ENGINEER COURSE

PACKET

3

Basics of Magnetic Silencing

SS WB

SELF-STUDY WORKBOOK

MAGNETIC SILENCING

FOR OFFICIAL USE ONLY

RECORD OF CHANGES			
Correction or Change No.	**Date of Change**	**Date Entered**	**By Whom Entered**

PACKET 3

BASICS OF MAGNETIC SILENCING

SECTION I

A. OBJECTIVES: Unless otherwise specified, the following objectives will be accomplished with the conditions and standards described in Packet l.

1. Describe the difference between a ship's permanent and induced magnetism.

2. Explain the relationship between the ship's magnetic field and the Earth's magnetic field.

3. Label the components of a ship's magnetic field and the corresponding shipboard degaussing coils.

4. Explain the application of electromagnetism as used to compensate for components of a ship's magnetism.

5. Explain the relationship between a ship's external fields and corresponding degaussing coils.

6. Explain the purpose of, and procedure for, accomplishing deperming and flash deperming.

7. Display a knowledge of the background of magnetic measurement of ships by describing the basis of measurements and the types of measurement equipment.

B. REFERENCE

- NAVSEA S5475-AF-GTP-010/INT HIST MSIL, Introduction and History of Magnetic Silencing (Reference No. 4)

C. PREREQUISITES

1. Completion of Packets 1 and 2.

PACKET 3

BASICS OF MAGNETIC SILENCING

SECTION I

D. OVERVIEW

1. This packet develops the relationship of the Earth's magnetic field to the magnetism of a ship's steel hull, and introduces the defenses required for mine warfare. Methods to reduce a ship's magnetism by shipboard degaussing coils are explained.

2. Information Sheet No. 3-1, Magnetics of Ships, gives details of ship magnetism. Information Sheet No. 3-2, Magnetic Silencing Techniques, presents basic information on magnetic silencing fundamentals. Information Sheet No. 3-3, Magnetic Measurements of Ships, provides background knowledge of the basis of measurements and measurement equipment. Diagrams 1 through 4 illustrate important concepts discussed in the Information Sheets. These sheets contain all of the necessary information to complete the packet.

3. Assignments 1 and 2 test your knowledge of magnetics of ships and magnetic silencing techniques. When you have completed these assignments, turn them in to your supervisor for correction.

4. For this packet, you will need only reference 4 and the materials contained herein.

PACKET 3

SECTION II

INFORMATION SHEET NO. 3-1
TITLE: Magnetics of Ships

Ship in Earth's Field

A ship is a large magnet because magnetic material, steel, is used in its hull and machinery. It has permanent magnetization like that of a permanent bar magnet, and induced magnetism like that induced in soft iron when placed in a magnetic field. The permanent magnetization is reasonably independent of the ship's heading and its position on the Earth's surface, but changes slightly with time. The induced magnetism depends upon the ship's heading and the Earth's magnetic field where the ship is located, and changes when the ship changes heading or moves to a place where the Earth's magnetic field is different. Chapter 3 of reference 4 gives additional information on magnetics of ships.

1. Susceptibility. The measurement by which intrinsic induction (B) relates to its magnetizing force is called susceptibility. In this respect we can say that soft steel is more susceptible than hard steel. Also, we can say that surface ships (with soft steel) are more susceptible than submarines (with hard steel). Thus susceptibility is another word that expresses the characteristics of various steels.

2. Induced Magnetism. The magnetic pole of induced magnetism in the bow of a ship is always the same polarity as the Earth's geographic pole toward which the ship is heading. For example, if a ship is on a northbound heading (toward the geographic north pole), the ship has its induced magnetic north pole in the bow.

3. Permanent Magnetism. A ship also tends to have many of the characteristics of a permanent magnet. Permanent magnetism does not change readily but becomes part of what is called the ship's magnetic history. This history relates to the materials from which the ship is built and the physical strains and electrical currents imposed upon it during construction and the earth's magnetic field. A ship's magnetic history continues after launching and is affected

in many ways, e.g., the changes in earth's field with different areas in which the ship operates, inherent vibrations, internal stresses and strains from wave action, gunfire, magnetic treatments, and numerous other causes.

Ship Magnetization

Magnetic lines of force within a steel hull ship act upon the ship as a whole unit. For study and analysis, the vector which represents the total induction within the ship is shown as three components labeled x, y, and z. The x component corresponds to the ship's longitudinal axis, the y component to its athwartship axis, and the z component to its vertical axis. These three components show a ship's magnetic field as three mutually perpendicular magnets, as shown by Diagram 1.

1. Longitudinal Induction. Those structural members of a ship having substantial longitudinal length and mass contribute to the longitudinal induction. The major contributors include the keel, the hull, and any associated armor plates, decks, longitudinal bulkheads, girders, and other longitudinal members. The magnetization of Earth's horizontal component field in alignment with these members causes longitudinal induction. In Diagram 1, the magnet in line with the x-x axis symbolizes the longitudinal induction.

2. Athwartship Induction. Structural members of a ship having substantial athwartship length and mass contribute to athwartship induction. These major structural members include transverse bulkheads and framing, beams, decks, and hull bottom. The magnetization of Earth's horizontal component field in alignment with these members causes athwartship induction. In Diagram 1, the magnet in line with the y-y axis symbolizes the athwartship induction.

3. Vertical Induction. Structural members of a ship having substantial vertical length and mass contribute to vertical induction. Major contributors include all bulkheads, vertical framing, and the sides of the hull with any side armor plates. The magnetization of

Earth's vertical component field is in alignment with these members and causes vertical induction. In Diagram 1, the magnet in line with the z-z axis symbolizes the vertical induction.

4. Ship External Fields.

a. Longitudinal Magnetism (LM). A ship's longitudinal induction (a self-contained magnetizing force) corresponds to an external magnetic flux, labeled LM. Diagram 2 shows this external field. The external LM influence field of a ship requires magnetic silencing.

b. Athwartship Magnetism (AM). A ship's athwartship induction (a self-contained magnetizing force) corresponds to an external flux, labeled AM. Diagram 3 shows this external field. Like LM and VM, the ship's influence field from AM requires magnetic silencing.

c. Vertical Magnetism (VM). A ship's vertical induction (a self-contained magnetizing force) corresponds to an external magnetic flux, labeled VM. Diagram 4 shows this external field. As part of the ship's influence field, VM requires magnetic silencing.

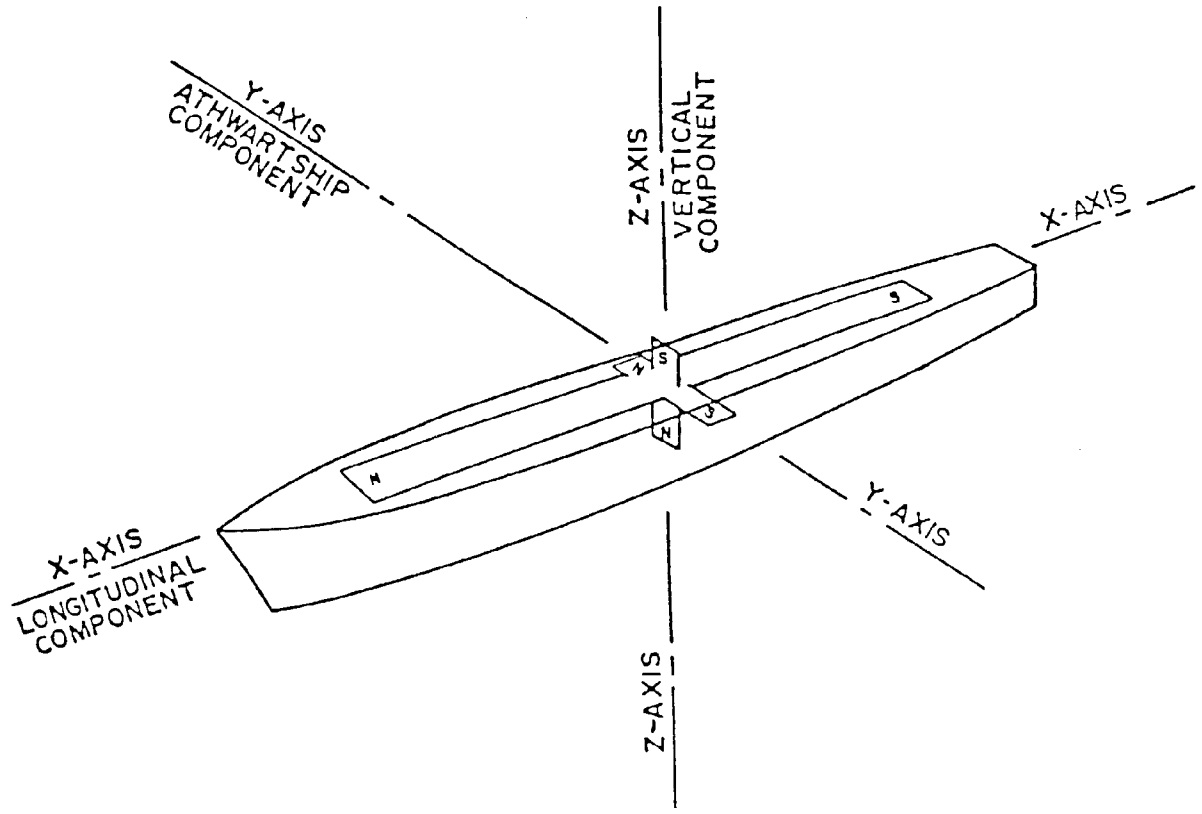
Magnetic Measurements

Magnetic mines create the necessity for continuously monitoring the magnetic status of all the ships and minesweepers involved in the magnetic silencing program. The effectiveness of degaussing systems, equipment installed aboard ships and minesweepers to reduce their influence field, must be measured periodically and corrected when necessary. Authorities have established magnetic criteria which the ships and minesweepers must meet. Degaussing ranges test ships and minesweepers for compliance with the criteria, conduct calibration, and make adjustments when criteria are exceeded. Engineers at the ranges specialize in the analysis of ranging data. Ships may require facilities for magnetic treatment. Treatments include deperming and flash deperming. Different facilities are required for testing stray magnetic fields for a minesweeper's equipment and installations. These facilities also test the effectiveness of the

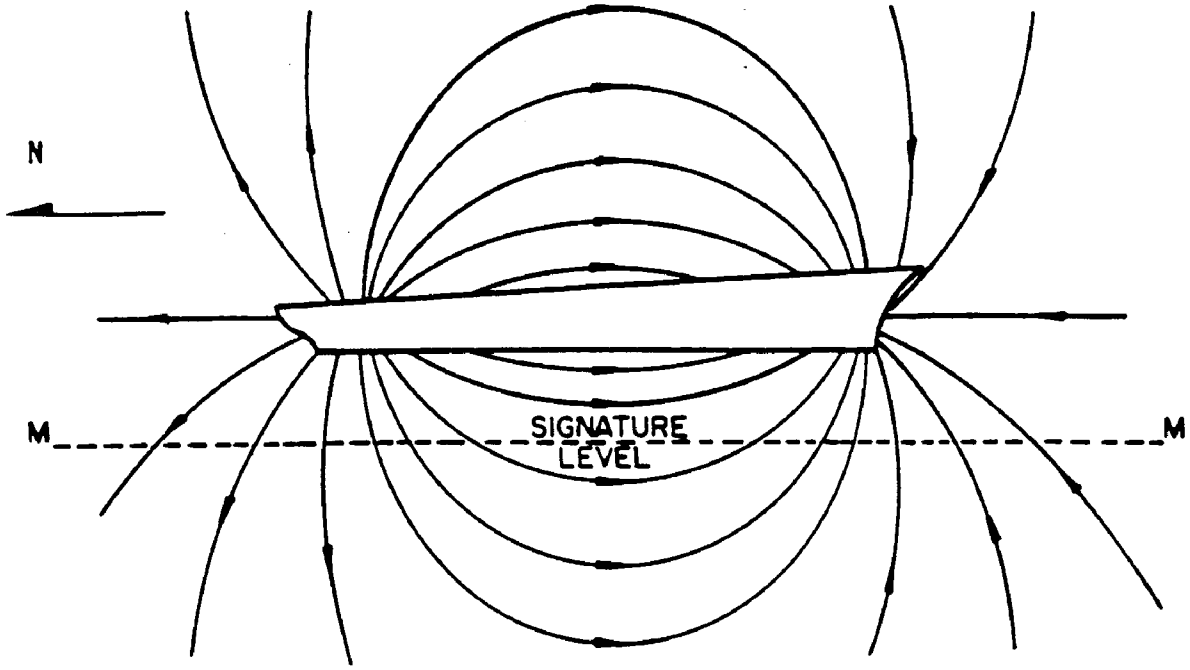
minesweeper's automatic magnetic compensation produced by the ship's degaussing controllers under roll conditions.

Minesweeper Signature Control

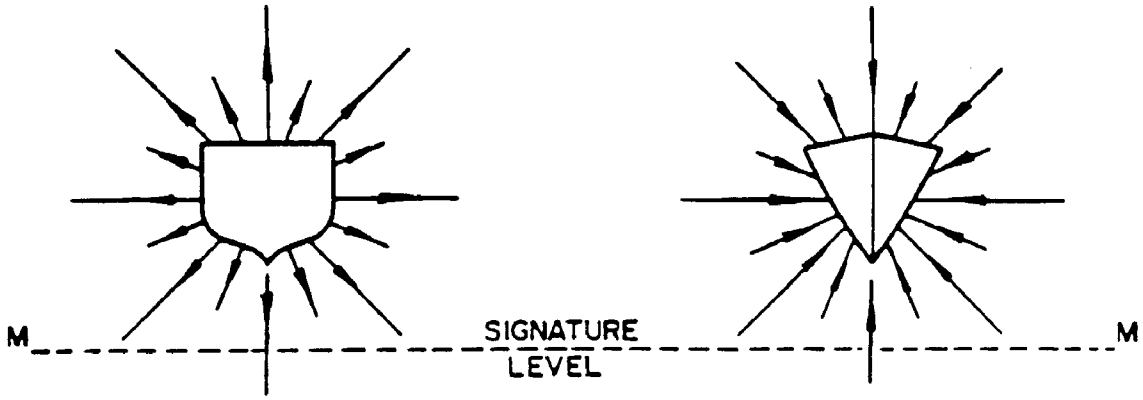
The minesweeper hull is constructed of wood or other nonmagnetic materials in order to reduce its total field. Since the hull is nonmagnetic, a magnetic field will pass through it as it would through water or air; therefore, magnetic fields of magnetic materials within the hull of a minesweeper will extend outside of the ship, unrestricted by the hull. As a result, the character of the magnetic environment around such a ship is quite different from that of steel hull ships. Considering the mission of a minesweeper, it is understood that its magnetic influence must be greatly reduced. Due to the character of a minesweeper's magnetic environment, the Signature Control (Degaussing Installation) System is more complex than that of a steel hull ship. The Shipboard Degaussing Installation for minesweepers will be discussed in detail in Packet 6.



The Three Components of Ship Magnetization



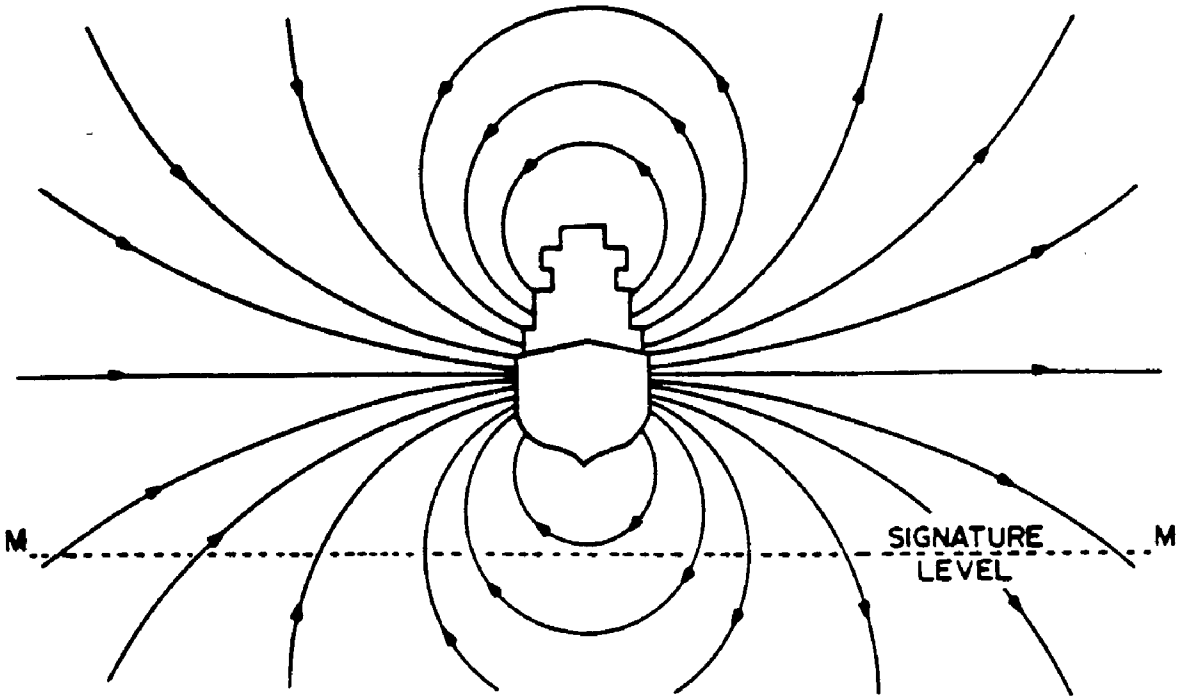
A. SIDE VIEW



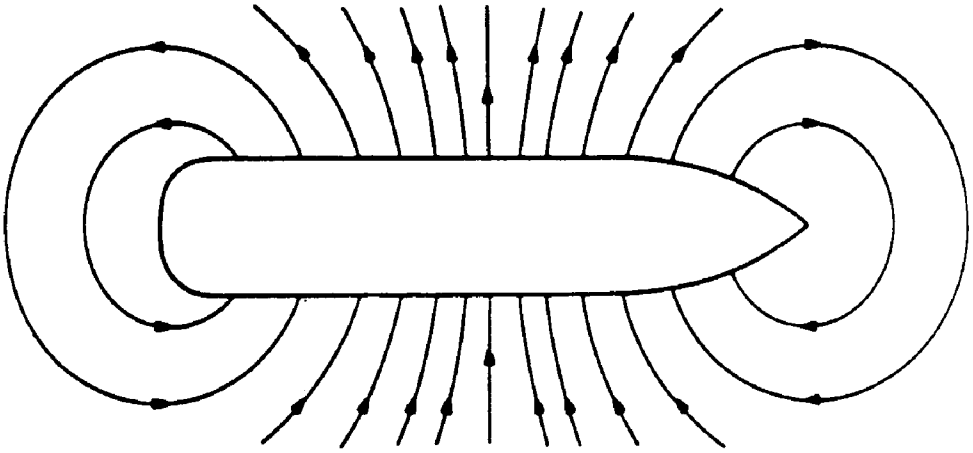
B. STERN VIEW

C. BOW VIEW

Ship Longitudinal Component External Field Characteristics

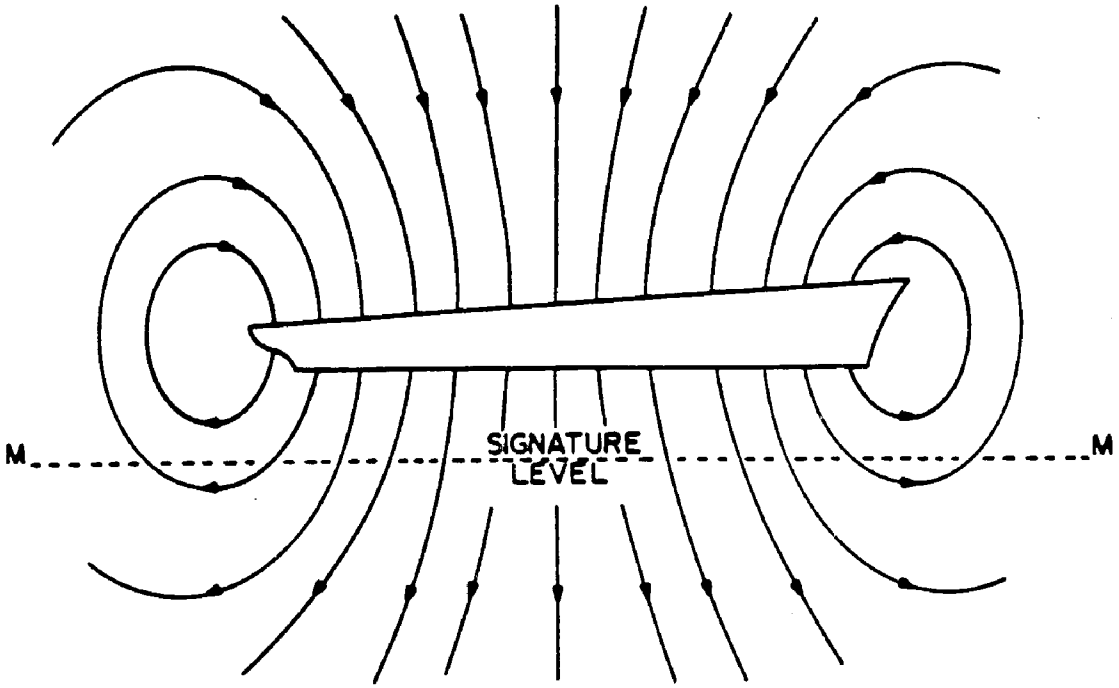


A. MIDSHIP SECTION

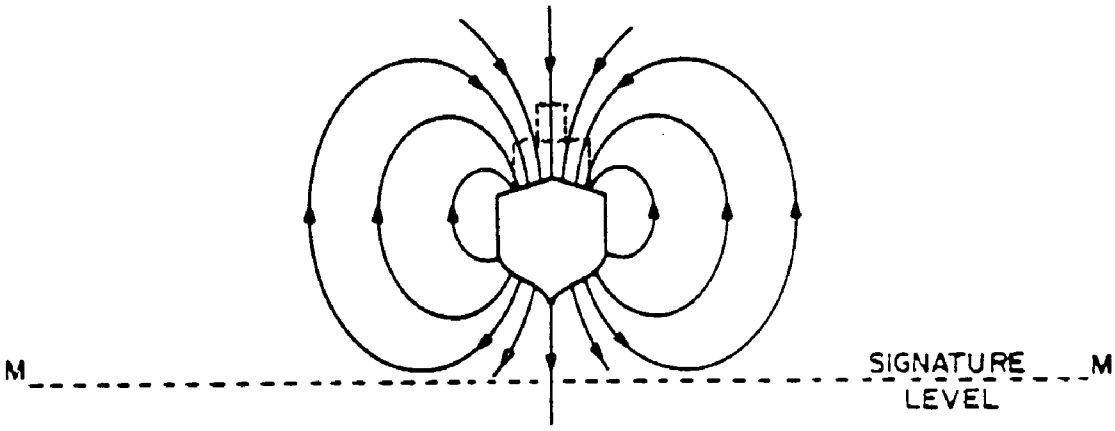


B. TOP VIEW

Ship Athwartship Component External Field Characteristics



A. SIDE VIEW



B. MIDSHIP SECTION

Ship Vertical Component External Field Characteristics

PACKET 3

SECTION II

ASSIGNMENT 1: Magnetics of Ships

DIRECTIONS: This assignment will help you understand Information Sheet 3-1. It consists of one diagram on which you must label various components and a number of statements with key words omitted. Select the word(s) which best complete the statements below and fill in the blanks provided. When you have finished, have your supervisor correct this assignment and critique with you.

1-1. Due to the type of material of which a ship is constructed, it is a large _____.

1-2. A ship has both permanent and _____ magnetism.

1-3. The Earth's magnetic field, where the ship is, and the ship's _____ determine the ship's induced magnetism.

1-4. When underway, the ship's induced magnetism _____ as the ship's heading and magnetic latitude change.

1-5. Induced magnetism in a ship's bow is always _____ in polarity to the Earth's magnetic pole toward which the ship is heading.

1-6. If a ship is headed toward the Earth's geographic north, the ship's bow will have a magnetic _____ pole.

1-7. A ship's permanent magnetism is subject to _____ changes caused by the Earth's field influence.

1-8. The longitudinal or athwartships induced magnetism is largely dependent upon the ship's position and _____.

PACKET 3

SECTION II

ASSIGNMENT 1: Magnetics of Ships

1-9. The _____ magnetism, which is not easily changed, is part of the ship's magnetic _____.

1-10. The major factors contributing to a ship's magnetic history are _____ from which the ship is constructed and strains and _____ _____ to which the ship is subjected during construction.

1-11. During ship's operation, the magnetic history is affected by such things as inherent _____, magnetic _____, _____ _____, and internal stresses and strains caused by wave action.

1-12. The three components that make up the ship's total magnetic field are labeled _____, _____, and _____.

1-13. The longitudinal component of a ship's magnetic field is the _____ component.

1-14. The y component is the _____ component of a ship's magnetic field.

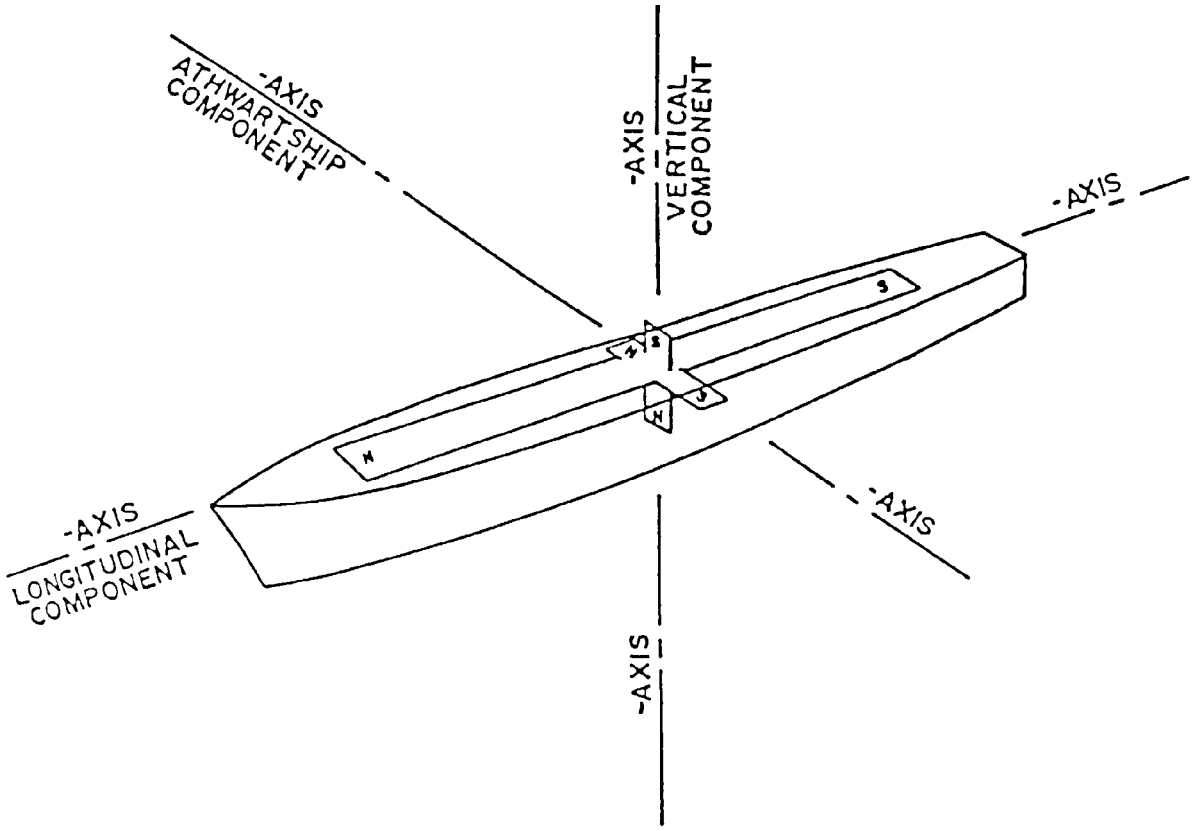
1-15. Three mutually perpendicular components make up a ship's magnetic field. They are _____ induction, _____ _____ induction, and _____ induction.

PACKET 3

SECTION II

ASSIGNMENT 1: Magnetics of Ships

DIRECTIONS: Label each axis with the correct letter from the list provided below.



Z Y X

INFORMATION SHEET NO. 3-2
TITLE: Magnetic Silencing Techniques

Mine Warfare Defense Measures

Additional, more detailed information on magnetic silencing techniques is given in reference 4, chapter 4.

1. Magnetic Silencing. Magnetic mines create the need to reduce the magnetic environment of all ships that may be exposed to these mines. All Navy ships, craft, and submarines, and all seagoing merchant ships, are subject to mine exposure in time of war. Because magnetic mines can be planted in a very short time, the magnetic condition of these ships must be kept in a constant state of readiness. Such readiness demands that a magnetic silencing program be in effect at all times for Navy ships. The Defense Department, however, has no peace time requirements for the magnetic silencing of merchant ships. The reduction of the strength of a ship's field forces the enemy to use mines of higher sensitivity. These higher sensitivity mines allow more effective minesweeping. Reducing a ship's influence field also increases protection of ships against magnetically sensitive torpedoes. Without a magnetic silencing program in effect, an enemy can bring an abrupt and extended stop to shipping to and from critical ports.

2. Magnetic Silencing Techniques. Magnetic silencing is used to reduce the intensity of a ship's magnetic field. Steel hull surface ships are magnetically silenced in two ways: one, the ship is depermed or demagnetized to remove unwanted permanent magnetism; and two, the ship uses a degaussing installation which is an onboard system of electromagnetic coils designed to neutralize the ship's overall magnetic field.

Submarines and landing craft do not have degaussing installations; these vessels require flash deperming. Flash deperming is a process of magnetizing the hull with a Z loop and then applying a regular deperming treatment to reduce the magnetism to a proper value (this will be discussed in greater detail in Packet 13). Submarines receive flash deperming for protection from Magnetic Anomaly Detector (MAD). This procedure

gives landing craft some protection from magnetic mines in shallow water. Minesweepers do not require deperming because of their nonmagnetic hulls. The degaussing installations of minesweepers differ from those of steel hull ships.

Shipboard Degaussing Installations

1. The components of a ship's magnetic field act like three mutually perpendicular magnets. These three magnets represent vertical magnetism (VM), longitudinal magnetism (LM), and athwartships magnetism (AM).

2. Compensation by Electromagnetic Loops. Packet 2 describes the magnetic field around a wire carrying current, and explains the application of this electromagnetism to wire loops encompassing an area. Magnetic compensation makes use of this application. Aboard a ship, electromagnetic loops create magnetic fields which act within distinctive areas and compensate for particular components of the ship's magnetic field.

   a. Ship Degaussing System. This system can compensate for each component (LM, VM, and AM) of the ship's magnetization. Electromagnetic coils covering large areas are installed vertically, horizontally, and athwartships within the hull as necessary to compensate for the corresponding components of the ship's magnetism. Each coil of the system consists of one or more loops installed in the same plane. Each loop consists of one or more turns of cable. All the effective turns in each cable are connected in series in each coil. A degaussing controller for the system regulates the current in each coil. The ship's external residual field can be reduced by adjusting coil currents and changing the number of effective turns. This system with its power supply is designed to keep the total magnetic field within limits specified for a particular ship.

   b. Control of Magnetic Fields. The regulation of current flowing through a coil controls the magnitude of a ship's magnetic

compensating field. If the magnitude of every coil compensating field is equal and opposite to the ship's intrinsic field in that area, the combination of the two fields equals zero. Certain factors do not permit a perfect match, but proper choice of loop currents and turns can reduce the ship's field well below a maximum prescribed value.

c. Example of VM Compensation. The coil which compensates a ship's VM is called the M, or main, coil and is located within the hull around the entire ship in a horizontal plane, as shown in Diagram 1(B). If a ship has a VM similar to the one shown in Diagram 1(C), a coil current flowing in the same direction as in Diagram 1(A) creates a counteracting field around the hull, as shown in Diagram 1(D). This counteracting field compensates the ship's intrinsic VM. Thus, the effects of the VM are neutralized, as shown in Diagram 1(E).

d. Ship Installations. The type and configuration of shipboard degaussing coils depend upon the type of ship and its size, construction, and mission. Loop placement and current control through the coils in a minesweeper are quite complex for accurate compensation of magnetic fields in all areas. In ships where effective reduction of the ship's field is not a tactical requirement, simpler degaussing coil arrangements are used. Diagrams 2 and 3 show steel hull ship and minesweeper shipboard arrangements of the installed coils respectively. Reference 4, Table 4-1, lists the principal degaussing coil arrangements used.

3. Degaussing Coils.

a. M coil. The M coil (main coil) counteracts the magnetic field produced by the permanent vertical and induced vertical magnetism of the ship. The M coil consists of one or more horizontal loops normally installed below the main deck at the skin of the ship. See Diagrams 2 and 3.

b. A coil. The A coil provides for compensation of induced and permanent athwartship magnetism. The A coil consists of a loop (or loops) located in a vertical plane parallel to the keel of the ship. See Diagrams 2 and 3.

c. L coil. L coils compensate for permanent and induced longitudinal magnetization. L coils are located in vertical planes perpendicular to the keel of the ship as shown in Diagram 3.

d. F coil. The F coil has one or more loops installed approximately horizontal in the forward or "forecastle" section of the ship, usually just below the upper deck as shown in Diagram 2. Its purpose is to neutralize the permanent and induced longitudinal magnetism in the forward (bow) area of the ship.

e. Q coil. The Q coil does for the stern what the F coil does for the bow. It consists of one or more loops installed just beneath the quarterdeck. See Diagram 2.

4. Other Compensating Coils. Other degaussing coils are a further development of the coils described above or are used as a supplement to or as a substitute for them.

a. FI - QI and FP - QP coils. Present-day installations (steel hull ships) utilize "split coils" where the coils known as F and Q are divided into two coils each. One, the FI-QI (forecastle induced-quarterdeck induced) coil, consists of the FI and QI coils connected in series; it neutralizes the induced longitudinal magnetism. The other, the FP-QP (forecastle permanent-quarterdeck permanent) coil, consists of the FP and QP coils connected in series; it is designed to neutralize permanent longitudinal magnetism.

b. P coils. The P (permanent) coil may be found in any area or plane of the ship. It is made up of one or more of the M, A, and L coils connected in series. The P coil compensates for

permanent vertical, athwartship, and longitudinal magnetization.

c. AUX coil. The AUX (auxiliary) coil is found in minesweepers and consists of supplemental M, A, or L coils. It is used in conjunction with the M, A, or L coils to provide for more

precise compensation of induced vertical, athwartship, or longitudinal magnetism.

Steel Hull Ships

Normal degaussing coil configuration on older steel hull ships consists of M coils, A coils, and F and Q coils. Newer steel hull ships utilize the FI-QI and FP-QP degaussing coils in place of the F and Q coils. Each coil normally consists of multiple conductors (more than one) and may be composed of more than one loop. See Diagram 2.

Minesweepers

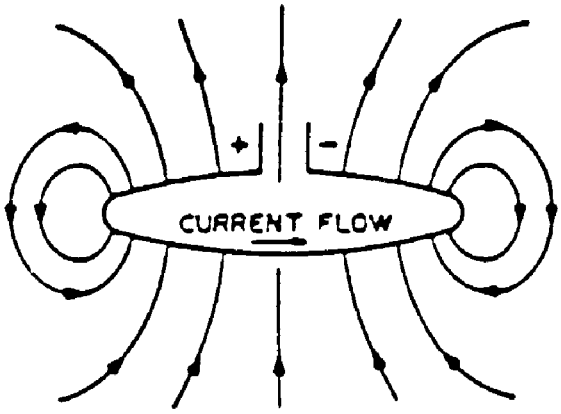
Coil arrangement. Nonmagnetic minesweepers utilize M and A coils as do steel hull ships. However, they use L degaussing coils instead of the F and Q coils common on steel hull ships. Additionally, minesweepers use AUX (auxiliary) coils extensively to provide for more precise neutralization. Thus MX (main auxiliary), LX (L auxiliary), AX (A auxiliary), and L coils are installed on minesweepers in addition to M and A coils. See Diagram 3.

Magnetic Treatment

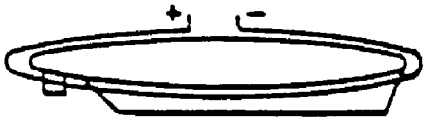
Magnetic Treatment of Steel Hull Ships. This degaussing technique consists of either the deperming or the flash deperming procedure. These procedures remove, alter, or control only a ship's permanent magnetism.

1. Deperming. This demagnetizing procedure encloses all magnetic material being treated with a solenoid, oriented on a horizontal longitudinal axis. This procedure applies to ships, submarines, and landing craft, and may also apply to items of magnetic material.

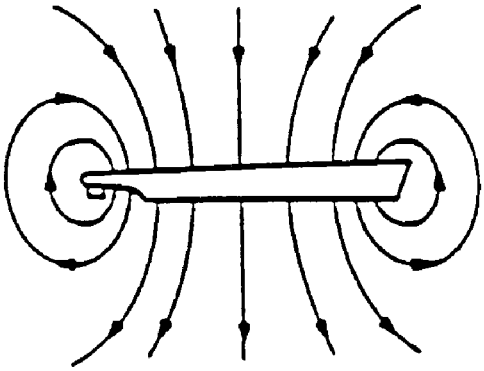
2. Flash Deperming. This procedure controls a ship's permanent vertical magnetism by creating ship vertical component fields of permanent magnetism. A normal deperming series follows this procedure. Submarines, landing craft, or other ships which do not have degaussing coils receive flash deperming.



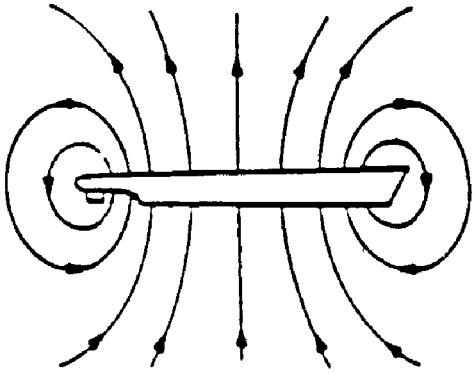
A. WHEN A CONDUCTOR WITH THIS FIELD



B. IS PLACED HORIZONTALLY AROUND THE HULL



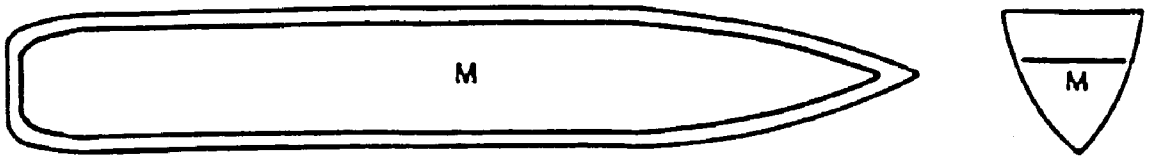
C. A SHIP WITH THIS VM FIELD



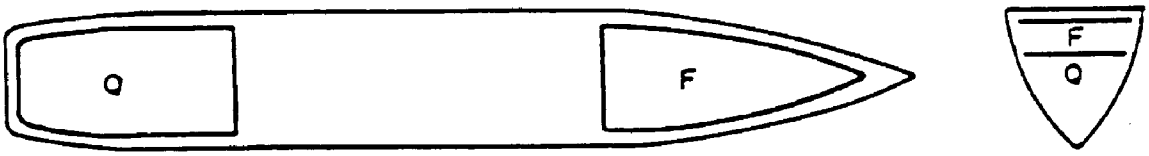
D. IS COMPENSATED BY THIS COUNTERACTING FIELD

E. RESULTING IN THIS MAGNETICALLY SILENT SHIP

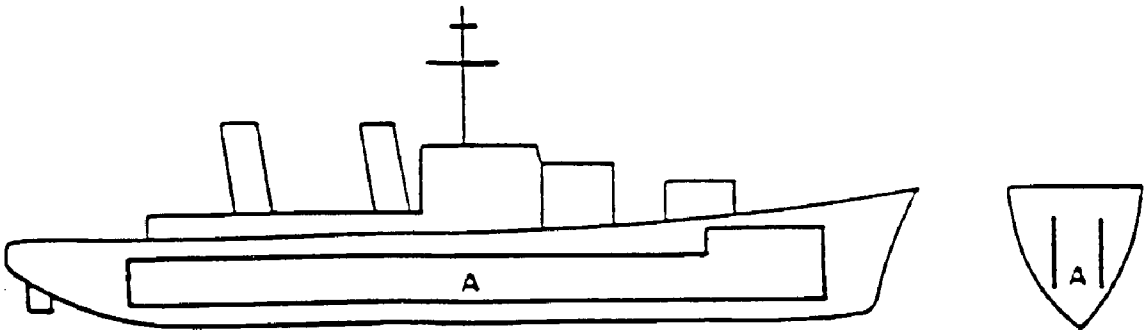
Example of Shipboard Compensation of VM



M COIL

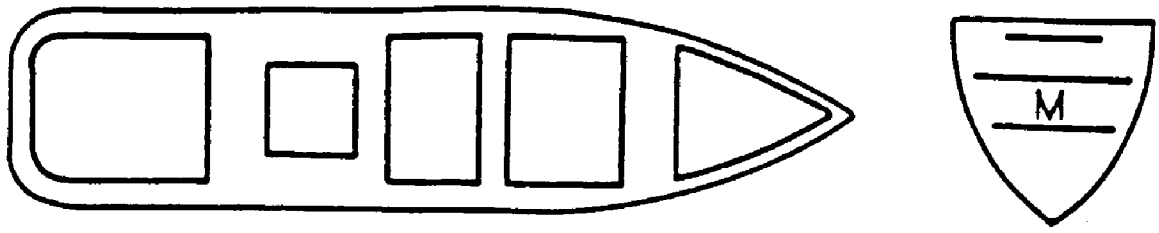


F AND Q COILS

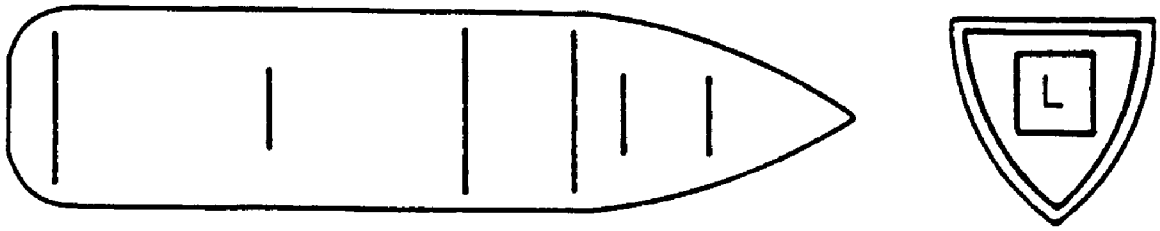


A COILS

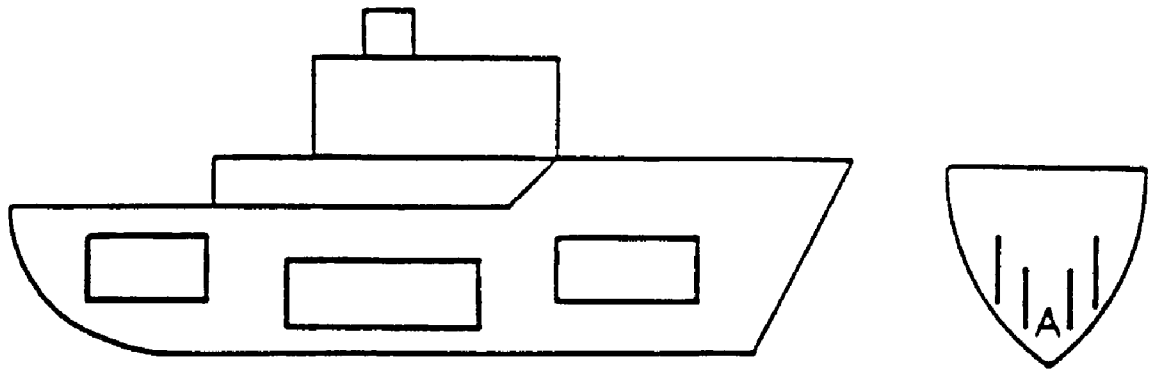
Degaussing Coil Functional Arrangement, Steel Hull Ship



M COIL ARRANGEMENT



L COIL ARRANGEMENT



A COIL ARRANGEMENT

Arrangement of Degaussing Coils, Nonmagnetic Minesweepers

PACKET 3

SECTION II

ASSIGNMENT 2: Magnetic Silencing Techniques

DIRECTIONS: This assignment will help you understand Information Sheets 3-1 and 3-2. It consists of three pages of diagrams on which you must label various components, and a number of statements with key words omitted. Select the word(s) which best complete the statements below and fill in the space provided. When you have finished, have your supervisor correct this assignment and critique it with you.

2-1. The ship's _____ changes with the Earth's field.

2-2. Because the Earth's field acts on magnetic materials during ship construction, a _____ is created.

2-3. As a ship passes through the Earth's field, it distorts the _____.

2-4. The ship's movement causes magnetic lines of force to _____.

2-5. The magnetic field of a steel hull surface ship is reduced by an onboard system of electromagnetic coils called a _____.

2-6. After construction, a steel hull ship is _____ to reduce unwanted permanent magnetism.

2-7. Magnetic fields on submarines and landing craft (that are not equipped with degaussing installations) are reduced by _____.

2-8. Submarine magnetic fields are reduced to protect against _____.

PACKET 3

SECTION II

ASSIGNMENT 2: Magnetic Silencing Techniques

2-9. A minesweeper has a very low magnetic field due to its _____.

2-10. Minesweepers use _____ degaussing coils instead of the _____ and _____ coils common on steel hull ships.

2-11. The longitudinal component of a ship's total magnetism is _____.

2-12. The vertical component of a ship's total magnetism, including induced and permanent magnetism, is _____.

2-13. A component of a ship's magnetism aligned with the athwartship axis is _____.

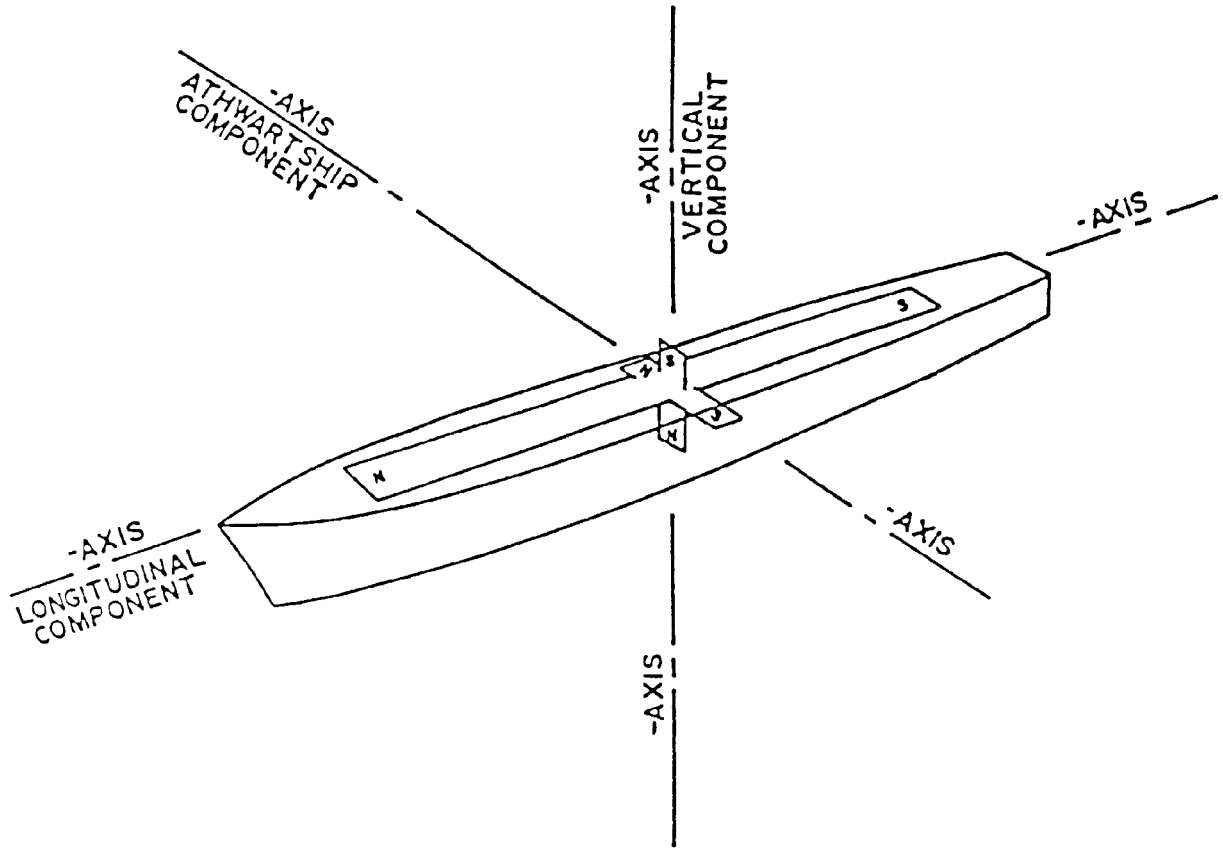
2-14. Imaginary lines in a magnetic field which have at every point the direction of magnetic induction of that point are _____.

PACKET 3

SECTION II

ASSIGNMENT 2: Magnetic Silencing Techniques

DIRECTIONS: Label each axis with the correct letter from the list provided below.



_____

Z Y X

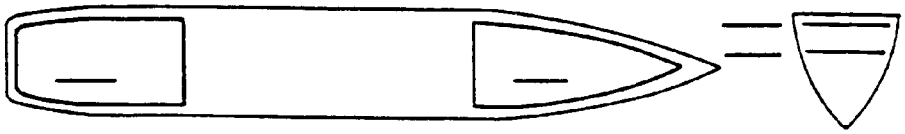
PACKET 3

SECTION II

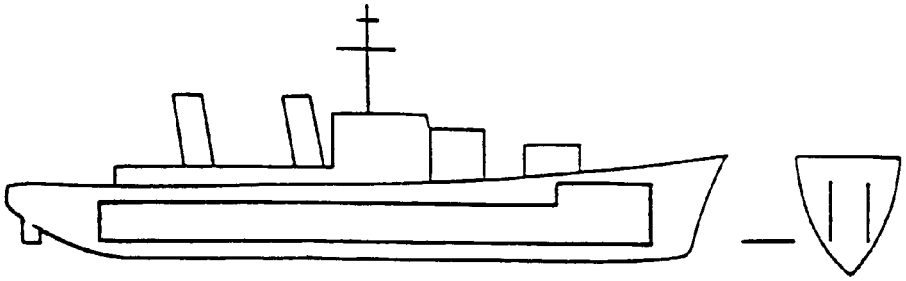
ASSIGNMENT 2: Magnetic Silencing Techniques

DIRECTIONS: Label each steel hull ship's coil arrangement with its correct name from the list provided below.

___ COIL



___ AND ___ COILS



___ COILS

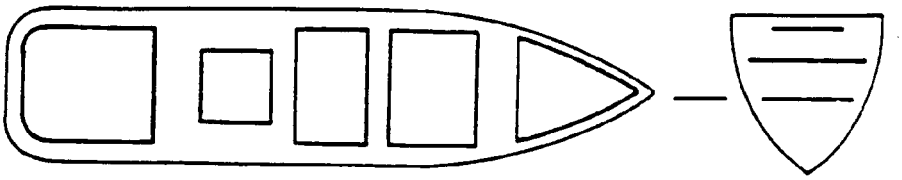
A Coil F Coil M Coil Q Coil

PACKET 3

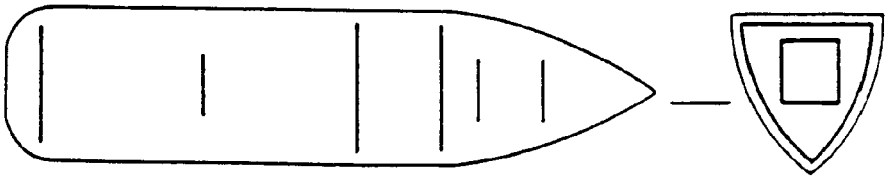
SECTION II

ASSIGNMENT 2: Magnetic Silencing Techniques

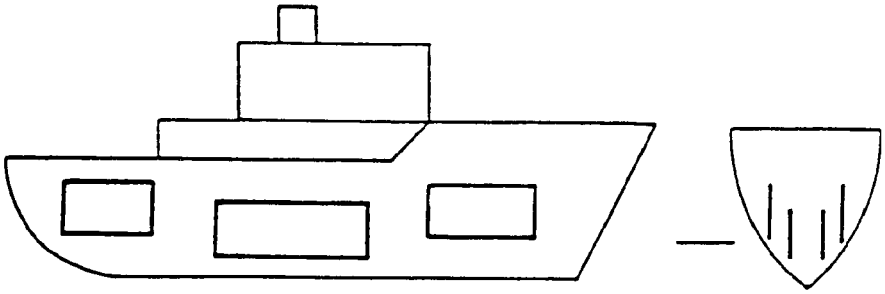
DIRECTIONS: Label each minesweeper's coil arrangement with its correct name from the list provided below.



___ COIL ARRANGEMENT



___ COIL ARRANGEMENT



___ COIL ARRANGEMENT

A Coil L Coil M Coil

Magnetic Measurements of Ships

More detailed information on magnetic measurements of ships is given in chapter 5 of reference 4.

1. Representation of Magnetic Measurements

a. Magnetic field measurements. Instruments used to measure magnetic fields are generally magnetometers, which provide values of flux density at some point. These instruments are installed underwater in locations that measure ship fields in a plane underneath the ship. Later packets will cover the details of the techniques more thoroughly. These magnetometers have a precise axis of measurement, and careful installation is required to assure measurement of only the vertical component of any field. A few special installations have used three-axis magnetometers which measure all three components of a magnetic field but, except for MSF Bangor these are not in general use at this time (1989). Measurement of only vertical components of a ship's total field provides sufficient data for identifying the three components of ship magnetization by using the external field characteristics shown in Information Sheet 3-1.

b. Ship field representation. Magnetometer measurements are made in terms of flux density, with units in terms of the SI tesla (or the cgs gauss). Distribution of sensor placements is designed to provide the essential field measurements under the keel of a ship and athwartship on both sides of the keel. With these measurements, ship fields can be represented both longitudinally and athwartships.

(1) Ship magnetic signature. When values of measurement are taken in a profile, either longitudinally or athwartships, and are shown with continuous lines through the measured values, the representation is called a signature. See 2 below.

(2) Ship magnetic contour. A second method of recording a ship's magnetic measurements is a contour. In a contour, values of readings are listed at points on graph paper showing a plan view of an area scaled to show locations of measurements relative to the ship's dimensions. A series of lines interconnecting locations of equal value is drawn on the plan view of the area. These lines are isomagnetic lines, as shown in Diagram 1. Both types of representations, signatures and contours, have their merits, but signatures are normally used by personnel at degaussing facilities.

2. Ship Signature Characteristics. The representation of ship magnetic fields by signatures is shown in Diagram 2.

a. LM signatures. Diagram 3 shows the external field characteristics of the ship's LM. The line M-M indicates a level of signature measurement under the ship. Diagram 2B and E show longitudinal and athwartship signatures for LM. The longitudinal LM signature is a keel signature. The two athwartship LM signatures are at the bow (15% LOA) and the stern (85% LOA), where the keel values are maximum. Diagram 1 shows a contour of the total LM.

b. VM signatures. Diagram 4 shows the external field characteristics of the ship's VM. The line M-M indicates a level of signature measurement under the ship. Diagram 2C and F show longitudinal and athwartship signatures for VM. The longitudinal VM signature is a keel signature, and the athwartship VM signature is taken amidships (50% LOA), where the VM field is near maximum. Diagram 1 shows a contour of the total VM.

c. AM signatures. Diagram 5 shows the external field characteristics of the ship's AM. The line M-M indicates a level of measurement under the ship. Diagram 2G shows an athwartship signature for AM. The athwartship AM signature is taken amidships (50% LOA). Diagram 1 shows a contour of the total AM.