



Aquascan International Limited

UNDERSEA DETECTION EQUIPMENT

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X25 PROTON MAGNETOMETER

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Operating Instructions

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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 much cheaper 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 quite cheaply.

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 X25 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 X25 is simple operation. This has been achieved by using a microcomputer to control the operation of the magnetometer.

PRINCIPLE OF OPERATION

The principle of operation of a proton magnetometer is unlike that of conventional hand held metal detectors. These detectors produce their own dynamic magnetic field and detect disturbances in the field caused by metal objects. This time varying magnetic field only extends about 2 metres from the search coil, so consequently the maximum detection range for large metal objects is still only about 2 metres. Their main advantage over a proton magnetometer is that by generating a time varying magnetic field non ferrous metals can be detected. The physical principles on which these detectors work is outside the scope of this article.

A proton magnetometer for wreck location measures the strength of the earth's magnetic field and for this it is extremely sensitive. The earth's field is a static field and because many non-ferrous metals do not 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 if it is attracted to a bar magnet then it can be detected. The proton precession magnetometer is so named because it utilises the procession of spinning protons in a sample of hydrocarbon fluid to measure the strength of any magnetic field through the fluid. In practice the sensor consists of a bottle of hydrocarbon fluid (i.e.kerosene) around which is wound a coil of wire.

To measure the earth's field, the fluid must first be polarised for a few seconds. The polarise state consists of connecting the coil to a battery which 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 process about the direction of the earth's magnetic field. The processing protons generate a small signal of approximately one microvolt in the coil, and 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 known as the gyromagnetic ratio.

POLARISE STATE

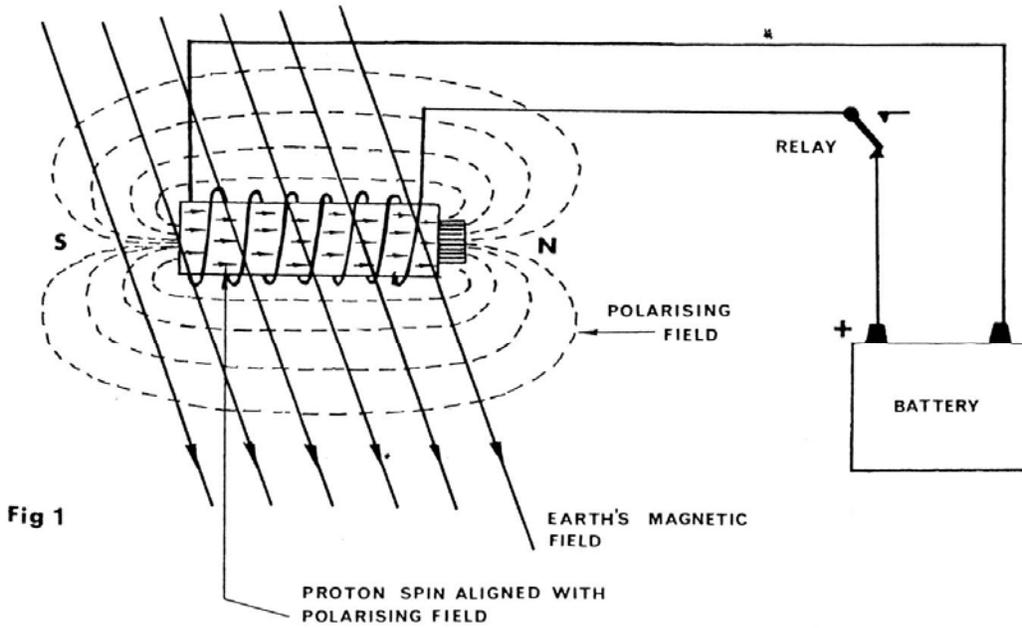


Fig 1

DETECTION STATE

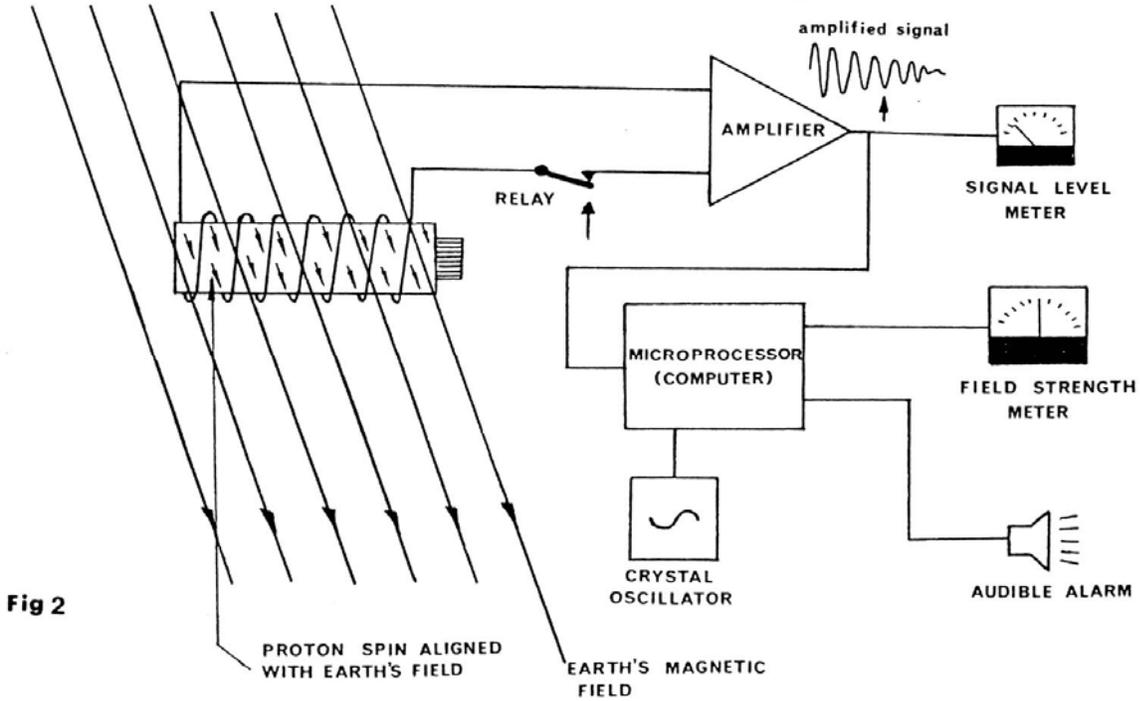


Fig 2

X25 Proton Magnetometer User Manual



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After the battery is disconnected the amplitude of the precession signal slowly decays over a few seconds, as the signal from the individual protons gradually lose phase coherence. The magnetometer must resolve the frequency of this signal within a few seconds of switch off. This is the Measurement State (FIG 2) and during this period the search coil is connected to an 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.

The use of a microcomputer makes it possible to program 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 X25 to make very accurate measurements which can be stored as data in the microcomputer's memory to be compared with previous measurements. The microcomputer is programmed to control the bleeper and meter if the change in magnetic field strength is detected.

MAGNETIC ANOMALIES CAUSED BY FERROUS OBJECTS

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

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 indicates the strength of the magnetic field at any point, and shows the field is stronger at the poles. When a ferrous object is placed in the magnetic field the lines of flux are distorted and become concentrated through the object. It is the ability of a material

to concentrate the field which is termed its permeability. The object will also possess its own permanent magnetization and this results in a greater flux density around the object.

The earth's magnetic field is similar to that of a bar magnet with the maximum strength at the 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 nanoteslas (nT) or gammas ($1\text{nT}=1\text{gamma}$). 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 but inclined at 70 degrees. Although the earth's field varies by 3000nT over the UK it can be considered uniform over the area of search.

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 probe 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 7 shows the relationship between distance and the theoretical maximum anomaly amplitude that would be measured by the probe, for various 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. While a steel wreck can cause magnetic anomalies extending to several hundred metres from the wreck site, smaller objects such as cannons, pipelines etc, cause more localised anomalies. The earth's magnetic field is unaffected by sand and mud and therefore the detection distances indicated above also apply equally to wrecks buried below the seabed.

Fig 3

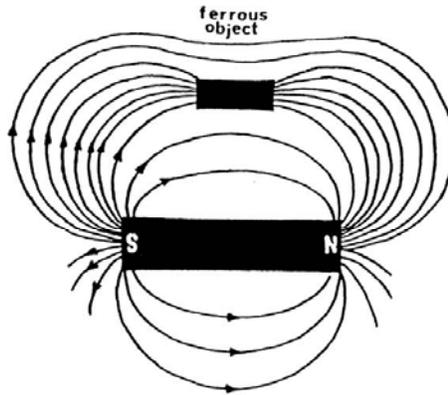


Fig 4

EARTH'S MAGNETIC FIELD

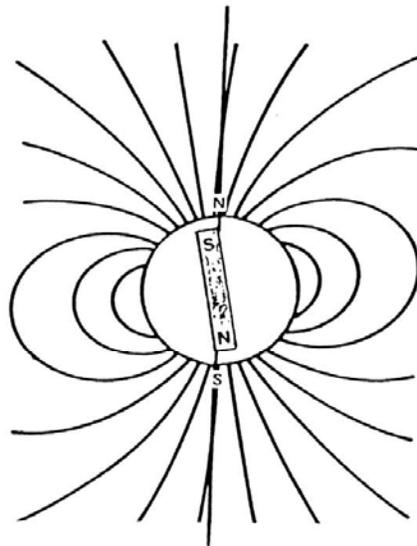
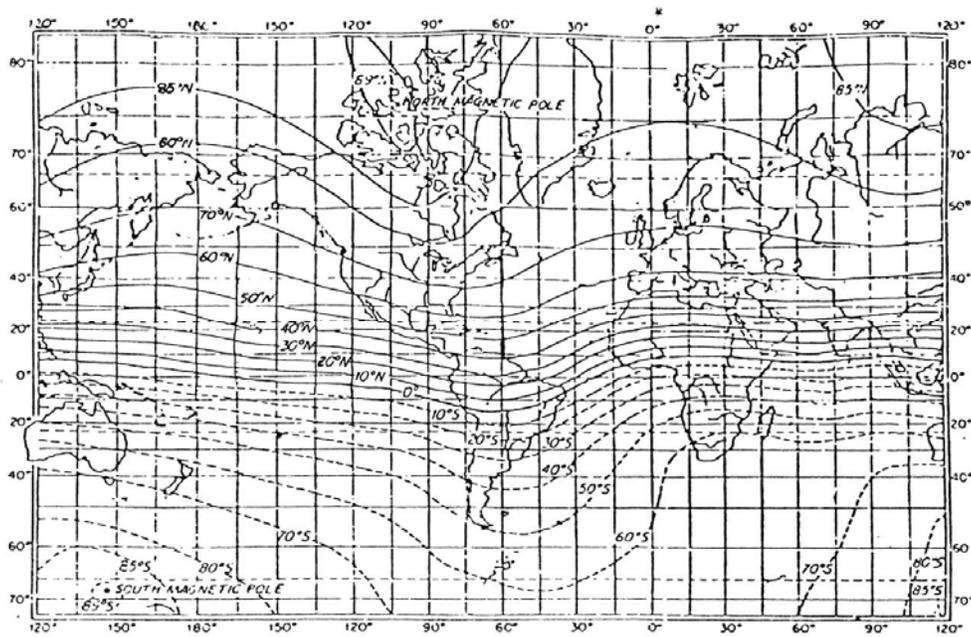
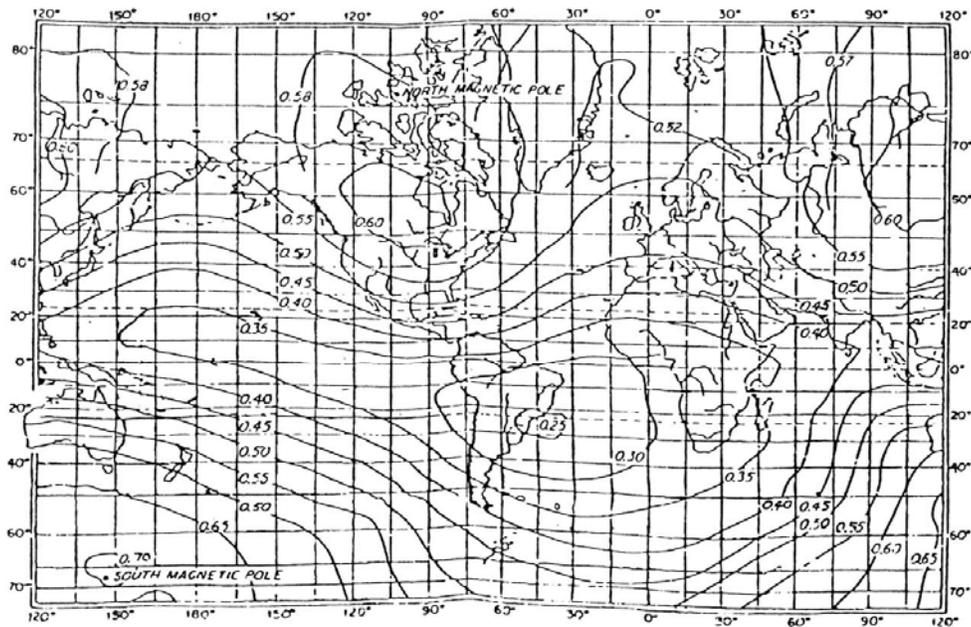


Fig 5



LINES OF EQUAL INCLINATION



LINES OF CONSTANT FIELD STRENGTH
(x1000 nanotesla)

Fig 6a

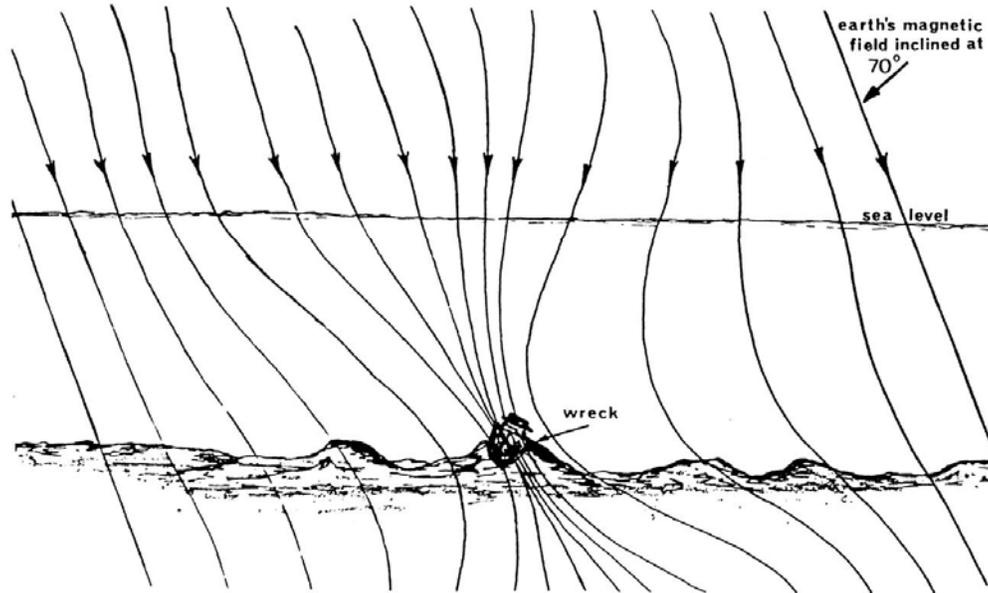


Fig 6b

PLOT OF MAGNETIC FIELD STRENGTH
AGAINST DISTANCE FROM THE WRECK

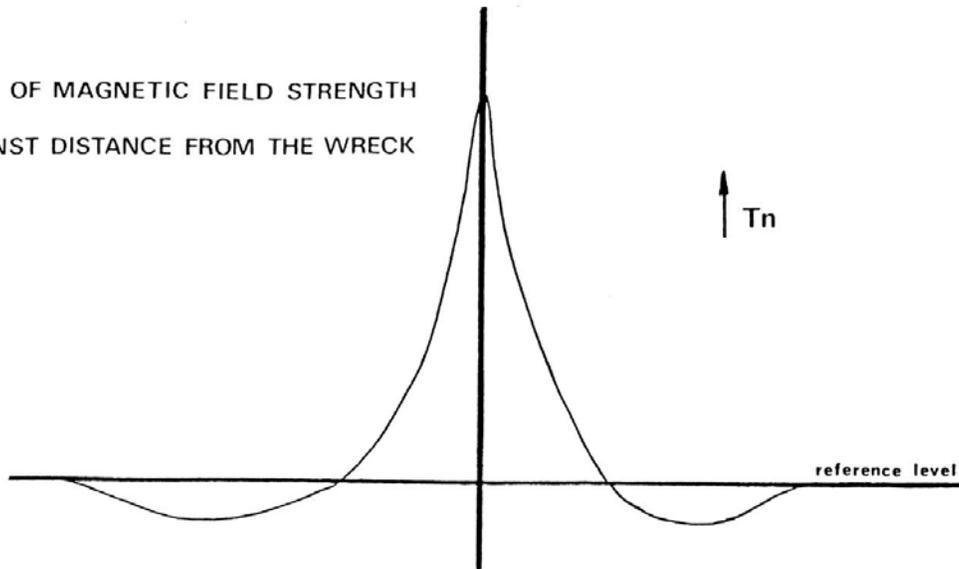
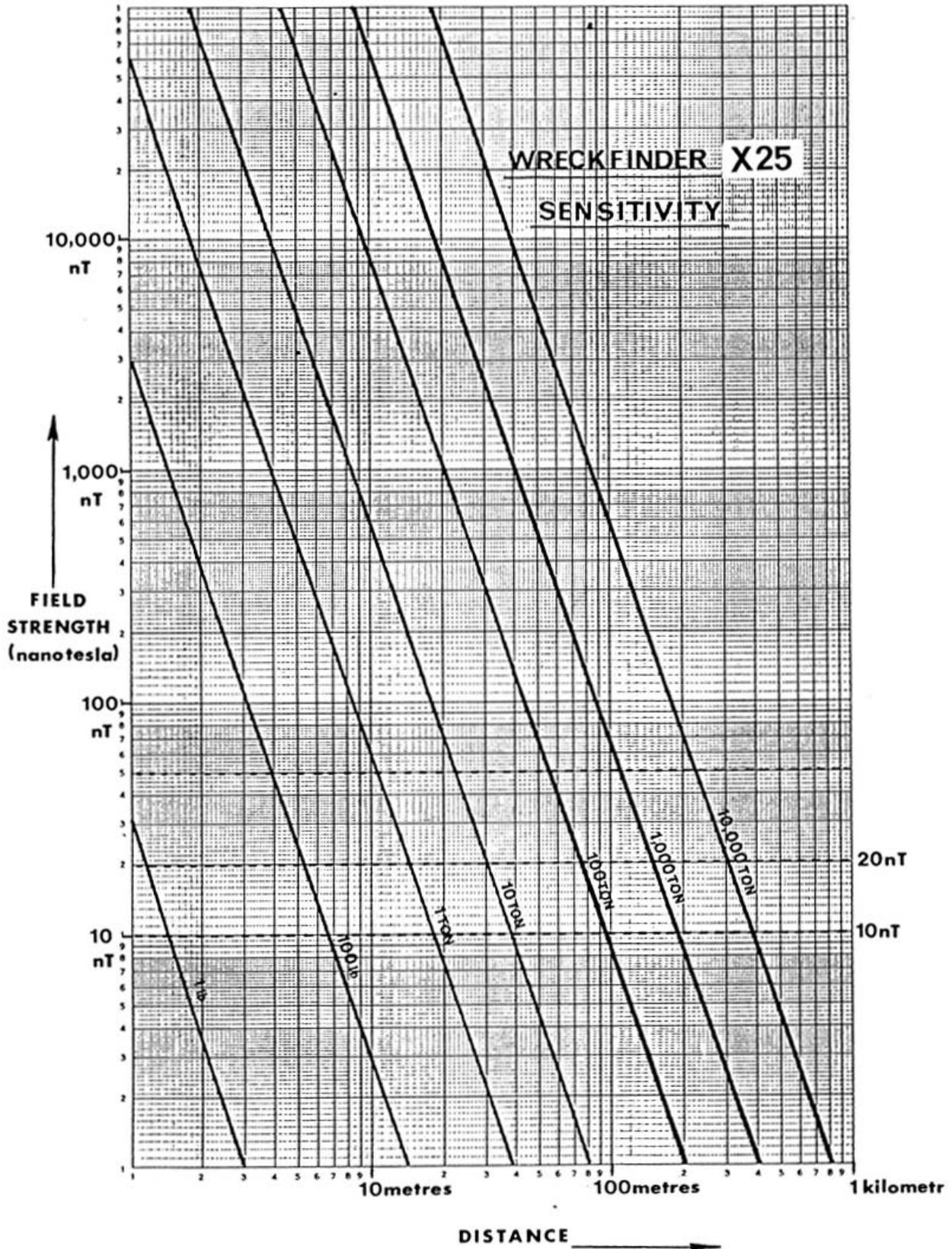


Fig 7





SETTING UP PROCEDURE

The X25 consists of two units; the search head (or probe) which is towed behind the boat and the electronics control box which remains in the boat. Before the X25 can be used to search a particular area the unit must be set up for maximum signal. The earth's magnetic field varies with geological position and therefore the magnetometer will require tuning for your area. Normally retuning is not necessary within a 20-30 mile radius of the initial tuning position. The following section describes the setting up procedure.

The magnetometer can only be used to search for ferrous materials or compounds, and for this purpose it is extremely sensitive with 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 the boat is at least 100 yards from the nearest power line or building. Trail the probe behind the boat and position the electronics unit so that you can see the meter clearly.

Switch the control knob to the "TUNE" position. The first thing you will notice is that the small meter needle will deflect across the scale every 2.4 seconds. Adjust the "AREA TUNE" control one position each time the meter deflects and observe the maximum reading. Find the position that gives the maximum deflection on the meter, the signal level should deflect into the green area on the meter scale. If this does not occur it may indicate that the battery is low and should be recharged before use. If all is well the magnetometer is now set up for your area. If you now switch to the "DETECT" position, the magnetometer will now calibrate itself to the local magnetic field strength and will set the large meter to centre scale. The field strength measured at calibration is stored in the computers memory and all subsequent measurements are compared with this value to determine the magnitude of any field disturbances. After each measurement the bleeper will give a number of bleeps if there is any iron in the detection range of the probe. The magnitude of the anomaly is also shown on the meter. A single bleep indicates no significant anomaly but shows the X25 is working correctly. The number of bleeps can vary between 1 to 36 in each 2 sec polarise period, depending on the size of the anomaly, also a continuous alarm indicates metal directly below the probe. You should now understand the basic setting up procedure. It is not necessary to repeat this procedure each time you switch on, provided you operate within 20 miles of your original setting up point. Just switch to the "DETECT" position directly.



CONDUCTING A SEARCH

During search operations the probe is towed behind the boat at sufficient distance to avoid detecting any metal on the boat itself. The probe can be towed at speeds up to 5 knots. Always pay out all of the cable as any cable left lying on the deck may get damaged. Take great care of the cable, as damage will result in malfunction of the magnetometer.

A check should be made to determine if the probe is detecting metal fittings on the boat. Choose an area where there are no wrecks or ferrous objects. Steer the boat on a straight course with the magnetometer setup as described and in the "DETECT" position; there should be only a little variation of the field strength reading. The boat should now be turned to both port and starboard. If the probe is detecting the boat this will be seen as deflection on the meter as the boat turns. If this is greater than 10 or 15 nT then 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 all is working well, the magnetometer should be giving only a single bleep, after each measurement is made. If the boat is now steered towards a wreck the number of bleeps will gradually increase as the wreck is approached. By observing the meter scale, the size of the maximum anomaly can be seen. This is a good indication of how near the wreck is; a typical example is a wreck of 1000 tons in 30 metres of water, should give a reading greater than 500nT when the probe is overhead.

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. For small ferrous objects try detecting marker buoys etc.

CAUTION

- 1. THE X25 PROBE CONTAINS KEROSENE AND THIS MUST NOT BE ALLOWED TO FREEZE.**
- 2. TAKE CARE TO AVOID FORMING SHARP BENDS IN THE TOW CABLE AS THIS CAN DAMAGE THE OUTER SHEATH.**
- 3. ALWAYS USE A TOWROPE FOR SPEEDS IN EXCESS OF 5 KNOTS.**
- 4. IN SOME CASES IT MAY BE DESIRABLE TO CONNECT THE X25 INTO THE BOATS POWER SUPPLY. IN GENERAL THIS PRESENTS NO PROBLEMS AND THE POWER LEAD SHOULD BE FUSED WITH A 3 AMP FUSE. IF HOWEVER THE MAGNETOMETER MALFUNCTIONS AN IN LINE POWER FILTER (AVAILABLE FROM AQUASCAN) WILL BE REQUIRED.**
- 5. THE X25 USES WATERPROOF CONNECTORS TO CONNECT THE EXTERNAL POWER TO THE MAGNETOMETER ELECTRONICS UNIT. THE PLUG AND SOCKET WITHIN THE WATERPROOF CONNECTORS MUST BE KEPT DRY AT ALL TIMES. REPLACE THE PROTECTIVE CAPS IMMEDIATELY THE POWER LEAD-IS DISCONNECTED FROM THE ELECTRONICS UNIT.**



SUMMARY OF X25 OPERATING INTRUCTIONS

SETTING UP PROCEDURE

- a) Trail probe (fish) over stern of operating vessel.
- b) Se-b the 'Area tune' switch to relate to your working area.
note.'A' is the most Northerly area - 'R' is most southerly.
- c) Set the 'Control' switch to 'Tune' - the meter will indicate the signal strength every 2 seconds. Rotate the 'Area Tune' switch one position at a time to determine the strongest signal- this should be in the green sector of the scale.
e.g. H J or K are the typical settings for the UK south coast (with the standard Northern Europe calibration).
- d) Once the correct tuning position is established - turn the 'Control Knob' to the 'Detect' position, the meter should give 1 more tuning indication followed by a centre scale ('0') reading - the unit is now calibrated and will update every 2 seconds.
- e) The meter reading should stay within a couple of divisions of the '0' position for subsequent updates with a single 'bleep' indicating each valid update.
- f) Deviations either +ve or -ve together with an increase in the 'bleep' rate indicate that changes are occurring the the magnetic field strength measured - these changes will vary considerably depending on the nature of the object or cause of the anomaly.

NB. ATHOUGH THE MAGNETOMETER CAN BE USED WITH GOOD EFFECT ON LAND THIS IS ONLY VALID FOR AREAS AWAY FROM BUILDINGS AND SOURCES OF ELECTRICAL INTERFERENCE. THE CLOSE PROXIMITY OF THE PROBE (FISH) TO FERROUS OBJECTS WILL ALSO ADVERSELY AFFECT THE SIGNAL LEVEL AND HENCE THE ABILITY OF THE MAGNETOMETER TO UPDATE (A PERSON HOLDING THE PROBE DURING SETTING UP OR DETECTION ON LAND SHOULD REMOVE SUCH ITEMS AS WRISTWATCHES BELT BUCKLES ETC. IT IS ALSO ADVISABLE TO MAINTAIN THE HEIGHT OF THE PROBE AT LEAST 1M ABOVE THE GROUND TO AVOID THE EFFECTS OF MAGNETIC PARTICLES IN THE SOIL.



CHARGING

The X25 should be recharged as soon as possible after each period of usage, this maintains the battery in a healthy condition and guarantees the optimum working life.

The magnetometer is charged with the 'Control Switch' in the "off" position, the charging unit should be fitted with a 13A or otherwise suitable position, the charging unit should be fitted with a 13A or otherwise suitable connector, charging time should be based on a ratio of about 3 to 1, i.e. 2 hours usage should be compensated by about 6 hours charge. If the battery is completely flattened it should be recharged for a minimum of 12 to 14 hours and at the earliest opportunity - preferably within 24 hours.



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:

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Website: www.aquascan.co.uk

X25

PROTON MAGNETOMETERS



Features

- ◆ **EASE OF OPERATION**
- ◆ **POSITIVE WRECK LOCATION**
- ◆ **COMPACT AND PORTABLE**
- ◆ **ROBUST AND RELIABLE**
- ◆ **RECHARGEABLE**
- ◆ **HIGH SENSITIVITY**
- ◆ **HIGH INTERFERENCE IMMUNITY**
- ◆ **RELATIVE LOW COST**

Applications

- ◆ **Fishing** — Easy location and relocation of new and existing deep water wrecks.
- ◆ **Diving** — An essential piece of equipment for diving clubs and wreck enthusiasts.
- ◆ **Salvage** — An essential piece of equipment for positive location.
- ◆ **Survey** — Locations of pipelines etc. on land or sea.

General Description

The X25 has been specifically designed for wreck location and is ideal for the amateur diver/fisherman operating from a small boat. Simple operation is a major feature of this design, with the use of advanced CMOS microprocessor technology only two controls are necessary.

Detection

Any ferrous object or mass — ranging from a few iron cannon balls or ballast ingots up to a large steel hull will cause localised magnetic variations in the earth's magnetic field. These variations can extend up to hundreds of metres for very large iron and steel objects.

The "AQUASCAN" X25 has the ability to measure these variations in magnetic field strength and hence detect both the presence and exact locations of a wide range of ferrous objects.

Physical Description

The X25 consists of a toroidal sensing head (fish) which is towed behind the boat and is coupled by a highly durable cable to the control box. This bright yellow box is made from high impact ABS, is completely splashproof and houses both the electronics and rechargeable battery. A mains recharger is also supplied. (110V AC option available).

Operation

With the fish trailed out over the stern of the boat the X25 is prepared for searching as follows:-

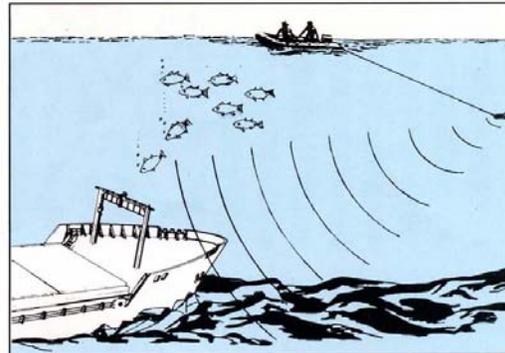
1. Maintain a straight course well away from known wrecks.
2. Set the control switch to 'tune' and adjust the AREA TUNE switch to obtain maximum deflection on the meter.
3. Switch to 'detect' — the X25 now automatically calibrates itself.
4. The X25 is now ready for searching. Note any change in the number of bleeps, and steer boat to obtain maximum bleeps/meter deviation.

Performance Data

The high sensitivity of the X25 enables a wreck to be detected up to 200 metres away; once detected the wreck can be easily homed onto. When a wreck is detected the audible bleeper indicates how close the wreck is. A varying number of bleeps per second are given depending on the closeness of the wreck (target). The size of the magnetic anomaly is also indicated on a large moving coil meter; this gives a good guide to the amount of metal below the tow fish when read in conjunction with the graph supplied.

Specification

Tune Range	Can be preset for any area of the world.
Sensitivity	2nT (gammas) resolution.
Audible Alarm	1 to 20 bleeps/2 secs up to 1000nT — continuous above.
Meter Scale	0 to + or — 1000nT (centre zero) logarithmic scale.
Power Supply	12 volt internal 6Ah battery giving 3 hours continuous use or external 11 to 14.5V at 1.5 Amp.
Charger	Constant voltage.
Cable	20 metre length.



1. Detection Range:

MAXIMUM DETECTION DISTANCE/MASS	
FERROUS MASS	DISTANCE (metres)
1 ton	15 m
10 ton	32 m
100 ton	70 m
1000 ton	150 m
10000 ton	300 m

Note: Due to variation in shape orientation, distribution and permeability of ferrous material only an approximate distance can be estimated for detection of various objects.

2. Battery Life:
3 hours continuous between charges.

Physical Data

DIMENSIONS (mm)		WEIGHT
BOX	250 × 200 × 200	5kg
FISH	280 × 910 × 190	5kg
CABLE	2500 × 7.5 (dia)	4kg

