Eddy-current magnetic field measurements on the hull of HMCS "Cowichan" (MCB 162): Esquimalt, B. C., March 2 and 3, 1957

Morris, R. M.; Pedersen, B. O.

Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERA); no. ERA-314, 1957-03

ERA-314

SECRET

NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

EDDY-CURRENT MAGNETIC FIELD MEASUREMENTS ON THE HULL OF HMCS "COWICHAN" (MCB 162)

ESQUIMALT, B. C., MARCH 2 AND 3, 1957

R. M. MORRIS AND B. O. PEDERSEN

OTTAWA

MARCH 1957

ABSTRACT

Trials were carried out on the hull structure of the second HMCS "Cowichan" (MCB 162) to determine the magnetic field due to eddy currents created by rolling of the ship in the earth's magnetic field. The hull was found to have a field about 2.5% that of HMCS "Comox". The principal source of this field appears to be the forward diesel oil tanks.

CONTENTS

TEXT

TABLE

FIGURES

EDDY-CURRENT MAGNETIC FIELD MEASUREMENTS ON THE HULL OF HMCS "COWICHAN" (MCB 162)

SECRET

Esquimalt, B.C., March 2 and 3, 1957

- R.M. Morris and B.O. Pedersen -

INTRODUCTION

HMCS "Cowichan" is representative of a number of new Canadian minesweepers which were designed to avoid the eddy-current problem present in earlier ships of this type [1, 2]. Most sources of eddy-current field have been eliminated from the hull structure, but the following eddy-current paths still exist and can create a field as the ship rolls:

1) A small number of framework loops in the fore and aft direction. These were retained for structural purposes (see Appendix).
2) Fore and aft framework loops which may have been introduced unintentionally during construction.
3) Fittings constructed of electrically conducting material in which fore and aft current loops can occur (see Appendix). The principal fittings of this type are oil and water tanks, superstructure, and funnel.

OBJECT OF THE TRIALS

The object of the trials described here was to determine the eddy-current field of HMCS "Cowichan" at an early stage of construction.

DESIGN DETAILS OF THE SHIP

The principal dimensions of this minesweeper are approximately the same as those of the ships tested earlier [1, 2]. The length overall is 152', breadth 28' 6", height 15' 4-11/16". The ship is constructed mainly of wood, but has retained aluminum bulkheads, deck-beams, and ribs. The transverse frame structures formed by the deck beams and ribs are not electrically continuous loops, since they have an insulating section at the wooden keel. Most large longitudinal aluminum members of the former design have been replaced by wooden members. The remaining aluminum longitudinal members such as bulwarks and ice protection belts, are not connected electrically to other metal framing members and are themselves not electrically continuous, since they are constructed of metal plates which are insulated from each other.

CONDITION OF SHIP DURING TRIALS

The ship was launched on February 26, 1957. She was prepared for rolling trials by the builders, Yarrows Ltd., of Victoria, B.C., in accordance with the requirements of the Royal Canadian Navy and the National Research Council. A report on the status of the ship at the time of the trials (March 2 and 3, 1957) has been submitted by the builders. Relevant details of this report are included here and in the Appendix.

The hull of the vessel was complete. Aluminum bulwarks and ice protection plates were attached, but bilge keels were absent. The Monel metal propeller shafts and their outboard supports were installed, but propellers and rudders were not in place.

Within the hull, a small amount of aluminum piping had been installed, and there were a few longitudinal connections between transverse frames. These longitudinal members are not specified in Yarrows' report, but the frames which they connect together are listed in the Appendix. All the aluminum tanks for fuel oil, lubricating oil, fresh water, etc., were installed. The largest of these are the main diesel oil tanks. These tanks not only form a large aluminum shell, but also have a number of internal stiffening members which contribute conducting paths. There were no ferromagnetic materials within the hull.

The aluminum superstructure and funnel were in place, and the anchor windlass was installed on the forecastle deck.

The ship's draft during the tests was: bow — 4' 3", stern — 4' 6".

METHOD OF CONSTRAINING AND ROLLING THE SHIP

Figs. 1 and 2 show the ship and the constraining arrangement. The method of constraint was similar to that used on HMCS "Comox", except that ball and socket joints were used as pivot points at bow and stern. This constraining method limited lateral and longitudinal surges to negligible amounts.

The rolling party consisted of 20 men running on the upper and forecastle decks, as shown in Fig. 3. No special platforms were installed. Roll angles obtained averaged about ±7°. The period of roll was 5.7 seconds.

INSTRUMENTATION

Tests were carried out in the Department of Transport dry dock. The

magnetometer range was installed on the dock bottom, Fig. 4, in the same pattern as that for the "Comox" trials [2]. The ship was maintained on a 241° magnetic compass heading throughout the trials, but was moved in the longitudinal direction into various positions over the range for a complete survey of the ship's field. The earth's field components were measured with a Mark V Mod.V US Navy Magnetometer. The vertical component at the range was Z = 515 mg. The horizontal component transverse to the ship was H = 156 mg.

The magnetic field and roll measuring instrumentations were identical to those used in the "Comox" trials. The sensitivity of magnetic field recording was 1 milligauss/cm. The minimum signal discernible was 0.05 milligauss peak-to-peak. The resolution obtainable from the records was therefore 0.003 mg/deg/sec for a ±7° 5.7 sec roll.

RESULTS

The results are shown graphically in Figs. 5, 6, and 7. The field under maximum condition of roll is tabulated and compared with that of HMCS "Comox" in Table I.

DISCUSSION OF RESULTS

The longitudinal signatures given in Figs. 5 and 6 show a general low level of field with two superimposed field peaks. The larger of these peaks occurs under the forward diesel oil tanks and the superstructure which are the largest aluminum structures in the ship. The second peak is much smaller and occurs under the cluster of aluminum shells in the after part of the ship (diesel oil tanks aft, control booth, fuel oil service tanks, Bofors magazine).

These results indicate that the field of the remaining fore and aft loops in the ship's framework itself (exclusive of tanks, etc.) is something less than the maximum of the smaller peak. This field is therefore less than 0.02 mg/deg/sec at 15.5 ft. depth. Assuming an inverse square law of depth for the framework, the field at 30 feet due to rolling would be less than 0.005 mg/deg/sec, which corresponds to a field of less than ±0.1 mg at ±25° roll in 8 seconds. This is comparable with the pitching field of 0.1 mg at ±4° in 4.5 seconds at 30 feet depth described for Design V in Ref. 3. This pitching field is due to bulkheads only. The presence of aluminum tanks and fittings will increase this pitching field.

The sources of the main field peak are evidently the main fuel oil tanks and the superstructure. Although the relative effects of these two cannot be determined from these measurements, the shape of the field peak and

SECRET

TABLE I

COMPARISON OF ROLLING EDDY-CURRENT FIELDS OF "COMOX" AND "COWICHAN" (MCB 162)

Water Depth (ft) Normal Conditions	Field Component	Max. Eddy Current Fields (Z = 520 mg, H = 160 mg)				Ratio "Comox" to "Cowichan"
		"Comox" (ERA-300)		"Cowichan" (MCB 162) (fuel oil tanks)		
		mg/deg/sec	mg for ±25°, 8 sec	mg/deg/sec	mg for ±25°, 8 sec	
15½	Vertical	2.1	±41	0.067±0.003	±1.3	32/1
15½	Transverse Horizontal	2.3	±45	0.051±0.003	±1.0	45/1
22	Vertical	1.05	±21	0.028	±0.55	38/1
22	Transverse Horizontal	1.15	±22	0.027	±0.53	41/1
30	Vertical	0.65	±13	0.013	±0.25	52/1
30	Transverse Horizontal	0.66	±13	0.0098	±0.19	68/1

NOTE: "Cowichan" fields were measured at 15.5 and 22 feet. The extrapolation to 30 feet was made using an inverse 2.5 power law. This law was determined from theoretical considerations assuming the field to be due to the main fuel oil tanks only. The "Comox" field was adjusted to these depths assuming an inverse square law.

the rate of decrease of field with depth seem to point to the diesel oil tanks as the principal source of eddy-current field in the ship. Table I shows that the maximum field due to rolling will be 0.25 mg at a depth of 30 feet.

CONCLUSIONS

1) The eddy-current magnetic field caused by rolling of the new type of minesweeper is about 2½% that of the AMc 143 and class.

2) The eddy-current field appears to be due chiefly to the main fuel tanks.

3) For future tests on ships of this type, the resolution of the measurements must be increased in order to obtain the signatures at a depth of 30 feet.

REFERENCES

1. Eddy-current Magnetic Field Measurements on Class AMc 143 Aluminum-Framed Minesweeper HMCS "Cowichan". NRC Report ERA-231 (Secret)
2. Eddy-current Magnetic Field Measurements on Aluminum-framed Minesweeper HMCS "Comox" (AMc 146). Esquimalt B.C., August and September, 1955. NRC Report ERA-300 (Secret)
3. Eddy-current Fields of Two Proposed Framework Designs of Minesweeper MCB 159 (Supplement to ERB-321). NRC Report ERB-343 (Secret)

APPENDIX

DESCRIPTION OF HULL AND FITTINGS

HULL

The hull framing consists of transverse frames of fabricated aluminum with wooden longitudinal stringers, girders, keel, keelson, engine seatings, etc. The outer shell of the ship consists of two layers of mahogany planking. The hull is subdivided by all-aluminum bulkheads. These bulkheads form transverse loops, but all other transverse frames are broken electrically at the keel.

A single aluminum grounding strap connects all frames and bulkheads.

A few aluminum longitudinal members were included for structural purposes. These are of unknown impedance, but it is known that they form fore and aft loops by connecting the following frames:

Frames 72 to 68 to 64
" 81 to 80 to 79 to 78
" 96 to 95 to 94 to 93

Although transverse deck beams are made of aluminum channel, all longitudinal deck supports are constructed of laminated wood. Decks are made of plywood covered with fir planking.

FITTINGS

Oil and water tanks, superstructure, and funnel are fabricated from aluminum plates and angles and are insulated electrically from the aluminum frames of the hull structure. These aluminum fittings and their dimensions are listed below.

1) Diesel Oil Tanks Forward

Length - 7'
Max. breadth - 23'
Max. depth - 10' 9"
Outer shell - 5/16" al. plate
Wash plates - 3/16" al. plate
Height above keel - C.G. is about 9' above keel

2) Diesel Oil Tanks Aft

There are two separate tanks, one at port and one at starboard. Dimensions of each tank are:

Length - 5' 6"
Max. breadth - 6' 9"
Max. depth - 8' 9"
Outer shell - 1/4" al. plate
Wash plates - 3/16"al. plate
Height above keel - C.G. is about 10' above keel
Lateral spacing of tanks - C.G.'s are about 16' 6" apart.

3) Fresh Water Tanks

There are two separate tanks, one at port and one at starboard. Dimensions of each tank are:

Length - 12'
Max. breadth - 6' 4"

Max. depth - 5' 9"
Outer shell - 1/4" al. plate
Wash plates - 3/16" al. plate
Height above keel - C.G. is 5' 6" above keel
Lateral spacing - C.G.'s are about 6' 6" apart

4) Fuel Oil Day Tank

This tank is located on the starboard side in the Generator Room.

Length - 3' 6"
Breadth - 3'
Depth - 8' 6"
Height above keel - C.G. is about 9' above keel
Lateral spacing - C.G. is about 11' to starboard of center line

5) Lube Oil Storage Tank

This tank is located on the port side in the generator room.

Length - 4' 9"
Breadth - 3'
Depth - 7' 10"
Height above keel - C.G. is 9' above keel
Lateral spacing - C.G. is 11' to port of center line

6) Fuel Oil Service Tanks

There are two separate tanks, one at port and one at starboard. Dimensions of each tank are:

Length - 5'
Max. breadth - 3'
Depth - 7' 6"
Height above keel - C.G.'s are about 10' above keel
Lateral spacing - C.G.'s are 10' 6" from center line

7) Bofors Magazine

This is in the form of an aluminum box which is open at the top.

Length - 6'
Breadth - 9'
Depth - 7' 3"

Height above keel - C.G. is about 11' above keel
Lateral spacing - on center line

8) Control Booth in Engine Room

Length - 6'
Max. breadth - 4' 6"
Depth - 6' 6"
Outer shell - Lower - 3/16" al. plate
Outer shell - Upper - 1/8" al. plate
Height above keel - C.G. is about 11' above keel
Lateral spacing - on center line

9) Funnel

Length - 8' 6"
Breadth - 7'
Depth - 13' 6"
Outer shell - 3/16" al. plate
Internally braced and stiffened with aluminum angles

10) Superstructure

a) Deckhouse

The deckhouse is in the form of an aluminum box open at the bottom.

Length - 18'
Breadth - 15'
Depth - 9'
Outer shell - 3/16" al. plate
Interior bulkheads - 2 bulkheads of 3/16" al. plate
Height above keel - C.G. is about 28' above keel
Lateral spacing - on center line

b) Bridge

The bridge is in the form of an aluminum box open at the top.

Length - 9'
Breadth - 24'
Depth - 4' 6"
Shell - 3/32" al. plate

11) Davit Seats

These are two open-ended aluminum drums, one on the port side and one on the starboard side, of the following dimensions:

Diameter	- 3'
Height	- 7' 9"
Outer shell	- 1/2" al. plate
Height above keel	- C.G. is about 19' above keel
Lateral spacing	- 9' 3" from center line

FIGURE 1
HMCS "COWICHAN" (MCB 162) — LOOKING EAST
CONSTRAINING ROPES AT BOW

Nat. Def. Photo by RCN

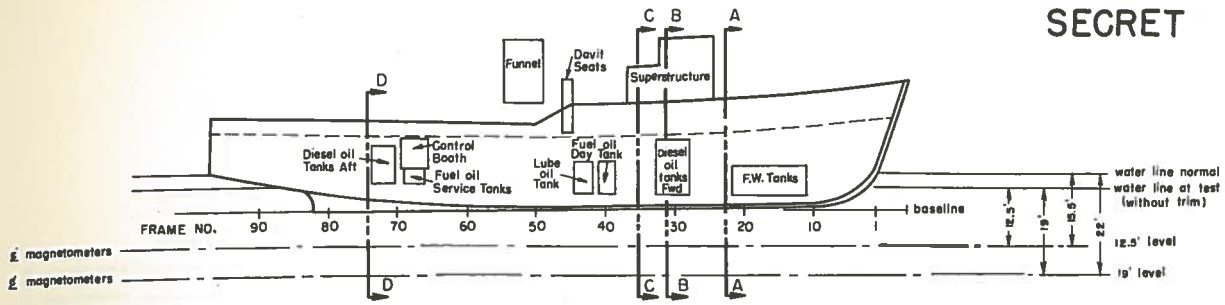
FIGURE 2
HMCS "COWICHAN" (MCB 162) — LOOKING WEST
CONSTRAINING ROPES AT STERN

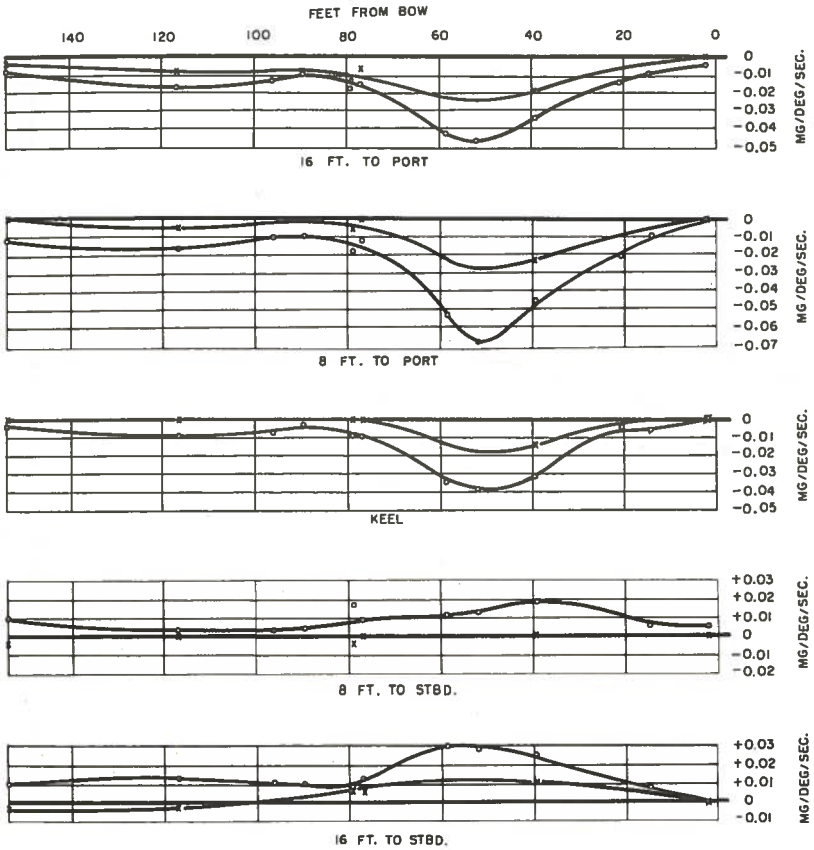
Nat. Def. Photo by RCN

FIGURE 3
HMCS "COWICHAN" (MCB 162) — LOOKING EAST
ROLL EXPERIMENT IN ACTION — RUNNING MEN AT STARBOARD SIDE
Nat. Def. Photo by RCN

FIGURE 4
MAGNETOMETER RANGE INSTALLED IN DEPARTMENT OF TRANSPORT DRY DOCK
Nat. Def. Photo by RCN

SECRET





LEGEND

—o— 12'-6" BELOW WATER LINE AT TEST

—x— 19'-0" BELOW WATER LINE AT TEST

NOTE

POSITIVE DIRECTION OF FIELD IS DOWNWARD.
FIELDS PLOTTED ARE MAXIMUM SINGLE AMPLITUDES FOR A ROLL FROM STARBOARD TO PORT.

EXCITING FIELD: Z = 515 mg
H = 156 mg

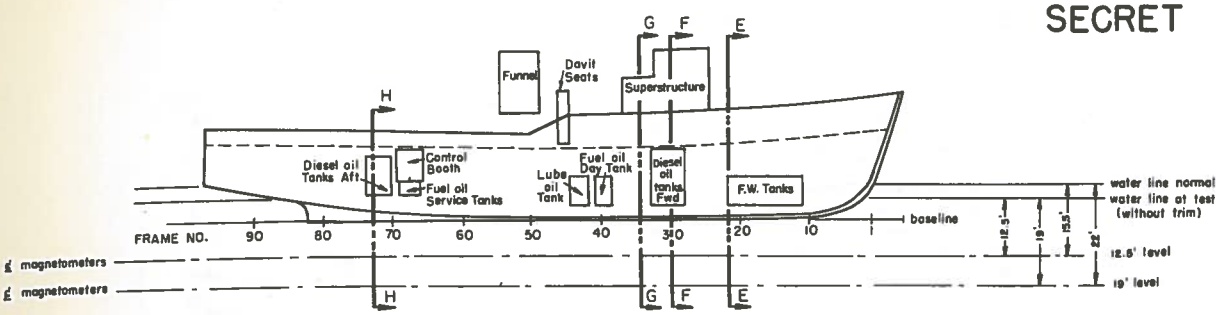
HEADING OF SHIP: 241° (magnetic)

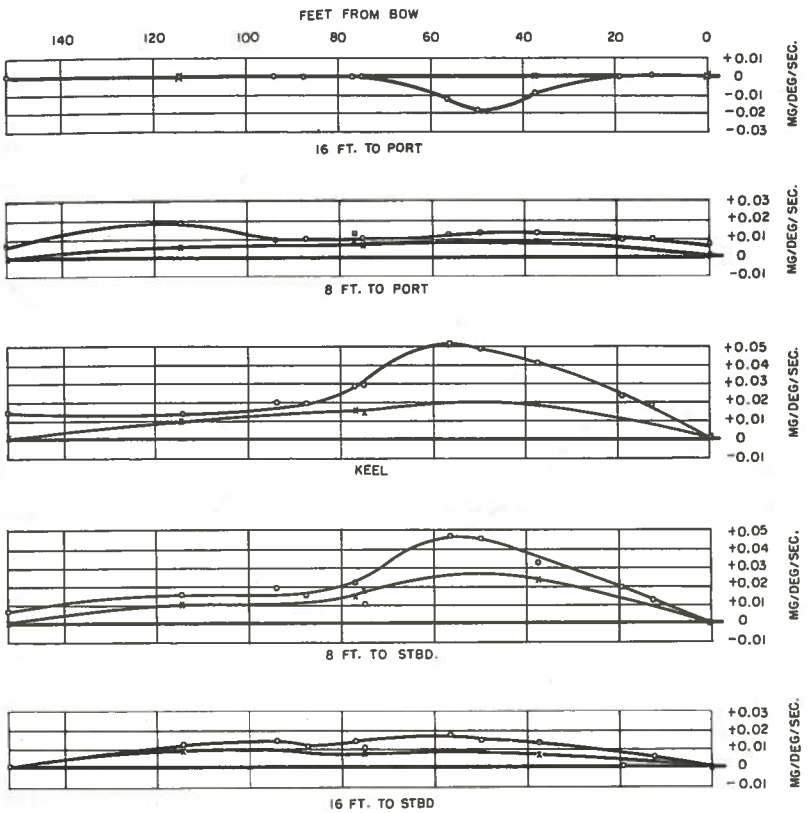
LONGITUDINAL PROFILES OF EDDY CURRENT FIELD VERTICAL COMPONENTS

HMCS "COWICHAN" (MCB 162)

FIG. 5

SECRET





LEGEND

—o— 12'–6" BELOW WATER LINE AT TEST

—x— 19'–0" BELOW WATER LINE AT TEST

NOTE

POSITIVE DIRECTION OF FIELD IS FROM STBD. TO PORT. FIELDS SHOWN ARE MAXIMUM SINGLE AMPLITUDES FOR A ROLL FROM STBD. TO PORT.

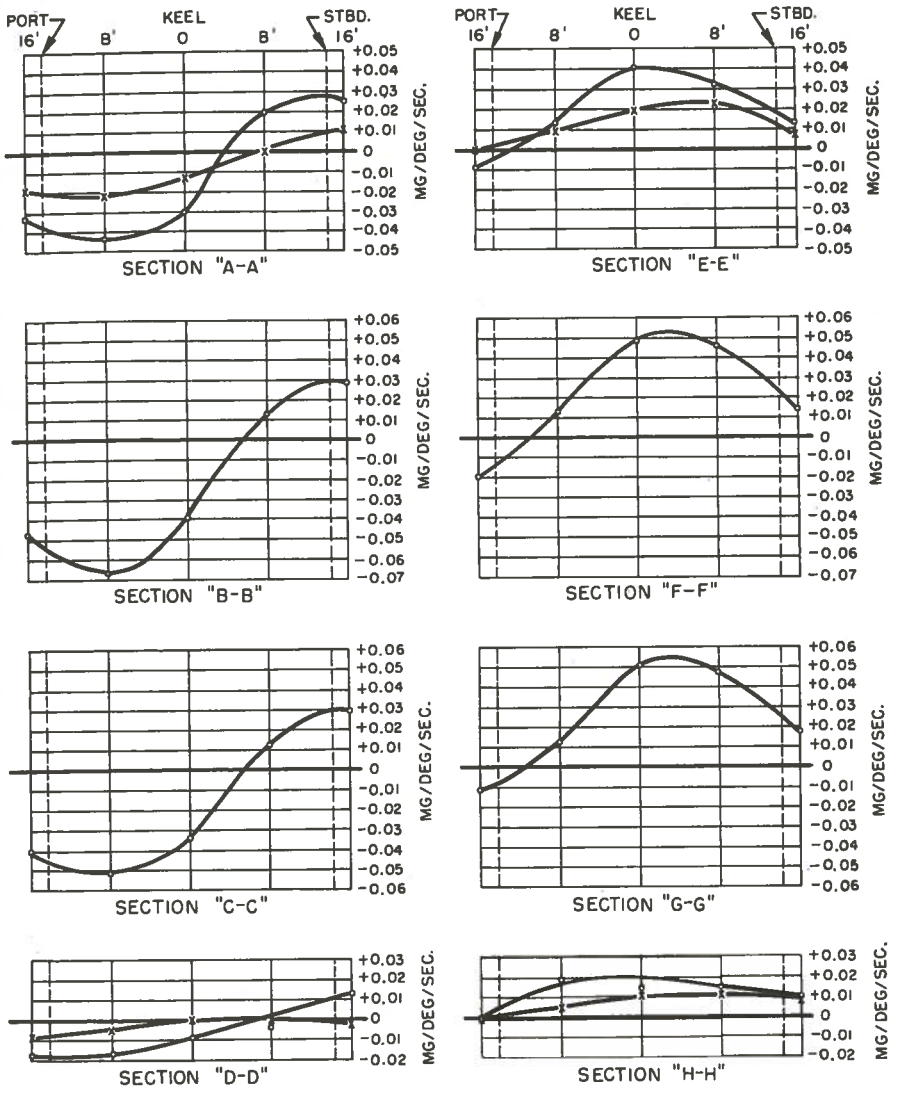
EXCITING FIELD: Z = 515 mg
H = 156 mg

HEADING OF SHIP: 241° (magnetic)

LONGITUDINAL PROFILES OF EDDY CURRENT FIELD TRANSVERSE HORIZONTAL COMPONENTS

HMCS "COWICHAN" (MCB 162)

FIG. 6



LEGEND

o 12'-6" BELOW WATER LINE AT TEST
x 19'-0" " " " " "

NOTE

POSITIVE DIRECTIONS: DOWN AND STBD. TO PORT. FIELDS PLOTTED ARE MAXIMUM SINGLE AMPLITUDES FOR A ROLL FROM STARBOARD TO PORT.

EXCITING FIELD: Z = 515 mg
H = 156 mg

HEADING OF SHIP: 241° (magnetic)

TRANSVERSE PROFILES OF EDDY CURRENT FIELD VERTICAL AND TRANSVERSE HORIZONTAL COMPONENTS HMCS "COWICHAN" (MCB 162)

FIG. 7