AQUASCAN INTERNATIONAL LTD.
AQUASCAN HOUSE
HILL STREET
NEWPORT.
SOUTH WALES. UK
NP20 1LZ

Tel: +44 1633 841117/255645
Fax: +44 1633 254829
Email: info@aquascan.co.uk
Website: www.aquascan.co.uk

UNDERSEA DETECTION EQUIPMENT

AX2000

GRAPHICAL MAGNETOMETER

TYPES DET

•••••

Operating Instructions

•••••

Issue 2.01 / Sep 2003.

CONTENTS

INTRODUCTION

The AX2000 GRAPHICAL MAGNETOMETER series is the result of natural progression in development, and has set a new standard in the 1990s and into the 2000s for a totally autonomous magnetometer survey system. The inclusion of the latest in liquid crystal display (LCD) technology, together with a numeric/function keypad, allows the flexibility associated with menu operation. Battery backed memory is the additional major inclusion in the AX2000 series, thus allowing successive magnetic measurements (together with position and depth data) to be stored.

The AX2DET50 systems are the Small-Vessel Professional Grade Systems for operating in equatorial regions in particular and as such give a very high performance. The Omni-directional nature of the TOROID sensor resulting in a very stable measurement of the earth's magnetic field. and hence a very optimised search tool for a very wide range of applications. The "depth of tow-fish" sensing transducer is also integrated into the towed assembly, depth of tow-fish is measured and included as a display parameter, thus allowing optimised quality control over the survey and providing important additional data for post-survey analysis.

I/O facilities are available to allow data-logging of water depth from a compatible (NMEA) based instrument, this facility is provided to take advantage of a trend in marine instruments to provide both depth and positional data from a single NMEA port. The AX2DET is supplied with 128Kbyte of data-logging memory representing a 6 hour survey buffer memory capability. Duration and frequency of survey dictate the frequency of down-loading to a computer allowing the memory to be cleared for re-use without loss of valuable data.

PC support software options are available to allow both real-time PC viewing/storing and subsequent PC analysis of stored data, this can provide a very powerful aid for survey. 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.

Hence, with the AX2000 series, a foundation has been laid to provide the basis for progressive inclusion of further innovations that will ultimately take the instrument far beyond the basic functional role of a proton magnetometer.

1.0 SYSTEM CODING

A simplified coding system has been adopted to cover a range of options available with the AX2000 series; the letters and numbers following "AX2" determine the status, type of sensor and length of cable supplied.

AX2ES/40 = System for European operation with Solenoid sensor and 40m cable.
AX2ET/60 = System for equatorial operation with Toroid sensor plus 60m cable.
AX2DES/50 = System for European operation with Solenoid sensor plus 60m cable and depth of tow-fish sensor.
AX2DET/50 = System for European operation with Solenoid sensor plus 60m cable and depth of tow-fish sensor.
AX2PED/150 = Professional version for Worldwide operation - supplied with integrated depth sensing, tow-fish pre-amplification & a Solenoid sensor, complete with 150m cable and a global tuning capability.
.

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 dealer or directly with AQUASCAN.

NB we suggest you keep the Freighting case and 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

2.1 MOUNTING

The AX2000 display unit is supplied with a conventional gimbal 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, however, it is recommended that where possible the unit should be mounted behind some form of spray shield - particularly when mounted on the console of Rigid Inflatable Boats (RIBs) and other similar type of high performance open boats.

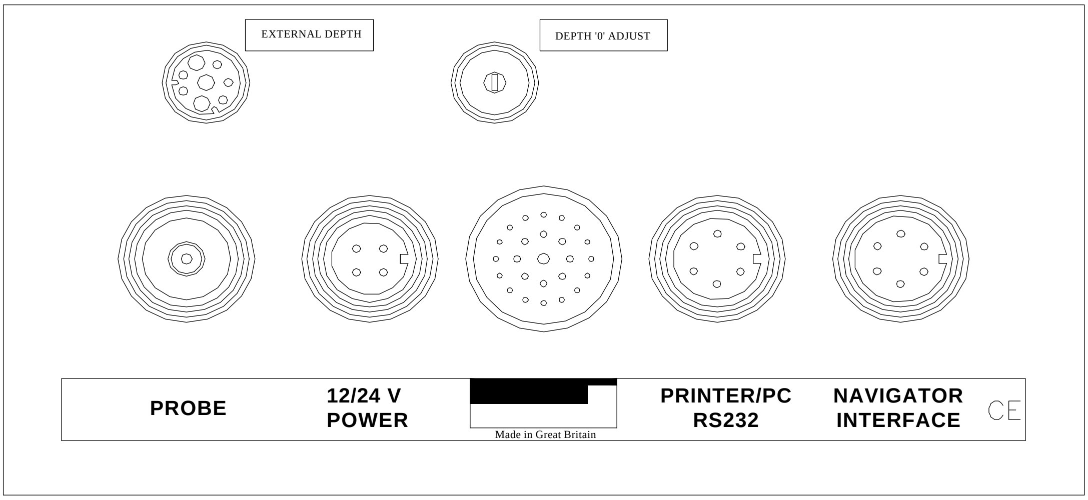
Mounting the AX2000 display should take account of the central role the instrument takes during magnetometer survey operations, this demands concentration and ease of keypad operation. Although the LCD display has a wide angle of view, it should be set to give the operator as direct a screen view as possible. 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 AX2000DES & DET 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) Multi-way connection to the tow-fish cable, or indirectly via the extension lead.
b) 24v dc supply.
c) Data output facility for printer/PC.
d) NMEA 0182/0183 position input from navigation device.

AX2000 – interconnect diagram



PROBE - The ***Toroid*** probe is connected via connects to the AX2000 via the dedicated waterproof phono connector.
NB. 1. It is essential to maintain this connection in a clean dry condition,

12/24v POWER - The dedicated 24v-battery pack (isolated) is fed via the dedicated power supply unit.
NB. 1. The display unit also has an internal 3.15A protection fuse.
2. The AX2000DET/50 will operate as a system with 12v-supply voltage. However this will result in a reduced performance and should only be done for testing purposes.

PRINTER/PC RS232 – This provides both the connection point for the RS232 "download lead" and the Opto-isolated lead for real-time data transfer to a PC.
NB. Although the standard RS232 download lead is also usable for real-time data transfer it does not provide ground isolation. Lack of ground isolation can lead to interference and hence reduce the stability of the readings.

NAVIGATOR INTERFACE - 0183 data is fed to the connector via the NMEA lead supplied, the connections are identified as NMEA DATA (RED) and NMEA RETURN (BLUE).

2.3 POWER SUPPLIES

The 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.

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

NB. Even in situations 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 ("tow-fish") the inboard section of cable has to be routed to the display 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 the "proton" magnetometer as a detection device is quite different to any other form of metal detection or sonar system, being primarily a totally passive system.

The magnetometer is by definition a 'magnetic meter', the "proton" magnetometer being an especially sensitive version, allowing a high resolution capability in relatively low field intensities, such as the earth's field. As a measuring instrument it thus allows us to determine small changes in the strength (total intensity) of the earth's natural magnetic field, and hence the presence of local anomalies.

A Proton magnetometer for wreck location measures the strength of local anomalies in the earth's magnetic field, and for this it is extremely sensitive. The earth's magnetic field value has a relatively good short-term stability, and in the absence of debris with magnetic properties, shows very little change over modest sized search areas. Within predictable distances, ferrous objects cause disturbances that can be detected and interpreted by the magnetometer, whereas non-ferrous metallic objects have little or no effect on the magnetic field and hence are not detectable directly by a proton magnetometer.

3.1 PROTON PRECESSION

The AX2000 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 AX2000 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.

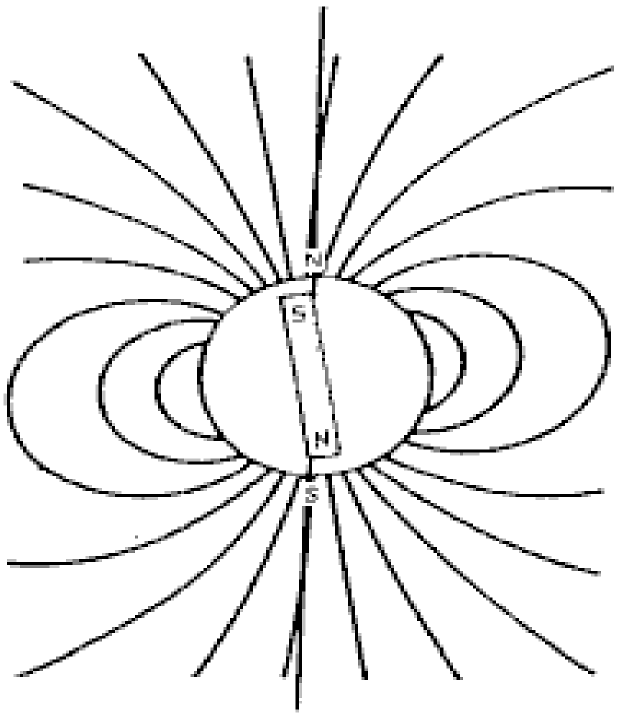
To measure the earth's magnetic field intensity, the fluid must first be polarised. This is the POLARISE state and is achieved by passing a dc current through the inductor for a predetermined time (typically 2 seconds), this is called the POLARISE TIME. During this period the hydrogen protons in the core are progressively aligned with the direction of the created electromagnetic field. Switching off the inductor current abruptly causes a large back EMF followed by proton activity (PRECESSION) in the core, The protons are caused to precess about the direction of the earth's magnetic field at a rate proportional to the strength of this field. This proton activity induces an ac signal of 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 strength is constant known as the gyro magnetic ratio. The amplitude of the generated signal slowly decays as the individual protons gradually loose phase coherence. The decay period is in the order of a couple of seconds before the signal becomes lost in noise. The magnetometer must resolve the frequency of this signal within a fraction of a second to optimise the measurement. This period immediately following polarisation is the DETECT or measurement period during which the search coil is connected to the amplifier. The amplifier contains a filtering system to minimise the effects of noise and unwanted signal induced into the system. The amplified signal is in turn passed on to the microcomputer which measures the frequency.
The use of a microcomputer is the key to providing an efficient measurement system, together with many secondary but sophisticated features. To measure the frequency of the precession signal the microcomputer compares the processed signal with its own crystal clock. This technique enables the AX2000 to make very accurate measurements which can be displayed

graphically and stored as data for later retrieval. The measured units are quoted to nano-Teslas (nT) or gammas Deviation, and relate to the small magnetic field strength changes that are being monitored. The nano-Tesla being a fractional part of the Tesla a unit of magnetic field strength.

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.

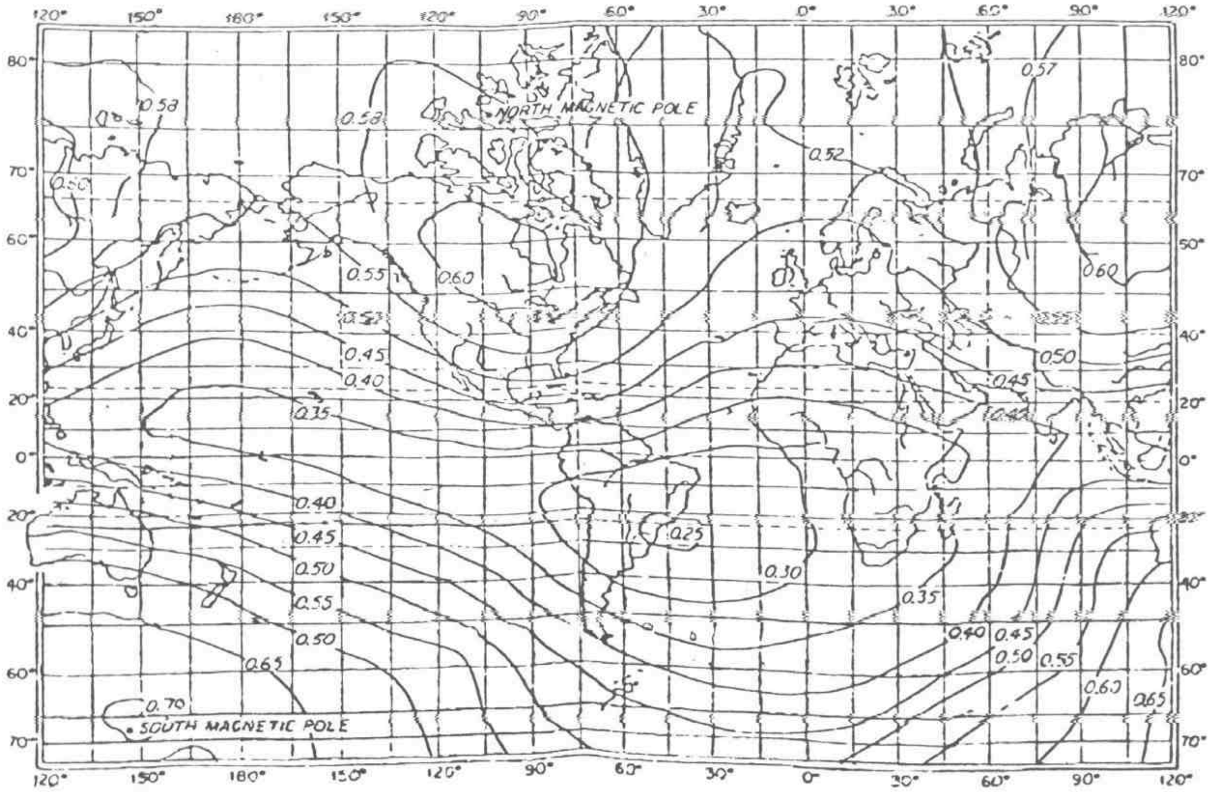
The earth's field has a number of parameters, the most important of which is the 'total intensity', and this is the parameter measured and analysed by the magnetometer. Under short-term static conditions the total intensity value is maintained to a stability which allows the magnetometer to measure to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



EARTH'S MAGNETIC FIELD

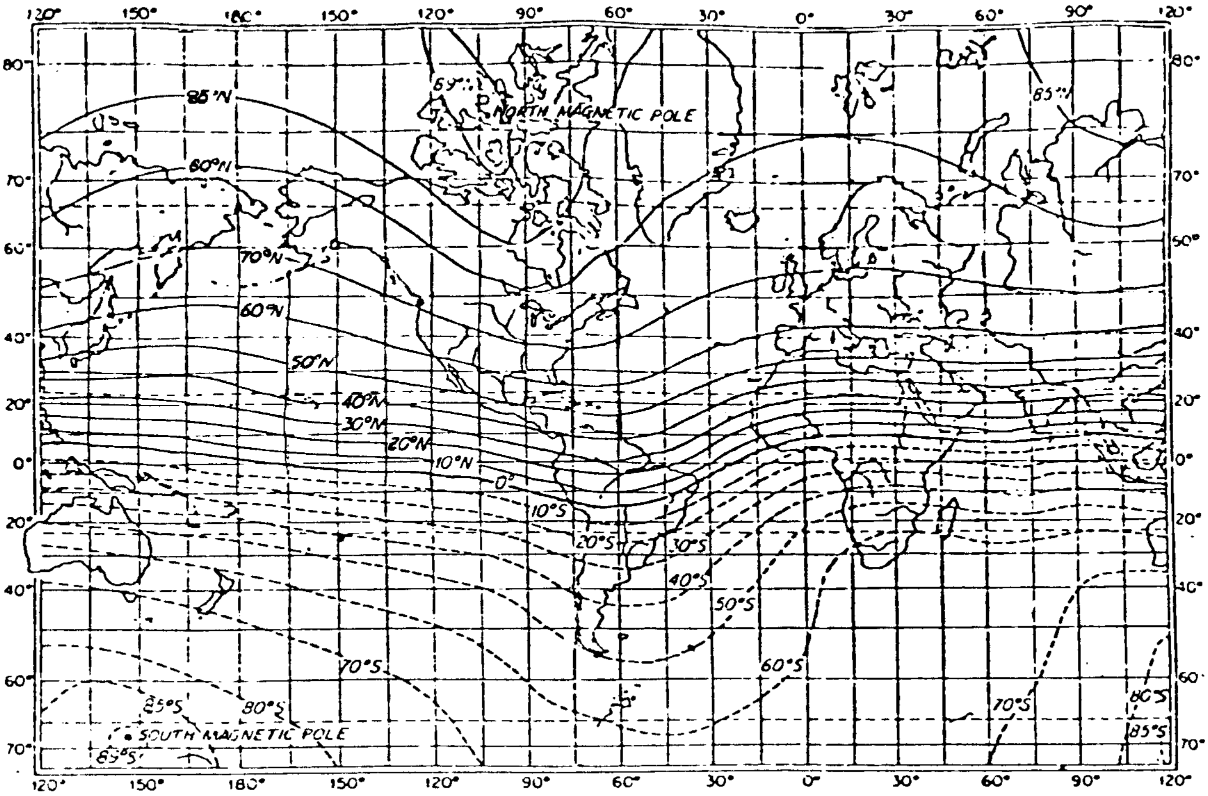
The Earth's magnetic field can be likened to that of a dipole such as a bar magnet, this exhibits a symmetrical field distribution with the maximum field intensity appearing at the poles. The earth's magnetic intensity however, is not so symmetrical due to geological affects. Over the major part of the world where magnetometers are likely to be deployed, variation in total magnetic field strength is between 20,000 & 70,000nT. Magnetic storms and even effects from the sun (sunspot activity) can affect the total intensity value measured at any instant. During mobile scientific and serious magnetic survey measurements a magnetometer base station is set up in a recording mode, this gives a time related database for comparison and post processing of results to enable spurious readings to be eliminated.

The Figure 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).



4.1 MAGNETIC INCLINATION

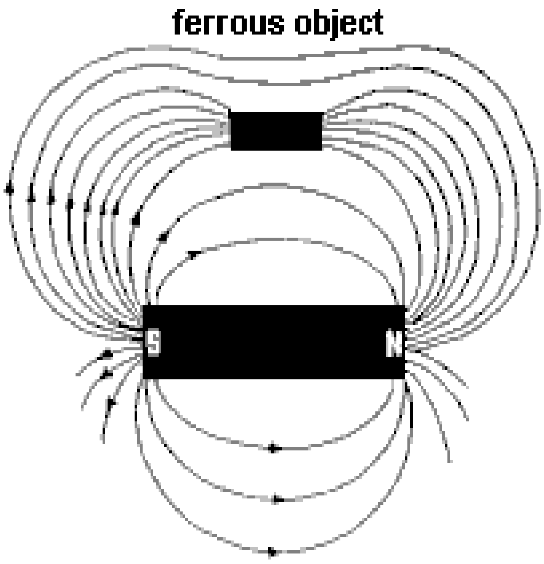
Another parameter of the earth's magnetic field that we have to take into consideration is the 'angle of inclination'; this is the angle at which the earth's field intersects with the horizontal plane of the earth's surface. A general plot of values for this angle over the surface of the earth is shown in the diagram below. The angle of incidence can have some influence on the type of magnetic sensor deployed in various parts of the world. In the Polar Regions the angle of inclination tends more towards the vertical, whereas, in the equatorial regions this angle becomes predominantly more horizontal. The relevance of angle of incidence is that, in order to allow a marine magnetometer sensor to effectively retrieve signals - irrespective of direction of tow - requires that a reasonably high angle be maintained, between the line of the sensor and the angle of inclination of the magnetic field. In this respect the SOLENOID type sensor works well in the majority of areas of the world, and particularly with an angle of inclination above 45 degrees. The SOLENOID however becomes inefficient in areas with low angles of inclination, particularly when the survey is predominately carried out in a north/south direction, which is essentially along the same axis as the earth's field. To compensate for the low angle of inclination a TOROIDAL (ring donut shape) sensor is utilised, this has a lower mean efficiency than the SOLENOID, but when maintained horizontal is reasonably unaffected by change of direction within the earth's magnetic field.



LINES OF EQUAL INCLINATION

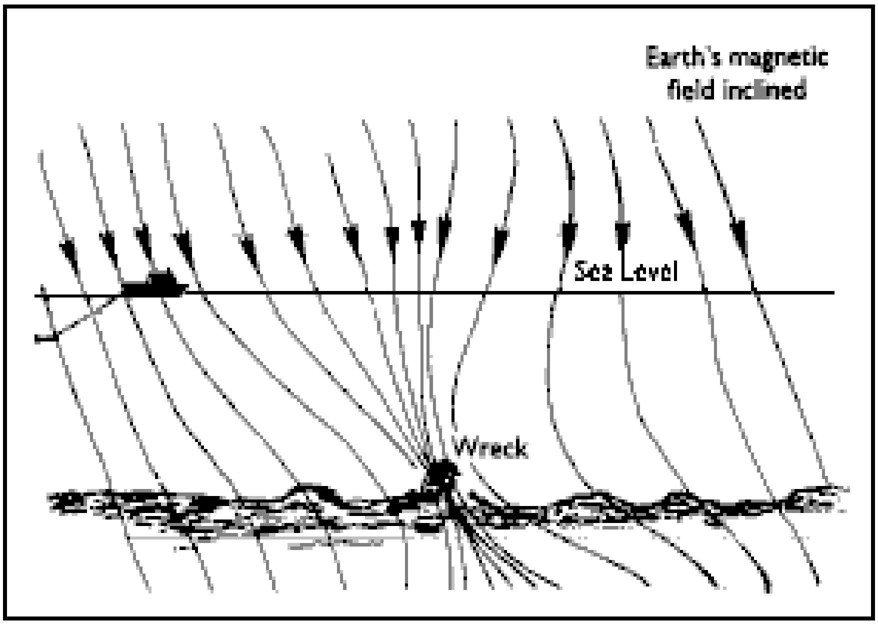
4.2 MAGNETIC ANOMALIES

In order to understand how a magnetometer can locate a ferrous object such as a shipwreck or parts of a shipwreck, it is necessary to understand the impact of such a ferrous object on the surrounding earth's magnetic field. The diagram below shows a 2 dimensional view of such an object within the earth's magnetic field, this diagram clearly shows the convergence of the lines through the ferrous object. The size of the object in relation to the earth's field is deliberately exaggerated to illustrate the effect. The effect shown is the 'induced field', which is due to the much higher permeability of the ferrous object to the surrounding matter.

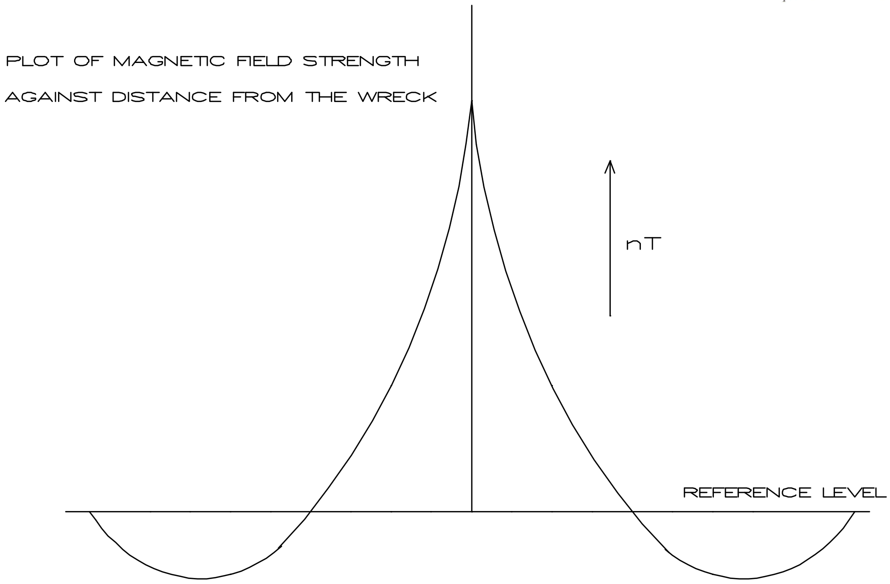


THE MAGNETIC ANOMALY OF A FERROUS OBJECT IN A UNIFORM MAGNETIC FIELD

Apart from objects of a ferrous nature, all other matter can be considered to have a permeability of near to unity, this in effect means that no other matter has an appreciable impact on the presence of the earth's field and hence has no magnetic detect-ability. The value of permeability of a given object is one of the major factors determining the amount of induced field, and hence the detect-ability distances. Permeability variations of many orders of magnitude are apparent in the many grades of ferrous material, such as wrought iron, cast iron, steel etc. Hence the detection range of various objects of a given mass depends upon the composition.



THE MAGNETIC INFLUENCE OF A WRECK CAN BE DETECTED AT DISTANCES EXCEEDING 400M



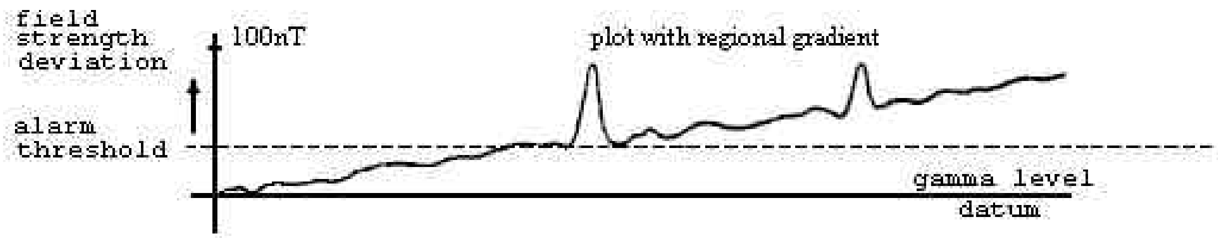
The above plot is a representation of the change in field strength as a survey progresses across the centre of an anomaly. Levels below the "reference level" are related to areas where the field strength has been reduced by the presence of the anomaly. The rate of change of field strength for an isolated anomaly is based on an inverse cube law, hence the rapid build up to a peak (which in reality has a broader the 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

4.3 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.



4.4 MAGNETOMETER SENSITIVITY

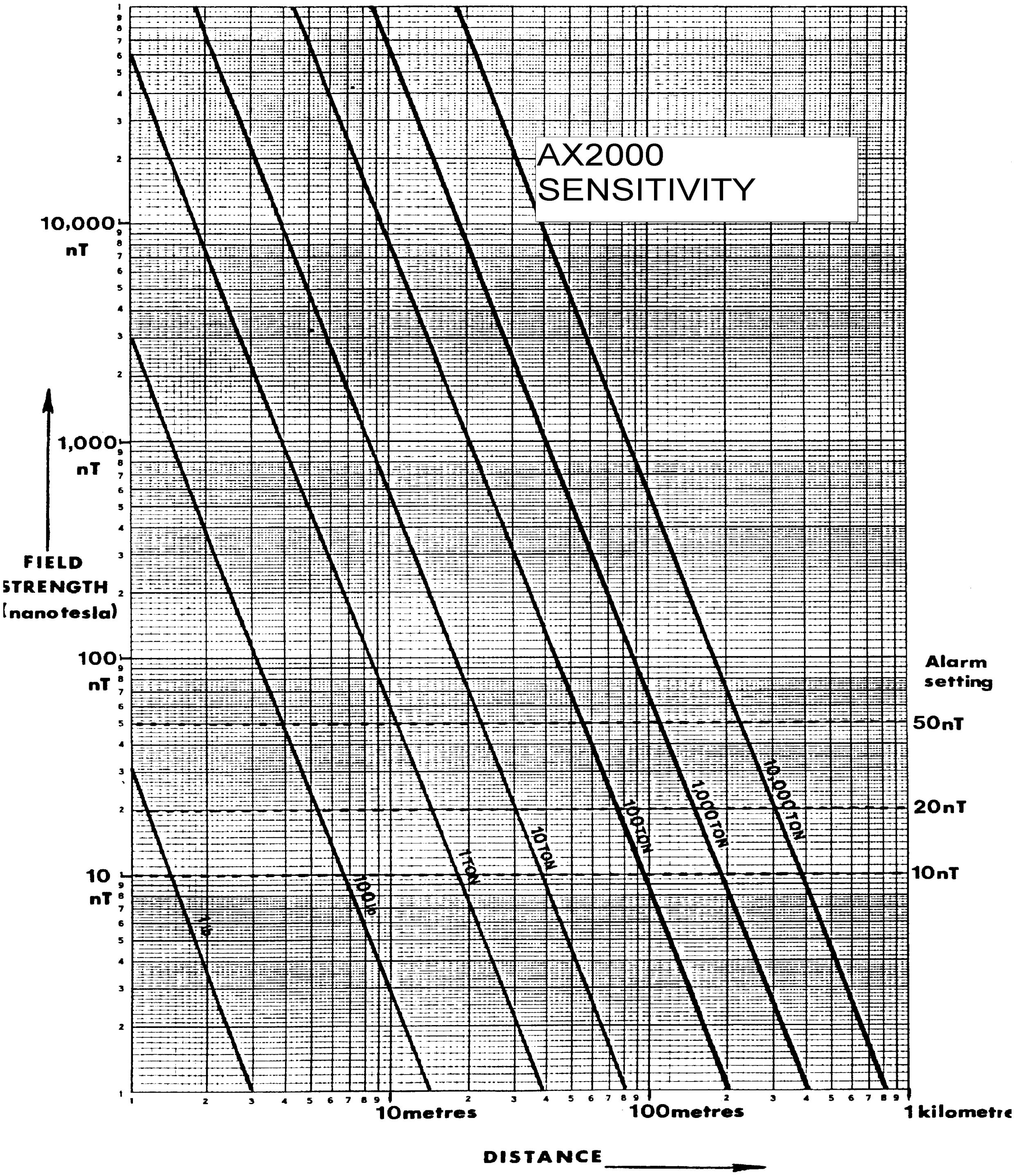
The AX2000 sensitivity in terms of detection distance is based on its capability to resolve changes down to a resolution of 1 nano-Tesla (nT). A magnetometer resolution of 1 nano-Tesla is considered to be the optimum for mobile marine search and survey applications. This 1nT value in terms of the total field measurement made gives a typical resolution in the order of 1 part in 50000 for measurements carried out in northern Europe for example, 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 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.

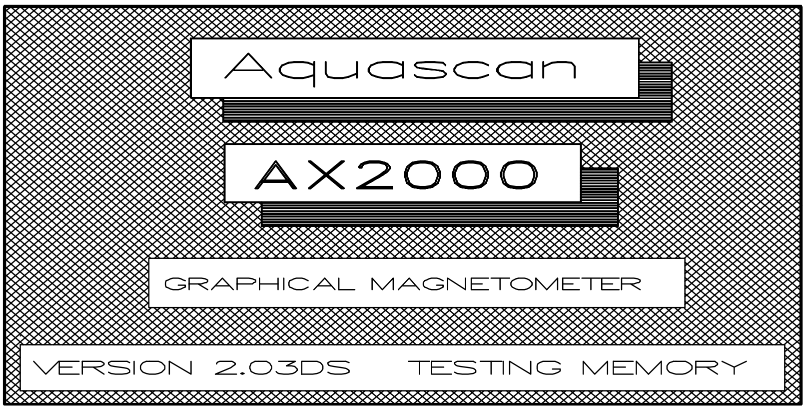
The implications of the above have a significant impact on pre-survey planning, and in particular lane width to be adopted for searching, and accordingly the degree of control required for the survey boat. The importance of probe height during survey for relatively small targets can also be determined 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.


AX2000
SENSITIVITY
10,000 nT
1,000 nT
100 nT
10 nT
FIELD
STRENGTH
(nanotesla)
Alarm
setting
50nT
20nT
10nT
1 lb
100 lb
1 TON
10 TON
100 TON
1,000 TON
10,000 TON
10metres
100metres
1 kilometre
DISTANCE

5.0 GETTING STARTED

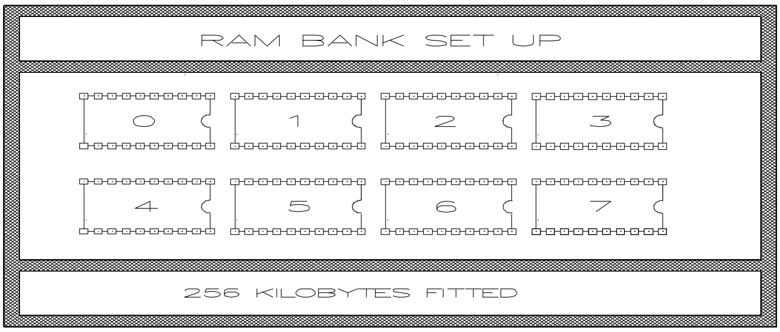
5.1 POWER UP

Press the red "PWR" button on the lower right of the keypad. The AX2000 will respond by presenting the title screen.



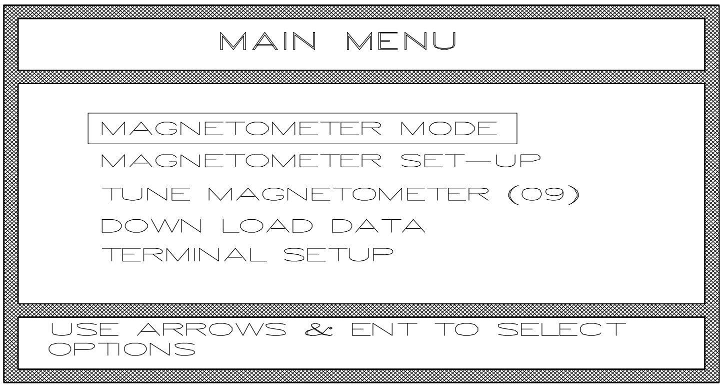
This screen will be present for approximately 10-15 sec's. During this time the AX2000 will perform its memory test. The words "TESTING MEMORY" will appear in the lower half of the screen and the sounder will emit a rapid burst of clicks. The version of software fitted to the AX2000 is also indicated. When the memory test has been successfully completed, a new screen will be display memory configuration installed e.g. 256Kbyte.

5.2 RAM BANK CONFIGURATION



The above display confirms the extended 256Kbyte RAM configuration is fitted; each position is occupied and is equivalent to 32Kbyte. In the case of the AX2000 PES & PET this equates to 8 x 32 i.e. 256Kbyte, this is the maximum capability, and allows a data-logging storage time of approximately 10hrs duration.

5.3 MAIN MENU



The main menu presents 5 options:

1. MAGNETOMETER MODE
2. MAGNETOMETER SET-UP
3. TUNE MAGNETOMETER
4. DOWN LOAD DATA
5. TERMINAL SET-UP

5.31 SELECTING A MAIN MENU OPTION

To select an option use the UP/DOWN keys to move the cursor (reverse video highlight) to the required option. Once highlighted pressing the “ENT” key can choose the option.

5.32 SELECTING A SUBMENU OPTION

Once an option has been selected from the main menu the AX2000 will provide the appropriate sub-menu. To select an option in any sub menu the CURSOR KEYS are used to move the "highlight box" around the screen. Once the required option is highlighted by the box, press the ENT KEY. The selection is confirmed by the relevant option being displayed in reverse video.

THE AX2000 WILL UPDATE Its CONFIGURATION TO THAT INDICATED BY THE “REVERSE VIDEO” ON RETURN TO THE MAIN MENU.

NOTE:

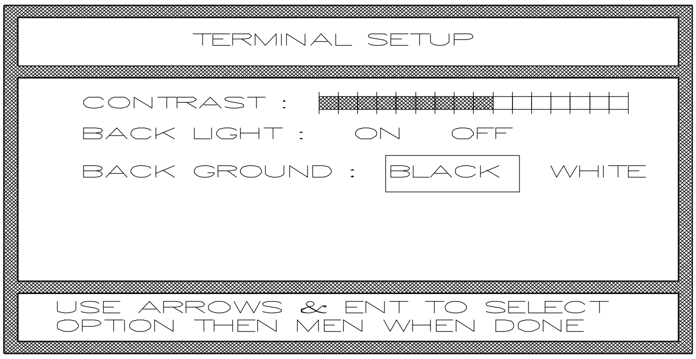
The only exception to the above statement is the "TERMINAL SET-UP" menu; this updates its configuration from within the sub menu.

To return to the main menu from the sub menu press the "MEN" key.

NB Changes to the initial default settings are maintained after power-down by the internal memory backup battery.

5.4 TERMINAL SET-UP

If the contrast needs optimising select "TERMINAL SET-UP" option.



5.41 CONTRAST

The current contrast setting is indicated by a small horizontal histogram at the top of the screen. To adjust the contrast:

1. Highlight the histogram.
2. Press the left/right cursor keys to increase/decrease the contrast, until an optimum setting is achieved.

5.42 BACKLIGHT

To switch the back-light on/off:

1. Highlight the relevant option.
2. Press ENT to select option.

CAUTION DO NOT SWITCH OFF THE BACKLIGHT IN LOW AMBIENT LIGHT CONDITIONS AS INSUFFICIENT CONTRAST MAY MAKE ANY FURTHER MENU SELECTION VERY DIFFICULT.

5.43 BACKGROUND

The screen background can be made predominately black or white to suit ambient light conditions by the following procedure:

1. Highlight the required option.
2. Press the ENT KEY to select option.
3. Return to main menu by pressing the MEN key.

6.0 POWER-DOWN

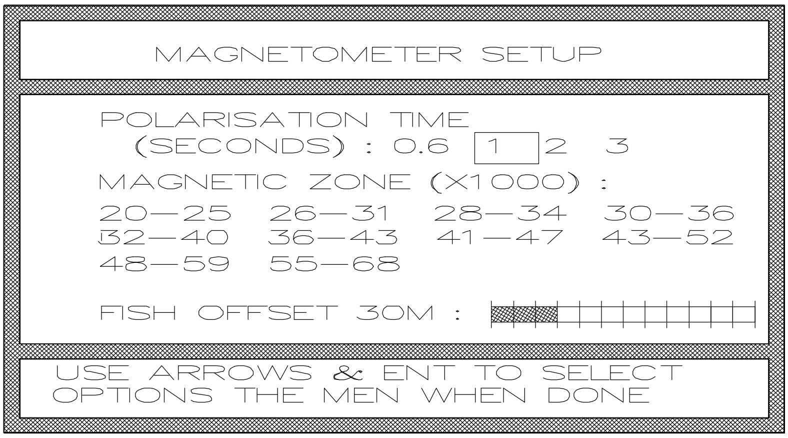
Press the PWR keypad and hold until an audible bleep is heard power will then be disconnected electronically as the keypad is released.

CAUTION DO NOT SWITCH OFF BY REMOVING POWER BY AN EXTERNAL SWITCH OR BY PHYSICAL DISCONNECTION OF THE POWER LEADS AS THIS WILL REVERT ALL INTERNAL SETTINGS TO THE INITIAL DEFAULT VALUES AND ALL STORED DATA WILL BE IRRETRIEVABLY LOST.

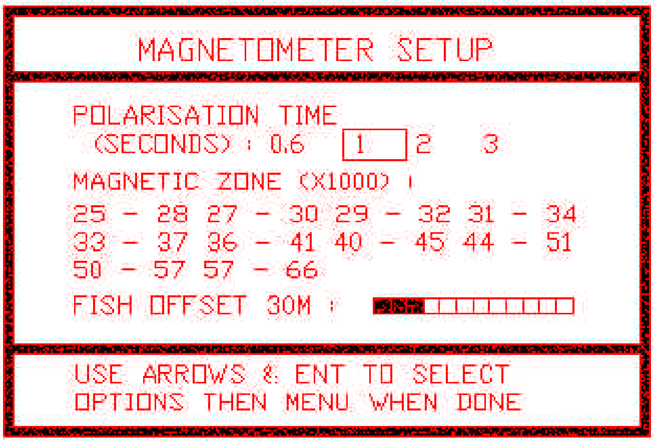
7.0 SETTING UP THE MAGNETOMETER

To adjust the magnetometer operating parameters select the "MAGNETOMETER SETUP" option.

7.1 MAGNETOMETER SET-UP MENU



NB. The above diagram shows the existing options within the SETUP MENU, however the settings related to these MAGNETIC ZONE options have been further optimised as per the diagram and conversion list below: -



OLD ZONE	NEW ZONE
20 - 25	25 – 28
26 - 31	27 – 30
28 – 34	29 – 32
30 – 36	31 – 34
32 – 40	33 – 37
36 – 43	36 – 41
41 – 47	40 – 45
43 – 52	44 – 51
48 – 59	50 – 57
55 - 68	57 - 66

THE ABOVE DIAGRAM SHOWS THE ACTUAL MAGNETIC ZONE VALUES THAT SHOULD BE INTERPRETED FOR THE EQUIVELENT MENU SELECTION

7.2 POLARISE TIME

Polarise time is the time interval devoted to energisation of the proton rich fluid in the tow-fish, the AX2000 has a polarise time default setting of 2 sec's, and this is the recommended setting for the majority of applications. The benefit of longer rather than shorter polarise times is to achieve a proportionately stronger burst of signal from the tow-fish. The benefit of increased signal strength is increased stability of measured results, this in turn gives a corresponding flatter base line on the display allowing easier interpretation of small responses, or the initial slow changes that occur with large targets at distance. The peak to peak envelope of random variations in the baseline are generally referred to as the "noise envelope".

Operating with the supply voltage at 24v (instead of 12v as on the short cable versions of the AX2000), also has a beneficial effect on the amplitude of received signal, and can compensate for the natural loss of signal when operating with short duration polarise times. The combination of longer polarise time together with 24v operation will always produce the optimum achievable results and maximise tolerance to the effects of noise interference.

Finally, because signal strength returned from the tow-fish is also affected by the total intensity value of the earth's magnetic field, the shorter polarise times can more readily be used in stronger magnetic field areas.

To set the required polarisation time

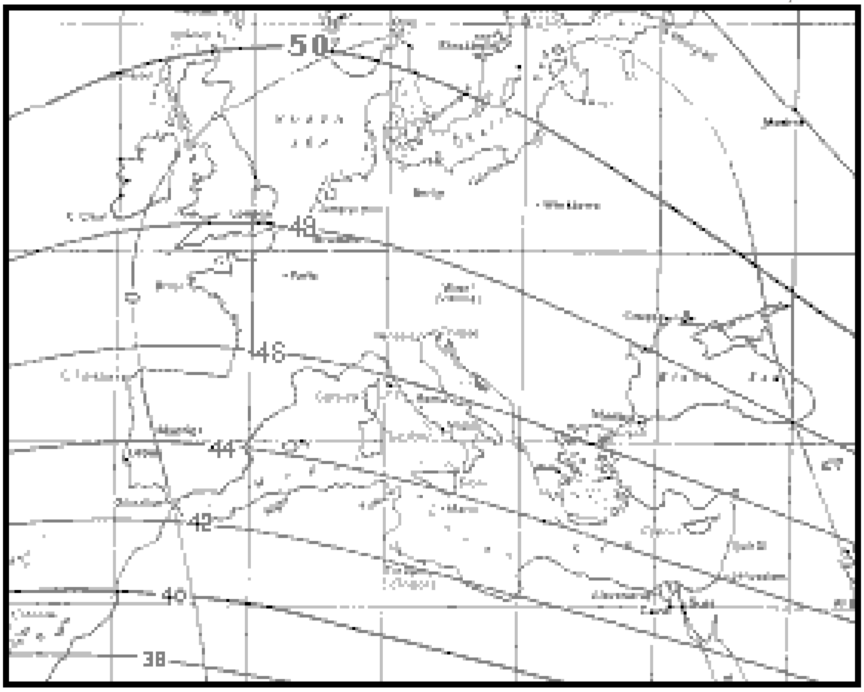
1. Highlight the required option.
2. Press **ENT** to select option.

NB. 2 SECS POLARISE IS THE MOST PRACTICAL SETTING FOR MOST APPLICATIONS.

7.3 MAGNETIC ZONE

The AX2000DET/50 has the capability to operate on a worldwide basis subject to pre-set selection of the correct IPA-3 board, and by MENU selection of the correct MAGNETIC ZONE. The analogue section of the magnetometer is frequency selective by means of "tuning" the probe sensor; further selectivity is obtained be means of a subsequent digital filter. It is important that both of these sections are pre-set for the relevant frequency of operation, this frequency is directly related to the magnetic field strength in the area of operation. The operator as such has to recognise the particular field strength (total magnetic intensity) of the operating zone.

To establish the relevant magnetic zone for your area of operation refer to the total intensity maps in the appendices. Referring to the example below, the major contours refer to lines of constant magnetic intensity (x 1000) nT (gammas). It can be seen for instance that the UK is roughly between 47 to 50,000 nT, which is easily accommodated by the 43 - 52 (44 - 51 actual) ZONE selection.



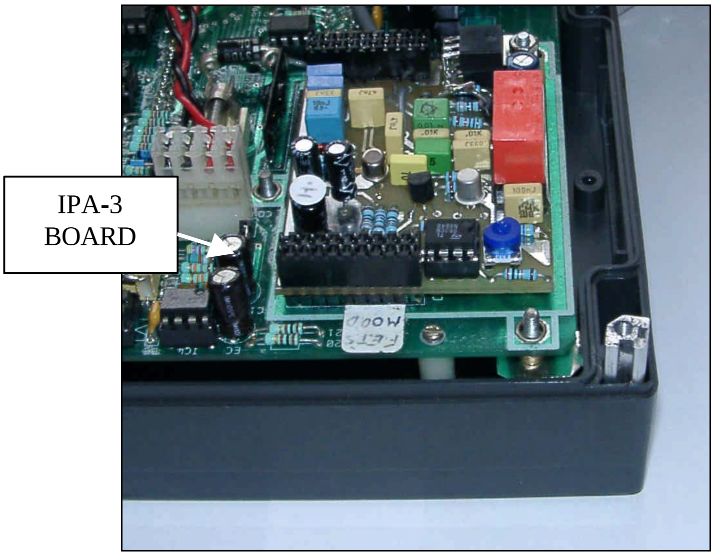
To set the appropriate magnetic zone: -

1. Highlight the required option.
2. Press **ENT** to select option.

CAUTION. The magnetic zone will not normally require to be reset unless the magnetometer is being re-located to an area with ambient field strength outside the MAGNETIC ZONE value indicated.

NB. In case of accidental memory loss, or reset, the standard default setting of 43 to 52 (44 – 51) will be selected automatically on power up (this a standard setting for parts of the world including Northern Europe, part of North America, and Northern Australia.

7.31 AX2000/IPA-3 FITTING



In order to change the area tuning zone of operation pre-tuned IPA-3 circuits are available and require to be substituted as follows.

1. Undo the 4 screws on the rear of the case to separate the two halves and expose the AX2000 circuit.

2. Remove the 3 screws retaining the metal screen at the top left above.

3. Carefully prise the existing IPA-3 circuit away from the connector strips.

4. Fit the new IPA-3 circuit taking care to properly locate with the connector strips.

5. Replace and secure the metal screening can.

6. Carefully relocate the 2 halves of the AX2000 case and secure with the 4 corner screws.

N.B. Ensure that the new zone is also selected from the AX2000 magnetometer *set-up* menu.

7.4 TOWFISH OFFSET

Although this has no direct functional significance within the AX2000, and will not effect the measurement and data storage functions, it is off importance to the subsequent processing and analysis of data. The position stored by the AX2000 is related to the position derived from the antenna of the navigation receiver, not the position of the actual magnetometer sensor.

The tow-fish offset can be entered to a resolution of 5m and it is suggested that the cable can be marked with a suitable waterproof tape to give an indication of each 5m step. Set the amount of "FISH OFFSET" to be comparable with the horizontal distance between the boat's navigation antenna and the position of the tow-fish. This must be set each time a different amount of cable is deployed, or if the tow-fish is towed relatively deep, in which case an allowance has to be made for the vertical component, which results in a reduced horizontal offset. The offset entered is appended to each logged file that is subsequently created.

With an assumed 50m of cable deployed, it can readily be appreciated that the same target response will occur at a radius of 50m for any approach (assuming a magnetic response that is symmetrical), with approaches to the target on reciprocal courses a resultant spread of 100m occurs. This is fine on a single search and locate exercise in real time, because this can be taken account of in the immediate position averaging from a number of passes, however, this is not practical when a comprehensive survey has to be carried out, and in particular where this is for commercial or archaeological purposes and the survey is carried out using a highly accurate navigation system such as differential GPS.

The Fish offset function is critical where the results are to be compiled and processed to produce 2D & 3D contour mapping.

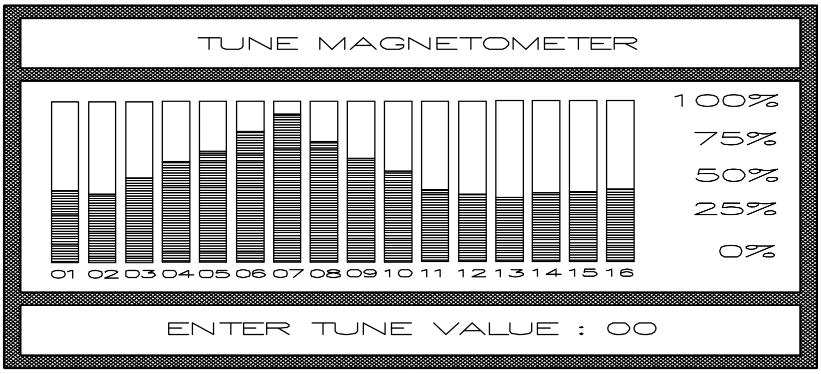
Return to MAIN MENU by pressing the **MEN** key.

7.5 TUNING THE MAGNETOMETER.

A facility is built in to the AX2000 to "fine tune" the magnetometer to the field strength in the general area of operation, this enables maximum signal strength to be achieved in a similar way to that in which a radio receiver is tuned to get maximum reception. This is normally only required when the magnetometer is first used in a new area. If the magnetometer is re-located by some tens of miles it is worth rechecking the fine tune response.

To "AREA TUNE" (fine tune) the magnetometer, select the "TUNE MAGNETOMETER" option.

The AX2000 will respond by presenting the TUNE MAGNETOMETER sub menu, which consists of 16 vertical histograms.



Once the TUNE MAGNETOMETER mode is selected the AX2000 automatically scans through the available tuning steps, measuring the signal strength for each step.

The signal level generated by a particular tuning step is indicated by the height of the corresponding histogram. The diagram shows the normal type of histogram response that can be expected, and indicates that in this case **07** would be the correct step to enter.

This tuning scan feature can be a used as a very good "health" test for the magnetometer, as either low signal or noisy signal conditions (through interference), can be readily interpreted.

Once the 16 steps have been scanned the AX2000 will prompt the user to "ENTER TUNE VALUE". If a single peak is not achieved but 2 adjacent steps give an equal amplitude either one can be selected, alternatively an additional tuning scan can be carried out by pressing the ENT key, this sometimes results in a more clearly defined separation between adjacent steps.

To select the appropriate tuning step.

1. Enter the relevant number via the numeric keys.
2. Press ENT to make the selection.

THE AX2000 WILL AUTOMATICALLY RETURN TO THE MAIN MENU.

7.6 MAGNETOMETER MODE

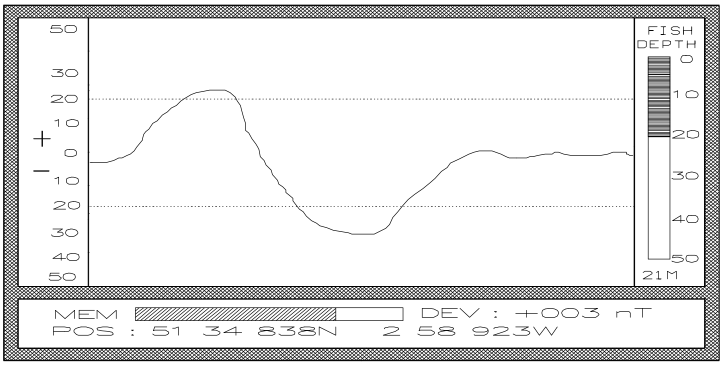
Selecting MAGNETOMETER MODE from the MAIN MENU sets the AX2000 in its operational mode **i.e.** it immediately begins to polarise the tow-fish and update measurements.

NOTE:
THE AX2000 MAY TAKE SLIGHTLY LONGER TO RESPOND TO KEY PRESSES IN THE MAGNETOMETER MODE (THIS IS BECAUSE OF THE "PROCESSOR INTENSIVE" WORK THAT IS INVOLVED). IT MAY SOMETIMES BE NECESSARY TO HOLD THE SELECTED KEY DEPRESSED FOR APPROX 1 SEC.

7.61 MAGNETOMETER DISPLAY

Selecting MAGNETOMETER DISPLAY places the AX2000 in its graphical mode.

In the graphical mode the AX2000 dedicates the full screen to displaying the magnetometer survey results.



The magnetic deviation is shown in two ways:

1. **GRAPHICALLY**
   The magnetometer trace is scrolled across the screen right to left as the readings are updated.

2. **NUMERICALLY**
   The digital value of the deviation in gammas (nT) is displayed at the lower right of the screen.

7.62 ALARM LEVELS

The current selected alarm threshold is indicated by horizontal dotted lines above and below the zero level. As the trace exceeds the +ve or -ve value indicated a two-tone audible alarm is triggered.

7.63 POSITION DISPLAY

When an appropriate navigation aid is connected to the AX2000 (via its NMEA interface port), the geographical (Lat./Lon) position is displayed digitally across the lower part of the screen,

NB. For more information see the section COMMS and NMEA SETTINGS, refer to the NMEA appendixes for detailed interface information.

7.64 MEMORY HISTOGRAM DISPLAY

The horizontal histogram at the lower left part of the screen indicates the amount of memory space left during data logging.

If data logging has not been selected then the words "NOT LOGGING" are displayed in the histogram.

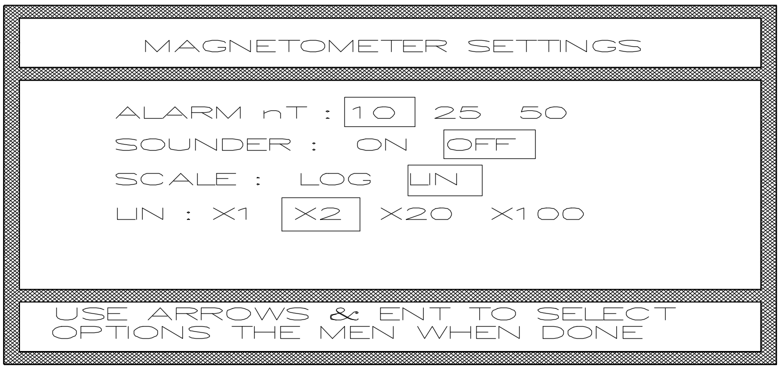
If data logging has been selected then the word "LOG" is placed next to the histogram and current memory status is displayed. The black portion indicates relative amount of used memory.

7.65 DEPTH OF TOWFISH DISPLAY

The current tow-fish depth is displayed both in analogue form, and as a digital value beneath the analogue histogram. The analogue display takes the form of a vertical histogram in which the lower part of the black section indicates the depth; this is to the right hand side of the display.

NB. Return to magnetometer mode sub menu by holding down the "MEN" button.

7.7 MAGNETOMETER SETTINGS



The MAGNETOMETER SETTINGS sub menu presents the following options:

7.71 ALARM nT

This allows a pre-set level of magnetic deviation to be selected that will trigger the AX2000 audio sounder. The value selected is indicated on the graphical display during operation.

7.72 SOUNDER (alarm)

The sounder can be set "ON" or "OFF" from this sub-menu muting the audio alarm threshold set by the previous step.

7.73 SCALE

Allows the user to display the survey results using :

1."LIN" for a linear scale.
2."LOG" for a logarithmic scale.

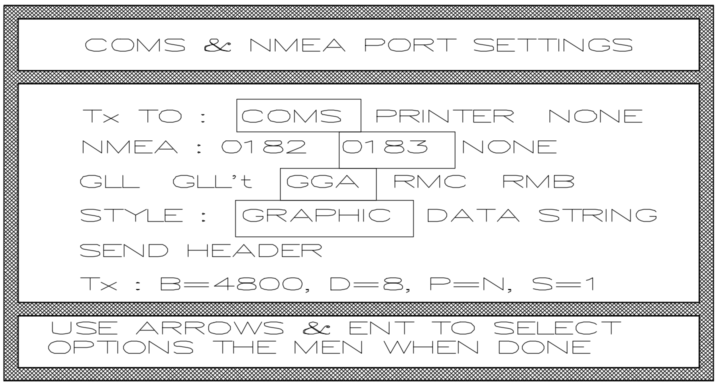
This could also be termed range selection, as the scaling factor (multiplier) chosen sets the initial maximum size of anomaly amplitude that can be accommodated within the display window.

The logarithmic mode has been designed to operate with a base 8 giving scale increments of 8, 64, 512 etc. The choice of a base 8 mirrors the inverse cubic law response for most magnetic anomalies, this in meaningful terms says that a change of proximity to an anomaly by a factor of 2 will produce a corresponding magnetic change by a factor of eight.

The choice of "LOG" or "LIN" scale is in no way crucial for any particular search application, however, where a large anomaly response is anticipated, the use of "LOG" scale will allow maximum resolution of the initial small changes that occur, whilst accommodating a reasonably large overall response without resorting to scale changes.

Return to MAGNETOMETER MODE sub menu by holding down the MEN button.

8.0 COMMS AND NMEA SETTINGS



8.1 TX TO

These options allow the user to choose what peripheral device the AX2000 interfaces with. Once correctly configured the AX2000 will echo the survey results to the chosen device - on every update.

8.2 COMS

Selecting the comma option instructs the AX2000 to output its data in the standard ASCII format that an IBM compatible P.C. can utilise.

The interface lead provided allows reliable communication via a standard 9 pin RS232 serial port.

9.0 NMEA INTERFACE

The AX2000 has a fully opto-isolated interface port that conforms to the NMEA 0182 & 0183 (1200 baud & 4800 baud) standards; the purpose of this port is to receive navigation data in the form of Lat./Lon positions. Whilst modern navigation systems -particularly **GPS** -provide the NMEA 0183 format, some of the older navigation receivers based on **Decca** and **Loran**, only provide the NMEA 0182 format, this features a position data stream identified as **GLL,** and provides position data in degrees, minutes and decimal minutes to 2 places (i.e. to 1/100 of a minute). The NMEA 0183 however is a more comprehensive interface standard and generally not only provides the **GLL** position data, but also 1 or both of **GGA** & **RMC** sentences, these include position data with minutes to 3 decimal places, which in effect gives a position resolution to 1/1000 part of a minute of position.

To optimise the choice of sentence utilised, it is necessary to refer to the operators manual for the particular navigation unit being employed, this may give a comprehensive NMEA structure listing enabling the operator to select GGA or RMC in preference to GLL, alternatively, by referring to the relevant appendix at the rear of this manual, the correct option may be identified. However if it is still not clear which interface sentences are transmitted by your navigator, it is possible to test each option in turn and confirm if the navigator position is repeated at the lower part of the screen whilst in magnetometer **display** mode.

NB. THE POSITION READINGS ARE NOT DISPLAYED UNLESS THE MAGNETOMETER IS FULLY OPERATIONAL AND UPDATING. EACH TIME THE MAGNETOMETER TAKES A NEW MEASUREMENT THE LAT/LON POSITION DISPLAY IS UPDATED.

The appropriate interface baud rate is set automatically when 0182 or 0183 is selected. The transmit baud rate is always the same as the NMEA input baud rate. The COMMS & NMEA SETTING menu shown indicates the current transmit (Tx) status as follows**: -**

B = 4800 (BAUD RATE)
D = 8 (NUMBER OF DATA BITS)
P = N (NO PARITY)
S = 1 (1 STOP BIT)

10.0 DATA OUTPUT

10.1 STYLE

The AX2000 can reproduce the survey data being transmitted in one of two different formats.

1. GRAPHICAL:

The AX2000 outputs the data in the form of a scrolling histogram annotated with the numerical magnetic deviations and position readings. (See fig.)

2. DATA STRINGS:

This option outputs the data in an alphanumeric sentence, which is similar to the NMEA standard and contains each magnetic deviation measured, together with the current boat position derived from the NMEA input (when available).

N.B. DATA STRING SHOULD BE SELECTED WHEN LOGGING DATA ON AQLOGEDIT SOFTWARE.

Return to the MAGNETOMETER MODE sub menu by holding down the "MEN" key.

11.0 DATA-LOGGING

11.1 DATA-LOGGING ON/OFF

Selecting this option either INITIATES logging of a new data set or terminates the data set currently being logged. NB. A shortcut to start and stop logging is by the use of the “1” keypad to start LOGGING and by use of the “2” key to stop LOGGING. Also note that a key press of about 1-second is necessary to ensure that the function is activated or de-activated – the “logging status” section of the display confirms this.

11.2 DATA SETS

The AX2000 automatically allocates a data set pointer to the set of data currently being logged. The data set pointer is a unique number allocated to the data set to aid the AX2000 in locating the relevant data in it's RAM (BATTERY BACKED MEMORY).
Because the data set number is unique it can be noted and used by the operator to reference the required data set. The AX2000 will increment the set pointer and allocate the new number every time logging is initiated.

The maximum data set pointer value is 99; once this value is reached the pointer will reset to and allocate 00 to the next data set opened. The numbering system allows a maximum number of 100 individual data sets to be logged, this is of course providing that the cumulative memory used does not exceed the 64k RAM (standard version) available.

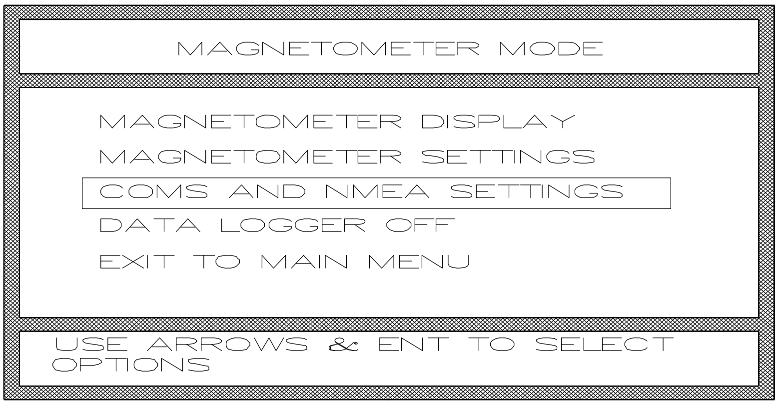
Data set title: Data Record 07
Polarise time: 2.0 sec’s
No. Of entries: 0019
Dev lat long
+00002,52.36.888N005.45.012E
+00001,52.36.894N005.45.012E
+00001,52.36.902N005.45.010E
+00000,52.36.902N005.45.010E
-00001,52.36.910N 005.45.010E
-00001,52.36.910N 005.45.010E
-00001,52.36.918N 005.45.008E
+00000,52.36.926N005.45.006E
+00003,52.36.926N005.45.006E
+00006,52.36.932N005.45.006E
+00011,52.36.932N005.45.006E
+00022,52.36.940N005.45.006E
+00024,52.36.940N005.45.006E
+00026,52.36.948N005.45.006E
+00022,52.36.948N005.45.006E
+00012,52.36.958N005.45.006E
+00008,52.36.968N005.45.004E
** End of data set **

The data on the previous page is part of a typical edited listing from a logged file; this file originally had a total of 119 readings. The highlighted reading is the most extreme result associated with an anomaly, and relates to the closest position obtained. Analysing the Lat./Lon readings shows that the course of the survey boat was predominately in a Northerly direction, to obtain a more true position the Latitude reading has to be modified by an amount that relates to the tow-fish cable length deployed.

11.3 START DATA-LOGGING

1. Highlight the option that reads **DATA LOGGER OFF**
2. Press **ENT**
3. The option should now read DATA **LOGGING ON**.

All measurements will now be logged to a data set held in the system RAM (battery backed MEMORY).



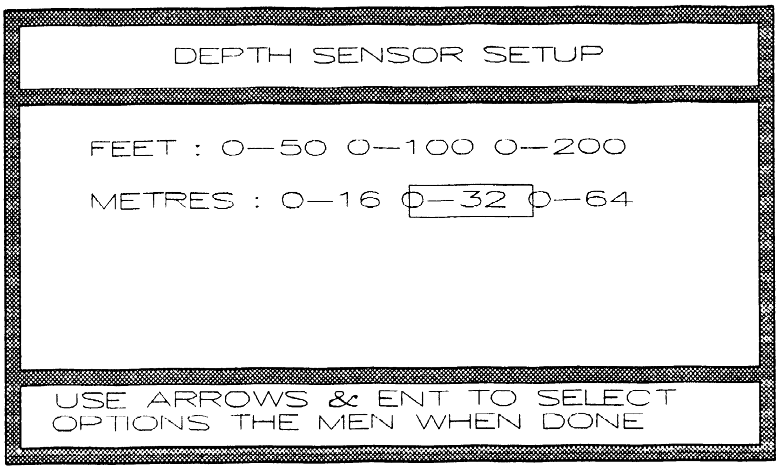
11.4 STOP DATA-LOGGING

1. Highlight the option that reads **DATA LOGGER ON**
2. Press **ENT**
3. The option will now read **DATA LOGGER OFF.**

11.5 START/STOP (QUICK KEY) LOGGING

Data-logging can be more readily stopped & restarted during magnetometer operation by pressing the "1” key to start and "2" to stop, data-logging status is displayed in the usual manner.

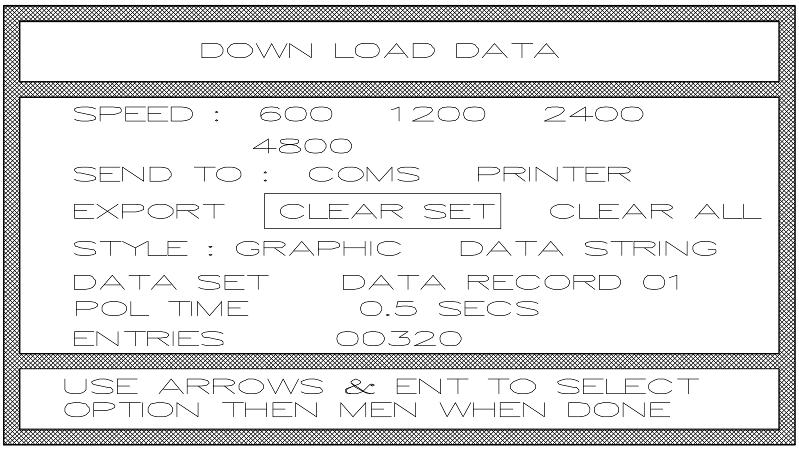
12.0 DEPTH MONITOR SETTINGS



The above menu selection allows for the units displayed to be selected as feet or metres, this is effected by highlighting the required range in the relevant units and pressing the **ENT** key followed by the **MEN** key to return to the MAGNETOMETER MODE MENU.

13.0 DOWN LOADING DATA

The AX2000 can export the contents of any logged data set to either a printer or a PC.



To export any of the data sets, select **DOWN LOAD DATA** from the **MAIN MENU: -**

13.1 SPEED (BAUD RATE)

The AX2000 can support communication speeds between **600** and **4800** baud

1. Highlight the required transmission speed

2. Press **ENT** to select

13.2 SEND TO

1. Highlight the required peripheral

2. Press **ENT** to select

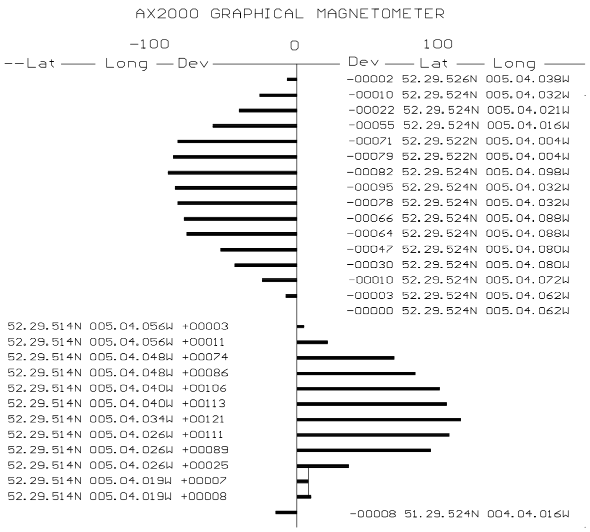
13.3 STYLE (DATA)

The AX2000 can EXPORT the data set in one of two formats: -

A. GRAPHICALLY - in the form of a histogram, this presentation gives an easier format to visually analyse results for anomalies and to determine the degree of editing that may subsequently required for a particular survey data-set.

B. **DATA STRING** - ASCII data in the form of a NMEA sentence, this is a more practical form for archiving or loading in to a PC for subsequent editing, filtering and mathematical manipulation for enhanced presentation.

1. Highlight the required format
2. Press **ENT** to select



Data set title: Data Record 07
Polarise time: 2.0 sec's
No. Of entries: 00109
Dev. Lat. Lon.

+00000,52.35.874N001.45.004E
+00000,52.35.888N001.45.012E
+00002,52.35.888N001.45.012E
+00001,52.35.894N001.45.012E
+00001,52.35.902N001.45.010E
+00000,52.35.902N001.45.010E
-00001,52.35.910N001.45.010E
-00001,52.35.910N001.45.010E

TYPICAL GRAPHICAL FILE **TYPICAL ASCII FILE**

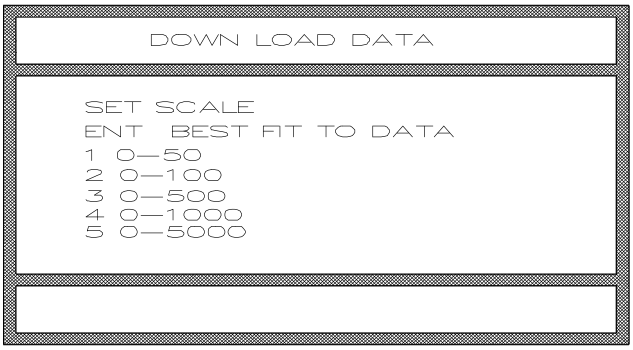
13.4 DATA SET

To select the DATA SET to EXPORT/ERASE:

1. Highlight data set
2. Press CURSOR LEFT/RIGHT until the relevant data set number is shown

13.5 BEST FIT TO DATA

When downloading information graphically the AX2000 now prompts the user to enter a choice of scale to print the data.



Pressing the ENT key instructs the AX2000 to automatically select the best-fit scale for the data to be printed on. The AX2000 achieves this by searching through the file to be printed, for the largest deviation. If possible, the scale selected will allow this maximum deviation to be printed.

1 - 5

Pressing any one of the numbers between 1 and 5 will select the scale opposite that number, this function allows the operator to examine the smaller detail sometimes lost when the same data is printed out on a larger scale.

13.6 EXPORT (DATA)

To EXPORT the data set:

1. Highlight EXPORT
2. Press ENT

The AX2000 responds by exporting the relevant data set in the format defined by the previous stages.

13.7 CLR

To halt transmission at any point hold down the **CLR** button.

13.8 CLR SET

To ERASE any particular data set from memory:

1. Select the data set to **ERASE**
2. Highlight **CLEAR SET**
3. Press **ENT**

13.9 CLEAR ALL

To ERASE ALL of the logged data from memory:

1. Highlight **CLEAR ALL**
2. Press ENT

WARNING:

ONCE THE MEMORY HAS BEEN CLEARED BY A "CLEAR ALL" FUNCTION THERE IS NO WAY OF RETRIEVING THE DATA THAT HAD BEEN PREVIOUSLY LOGGED.

NOTE:

The data set numbers do not reset to "0" when CLEAR ALL is selected, even though the total memory space of the AX2000 is available for logging.

The data set number retains its arithmetic progression to "99" before resetting to 0.

14.0 CONDUCTING A SEARCH

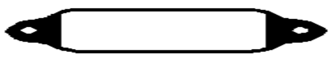
14.1 DEPLOYING THE TOWFISH

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***:



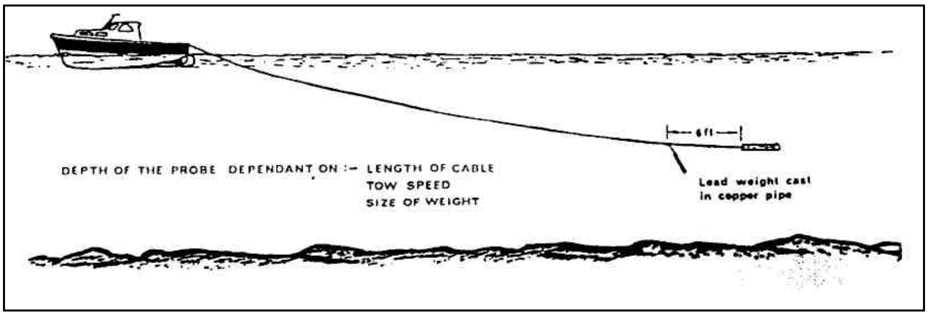
The anticipated minimum depth of water, including any potential hazards that could allow the tow-fish to snag has to be taken account of. The tow-fish has a natural tendency to sink, particularly at low speeds and related to the amount of cable deployed. To eliminate the possibility of snagging, particularly 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 8 for a change in proximity of a factor of 2.

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.

14.2 SEARCH METHODS & CONSIDERATIONS

A number of search patterns and methods exist for the magnetometer survey; these options are outlined in the following paragraphs. 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.

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 existing of other detectable material within the search area or closely 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:

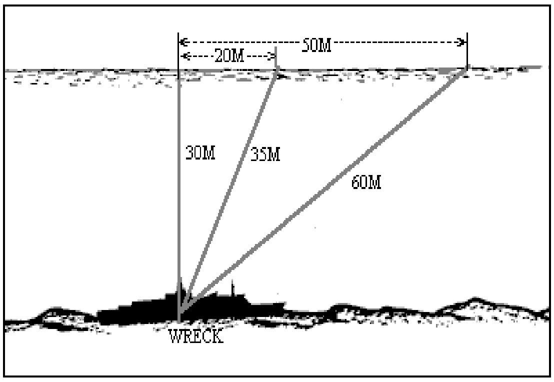
a. The survey is fully data-logged to allow an accurate assessment both during and subsequent to the search.

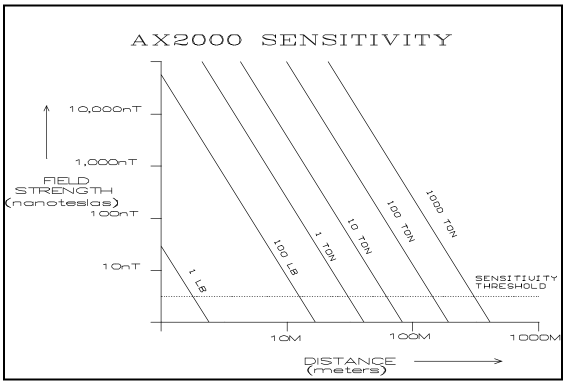
b. The survey is carried out to a standard guaranteeing that, should the target not be located within the prescribed area, then the ground covered can confidently be eliminated from any future search activity.

14.3 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 - 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.

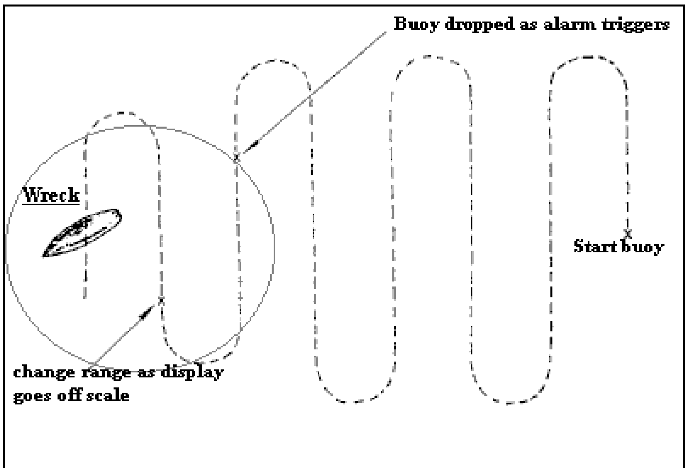
The above calculations have assumed that the tow-fish is deployed either at or near the surface, however, It will be readily observed that as the depth increases for a given target size the corresponding horizontal component of the sensing distance reduces accordingly. In situations where the depth of 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.

15.0 SEARCH PATTERNS

15.1 LANE SEARCHING

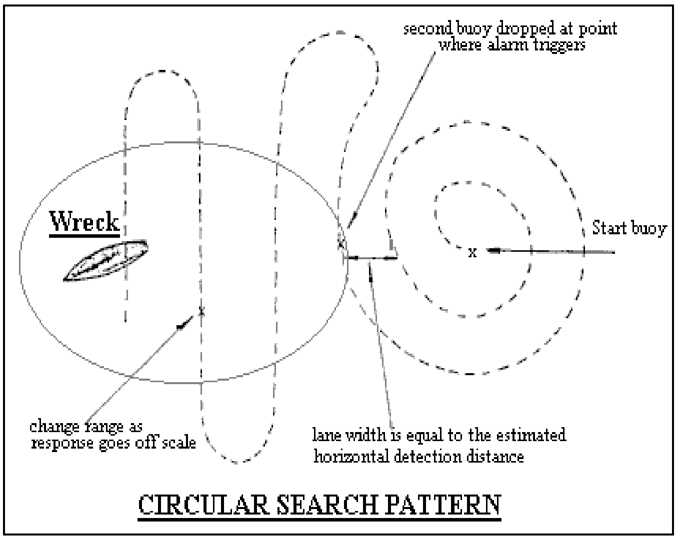
The most common and practical survey method is by means of the parallel lane search in N/S - E/W runs, where a predetermined lane length and calculated spacing is implemented. Lane integrity is maintained by relating the required spacing to decimal parts of units of Lat. & Lon, as a for instance if a 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 Metre 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.



PARALLEL LANE SEARCH

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.



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 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.

15.2 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.

APPENDIX I - 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. N.B. The demand on the battery alternates between a few hundred mA and a current in excess of an amp during the Polarise phase.

2. Check the condition of the Phono insert of the Towfish Connector and the mating insert on the rear of the AX2000 Display.

- If one or both of the connectors is badly corroded or loose fitting then they should both be replaced - the system is supplied with a spares kit containing these inserts. (See Appendix V)

N.B. An authorised Aquascan service agent or a suitably qualified person should carry out this work. Please contact your nearest Service Agent or the Aquascan support department before any work is carried out.

.

3. Check the resistance across the Towfish Phono Connector: -

- Connect a good quality multi-meter across the core (inner pin) and metal outer contact (screen) on the Phono plug and check the resistance, You should see a reading of about 9 to 15Ω depending on the actual sensor fitted and the cable length.

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 - irrespective of Area tune selection***

Check the following:-

1. Check to see if excessive noise is affecting the signal: -

- Under conditions described in section 7.5 for setting up the Area Tuning, place a ferrous metal object on top of the towfish and check to see if the signal level drops. Under normal conditions putting a piece of ferrous metal in close proximity will dramatically reduce the signal level. If the signal level remains high then background noise may be causing the problem (see next page).

Potential Noise Sources & recommendations for elimination

A. ***Generator or other electrical noise on the power source*** - It is highly recommended that you use a totally independent & fully isolated battery. An additional improvement can very often be obtained by use of a Sea Earth, this is a direct connection between the ground (-ve) battery terminal and the seawater. A piece of stainless steel or bronze inserted into the water and coupled to the battery with a copper or stainless wire will suffice - the metal contact can be hull mounted or can even be loosely coupled to the towfish cable behind the vessel.

B. ***Electrical noise coupled into the cable*** - The Towfish cable routing can be a critical issue for obtaining an optimum magnetometer performance. Ensure that the cable does not run parallel to any other cables that carry high level noise - such as generator or echo sounder cables. Ensure that the cable does not pass close to an outboard engine. Ensure that any excess cable that is not paid out over the stern is coiled in a "figure of eight" pattern - this ensures a high level of noise cancellation. Experiment with various cable routing options and note the

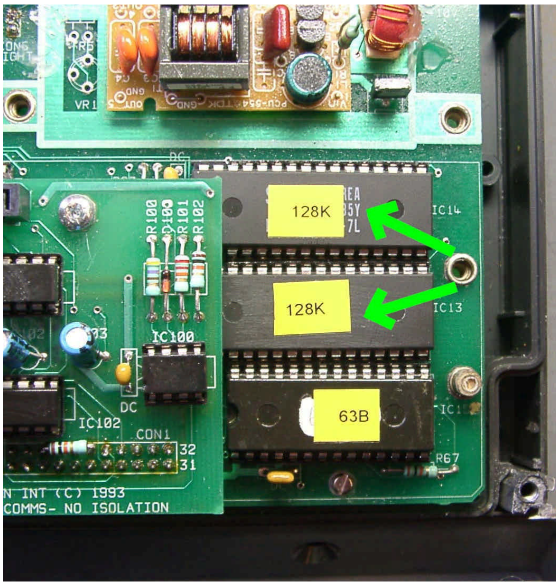
2. Check the integrity of the cable insulation.

- Feed the entire length of the cable into the sea and measure the resistance between the screen contact of the Towfish connector and a probe placed into the sea. If you measure less than 1MΩ , the cable insulation may have been damaged. The cable should be laid out and carefully 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.

.

APPENDIX II – AX2000 RAM INSTALLATION



The arrows above show the position of the RAM chips in an AX2000 PCB.

1. Make sure all power is disconnected from your AX2000 display unit.

2. If there is already a RAM chip installed, gently prise the existing chip from the DIL Socket using a flat blade screw driver or similar tool.

Note : Make sure the chip is lifted up level at all times as lifting it up at an angle will cause pins to bend and this can severely damage the chip.

3. Once you have removed the old RAM chip, gently slot the new chip into position.
4. Make sure all of the chip pins are lining up with the DIL socket pins and ensure the chip is orientated correctly.

5. The AX2000 Display should now be ready for testing out the new RAM.

APPENDIX III – AX2000 DATA FORMAT

The following format is output by the AX2000 family of magnetometers at 4800 baud via an opto-isolated RS232 port:-

```
                            Tow    depth
Header    Mag      lat   lon   Depth (DBT)

$AXMGD,-00010,5135.106,N,00259.698,W,0.0,14.0
$AXMGD,-00010,5135.116,N,00259.688,W,0.0,14.6
$AXMGD,-00010,5135.126,N,00259.678,W,0.0,14.9
```

The last two fields are only available in the AX2000DES/DET & AX2000PES/PET versions, these include the towfish depth monitoring facility, the last data field is provided by a combined source that provides depth ($SDDBT) in addition to a standard positional sentence. Alternatively a special combining circuit can be supplied by AQUASCAN that will pre-combine the data strings from a GPS & sounder that have the relevent NMEA data strings available.

APPENDIX IV – WORLD IPA-3 MODULE ZONES

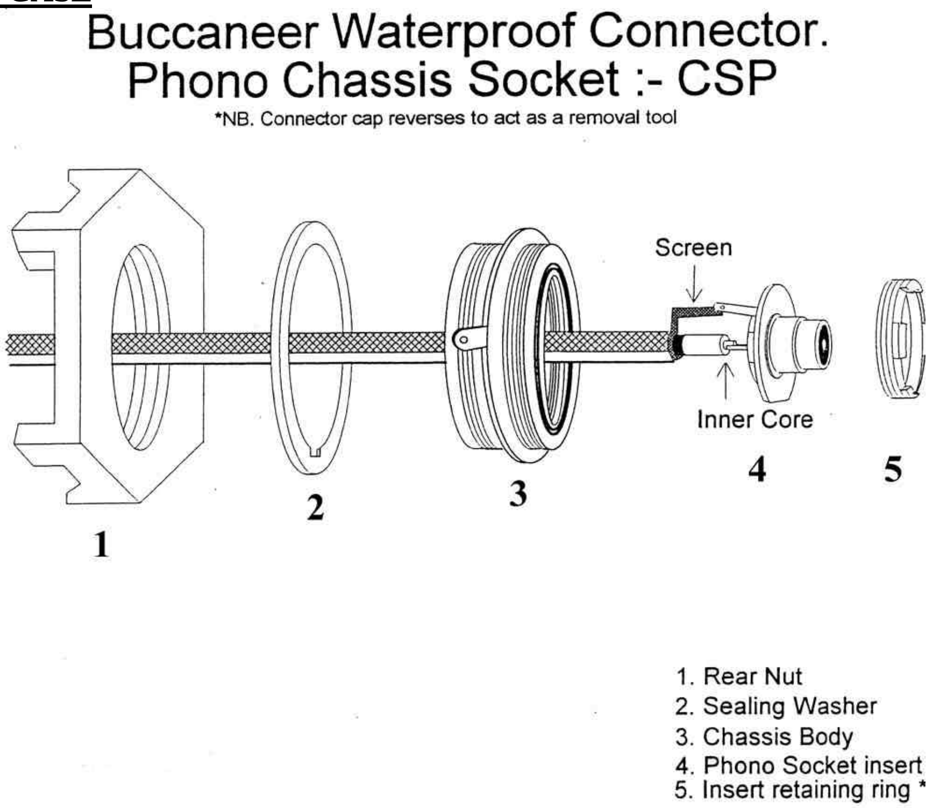
There are five standard types of IPA-3 Module which enable optimum operation of your AX2000 in all magnetic zones of the world. Below is a list of options available.

MODULE	STEPS	FROM	TO
T-A	5nf	64,074 2728	52,048 2216
T-B	6n8f	52,215 2224	43,029 1832
T-C	6n8f	43,452 1851	37,815 1610
T-D	10nf	38,707 1648	32,765 1395
T-E	15nf	33,000 1405	27,480 1170

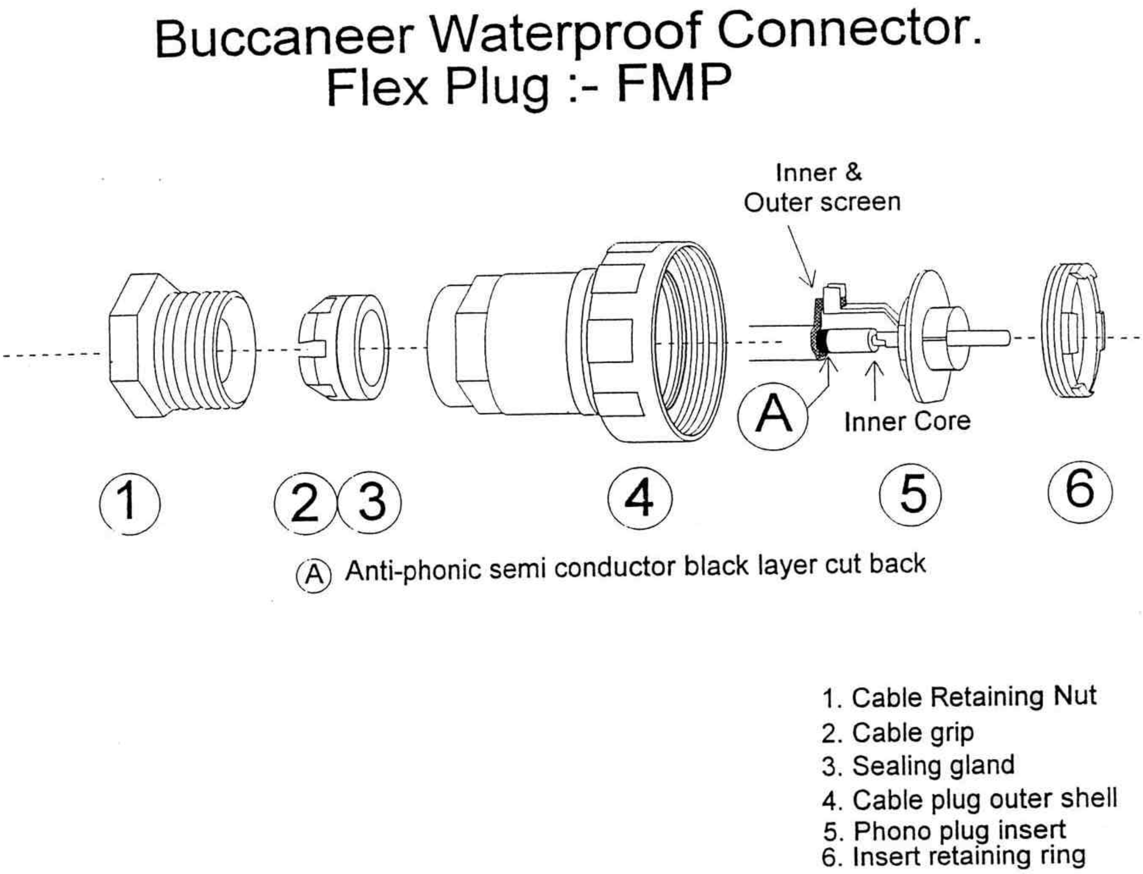
N.B. For more specific requirements please contact your nearest service agent or the support department at Aquascan International Ltd

APPENDIX V – SERVICING PHONO CONNECTORS.

REAR OF CASE



TOWFISH CABLE



APPENDIX VI – 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 255645
+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

Alternatively

Web Address: www.aquascan.co.uk