Report No. 355

LABORATORIUM VOOR SCHEEPSBOUWKUNDE

TECHNISCHE HOGESCHOOL DELFT

RESISTANCE DATA OF HULLFORM 114

by

Ir. J.J. v.d. Bosch

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Contents

1. Nomenclature

A_p	Horizontal projection of the area bounded by chines and transom, excluding external spray strips
$[A] = \frac{A_p}{\nabla^{2/3}}$	
B_c	Breadth over chines at any cross section
$B_{cm} = \frac{A_p}{L_p}$	Average breadth of area A_p
B_{cmax}	Maximum breadth over chines
b	Span of planing surface, i.e. actual breadth of planing surface measured at main spray point
C_A	Incremental resistance coefficient
$F_{n\nabla} = \frac{V}{\sqrt{g\nabla^{1/3}}}$	Speed-displacement coefficient based on volume of displacement at rest
G	Centre of gravity
g	Acceleration due to gravity
L_p	Length of A_p
l_c	Wetted length of chine, measured parallel to the keel from transom to main spray point
l_k	Wetted length of keel measured from transom
$l_m = \frac{l_c + l_k}{2}$	Mean wetted length
$[M] = \frac{L_p}{\nabla^{1/3}}$	
R	Resistance
R_A	Incremental resistance
S	Wetted surface
$[S] = \frac{S}{\nabla^{2/3}}$	
W	Weight density of water
V	Ship or model speed
X_p	Centre of area A_p
Z_G	Rise of centre of gravity
α	Angle of incidence, i.e. angle between still water surface and keel

α_o	initial trim angle between still water surface and keel
β	Deadrise angle
Δ	Ship or model weight
ν	Kinematic viscosity
ρ	Mass density of water
$\overline{AX}_p$	Distance of X_p from transom at keel
$\overline{AC}$	Distance of G from transom at keel
$\overline{KG}$	Height of G above base line
$\nabla = \frac{\Delta}{w}$	Volume of the displacement of the ship at rest

2. List of figures

3. Introduction

The tested model was one of a series of three :
the numbers 114, 115 and 116.
The aim of the test series was to compare the three hull forms with regard to the resistance in smooth water and the behaviour in irregular head seas in the speed range betwee $F_{nV} = 2$ and $F_{nV} = 4$. This was done in order to develop a hull form with a good overall performance at sea which could function as a parent for a systematic series.
In this report the resistance data of hull form 114 in sea water are given for displacements of up to 800 metric tons. For the information about the other test results the reader is referred to the references [1] , [2] and [3] .

The tests, although being a part of the research program of the Shipbuilding Laboratory of the University of Technology, were carried out at the Netherlands Ship Model Basin under the responsibility of the Netherlands Ship Research Centre, TNO.

4. Modeldata

The hull form is shown in figure 1.

The main particulars of the model 114 are given in the following table :

A_p	0.93312 m^2
B_{cmax}	0.54 m
B_{cm}	0.432 m
L_p	2.16 m
$L_{p/B_{cmax}}$	4
$L_{p/B_{cm}}$	5

	Test 1	Test 2
∇	0.04665 m^3	0.06133 m^3
$\overline{AX}_p$	0.936 m	0.936 m
$\overline{AG}$	0.792 m	0.792 m
$\overline{KG}$	0.18 m	0.197 m
[A]	7.2	6
[M]	6	5.477

5. Test procedure

The model was tested at the loading conditions stated in the preceding section, over a speed range which corresponded to the range of Froude numbers from $F_{nV} = 1.6$ to $F_{nV} = 4.0$.

The model was attached to the towing carriage in its centre of gravity by an air lubricated support, which allowed the model to pitch, heave and roll freely.

The following parameters were measured :

- the modelspeed, which equalled the carriage speed
- the resistance, measured by a strain-gauge dynamometer
- the rise of the centre of gravity, measured by a potentiometer
- the trim angle, measured by a gyroscope
- the form and magnitude of the area wetted by solid water were determined from visual observation.

6. Test results

The actual results are given in the appendix 1. The faired results are given in the figures 2 to 5. In figure 3 the resistance/weight ratio $\frac{R}{\Delta}$ is given for a standard displacement of $\Delta = 16000$ kg in seawater with a weight density of 1025 kg/m^3 and a temperature of 15°C, using the I.T.T.C. 1957 extrapolator without roughness allowance. When it is desired to take into account this additional resistance, use can be made of the curve in the lower part of the figure where the additional resistance/weight ratio $\frac{R_A}{\Delta}$ is given for an incremental resistance coefficient $C_A = 0.0002$.
This curve holds for any value of the ship's displacement; for

$$\frac{R_A}{\Delta} = \frac{C_A \cdot \frac{1}{2}\rho V^2 S}{\rho g \nabla} = 0.0001 . F_{n\nabla}^2 . \quad S$$

The angle of incidence is given in the same figure.

In figure 3 the wetted surface and the mean length of the wetted surface are given, reduced to nondimensional coefficients.

In figure 4 the wetted length at the keel and at the chine are given and the rise of the centre of gravity, also reduced to nondimensional coefficients.

In figure 5 the resistance/weight ratio is given for displacements of 1 to 250 metric tons. The resistance has been computed for seawater with $w = 1025$ kg/m^3 and $t = 15^{\circ}$ C. Use has been made of the I.T.T.C. 1957 extrapolator without roughness allowance.

7. Discussion of test results

There are no exceptional things to report.
The resistance and trim curves are smooth without accessive humps.
The resistance characteristics are good, considering the high deadrise of the hull.

8. References

[1] "Resistance data of hull form 115"
Shipbuilding Laboratory of the University of Technology, Delft.
Report no. 356.

[2] "Resistance data of hull form 116"
Shipbuilding Laboratory of the University of Technology, Delft.
Report no. 357

[3] "Comparative model tests of three planing hulls in calm water and irregular head waves"
Shipbuilding Laboratory of the University of Technology, Delft.
Report no. 358.

Appendix I

Results of resistance test with model 114 in still water

Test 1

Displacement 46.65 dm^3

Temperature 21.0 centigrade

model speed	rise of centre of gravity	trim angle	model resistance	wetted length of keel	wetted length of chine	wetted surface
m/sec	cm	degrees	kg	cm	cm	m^2
3.08	.52	2.84	5.33	196.5	176.0	1.040
3.86	1.67	3.27	6.13	-	-	.995
4.48	2.47	3.42	6.65	187.0	151.5	.960
5.17	2.93	3.08	7.30	-	-	-
5.98	3.34	3.02	8.11	179.0	129.0	-
6.64	3.84	2.84	9.21	-	-	-
7.46	4.54	2.60	10.31	179.0	118.0	-
6.00	-	-	-	-	-	.890
7.50	-	-	-	-	-	.870

Results of resistance test with model 114 in still water

Test 2

Displacement 61.33 dm^3

Temperature 21.9 centigrade

model speed	rise of centre of gravity	trim angle	model resistance	wetted length of keel	wetted length of chine	wetted surface
m/sec	cm	degrees	kg	cm	cm	m^2
3.28	.84	3.70	7.80	-	-	-
3.88	2.19	4.27	8.45	189.5	161.5	1.055
4.67	3.34	4.36	8.85	-	-	-
5.60	4.31	3.94	9.64	-	-	-
6.16	4.72	3.75	10.32	-	-	-
6.94	5.60	3.37	11.09	-	-	-
7.86	6.21	2.75	12.10	-	-	-
3.20	-	-	-	194.5	176.0	1.095
4.80	-	-	-	183.0	143.5	.905
5.61	[illegible]	-	-	178.5	131.0	.865
7.00	-	-	-	173.0	118.0	.840
7.84	-	-	-	172.0	114.0	.835

Appendix II

Table of offsets of model 114

wl	ord 0 mm	ord 2 mm	ord 4 mm	ord 6 mm	ord 7 mm	ord 8 mm	ord 9 mm	ord 10 mm
0	2.7	2.7	2.7	2.7	-	-	-	-
4	102.8	102.8	102.8	96.8	81.4	50.5	-	-
8	190.5	190.5	188.6	165.4	137.3	92.8	25.5	-
12	241.3	260.7	258.3	219.4	181.9	128.0	52.7	-
16	261.2	285.2	290.4	259.4	220.0	159.4	78.3	-
20	273.4	299.9	307.1	280.5	245.2	186.5	103.2	-
24	281.0	309.2	320.4	298.0	264.9	210.2	129.4	17.3
28	284.9	316.4	332.3	314.6	284.7	235.2	157.5	43.8

Deckline

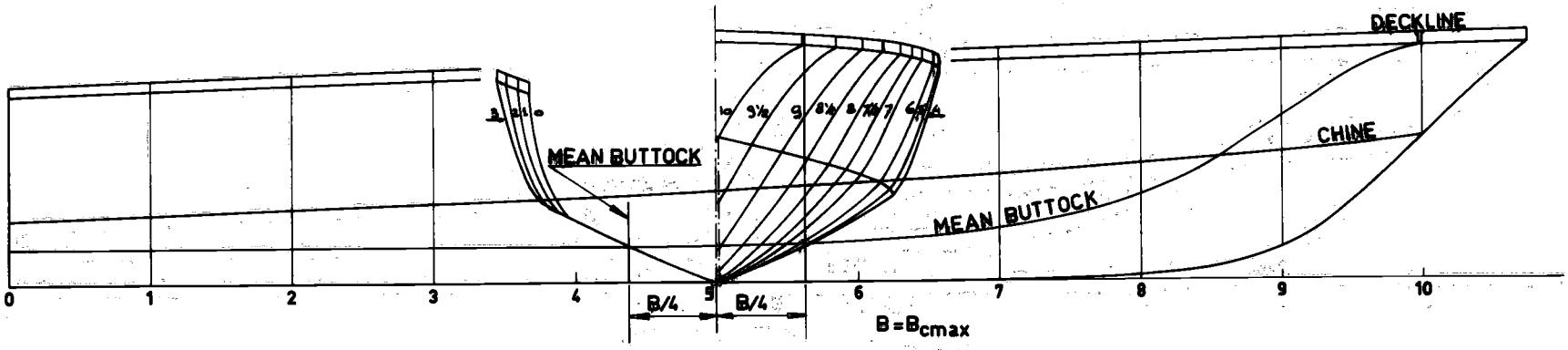
ord	beam mm	height
0	285	300.0
2	319	315.6
4	341	331.2
6	333.5	346.8
7	315.4	354.6
8	281.5	362.4
9	223.6	370.2
10	130.2	378.0

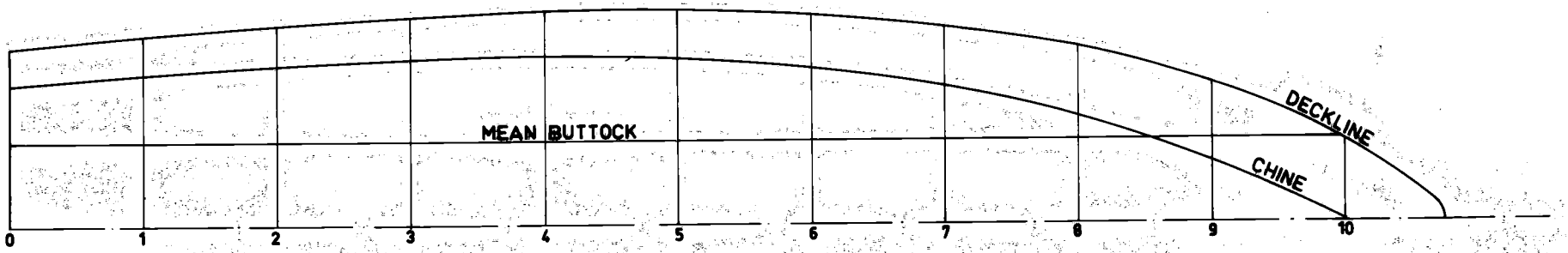
Chine

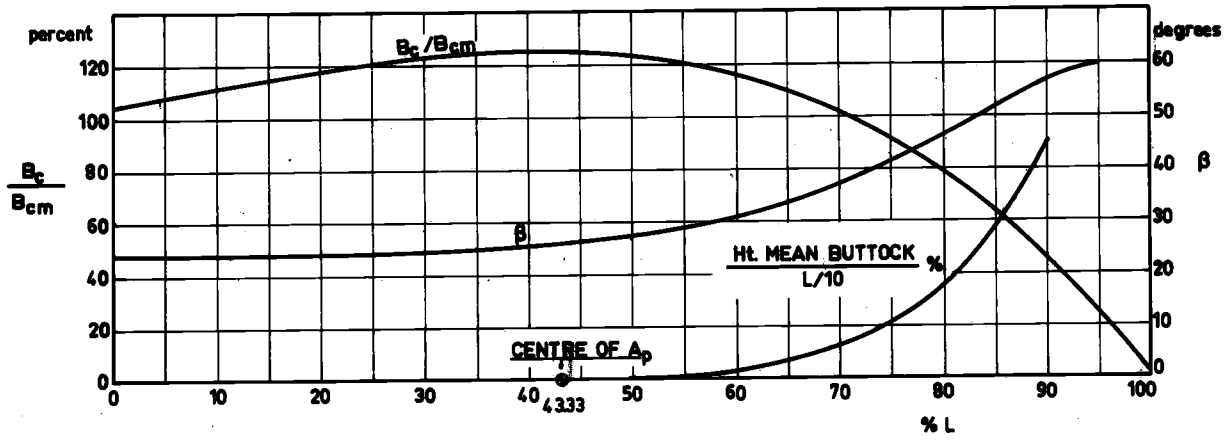
ord	beam mm	height mm
0	225.0	97.0
2	254.0	112.2
4	269.9	127.4
6	250.5	146.7
7	209.7	159.4
8	170.4	176.9
9	99.1	193.6
10	2.7	216.0

Keel and Stem

ord	beam	height
6	2.7	0
7	2.7	0.2
8	2.7	5.7
9	2.7	49.0
10	2.7	216.0







DETAIL SPRAYSTRIPS
SCALE 1:5 FOR Δ = 16 TON

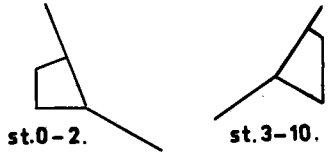


Fig.1. Lines and formcharacteristics of the hull of model 114.

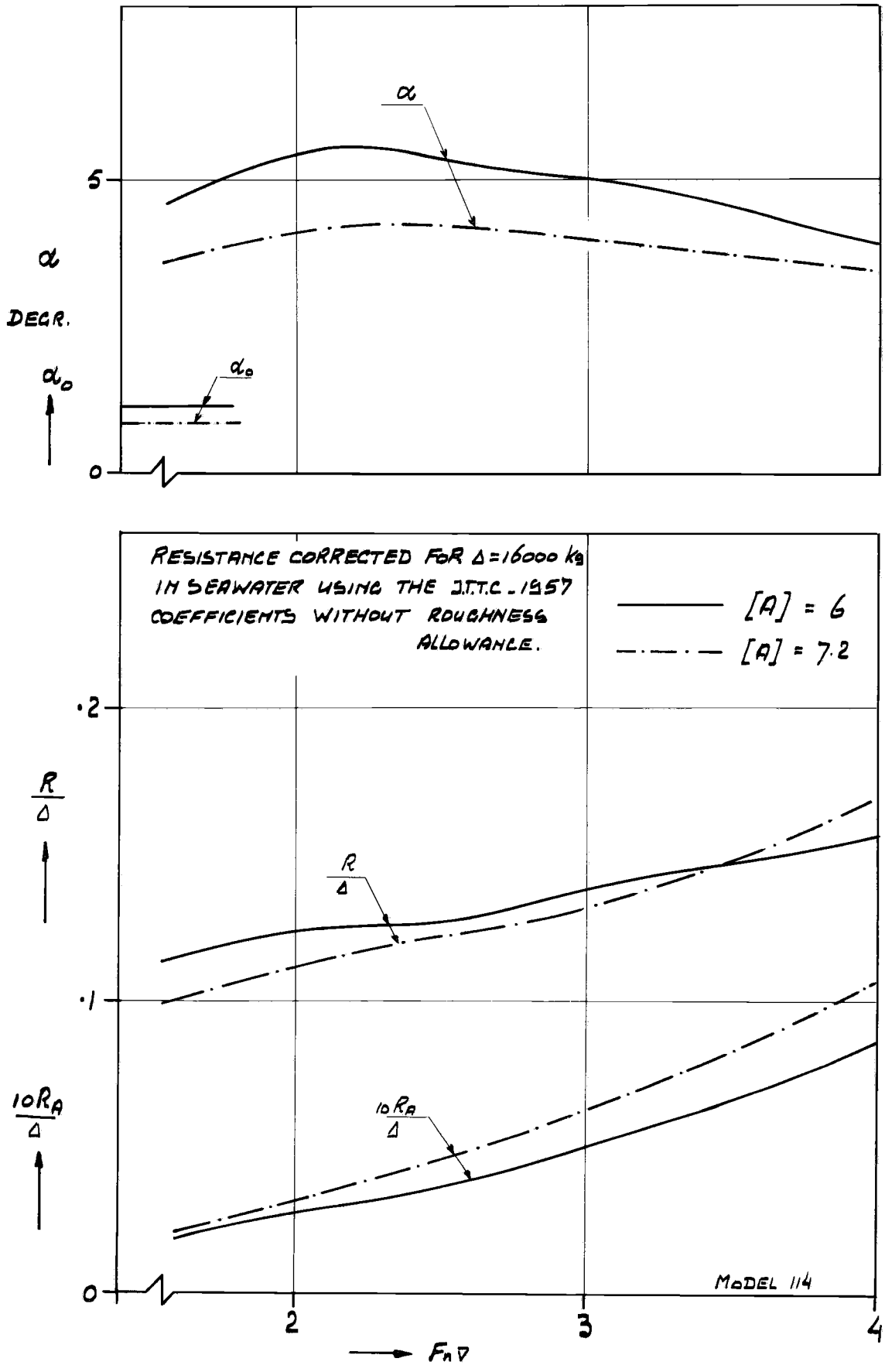


fig. 9 Resistance-weight ratio of the standard ship and angle of attack

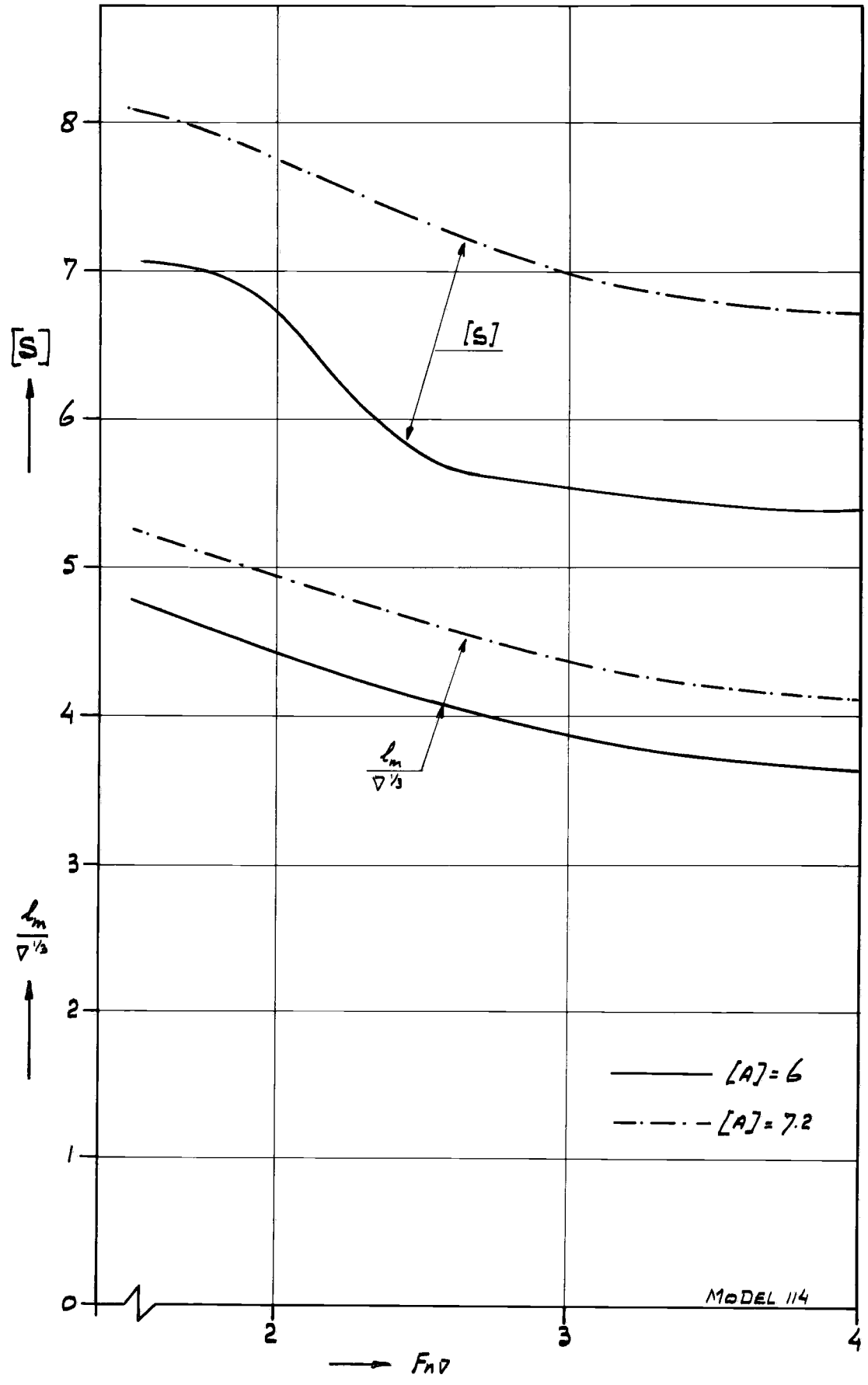


fig. 3 Wetted surface and mean wetted length ratio's

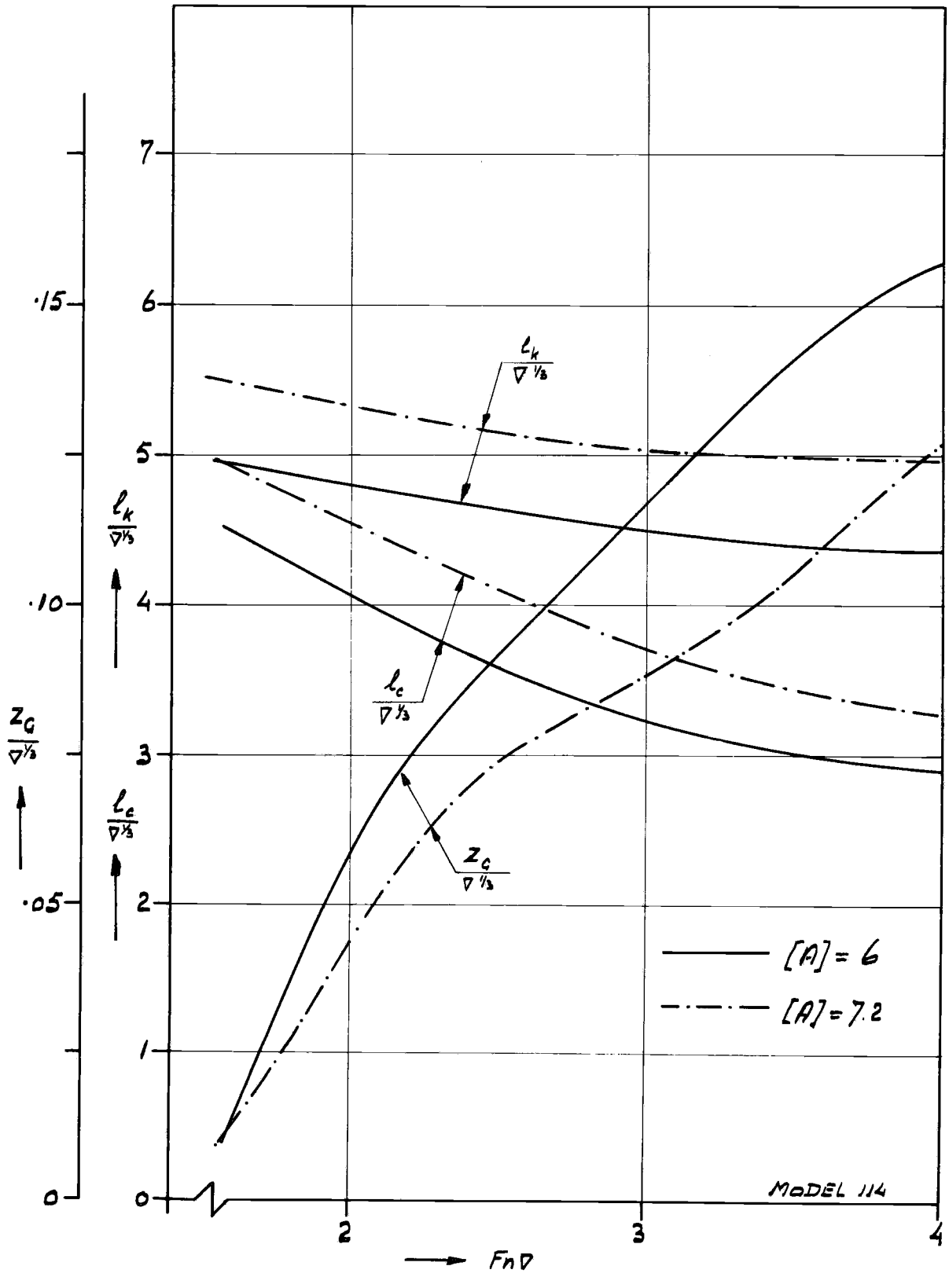


fig. 4 Wetted length ratio's and rise of centre of gravity

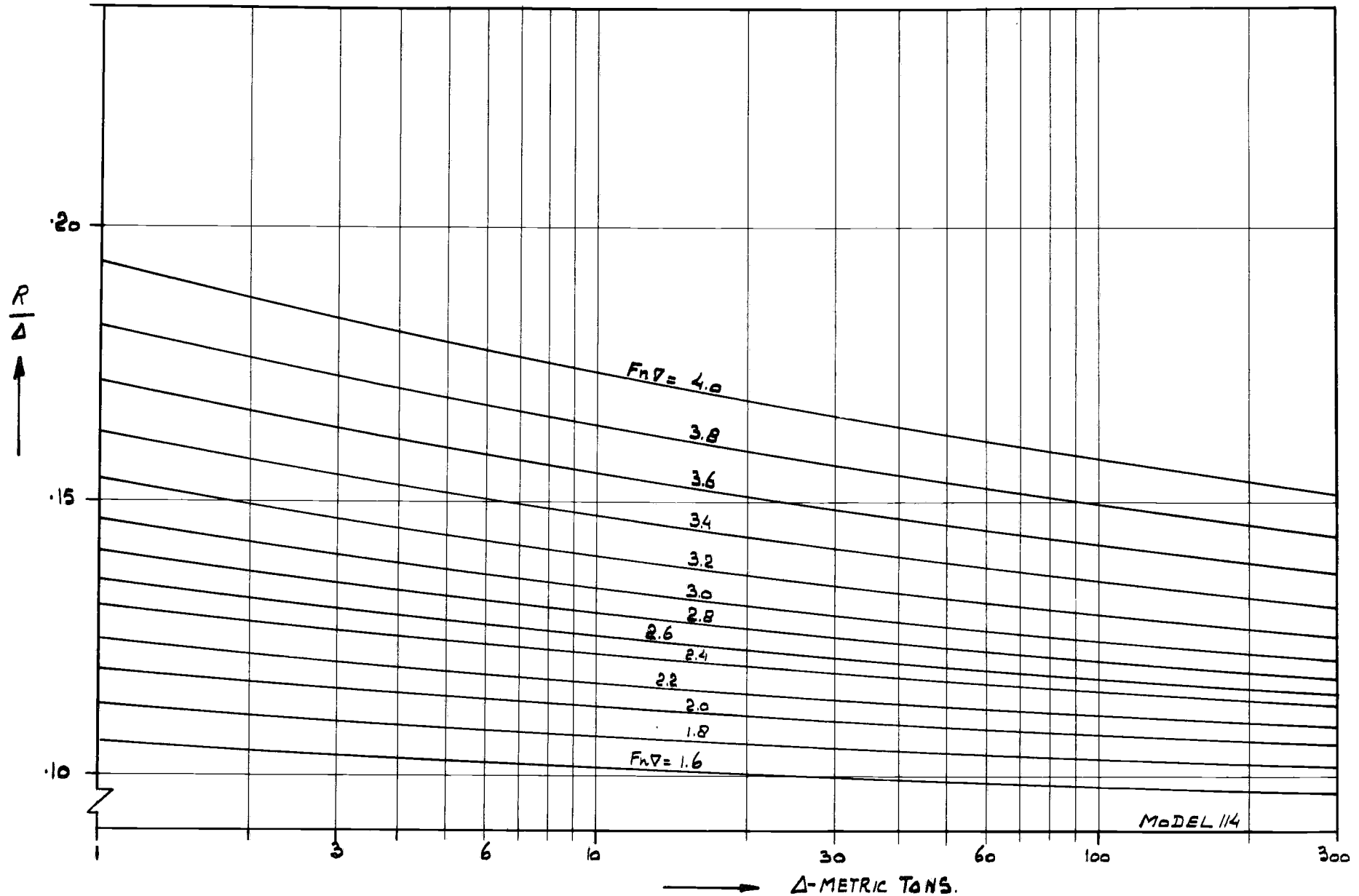


fig. 5 A Resistance-weight ratio as a function of Δ and $F_{n\nabla}$ [A] = 7.2

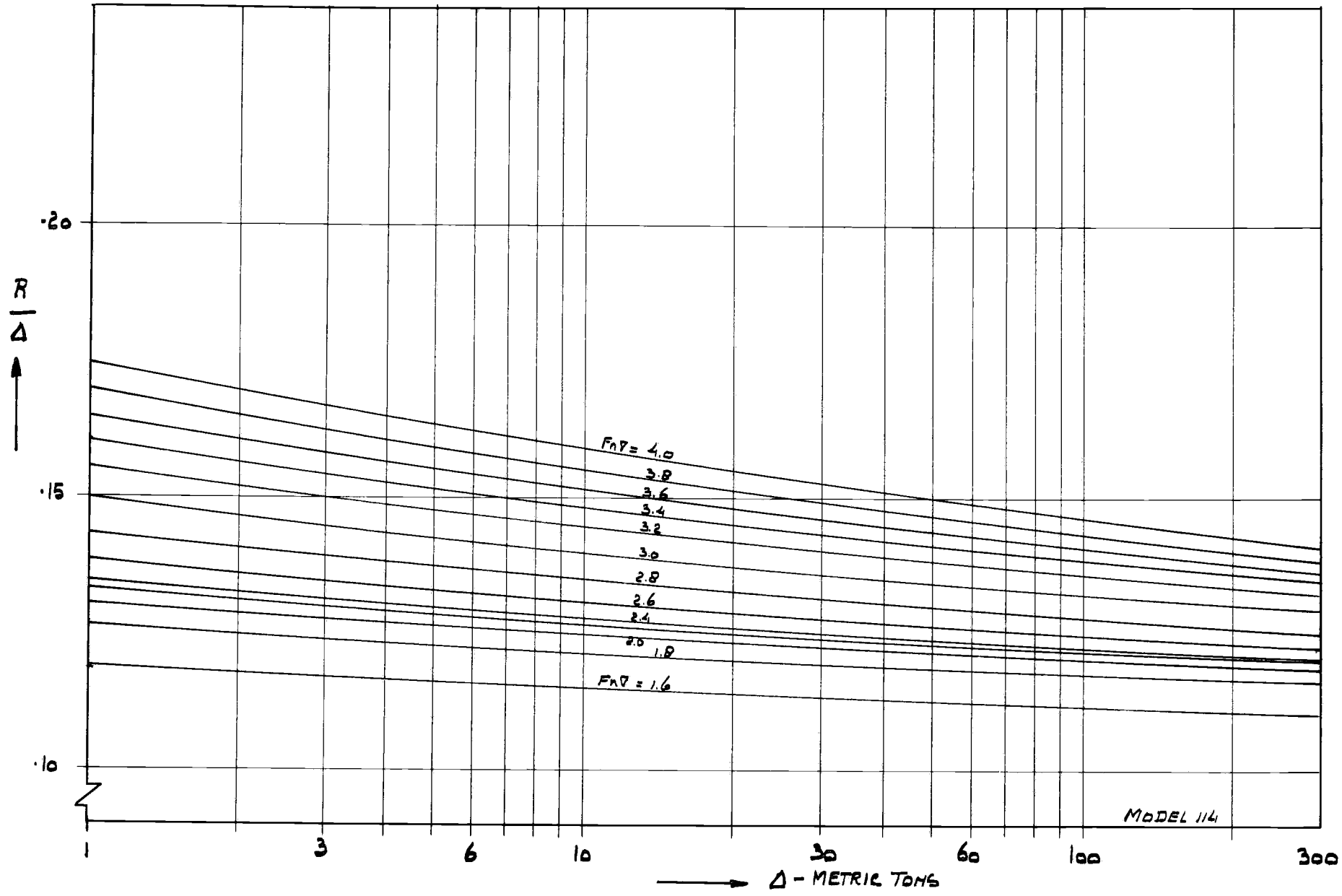


fig. 5 B Resistance-weight ratio as a function of Δ and $F_{n\nabla}$ [A] = 6