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Methods for Reducing Seaplane Take-Off Distances to Standard Conditions

By

J. A. Hamilton

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METHODS FOR REDUCING SEAPLANE TAKE-OFF DISTANCES TO STANDARD CONDITIONS

by

J.A. Hamilton

SUMMARY

In this report are developed methods for the reduction of seaplane take-off distances to standard conditions of weight, wind and ambient temperature. The expressions derived are applicable to the waterborne run and to the airborne run up to the 50 foot height point. The methods may be applied to take-off with simulated engine failure.

The theoretical results are in good agreement with measurements made on reciprocating engined seaplanes of 9000 lb. and 78,000 lb. weight for winds up to 20 knots, weight changes of 20% and a temperature range of 2 to 32 degrees C.

However the general application of the corrections should be limited to temperature changes of less than 10°C, weight changes of less than 10% and wind changes of less than 10 knots. These ranges should be adequate for the majority of flight trials conducted in one location.

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/ 1. INTRODUCTION

1. INTRODUCTION

The correction to standard conditions, of seaplane take-off distances to 50 foot height presents problems not entirely covered by the established methods for landplanes. At present, corrections are utilised for the unstick distance which have been developed over a number of years. Some of these have been confirmed only for flying boats having power/weight ratios, and wing and hull loadings low compared with existing and future aircraft.

During the course of an extensive series of tests to investigate the airworthiness problems of contemporary flying boats, considerable information was collected on the effect of such parameters as wind speed, take-off speed, weight and atmospheric temperature on take-off distance.

In this report the results from these tests are compared with corrections developed speciallly for the seaplane. Although the report demonstrates good agreement between measurement and theory over the following ranges of parameters,

wind	5 - 20 knots,
weight	80% to 100% of maximum,
temperature	2 - 32 degrees C,

its primary function is not to provide expressions which are generally valid over these ranges but to provide a means of correcting measurements in any one location to the standard conditions appropriate to that location e.g. in the United Kingdom, to temperate standard.

2. DESCRIPTION OF AIRCRAFT

The aircraft utilised for the experimental work was a production Seaford, converted to the profile of a civil Solent (Figure 1).

The hull of this seaplane is representative of flying boat design practice in the 1940-1950 era, but its forebody length/beam ratio of 3.36 is somewhat less that that normally employed at the present time, (1953).

The engines are Hercules Mk.19, (reciprocating) giving a nominal power of 1,700 h.p. for sea level take -off.

A few results were available from a much smaller seaplane, the Sealand (weight 9,100 lb.) and these have been included to check the applicability of the correction over as wide a range of size as possible.

Details of both aircraft are given in Tables 1 and 2.

3. RANGE OF TESTS AND TEST TECHNIQUE

The following ranges of parameters were investigated,

Solent

(a) weight, 60,000 to 78,000 lb.,
(b) temperature, 2 deg. to 32 deg. Centigrade, the latter being obtained in a series of sub-tropical trials in the Suez Canal Zone,
(c) wind speed, 4-22 knots,
(d) climb away speed, 90-108 knots.

Sealand

(a) weight 8,200 to 9,000 lb.,
(b) wind speed 5 to 10 knots.

/A consistent

A consistent take-off technique was employed throughout the tests. At the start of take-off, the aircraft was held into wind with engines idling; the throttles were then opened as quickly as possible, and unstick from the water achieved at the specified indicated airspeed. No elevator or trim tab positions were specified, but examination of representative attitude curves showed that the variation of attitude between take-offs was remarkably small.

After unstick , the aircraft was accelerated in level flight to the specified climbing speed, and then climbed away to 50 foot height keeping the climb speed constant. Care was taken to avoid an artificial rate of climb by "zooming".

Occasional deviations from this technique occurred during the accelerating airborne run, when the aircraft was allowed to climb instead of being flown parallel to the water surface, and during the actual climb away, when the climb speeds tended to wander from the specified constant value. However, with practice, pilots became adept at eliminating these errors.

A few tests (those with the high wind speed of 22 knots on the Solent) were done in which the aircraft was allowed to accelerate steadily throughout climb, the aim being to arrive at the 50 foot height at a pre-determined air speed.

4. INSTRUMENT INSTALLATION

4.1. Internal

Quantities being measured within the aircraft were recorded on a single automatic observer, using a Bell Howell A.4 camera operating at 5 frames per second (Figure 2). Details of the instruments recorded are given in Appendix I.

All instruments were calibrated at intervals throughout the trials and checked in situ before each day's work.

4.2. External

Take-off distances were measured by means of an optical method, using an F.47 and a modified Bell Howell A.4 camera. Briefly this method employs two cameras, situated at either end of a measured base line. The cameras are synchronised manually, and record the bearing of the aircraft throughout the take-off run. A simple graphical plot from the recorded bearing gives the required take-off run. The base lines were specially surveyed for these tests.

Wind speed was recorded during each take-off by a hand held vane type anemometer operated from a marine craft situated near the take-off path.

Outside air temperature and pressure were measured on the aircraft, and were checked against the readings of a nearby meteorological office.

Humidity was obtained from the meteorological office.

5. CORRECTION FORMULAE

5.1. Waterborne run

The problem of reducing the seaplane water run to standard conditions is similar to that for the landplane, with the added complication of the variation of water resistance with load, speed and attitude. Therefore, the derivation of suitable expressions for the seaplane has been attempted in a similar fashion to that for the landplane, utilising in particular the methods demonstrated in Reference 1. The basis of these methods rests on the assumption that in a landplane ground run, the acceleration falls off as the square of the speed, and that therefore,

$$a = a_o \left[1 - r \left(\frac{U}{U_t} \right)^2 \right], \qquad 1.$$

where $r = 1 - \frac{a_t}{a_o}$,

a_t = longitudinal acceleration at any instant during the waterborne run,

U_t = water speed at the same instant,

a_o = longitudinal acceleration at the start of the waterborne run,

U = unstick speed.

Hence, all the relevant reduction formulae can be expressed in terms of a mean acceleration a_m, which applies to a mean velocity $U_t/\sqrt{2}$.

Now arises the question of the validity of applying this assumption to the seaplane. Examination of a large number of acceleration records from seaplanes varying in weight between 9,000 and 80,000 lb. shows that a typical acceleration curve is of the form given in Figure 3, i.e. apart from a region at low speed, the acceleration is nearly constant. There are variations from this typical curve, depending on keel attitude during take-off, hull lines, etc., but the fundamental shape is generally of the form shown.

This form of acceleration curve implies that the mean acceleration exists at any speed in the planing region, i.e. after the speed corresponding to maximum resistance, but to keep in step with landplane corrections all mean acceleration corrections are referred to a velocity of 0.7 U_t. This assumption is also very convenient for reducing the complication of several of the correction formulae.

With these assumptions, the equation of motion may be written

$$\frac{a_m}{g} = \frac{T_m}{W} - \frac{D_m}{W} - \frac{R_m}{W}, \qquad 2.$$

where a = longitudinal acceleration,

T = total engine thrust,

D = air resistance,

R = water resistance,

W = mean take-off weight,

m refers to mean conditions i.e. at $0.7U_t$

and the relationship between the waterborne run X and a_m is

$$X = \frac{U_t^2}{2a_m}. \qquad 3.$$

From energy considerations,

$$F_m X = \frac{WU_t^2}{2g}, \qquad 4.$$

/where

where F_m = excess thrust at mean speed,

$$\text{and } F_m = \frac{W a_m}{g} \qquad 5.$$

These expressions are only strictly correct if the forward velocity at the start of the waterborne run is zero. Most seaplanes have a taxying velocity while the engines are idling, amounting to about 5% of the take-off speed. The error involved in ignoring the initial speed will be of the order of ½%. Considering the usual order of the corrections to be applied, this small additional error may be neglected.

All the later corrections are based on these expressions.

5.1.1 Corrections for wind speed and unstick speed

These are considered together since they are of the same form. The effect of wind on waterborne distance is twofold.

(i) The water speed at unstick is reduced - assuming the pilot leaves the water at constant T.A.S.

(ii) The mean water resistance is reduced owing to the reduced waterborne load at a given water speed.

Jones considered the wind correction in Reference 2 and deduced from measurements on seaplanes of that time (1934) that changes in resistance due to wind could be ignored, i.e. that the longitudinal acceleration would be the same with and without the presence of wind.

Jones obtained an expression of the form

$$X_s = \frac{X_a}{\left(1 - \frac{V_w}{V t_s}\right)^2} \qquad 6.$$

where X_s = waterborne run in zero wind,

X_a = measured waterborne run,

$V t_s$ = true air speed at unstick under standard conditions,

V_w = wind speed.

This may be written

$$\frac{X_s}{X_a} = \frac{{V_t}^2}{{U_t}^2} \qquad 7.$$

where V_t = true air speed at unstick,

U_t = water speed at unstick.

The validity of Jones' neglect of the effect of wind on resistance has been re-examined in the light of acceleration measurements made in the present investigation and the conclusion is that for seaplanes having wing loadings of 30-50 lb/sq. foot and greater, the effect on acceleration is

/negligible

negligible. For seaplanes of wing loadings of the order of 20 - 30 lb/sq.foot the effect is such that for wind corrections of greater than 10 f.p.s. the effect of wind on resistance may be appreciable. Unfortunately no simple analytical expression could be evolved for this part of the wind correction and such aircraft will have to be considered individually.

With this qualification Jones' expression may be accepted.

Standard unstick distances for seaplanes are usually quoted in terms of a standard T.A.S., and in zero wind i.e. in terms of a standard water speed at unstick. This being so, the corrections for wind and unstick speed can be combined to give a simple correction

$$\frac{X_s}{X_a} = \left(\frac{U_{t_s}}{U_{t_a}}\right)^2 \qquad 8.$$

where

X = waterborne distance,

U_t = water speed at unstick

and a and s refer to measured and standard conditions respectively.

5.1.2. Weight correction

The weight correction has been applied at constant speed. This assumes that in zero wind, the unstick water speed for the two weights being considered is the same. If they are not, then the speed correction of para. 5.1.1. must be applied. Details of the weight correction are given in Appendix II. The final expression is,

$$\frac{X_s}{X_a} = \frac{W_s}{W_a} \cdot \frac{F_{ma}}{F_{ms}} \qquad 9$$

where

X = Waterborne distance

W = Aircraft weight

F_m = Mean excess thrust during waterborne run

and a and s refer to measured and standard conditions respectively.

Of these quantities, X_a, W_s and W_a are known; F_{ma} may be deduced from the measurements made (cf. Appendix II). The problem is to determine F_{ms}, the excess thrust under standard conditions. F_{ms} may be obtained from F_{ma} by making the following assumptions.

(a) At the mean speed, the load on the water is equal to half of the total weight. This implies that the attitude of the aircraft remains constant between the mean speed and the unstick speed. Examination of a large number of typical take-off runs confirms that this is a reasonable assumption.

(b) The effect of the change in air drag due to weight change is negligible compared with the change in water drag.

(c) The coefficient $\frac{R_s}{\Delta}$ does not change with weight. (Δ is the waterborne load).

/(b) and (c)

(b) and (c) are admitted to be sweeping assumptions and their only justification at present is that corrections of the right order are obtained by making them (Figures 7 and 8). The problem is that the variation of water resistance with weight is not easily expressible analytically and one is faced with either a rigorously justifiable but cumbersome correction or an easily applied correction based on some oversimplification. With these assumptions a simple expression may be deduced (Appendix II) for the change in water resistance with weight, viz:

$$\delta R = \left(\frac{R}{\Delta}\right)_m \left(\frac{W_s - W_a}{2}\right) \qquad 10.$$

where $\left(\frac{R}{\Delta}\right)_m$ is the ratio $\frac{\text{water resistance}}{\text{load on water}}$

at the mean waterborne speed.

To apply this expression some value has to be deduced for $\left(\frac{R}{\Delta}\right)_m$. This may be obtained from tank tests on the hull or similar hulls or from generalised data, see for example, Ref.4. A typical value is 0.17.

Knowing the change in resistance δR, F_{ms} follows from the expression

$$F_{ms} = F_{ma} + \delta R \qquad 11.$$

and knowing F_{ms}, X_s may be deduced from equation 9.

5.1.3. Corrections for atmospheric temperature and pressure

Temperature and pressure effects on take-off appear primarily as alterations in thrust and may be corrected by substituting the appropriate values of nett thrust in equation 9. If δF is the change in thrust due to temperature and pressure changes then

$$F_{ms} = F_{ma} + \delta F \qquad 12.$$

Combining this expression with equation 11 gives a total correction to nett thrust for weight, temperature, and pressure, of the form

$$F_{ms} = F_{ma} + \delta R + \delta F \qquad 13.$$

and the final corrected waterborne distance is given by

$$\frac{X_s}{X_a} = \frac{W_s}{W_a} \frac{F_{ma}}{(F_{ma} + \delta R + \delta F)} \qquad 14.$$

5.2. Airborne Path

Corrections for the airborne path have been developed fully in Reference 1. The main modifications in this report have been made to render the appropriate expressions more convenient for routine handling.

5.2.1. Corrections for speed and wind

These have been combined as for the water run to give the expression,

$$\frac{X_{cs}}{X_{ca}} = \frac{(U_{cs}^2 - U_{ts}^2)/2g + 50}{(U_{ca}^2 - U_{ta}^2)/2g + 50} \qquad 15.$$

/ 5.2.2.

5.2.2. Corrections for weight and thrust

Corrections for weight and thrust, including the effect of temperature, pressure and drag, may be applied in one stage, using the relation,

$$\frac{X_{cs}}{X_{ca}} = \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_a} X_{ca} \Big/ \left\{ \frac{U_{ca}^2 - U_{ta}^2}{2g} + 50 \right\} \right]^{-1} \qquad 16.$$

where δF is the sum of the changes in effective thrust brought about by changes in weight, temperature, pressure, etc. Evaluation of these is discussed in detail in Reference 1.

5.2.3. Correction of airborne distance with engine failure

The correction methods developed for the all-engine airborne distance may be applied equally to the airborne distance with simulated engine failure. Considering the distances prior to and after failure, the following relationships result:

Before failure

Correction for speed and wind,

$$\frac{X_{cs}}{X_{ca}} = \frac{(U_{fs}^2 - U_{ts}^2)}{(U_{fa}^2 - U_{ta}^2)} \qquad 17.$$

Correction for weight and thrust,

$$\frac{X_{cs}}{X_{ca}} = \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_a} X_{ca} \Big/ \left\{ \frac{U_{fa}^2 - U_{ta}^2}{2g} \right\} \right]^{-1} \qquad 18.$$

Where U_{fa} = speed relative to water at engine failure.

After failure

Correction for speed and wind,

$$\frac{X_{cs}}{X_{ca}} = \frac{(U_{cs}^2 - U_{fs}^2)\ /2g + 50}{(U_{ca}^2 - U_{fa}^2)\ /2g + 50} \qquad 19.$$

Correction for weight and thrust,

$$\frac{X_{cs}}{X_{ca}} = \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_a} X_{ca} \Big/ \left\{ \frac{U_{ca}^2 - U_{fa}^2}{2g} + 50 \right\} \right]^{-1} \qquad 20.$$

6. COMPARISON WITH MEASUREMENTS

Wherever possible, the corrections derived in Section 5 and Appendix II have been compared with results covering an appreciable range of the parameter concerned. This is a much more satisfactory method of proving such expressions than relying entirely on their ability to reduce the scatter of an uncorrected set of results.

/ 6.1.

6.1. Waterborne distance

6.1.1. Correction for wind and speed

Figure 4 shows the variation of take-off distance with unstick speed at constant weights of 61,000, 69,000 and 77,000 lb.

The theoretical correction assuming that distance is proportional to U_t^2 follows the experimental points closely for $7,000 > U_t^2 > 5,000$ i.e. for a range of unstick water speeds of 70 to 84 knots. That this agreement is becoming less close at values of $U_t^2 < 4,000$ is indicated by a small number of points for a weight of 69,000 lb. These were obtained in wind speeds $>$ 20 knots and they suggest that for winds of this order the formulae of the present note are overcorrecting.

Since the wind correction assumed may be in some doubt because of the omission of the resistance component, the take-off distances, corrected to a common true airspeed at take-off, have been plotted against wind speed in Figure 5. Here again agreement with the simple form is good up to 18 knots wind speed. Results at 18 to 22 knots (Table 2) show the correction to be inaccurate above 18 knots but are not shown on Figure 5 to avoid confusion as they are at 69,000 lb.

In Figure 6 is plotted a corresponding diagram for the Sealand, (wing loading 25 lb./sq.foot). Here, the variation of estimated and actual take-off distances with wind speed is similar, but there is a discrepancy of about 8 per cent between the two. Apparently, the resistance component of the wind correction is becoming appreciable for seaplanes of this wing loading. (see Section 5.1.1.).

6.1.2. Corrections for weight and thrust

The measured variations of waterborne distance with weight in temperate (ambient temperature 10°C) and sub-tropical (ambient temperature 32°C) conditions are given in Figure 7.

In this figure are plotted also the estimated take-off distances at 78,000 lb. based on the measured distances at 61,000 lb. The estimates are based on the correction formulae of section 5.1.2. using a mean $\frac{R}{\Delta}$ of 0.175. This value has been deduced from the full scale resistance measurements of Reference 3.

Corresponding measured and estimated distance/weight variations for the Sealand are given in Figure 8. In the absence of measured values of $\frac{R}{\Delta}$ for the Sealand, the Solent value of 0.175 has been used. This should not be greatly in error since the two hulls are of similar shape and are operating at similar hydrodynamic loadings.

When the distances have been corrected to the same water speed at unstick the variation of waterborne run with atmospheric temperature is primarily variation with power. Figures 9 and 10 give the measured and estimated distance/power variations for weights of 77,000 and 61,000 lb. The measured distances are the means of the individual points given in Figure 7.

Horsepowers are the values measured by the aircraft's torquemeters and propeller efficiencies have been based on wind tunnel tests of a propeller similar in form to those fitted on the Solent.

6.1.3. Comparison between corrected and uncorrected results

The effect of the normal variations on measured take-off performance may be obtained by comparing Figures 7 and 11. In Figure 11 the sub-tropical and temperate distances have been plotted as measured and in Figure 7 the corrections developed in this report have been applied to bring each set of results to its mean values of power and take-off speed.

/ 6.2.

6.2. Airborne distances

The demonstration of the agreement between the measured and estimated variations of airborne distance with speed, weight, and thrust follows the same pattern as that for the waterborne distance.

Figures 12 and 13 show the combined variation with unstick speed, climb speed and wind speed.

Figure 14 shows the variation with weight and atmospheric temperature. The estimated distance at 77,000 lb. is based on the measured distance at 61,000 lb. and the correction of Appendix II. The change in nett accelerating thrust has been attributed entirely to a change in the drag due to lift, assuming C_L to be proportional to weight.

This figure also shows for general information, the effect of differing climb-away speeds on the airborne distance.

Finally, Figure 15 shows the uncorrected airborne distance results for comparison with Figure 14. The figures for the Solent at 69,000 lb. at 22 knots windspeed have not been included because of the different technique used and unknown corrections for these high wind speeds. (See para.6.1.1.).

7. DISCUSSION

The expressions developed in this report are intended for small corrections only. That their agreement with measured values has been demonstrated by using relatively very large variations in the appropriate parameters is intended only as proof of their usefulness for small corrections i.e. for correcting results made in temperate conditions at one nominal weight, to the standard value in temperate conditions.

They may be utilised to obtain rough preliminary estimates of such quantities as the increase in take-off distance when the seaplane is operated in tropical atmospheres but for an accurate estimation a more detailed analysis will be necessary, taking account of the non-quadratic variation in acceleration with speed in the region of maximum water resistance.

The most doubtful correction is that for weight, not only because of the assumptions made in developing it but also because it involves the estimation of $\frac{R}{\Delta}$ - a factor not easily resolvable into a general form.

8. CONCLUSIONS

Expressions have been developed for weight, speed, drag and thrust corrections to seaplane take-offs. These have shown good agreement with measured values over a much wider range of the appropriate variables than is normally encountered.

Use of the expressions should be confined however to the following ranges of parameter

Temperature	± 10°C from the standard value
Wind	± 10 knots from the standard value
Weight	± 10% from the standard value

The wind correction may be in error for seaplanes of wing loadings less than 30 lb/sq.foot though for wing loadings between 20 and 30 lb./sq. foot the error in correction should not exceed 20%.

9. ACKNOWLEDGEMENTS

Acknowledgement is made to Mr J. Taylor for his work in obtaining the full scale information as Chief Observer on the flight tests and his help in preparing the report.

/LIST OF SYMBOLS

LIST OF SYMBOLS

Symbols

Force

D	Air Resistance	lb.
R	Water Resistance	lb.
W	Aircraft Weight	lb.
T	Gross Thrust	lb.
F	Nett Thrust	lb.
Δ	Water Lift	lb.
L	Air Lift	lb.

Acceleration

a	Forward Acceleration

Speed

U	Speed Relative to Water Surface	f.p.s.
V	True Air Speed	f.p.s.
V_i	Equivalent Air Speed	f.p.s.
V_w	Wind Speed	f.p.s.

Distance

X	Distance	feet

Subscripts.

Subscripts are used with these symbols to distinguish various parts of the take-off run

a	Refers to conditions during actual measurement
s	Refers to standard conditions
m	Refers to a mean condition usually defined in the text.
o	Refers to conditions at start of waterborne run.
t	Refers to conditions at unstick or during the waterborne run.
c	Refers to condition at the screen height (50 feet here) or during the airborne part of take-off.

Thus V_t	is the T.A.S. at unstick.
V_{mt}	is the T.A.S. at mean conditions during the waterborne run.
V_c	is the T.A.S. at screen height.
V_{mc}	is the T.A.S. at mean conditions during the airborne run.

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LIST OF REFERENCES

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/ APPENDIX I

APPENDIX I

INSTRUMENTATION

The following quantities were recorded in the automatic observer:-

Quantity	Method of Measurement	Range and Accuracy
Aerodynamic Controls		
Aileron Rudder Elevator } Forces, angular movements and trimmer positions.	Desynn system. Aileron and elevator forces measured by R.A.E. twin-axis control wheel force recorder, fitted to the second pilot's control column in lieu of wheel. Rudder force measured by R.A.E. type pedal force recorders.	
Flap angle	Desynn angular movement recorder.	25° $\frac{1}{4}^\circ$
Aircraft Orientation and Position		
Pitch angle Roll angle	Indicated by microammeter from Anschutz horizontmutter electrical gyroscope. These readings were checked during the tests by comparison with bubble. inclinometers reading to $1/10^\circ$ over range of 8°.	Range: Pitch - 50° Roll - 90° Accuracy: $\frac{1}{4}^\circ$ during take-off and landing manoeuvres. Correct to $1/6^\circ$ in steady conditions.
Rate of yaw and roll	R.A.E. rate gyroscope with desynn indicator.	10. 25 and 50 deg. per second.
Direction	Compass repeater from standard R.A.F. distant reading compass.	360° 1°
Sideslip	R.A.E. desynn vane recorder.	Range: $\pm 30^\circ$. Accuracy: $\frac{1}{2}^\circ$.
Airspeed E.A.S.		
(i) Pitot head and static vent.	Low reading A.S.I.	
(ii) Pitot in venturi and trailing static.		Accuracy: 1 knot.
(iii) Pitot in venturi and static reservoir.		

/Altitude

APPENDIX I (Contd.)

Quantity	Method of Measurement	Range and Accuracy
Altitude	(i) Kollsman sensitive aneroid altimeter. (ii) Radio altimeter Type AYF.	10 feet. Unreliable during initial climb and final approach. Later abandoned.
Acceleration		
Longitudinal acceleration.	R.A.E. type 2-2 desynn accelerometer mounted rigidly to the main spar near C. of G.	-0.3 to +1.0g. Accuracy: 0.01g.
Normal acceleration.	Kollsman visual V.G. recorder.	Not used in automatic observer.
Engine Power		
Torque	4 Bristol type torquemeters with steel capillary tubing and Bourdon type gauges.	0-800 lb. 1 lb. p.s.i.
Engine speed	4 electric R.P.M. indicators.	
Miscellaneous		
Time	3-second timer stopwatch. Later replaced by master contactor driving a Veeder counter.	1/200 second. Indicates each $\frac{1}{2}$-second. By interpolation of film frames accuracy = 1/20 second.
Fuel contents	4 'gallons gone' indicators.	
Event lights	These operated by human observer to indicate events not recorded elsewhere, e.g. landing and take-off points, arbitrary end of recording, etc.	
Air temperature	Balanced bridge air thermometer.	
Water contact		
Means of indicating the time of making or breaking contact with the water.	Make and break, electrical circuit dependent on external pressure on diaphragm, between hull of flying boat and water.	used in automatic observer and on pilots, coaming indication light. Operationally instantanious.

/ APPENDIX II

APPENDIX II

DEVELOPMENT OF CORRECTION FORMULAE

1. WATERBORNE DISTANCE

1.1. The effect of changes in weight, thrust and drag

If we assume that the waterborne distance can be experessed in terms of mean values then:

$$F_{ma} = \frac{W_a \, U_{ta}^2}{2g \, X_{ta}} \qquad \text{II. 1}$$

where

X_{ta} = measured waterborne distance,

W_a = aircraft weight during run,

U_{ta} = water speed at unstick,

F_{ma} = mean excess thrust under conditions of test.

Assuming that the measured waterborne distances have been corrected to the standard unstick water speed, we may write

$$\frac{X_{ts}}{X_{ta}} = \frac{F_{ma}}{F_{ms}} \cdot \frac{W_s}{W_a} \qquad \text{II. 2}$$

where

X_{ts} = waterborne distance in standard conditions,

F_{ms} = mean excess thrust in standard conditions,

W_s = standard weight.

Now in Expression II 2, X_{ta}, W_a and W_s are known and F_{ma} may be deduced from the test measurements (Equation II.1). The problem is to derive an expression for F_{ms}.

For alterations in thrust and air drag, F_{ms} may be deduced directly from F_{ma} if the changes in thrust and drag are known or can be estimated, e.g. changes in thrust owing to change in engine power with ambient temperature and changes in air drag owing to the addition of external stores.

To correct for alterations in weight, we make the following assumptions.

(a) The mean waterborne load is $\frac{W}{2}$, i.e. the wing incidence remains constant between mean speed, 0.7 U_c, and unstick speed, U_t. This is a close approximation to the usual seaplane take-off technique.

(b) The air drag variation with weight is small in comparison with the water drag variation.

(c) The ratio $\frac{\text{water drag}}{\text{waterborne load}} = \frac{R}{\Delta}$ does not change with weight.

/If

If now the difference between the aircraft test weight and standard weight is δW, and the corresponding change in drag is δR, we may write

$$\delta R = \left(\frac{R}{\Delta}\right)_m \cdot \frac{\delta W}{2} \qquad \text{II. 3.}$$

Where δW is known, $\left(\frac{R}{\Delta}\right)_m$ must be deduced from tank tests on the hull or similar hulls or from generalised curves; see, for example, Reference 4. Hence, knowing δR,

$$F_{ms} = F_{ma} + \delta R,$$

and the standard waterborne distance X_{ts} follows from Equation II 2.

2. AIRBORNE DISTANCE

2.1. The effect of changes in unstick, climb and wind speeds

If U_{ta} = actual take-off water speed = $(V_{ta} - V_W)$,

U_{ca} = actual climb speed relative to the water,

γ_a = actual climb gradient and U_{ts}, U_{cs}, γ_s are the corresponding standard values,

then

$$X_{ca} = \frac{1}{\gamma_a} \frac{U_{ca}^2 - U_{ta}^2}{2g} + \delta h \cos \gamma_a \qquad \text{II. 4.}$$

$$X_{cs} = \frac{1}{\gamma_s} \frac{U_{cs}^2 - U_{ts}^2}{2g} + \delta h \cos \gamma_s \qquad \text{II. 5.}$$

where

δh = 50 feet normally

and assuming

$$\gamma_a \to \gamma_s \to 0$$

we can write

$$\frac{X_{cs}}{X_{ca}} = \frac{(U_{cs}^2 - U_{ts}^2)/2g + 50}{(U_{ca}^2 - U_{ta}^2)/2g + 50} \qquad \text{II. 6.}$$

2.2. The effect of changes in thrust and weight

If F_{ma} = actual mean excess thrust during airborne distance.

F_{ms} = standard mean excess thrust,

X_a = actual distance corrected to zero wind,

X_s = standard take-off distance,

we may write

$$\frac{X_{ca}}{X_{cs}} = \frac{\dfrac{W_a}{F_{ma}}\left[\dfrac{(U_{ca}^2 - U_{ta}^2)}{2g} + 50\right]}{\dfrac{W_s}{F_{ms}}\left[\dfrac{(U_{cs}^2 - U_{ts}^2)}{2g} + 50\right]} \qquad \text{II. 7.}$$

/Write

$$\text{Write } F_{ms} = F_{ma} + \delta F,$$

$$\text{then } X_{ca} = \frac{W_a}{F_{ma}}\left[\frac{(U_{ca}^2 - U_{ts}^2)}{2g} + 50\right] \qquad \text{II. 8.}$$

$$\text{and } X_{cs} = \frac{W_s}{F_{ma}} + \delta F\left[\frac{(U_{cs}^2 - U_{ts}^2)}{2g} + 50\right] \qquad \text{II. 9.}$$

$$\delta(U^2) = U_c^2 - U_t^2$$

$$= \frac{W_a}{W_s}\left[\frac{\frac{\delta(U_a)^2}{2g} + 50}{\frac{\delta(U_s)^2}{2g} + 50}\right] + \frac{\delta F}{W_s} \cdot \frac{W_a}{F_a}\,\frac{\left[\frac{\delta(U_a)^2}{2g} + 50\right]}{\left[\frac{\delta(U_s)^2}{2g} + 50\right]}$$

$$= \frac{\left[\delta(U_a)^2/2g + 50\right] + \frac{\delta F\, X_{ta}}{W_a}}{\left[W_s/W_a \quad \delta(U_s)^2/2g + 50\right]} \qquad \text{II. 10.}$$

$$\text{and } \frac{X_{cs}}{X_{ca}} = \frac{\frac{W_s}{W_a}\left[\frac{U_{cs}^2 - U_{ts}^2}{2g} + 50\right]}{\left[\frac{U_{ca}^2 - U_{ta}^2}{2g} + 50\right] + \frac{\delta F}{W_a} X_{ca}}$$

If X_{ca} has been corrected for wind speed, take-off speed and climb speed.

$$U_{cs} = U_{ca}$$

$$U_{ts} = U_{ta}$$

$$\text{and } \frac{X_{cs}}{X_{ca}} = \frac{W_s}{W_a} \cdot \left[1 + \frac{\delta F}{W_a} X_{ca}\Big/\left\{\frac{(U_{ca}^2 - U_{ta}^2)}{2g} + 50\right\}\right]^{-1} \qquad \text{II.11}$$

where δF includes the effect of changes in air drag, height, temperature and weight. These are discussed in detail in Reference 1.

/APPENDIX III

APPENDIX III

SCHEME OF CALCULATION FOR REDUCTION OF SEAPLANE TAKE-OFF DISTANCES TO STANDARD CONDITIONS

1. MEASURED QUANTITIES

Waterborne distance	X_{ta}
Airborne distance	X_{ca}

at

Unstick T.A.S.	V_{ta}
Screen height T.A.S.	V_{ca}
Wind speed	V_W
Weight	W_a

2. DERIVATION OF STANDARD WATERBORNE DISTANCE

2.1. Correct X_{ta} to zero wind and standard T.A.S. at unstick (V_{ts})

$$X_1 = X_{ta} \left(\frac{V_{ts}}{V_{ts} - V_W}\right)^2 .$$

2.2. Correct X_1 to standard weight, drag and atmospheric conditions.

(a) Estimate actual excess thrust

$$F_{ma} = \frac{W_a \, U_{ta}^2}{2g \, X_{ta}}$$

where U_{ta} = measured water speed at unstick.

(b) Calculate change in water drag due to weight change.

$$\text{Change in water drag} = \delta R = \frac{R}{\Delta} \left(\frac{W_a - W_s}{2}\right)$$

$\frac{R}{\Delta} = \frac{\text{water drag}}{\text{waterborne load}}$, and is estimated at a water speed of of $0.7 \left(\frac{U_{ts} + U_{ta}}{2}\right)$.

Tank tests or generalised curves may be used for estimation (Reference 4).

Then excess thrust corrected for weight is

$$F_c = F_{ma} + \delta R$$

(c) Calculate the thrust changes due to atmospheric changes, etc.

$$\delta F = \delta F \text{ (atmospheric change)} + \delta F \text{ (air drag)} + \ldots\ldots\ldots$$

The standard excess thrust is then

$$F_{ms} = F_{ma} + \delta R + \delta F.$$

(d) Calculate the standard waterborne distance

$$X_s = X_1 \left(\frac{W_s}{W_a}\right) \left(\frac{F_{ma}}{F_{ms}}\right)$$

/3. DERIVATION

3. DERIVATION OF STANDARD AIRBORNE DISTANCE

3.1. Correct X_{ca} to zero wind, standard unstick T.A.S. and standard climb T.A.S.

$$X_2 = X_{ca} \frac{(U_{cs}^2 - U_{ts}^2)/2g + 50}{(U_{ca}^2 - U_{ta}^2)/2g + 50}$$

where U_c = climb T.A.S. - wind speed,

U_t = unstick T.A.S. - wind speed,

and s and a refer to standard and measured quantities.

3.2. Correct X_2 for changes in thrust and weight.

If δF is the total change in excess thrust due to changes in atmospheric conditions, weight, air drag and height, the standard airborne distance may be derived from

$$X_{cs} = X_2 \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_c} . X_{ca} \Big/ \left\{ \frac{U_{ca}^2 - U_{ta}^2}{2g} + 50 \right\} \right]^{-1}$$

Methods of deriving δF are given in Reference 1.

4. DERIVATION OF STANDARD AIRBORNE DISTANCE WITH ENGINE FAILURE

This follows the same pattern as the normal airborne distance correction.

If U_f = T.A.S. at engine failure - wind speed, we have the following:

Before failure

Wind and speed correction

$$X_3 = X_{ca} \frac{(U_{fs}^2 - U_{ts}^2)}{(U_{fa}^2 - U_{ta}^2)} .$$

Weight and thrust correction

$$X_{cs} = X_3 \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_a} X_{ca} \Big/ \left\{ \frac{U_{fa}^2 - U_{ta}^2}{2g} \right\} \right]^{-1}$$

where X_{ca} and X_{cs} now apply to the airborne distances between unstick and engine failure.

After failure

Wind and speed correction

$$X_4 = X_{ca} \frac{(U_{cs}^2 - U_{fs}^2)/2g + 50}{(U_{ca}^2 - U_{fa}^2)/2g + 50} .$$

/Weight

Weight and thrust correction

$$X_{cs} = X_4 \frac{W_s}{W_a} \left[1 + \frac{\delta F}{W_a} \cdot X_{ca} \Big/ \left\{ \frac{U_{ca}^2 - U_{fa}^2}{2g} + 50 \right\} \right]^{-1}$$

Where X_{ca} and X_{cs} now apply to the airborne distance between engine failure and the 50 feet height point.

TABLE 1

Data - Solent N.J.201

Wings

Section	Gottingen 436 (mod.)
Gross Area	1688 square feet
Span	112.8 feet
S.M.C.	14.97 feet
Distance of S.M.C. leading edge in front of step	7.93 feet
Aspect ratio	7.54
Washout	0 deg.
Dihedral (to mid thickness 30% chord)	3 deg.
Sweepback (normal to aerofoil datum line)	4 deg.
Wing setting to hull datum	6 deg. 9 min.

Tailplane

Section	R.A.F. 30 (mod.)
Gross Area	265.6 square feet
Span	42.45 feet
Elevator Area	97.8 square feet
Dihedral (to lower surface measured at stub)	6 deg.
Leading edge root above datum	16.19 feet
Tailplane setting to hull datum	4 deg.

Flaps

Type	Gouge
Area	286.2 square feet
Flap span	38.1 feet
Flap chord ÷ wing chord	32.75 %

/ Hull

TABLE 1 (Contd.)

Hull

Beam at step chine	10.27 feet
Forebody length ÷ beam	3.36
Afterbody length ÷ beam	3.23
Unfaired step depth	10.1% of beam
Step fairing	1 : 3
Afterkeel angle to forebody keel (at step)	7.1 deg.
Forebody keel angle to hull datum	1.8 deg.

Engines

Four Hercules XIX giving 1700 B.H.P. at 2800 r.p.m. and + $8\frac{1}{2}$ p.s.i. boost pressure for sea level take-off.

Gear ratio	0.441:1

Propellers

Type	De Havilland D9/446/1
Diameter	12.75 feet
Solidity at 0.7R	0.141
Section	Clark Y
T/C at 0.7R	6.8%
No. of blades	4

/TABLE 2

TABLE 2

Data - Sealand G-AKLN

Wings

Gross Area	353 square feet
Span	59 feet
Aspect ratio	9.9
Section	A.D.6.
Wing setting to hull datum	6 deg.
Dihedral	2.3 deg.
Hull - overall length	42.2 feet
Beam at step	5 feet
Forebody length: beam ratio	3.66
Afterbody length: beam ratio	2.94
Step Fairing	1:3.5
Afterbody keel - Forebody keel angle	7.2 deg.

Engines

Two De Havilland Gipsy Queen Series 70, giving 331/345 B.H.P. at 2,000 r.p.m. and + 6 lb./sq.in. boost for sea level take-off.

Propellers

Type	De Havilland PD/83/312/1
Diameter	7.5 feet
Number of Blades	3

/TABLE 3

TABLE 3

SOLENT N.J.201

MEASURED WATERBORNE RUNS UNCORRECTED (TEMPERATE)

Run No.	Take-off Water Speed in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Uncorrected)
752	76	77,500	1573	12	2770
754	81	77,250	1579	8	2850
755	73	76,800	1550	14	2730
756	73	76,500	1577	15	2420
793	72	77,400	1547	17	2580
058	76	77,850	1547	15	2980
060	72	77,300	1518	15	2550
061	71	77,100	1536	15	2520
063	73	76,600	1530	15	2930
064	69	76,350	1489	15	2640
070	72	77,900	1525	15	2660
071	72	77,650	1525	15	2620
072	71	77,400	1539	13	2490
073	74	76,950	1529	13	2580
084	77	77,650	1533	11	3170
085	75	77,200	1519	12	3050
086	75	77,000	1521	12	2960
088	75	76,350	1523	10	3020
089	79	76,050	1516	10	2900
091	73	75,400	1519	10	2480
101	75	77,750	1509	14	3260
231	76	77,850	1518	14	3040
232	78	77,550	1507	15	3450
233	77	77,300	1513	13	3150
235	83	77,800	1528	9	3960
239	82	76,700	1516	5	3350
240	83	76,400	1516	5	3770
241	83	76,150	1479	4	3470
541	77	77,700	1600	9	2860
544	80	76,600	1580	9	3000
545	83	76,400	1585	10	3420
546	80	76,250	1575	8	2980
547	79	76,000	1580	12	2900
563	77	77,650	1515	12	3050
565	76	77,400	1520	13	3160
568	81	76,700	1500	11	3520
621	77	61,900	1630	9	1650
622	75	61,650	1620	10	1690
623	78	61,400	1620	11	1790
624	73	61,250	1615	12	1660
625	73	61,100	1620	13	1590
661	76	61,750	1620	13	1720
663	75	61,150	1620	16	1570
664	75	60,900	1600	13	1600
371	56	69,500	1582	22	1850
373	55	69,300	1565	22	1640
377	57	68,850	1570	21	1730
379	61	68,650	1570	19	1770
381	59	68,450	1570	18	1680

/ TABLE 4

TABLE 4

SOLENT N.J.201

MEASURED WATERBORNE RUNS UNCORRECTED (SUB-TROPICAL)

Run No.	Take-off Water Speed in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Uncorrected)
415	85	77,200	1470	5	4390
416	86	76,850	1470	6	4280
417	86	76,500	1480	6	4400
418	84	76,100	1460	7	4180
419	85	75,750	1460	7	4040
431	82	78,250	1460	8	4570
432	82	77,900	1465	7	4230
433	83	77,500	1450	8	4570
437	85	76,000	1475	8	4130
439	84	75,400	1480	10	3820
441	78	74,800	1480	10	3350
477	82	76,600	1461	8	3850
483	84	77,650	1484	7	3920
485	84	77,350	1479	8	4250
486	84	77,200	1483	7	4210
488	86	76,850	1479	6	4200
489	82	76,700	1486	10	3900
491	83	76,250	1490	10	3840
391	84	70,800	1505	9	3400
392	83	70,500	1500	10	3270
393	80	70,250	1510	11	2810
394	83	70,000	1504	10	2950
396	87	69,750	1500	8	3440
373	78	61,700	1525	10	2350
378	81	60,900	1525	12	2270
379	76	60,700	1530	11	2030
380	75	60,450	1520	18	2120

/ TABLE 5

TABLE 5

SOLENT N.J.201

VARIATION OF WATERBORNE DISTANCE WITH TAKE-OFF WATER SPEED (CORRECTED FOR WEIGHT AND ENGINE POWER)

Run No.	Take-off Water Speed in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Corrected to 1540 B.H.P.)
752	76	77,500	1573	12	2960
754	81	77,250	1579	8	3070
755	73	76,800	1550	14	2790
756	73	76,500	1577	15	2620
793	72	77,400	1547	17	2620
060	72	77,300	1518	15	2430
061	71	77,100	1536	15	2500
072	71	77,400	1539	13	2410
073	74	76,950	1529	13	2570
085	75	77,200	1519	12	2990
086	75	77,000	1521	12	2850
231	76	77,850	1518	14	2920
232	78	77,550	1507	15	3270
541	77	77,700	1600	9	3190
542	83	77,150	1575	8	3240
543	77	76,850	1570	8	3410
544	80	76,600	1580	9	3220
545	83	76,400	1585	10	3670
546	80	76,250	1575	8	3180
561	76	77,900	1520	13	3340
563	77	77,650	1515	12	2910
565	76	77,400	1520	13	3160
568	81	76,700	1500	11	3300
371	56	69,500	1582	22	1830
373	56	69,300	1565	22	1680
377	57	68,850	1570	21	1800
379	61	68,650	1570	19	1840
381	59	68,450	1570	18	1760
					Corrected to 1620 B.H.P.
621	77	61,900	1630	9	1680
622	75	61,650	1620	10	1690
623	78	61,400	1620	11	1790
624	73	61,250	1615	12	1650
625	73	61,100	1620	13	1590
661	76	61,750	1620	13	1720
663	75	61,150	1620	16	1570
664	75	60,900	1600	13	1550
665	71	60,750	1610	18	1580

/ TABLE 6

TABLE 6

SOLENT N.J.201

VARIATION OF WATERBORNE DISTANCE WITH WIND SPEED (CORRECTED FOR WEIGHT, UNSTICK SPEED AND ENGINE POWER)

Run No.	Take-off T.A.S. in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Corrected to 88 knots T.A.S. and 1540 B.H.P.)
752	88	77,500	1573	12	2960
754	89	77,250	1579	8	3010
755	87	76,800	1550	14	2860
756	88	76,500	1577	15	2620
790	87	77,850	1554	18	2290
793	89	77,400	1547	17	2560
060	87	77,300	1518	15	2490
116	85	77,900	1513	4	3400
117	85	77,700	1482	7	3470
233	90	77,300	1513	13	2870
237	86	77,250	1528	5	3330
541	86	77,700	1600	9	3330
544	89	76,600	1580	9	3150
546	88	76,250	1575	8	3180
371	81	69,500	1582	22	2190
373	81	69,300	1565	22	2000
377	81	68,850	1570	21	2150
379	84	68,650	1570	19	2030
381	20	68,450	1570	18	2090
					Corrected to 1620 B.H.P.
621	86	61,900	1630	9	1760
622	85	61,650	1620	10	1810
623	89	61,400	1620	11	1750
624	85	61,250	1615	12	1770
625	86	61,100	1620	13	1670
661	89	61,750	1620	13	1680
663	91	61,150	1620	16	1470
664	88	60,900	1600	13	1550
665	89	60,750	1610	18	1550

/ TABLE 7

TABLE 7

SOLENT N.J.201

VARIATION OF WATERBORNE DISTANCE WITH WEIGHT (CORRECTED FOR WIND, UNSTICK SPEED AND POWER, TEMPERATE)

Run No.	Take-off Water Speed in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Corrected to 80 kts. G.S. and 1600 B.H.P.)
752	76	77,500	1573	12	2900
754	81	77,250	1579	8	2670
755	73	76,800	1550	14	3010
756	73	76,500	1577	15	2780
793	72	77,400	1547	17	2890
058	76	77,850	1547	15	3020
060	72	77,300	1518	15	2690
061	71	77,100	1536	15	2830
063	73	76,600	1530	15	3130
064	69	76,350	1489	15	2940
070	72	77,900	1525	15	2870
071	72	77,650	1525	15	2830
072	71	77,400	1539	13	2830
073	74	76,950	1529	13	2620
084	77	77,650	1533	11	3060
085	75	77,200	1519	12	3020
086	75	77,000	1521	12	2940
088	75	76,350	1523	10	3020
089	79	76,050	1516	10	2510
091	73	75,400	1519	10	2540
101	75	77,750	1509	14	3210
116	81	77,900	1513	4	2750
117	78	77,700	1482	7	3060
118	79	77,600	1484	8	3290
231	84	77,850	1518	14	2920
232	80	77,550	1507	15	3110
233	84	77,300	1513	13	2920
235	83	77,850	1528	9	3280
239	82	76,700	1516	5	2720
240	83	76,400	1516	5	3050
241	83	76,150	1479	4	2560
541	77	77,700	1600	9	3080
542	83	77,150	1575	8	2700
544	80	76,600	1580	9	2890
545	83	76,400	1585	10	3090
546	80	76,250	1575	8	2850
547	79	76,000	1580	12	2860
563	77	77,650	1515	12	2820
565	76	77,400	1520	13	3060
568	81	76,700	1500	11	2890
621	77	61,900	1630	9	1860
622	75	61,650	1620	10	1970
623	78	61,400	1620	11	1940
624	73	61,250	1615	12	2030
625	73	61,100	1620	13	1960
661	76	61,750	1620	13	1960
663	75	61,150	1620	16	1840
664	75	60,900	1600	13	1820
371	56	69,500	1582	22	3490
373	55	69,300	1585	22	3180
377	57	68,850	1570	21	3320
379	61	68,650	1570	19	2980
381	59	68,450	1570	18	2990

TABLE 8

SOLENT N.J.201

VARIATION OF WATERBORNE DISTANCE WITH WEIGHT (CORRECTED FOR WIND, UNSTICK SPEED AND ENGINE POWER, TROPICAL)

Run No.	Take-off Water Speed in Knots	Weight in lb.	Power in B.H.P.	Wind Speed in Knots	Take-off Distance in feet (Corrected to 80 Knots G.S. and 1500 B.H.P.
373	78	61,700	1525	10	2560
378	81	60,900	1525	12	2310
379	76	60,700	1530	11	2360
380	75	60,450	1520	13	2490
391	84	70,800	1505	9	3080
392	83	70,500	1500	10	3040
393	80	70,250	1510	11	2810
394	83	70,000	1504	10	2740
396	87	69,750	1500	8	2910
415	85	77,200	1470	5	3610
416	86	76,850	1470	6	3330
417	86	76,500	1480	6	3620
418	84	76,100	1460	7	3430
419	85	75,750	1460	7	3230
431	82	78,250	1460	8	3980
432	82	77,900	1465	7	3710
433	83	77,500	1450	8	3780
437	85	76,000	1475	8	3420
439	84	75,400	1480	10	3270
441	78	74,800	1480	10	3340
477	82	76,600	1461	8	3300
485	84	77,350	1479	8	3660
486	84	77,200	1483	7	3660
488	86	76,850	1479	6	3440
489	82	76,700	1486	10	3580
491	83	76,250	1490	10	3480

/ TABLE 9

TABLE 9

SOLENT N.J.201

MEASURED AIRBORNE DISTANCES UNCORRECTED
(TEMPERATE)

Run No.	Take-off Water Speed in Knots	Climb Speed in Knots	Wind Speed in Knots	Weight in lb.	Airborne Distance in feet Actual
752	76	91	12	77,500	1540
755	73	90	14	76,800	1610
793	72	92	17	77,400	1890
101	75	94	14	77,750	1870
237	81	99	5	77,250	1940
543	77	98	8	76,850	2140
544	80	100	9	76,600	2060
545	83	100	10	76,400	1650
561	79	94	13	77,900	1710
563	77	95	12	77,650	1920
621	77	94	9	61,900	1260
622	75	93	10	61,650	1240
623	78	97	11	61,400	1220
624	73	94	12	61,250	1400
625	73	91	13	61,100	1150
626	78	98	9	60,900	1540
661	76	90	13	61,750	900
663	75	89	16	61,150	860
664	75	89	13	60,900	1080
063	73	82	15	76,600	950
231	76	84	14	77,850	1110
233	77	84	13	77,300	980
547	79	92	12	76,000	1630
665	71	82	18	60,750	790
060	72	76	15	77,300	760
061	71	76	15	77,100	780
062	69	75	15	76,850	580
064	69	75	15	76,350	660
070	72	73	15	77,900	570
071	72	77	15	77,650	910
072	71	75	13	77,400	650
073	74	80	13	76,950	830
234	72	78	14	77,000	810
		TROPICAL			
378	81	103	12	60,900	1730
379	76	105	11	60,700	2070
380	75	100	13	60,450	1800
391	84	108	9	70,800	1980
392	83	106	10	70,500	1780
393	80	107	11	70,250	2410
415	85	108	5	77,200	2330
416	86	109	6	76,850	2670
431	82	97	8	78,250	1850
433	83	96	8	77,500	1640
		TEMPERATE			
371	56	90	22	69,500	1270
373	55	89	22	69,300	1180
377	57	92	21	68,850	1310
379	61	91	19	68,650	1340
381	59	92	18	68,450	1240

For No's 371 onwards the Aircraft was allowed to accelerate, and steadily climbed so that it arrived at the screen height at 108 knots.
The climbing speeds given are the mean values.

/ TABLE 10

TABLE 10

SOLENT N.J.201

VARIATION OF AIRBORNE DISTANCE WITH TAKE-OFF, CLIMB AND WIND SPEEDS (CORRECTED FOR WEIGHT AND ENGINE POWER, TEMPERATE)

Run No.	Take-Off Water Speed in Knots	Climb Speed in Knots	Wind Speed in Knots	Weight in lb.	Airborne Distance in feet	$\frac{U_c^2 - U_t^2}{2g} + 50$
752	76	91	12	77,500	1540	162
755	73	90	14	76,800	1610	173
793	72	92	17	77,400	1890	196
060	72	76	15	77,300	760	76
061	71	76	15	77,100	780	83
063	73	82	15	76,600	950	112
070	72	73	15	77,900	570	56
071	72	77	15	77,650	910	83
072	71	75	13	77,400	650	76
073	74	80	13	76,950	880	91
101	75	94	14	77,750	1870	192
231	76	84	14	77,850	1110	107
233	77	84	13	77,300	980	100
234	72	78	14	77,000	810	89
237	81	99	5	77,250	1940	194
543	77	98	8	76,850	2140	213
544	80	100	9	76,600	2060	209
545	83	100	10	76,400	1650	187
547	79	92	12	76,000	1630	149
561	79	94	13	77,900	1710	165
563	77	95	12	77,650	1920	187
621	77	94	9	61,900	1260	178
622	75	93	10	61,650	1240	184
623	78	97	11	61,400	1220	197
624	73	94	12	61,250	1400	204
625	73	91	13	61,100	1150	180
626	78	98	9	60,900	1540	205
661	76	90	13	61,750	900	153
663	75	89	16	61,150	860	151
664	75	89	13	60,900	1080	151
665	71	82	18	60,750	790	124
371	56	90	22	69,500	1270	270
373	55	89	22	69,300	1180	265
377	57	92	21	68,850	1310	281
379	61	91	19	68,650	1340	250
381	59	92	18	68,450	1240	268

For No's 371 onwards the Aircraft was allowed to accelerate, and steadily climbed so that it arrived at the screen height at 108 knots. (Safety speed). The climbing speeds given are the mean values.

TABLE 11

SOLENT N.J.201

MEASURED TIME TO UNSTICK

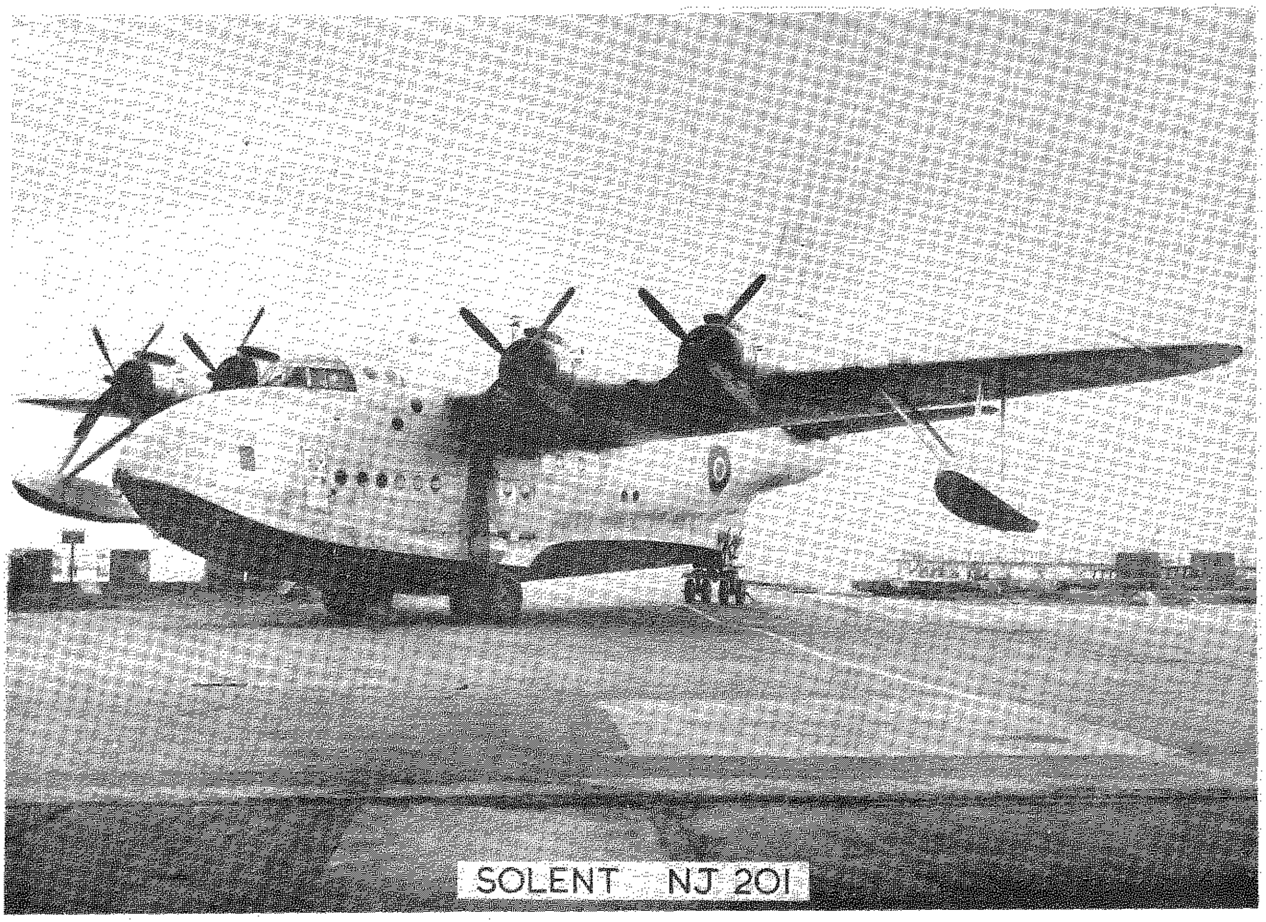
Temperate
of Table 3

Run No.	Time in sec.
752	38.6
754	37.4
755	36.8
756	37.6
793	36.7
058	40.9
060	38.0
061	37.0
063	38.5
064	37.1
070	39.2
071	39.1
072	39.1
073	39.2
084	42.7
085	42.3
086	41.0
088	41.7
089	40.7
091	38.1
101	-
116	48.3
117	44.8
118	46.0
231	42.3
232	44.6
233	42.1
235	45.3
239	43.0
240	46.8
241	46.6
541	39.7
542	42.9
544	40.4
545	44.0
546	41.5
547	39.8
563	40.1
565	41.8
568	43.6
621	22.7
622	23.8
623	24.4
624	22.5
625	23.0
661	24.4
663	23.3
664	23.5
665	23.0
371	33.0
373	31.0
377	32.0
379	33.0
381	31.0

Sub-tropical
of Table 4

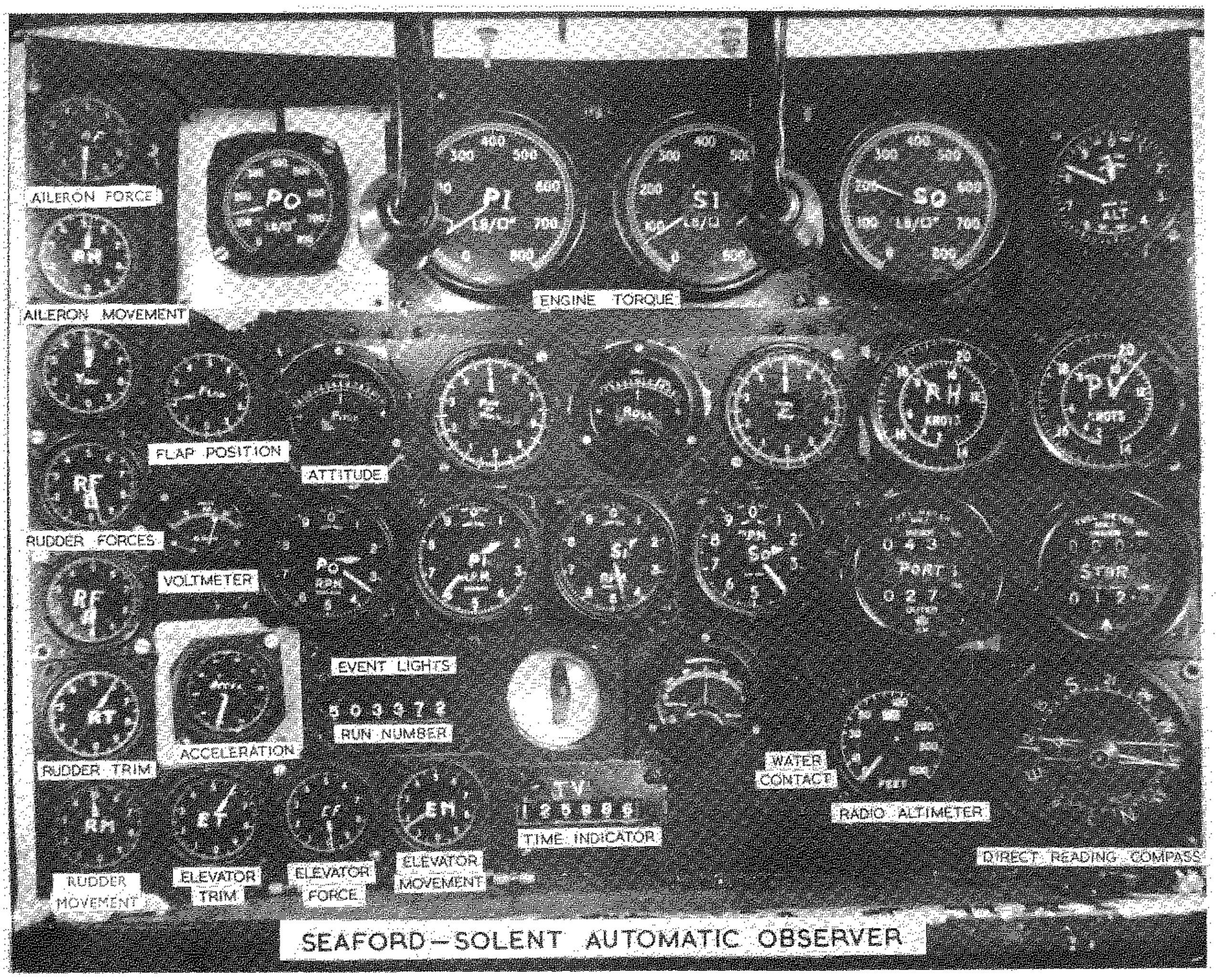
Run No.	Time in sec.
415	61.5
416	60.2
417	57.2
418	55.4
419	52.8
431	58.3
432	56.8
433	63.5
437	57.3
439	51.0
441	51.4
477	55.4
483	53.4
485	56.0
486	57.1
488	56.4
489	56.1
491	52.0
391	46.2
392	43.7
393	42.2
294	43.6
396	46.0
373	35.2
378	32.8
379	31.8
380	35.6

FIG. 1



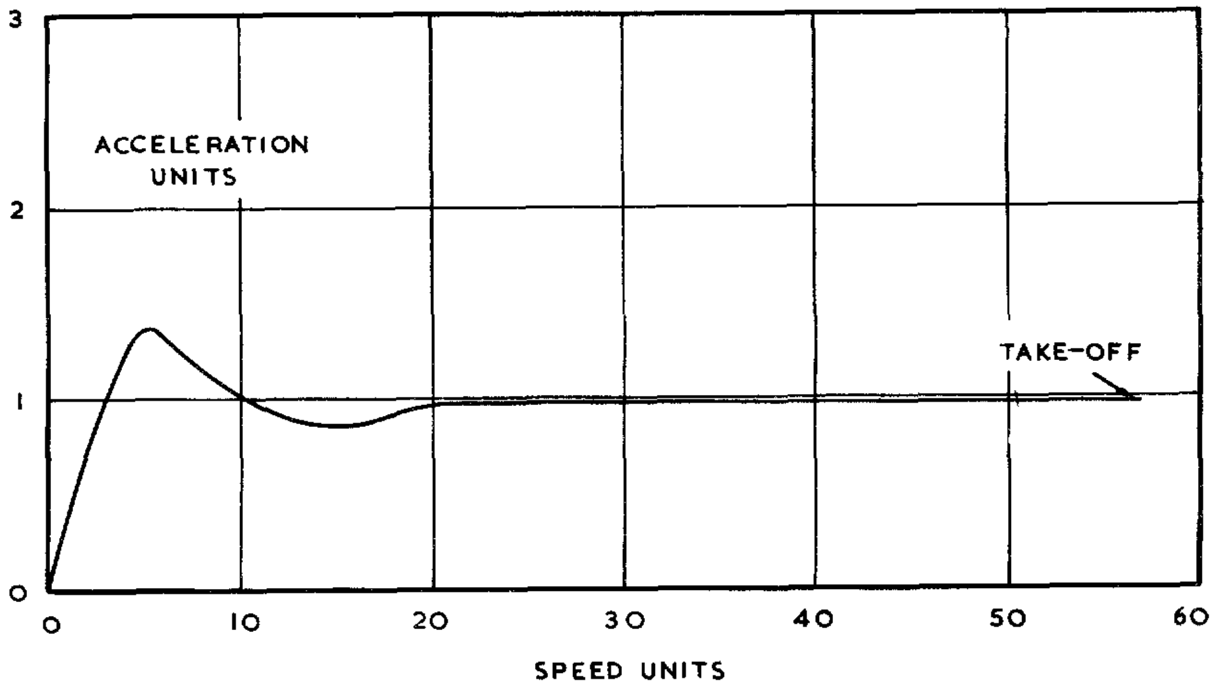
SOLENT NJ 201

FIG. 2

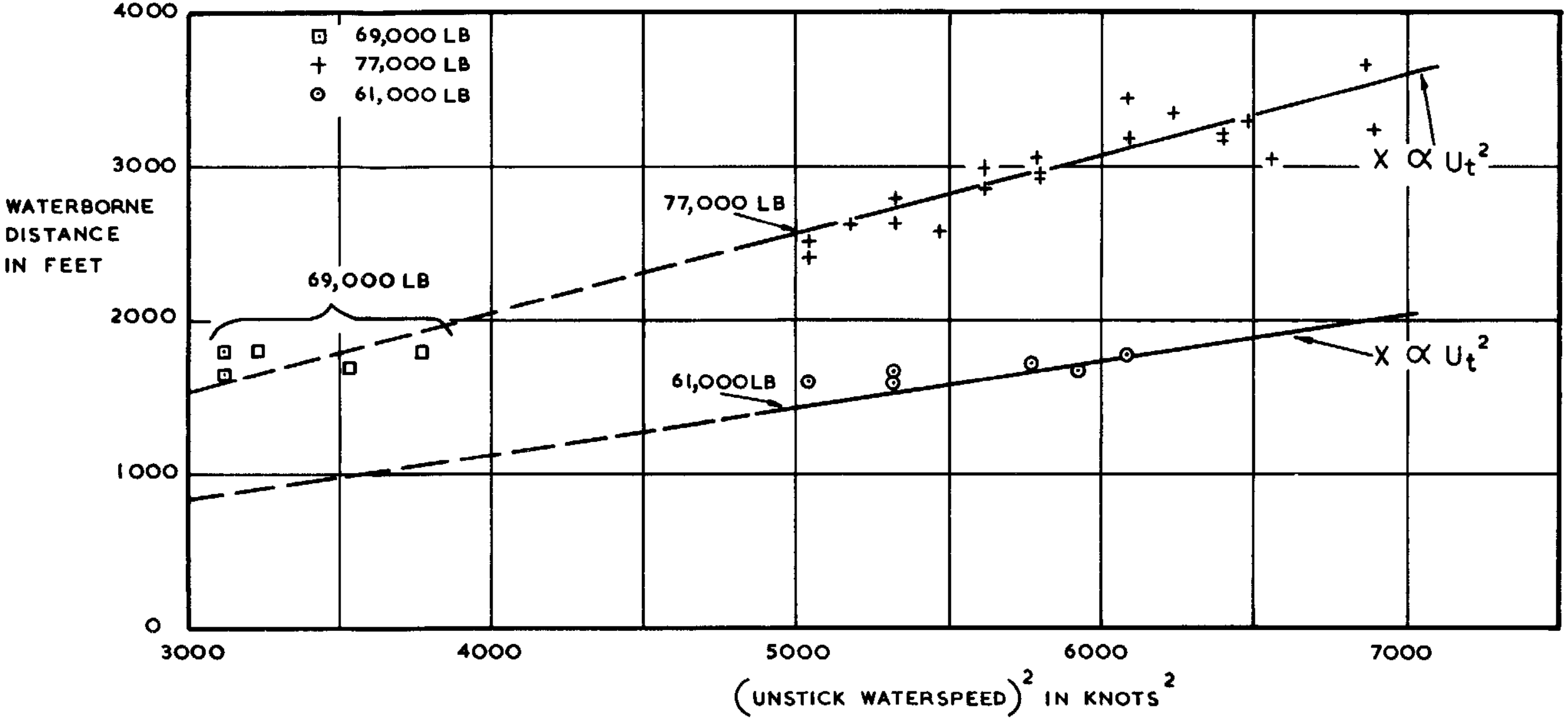


SEAFORD—SOLENT AUTOMATIC OBSERVER

FIG. 3.



TYPICAL VARIATION OF LONGITUDINAL ACCELERATION DURING A SEAPLANE TAKE-OFF.



VARIATION OF WATERBORNE DISTANCE WITH TAKE-OFF WATER SPEED AT UNSTICK.

FIG. 4.

FIGS. 5 & 6.

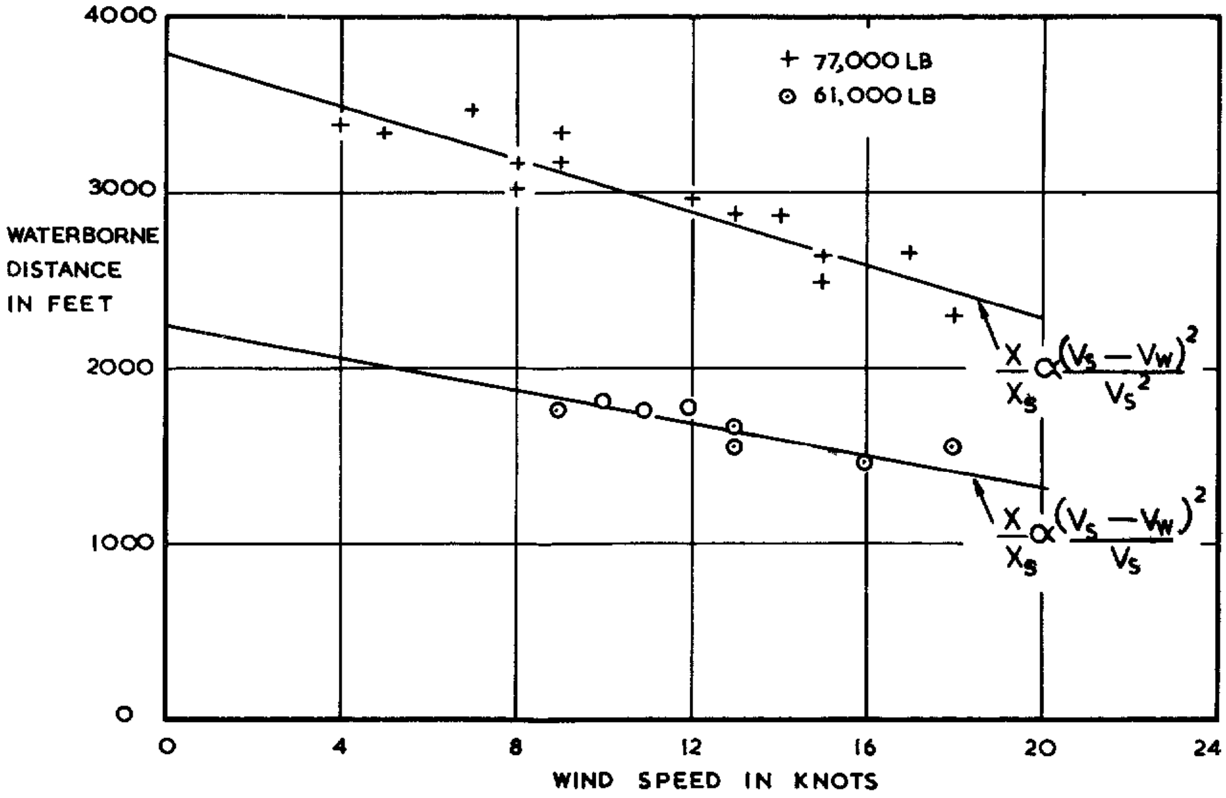


FIG. 5.

VARIATION OF WATERBORNE DISTANCE WITH WIND SPEED, SOLENT.

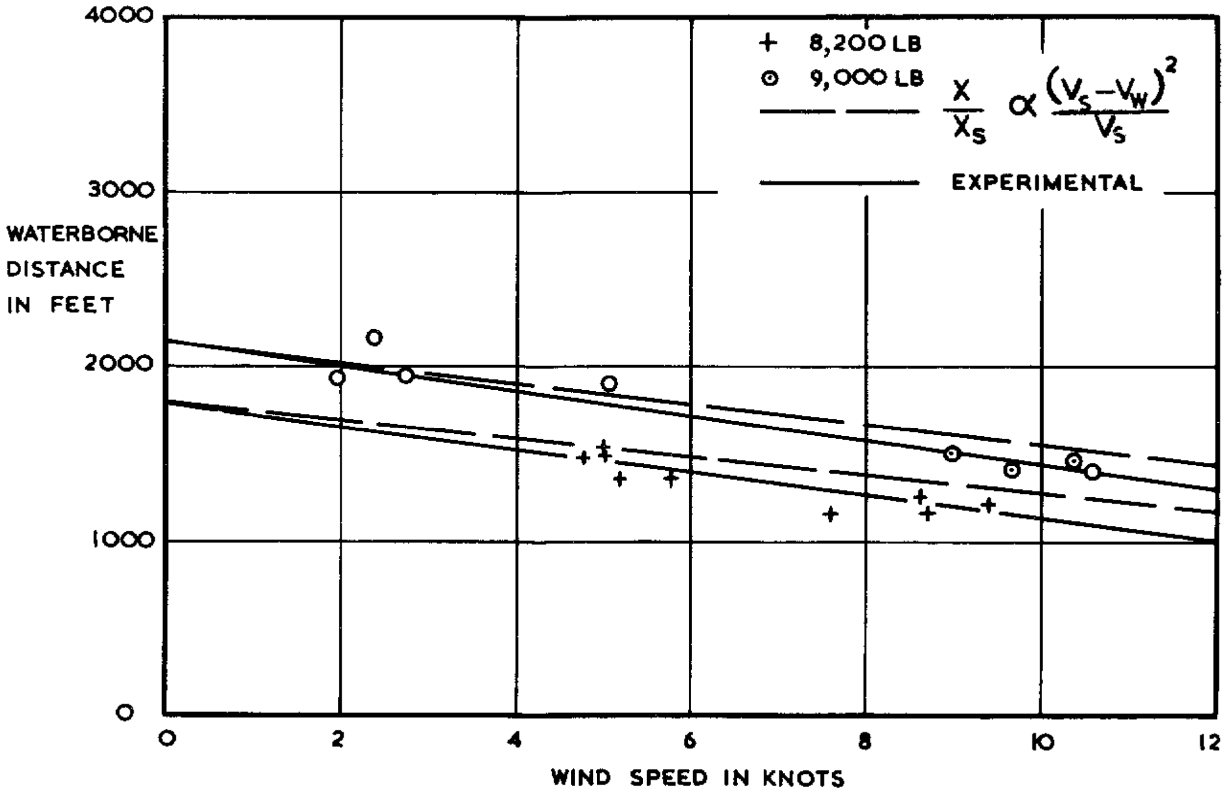
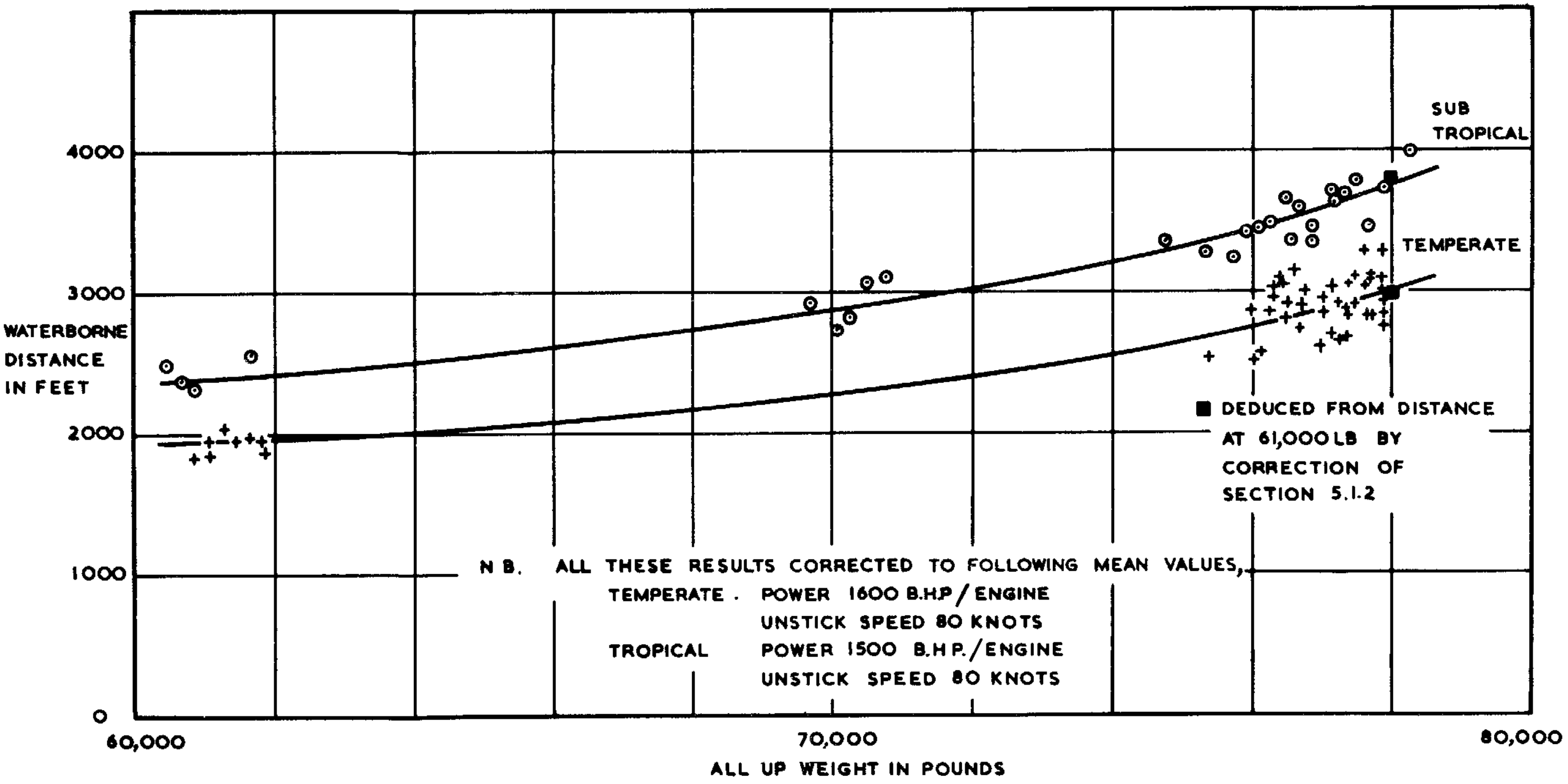


FIG. 6.

VARIATION OF WATERBORNE DISTANCE WITH WIND SPEED, SEALAND.



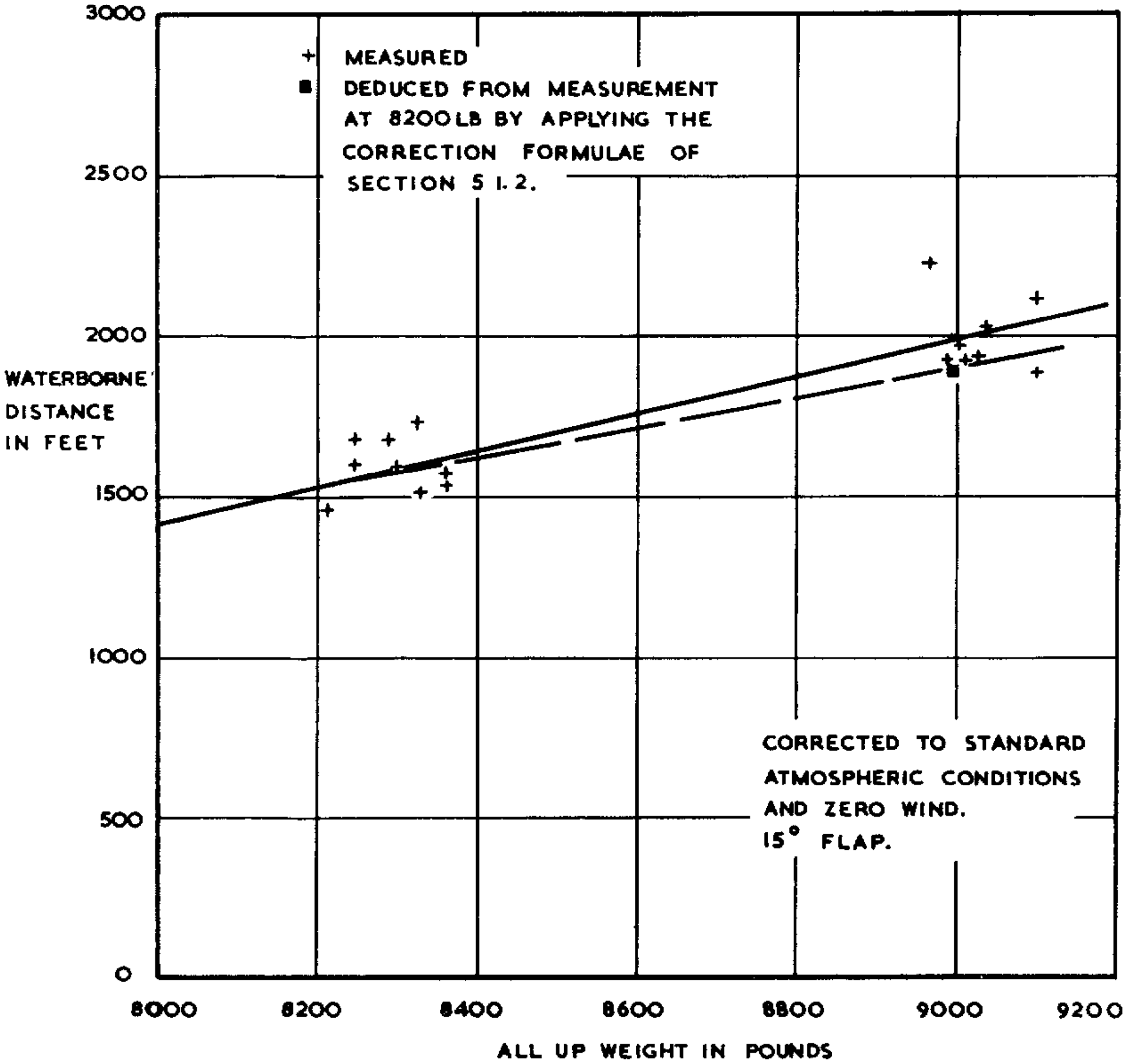
N.B. ALL THESE RESULTS CORRECTED TO FOLLOWING MEAN VALUES,

TEMPERATE. POWER 1600 B.H.P./ENGINE
UNSTICK SPEED 80 KNOTS
TROPICAL POWER 1500 B.H.P./ENGINE
UNSTICK SPEED 80 KNOTS

VARIATION OF WATERBORNE DISTANCE WITH WEIGHT, SOLENT.

FIG. 7.

FIG. 8.



VARIATION OF WATERBORNE DISTANCE WITH WEIGHT, SEALAND.

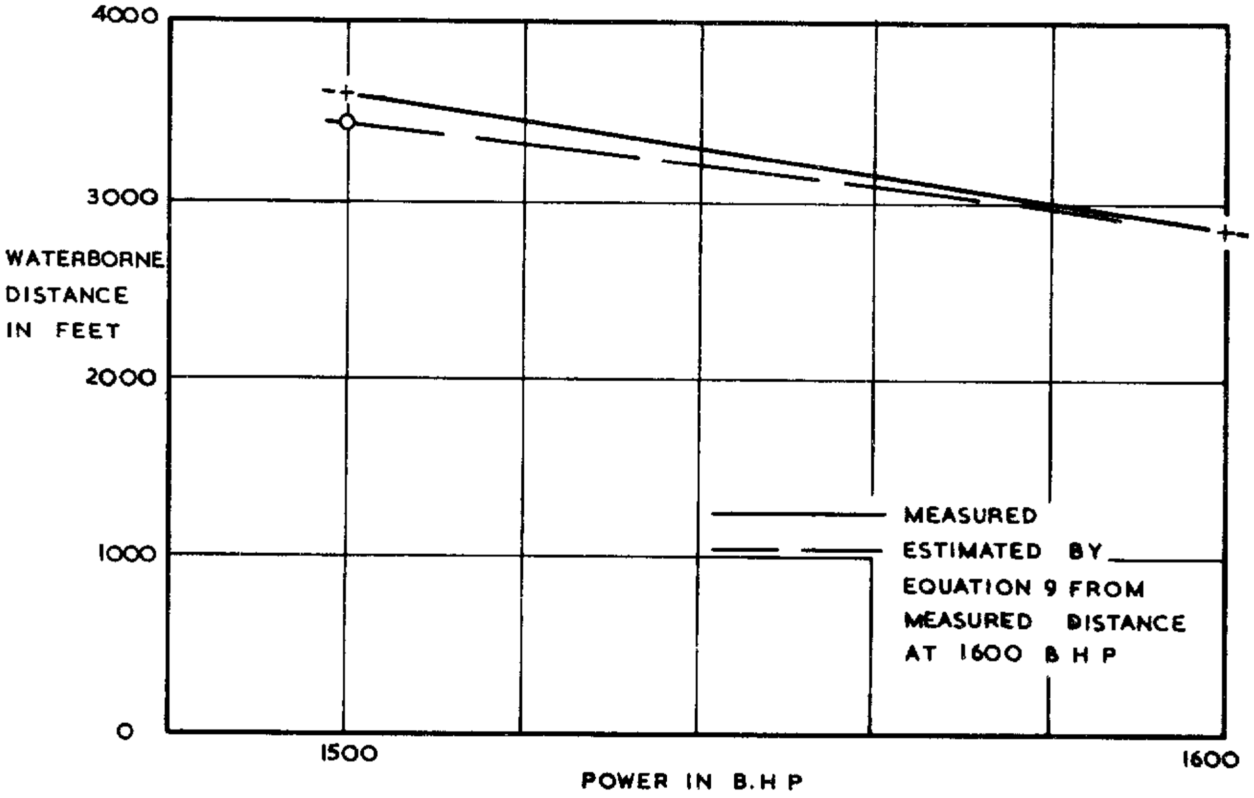


FIG. 9

VARIATION OF WATERBORNE DISTANCE WITH ENGINE POWER, SOLENT AT 77,000 LB.

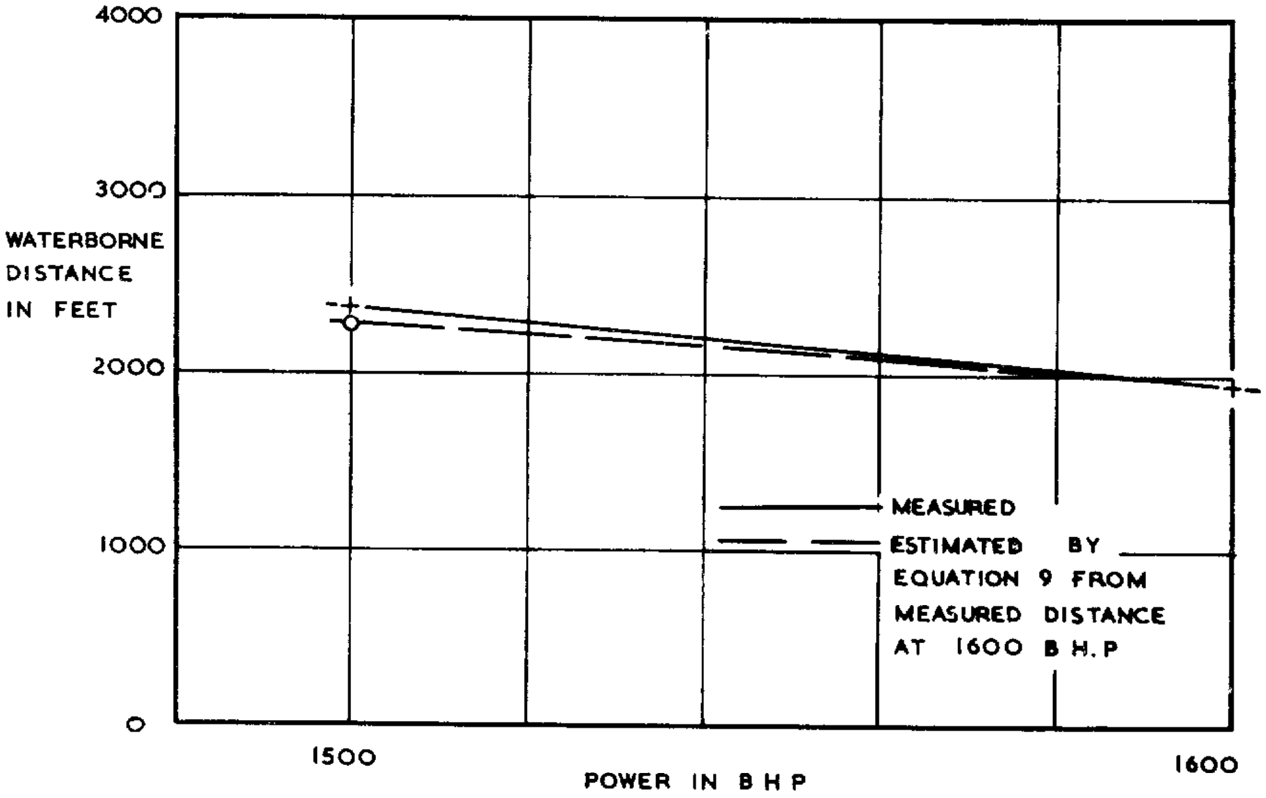
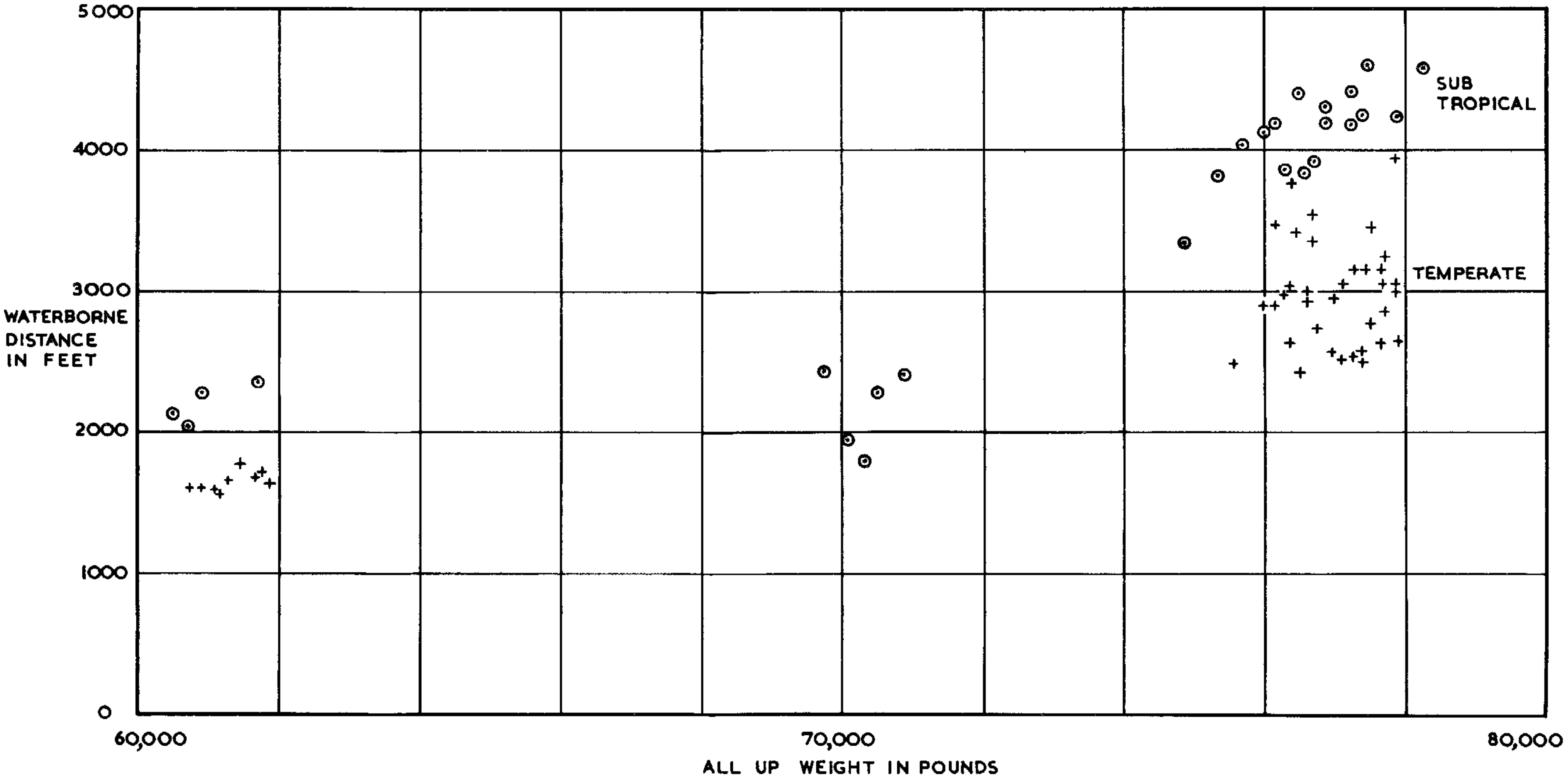


FIG. 10.

VARIATION OF WATERBORNE DISTANCE WITH ENGINE POWER, SOLENT AT 61,000 LB.

FIG. 11.



MEASURED WATERBORNE RUNS (UNCORRECTED) SOLENT.

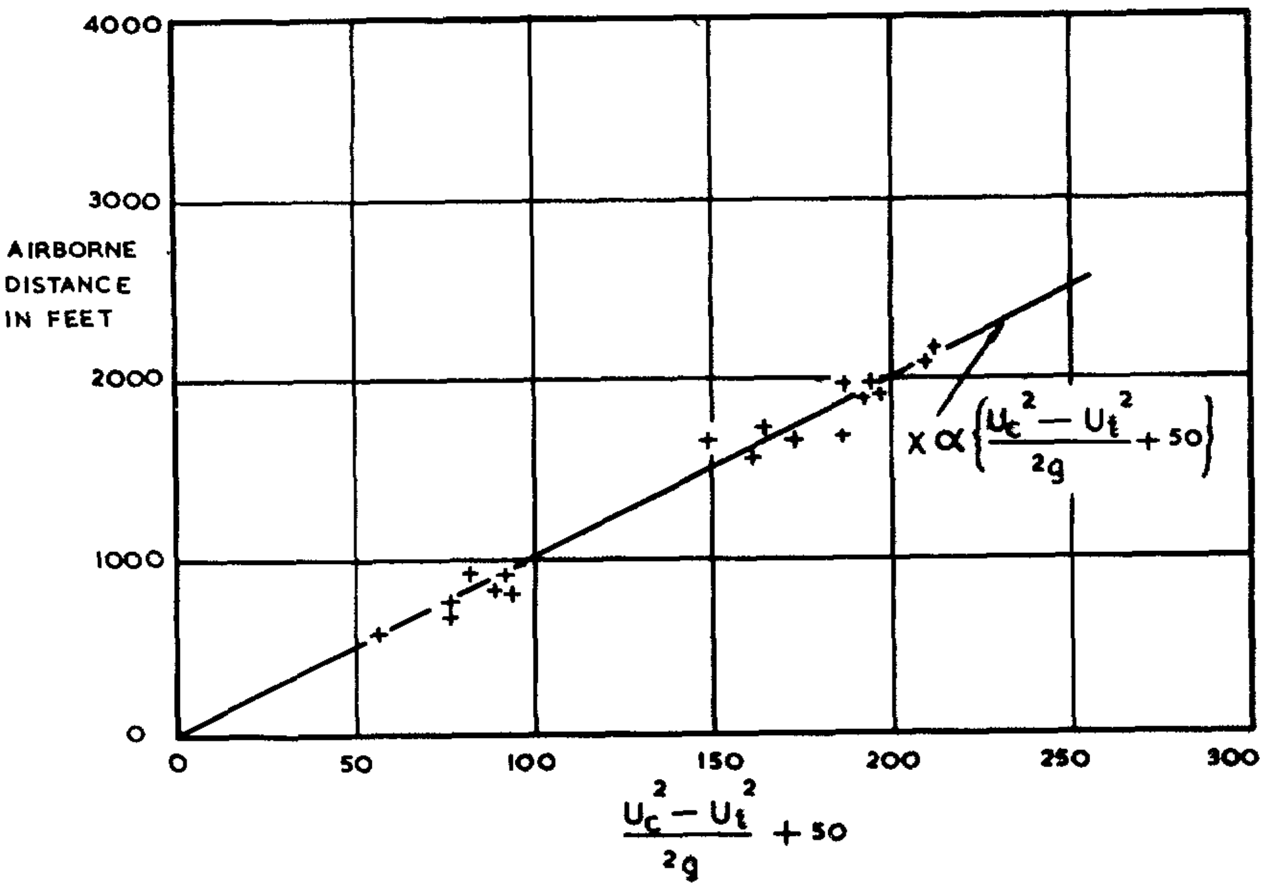


FIG. 12.
VARIATION OF AIRBORNE DISTANCE WITH UNSTICK, CLIMB AND WIND SPEEDS, SOLENT AT 77,000 LB.

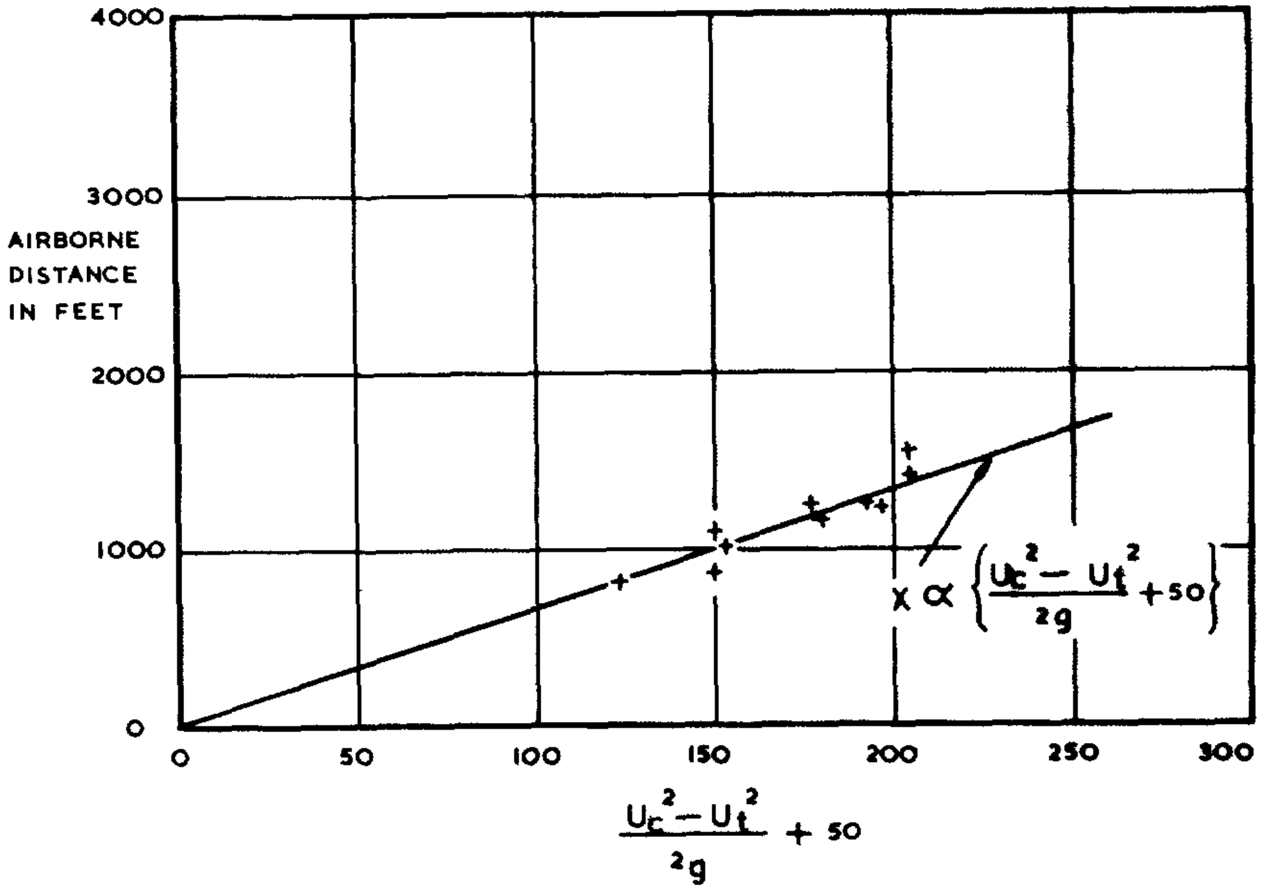
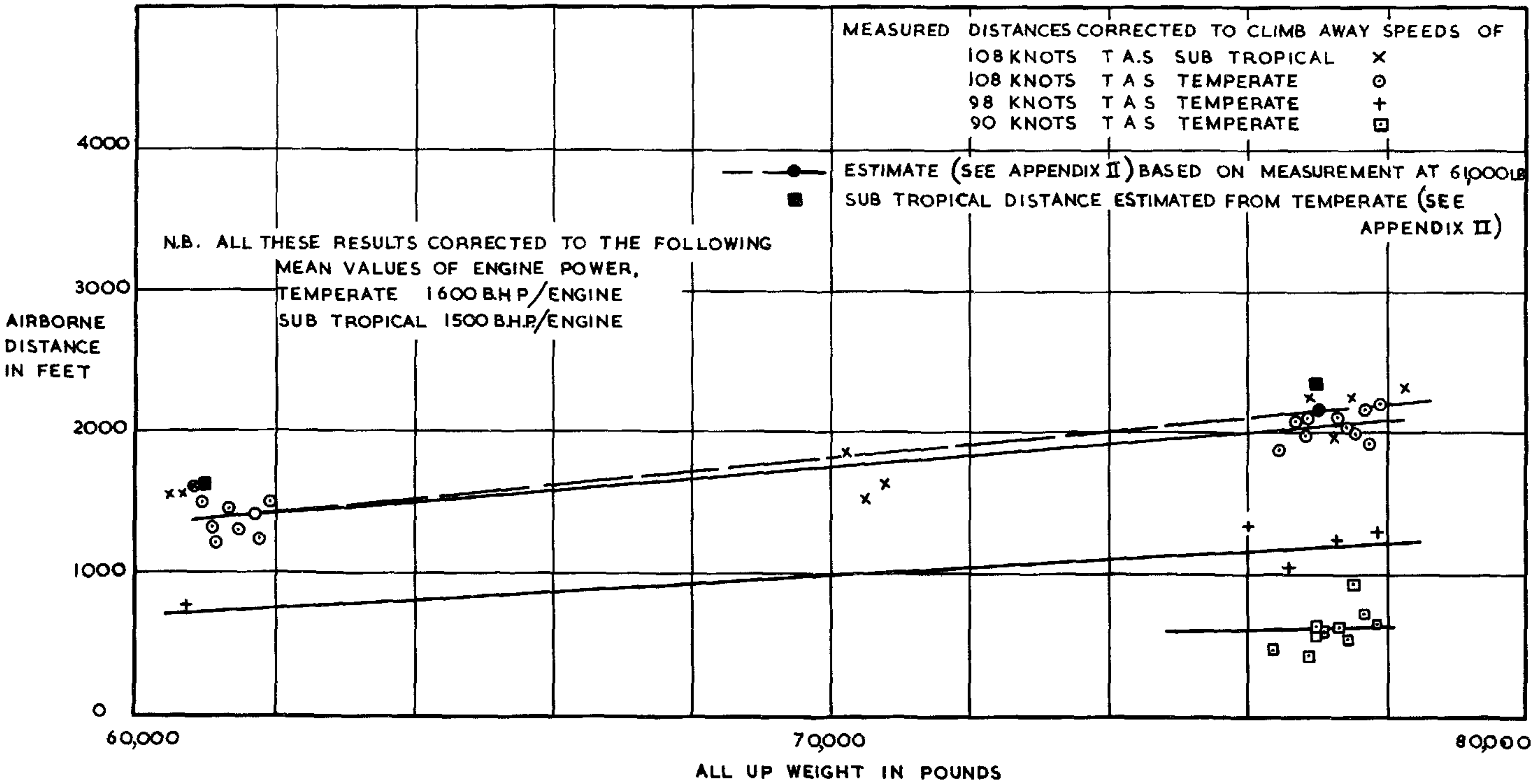


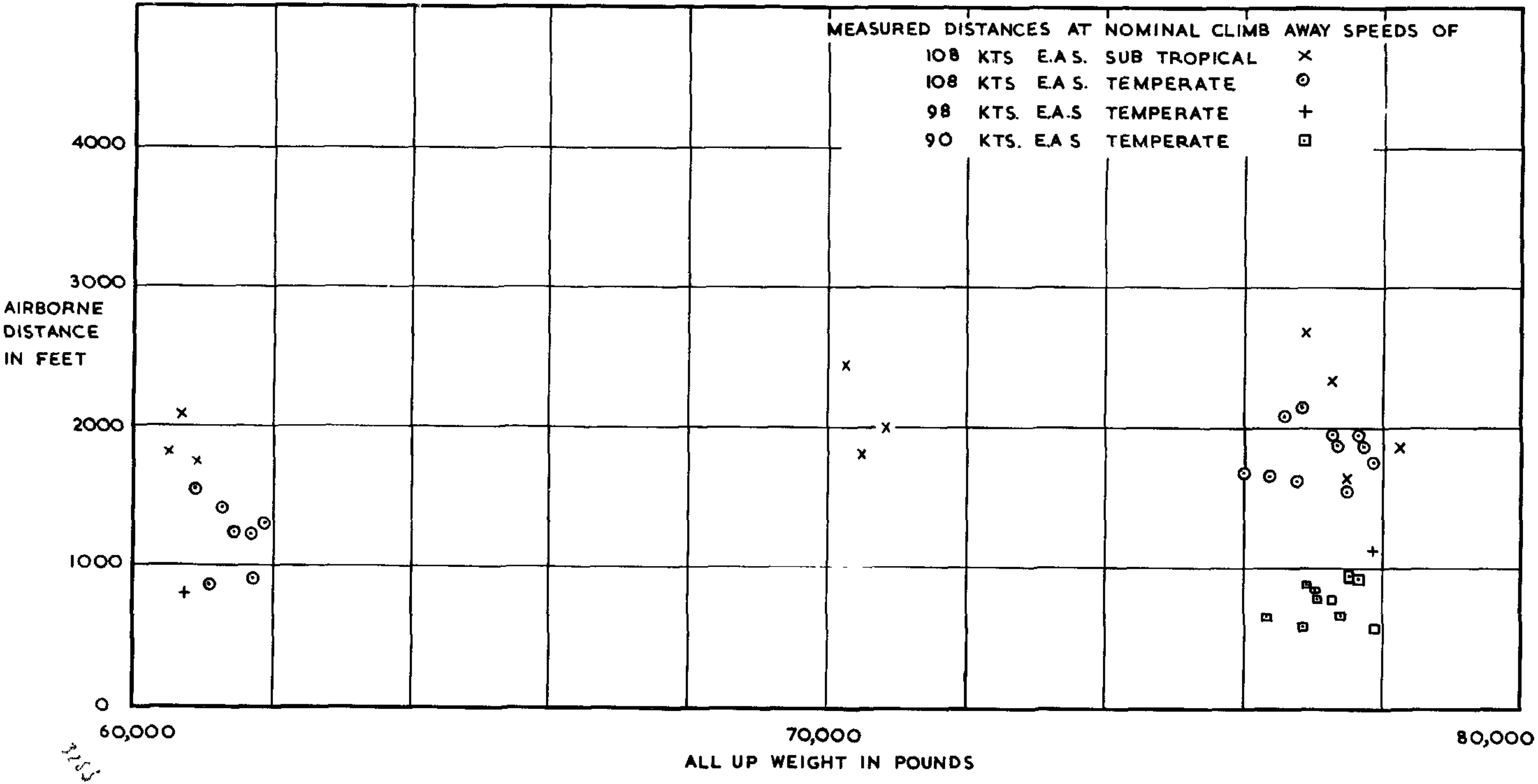
FIG. 13.

VARIATION OF AIRBORNE DISTANCE WITH UNSTICK, CLIMB AND WIND SPEEDS, SOLENT AT 61,000 LB.



VARIATION OF AIRBORNE DISTANCE WITH WEIGHT (CORRECTED), SOLENT.

FIG. 14.



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MEASURED AIRBORNE DISTANCES (UNCORRECTED), SOLENT.

FIG. 15.

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