Magnetic signature of HMCS "Cowichan" (MCB 162): Esquimalt, B.C., March, 1958

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OTTAWA

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ABSTRACT

This is the second of two reports describing the magnetic field of the minesweeper HMCS "Cowichan". In the first report the pure eddy-current field determined by rolling the hull structure only was described. In the present report the field of the fully fitted ship is given. Extensive tests were made to determine all components of the ship's magnetic signature and to observe the effectiveness of the degaussing system.

A non-symmetrical signature which cannot be compensated effectively by the ship's symmetrical coils was observed at shallow depths. However, at 30-foot depth the signature becomes more symmetrical and can be reduced to 1.5 milligauss by the degaussing system. The degaussing controller which performs automatic correction for heading, roll, and pitch was found to function correctly.

The minesweeping impulse equipment, the winch drive, and the magnetic clutch of the 400-cps supply motor-generator set each produce a stray field which is comparable in magnitude with the ship's signature. Consideration should be given to reducing the fields of these components.

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INTRODUCTION

Magnetic signatures of the Canadian Minesweeper HMCS "Cowichan" (MCB 162) have been obtained at two stages of construction. First measurements [1] were made in 1957 during rolling tests on the hull structure fitted with large aluminum components only. The object of these tests was to determine the basic eddy-current signatures of the ship. A second series of measurements were made in March, 1958, after the ship had been fully fitted and was in its normal seagoing condition. The objectives of this second series of trials were to measure all magnetic field components which contribute to the signature of the ship and to determine the effectiveness of the ship's degaussing system in reducing this signature.

Measurements and investigations carried out during these trials were as follows:

1) Measurement of the static ferromagnetic field
2) Investigation of the effectiveness of static degaussing
3) Measurements of the "tilt" field under both static list and rolling conditions ("Tilt" field is the variation of the static field as the ship departs from the even keel position.)
4) Investigation of the effectiveness of "tilt" degaussing
5) Measurement of the eddy-current field to determine changes due to the additional fittings and to ageing of the structure
6) Measurements of the stray field of the impulse minesweeping equipment
7) Measurement of the stray field of the minesweeping winch drive
8) Measurement of the stray field of a magnetic clutch on one of the 400-cps supply motor-generator sets
9) Measurement of the magnetic field of the cathodic protection system

During this series of trials the instrumentation was essentially the same as that used previously [1, 2]. Measurement techniques, however, differed in two notable instances.

In previous static tilt trials [2] a crane was used to move lead weights across the deck to list the ship. In these trials, 40 men, each carrying a 100-pound lead weight, applied the listing moment. The method was found to be very much superior.

In previous investigations of the impulse equipment [3, 4], all stray field measurements were made at positions above the impulse generator and controller. In these trials, measurements were made at points below the ship where the field is normally of interest.

DESCRIPTION OF SHIP AND ITS DEGAUSSING SYSTEM

The hull structure and large aluminum fittings have been described previously [1]. During the fitting process, a large number of parts were added which will contribute ferromagnetic and eddy-current field components to the signature. The principal ferromagnetic parts are shown in Fig. 1. Electrical equipment and machines which may be stray field sources are shown in Fig. 2. During ranging and rolling trials, cathodic protection circuits and one of the magnetic clutches shown in Fig. 2 were energized.

In preparation for the trials the ship was fitted with two "rolling" platforms (visible in Fig. 3) and then docked for installation of bow and stern fittings at the axis of roll. The bilge keels, rudders, and propellers remained in place. In order to reduce the righting moment and thus permit larger angles of list and roll than under normal ballasting conditions, lead weights were placed on the decks. The period of the rolling motion was therefore considerably increased from normal.

The ship was ranged at Esquimalt in December, 1957, by dockyard staff to determine static degaussing current settings. At the start of these trials the ship's static degaussing was readjusted to improve compensation at the shallow depths used during the tests.

The ship's degaussing coils are shown in Fig. 4. The currents in these coils are controlled by a system [5] which provides for manual adjustment of static degaussing currents, together with either manual compensation for changes in ship's heading, or automatic compensation for one of the following: heading; heading and pitch; heading and roll; heading, pitch and roll. Signals for the automatic control system are provided by the heading gyro and a gyro-stabilized vertical reference. These signals, together with some manually adjustable constants, are fed into a computer within the control system which, with magnetic amplifier outputs, provides signals of the required mathematical relationship (Eq. 1, Ref. 6) to the fields of the generators supplying the degaussing coils.

Static degaussing currents must compensate a total field consisting of a component of permanent field (P.M.) and a component of induced field (I.M.). Only the induced component need be varied to compensate for changes in heading and for roll and pitch. Provision has been made in the control for introducing various proportions of the two components into each of the main coil systems. The control panel for the degaussing system is shown in Fig. 5.

INSTRUMENTATION

The trials were conducted in the RCN dock (heading 0° magnetic) and the DOT dock (heading 241° magnetic) at Esquimalt, B.C. The thirty-detector magnetometer range described previously [2] was used. This is shown installed in the RCN dock in Fig. 6. Identical range patterns (Fig. 7) were used in the docks for tests on the ship. A smaller range pattern (Fig. 8) was used in the measurement of the field of electrical equipment and machines. The ship was moved to various positions over these ranges to permit measurements to be made over a wide area.

The 30 detectors were connected, in groups of three, to three magnetometer-and-recording channels through a switching unit. This system enabled signals from all detectors to be sampled.

Amplitudes and periods of roll were measured by the NRC recorder and a Muirhead recorder [2]. These were fastened to a rigid platform in the generator room of the ship. A common timing pulse generating unit controlled the placing of one-second interval timing marks on all records during rolling trials.

MAGNETIC SIGNATURES OF SHIP

The RCN dry dock was occupied from March 7 to March 15 and the ship was maintained on a north heading. The range and equipment were then moved to the outer section of the DOT dock and the ship maintained on the 241° heading from March 17 to March 24. The range and ship were then returned to the RCN dock where the ship was on a south heading from March 25 to March 28, except in the case of the minesweeping winch test on March 28 when the ship was on a north heading.

The tests, and results extrapolated to maximum conditions, are summarized in Table I. Individual tests and results are detailed in the following paragraphs.

Static Signature

As in the "Comox" measurements [2] the magnetometers were adjusted to zero output with the ship remote from the range. The ship was then towed into position over the range with all degaussing equipment operating but with the degaussing coils turned "off" at the switches shown on the right hand panel of Fig. 5. The field at each magnetometer was recorded by use of the magnetometer switching method. The degaussing currents were then turned on and the field again recorded. Finally, the ship was returned to a remote position and the zero level of the magnetometers re-checked.

A limited number of measurements were also made by towing the ship over the range while the three magnetometer channels were recording the fields at three

detector units. No switching was done during these tests. A series of longitudinal profiles at the keel and at various distances athwartship were taken. The results of tests of this type are in good agreement with those using the switching method.

Longitudinal profiles of the static field both uncompensated and compensated appear in Figs. 9 to 13.

The uncompensated profiles (particularly Figs. 9(a) and 11(a)) indicate the presence of a longitudinal dipole located to starboard of the keel line and centered about 60 feet from the bow. This dipole field creates a non-symmetrical signature which cannot be compensated by the symmetrical sets of coils shown in Fig. 4. The field decreases more rapidly with depth than the general field of the ship and its effect becomes small at depths of 30 feet or more.

With degaussing currents and coiling set as determined during the December 1957 ranging some preliminary tests of compensation were made. Minor adjustments were then made in the relative numbers of turns in various "M" coils to determine the optimum compensation of the non-symmetrical field. Numbers of turns finally used are given under the heading "adjusted coiling" in Fig. 4. Static degaussing currents are listed on each set of profiles.

Static Tilt Signature

The crew provided for rolling the ship was also used to produce the listing moment for static tilt tests. These men, each equipped with a 100-pound lead weight, were ranged along the starboard rails of the platforms. Counterbalancing lead weights were placed on the port side until the ship was level. The men carrying weights were than moved to the port rails of the platforms. In one case 46 men carrying 45 lead weights (total weight 11,820 lb) were able to list the ship 11°. Such a list could be applied in 20 to 30 seconds. Starboard lists were applied in a similar manner. Added top weight, in this case, exclusive of rolling platforms, listing and counterbalancing weights, consisted of 25,500 pounds of lead distributed over the forcastle and sweep decks and at the rails of the rolling platforms.

At the beginning of each test the ship was carefully positioned and levelled over the range, and the magnetometer detectors were adjusted to zero output by switching to each in turn. The ship was then listed and the output of each detector sampled. The ship was returned to level and the zero settings re-checked to determine drift. Measurements were made for tilts to port and starboard at two depths in both docks under three conditions as follows:

1) Degaussing off

2) Degaussing on, with correction for heading only

3) Degaussing on, with correction for heading and roll

At 30-foot depth a different method of measurement was used to increase the accuracy: continuous recordings of three detector outputs were made during each tilt.

Tilt angles were measured by means of the Muirhead D-697 Angle and Angular Velocity Recorder.

The measured fields, in milligauss/degree, are shown as longitudinal profiles in Figs. 14 to 22 and are summarized in Table I. From the profiles it appears that tilts to port and starboard produce fields of nearly equal magnitude, but of opposite sense. The field profiles are not symmetrical with respect to the keel. This dissymmetry is similar to that exhibited by the static field profiles. This type of signature cannot be compensated effectively by the ship's automatic degaussing system. With the settings finally adopted it was possible to obtain good compensation under the port side but over-all compensation was poor. The effectiveness of the over-all tilt compensation improved with depth.

Some continuous field recordings were made while tilting the ship in increments of about 4 degrees. Results in the form of graphs of "field vs. tilt angle" appear in Figs. 23 and 24. They show that the static tilt field varies linearly with tilt angle.

Rolling Signature

The method of constraining and rolling the ship is shown in Figs. 25 and 26. Ball-and-socket joints were fastened to bow and stern at the roll axis. Four pairs of mooring lines were attached. One pair at each pivot point prevented transverse surging and the other pair, being fastened to the dock well forward of the ship's bow or aft of the ship's stern, prevented longitudinal surging. The rolling crew, (Fig. 3), averaging about 42 men, was divided into three groups, each of which could roll the ship. It was possible to interchange one group with another while rolling and thus maintain a steady roll for as long as 5 minutes. Average roll amplitude was about $\pm 12°$. Average period, because of the added top weight of 13 tons, was about 11.5 seconds.

During most of the trials both platforms, (Fig. 3), were used. However, a small number of trials were made using the aft platform only, and the ship could be rolled effectively. It is recommended that the forward platform be dispensed with in future tests.

The ratio of Induced Athwartship Magnetism (IAM) to Permanent Athwartship Magnetism (PAM) was determined during the rolling tests in the north-south oriented RCN dock. The "A" coil current needed to compensate the permanent component of magnetic field had been set during the static signature tests. During rolling on a north heading an oscillating field may be considered to be applied transversely to the ship (Ref. 7, Fig. 11). This produces IAM in the ship which must be compen-

sated by the "A" coils. The induced magnetism component of the "A" coil current was adjusted until good compensation of the transverse horizontal component of the rolling field under the keel at midship was achieved (see Fig. 27). The required settings on the d.g. controller dials, as determined from the static and rolling tests, were AP = -9% and AI = 25%. The IAM/PAM ratio is therefore 2.8/1. These settings were used throughout the trials.

Some consideration was given to setting the IVM/PVM ratio in a similar manner on the west heading but the attempt was abandoned because variations in IVM field during rolling were masked by other effects, notably those due to movement of the magnetic clutch with respect to the range when rolling and those due to eddy currents. The "M" settings used were those calculated by dockyard staff and were MP = 12%; MI = 35%; the IVM/PVM ratio being 2.9/1.

With the above settings on the controller a survey was made of the magnetic fields due to rolling.

The fields measured were separated into a component in phase with the rolling motion and a component in quadrature with the rolling motion. For the purpose of comparison with other measurements, the two components were called "dynamic tilt field" and "eddy-current field", respectively, although these terms are not strictly applicable. The method of separating the two components is illustrated in Fig. 28. The dynamic tilt fields obtained in this manner are shown as longitudinal profiles in Figs. 29 to 33. These profiles are very similar to those of static tilt and the same general remarks apply.

Magnitudes of static and dynamic tilt fields are compared in Fig. 34 and are seen to be nearly equal.

Eddy-current fields are in general masked by the larger tilt fields and can be determined only with a low order of accuracy. A large number of magnetic records were analyzed to determine eddy-current components. Results of the type shown in Fig. 35, where a comparison is made with previous measurements on the empty hull, illustrate the spread in the measurements. There is an indication in Fig. 35, and in the results summarized in Table I, that the tilt corrector reduces eddy-current field magnitudes. With tilt compensation, the eddy-current field of the completed ship is only slightly greater in magnitude than that of the empty hull.

Performance of Degaussing System

The performance of the degaussing system in reducing the field of the ship is summarized in Table I.

As shown by Fig. 27 and the compensation at 30-foot depth, (Fig. 33), the tilt compensator operates properly. However, because of the poor space match be-

tween the field of the symmetrical degaussing coils and the unsymmetrical field of the ship at the 15.5 and 22 foot depths, both static degaussing and tilt compensation are limited in effectiveness at these depths.

While using the degaussing controller, it was observed that the degaussing currents could accidentally be reversed during switching from one position of the master switch, (Fig. 5), to the next. This could create a hazardous situation during minesweeping operations and should be corrected.

Another possible hazard is the large magnetic field transient which occurs when the automatic system is switched on. Fig. 36 illustrates the type of transient which is caused by this operation.

STRAY FIELD OF COMPONENTS

Pulsing Equipment

Previous pulse field measurements on the minesweeping impulse generator with added yoke ring, and its controller [4] were carried out at levels above the equipment. Tests on the units installed on the "Cowichan" (see Appendix for description of generator and controller) had two objectives. The first was to determine the field at levels below the ship, and the second was to make a second observation of the effectiveness of the added yoke ring in reducing the stray field of the generator.

Two series of measurements were made at water levels chosen so that the magnetometer range was 10 feet and 18.5 feet below the generator shaft. These correspond to the measurement levels above the machine adopted for previous tests [3, 4]. The relative positions of generator and controller, (Fig. 2), with respect to the range will be different below the ship than above, so that the total field distribution will not be directly comparable.

The generator was connected to a water resistor load [3] through a length of "ribbon tail" and a long length of "married" buoyant cable. The total load resistance including connecting cables was 0.067 ohms (about 10% higher than that during previous measurement). Field measurements were made while the generator was delivering square pulses of current of polarity alternately forward and reverse. Magnitudes of fields of both types of pulse were the same. Results in the form of field contours for forward pulses appear in Fig. 37.

The maximum vertical field occurs midway between generator and controller on these maps and the maximum horizontal field directly below the controller. The field of the controller is approximately equal to that of the generator and is in such a direction that the two fields (vertical components) add in the space between the machines. Some overall improvement in signature would probably result if these could be brought into opposition in this region.

A comparison of these measurements with previous measurements made directly above each component shows that the fields are almost identical at the same distance (compare with Appendix A, Table (a), Ref. 3, for the controller field and with Ref. 4 for the generator field). A plot of stray field directly below the generator against generator current shows linearity and therefore the yoke ring of this machine also is effective in reducing the stray field.

Fig. 38 is the field map of generator and controller at two depths. Depth laws determined from this figure are given in Table I.

To determine the field of the ribbon tail, the cables were stretched out aft of the ship to simulate sweeping conditions, as shown in Fig. 39. The cables were supported in the water by wooden floats. The field of the ribbon tail is shown in Fig. 40. It is small compared with the fields of the generator and controller. The dissymmetry with respect to the center line of the ship could be due to a slight twisting of the ribbon tail and to unequal division of the current in the four cables.

Winch Drive

The minesweeping winch on the ship is powered by a 65-hp d-c motor (see Appendix for name plate data) whose location is shown in Figs. 2 and 41. A contactor brake, operated by a longitudinally oriented d-c solenoid (see Fig. 41) is released when the winch is lifting.

The tests consisted of momentarily lifting two 6200-pound weights with the winch while measuring the resultant change of magnetic field under the ship. When lifting the weights the motor drew the rated full load current. It was found, however, that the stray field was independent of armature current.

The stray field of the winch drive, as measured at two depths, is shown in Fig. 41. It is similar to the field of a longitudinal horizontal dipole, one maximum of the vertical component of field occurring aft of the motor, another possibly occurring forward of the motor but not covered on the field maps.

These characteristics of the field indicate that the brake solenoid is the principal source of stray field of the winch drive.

Magnetic Clutch

The three-phase 400-cps power on the ship is supplied by one of a pair of motor-generator sets located in the generator room, the other motor-generator set being used as a spare unit. Name plate data of the machines are given in the Appendix. The frequency of the generator output is regulated by a hysteresis-type magnetic clutch. The clutch is operated by a d-c solenoid which is concentric with the motor shaft. The output torque of the clutch is proportional to the current in the solenoid. With the clutch control on automatic operation, the clutch, by controlling the slip between motor and generator shafts, maintains constant generator speed. With the control set on manual operation the clutch locks the shafts of the two machines together.

The location of the two motor-generator sets is shown in Fig. 2. Stray field meas-

urements were made on the unit which is closest to the keel. The measurements were made by switching the clutch control from "off" to "manual" to "automatic". The stray field of the clutch during manual operation was found to be of the same magnitude as during automatic operation, but of opposite sense. The measured fields for automatic operation are shown in Fig. 42.

The stray field of the clutch is of the same order of magnitude as the degaussed ship's structure. A more extensive series of measurements on the clutch was carried out in the laboratory and the possibility of reducing the stray field by degaussing techniques was investigated. A report dealing with these measurements will be issued separately.

Cathodic Protection System

The cathodic protection system of HMCS "Cowichan" consists of two 5' × 10" × 3" magnesium anodes mounted one on each side of the keel 118 feet from the bow, (Fig. 2), which are connected by cables through a rheostat and an ammeter to the aluminum framework of the ship. The most direct path to the ship for the anode current is to the propeller shafts and the rudder.

Measurements of the field of the cathodic protection currents were made on the RCN dry dock with the range shown in Fig. 8. Maximum currents were used, 3.5 amperes at each anode, and the field was measured while switching the current on and off. The vertical and transverse horizontal components at a depth of 15.5 feet are shown in Fig. 43.

Maximum fields occur about 9 feet aft of the anodes, or near the center of the anode to the propeller shaft circuit, as would be expected. The axis of symmetry of the field appears to be parallel with the keel and about two feet to starboard.

CONCLUSIONS

The residual field of the ship, exclusive of the stray fields of minesweeping equipment, is about 1.5 milligauss at a depth of 30 feet under maximum conditions. This field can be reduced by correcting a dissymmetry of the signature which is mainly due to the field of the magnetic clutch.

Minesweeping equipment such as the pulsing generator, the controller, and the minesweeping winch drive, when in operation, give rise to stray fields which are comparable in magnitude with the degaussed ship's signature. Methods of reducing these fields are suggested elsewhere in this report.

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APPENDIX

NAME PLATE DATA OF EQUIPMENT

Impulse Generator

Westinghouse D-C Generator

Shunt Wound, Type QH

Frame DB 810-6

KW 290, Amps 1200

Volts Full Load 240, Rpm 1200

No. 4-10E-0062

For Impulse Application:

KW 540, Amps 3000

Volts Full Load 180, Rpm 1300-1600

Special Service Controller

Mfr. Canadian Westinghouse Co.

Type S.O. 1 - Y - 288, Volts 250 D-C

Amps (Max.) 4000, Serial No. 6

Assembly Plan 65-NJ-11

Wiring Plan 65-NJ-49

M.S. Winch Motor

Bogue Electric D-C Motor

Model 3698, HP 65

Volts 225, Amps 230

Serial No. M-1360, Rpm 52/1048

Wdg. Compound, Cont. Duty, 60°C Rise

400-cps Motor-alternator Set

Bogue Electric A-C Motor

Model 2998A, Serial No. 172357

HP 7.5, Rpm 3600

440 V, 60 cps, 3-ph

13 Amp, Duty Cont. 70°C Rise

Bogue Electric A-C Generator

Model 2998A, Serial No. 172357

KVA 3.12, kW 2.5, Volts 120, Amp. 15

Rpm 3428, Freq. 400 cps, P.F. 0.8, 3-ph

Cont. Duty, 70°C Rise

400-cps Controller

Mfr. Bogue Electric

Model No. 2998A, Serial No. 172357/58

Supply 120 V.A.C. 400 cps
440 V.A.C. 60 cps

Type of Field	Heading	Degaussing	Maximum Field (mg)					
			15.5' Depth		22' Depth		30' Depth	
			Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component
Static Field	North	Off	6.8	12.4	3.2	5.5		
		On	1.4	4.0	2.0	2.5		
	West	Off	6.5	12.5	4.4	6.7	2.2	3.7
		On	2.0	5.8	2.0	3.3	0.6	1.0
Static Tilt Field (±25° Tilt)	North	Off	±3.5	±6.8	±1.75	±3.0		
		Hdg. Only	±4.3	±4.8	±2.0	±2.25		
		Hdg. and Roll	±4.5	±5.5	±1.25	±1.75		
	West	Off	±4.0	±5.0	±1.25	±1.50		
		Hdg. Only	±4.5	±5.5	±1.75	±2.0		±0.88
		Hdg. and Roll	±3.3	±5.0	±1.0	±1.5		±0.38
Dynamic Tilt Field (±25°, 8 sec. Roll)	North	Off	±3.8	±5.0	±1.5	±1.75		
		Hdg. Only	±3.0	±4.0	±1.75	±2.0		
		Hdg. and Roll	±2.5	±2.5	±1.25	±1.25		
	West	Off	±4.8	±5.3	±1.75	±1.75	±0.43	±0.55
		Hdg. Only	±3.8	±3.5	±1.75	±1.75	±0.70	±0.85
		Hdg. and Roll	±2.5	±3.8	±0.75	±1.0	±0.25	±0.38
Eddy Current Field (±25°, 8 sec. Roll)	North	Off	±2.2	±3.1	±0.7	±0.7		
		Hdg. Only	±1.4	±1.8	±0.9	±0.9		
		Hdg. and Roll	±1.0	±0.9	±0.9	±0.8		
	West	Off	±1.4	±2.0	±1.4	±1.6	±0.37	±0.49
		Hdg. Only	±1.6	±1.4	±0.9	±0.9	±0.49	±0.45
		Hdg. and Roll	±1.4	±1.2	±0.6	±0.8	±0.31	±0.37

Type of Field	Maximum Field (mg)					
	12.5' Depth		21' Depth		30' Depth	
	Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component
Stray Field of Impulse Generator and Controller 3000 Amp. Forward Pulses Load: 0.067 ohms	7.5	9.0	1.6	2.1	0.55* (n = 3)	0.8* (n = 2.8)
Field of Ribbon Tail 3000 Amp. Forward Pulses	0.23	0.35				

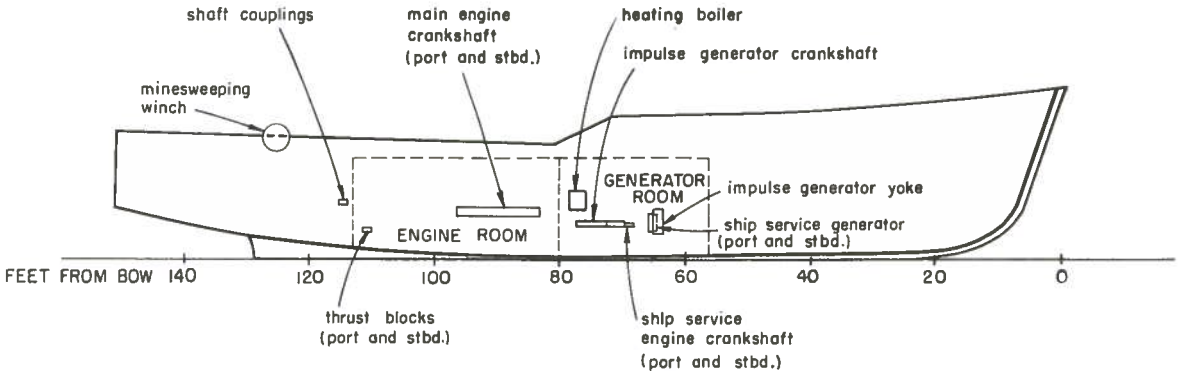
Type of Field	Maximum Field (mg)					
	15.5' Depth		22' Depth		30' Depth	
	Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component	Trans. Hor. Component	Vertical Component
Field of M.S. Winch Motor		4.6		2.1		0.8* (n = 2.6)
Magnetic Clutch Field (on Automatic Setting)		5.5				0.5* (n = 3)
Field of Cathodic Protection Currents (3.5 Amp in each Circuit)	1.4				0.1* (n = 2.5)	

* Values calculated from $B \propto d^{-n}$ using values of n as shown, where B is field strength and d is depth below source of field.

MAXIMUM MAGNETIC FIELDS

HMCS "COWICHAN" (MCB 162)

TABLE I

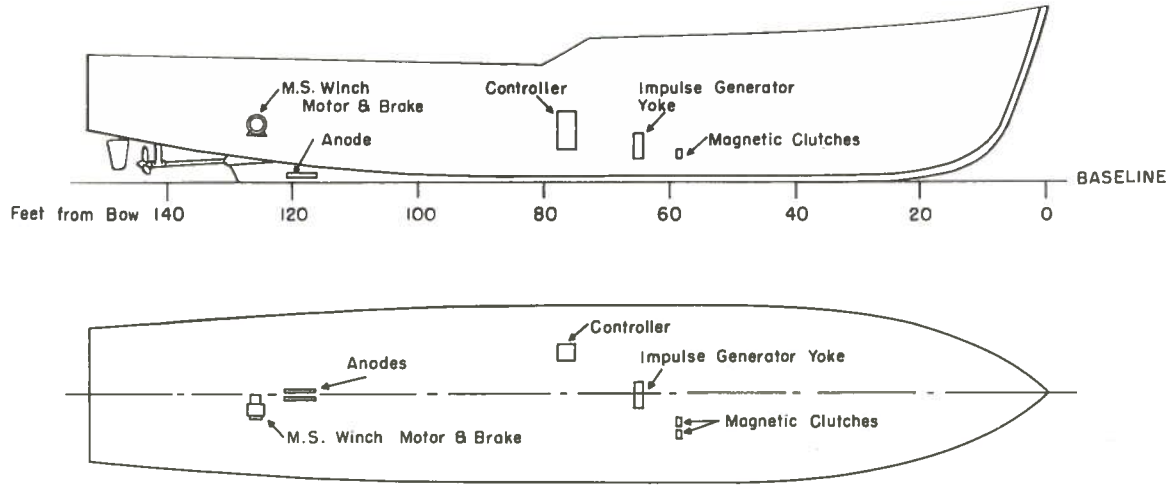


NOTE: A number of small rotating electrical machines are not shown. The majority of these are located in the engine and generator rooms.

0 10 20 FT.
SCALE

HMCS "COWICHAN" (MCB 162)
PRINCIPAL FERROMAGNETIC FITTINGS

FIG. 1



0 10 20 FT.
SCALE

HMCS "COWICHAN" (MCB 162)
SOURCES OF STRAY MAGNETIC FIELDS

FIG. 2

CONFIDENTIAL

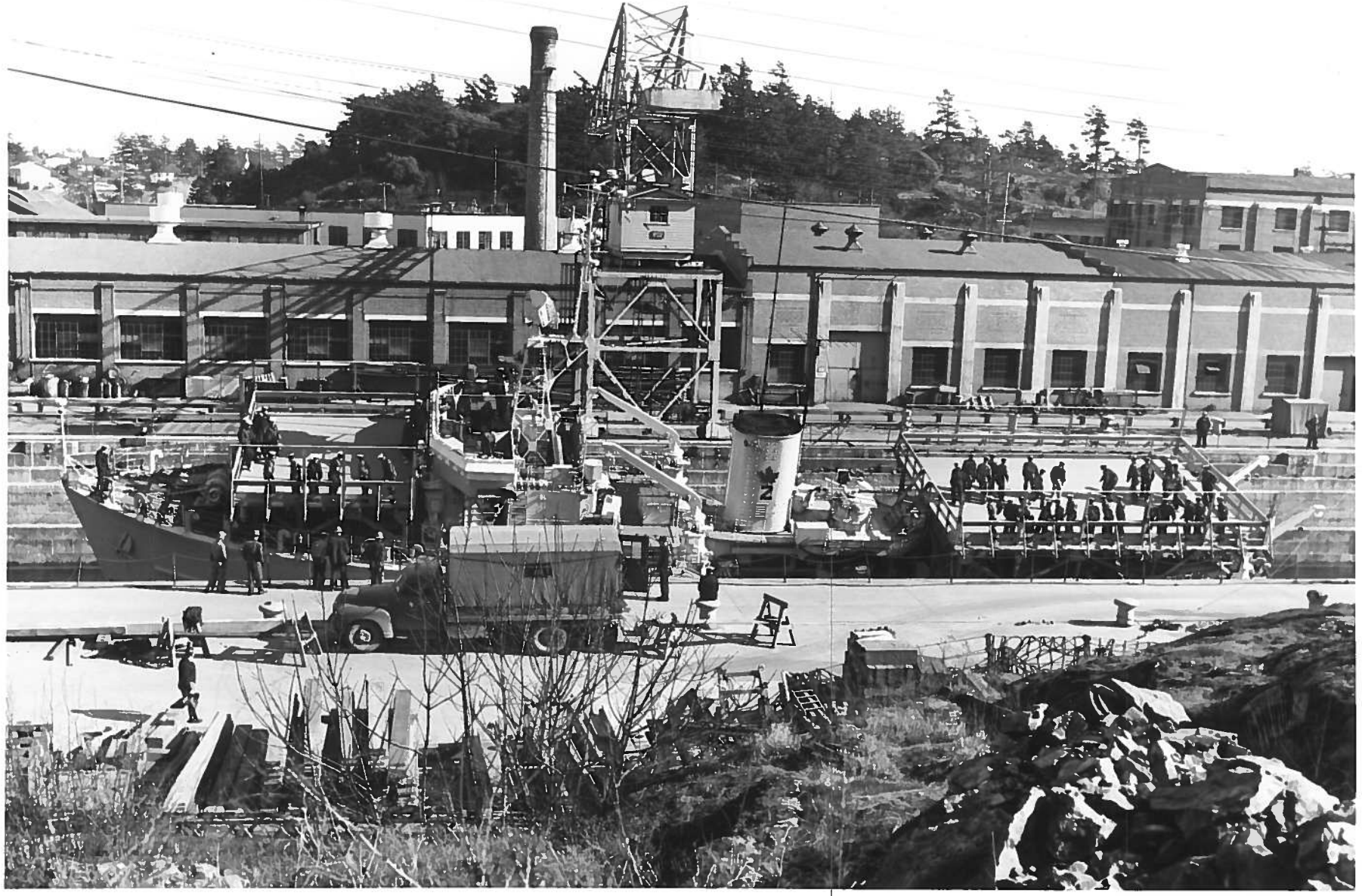
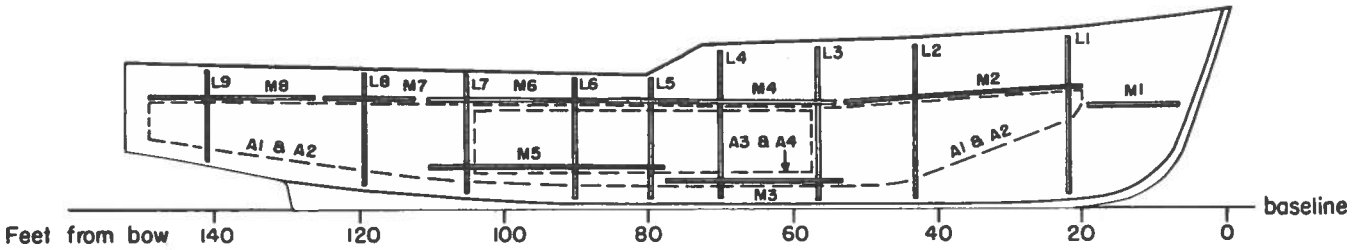
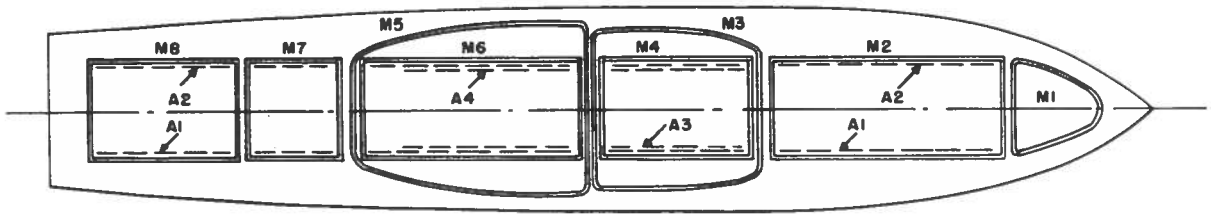


FIG. 3. SHIP IN N-S DOCK SHOWING "ROLLING" PLATFORMS AND "ROLLING" CREW (side view)





LOOP	TURNS CONNECTED	
	ORIGINAL COILING	ADJUSTED COILING
M1	0	28
M2	1	9
M3	6	6
M4	10	10
M5	3	3
M6	6	8
M7	25	25
M8	14	14
A1 , A2	0	0
A3, A4	19	19
L1,L2,L3,L5,L9	0	0
L4	0	19
L6, L7	3	3
L8	5	5

0 10 20 FT.
SCALE

HMCS "COWICHAN" (MCB 162)
DEGAUSSING COILS
FIG. 4

CONFIDENTIAL

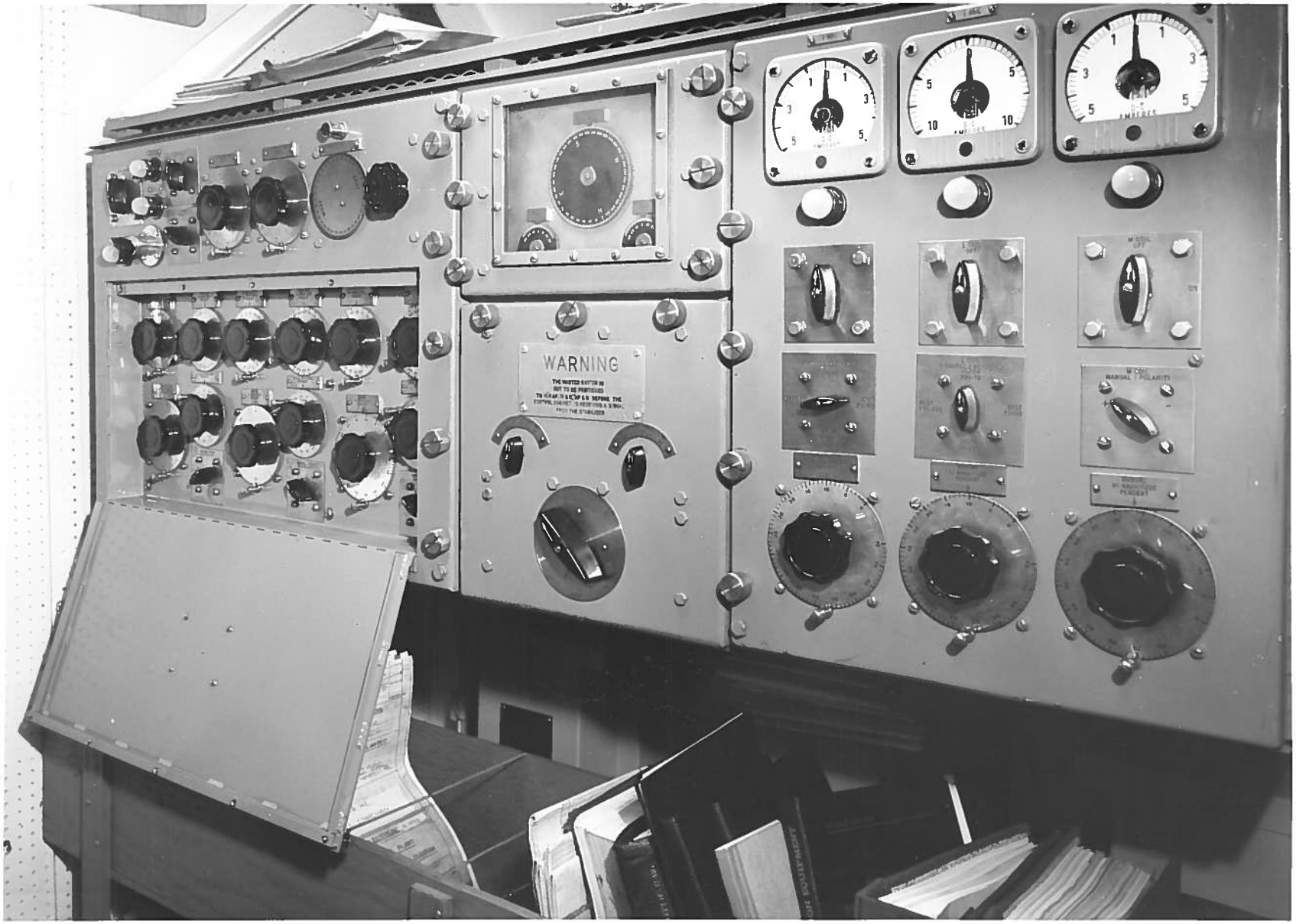


FIG. 5. DEGAUSSING CONTROL PANEL

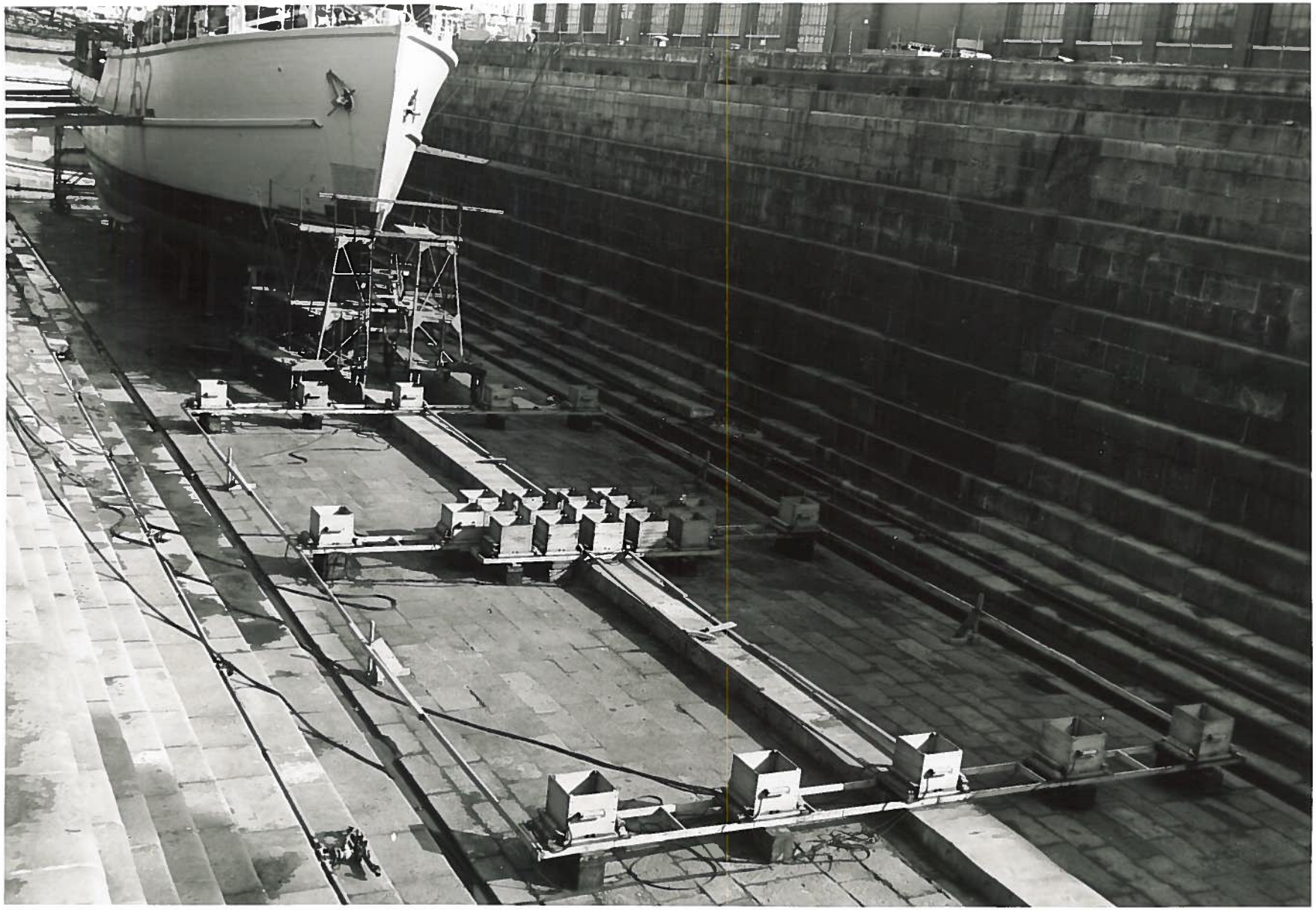
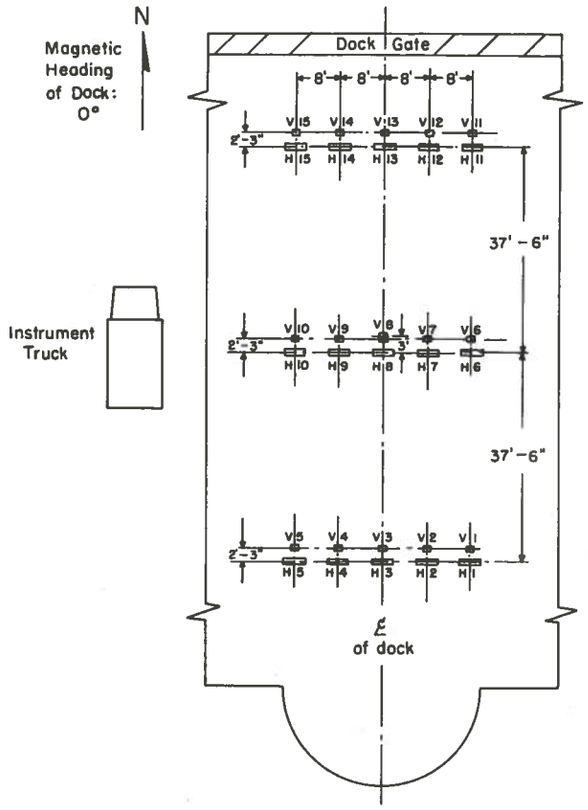
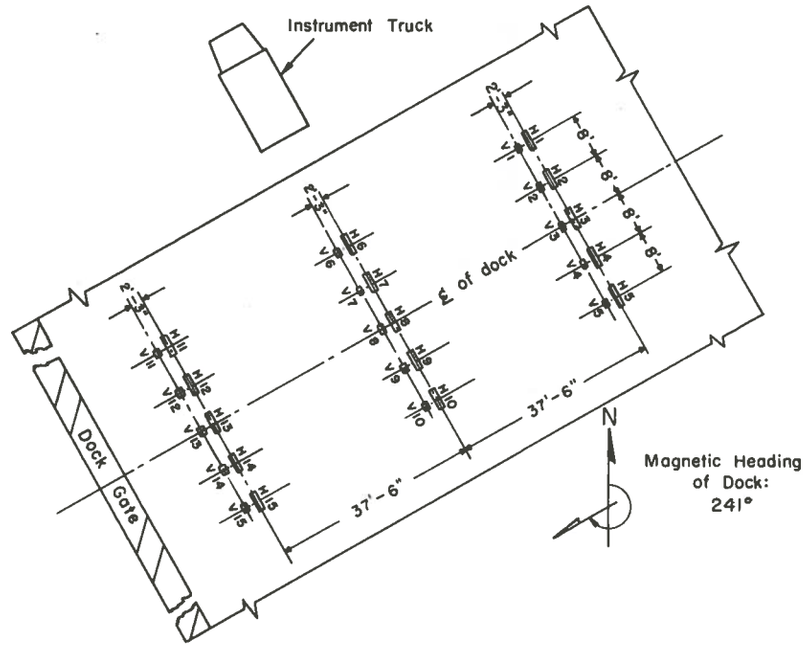


FIG. 6. MAGNETOMETER RANGES INSTALLED IN RCN DOCK (looking north)



RCN DRY DOCK
ESQUIMALT, B.C.

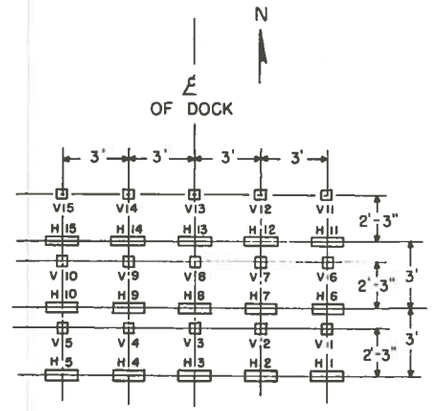


DEPT. OF TRANSPORT DRY DOCK
ESQUIMALT, B.C.

MAGNETIC RANGES USED IN
MEASUREMENTS OF SHIP'S STATIC FIELD, STATIC AND DYNAMIC TILT FIELDS,
AND EDDY CURRENT FIELD.

FIG. 7

CONFIDENTIAL

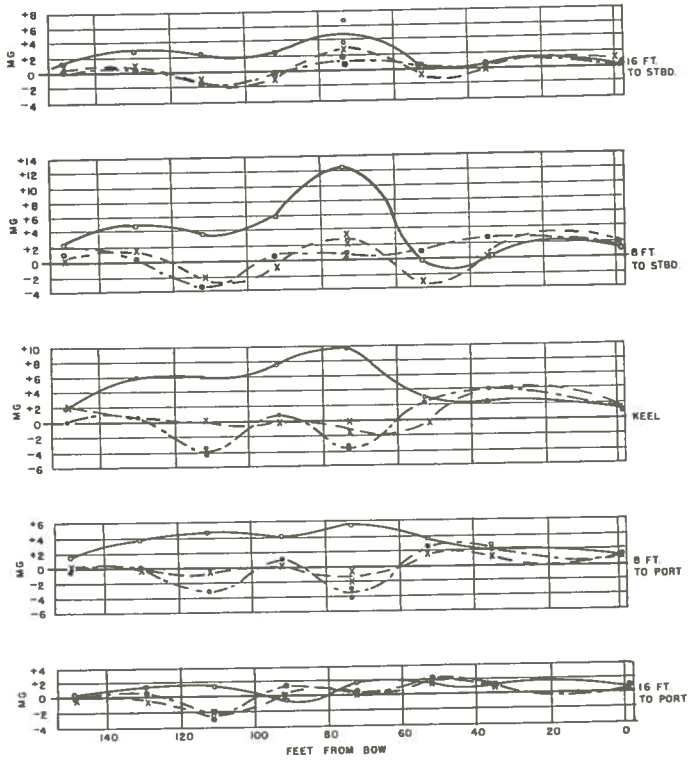


NOTE: Unit V8 was 4" higher than the other units to avoid interference from a local field.

RCN DRY DOCK, ESQUIMALT, B.C.

MAGNETIC RANGE USED IN MEASUREMENTS
OF STRAY FIELDS OF SHIP'S ELECTRICAL EQUIPMENT

FIG. 8



LEGEND

D.G. OFF

D.G. ON – ADJUSTED COILING
D.G. CURRENTS – A : – 0.3 AMP.
L : + 0.5 AMP.
M : + 1.8 AMP.

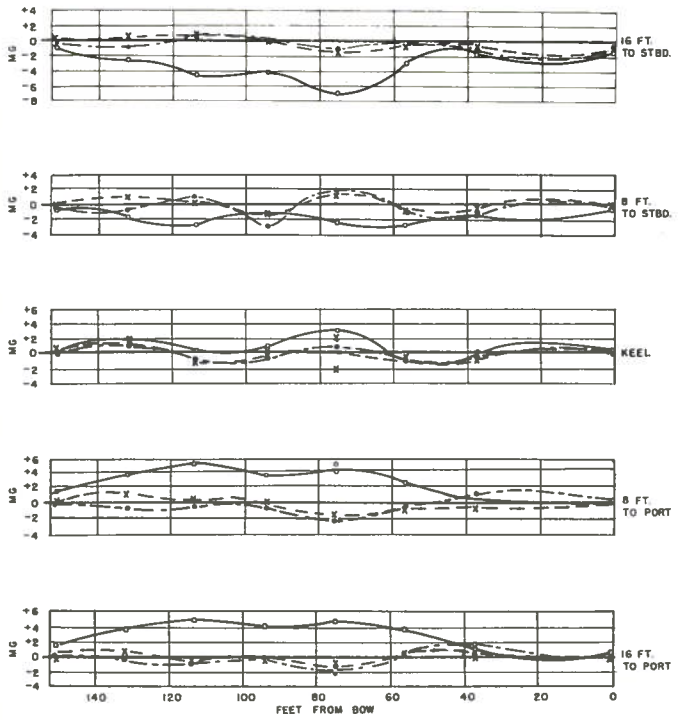
D.G. ON – ORIGINAL COILING
D.G. CURRENTS – A : – 0.3 AMP.
L : + 2.75 AMP.
M : + 1.8 AMP.

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD : Z = 515 MG.
H = 0
HEADING OF SHIP : 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC FIELD
VERTICAL COMPONENTS
HEADING : NORTH DEPTH . 15:5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 9(a)



LEGEND

D.G. OFF

D.G. ON – ADJUSTED COILING
D.G. CURRENTS – A : – 0.3 AMP.
L : + 0.5 AMP.
M : + 1.8 AMP.

D.G. ON – ORIGINAL COILING
D.G. CURRENTS – A : – 0.3 AMP.
L : + 2.75 AMP.
M : + 1.8 AMP.

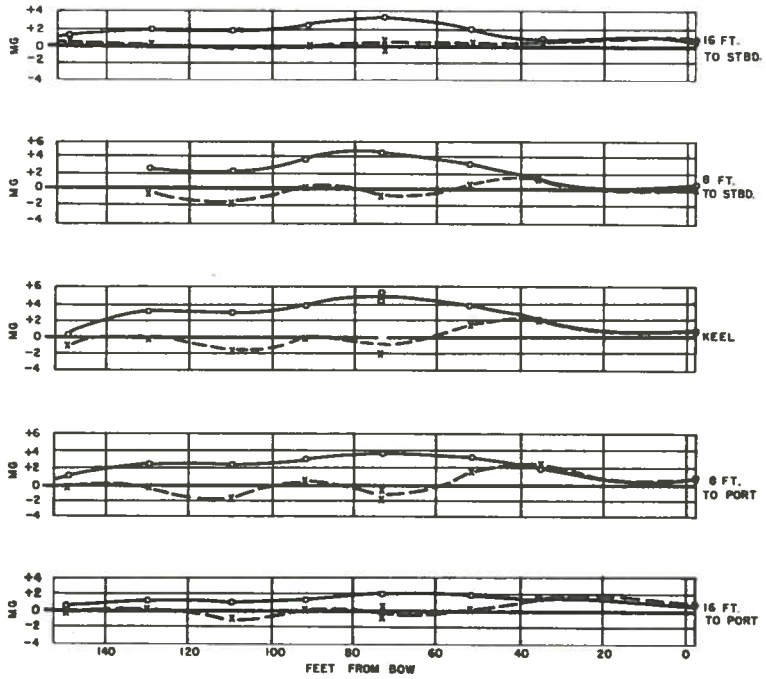
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD : Z = 515 MG.
H = 0
HEADING OF SHIP : 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING : NORTH DEPTH : 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 9(b)



LEGEND

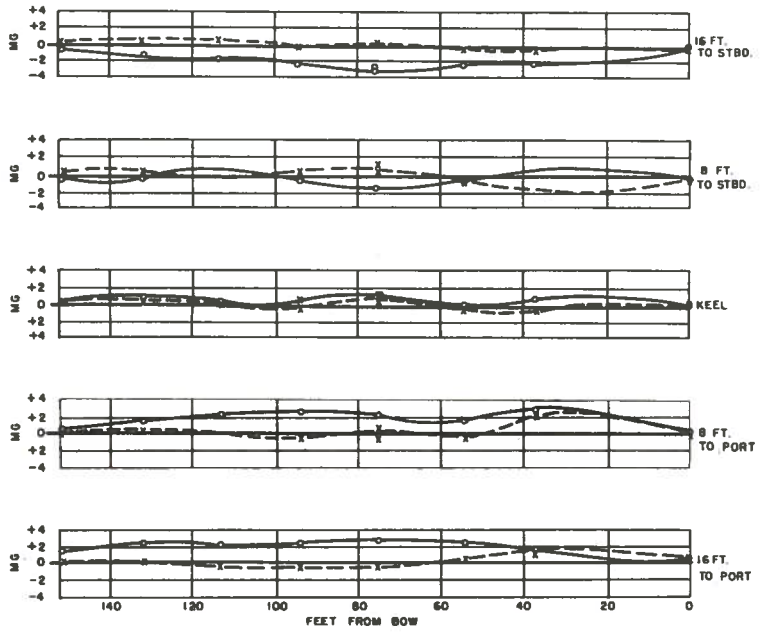
D.G. OFF

D.G. ON – ORIGINAL COILING

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG.
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
DEGAUSSING CURRENTS: A: – 0.3 AMP.
L: + 2.75 AMP.
M: + 1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
VERTICAL COMPONENTS
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)
FIG. 10(a)



LEGEND

D.G. OFF

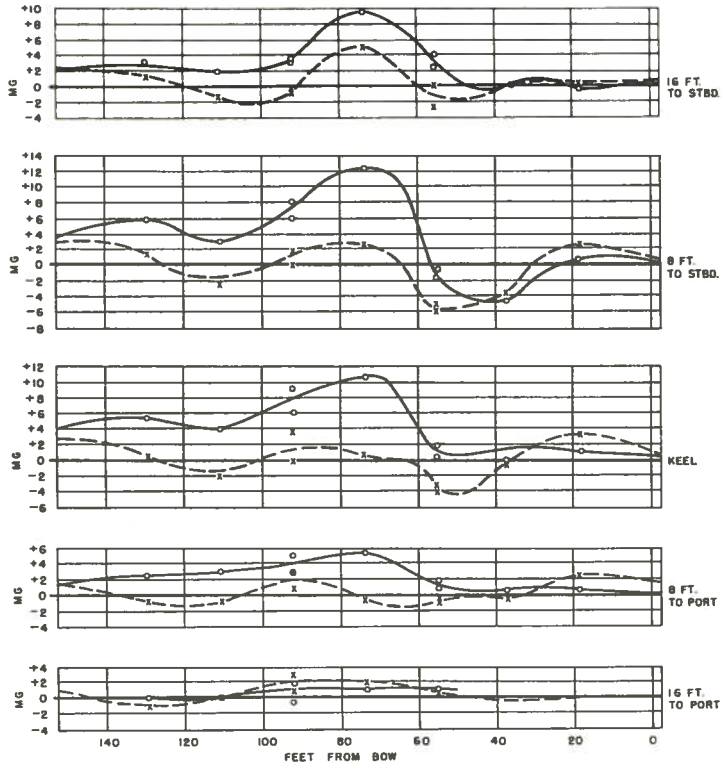
D.G. ON – ORIGINAL COILING

NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG.
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
DEGAUSSING CURRENTS: A: – 0.3 AMP.
L: + 2.75 AMP.
M: + 1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)
FIG. 10(b)

CONFIDENTIAL



LEGEND

D.G. OFF

D.G. ON

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD

EXCITING FIELD: Z = 515 MG

H = 156 MG

HEADING OF SHIP: 241° (MAGNETIC)

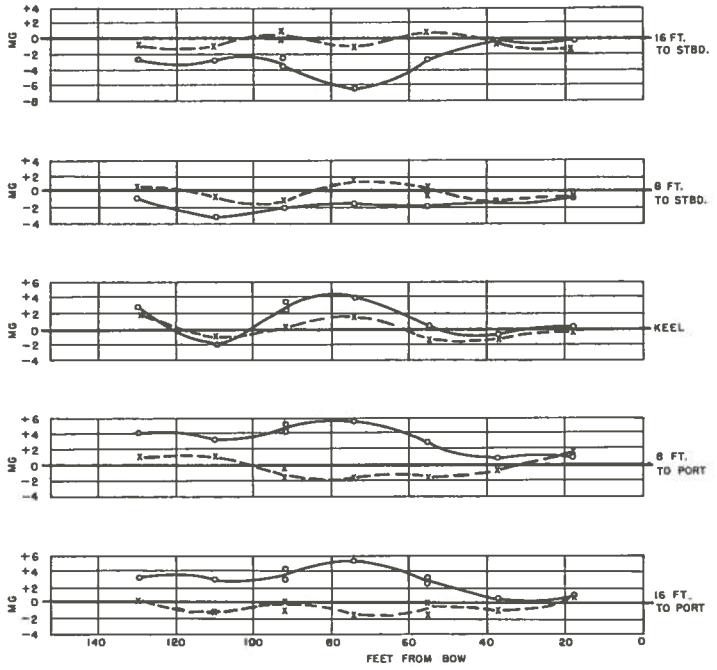
DEGAUSSING CURRENTS: A: −0.55 AMP.

L: 0

M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. II (a)



D.G. OFF

D.G. ON

NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.

EXCITING FIELD: Z = 515 MG.

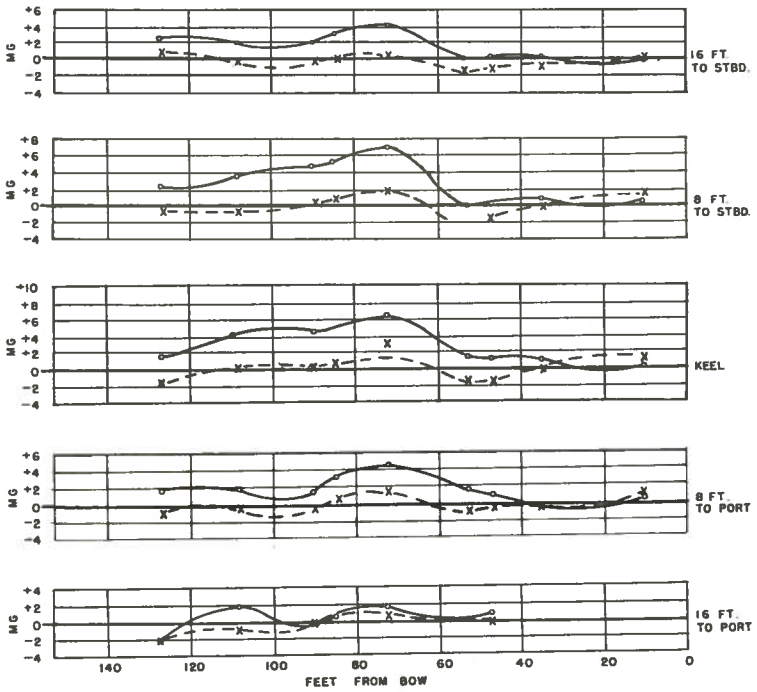
H = 156 MG.

HEADING OF SHIP: 241° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. II (b)

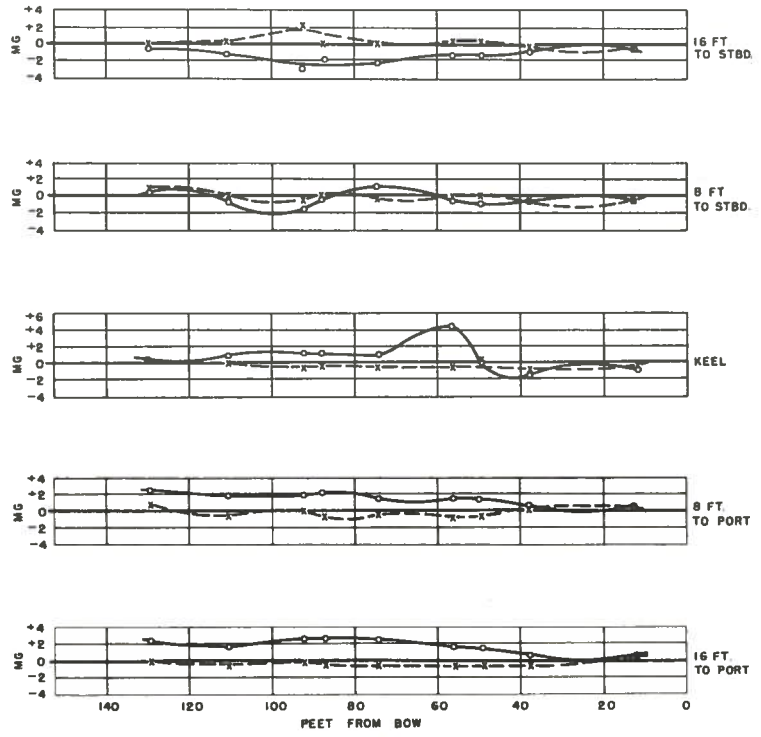


LEGEND
D.G. OFF
D.G. ON

NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
DEGAUSSING CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 12(a)



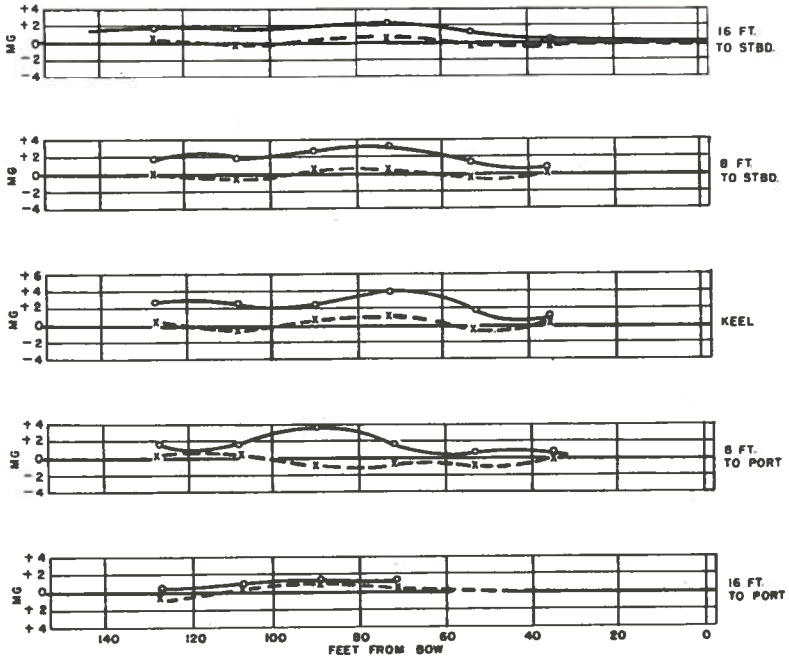
LEGEND
D.G. OFF
D.G. ON

NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
DEGAUSSING CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 12(b)



LEGEND

D.G. OFF

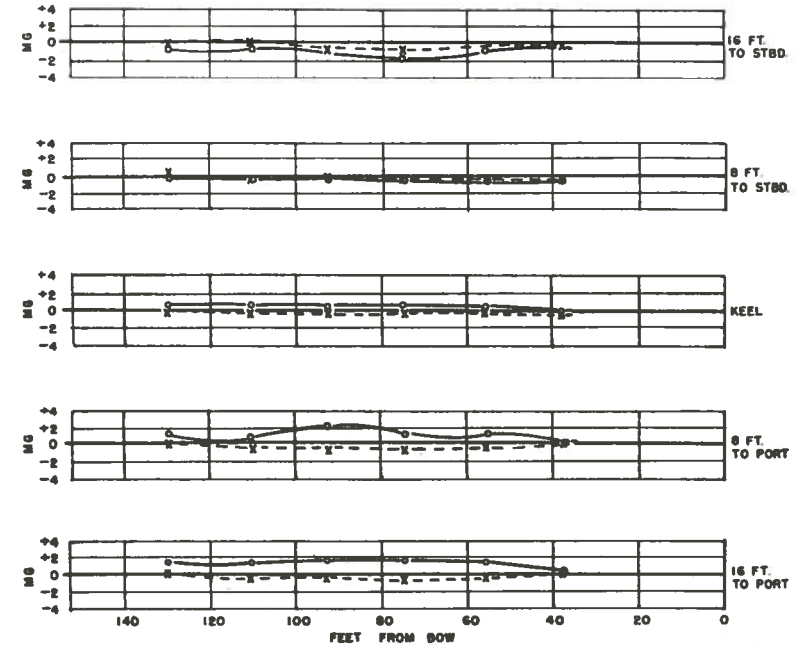
D.G. ON

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG.
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
DEGAUSSING CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 30 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 13(a)



LEGEND

D.G. OFF

D.G. ON

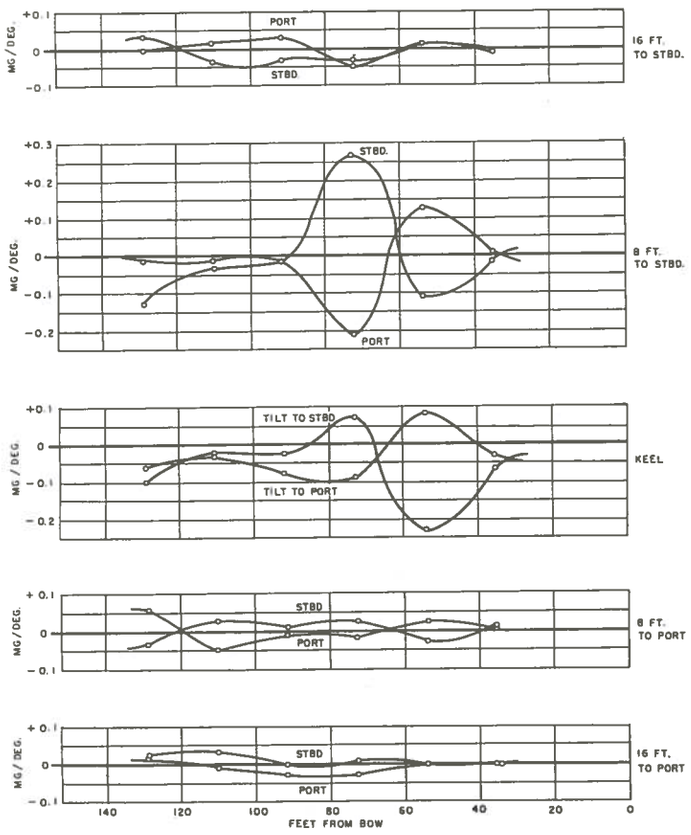
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
DEGAUSSING CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 30 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

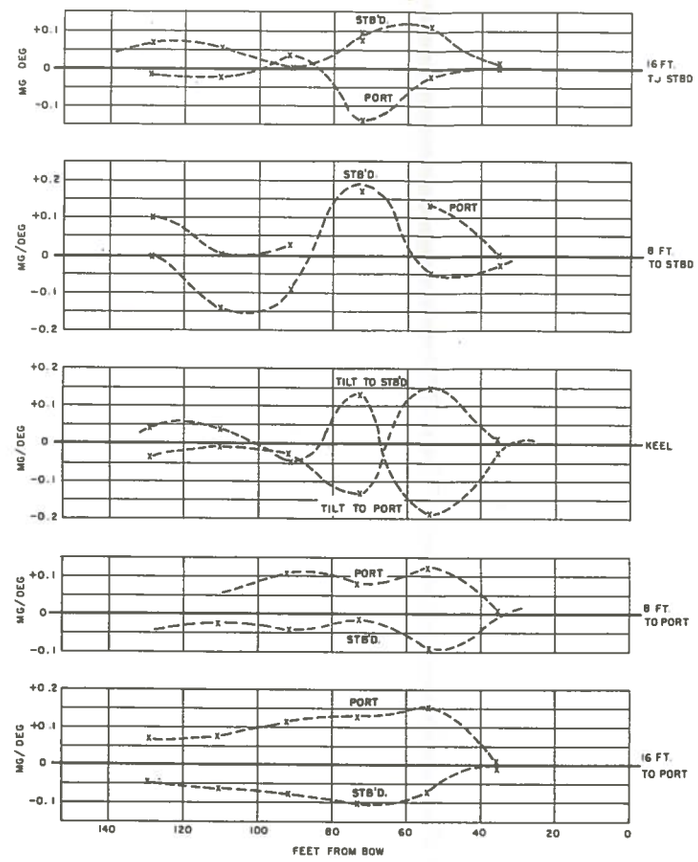
FIG. 13(b)



NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. OFF
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 14(a)

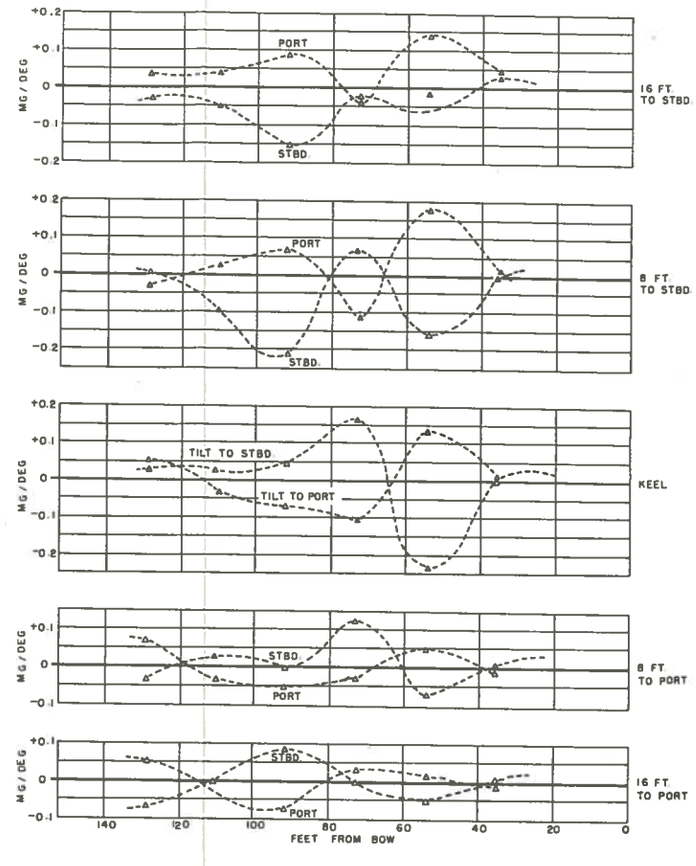


NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS A: −0.3 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON — HEADING ONLY
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 14(b)



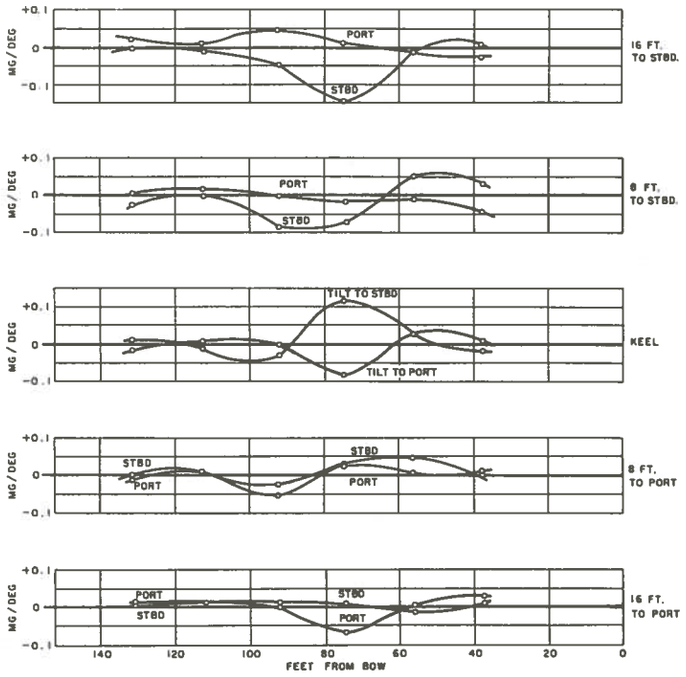
NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS (EVEN KEEL): A: −0.3 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON — HEADING AND ROLL
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

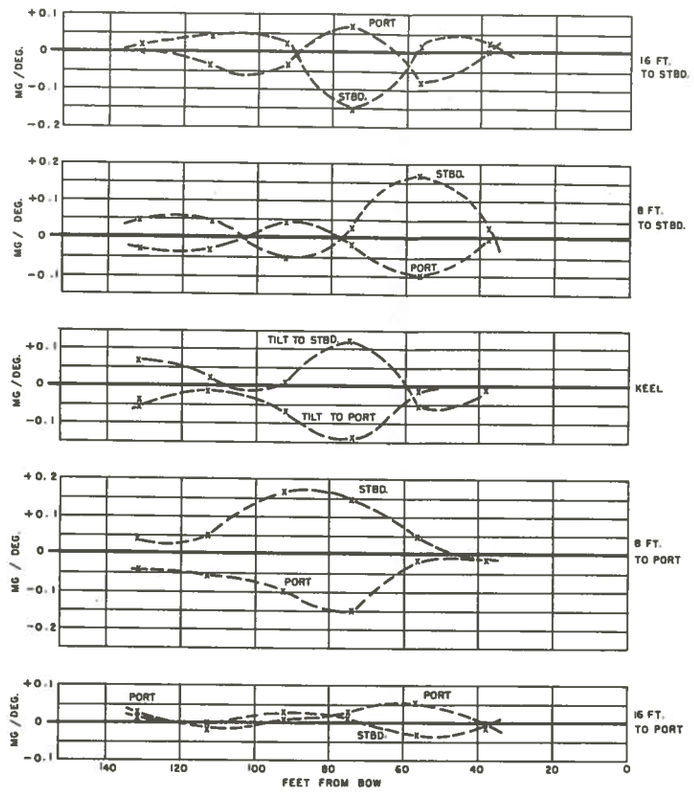
FIG. 14(c)



NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. OFF
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 15(a)

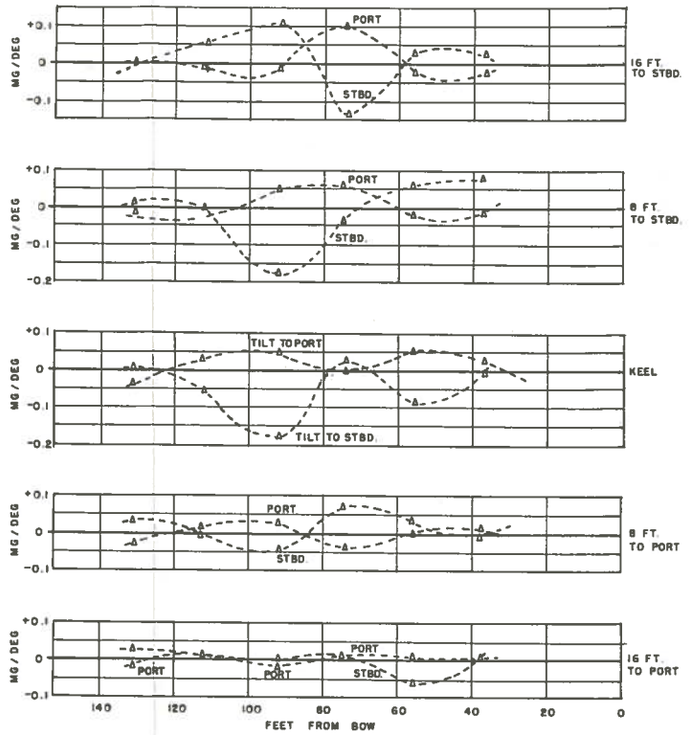


NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS: A: -0.3 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENT
D.G. ON — HEADING ONLY
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 15(b)



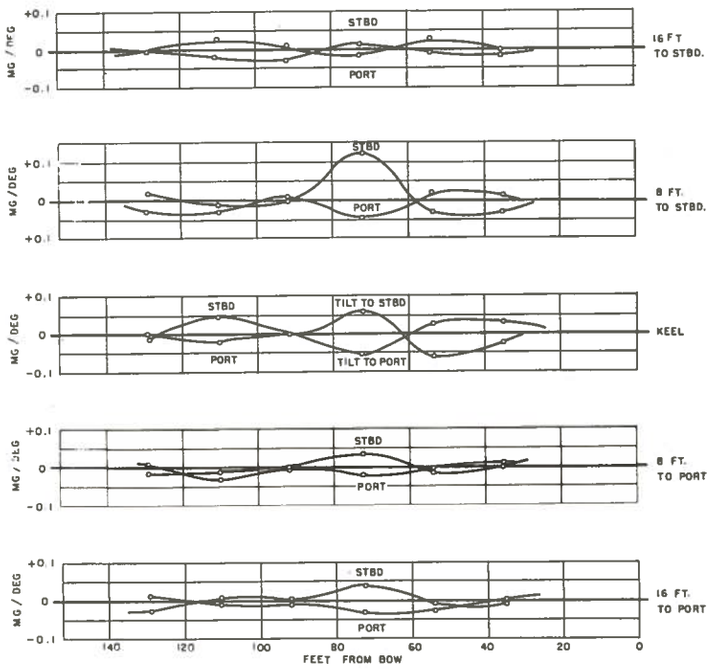
NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD TO PORT
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS (EVEN KEEL): A: -0.3 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: -9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON—HEADING AND ROLL
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

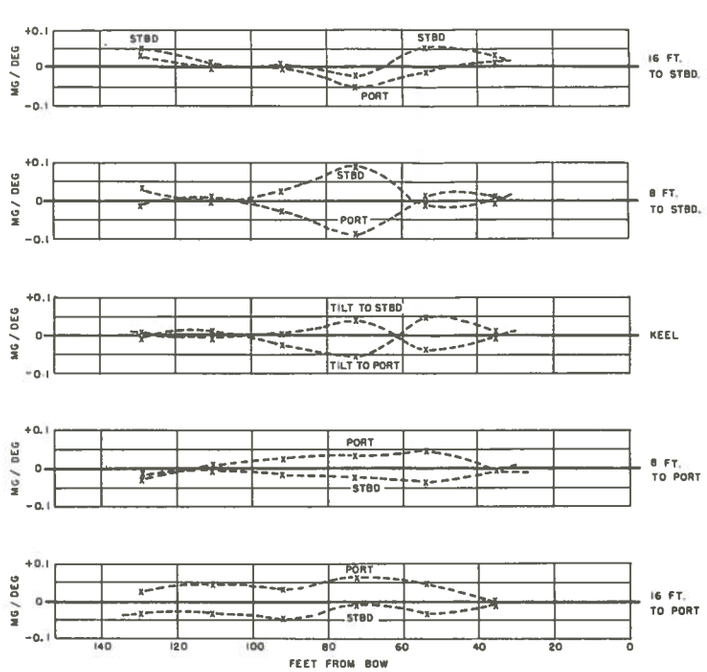
FIG. 15(c)



NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. OFF
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 16(a)

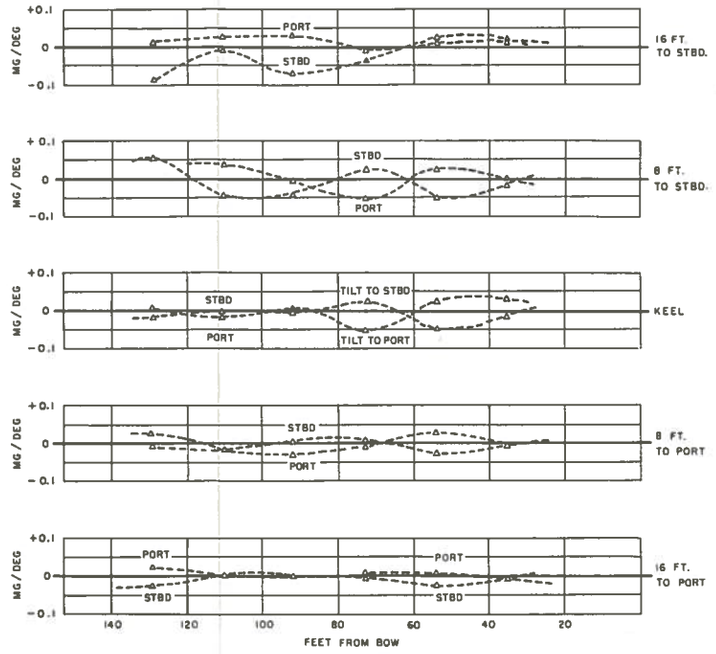


NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS: A: -0.3 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON – HEADING ONLY
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 16(b)



NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

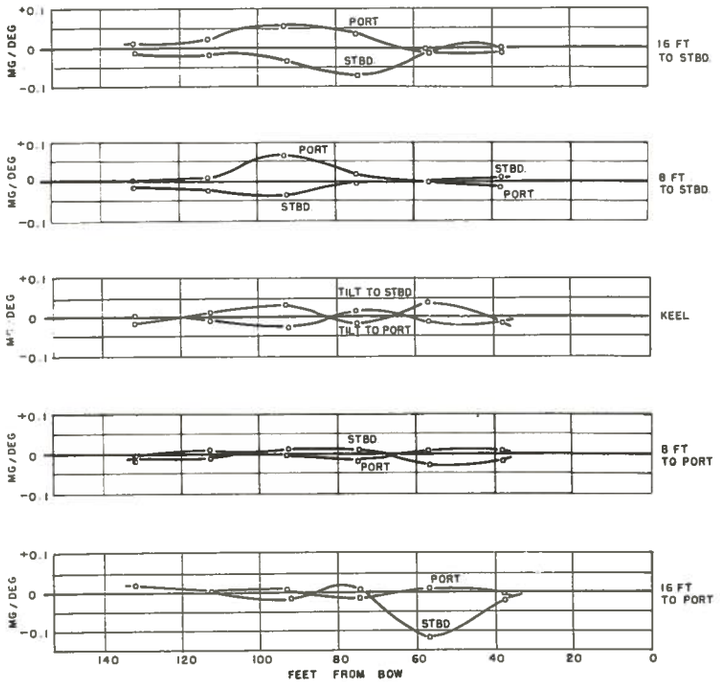
D.G. CURRENTS (EVEN KEEL) A: -0.3 AMP.
L: 0
M: +1.8 AMP.

D.G. CONTROLLER SETTINGS: AI: 25% AP: -9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON – HEADING AND ROLL
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 16(c)

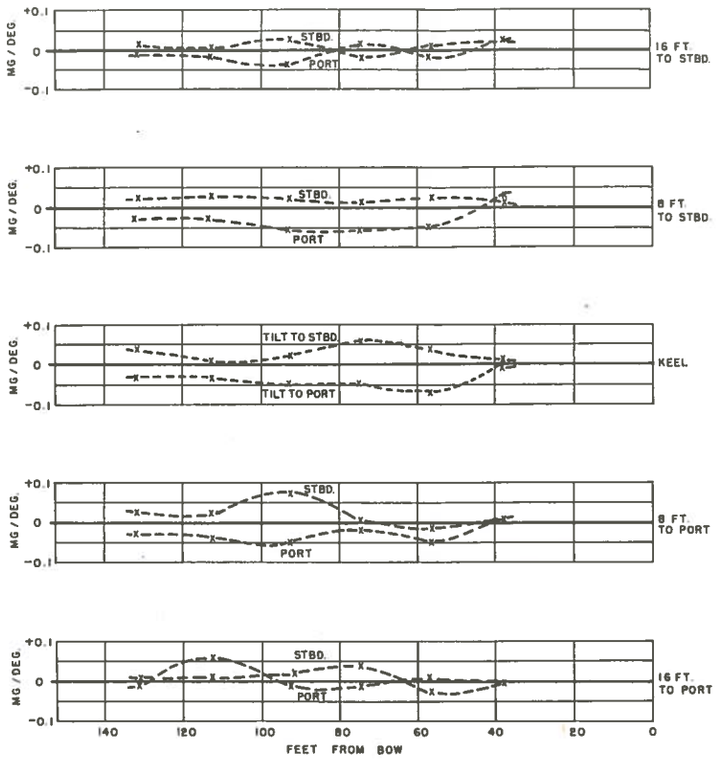


NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD TO PORT
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. OFF
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 17(a)



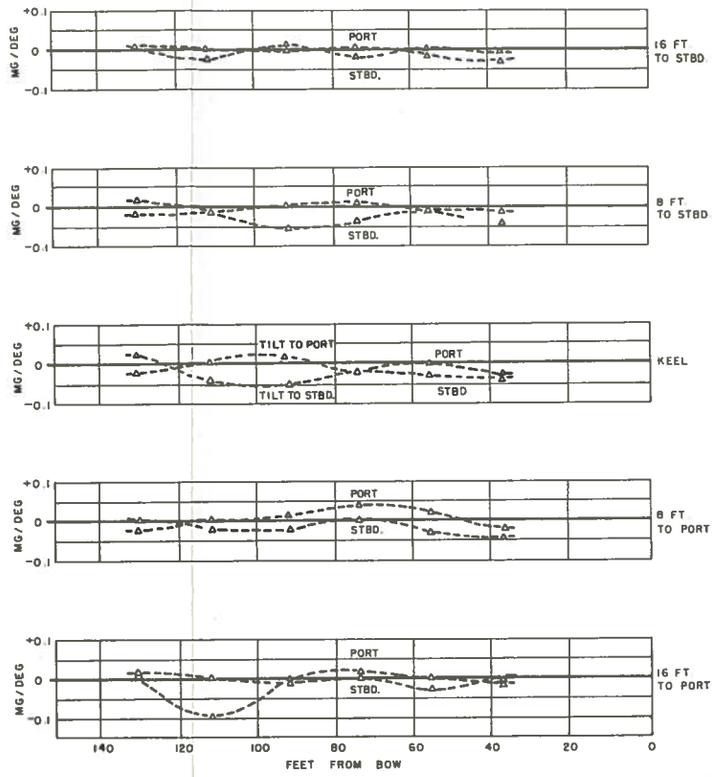
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

D.G. CURRENTS: A: −0.3 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON—HEADING ONLY
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 17(b)



NOTE:

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)

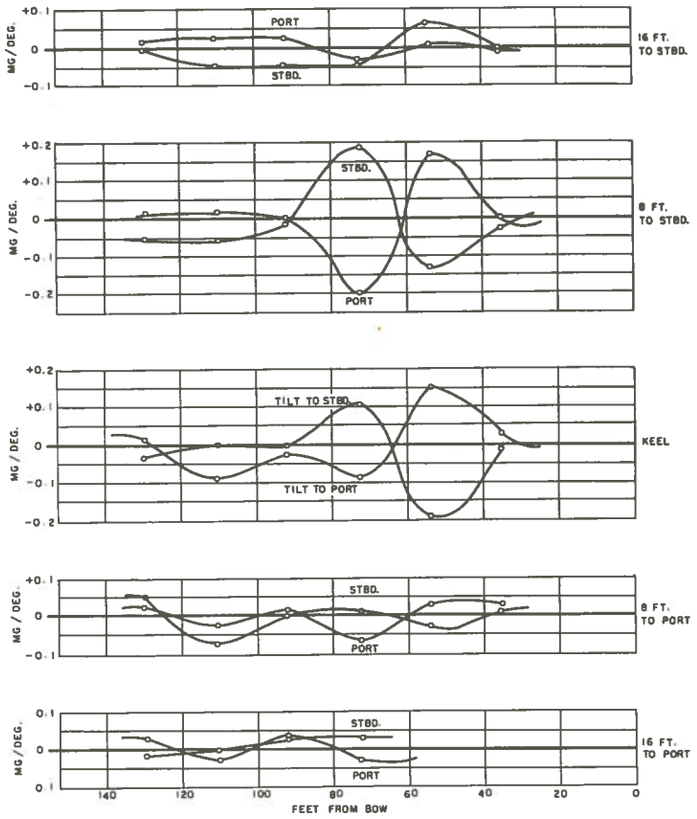
D.G. CURRENTS (EVEN KEEL): A: −0.3 AMP.
L: 0
M: +1.8 AMP.

D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON—HEADING AND ROLL
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 17(c)

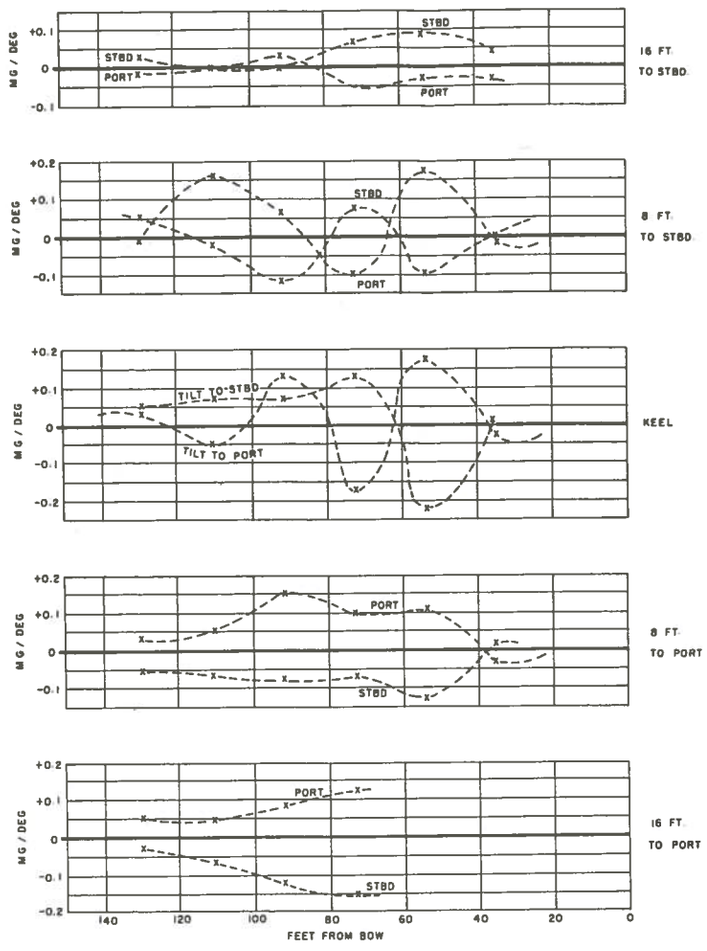
CONFIDENTIAL



NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 0° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. OFF
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 18(a)

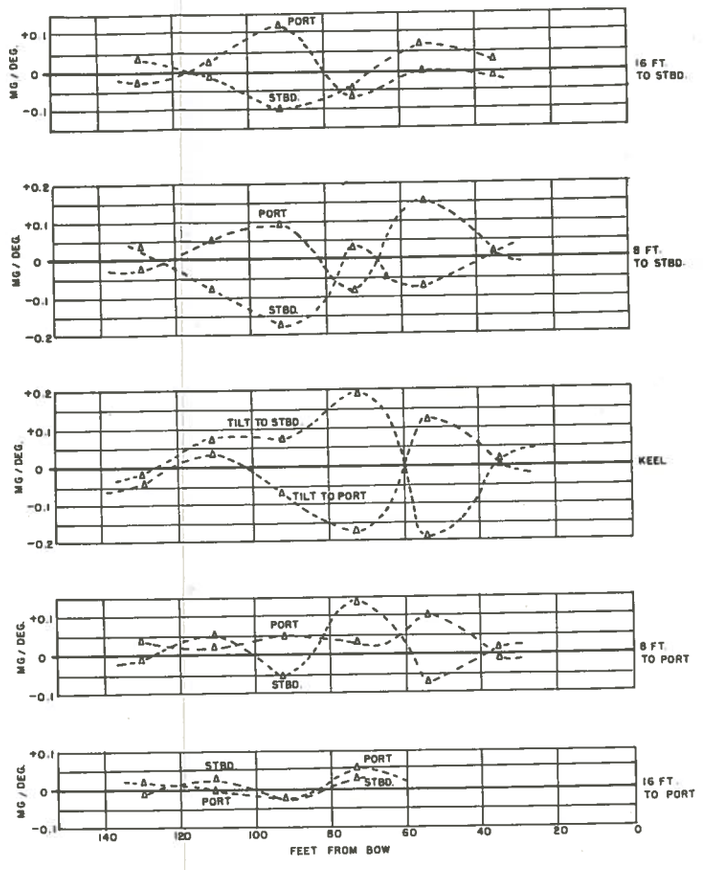


NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON — HEADING ONLY
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 18(b)



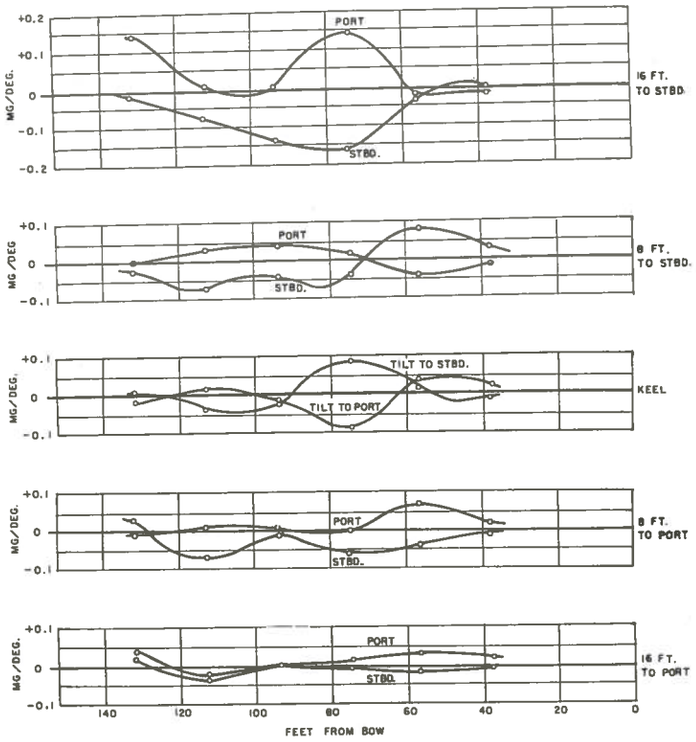
NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS (EVEN KEEL): A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: -9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON-HEADING AND ROLL
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

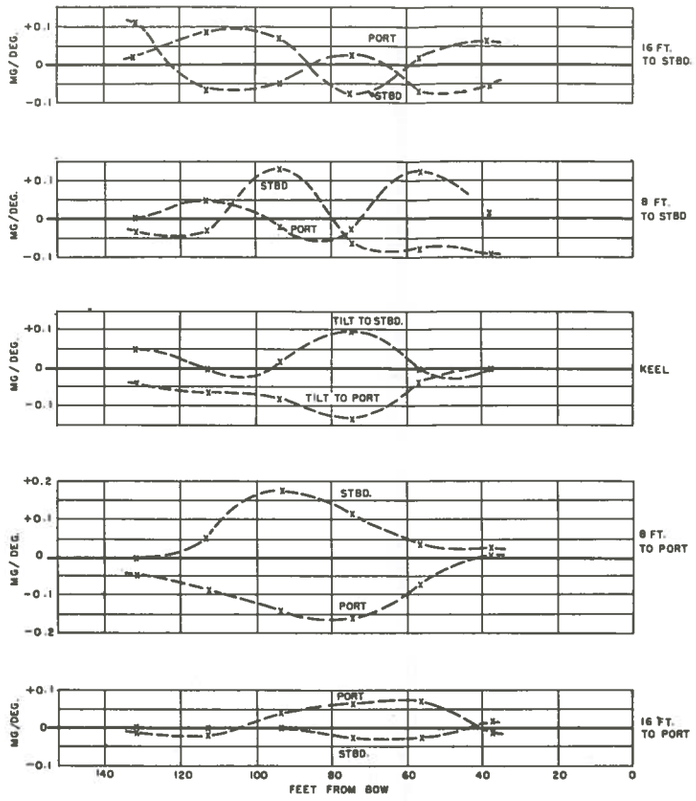
FIG. 18(c)



NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 241° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. OFF
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 19(a)

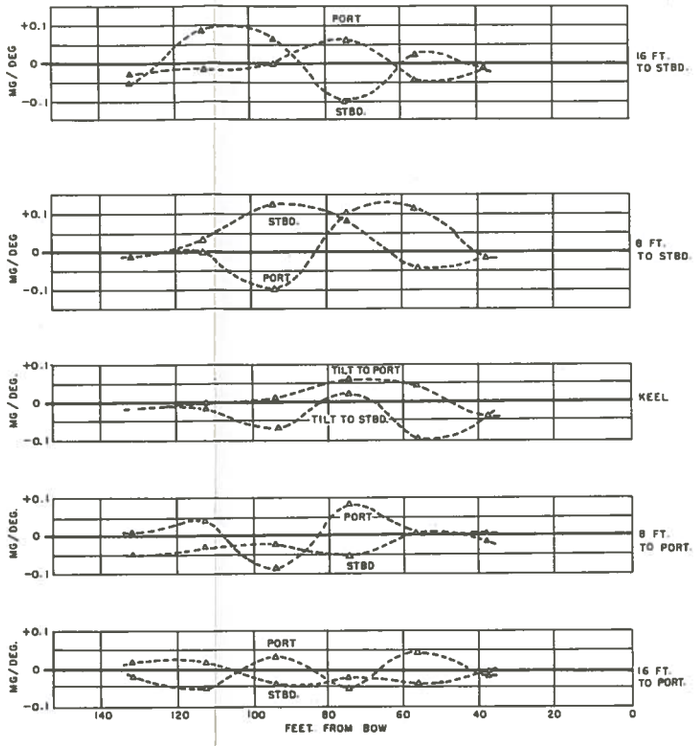


NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON — HEADING ONLY
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 19(b)



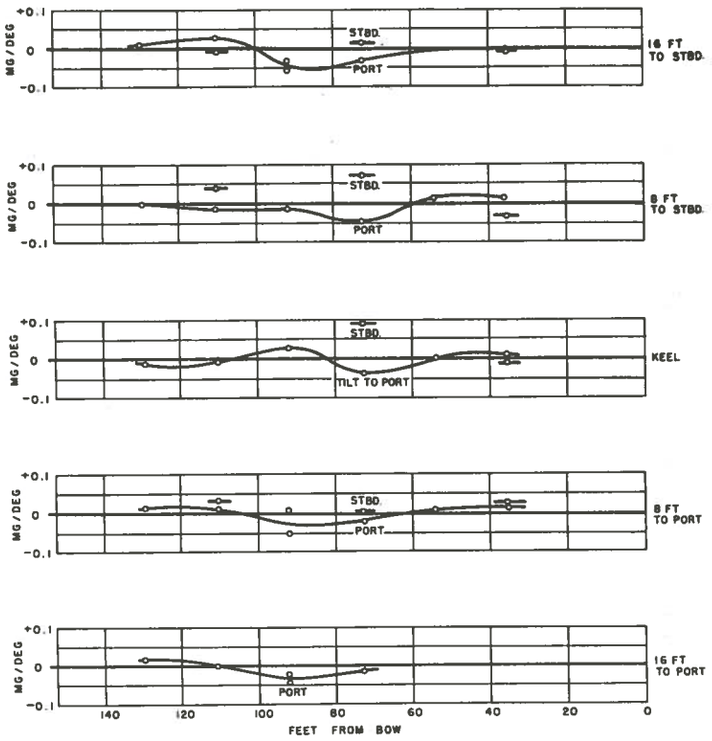
NOTE
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT.
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS (EVEN KEEL): A = −0.55 AMP.
L = 0
M = + 1.8 AMP.
D.G. CONTROLLER SETTING: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON-HEADING AND ROLL
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

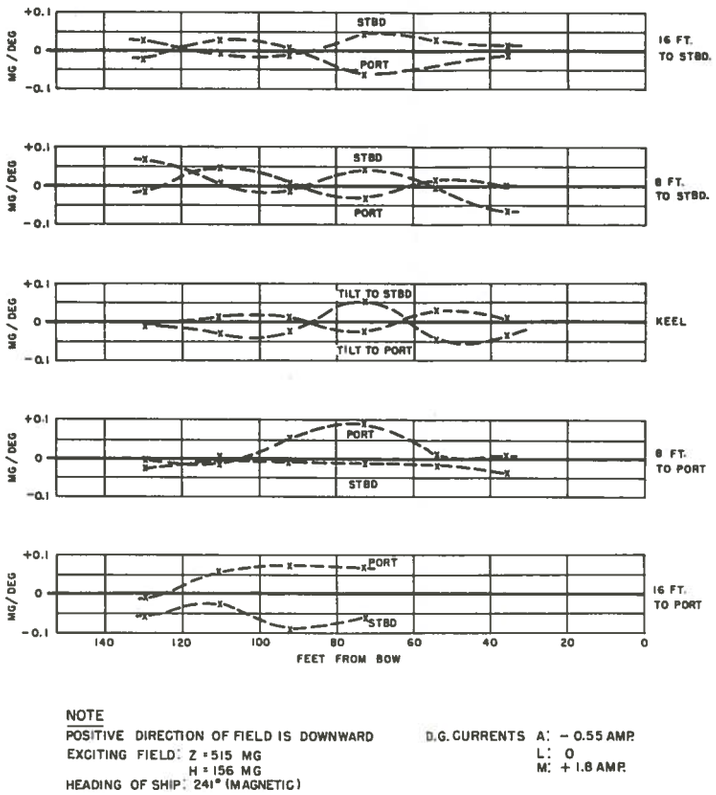
FIG. 19(c)



NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. OFF
HEADING : WEST DEPTH : 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 20(a)

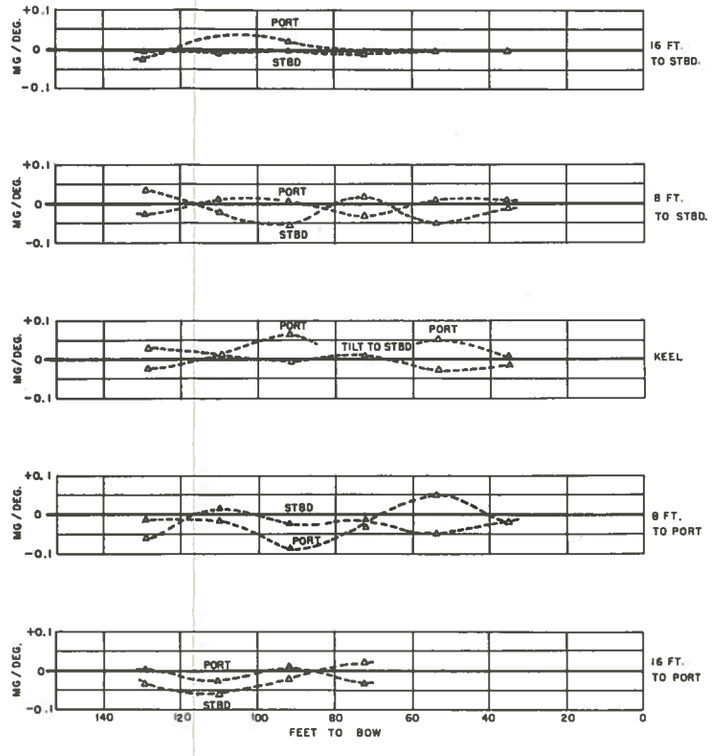


NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS A: − 0.55 AMP.
L: 0
M: + 1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON — HEADING ONLY
HEADING : WEST DEPTH : 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 20(b)



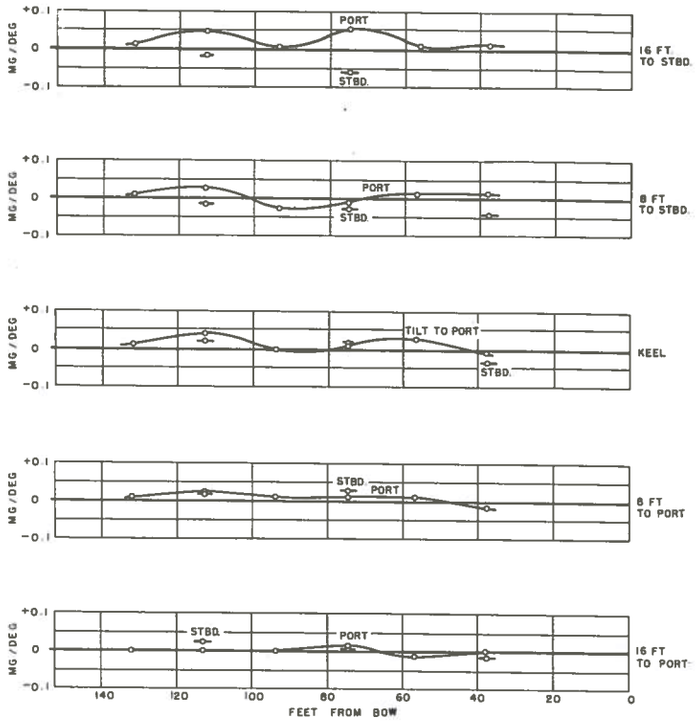
NOTE
POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS (EVEN KEEL): A: −0.55 AMP.
L: 0
M: + 1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
D.G. ON — HEADING AND ROLL
HEADING : WEST DEPTH : 22 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 20(c)

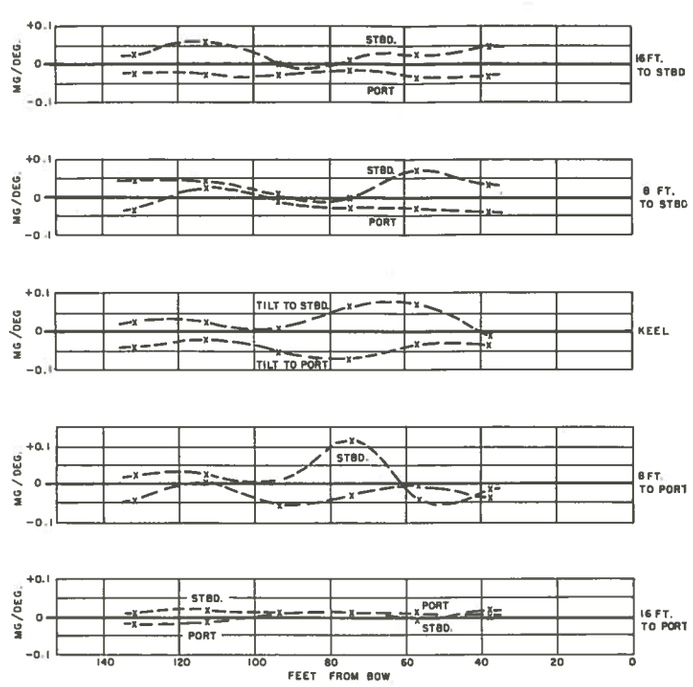


NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. OFF
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 21(a)



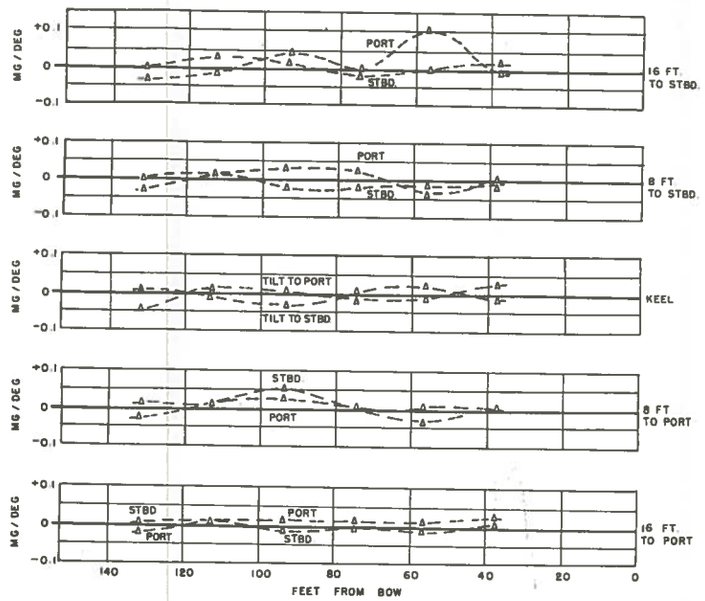
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 241° (MAGNETIC)

D.G. CURRENTS: A: -0.55 AMP.
L: 0
M: +1.8 AMP.

LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON — HEADING ONLY
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 21(b)



NOTE

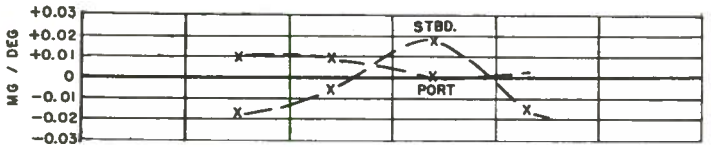
POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

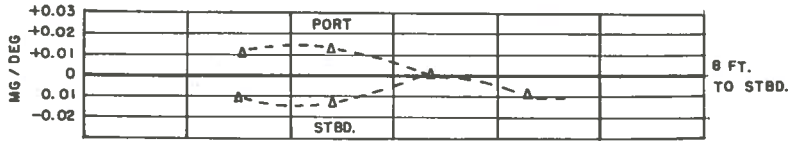
D.G. CURRENTS (EVEN KEEL): A: -0.55 AMP
L: 0
M: +1.8 AMP.
D.G CONTROLLER SETTINGS: AT: 25% AP: -8%
LT: 0 LP: 0
MT: 35% MP: 12%

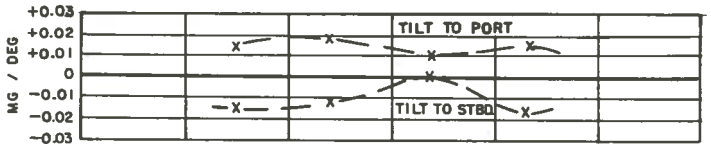
LONGITUDINAL PROFILES OF STATIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
D.G. ON—HEADING AND ROLL
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

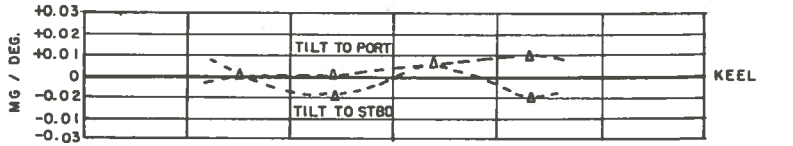
CONFIDENTIAL

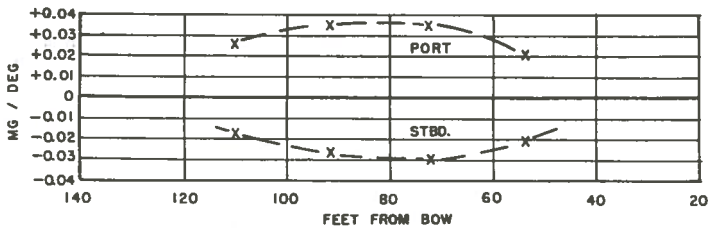
FIG. 21(c)

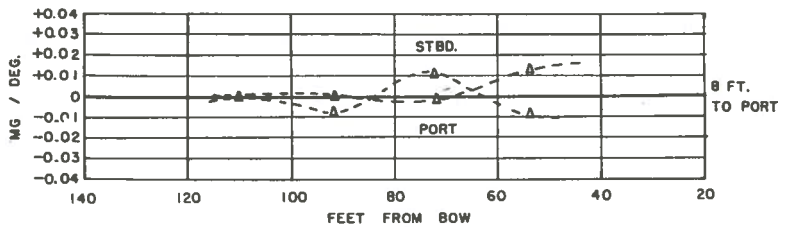












D.G. ON – HEADING ONLY

DEGAUSSING CURRENTS A: – 0.55 AMP.
L: 0
M: + 1.8 AMP.

D.G. ON HEADING AND ROLL

D.G. CONTROLLER SETTINGS AI: 25 % AP: – 9 %
LI: 0 LP: 0
MI: 35 % MP: 12 %

NOTE: POSITIVE DIRECTION OF FIELD IS DOWNWARD
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)

LONGITUDINAL PROFILES OF STATIC TILT FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 30 FT.
HMCS "COWICHAN" (MCB 162)
FIG. 22

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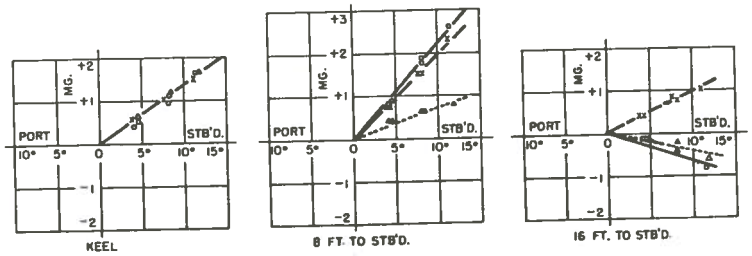
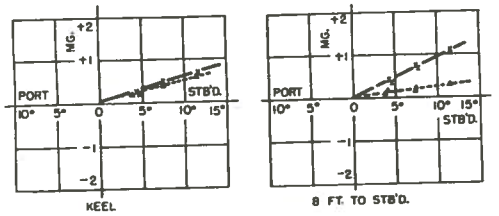


73 FEET FROM BOW, DEPTH 15.5 FT.



73 FEET FROM BOW, DEPTH 22 FT.

LEGEND
- D.G. OFF
- D.G. ON – HEADING ONLY
- D.G. ON – HEADING AND ROLL

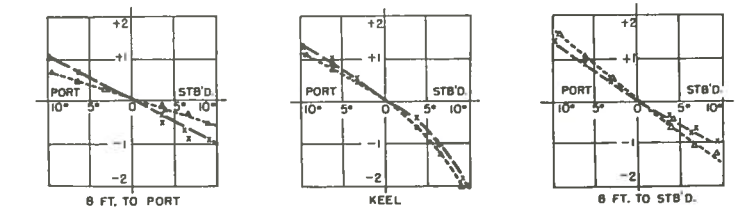
NOTE: Positive Direction of Field is Downwards.
Exciting Field: Z = 515 mg.
H = 0
Heading of Ship: 0° (magnetic)
Degaussing Currents: A: −0.3 Amp.
L: 0
M: +1.8 Amp.

D.G. Controller Settings:
AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

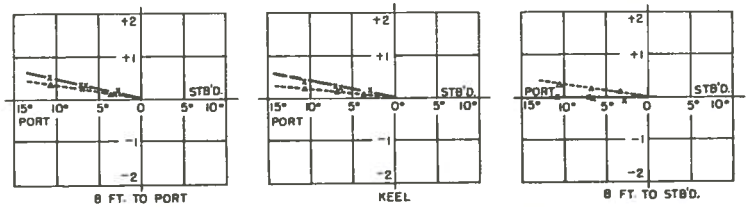
STATIC TILT FIELD VS. TILT ANGLE
VERTICAL COMPONENTS
HEADING: NORTH

HMCS "COWICHAN" (MCB 162)

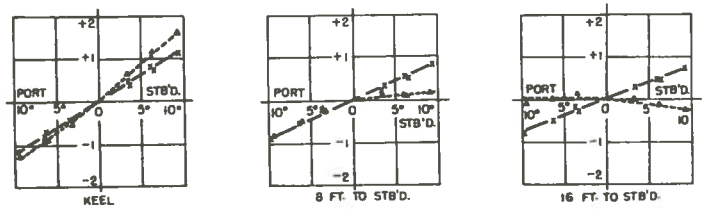
FIG. 23



54'-6" FROM BOW DEPTH: 15.5 FT.



54'-6" FROM BOW DEPTH: 22 FT.



73 FT. FROM BOW DEPTH: 15.5 FT.

LEGEND
- D.G. ON – HEADING ONLY
- D.G. ON – HEADING AND ROLL

NOTE: Positive Direction of Field is Downwards.
Exciting Field: Z = 515 mg.
H = 156 mg.
Heading of Ship: 241° (magnetic)
Degaussing Currents: A: −0.55 Amp.
L: 0
M: +1.8 Amp.

D.G. Controller Settings:
AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

STATIC TILT FIELD VS. TILT ANGLE
VERTICAL COMPONENTS
HEADING: WEST

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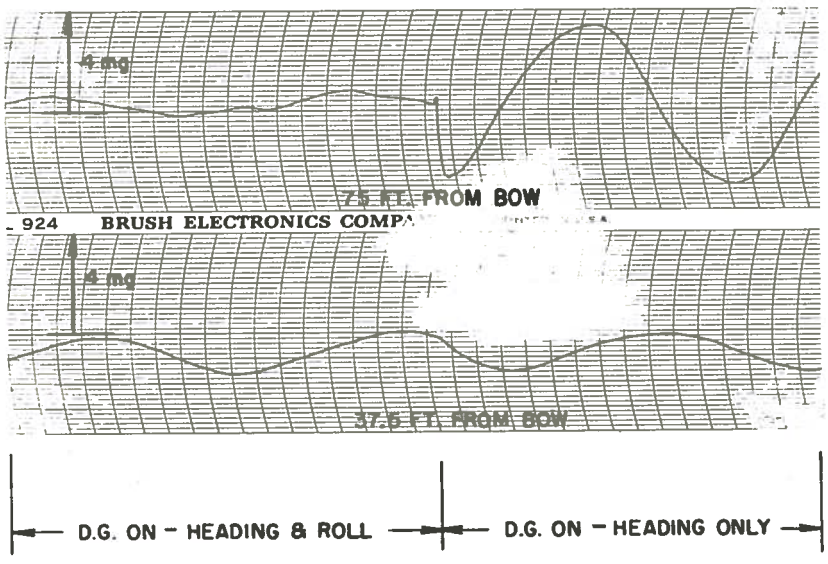
HMCS "COWICHAN" (MCB 162)

FIG. 24

FIG. 25. STERN VIEW OF ROLLING SHIP (west heading)

FIG. 26. BOW VIEW OF ROLLING SHIP (north heading)

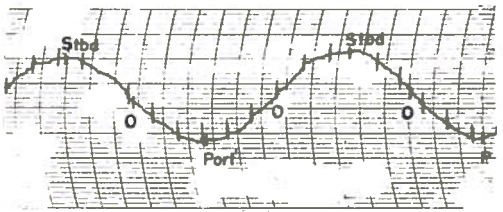


"A" COIL TILT CORRECTION

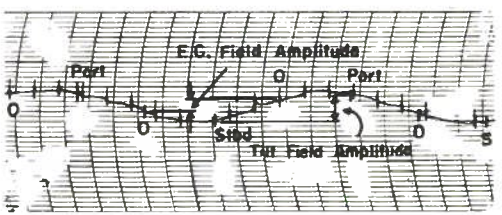
TRANSVERSE HORIZONTAL COMPONENT UNDER KEEL

HEADING: NORTH DEPTH: 15.5 FT.

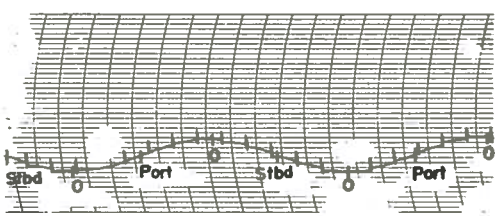
FIG. 27



Tilt Field
(in phase with rolling motion)



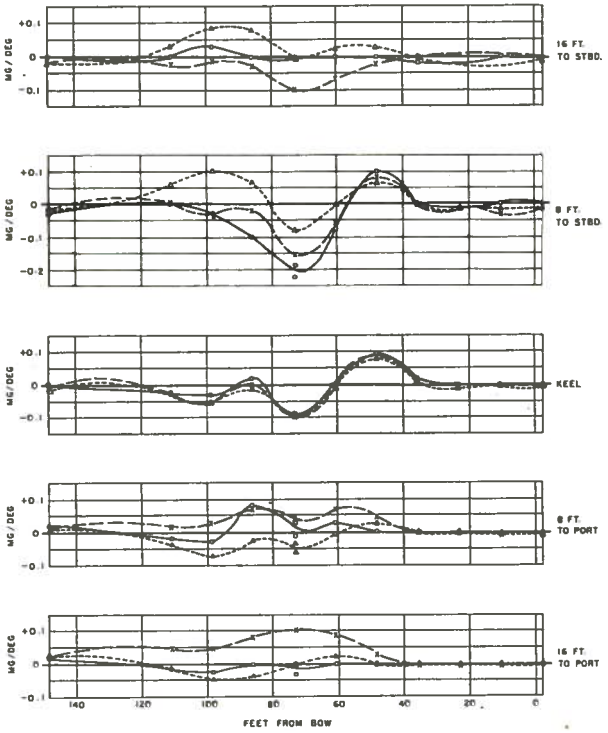
Tilt Field + Eddy Current Field



Eddy Current Field
(in quadrature with rolling motion)

SEPARATION OF ROLLING FIELDS
INTO TWO COMPONENTS

FIG. 28



LEGEND

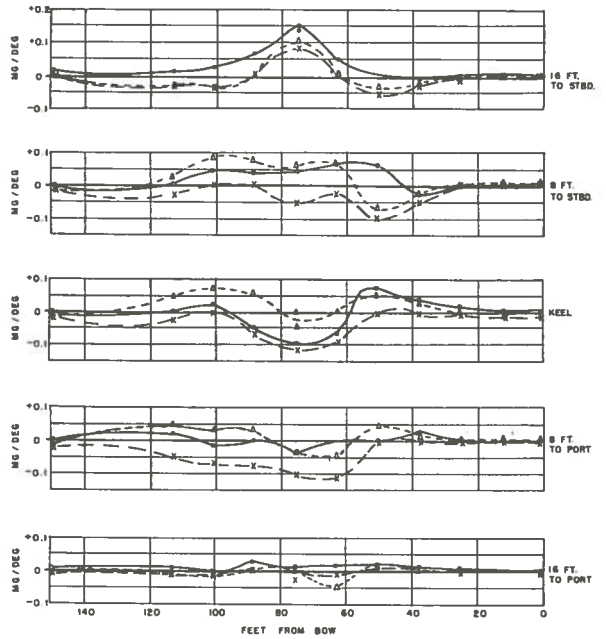
D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.3 AMP
L: 0
M: +1.8 AMP
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
VERTICAL COMPONENTS
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 29(a)



LEGEND

D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG.
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.3 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: NORTH DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 29(b)

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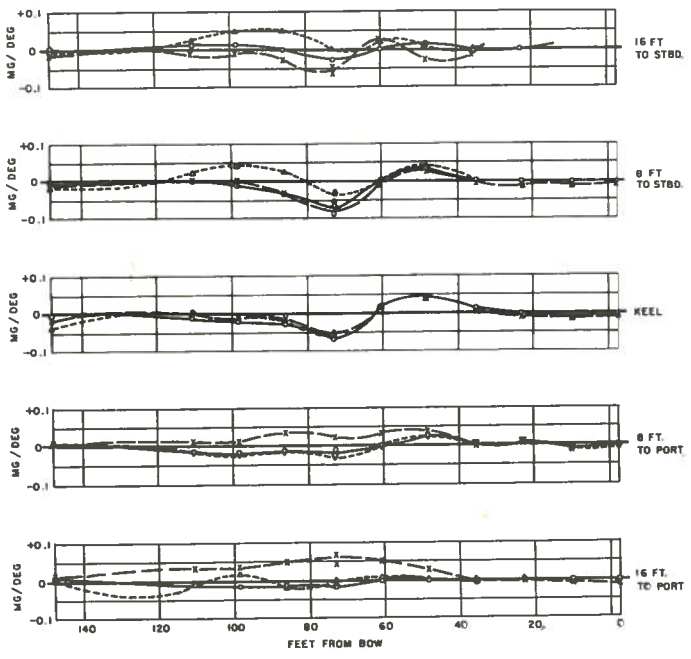


LEGEND

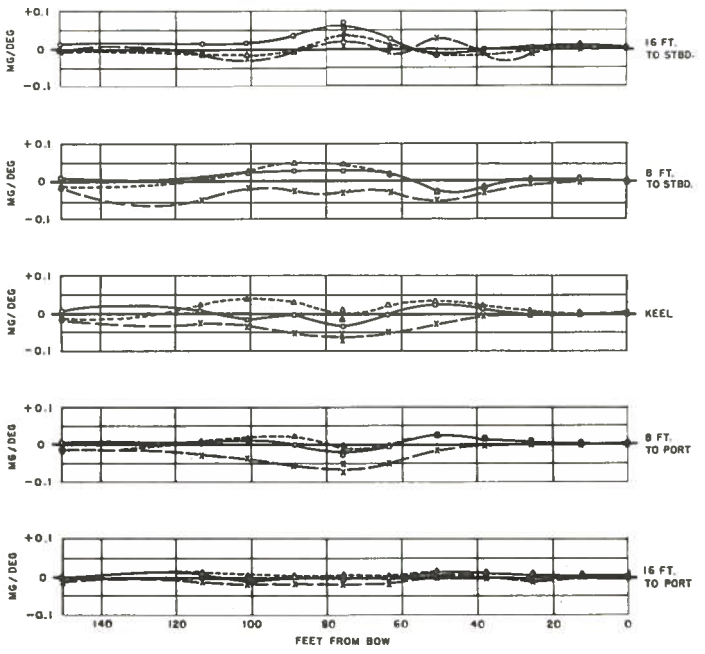
D.G. OFF
D.G. ON – HDG. AND ROLL
D.G ON – HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
D.G. CURRENTS (STATIC) A: – 0.3 AMP
L: 0
M: + 1.8 AMP
D.G. CONTROLLER SETTINGS: AI: 25 % AP: – 9 %
LI: 0 LP: 0
MI: 35% MP: 12 %

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
VERTICAL COMPONENTS
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 30(a)



LEGEND

D.G. OFF
D.G. ON – HDG. AND ROLL
D.G. ON – HDG. ONLY

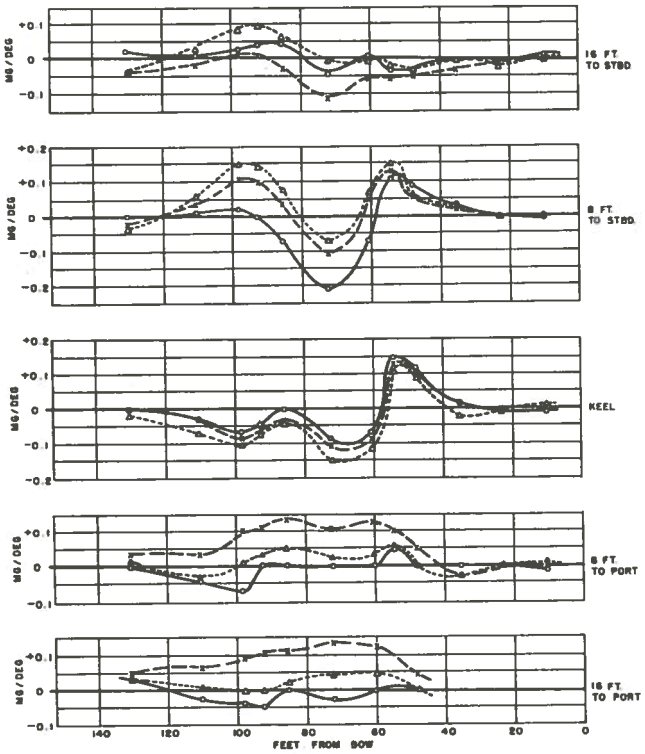
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 0
HEADING OF SHIP: 0° (MAGNETIC)
D.G. CURRENTS (STATIC) A: – 0.3 AMP
L: 0
M: + 1.8 AMP
D.G. CONTROLLER SETTINGS: AI: 25 % AP: – 9 %
LI: 0 LP: 0
MI: 35% MP: 12 %

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: NORTH DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 30(b)



LEGEND

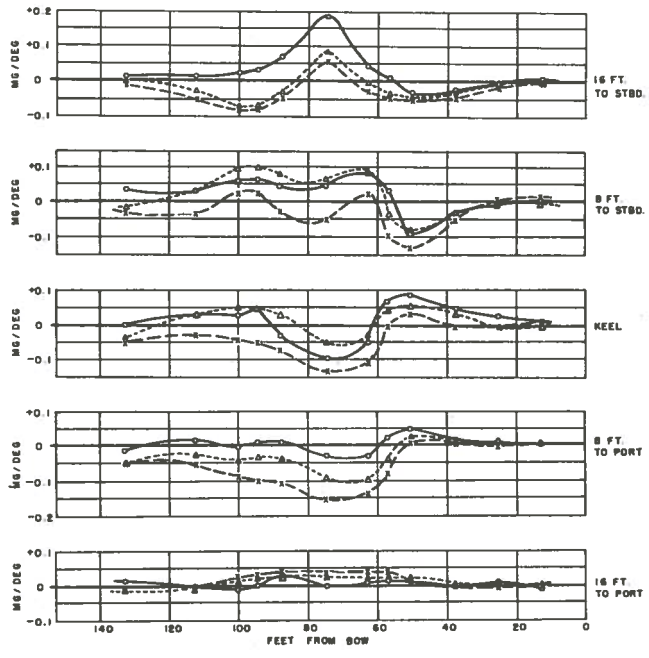
D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 31(a)



LEGEND

D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

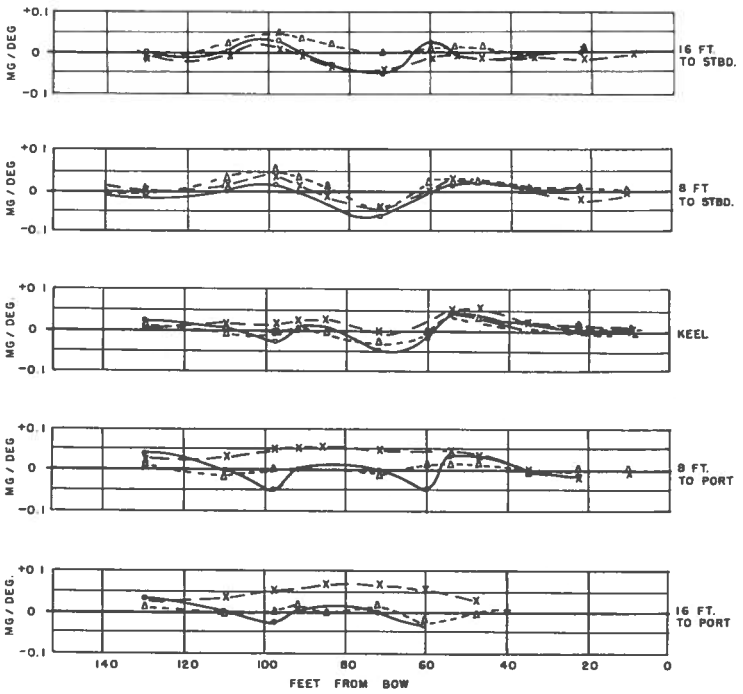
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 31(b)

CONFIDENTIAL



LEGEND

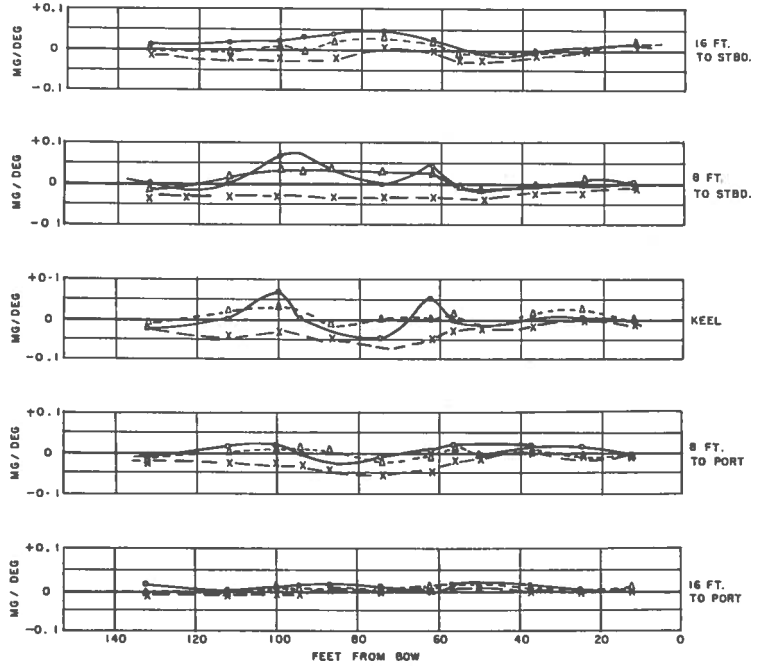
D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25 % AP: −9 %
LI: 0 LP: 0
MI: 35 % MP: 12 %

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 32(a)



LEGEND

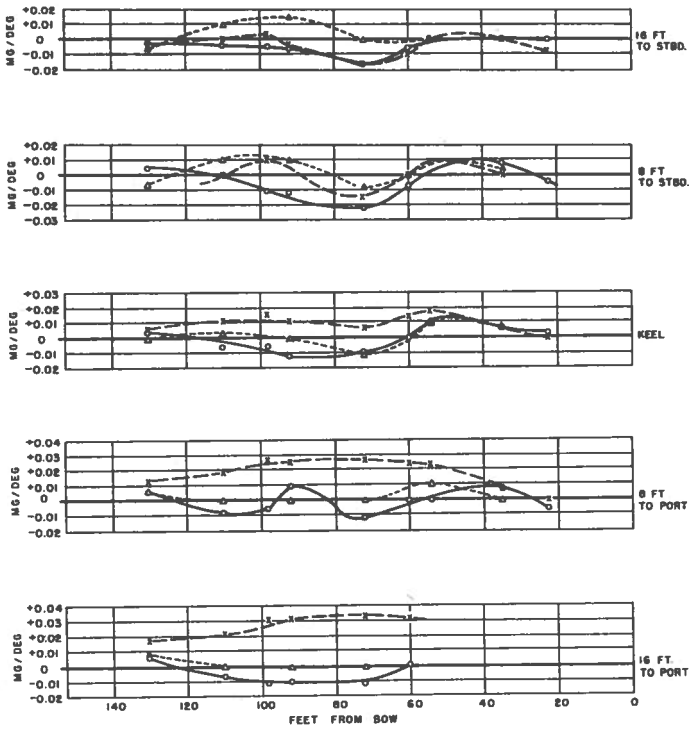
D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT FOR A ROLL TO PORT
EXCITING FIELD: Z = 515 MG.
H = 156 MG.
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: −0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 22 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 32(b)



LEGEND

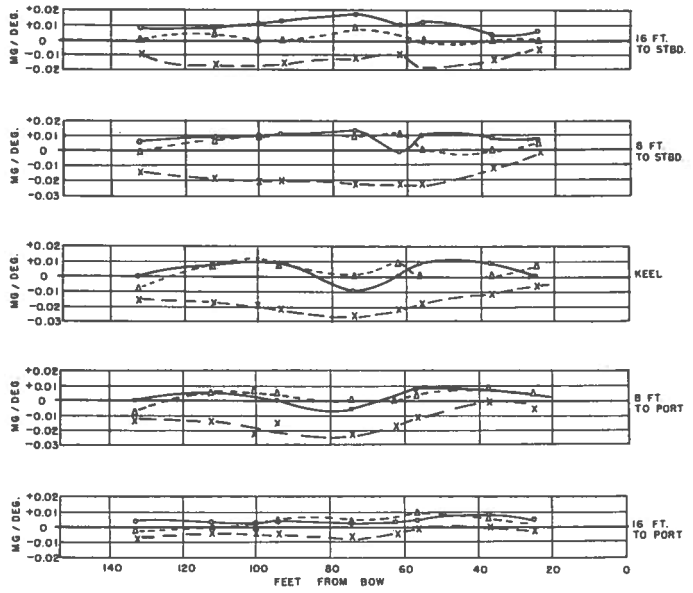
D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
VERTICAL COMPONENTS
HEADING: WEST DEPTH: 30 FT.
HMCS "COWICHAN" (MCB 162)

FIG. 33(a)



LEGEND

D.G. OFF
D.G. ON—HDG. AND ROLL
D.G. ON—HDG. ONLY

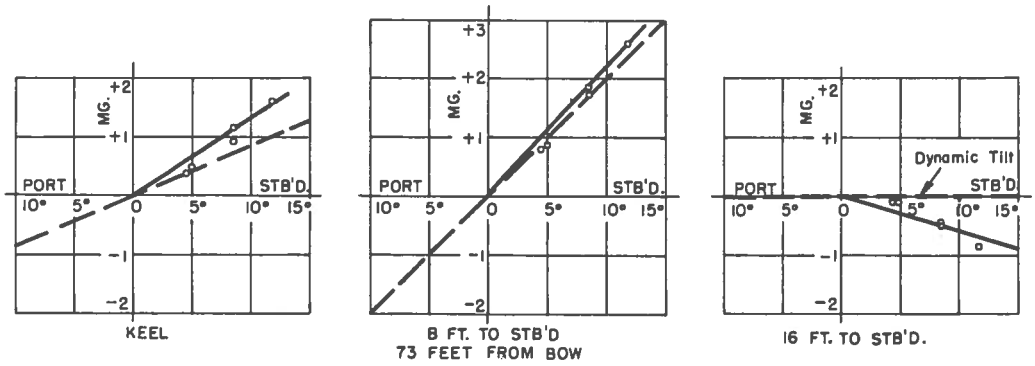
NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT FOR A ROLL TO PORT.
EXCITING FIELD: Z = 515 MG
H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS (STATIC) A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

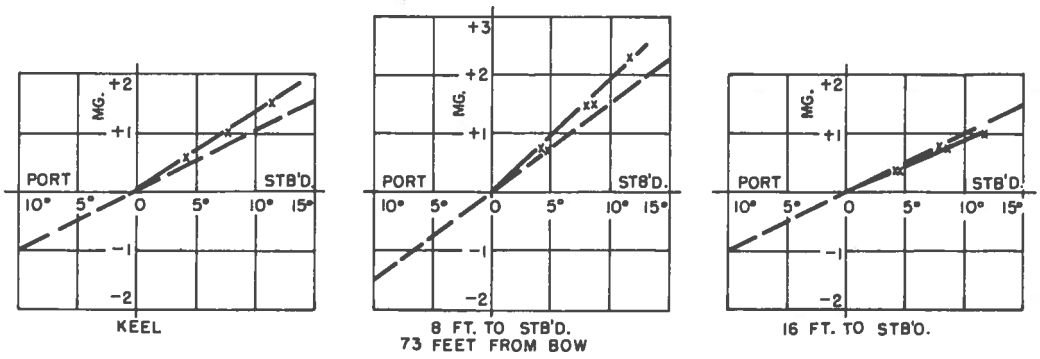
LONGITUDINAL PROFILES OF DYNAMIC TILT FIELD
TRANSVERSE HORIZONTAL COMPONENTS
HEADING: WEST DEPTH: 30 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

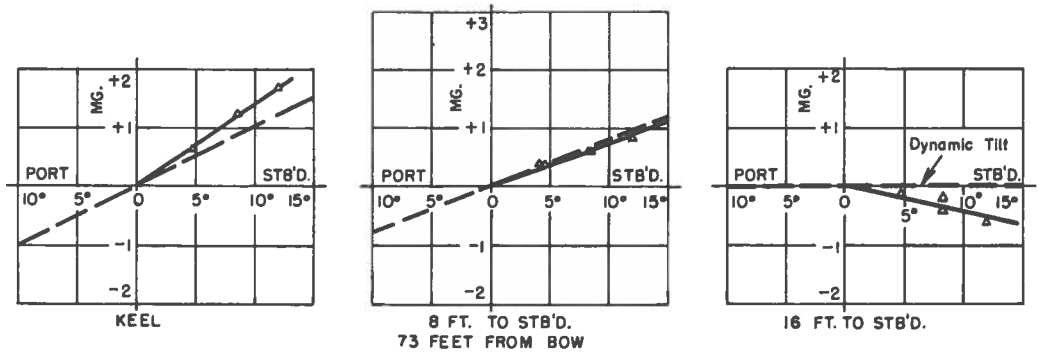
FIG. 33(b)



D.G. OFF



D.G. ON - HEADING ONLY
Degaussing Currents: A: - 0.3 Amp.
L: 0
M: + 1.8 Amp.



D.G. ON - HEADING AND ROLL
D.G. Controller Settings:

AI: 25%	AP: - 9%
LI: 0	LP: 0
MI: 35%	MP: 12%

LEGEND

——— STATIC TILT

– – – DYNAMIC TILT

NOTE: Positive Direction of Field is Downwards.
Exciting Field: Z = 515 mg.
H = 0
Heading of Ship: 0° (magnetic)

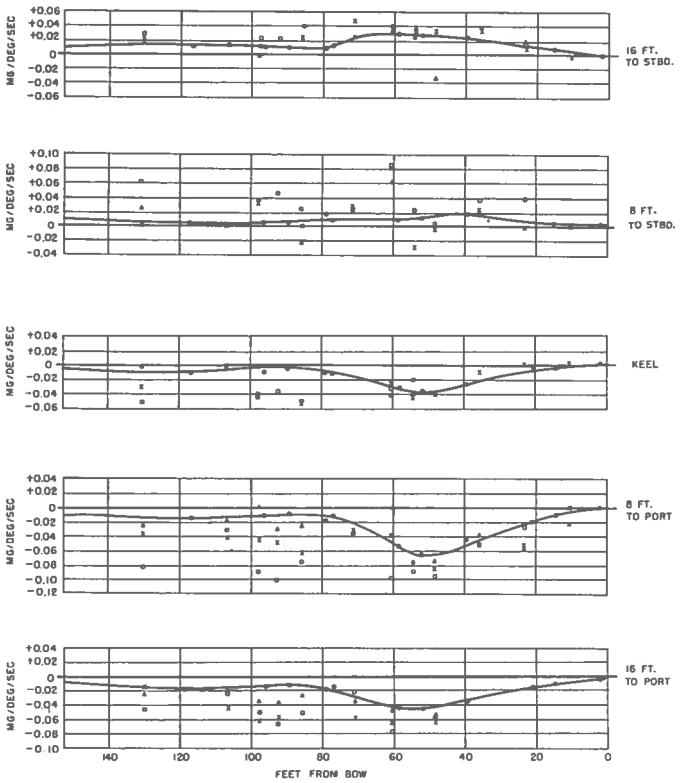
COMPARISON OF STATIC AND DYNAMIC TILT FIELDS

HEADING: NORTH DEPTH : 15.5 FT.

HMCS "COWICHAN" (MCB 162)

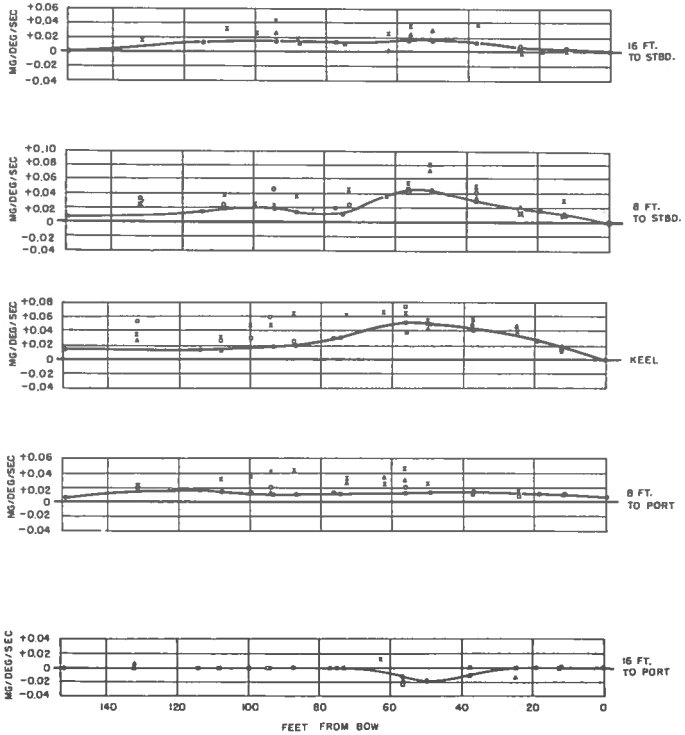
CONFIDENTIAL

FIG. 34



Positive Direction of Field is Downward for a Roll from Stbd. to Port

Vertical Components



Positive Direction of Field is from Stbd. to Port for a Roll Stbd. to Port

Transverse Horizontal Components

LEGEND

- EMPTY HULL (FROM PREVIOUS TESTS)
- COMPLETED SHIP — D.G. OFF
- COMPLETED SHIP — D.G. ON, HEADING ONLY
- COMPLETED SHIP — D.G. ON, HEADING AND ROLL

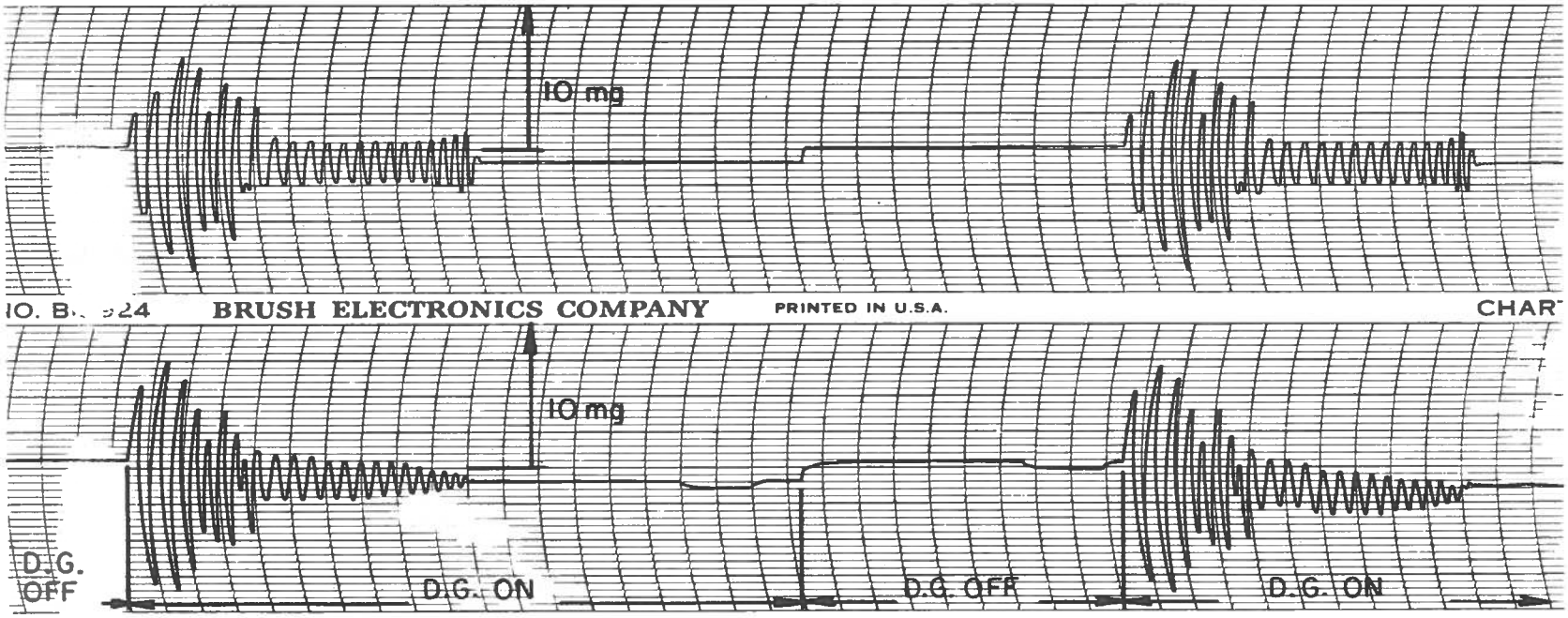
NOTE

EXCITING FIELD: Z = 515 MG, H = 156 MG
HEADING OF SHIP: 241° (MAGNETIC)
D.G. CURRENTS: A: −0.55 AMP.
L: 0
M: +1.8 AMP.
D.G. CONTROLLER SETTINGS: AI: 25% AP: −9%
LI: 0 LP: 0
MI: 35% MP: 12%

LONGITUDINAL PROFILES OF EDDY CURRENT FIELD
HEADING: WEST DEPTH: 15.5 FT.
HMCS "COWICHAN" (MCB 162)

CONFIDENTIAL

FIG. 35



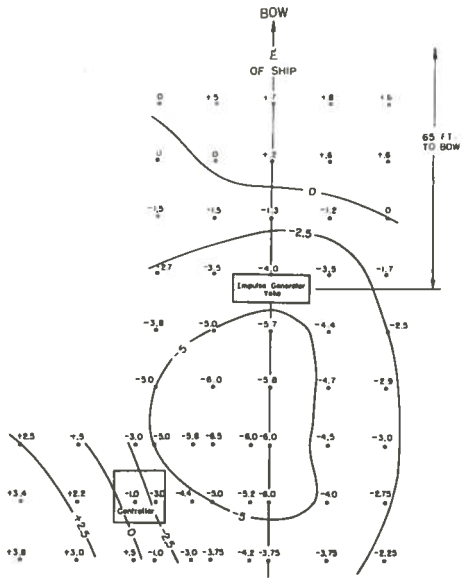
SAMPLE RECORDS OF
MAGNETIC FIELD TRANSIENTS CAUSED BY
TURNING ON THE AUTOMATIC D.G. SYSTEM

DEPTH: 22 FT.

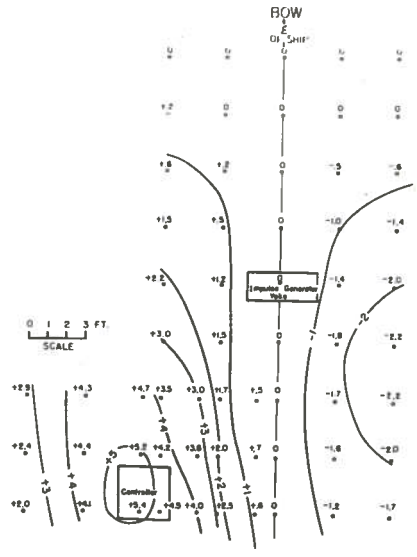
UNITS AT POSITIONS 16 FT. TO PORT

FIG. 36

CONFIDENTIAL

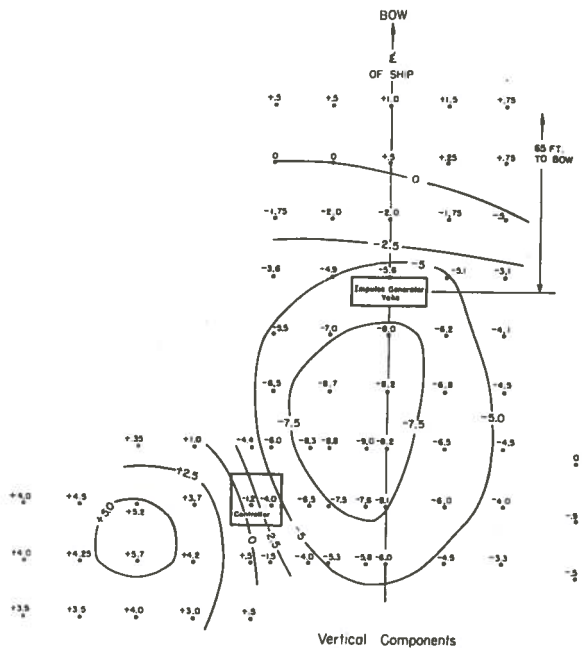


Vertical Components

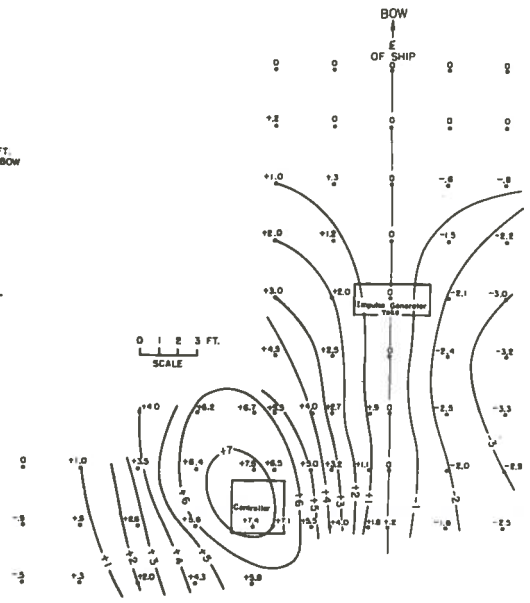


Transverse Horizontal Components

2000 AMP. FORWARD PULSES

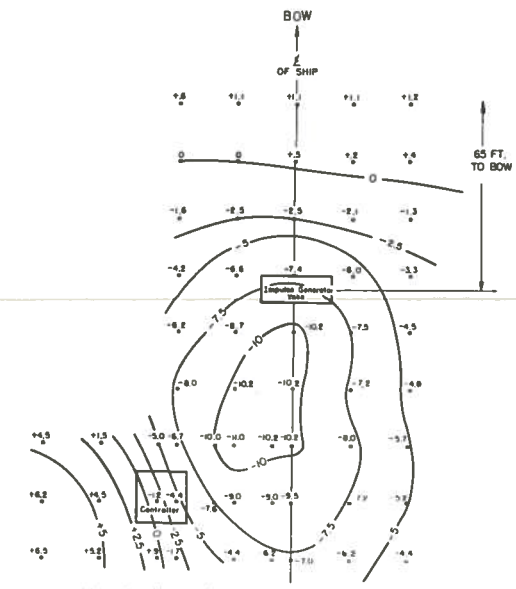


Vertical Components

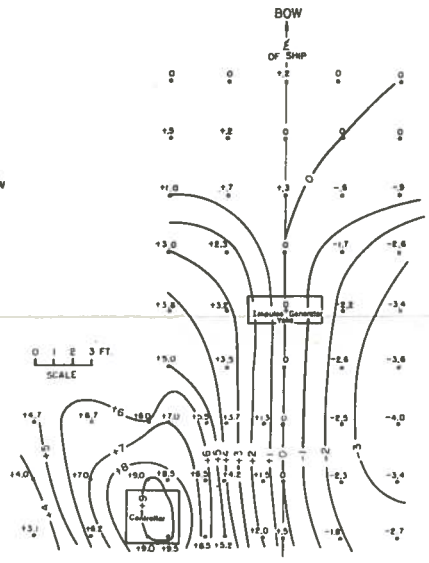


Transverse Horizontal Components

3000 AMP. FORWARD PULSES



NOTE: Positive Direction of Field is Downward.
Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.
Transverse Horizontal Components

3400 AMP. FORWARD PULSES

STRAY FIELD OF IMPULSE GENERATOR AND CONTROLLER

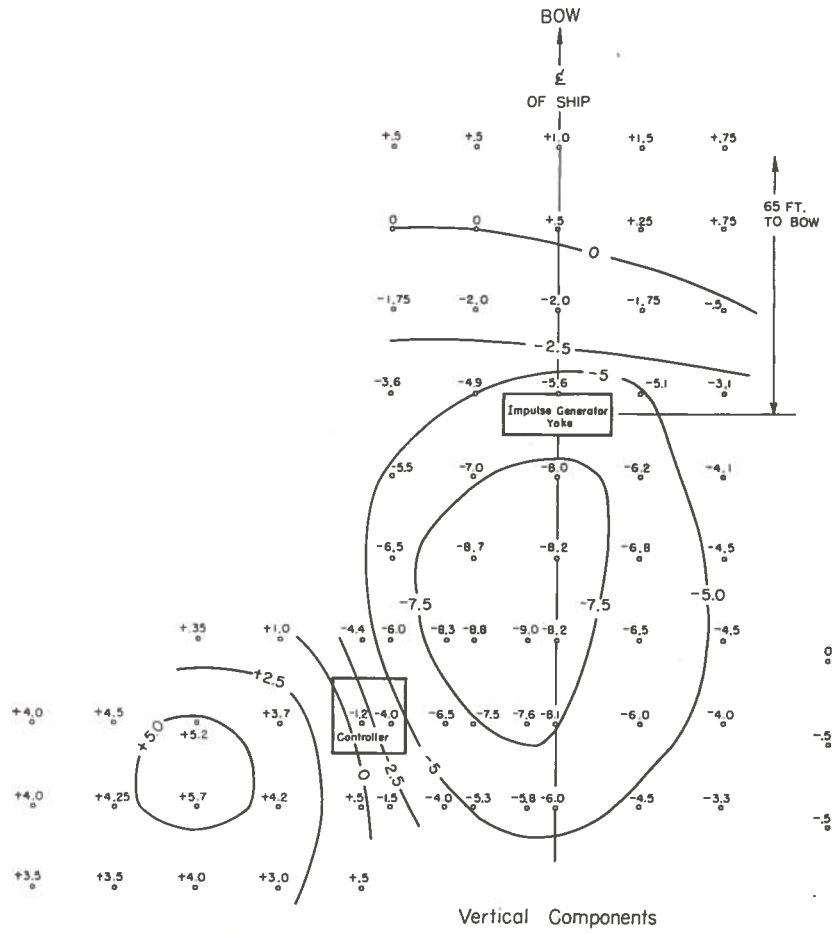
(IN MILLIGAUSS)

CONFIDENTIAL

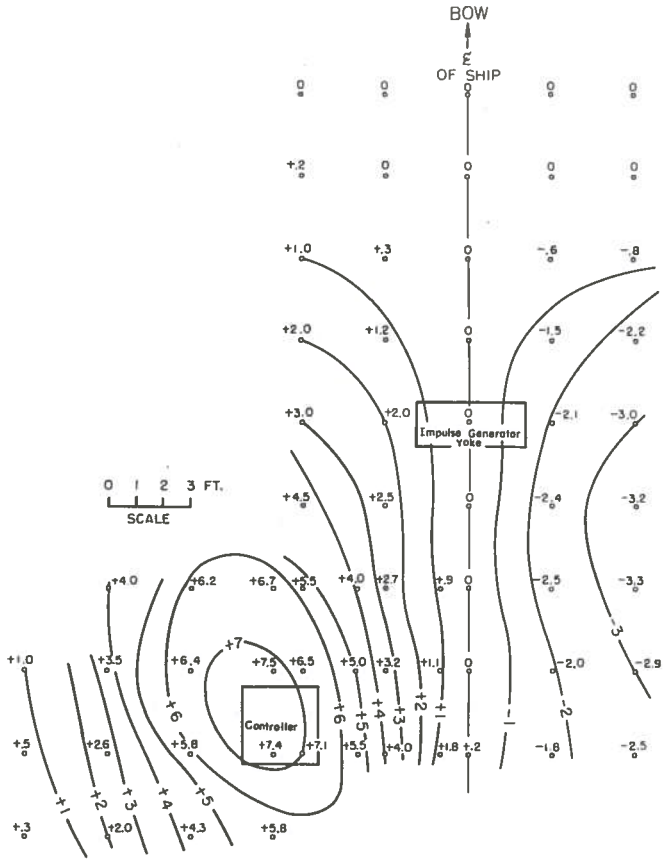
10 FT. BELOW GENERATOR (12.5 FT. BELOW WATER LINE)

LOAD: 0.067 OHMS

FIG. 37

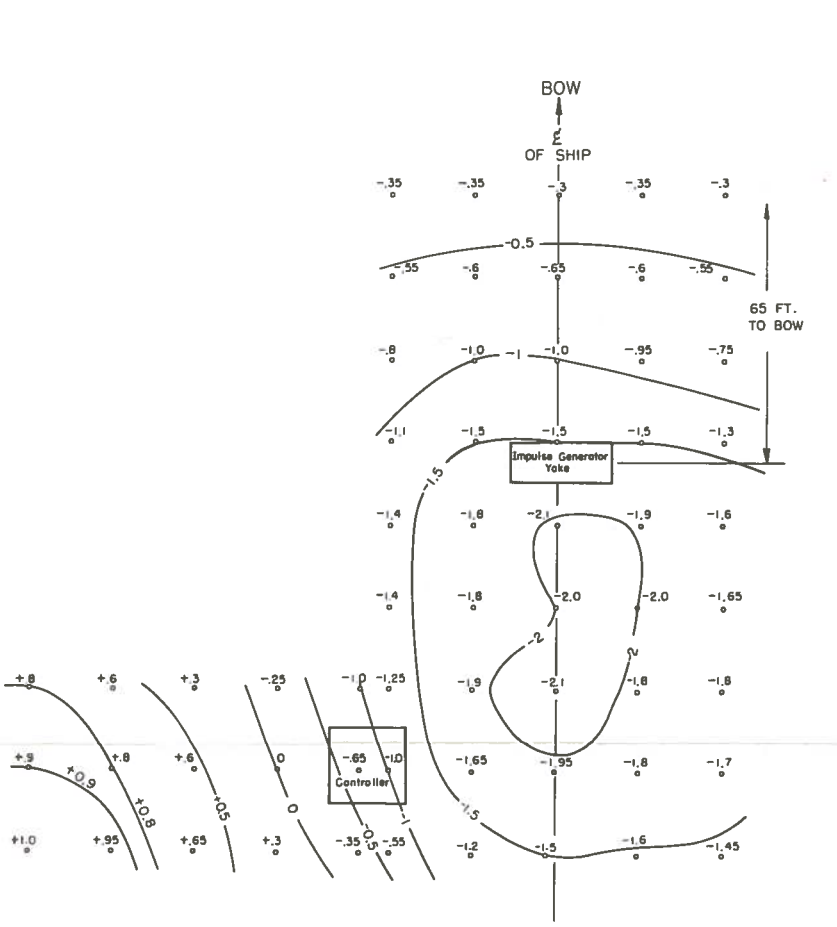


Vertical Components



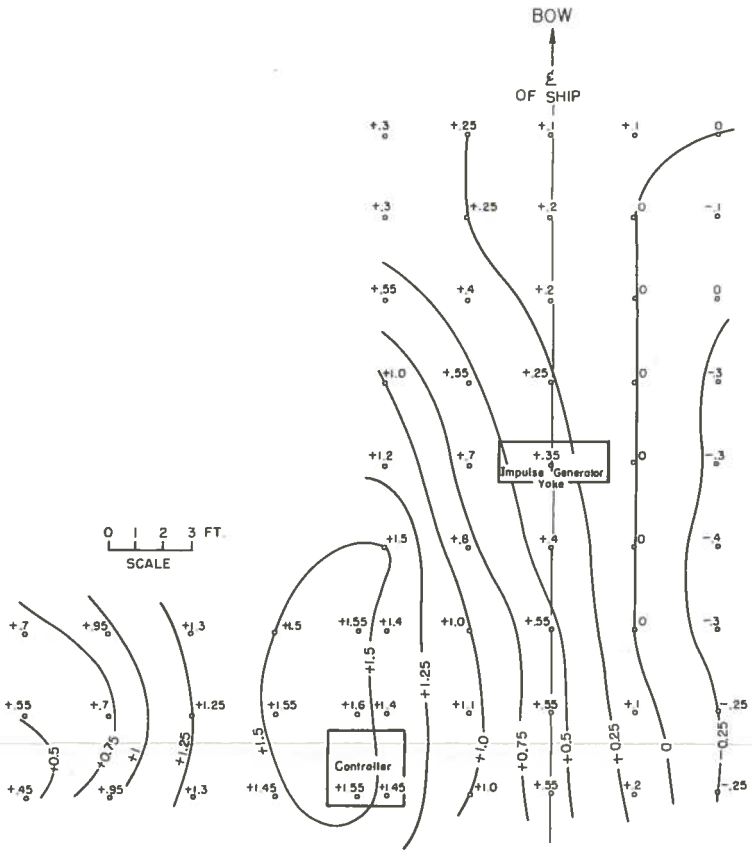
Transverse Horizontal Components

10 FT. BELOW GENERATOR (12.5 FT. BELOW WATER LINE)



NOTE: Positive Direction of Field is Downward.

Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.

Transverse Horizontal Components

18.5 FT. BELOW GENERATOR (21 FT. BELOW WATER LINE)

STRAY FIELD OF IMPULSE GENERATOR AND CONTROLLER

(IN MILLIGAUSS)

3000 AMP. FORWARD PULSES
LOAD: 0.067 OHMS

FIG. 38

CONFIDENTIAL

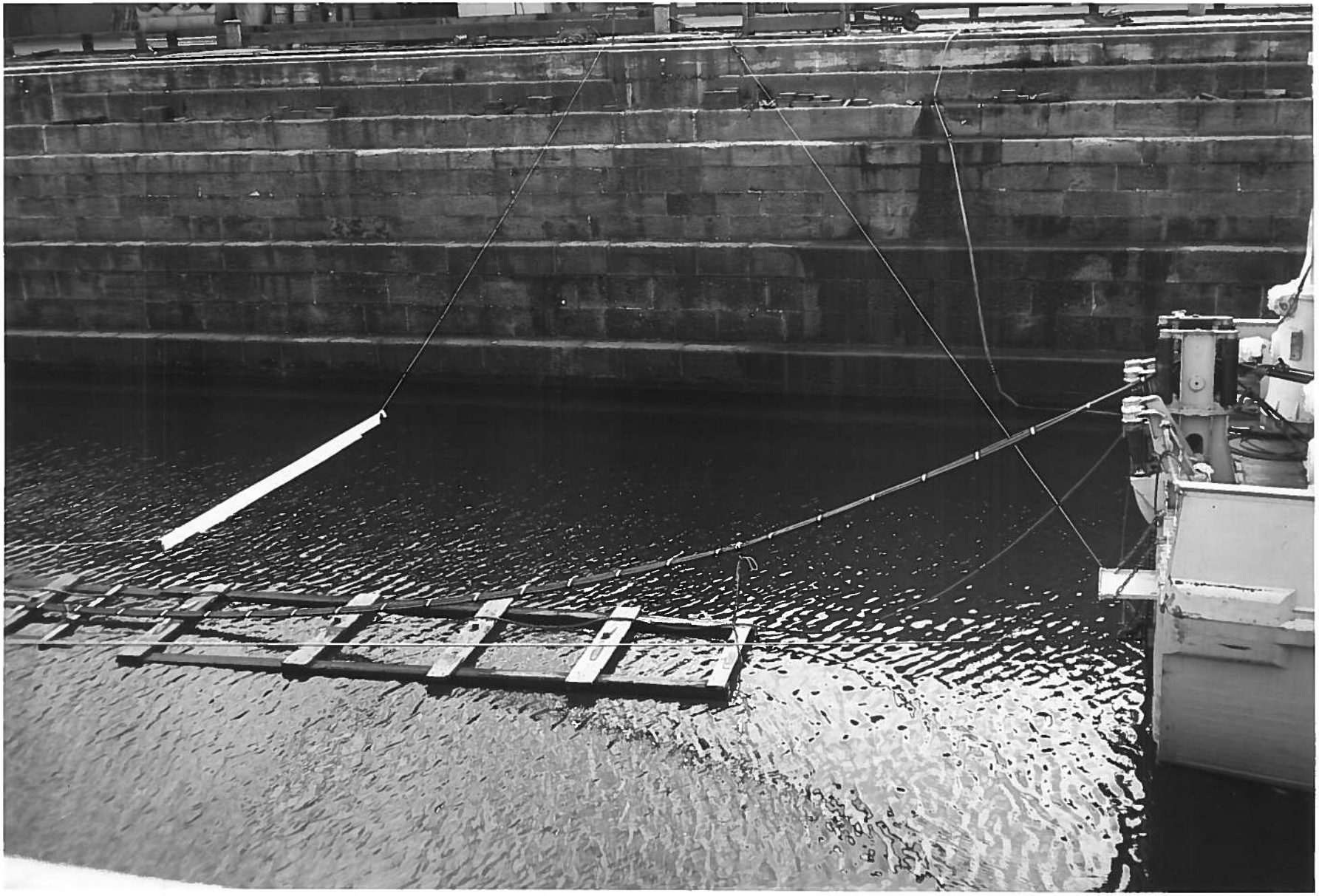
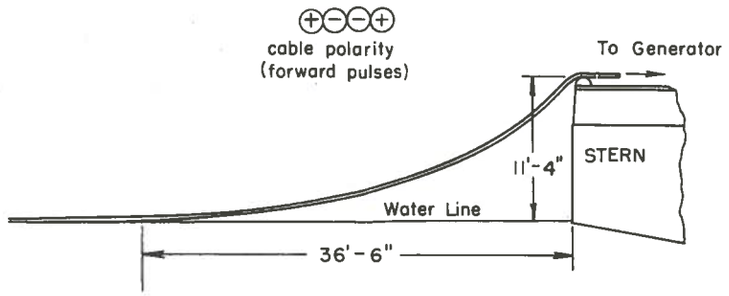
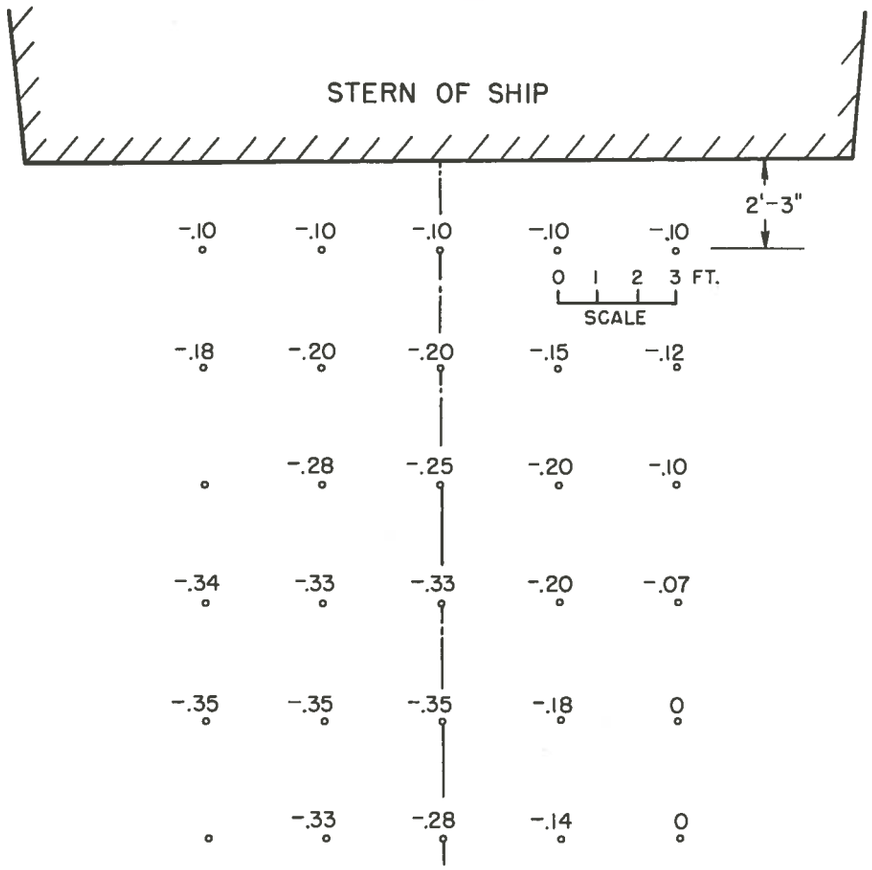


FIG. 39. RIBBON TAIL AND STERN OF SHIP

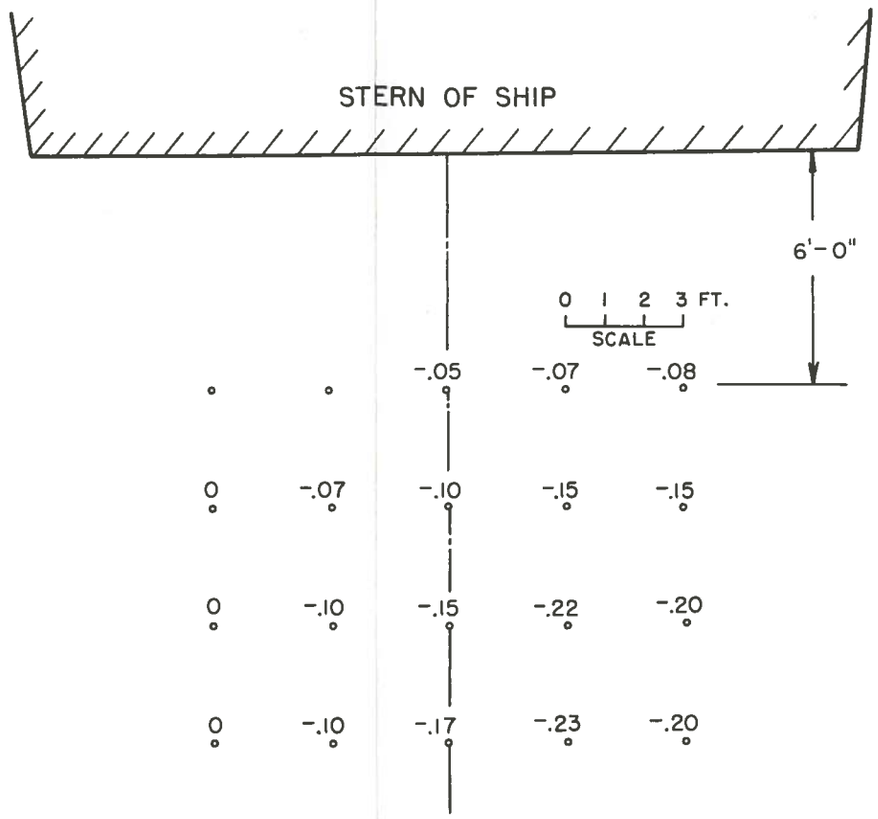


SKETCH OF RIBBON TAIL
DURING TEST



NOTE: Positive Direction of Field is Downward.

Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.

Transverse Horizontal Components

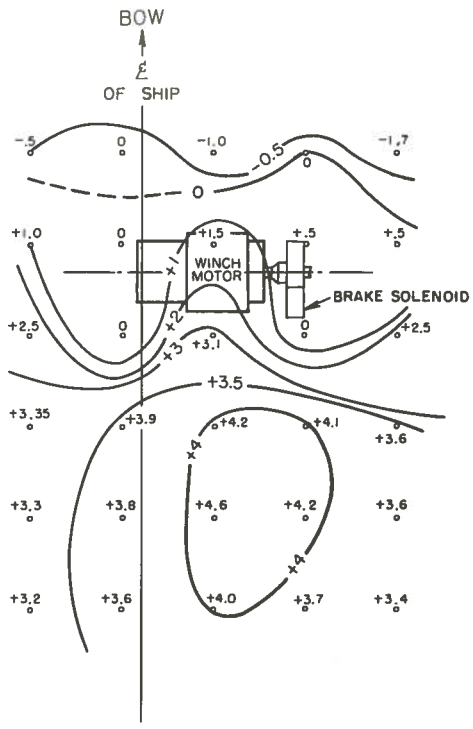
FIELD OF RIBBON TAIL

(IN MILLIGAUSS)

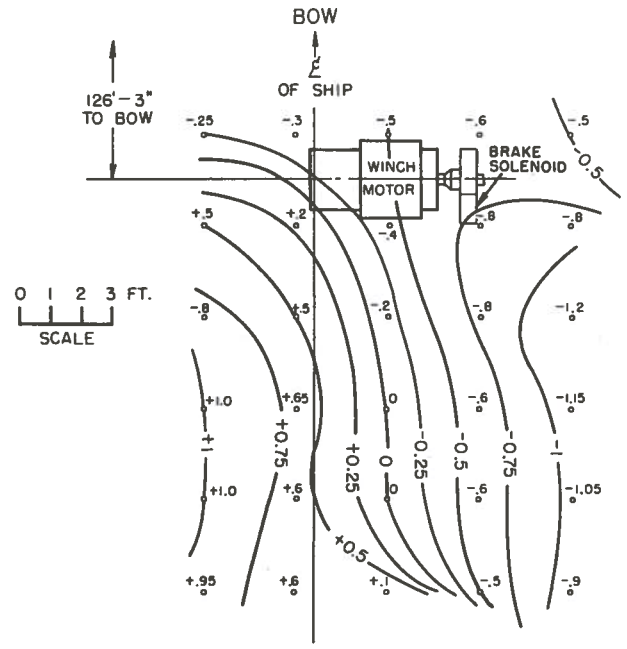
3000 AMP. FORWARD PULSES
DEPTH: 12.5 FT.

FIG. 40

CONFIDENTIAL

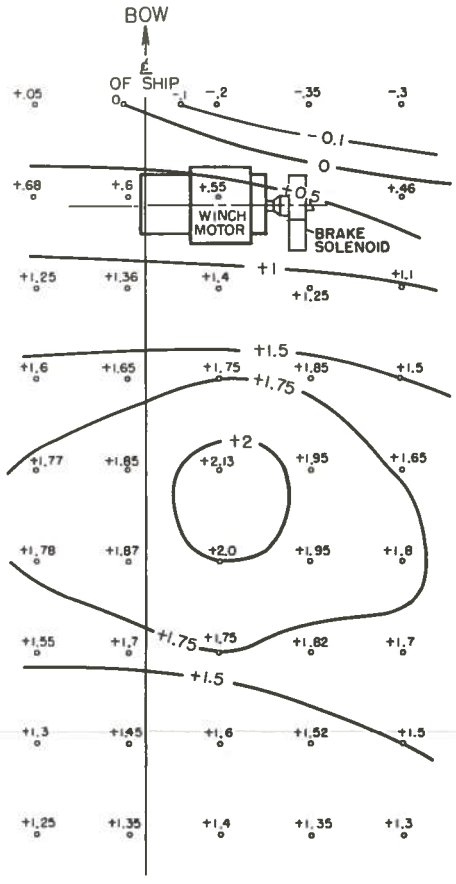


Vertical Components



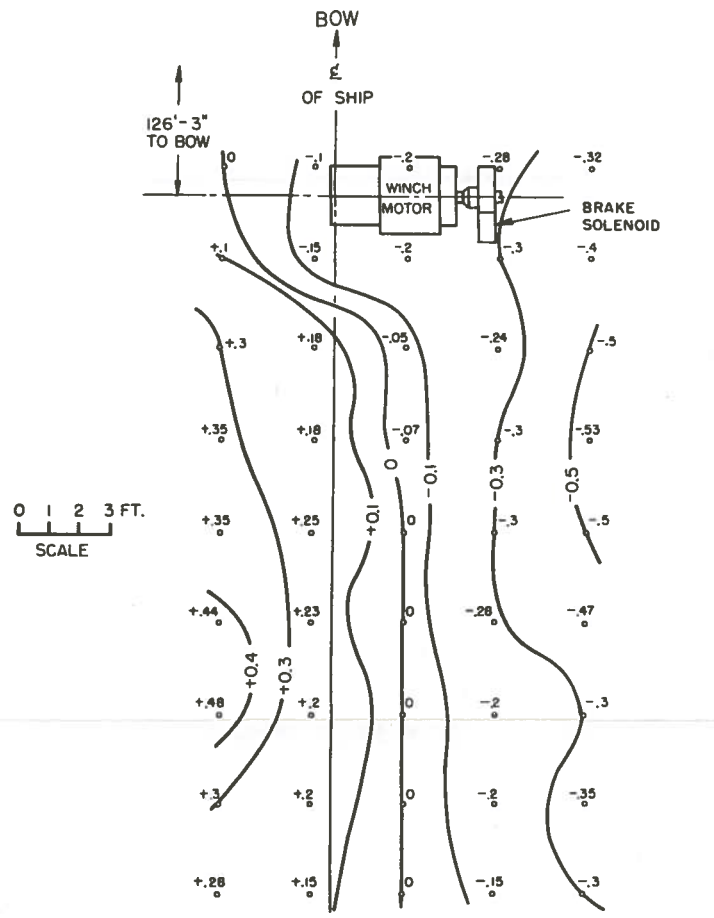
Transverse Horizontal Components

15.5 FT. BELOW WATER LINE



NOTE: Positive Direction of Field is Downward.

Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.

Transverse Horizontal Components

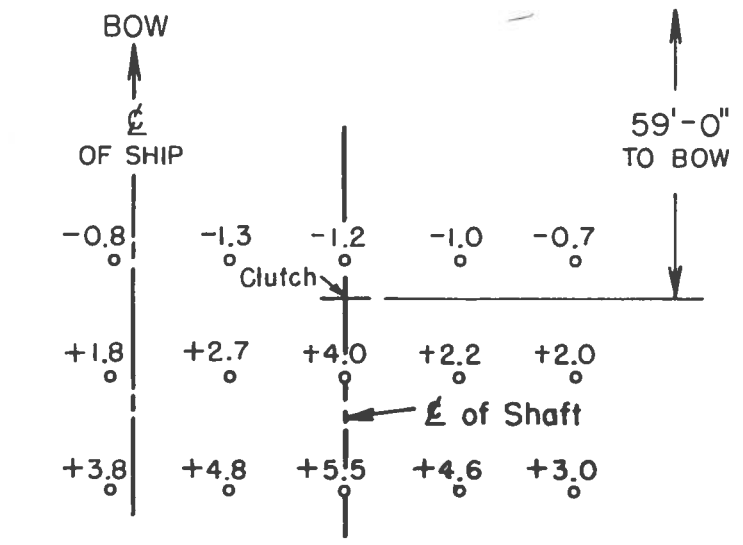
21 FT. BELOW WATER LINE

STRAY FIELD OF MINESWEEPING WINCH DRIVE

(IN MILLIGAUSS)

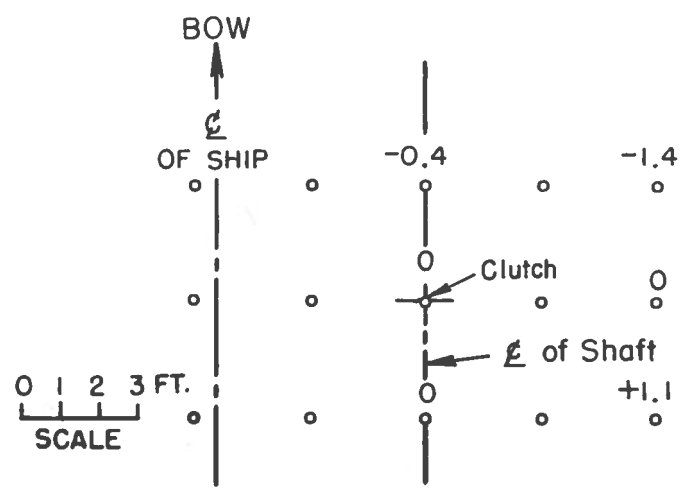
CONFIDENTIAL

FIG. 41



NOTE: Positive Direction of Field is Downward.

Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.

Transverse Horizontal Components

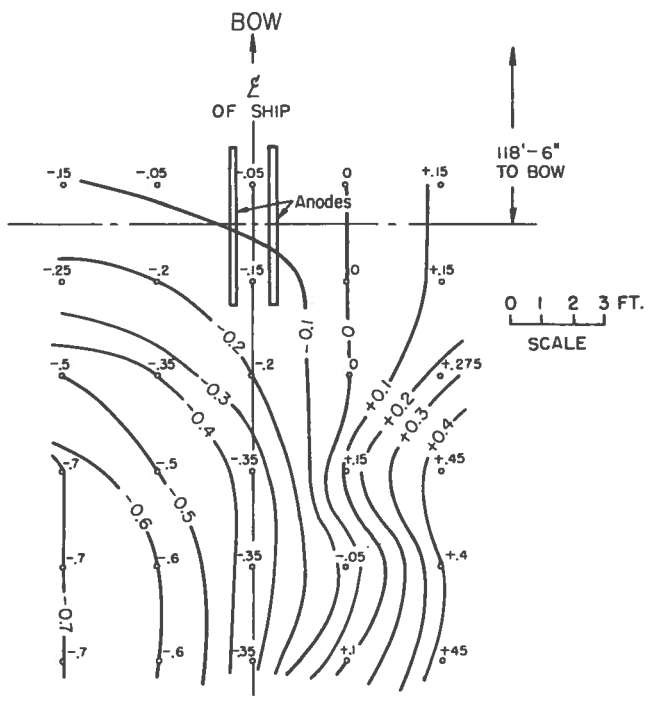
STRAY FIELD OF MAGNETIC CLUTCH

(IN MILLIGAUSS)

15.5 FT. BELOW WATER LINE
CLUTCH ON AUTOMATIC SETTING

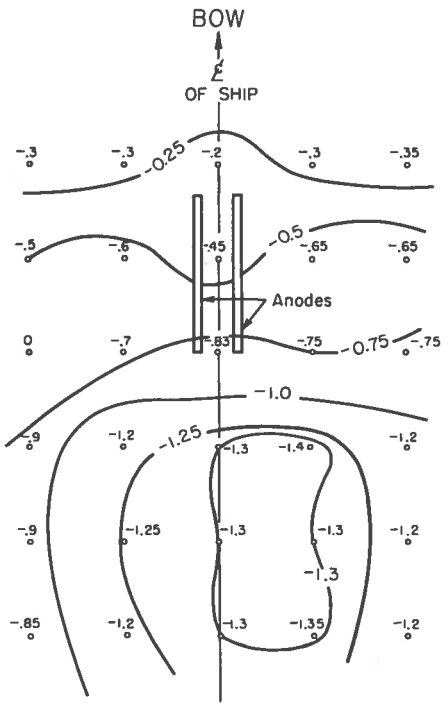
CONFIDENTIAL

FIG. 42



NOTE: Positive Direction of Field is Downward.

Vertical Components



NOTE: Positive Direction of Field is from Stbd. to Port.

Transverse Horizontal Components

FIELD OF CATHODIC PROTECTION CURRENTS

(IN MILLIGAUSS)

3.5 AMP. IN EACH CIRCUIT

15.5 FEET BELOW WATER LINE

CONFIDENTIAL

FIG. 43