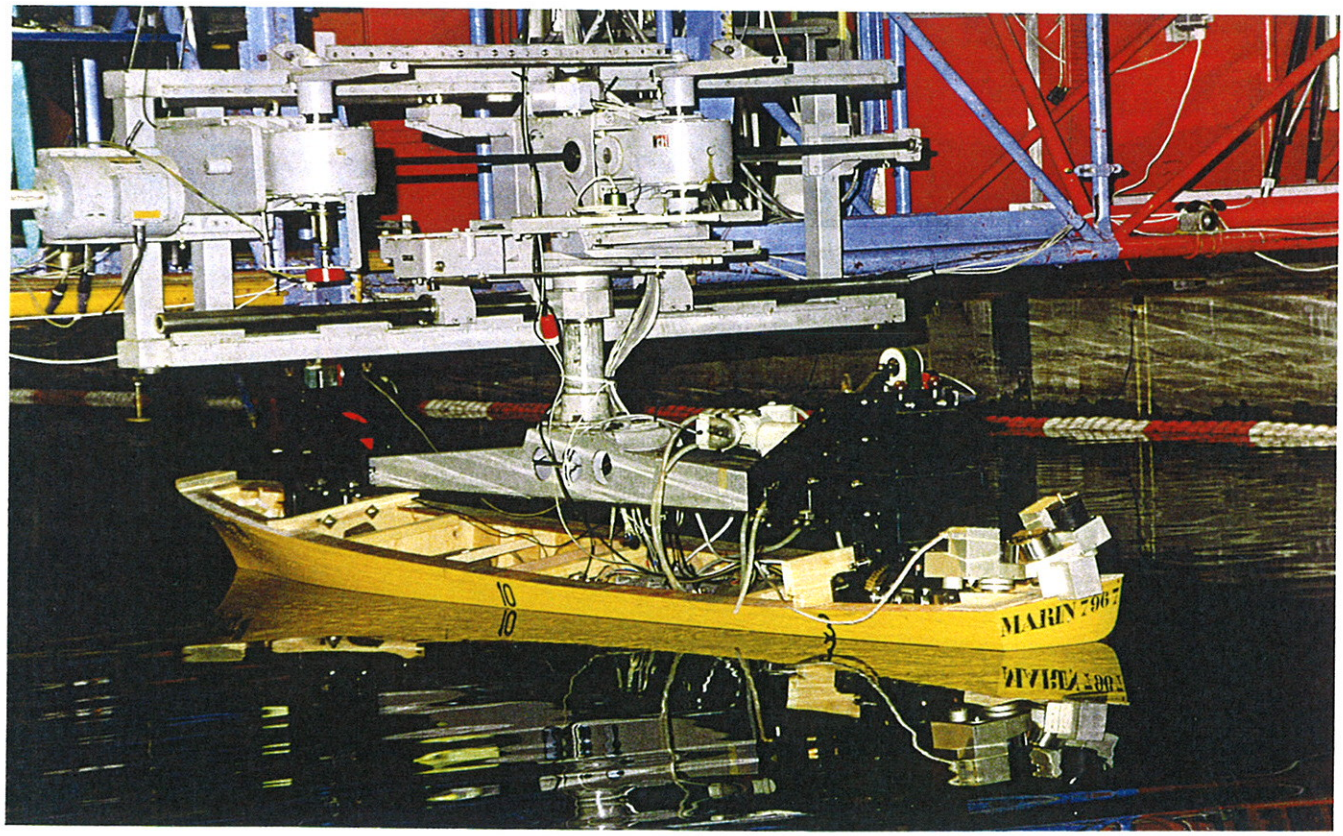
PMM Tests with a Model of a Frigate

DMI 2000071
Report No. 1



DMI
Danish Maritime Institute

Project No. and Title of Report:

EXTRACT OF :

DMI 2000071

Report No. 1

PMM-tests With a Model of a Frigate

Client:	*Client's Ref.:*
Author(s): Axel Mølgaard	*Date:* 2000-05-02 *Approved by:*

1.0	Final Report	AM	AD	AD	29/5-2000
Revision	*Description*	*By*	*Checked*	*Approved*	*Date*

Keywords:

PMM Tests Including Static Heel.
~~Simulation of Standard Manoeuvres.~~ REMOVED

Classification:

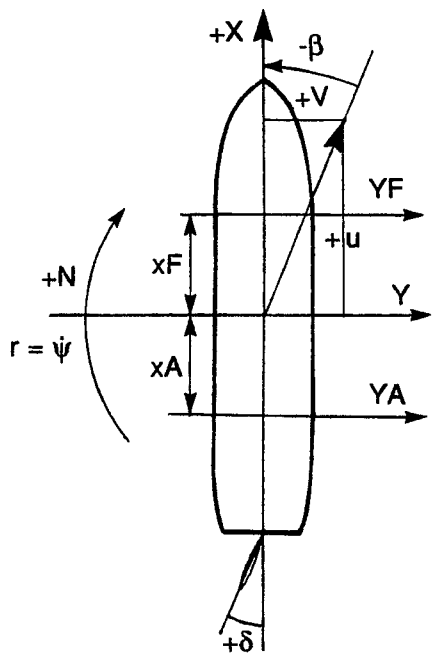
- ☐ Open
- ☐ Internal
- ■ Confidential

LIST OF CONTENTS: **PAGE:**

APPENDICES:

NOMENCLATURE

The commonly accepted nomenclature recommended by the 10th ITTC and which is essentially the same as that proposed by the SNAME has been used wherever possible.



$$Y = YF + YA$$
$$N = YF \cdot xF - YA \cdot xA$$

X, Y, N	:	Forces and moments on ship
u, v, r	:	Velocities and rate of turn
$\dot{u}$, $\dot{v}$, $\dot{r}$	:	Accelerations
δ, β, ϕ	:	Rudder, drift angle and heel angle
m, I_z	:	Mass and polar inertia
x_G	:	Distance of CG from ⊗

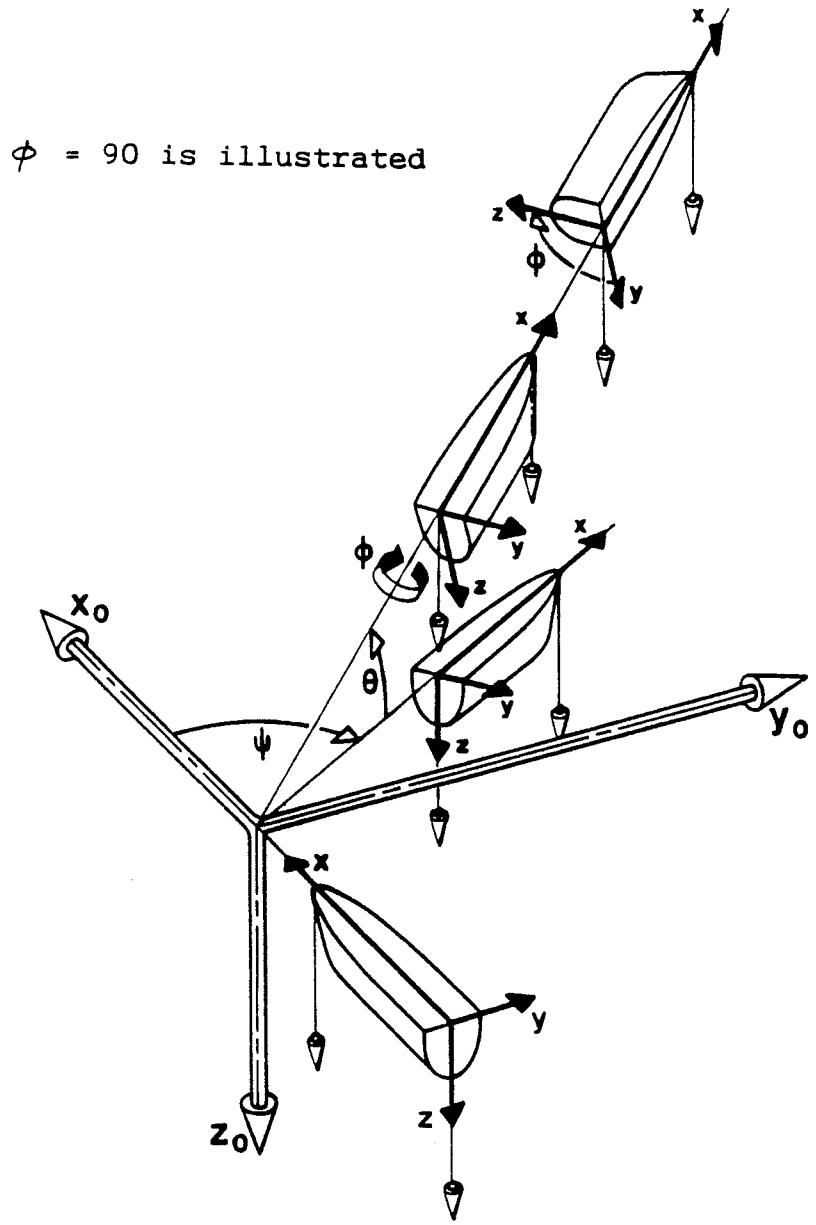
Partial derivatives are denoted by the subscript notation, e.g. $Y_v = \partial Y/\partial v$, $N_r = \partial N/\partial r$ etc., and non-dimensional terms by the prime notation, e.g. Y'_v.

SCALING FACTORS

The usual Froude scaling is used thus for scale α

				non-dimensionalized with
$Force_{ship}$	=	$Force_{model}$	$\cdot \alpha^3$	$\frac{1}{2} \rho Lpp^2U^2$
$Moment_{ship}$	=	$Moment_{model}$	$\cdot \alpha^4$	$\frac{1}{2} \rho Lpp^3U^2$
$Speed_{ship}$	=	$Speed_{model}$	$\cdot \alpha^{1/2}$	U
$Revolutions_{ship}$	=	$Revolutions_{model}$	$\cdot \alpha^{-1/2}$	U/Lpp
$Length_{ship}$	=	$Length_{model}$	$\cdot \alpha$	Lpp
$Time_{ship}$	=	$Time_{model}$	$\cdot \alpha^{-1/2}$	Lpp/U

Unless otherwise stated no corrections have been made for scale effects when analysing the model data.



For clarity, only forebody is illustrated.
Plumb-bobs indicate vertical.

1. Introduction

This report presents the results of manoeuvring tests performed in a PMM set-up with a scale model of a Frigate. The model was received from MARIN where it was designated, "MARIN 7967". The experiments and analysis were carried out by DMI

The purpose of the tests was to determine the vessel's general manoeuvring characteristics in one loading condition.

The tests took place at DMI from 24th to 30th March, 2000. The model was connected to the Horizontal Planar Motion Mechanism, HPMM, and tested in the deep-water towing tank.

The prognosis for the vessel's general manoeuvring characteristics was established by means of a time-stepping procedure based on the results from the PMM-tests.

The prognosis has been given in the form of simulated:

- Turning Circle Manoeuvres.
- Zig-Zag Manoeuvres.
- Spiral Manoeuvres.

The results of the simulated manoeuvres have been compared to the IMO Recommendations (see Ref. /1/).

2. Remarks and Conclusions

All tests described in this report are performed under the same conditions i.e.

- Same loading condition.
- Free in heave and pitch but otherwise constrained.
- Propeller revolutions at the nominal speed corresponding to the self-propulsion-point.

The PMM test programme comprised the usual static and dynamic tests including tests with heel angle as independent variable (see Section4).

Based on the PMM-measurements hydrodynamic coefficients have been derived and used as input to a time-stepping procedure for simulations of turning circle, zig-zag, and spiral manoeuvres. The PMM-tests and associated simulated manoeuvres were initiated from two different nominal speeds corresponding to 18 and 30 knots.

The PMM-test programmes covered speed ranges down to 40% of the nominal speeds. The propeller revolutions were manually regulated keeping the nominal shaft torque constant over the entire speed range.

A vessel's manoeuvring characteristics are normally grouped into three modes of performance namely:

- Steering or Course-Keeping Ability.
- Turning Ability.
- Manoeuvring or Yaw-Checking Ability.

The steering ability is judged from the spiral manoeuvre, the turning ability from the turning circles, and the manoeuvring ability is judged from the zig-zag tests.

Lacking other relevant criteria the simulated manoeuvres have been compared to the IMO-Recommendations, Ref. /1/.

Conclusions: REMOVED

REMOVED

3. Model Description and Test Set-Up

The model was received from MARIN. It is made of wood.

Model Scale : 1 : 35.48.

Model No. : MARIN 7967 (P 5174/A).

The model is shown on the photos in Appendix 1, and drawings and tabulated particulars are collected in Appendix 2.

Turbulence Stimulation : Sand on the bow and at the rudder supports.

Appendages : The model was equipped with twin open-shaft arrangements with A-bracket supports - twin balanced spade rudders and bilge keels.

Propellers : The stock propellers No. 6515 ps and sb used during these tests are four-bladed right and left-handed inward rotating propellers with diameters corresponding to 6.0 m in full-scale.

Pitch ratio, P0.7/D = 1.4

3.1 Test Condition

The test condition has been listed in Table 3.1.1 below:

		Model	Ship
Displaced Volume	(m^3)	0.188	8398
Draught Forward, T_F	(m)	0.172	6.110
Draught Aft, T_A	(m)	0.172	6.110
Nominal Speed, U_0	(m/s knots)	1.555 / 2.591	18 / 30
Nominal Prop. Revs., N_0	(RPM)	435 / 813	73 / 136

Table 3.1.1. Test Condition.

3.2 Test Set-Up

The tests took place in DMI's 240 m x 12 m x 5.5 m towing tank with the model attached to the Planar Motion Mechanism. During the tests the model was free to heave and pitch in the vertical plane, but otherwise constrained.

The origin of the co-ordinate system fixed in the model was located in the intersection between the water-line plane and the centre-line plane at amidships. This is thus the point referred to in the predicted manoeuvring trajectories. The x-axis is positive in the forward direction, the y-axis is positive towards starboard side and the z-axis is positive downwards. Angles, moments and directions of rotation follow the general right-hand rule.

The forward force gauge was located 1.514 m forward of the origin, while the aft force gauge was located 1.489 m aft of the origin.

3.3 Measured Parameters

All data were sampled at a frequency of 49 Hz.

In the List of Channels overleaf are listed the measured parameters with their dimensions and analogue-to-digital converter resolutions.

Channel No.	Designation	Dimension	A/D Resolution	Explanation
0	Y_F	N	0.1	Forward lateral force
1	Y_A	N	0.1	Aft lateral force
2	X_F	N	0.1	Forward longitudinal force
3	X_A	N	0.1	Aft longitudinal force
4	K_A	Nm	0.02	Aft heel moment
5	UC	m/s	0.005	Carriage speed
6	SINK F	mm	0.1	Squat forward
7	SINK A	mm	0.1	Squat aft
8	T-PROP P	N	0.02	Propeller thrust port side
9	Q-PROP P	N · m	0.002	Propeller torque port side
10	T-PROP S	N	0.02	Propeller thrust sb side
11	Q-PROP S	N · m	0.002	Propeller torque sb side
12	PROP REVS	RPM	0.6	Propeller revolutions
13	DELTA-P	Degrees	0.02	Rudder angle port side
14	DELTA-S	Degrees	0.02	Rudder angle sb Side
15	PHI	Degrees	0.01	Heel angle
16	THETA	Degrees	0.001	Pitch angle
17	PMM COS	-	-	Cosine (phase angle)
18	PMM SIN	-	-	Sine (phase angle)
19	PMM REVS	RPM	0.006	PMM frequency

Table 3.3.1. List of Channels.

4. Test Programme

An overview of the test programme is shown in Table 4.1. A detailed list giving the resulting measured responses versus the independent variables is included in Appendix 3 for the 18 knots test series and in Appendix 4 for the 30 knots test series.

Test	Run	Nominal Speed	Appendix
Pure & Drift	1022 – 1032	18	3,5,7
Speed & Drift	1064 – 1087	18	3,5,7
Speed & Rudder	1033 – 1100	18	3,5,7
Drift & Rudder	1153 – 1188	18	3,5,7
Drift & Heel	1254 – 1355	18	3,5,7
Pure Yaw	1194, 1201	18	3,7
Yaw & Rudder	1195,1196,1202,1203	18	3,7
Yaw & Drift	1197,1199,1204,1206	18	3,7
Yaw & Drift & Rudder	1198,1200,1205,1207	18	3,7
Pure & Drift	55 - 67	30	4,6,8
Speed & Drift	68 – 88	30	4,6,8
Speed & Rudder	107 – 135	30	4,6,8
Drift & Rudder	200 – 220	30	4,6,8
Speed & Heel	242 – 260	30	4,6,8
Drift & Heel	261 – 276	30	4,6,8
Pure Sway	400 - 404	30	4,8
Pure Yaw	441	30	4,8
Yaw & Rudder	442,451	30	4,8
Yaw & Drift	443,454	30	4,8
Yaw & Drift & Rudder	444,455	30	4,8

Table 4.1. Model Test Programme.

5. Results of Model Tests

The results of the PMM tests are found in Appendices 5 and 6 in the form of plots of measured points and faired curves for the 18 and 30 knots test series, respectively.

The results are presented as non-dimensional forces and moments versus the manoeuvring parameters.

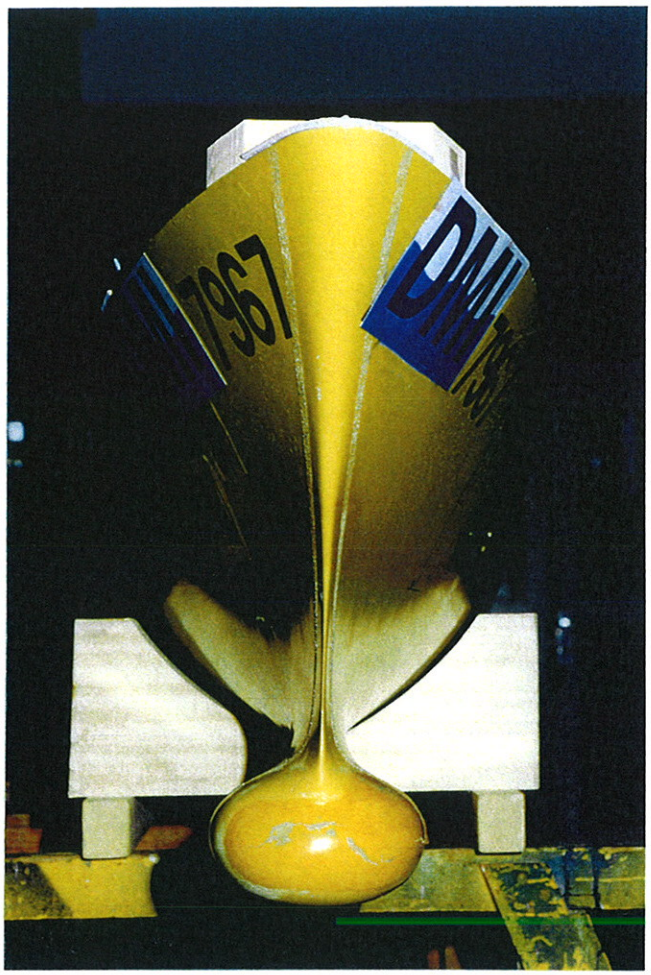
A detailed index is found on the front cover of each appendix.

6. List of Reference

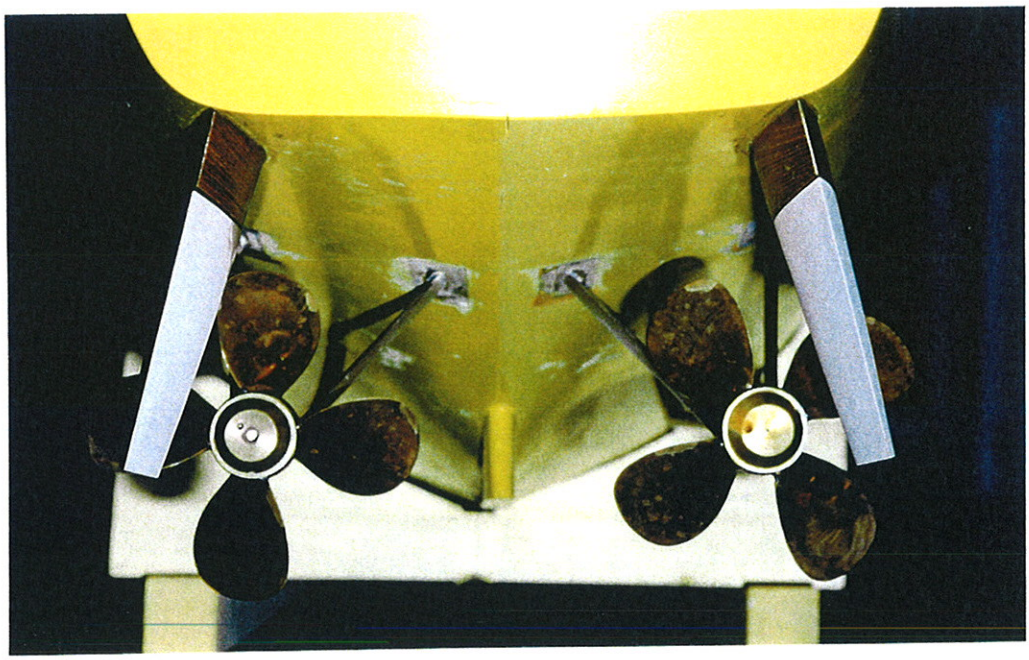
/1/ IMO Resolution A.751(18).

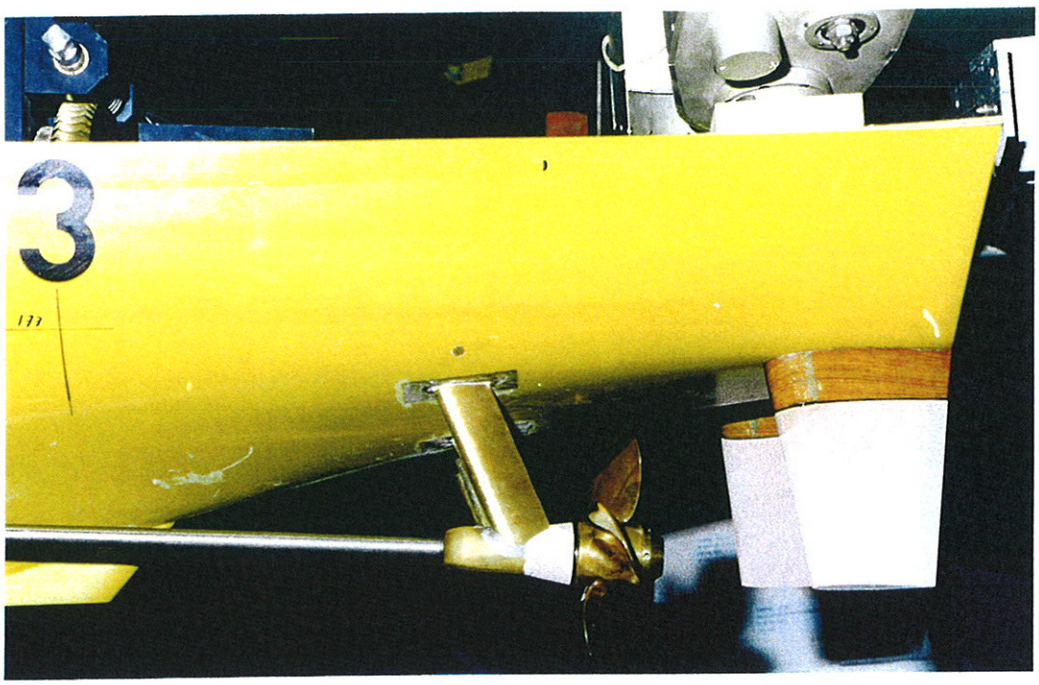
APPENDIX 1.

Photos.



Photos of the Fore-Body of the Vessel.





Photos of Aft-Body of the Vessel.

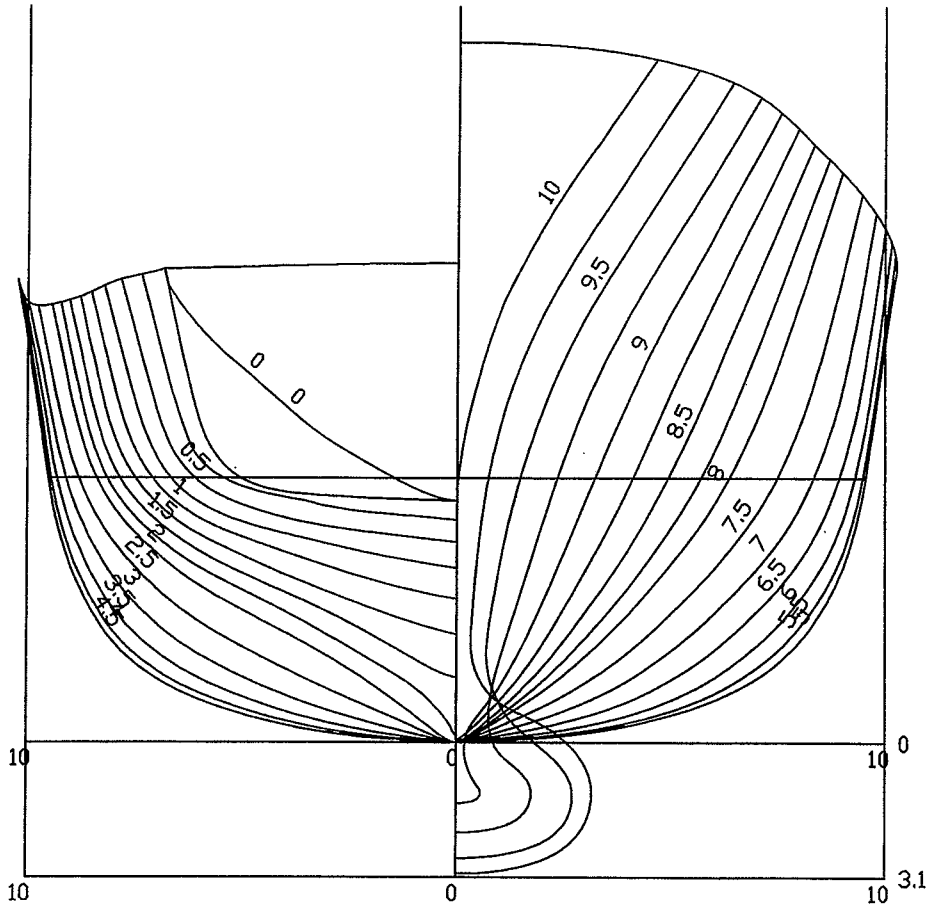
APPENDIX 2.

Drawings and Tabulated Particulars of the Vessel.

- **Body Plan.**
- **Stern / Stem.**
- **Hydrostatic Particulars.**

Fregat

Lpp.....	142.00	m
Bmould....	20.00	m
T cwl.....	5.00	m



TA/TF Cond. 01 6.11 /6.11 m

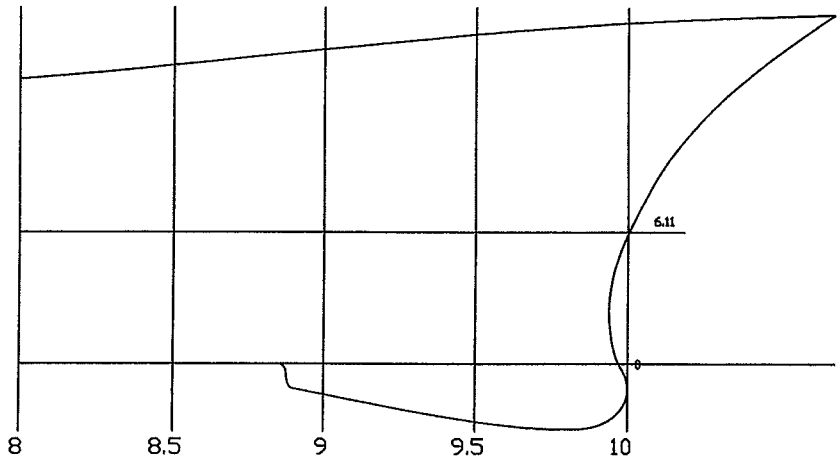
DMI DANISH MARITIME INSTITUTE

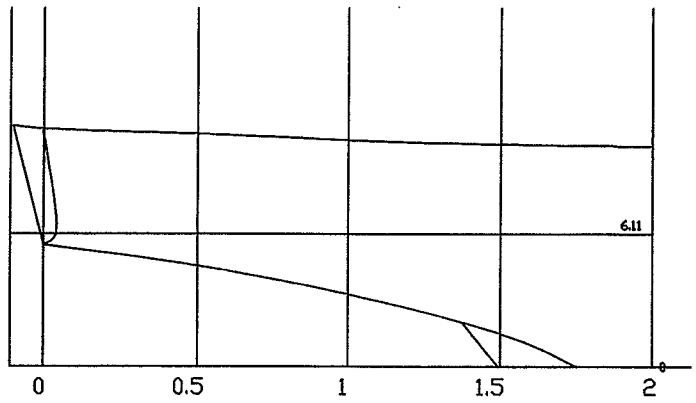
SCALE	DRAWN BY	TEL	CHECKED BY	TEL	ACCEPTED BY
175	JC				
	DATE 2000-03-06	DEP	GENERAL DRAWING P5174 HULL		

DRAWING NAME

BODYPLAN

DMI	DRAWING NUMBER	INDEX	SHEET
	2000071.10	A	





Fregat

Lpp..... 142.00 m
Bmould.... 20.00 m

DMI DANISH MARITIME INSTITUTE

SCALE	DRAWN BY	TEL	CHECKED BY	TEL	ACCEPTED BY
350	JC				
	DATE 2000-03-06	DEP	GENERAL DRAWING P5174 HULL		

DRAWING NAME

STERN/STEM

DMI	DRAWING NUMBER	INDEX	SHEET
	2000071.10	A	

DMI

Hydrostatic data
P5174
P5174/A
NAPA/D/HYD/990820

DATE 2000-03-06
TIME 09:55
DMI LYNGBY DK
USER JC

DMI order No.:	2000070
Model No.:	10
Condition No.:	1
Test carried out for:	THALES
Type of Ship:	FREGAT
Model scale:	1/35.48

HULL INCL. RUDDERS AND KEEL

DIMENSIONS:

			SHIP:	MODEL:
Length over all (ref):	LOA	M	150.460	4.2407
Length bet. perp. (ref):	LPP	M	142.000	4.0023
Length of waterline (1):	LWL	M	142.177	4.0073
Length total below wl. (1):	LTOT	M	142.177	4.0073
Breadth max. (ref):	B	M	20.000	0.5637
Breadth max. below wl. at XAP (1):	BX	M	19.077	0.5377
Breadth max. in wl. (1):	BR	M	19.080	0.5378
Draught fore:	TF	M	6.110	0.1722
Draught mean:	TM	M	6.110	0.1722
Draught aft:	TA	M	6.110	0.1722
Draught at XAP:	TX	M	6.110	0.1722
Max. sectional area (1):	AMX	M2	95.642	0.0760
Position of AMX from AP. (1):	XAP	M	67.450	1.9011
Volume (3):	VOLM	M3	8397.720	0.1880
Wetted surface area (2):	S	M2	3051.710	2.4242
Waterplane area (3):	AWL	M2	2095.260	1.6645
Transverse center of buoyancy (3):	TCB	M	0.000	0.0000
Vert. center of buoy. above BL (3):	KB	M	3.623	0.1021
Long. center of buoy. from AP. (3):	LCB	M	70.074	1.9750
Long. center of flot. from AP. (3):	LCF	M	64.224	1.8101
Transv. metac. height above BL. (3):	KMT	M	9.463	0.2667

(ref): HULL Def. from NAPA reference system.
(1): HULL Def. excl. appendage, excl thruster. ID: HULL
(2): HULL Def. incl. appendage, excl thruster. ID: APPHULL
(3): HULL Def. incl. appendage, incl thruster. ID: APPHULL

COEFFICIENTS:

Block coefficient:	VOLM/(LWL*BX*TX)	CB	0.507
Prismatic coefficient:	VOLM/(LWL*AMX)	CP	0.618
Maximum section coefficient:	AMX/(BX*TX)	CM	0.821
Waterplane coefficient:	AWL/(LWL*BR)	CW	0.772
Fatness ratio:	(VOLM*1000)/(LWL**3)		2.922
Fineness ratio:	LWL/VOLM**(1/3)		6.995
Wet. surface ratio:	S/VOLM**(2/3)		7.386
Length/Breadth:	LWL/BR		7.452
Breadth/Draught:	BX/TX		3.122
Trim % by stern:	(TA-TF)*100/LPP		0.000
LCB % aft of amidship:	((LPP/2)-LCB)*100/LPP		0.652
LCF % aft of amidship:	((LPP/2)-LCF)*100/LPP		4.772
X % aft of amidship:	((LPP/2)-X)*100/LPP		2.500

APPENDIX 3.

Test Programme: 18 knots series.

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 413

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
1022	-4.0	-0.1	-0.1	18.01	69.2	-318.4	-797.5	-44746.7	4716.9
1023	-2.0	-0.1	-0.1	18.01	69.2	-306.3	-366.1	-17249.6	2240.1
1024	-1.0	-0.1	-0.1	18.02	69.2	-240.6	-117.5	-7009.1	634.7
1025	-0.5	-0.1	-0.1	18.00	69.2	-206.6	-24.9	-3594.3	-2.8
1026	0.0	-0.1	-0.2	18.02	69.2	-263.1	91.4	-834.7	-886.7
1027	0.5	-0.1	-0.2	18.01	69.2	-257.5	199.0	2795.6	-1761.0
1028	1.0	-0.1	-0.2	18.02	69.2	-258.1	313.5	6835.1	-2564.0
1029	2.0	-0.1	-0.2	18.00	69.2	-284.3	518.1	18268.0	-3919.6
1031	3.0	-0.1	-0.2	18.03	69.2	-296.8	712.4	32426.3	-4873.8
1030	4.0	-0.1	-0.2	18.00	69.2	-210.2	983.0	42413.1	-6434.4
1032	4.0	-0.1	-0.2	18.02	69.3	-238.7	968.1	43346.4	-6133.6
1064	-12.0	-0.1	0.3	14.47	61.4	60.8	-2425.1	-67582.1	14184.8
1063	-10.0	-0.1	0.2	14.48	61.4	34.0	-1894.1	-53530.8	11413.7
1062	-8.0	-0.1	0.1	14.50	61.4	25.7	-1419.2	-40879.9	8995.3
1061	-6.0	-0.1	-0.0	14.51	61.4	54.5	-971.8	-32125.0	6305.2
1060	-4.0	-0.1	-0.0	14.51	61.3	36.5	-523.7	-24218.4	3668.4
1059	-2.0	-0.1	-0.1	14.52	61.3	56.6	-262.9	-8326.2	2039.2
1058	0.0	-0.1	-0.0	14.52	61.3	79.9	86.9	751.0	-647.9
1052	0.0	-0.0	-0.1	14.52	61.3	135.5	61.5	198.5	-593.7
1053	2.0	-0.0	-0.1	14.51	61.3	39.8	315.6	8800.8	-2473.4
1054	4.0	-0.0	-0.1	14.52	61.4	61.0	575.6	23369.6	-4003.2
1055	6.0	-0.0	-0.1	14.52	61.3	76.7	1012.3	28780.5	-6581.5
1056	8.0	-0.0	-0.1	14.52	61.4	67.5	1467.4	39706.4	-9373.3
1057	10.0	-0.0	-0.2	14.51	61.4	67.9	1964.9	52987.6	-12428.9
1076	-16.0	-0.0	0.2	10.80	53.9	337.1	-2069.6	-54037.0	12263.7
1075	-10.0	-0.0	0.0	10.81	54.0	355.0	-1086.7	-24898.5	7042.0
1074	-6.0	-0.0	-0.0	10.82	53.9	375.6	-518.9	-13965.3	3588.8
1073	0.0	-0.0	-0.1	10.83	53.9	370.0	25.8	601.3	-208.2
1065	0.0	-0.0	-0.0	10.83	53.9	380.2	37.9	394.0	-318.9
1066	4.0	-0.0	-0.1	10.83	54.0	365.8	344.1	10360.3	-2689.6
1067	8.0	-0.0	-0.1	10.83	54.0	387.7	799.6	16349.5	-5506.2
1068	10.0	-0.0	-0.1	10.83	54.0	386.1	1095.7	23210.2	-7259.2
1069	12.0	-0.0	-0.1	10.84	54.0	398.3	1392.9	31583.4	-8891.3
1070	16.0	-0.0	-0.1	10.84	54.0	390.3	2038.2	50734.2	-12485.0
1081	-16.0	-0.0	0.0	7.25	46.7	520.3	-884.0	-19316.1	5430.1
1082	-10.0	-0.0	0.0	7.25	46.7	563.0	-421.3	-8224.2	2687.7
1083	-6.0	-0.0	0.0	7.25	46.7	583.2	-161.3	-5783.8	980.1
1084	0.0	-0.0	-0.0	7.25	46.7	568.3	81.0	-567.6	-672.3
1085	6.0	-0.0	-0.0	7.26	46.7	564.2	325.5	2563.0	-2540.4
1086	10.0	-0.0	-0.0	7.25	46.7	566.2	577.3	7914.3	-4141.0

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 413

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
1087	16.0	-0.0	-0.0	7.25	46.7	551.0	998.6	18385.6	-6583.4
1033	0.0	-39.9	-0.0	18.02	69.2	-855.2	-849.7	60474.1	5562.5
1034	0.0	-34.2	-0.0	18.01	69.2	-729.0	-986.0	69867.9	6466.9
1035	0.0	-28.5	-0.0	18.01	69.2	-569.1	-924.8	65800.4	6165.6
1036	0.0	-22.6	-0.0	18.01	69.2	-465.1	-775.9	56008.3	5352.0
1037	0.0	-11.3	-0.1	18.00	69.2	-252.7	-503.5	39010.2	3728.3
1038	0.0	-0.1	-0.2	17.99	69.3	-200.3	96.8	-348.2	-829.5
1039	0.0	11.2	-0.2	18.03	69.1	-360.3	748.5	-43155.5	-5829.4
1040	0.0	22.5	-0.2	18.03	69.1	-537.4	1337.3	-82585.1	-10405.8
1041	0.0	28.2	-0.2	18.02	69.1	-638.6	1124.7	-69768.8	-8106.8
1042	0.0	33.8	-0.2	18.02	69.1	-757.9	1275.5	-78842.1	-9072.1
1043	0.0	39.6	-0.2	18.00	69.1	-888.6	1012.2	-60381.6	-7192.6
1134	0.0	-39.8	0.1	18.00	69.6	-873.4	-862.3	61120.5	5669.3
1135	0.0	-34.0	0.1	17.99	69.6	-755.2	-1091.3	76608.9	7237.5
1136	0.0	-28.3	0.0	18.00	69.6	-580.1	-921.3	66197.6	6194.1
1137	0.0	-22.4	0.0	17.99	69.6	-491.1	-768.7	55350.6	5308.7
1138	0.0	-16.9	0.0	17.98	69.6	-364.2	-823.2	60363.5	6106.9
1139	0.0	0.1	-0.1	17.98	69.6	-210.2	124.6	-947.9	-1024.5
1140	0.0	-0.1	-0.1	18.01	69.8	-259.4	106.6	-876.5	-781.8
1141	0.0	22.5	-0.1	18.01	69.8	-547.4	1365.3	-83642.3	-10511.9
1142	0.0	28.3	-0.1	18.01	69.8	-644.0	1180.2	-68561.1	-8294.3
1143	0.0	33.8	-0.1	18.01	69.8	-772.8	1287.5	-78635.9	-8958.6
1144	0.0	39.6	-0.1	17.98	69.8	-892.8	1033.0	-60818.8	-7156.2
1122	0.0	-39.9	0.0	14.48	60.9	-428.0	-625.5	46178.5	4037.8
1123	0.0	-34.1	0.0	14.48	60.9	-319.9	-563.8	41381.6	3639.7
1124	0.0	-28.5	0.0	14.47	60.9	-202.6	-689.6	49545.4	4469.4
1125	0.0	-22.6	0.0	14.47	60.9	-110.7	-552.4	40880.4	3686.6
1126	0.0	-17.1	-0.0	14.47	60.9	-55.2	-449.6	32746.4	3103.3
1127	0.0	-0.0	-0.1	14.46	60.9	95.1	61.5	-60.2	-561.4
1128	0.0	17.0	-0.1	14.48	60.9	-63.3	805.6	-47260.6	-6156.2
1129	0.0	22.5	-0.1	14.47	60.9	-159.6	708.8	-42206.8	-5057.9
1130	0.0	28.3	-0.1	14.47	61.0	-234.3	879.3	-51120.7	-6151.6
1131	0.0	33.8	-0.1	14.47	61.0	-339.2	945.6	-57321.4	-6547.3
1132	0.0	39.6	-0.1	14.46	61.0	-448.5	793.1	-47123.1	-5518.1
1133	0.0	39.6	-0.1	14.45	61.0	-438.7	793.2	-46456.3	-5507.2
1113	0.0	-39.6	0.0	10.80	53.6	-21.1	-487.4	33325.9	3112.2
1114	0.0	-33.8	-0.0	10.80	53.6	60.5	-420.8	30488.7	2652.5
1115	0.0	-28.1	0.0	10.79	53.6	141.7	-522.0	37268.8	3443.8
1116	0.0	-22.3	-0.0	10.79	53.6	209.7	-402.8	31049.3	2682.4
1117	0.0	0.3	-0.1	10.80	53.6	400.9	25.0	26.6	-287.4

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 413

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
1118	0.0	22.8	-0.1	10.79	53.6	212.8	522.2	-30992.9	-3823.2
1119	0.0	28.6	-0.1	10.79	53.6	160.5	601.3	-37374.9	-4316.9
1120	0.0	34.2	-0.1	10.78	53.6	95.3	673.6	-41455.0	-4803.5
1121	0.0	39.9	-0.1	10.77	53.6	-2.3	570.8	-33771.2	-3998.8
1090	0.0	-39.8	0.0	7.25	46.8	257.0	-323.3	23304.7	2271.7
1091	0.0	-34.0	-0.0	7.25	46.8	320.9	-369.6	26234.3	2591.9
1092	0.0	-28.3	-0.0	7.25	46.8	375.1	-358.1	25077.5	2559.2
1093	0.0	-22.7	-0.0	7.24	46.8	419.5	-300.9	21051.4	2207.0
1094	0.0	-17.0	-0.0	7.24	46.8	464.0	-229.7	16632.8	1696.7
1095	0.0	0.1	-0.1	7.24	46.8	561.3	13.0	-10.0	-78.1
1096	0.0	17.1	-0.1	7.24	46.8	504.4	330.8	-20721.9	-2533.1
1097	0.0	22.6	-0.1	7.24	46.8	432.2	326.1	-20974.9	-2476.4
1098	0.0	28.4	-0.1	7.23	46.8	379.4	389.0	-24425.8	-2903.8
1099	0.0	34.0	-0.1	7.23	46.8	343.2	432.0	-26260.2	-3136.7
1100	0.0	39.7	-0.1	7.22	46.8	266.8	417.5	-25338.2	-3067.1
1153	16.0	-39.8	-0.0	10.81	53.4	1.8	1378.6	108973.7	-7548.4
1154	16.0	-34.0	-0.1	10.81	53.4	82.4	1405.6	100396.1	-7844.6
1155	16.0	-28.3	-0.1	10.80	53.5	155.3	1493.0	95149.2	-8467.4
1156	16.0	-22.4	-0.1	10.80	53.5	232.6	1620.6	89118.6	-9289.8
1157	16.0	-17.0	-0.1	10.81	53.5	303.7	1652.6	83840.2	-9607.2
1158	16.0	0.1	-0.1	10.81	53.5	346.1	2054.1	52242.2	-12733.8
1159	16.0	11.4	-0.1	10.80	53.5	281.3	2304.9	33391.6	-14669.9
1160	16.0	22.6	-0.1	10.78	53.5	135.8	2390.5	30615.4	-14696.2
1161	12.0	-39.8	-0.1	14.49	61.2	-400.7	1364.9	144265.4	-7324.9
1162	12.0	-34.0	-0.1	14.49	61.2	-296.9	1384.6	135358.1	-7511.1
1163	12.0	-28.3	-0.1	14.49	61.2	-186.5	1608.6	130067.2	-8912.9
1164	12.0	-22.7	-0.1	14.49	61.2	-54.3	1652.0	125244.5	-9227.7
1165	12.0	0.1	-0.2	14.49	61.2	87.8	2464.4	63222.1	-15480.4
1166	12.0	11.4	-0.2	14.49	61.2	16.1	2888.0	33074.8	-18809.4
1167	12.0	22.6	-0.2	14.47	61.2	-194.8	2939.3	30604.8	-18429.6
1168	8.0	-39.8	-0.0	14.48	61.3	-435.7	469.3	112974.8	-2186.8
1169	8.0	-34.0	-0.1	14.49	61.3	-335.0	515.2	108622.5	-2496.4
1170	8.0	-28.3	-0.1	14.48	61.3	-230.5	606.8	100435.3	-3060.3
1171	8.0	-22.7	-0.1	14.48	61.3	-131.5	780.5	90104.8	-4255.0
1172	8.0	0.1	-0.1	14.48	61.3	61.7	1521.9	39795.0	-9862.2
1173	8.0	11.4	-0.2	14.48	61.3	-7.5	1957.5	8596.6	-13262.4
1174	8.0	22.6	-0.2	14.46	61.3	-191.0	2004.4	3869.8	-13041.5
1122	0.0	-39.9	0.0	14.48	60.9	-428.0	-625.5	46178.5	4037.8
1123	0.0	-34.1	0.0	14.48	60.9	-319.9	-563.8	41381.6	3639.7
1124	0.0	-28.5	0.0	14.47	60.9	-202.6	-689.6	49545.4	4469.4

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 413

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
1125	0.0	-22.6	0.0	14.47	60.9	-110.7	-552.4	40880.4	3686.6
1126	0.0	-17.1	-0.0	14.47	60.9	-55.2	-449.6	32746.4	3103.3
1127	0.0	-0.0	-0.1	14.46	60.9	95.1	61.5	-60.2	-561.4
1128	0.0	17.0	-0.1	14.48	60.9	-63.3	805.6	-47260.6	-6156.2
1129	0.0	22.5	-0.1	14.47	60.9	-159.6	708.8	-42206.8	-5057.9
1130	0.0	28.3	-0.1	14.47	61.0	-234.3	879.3	-51120.7	-6151.6
1131	0.0	33.8	-0.1	14.47	61.0	-339.2	945.6	-57321.4	-6547.3
1132	0.0	39.6	-0.1	14.46	61.0	-448.5	793.1	-47123.1	-5518.1
1133	0.0	39.6	-0.1	14.45	61.0	-438.7	793.2	-46456.3	-5507.2
1175	-8.0	-22.6	0.2	14.46	61.2	-163.7	-1825.2	-7107.2	11258.1
1176	-8.0	-11.1	0.2	14.46	61.2	10.1	-1791.7	-11224.9	11520.3
1177	-8.0	0.3	0.0	14.45	61.2	47.0	-1350.7	-41018.6	8531.0
1178	-8.0	22.8	-0.1	14.47	61.2	-148.1	-417.5	-103420.4	1500.1
1179	-8.0	28.5	-0.1	14.46	61.2	-270.5	-435.1	-99920.4	1941.7
1180	-8.0	34.1	-0.1	14.46	61.2	-353.9	-331.0	-108376.5	1259.2
1181	-8.0	39.9	-0.1	14.44	61.2	-454.5	-221.5	-114469.8	549.3
1182	-16.0	-22.7	0.2	10.78	53.4	174.3	-2245.4	-29953.3	13231.8
1183	-16.0	-11.3	0.2	10.78	53.4	254.1	-2117.0	-42570.7	12431.8
1184	-16.0	0.1	0.1	10.77	53.4	334.9	-1963.7	-52559.3	11631.5
1185	-16.0	22.6	-0.0	10.78	53.4	208.2	-1356.9	-85100.4	7600.3
1186	-16.0	28.4	-0.0	10.78	53.4	135.2	-1348.0	-94259.0	7310.2
1187	-16.0	34.0	-0.1	10.77	53.4	62.9	-1266.9	-100509.2	6754.2
1188	-16.0	39.8	-0.1	10.76	53.4	-12.2	-1164.4	-105270.4	6057.7
1254	4.0	-0.0	-4.0	14.46	61.1	61.9	583.4	24232.3	-4034.6
1255	6.0	-0.0	-4.1	14.47	61.1	86.3	1022.7	30008.5	-6653.4
1256	8.0	-0.0	-4.1	14.47	61.1	93.9	1493.7	41082.4	-9373.8
1257	10.0	-0.0	-4.2	14.46	61.1	84.2	1993.8	55300.6	-12262.7
1275	0.0	-0.0	-7.9	10.80	53.4	364.6	34.2	1951.4	-421.5
1276	6.0	-0.0	-8.0	10.80	53.4	349.9	559.7	16627.1	-3954.9
1277	10.0	-0.0	-8.0	10.80	53.4	347.1	1099.5	28318.3	-7033.3
1278	12.0	-0.0	-8.0	10.80	53.5	360.3	1393.4	37675.5	-8551.7
1279	16.0	-0.0	-8.0	10.80	53.5	341.9	1945.3	60696.8	-11231.2
1300	0.0	-0.0	8.1	10.81	53.6	392.1	93.5	-1938.3	-777.9
1301	-6.0	-0.0	8.0	10.81	53.6	396.0	-435.5	-17828.4	2934.6
1302	-10.0	-0.0	8.0	10.79	53.6	369.7	-977.2	-26062.5	6386.2
1303	-14.0	-0.0	8.1	10.79	53.6	378.9	-1545.1	-43535.2	9422.5
1304	-16.0	-0.0	8.0	10.78	53.6	352.8	-1882.7	-55585.6	10984.6
1325	0.0	-0.0	-10.0	7.25	46.6	555.6	34.6	-546.9	-496.4
1326	6.0	-0.0	-10.0	7.25	46.6	567.7	283.5	4539.6	-2490.1
1327	10.0	-0.0	-10.0	7.24	46.6	568.6	529.1	9188.4	-4005.4

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 413

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
1328	14.0	-0.0	-9.9	7.24	46.6	583.9	789.1	17875.0	-5460.7
1329	16.0	-0.0	-10.0	7.24	46.6	564.9	920.7	23588.6	-6021.4
1351	0.0	-0.1	10.2	10.79	53.2	355.8	68.2	-2409.2	-601.8
1352	-6.0	-0.1	10.2	10.79	53.2	353.3	-490.7	-18539.7	3061.8
1353	-10.0	-0.1	10.2	10.77	53.2	331.8	-1023.9	-27345.0	6511.9
1354	-14.0	-0.1	10.2	10.77	53.2	350.8	-1549.8	-44044.7	9271.1
1355	-16.0	-0.1	10.2	10.77	53.2	323.8	-1871.7	-54771.3	10709.4

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 414

KIND OF ANALYSIS: YAW AND DRIFT AND RUDDER
PARTICULARS IN MODEL SCALE

TEST PARTICULARS

RUN NO.	UC (M/S)	NPMM (RPM)	SMM (MM)	YMM (MM)	RAMP (DEG)	BETA (DEG)	DELTA (DEG)	PHI (DEG)	R MAX PRIME	RDOTMAX PRIME
1201	0.933	5.00	240	134.7	0.0	0.0	0.0	0.0	0.608	1.371
1202	0.932	5.00	240	134.7	0.0	0.0	-22.7	0.0	0.608	1.373
1203	0.931	5.00	240	134.7	0.0	0.0	22.6	0.0	0.609	1.377
1204	0.934	5.00	240	134.7	0.0	14.0	0.0	0.0	0.606	1.364
1206	0.931	5.00	240	134.7	0.0	-16.0	0.0	0.0	0.609	1.375
1205	0.933	5.00	240	134.7	0.0	14.0	-22.7	0.0	0.607	1.367
1207	0.931	5.00	240	134.7	0.0	-16.0	22.5	0.0	0.609	1.378
1194	0.933	5.00	120	67.3	0.0	0.0	0.0	0.0	0.303	0.681
1195	0.932	5.00	120	67.3	0.0	0.0	-11.2	0.0	0.303	0.683
1196	0.932	5.00	120	67.3	0.0	0.0	11.6	0.0	0.303	0.684
1197	0.934	5.00	120	67.3	0.0	8.0	0.0	0.0	0.302	0.678
1199	0.932	5.00	120	67.3	0.0	-8.0	0.0	0.0	0.303	0.682
1198	0.933	5.00	120	67.3	0.0	8.0	-11.4	0.0	0.302	0.679
1200	0.932	5.00	120	67.3	0.0	-8.0	11.2	0.0	0.303	0.682

Run No.	Uc (m/s)	N-PMM (RPM)	Smm (mm)	Ymm (mm)	R-AMP (deg)	Beta (deg)	Delta (deg)	Phi (deg)	r-max prime	rdot-max prime
1189	1.555	4	90.0	24.2	0	0	0	0	0.052	0.056
1190	1.555	4	170.0	45.8	0	0	0	0	0.099	0.106
1192	1.555	4	260.0	70.0	0	0	0	0	0.151	0.160
1193	1.555	4	350.0	94.3	0	0	0	0	0.203	0.212
1208	0.933	5	360.0	202.0	0	0	0	0	0.908	1.766
1209	0.933	5	360.0	202.0	0	0	-36	0	0.908	1.766
1210	0.933	5	360.0	202.0	0	0	36	0	0.908	1.766
1211	0.933	5	360.0	202.0	0	20	0	0	0.908	1.766
1213	0.933	5	360.0	202.0	0	-22	0	0	0.908	1.766
1214	0.933	5	360.0	202.0	0	-22	36	0	0.908	1.766
1219	0.933	5	360.0	202.0	0	0	0	10	0.908	1.766
1221	0.933	5	360.0	202.0	0	0	0	-10	0.908	1.766
1223	0.933	5	240.0	134.7	0	0	0	-8	0.605	1.274
1225	0.933	5	240.0	134.7	0	0	0	8	0.605	1.274
1227	0.933	5	240.0	134.7	0	0	0	-4	0.605	1.274
1229	0.933	5	240.0	134.7	0	0	0	4	0.605	1.274

APPENDIX 4.

Test Programme: 30knots series.

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 412

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
67	-4.0	-0.1	0.3	30.00	133.5	-577.7	-2999.5	-119203.9	16566.1
66	-3.0	-0.1	0.2	30.02	133.5	-696.7	-2147.5	-95264.7	12236.4
65	-2.0	-0.1	0.1	30.02	133.5	-640.6	-1290.8	-59879.7	7612.2
64	-1.0	-0.1	0.0	30.01	133.3	-574.8	-582.6	-29499.2	3445.6
63	-0.5	-0.1	0.0	30.04	133.3	-601.4	-210.1	-14456.5	1142.4
62	0.0	-0.1	-0.0	30.03	133.3	-642.6	178.0	14.5	-1516.0
55	0.0	-0.1	-0.0	30.00	133.4	-547.2	271.5	461.3	-2106.7
56	0.5	-0.1	-0.0	30.00	133.4	-582.3	535.1	12909.6	-3797.7
57	1.0	-0.1	-0.0	30.00	133.4	-528.8	919.9	27497.5	-6181.0
58	2.0	-0.1	-0.1	29.98	133.4	-596.8	1711.9	62044.6	-10811.2
59	3.0	-0.1	-0.1	30.04	133.2	-644.1	2514.4	90995.1	-15529.5
60	4.0	-0.1	-0.2	30.05	133.2	-600.3	3483.7	114798.3	-20692.8
61	5.0	-0.1	-0.2	30.03	133.2	-555.0	4494.9	139283.5	-25835.8
77	-10.0	-0.1	0.6	24.01	116.9	874.9	-5994.1	-189331.8	31682.4
76	-8.0	-0.1	0.4	24.03	116.9	903.4	-4422.4	-141254.6	24453.0
75	-6.0	-0.1	0.3	24.05	116.9	923.2	-3066.8	-103522.3	17587.7
74	-4.0	-0.1	0.2	24.05	116.9	894.8	-1809.9	-79497.5	10786.0
73	0.0	-0.1	-0.0	24.06	116.9	1021.7	193.3	1105.4	-1465.9
68	0.0	-0.1	0.0	24.06	116.9	992.2	140.3	329.1	-1030.7
69	4.0	-0.1	-0.1	24.07	116.9	941.9	2012.4	75988.7	-12129.3
70	6.0	-0.1	-0.2	24.08	116.9	944.6	3234.5	102936.6	-18725.4
71	8.0	-0.1	-0.2	24.07	116.9	929.3	4607.5	141362.0	-25776.8
72	10.0	-0.1	-0.3	24.05	116.9	876.0	6284.5	193970.1	-33508.4
88	-14.0	-0.1	0.5	17.98	104.3	1831.7	-5280.8	-137781.7	29708.8
87	-10.0	-0.1	0.3	17.99	104.3	1846.0	-3279.5	-81965.6	19213.3
86	-6.0	-0.1	0.1	18.00	104.3	1923.8	-1631.0	-49848.3	9853.8
85	0.0	-0.1	0.0	18.02	104.3	1923.4	102.8	235.1	-1075.4
79	0.0	-0.1	0.1	17.99	104.2	1952.6	106.8	381.4	-1099.5
80	6.0	-0.1	-0.0	17.99	104.2	1940.2	1730.0	47220.0	-11245.3
81	10.0	-0.1	-0.1	18.00	104.2	1888.4	3382.4	84342.7	-20597.5
82	14.0	-0.1	-0.2	17.99	104.2	1907.4	5264.2	134684.2	-30714.7
83	16.0	-0.1	-0.3	17.98	104.2	1795.8	6052.1	155013.8	-35840.1
107	0.0	-34.1	0.4	29.96	133.4	-1972.0	-3657.6	271725.5	26862.4
108	0.0	-28.3	0.4	29.95	133.3	-1609.8	-4254.8	303225.7	32370.0
109	0.0	-22.6	0.4	29.96	133.3	-1296.0	-3841.7	280297.1	29385.2
110	0.0	-11.2	0.3	29.95	133.3	-660.4	-1788.3	140552.0	13139.2
111	0.0	-0.1	-0.0	29.99	133.4	-564.5	309.9	-104.1	-2712.4
112	0.0	11.2	-0.1	29.99	133.3	-778.6	2334.1	-146468.7	-18979.6
113	0.0	22.4	-0.2	30.02	133.3	-1464.5	4430.2	-285265.6	-36000.1
114	0.0	28.2	-0.2	29.99	133.3	-1829.5	4273.8	-272551.8	-33997.7

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 412

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
115	0.0	33.8	-0.1	29.98	133.3	-2023.1	4051.7	-259482.2	-31028.3
116	0.0	-34.0	0.3	24.05	117.0	-33.9	-2455.7	178010.6	17875.7
117	0.0	-28.2	0.3	24.04	117.0	137.8	-2694.3	188515.4	20449.9
118	0.0	-22.6	0.3	24.05	117.0	455.4	-2677.4	189723.2	20878.6
119	0.0	-11.2	0.2	24.05	117.0	904.9	-1249.4	94017.2	9511.4
120	0.0	0.2	0.0	24.04	117.0	1050.8	174.6	-234.7	-1813.6
121	0.0	11.2	-0.0	24.11	116.6	824.5	1730.3	-99997.3	-14286.0
122	0.0	22.5	-0.1	24.10	116.7	351.4	3054.0	-196212.3	-25496.8
123	0.0	28.2	-0.1	24.10	116.7	92.6	2624.8	-167029.0	-20921.5
124	0.0	33.8	-0.1	24.09	116.7	-122.4	2814.2	-177698.6	-21871.3
126	0.0	-34.0	0.2	17.99	104.3	1003.0	-1946.9	135765.5	14081.7
127	0.0	-28.3	0.2	17.98	104.3	1209.2	-1848.8	129532.8	13693.1
128	0.0	-22.7	0.2	17.98	104.3	1526.3	-1918.6	130580.6	14582.2
129	0.0	-11.4	0.1	17.99	104.3	1845.5	-926.9	66540.1	6995.3
130	0.0	0.1	0.0	17.98	104.3	1965.5	88.9	-1263.4	-1145.7
131	0.0	11.4	-0.0	17.98	104.3	1833.9	1151.7	-70473.3	-9548.9
132	0.0	17.1	-0.1	18.00	104.2	1619.4	1717.2	-105137.2	-14362.9
133	0.0	22.6	-0.1	18.00	104.2	1453.1	2131.4	-132647.1	-17687.9
134	0.0	28.4	-0.1	17.99	104.2	1114.5	1966.8	-125724.8	-15885.0
135	0.0	34.0	-0.1	17.99	104.3	921.2	2096.5	-135028.7	-16597.7
200	12.0	-34.0	-0.1	18.03	104.1	1003.3	2156.0	269648.3	-8403.1
201	12.0	-28.2	-0.0	18.03	104.1	1315.3	2064.3	276778.1	-7560.5
202	12.0	-22.6	-0.1	18.03	104.1	1546.0	2482.5	246820.7	-10737.1
203	12.0	-11.2	-0.1	18.05	104.2	1843.8	3431.9	178836.2	-18368.2
204	12.0	0.2	-0.2	18.05	104.2	1907.6	4441.0	110241.2	-26437.6
205	12.0	11.5	-0.2	18.06	104.2	1733.1	5380.1	39252.8	-34237.3
206	12.0	22.7	-0.2	18.05	104.2	1299.4	5799.2	9483.4	-36835.9
207	8.0	-34.0	0.0	18.02	104.2	970.5	324.8	215548.6	1250.8
208	8.0	-28.2	0.0	18.02	104.2	1227.8	520.3	205317.5	-59.5
209	8.0	-22.6	0.0	18.02	104.2	1532.2	609.7	195271.3	-704.4
210	8.0	-11.2	-0.0	18.03	104.2	1845.7	1571.7	128592.8	-8433.3
211	8.0	0.2	-0.1	18.04	104.2	1916.6	2553.8	61999.3	-16353.6
212	8.0	11.5	-0.1	18.04	104.3	1759.9	3541.7	-8686.5	-24499.5
213	8.0	22.7	-0.1	18.04	104.3	1369.6	4442.1	-69690.3	-31636.3
126	0.0	-34.0	0.2	17.99	104.3	1003.0	-1946.9	135765.5	14081.7
127	0.0	-28.3	0.2	17.98	104.3	1209.2	-1848.8	129532.8	13693.1
128	0.0	-22.7	0.2	17.98	104.3	1526.3	-1918.6	130580.6	14582.2
129	0.0	-11.4	0.1	17.99	104.3	1845.5	-926.9	66540.1	6995.3
130	0.0	0.1	0.0	17.98	104.3	1965.5	88.9	-1263.4	-1145.7
131	0.0	11.4	-0.0	17.98	104.3	1833.9	1151.7	-70473.3	-9548.9

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 412

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
132	0.0	17.1	-0.1	18.00	104.2	1619.4	1717.2	-105137.2	-14362.9
133	0.0	22.6	-0.1	18.00	104.2	1453.1	2131.4	-132647.1	-17687.9
134	0.0	28.4	-0.1	17.99	104.2	1114.5	1966.8	-125724.8	-15885.0
135	0.0	34.0	-0.1	17.99	104.3	921.2	2096.5	-135028.7	-16597.7
214	-8.0	-22.6	0.4	17.97	104.2	1399.1	-4241.9	66070.1	28832.2
215	-8.0	-11.2	0.4	17.99	104.2	1762.8	-3321.4	4791.0	21573.8
216	-8.0	0.2	0.2	18.00	104.2	1909.1	-2326.3	-61978.3	13804.9
217	-8.0	11.5	0.1	18.01	104.2	1837.6	-1321.9	-131200.6	5862.3
218	-8.0	22.7	0.1	18.02	104.3	1475.3	-338.8	-196829.4	-2005.8
219	-8.0	28.5	0.0	18.00	104.3	1134.6	-326.7	-198984.7	-1845.6
220	-8.0	34.1	0.0	17.99	104.3	908.1	-100.5	-212473.5	-3421.6
242	0.0	-0.1	-10.0	18.03	104.4	1966.7	289.3	-12470.1	-1674.0
243	0.0	-0.1	-10.0	24.10	116.8	1033.6	374.0	-7725.0	-1633.0
244	0.0	-0.1	-10.0	30.00	132.7	-586.5	755.5	6595.4	-2465.1
246	0.0	-0.1	-8.0	18.03	104.2	1925.8	258.6	-10514.7	-1424.6
247	0.0	-0.1	-8.0	24.11	117.0	1039.5	360.7	-6822.6	-1367.9
248	0.0	-0.1	-8.0	30.03	133.1	-546.2	653.7	4272.5	-1745.3
250	0.0	-0.1	-4.0	18.03	104.5	1962.6	191.3	-5448.3	-1035.6
251	0.0	-0.1	-4.0	24.10	117.2	1052.7	295.1	-2541.3	-1351.8
252	0.0	-0.1	-4.0	30.02	133.4	-503.1	464.5	3389.3	-1631.1
254	0.0	-0.1	0.0	18.02	104.5	1977.2	131.5	-634.2	-812.2
255	0.0	-0.1	0.0	24.10	117.0	1040.2	222.5	1010.6	-1479.0
256	0.0	-0.1	0.0	30.01	133.1	-531.9	305.6	1771.7	-2060.2
258	0.0	-0.1	8.0	18.01	104.6	1942.9	-21.4	11475.3	-120.0
259	0.0	-0.1	8.0	24.09	117.5	1031.6	17.6	8573.7	-1171.6
260	0.0	-0.1	8.0	30.01	133.2	-574.2	-25.0	775.4	-2372.0
264	-12.0	-0.1	4.8	24.03	116.8	895.0	-7561.3	-232523.8	37586.9
263	-10.0	-0.1	4.7	24.06	116.7	946.8	-5868.5	-179534.3	30043.5
262	-8.0	-0.1	4.5	24.08	116.5	951.1	-4307.8	-133286.1	23048.5
261	0.0	-0.1	4.2	24.11	116.5	1036.7	114.0	3798.0	-1777.8
265	0.0	-0.1	-4.1	24.12	117.1	1003.5	261.8	-3062.2	-1821.8
266	4.0	-0.1	-4.2	24.13	117.1	991.7	2167.4	72311.2	-12664.9
267	6.0	-0.1	-4.4	24.14	117.2	1020.8	3400.7	101405.2	-19309.7
268	8.0	-0.1	-4.5	24.14	117.2	1008.6	4790.7	139917.9	-26434.2
269	10.0	-0.1	-4.6	24.14	117.2	974.3	6480.6	189984.2	-34063.3
270	0.0	-0.1	-8.1	18.03	104.4	1930.6	235.4	-10279.7	-1612.6
271	6.0	-0.1	-8.2	18.04	104.5	1945.0	1861.1	40909.2	-11184.1
272	10.0	-0.1	-8.3	18.06	104.5	1911.1	3555.6	76153.6	-20262.3
273	12.0	-0.1	-8.4	18.06	104.5	1913.1	4505.8	101037.5	-24834.3
274	16.0	-0.1	-8.5	18.06	104.5	1851.3	6101.0	158585.5	-32251.2

ORDER NO.: 20071 DATE OF TEST: 324 DATE OF CALCULATION: 412

MEASUREMENTS IN SHIP SCALE

RUN NO.	BETA DEG.	DELTA DEG.	PHI DEG.	SPEED KNOTS	RPM	X (KN)	Y (KN)	N (KN*M)	K (KN*M)
279	-16.0	-0.1	8.4	17.96	104.1	1881.9	-6041.3	-160905.7	31593.0
278	-12.0	-0.1	8.3	17.98	104.1	1905.9	-4197.0	-93519.0	23330.2
277	-6.0	-0.1	8.2	18.00	104.1	1976.2	-1605.1	-41622.6	9371.2
276	0.0	-0.1	8.1	18.02	104.1	1961.1	-5.5	10606.3	-456.7

KIND OF ANALYSIS: PURE SWAY
PARTICULARS IN MODEL SCALE

RUN NO.	UC (M/S)	NPMM (RPM)	SMM (MM)	YMM (MM)	RAMP (DEG)	BETA (DEG)	DELTA (DEG)	PHI (DEG)	V MAX PRIME	VDOTMAX PRIME
400	2.593	4.00	108	0.0	0.0	0.0	0.0	0.0	0.035	0.023
401	2.593	4.00	216	0.0	0.0	0.0	0.0	0.0	0.070	0.045
402	2.078	4.00	260	0.0	0.0	0.0	0.0	0.0	0.105	0.085
403	1.556	4.00	261	0.0	0.0	0.0	0.0	0.0	0.140	0.150
404	1.556	4.00	327	0.0	0.0	0.0	0.0	0.0	0.174	0.185

KIND OF ANALYSIS: YAW AND DRIFT AND RUDDER
PARTICULARS IN MODEL SCALE

RUN NO.	UC (M/S)	NPMM (RPM)	SMM (MM)	YMM (MM)	RAMP (DEG)	BETA (DEG)	DELTA (DEG)	PHI (DEG)	R MAX PRIME	RDOTMAX PRIME
441	1.299	8.00	120	77.6	0.0	0.0	0.0	0.0	0.401	1.036
442	1.298	8.00	120	77.6	0.0	0.0	-11.5	0.0	0.401	1.038
443	1.300	8.00	120	77.6	0.0	10.0	0.0	0.0	0.400	1.032
444	1.299	8.00	120	77.6	0.0	10.0	-11.5	0.0	0.401	1.034
451	1.299	8.00	180	116.4	0.0	0.0	22.6	0.0	0.602	1.556
454	1.295	8.00	180	116.4	0.0	-16.0	0.0	0.0	0.603	1.564
455	1.296	8.00	180	116.4	0.0	-16.0	22.5	0.0	0.603	1.563

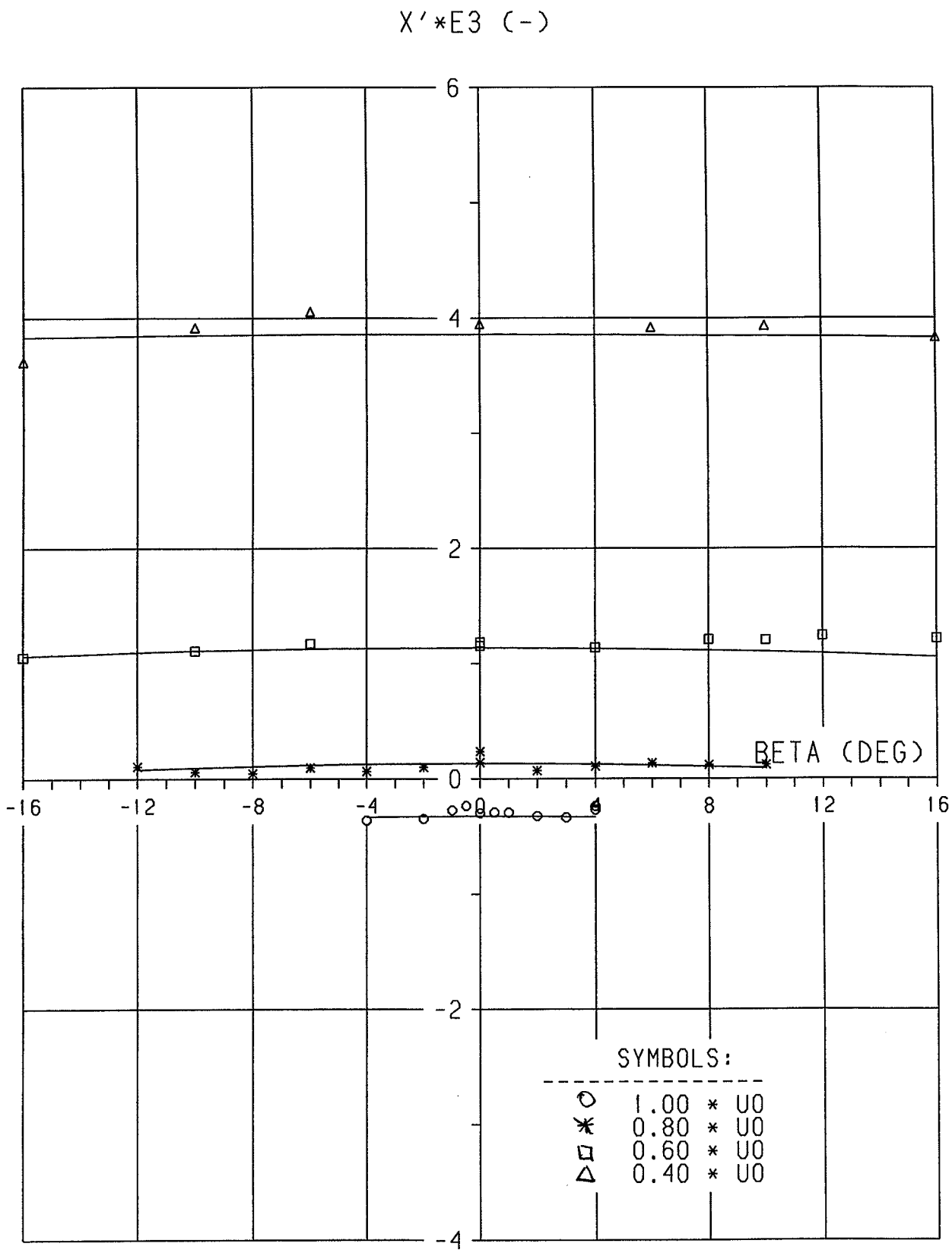
Run No.	Uc (m/s)	N-PMM (RPM)	Smm (mm)	Ymm (mm)	R-AMP (deg)	Beta (deg)	Delta (deg)	Phi (deg)	r-max prime	rdot-max prime
437	2.591	7	80.0	22.6	0	0	0	0	0.05	0.06
438	2.591	7	160.0	45.3	0	0	0	0	0.10	0.11
439	2.591	7	230.0	65.1	0	0	0	0	0.15	0.16
440	1.296	7	310.0	87.7	0	0	0	0	0.20	0.22
441	1.296	8	120.0	77.6	0	0	0	0	0.40	1.04
442	1.296	8	120.0	77.6	0	0	-12	0	0.40	1.04
443	1.296	8	120.0	77.6	0	10	0	0	0.40	1.04
444	1.296	8	120.0	77.6	0	10	-12	0	0.40	1.04
445	1.296	8	120.0	77.6	0	-10	0	0	0.40	1.04
446	1.296	8	120.0	77.6	0	-10	12	0	0.40	1.04
447	1.296	8	120.0	77.6	0	0	0	-4	0.40	1.04
448	1.296	8	120.0	77.6	0	0	0	4	0.40	1.04
449	1.296	8	180.0	116.4	0	0	0	0	0.60	1.56
450	1.296	8	180.0	116.4	0	0	-24	0	0.60	1.56
451	1.296	8	180.0	116.4	0	0	24	0	0.60	1.56
452	1.296	8	180.0	116.4	0	14	0	0	0.60	1.56
453	1.296	8	180.0	116.4	0	14	-24	0	0.60	1.56
454	1.296	8	180.0	116.4	0	-16	0	0	0.60	1.56
455	1.296	8	180.0	116.4	0	-16	24	0	0.60	1.56
456	1.296	8	180.0	116.4	0	0	0	-8	0.60	1.56
457	1.296	8	180.0	116.4	0	0	0	8	0.60	1.56
458	1.296	8	240.0	155.1	0	0	0	0	0.80	1.91
459	1.296	8	240.0	155.1	0	0	-36	0	0.80	1.91
460	1.296	8	240.0	155.1	0	0	36	0	0.80	1.91
461	1.296	8	240.0	155.1	0	20	0	0	0.80	1.91
462	1.296	8	240.0	155.1	0	20	-36	0	0.80	1.91
463	1.296	8	240.0	155.1	0	-20	0	0	0.80	1.91
464	1.296	8	240.0	155.1	0	.20	36	0	0.80	1.91
465	1.296	8	240.0	155.1	0	0	0	-10	0.80	1.91
466	1.296	8	240.0	155.1	0	0	0	10	0.80	1.91
467	1.296	8	300.0	193.3	0	24	0	0	1.00	2.28
468	1.296	8	300.0	193.3	0	24	-42	0	1.00	2.28
469	1.296	8	300.0	193.3	0	-24	0	0	1.00	2.28
470	1.296	8	300.0	193.3	0	-24	42	0	1.00	2.28

APPENDIX 5.

Test Results: 18 knots series.
Non-dimensional forces and moments versus manoeuvring parameters.

Figure:

5.1	Speed & Drift	:	Longitudinal force, X' as function of drift angle, β
5.2	Speed & Drift	:	Transverse force, Y' as function of drift angle, β
5.3	Speed & Drift	:	Yaw moment, N' as function of drift angle, β
5.4	Speed & Drift	:	Heel moment, K' as function of drift angle, β
5.5	Speed & Rudder	:	Longitudinal force, X' as function of Rudder angle, δ
5.6	Speed & Rudder	:	Transverse force, Y' as function of Rudder angle, δ
5.7	Speed & Rudder	:	Yaw moment, N' as function of Rudder angle, δ
5.8	Speed & Rudder	:	Heel moment, K' as function of Rudder angle, δ
5.9	Drift & Rudder	:	Longitudinal force, X' as function of Rudder angle, δ
5.10	Drift & Rudder	:	Transverse force, Y' as function of Rudder angle, δ
5.11	Drift & Rudder	:	Yaw moment, N' as function of Rudder angle, δ
5.12	Drift & Rudder	:	Heel moment, K' as function of Rudder angle, δ
5.13	Drift & Heel	:	Longitudinal force, X' as function of drift angle, β
5.14	Drift & Heel	:	Transverse force, Y' as function of drift angle, β
5.15	Drift & Heel	:	Yaw moment, N' as function of drift angle, β
5.16	Drift & Heel	:	Heel moment, K' as function of drift angle, β



SPEED & DRIFT

AGJ-3

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THALES
18 KNOTS

ORDER 20071
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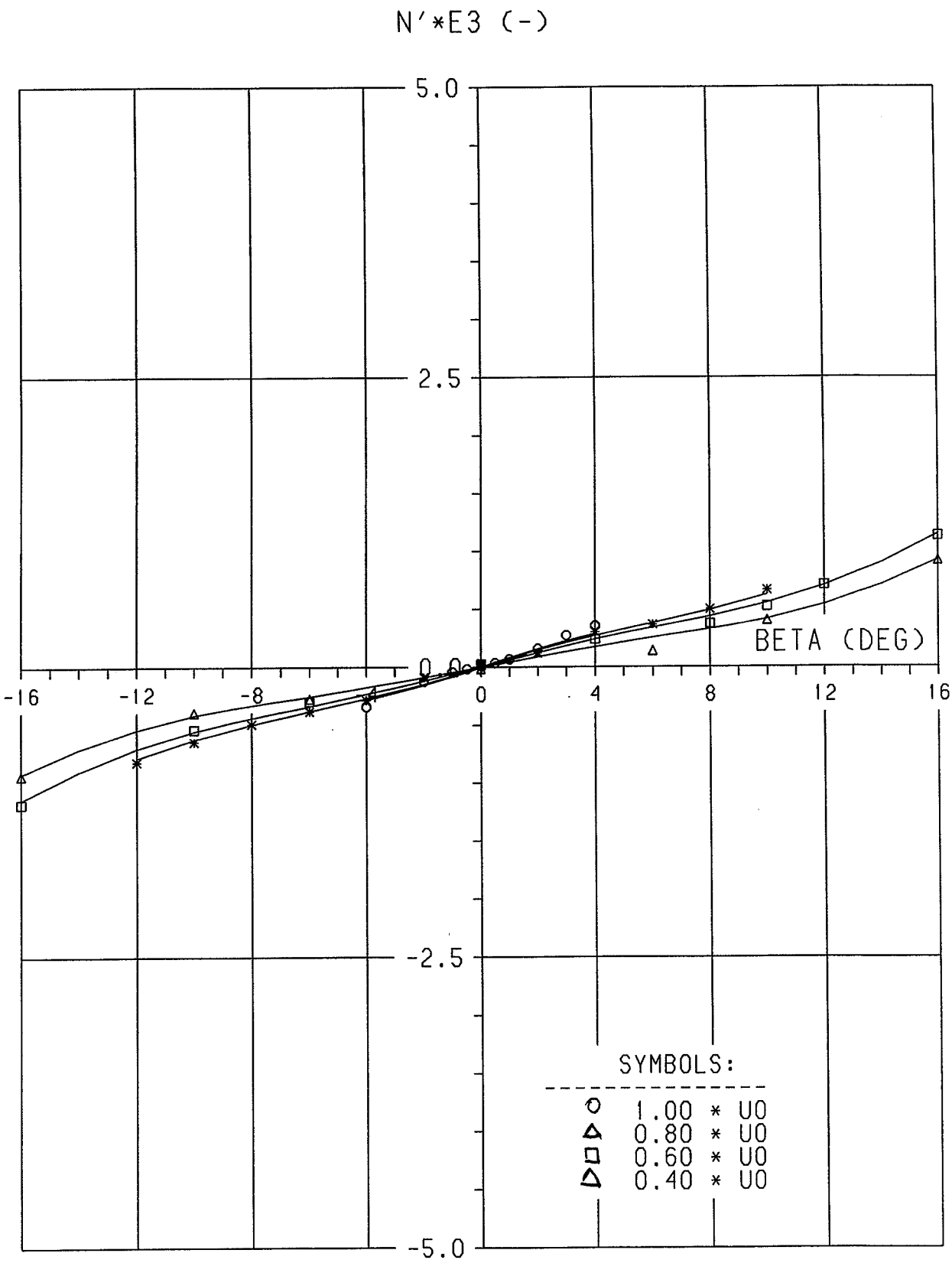
FIG 5.1



SPEED & DRIFT

AGJ-3

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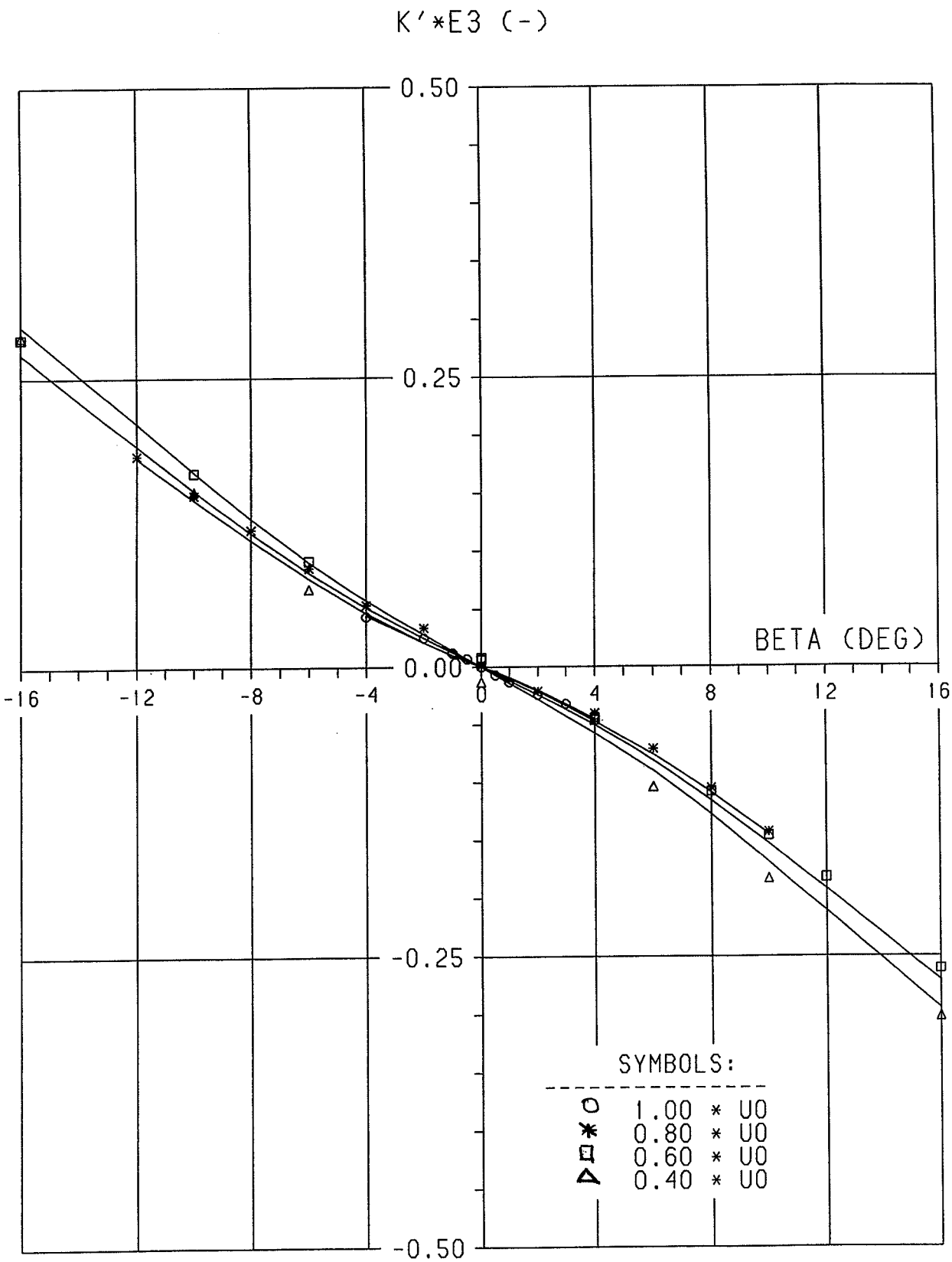
THALES
18 KNOTS

ORDER 20071
DATE 425

FIG 5.3



SPEED & DRIFT

AGJ-3

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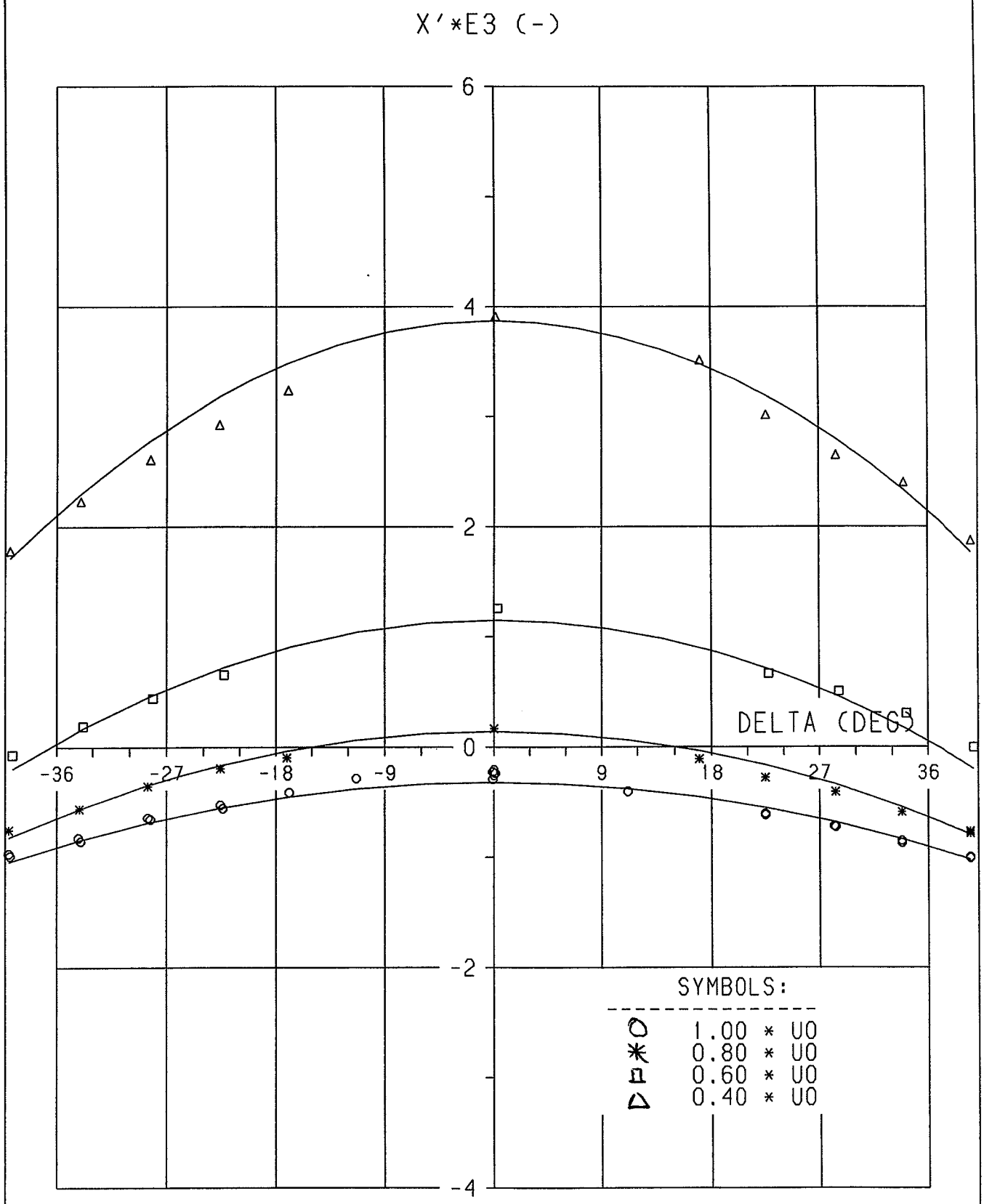
THALES
18 KNOTS

ORDER 20071
DATE 425

FIG 5.4



SPEED AND RUDDER

AGJ-3

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THALES
18 KNOTS

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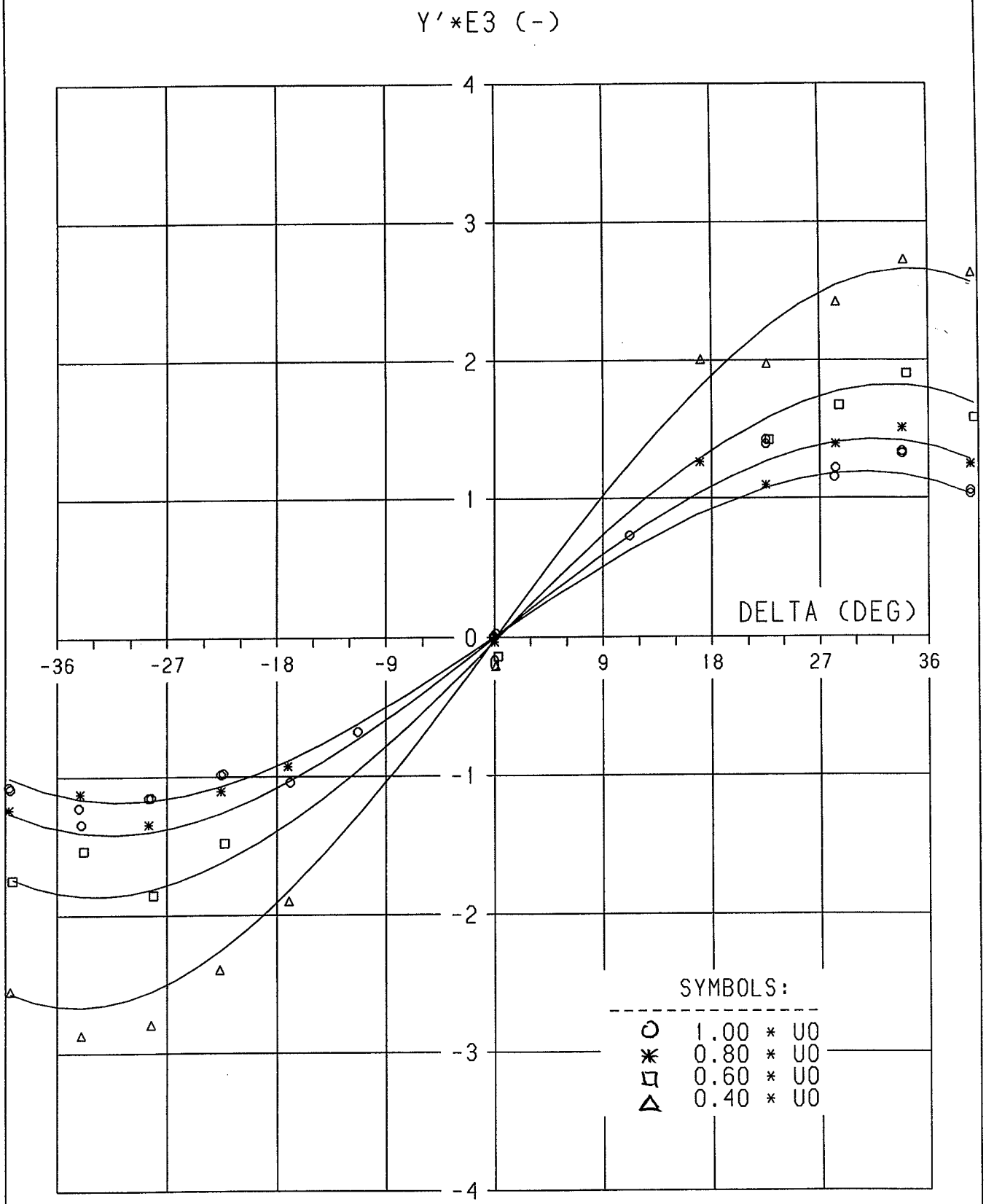
FIG 5.5



SPEED AND RUDDER

AGJ-3

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THALES
18 KNOTS

ORDER 20071
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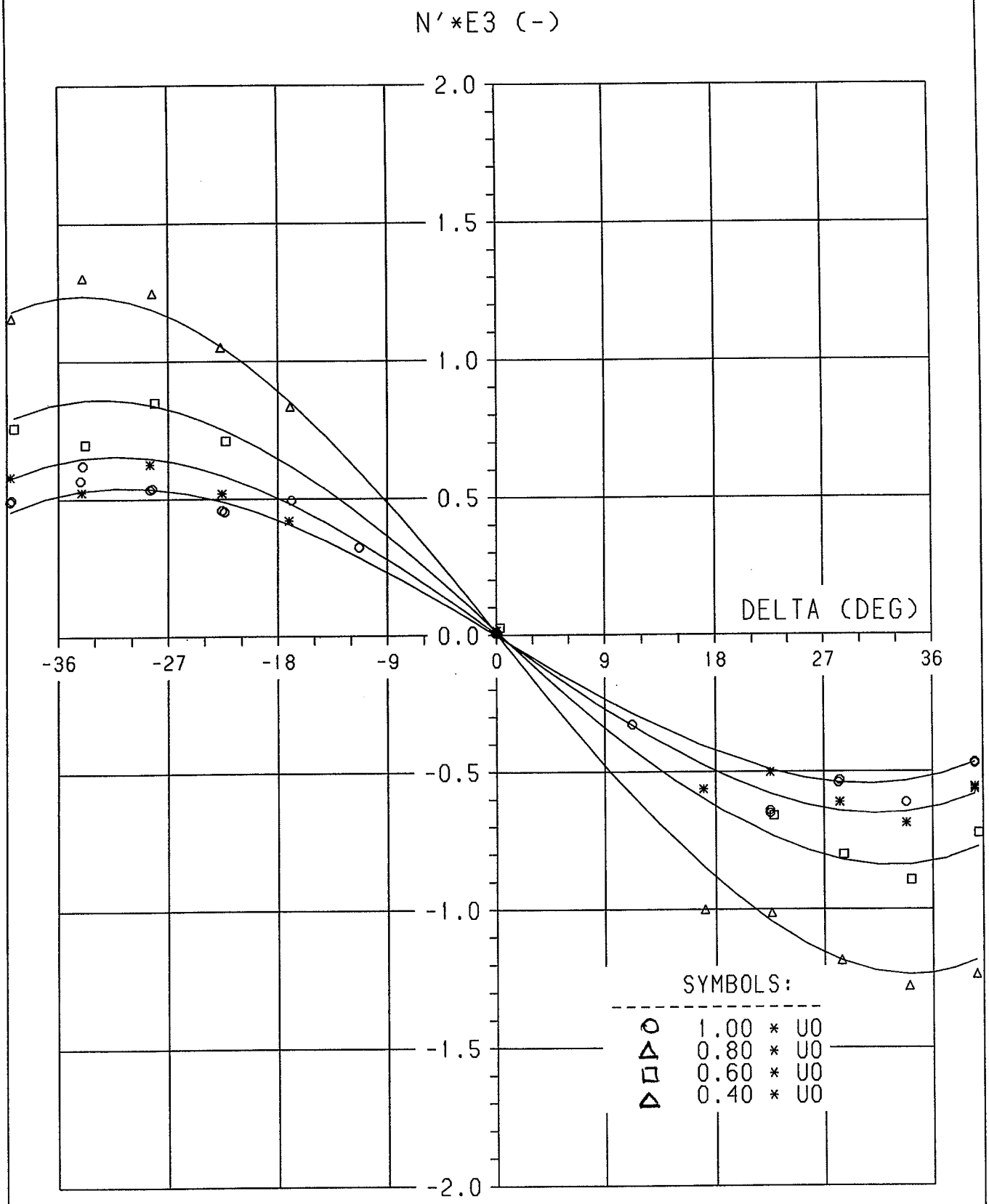
FIG 5.6



SPEED AND RUDDER

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FIG 5.7

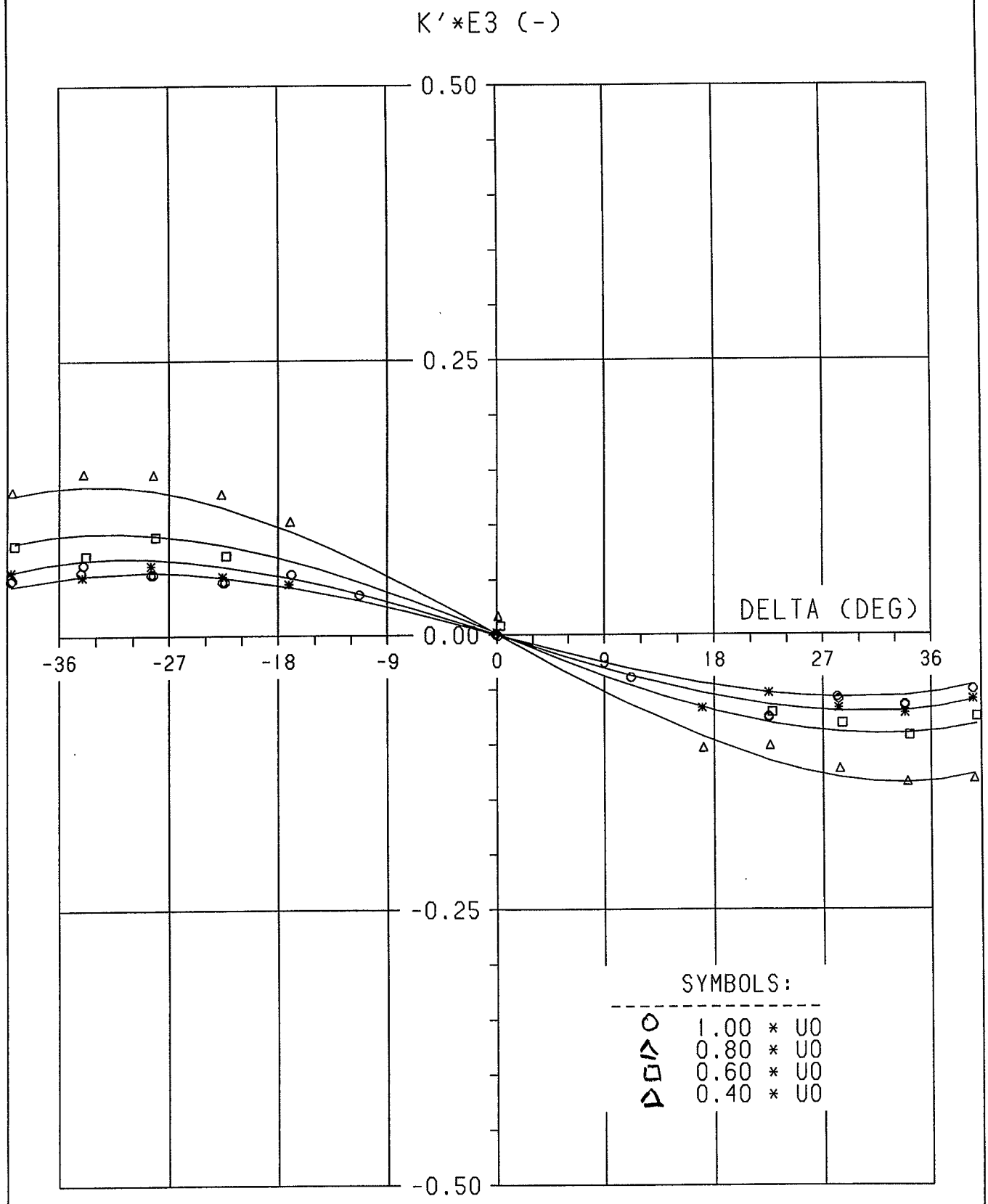

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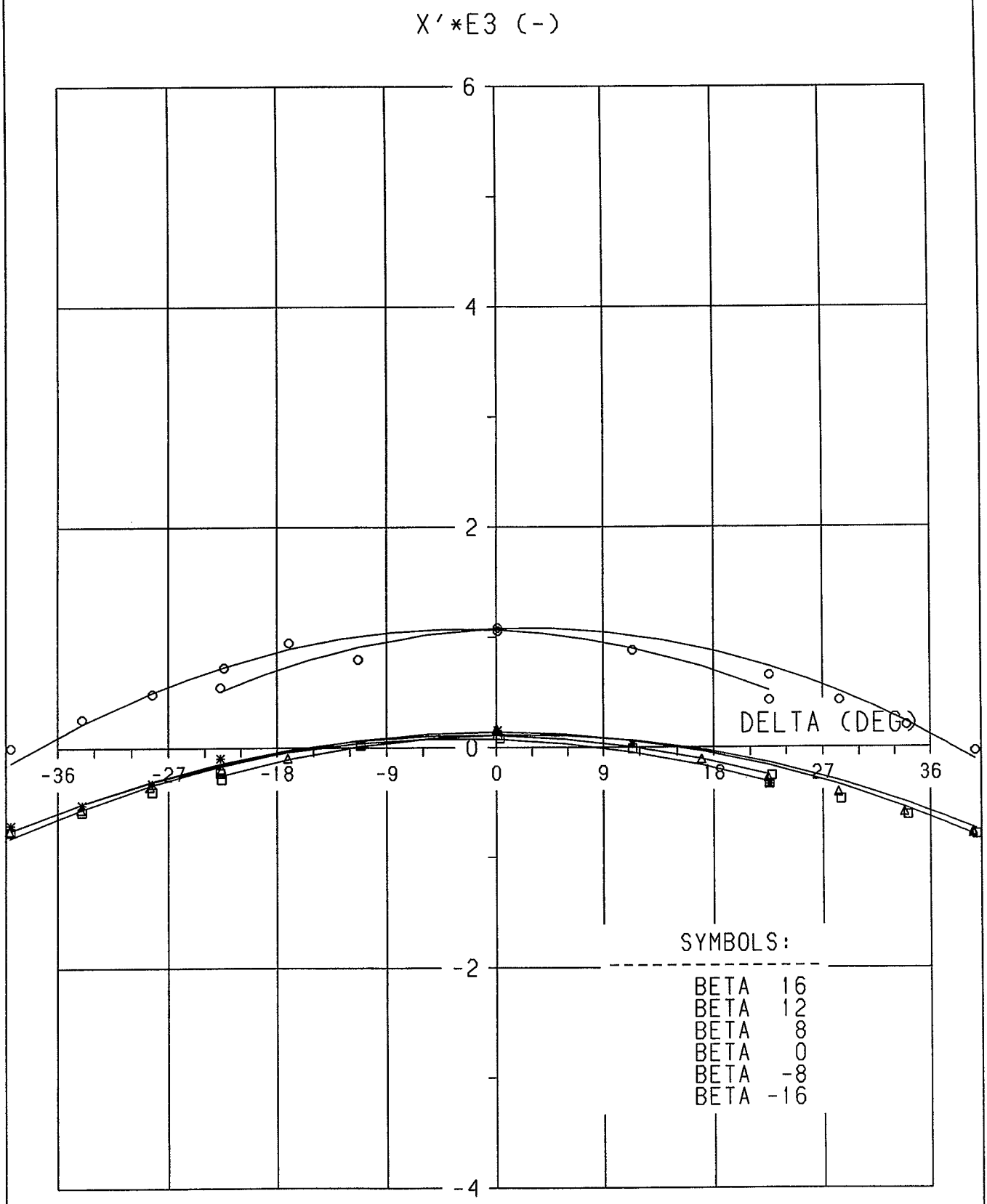
FIG 5.8



DRIFT AND RUDDER
0.4 AND 0.6 U0

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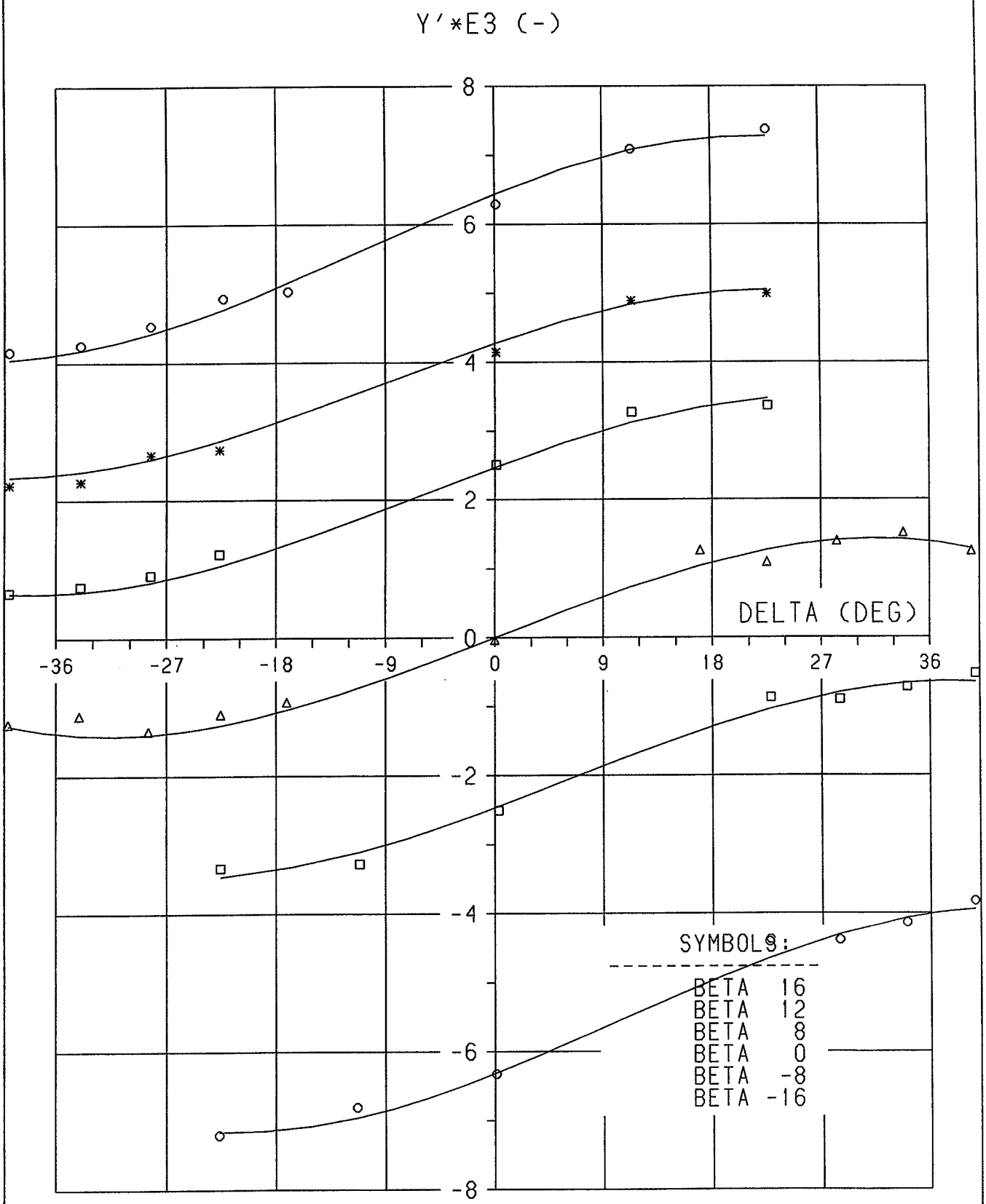
FIG 5.9



DRIFT AND RUDDER
0.4 AND 0.6 U0

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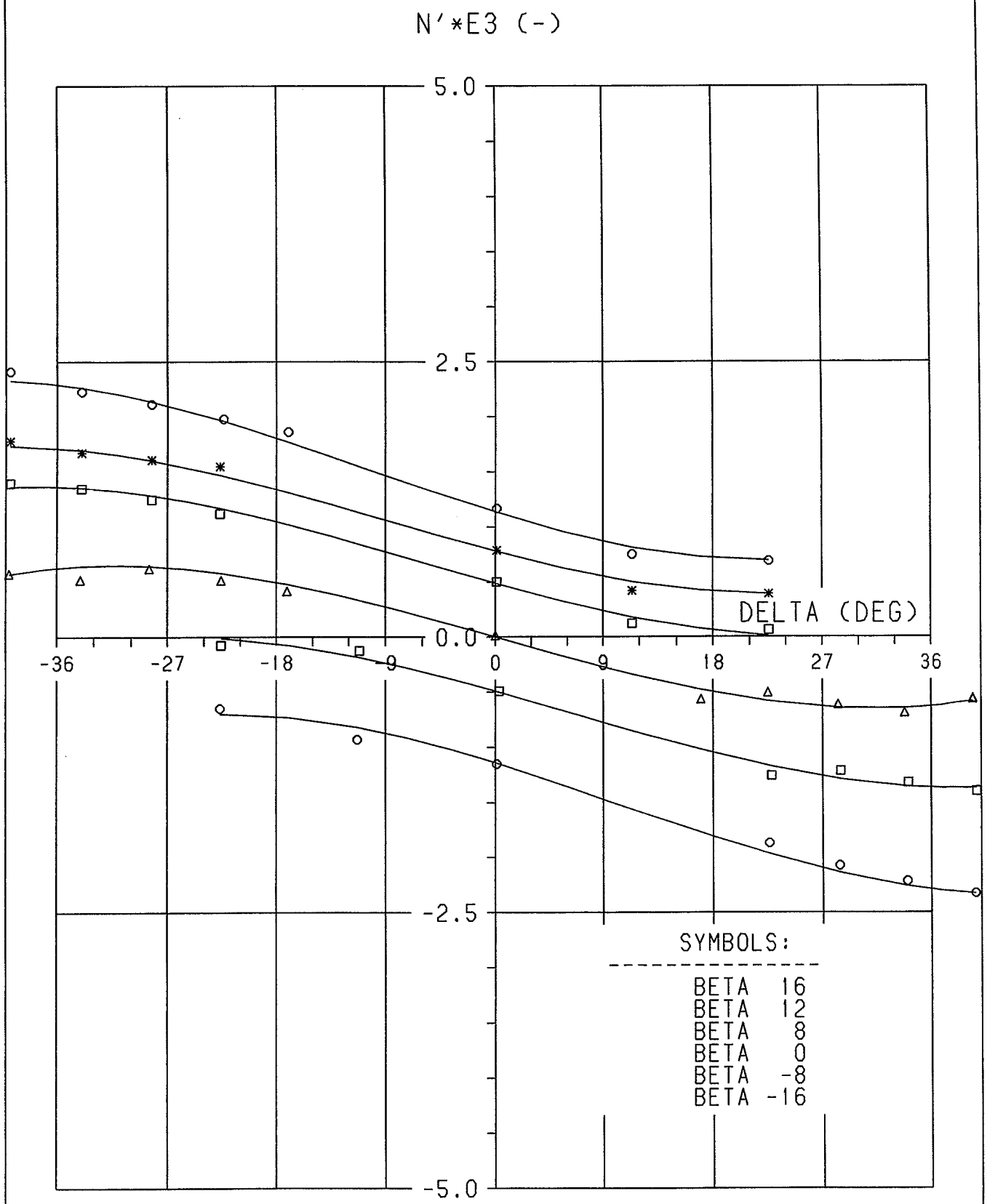
FIG 5.10



DRIFT AND RUDDER
0.4 AND 0.6 U0

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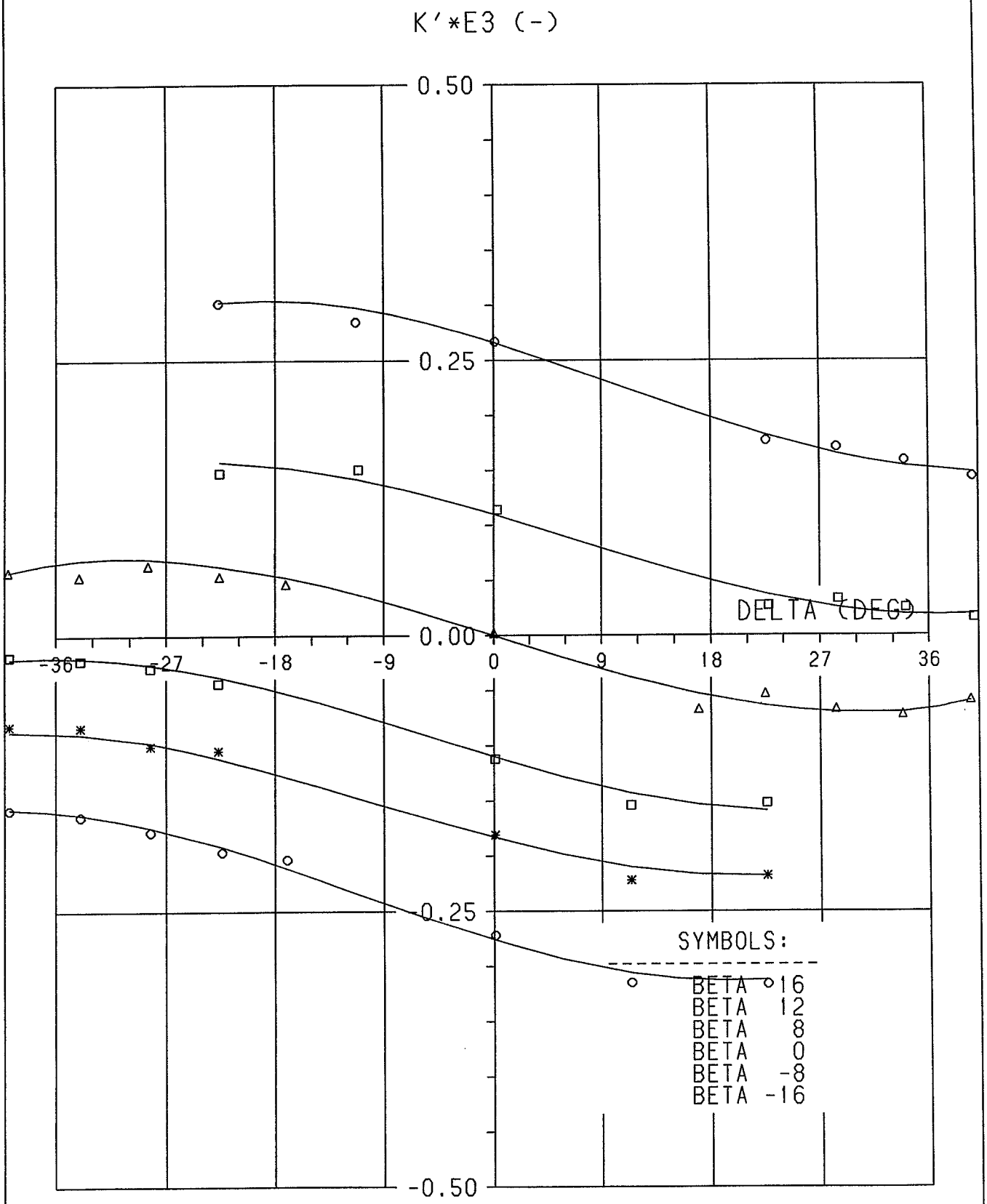
FIG 5.11



DRIFT AND RUDDER
0.6 U0

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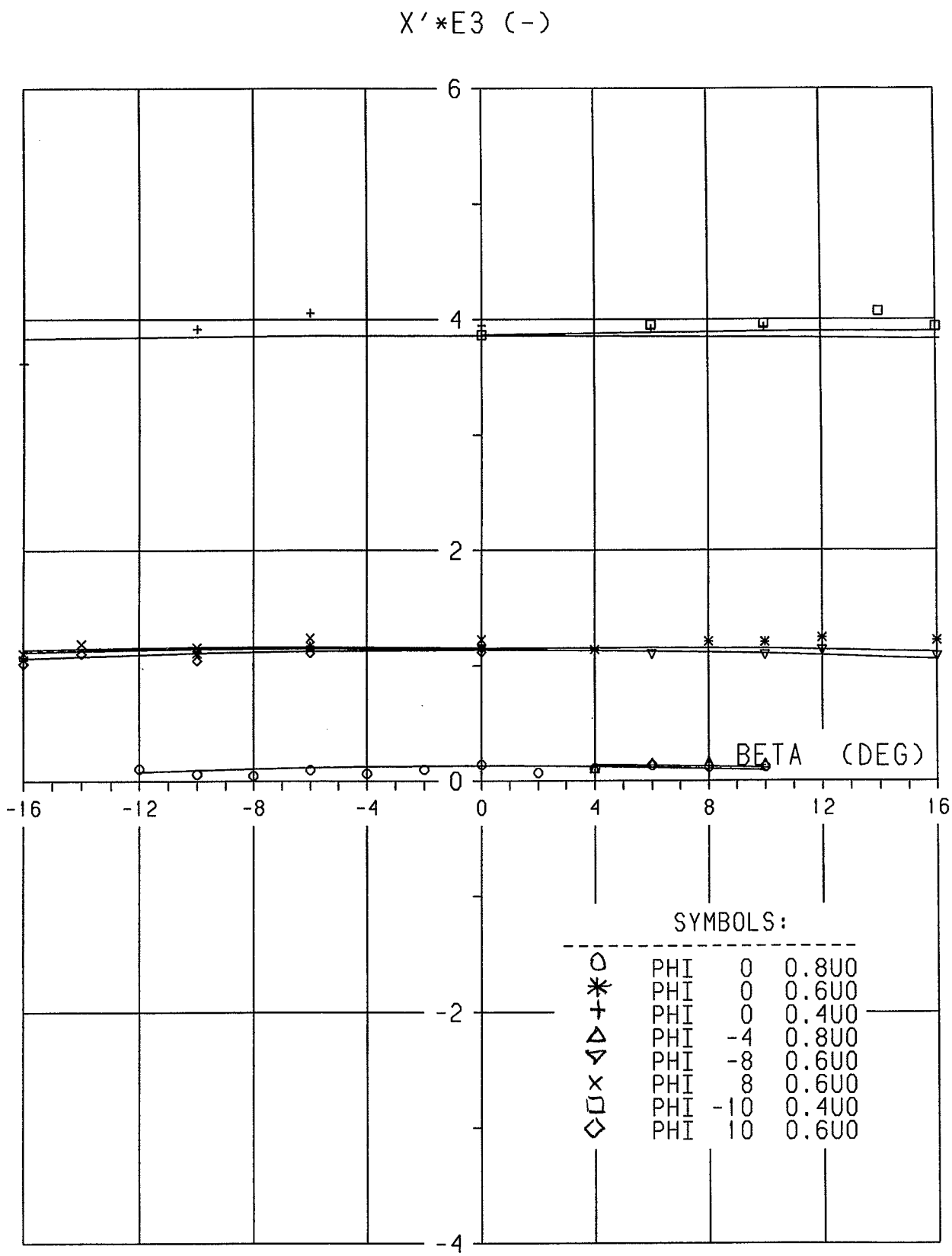
FIG 5.12



DRIFT AND HEEL
0.4U0 0.6U0 AND 0.8U0

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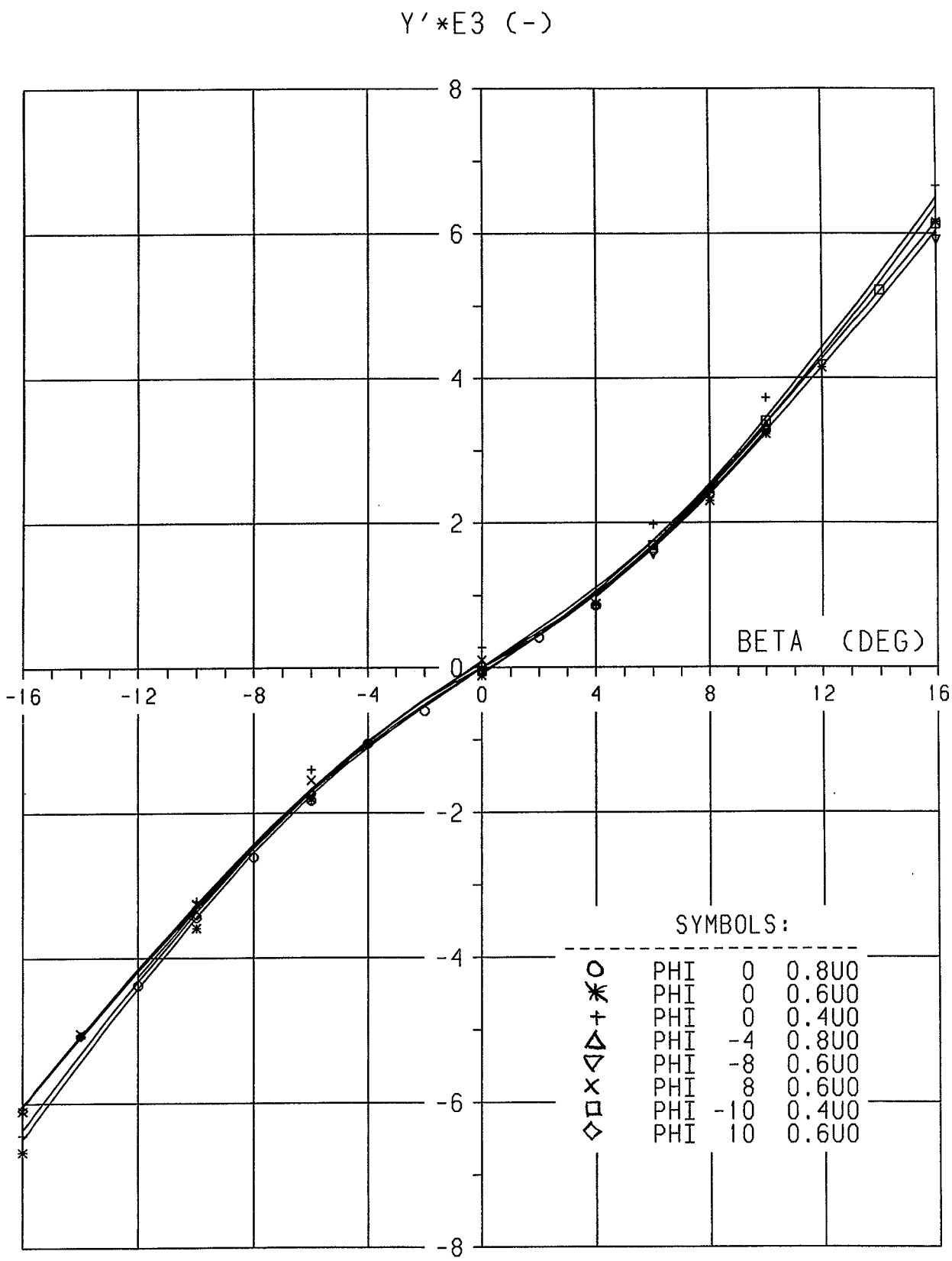
FIG 5.13



DRIFT AND HEEL
0.4U0 0.6U0 AND 0.8U0

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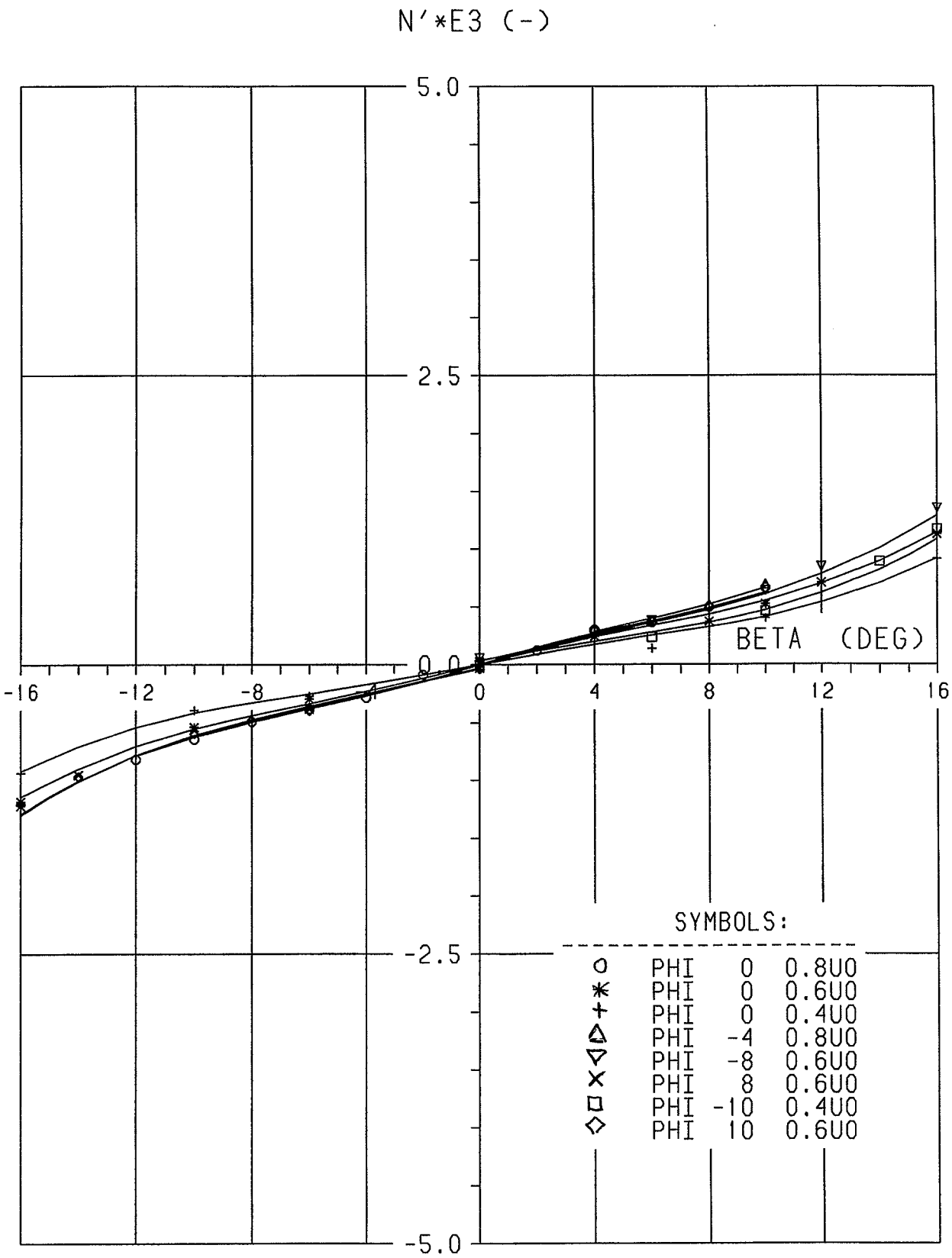
FIG 5.14



DRIFT AND HEEL
0.4U0 0.6U0 AND 0.8U0

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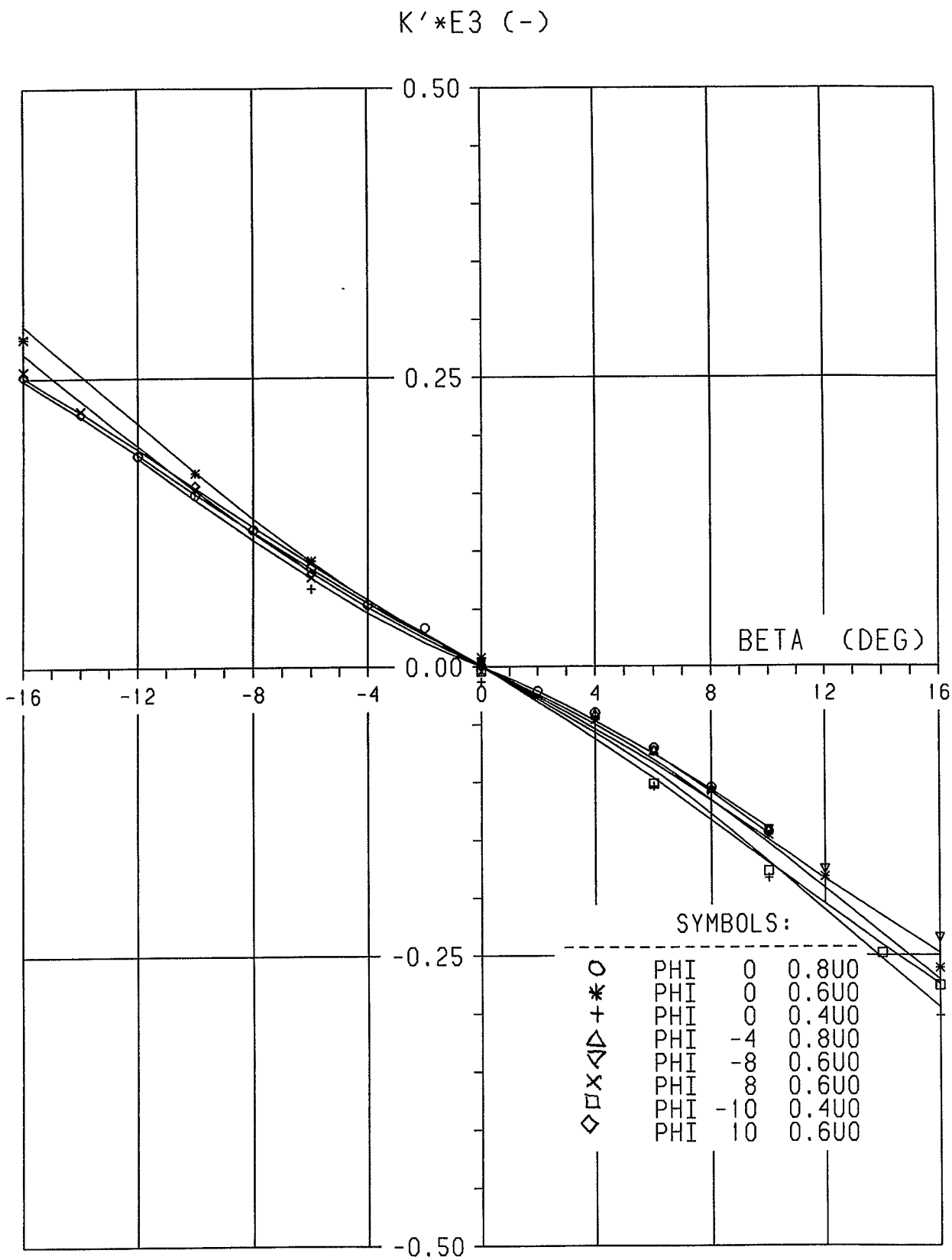
FIG 5.15



DRIFT AND HEEL
0.4U0 0.6U0 AND 0.8U0

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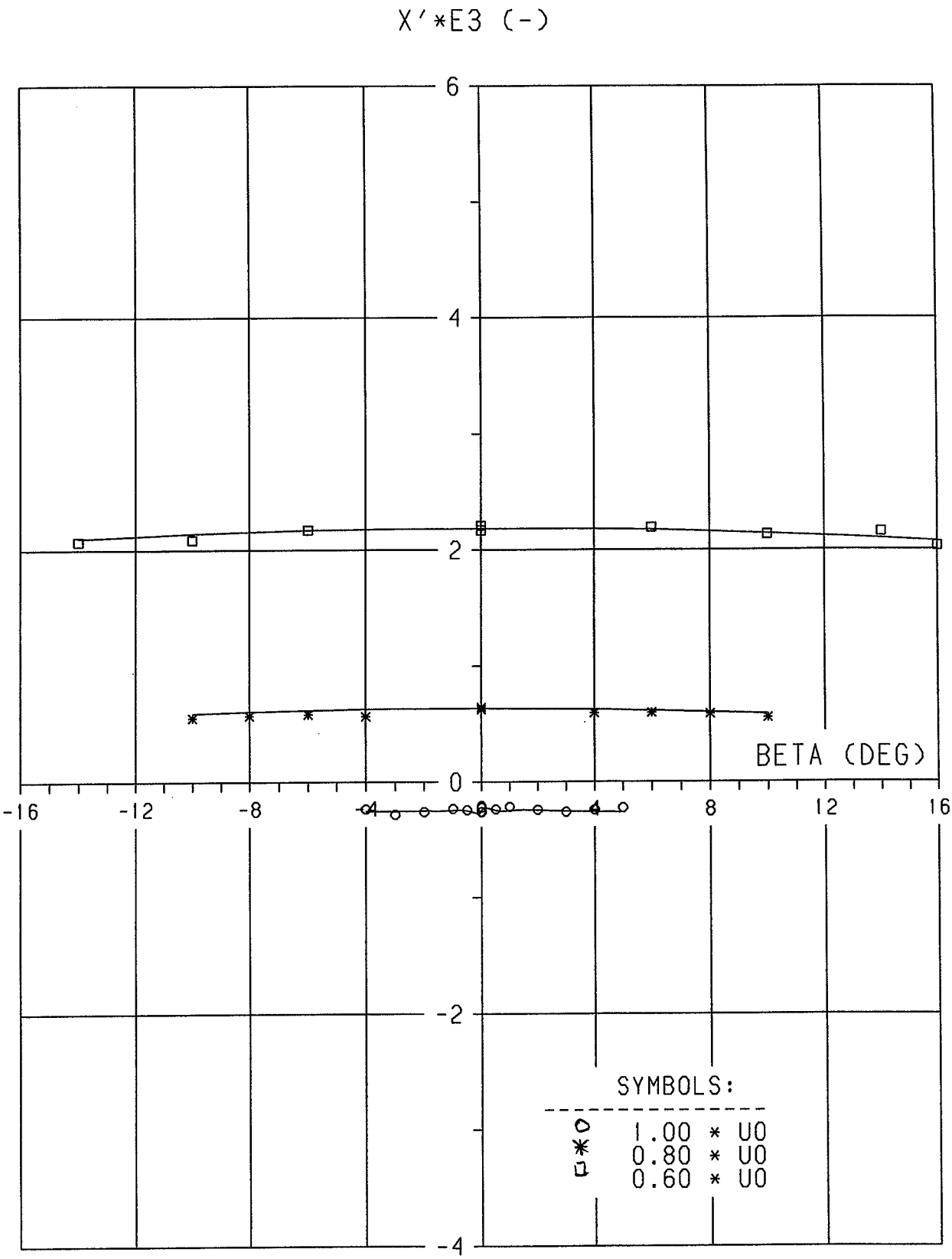
FIG 5.16

APPENDIX 6.

Test Results: 30 knots series.
Non-dimensional forces and moments versus manoeuvring parameters.

Figure:

6.1	Speed & Drift	:	Longitudinal force, X' as function of drift angle, β
6.2	Speed & Drift	:	Transverse force, Y' as function of drift angle, β
6.3	Speed & Drift	:	Yaw moment, N' as function of drift angle, β
6.4	Speed & Drift	:	Heel moment, K' as function of drift angle, β
6.5	Speed & Rudder	:	Longitudinal force, X' as function of Rudder angle, δ
6.6	Speed & Rudder	:	Transverse force, Y' as function of Rudder angle, δ
6.7	Speed & Rudder	:	Yaw moment, N' as function of Rudder angle, δ
6.8	Speed & Rudder	:	Heel moment, K' as function of Rudder angle, δ
6.9	Drift & Rudder	:	Longitudinal force, X' as function of Rudder angle, δ
6.10	Drift & Rudder	:	Transverse force, Y' as function of Rudder angle, δ
6.11	Drift & Rudder	:	Yaw moment, N' as function of Rudder angle, δ
6.12	Drift & Rudder	:	Heel moment, K' as function of Rudder angle, δ
6.13	Drift & Heel	:	Longitudinal force, X' as function of drift angle, β
6.14	Drift & Heel	:	Transverse force, Y' as function of drift angle, β
6.15	Drift & Heel	:	Yaw moment, N' as function of drift angle, β
6.16	Drift & Heel	:	Heel moment, K' as function of drift angle, β



SPEED & DRIFT

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30 KNOTS

FIG 6.1

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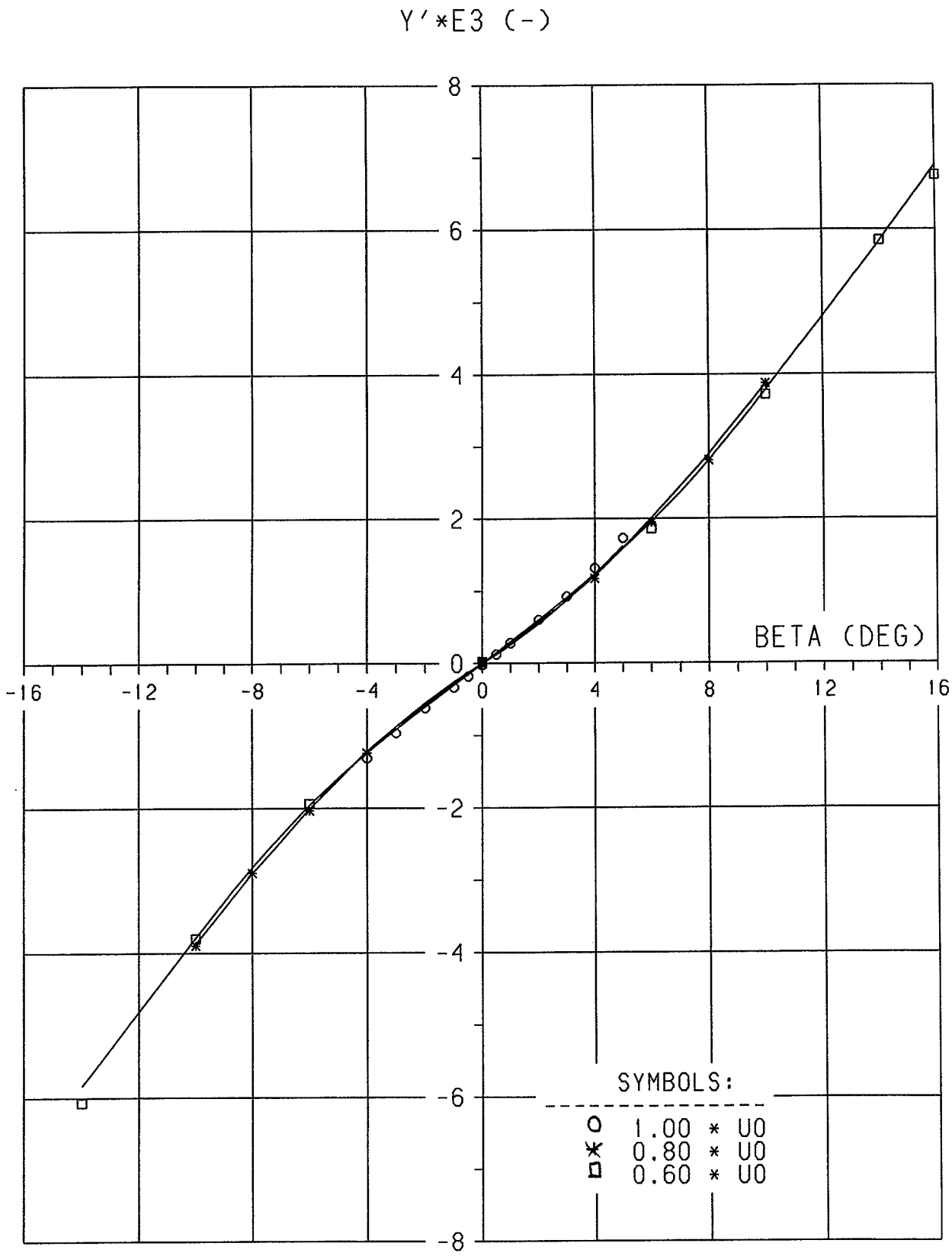

SPEED & DRIFT

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30 KNOTS

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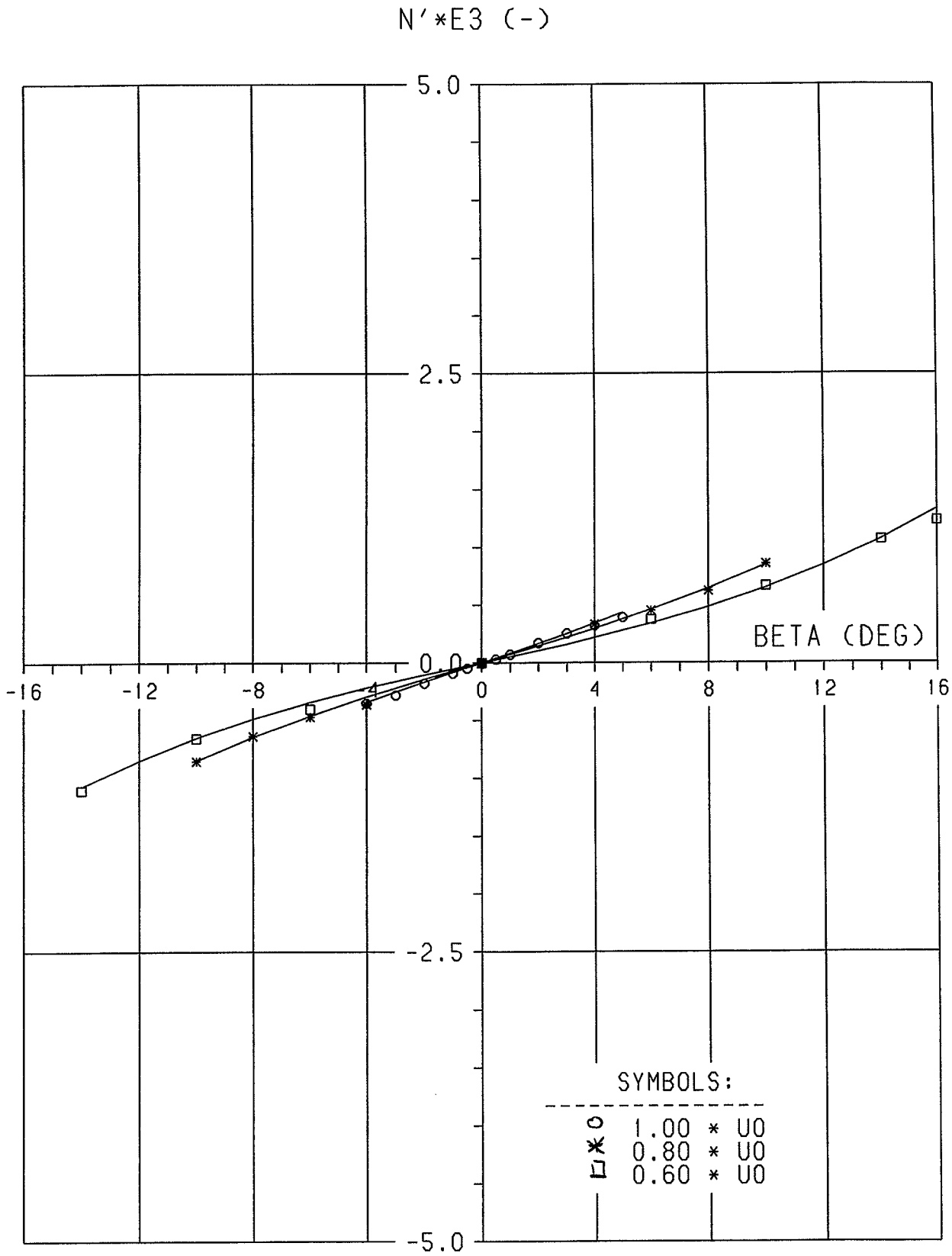
FIG 6.2



SPEED & DRIFT

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THALES
30 KNOTS

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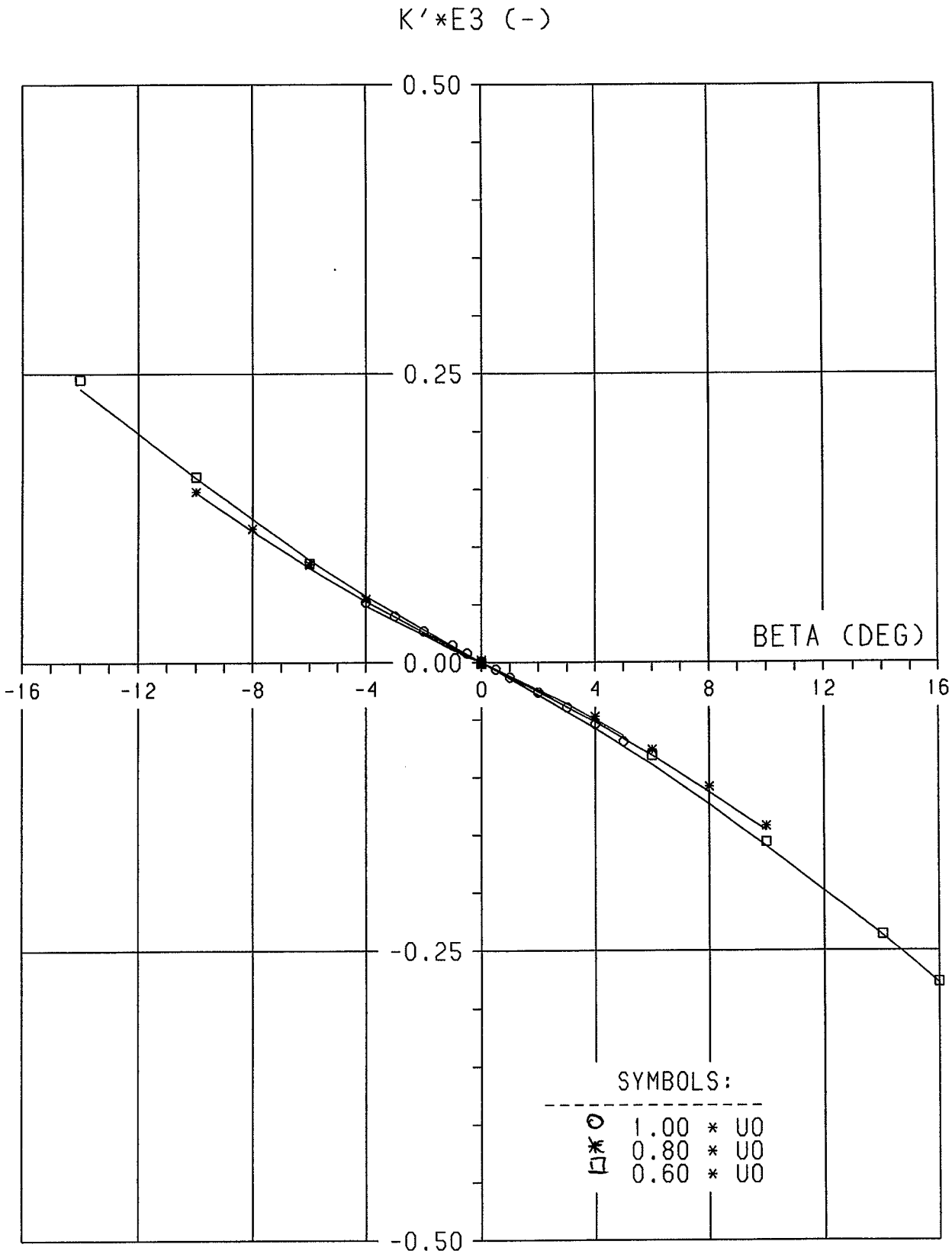
FIG 6.3



SPEED & DRIFT

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THALES
30 KNOTS

ORDER 20071
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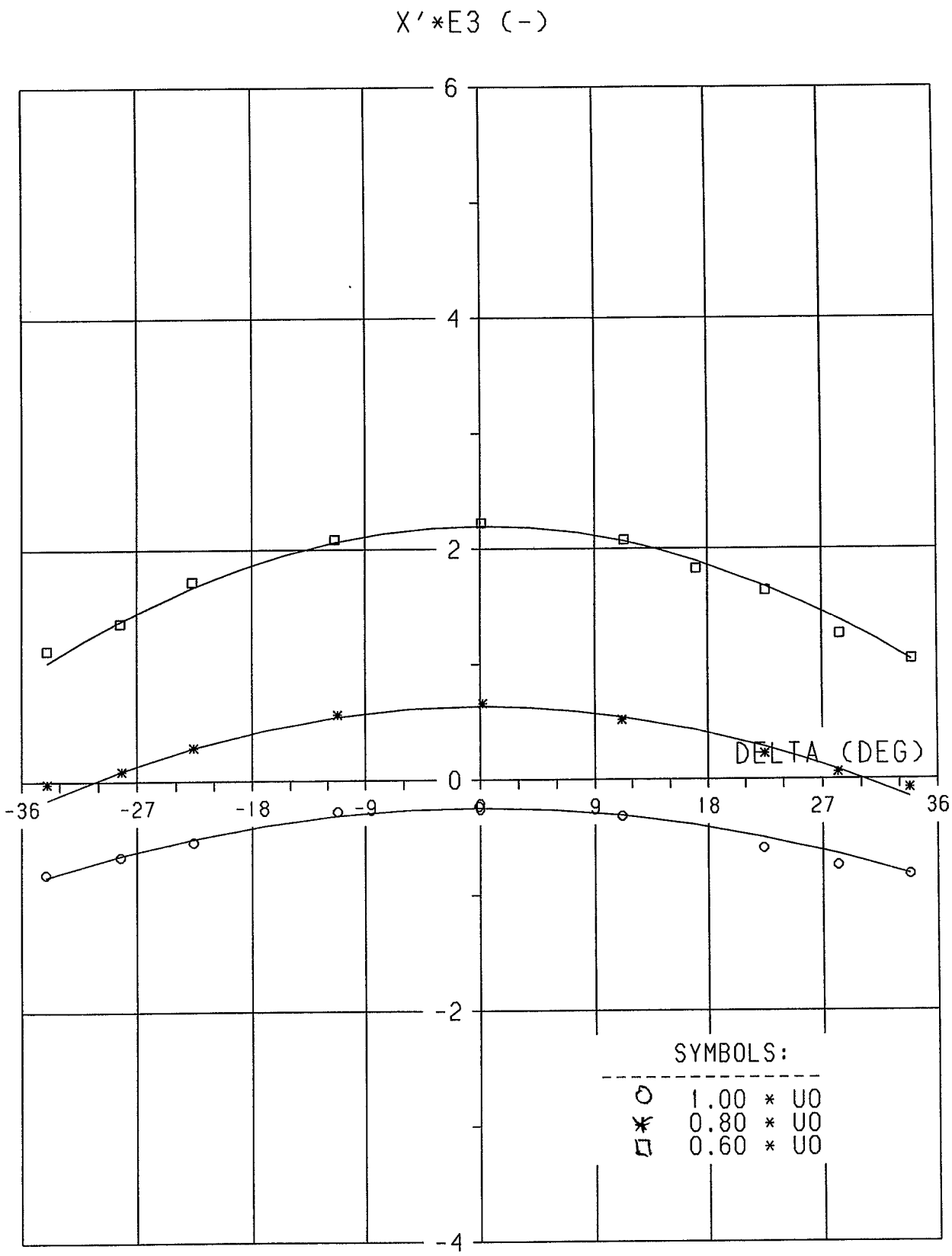
FIG 6.4



SPEED AND RUDDER

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THALES
30 KNOTS

FIG 6.5

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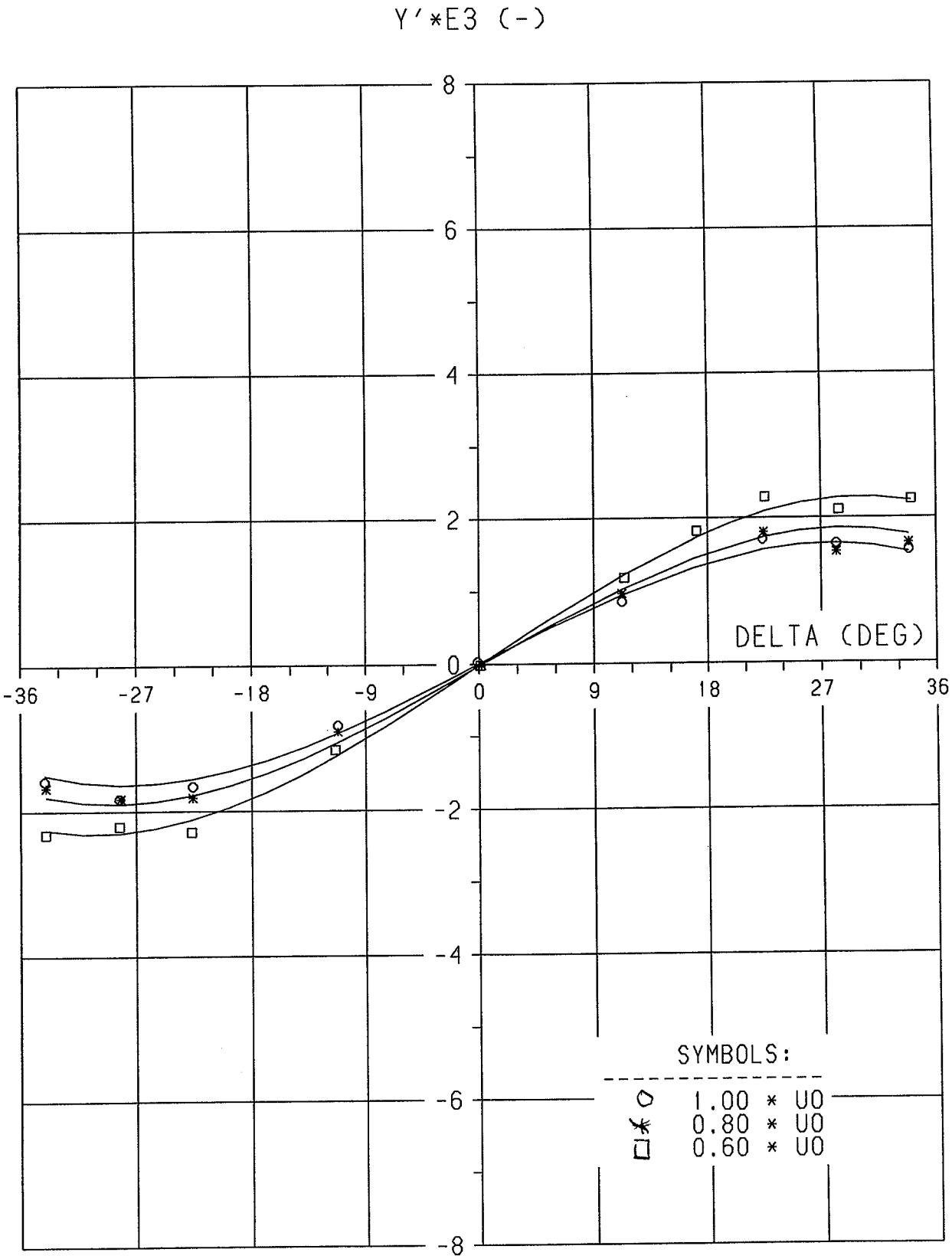

SPEED AND RUDDER

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THALES
30 KNOTS

FIG 6.6

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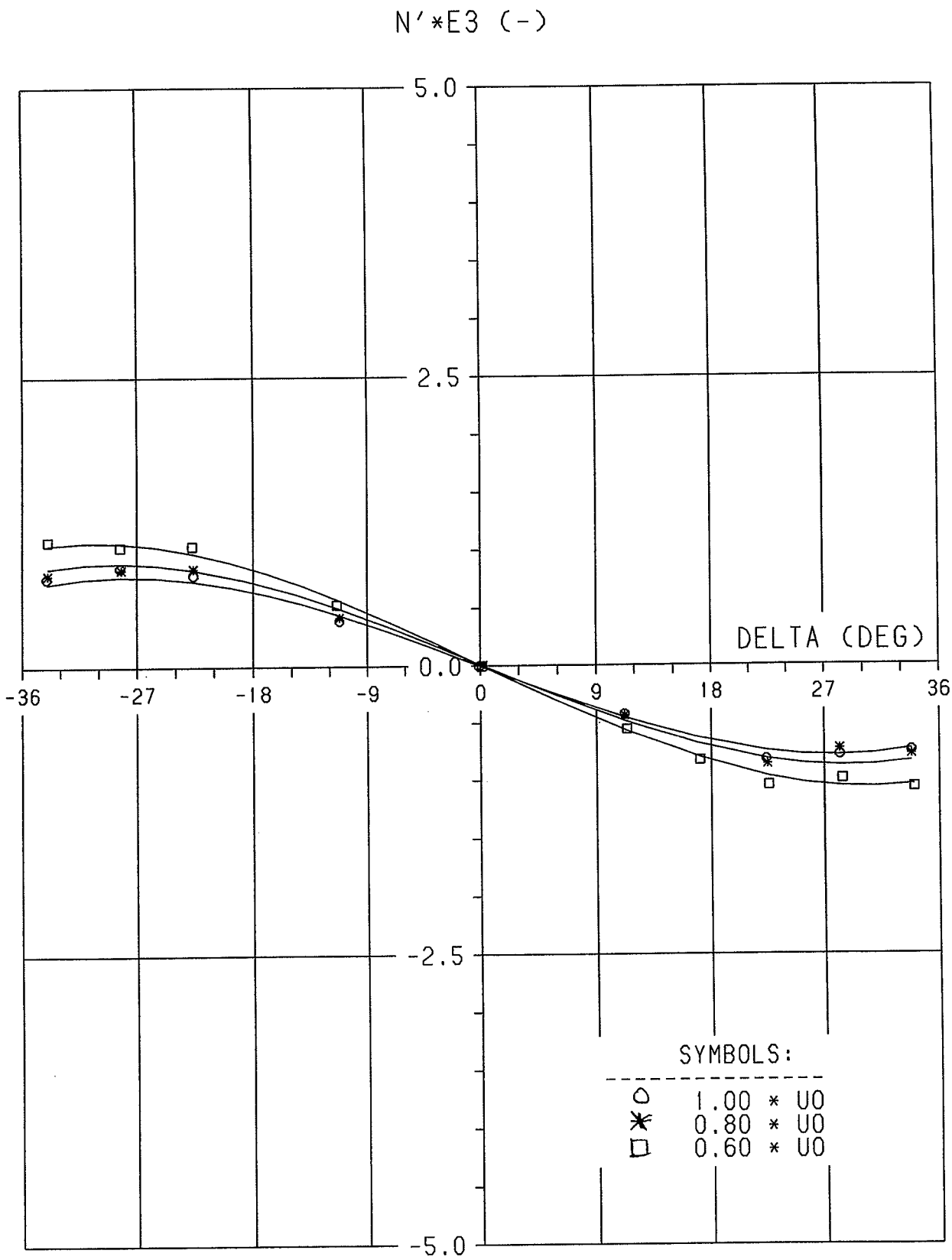

SPEED AND RUDDER

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THALES
30 KNOTS

ORDER 20071
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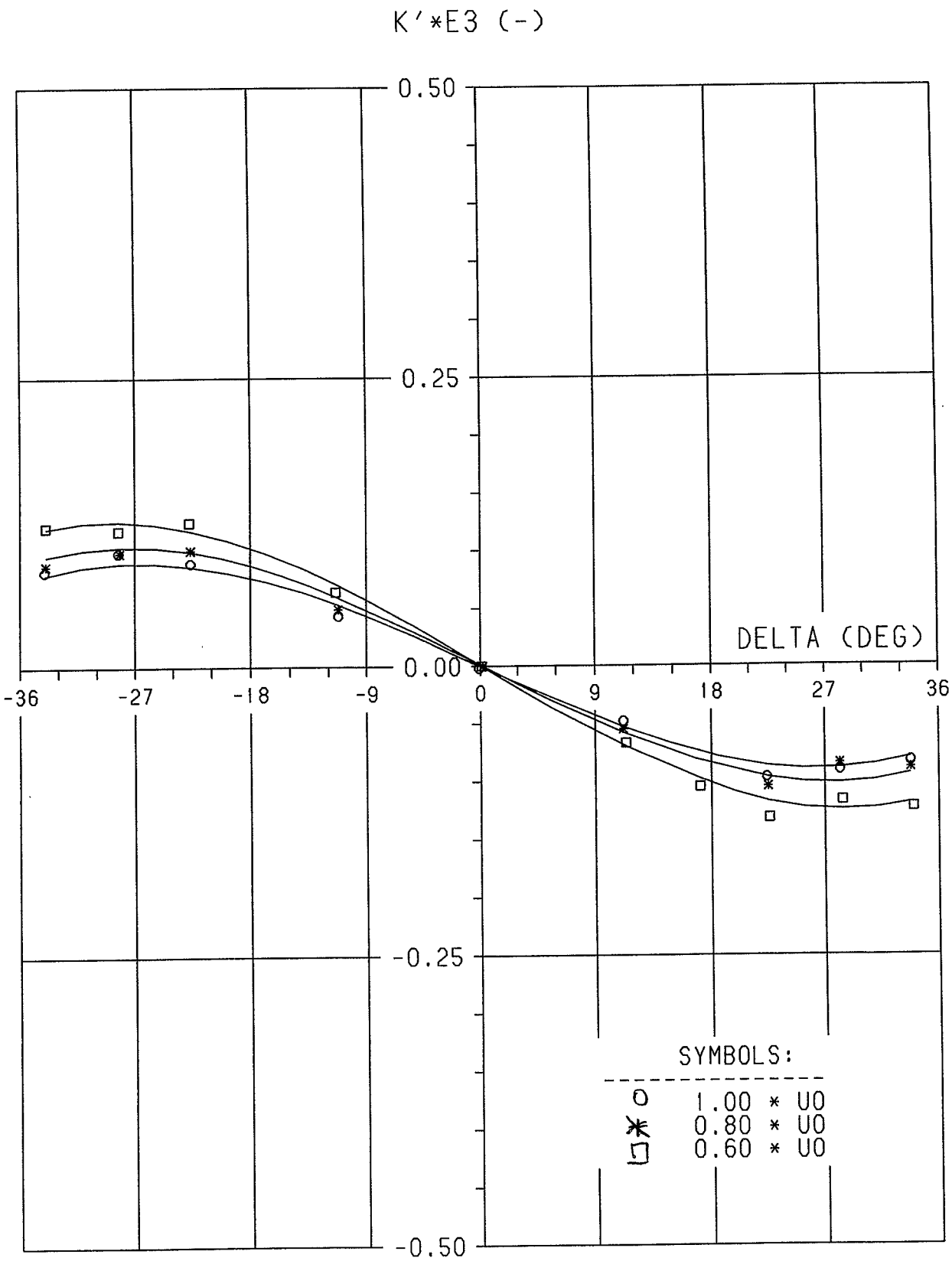
FIG 6.7



SPEED AND RUDDER

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30 KNOTS

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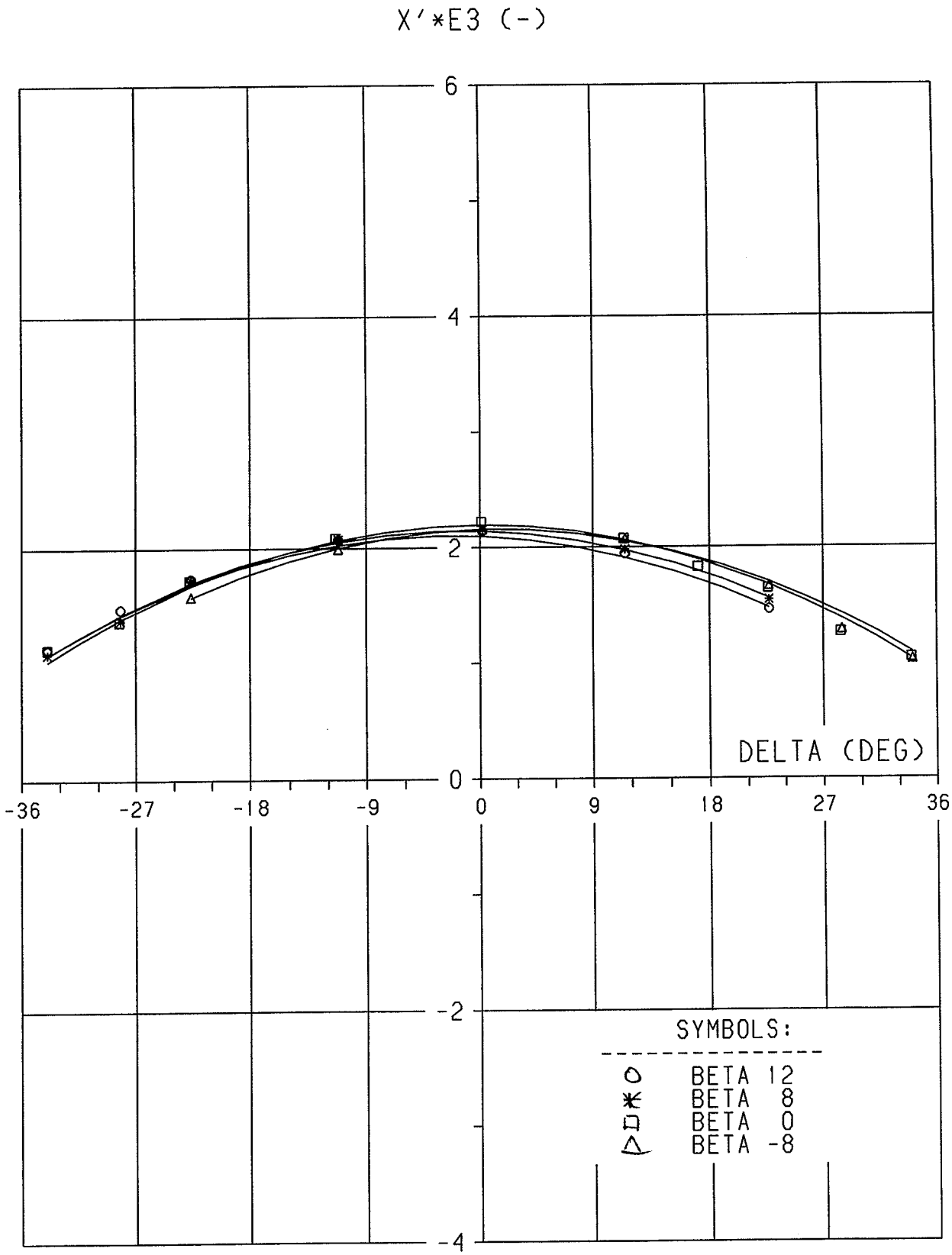
FIG 6.8



DRIFT AND RUDDER
0.6 U0

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30 KNOTS

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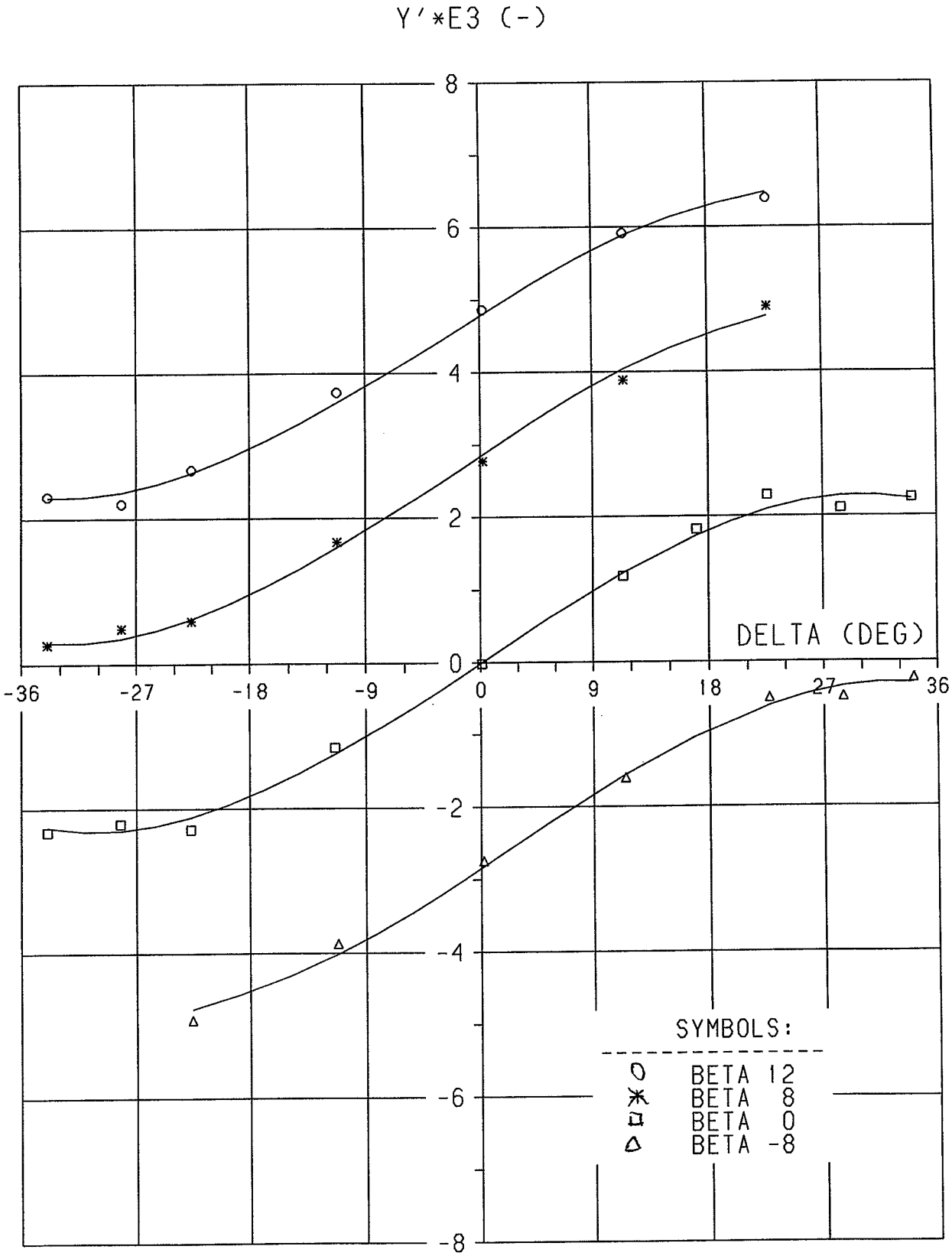
FIG 6.9



DRIFT AND RUDDER
0.6 U0

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THALES
30 KNOTS

FIG 6.10

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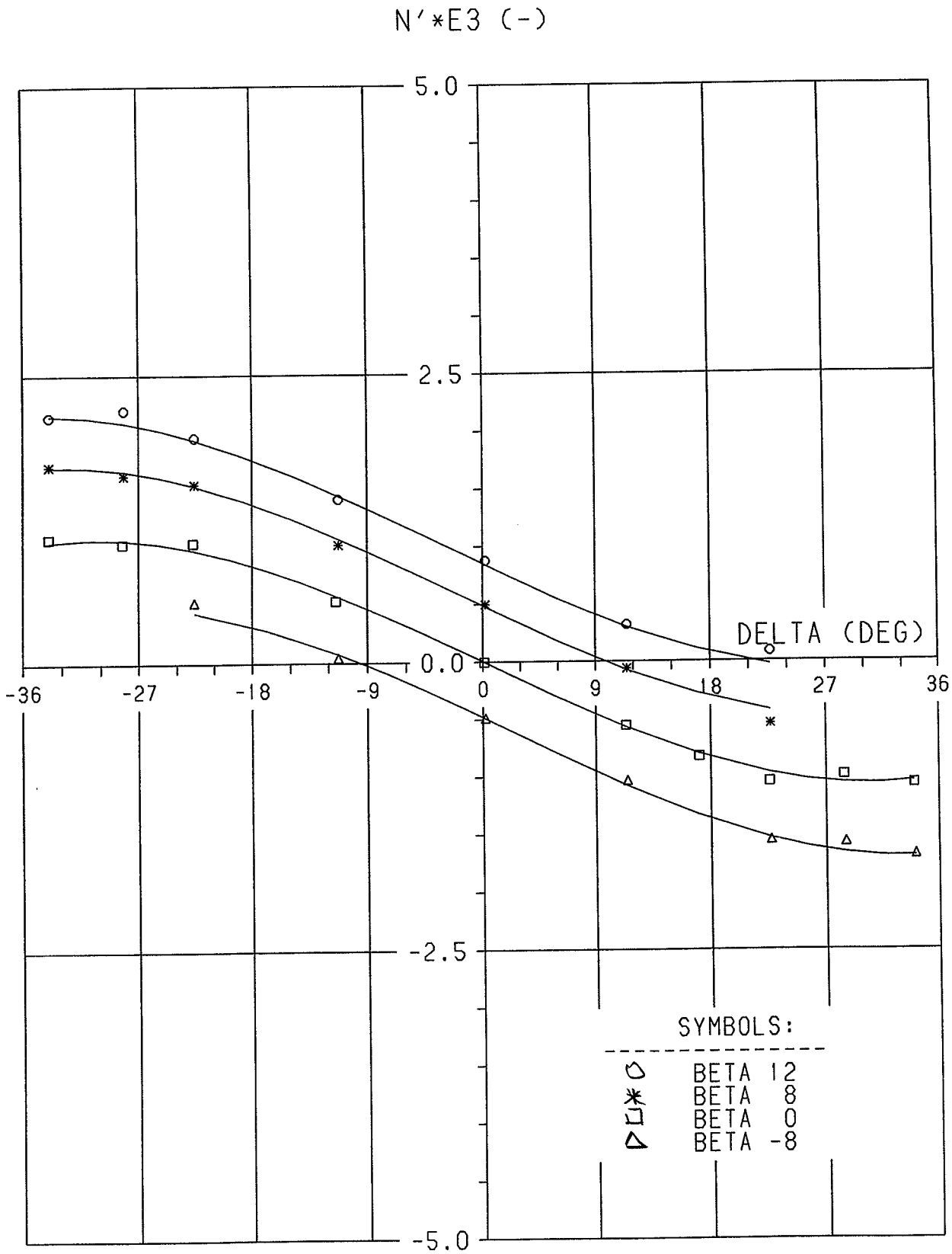

DRIFT AND RUDDER
0.6 U0

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THALES
30 KNOTS

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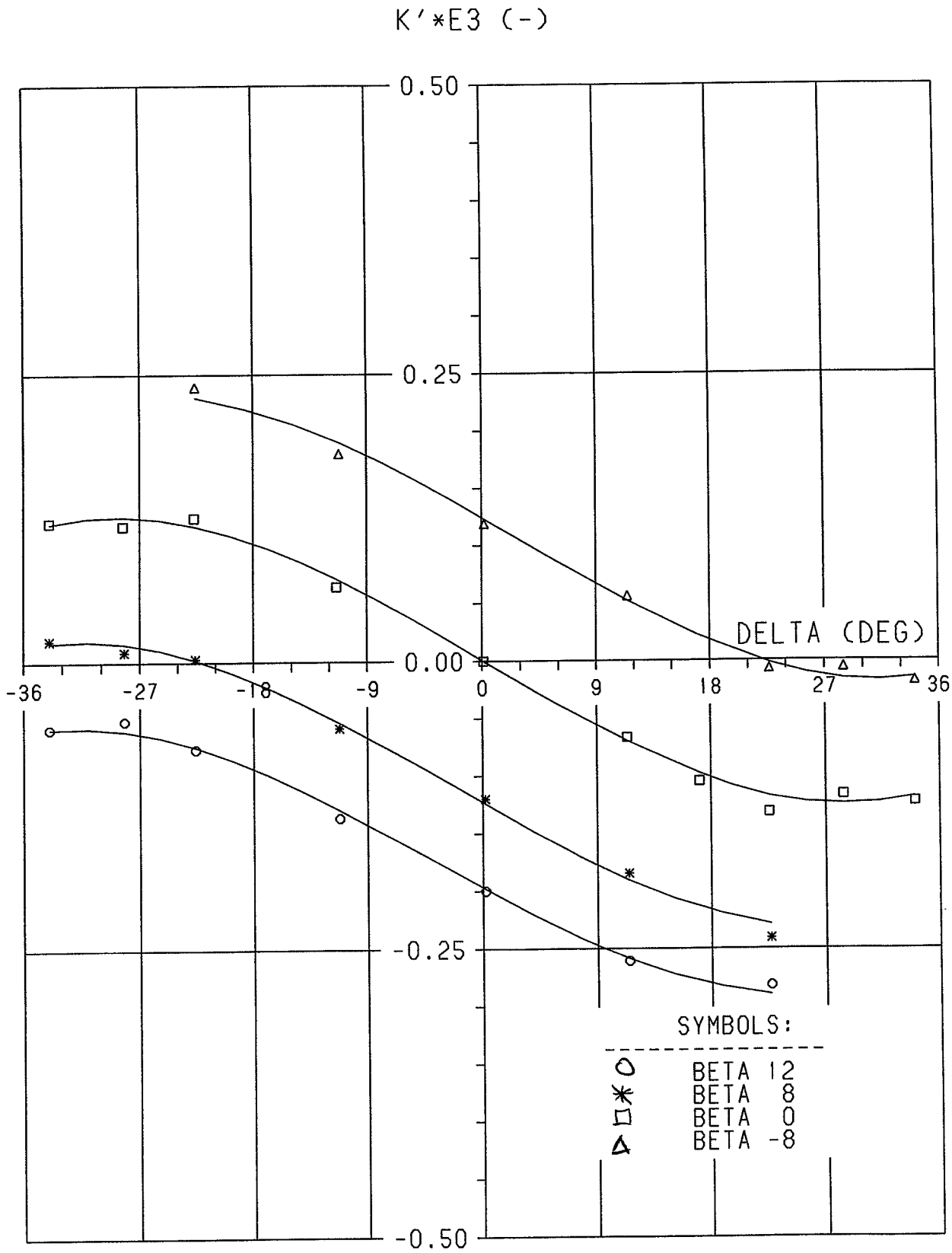
FIG 6.11



DRIFT AND RUDDER
0.6 U0

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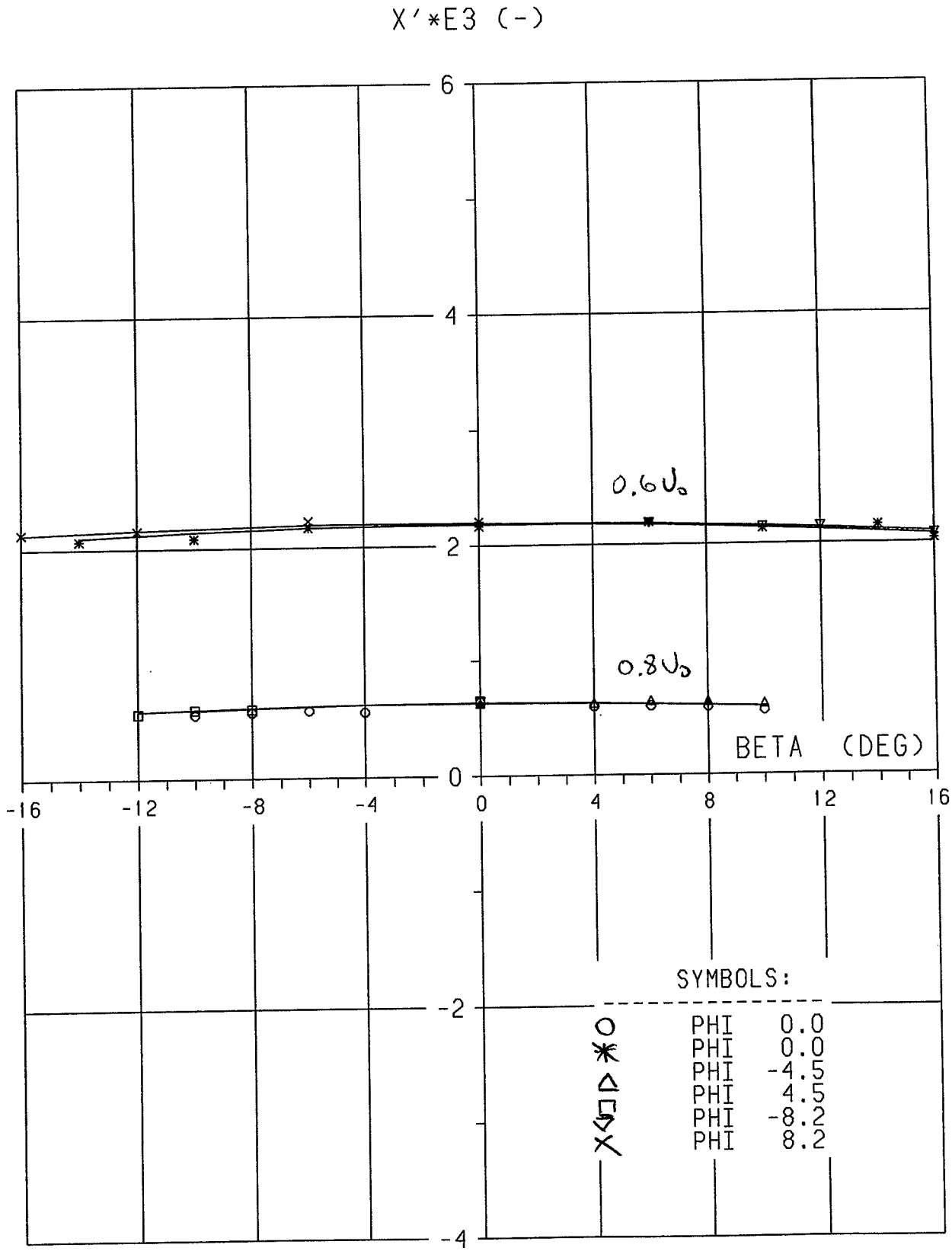
FIG 6.12



DRIFT AND HEEL
0.6U0 AND 0.8U0

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FIG 6.13

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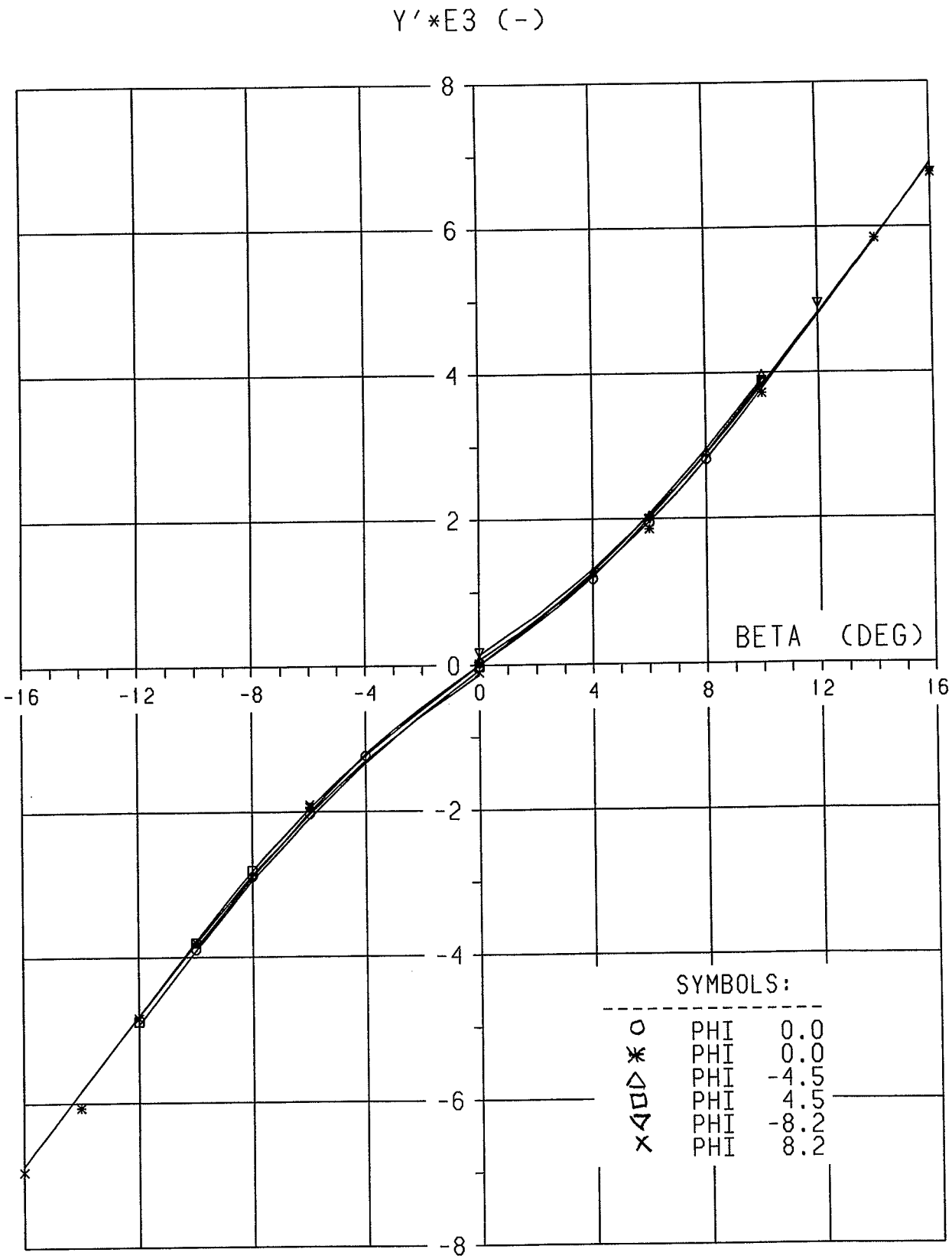

DRIFT AND HEEL
0.6U0 AND 0.8U0

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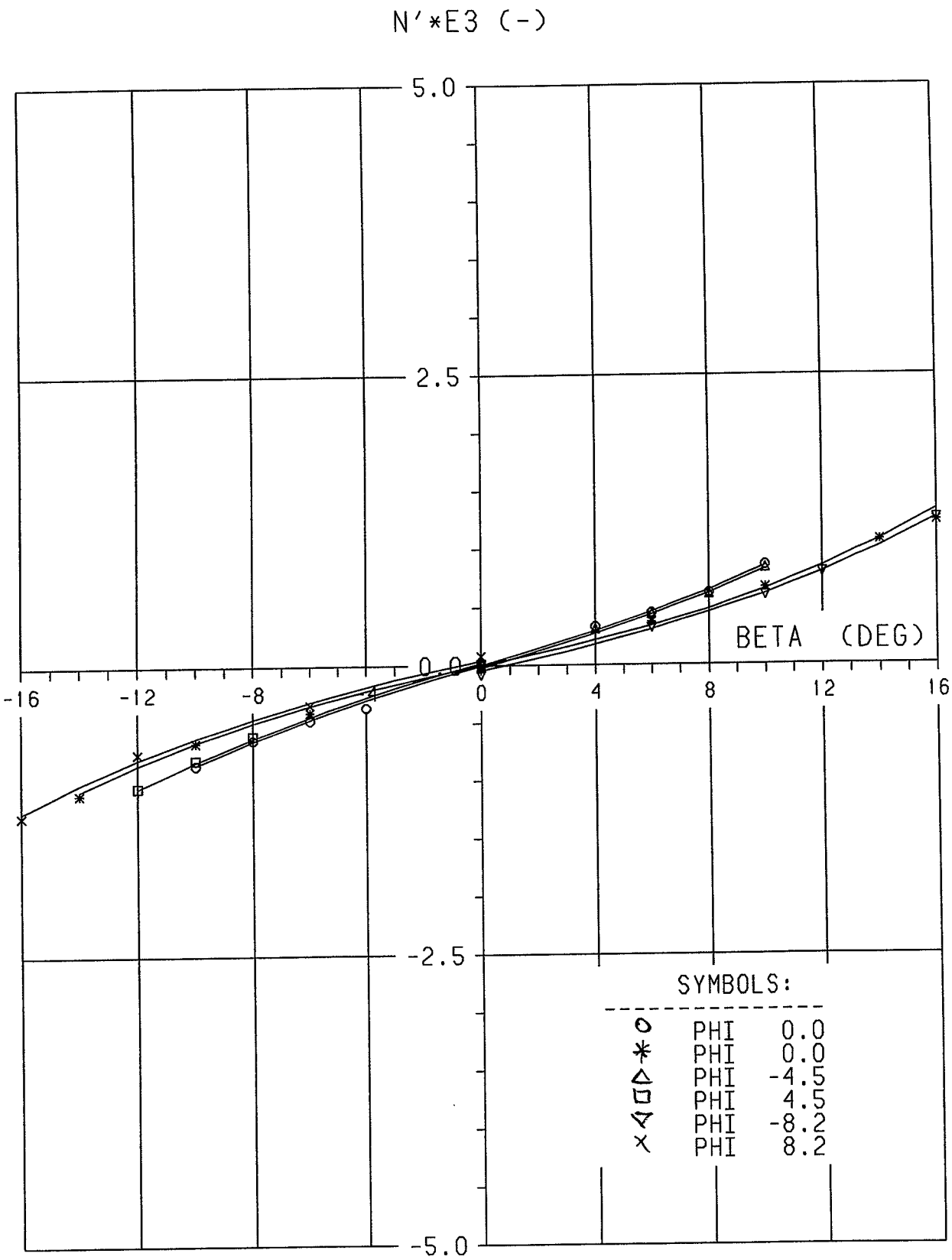
FIG 6.14



DRIFT AND HEEL
0.6U0 AND 0.8U0

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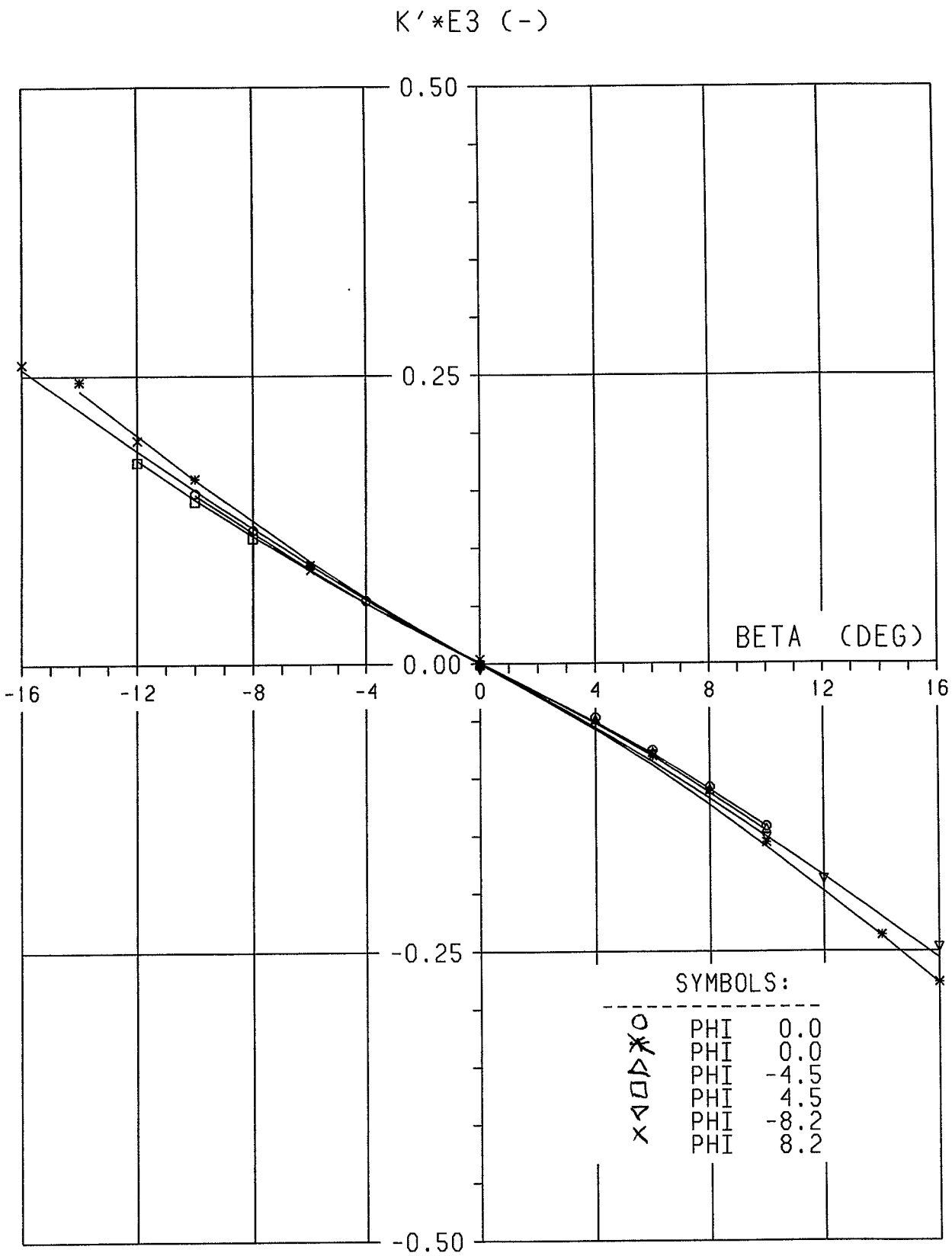
FIG 6.15



DRIFT AND HEEL
0.6U0 AND 0.8U0

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FIG 6.16

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