewhat larger than those formerly carried, and have gas-checks attached. An engine-room, store-room, and magazine have been built for the Whitehead torpedoes, of which the Sultan will carry 12. Racers, carriages, and transporting trolleys have also been fitted, and five torpedo ports have been cut through the armour on the main deck, two forward on the mess deck and two aft in the cabins. Arrangements are also being made to mount six Nordenfeldt guns on the gunwale of the ship—two forward, two amidships, and as many aft—while a couple of Gatlings will be fixed in the tops. It is also intended to fit nine 20-pounder torpedo guns on the upper deck, and on the deck above the upper battery, for the purpose of repelling torpedo attacks. Additional magazines have been erected for the storing of outrigger torpedoes and their gear, and a couple of torpedo boats will be carried above the upper deck. It is also proposed to adopt a suggestion made by the Duke of Edinburgh and build a conning tower over the central hatchway over the box battery. The Downton pumps have been supplied with improved valve suctions into the double bottom, the steam capstan and steam steering gear have undergone repair, one of Shand and Mason's pumps, capable of getting up steam in 10 minutes, has been placed on the lower deck for pumping out the water from the double bottoms, and it is intended to fit one of the same firm's fire-engines on the same deck. The ship will also be provided with two of Wilde's electric lights, the machines for which will be worked by one of Brotherhood's engines. An attempt has also been made to improve the ventilation of the engine-room and lower deck, which was always very defective; and although additional fans have been fitted and a cowl has been erected several feet above the hammock nettings, and connected with the stoke-hole, there is still room for further improvements being introduced.

The whole of the machinery has undergone a thorough overhaul by Messrs John Penn & Co, of Greenwich, the original contractors. The main engines are of the same type as those which were manufactured by the same makers for the Bellerophon, Hercules, Devastation, and some others of our first class ships of war, including the Neptune, the most powerfully-engined ship in the service, and which will have the advantage of lying flat on the engine-room floor and consequently well below the water line. The cylinders are each 127 inches in diameter, the trunk being 47 inches, thus giving an effective diameter of 118 inches. The stroke is 4 feet 6 inches, and the engines have developed 8,629-horse power, or as many as over 1,400 horses beyond the contract. The wisdom and the expediency of providing our powerful armourclads with superior machinery, at whatever cost in the first instance, are proved by the fact that the Sultan's engines, after nearly ten years of constant use, are today equally as efficient as when first placed on board. Notwithstanding the commissions through which they have passed, the cylinders were not required to be "trued" and only the junk rings and gudgeons needed to be renewed. The engine frames have been re-bored and the brasses have been "trued" and re-adjusted throughout the length of shafting. This is nearly all that was required to be done to the engines, and the satisfactory results of the official six hours' trial on Friday will compare very favourably with the original *data* on the mile, the more especially when it is stated that the superheaters with which the boilers were fitted have been removed. The new boilers, which were manufactured at Keyham, also possess less heating surface than the old ones. The trial on Friday was conducted on the part of the contractors by Mr Gosling, Mr J. Bannister representing the Admiralty, Mr C. Icely the Steam Reserve, Mr Newman, and Mr Durstan the Factory Department, and Mr Batt the Shipwright Department; Mr John Penn was also present on the occasion. The ship was under the command of Captain Richard Wells, and Mr Harding performed the pilotage duties. Altogether, the Sultan was under way eight hours between Spithead and the Nab, so that time did not permit of the first two half hours (during which the fires were foul with small coal, and steam was being raised to the *maximum* required) being thrown out. Had this been possible, the mean results of the six hours' full-power steaming without stopping would have exhibited still better figures, as the power was rising when the trial was brought to a close. The steam navigation coal was found so small that it was deemed advisable to mix it with north-country coal, and the stoking was not so uniform as could have been desired, the length of grate surface rendering it exceedingly trying to the men. The result was that the horse-power, which was 7,224.34 at the end of the first half-hour, reached a *maximum* of 8,531.12, and ended at the twelfth half-hour with 8,119.03. The means of the trial were:—Pressure of steam in boilers, 28.4lb., and in cylinders, 18.67lb.; vacuum in condensers, 26 inches; revolutions per minute, 69.45; and indicated horse-power, 7,736.11, being at the end of ten years 536 beyond the original guaranteed power. The mean of two runs on the measured mile showed a speed of 14.8 knots; but as the ship was a foot and a half lighter than when at her load-line, this result is of little practical importance from a service point of view. The engines were stopped in 13 seconds, started astern from dead stop in 8 seconds, and from going astern they were started ahead in 15 seconds. The amount of coal consumed during the trial amounted to 1,314 cwts., giving 3lb. for every unit of indicated horse-power. The engines gave no trouble from first to last, not a drop of water being necessary to keep the bearings cool during the long grind, while the boilers were entirely free from priming. The ship steamed into dock during the trial, and will be completed for the pendant.

A novel gun

A completely novel form of gun, much admired at Meppen during Krupp's experiments, was a muzzle-pivoting gun. This gun is mounted in a very peculiar manner. The muzzle of the gun is enlarged, and spherical, so as to form a ball and socket joint in the armour of the battery. The breech is so supported, that it can be trained through an angle of about 30 degrees right or left, up or down. The gunner sits astride the gun on a saddle, and sights it through a small aperture above the gun. An iron or steel convex shield is external to the battery, and can be made to rise or fall easily by a counterpoise, so as to protect the mouth of the gun, so that it would scarcely be jammed by the impact of a hostile projectile. The gun is mounted in an iron casemate, formed by sloping sides and a flat roof; which is intended to be further covered in with earth. The gun has ample room inside to traverse on a rail through the total deviation of 60 degrees. The gun itself is about 6¾ inches calibre, and takes a charge of about 14½ lbs. of prismatic powder. Its accuracy was very marked, as at a range of 600 yards this gun put seven shots out of twelve within a space of 18 inches square, and the remainder were not much more widely scattered. The penetration of the gun is exceptionally good, as there is no recoil, but a solid resistance by the armour. The vibration and concussion are so little that it can hardly be felt in the casemate, and a coin placed on the gun-metal was not shaken down.

1870 era . . .

A most deadly weapon of warfare

It has been said that facts are stranger than fiction. This has been lately strangely exemplified by the carrying out into practical effect of a sub-marine boat after the very startling description by Jules Verne in his "Twenty thousand leagues under the sea." The author has therein outlined what has generally been considered an impossible conception of a vessel carrying some 20 or 30 individuals which should be able to travel equally as well under water as upon it.

The scientific and mechanical details are well worked out; the atmosphere is carried under water at a pressure and is artificially renewed when required. The lowering or rising of the vessel in the water is effected by the admission or pumping out of the water. All these points have been carried into practical effect by the Rev. G. W. Garret of Manchester. He has built a small vessel 40 feet long and 9 feet beam, of a cigar shape, with a displacement of about 30 tons. In the centre of her upper surface is a conning tower from which the vessel is steered. The engine and propeller it is stated are driven by chemicals, from which also a supply of oxygen is derived to sustain life. The crew consists of three, the engineer, the captain and the owner, who wear helmets into which the oxygen is pumped. She has ventured out on a trip to sea from Liverpool to Portsmouth, but had stopped for a short period at Rhyl to perfect a few matters of some importance to the future comfort of the crew. Should this boat be the success which it so far promises, it will be a most deadly weapon of warfare as a submarine torpedo vessel. It is even difficult now for any ironclad to protect herself against fast sailing torpedo boats, when they attack her openly on the surface of the water. When the attack is made secretly and underneath the surface, we fear that it will be a sorry day for the ironclad, until some new and improved method of defence is introduced against such submarine attack.

A startling idea

Curiously enough, another apparently startling idea, as outlined by Jules Verne in the same volume has we notice been brought lately into practical effect. The author of "Twenty thousand leagues under the sea" has fitted the crew of the submarine vessel with diving apparatus which is represented as independent from any external air supply. This idea is by no means new, as it has been before suggested, but it is only now that the apparatus has been put into practical effect, as may be seen any day at the Polytechnic, Regent Street. A Mr Fleuss there dons a diving dress and helmet, which enables him to descend into the water, and remain there for some hours, without any connection by air tubes to the surface whatever. The increased efficiency offered by such an apparatus must be obvious to all. The great danger and embarrassment to a diver at present is the air tube with which he is supplied by air from the surface. If he should get entangled, or should break the air tube by any chance, his life is at stake. With the new self-contained apparatus, we do not think it is a great stretch of the imagination on the part of Jules Verne, to consider it possible for divers or even unskilled sailors to walk about, at a moderate depth, on the bed of the sea; to go for excursions of miles for the duration of hours entirely unfettered and free to move at will under water. Should this invention accomplish all we have thus indicated, a new and startling era of submarine discovery may begin.

That diabolical weapon

Our naval instincts of defence are still energetically devising fresh means against the diabolical methods of attack and destruction that seem to increase steadily around. The torpedo scare has been the last fright for our unfortunate sailors—sneaking, diabolical machines, that will explode and send a good ship to the bottom without the least warning. A harbour defended by sunken torpedoes has been thought practically impregnable. We find, however, that a trial of a new method of clearing harbours of sunken torpedoes has lately been tried with every promise of success. The apparatus was fixed on the gunboat *Bloodhound*, at Portsmouth, and consists in running out a couple of booms 30 feet in length from the bows of the ship. Across the submerged ends is fixed a horizontal beam 38 feet in length, having a zig-zag arrangement of iron rods in the form of a W. It is expected that the open space of each V as it is pushed through the water, will enclose the torpedo fastenings or connections and lead them to the point at the bottom. The V's are here fitted with a scissor contrivance which is worked by levers in connection with the capstan on board. The beam-searcher has a sweep of 50 feet and the mechanism is capable of cutting through the strongest electric cable. A net which is supported from the whiskers of the bowsprit receives the liberated torpedo, and prevents it exploding against the operating craft. We understand that the trial was a great success, and the plan will be largely adopted. The invention is by a Captain Arthur whilst in command of the "Vernon."

1870 era . . .

Torpedo warfare at Portsmouth

The long expected sham naval battle came off at Portsmouth on the 16th of last month. The event had been postponed on several occasions owing to unsuitability of the weather and other causes, and even on this occasion the gun-fire on shore was only represented by the explosion of detonating charges, owing to the severe illness of a high official in the neighbourhood. The fight took place in the roadstead at Spithead, commanded by the forts Gilkicher and Monckton, and the attacking enemy were supposed to have forced the passage of the Needles, and to be making a night attack on the dockyard.

The enemy were supposed to be obliged to pass through a passage 1800 yards in width. In this passage a channel was necessarily left for the supposed traffic of neutral or merchant vessels, the rest being thickly laid with contact mines or torpedoes, so as to be almost hopeless for passage. It was, however, in the neutral channel that the principal struggle took place.

A heavy boom of 600 yards in length and made of timber, 10 inches square was laid right across the passage, protecting all the wires and connections of the Observation and other torpedoes. The first business of the attacking force was to break this boom. As, however, this boom was situated under a raking fire of artillery and small arms, and was also illuminated by an electric light from the fort on shore, it was a work of much exposure to attempt to attach a bursting charge to this boom. Six launches were detailed for this business, but they were all soon rendered *hors-de-combat* by the fierce artillery and small-arms fire to which they were exposed. One of them, however, towing a small boat, succeeded in attaching a charge of dynamite to the boom, which, on explosion, made a gap sufficiently large for the gun boats to pass through.

It now devolved upon the *Bloodhound*, *Lightning*, and *Vesuvius* to enter the breach in the boom, and to clear away the Observation or other torpedoes within to make a passage for ironclads to follow. The *Bloodhound* was the first to essay, but she was disabled before she could even drop a line of counter-mines. The *Lightning* succeeded in cutting a large number of electric wires, and in dropping some counter-mines, but was disabled before she could explode them, in spite of her high speed and low hull. The *Vesuvius* was a little more successful, as she actually laid a complete line of counter-mines and exploded them, so that she practically cleared a channel of 30 feet in width.

As this, however, was scant room for an ironclad to pass in, it has been decided that the attack did not succeed.

Of course all the torpedoes were more imaginary in their explosion than real to prevent accident. For the full bursting charge of a torpedo is 500 lb. of powder, whilst the charges used were only 2 lb., just to indicate explosion. The whole passed off very successfully, the electric and other lights giving great vivacity to the scene.

They were still *at it* then!

To the Editor of the MARINE ENGINEER.

SIR,—Seeing that you are devoting attention to the position of Marine Engineering, I venture to hope you will do your best to ventilate some of the grievances of the Engineers of her Majesty's Service. The subject of pay which you have been ventilating is, of course, all important; but, at the same time, social position and recognition amongst our fellow officers is as sore a subject with ourselves of the Navy.

It was all very well to bar us as a class from participation in messes, and an equal footing with our brother officers, when the engine power of Her Majesty's ships was but a small consideration, and the ranks of the Engineers were recruited from fitters who did not pretend to education or breeding. But now that a special training is provided in colleges and dockyards, only obtained by competitive examination, the class of Engineers will become what they ought universally to be, and now, I hope, very largely are, men of education and breeding, in every way qualified to rank and take their place as gentlemen. It is rather absurd, too, I think, when everything now-a-days on board our ironclads is worked by machinery, and the safety of the vessel is entirely dependent thereon both for fighting or running away, that our status of Engineer should not rank at least "pari passu" with that of our brother officers in the other branch of the service.

AN ENGINEER OF HER MAJESTY'S SERVICE.

September 1, 1879.

We are deeply indebted to Mr. G. G. Maclennan, editorial director of The Marine Engineer and Naval Architect journal, for allowing us to reproduce these snippets from his archives.

HMS WILTON

The world's first glass reinforced plastic (GRP) warship

Some years before the merger, in 1966, of Vosper and Thornycroft, John I. Thornycroft & Co Ltd, were the lead yard for the construction of the fleet of Coastal minesweepers (CMS), which were given place names ending in -ton. Nearly 100 ships of this class were built, many of them by Thornycroft, who had three covered building berths for their construction. Because of the need to use non-magnetic materials as far as possible, to reduce the risk of the minesweepers setting off magnetic mines, the CMS's were built of wood on an aluminium alloy structural framework.

The CMS's of the *-ton* class are now nearing the end of their useful lives, although a number are still in service with the Royal Navy, Royal Naval Reserve, and overseas navies. For some years the Ministry of Defence has been working on a development programme to establish the best type of construction for their successors, and has been studying the potential of glass-reinforced plastics (grp) for this and other applications. This programme has included the construction of structural test specimens consisting of full-size midship sections spanning two structural bulkheads of ships of the CMS type, and a number of smaller panels. Two test sections have been moulded in glass-reinforced plastics at the Vosper Thornycroft yard at Woolston, one of sandwich construction on a system developed jointly with a plastics company, and one of solid grp laminate. A test specimen in glued laminated timber was also built by Vosper Thornycroft at the Portchester yard. All specimens were extensively tested at the Naval Construction Research Establishment at Dunfermline in Scotland, the tests covering the following main properties:—

- structural strength, including resistance to underwater explosions
- stability, strength retention and durability
- water absorption
- chemical resistance
- effect of high and low temperatures
- ease of repair

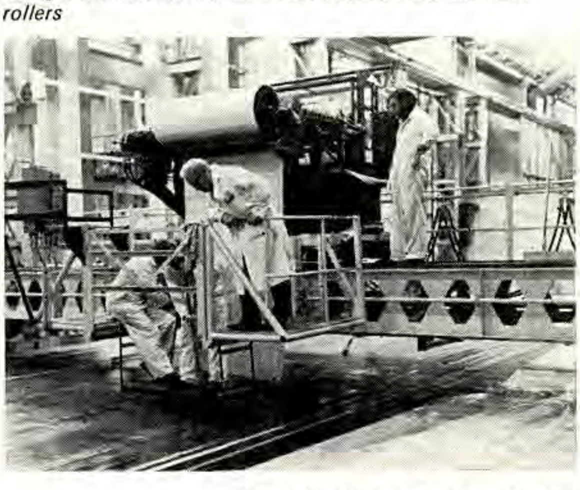
Artist's impression of HMS 'Wilton'

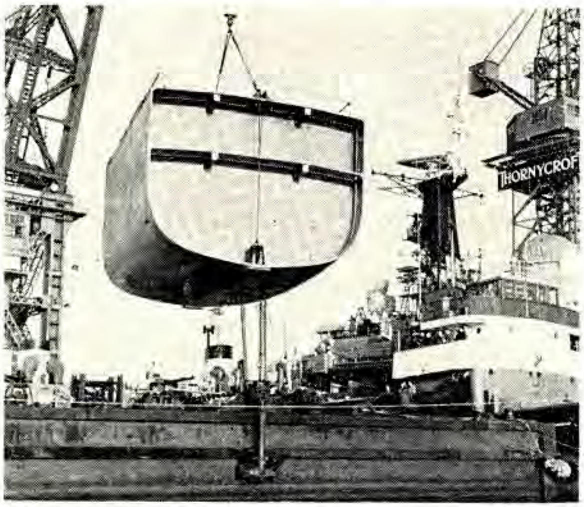
- thermal insulation
- fire resistance
- fatigue and creep resistance.

This programme formed a continuation of a long-term study by the Ministry of Defence (Navy) of the seagoing applications of grp. Many of the boats in naval service are now moulded in plastics as a matter of course, and for larger vessels, including submarines, a number of moulded assemblies have been used and thoroughly tried. The mine-hunter HMS *Wilton* is, however, the first complete ship to be built in grp.

As a result of these tests, the solid laminate grp structure was chosen as the best for further study, and a

Vosper Thornycroft dispensing machine laying impregnated woven rovings for a deck panel which is being consolidated by laminators using long-handled rollers





The first glass-reinforced plastics structural test section to be made by Vosper Thornycroft for the Ministry of Defence being shipped for transport to the Naval Construction Research Establishment in January 1967

The second glass-reinforced plastics structural test specimen completed in November 1968. The form of construction seen here is basically that which has been chosen for the complete mine-hunter prototype

full-size CMS, as similar in design to the earlier *-ton* class as possible, but in the new material, was ordered by the Ministry of Defence (Navy) from Vosper Thornycroft Limited in February 1970. The design had already been carried out under a contract placed late in 1968.

The material and its properties

Glass-reinforced plastics (grp) is a general term covering synthetic resins reinforced with fine-drawn glass fibre. The material is often loosely called "fibreglass". For the structure of HMS *Wilton* exhaustive tests have been used to determine the best combination of materials, and to establish the properties of the resulting laminates under a wide variety of conditions. The final choice has been a specially formulated isophthalic polyester resin, with a high heat distortion temperature, low water absorption, and good delayed lay-up characteristics, reinforced mainly by 24 oz/yard^2 glass woven roving having a high-grade silane finish. The materials have been supplied by BP Chemicals International Limited, Devonshire House, Piccadilly, London, W1X 6AY, and Fothergill & Harvey Limited, Littleborough, Lancs, respectively.

The BP Chemicals Cellobond resin used is a non-pigmented isophthalic-based one specially formulated for this application by scientists at the BP Chemicals laboratories at Barry, South Wales. A similar resin has been successfully used over the last few years in the construction of the casing and fins of *Oberon* class submarines.

The main reinforcement used in the grp hull structure was Tyglas Y920 woven roving, made by Fothergill & Harvey Limited and produced from Owens-Corning Fibreglass Araton-sized roving. The carefully controlled weave texture facilitates resin application in production by ensuring good "wetting-out" characteristics. The Tyglas Y920 material is available in the long lengths needed for mechanised application, and has good drape characteristics, so that it conforms to hull curvature without distortion or wrinkling. It is manufactured in quantity to a consistent, fault-free quality.

The exhaustive testing has established reliable values for mechanical and other properties of the type of grp developed for this project (see Table II). Testing of weathered specimens and specimens pre-loaded and immersed in seawater and distilled water at pressures ranging from 250 to 1,000 lb/in^2 showed negligible loss of strength in tension, compression and bending.

All resins begin to become weaker above a certain temperature, which will affect the properties of the composite, but the resin chosen in this case retains its strength at temperatures reached even under extreme tropical conditions. At low ambient temperatures, as in Arctic conditions, the strength properties of polyester resins tend to improve, and there is no embrittlement as there is with some steels.

Doubts have been expressed in the past about the strength of repairs in polyester laminates but with the materials developed for this project and proper preparation repairs using the same resin and glass as for the original moulding have been found to give strengths of more than 90% of that of the parent material.

Plastics have generally good thermal insulation properties, and in the case of HMS *Wilton*'s hull insulation values are nearly as good as for wood. This is important because of the need to keep an even temperature in accommodation and working spaces and of the effects of condensation which forms on cold surfaces inside a ship. This can be a serious problem in metal ships, which normally have to be fully insulated in accommodation and working spaces. Some linings are in fact being fitted in HMS *Wilton* to improve still further both thermal and acoustic insulation.

Some grp small boats have been badly damaged by fire, and fire resistance is naturally a matter of great concern to seamen, especially in warships. Tests have proved that with composites reinforced by woven rovings and of the thickness used in this project the surface layer of glass cloth provides a barrier which greatly reduces the rate of propagation of fire. The load-bearing characteristics of this type of material under fire conditions were in fact found to be better than those of aluminium alloy.

Fatigue tests on specimens in water indicated that the material exhibited a fatigue limit at about 25% of the ultimate tensile strength (uts)—this means that the composite retains at least a quarter of its strength for an indefinite life, under the alternating type of loading, in contrast to some other materials which under these conditions will ultimately fail at very low stresses. Fatigue properties for notched and un-notched specimens were similar, indicating that the propagation of cracks in the material would be slow, if it took place at all.

In this property of toughness grp is superior to both mild steel and aluminium alloy, and its superiority derives from its laminar structure. Any crack, if it is to propagate, must cross alternate strong and weak layers of glass and resin respectively, and in practice separation of the weak layer from the strong layer in the tension field ahead of the crack tip provides a series of crack stoppers which effectively halt or divert the crack.

In common with all types of grp the composite developed for this project is less stiff than traditional materials (tensile modulus is about one thirteenth that of steel and a quarter of that of aluminium). This is offset to some extent by the fact that the material can be used in greater thicknesses because it is much lighter than steel or aluminium, but grp structures are more flexible than conventional ones of the same strength. This poses certain problems in compressive loading and in the attachment and alignment of machinery and equipment, for example, but proper design caters for these cases. The inherent flexibility of grp gives it great resilience and resistance to shock loading—where metal would dent grp springs back.

The remaining structural property of importance is resistance to creep—that is to sustained deflexion or dimensional change under steady load. A creep limit of 40% UTS was established for this type of grp which means that for those parts of the structure subject to alternating loads, which is to say most of a ship's

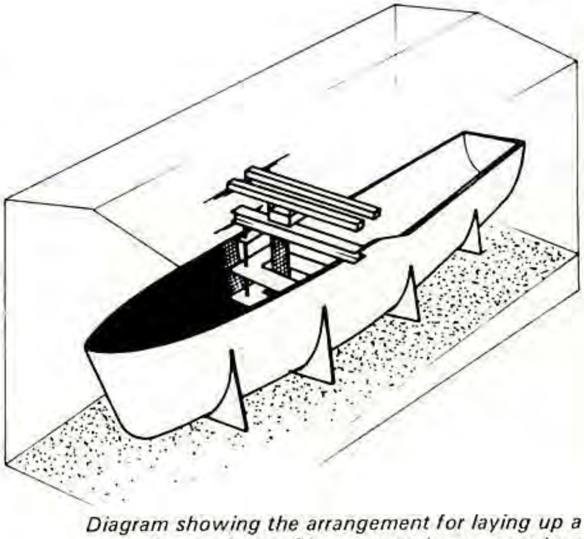
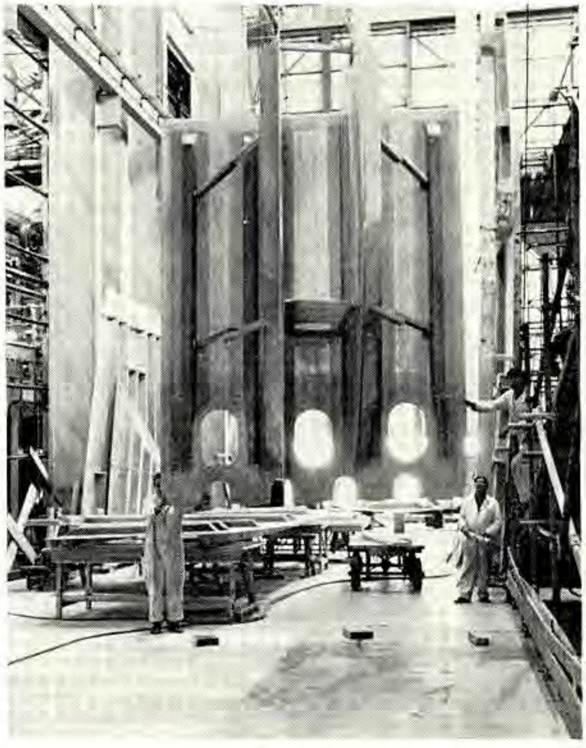


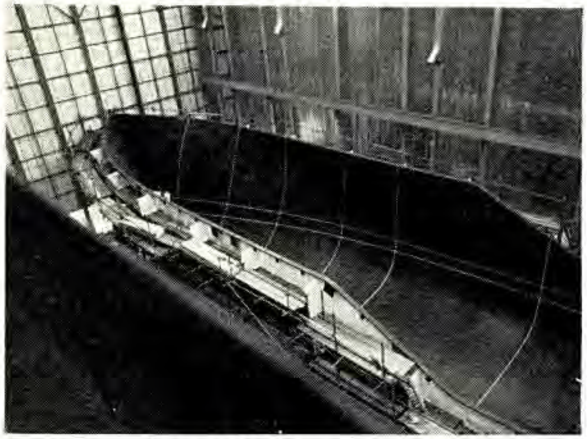
Diagram showing the arrangement for laying up a continuous layer of impregnated woven rovings transversely in the hull mould

structure, fatigue is the limiting case and if it is strong enough to prevent fatigue failure it will not fail due to creep.

The composite has excellent chemical resistance to

A sub assembly of bulkhead panels ready for positioning in the hull





The hull mould for HMS 'Wilton' in the main hull shop. The external framing and the aperture for the separate forefoot moulding can be seen. White lines on the black mould surface show through the translucent laminate and help to locate reinforcement cloths. They make plain the fairness of the mould

many substances and is unaffected by oils and fuels so that integral fuel tanks are used. Fresh water tanks are also integral.

For a project of this scale it was essential to establish values for all these specific properties, and check that they could be maintained for the full-scale ship. In doing this a number of areas of doubt about grp and its suitability as a shipbuilding material have been swept away, and precise specifications for the most suitable types of material established. In general the outstanding advantages of grp are that it is light, needs little maintenance because of its resistance to corrosion and marine borers, and, for mine countermeasures vessels, that it is non-magnetic.

Strength comparisons between different materials are

Table II

Mechanical properties of grp laminate used in HMS *Wilton* based on tests and used as the basis for design calculations.

Ultimate tensile stress (U.T.S.)	227 N/mm²	33,000 lb/in²
Tensile modulus (Young's modulus)	15.5×10^3 N/mm²	2.25×10^6 lb/in²
Flexural strength	206 N/mm²	33,000 lb/in²
Flexural modulus	13.7×10^3 N/mm²	2×10^6 lb/in²
Compressive strength	185 N/mm²	27,000 lb/in²
Compressive modulus	13.7×10^3 N/mm²	2×10^6 lb/in²
Shear strength	110 N/mm²	16,000 lb/in²
Shear modulus	3.43×10^3 N/mm²	0.5×10^6 lb/in²
Interlaminar shear strength	13.7 N/mm²	2,000 lb/in²

Note: these design values are conservative and the UTS value is lower than the experimental figure given in Table III.

Table III

Comparison of tensile strength of the type of grp laminate used in HMS *Wilton* with other materials.

Material	Specific gravity	Tensile strength (U.T.S.)		Specific strength (U.T.S./specific gravity)	
		N/mm²	lb/in²	N/mm²	lb/in²
Polyester/chopped[1] strand mat g.r.p.	1.4	103	15,000	73.6	10,700
Polyester/woven[2] roving g.r.p.	1.6	276	40,000	172	25,000
Polyester/woven cloth g.r.p.	1.7	345	50,000	203	29,500
Mild steel	7.8	434 (241 yield)	63,000 (35,000 yield)	55.6 30.9	8,080 4,49p
Aluminium alloy N8	2.7	276	40,000	102	14,800
Pine (along grain)	0.5	76	11,000	152	22,000
Pine (across grain)		6	500	12	1,000

1 This is the type of grp commonly used commercially in small craft construction.

2 As used for HMS *Wilton*.

always complicated because they depend on many factors, notably the type of loading the structure has to withstand and the importance of weight. Engineers and naval architects always prefer light materials if they are strong enough and not too costly. The simplest comparisons are based on the tensile strength—the load at which a rod of given thickness will break when pulled along its length. Some figures of tensile strength for different materials are given in Table III, together with their specific gravities and specific strengths. This last quantity compares the strengths for specimens of equal weight rather than equal thickness (cross-sectional area).

From these figures it can be seen that polyester resin reinforced with woven rovings, the type of grp used in HMS *Wilton*, is an excellent structural material in its own right, being as strong in tension as aluminium alloy but only 60% of its weight. Compared with mild steel, the main ship-building material, it has 64% of the tensile strength but is only about one fifth of the weight.

The relative strengths of grp and other materials are in practice somewhat modified by the fact that, as in any laminate, the bond between layers is less strong than is the material taken as a whole, but this is allowed for in design and the grp structure of HMS *Wilton* is for example, a great deal stronger than could be achieved in steel without prohibitive weight.

Structure

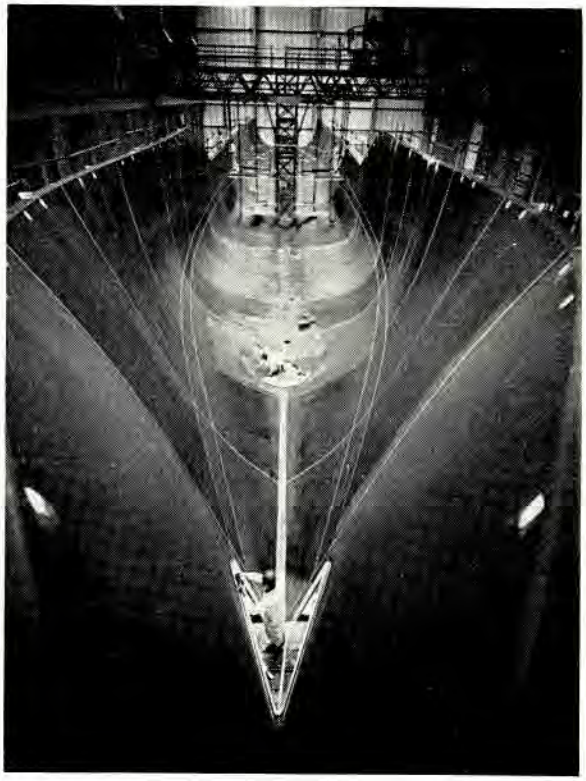
The structural scheme chosen for HMS *Wilton* consists of a single skin of grp laminate, in general about 32mm (1¼in) thick, with transverse framing, bulkheads and deck panels bonded in. Some longitudinal stiffeners, including engine bearers, are also worked in, but these are kept to a minimum because the laminating of their intersections with transverse frames is a complex and time-consuming task. Transverse framing was also the scheme for the wood and aluminium CMS's. The overall scheme was selected as giving the greatest resistance to the shock loads imposed when an underwater explosion takes place near the hull.

Frames are constructed by placing formers cut from blocks of rigid polyurethane foam in position and laying up laminate over them to give a "top hat" section. The flanges are tapered off where they are bonded to the hull shell to avoid abrupt changes in section. Although this type of subsequent bonding to grp laminate is entirely satisfactory for all normal structural purposes, including shipbuilding, the stresses resulting from underwater explosions can, for complex reasons, bring about failure of the flange-to-shell bond in direct tension. For this reason these joints are, in the case of HMS *Wilton*, being reinforced by through-bolts of a special bronze. Below the waterline, where the shell is thicker, the bolt heads are countersunk to give a flush finish which will not disturb the water flow and add resistance. In the thinner topsides countersinking is not possible and raised-head bolts have been used; these are visible on the finished hull.

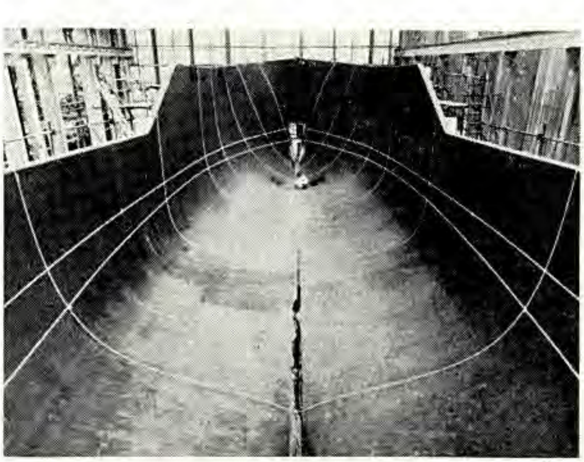
Bulkheads, lower deck panels and partitions are bonded into the structure in much the same way as frames, with reinforcing knees at junctions. The whole of the structure, including fuel and water tanks, sonar housing, and many small partitions and sub-assemblies are of grp laminate bonded in.

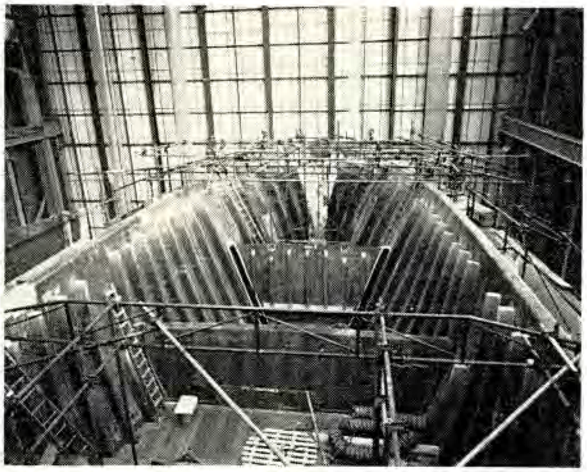
Design

Because HMS *Wilton* is a prototype to assess the suitability of a material and method of construction which are quite new in ships of this size, the design of the vessel, her hull form, internal structure and upperworks, together with her machinery and equipment, has been based as closely as possible on that of the existing *-ton* class CMS's. As the performance and structural characteristics of these ships are well known, the use of the same design for the grp ship will make it possible to assess accurately the performance of the material, and to reduce to a minimum the number of variables involved in making comparisons with the earlier vessels. It is not, however, intended that any later class of mine countermeasures vessels which may be built for the Royal Navy will be sisters to HMS *Wilton*; a completely new design is envisaged. The design values of malinate



These two illustrations show the hull mould which is of fabricated steel, built by normal shipbuilding methods, but faired and finished to an unusually high standard. The matt black surface is a polyurethane finish, which is coated with release agent before the laminate is laid up. The white lines define areas of different laminate thickness, or are for location of bulkhead and deck panels. The narrow forefoot is being moulded separately, which accounts for the gap at the far end of the mould in the lower illustration





Hull structure nearing completion, with decks still to be fitted

Principal dimensions and details of HMS Wilton

Length overall	46m	(153ft)
Beam	8.5m	(28ft)
Depth to upper deck	4.5m	(15ft)
Displacement (full load)	453 tonnes	450 tons
Engines	twin English Electric Deltic 18 diesel engines of 1,500bhp each	
Maximum speed	16 knots	

(These dimensions are as for coastal minesweepers of the *-ton* class.)

mechanical properties were established by exhaustive testing.

Most of the equipment, including main engines, to be fitted in HMS *Wilton*, was originally fitted in HMS *Derriton*, and is being reconditioned by Vosper Thornycroft as part of the Ministry of Defence contract before installation.

Manufacturing facilities and organisation

The construction of a grp ship calls for methods of working which are entirely different from those of traditional shipbuilding in steel or wood. The great increase in size over earlier grp craft, which were boats of a maximum length of about 80-90 feet, also meant that many new problems arose.

Deck panel with beams, longitudinals and knees. The laminate has not yet been laid up over the foam block cores for the two inboard longitudinals

Because with grp the basic structural material is being created as part of the moulding process, as distinct from normal shipbuilding where plates or planks of material bought to established specifications are assembled, great emphasis has to be placed on quality control. For grp to develop its full potential the moulding has to be carried out in controlled, warm, dry conditions. With the quantities of materials needed for a ship of this size pecial handling facilities were needed, and careful attention to ventilation and fire precautions was essential.

As a first step a special group of buildings was erected at the Vosper Thornycroft Woolston shipyard. These incorporated some of the facilities set up for test section manufacture, and are in fact on the site of the covered berths on which the Thornycroft CMS's of the *-ton* class were built. This group consists of a main hull shop 55m x 23m x 25m high (180ft x 75ft x 82ft), a panel shop 55m x 13m x 12m high (180ft x 43ft x 39ft), and a cutting bay 22m x 13m x 10m high (72ft x 43ft x 33ft). The new buildings have been carefully detailed to eliminate ledges which would hold dust and the concrete floors are painted to prevent dirt from rising. A comprehensive heating and ventilating system, with thermostatic control, is installed. An amenity block adjoins the shops, through which everyone must pass when entering or leaving. This has washing facilities and a "break" room.

Fire precautions take account of the highly flammable nature of the liquid resin before it cures in the solid laminate. Flameproof electrical equipment is fitted throughout the production areas, and only cleaning fluids having a high flash point are used. Smoking is banned. Fire doors are fitted every 15m (49ft) round the walls, and fire detectors in the roof are linked directly to the local municipal fire station.

The special buildings, costing approximately £¼ million, have been designed by the company's own construction department.

The main hull mould is built in steel by normal shipbuilding methods, but in sections bolted together with the framing outside. To ensure maximum fairness plating rather heavier than for a ship's hull of this size was used, and assembly was by huckbolting, a form of riveting, to avoid the distortion which welding tends to cause. Dimensional tolerances were ±3mm (⅛in) and a high degree of fairness was attained.

Because the mould could be made fairer than is possible for a normal welded ship structure the grp hull is smoother than a steel ship's would be, and this reduces resistance, making possible a little more speed with the same power.

Most of the decking complete, together with the break-of-forecastle moulding

A separate moulding was made for the forefoot, the narrow, lowest part of the stem, which was bonded and bolted on to the main hull moulding afterwards. This helped to ensure good access for laminating within the rather confined space of the forefoot, and the corresponding opening in the main mould also helped with ventilation and sweeping out during construction.

When the hull was complete the mould was removed in sections, the weight being transferred to shores and the ways from which the ship is to be launched in the normal way. A large door at the end of the main hull shop opens to allow this. Because the CMS design has a higher freeboard and superstructure forward than aft and the ship has to be built on a slope so that she will slide into the water down the ways, she is to be launched bows first. This means the roof of the building can be horizontal and no higher than necessary, while still providing working clearance over the hull.

Apart from the main hull the mouldings making up the structure are mainly either flat bulkheads or deck panels with camber and sheer. These are moulded in the panel shop where there are two mould surfaces, one with camber and one flat, both of which can be sprung to a suitable curvature to produce sheer in the decks. These are made of plywood and surfaced with melamine laminate. The cutting bay is used for trimming the edges of panels before they are bonded into the hull.

Because of the large quantities of materials used (about 100 tons of glass reinforcement and a somewhat greater quantity of resin), the need to complete the main lay-up as a continuous process, and the importance of quality control, steps were taken to mechanise the lay-up as far as possible. Resin and woven glass dispensers were designed and manufactured by Vosper Thornycroft which blended the resin constituents in their correct proportions and impregnated the cloth with them to a 50/50 resin/glass ratio by weight before feeding the material down into the mould. These dispensers were mounted on gantries to traverse the moulds. Manual work at this stage was confined to consolidating the laminate with rollers. Platforms suspended from the gantries provided access for the laminators doing this work. In the case of the main hull moulding the pre-impregnated cloth was laid in continuous lengths athwartships. The working platforms for the main mould were adjusted to conform to the changing shape of the hull as work proceeded along its length. There was limitation of gantry movement into the narrower part of the hull.

The dispensers used for this prototype ship proved very satisfactory although they were themselves of a prototype nature. It was found, however, that the more complex moulding tasks, such as the laying-up of frames, beams, longitudinals, and their inter-sections, were not entirely practical with these dispensers and much of this work had to be done by hand. Developments are envisaged in the design of dispensers to make them more suitable for this type of work.

Quality control is vital to the whole of this project, because only by strict quality assurance can it be established that the basic material of the structure will attain the properties determined in tests and used as the basis for design. Part of quality control is the design of the building to make it easy to keep clean, since dirt inclusions in the laminate can be points of weakness. A squad of cleaners is kept at work all the time.

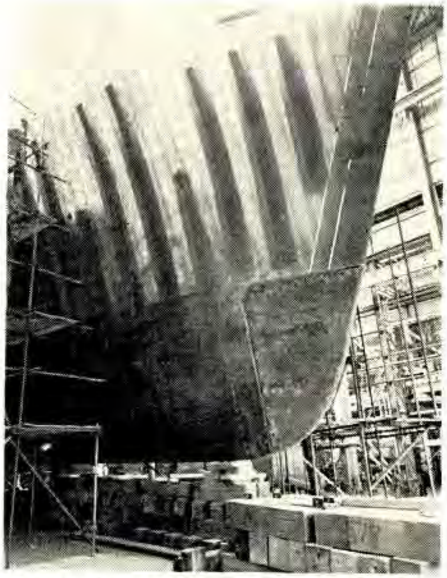
The use of dispensers which control resin/glass ratio is also a quality control measure, since it reduces dependence on the operator. Checks are made on resin and glass at the "goods inwards" stage, and samples of mixed resin checked. The lay-up of each lamination of cloth is inspected and logged, and pieces of finished laminate subjected to mechanical testing. Inspection is made easier by the use of clear, unpigmented, resin, so that the finished laminate is translucent and any flaws can be seen. Pigments can also have harmful effects on laminate properties.

Another key element in the success of the grp minehunter project was the selection and training of staff. Some of the traditional skills of the shipwright were needed, particularly lining off, sighting and setting up (that is, broadly, the techniques whereby the parts of the complex three-dimensional structure of a ship are erected in proper relationship to one another according to the drawings), and it was decided to train shipwrights and other tradesmen as laminators. There were also a substantial proportion of semi-skilled men trained. It was found, in most cases, preferable to train people specially to the standard necessary rather than to employ laminators with experience only of normal commercial boatbuilding work.

Laminators were trained by setting them to work on test pieces, each of which was inspected visually for voids and general neatness. Pieces which passed visual inspection were given laboratory tests for resin/glass ratio and mechanical properties. The man was only allowed to start on production laminating when his work was regularly achieving specified standards in these tests. About 70 men were employed on actual moulding work.

Much more detailed planning was needed than for a conventional ship of this size because of the time limits imposed by the materials. Once the constituents of the resin are mixed there is a limited time for placing and consolidating the lamination. The resin was chosen so that there was a reasonably slow, but thorough, cure, to help with this problem. The other time factor arises from the fact that as the longer the resin in a lamination cures the less good is the bond of the next lamination to it, unless the surface is laboriously abraded before another layer is applied. On a production basis, therefore, the successive laminations need to be placed within a limited time. For the main hull moulding of HMS *Wilton* work was carried out progressively from stern to bow, with the skin laminate built up so that it reached its full thickness next to the transom (a separate moulding bonded on subsequently) first, and tapered off forwards over the number of layers so that none was too fully cured when the next was applied. The overall planning and execution of the project has proceeded very smoothly, particularly for an experimental prototype project of this kind.

The assembly of decks and beams into the hull, with laminated knees connecting beams to frames, was carried out towards the end of the programme, followed finally by the superstructure and bridge. All structural grp work was completed and the fittings of linings, some equipment and machinery, and painting, were completed before launching so that they could be carried out under cover in controlled conditions.

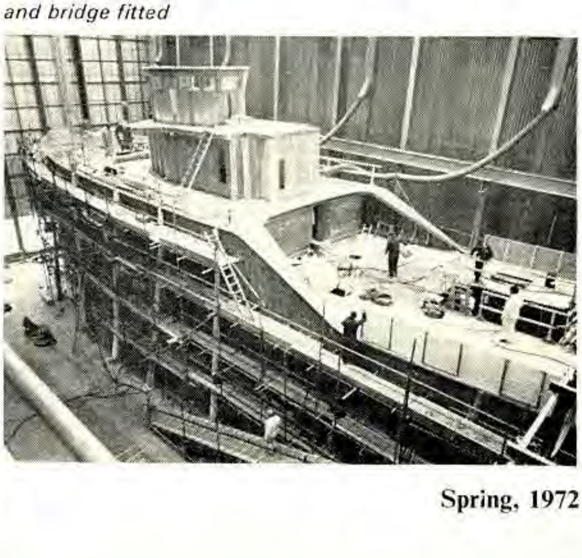


Forefoot in position and being fastened

The future for large grp ships

The non-magnetic properties of grp were the deciding factor in the selection of the material for HMS *Wilton*. It is not at present the most economical material for ships of this size, although the trend is in its favour because the cost of its constituents has been stable for some years while the cost of steel has risen rapidly with inflation. As labour costs for maintenance rise grp's

HMS 'Wilton' nears completion, with superstructure and bridge fitted



modest maintenance requirements will give it an increasing advantage compared with other materials.

For the present the application of grp to ships would seem to be mainly in certain specialised classes of vessel where its properties bring particular advantages. Examples are vessels to carry very cold cargoes, such as liquefied gases, which are liable to cause embrittlement of steel, and for aggressive chemicals which attack steel.

The saving in maintenance cost with grp can be very considerable. Experience with smaller work boats and pleasure craft has shown that upkeep of grp craft can cost as little as one fifth of that for wood or steel, a extrapolating this to the case of a light warship Vosper Thornycroft calculate that this could mean saving the whole cost of a new hull in 15 years. Reduced maintenance means less time spent in port, which fits in well with the trend to repair by replacement, that is replacing items like engines with reconditioned or new ones instead of repairing them *in situ*.

On a through-costed basis grp construction is already within reach of being competitive with conventional shipbuilding methods, even if mould costs are only spread over a fairly small number of vessels. Vosper Thornycroft are actively pursuing ways of applying the lessons learnt in the construction of HMS *Wilton*. Particular areas of study include the refinement of mechanised lay-up techniques, the development of the structural techniques best suited to economical production in grp, and the refinement of building methods. In each case the aim is to tip the competitive balance in favour of grp.

Improved techniques will reduce labour costs and the material costs are stable. By designing structures which can accommodate the material's flexibility, without overdesign or loss of strength, economies can be made, and sandwich construction is one way of doing this. A preliminary study by Vosper Thornycroft suggests that a 140-ft light warship employing an improved type of grp sandwich construction could be an economic proposition.

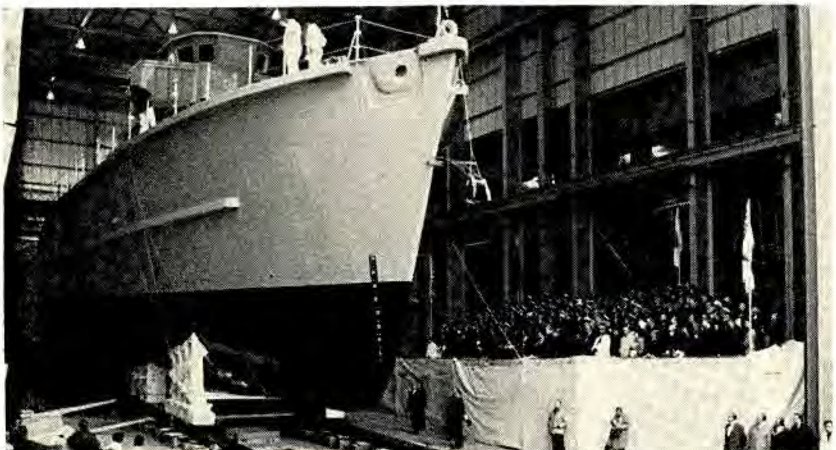
There does not seem to be any limit to the size of grp ships which are technically feasible, although it is likely that its use will extend by modest steps in size. The Vosper Thornycroft grp production facilities have been designed so that they can easily be extended to accommodate larger ships than HMS *Wilton*.

Glass-reinforced plastics is a seaman's material: the combination of strength, low maintenance needs, insulation and other properties make it particularly suitable for use at sea. HMS *Wilton* will provide the evidence and information on which its further application to ships can proceed.

Future mine countermeasures ships

HMS *Wilton* is a purely experimental prototype and not the first of a new class for the Royal Navy. Rather is she as close a sister of the earlier CMS's as could be built in grp. It is known, however, that the Ministry of Defence (Navy) had a requirement for a new design of mine countermeasures vessel (MCMV) to replace the ageing CMS's. No doubt the precise form that these will take, particularly in terms of materials and construction, will depend on the results of trials and operational experience with HMS *Wilton*.

As a prototype, HMS *Wilton* has probably cost more than a ship of similar size in wood or composite construction, because the basic materials are more costly and because of the special facilities, planning and quality control needed, but she should cost a great deal less to maintain. On a through-costed basis for the full life span of a ship of this type the grp vessel should prove more economical—exactly how much more is one of the things HMS *Wilton* was built to find out.



HMS 'Wilton' being launched bows-first from the enclosed shed in which she was built at the Woolston, Southampton, shipyard of Vosper Thornycroft Limited

'SEA KING'

A completely self-contained tactical unit capable of detecting, classifying and destroying advanced type submarines in all-weather operations

The Westland Sea King is an advanced twin engine helicopter, primarily intended for operations in the anti-submarine search and strike role but with the capability of operations in a number of secondary roles including Search and Rescue, Casualty Evacuation, Tactical Troop Transport and Cargo carrying.

Capable of operating by day or night from either ship or shore, in all weather conditions, the Sea King in its primary role is fitted with an integrated sonar and search radar weapons system and an automatic flight control system.

The main armament consists of four Mk. 44 torpedoes carried externally. The power plant for this versatile helicopter comprises two Rolls-Royce Gnome H.1400 gas turbine engines of 1,500shp each, with full power automatically available from individual engines in the event of a single engine failure.

To facilitate storage at sea, the aircraft is fitted with an automatic powered folding system for its five bladed main rotor together with a folding tail unit.

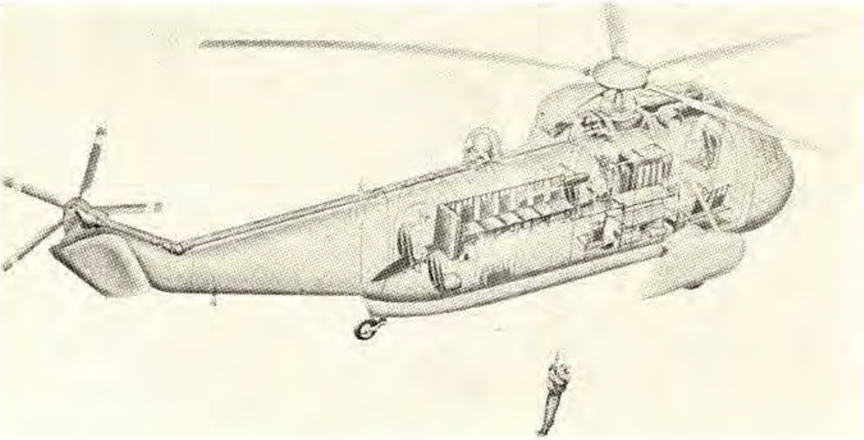
To meet a growing demand Westland Helicopters have also developed a special version of the Sea King for operations in the primary role of Search and Rescue duties. Its main cabin may be fitted with either seats or stretchers, or various combinations of both, depending entirely on the operators requirements. A highly developed rescue hoist with a 600lb load capacity and a large cabin door on the starboard side of the aircraft ensures easy and quick loading of survivors.

ASW

With its integrated airborne search radar and tactical display, medium range sonar, fully automatic flight control system and a variety of weapon loads, the Sea King is a completely self-contained tactical unit capable of detecting, classifying and destroying advanced type submarines in all-weather operations.

Basically intended for operation on cruisers and aircraft carriers in this role, the Sea King has an endurance of approximately four hours which gives it a "time-on-station" far in excess of machines currently in service. During such operations it carries a crew of four; two pilots, a sonar operator and an A.S. control officer, or observer as he is sometimes referred to. Its armament

Fitted with an integrated sonar and research radar weapon system and an automatic flight control system, the 'Sea King' is capable of operation by day or night and from either ship or shore in all weather conditions



'Sea King' fitted-out for search and rescue

consists of four Mk. 44 torpedoes or a similar number of depth charges.

Search and Rescue

To meet a growing demand for an effective long range search and rescue vehicle, Westland Helicopters have developed a special version of the Sea King helicopter for this particular type of operation. The main cabin can be fitted with either seats or stretchers or a combination of both, according to requirements and will accommodate up to a maximum of 18 passengers. If the Search Radar display equipment is removed this number is increased to 22 and this is over an area radius of 250 nautical miles which can be increased by the installation of externally mounted fuel tanks.

In many rescue operations an aircraft must carry both seated and stretcher casualties and the main cabin of Sea King has been designed to provide maximum flexibility of interior layout.

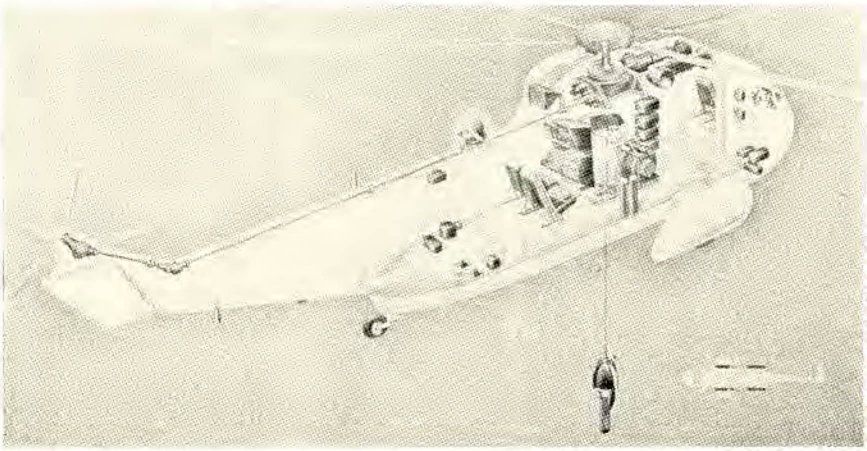
Other roles

In addition to its primary role of ASW and the search and rescue capability, the Sea King is easily adaptable for operations in a number of secondary roles which include, tactical troop transport, cargo carrying, mine counter measure and casualty evacuation.

The machine is of conventional layout with a single, five-bladed main rotor system and a five-bladed tail rotor. Its two engines are mounted fore and aft beside each other on top of the fuselage and drive a common gear box from which two power off-takes drive the rotor systems. The Sea King has a boat type hull and outrigger sponsons into which wheeled oleos retract. It could, in case of emergency, use its ability to land and take-off from the water.

Fuel is carried in bag tanks situated in under-floor compartments which have a total capacity for 704 gallons (5,600lb) in ASW role and 800 gallons (6,400lb) in the Search and Rescue role.

In its primary role the ASW systems in the Sea King include the Autopilot, Doppler navigation and search



'Sea King' fitted-out for anti-submarine warfare

Performance Details

	A.S.W.	S.A.R.
Maximum Speed	124 kts (230 km/hr)	124 kts (230 km/hr)
Maximum Cruise Speed	114 kts (210 km/hr)	114 kts (210 km/hr)
Maximum Endurance Speed	75 kts (130 km/hr)	75 kts (130 km/hr)
Vertical rate of climb	180 ft/min (0.91 m/s)	180 ft/min (0.91 m/s)
Best rate of climb	1770 ft/min (9 m/s)	1770 ft/min (9 m/s)
Service Ceiling	10,000 ft (3,048 m)	10,000 ft (3,048 m)
Maximum range (with reserves)	550 n.m. (1,010 km)	646 n.m. (1,160 km)
Endurance (A.S.W. on station 50% hover 50% cruise)	3½ hours	—
(Search and Rescue)		Over 6 hours

radar facilities. The modular automatic flight control system incorporates an automatic transition facility, which, on selection of a switch, flies the helicopter from forward flight into a hover condition for sonar operations. On completion, the helicopter is automatically transferred from the hover to forward flight in preparation for further operations. The search radar equipment gives in addition to the position of other operating helicopters, under-water plots and Azimuth data on surface craft in the vicinity. All this information is shown on a tactical display unit situated at the observers station. It offers all the data required by the observer to prepare for an attack or, alternatively, to assisting in co-ordinating the attack with other craft.

For loading cargo and when carrying out operations in the search and rescue role, a sliding door on the starboard side of the fuselage gives a large access opening. A 600lb capacity rescue hoist is situated just above the door of this opening.

Accessibility and ease of maintenance is of prime consideration on any aircraft and this is no exception in the case of the Sea King. Steps, handholds and walkways have been incorporated in important areas in order to facilitate maintenance, and in addition both the engine and the transmission cowlings fold down to provide working platforms.

The electronics compartment beneath the cockpit is easily accessible through a large watertight door.

Three jacking spigots are situated, one under the root end of each stub wing and one under the rear fuselage, forward of the tail wheel fork. There is an additional jacking spigot under each main wheel assembly.

To facilitate engine change, quick disconnect couplings are used on fuel and oil pipes and electric connections. An engine lifting hoist is available which can be attached to the engine bulkhead to lift and lower the engines from the mounting platform.

A self lubricating system on the rotor head significantly reduces servicing time.

Each main rotor blade, which is individually tracked and balanced, incorporates B.I.M. (Blade Inspection Method), a system which gives early indication of incipient failure.

Maintenance School

The Company's specially-equipped Helicopter Maintenance School is staffed by a team of qualified instructors who are under the supervision of the Chief Instructor.

Each training programme is carefully planned to suit individual requirements and pupils can be sure of personal attention at all times.

Visual training aids, including, the latest instructional film-strip techniques, are widely used and the workshops are equipped with airframe, flight control and engine installations for practical demonstrations of maintenance techniques.

Dimensions (All versions)

Overall length (rotors turning)	72ft 8in (22.1m)
Overall length (rotors folded)	47ft 3in (14.4m)
Overall height (rotors turning)	16ft 10in (5.1m)
Overall height (rotors spread and stationary)	15ft 11in (4.8m)
Overall width (rotors spread)	62ft 0in (18.0m)
Overall width (rotors and tail folded)	16ft 4in (5.0m)

Weights

	ASW machine	Search & Rescue machine
Basic Aircraft	13,036lb (5914.6kg)	11,603lb (5263kg)
Equipped weight less fuel	15,816lb (7176.1kg)	13,289lb (6028kg)
Maximum Take-off full fuel	20,500lb (9299kg)	20,500lb (9299kg)

Crossley–Premier engines ordered for RFA

Crossley-Premier Engines Ltd are to supply two 16PC2V engines of 8,000bhp for each of two Fleet tankers ordered by the Ministry of Defence (Navy) for the Royal Fleet Auxiliary from Swan Hunter Shipbuilder's Hebburn yard. The ships will be similar to the three *Rovers* built at Hebburn from 1969-1971 and the engines will be the first of SEMT-Pielstick design to be fitted in ships associated with the Royal Navy.

A self-plotting radar

The Predictor, from Marconi International Marine Co Ltd, is an advanced radar using electronic storage to give fully automatic plotting of all targets visible on the screen, including, when desired, the prediction of the effects of a proposed alteration by one's own ship.

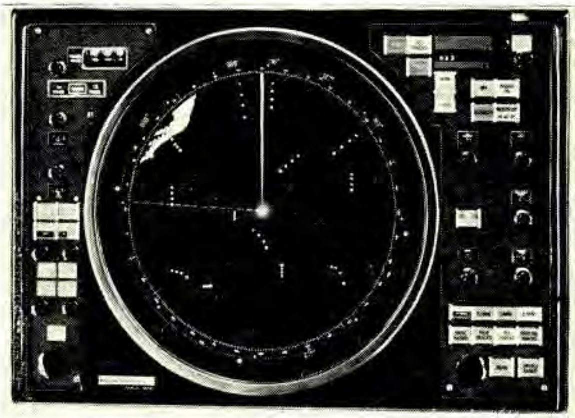
There are four alternative modes of display; basic, true tracks, relative tracks and predicted relative tracks; selected by illuminated push-buttons and built up within 10 seconds. In all modes, the ship's position remains central, due to compensation according to a ship's log or a manually set artificial log.

The basic radar mode shows the present position, as a conventional compass-stabilised relative motion radar picture. The present position, course and speed of every target may be graphically displayed in true motion, relative motion or predicted relative motion, as required. The displayed tracks are made up of four plots covering the last 6, 3 or 1½ minutes, as desired, which are printed sequentially with the last plot being the NOW position. Each complete radar picture is electronically stored on a magnetic tape loop and all plots are updated on the screen every 10 seconds.

The course of a target is given by the direction of the line through the four plots, while the distance between the plots gives the speed of the target.

The switch from true tracks display to a relative motion display is achieved by switching off the astern shifts, which offset own ship's motion. Since the NOW picture has no astern shift, the tracks of each target appear to swing around the NOW position. This gives a pictorial display of the triangle of velocities.

In the predicted relative tracks mode, a contemplated new course and/or speed of one's own ship is superimposed to test the effect of a proposed alteration. The new course and speed is chosen by control knobs, and within 10 seconds of pressing the "Predicted Relative Tracks" button, the relative motion plot of the scene is shown—as if own ship had reached the NOW position. An electronic bearing marker indicates the proposed heading of the PPI, while the heading marker continues to show the present course. A ring is superimposed around the ship's position to indicate the amount of overshoot corresponding to a turning radius of three cables. Tide corrections may be fed in, in the form of tide speed and direction. By issuing the predicted relative tracks mode, collision situations may be avoided before manoeuvring. The predicted plot may be held during the course correction, as it will be updated every 10 seconds. The electronic bearing marker will continue to indicate the proposed course. Once the ship has steadied on the new course, the bearing and heading markers will coincide.

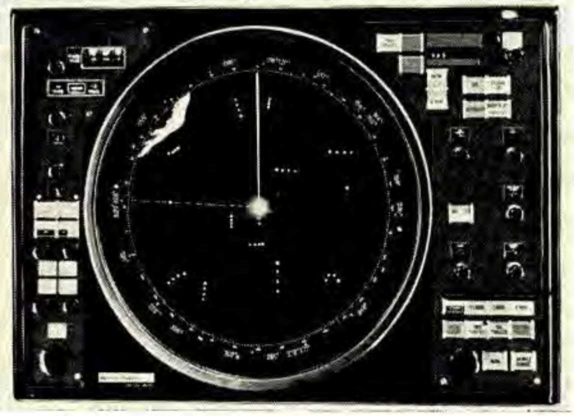


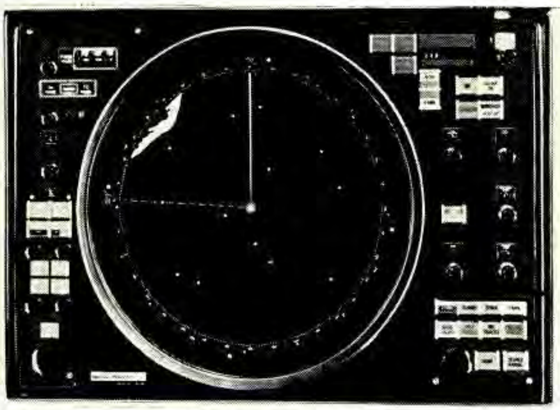
Basic radar mode providing a conventional compass-stabilised relative motion radar picture. Range 12 miles. Ship's head up presentation with ship's course 110°, speed 15 knots. The bearing marker is a dashed line at 023° true

The Predictor radar is made up of a Scanner Unit and Aerial, a servo control unit, a transceiver unit, a track storage unit and a display unit. All of which operate on 115 volts ac at 50 or 60 c/s single phase. Semiconductor devices, including integrated circuitry, are used wherever possible. The only two thermionic devices used in the

True tracks mode is used to ascertain the true course and speed for all visible targets. In four consecutive sweeps on the ppi, the true positions of every target 6 minutes ago, 4 minutes ago, two minutes ago and NOW, with updating every 10 seconds. The true course of each target can be measured using the parallel lines. The speed is determined by the length of the track

Targets bearing 023°, 189° are stationary
Target bearing 055°, at 10 knots and altered course 4 minutes ago to 156°
Target bearing 038°, steering 276° at 15 knots
Target bearing 116°, steering 302°, at 8 knots
Targets bearing 137°, 163° are fast ships crossing from starboard at 023°, 020° and 17 and 20 knots respectively





Relative tracks mode again presents the position of all targets from 6 minutes ago until NOW. The parallel cursor lines give the CPA and time of CPA for any target

Target bearing 055° will pass astern, CPA 2 miles

Target bearing 098° will pass to port, CPA 0.6 miles

Target bearing 116° will pass to starboard, CPA 0.2 miles

Target bearing 137° will cross ahead, CPA about 1.5 miles

Target bearing 163° is on collision course. We are the give way ship

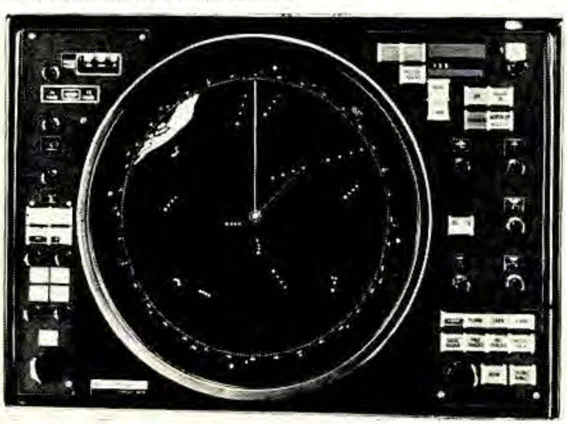
An alteration of 45° to starboard with no change in speed will avoid 163° target, but may raise a collision risk with 271° target or 116° target

system is the magnetron and the cathode ray tube.

The track storage unit contains a tape loop store on which is constantly recorded target information for use in the various modes. The restricted bandwidth of the tape is accommodated by expanding the incoming video to give maximum recording quality. This is achieved without loss of picture definition, and with a substantial increase in brightness in the Display unit. The degree of expansion is controlled by the range selected. The band-compressed signals are fed to the Track Storage Unit and the crt.

Predicted relative tracks mode allows the proposed change in course to be investigated. The new course (155°) and speed (15 knots) are set on the proposal controls. The predicted relative tracks button is pressed at the NOW sweep. This picture shows the ship on the new course of 155°—shown by bearing marker.

All collision risk targets will pass clear and there will be no immediate risk from others



The Track Storage Unit also maintains the relationship between the aerial and the display. A magnetic pick-up generates a 48 c/s tone at 24 rev/min from a 120 tooth wheel on the aerial shaft. This tone represents the aerial position relative to the ship's head. Its position relative to north is derived by phase shifting the 48 c/s tone with a phase shifter geared to a compass repeater in the Display Unit. It is then compared with a pre-recorded control tone from the Track Storage Unit in a phase comparator, the output of which, after appropriate processing and amplification energises the aerial drive motor, with an accuracy of 0.25° in azimuth.

The compact Display unit contains the display circuits, bandwidth compressor, shift generator and programmer. Circuitry for suppression of interference from other ships' radar is incorporated in the bandwidth suppressor. Markers, such as range rings, etc, are added after band-compression but are not stored.

The top is angled forward for easy presentation of the 16in crt and operating controls. All controls are grouped logically to ease operation.

Food For Thought

That was New Year's day, that was. Anybody notice it? Flashing past, after the drinks of the night before. And the good resolutions (if they are still in fashion) what happened to them? I don't mean about envy, conceit, hatred, greed, acquisitiveness and things like that, They are part and parcel of modern civilisation. I was thinking of important matters like giving up smoking and cutting down on meals to reduce dw and so forth.—Don't please, take this as a chiding by a do-gooder. I gave up resolutions even about smoking a long time ago.

But I have in my possession the diary of an old sea Captain, and it contains the following entry dated 1st January, 1874: "Early this morning I sent the helmsman below and spent an hour alone with my ship and the sea and the sky and my Maker. If He is giving me another year of grace, or if it will be only a brief time, I do not know, but this I know that I have only a short respite before I shall leave this world and all that is in it, and I shall only regret parting with the two things which alone are great and wonderful. They are the sea and the sky."

Oh, quite. He was merely an old sea Captain and didn't know better. Knew nothing of the bliss and the lasting content that money, and more money, can buy.

Svensk Sjöfarts Tidning 1.

*Gas turbines for marine propulsion**

The gas turbine is now firmly established as a power source for naval ships. The most striking and at the same time the most predictable benefits have been realised in fast patrol boats where the overriding consideration has been the provision of substantial amounts of power in very small space. It has, in fact, been possible to construct boats with performance which would not have been possible with any other type of engine.

In ships of larger displacement, such as frigates and destroyers (in most countries capital ships are no longer built) the virtues of the gas turbine are not so immediately obvious. The basic problem is set by the conflicting requirements of long endurance and high speed for fast deployment and action. Since the required power varies approximately as the cube of the speed, there is a wide variation in power. This is a difficult requirement for the gas turbine to meet with acceptable fuel consumption. It has been solved by the installation of separate engines for high and low speeds. Clearly, the high power engine should be a gas turbine. It is compact and light and will be required to run for only a small proportion of the operational life of a ship. For low speed, both gas turbines and diesel engines have been used, though there is an increasing tendency to choose the gas turbine, for a number of reasons.

Compactness and lightness remain useful qualities, although they are not dominant as in aircraft. The gas turbine requires very little attention while at sea; indeed its design is such that there is very little that can be done to it, a legacy from its aircraft origins. Repair of the gas generator is carried out by replacement. The number of engine room personnel is, therefore, reduced and this leads to economy in the crew accommodation. A gas generator can be replaced very quickly so the ship is more readily available to go to sea. The engines are capable of rapid starting (full power in about two minutes) so the ship can be ready to put to sea promptly when required.

None of the above factors is in itself decisive, but their combined effect is that a given operational requirement can be fulfilled with fewer, smaller and cheaper ships. It is this overall advantage which has led to the adoption of the aero derivative gas turbine by almost all the world's navies.

New applications for gas turbines

Recent improvements in gas turbine technology can be expected to lead to a range of new engines, some of them derived closely from aero engines, others developed *ab initio* for the industrial and marine environment. The first effect of this will be to increase the success of the gas turbine in those fields in which it is already established, but there are other applications in which the gas turbine has made little or no headway to date, which will be opened up by the new engines.

Many of the improvements in aircraft engines are of value in a diversity of applications. By far the most significant technical improvement in recent years has been the air-cooled turbine blade. The basic idea is not new; the key to its successful application has been the development of the appropriate manufacturing techniques.

A typical modern cooled blade design is shown in Fig. 1. It has elliptically shaped cooling holes. Cooling air enters the blade from both sides of the root and exhausts from the tip. The cooling airflow used is 2.0 per cent of the main turbine flow and reduces the midspan average blade temperature by 200°C.

Improvements have also been made in the methods of introduction of cooling air into the blade roots. One such method is shown in Fig. 2. Pre-swirl nozzles impart a tangential component to the cooling air so that it enters the blade root cleanly. This results in a lower cooling air temperature that would be given with an inefficient entry to the blade root.

Prior to the introduction of the cooled blade, the turbine entry temperature of aircraft engines rose at a rate of approximately 10°C per annum as a result of improvements in materials. With cooling, the rate of increase has been raised to almost 30°C per annum. Transferred to the industrial scene, the latter figure would imply rates of increase of power 6 per cent and of efficiency 2 per cent per annum. The introduction of the air-cooled turbine blade has doubled the potential rate of improvement over that which was possible before.

In the event, of course, one does not proceed steadily

* Abstract from the paper "The gas turbine—recent improvements and their effect on the range of applications", presented to the Eighth World Energy Conference in Bucharest in July, 1971, by A. W. T. Mottram, CEng, Chief Engineer (Future Projects), Rolls-Royce(1971) Ltd. Industrial and Marine Gas Turbine Division.

from year to year in the industrial field. An established engine has a much longer industrial life than it would have in aircraft where the pace of improvement is forced much harder. So the potential improvement accumulates until it is large enough to justify launching a new engine or, in the case of the aero derivative, choosing a new aero engine to adapt to industrial use.

The important question to answer is how high this top cycle temperature can be. In industrial and marine application, conditions are different from those of aircraft service. In particular, corrosion of the turbine blades is a serious problem due to the need to run for extended periods at high power in a polluted or salt-laden atmosphere. Surface metal temperature becomes a dominant parameter and the blade designer will try to limit this to a value shown to be safe by experience with uncooled blades in the same environment. Leading and trailing edges are critical areas, the former because they experience the highest heating and the latter because they are most difficult to cool. Creep as such is no longer a problem, being replaced by thermal fatigue stresses which are inherent in the cooled blade and tend to become more serious as internal cooling is increased. Blade cooling is also interrelated with other engine parameters, notably the pressure ratio. As the pressure ratio is increased, so the compressor delivery temperature increases, reducing the efficacy of the cooling air. So we may expect lower top cycle temperatures for high pressure ratio engines.

Broadly speaking, we may expect that industrial engines based on present technology could operate at turbine entry temperatures of about 1,400°K (1,130°C) at peak rating. Temperatures of about 1,500°K (1,230°C) should be possible in the not too distant future.

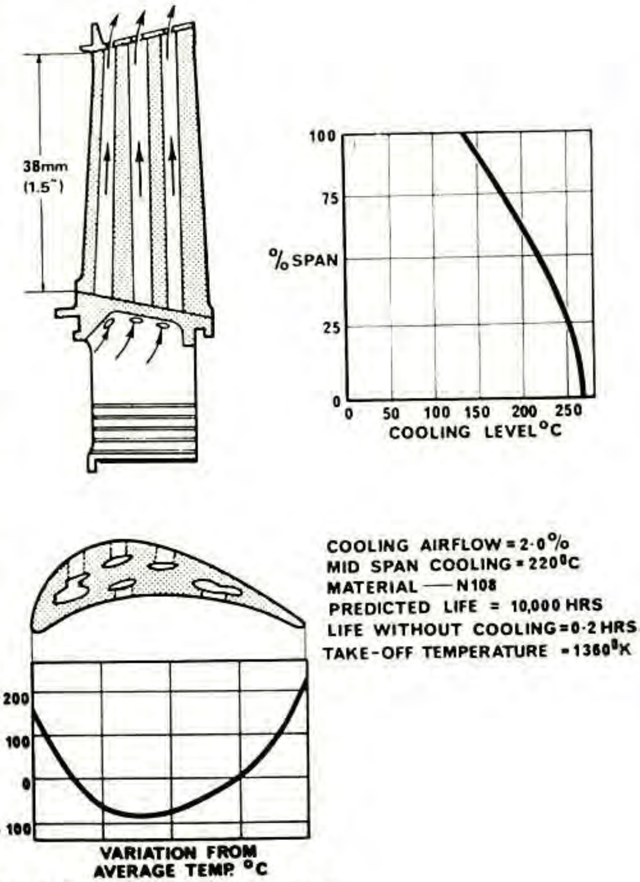
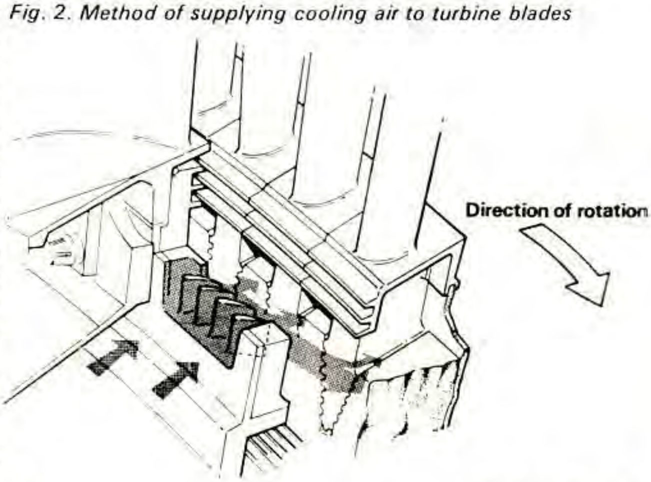


Fig. 1. Typical cooled turbine blade

The merchant marine market

A significant penetration of the merchant marine market by the gas turbine can be expected in the near future, partly due to engine improvements and partly due to changes in the requirements of ship design. The size and speed of ships are both increasing, creating the demand for more power. An increasing amount of cargo is carried in containers and experience to date suggests that the average full container is well below its maximum permitted weight. There is a trend towards lighter loaded weights. The number of containers that can be loaded is thus determined by the available space in the ship. Shorter stays in port are also required in container ship operation and the availability of the ship to operate a scheduled service is important. The gas turbine can meet all these requirements. Typical of the future engines suited to this application is the Marine RB.211 derived from the engine for the Lockheed Tristar airbus. This engine produces over 15MW

Fig. 2. Method of supplying cooling air to turbine blades



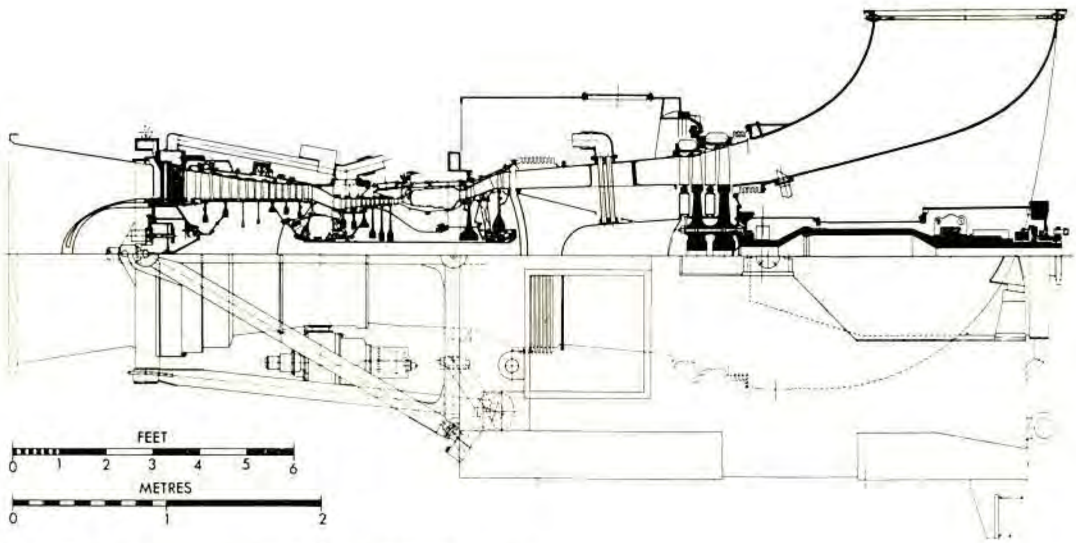


Fig. 3. General arrangement of Marine RB211 engine

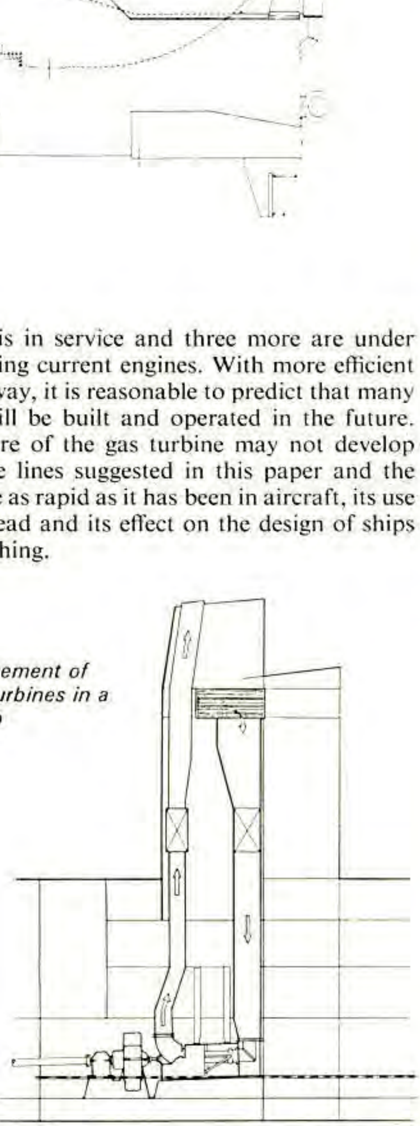
(20,000hp) at its service rating with a specific fuel consumption in the region of 183g/bhp-h (0.4lb/hp-h). It uses more fuel than a diesel engine of the same power. It burns distillate fuel, moreover, and this means that the fuel costs are higher unless special situations exist, as in liquefied natural gas carriers.

The compactness of the engine is clear from Figure 4. This makes more space available for cargo and leads to considerable weight savings. It is simple in design with only three major rotating assemblies. It is integrated into a power module which is a complete package including all auxiliaries. The module can be installed easily at a late stage in building the ship and will not delay the building programme. It is designed for remote control and fully automatic operation and will not require engine room manning. The engine can start rapidly and produce full power in a few minutes. It requires little maintenance limited to compressor washing, checking filters, visual inspection, etc., which could be carried out in about two hours by one man. Repairs of the gas generator by replacement can be completed within the ship turn-round time when required. All the above factors will lead to improved availability.

The assessment of the worth of all these advantages will differ in individual cases. What is implied is a change in the pattern of ships operating cost with an increase in fuel cost accompanied by reductions in every other area. A full economic evaluation involves the naval architect, engine designer and ship operator.

It is noteworthy that one gas turbine-powered container ship is in service and three more are under construction using current engines. With more efficient engines on the way, it is reasonable to predict that many similar ships will be built and operated in the future. Whilst the future of the gas turbine may not develop precisely on the lines suggested in this paper and the pace may not be as rapid as it has been in aircraft, its use will be widespread and its effect on the design of ships will be far reaching.

Fig. 4. Arrangement of two RB211 turbines in a container ship



Halmatic 65'

A guided-missile-armed patrol boat

The Halmatic 65' is a new class of fast patrol boat designed by Bernard Olesinski and based on his successful 60ft (18.28m) express cruiser, the *Tarquin*, for Aquarius Yacht Co Ltd. The hull and deck will be moulded in glass fibre to the highest Lloyd's standards and a Lloyd's certificate will be issued with each hull moulding. Halmatic are aiming to supply this part-assembly to yards who have to meet the requirements for high-speed patrol craft.

The Halmatic 65' should achieve a speed of 26 knots with twin MAN or Rolls-Royce DVS-CTM engines, or 20 knots with twin GM 12V diesels, giving a range of approximately 500 miles. It would be possible to consider a gas turbine installation giving speeds of approximately 35-40 knots.

The Halmatic 65' is based on a deep vee hull of 65ft (19.81m) overall length, a waterline length of 51ft (15.54m) and a beam of 17ft 6in (5.33m). It has a draught of about 4ft 9in (1.45m) and a displacement of about 30 tons, depending on armament carried. A good stable ride with a minimum of pounding in heavy seas is thereby ensured. Extensive tank tests on the hull design were carried out at Southampton University, and the results carefully evaluated to achieve the best possible hull form.

Armament

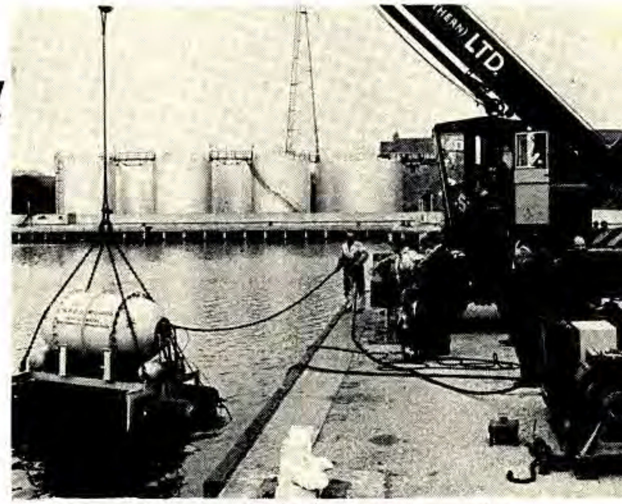
The boat has a fine clear foredeck and good aft deck, allowing a large degree of flexibility in the type of armament carried. The artist's impression shows a Hispano-Suiza 20mm cannon mounted on the fore deck with four "Seacat" missiles mounted aft. An excellent fire control station is provided in the flying bridge giving good all round vision.

Another sight-guided missile, named "Blowpipe", also by Short Brothers and Harland, would be eminently suitable for this type of craft, giving good protection for low weight.

Halmatic Limited are now ready to discuss various requirements for this new high-speed patrol boat and enquiries are invited on this project.

An artist's impression of the Halmatic 65 ft at 26 knots. On the foredeck is mounted a 20 mm cannon and aft are mounted four Seacat missiles

A recycle diesel engine for underwater power*

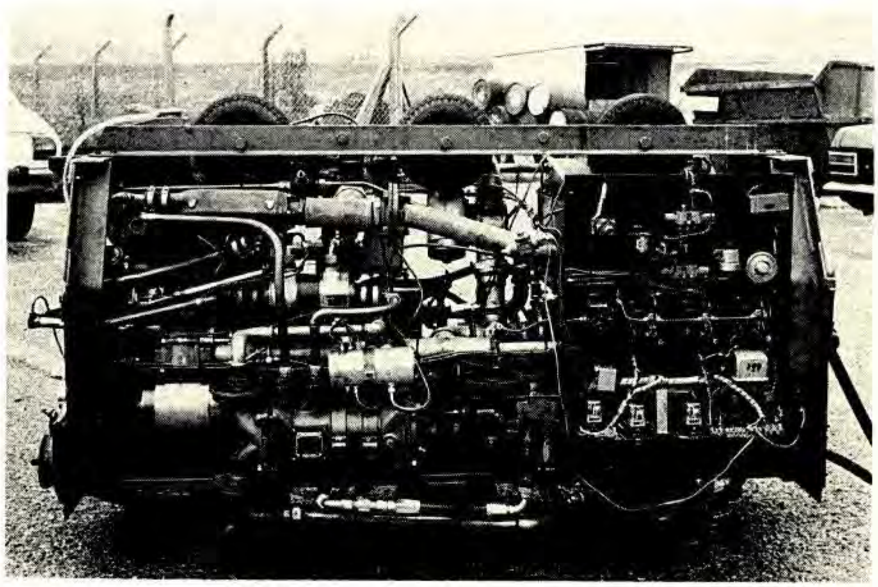


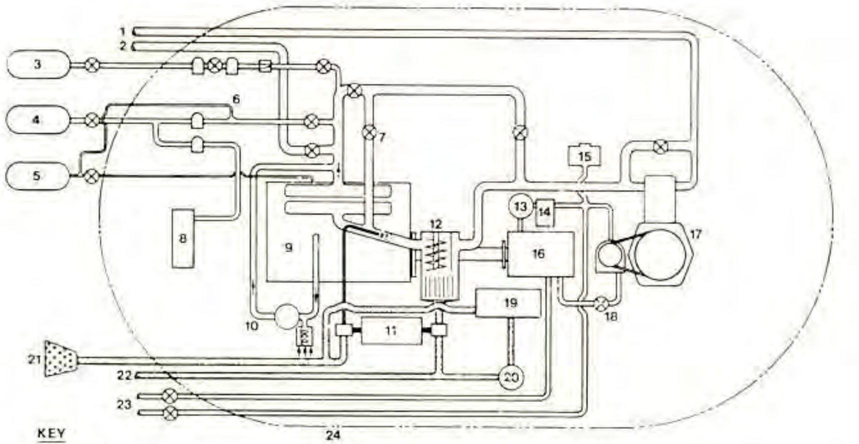
The unit being lowered into harbour water for submerged tests

A self-contained source of power for use under water has been developed by Ricardo & Co Engineers (1927) Ltd, under a contract from the NRDC, following an earlier investigation on behalf of the Ministry of Defence (Navy). The unit, which has largely been built from commercially available components, is in the form of a recycle diesel engine, driving an hydraulic pump. The prototype unit develops 35hp but the principle can be adapted to other types of drive over a wide power range.

The engine is a standard Perkins D3-152 diesel engine developing 35hp at 2,000 rev/min and driving a Lucas axial-piston hydraulic pump capable of delivering hydraulic power at 1.8 lbf/sec (8.0 N/sec) at 3,000 lb/in^2 (210 kg/cm^2). The engine can operate in a naturally-aspirated condition on the surface and can be switched to recycle operation by pneumatically-operated valves controlled by a pneumatic logic circuit. When starting with the pressure hull submerged, it is first necessary to provide pure air. After about 10 seconds running, the unit automatically changes over to recycle operation.

* *Gas & Oil Power*, November/December, 1971.


The unit within its framework embodies a Perkins engine as the basis of the prime mover



KEY

1 Exhaust
2 Atmospheric Intake
3 Oxygen
4 H.P. Air
5 Fuel
6 Servo Controlled
7 Hot Gas Restrictor
8 Pneumatic Control Panel
9 Engine
10 Blow-By Pump
11 Pump
12 Separator
13 Pump
14 Filter
15 Header Tank
16 Hydraulic Power Take-Off
17 Exhaust Compressor
18 Flow Control Valve (Servo Controlled)
19 Engine Hydraulic Compressor Intercoolers
20 Pump
21 Water Inlet
22 Water Outlet
23 Hydraulic Power Take-Off
24 Water Inlet

SYMBOLS

Valve — Reducing Valve — Jet

Layout and key of the Ricardo-NRDC power plant

When recycling, the exhaust gas is cooled by injecting sea water, which is subsequently removed in a separator. A proportion of the cooled exhaust gas is ejected by an exhaust compressor driven by a variable speed hydraulic motor. The pressure at the engine intake is 5 lb/in^2 (0.352 kg/cm^2), so that the compressor requires about 5hp (15 per cent) of the engine power output at the designed depth of 600ft (183m). The remainder of the exhaust gas is mixed with a small quantity of uncooled exhaust gas to raise the inlet temperature to about 100°C. Sufficient pure oxygen is then metered into the gas stream for the combustion of the oil fuel.

The in-line Simms Minimec fuel pump has been fitted, and adapted so that movement of the rack operates the oxygen metering valve. The exhaust manifold and the lubricating oil system are water-cooled. Also included in the power plant are exhaust cooling water supply and extraction pumps; engine jacket cooling water pump; crankcase blow-by compressor and hydraulic oil boost pump. Safety devices are fitted to shut down the engine if there is a loss of lubricating oil pressure, or if the oxygen content within the pressure hull reaches a dangerous level.

Maximum power may be sustained for 12 hours, the four oxygen bottles contain 2,440ft^3 (69.1m^3) of free oxygen at 2,000 lb/in^{2}g (140.6 kg/cm^{2}g), the fuel tank will hold 25 gallons of kerosene. The compressed air bottle has sufficient capacity for eight starts.

The complete unit is carried in a framework supported by pneumatic-tyred wheels, to locate it within the pressure hull and allow easy withdrawal. This form of resilient mounting helps to reduce the noise and vibration transmitted from the engine. The 12-ft (3.65-m) long, 8-ft (2.44-m) high, 8-ft (2.44-m) wide pressure hull is designed to withstand the water pressure at a depth of 600ft. Of the 8 tons total weight, 4¼ tons consists of fuel and oxygen.

New destroyer design for the Royal Australian Navy

Y-ARD (Australia) Pty Ltd, Australian subsidiary of Yarrow & Co Ltd, have completed their preliminary design of a 4,000tdispl destroyer for the Royal Australian Navy. This will be a fast and versatile ship, powered by gas turbines in COGOG arrangement. The design is suitable for conditions found around Australia's coast and will meet Australia's needs through the 1970s to the 1990s. Y-ARD (Australia) completed the work within the scheduled 64 weeks and within the approved cost of approximately Aust $1m. Six ships which may cost between A$40m and A$50m each, are expected to be ordered as a first series.

Fast patrol boats*

A range of designs from Fairey Marine

Fairey Marine has had some 15 years' experience in the design, construction and operation of offshore high-speed power craft and the knowledge gained from this experience is clearly reflected in their range of fast patrol boats. The basic range covers four boats, namely the 23ft (7m) Huntress, 30ft (9m) Spear, 33ft (10m) Sword, and 50ft (15m) Type 15.

Smallest in the range, the Fairey Huntress, is ideal for use as captain's motor boat—over 30 being in service with the British Royal Navy for this purpose and communications launch on board naval vessels. It is also suited for inshore patrol duties by customs, police and other civil authorities. A substantial number are on order for certain Middle East Governments for use in routine contraband and anti-infiltration patrols.

A deep vee hull form enables the craft to attain a maximum speed of 28 knots with an engine of 180bhp, while, at the same time providing a high degree of sea keeping ability, claimed to be unequalled for a boat of its size. Other less powerful engines can be fitted if required. The boat can be equipped with demountable light machine gun positions.

One of two methods of construction is employed for Huntress craft, either nylon sheathed, hot moulded wood or glass reinforced plastics. The hot moulding process is said to be unique to Fairey Marine and produces a hull of exceptional strength with excellent resistance to rot and marine borers, which is reinforced by the nylon sheathing by the cascover process.

'Fairey Spear'

The Fairey Spear is a high-speed patrol boat with a performance superior to most small craft available to smugglers and other intruders. It has an advanced deep vee hull with an extensively flared bow and the top speed with twin 180hp diesels is 30 knots while this can be increased to over 40 knots with alternative power installations. A Spear boat is employed by the police to patrol Poole Harbour (the second largest

* *Shipbuilding International*, March 1972.

An artist's impression of the Fairey type 15 fast patrol boat at high speed

natural harbour in the world) and is being used to test a range of advanced surveillance equipment including infra red and image intensifier systems. The boat's high speed and soft ride also suits it for the VIP transport communications role and a Spear will be supplied to the Muscat and Oman Navy to be carried on the flagship *El Said* for this purpose.

Spear hulls are moulded in glass reinforced plastics to Lloyds series standards. The cabin top and fore and side decks are moulded as a single grp unit which is bonded to the hull while the deckhouse and cabin layout are individually designed for each application. An example of the fitted-out vessel includes built-in racks along both sides of the cabin to accommodate a complete wireless installation together with a range of electronics surveillance aids.

Typical armaments which can be fitted are light machine guns on permanent mountings on foredeck and side decks port and starboard in way of aft cockpit.

'Fairey Sword Marine'

The Fairey Sword Marine uses the 33ft (10.05m) deep-vee hull which was first introduced in 1963 and is noted for its excellent handling in adverse weather conditions. The hull is made of hot moulded wood, a process in which up to nine veneers are bonded together under steam heat and pressures, impregnating the wood with the resin-based glue. This sets to produce a homogeneous wooden structure having a high strength to weight ratio and high resistance to moisture and marine borers which can be further improved by nylon sheathing (cascove process). There are two basic types available, an open version and a cabin version. The former has a forward cockpit for helmsman and navigation/radar operator, with the aft cockpit having space for 12 men plus stowage for rescue equipment. Alternatively, a single 20mm Hispano gun can be fitted together with ready use lockers.

The cabin version has a forward cockpit with accommodation for four with an open control position or wheelhouse as required and an aft cockpit or cabin to seat six. Armament comprises a single 20mm Hispano plus mountings in three positions for 0-300cal small arms: 20mm cannon only available with the large cockpit arrangement.

Propulsion is by twin 180hp diesel engines giving a maximum speed of 25 knots and a cruising speed of 22 knots.

'Type 15'

Largest in the range, the 50ft (15.24m) Type 15, is a completely new design of fast patrol boat intended for operation in Middle Eastern waters and other areas requiring a low-priced high-performance craft for customs surveillance duties, and anti-infiltration duties off long, exposed shorelines. This craft is designed to meet the requirements which hitherto have had to be met by either smaller performance boats lacking the sea-going capability, round bilged craft in the 40 to 50ft (12 to 15m) range lacking the performance, or larger naval vessels, which are too expensive to buy and operate for coastal duties.

The Type 15 is capable of detecting and intercepting intruders at distances up to 12 miles when operating offshore by day or night in sea conditions resulting from winds up to Force 4/5. A 20mm cannon is mounted aft and light machine guns are also fitted.

Like other Fairey Marine craft, the Type 15 has a deep-vee hull and is designed for a speed range of 20-40 knots according to available power plant.

A choice of power unit is offered to suit local availability of spares and service where this is not carried out by the operator, the standard installation is twin Cummins VT8 diesel engines rated at 360hp each giving a continuous cruising speed of 20 knots. Other engines available are twin General Motors 8V71TA of 400hp and twin CRM 12D/S-2 of 750hp giving a cruising speed of 27 knots.

In addition to supplying boats, Fairey Marine provides a consultancy service to help operators use their Fairey fast patrol boats at maximum efficiency. This service covers all aspects of fast patrol boat operation, handling and maintenance. It also includes the design of harbour and base facilities, training of seamen and mechanics and the establishment of appropriate maintenance facilities and stocks of spares.

Fastest surface ship in the Red fleet

According to NATO sources, the Soviet Navy is testing a new 400-foot, 3,000 ton guided missile destroyer which could be the fastest surface ship in the Red fleet. This 45 mile-an-hour, gas turbine vessel was first spotted undergoing sea trials in the Baltic in December 1970 and is the latest prototype ship in a string of new Soviet surface combat ships. Given the name "Krivak" by NATO, the principal mission of this destroyer is believed to be anti-submarine warfare (ASW). She has substantial surface-to-surface and anti-aircraft capabilities and is equipped with the latest electronic gear. She is armed with two quadruple ASW rocket-launchers, two triple ASW torpedo tubes, four surface-to-surface missile launchers, one twin surface-to-air missile launcher, and two twin 76mm guns.

Improved assistance for cold starting

For many years equipment has been provided for the correctly controlled admission of atomised special fuel to the intake system of a diesel engine when starting conditions call for such help. The suppliers have been Start Pilot Ltd, of 3 Hobart Place, London, SW1. The works are at Holland House, Burmester Road, London, SW17.

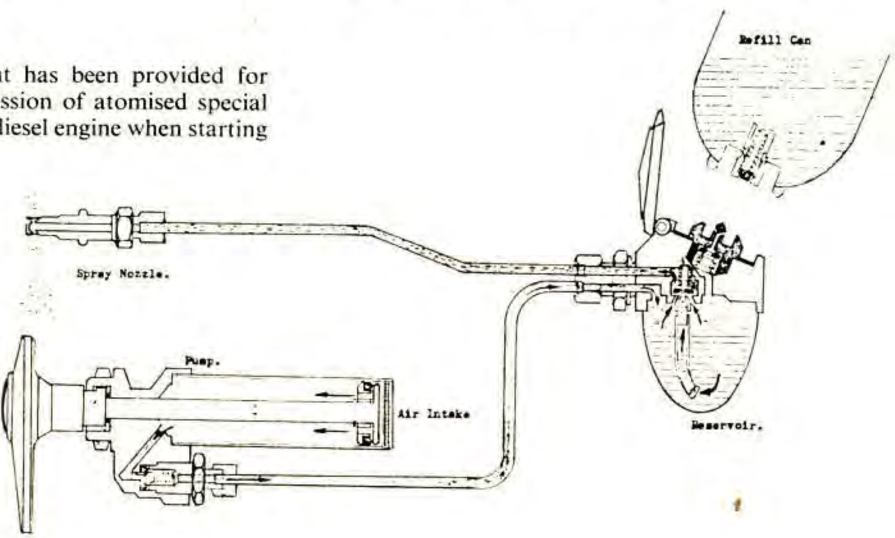


Fig. 1. Diagrammatic layout of the Start Pilot Viso-F starting aid equipment

The latest set of equipment is designated Viso-F, and offers some attractive features in both operational convenience and economic spheres. Briefly these are: (1) Fuel contained in low-pressure cans of 300cm^3 capacity instead of 17cm^3 capsules; obviously the increased volume is of value to the user as a time saver, and cost can be reduced. (2) Owing to the hand-operated air pump now being separate from the fluid reservoir unit, installation is made much easier. For example in marine practice the pump may be easily accessible by the person at the wheel, whilst the reservoir and jets in the manifold are a good many feet away. The same situation obtains in rear-engined commercial vehicles, or in some industrial plants where centralised control is established in a quiet room and the engines are in another room. (3) The components have been designed for low-cost production, and to make fluid replenishments cheaper also. Reduced consumption of starting fluid is occasioned with this new equipment, which also gives better carburation and thus smoother getaway.

Fig. 1 shows the diagrammatic layout, the pipework length and "topography" in practice being dictated by the fixed locations of the pump (Fig. 2), the reservoir (Fig. 3) and the spray nozzles (or nozzle).

Taking the components one by one, the air pump is usually mounted on a dashboard or fascia panel, with only the rubber-covered Tee handle visible; the actual pump is out of sight in an area which gives free access for air induced by the plunger action. The working stroke is that due to pulling the handle towards the operator. When not in use the handle is positively held in the "off" position. In cases where hand operation is not desirable an electrically-driven compressor can be supplied.

In operation the pump is actuated only when the starter is turning; if the ambient temperature is very low

Fig. 2. The pump unit which is installed at the 'control centre'

one or two extra strokes may help to sustain the first few ignitions of cylinder charges. Heating devices in the cylinders or air manifolding are not used with Start Pilot fuel "mist".

Turning to the reservoir, this is mounted vertically in a position which allows good visibility of the fluid level in the transparent bowl (of either 27cm³ or 55cm³ capacity), also ease of recharging from the 300cm³ Multi-fill can, seen in Fig. 3. The reservoir must be away from or guarded from a source of heat, such as the exhaust system. As a rule the capacity of the can suffices for around 100 assisted starts. The fluid used must be that provided in the Multi-fill vessel, and never have an ether content.

Tubing carries the air-fluid mixture to the nozzle in the air manifold; where there are separate manifolds for cylinder groups a separate nozzle is used in each such air duct. By a choice of jets in the reservoir unit and nozzle type the mixture strength can be made suitable for engine size and expected cold-weather conditions. An outlet check valve in the reservoir unit minimises the risk of fluid passing towards the engine when it is running normally.

Fig. 3. The reservoir and Multi-fill can

Explosive proof hand lantern

Londesborough Instruments Ltd. have recently introduced an explosion proof hand lantern for use in areas where there is an inherent danger from explosion.

Operating from a 6V dry battery source, the lantern produces 40,000 candle power in a concentrated beam ¼ mile in length which can be used with pinpoint accuracy. The beam produces no "black light" to hamper the operator and the lamp will float upright projecting its beam as a marker beacon. Operation of the lamp is by a magnetic switch thus completely eliminating any failure.

The case capsule is a one-piece super strength polypropylene injection moulded design to withstand great shock if dropped. A polycarbonate lens protector is fitted to protect the beam unit from damage whilst a rubber grommet takes any shock and wear to which the lamp may be subjected. Although the grommet is watertight it is secured by a compression band of EN53J steel which is both spark proof and resistant to chemical and seawater corrosion. The compression ring is designed with a swivel centre boss and socket screw with a special head permitting only the holder of a special shaped wrench key access to the inside of the lamp, this feature giving increased safety.

Internally, the battery compartment is effectively sealed off, isolating the magnetic switch and beam unit from the possibility of damage and risk of explosion, by a very strong rubber composition housing.

The lamp is provided with a standard pistol grip-type handle but top carrying handles are also available. A variety of lenses to give a wide range of light patterns and coloured polycarbonate screens are also available.

The lamp is powered by Londesborough sealed batteries having two years shelf life and giving eight hours operation. Alternatively, re-chargeable batteries giving 10 hours output are available.

USNS Hayes

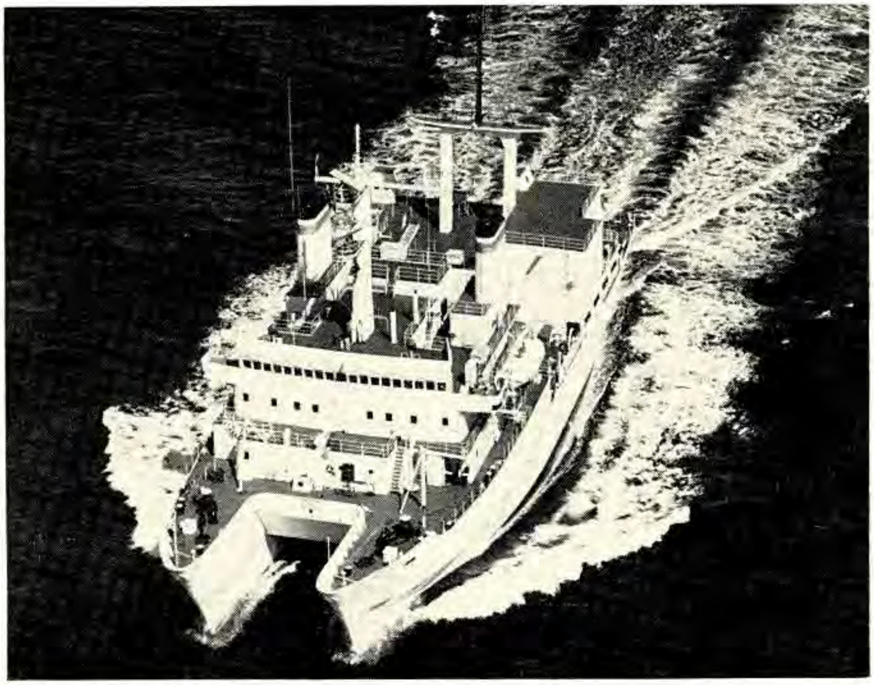
Catamaran research vessel provides a large work area and stable platform

Principal Particulars:	
Length o.a.	246ft 5in (75.11m)
Length b.p.	220ft 0in (67.05m)
Beam max.	75ft 0in (22.86m)
Beam, each hull	24ft 0in (7.31m)
Distance between hulls	27ft 0in (8.23m)
Depth amidships	34ft 0in (10.36m)
Draught, full load	17ft 9in (5.41m)
Displacement, light	2,329 tons
Displacement, full load	2,876 tons
Sustained sea speed	15 knots

Although catamaran designs have been widely used for yachts and, also, for various ferries operating in Japanese waters, the apparent advantages this type of hull has to offer has until recently been virtually overlooked. It is therefore interesting to note the entry into service with the United States Navy, of the catamaran research ship *Hayes* (T-AGOR-16) which has recently been constructed by the Seattle Division of Todd Shipyards Corporation.

It is expected that the catamaran design of the *Hayes* will afford advantages of: allowing heavy deck and scientific equipment to be handled and located at any deck position without excessive heel angles; the wide spacing of the hulls, and therefore the propulsion systems provide good station-keeping qualities at slow speeds; the centre well between the two hulls permits scientific gear to be streamed and deep sea research vehicles to be handled at the point of minimum ship motion; and the separate forward and aft centrebody structure allow separation of the scientific spaces from the machinery and accommodation spaces. In the USNS *Hayes* which has an overall length of 246ft 5in (75.11m), there are no less than ten scientific spaces giving over 8,000ft^2 of area space together with more than 7,000ft^2 of open deck space available for use in handling scientific equipment.

It is reported that the *Hayes* has been designed and constructed specifically to conduct acoustic research for



T-AGOR16-USNS 'Hayes' during sea trials anti-submarine warfare. The design of the ship was evolved jointly by the Naval Ship Systems Command, the Naval Ship Engineering Centre, the Office of Naval Research and the Naval Research Laboratory. Contract plans and specifications were developed by the Hull and Weapons Support Division of the Naval Ship Engineering Centre and M. Rosenblatt & Son Inc, served as design agents. To produce the detail construction plans, the builders selected the J. J. Henry Co Inc, as the prime contractor for most of the engineering work. In order to maintain close contact with the work in progress, J. J. Henry sub-contracted certain phases of the work to W. C. Nickum & Sons of Seattle.

Hull form

The hull form is identical to that of the US Navy's other catamaran ships—the ASR *Penguin* class of submarine rescue ships—but is slightly smaller. At the forward end the two hulls are assymetric about their centre line while at the aft end each hull is symmetrical about a buttock plane, thus each hull by itself is transversely unstable and there is no parallel midbody. In view of this the builders decided to use a modular construction technique in which 55 modules were delineated, 27 of these being below the water line, The transversely framed hulls are strengthened for navigation in ice while the cross structure is designed to withstand the maximum load created by the ship being supported diagonally, i.e. on one bow and on the opposite stern. To carry these loads, six transverse beams of "I" section and each about 21ft deep (6.4m) run across the ship. These deep beams form part of the transverse bulkheads. Above hull level the *Hayes* is basically divided into fore and after superstructures. The main ship control, centralised machinery control station and accommodation spaces are arranged in the forward superstructure while the aft superstructure houses the scientific laboratories, research control centre computer and data-processing spaces, and calibration and instrument test facilities. Open work areas are located forward on the starboard side amidships, and on the starboard side aft. Equipment handling is effected through the centre well and through bow and stern slots between the two hulls.

Deck machinery includes various winches fore and aft. At each of these positions there is a traction winch, the primary use of the forward one, which has a pull of 50,000 lb at 80ft/min is for deep sea anchoring in water down to 20,000ft deep. The aft traction winch has similar characteristics and is also used to handle heavy acoustic transducers. Other items of deck machinery are conventional windlasses and two electro hydraulic cranes with telescopic booms.

Propulsion machinery comprises two General Motors Corporation Electro-Motive Division, Model 20-645E5 geared diesel engines arranged one in each hull. Each engine drives a Lips/Ampower 12ft (3.6m) dia propeller via Western Gear Corporation reduction gears. In addition to the main engines, each of which develops 2,700bhp, there are two 165bhp auxiliary propulsion diesel engines for quiet operations. These latter units are clutch coupled to the reduction gear and provide sustained ship speed of 2-4 knots as compared to a sustained speed of 15 knots provided by the main engines. The wide spacing of the two shaft lines afford excellent manoeuvrability to the vessel which, by reversing the pitch of one of its cp propellers, can turn in about its own length.

Electrical requirements for ship's service are met by three 350kW, 450v, three-phase 60c/s Caterpillar diesel generator sets while two 75kW generators provide for scientific and essential service equipment. They are resiliently mounted to keep noise to a minimum during quiet operation. A further 75kW diesel generator is provided for emergency use.

To reduce manning requirements a General Electric Company (USA) machinery control system is installed. The controls are centralised in an engineering operating station known as the EOS, which houses the various electrical switchboards, the main control console, data logger, numerous remote controls for valves and machinery, and other displays and indicators. The EOS is situated on the main deck spanning the cross structure in such a way that it provides relatively direct access to both the machinery spaces. These latter are designed for unmanned operation with one licensed watchkeeper in the EOS.

On the main control console there is provision for remote selection, starting, speed control and stopping of the propulsion engines. Remote control of the propulsion machinery for ship speed and direction can also be effected from the control consoles on the bridge, both bridge wings, and from an auxiliary ship control station located aft. For ship's speed a single lever control system is used and is programmed for automatic matching of propeller pitch and speed, this being achieved by the use of electronic logic circuits. Remote operated manual controls for individual adjustment of pitch and speed are also provided.

Machinery monitoring is carried out in a General Electric Co (USA) data centre in which the most important operating data is continuously displayed. Other data is available on demand, and automatic logging facilities are incorporated.

Steering of the vessel is effected from the bridge or the secondary control station through Sperry Marine Systems steering units. The vessel is comprehensively equipped with the latest navigational aids and communication facilities including radar, Loran, depth sounder, radio direction finder, marine radio and radiotelephones.

Electrical controls for warships

Propulsion machinery

by D. MacGregor*

"These machinery control systems have been designed and installed in the Vosper Thornycroft Mark V and Mark VII frigates now at sea. This design on which much useful experience has been gained was the forerunner of a new generation of machinery controls now being designed for future frigates and similar vessels".

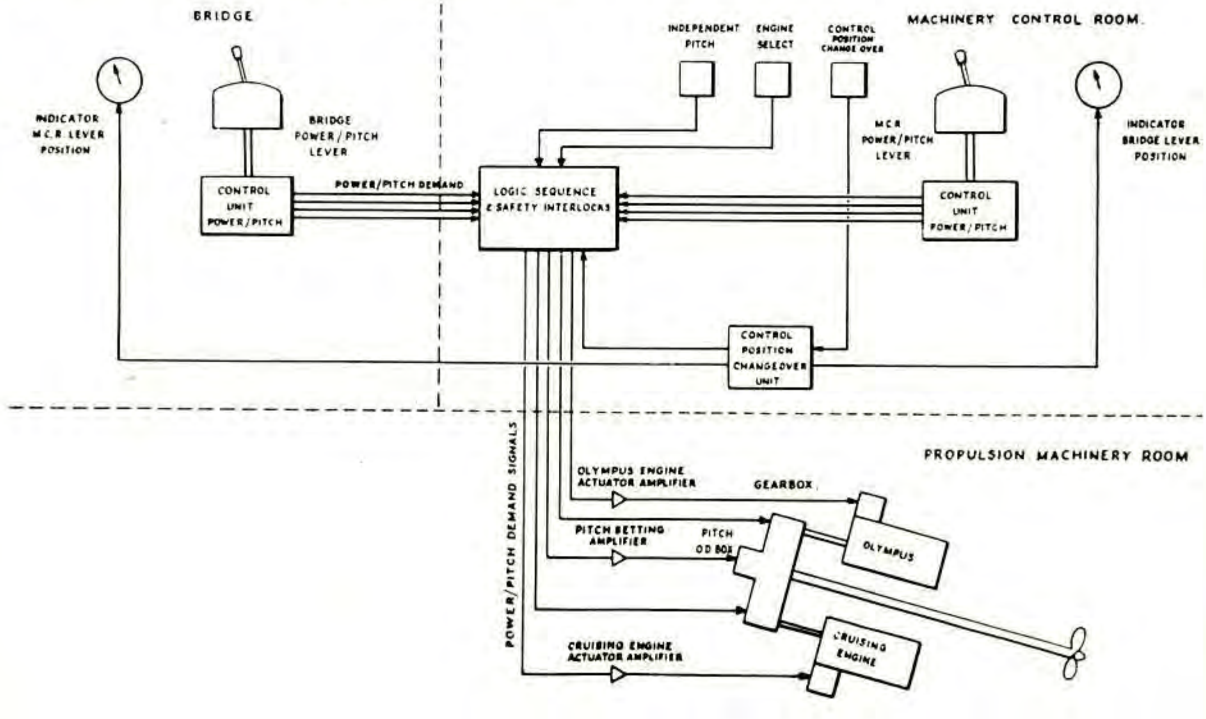
*Divisional Sales Executive, Controls Division, Vosper Thornycroft Ltd.

For some years Vosper Electic, the Industrial and Marine Controls Division of the Vosper Thornycroft Group, has been developing a range of electrical control equipment for warship power plants, and in particular gas turbine installations. Equipment is at present being manufactured for use with Rolls-Royce Olympus and Proteus engines, in close collaboration with the engine manufacturers.

For the Olympus it consists of single lever controls for each of the two CODOG propulsion units of the Vosper Thornycroft Mark 5 destroyers for Iran, including Olympus gas turbines, Paxman diesel cruising engines, and KAMEWA controllable-pitch propellers. Associated with this power plant control system, known as the power/pitch control, are comprehensive instrumentation and protection, alarm and monitoring systems. This type of equipment is at present under consideration for the Olympus/Tyne COGOG power plants of the Type 21 frigate for the Royal Navy.

In the case of the Proteus engine there are two sets of equipment available which can be used separately

Fig. 1. Schematic power pitch single lever control system



or in combination. One is an electric starter motor control unit, and the other an automatic sequence controller, which makes possible starting of the Proteus engine, with all necessary checks on the satisfactory functioning of the various stages, from a single push-button. This can be used with the electric starter unit, or separately for engines with other forms of starter. Both units are being fitted in the three Proteus-engined fast training boats being built by Vosper for the Royal Navy and in the company's new private venture fast patrol boat 'Tenacity'. Similar equipment is being supplied to the British Hovercraft Corporation for the BH7 hovercraft for the Ministry of Defence.

All these control systems, which have been developed for warship use, are based on solid state techniques and are designed for the utmost reliability in adverse environmental conditions, and a high degree of resistance to shock.

Power pitch control

The wide speed and power range made possible by the CODOG installation in the new generation of high speed frigates makes the use of controllable pitch propellers highly desirable, and these are being used in the Type 21 frigate and Vosper Thornycroft Mark 5 and Mark 7 designs now building.

In all these ships the propulsion system is of the combined type, with relatively low powered engines, diesel or gas turbines, for cruising, and Rolls-Royce Olympus main gas turbines developing 24,000 h.p. per shaft. The transfer of load from cruising to main engines is achieved through SSS (synchro-self shifting) clutches, and throughout a substantial proportion of the power and shaft rotational speed ranges the propeller pitch needs close control for optimum efficiency and performance.

The Vosper Electric engine control equipment makes it possible to select the required power on each shaft, from full astern to full ahead, by positioning a single lever, either in the machinery control room or on the bridge. Throughout the power range where propeller pitch is varied this is done automatically, although there is provision for separate control of propeller pitch if required.

The use of electrical controls makes possible a high degree of automation, while ensuring that little maintenance is needed. The system operates from a 115 volt 400 Hz, single phase supply. A comprehensive system of instrumentation and automatic protection is provided.

The basic control system for the CODOG frigates is shown in (Fig. 1) whilst electromechanical actuating boxes are mounted on the gas turbine throttle (Fig. 2), diesel engine governor (Figs. 3 & 4). These boxes convert the electrical input to mechanical movements which actuate the machinery controls directly. The control signals are derived from the single-lever controls (Fig. 5) via a logic sequence unit which also contains the safety interlocks. The system operates on the ac remote position servo principle. The control levers operate mechanically separate servo transmitters for the three functions (gas, turbine, diesel, propeller pitch) and these are adjusted so any lever setting automatically selects the corresponding engine power and propeller pitch. Each shaft has its own entirely independent system.

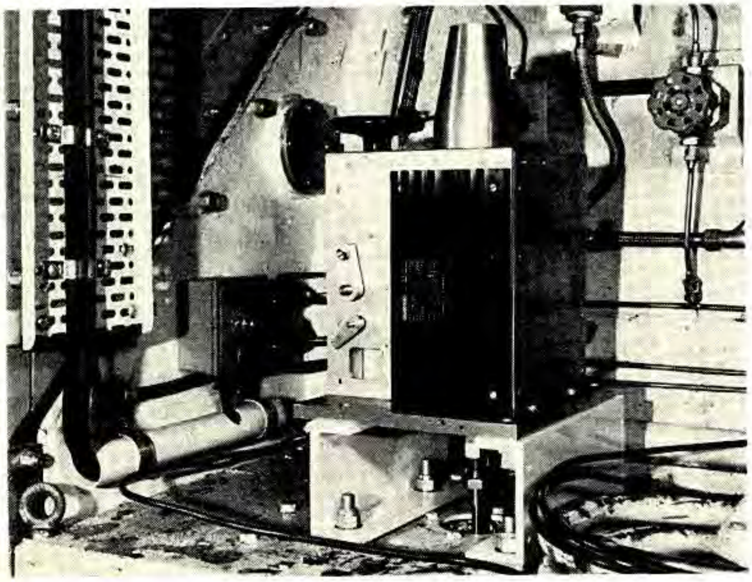


Fig. 2.
Gas turbine actuator installed in Mark 5 frigate

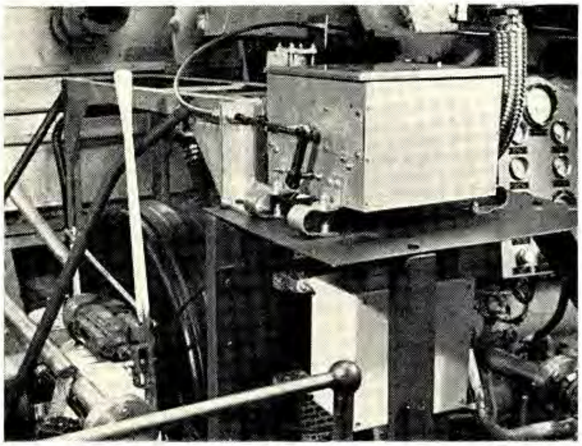
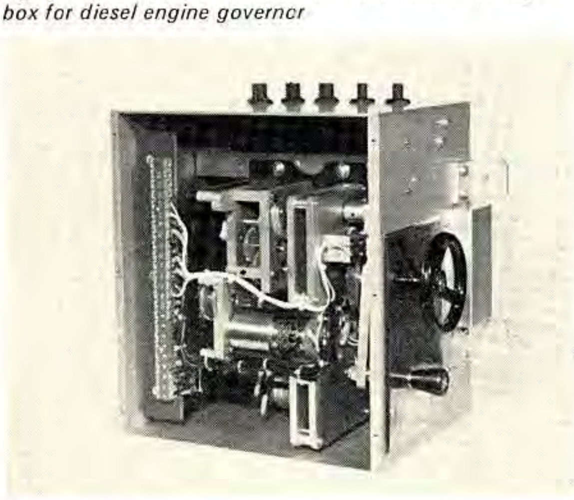


Fig. 3. Diesel actuator installed in a Mark 5 frigate

At the bridge control position, in addition to the pair of levers, there is an indicator showing the position of the corresponding lever in the machinery control room and an indicator lamp to show which position is connected, but no other controls. The machinery control room has a corresponding indicator, and a change-over control to select bridge or local control. An 'engine select' switch controls the SSS clutch, to transfer power from cruising engine to main gas turbine, and from main gas turbine to cruising engine. This can, of course, only be done when the disconnected engine has been started and is rolling in readiness. Load can only be transferred from main gas turbine to cruising engines when the control lever is set in a position corresponding to a power within the cruising engine range.

Fig. 4. Interior view of an electromechanical actuating box for diesel engine governor



Associated with the engine control system is comprehensive instrumentation, divided into two sections. The first, classed as essential to the running and efficient functioning of the ship, consists of analogue instruments under the constant supervision of the machinery controlroom watchkeeper. The second, for parameters such as engine temperatures and pressures, takes the form of digital indicators, served by a common system which scans the various points continuously. Faults detected cause warning lamps to come on and alarm horns to sound.

The control system has its own comprehensive safety interlocks. In addition there is an engine trip system which automatically closes the gas turbine high-speed shut-off cock in the event of certain serious conditions arising, or if the 'stop' button is pressed.

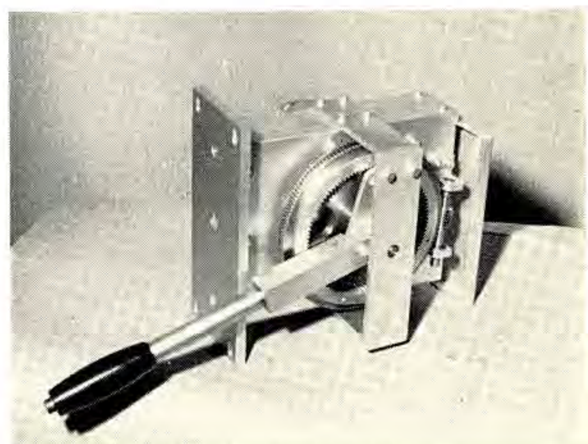


Fig. 5. Single control lever for Mark 5 frigate

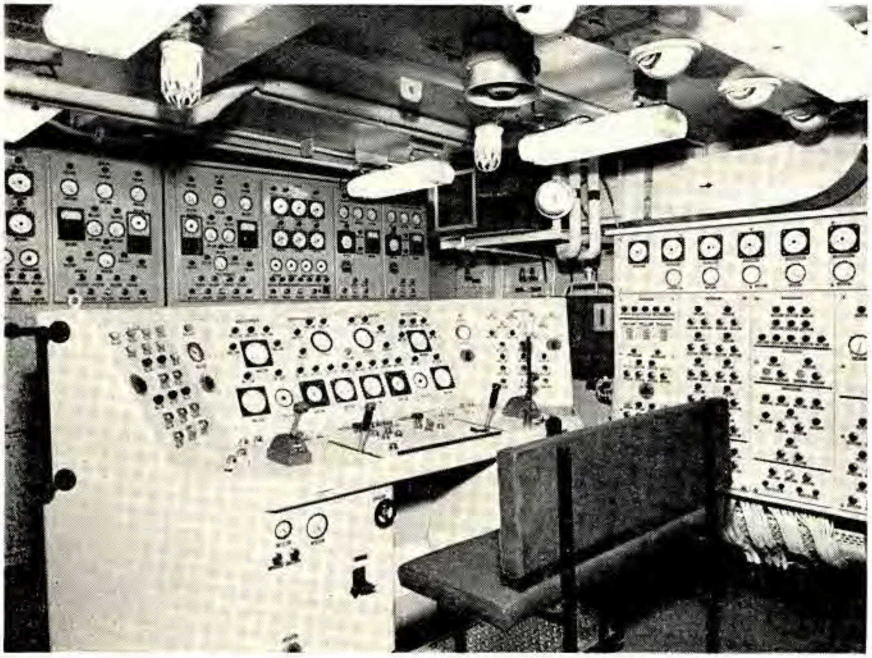
The engine starter system also has the necessary control interlocks and sequence timers for safe operations. It provides additional facilities for testing the engine without engaging the clutch, barring, local test of igniters, and start without ignition.

Electric starter unit for Rolls-Royce Proteus Type D135828

The Rolls-Royce Proteus gas turbine is normally started by a dc electric motor. The Vosper Electric solid state starter unit supplies and controls this motor, so that it delivers torque matched to the requirements of the engine. It operates from a 115V 3 phase ac supply at any frequency between 50 and 400 Hz.

Steering and machinery control console as fitted on the bridge of the Mark 5 frigate

A main thyristor diode bridge is connected to the ac supply, and its associated firing module determines the dc output to the starter motor. The start sequence is initiated by a signal from the sequence controller which passes via the protection and monitoring control module to a ramp generator. This provides the input to the thyristor firing module which increases the firing angle, and therefore the current passed by the thyristor diode bridge to the motor. As the current increases the motor will accelerate, and at the



Mark 5 frigate machinery control room showing the watchkeeper's desk, gauge board, and auxiliary machinery control panel appropriate speed ignition can be initiated. Acceleration of the engine under its own power will cause current in the starter motor to fall and a current sensing device transmit a signal to the thyristor firing module so that the starter motor supply is switched off. The protection and monitoring module automatically returns the unit to the 'ready for start' position.

The equipment is readily adjustable to cater for engines having different characteristics, and provides for manual control when required. The starter can be used with a wide range of dc motors and being all solid state has distinct advantages over a conventional electro/mechanical unit. Repairs are effected by direct replacement.

In the course of evaluation trials at Rolls-Royce Ltd's Ansty test beds this starter unit has been proved successful in operation.

Digital Sequential Control Unit—Type D200860

This equipment controls the complete sequence of starting up the Rolls-Royce Proteus gas turbine so that starting is reduced to the simple operation of a push-button. Pressing the button initiates the sequence, which involves the opening of fuel valves, starting fuels and lubricating oil pumps, and actuating the starter unit, which can be the Vosper Electric Unit previously described, or an air starter where the engine is so fitted.

Eash stage in the sequence can only be initiated when the control unit has received an indication that the preceding one has been satisfactorily completed. If at any stage an essential condition is not satisfied the sequence is interrupted and an alarm signal given. Any turbine running faults found (such as high turbine exhaust temperature or low lubricating oil pressure) will automatically shut down the engine, give an alarm and indicate the nature of the fault. Delay devices preceed shut-down as a result of transient conditions.

The design of the unit is based on the use of solid state circuitry with modular construction for ease of access. The number of printed circuit boards has been kept as small as possible, and each one is an independent plug-in unit for ease of replacement with minimum down-time.

First complete Ferranti CAAIS system will go to sea in HMS Torquay

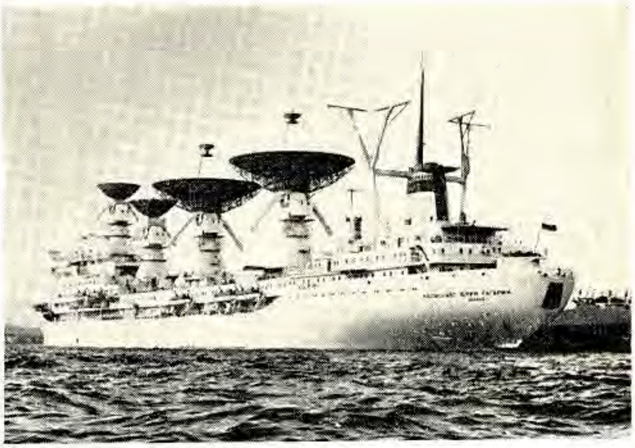
The first complete CAAIS (Computer Assisted Action Information System) to go to sea will be that installed in HMS *Torquay* during her recent refit at Chatham. The system, developed by the Digital Systems Division of Ferranti Limited, Bracknell, Berkshire, will undergo sea trials in *Torquay* later in the year. CAAIS is to be fitted in all the new Type 21 (*Amazon* class) and a number of *Leander* class frigates, although HMS *Torquay*, a Type 12 frigate, will be the only ship of that class to carry the system.

CAAIS, which is based upon a Ferranti FM1600B integrated-circuit computer, having 32K words of core store, will feed six Decca CA1600 conference displays. The system is designed to enhance the performance of the Action Information Organisation in the future Fleet. The displays can show a combined radar and computer generated tactical picture. The system can auto-track radar targets and process information from the ship's sonars and electronic warfare systems to provide accurate target indication information to the ship's weapon systems, as well as computer solutions to navigation problems and attack orders for weapon carrying anti-submarine helicopters.

The operations room of HMS 'Torquay' with the CAAIS system installed. Members of the 'Torquay's' crew are seen at the display units associated with the system

*Russian scientific vessel**

Floating laboratory for space research



Copyright Laurence Dunn

One of the latest vessels to enter service with the extensive fleet of scientific research ships operated by the Soviet Union is the *Kosmonaut Yuri Gagarin*. Built at the Baltiisky yards in Leningrad, the vessel is stated to be the world's largest and most powerful scientific vessel and will be employed in the study of outer space. The hull design appears to be that of a tanker while the upper works are dominated by four parabolic aerials, the two after ones being particularly large. These aerials weigh hundreds of tons but are balanced in such a way that they can easily be rotated and elevated, these operations being effected automatically. The aerial system enables investigations of the upper atmosphere layers to be carried out and also makes it possible to receive signals from spacecraft in near earth orbit, flying towards the Moon and Mars, or functioning on those planets. Not only can the vessel receive such signals but to relay information and commands on satellites of the earth, moon and sun and on board ships and orbital stations. Wherever in the world's oceans the vessel may be it is able to maintain constant communication with the control centre in the USSR. An aerial facilitating radio-telephony contact with cosmonauts is also installed.

Although the laboratories are on board ship, they are no smaller than land-based stations for space observations and incorporate highly sophisticated radio, telemetric, navigational, electrical and computing equipment. There are several sets of electronic computing machines and thousands of blocks mounted on instrument racks and grouped in individual consoles, a multitude of panels, tumblers, buttons and levers. More than 120 laboratories are provided and their equipment will rapidly and accurately solve manysided problems connected with the flight of spacecraft; process, in fractions of a second, the information received and relay it to the control centre. Although technology is advancing at a tremendous rate, the vessel will not be rendered obsolete as the pattern of its equipment is such that on any day, without interrupting the investigations, it is possible to replace any sub-assembly with a new, more advanced and reliable one.

Reliability is of major importance for a research centre that spends six or more months away from home waters, away from plants and workshops, that operates in rain and tropical heat and seldom in calm weather. The reliability of the apparatus and constructions of the *Kosmonaut Yuri Gagarin* is higher than usual. At all stages of the work there was the strictest control over individual elements and whole assemblies, careful selection of operating conditions, and special tests. Many of the blocks have been duplicated: if one fails, the other switches on. All the systems employ automatic circuits for recognising failures of elements and for their replacement through switchings.

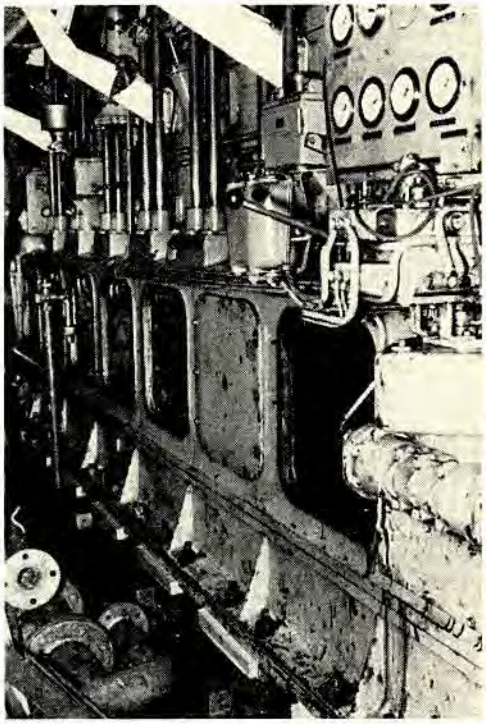
The ship's controls and her 19,000hp turbine make wide use of automation and remote control. A few bulkheads away is the stern power plant, a whole generating station. A similar one is located nearby. In order to counteract the enormous amount of heat released by the equipment when it is switched on, there is a cooling installation capable of maintaining normal temperature round the clock in all quarters when sailing in the tropics. The installation is three times as powerful as that which is conditioning the air in Moscow's Palace of Congresses.

The crew and members of the expedition—physicists, astronomers, mathematicians, engineers and technicians—have been provided with the maximum of amenities and comfort needed by people on complicated and lengthy cruises. These include an automatic telephone exchange, apart from other kinds of intercommunication, a library with 10,000 books, a cinema-lecture theatre in the form of an amphitheatre seating almost 300, rest rooms, three swimming pools, including one with heated water and a large gymnasium.

**Shipbuilding International, March 1972*

Rapid and effective re-chocking

Among features of the motor coaster *Amber*, built by Ailsa Shipbuilding Co of Troon, for the Baltic and short sea trades of William Robertson Shipowners Ltd, the Gem Line, are high-speed air-cooled engines, enclosed in soundproof boxes for driving the auxiliary generators. Seventeen years of hard service in the coastal and North Sea trades have resulted in fretting of the cast iron chock supporting the 1,650bhp Deutz RBVM366 engine, which weighs some 55 tons, including its 12-ton flywheel. Partial re-chocking was carried out some 18 months ago but further evidence of fretting was discovered in course of voyage repairs recently undertaken at Troon. Time could not be spared to re-chock yet again by conventional methods. It was decided to effect permanent repairs by using pourable resin chocks, and the assistance of Philadelphia Resins (UK) Ltd of Beaconsfield was sought. By calculation 38 chocks each 8in long by 5in wide would provide a total bearing surface of 1,520in^2, equivalent to a static loading of 81 lb/in^2. In practice, however, it was found more convenient to use chocks 16in by 5in wide, each

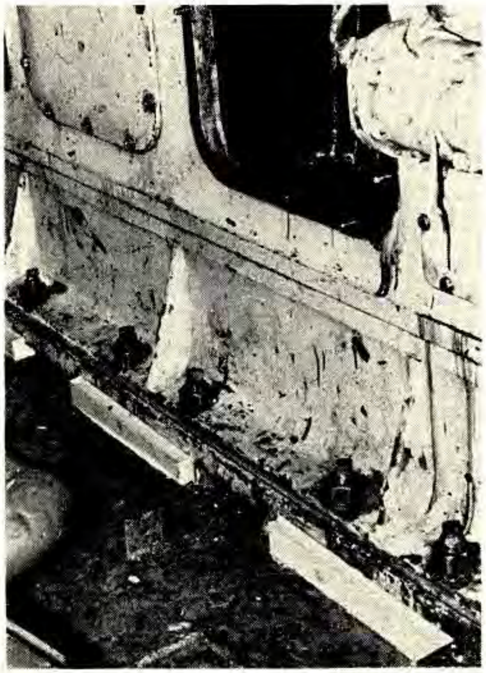


embracing two holding-down bolts. The material used was Chockfast Orange, which is resistant to high temperatures and the only resin approved by Lloyd's

Above: Neat appearance of the completed work

Left: Each chock embraces two holding-down bolts

Below: Close up of chock at corner of engine poured around the existing bolt



Register of Shipping for chocking main machinery. PR were called in by the shipyard on a Friday afternoon and their operators were in attendance at the yard by 0900 on the Sunday. Cleaners were then still working in the chocking area and a number of the metal chocks had still to be removed. That afternoon a start was made in preparing dams for the pourable chocks and by Monday morning all the holding-down bolts had been replaced and grommets fitted to seal the holes in the bedplate and to provide allowance for thermal expansion. It was found expedient in carrying out this work to leave certain of the existing metal chocks in position and to cast resin around them, to provide additional support and to prevent movement.

By 1400 on the Monday the metal fronts of the dams were in place and all dams were complete in spite of obstruction to several areas by the collision chocks which were not removed. Mixing of resin and hardener proceeded and all chocks had been poured by 1930 on the same evening. The dams were removed on the Tuesday morning and, when the holding-down bolts were tightened during the following day, the maximum change in the deflections was of the order of 0.001in. The *Amber* sailed from the yard on the Thursday.

From the foregoing it will be seen that the main engine was re-chocked in virtually three working days, against possibly some weeks using conventional cast-iron or steel chocks.

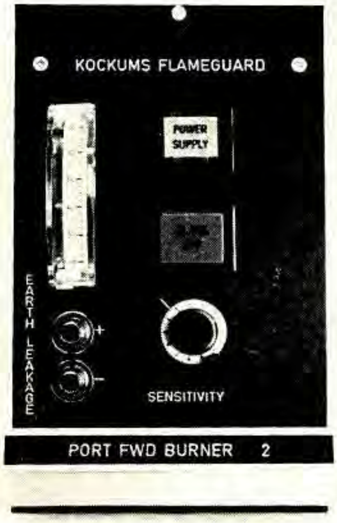
Kockum's flameguard

A problem common to most burner surveillance systems is that the sensitivity is such as to react to the light from a neighbouring flame. The recently-introduced Kockum's flameguard instead compares the emission of light from the various burners in use in a furnace and will give a failure indication when one scanner gives a much weaker signal than the others, even though the signal itself may be powerful. Dust deposits and ageing do not affect the comparison, if they should occur evenly. Individual burner jets which become clogged are easily detected, while new burner jets may be compared with the existing burners.

The scanners, one or two per burner, are light-sensitive photo-electric cells housed in accessible holders. They need to be calibrated only at the time of installation and are connected to a central display/alarm panel consisting of an electronic circuit with two stabilised rectifiers and an output relay for each burner. The fronts of the panels carrying two control lamps, one indicator, two push buttons and a potentiometer in standard 19in rack mounting.

When the cell is exposed to light, it will conduct electricity allowing a dc voltage to energise the indicator circuit. This is fed to an amplifier which transmits an output signal through a delaying network to a transistor which operates a relay, controlling the alarm light.

When one burner is ignited, the radiation picked up by the other scanners is increased by an amount which is compensated by an electric signal from the lit burner. It is this which prevents indication being given by a neighbouring flame. Preset potentiometers and the calibration instruments provide the initial adjustment for intrinsic differences between the light charatecristics of individual burners.



Panel for one burner

Flame scanner

UK – US joint hovercraft programme

Hovermarine Transport Limited has recently announced that they are to conduct a Hovercraft development test programme sponsored jointly by the Department of Trade & Industry and the US Navy.

The programme will utilise a Hovermarine 20-ton sidewall HM 2 hovercraft owned by the Department of Trade & Industry to generate data which will be useful in the further development of sidewall hovercraft. Large ocean-going sidewall craft having speeds in the 80 knots region are an objective of the US Navy.

The co-operative agency in the US Navy is the Surface Effect Ships Project Office who are currently sponsoring Surface Effect Ships (SES) development in the US. The SES Project Office is determining the feasibility of building large, high-speed ocean-going sidewall hovercraft for US Navy use in the mid to late 1970's. "Surface Effect Ship" is one of the American designations for what are known elsewhere as Hovercraft. The former term is usually applied to craft of the sidewall type such as Hovermarine's HM 2. The Hovercraft Directorate of the Department of Trade & Industry is the UK funding authority.

The purpose of the tests will be to accurately define the hydrodynamic resistance of the HM 2 craft and its powering requirements at various speeds and in various sea states, determine craft acceleration levels for various wave conditions, and to establish the propulsion efficiency and the dynamic behaviour of machinery installations.

The National Physical Laboratory of Hythe will be responsible for acquisition of the required data during the performance tests and will act as a sub-contractor to Hovermarine. NPL has performed similar work on other hovercraft developed in England. The HM 2 tests will be conducted in Southampton waters using Hovermarine's factory at Woolston as a base.

Hovermarine is the only UK manufacturer of the sidewall type of hovercraft. The rigid sidewall HM 2 craft developed thus far for commercial use, features catamaran type hulls that penetrate the water surface down each side of the vessel, inflatable skirts, for sealing the air cushion, installed only at forward and aft ends, and water screws. It is powered by standard marine diesel engines. The sidewall craft differs from the perhaps more widely known peripheral skirt type of hovercraft in that it is not amphibious. Being waterborne, however, has some advantages in that the craft is very manoeuvrable, quiet and has a high propulsive efficiency.

The Department of Trade & Industry's craft which will be used in the 10-month programme has recently been modified to what is called by Hovermarine, the Mark 3 configuration. This version of the 50ft (15.2m) fibreglass craft incorporates many technical modifications developed by the company in the past 18 months, details of which were given in the April 1971 issue of this journal. Craft modifications have resulted in significant improvements in reliability, comfort, seakeeping ability and lower noise generation. Hovermarine have been actively promoting the Mark 3 craft for commercial use throughout the world and this activity has resulted in recent sales of two passenger versions to Portugal and a general purpose version for hydrographic survey work in Belgium. The firm expects additional orders for both types of craft to be booked in the near future.

A Hovermarine 20-ton Sidewall HM2 hovercraft during sea trials

Hero's turbine revived

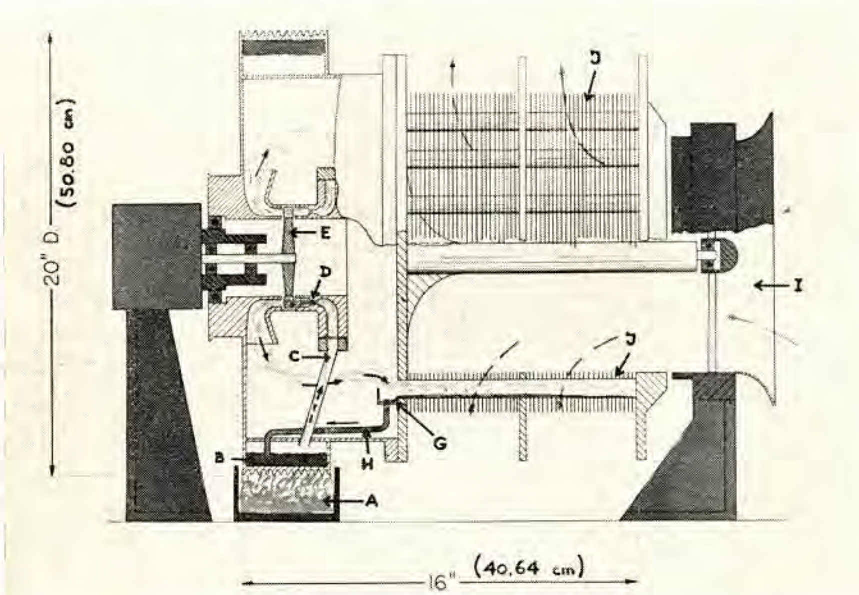
Externally-fired rotary boiler condenser with a central-rotating power turbine

A US patent has recently been granted for a Rankine cycle engine consisting of a cylindrical boiler and air-cooled condenser which rotate together at a controlled speed, with an internal turbine driven in the opposite direction by vapourised organic fluid under pressure. Rotation of the condenser-boiler unit results in efficient heat transfer in both sections, since no external blower is required to force air over the condenser. The engine is quiet and consumes relatively little power for operation of the condenser. The working fluid is returned from the condenser to the boiler by the centrifugal force produced by rotation. No additional pump or valves are required. Elimination of a separate pump is a major factor in simplifying the engine design.

A 20hp laboratory engine was built to demonstrate this "new" approach to the external combustion turbine engine. The patent was granted to Dr William A. Doerner, a research engineer in the Du Pont Company, who do not intend to manufacture the engine but to seek licensees to carry on mechanical refinement of the design, while they continue development work on organic fluids.

Increased attention is being paid to the external combustion engine because it can burn a variety of fuels and has good possibilities for low levels of pollutants in the exhaust. The engine may help to solve some of the problems of size and complexity that have held up development of practical engines. At the same time Du Pont have developed an improved fluid which permits operating at safe temperatures and pressure, and the use of low-cost materials. Initial studies indicate that the engine will be useful at ratings up to at least 200bhp. Potential applications for future developments include engine-generator sets for portable electric power, marine engines and fork-lift trucks, as well as cars.

Arrangement of the Doerner-Du Pont turbine. The assembly BCDHGJ is rotated by an external electric motor at 2,500 rev/min



- *A* *Source of heat*
- *B* *Liquid ring held against inside of extended surface by centrifugal force*
- *C* *Vapour inlet pipe*
- *D* *Nozzle ring*
- *E* *Output turbine wheel (27,500 rev/min)*
- *G* *Centrifugal force acts as feed pump*
- *H* *Feed pipe*
- *J* *Solid end condenser tubes—process is the reverse of that in B*
- *I* *Flow of cooling air into hollow condenser and thence out radially through rotating fin assembly*

Danube 'Incident'

by Lancaster

She was a peculiar ship—flat bottomed, draught 4ft 6in, two boilers under twin funnels athwart ship, two sets triple expansion reciprocating engines, twin screws tucked well under the hull in tunnels, three large rudders protruding from a square stern with the draughtiest "heads" ever conceived, mounted above at deck level. The funnels were hinged and with counter-balance weights. The mast too was hinged. Remarkably enough this assembly mounted two six inch guns, one twelve pounder, one two pounder pompom AA gun and six maxims. Total crew about 54.

But this peculiarity from which the following incident arose was that the fuel tanks were completely separate from the hull, this because the ship was designed to use coal as an alternative to oil and the oil tanks were separate entities which, in theory, could be rapidly removed from the coal bunkers in which they were fitted.

When using oil, fuel capacity could be increased greatly by permitting the oil to overflow from the tanks into the bunker spaces or by filling the bunker spaces outside the tanks direct.

Simple enough but there were complications such as the great variations in quality and viscosity of the oils available, the very high temperatures in summer when the vapour poured from filler connections and ventilators, visible as smoke; and the low Arctic conditions in winter when on occasion the oil had to be trimmed off the tank tops with shovels.

Testing apparatus consisted of a tobacco tin, two candles and a thermometer.

It was sometimes unnecessary, in summer, to use the heating candle.

Methods of oiling were by gravity:

(i) from railway tankers on a nearby siding,

(ii) from a river lighter alongside (using the ship's one bilge pump, belting its heart out to hold suction through an open ended leather pipe hanging vertically from the lighter's cargo hatch coaming to the botton of the hold, while the lighter rose well above the level of the ship's deck)

(iii) and sometimes from supply points at the river bank.

One hot summer's day refuelling was to be from one of the river bank points. The pumping station was nine kilometres away, contact by telephone, the pipe line about 6in diameter, had a capacity in the line itself of most, if not all the fuel required. When pumping ceased fuel remaining in the pipeline was driven through by

HMS Ladybird berthed in the Danube

compressed air, not, as will be seen, with 100% efficiency.

It was not known on board that naphtha lighters had shortly before taken on cargoes through the same line, but as soon as the station began pumping fuel oil in one end naphtha flowed out of the delivery end, some into a fuel tank before the discharge could be switched to the river—hazardous, but what else could one do? So volatile was the naphtha that some was collected and used as cigarette lighter fuel. Everything could not be put overboard and the first fuel in the tanks that day was a very doubtful mixture.

Normal procedure on the river was to steam by day and moor at nightfall to bollards, trees, rocks or anything available (once a broken down traction engine) but some few days after the naphtha intake and for reasons to be found in the history books, just before dark the anchor was dropped well out in the stream.

One of the fuel tanks, cubic in shape and situated forward of the boiler room, was empty and it was desired to pump into it oil from a port side bunker space, it being necessary to transfer such oil to a tank because there were no fuel pump suctions from the spaces. Transfer was via the bilge pump and ordinary canvas hose, almost invariably carried out by daylight and when not under way.

It was now being carried out at night and nearly everyone was asleep when there came a kind of "thud", a shaking of the ship from stem to stern and a loud crackling as flames leapt high from the deck and reflected in the river.

Fortunately the tank was about full when the explosion occurred so there was not room for much explosive mixture and the oxygen would appear to have been used up for the flames were confined to the oil splashed round the deck from the filling hose blown away from the tank. A metal plate was produced from somewhere and slid over the filling hole in the deck, so cutting off any further supply of vapour and the oil on deck soon burned out.

Subsequent examination showed all sides of the tank expanded outwards, it appeared to have bounced about in the space, the suction pipe to the fuel pump had been torn away and the oil had levelled off in space and tank.

One E.R.A. was in the sick bay with burns but was back on duty in a fortnight.

The inquiry made clear what had happened. There was a very small wardroom galley, not a standard fitting, at the forward end of the superstructure, with a most incongruous wooden door a few feet from the filling cap to the fuel tank. There was a two inch gap between door bottom and deck, there was some scorched dhobying on a line in the galley and there was the little coal fire burning away cheerfully. Obviously the vapour had passed under the door and ignited at the fire, and such was the finding. Orders were issued that the fire was never to be alight when oil transfer was in progress and after a year or so the fuel tank was replaced during refit.

All correct except that the galley fire was not responsible for the explosion. In fact a candle had fired off the gas.

The E.R.A. carrying out the transfer was experienced, had been on the river for three years and had expressed the opinion to his opposite number that they were living on an "explosive factory". He could not read the metal dip rod from the fuel tank in the dark so he went to the engine room, fortunately stopped the pump, then in some state of mental aberration, took a lighted candle along to read the rod.

As he did so he saw a blue flame round the candle, threw himself backwards with his arms up as protection and so excaped without too much damage.

Some few weeks later when oil was being transferred well away from his galley our cheerful fat Maltese ward room steward came with the request that I go and see what he had done, which was to place a metal plate over the front bars of the coal fire and, beaming all over his face, he asked "Is dat O.K.?". It would have been a shame to undeceive him but I might have done so had I not known what I did, and the little fire continued to roar away!

Six months later a Pensky Martin flash point tester arrived, rather late in the day, but it provided some interesting information.

Portable petrol engine driven welding set

For welding in places where there is no electricity supply, a welding set consisting of a generator coupled to a diesel motor or petrol engine is needed. There are many different sets of this type on the market but up to now the small lightweight units unfortunately have had small capacity, whereas the powerful units are usually heavy and cumbersome.

ESAB has now designed a *portable* petrol engine driven welding set, designated the KC170H0, which is a completely new type of welding generator coupled to a specially developed Husqvarna industrial engine.

The three-face synchronous generator, with silicon diode rectifier, is brushless and maintenance-free and in spite of its small size it has quite a high output. The engine is a single cylinder, fan-cooled, two stroke unit developing 8.5hp at 6,000rpm and can withstand maximum loading continuously. A centrifugal governor built into the crankcase maintains a constant speed and steady welding current. The result is a machine with the following outstanding properties:

It weighs only 38kg and can be carried in an ordinary private car.

It has a wide current range: 35A/21V—170A/27V at 60% duty cycle—as well as a high open circuit voltage, 58V, and can be used with most types of electrode up to 4mm diameter.

The KC170H is not just a welding machine. It is also a portable power source which can be used for lighting or driving electric drills and grinding machines. 1500W at 22V DC can be taken out from an auxiliary rectifier. In addition the engine has a socket for a 6V/20W inspection lamp, which can be used during welding.

The compact KC 170H fills an important need in harbours for small boats where welding, drilling and grinding are routine operations

Acoustic fuel atomiser

The acoustic atomiser which has been developed by Todd Combustion Ltd, of Swanley, Kent, over the past two years bears little resemblance to a conventional steam-atomising or steam-assisted nozzle. Among the advantages which this design offers are high combustion intensity, low concentration of stack solids, very wide turn-down ratios, excellent flame stability at all loads and reduced maintenance. A number are already in service at sea, in ocean-going ships.

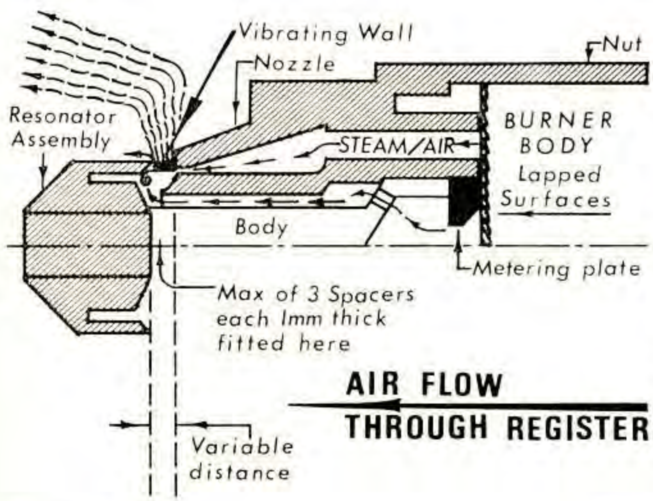
A dense high-frequency (14kHz) vibrating wall of pressure waves is formed by directing steam (or air) at high velocity through an annulus into a resonator chamber. The result is a vibrating cylindrical field through which the fuel oil must pass before igniting. The burner is described as acoustic because the sound level is in the higher audible range.

Fuel passes along the inner barrel of the burner and through a metering orifice plate and distributor holes before discharging through the inner annulus towards the resonator. The fuel has to turn through 90 degrees where it is forced through the vibrating wall of steam or air. This breaks the fuel into extremely fine droplets which ensure rapid and efficient mixing of fuel and combustion air.

The steam or air used as an atomising medium is continually replaced, and the flow cleans the surfaces of the resonator. This, combined with the fact that the flame base is clear of the nozzle, ensures that no carboning-up occurs. Acoustic nozzles have been in service for many months without attention while maintaining good combustion, even with residual fuel oils with viscosities up to 6,000 secs Redwood No. 1.

Marine boiler furnaces vary greatly in volume and proportions, and although a flame tends to adapt to the furnace shape, excessively long or wide flames often cause many problems. The acoustic nozzles, however, may be adapted to give a flame shape suitable for the furnace under consideration. This is achieved by using spacers to vary the dimensions between the resonator and the discharge annuli. This dimension is normally critical and with the distance set to a minimum (no spacers fitted) the flame will be short and wide. Up to three 1.0mm spacers may be fitted between the resonator and nozzle body to give an increasingly longer and narrower flame.

Tests have shown that the flame front is very stable. This can be attributed to the fine atomisation. Stable turn-downs exceeding 20 to 1 have been achieved using a wide range of fuels, including crude oil and waste chemical products. As the oil pressure falls below the constant atomising medium pressure of about 4 bars, the square root law, as applied to the flow of fluids through annuli and orifices, no longer applies and a substantial reduction in throughput is achieved with little reduction in fuel pressure. Atomisation of the fuel is not affected by variations in fuel pressure. The maximum capacity of the nozzle over the range of 50kg/hr (110 lb/hr) maximum to 4,000kg/hr (8,800 lb/hr) is varied by changing the metering plate.



Flame shape can be matched to suit furnace depth by changing spacer stack between resonator and body

*Mineseweeper – Pilot of a fleet**

by Ulf Delbro

All waters surrounding Sweden are suitable for mine warfare. This was demonstrated during World War II, as no part of the world saw such an extensive activity in mine warfare as the Baltic and the Baltic approaches.

Swedish strategy and tactics always take into account the use of mines to render it difficult for an aggressor to penetrate coastal areas, limiting in the same time the enemy's freedom of movement. Mine warfare is to be concentrated off the Swedish coast and at important narrow outlets and sea lanes.

A new minelayer, the Alvsborg, was delivered in the course of 1971 by the Kalskrona Shipyard to support the old minelayer Alvsnabben, while a second ship of the same class was ordered in June 1971.

The Alvsborg is powered by two Nohab-Polar 112-VS-F diesel engines developing 2,100hp each for a top speed of 17 knots. To facilitate landing manoeuvres, the ship is equipped with a steering propeller of the KaMeWa type set up in a "tunnel" athwart-ships in the prow and driven by an electric motor. Armament is made up of three 40-mm multi-purpose guns. The ship is also fitted with a helicopter landing platform.

The ship has room for 302 men including its own crew of 97. The Alvesborg is a multi-purpose ship and is required in peace-time to fulfil the roles of: submarine depot ship, platform for the training of crews of minelayers and of a target ship for torpedo launching from submarine and surface ships.

Minelayers of the Alvsborg class will be the biggest units in the new Swedish Navy, the characteristics of which were outlined already ten years ago. World War II heavy ships will be replaced by new, light and powerful vessels. By the end of the 'seventies, the bulk of the Swedish Navy will include, in addition to the minelayers of the Alvsborg class, a number of torpedo boats of the Spica I and Spica II class, a large number of fast patrol vessels which will replace the older MTB's, corvettes which will replace the frigates, a new type of minehunters and submarines of the Draken, Sjoormen and A14 classes, the latter replacing the submarines of the Abborren and Hajen classes.

Swedish MTB's are the first to be replaced on this modernisation programme. A ship of the Norwegian Snogg class has been ordered in Norway as a prototype for the future Swedish fast patrol boats. The prototype will be a 30-metre long and will have 150-ton displacement. The vessel will be powered by two diesel engines permitting a 35-knot speed, and will mount one 57-mm automatic gun and fire-control for surface and air targets enabling all-weather firing. The vessel will also be able to fire Norwegian Penguin missiles and lay mines as well. Extensive evaluation trials will be carried out on this prototype during this year.

During the 'seventies, the five frigates on the Kungl. Svenska Marinen will be withdrawn from service, and consideration is being given to replace them with 700-ton corvettes, suitable also to be used for anti-invasion and escort services. As for the destroyers, designed to be withdrawn from the service in the 'eighties, plans are being made to replace them with a new type of smaller ship to be used also as a MTB flotilla leader.

Future minehunters will probably operate according to a completely new technique for the removal of mines based on the experience of British and French navies. These ships will either be built in wood or plastic and will be fitted with an electronic equipment including mine-asdic and underwater TV to enable the localisation and removal of mines set up at the bottom of the sea.

The new submarines designated A14 will be slightly smaller than the five submarines of the Sjoormen class. A central computer will minimise all vital control and manoeuvring, reducing the crew from 23 to 17 men. No decision has yet been taken regarding the type of machinery to be used, whether diesels or Stirling engines, as tests are still being carried out. The order for a series of submarines of the A14 type is expected to be put through this year.

In any case, the extent and time planning for these new types of ships for the Kungl. Svenska Marinen will, however, not be definite until the Swedish Parliament will confirm the 1972 Defence Plan.

Aviazione Interconaire Marine

HMS Antelope launched

HMS *Antelope*, second of the Royal Navy's new Type 21—Amazon class-frigates, was launched at the Woolston shipyard of Messrs Vosper Throneycroft Ltd on March 16 by Mrs Kirk, wife of Mr Peter Kirk, MP.

With an overall length of 384 feet, HMS *Antelope* will be armed with the Seacat surface-to-air missile system and a 4.5in gun. The Wasp helicopter with which she is to be initially equipped will be subsequently replaced by a twin engined WG13 anti-submarine helicopter.

She is the tenth ship in the Royal Navy to bear the name Antelope. The first, constructed at Deptford in 1546, fought against the Spanish armada: the last, a Tyne built destroyer, took part in the Battle of the Atlantic and North Africa landings in the last war.

Measuring vibration levels can save maintenance time and reduce costs *

by Bertel Lundgaard †

The failure of a machine is preceded by an increase in its vibration level in more than 90 per cent of the cases. As a matter of fact, a study made by the Canadian Navy only showed one instance when failure occurred without such a warning. This is not surprising if one considers that vibration is an indication of imperfections in a machine.

Vibration levels are such a useful indication of the condition of a machine that this concept may be utilised as a quality check from the time the machine is purchased to the time it is scrapped.

Neither maximum vibration levels nor maximum noise levels are presently parts of the specifications for most commercial ships. They both should be. The Navy usually does specify maximum vibration levels by requiring that machinery meets MIL-STD-167. This standard requires that complex machinery shall not exceed a vibratory velocity of 0.15 inches per second. These standards are not applicable to reciprocating machinery, but only to rotating machinery. If we compare the MIL-STD requirements with a common commercial vibration severity chart, we find that the military requirement is not very severe.

**Maritime Reporter and Engineering News*, February 1972

†Mr Lundgaard, partner, Diehl and Lundgaard, Bainbridge Island Wash, presented the paper condensed here before a recent meeting of the Pacific North West Section of The Society of Naval Architects and Marine Engineers

A good, well-balanced machine is defined as one which has a vibratory velocity less than 0.1 inches per second. It has been our experience that quality rotating equipment often has a velocity below 0.02 inches per second and a new rotating machine should certainly not have a vibration velocity exceeding 0.1 inches per second. Table No. 1 gives the values used in a study undertaken by the Maritime Administration. If the 0.1 inches per second value is used in the specification, it should lead to very little if any additional purchase cost and it would give the owner the opportunity to reject a "lemon."

It is more difficult to specify vibration levels for reciprocating machinery, but a well-balanced multicylinder machine should not vibrate more than 0.3 inches per second.

If vibration monitoring is to be used for failure prediction and as a guide for a planned maintenance programme, it is extremely important that each machine be subjected to a vibration survey after it has been installed. This will provide the following information:

1. Insure that the manufacturer has complied with the specified vibration levels.

2. Determine that the installation work has not introduced unacceptable unbalance or misalignment to the equipment.

3. Determine the basic, new equipment vibration levels. These are the values with which all subsequent machinery deterioration will be compared.

The installation check-out is particularly important when two pieces of machinery are bought separately and combined and installed by the shipyard. Since each machine obviously has some inherent unbalance, the individual unbalances of the components will be either additive or subtractive. By rotating one machine relative to the other, total vibration can often be reduced substantially. It usually only takes two or three tries to determine the relative angular position which will result in a minimum vibration. This may pay off handsomely in reduced maintenance cost.

Unacceptable misalignment always can be discovered

Table No. 1—Vibration Velocity for Shipboard Machinery

Peak Velocity (in./sec.)	Severity Rating	Severity Classification
Above 0.6	Very Rough	High vibration level, considered potentially unsafe, detailed vibration analysis required to identify trouble. Excessive vibration may cause oil-film breakdown. Consider shutdown.
0.4 to 0.6	Rough	Considered hazardous. Detailed vibration analysis needed to identify trouble, rapid wear expected. More frequent periodic vibration checks needed to detect further increases. Schedule for repair.
0.2 to 0.4	Slightly Rough	Faults likely. Detailed analysis needed. Continue periodic checks. Schedule repair, if needed.
0.1 to 0.2	Fair	Minor faults. Continue periodic checks to detect increase.
0.0 to 0.1	Good	Typical of well balanced, well aligned equipment.

and corrected at this time. There is no faster and more accurate method for checking that a machinery assembly has been accurately aligned than to conduct a vibration survey as a part of the equipment test.

After the initial vibration levels have been determined, a programme of periodic vibration monitoring should be organised. The purpose of such a programme is three-fold: To be able to prevent deterioration from reaching the point of failure; to determine when a machine should be overhauled, and to act as a guide to the extent of the overhaul.

Ideally, overhaul should be undertaken right before the machine fails. Many attempts have been made to develop a definite set of vibration-level criteria which will indicate that failure is near. Most authorities appear to agree that a vibration velocity level of 0.5 inches per second or higher indicates that a failure is near and repairs should be scheduled as soon as possible. If the vibration level exceeds 0.75 inches per second, immediate shut-down is advisable. However, the rate of increase of vibration levels may be more important than the absolute levels. A reasonable interval between vibration surveys is a month. If the vibration levels have doubled since the previous survey, repairs may be in order, particularly if the resulting vibration levels are close to the allowable limit.

Every machine will have many frequency peaks. Usually, the vibration levels will only increase at one or two frequencies and these frequencies will indicate the source of the vibration. For instance, rolling-contact bearing failures are always associated with a high frequency vibration. The frequencies associated with a given type of bearing can be calculated and if the vibration level at any of these frequencies shows an increase, and if the resulting level gives reason for concern, the machine should be re-balanced.

Setting up a vibration-monitoring programme need not be expensive, but if it is to achieve its purpose, it must be carefully planned. The basic steps are:

1. Deciding which machines should be monitored.
2. Establish the basic vibration characteristics of the machine.
3. Determine the time intervals between surveys.
4. Develop a record sheet for each machine.
5. Instrumentation selection.
6. Operator training.

It has been determined that monthly vibration surveys will catch practically all beginning failures.

There has been a rapid advance in instrumentation for measuring vibration in the last few years. Not only has the number of available instruments increased, but they have become smaller, lighter and more versatile.

It is advantageous to be able to use as few operators as possible, two are ideal.

Conclusions

The only reason for using vibration monitoring for failure prediction and maintenance guidance is if it saves money. The costs of setting up a programme are not extreme. $10,000 to $40,000 initial cost, depending on the number of machines which are to be monitored, is a reasonable figure. After the programme is operational, it can usually be handled by one man, part time.

The benefits that may accrue from this are considerable:

1. Reduction in sailing delays due to unexpected machinery breakdowns. As already mentioned, more than 90 per cent of failures can be predicted and repairs made at a convenient time.

2. During overhauls, a great deal of "open and inspect" time can be eliminated once confidence in the programme has been created. The Canadian navy study listed a saving of 18,000 manhours on this item alone during the overhaul of five ships in one shipyard.

3. New machinery may be checked after purchase, and existing machinery may be checked after repair, to insure that it is satisfactory before the ship leaves the yard.

4. When a vibration survey indicates that repairs are required, it will usually also pinpoint the nature of the repair, thus saving maintenance time.

The relationship between machinery failures and vibration levels has long been established. I believe that in the future this relationship will lead to vibration monitoring becoming an important tool for the men who maintain ships.

Britain's Skynet II due to be launched in early 1973

A prototype model of Britain's Skynet II military communications satellite has been completed by Marconi Space and Defence Systems Limited, a GEC-Marconi Electronics company. This first prototype, designed and built in the company's spacecraft laboratories in Portsmouth, carries all of the main units of the satellite, each with its appropriate surface finish, and mounted in the correct position on the spacecraft framework. The completed prototype has been dynamically balanced on the spin table installed in the Marconi laboratories, and vibration tests have also been carried out in a specially built model with all the cable harnesses, pipes and other components which might be susceptible to vibration.

The prototype satellite has been tested at the Royal Aircraft Establishment at Farnborough in a vacuum chamber, with heating elements simulating the effect of the sun's energy. The satellite is being spun at its designed spin stabilisation speed in this thermal vacuum, to produce a precise simulation of the cyclic heating effects and consequent thermal distortion which will be experienced in practice.

*Internal fault protection for ac marine generators**

by J. A. Hall BSc (Hons) MIEE

In any marine installation the total loss of electrical power could greatly hazard the safety of a ship particularly when manoeuvring or when under adverse conditions. Hence a generator should be disconnected from the main bus-bars only as a last resort. Nevertheless, the situation does occur when such action is essential and one such situation is the occurrence of an internal fault within the machine itself. Should an internal fault occur the field current must be interrupted as quickly as possible and the generator disconnected from the rest of the system. If it was not disconnected energy would continue to be fed into the fault, resulting in the possible destruction of the machine. Furthermore, any generator running in parallel would be in danger of being lost. Fire risk increases with fault duration as does repair time and cost.

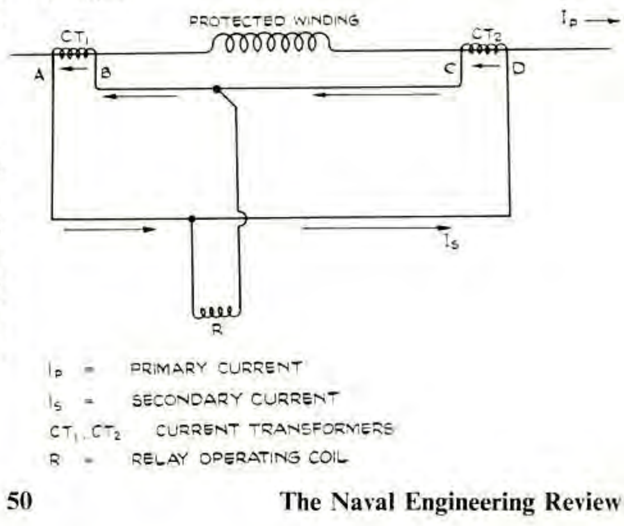
The methods used at present for alternator protection are well known and it is not proposed to discuss them further. It is not, however, usual for Merz Price systems to be used in 440-volt marine installations despite the fact that in the past many engineers have advocated their use. It is appreciated that winding faults on 440-volt machines are rare but they do occur and the consequences can be serious. The work undertaken at the British Ship Research Association attempts by statistical and economic arguments, using such parameters as fault incidence and repair costs, to put the problem in perspective.

Basic principles

The Merz Price system which may be used to protect generators, transformers and feeders incorporates the principle of either voltage or current balance. When applied to the protection of alternators the circulating current principle is used, the fundamental criterion being the current entering one end of a machine winding is equal in magnitude and phase to that leaving at the other. Current transformers are installed at each end of each phase winding their polarities arranged so that when a primary current passes through each in the same direction the secondary windings are in series and a current will flow in the pilot circuit, Fig. 1.

Assuming equal primary current, identical current transformers and uniform connecting leads, it follows that there is an infinite number of equi-potential points across which the relay may be connected. Under normal operating conditions no current will flow in the relay circuit, but should a fault occur inside the protected zone the current transformers become unbalanced and when the degree of unbalance reaches the value necessary to operate the relay the generator is disconnected from the system via the generator circuit breaker. In practice two current transformers and one relay are required per phase. The system is stable to through-faults, ie, those occurring outside the protected zone, and to obtain the maximum benefit the line current transformers are placed as near to the main circuit breaker as possible thus protecting the generator and the associated cabling. Various schemes are avail-

Fig. 1. Current balance system using circulating current principle



**The Marine Engineer & Naval Architect,* November 1971 able commercially and manufacturers should be consulted on their application.

Analysis of generator winding faults

In order to obtain as representative a sample as possible data have been collected from three separate sources on winding faults occurring on generators on board ship. The data were tabulated as shown in the example in Table 1.

TABLE 1

Machine at fault	Number of machines at risk	Number of faults occurring	Description	age of faulted machine Years
750kW	450	1	Full 3-phase short-circuit, burning out whole of lower half of stator winding and core.	6
1,000kW	100	1	Stator windings completely burnt out	4
150kW	650	1	Stator burnt out causing short circuit and fire.	10

For each sample the number of machines multiplied by the time at risk (machine years) was evaluated and the number of faults recorded was noted. Hence the expectation of a fault occurring per machine year could be calculated.

TABLE 2

Sample No.	Total machine years	Total number of faults	Expectation of a fault per machine year
1	3457	8	0.002
2	970	6	0.006
3	588	5	0.0085

As may be seen from the three samples the data consist of a small number of events, ie, winding faults in continuous time and therefore the Poisson distribution is considered a suitable model.

The Poisson probability distribution function is:

$$P(x) = \frac{e^{-m} m^x}{x!} \quad \text{————} (1)$$

where $x = 0, 1, 2,$ etc.
and m is the expected value of x.
For n numbers at risk for time t the expected number of faults is $n\lambda t$, where λ = number of faults per machine year.
Hence $m = n\lambda t$
From equation (1)

$$P(x) = e^{-m}\left(1 + m + \frac{m^2}{2!} + \frac{m^3}{3!} \text{————}\right)$$

The successive terms in the expression give the probability that an event, ie, a fault, will occur, 0, 1, 2, etc, times.

On considering various numbers of generators at risk the probability of any number of faults occurring per machine year may be computed. Thus, for example, considering 500 machines at risk for one year the following table is obtained.

TABLE 3

	P(0)	P(1)	P(2)	P(3)	P(4)
Sample 1	0.37	0.37	0.18	0.06	0.02
Sample 2	0.05	0.15	0.22	0.22	0.36
Sample 3	0.014	0.06	0.13	0.18	0.62

From inspection of Table 3 it is seen that the results from sample 1 predict much lower failure rates than samples 2 and 3. When tested statistically there was no significant difference between samples 2 and 3 but there is a difference between samples 2 and 3, and 1. It is difficult to draw rigorous conclusions from the data but factors such as age, environmental considerations and particular loading details should theoretically be taken into consideration. It is impossible in practice to obtain this information.

If any benefit is to be obtained from the results the correct value of λ must be used. It is noted that all the machines in sample 1 were ten years old or less and in samples 2 and 3 the age varied between one and 16 years. Thus as samples 2 and 3 predict λ values which do not differ significantly an overall value is calculated and applied to the results.

$$\text{ie, } \lambda_o = \frac{6 + 5}{588 + 970} = 0.007$$

Economic and general considerations

1 General

In the foregoing, the overall value λ_o was calculated and it is assumed that this value applies to machines up to a maximum age of 16 years. It should be noted that λ is not a constant and is a function of time, but sufficient data are not available to determine the variation. Hence the optimum course of action is to limit the time considered to 16 years and to assume that λ_o applies for the entire period. The expected repair costs for any number of machines at risk may then be calculated.

The cost of repairing any alternator depends on the extent of the damage sustained, and once again it is impossible to forecast how much a particular fault will cost. Thus after investigating the repair costs of actual occurrences it was decided to implement repair cost levels of 25, 50, 75 and 100 per cent of initial machine cost.

2. Evaluation of expected repair cost

Using the assumed fault cost levels, the cost of the machines and the Poisson probability function the expected repair cost over 16 years for any number of machines at risk can be computed. The prices of the generators and the protection schemes were supplied by a leading manufacturer and at the time of the original investigation (1970) were 5 per cent high. Hence $E(x) = P(1)x + P(2)2x + P(3)3x - - - P(n)nx$ where x is the repair cost at a particular level and E(x) is the expected cost. If we consider 50 generators (any number could be chosen) the following table is readily obtained.

TABLE 4

50 generators at risk for 16 years

Machine rating kW	Expected repair cost (per cent) 25	50	75	100	Cost of protection
350	6.82	13.64	20.46	27.28	18.5
500	7.89	15.78	23.67	31.56	18.5
750	8.53	17.06	25.59	34.12	20.0
920	9.51	19.02	28.53	38.04	20.5
1250	11.71	23.42	35.13	46.84	20.5
1500	13.07	26.14	39.21	52.28	20.5
2000	22.62	45.27	67.86	90.48	20.5

The above costs are given in £x10^3 and the results are plotted on Fig. 2.

Fig. 2 is plotted on a purely cost-to-cost basis only and no attempt has been made to include provision for depreciation or to consider potential reduction in any amount paid in corporation tax for the years during which failures may occur. Neither has the time value of money been considered as this would require a third dimension to be introduced into the problems based on the probability values attached to each incident. As stated earlier, this paper attempts to present the basic case for internal fault protection.

Explanation of Figure 2

The use of Fig. 2 is a matter of experience, for example, if the repair costs of an internal fault are likely to be 50 per cent of the generator cost curve 5 should be used. If they are likely to be 75 per cent of machine cost then curve 2 should be used. The nearly horizontal line (3) is the cost of protection.

Conclusions

1. On a purely cost to cost basis and in the light of personal experience it can be decided with the aid of Fig. 2 when to include internal fault protection equipment. Unfortunately it is impossible to cost delays to ships and loss of revenue but these factors only add to the case for its inclusion.
2. Provision of internal fault protection apart from limiting fault damage assures continuity of supply.

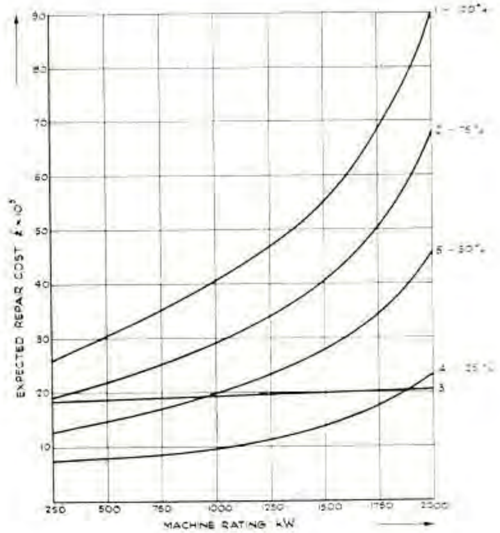


Fig. 2. Expected repair cost against cost of protection –50 generators at risk for 16 years

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General Secretary's notes and comments (cont. from page 3)

Chief Artificer is borne because the supervisory or managerial side of the job warrants it. Sometimes because the job is particularly highly technical and requires his expertise. In others the job is a combination of both. In every case the Chief Artificer/Mechanician should bear the Fleet Chief rate because of his qualifications and experience, whether in such a billet or not. A Lieutenant Commander does not lose half a "stripe" if he happens to be appointed to a post previously held by a Lieutenant or that is in fact held by a Lieutenant in a sister ship.

Many, who would stay in the Navy if they attained Fleet Chief rate on being promoted to Chief Artificer, are opting to leave the Service after 12 years (at the age of 30) rather than serve a further 10 years with comparatively little extra reward or prospects during that period. If they expect to get any appreciable improvement they have virtually to engage for another 15 years. Employment prospects at 30 or 40, for ex-Artificers are excellent. At 45 the picture changes. Private pension schemes, to which most firms subscribe, do not accept new members over 45 and because the pension policies usually stipulate that *all* the firm's employees must belong, firms are not keen to take over-45s.

HMS Juno win "The little Admiral"

As one of the highlights of Liverpool's recent "Meet the Navy Week", the Kelvin Hughes trophy was presented by Rear Admiral J. E. Pope, Chief of Staff Fleet, to Captain Vause, Commander of the Leander class frigate *Juno*.

Kelvin Hughes trophy is presented annually. It is open to all ships and helicopter squadrons of the fleet and is awarded to the ship or squadron that has carried out the best series of "attacks" on submarines over the past year. This is the first occasion that this coveted lignum vitae statue of the "Little Admiral" has been won by a ship and her embarked helicopter.

It is a carved replica of "The Little Admiral", a ship's figurehead which has associations with the company

Rear Admiral Pope, chief of staff fleet, addresses Captain Vause and officers and petty officers of HMS 'Juno' concerned with the VECTAC before presenting them with the Kelvin Hughes trophy

dating back over 200 years. The original "Little Admiral", was 3ft high, commissioned from a London East End carver by William Hughes, a Limehouse quadrant maker. It became the house sign of Henry Hughes and Son Limited, one of the founding companies of the Kelvin Hughes division of Smiths Industries and was a familiar sight to many generations of mariners and explorers.

HMS *Juno*, this year's winner has another connection with Kelvin Hughes for it is one of a class of vessel scheduled to be fitted with the Type 1006 navigation radar developed and produced for the navy by the company.

A successful vector attack or VECTAC on a submarine involves the skilled teamwork and co-operation of the sonar operators who detect and maintain contact with the submarine, the operations room personnel who plot and assess the submarine's course, speed and evasive tactics, the helicopter control team who guide the helicopter by means of radar and radio to the submarine's position and finally the helicopter pilot and flight ratings who keep it ready to fly off at a moment's notice and arm it with the homing torpedo that it drops over the submarine's position and that finally destroys it. Add to this list all the maintenance personnel whose hard work and vigilance keeps all the various complicated equipment in "top line", it can be seen that to win this trophy requires the efficiency of a large proportion of the ship's company.

Did you know that . . . ?

Over 10,000 hours of running time have now been accumulated with Rolls-Royce RB211 engines in flight and ground testing. This includes nearly 2,500 hours in over 400 flights by the four Lockheed Tri-Stars now engaged in the airliner's flight test programme. The RB211 first ran late in 1968 and flight testing of the Tri-Star began a year ago. Current ground testing of the RB211 is concentrated on the programme required to obtain airworthiness certification for the engine. This programme is now nearing completion. Extended endurance running is also being undertaken to prove the engine's reliability. The first RB211s for airline customers are now being assembled and undergoing their preliminary tests. The initial batch of customer engines will be installed in Tri-Stars for Eastern Air Lines and Trans World Airlines. Aircraft deliveries are planned to start in March and 50 RB211s are scheduled for delivery by mid-1972.

The first submarine for the West German Navy has been christened at Rheinstahl Nordseewerke GmbH, Emden. This submarine is one of a series of 18 vessels, nine of which are being built at Rheinstahl Nordseewerke GmbH at Emden and at Howaldtswerke-Deutsche Werft AG in Kiel.

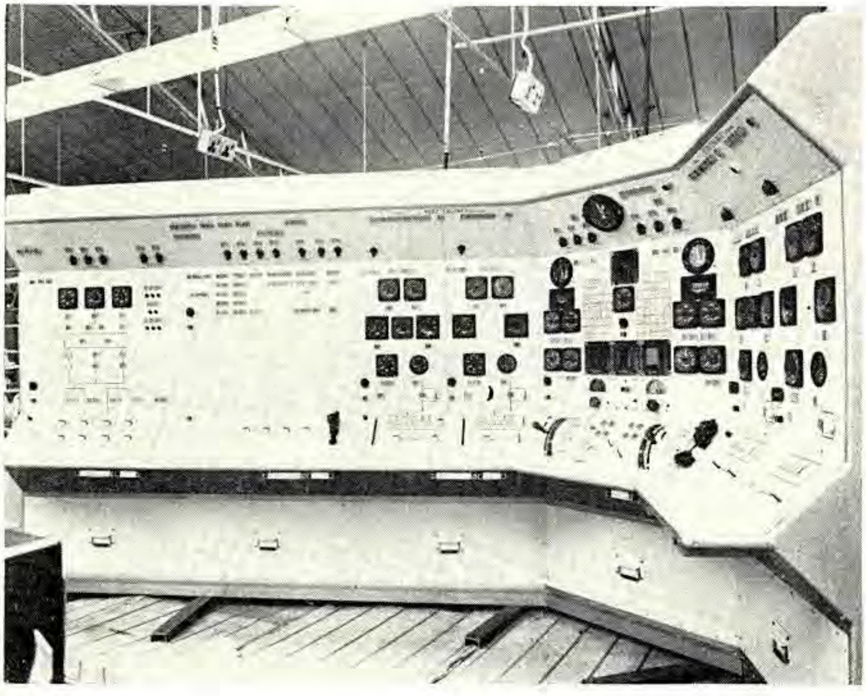
Designated "Klasse 206" these vessels are a similar type to the 15 submarines which were built by Rheinstahl Nordseewerke for the Royal Norwegian Navy during 1964-1967.

The vessels constructed under latest technical knowledge are built of non-magnetisable steel and will have high quality electronic equipment.

The submarines have a length of about 160ft (49.0m), a breadth of about 15ft 2in (4.6m) and a draught of 13ft 2in (4.0m) and are propelled by diesel engines, one electric motor and batteries.

The vessels are equipped with eight torpedo tubes and their crew will be 21.

The two COGOG guided-missile frigates ordered from the Royal de Schelde yard, at Flushing, and which will be powered by twin-screw Rolls-Royce-SSS-David Brown COGOG machinery similar to that of the Royal Navy's Type 21 frigates and Type 42 destroyers will be named *De Ruyter* and *Tromp*. *De Ruyter* was the name of one of the large cruisers which were under construc-



Main propulsion control console for Type 42 destroyer HMS 'Sheffield'. Small turn switches between the two control levers effect the changeover between Olympus and Tyne engines. The machinery is normally controlled from the bridge

Did you know that...?

tion during the war and not completed until 1953. The name *Tromp* was last borne by the small cruiser which served the Allied cause in the Eastern Fleet so well in the last war.

Marconi Space and Defence Systems has successfully completed the first full SCOT shipborne satellite communications system for the Royal Navy. SCOT, which uses two of the smallest space communications antennae in production in the world, is designed to meet the future long-haul communications needs of the Royal Navy and will work into the British Skynet satellite network.

This system, incorporating the two 1.1m diameter antennae, an engineering cabin containing the main electronic units, and a separate control rack, has now been installed for tests at the Admiralty Surface Weapons Establishment at Portsdown. Later this year it will be fitted into the frigate HMS *Grenville* for sea trials.

Marconi Space and Defence Systems, part of the GEC-Marconi Electronics Group, has a contract worth more than £1 million to build eight SCOT systems. Delivery schedules are designed to allow RN ships to operate into the Skynet II satellites. Marconi Space and Defence Systems are also designing and building these satellites.

The Riva Trigoso yard of Cantieri Navale del Tirreno e Riuniti has launched the 4,300 tdispl guided-missile destroyer *Audace*. Most advanced unit of the Italian Navy, she will be armed with anti-submarine, surface-air and surface-surface missiles, a Breda rocket launcher and three AB 204 helicopters. A sister ship, the *Ardito*, is building at the Castellammare di Stabia shipyard of Italcantieri. The ships are characterised by a so-called Mack (combined mast and stack) and have the following principal particulars:

Length bp	132.0m
Breadth	14.5m
Draught	4.3m

Twin-screw Franco Tosi turbines of 72,000shp will give a speed of 35 knots. At Riva Trigoso the shipyard is on the beach and ships are launched straight into the sea without any drag chains.

The strong position held by David Brown Gear Industries Ltd, Huddersfield, in the supply of naval main propulsion gearing to the world's navies is illustrated by this recent photograph of part of the assembly department at Park Gear Works.

Part of David Brown's gearing assembly department

Did you know that...?

Nearing completion in the foreground is a 50-ton gearbox being supplied to Yarrow (Shipbuilders) Ltd of Glasgow, to be fitted in a frigate with gas turbine/diesel machinery for the Royal Thai Navy. Behind are three units for Royal Navy type 21 frigates with all-gas turbine transmission being built by Vosper Thornycroft Ltd. The gear on the left is for a Chilean Navy frigate of the Improved Leander Type under construction at Yarrow (Shipbuilders) Ltd.

A pump produced by ITT Flygt Pumps Ltd, of Colwick, Nottingham, is made of hydranalium to British Standard LM5 and is, therefore, unaffected by sea water. Known as the Flygt B2082, the pump is designed to be suitable for work in narrow locations such as in ships. holds or emptying tanks via narrow manholes. The outside diameter is only 245mm (9.65in) and it weighs a mere 132 lb, with a maximum capacity of 170 gal/min and a maximum head of 185ft. The B2082 is designed to resist both use and abuse with the cable entry gland and discharge connection being housed within a circular heavy duty lifting handle which also provides effective protection.

Lightweight ITT Flygt submersible pump

A bayonet type hose connection is used enabling two of these units to be coupled in tandem very quickly for extra pumping height. All parts subjected to wear can be replaced quickly and easily on site and these parts are generally rubber lined with provision for simple adjustment to maintain pump efficiency even after considerable wear. This feature reduces maintenance and wear costs particularly where the fluids being pumped contain other matter in suspension. The integral motor is rated at 9.5hp, three-phase, running at 2,900 rev/min; voltage ratings from 200/550, three-phase are available. ITT Flygt Pumps Ltd, Colwick, Nottingham.

The recent £70m batch of orders placed by the Ministry of Defence (Navy) includes six major combatant vessels; four Type 21 frigates to be built by Yarrow and two Type 42 destroyers to be built by Swan Hunter. This implies firm orders for 12 Rolls-Royce Olympus and 12 Rolls-Royce Tyne propulsion gas turbines, twelve sets of David Brown combining and reduction gears, incorporating SSS synchro-self-shifting clutches. Apart from the military advantages in terms of space, weight and "instant power", a gas turbine frigate has a total engine room complement of 28, as against the 49 of a steam-turbine frigate. Looking to the future the Rolls-Royce Marine RB211 has the same rating as the existing Olympus—28,000bhp for warships and 21,000bhp for merchant operation—but because of its better efficiency it can offer much better economy. When the Olympus 593 becomes available in marine form it will be the most powerful gas turbine afloat, with a naval rating of 50,000bhp and a merchant ship rating of 40,000bhp.

Implementing the agreement signed earlier this year between Rolls-Royce (1971) Ltd and Kawasaki Heavy Industries Co for technical assistance and licence manufacture, the Ansty works of Rolls-Royce Industrial & Marine Division have shipped a Marine Olympus TM3B gas turbine module for testing at Kawasaki's Akashi aero-engine factory. Under the agreement Rolls-Royce will supply the Olympus gas generators and Kawasaki will manufacture, under licence, the industrial and marine power turbine. Kawasaki have presented a number of design studies based on the Olympus gas turbine to interested container ship and other operators. The agreement applies to both the Olympus TM3B engine of 28,000hp for marine propulsion, both civil and military, and Rolls-Royce Olympus SK20 and SK40 (20MW and 40MW respectively) skid-mounted industrial turbines for power generation. Kawasaki will set up a maintenance and overhaul facility for Olympus engines in the Far East.

Did you know that...?

Developed in conjunction with the Ministry of Defence (Naval), the Teddington Mk 4 system meets the requirements for the protection of essential machinery in modern warships. It is suitable for use with most types of machinery, and is already in service in the following applications: Diesel engines, gas turbines, steam turbines, pumps, hp air compressors, refrigeration and air-conditioning plant and distillation plant.

The Teddington Mark 4 system comprises watch-keeping panels of modular construction and sensing elements for pressures and temperatures. The system provides continuous monitoring of various machinery parameters and gives automatic warning of off-limit conditions. It includes facilities for automatic shut-down, audible alarm and remote indication. Temperatures and pressures not directly associated with the alarm system can be displayed on indicators on the modular panels.

The watchkeeping panel carries the plug-in modules of the system, power supply terminals, sensor and remote warning indicator connections. All modules are based on a six inch cube. The mains supply modules will supply a 48v dc supply from a 115v 60 Hz two-wire ac, 440v 60Hz three-wire ac or 48v dc input.

One protection module is fitted for each monitored parameter. It incorporates a meter to display the parameter, an alarm warning lamp and a lamp to show that the shut down circuits have operated. An alarm module is fitted with two "Master Fault" lamps, a "Fault Accept-Fault Reset" switch, together with module relays for remote indication and control.

Where centralised indication and control of individual plants is called for, panels with various additional facilities can be provided, such as:

Multi-point temperature indicators, using thermocouples.

Engine speed indicators driven by ac tachogenerators.

Elapsed time meters.

Position indicators for dampers and valves.

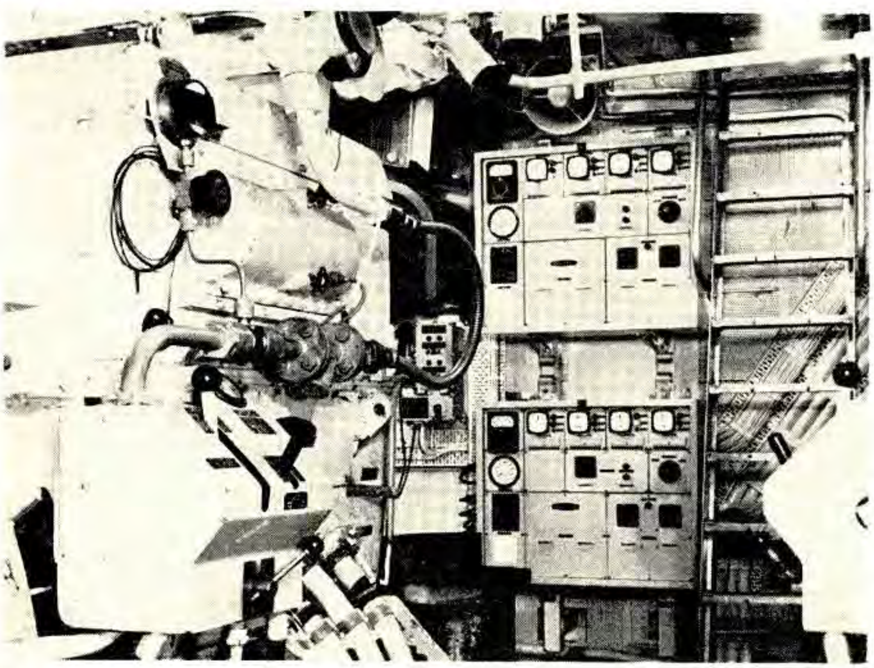
Motor control switches and running indicators.

Although the Teddington Mark 4 protection system is designed to fail safe, it can be arranged to prevent automatic shut down of the plant in the event of a failure in the power supply to the protection system.

Teddington Aircontrols Ltd, Sunbury-on-Thames, Middx.

A new development which could double the traffic capacity of satellite communications systems, is to be investigated by Marconi Communication Systems Limited, a GEC-Marconi Electronics company, on behalf of the British Post Office. The key to this development will be an "add-on" circuit, to improve the mode of operation of the travelling wave tube amplifiers used both in satellites and in their associated ground terminals.

The Post Office contract to Marconi calls for a thorough investigation of ways of improving the



A pair of Teddington Mark 4 equipments installed in HMNZS 'Canterbury' for diesel alternator surveillance linearity of these high-power amplifiers, in order to increase the effective power rating of the communications transmitters. In this way, it is anticipated that the addition of a single unit to an existing transmitter will double its effective power rating and, therefore, its traffic carrying capacity. It is intended that the Marconi development team should conclude their 6 month study by proposing the best solution to this problem, with an outline definition of the hardware involved.

Marconi engineers have already carried out a certain amount of work on this technique, and have registered a patent covering one solution which appears to offer considerable advantages. It is intended that the process of linearisation will be achieved by adding a passive circuit to the input of the final stage of the amplifier. This circuit would be in the form of a single add-on unit, to be added to existing transmitter units with the minimum of difficulty.

The Post Office anticipate using this technique to increase the capacity of their existing stations at Goonhilly, although the technique has much wider applications for other communication systems which depend upon travelling wave tubes or on klystron output stages. The technique will be based on a modification of the input signals, in such a way that their amplitude envelope represents an inversion of the output characteristics of the amplifier. By matching these two characteristics together, it is possible to produce the effect of a linear output characteristic over a much wider bandwidth. With this increased linear output performance, it will be possible to amplify signals at a higher power level without introducing unacceptable distortion, or intermodulation products, in the final output.

The final production unit will probably consist of a stripline circuit, incorporating the necessary passive components to provide the correction required.

Each correction circuit will obviously have to be matched carefully with the characteristics of the type of amplifier in use, but this should only involve changing the values of certain passive elements in the correction circuit, to effect gross changes in linearised characteristics. A number of fine adjustments to ensure precise compensation could also be provided. The same technique could achieve substantial power and weight savings in the satellite itself.

The restrictions under which travelling wave tube amplifiers are currently operated to provide sufficient linearity, can be demonstrated by the fact that the Marconi P2000 amplifiers, used at the Goonhilly 2 and 3 terminals, and in most of the stations built by the Company overseas, use a 10kW TWT, operating at only 3kW, to ensure satisfactory intermodulation performance.

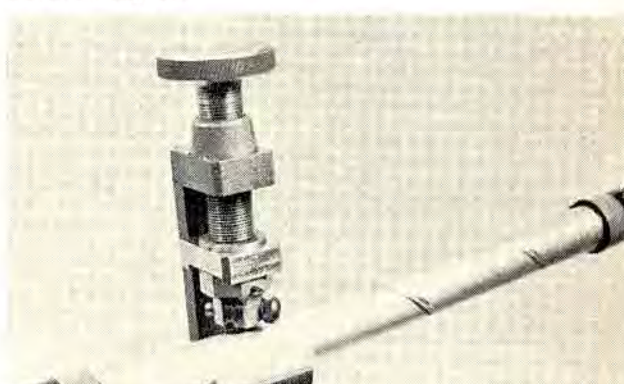
A new type of cargo net made of high-strength nylon webbing is now being supplied to the Navy Department of the Ministry of Defence by the Industrial Division of Irvin Great Britain Limited.

Illustration shows stores in Irvin nylon webbing cargo nets awaiting pick-up on the helicopter platform of Royal Fleet Auxiliary 'Tarbatness' for replenishment of HM ships in the South China Seas

It is light in weight, rot-proof in all climatic conditions and resistant to abrasion. Currently it is chiefly used as a sling for replenishment of ships at sea, either by jackstay (on a line from one ship to another) or by "vertrep"—the Navy's name for vertical replenishment from a helicopter.

The Mark III cable sheath cutter has been introduced by Bowthorpe Electric to replace an earlier model. The new feature is a snap-in/snap-out cutting wheel which can be replaced in seconds when blunt. The existing wheel on the Mark II tools can be used on the new tool. The Mark III tool can accommodate three- and four-core cables from 70 to 185mm^2 and is available on quick delivery. Bowthorpe Electric, Gatwick Road, Crawley, Sussex.

Mark III version of the Bowthorpe cable sheath cutting tool



Did you know that...?

The Ministry of Defence (Navy) has recently placed an order with the special packing division of Export Packing Ltd of Sittingbourne, Kent, to protect and pack Mirrlees Blackstone four-cylinder 330bhp marine diesel engines prior to dispatch to a Defence Distribution Centre in the United Kingdom. The engines are of the type used to power tenders and are complete with clutch and reduction gearbox. They are being given complete external and internal environmental and physical protection prior to packing. The environmental protection has a life of three years. The engines will be protected by double-skinned partial vacuum packs specially designed to eliminate the hazards likely to be encountered in transit. The Special Packing Division of EPL is one of the few companies in the United Kingdom authorised to undertake packing for the Ministry.

The *Hayase*, a 2,000-ton displacement mine sweeper tender has been delivered today to Japan's Defence Agency by the Tokyo Shipyard, Ishikawajima-Harima Heavy Industries Co Ltd, Japan.

The mine sweeper tender, the first of its kind ever built for the Defence Agency, has a length of 325ft (99m), is 47ft 7in (14.5m) wide, 27ft 7in (8.4m) deep, and has a draught of 13ft 9in (4.2m).

Main propulsion machinery consists of four units of Kawaju-Man V6V 22/30 ATL-type diesel engines, with a total output of 6,400shp corresponding to a shp speed of 18 knots. Complement is 180 persons.

Included in the vessel's weapons are a 3in rapid firing gun, two 20mm machine guns and two 3-barrel torpedo tubes. It also has a training mine laying system and mine sweeping equipment.

Ministry of Defence has placed orders worth between £2½ and £3m for five ICL 1900 Series computers for the Royal Navy Supply and Transport Service. A large 1906A system due to be delivered this spring to the RN Supply and Transport Service Inventory Control Centre at Ensleigh, Bath, will be linked to 1904A installations in the naval bases at Devonport, Chatham and Rosyth, and a 1902S at Portsmouth. The satellite computer centres should all be operational shortly. The five-computer complex will provide an integrated logistic system for the provision and supply of general naval stores, victualling and armament stores, and for the operation of motor transport. The principal aims of the system are to optimise stock holdings and inventory costs, to provide an economic level of service, and to improve information both to the customer (the Naval user) and to inventory management staff.

The 2,000-ton displacement mine sweeper tender 'Hayase'

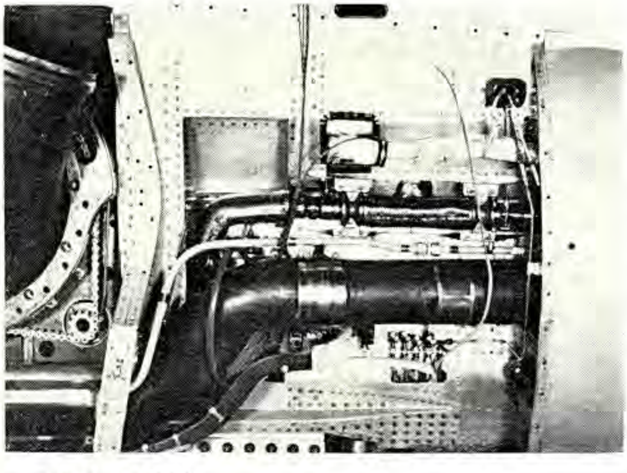
Did you know that...?

Cockerill Yards and Boelwerf have signed a contract valued at £1.5m with Rolls-Royce (1971) Ltd for the supply of marine gas turbines to power a new class of 1500tdispl fast escort ship for the Belgian Navy. Four CODOG ships are to be built in the late 1970s. Each will have a single 28,000bhp Rolls-Royce Marine Olympus gas turbine for boost and two CO240 Cockerill diesel engines for cruising. The Belgian Navy is the nineteenth to specify Rolls-Royce marine gas turbines for powering their warships.

The first commercial application of a new lightweight thermal insulation system for ducting and pipework is used on the bleed system for the lift engine of the VFW-Fokker-Fiat VAK 191B vertical take-off reconnaissance and fighter aircraft now being built in Germany. This insulation provides effective but low cost insulation of piping and ducting in ambient temperature areas of up to 300°C. It uses conventional fibrous thermal insulant held in place by a tensioned sleeve of knitted glass fibres, overlaid by a coating of sealing compound and clad with a layer of oil and fuel-resistant rubber-based paint. Delaney Gallay Ltd, Market Square, Biggleswade, Bedfordshire.

The last few years has seen the emergence of a significant new range of devices for the electronics manufacturer. Hybrid microelectronic circuits offer better performance and higher power levels than monolithic devices, whilst adding their advantages of greatly reduced size and vastly improved reliability.

Lightweight ductwork bleeds high temperature gas from the directed jet seen on the left



Ferranti, with the sound backing of their total capability in semiconductor technology, were among the first to introduce a complete range of hybrids known as Multilin. This equipment combines thin-film resistors and ceramic chip capacitors with integrated circuits and transistors. Earlier in the year the success of this standard range of hybrids, was underlined by their publication in Defence Standards by the Ministry of Defence (N), following extensive reliability trials over an eighteen month period. So successful were those tests that the Company is now quoting typical complete circuit lives in excess of 20,000 hours, making Multilins some two or three times more reliable than comparable conventional assembly on printed circuit boards.

Equally important with their acceptance by the Services, is the growing faith in this technique shown by most major electronic equipment manufacturers. This interest is not confined to the UK market and Multilin devices are currently being examined by some of the more important American manufacturers, with a view to including them in future designs of equipment.

The standard range of Multilins includes complete servo amplifiers, multiple operational amplifiers, power amplifiers and electronic switches, mainly in analogue circuits. New designs incorporate digital devices and the full range can be combined in custom-built versions.

Two sizes of Multilin hybrid packages are produced by the Aircraft Equipment Department of the Instrumentation Division of Ferranti, and their dimensions and weight demonstrate dramatically the high degree of miniaturisation which has been achieved. Two case sizes are used, one measuring 2.1in x 1.2in x 0.2in deep, and the other is 1.6in x 0.8in x 0.2in deep; each is only about 25 grams in weight, using leads in 0.1in centres.

Litton Industries has awarded a multi-year sub-contract, with a potential value of $36m, to Honeywell's Marine Systems Centre for the supply of A/S equipment to the fleet of 30 *Spruance*-class COGOG destroyers. The initial award is for $10.9m and covers the ASW engineering for nine destroyers funded to date by Congress. The ASW systems aboard the ships will include torpedo tubes with their associated handling and storage equipment, the Mark 116 underwater fire control system, and A/S marine rockets (ASROCS) with vertical loading magazines. Honeywell will engineer and integrate weapons systems designed for optimum fire control performance, as well as develop and install certain equipment. They will also provide planning for logistics support and data management procedures. The 7,000tdw vessels will be armed with Sea Sparrow defence missiles, two 5in guns and ASW weaponry. Helicopters will operate from each ship thus extending the fleet's ASW defence and attack capability.

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