MAGNETICS IN SUPPORT OF THE MCMV

BY
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Introduction

In today's high technology world of the microprocessor, fibre optics, and lasers it is perhaps not surprising that many find the subject of magnetics dull and uninteresting if not something of a black art. Although magnetic theory forms the basic structure of electrical engineering such aspects as domain theory, permeability, remanence, and hysterisis are to many only a vague memory of electrical and magnetic theory lectures tolerated years ago. But to many in the Fleet today and those who support the Navy in both the Ministry of Defence and the shipbuilding industry, magnetics has become an extremely important subject.

Those closely concerned with the introduction of the HUNT Class Mine Counter-Measure Vessels (MCMV) and the new design Single Role Mine Hunter (SRMH) are well aware of the importance of magnetics and magnetic hygiene in the development, production, and assessment of components, equipments, and systems destined for MCMV or SRMH.

This article is not intended to educate the reader in magnetic theory but to give an insight into the history and operation of the Magnetic Measuring Station at the Royal Aircraft Establishment Ditton Park, in support of the MCMV/SRMH ship programme.

RAE Ditton Park is an outstation of the Electrical Division of the Naval Engineering Department, RAE West Drayton.

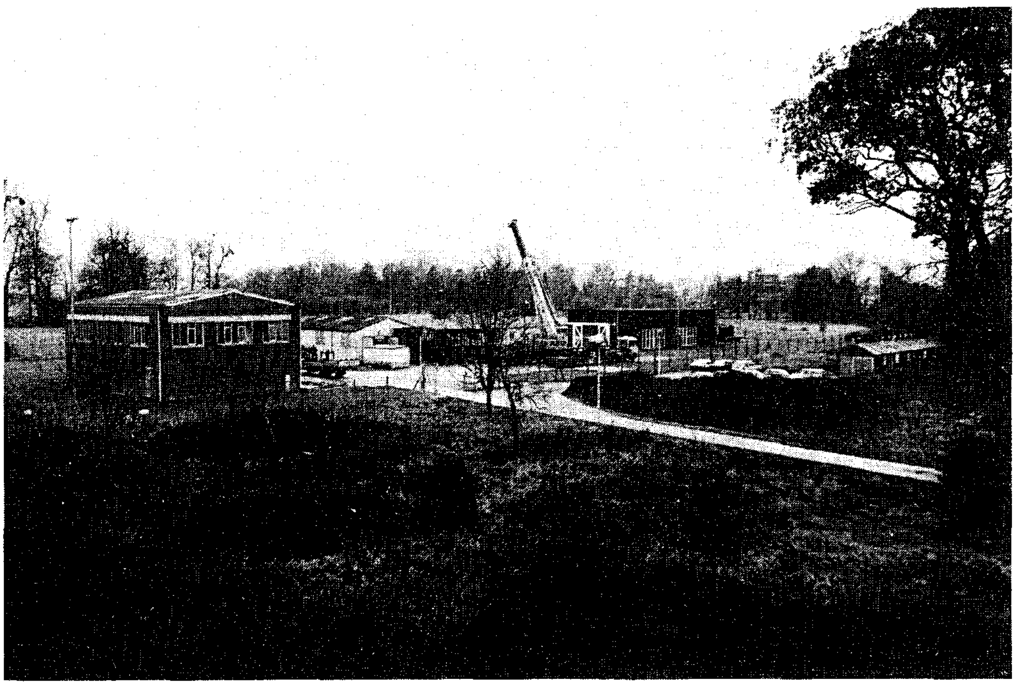

FIG. 1—RAE MAGNETIC RANGE, DITTON PARK, SLOUGH

History of Ditton Park

In the early 1960s with the projected low signature MCMV on the drawing board there became apparent the need for a specialist facility for measuring the magnetic signature of any equipment destined for the MCMV. If the overall target figures[1] were to be met and maintained the need to build and develop a reliable and accurate measuring station was paramount. So began the search for a magnetically quiet location that ended in the grounds of the Admiralty Compass Observatory in Slough. After careful survey of the magnetic conditions the foundations were laid for the birth of the Magnetic Range, a land-based research, development and production magnetic measuring assessment facility.

The range commenced operation in 1968 and was initially mainly concerned with the development and measurement of prototype low magnetic equipment and the assessment of the suitability of standard naval components and equipments for MCMV application. Equipments ranging in size and shape from spanner sets to the main propulsion engines and even uniforms were measured for their magnetic signature. This was a slow and painstaking learning process but as firms made extensive modifications to equipments and became more aware of the meaning of magnetic hygiene, the task for the Range staff became less formidable. Where it was necessary for equipment to have compensation coils fitted, range staff would undertake the initial design and testing to achieve a satisfactory result and then pass the information to the respective firms for incorporation in their future production items.

Full details of the magnetc assessment, the recorded signature, the details of individual equipment compensation, and the orientation of the equipment ranged would then be passed to the design and support sections within DCW/DCWE of the Sea Systems Controllerate (formerly DG Ships) for incorporation in the ships' drawings and for the signature of the equipments to be mathematically modelled to ensure that the ship signature could be kept within the prescribed limits.

Today the majority of the work undertaken at Ditton Park is in the monitoring of production equipments destined for the MCMVs, whether it be for the ships already in service, the ships in build, or merely for storage at one of the DGST(N) bases. Although this may tend to give the impression that the Range staff are merely engaged upon routine 'go/no go' assessment tasks, this is far from the real life situation. In the event of an equipment failing to meet its magnetic performance specification then a considerable amount of magnetic detective work is required to identify the cause of any magnetic anomaly. It is here where the expertise of the Range staff has been known to leave many a manufacturer and for that matter many of their Headquarters colleagues amazed at their ability to identify the incorrect use of material in a component of a complex equipment, or the identification of a rogue item in a large container of spare gear, or simply the area on an equipment where the signature is particularly high.

This expertise has been put to the test on many occasions through 'trouble-shooting' visits to manufacturers' works and to HUNT Class vessels following ship ranging trials.

Ranging Facilities

The Range building being constructed of wood, glass, brass bolts and brass screws, has zero ferromagnetic content, thereby reducing the risk of extraneous fields being present and affecting the magnetic measurements. Even the concrete was checked for contamination before being poured. The instrumentation and control room together with the office accommodation

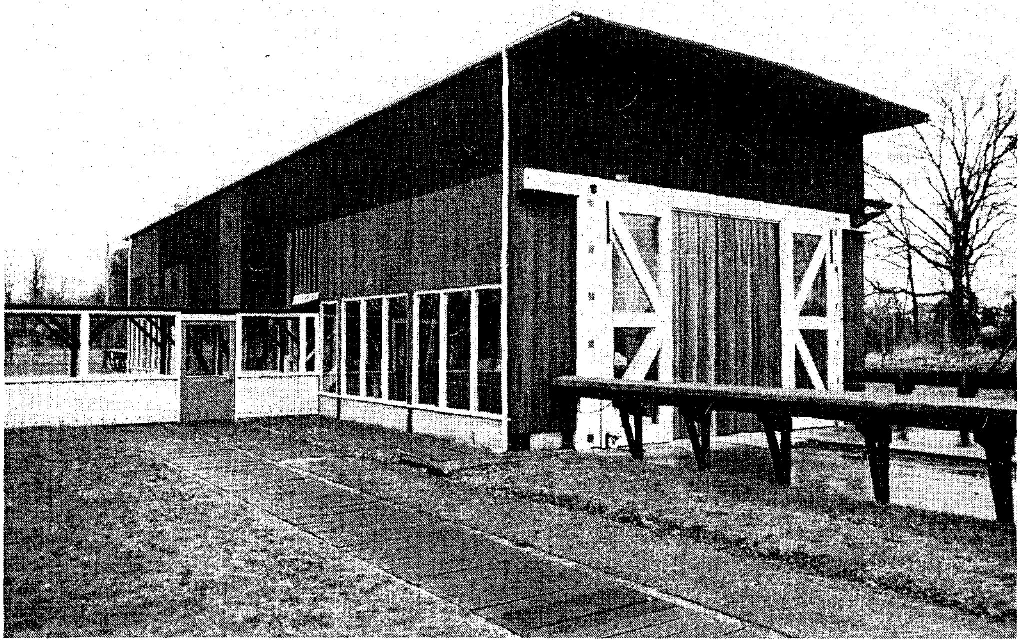

FIG. 2— MAGNETIC RANGE BUILDING

is sited some 15 metres from the Range itself and is likewise constructed mainly of wood.

The non-magnetic railway, some 50 metres in length, and the Range were aligned along the North-South magnetic axis, along which items under test are towed on a non-magnetic trolley by a non-ferrous rope. A hydraulic/electric winch system is employed.

The magnetometers (probes) are aligned in an East-West orientation and are arranged in sets of three at depths of 0·76 m, 1·5 m, and 4·4 m, in the centre of the range building. Depending upon the strength of field to be recorded the appropriate probes are selected accordingly. The strength of field emanating from an equipment and the depth chosen to record it are govered by the law that the strength of field is inversely proportional to the cube of the depth from which it is measured.

The probes are continually scanned and monitored in the control room during a test and the results stored in a computer which can then be transferred to hard copy via the teleprinter.

The original 3-axis magnetometers and associated instrumentation were designed and produced by the German firm Messrs. Forster Limited and gave sterling service for more than 15 years. However with old age advancing the operation and maintenance work load was increasing and 1983 saw the conclusion of an extensive modernization programme. A new British firm was contracted to produce and install a new magnetometer instrumentation system which, after a few minor teething problems, is now working to the prescribed specification laid down by Ditton Park.

The firm Domain Micro-Systems Limited combined modern up-to-date technology of microprocessor-based control systems for the range operation with tried and trusted 3-axis fluxgate magnetometers for the sensing of the anomaly fields. The Range has always been at the forefront of the application of new technology and the early 1970s saw the introduction of automatic data recording and processing using off-line digital punched tape techniques.

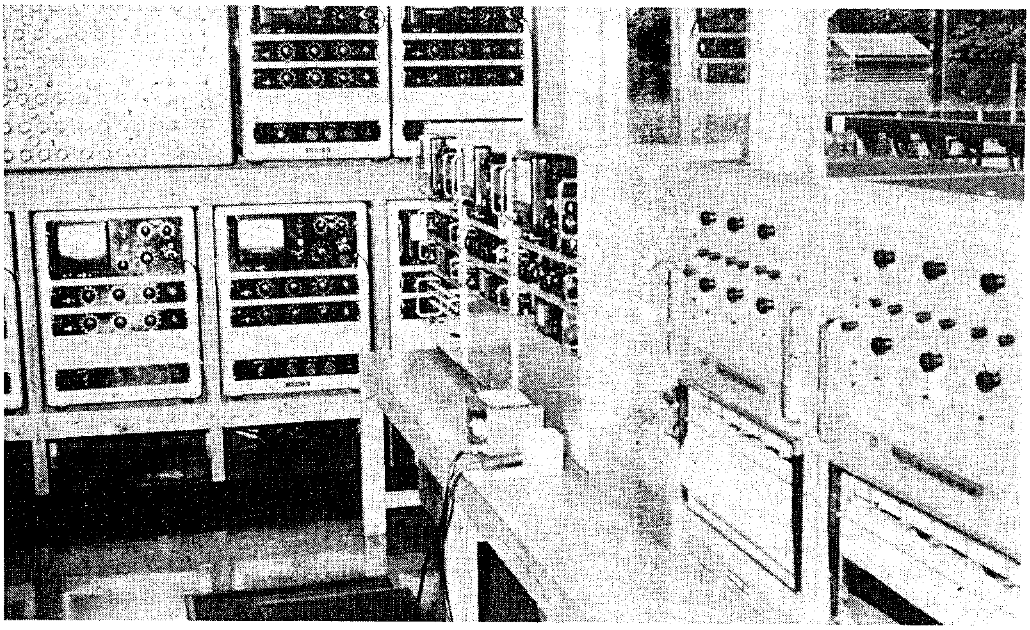

FIG. 3—INSTRUMENT/CONTROL ROOM: PRE-MODERNIZATION

This achieved a considerable increase in the throughput of work by eliminating the previous manual analysis of recorded data. Further improvements were effected during the late 1970s with the introduction of a computer-based data logging system which provided an on-line recording and processing capability and the automatic production of the magnetic test certificate. This capability has been incorporated into the present system and signature data may now be recorded additionally on magnetic disc for subsequent transfer to the Design Authority's Ship Magnetic Computer Model. Such improvements have enabled a reduced Range staff to increase throughput and annually issue some 700 Magnetic Performance Test Certificates.

Forms of Measurement

To enable the signature of an equipment to be assessed it is necessary to measure individually the two components of the resultant total magnetic field. These components are the *permanent* magnetic field and the *induced* magnetic field, and are measured with the geometric centre of the equipment over the magnetometers. Permanent magnetism, i.e. remanent magnetism, is that magnetism which is inherent in the material. Induced magnetism is a function of the permeability of the material times the surrounding field strength, i.e. in most cases earth's field.

For it to be possible to separate the two components it is necessary to create within the range building a magnetic vacuum, thus allowing the permanent field to be measured without any extraneous fields being present, i.e. earth's field. This is accomplished by feeding known currents into two very large orthogonal sets of coils surrounding the building, thereby nullifying the vertical and horizontal components of the earth's field. FIG. 5 shows the actual range layout.

To measure the induced component, one of the components of the earth's field is allowed through the range and this is achieved by simply switching off the current to the particular range coil in question, i.e. either the vertical or the horizontal coil. This then gives a measurement of, say, the induced

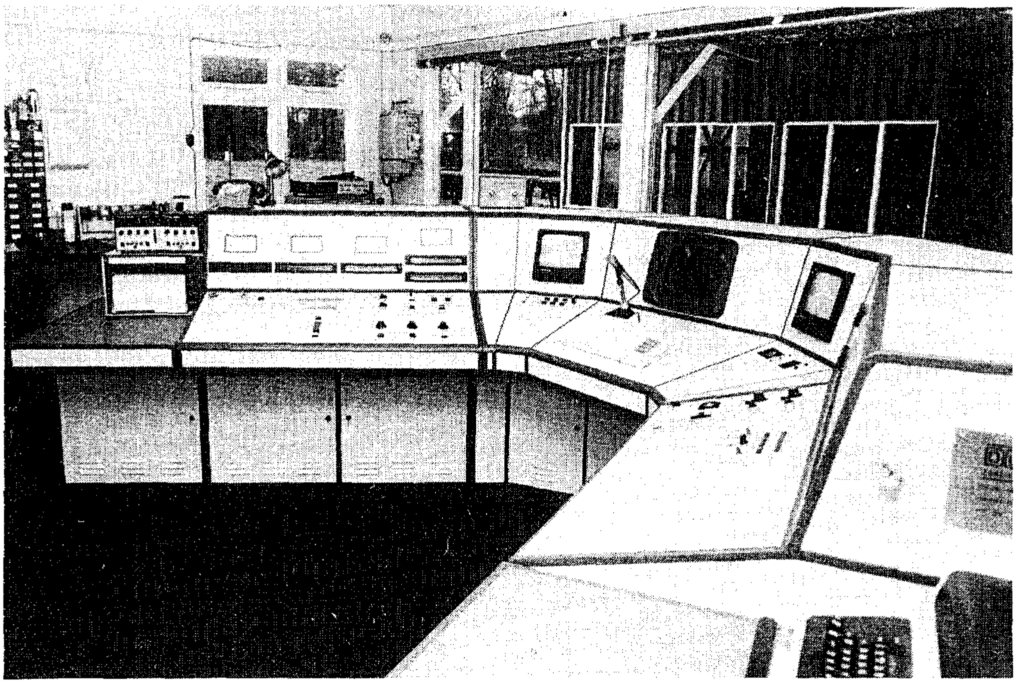

FIG. 4—INSTRUMENT/CONTROL ROOM: POST-MODERNIZATION

vertical field plus the permanent vertical field but, as the permanent vertical field has already been measured and the result stored in the computer, the computer does a simple subtraction and displays the induced vertical field reading. This process is then repeated for the horizontal and athwartship axes.

Equipment is normally ranged in a de-energized condition, but sometimes it is necessary to measure the d.c. stray fields emanating from a particular equipment, for example a Transformer Rectifier Unit. The equipment is placed over the magnetometers, successively switched on and off, and the stable condition magnetic fields measured.

In addition items such as engines, motors, transformers, etc. that contain ferromagnetic materials must be fitted with induced field compensation coils. This as explained previously is carried out by the manufacturer but they have to be energized and their field orientation checked, along with the fitting of suitable current limiting resistors so as to ensure that the equipment does not become over compensated when connected to the ship's own compensation system.

The foregoing is really only a brief summary of the work undertaken at Ditton Park. As well as ranging R.N. equipments, the Range also undertakes work for the Royal Australian Navy in support of their catamaran, work for AQD Woolwich Arsenal in support of their trepanning equipment, and some repayment work for firms who require the Range's expertise. These tasks are undertaken only on the basis that programmed work for the Ministry of Defence in support of the R.N. is not prejudiced.

The Range is also active in the research and development field and has been directly involved in the development of a low frequency (5 Hz), high power (500 Oersted) demagnetizing equipment for use with SRMH equipments. At present a number of manufacturers use a low power (150 Oersted), high frequency (50 Hz) demagnetizer to help reduce the permanent magnetism in components and equipments. A combination of low ferromagnetic content

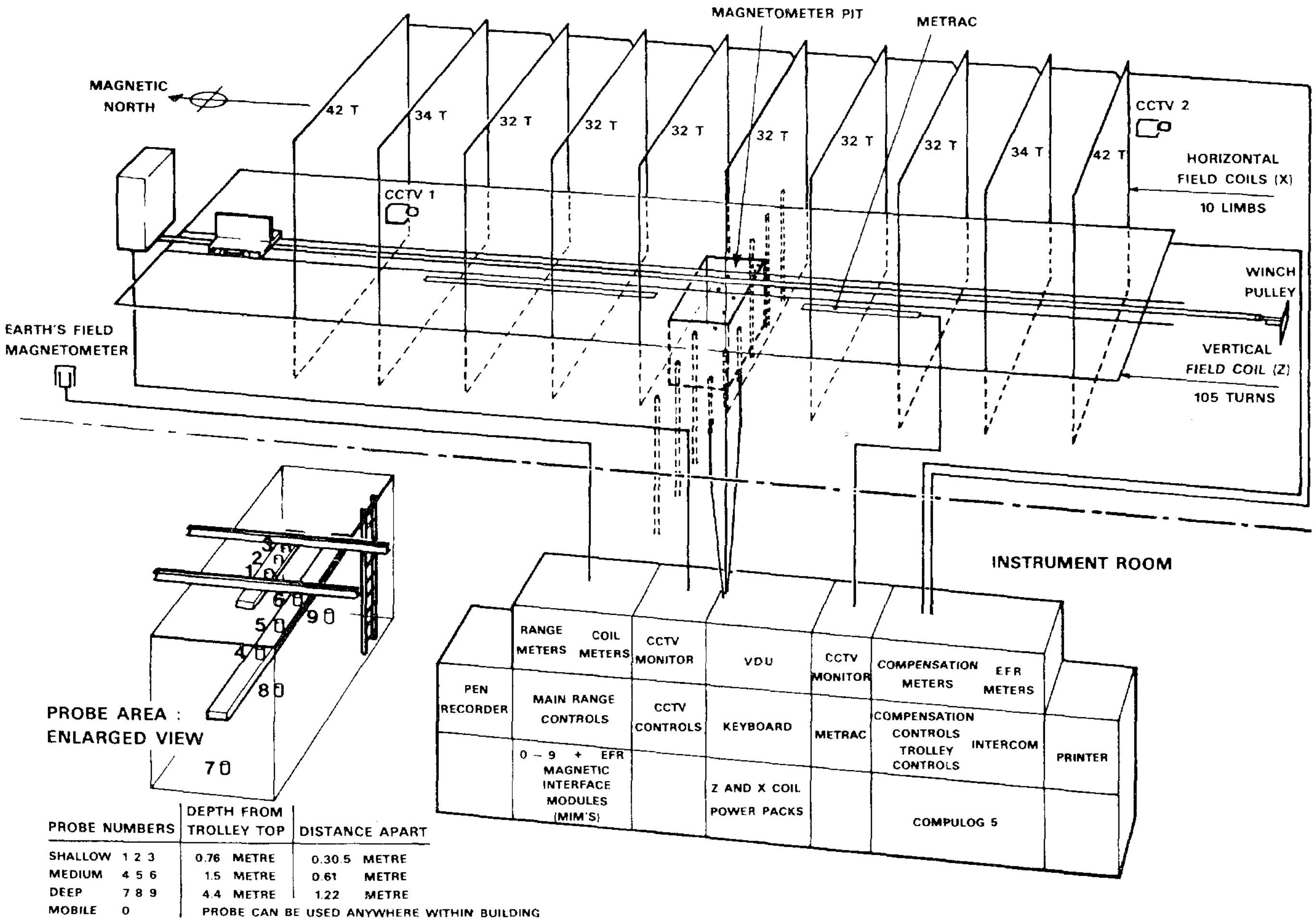

FIG. 5—LAYOUT OF MAGNETIC RANGE

and the use of min-mag materials with a fairly low permeability enables this existing system of demagnetization to work with reasonable success. However with the development of the SRMH, which will use a greater amount of ferromagnetic materials having an average permeability considerably greater than specified for the MCMV, work to date indicates the need for a low frequency, high power demagnetizer to achieve the desired results. The reduction in frequency will allow a greater penetration of the material by the demagnetizing field—the depth of penetration being proportional to the inverse of the square root of the frequency—thereby making the demagnetizing process more effective.

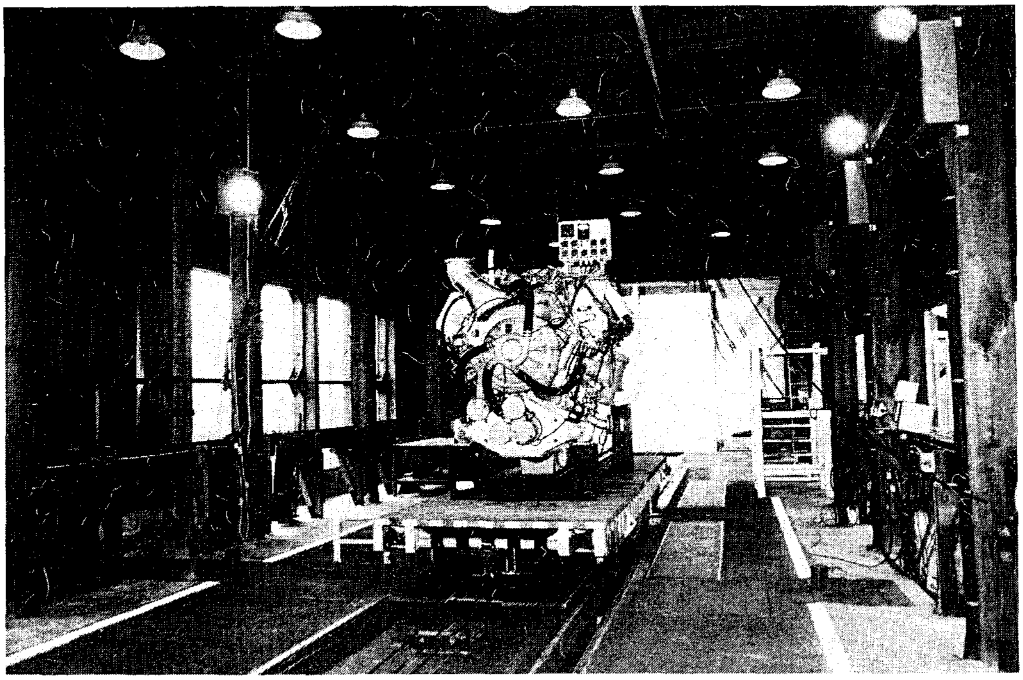

FIG. 6—AN MCMV PULSE GENERATOR ENGINE UNDERGOING MAGNETIC ASSESSMENT

The Way Ahead

In addition to the continuing support to the HUNT Class MCMV building and refit programmes, the Range is becoming increasingly involved in the assessment of prototype equipments for use in the new design SRMH. The latter has led to a programme of work involving the assessment of the suitability of standard commercial equipments in view of the acceptability of higher permeability figures[2] compared with the HUNT standards.

Nevertheless the need remains both during and following this development phase to maintain the magnetic standards.

Conclusion

It is hoped that this short article has served to provide the reader with an understanding of the main function in life of the Magnetic Measuring Station at Slough. For those who man the HUNT Class and those who may be called upon to man the future Single Role Mine Hunter class you can be assured that the Magnetic Range will continue to provide a service second to none in the provision of proven magnetically clean equipments.

It may be that magnetic assessment of ships equipments does not capture the imagination but to those whose lives depend upon it, it must seem pretty wonderful, be it a 'Black Art' or not.

Acknowledgement

The author wishes to thank the Director RAE for his kind permission to publish this article. Any views expressed in this paper are those of the author and do not necessarily represent those of the Ministry of Defence.

References

1. DGS Equipment Specification 12B: 'Statement of requirements for equipment having minimum stray and eddy current magnetic fields and specifying magnetic permeability of materials' (Sept. 1968).
2. Naval Engineering Standard 617: 'Requirements for equipment to achieve a low magnetic signature [for the] Single Role Mine Hunter' (May 1983).

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the requirements for independent control are satisfied.