Radar Systems International

MARCONI

No. 21

Marconi Small Ships Packages

The rapid developments in armaments, the increasing sophistication of guidance systems for missiles, improved gun control and target acquisition facilities have endowed a single ship with greater destructive power than a whole fleet of ships twenty years ago.

Part of the changes taking place in naval tactical defence schemes has thrown more emphasis on the small, fast surface craft which can carry the new lightweight weapon systems and present a difficult target themselves. These high speed attack craft, armed with missiles, have changed the balance of sea power in many important areas of the world, especially in the defence of countries with long coast lines.

An example of the fast patrol craft which is filling this role is the thirty metre class being built in large quantities, not only by European builders but by many other countries. To meet the armament needs of this class of small ship new, compact and lightweight armament and electronic systems have been designed or adapted.

Marconi Radar Systems have produced a range of high technology radars for surveillance and tracking ideally suited for use on vessels from fast patrol boats from 100-500 tons up to corvette and frigate size.

The 800 Series
Advanced Technology Radars
This range of modern lightweight compact radars uses the latest technology and Marconi naval design experience in producing weapon systems for the control of guns and missiles. Their modular construction gives flexibility of layout under conditions where space is limited; built-in monitoring permits speedy servicing.

Both surveillance and tracking radars are available and an unusually effective digital MTI (Moving Target Indication) Facility can be incorporated that enables targets to be engaged under conditions where most other radars would be swamped by weather or sea clutter returns.

The Complete System
The fully integrated radar and weapon control system for the smaller naval craft such as fast patrol boats (FPBs) employs one of the range of X-Band surveillance radars which have a detection range out to 40km with a stabilized antenna of either 1.2m or 2.4m size mounted in a radome.

The fire control is based on either one or two ST802 tracking radars which are used to control guns or surface-to-air missiles. The ST802 is a modern monopulse radar with digital MTI and is also able to perform a most effective low-level, horizon-stabilized search. This provides very effective detection of low-level attacking aircraft or surface-to-surface missiles. Detection and allocation to weapons is carried out at the Tactical Command Suite which provides the necessary features of a full AIO without the considerable cost and complexity. Designation of targets is made to either the fire control radar or to the Otomat fire control channel.

A typical system would use an ST802 controlling an Oto Melara 76mm gun and a Shorts' Seacat missile. Control is exercised from a weapon control console.

A television camera is co-mounted with the radar antenna and is used to gather and guide the missile. The television also provides a secondary control mode, enables a visual identification of the attacker and allows damage assessment. An optical sight may be used to track secondary targets and to supplement the tracking radar.

The system may control the following:

i.) Otomat against a surface target
ii.) Seacat or the gun against an air target using the tracking radar
iii.) The gun against a further surface target using the surveillance radar, or alternatively, the gun may be controlled from the optical sight against a further sea or air target.

S800 radar proved 100% accuracy in trails at HMS Cambridge gunnery range

Surveillance for Small Ships
The S811 X-Band Surveillance radar has a range against surface targets out to the radar horizon. Target detection and allocation is made at the Tactical Command Suite which comprises a 30cm PPI display and a digital computer which provides tracking assistance to the operator. The S811 provides accurate target data for offensive weapons such as surface-to-surface missiles, Otomat or torpedoes to give these small craft a very considerable offensive capability.

Surface-to-surface missiles
Control systems are available for the Exocet, Otomat and Penguin surface-to-surface missiles, all of which have excellent range and lethality and may be fitted into fast patrol craft.

Gun Control
The Sapphire gun control system will control servo-operated guns from 30mm upwards. The system offers three modes of operation:

Anti-aircraft (AA) for defence against high and low level air targets.

Surface (SU) for use against surface vessels moving at speeds up to 60 knots

Naval Gunfire Support (NGS) including: Direct Bombardment, Indirect Bombardment and Blind Bombardment.

Systems in production include — the SP1 which may control one or more guns of the same ballistic type and the SP2 which is a dual-ballistic predictor.

Surveillance
Radars Type S810 and S811 are lightweight, stabilized X-Band surveillance radars, specially designed for offshore craft and fast patrol boats, where there are limitations of space and weight. A narrow horizontal beamwidth and an antenna stabilized against ship's motion ensures accurate target indication data for pointing weapons and for putting-on a tracking radar.

Detection of surface targets is horizon limited but aircraft can be detected at ranges up to 40 km.

Any one of these radars can also operate as ship's navigation radar.

Tracking
The ST802 is a fully automatic lightweight tracking radar giving accurate space-stabilized target data for a variety of weapon control systems. The radar is autonomous and generates its own stabilized search patterns based on target range and azimuth data obtained from the Tactical Command Suite of Ship's AIO. Its acquisition and tracking modes are automatic. The radar has a low level search mode in which the antenna is rotated at 20 r.p.m. to provide a stabilized horizon search.

The radar, tunable from the console over the range 8.6-9.5GHz, incorporates a particularly effective digital MTI system to reduce the effects of sea and land clutter. An extensive range of ECCM facilities allows operation in a jamming environment. The ST801 version is available for use in systems with a central computer complex.

A television camera is co-mounted with the radar antenna on the director and the display unit is mounted on the weapon control console. The system is used to gather and control the missile automatically and provide an alternative control mode which may be used in conditions of radar silence and as an aid to low-level tracking.

Predictor
The new effective lightweight fire control system, Sapphire, is based on the Sperry 1412 digital computer. The 1412 is now entering service with the Royal Navy as part of the Exocet missile system. Sapphire is capable of controlling a number of gun mountings of the same type. A dual ballistic predictor is also available to control two guns of different types.

Tactical Command Suite (TCS)
The TCS is a flexible AIO system for small ships where a fully integrated AIO is not economically justified.

The basic TCS comprises a 30cm radar display with facilities to allow a single operator to track four targets and to allocate these to the ship's weapon systems. Automatic track sequencing allows the operator quickly to update his tracks by means of a tracker ball. The Locus 16 computer provides the central control for the Tactical Command.

Weapon Control Console
The Weapon Control Console provides an integrated radar and weapon control. Much of the operational sequence is automatic but a full range of monitors and controls are provided for selection of essential parameters. A single operator mans the console.

CONTROL SYSTEM CAPABILITY

Marconi Radar Systems are known throughout the world for the radars and associated equipments supplied to the Royal Navy and navies overseas, but the company's involvement in naval equipment also covers a wide range of electronic, electrical and mechanical devices and systems.

Over the years, the experience gained from close cooperation with naval and military experts in all types of weaponry, controls and tactical requirements has guided studies leading to the design and development of advanced systems in use today in fighting ships around the world.

Although not so widely publicised, these equipments, which carry out many of the essential functions during operations aboard ship, form a growing area of activity within the company.

The formation, in 1976, of the Control and Simulation Division brought together the expertise and design facilities of the Control Systems Department and the Simulation and Instrumentation Department to concentrate this effort and amalgamate all the applications experience in this field.

In the first year of operation the Division received orders totalling some £5M, with a forecast this year of over £6M. More than 50% of the defence orders are for export and a large percentage of production is for naval equipment and systems.

Typical of these equipments are weapon stabilizers, power supplies and conversion equipment. Marconi Remote Power Controls (RPC) are found on nearly every gun mounting and missile launcher in service with the Royal Navy. An example is the new generation Type 82 destroyer HMS Bristol, which uses these systems for the 4.5 inch Mk8 gun, the Ikara launcher, the Sea Dart missile launcher and A/S Mk10 anti-submarine mortar.

Orders for servo systems, fire control and gun control equipment exceeded £1.5M in 1976, with an additional £200,000 for servo modules and other servo controlled systems.

Since the Sea Slug, the first guided missile in the Royal Navy, launcher power controls have been designed and installed for a number of these weapons up to the Seawolf/GWS25, the latest and most deadly anti-missile system.

Another important area of activity concerns equipment and machinery controls for naval vessels, comprising primary and secondary plant for surface ships and submarines.

This range covers equipment for power generation, distribution, conversion and control and surveillance; most of which has become standard fit for the Royal Navy and certain Commonwealth and foreign navies.

Shipborne degaussing equipment, sales of which now exceed £2.5M, is supplied for vessels ranging from minehunters to frigates and submarines, including a gyro-controlled system used in Royal Navy submarines. Magnetometer degaussing equipment, specially designed for mine countermeasures vessels and similar systems for steel hulled surface vessels are manufactured for many types of ships. This type of degaussing ensures a better magnetic signature than that of other degaussing systems

Among the extensive range of equipment designed, manufactured and installed by Marconi are included static inverters, frequency changers, dc/dc converters, variable-speed ac motor controls, cathodic protection and battery switching and automatic charging equipment for submarines.

Many special static converters have been designed specifically for UK MoD and total sales are around £1M annum. Another active area within the Division is the design and supply of automatic cathodic protection for fighting ships. These equipments, totally about £200,000 a year, are sold directly and indirectly to many navies throughout the world, the latest vessel to install automatic cathodic protection from Marconi Radar is an 'S' Class frigate of the Royal Netherlands Navy.

Automatic voltage regulators play an important, though unseen, part in the reliability and functional capability of many ships' systems. Every year some 50 or 60 AVRs, to the value of £200,000 are sold for naval use on main generators and motor generators. Among the small equipments which safeguard the operation of systems aboard ships, the Division supplies 150 to 200 motor thermal protection units every year, just one of the many special devices supplied to improve efficiency and reliability.

The Sea Watch Racon (Radar Beacon) is finding increasing use in many parts of the world. The Division sells around 70 or 80 per year, a figure which is expected to rise as their contribution to safety and navigation at sea is increasingly recognized. This beacon can be mounted on a buoy or any sea-going or shore-based installations to transpond, when interrogated by X-Band radar emission, with an identity code from which the exact position of the beacon can be interpolated.

The other area of activity, simulation, is typified by Tepigen, a computer controlled television picture generator which is the heart of a number of advanced training systems. Out of the orders for simulators, one large order was received from the UK MoD for an Aimer Trainer System and an overseas order for a Gun Aimer Trainer. These cost-effective systems which provide controlled realism in visual form have an ever widening range of applications.

Systems are available which make use of on-line data transmission and digital control techniques, such as CMM described in this issue, also a range of remote engine room plant logic systems. The normal standards to which all equipment is manufactured and inspected is covered by Defence Standard 05-21 (Quality Control System Requirements for Industry) and Marconi Radar Systems was one of the first companies to be approved at the first application.

Services offered by the Division include system design analysis and study work, also arising from long experience in naval technical requirements, many private venture developments are carried out to improve techniques and extend the product range.

Every fighting ship in this picture carries Marconi equipment

New Surveillance Radars for Navy

Contracts have been placed with Marconi Radar for development of the next generation of naval search radars, the Type 1022 Surveillance Radars and the Type 1030 Surveillance and Target Indication Radar (STIR). These will replace the Type 965 and Type 992Q which are in current service. The first model of Type 1022 has already been delivered and further equipments are on order.

Since the design of the world's first operational radar, Marconi Radar Systems has become Europe's largest supplier of naval, ground defence and air traffic control radars.

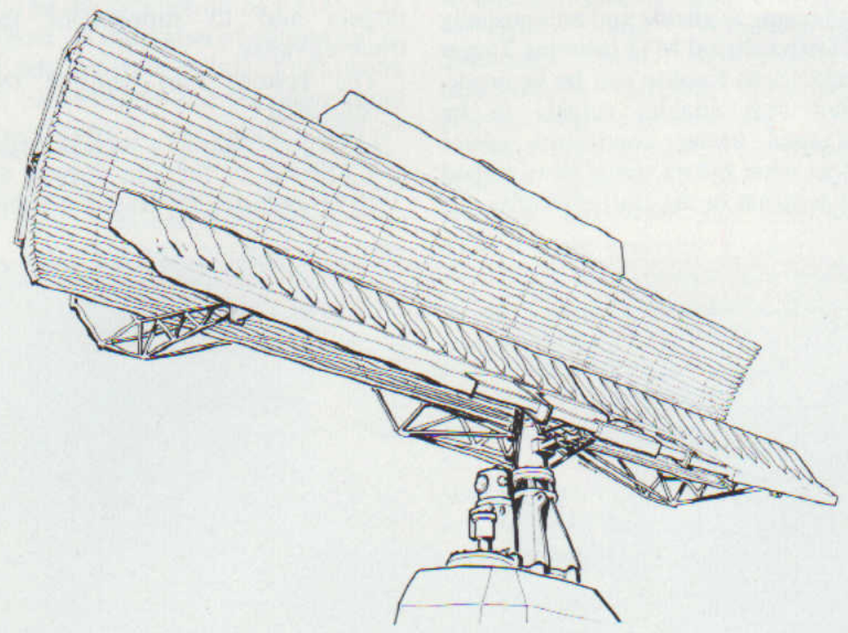
The Company has supplied over £380,000,000 worth of radar systems and equipment to more than half the countries in the world and is the leading supplier of naval radar in the United Kingdom.

The profound knowledge and experience in naval radar requirements has been built up over many years of close cooperation between naval experts and Marconi Radar engineers. Although the purpose designed radar systems supplied to the Royal Navy and overseas navies are the result of studies into specified naval defence requirements, advanced research is constantly being carried out into all aspects of radar technology and signal processing systems.

The most recent example of the application of the products of military research of this nature is the development of extremely accurate, fast reaction missile tracking radars typified by the Seawolf/GWS25 system described in this issue. Allied to the powerful, high definition techniques of the latest radars are developments such as Moving Target Indication and a number of specialized signal processing techniques which reduce the effect of clutter and other distractions.

Among shipborne surveillance radars, the Type 965 long range early warning radar and the Type 992Q high power target indication radar have given long and successful service with the Royal Navy and foreign navies. The Type 992Q is a fully stabilized, pulse radar providing space stabilized output data which can be synchronized in pulse and rotation with other ship's radar equipment. Apart from its air and surface surveillance role, it is also capable of target indication and weapon direction functions for surface targets.

The Marconi 800 Series X-band radars includes surveillance radars suitable for warships down to fast patrol boats. These lightweight radars provide good coverage against air and surface targets, with stabilized antennas and narrow horizontal bandwidth to ensure accurate target indication data for pointing weapons or tracking radars. The ST802 tracking radar can be used with a variety of weapon control systems. It is a lightweight, fully automatic tracker which generates its own stabilized search patterns for acquisition and tracking in addition to a low level search mode which scans the horizon at 20 r.p.m. The radar can be tuned from the console over the range 8.6 - 9.5GHz and incorporates an extremely advanced MTI system to reduce the effects of sea and land clutter. An extensive range of ECCM facilities allow operation in a jamming environment. In conditions of radar silence and as an aid to low level tracking, a television camera is mounted on the director beside the antenna.



New Surveillance Radars for Navy

Constant research and development means not only innovation but also continual improvement in existing techniques. Both factors contribute to the quality and reliability which is required to ensure the maximum radar performance required by the Royal Navy.

SEAWOLF HITS SHELL IN FLIGHT

'THRICE ARMED IS HE WHO GETS HIS BLOW IN FIRST'

During firing trials aboard the frigate HMS Penelope a 4.5 inch shell was successfully engaged by a Seawolf anti-missile missile.

In what is believed to be the first attempt anywhere in the world to engage a target of such small size and high velocity, the shell was destroyed in flight by a missile under the control of the Marconi GWS25 radar guidance system.

An initial closing speed in excess of Mach 2.5 was attained and the success of the firing demonstrates convincingly the high manoeuvrability of the missile and the fast response time and accuracy of the radars and guidance system.

These and other trials aboard the frigate HMS Penelope have proved convincingly the unique capability of the Seawolf/GWS25 anti-missile weapon system against a wide spectrum of targets even under conditions of severe ship motion. In particular, the ability was demonstrated to track and destroy a greater variety of anti-ship missiles and aircraft than any known comparable system in production. Seawolf/GWS25 is a point defence anti-missile system designed to give ships of frigate size and above a powerful means of defending themselves against the missile and close air and surface threats of the 1980s. The system was shown to be capable of operating effectively under very severe environmental conditions, and its fully automatic response to threatening targets ensures that every incoming missile or other target will be engaged.

The recent firings, part of the sea trials programme which will be completed later this year, produced excellent results using both radar and TV missile guidance and confirmed the success achieved during land firings at Woomera, Australia and Aberporth in Wales.

Test targets included the towed Rushton, only 2.25 metres long by 13 centimetres in diameter and the Mach 2+ Petrel missile, and the exceptional results also confirmed the system's capability against glinting targets. A successful low-level firing programme was carried out in 1975/76 to prove the system's capability against sea-skimming missiles.

In recent years, naval exercises have increasingly shown that the anti-ship missile now represents the major threat to the survival of surface warships of all types. Developments in the field of submarine and aircraft-launched missiles, and in missile technology, notably in the case of sea-skimming missiles, now mean that an attack can take place with little or no warning, and with the launch vehicle never coming within range of the target's self-defence armament.

As well as the sub-surface and air-launched threats, there exists a very considerable surface threat as few warships of corvette size and above are built today without an armament of anti-ship missiles.

Modern missiles can fly at speeds in excess of Mach 2, and their trajectories can vary from a straight-in approach a few metres above sea level to a steep dive at an angle well in excess of 45°. They may also carry out terminal manoeuvres designed to optimize their striking angle and render the task of self-defence weapons more difficult. Their radar echoing areas are often as small as a fraction of a square metre. The threat that they represent can only be countered by a very sophisticated anti-missile system designed from the outset to take account of the full range of hostile missile capabilities.

While the principal threat to warships in the 1980's will come from anti-ship missiles, the manned aircraft threat will continue to exist. High priority was given to this threat during the development of the Seawolf/GWS25 system, and the system is fully effective against all aircraft targets coming within range, including Remotely Piloted Vehicles. An important characteristic of the system is its completely automatic operation, coupled with the very high reliability which is essential if the system's capability of engaging very fast missile targets is to have any practical value. Target detection, track initiation, threat evaluation and weapon allocation are all entirely automatic, as are the processes of target indication, target acquisition and engagement. Manual intervention is not required under normal circumstances, the appropriate Weapon Direction and Control personnel merely monitoring the progress of the engagement.

HMS Penelope on sea trials

Detection and threat evaluation

A typical engagement sequence for the Seawolf/GWS25 system starts with the detection of an incoming missile target by the Type 967 L-Band pulse doppler radar. Target bearing, range and velocity are automatically extracted and fed into the surveillance data-handling computer. A small number of consecutive detections is sufficient to enable the computer to form an unambiguous track on the target for automatic threat evaluation. The IFF system first identifies targets which are potentially hostile and then the computer compares the characteristics of the tracks with a stored table of criteria for threat assessment. In the event of an immediate threat the appropriate tracker/launcher combination will be selected to engage it. All the above operations take place automatically within only 5 to 6 seconds of initial target detection.

Target acquisition

Once a tracker and launcher has been selected to engage a particular target, target data is passed to the tracker which, under the control of the tracker computer, slews to the indicated bearing and then commences a search in elevation. The extremely accurate target indication data minimizes the tracker search time.

The tracker computer also calculates the launcher aim-off necessary to ensure that when fired the Seawolf missile enters the gathering beam. The entire operation is automatic under control of the tracker computer.

Once the Type 910 tracker has detected the target it 'locks-on' for bearing, elevation, range and velocity and commences to track the target.

Radar engagement

Radar tracking will be used for both the target and the missile, unless the target is at low level and the quality of radar tracking is degraded in elevation, in which case the system will automatically switch to the television mode. The computer will automatically fire the first Seawolf missile so that interception will take place at maximum missile range. If salvo firing has been selected, a second Seawolf missile will be fired a few seconds after the first. Both missiles will be tracked separately by the radar tracker, and the appropriate missile-to-target misalignments will be used to generate commands to steer the missiles back to the line of sight.

The Type 910 Tracking Radar is a differential tracker with an all-weather performance against the smallest attacking missile in the most exacting radar clutter conditions.

Electronic Angle Tracking is the means whereby the target and missile sight-lines are compared differentially and the resulting angular difference and rate of turn used in the guidance shaping unit to generate commands to bring the missile back to the sightline. In respect of small angles this is achieved without physically moving the mount; this contributes to the smoothness and accuracy of the track.

After launch the missile is immediately acquired by the wide angle gathering beam of the tracking radar, and automatically and quickly gathered onto the established target sightline, giving SEAWOLF its excellent minimum range performance. Thereafer, target and missile are tracked together using the same antenna and receiving system in a time multiplexed mode with the electronic angle tracking feature. Depending upon whether only one, or a salvo of two missiles are fired, there may be up to three separate channels of electronic angle tracking in operation simultaneously.

Television engagement

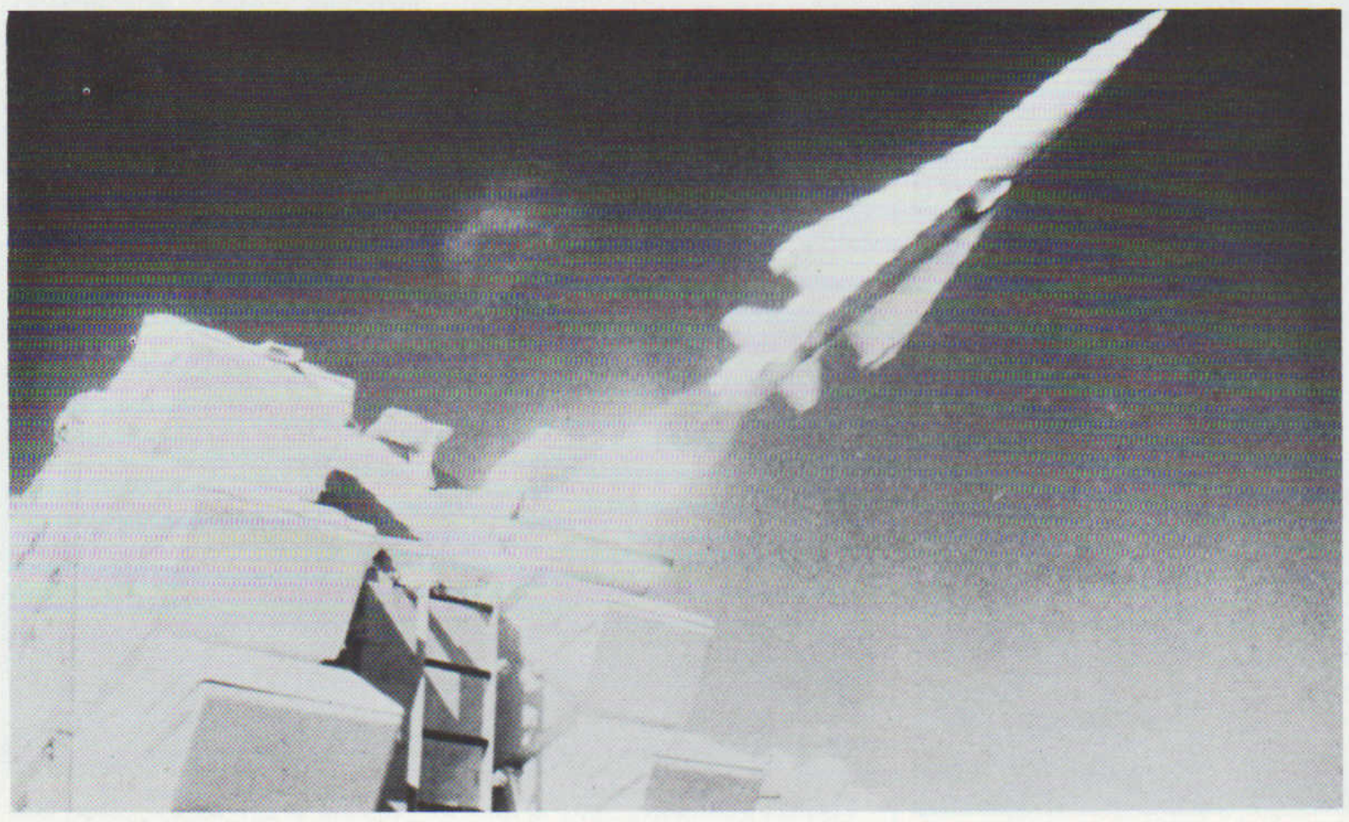
If, due to the low height of the target or other causes, a television engagement is selected, the sequence of events is similar to that described above, but with target and missile tracking being done by television. The operator at the Missile Control Console observes the target on a television screen and uses a pressure-type joystick to maintain the cross-wires on the target. The missile is gathered and guided optically using the television system, in a similar way to the radar engagement.

Particular attention has been paid to reliability and ease of maintenance in the design of Seawolf/GWS25. A built in automatic test facility ensures rapid and effective fault diagnoses and the Mean Time To Repair (MTTR) is 10 minutes. During daily checks the system remains at 1 second's notice and during the fortnightly checks full readiness is achieved within one hour.

The Seawolf missile is capable of being left in the launcher for long periods at sea, and whilst embarked no maintenance or testing is required.

The Type 22 anti-submarine frigates will be the first class ship to be fitted with the Seawolf/GWS25 system. The first of class, HMS Broadsword, is currently fitting out at Messrs. Yarrow's yard in Glasgow, and will enter service at the end of the 1970's.

Further ship-fitting is planned, and both the Contractors and the Ministry of Defence are actively engaged in marketing the system overseas.



Seawolf missile leaving launcher

Marconi fit Swedish submarines

ORDER FOR STATIC POWER INVERTERS AND DEGAUSSING SYSTEMS

Three of Sweden's latest submarines, Type A-14 Näcken class, are being fitted with static power inverters and degaussing equipment by Marconi Radar.

The order, which was won with the cooperation of the Company's Swedish associates, Svenska Radio AB, is being implemented by the Control and Simulation Division at Leicester where a wide range of advanced electronic equipment for warships is designed and manufactured.

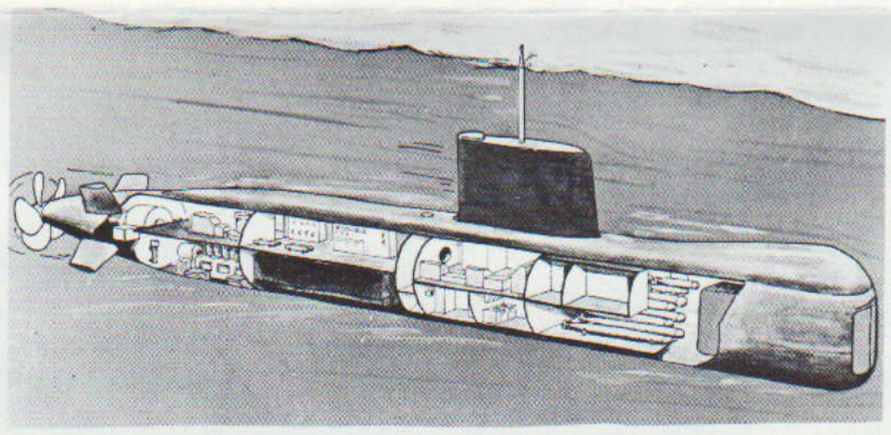
Static inverters are smaller, quieter and lighter than equivalent rotary converters, have faster transient performance and need very much less maintenance. Submarines running below the surface depend on batteries as their primary power source and, historically, have been obliged to use d.c. machinery for heavy duty pumps etc, with attendant problems such as poor reliability and high maintenance costs. The use of static inverters to produce a.c. power is not only an advantage for all the conventional pumps, drives and on-board machinery, but is essential for the efficient operation of weapon systems, radar, radio, servo systems and sonar. The requirements in this case were for a power supply to provide regulated, three-phase 440V, 60Hz, 75kVA and 115V, 400Hz, 10kVA supplies from a variable d.c. source. Two inverters for each supply were required to operate in a changeover mode.

In a submarine environment, there are limitations on space and many problems to be overcome including vibration, radio frequency interference and cooling. The equipment must respond instantaneously to variations in power demand up to the maximum output of 170kVA in silence and without radiation. The output parameters are defined by tight specifications regarding waveshape, frequency, audible noise, magnetic leakage and electromagnetic interference. Even the design of cabinet structure and mounting requires careful study, specialist experience and a high degree of skill to ensure the reliability and safety of equipment weighing nearly 5000kg and subject to possible roll, pitch and acceleration in any direction plus the various types of shock which can occur in action.

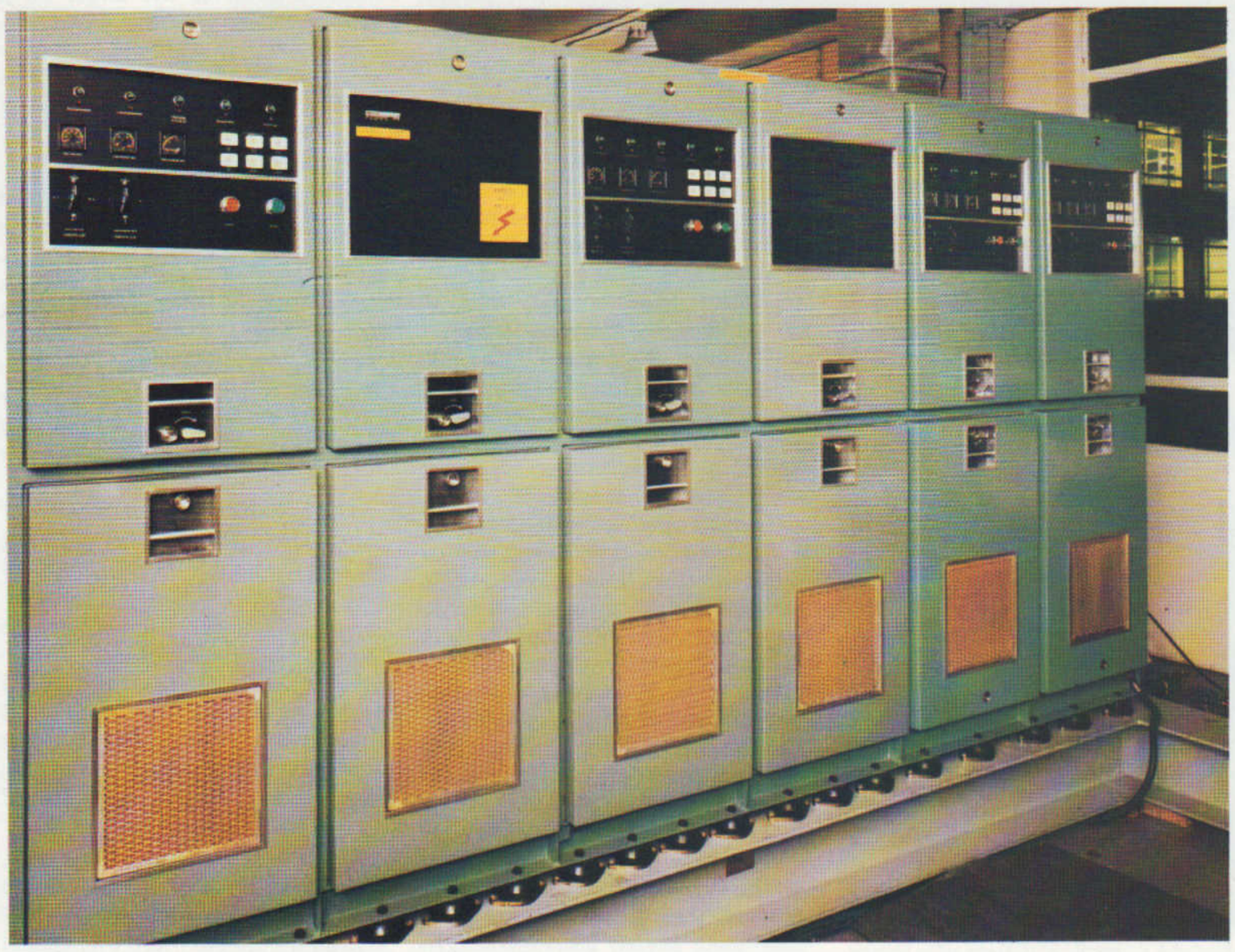
Two other design factors assume greater importance when the equipment operates in submarines. The first is the cooling system, which must operate without noise in a restricted environment; the second is that the whole static inverter suite must be designed to be dismantled to pass through the submarine hatch.

The degaussing equipment is also designed for use in submarines where space is at a premium, and is one of the systems supplied by 440V 60Hz from the static inverters. The coil currents are constantly varied according to the orientation of the ship relative to the earths magnetic field to render the vessel magnetically neutral and obscured from magnetic detection. The automatic variation of coil current is controlled by the ships computer which takes its directional information from a gyro-compass and calculates the varying degaussing requirements according to the global position of the vessel and other physical factors.

The installation of the static inverters and degaussing equipment is being carried out in Sweden where the first vessel is nearing completion.



Artists impression of Type A-14 Näcken class submarine



Static Inverter Suite for submarines

CMM ON WATCH

Computerized Modular Monitoring improves the management and maintenance of complex electronic equipment. The new system from Marconi Radar is designed to keep constant watch on every piece of electronic equipment on board a fighting ship and to report instantly on any failure or deviation from operational condition.

From a central control room, or any other position using a portable display, it is possible to make an instant 'all systems' check or, if required, a more detailed status survey of one particular facility such as communications or weapon control. For record purposes, hard copy can be provided on demand or at preset intervals.

The use of this system dramatically reduces the need for skilled men who must otherwise occupy themselves on routine testing of equipment. It is possible for a system to develop a fault immediately after manual testing; this fault would not be found until the next test or when the equipment is brought into use.

Computerized Modular Monitoring checks and assesses the operational status of all equipment immediately and positively at all times, day or night, to assure the officers on duty that all is well or to announce which functions are not operational and why. This allows personnel to carry out their work in the certain knowledge that any equipment brought into use is operating correctly; alternatively, they will know which functions are useable in systems which may have faults in other areas.

Facilities can be incorporated into CMM systems to change the state or functions of equipment by remote control, thus contributing a flexibility to the ships operation which could be vital in emergency situations.

The main function of CMM is to report on the status of equipment at widely separate points, monitoring its performance and providing rapid assessment of any failure, drift or fault. The computer enables the monitoring system to perform complex measurements, process the information and present it in any required form, thus providing a continuous, updated report, on demand, on the extent of equipment failure, its location and the loss of operational ability.

Remote switching facilities enable test measurements to be applied, also the same system can be used to reconfigure the equipment to change its operational mode.

CMM is designed for reliability and integrity with comprehensive built in self-checking facilities, it will also operate satisfactorily in areas of high electrical noise such as the vicinity of high power radars.

Data Gathering

Accommodated within the equipment are Data Selector Units capable of reading analogue or digital data which is then multiplexed into the system. Similar Remote Switching Units can be used to apply stimuli or change the equipment state.

Digitizing and Control

The Digitizing and Control Unit measures the analogue data and converts it into digital form for transmission to a local or central computer.

Processing and Display

The computer analyses the information which is fed to a Visual Display Unit or a printer.

The incorporation of this versatile system into electronic equipment provides a constant assurance of the state of readiness and immediate recognition and location of an operational fault. Up to 1000 points can be monitored with multiple measurements at each point including values such as voltage, current, frequency, phase, time intervals, waveform and non-electrical quantities such as pressure, temperature, bending moments, angular rotation or vibration.

CMM systems can be applied to existing equipments or to new projects. Hardware and software packages are available to meet the requirements of almost any group of electronic or electromechanical equipments, and the system can be expanded from a simple data gathering network to a comprehensive system, remotely controlled from a central computer with facilities for automatic data analysis and fault diagnosis.

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MARCONI RADAR SYSTEMS LIMITED

A GEC-Marconi Electronics Company

Writtle Road, Chelmsford, England CM1 3BN

Telephone: Chelmsford (STD 0245) 67111. Telex: 99108 and 99449