Radar Systems International

MARCONI

No. 17

Seawolf in action

Recently HMS *Penelope* was rededicated, having just been fitted for the sea trials of Seawolf/GWS25, the new self-defence system for the Royal Navy.

Penelope has now started a series of firing trials. The pictures on the right show clearly the measure of success achieved by the system in previous trials. The top picture shows a Seawolf missile intercepting an 'enemy' missile (right). The gap between is closing at about four times the speed of sound. The bottom picture shows the moment of impact. The ball of fire gives vivid proof of accuracy of the Seawolf system.

Because of the nature of the design, Marconi Radar Systems has been given the overall responsibility for the Seawolf/GWS 25 contract which is required to meet one of the most stringent technical specifications ever laid down for naval short-range anti-missile/anti-aircraft defence system for frigates. Marconi Radar's responsibility results from the fact that the major part of the sophisticated electronics is concentrated in the ship; the missile is low cost, small and extremely fast, containing only the minimum of electronics. It has been designed by the British Aircraft corporation and the launcher by Vickers Limited.

The system is designed to meet a variety of missile or aircraft threats covering a wide range of speeds up to in excess of mach 2·0 in trajectories from very low to very high altitudes. The system must be capable of detecting small targets in severe weather conditions and reacting extremely rapidly. In these circumstances there is no time for human intervention, and the system is entirely automated from first detection to interception, once the peace/war switch has been made.

The main electronics package is very advanced, with both the surveillance and tracking radars being of a new design.

Surveillance is catered for by two S and L band radars which are associated with highly sophisticated data handling, capable of solving range and velocity ambiguities, initiating tracks, evaluating threats, taking engagement decisions and performing attack allocations. The new X-band tracker is capable of directing a number of Seawolf missiles to interception, using differential tracking and providing radio control for line-of-sight guidance.

The complete system can be kept in a state of readiness for long periods of time. Reliability is maintained by an automatic monitoring system and built-in test equipment under the control of the system computers.

Marconi Radar's proved capability in the design of naval radars has enabled it to produce what is one of the most advanced and effective ship defence systems in the world.

The system also incorporates an advanced differential tracking optical television system, designed and manufactured by the Electro-Optical Systems Division of Marconi-Elliott Avionic Systems. This monitors the firing and can take over the control of the missile during flight if necessary.

BAC order Locus 16

The British Aircraft Corporation have placed a £150,000 order for a secondary radar data display system for their important flight test centre at Warton, where the development flying programme for the new Multi-Role Combat Aircraft (MRCA) is taking place.

Based on the Locus 16 data processor, the system will increase air safety by providing additional flight data to the air traffic controllers at Warton, where full flight envelope testing takes place relatively close to civil air lanes and the busy Manchester control zone.

A new dimension, that of height of transponding aircraft (Mode-C replies) plus the ability to identify and label the targets (Mode 3-A replies), will be added to the controller's displays to give a clearer picture of the airspace in which the varied and complex sorties are flown.

At present the ATC unit at BAC Warton relies for area control solely upon a Marconi S264 primary radar, backed by a type 424 for precision approaches. The S264, in use since 1960, has recently been improved by the addition of a Marconi digital signal processor Type 7100, and provides excellent primary cover out to 160 miles. The secondary radar data display system to be provided under the new contract will take this primary information in its raw form, and present it to the controller combined with secondary and primary extracted radar data obtained via landline from the Civil Aviation Authority's St Annes facility some four miles away. The ability to revert to a local primary picture is retained and the radar data processing configuration allows failure of part of the system without detriment to the remainder and thus flying operations can continue uninterrupted.

The tri-national MRCA landing at Warton Aerodrome

Two fully processed radar display positions are to be provided, each based on a dedicated Locus 16 processor, with fully comprehensive facilities at each. An additional subsystem at each position provides a television tabular situation display carrying airfield situation, aircraft serviceability, flight operations and weather data, with update facilities via video data terminals in the Control Tower and the Flight Operations Centre.

The BAC Military Aircraft Divisions base at Warton, Britain's busiest development and experimental flight test centre, is used for the production flight testing of such aircraft as the Anglo-French Jaguar and is now the UK flight trials base for the tri-national Panavia MRCA.

Tepigen for Royal Navy

Marconi Radar Systems have received a contract from Ministry of Defence (Procurement Executive) to manufacture a television picture generator (Tepigen) for the ashore training of Royal Navy missile aimers. This new simulation concept was developed in collaboration with the Admiralty Surface Weapons Establishment.

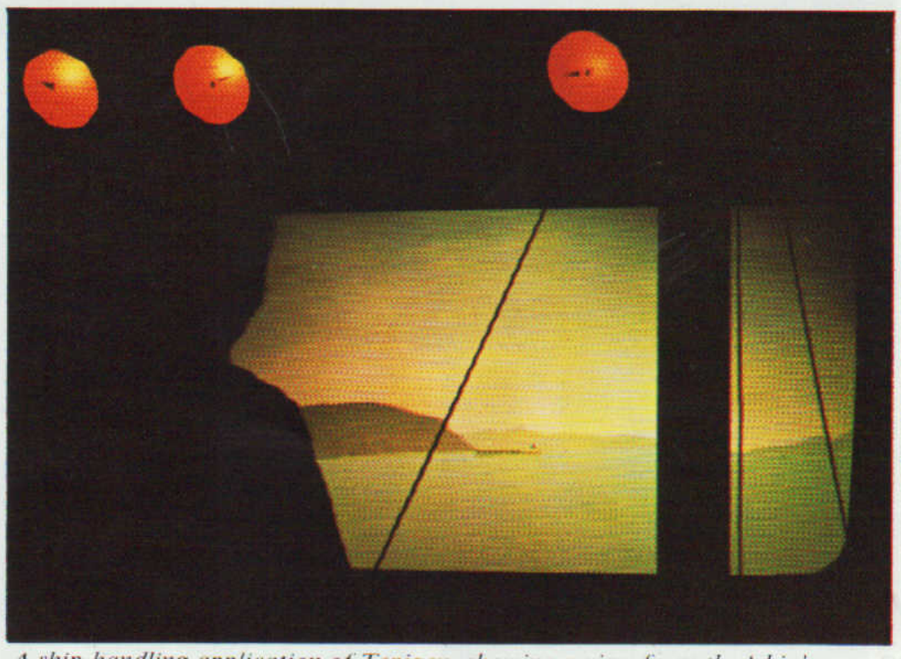
On many new vessels, missiles are controlled not from visual sights above decks but from television displays below. Tracking radar keeps the television camera pointed at the target, while the operator observes the missile position from its flare and controls it manually into coincidence with the target. The time of the whole operation from launch to impact is so short that good aiming requires natural aptitude and a very high degree of special training.

Tepigen, using the new techniques of Computer Generated Imagery (CGI), is particularly suited to this kind of training as it presents the visual element in a form which instantly interacts with the operator. The CGI, driven from a performance simulator, thus offers a valid equivalent to real situations.

Most of the visual systems in use at present generate the operator's picture by pointing a television camera at a scale model of the scene and obtaining by means of servos, lenses and mixing circuits the desired size, aspect and position of the model in the field of view. If the picture has to show several independently-controlled 'vehicles', a separate camera and servo mechanism is required for each.

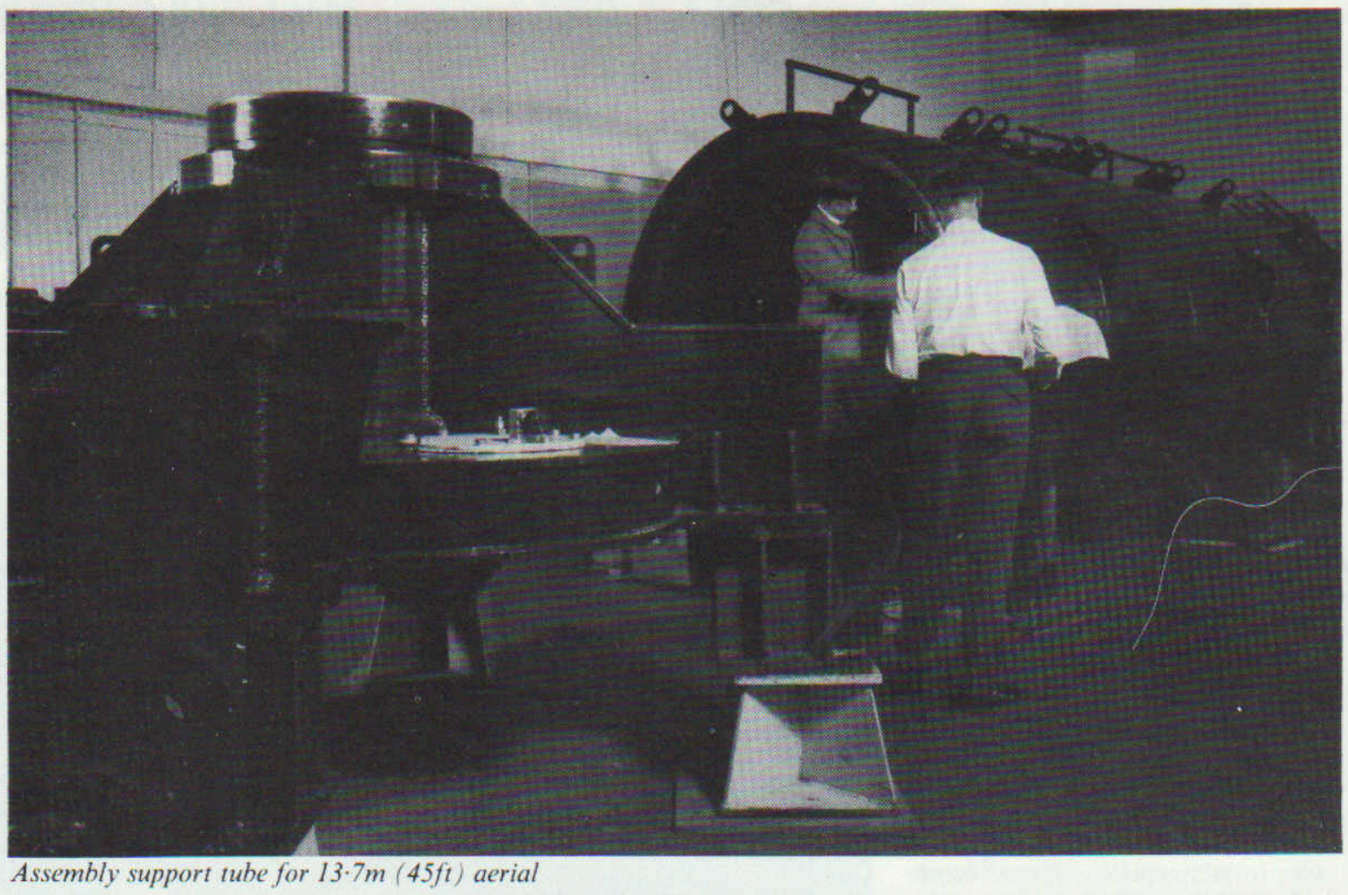
Tepigen, on the other hand, presents a picture on a TV display which is wholly generated by computer. The scene can be displayed as seen from any point by suitable mathematical processing of the stored coordinates: it alters in accordance with the operation of the controls, without the limitations of cameras or models. The synthesized picture is constantly composed afresh at television frame rate and can be provided either in colour or black-and-white.

Research and development contracts are also on hand for ship handling from the Department of Industry, for flight simulation from MoD (RAF), and for military assessment by the Royal Armament Research and Development Establishment (RARDE).



A ship-handling application of Tepigen, showing a view from the 'ship's bridge' of a training simulator. The scene is entirely generated by computer

Marconi radar manufacture



Assembly support tube for 13·7m (45ft) aerial

Marconi Radar is well known for its design and production capabilities in electronics. What is not perhaps so well known is the considerable capability of its manufacturing plant.

The Company maintains five factories, two at Chelmsford, two at Leicester and one at Gateshead, which provide facilities varying from model shops to large scale mechanical assembly.

Capability

Electronic systems in general and radar systems in particular demand accuracy of working to electrical engineering tolerances in structures of a size more generally associated with civil engineering. For example one of the principal defence radars manufactured by the Company is the S621. This has an aerial, working at a wavelength of 10cm, measuring some 13·7m (45ft) in length. The radar beam is formed by a single curvature reflector fed from a squintless linear feed. This complete assembly is rotated at speed up to 8 rev/min by an electrically driven turning gear, maintaining its performance in winds up to 60 knots and ice loads of 9·8kg/m² (2lb/ft²).

The reflector is of either parabolic or cosec² profile, and is made up from six sections each 2·3m (7·5ft) long with a vertical aperture of 4·6m (15ft). In order to produce a radar beam capable of discriminating between two targets 4·827km (3 miles) apart at a range of 482·7km (300 miles), the profile accuracy must be maintained to within 0·76mm (0·030in) over the whole reflector. Thus not only must each section be accurate but also the assembly of six together must maintain this accuracy under the deformation loads of wind and ice.

Each reflector section is fabricated from two aluminium sheet skins, preformed to shape then riveted front and back to an accurately welded grill framework of square aluminium tube, larger aluminium ribs being used at each edge to enable sections to be joined. The support structure comprises a steel cylinder, made in three sections each 4·6m (15ft) long and 2·04m (6ft 7in) diameter, with fixing lugs for the reflector positioned along its length. These lugs are optically aligned.

The whole manufacturing operation, including precision cutting, punching, rolling, riveting and welding of aluminium, profile cutting, machining and welding of very large steel sections, assembly and alignment of the complete aerial, is carried out at the Gateshead plant. In fact the plant carries out work for outside agencies, as an acknowledged specialist in a region not unknown for large scale structural fabrications.

Due to their inherent shape and the severe environmental conditions encountered at most radar sites, radar aerials present considerable problems in their rotation. Under widely varying load conditions, speeds must be maintained to within 10% and the azimuth position of the radar beam must be told back to an accuracy of typically 4 minutes of arc, otherwise positional errors at working ranges of some 300 nautical miles become unacceptable for precision control of interceptors. This demands the production of gearboxes of two extreme types, one capable of transmitting loads up to 260 h.p. peak, the other having backlash errors less than 1 min of arc. The machining of support plates, bearings and complete mounts, the precision cutting of gears and the necessary clean area assembly and testing use the skills of both the Gateshead and Leicester plants.

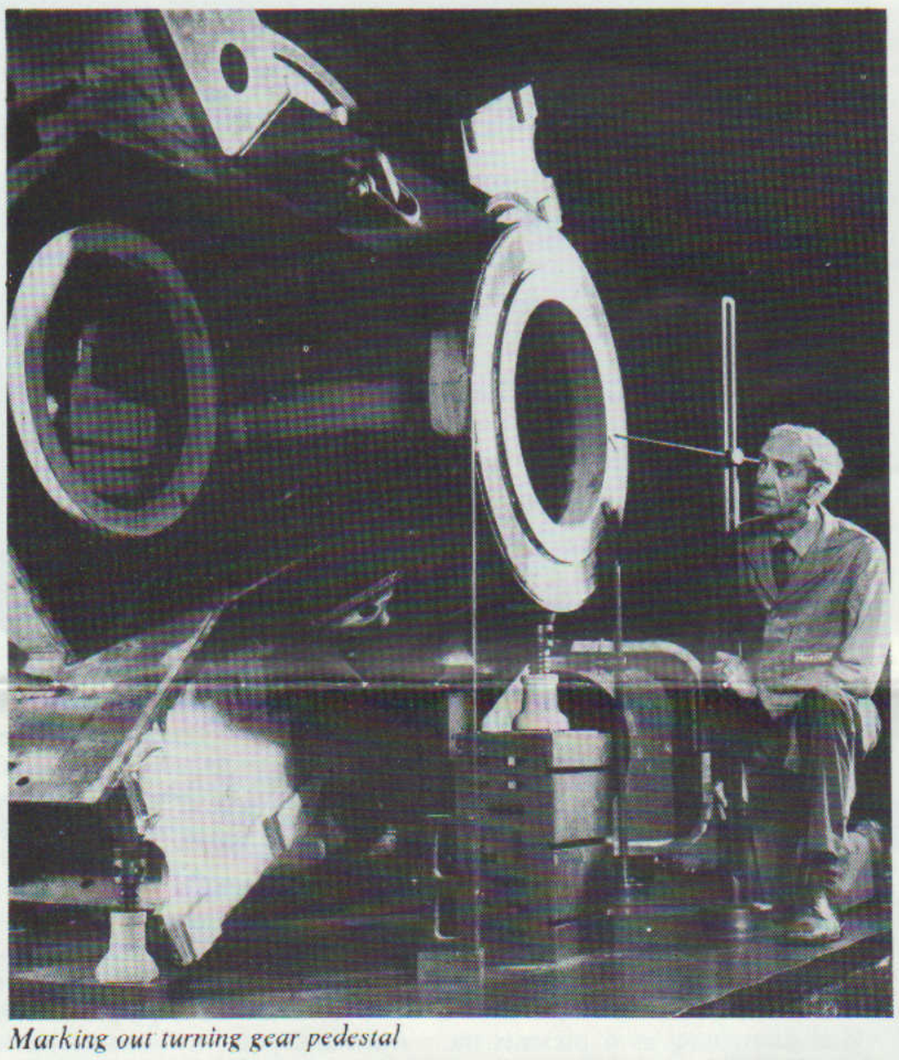
The squintless linear feed is a Marconi patented device to enable a radar simultaneously to operate at several discrete frequencies within a band, thus providing good electronic counter measure capability against enemy jamming through both diversity working and good sidelobe performance. To achieve its purpose the feed must deliver high power microwave energy at accurately matched levels and phases across the full width of the reflector. In the case of the S621 radar the parameters are a bandwidth of 120MHz with sidelobes of –28dB at a power level of 5MW over a total feed length of 13·7m (45ft).

The feed relies on the use of waveguide networks. However to build these up from conventional components proved to be completely impracticable. The only solution was to design large modular units which could be manufactured from solid metal. Mechanical Engineering, Aerial Design and Production Engineering Departments combined to produce a feasible design. This called for operation at power levels of 5MW, along a length of 3·8m (12·5ft) conforming to a complex power law within 5% and to phase accuracies of ±2°, four modules being combined to form the complete feed. Each module is made as two halves, which when placed together must match with a precision such that the cavities so formed are of waveguide quality.

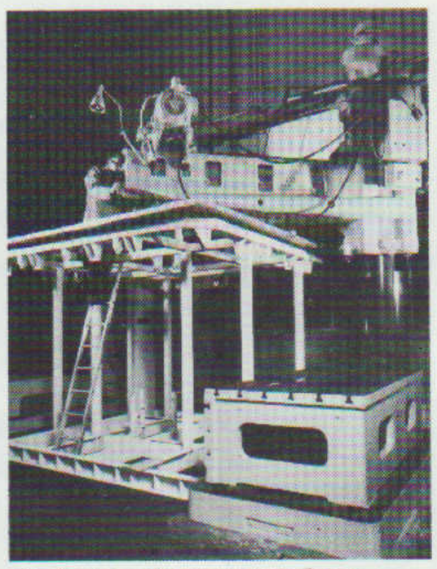
To achieve this aim the Company has installed at Chelmsford, as a unit, a number of numerically controlled machine tools, the largest of which is a Maxitrace twin head mill, capable of machining a billet of aluminium 5·6m × 1·37m × 254mm (18ft × 4·5ft × 10in) to tolerances of 0·05mm. This can produce a single module for an S621 feed or two complete feeds for the smaller S600 5·6m (18ft) mobile surveillance radars in 50 hours.

To complement these tools a Ferranti Conquest computer-controlled inspection machine is available, which allows an initial model to be accurately taped for subsequent manufacture. The complete unit includes all necessary programming facilities.

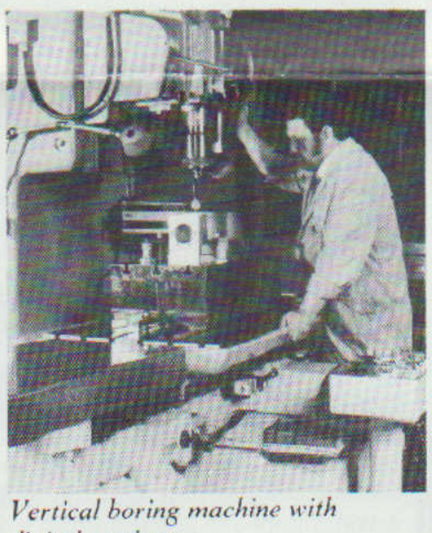
The S621 is only one of many large radars in the Company catalogue;



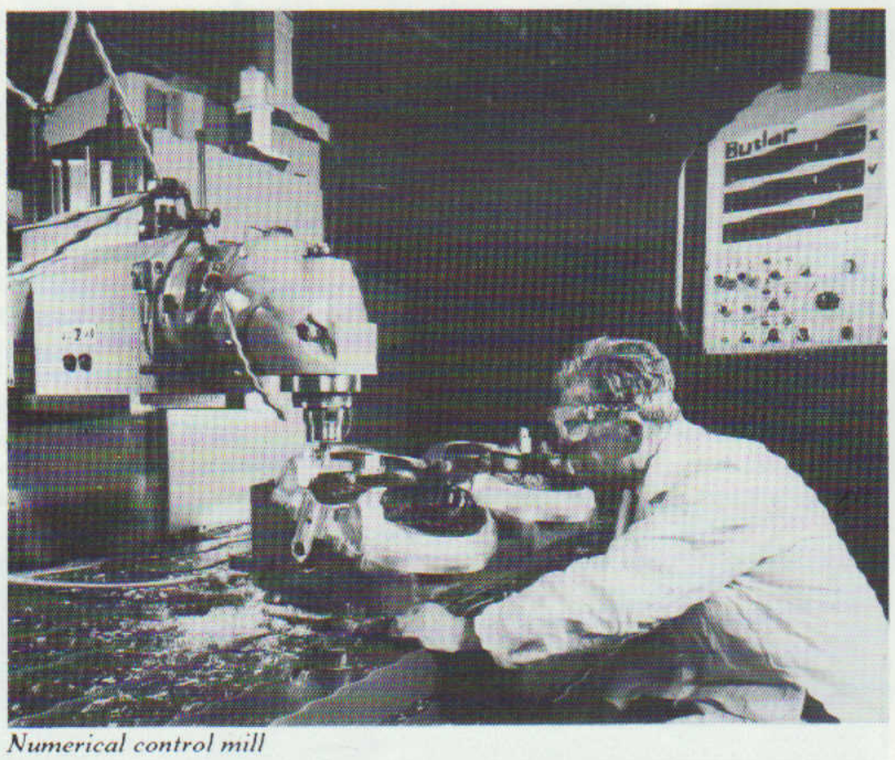
Marking out turning gear pedestal



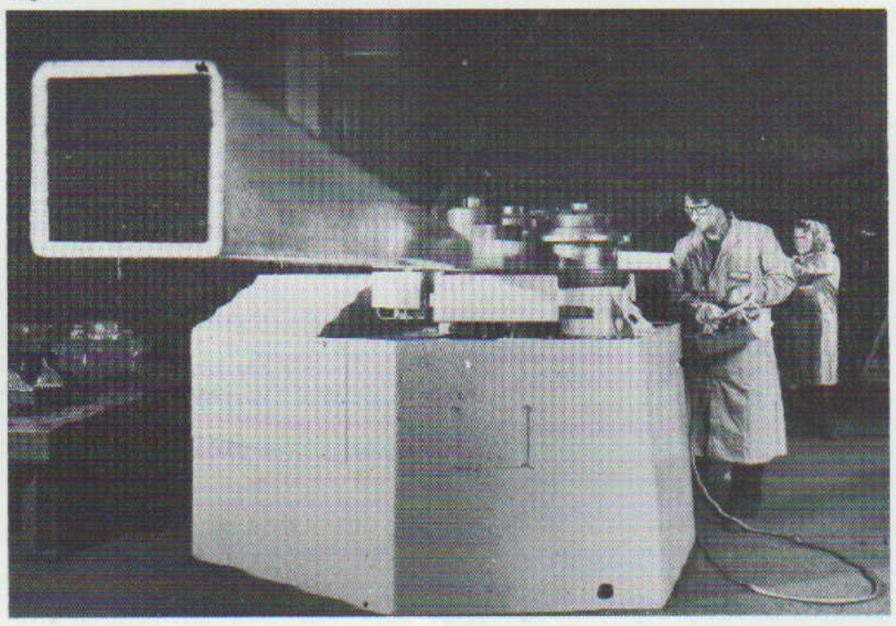
Jig boring of transmitter frame



Vertical boring machine with digital readout

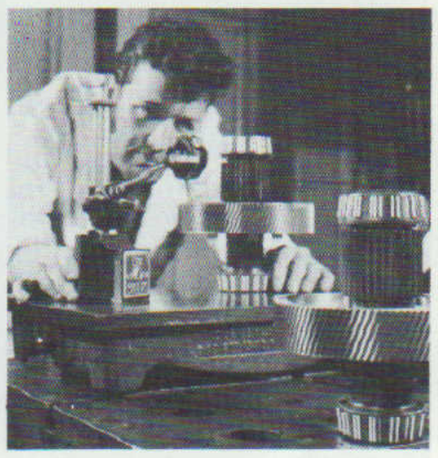


Numerical control mill



Tube bender for aerial framework

Numerical control press



Checking gearbox components

Four-head profile cutter

the S650, S670 and S654 civil radars all pose particular problems of manufacture as these must give satisfactory service over a 24 hour period, seven days a week for many years to ensure the safe and expeditious flow of air traffic. One 50cm aerial in New Zealand has been turning for 16 hours a day for 14 years, occasionally in typhoon conditions.

A particular field is the production of naval radars. All plants are heavily involved in this task. Shipborne equipment must operate and survive in conditions of shock, vibration, humidity and temperature far exceeding those of any land-based systems. It is therefore of particular significance that at Leicester have been manufactured the 965, 901 and currently the 909 naval radars as well as the Seawolf radars and other equipment.

Marconi Radar is best known for its complete systems capability and in particular for the highly successful S600 transportable series. These complexes of surveillance radars, heightfinders, operations cabins and ancillaries were designed and funded and are manufactured completely in house. Designed for operation in all climates of the world, for road, rail, air and helicopter mobility, for the housing of displays and computers, high power radar transmitters and radio communications systems the S600 series cabins presented problems which could not be solved by utilising a commercially available item.

The construction uses a space frame skeleton of steel tube, which provides rigidity for the rigours of movement. This frame is built by hand, using no jigs, with a gas shielded moving wire arc to provide continuously welded joints free from stress. Inner and outer skins of aluminium sheet, shaped and punched on a tape-controlled press, provide electrical shielding. A thermal insulating layer is fitted between the skins. All access panels, service and personnel doors are fully sealed against both the climate and radiation environment. The Fabrication area has paint spraying and drying chambers capable of taking a complete 2·3m × 3·6m × 2·3m (7ft 5in × 11ft 8in × 7ft 5in) cabin. To date the throughput totals 130.

A particular form of specialist fabrication is that of fibre glass moulding. This is used mainly for the production of radomes, which provide protection for aerials, particularly for ship systems, but which must not degrade performance. Again this requires working to tolerances not normally associated with the material. Typically, a complete envelope, made by hand layering onto a contact mould 4·343m (14ft 3in) long, with a complex curve cross section 914mm (3ft) in circumference, has a thickness tolerance of ±0·508mm (0·02in).

Management

All the factories are under the executive control of one director of the Company, to whom a Production Coordinator is responsible. This ensures an overall view when new products are planned or repeat orders received and also when installation of new plant is considered. Each factory has a Works Manager, responsible for general administration and efficient performance, with his own support facilities, such as planning, production engineering, stores and individual special departments.

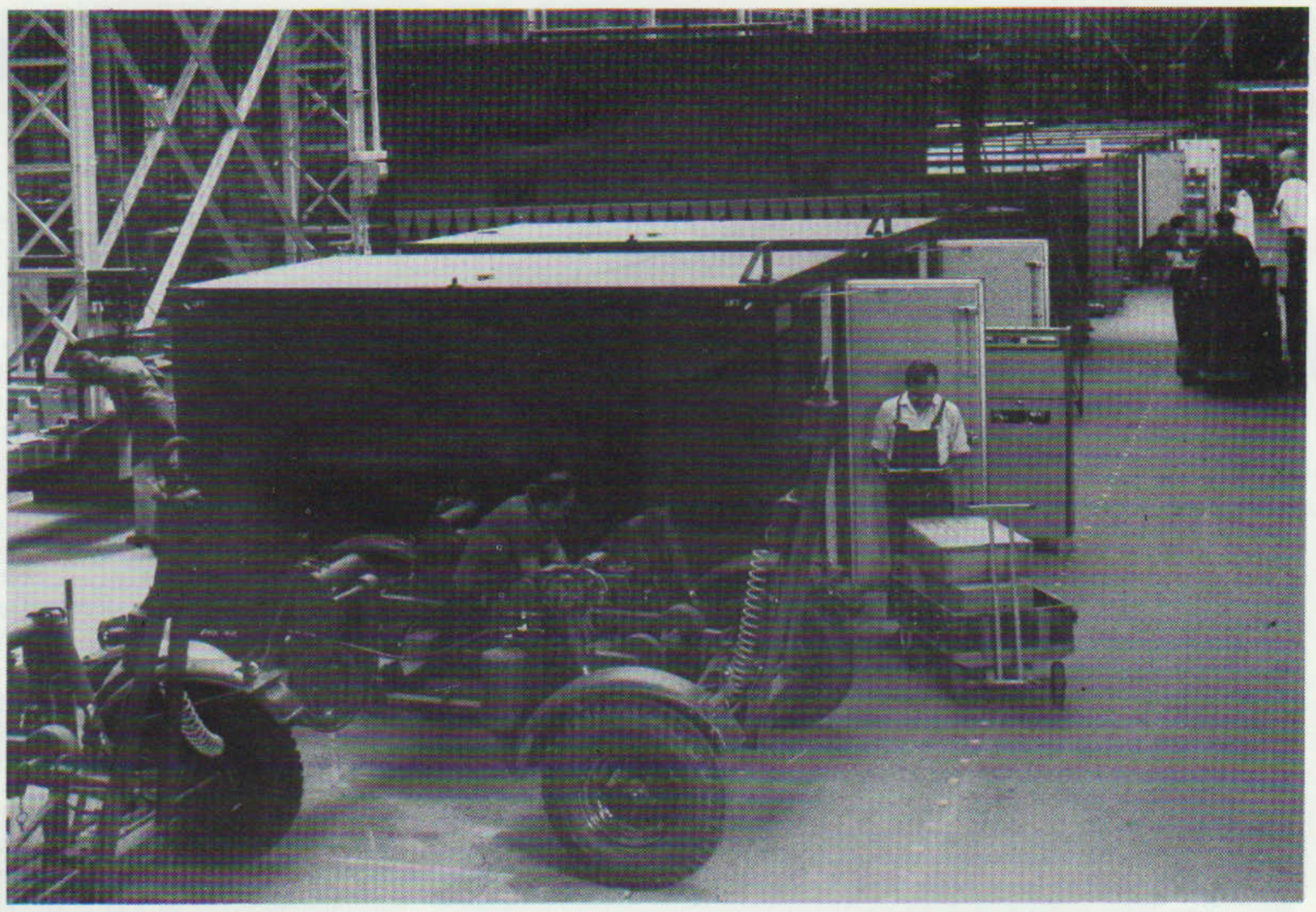
Supporting Facilities

The concentration of precision equipment is such that the Company has its own Metrology Departments. These are equipped to check and calibrate not only the everyday standards of micrometers and clock gauges but can also undertake precision gear checking, profile measurement and absolute standards checks.

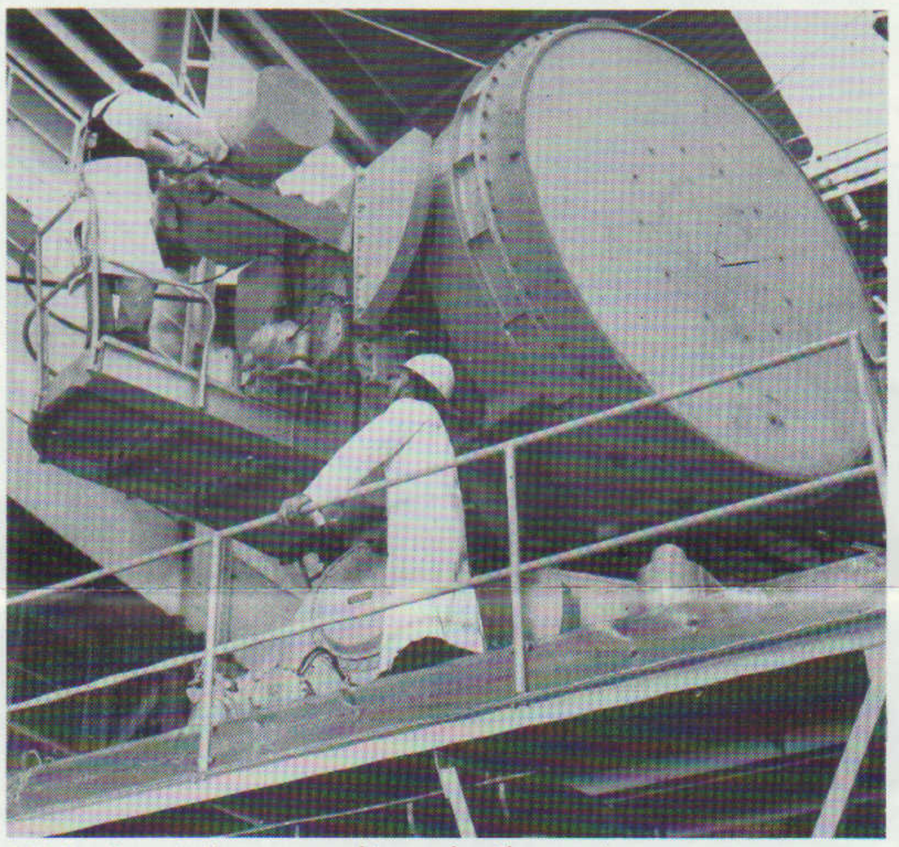
The Production Engineering Departments have the responsibility for assessing the ongoing requirements for cost effective operation. They examine new methods of machining and fabrication, specify plant layout and are responsible for bringing new items on line. They are involved in the early product design stages to advise on preferred methods of construction and anticipate when radical new techniques will be needed. The squintless feed is one particular instance of such close cooperation. When a Company is building up its manufacturing resources at the rate of investment of over £1M per year the management must be very sure the correct plant and facilities are provided.

No factory can operate without raw materials and the Company has set up Stores and Supplies organizations using computer control of stock and ordering. In the present economic conditions keeping the correct balance between the tying up of capital in stock and avoiding delays due to long delivery times from suppliers can be the most crucial factor in a company's operations.

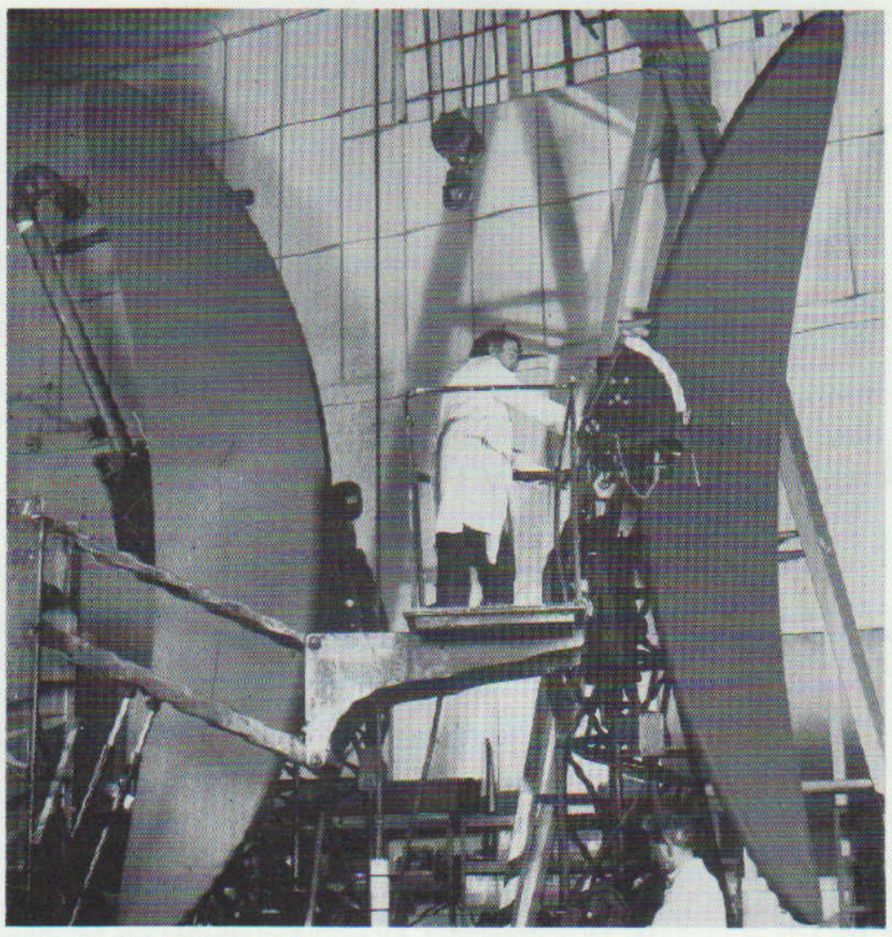
Overall Marconi Radar now has a total of 46,450m² (500,000ft²) area devoted to manufacturing facilities and 52% of the workforce are involved. The major part of its products is exported and very little of the raw material or bought-in components is imported. Its orders are won in competitive conditions and customers frequently place repeat orders. If the right equipment is efficiently manufactured it will sell, as Marconi Radar has proved.



S600 Radars in assembly

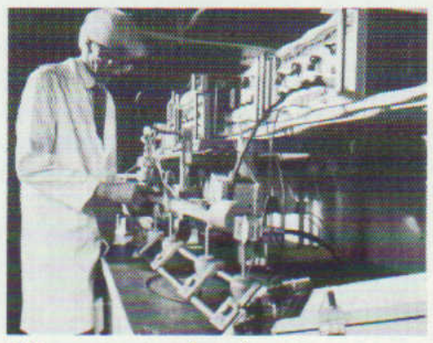


901 Seaslug missile target tracking and guidance radar antenna



Assembly of S600 heightfinder

Conquest Profile Measurer



Microwave test bench

Visits and visitors

CHIEF PROCUREMENT EXECUTIVE VISITS MARCONI

The Chief Executive of the Ministry of Defence Procurement Executive (MoD.PE) Mr E. C. Cornford, CB, together with Deputy Under Secretary of State (Policy) Mr Green and Mr D. R. Fisher also of MoD.PE visited Marconi Radar Systems Limited at Chelmsford recently for high level talks with senior company management.

During their visit the Defence Ministry officials saw some of the latest developments in military radar systems including a number of projects being carried out for MoD.

The photograph shows (left to right) Mr Fisher, Mr Green, Mr Cornford, Mr R. Telford (Managing Director, GEC-Marconi Electronics Ltd) and Mr J. W. Sutherland (Managing Director, Marconi Radar Systems Ltd) at a small exhibition of radar systems. On the table in the foreground is an example of high precision radar waveguide engineering.

EGYPTIAN NAVAL CHIEFS AT LEICESTER

A party of four senior Egyptian naval officers, headed by Vice Admiral Mohammed Fouad Zikri, Commander-in-Chief of the Egyptian Navy, and Rear Admiral Ashraf M. Refaat, Chief of Naval Operations, visited the Company at Leicester.

Other members of the party were Captain Mahmoud Medhat and Captain Shawki Khamis. They were accompanied during their visit by Commander K. Day, British Naval Attache, Cairo.

Pictured during the visit are (left to right) Owen Jones, Works Manager; Vice Admiral Zikri; Rear Admiral Refaat; Peter Way, Director and General Manager, Leicester; and Commander Keith Day.

Increased safety in all-weather aircraft operations

MARCONI IVR SYSTEM CONTINUES SUCCESS

Marconi Radar has had a continuing run of success in providing runway visual range (RVR) measurement systems for airports throughout the world. Marconi IVR (Instrumented Visual Range) systems are in use on nearly all the major British airports, including Heathrow, Gatwick, Manchester, Liverpool, Glasgow and Edinburgh. The Civil Aviation Authority has now ordered an IVR Mk 2 Category 3 version for Belfast's Aldegrove airport. Sales abroad include installations for Cairo, Prague and for Riyadh, Jeddah, Dhahran and Medina in Saudi Arabia. It has also been evaluated by the Federal Aviation Administration at their test centre in Atlantic City, New Jersey. This spread of orders shows clearly the ability of the equipment to contend with all types of visibility problems including fog, rain, hail, snow, sand and dust.

A Central Processor and teletype

All-weather flying operations are categorized by the standards of the instrumentation of the aircraft and also of the airport. For each category there is a minimum value of the runway visual range, and these go from Category I at 800 metres down to Category 3B at only 50 metres.

The pressure of increasing traffic gives airline and airport operators the incentive to improve the category of their instrumentation so that schedules can be maintained and diversions avoided, despite adverse weather conditions. The International Civil Aviation Authority (ICAO) recommendations state that for Category 2 and 3 operations, rapid and simultaneous reports of RVR from a number of different observation posts along the runway should be maintained. This implies that the use of human observers, such as are used in many countries, is precluded.

The computerized Marconi IVR system measures continually and records the range of visibility at an airport runway under all atmospheric conditions.

The IVR Mk 2 system can be configured to meet most airport operational and layout requirements. The modular concept of the system enables the most effective system deployment to be achieved at the minimum cost, as well as allowing economical up-grading or extending the equipment as and when airport development requires.

The system employs a variable number of unattended field-sites installed alongside the runway, which gather photometric data used to assess visual range. These optical systems are housed in special casings which protect them fully from weather, dust, insects and birds. A background luminance monitor is also included, and information from this and the photometric data are digitized and passed to a central processing unit, where a computer scales the optical data against calibrated references, assesses the visual range and displays it digitally in a form compatible with international ATC operational procedures.

IVR Mk2 at London airport, Heathrow

The IVR Mk 2 system is being produced at the Leicester works of Marconi Radar Systems and is an updated version of the former IVR-1. The Mark 2 system provides facilities for both Category 2 and (with alternative modules) Category 3 airfields, and is capable of handling up to six field sites on various runway configurations. Systems engineering of the IVR Mk2 ensures that RVR assessment is performed with the maximum accuracy. A built-in auto checking and alarm system is incorporated which ensures that RVR is not displayed when a fault is present.

Marconi Radar Systems offer a comprehensive world wide back-up service for its IVR range covering spares, repairs and a full training facility.

Vital role for Racon

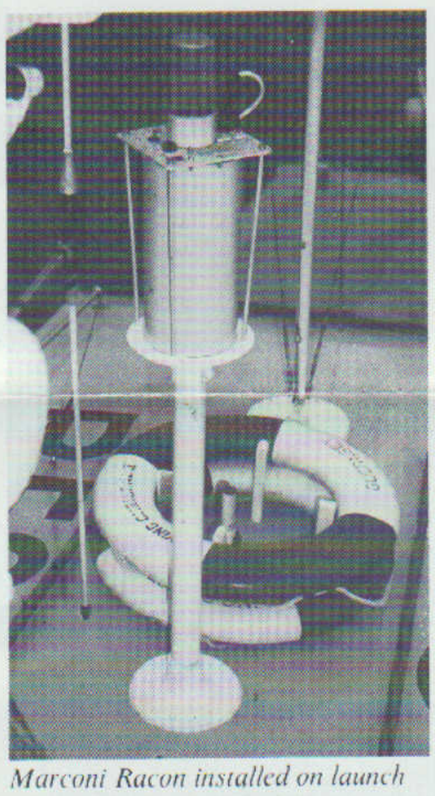
The Marconi Sea Watch 300 Radar Beacon is playing a new and vital role with the St John Ambulance Brigade in the Channel Island of Guernsey, where it is proving to be a valuable aid in sea-going rescue operations.

The Guernsey Brigade operates a number of small rescue craft which are 'on call' throughout the year and attend accidents within some 20 miles of the island. Recently the Brigade decided that they wanted to be able to advise and track the craft to and from the accident scene. On the advice of their independent radar consultant, T. W. Welch and Partners, the Brigade purchased a mobile land-based radar and approached Leicester for a racon capable of clearly marking the rescue craft's position amid heavy sea clutter.

A racon supplied for a short trial period proved that the system fulfilled all expectations, and as a result of the trials an order was placed on the Leicester factory for a special lightweight fixed frequency version suitable for use in a sea-going rescue craft.

The success of the racon was highlighted recently when the Brigade staged a sea-going rescue operation which was televised by the BBC in the popular technological programme 'Tomorrow's World'. It is hoped that eventually all craft operating in these waters will carry their own individual transponders.

The Marconi Sea Watch 300 Racon, an all-weather navigation aid in service throughout the world, automatically responds to ordinary X-band radars and returns a coded response on the radar screen indicating its exact position and identity.



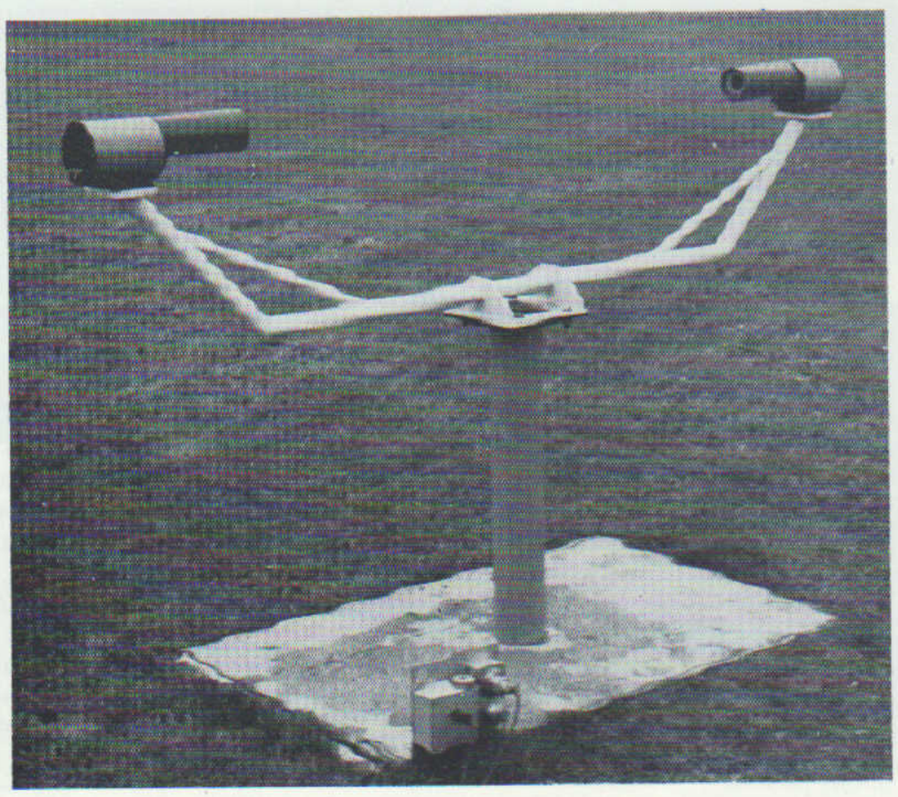
Marconi Racon installed on launch

Introducing MET-1

Continued investigation into visibility monitoring techniques and experience gained with the highly successful Marconi Instrumented Visual Range (IVR) system for airport runways has led to the development of a new low-cost type of instrument for measuring visual range.

Known as MET-1 (Marconi Environmental Transmissometer), the new instrument is intended primarily for use on the smaller airfields, though it has potential application in any situation where the presence of fog, dust, rain, snow, smoke or other pollutants may adversely affect the level of visibility. Such areas could include motorways, ports, ships, industrial locations, tunnels, underpasses, and so on.

A main advantage of the new instrument is that it measures atmospheric transmission using only a short baseline. This is a significant advance in technique since it enables the two ends of the baseline to be mounted on the same rigid bar, resulting in a single compact unit for installation. The standard instrument operates over a folded baseline of 2 × 2m and weighs approximately 35kg. For ground level installations it is supported at the required operating height on a single central support pillar.



MET-1 consists essentially of an optical Transmitter/Receiver unit and a Reflector unit which are mounted facing each other. The light source used is an electronically modulated light-emitting diode, and the retro-reflector returns radiation to the transmitting lens to be focused on to a silicon photodiode. The receiver incorporates a phase sensitive detector to provide a good analogue signal-to-noise ratio. Analogue signals are subsequently digitized and processed to derive atmospheric transmission for conversion to visual range.

A unique self-calibration facility enables the system to tolerate a large amount of contamination on the optical windows without loss of accuracy.

Digilux for British Steel Corporation

A Marconi Digilux 'touch-sensitive' display is to play an important role in the investigation of data processing systems and information display techniques being carried out by the British Steel Corporation.

Under a contract recently received by Marconi Radar Systems Limited, the Digilux unit and a television alphanumeric display are to be supplied to the Control and Human Factors Department of the BSC's Corporate Engineering Laboratory.

The BSC is to use the Digilux in conjunction with the Laboratory computer (a PDP 11/45) to evaluate data processing systems and programs developed for specific steelworks applications, one of which is an operator guidance system for 'basic oxygen' steelmaking control.

The planned experimental programme being carried out by the Corporation also includes comparative evaluation of equipment and an investigation of the display parameters such as desirable contrast ratios, character size, alpha-numeric data format design and techniques of graphical display.

Digilux operates like a programmable keyboard but has the advantages of being faster and less prone to error, has a very short learning time and can offer a significant saving in space. Used in a similar way to the highly successful Touchwire system Digilux is, however, 'wireless' and does not rely on physical contact between finger and a bare wire conductor. Instead, it uses narrow infra-red light beams which form an invisible grid over the display screen. At each of the intersection points a small stud is let into the screen and above each stud an item of data to serve as a label is written electronically on the tabular display screen. By touching the appropriate stud two beams at right angles are intercepted and the data designated by the label is signalled to the computer. This data is then written on the screen and at the same time a new set of labels, designating the next stage of information 'call-up', is written above the studs.

Marconi Digilux touch sensitive display, showing location studs

The information displayed may be altered by the operator at any time, by the use of the labelled studs, in order to up-date the data stored in the computer. Insertion of impractical or impossible information is automatically rejected and the operator is warned on the display.

Operators become adept and confident in the use of Digilux within hours and this comes with the knowledge that the unrecognized errors and false entries, encountered in keyboard systems, are not possible when using this new equipment.

Since its introduction in September 1974, more than 60 Digilux units have been sold finding application in both the civil and military installations.

Radar Systems International

the journal of

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