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UNDERSEA DETECTION EQUIPMENT

MC5

PROTON MAGNETOMETER

TYPES PES / PET

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Operating Instructions

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Issue 6 /March 2008

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INTRODUCTION

Marine magnetometers have been used in professional applications with great success for many years. However the high cost of these units have restricted their use for general wreck location. Recent advances in electronic technology have however enabled such lower cost magnetometers to be produced without sacrificing any of the features of these professional models. In fact the use of microcomputers has enabled costly features on previous designs to be implemented as standard.

For wreck location the magnetometers great advantage over an echo sounder, is its ability to detect a wreck at a distance and then enable the search vessel to home onto it. It can also detect wrecks buried in sand etc., or lying on rocky ground: both of which are very difficult with an echo sounder

The **AQUASCAN MC5** is a proton magnetometer, which is used to measure the earth's magnetic field strength and can detect variations in this field caused by the presence of ferrous objects. The earth's field is normally uniform, but will be disturbed by local concentrations of magnetic material such as a steel wreck. These variations can extend up to several hundred metres from a wreck site with the maximum occurring over the wreck itself. It is however difficult to give accurate performance figures for the detection of various objects as much depends on the size, attitude and permeability of the object disturbing the field.

A major feature of the MC5 is simple operation. This simplicity of operation has been achieved by linking manual controls to the internal microcomputer. The microcomputer has also allowed an upgrade path for the MC5 to provide a link to an external computer for display and storage of data.

Expanded I/O facilities allow data logging of GPS positional data and water depth from a compatible echo sounder with an NMEA data output. Depth contours (bathymetric data) can add valuable information to the magnetic survey data analysis.

PC support software options are available to allow both real-time graphical viewing and or later use of a PC, this can provide a very powerful aid for survey, downloading, and post processing and evaluating the accumulated data. Real time display and direct data logging of measurements on a PC can greatly enhance a survey. The application of the PC for the processing of magnetometer data can virtually bring order to chaos; an apparent meaningless set of magnetic deviations can be processed and represented as a series of contours giving a clear picture for interpretation. The current high-resolution colour screens (VGA/SVGA) used on PCs allow a further dimension to the display of processed data. Progressive changes in the measured values of the magnetic field can be attributed a range of colours from the spectrum available, alternatively, successive surveys can be overlaid on the same screen with a clear separation.

AQUASCAN MC5##/##

1.0 SYSTEM CODING

A simplified coding system has been adopted to cover a range of options available with the MC5 series; the letters and numbers following determine the status, type of sensor and length of cable supplied. Some examples are listed below: -

MC5ES/40 = System for European operation with Solenoid sensor and 40m cable.
MC5ET/40 = System for equatorial operation with Toroid sensor plus 40m cable.
MC5RES/40 = System for European operation with Solenoid sensor plus 40m cable and RS232 output of magnetic deviation.
MC5PES/60 = System for European operation with Solenoid sensor plus 60m cable and full NMEA/RS232 interface facilities & supplied with Windows software.

1.1 PACKING LIST CHECK

A (loose sheet) packing list will be found at the front of this manual - representing a comprehensive inventory of individual items that have been included - this sheet should be used as a checklist. Any queries resulting from this initial check should be raised with your local representative or directly with AQUASCAN.
NB we suggest you keep the packing material, as a precaution for returning the instrument, should this be necessary for upgrade or service at a future date.

2.0 SYSTEM INSTALLATION

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2.1 MOUNTING

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The MC5 display unit is supplied with a conventional gimbals mount bracket allowing the unit to be mounted on horizontal, vertical or sloping surfaces. The degree of weatherproofing and the watertight nature of the connections make the unit suitable for mounting in exposed positions. It is recommended that where possible the unit should be mounted behind some form of spray shield - particularly when mounted on the console of RIBs and other similar type of high performance open boats.
Mounting the MC5 display should take account of the central role the instrument takes during magnetometer survey operations, this demands concentration and ease of access to the controls. Apart from the normal compass considerations, mounting the unit in close proximity to other general marine instruments should not cause any mutual interference.

The recommended minimum mounting proximity to a conventional compass is 20cm (8") - for minimal effect. If a central mounting position is not available then angle the unit as much as possible to present a view "square" to the operator.

2.2 CONNECTIONS

The MC5PES & PET systems are fitted with four waterproof connectors; these are complete with protective caps. The protective caps should be utilised both during operation to cover unused connectors, and for protecting the instrument and cable end connections when unmated. The interconnect system allows ease of disconnection and hence removal from the boat as required. Connectors cater for the following needs: -

a) Coaxial connection to the tow-fish cable, or indirectly via an extension lead.
b) 12v/24v dc supply.
c) Data output facility for PC.
d) NMEA 0183 GPS & Echo sounder data.

MC5 - interconnect

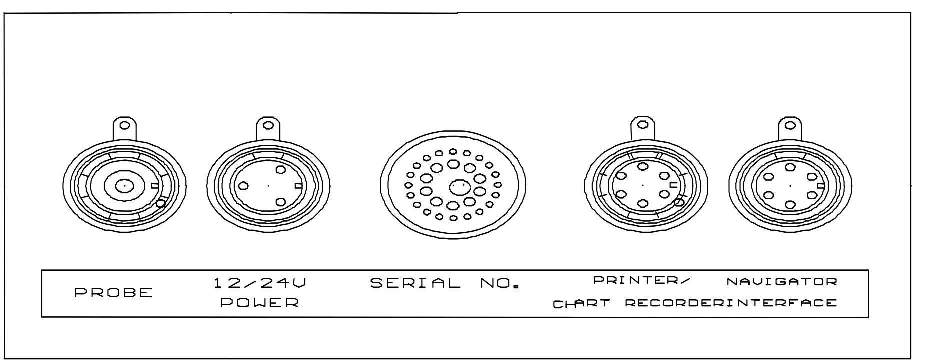
PROBE - The ***Towfish*** sensor is connected via the tri-axial (double shielded coax) cable, this cable connects the sensor to the MC5 via the PROBE connector.

NOTE. It is essential to maintain this connection in a clean dry condition.

12/24v POWER. The power supply lead is fitted with an inline 3A fuse. NB. The control unit also has an internal 3.15A protection fuse. The MC5 will provide a higher quality performance using 24v, however it will in many cases provide a very adequate performance with a 12v supply.

PRINTER/PC RS232 – This provides the connection point for the RS232 data lead. In addition to data & data ground the interface lead provides external power from the PC serial port to energise the internal opto-isolator. In some cases where a laptop is used the port may not energise the opto-isolator circuit; in this case a PP3 style (9v) battery can be used with the connector provided. Note. The 9v battery will continue to supply power even when the MC5 is switched off.

NAVIGATOR INTERFACE - 0183 data is fed to the connector via the NMEA lead supplied, the connections are identified with printed labels. Internally the NMEA inputs are opto-isolated.



2.3 POWER SUPPLIES

The 12/24v-power supply is one of the most fundamental aspects to get right for optimum system performance. The combination of extremely high sensitivity together with the very low operating frequency make the magnetometer instrument very **vulnerable to interference via the power supply cables**. The ideal power source for the AX2000 magnetometer is a totally isolated & independent battery, isolation eliminates both noise from a ships' charging generator (the major source of interference) and the superimposed noise from other instrumentation.

24v Battery supply - The ideal 24v power source is a pair of 12v/60AH (or larger) lead acid batteries in good condition, this will allow an operational period in excess of 24 hours before it becomes essential to recharge.

NB. Even in vessel installations where a dual battery system is available - allowing one battery system to be isolated from the charging system - **both +ve and -ve leads have to be fully isolated** from the boat system to ensure interference free operation of the magnetometer.

To evaluate the feasibility of using a boats "un-isolated" main battery system a test facility is outlined in the "SETTING UP PROCEDURE" section, this gives a means of testing the complete installation for interference.

2.4 TOWFISH INSTALLATION

Although the magnetometer sensor is a towed unit ("Towfish or Probe") the inboard section of cable has to be routed to the control unit. The main considerations in routing this cable are as follows: -

1. Avoid the cable passing close to the outboard/inboard engine.
2. Avoid the cable passing close to the main battery supply and charging cables.
3. Where it is necessary to cross other cables, do this at 90 degrees if possible.
4. Any runs parallel to other cables should be kept as short as possible and with maximum spacing (even spacing of a few centimetres can make an appreciable difference to the induced interference level.

3.0 PRINCIPLES OF OPERATION

The principle of operation of a proton magnetometer is unlike that of any conventional metal detector that generally relies on creating it's own localised field of influence. Conventional metal detectors producing their own dynamic field can detect localised disturbances in the field caused by metal objects. This time varying dynamic field only extends about 2 metres from the search coil, so consequently the maximum detection range even for larger metal objects is still only 2 metres. Conversely the proton magnetometer uses the existing static earth's magnetic field as a medium for determining the presence of ferrous metal by measuring the changes occurring in the surrounding area, this can yield detection distances of several hundred metres.

A proton magnetometer for wreck location measures the strength of the earth’s magnetic field to a resolution of about 1 part in 50,000, for this level of resolution it has to be extremely sensitive. The earth’s field is a static field and because most non-ferrous metals do not have any significant effect a static magnetic field then they cannot be detected by a proton magnetometer. A good rule of thumb to determine if a material will be detected by a magnetometer is to consider if it will be attracted to a conventional bar magnet. The proton precession magnetometer is so named because it utilises the precession of spinning protons in a sample of hydrocarbon fluid to measure the strength of the magnetic field within the fluid sample. In practice the magnetometer sensor consists of a chamber of hydrocarbon fluid (i.e. Kerosene) around which is wound an inductor (sensor coil).

3.1 PROTON PRECESSION

The MC5 proton magnetometer utilises the well-established principle related to deriving an AC signal from the PROTON PRECESSION activity that can be induced in a hydrocarbon sample contained within the core of an electromagnet.

In the case of the MC5 the electromagnet/sensing element, is formed by a multi-turn inductor in the form of a solenoid or Toroid inductor. The inductor is initially formed as an air cored coil, but subsequently has the core filled with or immersed in a hydrocarbon fluid.

To measure the earth’s field, the fluid must first be polarised for a time period in the order of a second or more. The polarising state entails connecting the sensor coil to a battery; this produces a strong magnetic field through the fluid. The protons behave as small spinning magnets and temporarily align themselves with this strong field, as shown in (Fig. 1). When the battery is disconnected the magnetic field collapses and the spin of the protons causes them to precess about the direction of the earth’s magnetic field. The precessing protons generate a small signal of approximately a few microvolts in the coil; the frequency of this signal is directly proportional to the strength of the earth’s magnetic field. The precise relationship between the frequency of the signal and the magnetic field is known as the gyromagnetic ratio.

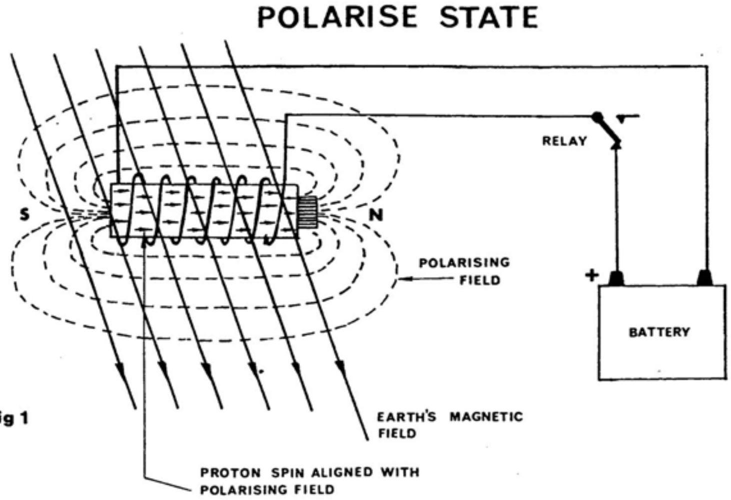


Fig 1

After the battery is disconnected the amplitude of the precession signal slowly decays over a second or so, as the signal from the individual protons gradually loose phase coherence. The magnetometer must resolve the frequency of this signal within a second of switch off. This is the Detection state (measurement phase) (Fig. 2), during this period the sensor coil is connected to a tuned amplifier. The amplifier contains a filter to reject noise and unwanted external signals induced in the coil. The amplified signal is then fed to a microcomputer.

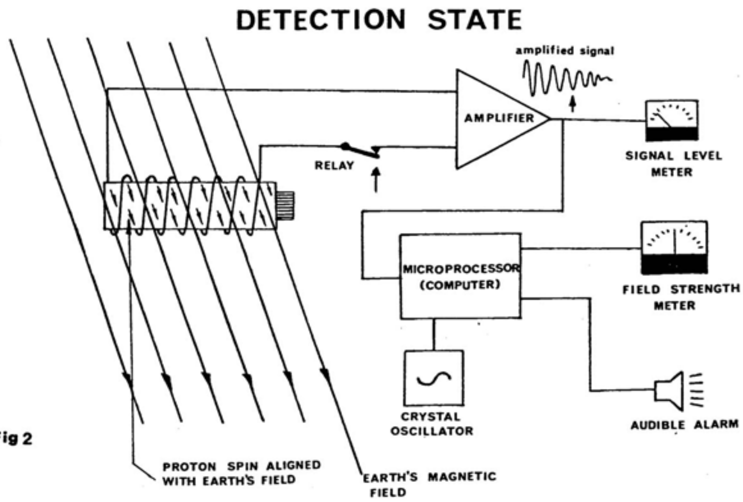


Fig 2

The use of a microcomputer makes it possible to programme in sophisticated features that would be uneconomical in previous designs. To measure the frequency of the precession signal the microcomputer compares the signal with its own crystal oscillator. This technique enables the MC5 to make very accurate measurements; these can be stored as data in the microcomputer's memory to be compared with previous measurements. The microcomputer is programmed to automatically actuate an alarm if the change in magnetic field strength is greater than the value selected; this is controlled using the front panel switch. This audible alarm facility avoids the need to continually concentrate on the magnetometer when searching, as the microcomputer is analysing every measurement to check for any field change. Each measurement is automatically converted into an analogue current to drive the large front panel "Deviation" meter and in some later (or upgraded) versions, a data string for combining with position data from a GPS receiver and depth information from an echo sounder.

4.0 THE EARTH'S MAGNETIC FIELD

A reasonable understanding of the earth's magnetic field is fundamental to a successful operation of a proton magnetometer, particularly when used for detection purposes.

The earth's field has a number of parameters, the most important of which is the 'total intensity', and this is the parameter measured and analysed by the magnetometer. Under short-term static conditions the total intensity value is maintained to a stability which allows the magnetometer to measure to a resolution of better than 1 nT (gamma).

4.1 MAGNETIC FIELD STRENGTH & INCLINATION

The earth's magnetic field is similar to that of a bar magnet with the maximum strength at the magnetic poles (Fig. 4). However, it is not an ideal bar magnet, but has variations in field strength due to certain geological effects. Fig. 5 is a magnetic map showing the lines of constant field strength throughout the world. The change in magnetic field strength measured by a proton magnetometer is expressed in nanoTesla (nT) or gamma (1nT=1gamma). As an example - around the UK the earth's magnetic field strength varies from approximately 47000nT in the south to 50000nT north of SCOTLAND. The lines of magnetic flux are not horizontal to the ground but inclined at 70 degrees. Although the earth's field varies by 3000nT over the UK it can be considered uniform over the localised area of search.

EARTH'S MAGNETIC FIELD

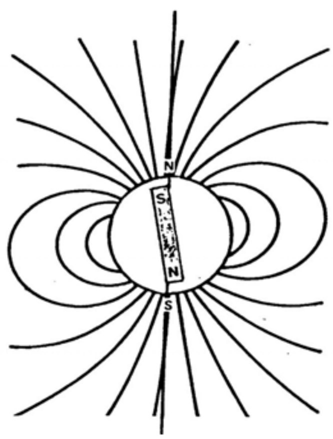
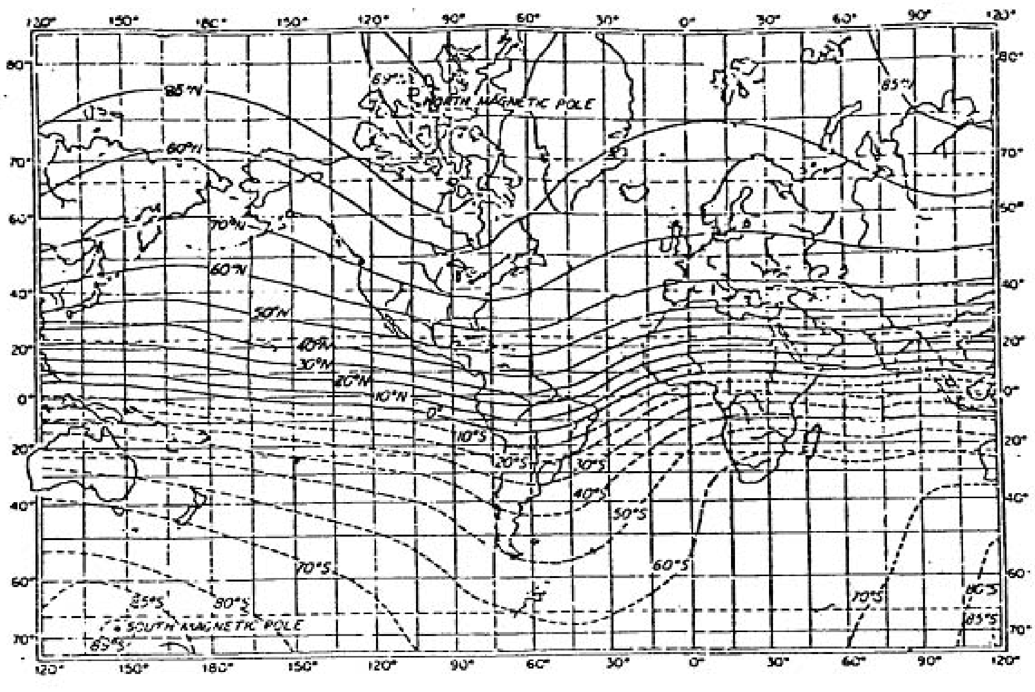


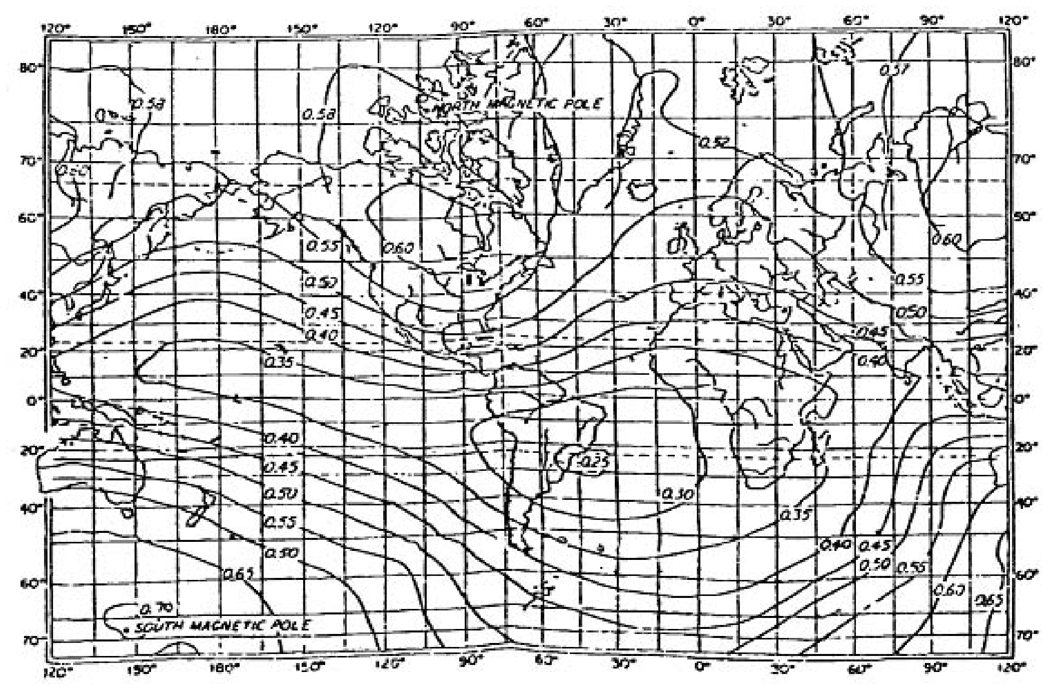
Fig 4

The upper part of Figure 5 below shows the distribution of magnetic field strength over the major part of the earth's surface, The relevance to the operator of this diagram, is covered in the section that refers to initially setting the correct operating **ZONE**. The contours are shown in Gauss (100,000 nT = 1Gauss).

Fig 5



LINES OF EQUAL INCLINATION



LINES OF CONSTANT FIELD STRENGTH
(x1000 nanotesla)

4.2 MAGNETIC ANOMALIES CAUSED BY FERROUS OBJECTS

In order to understand how a magnetometer can locate a shipwreck or other ferrous object it is necessary to consider what happens to the earth's magnetic field around such an item.

Consider the diagram shown in (Fig.3), this shows how the lines of magnetic flux are distributed for a simple bar magnet. The spacing of these lines represents the strength and linearity of the magnetic field at any point; it also shows the field is strongest at the poles. When a ferrous object is placed in the magnetic field the lines of flux are distorted and generally become concentrated through the object. It is the ability of a material to concentrate the field that is termed its permeability. Ferrous material can have a permeability factor in the order of thousands with a proportional impact on the surrounding earth's field. Generally the ferrous object will additionally possess its own permanent magnetisation; this will further distort the flux density around the object.

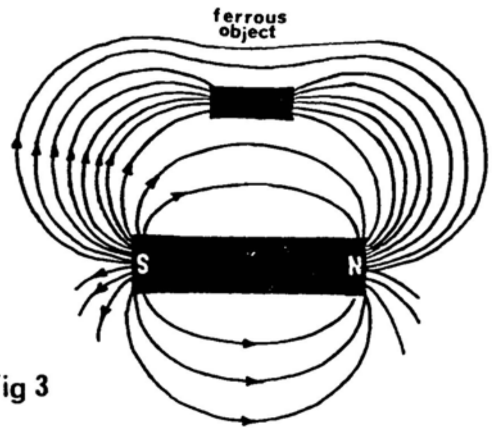


Fig 3

The distortion caused to the earth's field by a steel wreck is shown in (Fig. 6a). This distortion is usually referred to as a magnetic anomaly. The associated graph (Fig 6b) shows the variation in field strength measured by the proton magnetometer as the probe is towed past a wreck. The detection distance used for the graph is the distance obtained by drawing a straight line between the magnetometer sensor coil and the wreck. The magnitude of the field disturbance is very small at the maximum detection range, while large variations exist close to the wreck. It is this large increase in the anomaly amplitude as the wreck is approached that enables the wreck to be homed onto once an initial detection is made. The peak value of the magnetic anomaly depends on the mass of metal and the depth of water.

Fig 6a

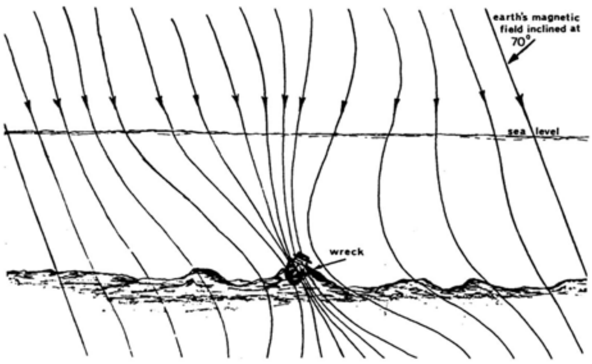
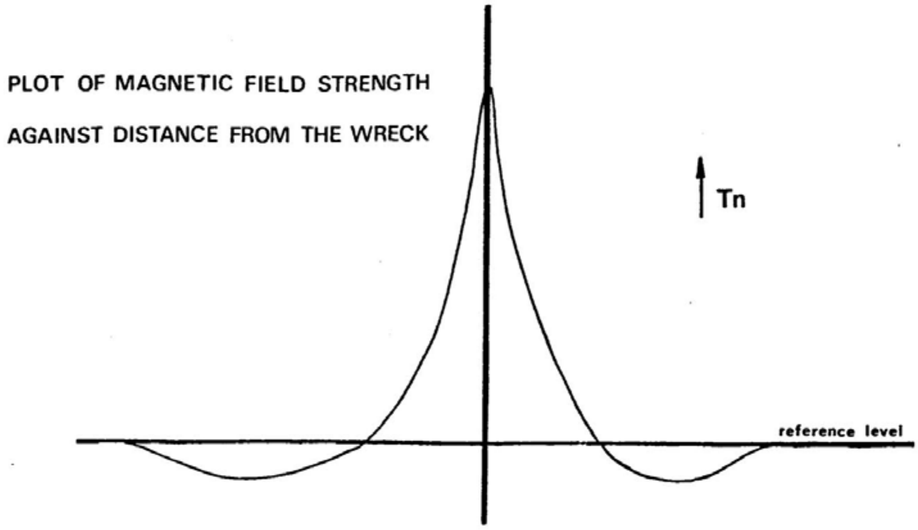


Fig 6b



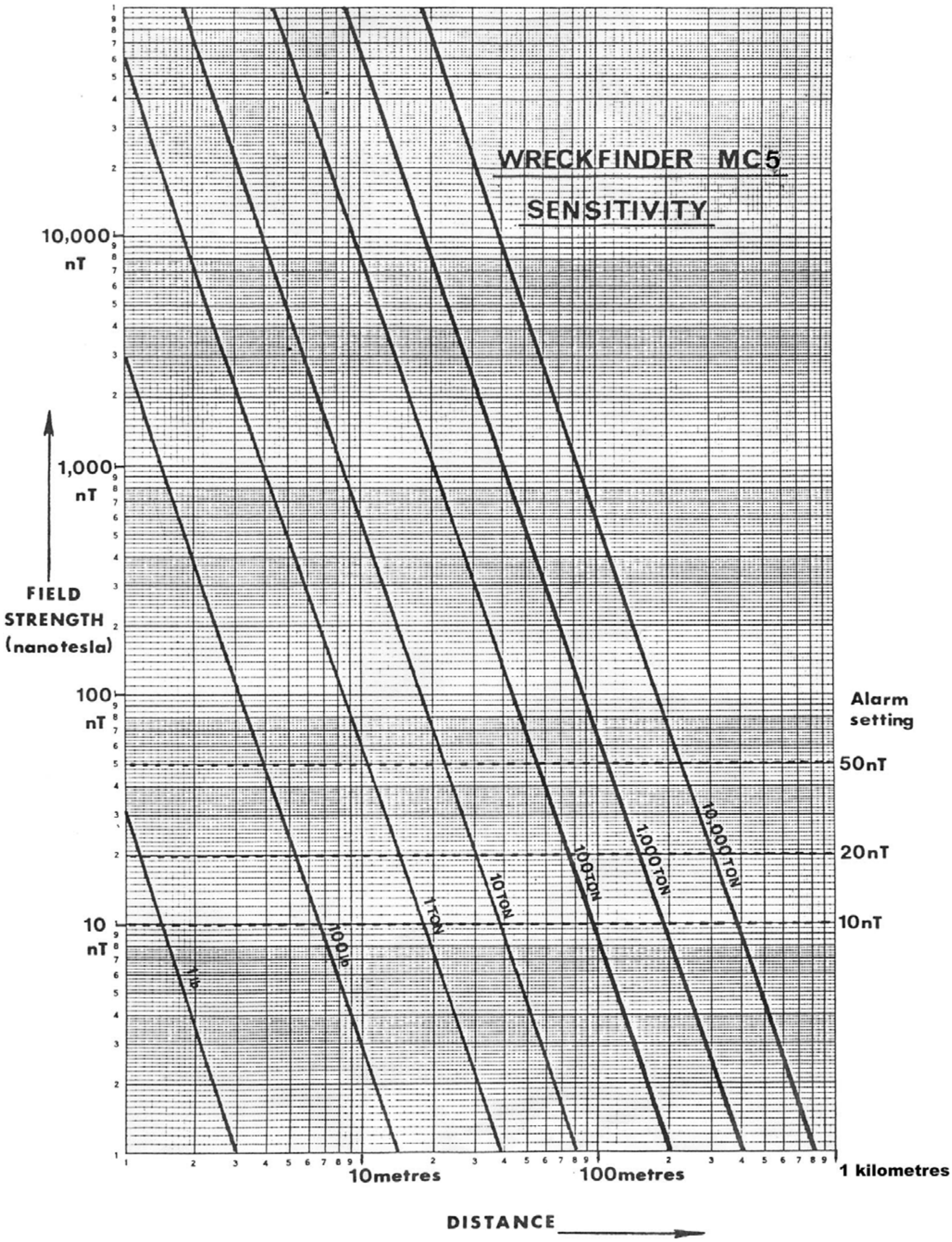
The above plot is a representation of the change in field strength as a survey progresses across the centre of an anomaly. Levels below the "reference level" are related to areas where the field strength has been reduced by the presence of the anomaly. The rate of change of field strength for an isolated magnetic anomaly is based on an inverse cube law, hence the rapid build up to a peak (which in reality has a broader peak than the diagram illustrates). Another way of expressing the law relating to change is that 2 times distance gives 8 times deviation change. The other major influence on detect-ability of an object is the presence of it's own permanent magnetic field, this will itself produce a surrounding distortion in the earth's field. Like the variations in permeability, the strength of permanent magnetic field displayed will also be variable for different ferrous material. The above-described influences plus other general factors contribute to the overall size of the magnetic anomaly and hence detection distance, these are listed below: -

a. Mass
b. Permeability
c. Permanent magnetism
d. Orientation within the earth's field
e. Scattering

Fig. 7 shows the relationship between distance and the theoretical maximum anomaly amplitude that would be measured by the magnetometer; this is shown for various sizes of ferrous objects. These maximum anomalies are estimated values and are only valid to within an order of magnitude, however they do give some idea of what to expect for different objects. Whereas a steel wreck can cause measurable magnetic anomalies extending to several hundred metres around the wreck site, smaller objects such as cannons, anchors and pipelines etc., cause somewhat more localised measurable anomalies.

The static earth's magnetic field is substantially unaffected by sand, sediment and other mobile seabed materials, therefore the detection distances indicated above also apply equally to wrecks buried below the seabed. The MC5 will equally detect objects that are buried or proud of the seabed, it's only the distance away from the sense coil that matters.

Fig 7


WRECKFINDER MC5
SENSITIVITY
10,000 nT
1,000 nT
100 nT
10 nT
FIELD STRENGTH (nanotesla)
Alarm setting
50nT
20nT
10nT
1lb
100lb
1TON
10TON
100TON
1,000TON
10,000TON
10metres
100metres
1 kilometres
DISTANCE

4.3 SENSITIVITY GRAPH

Having established the resolution and detection criteria for the magnetometer, the potential detection distance can be assessed for any given size of ferrous object, within a reasonable predictability. This is compiled as a graph of field strength deviation against distance. This graph is very important to the magnetometer operator, and can provide the information base necessary, for the planning required to guarantee a successful search operation.

If we analyse the graph whilst taking account of the above criterion, we can establish the following useful factors:

1. The maximum detection distance for any given ferrous mass, by determining the intersection of the horizontal distance line to the 5nT point of the tonnage line.
2. The relationship between increased tonnage and distance is roughly based on a 2 times increase in detection distance for a 10 times increase in ferrous tonnage.
3. The change in deviation (nT) as distance from a given object changes, this is seen as a factor of 8 change in nT, for a change of 2 times in distance.

The implications of the above have a significant impact on pre-survey planning, and in particular lane width to be adopted for searching, and accordingly the degree of control required for the survey boat. The importance of probe height during survey for relatively small targets can also be determined from the graph, particularly where it is used in conjunction with depth of water information. Further information on these aspects is covered in the section of this manual concerned with Survey Techniques and Magnetometer Applications.

4.4 MAGNETOMETER SENSITIVITY

The MC5 sensitivity in terms of detection distance is based on its capability to resolve changes down to a resolution of 1 nanoTesla (nT). A magnetometer resolution of 1 nanoTesla is considered to be the optimum for mobile marine search and survey applications. This 1nT value in terms of the total field measurement made: gives a typical resolution in the order of 1 part in 50000 for measurements carried out in northern Europe. Resolution quoted as a fraction or a ratio will obviously relate to the total intensity for the part of the world where the magnetometer is employed An accepted level of change that is the smallest change attributable as a positive indication of an anomaly is **5nT**. Fundamentally important to maximise sensitivity, is to achieve a stable base line from which to analyse changes, if the base line changes outside detection range of any anomalies can be maintained within 2 to 3nT this relates to a well optimised magnetometer installation.

4.5 MAGNETIC CONTOUR & ANOMALY MAPS

The above analysis has been concerned with the effects and detect-ability of man made ferrous objects, there are however many anomalies due to the natural occurrence of

geological features that exhibit magnetic properties, in many parts of the world these can have a serious impact on the interpretation of results from a magnetometer. The general magnetic/geological nature of many parts of the world can be obtained by reference to magnetic anomaly maps, these maps can be obtained through an Institute of Geological Science or similar body that is generally concerned with the compilation of geological data.
The degree, to which we can tolerate a natural variable magnetic background, depends on the proximity and intensity of the geological features, in comparison to the size of the anomaly anticipated. Where the geological feature is at some depth or distance from our magnetic sensor, a localised anomaly can still be picked out quite readily from the more
gradual change due to the background anomaly.

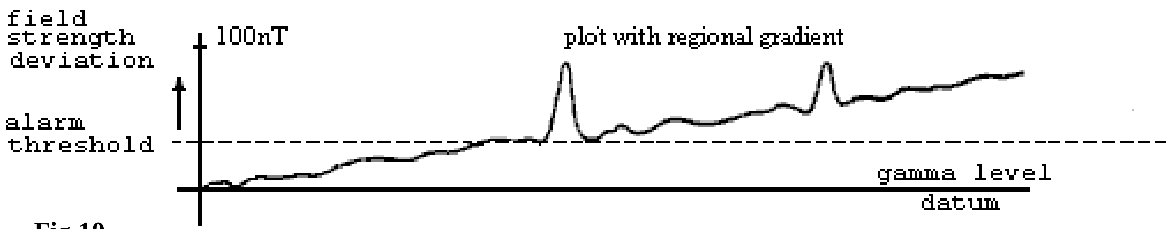


Fig 10

5.0 GETTING STARTED

The MC5 consists of two units, the sensor (probe or towfish), which is towed behind the boat with it's associated cable, and the control box, this being installed on the towing craft. An independent 12 or 24 volt (2 x 12v in series) car or motorcycle battery is required to power the magnetometer, this power source is connected to the control box via the power lead provided.

Prior to the MC5 being used to search a particular area the unit must be first be set up for maximum signal response from the towfish. The MC5 is generally provided with a suitable internal module to allow the system to be optimally tuned for the localised field strength of a given area. The earth’s magnetic field varies with geological location; therefore the magnetometer will require tuning for your area. Normally once carried out re-tuning is not necessary within a 20-30 mile operating radius of the initial tuning position. It can be useful - if the operator is unfamiliar with the setting up procedure - to try setting up the magnetometer on land before attempting to search at sea. The following section describes the setting up procedure.

5.1 TUNING PROCEDURE

The magnetometer can only be used to search for ferrous materials or compounds, and for this purpose it is extremely sensitive and has considerable range. This high sensitivity to field variations means that the magnetometer may only be used remote from known earth field disturbers, such as power lines or buildings. Before attempting to set up the magnetometer ensure that it is positioned at least 50 metres (160ft) from the nearest power line or building, additionally ensure that any vehicles are at least 10 metres (30ft) away.

Assuming the initial setting up is carried out on land the TOWFISH should be positioned at least 3 metres (10 ft) from the electronics unit and battery. The towfish should be set up horizontally at least 1.25 metres (4 ft) off the ground using some form of totally non magnetic support - NOT EVEN CONTAINING SMALL NAILS, SCREWS OR EVEN STAPLES. Elevation of the sensor is very important unless carrying out the "land tuning" on totally magnetically clean ground such as the sand of a beach. **Note.** Additionally, if the magnetometer is provided with the Solenoid type towfish rather than the Omni-directional Toroid version then position it so that it is aligned in approximately an east-west direction to maximise the response. If the initial tuning is being done at sea then it should be carried out with the TOWFISH cable fully extended - if carried out in very shallow water it is advisable to use a float such as a tubular boat fender as a support for the sensor.

Control Unit Settings: Set the POLARISE control to 3 sec, the range to X1 and the alarm to 10nT. Set the AREA TUNE control to the centre of its tune range i.e. position ‘J’. Connect the power cable to the battery (red to positive), the MC5 is now ready to be switched on. After switch-on observe that the small (signal) meter needle deflects across the scale every 3 seconds. Adjust the AREA TUNE control one step at the time to find the setting that maximises this deflection. Note this optimum setting for subsequent usage, the magnetometer is now set up for your area. If you now switch off, then on again the magnetometer will now set itself up with the benefit of maximum signal level. NOTE. If the initial set-up is carried out on land then the procedure should be repeated at sea as this may vary by one or two steps due to distortion of the natural field value by buildings or underground features. When the magnetometer is switched on there is a short delay period before an initial bleep is heard, then two measurements are made to determine the reference value of the magnetic field. Once the reference measurement has been completed it calibrates the magnetometer to the measured field strength and sets the large meter to centre scale. The field strength measured at calibration is stored in the microcomputer memory and all subsequent measurements are compared with this value to determine the magnitude of any field disturbances. After each subsequent measurement the audible alarm will provide a short reassurance bleep if a valid measurement is made. This bleep indicates that the magnetometer is working correctly. If the magnetometer fails to bleep when the alarm control is on then something is wrong i.e. low battery voltage or electrical interference etc. Once the system is taking regular measurements a ferrous object gradually brought near to the probe will cause the alarm to sound immediately the change in magnetic field strength exceeds the alarm setting.

Based on the above you should now have a working understanding of the setting up procedure. It is not necessary to repeat the setting up procedure each subsequent time you "switch on", provided you operate within 20 miles of your original setting up point and maintain your chosen AREA TUNE selection. Just switch on and the magnetometer will automatically calibrate itself. The following two sections describe how to use the POLARISE and RANGE controls to optimise the survey.

5.2 POLARISE CONTROL

A polarise time of 0.5,1,2, or 3 seconds can be selected by the front panel control. Increasing the polarise time gives a greater signal strength from the sensor, therefore a greater deflection of the signal strength meter. The greater signal level enables the magnetometer to make a more accurate measurement giving the system more inherent stability. Short polarise times allow faster updates and can be used when looking for relatively small objects. With short polarise times the boat travels a shorter distance between successive measurements, it therefore has more chances to be close to the object when a measurement is made.

5.3 RANGE CONTROL

The range control can be set to X1, X2, X10, X100 grad or grad2. The X1 range is the most sensitive; with scale deflection on the field strength meter corresponding to +50 or –50 nT. X2 decreases the sensitivity be a factor 2, X10 decreases the sensitivity further to give a full scale deflection of +500 or –500 nT, and X100 reduces it by another factor of ten. NOTE. The range control will only affect the displayed meter reading it will not affect the data output to a PC - where this additional facility is being utilised.

Select the X1 range initially as this is the most sensitive and is more generally used range whilst searching. Once a magnetic field anomaly is detected it may be necessary to select a lower sensitivity range in order to measure the peak of the anomaly. Should a change in magnetic field strength exceed the range displayed on the meter the audible alarm will bleep to indicate this is so.

When searching in areas containing exposed or underlying magnetic rock the associated magnetic variations will cause the meter to either gradually deflect across the scale as the boat moves position or in cases with very localised geological anomalies it will deflect more randomly. On the X1, X2, X10 and X100 ranges the operator can re-position the meter to centre scale by switching the magnetometer off momentarily. This will cause the microcomputer to re-calibrate the magnetometer to the boats new position. However if either of the “grad” positions is selected on the range control the microcomputer attempts to cancel the effect of the gradual change in the magnetic field strength while still responding to localised changes caused by ferrous objects. It does this by only comparing the differences between any two successive readings. On making a measurement the microcomputer compares the field strength with the previous reading and displays the difference. It also saves the current reading as the new reference for comparison with the next reading. In this way only significant changes in the field strength are registered, the gradual change caused by the magnetic rock has little effect. However when searching for a steel wreck then the enormous change in the magnetic field caused by such a wreck will leave little doubt that a wreck has been detected. In areas with magnetic rock the performance of a magnetometer is reduced, as a greater change in the magnetic field is required before a positive detection is assumed. Even though the detection range is less in these areas it is still large enough to make the use of a magnetometer a considerable advantage over just an echo sounder.

5.4 ALARM CONTROL

The alarm control can be set to either OFF, 10, 20 or 50nT. This feature enables a search to be made without the need to continually watch the Deviation meter. Each time the microcomputer makes a measurement it compares the change in field strength with the alarm setting, and sounds the alarm if it is greater. On the lower sensitivity ranges not all the alarm settings are possible. Table 1 shows the alarm value used by the computer for various settings.

TABLE 1

RANGE	ALARM SETTING
	10 20 50
X1	10 20 50
X2	20 20 50
X10	20 20 50
X100	NO ALARM
Grad1	10 20 50
Grad2	20 40 50

Even if the alarm control is set to "off" the microcomputer will make the audible alarm bleep if a measurement is made which is greater than can be displayed on the meter. This bleep is a prompt to indicate when the range control should be adjusted.

6.0 CONDUCTING A SEARCH

During search operations the probe is towed behind the boat at sufficient distance to avoid detecting any magnetic properties of the boat itself. The probe should normally be towed as speeds of 1 to 5 knots, if however it is desirable to search at faster speeds, a cord with low a stretch specification can be attached to the brass towing loop to avoid undue strain on the cable. Where possible lay out all of the available cable over the stern as any cable left lying on the deck may get damaged or may cause noise to be induced. Take great care to avoid damaging the cable sheath, as any water intrusion will result in a malfunction of the magnetometer.

RECOMMENDED LENGTHS OF CABLE

SIZE OF BOAT	MINIMUM CABLE LENGTH
Up to 7.5 metres (Wood/GRP/Aluminium)........	25 metres
Up to 16 metres (Wood/GRP/Aluminium)..........	40 metres
Up to 20 metres (Wood/GRP/Aluminium)..........	50 metres
Up to 15 metres (Steel)	60 metres
Up to 20 metres (Steel)	80 metres
Up to 30 metres (Steel)	120 metres

When commencing a survey a check can be made to determine if the probe is outside the detection range of the ferrous content of the boat. Choose an area to carry out the search where there are no known wrecks or ferrous objects. Steer the boat on a straight course with the magnetometer switched on; there should be only a little variation of the field strength reading. If 10% of the deployed cable is carefully recovered the magnetometer should indicate little or no change in the displayed deviation. If the probe is detecting the boat this will be seen as deflection on the field strength meter as the boat turns. If this is greater than 10 or 15 nT a longer cable is necessary. For small boats with outboard motors keep the tow cable away from the motor as this may induce ignition interference in the cable.

If you have not used a magnetometer before try detecting some known wrecks of different sizes to get a feeling for the type of response produced. A simple rule of thumb for estimating the detection range is to assume that a response will be noted at a distance of between two to five times the longest dimension of the object.

Examples:

Two to three ton/ 4 metre anchor …… typically 8 to 20 metres detection distance.
One Hundred ton/30m steel wreck…… typically 60 to 150 metres detection distance.
Five thousand ton/100m+ steel wreck… typically 200 to 500 metres detection distance.

With further regard to detection distance - you will find the distance at which you detect a wreck of a given size will vary according to how it lies on the seabed and which direction you approach it. Sensing distance is not uniform in all directions. Finally, when towing the magnetometer sensor towards a target don't forget your towfish is always further away than the boat by the trailing distance, this will foreshorten the apparent sensing distance. If you consider a wreck as a permanent magnet (with North & South poles) laying in the earth's magnetic field, then depending on which section of the wreck you approach will determine whether you observe a +ve or a -ve deviation. The distortion caused to the earth's magnetic field is a complex mix of induction and the combining of two static 3 dimensional fields.

6.1 HORIZONTAL DETECTION DISTANCE

The single most important factor affecting the detectability of an object is the distance between the magnetometer probe and the object. With knowledge of the mass of ferrous material on the wreck site and the depth of water an approximate horizontal detection range can be determined. Using (Fig. 7) the maximum distance between the probe and the object that will just trigger the alarm can be found. For search purposes it is necessary to determine the horizontal component of this distance as this indicates how close the search vessel must pass by the wreck in order to detect it. The horizontal detection range can either be determined mathematically or for those who have forgotten their school maths (Pythagorus) by a scale drawing. This estimated horizontal detection distance is a good choice for the width of each search lane, as it allows for a certain amount of error in the initial estimate.

6.2 SELECTING THE OPTIMUM CONTROL SETTINGS

For a steel wreck a polarise time of at least 2 seconds is best as this gives a more accurate measurement and therefore a greater detection range. An alarm setting of 10nT and the range control set to the maximum sensitivity X1 will give the optimum performance for the initial search. Once the wreck is detected it will be necessary to reduce the sensitivity of the magnetometer in order to home onto the exact location of the wreck. Switching to X10 reduces the sensitivity by a factor of ten. For large wrecks or ones close to the surface the X100 range may be necessary to determine the exact point when the probe is over the wreck. This ability to reduce the sensitivity is just one of the advantages the MC5 has over magnetometers which use the audio beat principal. For wrecks in very shallow water i.e. less than 10 metres when the probe actually passes over the wreck no signal will be obtained from the magnetometer. This is not the magnetometer malfunctioning but is due to a very large magnetic gradient around the probe. This phenomena can be used to advantage with shallow water wrecks, as it is a positive indication that ferrous metal is very close to the probe.

The MC5's built in microcomputer requires less than half a second to measure the earth's magnetic field strength, so that very short polarise times can be used. A short polarise time of 0.5 second is used when searching for small objects such as iron cannon, anchors etc. This is because with small objects the magnetic anomaly is much more localised, so with a short polarise time the magnetometer probe travels a shorter distance between measurements and is therefore much more likely to be making a measurement when near the object. Selecting the X1 range and an alarm setting of 10nT ensures maximum sensitivity when searching for small objects. If the probe can be made to pass relatively close to the object then there will be a much greater chance of detection. One technique is to sink the probe by adding a weight to the cable just in front of the probe (Fig. 9). The depth the probe will run at is dependent on the size of weight, the length of cable and the speed of the boat. It is best to use long thin weights, which will offer the minimum resistance to the water and must be made of a non-magnetic material, such as lead. If the probe cannot be made to run deep enough using weights a drift search should be used. The probe is suspended directly below the boat to the required depth and the boat drifts in the current. As the same influences both the boat and probe current the probe remains directly below the boat. The probe should be suspended so that it is horizontal during the search.

In areas containing magnetic rock the choice of the X1 range may be inappropriate. Fig. 10 shows the effect of a regional magnetic gradient caused by such rock. In the UK this type of rock is mainly found in north Wales and the west of Scotland. It's effect on the magnetometer when switched to X1 range is to cause the field strength meter to gradually deflect across the scale as the boat moves position. The function of the microcomputer in the grad mode is described in section 4. This assumes that the probe is towed a constant distance above the seabed and the seabed is relatively flat. If for instance there are rock formations, which rise above the surrounding seabed, or the boat slows and the probe sinks closer to the seabed then the effect of the magnetic rock will be greater and will causes deflection on the field strength meter. It is important to be aware of this type of effect as it can result in false optimism that a wreck has been located. The sensitivity on the "grad" range is the same as the X1 range and the alarm trigger values are the same. It may also be necessary in some magnetic areas to de-sensitise the alarm setting to avoid the alarm being triggered by the response from magnetic rock.

6.3 DEPLOYING THE TOWFISH

The cable is fitted with a moveable sheath which can be pushed along the cable to any required position, this sheath grips the cable tight when under tension and will allow the cable to be held when the loop end is secured. if more cable needs to be paid out then this can be achieved by gripping the tail end of the sheath and easing it towards the transom to effectively take the tension off the weave, at the same time hold the inboard section of cable to control the release of more cable. Onc the required amount of cable is deployed the weave of the sheath should be closed by stretching the weave over the cable with a smoothing action towards the tail end - efectively stretching the sheath.

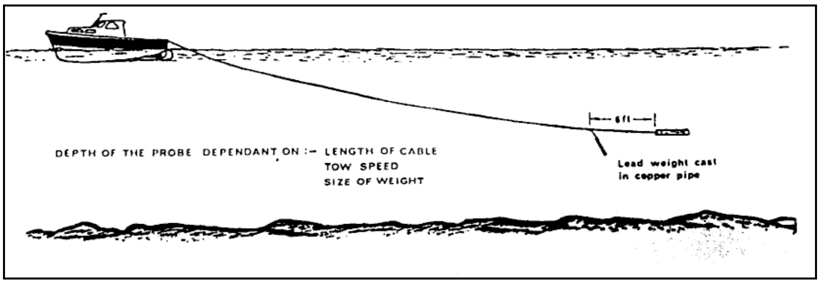
The following points should be considered when deploying the tow-fish (probe): -

1. ***The ferrous mass of the operating vessel***: The vessel itself must be considered as a mobile magnetic anomaly, and as such has a detectable field distribution pattern that surrounds it, this pattern will not be symmetrical and will vary as the vessel rotates within the earth's field. A positive means of evaluating the safe distance for the probe is to initialise the magnetometer whilst the boat is maintaining a steady course. Once a stable reading has been established the probe is gradually drawn towards the towing vessel, this should be done a couple of metres at a time, allowing the magnetometer to update each time. At some point a detection will be indicated on the magnetometer by a +ve or -ve change in the steady reading. This exercise should be repeated with the vessel operated on different bearings with the result noted for each direction. Once the minimum distance is established this should be taken as the minimal deployable length of cable and should be marked accordingly. With this distance established and the cable deployed the boat should be able to complete a long circular course, without any significant change in the steady state reading of the magnetometer.

2. ***The potential hazards of snagging the tow-fish***: The anticipated minimum depth of water, including any potential hazards that could allow the tow-fish to snag has to be taken account of. The tow-fish has a natural tendency to sink, particularly at low speeds and related to the amount of cable deployed. To eliminate the possibility of snagging, particularly in depths of water less than 10m (30ft), a tail float on a light line of a suitable length will act as a drogue, and should the boat become stationary, will support the weight of the tow-fish. The ideal float is a slim-line fender with the ease of attachment through the eyelets and it's reasonable ability to be towed through the water.

3. ***The nature and mass of the object to be detected***: The relative depth of the tow-fish in the water has to be considered in relation to the size of the object to be detected. Fig ** gives the maximum distance at which various tonnage's can be detected, this has to be related to the depth of water in which the search has to be carried out. Where the target is estimated to give a sensing distance which is large in relation to the depth of water, the depth at which the probe is deployed is relatively unimportant, however, where the detection distance is close to, or greater than the depth of water, the probe needs to be deployed as deep as possible. NB. From the earlier stated laws - relating to magnetic signatures of ferrous objects: - the general rule is: anomaly responses increase by a factor of eight for a change in proximity of a factor of two

4. ***The requirement to add ballast weight to the tow-fish***:



In cases where the object to be detected is at a depth that would not allow positive detection with the tow-fish at the surface, requires that the tow-fish be deployed at a height above bottom that would guarantee a response within the search parameters employed. The use of a lead ballast weight close to the tow-fish, is a simple but effective method of achieving increased tow-fish depth for a given speed.

NB. Care should be exercised in the way the lead weight is attached to the tow cable, the weight should never be attached directly to the cable but via an auxiliary line, which should be taped to the tow-cable at a maximum of 2 metre (6ft) intervals. The final section of cord attaching the lead weight, should be the weakest link in the chain to safeguard the system in the case of an accidental foul of the ballast weight.

6.4 SEARCH METHODS & CONSIDERATIONS

A number of search patterns and methods exist for the magnetometer survey to be carried out. The following factors influence the methods adopted: -

1. ***The size and nature of the target***: This is without doubt the most fundamental single aspect of the decision making process. By reference to the graph showing the tonnage/distance relationship, the maximum detection range can be established.

2. ***The depth of water to be searched***: The general, and maximum depth of water to be encountered, is the second factor in order of importance to establish a lane with for the search. Increasing water depth has the effect of reducing the distance to each side of the target that detection can be anticipated.

3. ***The local conditions at the time of search***: Whilst the general search pattern should establish it's lines along lines of Latitude (EW) or Longitude N/S, it is sometimes necessary to move away from the ideal to take account of strong tidal flow and wave action. The effect of tide can in some circumstances be used to advantage, for both control of direction and improved depth of tow-fish against speed over ground. The tow-fish can be more easily deployed at depth whilst travelling with the tidal flow where the speed over ground can far exceed the speed in water.

4. ***The presence of other craft***: In busy waterways the affects of other vessels both moored or mobile can have a serious impact on the continuity of the survey, where this cannot be avoided the positions of moored vessels should be noted for subsequently relating to logged results. The area masked by the vessel can then subsequently searched to complete the survey. The unexpected passing of a vessel within sensing distance of the tow-fish can also corrupt a set of results.

NB. When towing long cable lengths in busy waterways caution is necessary to avoid interfering with legitimate boat movements of other vessels and to minimise the danger of damage or at worst total loss of the cable and probe.

5. ***The possibility of other detectable material within the search area or adjoining area***. As much information as possible about the search area should be obtained relating to wrecks, debris, pipes and cables. Other more obvious structural features such as jetties, piers and breakwaters etc also have to be taken account of, both in the survey activity and during the post- processing of the data obtained. Even where the survey has to operate within the detectable distance of such structures it can still be possible to observe secondary localised magnetic anomalies by the difference in rate of change of magnetic field.

6. ***The nature of the local geology, which could influence the magnetometer readings***: Aeromagnetic anomaly maps can be of great assistance in establishing the general level of change that can be expected as the search progresses. Taking account of the direction of magnetic contours can also be influential in deciding the general direction of the search lanes. Following the general direction of the contour lines can

give a very flat base line and hence maximum ability to note changes due to man made anomalies.

7. ***The size and type of vessel deployed for the search***: The larger the survey vessel the less the manoeuvrability, which is fine for the survey of a large area, where each lane is of substantial length, but is not necessarily an asset for the search exercise in small confined areas. Another disadvantage of large vessels is the fact that a long cable length has to be deployed giving an appreciable difference between boat position and actual tow-fish position.

8. ***The total size of area required to be surveyed***. Assuming that sufficient is known about the target in terms of tonnage and dimensions, a plan of action can be determined to cover the search area in such a way that:

a. The survey is fully data-logged to allow an accurate assessment both during and subsequent to the search.

b. The survey is carried out to a standard guaranteeing that, should the target not be located within the prescribed area, then the ground covered can confidently be eliminated from any future search activity.

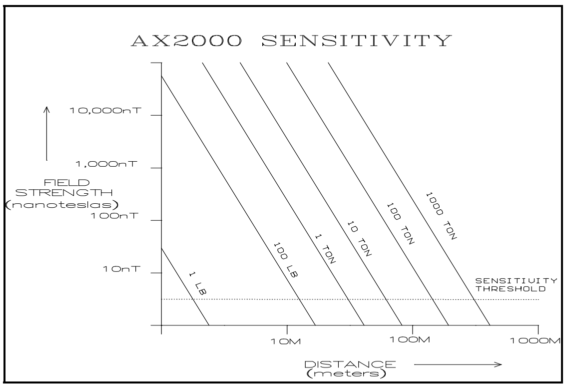
6.5 SURVEY CALCULATIONS

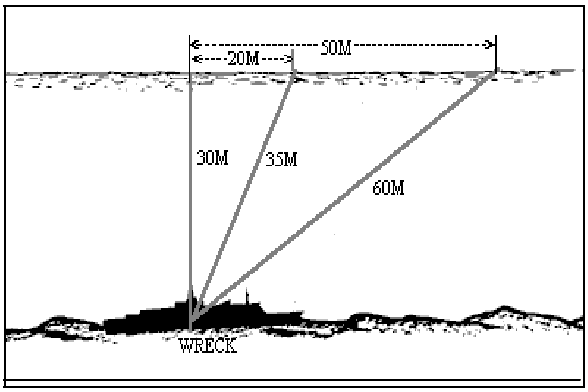
By reference to the sensing distance graph it is possible to determine: -

1. The maximum distance at which a given target can be detected from the surface.

2. The degree of magnetic change that can be anticipated, when size, tonnage and nature are known.

3. The approximate lane width to be adopted.





By taking the maximum sensing distance for a given target and producing a simple scale diagram - the optimum search lane width can be derived. The procedure is as follows: -

1. Adopt a suitable scale say 2mm is equal to 1metre.

2. Draw a horizontal line representing the surface.

3. Draw a vertical line downward from the horizontal line and perpendicular to it that is scaled to represent the mean depth of the target.

4. From the base of the vertical line (depth) draw a line to scale - relating to the maximum sensing distance - to intersect with the surface horizontal line such that it creates the hypotenuse of a right angle triangle.

5. The distance established between the point of intersection at the surface and the top of the vertical depth line represents the maximum horizontal sensing distance to the target.

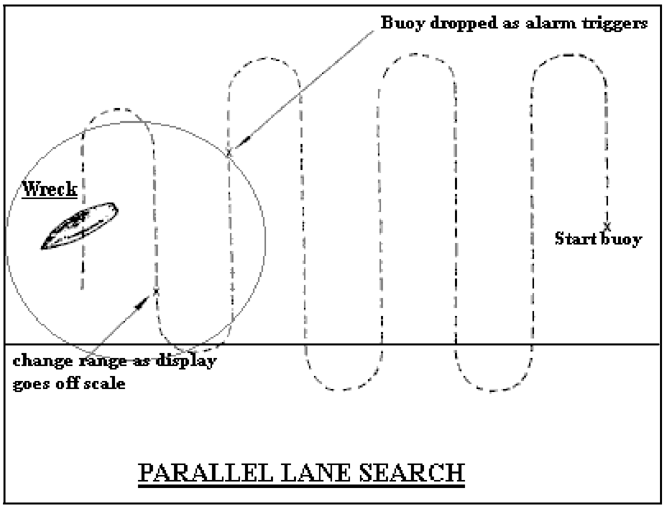
The above calculations have assumed that the tow-fish is deployed either at or near the surface, however, It will be readily observed that as the depth increases for a given target size the corresponding horizontal component of the sensing distance reduces accordingly. In situations where the depth of water exceeds the maximum sensing distance and it becomes necessary to plan deployment of the tow-fish to some depth, it is to this level that the horizontal line corresponds and which in essence becomes our artificial surface for the basis of calculations.

7.0 SEARCH PATTERNS

7.1 PARALLEL LANE SEARCHING

The most common and practical survey method is by means of the parallel lane search in N/S - E/W runs, where a predetermined lane length and calculated spacing is implemented. Lane integrity is maintained by relating the required spacing to decimal parts of units of Lat. & Lon. As a for instance, if a 200 Metre spacing is required and the survey is along an East/West line, the choice of 0.1 of a minute of latitude gives slightly less than the 200 Metres required. Increasing or decreasing the distance is just a question of proportionately changing the decimal part of a minute related to 1/000 minute = 2 metres. For control of Longitude spacing during N/S runs the same principal applies but the actual metres to minutes of Lon have to be derived from a table or chart for the particular Latitude of operations. E.g. at a Latitude of 50 degrees an increment of 0.1 minutes of Longitude gives about 120 metres.

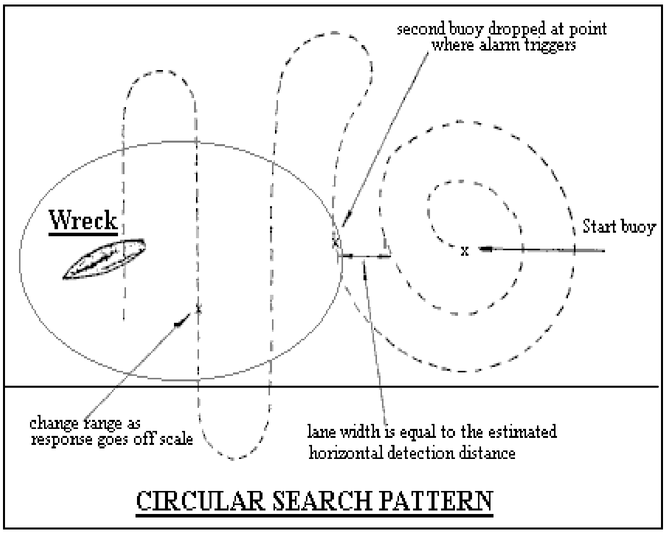
The parallel lane search is particularly appropriate where a large area has to be searched on a speculative basis, or where the position of a wreck is very approximate **(PA),** it is also a more precise way of covering a pre-planned area of seabed as a square or rectangular shape.



Where the position for location of a wreck or object is known with a high degree of certainty the simple circular search method can be the more appropriate method. The anticipated position is marked with a large bright coloured marker buoy, this datum is then used to commence an expanding spiral search as shown in the diagram, at some point in the search a response will occur which will indicate the general direction of the target. Once the general direction is established the search becomes a number of short parallel runs across the anticipated area until the maximum peak reading is obtained, in the case of a structure standing proud of the seabed the final confirmation is obtained on a graphical echo sounder.

7.2 CIRCULAR SEARCHES

The circular search pattern is particularly suited when a graphical plotting navigator can be used in conjunction with the AX2000 magnetometer.



In both the above search methods the procedure once the initial alarm threshold has been exceeded is the same. If the boat position is observed whilst monitoring the display for the peak in the initial response, a line of position running through the anomaly and at right angles to the course of the survey boat can generally be established. Having established a line of Lat. or Lon that runs through the anomaly it is just a question of establishing the peak reading when running at right angles to the initial course. Once a peak reading has been established in the other direction and the Lat./Lon. numbers for the anomaly have reasonably accurately been established, some account needs to be taken for the layback of the tow-fish. For instance with 60m (200ft) of cable deployed and the boat on a N/S course, the navigator readings need to be corrected by a factor of 0.030 minutes (decimal). Whilst on an E/W course the correction factor will be related to the actual latitude, this however at a Latitude of 50 degrees, would relate to a correction factor of 0.050 minutes decimal.

NB. There is no substitute for practising the art of magnetometer survey on a known target or range of targets before venturing on to the more serious activity of locating a totally new wreck. The response although predicable from a familiar wreck does give a feeling of elation at mastering the black art of magnetometers

CAUTION in all surveys with the magnetometer it is important to ensure that the initialisation of the magnetometer is away from the centre of operation such that the magnetometer gets a true initial sample of the earth's magnetic field.

7.3 DRIFT SEARCHING

A particularly effective method of maintaining close proximity to the seabed is by drift searching, this entails suspending the tow-fish directly beneath the boat at a suitable height above the sea/river bed to avoid snagging.
The essential factor with this method is to ensure that the tow-fish is below the detection range of the search boat, smaller boats are obviously more suited where this is carried out in fairly shallow water. This method can also be used as a follow up to a search that has located an anomaly in a low visibility area by conventional towed searching, but needs to be pinpointed very accurately for follow-up diving activities. The particular advantage being the ability to drop a shot line in very close proximity to the tow-fish in response to magnetic indications.

The recommended procedure is as follows: -

1. With the tow-fish and cable deployed such that the sensor is suspended horizontal and clear of the seabed or any anticipated hazards.

2. A marker buoy is placed at the start of the first run as a reference point.

3. The run is terminated after a set distance either by use of a positional navigator transits or by timing the run in conjunction with current speed.

4. A marker is dropped to indicate the termination of the first run; this enables subsequent runs to be terminated after the same distance.

5. The tow-fish is temporarily retrieved whilst the boat is returned to the start line.

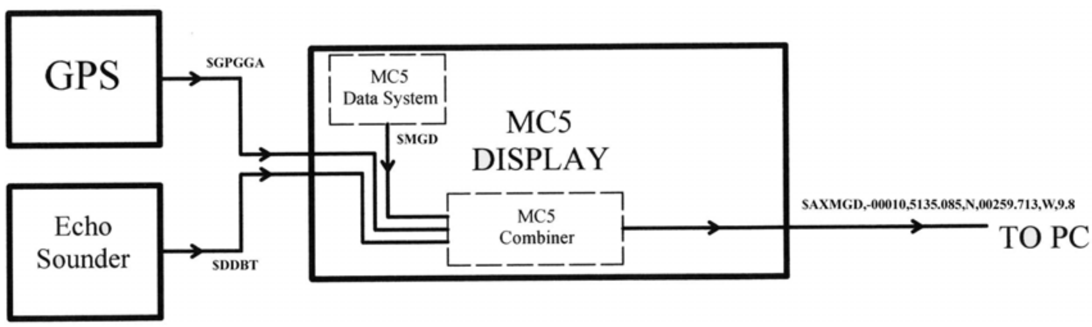
6. The second and subsequent runs are started at a set spacing from the first marker (based on the calculated lane spacing required).

7 The accuracy of the lanes can be confirmed by noting that the spacing at the terminating marker coincides with that at the start.

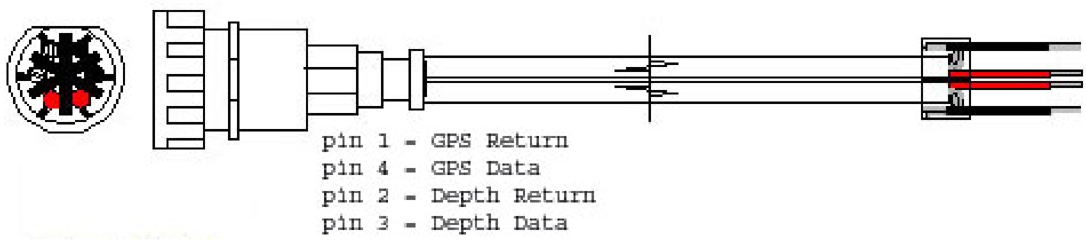
8.0 NMEA INTERFACE

The MC5PES & MC5PET control units are fitted with an NMEA combiner to allow positional data ($GPGGA) & depth of seabed (SDDBT) to be merged with the magnetometer measurement ($MGD). NB. If a combined GPS/Sounder is used then the NMEA output should be supplied to both the GPS & Sounder leads in parallel.

NOTE. It is important to have the GPS connected and full operational at the time of starting up the MC5 to ensure the internal combiner can verify the presence of a GPS signal, it will otherwise revert to a magnetometer data only" this will only be recognised by the AQLOGEDIT software if the "OTHER" option is selected for the data source.



NMEA - Interface connections

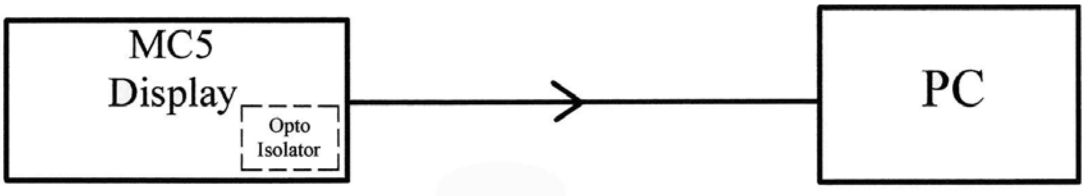


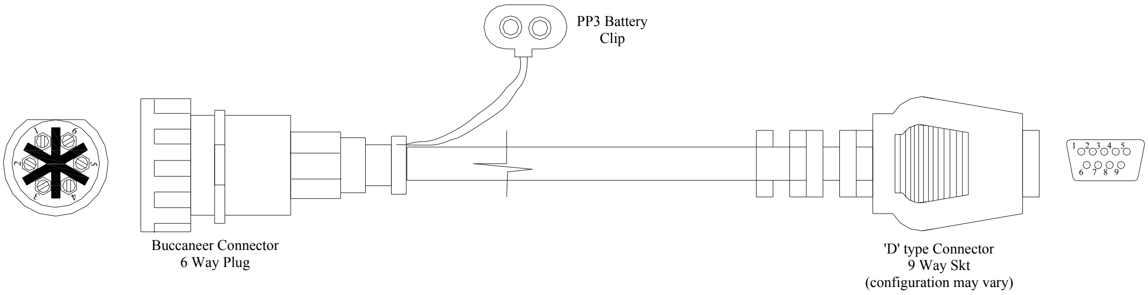
PC INTERFACE

The MC5PES & MC5PET control units are fitted with an Opto Isolator which protects the MC5 from unwanted noise or spikes from the PC. The Opto Isolator is powered via the PC lead using the +ve voltage present on pins 4 or 7 of the 9 way connection. On some occasions the computer is unable to provide the required power, such as when using a USB to Serial adaptor. In this situation an external supply voltage can be supplied by a PP3 Battery using the Battery Clip fitted on the PC interface lead – this should only be connected during the period of recording data as the battery will continue to supply power even with the MC5 switched off.

The data output of the MC5PES/PET is designed to simulate the AX2000 data string such that the AQLOGEDIT software can be utilised. When using this software with the MC5 the **AX2000** option should be selected for the **Log** function. Do not select the

MC5 option as this was for an earlier version of MC5 data. For further information refer to the software users guide supplied with the AQLOGEDIT CD.

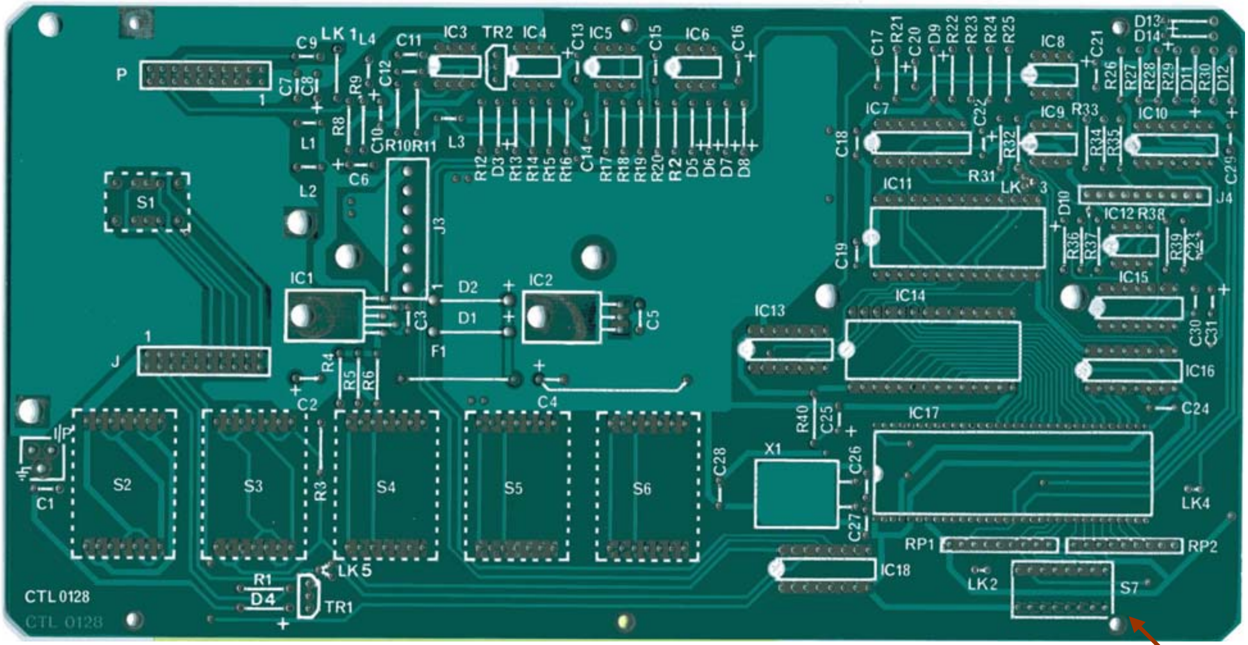


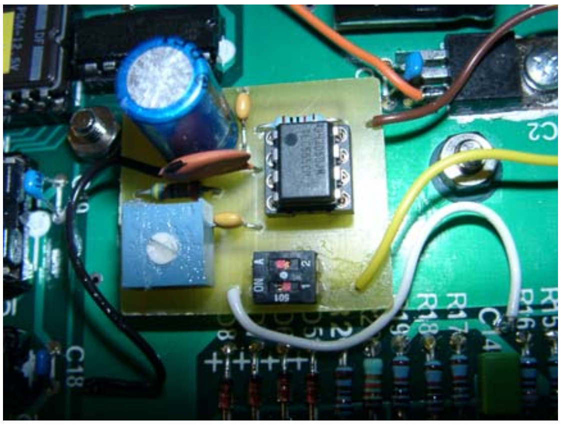


PIN	DATA LEAD	T-SHAPED PP3 CLIP
1	YELLOW	BLACK
2	RED	N/C
3	BROWN	N/C
4	N/C	RED
5	ORANGE	N/C
6	BLUE	N/C

PIN	DATA LEAD	
1	N/C	N/C
2	BROWN	DATA TX
3	RED	DATA RX
4	ORANGE	11V
5	YELLOW	GND
6	N/C	N/C
7	BLUE	11V
8	N/C	N/C
9	N/C	N/C

9.0 CHANGING THE OPERATING ZONE





A special board is fitted to Produce the correct operating conditions for magnetic field strengths below 27,000nT. When other magnetic zones are required the switch on the special board has to be changed so that both positions 1 & 2 are on. For <27,000nT the switch should be as shown i.e. 1 = off and 2=on.

Mag Zone (nT x 1000)	S7 Switch Setting 12345678
23.5-27	****↓↑↓↑
27-30	****↑↓↓↑
29-32	****↓↓↓↑
31-34	****↑↑↑↓
33-37	****↓↑↑↓
36-41	****↑↓↑↓
40-45	****↓↓↑↓
44-51	****↑↑↓↓
50-57	****↑↓↓↓
57-66	****↓↓↓↓

The above settings should be applied to positions 5,6,7&8 of S7 (the MC5 Zone selection pre-set switch), NB. Leave the factory settings on positions 1 to 4. For operating in the areas of the world with the listed magnetic intensity - see relevant appendices.

The appropriate IPA-3 tuning module for the nominal magnetic intensity in the operating area should also be fitted. The pre-set gain adjustment control on the IPA-3 can be adjusted to increase or decrease the signal meter strength if necessary, ideal signal meter reading is 85 deflection when optimum Area Tune selection is made. The location of the IPA-3 tuning module is in the upper left comer of the above image and beneath a metal shielding cover. Removal of the three securing screws allows access for removal and replacement of the IPA-3 tuning module.

N.B. Take care not to bend the pins on the "mother board" when removing the IPA-3 module, a combination of prising from the underside whilst applying an upward pull should be used. A moderate rocking motion may help to remove the existing module. Take care to get the correct alignment of the module to the headers on the motherboard to avoid misconnection.

APPENDIX I – WORLD IPA-3 MODULE ZONES

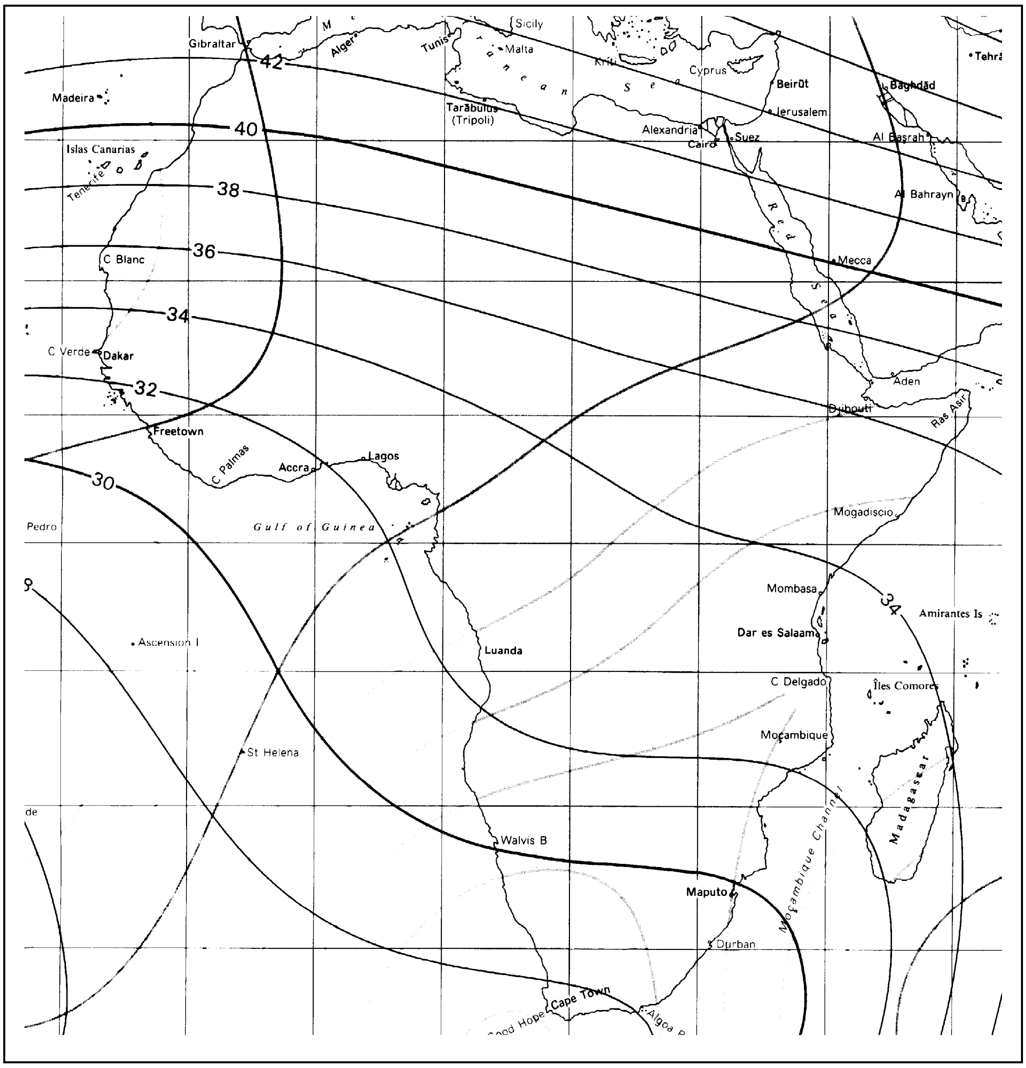
There are six standard versions of IPA-3 Module which enable optimum operation of your MC5 in all magnetic intensities of the world. Below is a list of options available that indicate the operating range.

MODULE	STEPS	FROM	TO
T-A	5nf	52,000nT	64 ,000nT
T-B	6n8f	43,000nT	52,200 nT
T-C	6n8f	37,800 nT	43,500 nT
T-D	10nf	32,700 nT	38,700 nT
T-E	15nf	27,500 nT	33,000 nT
T-F	15nf	23,500 nT	27,000 nT

N.B. For more specific requirements please contact your nearest service agent or the support department at Aquascan International Ltd

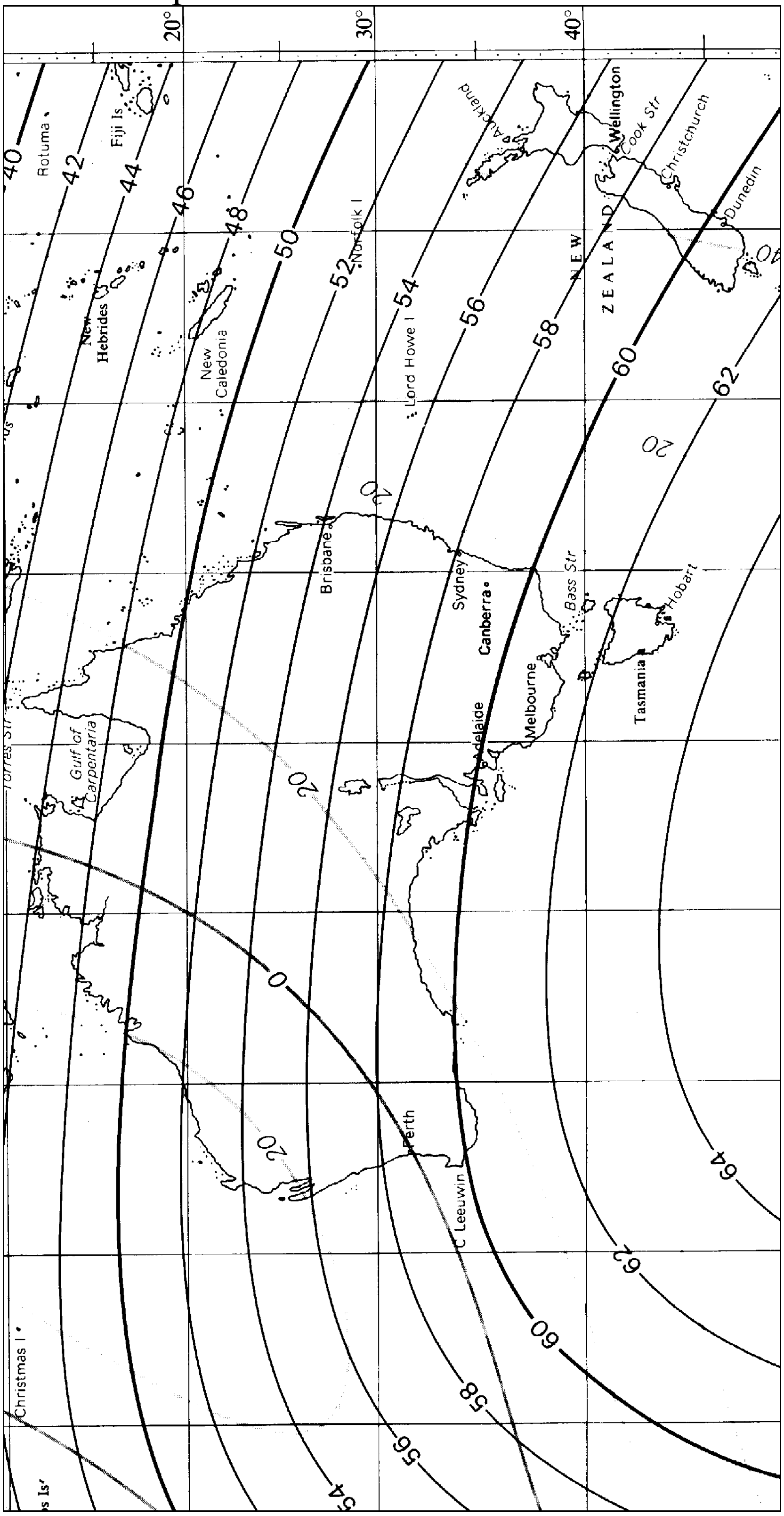
APPENDIX 11A –

Magnetic Contour Map - Africa



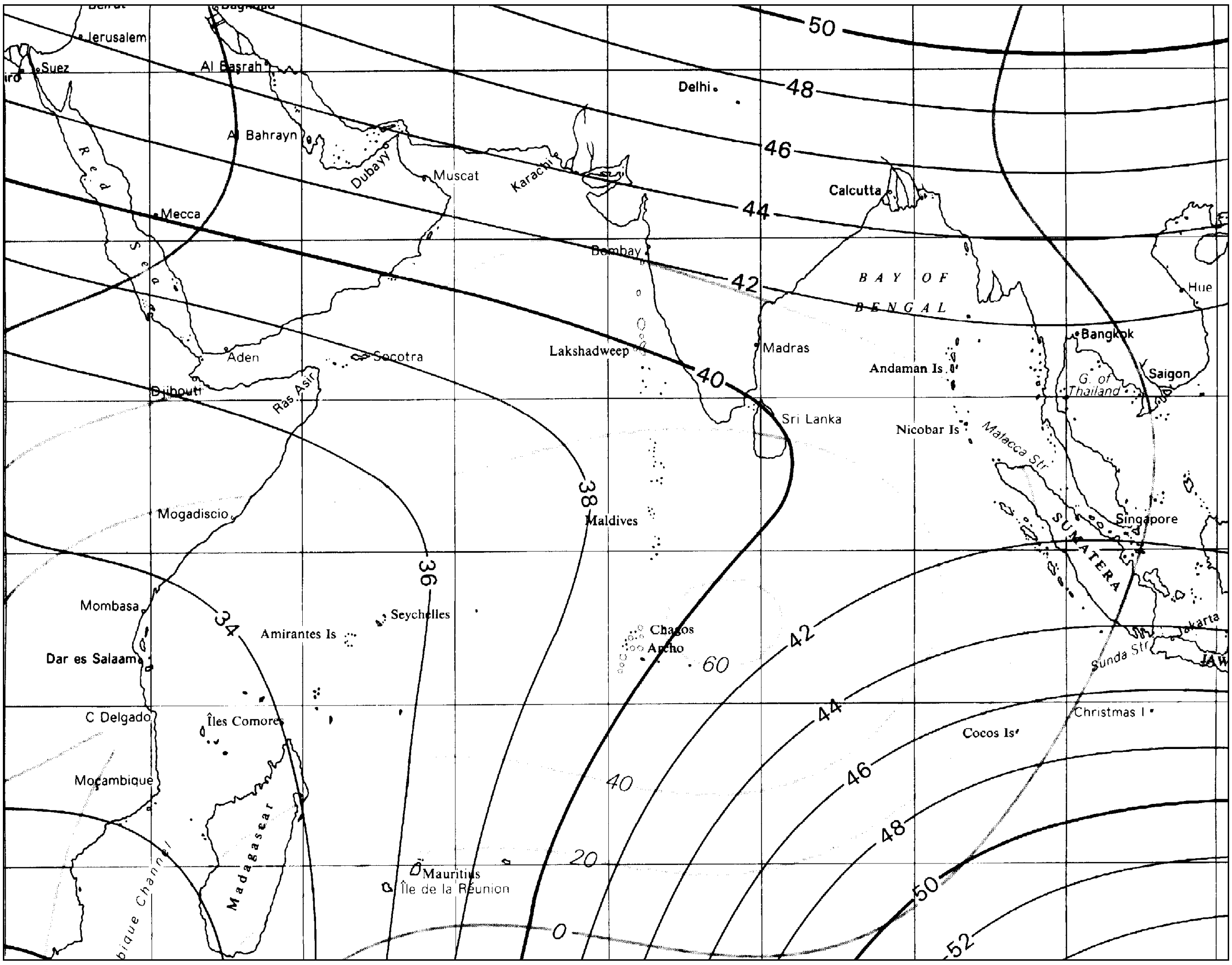
APPENDIX 11B –

Magnetic Contour Map - Australia & New Zealand



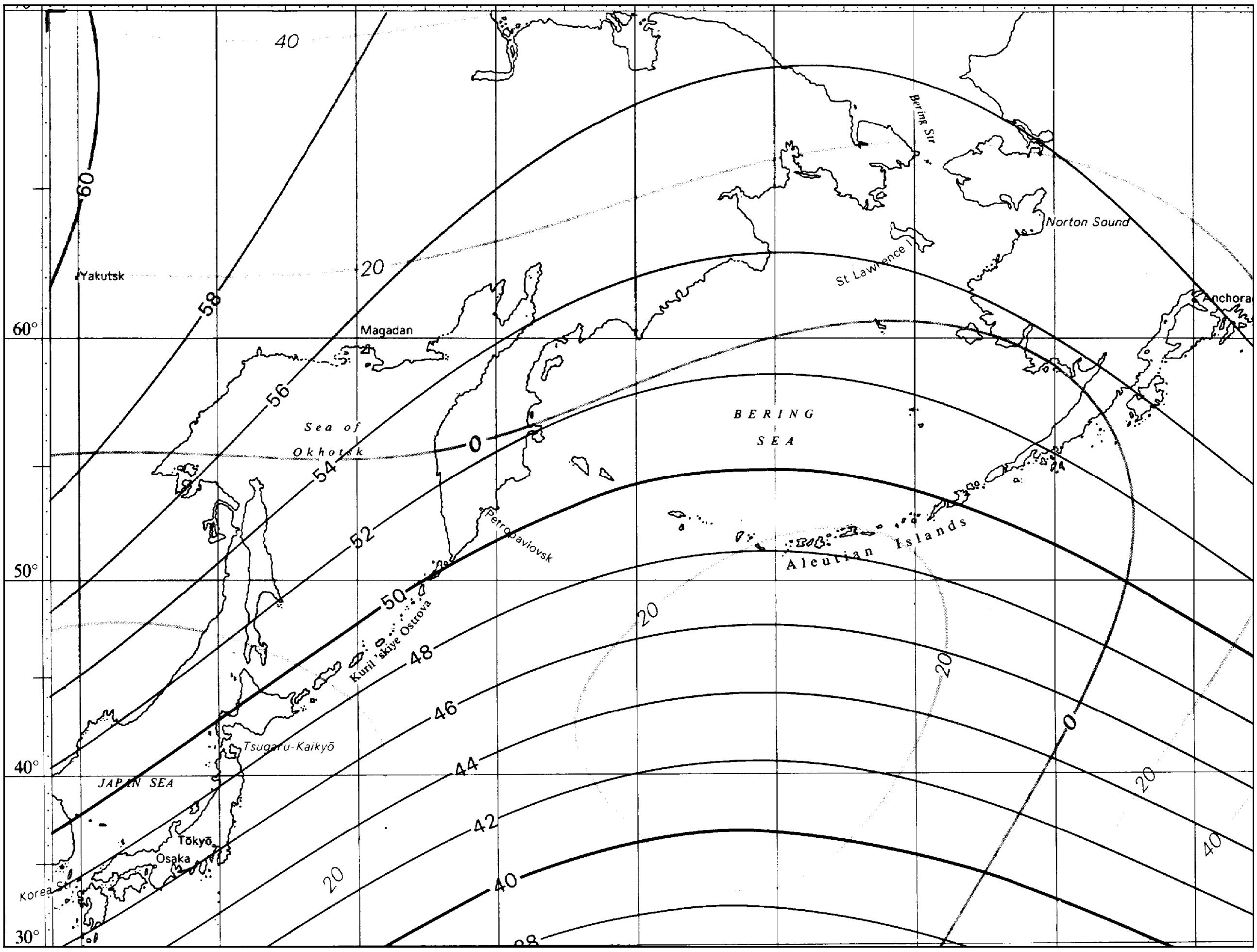
APPENDIX 11C –

Magnetic Contour Map Red Sea/Gulf & Indean Ocean



APPENDIX 11D –

Magnetic Contour Map – Japan & Bering Sea

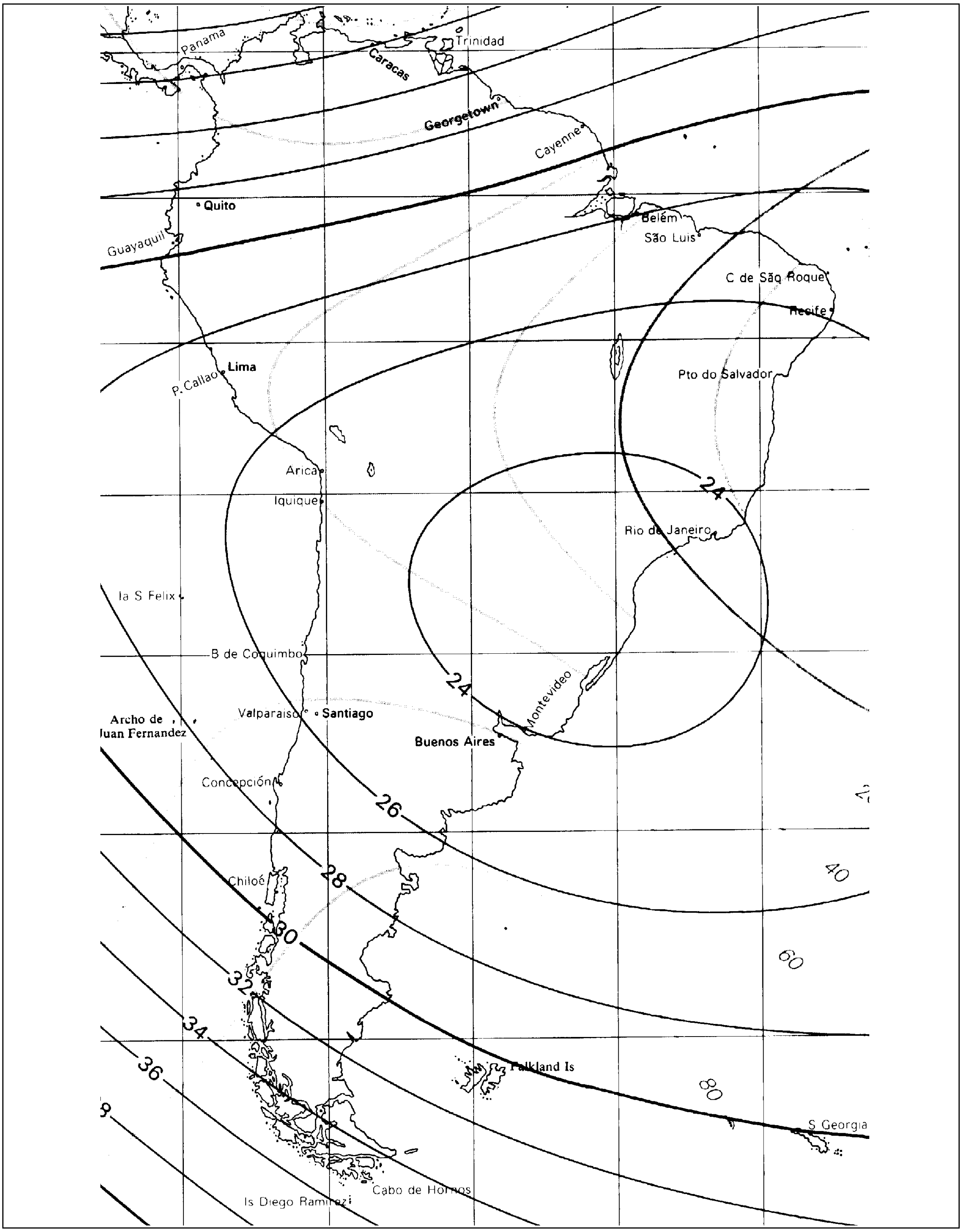


APPENDIX 11E –

Magnetic Contour Map – Pacific Ocean

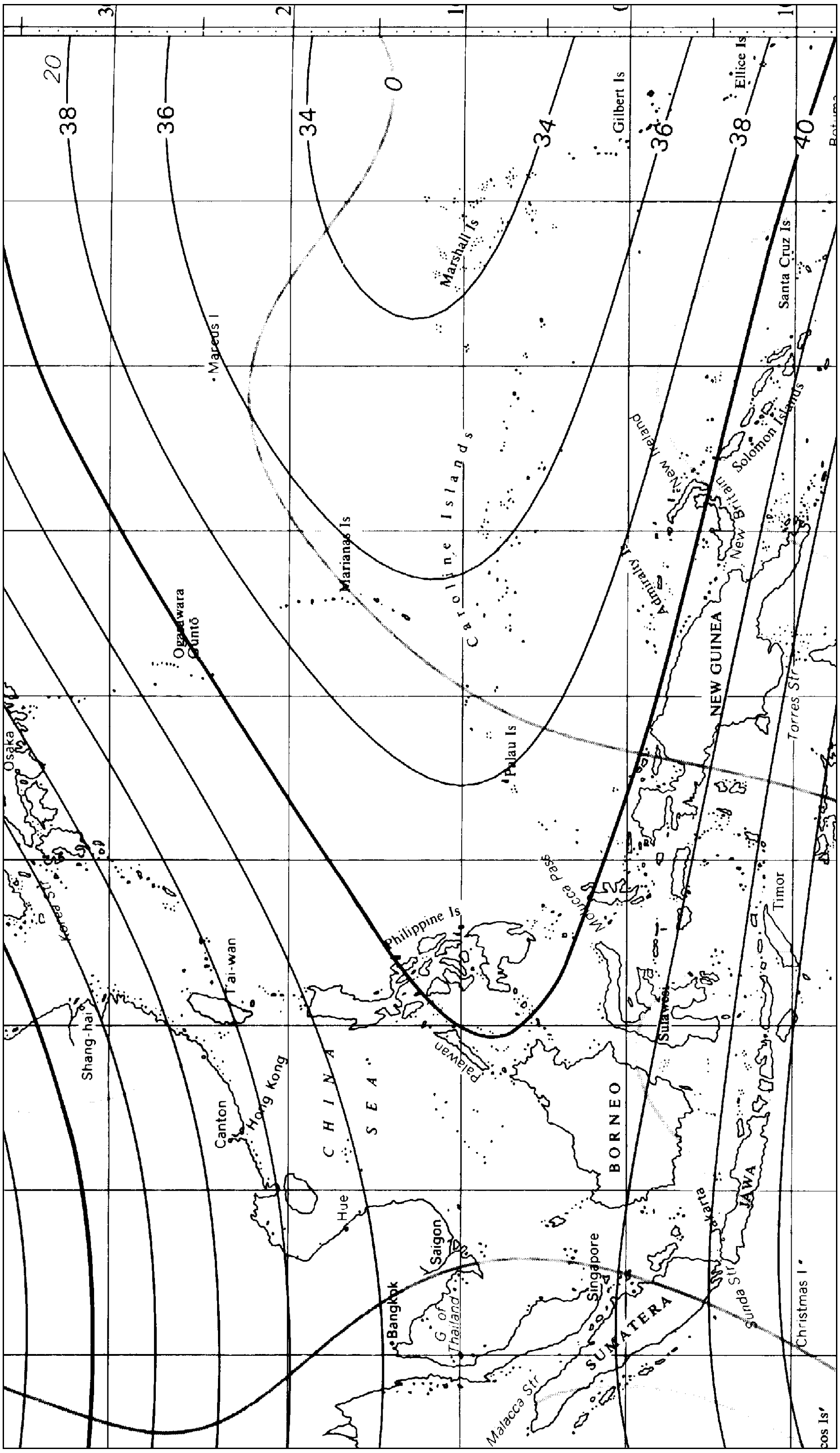
APPENDIX 11F –

Magnetic Contour Map – South America



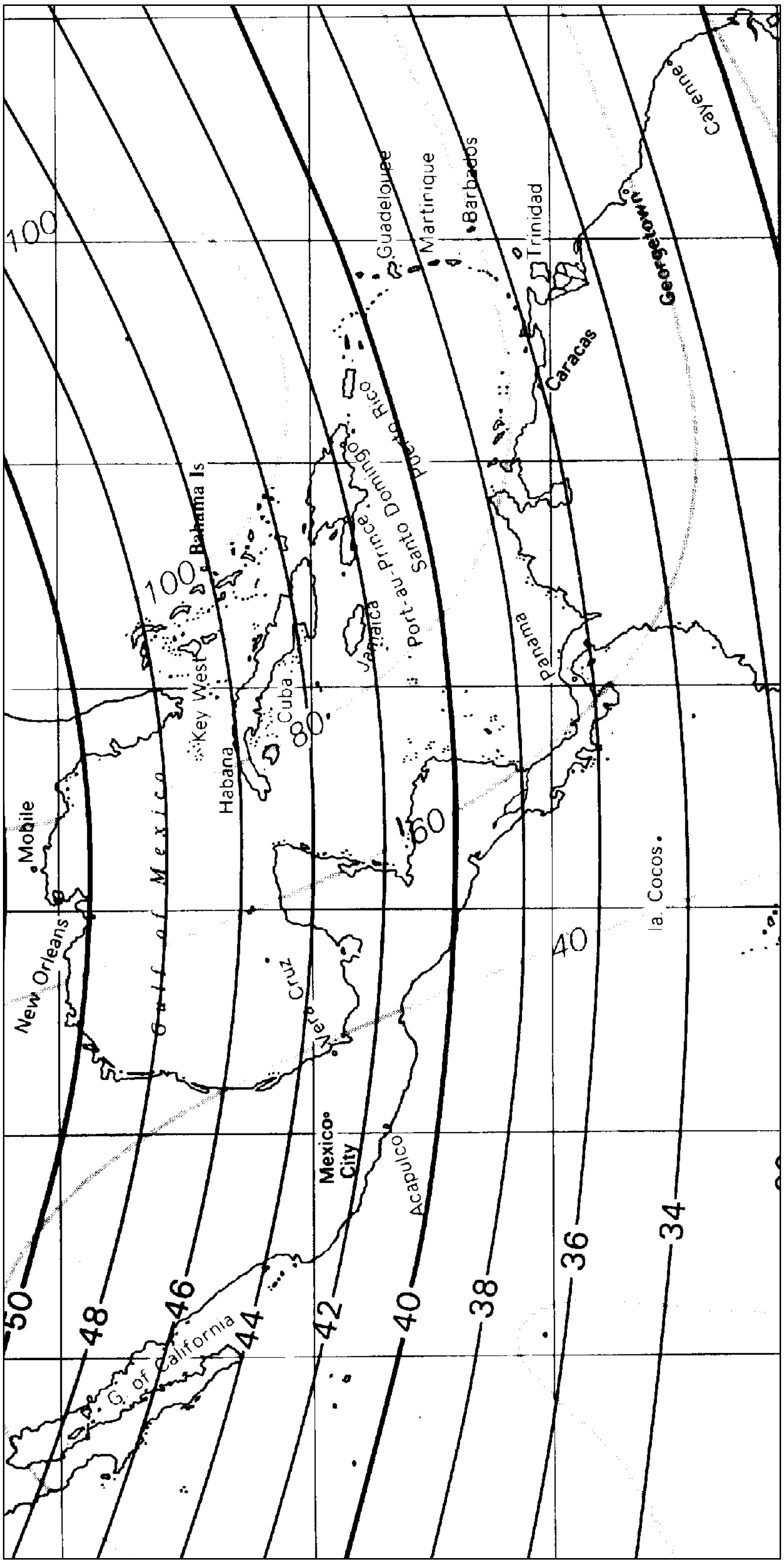
APPENDIX 11G –

Magnetic Contour Map – South China Seas



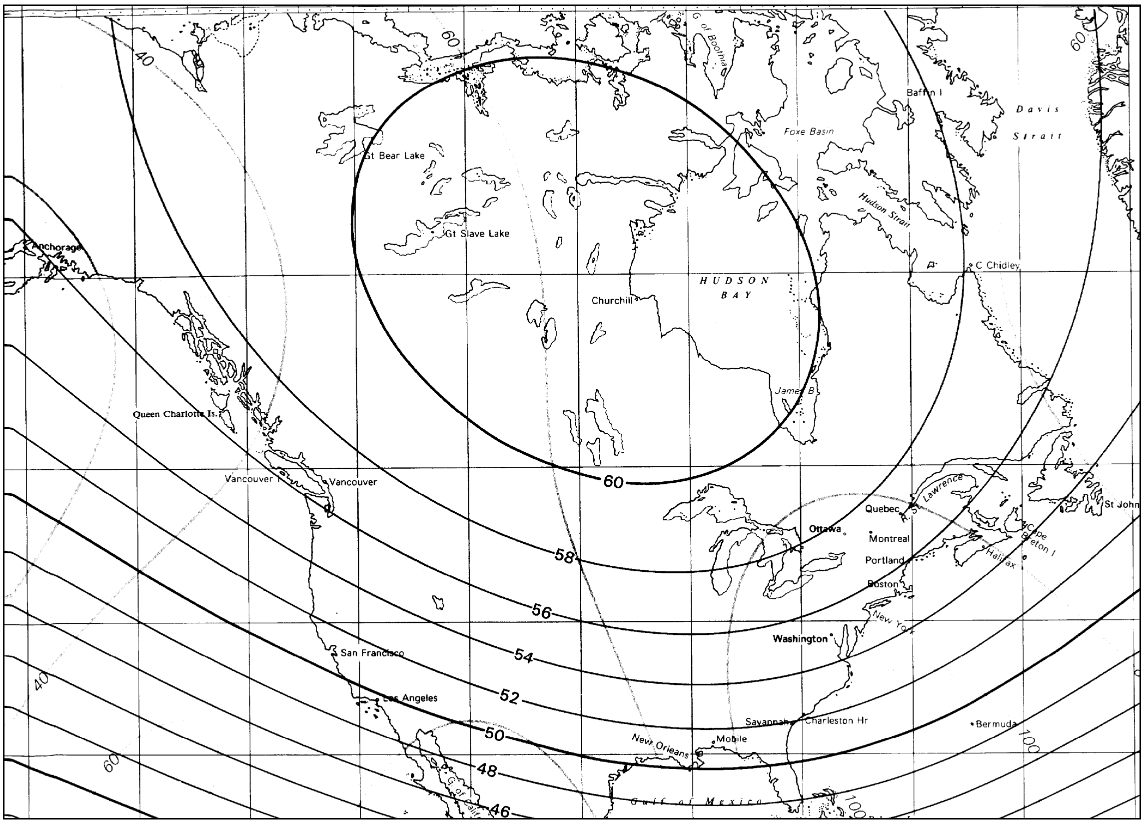
APPENDIX 11H –

Magnetic Contour Map – Southern USA & Carib.



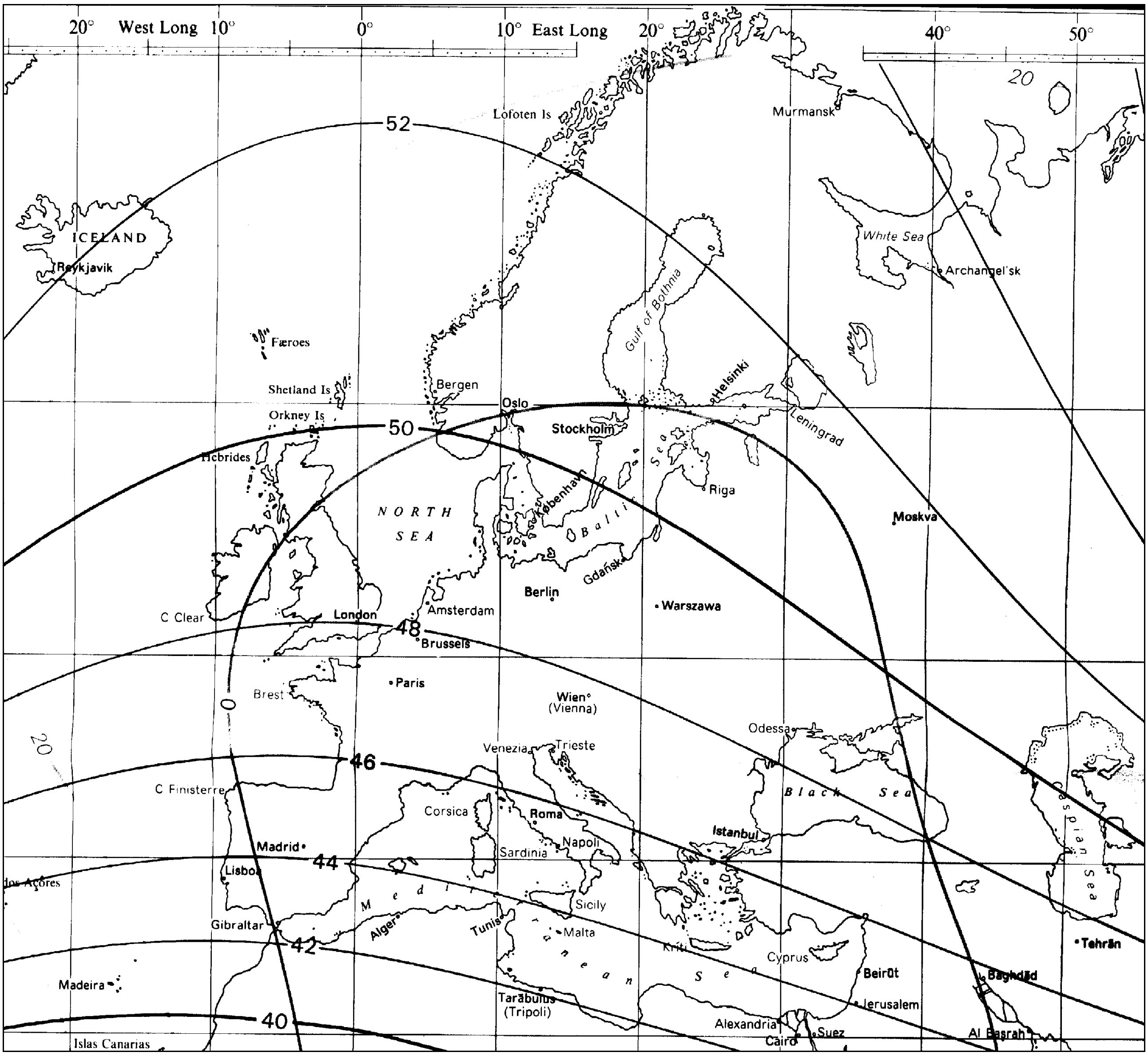
APPENDIX 11J –

Magnetic Contour Map – USA & Canada

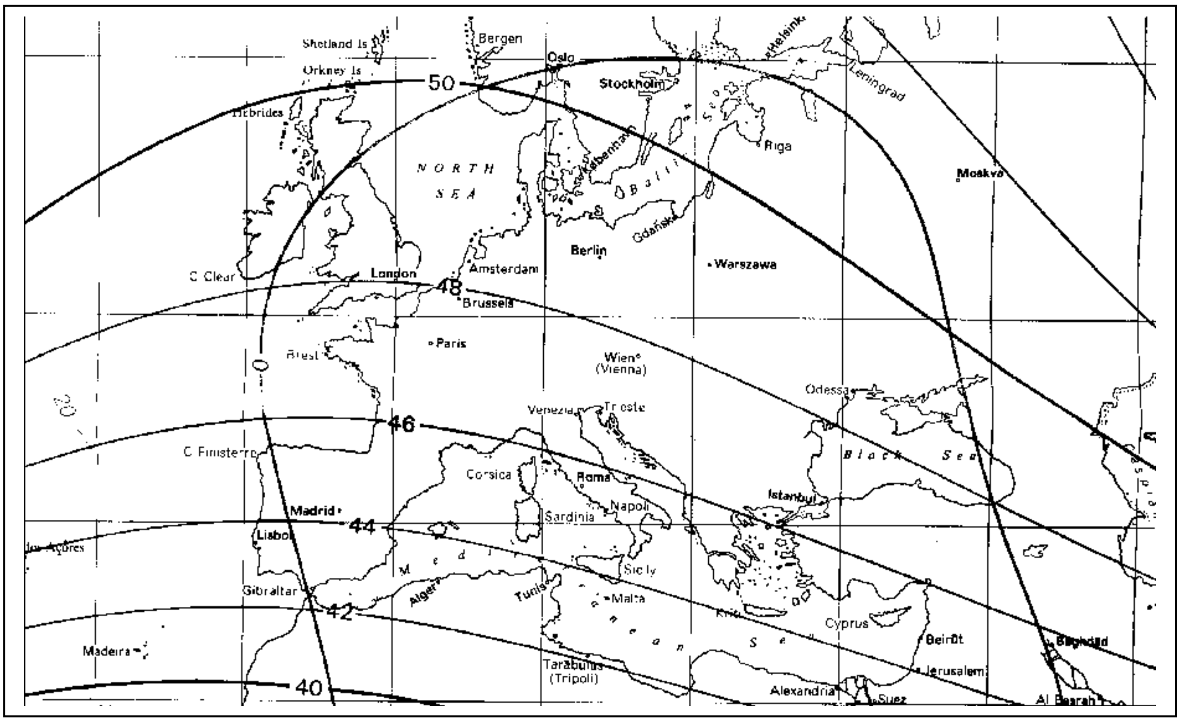


APPENDIX 11K –

Magnetic Contour Map – W_Europe & Med



APPENDIX 11A - MC5 TUNING - EUROPE



Contour lines above relate to values of total magnetic field x 1000 (eg 44 = 44000)

The world has a wide variation in it's ambient magnetic field strength (total intensity), for our purposes this strength is expressed in gammas (g) or nano-Teslas (nT) .

The above mapped area shows the typical coverage of a single tuning module (IPA-3) fitted to the MC5ES & MC5ET units and relates to a magnetic field strength of between 42,000 to 50,000 nT. Area coverage is associated with both the **AREA TUNE** switch and Zone settings pre-set by internal dil switch S7. The AREA TUNE switch has 16 positions designated A to R which in turn relate to the most Northerly and Southerly areas respectively. Coverage of **AREA TUNE** is always greater than coverage of a single Magnetic Zone setting, Zone coverage for the European area is as follows:-

MAGNETIC FIELD STRENGTH SETTING S7 SWITCH (MC5 PCB)
(nT x 1000) POSITIONS 5,6,7,8,
----
40 to 45 Southern France, Spain, Med & Upper Red Sea ↓↓↑↓
44 to 51 Default setting for UK etc. ↑↑↓↓

NOTE. A picture of the PCB showing the position of S7 is to be found towards the rear of the MC5 handbook – see section 9.0 "CHANGING THE OPERATING ZONE".

APPENDIX II1 – MC5 SPECIFICATION

DIMENSIONS
CABLE
Diameter - 8.0mm Arctic grade PVC
Length options from 25M-250M

INSTRUMENT CASE
Housing 280x153x65mm
Overall length between gimbals 330mm
Bracket (Stainless Steel) 305x100x25mm

SOLENOID PROBE
Plastic pressure housing with moulded nose & tailfin array:
Standard 460mm(L) x 90mm(W) x 150mm
High power 700mm(L) x 90mm(W) x 150mm

TOROID PROBE
Cast Epoxy sealed housing 300mm(L) x 180(W)

Polarisation time 0.5, 1, 2, 3 seconds

Power +12v @ 1.5amps +24v @ 2.5amps

Alarm settings OFF, 10, 20, 50 nT

Ranges LIN 0+/-5000nT. GRAD 0+/-100nT

AREA TUNE RANGE
World 25000 to 65000 (nT)/W
European 40000 to 65000 (nT) / E
SENSITIVITY /RESOLUTION

1nT in range 25000nT to 60000nT
2nT in range > 60000nT
GRADIOMETER RANGE
Indicates the difference between successive readings
MEASUREMENT DISPLAY
1mA moving coil meter.
INPUT / OUTPUT
1 Print/PC o/p interface port 1200/4800 Baud (5v logic)**
1 NMEA 0183 i/p interface port Lat/Lon GGA/GLL/RMC
1 NMEA 0183 input interface port for $SDDBT (depth)
** fully opto-isolated RS232 output port.

Mc5spec_0602.doc

APPENDIX IV - TROUBLESHOOTING GUIDE

Symptom: Signal Level Constantly Low

Check the following:-

1. Check that the supply battery has a sufficient charge -
   - If not, place battery on charge and then re-test or replace battery.

2. Check the condition of the Phono Connector from the Towfish and on the rear of the MC5 Display.
   - If one or both of the connectors is badly corroded then they should be replaced.

N.B. This work should be carried out by an authorised Aquascan service agent or a suitably qualifed person. Please contact your nearest Service Agent or the Aquascan support department before any work is carried out.

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3. Check the resistance across the Towfish Phono Connector.
   - Connect a good quality multi-meter across the core(inner pin) and screen on the Phono plug and check the resistance. You see a reading of around 9-15ς

NB. It is good policy to firstly check the multi-meter's reading with the leads shorted together - this provides a measure of what residual reading to take into account.

Symptom: Signal Level Constantly High.

Check the following:-

1. Check to see if excessive noise is affecting the signal.
   - Attach a ferrous metal object on top of the towfish, tow as normal and check to see if the signal level drops to a very low level. If the signal level remains high then background noise may be causing the problem.

2. Check the integrity of the cable insulation.
   - Feed the entire length of the cable into the sea and measure the resistance between the the outer of the connecter contacts and a metal contact placed into the sea. If you measure less than a few Mohm the cable insulation may have been damaged. The cable should be laid out on land and checked for physical damage.

If none of the above checks help cure or identify your problem then please contact your nearest service agent or the support department at Aquascan International Ltd.

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Minimising noise and interference - AX2000 & MC5 installation

INTRODUCTION

Magnetometers can be successfully installed in almost any type of vessel with minimal intimidation from other electrical equipment, however a number of rules have to be obeyed and precautions taken.

Due to the high sensitivity of a proton magnetometer - enabling it to respond to signal levels of a few microvolts - there will always be a risk of interference from other electrical equipment and instrumentation. This document is intended to define the rules and detail the precautions to enable a successful installation & optimised performance to be achieved.

POWER SUPPLIES

The power supply for the magnetometer is the most common source of interference where this is not a totally independent supply devoted only to the magnetometer. A number of factors can combine to produce a high level of noise in the audio frequency range in which the magnetometer operates, these include: -

A. Harmonics & voltage spikes from the charging system.

B. Harmonics from power inverters - one of the worst offenders.

C. Voltage spikes from pulsed instruments such as sonar & radar.

D. Bilge pumps and other motors.

The answer is to provide the magnetometer with it's own battery supply of either 12v or 24v as appropriate. 12v is normally adequate if the magnetometer is supplied with a reasonably short towfish cable - up to 60m (200ft) - however in all cases a better signal to noise ratio is achieved with a 24v supply. 24v powering will provide a more aggressive polarisation of the protons in the towfish sensor with a corresponding higher returned signal level.

The battery system should consist of a single (12v) or series connected pair (24v) in a well-maintained condition with clean terminals for good low resistance connections. The size of the batteries is not the most important factor, however the minimum recommended size is 15A/H, this should be capable of supplying the magnetometer for an 8 hour survey period before requiring a full recharge.

MAGNETOMETER SEA EARTH

A magnetometer "Sea Earth" is a direct connection between the low side (-ve) of the isolated battery system and a metallic contact with the sea, this can be a Bronze or stainless steel strip attached to the hull below the waterline. The addition of a Sea Earth can sometimes be the final step to minimise any residual induced noise in the magnetometer system, however the improvement should be verified by checking the signal to noise ratio of the system, both with and without the Sea Earth attached. See the later section on checking signal to noise ratio.

NOISE VIA INTERFACES

Another point of entry for noise to get into the magnetometer system is via the PC & NMEA interface connections. The NMEA input has an internal opto-isolator providing full ground isolation; this eliminates ground noise except in very rare cases. The PC/laptop connection is a likely route for noise to get into the magnetometer, particularly when the PC is powered via a DC to AC inverter. Prior to 2003 models an external opto-isolator is provided with some models and is an optional extra with others, models supplied 2003 onwards have the opto-isolator fitted internally.

Noise elimination - Test methods

The following is a method of confirming the amount of noise being produced in the magnetometer:

MC5 - With a piece of steel such as a spanner taped centrally on the body of the towfish the signal is suppressed. Trail the tow-fish at a suitable distance behind the boat in an open sea area and observe the reading on the signal (small) meter. The observed readings should only be about 5 to 10% deflection. Rotate the Area Tune switch and see that a low meter deflection is observed over the whole range. If the displayed readings are higher than 10% then try re-routing the towfish cable to minimise any induction from ignition, generator or echo sounder transducer cables. In addition try the "Sea Earth" to see if an improvement (lower reading) is obtained - if so make this a permanent part of the installation. Having achieved the desired low noise result then the metallic object can be removed from the towfish; the standard tuning procedure can now be carried out to determine the optimum setting for the Area Tune Switch. Tuning should be carried out in an E/W or W/E direction where possible and give a deflection of between 60 to 95%. Once established this “area tune” selection will be appropriate within a 50-mile radius.

AX2000 – The above procedure is also valid for the AX2000 the only difference is that the tuning procedure is controlled by the menu and the results monitored on the graphical display.

General recommendations for optimum performance:-

1. Use a fully isolated dedicated 24V battery system.

2. Use a sea earth between the -ve (ground) of the magnetometer battery and the seawater - this is a stranded wire link attached to a stainless steel or bronze plate into the sea.

3. Avoid any mobile phones or VHF antenna close to the AX2000 receiver - this can cause spurious responses during each start of transmission.

5. Avoid traveling towards the equator (Due south in the Northern hemisphere) as this gives the worst signal level and increases vulnerability to noise.

6. Any unused towfish cable should be stowed in a figure 8 on deck to avoid noise induction.

7. Any inboard cable should be kept away from outboard/inboard alternators & Ignition systems.

8. Ensure that no additional metal items such as stainless steel shackles have been introduced on auxiliary towing lines at the towfish end of the cable.

Possible Cable Damage

If all the above recommendations have been followed and still a high level of noise persists on the magnetometer it is possible that damage to the insulation of the cable is the cause. Any leakage between the inner cores of the magnetometer cable and the seawater will induce noise into the signal path. In models with a secondary cable for depth of sensor monitoring the problem could exist in this cable or the main cable, try testing the magnetometer with the secondary cable disconnected at the rear of the magnetometer – if the problem disappears the insulation of the depth cable is likely to be damaged. Tests can be carried out to check the integrity of the cable insulation, using a multi-meter, the procedure is as follows:-

1. Attach a small piece of metal to one of the leads of a multi-meter to act as a submersible conductor, e.g. brass, stainless steel or copper.
2. Either prepare to submerge the cable directly into the sea or otherwise fill a plastic bin or tub with sea water or fresh water with sufficient salt to make it very conductive. The plastic container should be large enough to submerge the whole cable and tow-fish.
3. Place the lead with the conductive metal contact into the salt water and connect the other lead to the centre contact of the tow-fish connector.
4. Set the multi-meter to the highest M-ohm resistance range available.
5. Slowly immerse the tow-fish and cable into the salt water, monitoring the multi-meter reading continuously. Any sudden reduction in the reading – which should normally be completely open circuit or be at least be in the tens of M-ohms – will indicate a weakness in the insulation, it will also localize the problem.
6. The same test can be carried out with the depth cable where this is also included, if possible make contact with all three contacts in the depth connector or test with each in turn.
7. If any weakness is detected in the cable this will need remedial action, a short term solution may be to use insulation tape locally, however once salt water has entered the cable it should ideally be replaced as the cable will continue to deteriate.

TESTING AN AX2000 MAGNETOMETER ON LAND

Where the performance of the magnetometer needs to be tested prior to going to sea or to check the noise and tuning performance, an effective test can be carried out on land.

The high sensitivity to field variations means that the magnetometer may only be used remote from known earth field disturbers, such as power lines or buildings. Before attempting to set up the magnetometer on land ensure that it is positioned at least 50 metres (160ft) from the nearest power line or building, additionally ensure that any vehicles are at least 10 metres (30ft) away.

Assuming the initial setting up is carried out on land the TOW-FISH should be positioned at least 3 metres (10 ft) from the electronics unit and battery. The tow-fish should be set up horizontally at least 1.25 metres (4 ft) off the ground using some form of totally non magnetic support - NOT EVEN CONTAINING SMALL NAILS, SCREWS OR EVEN STAPLES. Elevation of the sensor is very important unless carrying out the "land tuning" on totally magnetically clean ground.

Note although beach sand is generally magnetically clean this is not always guaranteed to be the case, if in doubt elevate the tow-fish as described above.

APPENDIX V - Manufacturer Contact Information

If you should need to contact Aquascan International Limited for advice on your purchase, to order further equipment or to arrange a repair, please use the following contact information: -

Mailing Address:

Aquascan International Limited
Aquascan House
Hill Street
Newport
South Wales
NP20 1LZ
United Kingdom

Tel: +44 1633 841117
Fax: +44 1633 254829

E-mail: Sales Enquiries: sales@aquascan.co.uk

General Inquiries: info@aquascan.co.uk

Technical Support: support@aquascan.co.uk

Web Address: www.aquascan.co.uk