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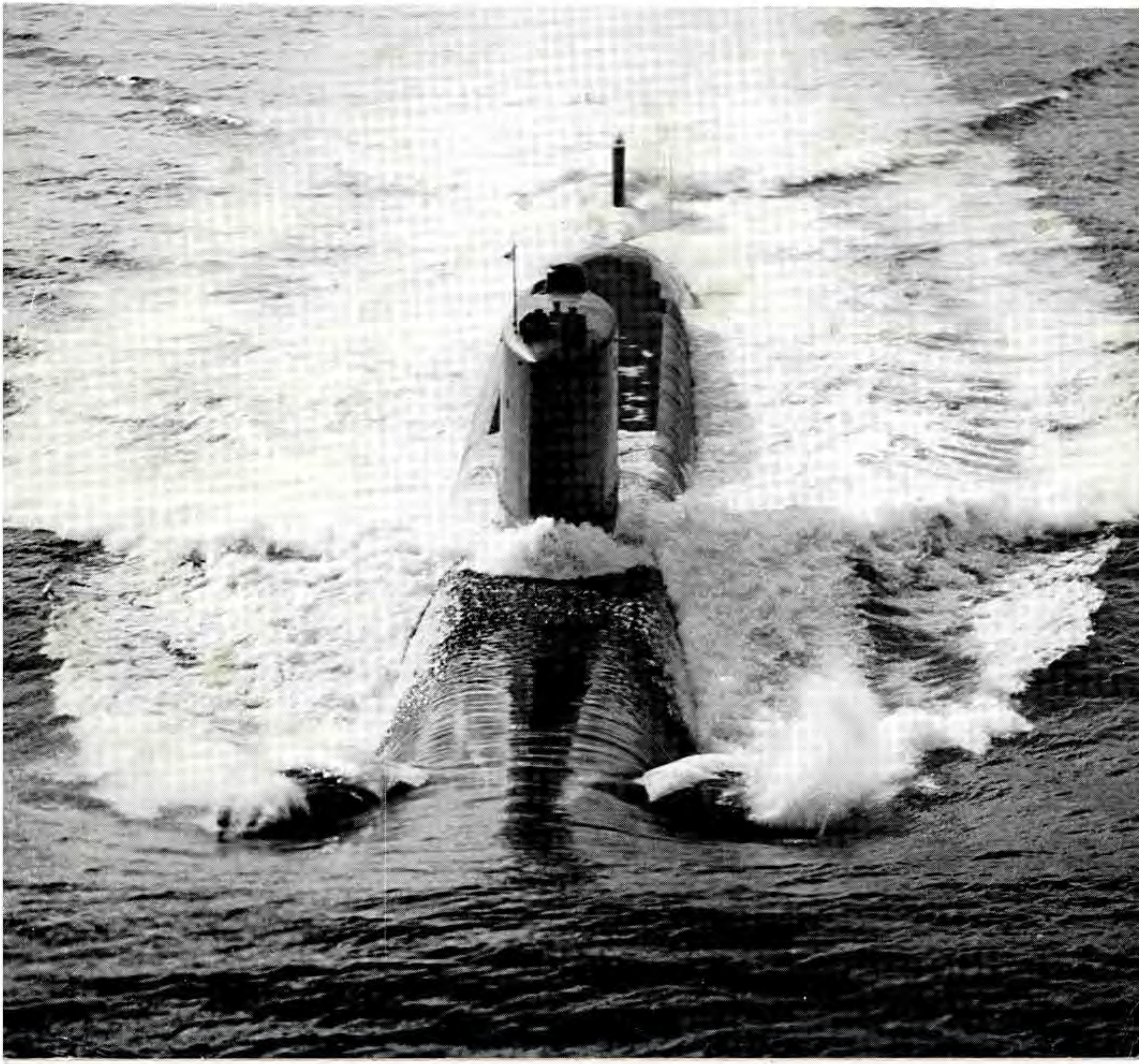

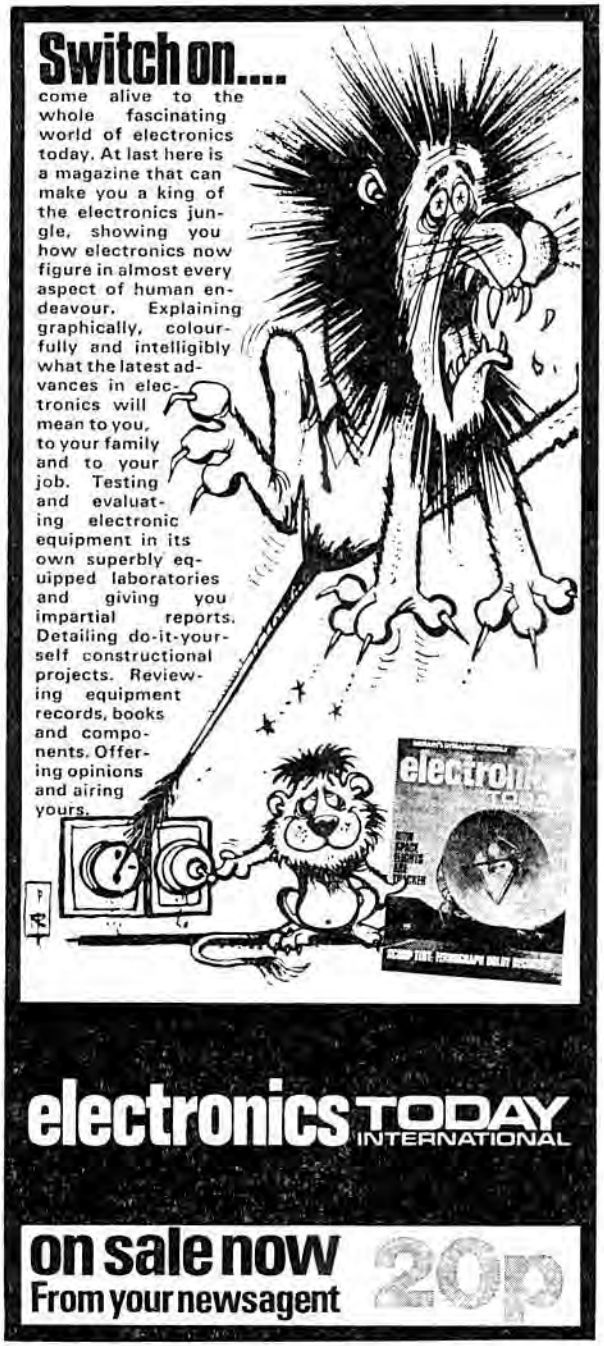

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FRONT COVER ILLUSTRATION

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HMS Revenge, one of Britain's four nuclear powered, ballistic missile submarines carrying out surface speed trials. Each submarine of this class carries sixteen Polaris missiles.

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General Secretary's Notes and Comments

There are welcome indications that for the next entry of Artificer Apprentices the MOD (Navy) will be able to be selective to a degree not experienced for many a long year, probably more than at any time in the last 20 years. Whether this phenomenon is due mainly to the current employment situation or whether it is the beginning of a new trend, remains to be seen. It is undoubtedly influenced by the new regulations allowing apprenticeships to commence up to the age of 21 years. For the first year or two there is bound to be a large reservoir of potential recruits still untapped. This is reflected in the present figures for applications.

Recruits currently include a number who are up to university entrance level, a standard which is desirable, but one which has not been achieved for very many years. I have long advocated that the general educational level of entrants should be raised, but the truth is that it has not been possible to obtain sufficient numbers of even the minimum standard. This dismal trend culminated in the all-time record low entry of April 1971, when only twelve U.K. entrants could be found. Four of these were eventually back-classed.

The scheme to extend the age of Artificer Apprentice entry will undoubtedly have some advantages. Though it has been talked about for a number of years, one of the chief reasons for delaying its introduction was the obvious difficulty of working out an equitable pay scheme. That such a pay scheme was difficult is apparent in that now the pay scales are known, they contain a number of anomalies. These have been pointed out to the MOD and it is hoped that action will soon be taken to remove them.

The older apprenticeship entry has led to the abolition of the Mechanician Apprentice, as being no longer necessary. In my view it is also likely to lead, in time, to the end of Mechanicians as such. There has been difficulty for some years past in obtaining sufficient suitable candidates for training as Mechanicians. The introduction of Mechanician Apprentices retrieved the situation to some extent. Now that suitable ratings may be transferred to become Artificer Apprentices it is obvious that many who would have been potential Mechanicians will so transfer, thus depleting still further the number likely to become Mechanician candidates later. It may well be thought not worth while keeping open this avenue and all the necessary organisation for training, for such small numbers as may be forthcoming in a few year's time. There still remains the Upper Yardman and Special Duties List as opportunities for promotion from the various Mechanics branches. Could it be, therefore, that the Mechanician branch, which created such a furore when introduced by Admiral Fisher, and caused a great deal of bitterness in the early days of this century, is on its way out on completion of an "allotted span" of three score years and ten?

Admiralty Experiment Works

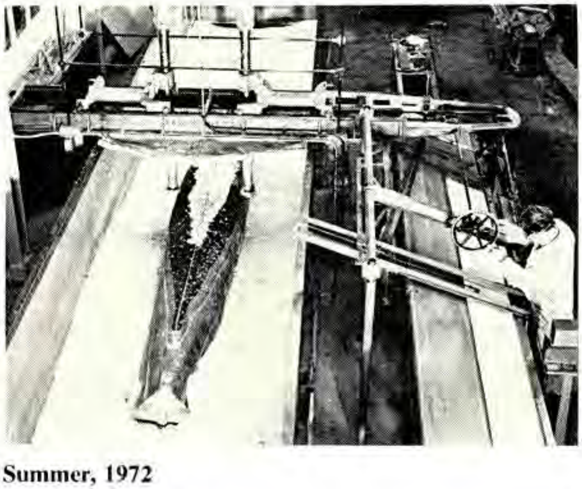
100 Years of Naval Ship Testing

Born in 1810, William Fronde was a civil engineer who retired from professional work in 1846 and from then on devoted himself to his main interest, the study of problems associated with the resistance to motion of ships.

In 1869 the British Association recommended that full-sized ships be towed to measure their resistance. Fronde, however, who had undertaken some rather crude model tests on the River Dart, maintained that this information could be obtained more economically from model tests. In June 1870 work began on the construction of a towing tank at Torquay and the first experiment was run on 3rd March 1872. This involved a model of HMS *Greyhound*, a ship which in 1871 had been towed behind the corvette *Active*. Satisfactory agreement was obtained between the model and ship results.

This Torquay test tank subsequently became known as the Admiralty Experiment Works and to celebrate the Century the establishment recently held a series of Open Days at its facilities at Haslar, near Gosport, to where it moved in 1886. The move coincided with a big increase in the naval shipbuilding programme and by 1918 some 500 different warship designs had been tested. Models of all the First World War British fleet all passed through the one ship tank at AEW.

Cutting the wax model of a hull form, one of the first stages in model making



Between the two World Wars a second ship tank was built and there was also a general re-equipment of the Establishment. Since the Second World War the experimental facilities have been expanded to improve the quality of manoeuvring and seakeeping investigations. At the present time the facilities include the following:

Ship Tanks	No. 1	No. 2
Length	475ft (145m)	885ft (270m)
Width	20ft (6m)	40ft (12m)
Depth	8ft (2.4m)	18ft (5.5m)
Max carriage speed	25ft/sec (7.5m/sec)	40ft/sec (12m/sec)
Circulating Water Channel		
Width	4ft 6in (1.4m)	
Depth (variable)	1in to 2ft 9in	(20-840mm)
Max water speed	18ft/sec	(5.5m/sec)
Max operating pressure	300mm Hg at surface	
Cavitation Tunnels		
	No. 1	No. 2
Working section	2ft x 2ft (0.65 x 0.65m)	8ft 8in x 4ft 3in (2.63 x 1.3m)
Normal water speed	20ft/sec (6m/sec)	15ft/sec (4.5m/sec)
Max water speed	40ft/sec (12m/sec)	26ft/sec (8m/sec)
Range of cavitation		
Number at normal speed	0.5-5.8	0.8-15
Maximum thrust	(4.5kN)	(10kN)
Maximum torque	(240Nm)	(600Nm)
Manoeuvring Tank		
Length	400ft	(122m)
Width	200 ft	(61m)
Depth	18ft	(5.5m)

The manoeuvring tank is equipped with a large rotating arm which can be operated at speeds up to 35 degrees/sec and models can be attached at various radii up to 90·5ft (27.5m). This tank is fitted with ten plunger-type wave makers, five of which are at the opposite end to the rotating arms and the other five on one side adjacent to these. Space does not permit a description of all the experiments shown at the Open Days and the following gives only a representative cross section of the various tasks undertaken.

Propeller design

Although there is little difficulty in designing efficient propellers for conventional warships, problems arise in the requirements for quiet vibration-free running. These problems are due to cavitation which causes loss of efficiency or damage to the propeller, and noise.

Initially, work at AEW was concentrated on loss of efficiency which was serious in the fast patrol boats of World War II. The study of cavitation requires that the total pressure at the model propeller is reduced by the correct scale factor from that on the ship propeller. This reduction of pressure necessitates testing the model propeller in a cavitation tunnel, in which pressure and water velocity can be controlled.

Since the end of World War II the main emphasis in propeller design work has been on the reduction in noise generated by the propeller, which forms the major component of the total radiated noise. The noise produced by the ship and its propeller can seriously affect the use of the ship's own sonar and render it vulnerable to attack by acoustic weapons. Model tests are insufficient to predict the cavitation performance of full-scale propellers and are supplemented by full scale trials in which cavitation patterns are observed through glass windows in the ship's bottom.

Recently, effort has been concentrated on matching the propeller to the flow. This work has been aided by the introduction of the large cavitation tunnel in which complete model ships and submarines can be tested.

A propeller model on test showing cavitation from the blades

Seakeeping

Since the open oceans are rarely calm, warships and their crews spend much of their lives in moderate seas and must be able to withstand very severe storms occasionally. New ships and their equipment must be designed to operate effectively and safely in all these conditions of weather. For studies in head and following seas a Ship Tank is used while the Manoeuvring Tank is needed for oblique seas. Research into the behaviour of ships in a seaway is leading to a much better understanding of the hull form characteristics which distinguish the good sea boat and is leading to an increase in the range of sea conditions in which warships are operationally effective.

Seakeeping experiments are carried out in both Ship Tanks and in the Manoeuvring Tank.

Submarine control

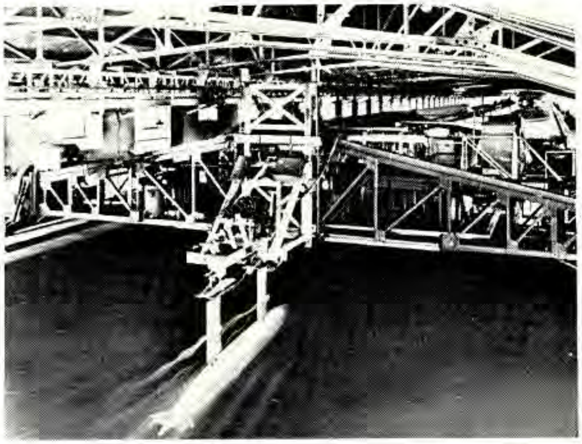
To ensure that the submarine can manoeuvre safely. AEW studies the motion of the submarine in response to engine orders, hydroplane and rudder movements and ballast changes. Since the submarine is free to move in six different motions simultaneously—surge, heave, sway, roll, yaw and pitch—these studies can be very complicated.

No experimental facilities exist in which the manoeuvring of submarines in three dimensions can be studied using free models. It is necessary to use a blend of mathematical models, computer simulation and simple model experiments. Differential equations of motion are established and model tests on the Rotating Arm and Planar Motion Mechanism are used to obtain numerical values for some of the coefficients. Predicted behaviour is checked during full scale trials on the submarine.

The Planar Motion Mechanism applies simple harmonic motion in the vertical plane to a model suspended below it. The centre of gravity of the model follows a sinusoidal path while the model either remains horizontal or pitches to follow the sinusoid. These tests provide the coefficients required to solve the equations of motion in the vertical plane (rise and dive). Similar tests with the submarine mounted on its side provide the data for motions in the horizontal plane (turning). The Planar Motion Mechanism is also able to roll the model while the model moves along a straight and level path.

The Planar Motion Mechanism gives information on gentle turns of large radius. It is complemented by tests on the Rotating Arm which gives the necessary data for small radius manoeuvres. Again, the model may be mounted upright or on its side so that manoeuvres in both the horizontal and vertical planes are covered.

The planar motion mechanism on No 2 carriage



Using the equations of motion and the coefficients from model tests, it is possible to compute the path of the submarine. The effect of moving a control surface deliberately, of a control surface jam or of accidental flooding can be calculated. This work has had a great influence on the effectiveness and safety of modern submarines. Current research is aimed at the effect of changes to the configurations of central surfaces, propulsors, bridge fin and other appendages.

Development of Anchors

The Admiralty Standard Stockless anchor has one serious defect in that if dragged for any distance it rolls over and the flukes come out of the sea bed.

In consequence, AEW was asked to develop an improved anchor. A small test tank (7.6m x 1m x 1m) was built in 1948 with a 0.7m fine sand bed covered with 0.2m of water. Anchors could be pulled along this bed by a small electric winch fitted with a dynamometer to measure the pull. A long series of tests of existing and new shapes of anchor led to the AC10 design which had a holding power of 10 times its weight. A few modifications to this produced the current AC14 design used in all new British warships. Some commercial applications have been licensed by the National Research and Development Council.

Another anchor, the AC17, has been developed for use in submarines. This has some of the features of the AC14 but hangs with the flukes in line with the shank so that it can stow vertically in a small hole in the bottom. This design should be suitable for use in ships with large bulbous bows.

AEW experience in this field enables the establishment to advise on mooring problems and also on the depth to which power lines, etc, should be buried to avoid damage from anchors.

It is British Government policy to encourage Ministry of Defence Establishments to assist industry as far as they are able without interfering with their primary defence role. AEW has facilities and expertise not available elsewhere in the United Kingdom and it is usually possible to provide assistance. Charges are made sufficient to recover the actual cost of this work.

The biggest recent task for industry was an investigation into the motions of oil drilling rigs of various designs in waves. This work for ESSO included a study of the forces in the moorings of the rigs.

The skill, experience and facilities of AEW have frequently been used by both British and Overseas companies developing their own designs of surface warship and submarines. The Manoeuvring Tank and its associated equipment is unique and has been used extensively by National Physical Laboratory (Ship Division) and by the British Ship Research Association for studies on the control of super tankers.

Recent activities have included:-

Steering and seakeeping of a very large container ship
Manoeuvrability of a naval support ship
Design of a cable-laying plough
Advice on anchor work
Mooring of hovercraft
Tests of stabiliser fins.

Submarine model below the rotating arm

*Common Purpose—Common Ship**

By Commander Eric Eugene Johnston, O.B.E., R.A.N.†

At the end of World War II, the United States donned the mantle of leadership in its international alliances. It alone of the Free World nations had the requisites for this position, a homeland unscarred by war, a mammoth industrial base, a sound economy, and a vast and brilliant pool of technology. Its allies and friends, weakened by war, were only too grateful for American support and assistance. Today the position has changed; the weak are now strong, while the relative strength of the United States has diminished. New giants have emerged in Asia and Western Europe, with shoulders and thews capable of bearing part of the load.

In February 1970, President Richard M. Nixon placed before Congress his new "Strategy for Peace." Inherent in this policy, now known throughout the world as the "Nixon Doctrine," is the seeking of peace through partnership. Individual nations have been enjoined to re-examine their defence postures for, while the United States is prepared to participate in the defence and development of allies and friends, they in their turn must be prepared to contribute more.

If the Free World is to follow this path, then each nation must tailor its defence posture to meet the new look. The threat must be re-examined, and forces and equipment shaped to meet this threat. For smaller states, a unilateral posture does not bear consideration; limited in manpower, technology, and finance, they must either complement neighbours or bow to the inevitable offers of hardware and protection from one or more of the superpowers, thereby losing a portion of their independent stance.

There are a vast number of World War II vehicles of war available at a minimal cost, and the smaller states could well purchase these and build their strength without any undue strain on their economies. However, they are then faced with the task of persuading their potential adversaries into using vehicles of similar vintage in any future conflict.

What, then, is the universal threat? Is there any maritime savant alive who would have the temerity to single out one single common threat as seen through the eyes of each and every Free World nation? To some, the threat lies in their immediate neighbours or even internal factions; to others, a threat is posed right across the face of the globe by each international move made by countries whose ideologies differ from their own. But, the threat can be generalised to a degree, at least for those nations whose frontiers in some part meet the sea. To them, the threat is contained in anything that menaces their sea lines of communication. All maritime nations of the Free World require the ability to achieve control of the seas; for smaller nations, this control may be required only over their territorial and contiguous waters; for larger nations, control must stretch across broad oceans wherever their flag vessels sail upon vital commerce missions.

The sizes and types of vessels contained within the Fleets of the Soviet Navy demonstrate Russia's rapid acquisition of a formidable maritime capability. There can be no doubt that the Soviets intend to build up an overwhelming global maritime strength based on the *troika* of fishing fleets, merchant vessels and men of war. Whilst it may be argued that the Soviet naval strength is intended to provide defence for their merchant fleet, both naval and merchant vessels in time of peace have their place in Russian strategy with regard to political, economic, and military influence in the so-called "Third World."

While, in the face of immediate facts, smaller naval powers must re-appraise their concepts of naval defence requirements, they must bear in mind that, despite budgetary limitations, there are many areas of common interest throughout the world which will generate the need for larger naval forces. Such forces can best achieve a more effective common defence through the flexible deployment of compatible units and close co-ordination in combined operations with other friendly forces. This concept of partnership in common defence can be achieved by a careful re-examination of the nation's maritime needs on a regional, as well as a national, basis. For example, the possession by every nation of a number of CVAs, while impressive, is hardly laudable if the escort forces are consequently forced to an unacceptably low level.

Suggesting common naval defence policies does not mean that nations should subordinate their own interests to those of their partners, nor tailor their forces to meet the needs of others. It does mean that they should recognise that common interests can be served by common efforts and that international harmony can be achieved only by practising the spirit of partnership at all levels. Despite the continuing rising costs of naval ship construction and the limited budgets of smaller

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† Commander Johnston joined the Royal Australian Naval College at the age of 13 and on graduation proceeded to the United Kingdom for further training. He has seen service in frigates, destroyers, cruisers and carriers and served as Executive Officer of a Frigate and a Destroyer. In 1969-70, he commanded HMAS *Vendetta* (DD-08) on gunline duty off Vietnam and, subsequent to that posting, attended the Naval Command Course at the U.S. Naval War College, Newport, R.I. He is at present serving as Chief of Staff and Chief Planner for a forthcoming SEATO Exercise.

nations, one of the many possible answers could be found in the encouragement of commonalty in key ship design features. Such an approach may foster the employment of these ships in possible multi-national naval operations among nations having common regional interests, while gaining real economies in logistic and maintenance support.

It is therefore possible that some of the problems besetting the smaller maritime nations, financially incapable of mounting and supporting an extensive research and development programme, could be overcome by the production of a small vessel of war with universal appeal, which we can dub the "Free World Frigate," a vessel of around 2,000 tons with a good mix of weapons and sensors.

The desired vessel should be capable of carrying out a mission along the following lines: "To be capable of operating effectively and efficiently in support of task assigned under individual national naval requirements, and also to be compatible in operating in combined naval task forces with ships of any friendly nation, or international authority, supported by individual governments."

What, then, are the primary tasks to be considered prior to proceeding on to a design study in depth?

A perfunctory glance at any publication dealing with world trade will quickly reveal the large degree to which maritime nations of the Free World depend upon sea transportation for those commodities which are not only essential for the conduct of war, but, more importantly, for their very existence. Carried under many and varied flags, these commodities must be brought across the ocean highways, which, if inscribed upon the face of the globe, could be likened to the umbilical cords of nations. These cords, like those of newborn children, lie vulnerable to the scalpel, and experience gained in the last two global conflicts should have left us in no doubt as to the identity of the prime surgeon of the high seas—the submarine.

In the early 1940s, Germany, with but a handful of slow submarines, brought the United Kingdom to its knees, to the point where the Western world tottered on the very brink of disaster. Today, the Soviet Union possesses over 400 submarines capable of deployment throughout the world, more than 400 scalpels poised to begin their surgery without even the solace of anaesthesia. It should be noted that an additional 400 submarines are in the possession of 32 other nations, with many more projected or building.

Each navy, either separately or in conjunction with its allies, must have the ability to seek and destroy those enemy submarines which threaten its country's lifelines. This task must be accomplished either in focal areas, or while escorting convoys or single ships, or while providing protection for major naval vessels. It is with these thoughts in mind that ASW is selected as the vessels' primary task.

Brushfire wars, insurgencies, missile-firing patrol boats, and heavily armed surface units and aircraft, all pose differing threats; and allied to the prime task of ASW, we may add the following:

- The conduct of surveillance and patrol duties;
- The destruction or nullification of missile-carrying patrol boats;
- The destruction of aircraft and missiles within limited range; and
- The destruction of ships to a limited range.

At this point we should pause and allow the united voices of gunnery officers throughout the world to bellow for a naval gunfire support capability. The immediate lessons of the Vietnam War would form the platform for their vociferation and the author, privileged in having commanded a destroyer on the gunline, could well be expected to add his voice to theirs. It is my contention, however, that sufficient NGFS platforms are already in existence and further, to burden our small vessel with a gun of worthwhile range and firepower, would be to increase her size to a degree where she becomes an unattractive proposition.

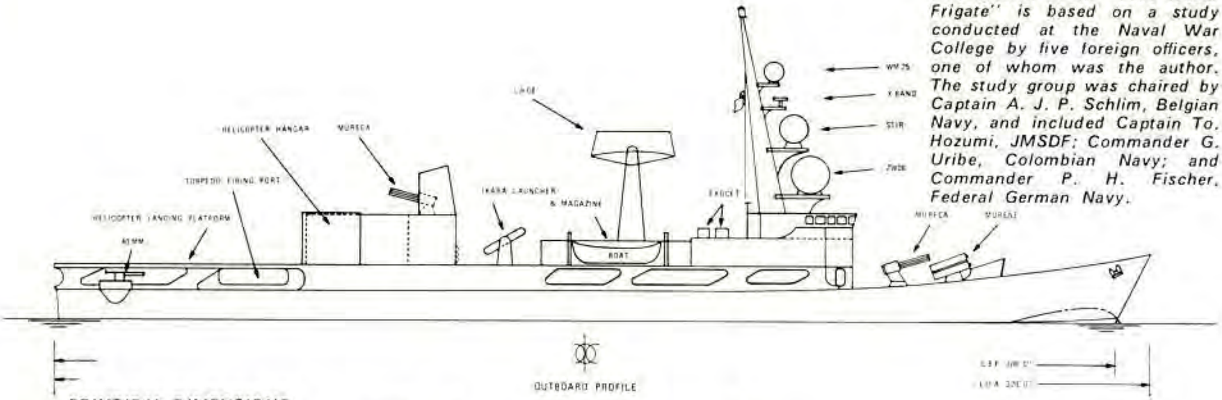
Before selecting the method of propulsion of the vessel it is necessary to set certain speed and endurance figures which must be met by the plant. We must take into account the vessel's tasks and the general configuration, while bearing in mind the need to keep the propulsion unit relatively small in comparison to the overall hull size. Thus, we will achieve the maximum availability of weight and space for weapons, sensors, and control systems, i.e., the vessel's *raison d'etre*.

Included under our primary task, ASW, is the escorting of merchant vessels and major naval units. It can be assumed that the days of convoys with speeds of advance of 10 to 12 knots are numbered and, while the occasional slow convoy will still be formed, the escort of the future must be able to cope with duties in association with convoys whose SOA is in the 16-to-18-knot bracket.

It can be further assumed that convoys during future global conflicts, like those of World Wars I and II, will suffer from a lack of escorts, leading to a requirement for each to patrol a fairly large sector on a screen. Therefore, it would appear reasonable to expect our escort to have a speed advantage over the convoy of at least 4 to 6 knots. The escort should be capable of maintaining this speed throughout an Atlantic-type crossing without requiring replenishment, and we can this mark both escort and economical speed at approximately 22 knots. It is significant that, with existing medium-range sonars, a serious decrease in performance figures occurs above this speed.

Other convoy escort requirements can be stated as fast movement from a screening position to a median distance datum, fast movement and acceleration to intercept surface raiders, and rapid return to a depleted screen after prosecution of a datum. A high-speed

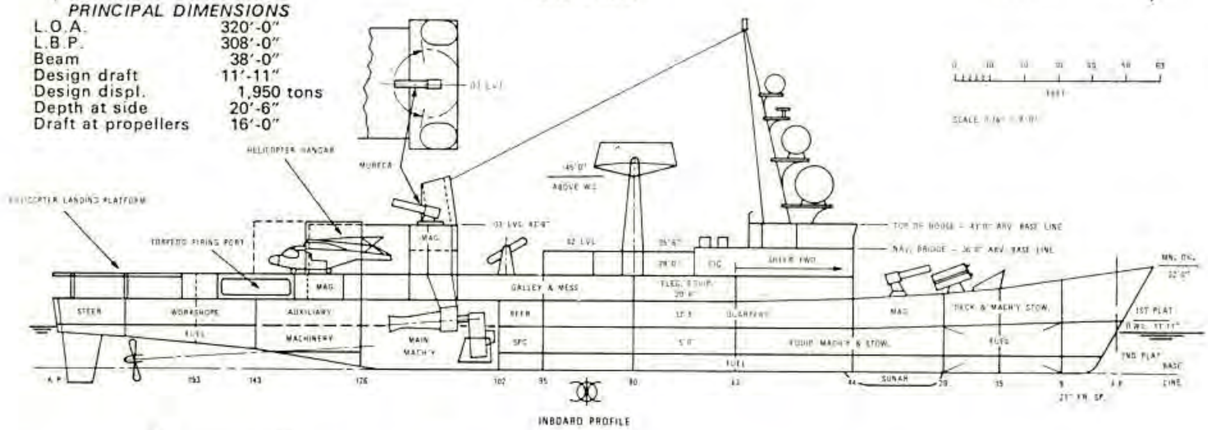
This version of the "Free World Frigate" is based on a study conducted at the Naval War College by five foreign officers, one of whom was the author. The study group was chaired by Captain A. J. P. Schlim, Belgian Navy, and included Captain To. Hozumi, JMSDF; Commander G. Uribe, Colombian Navy; and Commander P. H. Fischer, Federal German Navy.



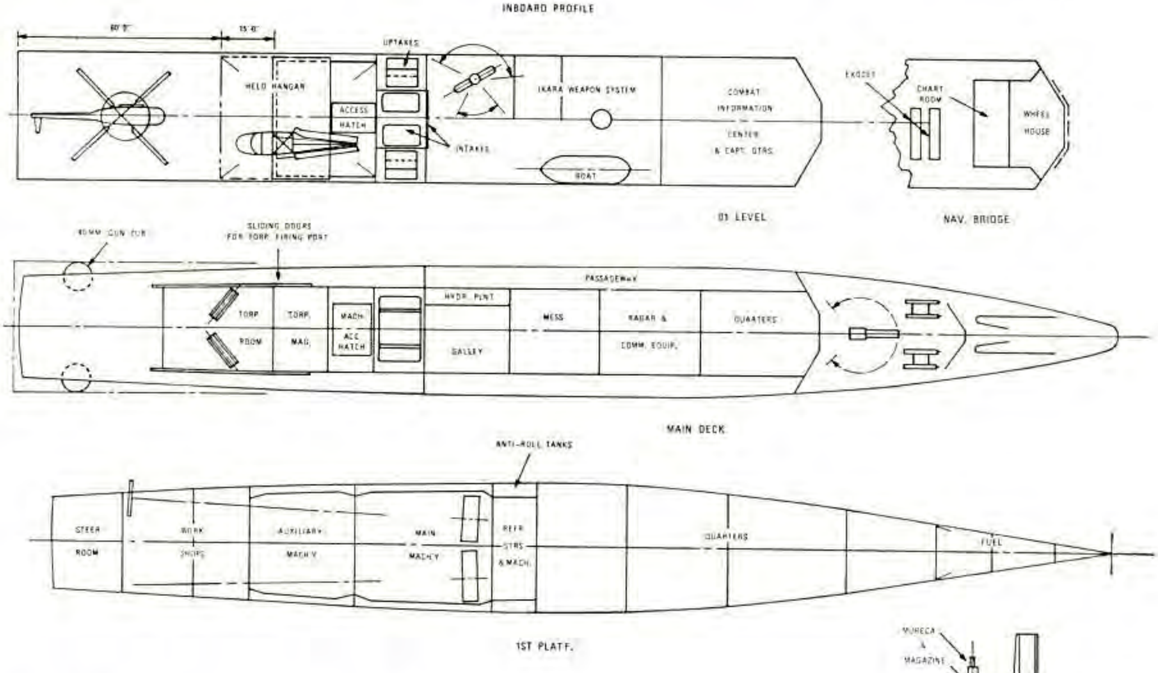
OUTBOARD PROFILE

PRINCIPAL DIMENSIONS

L.O.A.	320′-0″
L.B.P.	308′-0″
Beam	38′-0″
Design draft	11′-11″
Design displ.	1,950 tons
Depth at side	20′-6″
Draft at propellers	16′-0″



INBOARD PROFILE

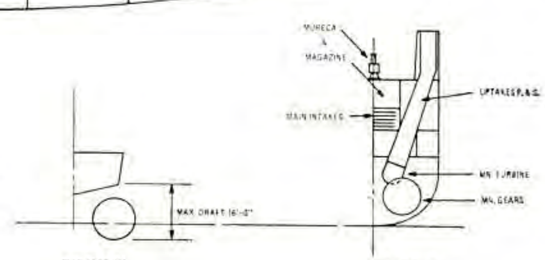


01 LEVEL

NAV. BRIDGE

MAIN DECK

1ST PLATF.



ARMAMENT

(1) Ikara launcher
(2) Mureca launcher
(2) Murene launcher
(2) Exocet launcher
(2) Torpedo launcher
(2) Manned helicopter

MACHINERY

Direct drive gas-turbines		
Controllable feathering propellers		
No. Props.		2
S.H.P.	2 x 15,000	2 x 25,000
Max. Speed	30 knots	37 knots
Range @ 22 kts.	5,200 n.mi.	4,400 n.mi.

requirement also exists in ship-to-ship combat, and the ability of an escort to repeatedly and rapidly change position around a convoy's flanks, providing point anti-missile defence, may well prove to be of paramount importance. To compete adequately with existing threats and those of the immediate future, the speed and endurance parameters of our hypothetical vessel would appear to include the following:

- Maximum speed = 35 + knots
- Economical speed = 22 knots
- Endurance = 4,000 + nautical miles at economical speed.

Since the day when primitive man, paddling his dugout canoe, discovered that by holding a number of joined skins against the wind he could propel his vessel by using the forces of nature, the world's mariners have seen a number of further significant changes in the method of seaborne propulsion—steam, diesel, combinations of diesel/steam/gas turbines, gas turbines and nuclear power. The cost and degree of skill required for nuclear propulsion render it unfeasible for most nations; however, the gas turbine appears to invite closer inspection.

In 1965, marine gas turbine horsepower was just over 1,900,000; by late 1969, this figure had soared to 5,800,000. In addition, it is perhaps significant that of the 1,100 marine gas turbines in use at the end of 1969, 96% were powering naval or coast guard vessels of 14 different nations. The rapid increase in use of the marine gas turbine, together with the arrival of such second generation plants as the General Electric LM2500, the Rolls-Royce RB211, and the Pratt & Whitney FT9, with their lower weights and 30% improvement in fuel consumption per shaft horsepower, would appear to indicate that for minor vessels of war at least, the gas turbine is the only way to travel.

The gas turbine, sufficiently powerful to provide our desired maximum speed, is designed for minimum specific fuel consumption (SFC) at the design power point, in order to provide the best possible range at full power or flank speed. This follows on logically from aircraft jet design—aircraft jet engines being most efficient at maximum speed, i.e., when the efflux velocity most closely approaches the aircraft's forward speed.

The problem, of course, is that as we drop in power, (and therefore speed), the SFC rises at an alarming rate, hence the number of CODAG, COSAG, COGOG, etc., combinations presently at sea. These combinations, while overcoming the fuel problem, seriously reduce the space available for other purposes and introduce a requirement for two types of engineroom maintenance, skill, and training. If we accept as a prime requirement the need for only two gas turbines to be fitted, the answer could well lie in locking or trailing one shaft at cruise speeds. At those speeds, which can be achieved by one engine and one propeller, the other engine could be shut down at immediate notice and its associated shaft either trailed or locked; the running shaft meanwhile being maintained at revolutions which would achieve 22 knots with the best possible SFC. Any excess revolutions, or power, could be throttled by using a controllable reversible pitch propeller, the fitting of which has the added advantage of doing away with the need for complicated and space-consuming astern gearing.

While commercial security classifications do not at present permit the reproduction of SFC curves, research indicates that, with a fuel capacity of 550 tons, a 2,000-ton ship steaming at between 22 and 24 knots would have a range of around 4,500 nautical miles.

Twin shafts and twin propellers have been assumed as a necessity and while there is insufficient space in this article to argue the pros and cons, it would appear that the disadvantages inherent in a single shaft outweigh the increased costs brought about by two shafts and two propellers. To achieve good response when backing, the CRPs must be inward rotating so as to move the centre of thrust outward of the propeller centre, thereby increasing the moment of radius and improving the steering effect.

It is readily apparent that the small ship/helicopter marriage is a magnificently flexible and mobile partnership, increasing to a great extent the fighting capabilities of both vehicles. Today's small fleet escorts face two major threats—the submarine and the missile-carrying ship or aircraft. In ASW, the deficiencies arise from the difficulty in classifying and holding subsurface contacts and the inability to deliver weapons at long range; for the missile threat, the escorts' problems arise from a shortfall in surveillance capability. The need to increase the sensor range of the ship to "beyond the horizon" and to provide a long-range offensive and defensive weapon system is of the highest priority; a fact driven home by the sinking of the Israeli destroyer *Eilat*.

Two helicopters are required to provide flexibility in operation and availability. They should be large enough to carry out their varied missions, and yet be small enough to fit into the hangar space available in a small ship. They must be configured so as to carry out the following roles:

- Attack missions against submarines or surface craft.
- Investigation and classification of long-range sonar and radar contacts;
- Provision of a defensive barrier against surface-launched missiles;
- Provision of "beyond the horizon" visual and radar information;
- Carrying out ancillary missions such as SAR, personnel and logistic transfers, coastal and inshore patrols and NGFS spotting for ships in company.

To perform these multiple missions the selected helicopter must be capable of carrying a variety of equipment, some permanently installed and others capable of quick installation and removal to provide rapid reaction to the changing requirements of any operational situation. These requirements appear to be met most satisfactorily by the Westland/Sud Aviation WG-13, shortly to be produced in America in the Sea Lynx version by Sikorsky. This medium-sized, twin-engined vehicle is rated as an advanced frigate-borne anti-submarine search-and-strike helicopter, and has a single engine capability. It is equipped with a non-retractable tricycle-type landing gear designed for high shock absorption, facilitating take-off and landing when operating from small decks under severe weather and sea conditions. In addition, it is fitted with a Harpoon landing system and the helicopter can also be pressed to the deck with a force of 3,000 pounds by use of the rotors. By holding with the harpoon, the aircraft can rotate on deck and point into wind without the ship having to be turned.

It can carry two torpedoes, Sparrow, Chaff, MAD, radar, IFF, data link, and a small dipping sonar and, with an economical cruising speed of 159 nautical miles, has a range of over 500 miles.

The requirement for the vessel to operate around the world, in shallow coastal waters and berthing in shallow harbours, with limited access to drydocking facilities, narrows the selection field for the sonar fit. The attractiveness of a bow mount is decreased by the need to keep the draught to a minimum; the space required for two helicopters renders a variable depth sonar (VDS) fit unfeasible. What is required is a retractable hull mount, capable of underwater repair and replacement without recourse to drydocking. It must have active and passive modes, be capable of search and attack, have good performance in both deep and shallow water, have a low power requirement, and be simple to operate and maintain.

For ASW weapon launchers, the requirement exists to fire at close-range targets, while retaining the ability to cover long-range detections held by ship's sensors, helicopters, or other units. The ability to control a missile in flight from launcher to point of water entry has moved from the desirable to the mandatory, bearing in mind the significant increases in submarine speed and manoeuvrability over the past decade.

Logistics, maintenance, and training are simplified by having a single weapon, and the aim should be for the helicopters, the close-range and the long-range launchers to all carry or fire the same missile.

For our surface armament, we must examine separately the surface-to-surface and the surface-to-air spheres. The need for a gun in a small escort has already been argued in this paper; what is required is a missile which has a performance at least comparable to that carried in small ships of a potential aggressor nation. It must have a good hit probability, be difficult to detect and engage, require minimal maintenance and operational personnel, and have compact and light-weight construction. Additionally, like all equipment for this vessel, it must be available now or be in the very last stages of development so that research and development costs are not borne.

For surface-to-air it would be impracticable to hope for a missile system in this size vessel which would provide area defence. What should be possible is a system which will give a high-hit probability in point defence, rapid acquisition and shifting of targets, while retaining low weight, space and personnel requirements.

Finally, for close-range low-value targets, such as waterborne logistics craft WBLCs, we need a number of lightweight small-calibre gun mountings with a high rate of fire and a good mix of ammunition.

The fire control system for all weapons, ASW, SAM and SSMs, must use standard building blocks to permit the design of an integrated system.

All these weapon systems, covered in the previous paragraphs, have a final requirement for overall control. The speed and complexity of modern maritime operations indicates that this control should be sited in some centralised location, and be assisted as far as possible by computerisation. The logical site, of course, is the combat information centre. From here, the captain can fight his ship in all types of action, with ready access to all the data necessary for the professional performance of his duties. It is realised that there is still a school of thought whose advocates propound the theory that the captain's place in action is on the bridge. This would appear to be an incongruous line of thought. Given proper compilation of fitness reports and career planning it must be assumed that the captain, by virtue of his years of background experience, is the tactical expert in the ship; how illogical then to separate this man from the prime source of tactical information.

The principal purposes of the combat information centre should be:

- To provide the command with a clear, concise, comprehensive, and up-to-date picture of the tactical situation in its entirety;
- To provide the facilities for exchange of tactical information between units, both surface and airborne, via a data link; and
- To provide facilities for rapid and accurate target designation to all the ship's weapon systems.

All this must be accomplished with a minimum cost in manpower.

Up to this point, we have dealt with the weapon and sensor fit in generalities, postulating requirements which approach the ideal. Is such a ship in fact feasible using off-the-shelf equipment? I believe it is.

First, let us take a well-known hull form with proven underwater characteristics, say the *Hamilton*-class WHEC. For propulsion we will fit two General Electric LM2500 gas turbines, each driving a shaft fitted with a Ka Me Wa controllable reversible pitch propeller.

For ASW, the hull could be fitted with a Canadian Type 505 retractable hull-mounted sonar. The long-range weapon answer is best found in an Ikara mount with 24 vehicles and for close-range firings two Mk. 32 triple launchers should be fitted aft. The actual weapons for these launchers and the helicopters would be Mk. 46 homing torpedoes.

For surface-to-surface firings, the Exocet appears to be the best available. This missile has an all-weather attack capability and a range of around 25 nautical miles. Its radio-altimeter-controlled, low-flight path makes it extremely difficult to detect until the final 10 kilometres of flight, when terminal guidance is provided by active radar homing. One of its most attractive features is that the missile and its containers require no maintenance for a period of one year and the operational side can be handled by one man. Six missiles would be an adequate fit, with additional requirements being filled by normal unrepping.

For point air defence, it is suggested that the vessel be fitted with two Mureca systems. The Catulle part of Mureca consists of quick reloading multi-tubes of rocket-assisted projectiles, providing multiple gun effect salvos with predetermined dispersion between .3 and 2.5 kilometres, and a kill probability of better than 70% at 1,500 metres. The Murene part of Mureca, which has an effective range of between 1.5 and 8.5 kilometres, is fired from a launcher which holds eight missiles. This Mach 2.3 missile has a warhead fitted with an infra-red/VT fuse combination which is unaffected by counter-measures or atmospherics; the warhead itself being designed to produce a very high velocity directed fragmentation burst (2,300 metres/second), which is effective at a range of 8 metres. One target acquisition unit can control both launchers and handle up to 12 threats simultaneously. The launcher itself, using a divergent monopulse tracking, three-beam receiver radar can guide two divergent missiles onto the same target.

For low-value surface targets, it is suggested that each quarter be fitted with a gun sponson, each carrying a twin 35-mm/.90 Oerlikon KDA-Otomelara mount, which requires no below deck space.

For overall weapon control, the Netherlands company H.S.A. produce an advanced combination which, with the addition of one STIR antenna, gives the best possible answer in a small ship, and the total control in the CIC would be handled by the Ferranti/Decca computer aided action information system, (CAAIS). The type fitted in vessels of comparable size can accept inputs from three radars and IFF, auto-tracking up to 20 selected air and surface targets with past history on selected tracks being stored for display on request. Four submarine tracks can be displayed as well as 16 unassociated contacts and three datums with associated furthest-on-circles. At full capacity, CAAIS will display up to 60 tracks from all sources, provide six outputs of bearing, range, and elevation for target designation and indication, solve ASW helicopter VECTAC problems, solve relative velocity problems, record data for later analysis and training, and costs around $400,000.

Finally, for radars, we could turn again to the HSA company and fit one LW08, one ZW06 and a STIR antenna, together with a small navigational radar, as desired by the buyer.

Our Free World frigate then, is a high-performance, ocean-going multi-purpose escort ship capable, as her name implies, of being constructed, in Free World countries. She is in effect an ocean platform for a mix of Free World weapons and sensors. Her construction has a number of desirable features; the placement of the machinery in the after one-third of the ship releases the comfortable midships area to crew quarters and control spaces. The helicopter hangar and landing deck use the after one-third of the topside area and give the ship her distinctive look. The uptakes and intakes are located at the forward end of the hangar which serves not only for the maintenance and protection of the helicopters but also provides access to the engineroom and the torpedo magazine.

The ship has the ability to make fast (22-knot), economical ocean passages, can be manoeuvred rapidly and with ease, can come to full power quickly, and remain at sea for extended periods of time. The crew, approximately 120 in number, would live in above-average comfort with more than adequate space available for the stowage of gear. It is, subject, of course, to detailed design study, a viable and highly desirable small escort.

The effectiveness of this and similar projects, however, depends largely upon the number of vessels purchased; and the effectiveness of the vessels themselves can be enhanced by the installation of the most modern, reliable and proficient weaponry and sensors. Obviously, this sophistication in equipment will not only increase the cost, but will also make it technologically impossible for some smaller under-developed states to produce such a vessel on their own. Cold realism drives home to us all that, if we wish to compete on the high seas with any hope of success, the burdens of high cost and high degrees of sophistication must then be borne.

The necessary steps must be made now, while the smaller nations still have a chance of catching their more fortunate brothers; each year of delay makes the task more difficult and less likely of success. But, even while propounding this blinding glimpse of the obvious, we must acknowledge that it is tied to another realism—that the world is made up of "haves" and "have nots." It would at first seem as though the smaller nations were faced with the unpleasant choice between remaining in possession of outdated equipment or increasingly relying on handouts from more affluent states. Today, however, multinational co-production and co-development of weaponry offers many advantages to the participants, derived from the sound management practices required to co-ordinate a multinational and multi-industrial organisation.

Success can be achieved by grouping together states which have geographical proximity and common regional interests. Such organisation would not only reduce the cost of personnel movement and transportation of material, but also would permit close co-operation and frequent contact between regional neighbours.

Let us divide the Free World into three regional groupings—Europe and Africa, Asia, and the Americas. The United States, leader of the Free World, would appear in all three groups. Next, let us follow the kernel of the Nixon Doctrine in that financial and technical help would be given to under-developed nations to help modernise their armed forces, which, even though it was an American statement, could well be echoed by other developed nations.

The vessels should be built in each of the three regions, at sites selected by regional committees. Costs of building, material, and equipment should be subsidised by the "haves" with the United States bearing a portion of the load in each region. Yardworkers and technicians from each purchasing country should be employed in the shipyards while their national vessels are being constructed and set to work, in an effort to spread advanced technology throughout the world.

The most common language throughout the three areas would appear to be English and therefore it is further proposed that the technical and operational training centres for personnel manning the vessels should be established in America, Australia, and England, with the costs of training also being subsidised by the "haves." The amount of subsidy would be agreed regionally, based perhaps on per capita GNP, but in no instance would the subsidy be total, for it is necessary that each purchasing country contribute something. For those small nations whose balance of trade would be seriously affected by any contribution, the supplying nations could doubtless restore the balance by agreeing to purchase a like monetary amount of goods, ensuring that foreign exchange balances were not seriously affected.

So far we have seen what is mainly a one-way flow, from the "haves" to the "have nots." How can the "have nots" effectively contribute, an essential both for national pride and the implementation of the Nixon Doctrine?

The final proposal, therefore, is that all nations who wish to take advantage of this subsidised building and training programme must agree to commit, for predetermined periods, vessels so purchased to regional standing forces along the lines of StaNavForLant.

By following these steps, countries such as the United States can assist the smaller nations in obtaining modern, sophisticated vehicles of war, while at the same time achieving a reduction in forces and equipment stationed abroad: the smaller nations will acquire modern vessels, weapons, sensors, and training, achieve higher standards in military operations, and help in the provision of their own regional security.

But, perhaps Free World nations are not yet ready and willing to spend the money necessary to purchase such vessels in adequate numbers. Perhaps, instead, they prefer to sit back and bemoan the inadequacies of their forces—while the potential aggressor goes from strength to strength.

Quartz-Rod lighting has greater brilliance than optical fibres

Specfield Ltd have been appointed sole UK licensees for the Anvar quartz-rod endoscope lighting system. Quartz-rod lighting gives a brilliant cold-light illumination unmatched by any other system. Fibre-optics are estimated to give up to forty times the intensity of light of which distal (far end) bulbs are capable, but Specfield claim that their quartz-rod system can illuminate with even greater brilliance than optical fibres. The remote lighting source is an air-cooled bulb (up to 250W air-cooled tungsten projection lamps or (to special order) 50 to 150W quartz-iodine air-cooled projection lamps). Specfield endoscopes are invaluable inspection instruments for looking inside pipes, pressure cylinders, tanks, combustion chambers (turbine and diesel)—in fact anywhere with an aperture large enough to take the slim endoscope body. Specfield, 12 Park Street, Windsor, Berks.

Inside inspection using a Anvar quartz-rod endoscope

*Two-stroke engine piston developments**

For many years pistons have been regarded as the "Achilles heel" in the search for higher specific outputs from both two-stroke and four-stroke diesel engines. In the former field an interesting design step related to one of the best known series—the 71 of General Motors, Detroit Diesel Allison Division. These remarks apply with particular force to turbocharged models ot 250bhp (6-cyl vee), 262bhp (6-cyl in-line), and the 308bhp, 335bhp or 350bhp (8-cyl vees) shown in Figs. 1 and 2. The same piston forms are used also in the normally aspirated versions of the series.

The series 71 is a uniflow two-stroke of $4\frac{1}{4}$in. bore by 5in stroke (107.95 by 127mm), with Rootes-type scavenge blower having three-lobed rotors. A special feature of the design is a combined fuel pump and injector unit in each cylinder head, rocker actuated from a high-level gear-driven camshaft.

This new piston is a two-piece design, known as the "crosshead". It is already in use in limited quantities, allowing power increases up to 15 per cent in the non-turbocharged models. The two-piece character is demonstrated in Fig. 3, whilst Fig. 4 shows the detail build-up.

The skirt or lower part carries all the side-to-side motion imparted by the connecting rod angularity; because it is not affected by thermal or mechanical loads arising from combustion, distortion is virtually eliminated. The crown (or piston dome) passes combustion loading to the gudgeon pin which is bolted to the connecting rod. Thanks to the skirt portion taking thrust loading the crown unit is stabilised in the centre of the bore and the compression rings have a much easier time than usual, not having to cope simultaneously with gas sealing while the piston "wriggles" in its upward and downward paths. This can be studied in Figs. 5 and 5A.

A great deal of research into piston problems was effected before the adoption for production of this latest design. Throughout the study period a two-piece construction was considered essential as providing good castability with minimum weight, oil cooling by

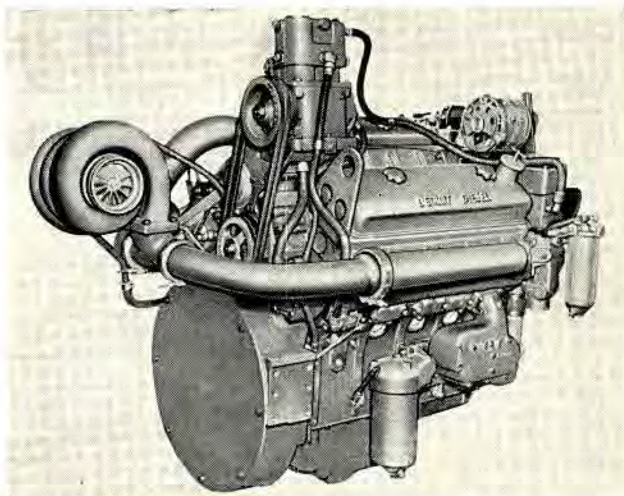


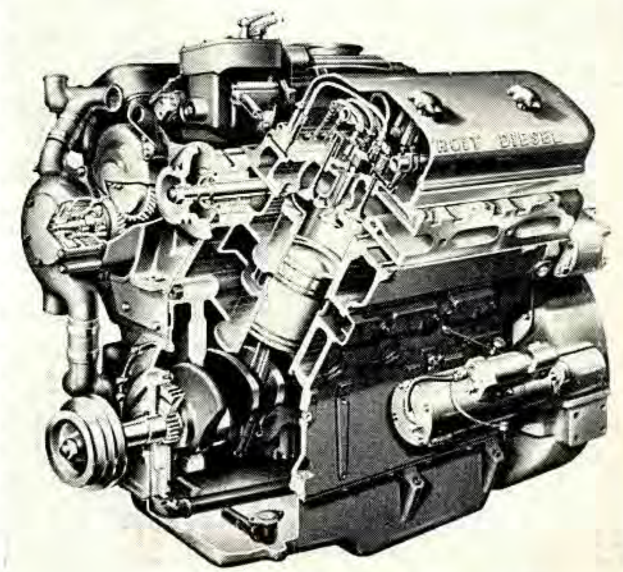
Fig 1. Most powerful of the turbocharged GMC two-stroke diesels embodying the new type of piston is the 8V-71T available at ratings of 308, 335 or 350bhp at 2100 rev/min

"cocktail shaker action", a distortion-free skirt, and a maximum of piston pin bearing area.

Crosshead piston features

The crown of piston dome is the main working component and carries the three compression rings. A pre-finished heavy duty piston pin bearing is inserted into a broached slot in the lower portion of the crown

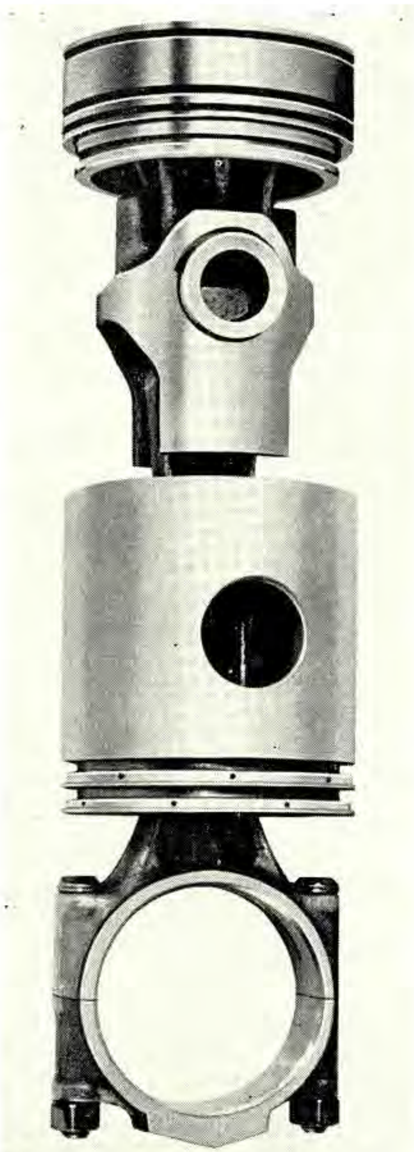
Fig 2. Partly sectioned Vee 8, showing the new piston, inlet port belt and exhaust valves



* Gas & Oil Power, Spring 1972.

to serve as the load-carrying wear surface on the gudgeon pin. The crown is made of malleable iron and incorporates eight cooling fin type load-carrying struts. These struts distribute the combustion gas pressure loads in a very direct manner to the slipper bearings and, through the gudgeon pin, to the top of the connecting rod.

The skirt is entirely free from the crown and is held in place by the ends of the gudgeon pin; it is of malleable iron and tin plated. The skirt carries all side thrust loads, also forming the outer member of the "cocktail shaker" container for the cooling oil, being close to the lower circular part of the piston crown underside (Fig. 5A). The skirt carries typical two-stroke oil-control rings at its lower end. Two gudgeon pin retainers, which are actually only sealing units, are snapped into place to prevent oil or air leakages. A sealing ring is incorporated between the skirt and crown to prevent oil leakage from the "cocktail shaker" or scavenging air leakage to the crankcase. The skirt is machined to a prescribed weight, as is the crown, so that engine balance is maintained without need for parts matching.



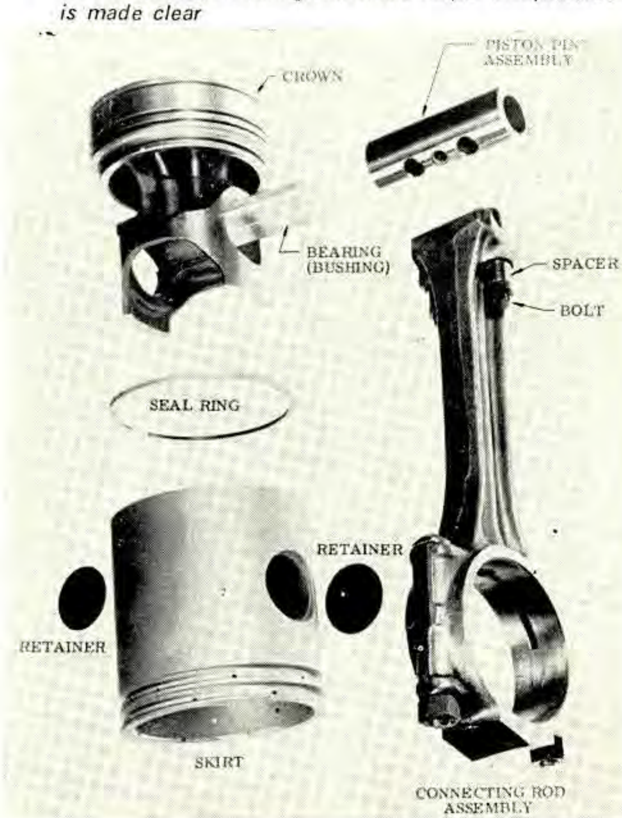
A saddle is machined on the top of the connecting rod into which the gudgeon pin is bolted; this pin includes a pressed-in steel oil-supply tube to carry oil under pressure from the drilled connecting rod directly to the bearing grooves. This provides not only lubrication in the small end bearing but refills the cooling chamber with oil. The rod is secured to the gudgeon pin by bolting into a nut-type component inside the pin.

Functional results

By reason of the "two-piece" construction several

Left: Fig. 3. The crosshead piston showing the two major portions apart, namely the crown plus upper assembly and the separate skirt unit

Below: Fig. 4. Crosshead piston and connecting rod components; the function of the piston pin as the item connecting the three major components is made clear



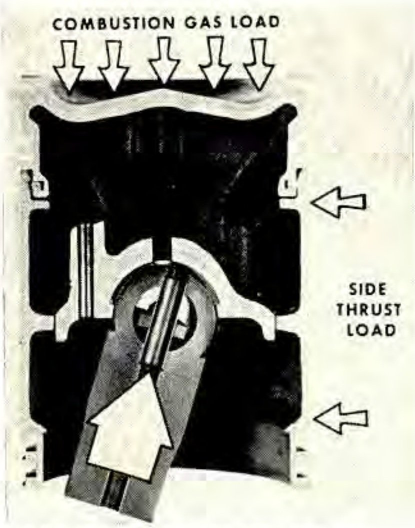


Fig 5A shows how the loadings are translated in actual practice

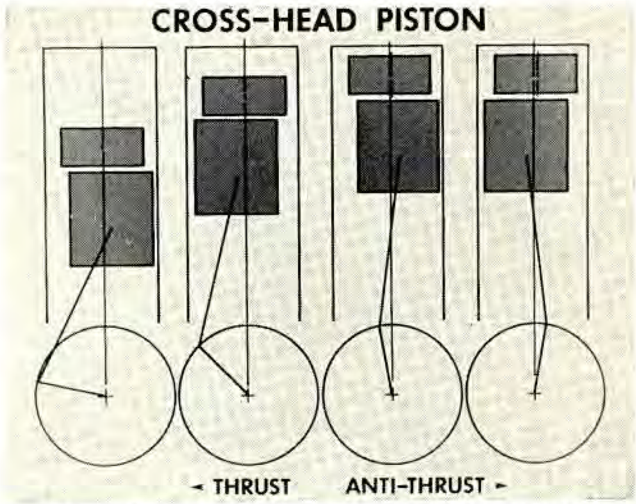


Fig 5. A diagrammatic demonstration of the working of the two parts of the piston during a cycle of operations

advantages accrue. The running clearance is better controlled, thanks to there being less distortion of the skirt member, which maintains its designed shape. Because the piston crown motion is better constrained laterally, as compared with previous designs, ring and groove wear is reduced. Improved lubrication and cooling of the piston crown are obtained, due to the "cocktail shaker" action. Longer gudgeon pin and small end bearing life result from the greater bearing area and reduced bending stress on the gudgeon pin.

In addition to the advantages obtained from the latest piston design the turbocharged models employ a cylinder block giving improved cooling flow, particularly in the zone of the lower portions of the cylinder liners and piston skirts. A fuel-control delay device helps to minimise acceleration smoke without affecting performance. Another item in the recent development programme is the "clean tip" fuel injector which is planned to reduce exhaust emission in order to comply with present and future requirements in this connection.

Ultrasonic cleaning

Ultrasonic cleaning techniques using Du Pont *"Freon" solvents and Kerry cleaning tanks and generators are being successfully applied to vital components of warship control systems by a British marine re-fitting company for maintenance cleaning.

Three former Royal Navy Ships are currently undergoing complete re-fitting and modernisation before they are taken into the Peruvian and Nigerian naval services at the end of 1972.

A high standard of cleaning is essential for cleaning intricate components such as electronic fire control systems, gun control amplifiers and elevation servo units, hydraulic control pumps and valves. Some of this equipment can take as long as two days to dismantle, clean and re-assemble. By using Du Pont *"Freon" solvents supplied by Du Pont (U.K.) Ltd, 18 Breams Buildings, Fetter Lane, London, E.C.4, and a **"Pulsatron" ultrasonic cleaning system, manufactured by Kerry Ultrasonics Limited, Hitchin, Herts., all parts can be thoroughly cleaned in from five to seven minutes without costly dismantling.

Parts to be cleaned are suspended from an overhead hoist and lowered by pulley into an ultrasonic stage of *"Freon" T-WD 602 solvent. They are next double-rinsed ultrasonically in *"Freon" TF solvent and pass through a solvent vapour blanket.

This method of cleaning achieves extremely high standards at a fraction of the time required to obtain similar results by hand or by other mechanical methods.

The makers claim it efficiently removes contamination from interstices and intricate parts inaccessible to hand or mechanical cleaning. The violent distension and contraction of the solvents produces "cavitation"—the rapid formation and collapse of millions of microscopic vacuum bubbles—giving an intense local scrubbing action throughout the fluid.

* 'Freon' Du Pont Registered Trade Mark.

** 'Pulsatron' Kerry Registered Trade Mark.

Space tracking stations *

The Honeysuckle Creek Tracking Station plays a major role in NASA's Apollo missions. Here is a detailed description of the equipment and techniques used

NASA's tracking network for Apollo missions has three prime sites about 120° longitude apart. They are at Madrid (Spain), Goldstone (California) and Honeysuckle Creek (ACT). Other stations, located at various sites throughout the world, support the earth-orbit phase of the missions. Once the spacecraft is about 16,000 kilometres (10,000 miles) from earth, the prime stations assume the responsibility.

Two areas in Australia are concerned with the operational aspects of Apollo missions. These are near Canberra and at Carnarvon (WA).

The Canberra complex consists of two stations, Honeysuckle Creek and Tidbinbilla, each with a 26-metre (85ft) diameter antenna.

For operational purposes the CSIRO's radio-astronomy telescope at Parkes (NSW) is also considered to be part of the Canberra Complex when it is made available for lunar-phase tracking of Apollo missions.

Honeysuckle Creek is the co-ordinating and data processing centre for the complex. Tidbinbilla and Parkes are linked to Honeysuckle Creek via microwave links.

Carnarvon, 1,000 kilometres (600 miles) north of Perth, has two 9-metre (30ft) diameter antennas and is concerned with the earth-orbit phase of the missions, but also acts in a back-up role during the lunar phase.

Tracking requirements

A glance at Fig. 1 shows the multiplicity of signals that had to be tracked at various stages of the Apollo 15 mission and Fig. 2 shows how the downlink signals were shared. In the Canberra complex, for instance, Honeysuckle Creek and Parkes tracked the lunar module and lunar rover on the lunar surface, while Tidbinbilla tracked the command module which was orbiting the moon at an altitude of about 100 kilometres (60 miles).

Sharing is used when more than one signal source is using the same frequency. An example of this was the instrumentation unit of the Saturn IVB launch vehicle stage, the lunar module and the particles and fields sub-satellite—all using 2282.5MHz. The instrumentation unit and lunar module transponders would be offset by 85kHz in opposite directions and tracked in this offset frequency.

During the outward journey, the lunar module was powered down on the lunar surface. This frequency was then available for the lunar module for use during its selenographic excursion.

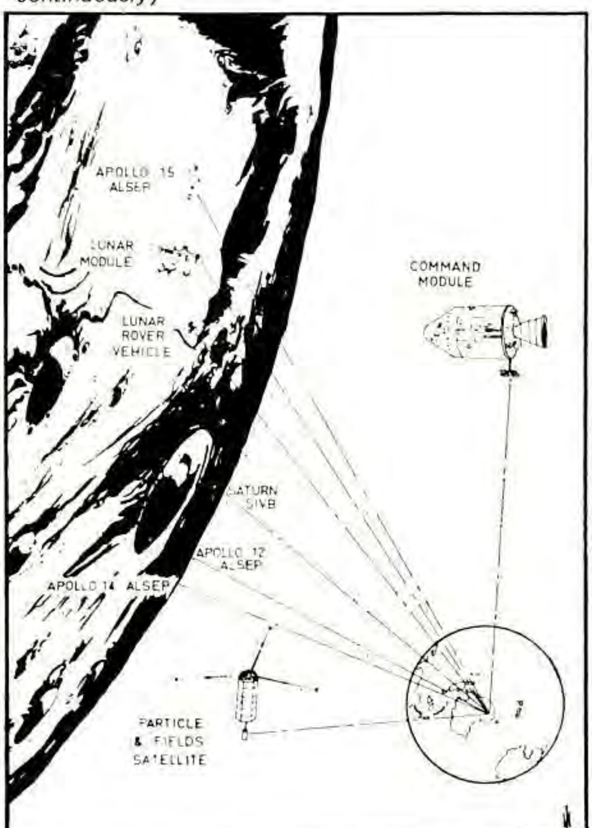
Finally, it too was crashed on the lunar surface and the 2282.5MHz was available for the particles and fields sub-satellite which was ejected from the command module just before its return to earth.

Canberra complex

A brief description of the operational centre of the complex (located at Honeysuckle Creek) will provide an insight into what is involved when a manned mission is in progress.

Located 3,600ft above mean sea level, and 50 kilo-

Fig 1. The various signal sources tracked during the Apollo 15 Mission. (ALSEP 12 and 14 operate continuously)

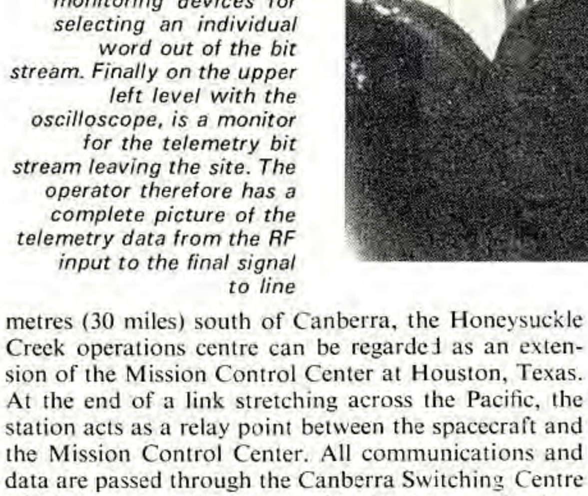


* Electronics Today, International May 1972

Bill Perrin monitoring the spacecraft signals at the Telemetry Console. The oscilloscope above the chart recorder on the left shows the RF down link spectrum from the Command Module. The display in the centre shows the PCM Telemetry bit streams from the Demodulators. Upper right are the switching matrices used to select data streams to the telemetry processing equipment. Directly below this are monitoring devices for selecting an individual word out of the bit stream. Finally on the upper left level with the oscilloscope, is a monitor for the telemetry bit stream leaving the site. The operator therefore has a complete picture of the telemetry data from the RF input to the final signal to line

metres (30 miles) south of Canberra, the Honeysuckle Creek operations centre can be regarded as an extension of the Mission Control Center at Houston, Texas. At the end of a link stretching across the Pacific, the station acts as a relay point between the spacecraft and the Mission Control Center. All communications and data are passed through the Canberra Switching Centre which is part of NASA's world-wide communications network.

Fig 2. Frequencies used during the Apollo 15 Mission



Functions

The station—a block diagram of it is shown in Fig. 3—is known as a Unified S-Band site, using frequencies in the "S" Band. All uplink and downlink signals are modulated on to single carriers. In the earlier Mercury and Gemini programs each function used a separate frequency and antenna.

Bearing in mind the station is merely a relay point, the drawing is basically a flow diagram of information (data) between Houston on the right and the spacecraft on the left.

Uplink or transmit path

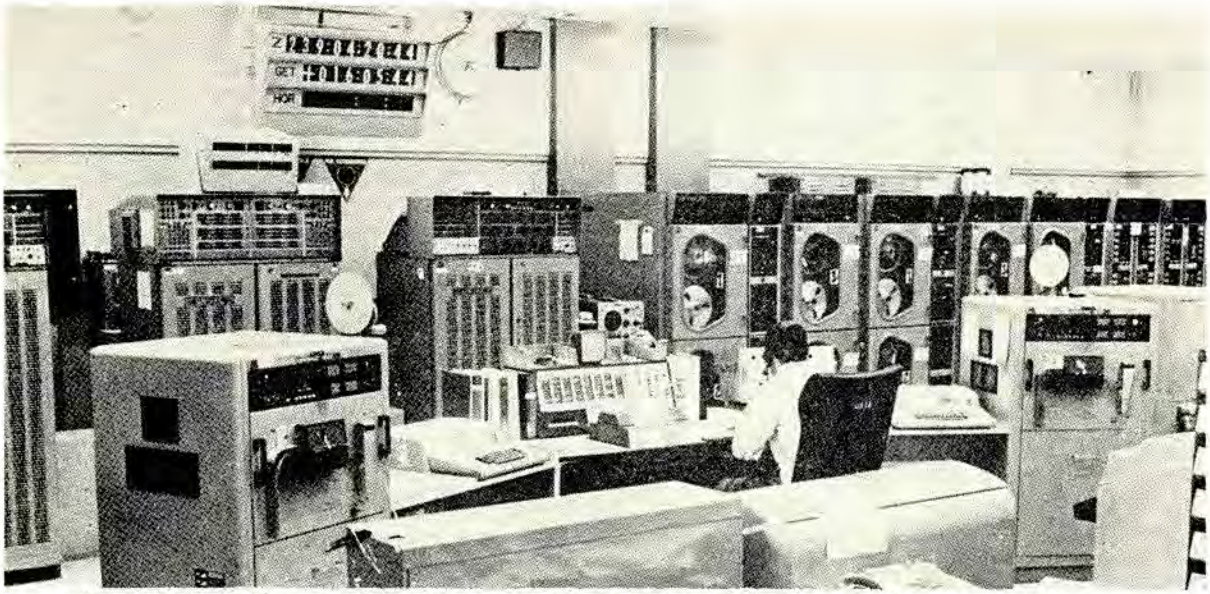
Taking the simpler of the two, the link from Houston to the spacecraft is called the uplink or transmit path.

Voice

Speech is perhaps the prime requirement of the uplink path and in simplified terms provides a telephone link between the capsule communicator at Houston and the astronauts. A communication technician at the station monitors all traffic and ensures the best channel is used. The baseband voice signal is an analogue waveform, of frequency range 300-2500Hz, modulated on to a 30kHz subcarrier, summed with the other uplink information, and phase-modulated on the carrier.

Command

Commands consist of instructions to spacecraft equipment, primarily to relieve the astronauts of regular



From left two Univac 642B computers with an expanded memory unit between. In the centre right are eight tape transports fully duplexed with the 642B computers. To the right are two Univac 1218 computers and associated magnetic tape unit with two tape transports. In the foreground are the I/O consoles and the operator's monitoring position

chores. Examples are spacecraft antenna switching for optimum signal strength at the ground station, recorder control for transferring information stored on magnetic tape from the spacecraft to the ground, and the more important navigational data to update the command module/lunar module computer.

Commands are loaded into the station's Univac 642B command computer by high-speed data lines from Houston. These are transmitted, using a digital code of 57 bits at a rate of 4.8 kilobits/sec.

Commands can be called up for transmission to the spacecraft at a designated time or be sent in real time. Instructions to transmit a command are initiated in Houston and the 642B computer recalls the required command from memory and transmits it to the spacecraft, where a digital word is returned with the telemetry stream back to the computer. If no return word is received by the computer, it re-transmits the command a predetermined number of times before raising the alarm.

The command leaves the computer in a digital 30-bit parallel code, which is converted to a serial phase-shift keyed (PSK) waveform consisting of a 2-kHz data signal combined with a 1-kHz reference. This baseband command signal is first frequency-modulated on a 70kHz carrier before being summed with the other uplink signals and phase-modulated on the carrier.

During the Apollo 15 mission a total of 3,540 commands were uplinked to the spacecraft from the Australian stations. Honeysuckle and Tidbinbilla uplinked 3,533. Of these 2,000 were commands to the camera unit mounted on the lunar rover.

Ranging

Ranging is a code transmitted to the spacecraft and returned for time comparison with the original code. The pseudo random-noise range code, generated by the ranging system, is a combination of five codes to form a 5.4 second period code of 5,456,682 bits, which gives a maximum unambiguous range of 800,000 kilometres (500,000 miles) or twice the distance to the moon.

The range code is summed with the other uplink information and phase-modulated on to the carrier.

Resolution within the ranging system is ± 1 metre (3ft), but system inaccuracies due to jitter and ground instabilities give an overall accuracy of ± 15 metres (50ft).

Ranging is manually initiated by the station and once acquired is updated by doppler only. The range code is only used to measure the initial distance.

Uplink

Both Honeysuckle Creek and Tidbinbilla can transmit two uplinks simultaneously. Both have dual equipment capable of handling two independent RF links. This provides both a backup in case of failure of one link, or the capability of tracking two spacecraft within the antenna beamwidth.

The final modulation process on the uplink carrier is phase modulation using relatively narrow deviation to ensure that a phase stable carrier component arrives at the spacecraft, as the spacecraft transmission carrier is derived from the received carrier. The total rms phase deviation on the uplink carrier is kept at about 1 radian.

The command subcarrier of 70kHz and voice subcarrier of 30kHz are combined in a subcarrier oscillator system, and delivered to the exciter as normal modulation, phase-modulated on to the S-Band carrier.

The power amplifier uses a klystron and delivers a continuously variable output of 1 to 20kW, CW. The bandwidth of 10kHz is wide enough to accommodate both uplink frequencies. Five hundred milliwatts drive is required to produce the full 20kW.

Antennas

The 26-metre-diameter parabolic dish at Honeysuckle Creek is a steerable antenna using an XY mount, which means the antenna can tilt in two directions, in this case N to S, and E to W. With combined operation, almost the whole sky can be covered. Both axes of the XY mount are horizontal at zenith.

Some antenna facts

Beamwidth
7.5m rad $\pm$ 1.0m rad ($0.43^\circ \pm 0.05^\circ$)
Pointing accuracy
0.2m rad—(40 secs of arc)
Max tracking rate
50m rad/sec—(3°/sec)
Polarisation
Right-hand circular/or left-hand circular switchable
Gain
51 dB up 53 dB down
Acceleration
90m rad/sec^2 ($5^\circ/sec^2$)

There is a 2 metre (6ft) diameter acquisition antenna and tracking system, but this is only useful on earth-orbit tracking where the spacecraft is a relatively rapidly moving target. This system is not included in this discussion.

The Tidbinbilla 26-meter-diameter parabolic dish is a steerable hour angle-declination antenna and the Parkes 64-metre-diameter parabolic dish is a steerable AZ-EL antenna.

Due to the narrow beam width of the antenna it has to be extremely accurately directed. To achieve this, computers in Goddard Space Flight Center calculate the spacecraft trajectory from previous tracking and the information is then fed into a 1218 computer which can be switched to control the antenna directly.

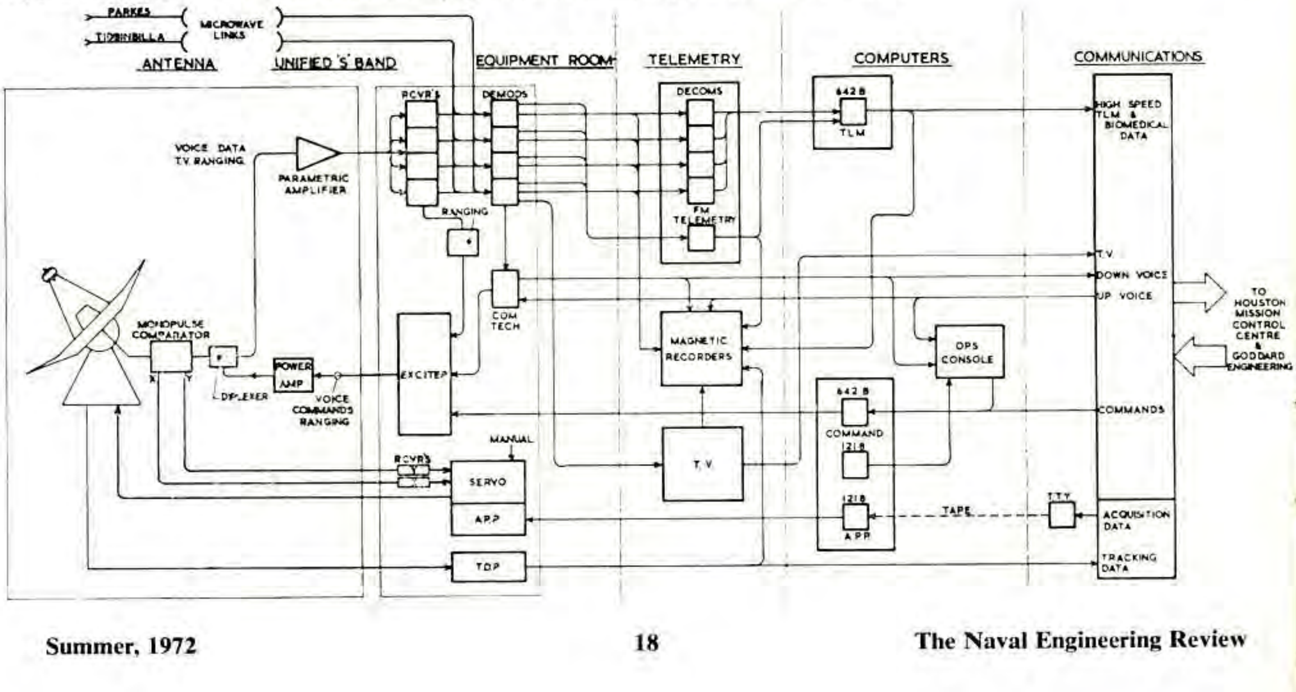
Combined with the antenna position programmer (APP), the antenna can be directed to follow the spacecraft's path, even through a signal loss. Normally, once the spacecraft's signal has been acquired, the antenna follows the signal.

The range (determined by the ranging system) and speed of the spacecraft relative to the station, and the antenna angles relative to the station's geographical location are coded in the tracking data processor (TDP), transmitted to line and recorded. This data is coded both in high-speed data at 2400 bits per second and in teletype code.

Downlink or receive path

The spacecraft downlink "S"-Band frequency can be received from the spacecraft at levels of about —150 to —90 dbm. The signals are bounced to the hyperbole focus where the feed system is split into four parts,

Fig 3. Block diagram of the functions of Honeysuckle Creek during the Apollo 15 Mission



giving a common monopulse tracking system. This can be left or right circular polarisation, selected remotely.

The sum output of the monopulse comparator is fed into a cryogenic parametric amplifier (paramp) having a low system temperature. This paramp output is split five ways, four to independent phase-locked receivers, with tracking bandwidths switchable between 1kHz to 12Hz. (These receivers are capable of tracking down to —160 dbm).

The X and Y outputs of the monopulse comparator are fed to a triple-channel warm paramp and then to tracking receivers whose reference is derived from the original sum channel. The remaining channel of the warm paramp is used as a backup for the main cryogenic paramp.

The function of the diplexer (together with the band pass and reject filters) is to combine the uplink and downlink frequencies, giving a rejection of 180 db in the receive spectrum.

Receivers

The S-Band frequency from the paramp is converted down to an IF of 50MHz and reconverted to a 10MHz reference frequency. Phase detection at this frequency drives programmable local oscillators and multiplier chains for the phase-locked operation. The outputs from the receivers, that of 50MHz and 10MHz, are composite signals which are fed into the demodulators where the various channels of information are stripped off and patched to the appropriate areas.

Demods

The demodulars accept these composite signals from the Honeysuckle Creek, Tidbinbilla and Parkes receivers. They contain the voice, telemetry, biomedical and television information and break them down into a pulse code modulated (PCM) bit stream, voice and biomedical data. These are patched in both PM or FM modes as dictated by operational requirements.

The television information, which was frequency-modulated directly on the carrier in the spacecraft, enters via the 50MHz FM channel and is completely demodulated and fed to the TV processing equipment.

Now let us take each data stream in turn and see how it is transmitted to Mission Control Center at Houston.

Voice

The recovered voice from the demodulators is fed to the communications technician who monitors and switches for best signal sources. The audio is then recorded on magnetic tape and sent to line to the Mission Control Center either by undersea cable or satellite.

Biomedical

The biomedical data are in two distinct paths. One is used while the astronauts are in the command module when the biomed data comes via the pulse code modulated (PCM) telemetry. The other is used while they are in the lunar module or in their suits for external activities. Then the biomedical data, containing information on the condition of the astronauts as they are walking around the moon's surface (such as oxygen remaining, suit cooling, suit temperature, physical condition) are routed down separate analogue FM telemetry channels to special processing equipment which converts the analogue information to digital for the computer. Both sets of information, together with the other PCM data, are presented to the 642B computer.

Telemetry

The PCM bit stream is routed to four decommutators in the telemetry area. The rates are variable, normally high at 51.2 kilobits and low at 1.6 kilobits a second.

The prime function of the PCM decommutators is to present all decoded data to the telemetry 642B computer in 30-bit parallel form, but they also allow station personnel to monitor selected data on indicators or chart recorders.

The PCM telemetry can be broken down into 6,400 words of information on the spacecraft antenna direction, physical condition of the astronauts in the CSM, the quantities of consumables, engineering data, etc.

Computers

As the data lines between the station and Mission Control Center have limited capability for data transmission, all the telemetry is presented to the 642B computers, where only data selected by the flight controllers in Houston are transmitted to line. The output from the computer of 30-bit parallel words is converted to a serial bit stream at 4.8 kilobits a second and transmitted to line on similar circuits to the voice circuits.

Both command and telemetry computers are identical and interchangeable and have 20 input and 20 output channels, 64k memory and duplex magnetic tape units, each with four tape transports.

Programmes used during the mission are sent from Goddard on magnetic and paper tape and loaded into the computer at predetermined times.

The magnetic tape units are used for fault analysis and storing information. They also hold the operational programme.

Television

The television signal from the spacecraft is 525 lines/60 field frame sequential colour TV and also contains information on the TV camera temperature, battery voltage, etc. This TV signal from the demodulators is presented to a switch matrix which selects the best signal source available from the Honeysuckle, Tidbinbilla and Parkes receivers. The voice and telemetry subcarrier is filtered out with a subcarrier cancellation device which eliminates the subcarriers by a locally generated subcarrier locked to the incoming signal and 180° out of phase with it.

The signal is cleaned up and processed in a standard TV processing amplifier before vertical interval test (VIT) signals, multiburst and grey scale, are inserted on line 16 and 17 of the vertical blanking period.

The composite processed TV signal from Honeysuckle Creek/Tidbinbilla is monitored on a modified Conrac colour monitor and transmitted to a video centre in Sydney for selective distribution to the local networks and to Houston via the Overseas Telecommunications Commission's Intelsat satellite link over the Pacific. The TV signal from Parkes is sent direct to the video centre at Sydney.

The TV is also recorded on Ampex VR 660 video tape recorders.

Time

All activities in the station revolve around a dual time standard which provides multiple readouts, pulses and various coded times for time tagging all data produced by the station.

Needless to say accuracy is essential, and various means are used to keep the station time within 10 microseconds of universal time. The well-known WWV and WWVH time signals are used for a coarse adjustment, but for a vernier adjustment down to ± 10 microseconds, the 100kHz Loran C signals, now synchronised to universal time are used.

The North-West Pacific Chain with the master station at Iwo Jima is presently used to monitor the station's drift. Prime frequency source is a Hewlett Packard Caesium beam frequency standard giving a stability of around 1×10^{12} with a Varian rubidium as back-up.

Operations console

A central co-ordinating console controls and interfaces the station with external organisations. The console is supplied with numerous lamp displays giving station configuration and equipment status. The console also has facilities for communication with the spacecraft and the initiation of commands.

Staffing

The responsibility of Honeysuckle Creek Station's activities is vested in a Station Director who is a senior officer of the Department of Supply. Standard Telephones & Cables Pty Ltd have contracted to provide the operations and maintenance services and employ about 100 professional technical and administrative personnel at the station for this task.

Electronics Today acknowledges the assistance of the Dept. of Supply in the preparation of this article.

Book review

A QUEST FOR SPEED AT SEA

Published by Hutchinson & Co. 96 pages, profusely illustrated. Price £3.00 net.

The quest for speed at sea has been a preoccupation of the human race ever since man first risked his life and possessions on the high waters. Since the days of the fast sailing vessels, progress towards higher speeds has depended on the development of engines; on the limits of the power outputs of the available machinery, particularly in relation to its size and weight and to the hull in which it is fitted. The amazing progress in this field was made possible by the coming together at the turn of the century of the two essential elements for achieving higher speeds in the water: engines giving enough power for their weight, and hulls which would plane. With the dual forcing grounds of naval requirements and power boat racing, the rapid advancement since the 1914-18 war accelerated to the stage we have now reached where fully equipped naval craft are capable of speeds of over forty knots.

It is a fascinating story, written by Christopher Dawson, and marks the centenary of the foundation of the firm of Vosper.

The book opens with a short account of the firm's development under H. E. Vosper and its work of engine building, ship and boat building, repairs and refits. The main part of the story begins in 1931, when Commander Peter Du Cane took over the company, and established the policy of concentrating on fast craft, mainly for use by the Royal Navy, Royal Air Force, and services abroad.

Success with small vessels before 1939 led to Vosper playing a leading part in the design and construction of MTB's for the Light Coastal Forces during the war, and it is with this type of craft that the firm is still associated in many people's minds. Recent years have, however, seen the extension of its interest in larger warships, to frigate size, and, following the merger with Thornycroft in 1966, the establishment of Vosper Thornycroft Limited as leading warship designers and builders.

A Quest for Speed at Sea covers all these developments, and outlines for the general reader some of the technical problems met in achieving high speeds in the open sea. This book should find pride of place on the shelves of all those who are interested in speed at sea, whether their interest be practical or theoretical, specific or general. The book is beautifully illustrated in colour by Laurence Bagley.

Pinpoint accuracy in weapon aiming for light combat aircraft

A new kind of head-up display which can give light combat aircraft pin-point accuracy in weapon aiming will shortly be ordered for evaluation from Marconi-Elliott Avionic Systems Ltd (a GEC-Marconi Electronics company) by the Ministry of Defence Procurement Executive subject to agreement on contract terms. Called HUD-WAS Type 664, this important new development was exhibited for the first time at the Hanover Air Show on April 21 (Marconi-Elliott Avionics Stand 914).

Key feature

The major breakthrough in weapon delivery accuracy in advanced attack aircraft has been achieved with digital computer techniques, and the Type 664 makes this feature available for light combat aircraft which do not need or have room for central computers or high-cost, sophisticated sensors.

Key feature of the Type 664 is the ability of the single-box digital electronic display generator to perform these complex weapon aiming calculations in addition to projecting the flight and weapon aiming symbols in the head-up display. This dual capability is achieved by Marconi-Elliott Avionics' well proven digital display processor which includes a small, very effective general-purpose airborne computer which is here programmed to perform both tasks.

The Type 664 gives existing and projected military aircraft a major increase in their weapon delivery effectiveness at a cost which is little greater than that of the head-up display system of the more complex integrated systems.

The new system will give the pilots of light combat aircraft freedom to approach targets in level flight or at any dive angle. It provides them with a simplified flight director aiming display, with either manual or automatic weapon release (CCIP* or CCRP**) and the new tracer line "Snap-shoot" technique for air-to-air gunnery (CCIL***). These features have already been shown to give major improvements in accuracy combined with much reduced vulnerability during the attack manoeuvre.

The HUD-WAS Type 664 provides these capabilities in a small and functionally simple, three-box package tailored for installation in light combat aircraft such as projected lightweight fighters. Of particular value is the ease with which it can be retrofitted in existing military aircraft, thus giving an advanced strike and weapon delivery capability to a wide variety of present-day in-service military aircraft such as F-5, Canberra, Buccaneer or Harrier.

HUD-WAS Type 664 is a head-up display system with full flight instrument and flight director capability, able to operate with analogue or digital sensor information. A full 4 inch diameter optical system giving 25° wide field of view, includes an entirely independent, collimated stand-by aiming sight and a new side-mounted combat camera attachment. Nevertheless, the Type 664 pilot's display unit, complete with high-voltage supply, is under 19 inches long and weighs only 24lb.

Secret of the Type 664's integral weapon aiming capability is its digital electronics unit, a development of the A-7D/E Corsair 2 digital HUD system, of which some 800 have been delivered. The system is the only one in the World to have been used in combat operations.

Digital wave-form generation has been the key factor in providing fully satisfactory flight guidance display symbology. Digital weapon aiming was equally the key factor in CCIL, CCIP and CCRP deliveries. Marconi-Elliott Avionics pioneered both techniques respectively in the A-7D/E HUD and in Nimrod and British Jaguar.

The Type 664 electronics unit combines symbol generation and weapon aiming functions in a single compact electronics unit. The processor is a fixed-programme, whole number unit with 4,096 x 20 bit-word MOS read-only programme store and bipolar integrated circuit data store. A fast digital-to-analogue and analogue-to-digital converter accepts either form of input from the type of attitude, rate, air data and range sensors now usually fitted in light combat aircraft. The complete electronics unit is in a ¾ ATR short case weighing 19lb. The third unit is the 4lb control panel.

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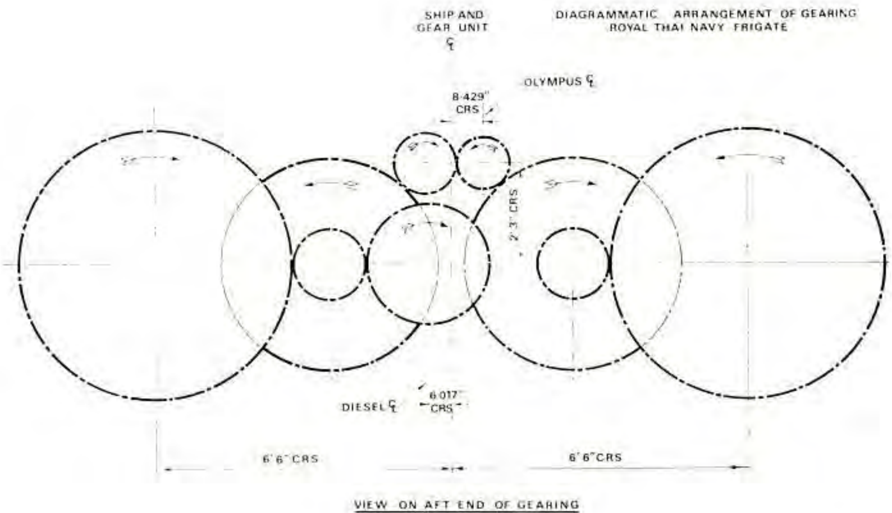
* CCIP: Continuously computed impact point: weapon impact point displayed in HUD as aiming point for manual bomb release in any attitude from lay-down to steep dive.

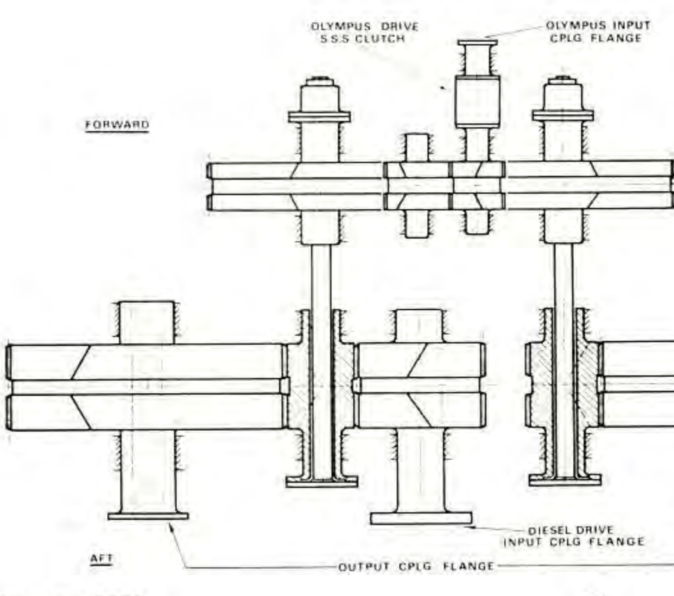
** CCRP: Continuously computed release point: steering command display in HUD combined with automatic release in any attitude from over-the-shoulder, through lay-down to dive.

*** CCIL: Continuously computed impact line: fully predicted bullet flight profile displayed in HUD with stadiometric (manual/optical) or automatic radar target range assessment.

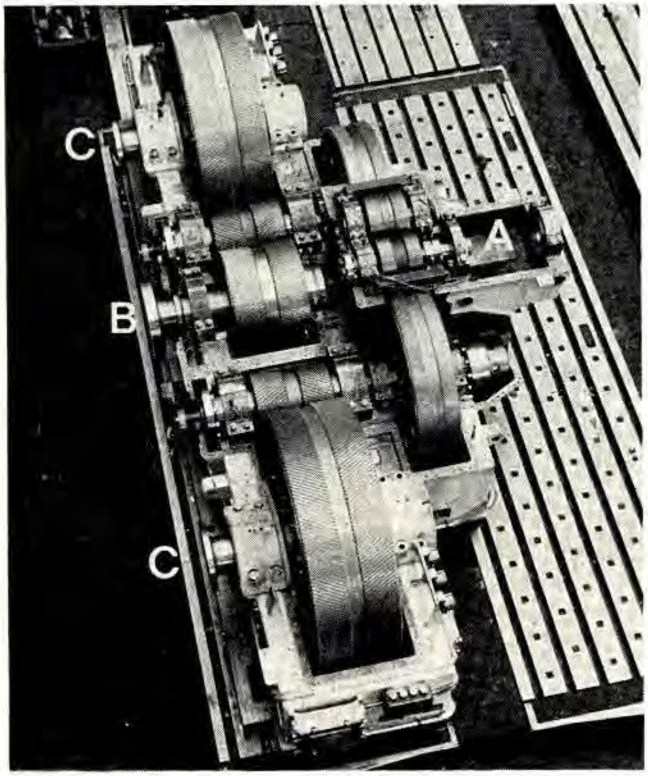
Transmission for the Thai frigate

David Brown Gear Industries Ltd, Huddersfield, have delivered the CODOG transmission for a frigate under construction by Yarrow (Shipbuilders) Ltd, Glasgow, for the Royal Thai Navy. Input is from either a Rolls-Royce Marine Olympus 28,000hp gas turbine arranged forward of the gearcase, to provide the main drive, *or* a Crossley-Pielstick 12PC2V diesel engine situated aft of the gear, which is used for cruising. Double reduction is employed in the gas turbine train which incorporates an SSS (Synchro-Self-Shifting) clutch at the input end. A single reduction arrangement with input through a Geislinger flexible coupling and Wichita pneumatically-operated plate clutch is used to enable the diesel to



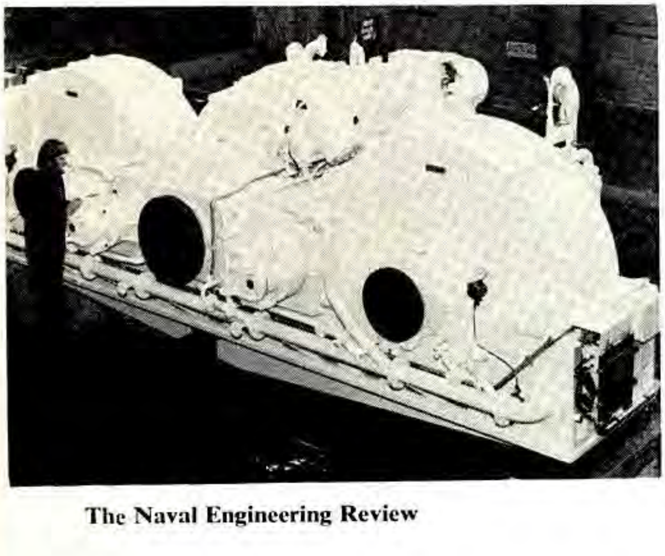


Arrangement of the CODOG gear system. The entire assembly rotates in both modes and only the diesel input pinion is unloaded when the assembly is powered by the gas turbine



The gears with covers lifted. A; Turbine input (space for SSS clutch); B: Diesel input; C: Couplings to port and starboard shafts

Completed gear seen from the after end. The pinions are hardened and ground—hence the wide gap between the helices



overcome the considerable inertia of the system. The output is split between two shafts carrying cp propellers. Double helical gears are used throughout and the transmission includes an integral sump and two attached David Brown Roloid oil pumps, filters and coolers. The welded steel gearcase was made in the David Brown Group fabrication shops at Penistone.

Short Blowpipe accepted by British Army for final evaluation

The Blowpipe guided missile system, produced by Shorts of Belfast, has been formally accepted by the British Army for final evaluation.

This is the last stage before the placing of an official production order and it coincides with an announcement by Shorts that the missile has successfully completed its research and development trials—leaving the way clear for large-scale production at the Company's Queen's Island factories.

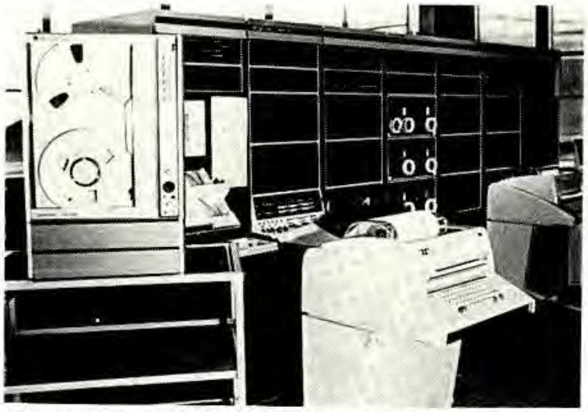
The radical new weapon—it is fired from the shoulder by one man, yet has the punch to destroy an attacking aircraft—has achieved its Army acceptance in record time. The Ministry of Defence considers no other UK weapon has ever achieved the level of satisfaction of a British Army Staff Requirement at such an early stage in its project programme.

Blowpipe is the latest product of Shorts' Missile Systems Division and embodies the unrivalled experience of short-range guided missiles which Shorts gained with their highly successful Seacat and Tigercat. Like those missiles, Blowpipe is radio guided by the aimer along his line of sight, but the entire system weighs little more than 40lb and is easily carried by one man.

The newly completed R & D trials confirmed earlier computer predictions that Blowpipe would meet the lethality figure called for in British Army General Staff Requirements. Many of the world's armed forces are interested in Blowpipe and the new weapon is expected to be an even bigger export success than Seacat.

Blowpipe's accuracy, simplicity and extreme portability make possible a wide range of applications, including multi-round launchers for small ships and submarines.

Bell & Howell equipment used in naval research



The computer room at Y-ARD's establishment in Glasgow showing in the foreground Bell & Howell's VR 3360 magnetic tape recorder/reproducer used to play back important field-trials data

The Naval Construction Research Establishment at Rosyth, Scotland, is currently carrying out important explosion trials which are primarily concerned with research into the shock effects of underwater explosions on surface warships and submarines. To assist in this, the establishment is employing seven instrumentation magnetic tape recorders and two ultra-violet oscillographs manufactured by the Electronics and Instruments Division of Bell & Howell Ltd.

Ex-naval warships and specially designed waterborne test vehicles are being used as targets by the Shock and Impact Division of NCRE to obtain valuable information about shipboard shock environments, and the nature and extent of damage the modern warship can sustain before losing its fighting efficiency.

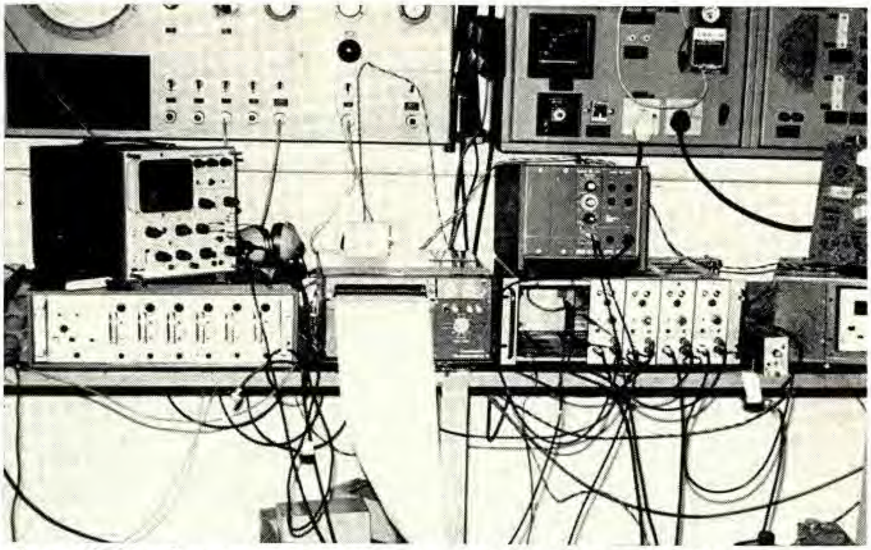
The tests enable hull sections, fittings, machinery and a wide range of ancillary equipment to be evaluated under severe shock conditions. From the results obtained, techniques are developed for damage prediction and prevention.

The instrumentation vessel used in this work is a 103ft (31m) wartime torpedo recovery ship specially converted into a floating laboratory/workshop. On board this craft are four Bell & Howell VR3300 instrumentation magnetic tape recorders which simultaneously store 56 channels of information transmitted by cable from transducers mounted in the target vessel. The signals from these sensors are conditioned by an array of Bell & Howell Type 1-165 and 1-168 amplifiers before being recorded at 60ips.

Equipment reliability is an essential factor. Not only are the trials very costly, but many of the results obtained contain irreplaceable scientific data.

Once the results of a test have been recorded, the tapes are replayed on a fifth VR3300 on shore. Exact

NCRE's full-scale explosion trials using Bell & Howell recorders yield valuable information about shipboard shock environments



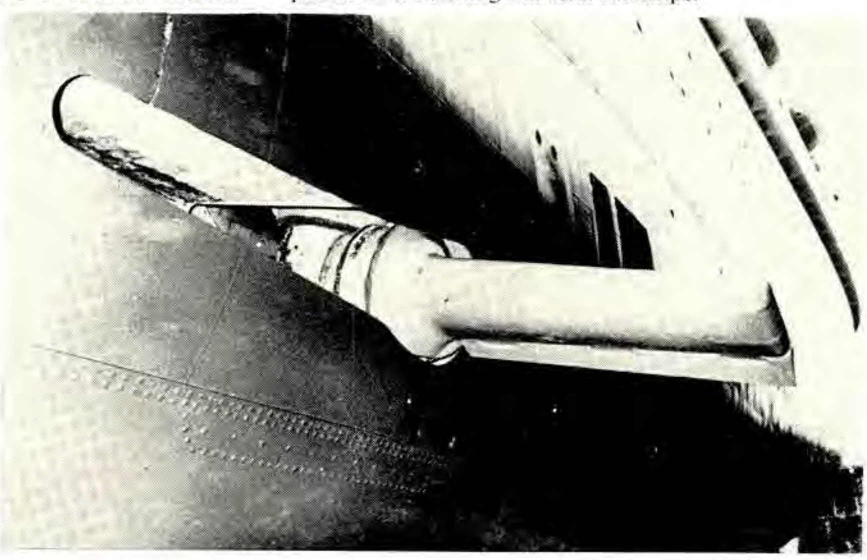
Bell & Howell Type 5-127 U.V. recording oscillograph (centre) being used by the Technical Investigation Department of Lloyd's Register of Shipping to record the vibration profile of a ship's main gearbox during investigations into gearbox main wheel failure

time correlation is achieved by using a 1kHz reference signal on each of the five recorders. The information is then fed, one channel with reference signal at a time, into a Bell & Howell Type 5-124 U.V oscillograph for visual examination before being digitised for computer analysis.

For some of its work NCRE also use scale models in proportional explosive environments. The frequency of the velocity time traces achieved in such experiments, however, are far higher than in full scale trials, and it is necessary for the time-base to be considerably expanded for accurate analysis.

In this work a Bell & Howell VR3700A tape machine is used to record 14 channels of data from the laboratory test tank at a speed of 120ips. The recording is then played back at $7\frac{1}{2}$ips into a Bell & Howell VR3360 magnetic tape machine running at 60ips. From this recorder the signals are finally replayed into a Bell & Howell 12-channel 5-124 recording oscillograph for analysis. The time-base expansion capability of this system is 256:1.

With experiments and trials such as these, NCRE's acknowledged expertise in the design and testing of heavy marine structures enables it to be of great assistance to the marine industry. Its work in this area has included frame research for the production of super-tankers, dredging by explosives, investigations into the design of specialised containers for the disposal of radio-active waste at sea, designs of submersibles for ocean engineering, advice on underwater demolition and research into the applications of glass-reinforced plastic as a building material for ships.



Brown Brothers of Edinburgh use Bell & Howell pressure transducers and oscillographs to monitor critical parameters during sea trials of newly-fitted stabilisers

Corrosion – the silent destroyer*

This article is presented as a quick guide to the ever present problem of corrosion which we must combat every day. Because of the complexity of the subject, this article will only skim the surface in order to acquaint the reader with the types of corrosion and the methods to combat it.

The subject of corrosion is always present in any preventive maintenance programme. When you consider the conferences, technical meetings, surveys, briefings, studies and libraries volumes written on the subject, it is not difficult to realise why this is true.

Corrosion by its very nature is deceptive. It very quietly destroys the functional efficiency of our system. The hazards and problems it creates are many times hidden until it is too late to prevent them. The problem of corrosion is large. Corrosion can attack every nut, bolt, flange, hinge, and pipe all the way up to the large number of individual pieces of system hardware. There are about ten types or forms of corrosion depending on how they are classified. Now multiply the number of things corrosion can attack by the number of ways corrosion can work and you will have an idea of the magnitude of the problem.

It is obvious that this approach is an over simplification. Not every item is prone to all forms of corrosion, nor does this method allow for the variable of time. For example, many system components can accept a substantial amount of corrosion without any degradation in performance. Components such as large supporting structures and work platforms can be classified in this area. Eventually they may not look very good, but there is no need to employ a frantic corrosion programme.

On the other hand, items such as fuel valves, high pressure piping and environmental life support fixtures are items which require immediate action when corrosion is noticed.

Unfortunately, some results of corrosion control efforts end up being nothing but a beautification programme.

Effective corrosion control requires an all out effort. This means that the prevention of corrosion should be emphasized during all phases of design, development, and operational use.

Corrosion prevention policies covering all phases of design are not new. Adequate coverage is included in specifications, work statements and other documents. However, despite good design and proper protective coatings, poor workmanship often transfers the corrosion problem to the user activity.

The following is a quick guide to corrosion information which can be utilised as a quick reference.

Galvanic corrosion

This is a complete class of corrosion types involving electro-magnetic action between two metals or between different areas of the same metal having different heat treatments or other metallurgical differences.

Dissimilar metal corrosion

This is a subgroup under the general class of galvanic corrosion. In this type, the electro-chemical reaction is caused by two different metals in contact with an electrolyte. Dissimilar metal corrosion is almost always localised to one or the other of the metals involved.

Intergranular corrosion

This type of corrosion is also a form of galvanic action where the metallic grain boundaries and the grain particle create a cell in an ambient corrosive solution or atmosphere. Intergranular corrosion is a particularly dangerous form of corrosion because it attacks the basic grain boundary structure of metal. Some stainless steels are prone to this form of corrosion when heated such as during welding. The heating causes chromium carbides to collect at the grain boundaries and the corrosion begins.

Stress corrosion

This type of corrosion is caused by the inter-action of a corrosive attack and sustained tension stress. Cracking of the surface is usually present. Stress corrosion is intergranular corrosion but with tension loads either from "locked in" stress or externally applied forces.

Pitting corrosion

This is a localised form of corrosion in which a break in the passive film occurs. Once broken, a cell is formed between the exposed metal and the passive metal. Such breakdowns in the protective coating can occur at a rough spot, machining mark, scratch, or other surface flaw. Pitting corrosion can also occur under small deposits which prevents the access of oxygen to the metal. If the products of corrosion are conductive, pitting corrosion will proceed at a rapid rate.

Erosion corrosion

In erosion corrosion, the corrosion products are removed by the action of fluid flow or pressures, thus

* Coast Guard Engineer's Digest, Jan./Feb./March, 1972.

CORROSION TYPE	DESCRIPTION	PRECAUTION
Uniform	1. A general attack on unprotected surface. 2. Combined effects of moisture, temperature, condensation and evaporation. 3. Also caused by direct chemical attack.	1. Over design structure to accept corrosion. 2. Remove with chemicals or abrasive techniques and apply protective coating. 3. Isolate metal from corrosive environment.
Galvanic	1. Electrochemical corrosion cells are formed. 2. An electrolyte in contact with two different metals or one metal having different characteristics.	1. Avoid dissimilar metals. 2. Use coatings and/or cathodic protection. 3. Place a dielectric barrier between the dissimilar metals. 4. Interrupt the electron flow through the electrolyte.
Intergranular	1. Galvanic cell between grain boundaries (positive) and grain centre (negative). 2. Destroys structural bonding of the metal.	1. Different heat treatment, annealing a new metallurgical design. 2. Use stabilised stainless steels or low carbon steels.
Stress	1. Combined effects of tensile stress and corrosive treatment. 2. Tensile stresses expose metal to the corrodent.	1. Reduce stress level. 2. Use shot-peening or annealing to reduce the residual stresses. 3. Alter the corrosive environment.
Pitting	1. Incomplete protective film or coating. 2. Particles deposited on metal surface break down the film by creating an oxygen deficient area.	1. Any metallic coating which is anodic to the base, i.e., zinc or steel. 2. Organic coatings such as paint, asphalt, epoxies or rubber.
Erosion Corrosion	1. Corrosion products are removed by erosion, thereby exposing fresh metal to the corrodent.	1. Sacrificial, non-metallic coatings. 2. Better design, more metal when it is needed.
Concentration Cell	1. Dissimilar electrolytes in contact with the metal. This includes differences in acidic content of oxygen concentration.	1. Coatings, cathodic protection and corrosion inhibitors.

exposing fresh metal to the corrosion attack. The progress of this type corrosion is very rapid.

Concentration cell

This is a form of galvanic corrosion wherein dissimilar electrolytes are in contact with a metal. It is not as prevalent as the preceding types of corrosion, but it none the less is important.

In conclusion here are some methods depending on the problem, which can be utilised to control corrosion.

1. Use materials which are compatible with the environment.

2. Use inhibitors which will form a protective coating as the corrosive materials come in contact with the metal.

3. Use protective coatings which do not permit corrosion cells form since they prevent the completion of the electrical path.

4. Use protective materials such as galvanising or anodising over the metal.

5. Use counter current electrical flow to oppose the current generated in the corrosion cell.

6. Use environmental controls such as air conditioning to remove the moisture from the air which might condense on metallic surfaces and start corrosion cells.

7. Use similar metals whenever possible.

8. Use protective anodes, those anodes which are more active than the metal to be protected such as zinc anodes on the under-waterhull of a ship.

£1.5m order for Rolls–Royce (1971)

The Industrial and Marine Division of Rolls-Royce (1971) Ltd has received an order worth approximately £1.5m from the Royal Danish Navy for twelve more Marine Proteus gas turbines to power a new class of fast patrol boat. In April last year the Royal Danish Navy ordered 16 Proteus engines. These will power eight new triple-engine fast patrol boats to be built in Denmark. This repeat order makes the Royal Danish Navy the second largest user of marine Proteus engines in the world. Over 200 Proteus marine engines have been sold and operational experience at sea is over 180,000 hours. Total marine experience with Rolls-Royce gas turbines of all types is nearing 300,000 hours.

Short's Seacat hydraulic isolator strut

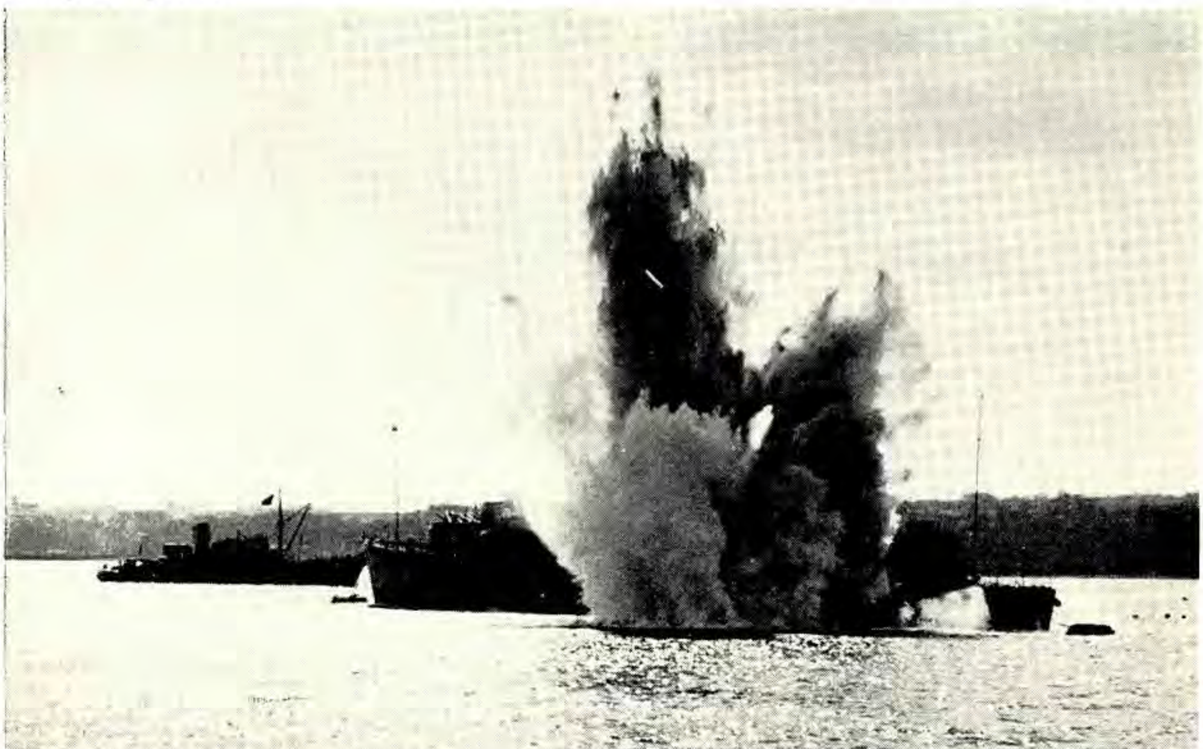
Warships must be designed to withstand severe shocks caused by the explosions of enemy weapons which detonate in contact with, or very close to, the ship's structure. Equipment which must continue to operate after a ship has been subjected to such shocks has either to be designed to withstand shock or to be isolated from shock. To design to withstand shock often results in heavy and bulky equipment which is not welcome especially in these days when warships are required to be compact as possible. On the other hand, it is not always possible to isolate equipment from the ship's structure without introducing further problems. This is particularly true of gun-mountings and missile launchers which move relative to the ship's structure and whose direction relative to the ships' axes must be accurately controlled.

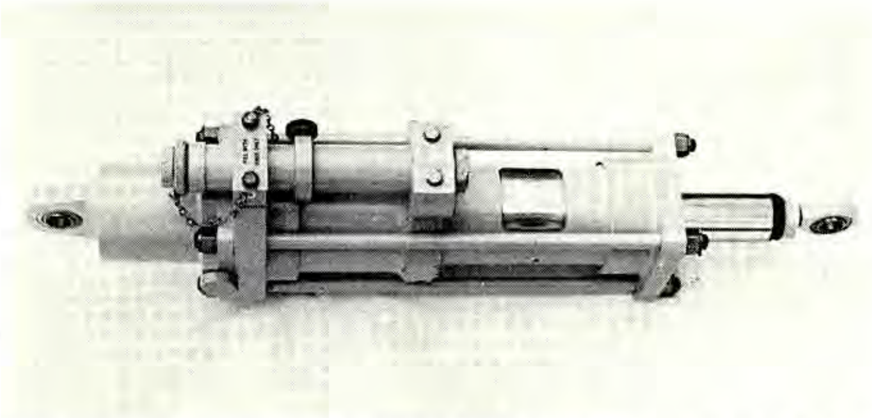
One way to reduce the level of shock to which equipment is subjected is to place a sandwich of yielding material such as a corrugated steel sheet between the equipment and the ship's structure. Much of the shock energy is absorbed by the deformation of the sandwich. The equipment will, however, be permanently displaced and although it may be possible in some cases for the equipment to operate at reduced effectiveness, the displacement must be corrected by replacement of the deformed sandwich.

Another possibility is to put resilient material such as a rubber sheet between the equipment and the ship's structure. This material will not suffer permanent deformation by shock and the equipment will return to its original position after the shock has passed. However, because of the resilience of the material there will always be slight movement of the equipment relative to the ship's structure. Even minute vibration may be sufficient to cause severe oscillations in guns, radars, missile launchers and similar power-controlled systems. There may also be long-term deterioration of the resilient material due to creep.

For their new lightweight Seacat missile launcher,

A powerful underwater explosion rocks the ex-RN destroyer 'Scorpion' during tests which proved the ability of the new Seacat isolator strut, developed by Shorts of Belfast, to protect ship equipment from shock damage during battle





The new hydraulic isolator strut, developed by Shorts of Belfast for their lightweight Seacat guided missile system, which is now available for general naval and commercial use

Shorts have developed a system of hydraulic struts which avoids the problems arising from yielding or resilient shock mounts. Under normal operating conditions the struts support the launcher rigidly and there is no unwanted movement relative to the ship's structure to interfere with the launcher control system. Under shock conditions the struts can expand or contract to absorb the shock and when the shock has subsided will return to their normal state. The launcher retains its full effectiveness without further adjustment.

Although a certain amount of shock testing or equipment can be carried out in the laboratory, the nature of the shocks to which shipborne equipment may be subjected is so complex that the only really satisfactory way to check the ability of such equipment to survive is to install it in a ship and subject the entire ship to shock. This, of course, can only be done on rare occasions when, for example, a ship is due to be broken up for scrap. The performance of the shock mounting for the Seacat launcher has been checked by simulation using sophisticated computers, by laboratory tests using shock-test machines and finally by being subjected to the effects of real underwater explosions while installed in *HMS Scorpion*. These tests carried out by the Naval Constructions Research Establishment at Dunfermline showed that the launcher returned to its normal position within one second of each explosion and suffered no damage whatsoever. Shorts have now made this equipment available for general naval and commercial use. Its function in this roll is to support any kind of large or heavy equipment on ships and to protect it from shock and vibration.

Second Type 21 frigate launched

The second Type 21 frigate for the Royal Navy was recently launched by Mrs Peter Kirk, wife of the Parliamentary Under-Secretary of State for Defence for the Royal Navy, and named HMS *Antelope*. The ceremony took place at the Woolston, Southampton, shipyard of Vosper Thornycroft Limited, who designed the class, in collaboration with Yarrow (Shipbuilders) Limited, and are building three of them. HMS *Amazon*, first of the class, was launched at Woolston by Princess Anne in April 1971, and is now being fitted out at the Vosper Thornycroft yard.

The Type 21 frigates are ships of some 2,500 tons displacement, 384ft long, and powered by Rolls-Royce Olympus and Tyne gas turbines to give a top speed of 34 knots. The armament consists of one Vickers Mark 8 4.5-in automatic gun and mounting, quadruple Seacat launcher for anti-aircraft missiles, WG13 helicopter carrying air-to-surface guided missiles and torpedoes, two 20-mm Oerlikon guns, two sets of triple torpedo tubes, and two 2-in rocket flare launchers. There is also provision for carrying the Seawolf guided missile. A sophisticated Ferranti weapon control system is fitted.

*Background to new small engine design**

The Ford 2.4 litre 'inclined' unit for commercial vehicle, industrial and marine applications

Among the British makers of compression-ignition engines of the high-speed form the Ford Motor Co Ltd is one of the largest producers, all the designs having primarily a road vehicle origin; they are, however, widely used for other tasks on land and on water. This policy applies to the latest units at the small end of the power output scale, known as the "2400". Here we are concerned with the four-cylinder 2401E of 2.4 litres ($144in^3$) capacity; there is also to be a six-cylinder model, the 2402E (3.54 litres, $216in^3$) rated at 87bhp maximum.

As to the ratings of the four-cylinder model, various data are given in Table A. Vehicle optional applications are these, in the Ford Transit commercial vehicle range:

Low Rating: 54bhp. Short wheelbase Transit 75, 90 and 115 models. 100 parcels van, also 9-, 12- and 13-seater buses. All these have manual-type gearboxes.

* Gas & Oil Power, Spring 1972.

High Rating: 61bhp. Short wheelbase 125. Long wheelbase 130, 150 and 175 types. 150 parcels van. 15- and 17-seater buses. Also in any chassis with automatic transmission. This engine can be optional in short wheelbase models.

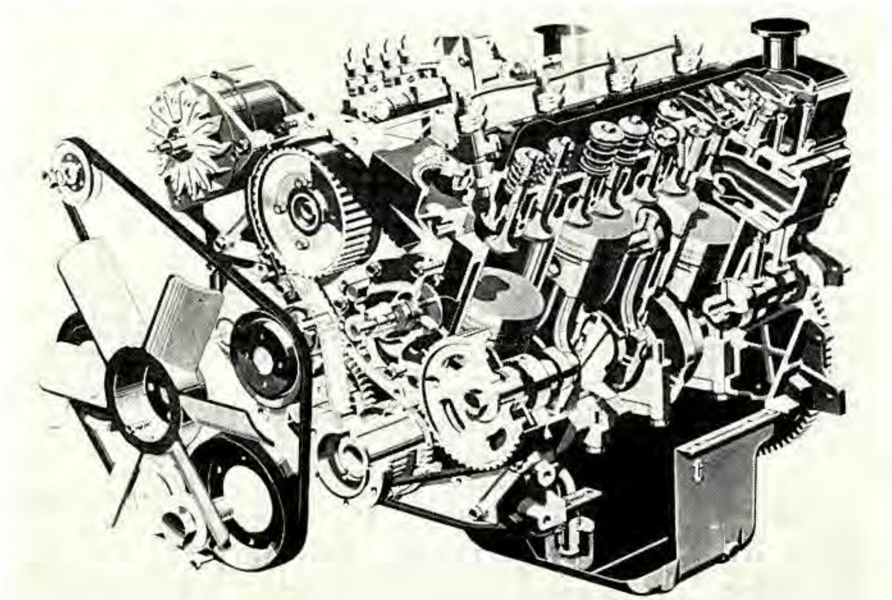
To cater for the marine market the range will come from Ford with special features, including a special corrosion-resistant alloy sump, combined heat exchanger, header tank and exhaust manifold, steel fuel lines, marinised electric equipment, and facilities for sea-water pump and oil cooler. In this form the engines are being supplied only to specially approved marinisers.

The objectives

Some five years ago Ford decided to make its own small diesels to replace proprietary models, with several special objectives: (1) more generous performance; (2) reduced noise, both in the cab and audible to passers-by; (3) more economical in running costs, including maintenance; (4) improved flexibility; (5) better standards of exhaust emission. The new units to be made to metric standards throughout.

After initial design at the Ford Research and Engineering Centre at Dunton, Essex, 150 pilot type engines were tested, totalling 50,000 running hours, including tests to destruction, Arctic conditions trials, and repeated cycles of running hot, draining the jackets and cold fill-up without damage.

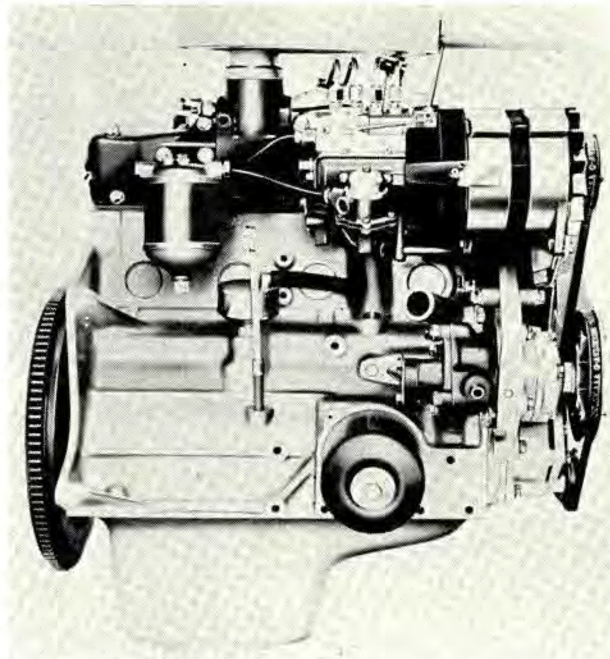
Combustion principles being basic, it was decided that the indirect system is best for a small bore unit governed to 3600 rev/min, from the standpoints of



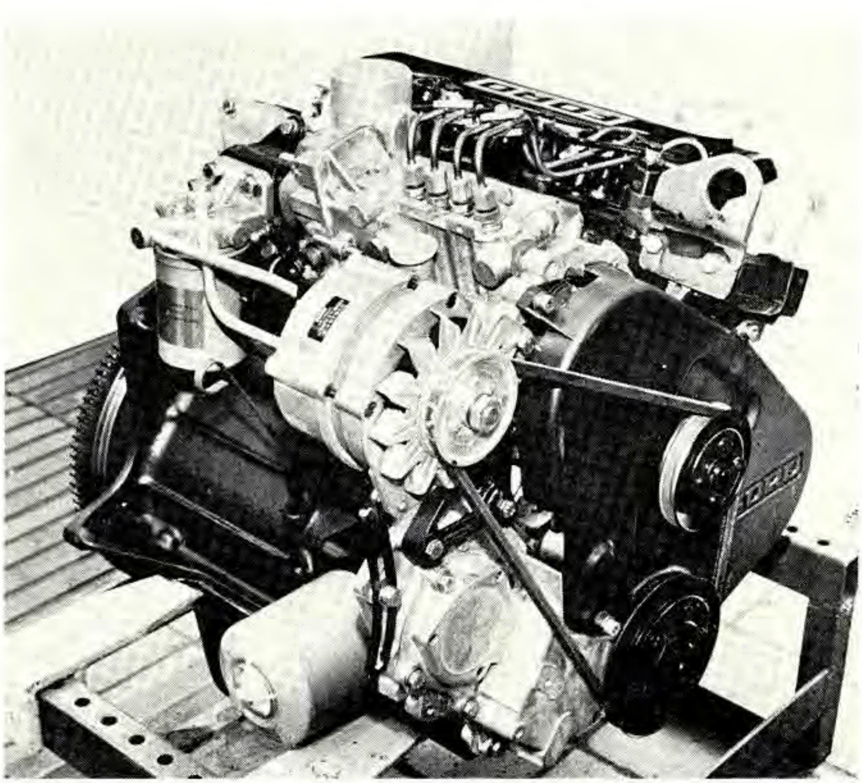
Cutaway view of the new Ford engine which is the latest diesel power option for the Transit vehicle range, and is also available for industrial and marine duties. Note the 22·5-degree angled cylinder block to reduce overall engine height. Also visible are the indirect combustion chamber with clover-leaf depression in the piston crown, three-ring pistons and toothed-belt drive from the crankshaft to fuel-injection pump and camshaft smooth running, fuel economy, low level of noise and acceptable exhaust quality. Other features to be worked in were over-square cylinder dimensions (3.6in bore, 3.3in stroke), cylinder bores being directly machined in the block, angled cylinder block (22.5 degrees to vertical) to reduce height in the vehicle, nodular-iron long-life crankshaft, three-ring pistons to give low frictional losses, oil jet cooling of pistons' undersides, toothed belt drive for the camshaft and fuel-injection pump, valves of welded construction employing two metals—each suited to its particular function, valve seats for both duties, also all ancillaries requiring maintenance access situated on top or to the right of the engine. In view of this small diesel being planned for both home and export, provision is made for the use of Simms fuel-injection equipment for the home market, or Bosch equipment when installed in Genk for European models.

Constructional details

Alloy iron is used for the cylinder block-crankcase casting, the skirt of which is carried well down below the crankshaft centre line to afford maximum rigidity. The cylinder bores are machined directly in the casting, which helps to minimise the block length and weight, as compared with one housing separate liners. Additionally cooling and rigidity are enhanced. This



Side view of the new diesel with Simms fuel-injection equipment for the British market



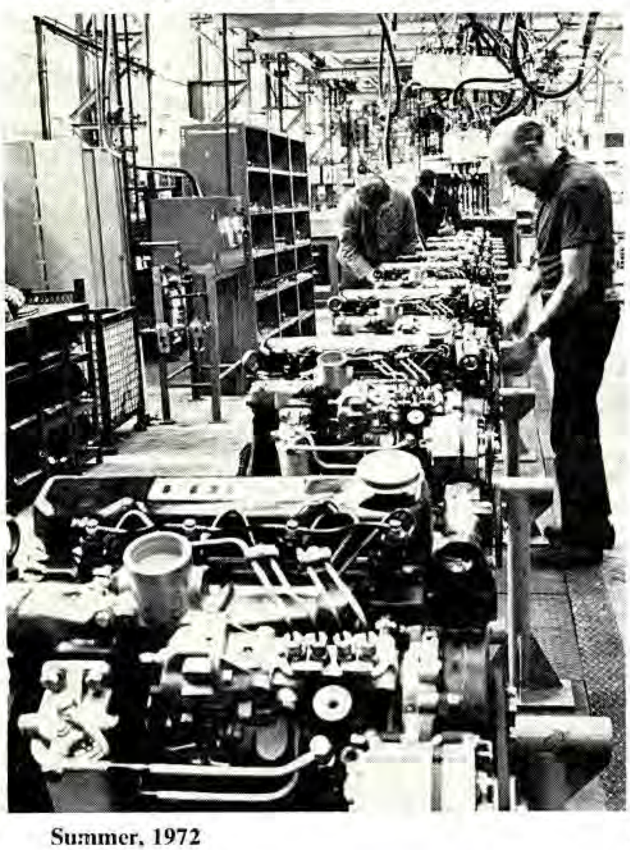
Ford 2·4-litre diesel with Bosch electrical and fuel-injection equipment

TABLE A
PERFORMANCE DATA FOR FORD 2401E DIESEL ENGINE

		LOW RATING	HIGH RATING
BS AU141:	Net output	54bhp at 3600 rev/min	61bhp at 3600 rev/min
	Torque	85lb-ft at 2500 rev/min	95lb-ft at 2250 rev/min
	Bmep	89.08lb/in^2 (6313kg/cm^2)	99.56lb/in^2 (7354kg/cm^2)
DIN 70020:	Net output	51 PS at 3600 rev/min	62 PS at 3600 rev/min
	Torque	11.4kgm at 2500 rev/min	13.6kgm at 2250 rev/min
Specific fuel consumption			
At full load and maximum speed		0.482lb/bhp h (0.219kg/bhp h)	0.492lb/bhp h (0.223kg/bhp h)
At full load and maximum torque		0.440lb/bhp h (0.200kg/bhp h)	0.449lb/bhp h (0.244kg/bhp h)

compactness is especially important with an over-square design (3.6in bore to 3.3in stroke). The short stroke means that at 3600 rev/min the piston speed is only 2020ft/min, which is claimed to be considerably lower than in any other present-day European diesel of this power. The crankcase is sealed to comply with crankcase emission regulations now becoming internationally standard. The ventilation system embodies an air intake on the rocker cover, whence the stream is into the crankcase; an oil separator and flow controller are on the right hand side of the block; fumes are fed back to the intake manifold via an external pipe. The sump pan can be reversed if application conditions make that desirable.

Final assembly of the Ford 2·4 litre diesel at Dagenham; before leaving the production line every engine is fully bedded in by 75 minutes' test running, being checked for correct power output and emission levels



Five copper-lead indium-plated main bearings carry the nodular-iron cast crankshaft; casting is preferred because it allows optimum sections to be achieved to meet operational conditions, also easing machining and giving longer bearing life according to Ford experience. The rear main is 77mm in diameter against 70mm for the others, in order to give increased overlap with the No. 4 crankpin, which confers greater strength and reduced length because the flywheel mounting runs within the length of the journal. No. 3 main carries the thrust provision.

Big end bearings are of the same material as the mains. Drillings in the crankshaft feed the big ends, which are of 60mm diameter. At the front end of the shaft is a sintered metal gearwheel for the oil pump

TABLE B
FORD 2.4 LITRE DIESEL 2401E

Indirect injection, naturally aspirated, four cylinders in line (at 22.5 degrees to the vertical).

Bore	3.687in (93.67mm)
Stroke	3.37in (85.60mm)
Swept volume	144in^3 (2.358 litres)
Compression ratio	22 to 1
Peak cylinder pressure, (approx.)	1350lb/in^2 (95kg/cm^2)
Maximum mean piston speed	2020ft/min (10.272m/sec)
Weight without starter ..	490lb (222kg)
Weight per bhp (high rating)	8.09lb (3.66kg)
Length	22.1in (561.5mm)
Width	25.16in (639mm)
Height	31.04in (798.4mm)

drive, beyond which is the toothed wheel for driving the belt which rotates the fuel-injection pump and the camshaft. The rear end of the shaft is formed as the mounting flange for the 12.8in diameter flywheel, carried on eight bolts.

Forged steel connecting rods carry 29mm bore small end steel backed bronze bushes. Oil for these bearings is obtained from the jets which provide for underpiston cooling. Diamond-turned pistons have surface design features for oil spread and retention. Reduced friction is achieved by using only three rings—two for compression and one for oil control. The top ring is barrel faced, the second taper faced, and the oil control ring is of U section with separate springs; all rings are chrome plated. The piston crowns are basically flat topped but have shallow clover-leaf depressions as part of the combustion system.

Piston cooling is carried out very thoroughly in order to exercise strict control of the ring belt temperature, also to permit ring-bore clearances to be kept to small values, so ensuring long life and freedom from ring breakages. A jet from each main bearing sprays one piston crown's underside when at top dead centre. The oil spreads all over the back of the ring belt and lubricates the adjacent small end bearing.

Eighteen bolts of 0.47in diameter hold the alloy iron cylinder head to the block; each cylinder circle is surrounded by six bolts to clamp down the head against a laminated rubber-asbestos wire mesh gasket; the original torque loading upon the bolts does not need subsequent attention. As to the combustion chamber, the spherical portion has the upper half cast in the head, whilst the lower half (including the throat) is in high nickel steel. The throat directs the burning gas into the clover leaf. The air intake manifold is approximately on the centre line of the engine and the exhaust outlet on the left side, providing a cross flow. The injectors are located vertically to the left of the intake manifold.

Long term durability of the valves is a target, for which 21-4-N heads are welded to EN 18C stems. Each valve seats upon centrifugally spun alloy iron cast inserts. Valve operation is by short push rods, the tappets of which rotate for wear spreading. Rockers are in nodular iron and have self-locking adjustment screws; drillings provide lubrication to the rocker ends contacting the valve stem ends. The exhaust valves have double springs but there are single ones on the inlet valves. The valves are positively rotated at between 4 and 8 rev/min.

Running in five bearings is the hollow camshaft; oil from within the shaft feeds these bearings, the supply being derived from the centre main bearing.

Much interest centres in the use of toothed belt drive for the camshaft and fuel-injection pump. Ford has had wide experience with such drives in automotive units including racing cars, and has spent much time upon research. The noise is much less than is emitted by chain or gear systems. The belt is of rubber with glass fibre reinforcements and nylon tooth facings. The maker gives the life of the belt as at least equivalent to that of the basic engine. Silence is aided by the use of a cover in the form of a plastic moulding over the belt "triangle."

Rating difference between the "low" and "high" versions is effected by injection pump settings; the lower output is obtained with $36mm^3$ per stroke, whereas the higher one runs at $40mm^3$ per stroke. Home market units employ the Simms Minimec pump with a mechanical all-speed governor, with the drive first passing through the governor; automatic injection advance up to 10 degrees is provided. Fuel is fed to CAV pintle-type nozzles, opening at 145 atmospheres. The Bosch M-type pump is the alternative, with a mechanical all-speed governor. The Simms has a manually operated excess fuel device for starting, whilst the Bosch has an automatic one. In both cases the pump is lubricated from the engine's main system.

The in-line form of pump is adopted because Ford engineers regard it as best for reliability and maintenance of "tune," also because it is familiar to dealers everywhere. The pump can be mounted high up, and thus be unusually accessible, because the inverted-

Ford Transit body shell being lowered above the 2·4-litre diesel power unit at the commercial vehicle plant at Langley, Bucks

tooth belt system is not limited by normal chain or gear layout. There is no need to check the oil level in the pump camshaft housing.

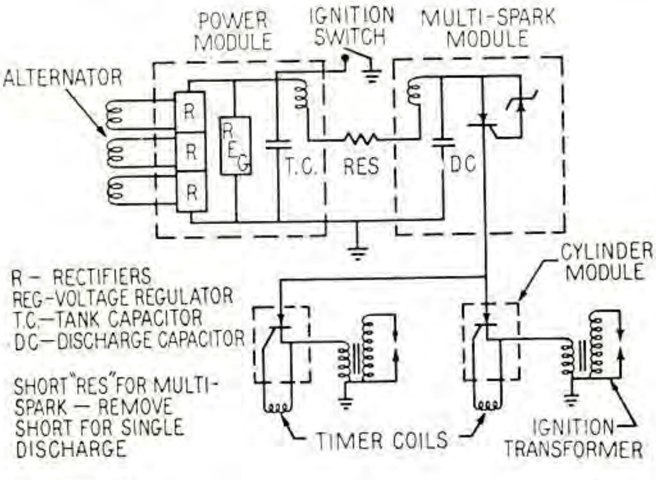
Sump oil changes are recommended at 3,000 miles or 5,000 kilometres, the quantity being 11 pints (6.25 litres). At maximum engine speed the pumped quantity is 12.3gal/min (56 litres) and the working pressure is 60lbf/in^2 (4.2kgf/cm^2). A full-flow filter with paper element is used. As to the cooling pattern, water from the pump enters the front of the block, flows around the cylinder bores and on to the head through metering holes in the head gasket which equally distributes the volume in the head passages on both sides. Each valve bridge is force cooled through a drilling. Water leaves the head via a thermostat of the wax type set to open at between 69 degrees C and 73 degrees C.

For cold start assistance down to -10 degrees C there is a flame-start equipment in the entry to the manifold; for temperatures down to -20 degrees C there are two electric glow plugs, one at each end of the manifold. For arctic conditions two heavy-duty batteries are provided.

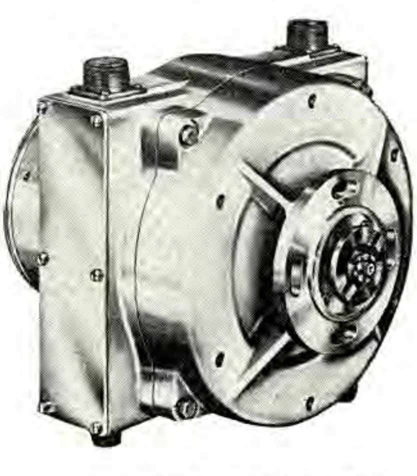
American Bosch multiple discharge ignition for gas engines

CIMD (Controlled Interval Multiple Discharge) introduced by American Bosch, is a refinement of the Pulstronic 1000 capacitor discharge system for gas engine ignition, which has been in production for some time. The aim of CIMD is to give higher performance and improved reliability from large gas engines and gas engine-compressor sets. The system releases the ignition energy in short, timed high-rate pulses to provide the most effective spark duration, thereby reducing plug electrode erosion and improving lightload performance and startability, while increasing the ability to ignite lean mixtures. It has been found possible to advance the engine timing of these engines somewhat, due to the greater consistency of combustion pressures. Two versions of the timer are available for two-stroke (engine speed) and four-stroke (half engine speed) applications. The ignition generator is exceptionally neat and consists of three sections: the drive-end, containing a three-phase alternator, a centre module containing the solid-state electronic components and a third which contains the timer. The normal A timer will provide starting ignition at as low as 25 rev/min and will operate up to 300 rev/min. The B timer covers the range 30 to 600 rev/min. The assembly is mounted by a flange with four slotted bolt-holes permitting 30 degrees movement for automatic advance and retard.

Schematic diagram of the American Bosch Pulstronic 1000 ignition system



Compact ignition generator incorporating alternator (nearest) solid state electronics (centre) and timer



Did you know that . . . ?

The accompanying photograph shows HMS *Bristol* a new type of guided missile destroyer built at the Wallsend-on-Tyne shipyard of Swan Hunter Shipbuilders Ltd, leaving the Tyne for sea trials.

The *Bristol* has a standard displacement of 5,650 tons, an overall length of 507ft (154.5m), a beam of 54ft (16.5m) and will carry the following armaments: Sea Dart missile system, an Ikara long range anti-submarine guided weapons system, radar-controlled 4.5in guns and an anti-submarine mortar.

Although not fitted normally to carry a helicopter, HMS *Bristol* is fully equipped for helicopter landing and control for anti-submarine operations.

Control of operations will be effected by the most advanced action data automation system yet fitted in a ship of the Royal Navy.

The propulsion machinery consists of two sets of AEI-built, geared, steam turbines for normal steaming conditions, with Rolls-Royce Olympus gas turbines to provide additional boost.

Accommodation for her complement of about 40 officers and 400 ratings is of a very high standard. The whole ship will be air-conditioned and have large dining halls served by a modern galley providing varied meals on a self-service system.

'HMS Bristol' prior to proceeding on extensive sea trials

The first Westland-Aerospatiale Gazelle for the Royal Navy (XW 845) made its maiden flight on Thursday, 6th July. The Gazelle was airborne for 30 minutes and was flown by Test Pilot, Michael Fuller who was accompanied by Flight Test Engineer, John Keyes.

The Gazelle is scheduled for evaluation by the Intensive Flying Trials Unit later this year prior to operational use by the Royal Navy in the training role. Thirty Gazelles are on order for this service, 99 for the British Army and 13 for the Royal Air Force.

The Gazelle forms part of the Anglo/French helicopter co-operation programme, the other two being the Lynx and Puma, and this aircraft is scheduled to enter service with all three British armed forces.

Redifon Telecommunications Ltd exhibited an advanced range of MF-HF equipment designed for civil, military and naval applications at the "Communication '72" exhibition (Brighton, 13th-15th June, 1972).

Exhibits included all-solid-state broadband HF transmitters with outputs from 100 watts to 1 kilowatt, a series of communications receivers to meet the requirements of all MF and HF users, and the new Redifon Omega Navigator which provides position-fixing at any point in the world at any time of the day or night and in all weather conditions.

Among the naval equipment displayed were the Redifon 643 Transmitter and the CJP Receiver, which are being supplied to the Royal Navy as replacements for the earlier type 618 and 619 Transmitters and Receiver Outfit CAT. Together they form a 100 watt station for SSB, CW and RATT working in the 1.5-

This Gazelle (XW 845) recently flew for the first time and is scheduled for evaluation by the Intensive Flying Trials Unit later this year prior to operational use by the Royal Navy in the training role. Thirty Gazelles are on order for this service

Did you know that . . . ?

20MHz band, with reception down to 100kHz. The transmitter, which is broadband, and the receiver both employ frequency synthesis for tuning in 100Hz steps. Additionally, the receiver is continuously tunable throughout its range.

Military equipment on show demonstrated the flexibility with which various types of stations can be built up from standard units in Redifon's HF range for use in vehicles or as transportable containerised radio stations.

The TF range of two-shaft marine and industrial gas turbines built by the Avco Lycoming Division are marketed in the United Kingdom by Amalgamated Power Engineering Ltd, of Bedford. The nominal continuous power range commences at 800bhp (TF12) and extends to 3,380bhp (TF35).

A feature of these gas turbines of great benefit to users is their modular-assembly construction. The complete engine is made up of a number of sub-assemblies or modules which, as shown in the diagram, can be quickly replaced by a spare and subsequently overhauled at leisure in a workshop. The time that the gas turbine is out of operation is thereby reduced to an absolute minimum.

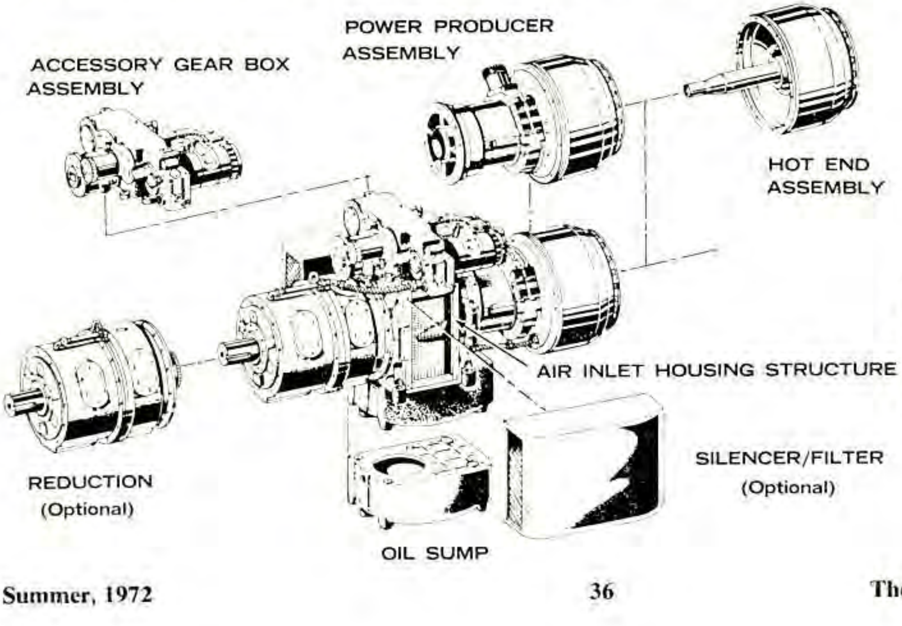
A thorough examination of the power turbine and annular combustion chamber can be completed within a few hours by removing the entire hot end assembly. The engine drives have been grouped together to form another modular assembly mounted on the air inlet housing. In this module are the engine starter (electric hydraulic or pneumatic), the fuel and speed controls. The speed reduction gearbox is another module, usually a tailor-made double-helical epicyclic gear unit produced by the Pershore Division of the A.P.E. Group.

No scheduled TBO maintenance is considered. The instrumentation provided with the engine is used to determine the engine operational characteristics and is further used to assist in trouble-shooting to isolate problems in specific modules.

The Ministry of Defence is to buy the twin-screw Rolls-Royce Proteus-engined fast patrol boat *Tenacity* from Vosper Thornycroft. The ship, which was built by Vosper in 1969 to demonstrate its light-weight highly armed fast patrol boats has twice been on charter to the Ministry of Defence and has made several sales tours to European countries.

The supplements to most of the 1972 naval annuals make reference to a new class of all-gas turbine-powered general-purpose destroyer. These appear to be vessels of about 475ft (145m) long and 4,400tdispl with a simpler machinery installation than the twin Y-funnelled *Kashins*. Estimates of power vary between 48,000 and 112,000shp, presumably from aero-derived gas turbines. Armament consists of a quadruple surface-surface missile launcher forward, two twin surface-air missile launchers and four 3in dp guns in twin mountings aft, and eight torpedo tubes.

A production contract worth over £1,000,000 has been placed with Marconi-Elliott Avionic Systems Limited, a GEC-Marconi Electronics company for



This sketch shows a Lycoming TF gas turbine and the modular sub-assemblies into which it can be broken down for maintenance

Did you know that . . . ?

automatic television control systems to be used with the Royal Navy's Seacat surface-to-air missile.

This new contract, awarded to the Electro-Optical Systems Division of the company, was the result of a long design and development programme carried out by the Division, in close co-operation with Director General Weapons (Navy) for Ministry of Defence (Navy). During this programme the system was evaluated both ashore and in an operational warship at sea.

The television system automatically gathers the missile after launch, and brings it on to the target sightline, so removing the responsibility of this critical stage from the aimer. The TV camera, which is fully automatic, is mounted in a weatherproof housing on the weapon system director and is collimated to the tracking radar. The display, control panel and data extraction unit are mounted below decks in an operations console. Flares on the tail of the missile are detected by the television camera and the video signal is processed to produce analogue signals proportional to the "missile' to-sightline" error. These signals, after processing, are fed to the missile command transmitter to bring the missile smoothly onto the target sightline.

Once gathering is complete, the final guidance phase may be handed over to the aimer who will keep the missile on the sightline until the target range is reached. A statistical analysis carried out by MoD(N) has shown that smooth and rapid gathering of the missile significantly improves the short range capability and accuracy of the weapon system. The television equipment is based on the Marconi-Elliott V323 military range, which was developed as a private venture by the company at their Basildon, Essex, laboratories. Additional units have been designed and developed by the Electro-Optical Systems Division under sponsorship from the Ministry.

Two versions of the equipment have been ordered. One is for use on General Purpose Frigates and Guided Weapon Destroyers and the other is for use with the new "Type 21" Frigates. It is expected that the first equipments will become operational early in 1973.

Negotiations are now being conducted with several other overseas Navies, and further orders are expected in the near future.

Newest addition to the Lufkin range is the Ultralok 5-m/16-ft metric/imperial tape. The case is chrome plated on strong ABS plastic and can withstand the knocks encountered in general use.

Features include a positive locking button which holds the blade firmly in any chosen position; a cushioning buffer against which the end hook impinges

Latest addition to the Lufkin range is the Ultralok 5m/16ft tape, available in ½ and ¾-in widths

when the tape is allowed back into the case; and a steel blade, covered in white enamel and with markings in black and red. The blade is coated with a hard epoxy resin to resist abrasion.

Available in ½ and ¾-in widths, the tapes retail at £2.35 and £2.78 respectively. Weller Electric Limited, Redkiln Way, Horsham, Sussex RH13 5QL.

A permanent type filter developed by Pall Trinity Micro Corporation has been specifically designed for use on fuel gas lines supplying gas-fired turbines. The filter contains sintered and pleated wire mesh installed in the line downstream of the disposable filters normally used on these fuel lines. It is thus located to provide protection against damage to the turbine in case of collapse of the disposable first cartridge. Removal rating of the permanent medium is coarser than that of the disposable filter in order to avoid any possibility of plugging.

A new general purpose weatherproof closed-circuit television camera has been introduced by EMI for use in education, commerce and industry. Costing around £300 including electrostatic vidicon tube, the solid-state camera is capable of providing acceptable pictures under adverse lighting conditions. Electronic circuits automatically ensure that the camera output signal is maintained constant over a very wide range of light intensity. Television pictures can be displayed on any television monitor or be recorded on any compatible video tape recorder for analysis or record purposes. Included in the range of accessories is a series of fixed focus and zoom lens packages, a weathershield, a pan and tilt head and various types of remote control equipment. In remote controlled applications Surveyor can be fitted to the motorised pan and tilt head which allows movements of the camera to view a wide area.

Did you know that . . . ?

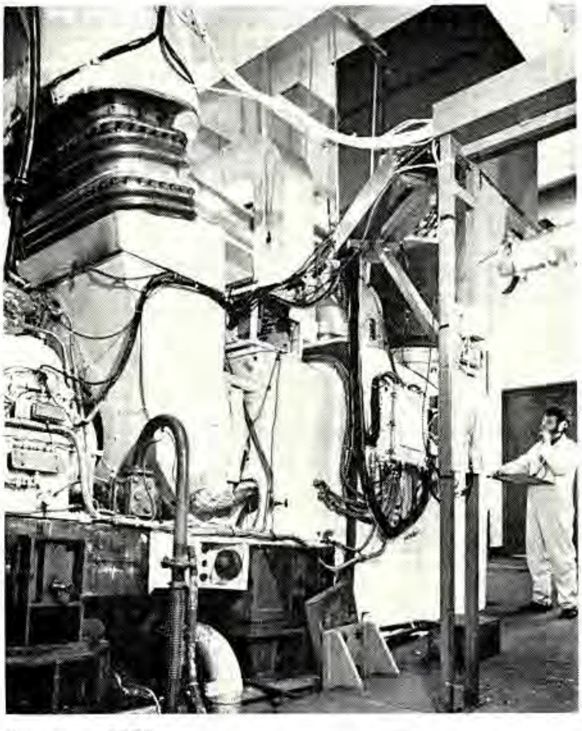
The weathershield is used to protect the camera from direct sunlight and to shield the front port of the lens package from adverse weather conditions. EMI Electronics & Industrial Operations, Blyth Road, Hayes, Middx.

The accompanying illustration shows the cruise engine for the Royal Navy's new frigates and destroyers, the Rolls-Royce Marine Tyne gas turbine, undergoing shore trials. The 4,250bhp engine is on a 2,500-hour test programme to be completed this year.

It has been installed at the Industrial and Marine Division's Ansty factory to reproduce the conditions of a typical gas turbine installation in a modern warship. This includes ship type intake and exhaust ducting, installed angle of rake and the ingestion of sea water into the air and fuel supply. To further simulate the arduous conditions which will occur in the new gas turbine warships, the testing is being run to a cyclic schedule.

A 1,400 hour development programme preceded the present shore trials and back-up development will continue alongside in order to solve problems that may occur from the shore trial and sea operation.

The cruise engine for the Royal Navy's new frigates and destroyers, the Rolls-Royce Marine Tyne gas turbine, undergoing shore trials at the Company's Ansty factory, near Coventry



In addition the design phase of a programme to increase the power rating of the Tyne from 4,250bhp to 5,340bhp has been completed.

Two of the 4,250bhp engines are to be installed in the new ships of the Royal Navy and frigates and destroyers for the Royal Netherlands Navy and the Argentine Navy for cruise conditions Two Rolls-Royce Marine Olympus, each of 28,000bhp, will also be installed in these warships for full power.

Claimed by its makers to be the world's smallest, am underwater television camera, only 1¾in (44.45mm) in diameter and 7in (177.8mm) in length was exhibited on the Seer TV Surveys stand at the recent Oceanology International '72 conference and exhibition at Brighton. Called the Falcon VE12 it is a specially developed ½in (12.7mm) vidicon in a pressure proof stainless steel housing that contains a remote focus facility. The use of encapsulated electronics in the camera head contributes to its robustness, and printed circuit modules of advanced electronic techniques are employed in the camera control unit for reliability. The camera has unrivalled versatility due to its small size and is currently being used by BAC and Sud Aviation on the Concorde project. Seer TV Survey equipment is used in all parts of the world in oil rigs, submarine pipelines and cables, harbour defences, ship's hulls, boreholes and wells.

A night viewing telescope for military, police and civilian security use has been developed by Barr and Stroud using the latest ITT image intensifier technology.

Designated the CU17, this small, compact and self-contained device uses an F4747 image intensifier supplied by ITT Components Group Europe to give a passive viewing capability down to starlight conditions (10^{-3} lux).

This image intensifier uses a channel plate amplifier matched to an input photocathode and output phospher to give maximum luminous gain and to keep the image free from loss and distortion across its whole area.

The F4747 uses proximity focusing and has major advantages in size and weight over conventional 3-stage cascade image intensifiers. Proximity focusing also results in a shorter length than could be obtained with an electrostatically-focused channel plate image intensifier.

Barr & Stroud's CU17 telescope has an overall length of 23cm and weighs less than 1kg. With a 10° field of view and optics giving a x 4 magnification, the telescope can detect a man at 250m under starlight conditions. A single 2.7 V military-type dry battery provides up to a week's use under normal operational conditions.

Further details from Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex.

Did you know that . . . ?

Jubilee have introduced the improved Jubilee Clipdriver, a redesigned driver that eliminates the problem of tightening a Jubilee clip to the desired degree when working space is restricted and pressure on a conventional screwdriver often causes the clip to slip.

Jubilee's redesigned Clipdriver is available in two sizes

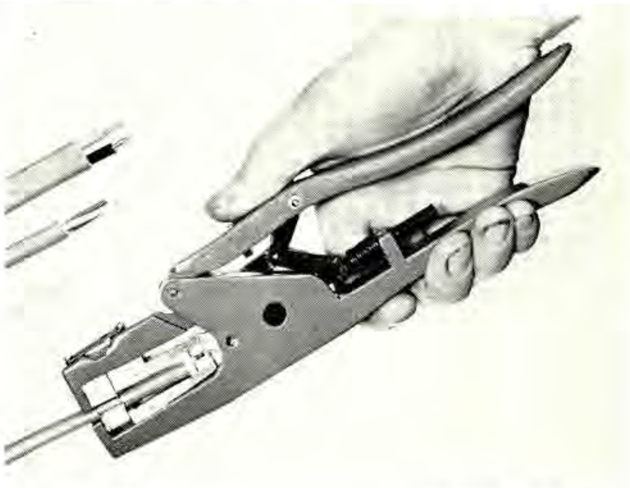
The drivers are available in two sizes, 3¾ and 6¼-in, and retail at 45p each. L. Robinson (Gillingham) Ltd, London Chambers, Mill Road, Gillingham, Kent.

Four Vosper Mark 10 frigates are to be built at Woolston, Southampton by Vosper Thornycroft Ltd and two more in Brazil for the Brazilian Navy. The 3,000-ton displ frigates will be powered by MTU diesel engines and Rolls-Royce Olympus gas turbines arranged in CODOG. In each ship four MTU MA16V 956 TB91 (formerly MAN 16-cylinder 23/23TLs) engines, 4,000bhp(m) at 1,550 rev/min will be coupled in pairs to their respective transmission systems through Fluidrive size 36 type SRD 3 fluid couplings. These will isolate the engine torsional systems from the David Brown gearing and will assist the relatively small and light-weight but powerful diesel engines to overcome the considerable inertia of the main transmission, which is proportioned to handle the 28,000hp of the Olympus boost gas turbines. The fluid couplings are also used as non-wearing disengaging clutches for the diesel engines. In each ship there will be four diesel-alternator sets consisting of an MA12V 956 TB61 engine (12-cylinder lower-rated version of the main diesel) and a 1,000kW Laurence Scott 440v GOH_2, alternator, with static thyristor automatic voltage regulation.

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.

One of the more time-consuming jobs in wiring up, is that of stripping the cable ends, particularly when tough vinyl insulation is used. A new range of self-adjusting wire strippers has been introduced. The three models in the range are designed to deal with stranded or solid aluminium or copper wire in many sizes. Either individual or multiple wires can be handled without adjusting the tool. The wire is inserted in the jaws, to the length which is required to be stripped. The wires do not have to be aimed as there is no stripping hole to

Self-adjusting wire stripper



Did you know that . . . ?

locate. Automatically adjusting multiple cutting blades, cushioned by a resilient pad, strip off the insulation as the wire is drawn through the closed jaws. A stop can be fitted to determine a precise stripping length. The same tool will strip off outer and inner insulation without adjustment. The two hand-operated models are suitable for stripping insulation diameters from 0.010in to 0.10in (0.254mm to 2.54mm) and 0.80in to 0.20in (2.0mm to 5.0mm). A third model, for bench production line use, will take diameters from 0.060in to 0.30in (1.5mm to 7.6mm). The hand models, which are ideal for general electrical installation and maintenance work, are priced £9.25 and £12.50: the bench model costs £125.00.

Official approval under Defence Quality Assurance Board Part 3 conditions has been given to the Environmental Test Laboratory of Marconi-Elliott Avionic Systems Limited (a GEC-Marconi Electronics company) at Rochester, Kent, to perform climatic, mechanical and electromagnetic tests on electronic equipment.

Part 3 approval means that Marconi-Elliott Avionics test laboratory at Rochester is one of the select few establishments authorised to provide this service to other manufacturers, as well as dealing with equipment of its own manufacture.

The Marconi-Elliott Avionics test laboratory is equipped to perform a wider range of tests than any other test house in south-east England. Additionally, it is unique in Britain in being able to perform officially approved electromagnetic compatibility tests, a service which is extremely important to exporters of avionic equipment and to those participating in international aviation programmes such as the Anglo-German-Italian Multi-Role Combat Aircraft (MRCA).

Modern aircraft carry numerous electronic control sensing and communications systems and it is vital that there is electromagnetic compatibility so that unwanted electromagnetic radiation from one "black-box" cannot cause spurious responses in another. Neither should any "black-box" be unduly susceptible to such effects.

At a meeting of the International Hydrographic Organisation in Monaco it was agreed to publish a new series of marine charts to agreed specifications. Nations were allocated areas of responsibility for the new series which is aimed at reducing duplication of effort resulting from several countries making charts of the same general sea area, with differing scales, geographical limits and information. Agreement was reached on limits and scales—either 1 to 3½M or 1 to 10M—and the intention is that all charts will be available for reprinting by any member of the organisation for inclusion in their own national series.

The first chart in the new series, BA Chart 4701 (also numbered INT 701) has been produced by the Hydrographer of the Navy. It covers Lourenco Marques to Mogadiscio and is one of fifteen international charts on routes from the English Channel around the Cape of Good Hope to the Persian Gulf and Malacca Strait that the United Kingdom has agreed to compile. Contours are given at every 1,000 metres throughout the whole of the depth range and a new symbol, an encircling dotted line, denotes reported, but unconfirmed, depths or danger. Compass roses will be magenta rather than the usual black.

GEC Machines Ltd, of Rugby, are currently manufacturing 22 (20 plus two depot spares) 1,000kW, 1,200 rev/min, 450V, 3-phase, 60Hz brushless alternators for the Royal Navy's Type 42 general purposes destroyers, *HMS Coventry, Birmingham,* 04, 05 *and* 06 (four per ship). They will be driven by Ruston Paxman 16 YJCAZ Ventura 1,440hp, 16-cylinder turbocharged diesel engines. Each will be complete with overhung ac exciter, belt-driven permanent magnet pilot exciter and separately mounted AVR. The machines will be similar to those already supplied for *HMS Sheffield* and other ships. The total quantity of 1,000kW brushless units ordered to date for vessels of various navies is 54.

A new electronic shooting range system permits marksmen to manoeuvre targets from the firing point and simultaneously to receive results of their marksmanship. The system has been developed by the computer and electronics division of Sweden's Saab-Scania group, Lindoping.

The wholly automatic system features moving tragets made of rubber—usually in the form of an elk, favoutite quarry of Swedish hunters—which incorporate a layer of electrically conductive material.

The latter short-circuits each time the target is hit and causes an electric impulse to travel to a special registration unit immediately beside the marksman. Complete data on his performance and scoring is registered on this device and is also recorded within, on a punched tape. A larger unit beside the shooting range also performs this function.

Since the marksman needs no assistants to manoeuvre or adjust the targets or check scores, the new system—which also allows a shooting session to be completed in only half the usual time—is no more expensive than conventional alternatives besides being safer and more accurate, the manufacturers say.

The targets used are said to be highly durable and can be hit "several thousand times" before needing to be repaired or scrapped. They are mounted on electrically powered wagons which move backwards and forwards across the range.

OBITUARY

Rear-Admiral Sir Sydney Oswell Frew, KBE, CB, who died on June 10th in his 83rd year, was the first Artificer to be promoted to the rank of Rear-Admiral.

He joined the navy as a Boy Artificer at the age of 15 in 1905 from the Royal Hospital School, Greenwich, and went to sea as an Engine Room Artificer in 1909 in the battleship *Formidable*. In 1916 he was promoted to the new commissioned rank of Mate(E) which had been introduced in 1914. His war service included the battleships *Ajax* and *St. Vincent* in the Grand Fleet and as Engineer Officer of the destroyer *Mameluke*. He was promoted to Engineer Lieutenant in 1918.

In 1919 he commenced a long period of service in submarines, in the depot ships *Maidstone* and *Pandora* and in submarines *K*12 and *K*14. Also as instructional Engineer Officer and Senior Engineer of HMS *Dolphin*, the submarine headquarters, until his promotion to Lieutenant Commander in 1926.

There followed a period of general service as Senior Engineer of the cruiser *Hawkins*, flagship of the C. in C. China Station, but he returned to the submarine service in 1929 in the depot ship *Vulcan*, was promoted Engineer Commander and served as the Engineer Officer of the depot ships *Titania*, *Cyclops* and *Douglas*.

His next appointment, in 1933, was to the new cruiser *Arethusa* in the Mediterranean. In 1937 he was appointed to the battleship *Royal Oak* in the Home Fleet. He returned to the submarine service in 1938 as Flotilla Engineer Officer in the depot ship *Medway* in China and, in 1939, was the first artificer to reach the rank of Engineer Captain.

Returning to England, he was appointed to the Admiralty and, in 1941, as Fleet Engineer Officer on the staff of Admiral (Submarines). He was promoted to Engineer Rear-Admiral in 1945.

In 1946 he was made a CB and in 1949 a KBE.

Although he did not remain a member of our Society, he maintained a keen interest in the ranks of those from whom he was promoted. Soon after his retirement from the navy in 1950, on reaching the age of 60, he was employed for some time by the (then) Ministry of Fuel and Power.

The above is the bare history of his naval career, but what of the man? I met him a number of times after he became an Admiral, but these were more or less formal occasions, at Dinners or Dances, so it cannot be said that I knew him personally. My impression was of a kindly but rather austere man. I never served in a ship with him, but have been messmates with several who served with him as a Lieutenant Commander and Commander. By repute he was one whose promotion was well deserved. It had to be, because promotion to the higher ranks did not come easily to those from the lower deck in his day. His reputation was that of a thorough-going engineer in the true sense of the word and he was never afraid of getting down to the job himself if difficulty was being experienced. He knew his job and expected the same from everyone else. I have heard it said many times that, "If you knew your job you were OK with Sydney, but woe betide any scrimshankers". He did not suffer fools gladly and saw to it that every young ERA got to know his ship thoroughly.

He is assured of a place in the annals of our Corps as the first Artificer to reach the rank of Captain and Rear-Admiral. None who followed him along that trail which he blazed could have been more deserving.

R.H.C.

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