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Contract No. N62558 - 4457 O.N.R.

Modeltests with a Catamaran Seaplane in waves.

Final Report.

September 1966

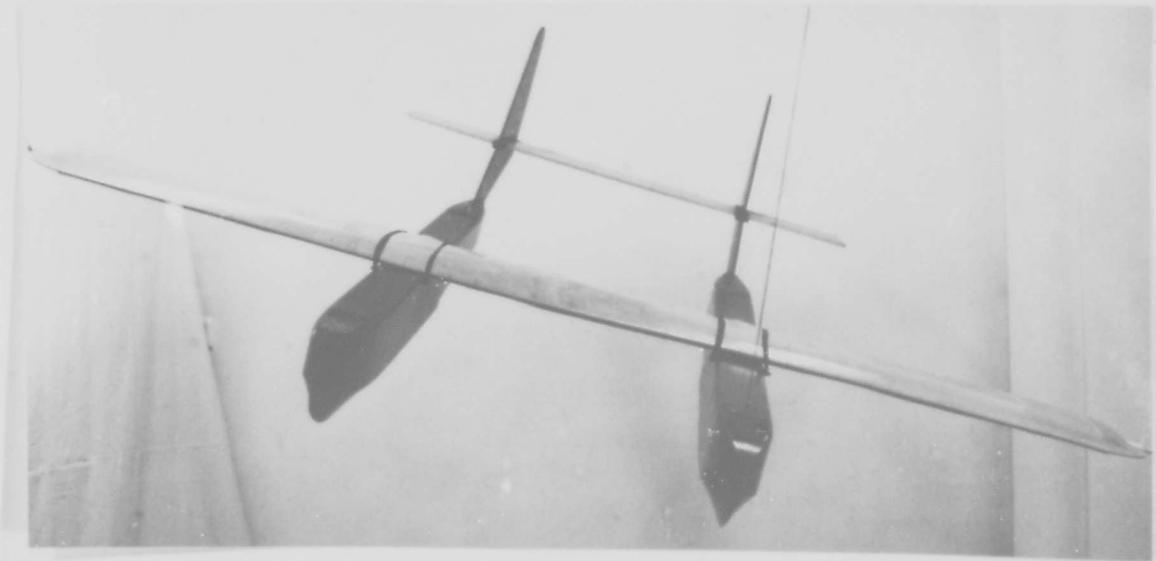
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NSMB

NETHERLANDS SHIP MODEL BASIN
P.O. BOX 28 · WAGENINGEN · THE NETHERLANDS



Modeltests with a Catamaran Seaplane in waves.

Model No. 3042Z.

This investigation has been carried out under Contract No. N62558 - 4457 of the Department of the Navy, Office of Naval Research through its U.S. Navy European Research Contracts Program.

Final Report.

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Report by: Ir. R. Wahab
Principal investigator: Ir. W. L. Swaan

1. Purpose of the investigation

The rolling properties of a Catamaran are largely affected by the distance between the hulls. This degree of freedom in the design makes a Catamaran configuration attractive for vehicles which are to have good seakeeping qualities. In order to obtain some insight into the possibilities of a Catamaran configuration for a seaplane, tests were performed with a model in head, bow and beam seas. During these tests the distance between the hulls and the height of the centre of gravity were varied.

2. General considerations.

The model of the seaplane was tested in the Seakeeping Laboratory of the NETHERLANDS SHIP MODEL BASIN.

It would have been desirable to use a model with six degrees of freedom, but that would require an autopilot in order to keep the model on its track.

Because of weight considerations it was decided to suffice with only three degrees of freedom for the model. In terms normally used in naval architecture, (see Figure 4), they are: heave, pitch and roll.

This restriction may be of importance for the behaviour of the model in beam and oblique seas.

In order to compensate for the lack of information caused by restricting some of the motions the exciting forces were measured for surge and sway together with the yawing moment.

3. Description of the model.

The main characteristics of the model used during the tests are given in the Figures 1,2 and 3 and in Table I. The detailed lines of the hulls of the seaplane are given in the enclosed drawing No. M3042-2.

The most remarkable features of the hulls are a deadrise angle of 60° and a length-beam ratio of 25. These values are expected to give the vehicle a favourable behaviour in head seas. However, no investigations were performed to justify the choice of these values.

4. Test procedure.

4.1. General.

The forward speed of the model was provided by the towing carriage. The connection between the model and the towing carriage consisted of an apparatus which leaves the model free to heave, pitch and roll. It enabled the measurement of these motions by means of potentiometers, see drawing no. WO 15-212-3-100485. The resistance, sway forces forward and aft were determined by means of strain gauge balances. In Figure 5 the locations are shown where the measurements were made.

4.2. Test programme.

A review of the performed tests, is given in the Tables II, III and IV. The test programma can be divided into three parts.

a. Smooth water tests.

During the tests in smooth water the resistance and the roll-pitch- and heave- extinction curves were measured at the following speeds: 0, 3,0, 3,5, and 4,0 m. sec⁻¹. The results of these tests are given in the Figures 6 through 20.

b. Tests in regular beam seas .

During these tests the wave height was kept constant at 40 mm measured from trough to crest. The tests were performed at zero speed and in the speedrange between 3,0 and 4,0 m. sec⁻¹. The results are given in the Figures 22 through 47.

c. Tests in regular head and bow seas .

In part "a" and part "b" of the test programme the distance between the hulls and the height of the centre of gravity were varied. For those values, which give the model the most favourable behaviour in beam seas, tests were performed in head and bow seas. Again, the wave height was kept constant at 40 mm measured from trough to crest. In order to have a check on the linearity of the measured phenomena, the tests in bow seas have been repeated with a wave height of 80 mm. The results of the tests are given in the Figures 48 through 74.

During the tests care has been taken that the range of wave lengths in which the model was investigated included the natural frequencies of the three modes of freedom of the model. The length of the shortest waves which can be generated in the Seakeeping Laboratory determined that only tests in head, bow and beam seas could be performed in resonance conditions.

It would have been desirable to extend the range of wave lengths in which the model was tested in such a way that it included the conditions in which the exciting roll moments are large. This demands waves with a length of the order of the distance between the hulls of the seaplane, which could not be generated unfortunately.

4.3. Definitions.

The definitions of the terminology used for motions due to the wave action (pitch, yaw, roll, heave, surge and sway) are given in Figure 4.

The definition used for the wave direction is given in Figure 21. The phase lag is determined with respect to the wave height at the centre of gravity of the vehicle.

5. The recorded data.

The Figures 6 through 74 are graphical representations of the most characteristic data recorded.

The given values apply to the model, the data were not extrapolated to full scale, since the model scale is unknown. Motions, forces and moments are in general characterized by a mean value and a periodic oscillation round that mean. The periodic oscillations as shown are double amplitudes. The mean values are given as the difference with respect to the stationary condition at zero speed in smooth water. In general the test results appeared to be reproducible in a satisfactory manner. Only in short beam seas, when the lateral forces are high the measurements show a tendency to scatter. This is caused by the measuring apparatus which connected the model with the towing carriage. When the lateral forces were high the model was now and then restrained in its motions because the air lubricated bearings were overloaded which resulted in metallic contact between the vertical rod and the guiding of the measuring apparatus.

6. Discussion of the results.

a. Smooth water behaviour.

During the experiments at speeds between 3.0 and 4.0 m.sec⁻¹ the flow at the steps of the Seaplane was observed to be smooth. The Figures 7 and 8 indicate, that the lifting force on the model due to planing is still very small.

This suggests that the model was not in the planing condition yet, but might be near it.

The extinction curves in the Figures 9 through 20 show that at zero speed the roll, heave and pitch motions, were only slightly damped or specially when the motions are small.

These curves also show an important mutual influence between the hulls.

When the distance between the hulls is decreased the damping becomes less. This is especially valid for roll and pitch, and to a lesser degree also for heave. In the speedrange from 3.0 to 4.0 m.sec⁻¹, when the flow condition around the hulls has changed, the damping appeared to be increased considerably. The mutual influence of the hulls seems to be reduced, but is still present.

During the extinction tests the coupling between roll, pitch and heave appeared to be important. As could be expected the distance between the hulls affect the natural roll periods largely.

The extinction curves indicate that the natural periods of the model are not much affected by the forward speed.

b. Behaviour in beam seas.

As could be expected from the foregoing, the motions of the Seaplane were strongly dependent of the distance between the hulls. At zero speed a long distance between the hulls proved to be very favourable. In the speedrange between 3.0 and 4.0 m.sec⁻¹ the shortest distance investigated was also favourable with respect to motions and accelerations. Then, a distance between the hulls exists which gives the Catamaran the worst behaviour.

Leaving the shortest investigated distance between the hulls out of account, the influence of the forward speed on roll and heave was small. The influence of the forward speed on the accelerations at the wing-tips was also rather small. The pitch motions and the accelerations of the hulls, on the contrary, increase distinctly with increasing speed. A coupling between the various modes of freedom is also present.

E.g. the hump in Figure 24 for the heave motion in 7m waves probably originates from the rolling motion. Though less distinct, such humps are also present in some of the other Figures.

c. Effect of wave direction.

As could be expected, roll amplitudes and lateral forces were largest in beam seas. At constant frequency of encounter and constant wave height, heave and pitch increase when the wave direction was varied from 90 to 180 degrees.

The same was observed for the accelerations of the hulls and wing-tips.

The variation of the resistance in head and bow seas was large. Therefore the surge motion of the vehicle is expected to be large also.

d. Effect of wave height.

The Figures show that the motion and acceleration amplitudes are generally fairly linear with the wave height. The harmonic part of the resistance also shows a fair linearity.

The waves in which the model was investigated were rather long with respect to the model length. These aspects give rise to the supposition that the measured harmonic part of the resistance consists mainly of the horizontal component of the buoyancy force. The difference between the mean resistance in waves and that in smooth water, to so called added resistance, is expected to be about proportional to the waveheight squared.

Fig. 62 indicate that the measured added resistance is even less than proportional to the waveheight. Because this quantity is relatively small, the discrepancy may partly be attributed to the inaccuracy of the measurements.

7. Conclusions.

The behaviour of the Catamaran in regular beam seas was best if the distance between the hulls was either very short or very long. The longest investigated distance proved to be slightly better than the shortest. The natural frequencies in these two cases differed very much.

In some cases a strong coupling between roll, pitch and heave occurred.

The investigated changes in the height of the centre of gravity did not affect the behaviour of the vehicle.

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Table I.

	weight distribution I	weight distribution II
Draft forward	72 mm	72 mm
Draft aft	83 mm	83 mm
Displacement	8.26 kg	8.26 kg
Longitudinal radius of gyration	740 mm	739 mm
Height of the C.G. above base line	189 mm	224 mm

Table II.

Smooth water tests.

Distance between hulls (m)	Weight distribution	Speed (m.sec⁻¹)	Results given in Figure no.
0.20	I	3.0, 3.5,	6, 7, 8
0.40	"	4.0	6, 7, 8
0.70	"		6, 7, 8
1.00	"		6, 7, 8

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Table III.

Extinction tests.

Test no.	Distance between hulls (m)	Weight distribution	Speed (m.sec ⁻¹)	Motion	Results given in Figure no.
2186	0.20	I	0	roll	9
2187	"	"	"	pitch	17
2188	"	"	"	heave	13
2189	0.40	"	"	roll	9
2190	"	"	"	pitch	17
2191	"	"	"	heave	13
2192	0.70	"	"	roll	9
2193	"	"	"	pitch	17
2194	"	"	"	heave	13
2195	1.00	"	"	roll	9
2196	"	"	"	pitch	17
2197	"	"	"	heave	13
2198	0.20	II	0	roll	9
2199	"	"	"	pitch	17
2200	"	"	"	heave	13
2201	0.40	"	"	roll	9
2202	"	"	"	pitch	17
2203	"	"	"	heave	13
2204	0.70	"	"	roll	9
2205	"	"	"	pitch	17
2206	"	"	"	heave	13

Table III (continued)

Test no.	Distance between hulls (m)	Weight distribution	Speed (m.sec ⁻¹)	Motion	Results given in Figure no.
2207	1,00	II	0	roll	9
2208	"	"	"	pitch	17
2209	"	"	"	heave	13
2210	"	"	3,0	roll	10
2211	"	"	3,5	"	11
2212	"	"	4,0	"	12
2213	"	"	3,0	pitch	18
2214	"	"	3,5	"	19
2215	"	"	4,0	"	20
2216	"	"	3,0	heave	14
2217	"	"	3,5	"	15
2218	"	"	4,0	"	16
2219	0,70	"	3,0	roll	10
2220	"	"	3,5	"	11
2221	"	"	4,0	"	12
2222	"	"	3,0	pitch	18
2223	"	"	3,5	"	19
2224	"	"	4,0	"	20
2225	"	"	3,0	heave	14
2226	"	"	3,5	"	15
2227	"	"	4,0	"	16
2228	0,40	"	3,0	roll	10
2229	"	"	3,5	"	11
2230	"	"	4,0	"	12
2231	"	"	3,0	pitch	18

Table III (continued)

Test no.	Distance between hulls (m)	Weight distribution	Speed (m.sec ⁻¹)	Motion	Results given in Figure no.
2232	0,40	II	3,5	pitch	19
2233	"	"	4,0	"	20
2234	"	"	3,0	heave	14
2235	"	"	3,5	"	15
2236	"	"	4,0	"	16
2237	0,20	"	3,0	roll	10
2238	"	"	3,5	"	11
2239	"	"	4,0	"	12
2240	"	"	3,0	pitch	18
2241	"	"	3,5	"	19
2242	"	"	4,0	"	20
2243	"	"	3,0	heave	14
2244	"	"	3,5	"	15
2245	"	"	4,0	"	16
2246	"	I	3,5	roll	11
2247	"	"	"	pitch	19
2248	"	"	"	heave	15
2249	0,40	"	"	roll	11
2250	"	"	"	pitch	19
2251	"	"	"	heave	15
2252	0,70	"	"	roll	11
2253	"	"	"	pitch	19
2254	"	"	"	heave	15
2255	1,00	"	"	roll	11
2256	"	"	"	pitch	19
2257	"	"	"	heave	15

Table IV.

Tests in waves.

Test no.	Distance between hulls (m)	Weight distribution	Speed (m.sec ⁻¹)	Wave direction (degrees)	Wave height (m)	Results given in Figure no.
7042	0.20	I	0	90	0,04	22through33
7043	0.40	"	"	"	"	"
7044	0.70	"	"	"	"	"
7045	1.00	"	"	"	"	"
7046	0.20	II	"	"	"	22through33
7047	0.40	"	"	"	"	"
7048	0.70	"	"	"	"	"
7049	1.00	"	"	"	"	"
7050	1.00	"	3,0, 3,5, 4,0	"	"	34through47
7051	0.70	"	"	"	"	"
7052	0.40	"	"	"	"	"
7053	0.20	"	"	"	"	"
7056	0.20	I	3,5	"	"	34through47
7057	0.40	"	"	"	"	"
7058	0.70	"	"	"	"	"
7059	1.00	"	"	"	"	"
7066	1.00	"	"	135	"	48through62
7067	"	"	"	180	"	63through74
7068	"	"	"	135	0,08	48through62

<p>NEDERLANDSCH SCHEEPSBOUWKUNDIG PROEFSTATION WAGENINGEN</p>	<p>Report No. 66-086-ET.</p>	<p>BLZ. 14.</p>
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Appendix.

Text of the motion pictures.

Netherlands Ship Model Basin
Wageningen

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Tests with a Catamaran Seaplane model

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Model No. 3042Z

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Research sponsored by the Office of Naval Research,
Department of the Navy.

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Contract No. N 62558-4457

-

SMOOTH WATER

-

Distance between the hulls 0.70 m
Speed 3.5 m.sec⁻¹

-

Scene

-

REGULAR BEAM SEAS

-

The motions of the model are shown when the frequency of
encounter is equal to the natural frequency for roll

-

Wave height 0.04 m
Weight distribution I
Speed 3.5 m.sec⁻¹

-

Distance between the hulls 0.20 m
Wave length 5.5 m

-

Scene

-

Distance between the hulls 0.40 m
Wave length 2.1 m

-

Scene

-

Distance between the hulls 0.70 m
Wave length 1.8 m

-

Scene

-

Distance between the hulls 1.00 m
Wave length 2.1 m

-

Scene

-

REGULAR BOW SEAS

-

Distance between the hulls 1.00 m
Wave height 0.04 m
Wave length 9.5 m

-

Scene

-

Distance between the hulls 1.00 m
Wave height 0.08 m
Wave length 9.5 m

-

Scene

-

REGULAR HEAD SEAS

-

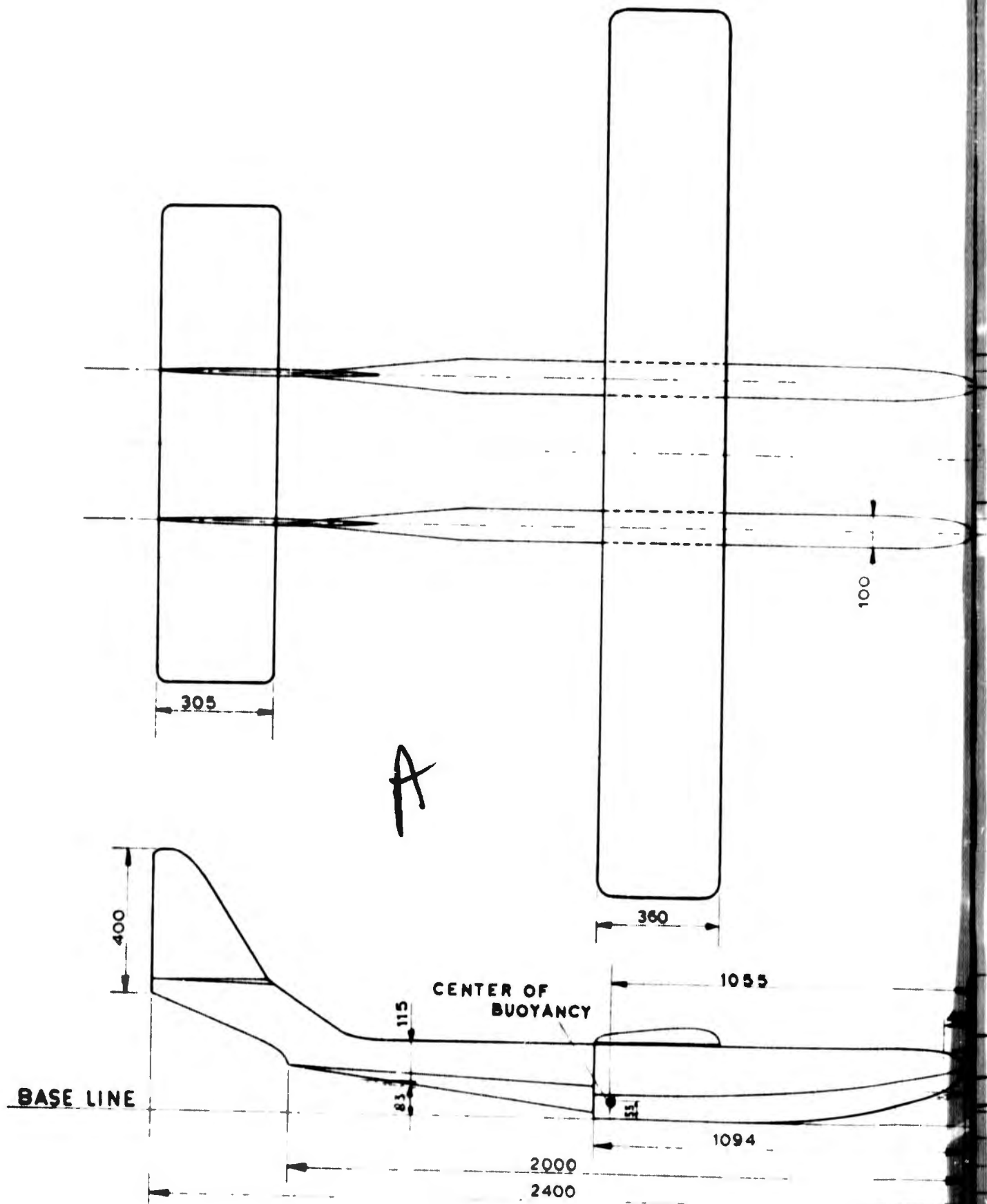
Distance between the hulls 1.00 m
Wave height 0.04 m
Wave length 5.5 m

-

Scene

-

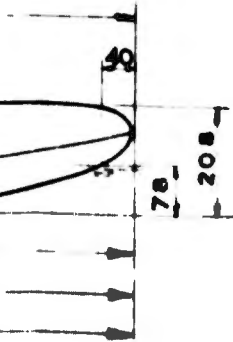
THE END.



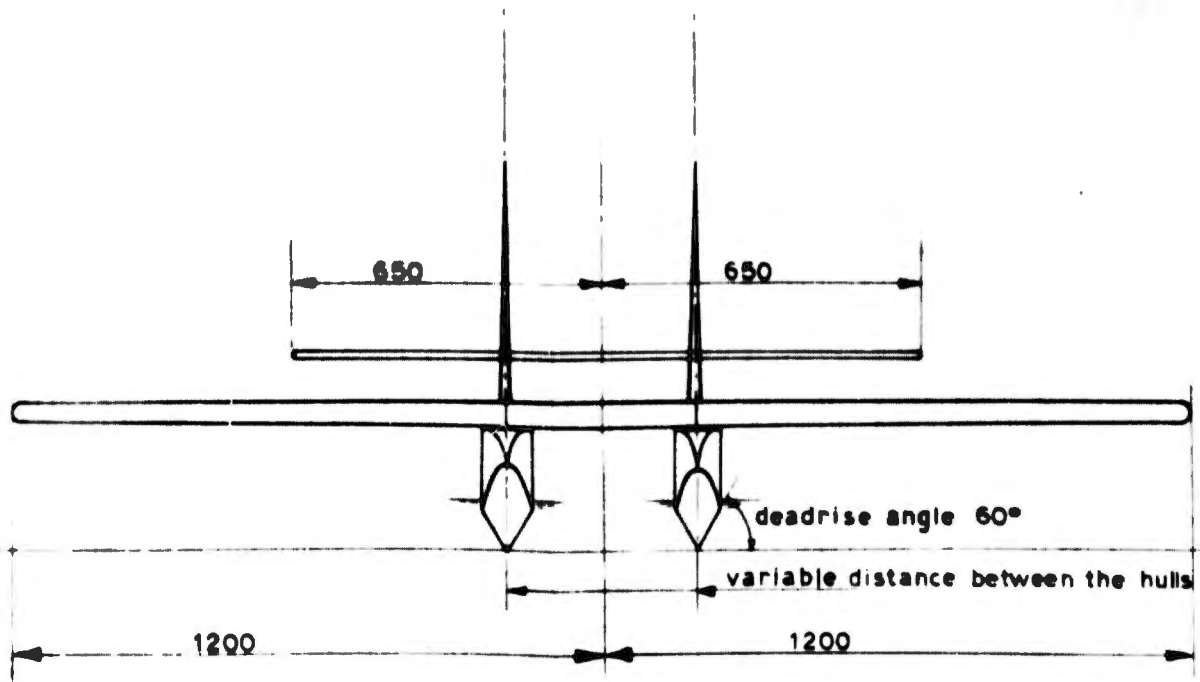
MODEL OF CATAMARAN SEAPLANE

GENERAL ARRANGEMENT

ALL DIMENSIONS ARE GIVEN IN MILLIMETERS

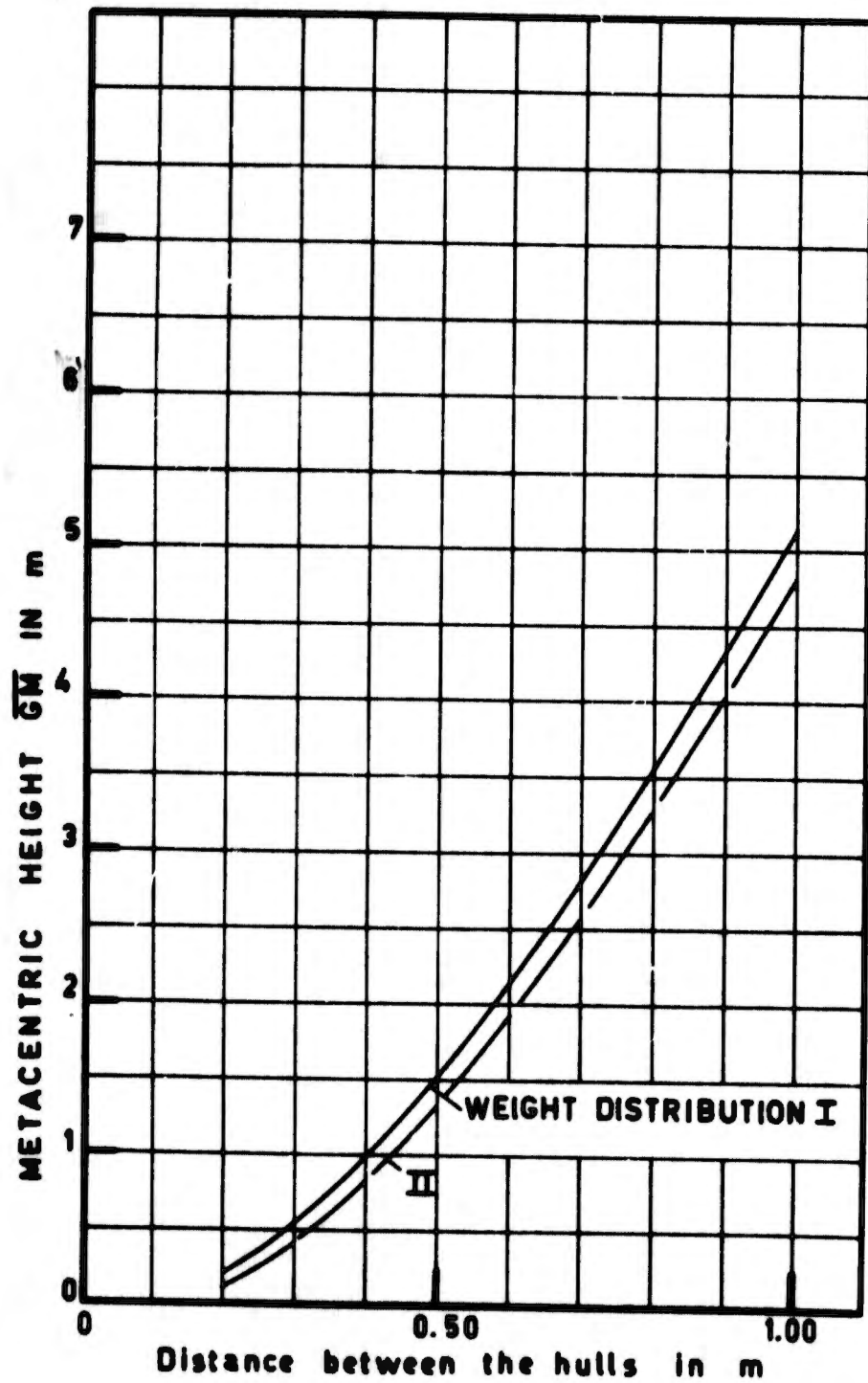


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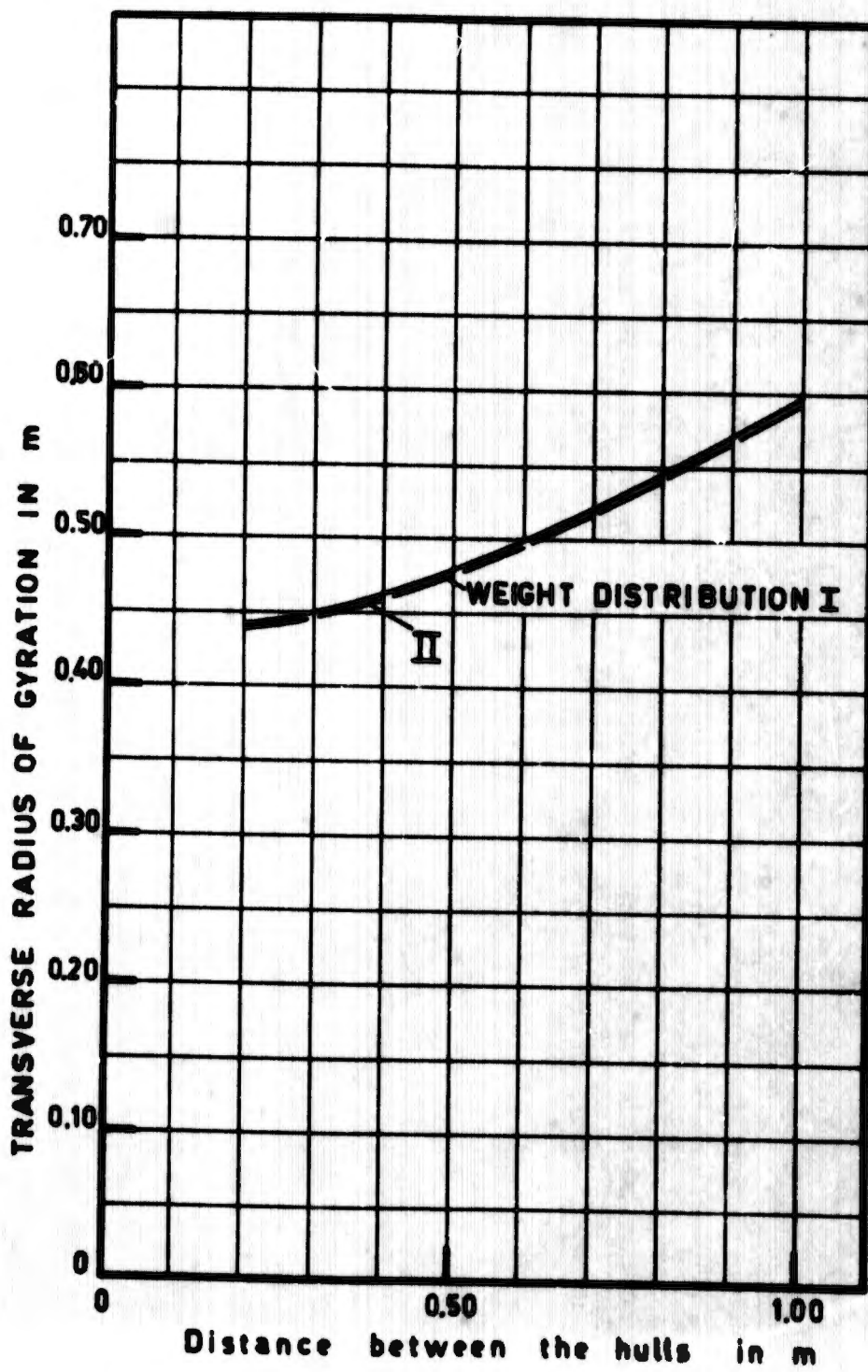
CATAMARAN SEAPLANE

METACENTRIC HEIGHT



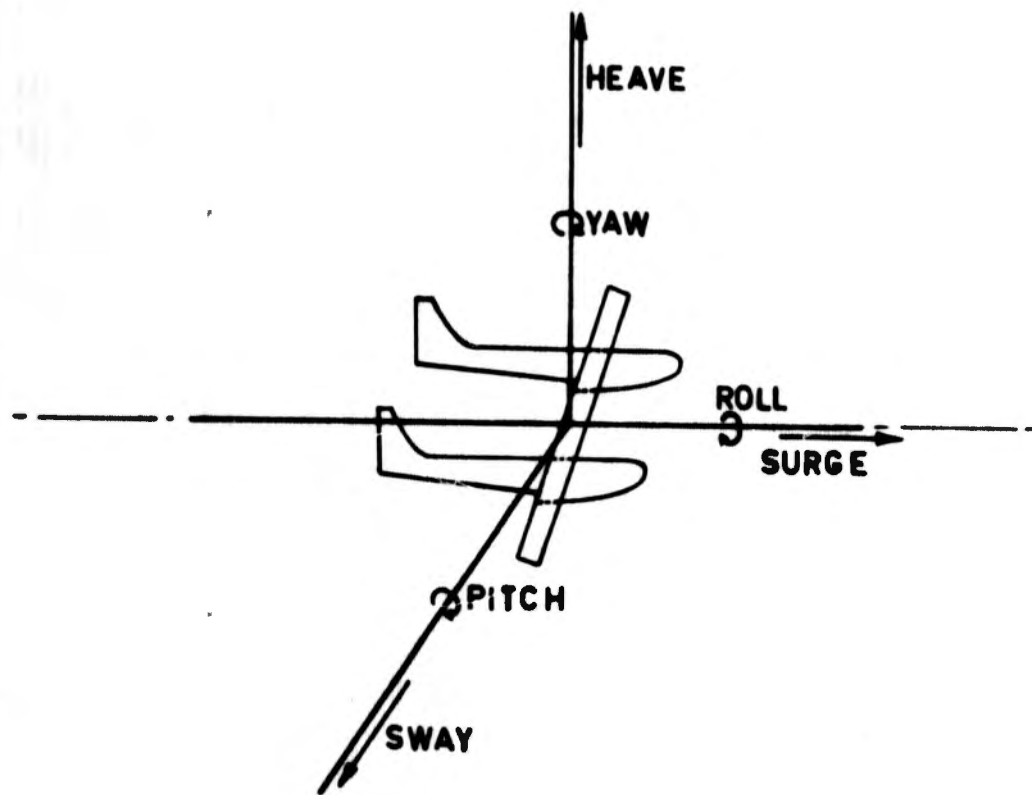
CATAMARAN SEAPLANE

TRANSVERSE RADIUS OF GYRATION



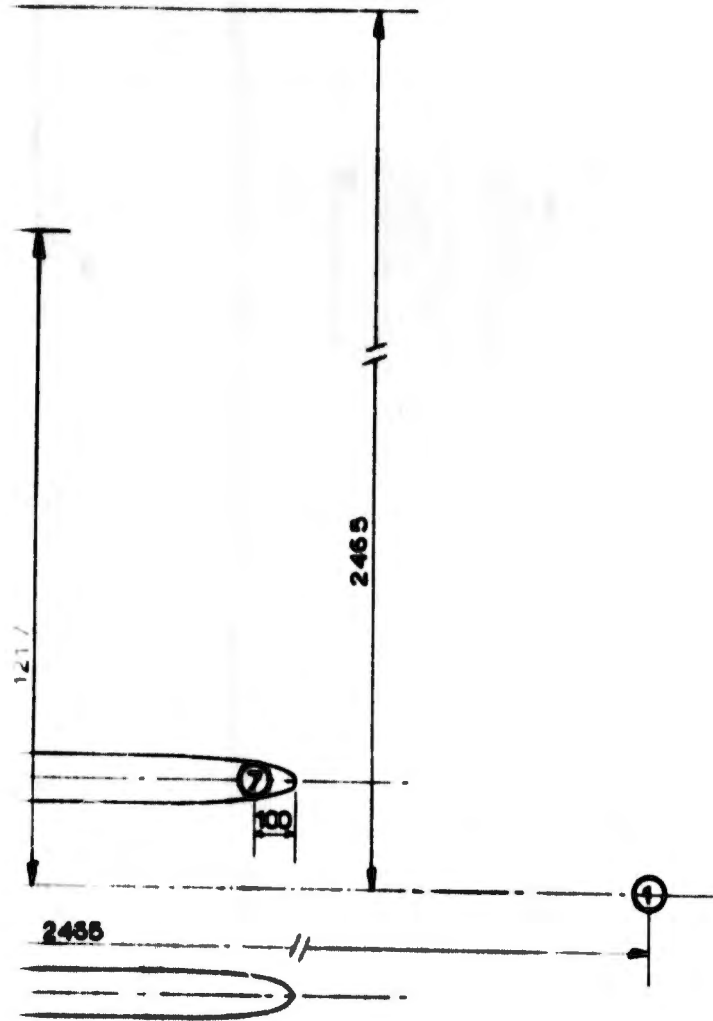
CATAMARAN SEAPLANE

DEFINITION OF MOTIONS DUE TO WAVE ACTION

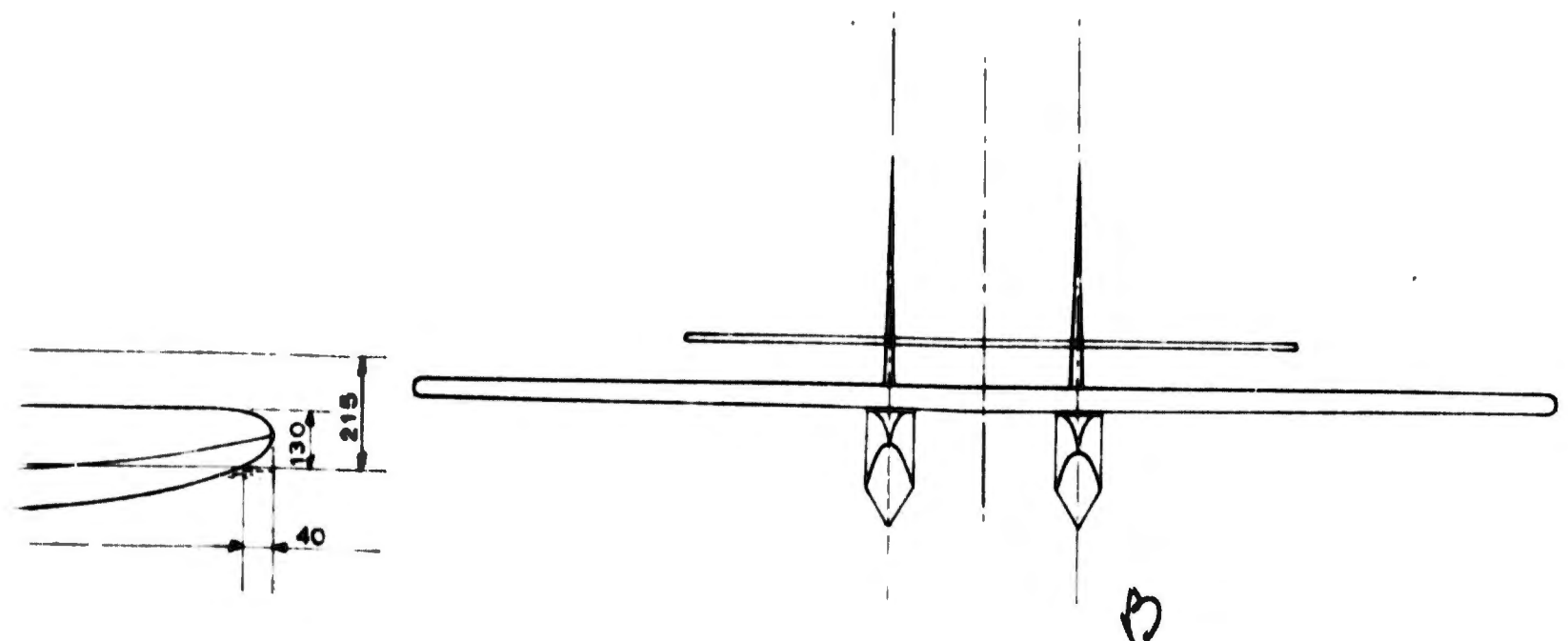


CATAMARAN SEAPLANE

TEST ARRANGEMENT



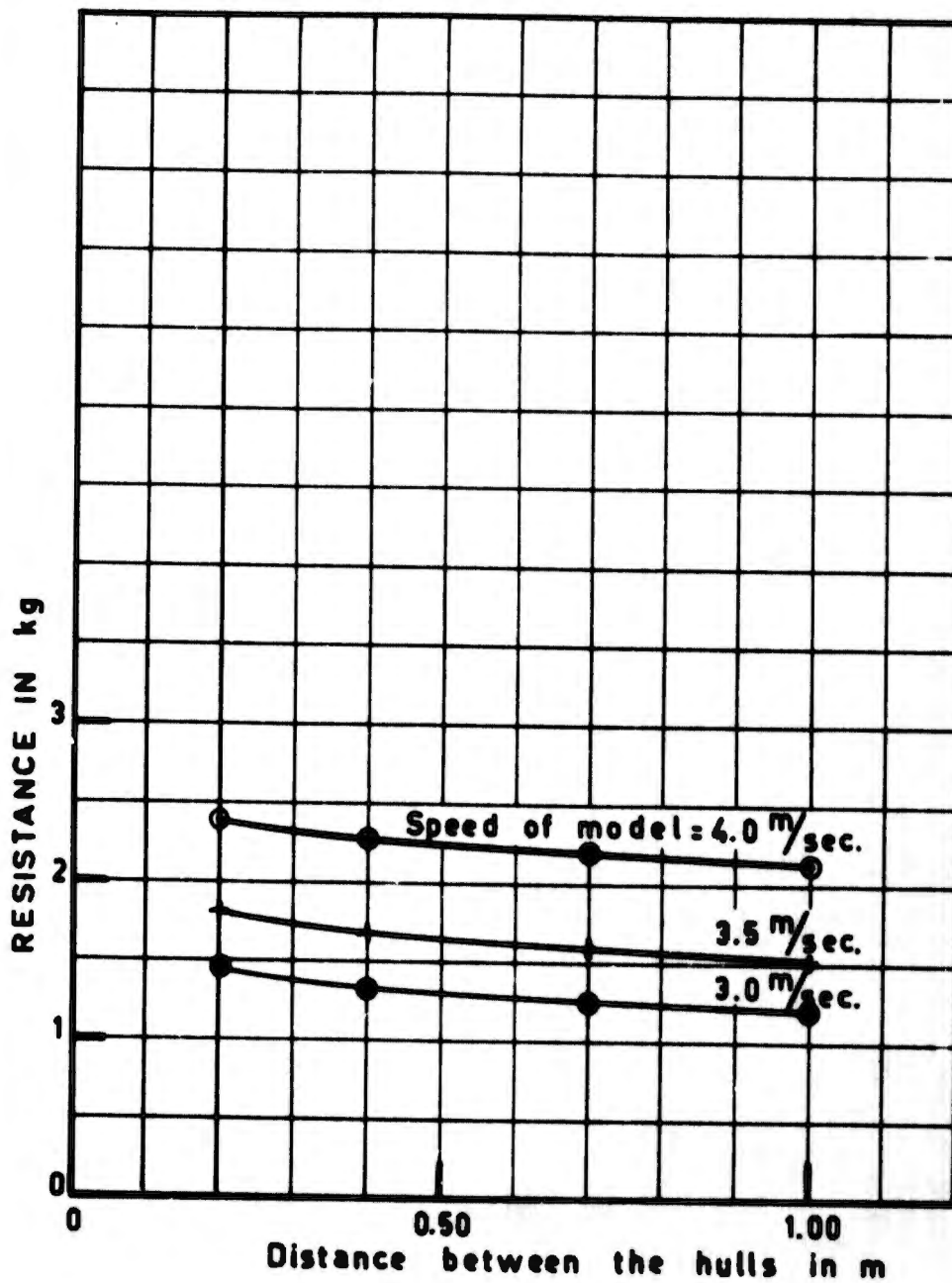
- ① Wave height transducers
- ② Heave
- ③ Roll angle
- ④ Pitch angle
- ⑤ Relative motion to watersurface
- ⑥ Acceleration of the wing-tip
- ⑦ Acceleration of the hull
- ⑧ Lateral force forward
- ⑨ Lateral force aft



CATAMARAN SEAPLANE

SMOOTH WATER — RESISTANCE

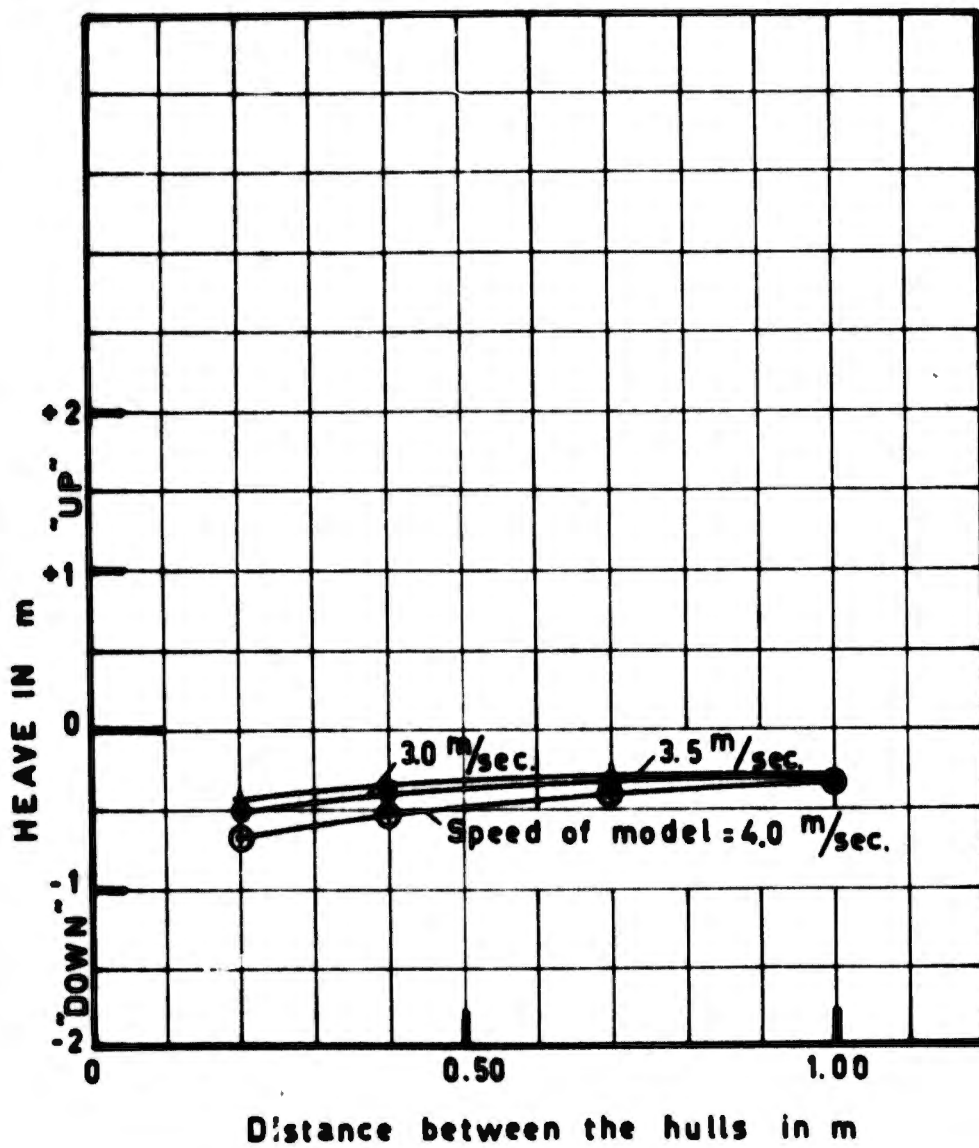
WEIGHT DISTRIBUTION I AND II



CATAMARAN SEAPLANE

SMOOTH WATER — HEAVE

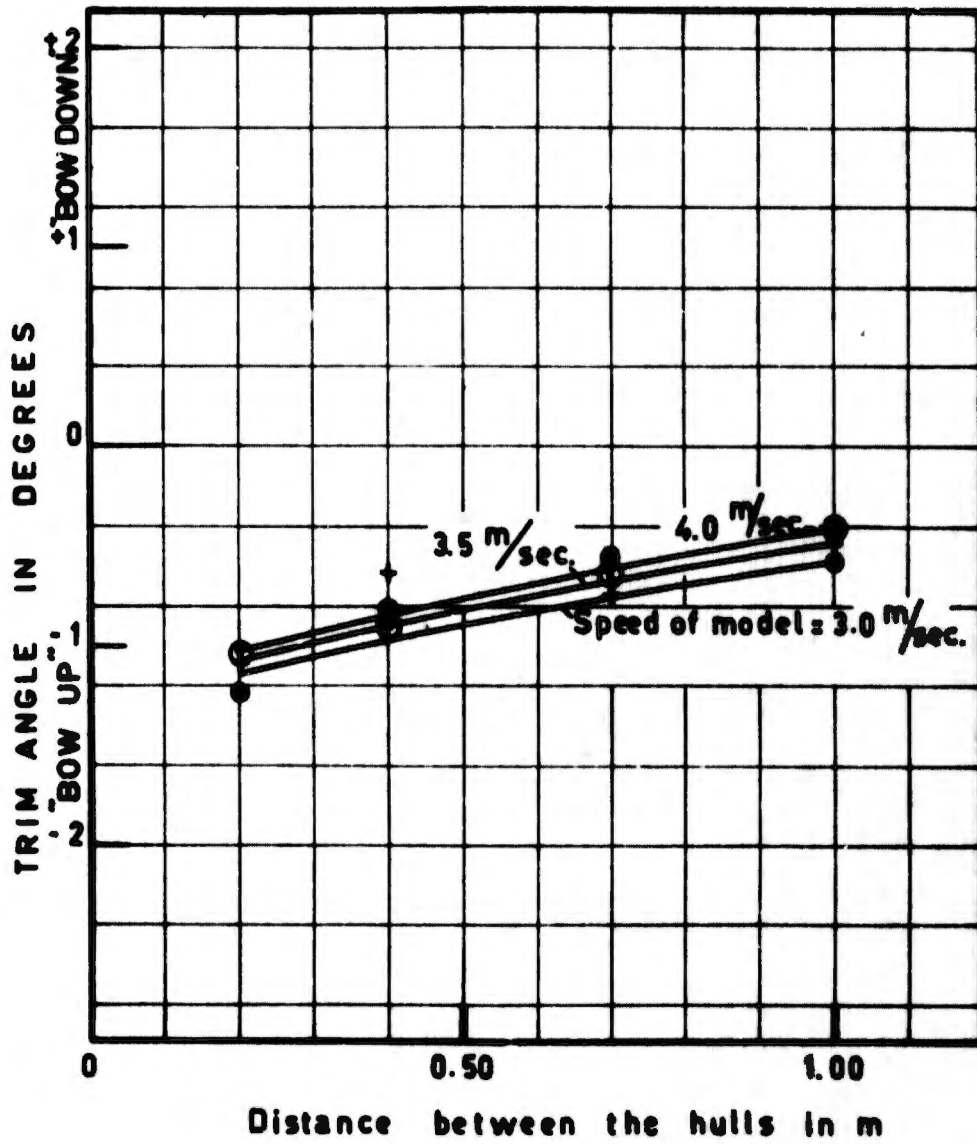
WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE

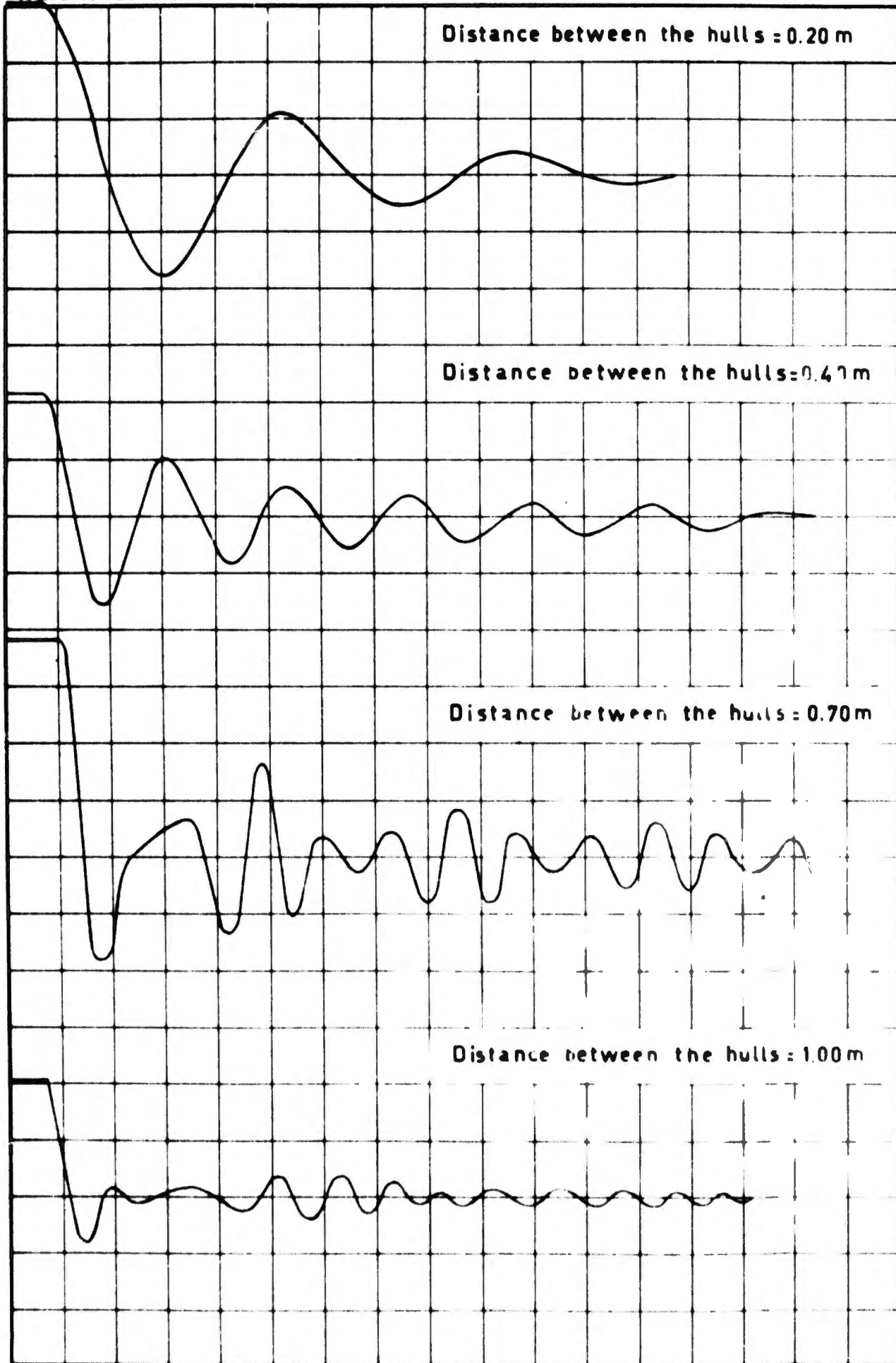
SMOOTH WATER — TRIM

WEIGHT DISTRIBUTION II



WEIGHT DISTRIBUTION I

SPEED OF MODEL ZERO



1 sec

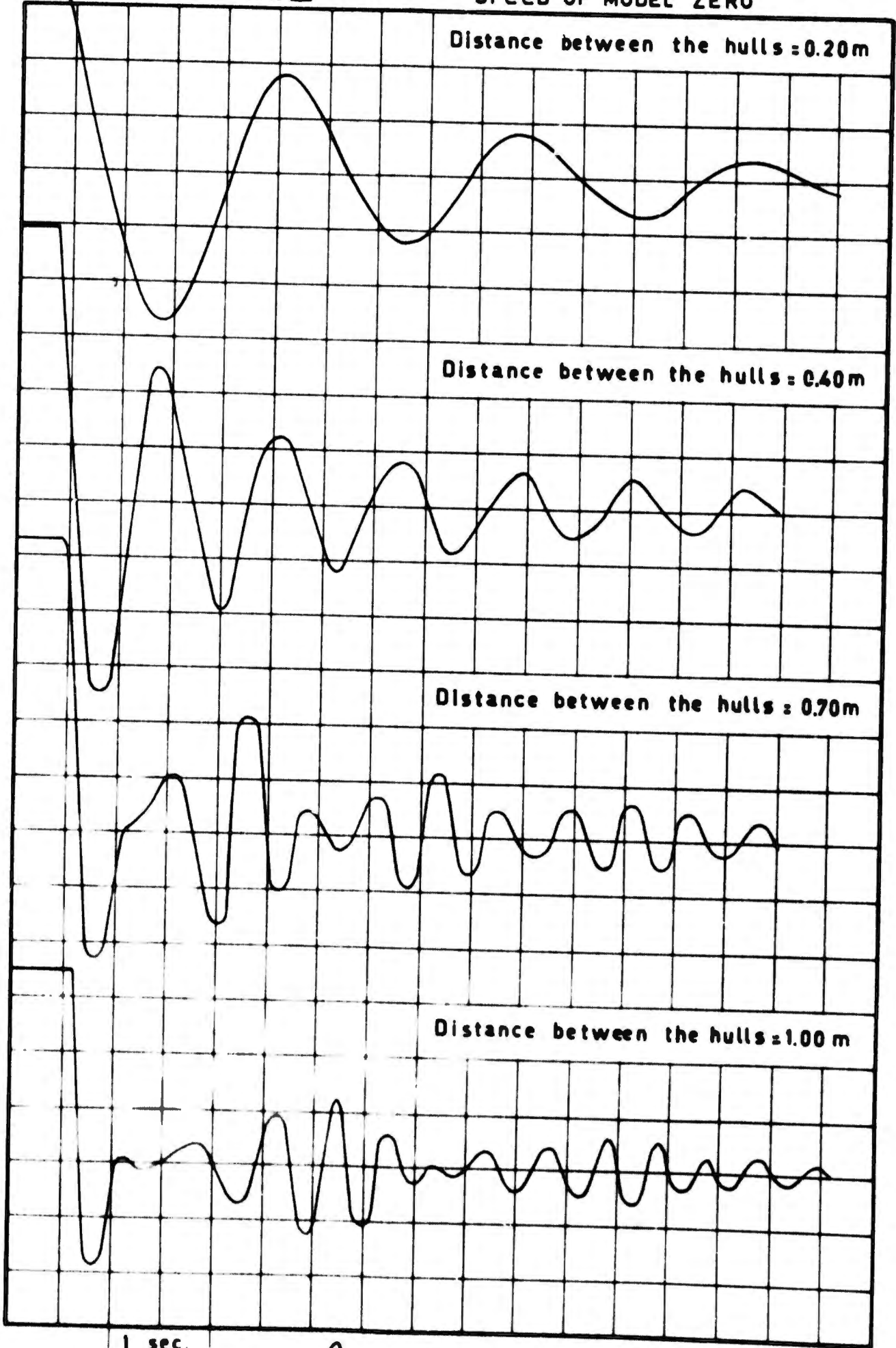
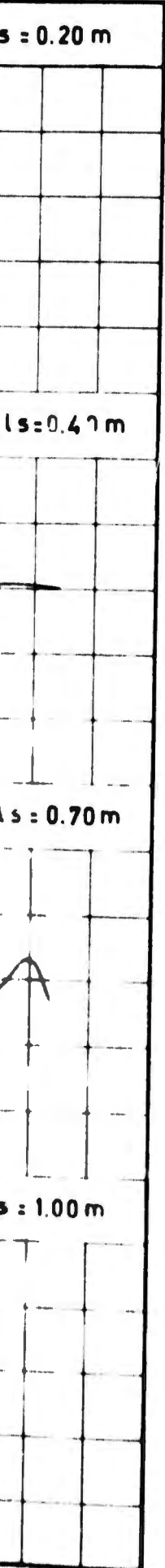
A

CATAMARAN SEAPLANE

ROLL EXTINCTION

WEIGHT DISTRIBUTION II

SPEED OF MODEL ZERO

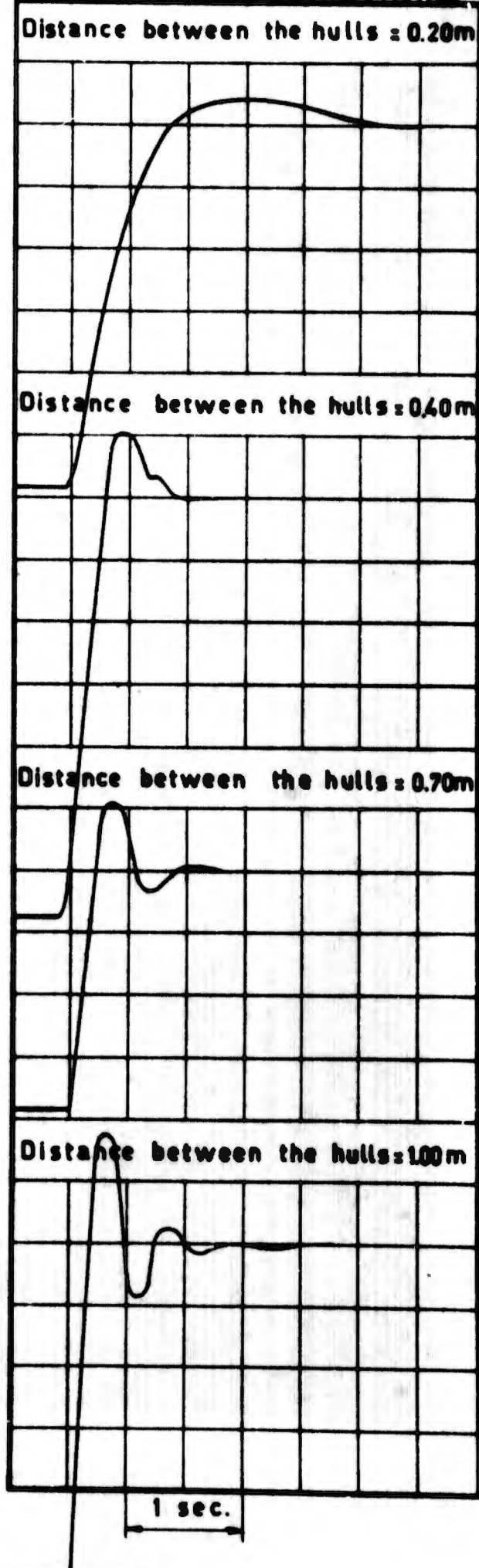
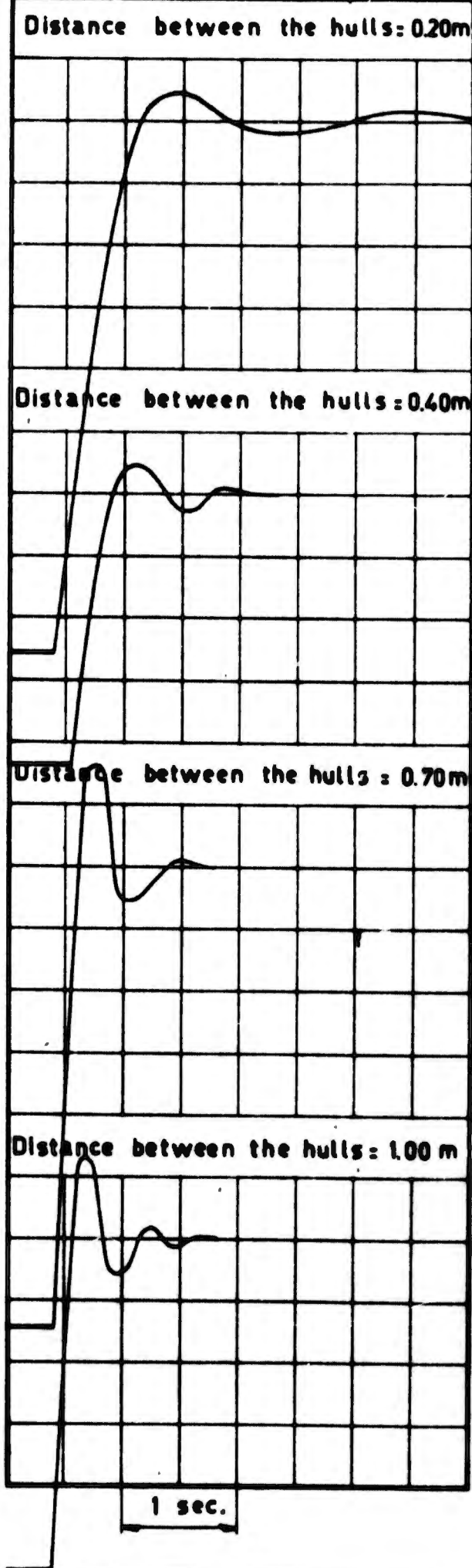


B

CATAMARAN SEAPLANE

ROLL EXTINCTION

WEIGHT DISTRIBUTION I - SPEED OF MODEL = 3.5 m/sec. - WEIGHT DISTRIBUTION II

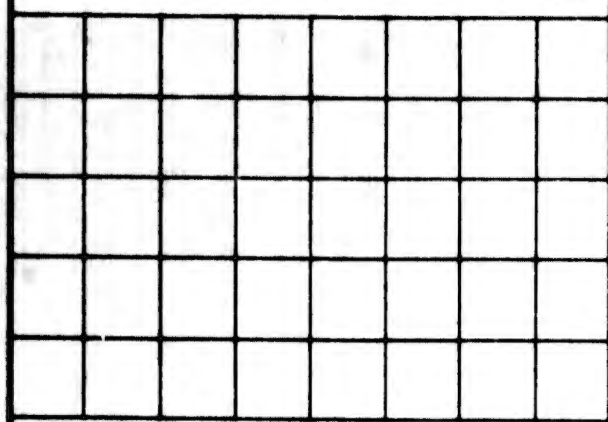


CATAMARAN SEAPLANE

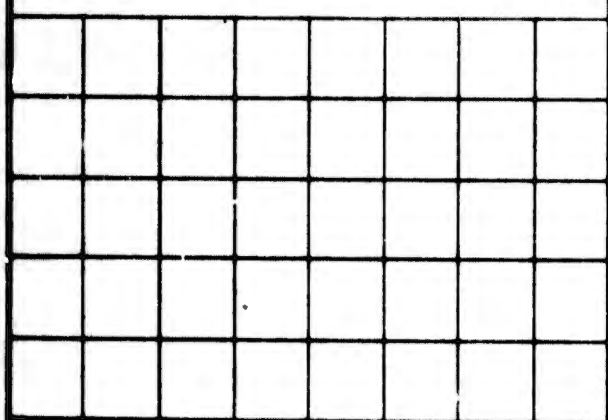
ROLL EXTINCTION

WEIGHT DISTRIBUTION I - SPEED OF MODEL: 4.0 m/sec. - WEIGHT DISTRIBUTION II

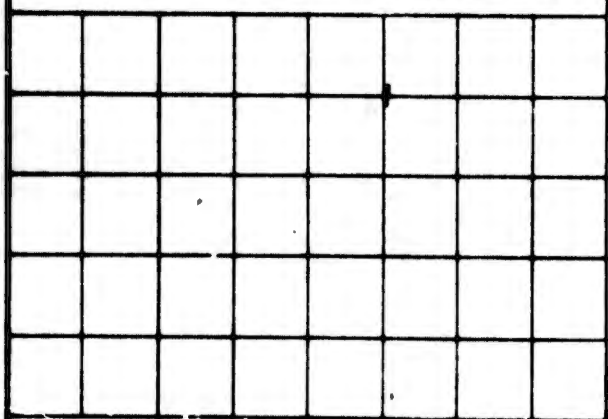
Distance between the hulls: 0.20m



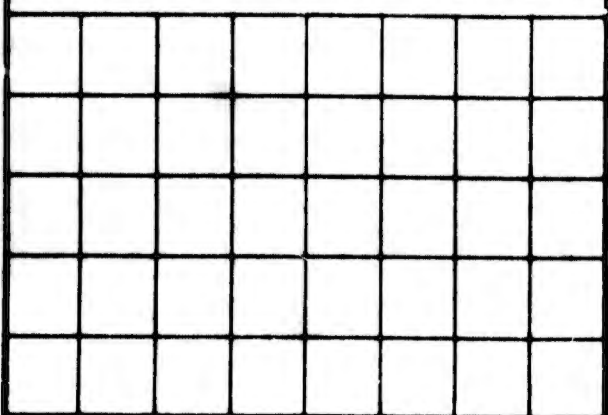
Distance between the hulls: 0.40m



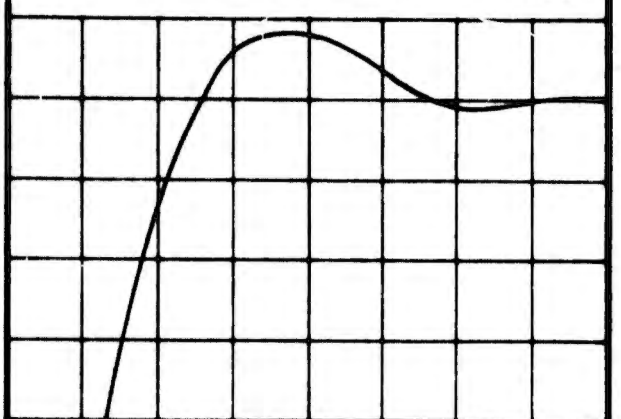
Distance between the hulls: 0.70m



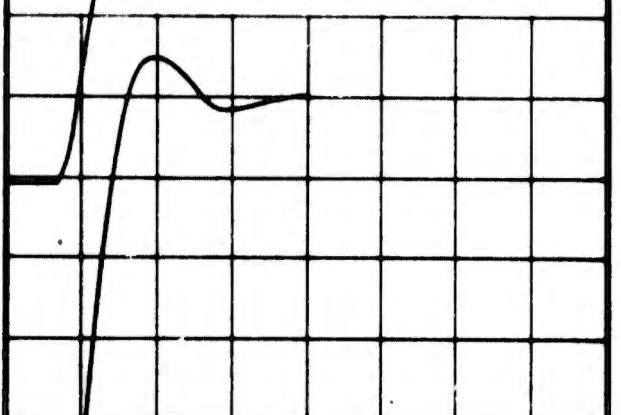
Distance between the hulls: 1.00 m



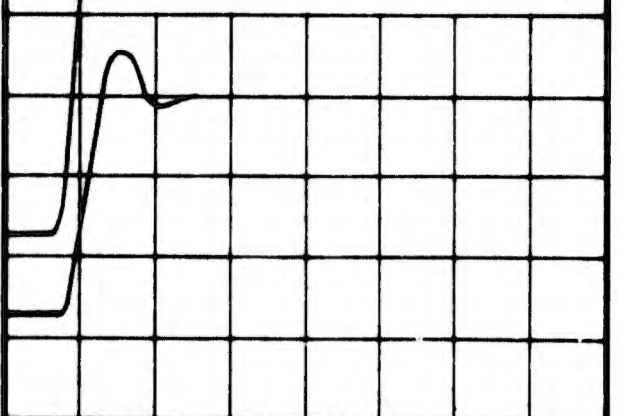
Distance between the hulls: 0.20m



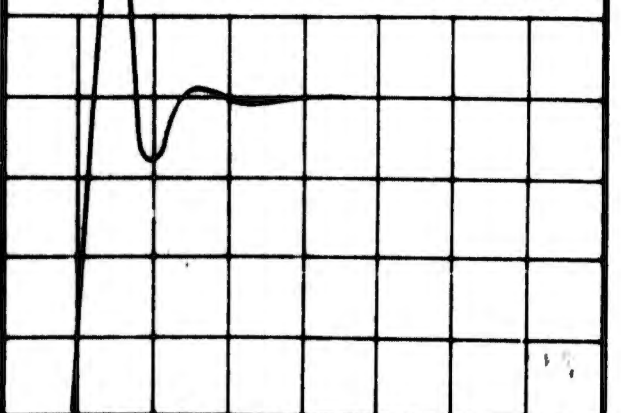
Distance between the hulls: 0.40m



Distance between the hulls: 0.70m



Distance between the hulls: 1.00m



1 sec.

WEIGHT DISTRIBUTION I

SPEED OF MODEL ZERO

WEIGHT DISTRIB

Distance between the hulls = 0.20 m

Distance between the hulls = 0.40 m

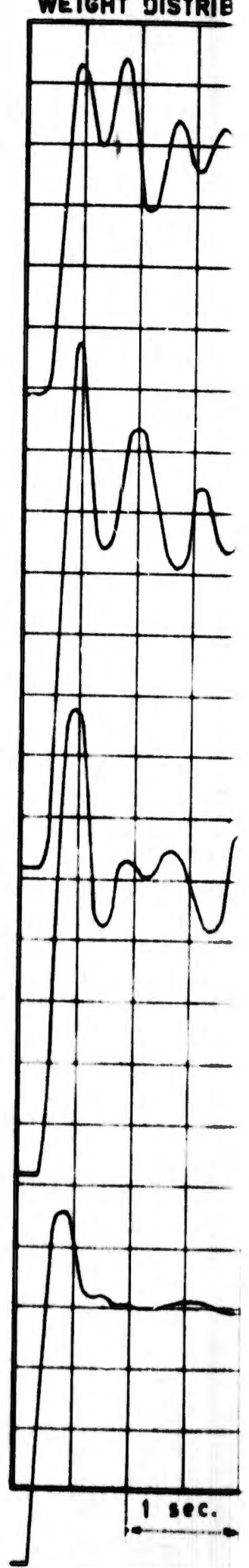
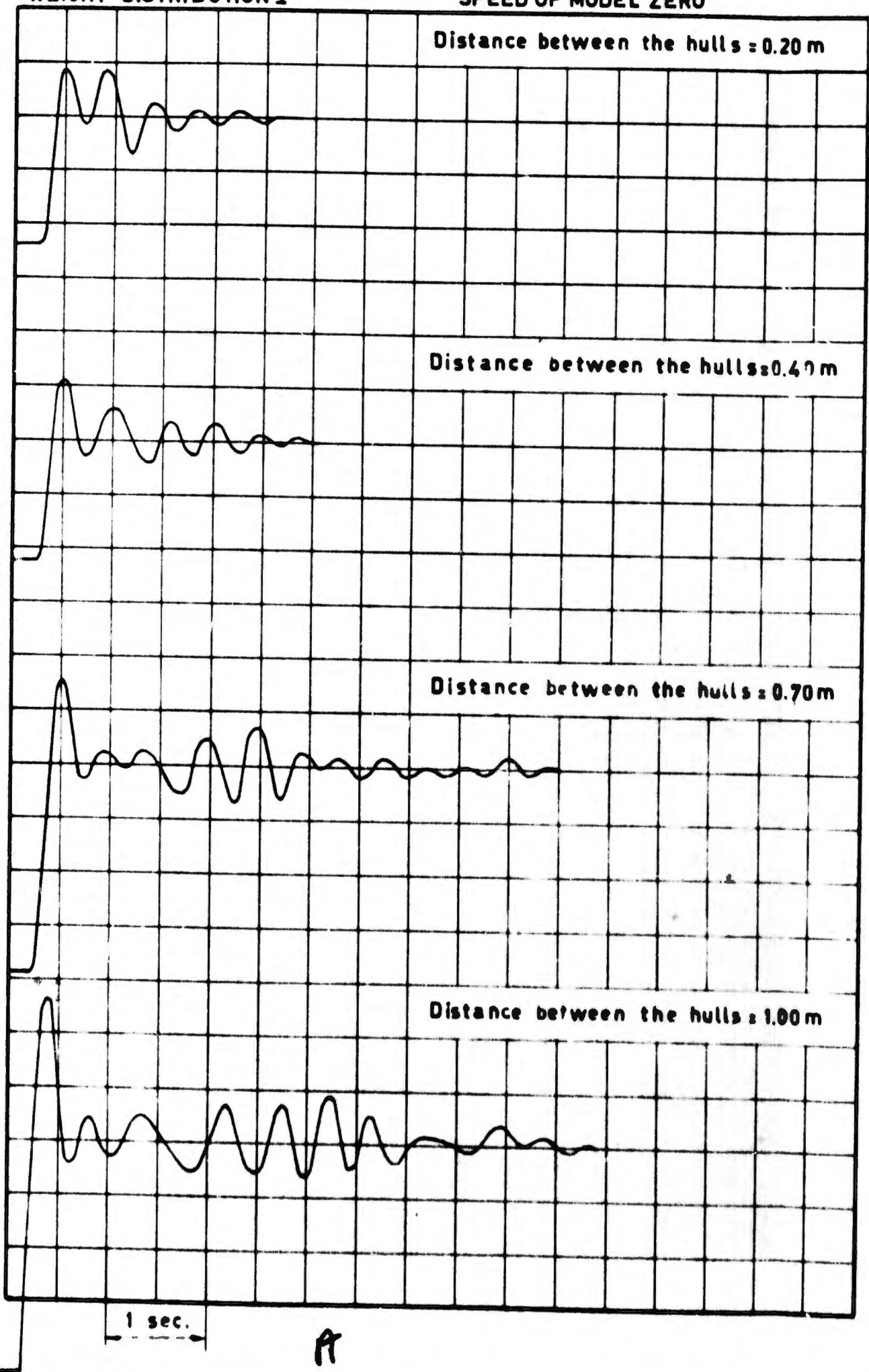
Distance between the hulls = 0.70 m

Distance between the hulls = 1.00 m

1 sec.

A

1 sec.



CATAMARAN SEAPLANE

HEAVE EXTINCTION

ZERO

WEIGHT DISTRIBUTION II

SPEED OF MODEL ZERO

Distance between the hulls = 0.20 m

Distance between the hulls = 0.20 m

Distance between the hulls = 0.40 m

Distance between the hulls = 0.40 m

Distance between the hulls = 0.70 m

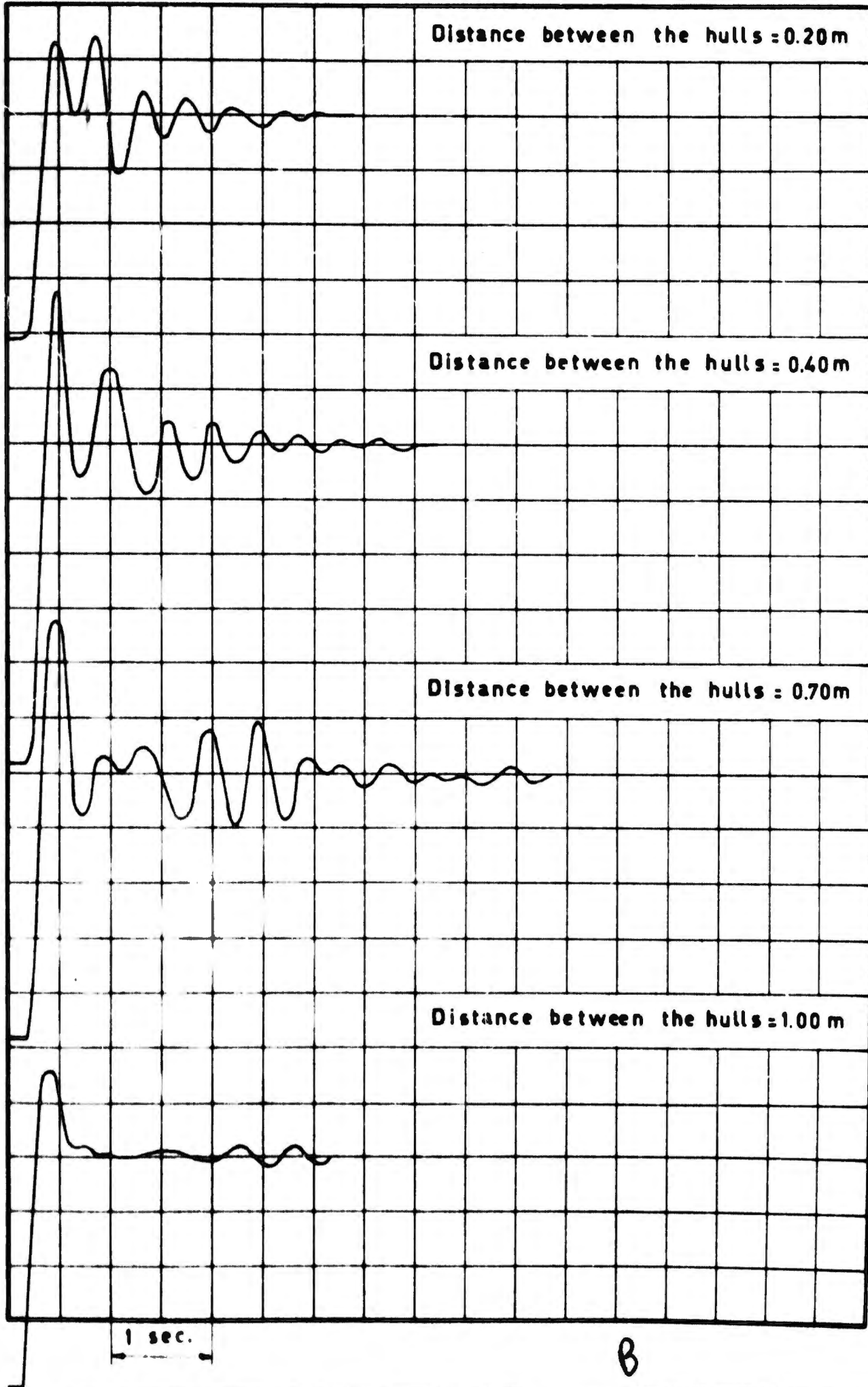
Distance between the hulls = 0.70 m

Distance between the hulls = 1.00 m

Distance between the hulls = 1.00 m

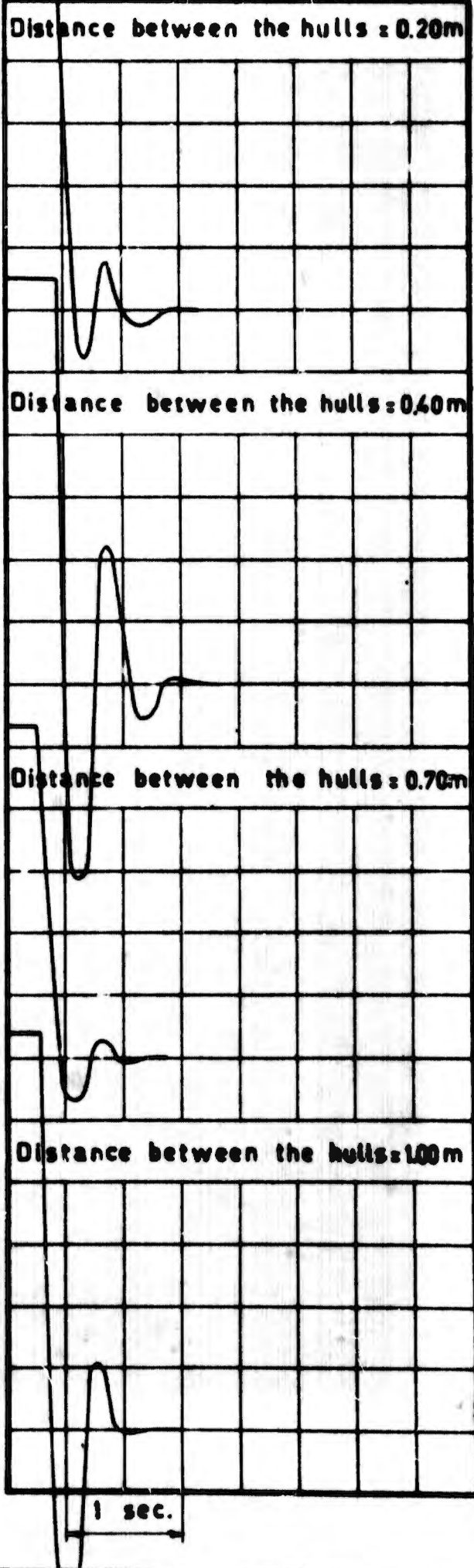
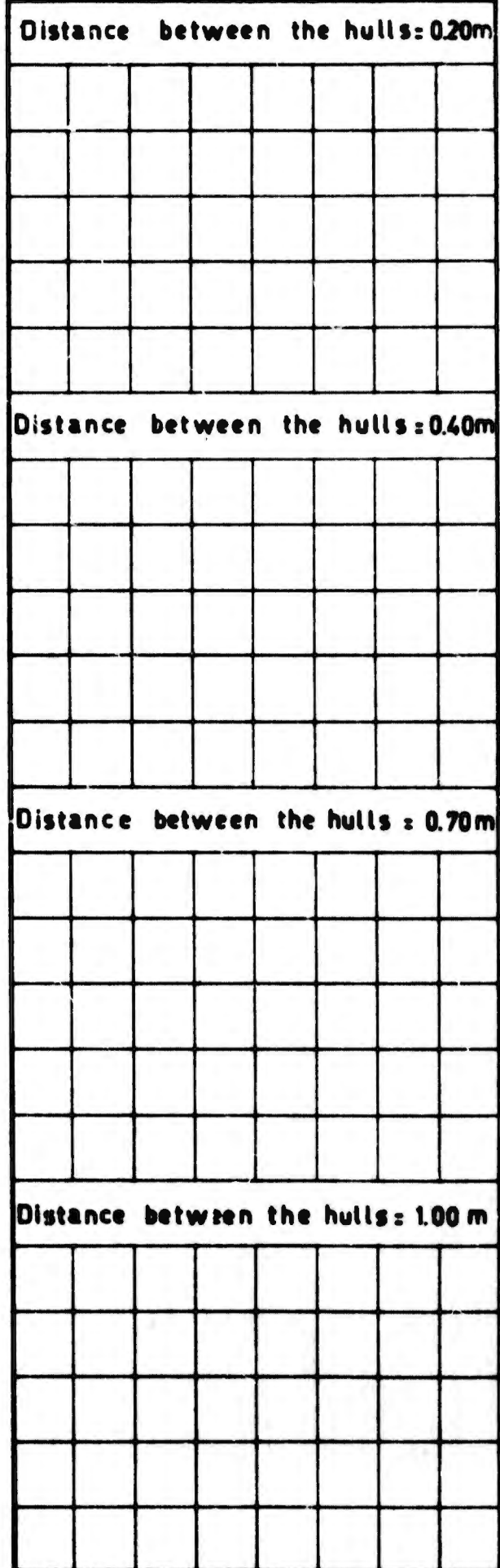
1 sec.

B



CATAMARAN SEAPLANE
HEAVE EXTINCTION

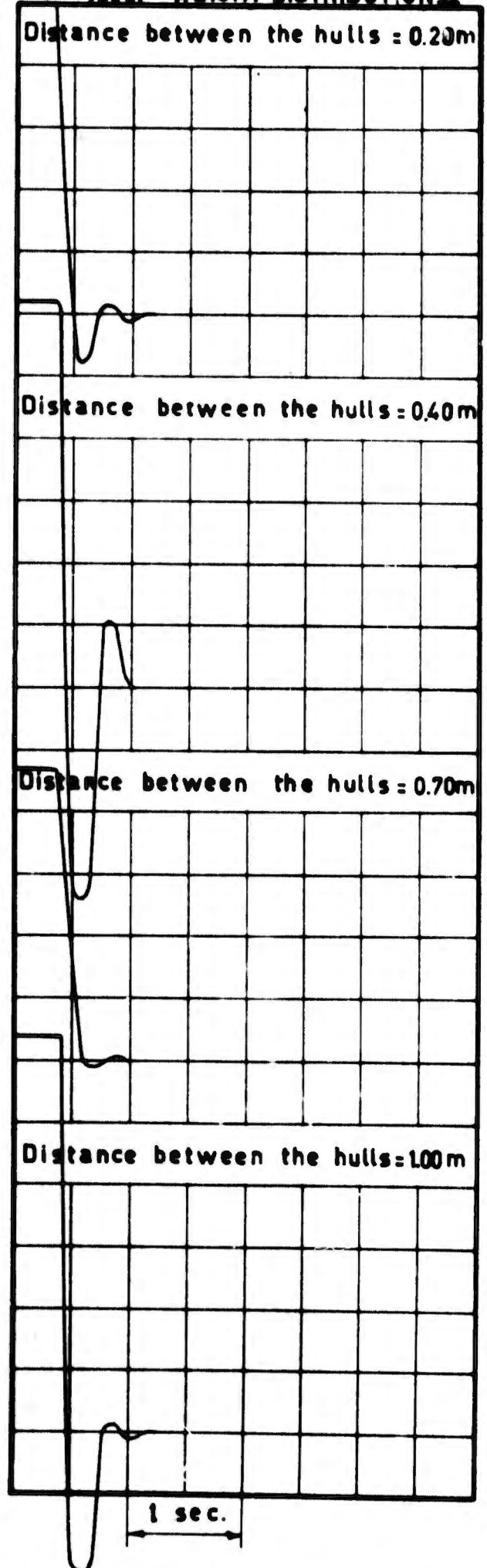
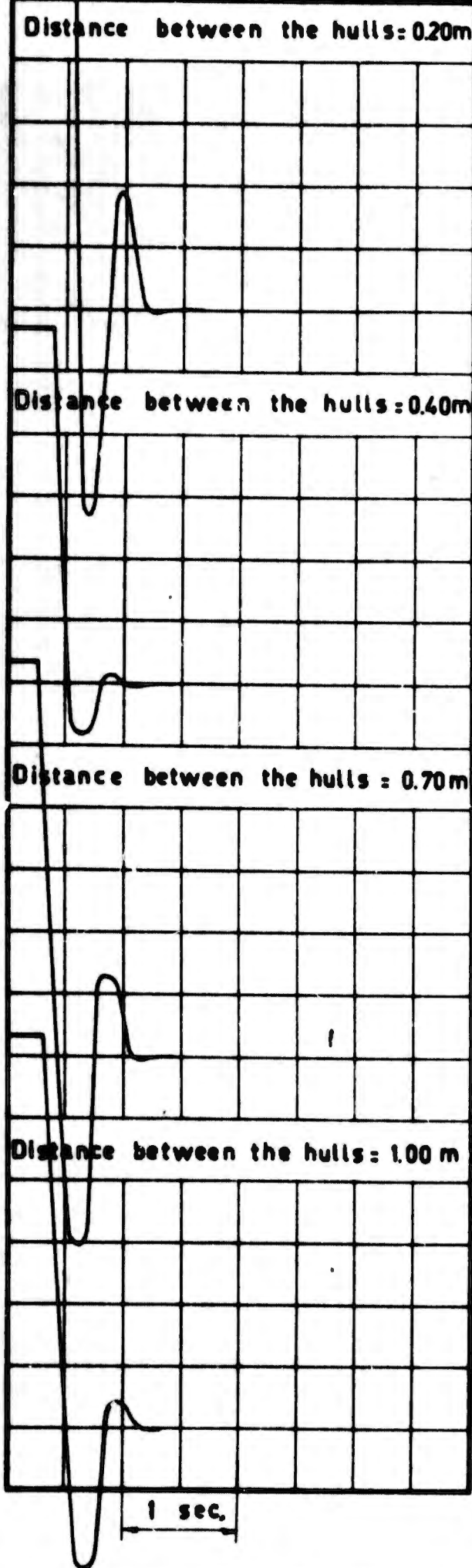
WEIGHT DISTRIBUTION I - SPEED OF MODEL = 3.0 m/sec. - WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE

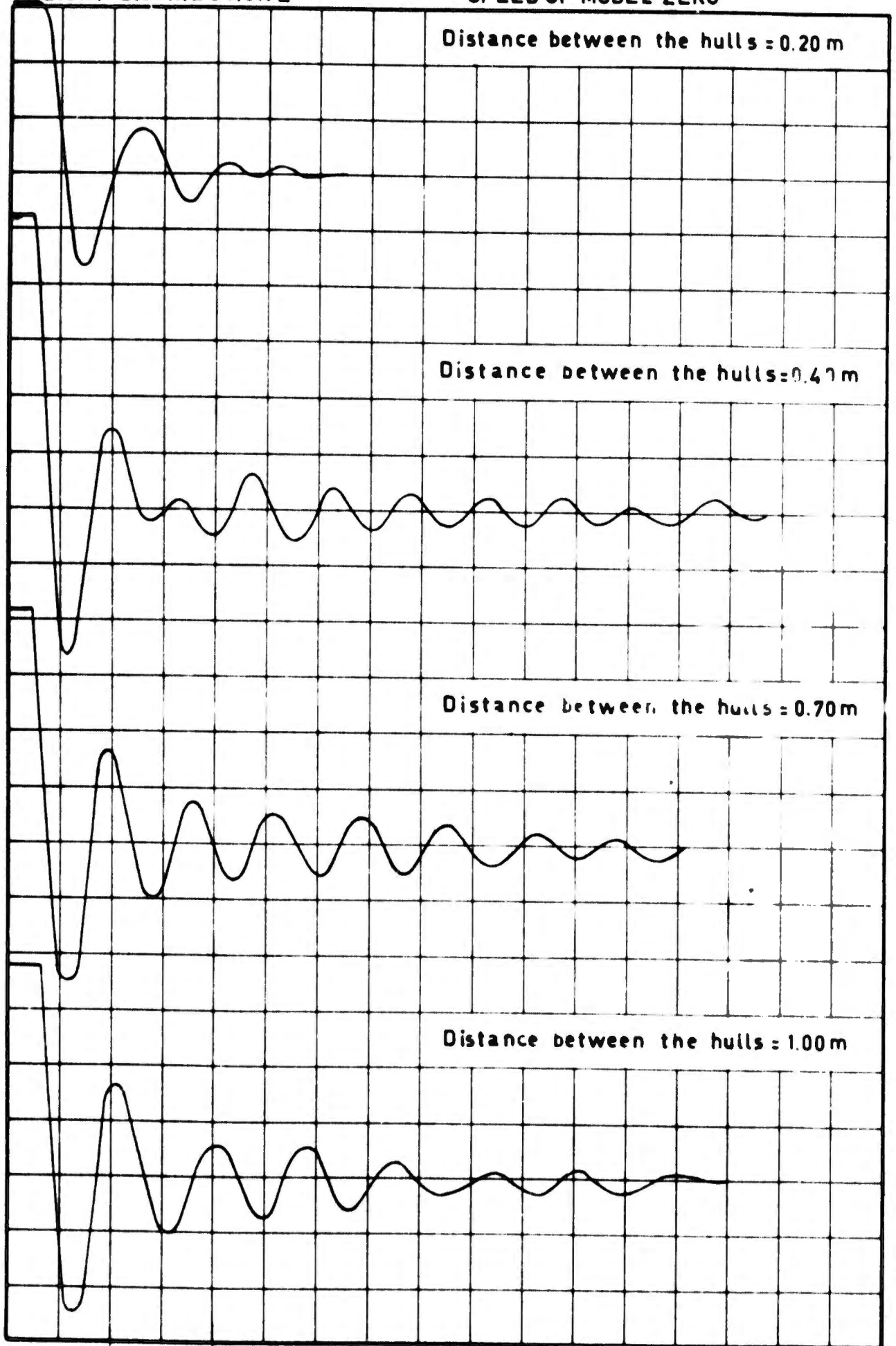
HEAVE EXTINCTION

WEIGHT DISTRIBUTION I - SPEED OF MODEL: 3.5 m/sec. - WEIGHT DISTRIBUTION II



WEIGHT DISTRIBUTION I

SPEED OF MODEL ZERO



1 sec.

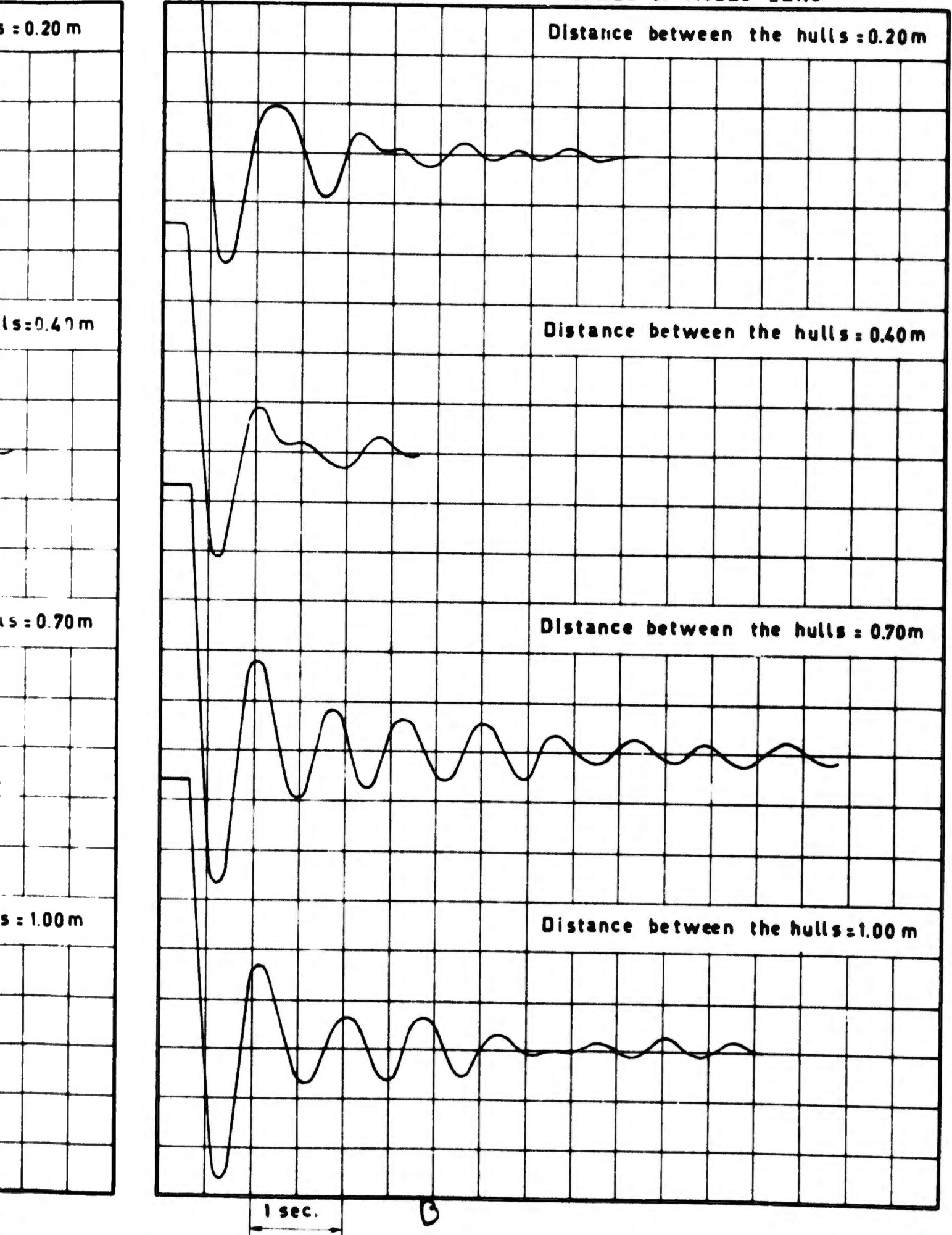
A

CATAMARAN SEAPLANE

PITCH EXTINCTION

WEIGHT DISTRIBUTION II

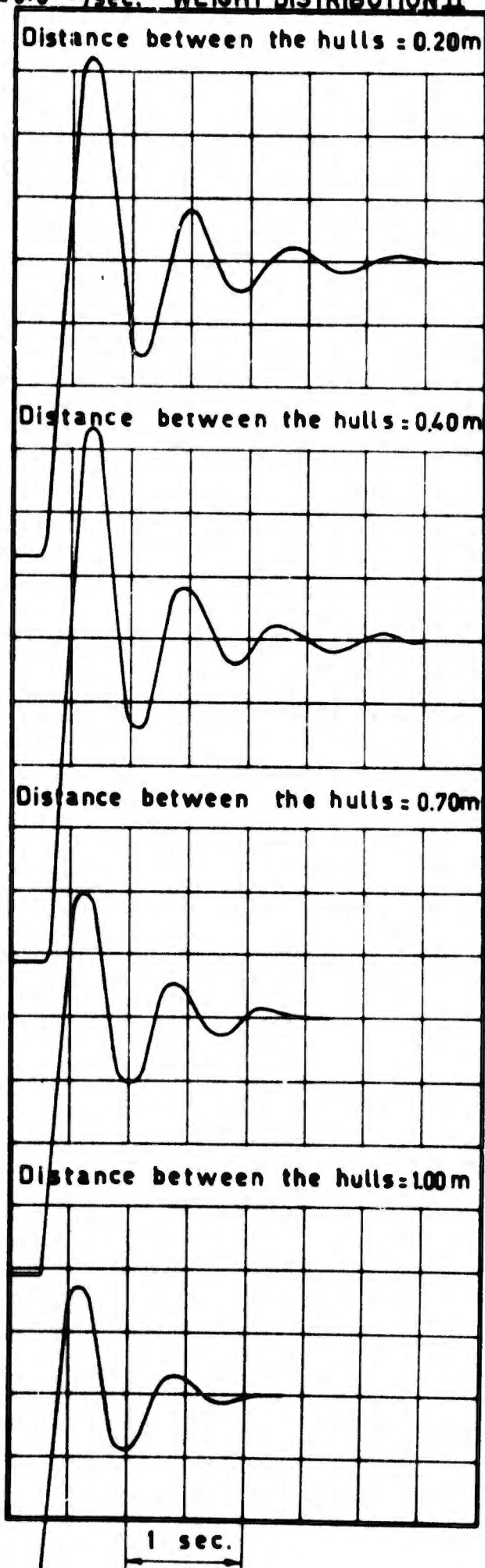
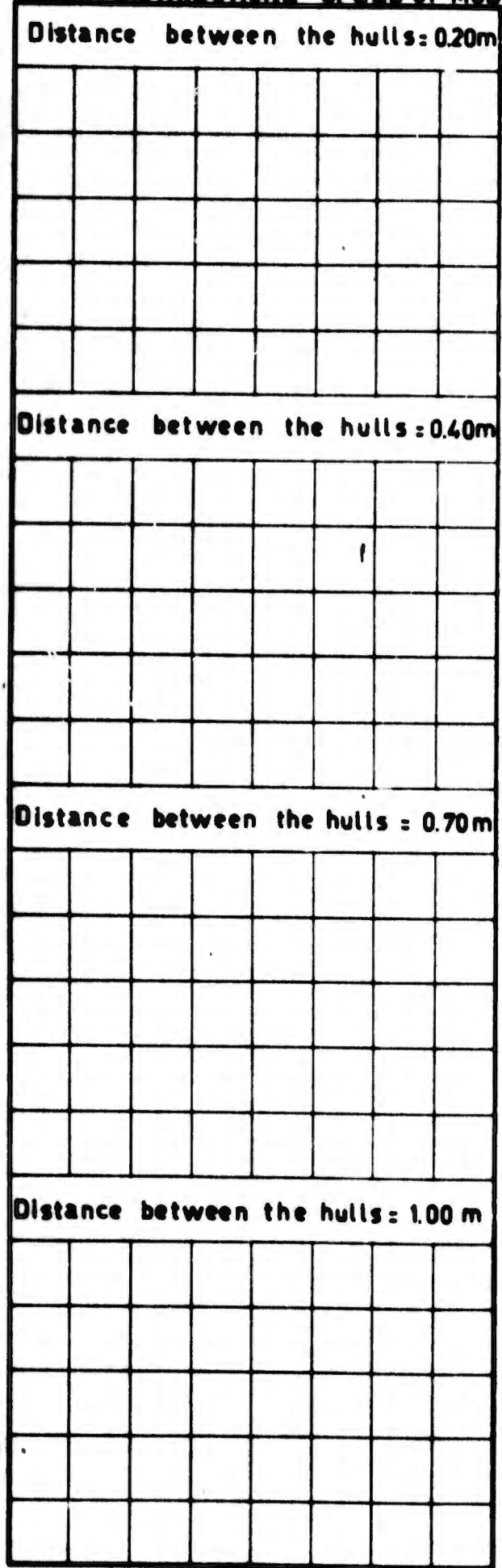
SPEED OF MODEL ZERO



CATAMARAN SEAPLANE

PITCH EXTINCTION

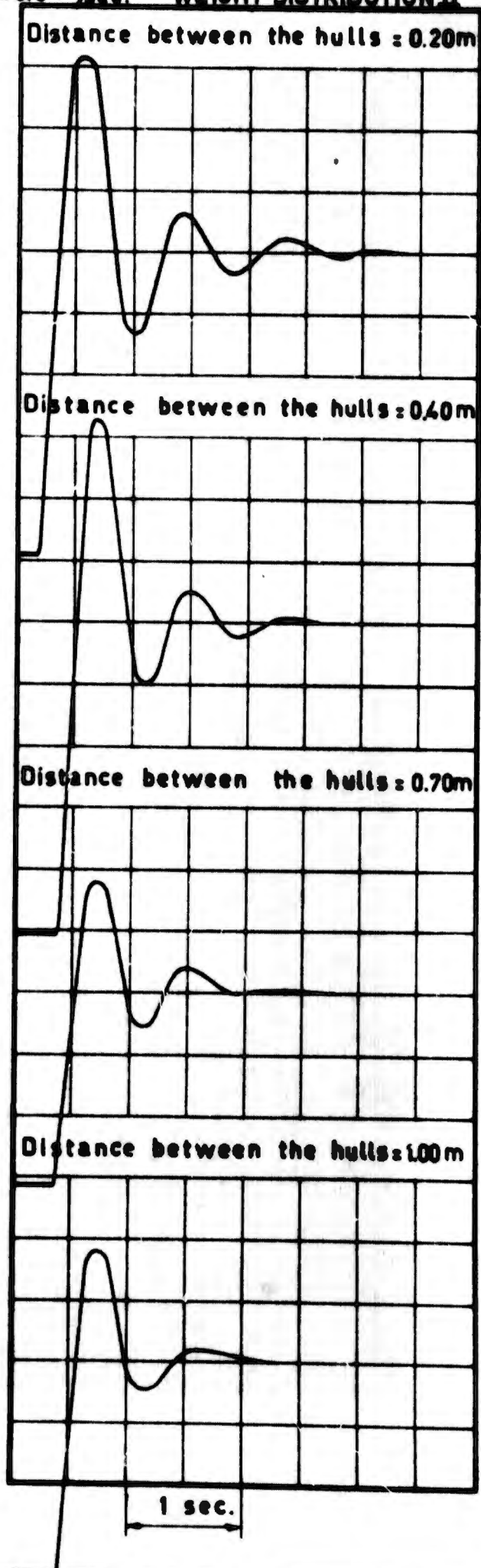
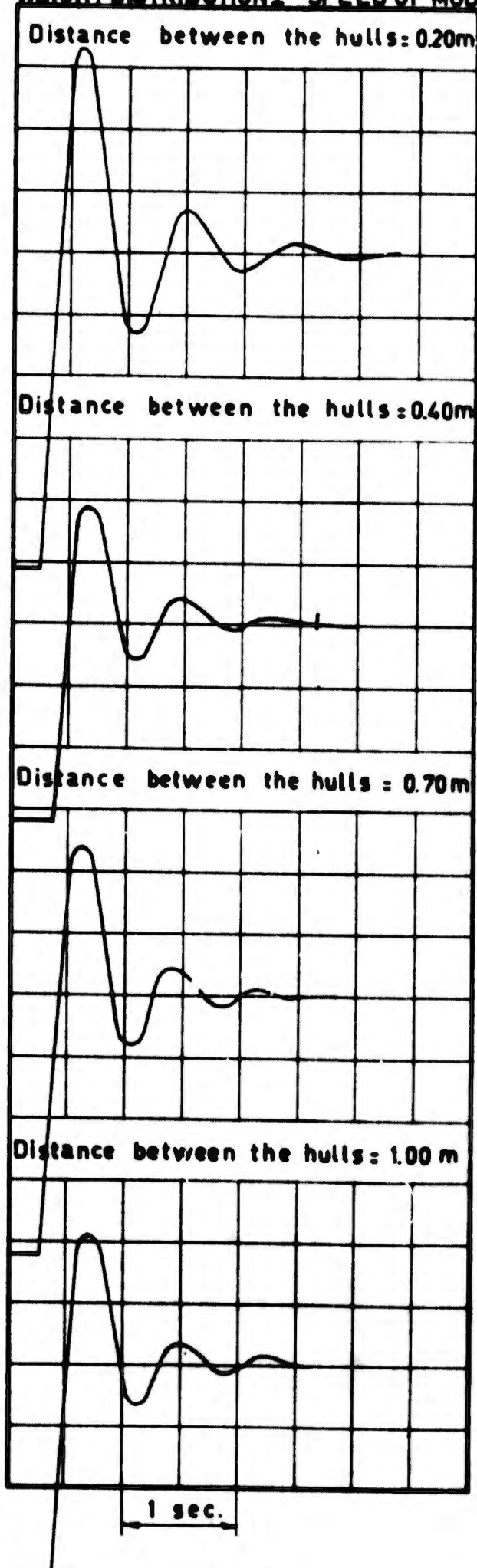
WEIGHT DISTRIBUTION I - SPEED OF MODEL = 3.0 m/sec. - WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE

PITCH EXTINCTION

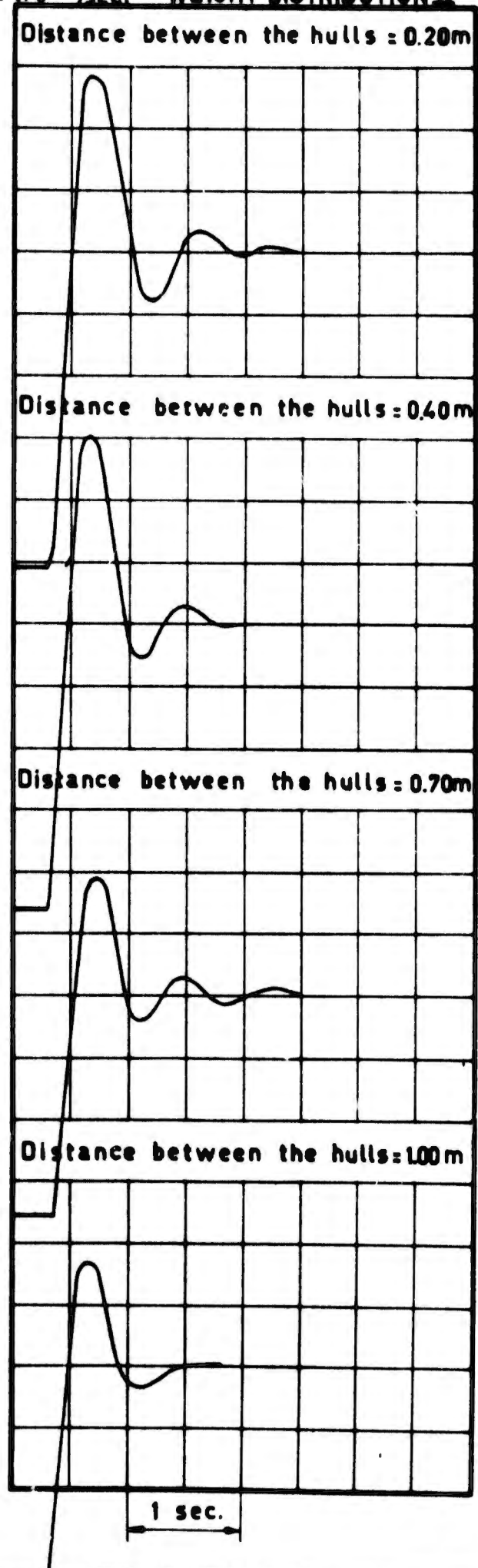
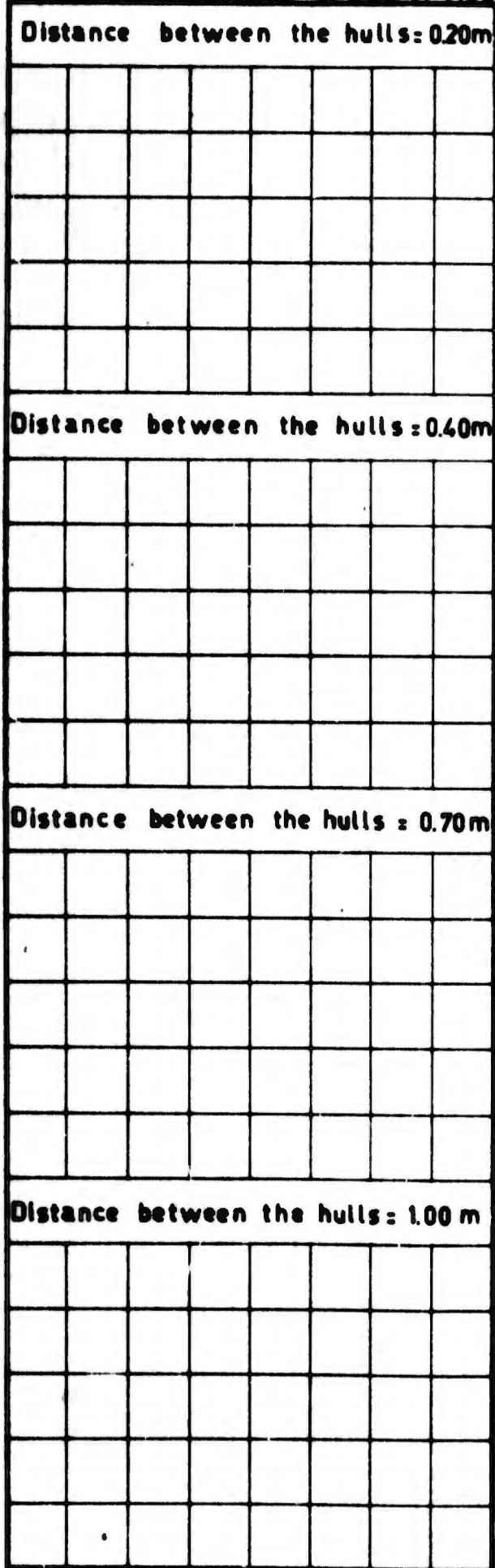
WEIGHT DISTRIBUTION I - SPEED OF MODEL: 3.5 m/sec. - WEIGHT DISTRIBUTION II



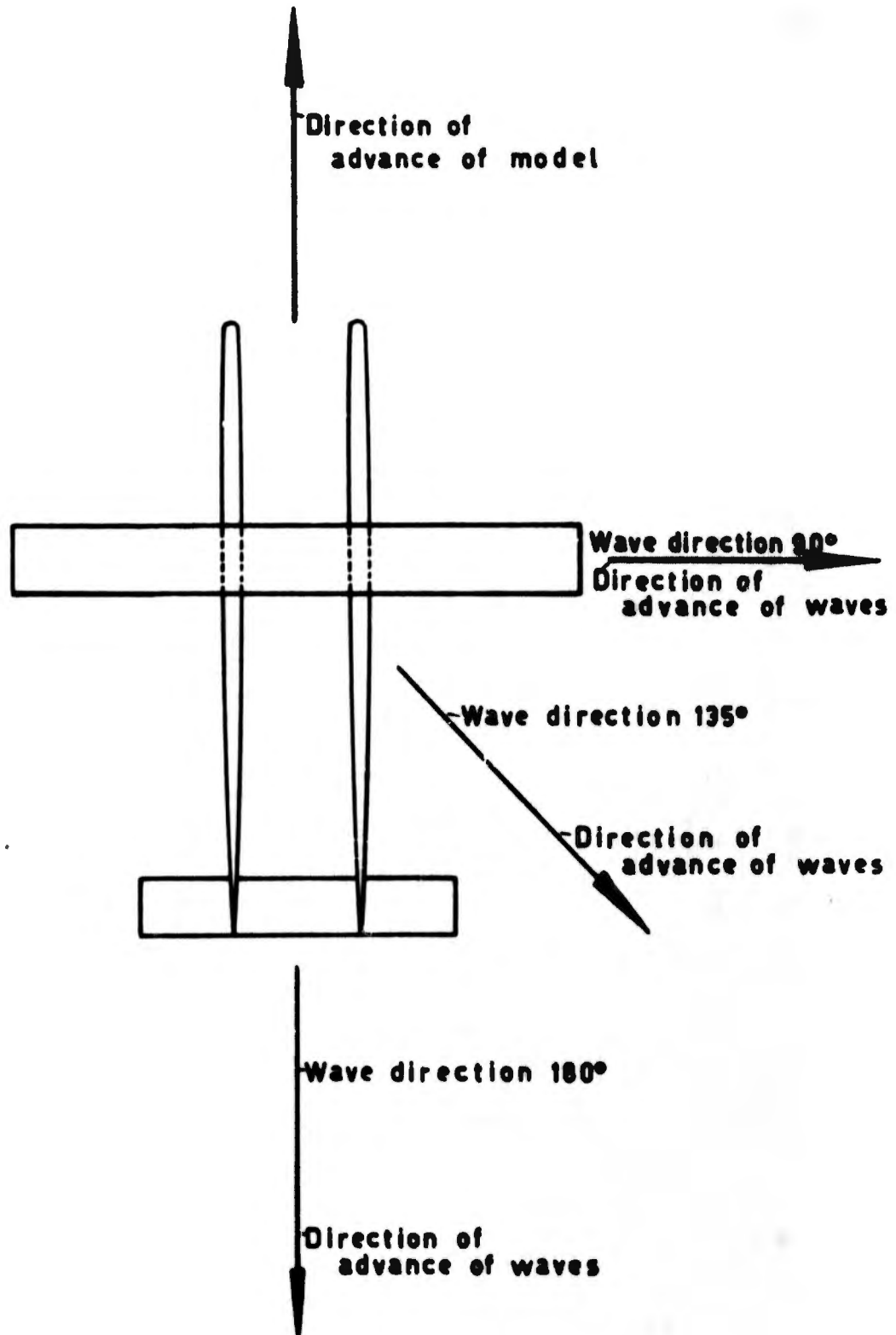
CATAMARAN SEAPLANE

PITCH EXTINCTION

WEIGHT DISTRIBUTION I - SPEED OF MODEL: 4.0 m/sec. - WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE



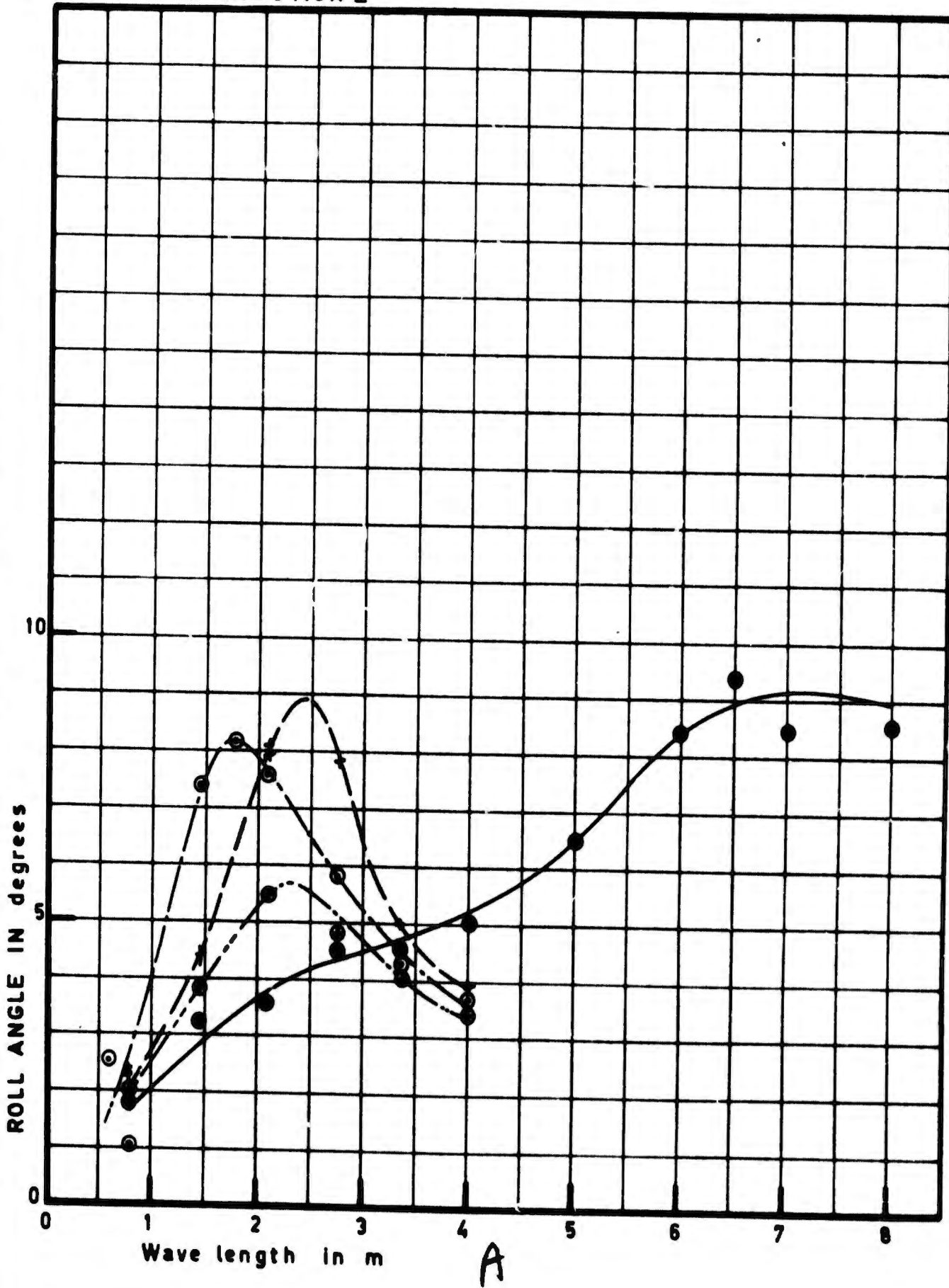
BLANK PAGE

WAVE DIRECTION 90°

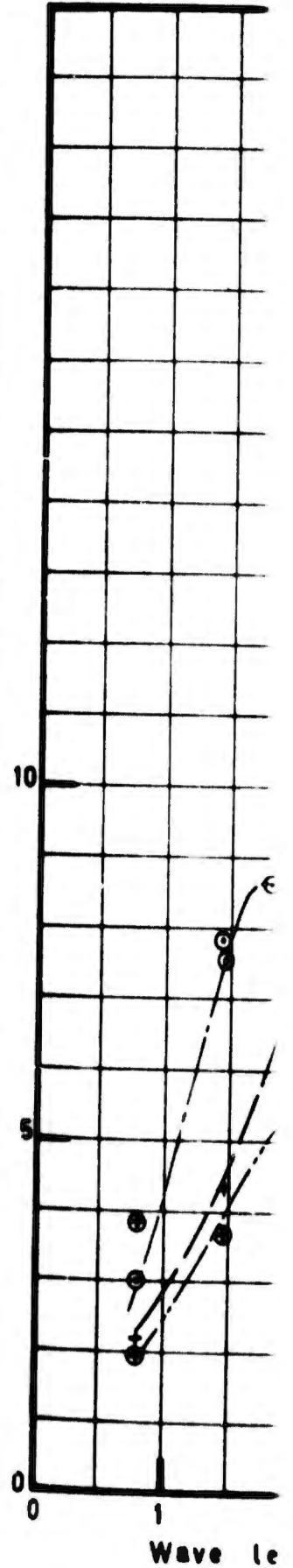
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- ⊙ - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I



WEIGHT DISTR



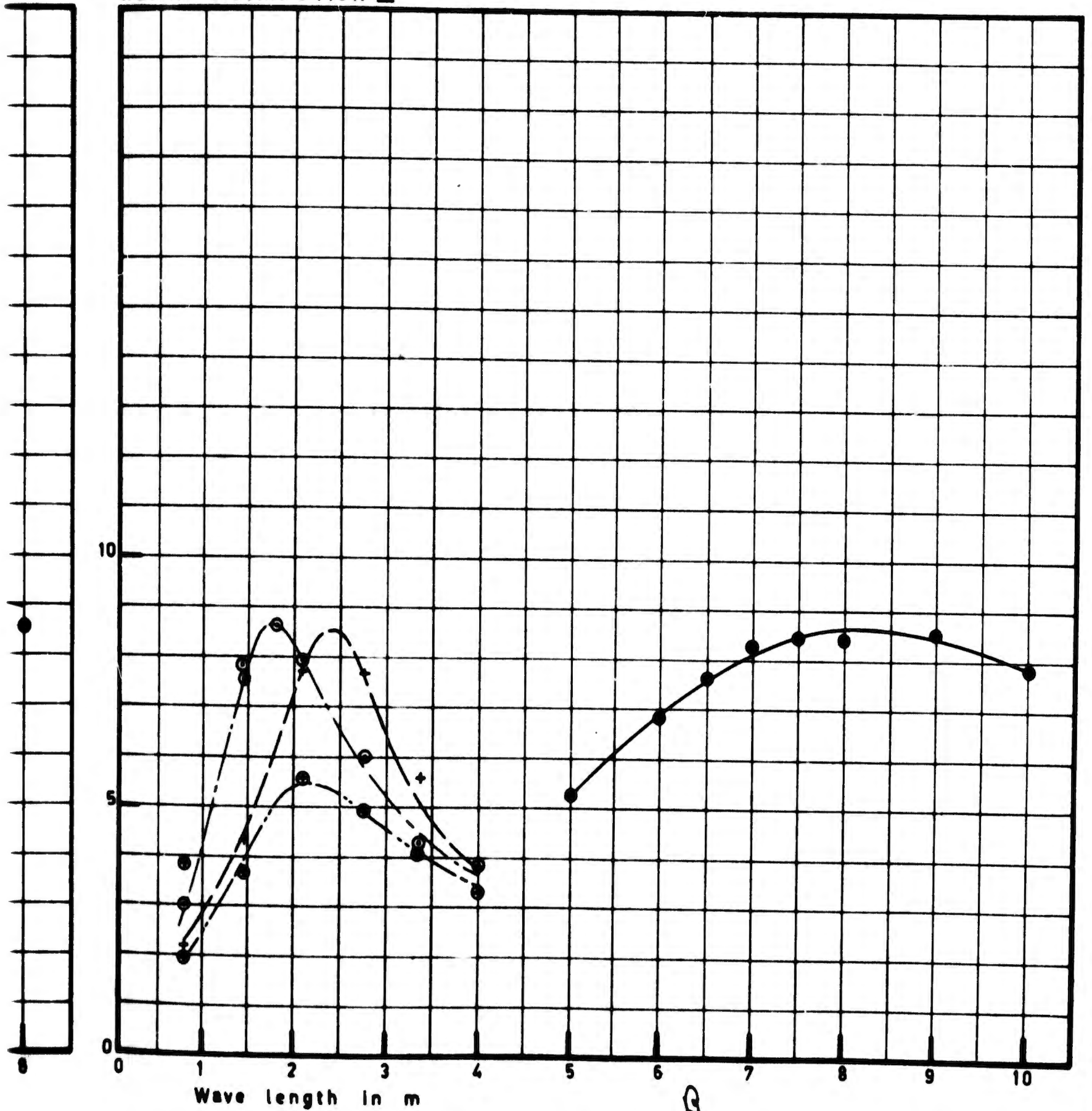
CATAMARAN SEAPLANE

ROLL ANGLES

(Double amplitudes)

0.20 m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II



PHASE LAG IN DEGREES

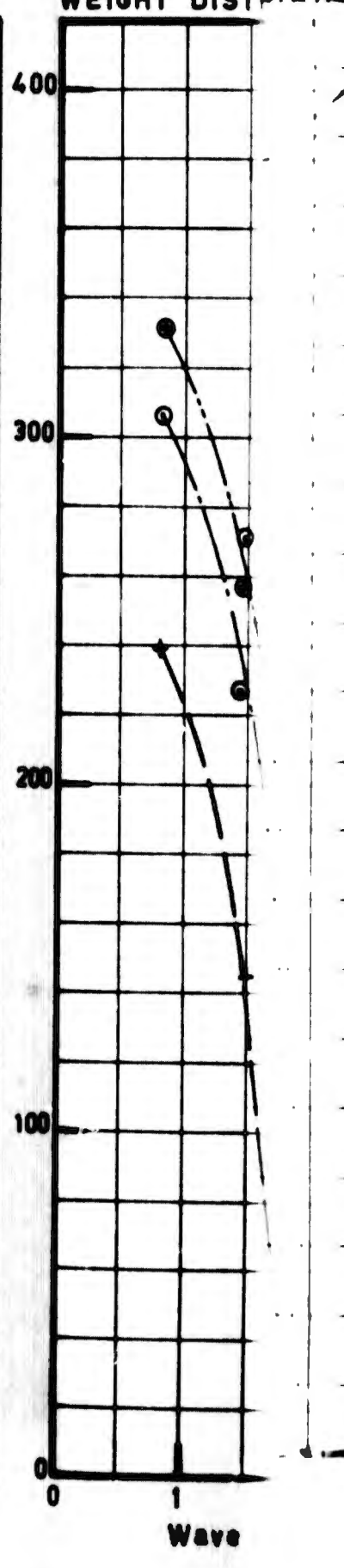
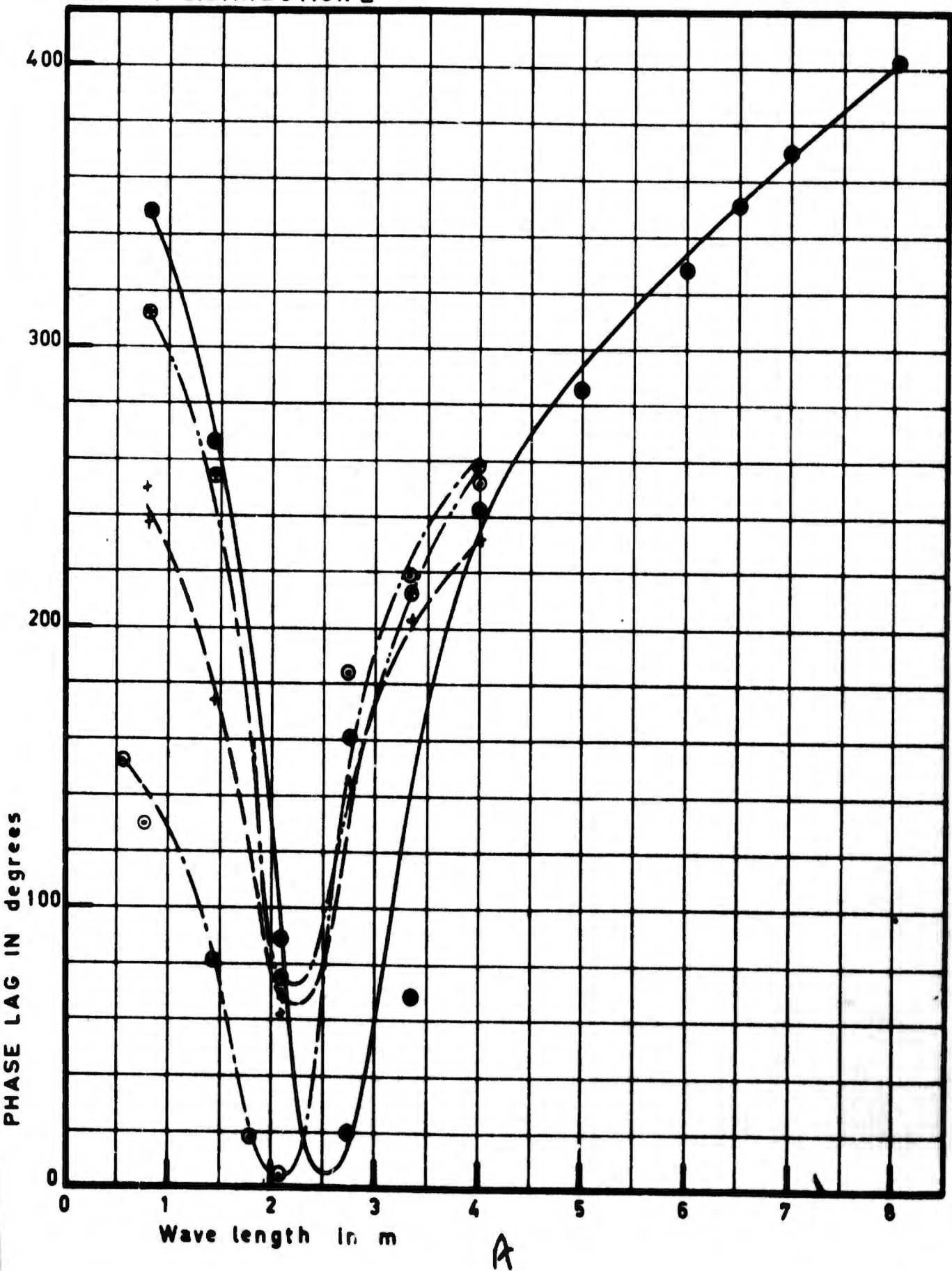
WAVE DIRECTION 90°

SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- ⊙ - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I

WEIGHT DISTRIBUTION II

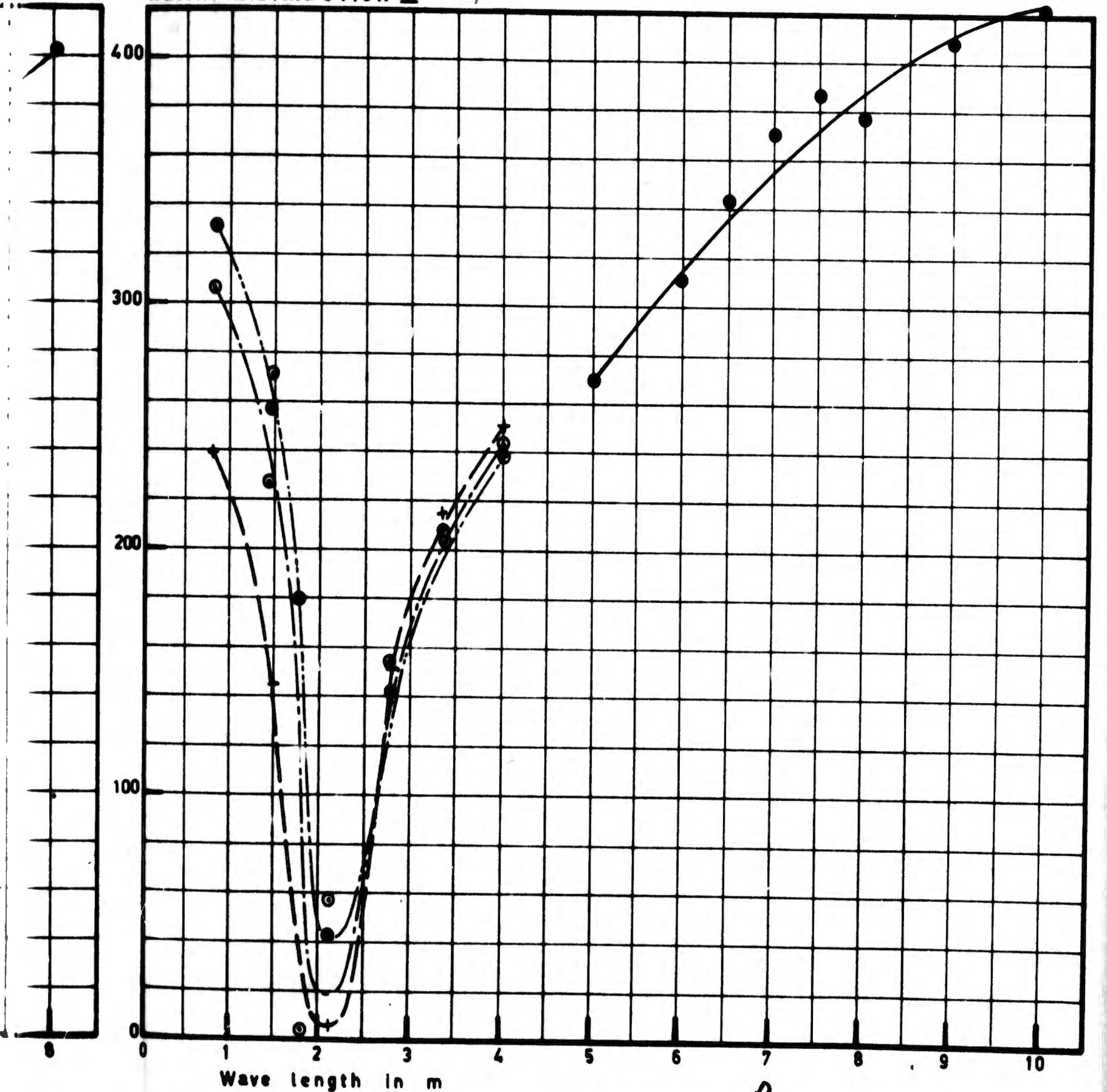


CATAMARAN SEAPLANE

PHASE LAG BETWEEN WAVE HEIGHT AND ROLL MOTION

$\sigma = 0.20$ m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II



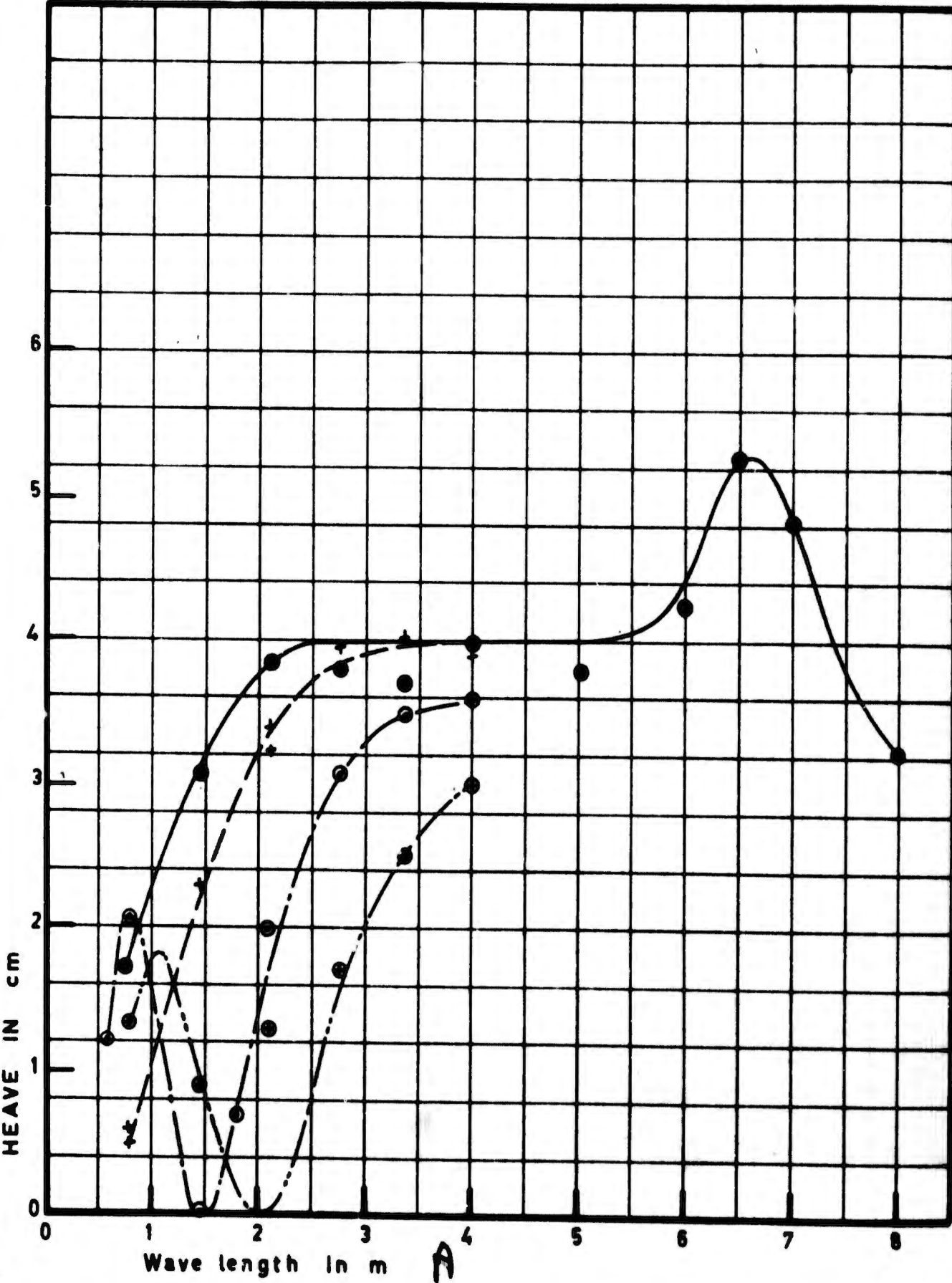
B

HEAVE IN CM

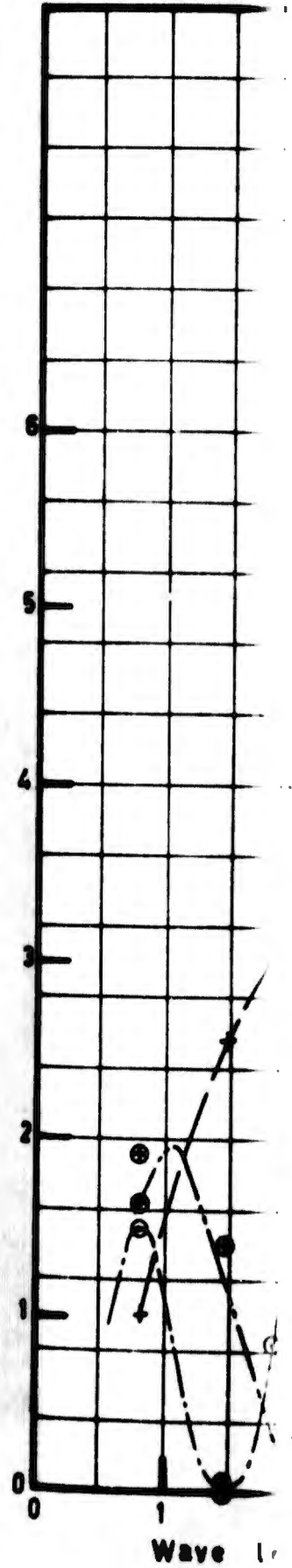
WAVE DIRECTION 90°
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 .
- + - - - - - 0.40 m.
- ⊙ - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I



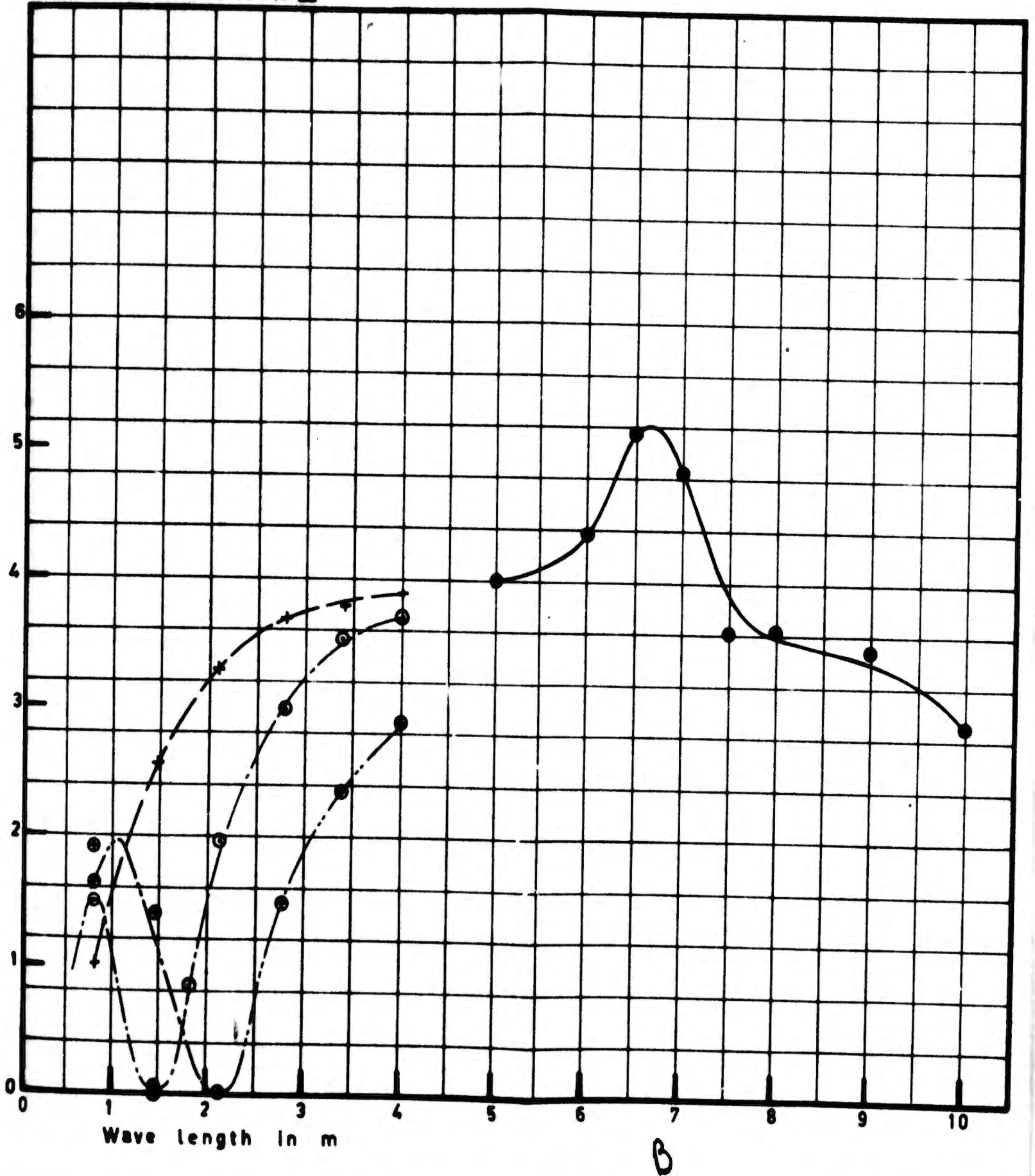
WEIGHT DISTR



CATAMARAN SEAPLANE

HEAVE
(Double amplitudes)

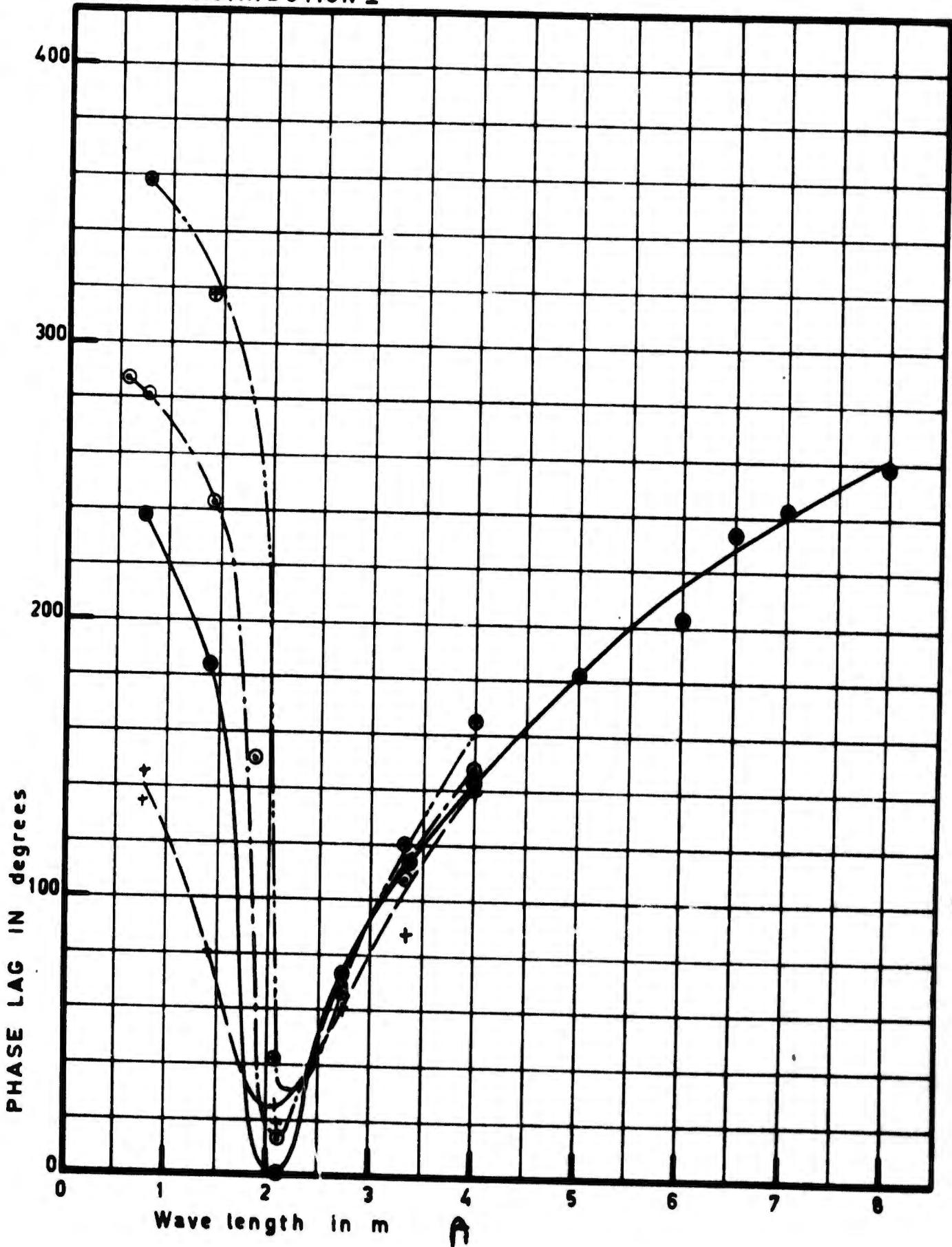
WEIGHT DISTRIBUTION II



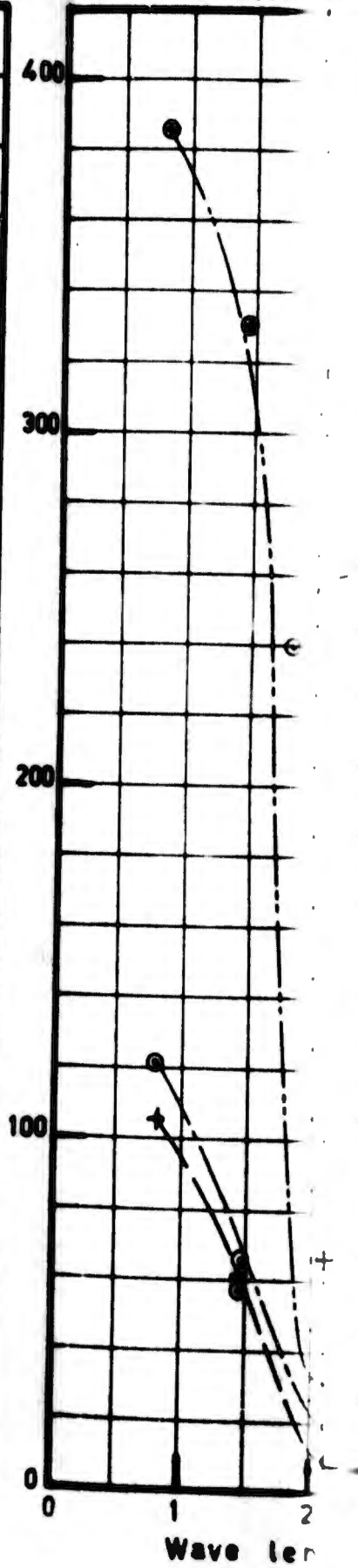
WAVE DIRECTION 90°
SPEED OF MODEL ZERO

● ————— Distance between the hulls: 0.20 m
 + ———— 0.40 m
 ⊙ - - - - 0.70 m
 ⊕ - · - · - 1.00 m

WEIGHT DISTRIBUTION I



WEIGHT DISTRIBUTION II

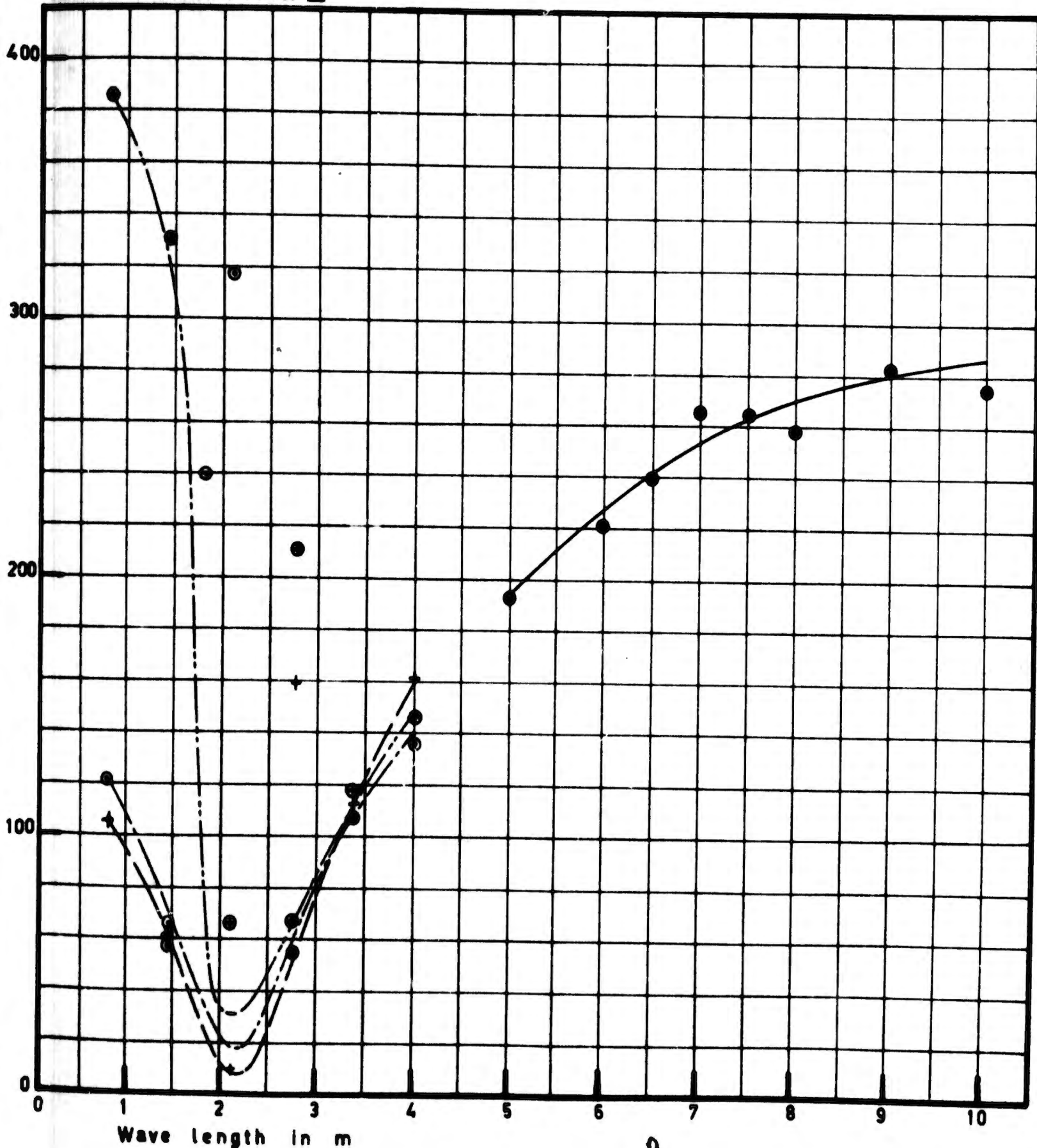


CATAMARAN SEAPLANE

PHASE LAG BETWEEN WAVE HEIGHT AND HEAVE MOTION

0.20 m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II



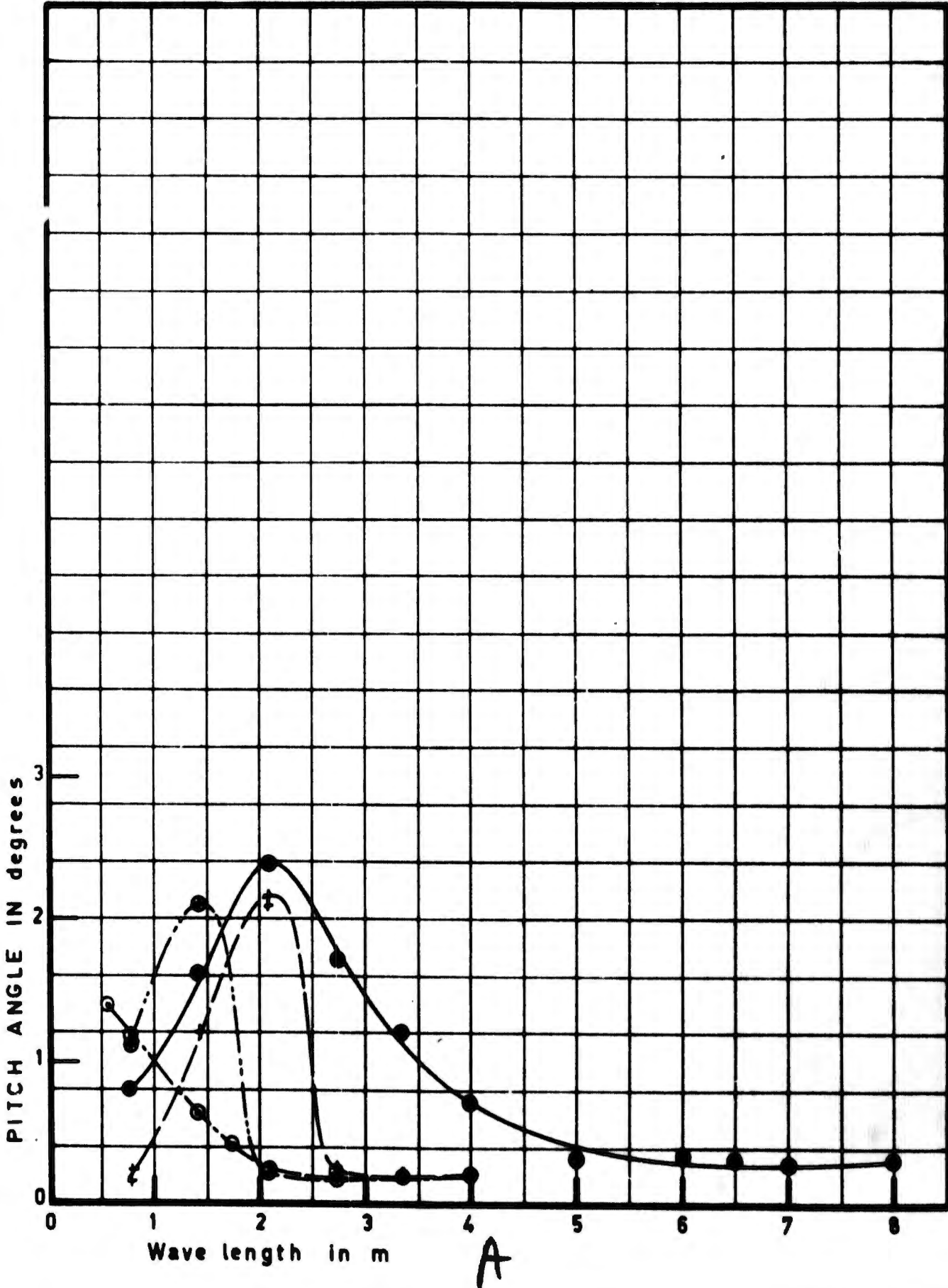
B

WAVE DIRECTION 90°

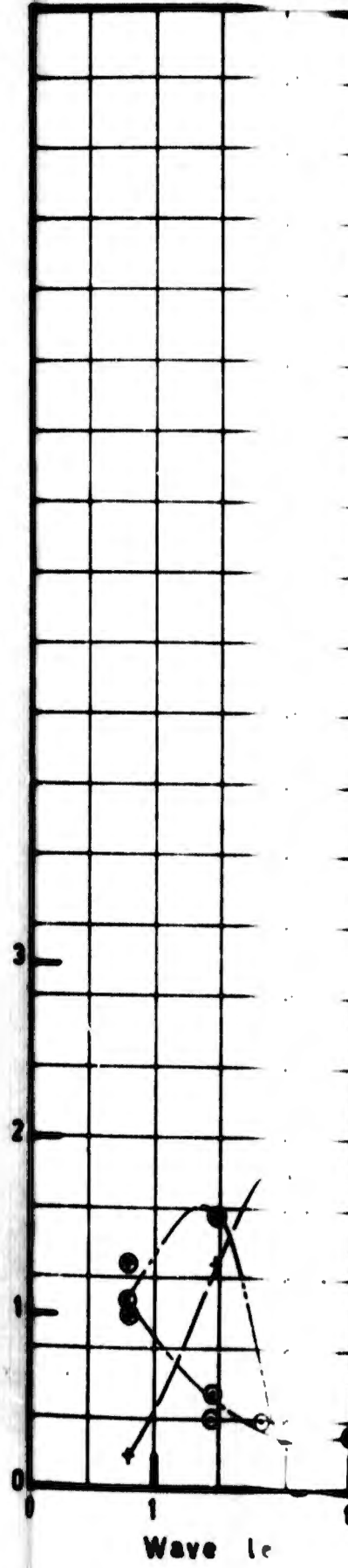
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I



WEIGHT DISTRI



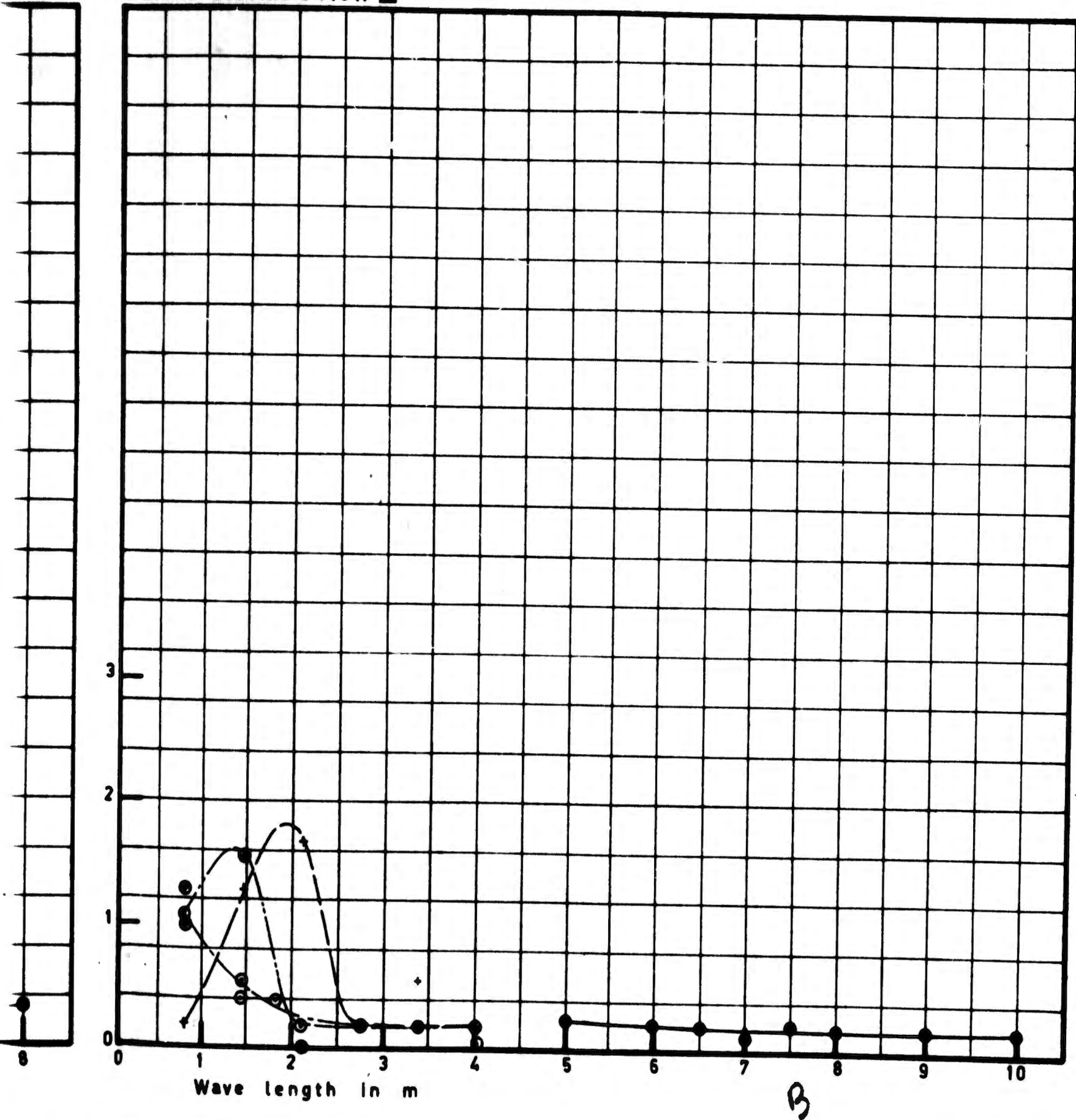
CATAMARAN SEAPLANE

PITCH ANGLES

(Double amplitudes)

0.20 m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II

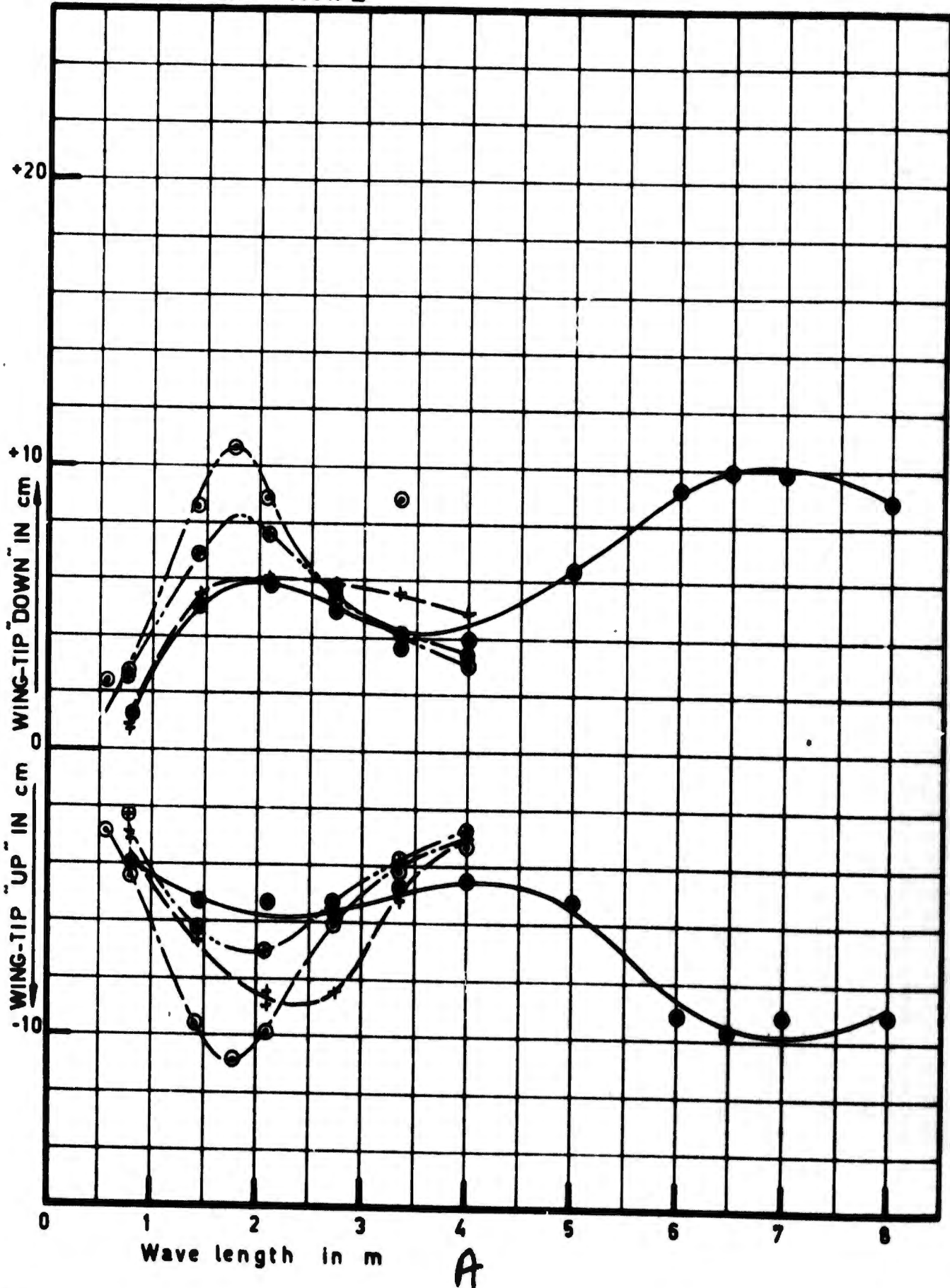


WAVE DIRECTION 90°
SPEED OF MODEL ZERO

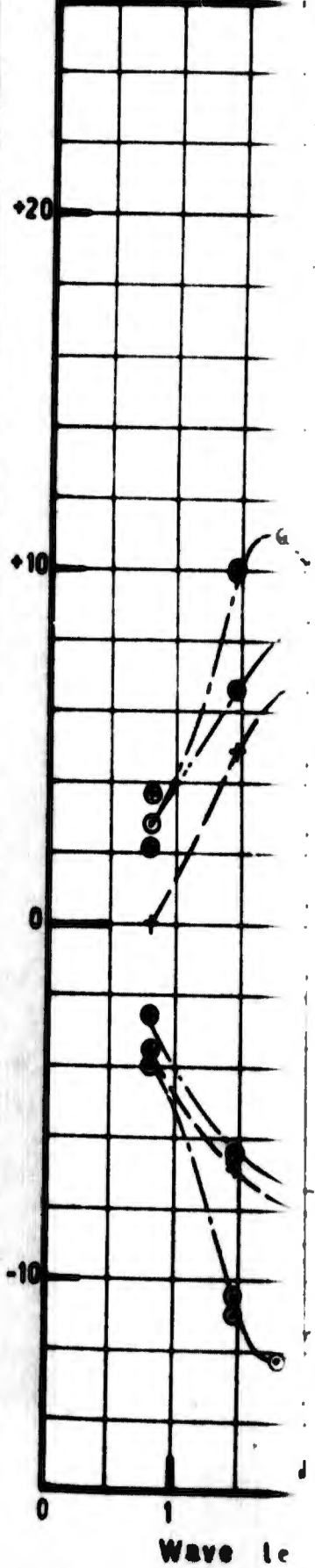
- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- ······· 0.70 m
- ⊕ - - - - - 1.00 m

MOTIONS OF

WEIGHT DISTRIBUTION I



WEIGHT DISTRIBUTION II

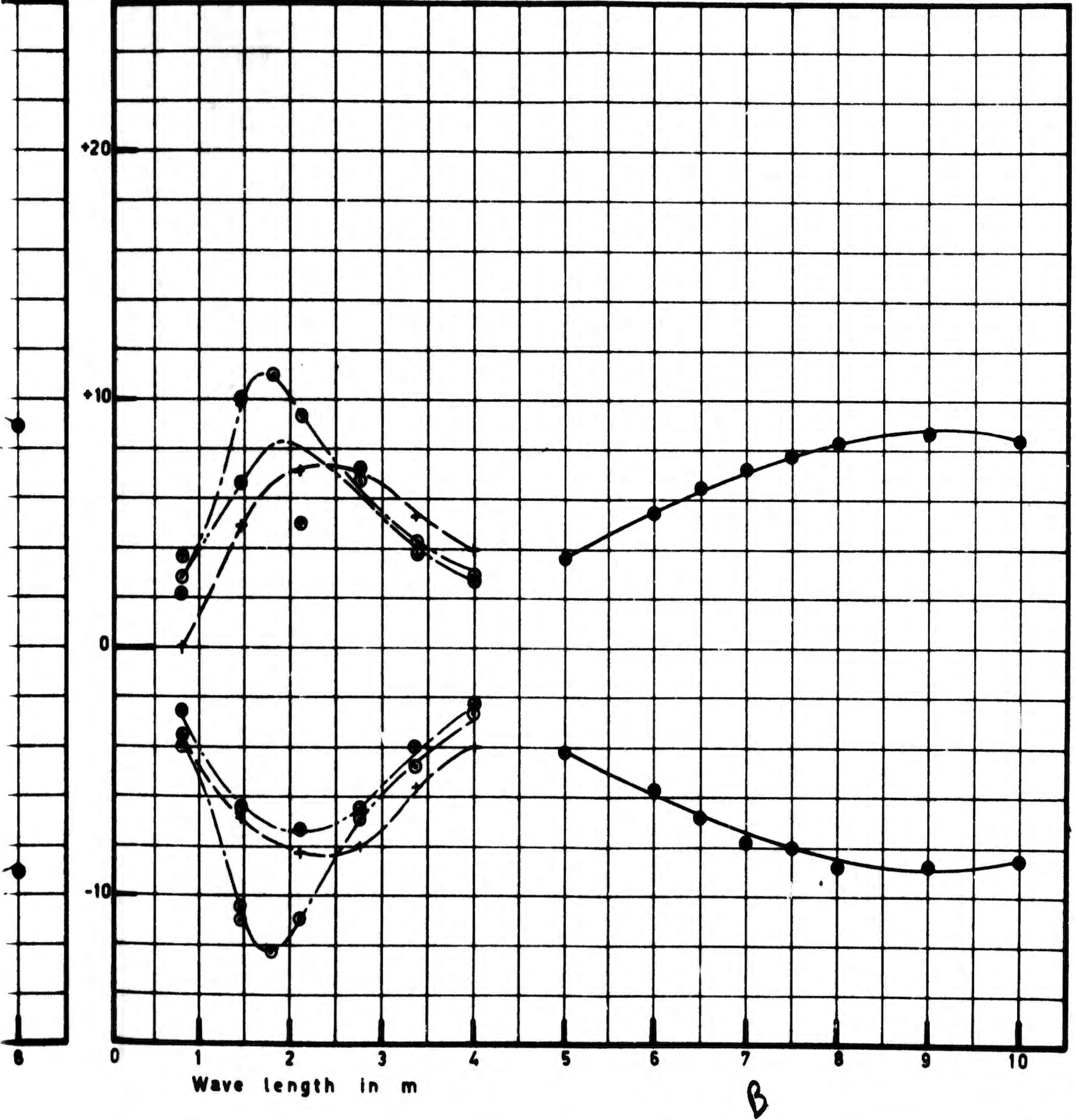


CATAMARAN SEAPLANE

MOTIONS OF THE STARBOARDSIDE WING-TIP RELATIVE TO THE WATERSURFACE

0.20 m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II



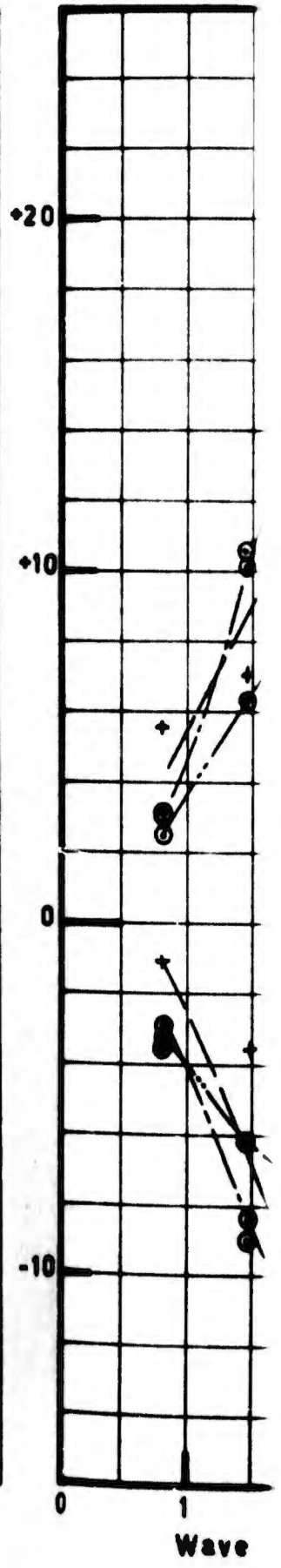
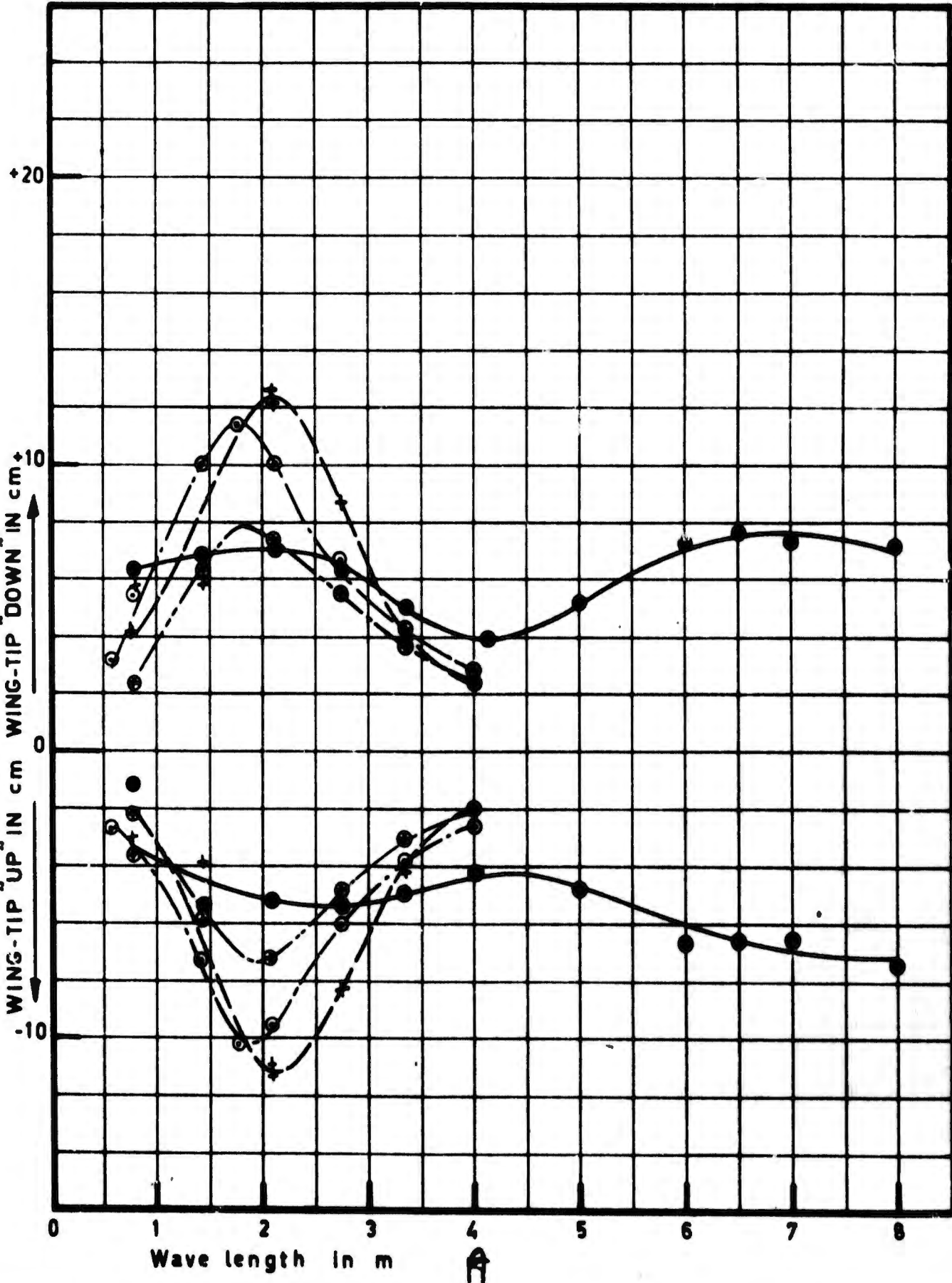
WAVE DIRECTION 90°
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + ———— 0.40 m
- - - - - - 0.70 m
- ⊕ ······ 1.00 m

M

WEIGHT DISTRIBUTION I

WEIGHT DIST

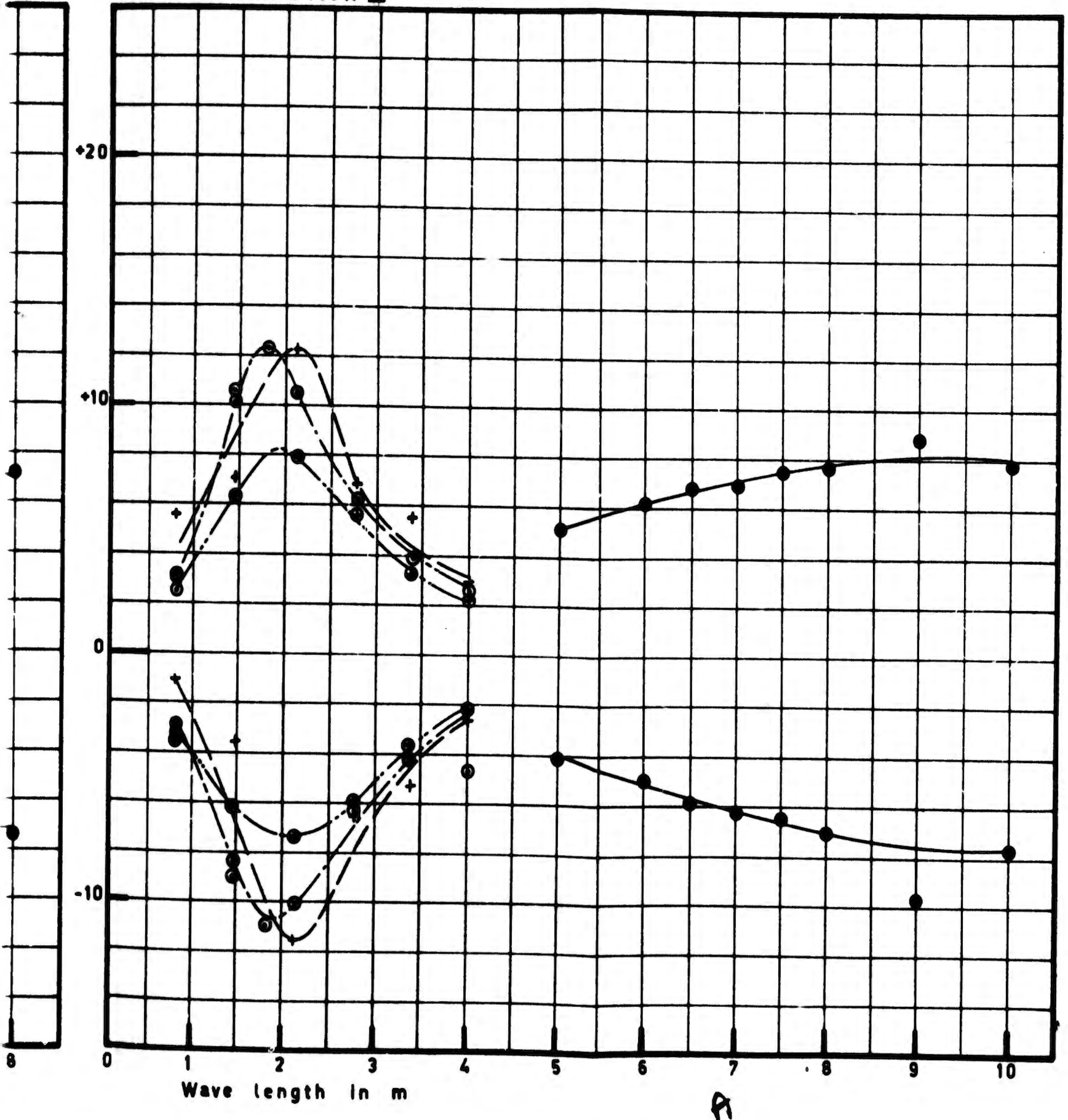


CATAMARAN SEAPLANE

MOTIONS OF THE PORTSIDE WING-TIP RELATIVE TO THE WATERSURFACE

0.20 m
0.40 m
0.70 m
1.00 m

WEIGHT DISTRIBUTION II

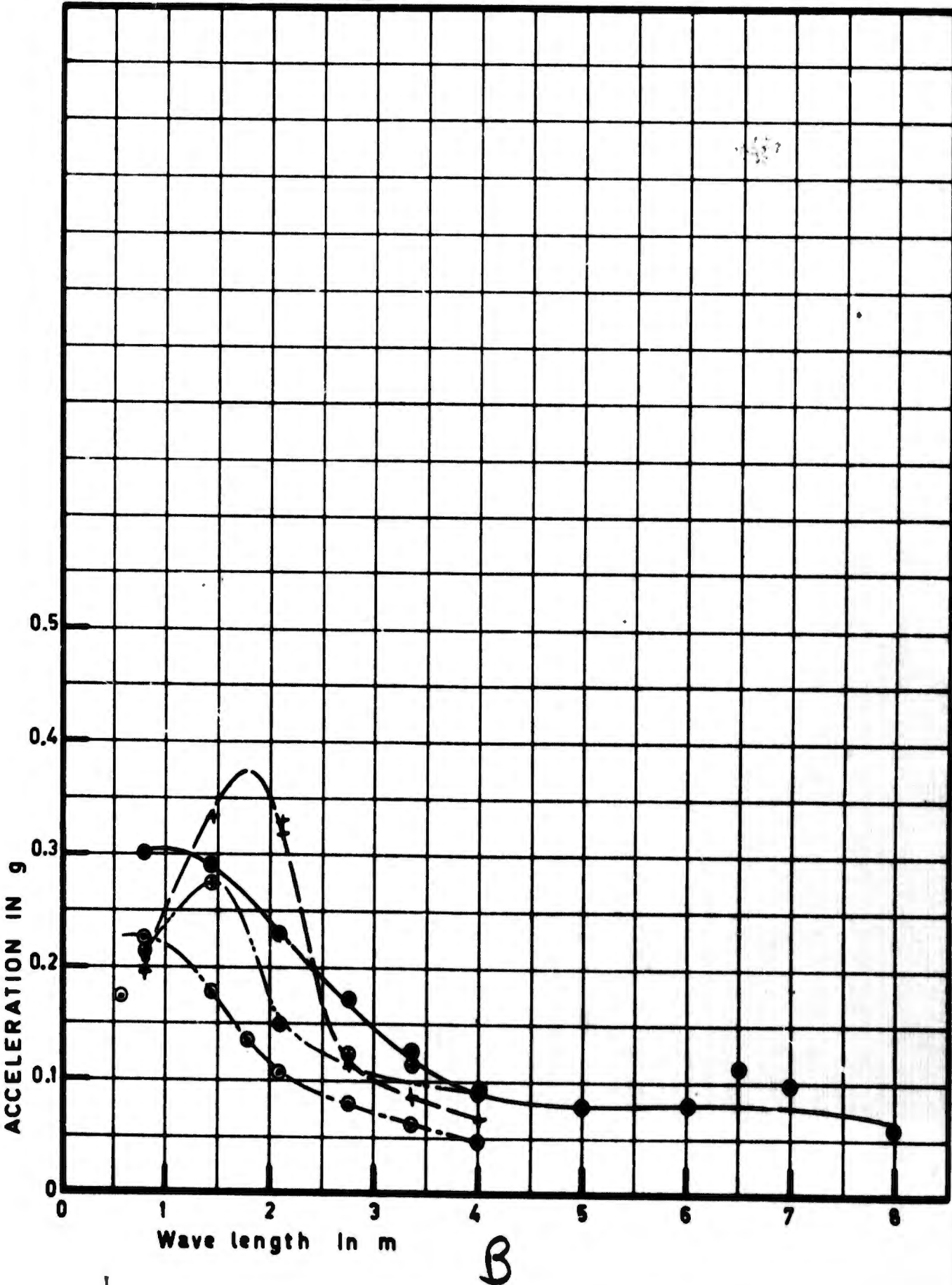


WAVE DIRECTION 90°

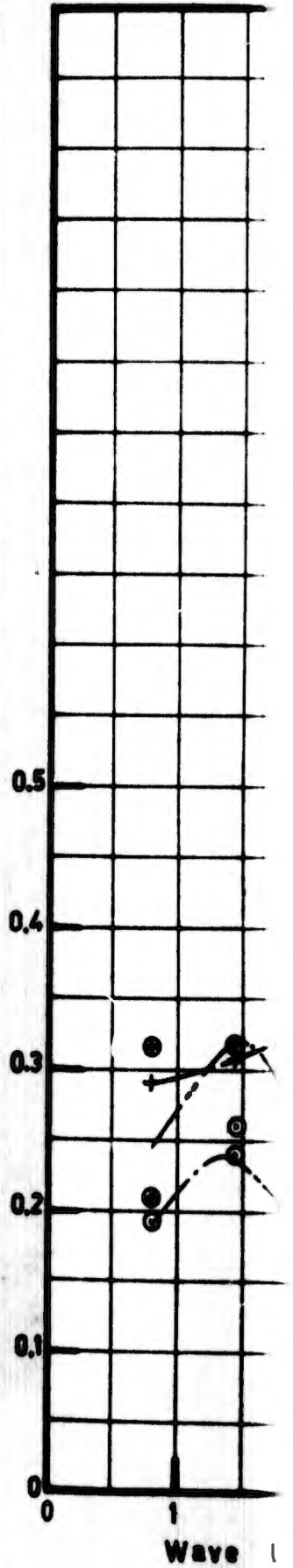
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- - · - · - · 0.70 m
- ⊕ - · - · - · 1.00 m

WEIGHT DISTRIBUTION I

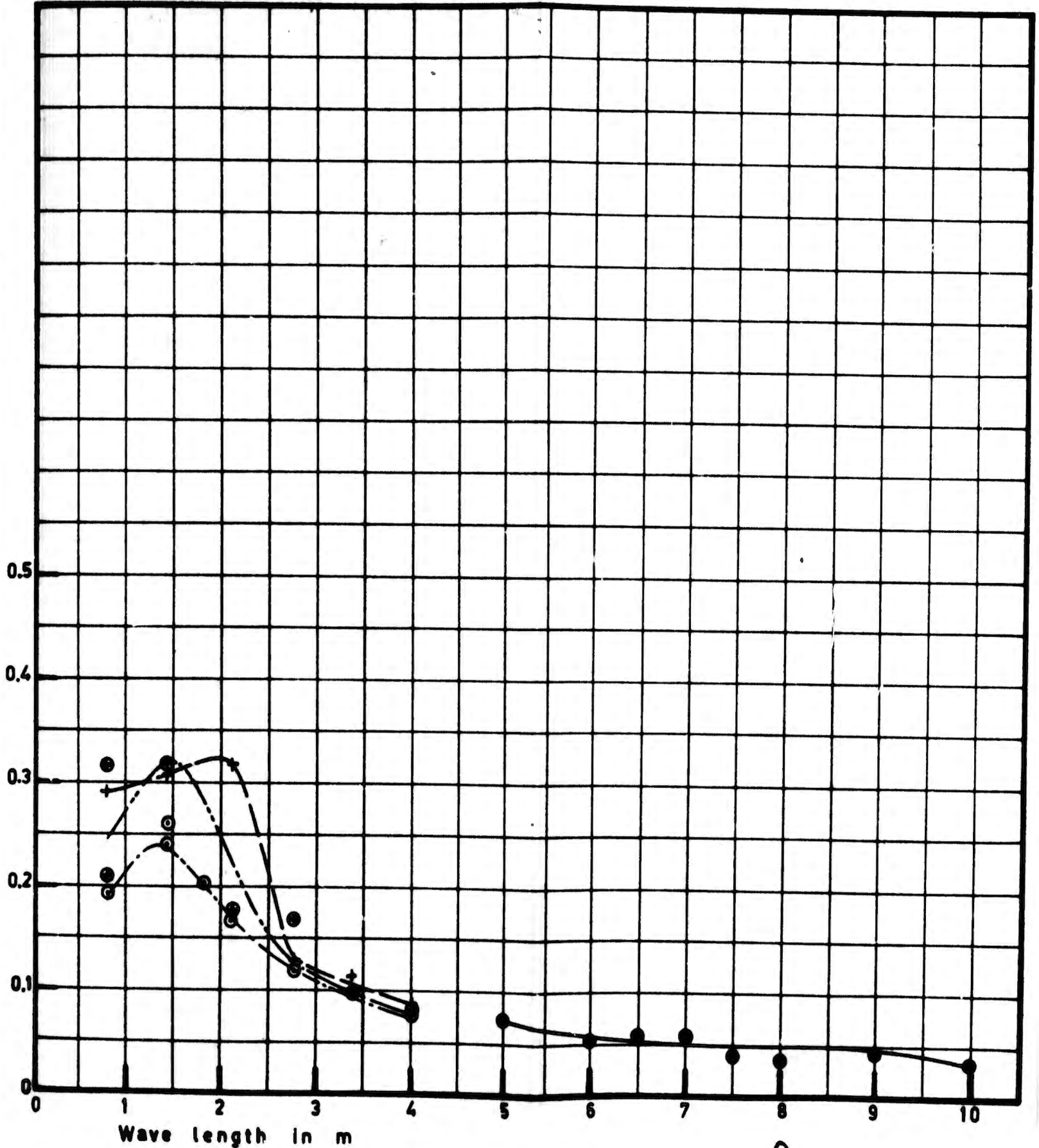


WEIGHT DISTR



CATAMARAN SEAPLANE
ACCELERATIONS OF THE HULLS
(Double amplitudes)

WEIGHT DISTRIBUTION II

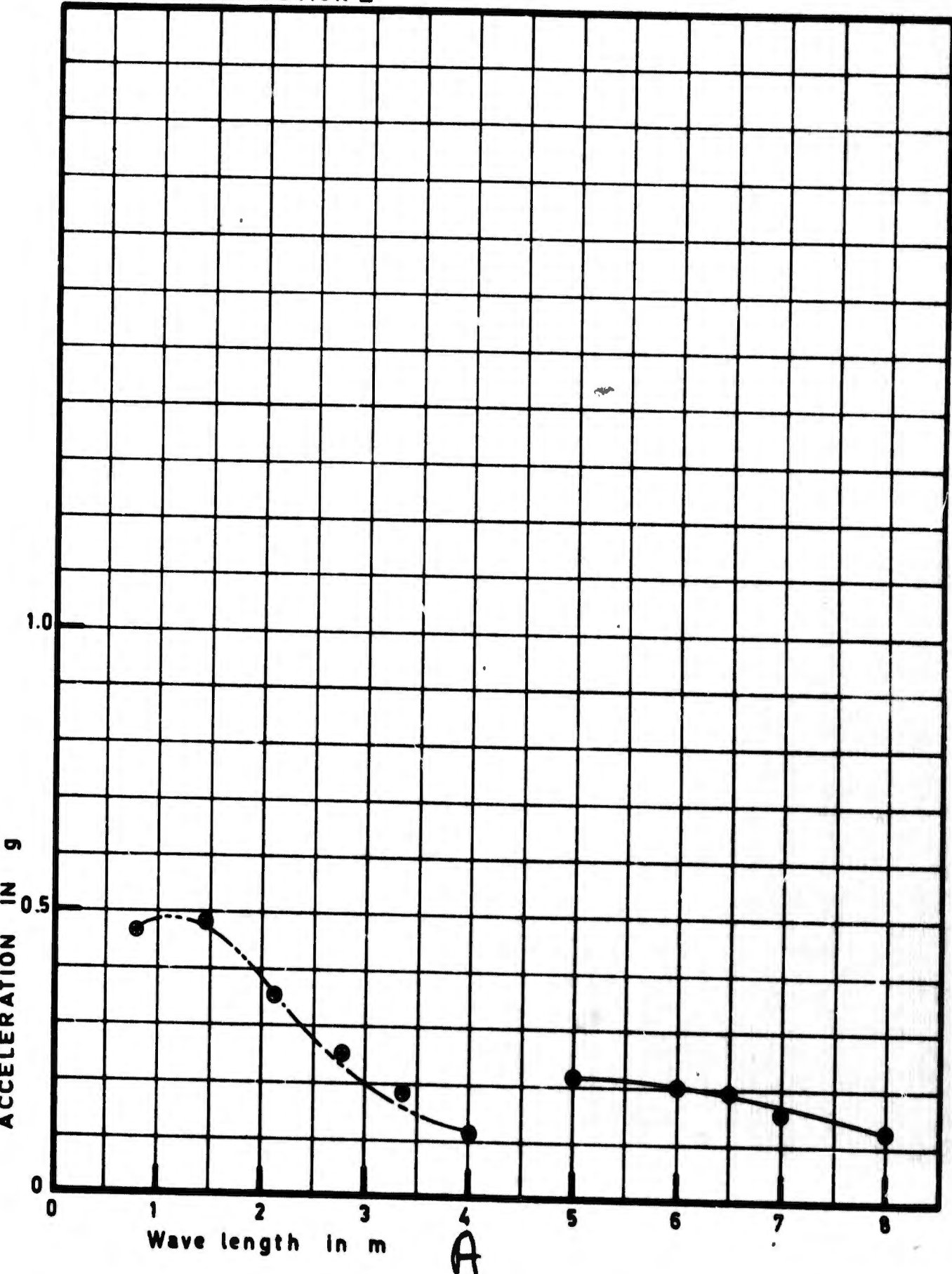


B

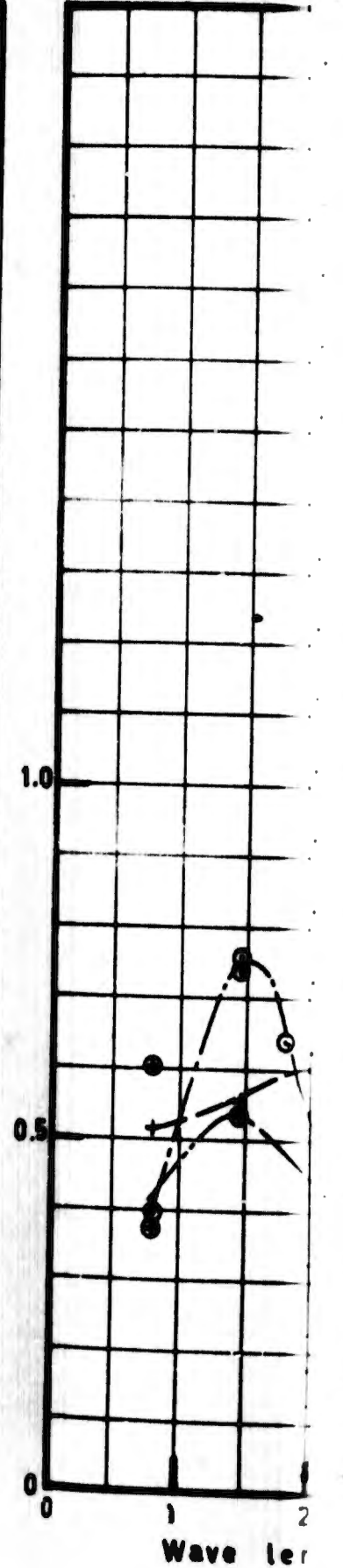
WAVE DIRECTION 90°
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- ⊙ - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I



WEIGHT DISTRIBUTION II

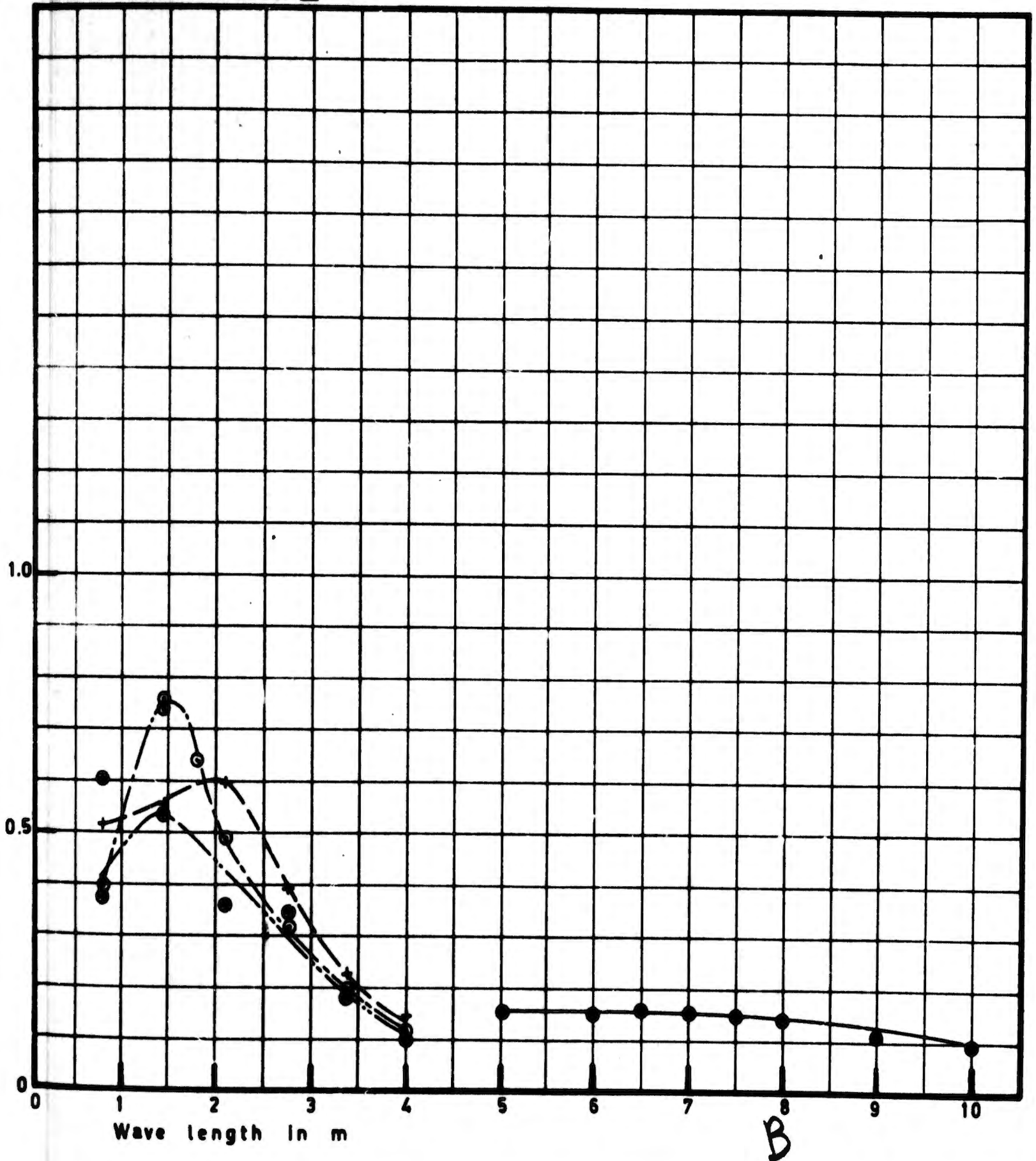


CATAMARAN SEAPLANE

ACCELERATIONS ON PORTSIDE WING-TIP

(Double amplitudes)

WEIGHT DISTRIBUTION II

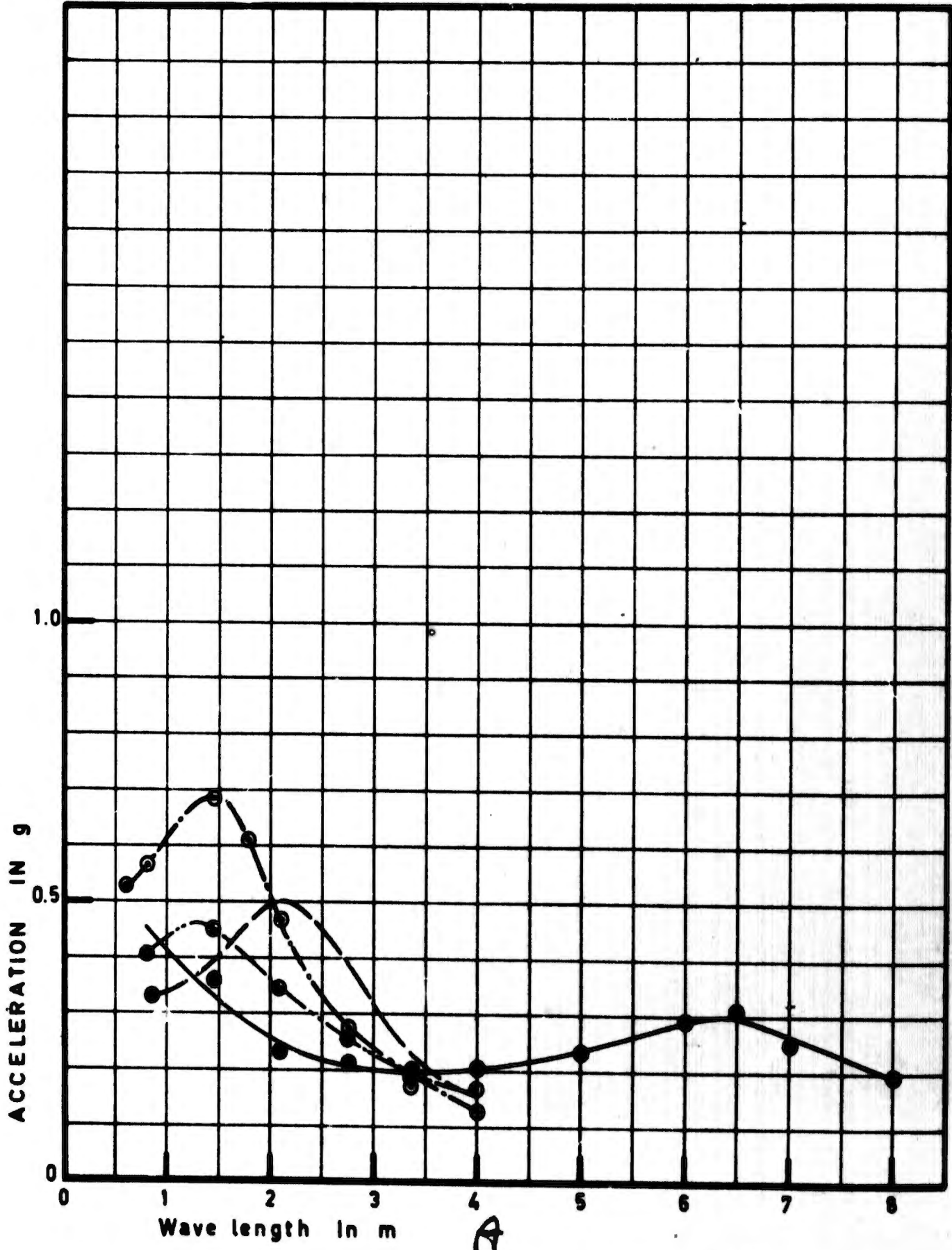


WAVE DIRECTION 90°

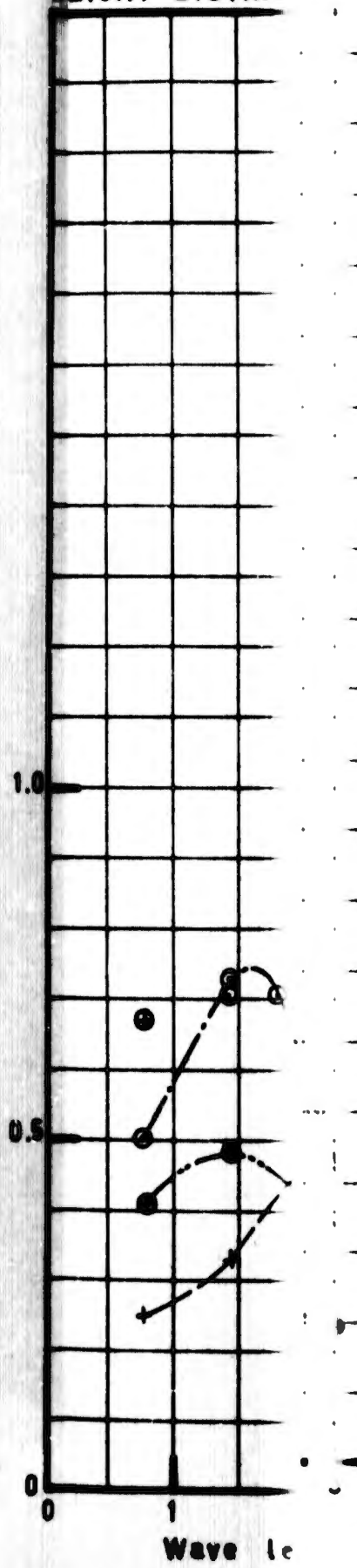
SPEED OF MODEL ZERO

- ————— Distance between the hulls=0.20 m
- + - - - - - 0.40 m
- ⊙ - - - - - 0.70 m
- ⊕ - - - - - 1.00 m

WEIGHT DISTRIBUTION I



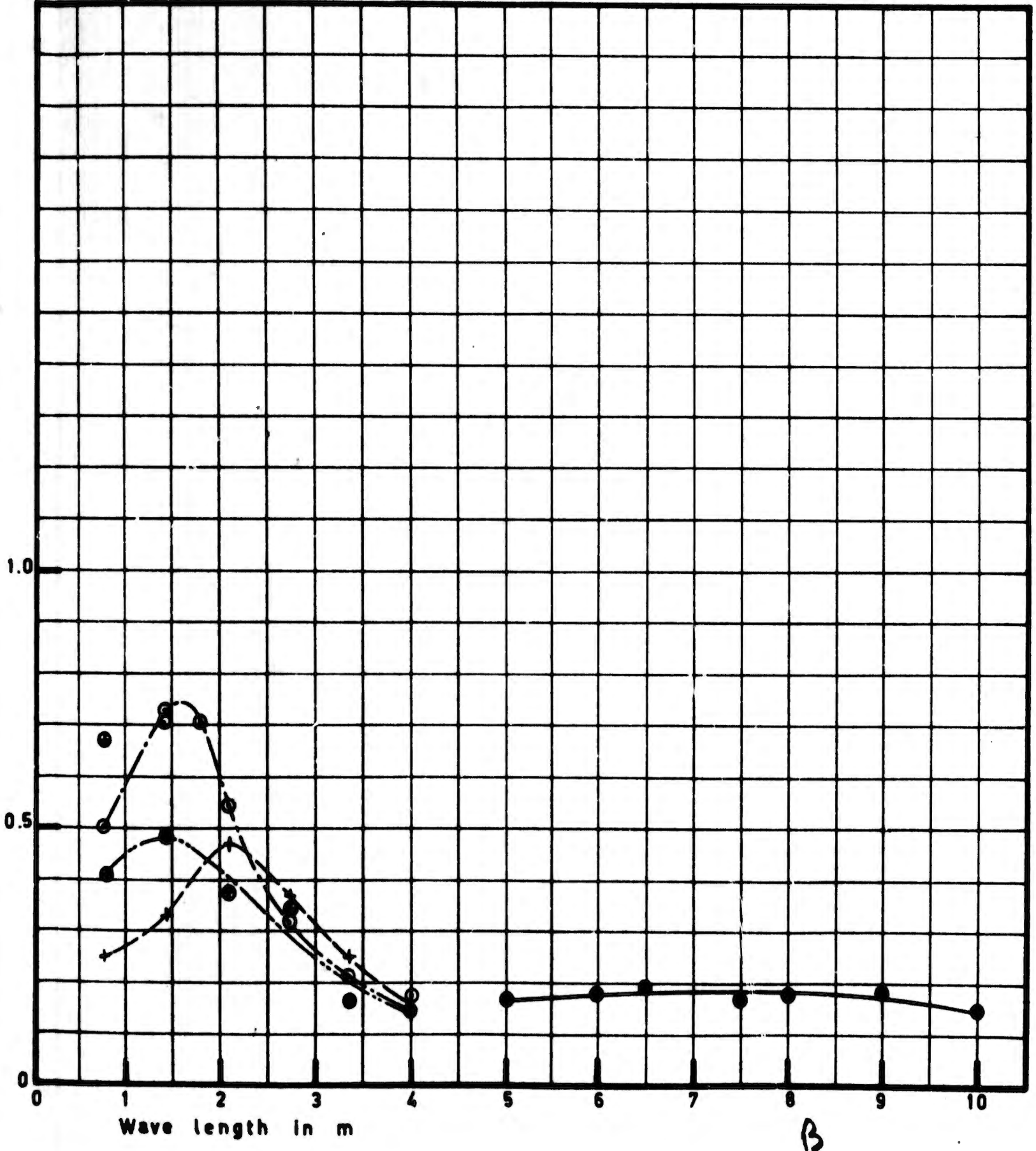
WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE

ACCELERATIONS ON STARBOARDSIDE WING-TIP
(Double amplitudes)

WEIGHT DISTRIBUTION II

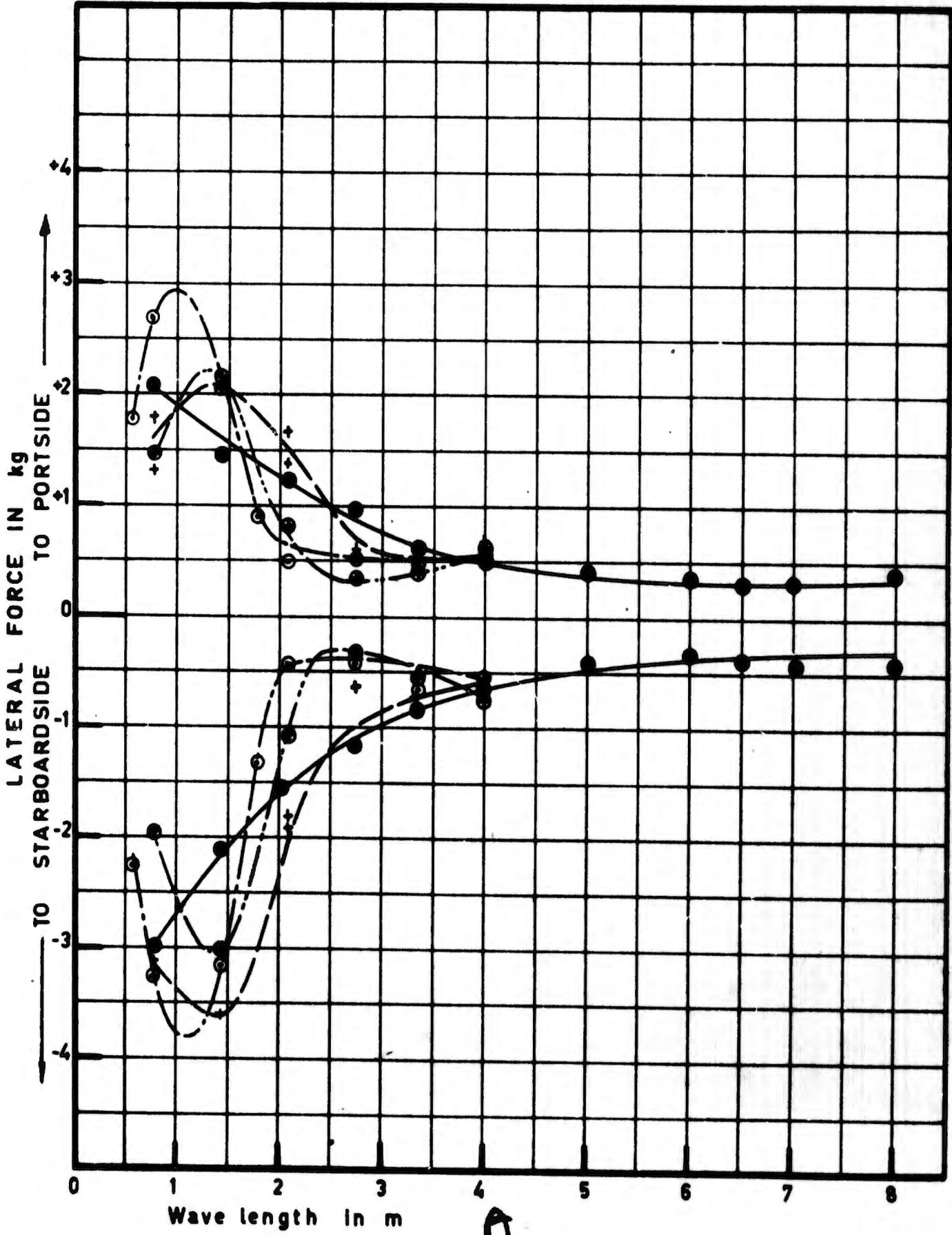


WAVE DIRECTION 90°

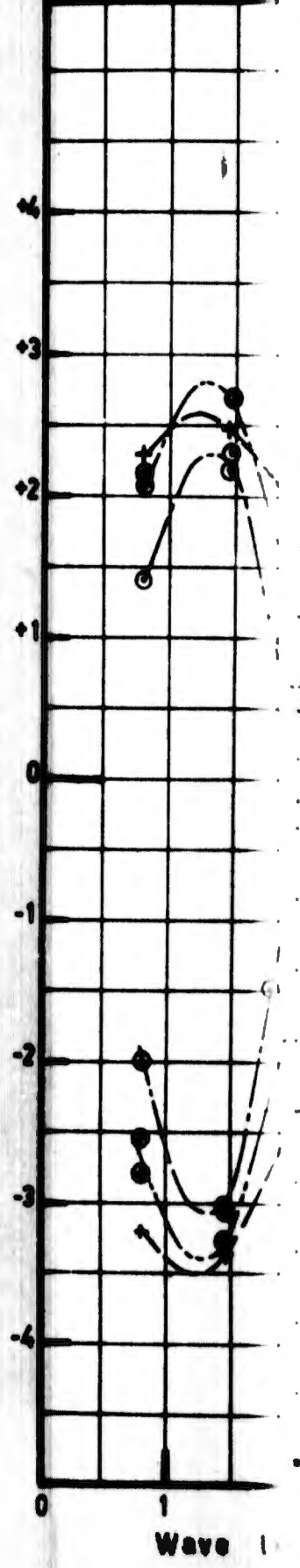
SPEED OF MODEL ZERO

- ————— Distance between the hulls = 0.20 m
- + - - - - - 0.40 m
- ⊙ - · - · - · 0.70 m
- ⊕ - · · · · · 1.00 m

WEIGHT DISTRIBUTION I

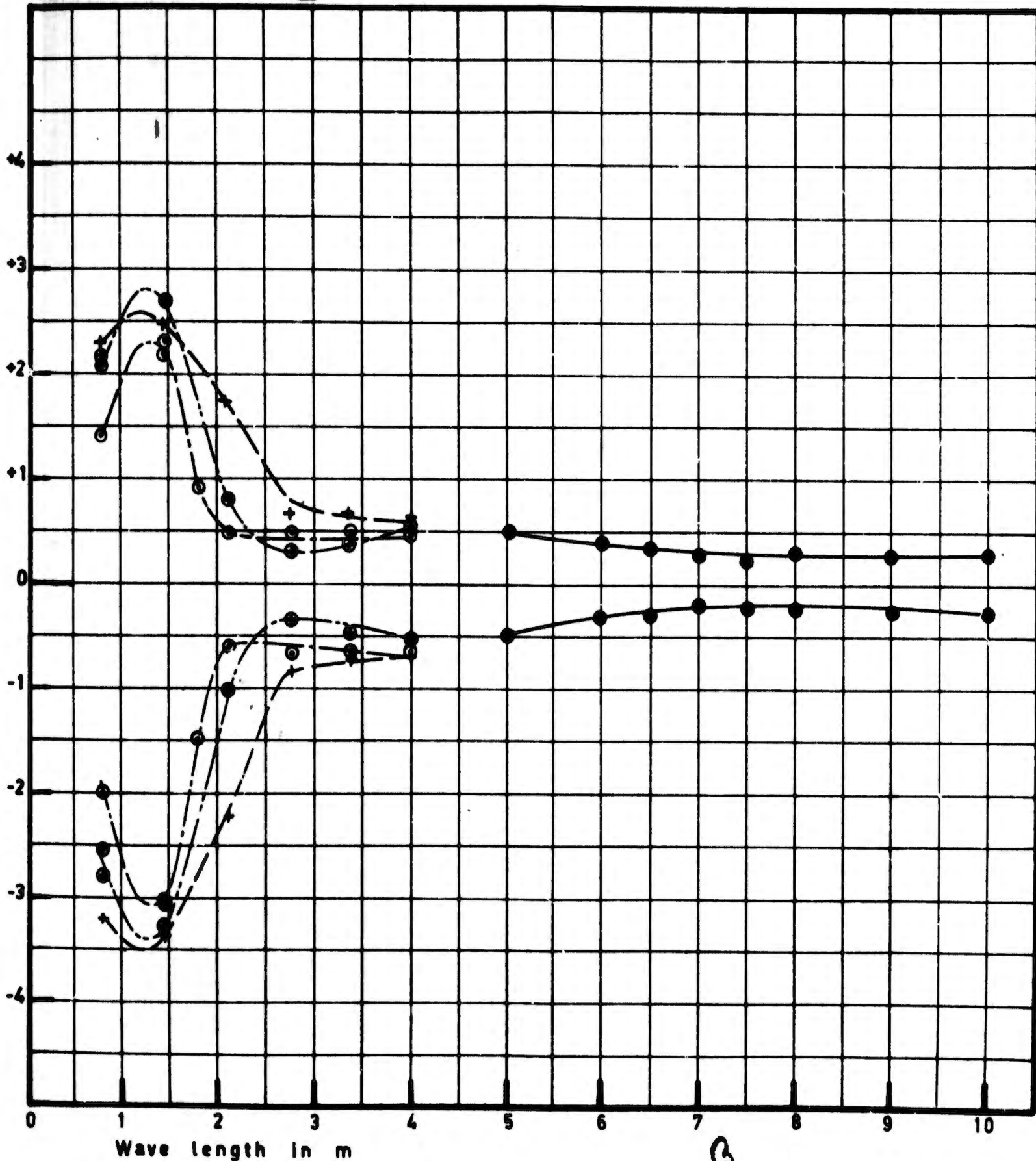


WEIGHT DISTRIBUTION II



CATAMARAN SEAPLANE
LATERAL FORCE FORWARD

WEIGHT DISTRIBUTION II



B

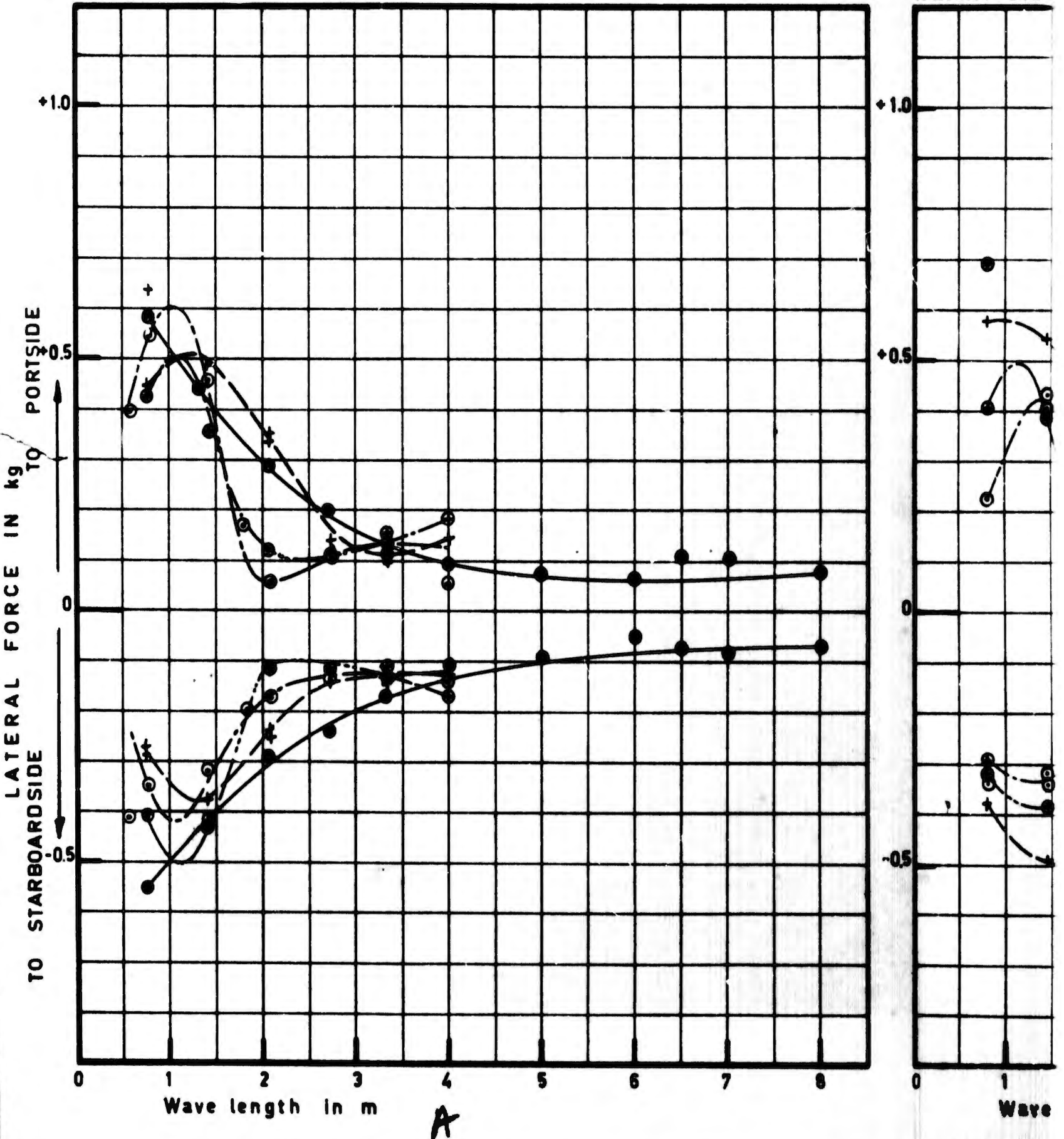
WAVE DIRECTION 90°

SPEED OF MODEL ZERO

- ————— Distance between the nulls = 0.20 m
- + - - - - - 0.40 m
- - · - · - · 0.70 m
- ⊕ - · - · - · 1.00 m

WEIGHT DISTRIBUTION I

WEIGHT DIST

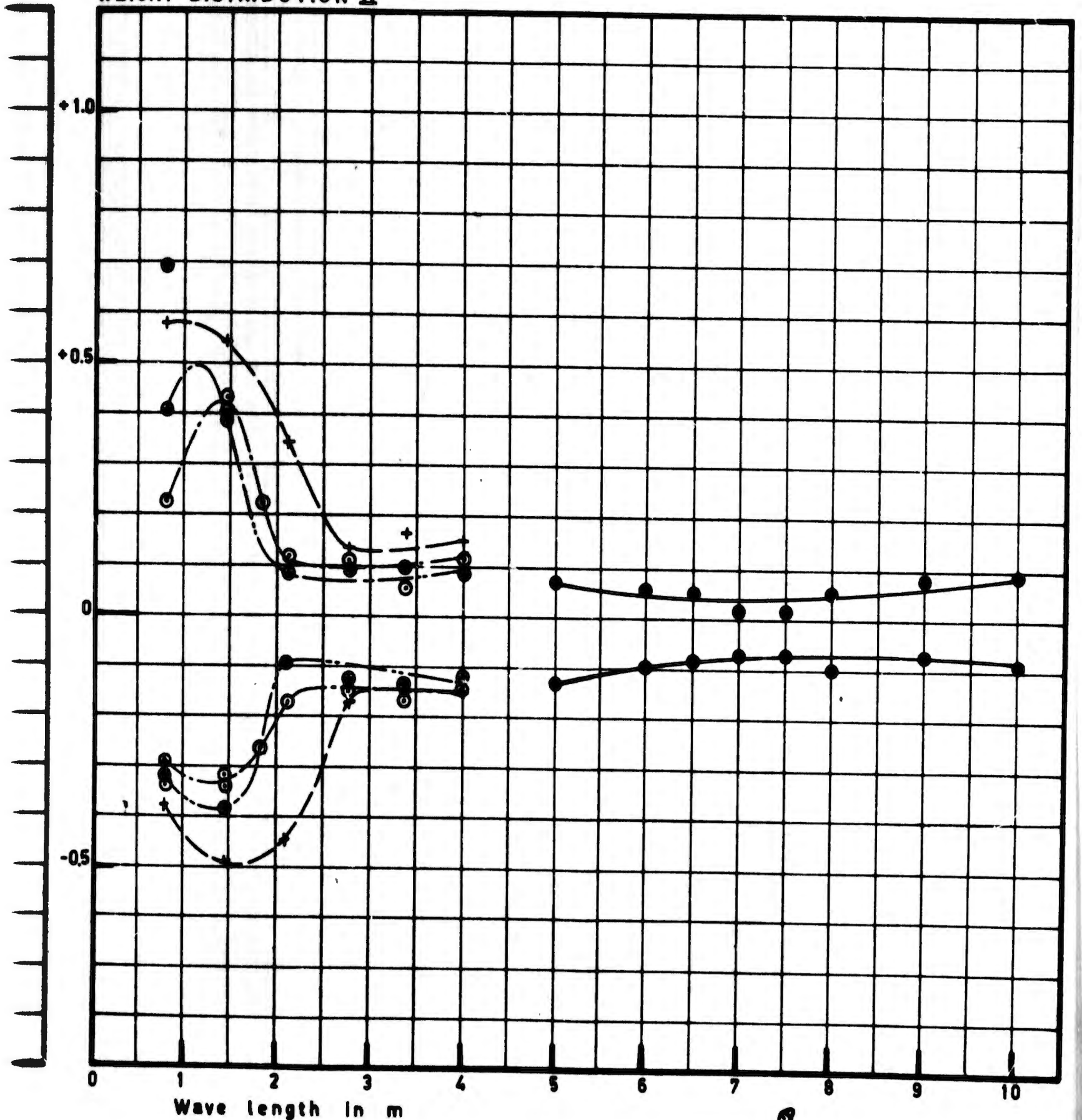


CATAMARAN SEAPLANE

LATERAL FORCE AFT

20 m
40 m
70 m
100 m

WEIGHT DISTRIBUTION II



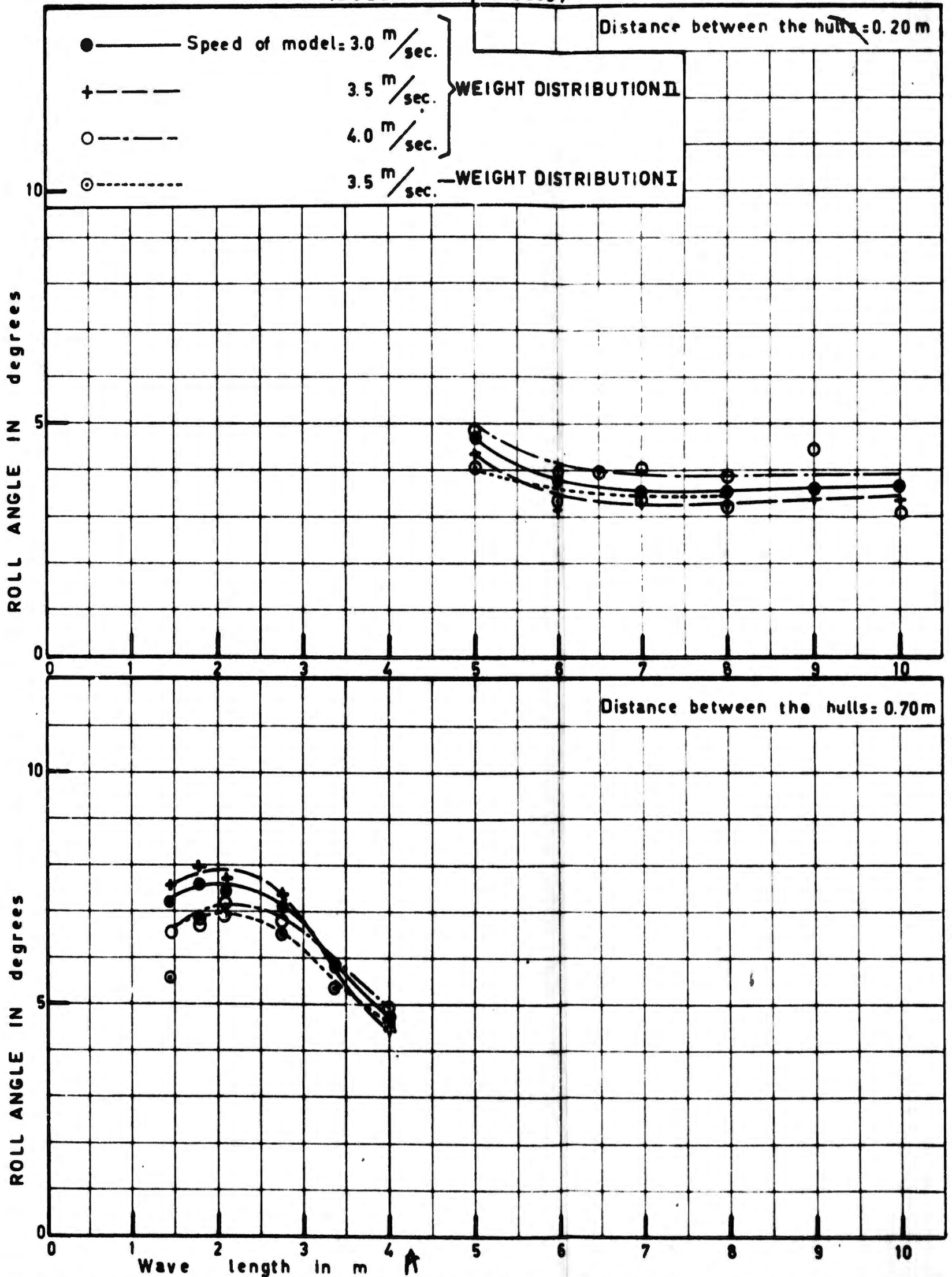
B

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — ROLL ANGLES

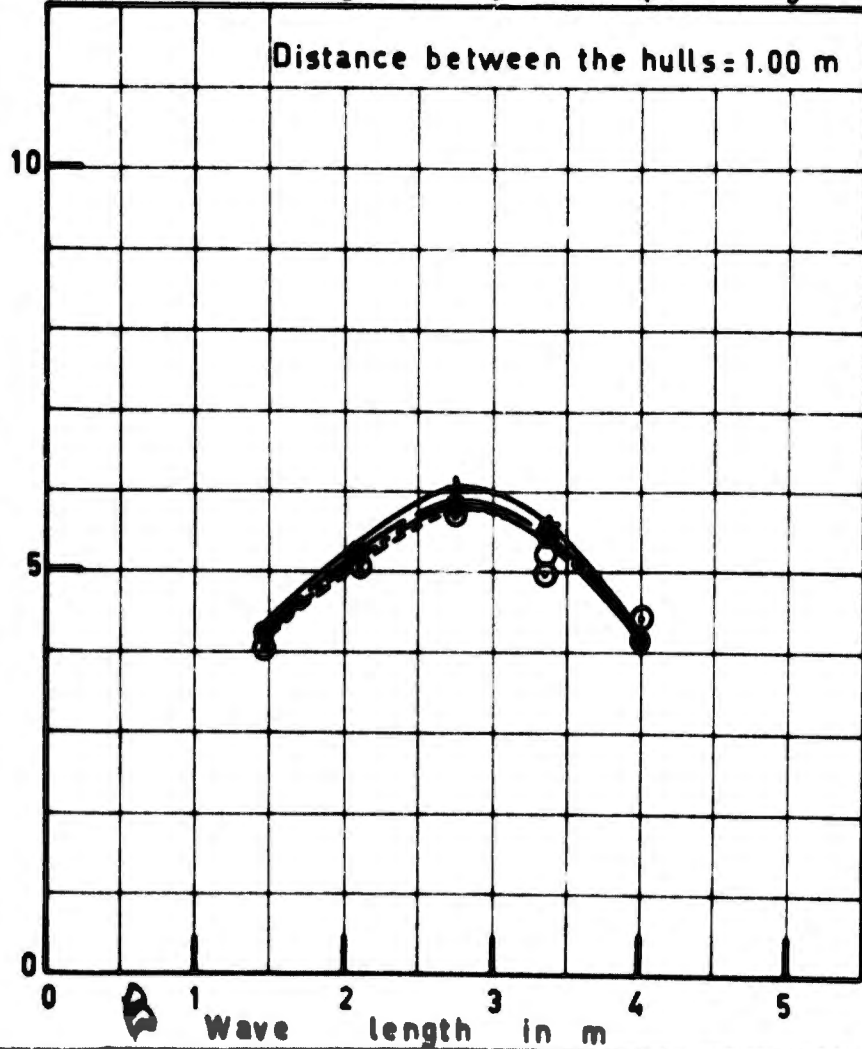
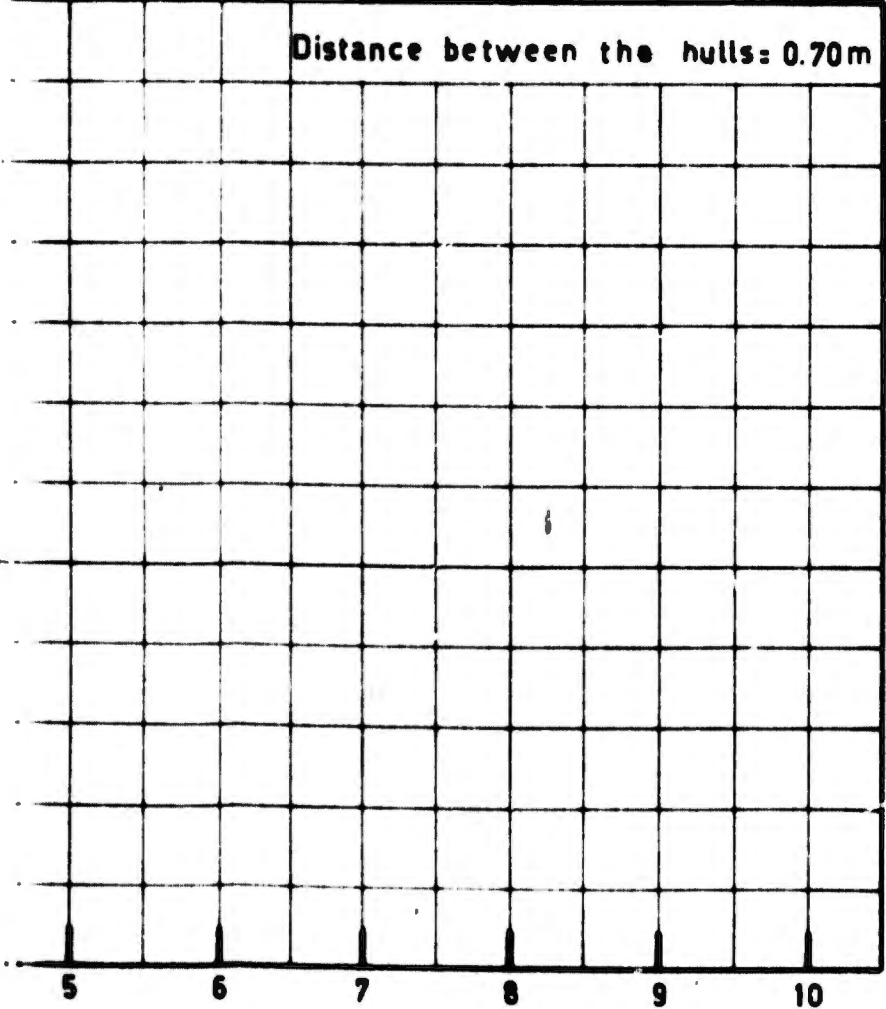
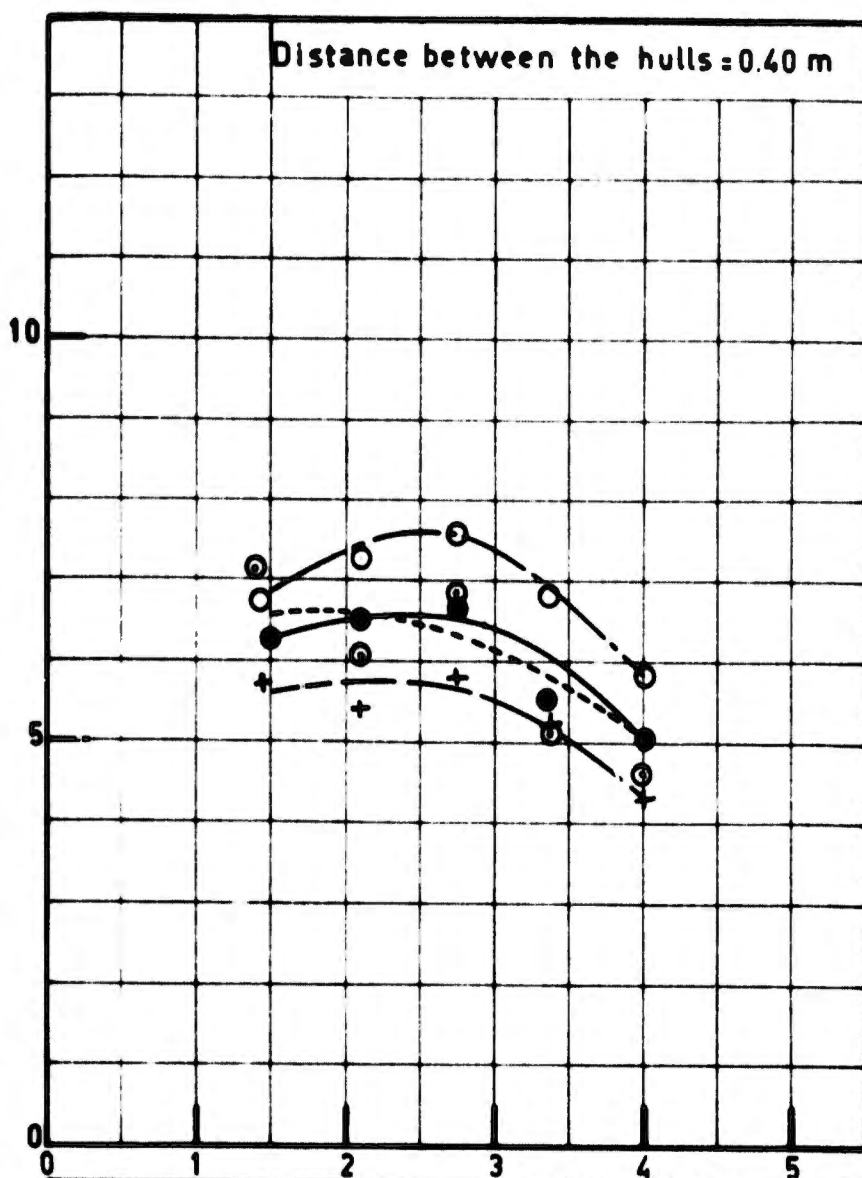
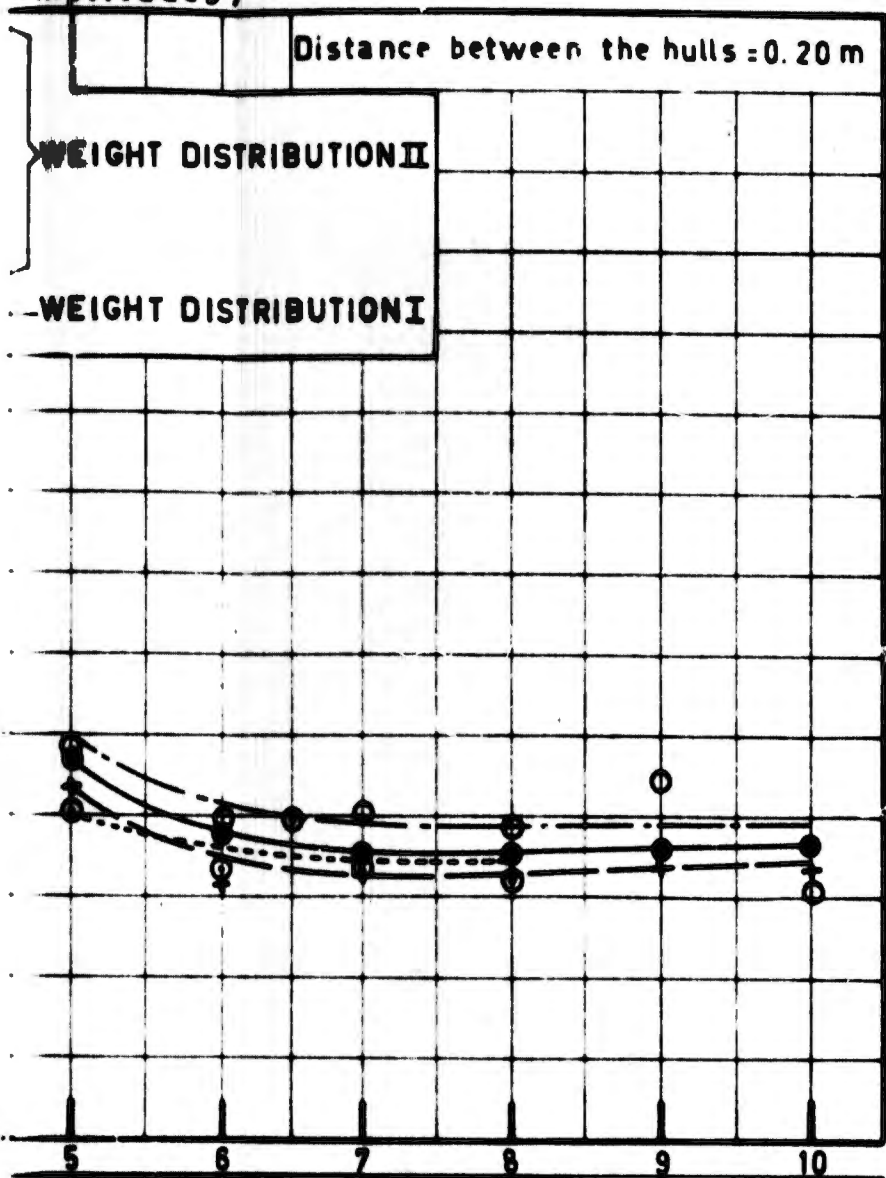
NEDERLANDSCH SCHEEPSBOUW...
PROEFSTATION WAG:

(Double amplitudes)



LANE
ANGLES

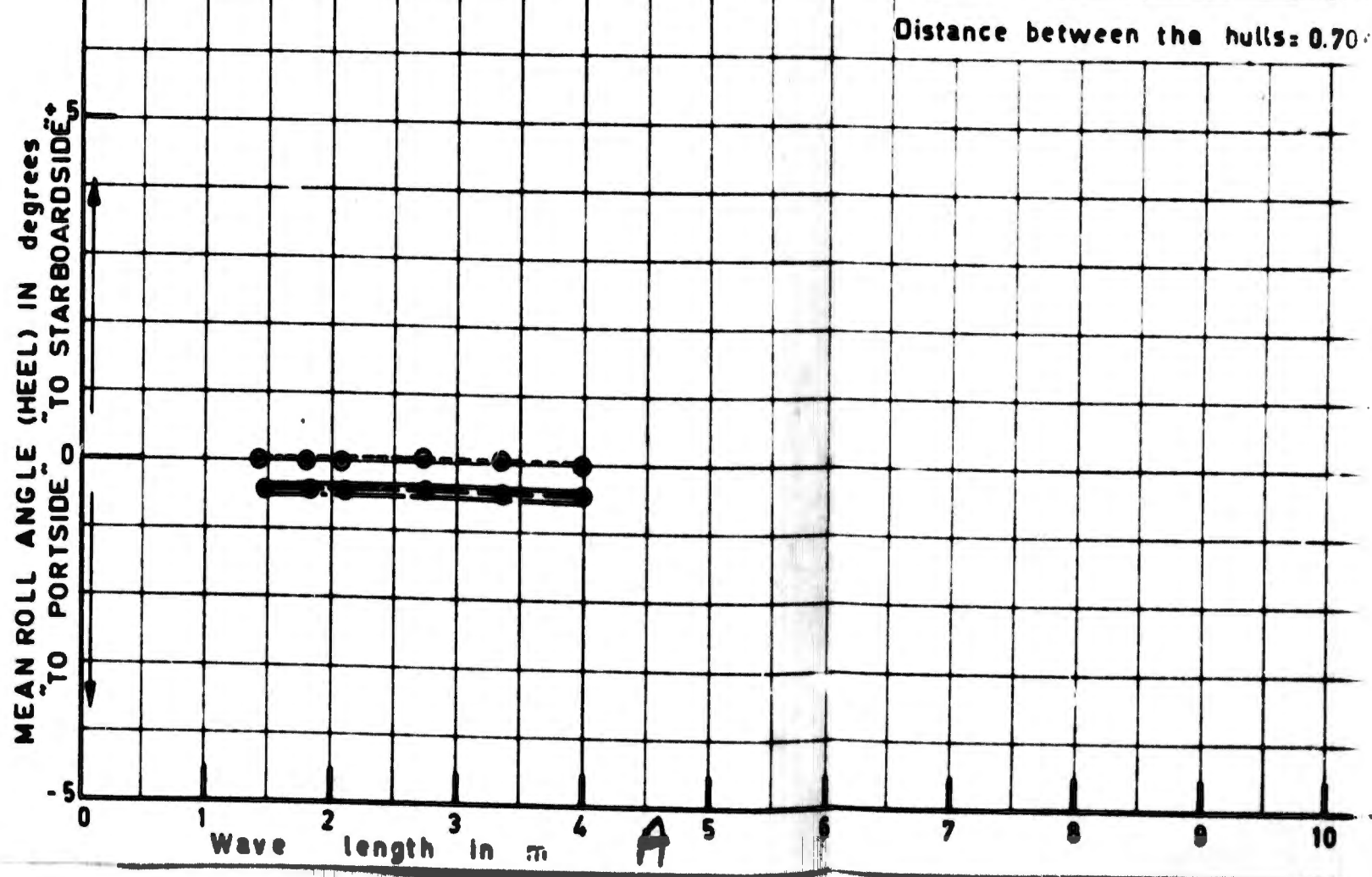
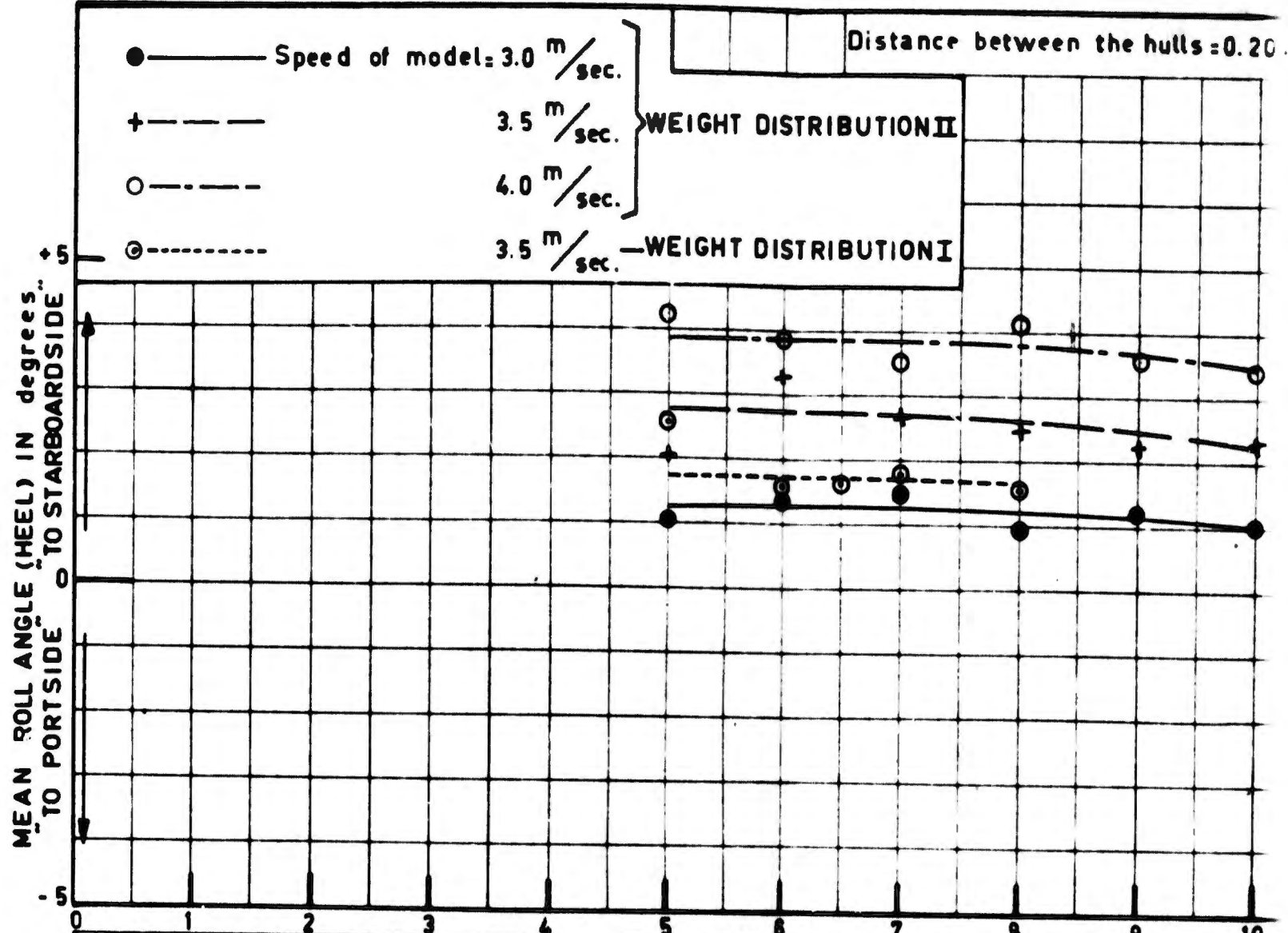
(amplitudes)



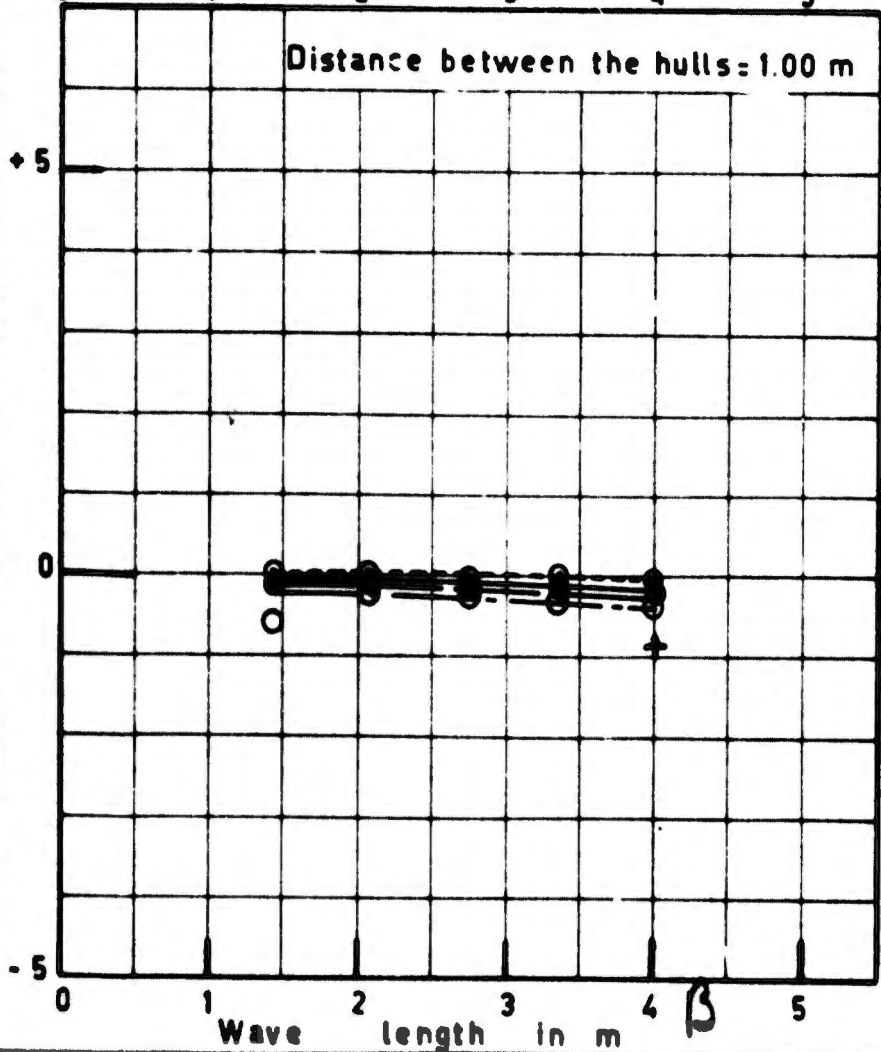
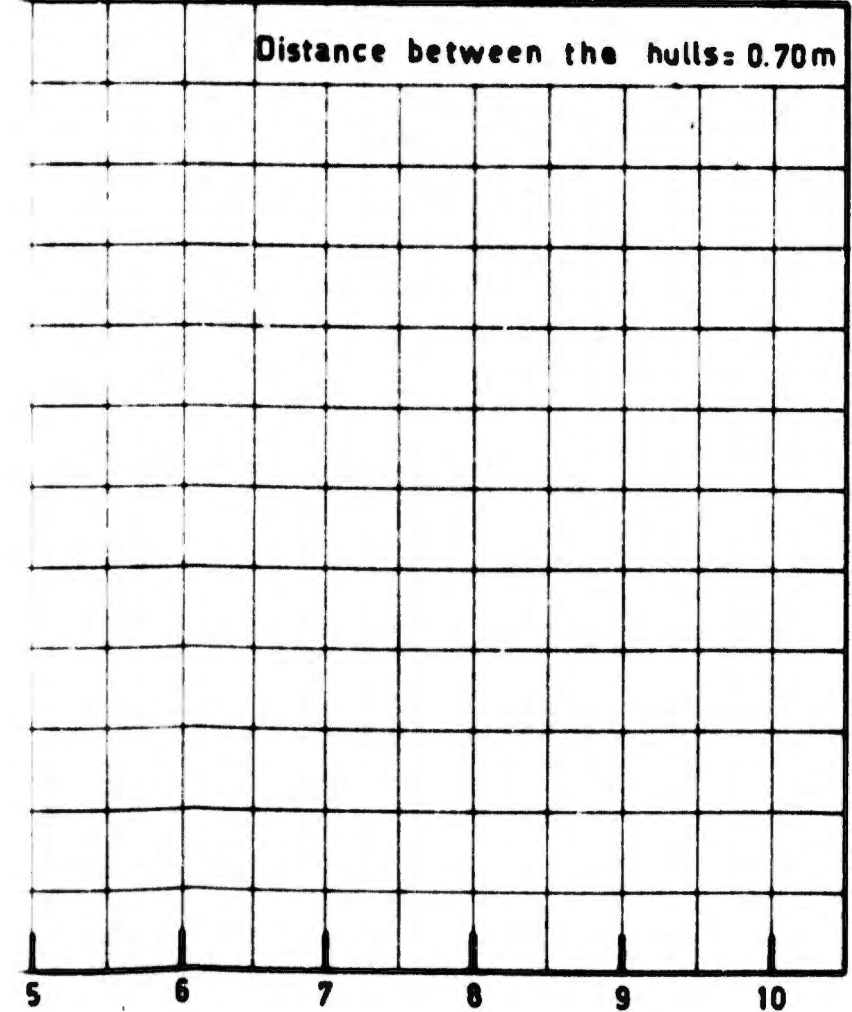
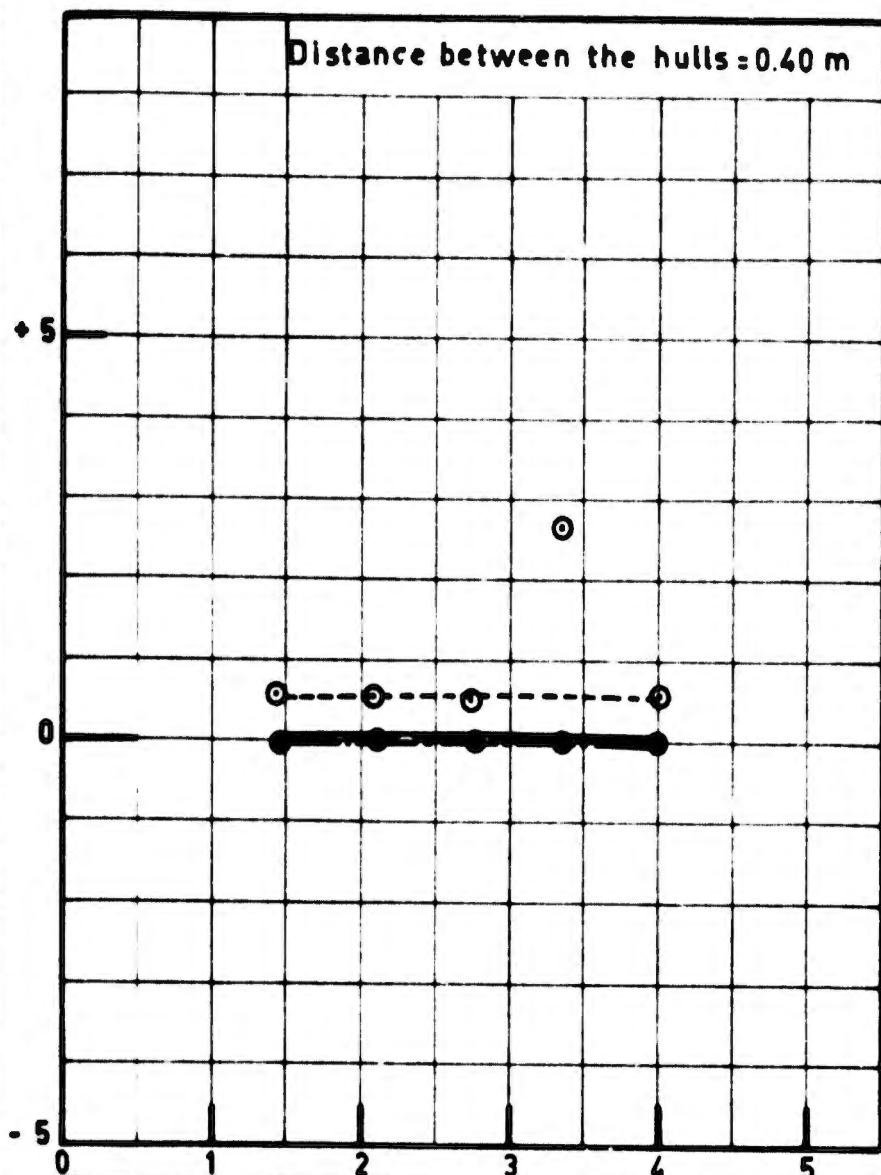
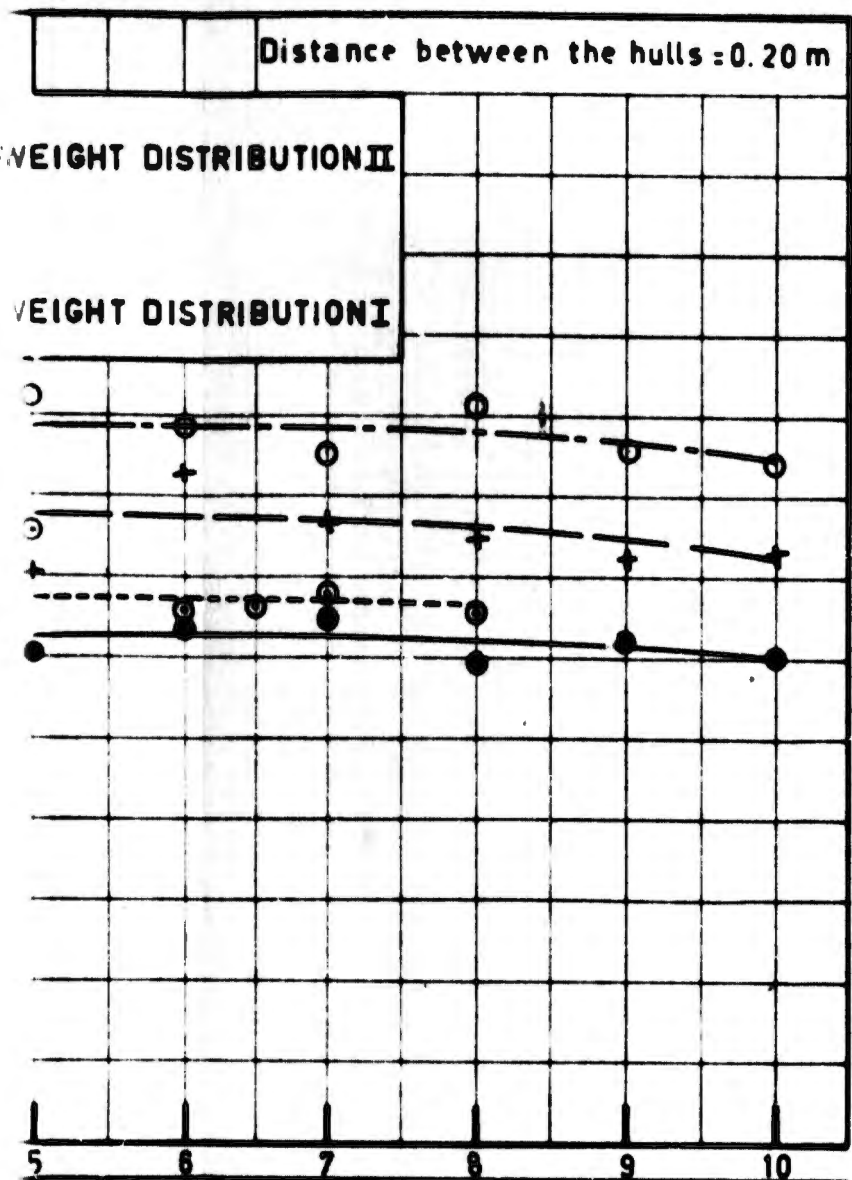
CATAMARAN SEAPLANE

WAVE DIRECTION 90° — MEAN ROLL ANGLES

NEDERLANDSCH SCHEEP-
PROEPTSTATION



Wave length in m A

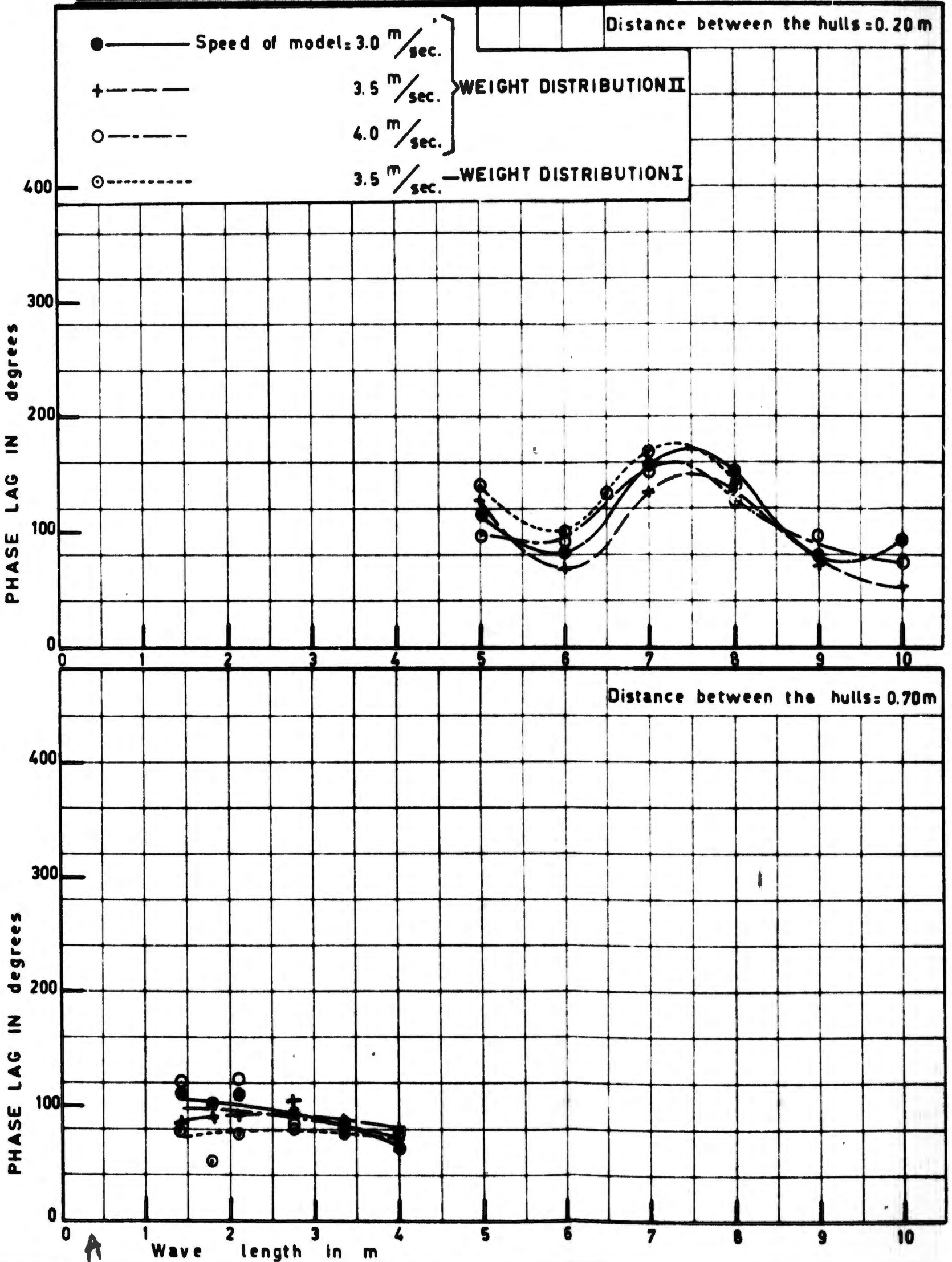


Wave length in m

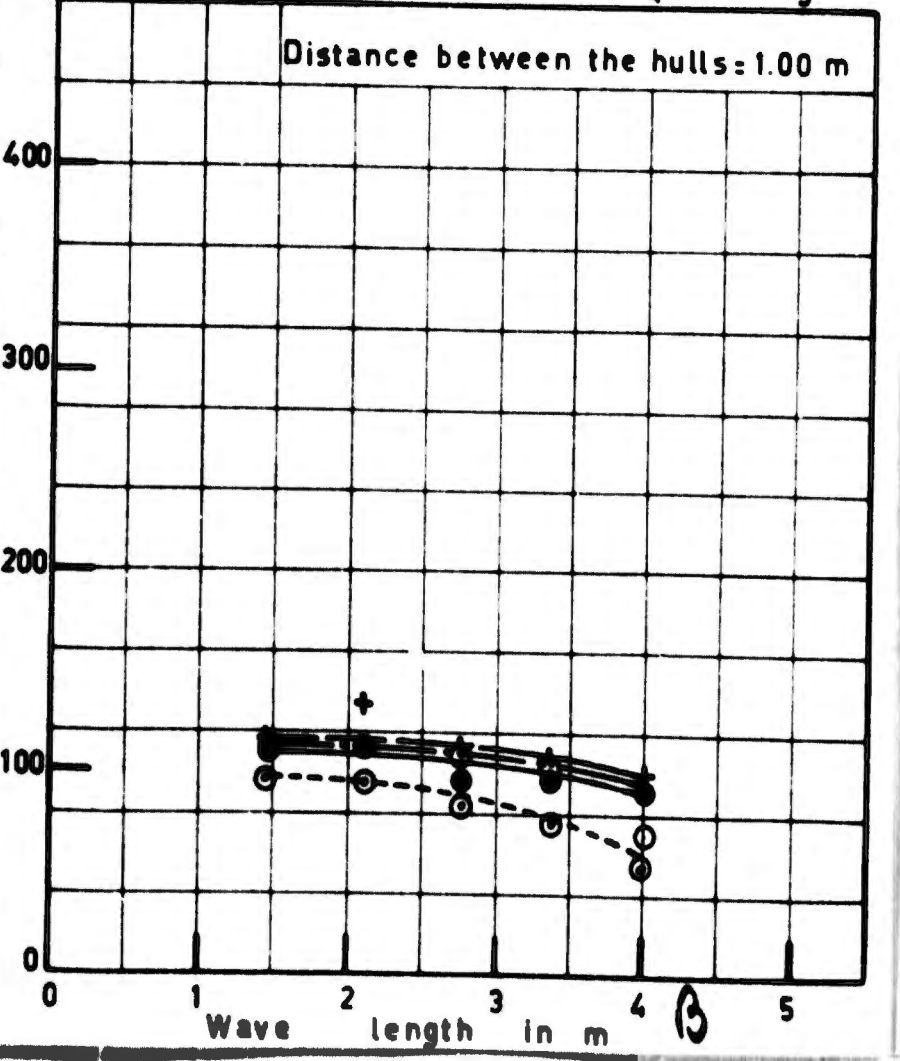
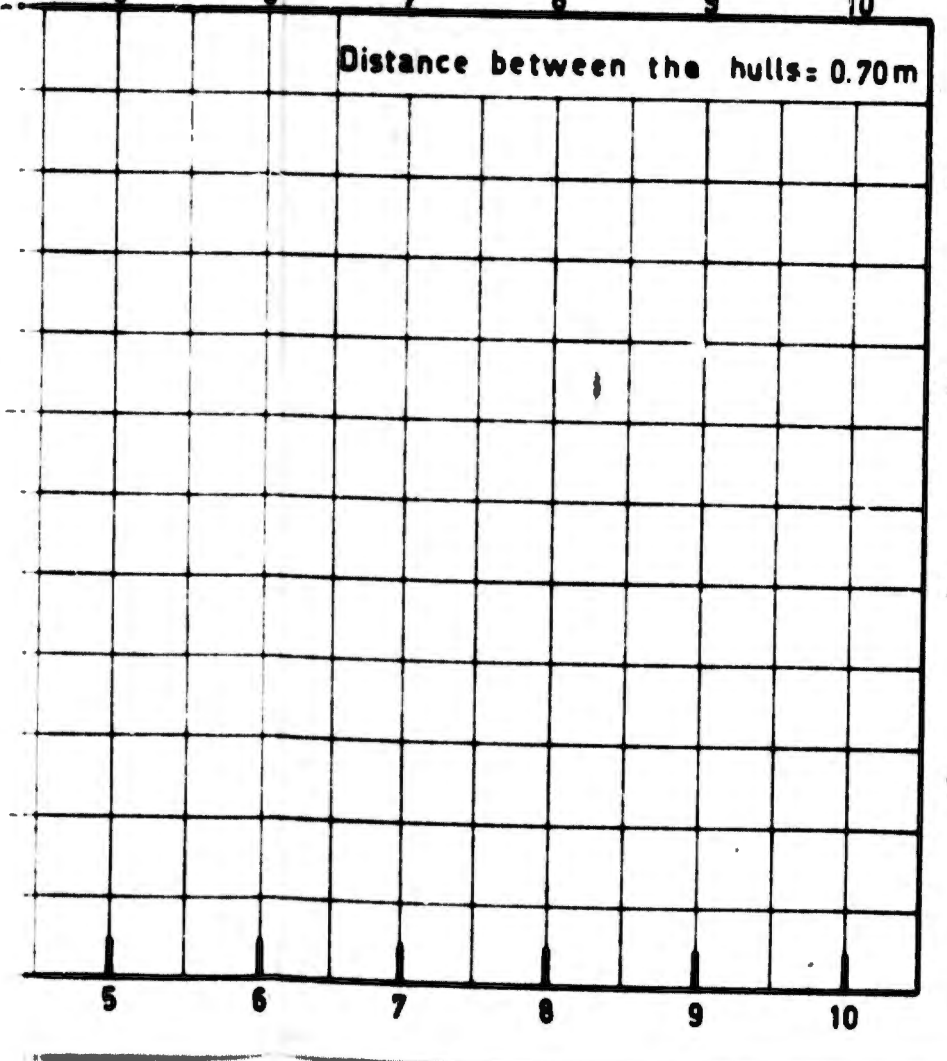
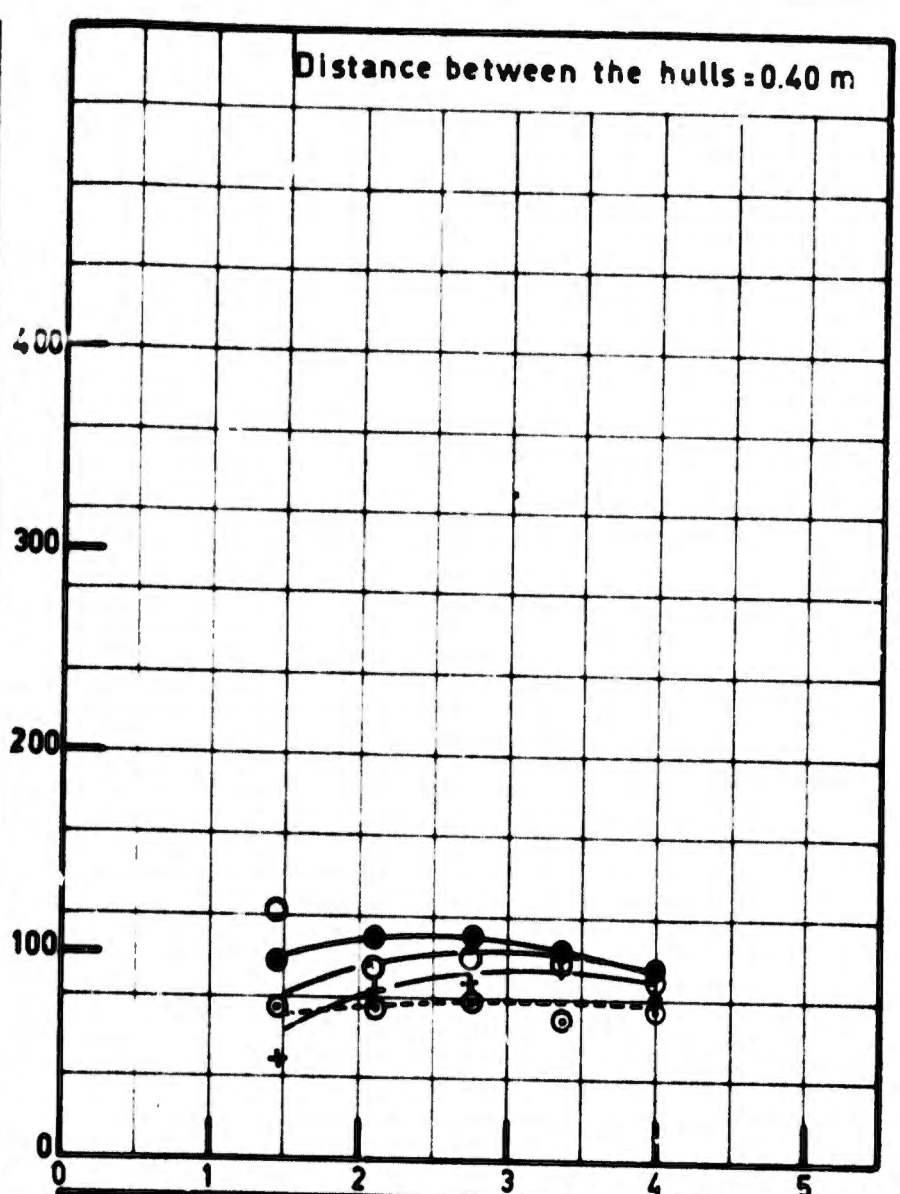
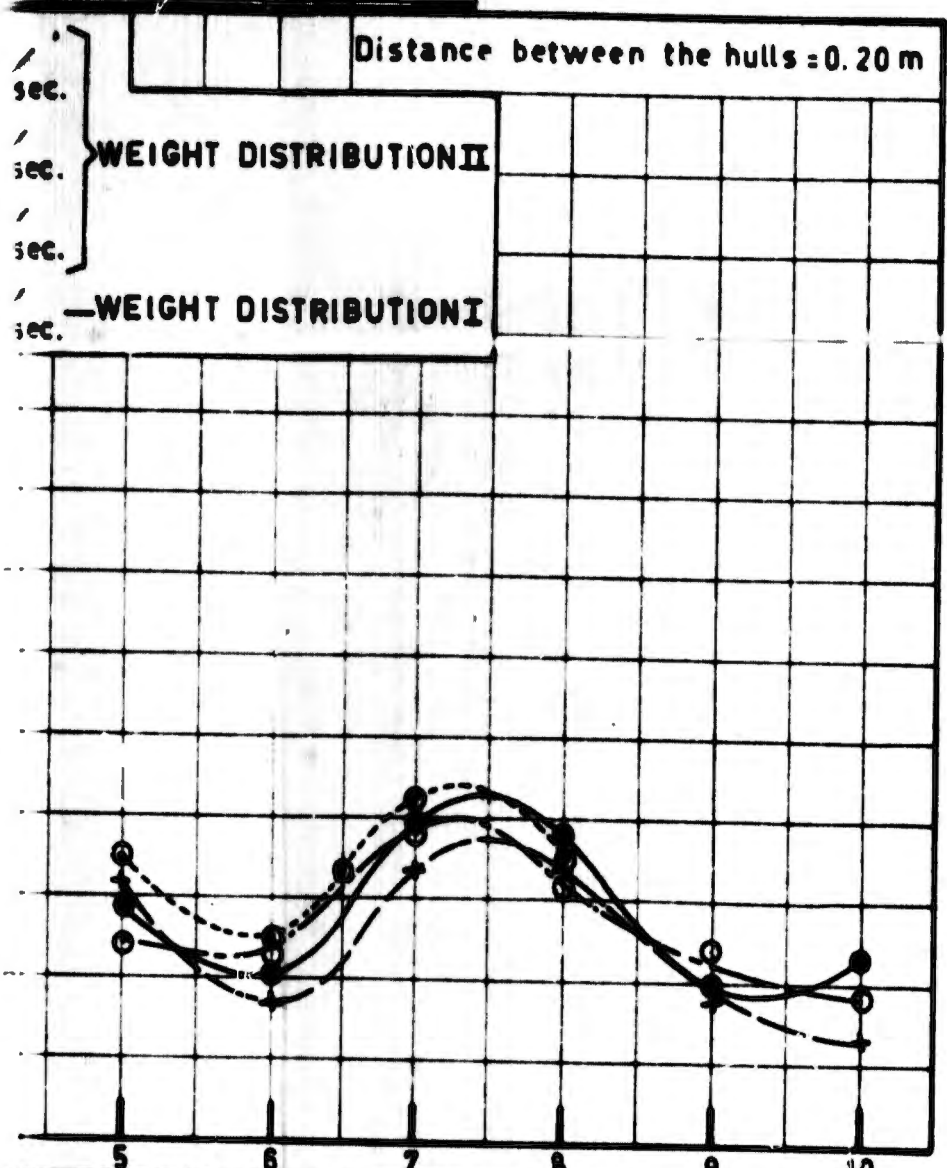
CATAMARAN SEAPLANE

NEDERLANDSCH SCHEEPSBOUW
PROEPOSTATION WAG 291

WAVE DIRECTION 90° —
PHASE LAG BETWEEN WAVE HEIGHT AND ROLL MOTION



HEIGHT AND ROLL MOTION



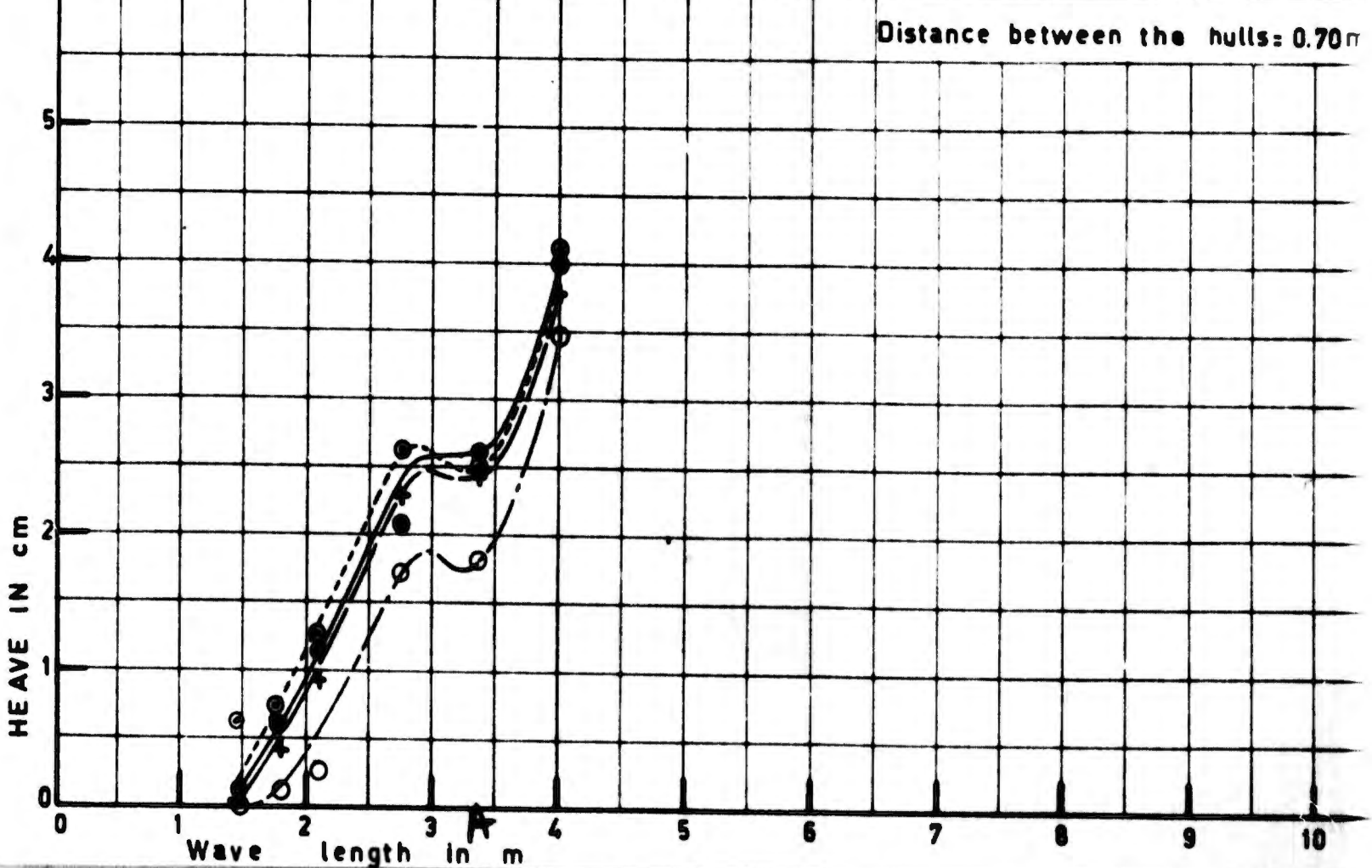
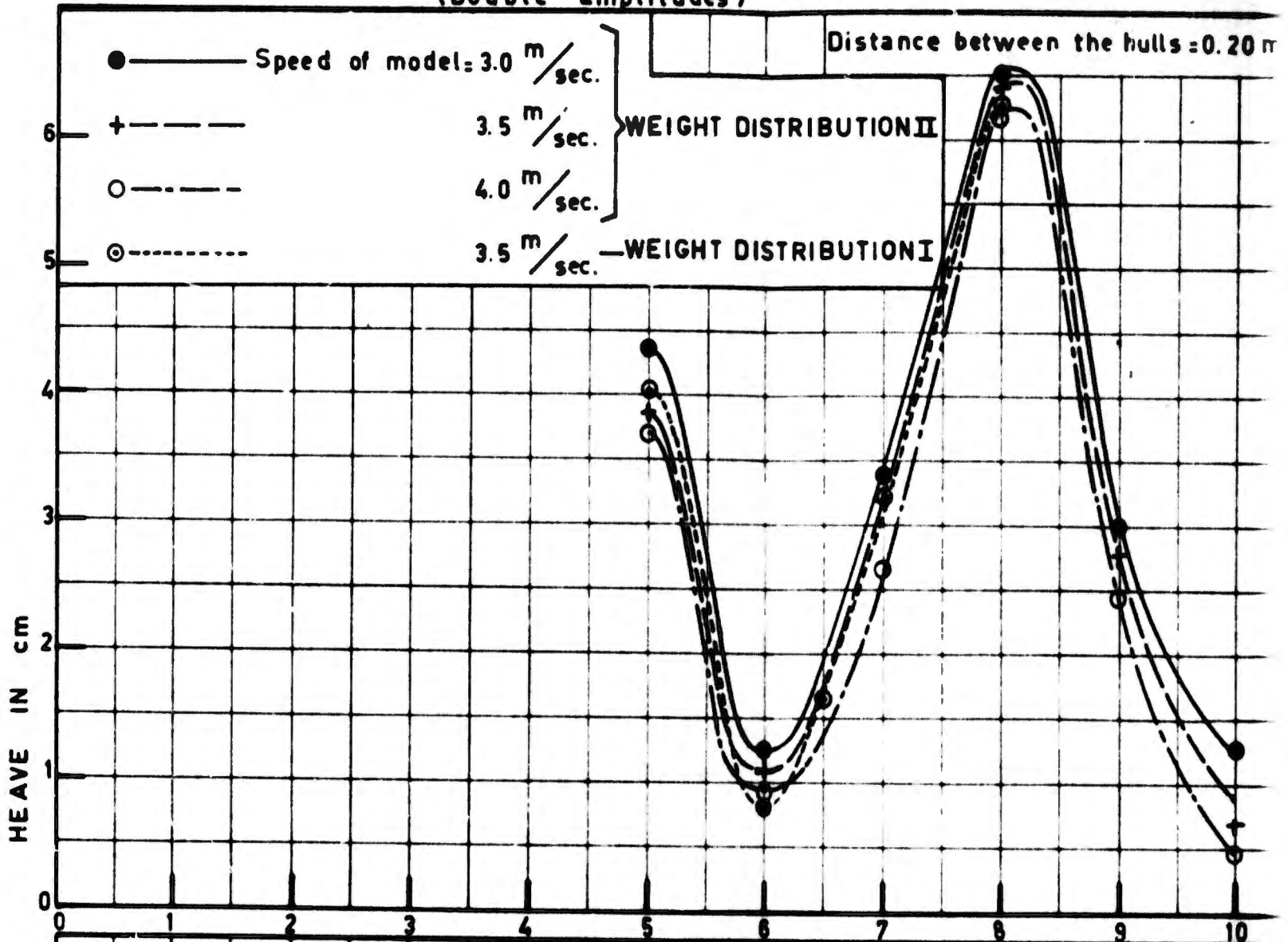
Wave length in m

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — HEAVE

NEDERLANDSCH SCHEEPSBOUW
PROEFSTATION

(Double amplitudes)

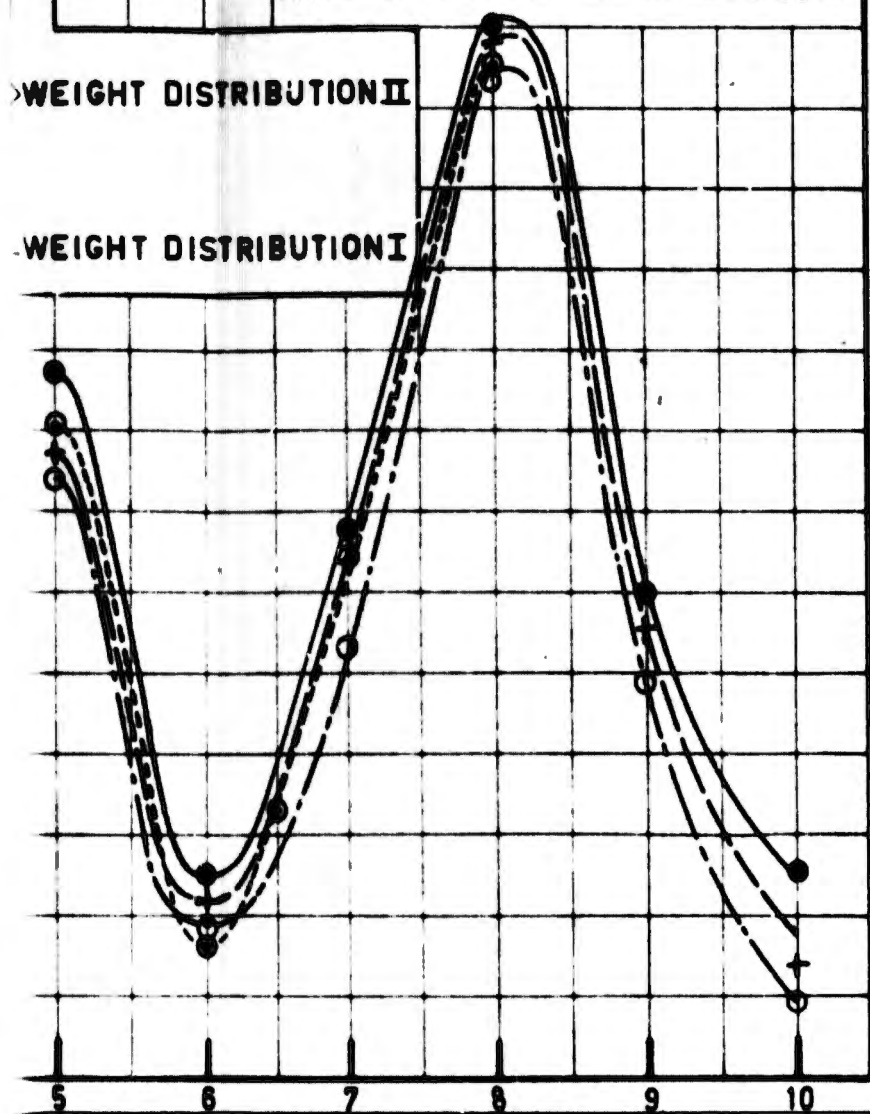


plitudes)

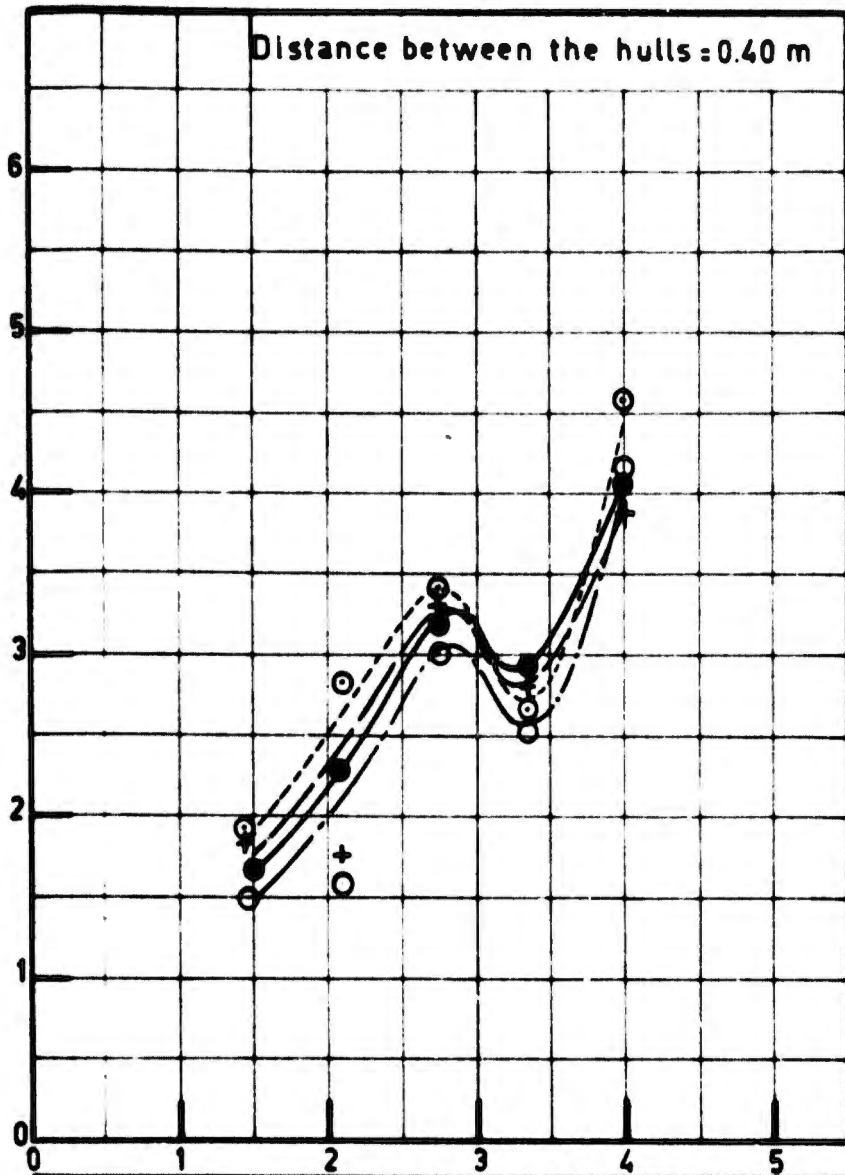
Distance between the hulls = 0.20 m

WEIGHT DISTRIBUTION II

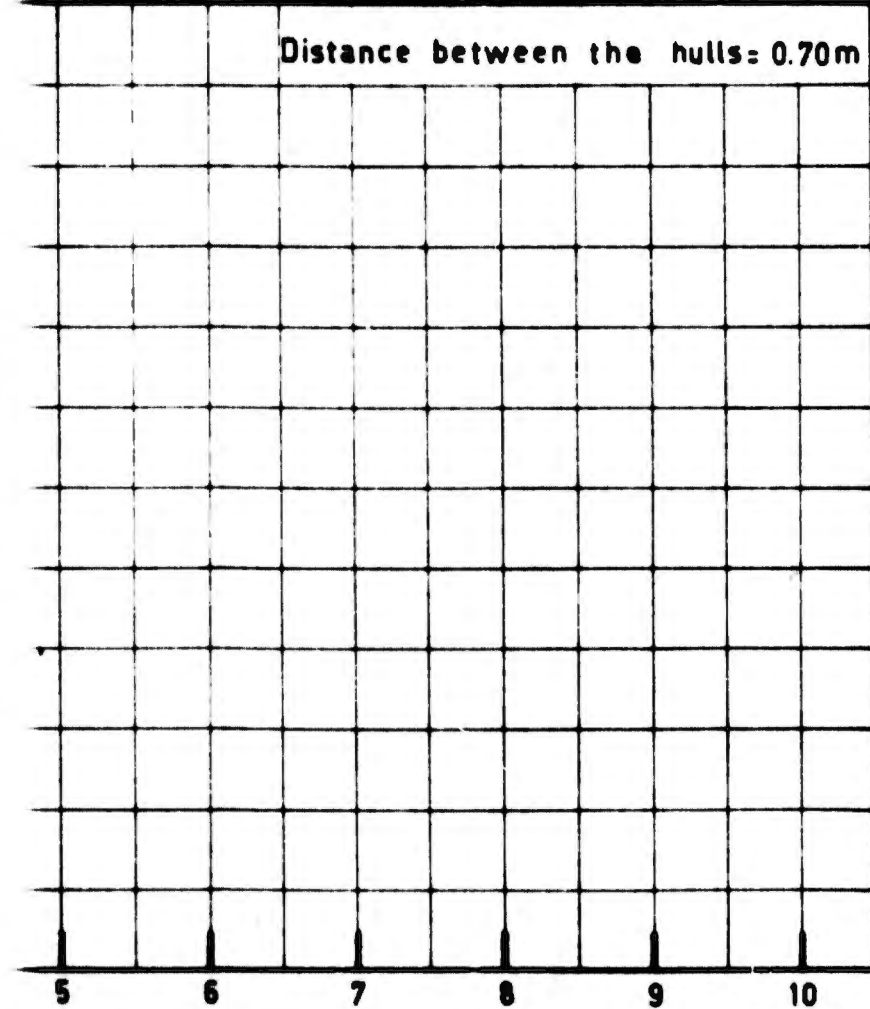
WEIGHT DISTRIBUTION I



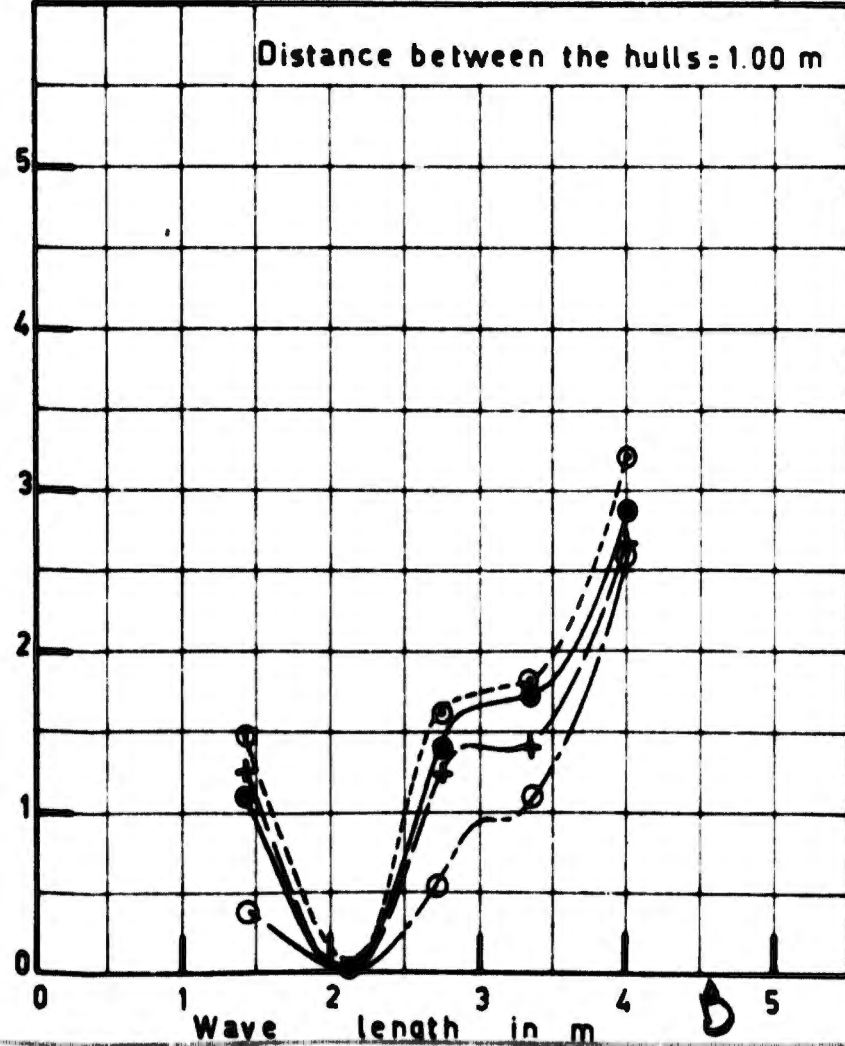
Distance between the hulls = 0.40 m



Distance between the hulls = 0.70 m



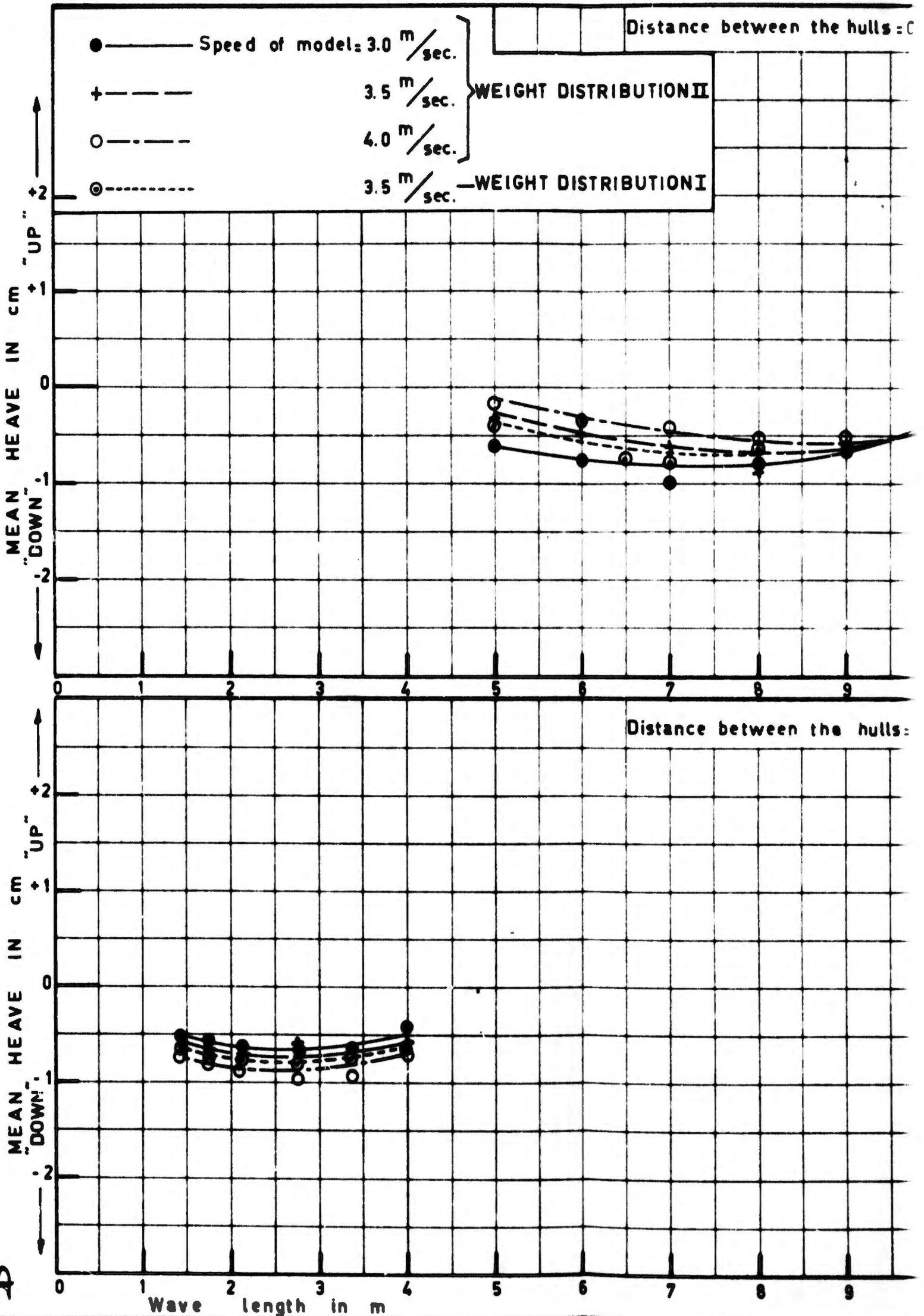
Distance between the hulls = 1.00 m

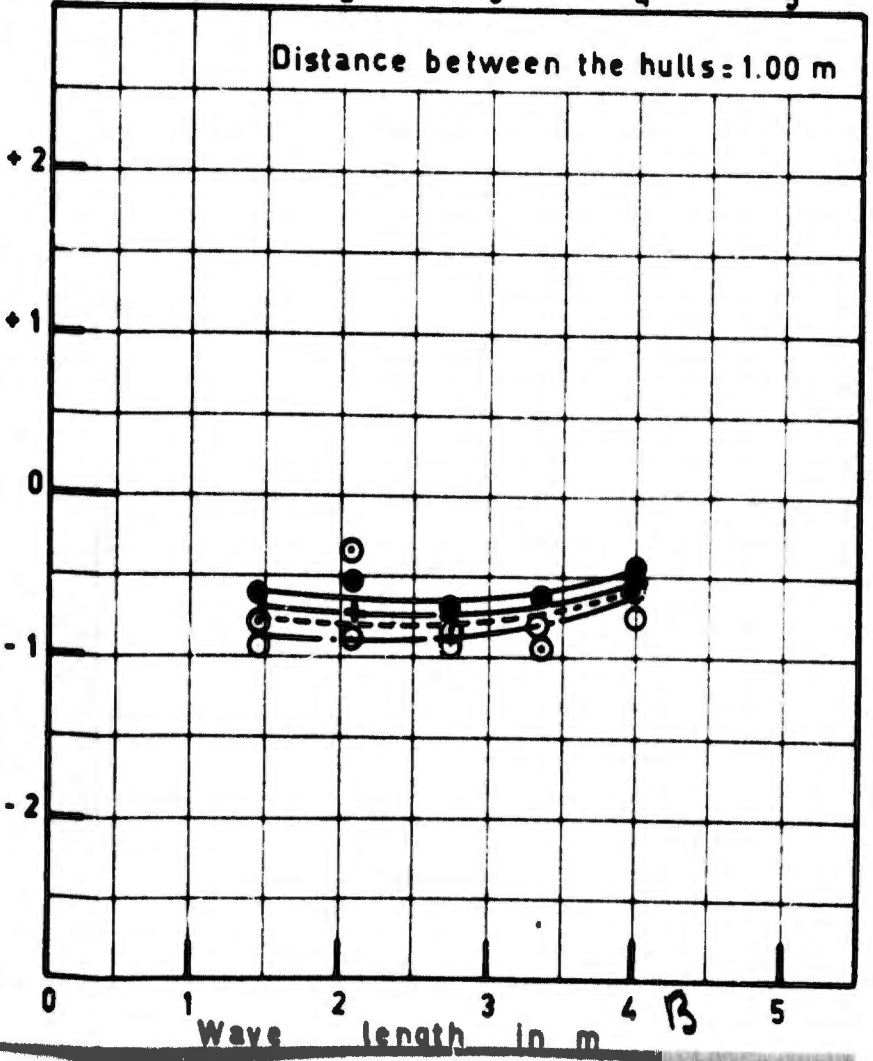
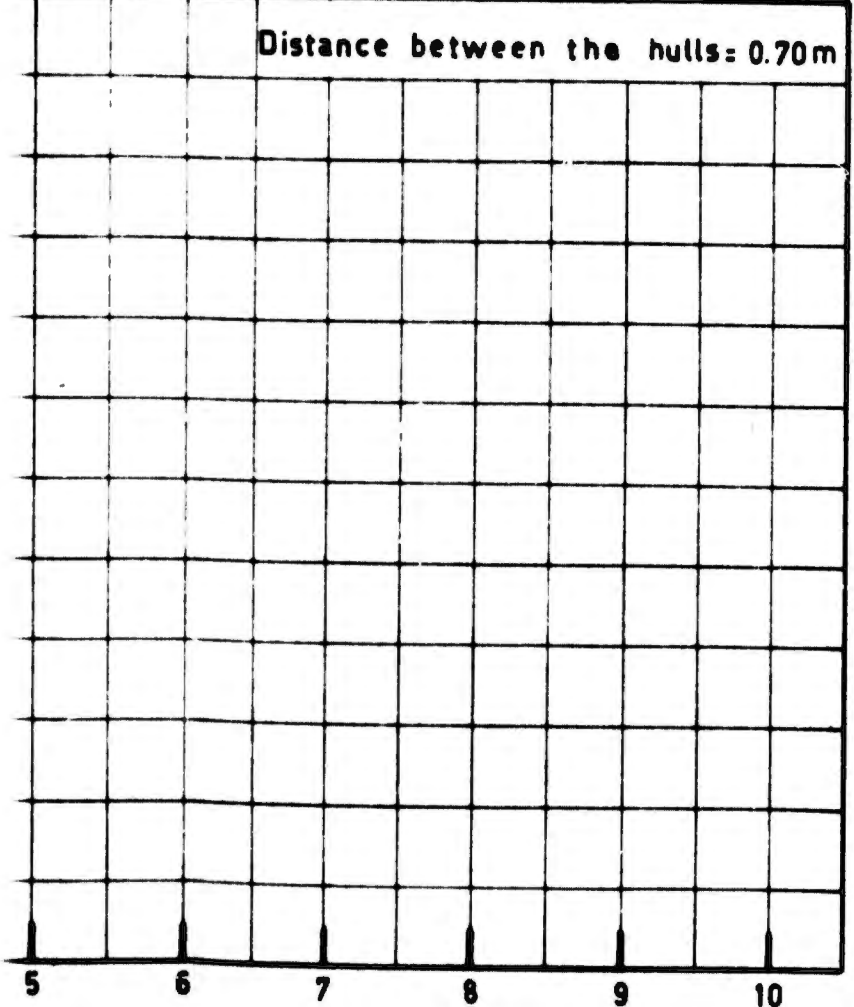
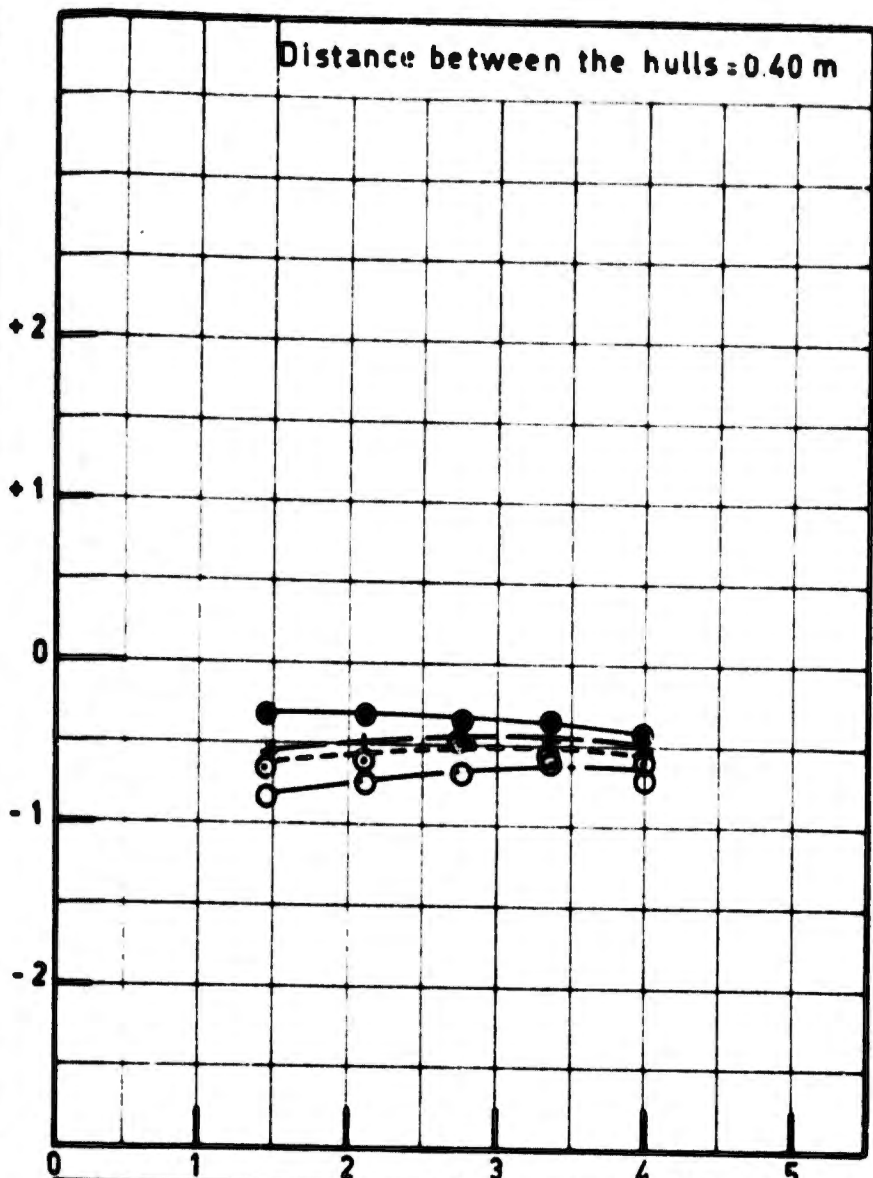
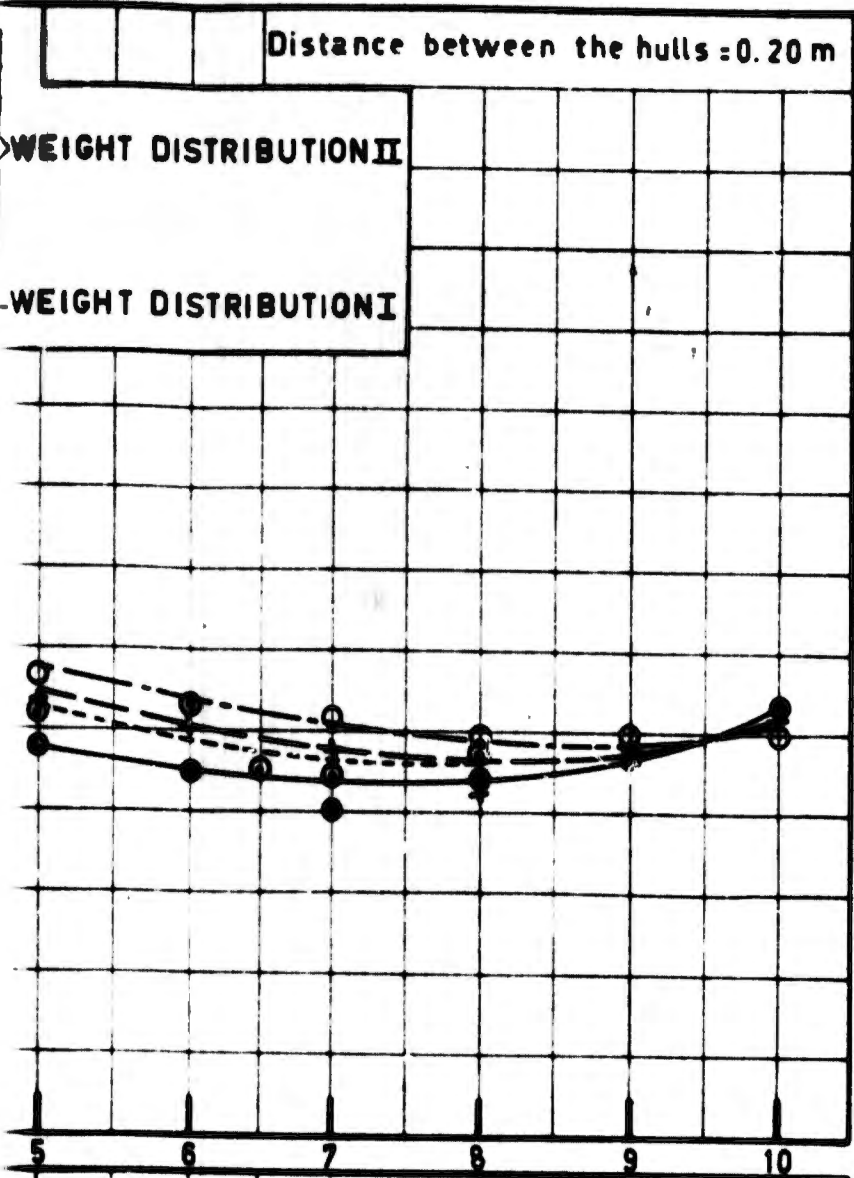


CATAMARAN SEAPLANE

WAVE DIRECTION 90° — MEAN HEAVE

NEDERLANDSCH SCHIFFS
PROEFSTATION



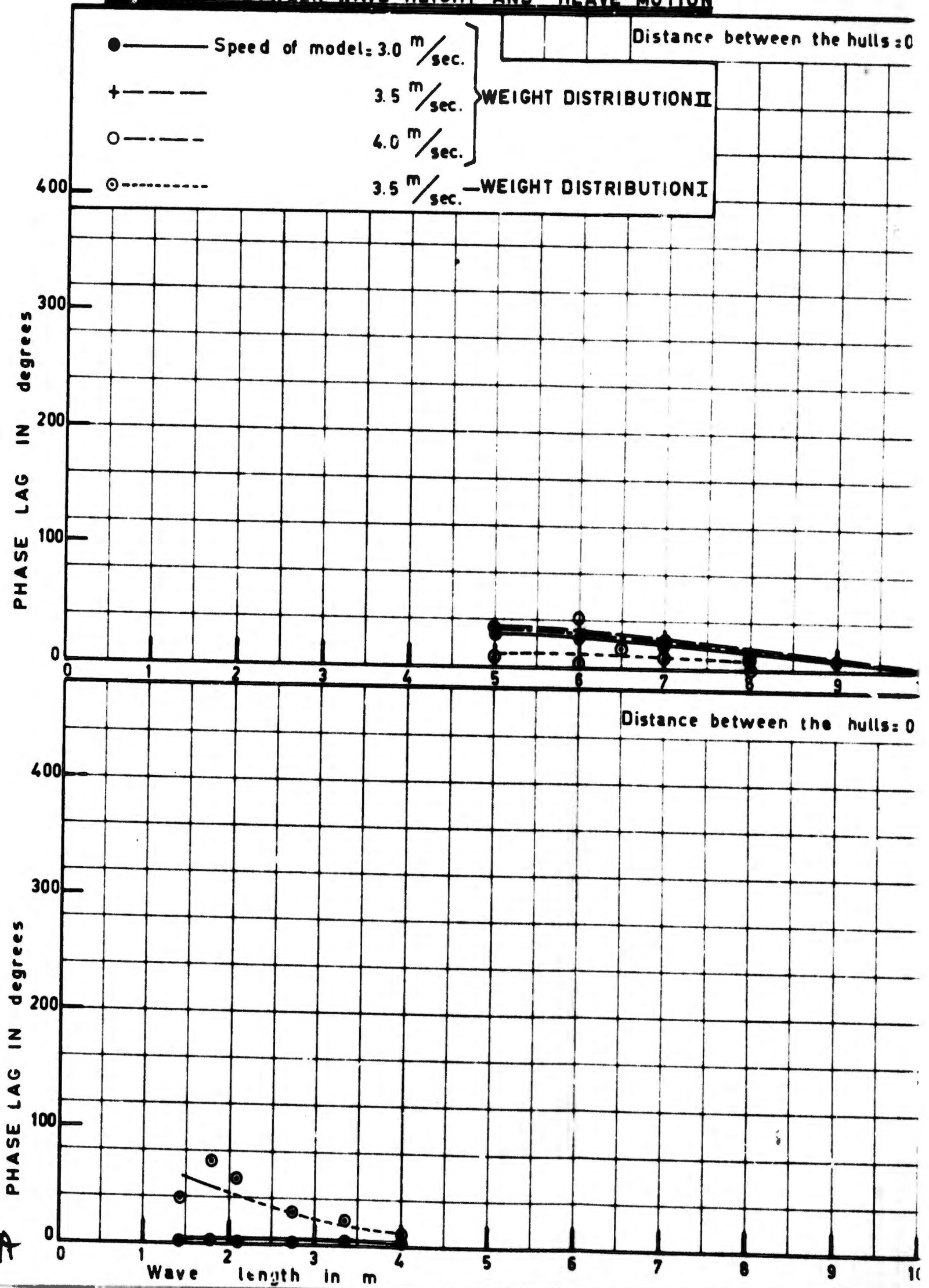


CATAMARAN SEAPLANE

NEDERLANDSCH SCH
PROEFSTATION

WAVE DIRECTION 90° —

PHASE LAG BETWEEN WAVE HEIGHT AND HEAVE MOTION



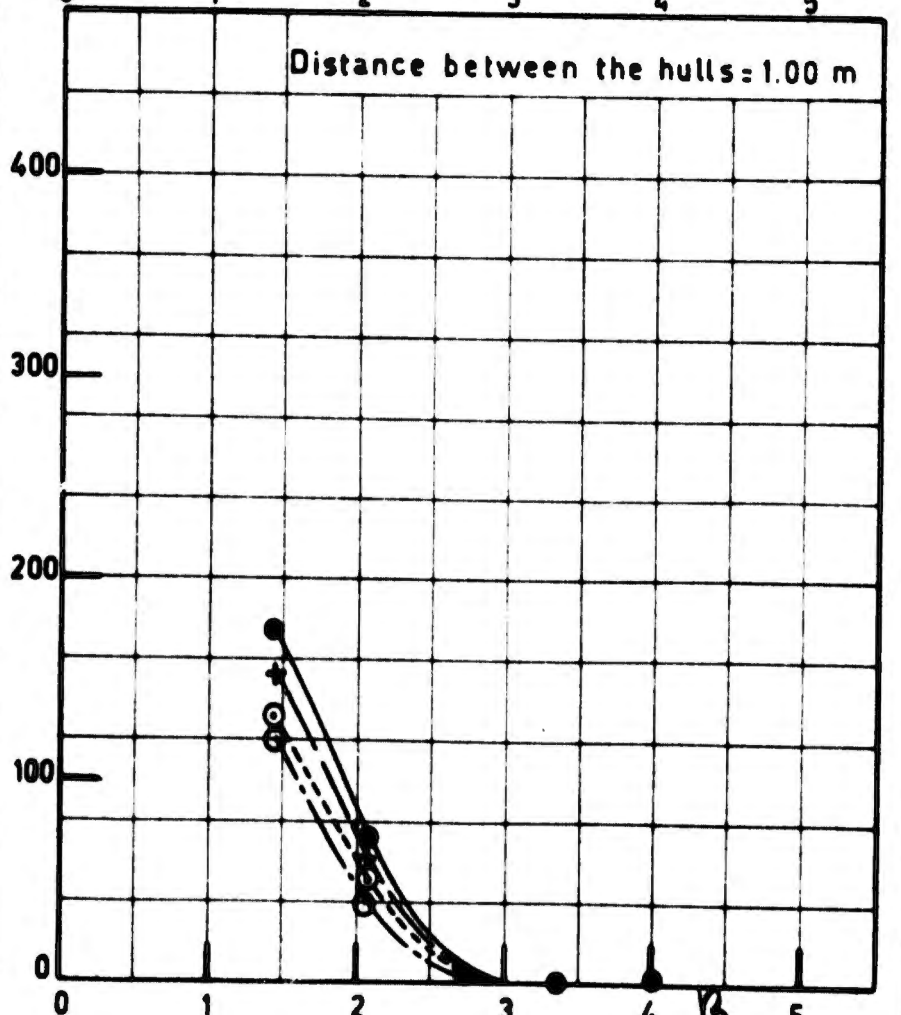
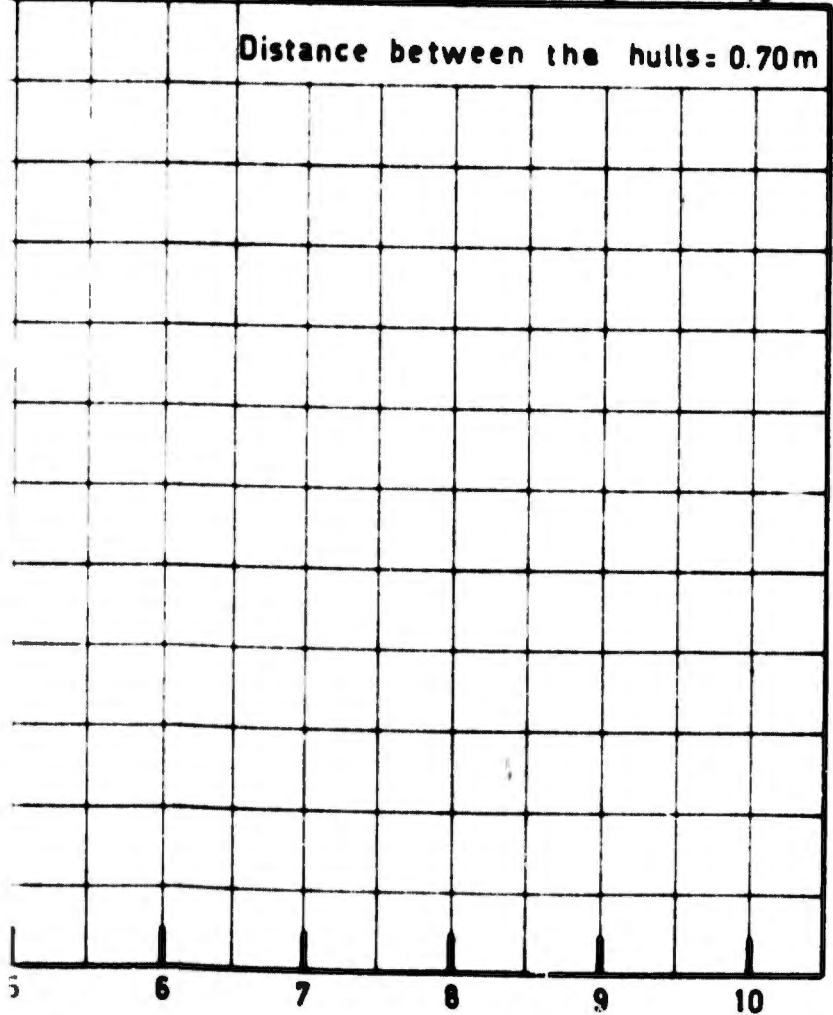
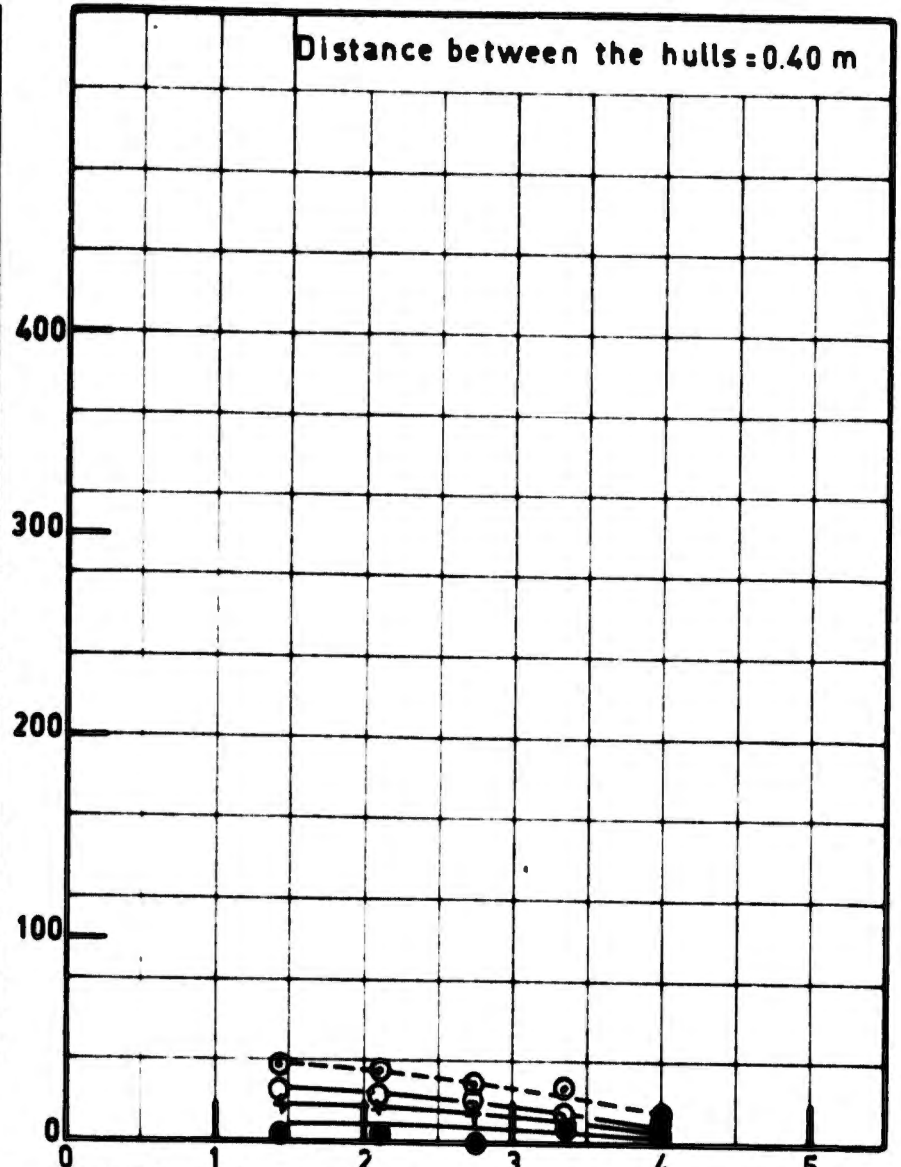
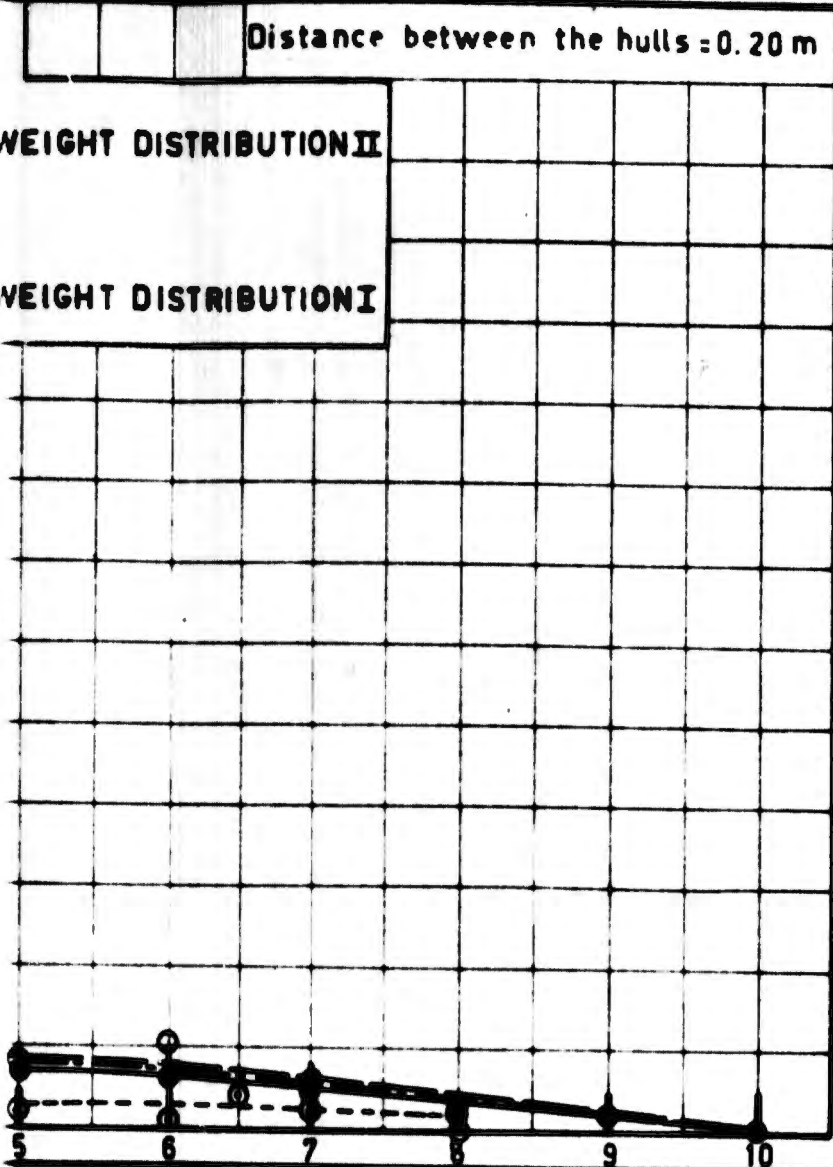
ANE

NEDERLANDSCH SCHEEPSBOUWKUNDIG
PROEFSTATION WAGENINGEN

REPORT No 66-086-ZT

FIG. 39

AND HEAVE MOTION

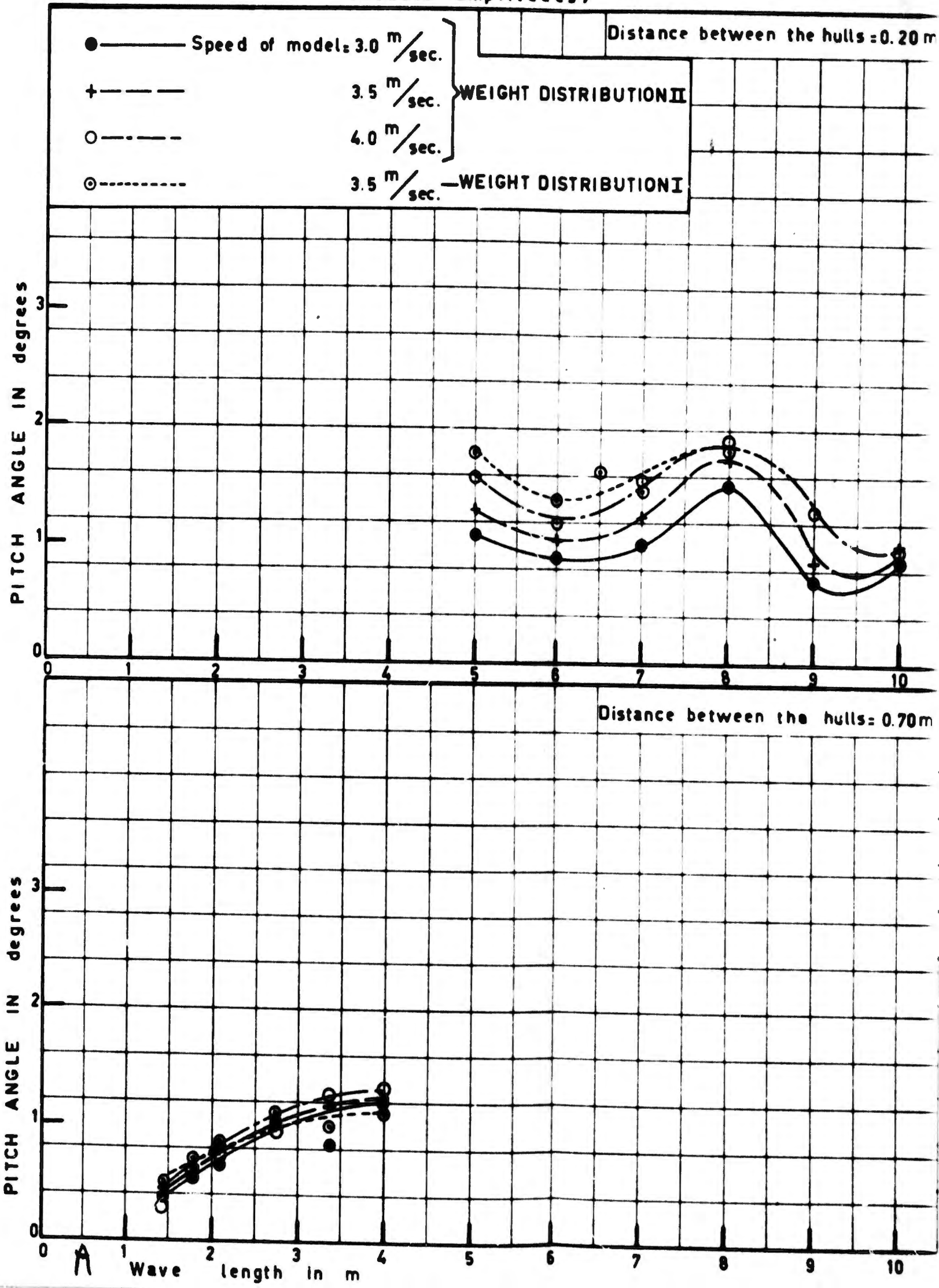


Wave length in m

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — PITCH ANGLES
(Double amplitudes)

NEDERLANDSCH SCHEEPSB
PROEFSTATION

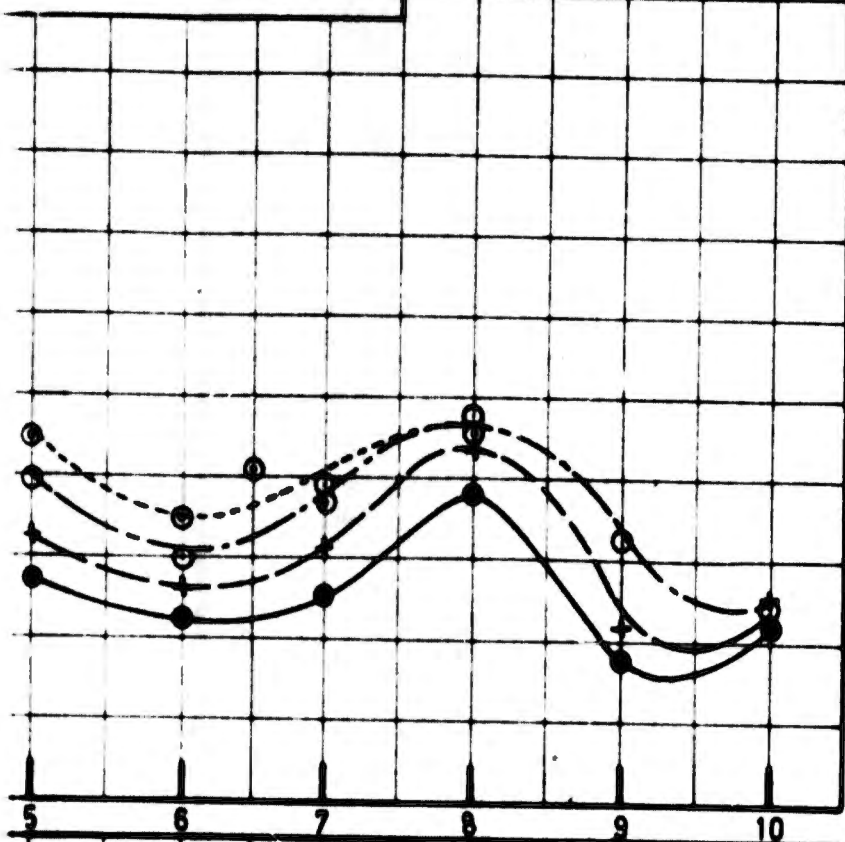


LANE
 ANGLES
 amplitudes)

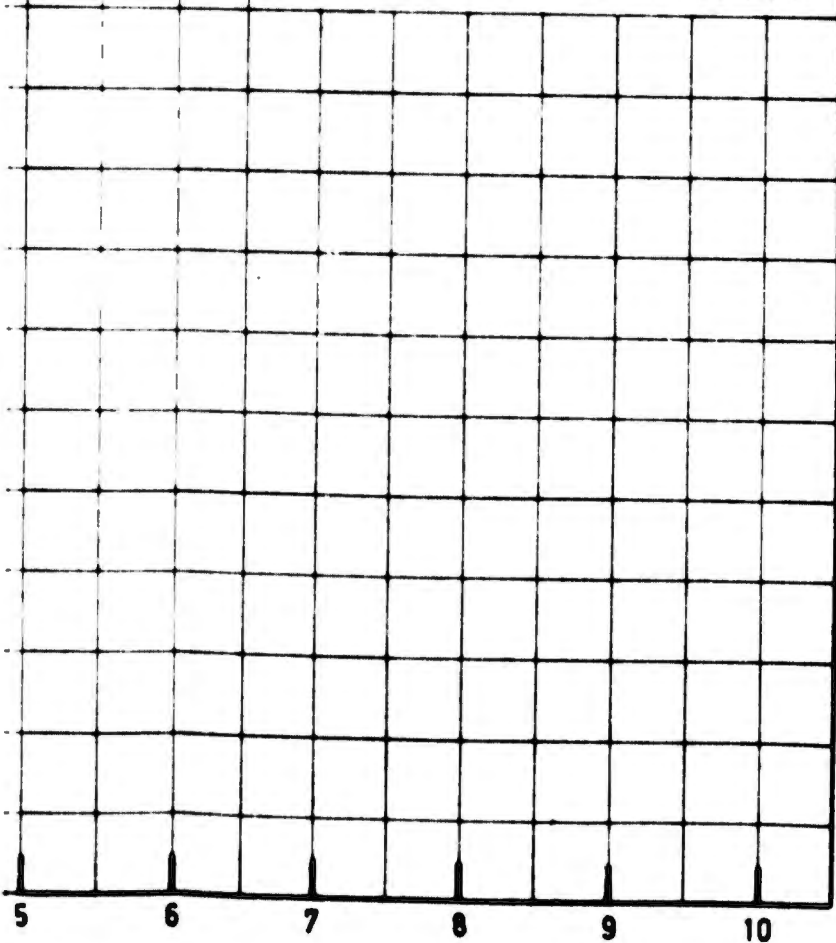
Distance between the hulls = 0.20 m

WEIGHT DISTRIBUTION II

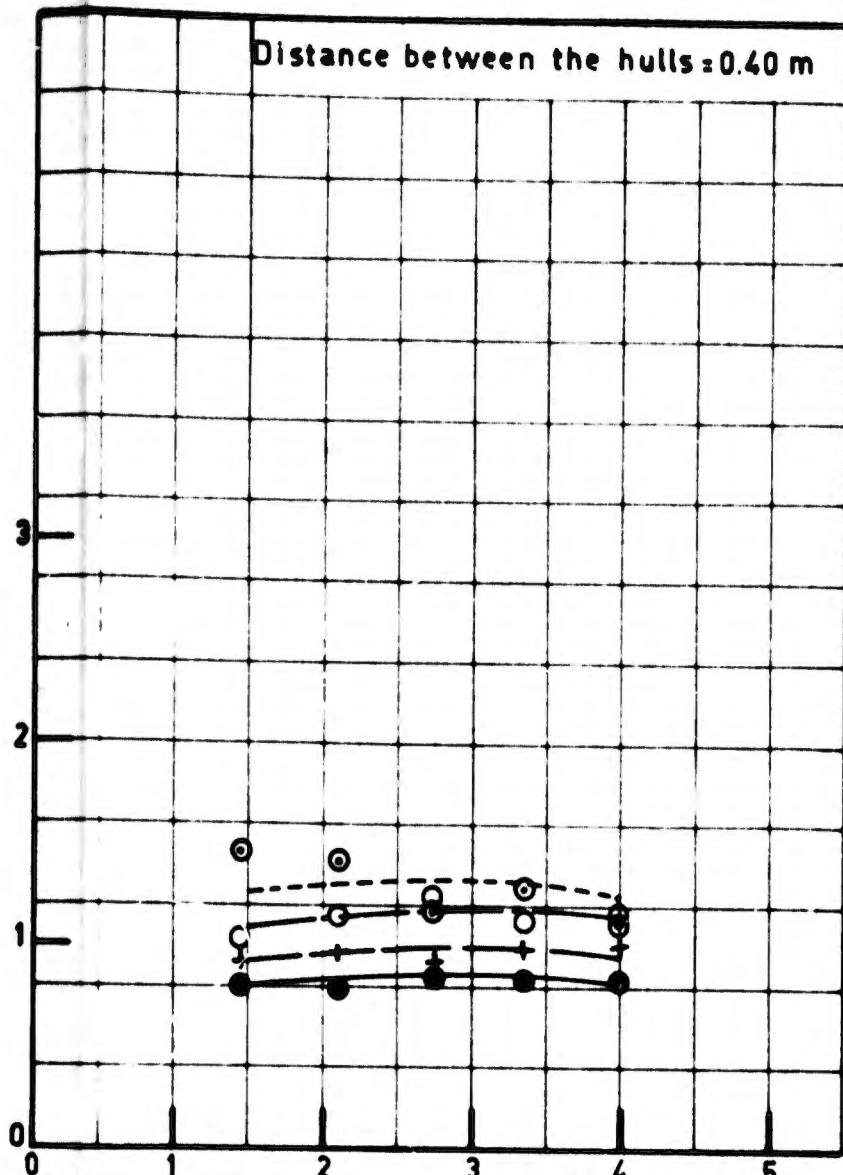
WEIGHT DISTRIBUTION I



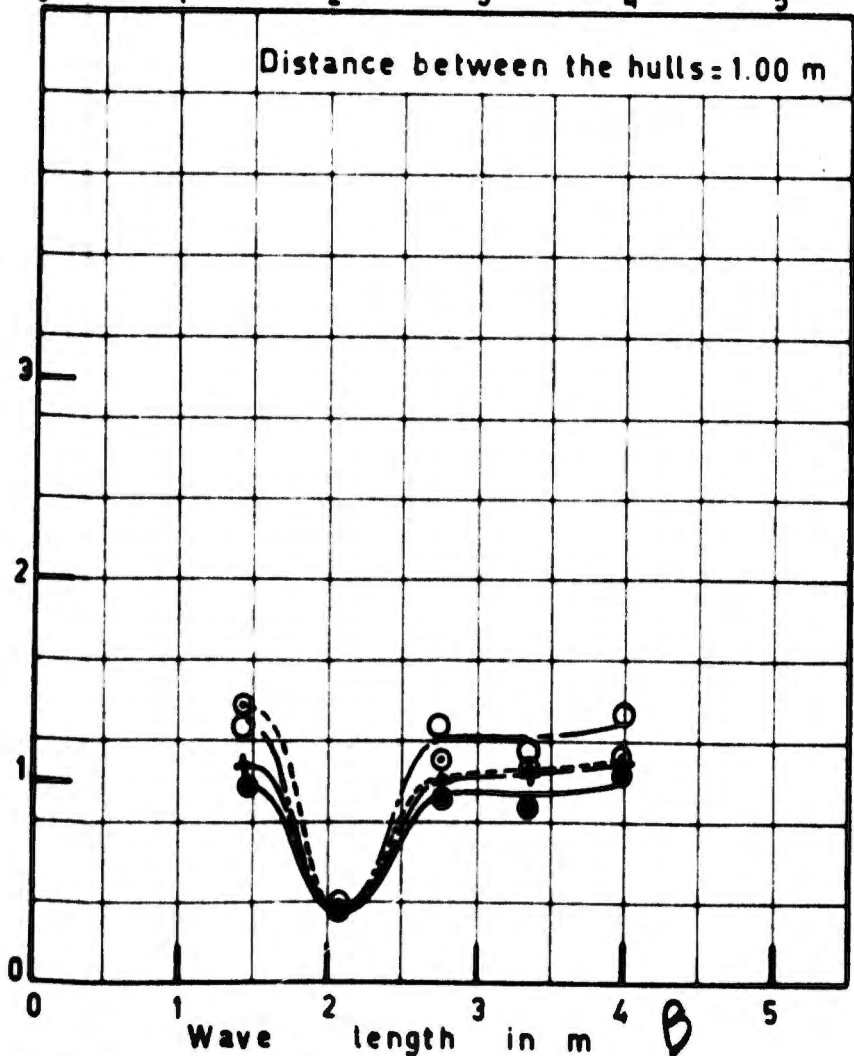
Distance between the hulls = 0.70 m



Distance between the hulls = 0.40 m



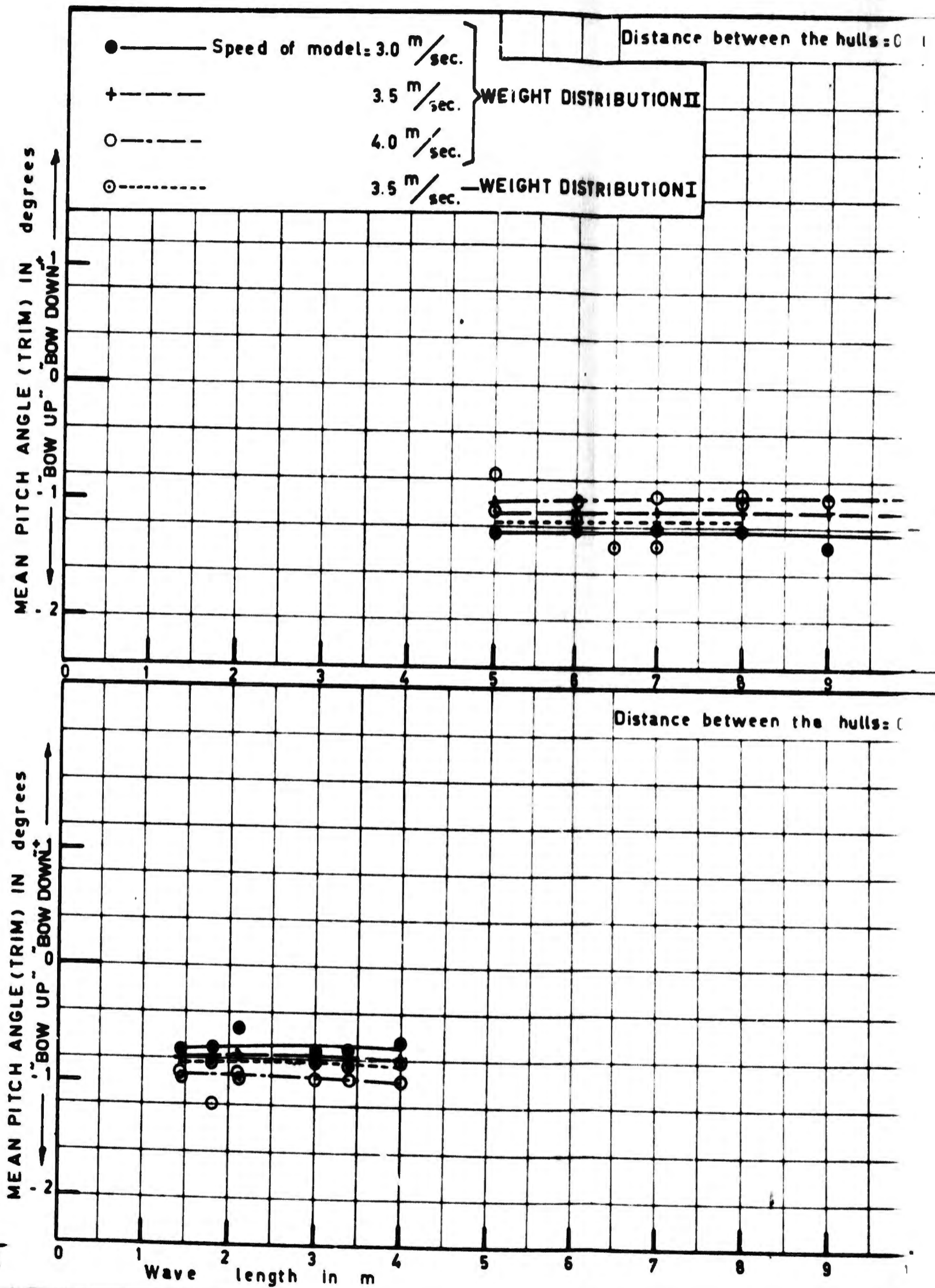
Distance between the hulls = 1.00 m

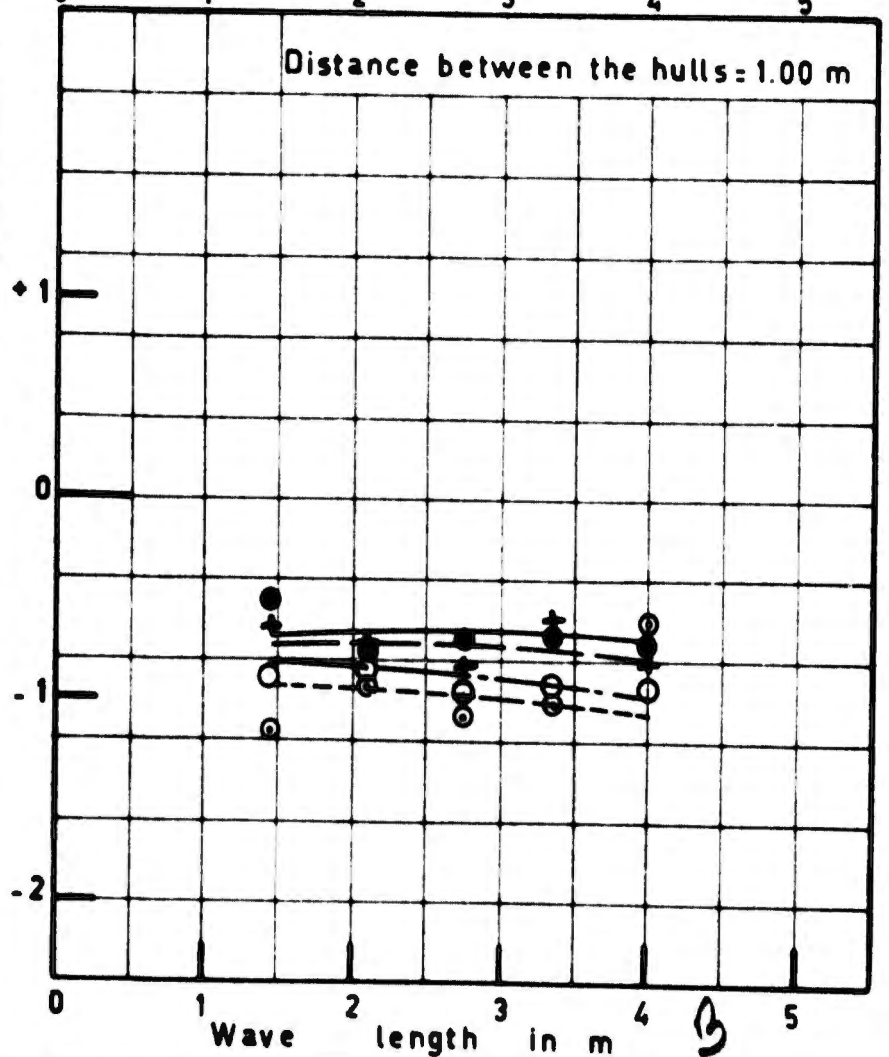
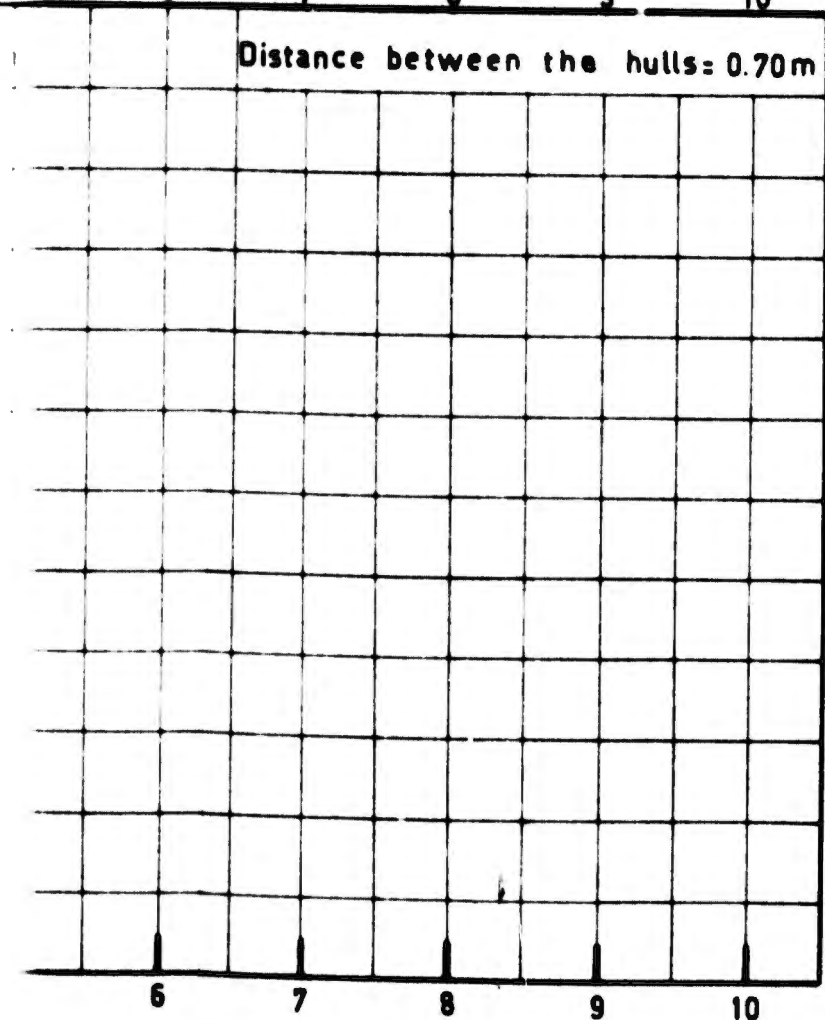
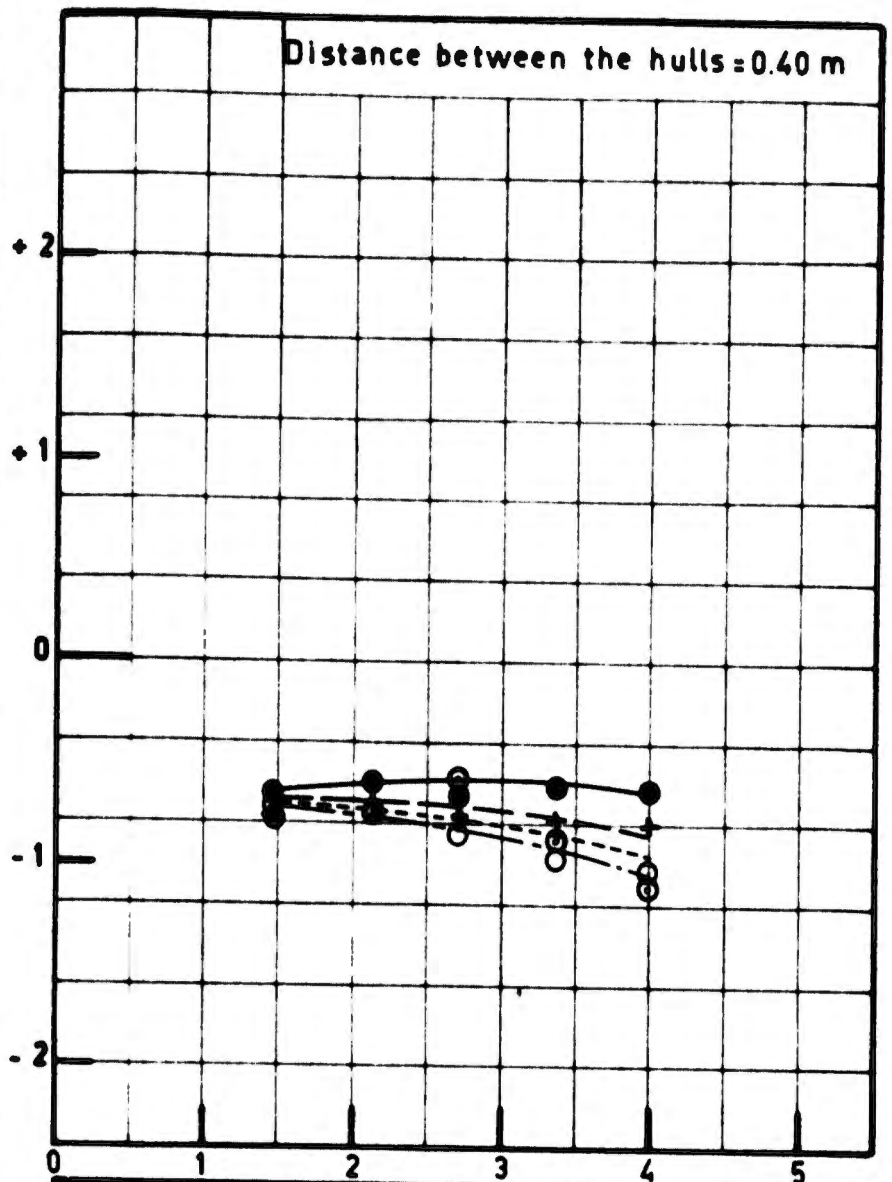
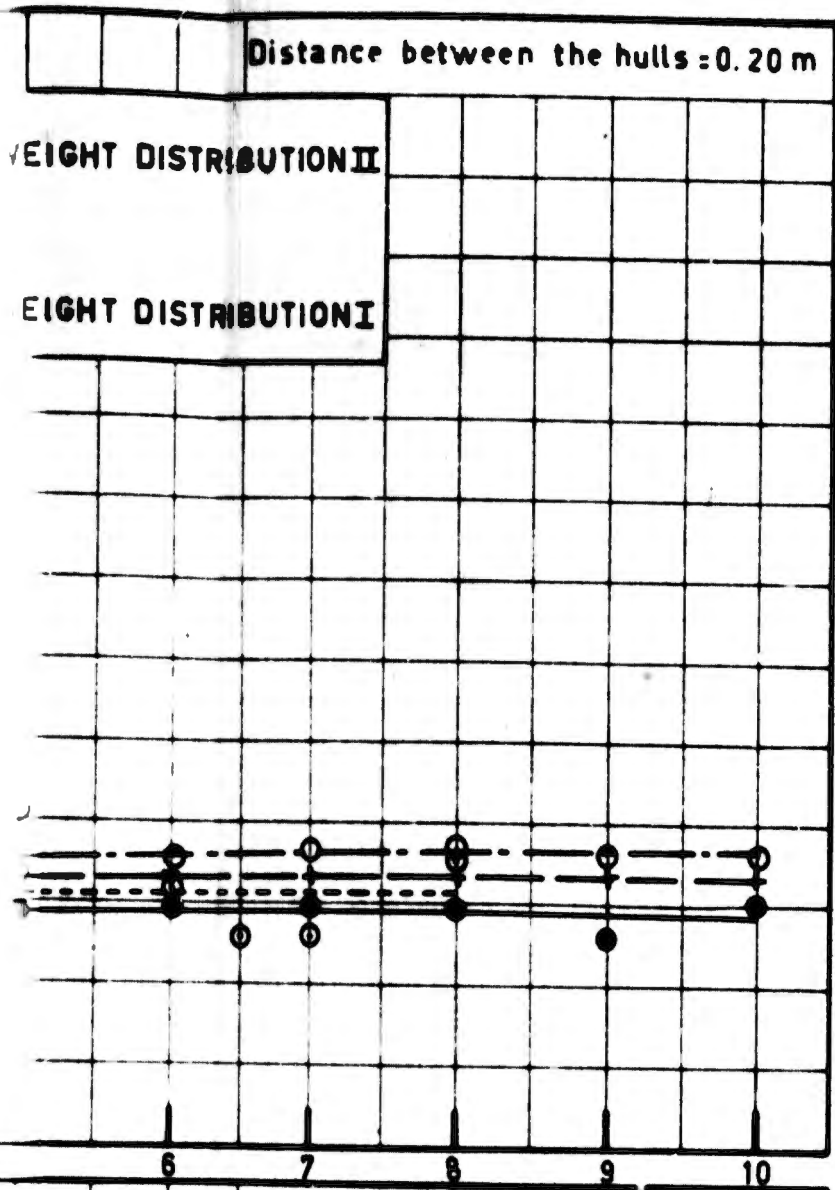


CATAMARAN SEAPLANE

WAVE DIRECTION 90° — MEAN PITCH ANGLES

NEDERLANDSCH SCHIP
PROEFSTATION

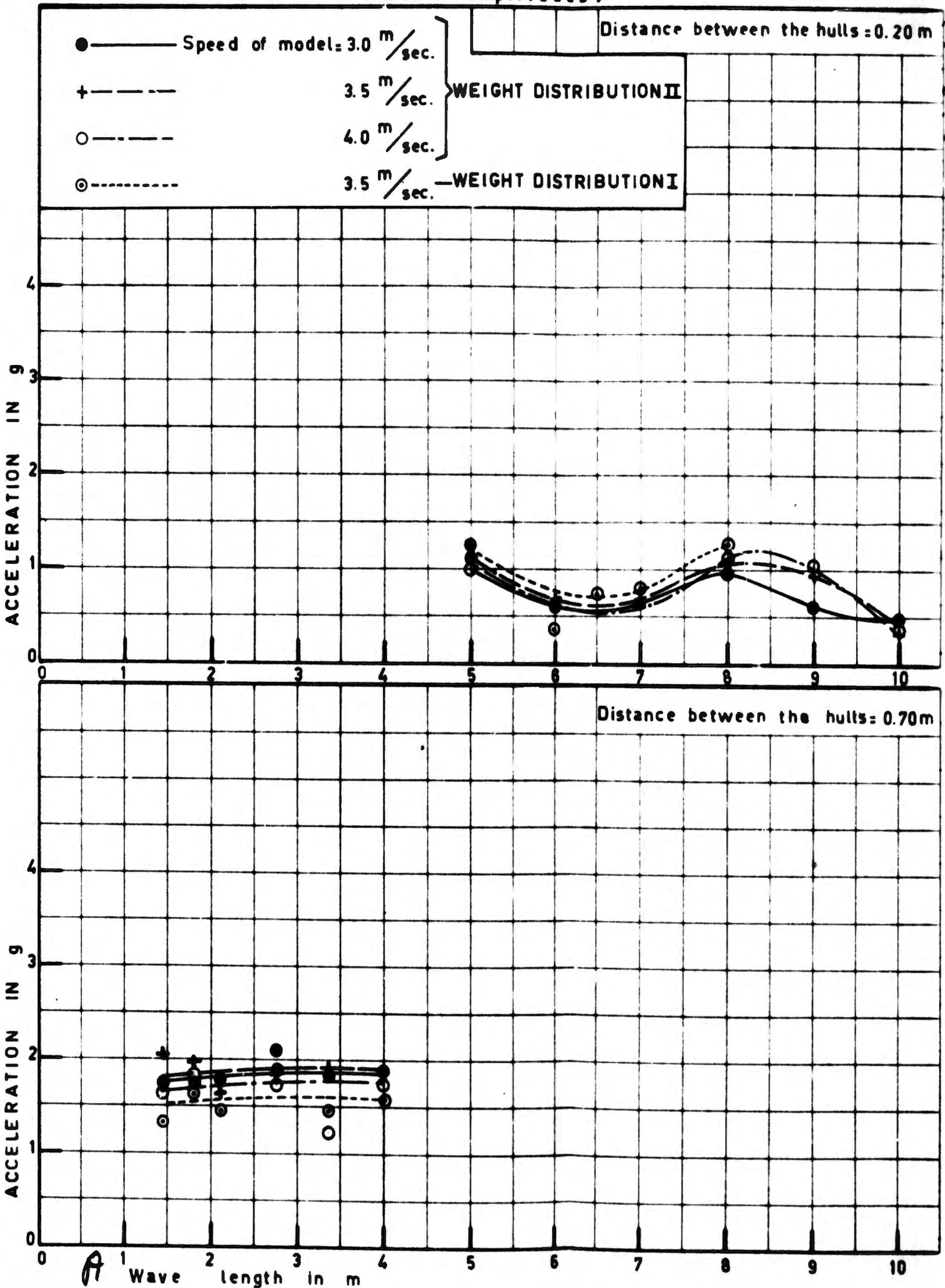




CATAMARAN SEAPLANE

WAVE DIRECTION 90° — ACCELERATIONS OF THE HULLS
(Double amplitudes)

NEDERLANDSCH SCHEEPBOUW
PROEFSTATION WAGeningen

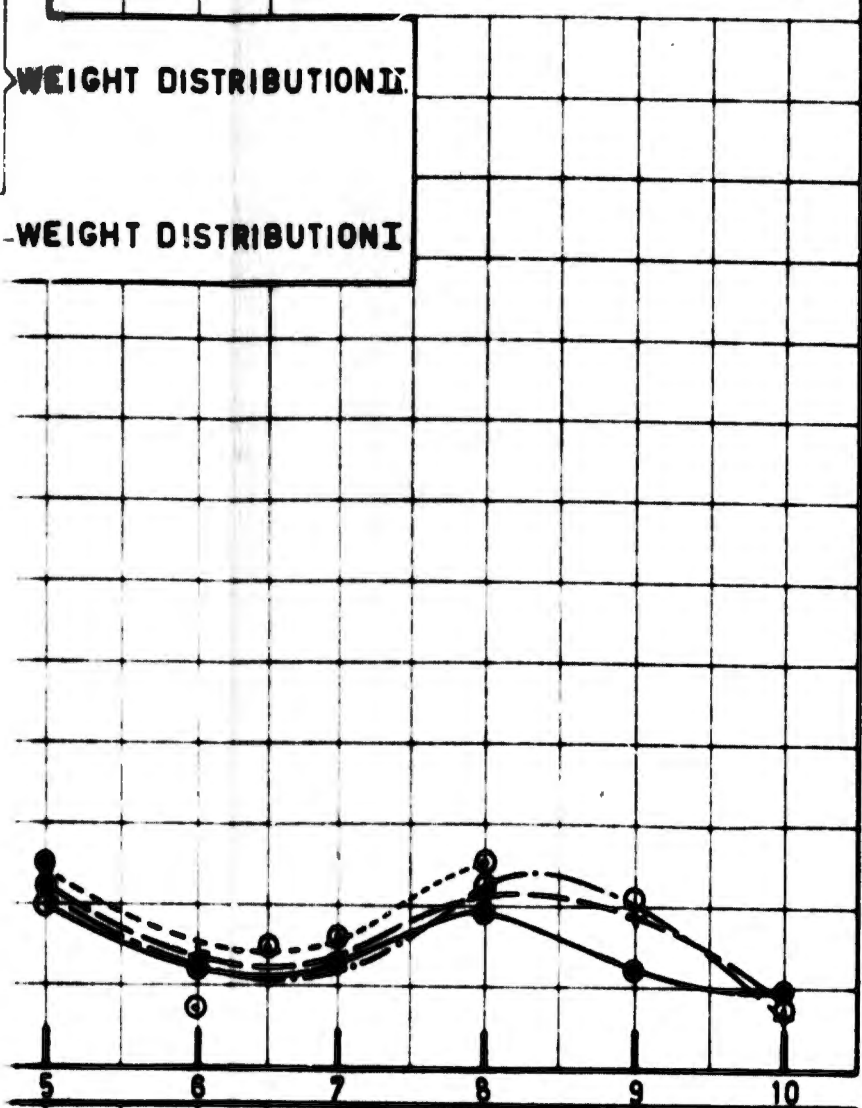


(amplitudes)

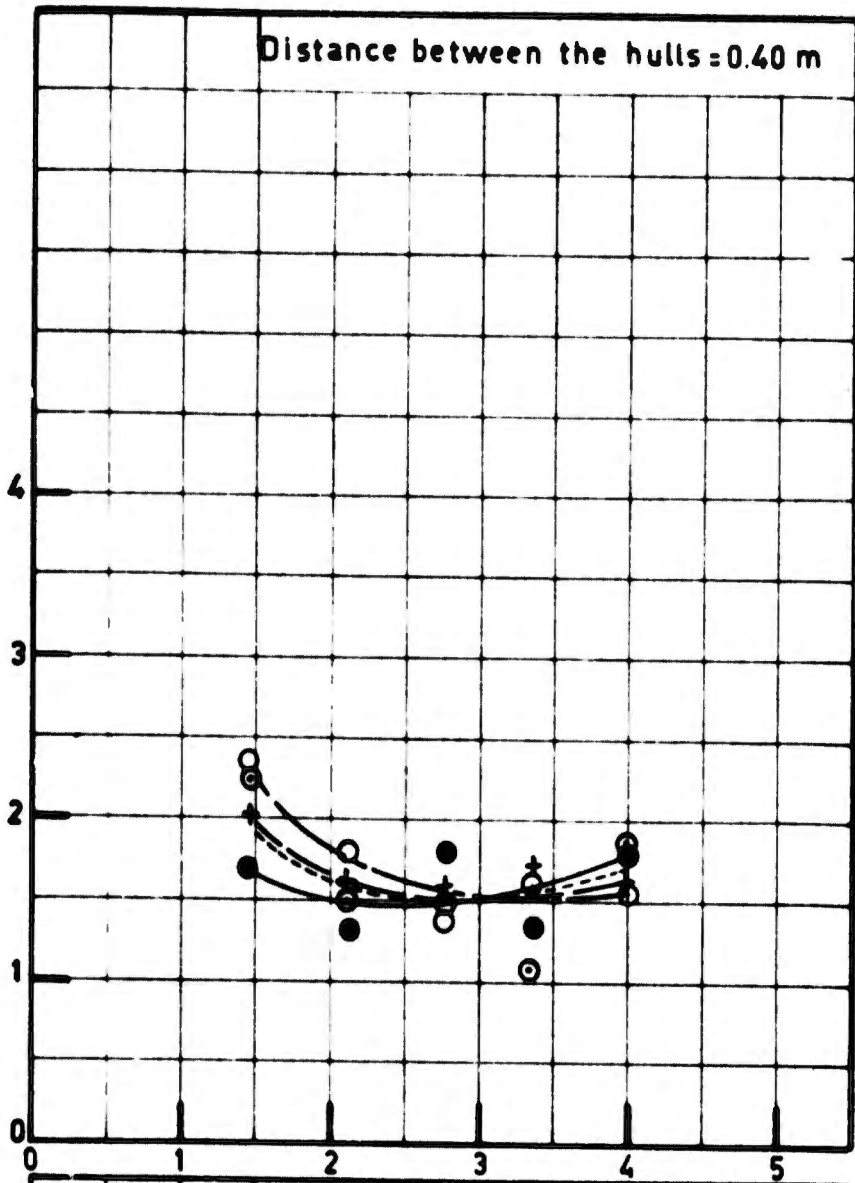
Distance between the hulls = 0.20 m

WEIGHT DISTRIBUTION II

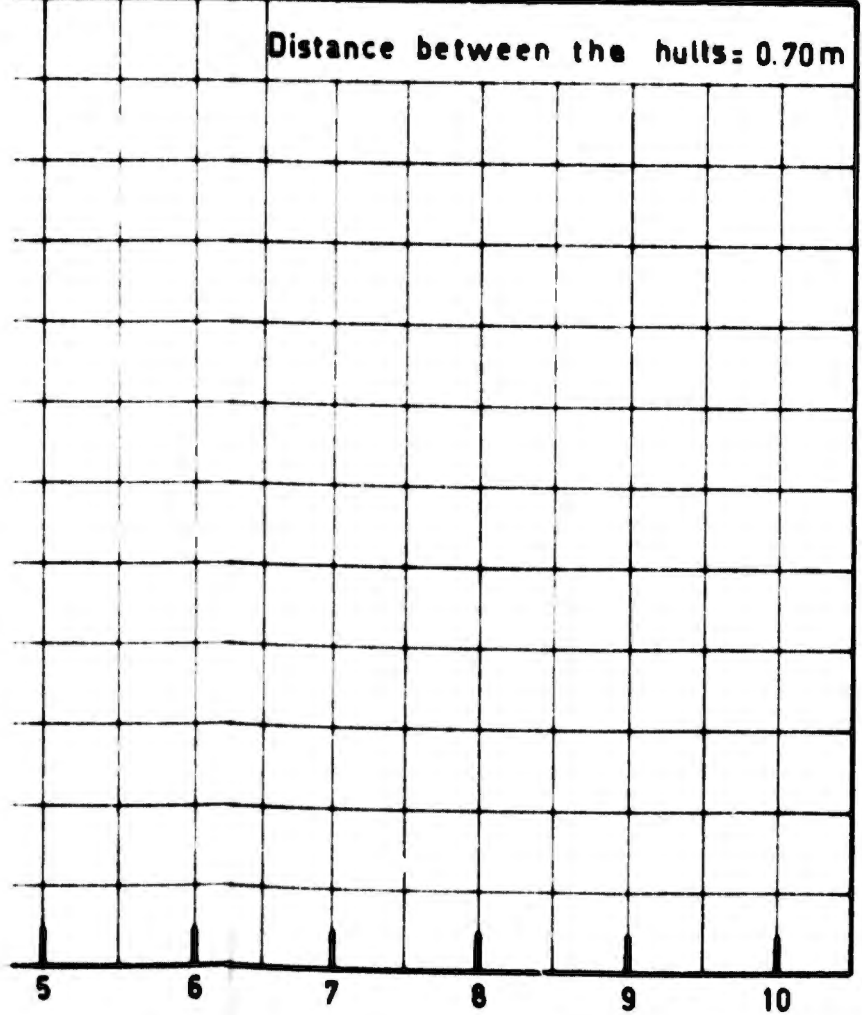
WEIGHT DISTRIBUTION I



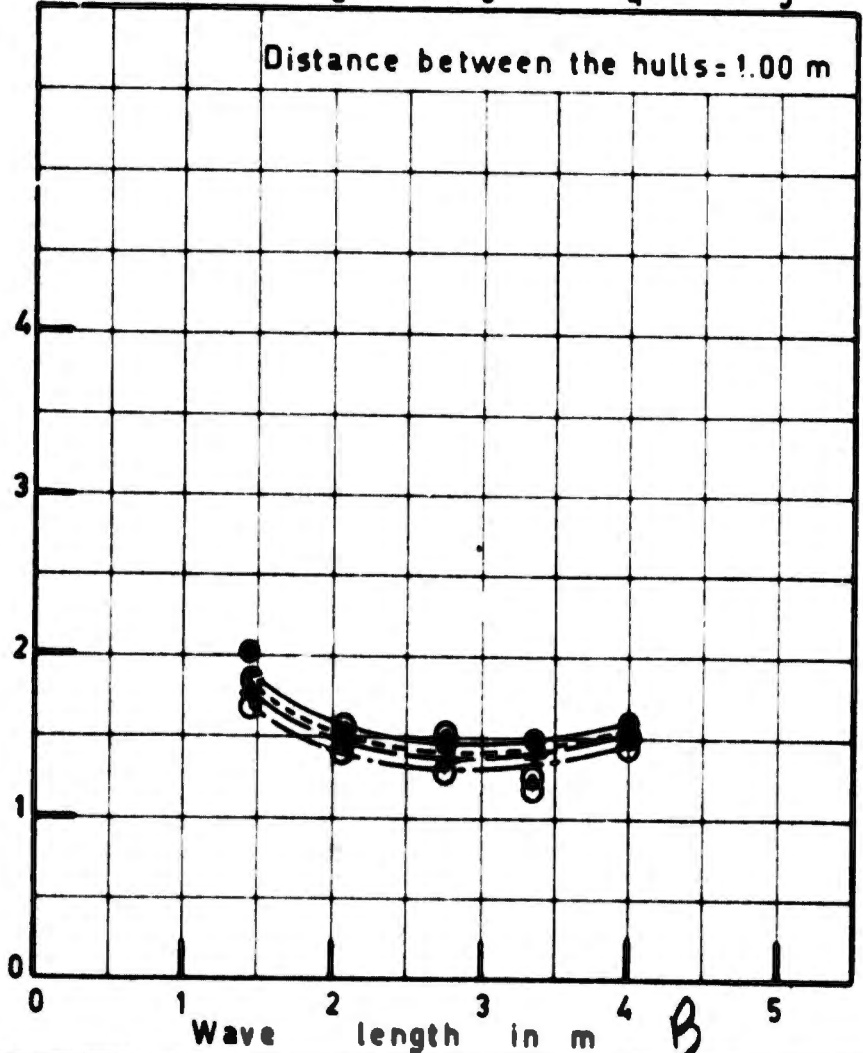
Distance between the hulls = 0.40 m



Distance between the hulls = 0.70 m



Distance between the hulls = 1.00 m



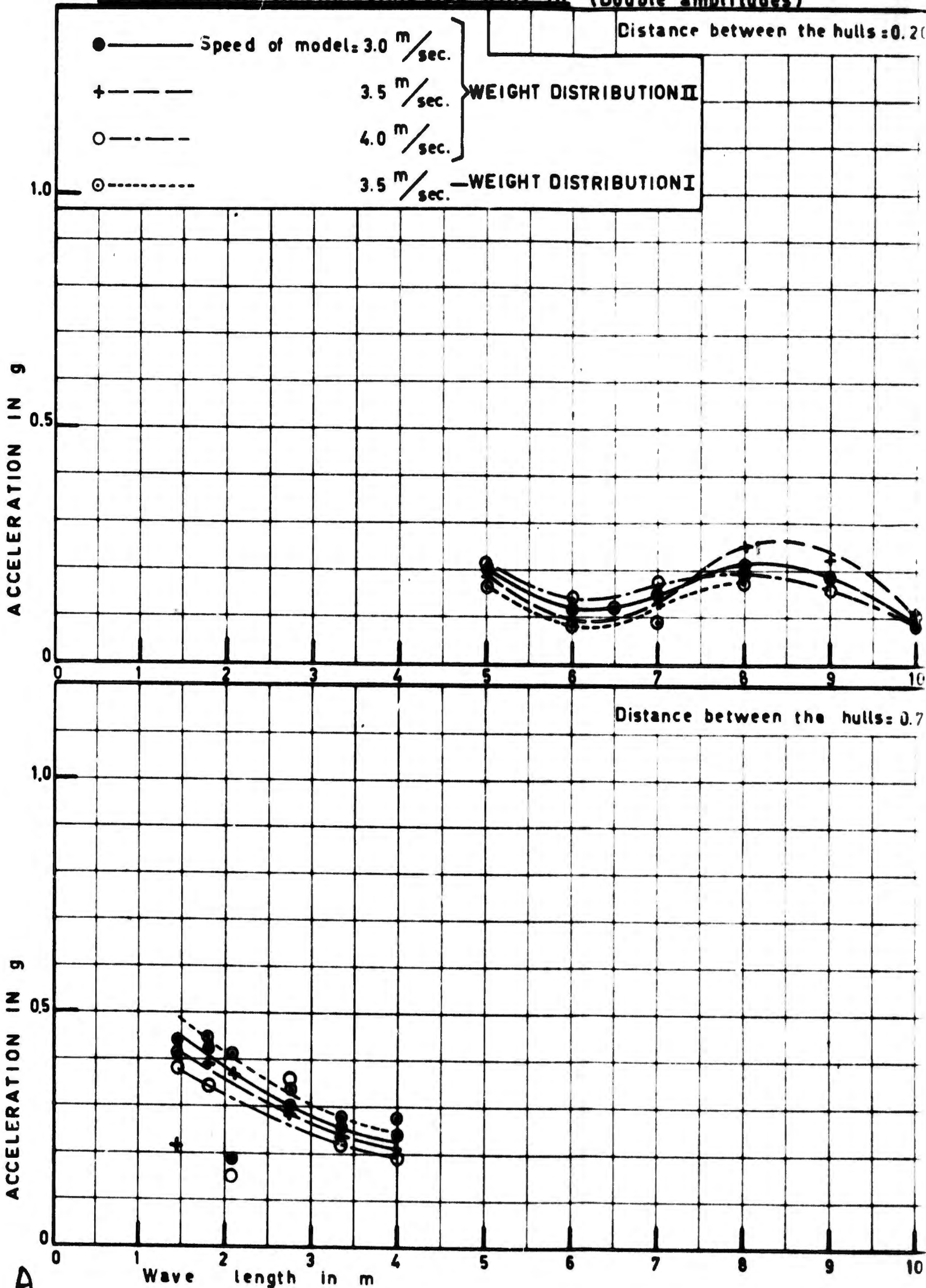
Wave length in m B

CATAMARAN SEAFLANE

NEDERLANDSCH SCHEEP
PROEFSTATION

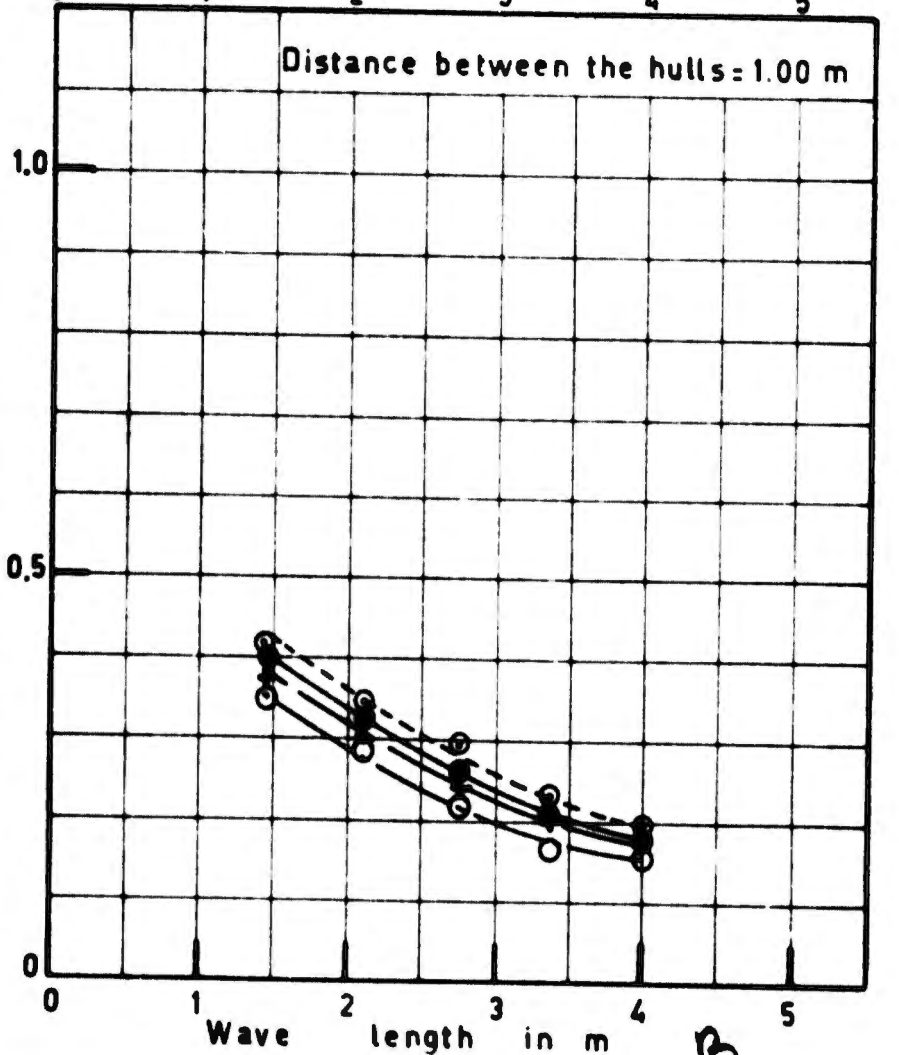
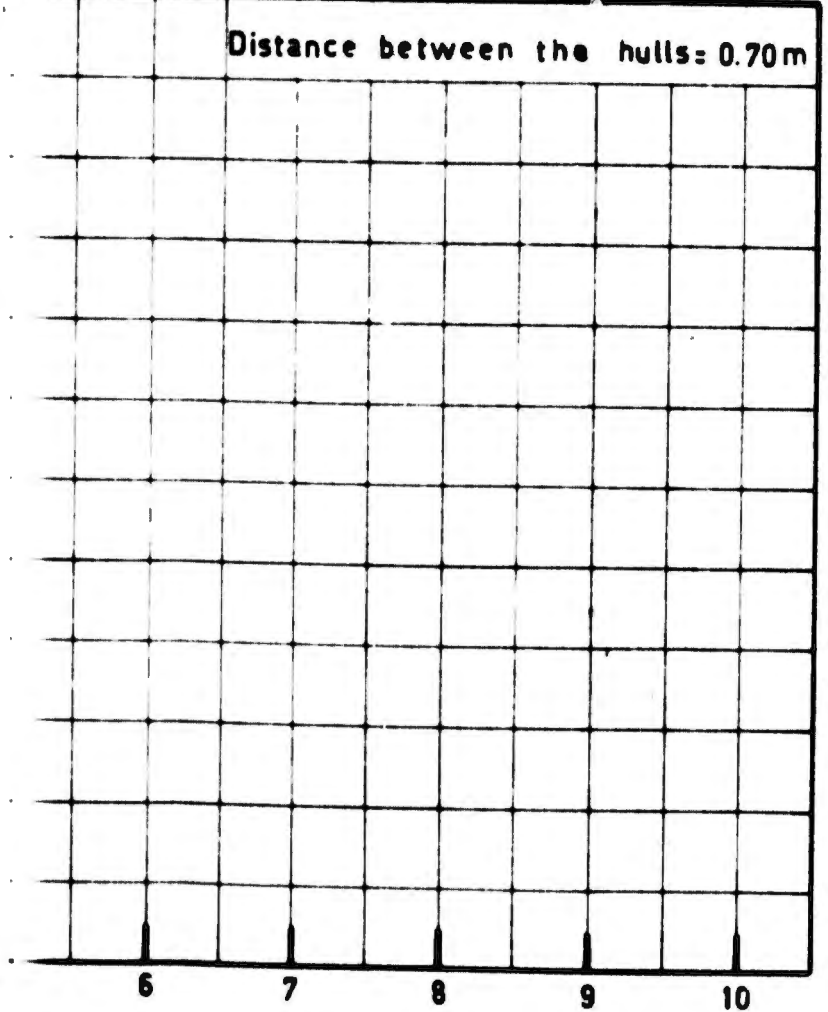
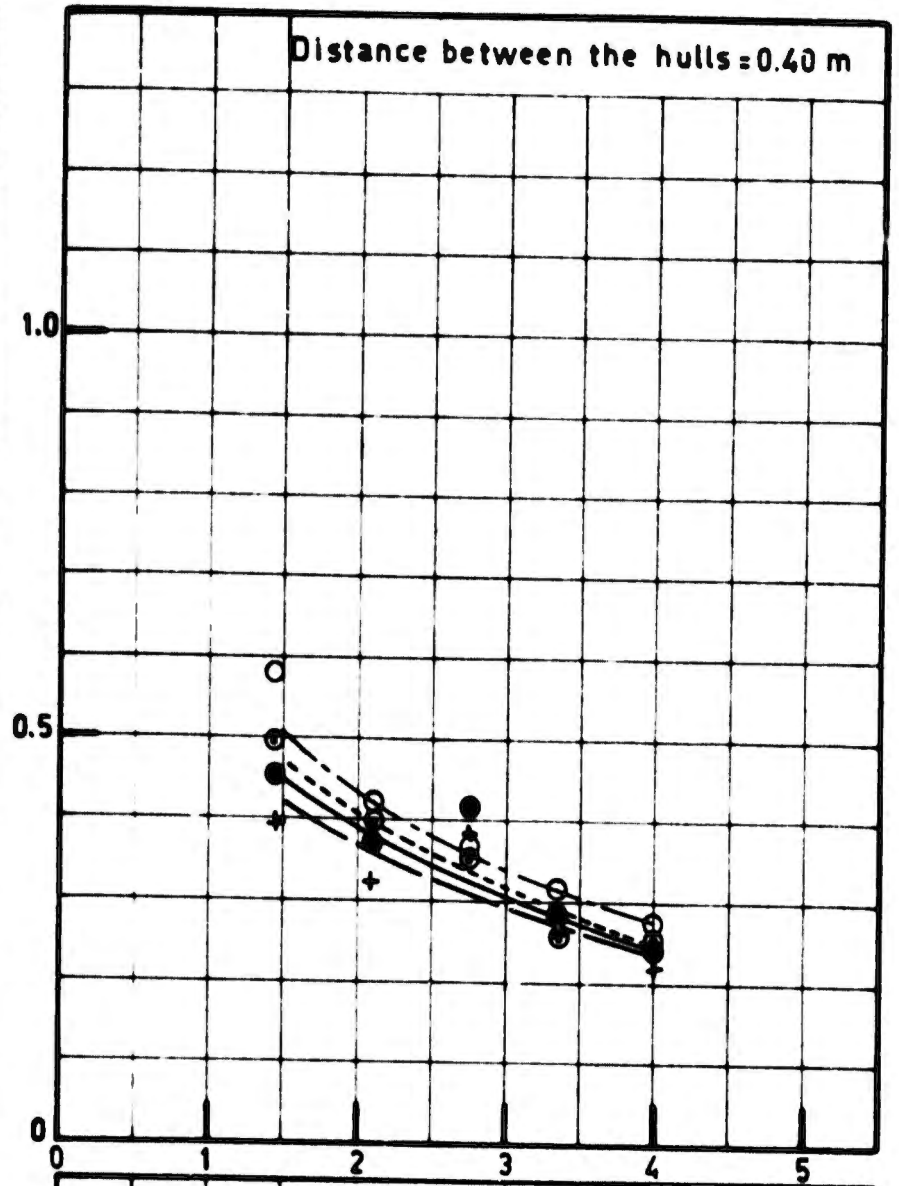
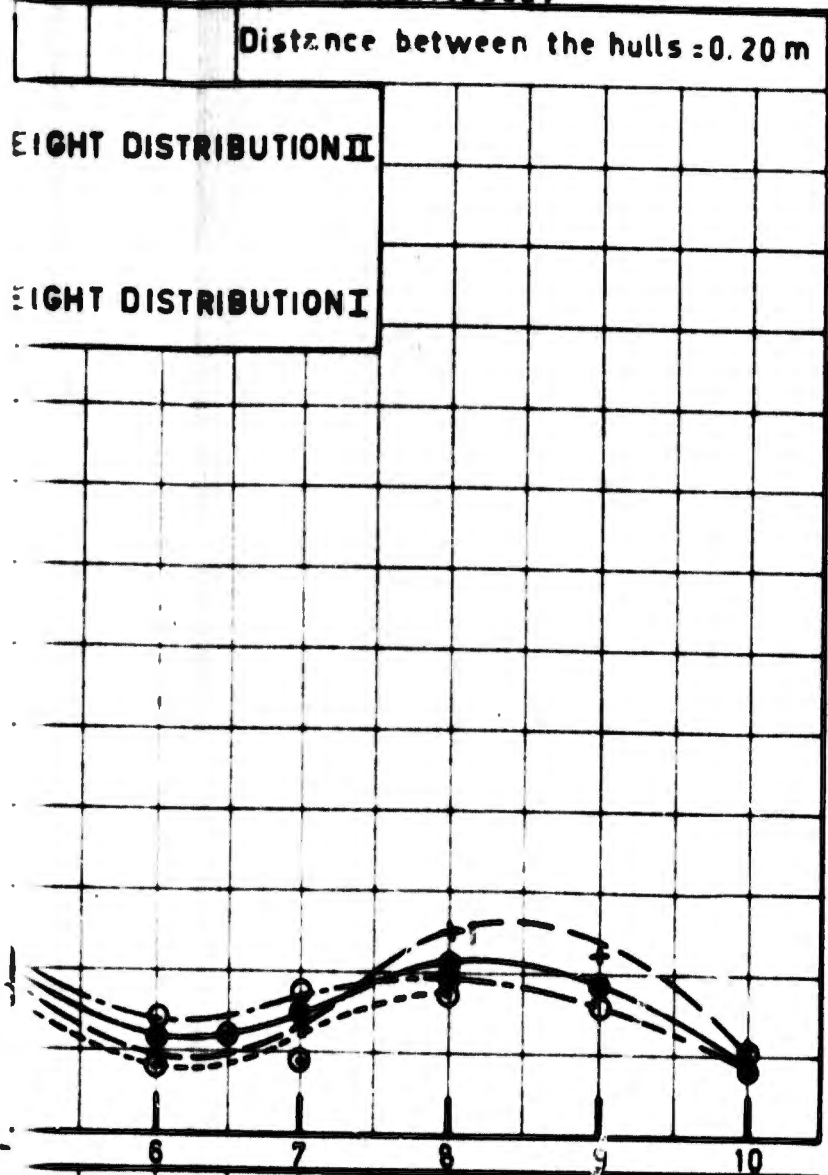
WAVE DIRECTION 90° —

ACCELERATIONS ON STARBOARDSIDE WING-TIP (Double amplitudes)



A

WING-TIP (Double amplitudes)



Wave length in m

B

CATAMARAN SEAPLANE

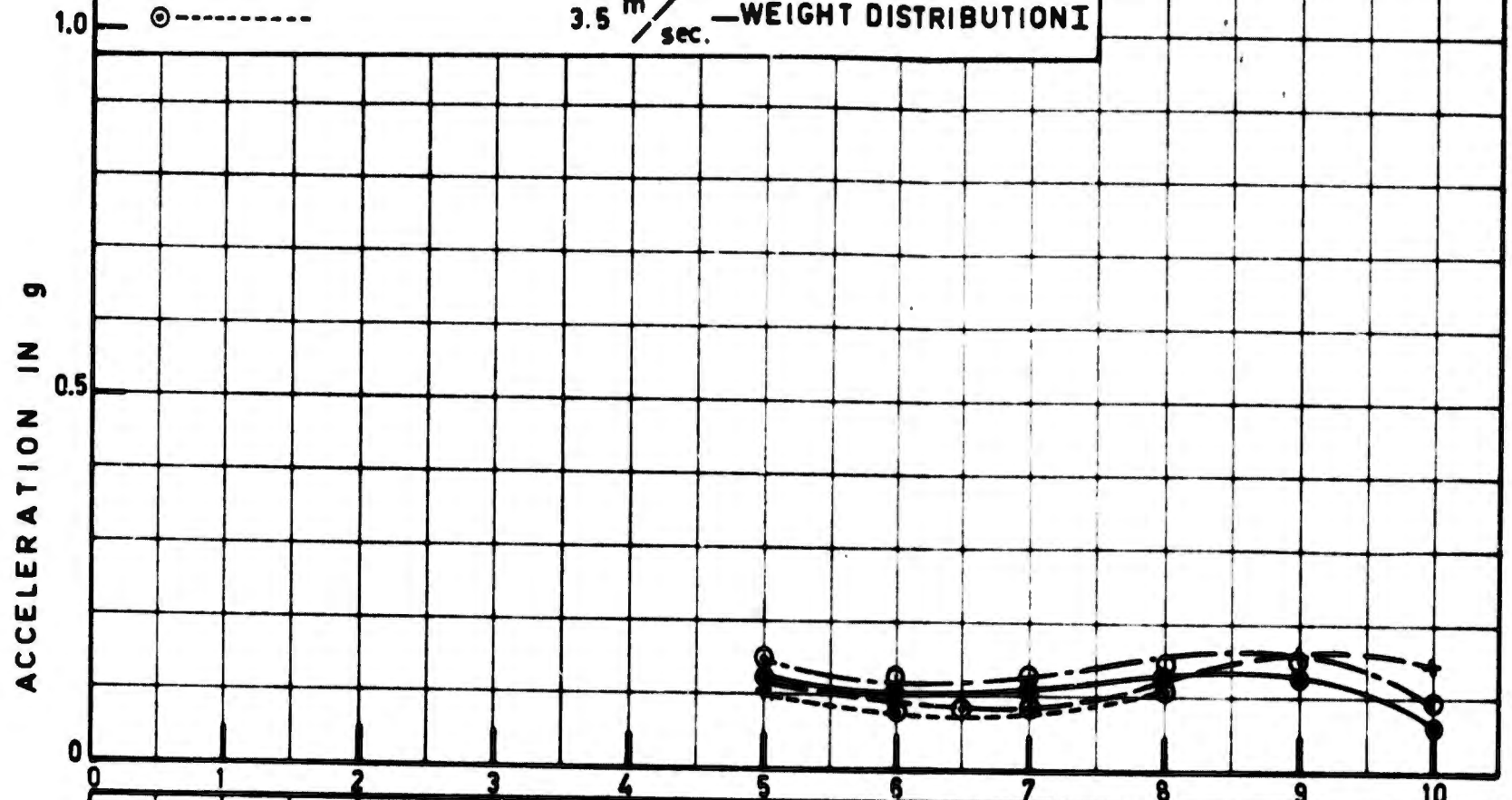
WAVE DIRECTION 90° —

NEDERLANDSCH SCHEEPSBOUW
PROEFSTATION WAGENINGEN

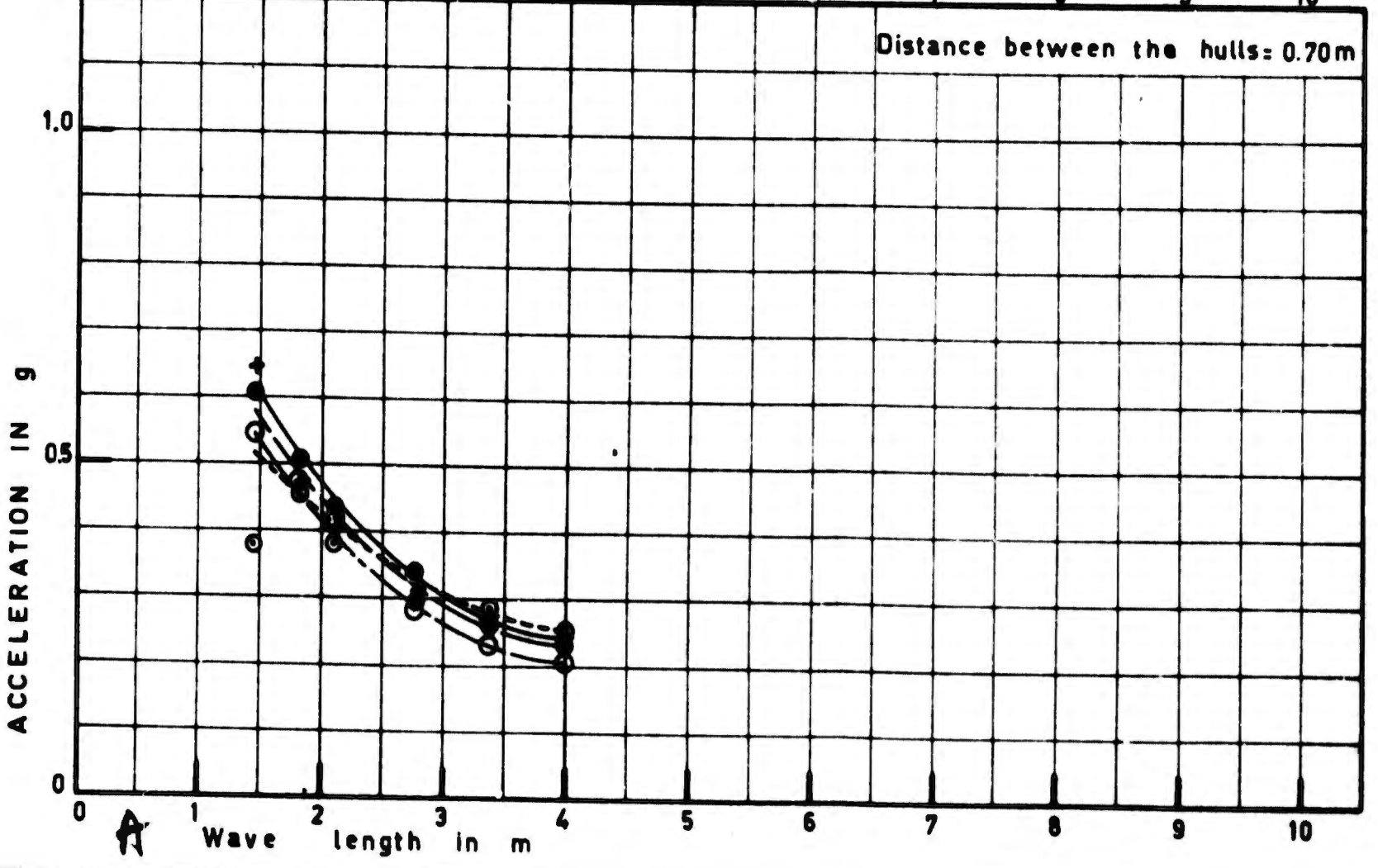
ACCELERATIONS ON PORTSIDE WING-TIP (Double amplitudes)

- — Speed of model: 3.0 m/sec.
 - + — 3.5 m/sec.
 - — 4.0 m/sec.
 - ⊙ — 3.5 m/sec.
- WEIGHT DISTRIBUTION II
- WEIGHT DISTRIBUTION I

Distance between the hulls = 0.20 m



Distance between the hulls = 0.70 m

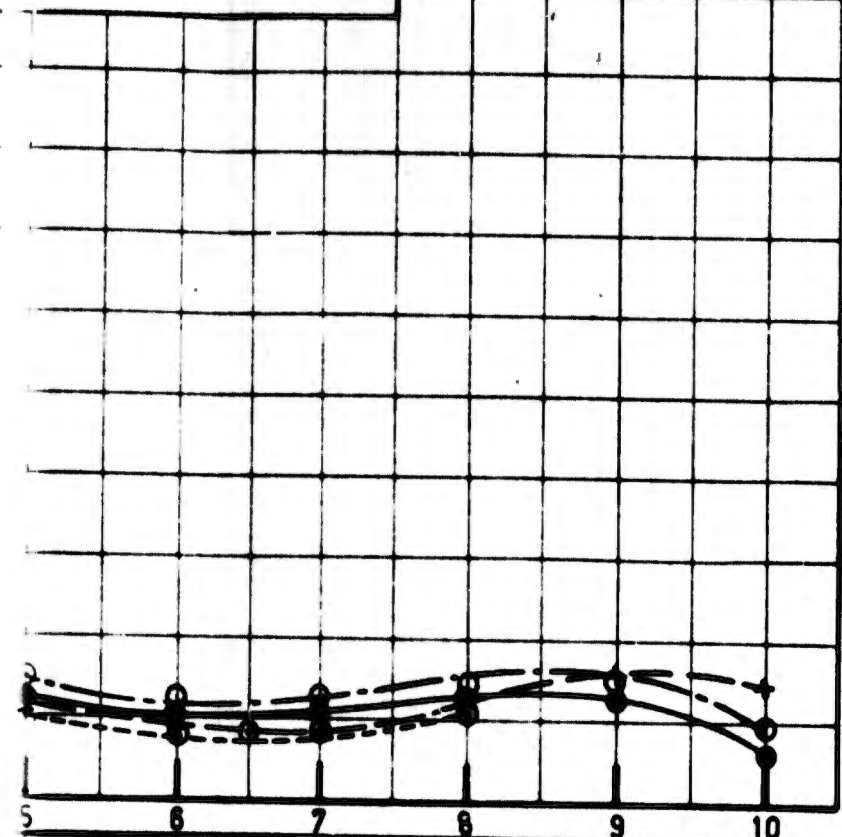


G-TIP (Double amplitudes)

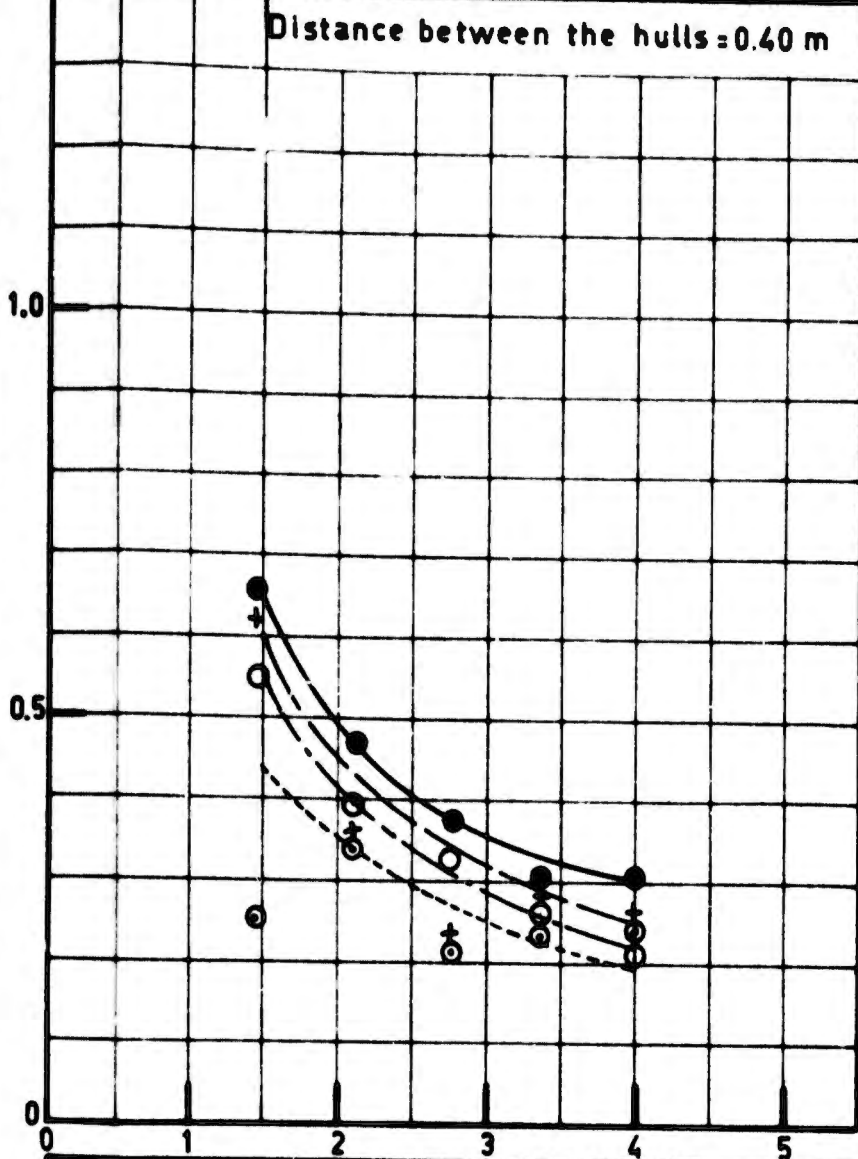
Distance between the hulls = 0.20 m

WEIGHT DISTRIBUTION II

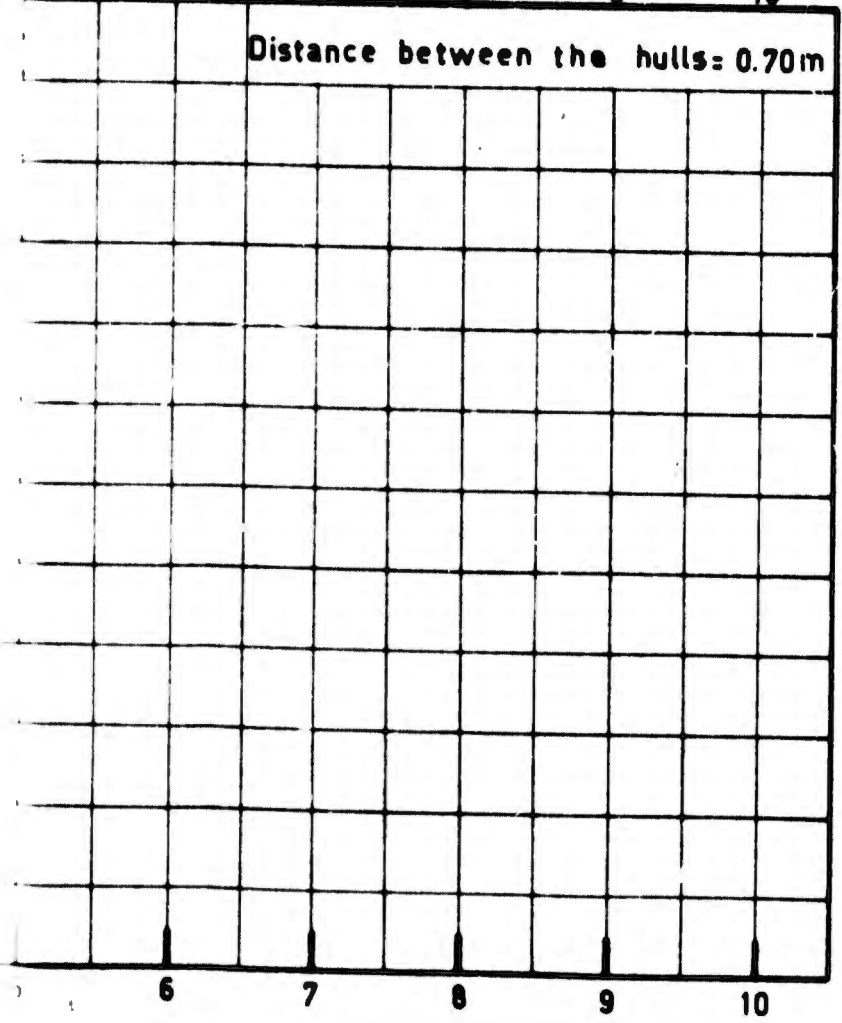
WEIGHT DISTRIBUTION I



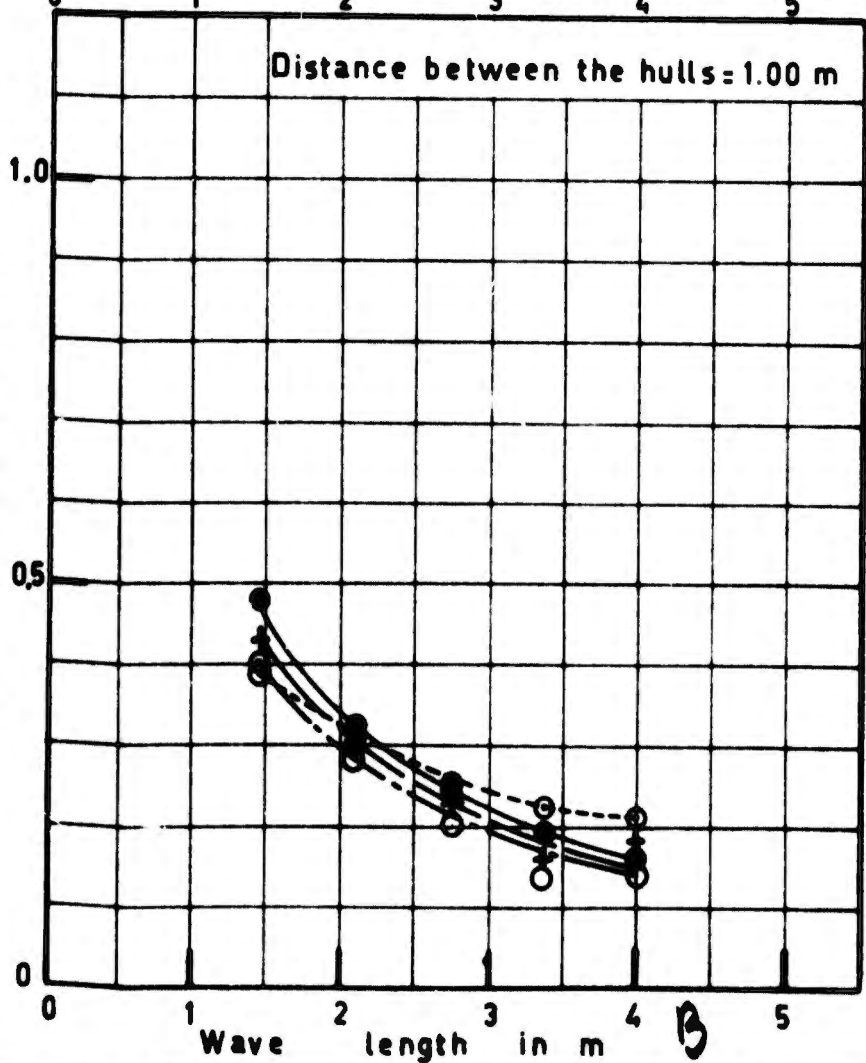
Distance between the hulls = 0.40 m



Distance between the hulls = 0.70 m



Distance between the hulls = 1.00 m

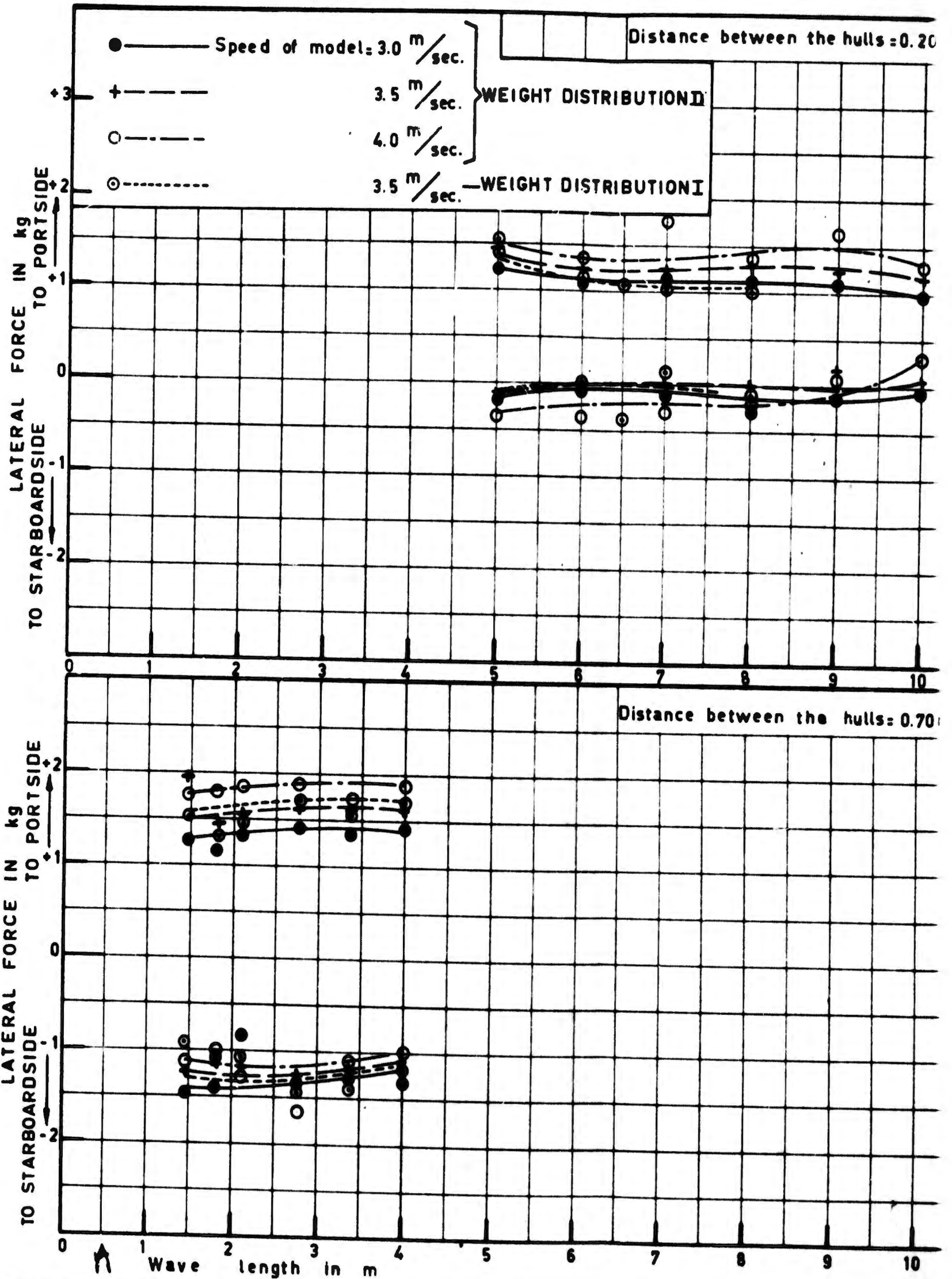


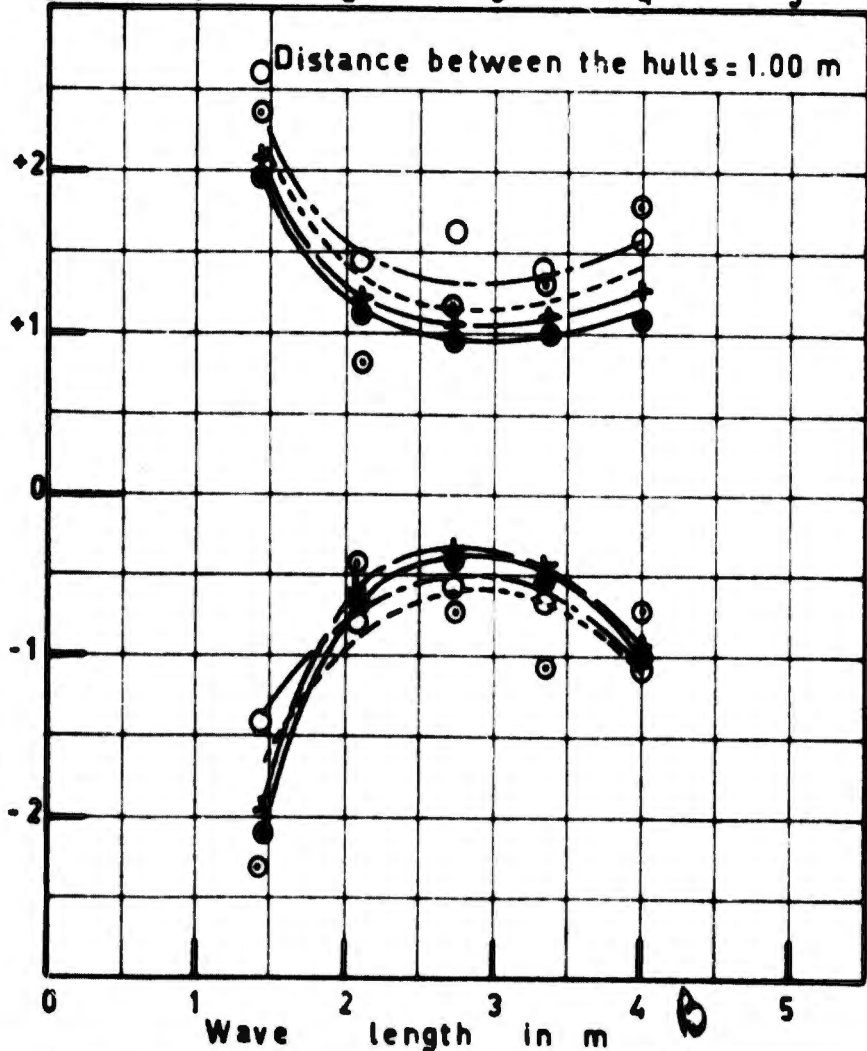
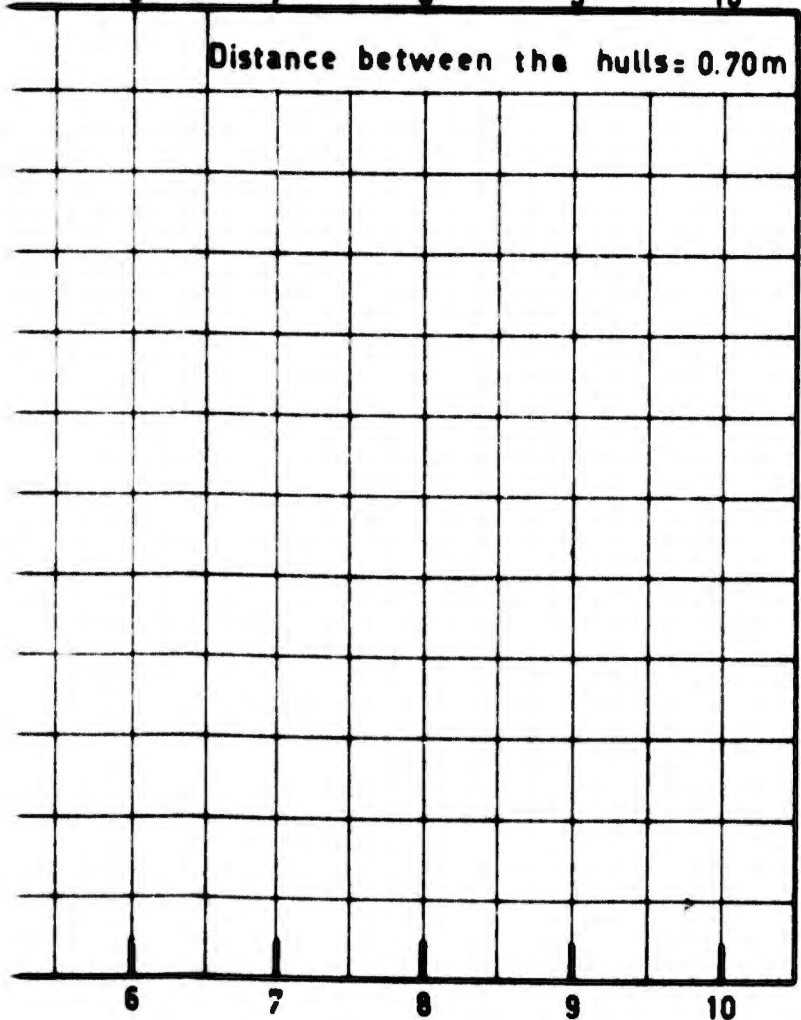
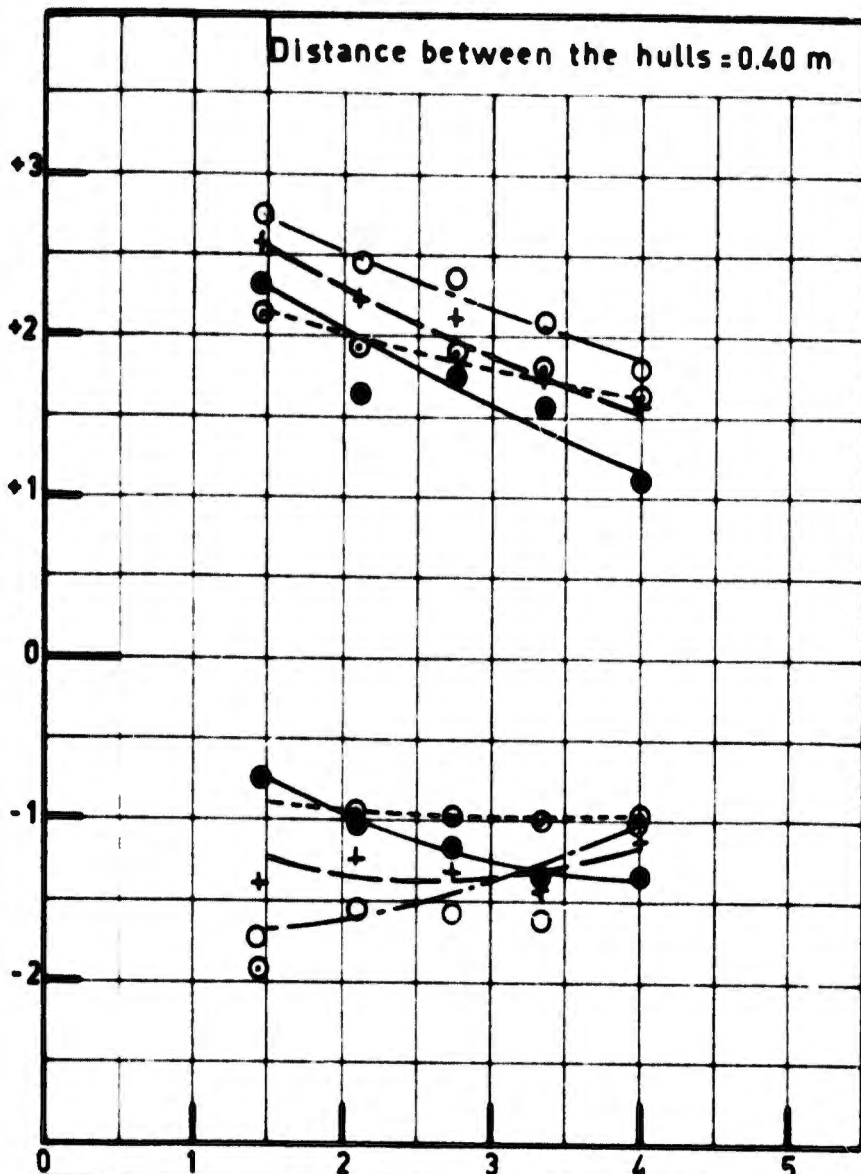
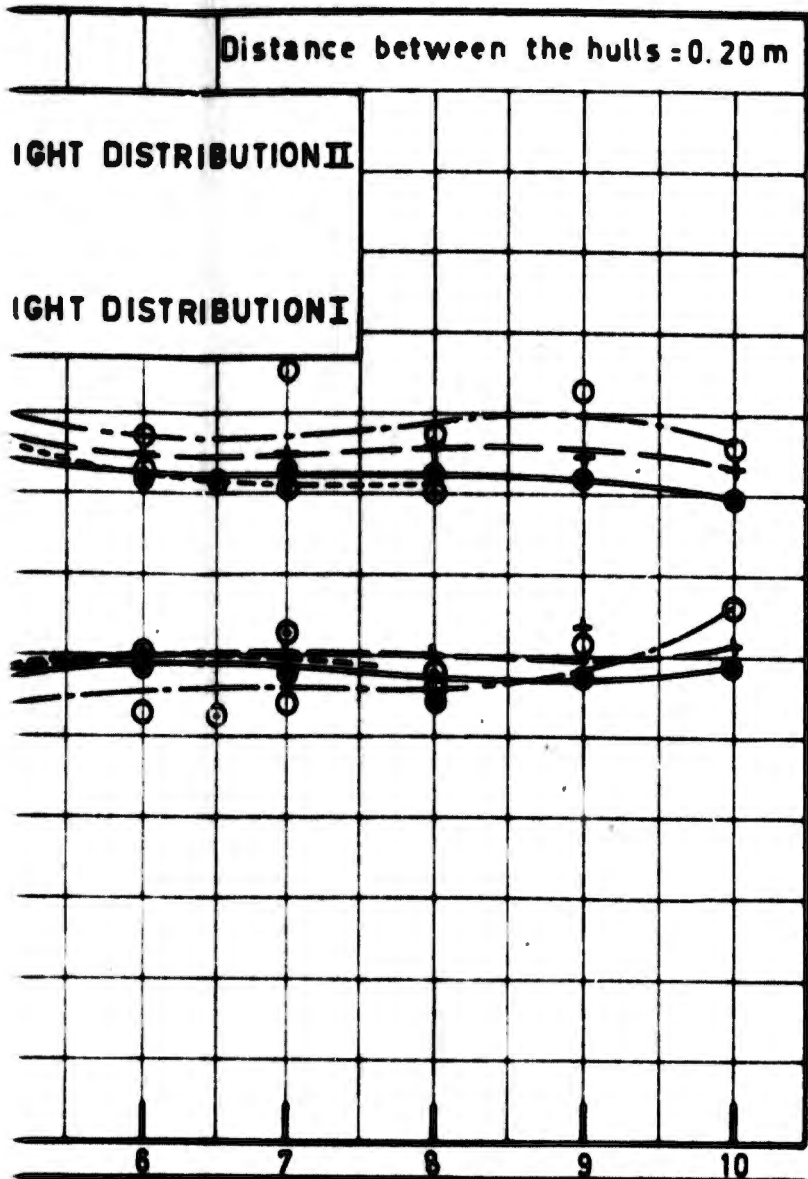
Wave length in m

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — LATERAL FORCE FORWARD

NEDERLANDSCH SCHEEP
PROEFSTATION



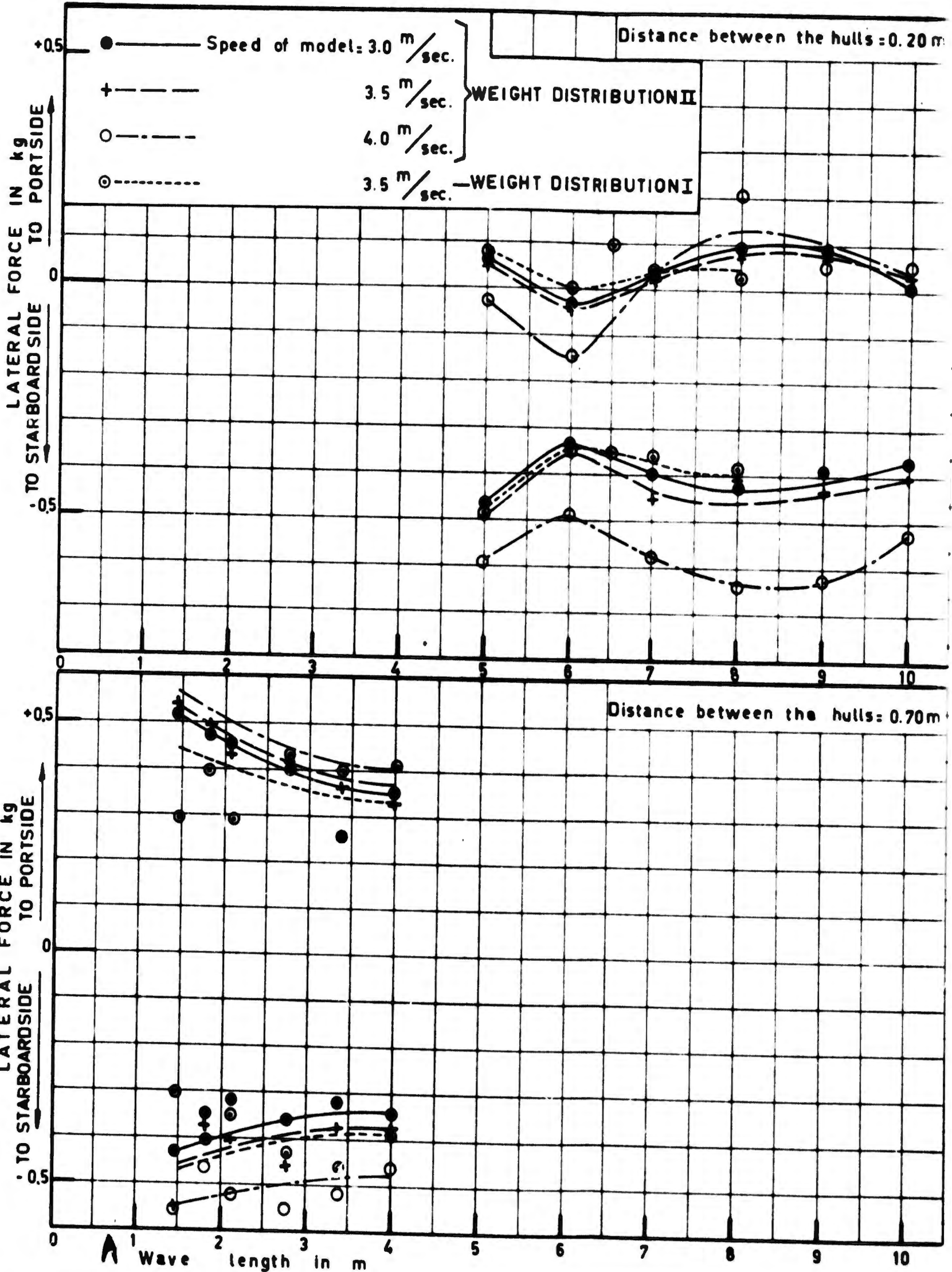


Wave length in m

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — LATERAL FORCE AFT

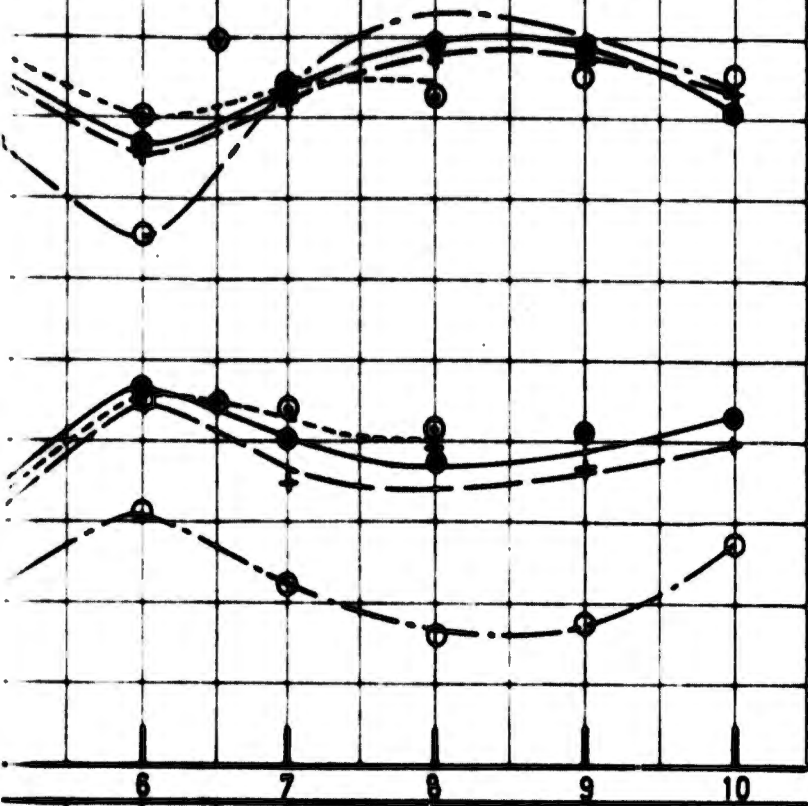
NEDERLANDSCH SCHEEPBOUW
PROEFSTATION



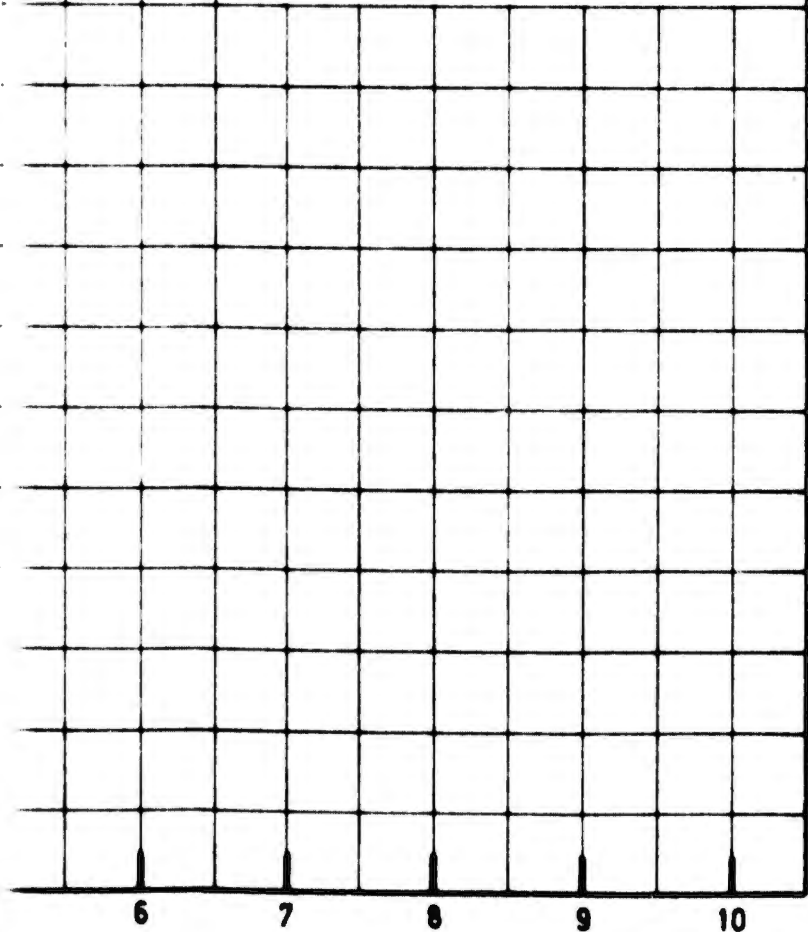
Distance between the hulls = 0.20 m

LIGHT DISTRIBUTION II

LIGHT DISTRIBUTION I



Distance between the hulls = 0.70 m



+0.5

Distance between the hulls = 0.20 m

0

-0.5

0

+0.5

0

-0.5

0

Wave length in m

B

0

1

2

3

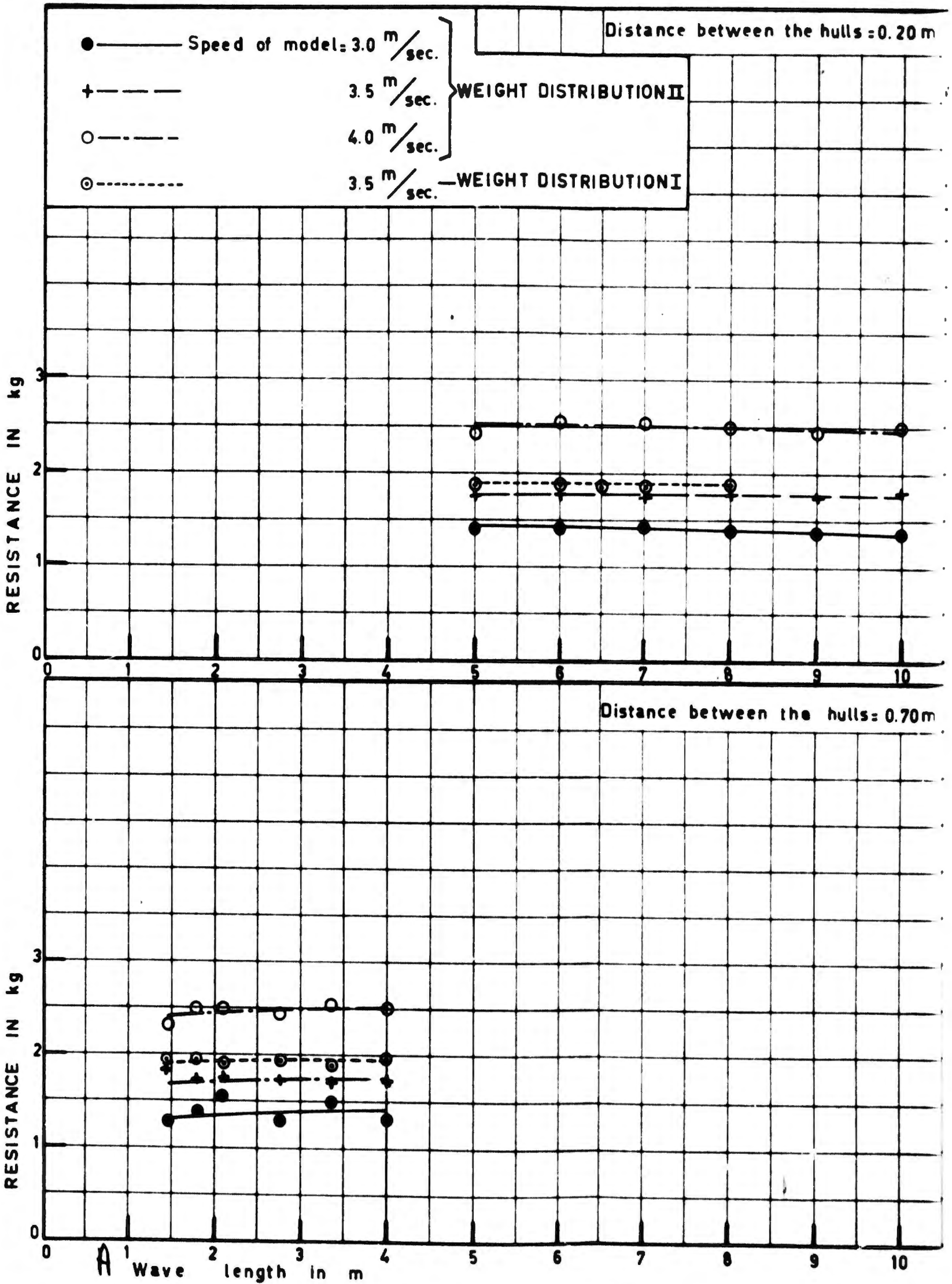
4

5

CATAMARAN SEAPLANE

WAVE DIRECTION 90° — MEAN RESISTANCE

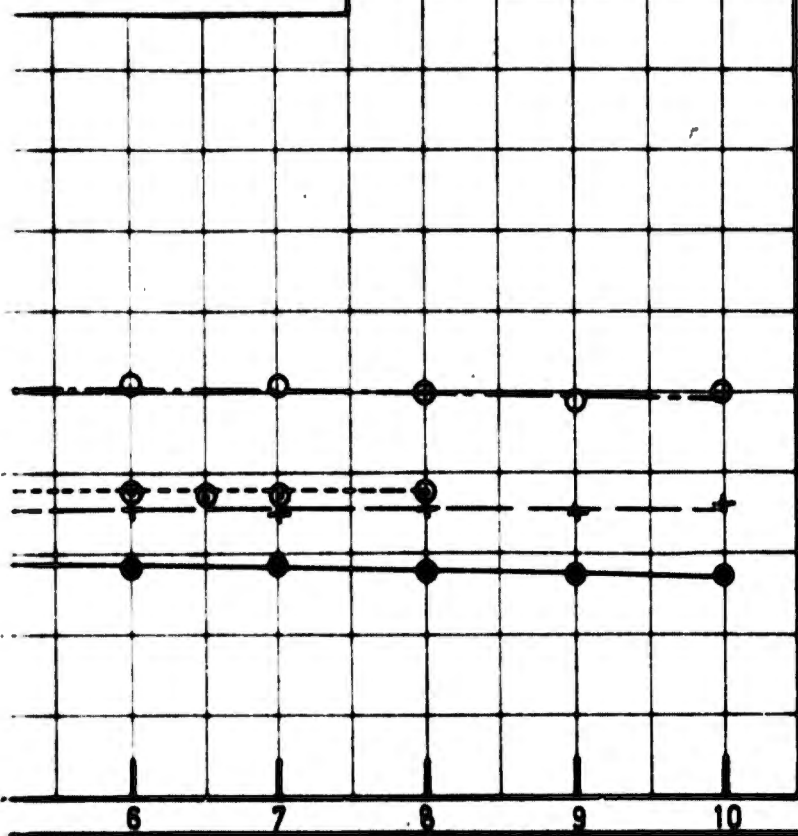
NEDERLANDSCH SCHEEPSBUREAU
PROEFSTATION



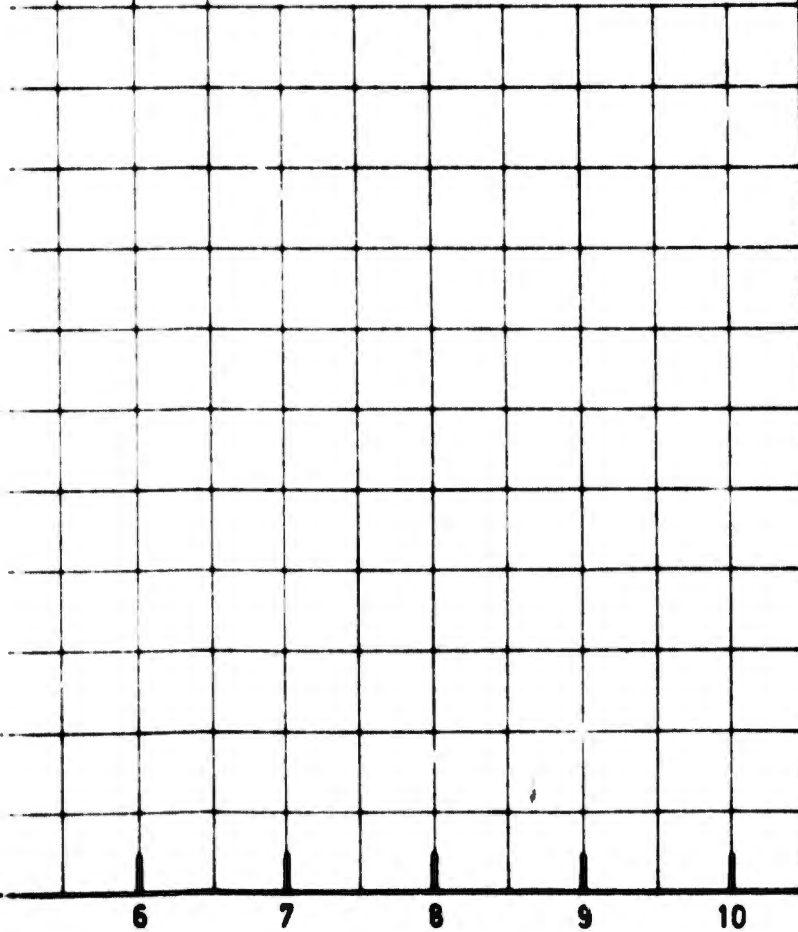
Distance between the hulls = 0.20 m

GHT DISTRIBUTION II

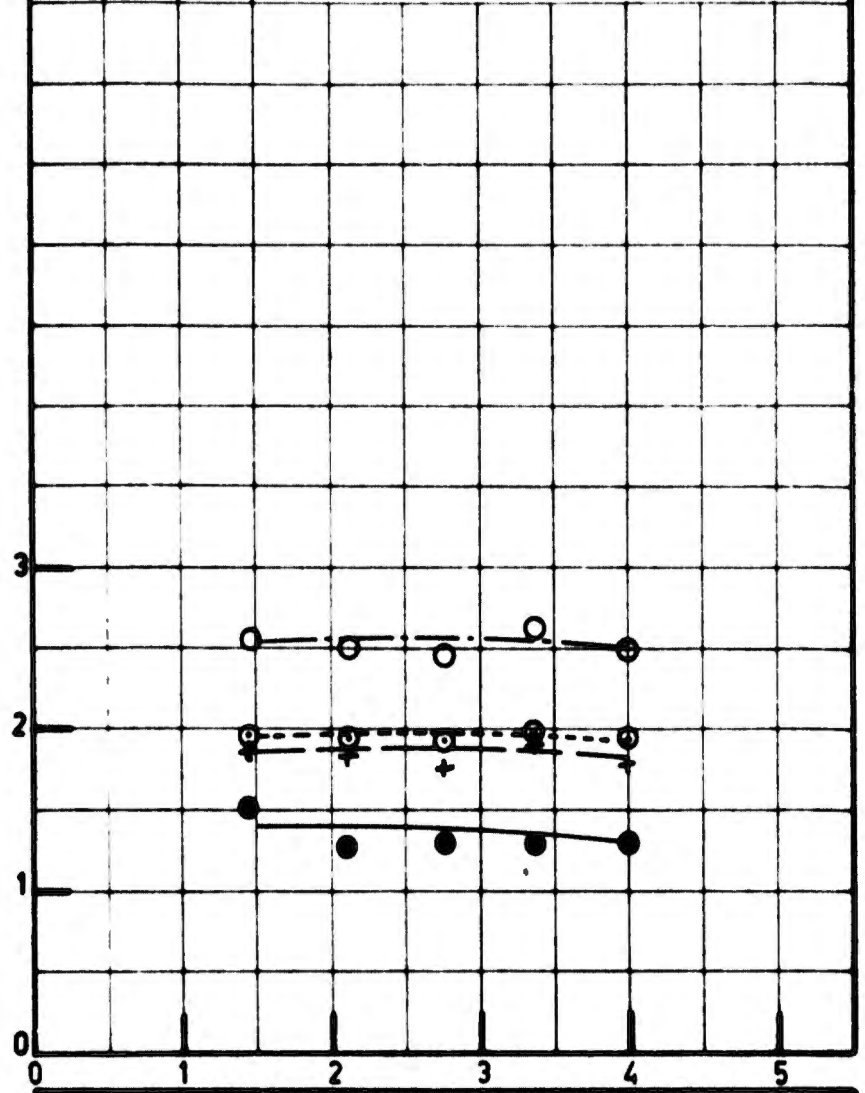
GHT DISTRIBUTION I



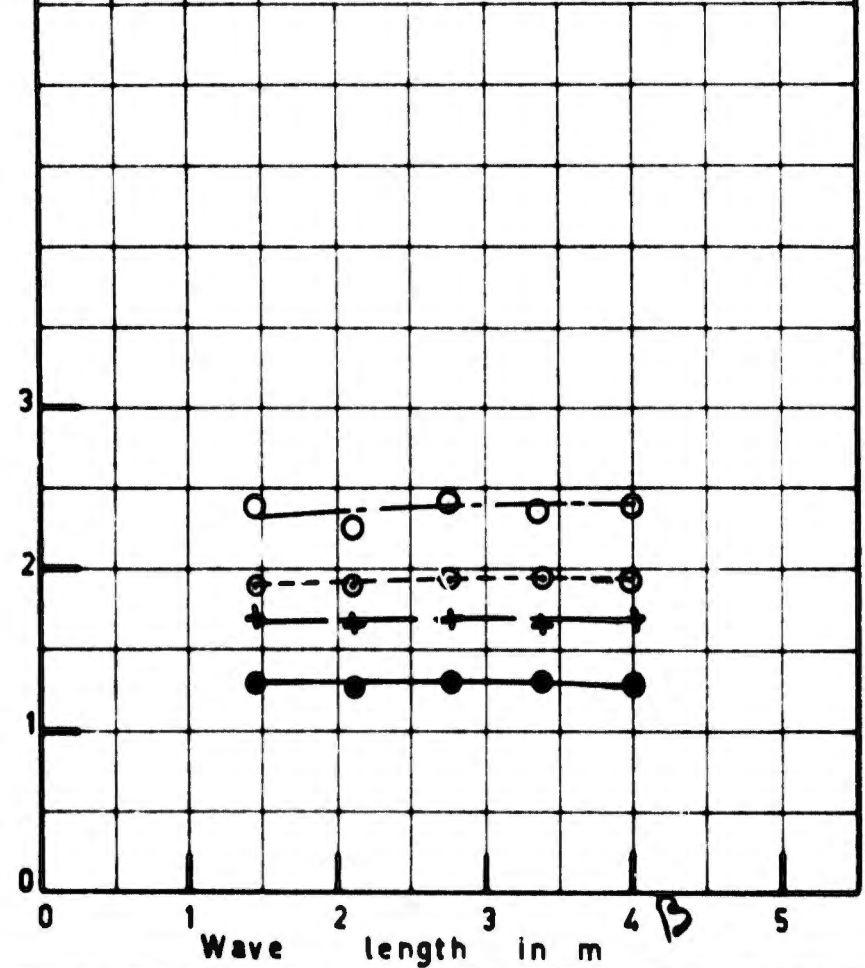
Distance between the hulls = 0.70 m



Distance between the hulls = 0.40 m



Distance between the hulls = 1.00 m

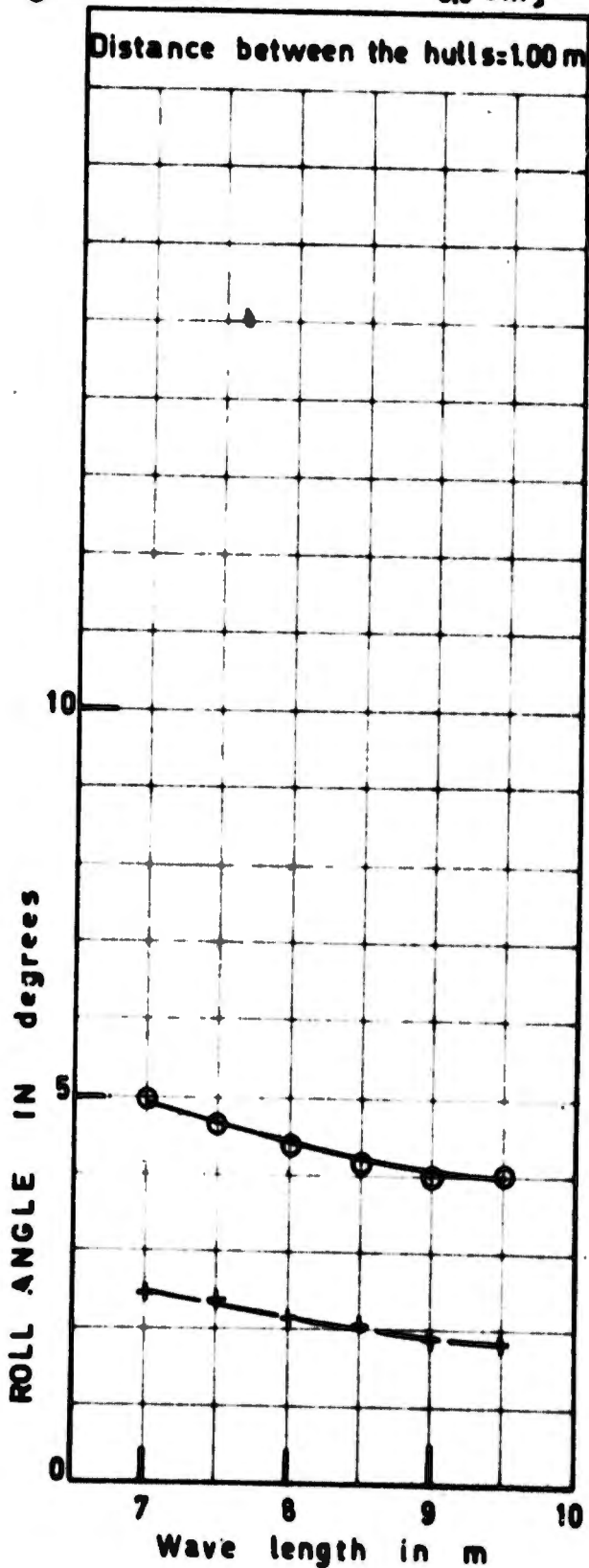


Wave length in m

CATAMARAN SEAPLANE

WAVE DIRECTION 135° - ROLL ANGLES
WEIGHT DISTRIBUTION I (Double amplitudes)
SPEED OF MODEL = 3.5 m/sec.

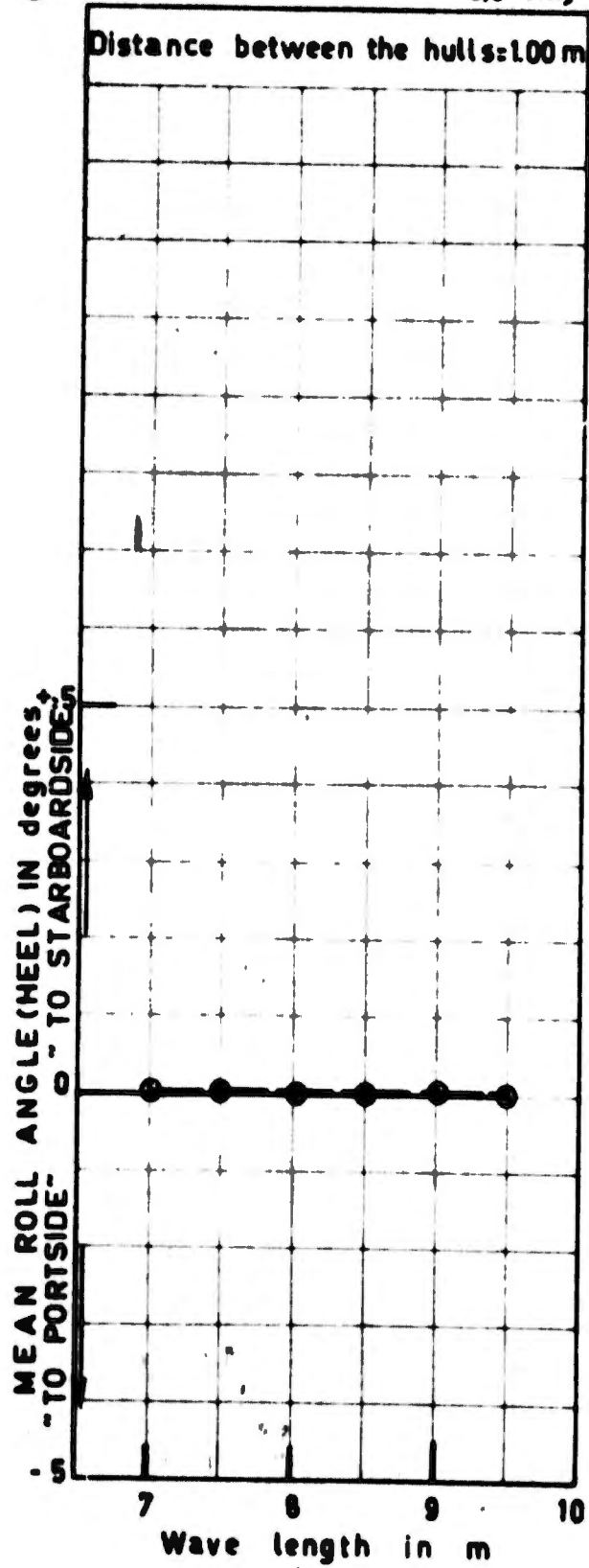
+ ——— Wave height = 4.0 cm } Double amplitude
○ ——— 8.0 cm }



CATAMARAN SEAPLANE

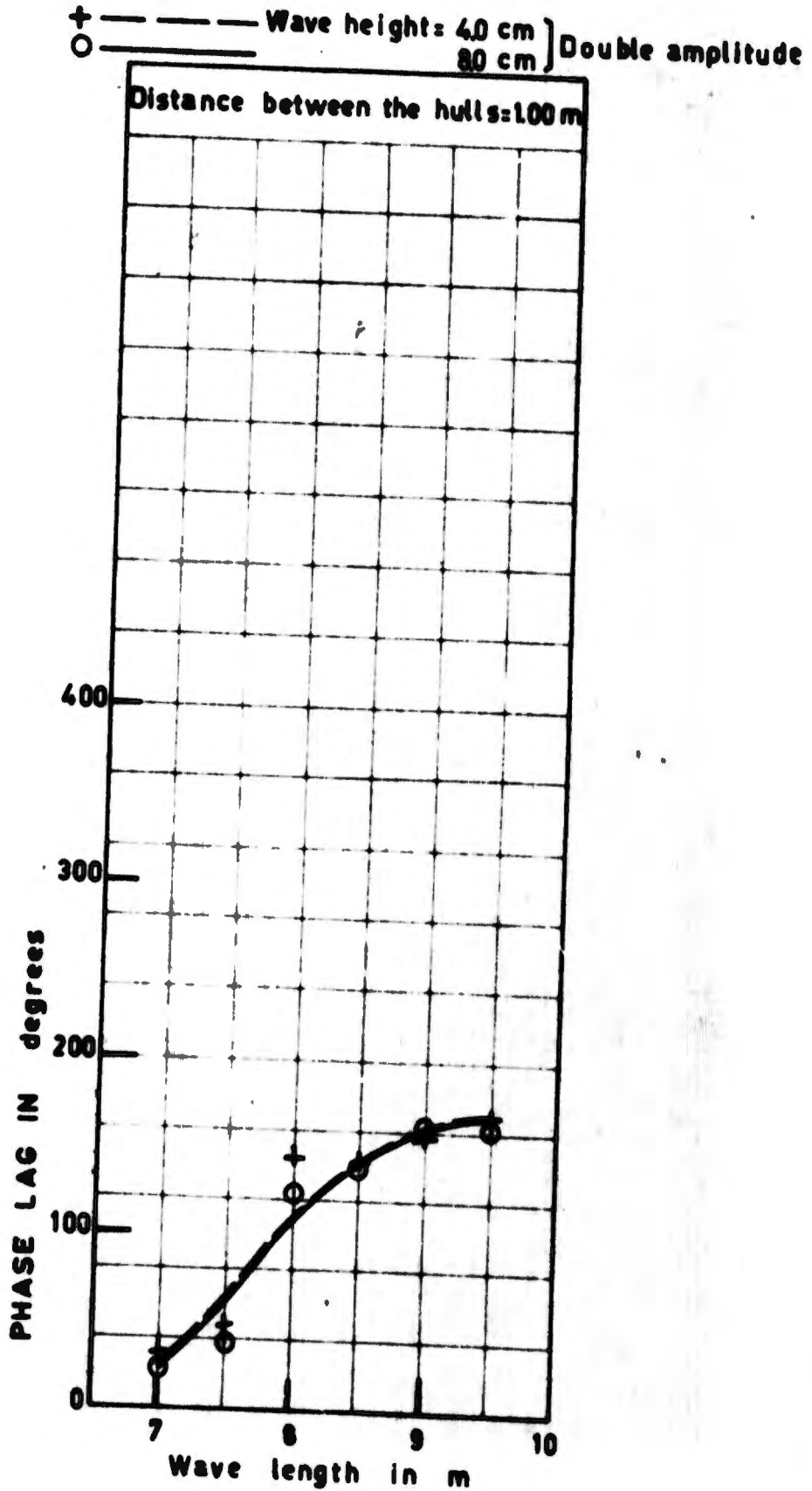
WAVE DIRECTION 135° - MEAN ROLL ANGLES
WEIGHT DISTRIBUTION I
SPEED OF MODEL: 3.5 m/sec.

+ ——— Wave height: 4.0 cm } Double amplitude
O ——— 8.0 cm }



CATAMARAN SEAPLANE

WAVE DIRECTION 135° - PHASE LAG BETWEEN WAVE HEIGHT
WEIGHT DISTRIBUTION I AND ROLL MOTION
SPEED OF MODEL: 3.5 m/sec.



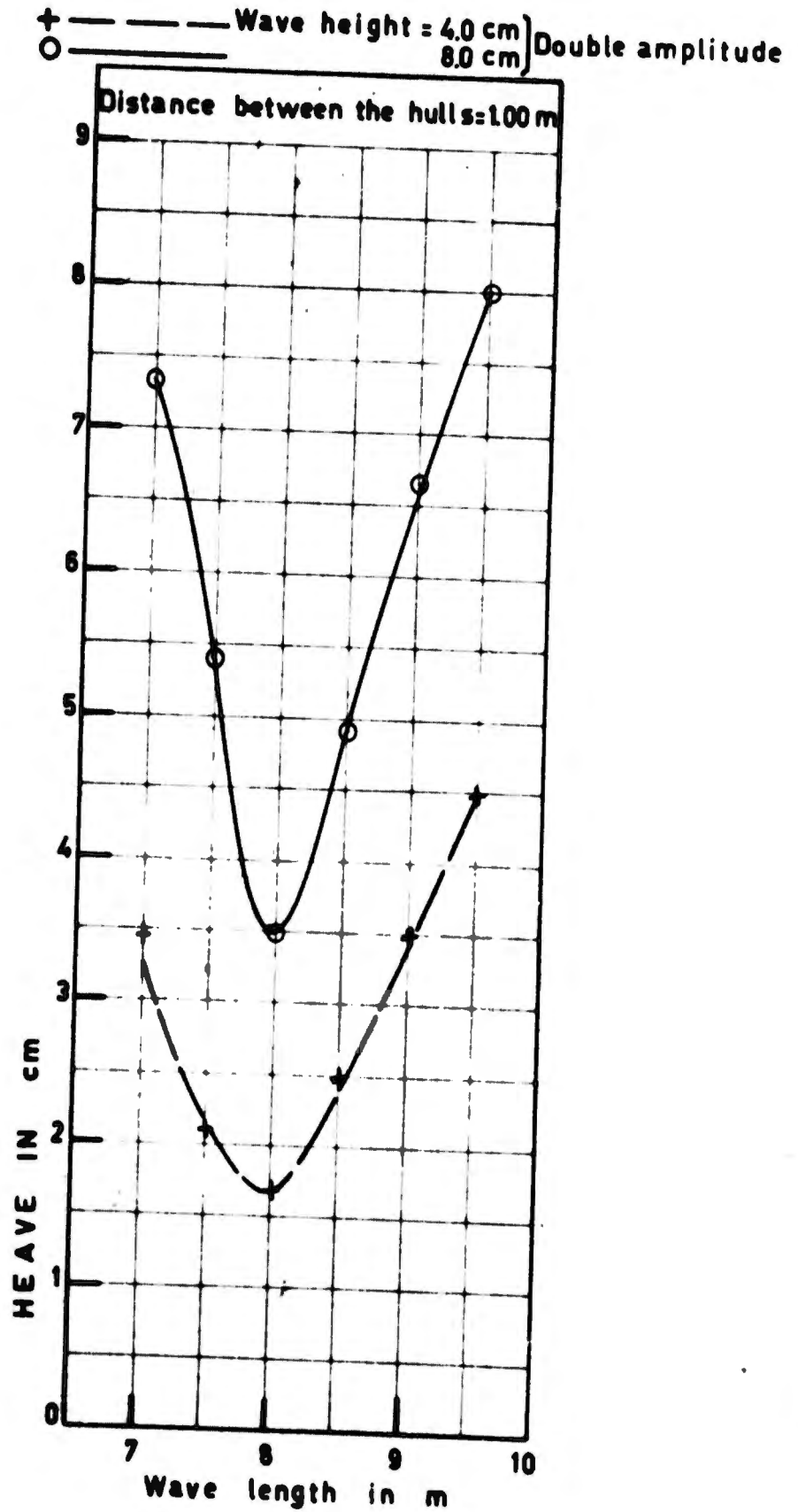
CATAMARAN SEAPLANE

WAVE DIRECTION 135° -
WEIGHT DISTRIBUTION I

SPEED OF MODEL = 3.5 m/sec.

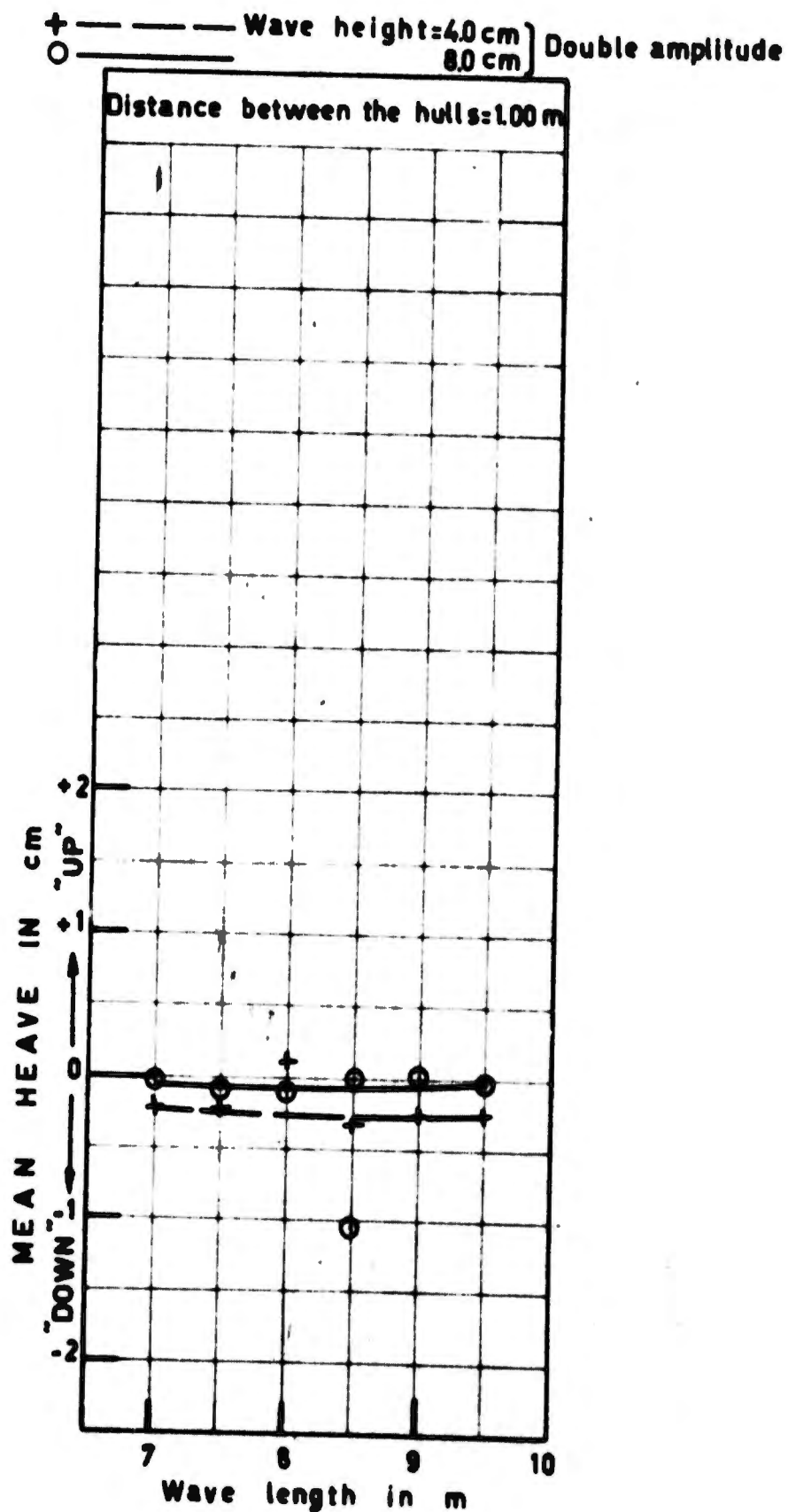
HEAVE

(Double amplitudes)



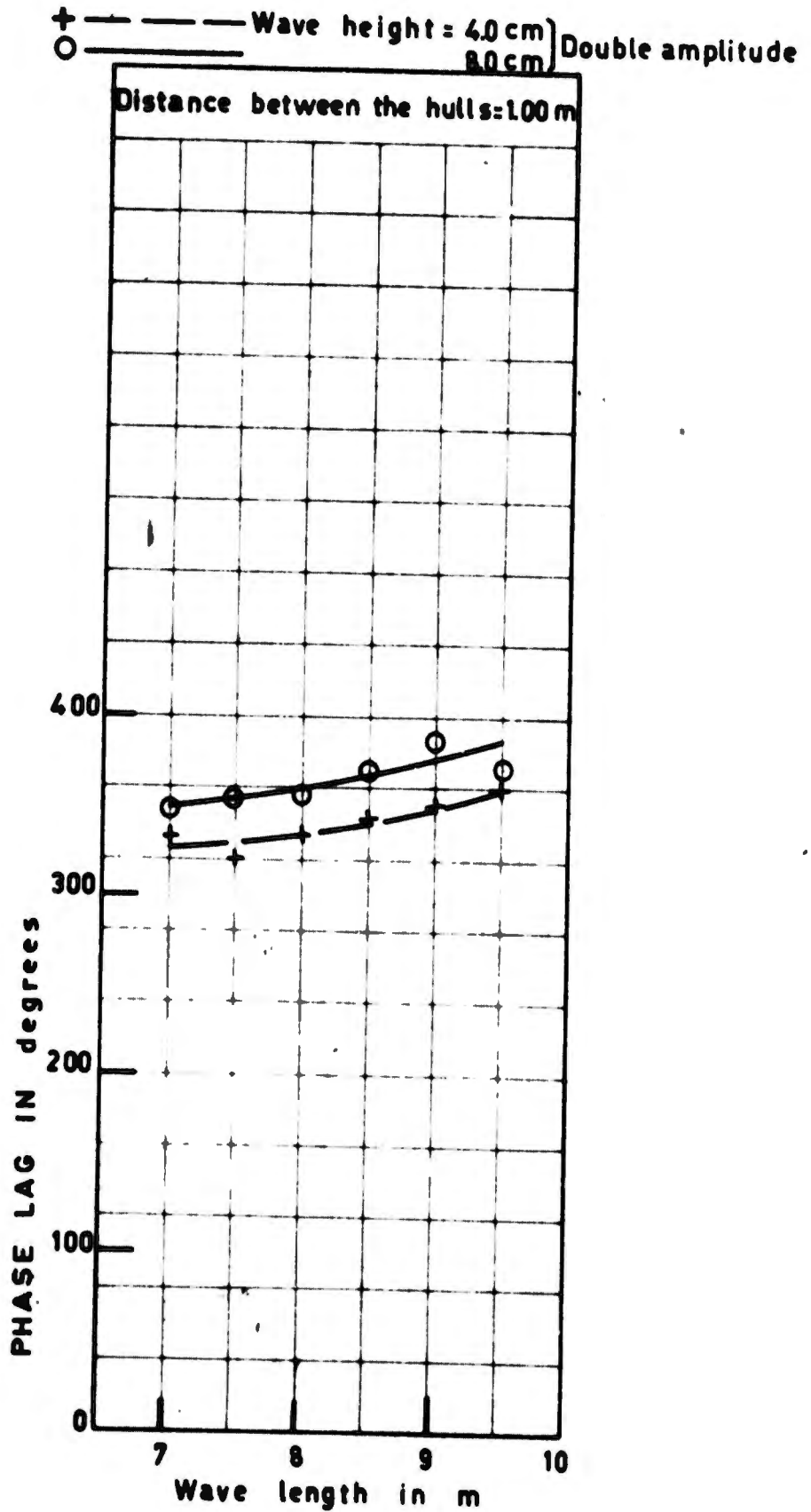
CATAMARAN SEAPLANE

WAVE DIRECTION 135° - MEAN HEAVE
WEIGHT DISTRIBUTION I
SPEED OF MODEL = 3.5 m/sec.



CATAMARAN SEAPLANE

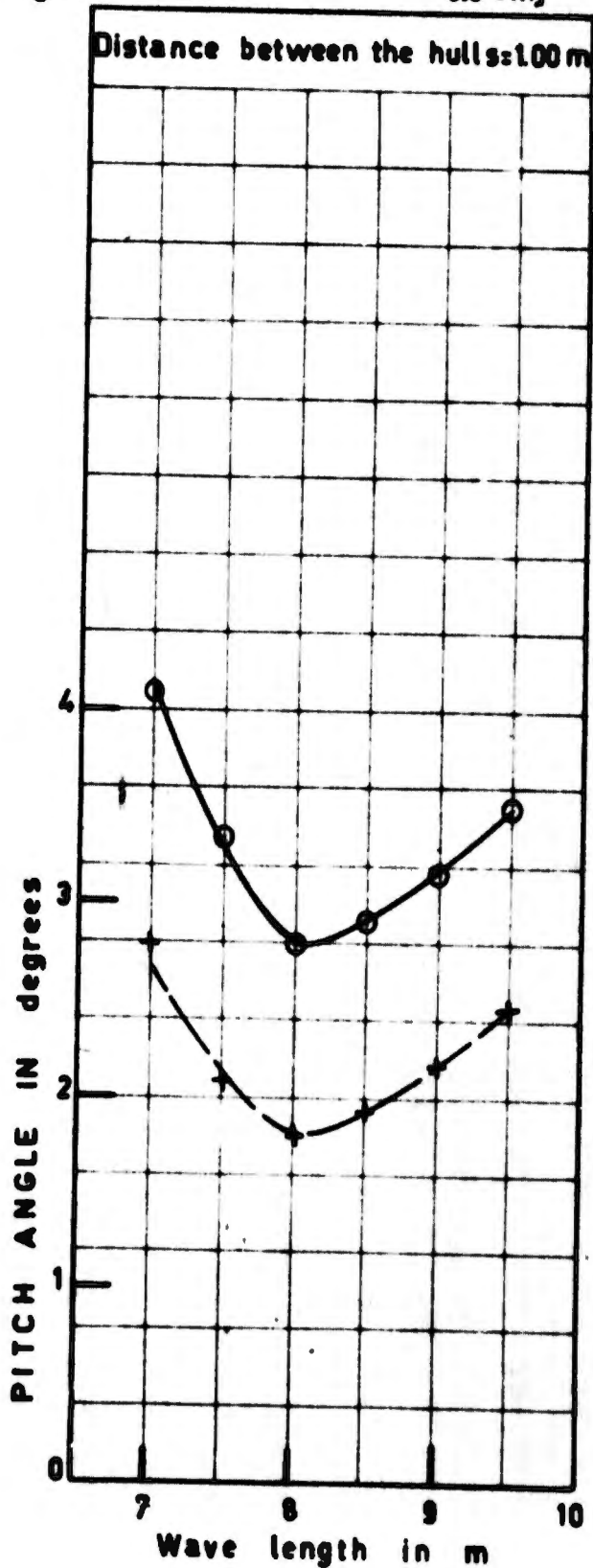
WAVE DIRECTION 135° - PHASE LAG BETWEEN WAVE HEIGHT
WEIGHT DISTRIBUTION I AND HEAVE MOTION
SPEED OF MODEL = 3.5 m/sec.



CATAMARAN SEAPLANE

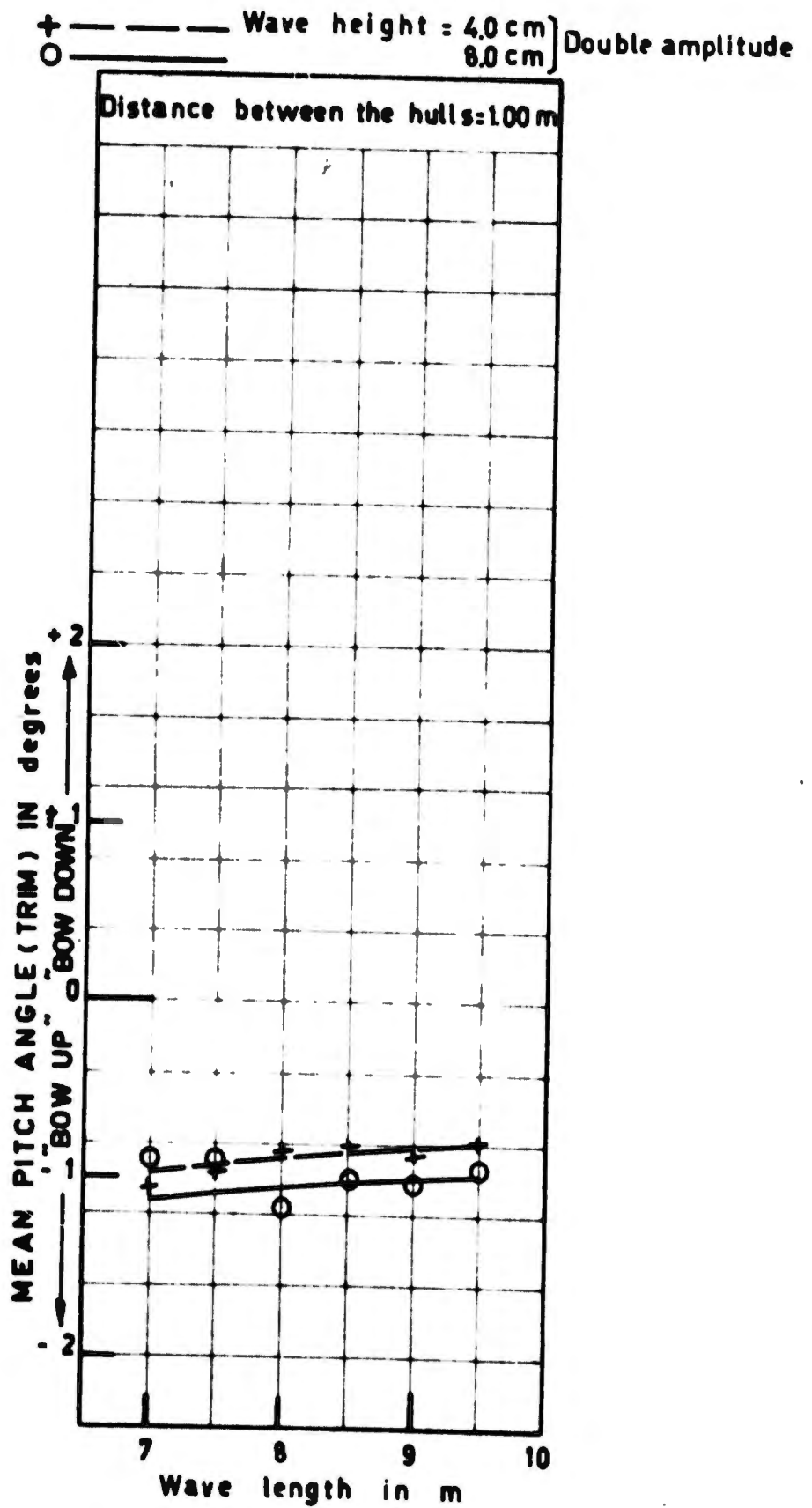
WAVE DIRECTION 135° - PITCH ANGLES
WEIGHT DISTRIBUTION I (Double amplitudes)
SPEED OF MODEL: 3.5 m/sec.

+ --- Wave height = 4.0 cm } Double amplitude
o --- Wave height = 8.0 cm }



CATAMARAN SEAPLANE

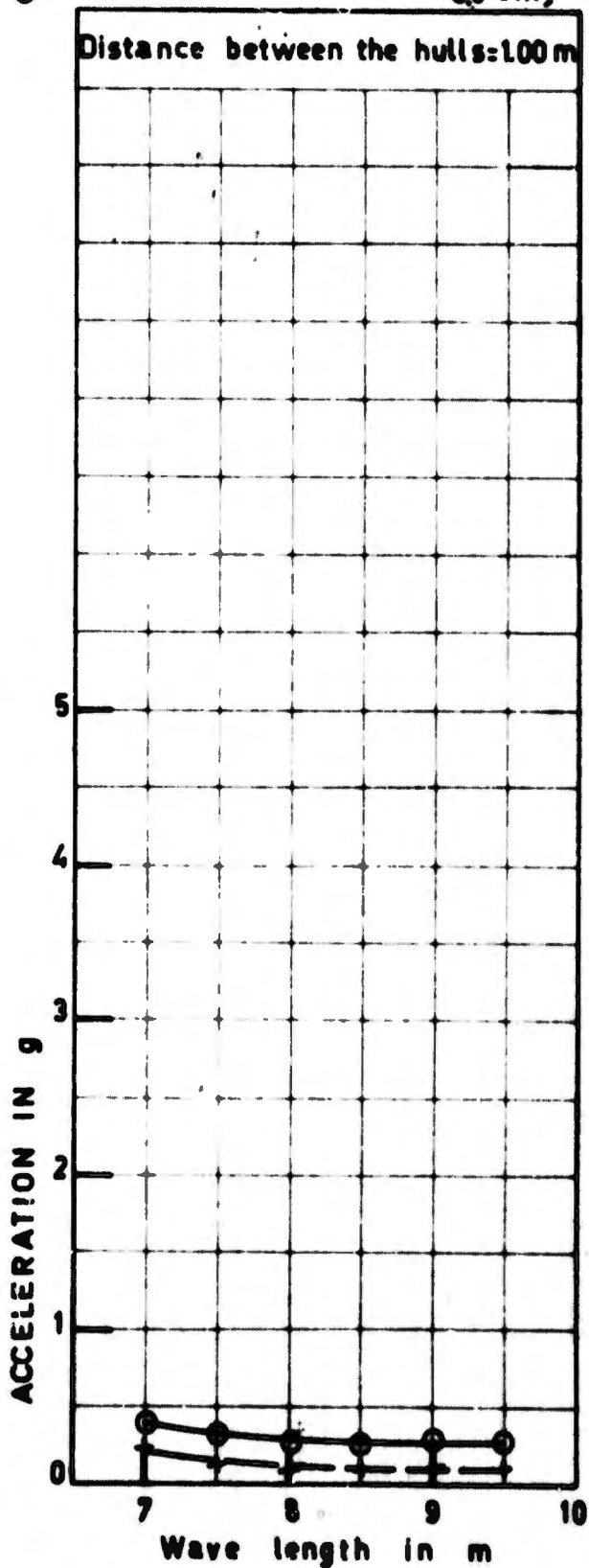
WAVE DIRECTION 135° - MEAN PITCH ANGLES
WEIGHT DISTRIBUTION I
SPEED OF MODEL: 2.5 m/sec.



CATAMARAN SEAPLANE

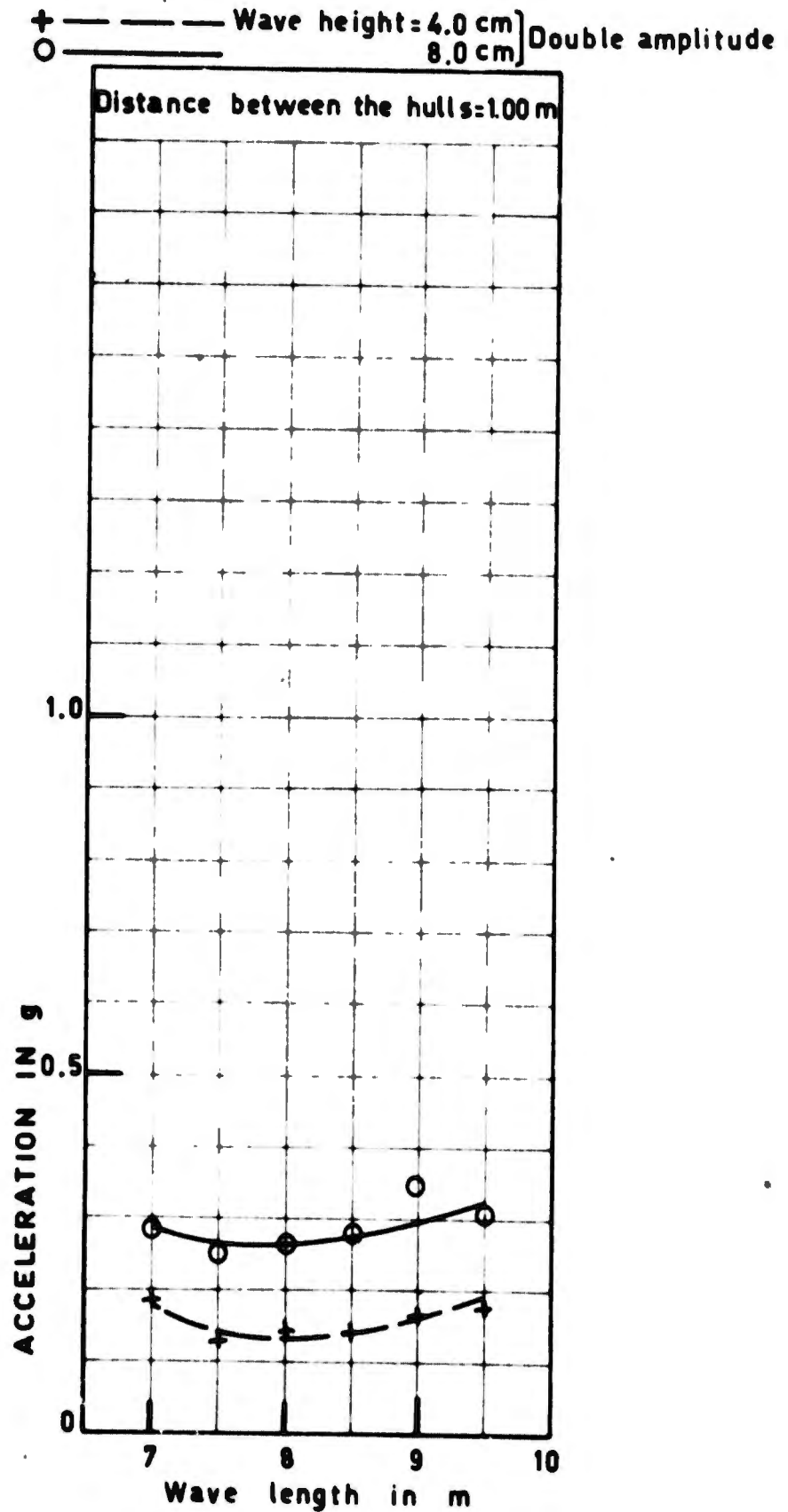
WAVE DIRECTION 135° - ACCELERATIONS OF THE HULLS
WEIGHT DISTRIBUTION I (Double amplitudes)
SPEED OF MODEL: 3.5 m/sec.

+ ——— Wave height: 40 cm } Double amplitude
○ ——— 80 cm }



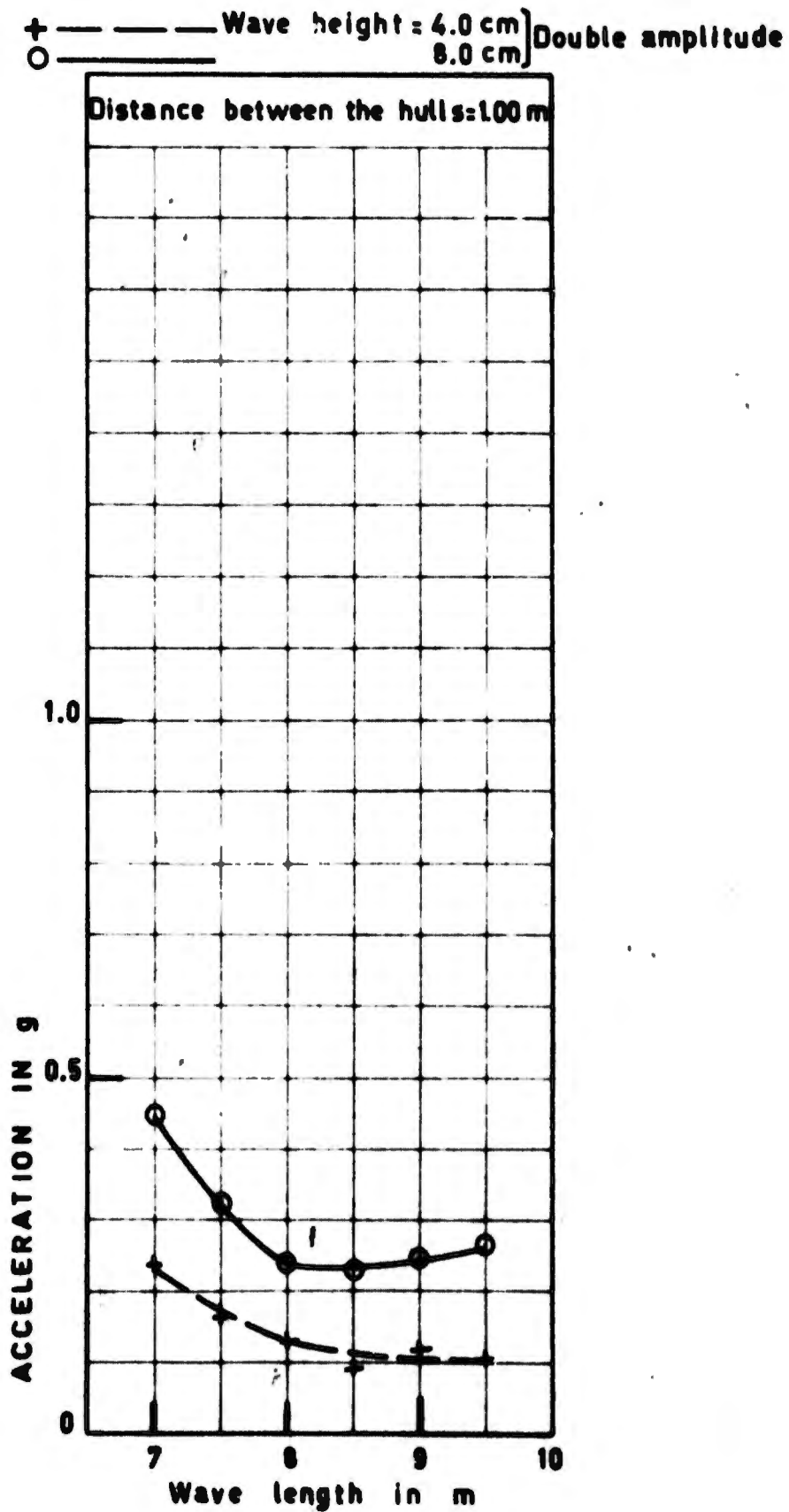
CATAMARAN SEAPLANE

WAVE DIRECTION 135° - ACCELERATIONS ON STARBOARDSIDE
WEIGHT DISTRIBUTION I WING-TIP
SPEED OF MODEL: 3.5 m/sec. (Double amplitudes)



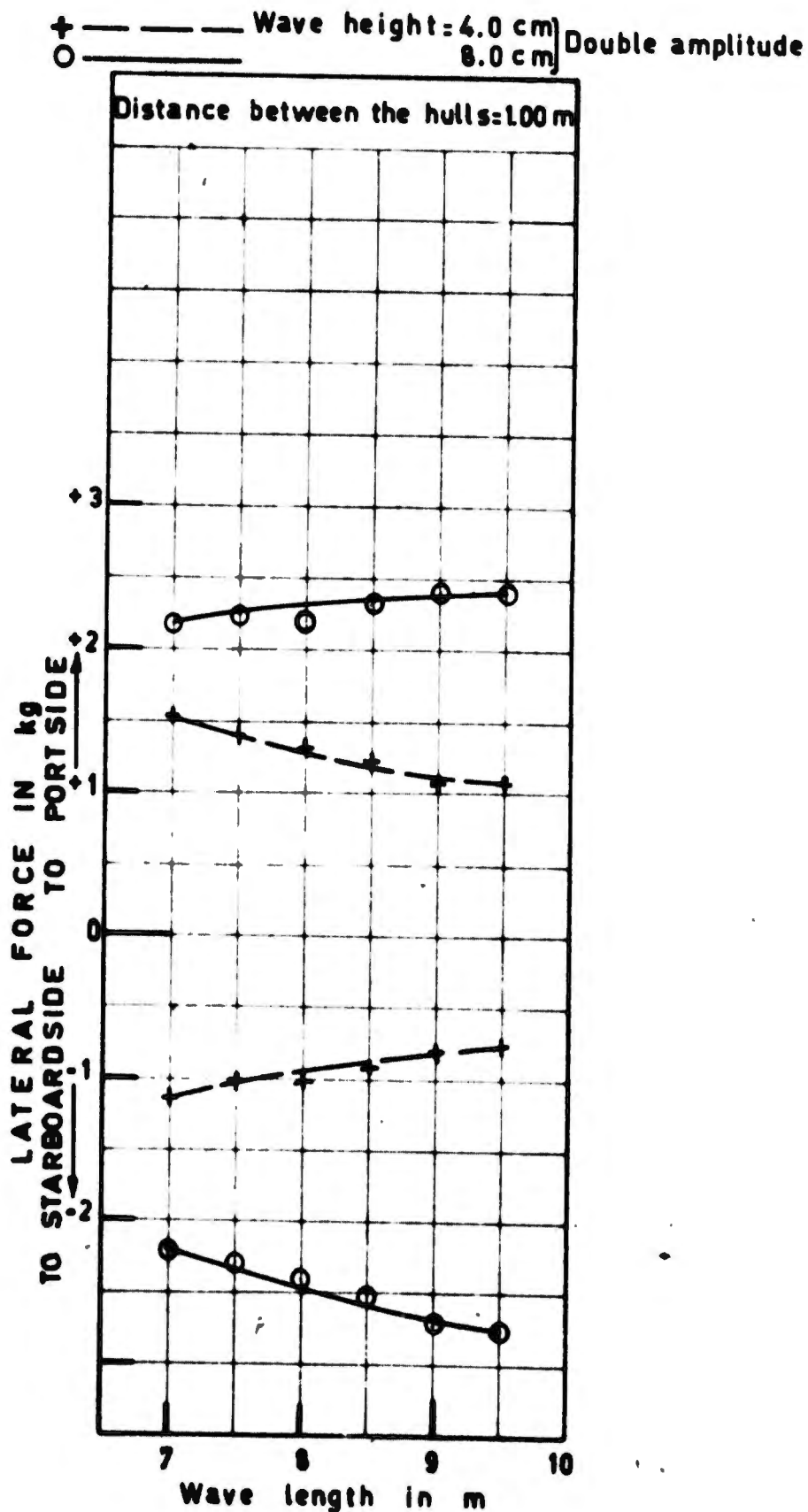
CATAMARAN SEAPLANE

WAVE DIRECTION 135° - ACCELERATIONS ON PORTSIDE
WEIGHT DISTRIBUTION I WING-TIP
SPEED OF MODEL: 3.5 m/sec. (Double amplitudes)



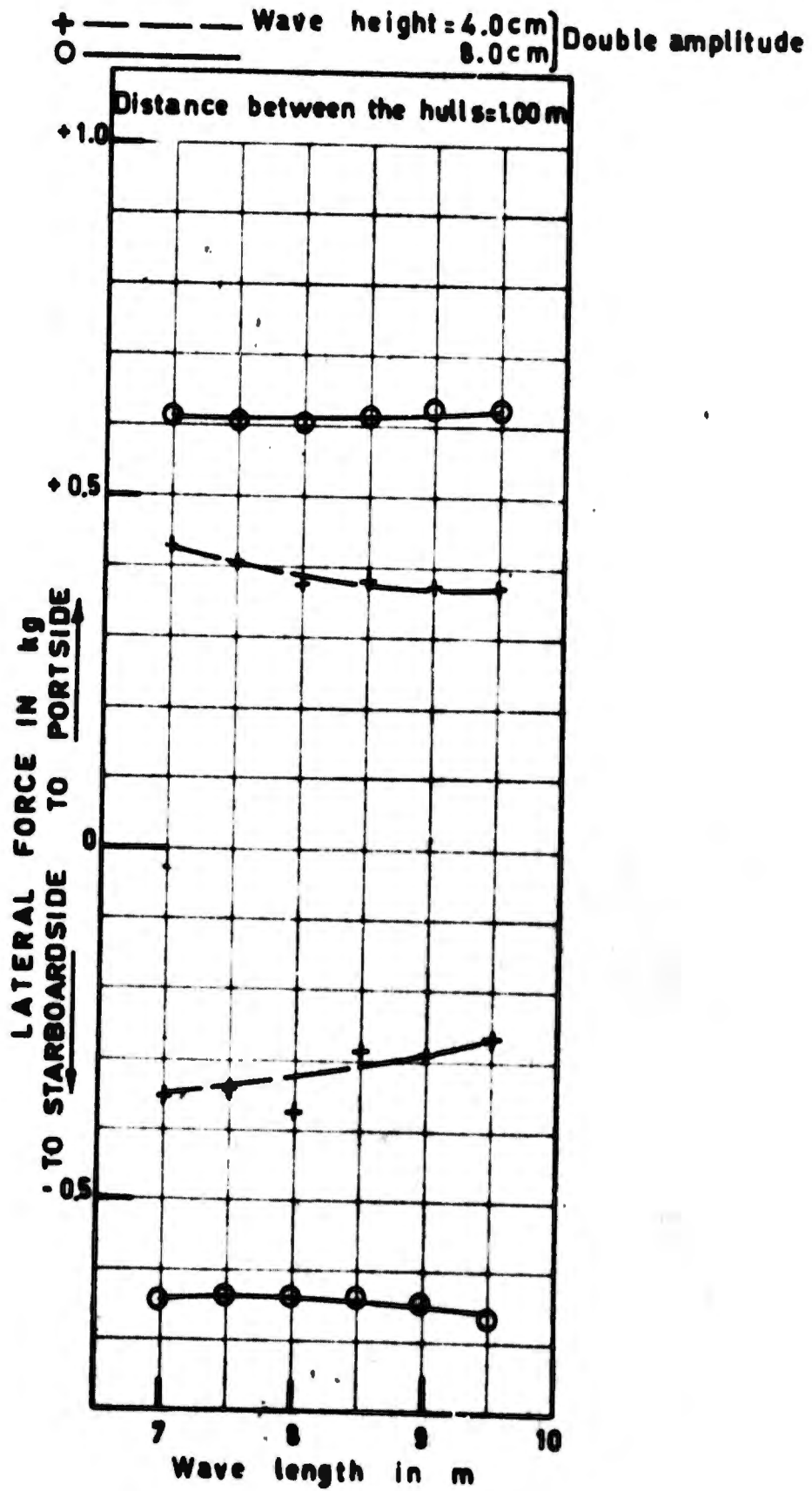
CATAMARAN SEAPLANE

WAVE DIRECTION 135° - LATERAL FORCES FORWARD
WEIGHT DISTRIBUTION I
SPEED OF MODEL: 3.5 m/sec.



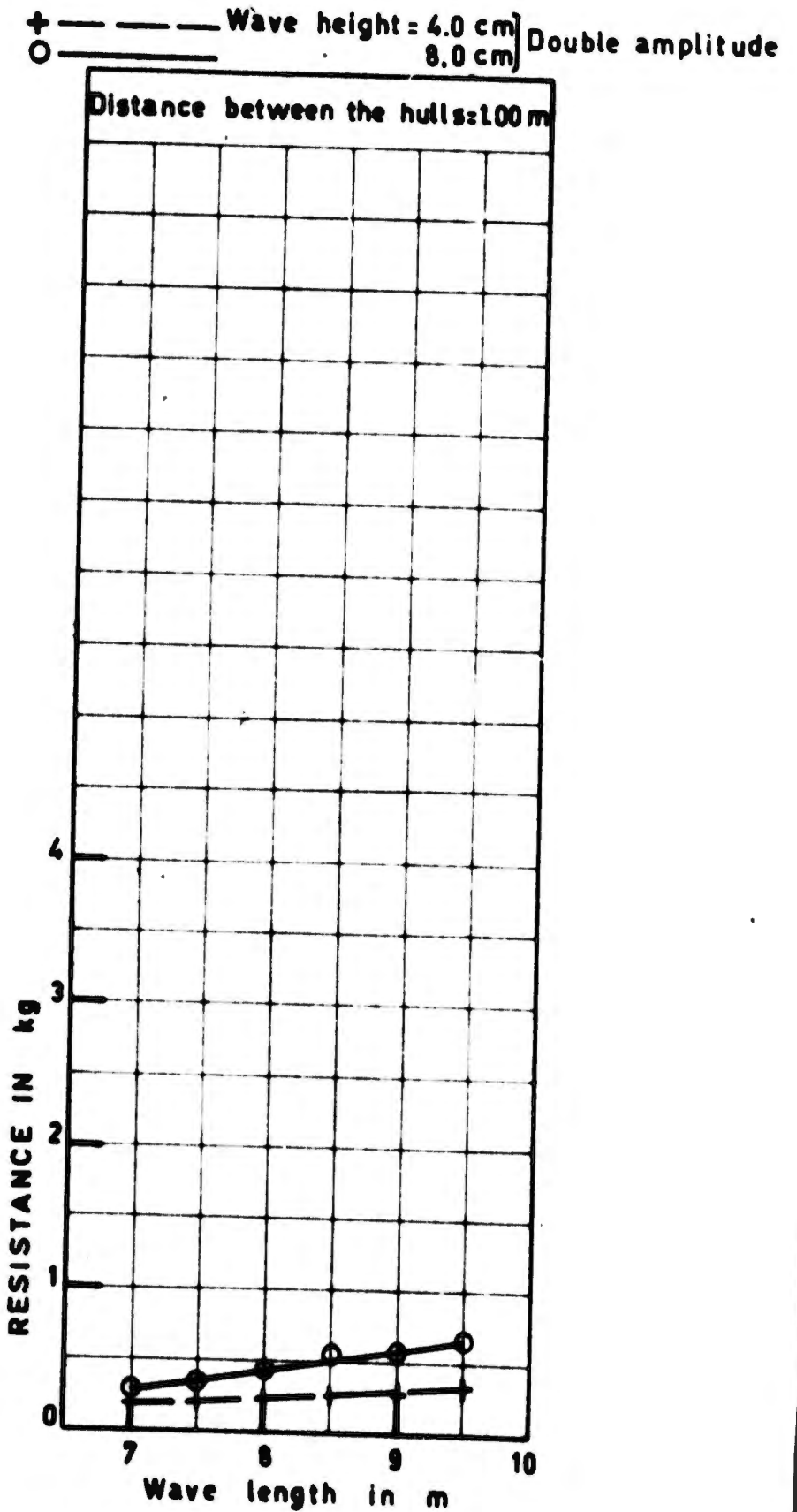
CATAMARAN SEAPLANE

WAVE DIRECTION 135° - LATERAL FORCES AFT
WEIGHT DISTRIBUTION I
SPEED OF MODEL = 3.5 m/sec.



CATAMARAN SEAPLANE

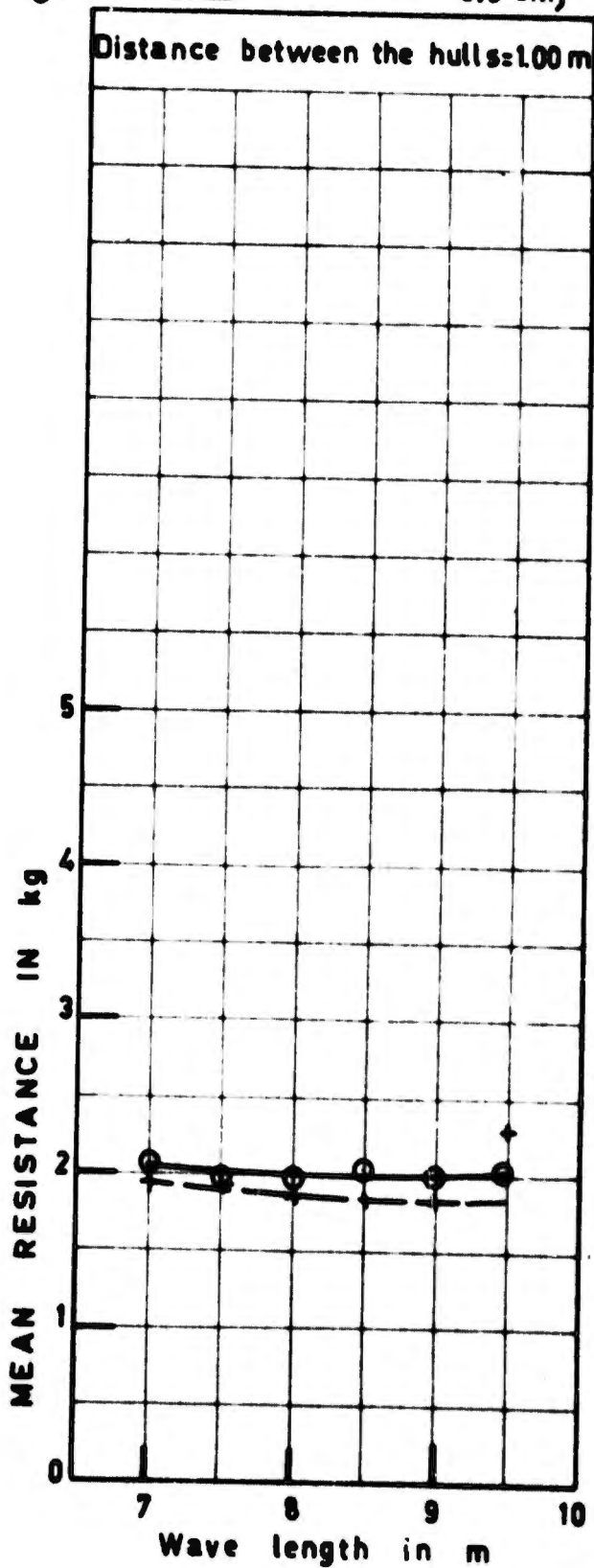
WAVE DIRECTION 135° - RESISTANCE
WEIGHT DISTRIBUTION I (Double amplitudes)
SPEED OF MODEL: 3.5 m/sec.



CATAMARAN SEAPLANE

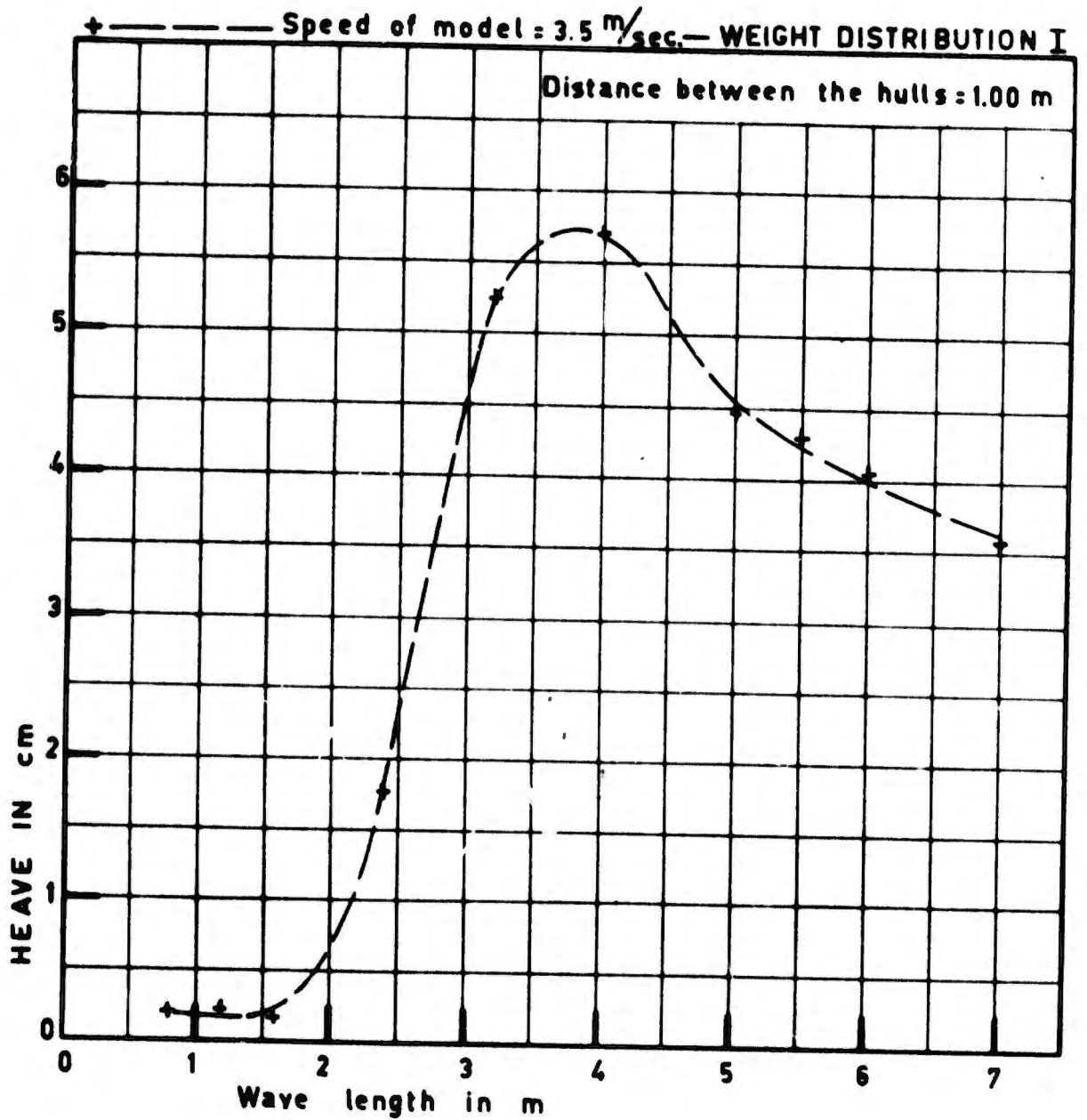
WAVE DIRECTION 135° - MEAN RESISTANCE
WEIGHT DISTRIBUTION I
SPEED OF MODEL: 3.5 m/sec.

+ ——— Wave height = 4.0 cm
○ ——— 8.0 cm } Double amplitude



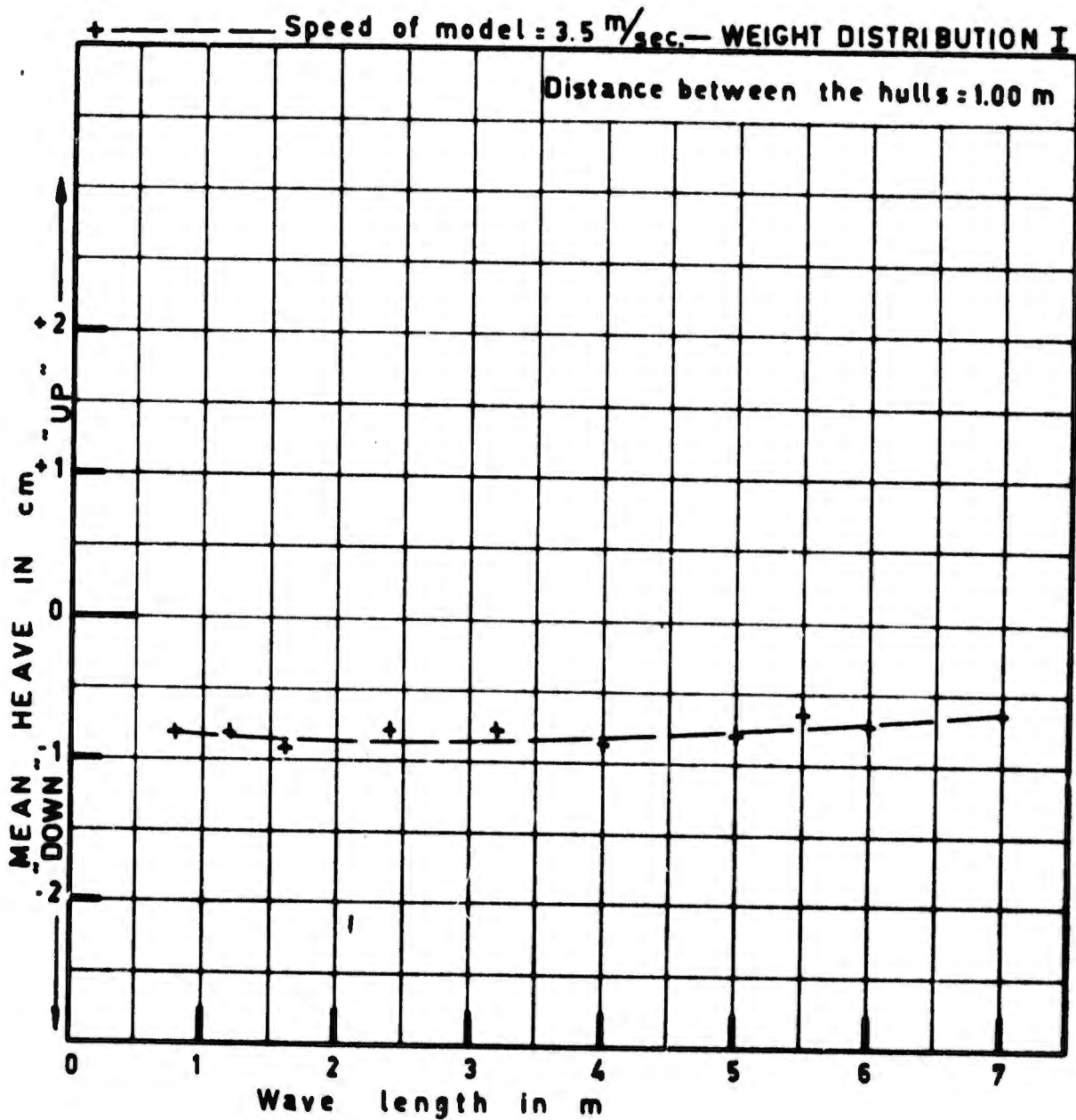
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - HEAVE
(Double amplitudes)



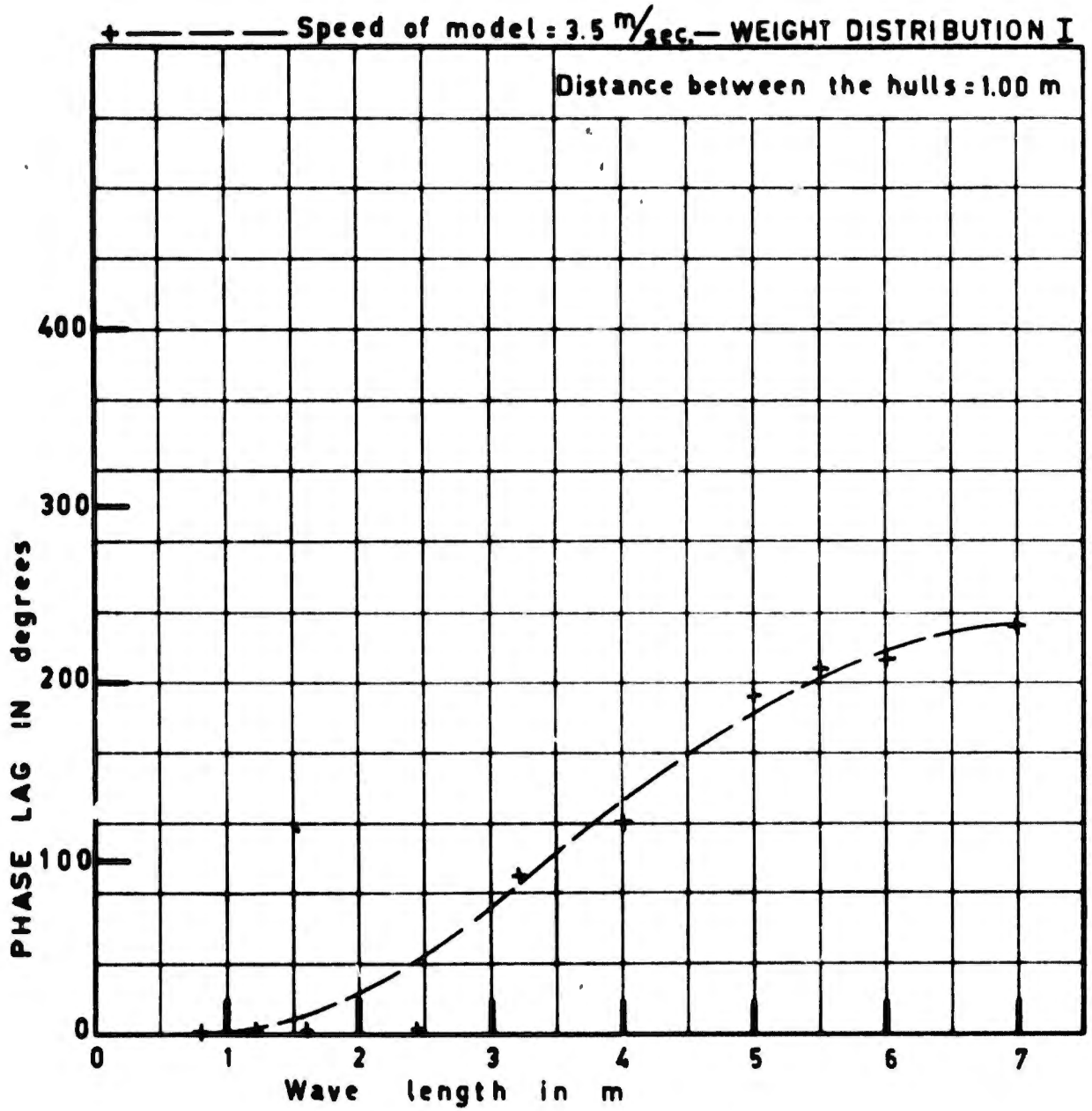
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - MEAN HEAVE



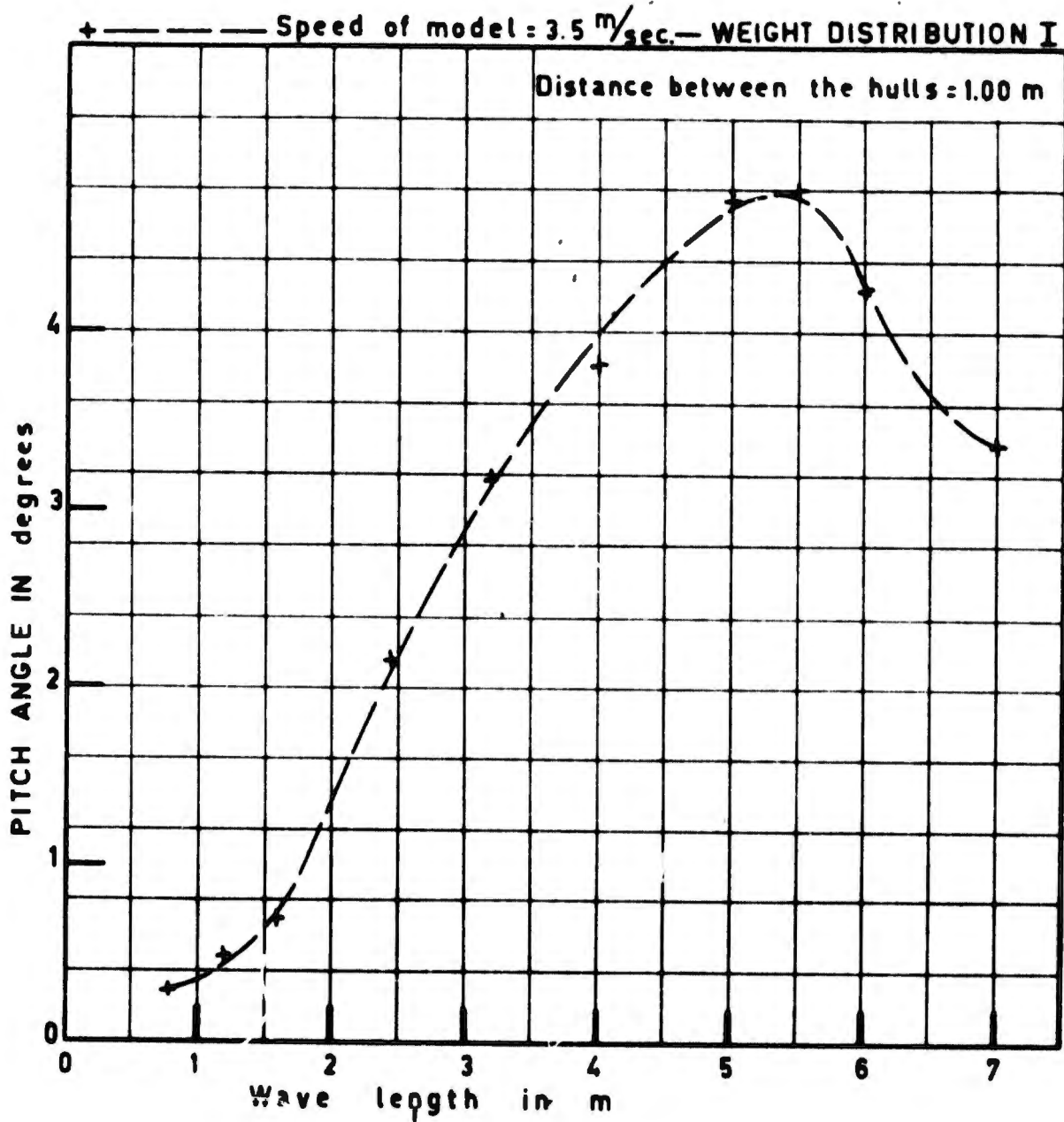
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - PHASE LAG BETWEEN WAVE HEIGHT
AND HEAVE MOTION



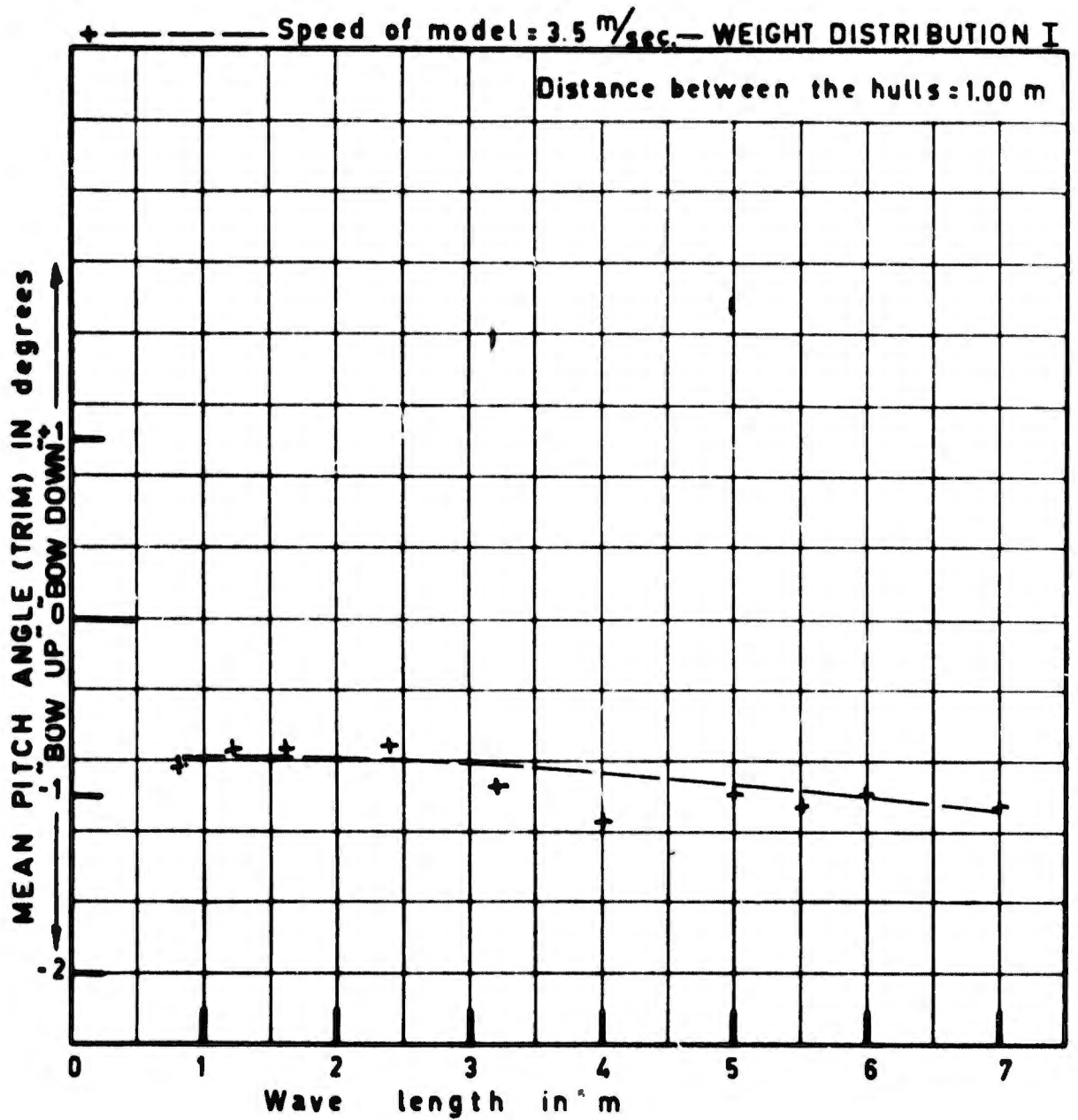
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - PITCH ANGLES
(Double amplitudes)



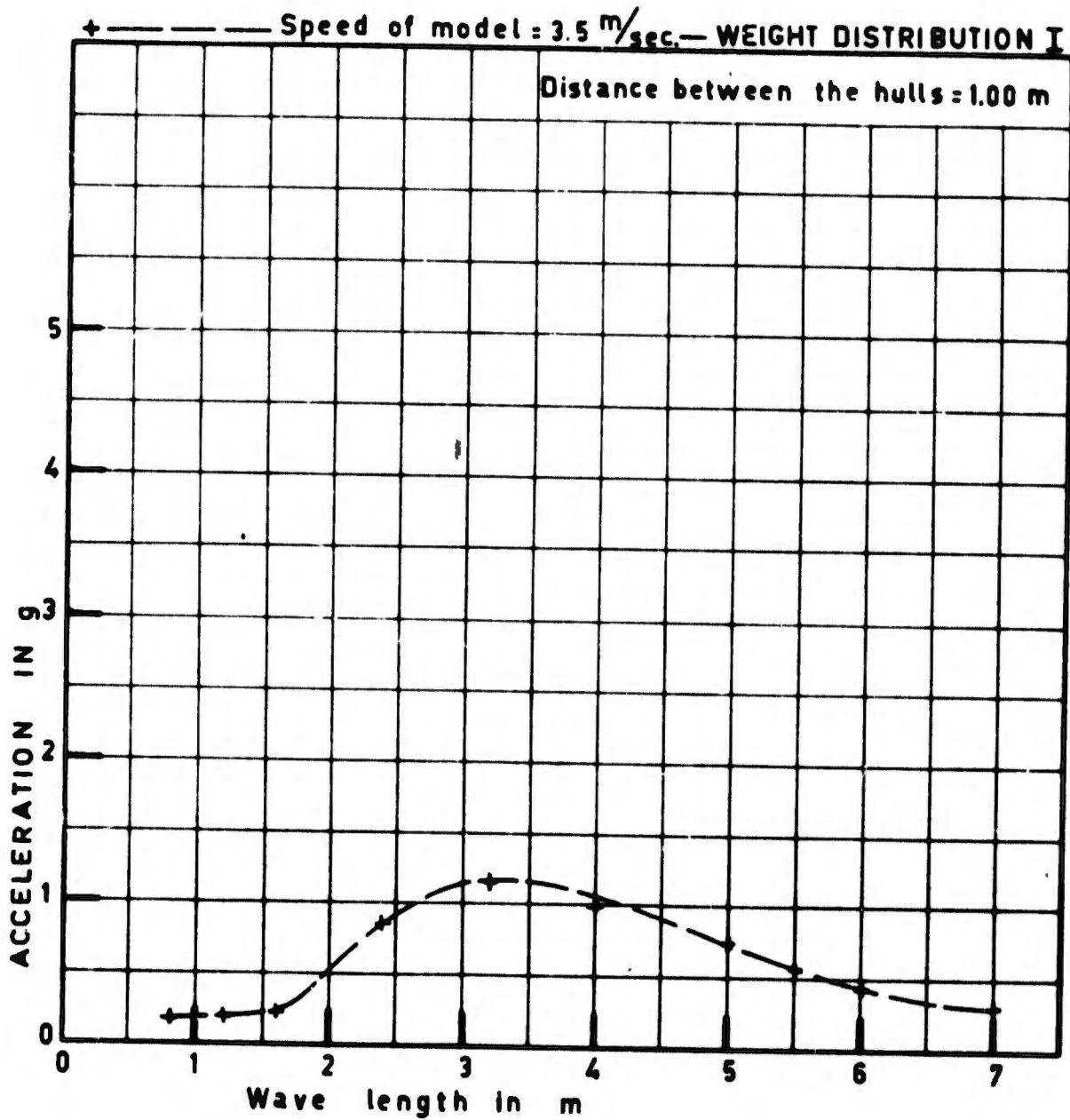
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - MEAN PITCH ANGLES



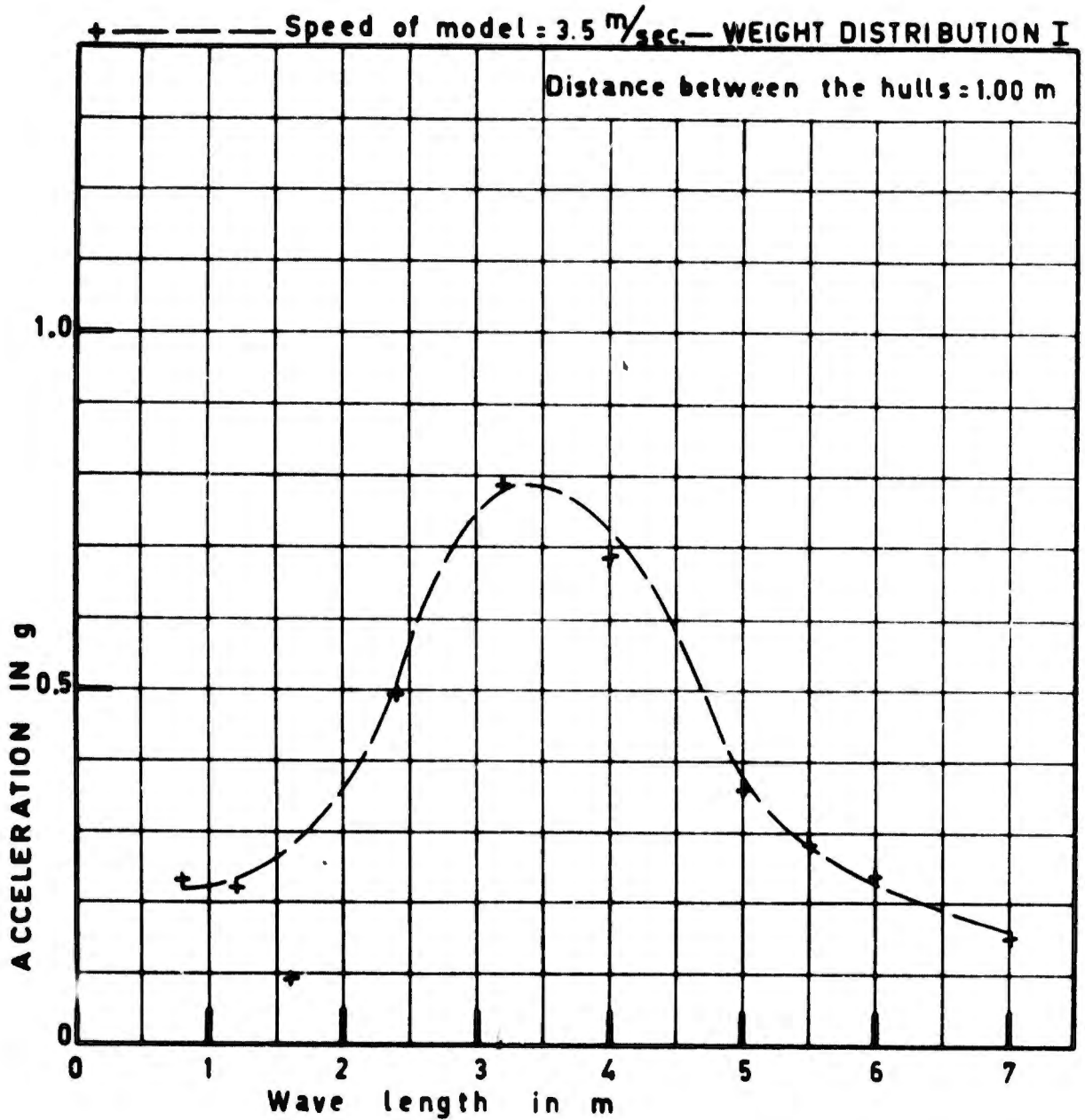
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - ACCELERATIONS OF THE HULLS
(Double amplitudes)



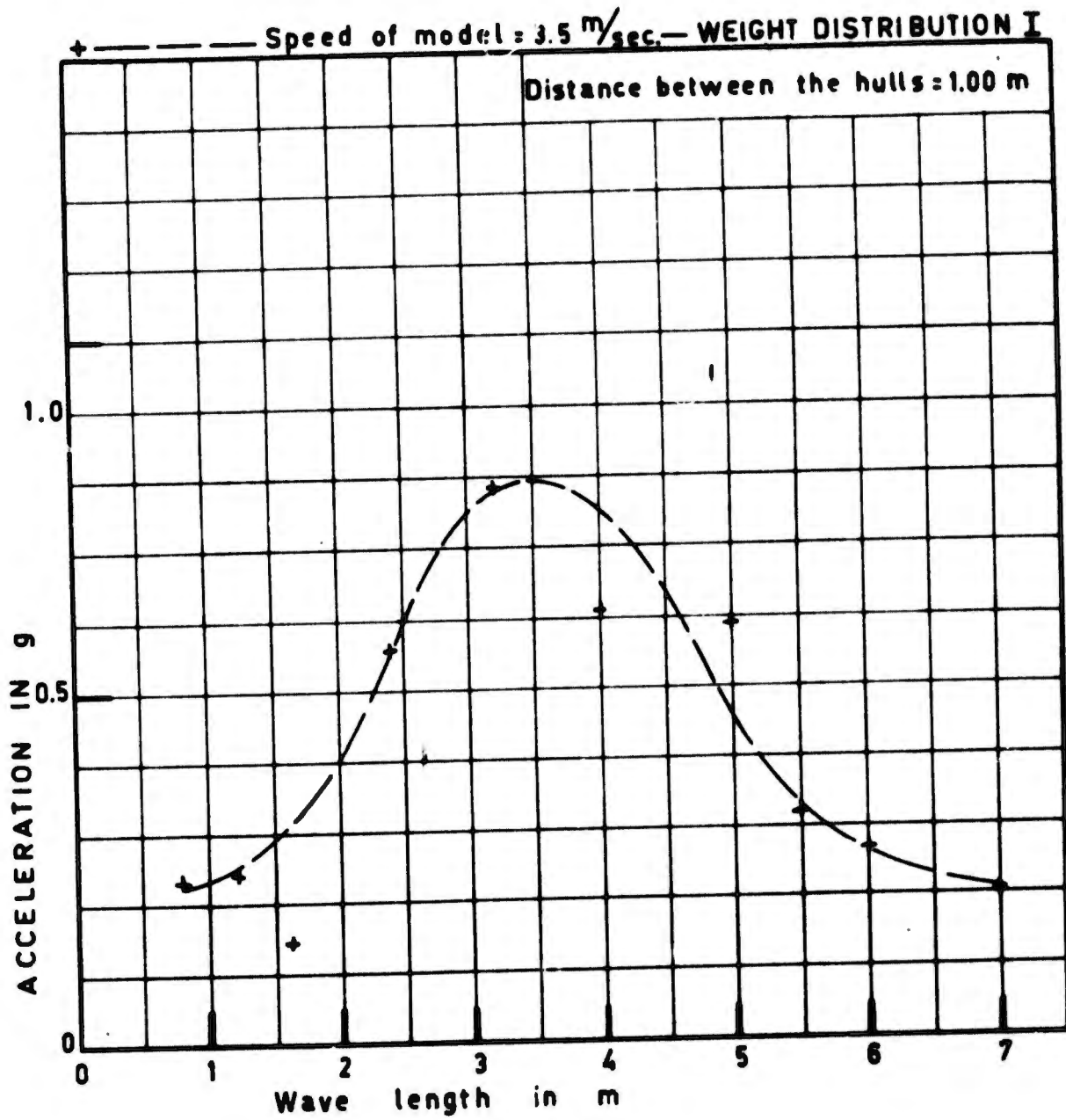
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - ACCELERATIONS ON STARBOARDSIDE
WING-TIP
(Double amplitudes)



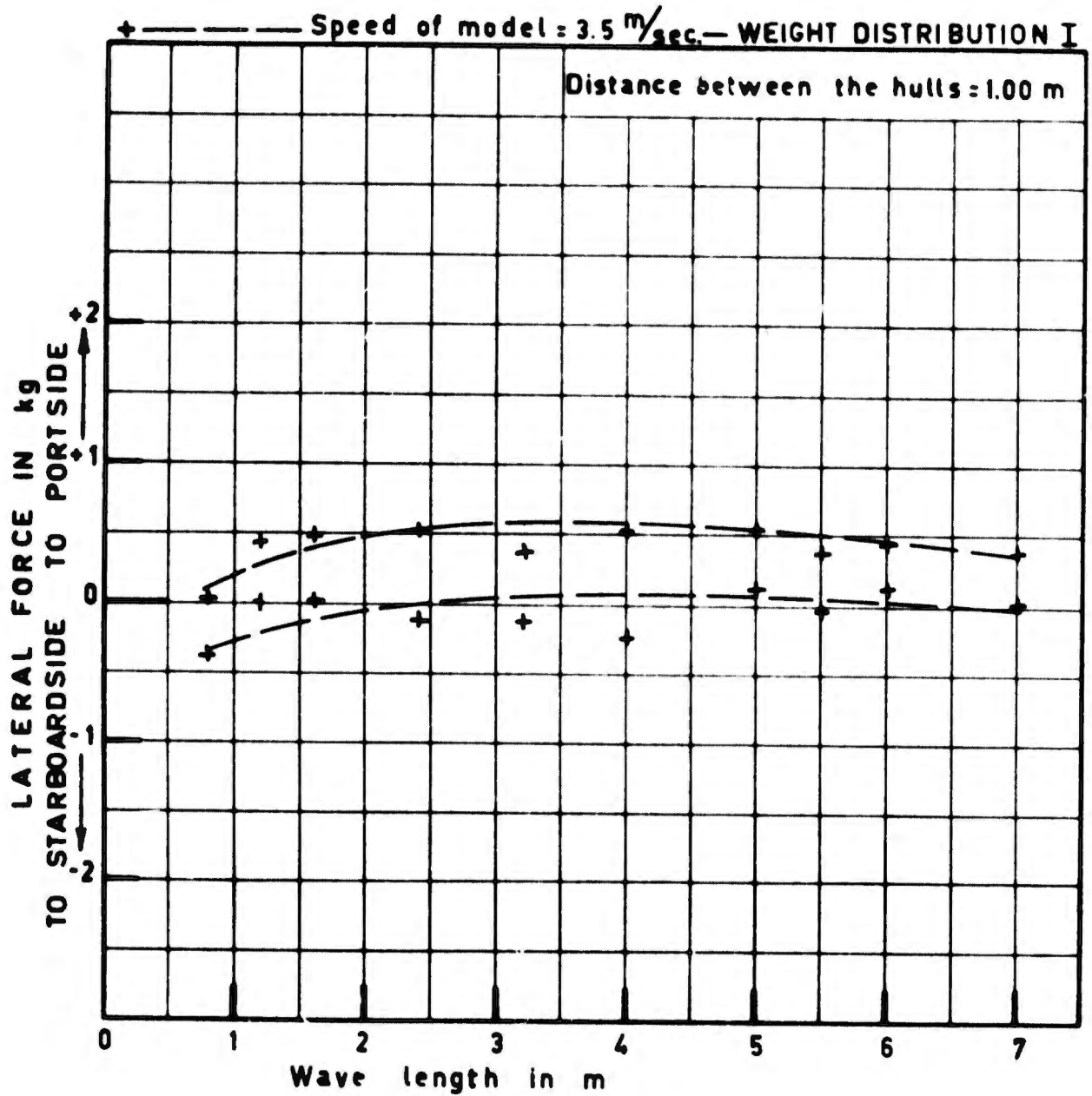
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - ACCELERATIONS ON PORTSIDE
WING-TIP
(Double amplitudes)



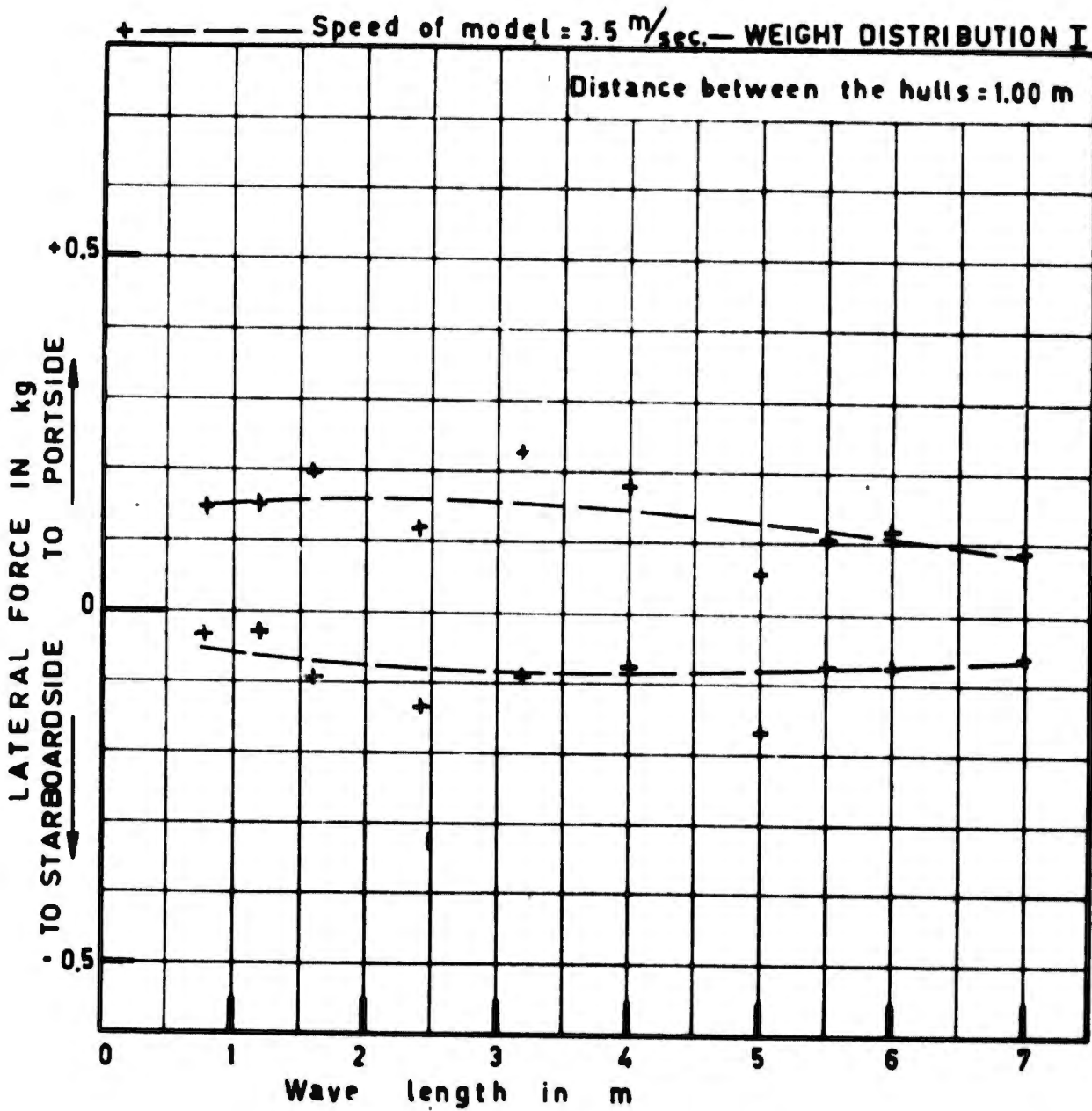
CATAMARAN SEAPLANE

• WAVE DIRECTION 180° - LATERAL FORCES FORWARD



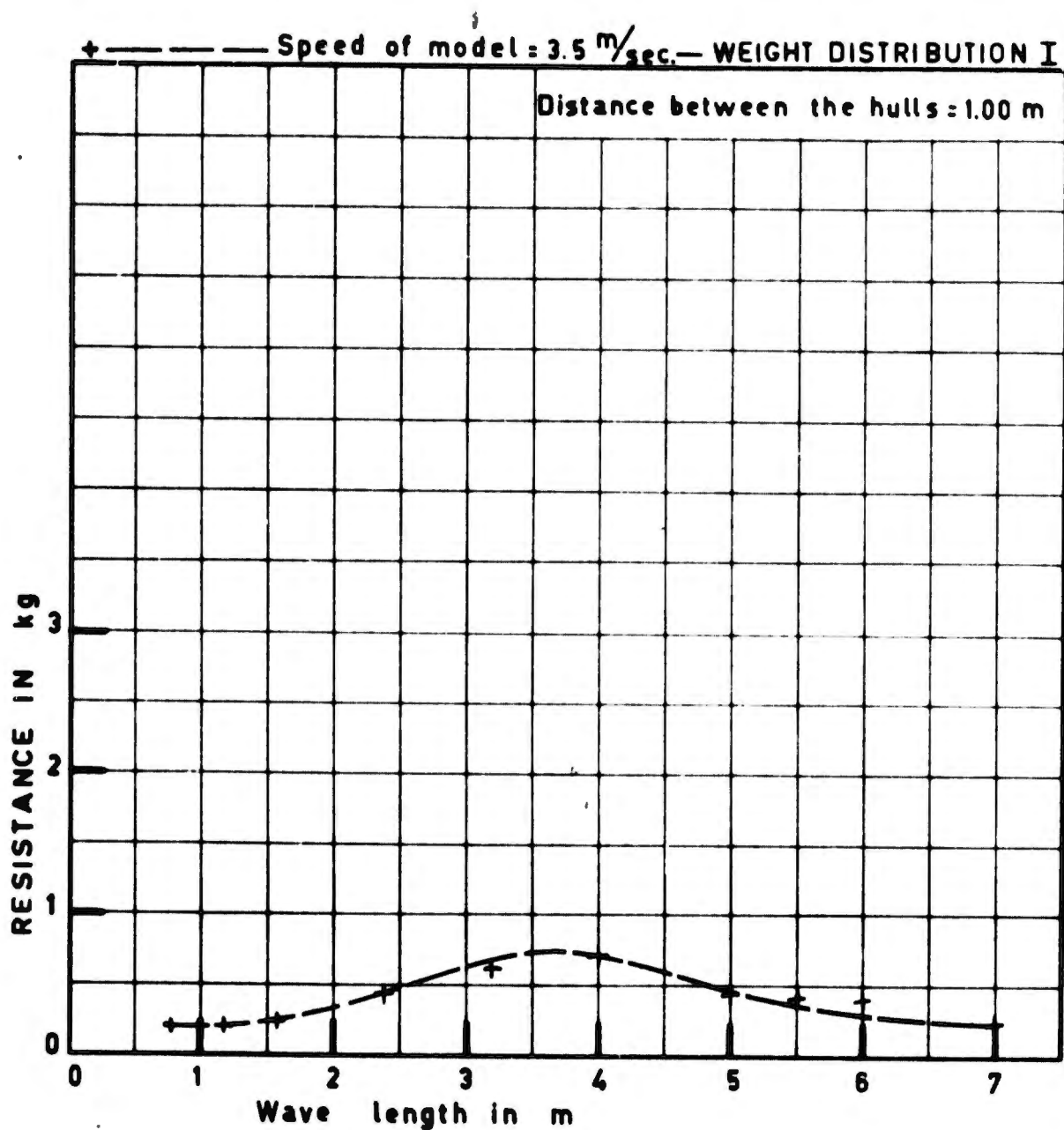
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - LATERAL FORCES AFT



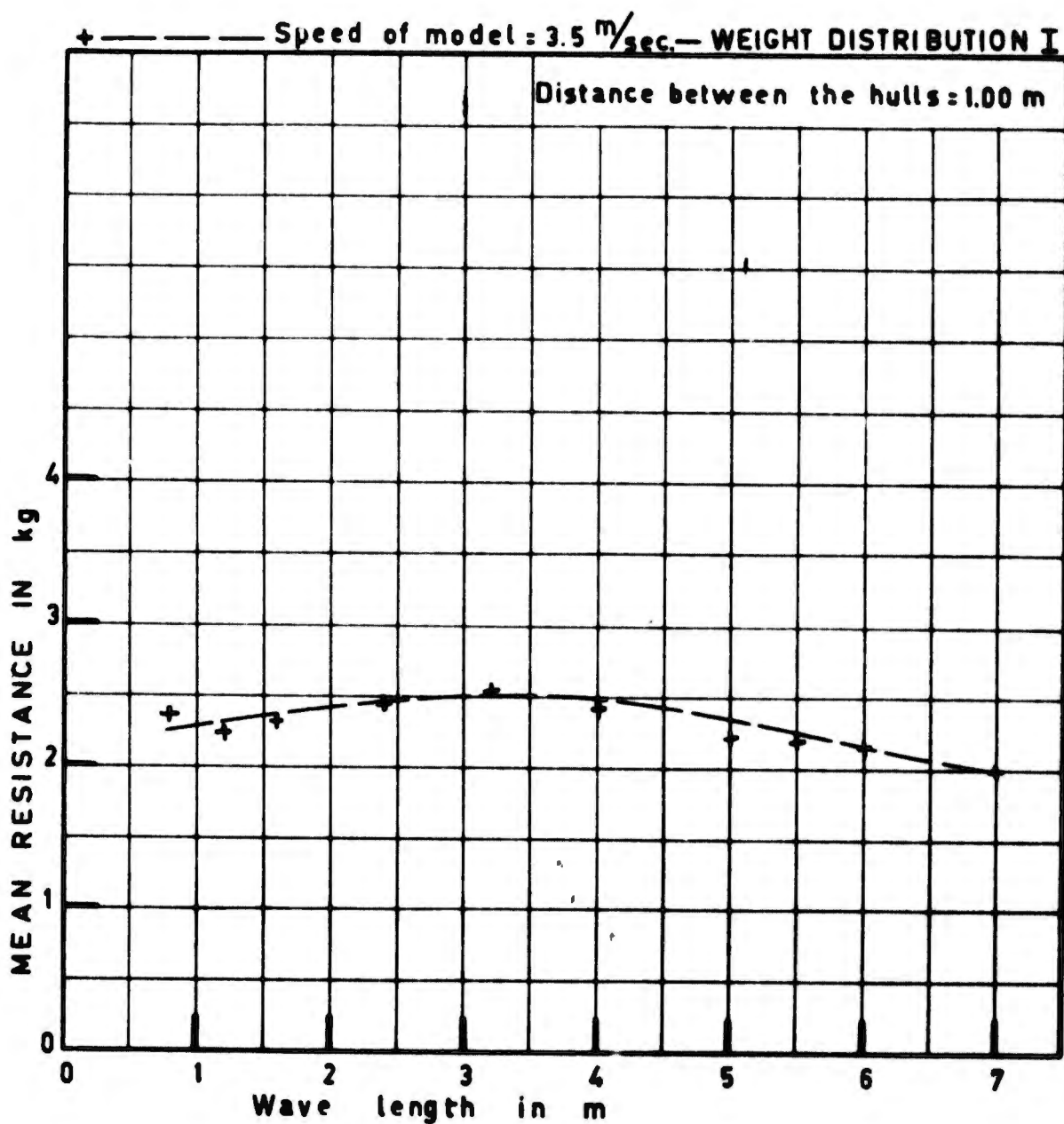
CATAMARAN SEAPLANE

WAVE DIRECTION 180° - RESISTANCE
(Double amplitudes)

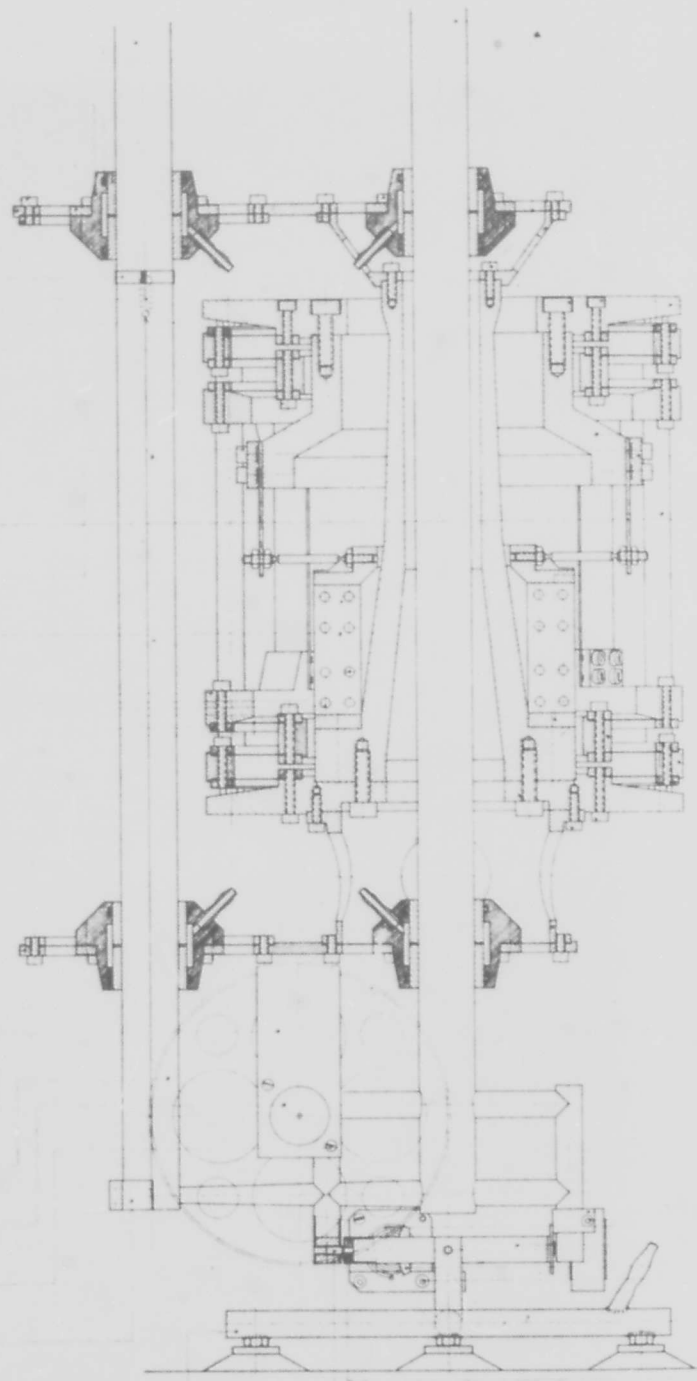


CATAMARAN SEAPLANE

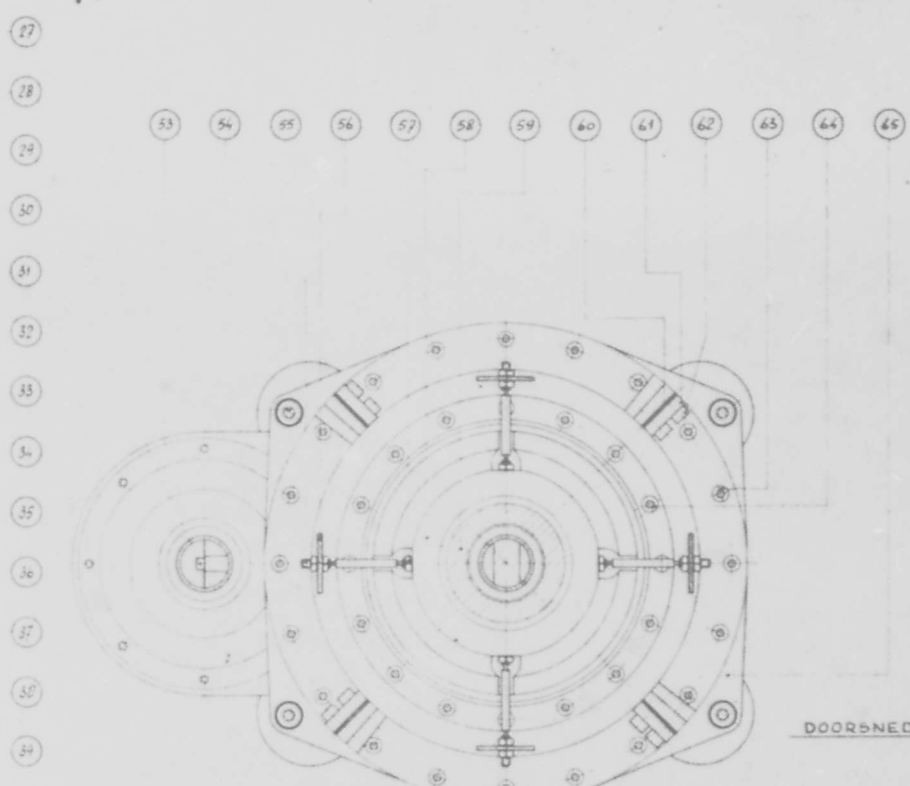
WAVE DIRECTION 180° - MEAN RESISTANCE



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A



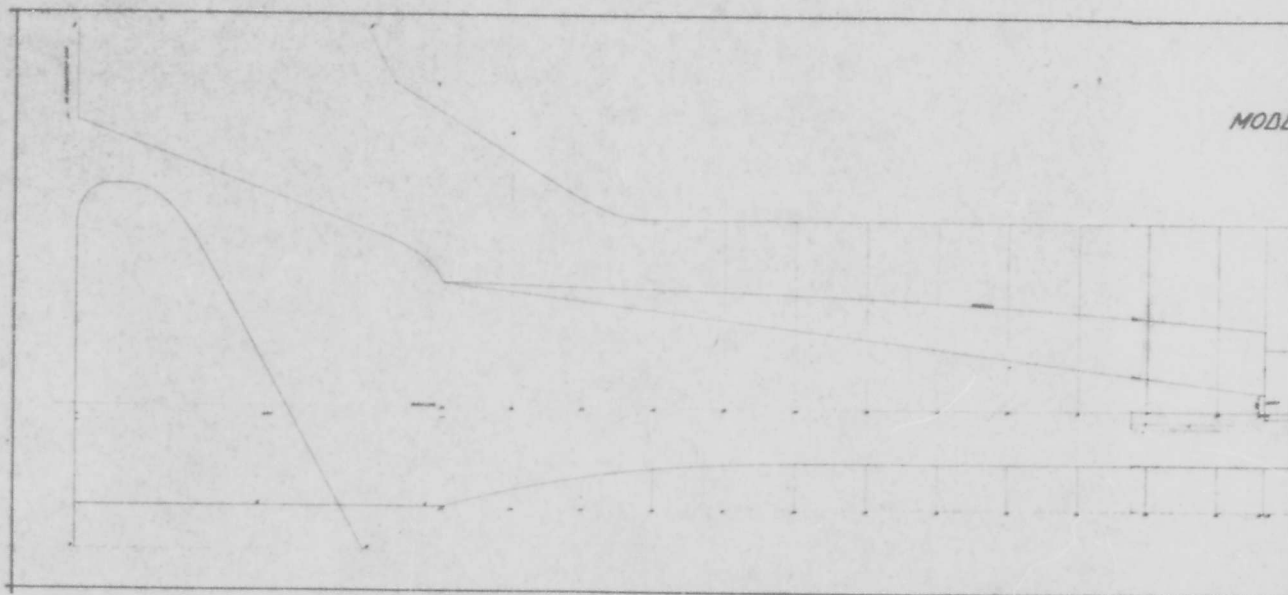
DOORSNEDE A-A

69	8	SCHROEF	ST	M5 x 20 MC	30	1	KOM	AL hard	
68	8	KLEMPLAATJE	ST 50	PARACHROMEREN	29	4	MEMBRAAM	POSPORBRONS	
67	4	KLEMPLAAT	MESS	BEH. BS. POS. 13	25	1	MEETARM	AL / ANTENNEPUP	
66	4	KLEMPLAAT	MESS	" " " "	27	24	SCHROEF	ST	M5 x 10 MC
65	1	ONDERPLAAT	AL	" " " "	26	1	ZUIGNAPPENFRAME	ANTENNEPUP	
64	32	SCHROEF	ST	M5 x 17 MC	25 ^a	3	SCHROEF + MOER	MESS	CK M2 x 6 met 1/2 draad 9
63	80	SCHROEF	ST	M5 x 14 MC	25	1	KLEMPANDJE	POSPORBRONS	
62	32	SCHROEF	ST	M5 x 10 MC	24	2	SCHROEF	MESS	CK. MEX.
61	8	KLEMPLAATJE	ST 50	PARACHROMEREN	23	3	POTENTIOMETER	TYPE Abc 1521	NOVOTECHNIK
60	4	MEETVEER	POSPORBRONS	" " " "	22	1	WIEL	PERSEPEX	
59	1	KOPPELPUP	AL (hard)	" " " "	21 ^a	4	SCHROEF	ST	M5 x 5 MC
58	1	KRUISRING	ST 50	PARACHROMEREN	21	1	STEUN	MESS	
57	12	MOER	ST	M4	20	1	AFSTANDPLAAT	AL (hard)	
56	4	MEETVEER	POSPORBRONS	" " " "	19	6	MEMBRAAM	POSPORBRONS	
55	4	TREKSTANG	ST 110	" " " "	18	2 x 2	KLEMRING	ST 37	PARACHROMEREN
54	4	TREKSTANG	ST 110	" " " "	17	4 x 2	KLEMRING	ST 37	PARACHROMEREN
53	1	SCHROEF	ST	M2 x 5 MC	16	16	SCHROEF	ST	M5 x 10 MC
52	4	SCHROEF	ST	M3 x M5	15	16	SCHROEF	ST	M5 x 6 ^{1/2} M.K.
51	2	LAGER	ST	" " " "	14	2	KRUISRING	ST 50	PARACHROMEREN
50	4	SCHROEF	ST	M2 x MC	13	4	BLADVEER	POSPORBRONS	
49	2	HEUDEL	POSPORBRONS	" " " "	12	16	SCHROEF	ST	M5 x 16 MC
48	1	KRUIS	ANTENNEPUP	" " " "	11	4	SLANGAANSLUITSTUK	MESS	VERKKELEK.
47	2	SPIRAALVEER	ST	" " " "	10	1	VEERTJE	PIANOST. DR.	Ø 15 x 5 x 10 lang
46	2	SCHROEF	ST	M2 x 5 MC	9	1	KLEMPANDJE	AL	
45	2	KLEM	AL (hard)	" " " "	6	2	KLEMRING	ST 37	PARACHROMEREN
44	1	CILINDER	ST 37	PARACHROMEREN	7	1	AFSTANDPLAAT	AL (hard)	
43	8	SCHROEF	ST	M5 x 10 MC	6	22	SCHROEF	ST 37	M5 x 7 MC
42	16	SCHROEF	ST	M5 x 15 MC	5	4	KLEMRING	ST 37	PARACHROMEREN
41	2	KLEMRING	ST 37	PARACHROMEREN	4	4	LUCHTLAGERHUIS	AL	
40	2	AFSTANDRING	AL	" " " "	3	8	O'RING	N5 64x7	
39	2	AFSTANDRING	AL	" " " "	2	4	LUCHTLAGER	Prop. AL	
38	1	KRUISRING	ST 50	PARACHROMEREN	1	1	MULPARM	AL	
37	4	AFSTANDPUP	ANTENNEPUP	" " " "					
36	4	KLEMPLAATJE	ST 50	PARACHROMEREN					
35	1	DWARSKRACHTSTUK	AL (hard)	" " " "					
34	1	BOVENPLAAT	AL (hard)	" " " "					
33	16	SCHROEF	ST	M5 x 12 MC					
32	8	SCHROEF	ST	M5 x 18 MC					
31	4	SCHROEF	ST	M5 x 10 MC					

MEETELEMENT GEM II

N.S.P. WAGENINGEN TEK. Nr. WQ 15-212-3-1004

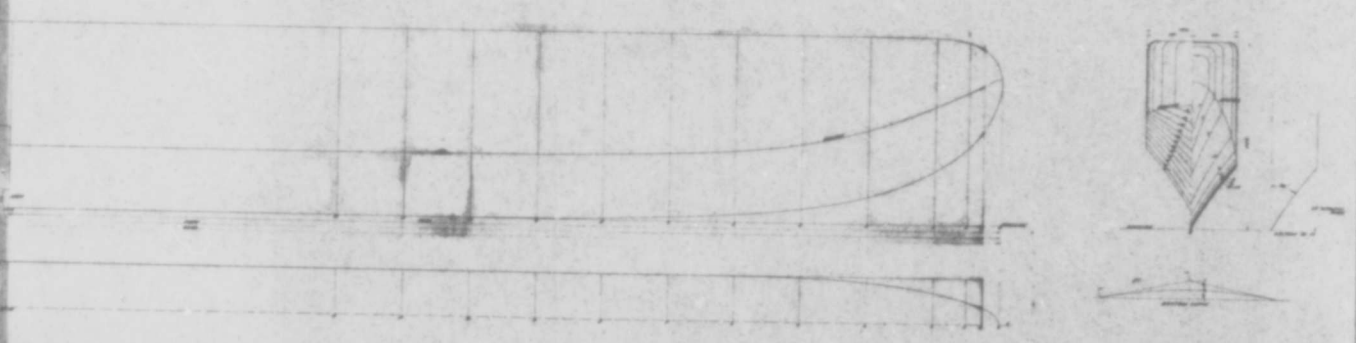
B



A

MODEL N° 3042²

MODEL OF CATAMARAN SEAPLANE



PROJECCION DE LA SUPERFICIE DEL MODELO
EN UN PLANO VERTICAL
EN UN PLANO HORIZONTAL

END

B

12-22-66