C.P. No. 284
(18,022)
A.R.C. Technical Report

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CURRENT PAPERS

Towing Tank Tests to Determine the Water Drag of the Hull of a Jet Propelled Flying Boat Fighter (Spec. E.6/44) and Comparison with Full Scale Measurements

By

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and

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LONDON HER MAJESTY'S STATIONERY OFFICE

1956

EIGHT SHILLINGS NET

C.P. No. 284

Corrigenda to M.A.E.E. Report No. F/Res/263

March, 1956

MARINE AIRCRAFT ESPERIMENTAL ESTABLISHMENT, FELIXSTOWE, SUFFOLK

TOWING TANK TESTS TO DETERMINE THE WATER DRAG OF THE HULL OF A JET-PROPELLED FLYING BOAT FIGHTER (SPEC.E.6/44) AND COMPARISON WITH FULL SCALE MEASUREMENTS

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Corrigenda

p.5 lines 22-24 — Delete "and in addition a number of runs . . . . Section 4.1)".

p.6 lines 28-29 — For 'With the nomenclature .... formula," substitute 'With the nomenclature of Figure 8 and the assumptions above this leads to the formula (cf. References 1 and 2),"

p.7 lines 18-20 — For "A number of screened runs . . . . . . Figure 13" substitute "A number of test results for the low draught planing region, where conditions made possible the calculation of water skin friction coefficients, were analysed to determine these coefficients for comparison with the skin friotion curve of Referenoe 2. This standard curve and the test points for the present investigation are plotted together in Figure 13".

p.11 line 17 — Delete existing definition of S and substitute "Total wetted area".

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SUMMARY

The water drag, draught, wetted areas and mean wetted lengths of a 1/9th scale E.6/44 flying boat model hull have been measured far all anticipated take-off loads and attitudes over the take-off run.

A method of scaling up model drag, to make allowances for the differences in skin friction, model and full scale, has been used and the results compared with actual full scale tests.

There is not satisfactory agreement between estimated and measured full-scale results, and the tests do not provide sufficient evidence to determine whether the accurate estimation of full-scale water resistance by the methods used is possible.

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/1. INTRODUCTION

1. INTRODUCTION

Full scale measurements of hydrodynamic resistance were made on the E.6/44 jet propelled flying boat fighter (Saunders-Roe A.1) by Messrs. Saunders-Roe, in collaboration with M.A.E.E. As this was the first jet propelled seaplane in existence, it offered an opportunity for more accurate measurements of a flying boat hull water drag than had been possible hitherto, and for a reliable comparison with model-scale data.

Previous tank measurements of model water drag have shown discrepancies when compared with full scale results. While some of the differences involved could be attributed to changes in the skin friction coefficients, from model to full scale, the size of this effect could not be determined owing to lack of knowledge of the boundary layer conditions on the model hull bottom.

Accordingly, a new technique of model testing was evolved at the R.A.E. Seaplane Tank which involved applying a constant degree of surface finish to hull bottoms and determining the skin friction coefficient values over the Reynolds Number range experienced in the tank, to facilitate the accurate scaling up of model drags. This method is described in Reference 1, and Reference 2 describes in more detail the practical aspects of the method, with some adaptations, as it was applied to model tests to measure the water drag of the Princess flying boat. In the tests of the present report substantially the same procedure as for the Princess tests was employed, with the following objects in view:-

(i) to provide a comparison with the full scale values, and

(ii) depending on the degree of agreement found in (i), assessing the validity of using the results obtained in Reference 2 to estimate the take-off performance of the full scale Princess and of using the new experimental technique in future investigations.

2. DESCRIPTION OF MODEL

The model, the lines of which are given in Figure 1, was made of mahogany to 1/9th scale. This scale gave the largest model which could be accommodated in the tank to give a reasonable range of speed and load, so keeping scale effects to a minimum. Balsa fairings were fitted over the jet entry and exit duct positions to simulate the full scale airflow as closely as possible, without the complication of providing airflow through the ducts. The planing surface was brought to the standard degree of smoothness by the application of a hard black phenolglaze, suitable for the determination of wetted areas by the white chemical indicator method.

3. EXPERIMENTAL METHODS AND ANALYSIS OF RESULTS

As already stated, the methods used were basically those employed for the Princess model [1,2], and only outlines of the methods are therefore given below. The only change made was in the method of calculating the mean wetted length when the afterbody was wetted. The new method is described in section 3.3.1, and caters more satisfactorily from a logical point of view for the afterbody flow conditions experienced than does the original method; the numerical change involved is however small and does not affect any assessments of the Princess test methods made later in this report.

It was felt by the authors of the present report that other changes could advantageously be made in the analytical methods of References 1 and 2 to improve their logical basis. As these are of a more controversial nature than the change mentioned above and at the same time would seem from preliminary calculations to have only a small effect on the results, it was decided not to incorporate the changes but to pursue the matter in a later report.

/3.1.

3.1. Drag measurements

3.1.1. Low and hump speed ranges

In the low and hump speed ranges, the model was tested at various speeds and, at each speed tested, a selection of three fixed attitudes combined with four, five, or six loads was used, the drag being measured for each combination. The choice of attitude was made by reference to full scale tests, and approximate free to trim attitudes to the nearest whole degree were selected in conjunction with values differing by ± 2° from these attitudes. The combination of loads and attitudes gave a coverage of all reasonable C.G. positions, power and loads, full scale, and gave results, presented on a generalised base in Figures 2 and 3, from which interpolation in the main can be carried out with a fair degree of accuracy. (The generalised base has been used solely as a matter of convenience in scaling up results, and not because a collapse was expected).

3.1.2. Planing speed range

In the planing speed range, in accordance with the standard technique, the model was tested at a single carriage speed of 25 ft. per sec. (C_V = 5.25: full scale speed 44 knots) at keel attitudes of 4°, 6°, 8° and 10°. Generalised test methods were employed and runs were made at values of $C_\Delta^{?}/C_V$ from 0.05 to 0.25, corresponding to values of Δ, the load on water, from 1.5 to 38 lb; the results are given in Figure 4. All the main tests were made with airflow present and in addition a number of runs over a limited range were made screened from airflow to check agreement with the skin friction line of Reference 2 for a 25° Vee wedge (see Section 4.1).

3.2. Draught measurements

Draught readings were taken in conjunction with drag measurements and are plotted in Figures 5, 6 and 7 for the same ranges of the variables.

The low and hump speed plots of Figures 5 and 6 are not needed for estimation of full scale drag, but are included for the sake of completeness, as the planing speed graph, Figure 7, is essential (see Section 3.3.2).

3.3. Wetted area and mean wetted length determinations

The same method of measuring wetted areas was used as on the Princess model.* It is a laborious and time consuming process, and only the minimum number of runs necessary to cover the range adequately without excessive error was made.

3.3.1. Method of determining mean wetted lengths

Mean wetted lengths were determined from the wetted areas, Figure 8 illustrating how this was done.

It was assumed,

(i) that the flow over the main wetted area of the forebody was parallel to the keel, and that the afterbody, when wetted, was wetted by part of the flow from the forebody;

/(ii)

---

* Reference 1 states that the model must not be allowed to touch the water when it is being mounted on the balance after spraying, or removed after a run has been completed. It was found, however, that if the model was placed in the water gently, and no violent disturbance given to the water or the model, satisfactory results were obtained. A static water level line was just discernible, where the water had dissolved the indicator, but this was easily distinguishable from the flow pattern lines.

(ii) that the flow over the spray wetted area of the forebody was parallel to the spray leading edge;

(iii) that if the flow over the main step was turbulent, then it would be turbulent over the whole of the wetted afterbody;

(iv) that there was negligible spray area on the afterbody.

Observations confirmed the last two assumptions, except where wetting on the afterbody occurred very near the rear step. The exceptional cases showed only very small laminar and spray areas on the afterbody, the ignoring of which made little difference to the results.

In conformity with these assumptions a single mean wetted length was determined for the forebody and afterbody combined when the afterbody was wetted (the mean wetted length in the cases when only the forebody was wetted being determined in accordance with normal practice). This single mean wetted. length was determined as follows.

In view of the fact that the curvature of the afterbody chine was slight, it was possible in most cases to regard the afterbody wetted area as a triangle. The simple shape of the main step made possible the construction of a. triangle with the same area as the afterbody wetted area and with equal base length, placed in line with the keel, one end coincident with the step and keel intersection point, and one side along the main step line (Figure 8). It was assumed that the flow over this new single area would be the same as that over the two individual areas in the actual experimental case,as far as lengths and directions of streamlines and the nature of the boundary layer were concerned, and the mean wetted length of this new complete shape was defined as:

$$\bar{l} = \frac{\Sigma l \, \delta S}{\Sigma \, \delta S}$$

where l was the length of a flow line and δS the area of the elementary strip defined by the line. With the nomenclature of Figure 8 this leads to the formula,

$$\bar{l} = \frac{S_{1B} \, \bar{l}_{1B} + S_4 \, \bar{l}_4 + S_3 \, l_3 \cos\phi'}{S_1 + S_2 + S_3 \cos\phi'}$$

The values of the wetted area coefficient, C_S, and of $\bar{l}/b$ are given in Figures 9 and 10 for the low and hump speed ranges, and Figures 11 and 12 for the planing region.* It nay be mentioned that when the sides of the model were wetted, as happened occasionally at low speeds, the wetted side areas were included when calculating the wetted ares. coefficient but ignored in the determination of the mean wetted length. This is actually the same procedure as was followed in the tests on the Princess model, although no mention is made of it in Reference 2, and it is unlikely to affect the accuracy of the Reynolds Number determination materially; flow and boundary layer conditions in a side wetted area are in any event so confused that it would be extremely difficult to make allowance for it.

3.3.2. Calculation of areas and mean wetted lengths in the low draught planing region

In the low draught planing region, where there was no wetting of the afterbody and the wetted forebody was wholely contained within the limit of constant cross-section, wetted areas and lengths were in general calculated instead of measured, though a few check measurements were made. The

/values

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* In calculating C_S and $\bar{l}$, the term $\cos\alpha_{KK}$ which occurs in the corresponding formulae in References 1 and 2 has been omitted es for practical purposes its value is unity.

values of ϕ, ϕ' and ℓ_k/d for the calculated. areas obtained in this region compared favourably with unpublished results from tests on a 25° wedge. Mean values were taken from the wedge results and used to calculate the low draught region curves of Figures 11A and 12A. The mean values were:

a_k (degrees)	ϕ (degrees)	ϕ' (degrees)	ℓ_k/d
4	15	23	14.7
6	23	39	9.7
8	30	54.5	7.6
10	36	69	6.3

It can be seen that in the low draught region, the points obtained from areas measured on the model show excellent agreement with the calculated curves.

Figures 11B and 12B were derived from Figures 11A and 12A cross-plotted against Figure 7. They give the results in a form more convenient for scaling-up calculations.

4. ESTIMATION OF FULL SCALE WATER DRAG

A number of screened runs were made in the low draught planing region where conditions made possible the calculation of water skin friction coefficients, shown plotted with the standard curve in Figure 13. Although there is a fair amount of scatter, there is no evidence to show that the standard curve, obtained from tests on a 25° deadrise phenolglazed wedge, is in error. Model skin friction coefficient values were accordingly taken from this line, Reynolds Numbers being calculated from model speeds and mean wetted lengths.

Full scale skin friction coefficients were estimated as follows. To obtain the appropriate full scale Reynolds Numbers, the model Reynolds Numbers were scaled up simply by multiplying them by $n^{1.5}$, in this case 27, changes in kinematic viscosity from model to full scale, due to the change from fresh to salt water, being considered too small to take into account.

In the full scale case, the hull bottom surface was sufficiently smooth to ensure that there would be smooth turbulent flow. It was therefore assumed that the skin friction coefficient line would approximate to the Schoenherr smooth turbulent curve, and this curve was therefore used in the calculations, in conjunction with the scaled-up Reynolds Numbers. (This of course assumes that the curve for a wedge shape will be the same as that for a flat plate, which seems to be approximately true from what little evidence id available). Figure 14 gives the Schoenherr curve covering the fill scale range, together with the model skin friction coefficient curve.

Raving determined the values of the model and full scale skin friction coefficients as already indicated, an estimate of the full-scale resistance was obtained by using the relation[2]

$$\frac{R'}{\Delta'} = \frac{R}{a}\left[1 + \frac{(C'_F - C_F)}{C_F}\,\frac{R_F}{R}\right]$$

where

$$\frac{R_F}{R} = C_F\, C_S\, \frac{C_V^2}{C_\Delta}\cos a_k \Big/ \frac{R}{A}$$

/and

and

[illegible] An^3 The estimated full-scale values are plotted in Figure 21 (a-a) over ranges of $C_{\Delta}^{2/3}/C_V$ corresponding to those in the full-scale tests at the attitudes concerned.

5. FULL SCALE TESTS

The programme of tests on the aircraft was planned by M.A.E.E., and agreed and executed by Messrs Saunders-Roe Ltd., the instrumentation being carried out by M.A.E.E. Such analysis of the test results as was required for the drag comparison was performed by M.A.E.E. from test records supplied by the manufacturers.

The tests designed for the measurement of total resistance included take-offs, landings and loop runs, all made without the use of flaps (a loop run being defined as a run in which the aircraft is accelerated up to a speed near the take-off speed, the engines then being throttled and the aircraft decelerated to rest). Aerodynamic tests were also performed which, in conjunction with a bench test engine calibration (carried out by Messrs Metropolitan Vickers, Ltd., makers of the Beryl engine), enabled. the air lift and drag to be calculated.

During all the tests, an automatic observer, mounted on the aircraft gun platform, was operated and records taken of longitudinal acceleration, aircraft attitude, air speed, elevator angle, engine speed and jet pipe pitot pressure. An Anschutz gyroscope was used to measure the attitude and a desynn accelerometer the acceleration.

The acceleration records were used in conjunction with the thrust calculated from the engine bench calibration to derive the total resistance of the aircraft when on the water.

The air lift and air drag were calculated by standard methods, the results of these calculations being plotted against keel attitude in Figures 15 and 16 respectively. It will be observed that there is considerable scatter on these plots; it is thought that this is due to errors in the attitude readings, particularly as there is so little scatter on the C_D/C_L^2 curve (Figure 17). The results have been replotted in Figures 18 and 19 against wing incidence instead of keel attitude, omitting points for which the measured attitudes are thought to be in error. Also shown *in* Figure 18 *is* the lift curve corrected for ground effect by the method of Reference 3 (see Appendix I). Figure 19 and the corrected curve in Figure 18 have been used to derive the water drag of the aircraft from the total resistance measurements. These final values of water drag are plotted in Figure 20 (a-h) over a range of water speeds from 20 to 90 knots, and cross-plots from the mean curves through each set of points on to a $C_{\Delta}^{2/3}/C_V$ base are nude in Figure 21 (a-d) for comparison with the full-scale resistance estimated from the model results.

Some remarks on the full-scale tests are appropriate here. An overall limitation is that due to unavoidable circumstances it was not possible to finish the originally agreed programme, so that a complete picture of the full-scale resistance characteristics was not obtained. In addition, various inadequacies in the test procedure gave rise to possible *errors, as* detailed below.

Only measurements of mean windspeed *and* direction were made, and hence the water speed could not be determined with an accuracy greater than ± 2 to 3 knots. The tests were confined however to times when the mean windspeed was less than 5 knots, and in calculating the water speed a constant windspeed of 3 knots was assumed.

/The

The fact that the aircraft was a single scater led to insufficient attention being paid to the operation of the Anschutz Gyroscope. It is thought that some resistance runs were made with the gyroscope not fully erected, causing considerable error in the attitude measurements, and it is considered that this is the main cause of the scatter in the CL and CD plots of Figures 13 and 14.

Because of practical difficulties, in only a few of the resistance runs were automatic observer records taken over the hump. This means a sparsity of results over the range of greatest importance for correlation purposes.

These points all detract from the value of the full-scale results and make the comparison of model and full-scale data less accurate than was originally hoped.

6. COMPARISON OF ESTIMATED AND MEASURED FULL-SCALE WATER DRAGS

An examination of Figure 21 (a-d), in which the estimated end measured full-scale resistances are plotted together for comparison, shows that there is far from being satisfactory agreement. While for each of the attitudes concerned there are some values of $C_\Delta^{\frac{1}{2}}/C_V$ for which there is little or no difference between estimated and measured resistances, there are other values at which the estimate exceeds the measured resistance by 60% or is short by 30%. In general the estimate is too high at low attitudes and too low at high attitudes, though the irregular nature of the curves confuses this trend somewhat.

There is no obvious reason why this should be the case. The method used for scaling up the model skin friction results and the assumptions on which they are based, while not perfect, are not so far removed from reality that the refinements involved in making them logically more rigorous would produce a change of anything like the desired magnitude. Alternative methods of scaling up are of course available and might possibly give better agreement between estimated and actual fill-scale results, but they lie outside the scope of the present report in view of the purpose of the tests, which was merely to prove or disprove the existing system of analysis.

Similarly, despite the inadequacies of the full-scale tests and the scope for error in calculation of full-scale water resistance, there is no single cause which would be likely to give rise to the systematic differences experienced. As has already been mentioned, the attitude readings were suspect in a number of the full-scale experiments, and errors here may lie at the root of the discrepancies, but the cause may well be, for instance, an error in the allowance for ground effect or a difference between the actual thrust and that calculated from engine bench tests. It is, however, fairly certain that any experimental error there may bc is in the determination of the full-scale resistance, and it is unfortunate that the full-scale test results are not more reliable so that it can be firmly establishedwhether or not the methods of analysis used (both for model and fill-scale results) give values which agree with one another.

7. CONCLUSIONS

It may be concluded that there is not satisfactory agreement between estimated and measured full-scale results, and that if the disagreement is due to experimental error then the error lies in the full-scale measurements. There seems no reason to suspect the model teat results or the method of scaling up the skin friction resistance (though alternative methods are available which might give closer agreement) and while minor improvements can be made to the latter they will not have any significant effect on the results.

The tests do not provide sufficient evidence to determine whether or not the accurate estimation of full-scale water resistance by the methods of References 1 and 2 is possible. It would be of interest to examine the extent of agreement using alternative methods of analysis; this might provide evidence as to whether a more fundamental scrutiny of resistance analysis techniques is required.

/ADVANCE DISTRIBUTION LIST

LIST OF REFERENCES

No.	Author	Title
1	T.B. Owen A.G. Kurn	Model testing technique employed in the R.A.E. Seaplane Tank. R.A.E. Report No. Aero.2505. R. & M. 2976. September, 1953.
2	T.B. Owen A.G. Kurn	Towing tank tests to determine the water drag and pitching moments on the final hull form of a large flying boat seaplane (Princess, Spec. 10/46). R.A.E. Tech. Note No. Aero 2159. A.R.C, 15,178.
3	J.L. Hutchinson	The theory of ground interference on the lift of an aeroplane. M.A.E.E. Report No. F/Res/73. A.R.C. 1,398.

LIST OF SYMBOLS

b	Hull maximum beam, ft. (0.7 ft. model scale).
C_F	Skin friction coefficient, model scale.
C_F'	Skin friction coefficient, full scale.
C_S	Wetted area coefficient = $S/2b^2$.
C_V	Water speed coefficient = $V/\sqrt{gb}$.
C_Δ	Load coefficient = Δ/wb^3.
d	Draught, ft.
d/b	Draught coefficient.
$\bar{l}$	Mean wetted length, ft.
l_K	Wetted keel length, model scale - forebody only.
n	Scale = $\frac{\text{Full scale hull length}}{\text{Model hull length}}$.
R	Water drag, model scale, lb.
R'	Water drag, full scale, lb.
R_e	Mean Reynolds Number = $\frac{V\bar{l} \times 10^5}{1.2285}$
R_F	Skin friction drag, model scale.
S	$= S_1 + S_2 + S_3 \cos\phi'$ (S_1, S_2 and S_3 as in Fig.8).
V	Water speed, ft./sec.
w	Water density (62.37 lb./cu.ft.).
α_k	Hull attitude (measured between forebody keel at step and the undisturbed water surface).
Δ	Load on water, model scale, lb.
Δ'	Load on water, full scale, lb.
ϕ	Angle between forebody stagnation line and keel line.
ϕ'	Angle between forward edge of spray wetted area and keel line.
ν	Kinematic viscosity of fresh water = 1.2285×10^{-5} ft.^{2}/sec.

/ TABLE I

TABLE I

LEADING PARTICULARS OF E6/44 FLYING BOAT (FULL SCALE)

Hull

Gross area	928 sq.ft.
Wetted area	913 sq.ft.
Gross volume	1,300 cu.ft.
Maximum beam	6.3 ft.
Maximum depth	a.55 ft.
Forebody length	22.75 ft.
Afterbody length	la.83 ft.
Counter length	8.42 ft.
After-keel angle	a" 28'
Heel to heel angle	10° 40'
Forebody deadrise angle at step	25° 0'
Forebody overall deadrise angle	21" 30'
Afterbody deadrise angle	30" 0'
Step depth unfaired	5.00 in.
Cove depth	1.30 in.
Fairing ratio	3:1

Float

O/A length	6.75 ft.
Beam	2.55 ft.
Depth	2.15 ft.
Buoyancy	865 lb.(3rd a/c.)
Angle to submerge	5.780 (3rd a/c.)
Float arm	15'7"

Wing

Span	46.0 ft.
Gross area	415.0 sq.ft.
Root chord	140.0 in.
Tip chord	65.0 in.
Taper ratio	0.47
Aspect ratio	5.1
S.M.C.	108.36 in.
Sweepback	3.0°
Section	Goldstein Modified
T/C ratio	14 - 12%
Dihedral (at 0.35c) Top surface	0°
Setting (to hull datum)	4.5°
Flap setting take-off	33°
Flap setting landing	75°
Flap area	24.4 sq.ft.
Flap span % wing span	30.5

Tailplane

Horizontal tail area	81.25 sq.ft.
Gross elevator area	26.37 sq.ft.
Span	16.25 ft.
Root chord	86.0 in.
Tip chord	13.5 in.
Aspect ratio	3.2
Setting (to hull datum)	2.5°

/TABLE I (Contd.)

TABLE I (Contd.)

Fin and Rudder

Fin area	60.6 sq.ft.
Span	8.81 ft.
Mean chord	6.80 ft.
Geometric A.R.	1.28
Root chord	9.37 ft.
Tip chord	4.95 ft.
Rudder area	18.60 sq.ft.
Span	8.60 ft.
Mean chord	2.16 ft.

Power Plant

1st Aircraft -	Two Metropolitan-Vickers F 2/4A axial flow jet engines Nos. 50 and 51.
Static power,	at 7,400 r.p.m. for take-off, 5 minutes limitation, 3,230 lb. per engine
	at 7,300 r.p.m. for climb, 30 minutes limitation, 3,080 lb. per engine
	at 7,050 r.p.m. for continuous cruising 2,790 lb. per engine
3rd Aircraft -	Two Metropolitan-Vickers Beryl axial flow jet engines Nos. 56 and 48.
Static power,	at 7,750 r.p.m. for take-off, 5 minutes limitation, 3,850 lb.
	at 7,600 r.p.m. for climb, 30 minutes limitation, 3,670 lb.
	at 7,400 r.p.m. for continuous cruising 3,400 lb. per engine
C.G. range	over which tests have been made 28% to 31.88% S.M.C.

/APPENDIX I

APPENDIX I

GROUND EFFECT ON LIFT FOR E.6/44. ESTIMATED BY THE METHOD OF REFERENCE 3

(i) Effect of Longitudinal Induced Velocity

$$\delta C_L = -\frac{\theta}{2} C_L^2$$

where
$$\theta = \frac{1}{\pi A}\left\{\sqrt{1 + \frac{4s^2}{z^2}} - 1\right\}$$

Mean of static water line and keel line to mean height of wing $= 6.9' = \frac{z}{2}$

A = Aspect Ratio = 5.1

s = Semi - Span = 23.0'

$$\therefore \theta = -0.1546$$

$$\therefore \delta C_L = -0.0773\ C_L^2$$

(ii) Effect due to Reduction in Downwash

$$\delta \alpha_1 = -\mu \cdot \frac{C_L}{2}$$

where
$$\mu = \frac{2}{\pi A}\sigma$$

σ depends upon $\frac{z}{2s}$, = 0.3, for which $\sigma = 0.37$

$$\therefore \mu = 0.0374$$

$$\therefore \delta \alpha_1 = -0.0374 \frac{C_L}{2}$$

(iii) Effect due to distortion of curvature of flow

$$\delta \alpha_2 = -\beta \frac{C_L}{2}$$

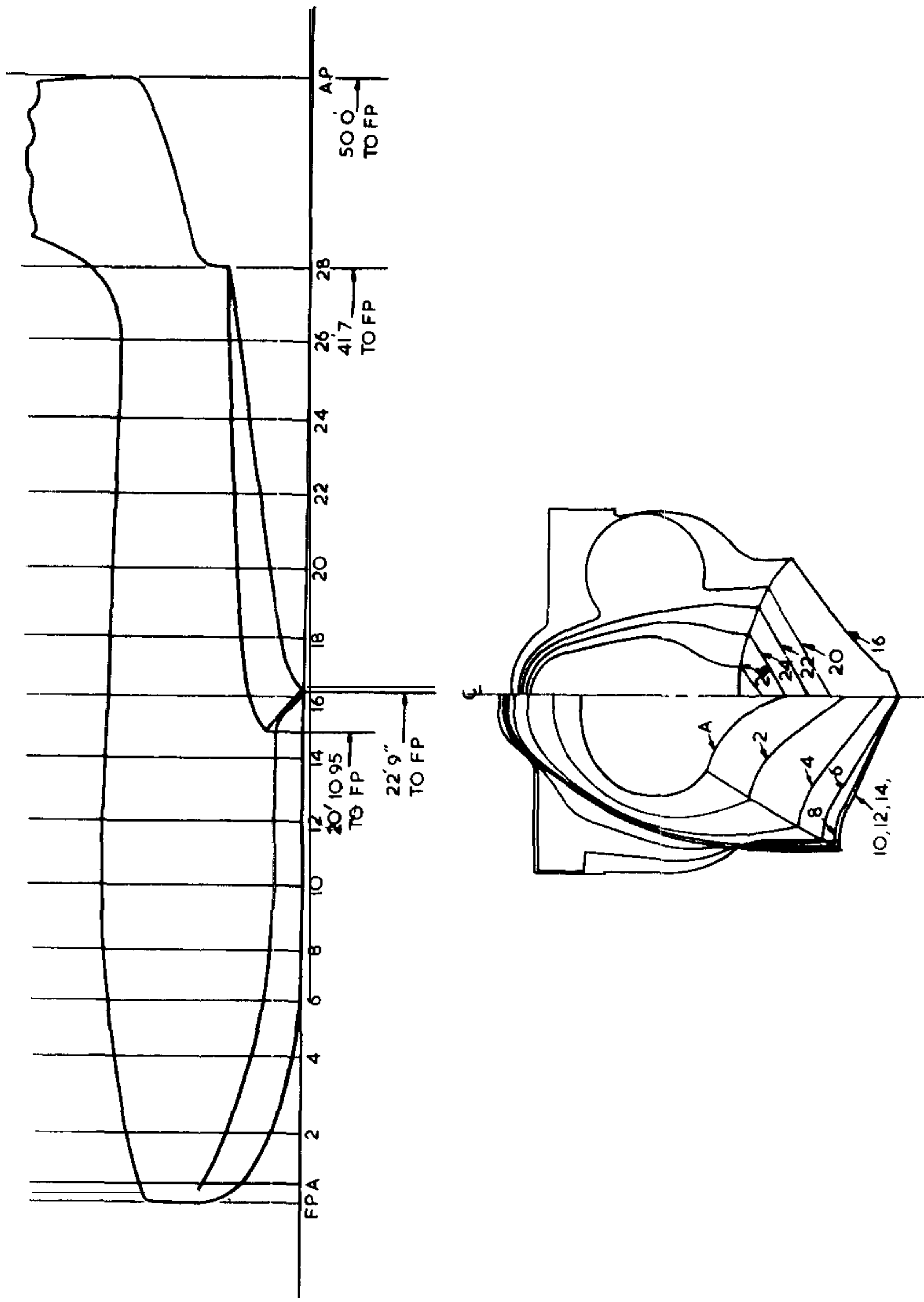
β depends upon $\frac{z}{c}$, = 1.56, for which $\beta = 0.0265$

$$\therefore \delta \alpha_2 = -0.0265 \frac{C_L}{2}$$

Effect due to (ii) and (iii) :- $\delta\alpha = -(\mu+\beta)\frac{C_L}{2}$

$$\delta\alpha = -\frac{0.0374 + 0.0265}{2} C_L \qquad \therefore \delta\alpha = -3.032\ C_L$$

FIG. 1.



HULL LINES OF E6/44

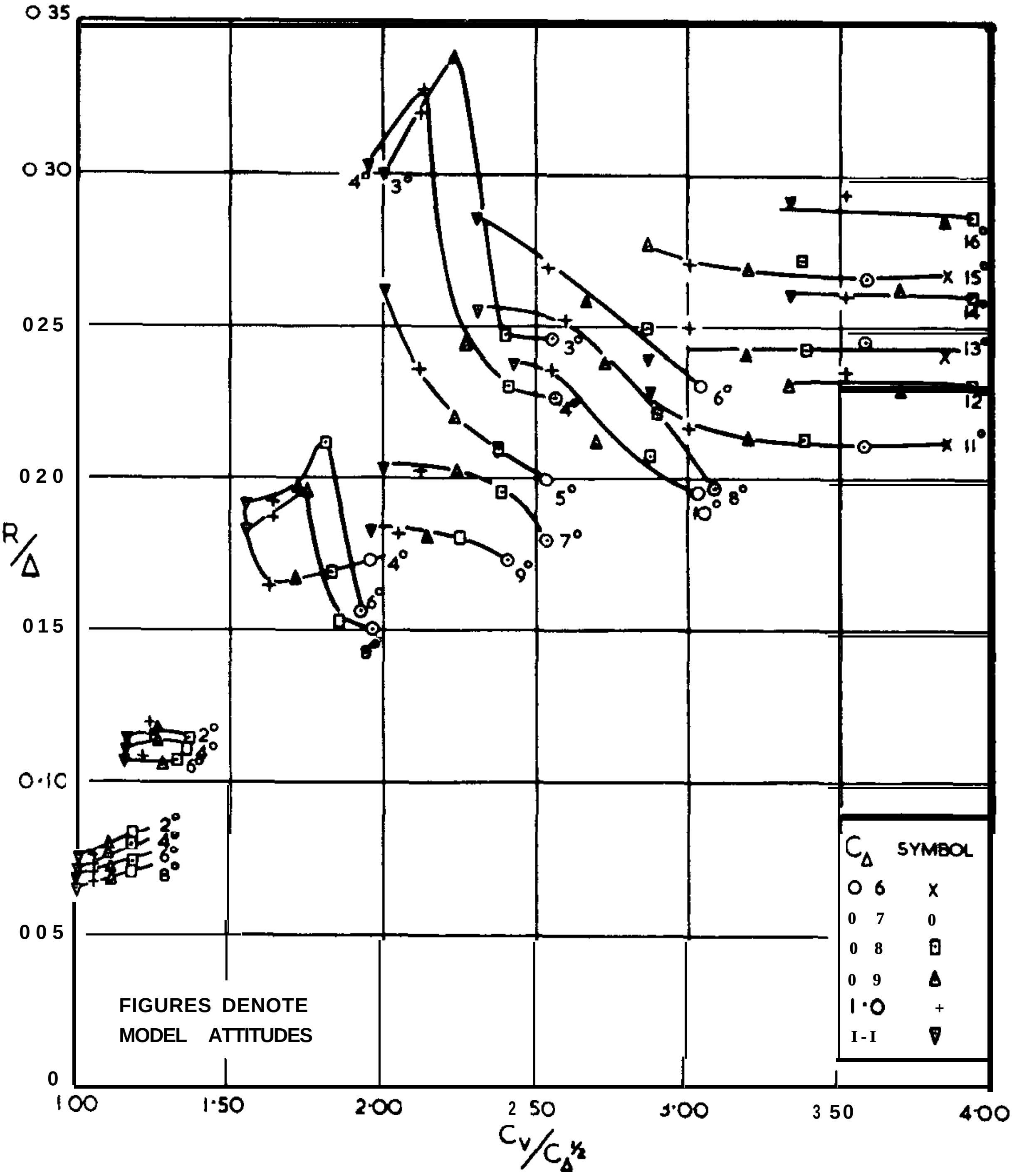


FIG. 2. MODEL SCALE WATER DRAG - LOW SPEED RANGE.

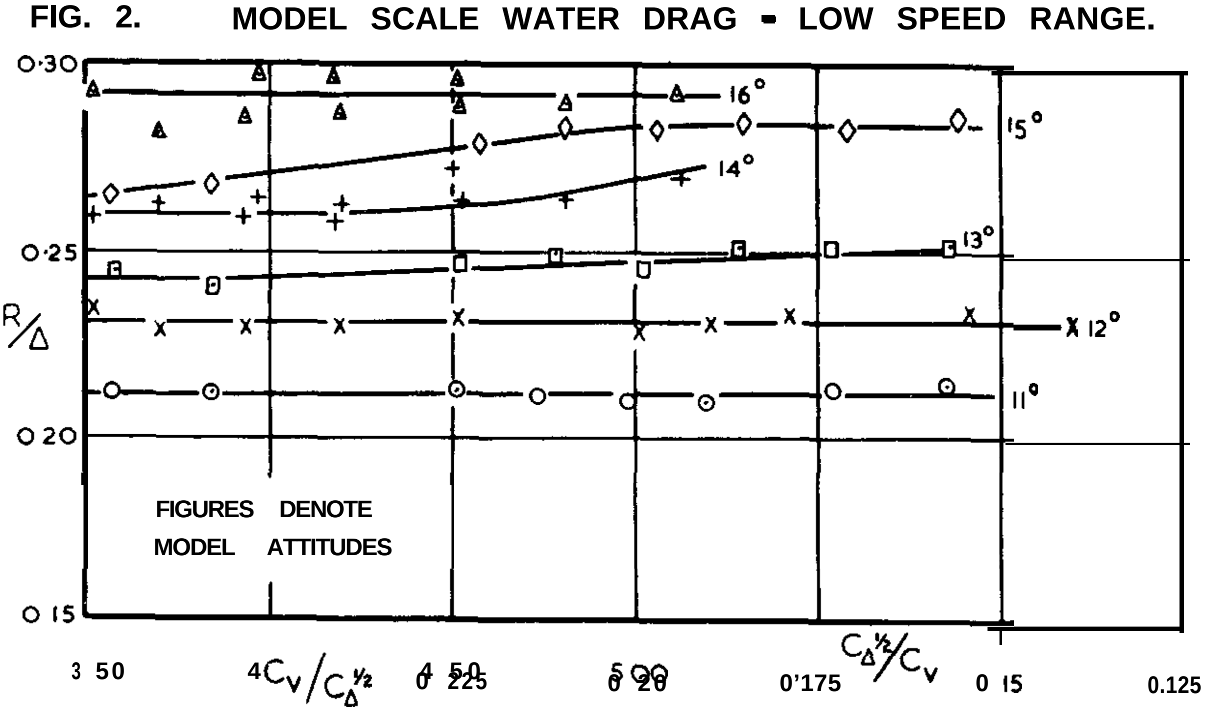
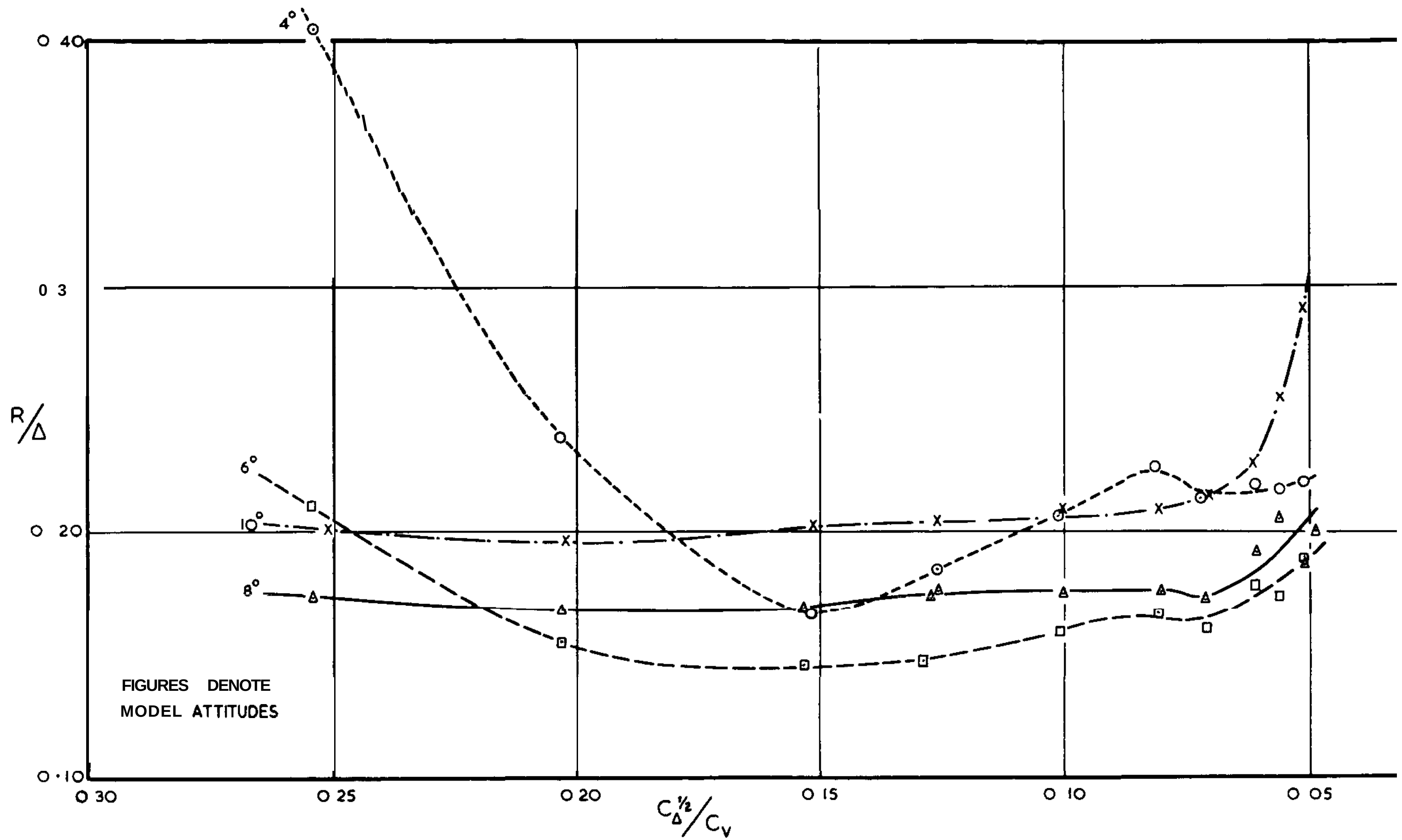
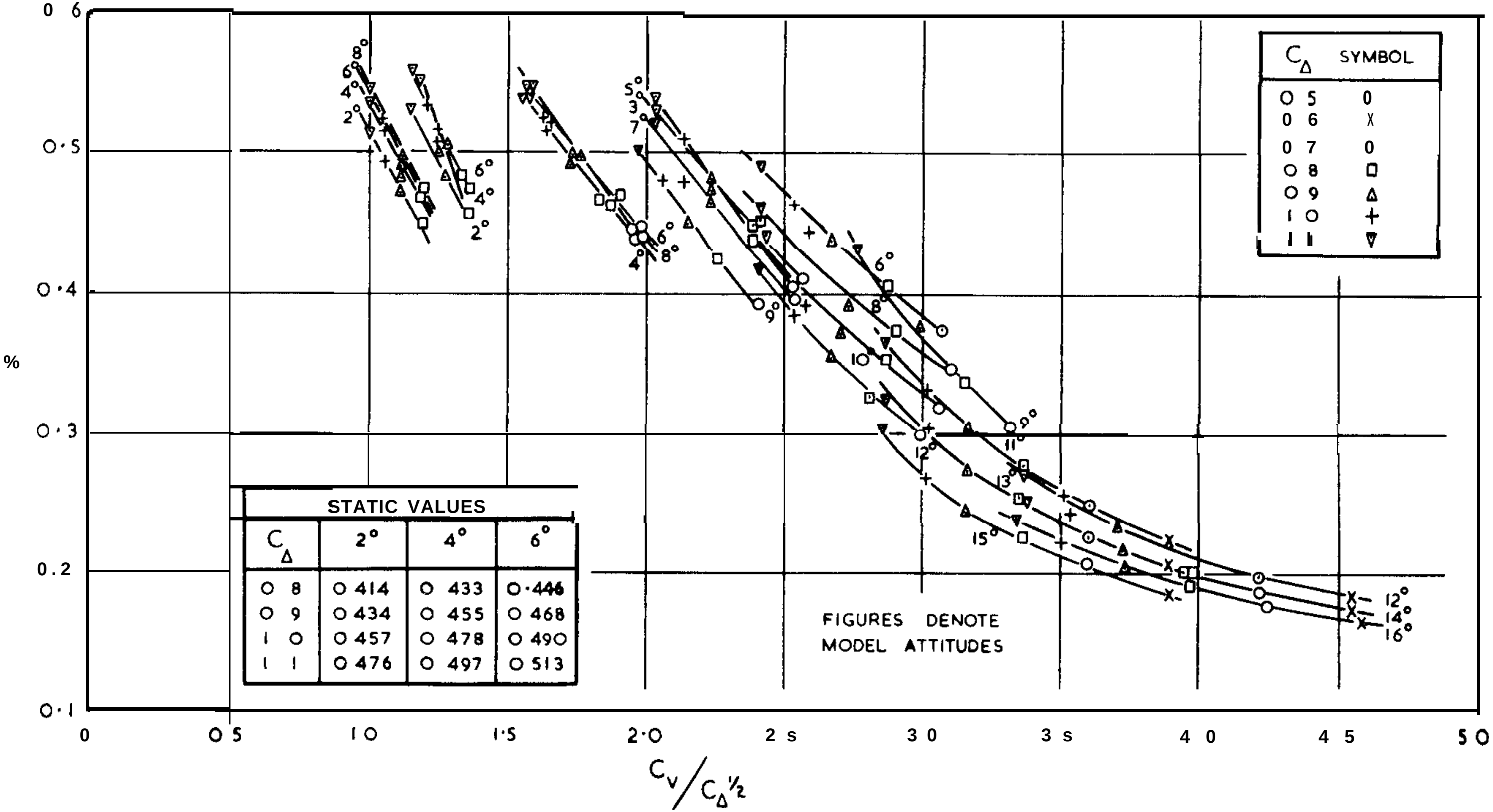


FIG 3. MODEL SCALE WATER DRAG -HUMP SPEED RANGE.



MODEL SCALE WATER DRAG - PLANING SPEED RANGE.

FIG. 4.



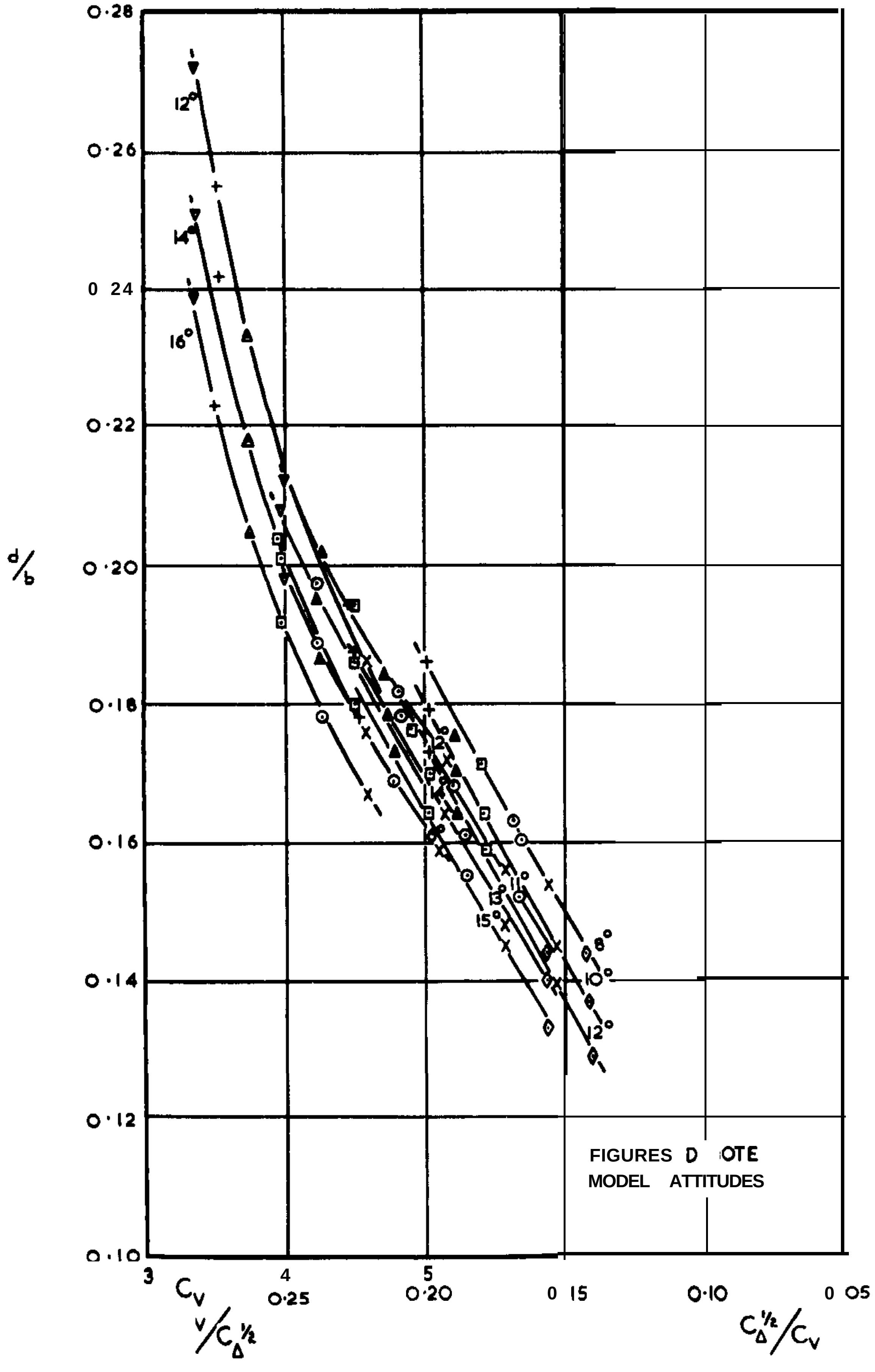
STATIC VALUES

C_Δ	2°	4°	6°
O 8	O 414	O 433	O·446
O 9	O 434	O 455	O 468
I O	O 457	O 478	O 490
I I	O 476	O 497	O 513

MODEL SCALE DRAUGHT MEASUREMENTS - LOW SPEED RANGE

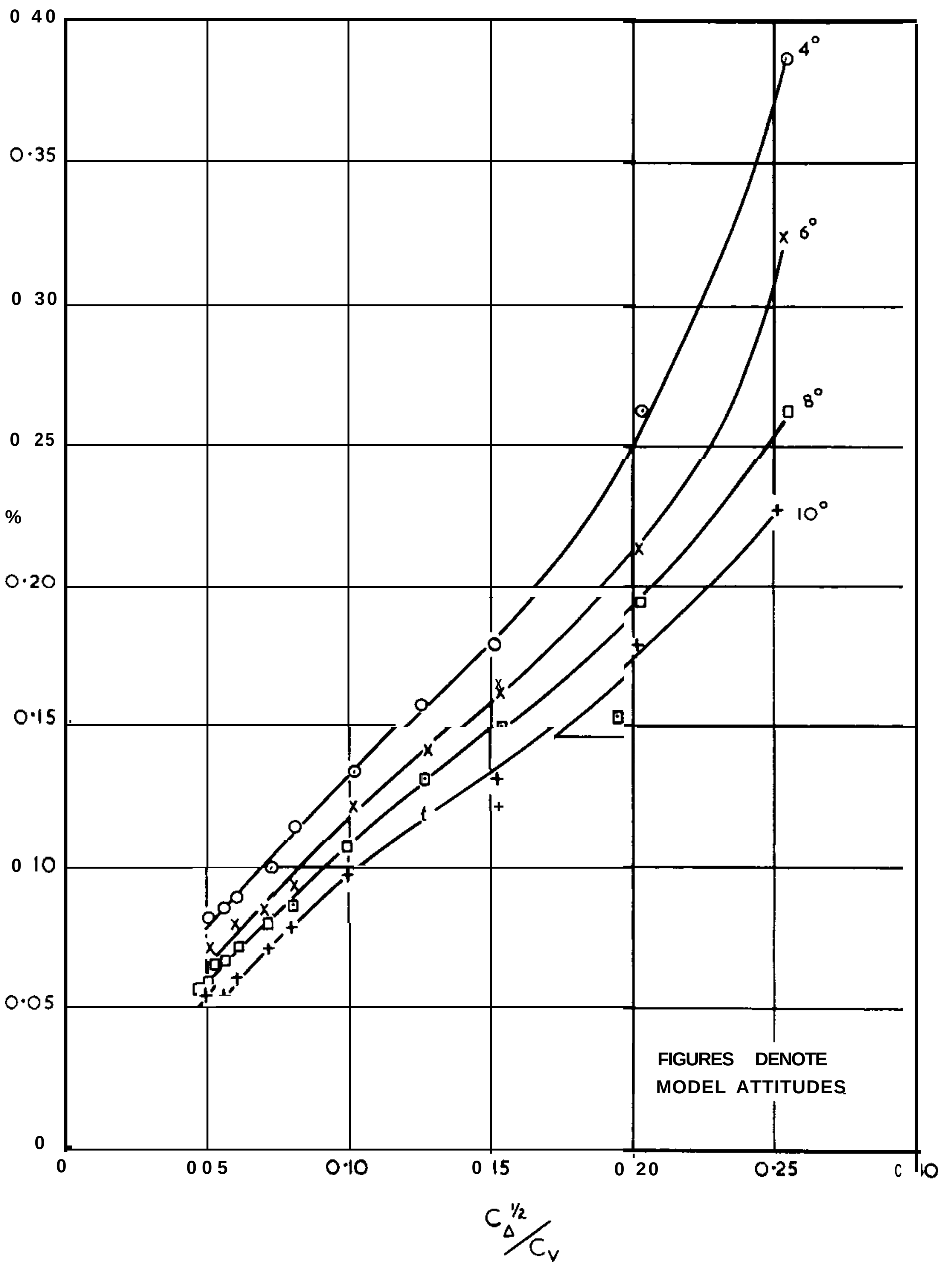
FIG. 5.

FIG. 6 .

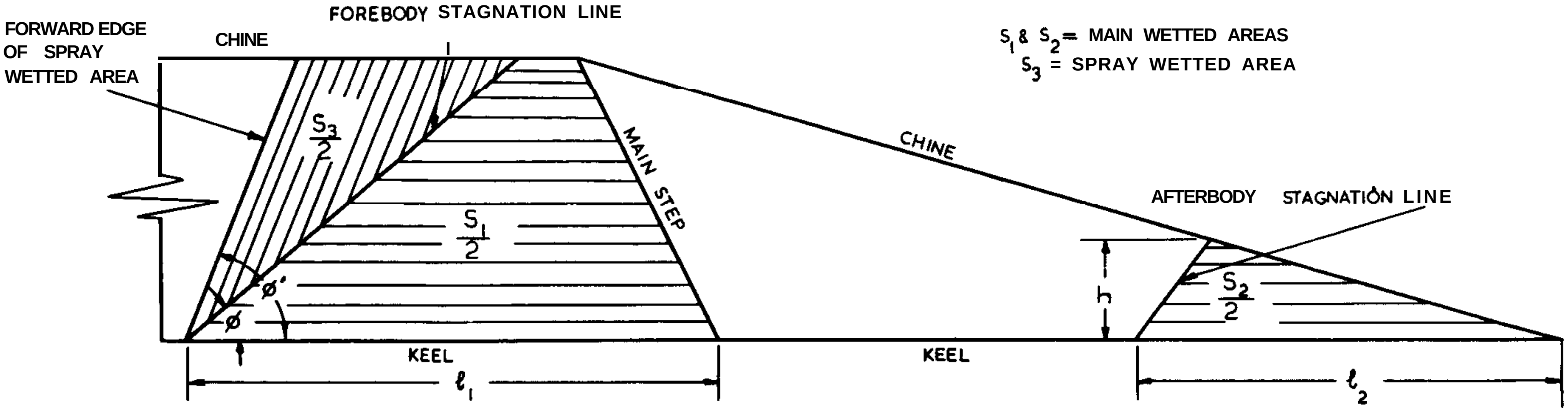


MODEL SCALE DRAUGHT MEASUREMENTS, HUMP SPEED RANGE.

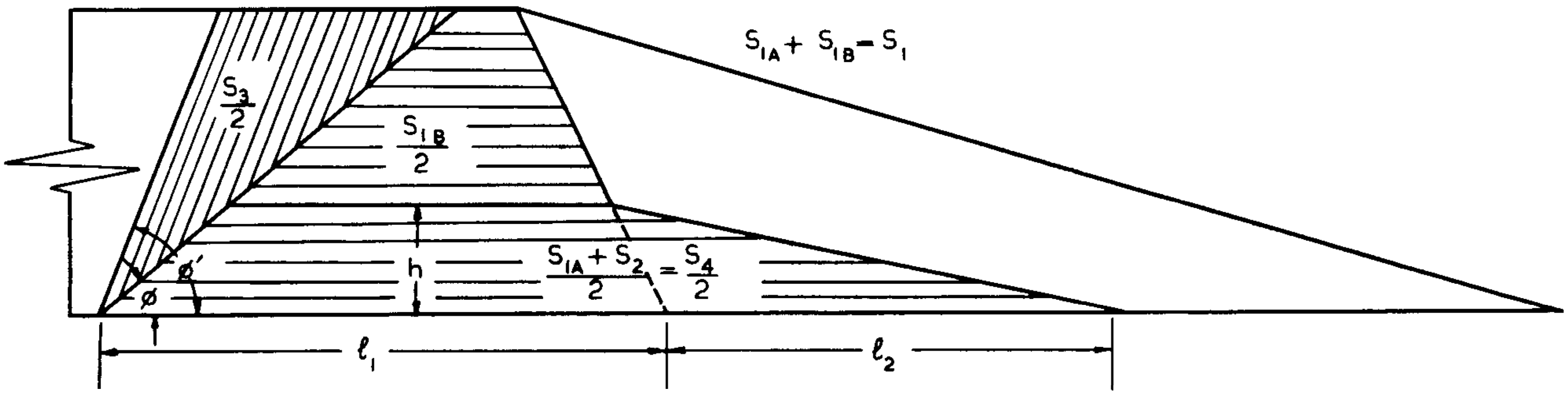
FIG. 7.



MODEL SCALE DRAUGHT MEASUREMENTS - PLANING SPEED RANGE.



APPROXIMATE DRAWING OF ONE SIDE OF HULL BOTTOM, DISTORTED SO THAT VIEW IS EVERYWHERE PERPENDICULAR TO PLANE OF HULL BOTTOM SURFACE.

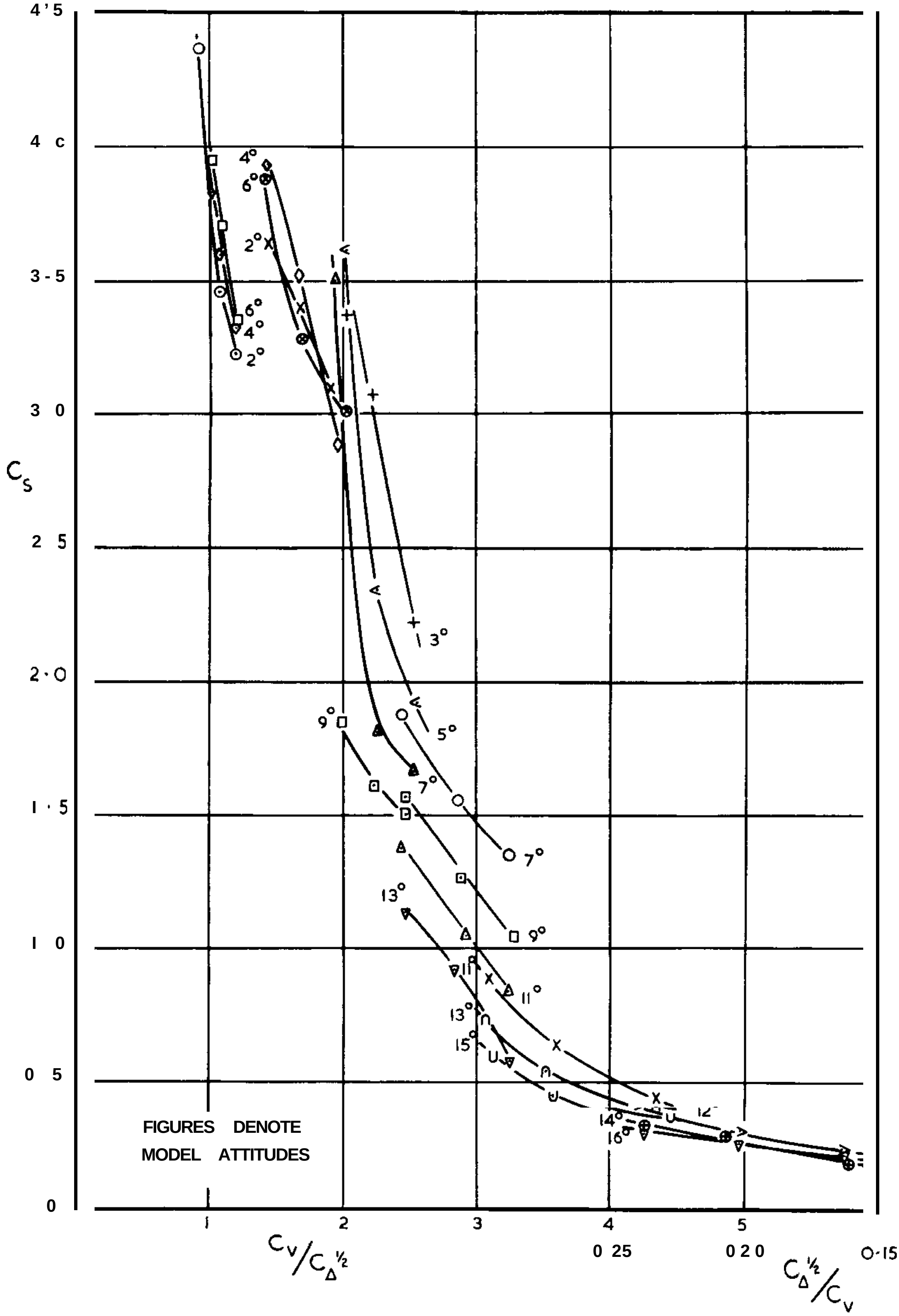


METHOD OF COMBINING WETTED AREAS IN ORDER TO DETERMINE MEAN WETTED LENGTHS

FIG. 8

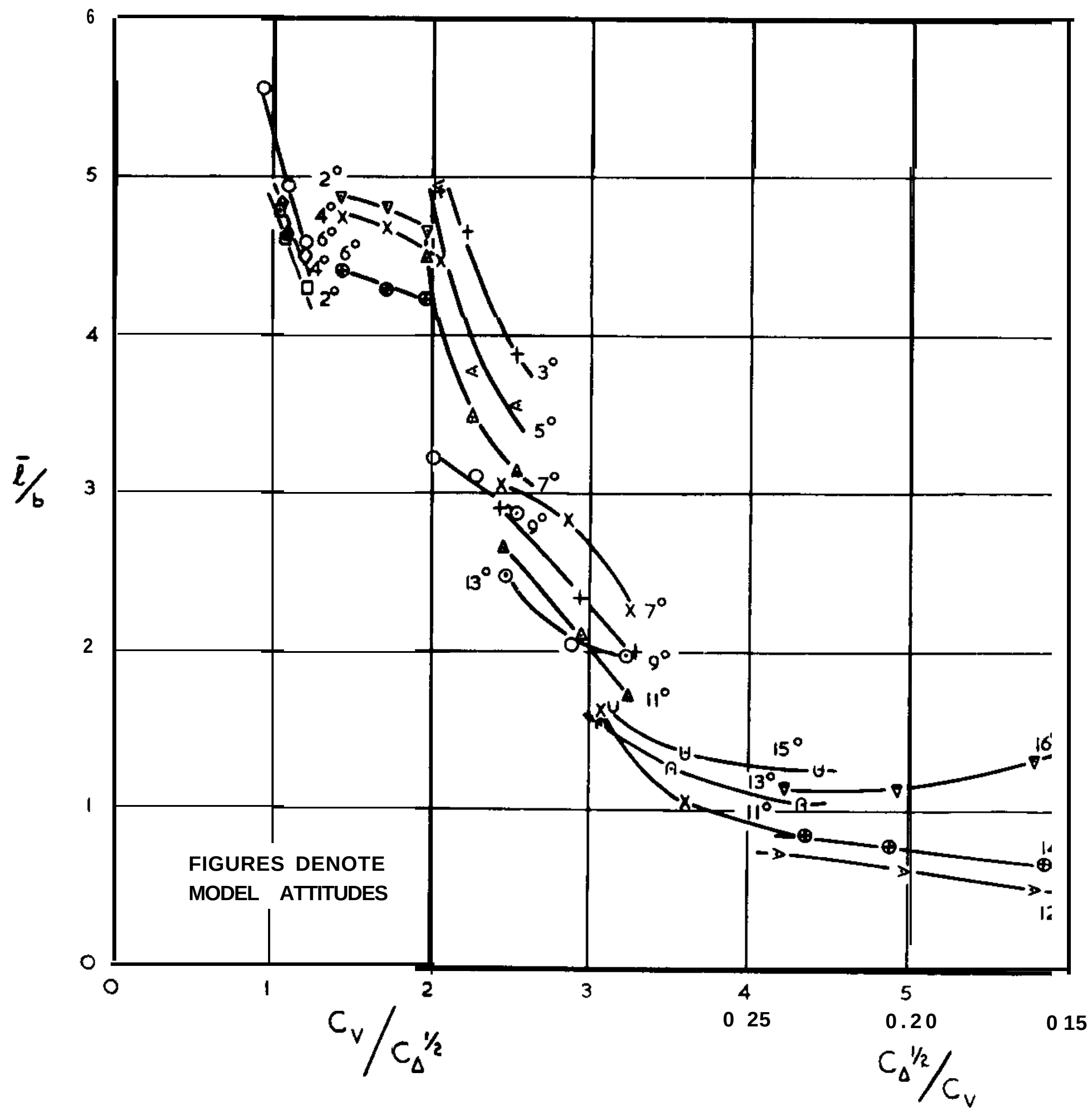
DIAGRAMMATIC VIEW OF MODEL HULL BOTTOM SHOWING WETTED AREAS, FLOW PATTERN, AND METHOD OF COMBINING AREAS TO DETERMINE MEAN WETTED LENGTHS.

FIG. 9.



MODEL SCALE WETTED AREA COEFFICIENTS, LOW AND HUMP SPEED RANGE.

FIG. 10.



MODEL SCALE MEAN WETTED LENGTHS, LOW AND HUMP SPEED RANGE.

FIG. II A.

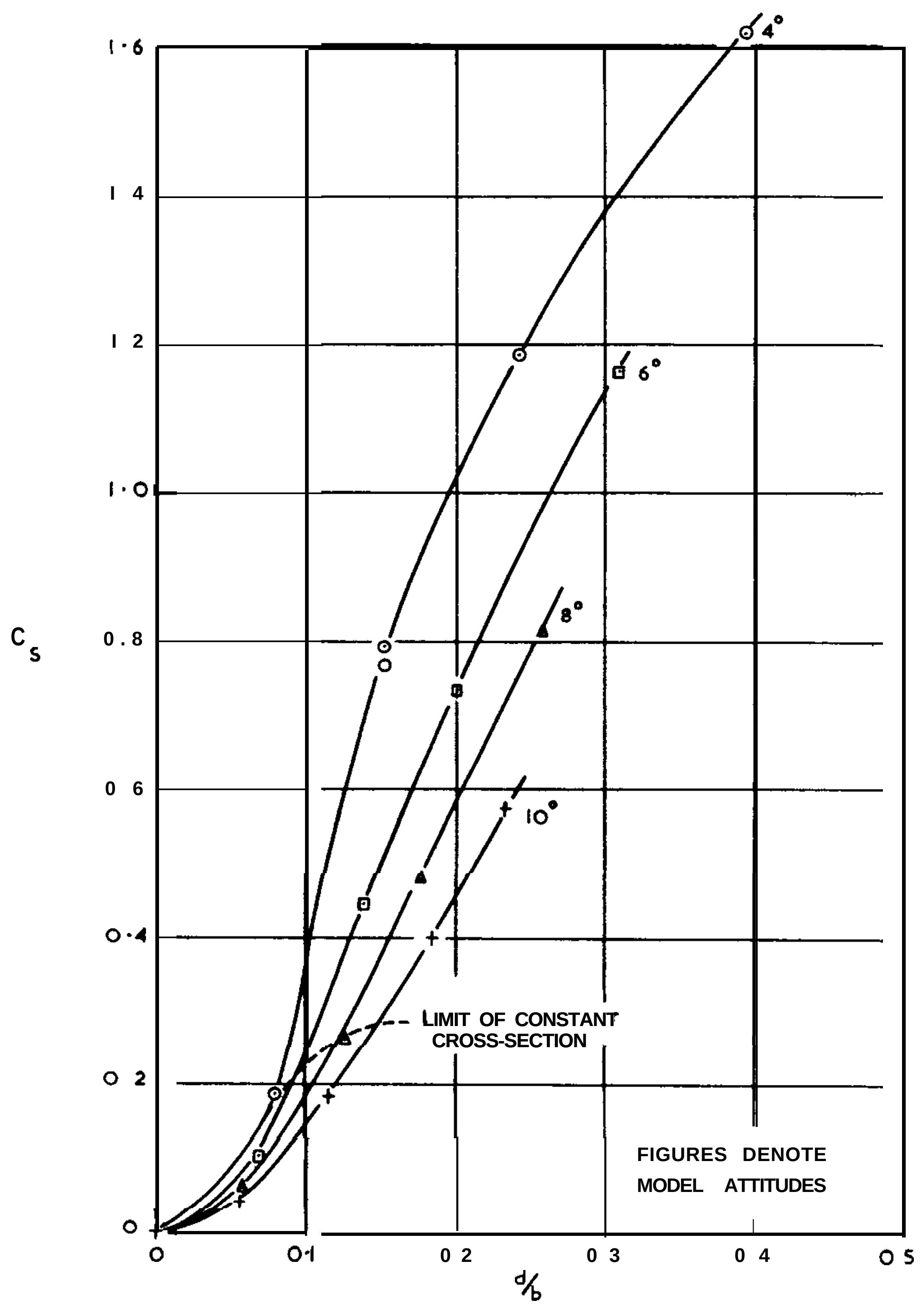
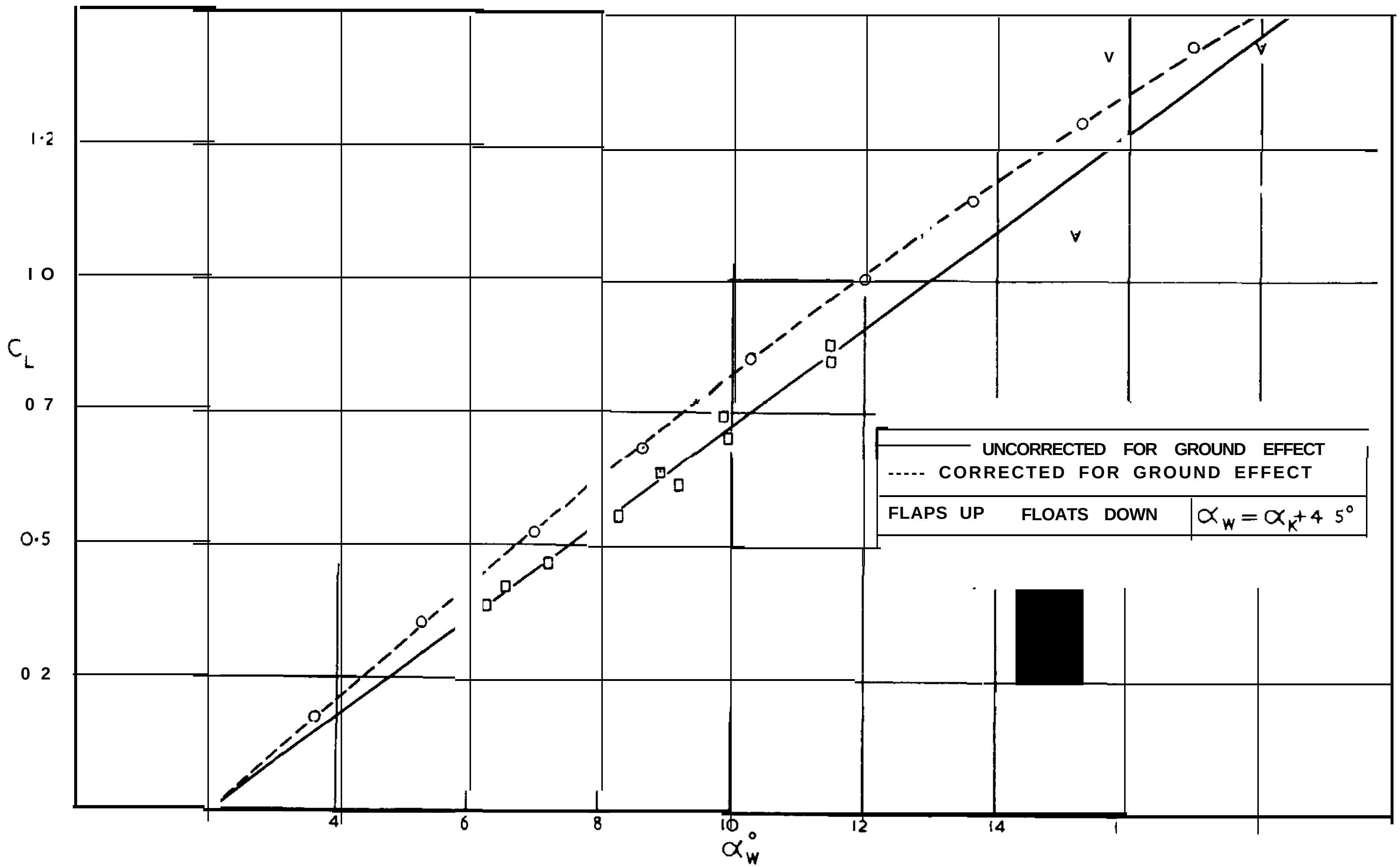


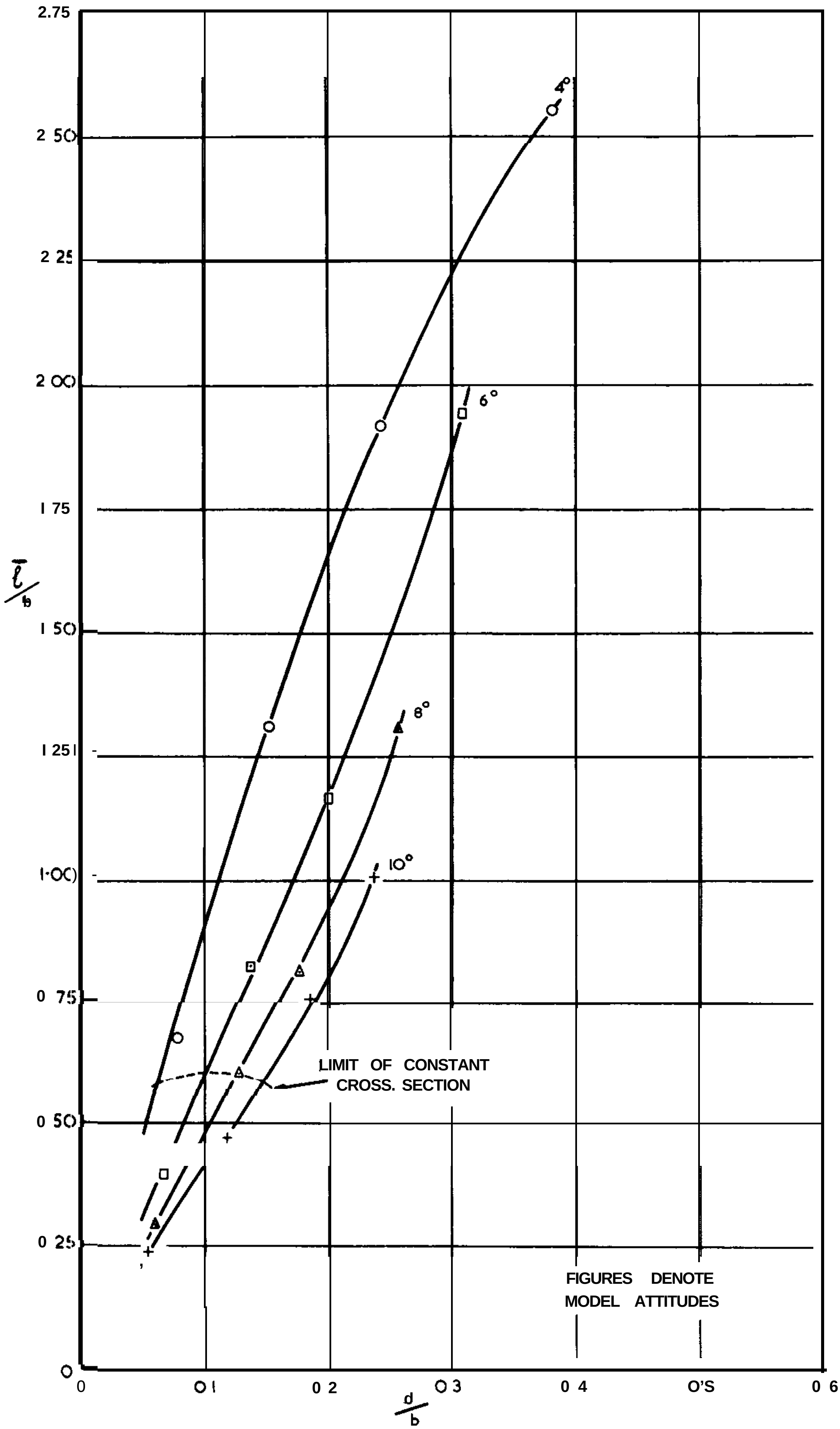
FIG. II A. MODEL SCALE WETTED AREA COEFFICIENTS, PLANING SPEED RANGE.



FULL SCALE AIR LIFT RELATED TO WING INCIDENCE.

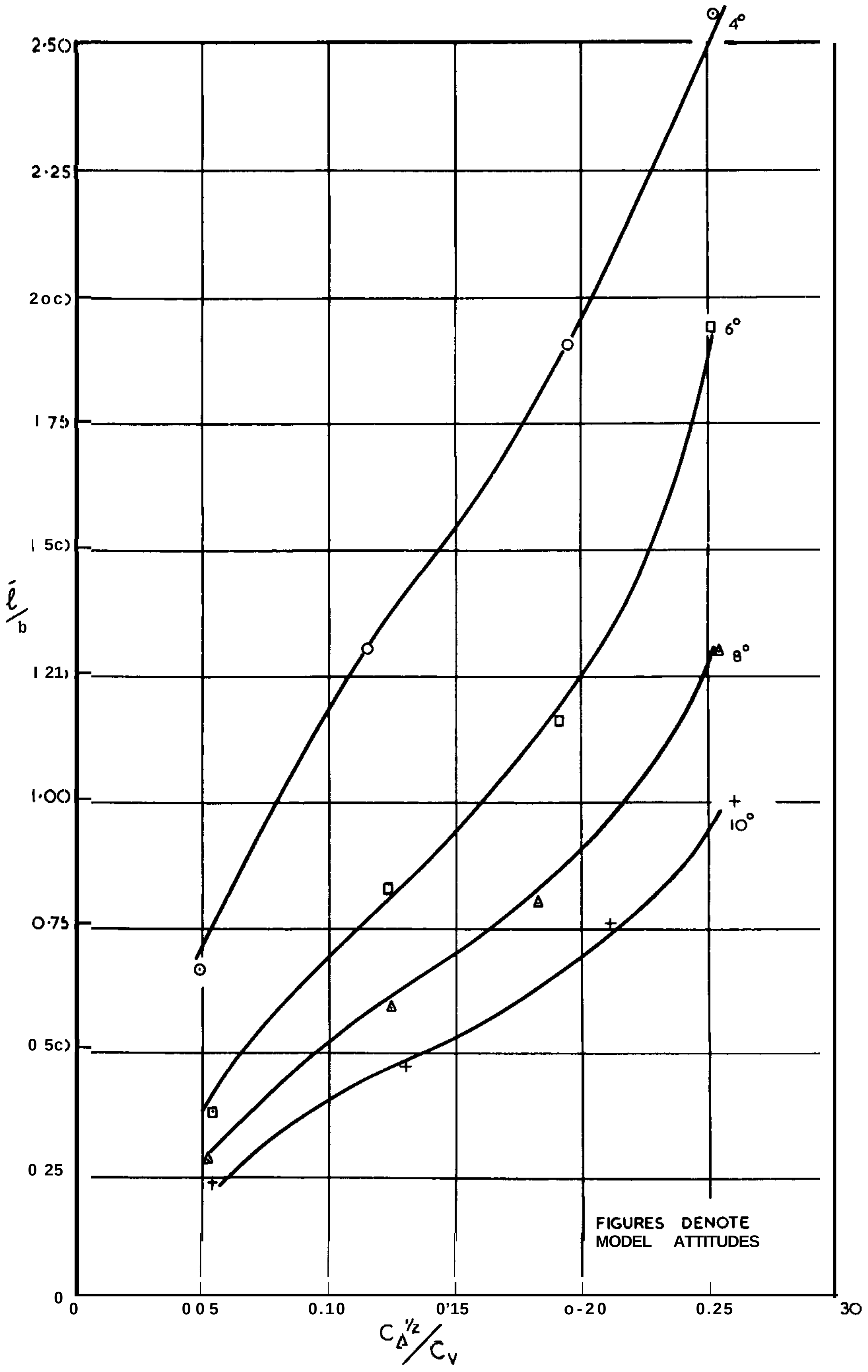
FIG 18

FIG. 12 A.

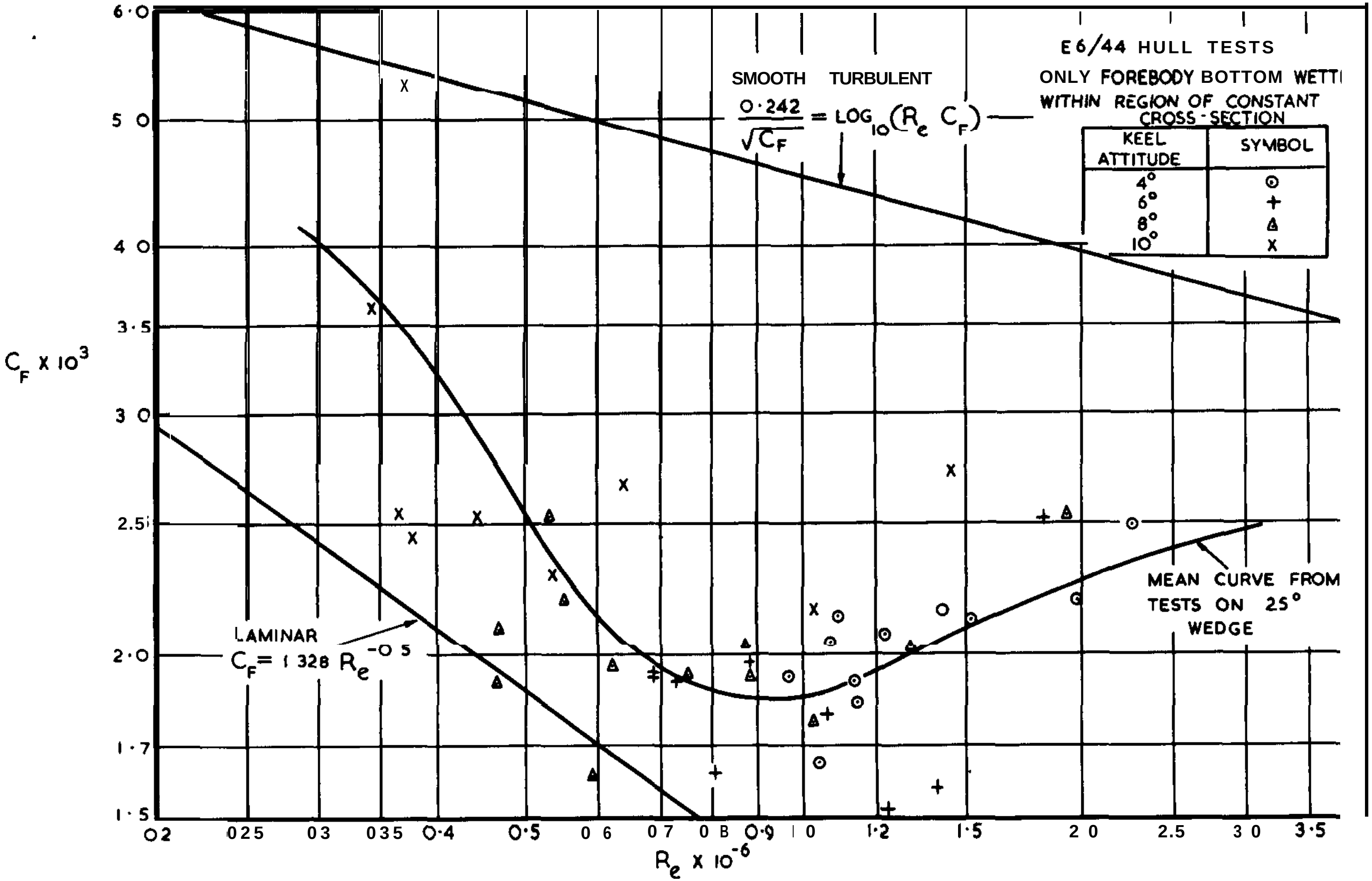


MODEL SCALE MEAN WETTED LENGTHS - PLANING SPEED RANGE.

FIG.12B.



MODEL SCALE MEAN WETTED LENGTHS-PLANING SPEED RANGE.



VARIATION OF MEAN MOCEL C_F WITH MEAN REYNOLDS NUMBER

FIG. 3.

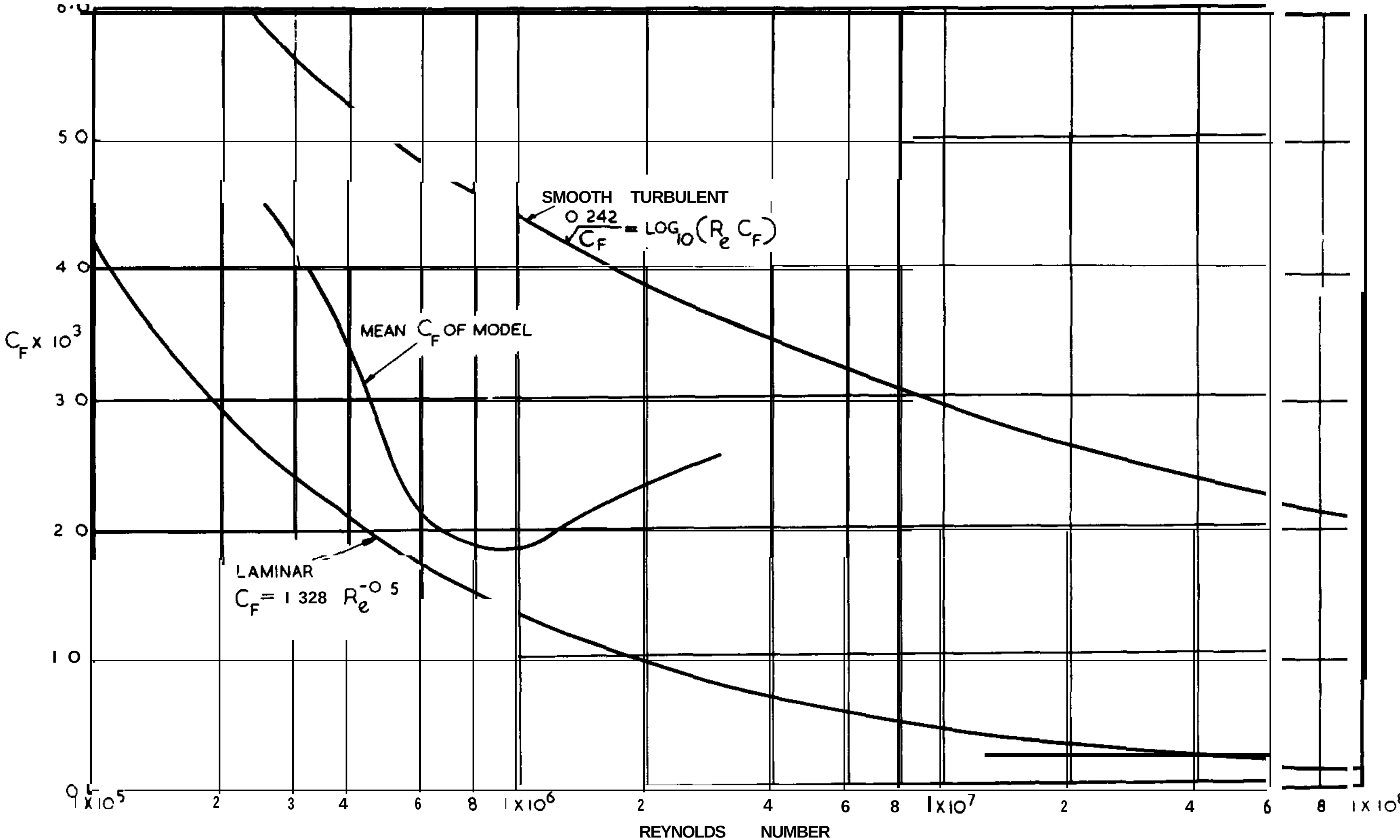
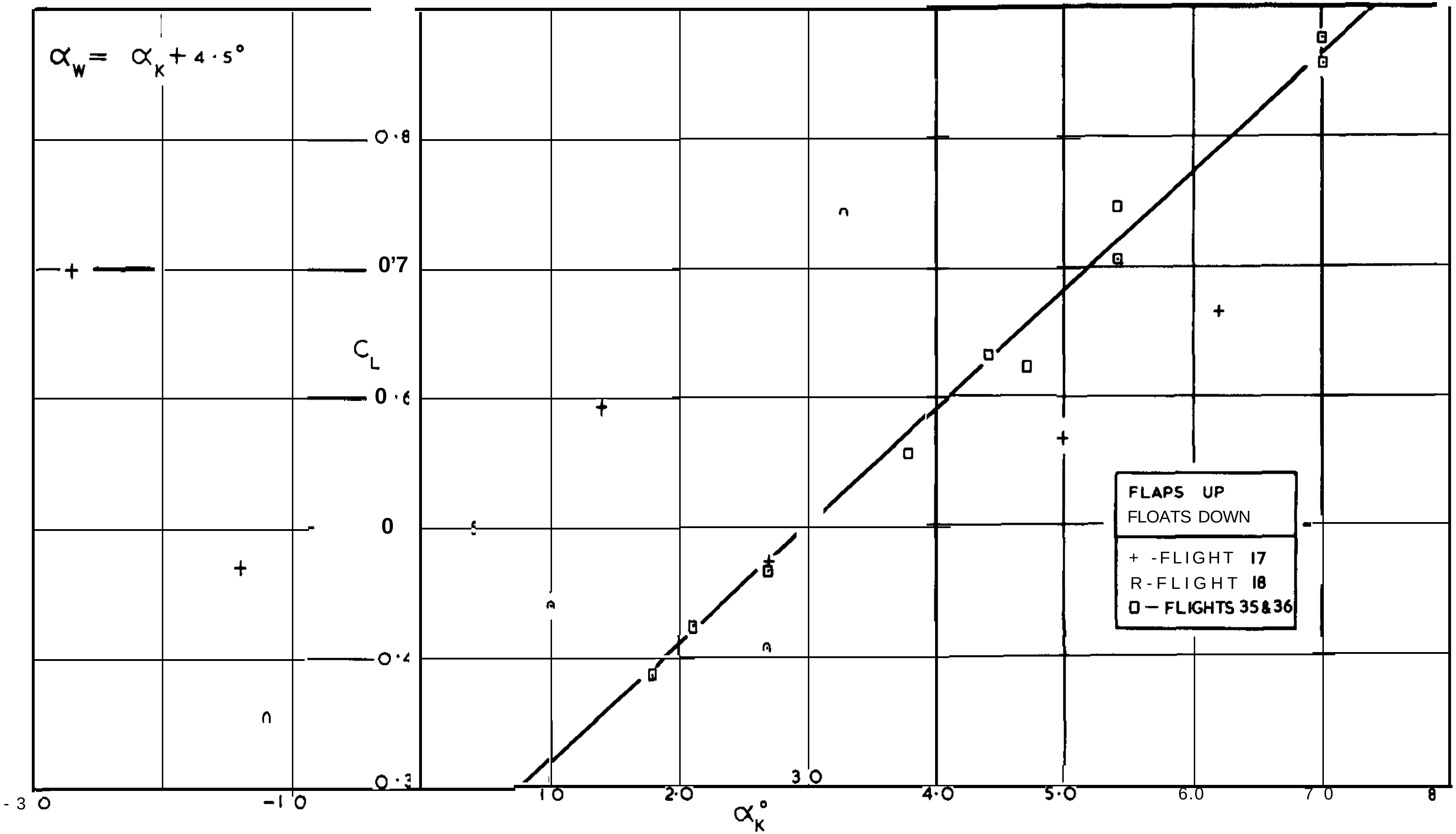


FIG. 14

SCHOENHERR SMOOTH TURBULENT CURVE EXTENDED TO FULL SCALE REYNOLDS NUMBERS



FULL SCALE AIR LIFT RELATED TO KEEL ATTITUDE.

FIG. 15.

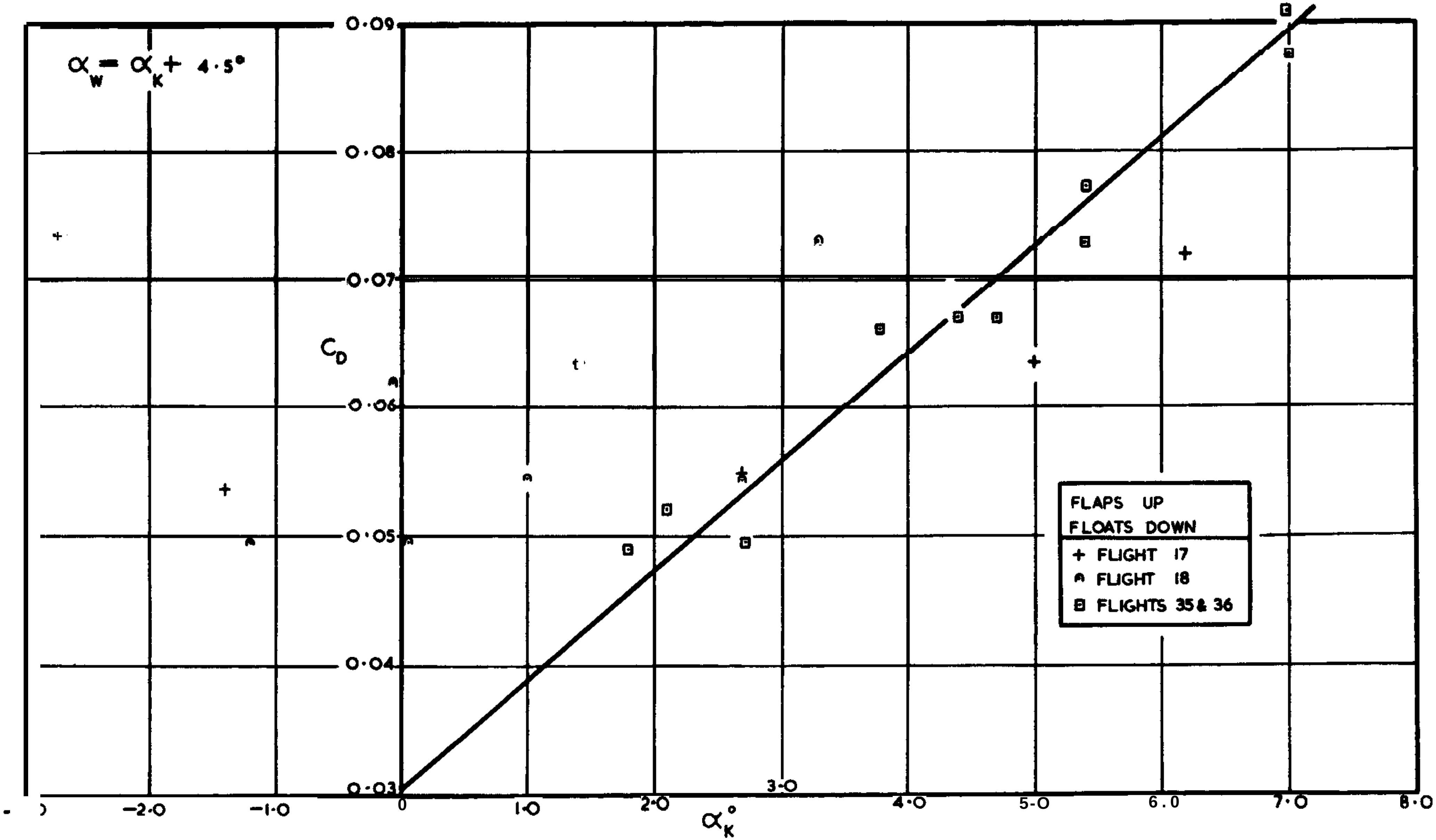
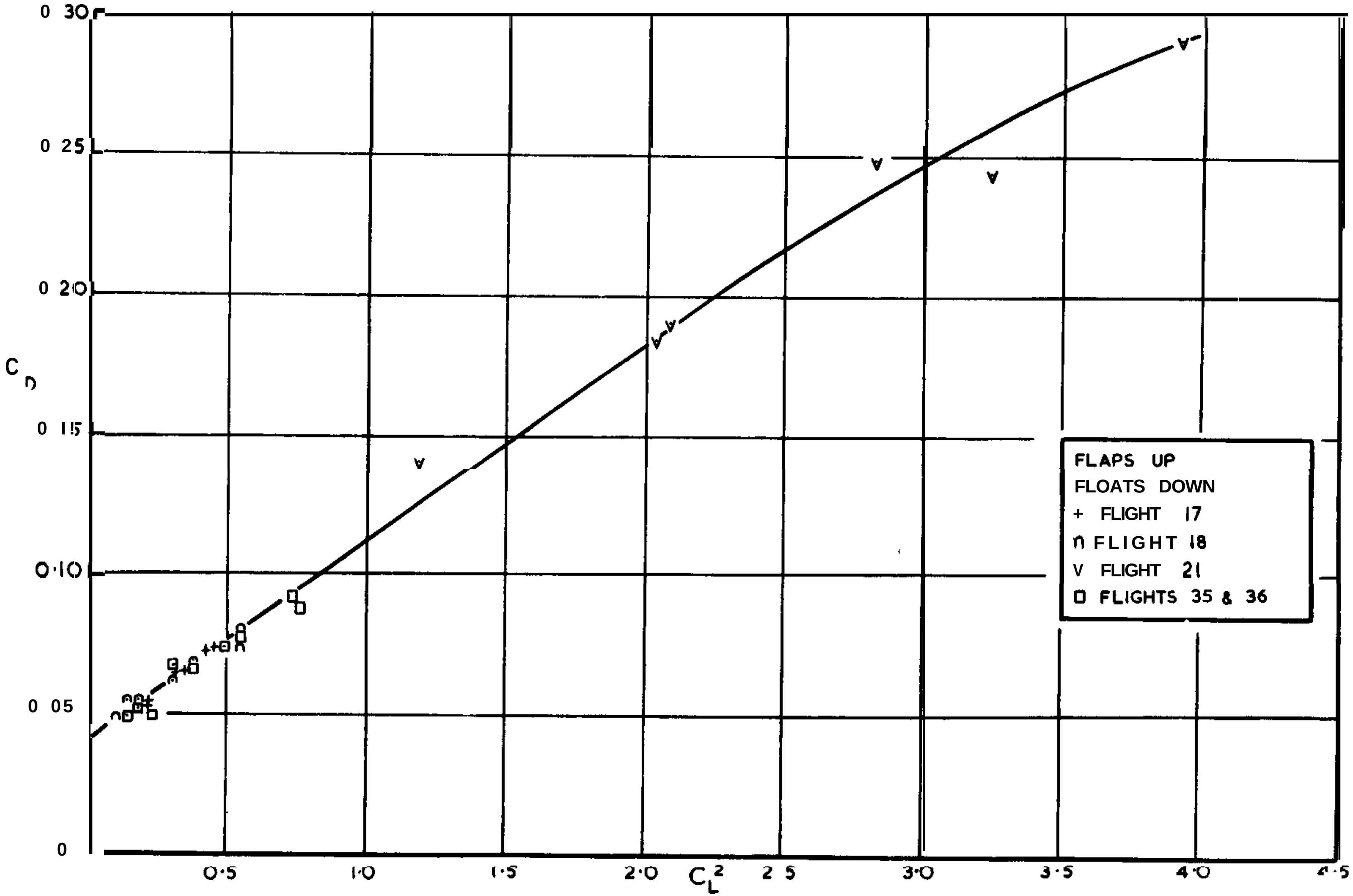


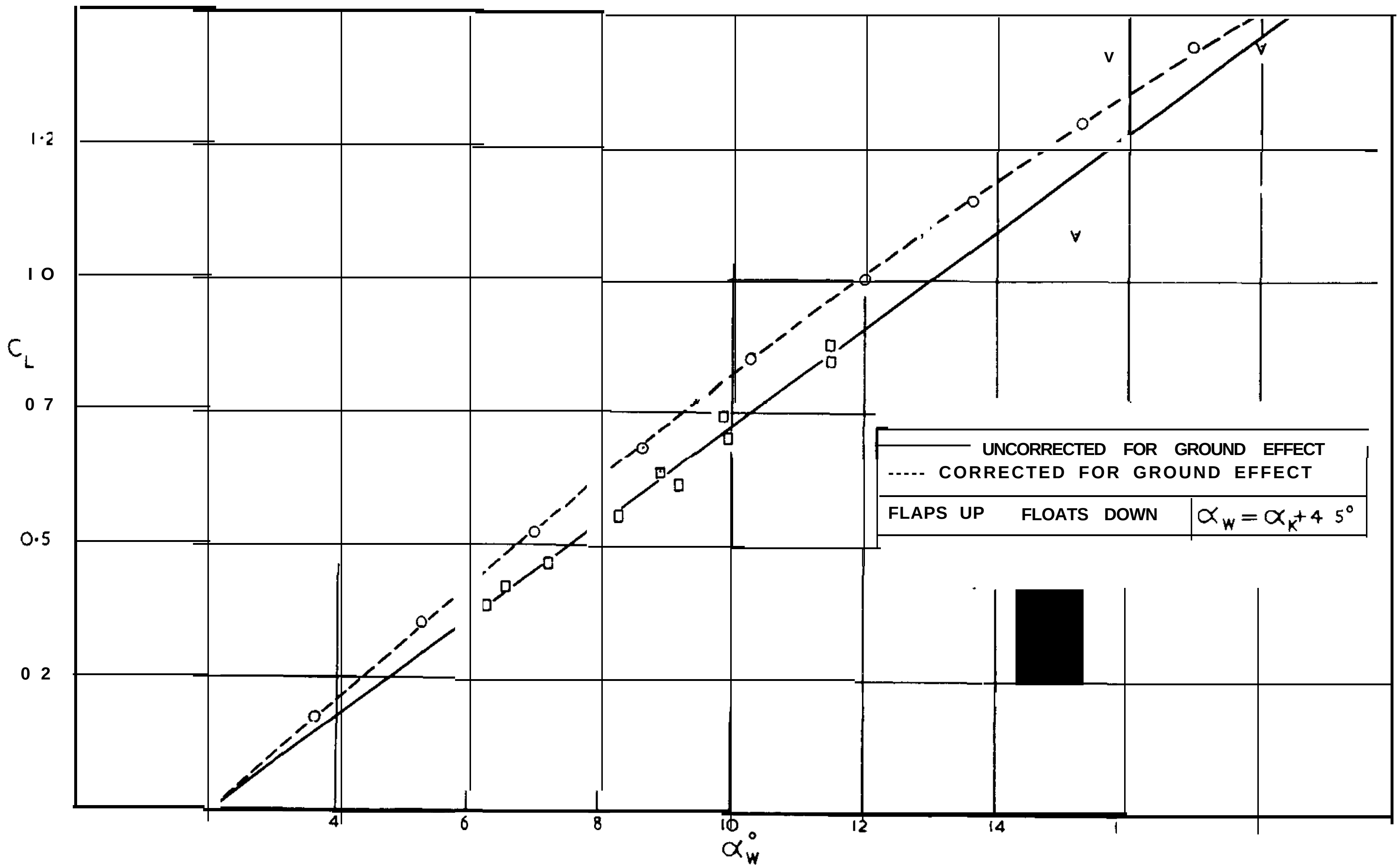
FIG. 16.

FULL SCALE AIR DRAG RELATED TO KEEL ATTITUDE.



FULL SCALE LIFT - DRAG CHARACTERISTICS.

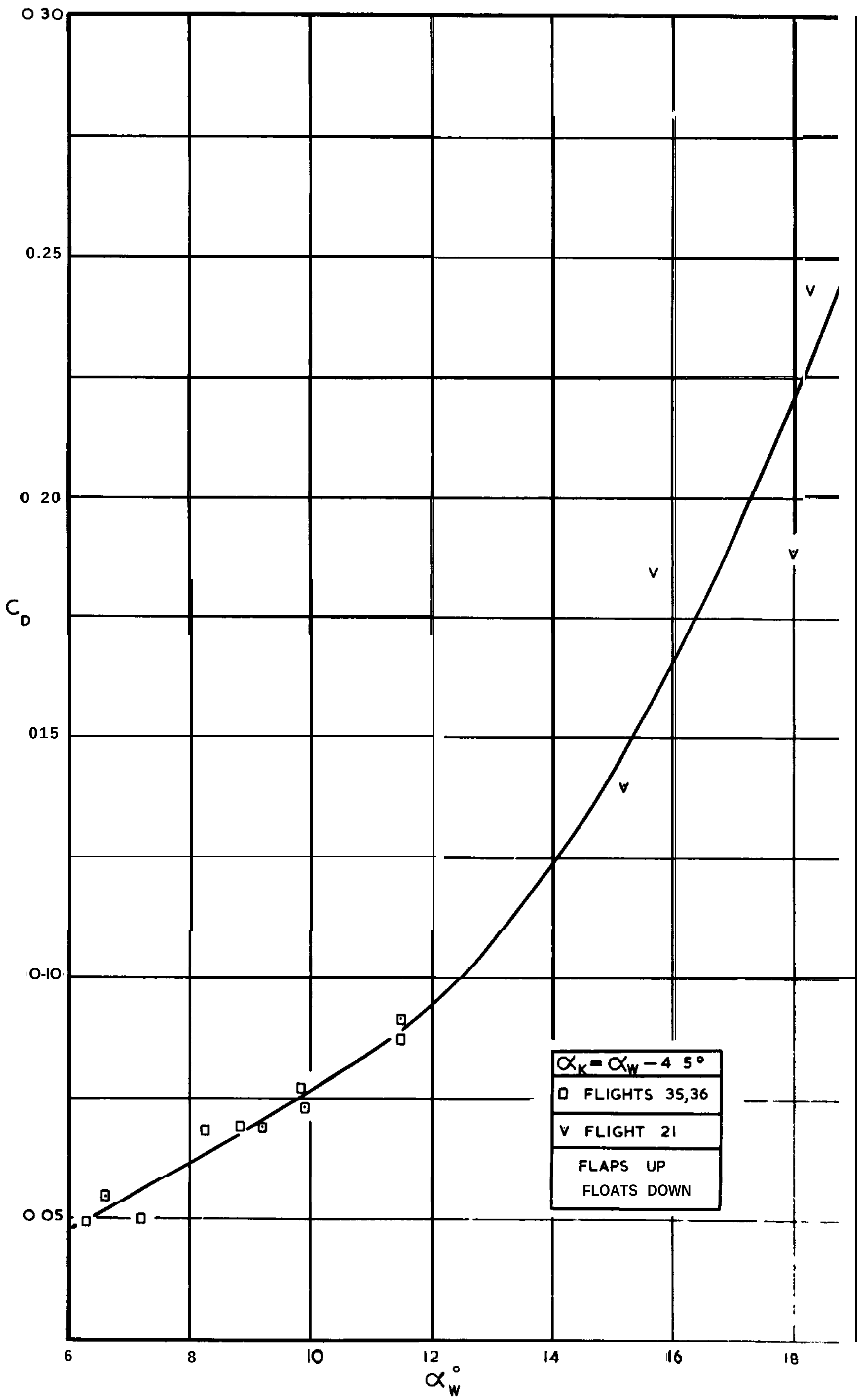
FIG. 17.



FULL SCALE AIR LIFT RELATED TO WING INCIDENCE.

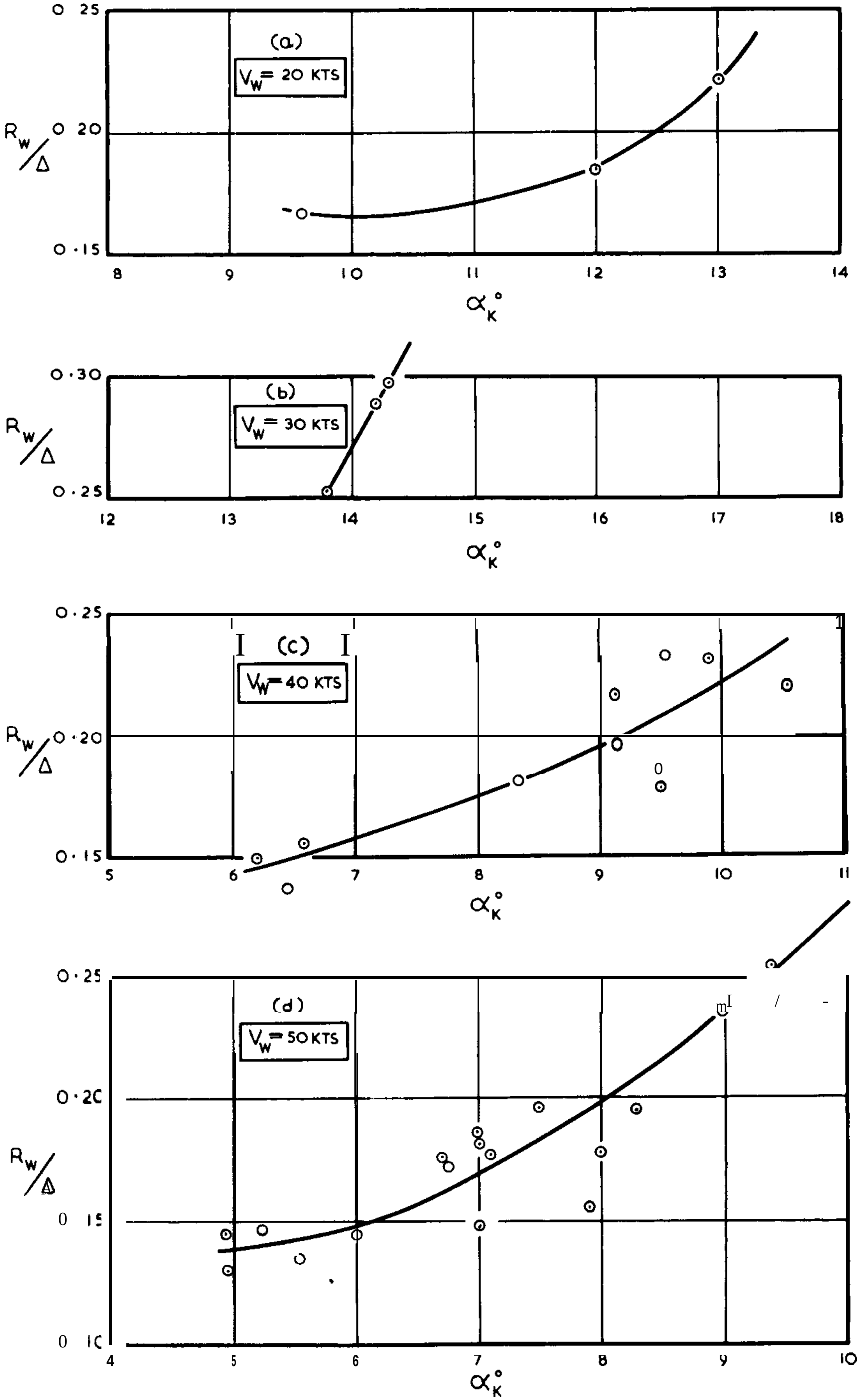
FIG 18

FIG. 19.



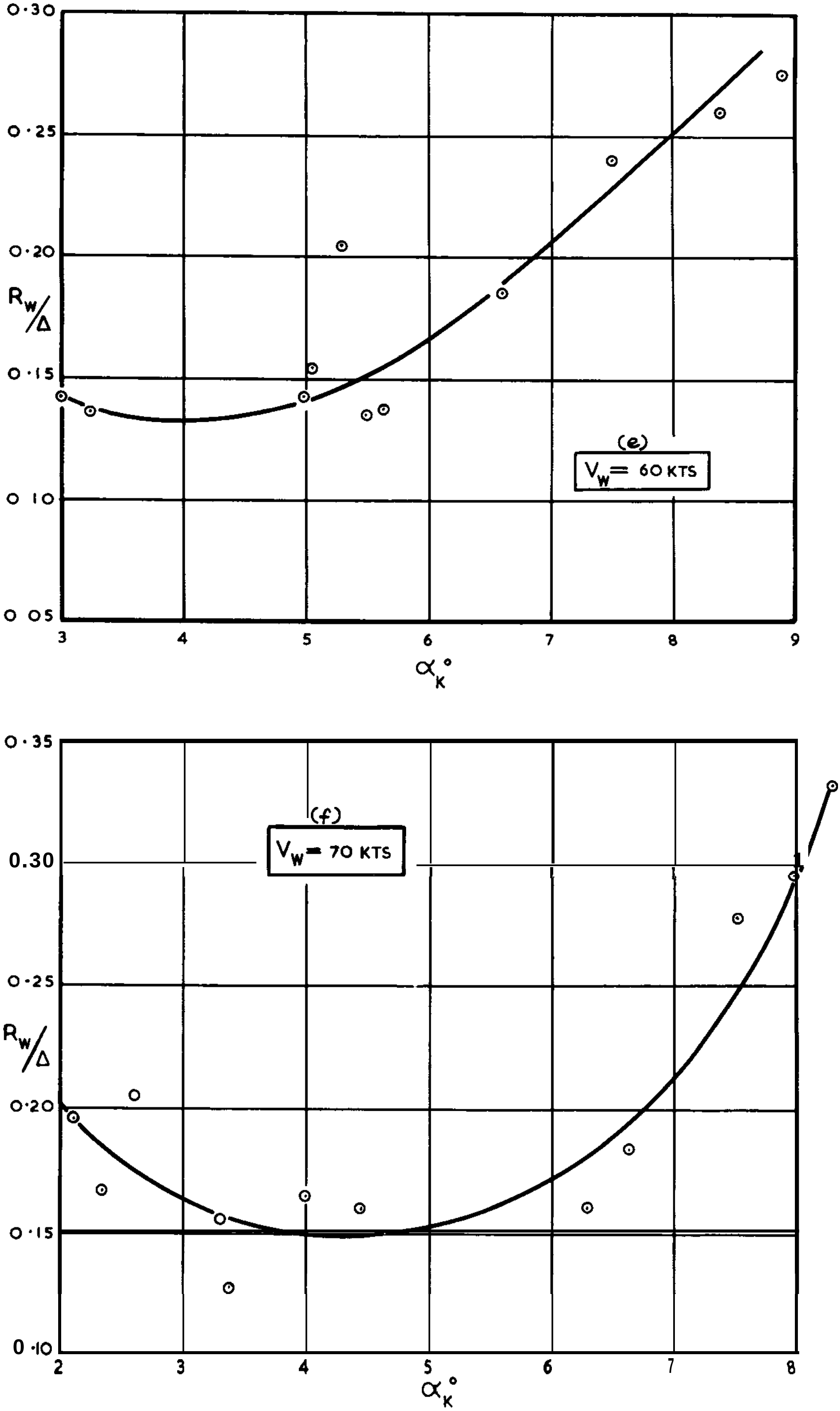
FULL SCALE AIR DRAG RELATED TO WING INCIDENCE.

FIG. 20 a,b,c,d.



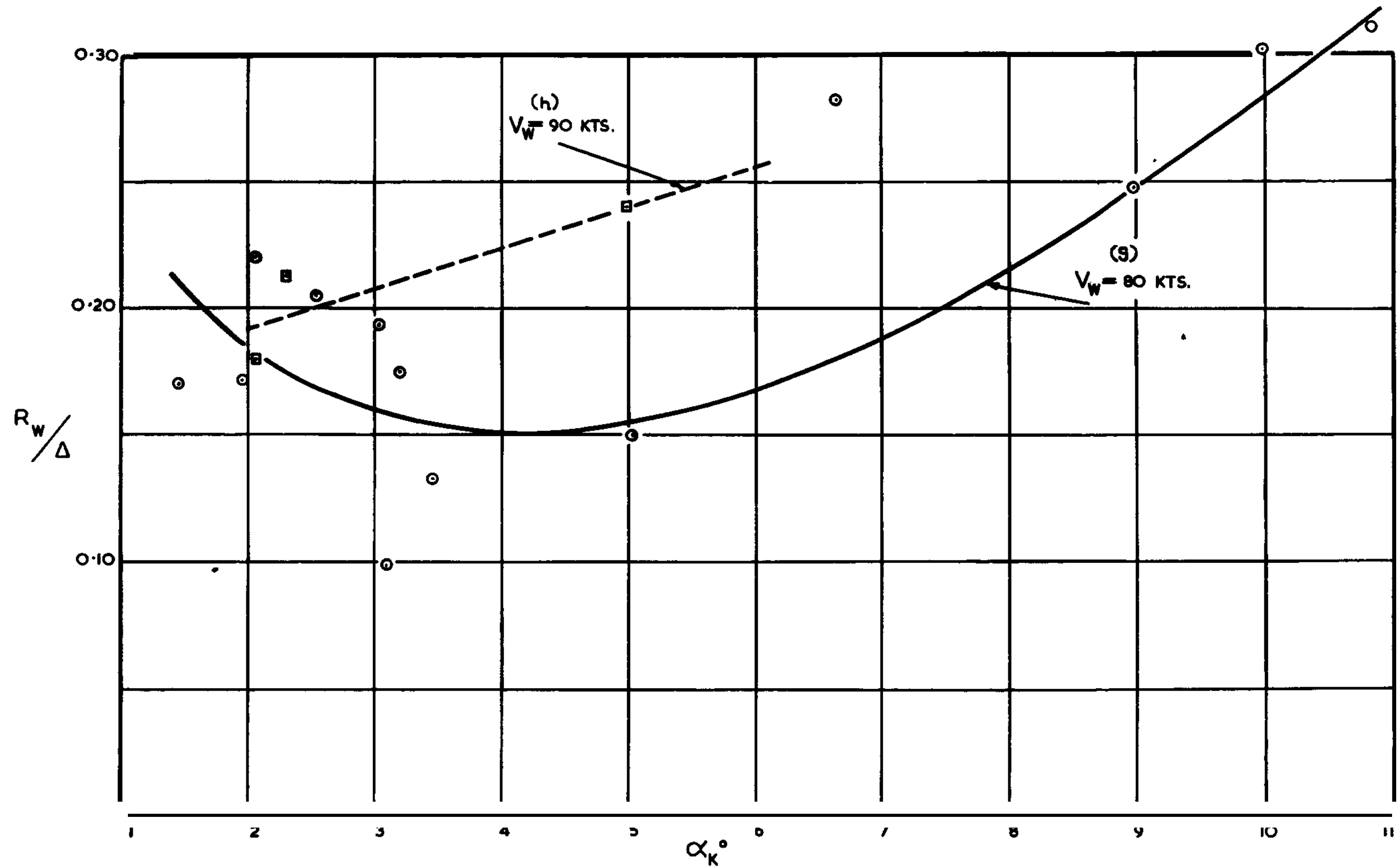
FULL SCALE WATER DRAG.

FIGS. 20 e,f.

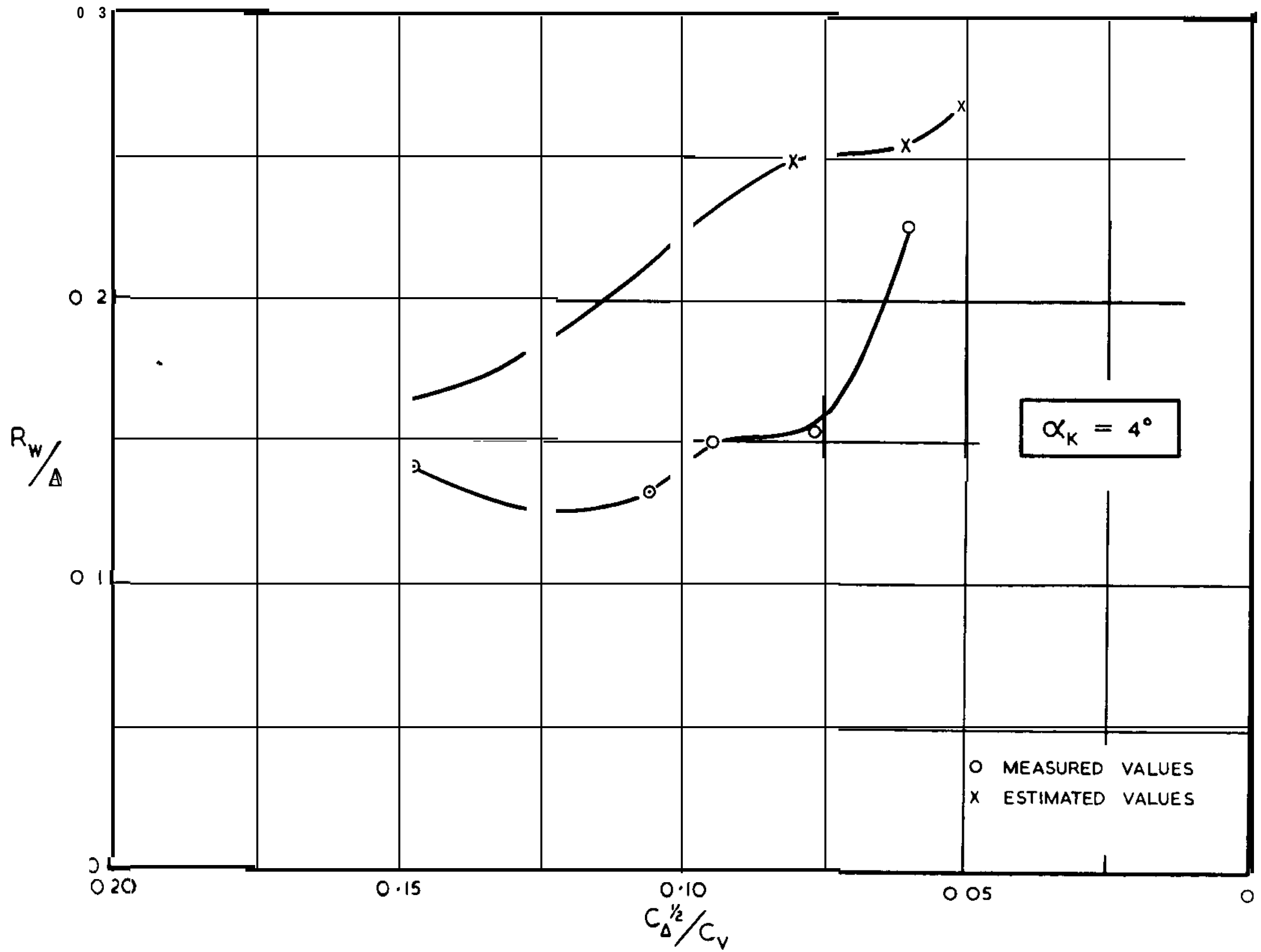


FULL SCALE WATER DRAG

FIG. 20 g, h.

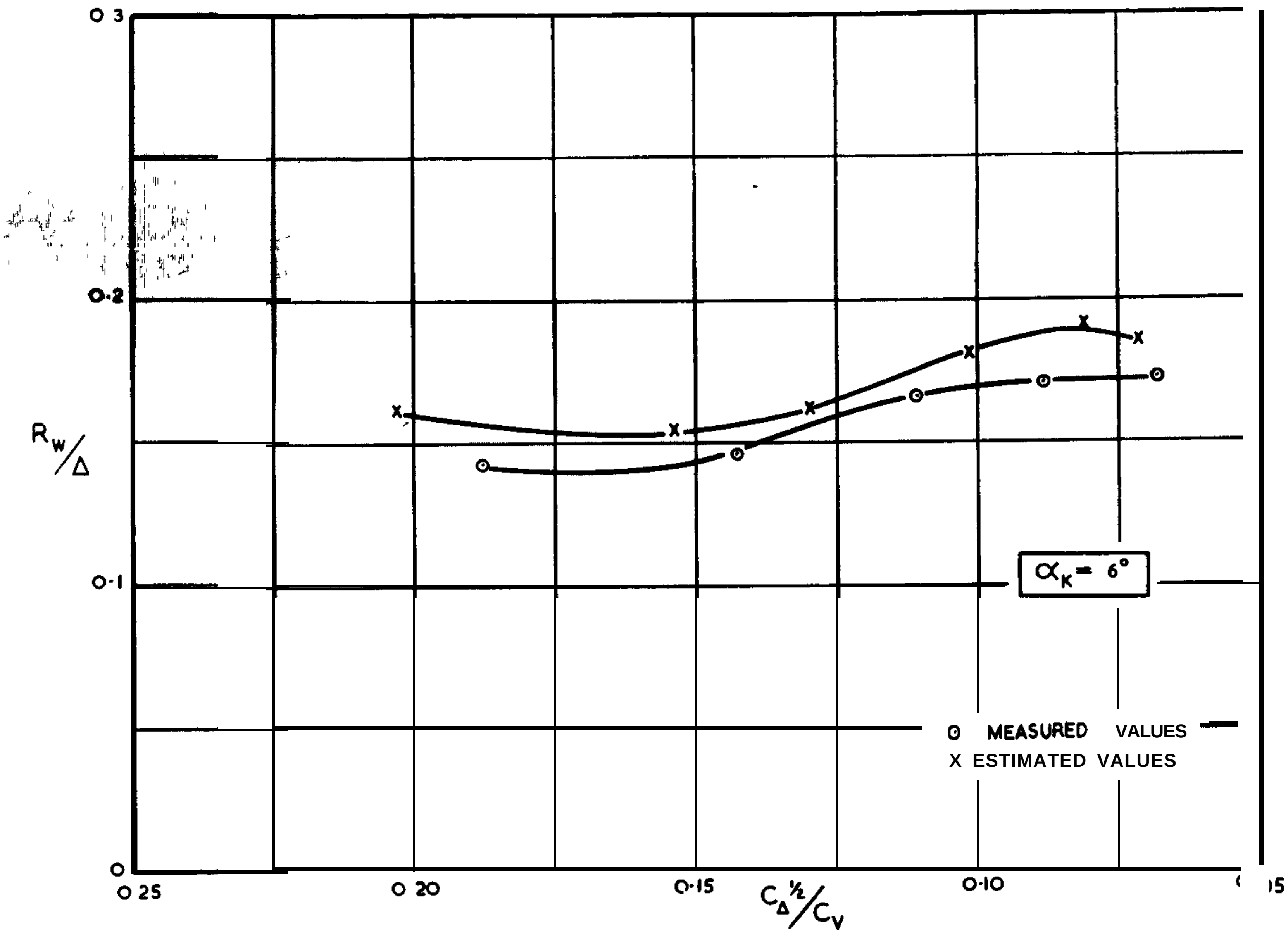


FULL SCALE WATER DRAG.



COMPARISON OF ESTIMATED AND MEASURED FULL SCALE WATER DRAGS.

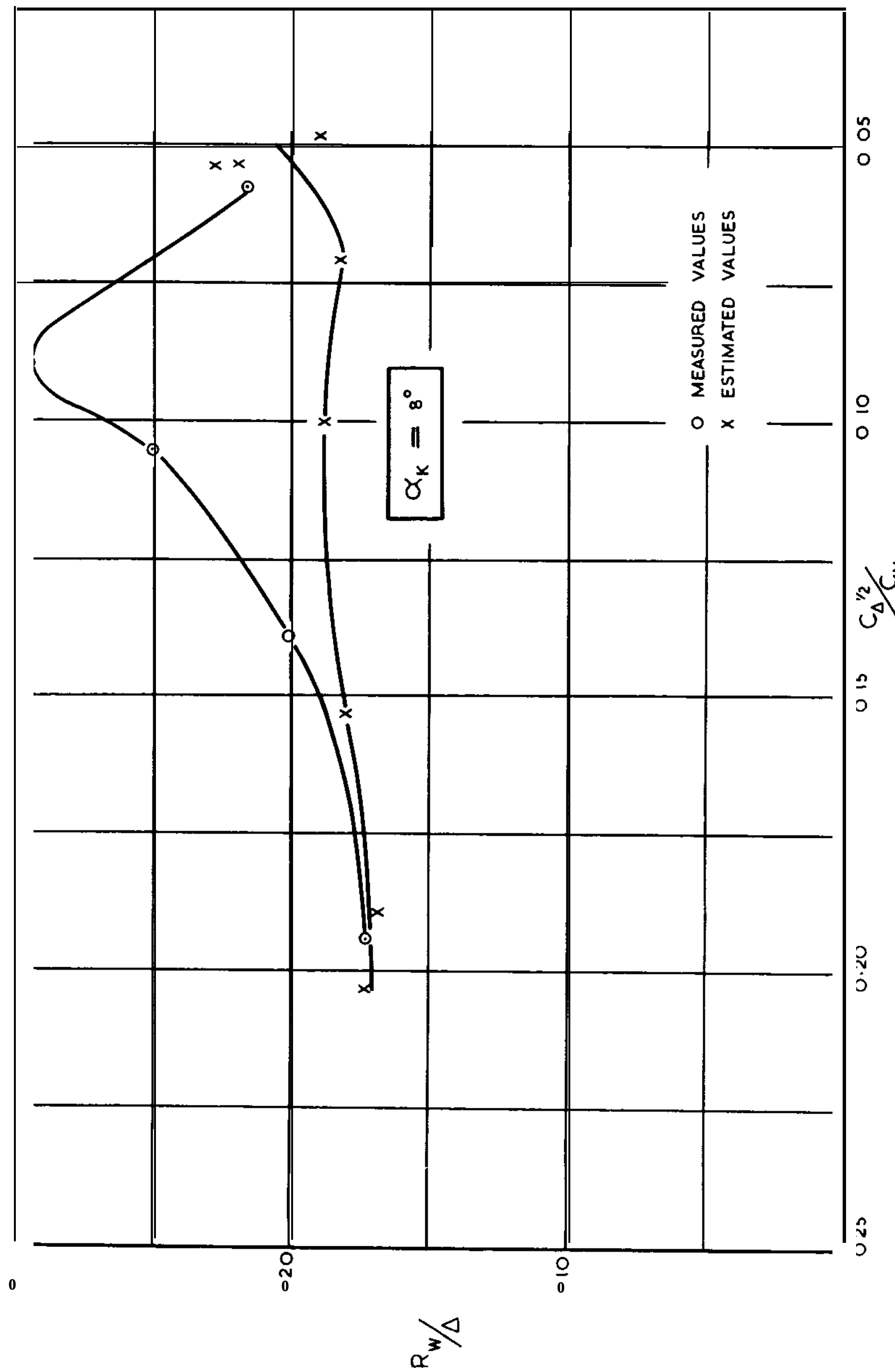
FIG. 21a.



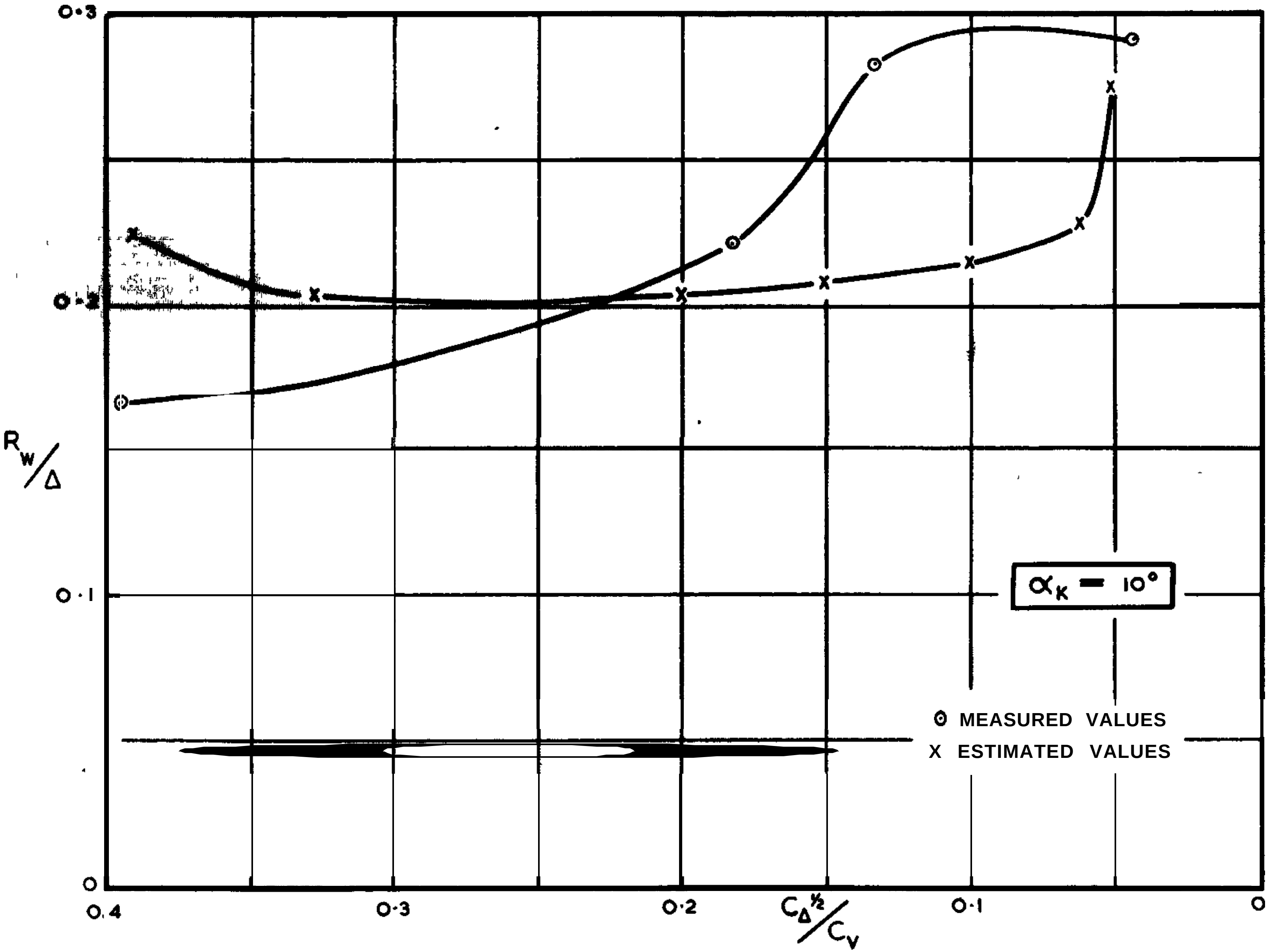
COMPARISON OF ESTIMATED AND MEASURED FULL SCALE WATER DRAG.

FIG. 21b.

FIG. 21 C.



COMPARISON OF ESTIMATED AND MEASURED FULL SCALE WATER DRAG.



COMPARISON OF ESTIMATED AND MEASURED FULL SCALE WATER DRAG.

FIG. 2 d.

Report No. F/Res/263A

March 1956

MARINE AIRCRAFT EXPERIMENTAL ESTABLISHMENT, FELIXSTOWE, SUFFOLK.

TEST DATA FOR TOWING TANK AND FULL SCALE TESTS TO DETERMINE THE WATER DRAG OF THE HULL OF A JET-PROPELLED FLYING BOAT FIGHTER (SPEC. E.6/44)

by

R.V. Gigg
B.C. Kurn, Grad. R.Ae.S.
J.K. Friswell, B.Sc.

S U M M A R Y

This report lists the test data relevant to the towing tank and full scale tests to determine the water drag of the hull of a jet-propelled flying boat fighter, the results of which are compared in M.A.E.E. Report F/Res/263.

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LIST OF FIGURES

1. INTRODUCTION

This report lists the test data relevant to the towing tank and full scale tests to determine the water drag of the hull of a jet-propelled flying boat fighter, the results of which are compared in M.A.E.E. Report F/Res/263. The data are divided into groups corresponding approximately to the various illustrations in that report.

2. TEST DATA

2.1. Model Scale Drag and Draught Measurements

2.1.1. Low and Hump Speed Ranges

V ft./sec	α_k degs	Δ lb.	d in.	R lb.	$\frac{d}{b}$	$\frac{R}{\Delta}$	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$	$C_V/C_\Delta^{\frac{1}{2}}$
0	2	17.1	3.48	0	0.414	0	0.799	0		0
0	2	19.3	3.64	0	0.433	0	0.90[illegible]	0		0
0	2	21.5	3.84	0	0.457	0	1.005	0		0
0	2	23.7	4.00	0	0.476	0	1.107	0		0
0	4	17.1	3.64	0	0.433	0	0.799	0		0
0	4	19.3	3.82	0	0.455	0	0.90[illegible]	0		0
0	4	21.5	4.01	0	0.477	0	1.005	0		0
0	4			0	0.456	0	1.107	0		0
0	6	17.1	3.75	0	0.446	0	0.799	0		0
0	6	19.3	3.93	0	0.468	0	0.90[illegible]	0		0
0	6	21.5	4.12	0	0.490	0	1.005	0		0
0	6			0	0.513	0	1.107	0		0
5.0	2	17.1	3.76	1.42	0.448	0.083	0.799	1.05	0.851	1.17
5.0	2	19.3	3.96	1.53	0.471	0.079	0.902	1.05	0.905	1.11
5.0	2	21.5	4.14	1.65	0.493	0.077	1.005	1.05	0.955	1.05
5.0	2	23.7	4.33	1.80	0.515	0.076	1.107	1.05	1.002	1.00
5.0	4	17.1	3.93	1.38	0.468	0.081	0.799	1.05	0.851	1.17
5.0	4	19.3	4.13	1.49	0.492	0.077	0.902	1.05	0.905	1.11
5.0	4	21.5	4.33	1.59	0.515	0.074	1.005	1.05	0.955	1.05
5.0	4	23.7	4.49	1.71	0.535	0.072	1.107	1.05	1.002	1.00
5.0	6	17.1	3.96	1.27	0.471	0.074	0.795	1.05	0.851	1.17
5.0	6	19.3	4.18	1.41	0.498	0.073	0.902	1.05	0.905	1.11
5.0	6	21.5	4.39	1.51	0.523	0.070	1.005	1.05	0.955	1.05
5.0	6	23.7	4.58	1.62	0.545	0.068	1.107	1.05	1.002	1.00
5.0	8	17.1	3.97	1.22	0.473	0.071	0.799	1.05	0.851	1.17
5.0	8	19.3	4.09	1.35	0.487	0.070	0.902	1.05	0.905	1.11
5.0	8	21.5	4.39	1.44	0.523	0.067	1.005	1.05	0.955	1.05
5.0	8	23.7	4.60	1.57	0.548	0.066	1.107	1.05	1.002	1.00
5.7	2	17.1	3.84	1.95	0.457	0.114	0.799	1.20	0.745	1.34
5.7	2			2.28	0.482	0.118	0.902	1.20	0.791	1.26
5.9	2	[illegible]	[illegible]	2.57	0.507	0.120	1.005	1.24	0.808	1.24
5.7	2	19.3	4.44	2.62	0.529	0.111	1.107	1.20	0.877	1.14
5.7	4	21.5	4.26	1.94	0.474	0.113	0.799	1.20	0.745	1.34
5.6	4	19.3	4.21	2.21	0.501	0.115	0.902	1.18	0.805	1.24
5.9	4	21.5	4.33	2.54	0.515	0.118	1.005	1.24	0.808	1.24
5.8	4	23.7	4.62	2.72	0.550	0.115	1.107	1.22	0.862	1.16
5.6	6	17.1	4.04	1.84	0.481	0.108	0.799	1.18	0.758	1.32
5.7	6	19.3	4.25	2.04	0.506	0.106	0.902	1.20	0.791	1.26
5.7	6	21.5	4.48	2.35	0.533	0.109	1.005	1.20	0.835	1.20
5.7	6	23.7	4.69	2.56	0.558	0.108	1.107	1.20	0.877	1.14
7.7	4	15.0	3.69	2.59	0.439	0.173	0.701	1.62	0.517	1.93
7.7	4	17.1	3.99	2.90	0.475	0.170	0.799	1.62	0.552	1.81
7.7	4	19.3	4.13	3.23	0.492	0.167	0.902	1.62	0.586	1.71
7.7	4	21.5	4.33	3.55	0.515	0.165	1.005	1.62	0.619	1.62
7.7	4	23.7	4.55	4.57	0.542	0.193	1.107	1.62	0.649	1.54
7.6	6	15.0	3.70	2.35	0.440	0.157	0.701	1.60	0.523	1.91
7.6	6	17.1	3.96	3.62	0.471	0.212	0.799	1.60	0.559	1.79
7.7	6	19.3	4.19	3.78	0.499	0.196	0.902	1.62	0.586	1.71
7.7	6	21.5	4.39	4.17	0.523	0.194	1.005	1.62	0.619	1.62
7.4	6	23.7	4.60	4.58	0.548	0.193	1.107	1.56	0.674	1.48
7.7	8	15.0	3.65	2.26	0.435	0.151	0.701	1.62	0.517	1.93
7.8	8	17.1	3.89	2.61	0.463	0.153	0.799	1.64	0.545	1.83
7.8	8	19.3	4.15	3.78	0.494	0.196	0.902	1.64	0.579	1.73
7.7	8	21.5	4.34	4.06	0.517	0.189	1.005	1.62	0.619	1.62
7.7	8	23.7	4.58	4.33	0.545	0.183	1.107	1.62	0.649	1.54

/10.2

V ft./sec.	α_k degs	A lb.	d in.	R lb.	$\frac{d}{b}$	$\frac{R}{\Delta}$	C_Δ	C_V	$C_\Delta^{1/2}/C_V$	$C_V/C_\Delta^{1/2}$
10.2	3	15.0	3.46	3.69	0.412	0.21+6	0.701	2.15	0.389	2.57
10.2	3	17.1	3.79	4.22	0.451	0.247	0.799	2.15	0.416	2.41
10.1	3	19.3	3.99	6.54	0.475	0.339	0.902	2.13	0.446	2.24
10.1	3	21.5	4.26	6.87	0.510	0.320	1.005	2.13	0.465	2.12
10.1	3	23.7	4.17	7.14	0.532	0.301	1.107	2.13	0.494	2.02
10.2	4	15.0	3.43	3.31	0.408	0.226	0.701	2.15		2.57
10.2	4	17.1	3.73	3.56	0.444	0.232	0.799	2.15		2.41
10.2	4	19.3	4.02	4.72	0.479	0.245	0.902	2.15		2.26
10.2	4	21.5	4.33	7.01	0.515	0.326	1.005	2.15		2.14
10.2	4	23.7	4.47	7.29	0.532	0.308	1.107	2.15		2.04
10.1	5	15.0	3.40	3.01	0.405	0.201	0.701	2.13	0.393	2.54
10.1	5	17.1	3.77	3.59	0.449	0.210	0.799	2.13	0.420	2.38
10.1	5	lY.3	Lt.04	4.24	0.481	0.220	0.902	2.13	0.446	2.24
10.1	5	21.5	Lt.29	5.10	0.511	0.237	1.005	2.13	0.466	2.12
10.1	5	23.7	4.53	6.24	0.539	0.263	1.107	2.13	0.494	2.02
10.1	7	15.0	3.35	2.70	0.399	0.180	0.701	2.13	0.393	2.54
10.1		17.1	3.69	3.35	0.439	0.196	0.799	2.13	0.420	2.38
10.1	3	19.3	3.91	3.31	0.465	0.203	0.902	2.13	0.446	2.24
10.1	7	21.5	4.03	Lk.34	0.480	0.202	1.005	2.13	0.466	2.12
10.1	7	23.7	4.39	4.84	0.523	0.204	1.107	2.13	0.494	2.02
9.5	9	15.0	3.28	2.61	0.390	0.174	0.701	0.20	0.L1.19	2.39
9.5	9	17.1	3.56	3.09	0.424	0.181	0.799	0.20	0.147	2.24
9.6	9	19.3	3.80	3.43	0.452	0.181	0.902	0.20	0.470	2.13
9.7	9	21.5	4.03	3.92	0.480	0.182	1.005	0.20	0.491	2.04
9.7	9	23.7	4.22	4.37	0.502	0.184	1.107	0.20	0.516	1.94
12.2	6	15.0	3.16	3.47	0.376	0.231	0.701	2.57	0.326	3.07
12.2	6	17.1	3.41	4.27	0.406	0.250	0.799	2.57	0.348	2.88
12.0	6	19.3	3.70	4.97	0.440	0.258	0.902	2.53	0.375	2.66
12.0	6	21.5	3.89	5.86	0.463	0.273	1.005	2.53	0.396	2.52
12.0	6	23.7	4.13	6.79	0.492	0.286	1.107	2.53	0.416	2.40
12.3	8	15.0	2.91	2.95	0.346	0.197	0.701	2.59	0.223	3.09
12.3	a	17.1	3.15	3.80	0.375	0.222	0.799	2.55	0.345	2.90
12.3	8	19.3	3.31	4.58	0.394	0.237	0.902	2.59	0.367	2.73
12.0	8	21.5	3.73	5.45	0.444	c.253	1.005	2.53	0.396	2.52
12.0	8	23.7	3.88	6.07	0.462	0.256	1.107	2.53	0.416	2.40
12.2	10	15.0	2.70	2.93	0.321	0.195	0.701	2.57	0.326	3.07
12.2	10	17.1	2.99	3.53	0.356	0.206	0.799	2.57	0.348	2.88
12.2	10	19.3	3.20	4.13	0.381	0.214	0.902	2.57	0.370	2.71
12.2	10	21.5	3.41	4.89	0.406	0.227	1.005	2.57	0.390	2.56
12.2	IO	23.7	3.71	5.65	0.442	0.238	-1.107	2.57	0.409	2.44
11.8	12	15.0	2.52	3.30	0.300	0.220	0.701	2.48		2.96
11.8	12	17.1	2.76	3.76	0.329	0.220	0.799	2.48		2.77
11.9	12	19.3	3.01	4.15	0.358	0.215	0.702	2.51		2.64
12.0	12	21.5	3.24	4.79	0.386	0.223	1.005	2.53		2.52
11.9	12	23.7	3.51	5.18	0.418	0.219	1.107	2.51		2.39
13.1	9	15.0	2.58	2.78	0.307	0.185	0.701	2.76		3.30
13.2	9	17.1	2.84	3.36	0.338	0.196	0.795	2.78		3.11
13.2	9	19.3	3.18	4.22	0.379	0.219	0.902	2.78		2.93
13.2	9	21.5	3.45	5.10	0.411	0.237	1.005	2.78		2.77
13.7	9	23.7	3.63	6.06	0.432	0.256	1.107	2.88		2.74
14.3	11	12.9	1.89	2.74	0.225	0.212	0.603	3.01	0.258	3.88
14.3	11	15.0	2.09	3.18	0.249	0.212	0.701	3.01	0.278	3.60
14.3	11	17.1	2.33	3.67	0.277	0.215	0.799	3.01	0.297	3.37~
14.3	11	19.3	2.57	4.12	0.306	0.213	0.902	3.01	0.316	3.17
14.3	11	21.5	2.79	4.67	0.332	0.217	1.005	3.01	0.333	3.00
14.3	II	23.7	3.09	5.43	0.368	0.229	1.107	3.01	0.350	2.86
14.3	13	12.9	1.73	3.11	0.206	0.241	0.603	3.01	0.258	3.88
14.3	13	15.0	1.90	3.67	0.226	0.245	0.701	3.01	0.278	3.60
14.3	13	17.1	2.11	4.16	0.251	0.243	0.799	3.01	0.297	3.37
14.3	13	19.3	2.29	4.65	0.273	0.241	0.902	3.01	0.316	3.17
14.3	13	21.5	2.56	5.37	0.305	0.250	1.005	3.01	0.333	3.00
14.3	13	23.7	2.75	5.70	0.327	0.241	1.107	3.01	0.350	2.86
14.4	15	12.9	1.56	3.45	0.186	0.267	0.603	3.03	0.256	3.90
14.4	15	15.0	1.73	4.00	0.206	0.267	0.701	3.03	0.276	3.62

V ft./sec	α_k deg.	A lb.	d in.	R lb.	$\frac{d}{b}$	$\frac{R}{\Delta}$	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$	C_V/C_Δ
14.4	15	17.1	1.90	4.67	0.226	0.273	0.799	3.01	0.295	3.39
14.4	15	19.3	2.06	5.19	0.245	0.269	0.502	3.03	0.313	3.19
14.4	15	21.5	2.26	5.84	0.269	0.272	1.005	3.03	0.331	3.02
14.2	15	23.7	2.56	6.60	0.305	0.278	I.107	2.99	0.352	2.84
16.7	12	12.9	1.56	3.02	0.186	0.234	0.603	3.52	0.221	4.53
16.7	12	15.0	1.66	3.45	0.198	0.230	0.701	3.52	0.238	4.20
16.7	12	17.1	1.71	3.95	0.204	0.231	0.799	3.52	0.254	3.94
16.7	12	19.3	1.96	4.44	0.233	0.230	0.902	3.52	0.270	3.71
16.7	12	21.5	2.14	5.06	0.255	0.235	1.005	3.52	0.285	3.51
16.7	12	23.7	2.29	5.50	0.273	0.232	1.107	3.52	0.299	3.35
16.7	14	12.9	1.48	3.42	0.176	0.265	0.603	3.52	0.221	4.53
16.7	14	15.0	1.59	3.95	0.189	0.263	0.701	3.52	0.238	4.20
16.8	14	17.1	1.69	4.45	0.201	0.260	0.799	3.54	0.253	3.96
16.8	14	19.3	1.83	5.08	0.218	0.261	0.902	3.54	0.268	3.73
16.8	14	21.5	2.03	5.60	0.52	0.260	1.005	3.54	0.283	3.53
16.8	14	23.7	2.11	6.18	0.251	0.261	I.107	3.54	0.297	3.36
16.8	16	12.9	1.40	3.73	0.167	0.289	0.603	3.54	0.219	4.56
16.8	16	15.0	1.50	4.31	0.179	0.287	0.701	3.54	0.237	4.23
16.8	16	17.1	1.61	4.90	0.192	0.287	0.799	3.54	0.253	3.96
16.8	16	19.3	1.72	5.48	0.705	0.284	0.902	3.54	0.268	3.73
16.6	16	21.5	1.87	6.32	0.223	0.294	1,005	3.49	0.287	3.48
16.6	16	23.7	2.01	6.94	0.239	0.293	1.107	3.49	0.301	3.32
19.0	12	12.9	1.44	3.05	0.171	0.236	0.603	4.00	0.194	5.15
19.0	12	15.0	1.53	3.45	0.182	0.230	0.701	4.00	0.209	4.78
19.0	12	17.1	1.63	3.99	0.194	0.233	0.799	4.00	0.223	4.47
19.0	12	19.3	1.70	4.41	0.202	0.228	0.902	4.00	0.237	4.21
19.0	12	21.5	1.78	5.07	0.212	0.236	1.005	4.00	0.251	3.99
19.0	14	12.9	1.38	3.50	0.164	0.271	0.603	4.00	0.194	5.15
19.0	14	15.0	1.48	3.97	0.176	0.265	0.701	4.00	0.209	4.79
18.9	14	17.1	1.56	4.50	0.186	0.263	0.799	3.98	0.225	4.45
18.9	14	19.3	1.64	4.97	0.195	0.258	0.902	3.98	0.739	4.19
18.9	14	21.5	1.75	5.70	0.208	0.265	1.005	3.98	0.252	3.97
18.9	16	12.9	1.34	3.80	0.160	0.295	0.603	3.98	0.195	5.13
18.9	16	15.0	1.42	1.38	0.169	0.292	0.701	3.98	0.210	4.75
19.0	16	17.1	1.51	5.08	0.130	0.297	0.799	4.00	0.223	4.47
19.0	16	19.3	1.57	5.66	0.187	0.293	0.902	4.00	0.237	4.21
19.0	16	21.5	1.67	6.40	0.199	0.298	1.005	4.00	0.251	3.99
21.4	11	10.7	1.21	2.30	0.144	0.215	0.500	b.51	0.157	
21.4	11	12.9	1.31	2.75	0.156	0.213	0.603	4.51	0.172	
20.9	II	15.0	1.41	3.15	0.168	0.210	0.701	4.40	0.190	
20.9	11	17.1	1.48	3.59	0.176	0.210	0.799	4.40	0.203	
21.2	11	19.3	1.55	4.09	0.185	0.212	0.902	4.46	0.213	
21.2	11	21.5	1.63	6.57	0.194	0.213	1.005	4.46	0.225	
21.4	13	10.7	1.18	2.71	0.140	0.253	0.500	4.51	0.157	
21.4	13	12.9	1.24	3.25	0.148	0.252	0.603	6.51	0.172	
21.4	13	15.0	1.35	3.78	0.161	0.252	0.701	4.51	0.186	
21.4	13	17.1	1.43	4.21	0.170	0.246	0.799	4.51	0.198	
21.4	13	19.3	1.50	4.82	0.179	0.250	0.902	4.51	0.211	
21.4	13	21.5	1.57	5.34	0.187	0.248	1.005	4.51	0.222	
21.5	15	10.7	1.12	3.07	0.133	0.287	0.500	4.53	0.156	
21.5	15	12.9	1.22	3.66	0.145	0.284	0.603	4.53	0.171	
21.5	15	15.0	1.30	4.28	0.155	0.286	0.701	4.53	0.185	
21.5	15	17.1	1.38	6.85	0.164	0.284	0.799	4.53	0.197	
21.5	15	19.3	1.45	5.50	0.173	0.285	0.902	4.53	0.210	
21.5	15	[illegible]	1.50	6.02	0.179	0.280	1.005	4.53	0.221	
23.5	8	10.7	1.21	1.81	0.144	0.169	0.500	4.95	0.143	
23.5	8	12.9	1.29	2.12	0.154	0.164	0.603	4.95	0.157	
23.6	8	15.0	1.37	2.50	0.163	0.167	0.701	4.97	0.168	
23.6	8	17.1	1.44	2.80	0.171	0.164	0.799	4.97	0.180	
23.8	8	19.3	1.47	3.15	0.175	0.163	0.902	5.01	0.190	
23.8	8	21.5	1.60	3.63	0.190	0.169	1.005	5.01	0.200	
23.8	IO	10.7	1.15	2.13	0.137	0.199	0.500	5.01	0.141	

/23.8

V ft./sec.	α_k degs	Δ lb.	d in.	R lb.	$\frac{d}{b}$	$\frac{R}{\Delta}$	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$	$V/C_\Delta^{\frac{1}{2}}$
23.8	10	12.9	1.22	2.56	0.145	0.198	0.603	5.01	0.155	
23.8	10	15.0	1.35	3.01	0.161	0.201	0.701	5.01	0.167	
23.8	10	17.1	1.38	3.32	0.164	0.194	0.799	5.01	0.178	
23.8	10	19.3	1.41	3.77	0.168	0.195	0.902	5.01	0.190	
23.8	10	21.5	1.49	4.17	0.177	0.194	1.005	5.01	0.200	
23.8	12	10.7	1.08	2.49	0.129	0.233	0.500	5.01	0.141	
23.8	12	12.9	1.18	3.03	0.140	0.235	0.603	5.01	0.155	
23.8	12	15.0	1.28	3.57	0.152	0.238	0.701	5.01	0.167	
23.8	12	17.1	1.34	3.97	0.160	0.232	0.799	5.01	0.178	
23.8	12	19.3	1.38	4.45	0.164	0.231	0.902	5.01	0.190	
23.8	12	21.5	1.45	4.93	0.173	0.229	1.005	5.01	0.200	

/2.1.2. Planing Speed Range

2.1.2. Planing Speed Range

V ft./sec.	α_k degs	Δ lb.	d in.	R lb.	$\frac{d}{b}$	$\frac{R}{\Delta}$	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$
	4								
25.1	4	1.55	0.67	0.34	0.083	0.219	0.072	5.28	0.051
25.1	4	1.85	0.71	0.40	0.085	0.216	0.086	5.28	0.056
25.2	4	2.25	0.74	0.49	0,088	0.21%	0.105	5.31	0,061
24.8		3.00	0.83	0.64	0.099	0.213	0.140	5.22	0.072
25.1	4	3.90	0.94	0.88	0.112	0.226	0.182	5.2%	0.081
25.1	4	6.10	1.12	1.26	0.133	0.207	0.285	5.28	0.101
25.1	4	9.55	1.34	1.77	0.160	0.185	0.446	5.28	0.126
25.1	4	13.80	1.52	2.35	0.181	0.170	0.645	5.2%	0.152
25.1	4	24.60	2.21	5.06	0.263	0.238	1.150	5.2%	0.203
25.1	4	38.40	3.26	15.56	0.388	0.405	1.794	5.2%	0.254
25.1		1.55	0.57	0.29	0.068	0.187	0.072	5,28	0.051
	6	[illegible]							0.056
25.0 / 25.1	6	1.85 / 2.25	0.64	0.40	0.760	0.173 / 0.178	0.066 / 0.105	5.26 / 5.2%	0.061
25.1	6	3.90	0.78	0.4%	0.086	0.160	0.140	5.28	0.071
25.1		6.10		0.65	0.093	0.167	0.182	5.2%	0.081
25.1	6	[illegible]	0.99	0.97	0.118	0,159	0.285	5.28	0.101
24.6	6	9.55	1.18	1.40	0.140	0.147	0.446	5.18	0.129
25.0	6	13.80	1.39	2.00	0.165	0.145	0.645	5.26	0.153
25.1	6	24.60	1.80	3.82	0.214	0.155	1.150	5.28	0.203
25.1	6	38.40	2.73	8.09	0.325	0.211	1.794	5.28	0.254
25.0	8	1.40	0.47	0.28	0.056	0.200	0.065	5.26	0.04%
25.0	8	1.55.	0.48	0.29	0.057	0.187	0.072	5.26	0.051
25.0	E	1.85	0.55	0.38	0.065	0.205	0.086	5.26	0.056
25.1	8	2.25	0.59	0.43	0.070	0.191	0.105	5.2%	0.061
25.1	8	3.00	0.65	0.52	0.077	0.173	0.140	5.2%	0.071
25.2	8	3.90 / 6.10	0.89	0.67 / 0.79	0.085 / 0.106	0.175	0.285	5.31	0.080
									0.101
25.2		9.55	1.09	1.68	0.130	0.176	0.446	5.31	0.126
25.1	8	9.55	1.09	1.66	0,130	0.174	0.446	5.28	0,126
24.9	8	13.80	1.29	2.33	0.154	0.169	0.645	5.24	0.153
25.0	8	24.60	1.63	4.13	0.194	0.168	1.150	5.26	0.204
25.0	8	38.40	2.21	6.70	0.263	0.174	1.794	5.26	0.255
25.1	IO	1.55	0.47	0.45	0.056	0.290	0.072	5.28	0.051
25.1	10	1.85	0.45	0.47	0.054	0.254	0.086	5.28	0.056
25.0	10	2.25	0.50	0.51	0.060	0.227	0.105	5.26	0.062
25.0	10	3.00	0.59	0.64	0.070	0.213	0.140	5.26	0.071
25.2	IO	3.90	0.64	0.81	0.076	0.208	0.182	5.31	0.080
25.2	10	6.10	0.81	1.27	0.096	0.208	0.285	5.31	0.101
25.2	IO	9.55	0.99	1.95	0.118	0.204	0.446	5.31	0.126
25.3	10	13.80	1.09	2.79	0.130	0.202	0.645	5.33	0.151
25.3	10	24.60	1.49	4.85	0.177	0.197	1.150	5.33	0.201
25.3	10	38.40	1.94	7.71	0.231	0.201	1.794	5.33	0.251

2.2 EL SC LE WETTED AREA MEASUREMENTS

V ft/sec	α_K deg.	Δ lb.	d in.	ℓ_1 in.	ℓ_2 in.	ℓ_3 in.	ℓ_4 in.	ℓ_5 in.	ℓ_6 in.	ℓ_7 in.	ℓ_8 in.	$\frac{1}{2}S_1$ sq.in	$\frac{1}{2}S_2$ sq.in.	$\frac{1}{2}S_3$ sq.in.	$\frac{1}{2}S_5$ sq.in	$\frac{1}{2}S_6$ sq.in.	$\frac{1}{2}S_7$ sq.in.	ϕ deg.	ϕ' deg.	ϕ_3 deg.	ϕ_4 deg.	h in.	$\frac{1}{2}S$ sq.in.	d/b	C_s	ℓ/b	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$	$C_V/C_\Delta^{\frac{1}{2}}$
5.0	2	17.0	3.74	29.55	+	23.7	+	26.0	-	-	-	123.8	64.2	3.9	-	24.9	15.4	56.0	80.5	+	-	4.27	226.8	0.445	3.215	4.57	0.794	1.05	0.849	1.18
5.0	2	21.0	4.09	30.2	+	24.0	+	27.2	-	-	-	125.6	67.7	5.1	-	30.1	22.2	53.5	90.0	-	-	4.45	244.1	0.487	3.46	4.92	0.981	1.05	0.943	1.06
5.0	2	30.0	4.83	+	+	+	+	+	-	-	-	136.7 inc. $\frac{1}{2}S_3$	74.2	see $\frac{1}{2}S_1$	-	96.4	inc. $\frac{1}{2}S_7$	+	+	-	-	4.60	307.3	0.575	4.36	5.56	1.402	1.05	1.128	0.89
5.0	4	17.0	3.88	28.0	+	21.5	+	23.9	-	-	-	116.0	74.2	4.8	-	21.6	23.4	50.5	73.5	+	-	4.67	234.3	0.462	3.321	4.50	0.794	1.05	0.849	1.18
5.0	4	21.0	4.16	28.7	+	22.8	+	25.1	-	-	-	120.2	74.2	4.3	-	27.7	33.0	55.5	80.0	+	-	4.66	253.6	0.495	3.595	4.62	0.981	1.05	0.943	1.06
5.0	4	24.0	4.41	29.1	+	23.9	+	26.2	-	-	-	123.4	74.2	4.1	-	31.5	43.3	61.0	98.5	+	-	4.65	270.2	0.525	3.829	4.81	1.121	1.05	1.008	0.99
5.0	6	17.0	3.99	26.2	+	17.6	+	21.75	-	-	-	104.0	74.2	8.6	-	17.5	37.5	40.0	70.0	+	-	4.71	234.7	0.475	3.33	4.29	0.794	1.05	0.943	1.06
5.0	6	21.0	4.36	27.1	+	20.6	+	23.9	-	-	-	112.3	74.2	4.8	-	23.3	51.9	51.0	73.5	+	-	4.69	260.7	0.519	3.70	4.59	0.981	1.05	0.849	1.18
5.0	6	24.0	4.65	27.6	+	21.6	+	23.7	-	-	-	115.2	74.2	4.3	-	28.0	63.0	54.0	75.0	+	-	4.70	279.1	0.554	3.96	4.78	1.121	1.05	1.008	0.99
7.5	2	14.5	3.51	28.0	-	22.8	-	25.35	-	-	-	121.9	65.5	6.1	-	23.9	6.5	-	87.5	-	-	-	218.15	0.418	3.09	4.68	0.678	1.58	0.521	1.93
7.6	2	19.5	4.05	29.1	-	24.15	-	26.6	-	-	-	127.8	65.5	5.9	-	38.7	7.5	-	90.0	-	-	-	239.6	0.482	3.40	4.82	0.911	1.60	0.597	1.68
7.5	2	27.0	4.69	30.0	-	24.0	-	28.5	-	-	-	129.6	65.5	10.8	-	57.2	8.5	-	101.0	-	-	-	258.8	0.558	3.67	4.86	1.262	1.58	0.711	1.41
7.8	4	14.5	3.69	27.4	-	20.1	-	23.4	-	-	-	113.9	65.5	7.9	-	23.4	7.4	-	72.0	-	-	4.80	212.8	0.439	3.01	4.48	0.678	1.64	0.502	1.99
7.6	4	19.5	4.17	28.0	-	21.75	-	25.0	-	-	-	119.1	62.5	7.8	-	39.4	8.8	-	89.5	-	-	4.80	229.9	0.496	3.26	4.62	0.911	1.60	0.597	1.68
7.5	4	27.0	4.88	28.75	-	24.7	-	26.9	-	-	-	128.3	74.4	5.3	-	51.1	20.1	-	98.5	-	-	4.80	273.5	0.581	3.88	4.76	1.262	1.58	0.711	1.41
7.6	6	14.5	3.66	25.3	-	18.1	-	21.2	-	-	-	104.2	68.0	7.5	-	14.3	14.6	-	68.5	-	-	-	203.8	0.436	2.89	4.25	0.578	1.60	0.515	1.94
7.6	6	19.5	4.19	26.8	-	20.3	-	23.3	-	-	-	113.0	75.8	7.2	-	33.6	24.2	-	77.5	-	-	-	248.3	0.499	3.52	4.29	0.911	1.60	0.597	1.68
7.5	6	27.0	4.95	27.7	-	22.5	-	25.2	-	-	-	120.5	75.8	6.5	-	52.6	26.3	-	89.5	-	-	-	275.1	0.589	3.90	4.41	1.262	1.58	0.711	1.41
9.9	3	15.0	3.55	28.05	16.2	21.3	16.2	24.55	-	-	-	115.5	27.5	6.7	-	9.9	5.1	48.0	80.5	84.0	-	3.55	157.3	0.423	2.23	3.89	0.701	2.08	0.403	2.48
9.8	3	19.0	4.05	29.1	+	23.5	+	26.3	-	-	-	122.5	74.2	4.9	-	16.1	5.7	58.0	92.0	+	-	4.66	216.4	0.482	3.067	4.66	0.888	2.06	0.457	2.19
10.0	3	24.0	4.37	30.6	+	24.0	+	27.8	-	-	-	126.5	74.2	5.8	-	37.7 inc. $\frac{1}{2}S_7$		50.5	93.0	+	-	4.64	237.8	0.520	3.37	4.92	1.121	2.11	0.501	1.99
9.9	5	15.0	3.50	25.9	17.0	16.95	14.3	22.6	-	-	-	106.0	25.5	7.7	-	4.4	-	48.0	84.0	44.5	-	3.20	135.0	0.417	1.914	3.57	0.701	2.08	0.403	2.48
9.9	5	19.0	3.99	27.1	+	20.55	+	24.0	-	-	-	112.1	36.3	7.2	-	11.6	6.8	50.5	86.5	+	-	4.10	165.4	0.475	2.344	3.79	0.888	2.08	0.453	2.20
9.9	5	24.0	4.55	28.6	+	22.4	+	26.0	-	-	-	119.1	74.2	6.9	-	63.2 inc. $\frac{1}{2}S_7$		53.0	94.5	+	-	4.66	254.6	0.542	3.61	4.94	1.121	2.08	0.509	1.96
9.9	7	15.0	3.40	23.45	16.8	15.7	13.4	20.2	-	-	-	93.1	24.3	9.9	-	-	-	44.5	84.0	38.0	-	3.00	118.2	0.405	1.675	3.14	0.701	2.08	0.403	2.48
10.0	7	19.0	3.91	24.9	17.3	17.4	14.8	21.9	-	-	-	100.9	27.3	9.7	-	-	-	45.0	87.5	47.0	-	3.30	128.2	0.465	1.817	3.49	0.888	2.11	0.447	2.24
9.7	7	21.0	4.45	26.2	+	19.5	+	23.3	-	-	-	107.5	74.2	8.0	-	9.2	58.3	50.0	89.5	+	-	4.71	247.8	0.530	3.51	4.49	1.121	2.04	0.519	1.93
9.9	9	15.0	3.32	20.3	16.7	12.6	14.0	17.1	-	-	-	78.9	24.5	10.8	-	-	-	-	81.0	-	-	2.94	105.1	0.395	1.49	2.88	0.701	2.08	0.403	2.48
10.0	9	19.0	3.77	22.1	17.3	14.4	13.9	19.3	-	-	-	87.6	25.6	11.8	-	-	-		86.0	-	-	2.92	114.0	0.449	1.62	3.12	0.888	2.11	0.447	2.24
10.0	9	24.0	4.32	24.0	18.4	17.05	15.8	21.35	-	-	-	98.5	30.5	10.3	-	-	-	-	87.5	-	-	3.32	129.5	0.514	1.84	3.24	1.121	2.11	0.502	1.99
12.5	7	14.5	3.01	22.0	8.3	14.0	6.1	18.4	-	-	-	86.4	5.3	10.5	-	-	-	-	73.5	-	-	1.28	94.7	0.358	1.34	2.33	0.678	2.63	0.313	3.20
12.5	7	18.5	3.47	24.1	11.6	16.6	8.9	20.5	-	-	-	95.7	10.8	9.35	-	-	-	-	73.5	-	-	1.87	109.2	0.413	1.55	2.86	0.864	2.63	0.353	2.83
12.5	7	25.5	4.21	26.1	13.4	19.7	10.6	23.2	-	-	-	109.9	14.9	8.4	-	-	-	-	84.5	-	-	2.23	132.7	0.501	1.88	3.06	1.192	2.63	0.415	2.41
12.7	9	14.5	2.70	18.0	8.1	9.9	6.2	14.8	-	-	-	66.9	5.3	11.7	-	-	-	-	82.5	-	-	1.30	73.8	0.321	1.05	1.98	0.678	2.67	0.308	3.24
12.8	9	18.5	3.25	20.6	10.6	13.1	7.6	17.8	-	-	-	80.9	8.5	11.3	-	-	-	-	86.0	-	-	1.60	90.2	0.387	1.28	2.34	0.864	2.69	0.346	2.89
12.6	9	25.5	4.04	23.5	13.0	16.9	10.3	21.0	-	-	-	96.9	10.5	9.85	-	-	-	-	89.5	-	-	2.16	111.1	0.481	1.575	2.90	1.192	2.65	0.412	2.43
12.5	11	14.5	2.47	14.4	10.4	6.6	7.7	11.5	-	-	-	50.4	8.4	11.75	-	-	-	-	84.5	-	-	1.62	59.9	0.294	0.85	1.74	0.678	2.63	0.313	3.20
12.7	11	18.5	2.97	16.9	11.9	9.5	8.3	14.7	-	-	-	63.4	10.4	12.5	-	-	-	-	93.0	-	-	1.74	74.1	0.354	1.05	2.10	0.864	2.67	0.348	2.87
12.5	11	25.5	3.77	20.6	13.7	14.1	10.7	18.8	-	-	-	83.2	15.4	11.3	-	-	-	-	97.5	-	-	2.25	97.1	0.449	1.38	2.62	1.192	2.63	0.415	2.41
12.5	13	14.5	2.23	11.6	12.5	4.8	9.6	9.9	-	-	-	39.4	12.6	12.2	-	-	-	-	99.0	-	-	2.02	45.05	0.265	0.64	1.98	0.678	2.63	0.313	3.20
12.4	13	18.5	2.73	14.0	13.4	7.3	10.3	12.5	-	-	-	52.05	14.5	12.45	-	-	-	-	101.0	-	-	2.16	64.1	0.325	0.91	2.06	0.864	2.61	0.356	2.81
12.7	13	15.5	3.45	17.3	13.9	11.1	10.8	16.2	-	-	-	68.1	15.8	12.2	-	-	-	-	105.5	-	-	2.27	80.6	0.411	1.14	2.48	1.192	2.67	0.409	2.45

\+ appropriate areas measured direct from tracing.

2.2 MODEL SCALE WETTED AREA MEASUREMENTS (CONTD.)

V ft/sec	τ deg.	Δ lb.	d in.	ℓ_1 in.	ℓ_2 in.	ℓ_3 in.	ℓ_4 in.	ℓ_5 in.	ℓ_6 in.	ℓ_7 in.	ℓ_8 in.	$\frac{1}{2}S_1$ sq.in.	$\frac{1}{2}S_2$ sq.in.	$\frac{1}{2}S_3$ sq.in.	$\frac{1}{2}S_5$ sq.in.	$\frac{1}{2}S_6$ sq.in.	$\frac{1}{2}S_7$ sq.in.	ϕ deg.	ϕ' deg.	ϕ_3 deg.	ϕ_4 deg.	h in.	$\frac{1}{2}S$ sq.in.	d/b	C_S	$\bar{\ell}/b$	C_Δ	C_V	$C_\Delta^{\frac{1}{2}}/C_V$	$C_V/C_\Delta^{\frac{1}{2}}$
15.1	11	12.0	1.67	9.05	+	1.7	+	7.05	-		-	27.5	0.8	12.8		-	-	38.5	84.0	+	-	0.4	31.2	0.199	0.442	0.82	0.561	3.18	0.236	4.25
15.4	11	18.0	2.17	12.8	+	4.9	+	10.2	-		-	42.3	1.2	12.8		-	-	40.5	87.5	+	-	3.51	45.4	0.258	0.644	1.05	0.841	3.24	0.283	3.53
15.3	11	24.0	2.83	16.3	5.9	8.6	4.0	14.1	-		-	58.5	2.7	13.1	-	-	-	42.0	91.5	24.5	-	0.9	62.6	0.337	0.887	1.62	1.121	3.22	0.329	3.04
15.1	13	12.0	2.63	8.15	8.5	1.3	5.9	6.3	-		-	21.9	5.75	12.0		-	-	46.0	96.5	26.5	-	1.3	27.2	0.194	0.386	1.06	0.561	3.18	0.236	4.25
15.0	13	18.0	2.06	10.45	8.6	3.65	6.0	8.4	-	-	-	32.7	5.9	11.5		-	-	47.0	94.5	26.5	-	1.3	37.8	0.245	0.536	1.27	0.841	3.16	0.290	3.45
15.2	13	24.0	2.59	13.1	9.0	6.2	6.4	11.4	-		-	45.8	6.6	12.5		-	-	46.5	98.0	28.0	-	1.4	51.7	0.308	0.733	1.53	1.121	3.20	0.331	3.02
15.4	15	12.0	1.46	6.65	11.4	0.55	7.1	5.45	8.6		-	16.6	9.5	11.6	2.0	-	-	51.5	103.5	20.5	3.5	2.6	24.9	0.174	0.353	1.27	0.561	3.24	0.231	4.33
15.3	15	18.0	1.84	8.5	11.3	2.35	7.2	7.8	8.4		-	15.2	9.5	12.9	1.5	-	-	51.5	109.5	21.5	0.5	1.6	32.9	0.219	0.466	1.36	0.841	3.22	0.285	3.51
15.4	15	24.0	2.36	10.6	11.3	4.9	8.7	10.2	-		-	36.0	1.5	12.7	-	-	-	55.5	112.5	14.5	-	2.01	43.0	0.281	0.609	1.65	1.121	3.24	0.327	3.06
19.8	12	10.0	1.22	6.55	-	-	-	4.1	-	4.55	-	13.4	-	11.4		-	-	42.0	89.0		-		14.5	0.145	0.205	0.51	0.467	4.17	0.164	6.10
a.1	12	16.0	1.46	7.85	-	0.3	-	5.7	-		-	18.5		13:o		-	-	41.5	93.0		-		20.0	0.174	0.283	0.61	0.748	4.23	0.204	4.89
19.8	12	22.0	1.76	9.25	-	1.25	-	7.0	-	.	-	24.4		13.95		-	-	39.5	91.5		-		27.1	0.210	0.384	0.71	1.028	4.17	0.243	4.11
20.0	14	10.0	1.16	5.45	5.8	-	3.45	4.0	-	4.25	-	10.4	2.25	11.7		-	-	47.0	101.0	17.5	-	.77	11.8	0.138	0.167	0.68	0.467	4.21	0.162	6.16
19.5	14	16.0	1.46	6.9	5.9	-	4.05	5.85	-		-	15.7	2.7	13.9		-	-	45.0	100.5	24.5	-	.91	18.4	0.174	0.261	0.78	0.748	4.11	0.210	4.75
20.2	14	22.1	1.64	7.65	4.9	1.05	3.15	6.7	-		-	20.4	.65	13.55		-	-	48.0	106.5	20.0	-	.69	21.5	0.195	0.305	0.76	1.033	4.25	0.239	4.18
19.9	16	10.0	1.08	4.5	0.3	-	6.95	3.55	8.1	1.9	-	7.9	.5	11.0	1.4	-	-	52.0	107.0	23.5	3.5	.61	14.7	0.129	0.208	1.31	0.467	4.19	0.163	6.13
20.0	16	16.0	1.39	5.75	9.8	-	6.4	5.2	7.55	4.9	-	12.5	.2	13.0	1.3	-	-	51.0	111.5	22.0	2.5	.48	17.9	0.165	0.254	1.13	0.748	4.21	0.205	4.87
20.0	16	22.0	1.58	6.65	9.75	0.65	6.1	5.8	7.1		-	16.8	.8	12.2	1.1	-	-	52.0	108.0	20.0	9.5	.41	21.5	0.188	0.305	1.12	1.028	4.21	0.241	4.15
25.1	4	1.5	0.66	8.75	-	-	-	-	-	2.2	.55	8.5		5.4		-	-	14.0	23.5		-	-	13.3	0.079	1.183	0.67	0.070	5.28	0.050	19.96
25.0	4	9.0	1.27	17.9	-	1.25	-	6.2	-		-	44.0		12.6		-	-	17.5	27.0		-		54.3	0.151	0.770	1.31	0.421	5.26	0.123	8.11
25.0	4	9.0	1.27	17.3	.	0.7	-	7.95	-		-	40.9		18.5		-	-	18.0	35.0	-	-		55.9	0.151	0.793	1.11	0.421	5.26	0.123	8.11
24.6	4	21.0	2.03	21.7	-	11.15	-	16.65	-		-	77.9		12.65		-	-	31.0	61.0		-	-	83.8	0.242	0.188	1.92	0.981	5.18	0.191	5.23
24.9	4	38.0	3.21	26.0	-	8.15	-	22.2	-	-	-	225.6		8.6		-	-	43.5	77.5		-	-	114.1	0.382	1.617	2.56	1.776	5.24	0.254	3.93
25.0	6				-	-	-	-	-	2 5	.55	4.8		3.5		-	-	23.0	41.0		-	-		0.067	0.103	0.105	0.070	5.26	0.050	19.88
24.2	6	9.0	0.56 1.16	11.5 5.25	-	-	-	3.3	-	4.65	-	23.8		10.8		-	-	24.0	39.0		-	-	3:::	0.138	0.441	0.85	0.421	5.10	0.127	7.87
25.1	6	21.0	1.67	15.65	-	3.2	-	8.15	-		-	43.5		12.6		-	-	25.0	45.0		-	-	51.5	0.199	0.731	1.17	0.981	5.28	0.188	5.33
25.0	6	38.0	2.60	21.1	-	2.05	-	17.5	-		-	78.4		12.7		-	-	36.5	76.5	-	-	-	82.2	0.310	1.165	1.95	1.776	5.26	0.253	3.95
25.0	8					-	-	-	-	1.9	.5	3.1		2.65	-	-	-	30.5	55.5		-	-	4.4	0.046	0.062	0.295	0.070	5.26	0.050	19.88
25.0	8	9.0 1.5	0.39 1.07	7.95 3.7	-	-	-	2.0	-	4.0	-	14.1		9.1		-	-	30.0	53.0		-	-	18.6	0.127	0.264	0.605	0.421	5.26	0.123	8.11
25.1	8	21.0	1.49	11.15	-	1.15	-	6.1	-		-	28.3		12.2	-	-	-	31.5	61.0		-	-	33.9	0.177	0.480	0.82	0.981	5.28	0.188	5.33
25.0	8				-	6.3	-	11.85	-		-	52.1		13.3	-	-		33.0	70.5		-	-	57.5	0.260	0.815	1.305	1.776	5.26	0.253	3.95
25.0	10	38.0	2.18	15.95	-	-	-	-	-	1.8	.5	2.3		2.2		-	-	38.0	67.0		-	-	2.9	0.054	0.041	0.24	0.070	5.26	0.050	19.88
25.0	10	9.0	0.99	6.15	-	-	-	2.05	-	3.65	-	10.0		9.1		-	-	3G:0	70:0		-	-	12.9	0.118	0.183	0.38	0.421	5.26	0.123	8.11
24.7	10	25.0	1.54	9.6	-		-	6.05	-		-	26.0		11.0		-	-	39.0	76.5		-	-	22.2	0.183	0.400	0.755	1.168	5.20	0.208	4.81
25.0	10	38.0	1.97	12.1	-	1::	-	9.05	-		-	38.5	-	11.9		-	-	40.0	82.0		-	-	40.6	0.235	0.575	1.01	1.776	5.26	0.253	3.95

2.3. Model Scale Skin Friction Coefficients

α_k degs	Δ lb.	R lb.	R_F lb.	C_S	C_F x 10^3	$C_\Delta^{\frac{1}{2}}/C_V$	$\bar{l}/b$	R_N x 10^{-6}
4	1.55	0.34	0.23	0.20	1.93	0.051	3.68	0.98
4	1.85	0.40	0.27	0.22	2.04	0.056	3.725	1.04
4	2.25	0.49	0.33	0.26	2.16	0.061	3.75	1.07
4	3.00	0.64	0.43	0.35	2.07	0.072	0.85	1.215
4	3.90	0.88	0.605	0.46	2.20	0.081	0.975	1.395
4	6.10	1.26	0.83	0.66	2.10	0.101	1.16	1.66
4	9.55	1.77	1.10	0.82	2.23	0.126	1.38	1.97
4	13.80	2.35	1.38	0.92	2.50	0.152	1.55	2.22
4	24.60	5.86	4.125	1.26	5.46	0.203	2.075	2.965
6	1.55	0.29	0.13	0.11	1.90	0.051	0.475	0.68
6	1.85	0.32	0.13	0.11	1.88	0.056	3.475	0.68
6	2.25	0.40	0.16	0.145	1.91	0.061	0.515	0.74
6	3.00	0.48	0.165	0.17	1.62	0.071	3.56	0.80
6	3.90	0.65	0.24	0.20	1.99	0.081	0.62	0.885
6	6.10	0.97	0.33	0.315	1.76	0.101	0.75	1.07
6	9.55	1.40	0.41	0.45	1.51	0.129	0.86	1.23
6	13.80	2.00	0.55	0.58	1.59	0.153	1.00	1.43
6	24.60	3.82	1.23	0.82	2.53	0.203	1.28	1.03
6	38.40	8.09	4.05	1.20	5.65	0.254	2.05	2.93
8	1.40	0.28	0.08	0.06	2.14	0.048	0.33	0.47
8	1.55	0.29	0.07	0.06	1.88	0.051	0.33	0.47
8	1.85	0.38	0.12	0.08	2.57	0.056	0.375	0.535
a	2.25	0.43	0.11	0.08	2.25	0.061	0.385	0.555
8	3.00	0.52	0.10	0.10	1.62	0.071	c.415	0.59
8	3.90	0.69	0.14	0.12	1.96	0.080	0.44	0.63
a	6.10	1.07	0.21	0.18	1.92	0.101	0.52	0.74
8	9.55	1.68	0.33	0.27	2.04	0.126	0.615	0.88
8	9.55	1.66	0.315	0.27	1.94	0.126	0.62	0.89
8	13.80	2.33	0.395	0.38	1.75	0.153	0.725	1.04
8	24.60	4.13	0.67	0.55	2.03	0.204	0.935	1.34
8	38.40	6.70	1.275	0.83	2.56	0.255	1.37	1.96
10	1.55	0.45	0.17	0.05	6.07	0.051	0.225	0.32
10	1.85	0.47	0.14	0.04	5.40	0.056	0.22	0.32
10	2.25	0.51	0.11	0.05	3.60	0.062	0.24	0.34
10	3.00	0.64	0.11	0.07	2.60	0.071	0.25	0.36
10	3.90	0.81	0.12	0.08	2.45	0.030	0.26	0.37
10	6.10	1.27	0.19	0.125	2.58	0.101	0.31	0.445
10	9.55	1.95	0.26	0.19	2.35	0.126	0.375	0.54
10	13.80	2.79	0.35	0.22	2.70	0.151	0.445	0.64
10	24.60	4.85	0.50	0.38	2.17	0.201	0.70	1.005
10	38.40	7.71	0.92	0.56	2.73	0.251	1.00	1.43

(V $\simeq$ 25.1 ft./sec.

/2.4.

2.4. Estimates of Full Scale Resistance

α_k degs	V ft./sec.	$C_\Delta^{\frac{1}{2}}/C_V$	$\bar{l}/b$	$R_N \times 10^{-6}$	R/Δ	$C_F \times 10^3$	$R_N' \times 10^{-6}$	$C_F' \times 10^3$	C_S	R'/Δ'
4	25.1	0.051	0.73	1.03	0.219	1.86	2.79	2.50	0.19	0.267
4	25.2	0.061	0.80	1.14	0.218	1.90	3.08	2.46	0.24	0.255
4	25.1	0.081	1.00	1.42	0.226	2.07	3.84	2.37	0.48	0.248
4	25.1	0.126	1.37	1.94	0.185	2.31	5.24	2.27	0.83	0.183
4	25.1	0.152	1.55	2.15	0.170	2.37	5.81	2.23	0.94	0.164
6	25.1	0.071	0.51	0.72	0.160	1.91	1.35	2.63	0.16	0.183
6	25.1	0.081	0.57	0.81	0.167	1.86	2.18	2.59	0.21	0.190
6	25.1	0.101	0.70	0.99	0.159	1.85	2.68	2.50	0.33	0.180
6	24.6	0.129	0.81	1.12	0.147	1.89	3.02	2.46	0.44	0.162
6	25.0	0.153	0.95	1.34	0.145	2.03	3.62	2.40	0.56	0.154
6	25.1	0.203	1.27	1.00	0.155	2.27	4.86	2.30	0.79	0.156
8	25.1	0.053	0.31	0.44	0.223	3.03	1.19	2.87	0.075	0.219
8	25.0	0.048	0.27	0.38	0.200	3.48	1.03	2.92	0.06	0.190
8	25.1	0.071	0.37	0.525	0.173	2.40	1.42	2.78	0.11	0.181
8	25.2	0.100	0.51	0.725	0.175	1.91	1.96	2.63	0.20	0.189
8	23.5	0.143	0.66	0.875	0.169	1.84	2.36	2.56	0.32	0.180
8	24.9	0.153	0.72	1.01	0.169	1.85	2.73	2.50	0.39	0.180
8	23.8	0.190	0.85	1.14	0.163	1.90	3.08	2.46	0.50	0.170
8	25.0	0.204	0.92	1.30	0.168	2.00	3.51	2.40	0.55	0.173
10	25.1	0.051	0.24	0.33	0.290	3.90	0.90	2.99	0.04	0.275
10	25.0	0.062	0.25	0.35	0.227	3.73	0.95	2.96	0.05	0.227
10	25.2	0.101	0.40	0.57	0.208	2.20	1.54	2.74	0.13	0.215
10	25.3	0.151	0.52	0.74	0.202	1.90	2.03	2.62	0.23	0.209
10	23.8	0.200	0.69	0.925	0.194	1.84	2.50	2.52	0.36	0.204
10	25.3	0.251	0.98	1.40	0.201	2.06	3.78	2.39	0.56	0.204
10	12.2	0.328	1.70	1.17	0.199	1.91	3.16	2.44	1.00	0.204
10	12.2	0.392	2.80	1.93	0.227	2.30	5.21	2.27	1.45	0.224

/2.5

2.5. Full Scale Aerodynamic Characteristics

2.5.1. Aerodynamic Lift and Drag (with ground effect corrections)

Flight No.	Speed Knots	α_k degs.	α_w degs.	C_L uncor-rected	$-6a_w$ degs.	α'_w degs.	C_L^2	$-6\,C_L$	C_L cor-rected	C_D
17	124.0	-2.7	1.6	0.700						0.0737
	125.0	1.4	10.7	0.663						0.0720
	135.5	5.0	5.9	0.593						0.0637
	135.5		9.5	0.566						0.0636
	153.5	2.7	7.2	0.468						0.0545
	154.5	-1.4	3.1	0.470						0.0536
18	117.0	3.3	7.8	0.742						0.0730
	136.0	-0.1	4.4	0.560						0.0620
	158.0	-0.1	4.4	0.440						0.0546
	158.0	2.7								0.0542
										0.0496
	171.0 / 168.0	-1.3 / -0.4	4.6	0.366						0.0496
5& 36	114.5	7.0	11.5	0.857						0.0910
	116.0	7.0	11.5	0.877						0.0875
	122.0	5.4	9.9	0.742						0.0770
	125.5	4.4	9.9	0.704						0.0730
	132.0		8.9	0.631						0.0670
	133.5	4.7	9.2	0,622						0.0670
	140.0	3.8	7.2	0.466						0.0660
	152.5	2.7	6.6	0.424						0.0497
	160.0	2.1								0.0520
	167.0	1.8	4.3	0.387						0.0490
			6	0.175	0.321	3.68	0.031	0.0024	0.173	
					0.669	5.33	0.1335	0.0103	0.355	
			8	0.540	0.990	7.01	0.291	0.0225	0.517	
			IO	0.725	1.330	8.67	0.525	0.0406	0.684	
			12	0.910	1.670	10.33	0.827	0.0639	0.846	
			14	1.090	1.998	12.00	1.186	0.0916	0.998	
			16	1.275	2.335	13.66	1.622	0.1253	1.150	
			18	1.460	2.675	15.32	2.135	0.1642	1.296	
			20	1.645	3.015	16.98	2.700	0.2090	1.436	

/2.5.2.

2.5.2. C_D/C_L^2 Characteristics

Flight No.	Speed Knots	C_D	C_L^2
17	124.0	0.074	0.490
	125.0	0.072	0.440
	135.5	0.064	0.352
	135.5	0.064	0.320
	153.5	0.054	0.219
	154.5	0.054	0.221
18	117.0	0.073	0.550
	121.0	0.077	0.550
	134.0	0.065	0.396
	136.0	0.062	0.314
	15a.c	0.054	0.194
	158.0	0.055	0.163
	168.0	0.050	0.127
	171.0	0.050	0.134
21	83.0	0.2%	3.92
	83.0	0.243	3.24
	88.5	0.249	2.82
	93.0	0.183	2.09
	93.0	0.184	2.04
	104.5	0.1405	1.18
35 & 36	114.5	0.091	0.735
	116.0	0.0875	0.770
	122.0	0.077	0.550
	125.5	0.073	0.495
	1 j2.C	0.067	0.398
	133.5	0.067	0.387
	140.0	0.066	0.310
	152.5	0.050	0.212
	160.0	0.052	0.180
	167.0	0.049	0.150

/2.6

2.6. Full Scale Water Drag Measurements (Corrected for ground effect)

light No.	α_k degs.	α_w degs.	V_w knots	V_a knot	C_L	L lb.	Δ lb.	R_w lb.	R_w/Δ
24/1	9.6	+.1	20	23	1.185	890	15,297	2,550	0.167
24/2	12.0	6.5	20	23	1.390	1,040	11,391	2,100	0.1845
24/3	13.0	7.5	20	25	1,475	1,300	14,045	3,110	0.2215
24/1	13.8	8.3	30	33	1.535	2,370	13,817	3,480	0.252
24/3	14.2	8.7	30	35	1.570	2,715	12,630	3,650	0.289
24/2	14.3	8.8	30	33	1.575	2,420	10,011	2,880	0.285
24/3	6.2	3.7	40	45	0.875	2,500	12,845	1,900	0.148
18	6.45	0.95	40	43	0.900	2,350	11,190	1,530	0.1365
24/1	6.6	1.1	40	43	0.920	2,405	13,782	2,130	0.1545
26/2	8.25	2.75	40	43	1.070	2,790	12,783	2,300	0.180
26/3	9.15	3.65	40	43	1.150	3,000	12,161	2,400	0.197
24/1	9.15	3.65	40	43	1.150	3,000	13,187	2,900	0.2215
26/4	9.5	4.0	40	43	1.175	3,065	11,776	2,140	0.182
24/3	9.5	4.0	40	45	1.175	3,365	11,980	2,140	0.1785
24/2	9.55	4.05	40	43	1.180	3,075	9,356	2,180	0.233
22	9.9	4.4	40	43	1.215	3,180	11,980	2,780	0.232
18	10.55	5.05	40	43	1.270	3,315	12,847	2,840	0.221
26/4	11.0	5.5	41	44	1.310	3,580	11,341	2,450	0.216
17	15.0	9.5	40	43	1.625	4,250	11,980	3,500	0.292
24/3	4.95	9.45	50	55	0.755	3,230	12,115	1,750	0.1445
24/1	4.95	9.45	50	53	0.755	3,000	13,187	1,700	0.129
18	5.25	9.75	50	53	0.785	3,115	10,425	1,530	0.1465
26/1	5.55	0.05	50	53	0.820	3,255	12,839	1,720	0.134
24/2	6.0	0.5	50	53	0.860	3,410	9,021	1,310	0.145
24/1	6.7	1.2	50	53	0.925	3,670	12,517	2,190	0.175
24/3	6.75	1.15	50	55	0.920	3,930	11,415	1,960	0.1715
24/2	7.0	1.5	50	53	0.950	3,765	8,666	1,280	0.148
26/3	7.0	1.5	50	53	0.955	3,780	11,381	2,070	0.182
26/2	7.0	1.5	50	53	0.955	3,780	11,793	2,180	0.185
26/4	7.1	1.6	50	53	0.960	3,805	11,036	1,950	0.177
18	7.5	2.0	50	53	1.000	3,970	12,192	2,390	0.196
26/3	7.9	2.4	50	53	1.030	4,080	11,081	1,775	0.160
26/2	6.0	2.5	50	53	1.050	4,160	11,413	2,020	0.177
26/4	8.3	2.8	50	53	1.07:	4,260	10,581	2,060	0.1945
22	9.0	3.5	50	53	1.135	4,505	10,655	2,500	0.235
17	9.4	3.9	50	53	1.170	4,645	11,585	2,980	0.257
24/3	3.0	7.5	60	65	0.570	3,405	11,940	1,690	0.141:
24/1	3.25	7.75	60	63	0.590	3,310	12,877	1,750	0.136
24/3	5.0	9.5	60	65	0.770	4,600	10,745	1,530	0.1425
18	5.05	9.55	60	63	0.770	4,320	9,220	1,420	0.154
24/2	5.3	9.8	60	63	0.785	4,400	8,931	1,640	0.204
26/1	5.5	0.0	60	63	0.810	4,540	11,554	1,560	0.135
24/1	5.6	0.1	60	63	0.820	4,595	12,592	2,180	0.173
24/	5.65	0.15	60	63	0.830	4,640	7,791	1,060	0.137
18	6.6	1.1	60	63	0.915	5,130	11,032	2,040	0.185
22	7.5	2.0	60	63	1.000	5,610	10,067	2,440	0.242
22	8.4	2.9	60	63	1.080	6,050	9,110	2,380	0.261
17	8.9	3.4	60	63	1.12:	6,310	9,920	2,750	0.277
26/1	9.05	3.55	60	63	1.135	6,370	9,724	1,700	0.175
24/3	2.2	6.7	70	75	0.490	3,890	11,455	2,250	0.196:
24/1	2.35	6.85	70	73	0.505	3,810	12,317	2,050	0.1665
24/2	2.6	7.1	70	73	0.530	3,990	8,441	1,750	0.207
24/1	3.3	7.8	70	73	0.600	4,515	12,672	1,980	0.156
24/3	3.35	7.85	70	75	0.60:	4,810	10,535	1,350	0.128
24/2	4:o	8.5	70	73	0.670	5,030	7,401	1,220	0.165
18	4.45	8.95	70	73	0.710	5,350	8,190	1,310	0.1595
26/1	6.3	0.8	70	73	0.885	6,670	9,324	1,490	0.160

/2.6 (Contd.)

2.6 Full Scale Wafer Drag Measurements (Corrected for ground effect) (Contd.)

Flight No.	α_k degs.	a_w degs.	V_w knots	V_a knots	C_L	L lb.	Δ lb.	R_w lb.	R_w/Δ
18	6.65	11.15	70	73	0.920	6,940	9,222	1,700	0.184
22	7.55	12.05	70	73	I.005	7,570	8,107	2,250	0.2775
17	8.0	12.5	70	73	I.050	7,910	8,320	2,450	0.2945
22	8.3	12.8	70	73	1.075	8,080	7,080	2,350	0.332
26/1	10.0	14.5	70	73	1.220	9,190	6,904	1,610	0.233
24/1	1.45	.5.95	80	83	0.420	4,090	12,097	2,070	0.171
24/1	1.95	6.45	80	83	0.470	4,575	92,612	2,150	0.1705
24/3	2.05	6.55	80	85	0.475	4,850	10,495	2,310	0.220
24/2	2.55	7.05	80	83	0.525	5,110	7,321	1,500	0.205
24/2	3.05	7.55	80	83	0.575	5,590	6,841	1,320	0.193
24/3	3.2	7.7	80	85	0.585	5,980	9,465	1,650	0.1745
18	3.45	7.95	80	83	0.610	5,940	10,222	1,350	0.132
18	5.05	9.55	80	83	0.770	7,490	6,050	905	0.150
22	6.65	11.15	80	83	0.920	8,960	6,717	1,905	0.2835
26/1	9.0	13.5	80	83	1.130	1,000	5,094	1,260	0.247
17	10.0	14.5	80	83	1.220	1,900	4,330	1,320	0.3045
26/1	10.85	15.35	80	83	1.300	2,660	3,434	1,070	0.312
22	11.8	16.3	80	83	1.375	3,400	1,760	1,450	0.824
24/2	2.05	6.55	90	93	0.475	5,800	6,631	1,200	0.181
24/2	2.3	6.8	90	93	0.500	6,100	6,331	1,340	0.212
18	3.1	7.6	90	93	0.575	7,020	9,142	900	0.0985
22	5.0	9.5	90	93	0.760	9,280	6,397	1,550	0.242

/2.7

2.7 Mean Full Scale Water Drag For Comparison With Estimates

α_k degrees	C_L	V_a knots	V_W knots	L lb.	Δ * lb.	$C_\Delta^{\frac{1}{2}}/C_V$	R_W/Δ
4	0.670	53	50	2,655	12,345	0.1475	0.140
		63	60	3,760	11,240	0.106	0.132
		73	7C	5,050	9,950	0.0945	0.149
		83	PO	6,520	8,480	0.0765	0.153
		93	90	8,190	6,810	C.061	0.224
6	0.860	43	40	2,245	12,755	0.1875	0.142
		53	50	3,415	11,585	0.1425	0.147
		63	60	4,830	10,170	0.111	0.165
		73	70	6,470	8,530	C.088	0.173
		a3	80	8,370	6,630	0.068	0.172
8	1.050	43	40	2,740	12,260	0.1945	0.173
		53	50	4,170	10,830	0.138	0.200
		63	60	5,890	9,110	0.1055	0.250
		73	70	7,910	7,090	0.080	0.235
		83	80	0,250	4,750	0.057	0.215
10	1.220	23	20	910	14,090	0.324	0.165
		43	40	3,185	11,815	0.182	0.222
		53	50	4,840	10,160	0.1335	0.252
		83	80	1,890	3,110	0.046	0.202

* based on an all-up weight of 15,000 lb.

/LIST OF SYMBOLS

LIST OF SYMBOLS

All symbols used have the same meanings as in M.A.E.E. Report F/Res/263 (defined on p.11 and in Figure 8 of that report) though it should be noted that the units are different in some cases. The following additional symbols have been used in the present report, and additional geometric parameters are illustrated in Figure 1.

4	Air drag coefficient, full scale	
C_L	Air lift coefficient, full scale	
L	Air lift, full scale	
R_N	Reynolds Number, model scale	
R_N'	Reynolds Number, full scale	
R_W	Water drag, full scale	
V_a	Air speed, full scale	
V_W	Water speed, full scale	
a_W	Wing incidence, actual	
α'_W	Wing incidence, corrected.	cf. Appendix I, F/Res/263
$\delta\alpha_W$	Wing incidence correction	cf. Appendix I, F/Res/263
δC_L	Air lift coefficient correction	cf. Appendix I, F/Res/263

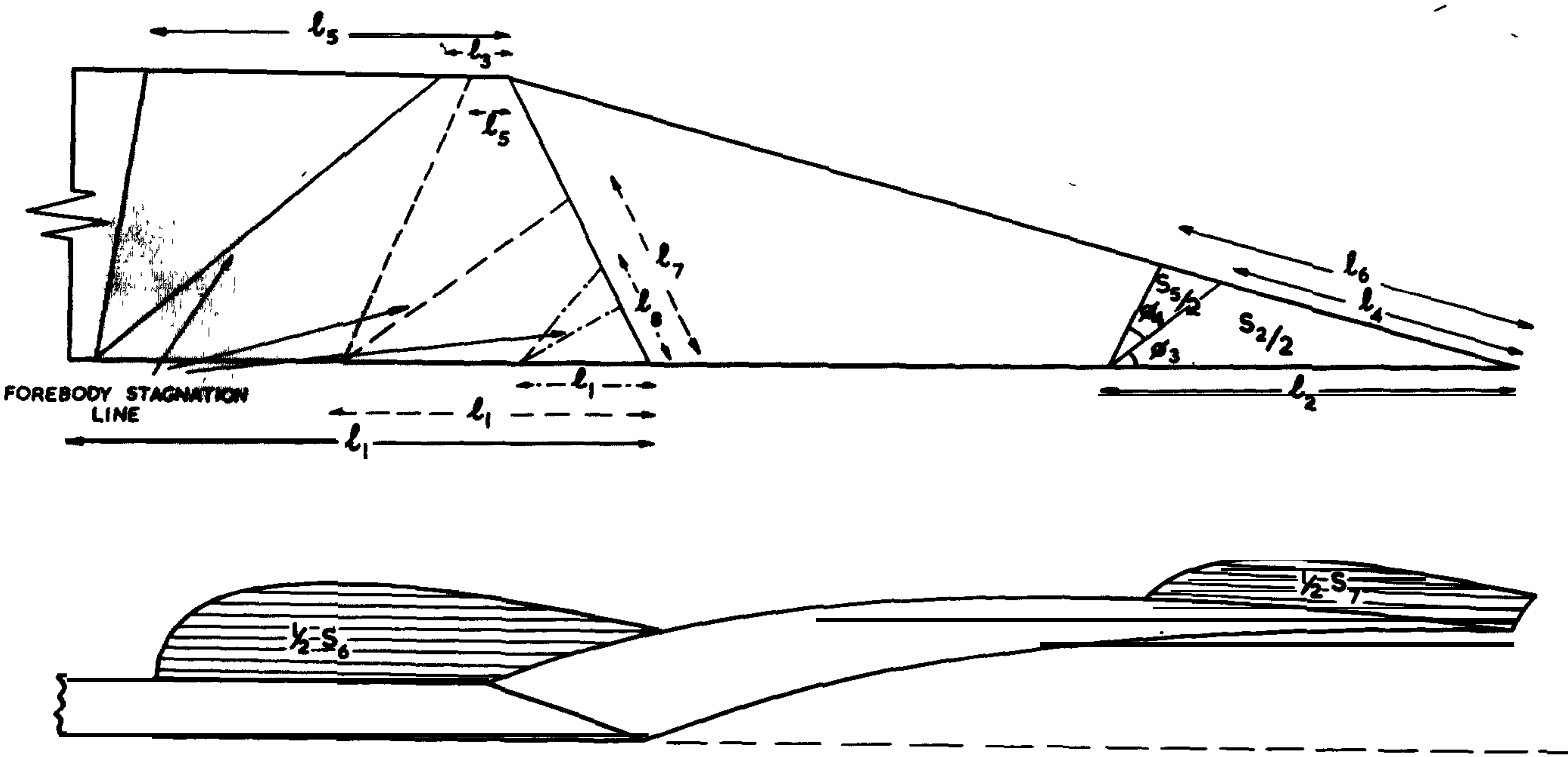

FIG. .

NOTATION USED IN WETTED AREA INVESTIGATION

(SEE ALSO FIG. 8, F/RES/263)

C.P. No. 284

18.0221

A.R.C. Technical Report

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