UNCLASSIFIED

AD 271 502

Reproduced
by the

ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA

UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

AD No. 271502
ASTIA FILE COPY

271 502

AVROCAR CONTINUATION PROGRAM

DATA REPORT

FOR

1/20 SCALE AVROCAR MODEL

500/AERO TEST/410

FILE COPY

Return to
ASTIA
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA

Attn: TIRS

ASTIA
FEB 14 1962
TIPDR

AVRO AIRCRAFT LIMITED

500/AERO TEST/410

AVROCAR CONTINUATION PROGRAM

DATA REPORT

F

1/20 SCALE [illegible]

JANUARY 1

Issued by

AVRO AIRCRAFT LIMITED

Malton, Ontario, Canada

U.S.A.F. Contract AF 33(600)42163

(S.W.2

Compiled by

P.J. McGee
Aerodynamics Office
Avro Aircraft Limited

Approved by

T.D. Earl
Chief Aerodynamicist
Avro Aircraft Limited

The number of pages in this report including Title Page and Table of Contents is 454.

To:
Date:
Copy No: 16

TABLE OF CONTENTS

Section	Title	Page
1	INTRODUCTION	1
2	DESCRIPTION OF TEST APPARATUS	3
3	DESCRIPTION OF TESTS	5
4	DATA REDUCTION	9
5	[illegible]	12
6	[illegible]	18
8	DISCUSSION [illegible]	21
9	CONCLUSIONS	24
10	[illegible]	26

1. INTRODUCTION

The Avrocar (Fig. 1) is an unconventional research aircraft of circular planform, with vertical take-off capabilities and a high forward speed.

A fan, driven by the jet exhaust of three J-69-T9 gas turbine engines, draws air from the upper surface of the aircraft and expels it at the periphery. Close to the ground the aircraft utilizes the favourable lift augmenting characteristics of the annular jet.

It is visualised that the aircraft will take off vertically to a height of of approximately three feet (due to present power limitations) and make a transition in the ground cushion to free air.

The aircraft was originally designed with a spoiler control system fitted close to the periphery which was tested in the static rig, in tethered flight and in free flight in the ground cushion. Although successful free flight was achieved, the lift loss associated with application of control, which had originally been thought to be acceptable, was much greater than anticipated. It was therefore decided to install a focussing ring control system which had been tested on the 1/20th scale model (Ref. 1) with favourable results. Testing on the full scale aircraft with the focussing ring control system was proved first in the static rig and later in the tethered rig and in free flight. A number of testing hours was spent in the static rig before a suitable position for the hanger rods was obtained to achieve stability of the focussing ring at all engine speeds in the ground cushion and in free air. Due to the power limitations of the aircraft it was deemed necessary to concentrate efforts in the ground cushion and study the forward speed capabilities. Stability in the ground cushion was also a major problem and various combinations of central jets were tested in the tethered rig and in free flight. The handling characteristics of the aircraft had improved considerably and flights were made with U.S.A.F. and N.A.S.A. pilots.

In March 1960 the first of the two aircraft manufactured was tested in the 40 ft. x 80 ft. subsonic wind tunnel at the Ames Research Center, N.A.S.A. The analysis of the wind tunnel results indicated that more control power and forward thrust was required, hence all flying on the second vehicle was terminated in order to conserve the vehicle while investigation took place to rectify these deficiencies.

On July 28th, 1960 a proposal was submitted to the Wright Air Development Center (W.A.D.C.) Dayton, Ohio by Avro Aircraft Limited recommending modification to the Avrocar and seeking permission to continue further development. This proposal was

supported by favourable results from the 1/20 scale model tests which were initiated almost immediately and have continued through until October 1960.

This report is therefore a summary and analysis of the results of numerous configurations which have been tested to support the design changes for the vehicle.

2. DESCRIPTION OF TEST APPARATUS

2.1 General

The 1/20 scale model was mounted in the Avro Aircraft Company's 18 inch square ejector powered wind tunnel, by a strut attached to a five component strain gauge balance. The installation is shown in Fig. 2.

2.2 Model

The model has the same external profile as the full scale aircraft except that the cockpit covers were removed from the model. In the first phase of tests, which will be known as the Series 1 tests, the wing tip fitted to the model was the same as that used in the initial 1/20 scale tests reported in AVRO/S.P.G./T.R.266, Fig.15. In this series of tests the idea was to study, in free air, the aerodynamic characteristics of a peripheral jet with varying degrees of focussing. To represent the aircraft in its present condition the upper portion of the spoiler nozzle was taped over.

In the second phase of tests known as the Series 2 tests two basic 360° upper and lower wing tips were manufactured and fitted to the upper and lower bodies of the existing 1/20 scale model (see Fig. 3). Starting from these two basic wing tips various combinations were tested.

The circular intake in the upper wing surface accommodates an axi-symmetric centre body to guide the intake air into a radial duct leading to the peripheral nozzle. The base of the centre body was maintained at a height of 0.093" above the floor of the duct by packing washers on the retaining screw. A tube incorporated in the hollow centre body serves both to support the model from the balance and to carry compressed air from the external supply to an ejector, formed by the gap between the centre body and the duct floor. The ejector uses a small quantity of high energy primary air to draw the flow of secondary air through the intake. By this means the aircraft intake flow can be partially represented and the supply pipe diameter (and hence tunnel blockage and strut effect) is reduced to a minimum. Incorporated in the model is a central, annular nozzle; for both series of tests it was blanked off with an internal plate. Cross sections through the model are shown in Figs. 4 and 5.

2.3 Model Mounting and Air Supply

The model support strut passed through a slot in the roof of the tunnel working section and was attached by a flanged joint to the cross-member of a tubular balance frame which fitted over the roof and down both sides of the tunnel. Ring type strain gauge dynamometers supported the frame at its pivot point and transmitted loading strains.

Primary air supply for the model ejector was introduced into the tubular support frame through an air bearing to prevent transmission of pitching moment from the air supply line. Between the air bearing and the tubular frame was a light alloy tube with flexible couplings at each end, its purpose being to minimize at the dynamometer end any forces or moments arising at the air bearing end due to misalignment of the two halves of the bearing.

Primary air flow measured on the model using a "Flowrator" and taking into account the loss through the air bearings, was 0.375 lb/sec (see Fig. 13) at an indicated 50 P.S.I.G. (true 52 P.S.I.G. due to gauge inaccuracies). Secondary air flow induced through the intake by the ejector (set at 0.093") was determined to be of the order of 0.49 lb/sec. (Fig. 19). Hence the total model mass flow was approximately 0.865 lb/sec. which corresponded to a full scale aircraft mass flow of 346 lb/sec. (See Section 7).

3. DESCRIPTION OF TESTS

3.1 Series 1 Tests

Figs. 20, 21 and 22 illustrate the six cases that were tested at h/d = 0.8 (free air) at a tunnel q of 0, 5 and 17 over a range of angles of attack from +12 to -12 in 3° steps. For each case following case 1 the lower portion of the wing tip was cut back approximately 0.040 inches (this dimension varied due to the ring not being truly symmetrical). A constant primary air supply pressure to the model of 50 P.S.I.G. Indicated at an ejector gap of 0.093" was used throughout these tests. (See Section 2.3).

3.2 Series 2 Tests

In this series all the configurations tested are shown chronologically in Figs. 46 to 69. For ease of description, the similarities between certain configurations, together with the reason for testing a given configuration, are detailed in the following paragraphs.

Tests A and T (Hovering Configuration)

These two configurations represented the aircraft in the hovering position with the air discharging at the periphery from the undersurface of the model. For test "T" the jet was fully focussed and formed a very strong "tree trunk" type flow, as compared with test "A" where the jet was not attached to the lower surface of the model. Both tests were carried out to determine the relative merits of a focussed jet and an unfocussed jet at varying tunnel q and for comparison with the Series 1 tests. Each configuration was tested at tunnel q's of 0, 3, 5, 8, 12 and 17, at angles of attack from +12 to -12 in 3° steps and at a ground height equivalent to an h/d = 0.8 (free air).

Tests B and S (1st Stage Transition)

The rudder turning vanes were simulated here with the unfocussed jet (Test B) and the focussed jet (Test S). The rudder vanes extended over an arc of 45° extending forward of the lateral axis. It is considered that rudder vanes pointing aft will be the first step of transition, and here the effect of the increase in thrust was studied. Both tests were carried out at an h/d value = 0.8 (free air) at a tunnel q of 0, 3, 5, 8, 12 and 17, and angle of attack from -12° to +12°.

Tests E and K (2nd Stage Transition)

With these configurations the second stage of transition was represented with an unfocussed jet (Test E) and a focussed jet (Test K). A 50° segment aft of the lateral axis turned the air at the periphery, by means of cascades, in an aft direction. The rudder vanes were still pointing aft. The forward 180° and the aft 80° were similar, delivering the air at the periphery on the lower surface forming an unfocussed jet (not attached to the bottom surface) Test E and a focussed jet (free trunk type flow) Test K. The tests were carried out in free air (h/d = 0.8) at a tunnel q of 0, 3, 5, 8, 12 and 17 and angles of attack from -12° to +12°. A study of both configurations in the ground cushion was made at zero angle of attack at q = 0.

A further study of the ground effect was made with configuration 'K'. Five ground heights were simulated, viz. h/d values = 0.091, 0.14, 0.195, 0.25 and 0.318. Tunnel q = 0, 3, 8, 17, at angles of attack from -12° to +12°.

Tests F and G (Inflight Configuration)

The configuration of these two tests was similar to that for Tests E and K, except that the aft 80° segment was replaced with an 80° segment which discharged the air aft and downwards at an angle of 30° to the horizontal datum. For test 'F' the forward 180° jet was unfocussed and for test 'G' was a focussed jet. In both configurations the tests were carried out at an h/d value = 0.8 (free air), tunnel q = 0, 3, 5, 8, 12, 17 and an angle of attack from -12° to +12°. In test 'F' ground height was studied at zero angle of attack and at q = 0.

Tests N, O, Q, H and J (Transition from 2nd Stage to Inflight Configuration)

An attempt was made to study the aerodynamic characteristics of the aircraft from the 2nd stage transition to the inflight case. In the full scale aircraft transition doors located in the aft segments of the peripheral nozzle will control the air discharging to the undersurface of the aircraft or in an aft direction. The air discharging aft can be controlled by Pitch and Roll Control vanes, downstream of the door, which deflect the air through an angle of 0° to 60° from the horizontal datum.

On the model this system cannot be truly represented due to cost and time involved in manufacturing suitable parts. As already described two basic wing tips were designed for the model. One to discharge the air to the lower surface of the model, forming a focussed or

unfocussed jet, and tne other to discharge the air aft at an angle of 30° to the horizontal datum.

To simulate the aircraft pitch control vane a series of flaps was manufactured which were attached to the "inflight" wing tip segment to deflect the air to 0°, 15°, 45°, 60° and 90°. These five flap positions (Tests N, O, Q, H and J) were tested with the forward 180° wing tip segments focussed. No comparison was made with the forward 180° wing tip segment unfocussed. Each configuration was tested at an h/d = 0.8 (free air) at q values = 0, 3, 5, 8, 12 and 17 and angles of attack from -12° to +12°.

Tests C and D, and P and R - Tailplane Tests

The effect of the tailplane was evaluated with a "hovering configuration" and an "inflight configuration". For these tests the model was mounted in the tunnel upside down, to provide a clean flow of air over the upper surface of the model and thus avoid strut interference on the tailplane, Due to time limitation on the test program strut corrections with the model upside down were not available. Tests C and P were the "hovering" and "inflight" configurations without the tailplane and tests D and R with the tailplane. Hence, with this arrangement the effect of the tailplane could be obtained by subtracting test 'C' from test 'D' (and likewise with test P from test R) without knowing the strut effect. For test 'C' tunnel speeds of 0, 5, 12 and 17 were tested at a model incidence of -6°, 0° and +6°. For test 'D' the same tunnel schedule was adhered to at tailplane settings of +10°, +20°, +24° and +30° from the horizontal model datum. For test 'P' additional α 's of -12 and +12 were tested and in test 'R' the tailplane settings were +10°, +13°, +16°, +20°, +24°, +27° and +30°.

Tests U, W and Y (2nd Stage Transition to Forward Flight)

The model configuration for tests 'U', 'W' and 'Y' was similar to tests 'G', 'O' and 'M', i.e. the air discharging over the rear 80° was deflected at 30°, 15° and 60°. The wing tip cascades which existed 50° aft of the lateral axis were now extended an additional 30° forward of the lateral axis and the rudder vanes decreased to extend 23° forward of the cascades. The purpose of the wing tip cascades was (a) to give a thrust increase and (b) to give a lift increase due to a larger effective aspect ratio. Introducing the additional cascades a further increase in lift was anticipated. A study of ground effect with each configuration was also made and for tests 'U' and 'W' h/d values of 0.8 (free air) 0.318, 0.25, 0.195, 0.15 and 0.091 were tested at tunnel speeds of 0, 3, 5, 8, 12 and 17 with a model incidence range of +12 to -12 in 3° steps. For test 'Y', due to time limitations, tunnel speeds of 0 and 8 only were used with the same h/d values, incidence range and supply pressure.

Test Z (Jet Flap)

The configuration for this test was similar to test 'Y', i.e. with the 60° flap, except that the forward 120° focussing wing tip was blanked off allowing no air to be discharged over this area. The reason for this configuration was to isolate and study the effect of a forward focussed jet on the jet flap arrangement that existed over the rear 80° of the model. Tests were carried out at h/d values = 0.8 (free air) and 0.14, at tunnel speeds of 0 and 8 at a model incidence of +12 to -12 in 3° steps. For h/d values = 0.091, 0.195, 0.25 and 0.318 the model incidence was 0° and tunnel speed was set at 0 and 8.

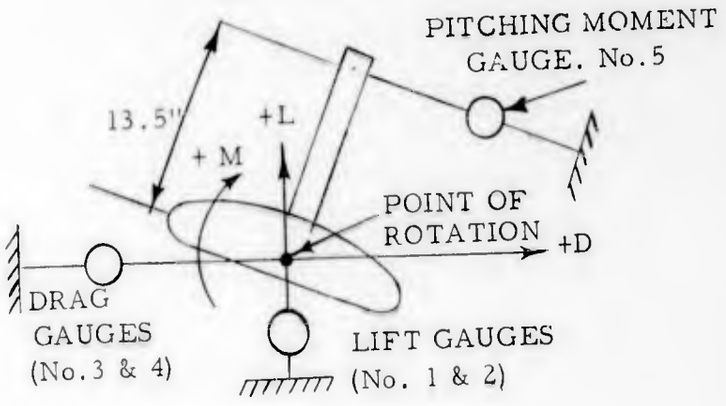
Tests L, M and X (Ames Tunnel Test Comparison)

The configurations tested for L, M and X were carried out to correlate the results of the Ames Tunnel tests. For test 'L' a focussed jet existed over the forward 180°, with the aft 50° either side of the lateral axis having an unfocussed jet. Over the rear 80° the air was discharged at an angle of 60° by attaching the 60° flap to the "inflight" configuration wing tips. In test 'M' a focussed jet replaced the unfocussed jet of test 'L'. Both tests were carried out at an h/d = 0.8 (free air) at tunnel speeds of 0, 3, 5, 8, 12 and 17, and an α range of +12° to -12°. The configuration of test 'X' was identical to test 'M' except that the exit area over the rear 80° of the model was reduced 50%. This was because the effective exit area of the Avrocar configuration tested at Ames was much reduced (Ref. 2 Config. N.1). Check runs were carried out at tunnel speeds of 0, 5 and 17 at an h/d = 0.8 (free air).

4. DATA REDUCTION

4.1 Derivation of Equations

The diagram below shows the arrangement of forces and gauges from which the equations are derived:



The equations are:

$$\text{Lift} = -K_1(\Delta L_1 + Z_1) - K_2(\Delta L_2 + Z_2) - \frac{K_5(\Delta L_5 + Z_5)}{13.5} \sin\alpha \text{ (lb)}$$

$$\text{Drag} = -K_3(\Delta L_3 + Z_3) - K_4(\Delta L_4 + Z_4) + \frac{K_5(\Delta L_5 + Z_5)}{13.5} \cos\alpha \text{ (lb)}$$

$$\text{Pitching Moment} = K_5(\Delta L_5 + Z_5) \text{ (lb.ins)}$$

where the ΔL's are the increments in S.R.4 indicator readings from the no load condition. Compression in a dynamometer produced a positive ΔL. The third terms in the lift and drag equations are components of the force in the pitching moment gauge.

The Z's are gauge corrections due to the shift in the dynamometer zeros obtained by pressurization of the tubular balance frame and the aluminum connecting tube. The gauge corrections used in this report were taken from Avro/S.P.G./TR 313 page 8, and are as follows:

SUPPLY PRESSURE P.S.I.G.	GAUGE CORRECTION MICROINCH/INCH				
	Z_1	Z_2	Z_3	Z_4	Z_5
50	-1	5	-2	6	1

The K's are dynamometer gauge calibration factors, listed below:

Gauge No.	Constants
1 Stbd.	K_1 = 0.0206 lb/microinch/inch
2 Port	K_2 = 0.0179 lb/microinch/inch
3 Stbd.	K_3 = 0.0132 lb/microinch/inch
4 Port	K_4 = 0.0132 lb/microinch/inch
5	K_5 = 0.035 lb/microinch/inch

4.2 Formulating of Results

Due to the length of the test program that was being considered it was deemed advisable to establish an I.B.M. 650 computer program for calculation of results.

The program was established to obtain three cases:

1. Static Case - Wind Off - Power On
2. Basic Aerodynamic Case - Wind On - Power Off
3. Complete Case - Wind On - Power On

Corrections to force and moment readings fall into three categories.

1. Tunnel wall effects
2. Blockage effects
3. Model support strut effects

Together, these effects necessitate corrections to the aerodynamic coefficients, the angle of attack and the dynamic head in the tunnel in order to correspond to free air conditions or free air with ground effect.

Test data for h/d = 0.8 have been reduced to free air conditions but for lower values of h/d, where ground effect is important, the test results have been corrected to eliminate the effect of the tunnel side walls and roof but to include the ground board effect.

Sections 5 and 6 deal with tunnel wall and blockage effects and strut effects respectively.

The final form of the equations for corrected coefficients is

C_L Corr. = C_L ind + C_L Blockage + C_L Strut

C_D Corr = C_D ind + C_D Blockage + C_D Strut + C_D Wall

C_M Corr = C_M ind + C_M Blockage + C_M Strut

α Corr = α ind + $\Delta\alpha$

q Corr = q ind $(1 + 2\epsilon)$

where ϵ is due to blockage and is defined in section 5.

5. WIND TUNNEL CORRECTIONS

5.1 General

Wind tunnel corrections arise because of the following effects:

1. Modification of the downwash
2. Blockage due to the model
3. Blockage due to model wake
4. Blockage due to part of jet air supplied from outside the tunnel.

With the model close to the ground the effects of the ground are required. Hence, the effect of the other three walls of the tunnel are to be evaluated.

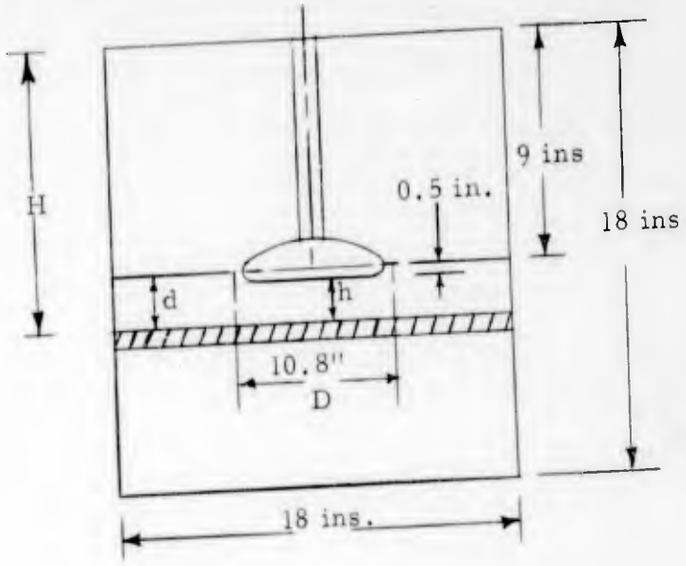
5.2 Model Data

Diameter	= 10.855 inches
Plan Area	= 92.556 sq. inches
Cross Section Area	= 18.36 sq. inches
Volume	= 132.63 cubic inches
Distance of model datum above bottom of model	= 0.58 inches

5.3 Tunnel

Size: 18 inches x 18 inches

5.4 Model and Ground Board Installation



(1) $\sigma = \frac{s}{b} = \frac{\text{model semi-span}}{\text{tunnel breadth}} = \frac{5.4275}{18} = 0.301$

(2) $E = \frac{d}{H} = \left(\frac{h}{D}\right)\left(\frac{D}{H}\right) + \frac{1}{2H}$

where $H = 9.5 + \frac{h}{D} \cdot D$

$$\therefore E = \left(\frac{h}{D}\right)\left(\frac{D}{9.5 + \frac{h}{D} \cdot D}\right) + \frac{1}{2\left(9.5 + \frac{h}{D} \cdot D\right)}$$

$$= \frac{h}{D}\,\frac{1}{\left(\frac{9.5}{D} + \frac{h}{D}\right)} + \frac{1}{2D\left(\frac{9.5}{D} + \frac{h}{D}\right)}$$

$$= \left(\frac{h}{D} + \frac{1}{2D}\right) \cdot \left(\frac{1}{\frac{9.5}{D} + \frac{h}{D}}\right)$$

Now D = 10.855 inches

$$\therefore E = \frac{h/D + 0.046}{h/D + 0.875}$$

(3) Tunnel $H/b = \frac{9.5 + h/D \cdot D}{18} = 0.5278 + 0.603\frac{h}{D}$

5.5 Downwash Corrections

5.5.1 Corrections to Downwash in Ground Effect Tests

Corrections to the downwash in ground effect cases are given in Ref. 3.

The change in downwash angle is

$$\Delta\alpha = \bar{\delta}_g \cdot \frac{S}{C} \cdot K_L = \bar{\delta}_g \cdot \frac{S}{C} \cdot \frac{C_L}{2} \quad \text{(rad)}$$

where $\bar{\delta}_g$ is correction factor to ground effect.

S = Model wing area

C = Tunnel cross-sectional area

$K_L = C_{L/2}$

$\Delta\alpha$ = change in angle of attack due to tunnel sides and roof.

For $\sigma = 0.3$ and $H/b = 0.5$, the values of $\bar{\delta}_g$ corresponding to the given values of h/D were determined from Ref. 3.

Then since C varies as h/D varies

$$\Delta\alpha = \overline{\Delta_g} \cdot C_L$$

where $\overline{\Delta_g} = \overline{\delta_g} \cdot \frac{S}{2C}$

A plot of $\overline{\Delta_g}$ versus h/D is given in Fig. 6.

Note that the lift coefficient to be used when calculating $\Delta\alpha$ is that part of the total C_L which gives rise to circulation.

The total C_L is written

$$C_L = C_{L_b} + C_{L_i} + C_{L_j}$$

where C_{L_b} = Basic Aerodynamic Lift (jet off)

C_{L_i} = Induced lift due to jet on

C_{L_j} = Jet reaction lift coefficient

$$= \frac{\text{Lift at zero fwd. speed}}{qS} = \frac{L\,(q = 0)}{qS}$$

Hence for calculating $\Delta\alpha$ (wind on - power on) we use the expression

$$\Delta\alpha = \overline{\Delta g}\ (C_{L_T} - C_{L_j})$$

Where C_{L_T} is the C_L indicated (Complete case - wind on power on) and must include strut effects.

i.e. $$\Delta\alpha = \overline{\Delta g}\ (C_{L_{IND}} - C_{L_j})$$

Now for calculating $\Delta\alpha$ (wind on - power off) we use the expression

$$\Delta\alpha = \overline{\Delta g}\ .\ C_{L_T}$$

where C_{L_T} is the C_L indicated (wind on - power off)

5.5.2 Corrections to Downwash for "Free-Air" Tests

In order to correct the test results at h/D = 0.787 to "Free-Air" results we refer to Pankhurst and Holder P. 371 (Ref. 4).

The change in mean downwash angle is

$$\Delta\alpha = \delta . \frac{S}{C} . C_L$$

For a span/tunnel breadth = 0.6 in a square closed tunnel and assuming elliptic loading spanwise across the model we get

$$\delta = 0.148$$

Then $$\Delta\alpha = 0.148\ \frac{S}{C} . C_L$$

where $0.148 \times S/C$ is equivalent to $\overline{\Delta g}$ in ground cushion tests

Hence $\Delta\alpha = 0.0418\ C_L$ (rad)

$= 2.395\ C_L$ (deg)

Here also $C_L = C_{L_{IND}} - C_{L_j}$ (Wind on - power on)

or $C_L = C_{L_{IND}}$ (Wind on - power off)

NOTE: Owing to the change of incidence ($\Delta\alpha$) the lift vector is inclined and a correction to drag (free air, and ground cushion) is required (Ref. 4 page 354). This is given by $\Delta C_D = \Delta\alpha \cdot C_{L_{IND}}$ where $\Delta\alpha$ is in radians.

where $C_{L_{IND}}$ = Measured C_L including strut effect

5.6 Solid and Wake Blockage Corrections

5.6.1 Solid Blockage

From Ref. 4 page 344, solid blockage is defined

$$\epsilon_S = 0.65 \frac{V}{h^2 b}$$

Where V = volume of model, strut, and ground board where applicable

h = tunnel height

b = tunnel breadth

5.6.2 Wake Blockage

From Ref. 4 page 348, wake blockage is defined as

$$\epsilon_W = 0.25 \cdot \frac{S}{bh} \cdot C_D$$

where S = Model wing area

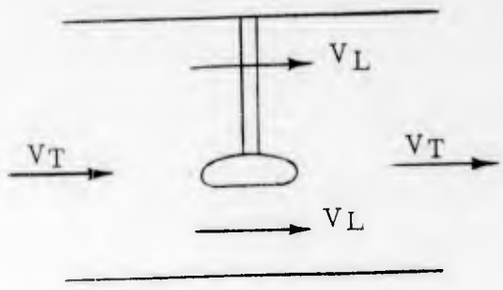
b = Tunnel breadth

h = Tunnel height

and where C_D = the value of C_D (jet off, model + strut), which for these tests was considered to be 0.17.

Therefore total blockage $\epsilon_T = \epsilon_S + \epsilon_W$

5.6.3 Application of Solid and Wake Blockage Corrections



If V_T = Tunnel velocity

and V_L = Local disturbed tunnel velocity

the increase in wind speed around the model due to blockage is given by:

$$\frac{V_L}{V_T} = 1 + \epsilon$$

Therefore $\frac{q_L}{q_T} = 1 + 2\epsilon$ approx.

i.e. $qc = qu\ (1 + 2\epsilon)$

where qc = corrected q

qu = uncorrected q

Hence, for cases with ground board removed (h/d = 0.787) the total volume:

V_T = V model + V strut = 148 cu. inches

therefore $2\epsilon = 0.0330 + 0.1414\ C_{D_T}$ (jet off).

and for cases with ground board the total volume

V_T = V model + V strut + V ground board = 580 cu. inches

therefore $2\epsilon = 0.1293 + 0.1414\ C_{D_T}$ (jet off)

6. STRUT CORRECTIONS

Top strut corrections were available from previous 1/20 scale model tests as described in AVRO/S.R.G./TR.313. The results of these tests are shown in figs 7 to 12. In studying Figs. 7, 9 and 11 it will be observed that we have C_L C_D & C_M vs α for a constant wind speed (120 ft./sec), h/d = 0.8 (free air) and supply pressure to the model of 50 P.S.I. In Figs 8, 10, 12, C_L C_D C_M is shown against forward speed, for varying ground positions at a constant α = 0, and supply pressure 50 P.S.I.G. Hence for all ground heights and varying wind speed at α = 0 strut corrections for C_L C_D and C_M could be obtained. For varying α, knowing the α = 0 value, it was assumed that C_L C_D and C_M varied as in Figs 7, 9 and 11.

The same strut corrections were used for each configuration tested and therefore some error was introduced since strut effects are affected by the jet flow pattern.

7. EVALUATION OF PRIMARY AND SECONDARY AIR FLOW

7.1 General

Throughout the test program the ejector gap was set at a constant value of 0.093" and pressure to the model, controlled just upstream of the air bearing, was set at a true gauge reading of 52 PSIG (50 PSIG indicated). It was considered that at this ejector gap and supply pressure, the model results would compare with the aircraft running at 90% engine RPM. As part of the test program an attempt was made to confirm this.

7.2 Evaluation of Primary Air Mass Flow

In order to establish the true mass flow passing through the model ejector gap a "FLOWRATOR" was connected into the pressure line. The loss in mass flow through the air bearing was determined by placing a blanking plate at the point where the model strut is connected to the balance. The results of this test are shown in Fig. 13 together with the mass flow variation, for varying ejector gap and supply pressure. It can be seen from Fig. 13, at a supply pressure of 52 PSIG (TRUE) that the supply line is choked at an ejector gap beyond 0.039 inches. This is supported by Fig. 14 where the total pressure at the ejector was measured with varying ejector gap at a constant pressure controlled just upstream of the air bearing.

7.3 Evaluation of Secondary Air Flow

A method was evolved to provide an estimate of intake mass flow (see Ref. 2 Section 4.3.2). A plot was made of D-F versus free stream velocity at constant α (preferably $\alpha = -12^{o}$) and a tangent to the curve at V = 0 is drawn. The slope of the tangent is then equal, approximately, to the total intake mass flow. Assumptions to be made with this method are as follows:

(1) That the mass flow is constant with speed.

(2) That the horizontal component of jet reaction force remains constant with speed.

(3) When drawing the tangent to D-F versus V curve, a certain amount of intuition is called for. Some guidance is obtained by assuming that the difference in drag between the "mass flow tangent" and the D-F curve varies as the velocity squared. This implies the assumption that $C_{D_B + i}$ is constant with speed.

This method was applied to tests A and T (Fig. 15), B and S (Fig. 16), F and G (Fig. 17), U (Fig. 18) and test W (Fig. 19). A variation in intake mass flow is expected with different configurations, but the variation that was obtained from these tests does show a large scatter, hence it is felt that an accurate value of intake mass flow is probably impossible to determine.

8. BRIEF DISCUSSION OF RESULTS

8.1 Series 1 Tests

The results of these tests are shown in Figs. 23 to 45 for q values of 0, 5 and 18. Statically, the lift is larger with a focussed jet and decreases as the jet becomes annular, but with forward speed the unfocussed or annular jet gives a greater lift value. The lift loss associated with the focussed jet at low forward speeds is probably due to the fully focussed "tree trunk" type flow which makes it impossible to obtain any induced lift. A focussed jet also produces a very large nose-up pitching moment which decreases to a substantial nose-down moment as the jet becomes annular. The table below shows the variation in the lift curve slope and the position of the aerodynamic centre with degree of focussing and forward speed. It appears, the aircraft becomes more stable as the jet becomes less focussed.

	q	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
$^{d}C_{L/d}$	5.265	-	0.229	1.49	1.031	2.349	2.292
(Per Rad)	18.113	1.489	2.063	1.833	2.292	2.235	2.235
$^{d}C_{M/dC_L}$	5.265	-	-	0.15	0.25	0.12	0.09
	18.113	0.25	-	0.155	0.138	0.128	0.114

8.2 Series 2 Tests

Figs 70 to 405 show the results of all configurations tested.

For each test a similar number of graphs has been prepared to enable direct comparisons to be made between configurations.

In comparing tests A and T a similar trend exists between lift and moment as experienced in the Series 1 Tests.

Effect of Forward Turning Vanes

The effect of adding the forward turning vanes decreased the static lift but increased the lift with forward speed. The drag decreased by approximately 0.5 lb., but was slightly less with a fully focussed

jet at the maximum q tested. The negative pitching moment (Test B-A) increased by approximately 3.5 lb/ins. but with the focussed configuration (Test S-T) the nose up moment was reduced approximately 5 lb. ins.

Effect of Lateral Cascades

The nose up moment which existed with 360° of focussed jet disappeared when the jet was deployed outwards over two 50° sectors to the rear of the lateral axis by means of cascades (Test K) and gave a greater nose down moment than Test E where the forward 180° and rear 80° jet was unfocussed. The drag for both tests was reduced approximately 2 lb. and a static thrust of 2.5 lb. was obtained at α = -12°. Test K also produced a slightly higher lift.

Inflight Configuration

In deploying the aft 80° of the jet in a rearward direction at an angle of 30°, Test F and G, the propulsive thrust and nose down moment especially in Test G was increased considerably compared with Test K. It has already been shown that the nose up moment which existed is destroyed when the side jets are deployed outwardly. In studying tests F and G the effect on moment due to focussing and unfocussing the forward 180° shows that an increase in nose down moment of approximately 5 lbs/ins at negative angles of attack can be attributed to focussing. A larger thrust is also shown for Test G over Test F. The lift obtained in both cases is similar. In Test U additional cascades were positioned forward of the lateral axis producing an α TRIM which is less positive, a higher lift curve slope, but slightly less thrust.

Control Cases, Jet Deflection Angle Varied

In comparing tests N, O, G, Q, H and J, the larger jet deflection angle produced high lift values and large nose down pitching moment. Maximum thrust is obtained at 0° deflection angle but the increase is small below the 30° value and the loss of lift and nose down moment is quite apparent. In Figs. 406, 7, 8 the lift drag and moment for jet deflection angles of 30°, 45° and 60° at a q of 18 are compared with the results obtained from the 1/20 scale model focussing ring control tests (Avro/SPG/TR 313).

At J_e = 1.0 and α = 0, at full scale the new inflight configuration produced approximately 2,000 lb. more lift, a thrust increase of 510 lb., and an increase in nose down moment of 11,800 lb.ft. compared with the earlier model values for the focussing ring.

At $J_e = 0$, and $\alpha = 0$ the new inflight configuration produced a decrease in lift of approximately 300 lbs, a thrust increase of 2,500 lb. and an increase in nose down moment of 3,500 lb.ft.

It should be noted that with the focussing ring, aft movement of the control ring produced no change in lift, and an increase in thrust and nose down moment. With the new inflight configuration downward deflection of the pitch control vane increases the lift and nose down moment but decreases the thrust. The effect of introducing additional cascades forward of the lateral axis (Test U) increases the lift with forward speed and gives a larger nose down moment at negative angles of attack but produces a greater nose up moment at positive angles of attack. The thrust is reduced approximately 0.5 lb.

Ground Effect

In comparing ground effect with the inflight configurations and varying jet deflection angles (Tests W, U, X, 15°, 30° and 60°), it is apparent that a positive ground effect is available at a jet deflection angle of 60°.

At jet deflection angles of 30° and 15° there is no ground effect at zero angle of attack but ground effect appears as angle of attack becomes more positive. The thrust at positive angles of attack is fairly linear with ground height but at negative angles of attack the thrust decreases. The curve of pitching moment vs α takes the form of a parabola as h/d decreases indicating a positive pressure build up under the rear of the model at positive angles of attack producing a nose down moment.

Tailplane Effect

The net effect of the tailplane is shown in Figs. 103-108 for tests C and D. Figs. 259 - 261 and 274 - 285 i.e. tests P and R indicate that the tailplane has little effect with the two configurations tested.

NOTE: For certain configurations tested an effective static moment, which is obtained from the intersection of the moment vs α curves for the forward speed cases, has been used to produce additional graphs of $C_{mB} + _i$ vs α and pitching moment vs dynamic pressure. These are indicated by placing the number 1 following the respective Fig. No. eg. Fig. 111/1, Fig. 115/1, Fig. 120/1. A full discussion of effective forces and moments is given in 500/AERO TEST/407, Section 4.3.1.

9. CONCLUSIONS

1. A highly focussed peripheral jet produces a zero lift curve slope at relatively low speed, i.e. q = 5, and hence the aerodynamic centre is very far forward of the leading edge. De-focussing the peripheral jet reduces the instability and the nose up pitching moment progressively. The drastic effects of focussing are only slightly moderate at q = 18.

2. With the focussing ring control used previously on the 1/20 scale model the pitching moment at α = 0 and q = 18 with control neutral was +1925 lb.ft. The change of moment from control neutral to control aft was 3900 lb.ft. (equivalent to a 10^{o} change in angle of attack) both figures being scaled for the full-size aircraft. The new "in-flight" configuration produces a nose down moment change of 12,400 lb.ft. from the neutral control value of-1,500 lb.ft., a three fold increase in control power, six times the previous maximum nose down moment and equivalent to a 25^{o} change in angle of attack at this speed. A large increase in propulsive thrust was also measured with the "in-flight" configuration, eg. 2,500 lb. increase with neutral control and 480 lb. increase with fully aft control. Model thrust level is thought to approximate to half thrust. Changes are considered reasonably representative of full scale, and full scale differences fairly applicable, except that model intake mass flow is less than nozzle mass flow by a greater amount than full scale necessitating a large momentum drag correction and nose up moment corrections (See Ref. 2).

3. The large nose up moment which existed with the 360^{o} fully focussed jet was replaced by a nose down moment when air was directed rearwards via peripheral nozzle cascades near the lateral axis. In fact at q = 18 and α = 0 a nose down moment of 4,800 lb.ft. could be attributed to this cause.

4. Ground effect with the "in-flight" configuration with control neutral is practically non-existent both statically and at forward speed for zero and negative angles of attack. A typical lift increase due to ground proximity is however found at positive angles of attack. With full nose down control in the inflight configuration a positive ground effect at α = 0 is found.

   By blanking-off the forward (focussed) region of the peripheral jet in the ground cushion an appreciable reduction in lift was observed, the configuration then somewhat resembling a single jet-flapped wing. The model did then in fact show the typical

negative ground effect in this configuration, in contrast to the case with the front sector blowing. It also showed greater lift and nose down moment in free-air since all the air supplied to the model was being utilized in the 'jet-flap' at the rear. It is not, however, known how the total jet momentum compares in the two cases. The effect on moment in the ground cushion is reversed.

5. The effect of introducing a tailplane to the in-flight configuration produced a 2% rearward shift of the aerodynamic center. A 50% larger tailplane has been manufactured and will be tested on the aircraft in the 40' x 80' low speed wind tunnel at the Ames Research Center.

6. With the focussing ring control used previously on the 1/20" scale model the position of the aerodynamic centre was 11% and 16% forward of the C.G. with neutral and fully aft control respectively. With the present control scheme the corresponding positions are 10% and 6%. Despite the small difference with control neutral a general view of the results indicates that a rearward shift in A.C. of at least 10% may be expected to result from the proposed modifications.

10. LIST OF REFERENCES

Ref.1 Garland, D.B. — Data Report for 1/20th Scale Avrocar Model Focussing Ring Control Forward Flight Tests. AVRO/SPG/TR 313. Issued June 1960.

Ref.2 Garland, D.B. — Analysis of Phase 1. Tests of the Avrocar at N.A.S.A. 500/AERO TEST/407 Issued December 1960.

Ref.3 Brown, W.S. — Wind Tunnel Correction on Ground Effect British R.A.E. R and M 1865. Issued July 1938.

Ref.4 Pankhurst and Holder — Wind Tunnel Technique Pitman 1952.

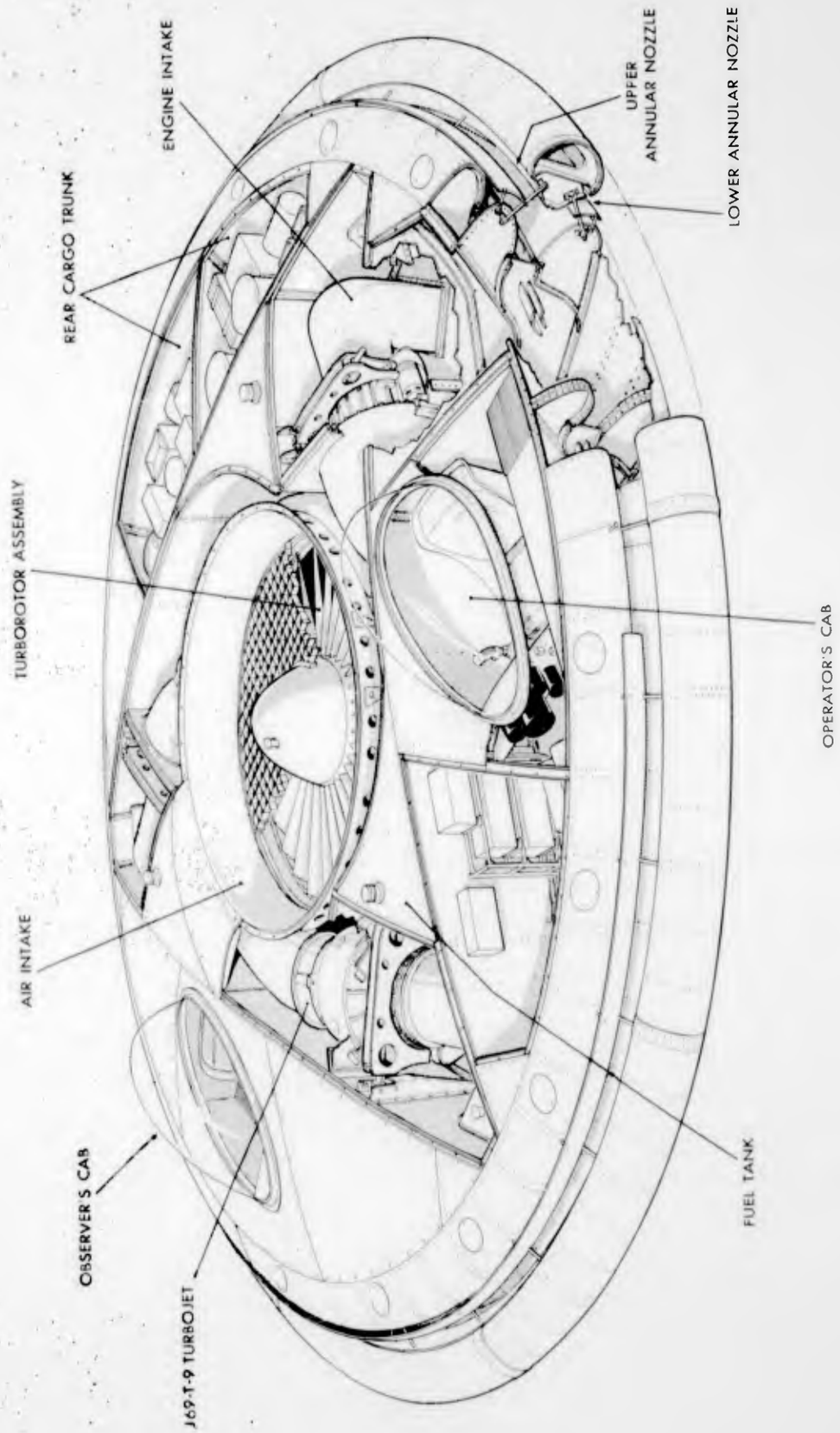


FIG. 1 STRUCTURE CUTAWAY

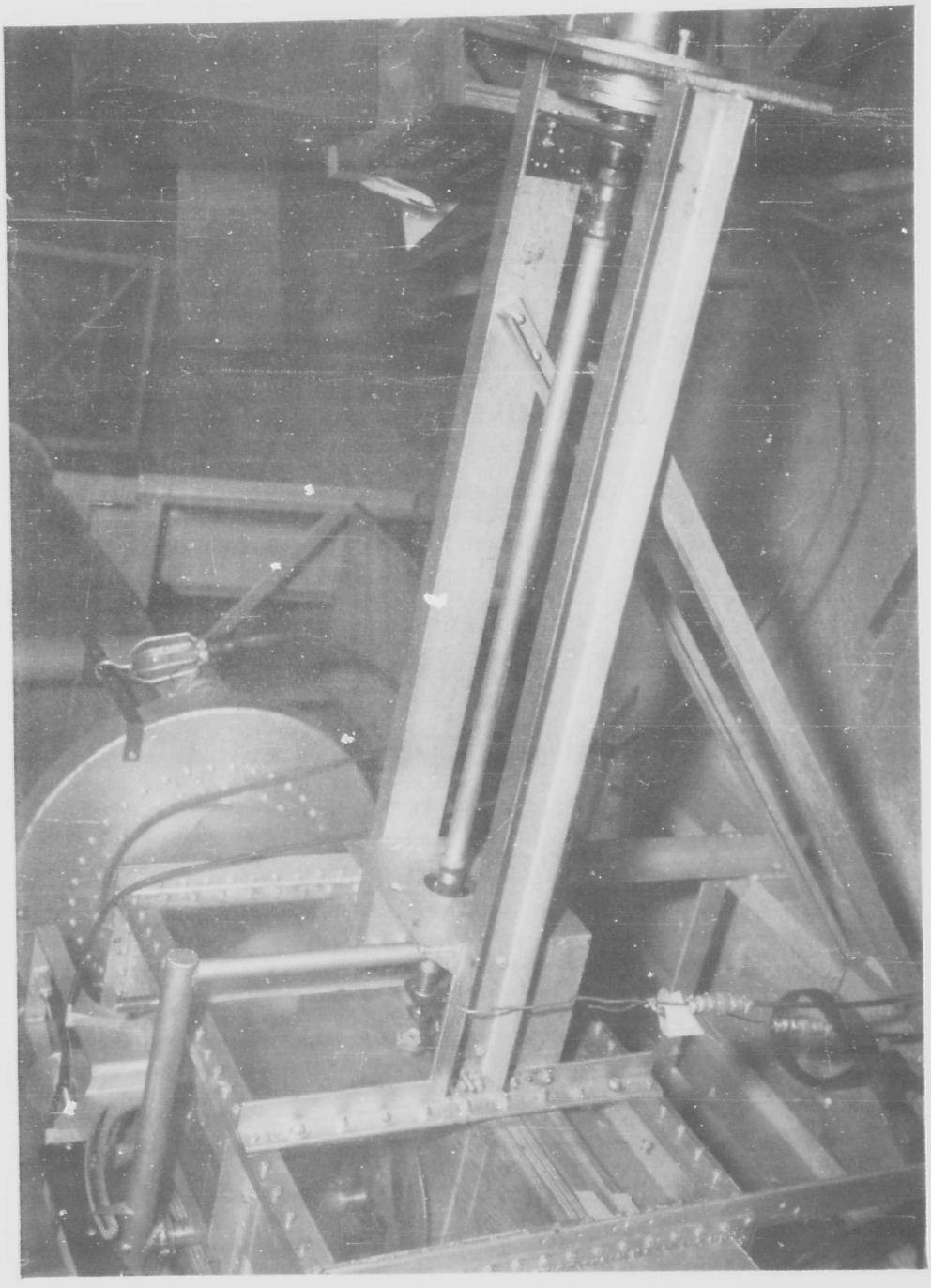
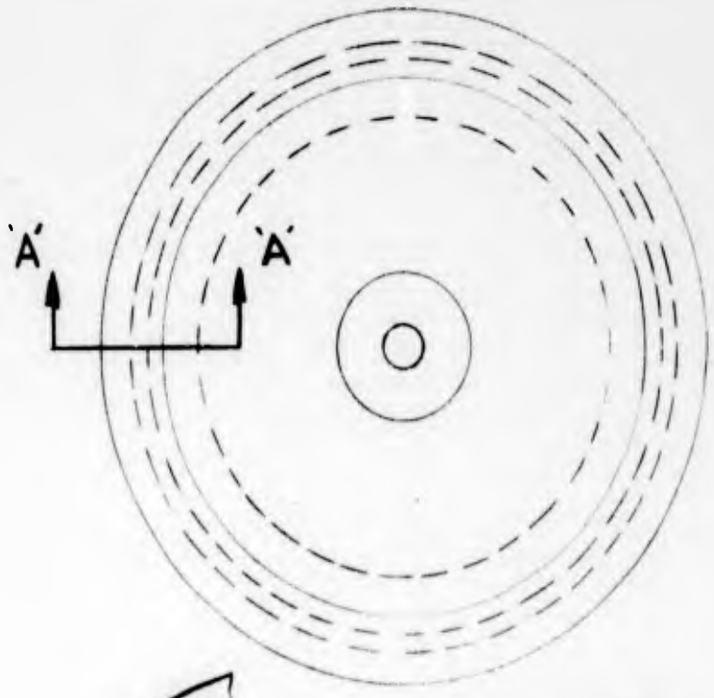


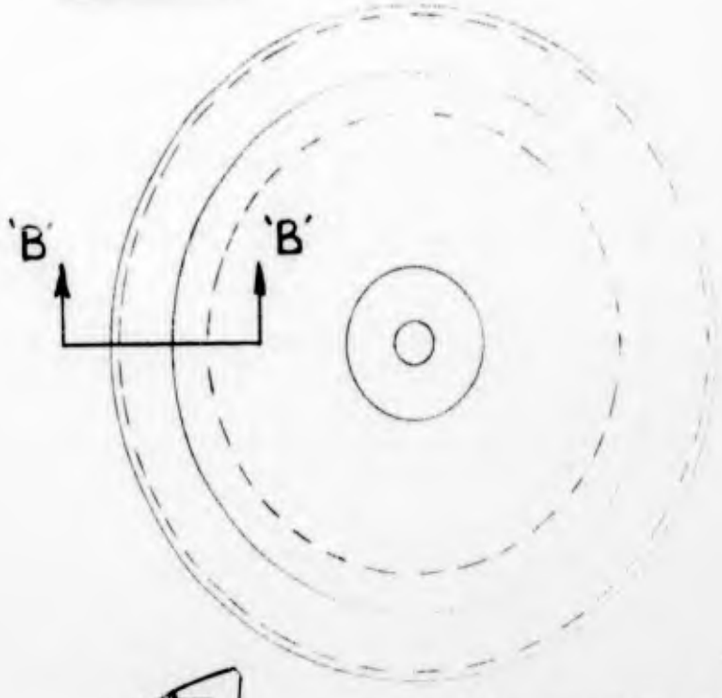
FIG. 2 VIEW OF TUNNEL BALANCE

BASIC CONFIGURATIONS



360° CONFIGURATION N°1

SECTION 'AA'



360° CONFIGURATION N°2

SECTION 'BB'

FIG 3

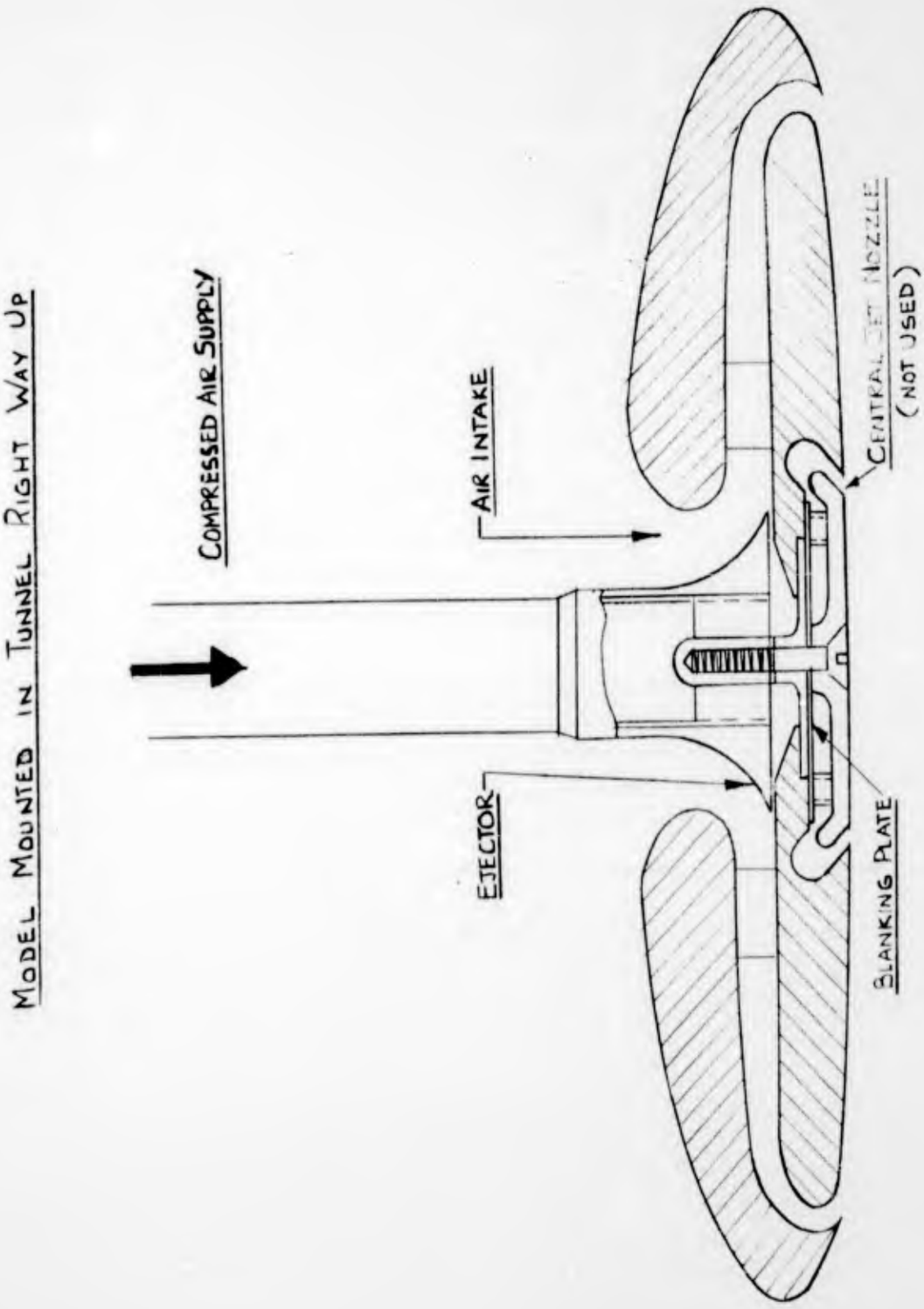

MODEL MOUNTED IN TUNNEL RIGHT WAY UP
COMPRESSED AIR SUPPLY
AIR INTAKE
CENTRAL JET NOZZLE
(NOT USED)
EJECTOR
BLANKING PLATE

FIG 4

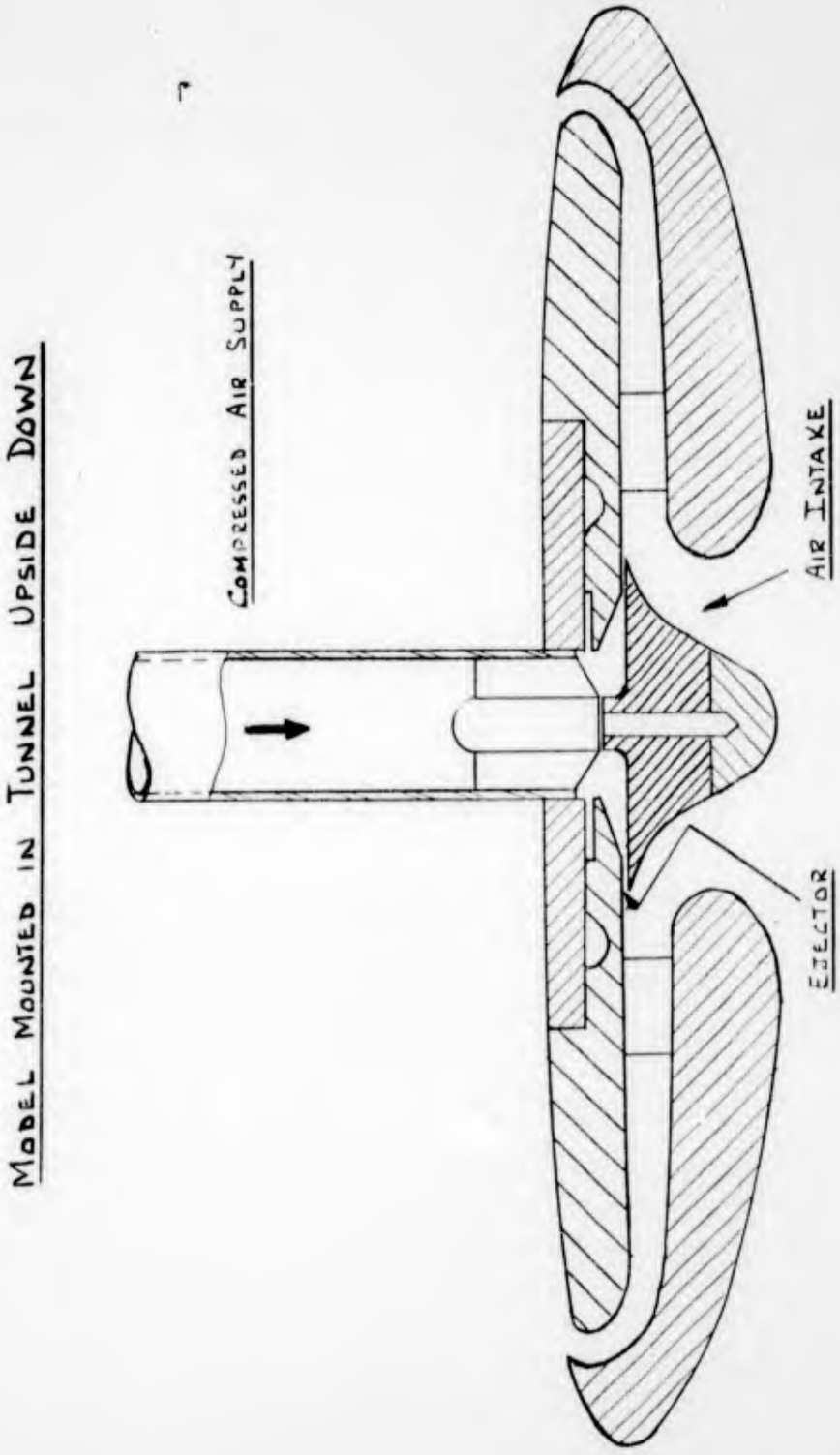

MODEL MOUNTED IN TUNNEL UPSIDE DOWN
COMPRESSED AIR SUPPLY
AIR INTAKE
EJECTOR

FIG 5

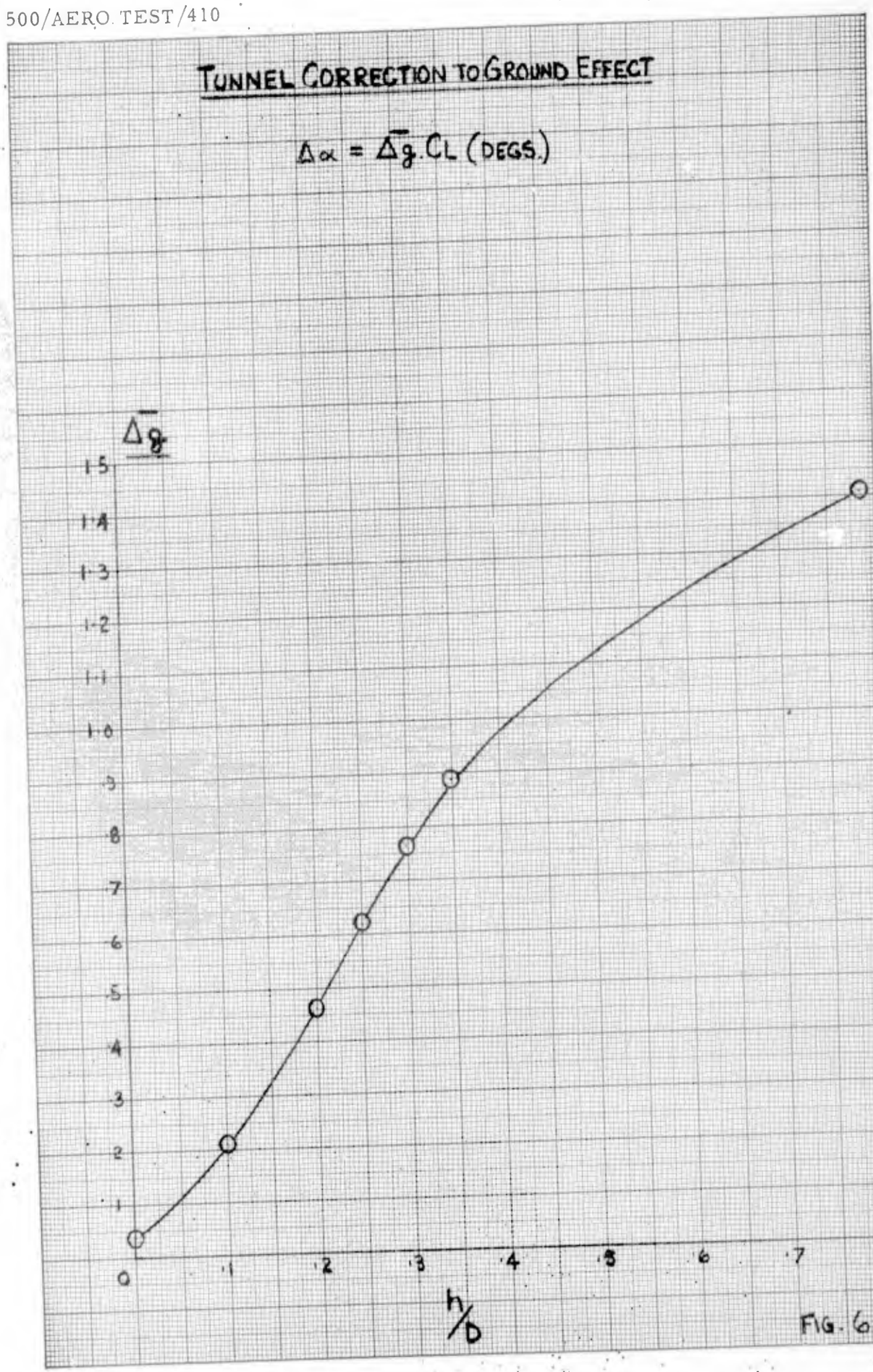

TUNNEL CORRECTION TO GROUND EFFECT
$\Delta\alpha = \bar{\Delta g}.C_L$ (DEGS.)
$\bar{\Delta g}$
1·5
1·4
1·3
1·2
1·1
1·0
·9
·8
·7
·6
·5
·4
·3
·2
·1
0
·1
·2
·3
·4
·5
·6
·7
·8
h/D

FIG. 6

TOP STRUT CORRECTION

LIFT COEFFICIENT VS ANGLE OF ATTACK

$h/D = .80$

$V = 120$ FT/SEC.

$P = 50$ P.S.I.G.

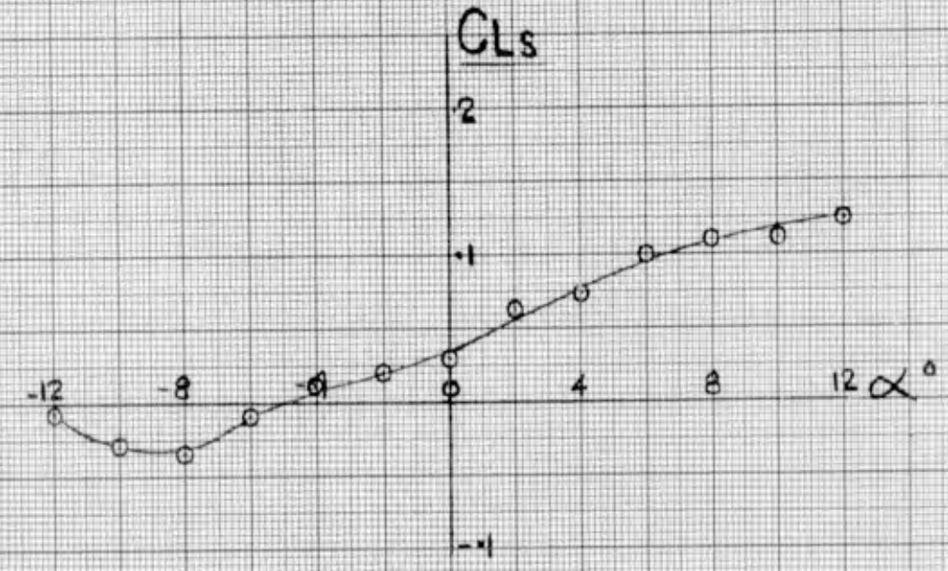
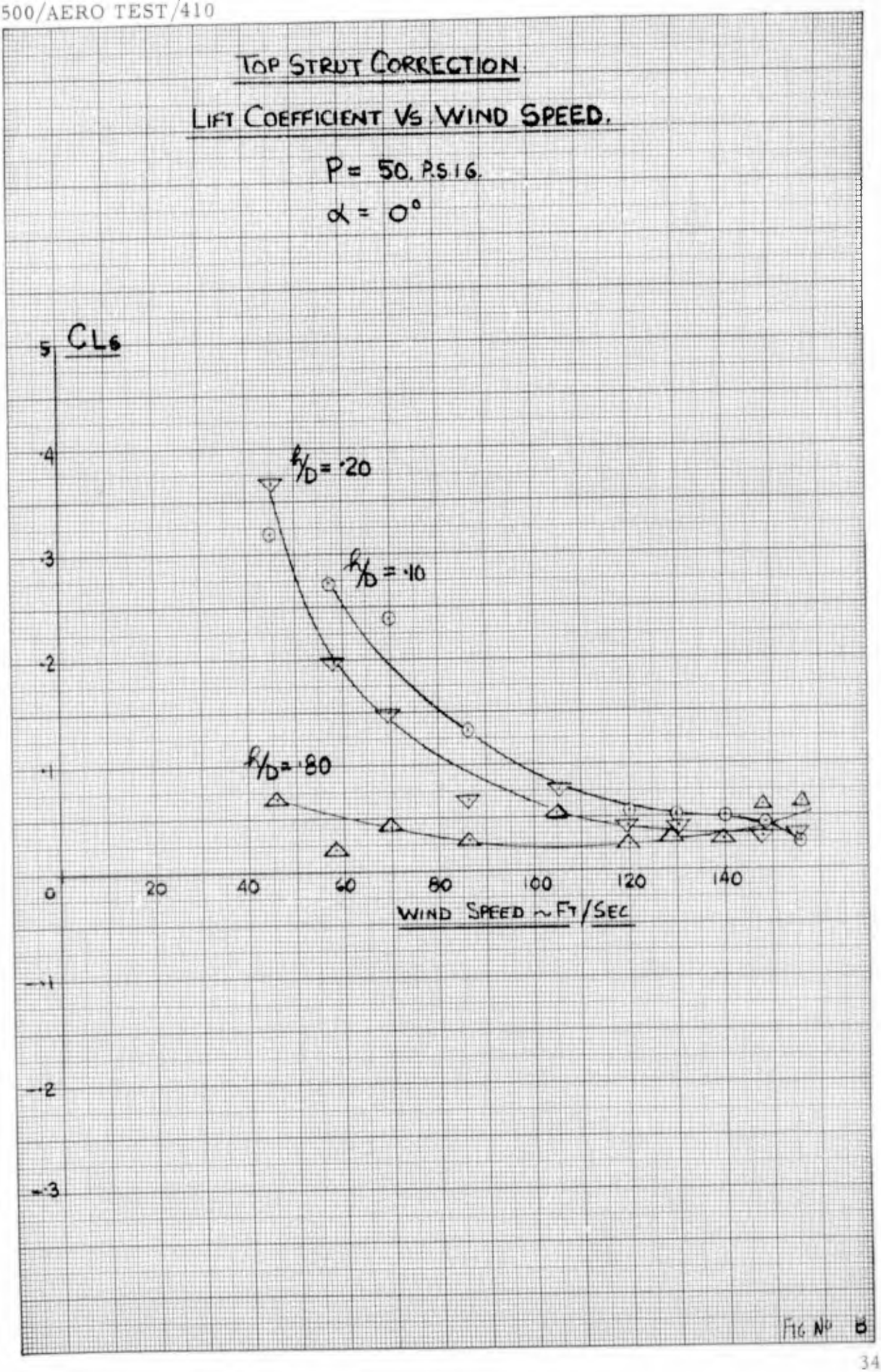


FIG. Nº 7


TOP STRUT CORRECTION
LIFT COEFFICIENT VS WIND SPEED.
P = 50. P.S.I.G.
α = 0°
CL6
5
·4
·3
·2
·1
0
-·1
-·2
-·3
h/D = ·20
h/D = ·10
h/D = ·80
20
40
60
80
100
120
140
WIND SPEED ~ FT/SEC
FIG Nº 6

TOP STRUT CORRECTION

DRAG COEFFICIENT VS ANGLE OF ATTACK

$h/D = .80$

$V = 120$ FT/SEC.

$P = 50$ P.S.I.G.

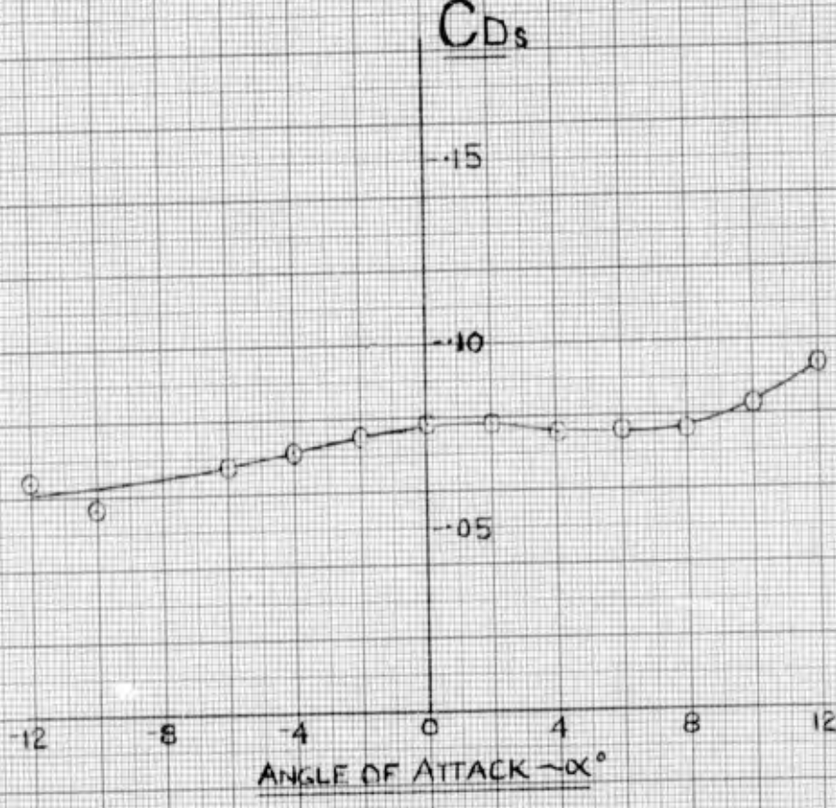


FIG Nº 9

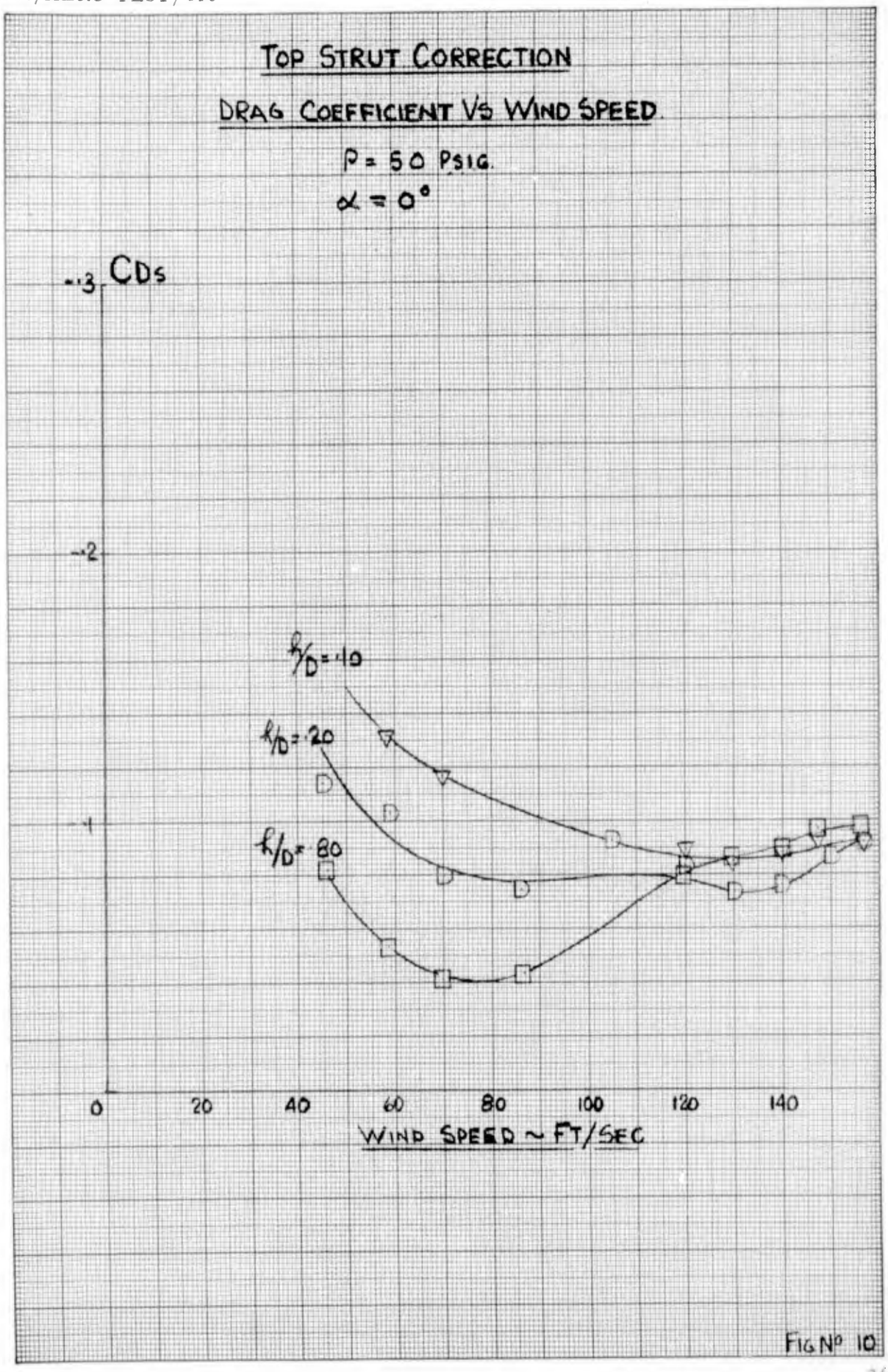

TOP STRUT CORRECTION
DRAG COEFFICIENT VS WIND SPEED.
P = 50 PSIG.
α = 0°
.3 CDs
.2
.1
h/D = .10
h/D = .20
h/D = .80
0
20
40
60
80
100
120
140
WIND SPEED ~ FT/SEC

FIG Nº 10

TOP STRUT CORRECTIONS

PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK

$-h/D = .80$

$V = 120$ FT/SEC

$P = 50$ P.S.I.G.

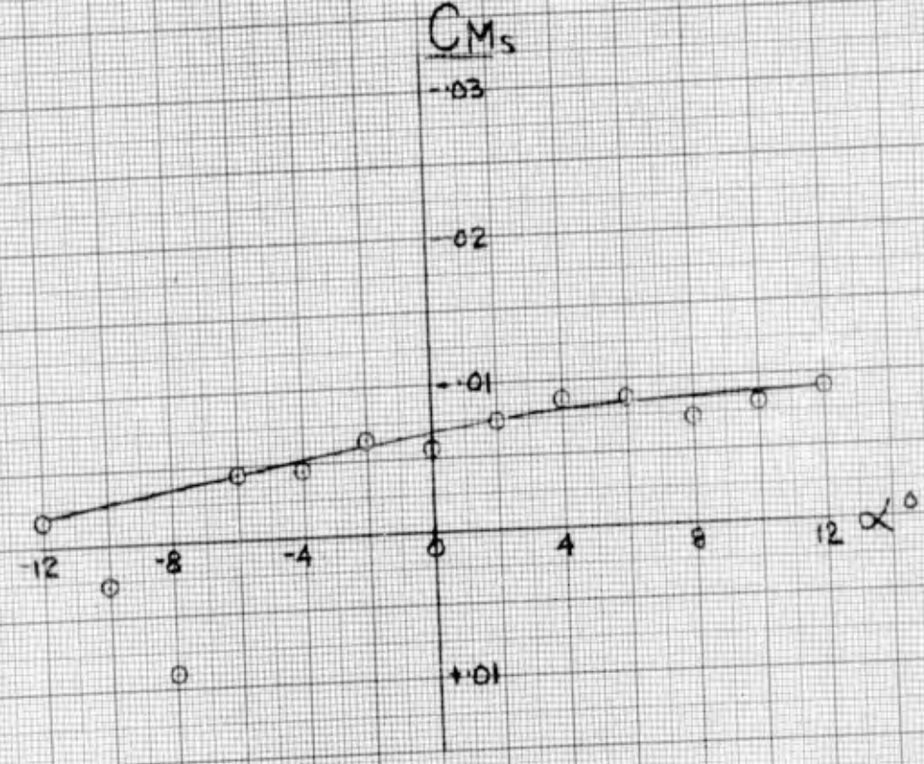


FIG. NO. 1

TOP STRUT CORRECTIONS

PITCHING MOMENT COEFFICIENT VS WIND SPEED

P = 50 P.S.I.G.

α = 0

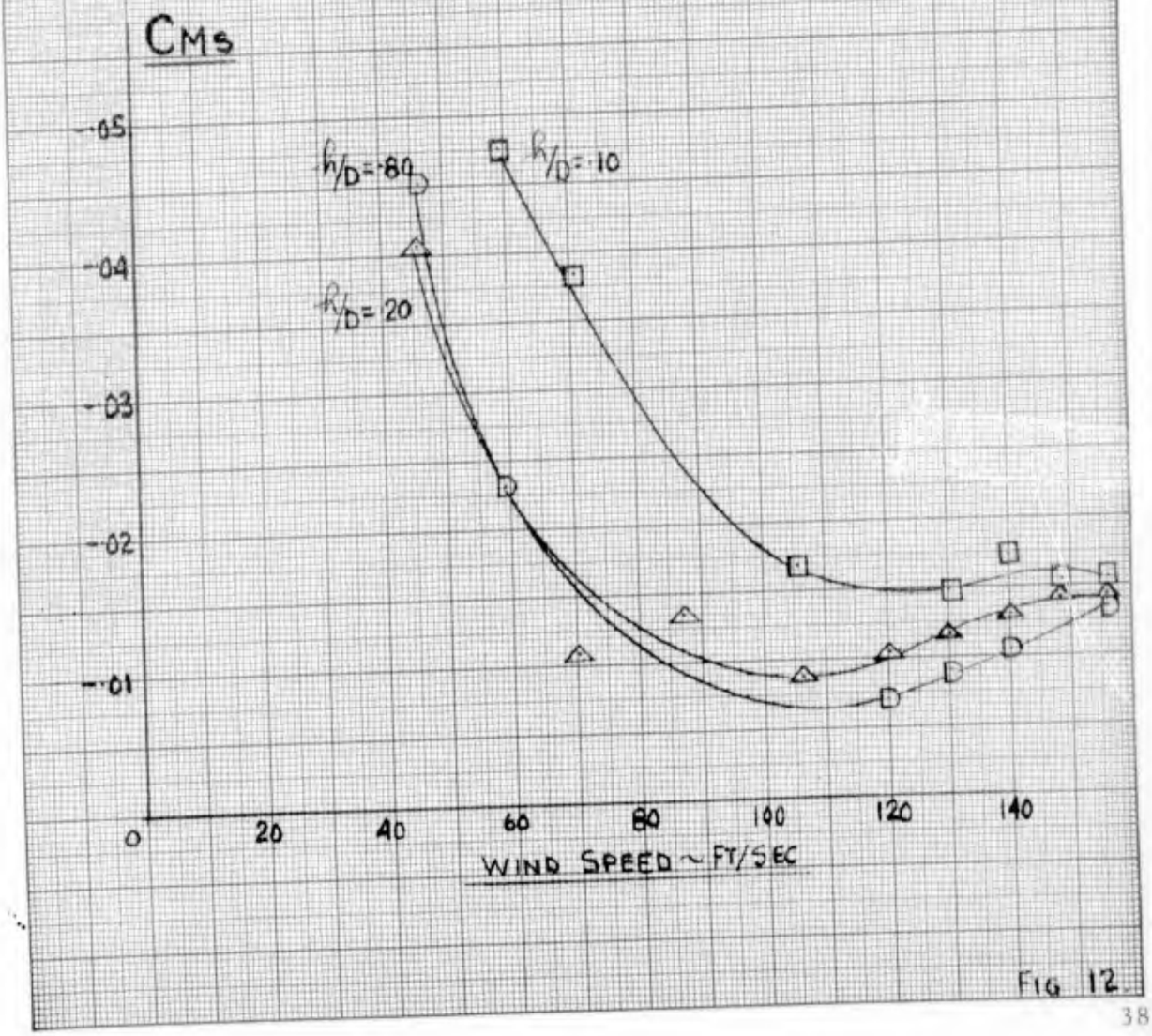


FIG 12

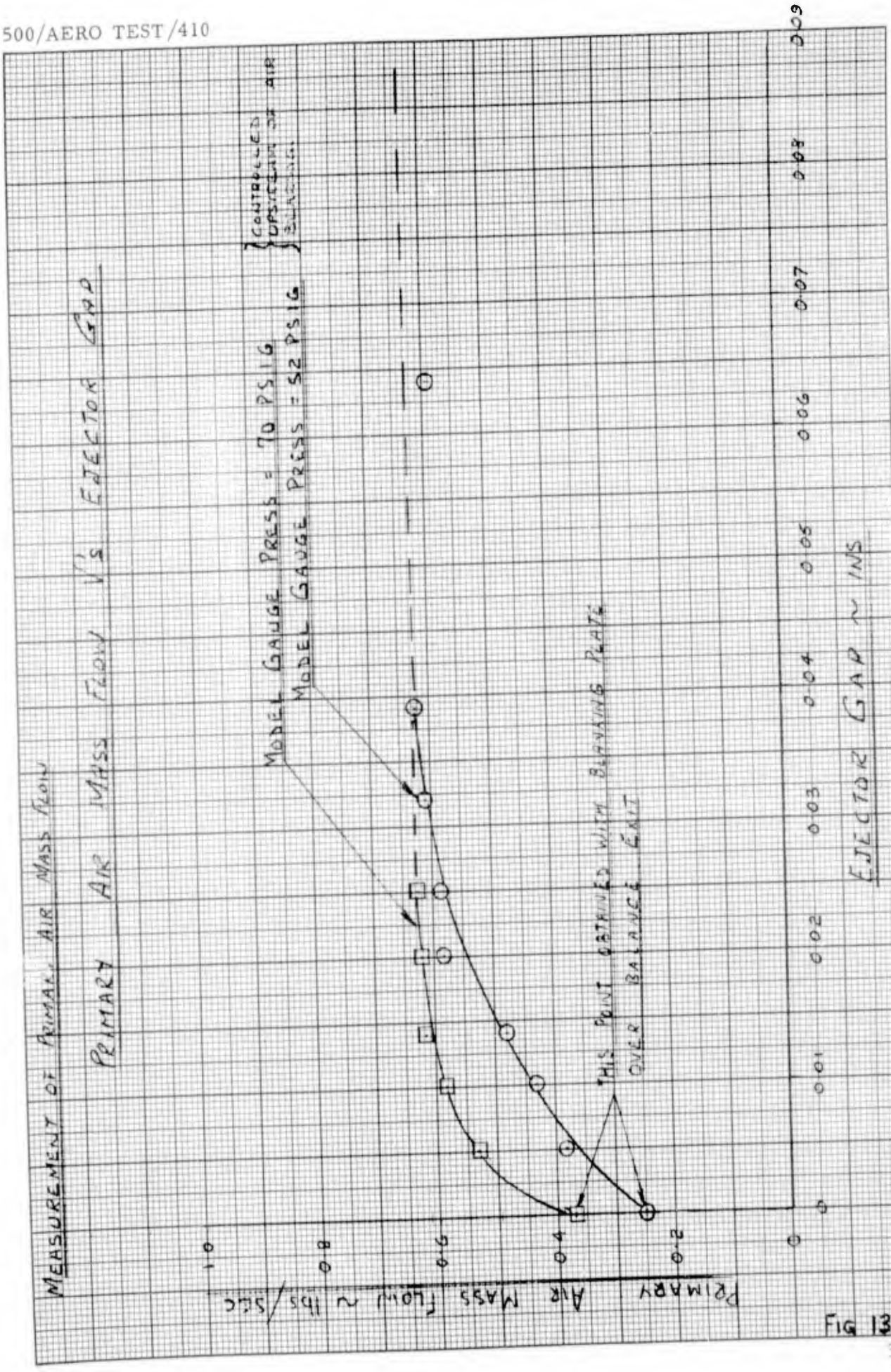

MEASUREMENT OF PRIMARY AIR MASS FLOW
PRIMARY AIR MASS FLOW VS EJECTOR GAP
MODEL GAUGE PRESS = 70 PSIG
MODEL GAUGE PRESS = 52 PSIG
CONTROLLED OPPOSITION OF AIR ENTERING
THIS POINT OBTAINED WITH BYPASSING PLATE OVER BALANCE GAUGE EXIT
PRIMARY AIR MASS FLOW # lbs/sec
EJECTOR GAP IN INS
0
0.2
0.4
0.6
0.8
1.0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009

Fig 13

MEASUREMENT OF PRIMARY AIR MASS FLOW

EJECTOR SUPPLY PRESS Vs EJECTOR GAP

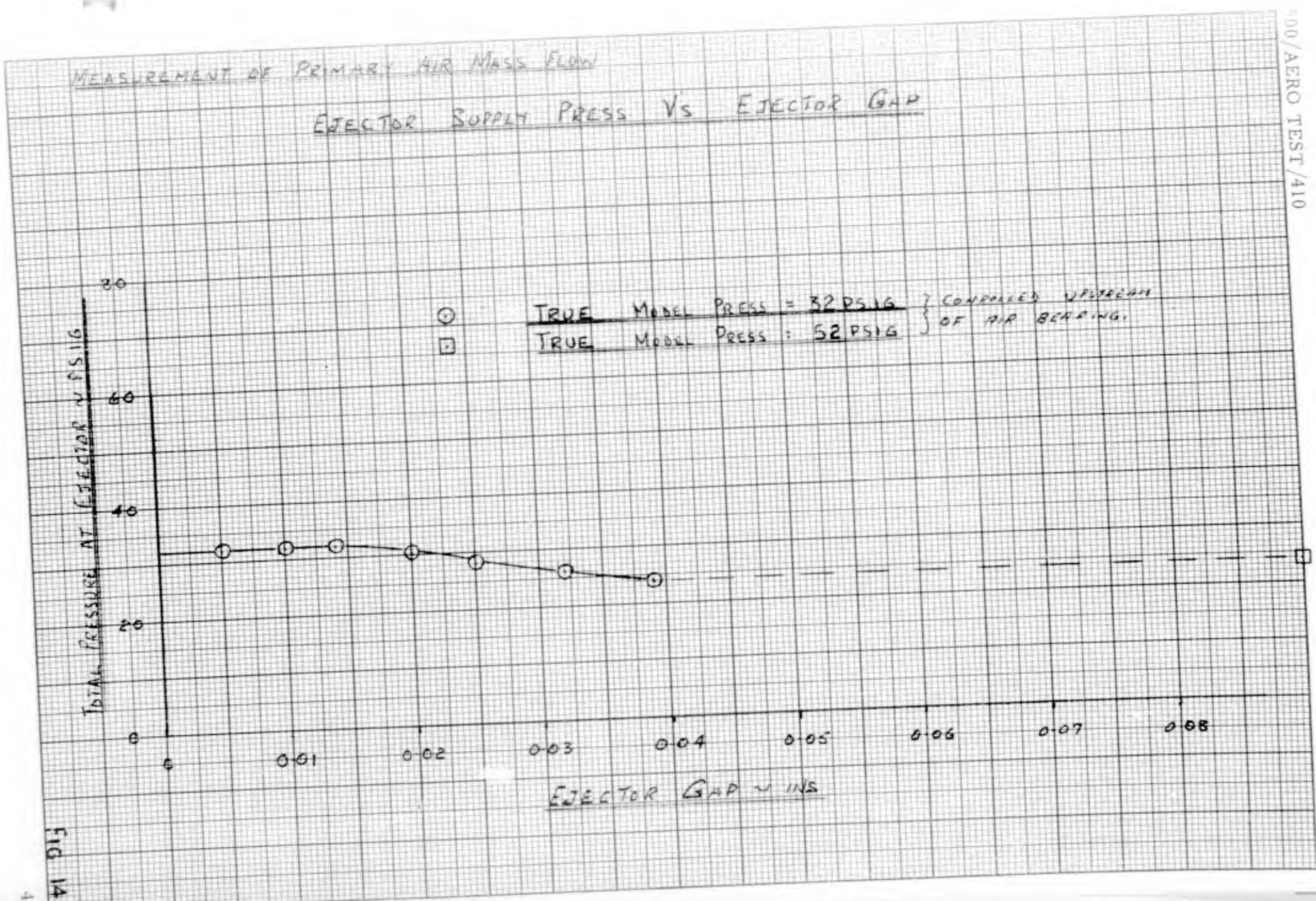


FIG 14

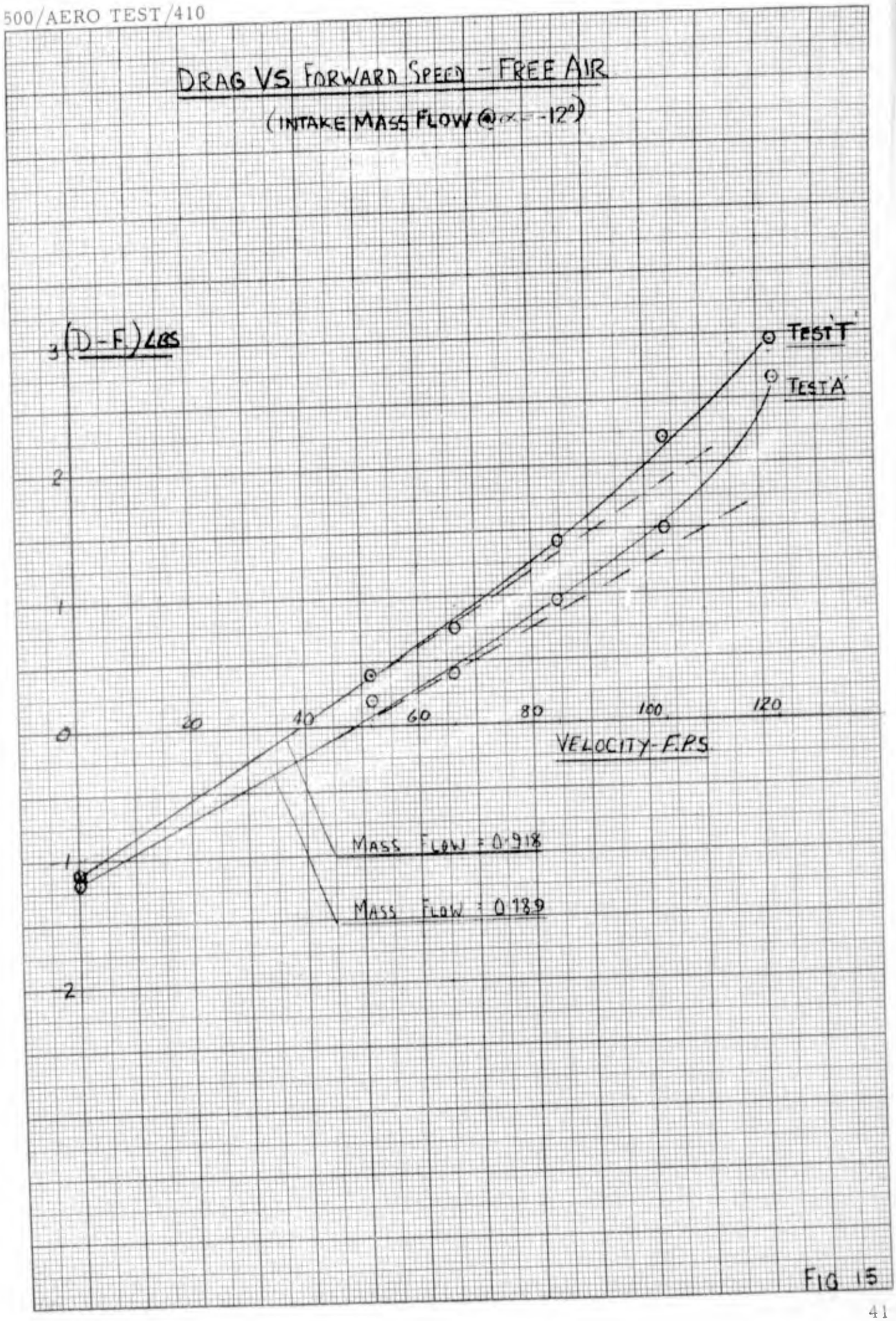

DRAG VS FORWARD SPEED - FREE AIR
(INTAKE MASS FLOW @ α = -12°)
(D-F) LBS
3
2
1
0
1
2
20
40
60
80
100
120
VELOCITY-F.P.S
TEST T'
TEST A'
MASS FLOW = 0·918
MASS FLOW = 0·789

FIG 15

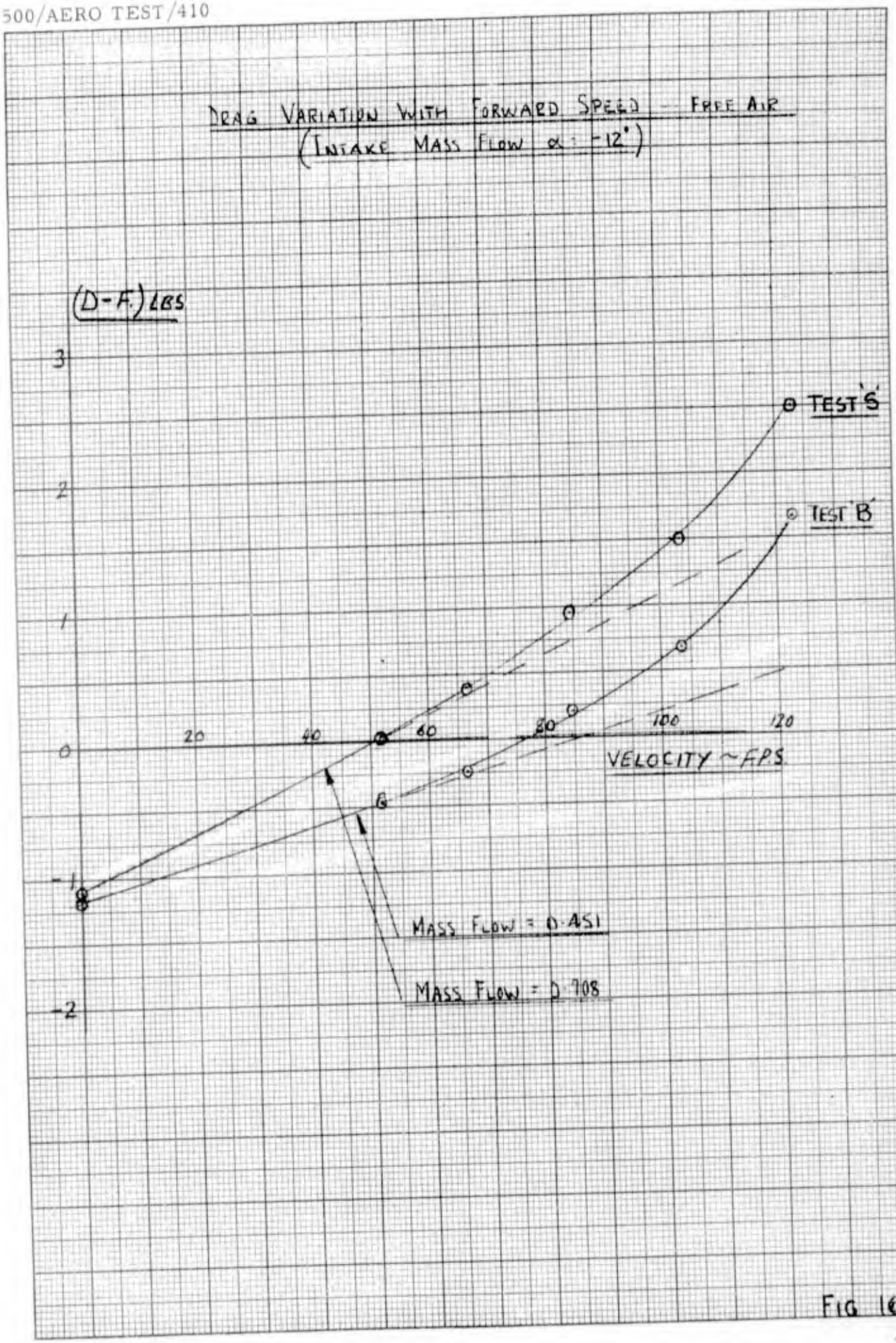

DRAG VARIATION WITH FORWARD SPEED - FREE AIR
(INTAKE MASS FLOW α = -12°)
(D-F) LBS
3
2
1
0
-1
-2
20
40
60
80
100
120
VELOCITY ~ F.P.S.
TEST 'S'
TEST 'B'
MASS FLOW = 0.451
MASS FLOW = 0.708

FIG 16

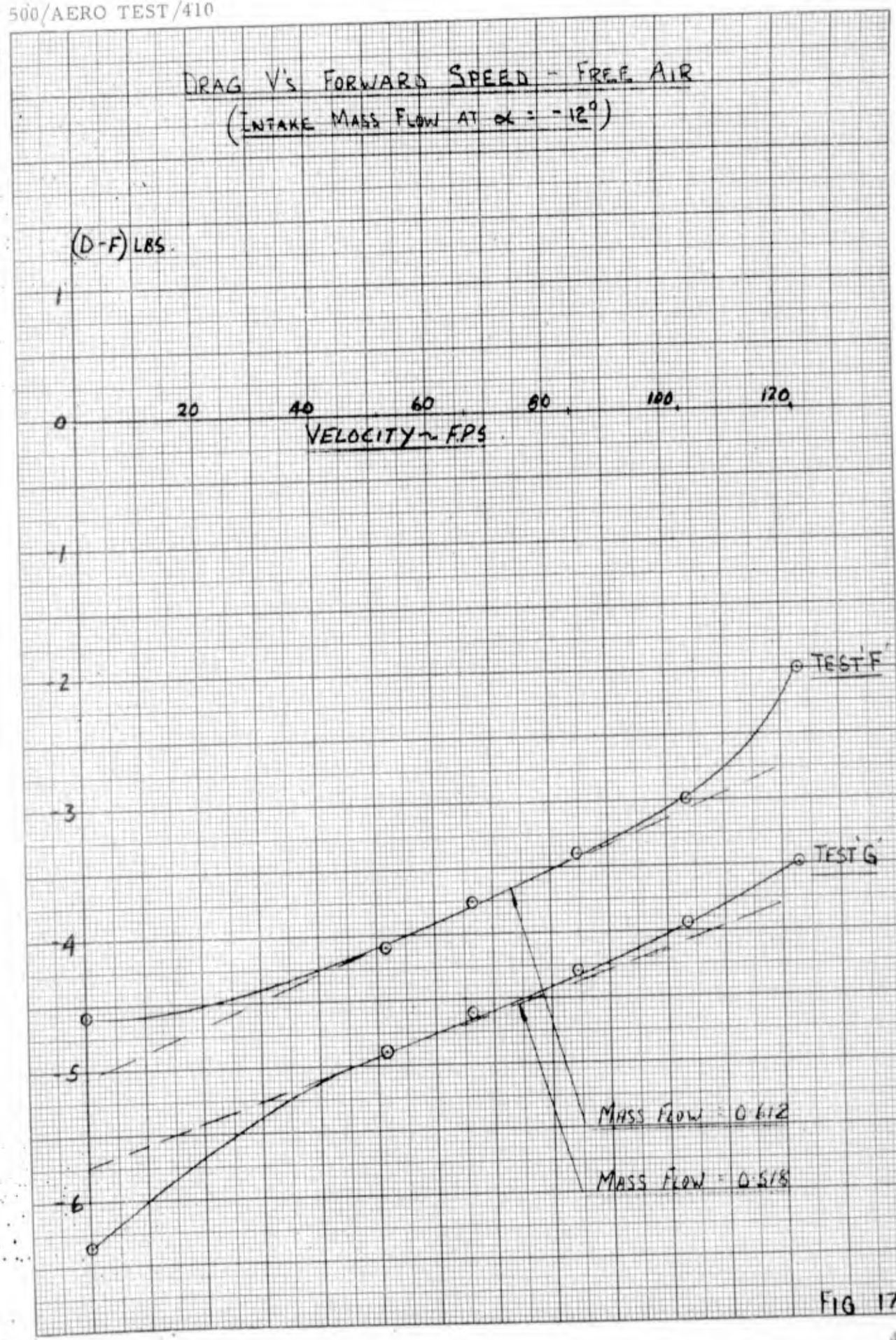

DRAG V's FORWARD SPEED - FREE AIR
(INTAKE MASS FLOW AT α = -12°)
(D-F) LBS.
1
0
-1
-2
-3
-4
-5
-6
20
40
60
80
100
120
VELOCITY - FPS
TEST F
TEST G
MASS FLOW = 0.612
MASS FLOW = 0.518

FIG 17

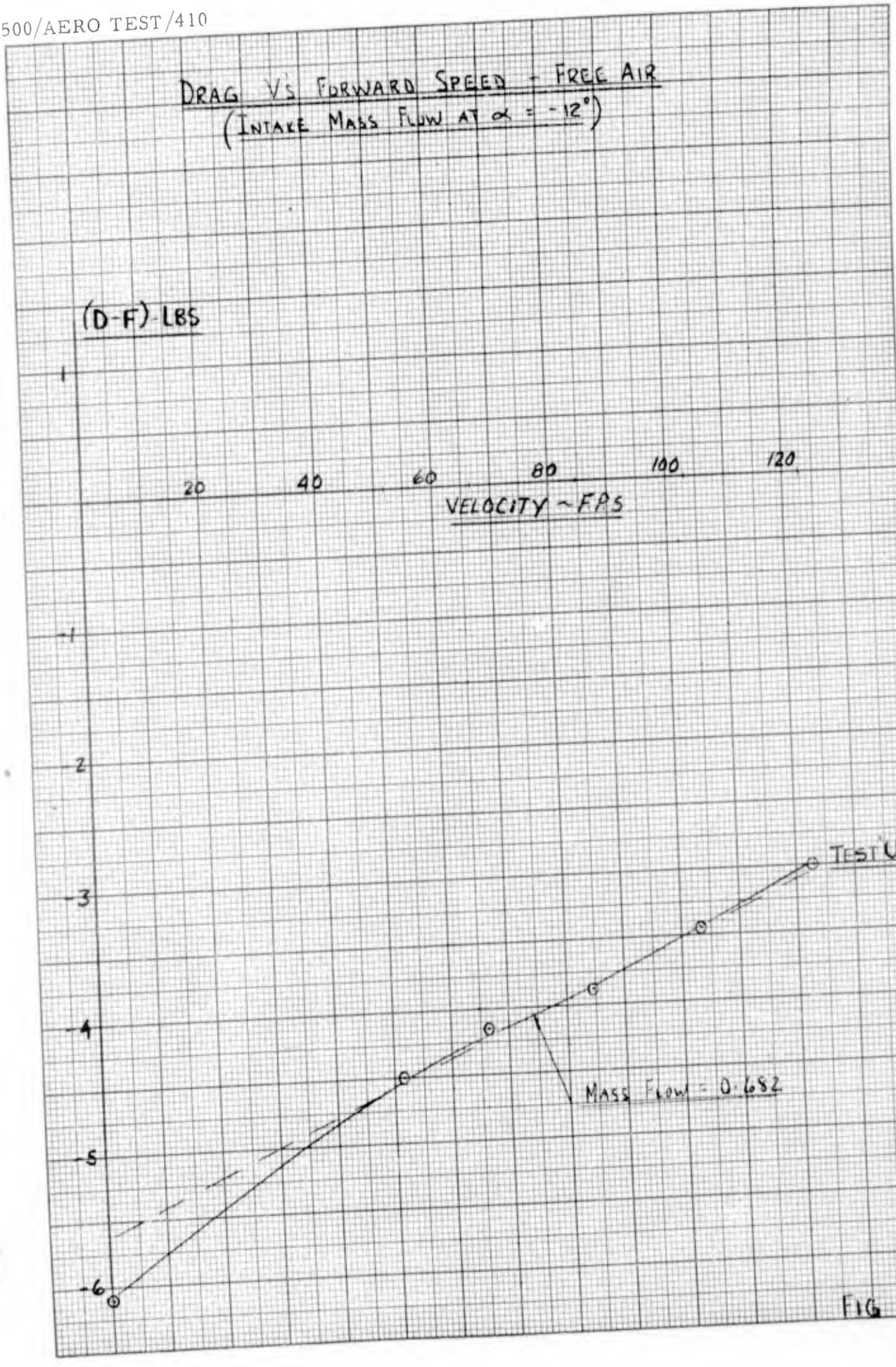

DRAG V's FORWARD SPEED - FREE AIR
(INTAKE MASS FLOW AT α = -12°)
(D-F) LBS
1
-1
-2
-3
-4
-5
-6
20
40
60
80
100
120
VELOCITY - FPS
TEST U
MASS FLOW = 0.682

FIG 18

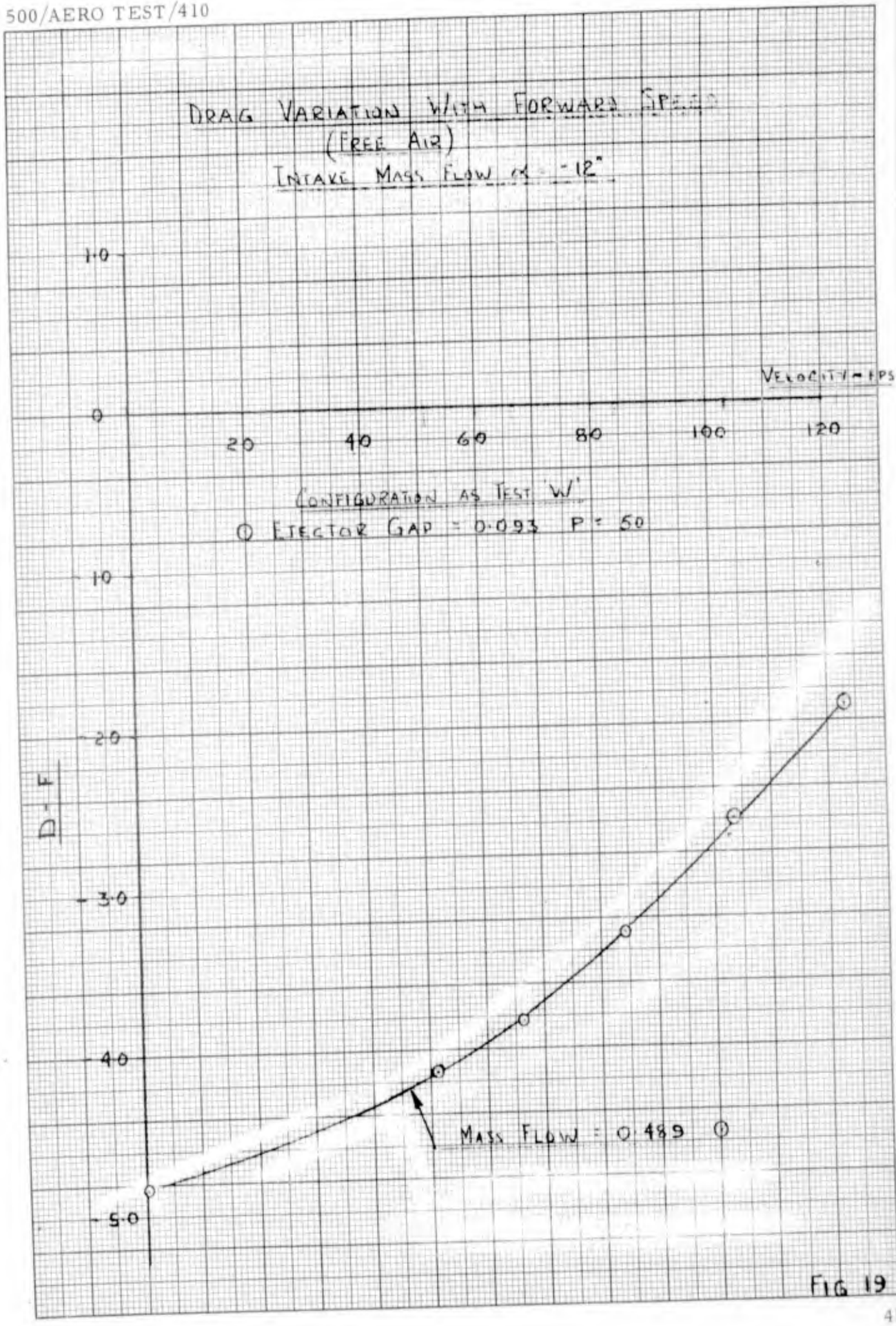

DRAG VARIATION WITH FORWARD SPEED
(FREE AIR)
INTAKE MASS FLOW CONSTANT
1·0
0
20
40
60
80
100
120
VELOCITY - FPS
CONFIGURATION AS TEST 'W'
EJECTOR GAP = 0·093 P = 50
-1·0
-2·0
-3·0
-4·0
-5·0
L/D
MASS FLOW = 0·489

FIG 19

A. V

AIR
WE
C.

1/20th SCALE MODEL TESTS

Index to Fig. No's. of Series 1 and 2 Tests

and Comparison with Ames

	Test	Lift vs α	1 Drag vs α	2 P_M vs α	3 C_L vs α	4 C_D vs α	5 C_M vs α	6 C_{L_B+i} vs α	7 C_{D_B+i} vs α	8 C_{M_B+i} vs α	9 C_M vs C_L	10 C_{M_B+} vs C_{L_B+}
SERIES 1 TESTS	q = 0	Fig 23	Fig 26	Fig 29								
	q = 5	24	27	30	Fig 32	Fig 34	Fig 36	Fig 38	Fig 40	Fig 42	Fig 44	
	q = 18	25	28	31	33	35	37	39	41	43	45	
SERIES 2 TESTS	A	70	71	72	73	74		75		76	78	Fig 77
	B	82	83	84	85	86		87		88	90	89
	C	94	95	96 96-1								
	D	97,98 103,104	99,100 105,106	101,102 107,108								
	E	109	110	111 111-1	112	113		114		115 115-1	117	116
	F	123	124	125 125-1	126	127		128		129 129-1	131	130
	G	137	138	139 139-1	140	141		142		143 143-1	145	144
	H	152	153	154	155	156		157		158	160	159
	J	167	168	169	170	171		172		173	175	174
	K	179	180	181	182	183		184		185	187	186
	K	193 to 200	201 to 205	206 to 210								

1

Series 1 and 2 Tests

A. V. ROE CANADA LIMITED

MALTON, ONTARIO

TECHNICAL DEPT. (AIRFRAME)

AIRCRAFT . . _____

WEIGHT . . _____

C. G. POSITION . _____

REPORT NO. . 500/AERO TEST/410

SHEET . . 1

DATE . . _____

PREPARED BY . _____

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
C_M vs α	$C_{L_{B+i}}$ vs α	$C_{D_{B+i}}$ vs α	$C_{M_{B+i}}$ vs α	C_M vs C_L	$C_{M_{B+i}}$ vs $C_{L_{B+i}}$	$\frac{\Delta C_M}{\Delta C_L}$ vs q	$\frac{\Delta C_L}{\Delta \alpha}$ vs q	P_M vs q	Lift vs h/D	Drag vs h/D	P_M vs h/D	L vs q	D vs q	$C_{D_{B+i+m}}$ vs α
36	Fig 38	Fig 40	Fig 42	Fig 44										
37	39	41	43	45										
	75		76	78	Fig 77	Fig 79	Fig 80	Fig 81						
	87		88	90	89	91	92	93						
	114		115 115-1	117	116	118	119	120 120-1	Fig 121	Fig 121	Fig 122			
	128		129 129-1	131	130	132	133	134 134-1	135	135	136			
	142		143 143-1	145	144	146	147	148 148-1				Fig 149	Fig 150	Fig 151
	157		158	160	159	161	162	163				164	165	166
	172		173	175	174	176	177	178						
	184		185	187	186	188	189	190	191	191	192			

2

1

1/20th SCALE MODEL TESTS

Index to Fig. No's. of Series 1 and 2 Tests

and Comparison with Ames

A. V. F

AIRCRA

WEIGHT

C. G. F

SERIES 2 TESTS

Test	Lift vs α	1 Drag vs α	2 P_M vs α	3 C_L vs α	4 C_D vs α	5 C_M vs α	6 $C_{L_{B+i}}$ vs α	7 $C_{D_{B+i}}$ vs α	8 $C_{M_{B+i}}$ vs α	9 C_M vs C_L	10 $C_{M_{B+i}}$ vs $C_{L_{B+i}}$
L	211	212	213	214	215		216		217	219	218
M	223	224	225	226	227		228		229	231	230
N	235	236	237	238	239		240		241	243	242
O	247	248	249	250	251		252		253	255	254
P	259	260	261								
Q	262	263	264	265	266		267		268	270	269
R	274,275 276,277	278 to 281	282 to 285								
S	286	287	288	289	290		291		292	294	293
T	298	299	300	301	302		303		304	306	305
U	310	311	312 312-1	313	314		315		316 316-1	318	317 317-1
U	322 to 329	330 to 334	335 to 339								
W	340	341	342								
W	343 to 347	351 to 355	356 to 360								
X	361	362	363	364	365		366		367	369	

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
C_M vs α	$C_{L_{B+i}}$ vs α	$C_{D_{B+i}}$ vs α	$C_{M_{B+i}}$ vs α	C_M vs C_L	$C_{M_{B+i}}$ vs $C_{L_{B+i}}$	$\frac{\Delta C_M}{\Delta C_L}$ vs q	$\frac{\Delta C_L}{\Delta \alpha}$ vs q	P_M vs q	Lift vs h/D					
	216		217	219	218	220	221	222						
	228		229	231	230	232	233	234						
	240		241	243	242	244	245	246						
	252		253	255	254	256	257	258						
	267		268	270	269	271	272	273						
	291		292	294	293	295	296	297						
	303		304	306	305	307	308	309						
	315		316 316-1	318	317 317-1	319	320	321 321-1	327 to 329					
									348 to 350					
	366		367	369										

2

A. V

AIR
WE
C.

1/20th SCALE MODEL TESTS

Index to Fig. No's. of Series 1 and 2 Tests

and Comparison with Ames

SERIES 2 TESTS

AMES TUNNEL COMPARISON TESTS

Test	Lift vs α	1 Drag vs α	2 P_M vs α	3 C_L vs α	4 C_D vs α	5 C_M vs α	6 $C_{L_{B+i}}$ vs α	7 $C_{D_{B+i}}$ vs α	8 $C_{M_{B+i}}$ vs α	9 C_M vs C_L	10 $C_{M_{B+}}$ vs $C_{L_{B+}}$
Y and Z	370	371	372	373	374		375		376	378	377
Y and Z	379 to 383	384 to 388	389 to 393								
Ames N-1 and(L)	397	398	399								
Ames N-1 and(M)	400	401	402								
Ames N-1 and(X)	403	404	405								

1

Series 1 and 2 Tests

A. V. ROE CANADA LIMITED

MALTON, ONTARIO

TECHNICAL DEPT. (AIRFRAME)

AIRCRAFT

WEIGHT

C. G. POSITION

REPORT NO. 500/AERO TEST/410

SHEET 3

DATE

PREPARED BY

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
C_M vs	$C_{L_{B+i}}$ vs α	$C_{D_{B+i}}$ vs α	$C_{M_{B+i}}$ vs α	C_M vs C_L	$C_{M_{B+i}}$ vs $C_{L_{B+i}}$	$\frac{\Delta C_M}{\Delta C_L}$ vs q	$\frac{\Delta C_L}{\Delta \alpha}$ vs q	P_M vs q	Lift vs h/D					
	375		376	378	377									
									394 to 396					

2

SERIES 1 TESTS

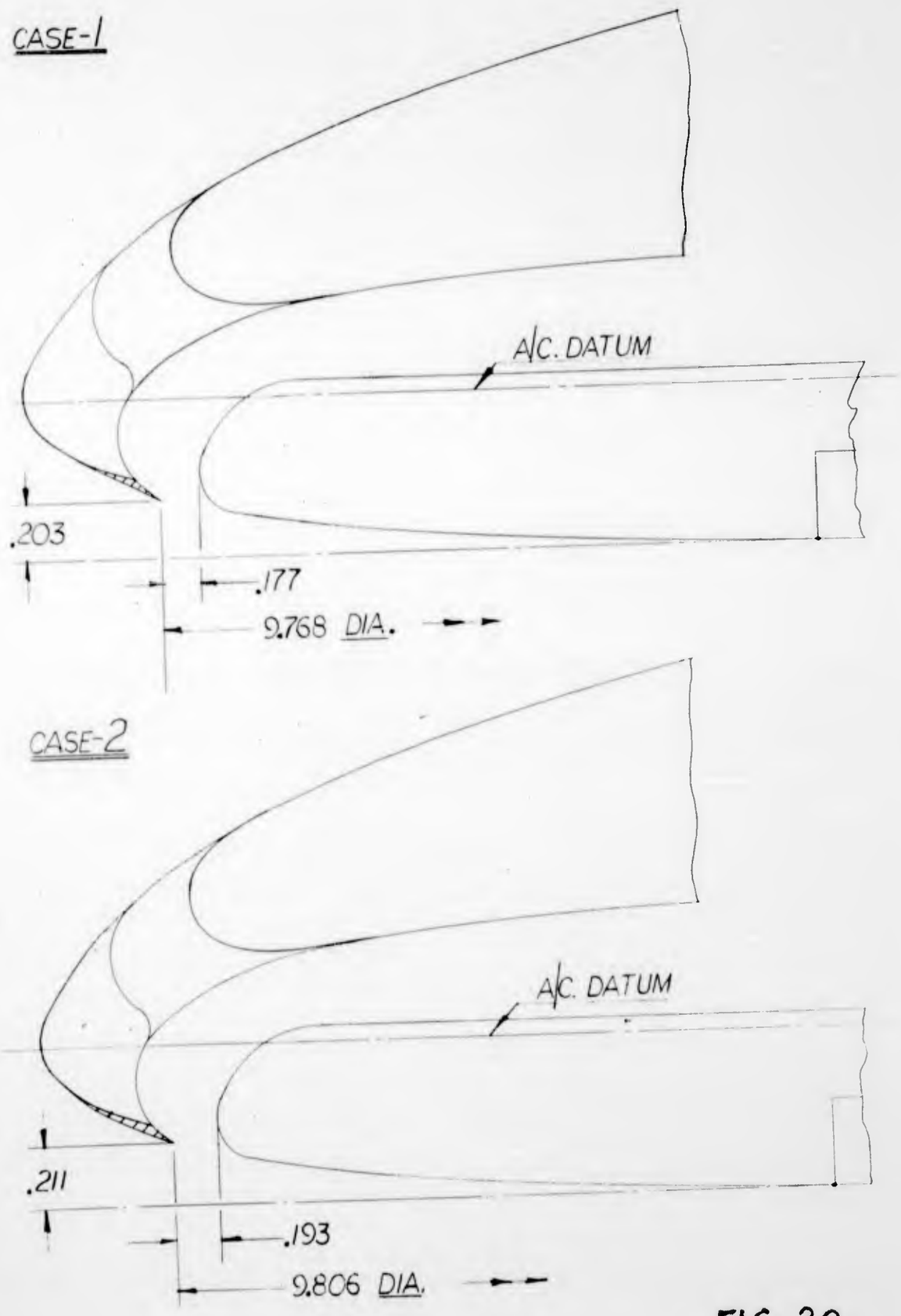


FIG 20

SERIES 1 TESTS

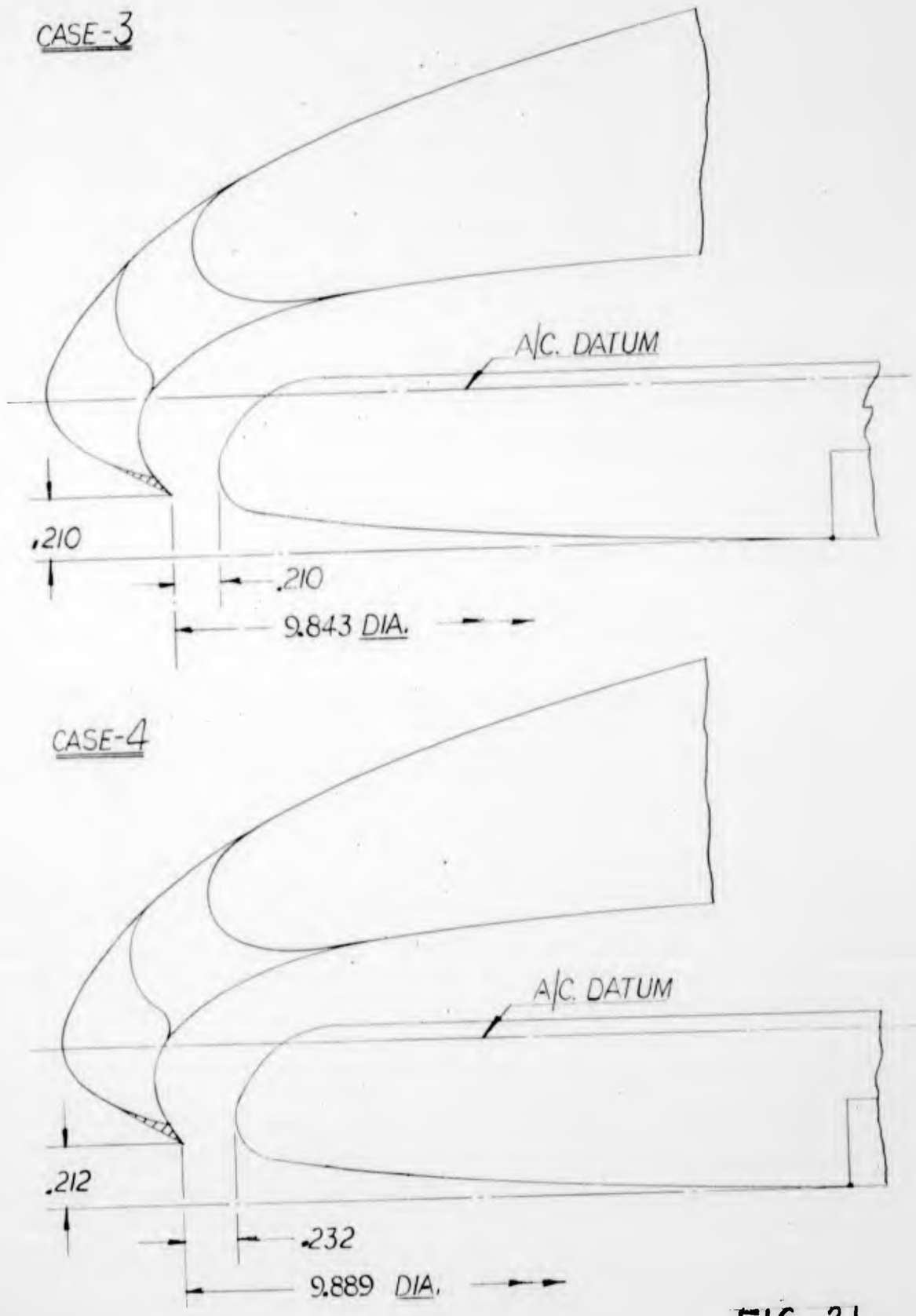
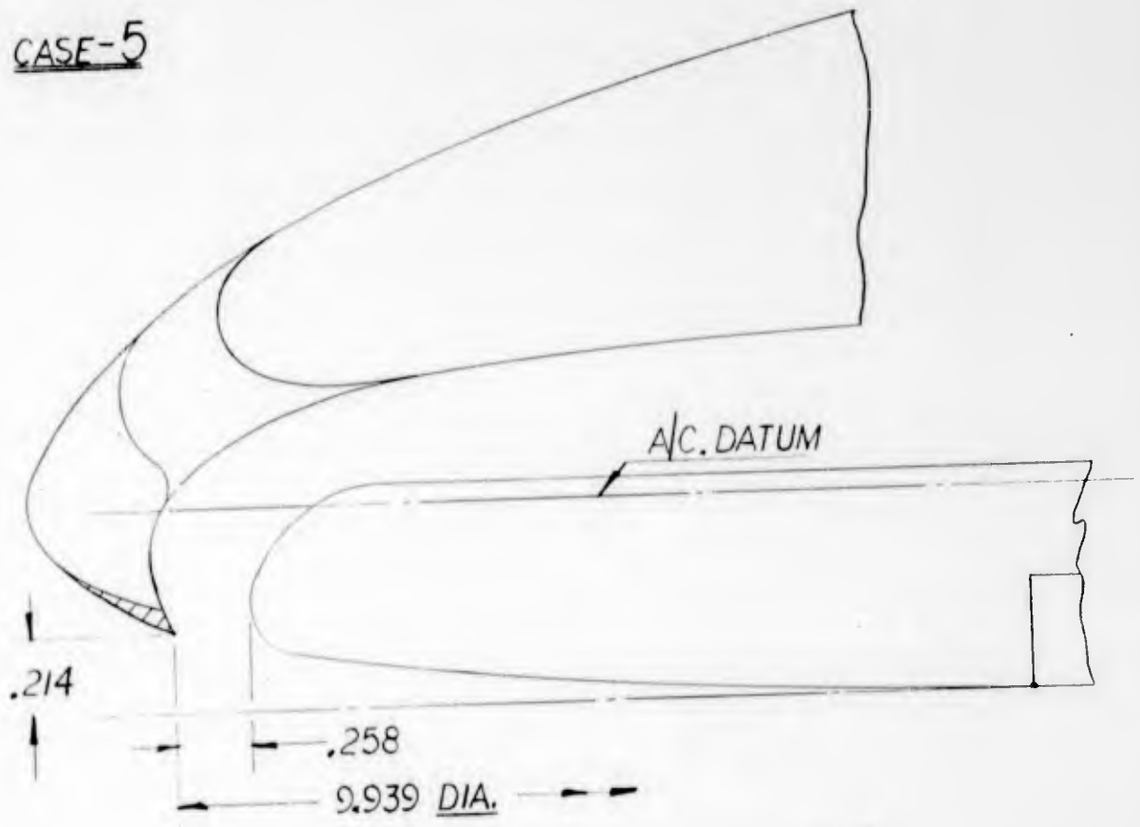


FIG 21

SERIES 1 TESTS

CASE-5



CASE-6

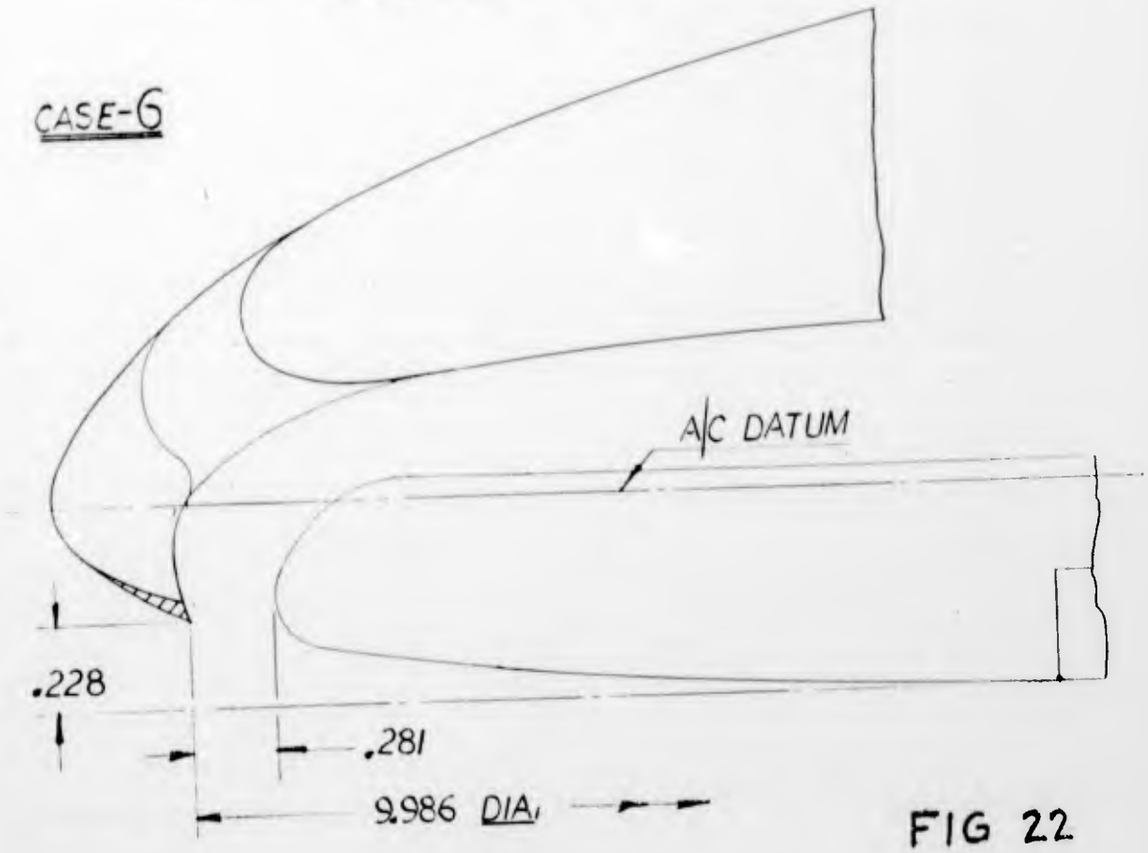


FIG 22

LIFT VS ANGLE OF ATTACK

(FREE AIR)

- ○ RUN Nº 1 CASE 1 RING 1/D = 9.768
- □ RUN Nº 4 CASE 2 RING 1/D = 9.806
- △ RUN Nº 9 CASE 3 RING 1/D = 9.843
- ◇ RUN Nº 10 CASE 4 RING 1/D = 9.889
- ▽ RUN Nº 16 CASE 5 RING 1/D = 9.939
- ⬭ RUN Nº 19 CASE 6 RING 1/D = 9.986

} q = 0

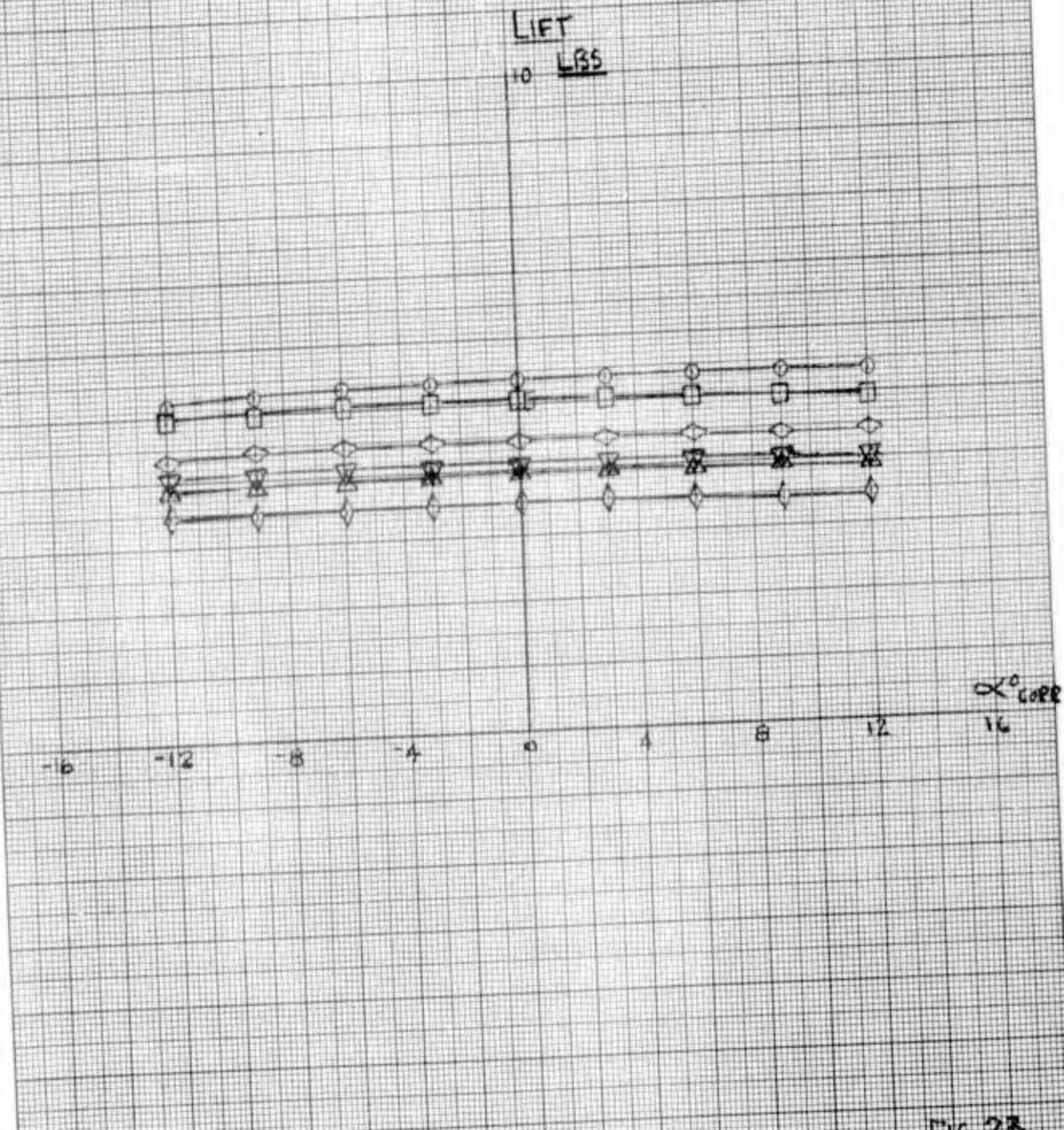


FIG. 23

LIFT VS ANGLE OF ATTACK

(FREE AIR)

- ○ RUN N° 2 CASE 1 RING ½D = 9.968
- □ RUN N° 5 CASE 2 RING ½D = 9.806
- △ RUN N° 7 CASE 3 RING ½D = 9.843
- ◇ RUN N° 11 CASE 4 RING ½D = 9.899
- ▽ RUN N° 17 CASE 5 RING ½D = 9.939
- ◇ RUN N° 20 CASE 6 RING ½D = 9.986

$q = 5.265$

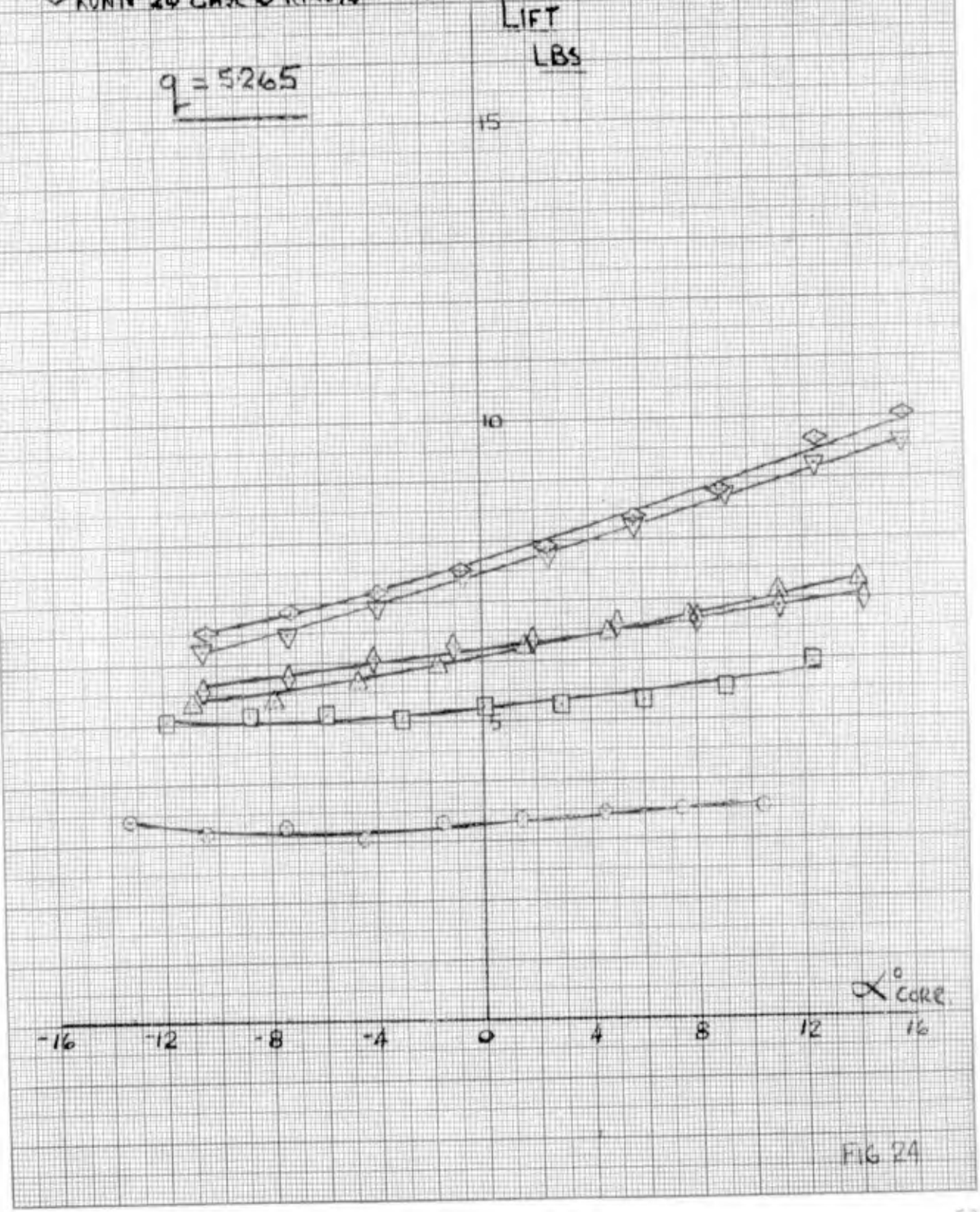


FIG 24

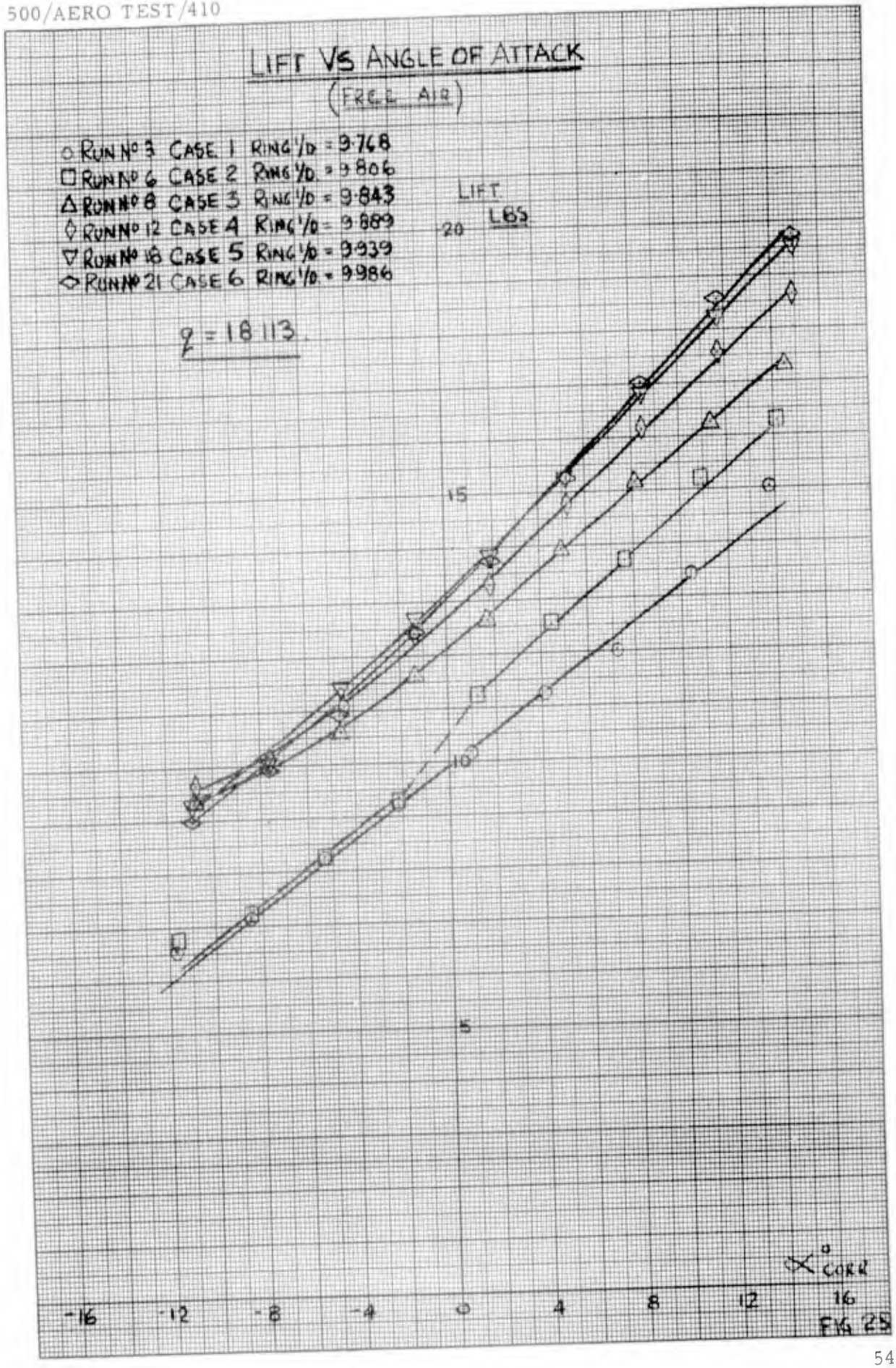

LIFT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN Nº 3 CASE 1 RING 1/D = 9.768
□ RUN Nº 6 CASE 2 RING 1/D = 9.806
△ RUN Nº 8 CASE 3 RING 1/D = 9.843
◇ RUN Nº 12 CASE 4 RING 1/D = 9.889
▽ RUN Nº 16 CASE 5 RING 1/D = 9.939
◇ RUN Nº 21 CASE 6 RING 1/D = 9.986
q = 18.113.
LIFT LBS
20
15
10
5
α CORR
-16
-12
-8
-4
0
4
8
12
16

FIG 25

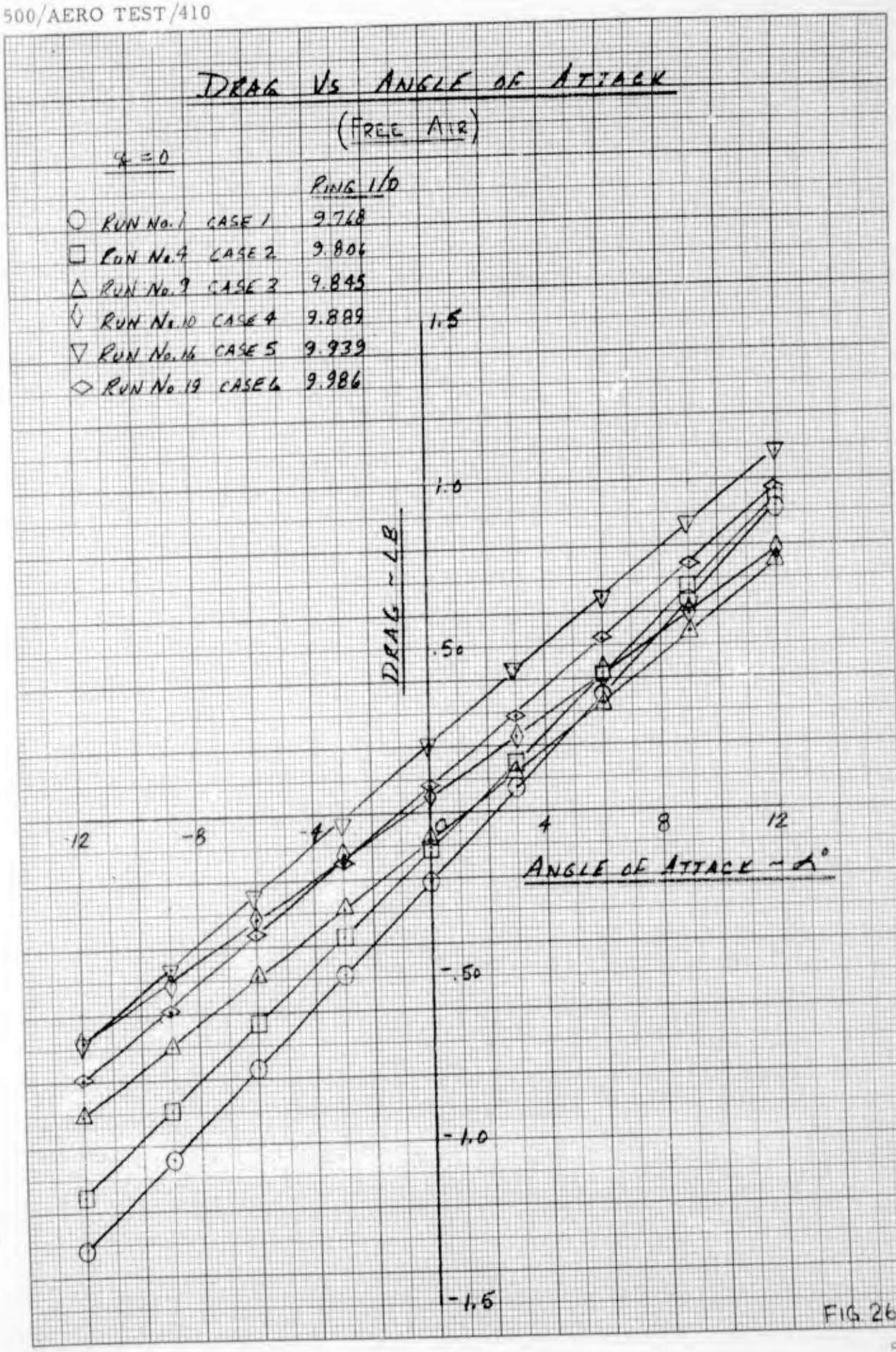

DRAG Vs ANGLE OF ATTACK
(FREE AIR)
$\psi = 0$
RING I/D
RUN No.1 CASE 1 9.768
RUN No.4 CASE 2 9.804
RUN No.7 CASE 3 9.845
RUN No.10 CASE 4 9.889
RUN No.16 CASE 5 9.939
RUN No.19 CASE 6 9.986
1.5
1.0
.50
-.50
-1.0
-1.5
DRAG - LB
12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

FIG 26

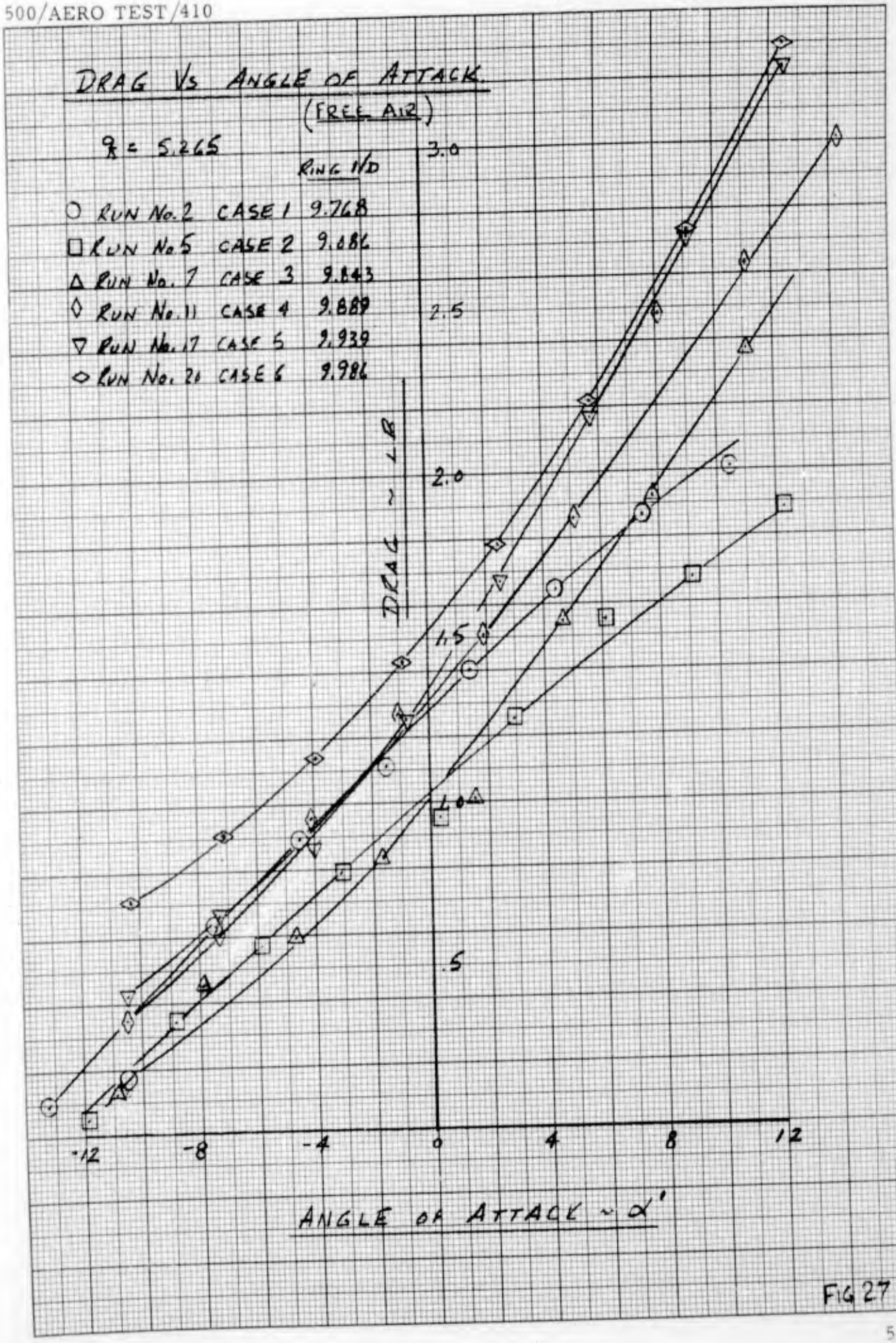
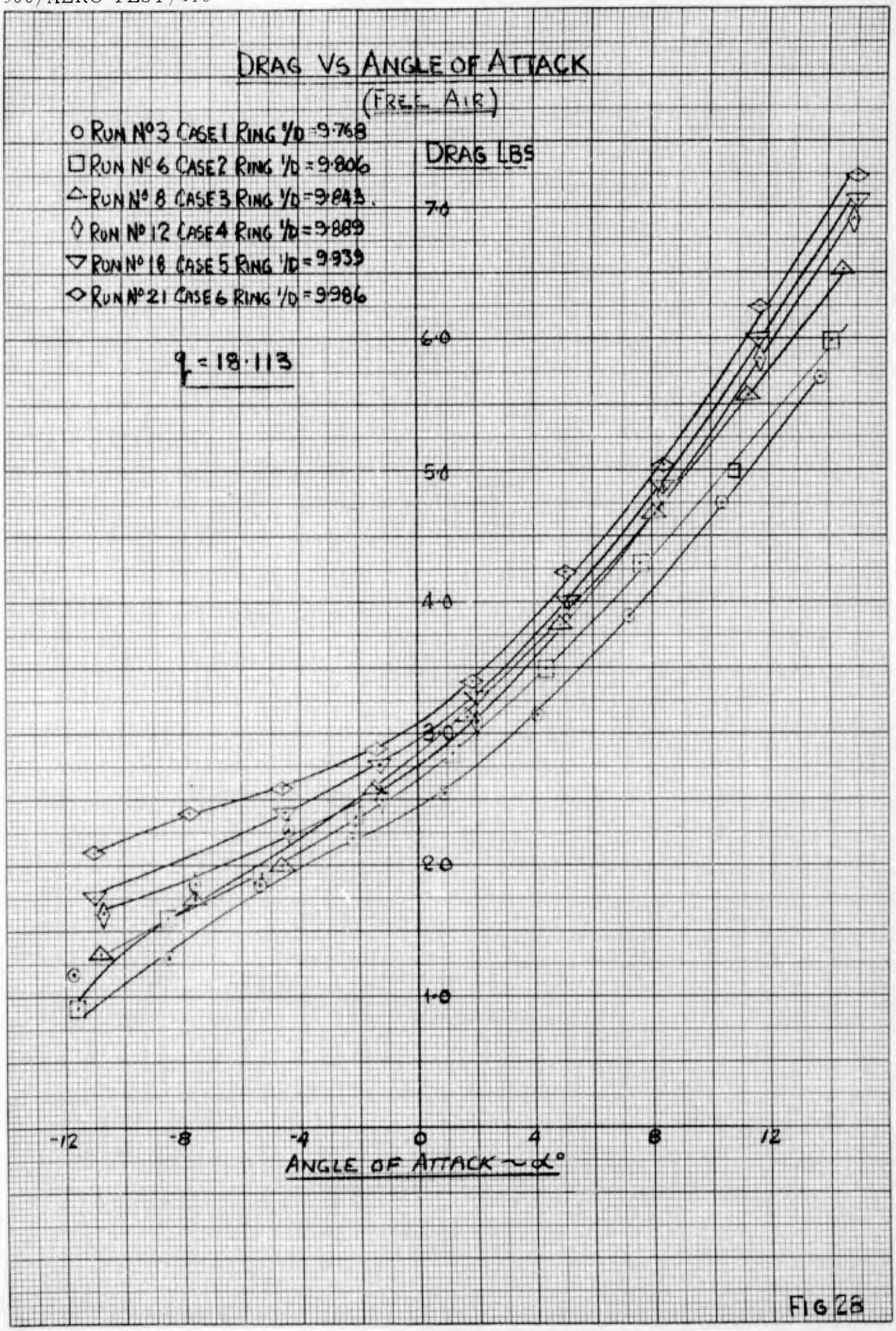
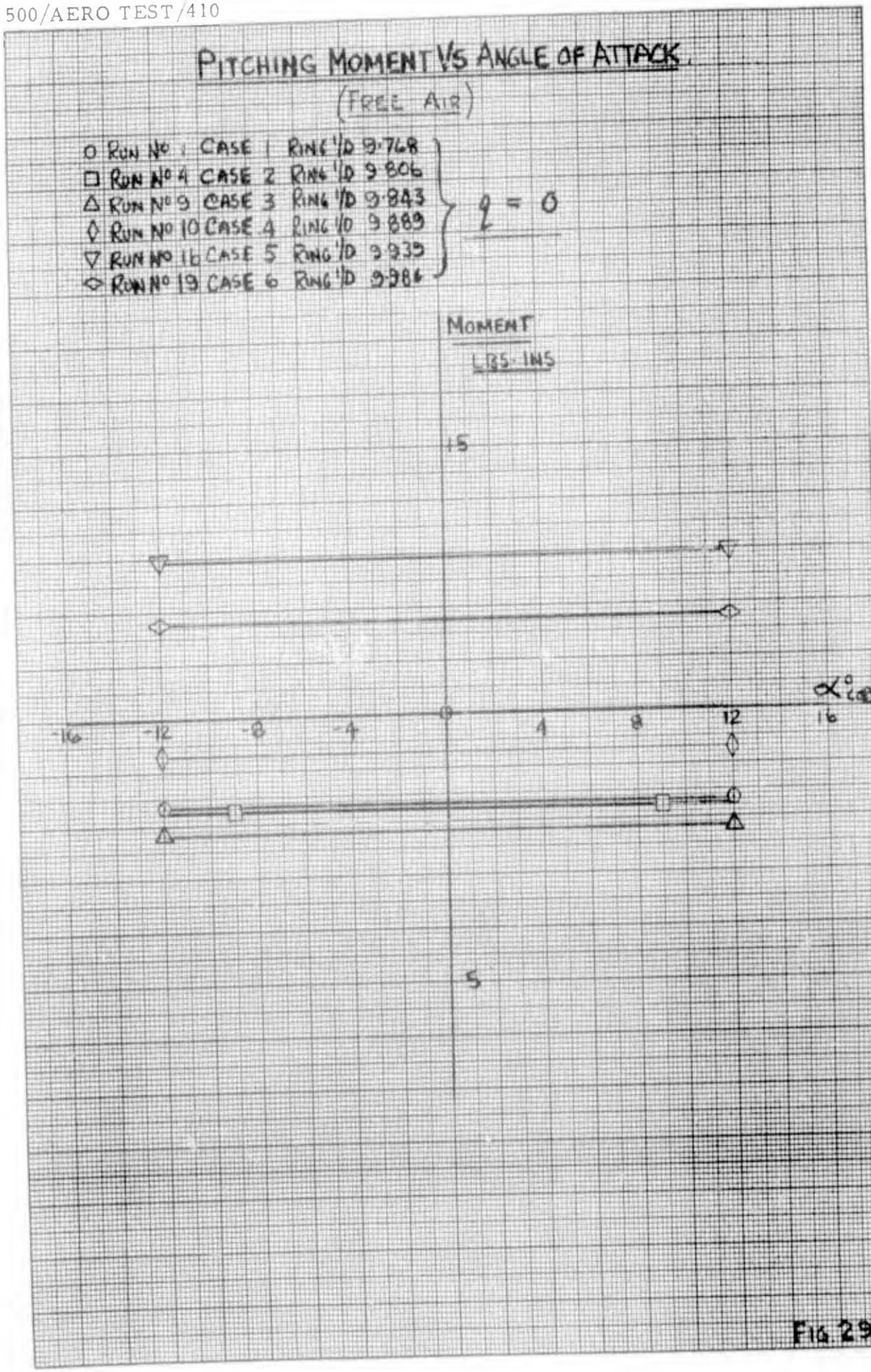
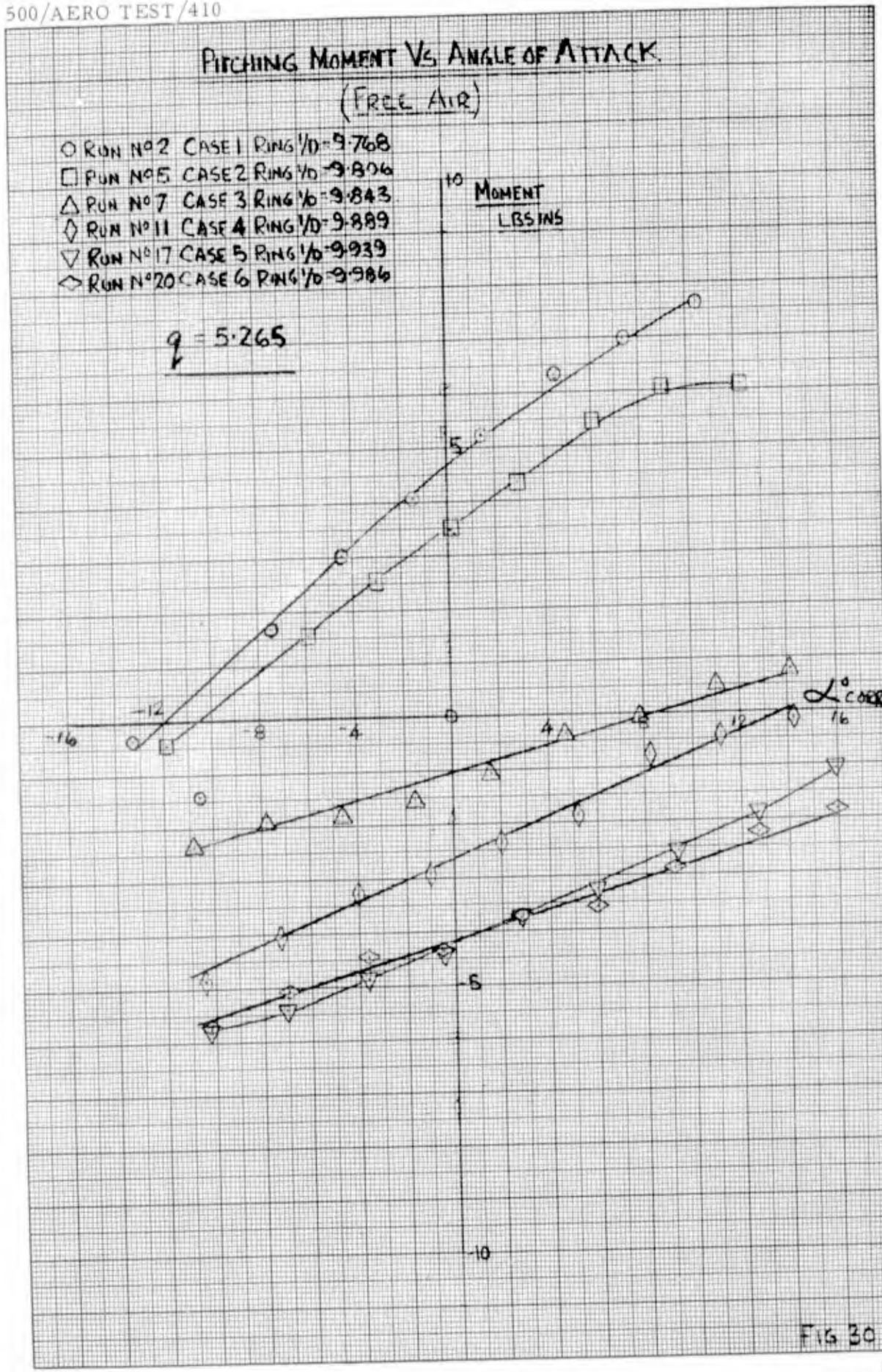

DRAG Vs ANGLE OF ATTACK.
(FREE AIR)
q = 5.265
RING N/D
○ RUN No.2 CASE 1 9.768
□ RUN No.5 CASE 2 9.686
△ RUN No.7 CASE 3 9.843
◇ RUN No.11 CASE 4 9.889
▽ RUN No.17 CASE 5 9.939
◇ RUN No.21 CASE 6 9.986
DRAG ~ L/R
3.0
2.5
2.0
1.5
1.0
.5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α'

FIG 27


DRAG VS ANGLE OF ATTACK
(FREE AIR)
○ RUN Nº3 CASE 1 RING 1/D = 9·768
□ RUN Nº 6 CASE 2 RING 1/D = 9·806
△ RUN Nº 8 CASE 3 RING 1/D = 9·843
◇ RUN Nº 12 CASE 4 RING 1/D = 9·889
▽ RUN Nº 18 CASE 5 RING 1/D = 9·939
◇ RUN Nº 21 CASE 6 RING 1/D = 9·986
q = 18·113
DRAG LBS
7·0
6·0
5·0
4·0
3·0
2·0
1·0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
FIG 28


PITCHING MOMENT VS ANGLE OF ATTACK.
(FREE AIR)
○ RUN Nº 1 CASE 1 RING ½D 9·768
□ RUN Nº 4 CASE 2 RING ½D 9·806
△ RUN Nº 9 CASE 3 RING ½D 9·843
◇ RUN Nº 10 CASE 4 RING ½D 9·889
▽ RUN Nº 16 CASE 5 RING ½D 9·935
◈ RUN Nº 19 CASE 6 RING ½D 9·986
q = 0
MOMENT
LBS·INS
+5
-5
α° (body)
-16
-12
-8
-4
4
8
12
16
FIG 29


PITCHING MOMENT VS ANGLE OF ATTACK.
(FREE AIR)
○ RUN N°2 CASE 1 RING 1/D = 9.768
□ RUN N°5 CASE 2 RING 1/D = 9.806
△ RUN N°7 CASE 3 RING 1/D = 9.843
◇ RUN N°11 CASE 4 RING 1/D = 9.889
▽ RUN N°17 CASE 5 RING 1/D = 9.939
◇ RUN N°20 CASE 6 RING 1/D = 9.986
q = 5.265
MOMENT
LBS INS
10
5
-5
-10
-16
-12
-8
-4
4
8
12
16
α° CORR
FIG 30

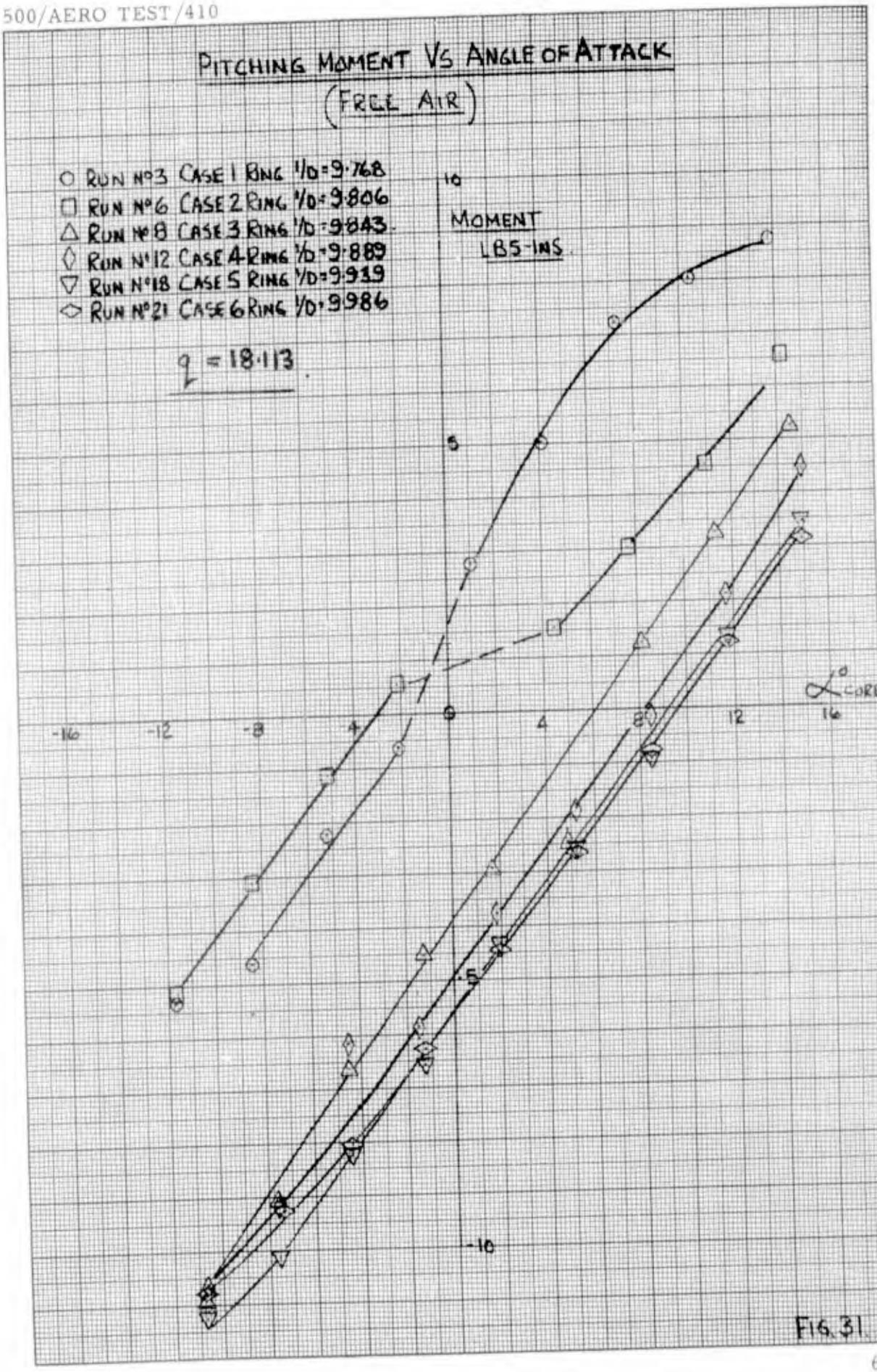

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN N°3 CASE 1 RING 1/D=9·768
□ RUN N°6 CASE 2 RING 1/D=9·806
△ RUN N°8 CASE 3 RING 1/D=9·843
◇ RUN N°12 CASE 4 RING 1/D=9·889
▽ RUN N°18 CASE 5 RING 1/D=9·939
◇ RUN N°21 CASE 6 RING 1/D=9·986
q = 18·113
MOMENT
LBS-INS
10
5
-5
-10
-16
-12
-8
-4
0
4
8
12
16
α° CORR

FIG 31

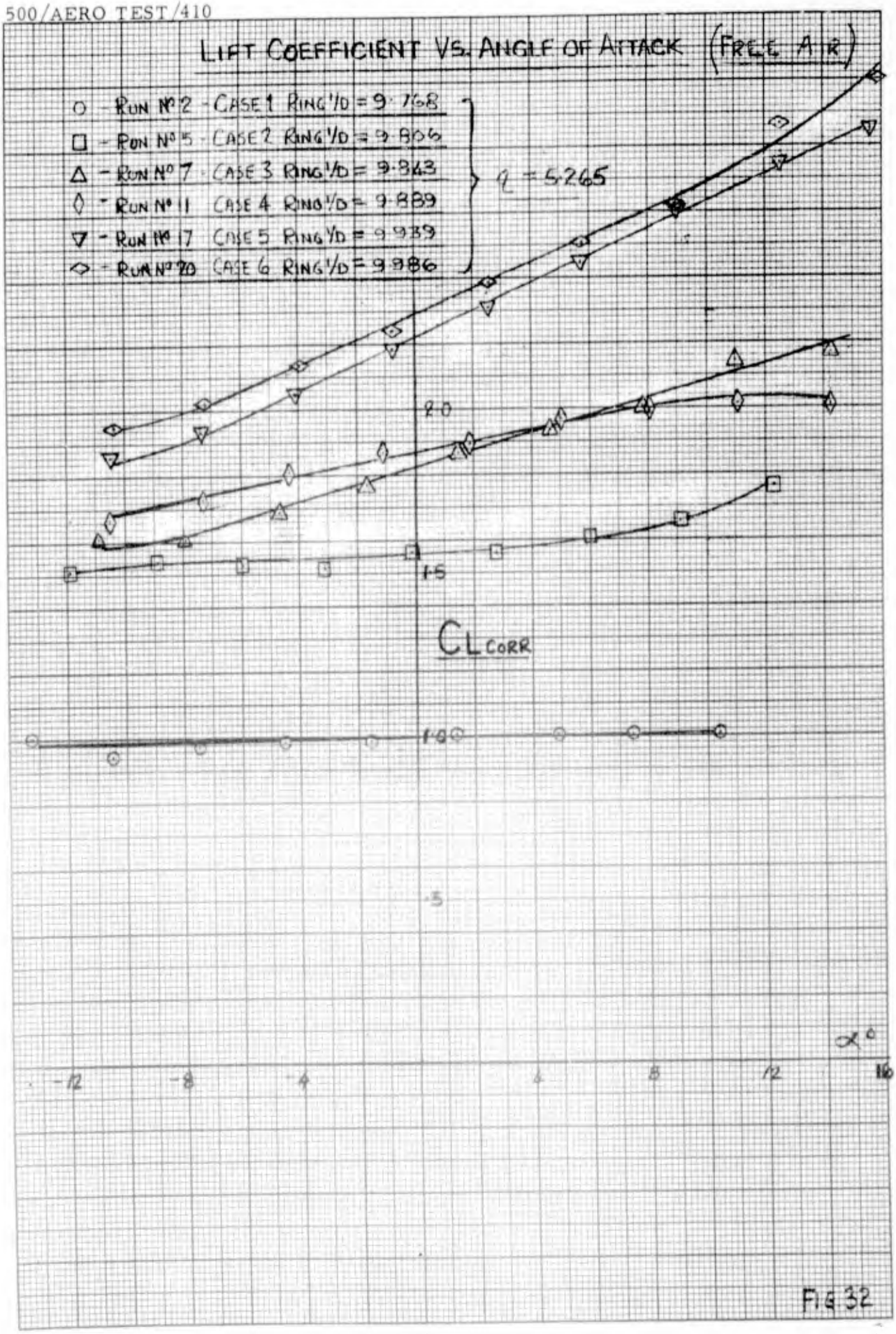

LIFT COEFFICIENT VS. ANGLE OF ATTACK (FREE AIR)
○ - RUN Nº 2 - CASE 1 RING 1/D = 9.768
□ - RUN Nº 5 - CASE 2 RING 1/D = 9.806
△ - RUN Nº 7 - CASE 3 RING 1/D = 9.843
◇ - RUN Nº 11 CASE 4 RING 1/D = 9.889
▽ - RUN Nº 17 CASE 5 RING 1/D = 9.939
◇ - RUN Nº 20 CASE 6 RING 1/D = 9.986
q = 5.265
2.0
1.5
CL CORR
1.0
.5
α°
-12
-8
-4
4
8
12
16

Fig 32

LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)

- ○ - RUN N°3 - CASE 1 RING 1/D = 9·768
- □ - RUN N°6 - CASE 2 RING 1/D = 9·806
- △ - RUN N° 8 - CASE 3 RING 1/D = 9·843
- ◇ - RUN N°12 - CASE 4 RING 1/D = 9·889
- ▽ - RUN N°18 - CASE 5 RING 1/D = 9·939
- ◇ - RUN N°21 - CASE 6 RING 1/D = 9·986

} q = 18·113

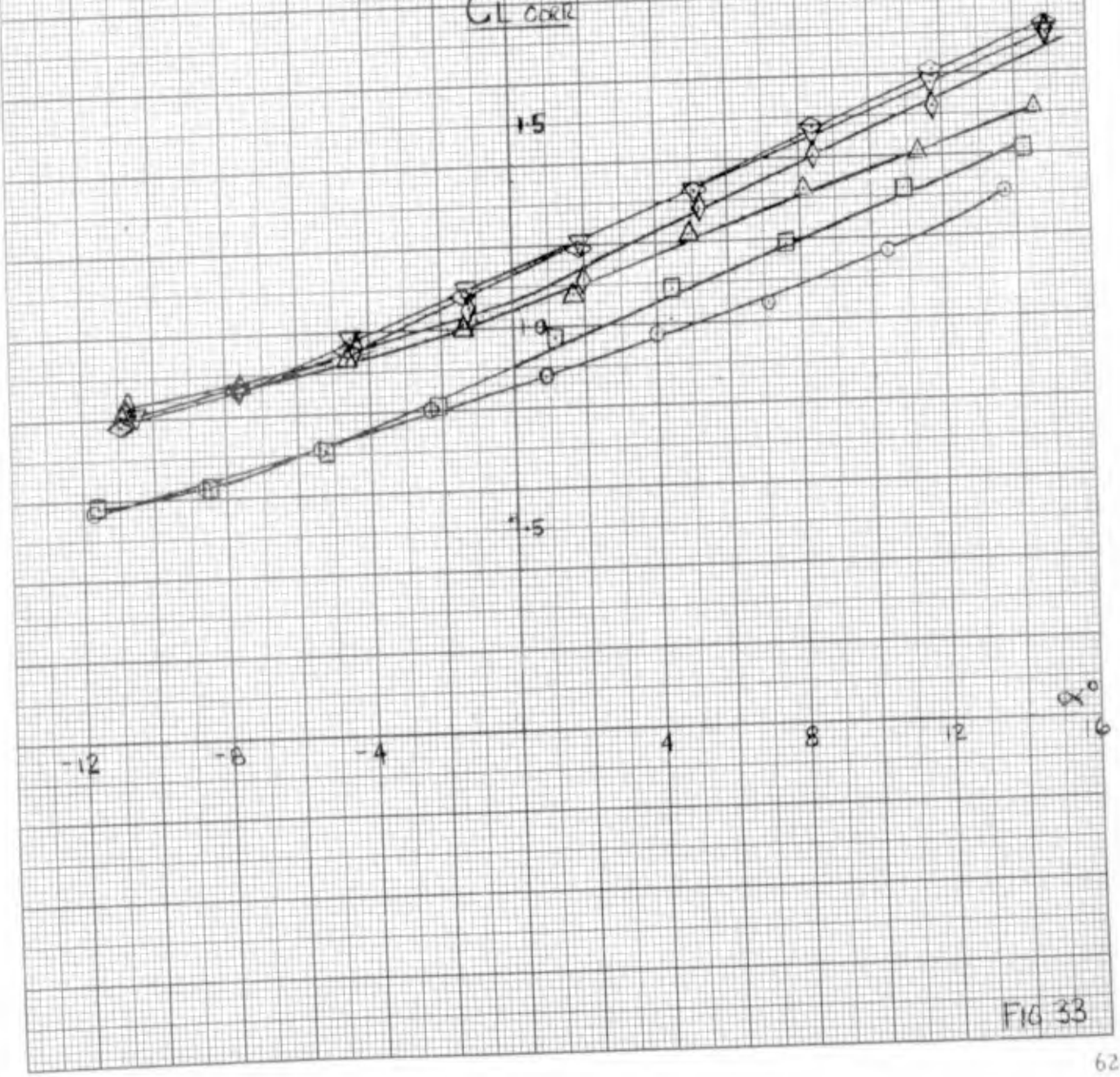


FIG 33

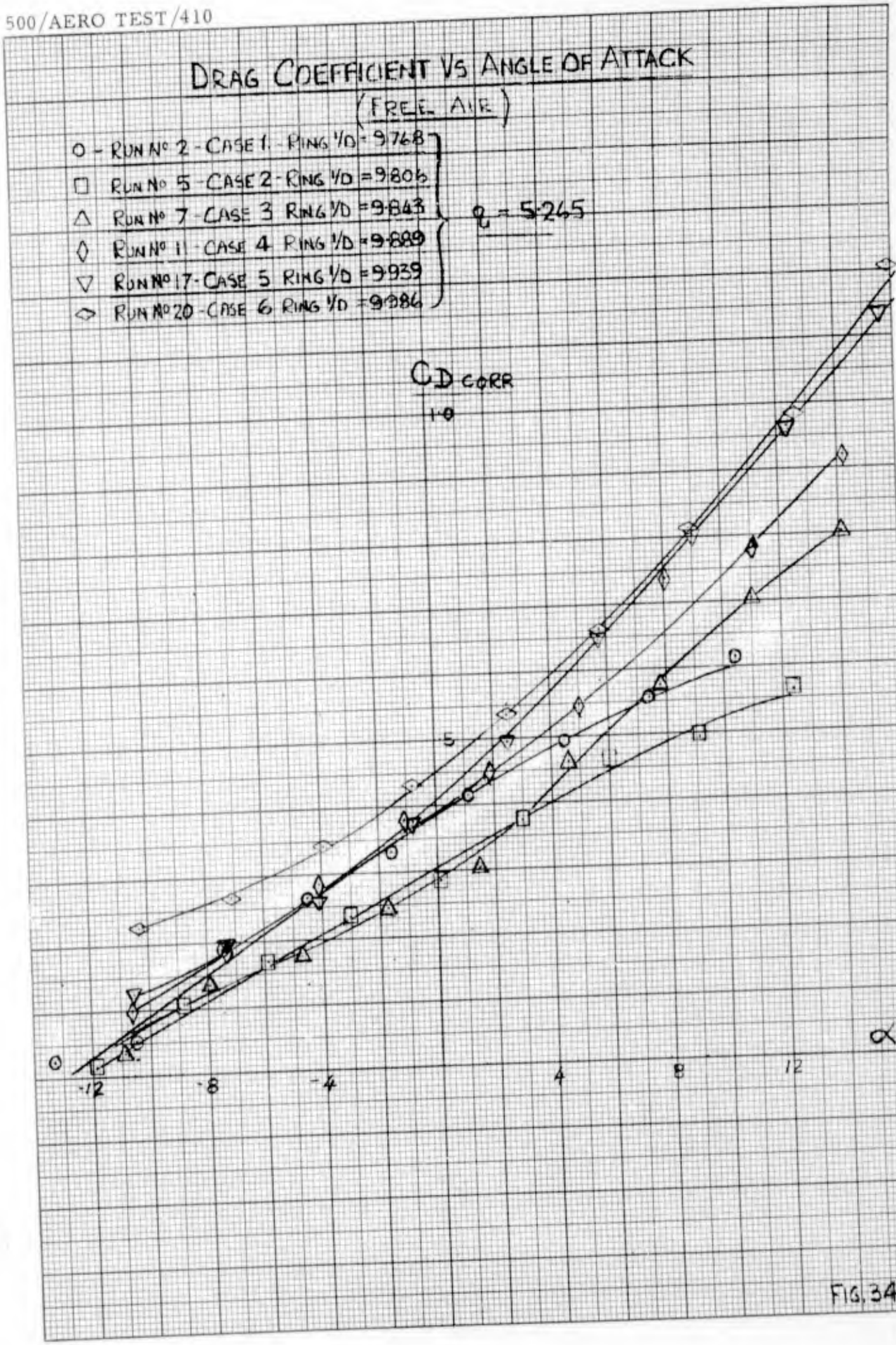

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
O - RUN Nº 2 - CASE 1 - RING 1/D = 9.768
□ RUN Nº 5 - CASE 2 - RING 1/D = 9.806
△ RUN Nº 7 - CASE 3 RING 1/D = 9.843
◇ RUN Nº 11 - CASE 4 RING 1/D = 9.889
▽ RUN Nº 17 - CASE 5 RING 1/D = 9.939
◇ RUN Nº 20 - CASE 6 RING 1/D = 9.986
q = 5.245
CD CORR
1.0
5
11
0
-12
-8
-4
4
8
12
16
α°

FIG. 34.

DRAG COEFFICIENT VS ANGLE OF ATTACK. (FREE AIR)

○	RUN No 3 - CASE 1	RING D/D = 9·768
□	RUN No 6 - CASE 2	RING D/D = 9·806
△	RUN Nº 8 - CASE 3	RING D/D = 9·843
◇	RUN Nº 12 - CASE 4	RING D/D = 9·889
▽	RUN Nº 18 - CASE 5	RING D/D = 9·939
◆	RUN Nº 21 - CASE 6	RING D/D = 9·986

$q = 18 \cdot 113$

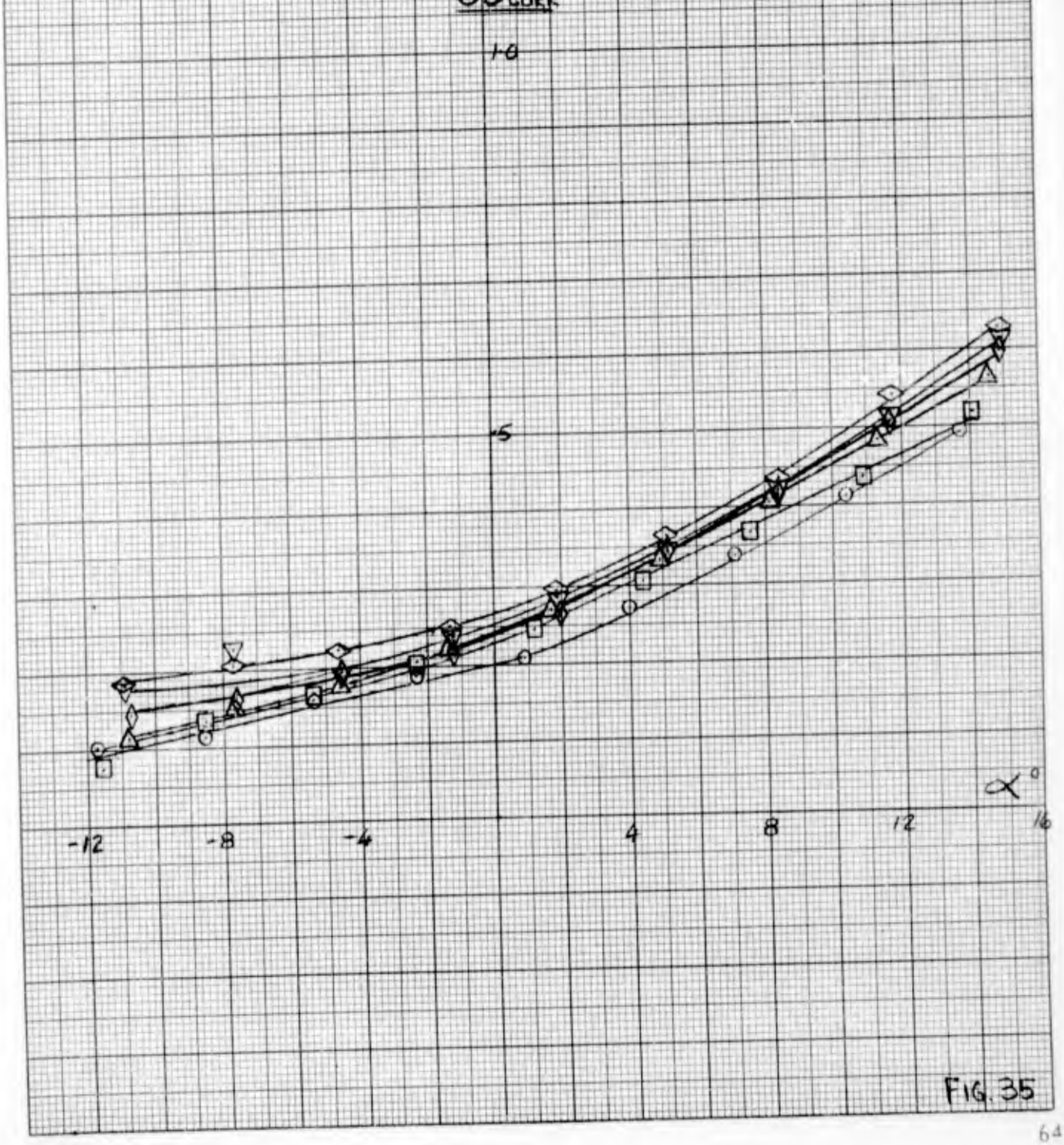
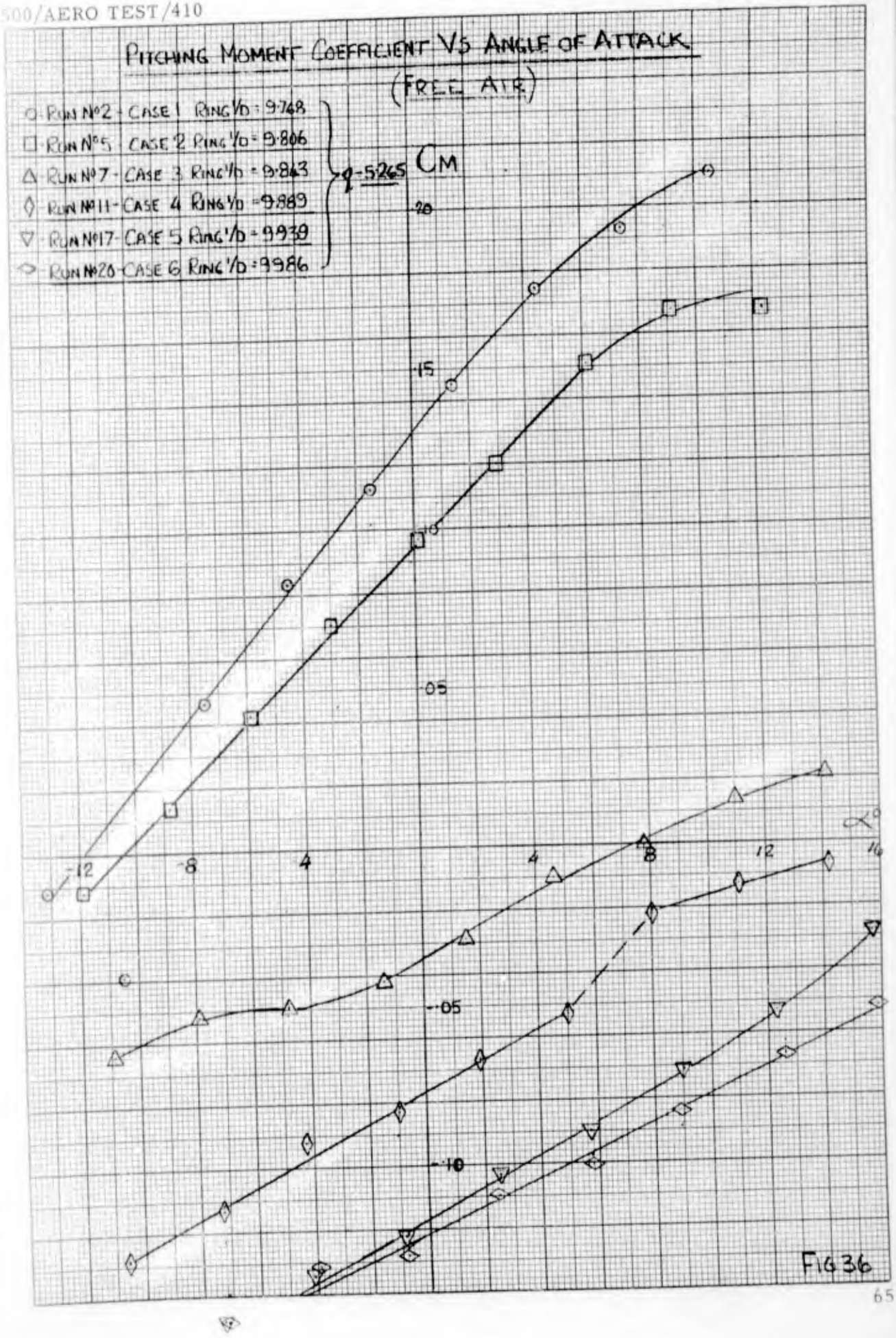


FIG. 35


PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN N°2 - CASE 1 RING ½D = 9·748
□ RUN N°5 - CASE 2 RING ½D = 9·806
△ RUN N°7 - CASE 3 RING ½D = 9·863
◇ RUN N°11 - CASE 4 RING ½D = 9·889
▽ RUN N°17 - CASE 5 RING ½D = 9·939
◇ RUN N°20 - CASE 6 RING ½D = 9·986
q = 5·265
CM
·20
·15
·05
-12
-8
4
4
8
12
16
α°
·05
·10
FIG 36

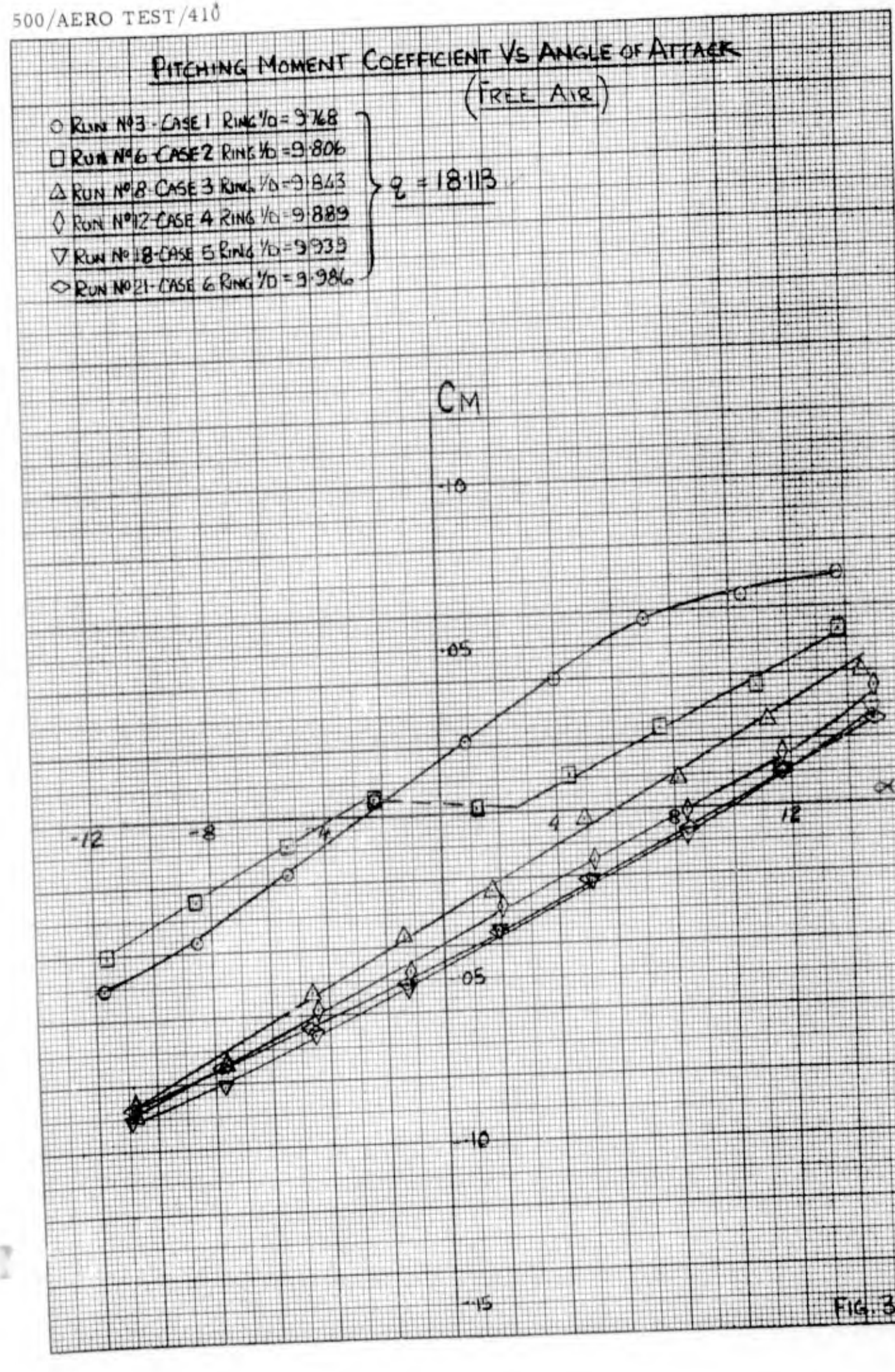
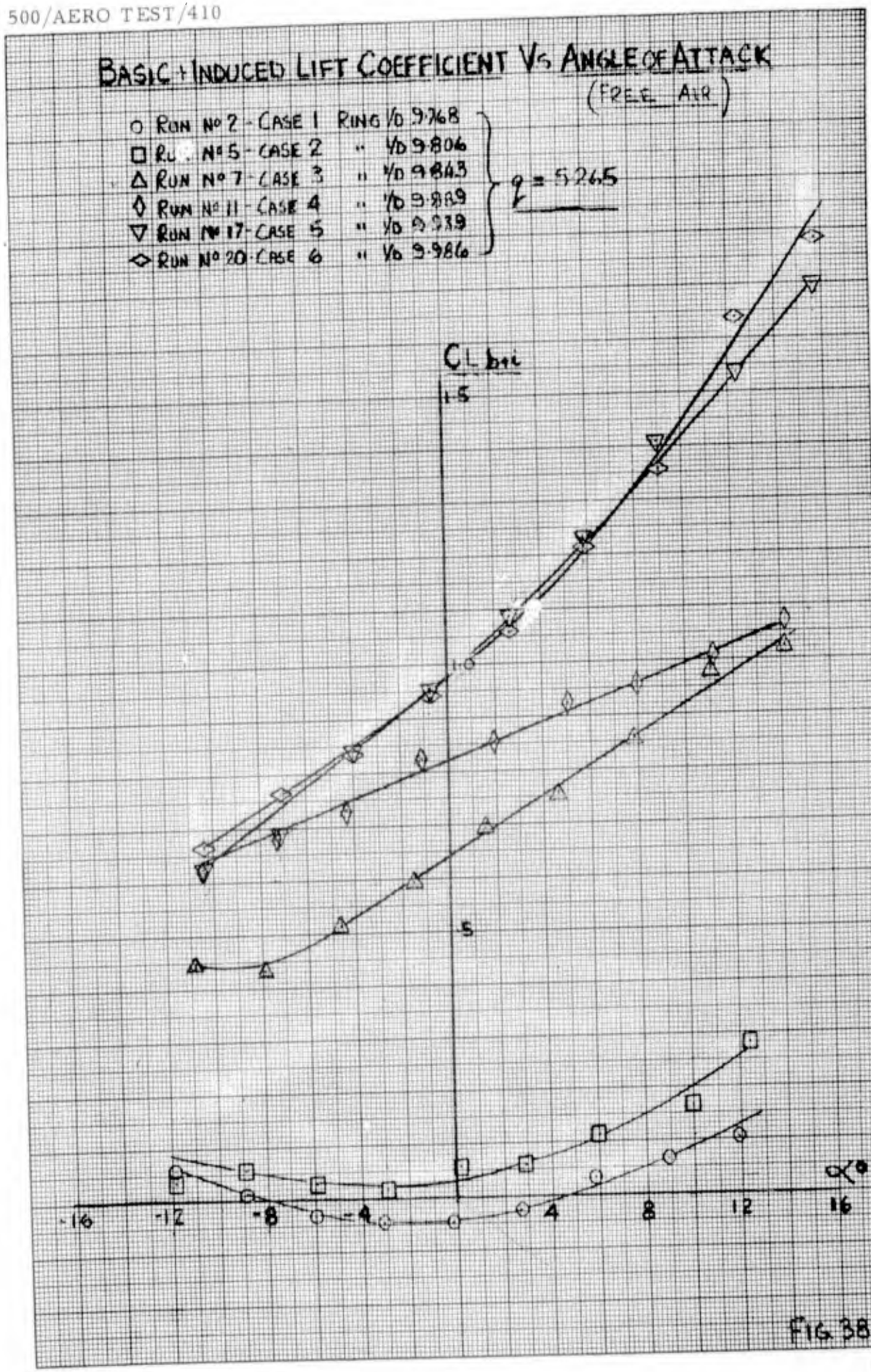

PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN Nº3 - CASE 1 RING 1/D = 3768
□ RUN Nº6 - CASE 2 RING 1/D = 3806
△ RUN Nº8 - CASE 3 RING 1/D = 3843
◇ RUN Nº12 - CASE 4 RING 1/D = 3889
▽ RUN Nº18 - CASE 5 RING 1/D = 3933
◇ RUN Nº21 - CASE 6 RING 1/D = 3986
q = 18·118
CM
-10
-05
-12
-8
-4
4
8
12
α°
-05
-10
-15

FIG. 37.


BASIC + INDUCED LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
RUN No 2 - CASE 1 RING V/D 9.768
RUN No 5 - CASE 2 " V/D 9.806
RUN No 7 - CASE 3 " V/D 9.843
RUN No 11 - CASE 4 " V/D 9.889
RUN No 17 - CASE 5 " V/D 9.939
RUN No 20 - CASE 6 " V/D 9.986
q = 52.65
CL bri
1.5
1.0
.5
-16
-12
-8
-4
4
8
12
16
α°
FIG 38

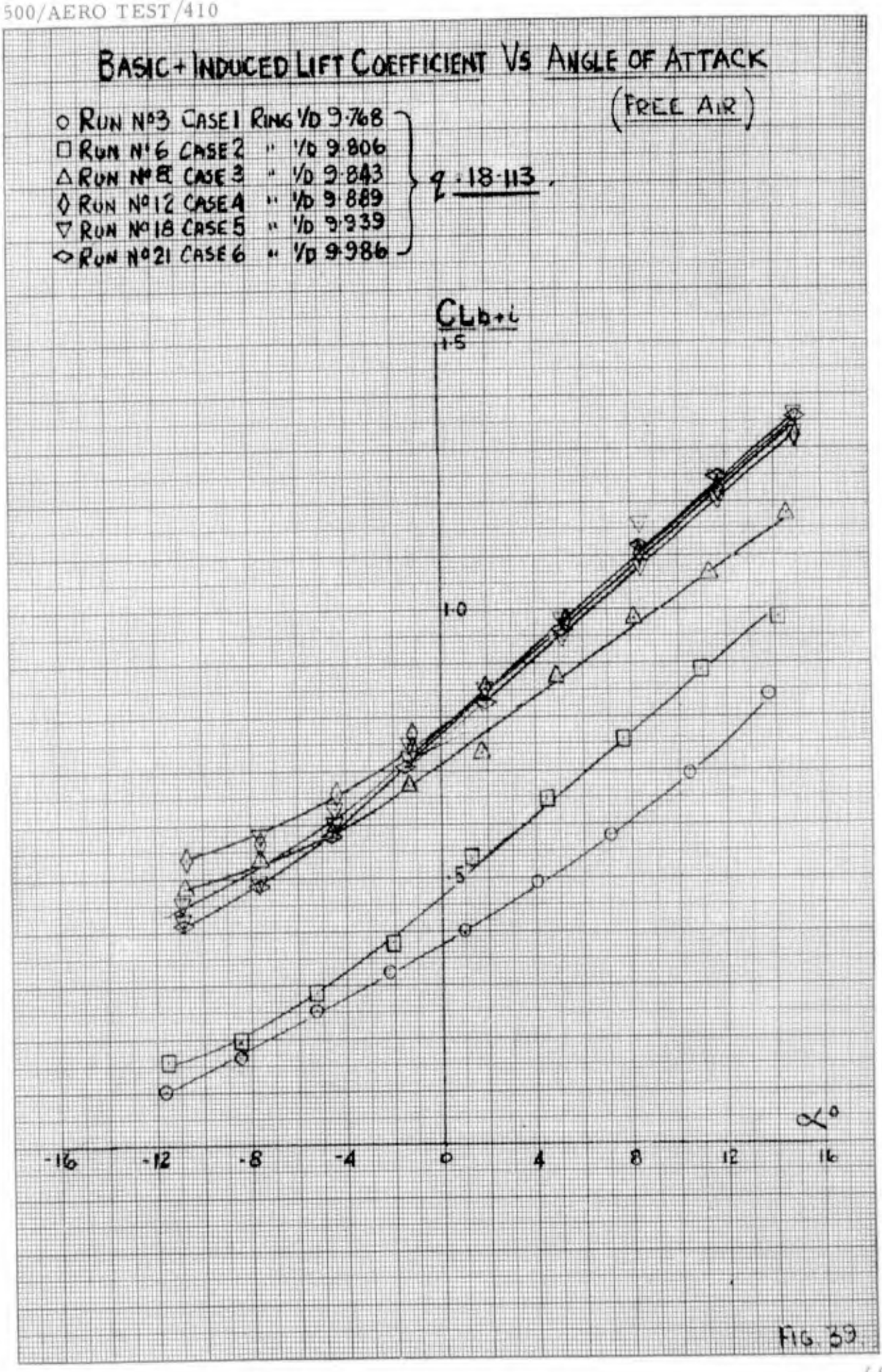

BASIC + INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN Nº3 CASE 1 RING 1/D 9·768
□ RUN Nº6 CASE 2 " 1/D 9·806
△ RUN Nº8 CASE 3 " 1/D 9·843
◊ RUN Nº12 CASE 4 " 1/D 9·889
▽ RUN Nº18 CASE 5 " 1/D 9·939
◇ RUN Nº21 CASE 6 " 1/D 9·986
q · 18·113
CLb+i
1·5
1·0
·5
-16
-12
-8
-4
0
4
8
12
16
α°

FIG 39

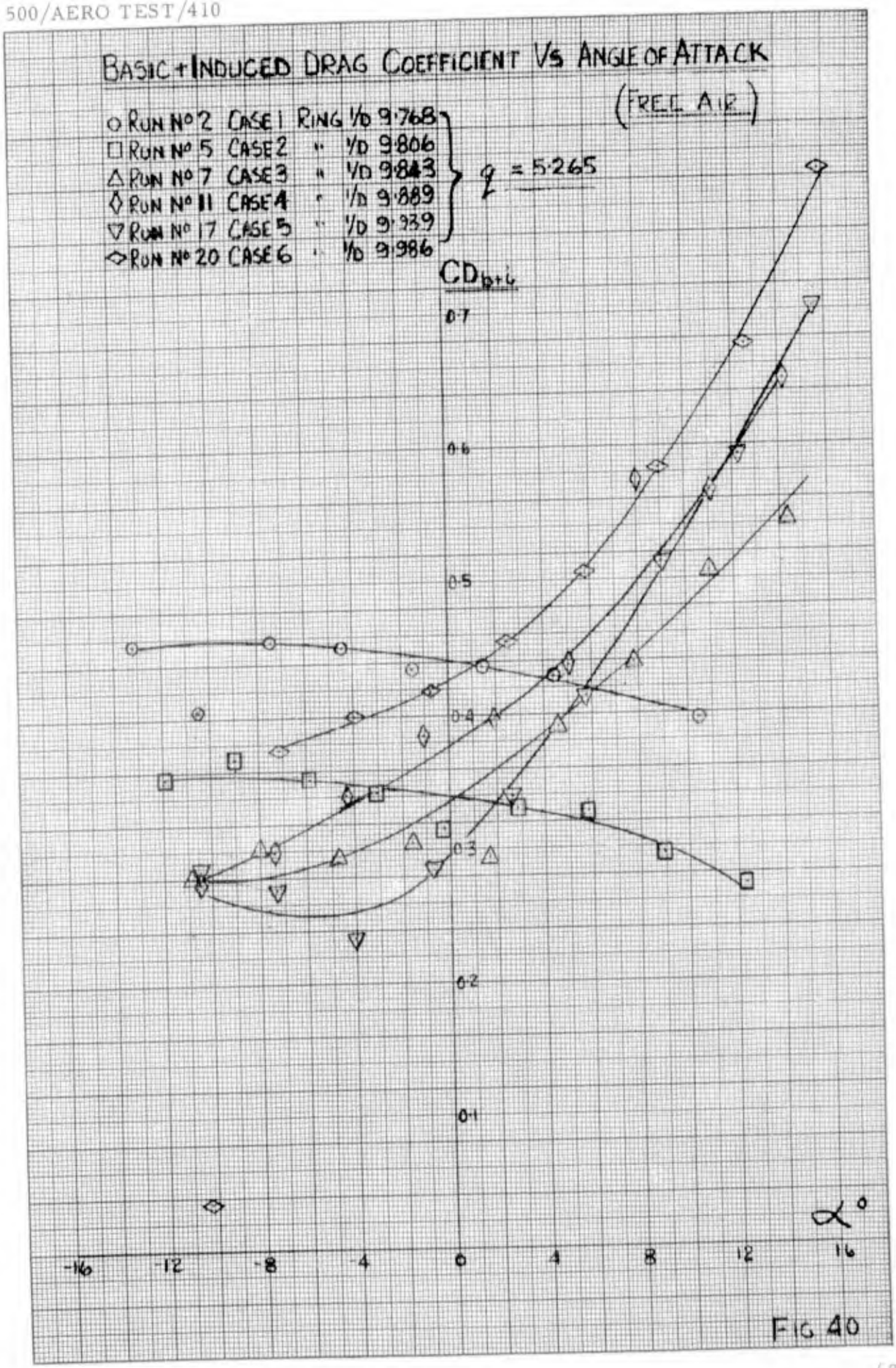

BASIC + INDUCED DRAG COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
○ RUN N° 2 CASE 1 RING l/D 9·768
□ RUN N° 5 CASE 2 " l/D 9·806
△ RUN N° 7 CASE 3 " l/D 9·843
◇ RUN N° 11 CASE 4 " l/D 9·889
▽ RUN N° 17 CASE 5 " l/D 9·939
◇ RUN N° 20 CASE 6 " l/D 9·986
q = 5·265
CD b+i
0·7
0·6
0·5
0·4
0·3
0·2
0·1
-16
-12
-8
-4
0
4
8
12
16
α°

FIG 40

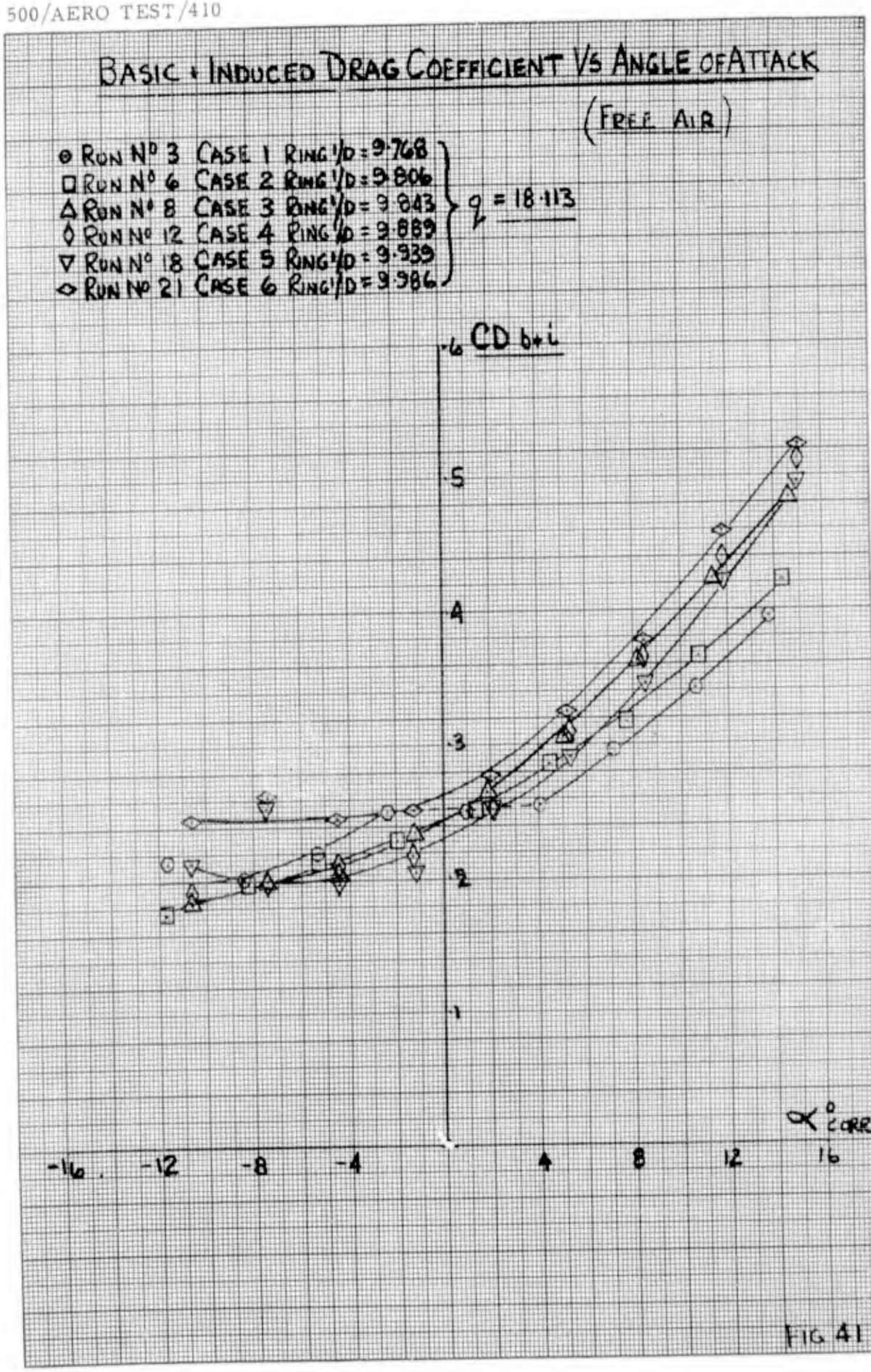

BASIC + INDUCED DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
RUN Nº 3 CASE 1 RING 1/D = 9.768
RUN Nº 6 CASE 2 RING 1/D = 9.806
RUN Nº 8 CASE 3 RING 1/D = 9.843
RUN Nº 12 CASE 4 RING 1/D = 9.889
RUN Nº 18 CASE 5 RING 1/D = 9.939
RUN Nº 21 CASE 6 RING 1/D = 9.986
q = 18.113
CD b+i
.6
.5
.4
.3
.2
.1
α° CORR
-16
-12
-8
-4
4
8
12
16

FIG 41

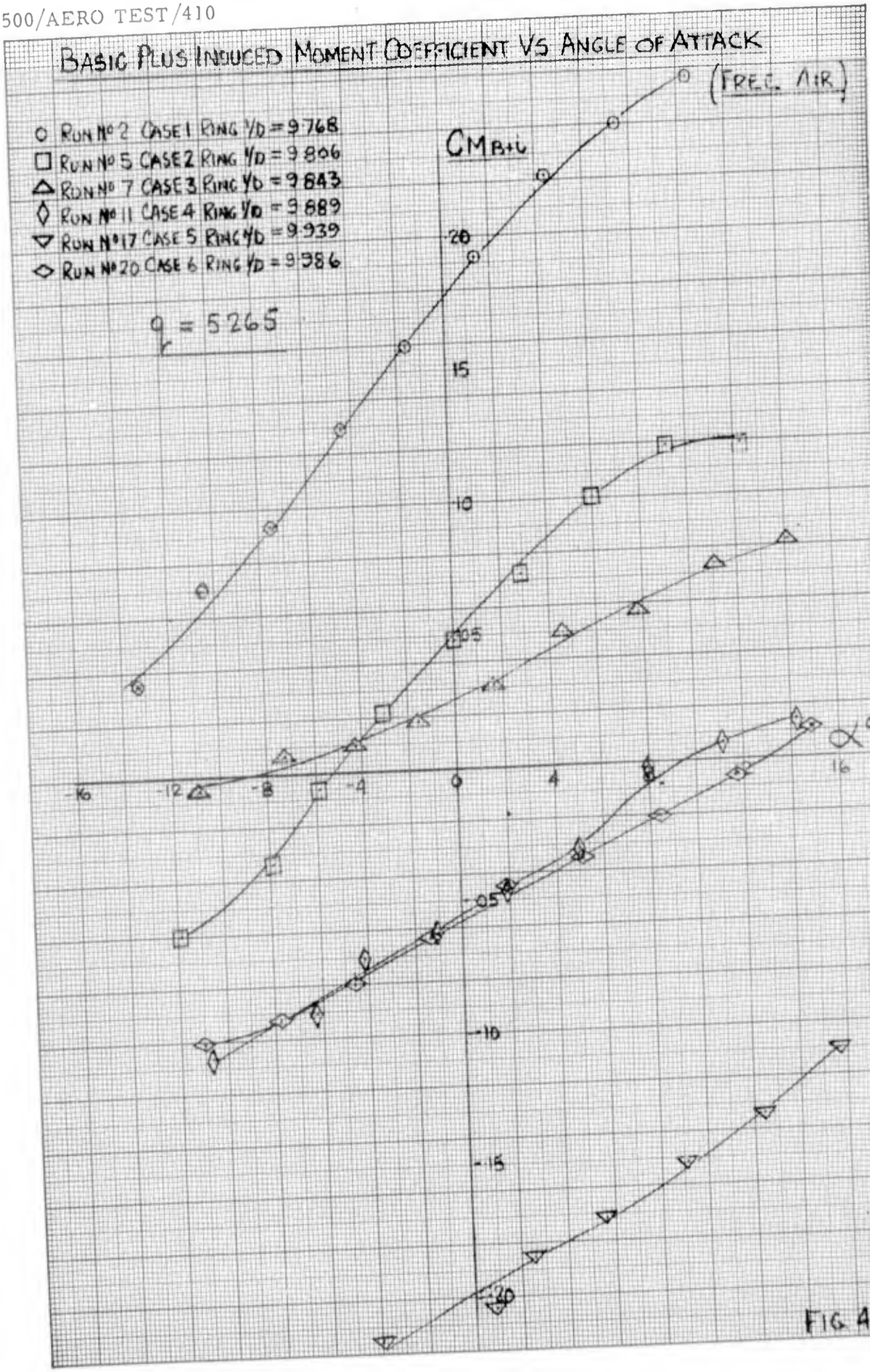

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
○ RUN Nº 2 CASE 1 RING Y/D = 9.768
□ RUN Nº 5 CASE 2 RING Y/D = 9.806
△ RUN Nº 7 CASE 3 RING Y/D = 9.843
◇ RUN Nº 11 CASE 4 RING Y/D = 9.889
▽ RUN Nº 17 CASE 5 RING Y/D = 9.939
◇ RUN Nº 20 CASE 6 RING Y/D = 9.986
q = 5265
CMB+U
20
15
10
.5
-.5
-10
-15
-20
-16
-12
-8
-4
0
4
8
16
α°

FIG. 42

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

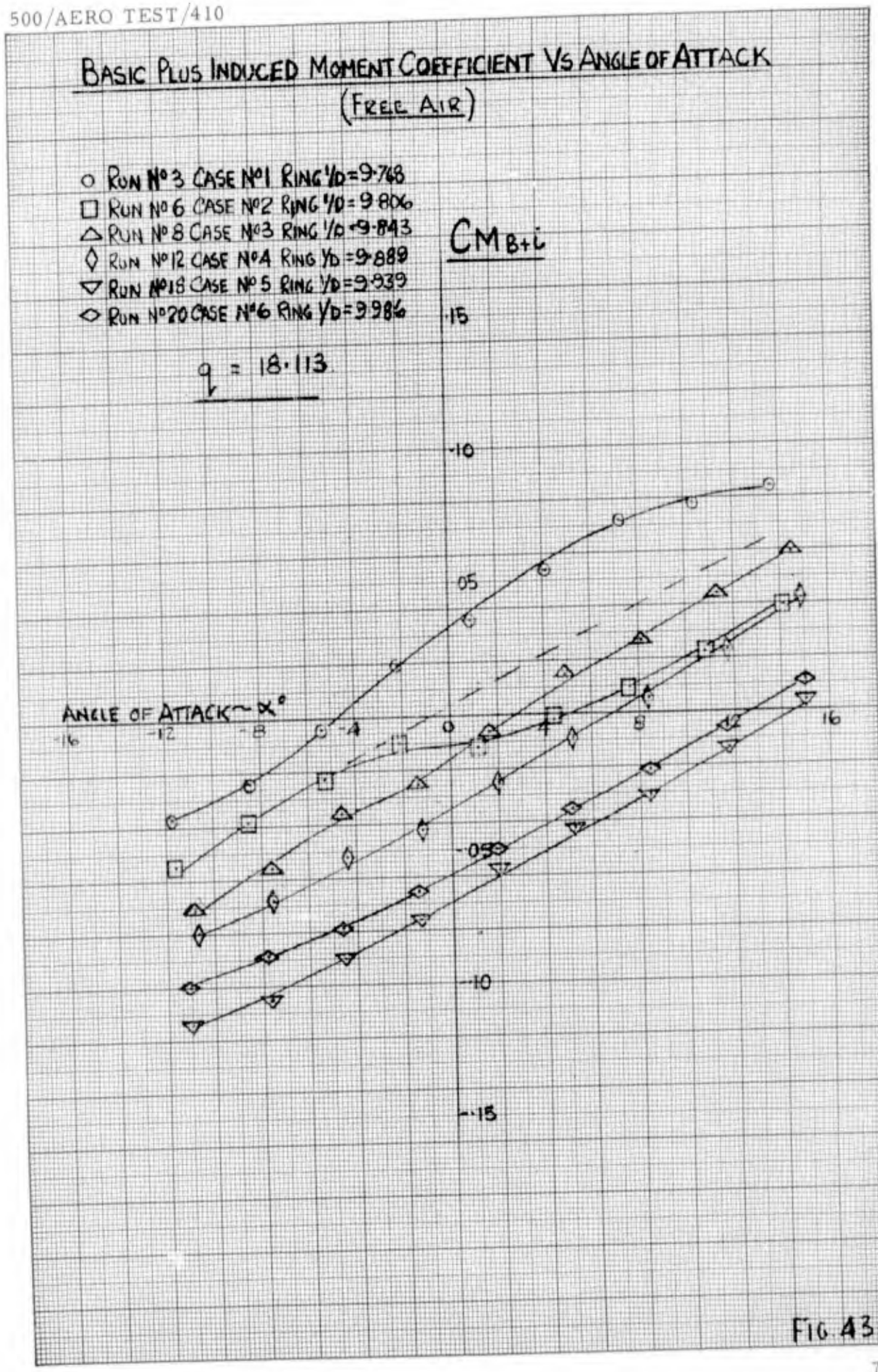
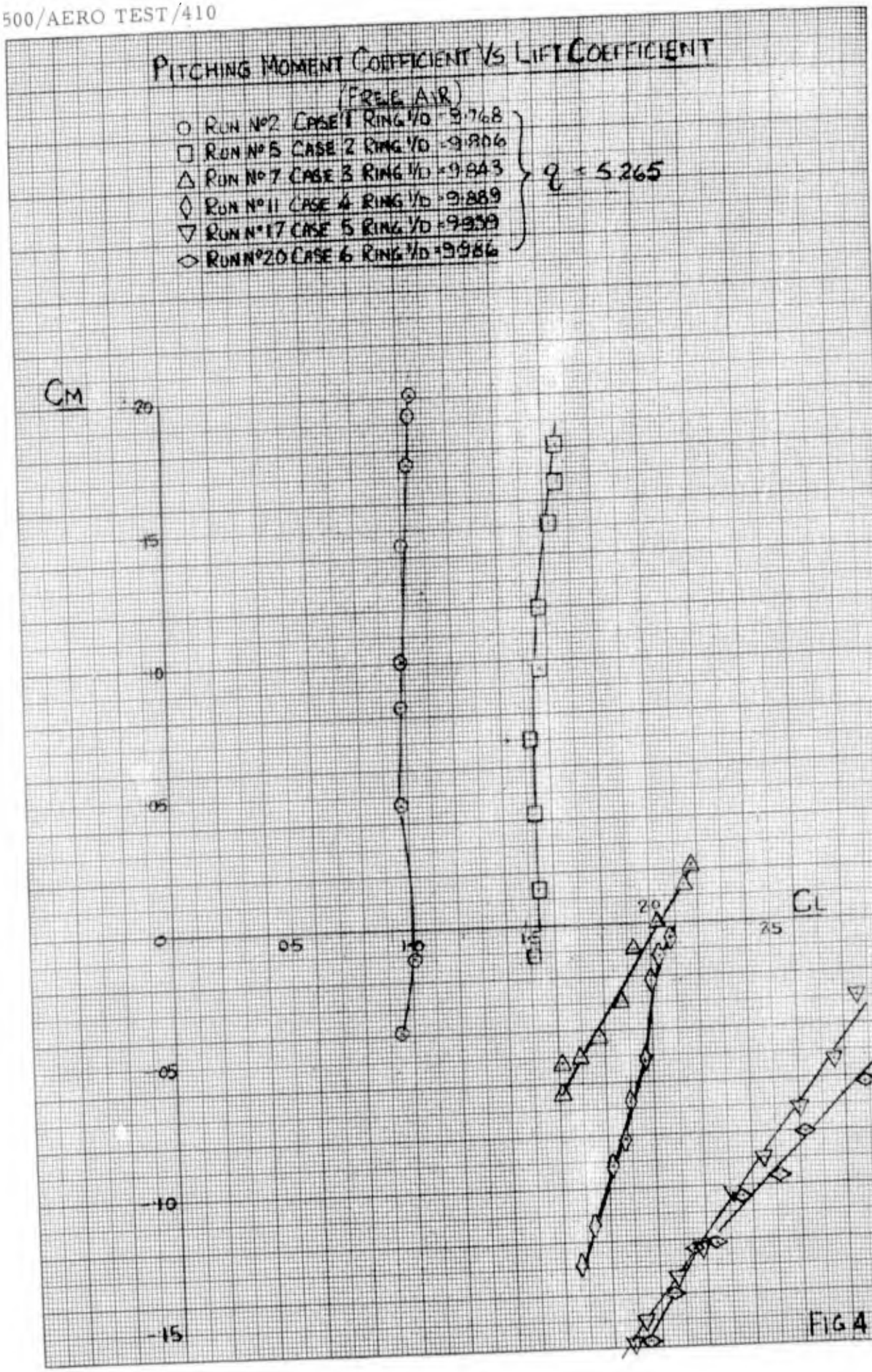


FIG. 43


PITCHING MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
○ RUN N°2 CASE 1 RING 1/D = 9.768
□ RUN N°5 CASE 2 RING 1/D = 9.806
△ RUN N°7 CASE 3 RING 1/D = 9.843
◇ RUN N°11 CASE 4 RING 1/D = 9.889
▽ RUN N°17 CASE 5 RING 1/D = 9.939
◇ RUN N°20 CASE 6 RING 1/D = 9.986
q = 5.265
CM
.20
.15
.10
.05
0
-.05
-.10
-.15
.05
.10
.15
.20
.25
CL
FIG 44

PITCHING MOMENT COEFFICIENT VS LIFT COEFFICIENT

(FREE AIR)

○ RUN Nº 3 CASE 1 RING I/D = 9·768
□ RUN Nº 6 CASE 2 RING I/D = 9·806
△ RUN Nº 8 CASE 3 RING I/D = 9·843
◇ RUN Nº 12 CASE 4 RING I/D = 9·889
▽ RUN Nº 18 CASE 5 RING I/D = 9·939
◇ RUN Nº 21 CASE 6 RING I/D = 9·986

$q = 18·113$

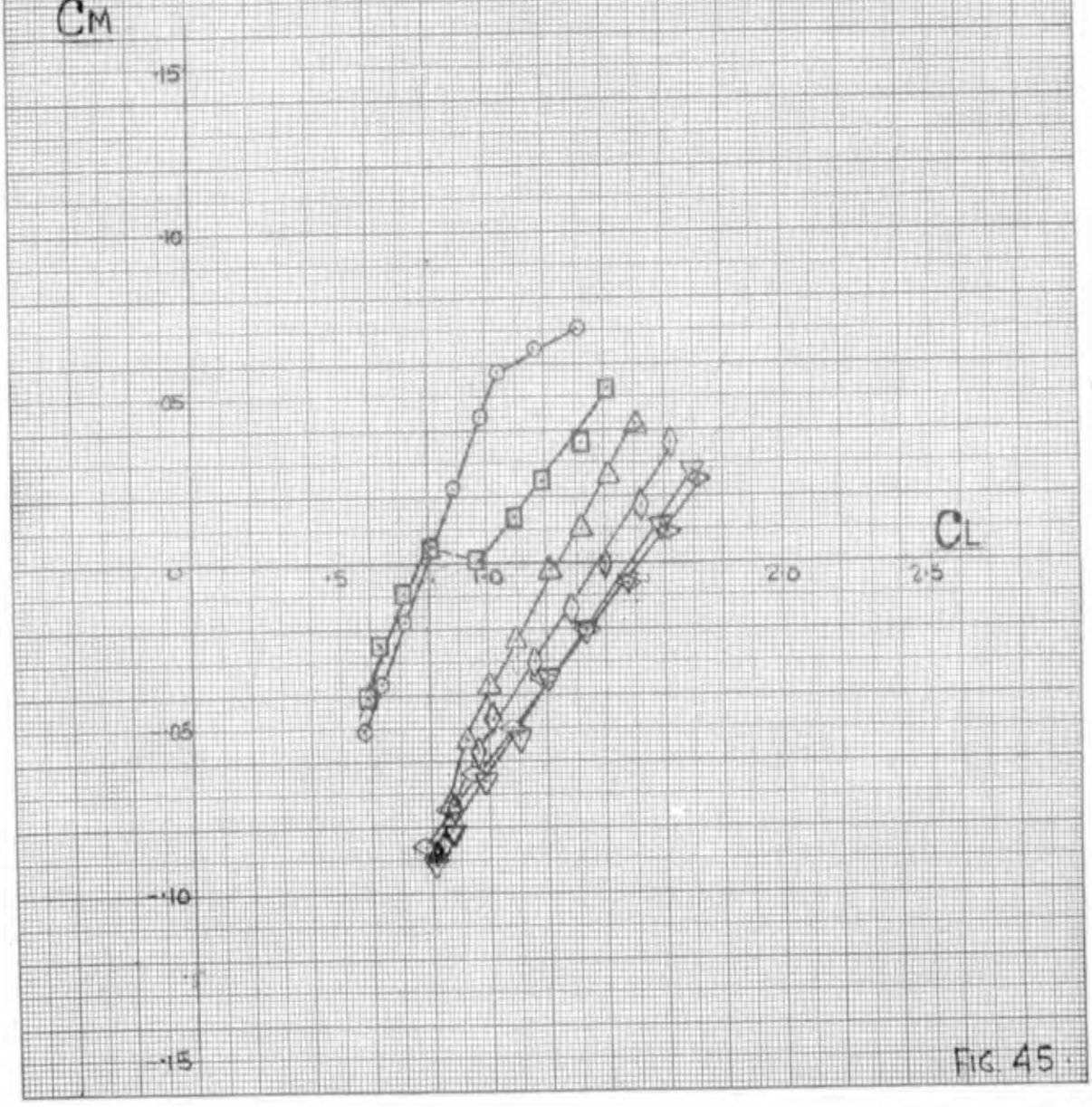
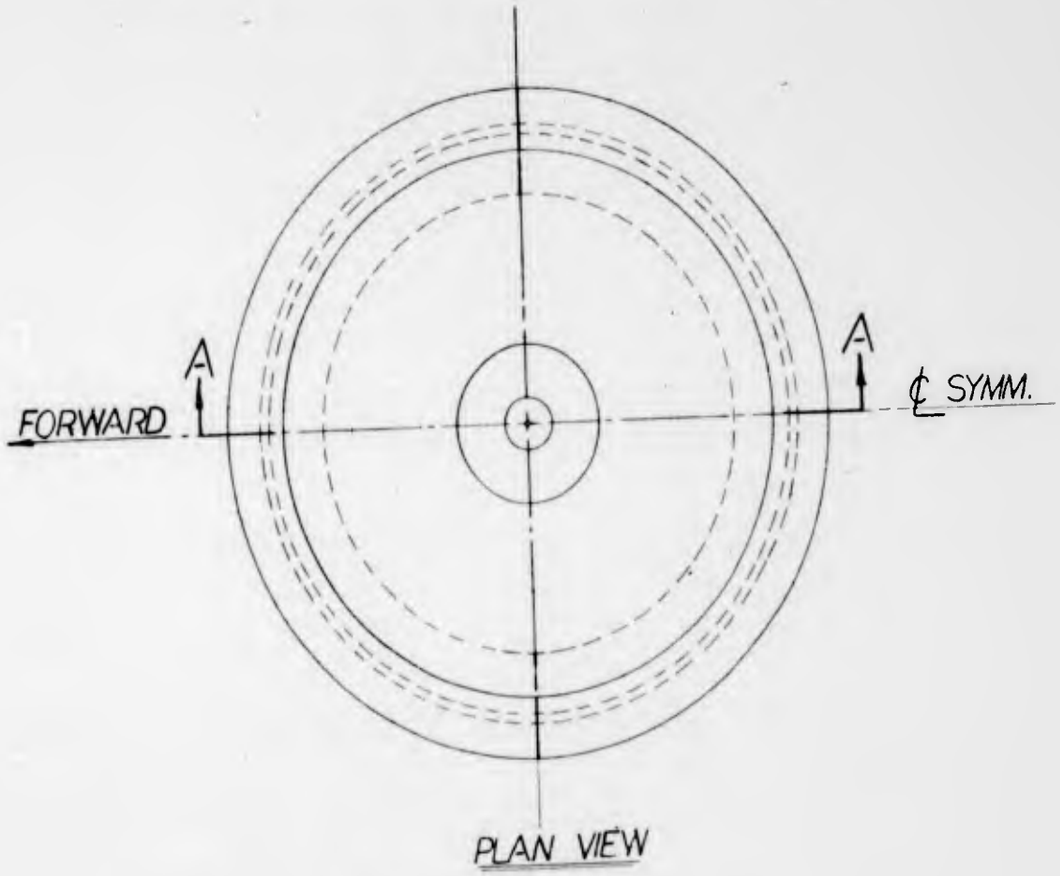


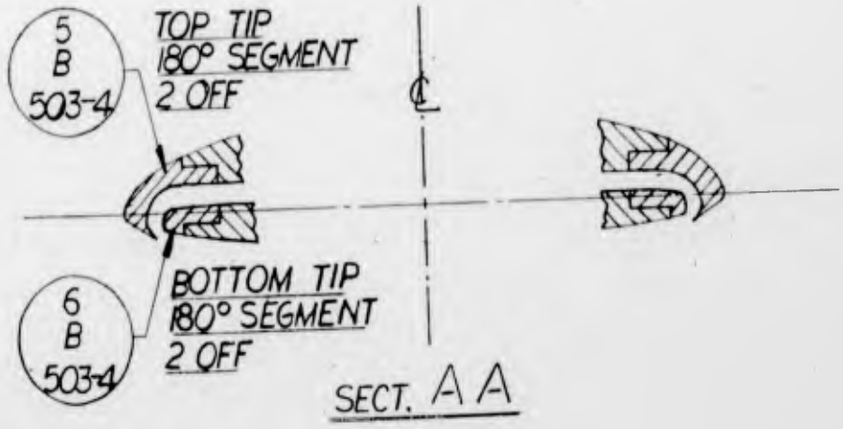
FIG 45

TEST "A" – 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

NOTE:- UNFOCUSSED JET.



PLAN VIEW

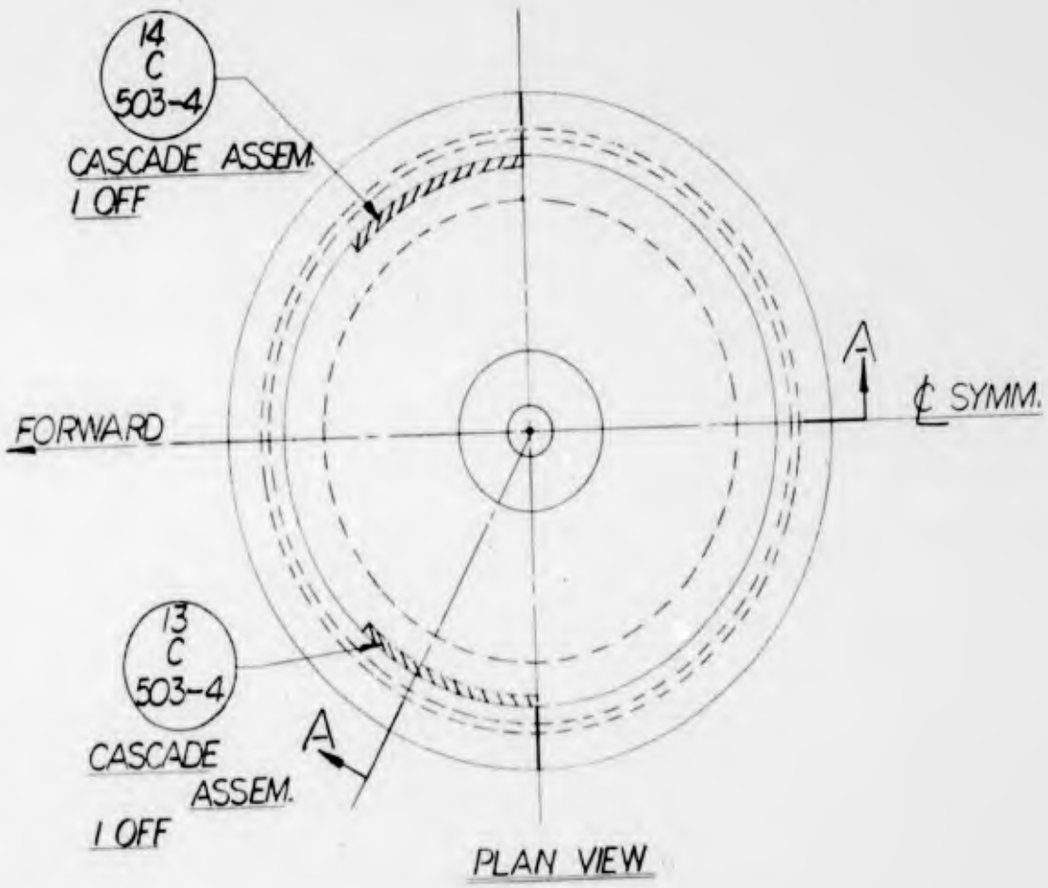


SECT. A A

FIG 46

TEST "8" 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

NOTE:- UNFOCUSSED JET.



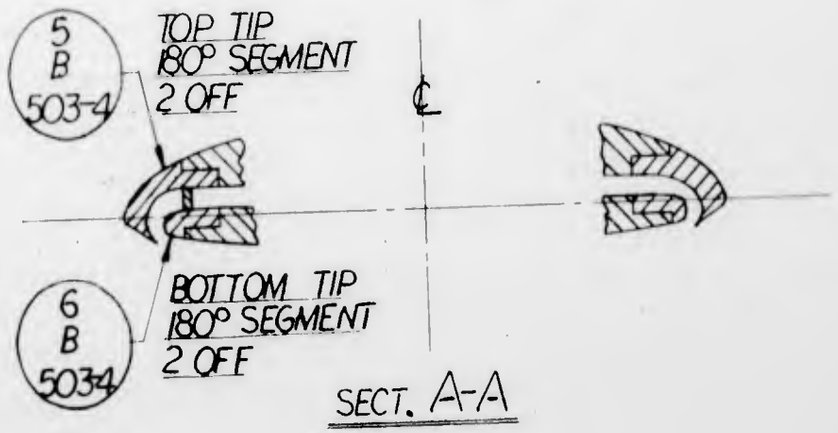
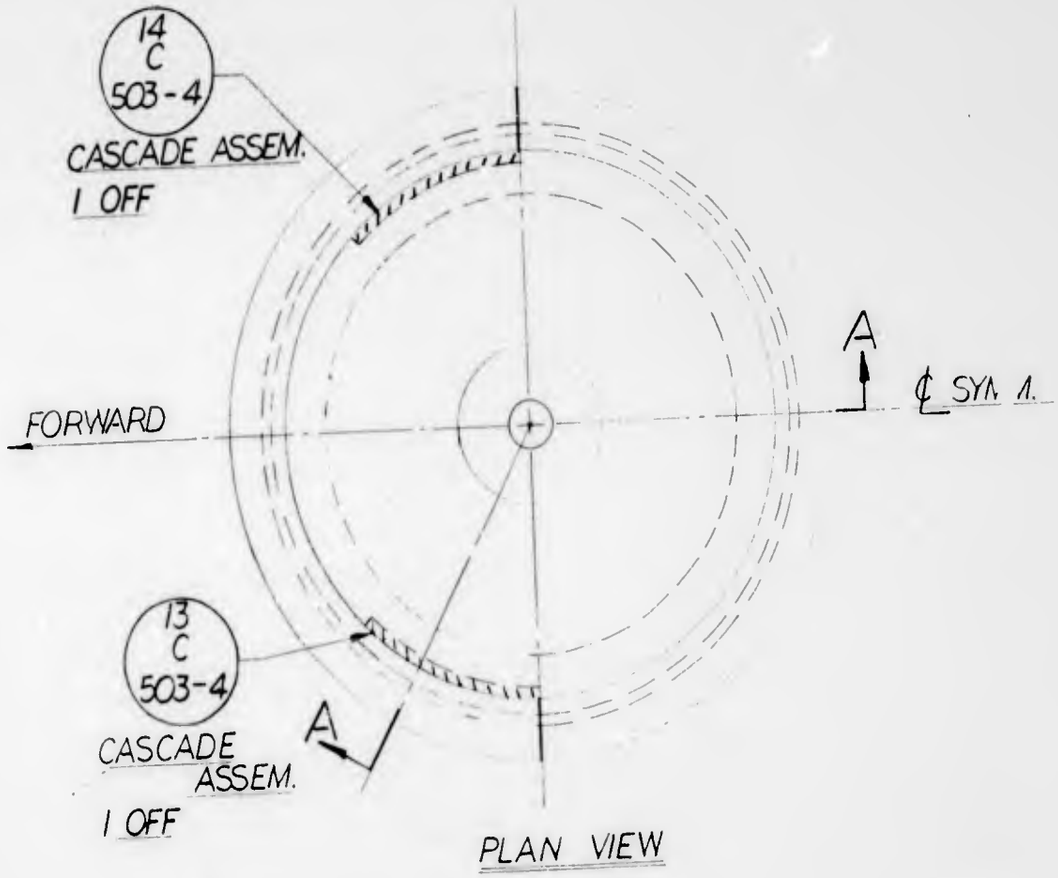


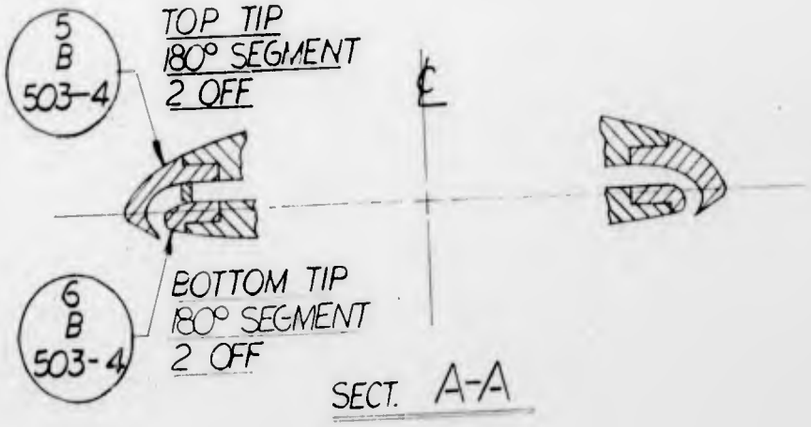
FIG 47

TEST 'C' – 1/20 SCALE MODEL (MOUNTED IN TUNNEL UPSIDE DOWN)

NOTE :– UNFOCUSSED JET



PLAN VIEW



SECT. A-A

FIG 48

TEST 'D' – 1/20 SCALE MODEL (MOUNTED IN TUNNEL UPSIDE DOWN)

NOTE :– UNFOCUSSED JET.

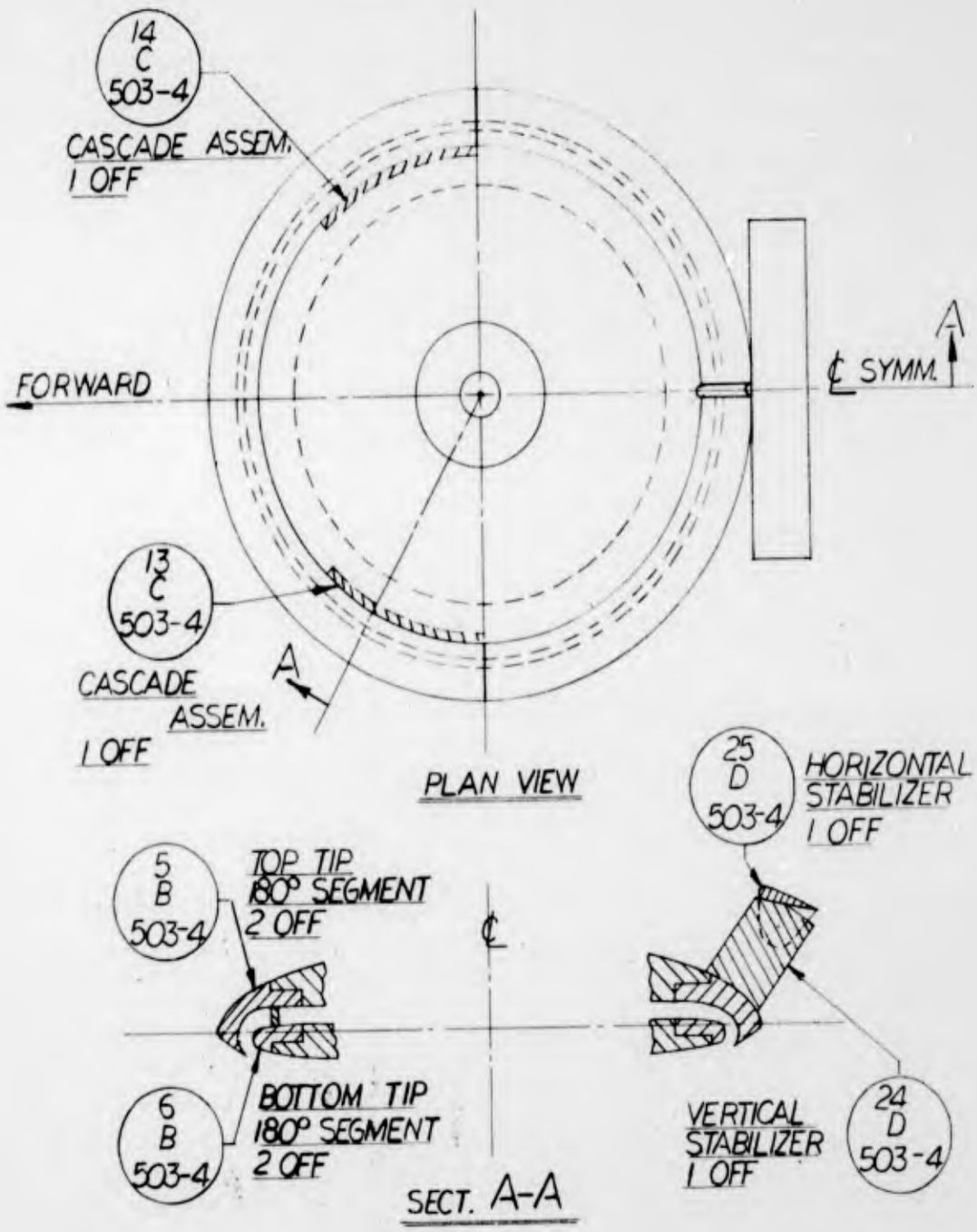


FIG 49

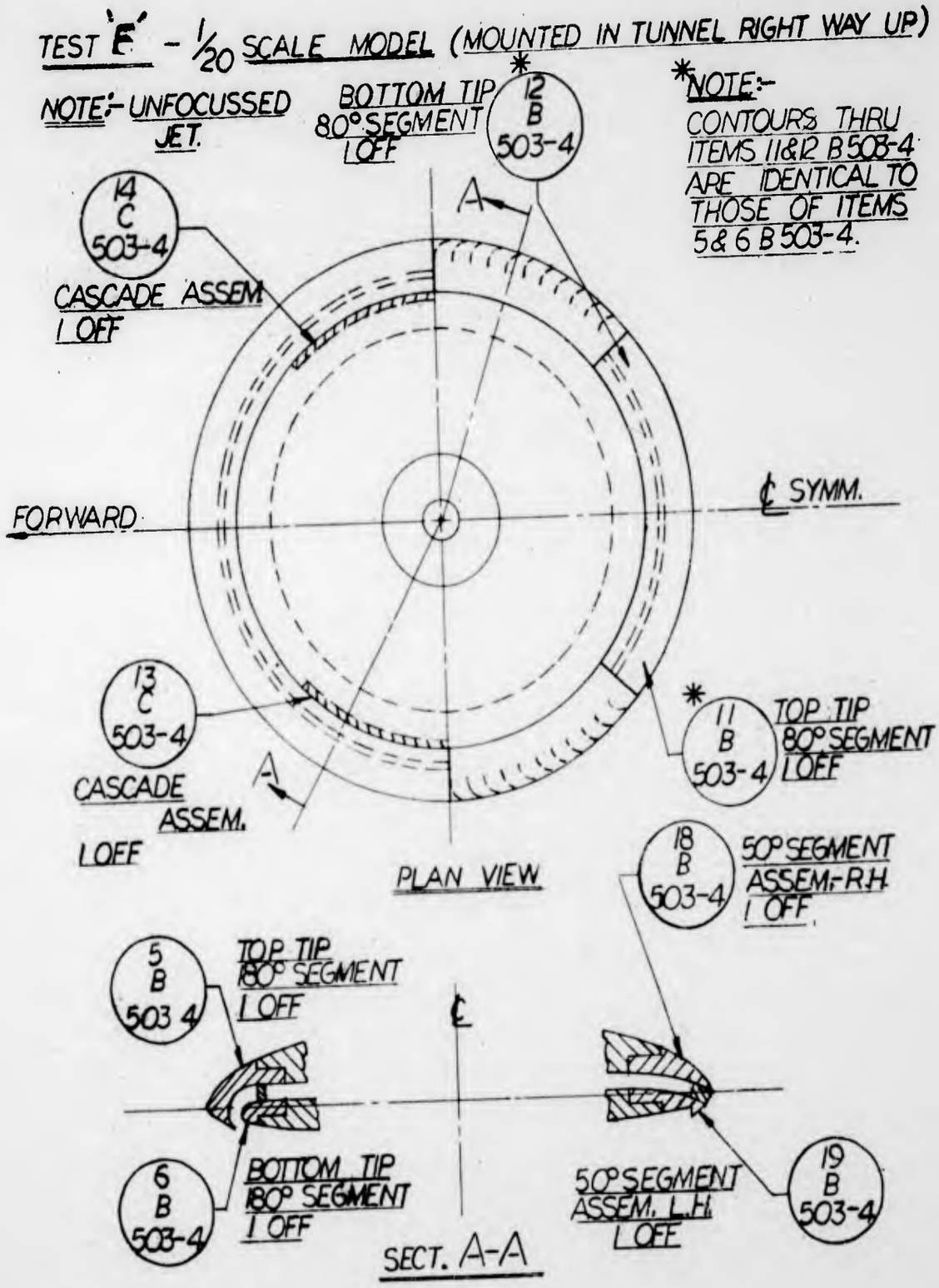

TEST 'E' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- UNFOCUSSED JET.
BOTTOM TIP 80° SEGMENT 1 OFF
12 B 503-4
*NOTE:- CONTOURS THRU ITEMS 11&12 B 503-4 ARE IDENTICAL TO THOSE OF ITEMS 5&6 B 503-4.
14 C 503-4
CASCADE ASSEM. 1 OFF
A
FORWARD
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
11 B 503-4
TOP TIP 80° SEGMENT 1 OFF
PLAN VIEW
18 B 503-4
50° SEGMENT ASSEM.- R.H. 1 OFF
5 B 503 4
TOP TIP 180° SEGMENT 1 OFF
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF
50° SEGMENT ASSEM. L.H. 1 OFF
19 B 503-4
SECT. A-A

FIG. 50

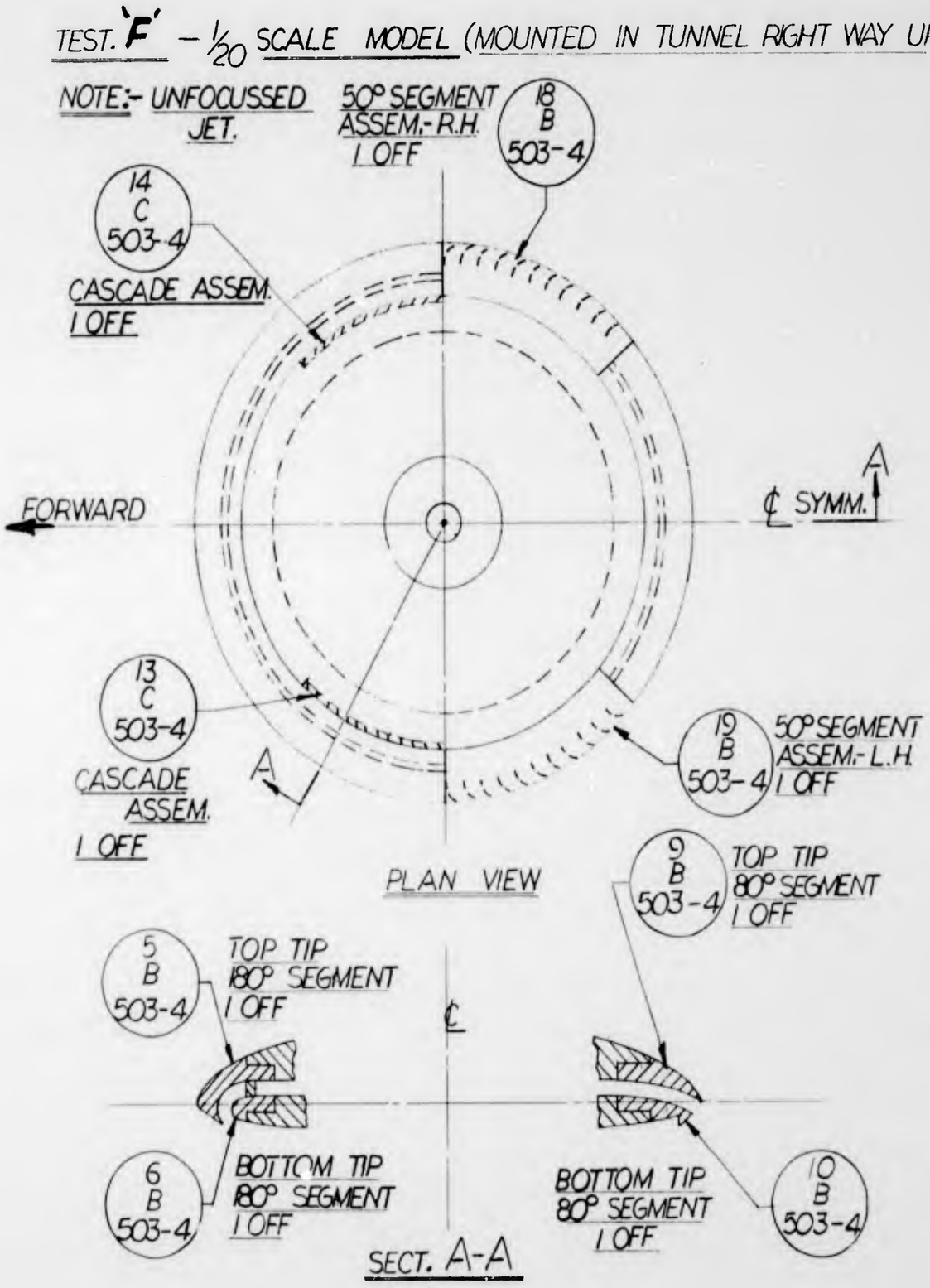

TEST. 'F' – 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- UNFOCUSSED JET.
50° SEGMENT ASSEM.- R.H. 1 OFF
18 B 503-4
14 C 503-4
CASCADE ASSEM. 1 OFF
FORWARD
℄ SYMM.
A
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM.- L.H. 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
℄
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
SECT. A-A

FIG. 51

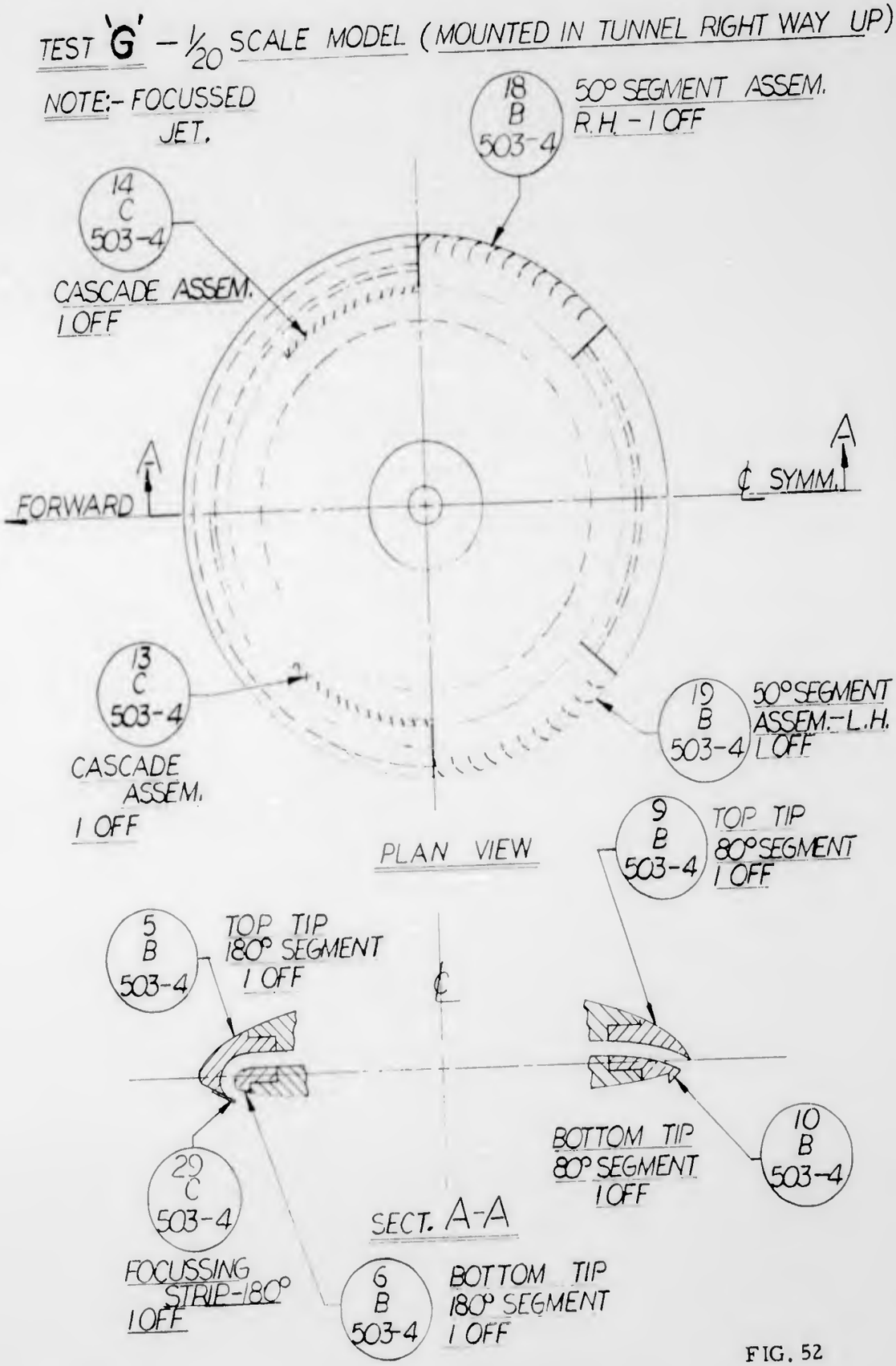

TEST 'G' – 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET.
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM. 1 OFF
FORWARD
A
A
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM.- L.H. 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
℄
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
SECT. A-A
20 C 503-4
FOCUSSING STRIP-180° 1 OFF
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 52

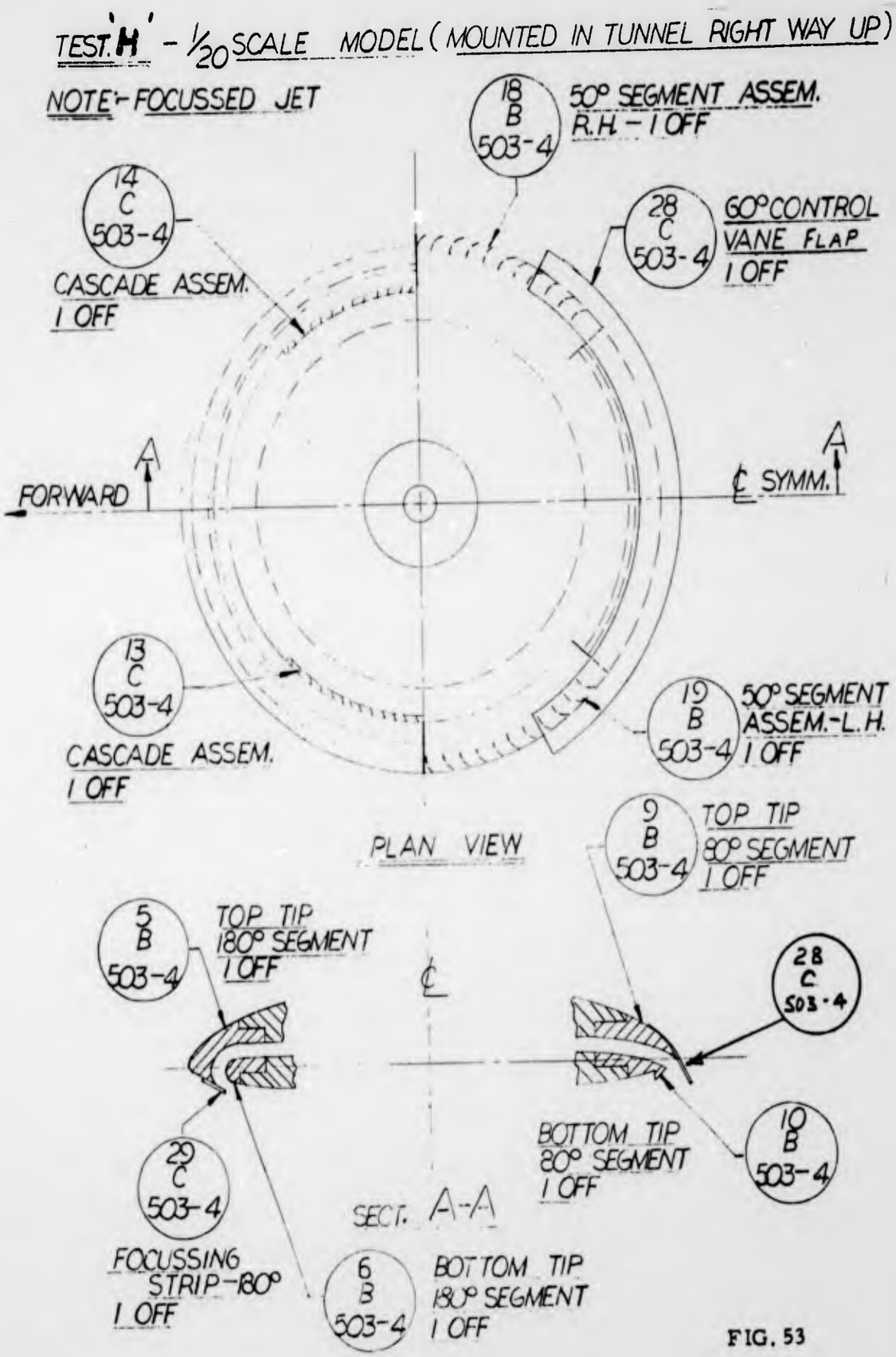

TEST 'H' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM. 1 OFF
28 C 503-4
60° CONTROL VANE FLAP 1 OFF
A
FORWARD
A
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM.-L.H. 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
℄
28 C 503-4
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
29 C 503-4
FOCUSSING STRIP-180° 1 OFF
SECT. A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 53

TEST 'J' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

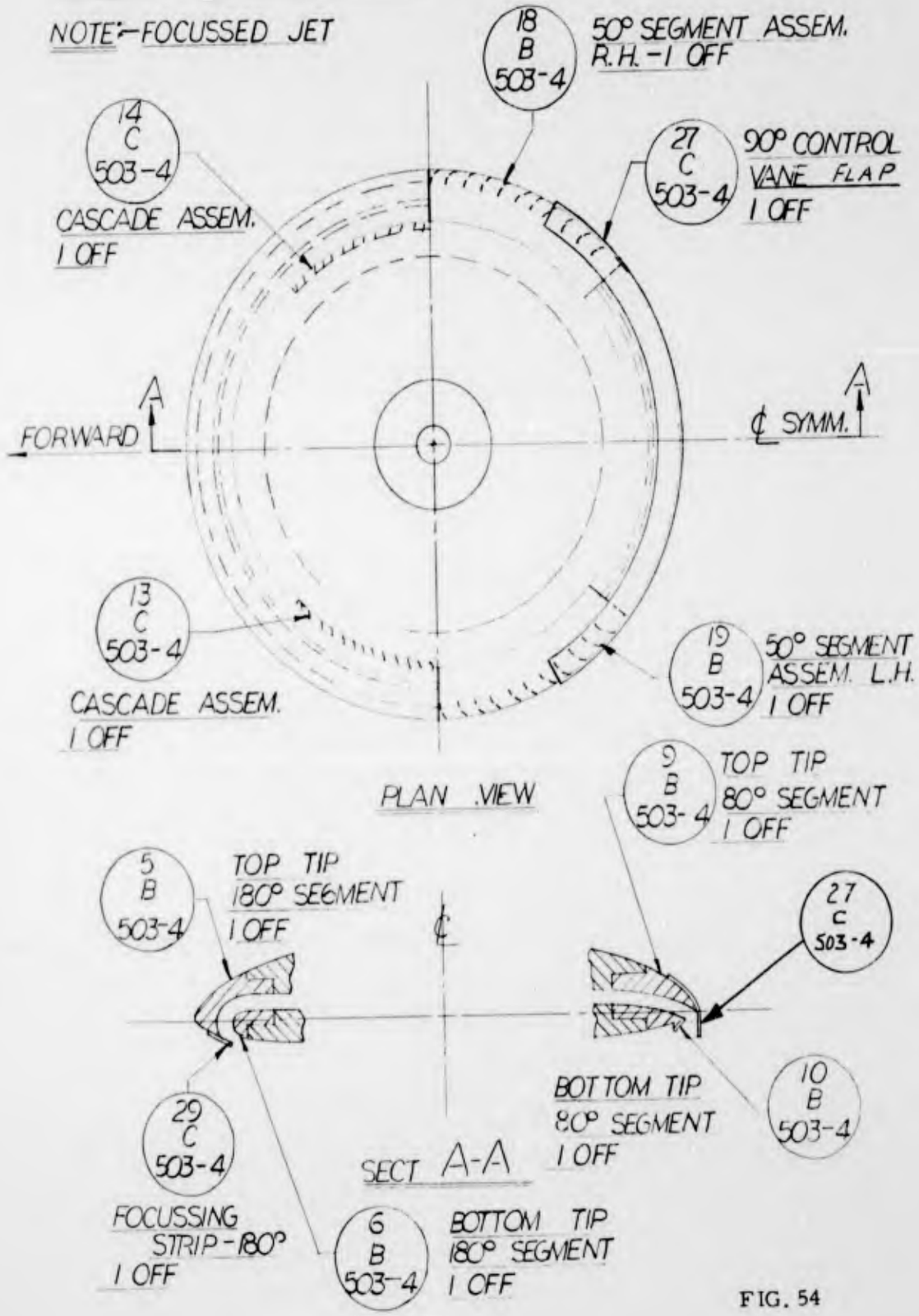


FIG. 54

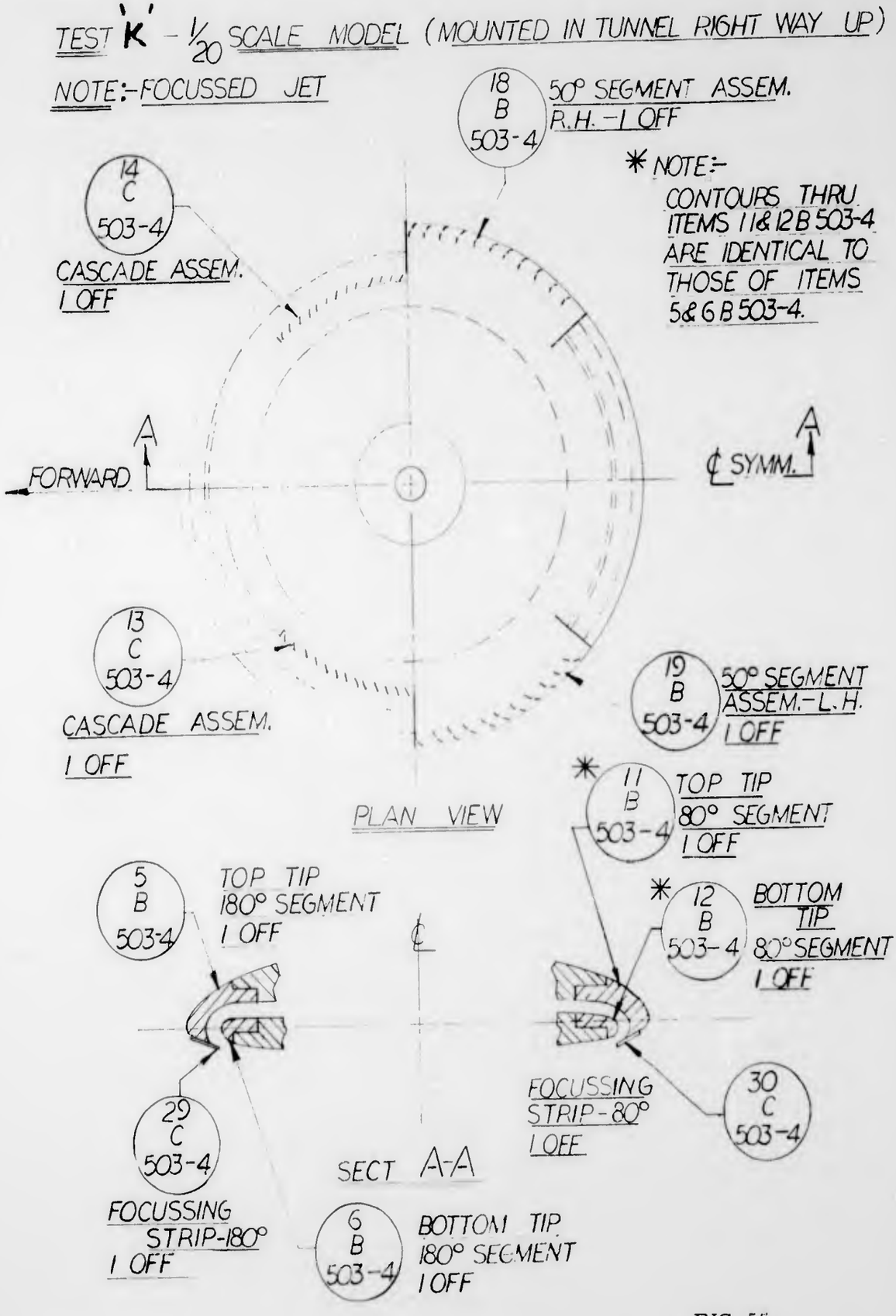

TEST 'K' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:-FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
* NOTE:- CONTOURS THRU ITEMS 11 & 12 B 503-4 ARE IDENTICAL TO THOSE OF ITEMS 5 & 6 B 503-4.
14 C 503-4
CASCADE ASSEM. 1 OFF
A
FORWARD
A
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM. - L.H. 1 OFF
PLAN VIEW
* 11 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
* 12 B 503-4
BOTTOM TIP 80° SEGMENT 1 OFF
℄
FOCUSSING STRIP - 80° 1 OFF
30 C 503-4
29 C 503-4
FOCUSSING STRIP-180° 1 OFF
SECT A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 55

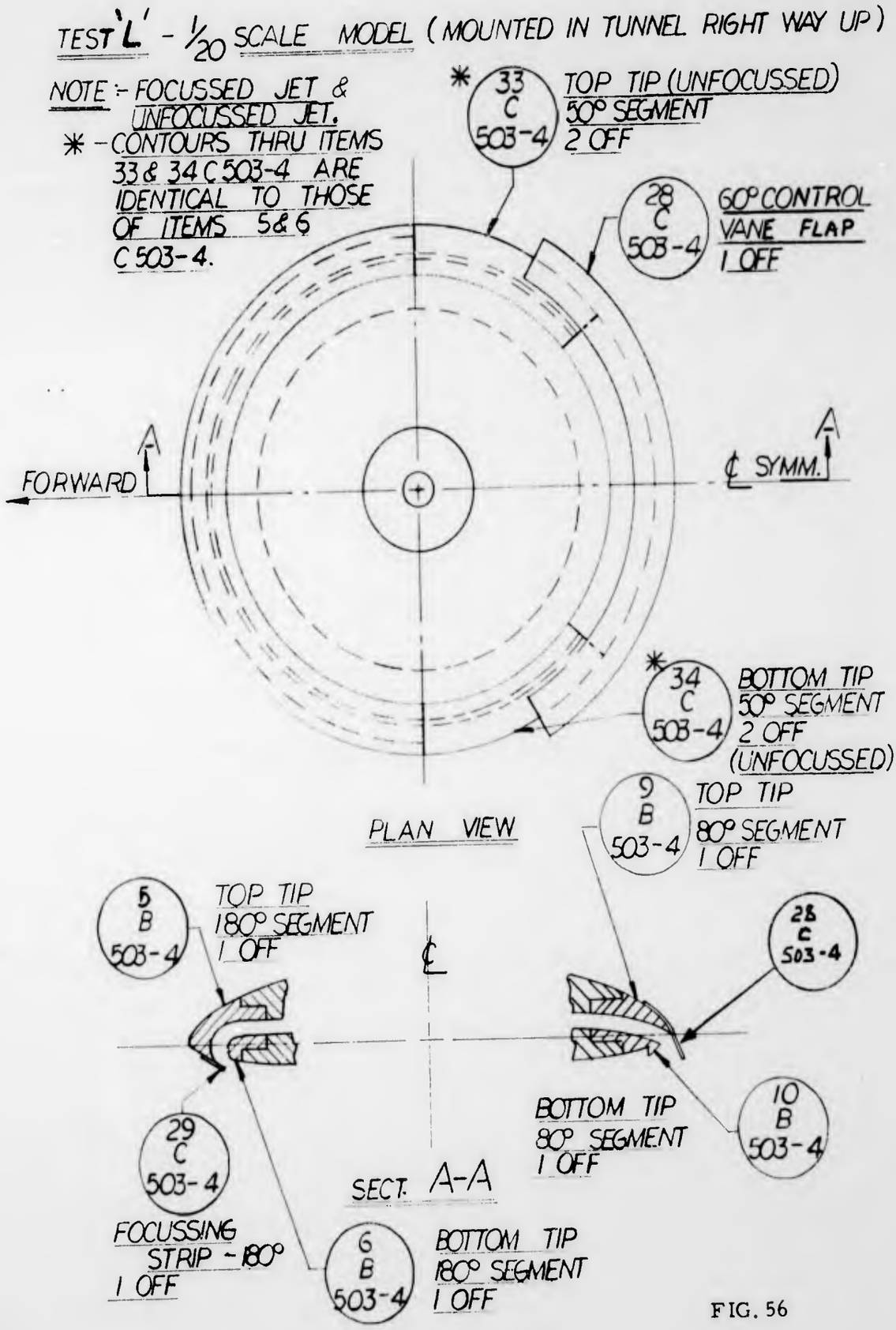

TEST 'L' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE :- FOCUSSED JET & UNFOCUSSED JET.
* - CONTOURS THRU ITEMS 33 & 34 C 503-4 ARE IDENTICAL TO THOSE OF ITEMS 5 & 6 C 503-4.
* 33 C 503-4 TOP TIP (UNFOCUSSED) 50° SEGMENT 2 OFF
28 C 503-4 60° CONTROL VANE FLAP 1 OFF
FORWARD
A
A
℄ SYMM.
* 34 C 503-4 BOTTOM TIP 50° SEGMENT 2 OFF (UNFOCUSSED)
9 B 503-4 TOP TIP 80° SEGMENT 1 OFF
PLAN VIEW
5 B 503-4 TOP TIP 180° SEGMENT 1 OFF
℄
28 C 503-4
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
29 C 503-4
SECT. A-A
FOCUSSING STRIP - 180° 1 OFF
6 B 503-4 BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 56

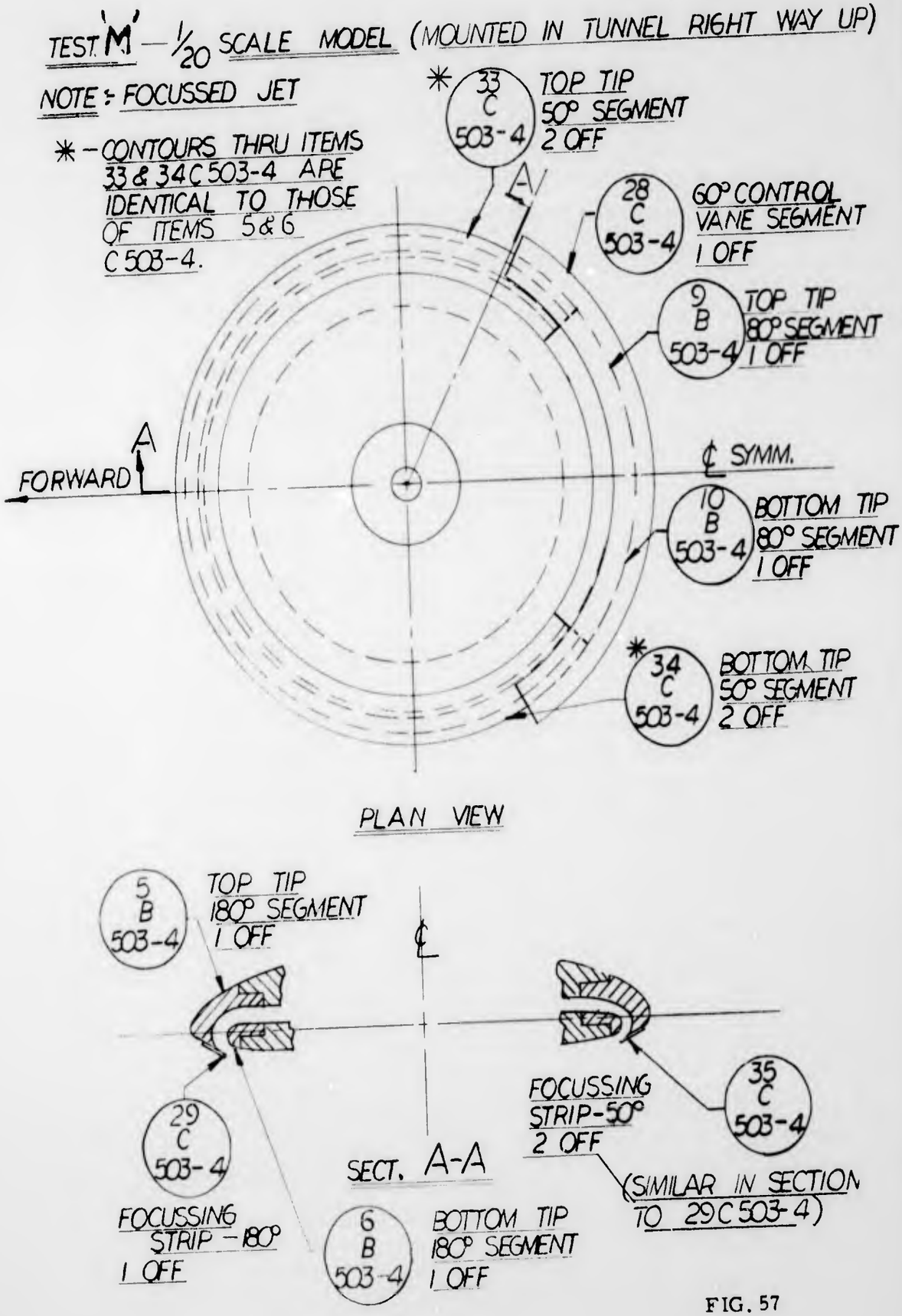

TEST 'M' — 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE: FOCUSSED JET
* - CONTOURS THRU ITEMS 33 & 34 C 503-4 ARE IDENTICAL TO THOSE OF ITEMS 5 & 6 C 503-4.
* 33 C 503-4 TOP TIP 50° SEGMENT 2 OFF
28 C 503-4 60° CONTROL VANE SEGMENT 1 OFF
9 B 503-4 TOP TIP 80° SEGMENT 1 OFF
FORWARD
A
A
℄ SYMM.
10 B 503-4 BOTTOM TIP 80° SEGMENT 1 OFF
* 34 C 503-4 BOTTOM TIP 50° SEGMENT 2 OFF
PLAN VIEW
5 B 503-4 TOP TIP 180° SEGMENT 1 OFF
℄
29 C 503-4
FOCUSSING STRIP - 180° 1 OFF
SECT. A-A
FOCUSSING STRIP - 50° 2 OFF
35 C 503-4
(SIMILAR IN SECTION TO 29 C 503-4)
6 B 503-4 BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 57

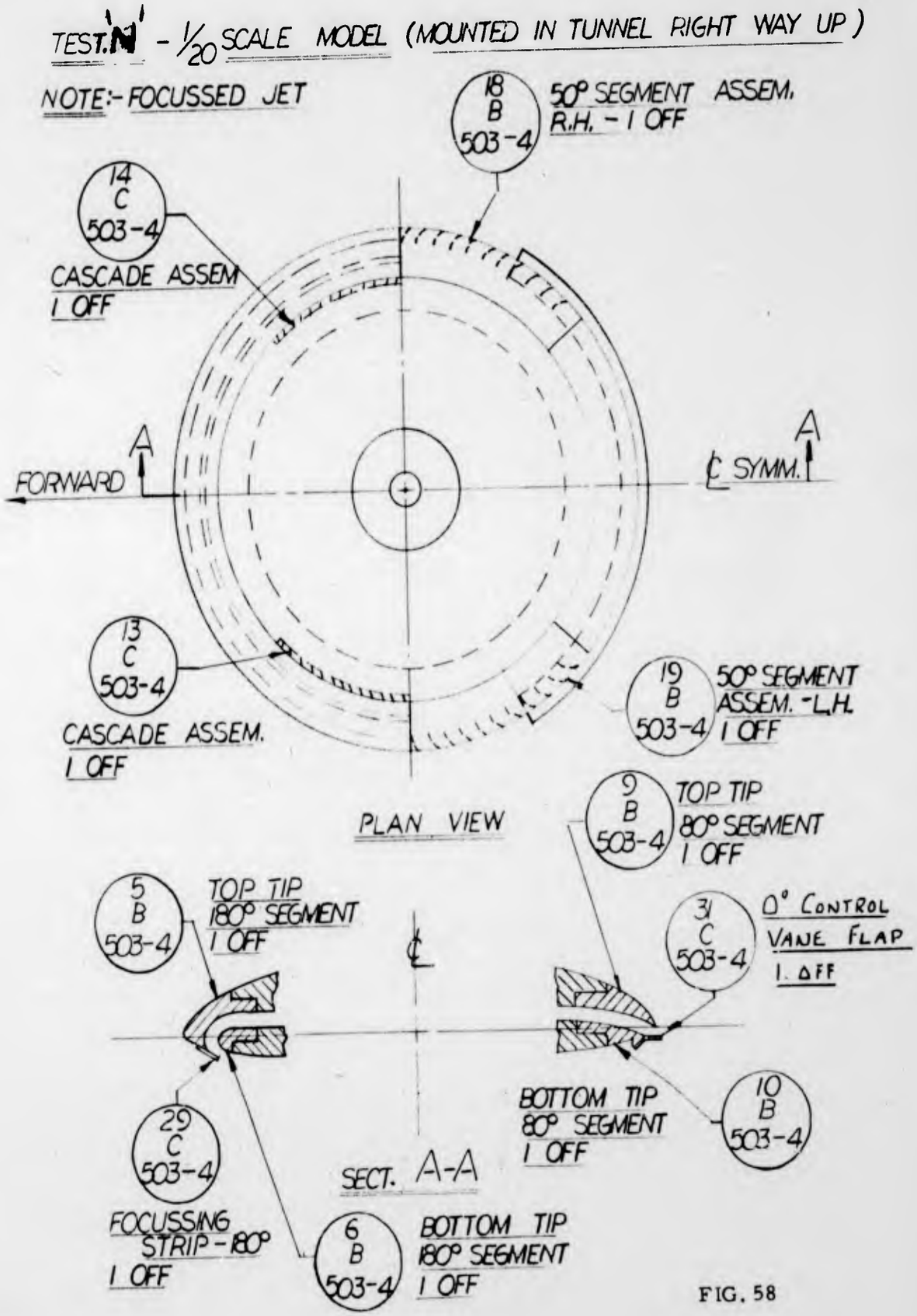

TEST 'N' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM 1 OFF
A
FORWARD
A
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM. - L.H. 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
31 C 503-4
0° CONTROL VANE FLAP 1. OFF
℄
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
29 C 503-4
FOCUSSING STRIP - 180° 1 OFF
SECT. A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 58

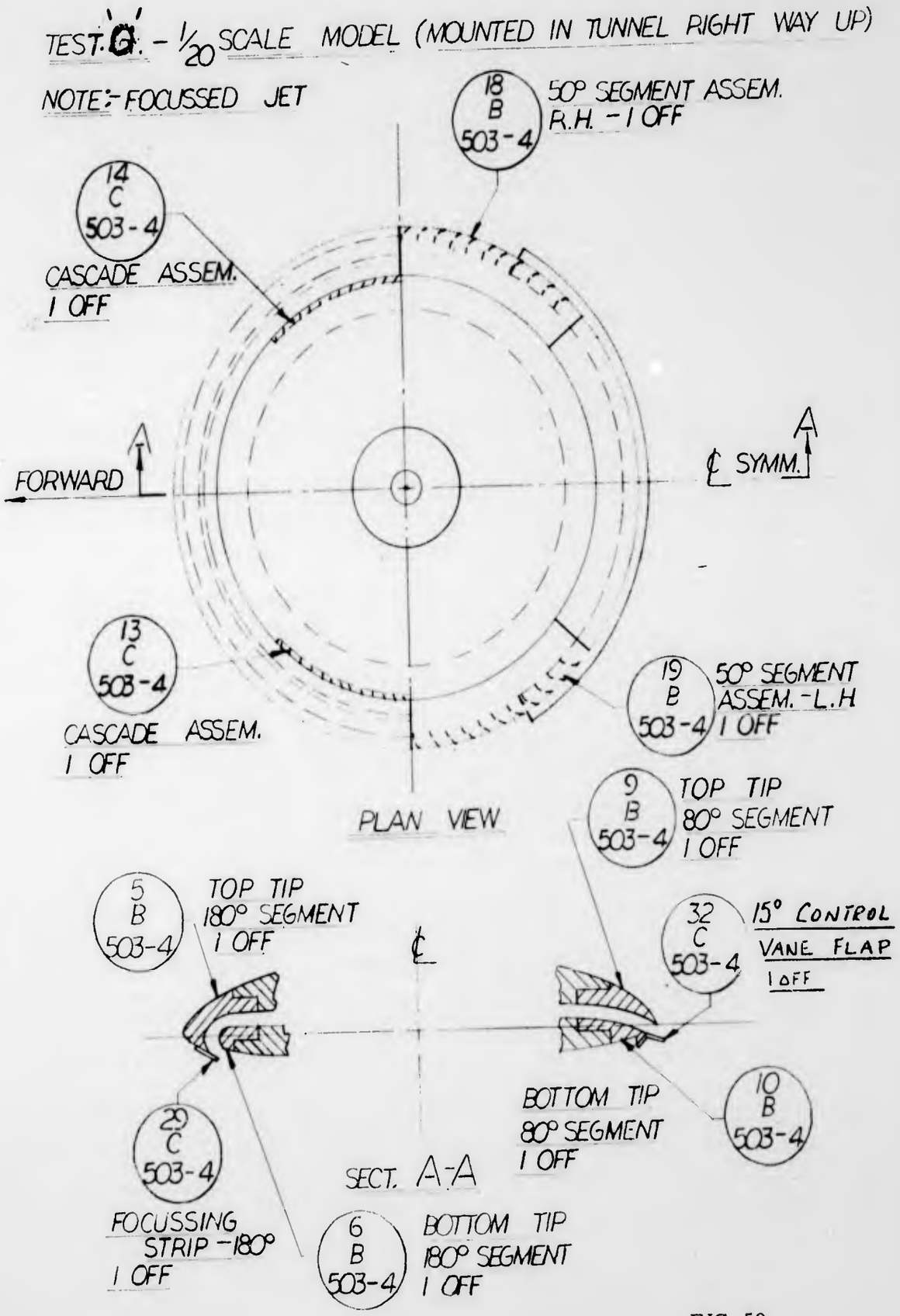

TEST 'G' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM. 1 OFF
FORWARD
℄ SYMM.
A
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM. - L.H 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
32 C 503-4
15° CONTROL VANE FLAP 1 OFF
℄
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
20 C 503-4
FOCUSSING STRIP - 180° 1 OFF
SECT. A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 59

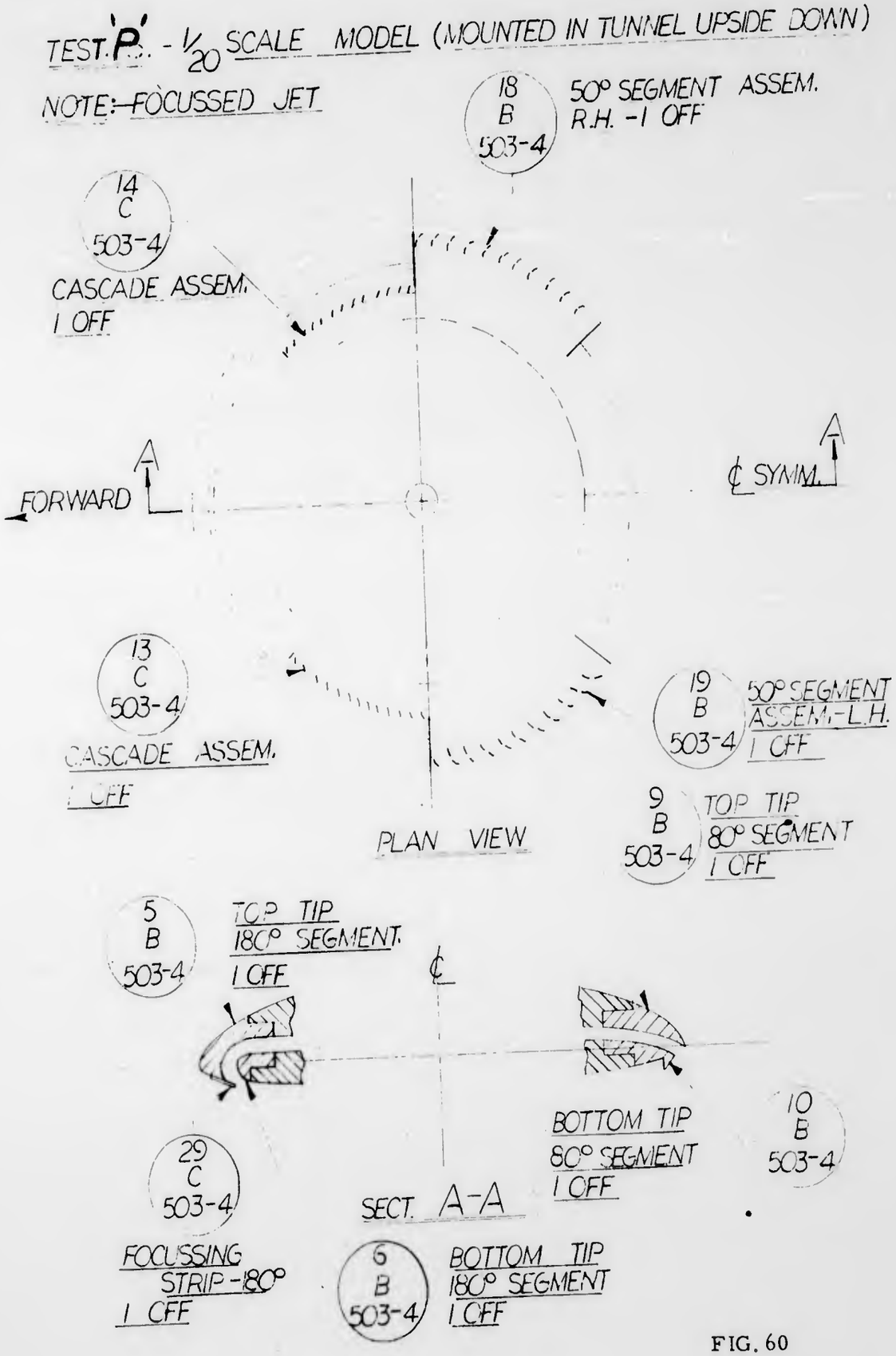

TEST 'P' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL UPSIDE DOWN)
NOTE:-FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. -1 OFF
14 C 503-4
CASCADE ASSEM. 1 OFF
FORWARD
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM.-L.H. 1 OFF
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
PLAN VIEW
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
℄
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
29 C 503-4
FOCUSSING STRIP -180° 1 OFF
SECT. A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 60

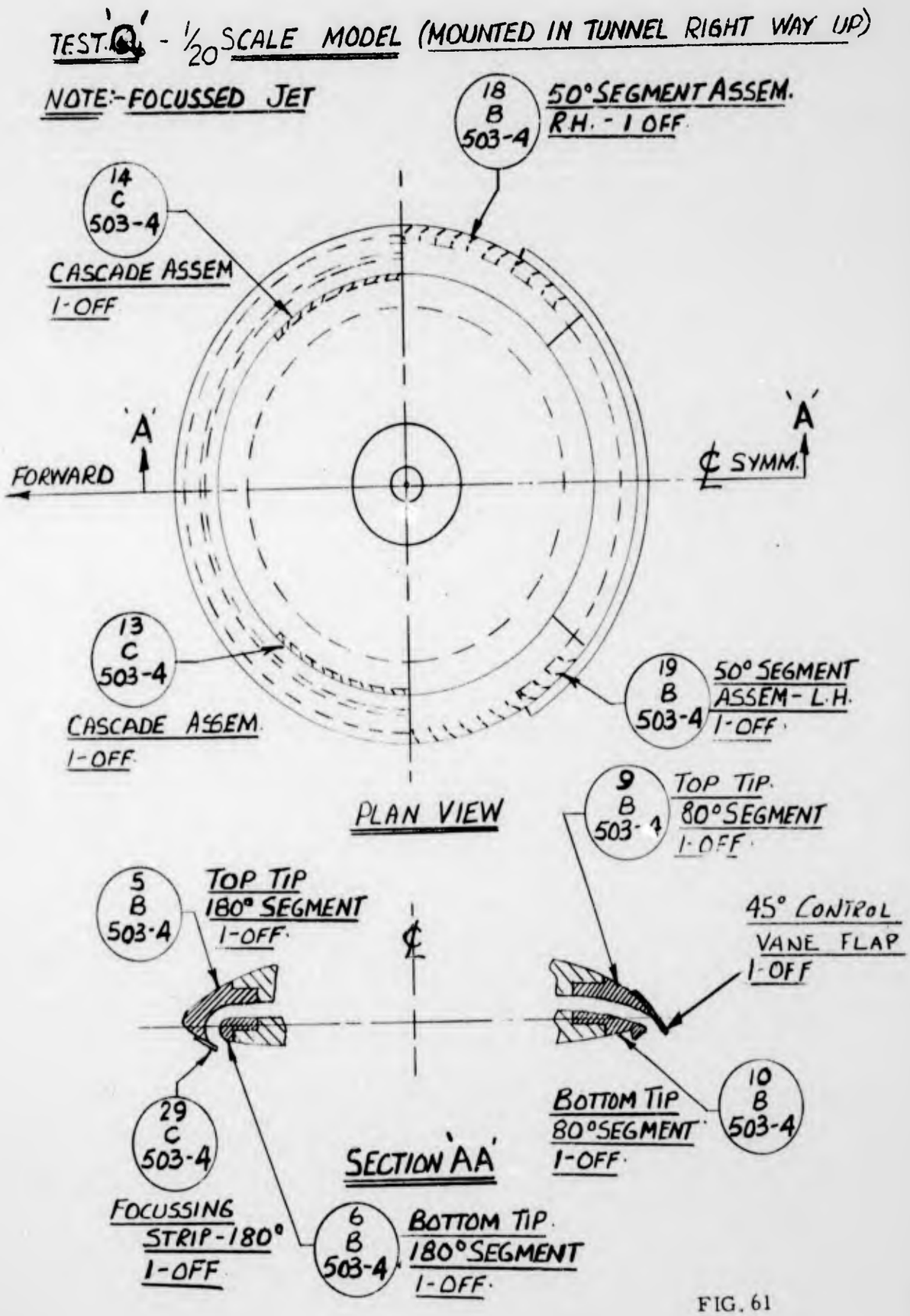

TEST 'Q' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM 1-OFF
'A'
'A'
FORWARD
℄ SYMM.
13 C 503-4
CASCADE ASSEM 1-OFF
19 B 503-4
50° SEGMENT ASSEM - L.H. 1-OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1-OFF
5 B 503-4
TOP TIP 180° SEGMENT 1-OFF
℄
45° CONTROL VANE FLAP 1-OFF
10 B 503-4
BOTTOM TIP 80° SEGMENT 1-OFF
29 C 503-4
FOCUSSING STRIP - 180° 1-OFF
SECTION 'AA'
6 B 503-4
BOTTOM TIP 180° SEGMENT 1-OFF

FIG. 61

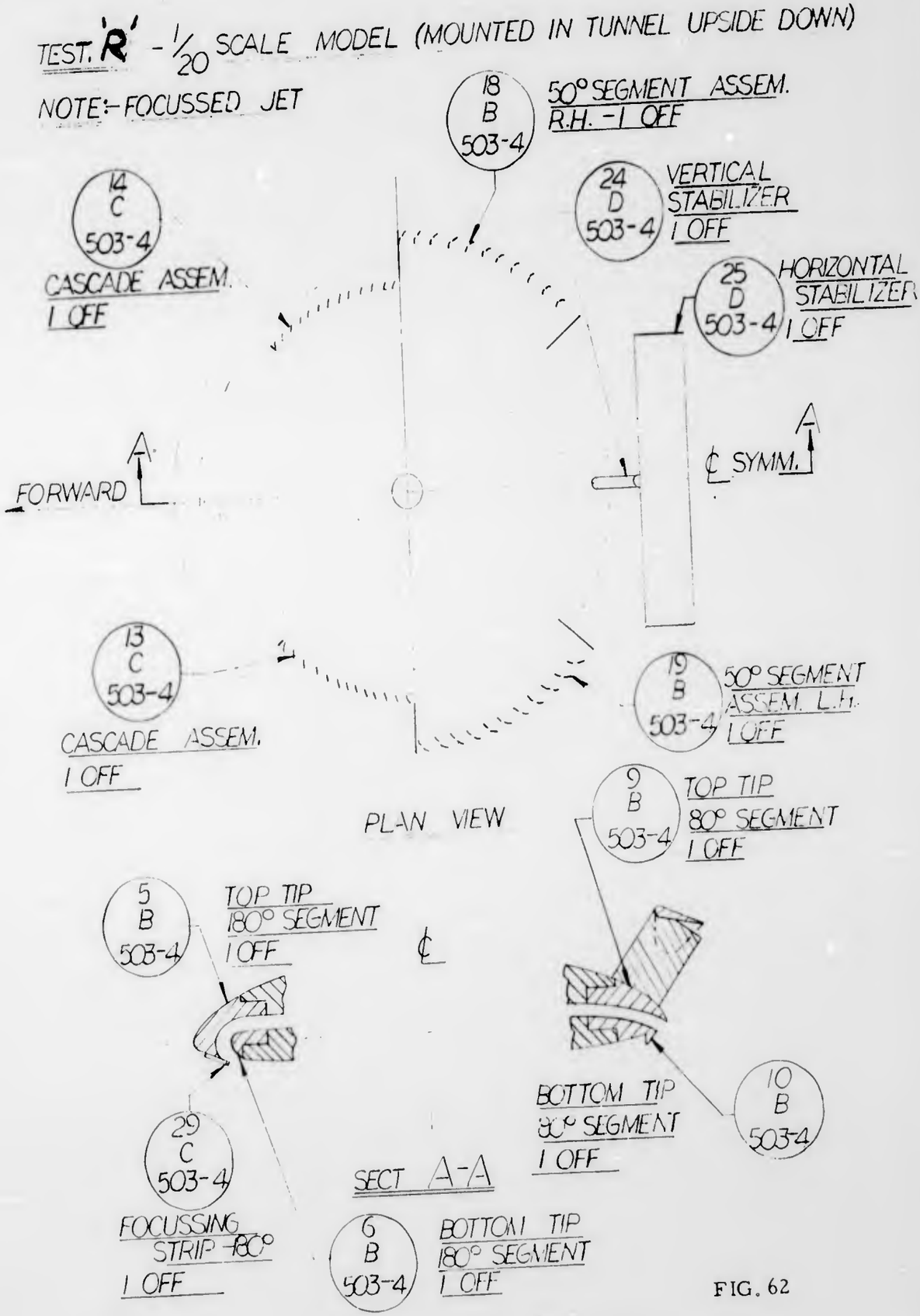

TEST 'R' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL UPSIDE DOWN)
NOTE:- FOCUSSED JET
18 B 503-4
50° SEGMENT ASSEM. R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM. 1 OFF
24 D 503-4
VERTICAL STABILIZER 1 OFF
25 D 503-4
HORIZONTAL STABILIZER 1 OFF
A
FORWARD
A
℄ SYMM.
13 C 503-4
CASCADE ASSEM. 1 OFF
19 B 503-4
50° SEGMENT ASSEM. L.H. 1 OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT 1 OFF
5 B 503-4
TOP TIP 180° SEGMENT 1 OFF
℄
BOTTOM TIP 80° SEGMENT 1 OFF
10 B 503-4
29 C 503-4
FOCUSSING STRIP 180° 1 OFF
SECT A-A
6 B 503-4
BOTTOM TIP 180° SEGMENT 1 OFF

FIG. 62

TEST 'S' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

NOTE:- FOCUSSED JET

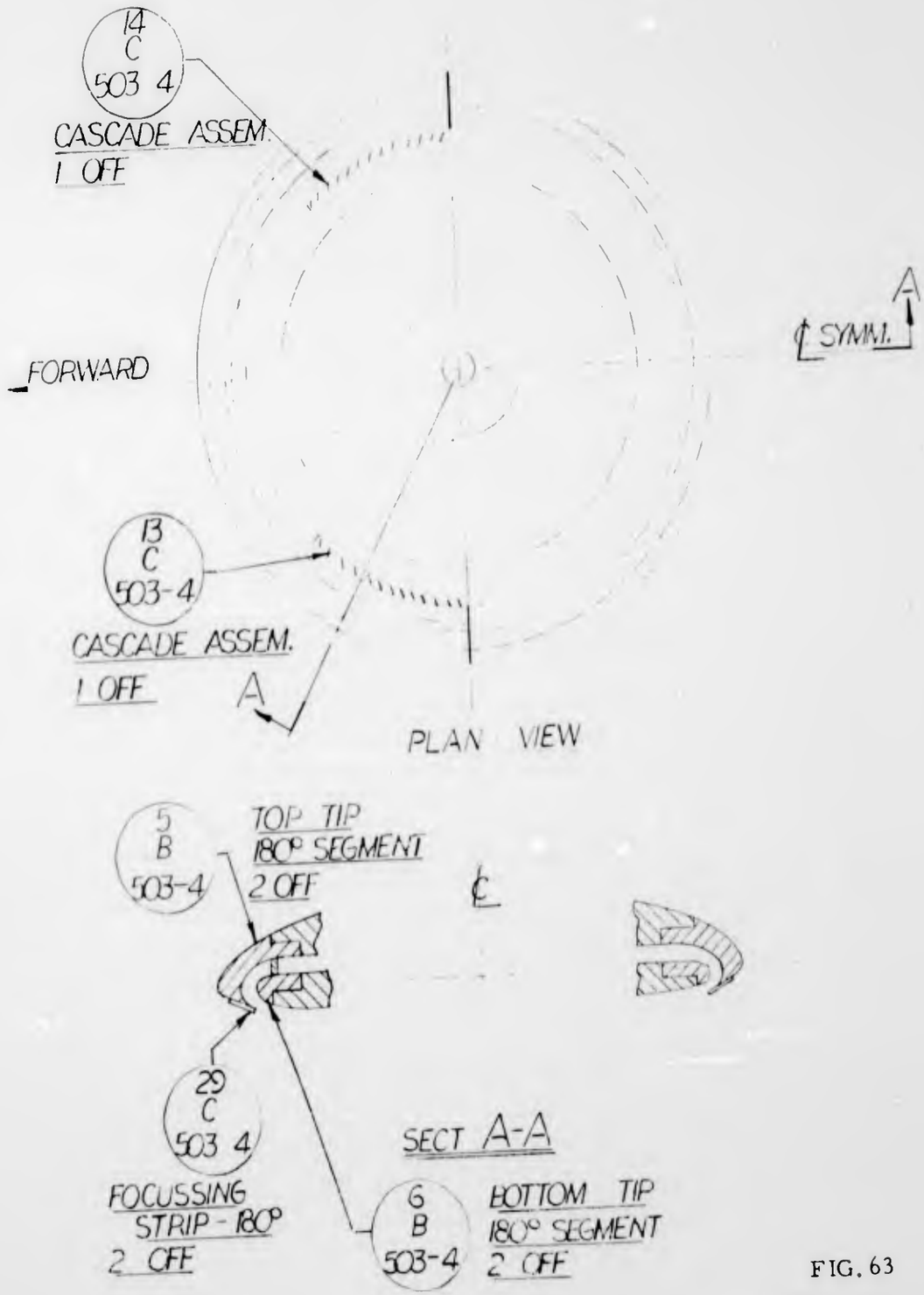
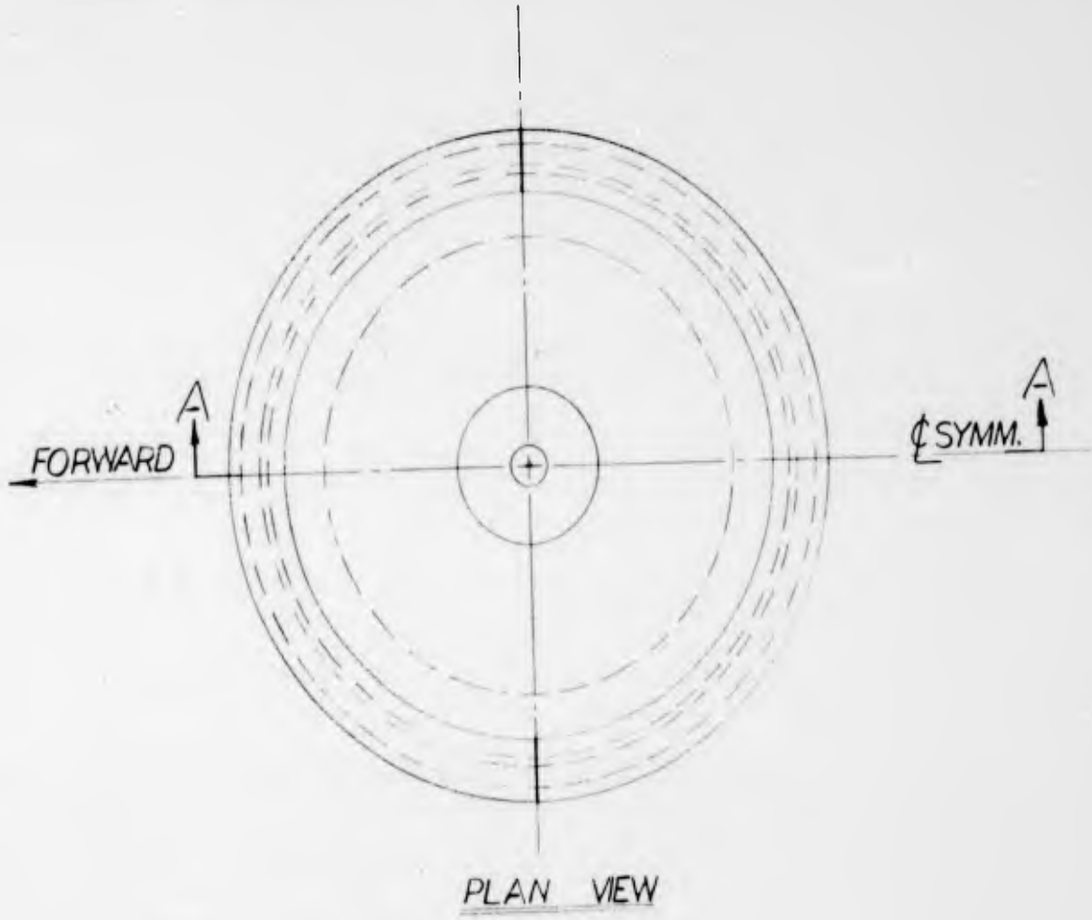


FIG. 63

TEST 'B' – 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

NOTE:- FOCUSSED JET



PLAN VIEW

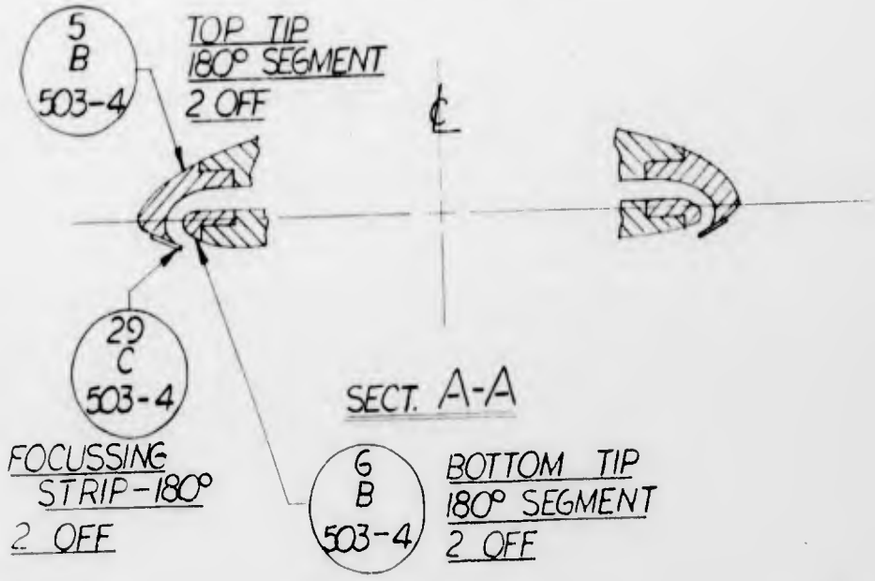


FIG. 64

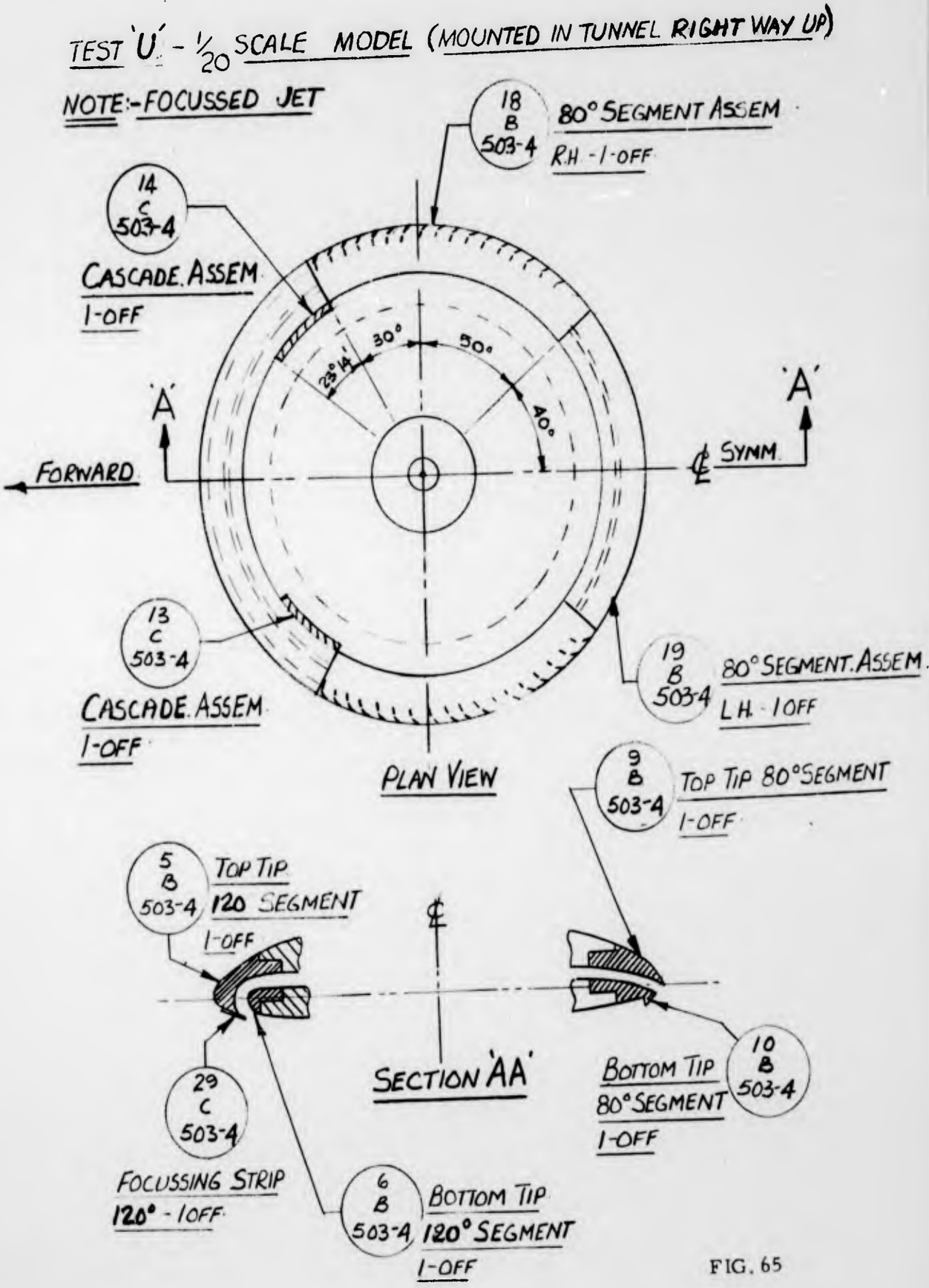

TEST 'U' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:-FOCUSSED JET
18 B 503-4
80° SEGMENT ASSEM
R.H. - 1-OFF
14 C 503-4
CASCADE. ASSEM
1-OFF
30°
30°
23°14'
40°
'A'
'A'
FORWARD
℄ SYMM
13 C 503-4
CASCADE. ASSEM
1-OFF
19 B 503-4
80° SEGMENT. ASSEM.
L.H. - 1OFF
PLAN VIEW
9 B 503-4
TOP TIP 80°SEGMENT
1-OFF
5 B 503-4
TOP TIP
120 SEGMENT
1-OFF
℄
SECTION 'AA'
10 B 503-4
BOTTOM TIP
80° SEGMENT
1-OFF
29 C 503-4
FOCUSSING STRIP
120° - 1OFF
6 B 503-4
BOTTOM TIP
120° SEGMENT
1-OFF

FIG. 65

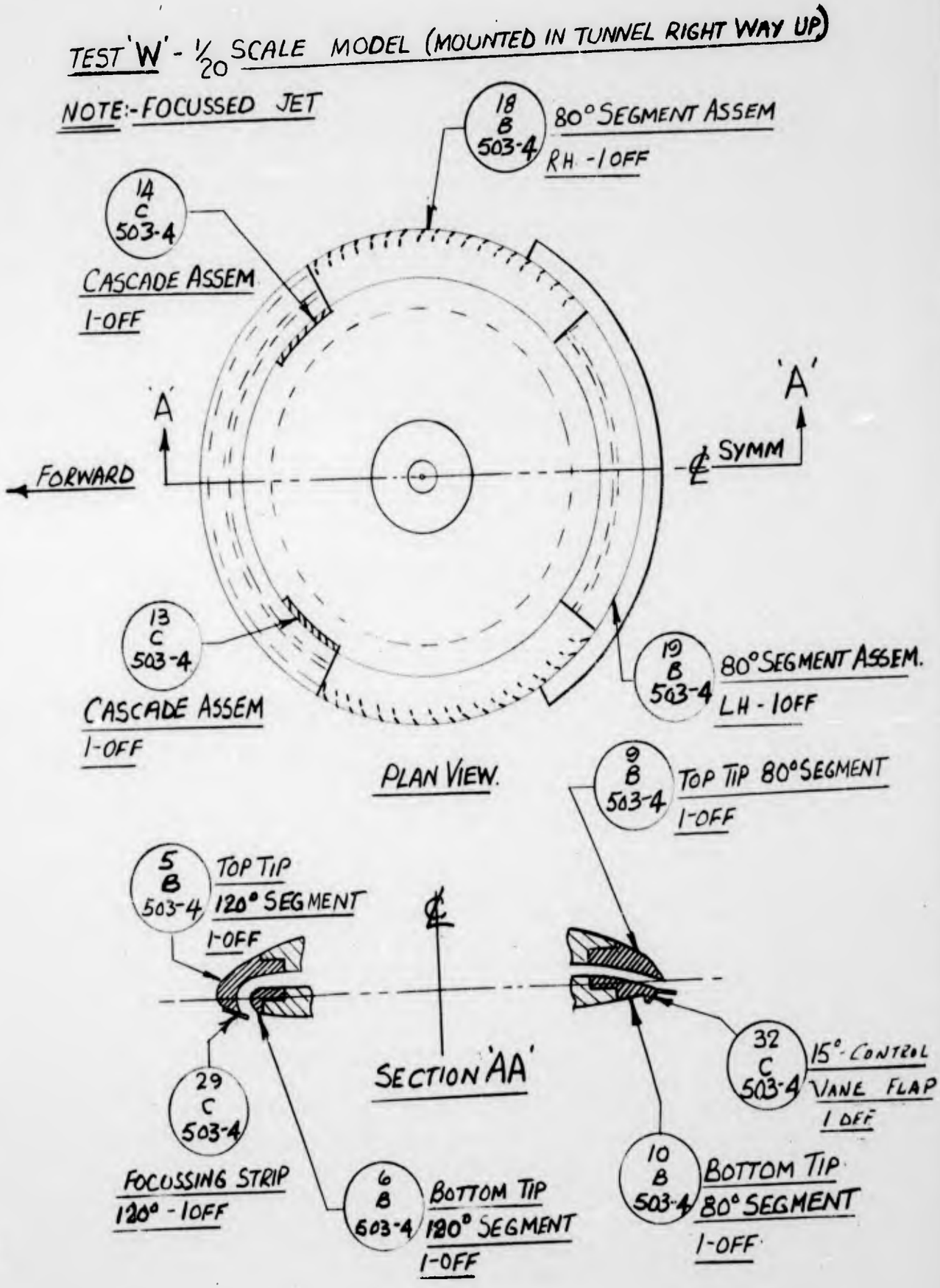

TEST 'W' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
80° SEGMENT ASSEM
RH - 1 OFF
14 C 503-4
CASCADE ASSEM
1-OFF
'A'
'A'
FORWARD
℄ SYMM
13 C 503-4
CASCADE ASSEM
1-OFF
19 B 503-4
80° SEGMENT ASSEM.
LH - 1 OFF
PLAN VIEW.
9 B 503-4
TOP TIP 80° SEGMENT
1-OFF
5 B 503-4
TOP TIP
120° SEGMENT
1-OFF
℄
32 C 503-4
15° CONTROL
VANE FLAP
1 OFF
SECTION 'AA'
29 C 503-4
FOCUSSING STRIP
120° - 1 OFF
6 B 503-4
BOTTOM TIP
120° SEGMENT
1-OFF
10 B 503-4
BOTTOM TIP
80° SEGMENT
1-OFF

FIG. 66

TEST 'X' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)

NOTE:-FOCUSSED JET

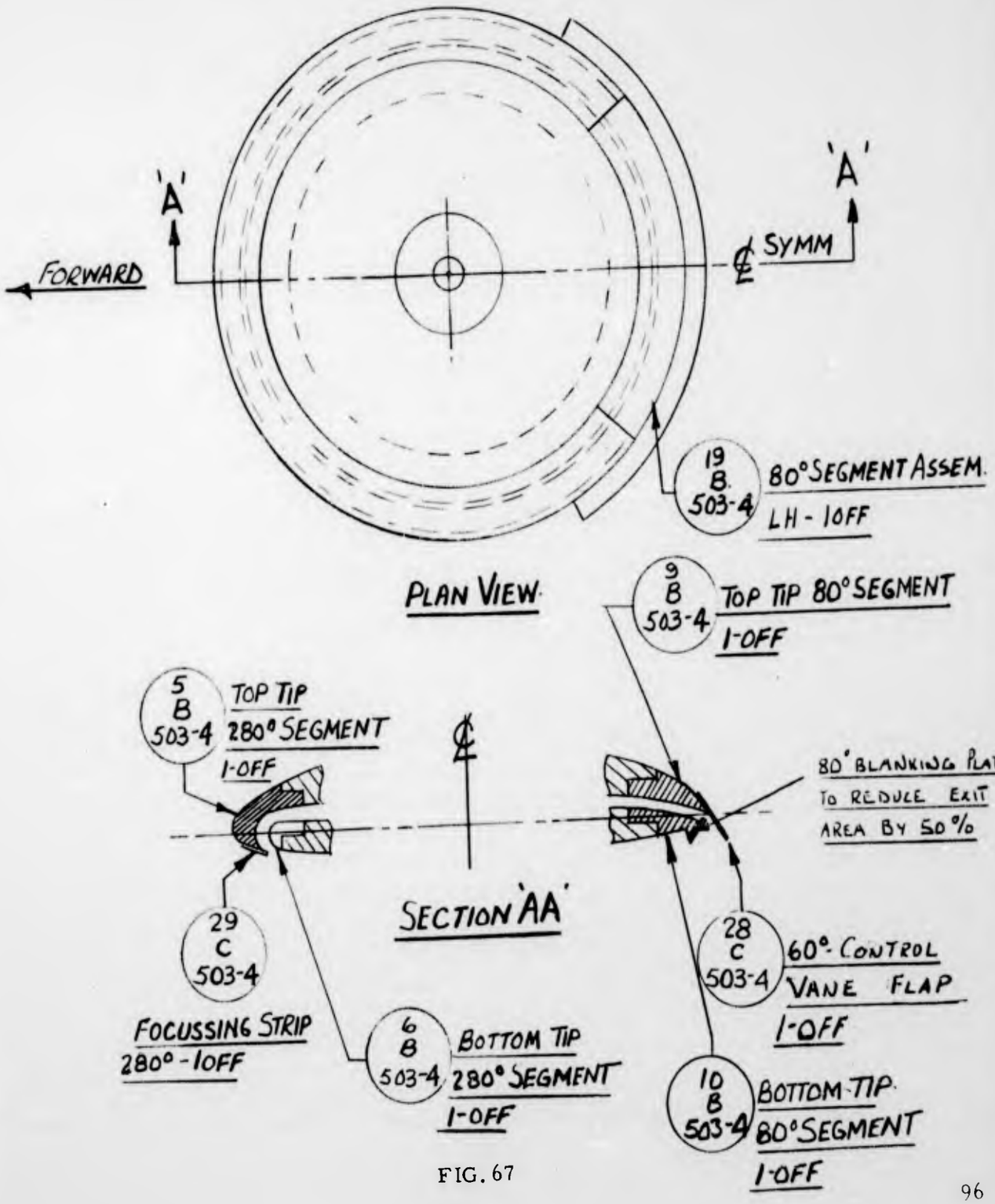


FIG. 67

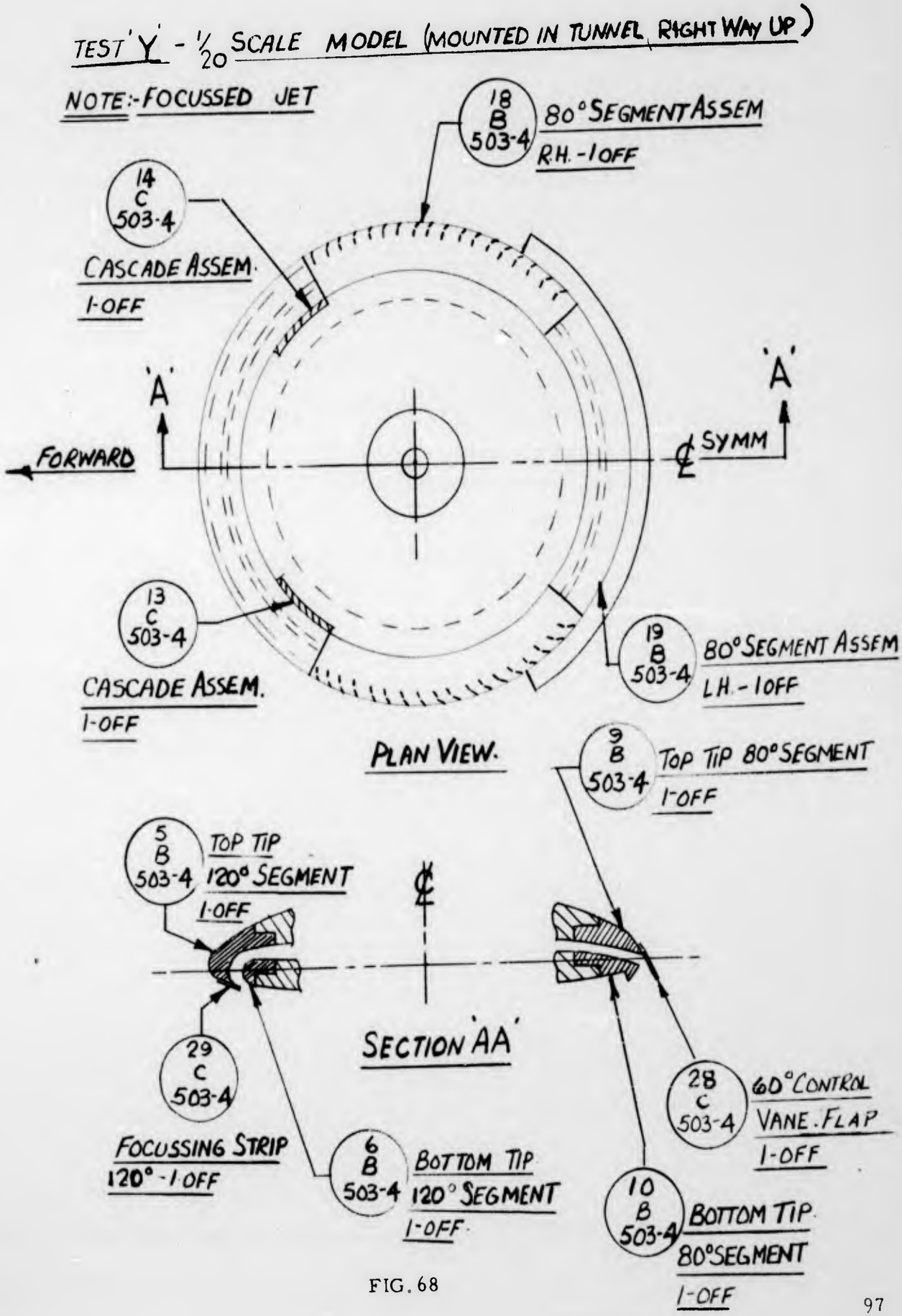

TEST 'Y' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL, RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
80° SEGMENT ASSEM
R.H. - 1 OFF
14 C 503-4
CASCADE ASSEM.
1-OFF
'A'
'A'
FORWARD
℄ SYMM
13 C 503-4
CASCADE ASSEM.
1-OFF
19 B 503-4
80° SEGMENT ASSEM.
L.H. - 1 OFF
PLAN VIEW.
9 B 503-4
TOP TIP 80° SEGMENT
1-OFF
5 B 503-4
TOP TIP
120° SEGMENT
1-OFF
℄
SECTION 'AA'
29 C 503-4
FOCUSSING STRIP
120° - 1 OFF
6 B 503-4
BOTTOM TIP
120° SEGMENT
1-OFF
28 C 503-4
60° CONTROL
VANE. FLAP
1-OFF
10 B 503-4
BOTTOM TIP
80° SEGMENT
1-OFF

FIG. 68

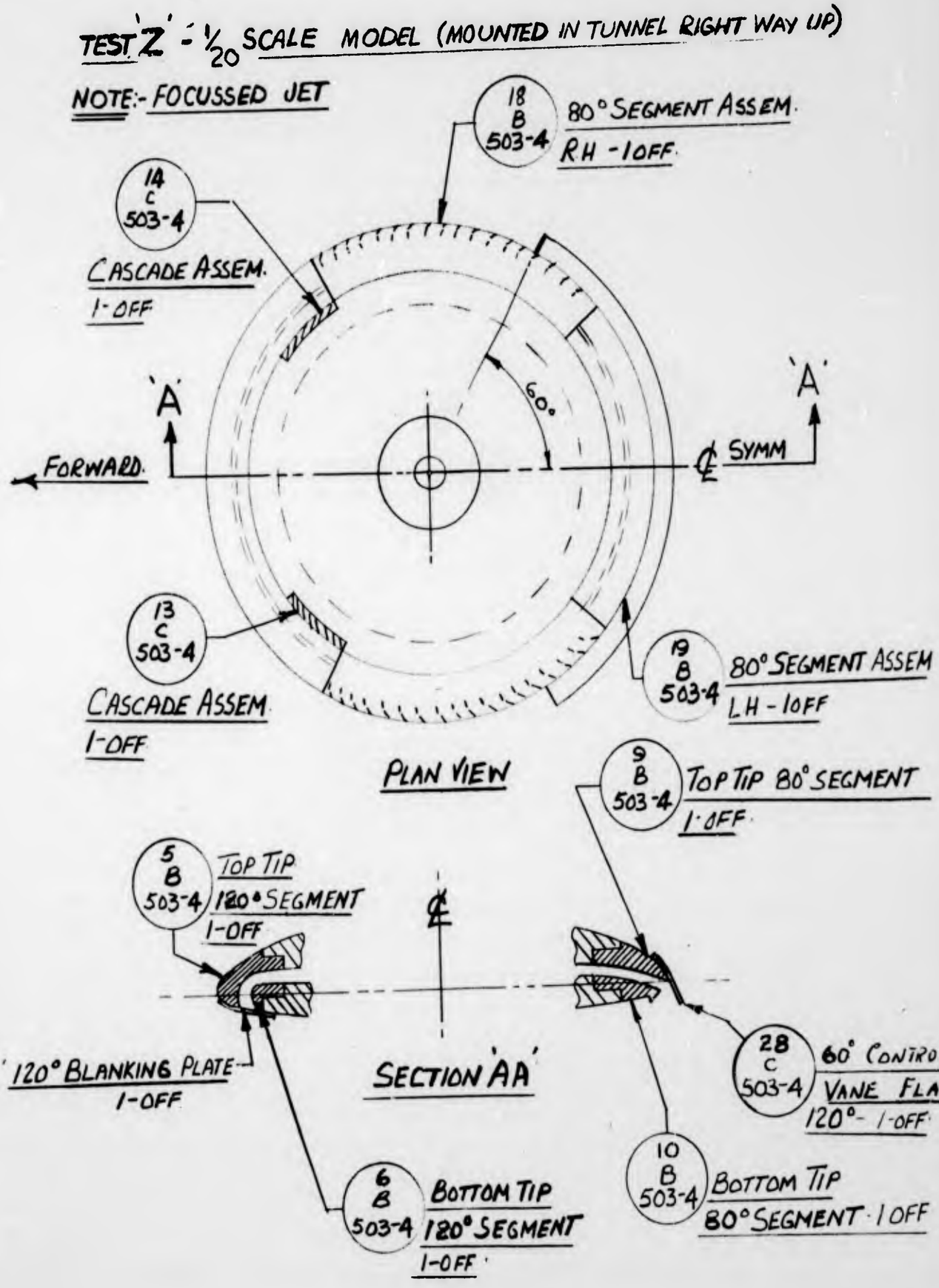

TEST 'Z' - 1/20 SCALE MODEL (MOUNTED IN TUNNEL RIGHT WAY UP)
NOTE:- FOCUSSED JET
18 B 503-4
80° SEGMENT ASSEM.
RH - 1OFF.
14 C 503-4
CASCADE ASSEM.
1-OFF
'A'
'A'
60°
FORWARD.
℄ SYMM
13 C 503-4
CASCADE ASSEM
1-OFF
19 B 503-4
80° SEGMENT ASSEM
LH - 1OFF
PLAN VIEW
9 B 503-4
TOP TIP 80° SEGMENT
1-OFF
5 B 503-4
TOP TIP
120° SEGMENT
1-OFF
℄
120° BLANKING PLATE
1-OFF
SECTION 'AA'
28 C 503-4
60° CONTROL
VANE FLAP
120° - 1-OFF
10 B 503-4
BOTTOM TIP
80° SEGMENT - 1OFF
6 B 503-4
BOTTOM TIP
120° SEGMENT
1-OFF

FIG. 69

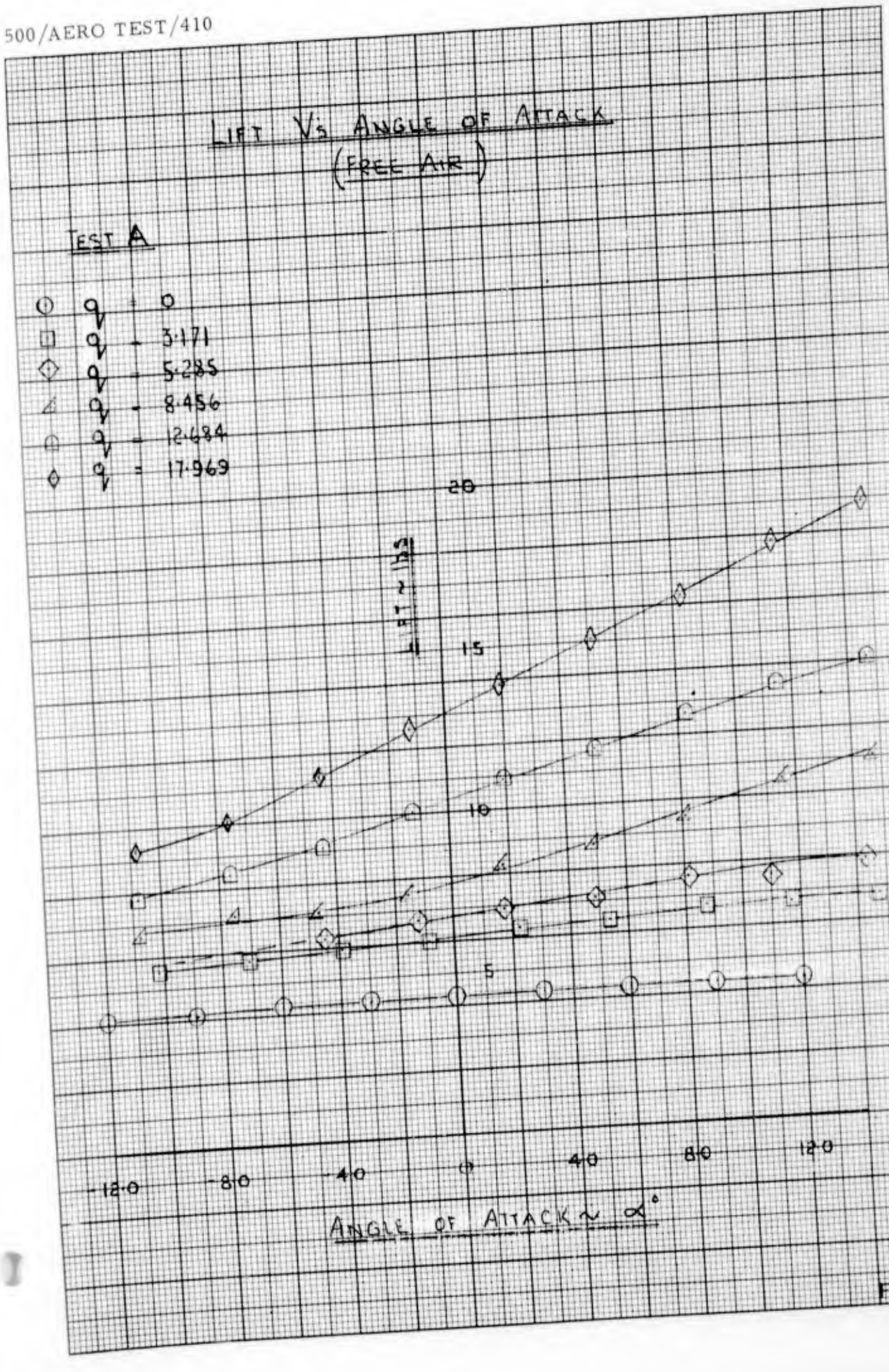

LIFT Vs ANGLE OF ATTACK
(FREE AIR)
TEST A
q = 0
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
20
15
10
5
-12·0
-8·0
-4·0
0
4·0
8·0
12·0
ANGLE OF ATTACK ~ α°

FIG 7

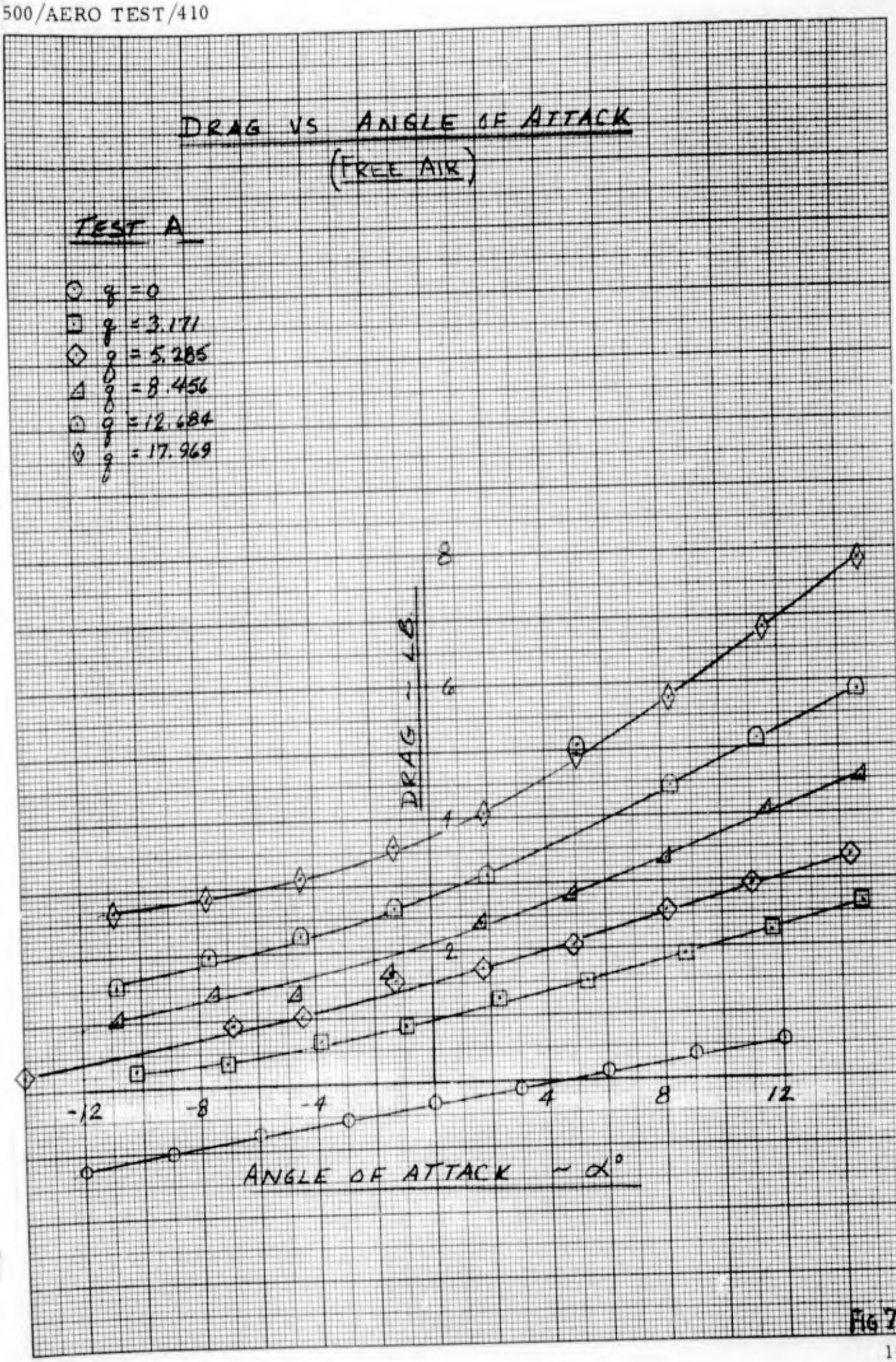

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST A
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
DRAG ~ LB
8
6
4
2
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°

Fig 71.

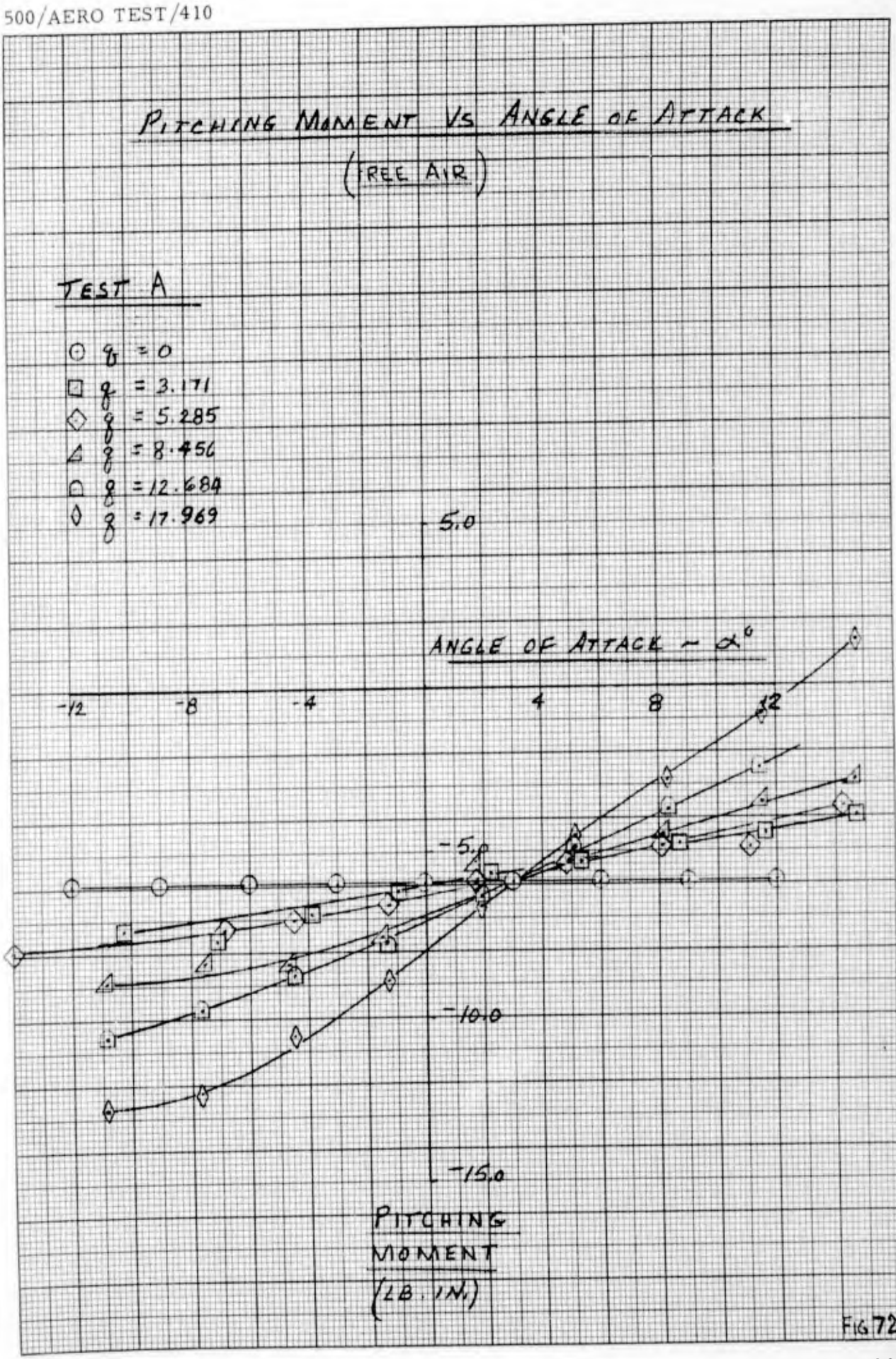

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST A
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
5.0
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
-5.0
-10.0
-15.0
PITCHING MOMENT (LB. IN.)

FIG 72

LIFT COEFFICIENT VS ANGLE OF ATTACK.

(FREE AIR)

TEST A

- □ $q = 3.171$
- ◇ $q = 5.285$
- ◿ $q = 8.456$
- ⬠ $q = 12.684$
- ◊ $q = 17.969$

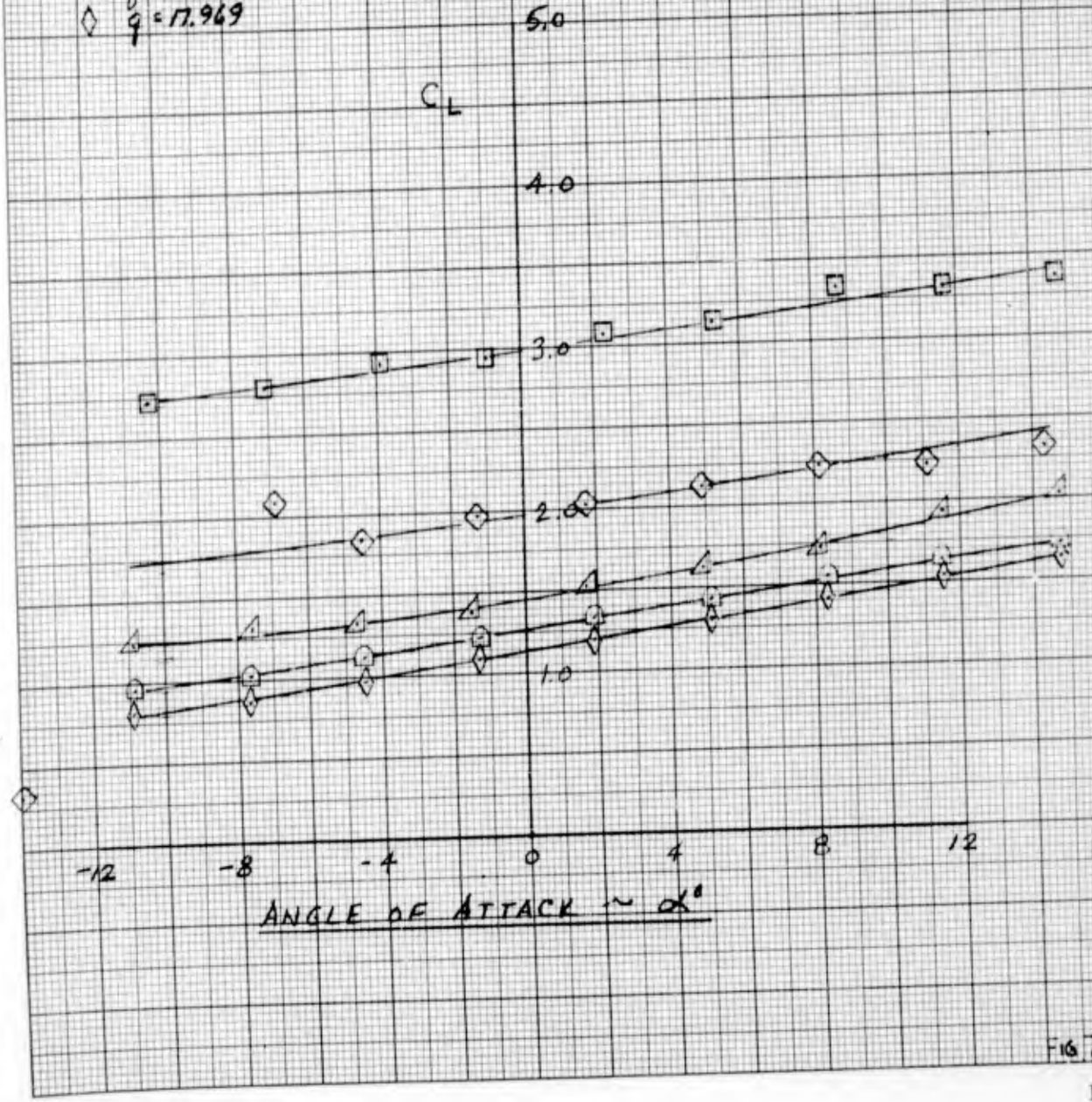


FIG 73

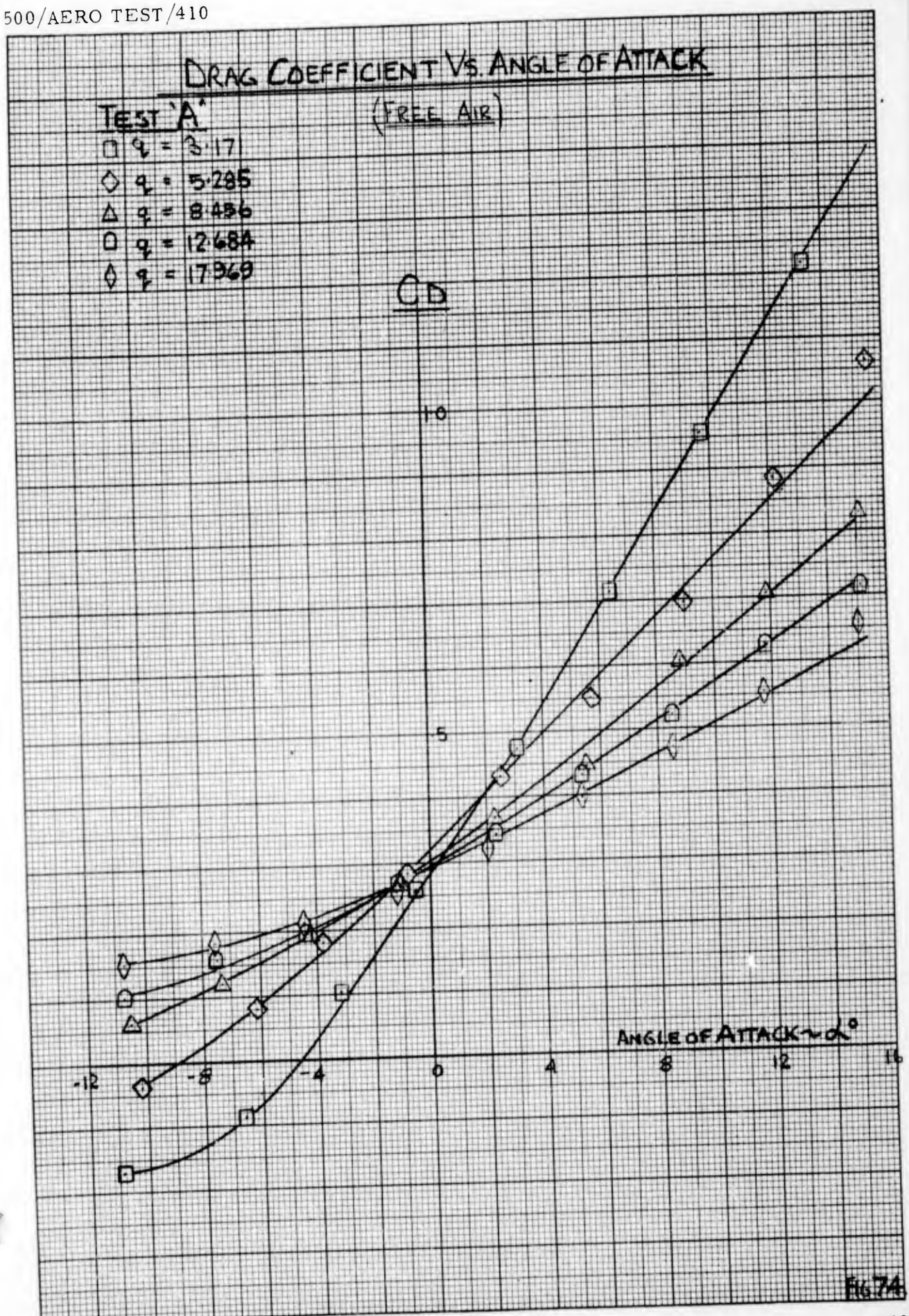

DRAG COEFFICIENT VS. ANGLE OF ATTACK
TEST 'A'
(FREE AIR)
q = 3.17
q = 5.285
q = 8.456
q = 12.684
q = 17.969
CD
1.0
.5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

Fig 74

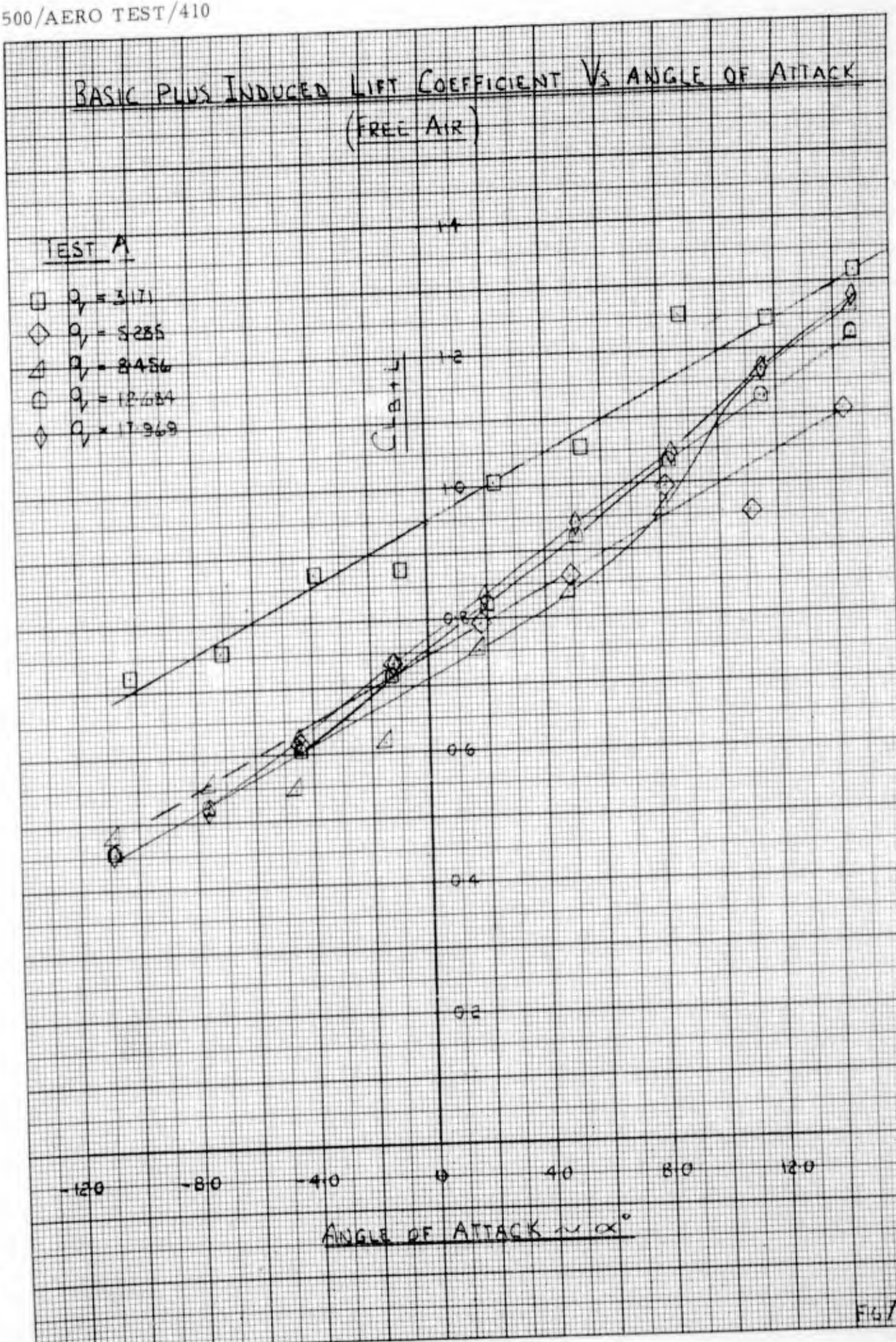

BASIC PLUS INDUCED LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST A
q_v = 3.171
q_v = 5.285
q_v = 8.486
q_v = 12.684
q_v = 17.969
$C_{L_{d+}}$
1·4
1·2
1·0
0·8
0·6
0·4
0·2
-12·0
-8·0
-4·0
0
4·0
8·0
12·0
ANGLE OF ATTACK α°

FIG 5

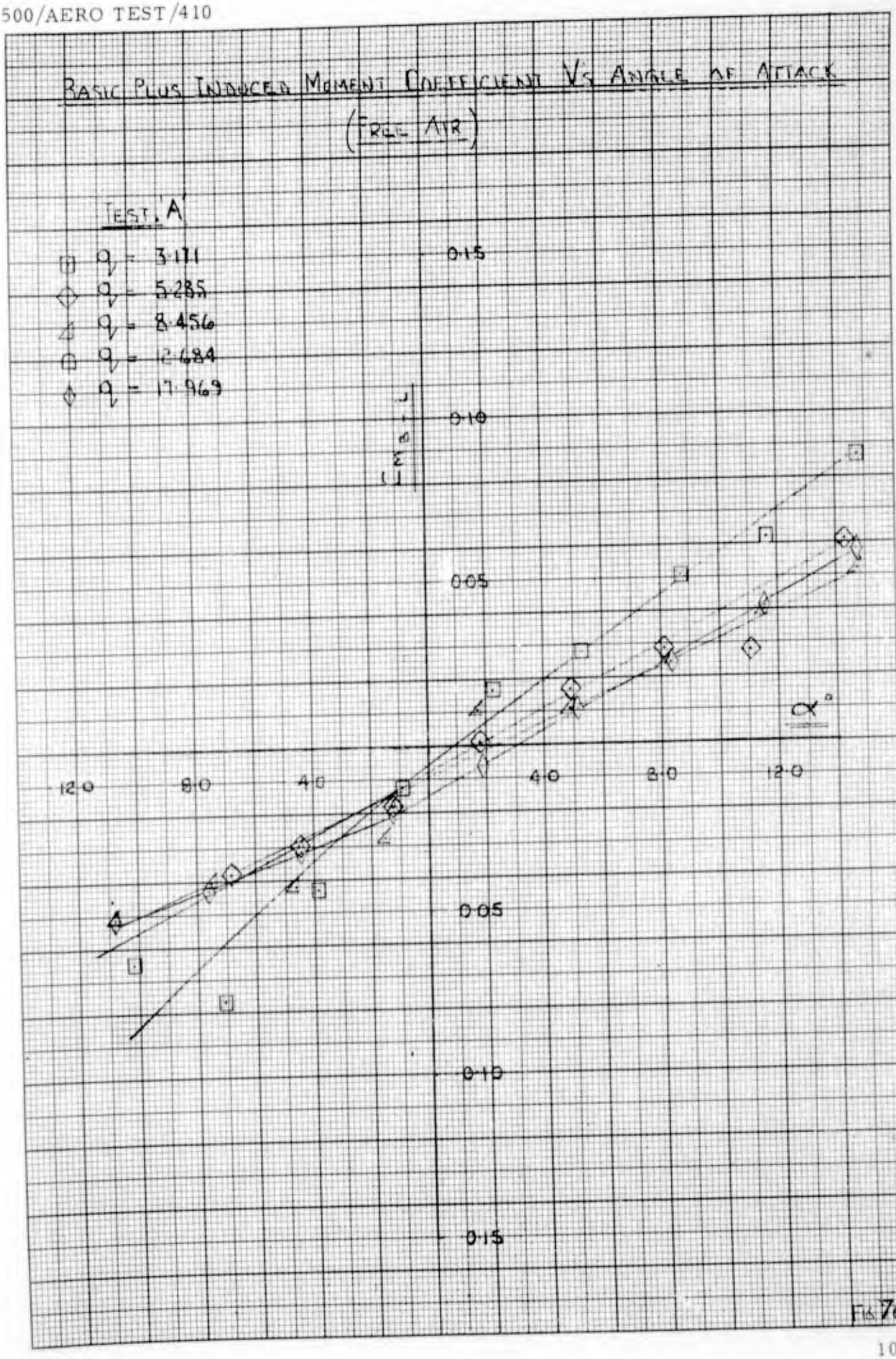

BASIC PLUS INDUCED MOMENT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'A'
q_v = 3.171
q_v = 5.285
q_v = 8.456
q_v = 12.684
q_v = 17.969
0.15
0.10
0.05
0.05
0.10
0.15
12.0
8.0
4.0
4.0
8.0
12.0
α°

Fig 76

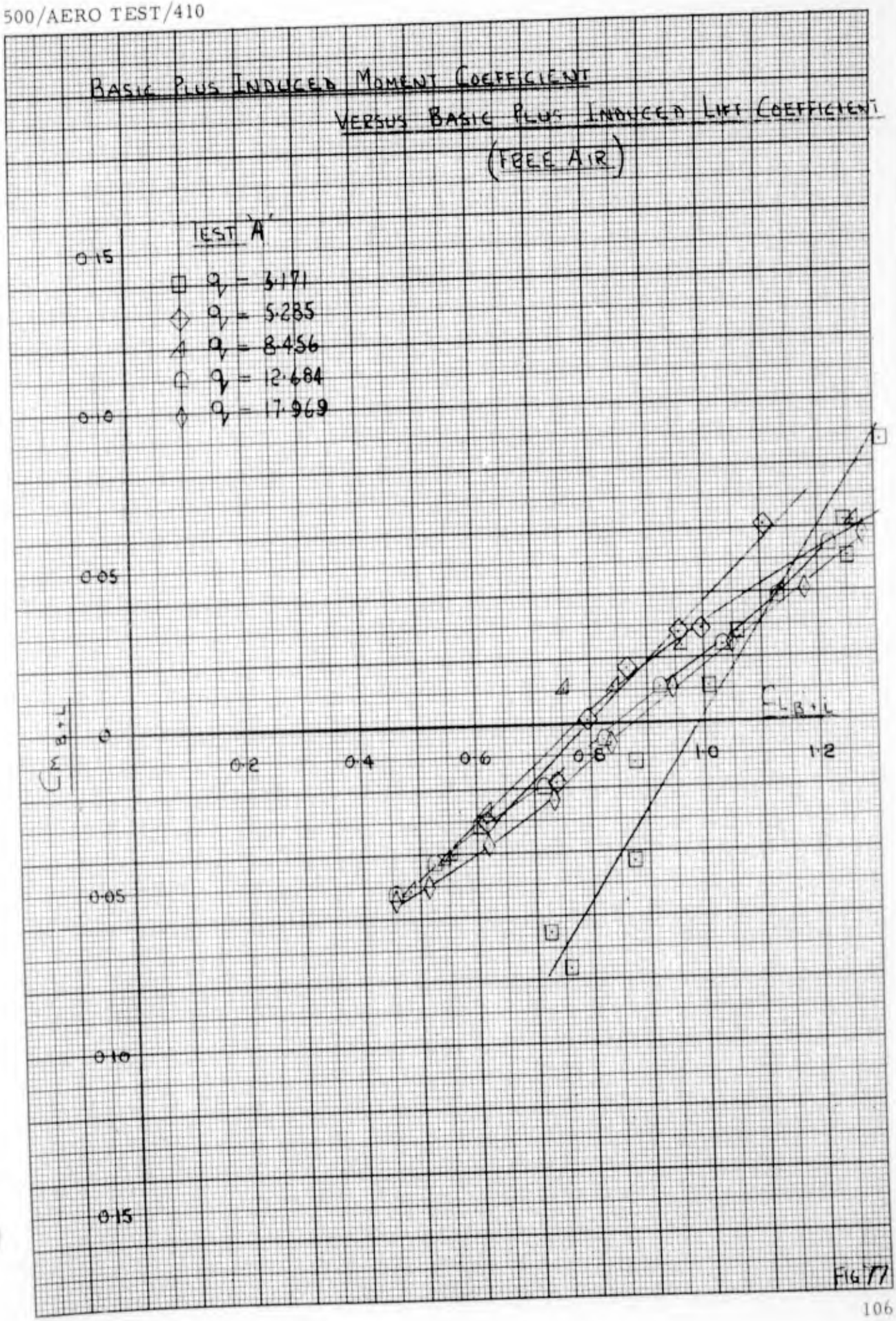

BASIC PLUS INDUCED MOMENT COEFFICIENT
VERSUS BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'A'
q_v = 3.171
q_v = 5.285
q_v = 8.456
q_v = 12.684
q_v = 17.969
0.15
0.10
0.05
0
0.05
0.10
0.15
0.2
0.4
0.6
0.8
1.0
1.2
$C_{L_{B+I}}$
$C_{m_{B+I}}$

FIG 77

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)

TEST 'A'

□ q = 3.171
◇ q = 5.285
△ q = 8.456
▭ q = 12.684
◇ q = 17.969

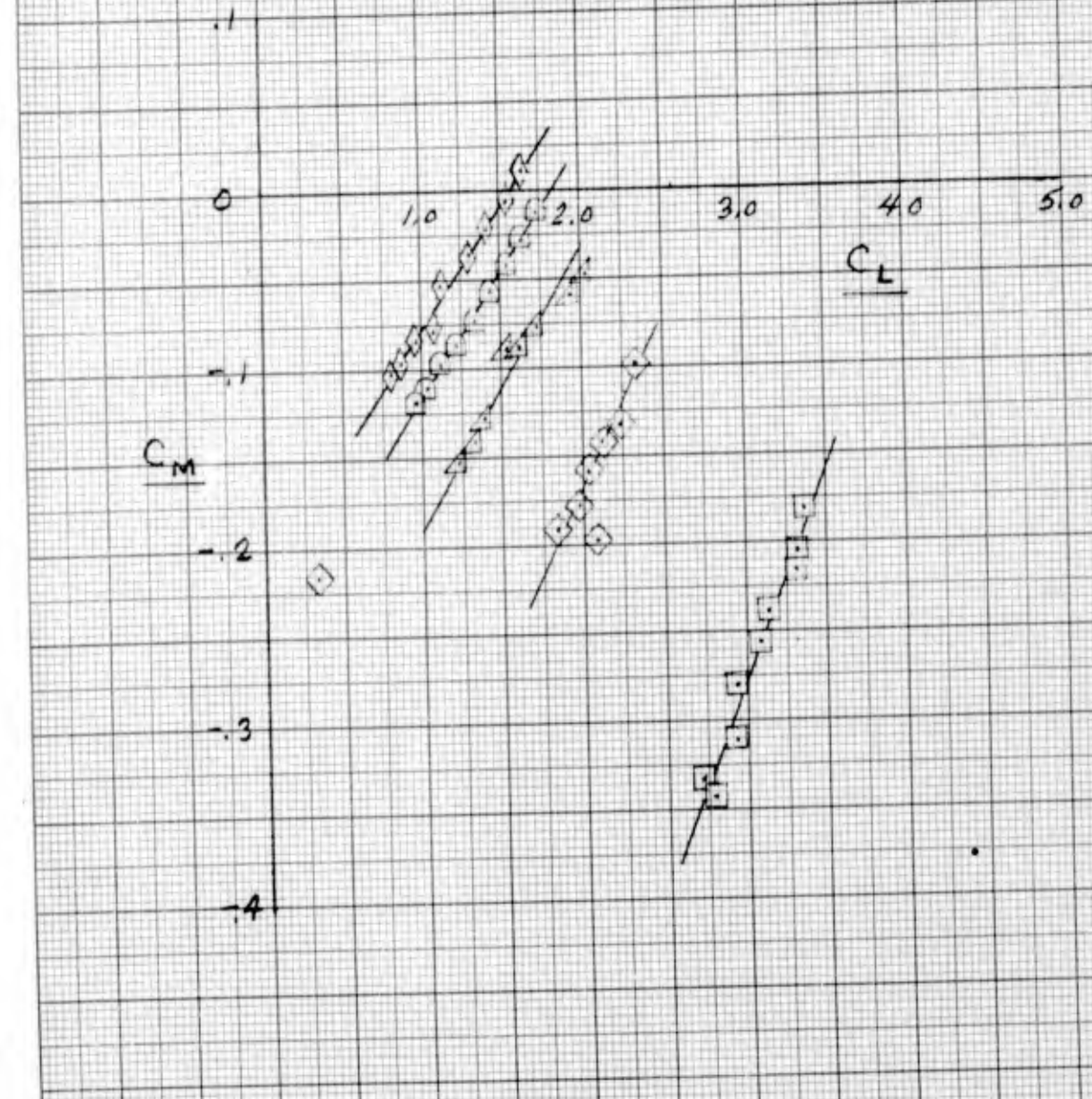


FIG. 78

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)

TEST 'A'

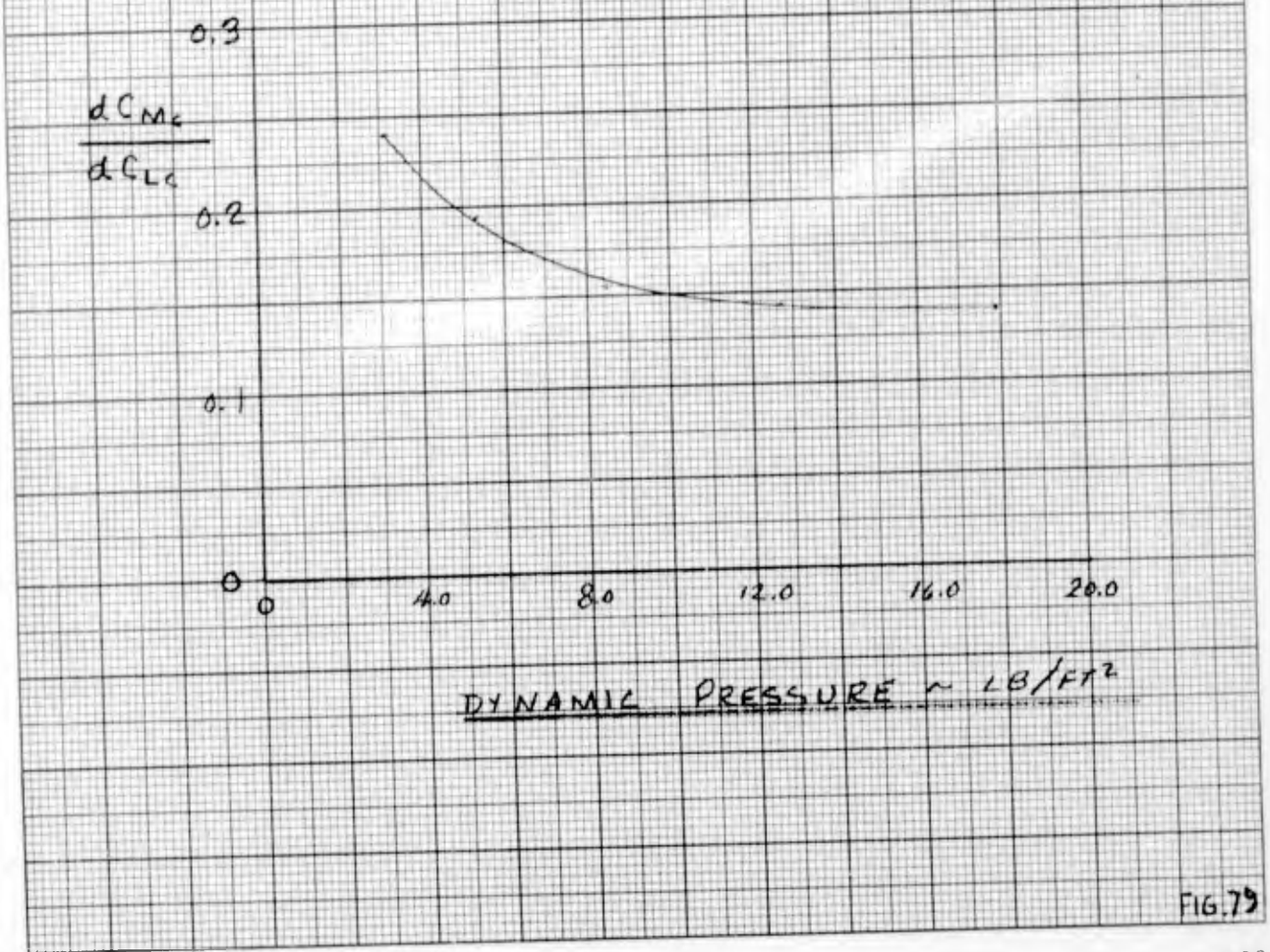


FIG. 79

LIFT CURVE SLOPE VS FORWARD SPEED

(FREE AIR)

TEST 'A'

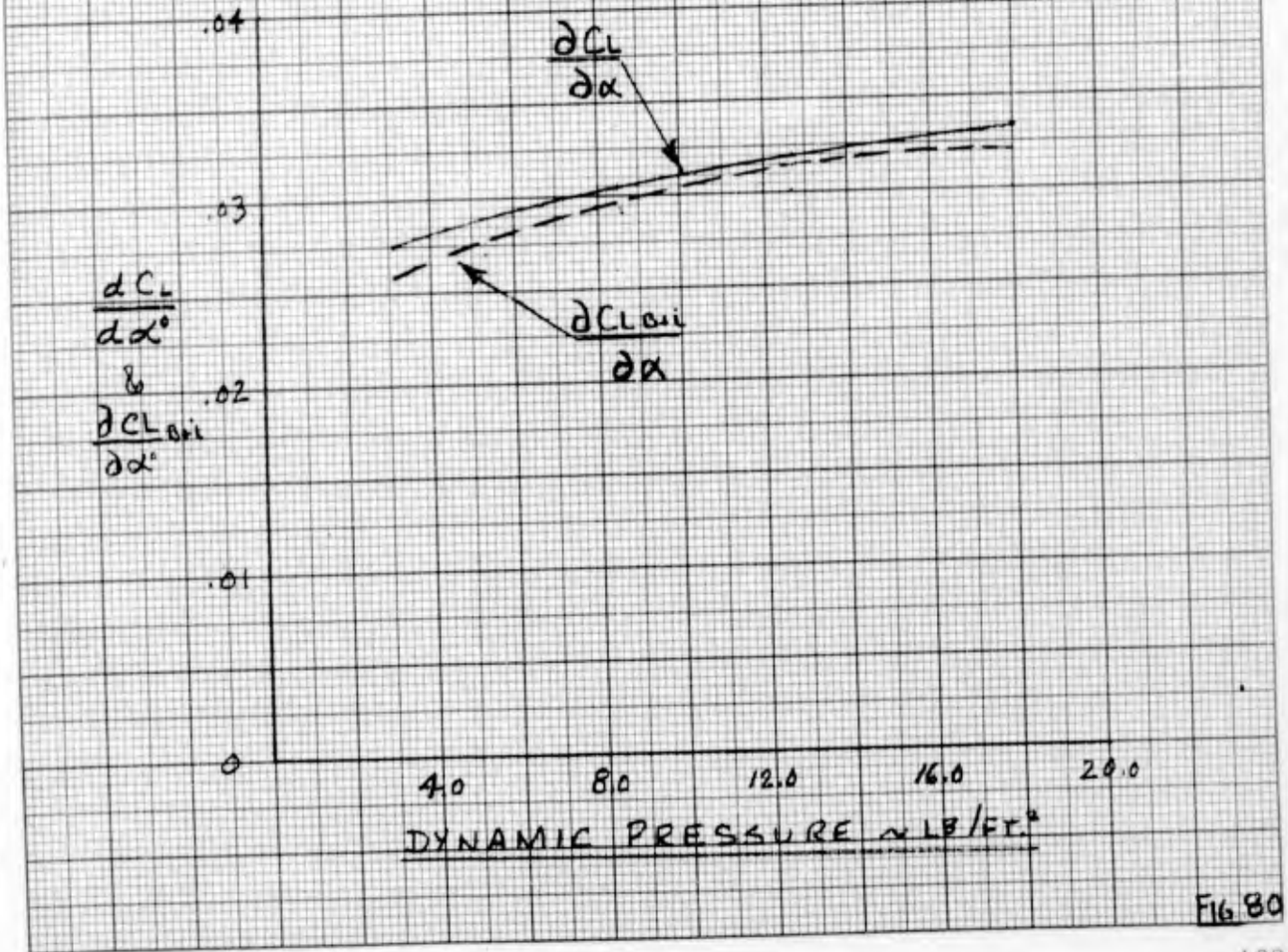


FIG 80

PITCHING MOMENT Vs DYNAMIC PRESSURE

FREE AIR

TEST 'A'

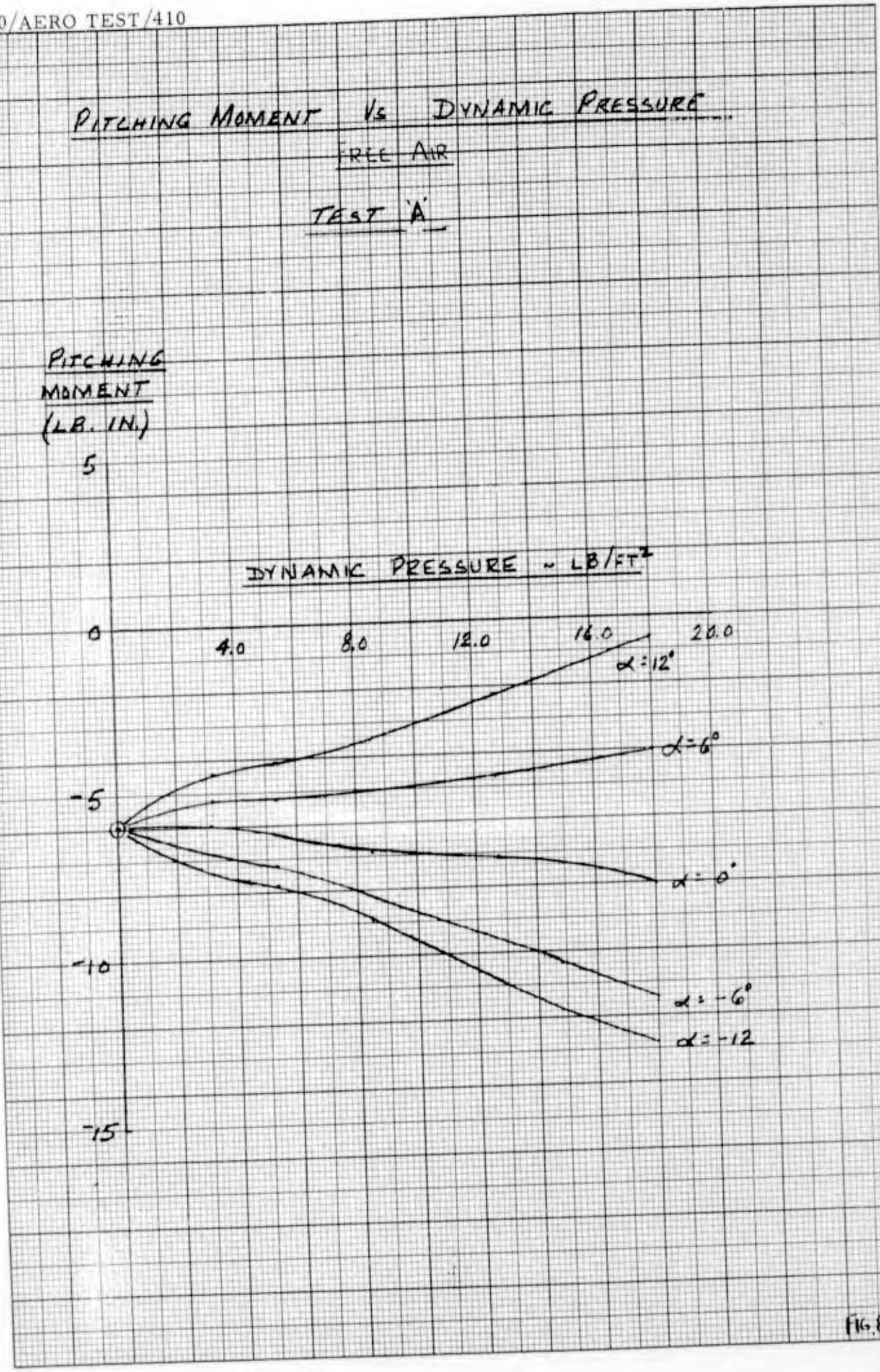


FIG. 81

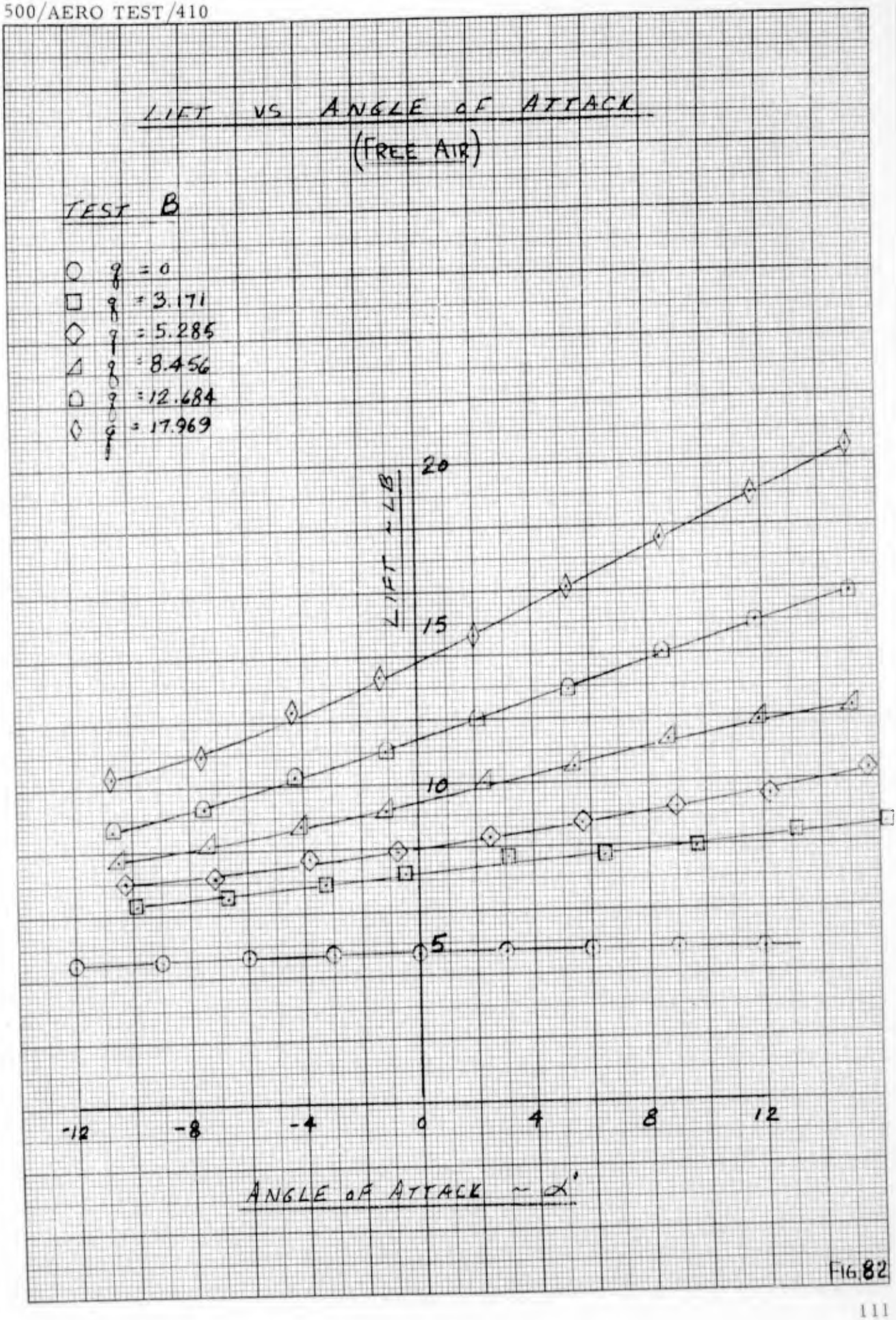

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST B
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
LIFT - LB
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α'

FIG. 82

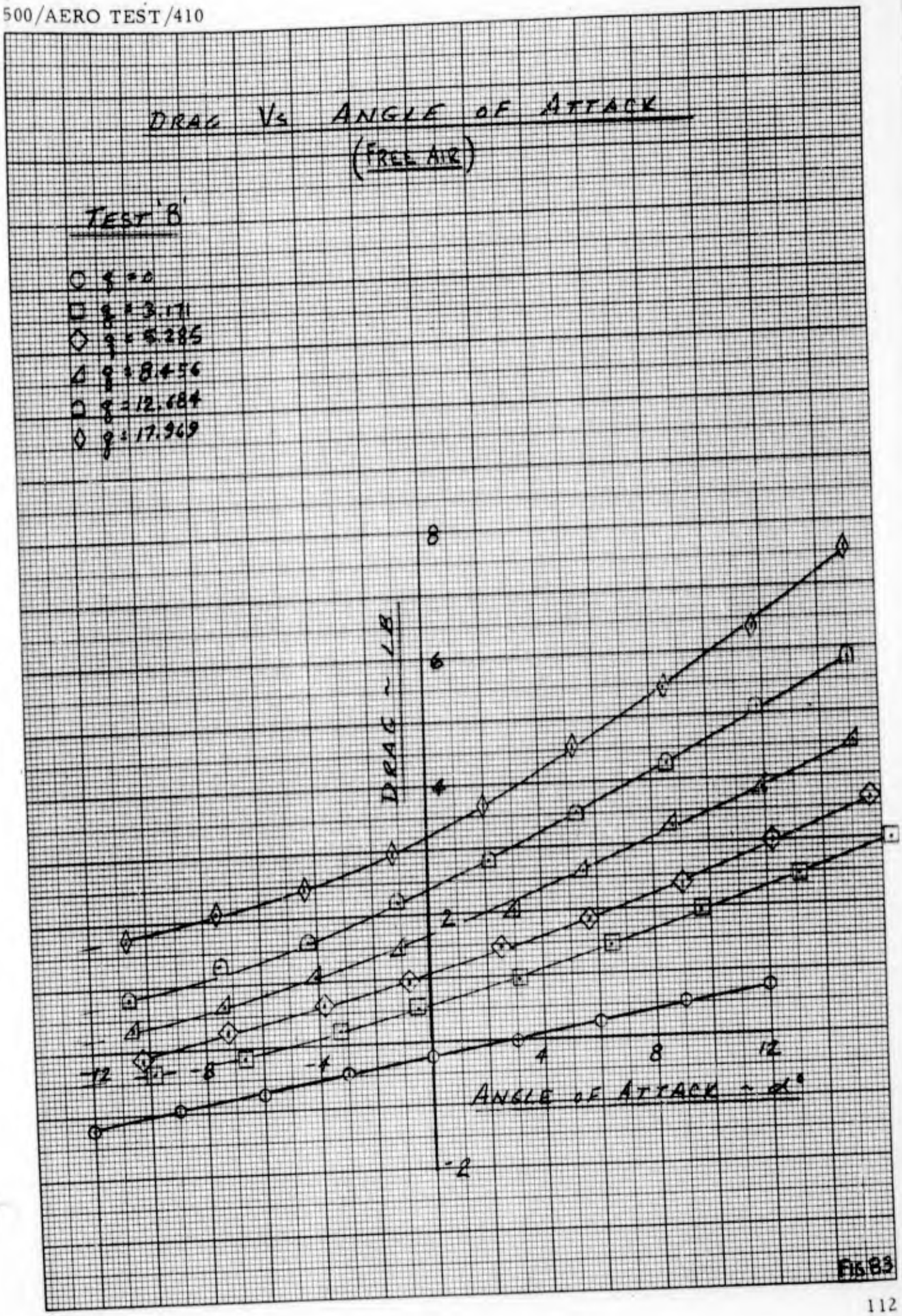

DRAG Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'B'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.684
◇ q = 17.969
DRAG - LB
ANGLE OF ATTACK - α°
8
6
4
2
-2
-12
-8
-4
4
8
12

Fig B3

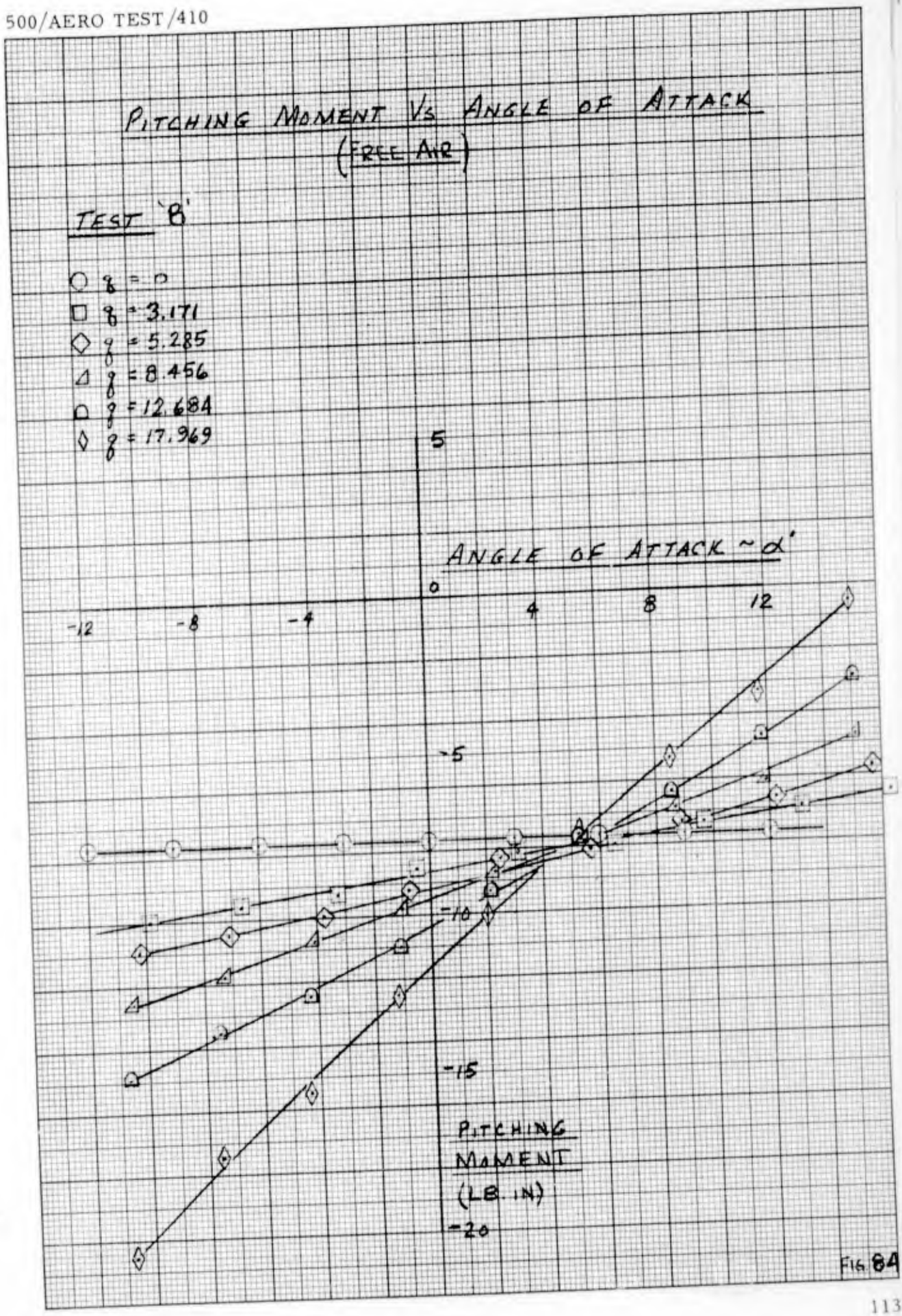

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'B'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
ANGLE OF ATTACK ~ α'
5
0
4
8
12
-12
-8
-4
-5
-10
-15
-20
PITCHING MOMENT (LB. IN)

FIG 84

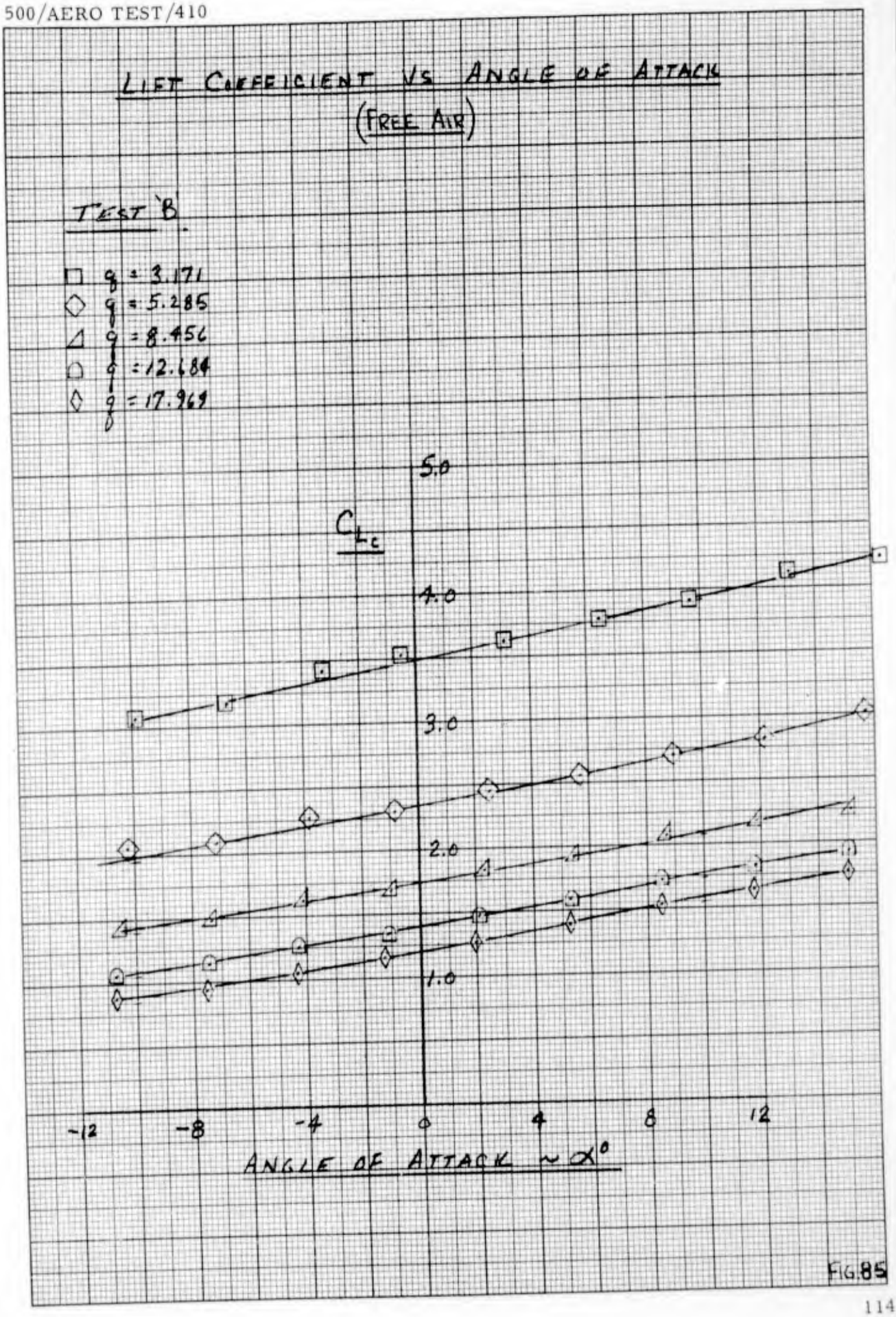
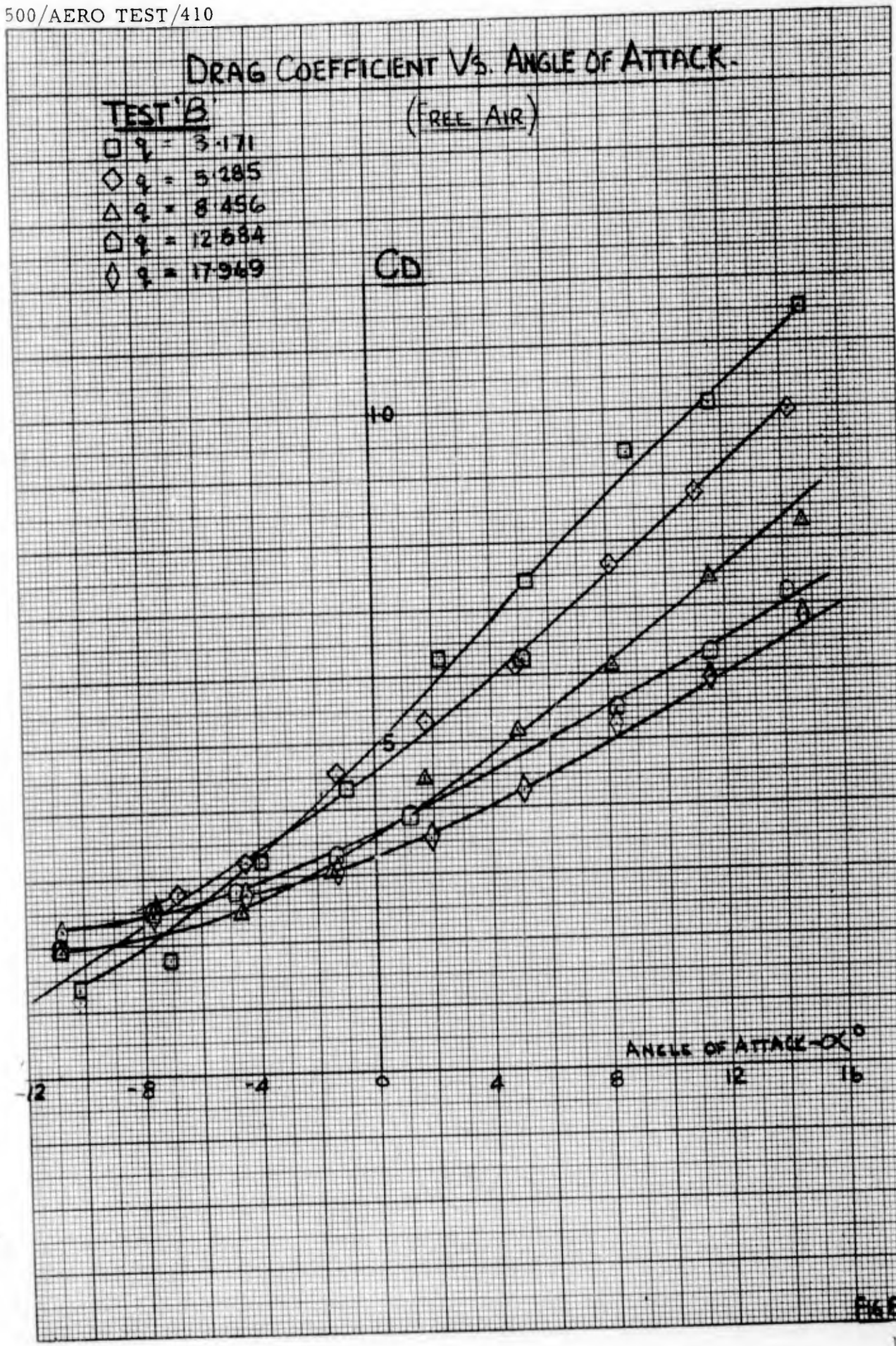

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'B'
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
C_{L_c}
5.0
4.0
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α^0

FIG. 85


DRAG COEFFICIENT Vs. ANGLE OF ATTACK.
(FREE AIR)
TEST 'B'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.949
CD
1.0
.5
ANGLE OF ATTACK - α°
-12
-8
-4
0
4
8
12
16
FIG 86

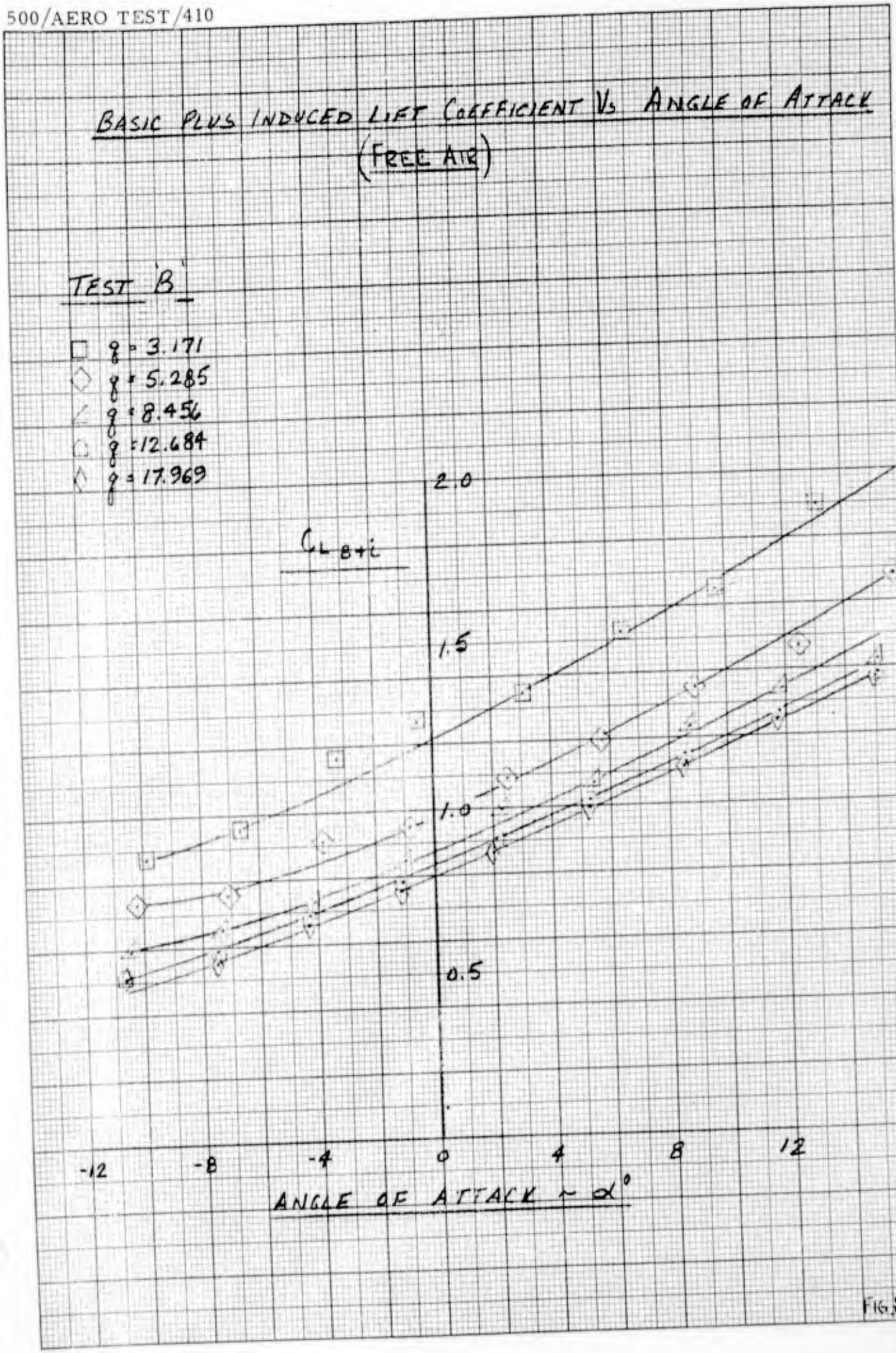

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST B
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
$C_{L\ B+i}$
2.0
1.5
1.0
0.5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α^0

FIG. 87

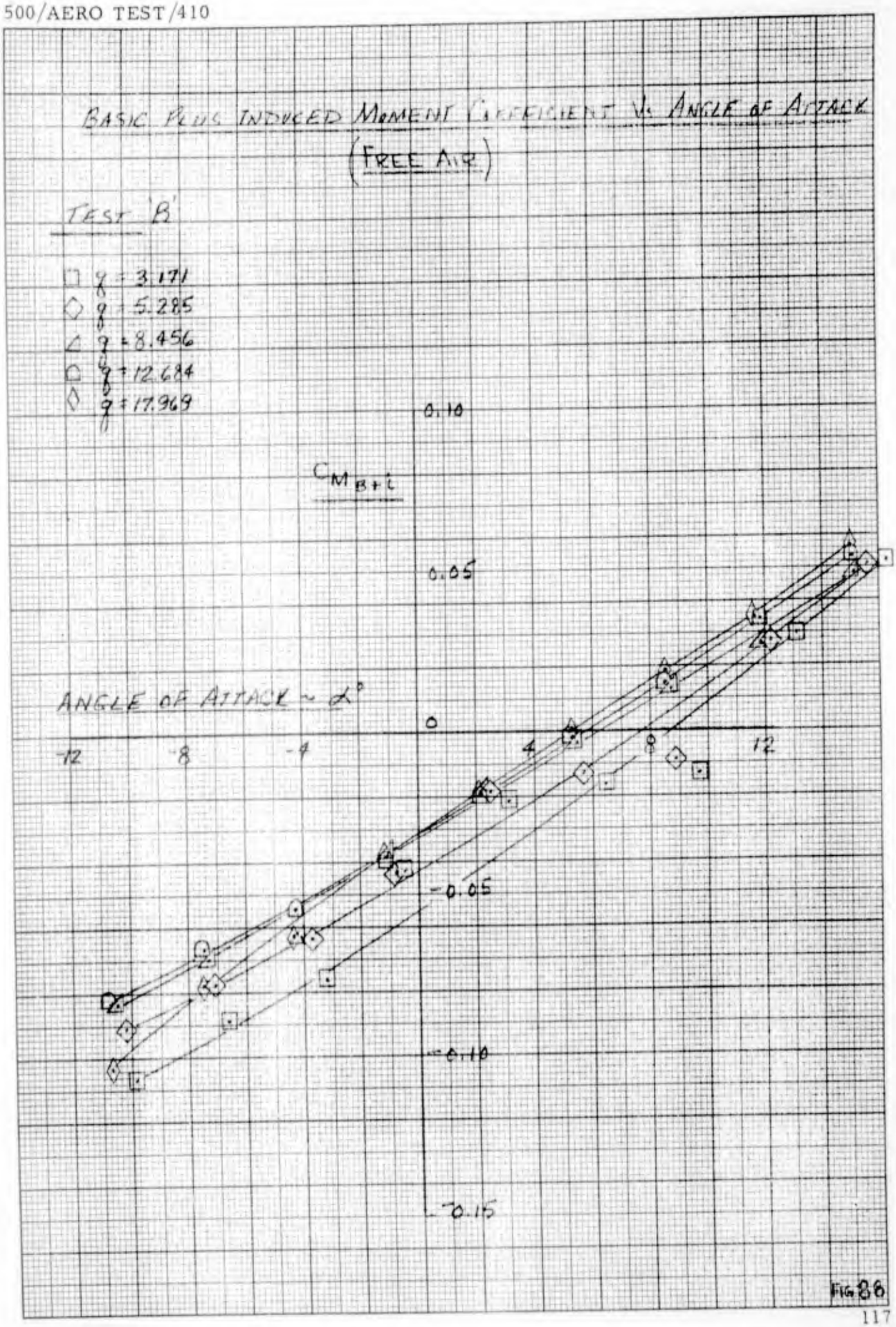

BASIC PLUS INDUCED MOMENT COEFFICIENT VS. ANGLE OF ATTACK
(FREE AIR)
TEST 'B'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◇ q = 17.969
$C_{M_{B+t}}$
0.10
0.05
0
-0.05
-0.10
-0.15
ANGLE OF ATTACK = α°
-12
-8
-4
4
8
12

FIG 86

BASIC PLUS INDUCED MOMENT COEFFICIENT
-VS-
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)

TEST 'B'

□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◇ q = 17.969

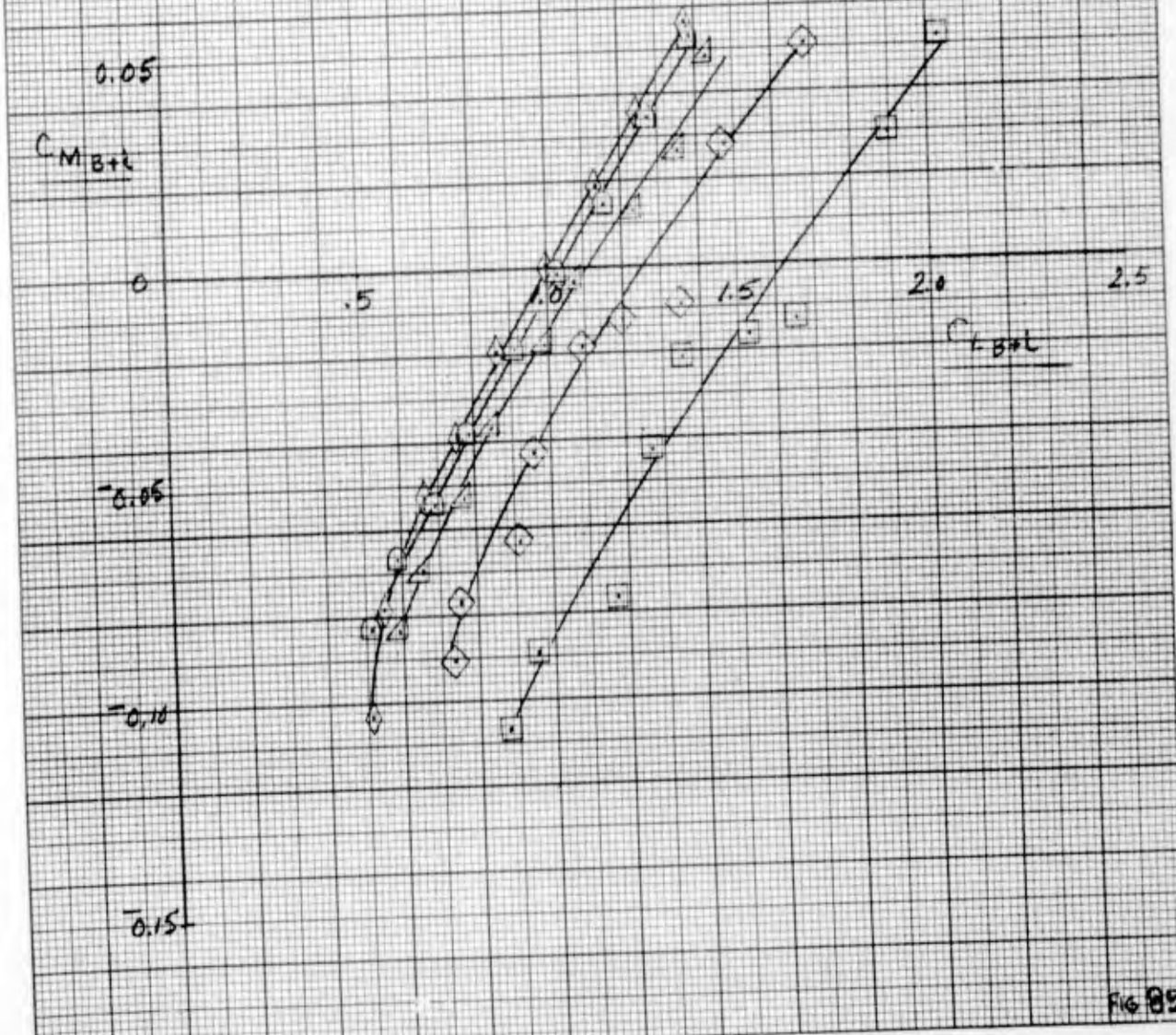


FIG 82

MOMENT COEFFICIENT VS LIFT COEFFICIENT

(FREE AIR)

TEST "B"

- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- □ q = 12.684
- ◇ q = 17.969

FIG. 90

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)

TEST 'B'

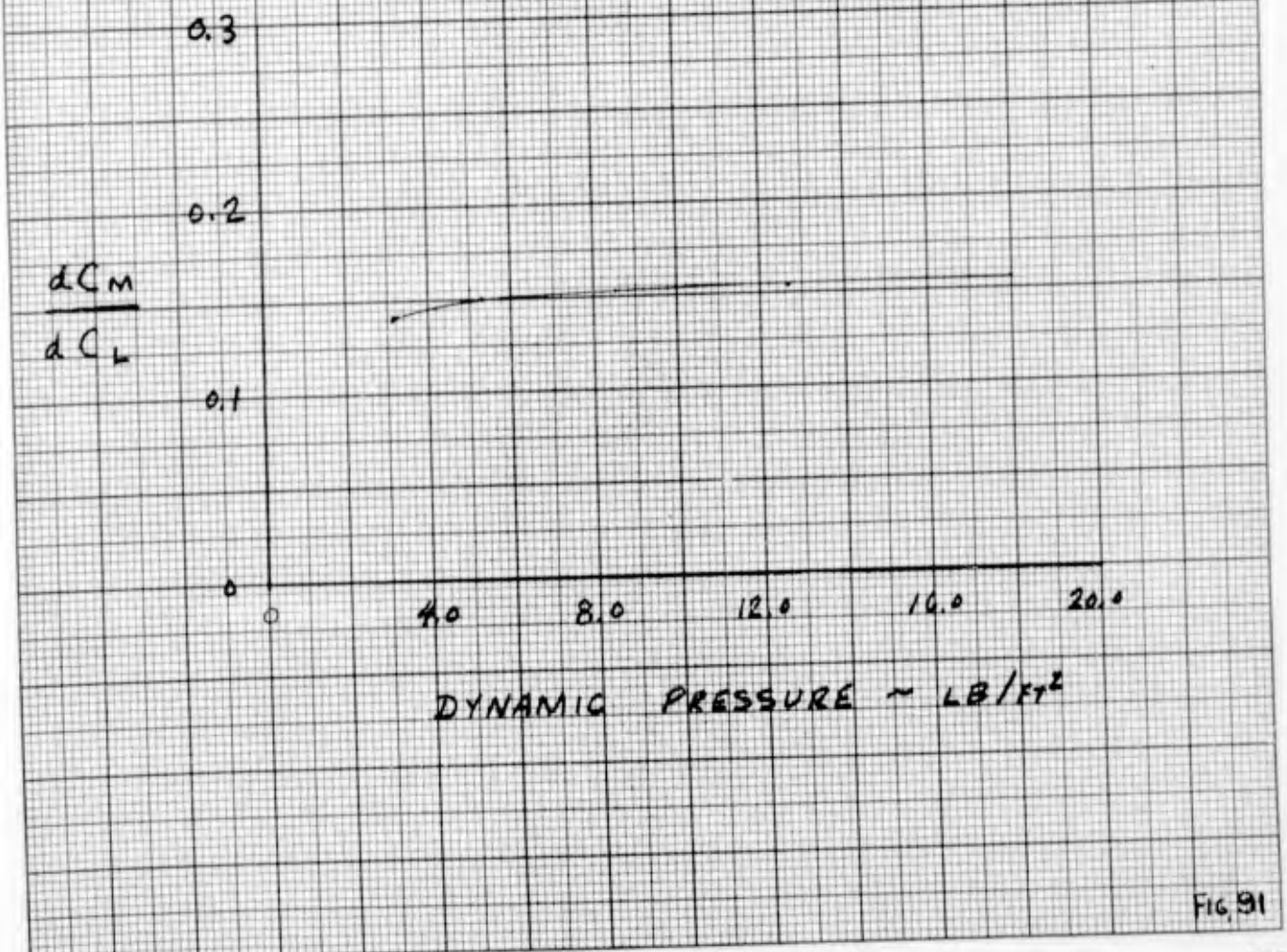


FIG. 91

LIFT CURVE SLOPE VS FORWARD SPEED

(FREE AIR)

TEST 'B'

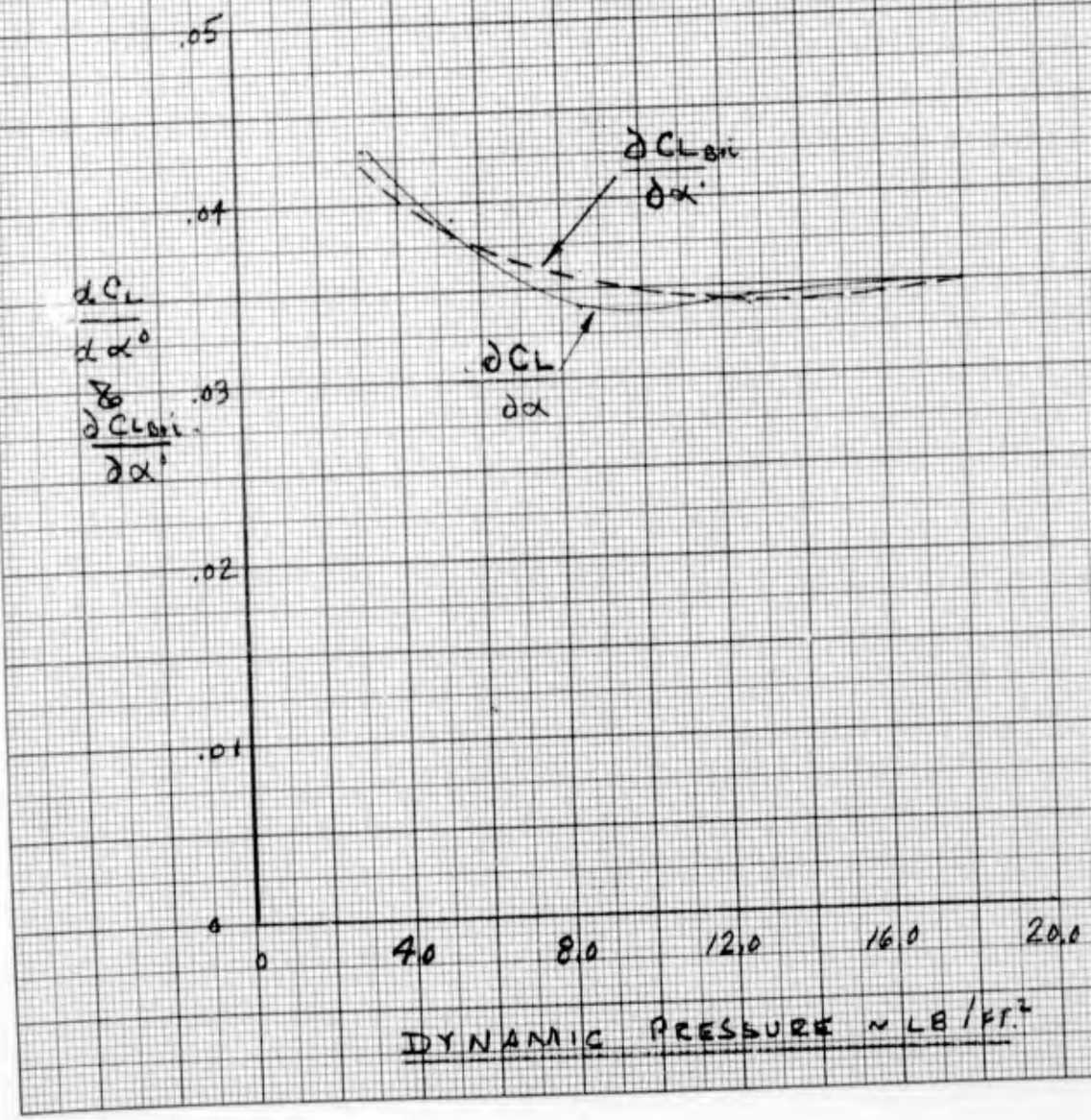
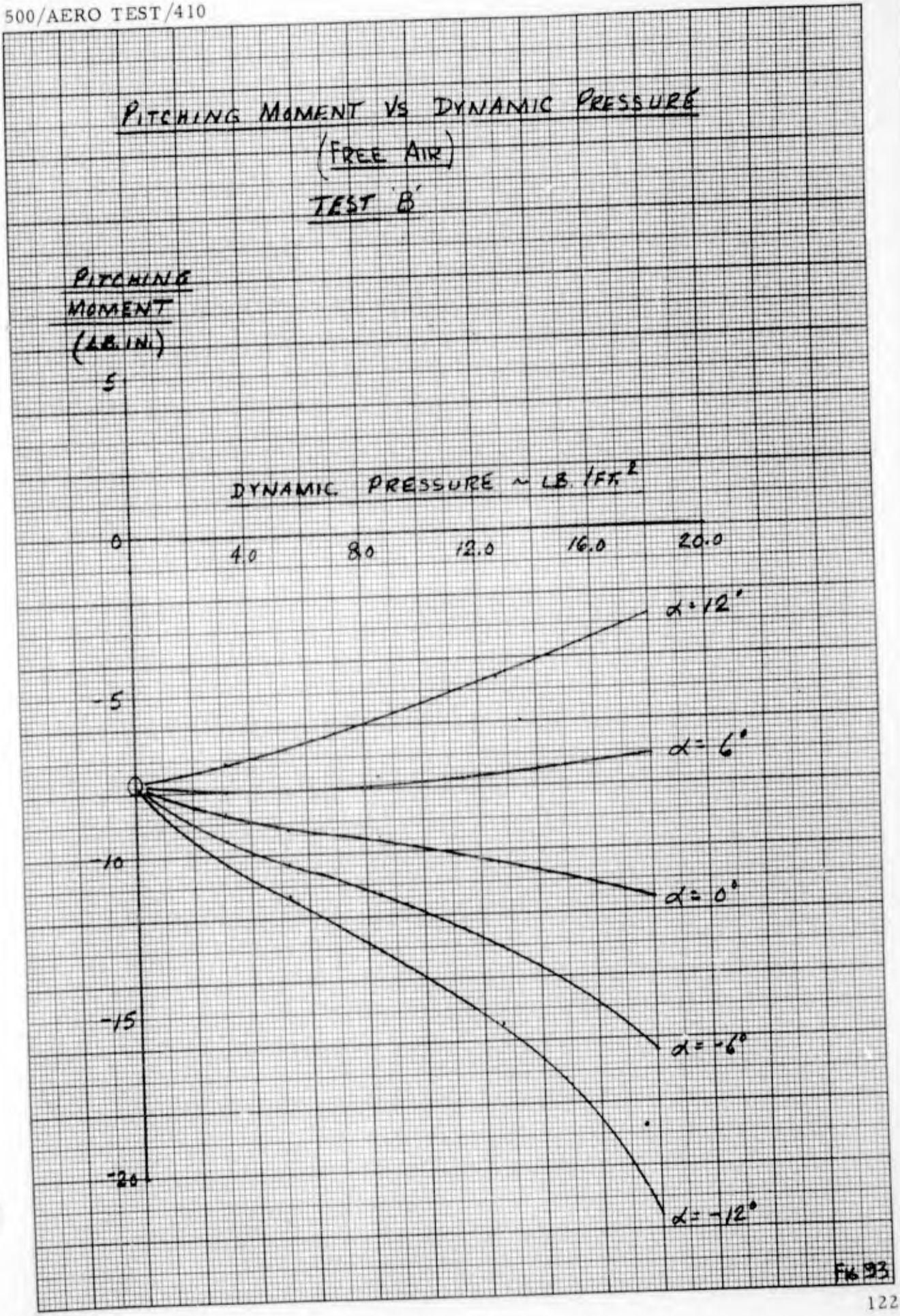


FIG 92


PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST B
PITCHING MOMENT (LB. IN.)
5
0
-5
-10
-15
-20
DYNAMIC PRESSURE ~ LB. / FT.²
4.0
8.0
12.0
16.0
20.0
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°
F6 93

LIFT VS ANGLE OF ATTACK.
(FREE AIR)

TEST C

- ○ q = 0
- ◇ q = 5·285
- ⬠ q = 12·684
- ◊ q = 17·969

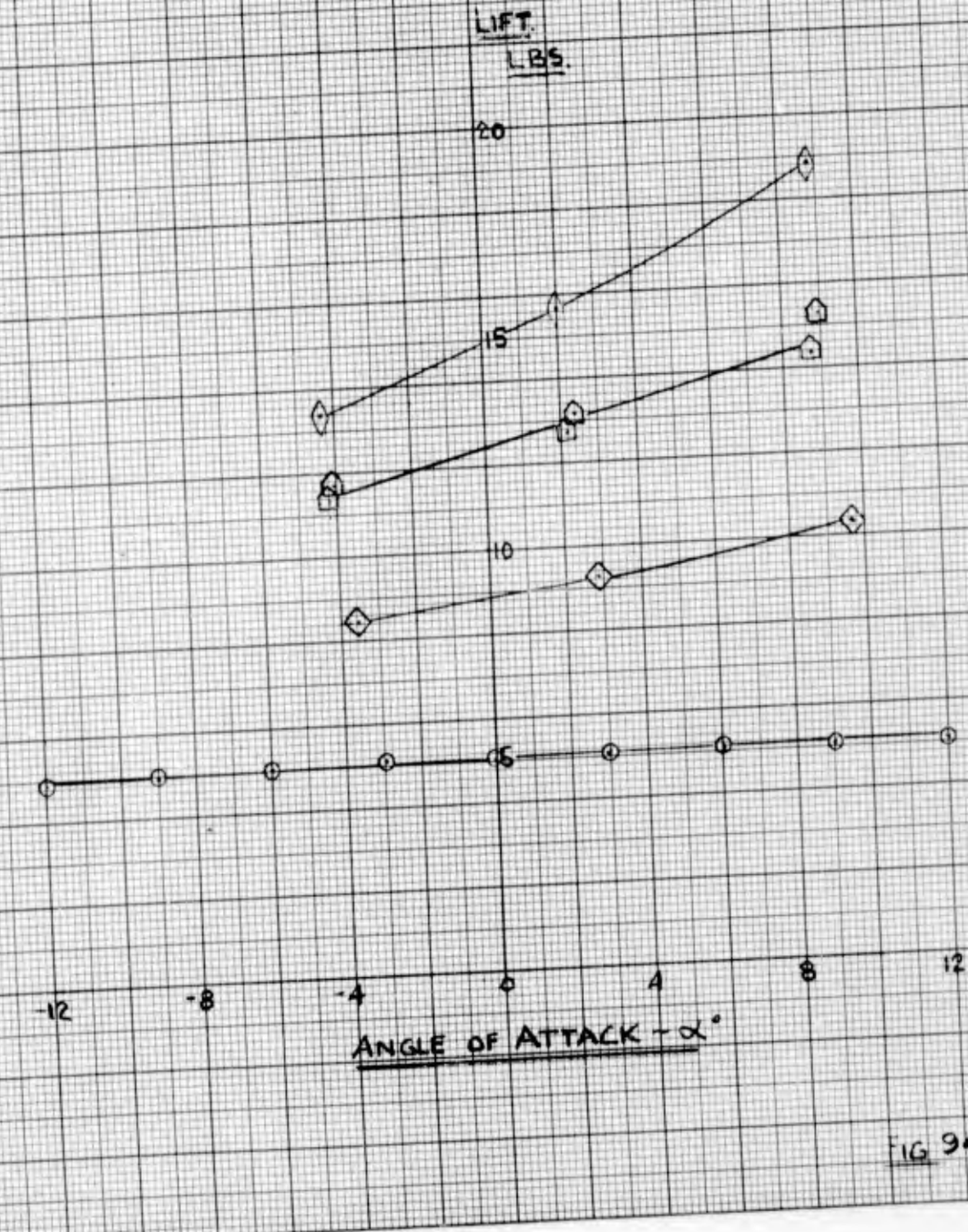


FIG 94.

DRAG VS ANGLE OF ATTACK (FREE AIR)

TEST 'C'

○ q = 0
◇ q = 5.285
⌂ q = 12.684
◊ q = 17.969

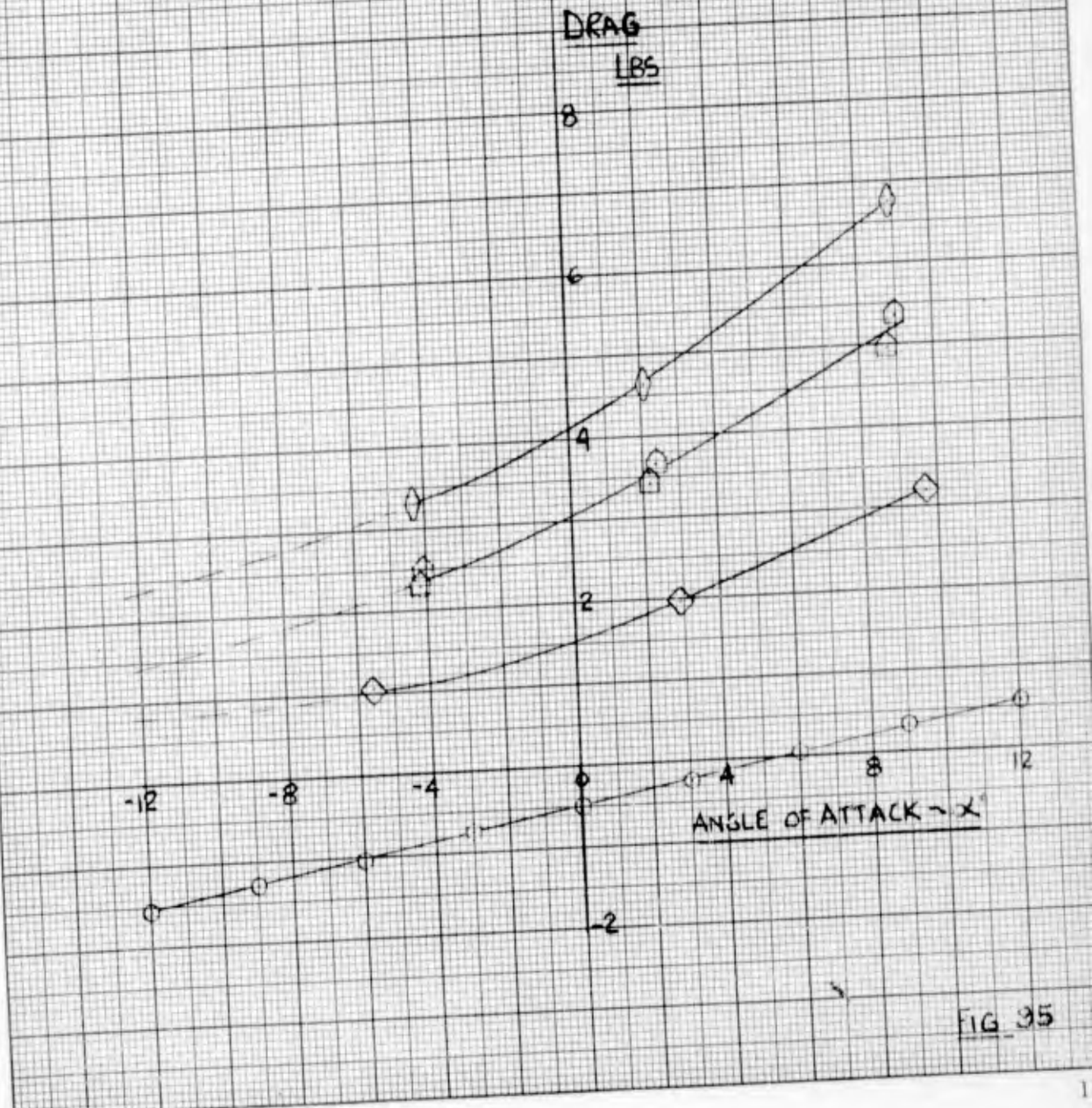


FIG 35

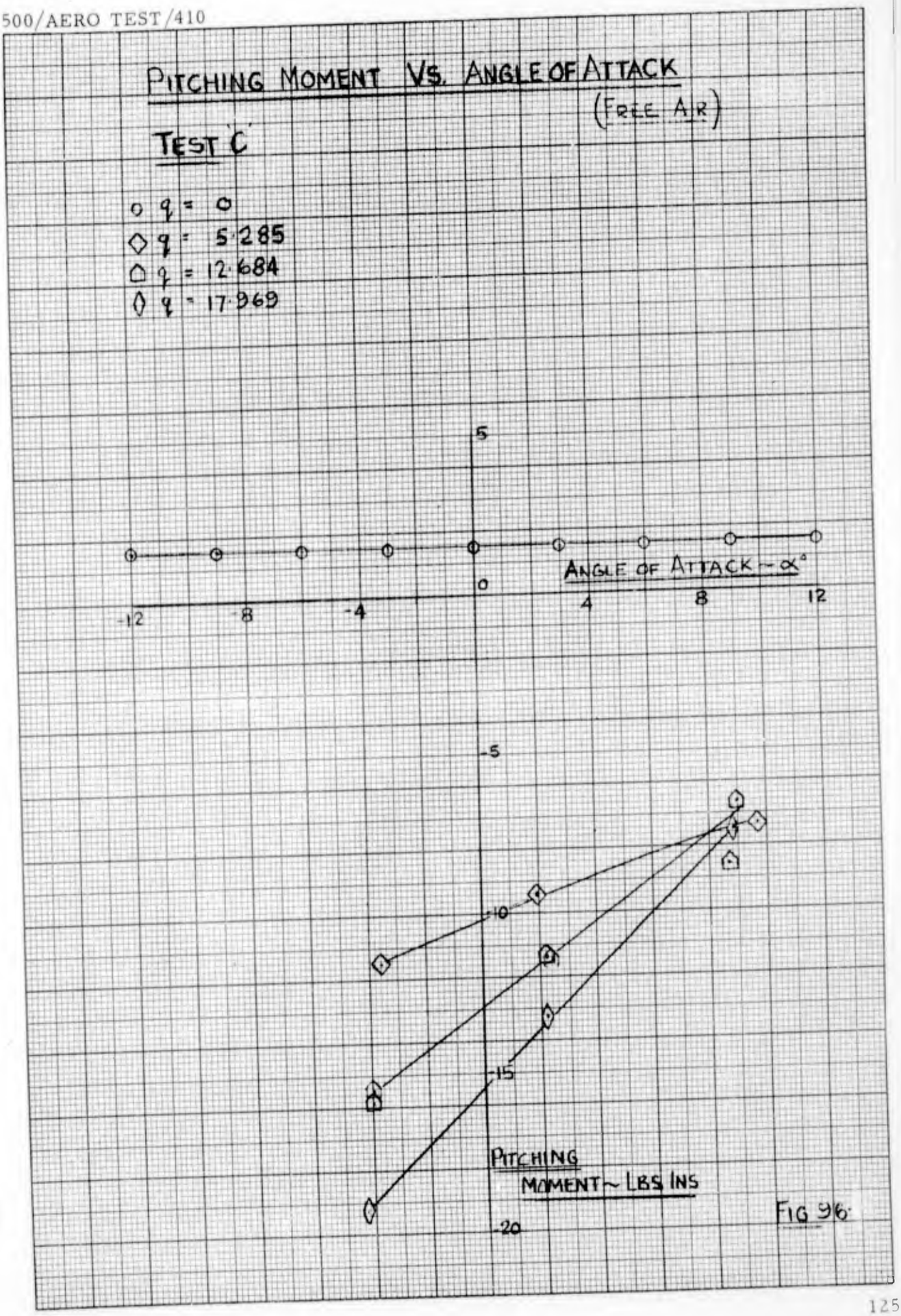

PITCHING MOMENT VS. ANGLE OF ATTACK
(FREE AIR)
TEST C
○ q = 0
◇ q = 5.285
⌂ q = 12.684
◊ q = 17.969
5
0
-5
-10
-15
-20
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°
PITCHING MOMENT ~ LBS INS

FIG 96

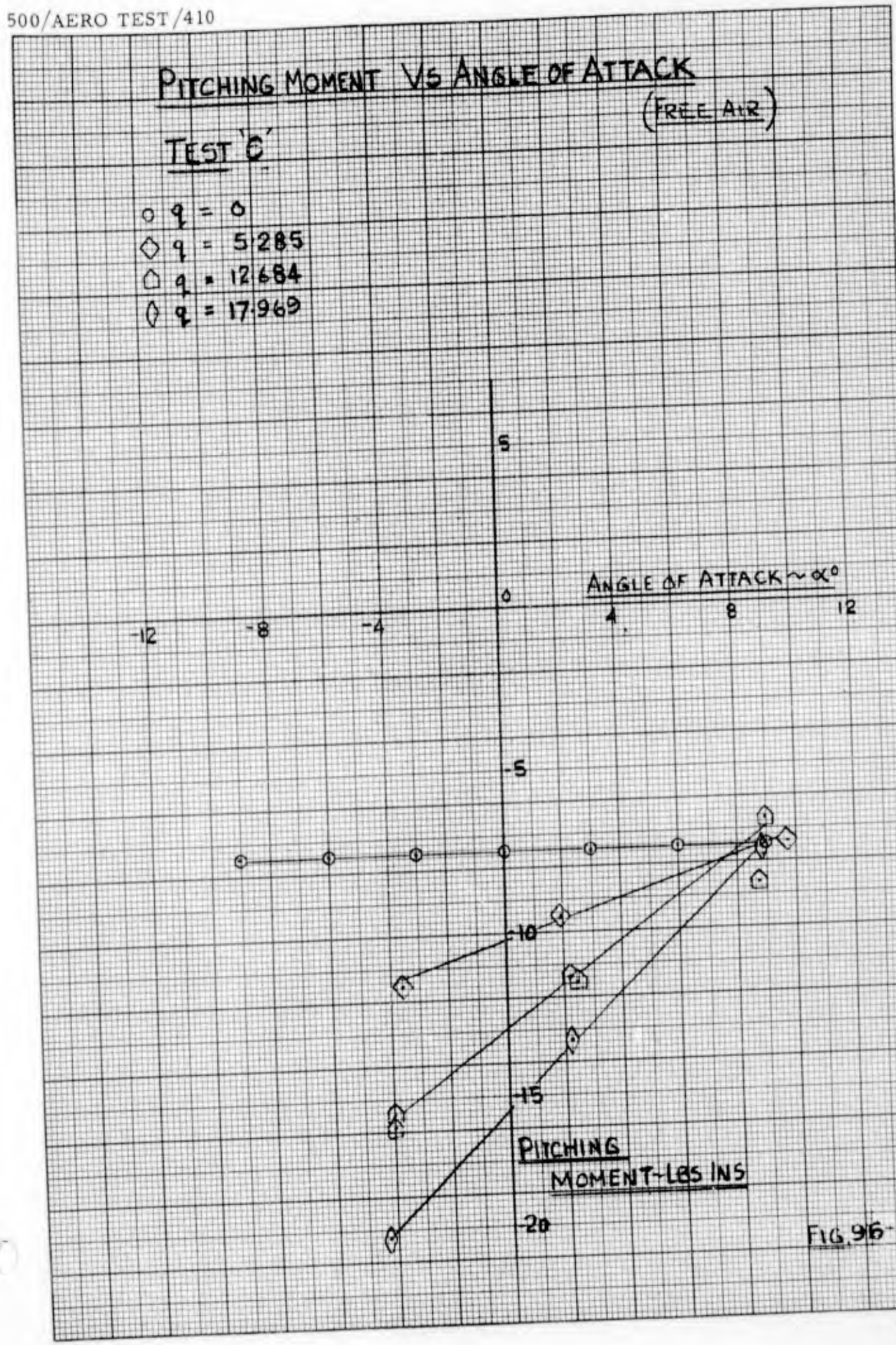

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'C'
○ q = 0
◇ q = 5285
⬠ q = 12684
⬡ q = 17969
5
0
-5
-10
-15
-20
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°
PITCHING MOMENT-LBS INS

FIG. 96-1

LIFT VS ANGLE OF ATTACK (FREE AIR.)

TEST 'D'

◇ q = 5·285
○ q = 12·684
◇ q = 17·969

T/PLANE SET AT 10°

LIFT LBS

15
10
5

-4 0 4 8

ANGLE OF ATTACK ~α°

T/PLANE SET AT 20° (NEUTRAL POSN)

LIFT LBS

15
10
5

-4 0 4 8

ANGLE OF ATTACK ~α°

FIG 97

LIFT VS ANGLE OF ATTACK (FREE AIR)

TEST 'D'

◇ q = 5·285
⬠ q = 12 684
◊ q = 17 969

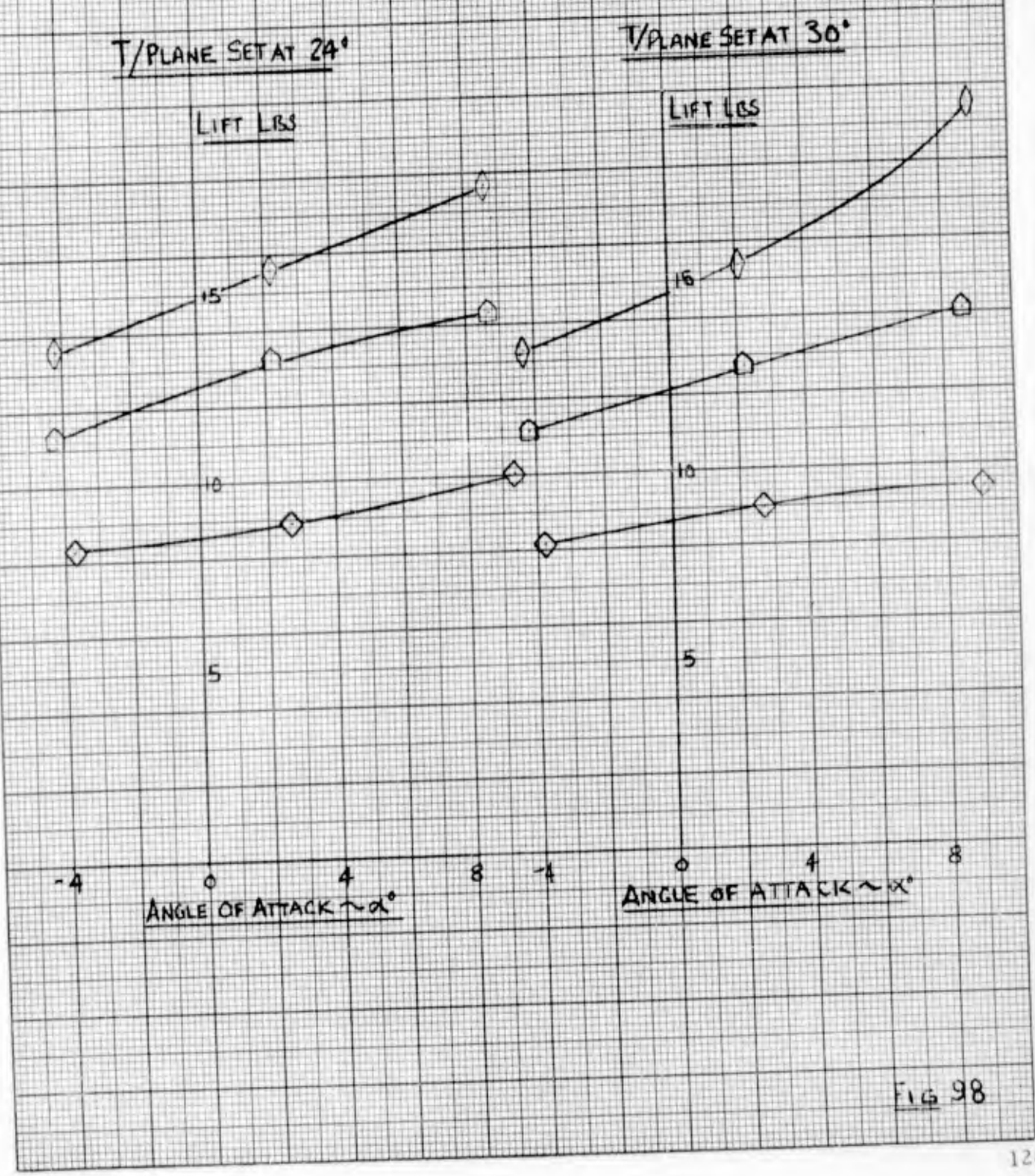


FIG 98

DRAG VS. ANGLE OF ATTACK

(FREE AIR)

TEST 'D'

◇ q = 5·285
⌂ q = 12·684
◊ q = 17969

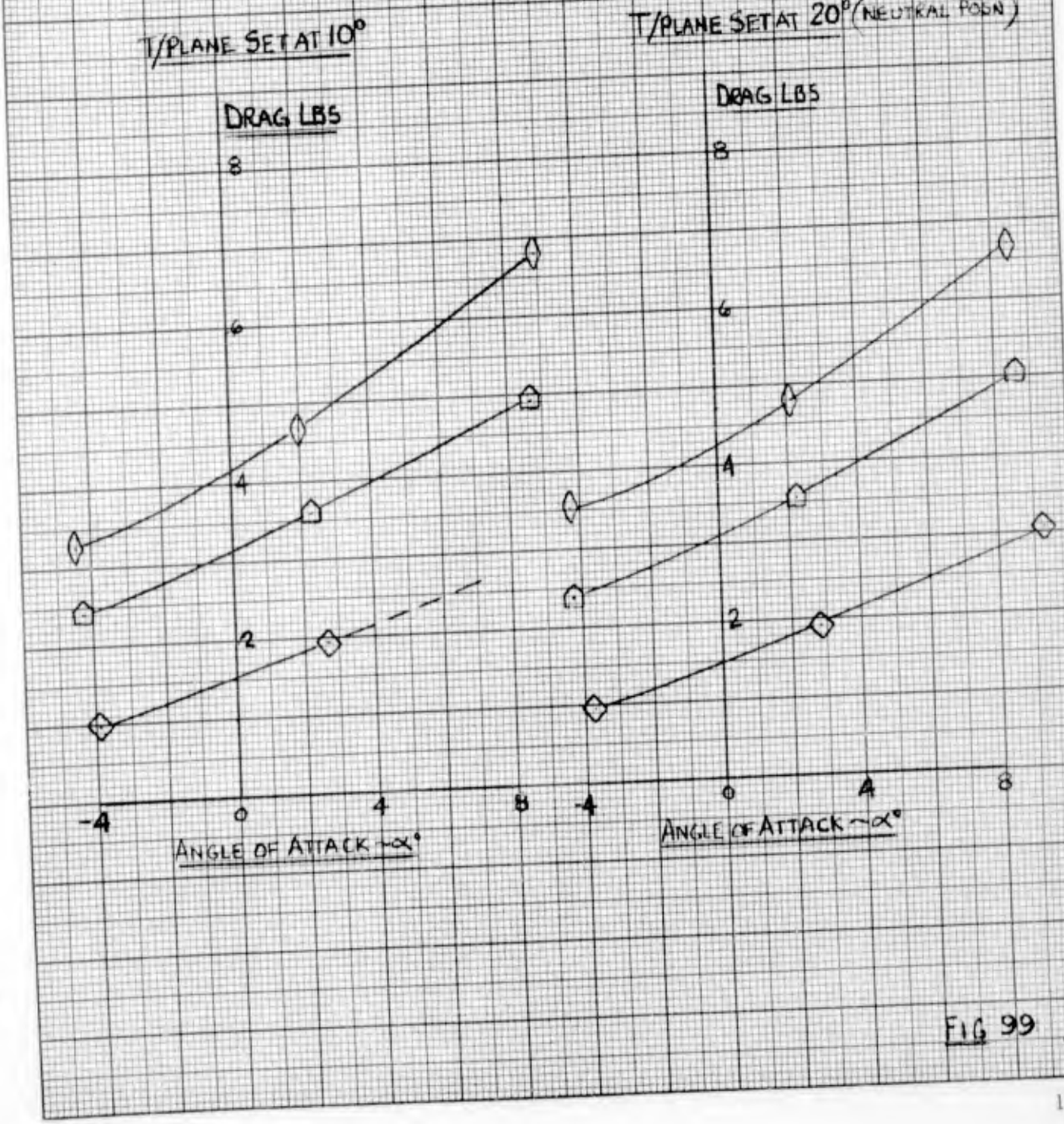


FIG 99

DRAG VS. ANGLE OF ATTACK

(FREE AIR)

TEST 'D'

◇ q = 5.285

⬠ q = 12.684

◊ q = 17.969

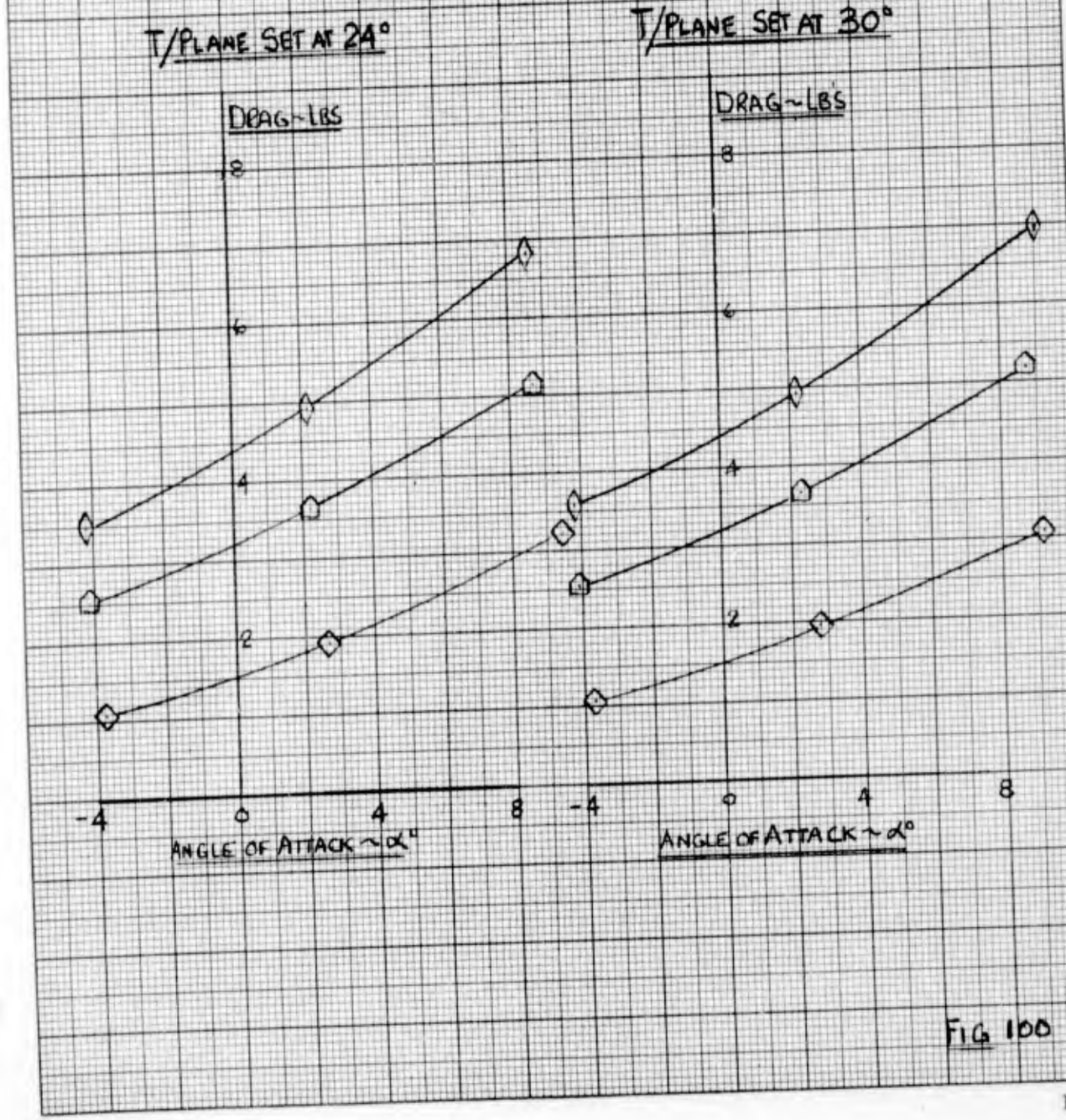


FIG 100

PITCHING MOMENT VS ANGLE OF ATTACK

(FREE AIR)

TEST D

◇ q = 5·285
△ q = 12·684
◊ q = 17·969

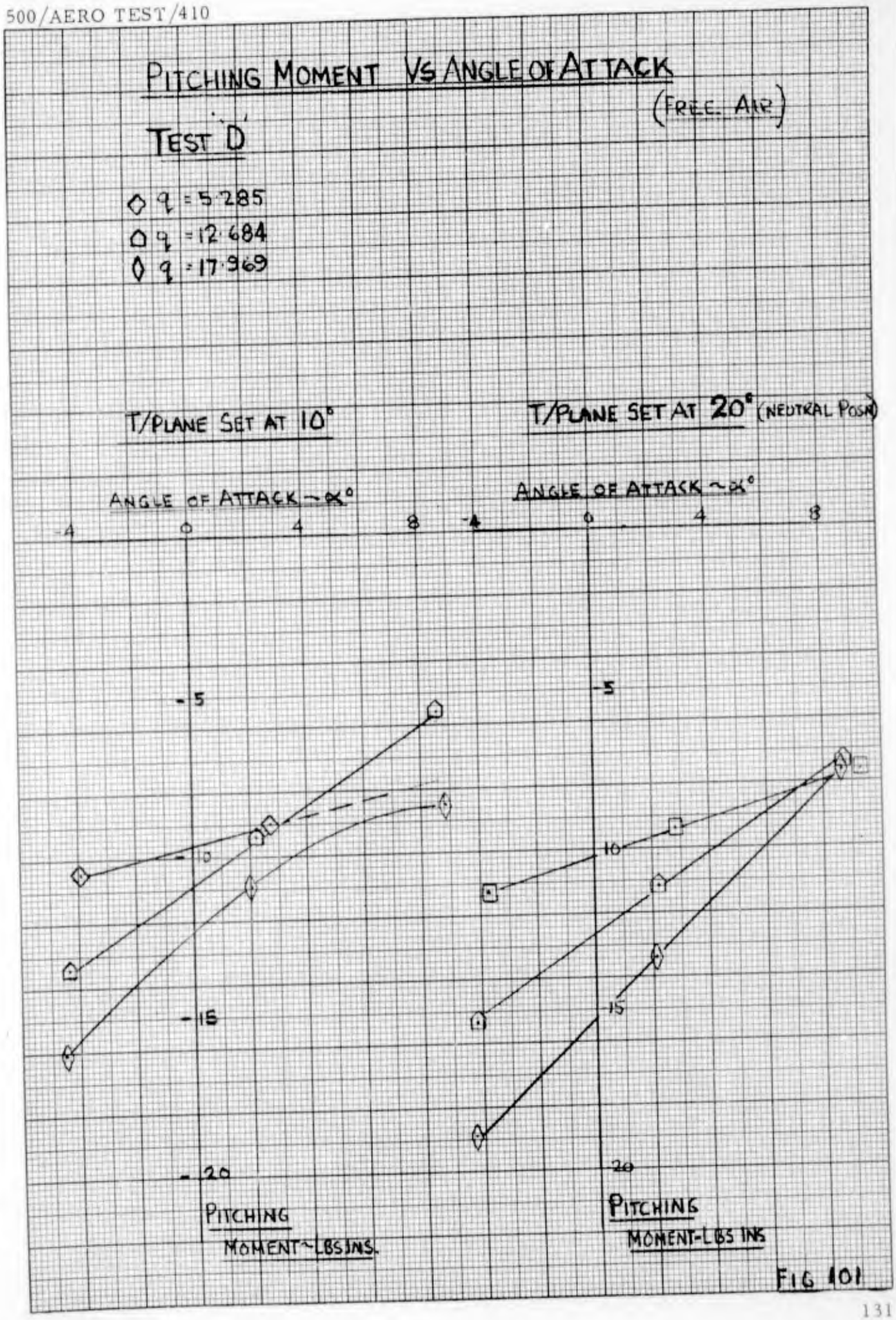


FIG 101

PITCHING MOMENT VS ANGLE OF ATTACK

(FREE AIR)

TEST 'D'

◇ q = 5·285
△ q = 12·684
◇ q = 17·696

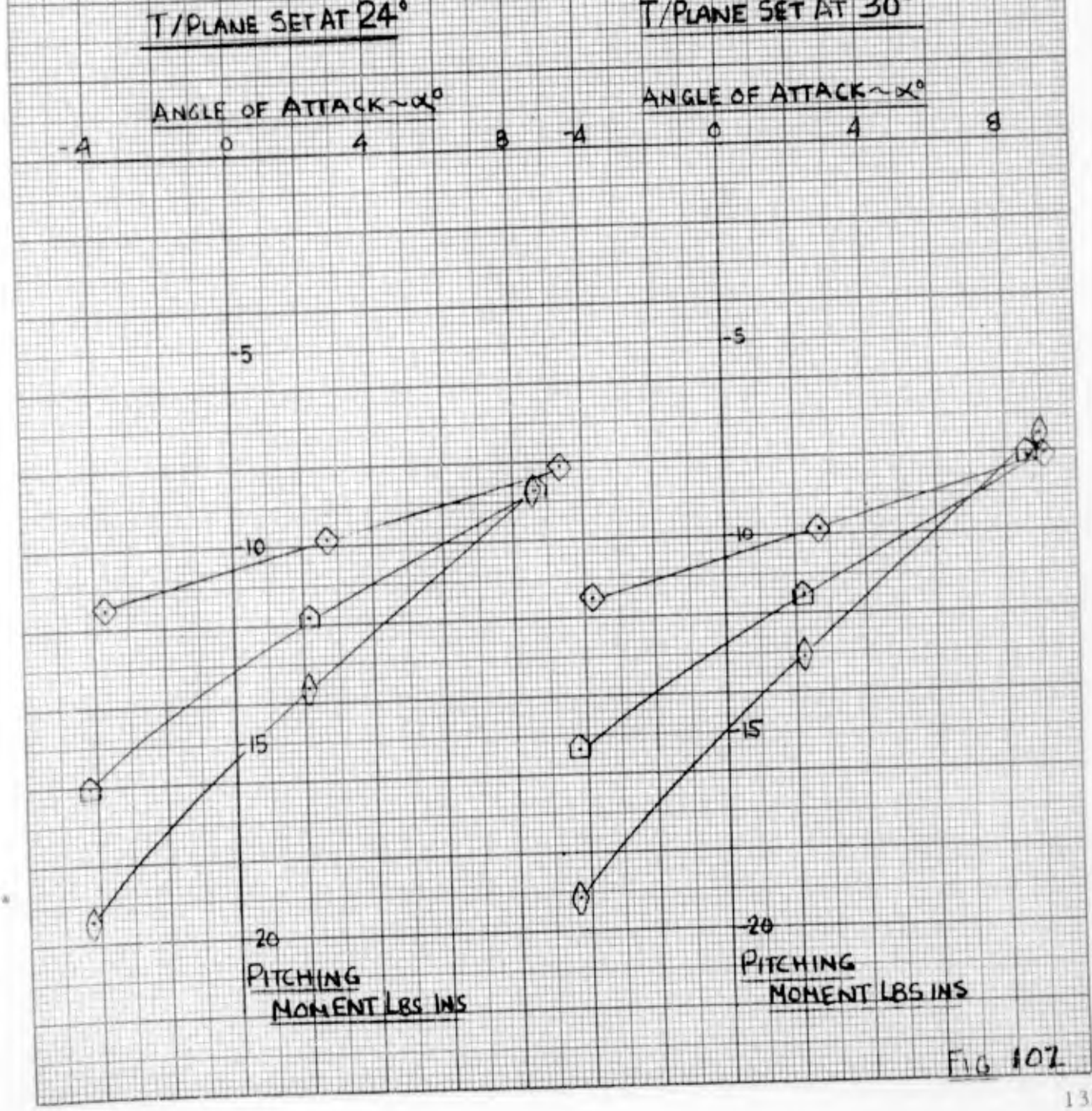


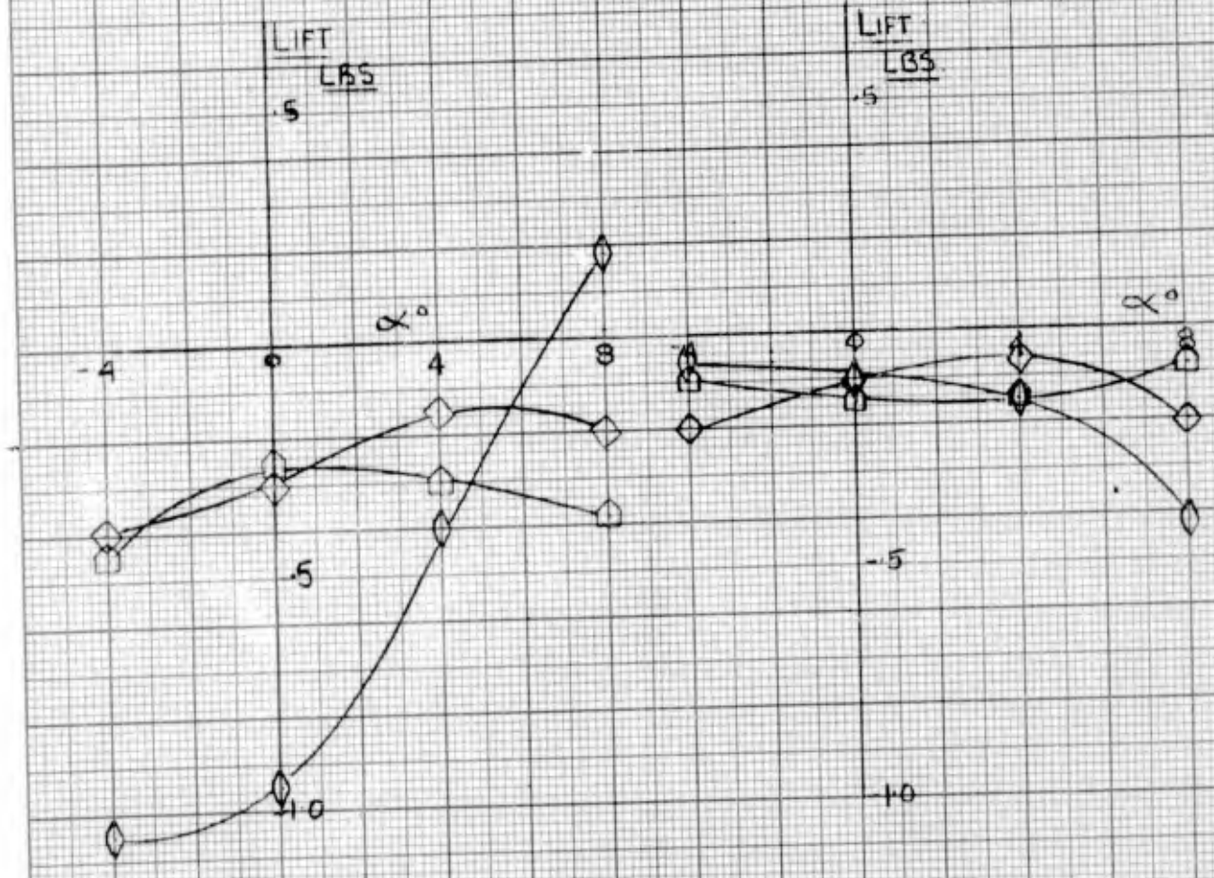
FIG 107

LIFT. Vs ANGLE OF ATTACK

TAIL PLANE EFFECT – RUN 'D' - 'C'

(FREE A.P.)

◇ q = 5·285
⬡ q = 12·684
◊ q = 17·969



T/PLANE SET AT 10°

T/PLANE SET AT 20°
(NEUTRAL POSN.)

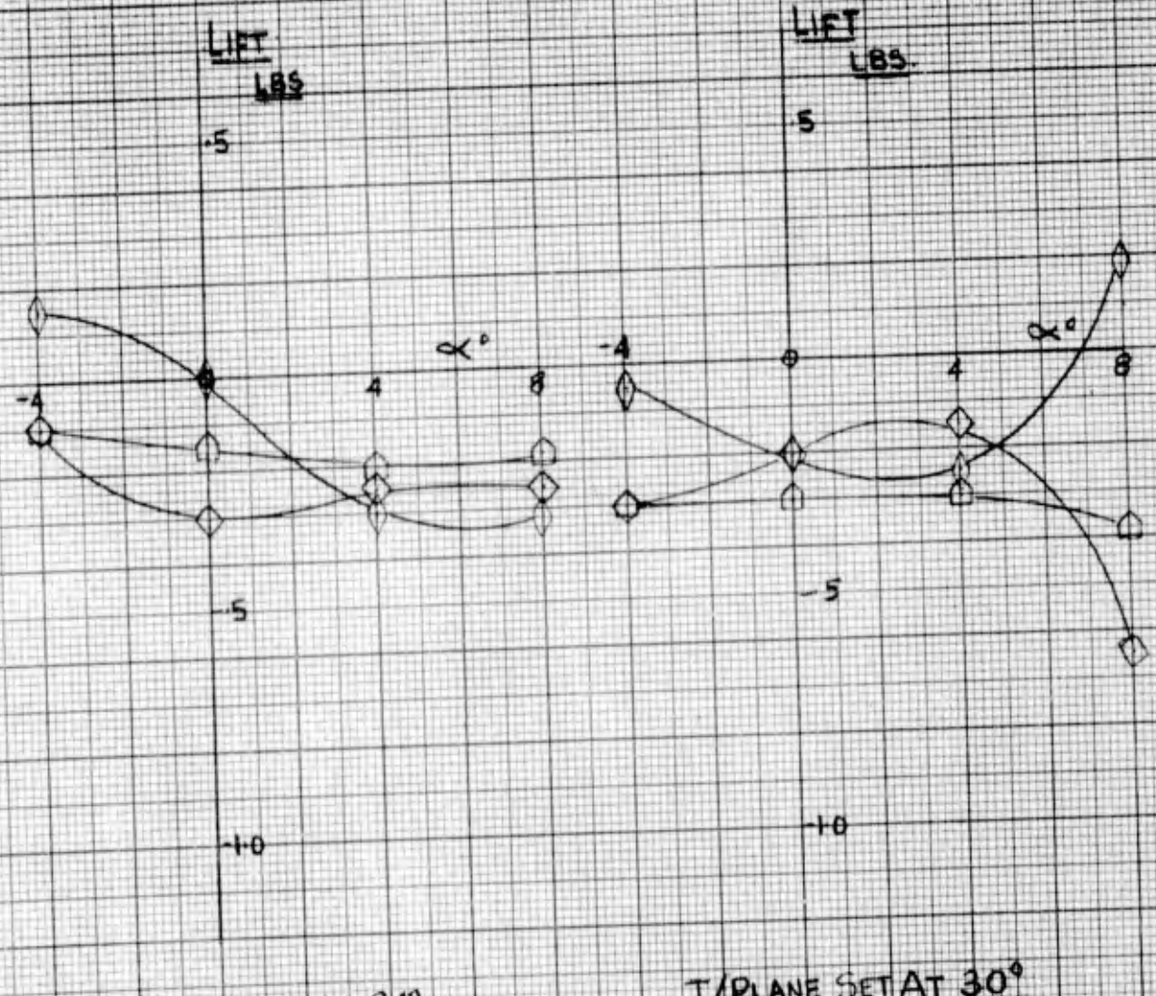
FIG 103

LIFT VS ANGLE OF ATTACK

TAIL PLANE EFFECT ~ RUN 'D' - 'C'

(FREE AIR)

◇ q = 5·285
⬡ q = 12·684
◇ q = 17·969



T/PLANE SET AT 24°

T/PLANE SET AT 30°

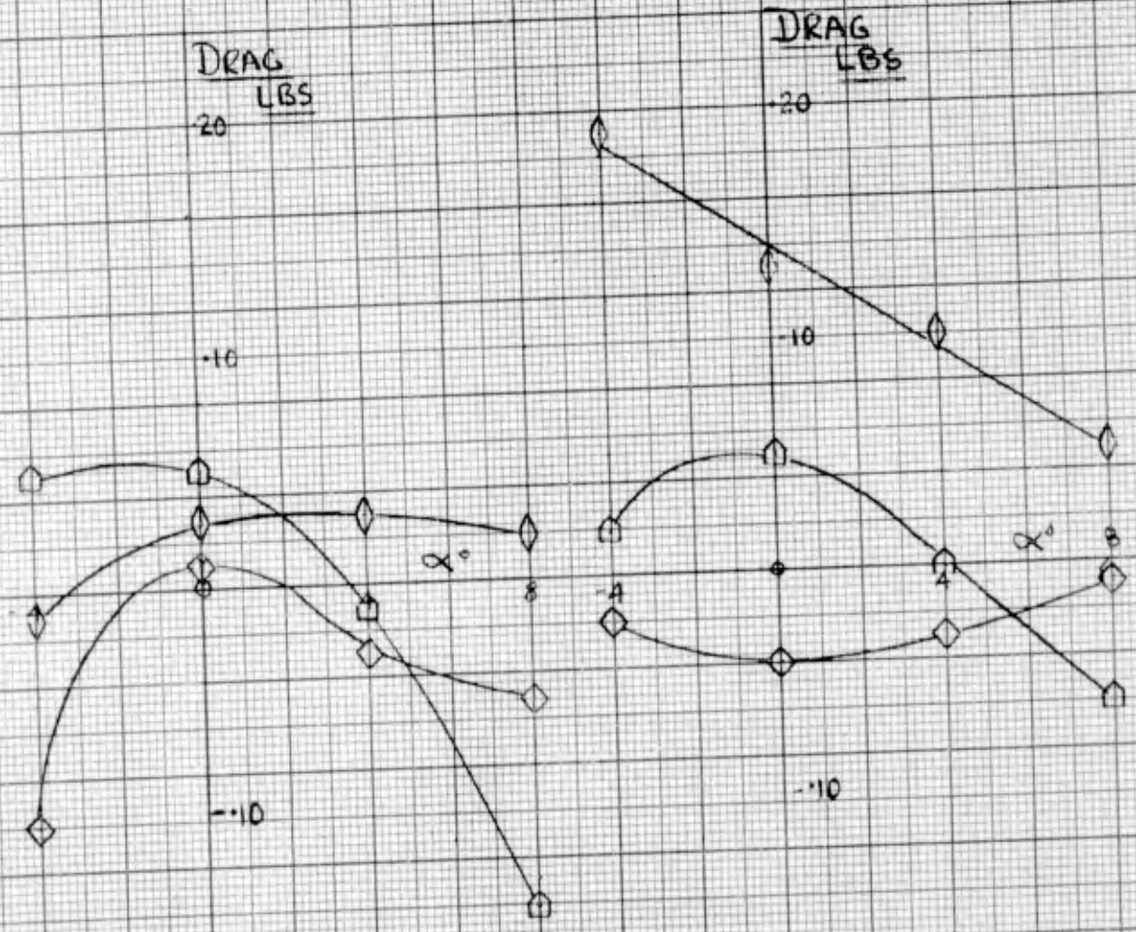
FIG 104

DRAG VS ANGLE OF ATTACK

TAIL PLANE EFFECT ~ RUN D'-C'

(FREE AIR)

◇ q = 5·285
⌂ q = 12·684
◊ q = 17·969



T/PLANE SET AT 10°

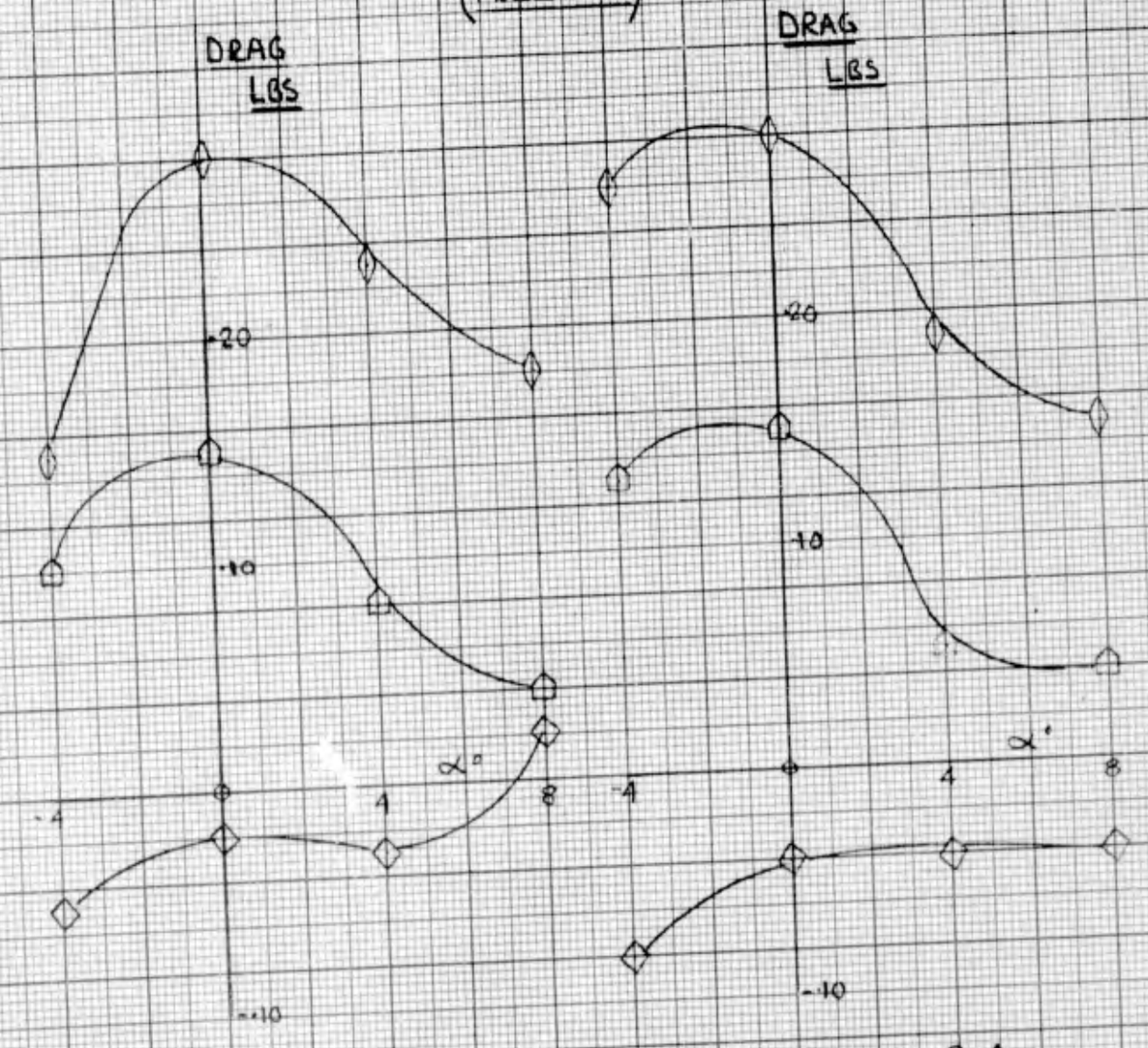
T/PLANE SET AT 20°
(NEUTRAL POS'N)

FIG 105

DRAG VS ANGLE OF ATTACK

TAIL PLANE EFFECT ~ RUN D'-C'

(FREE AIR)

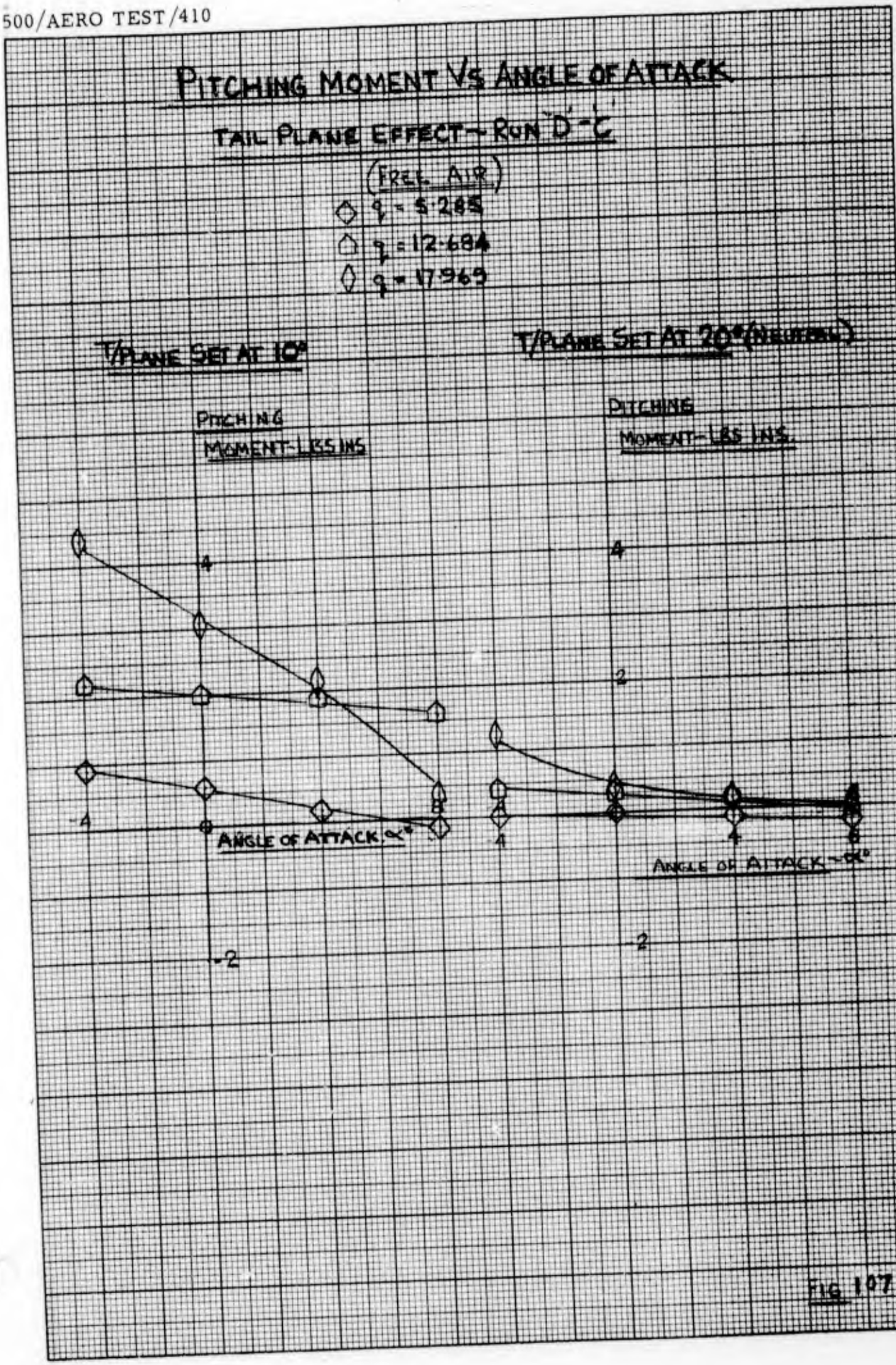


T/PLANE SET AT 24°

T/PLANE SET AT 30°

◇ q = 5·285
⬡ q = 12·684
⬯ q = 17·969

FIG 106


PITCHING MOMENT VS ANGLE OF ATTACK
TAIL PLANE EFFECT - RUN 'D' - 'C'
(FREE AIR)
q = 5.285
q = 12.684
q = 17.969
T/PLANE SET AT 10°
T/PLANE SET AT 20° (NEUTRAL)
PITCHING MOMENT-LBS INS.
PITCHING MOMENT-LBS INS.
4
2
-2
-4
ANGLE OF ATTACK α°
ANGLE OF ATTACK α°
FIG 107

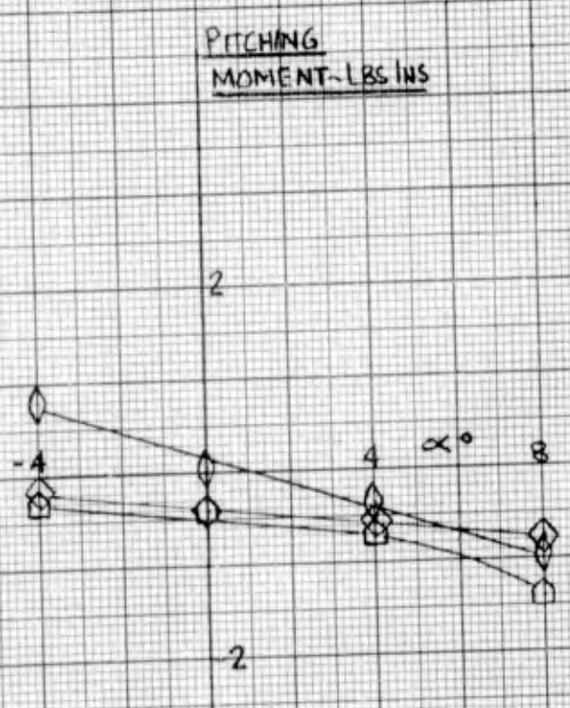
PITCHING MOMENT Vs ANGLE OF ATTACK

TAIL PLANE EFFECT ~ RUN D - C

(FREE AIR)

◇ q = 5·285
□ q = 12·684
◇ q = 17·969

T/PLANE SET AT ~ 24°



T/PLANE SET AT ~ 30°

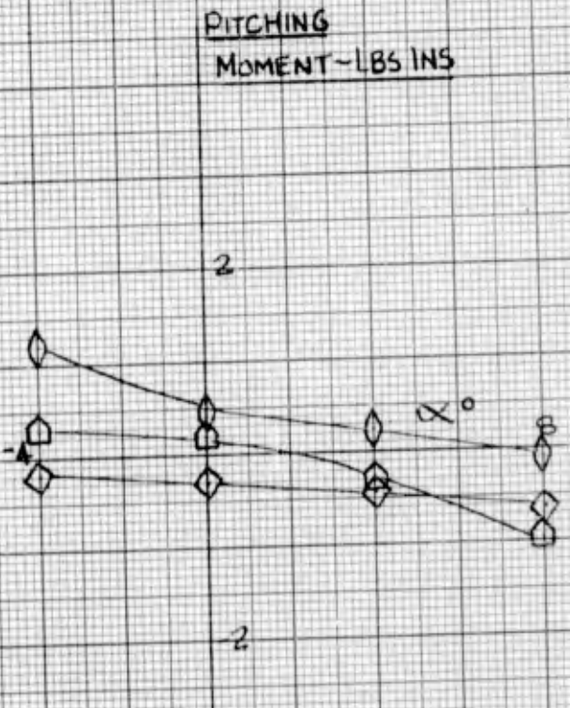


FIG 106

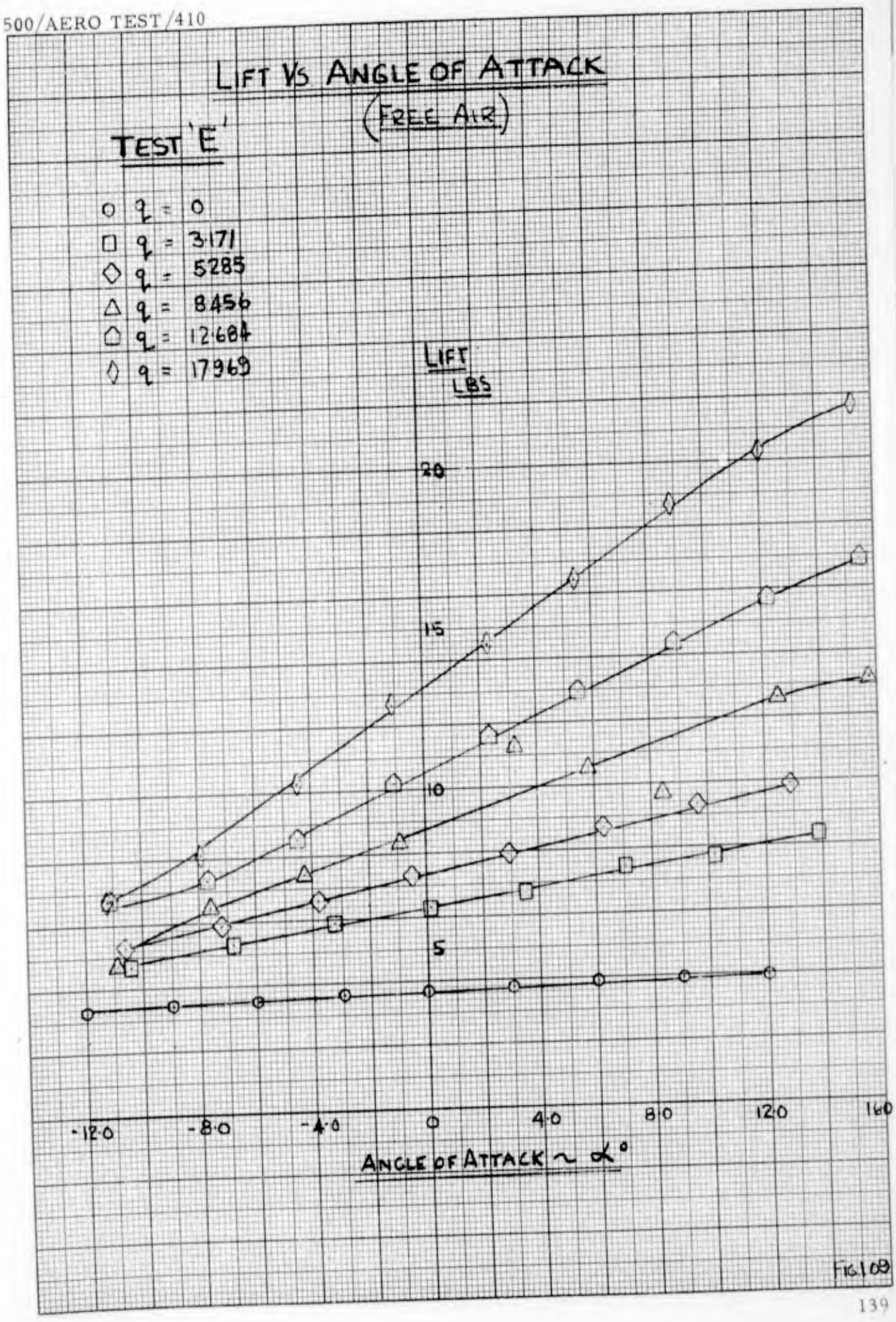

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
○ q = 0
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 17969
LIFT
LBS
20
15
10
5
-12·0
-8·0
-4·0
0
4·0
8·0
12·0
16·0
ANGLE OF ATTACK ~ α°

Fig 109

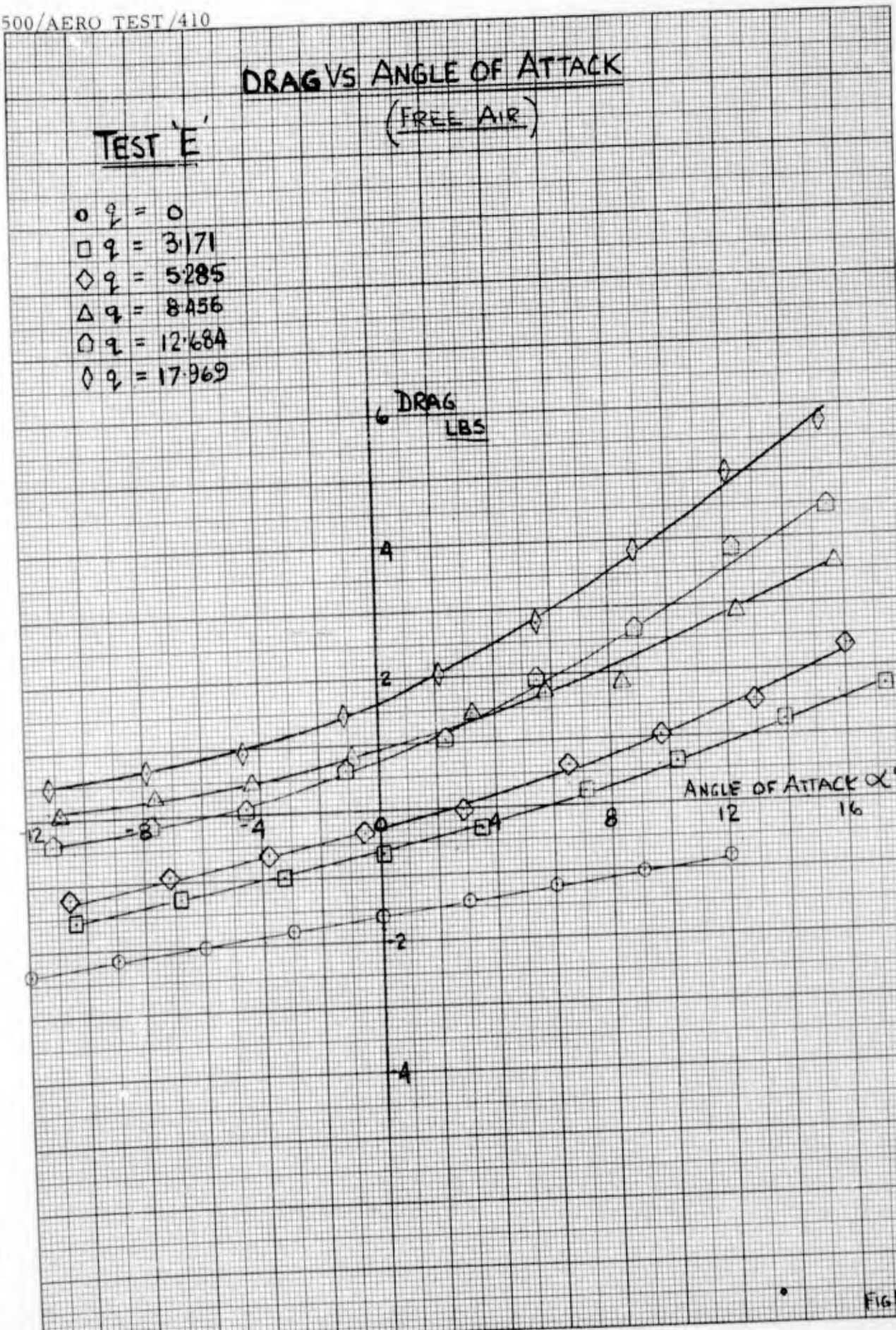

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
o q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
DRAG
LBS
6
4
2
-2
-4
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK α°

Fig 10

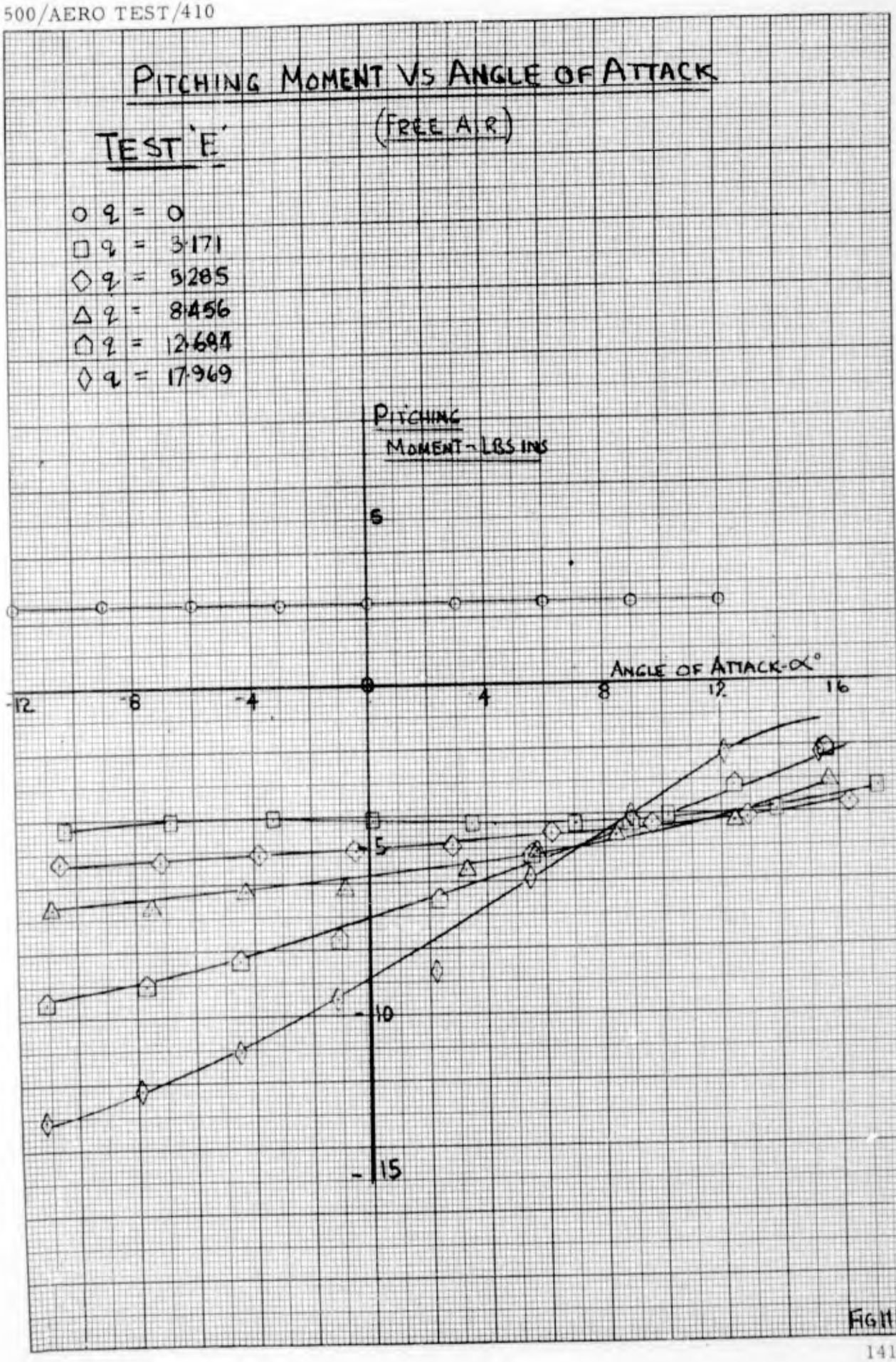

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·694
◊ q = 17·969
PITCHING MOMENT - LBS INS
ANGLE OF ATTACK-α°
-12
-8
-4
4
8
12
16
5
-5
-10
-15

FIG II E

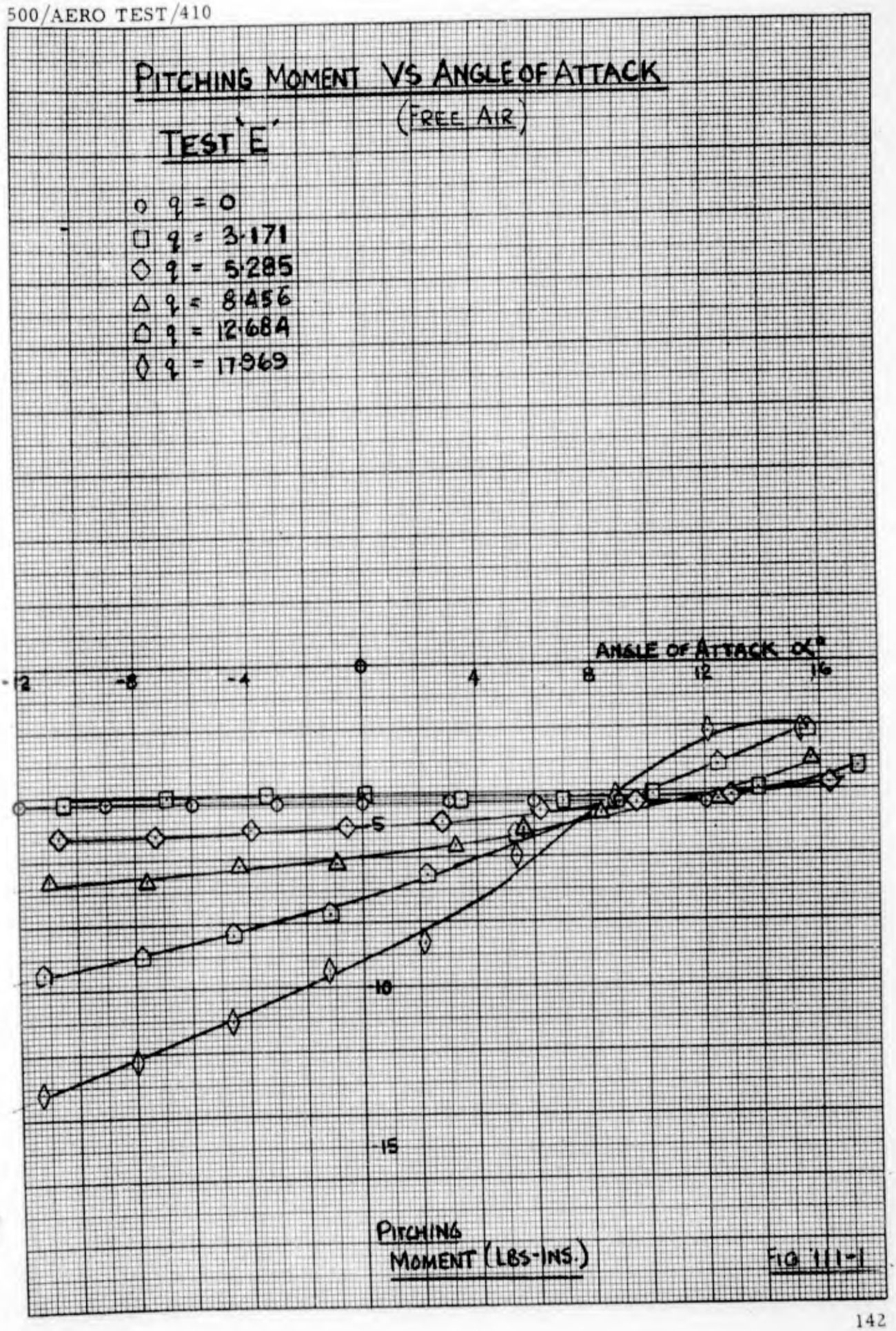

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
16
-5
-10
-15
PITCHING MOMENT (LBS-INS.)

FIG 111-1

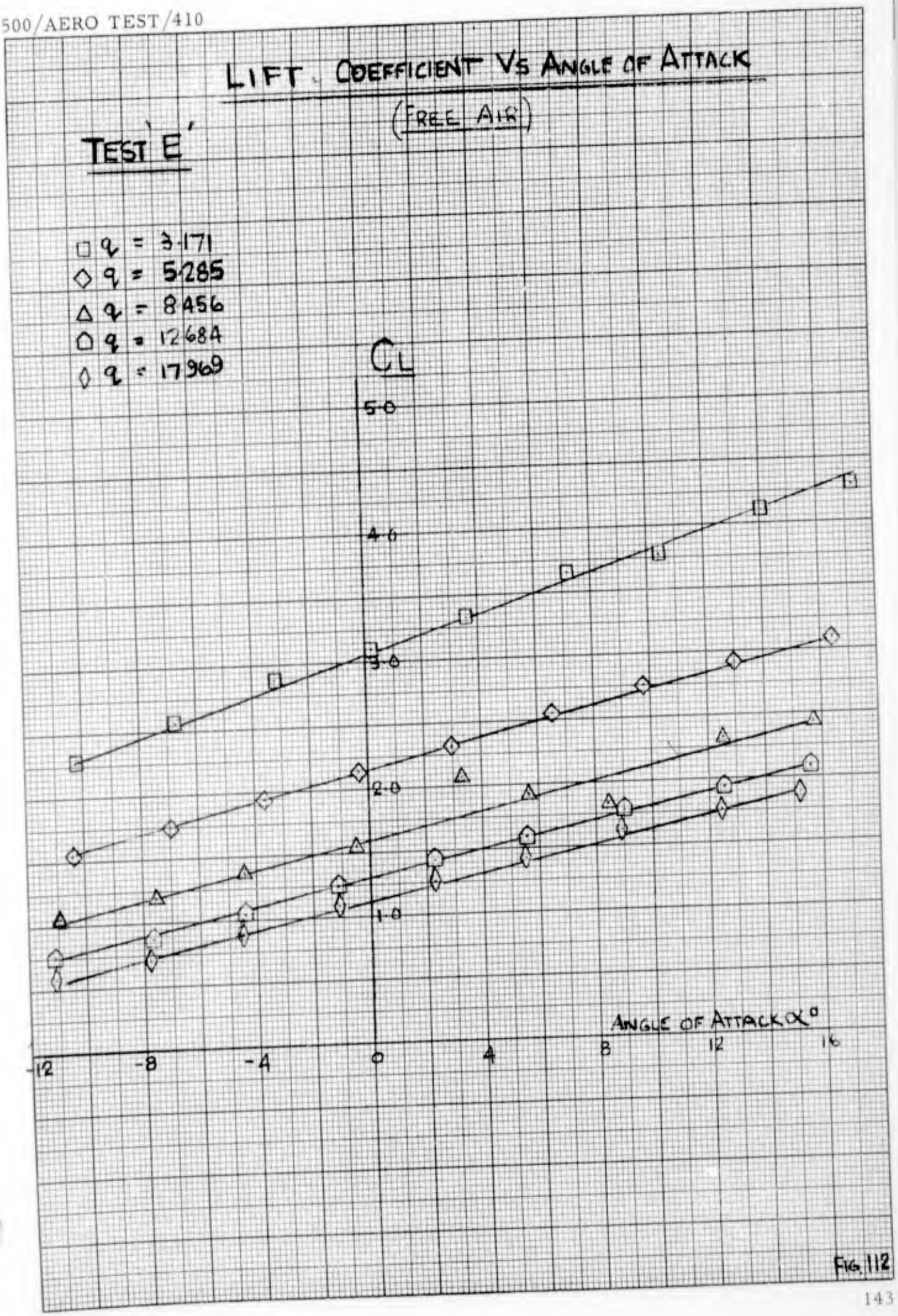

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST E'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CL
5·0
4·0
3·0
2·0
1·0
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
16

FIG. 112

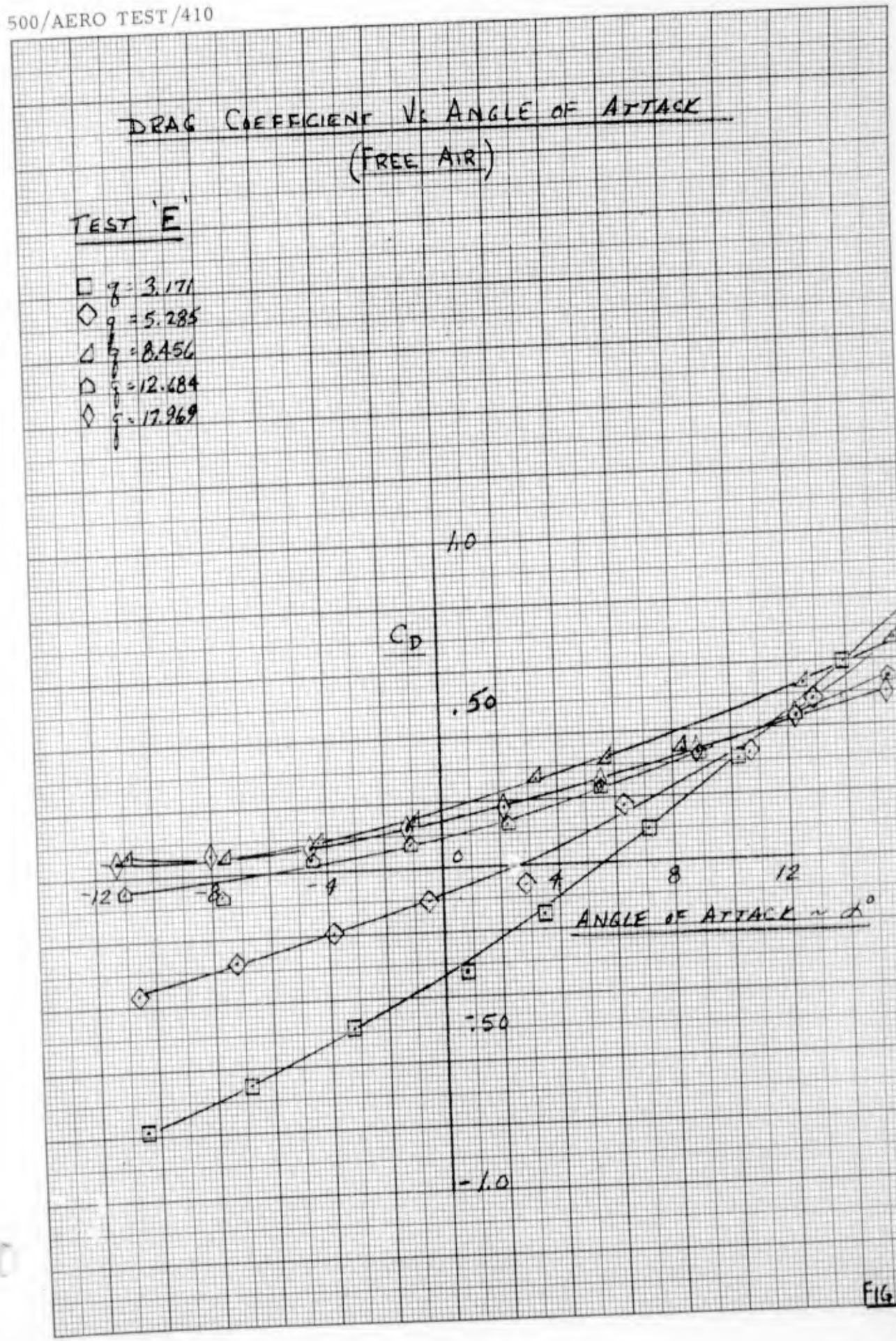
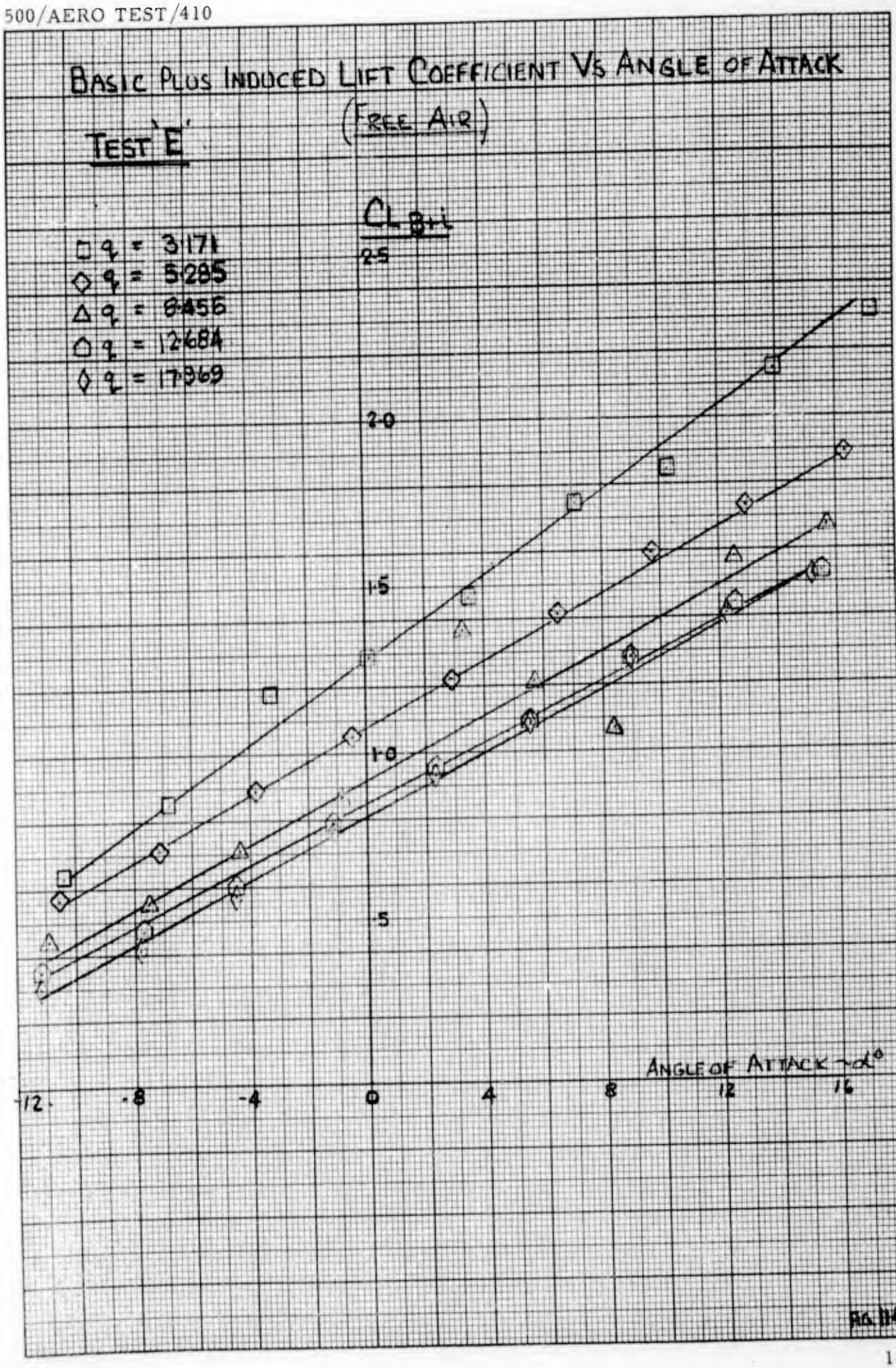

DRAG COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
1.0
C_D
.50
0
4
8
12
-12
-8
-4
ANGLE OF ATTACK ~ α°
-.50
-1.0

FIG 113


BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 17969
CL B+i
2.5
2.0
1.5
1.0
.5
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
16

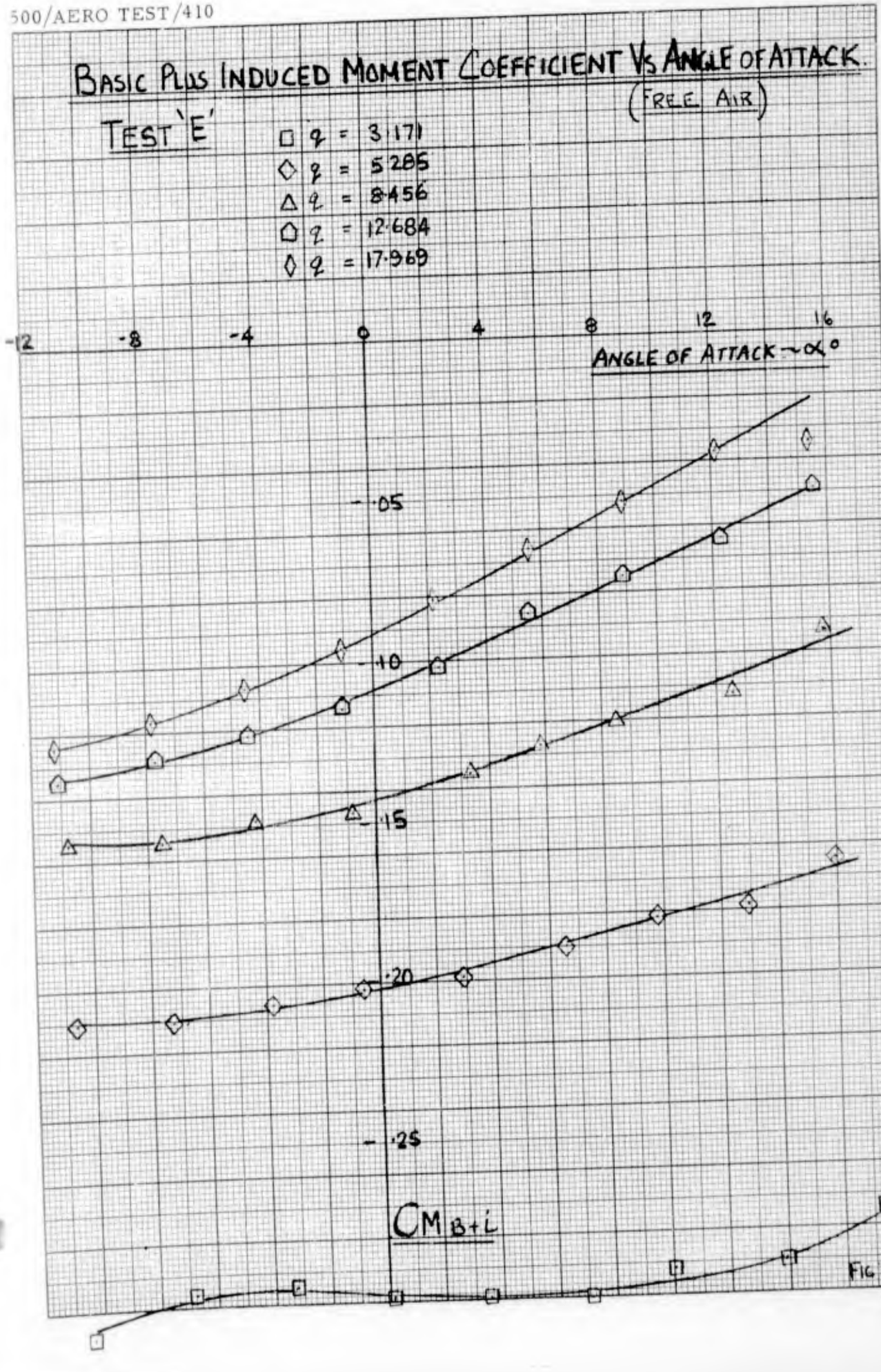
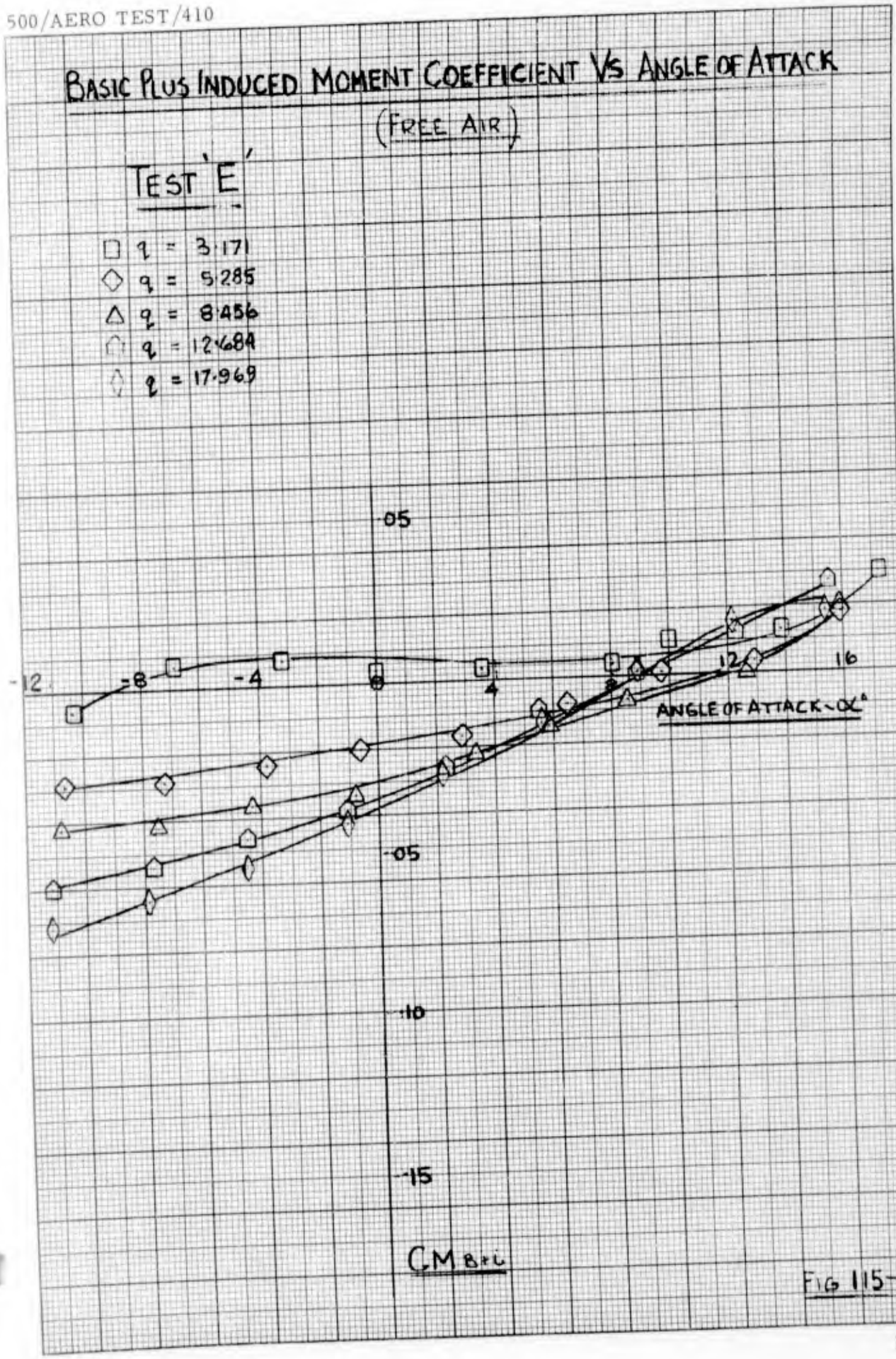

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'E'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°
-·05
-·10
-·15
-·20
-·25
CM B+i

FIG 115


BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'E'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
⬡ q = 17.969
-05
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK - α°
-05
-10
-15
CM B+L
FIG 115-1

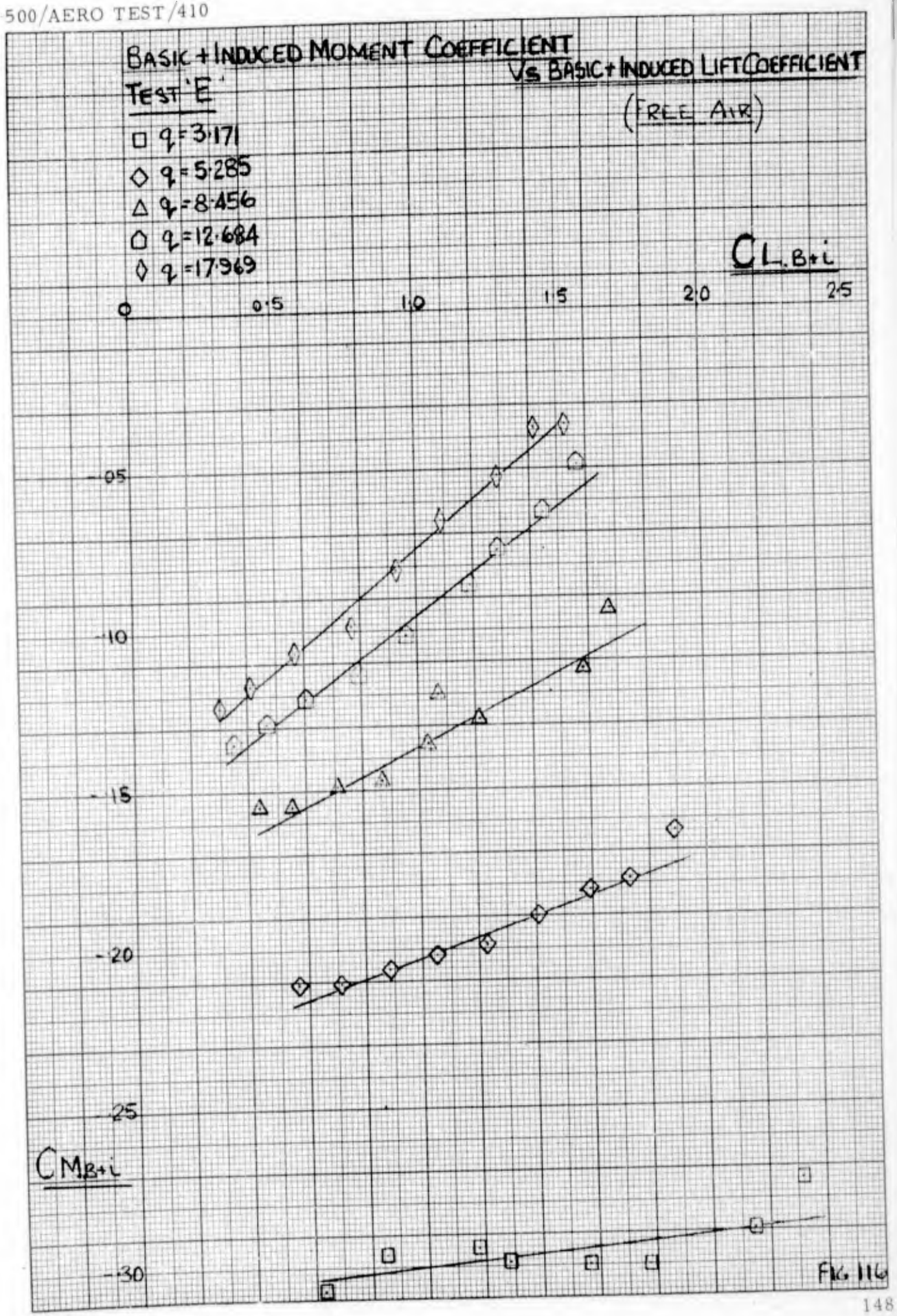

BASIC + INDUCED MOMENT COEFFICIENT
Vs BASIC + INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'E'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CL.B+i
0
0.5
1.0
1.5
2.0
2.5
-05
-10
-15
-20
-25
-30
CMB+i

Fig. 116

PITCHING MOMENT COEFFICIENT VS. LIFT COEFFICIENT

(FREE AIR)

TEST E'

□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969

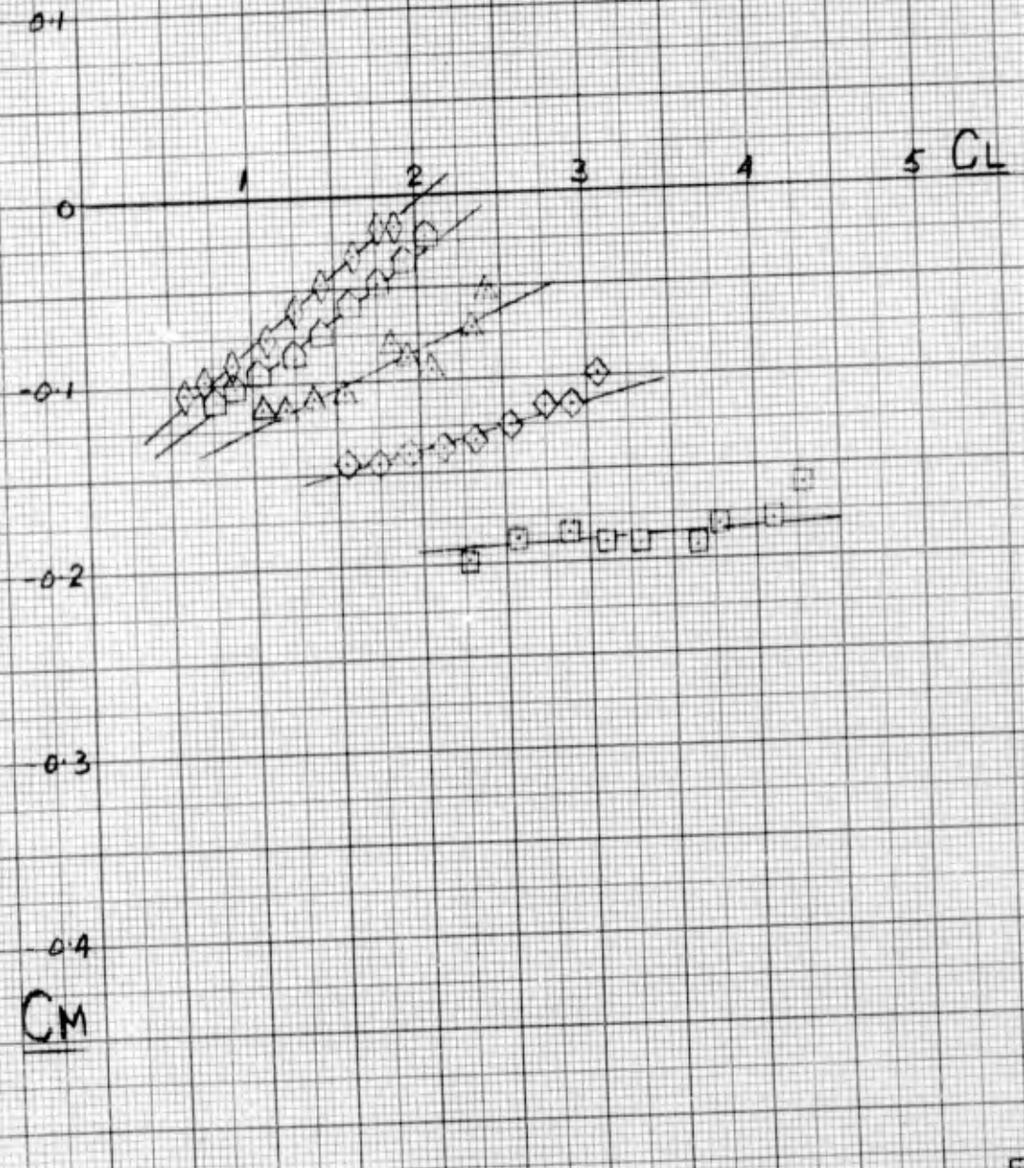


FIG 117

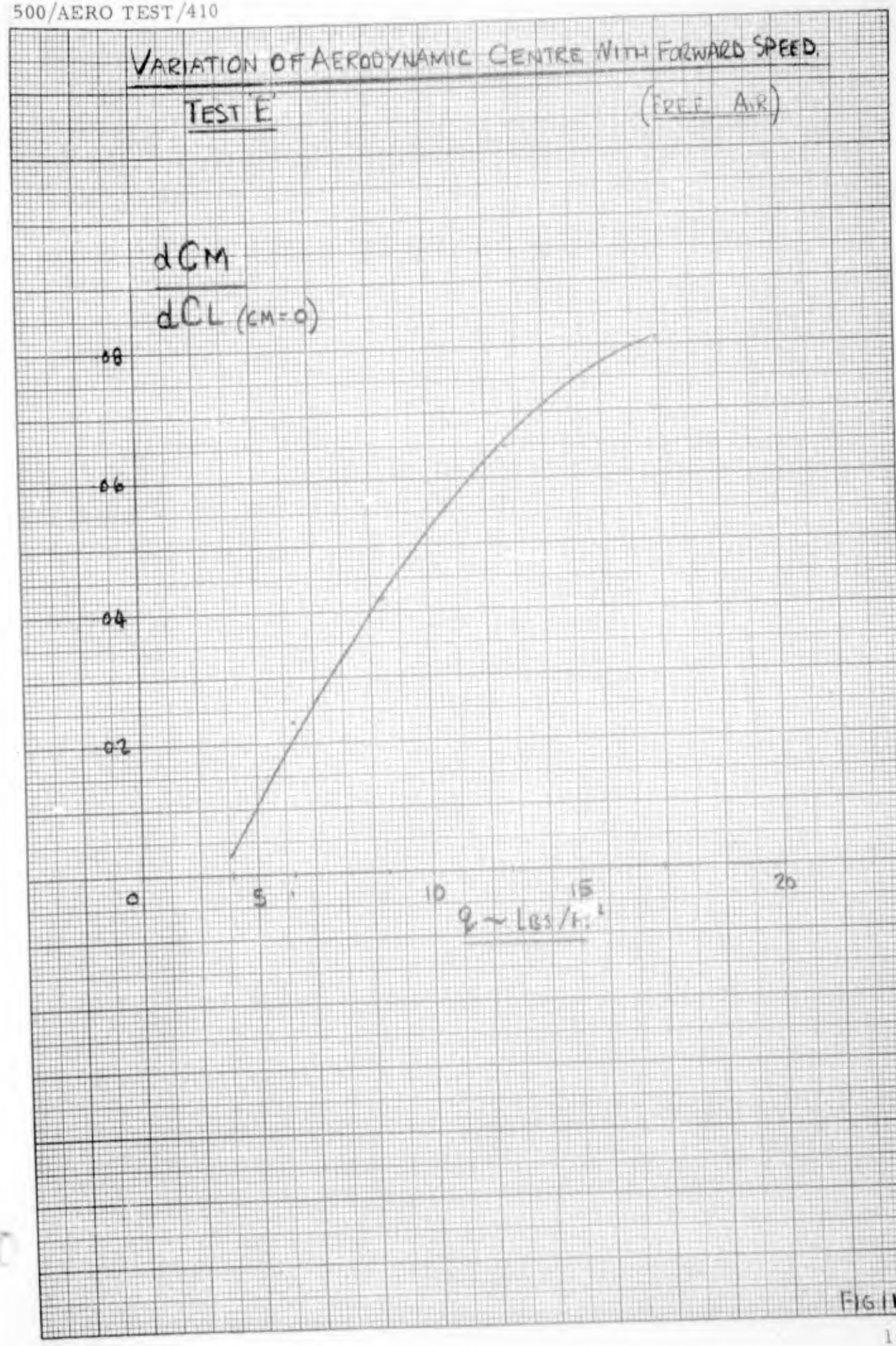

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED.
TEST E
(FREE AIR)
dCM / dCL (CM=0)
·08
·06
·04
·02
0
5
10
15
20
q ~ LBS/FT.²

FIG 118

LIFT CURVE SLOPE VS. FORWARD SPEED.

TEST 'E' (FREE AIR)

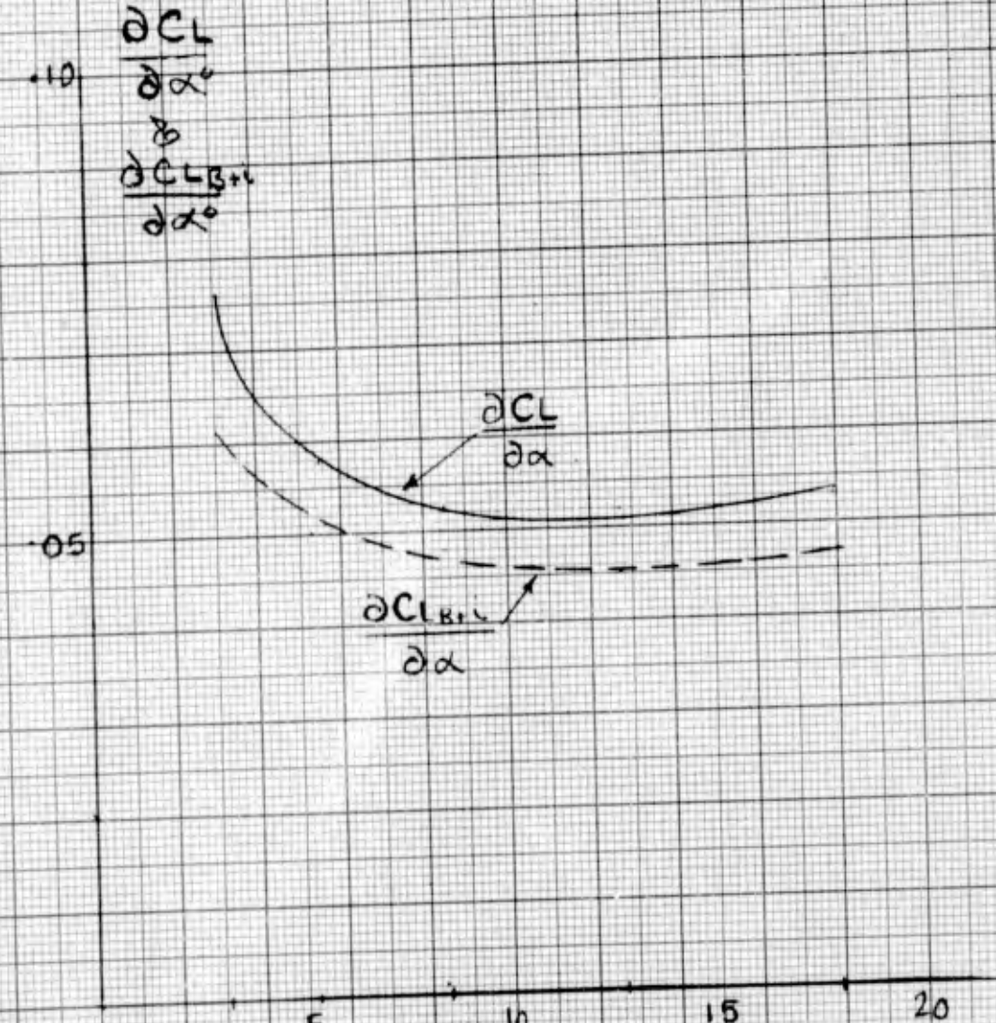


FIG 119

PITCHING MOMENT VS DYNAMIC PRESSURE

(FREE AIR)

TEST 'E'

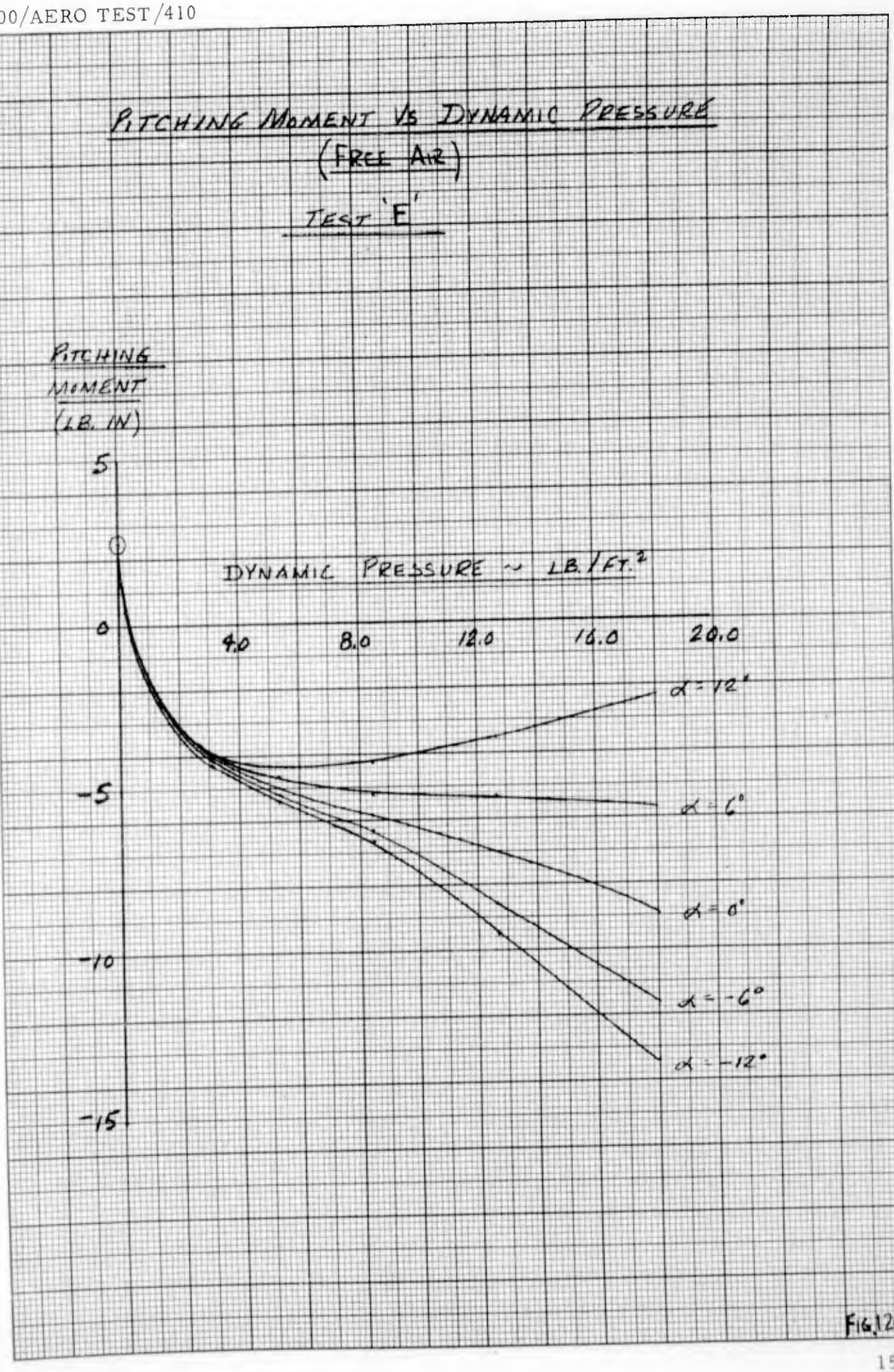


FIG. 120

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST 'E'

(FREE AIR)

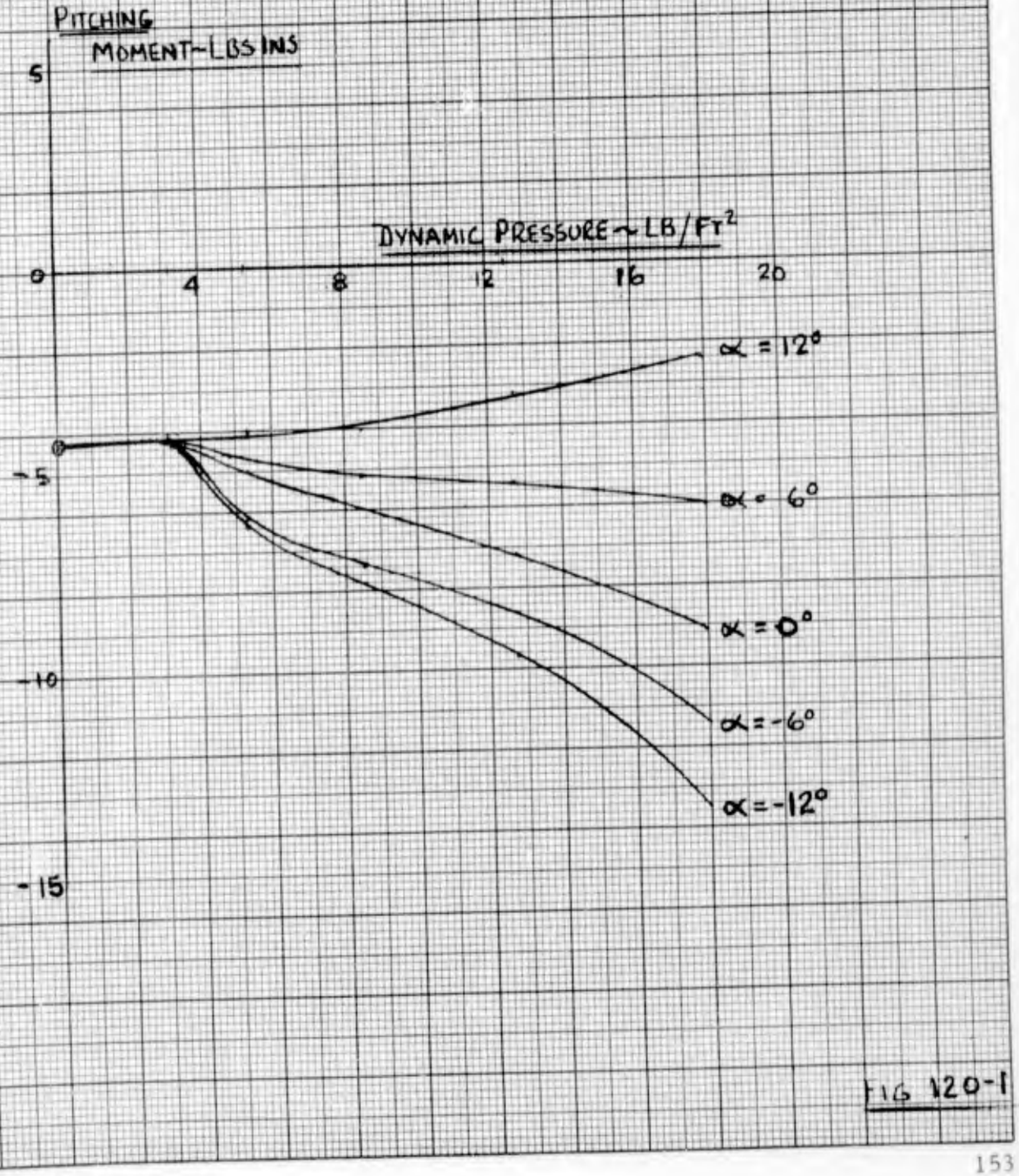


FIG 120-1

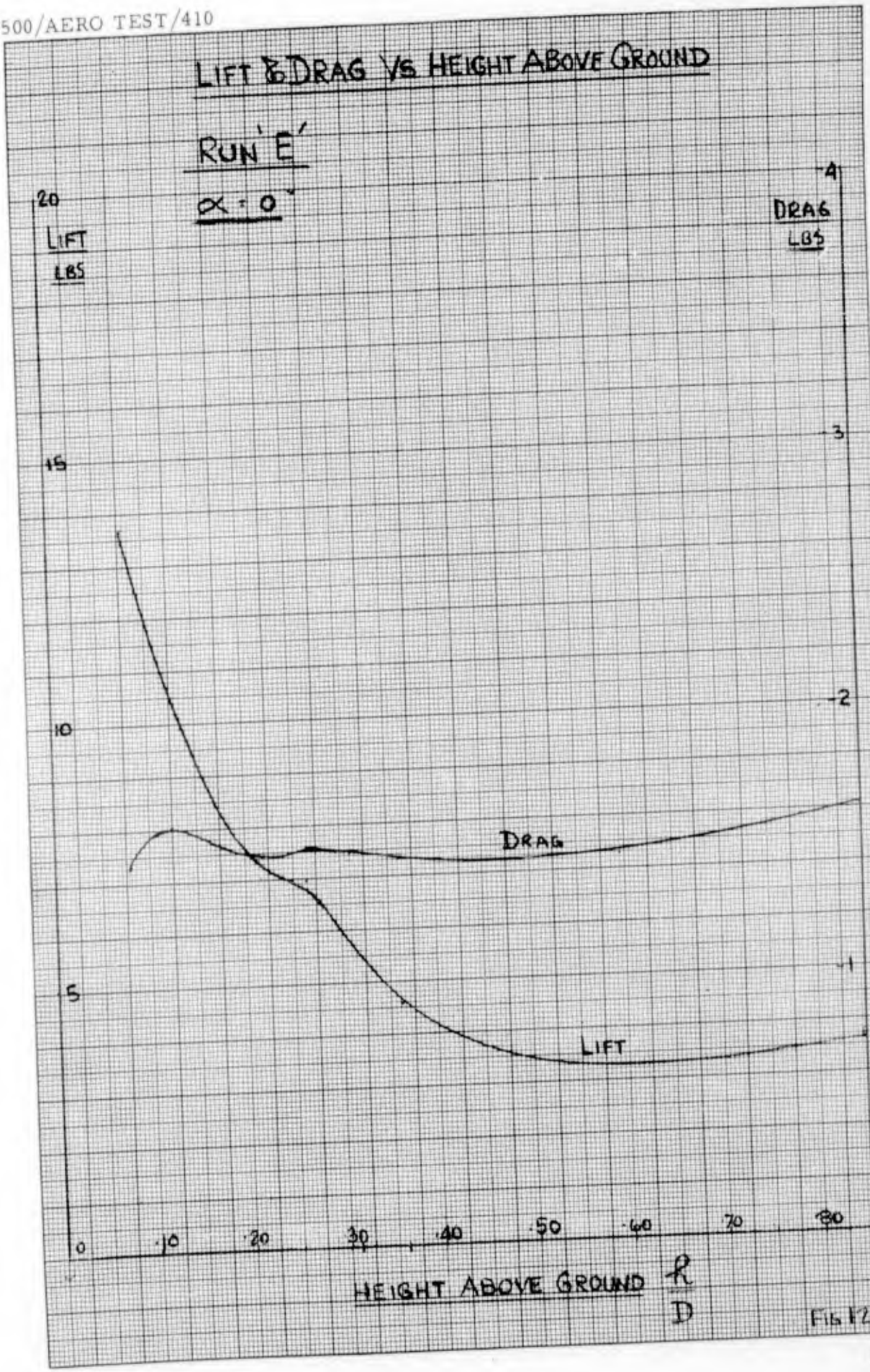

LIFT & DRAG VS HEIGHT ABOVE GROUND
RUN 'E'
α = 0°
LIFT LBS
DRAG LBS
20
15
10
5
4
3
2
1
DRAG
LIFT
0
10
20
30
40
50
60
70
80
HEIGHT ABOVE GROUND
h/D

Fig 12

PITCHING MOMENT VS. HEIGHT ABOVE GROUND

TEST 'E'

$\alpha = 0°$

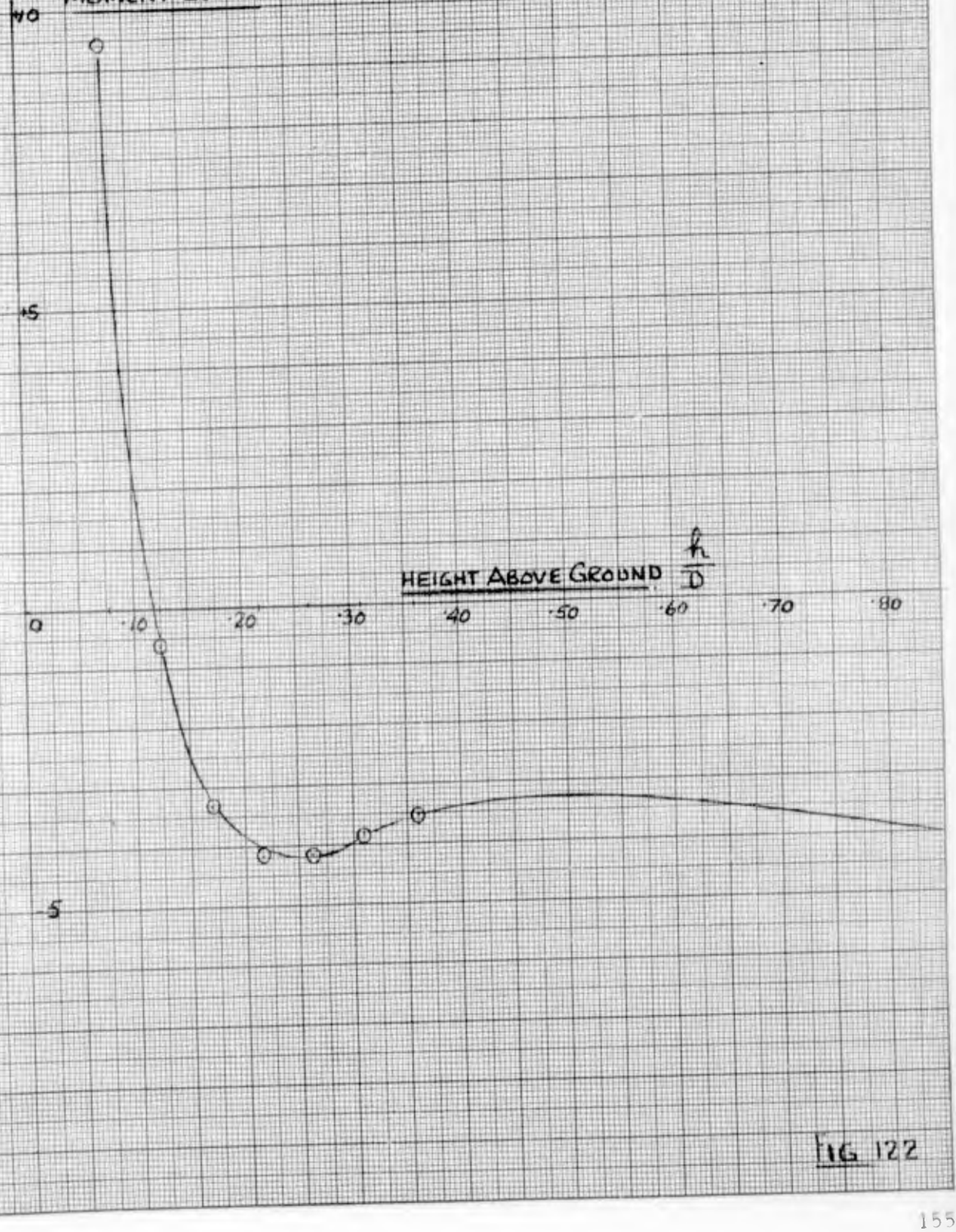


FIG 122

THIS PAGE DELETED

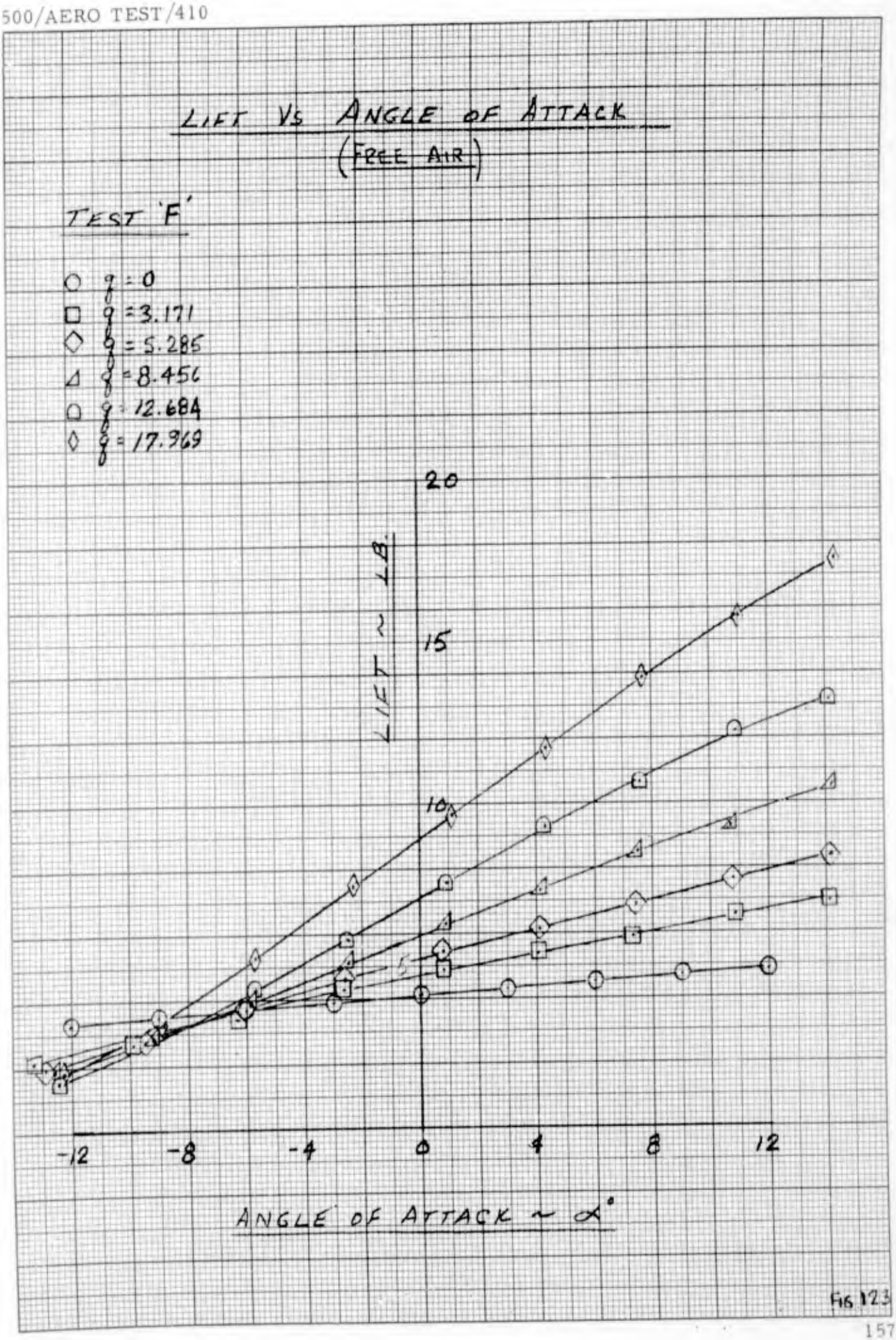

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◇ q = 17.969
LIFT lb.
20
15
10
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 123

DRAG VS ANGLE OF ATTACK
(FREE AIR)

TEST 'F'

- ○ $q = 0$
- □ $q = 3.171$
- ◇ $q = 5.285$
- △ $q = 8.456$
- ⬠ $q = 12.684$
- ◊ $q = 17.969$

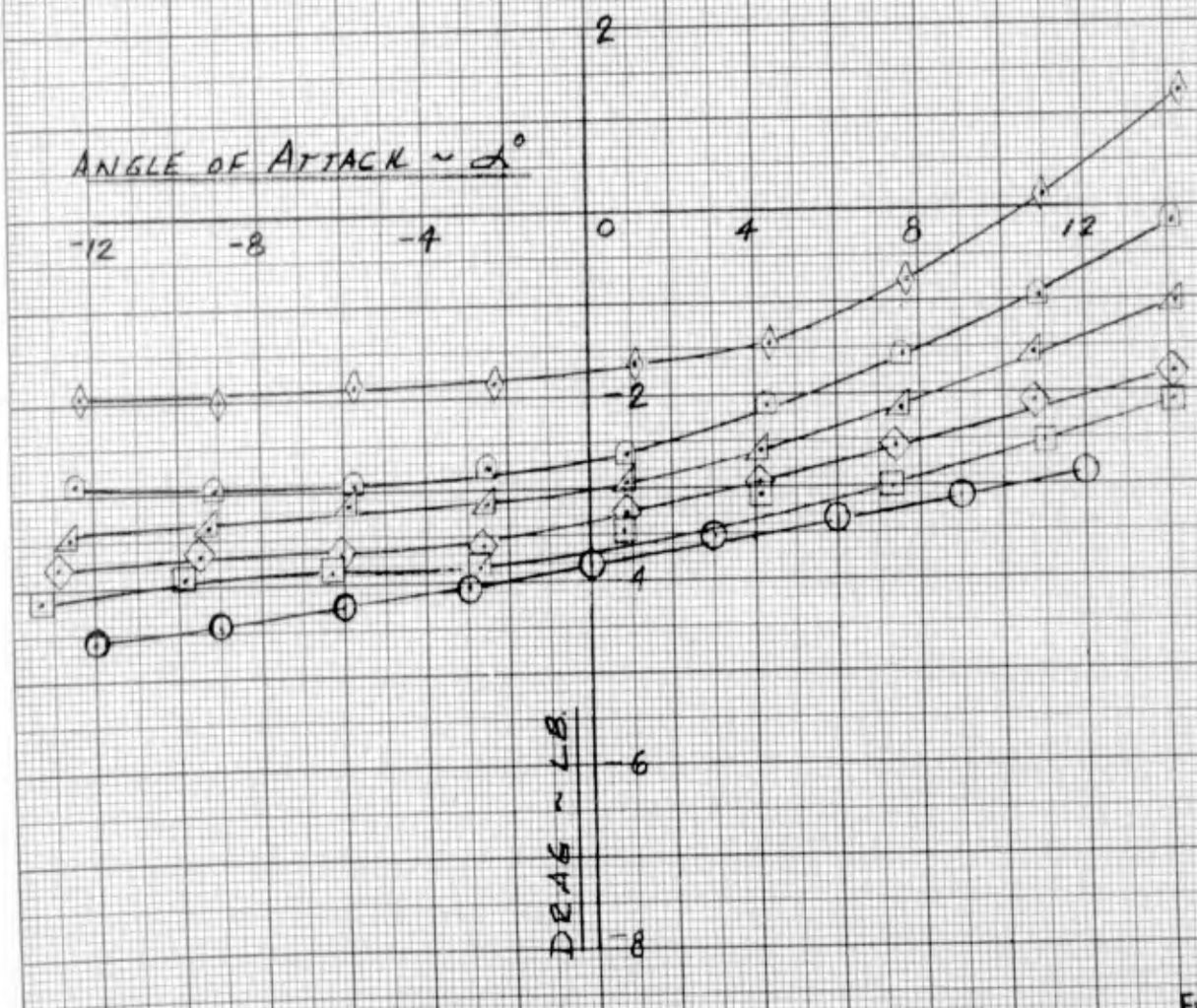


FIG 124

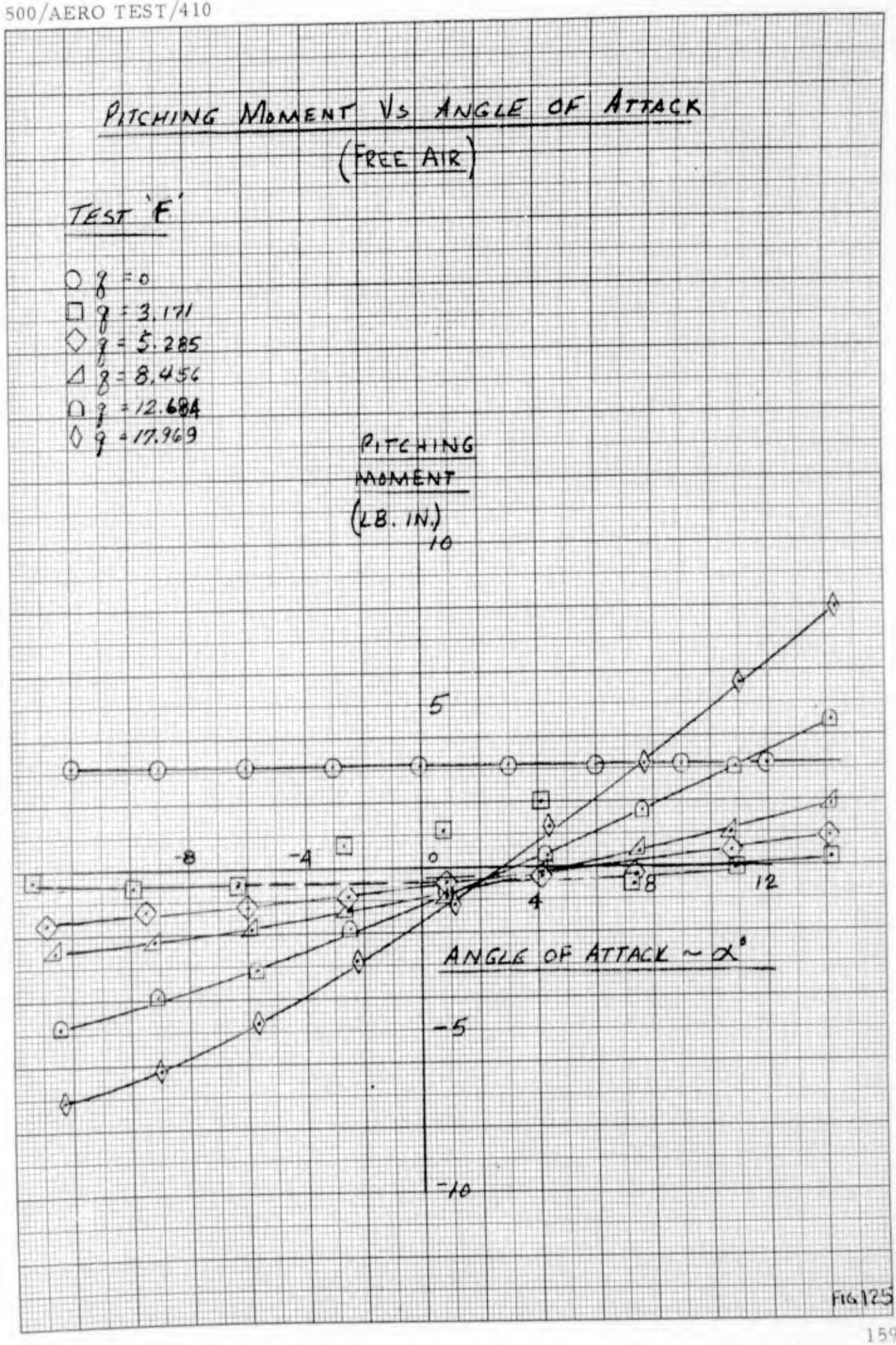

PITCHING MOMENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
∩ q = 12.684
◊ q = 17.969
PITCHING MOMENT (LB. IN.)
10
5
-5
-10
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 125

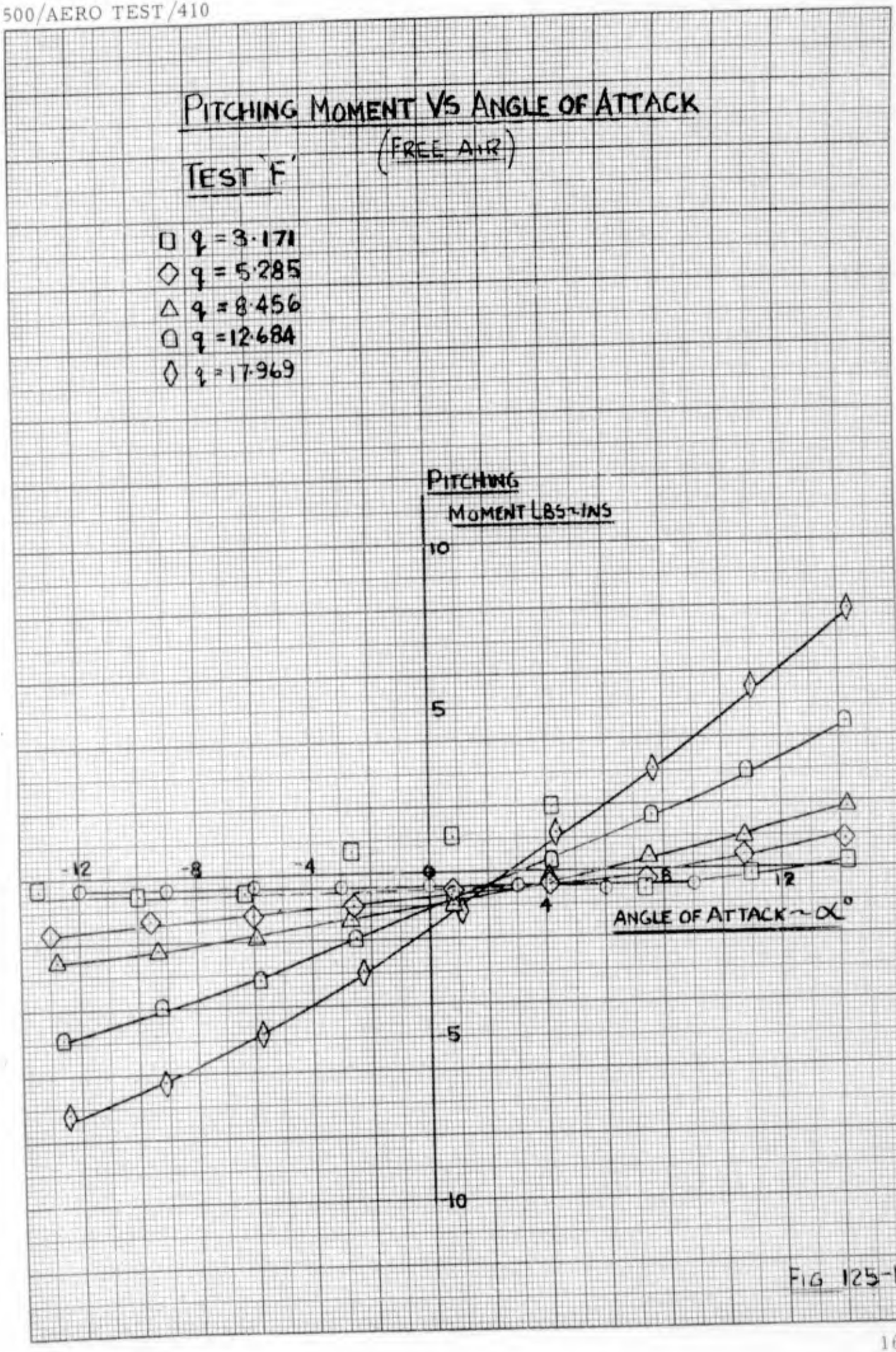

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
○ q = 12·684
◊ q = 17·969
PITCHING
MOMENT LBS-INS
10
5
-5
-10
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 125-1

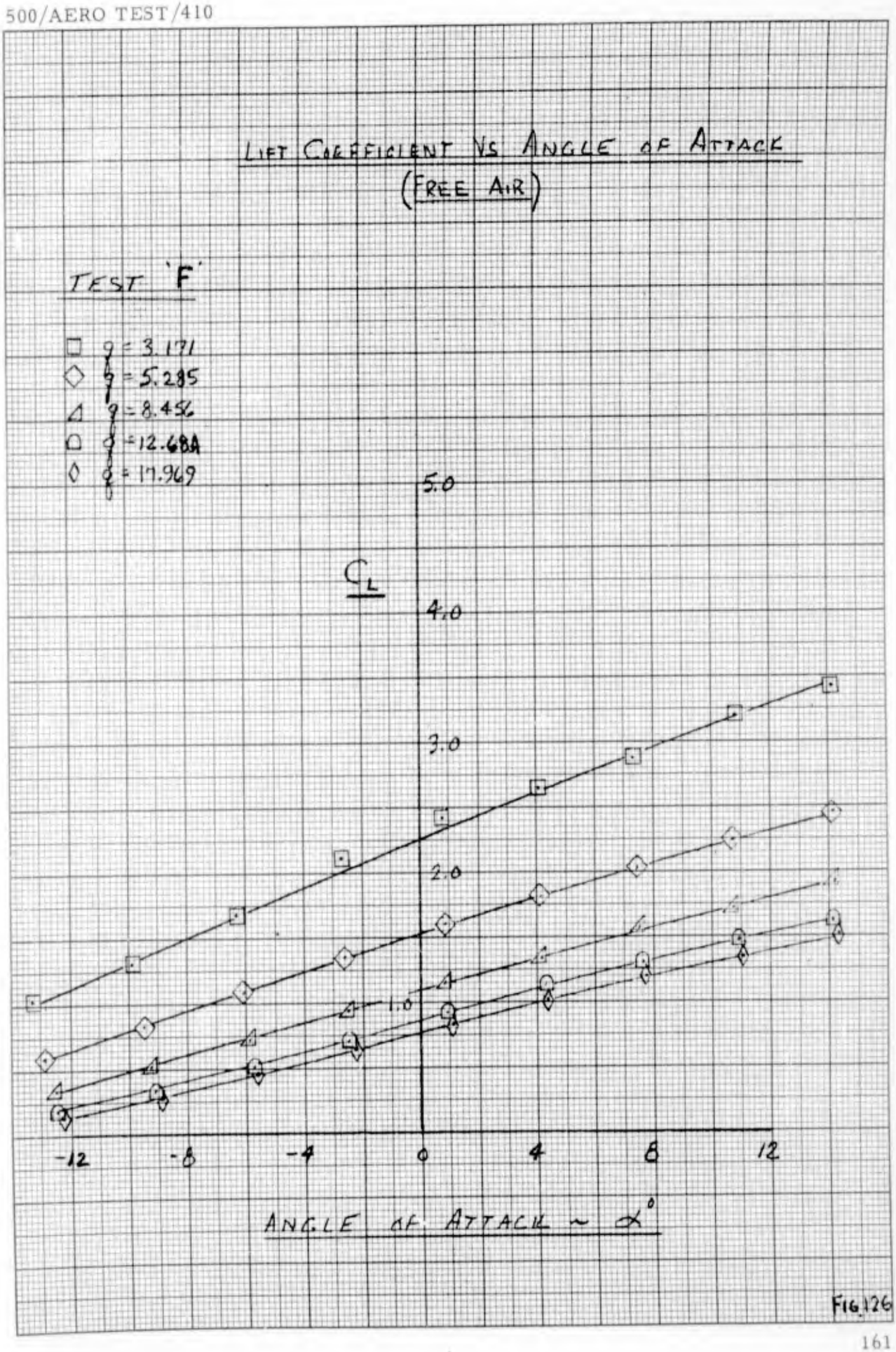

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.68A
◇ q = 17.969
5.0
C_L
4.0
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α^0

FIG 126

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)

TEST 'F'

□ $q = 3.171$
◇ $q = 5.285$
△ $q = 8.456$
○ $q = 12.684$
◊ $q = 17.969$

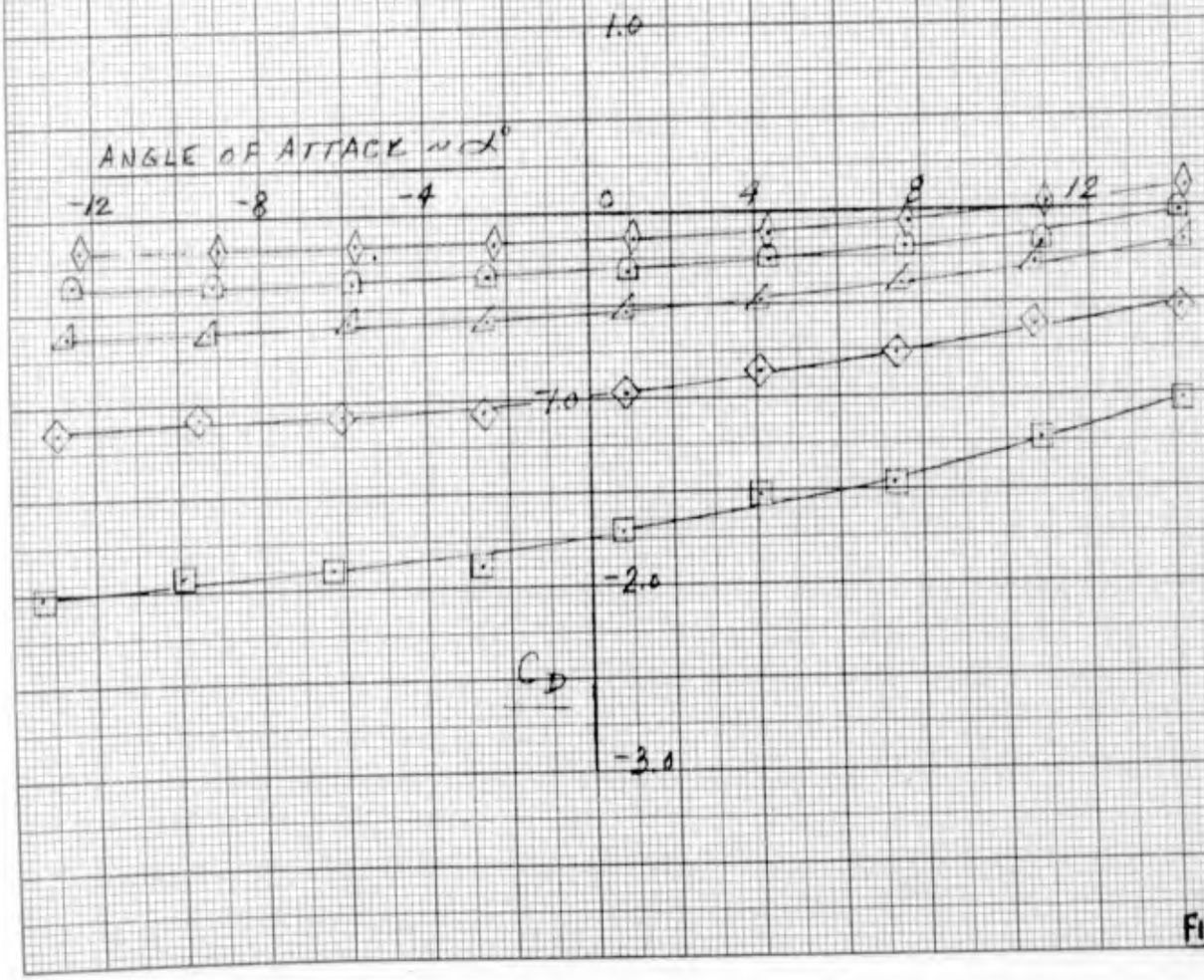


FIG. 127

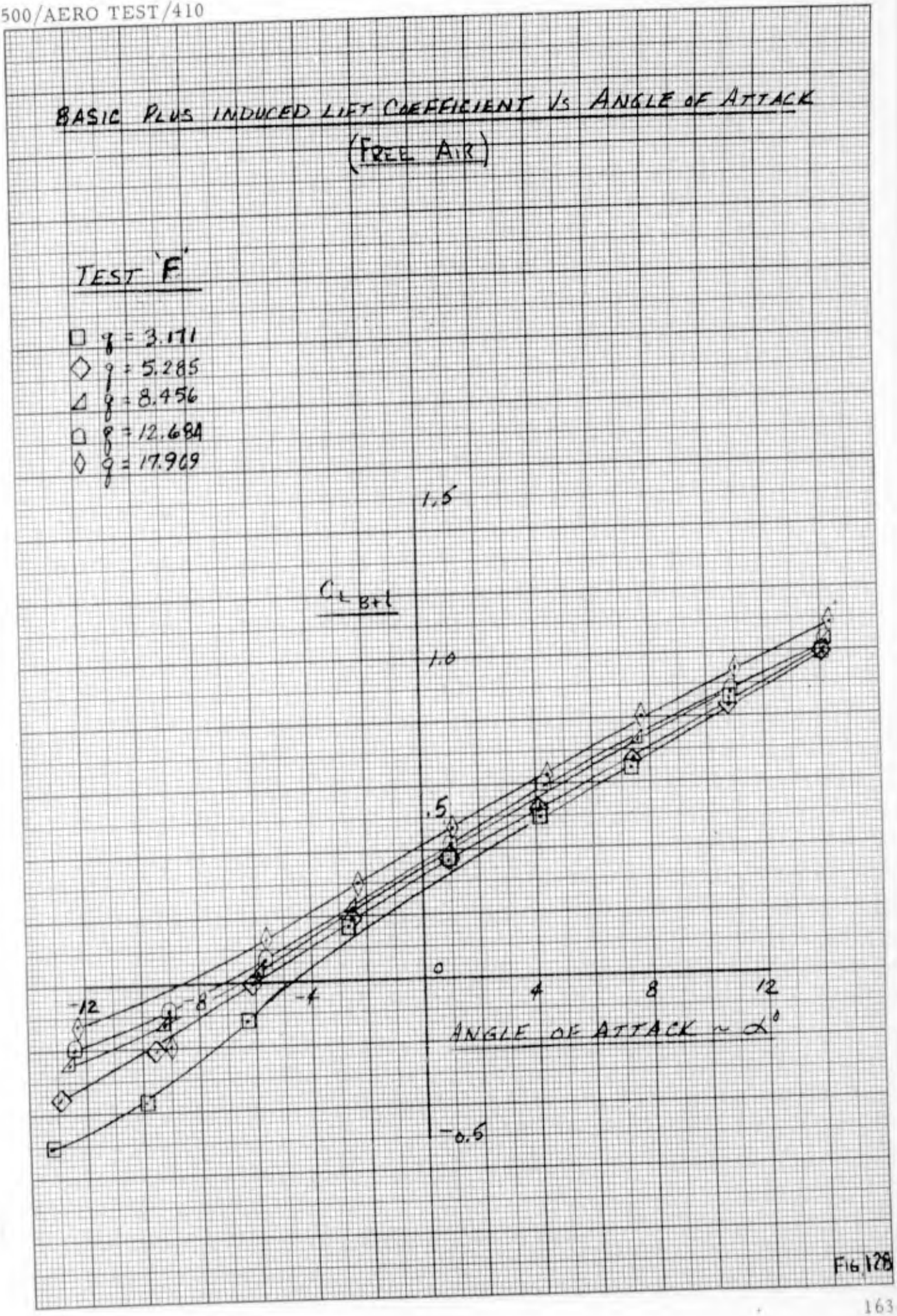

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.684
◇ q = 17.909
1.5
$C_{L_{B+I}}$
1.0
.5
0
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α^0
-0.5

Fig 128

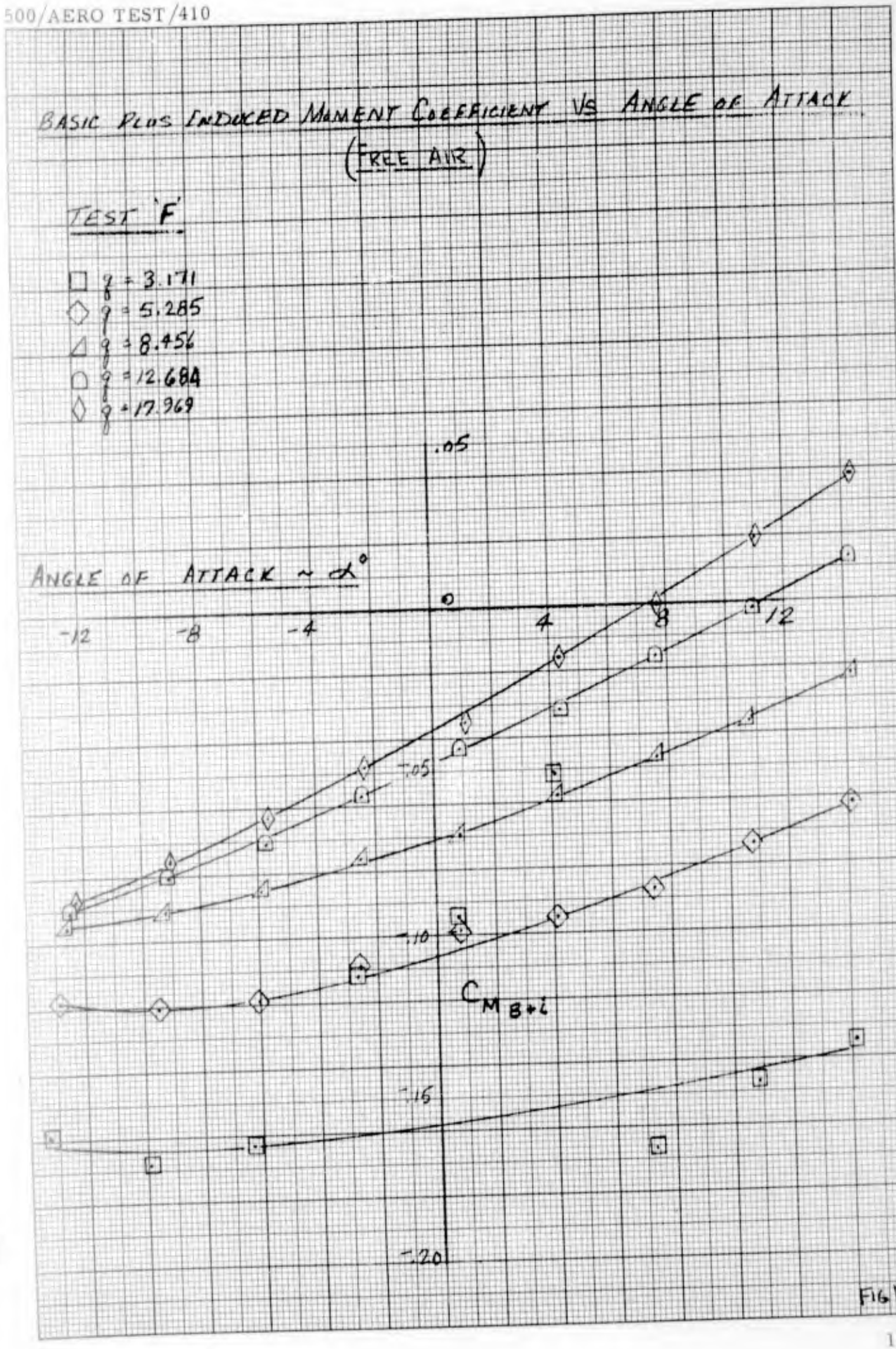

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'F'
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
.05
ANGLE OF ATTACK ~ α°
0
-12
-8
-4
4
8
12
-.05
-.10
$C_{M_{B+i}}$
-.15
-.20

Fig 12

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

TEST F

- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ○ q = 12.684
- ◊ q = 17.969

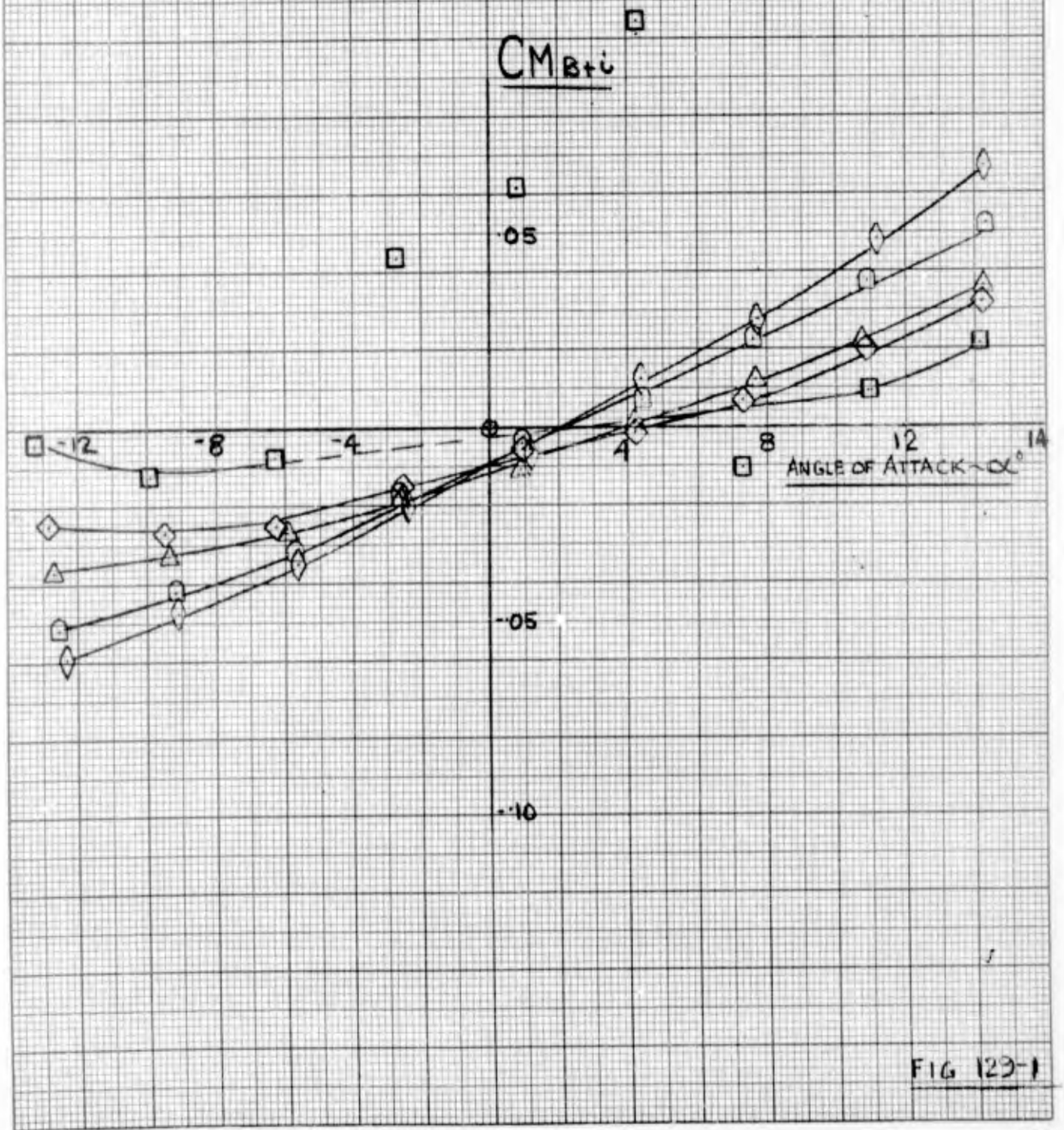


FIG 123-1

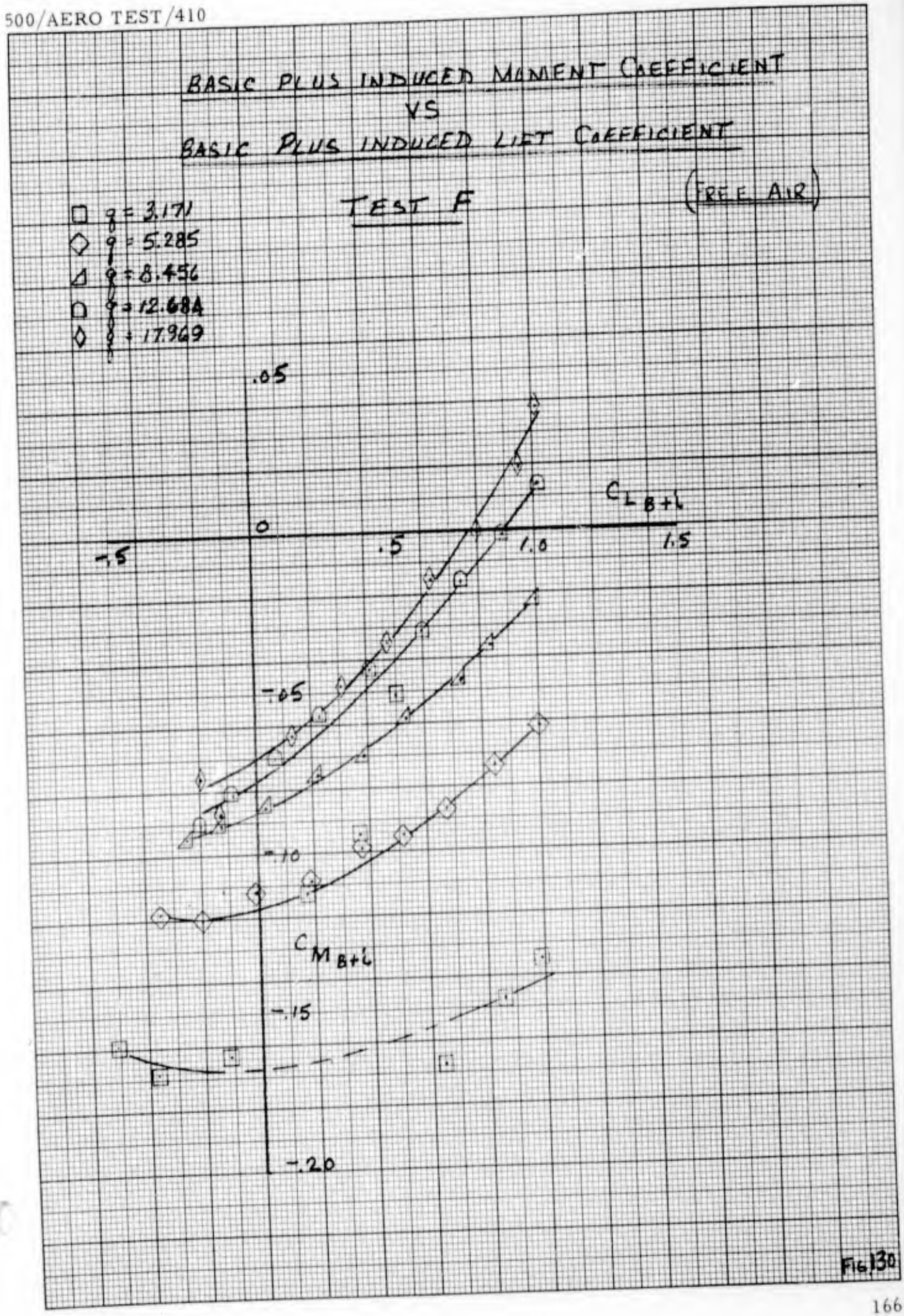

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
TEST F
(FREE AIR)
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
.05
0
-.5
.5
1.0
1.5
$C_{L_{B+L}}$
-.05
-.10
$C_{M_{B+L}}$
-.15
-.20

Fig 130

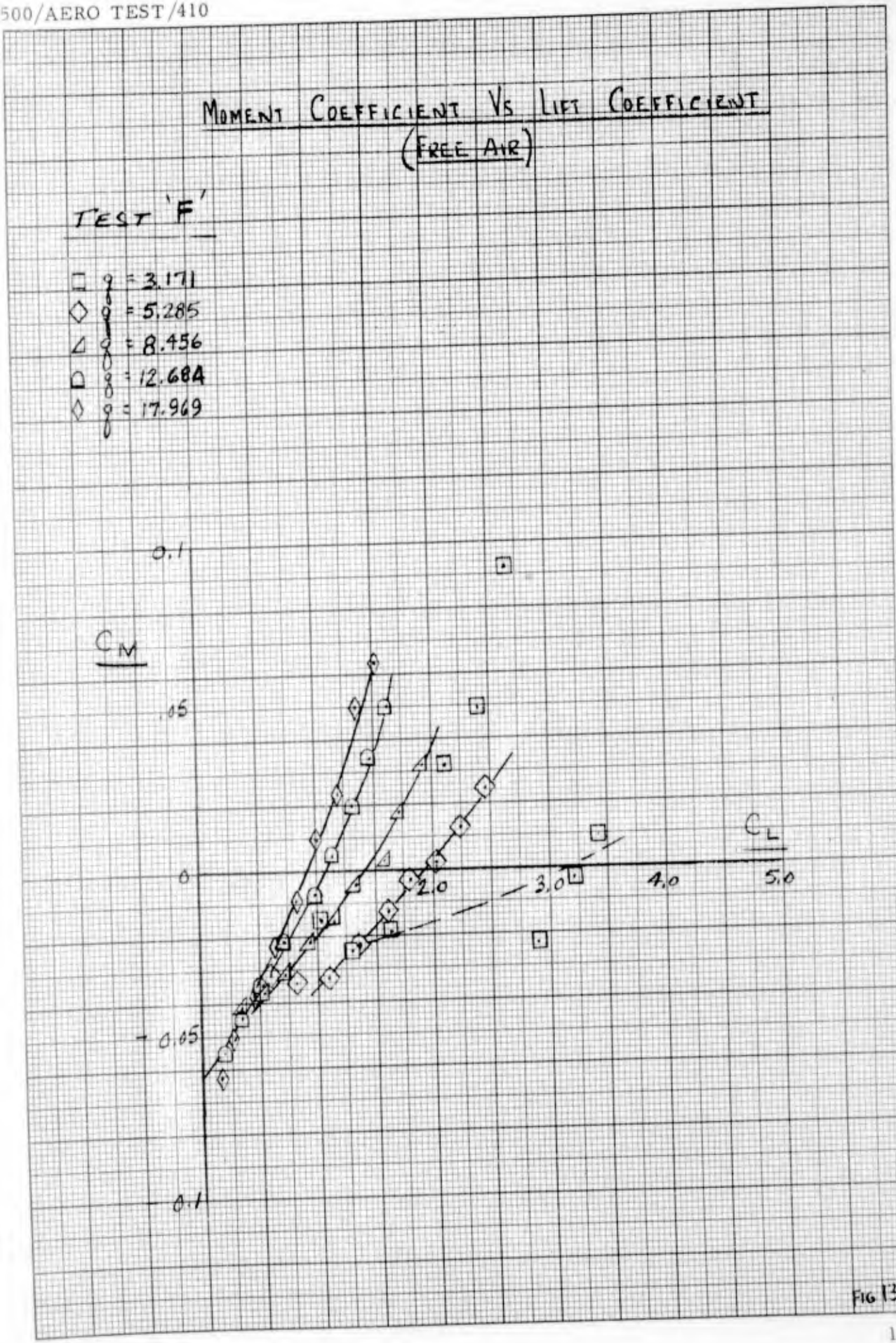

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'F'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
0.1
C_M
.05
0
- 0.05
- 0.1
2.0
3.0
4.0
5.0
C_L

FIG 131

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)

TEST F

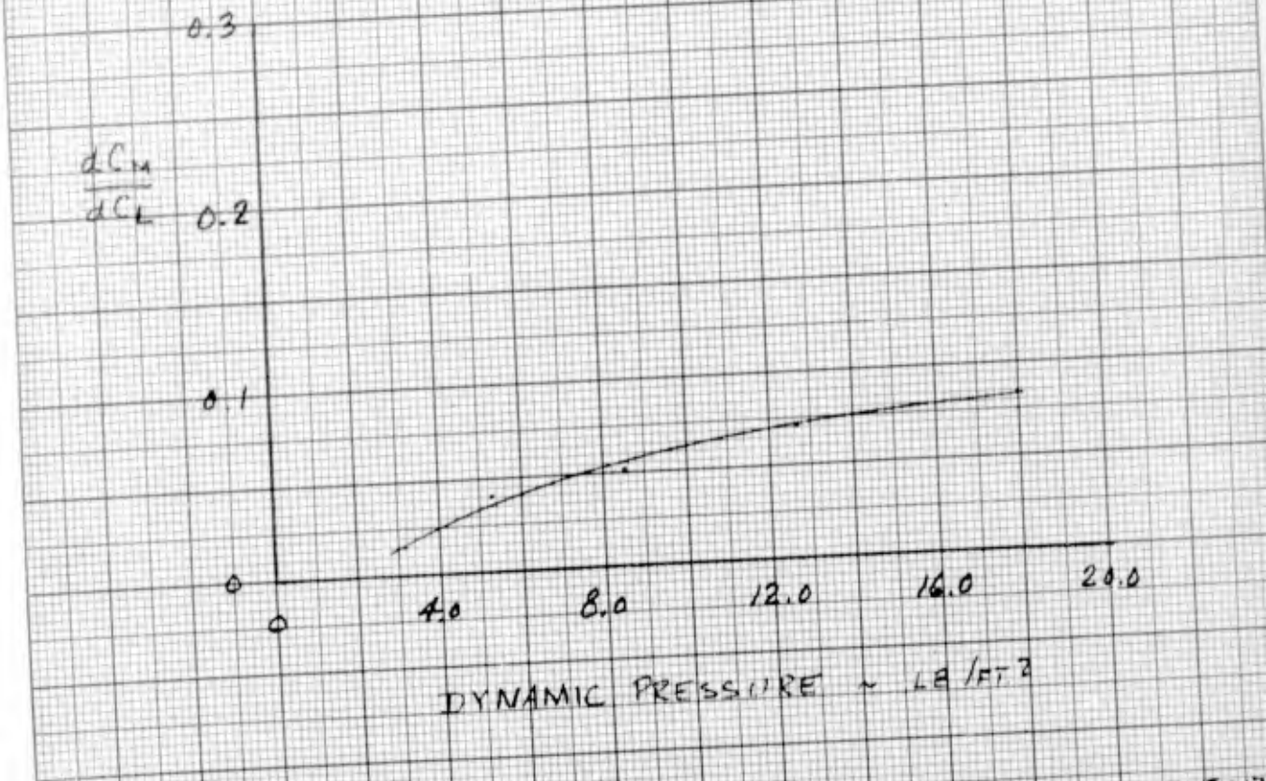


FIG.13

LIFT CURVE SLOPE V's FORWARD SPEED
(FREE AIR)

TEST F

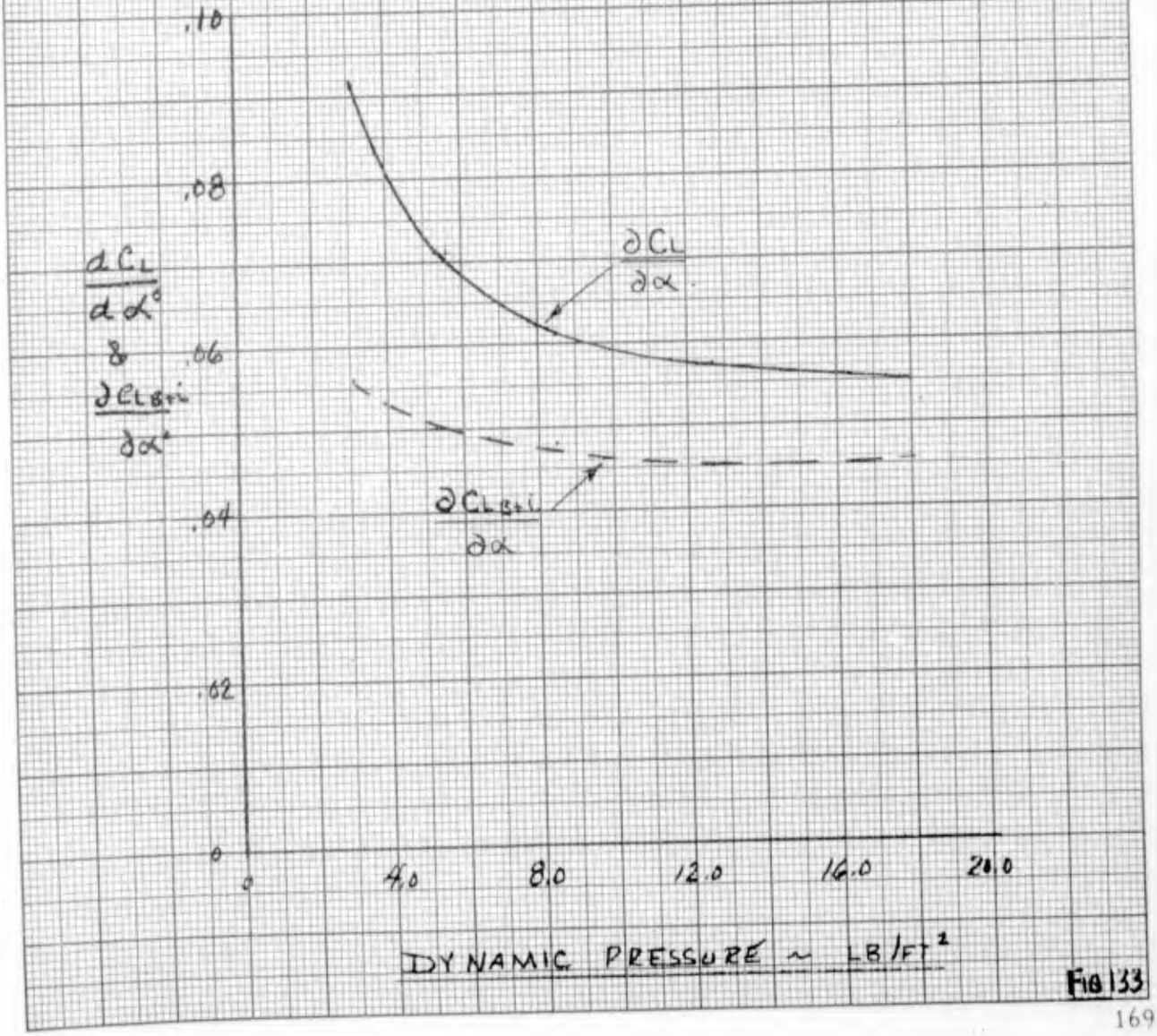


FIG 133

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST F

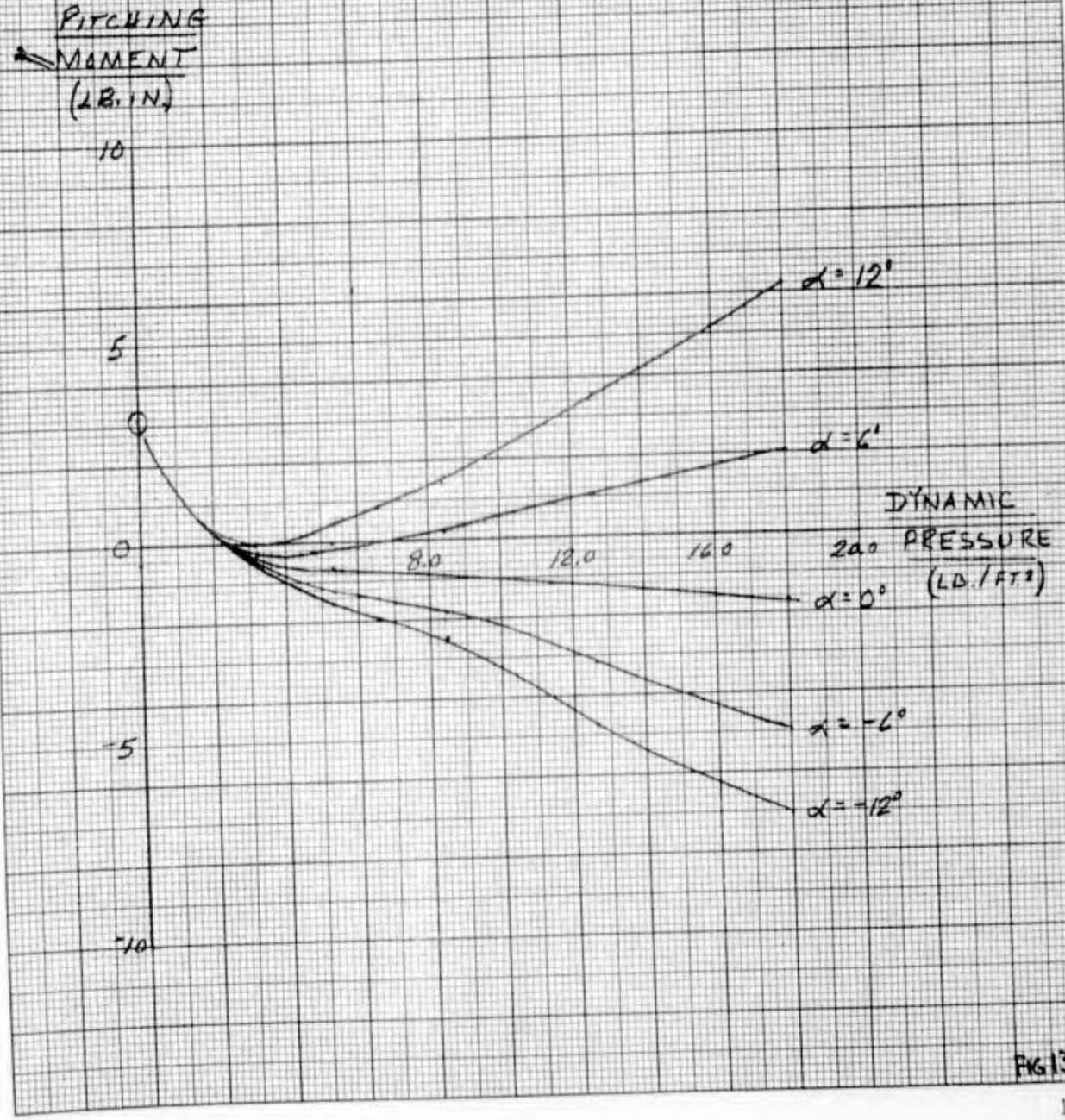


FIG 134

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST 'F' (FREE AIR)

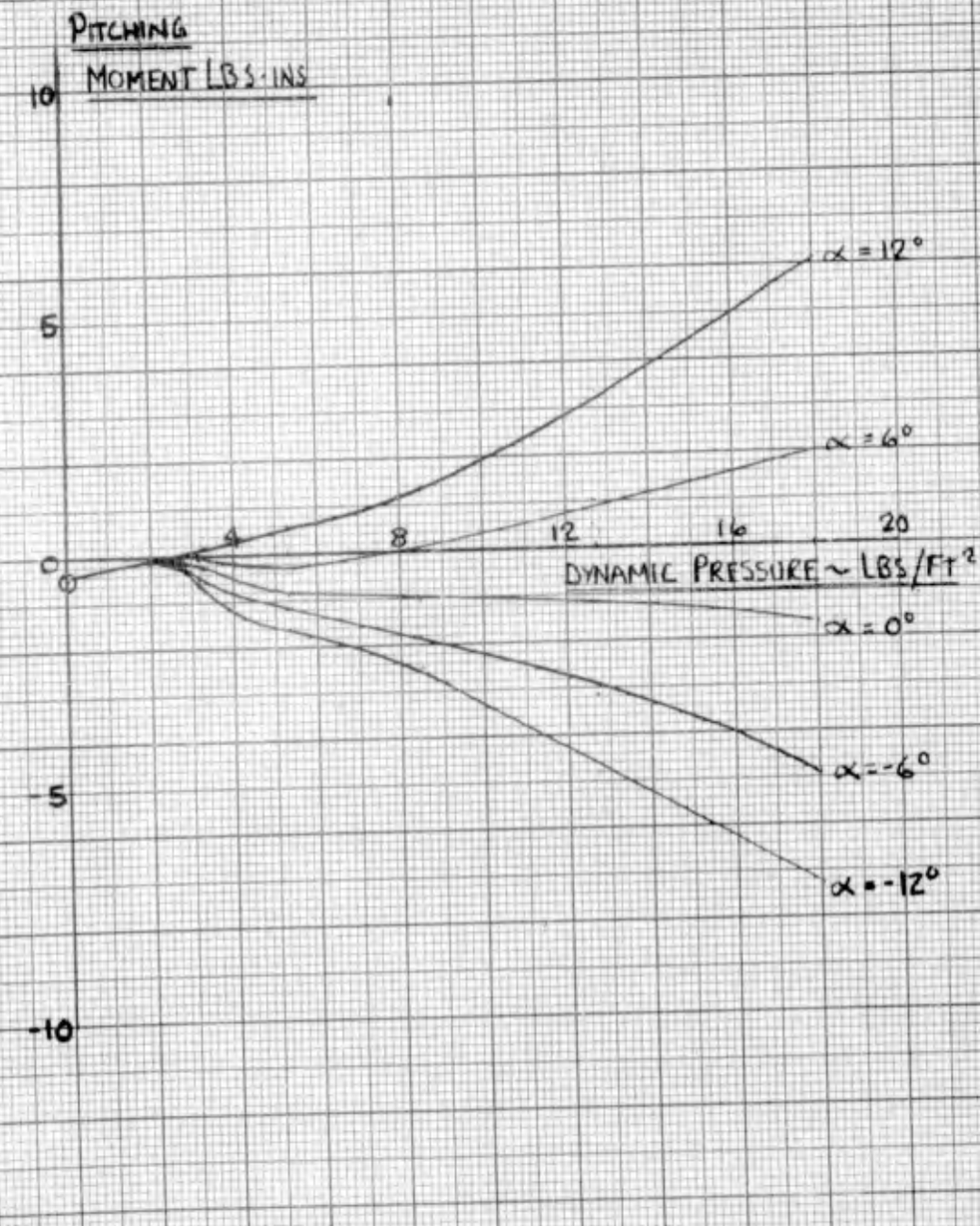


FIG. 134-1

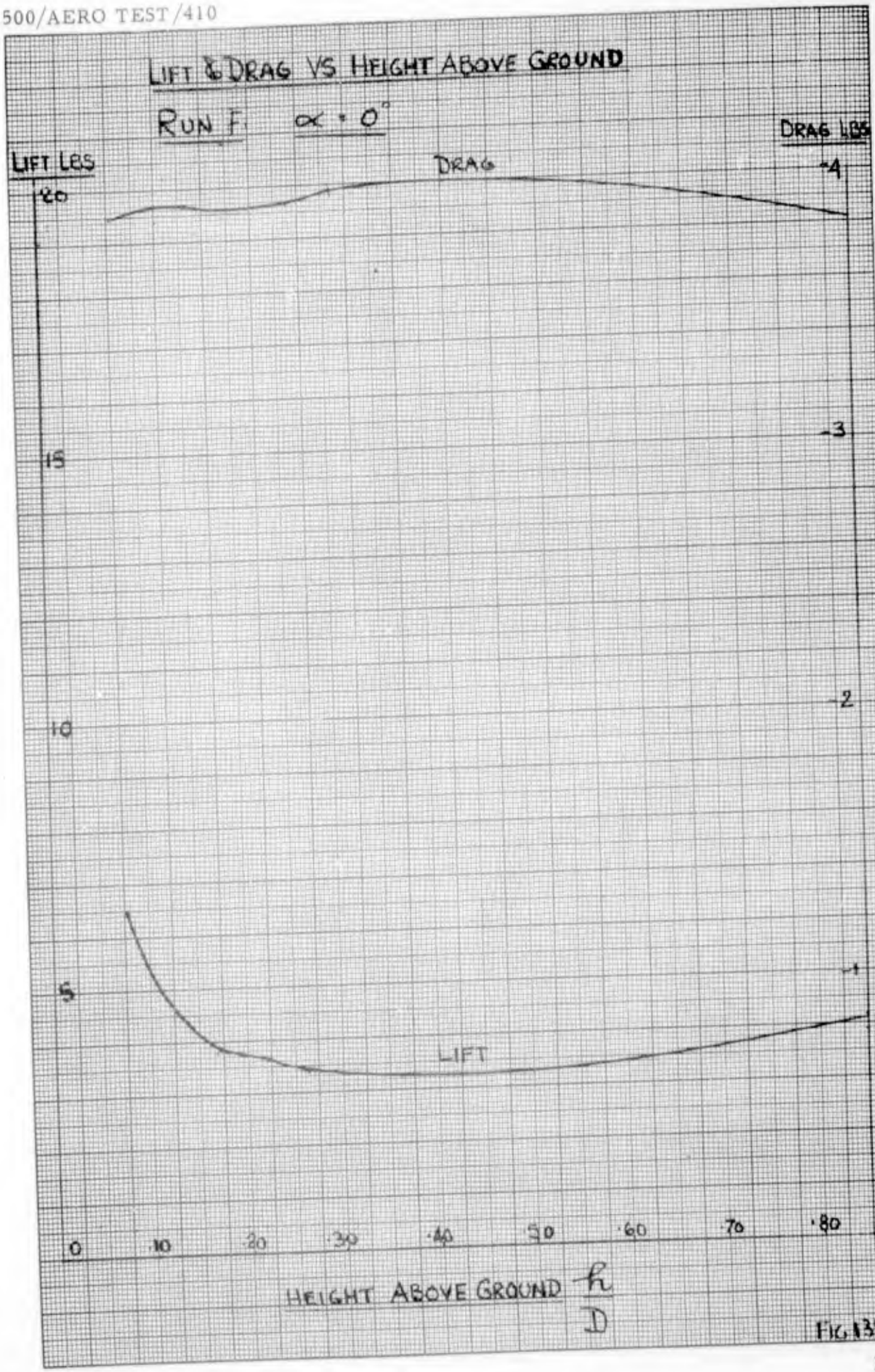

LIFT & DRAG VS HEIGHT ABOVE GROUND
RUN F α = 0°
LIFT LBS
DRAG LBS
DRAG
LIFT
20
15
10
5
4
3
2
1
0
10
20
30
40
50
60
70
80
HEIGHT ABOVE GROUND h/D

FIG 135

PITCHING MOMENT VS HEIGHT ABOVE GROUND

TEST 'F' $\alpha = 0°$

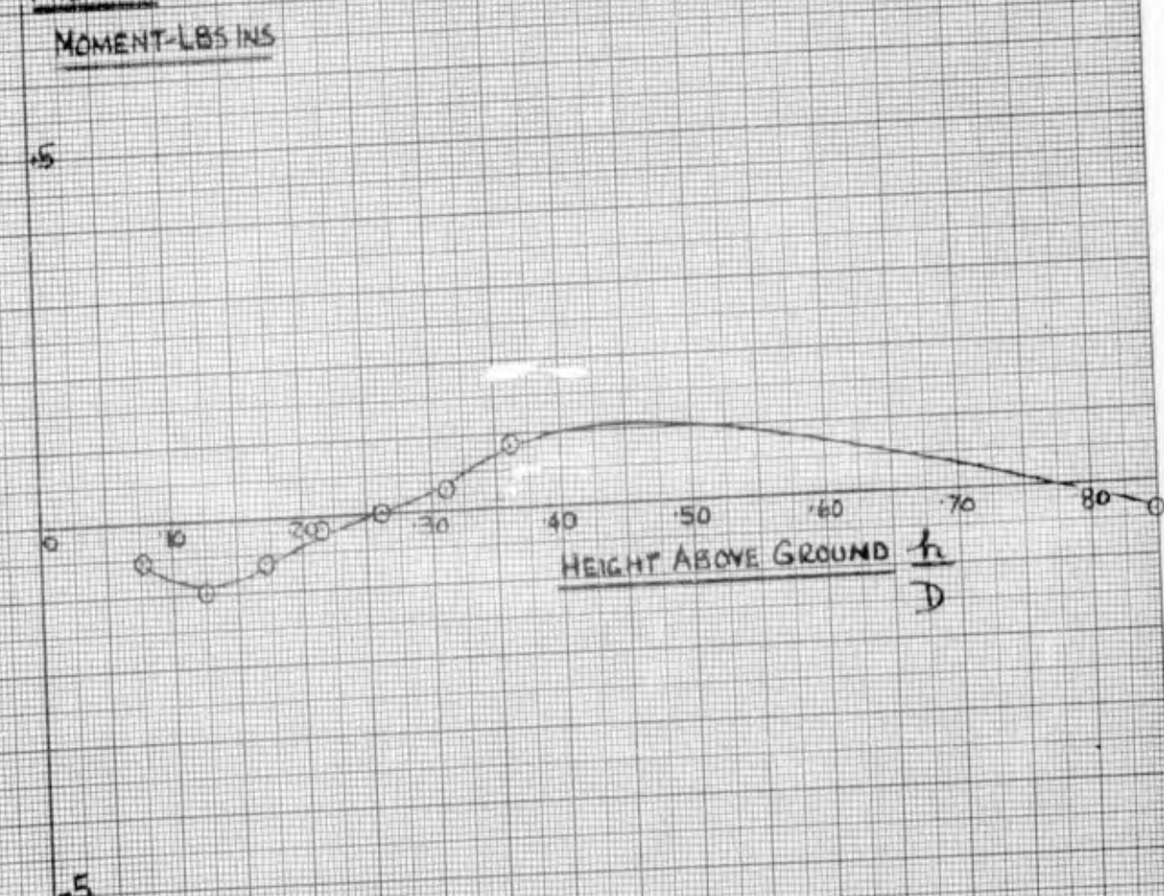
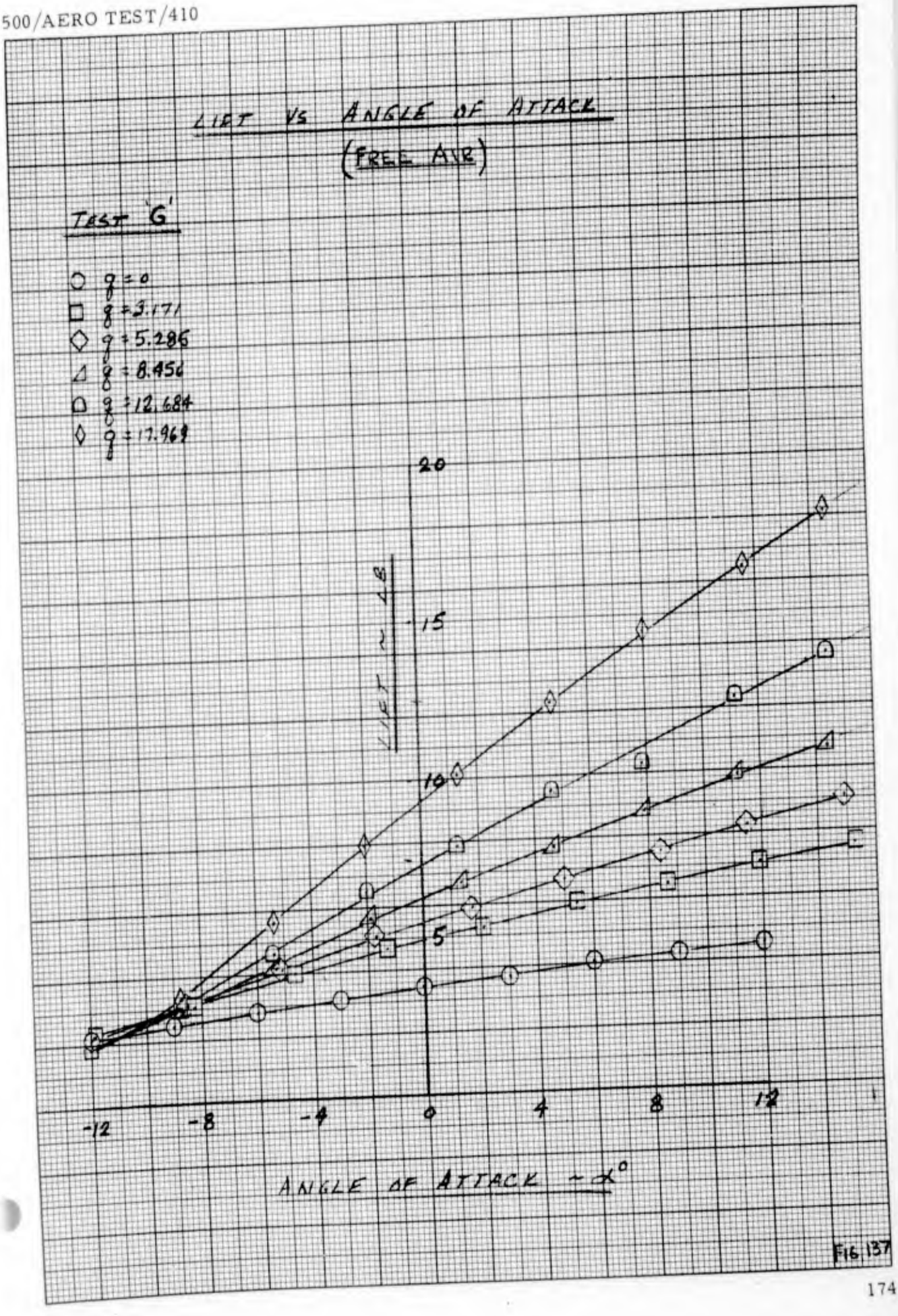
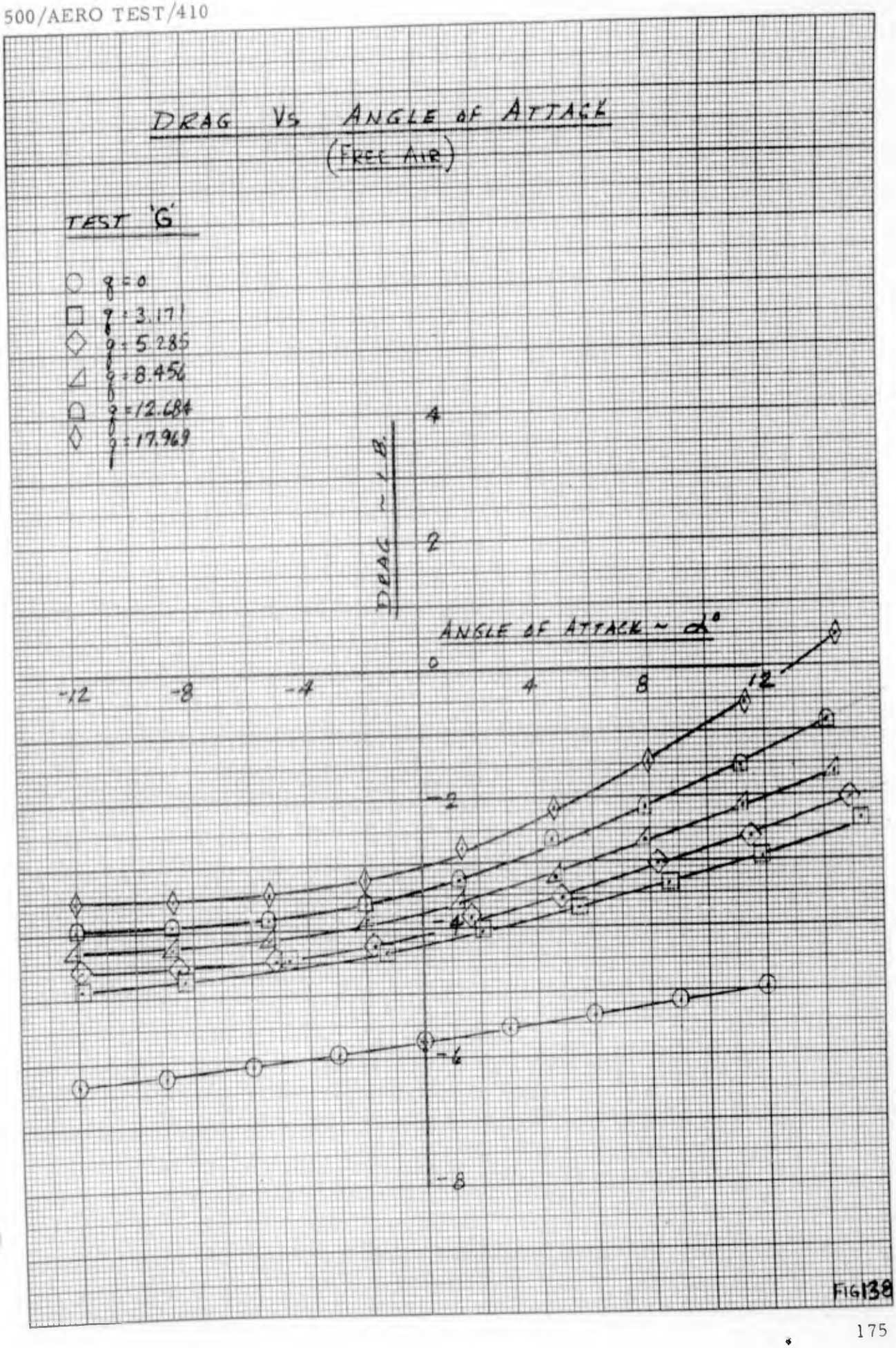


FIG 136


LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
q = 0
q = 3.171
q = 5.286
q = 8.456
q = 12.684
q = 17.969
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°
FIG 137


DRAG Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
DRAG - C'
4
2
ANGLE OF ATTACK ~ α°
0
-12
-8
-4
4
8
12
-2
-4
-6
-8
FIG 138

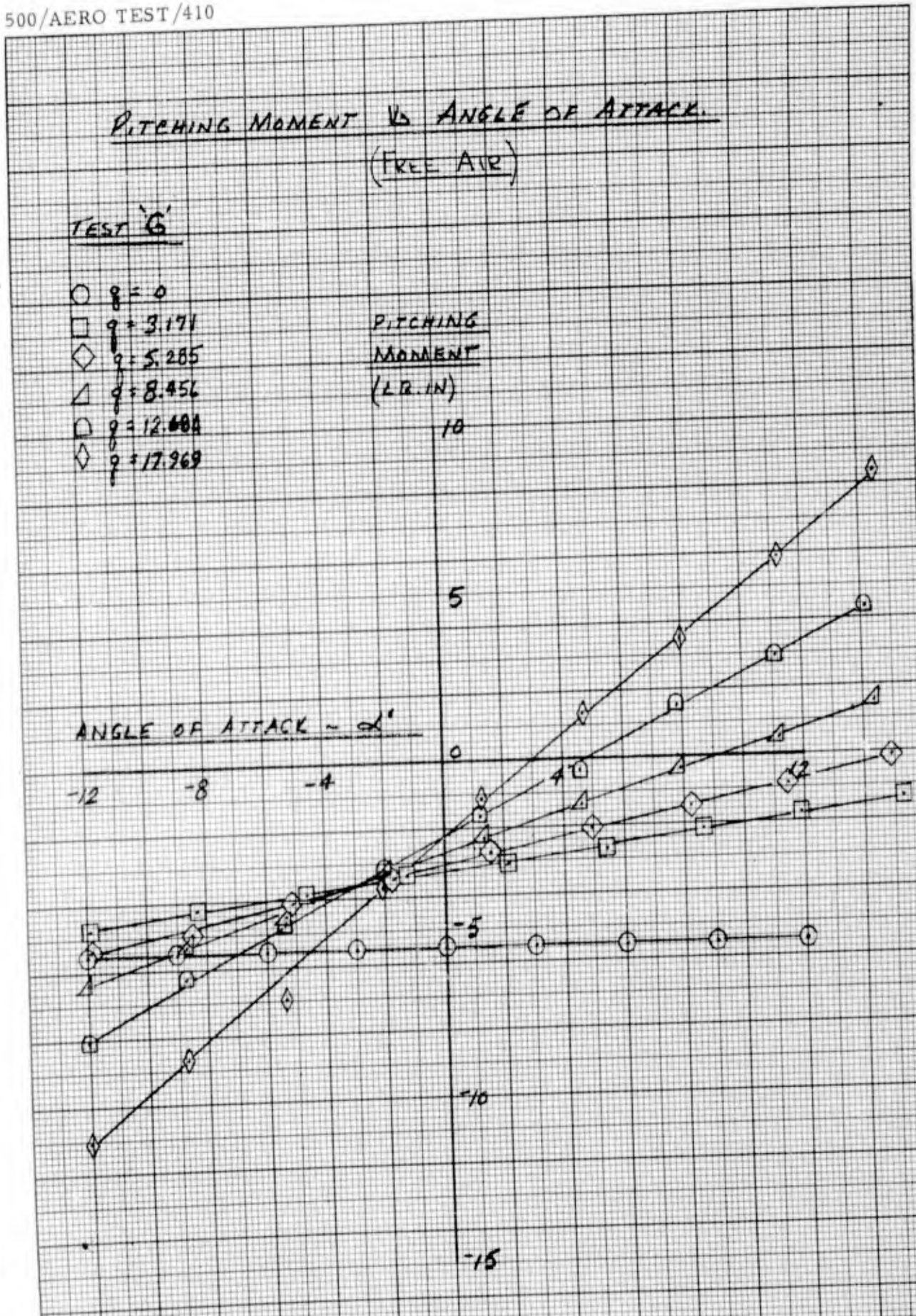

PITCHING MOMENT Vs ANGLE OF ATTACK.
(FREE AIR)
TEST 'G'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
PITCHING MOMENT (LB. IN)
10
5
0
-5
-10
-15
ANGLE OF ATTACK - α'
-12
-8
-4
4
12

FIG 139

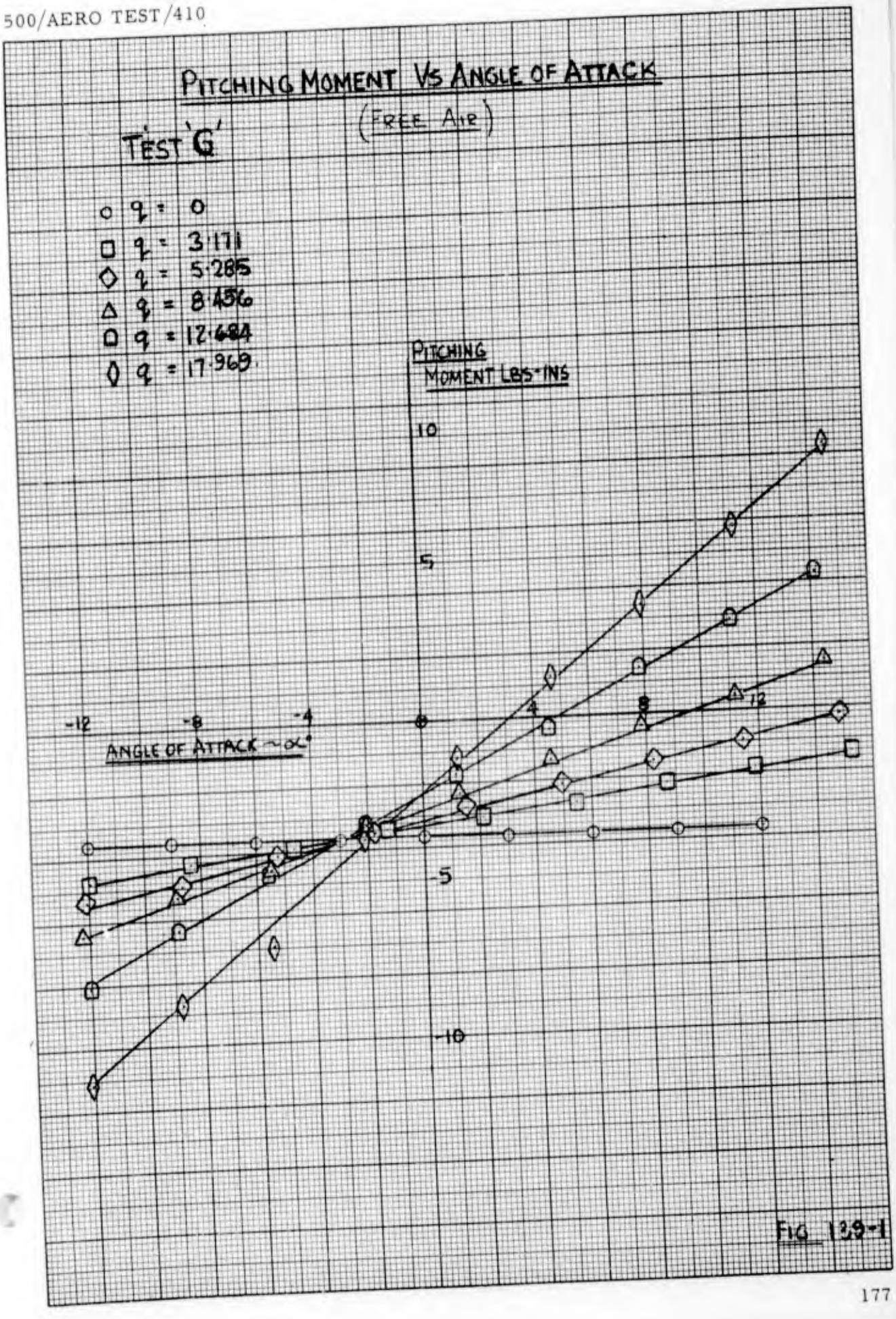

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
PITCHING MOMENT LBS-INS
10
5
-5
-10
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°

FIG 139-1

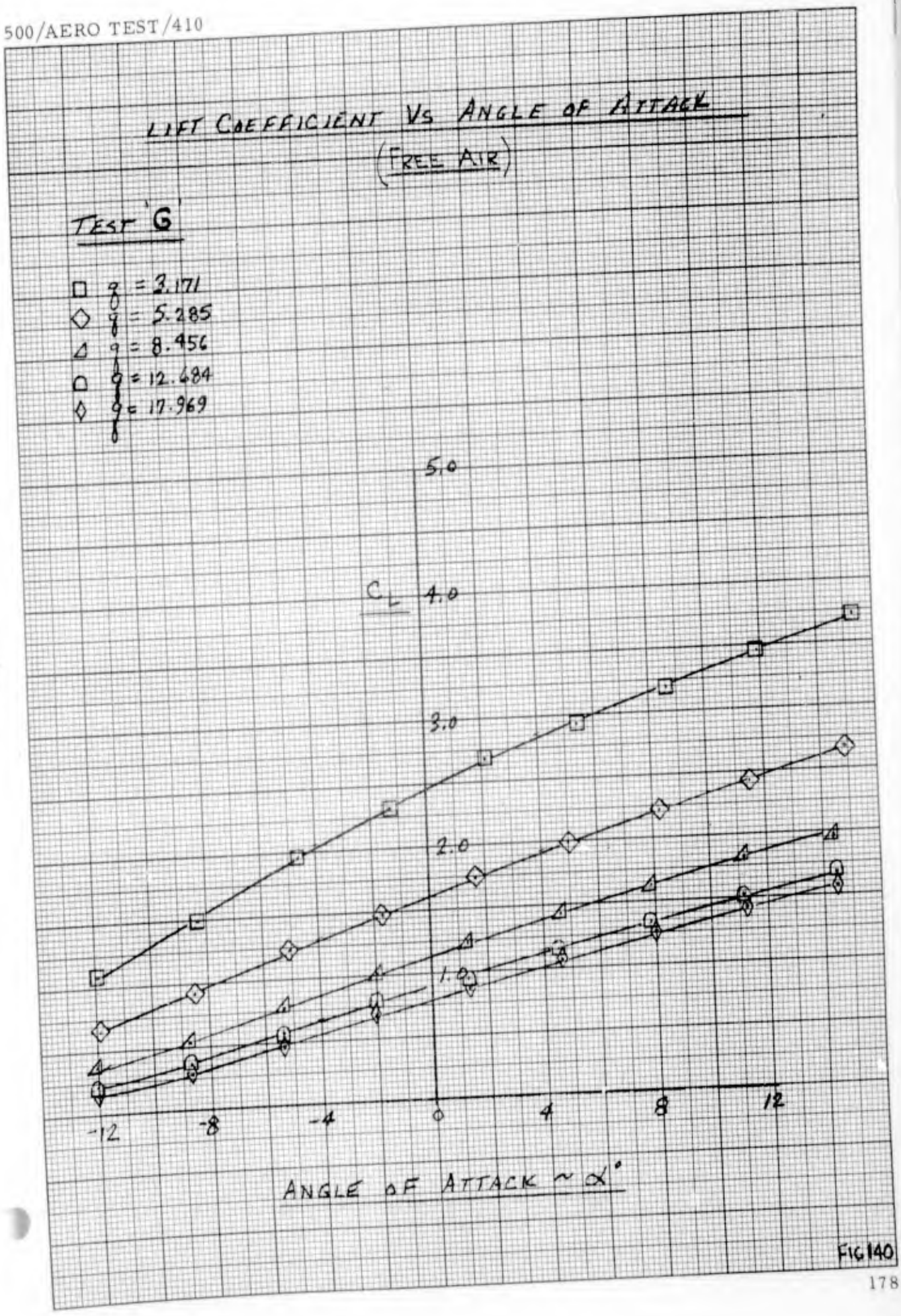

LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
5.0
C_L
4.0
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 140

DRAG COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

TEST G

- □ $q = 3.171$
- ◇ $q = 5.285$
- △ $q = 8.456$
- ⬠ $q = 12.684$
- ◊ $q = 17.969$

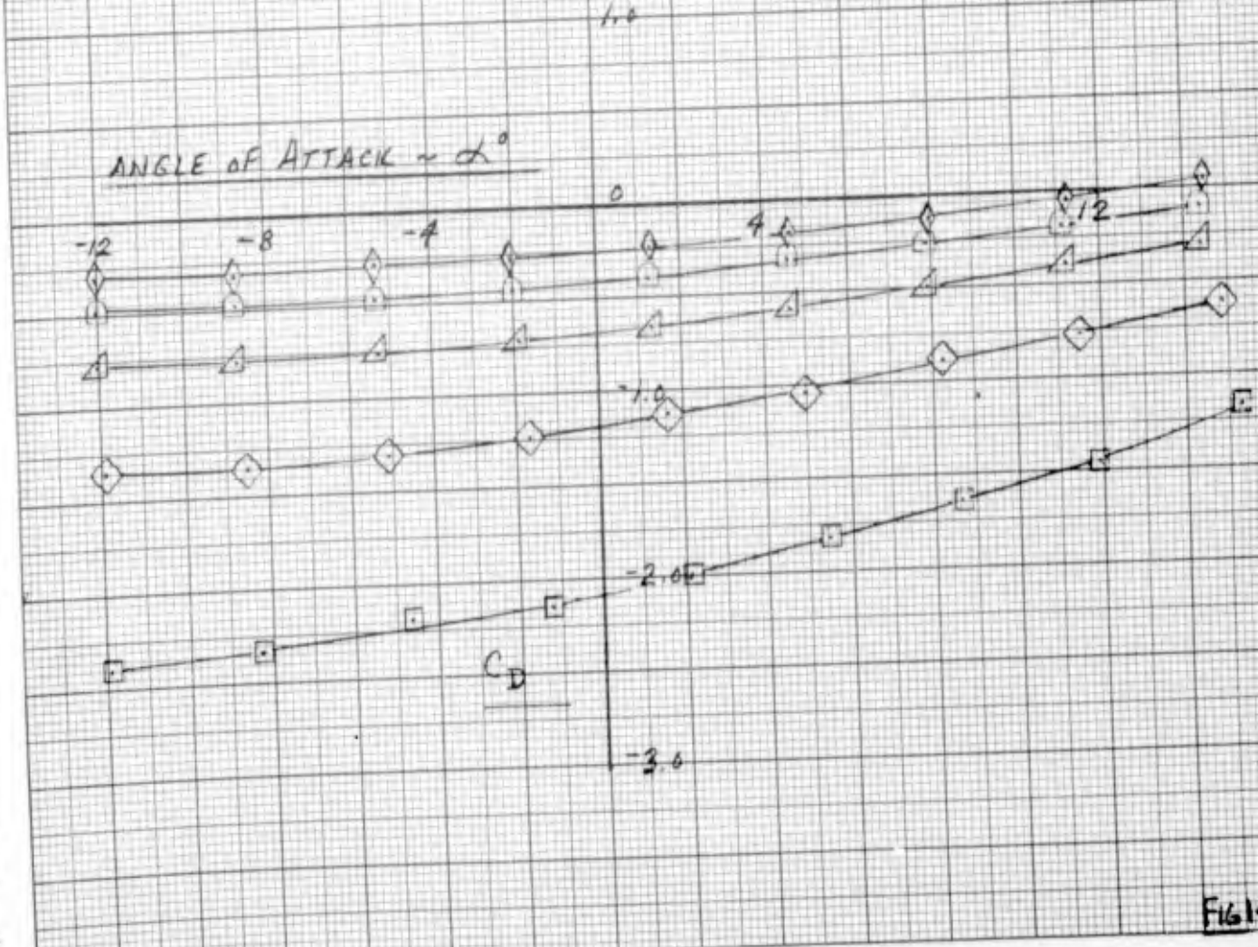


FIG 141

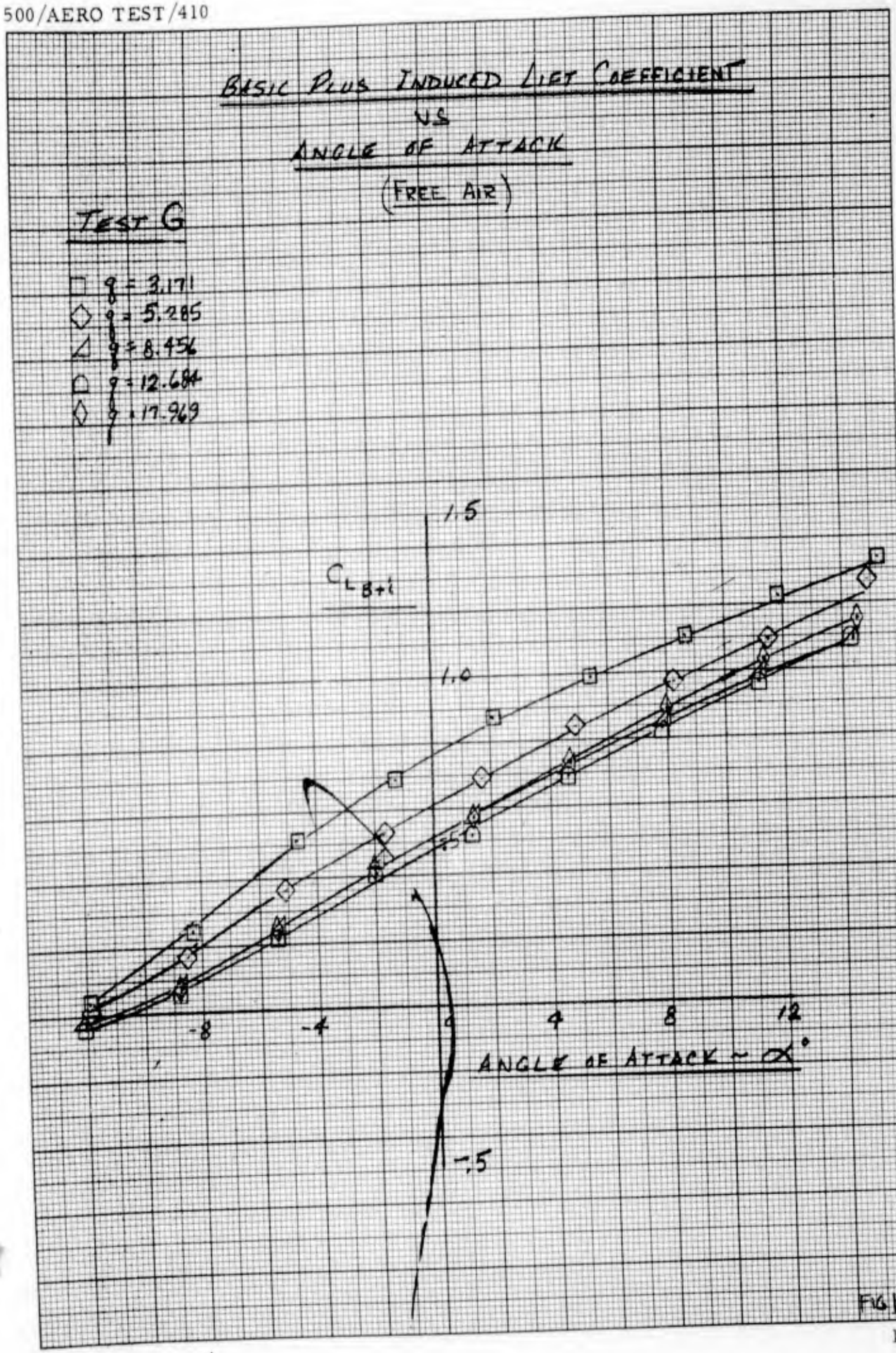

BASIC PLUS INDUCED LIFT COEFFICIENT
VS
ANGLE OF ATTACK
(FREE AIR)
TEST G
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◇ q = 17.969
1.5
$C_{L_{B+i}}$
1.0
.5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
-.5

FIG 142

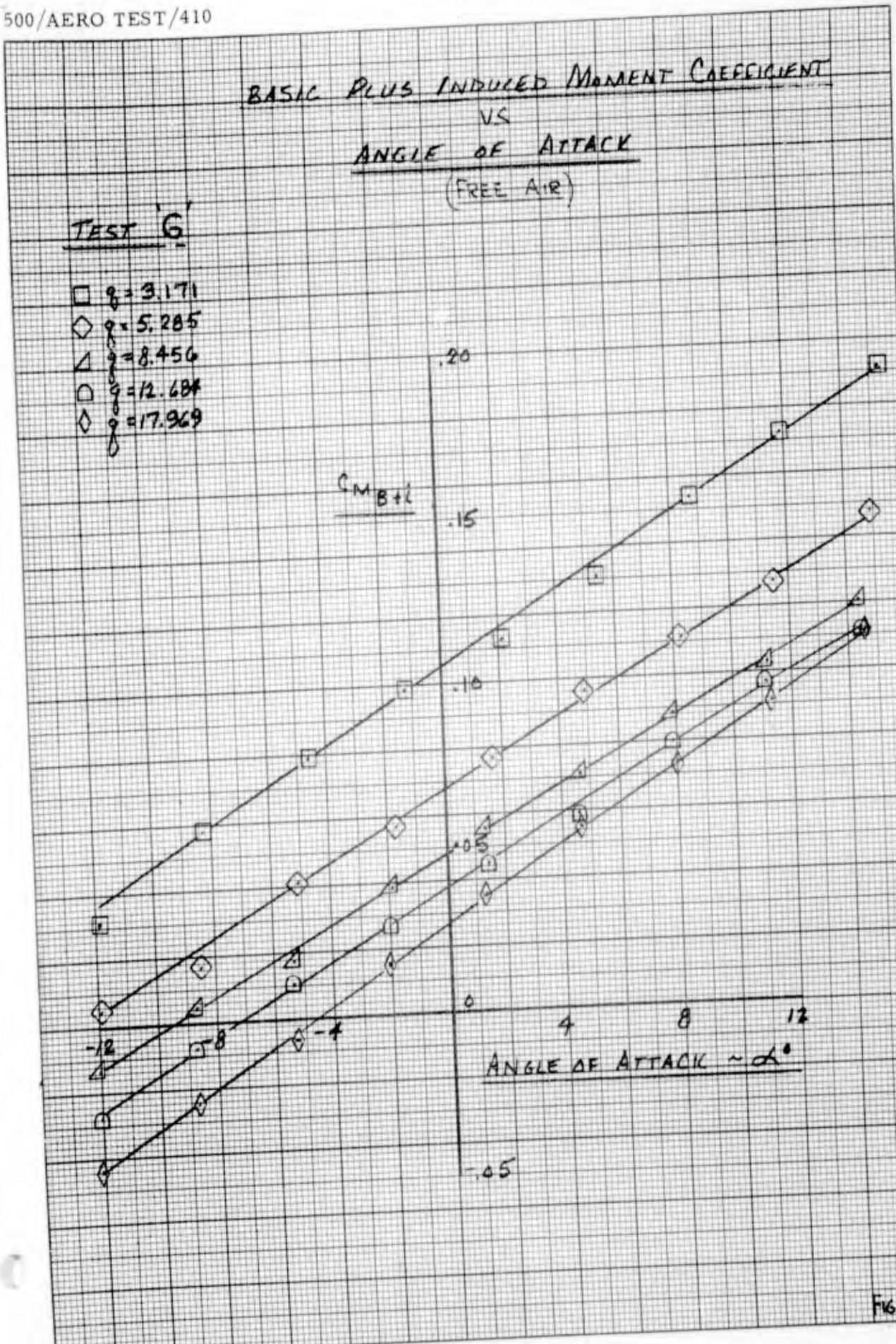

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
$C_{M_{B+t}}$
.20
.15
.10
.05
0
-.05
4
8
12
-12
-8
-4
ANGLE OF ATTACK ~ α°

FIG 143

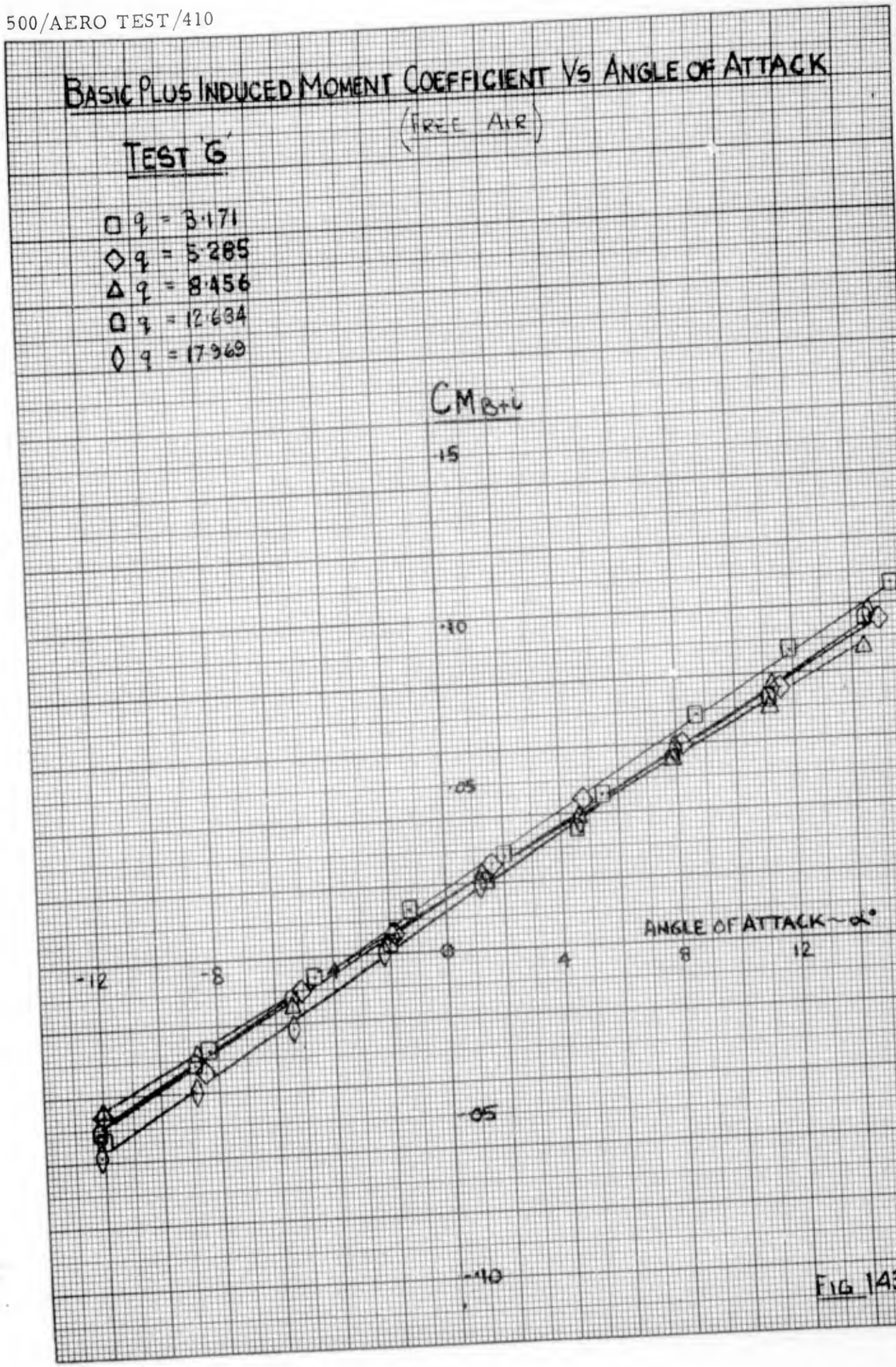

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'G'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CMB+i
.15
.10
.05
-.05
-.10
-12
-8
4
8
12
ANGLE OF ATTACK - α°

FIG 143

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS.
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)

TEST 'G'

□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969

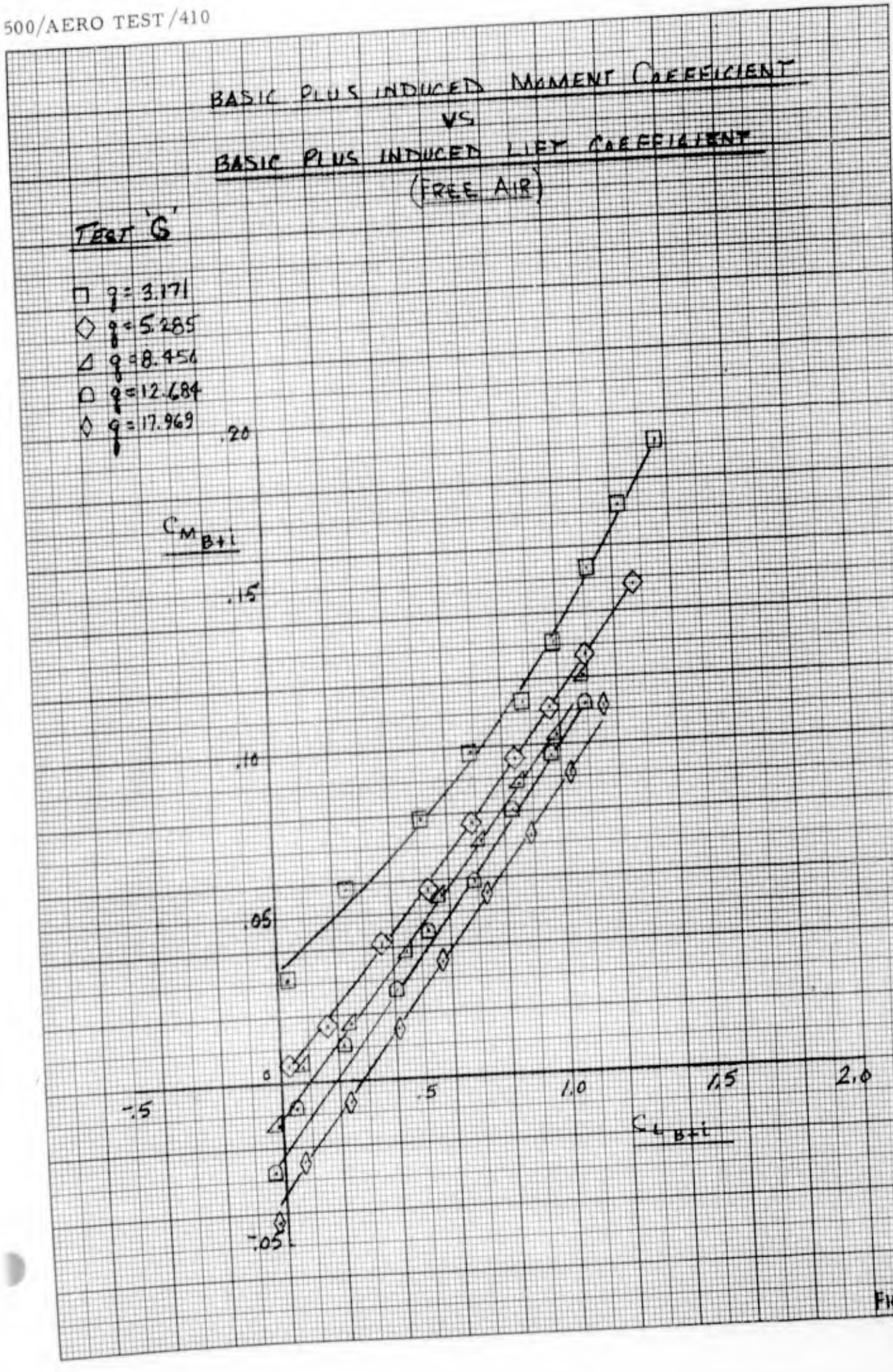


FIG 14

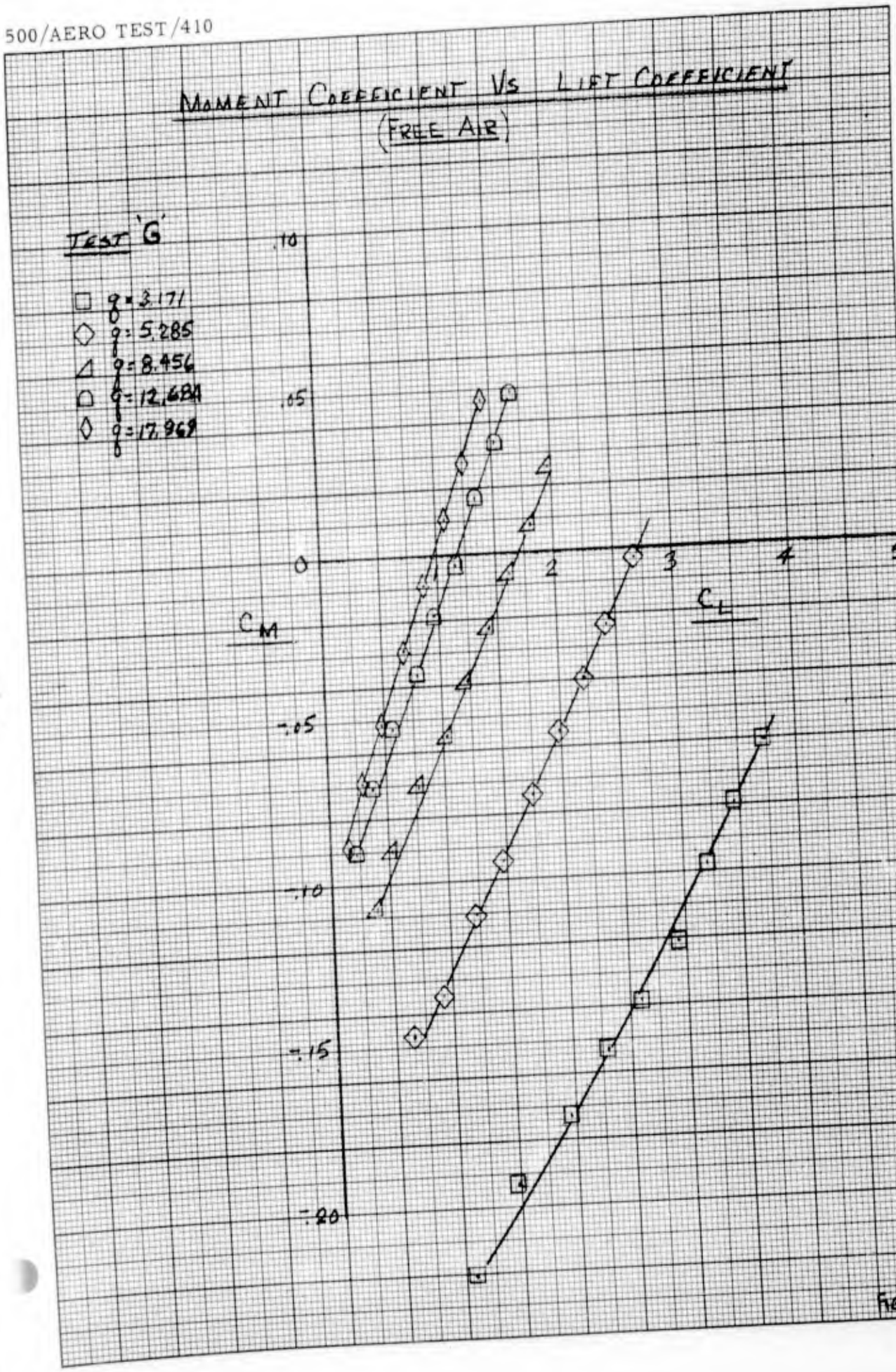

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'G'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
.10
.05
0
-.05
-.10
-.15
-.20
1
2
3
4
5
C_M
C_L

Fig 145

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST G

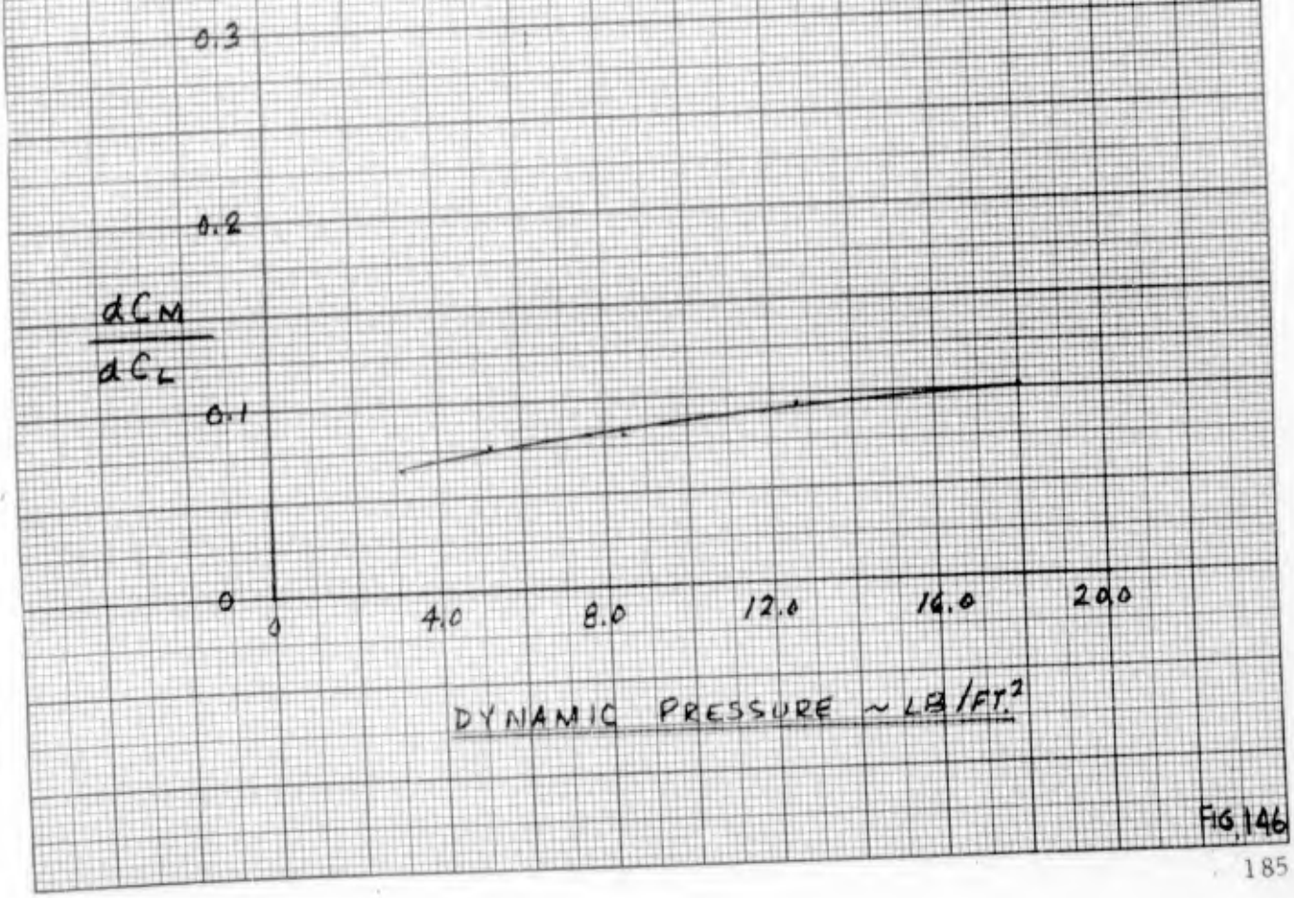


FIG. 146

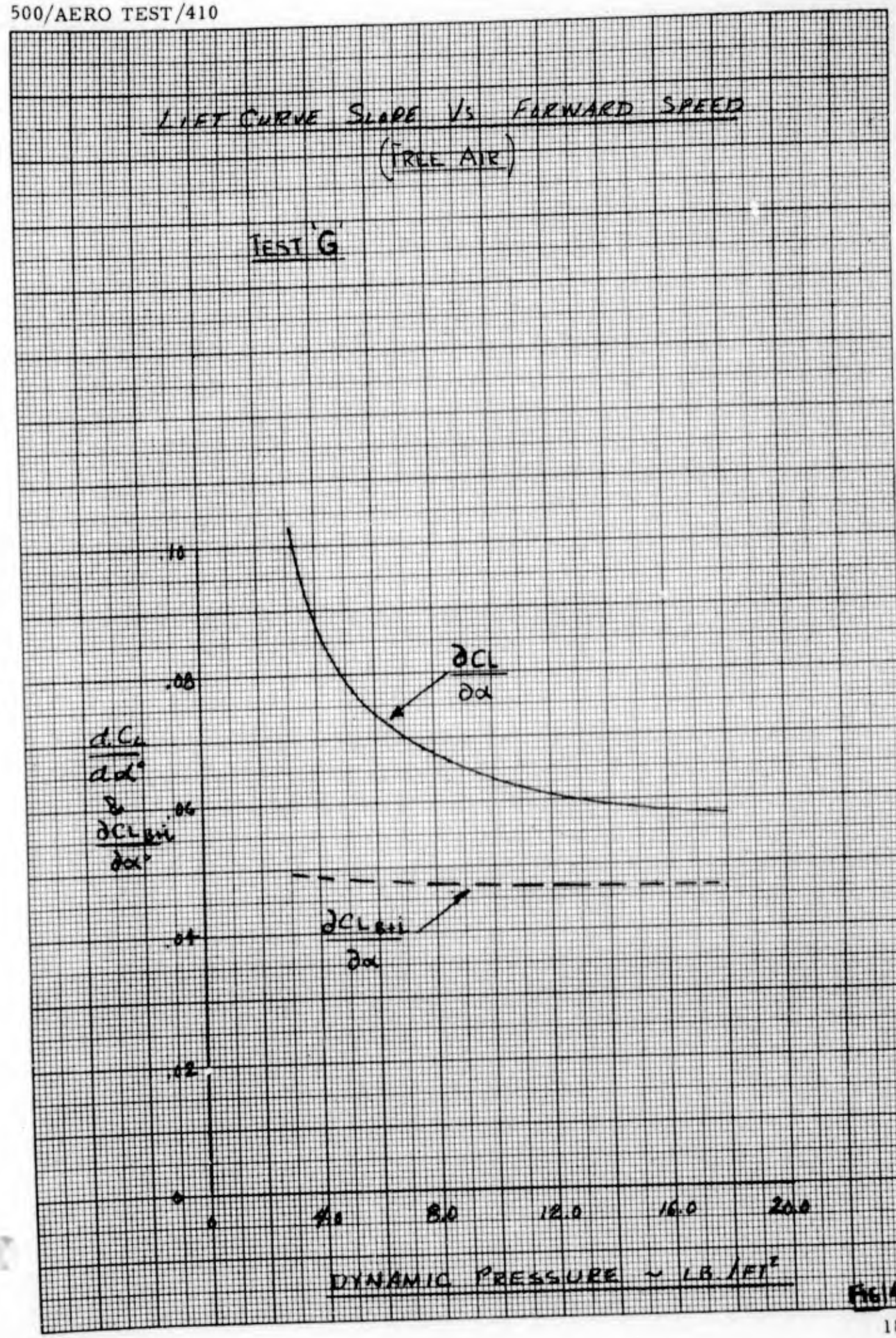

LIFT CURVE SLOPE VS FORWARD SPEED
(FREE AIR)
TEST 'G'
.10
.08
.06
.04
.02
0
$\frac{\partial C_L}{\partial \alpha}$
$\frac{\partial C_{L_{wi}}}{\partial \alpha}$
4.0
8.0
12.0
16.0
20.0
DYNAMIC PRESSURE ~ LB./FT²

Fig 147

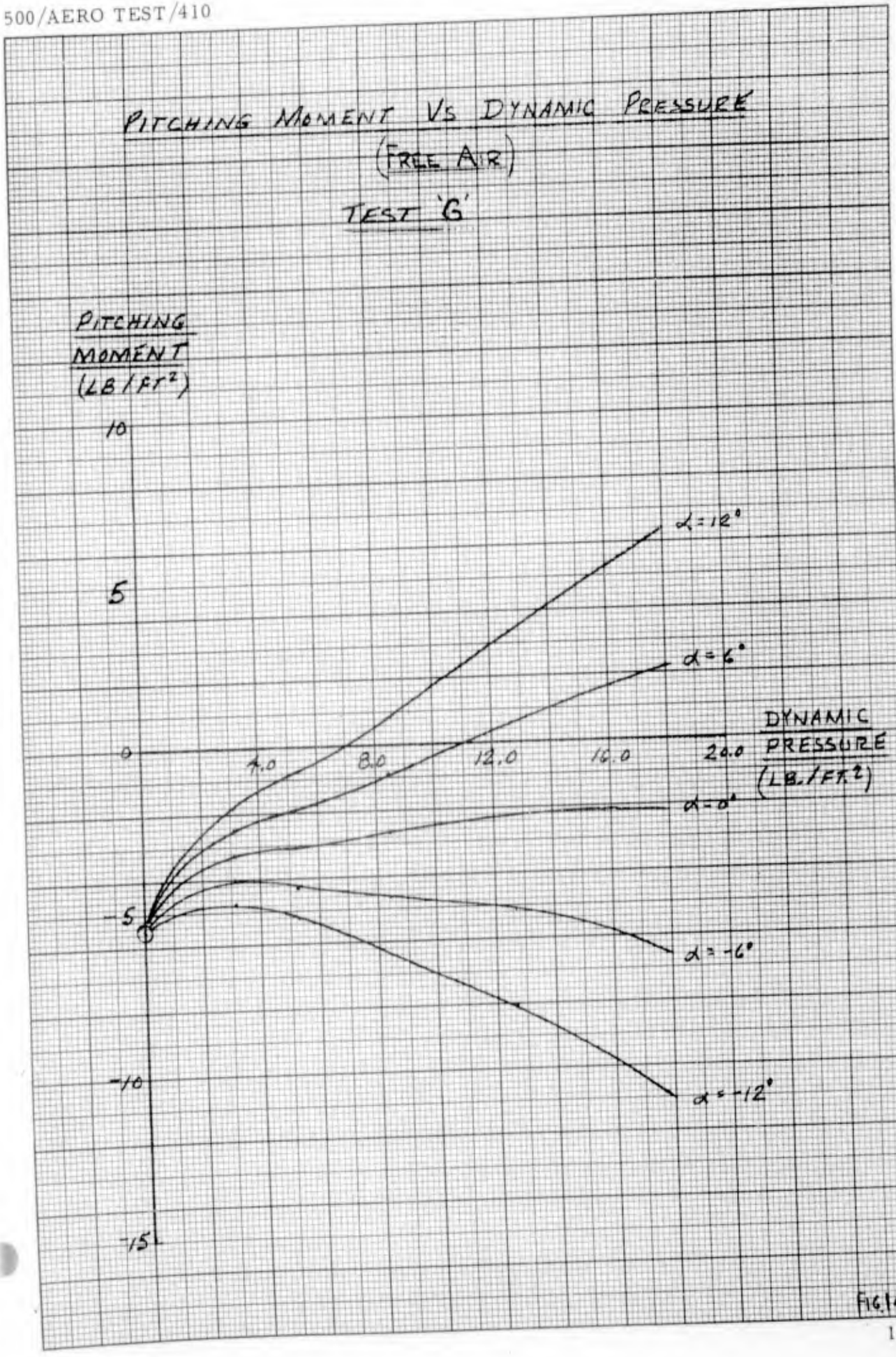

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 'G'
PITCHING MOMENT (LB/FT²)
10
5
0
-5
-10
-15
4.0
8.0
12.0
16.0
20.0
DYNAMIC PRESSURE (LB./FT²)
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG. 148

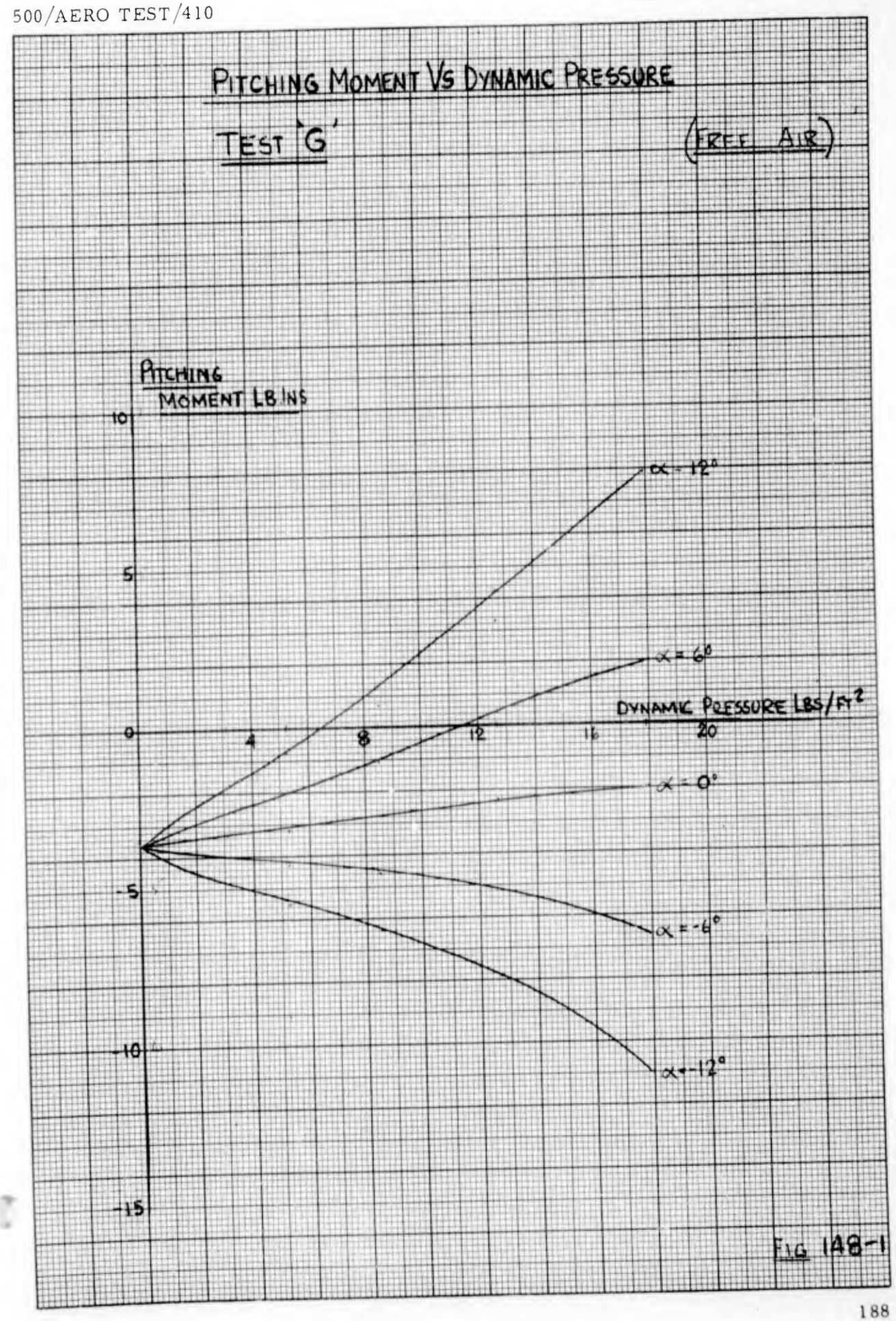

PITCHING MOMENT VS DYNAMIC PRESSURE
TEST 'G'
(FREE AIR)
PITCHING MOMENT LB INS
10
5
0
-5
-10
-15
4
8
12
16
20
DYNAMIC PRESSURE LBS/FT²
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 148-1

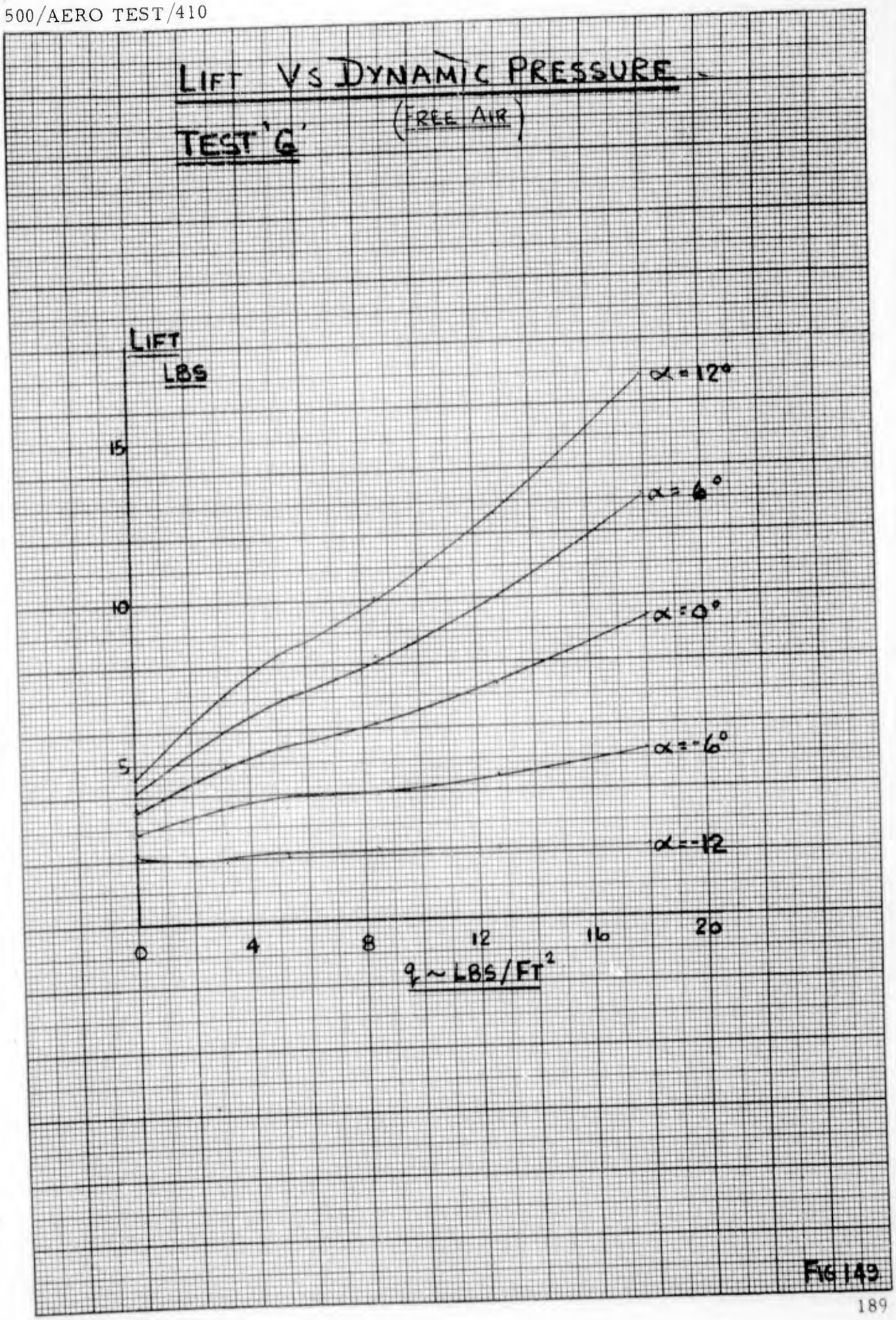

LIFT VS DYNAMIC PRESSURE
TEST 'G' (FREE AIR)
LIFT
LBS
15
10
5
α = 12°
α = 6°
α = 0°
α = -6°
α = -12
0
4
8
12
16
20
q ~ LBS/FT²

FIG 149

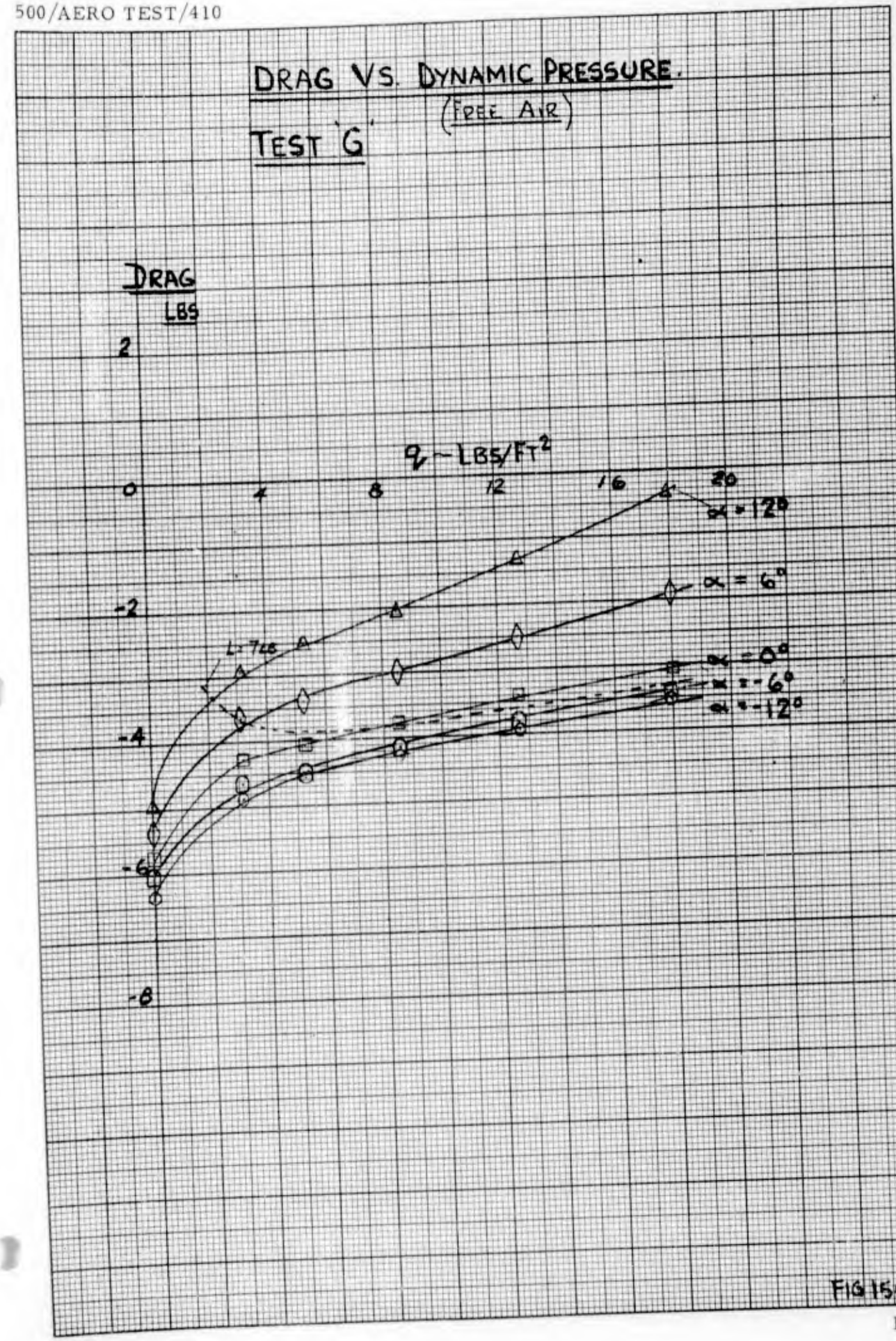

DRAG VS. DYNAMIC PRESSURE.
(FREE AIR)
TEST 'G'
DRAG
LBS
2
0
-2
-4
-6
-8
q - LBS/FT²
4
8
12
16
20
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°
L = 7LB

FIG 150

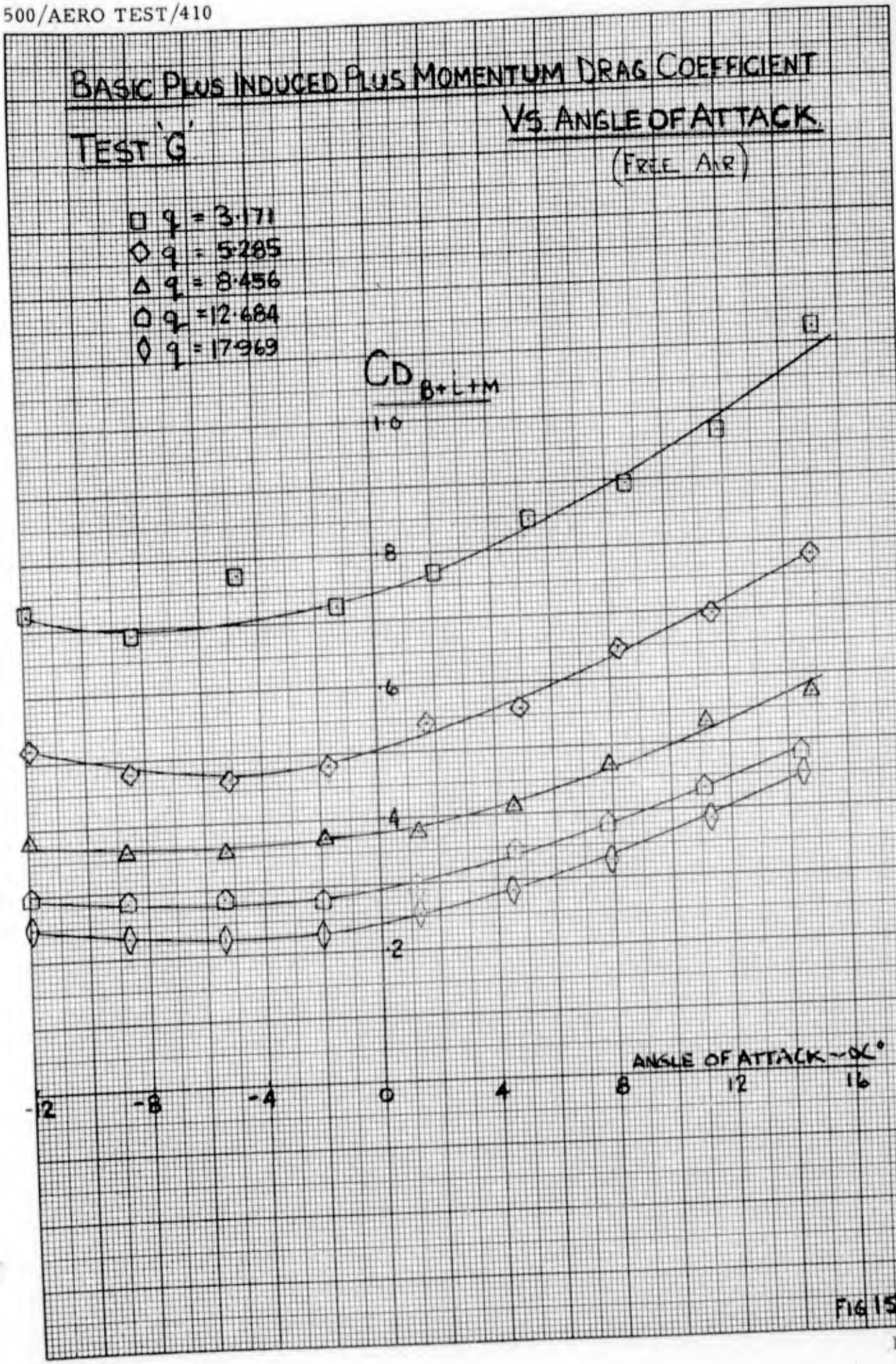

BASIC PLUS INDUCED PLUS MOMENTUM DRAG COEFFICIENT
VS. ANGLE OF ATTACK
TEST 'G'
(FREE AIR)
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
$C_{D_{B+L+M}}$
1·0
·8
·6
·4
·2
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK - α°

FIG 151

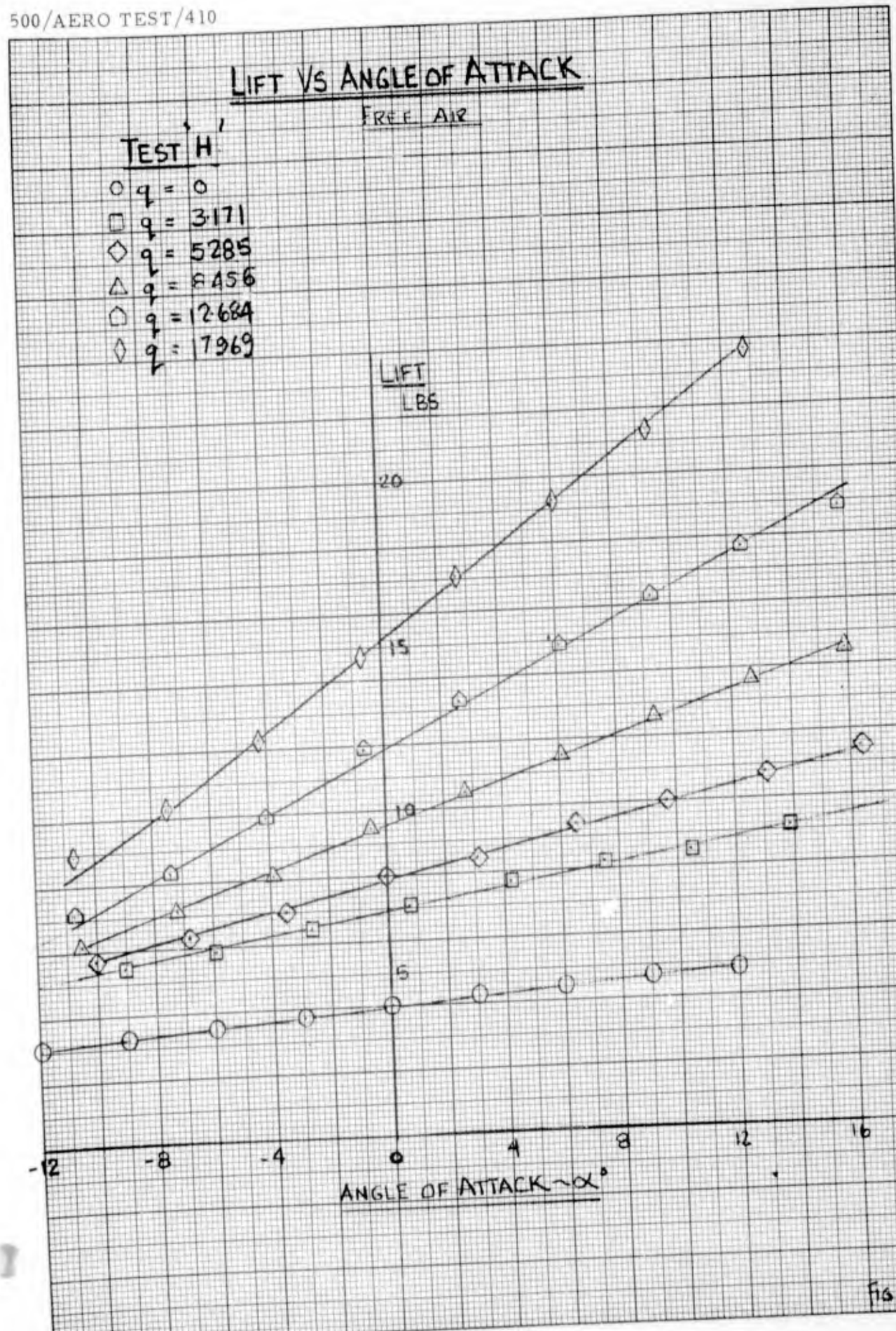

LIFT VS ANGLE OF ATTACK
FREE AIR
TEST H'
○ q = 0
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 7969
LIFT
LBS
20
15
10
5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

Fig 152

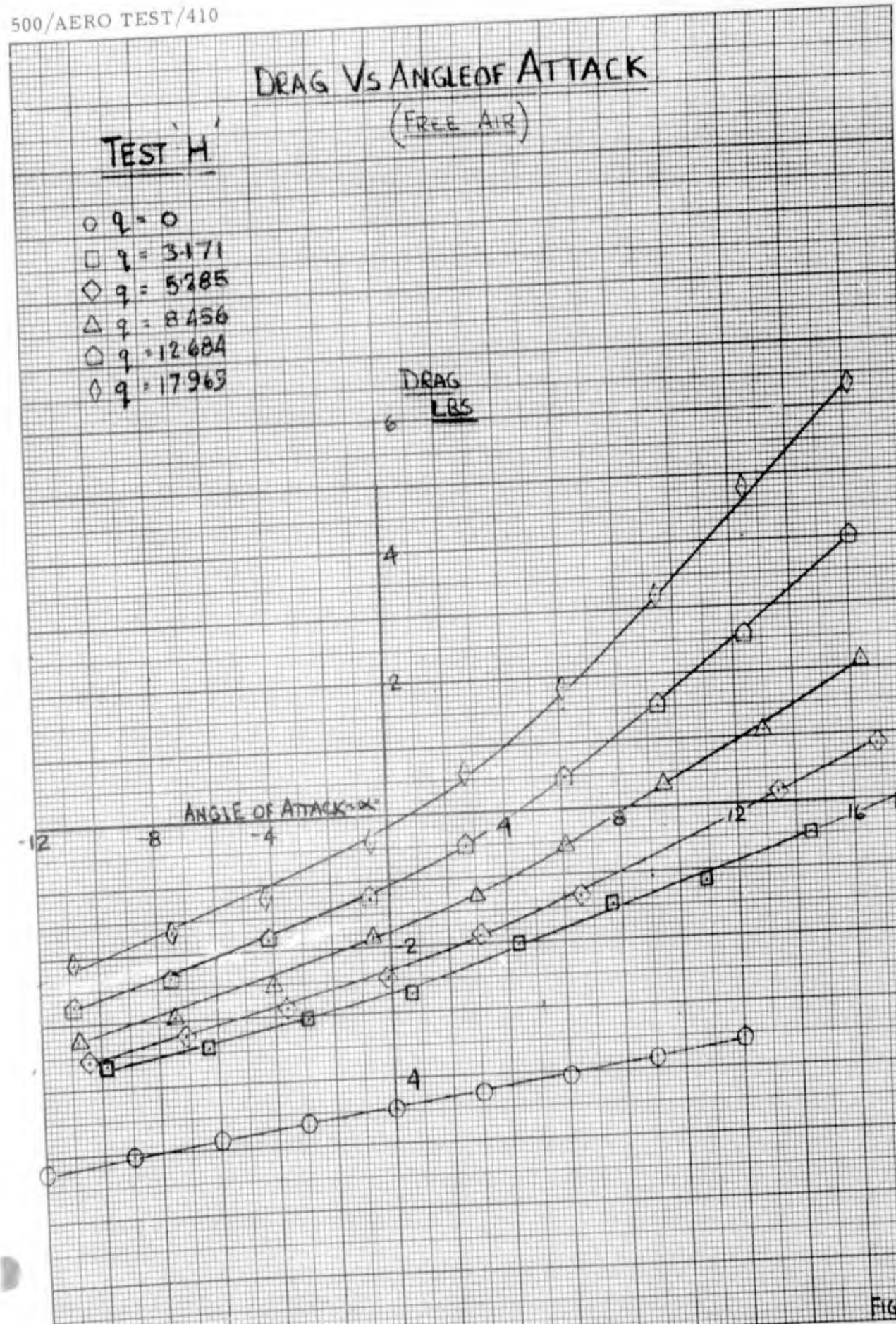

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'H'
○ q = 0
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 17963
DRAG LBS
6
4
2
ANGLE OF ATTACK = α°
-12
-8
-4
4
8
12
16
2
4

FIG 153

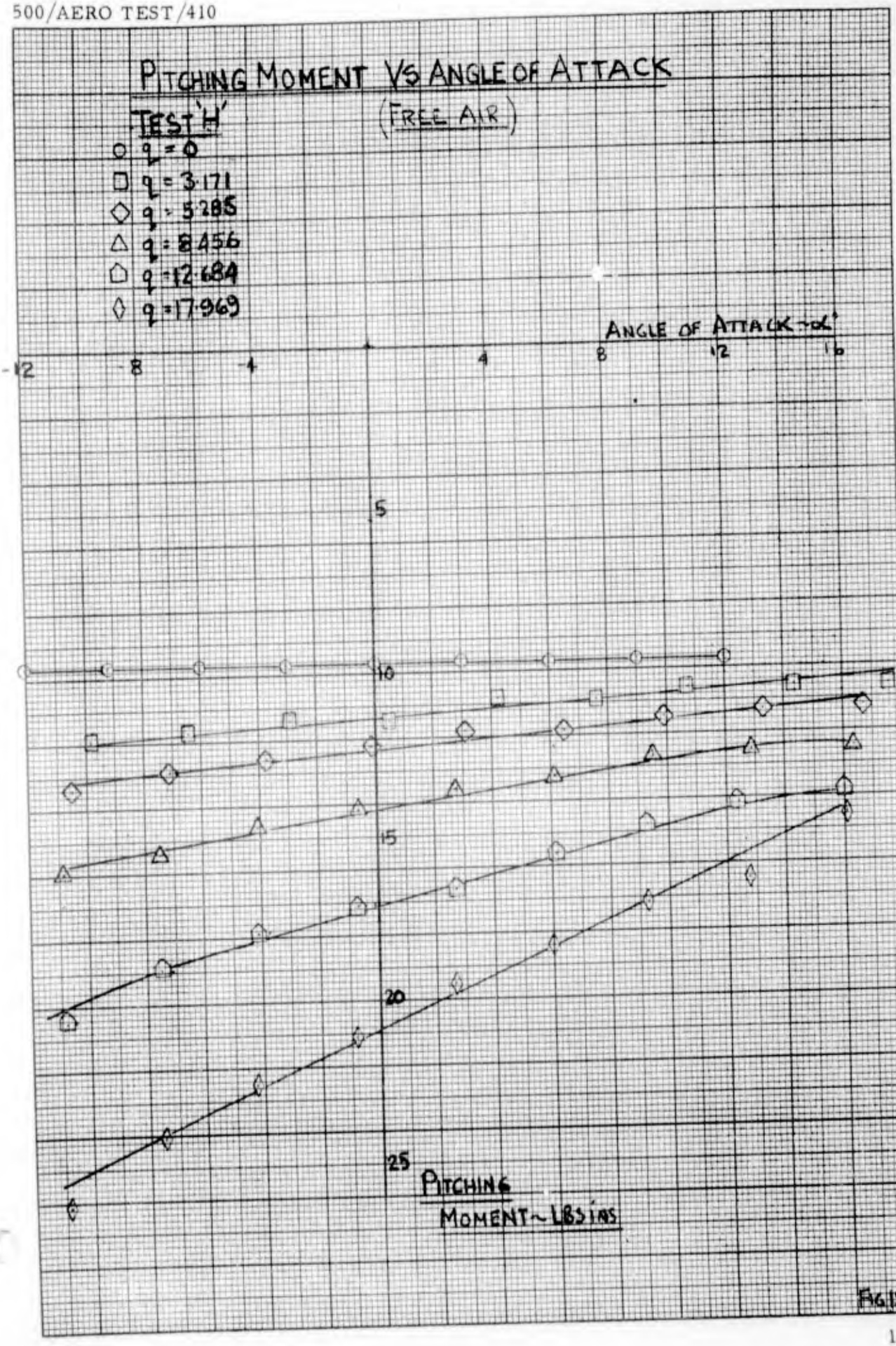

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'H'
(FREE AIR)
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
16
5
10
15
20
25
PITCHING MOMENT ~ LBS INS

Fig 154

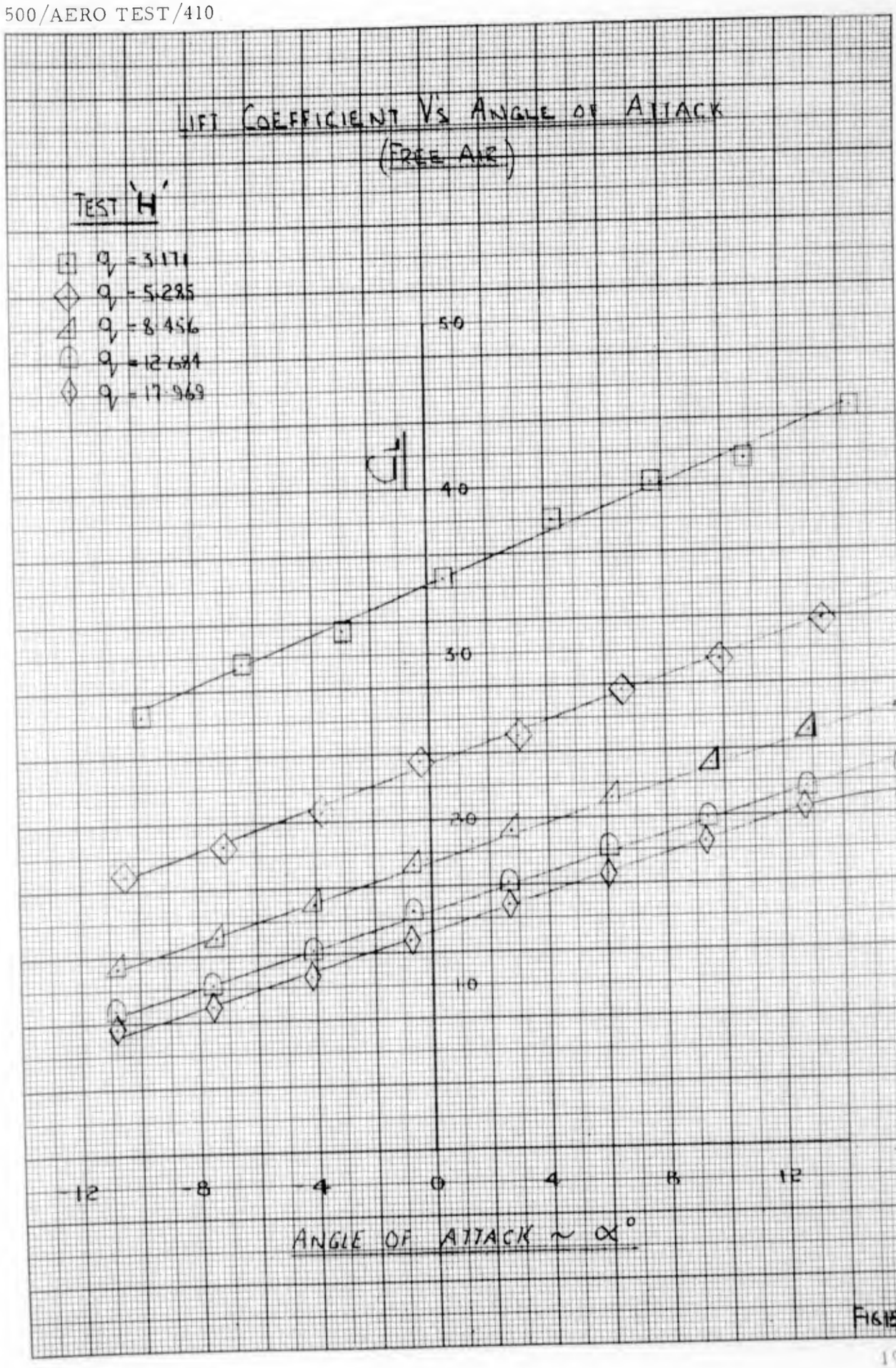

LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'H'
q_v = 3.171
q_v = 5.285
q_v = 8.456
q_v = 12.684
q_v = 17.969
5.0
4.0
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

Fig 155

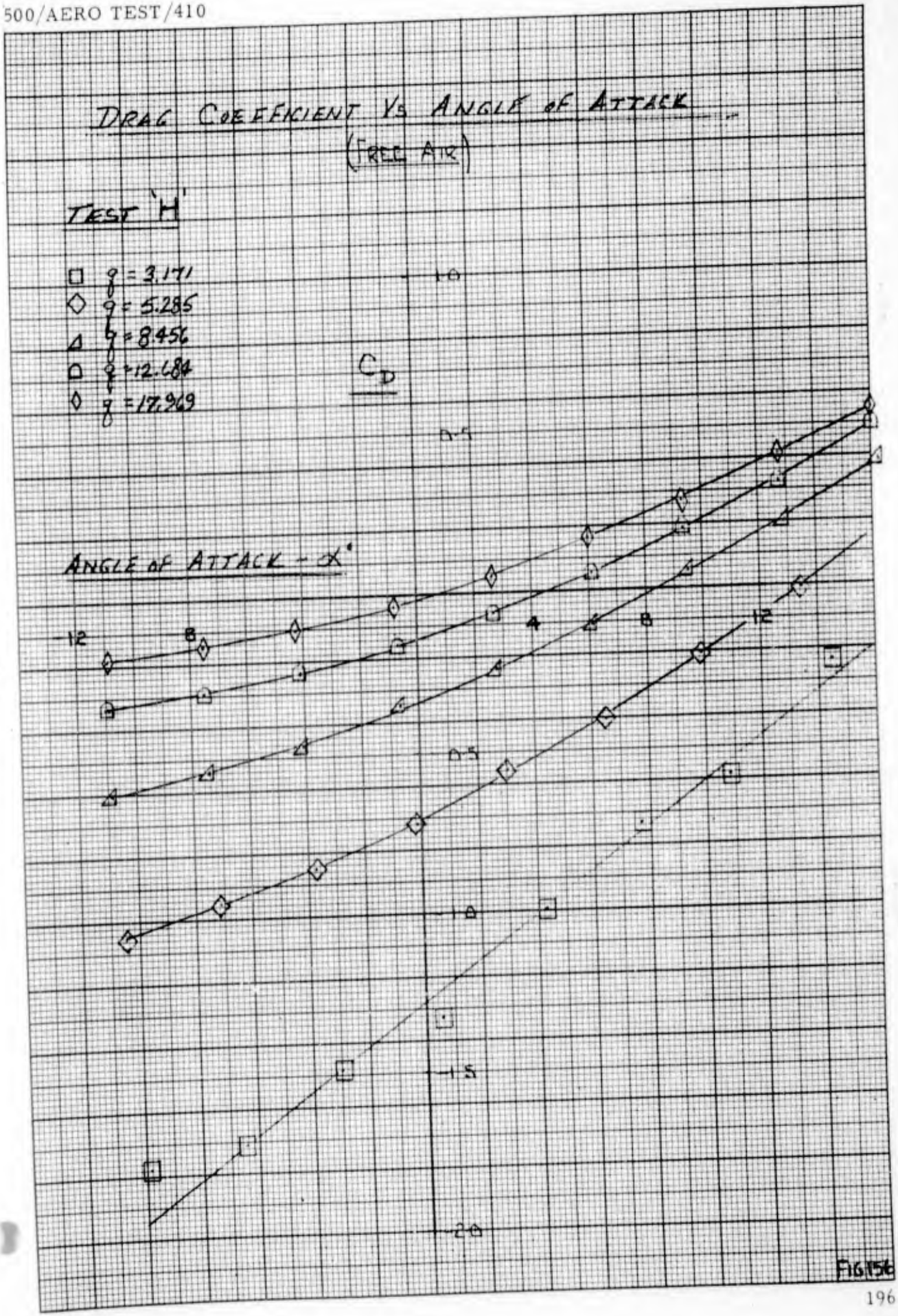

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'H'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.684
◇ q = 17.969
C_D
ANGLE OF ATTACK = α°
-12
-8
-4
4
8
12
.5
1.0
1.5
2.0

Fig 156

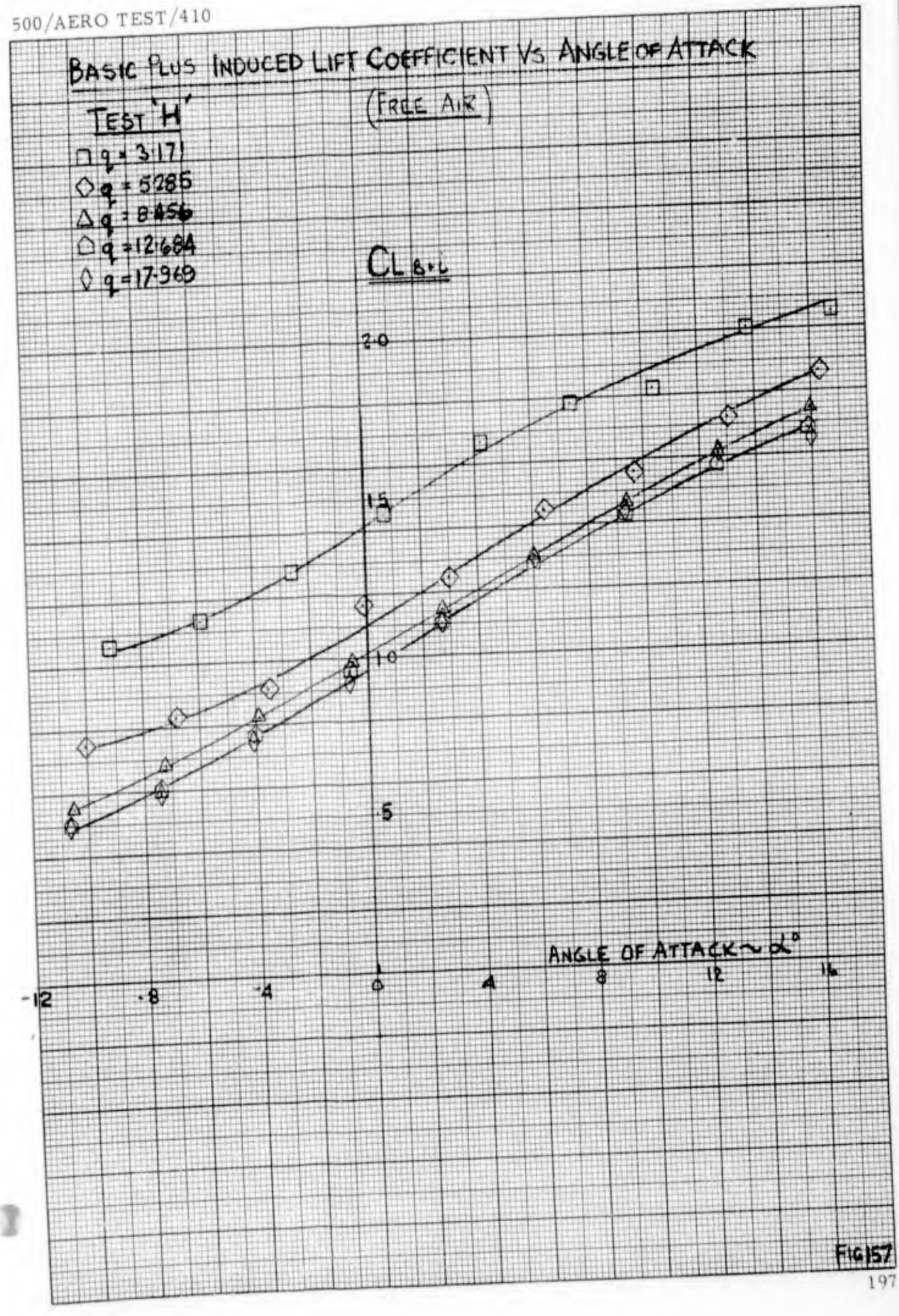

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'H'
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 17969
CL B+L
2.0
1.5
1.0
.5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG 157

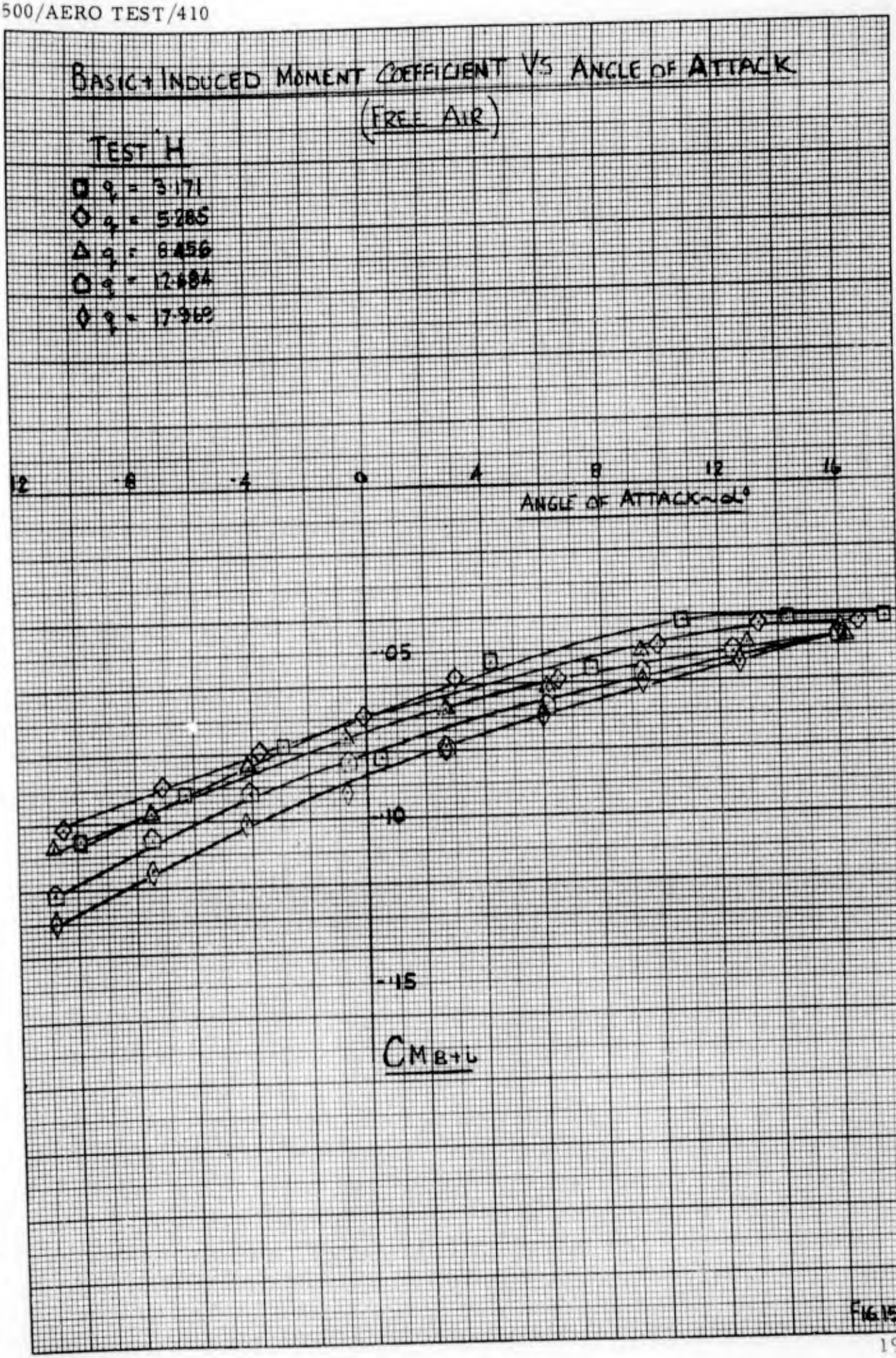

BASIC + INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST H
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°
-05
-10
-15
CM B+L

FIG 15B

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)

TEST 'H'

□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969

$C_{L_{B+L}}$

0 .5 1.0 1.5 2.0 2.5

$C_{M_{B+L}}$

-.05

-.10

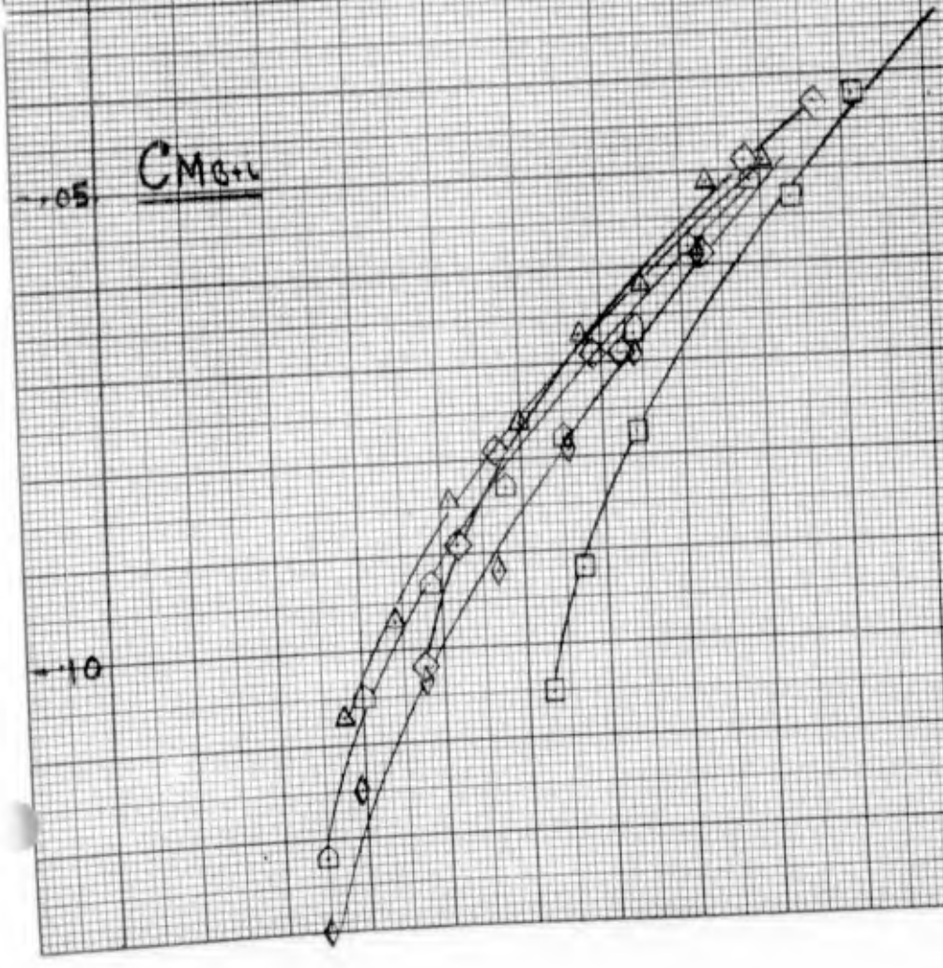


FIG 153

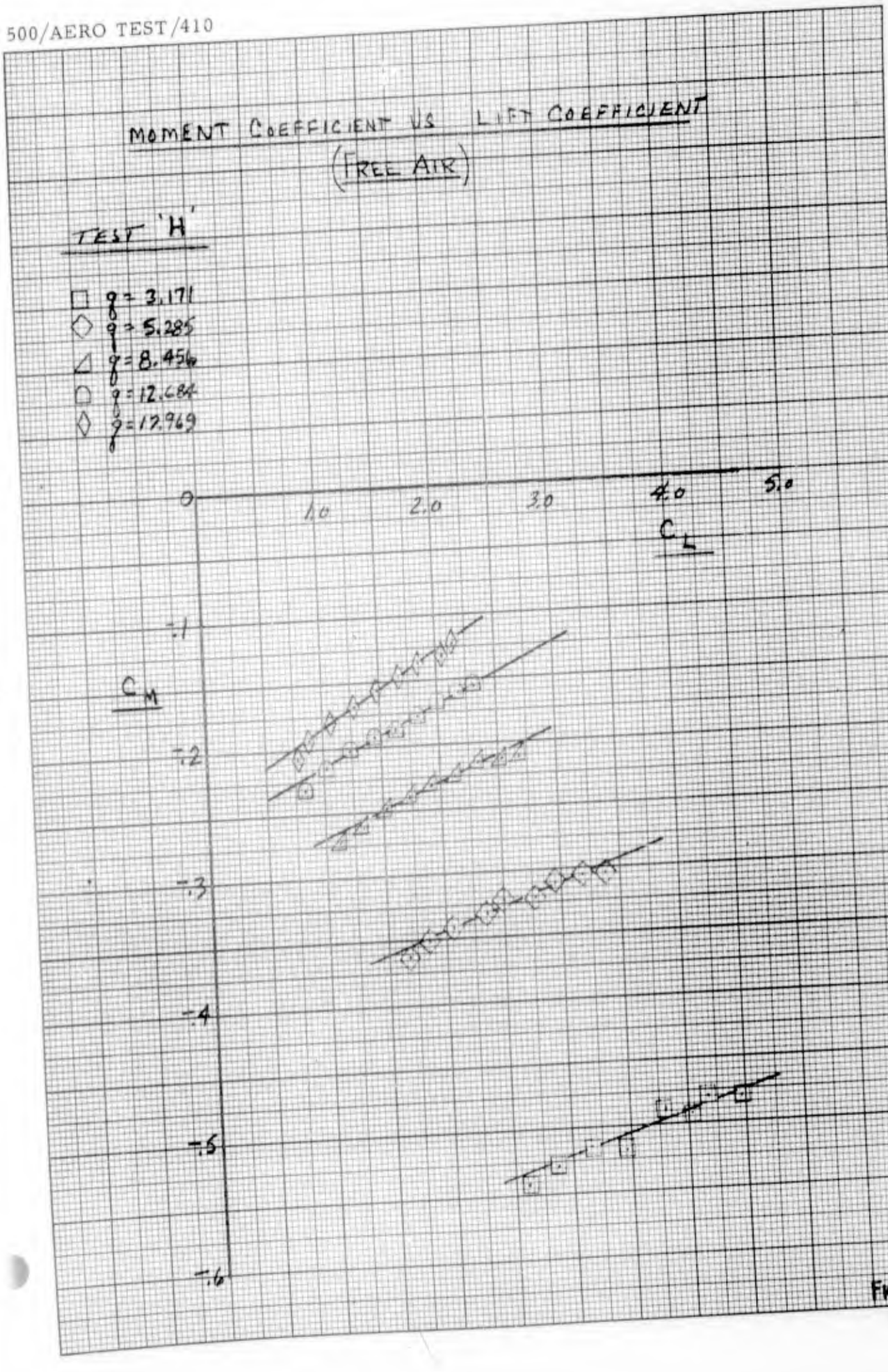

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'H'
□ q = 3.171
◇ q = 5.285
◿ q = 8.456
⬠ q = 12.684
◇ q = 17.969
0
1.0
2.0
3.0
4.0
5.0
C_L
-.1
C_M
-.2
-.3
-.4
-.5
-.6

FIG 160

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 'H'

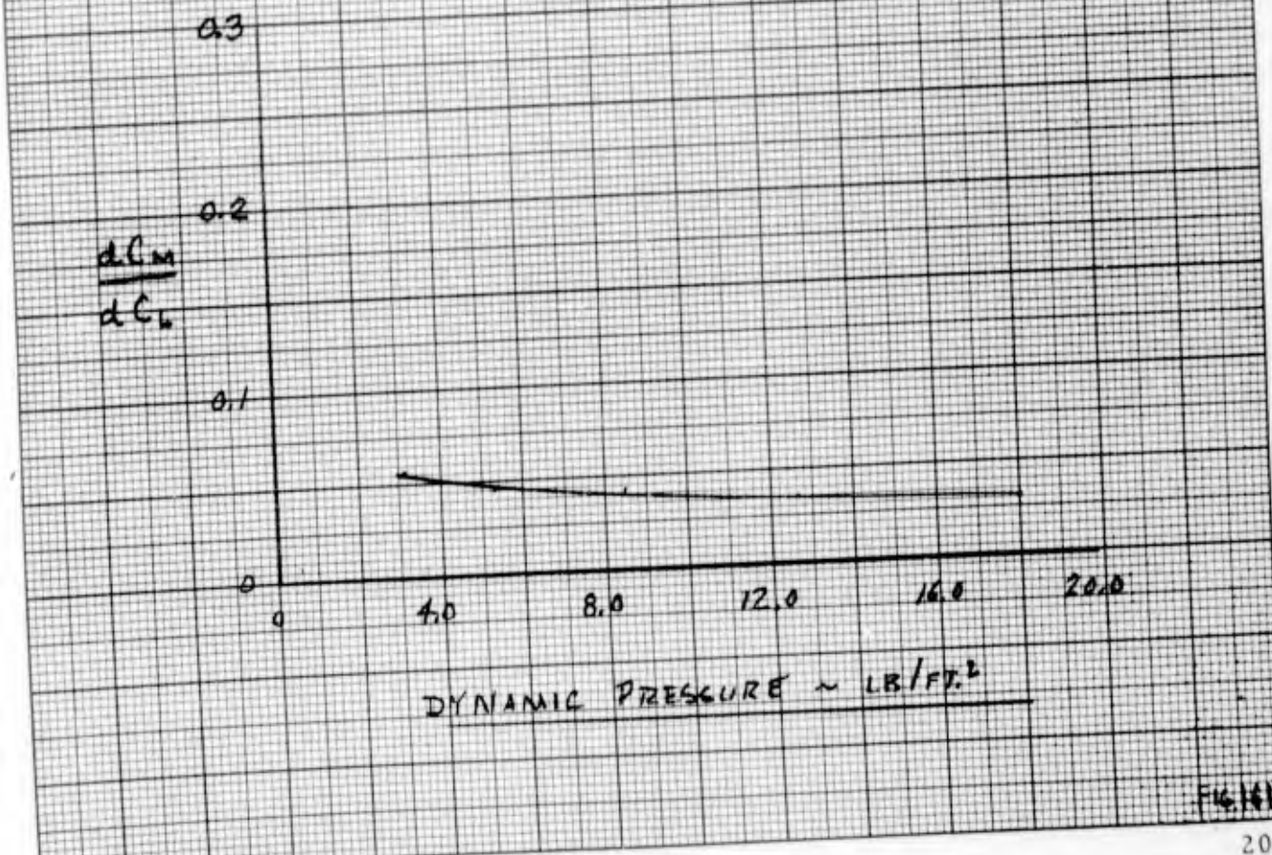


FIG 161

LIFT CURVE SLOPE VS DYNAMIC PRESSURE
(FREE AIR)

TEST 'H'

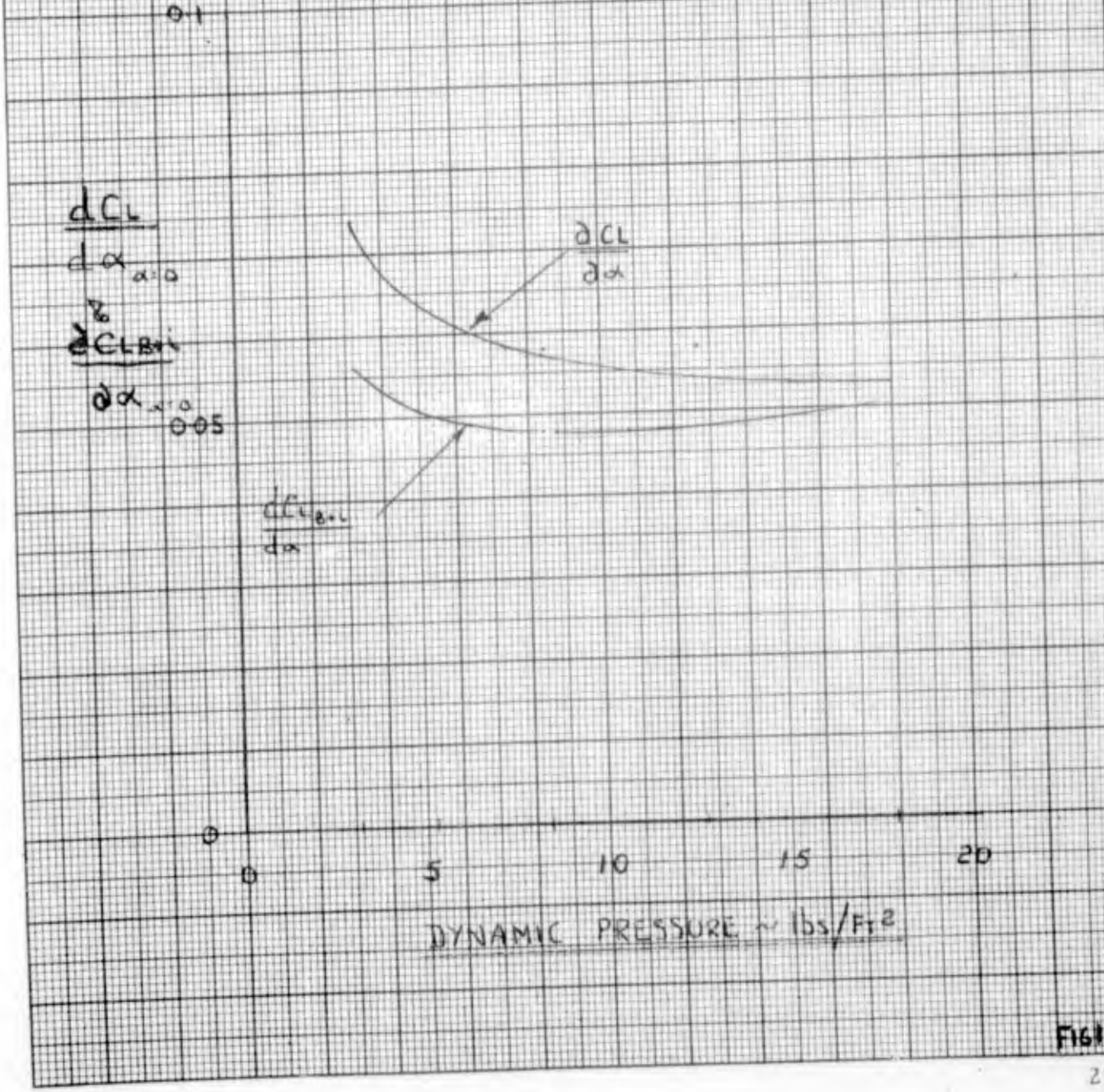


FIG 6

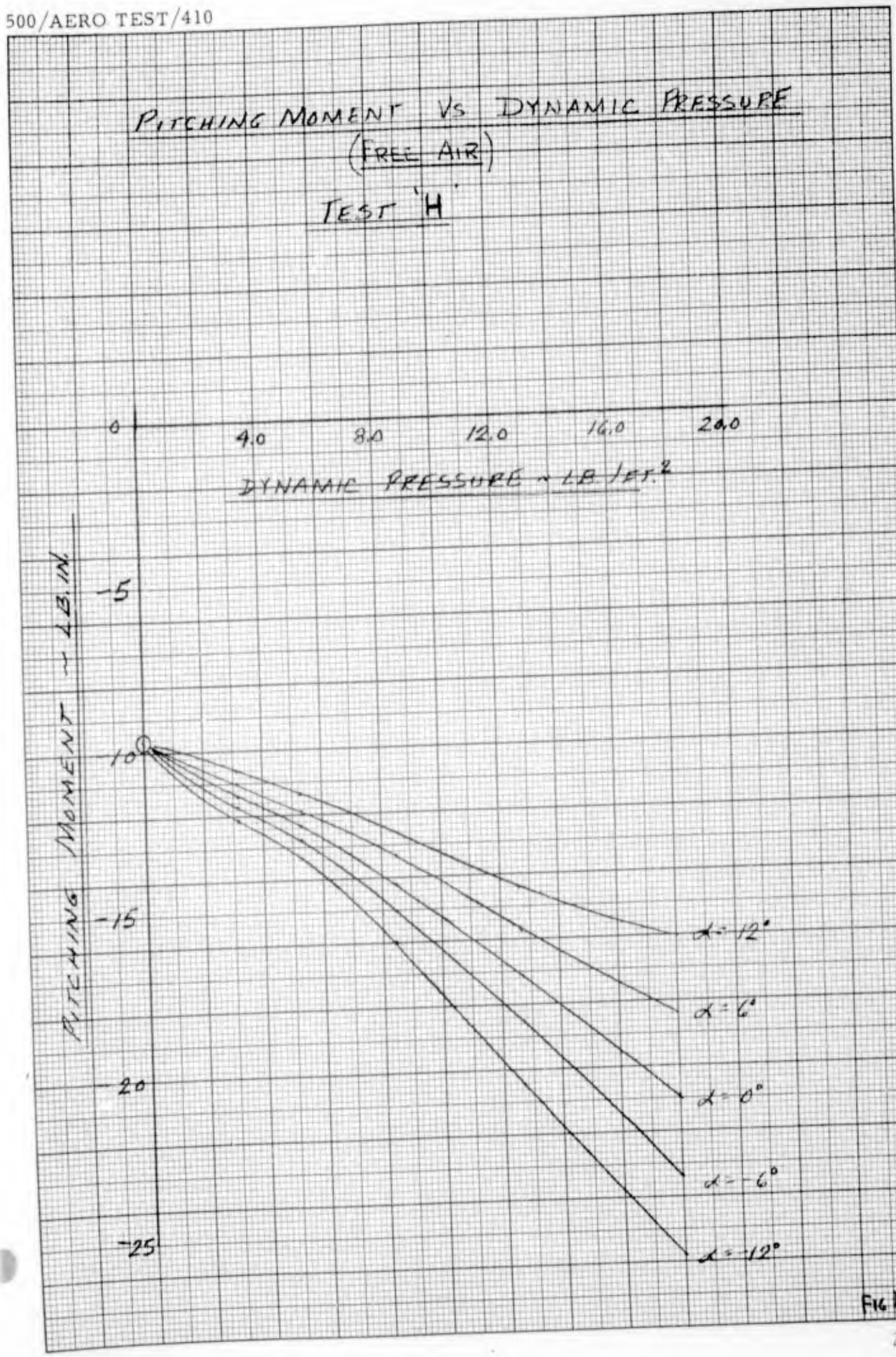

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 'H'
0
4.0
8.0
12.0
16.0
20.0
DYNAMIC PRESSURE - LB./FT.²
PITCHING MOMENT - LB. IN.
-5
-10
-15
-20
-25
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 163

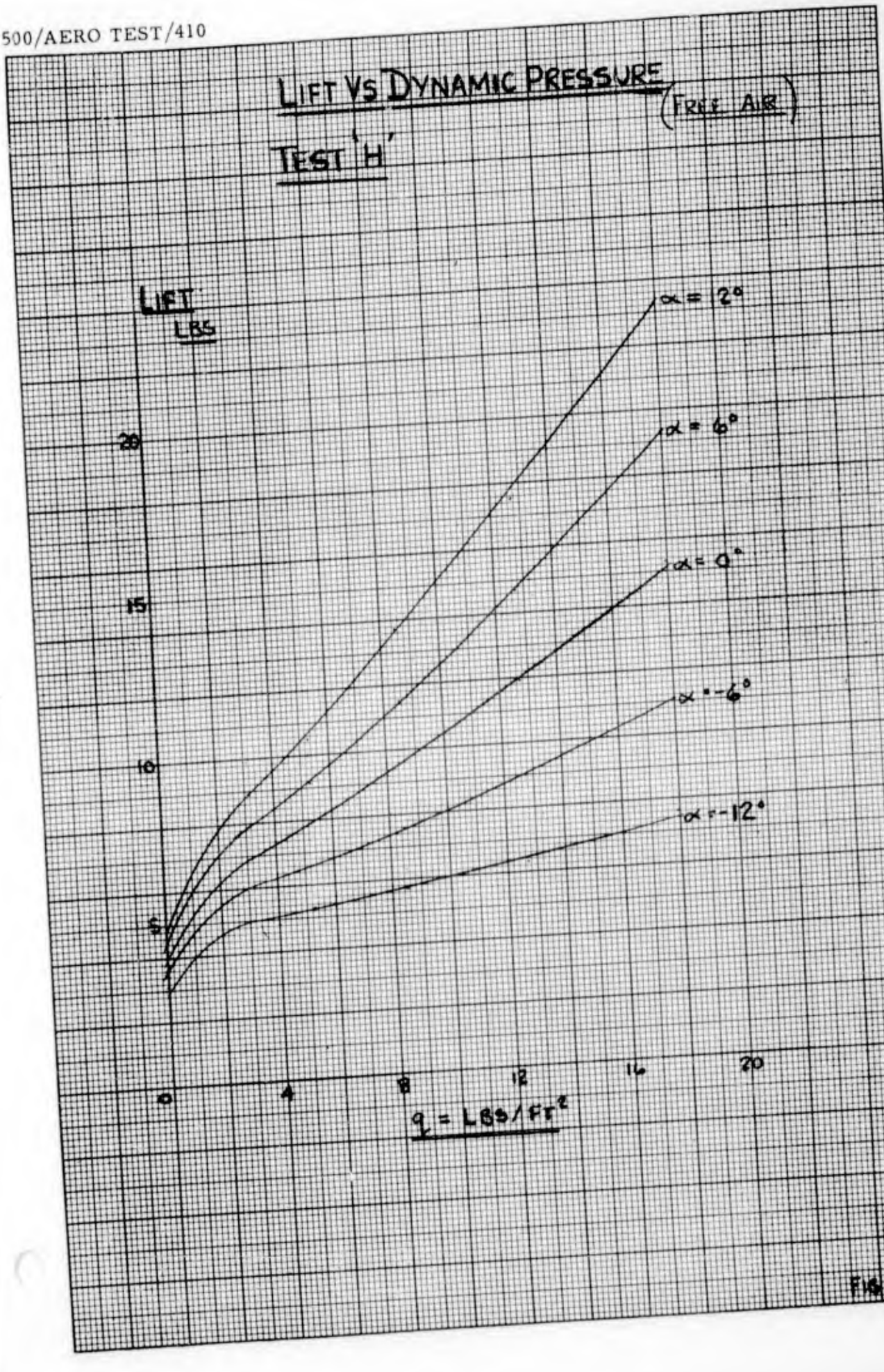

LIFT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 'H'
LIFT
LBS
20
15
10
5
0
4
8
12
16
20
q = LBS/FT²
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 11

DRAG VS DYNAMIC PRESSURE (FREE AIR)

TEST 'H'

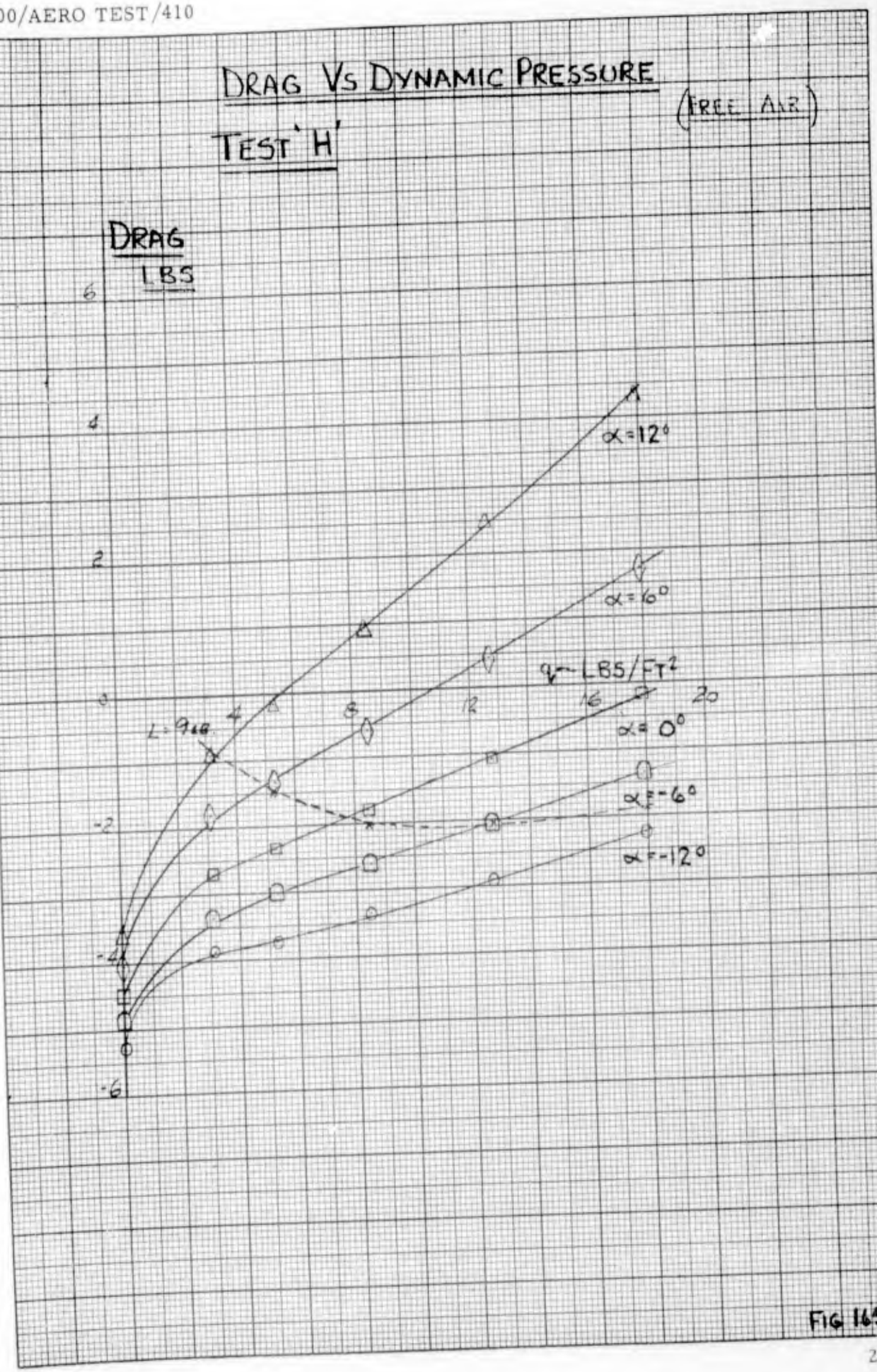


FIG 165

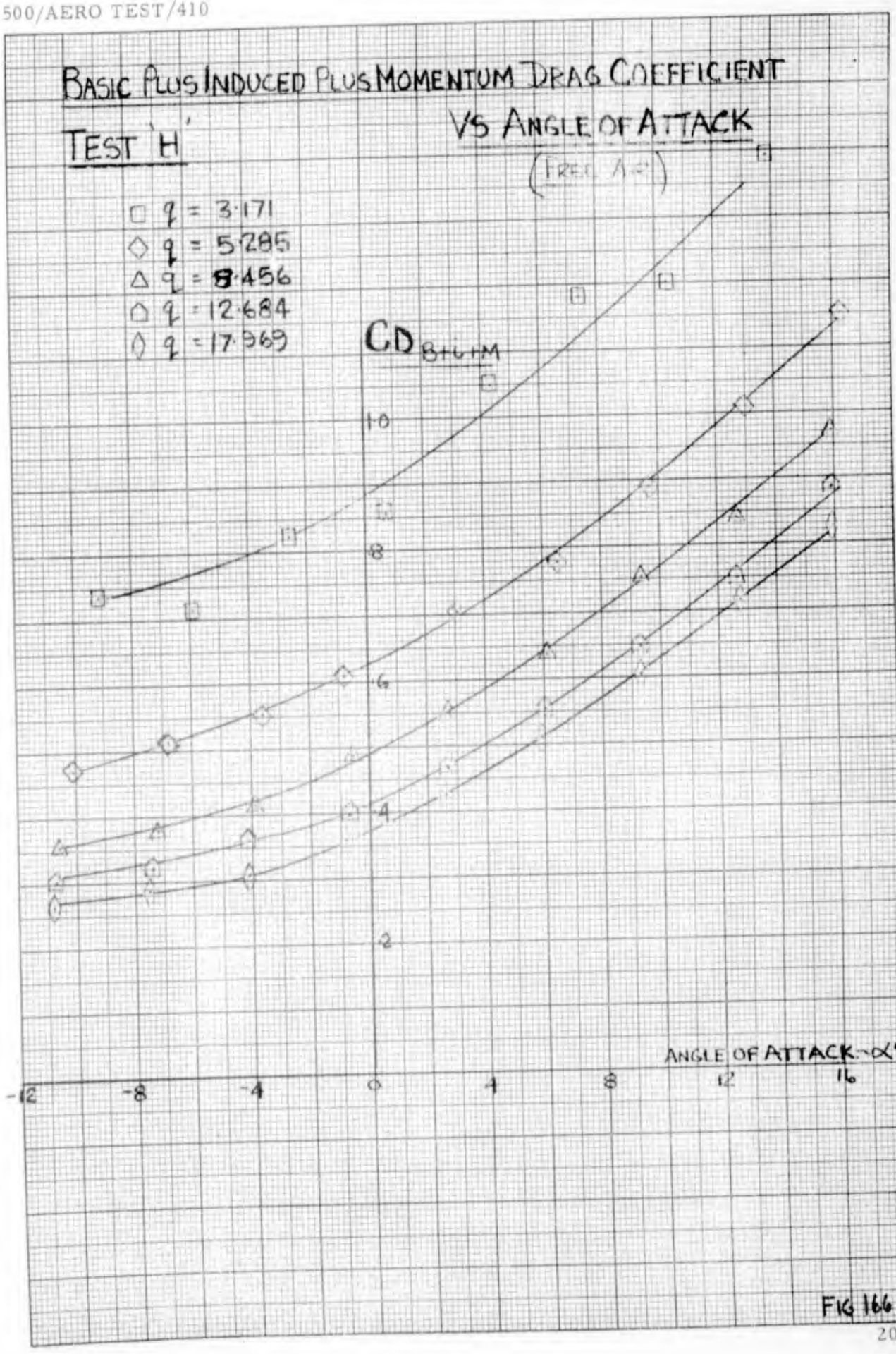

BASIC PLUS INDUCED PLUS MOMENTUM DRAG COEFFICIENT
VS ANGLE OF ATTACK
TEST 'H'
(FREE AIR)
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⌂ q = 12·684
◊ q = 17·969
CD B+I+M
10
8
6
4
2
ANGLE OF ATTACK - α°
-12
-8
-4
0
4
8
12
16

FIG 166

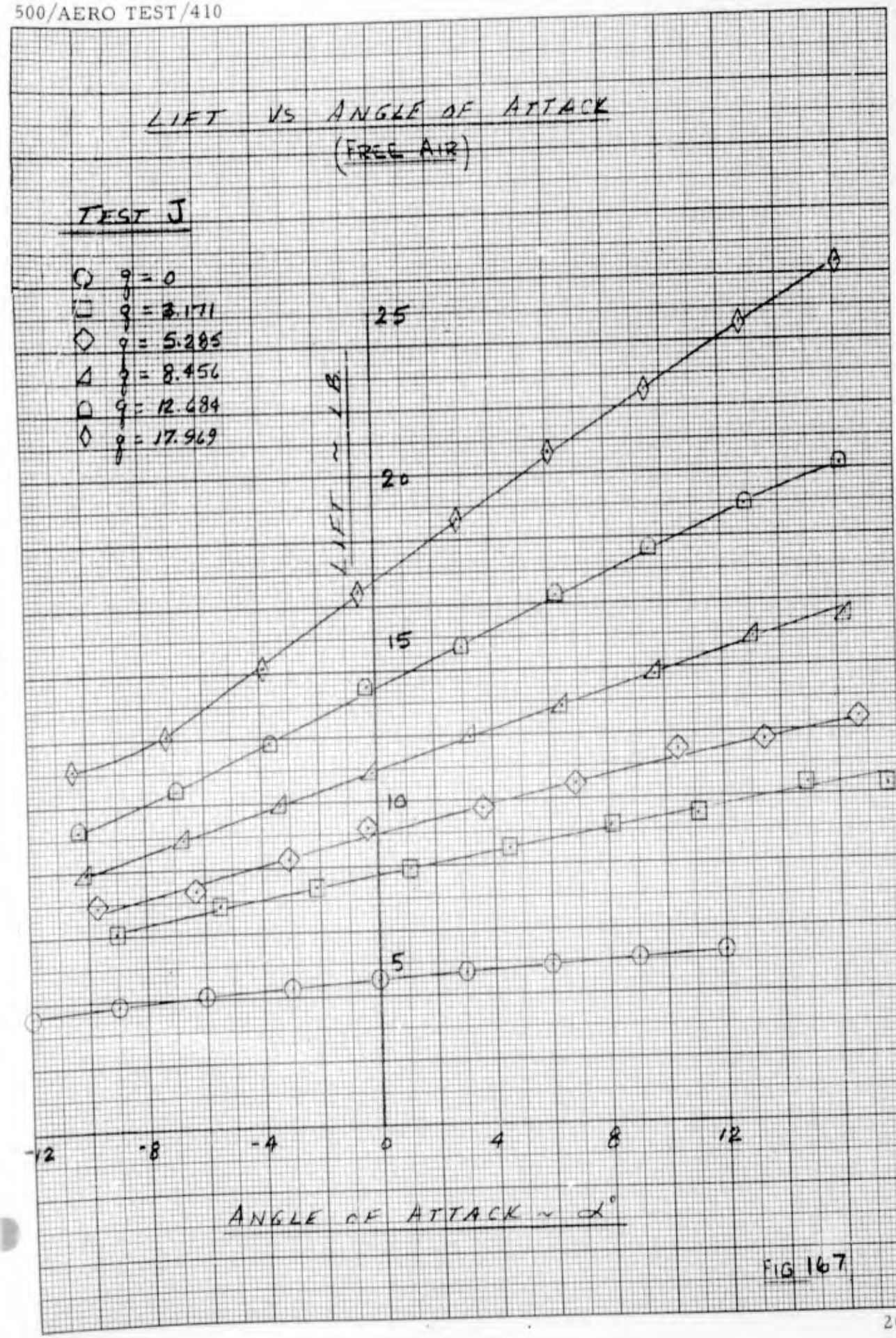

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST J
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
LIFT
25
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 167

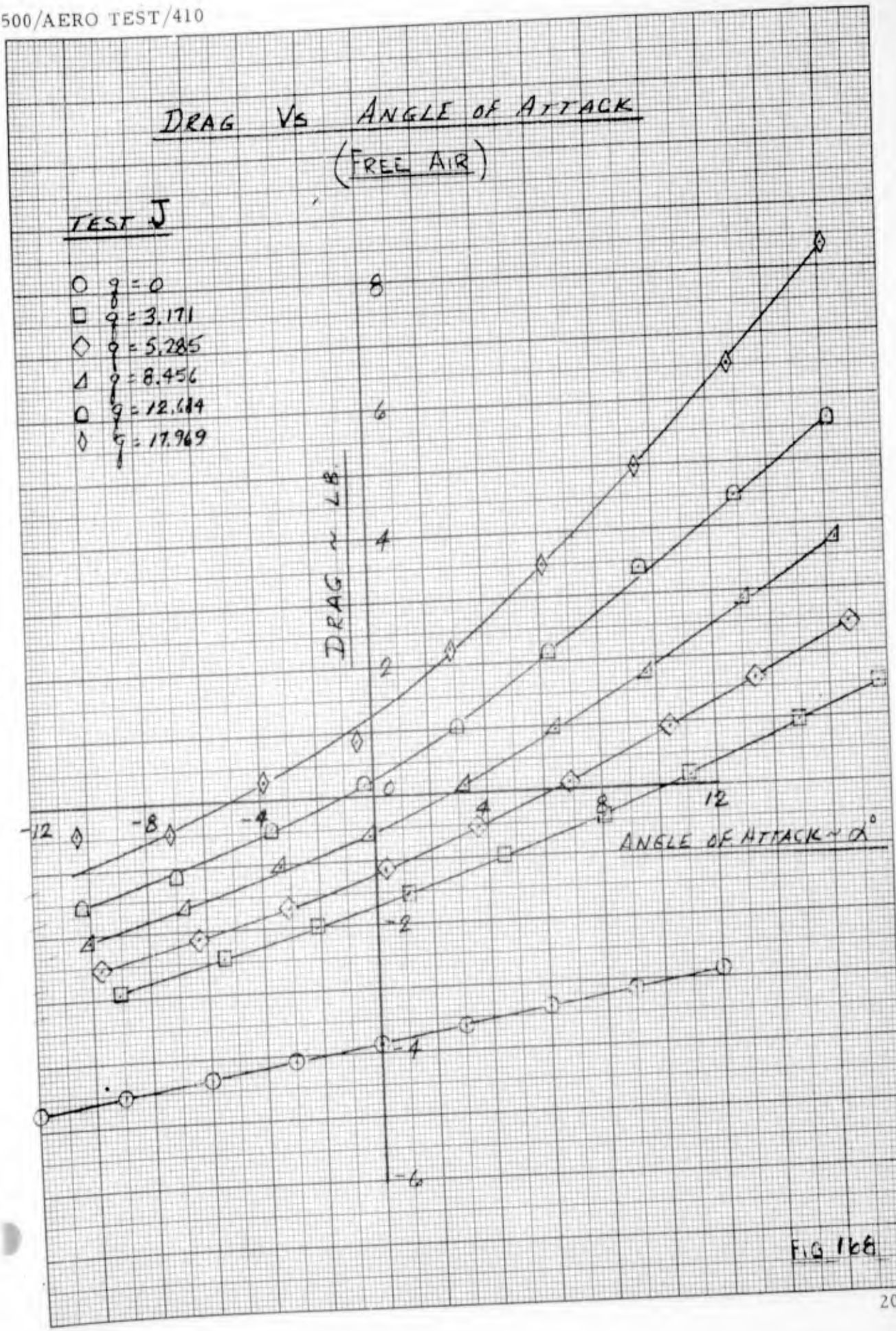

DRAG Vs ANGLE OF ATTACK
(FREE AIR)
TEST J
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◇ q = 17.969
DRAG ~ LB.
8
6
4
2
0
-2
-4
-6
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°

FIG 166

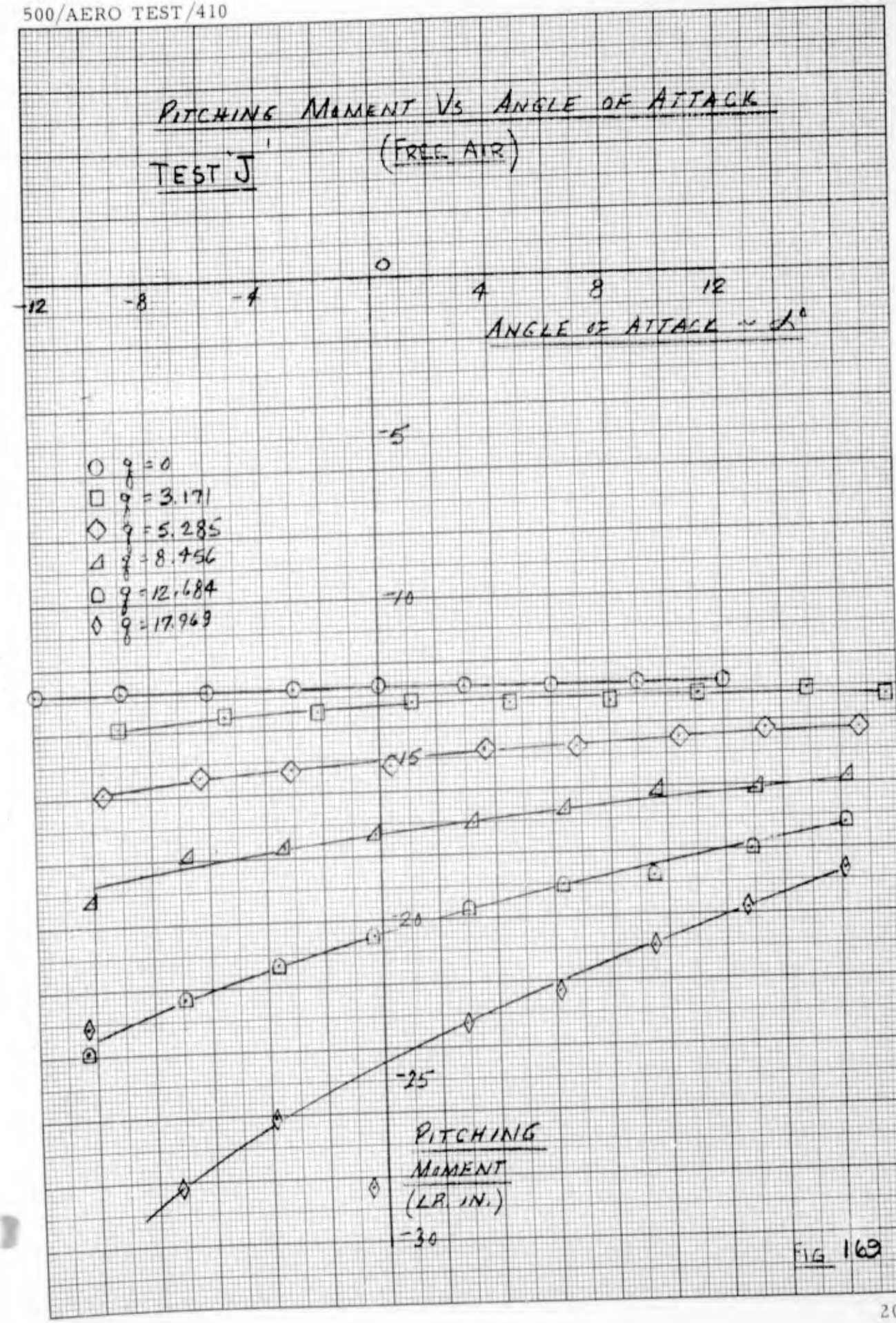

PITCHING MOMENT VS ANGLE OF ATTACK
TEST J'
(FREE AIR)
0
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°
-5
-10
-15
-20
-25
-30
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.684
◇ q = 17.969
PITCHING MOMENT (LB. IN.)

FIG 169

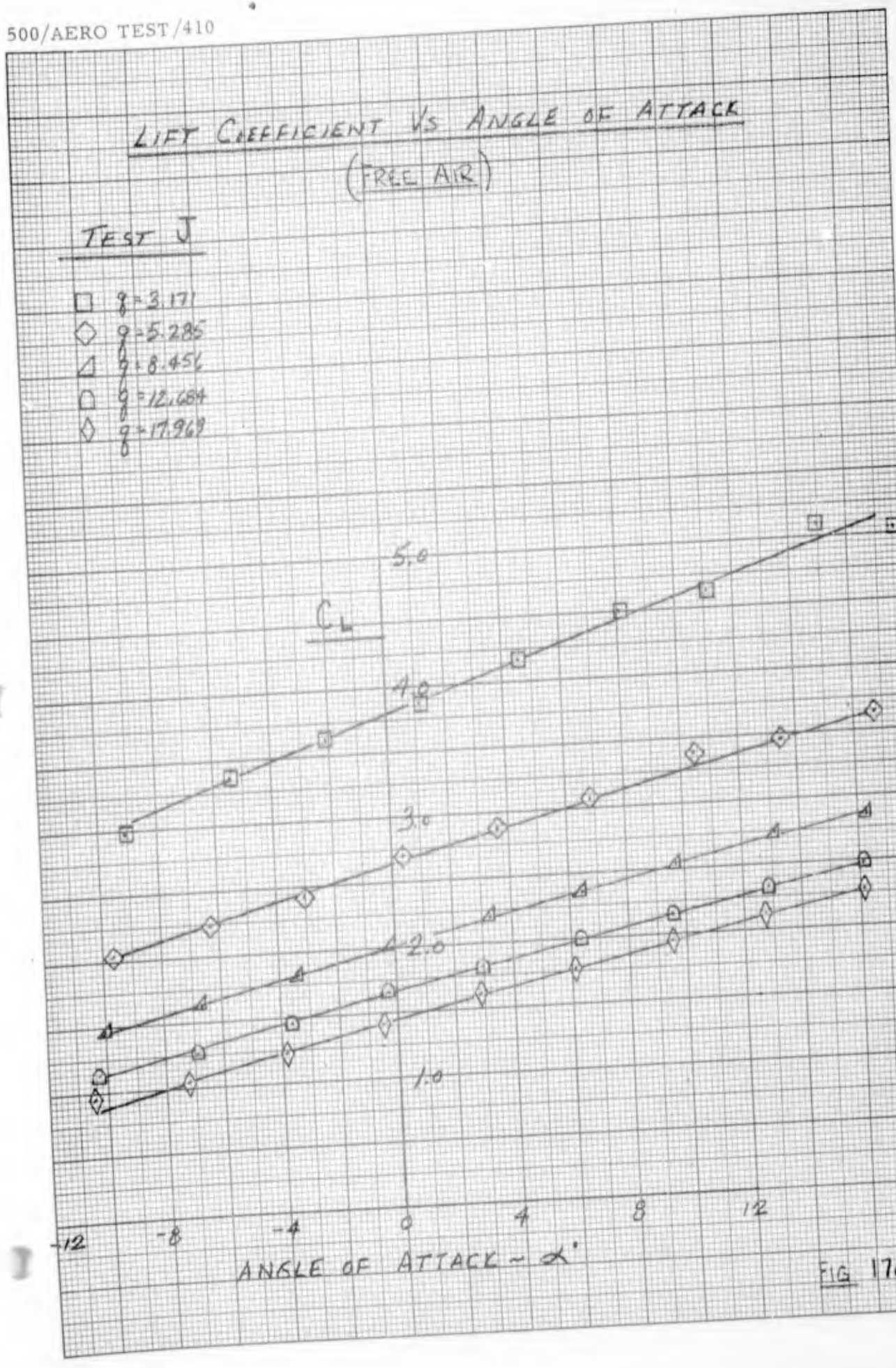

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST J
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
5.0
C_L
4.0
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

FIG 170

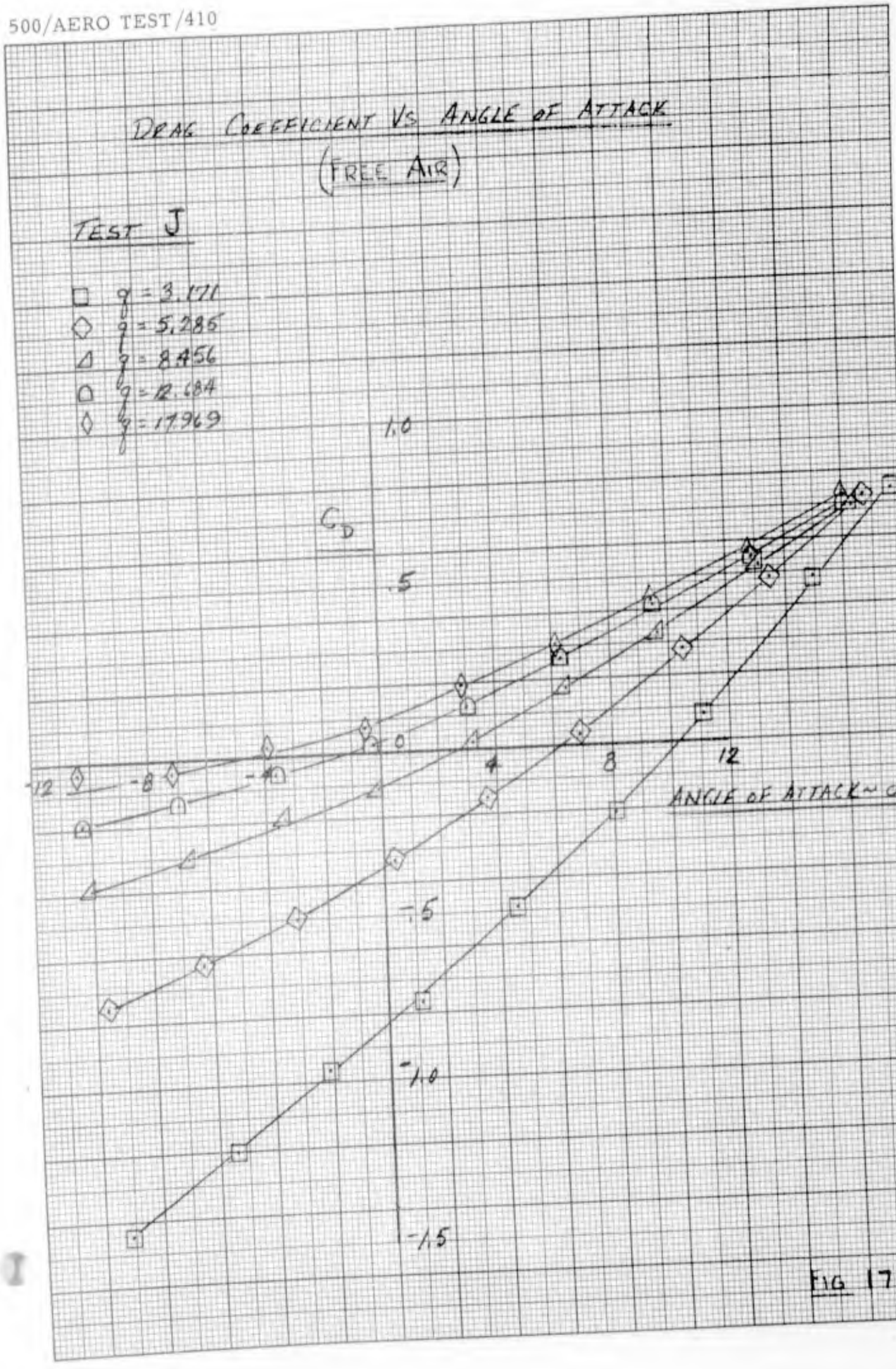

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST J
□ q = 3.171
◇ q = 5.286
△ q = 8.456
○ q = 12.684
◇ q = 17.969
1.0
C_D
.5
0
4
8
12
-12
-8
-4
ANGLE OF ATTACK ~ α
-.5
-1.0
-1.5

FIG 171

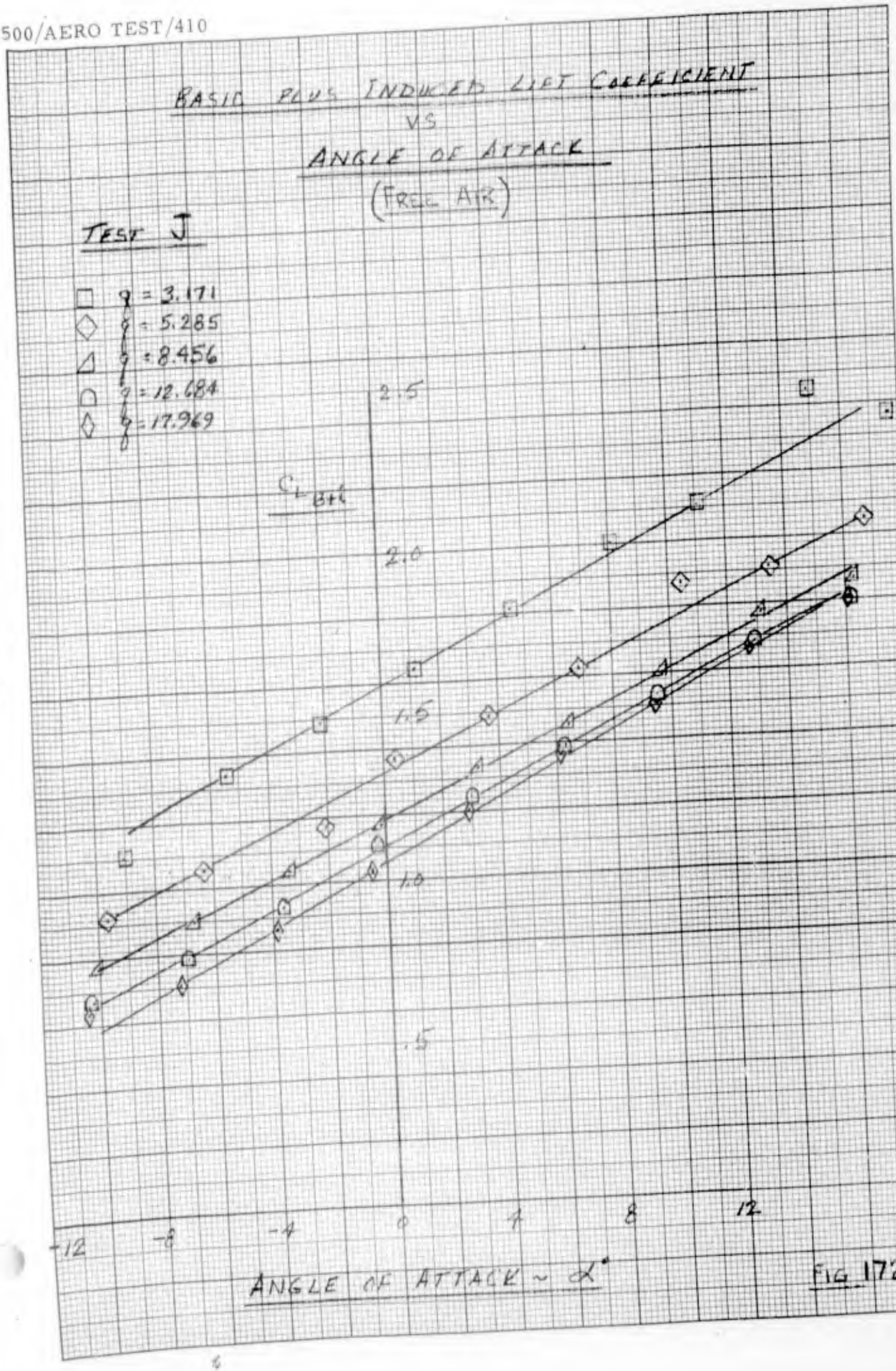

BASIC PLUS INDUCED LIFT COEFFICIENT
VS
ANGLE OF ATTACK
(FREE AIR)
TEST J
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
$C_{L_{B+i}}$
2.5
2.0
1.5
1.0
.5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 172

BASIC PLUS INDUCED MOMENT COEFFICIENT VS. ANGLE OF ATTACK (FREE AIR)

TEST J

□ $q = 3.171$
◇ $q = 5.285$
△ $q = 8.456$
⌂ $q = 12.684$
◊ $q = 17.969$

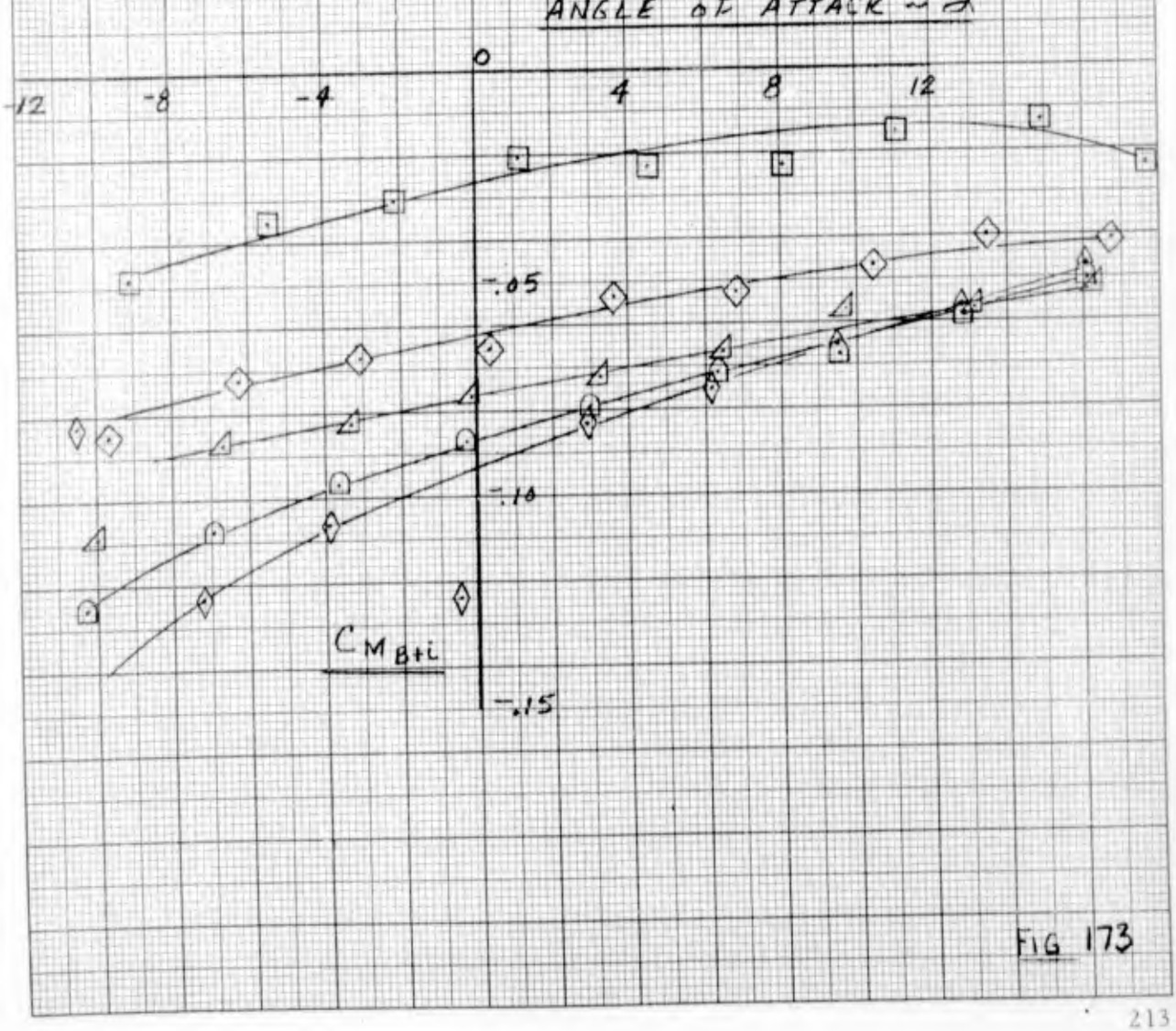


FIG 173

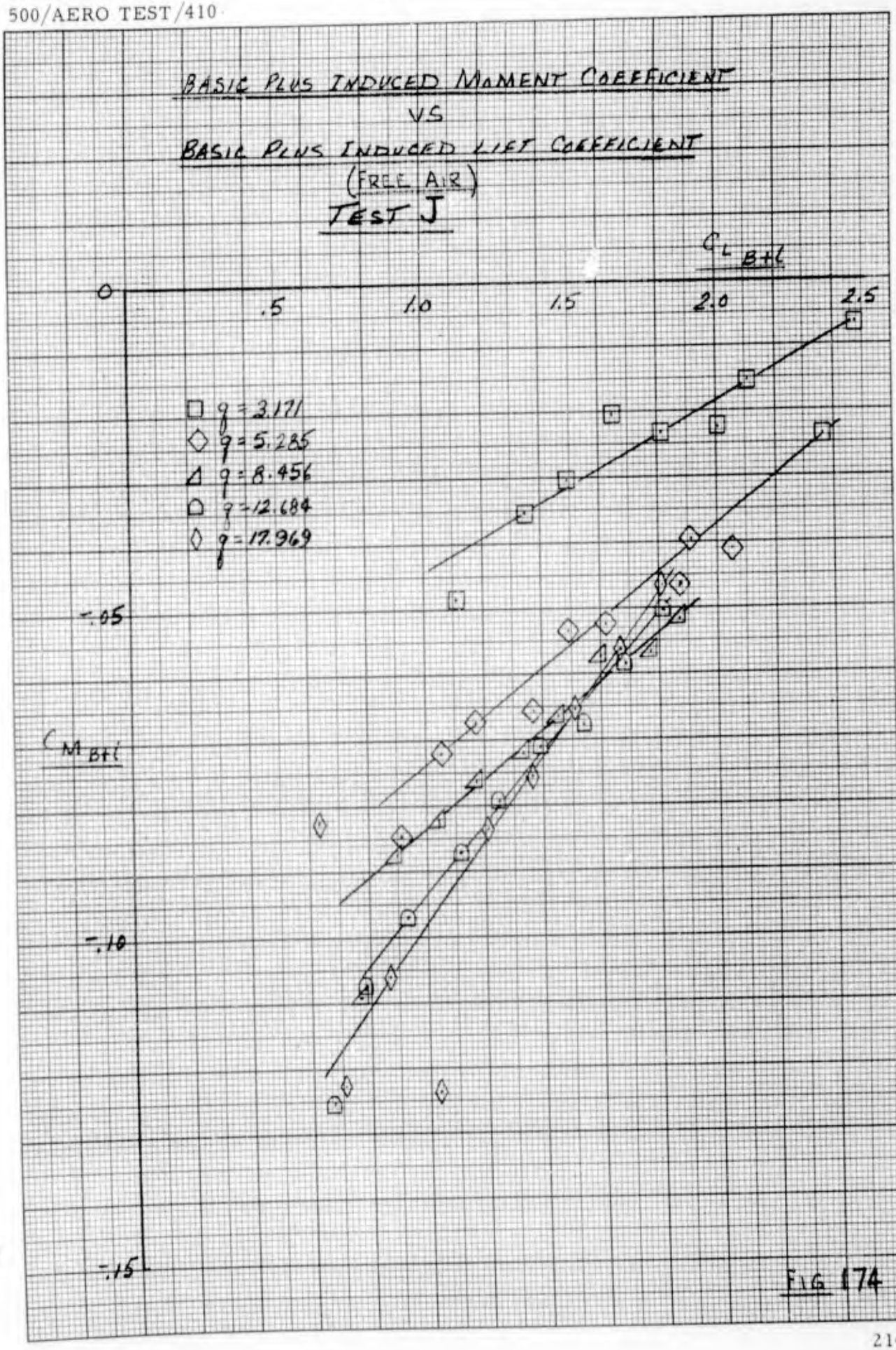

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST J
$C_{L\ B+i}$
0
.5
1.0
1.5
2.0
2.5
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
-.05
$C_{M\ B+i}$
-.10
-.15

FIG 174

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)

TEST J

□ q = 3.171
◇ q = 5.285
△ q = 8.456
□ q = 12.684
◇ q = 17.969

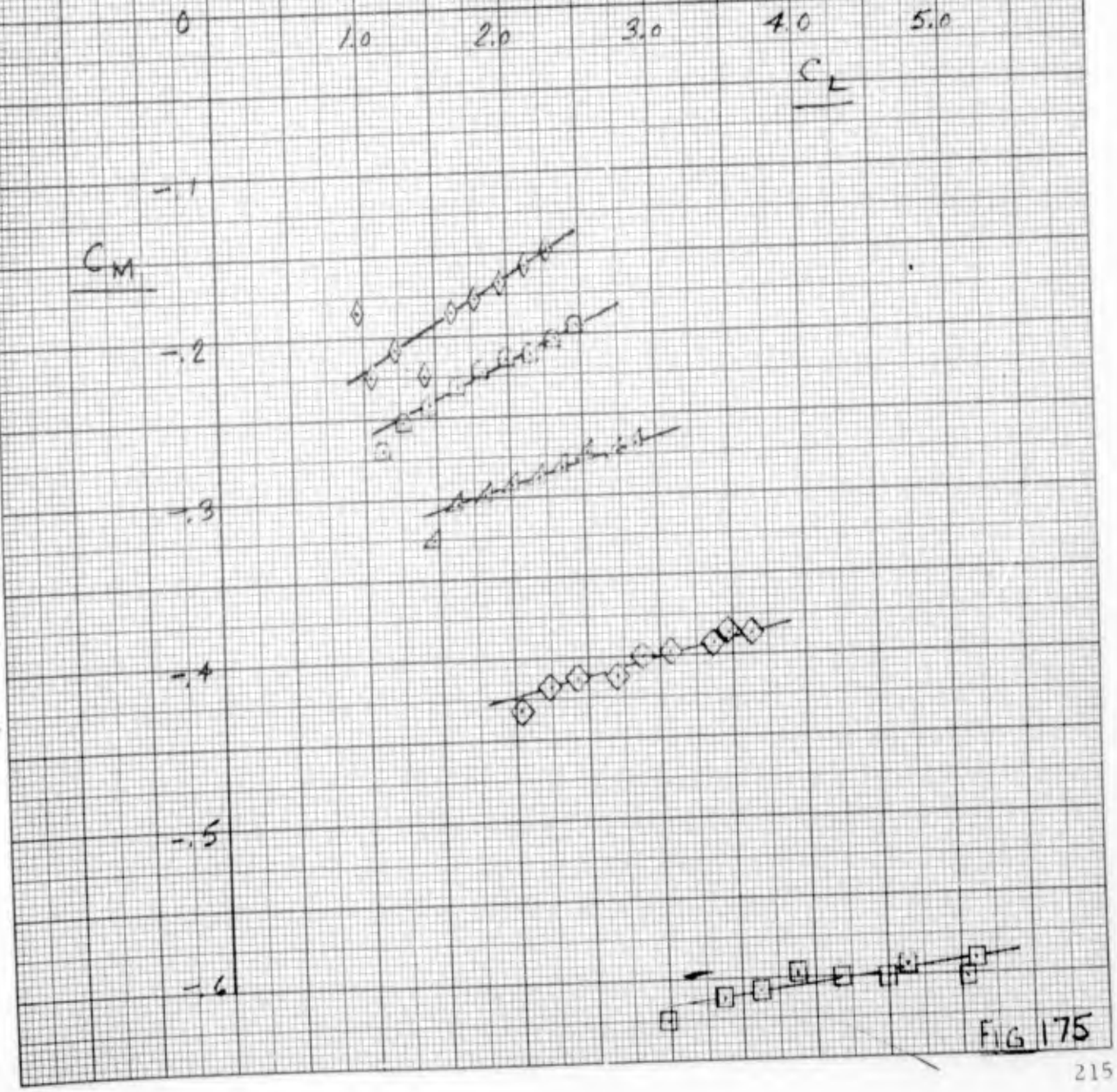


FIG 175

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST J

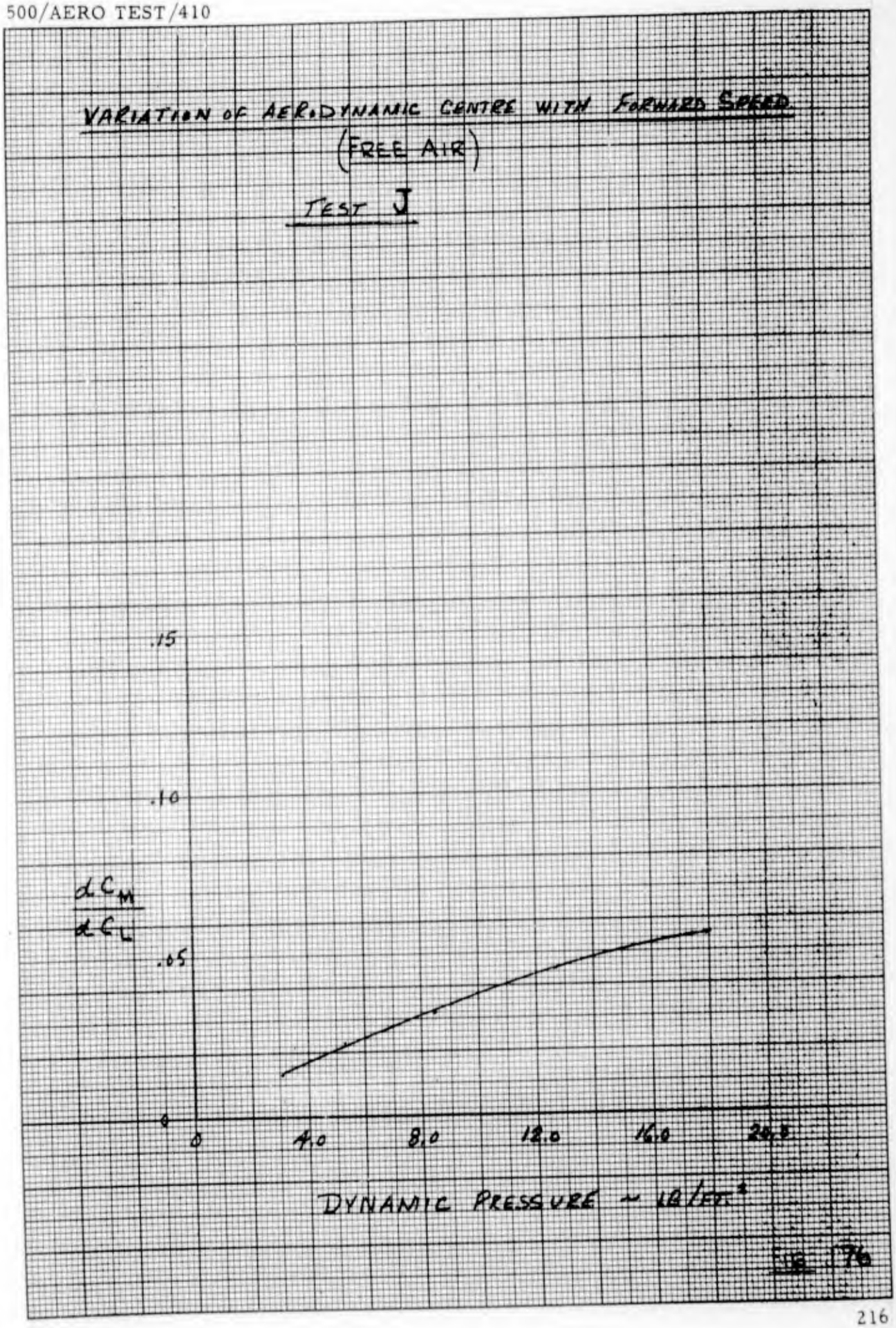


FIG. 76

LIFT CURVE SLOPE VS DYNAMIC PRESSURE

(FREE AIR)

TEST 1

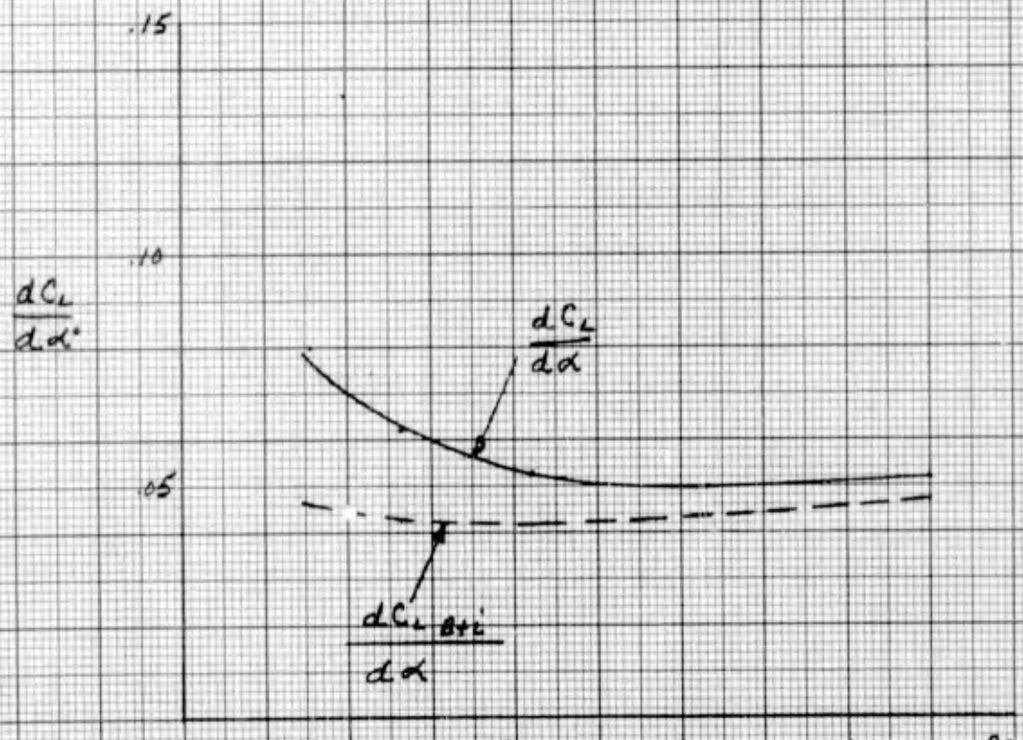


FIG 177

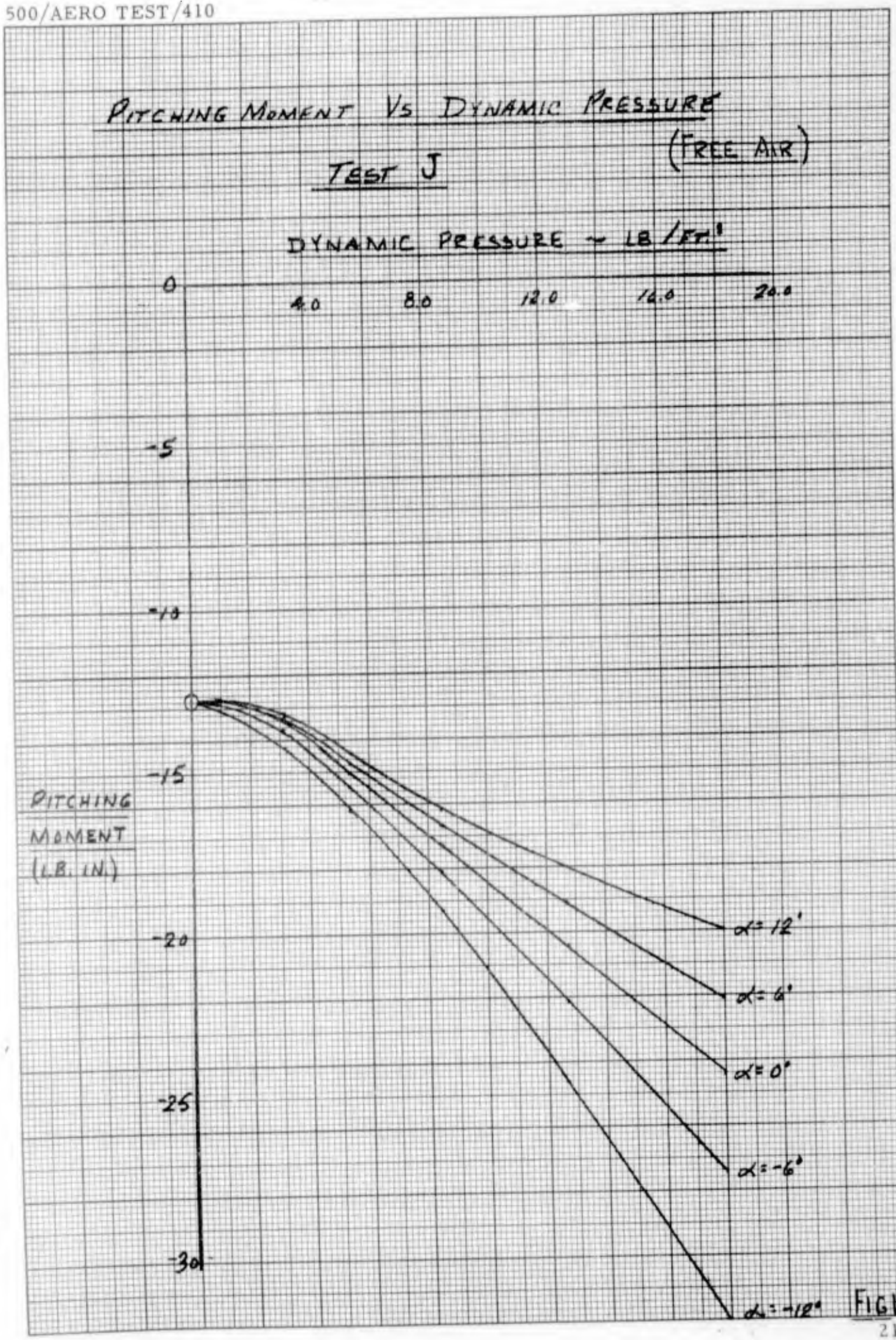

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST J
DYNAMIC PRESSURE ~ LB/FT²
0
4.0
8.0
12.0
16.0
20.0
-5
-10
-15
-20
-25
-30
PITCHING MOMENT (LB. IN.)
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 178

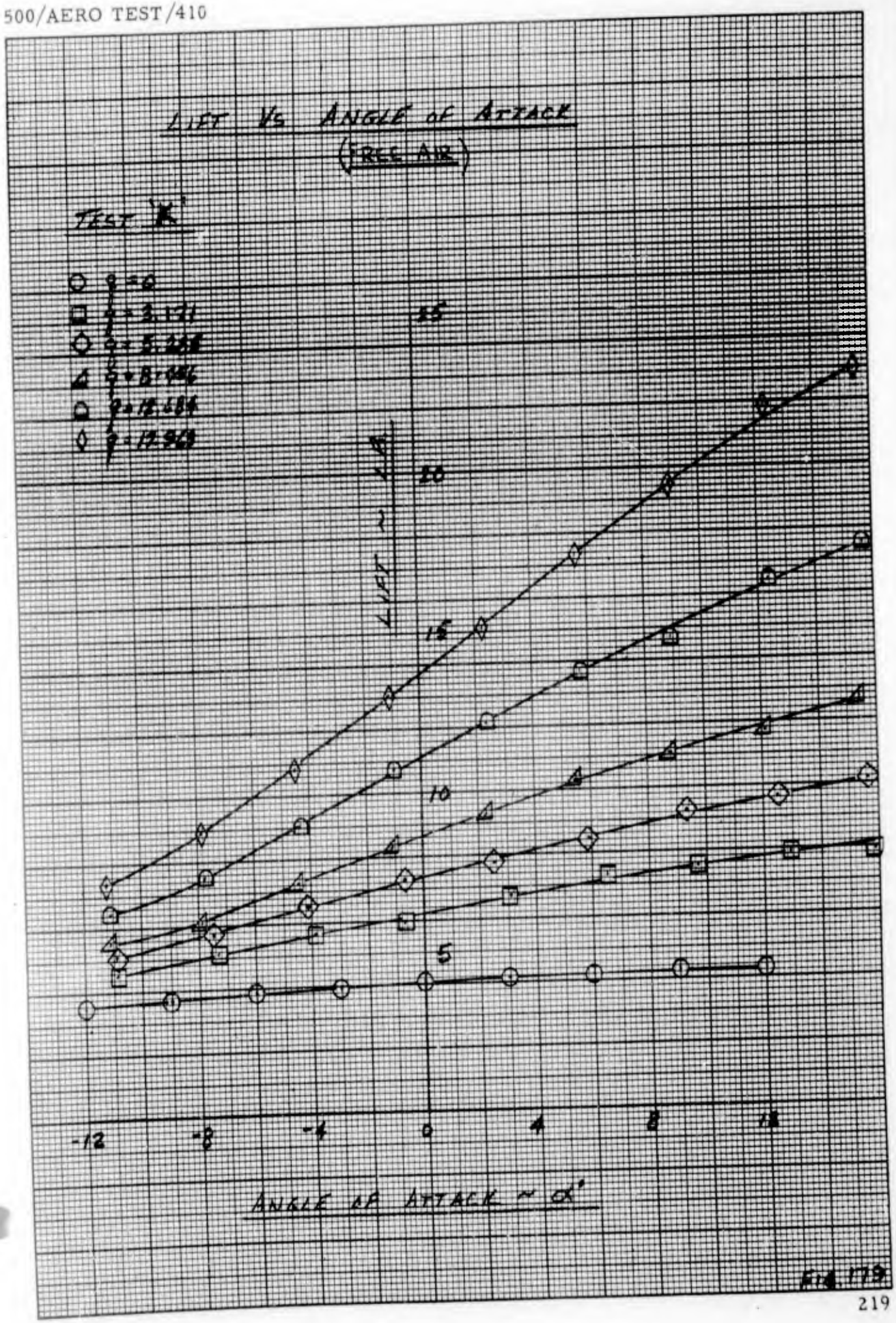

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'K'
q = 0
q = 3.121
q = 5.288
q = 8.106
q = 12.684
q = 17.969
25
20
15
10
5
LIFT
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α'

FIG 179

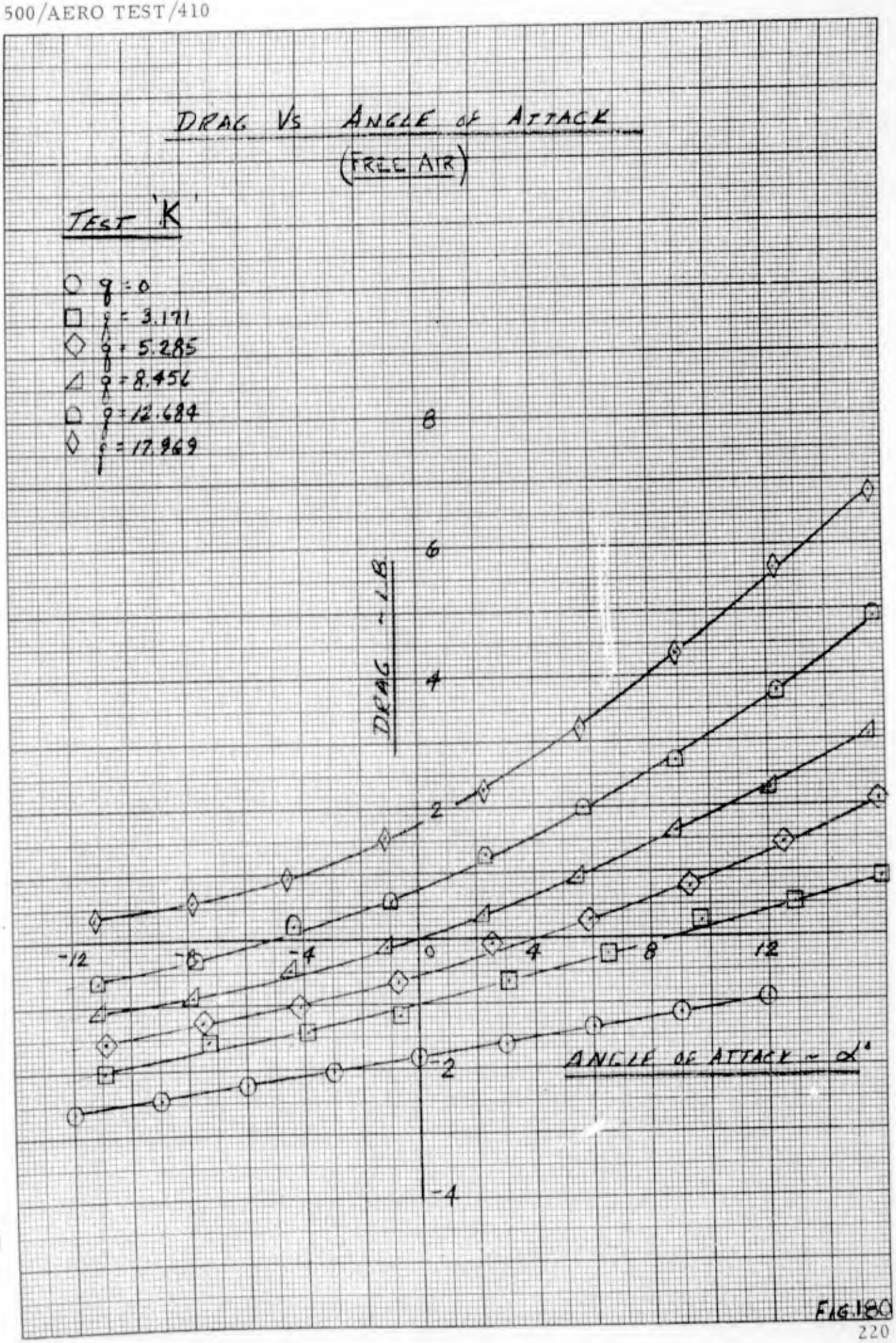

DRAG Vs ANGLE of ATTACK
(FREE AIR)
TEST 'K'
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
DRAG - LB
ANGLE OF ATTACK - α°
8
6
4
2
-2
-4
-12
-8
-4
0
4
8
12

FIG 180

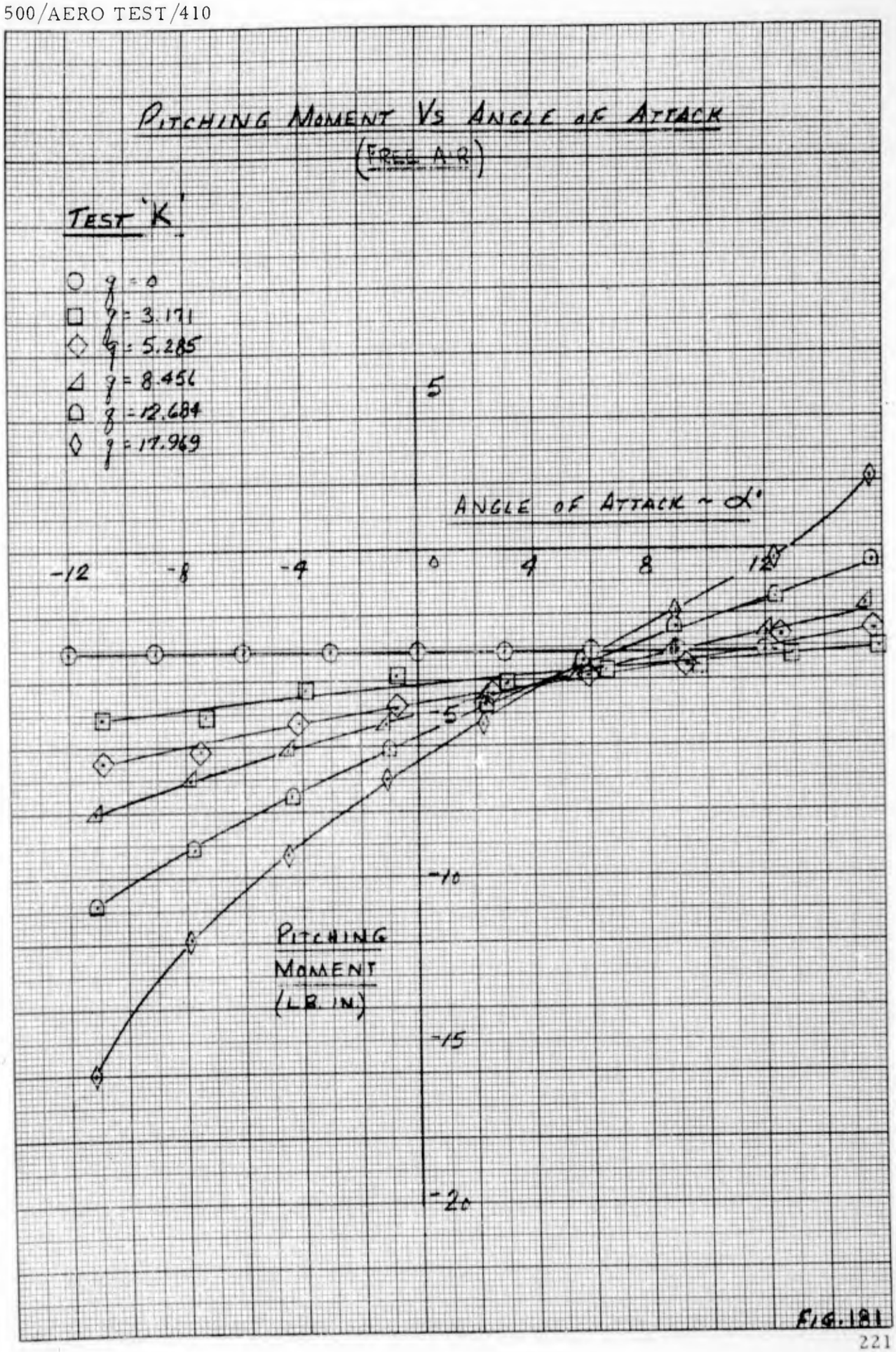

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'K'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
5
ANGLE OF ATTACK ~ α'
-12
-8
-4
0
4
8
12
-5
-10
-15
-20
PITCHING MOMENT (LB. IN.)

FIG. 181

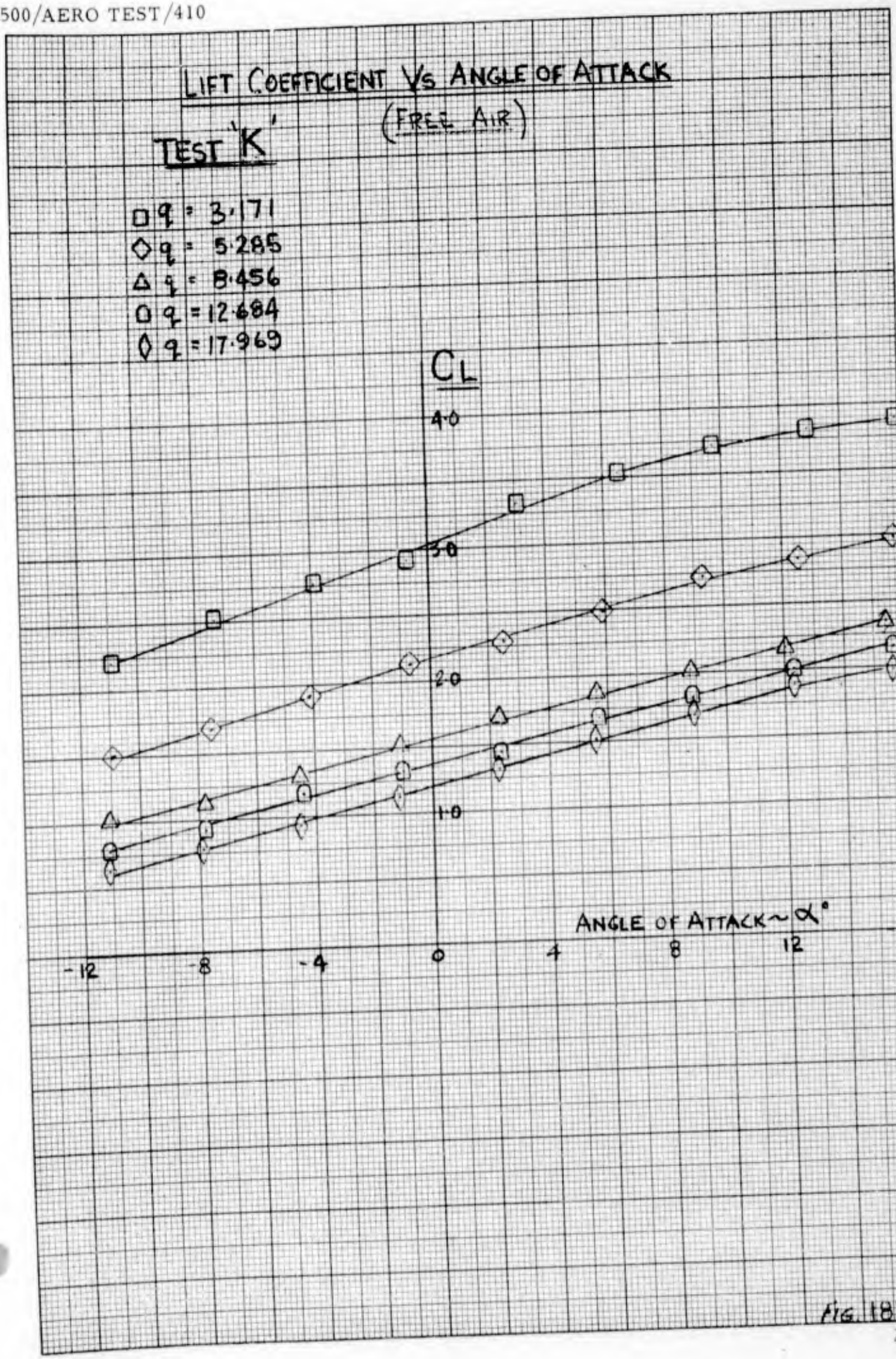

LIFT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CL
4.0
3.0
2.0
1.0
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG. 182

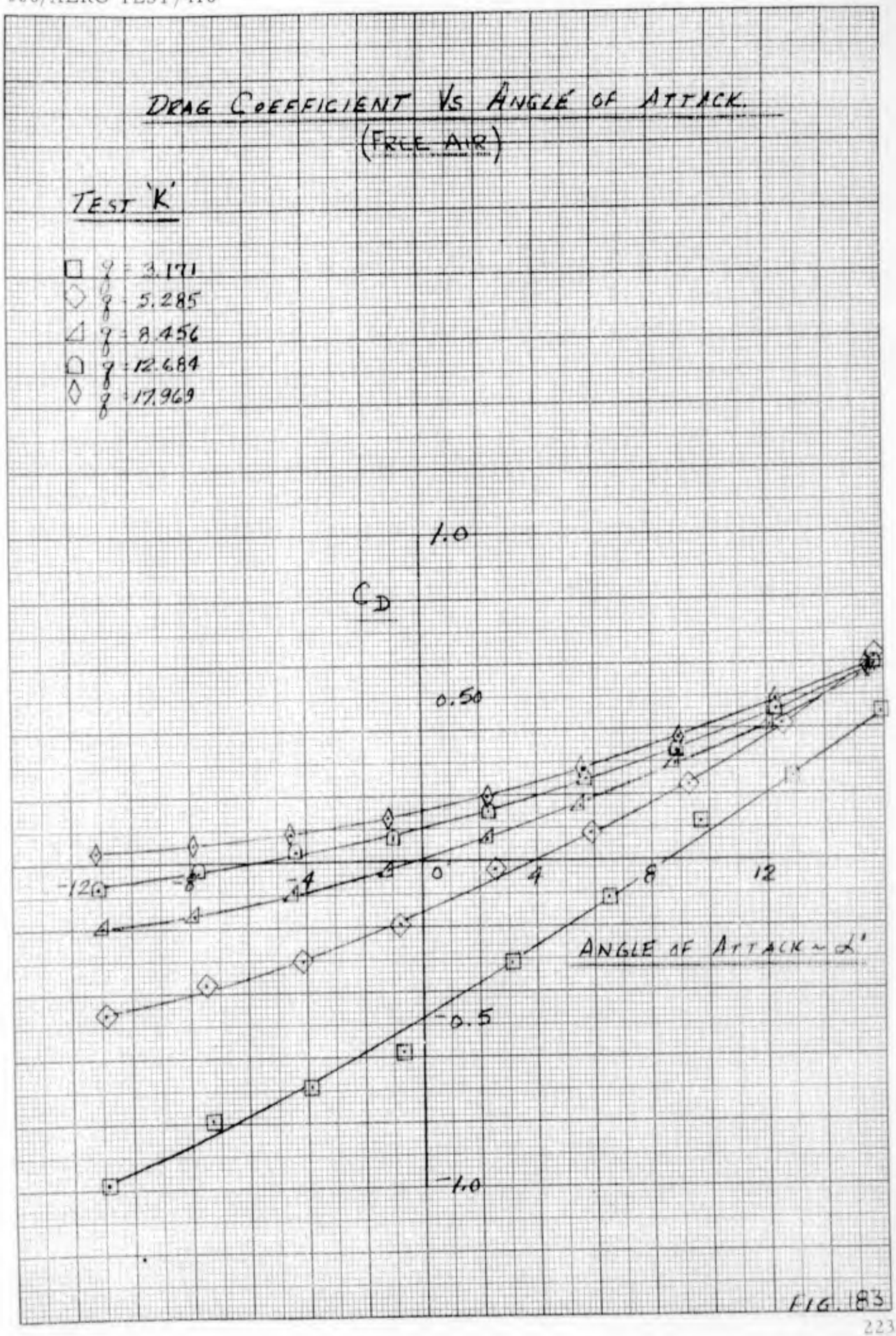

DRAG COEFFICIENT VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◇ q = 17.969
1.0
C_D
0.50
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK = α'
-0.5
-1.0

FIG. 183

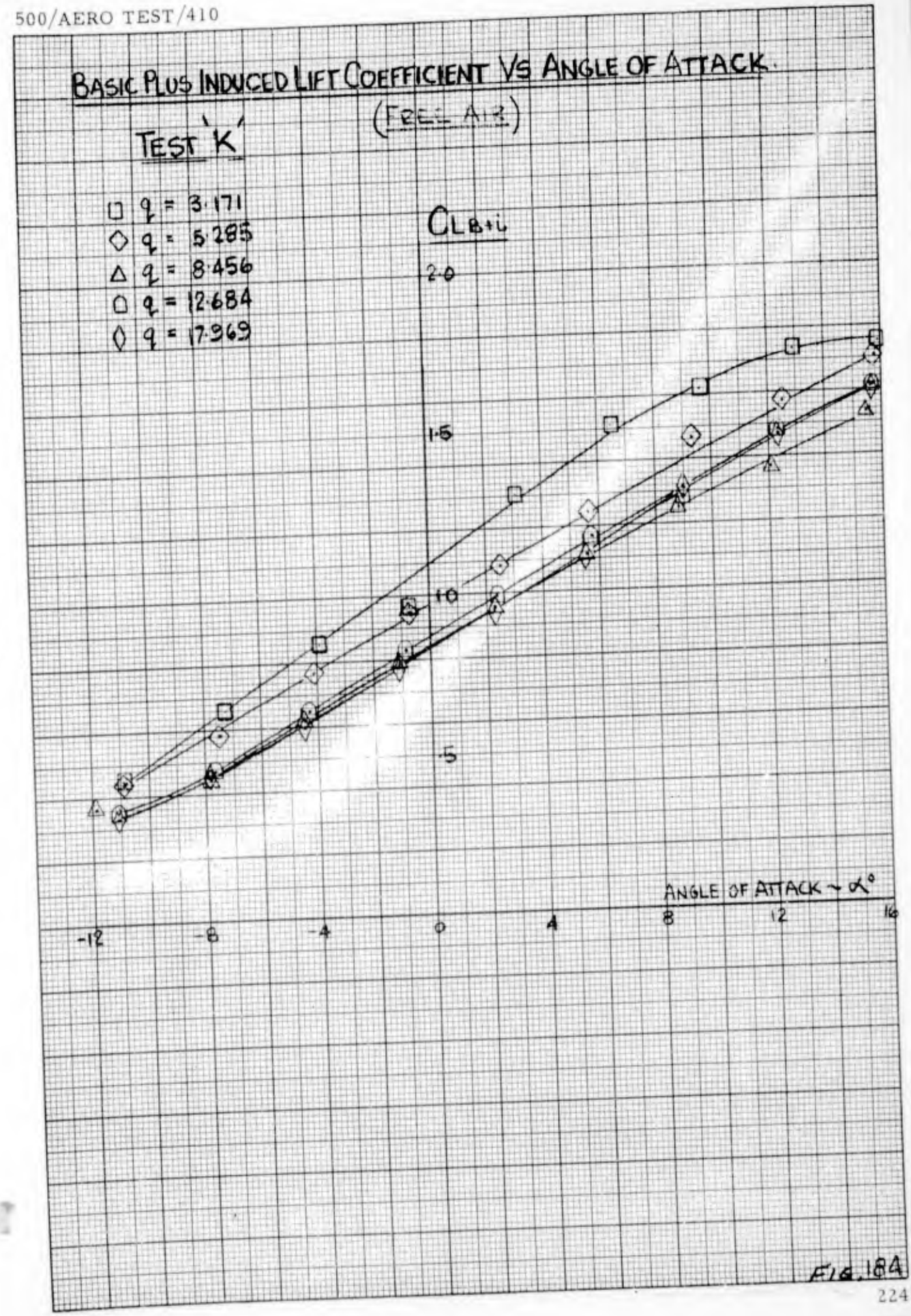

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CLB+i
2.0
1.5
1.0
.5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG. 184

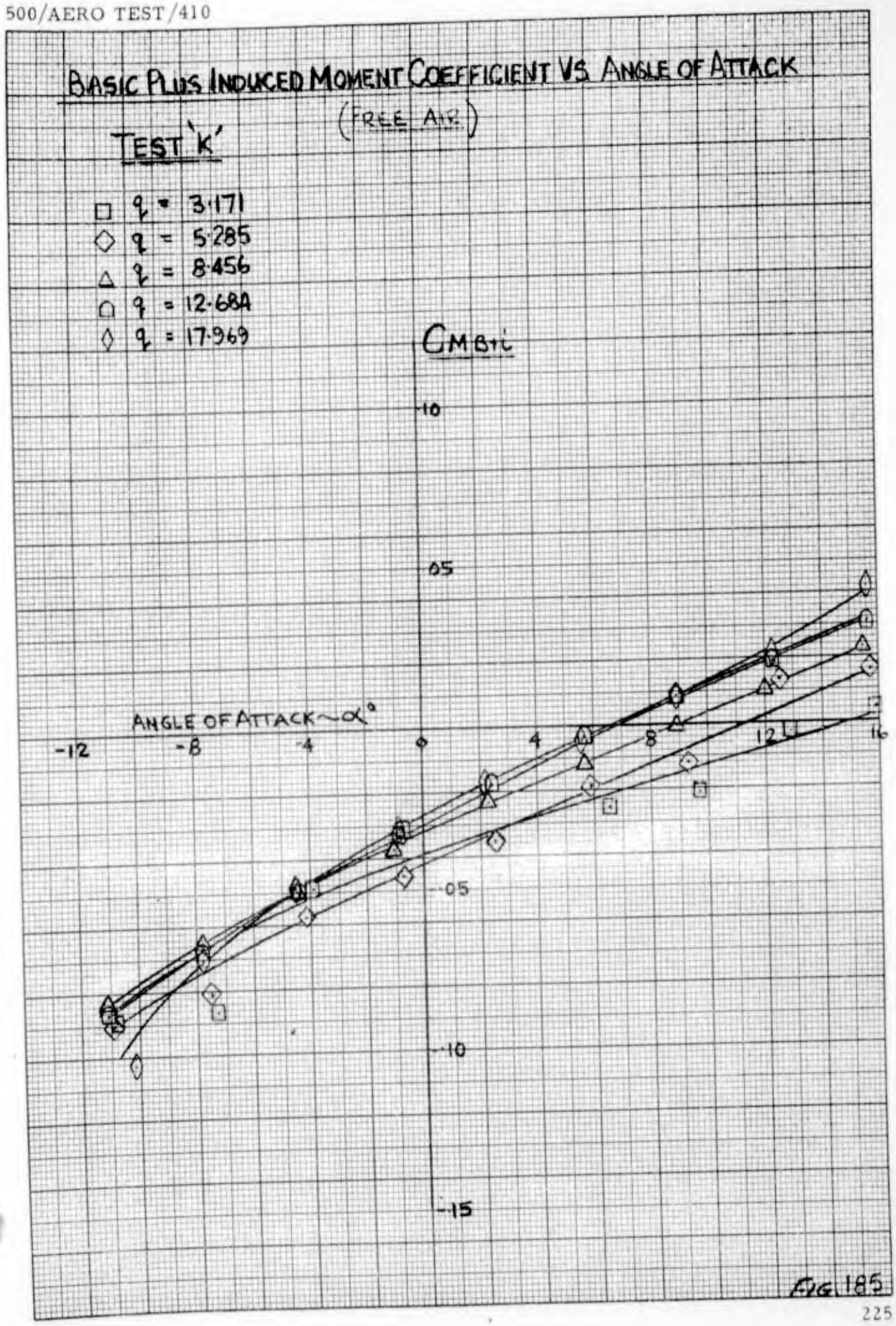

BASIC PLUS INDUCED MOMENT COEFFICIENT VS. ANGLE OF ATTACK
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⌂ q = 12.684
◊ q = 17.969
CMBTi
10
05
-05
-10
-15
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
16

FIG. 185

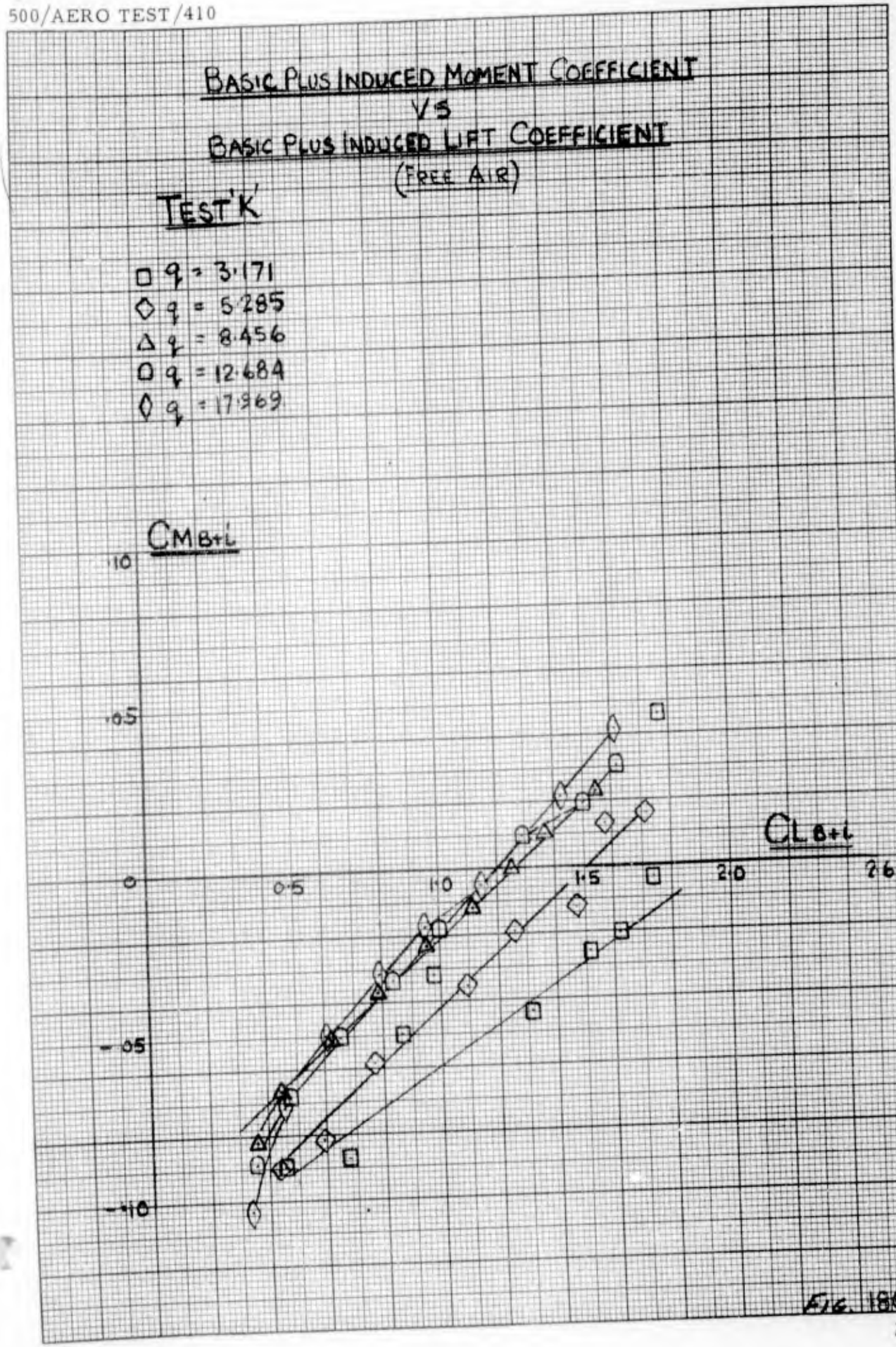

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CMB+L
CLB+L
.10
.05
0
-.05
-.10
0.5
1.0
1.5
2.0
2.6

FIG. 186

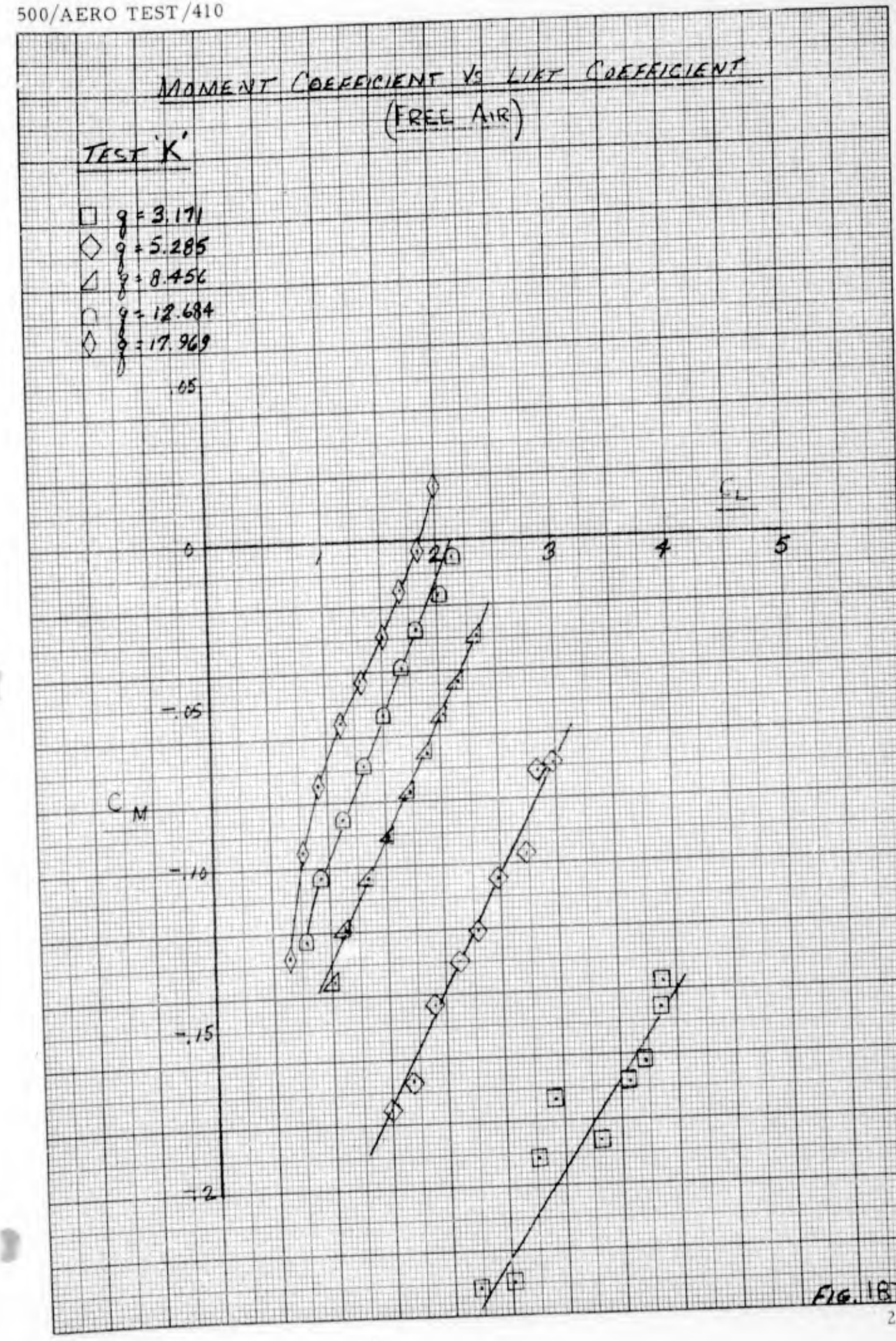

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'K'
□ q = 3.171
◇ q = 5.285
q = 8.456
q = 12.684
q = 17.969
.05
0
-.05
-.10
-.15
-.2
C_M
C_L
1
2
3
4
5

FIG. 187

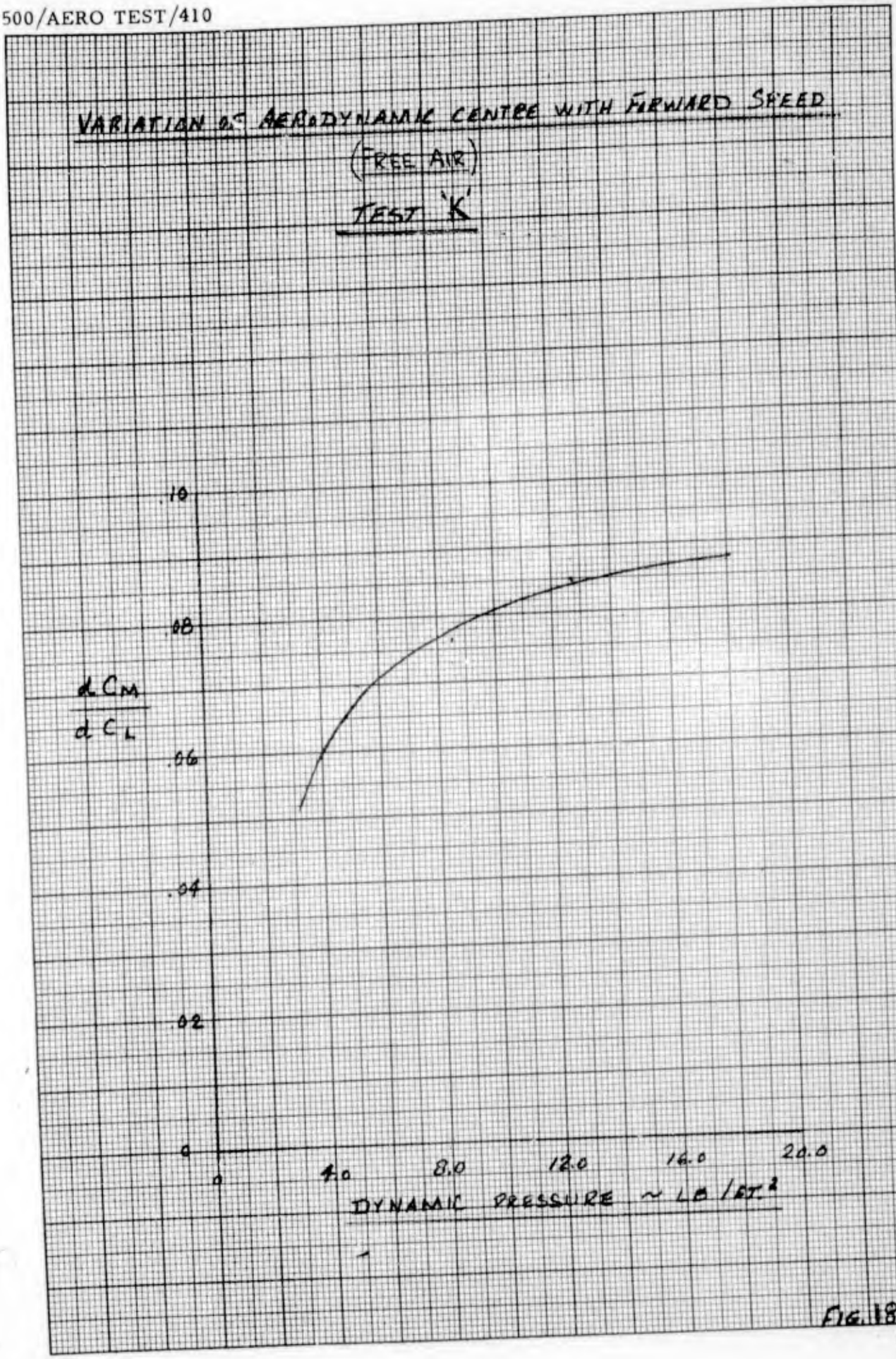

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)
TEST 'K'
.10
.08
$\frac{d C_M}{d C_L}$
.06
.04
.02
0
0
4.0
8.0
12.0
16.0
20.0
DYNAMIC PRESSURE ~ LB/FT²

FIG. 188

LIFT CURVE SLOPE VS DYNAMIC PRESSURE

(FREE AIR)

TEST 'K'

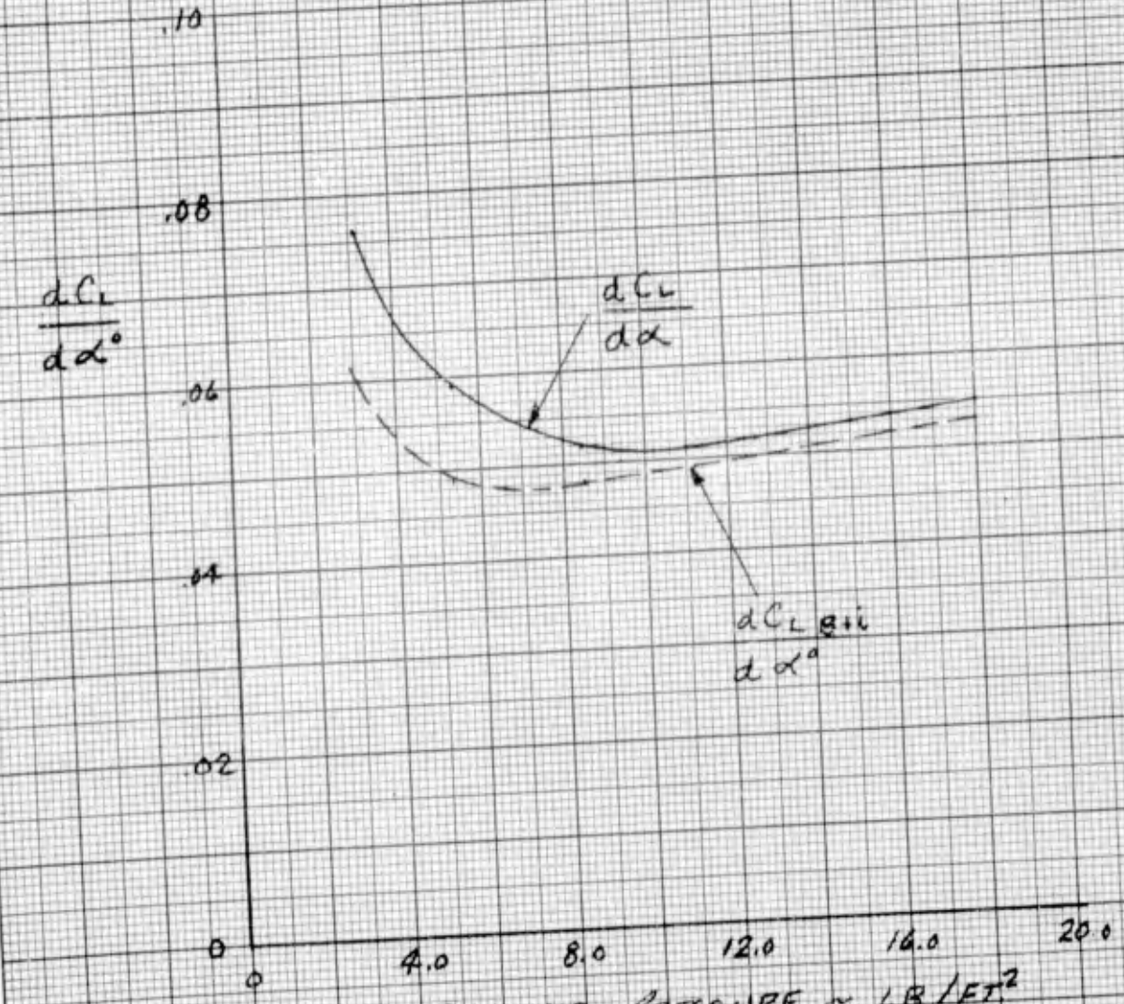


FIG. 18

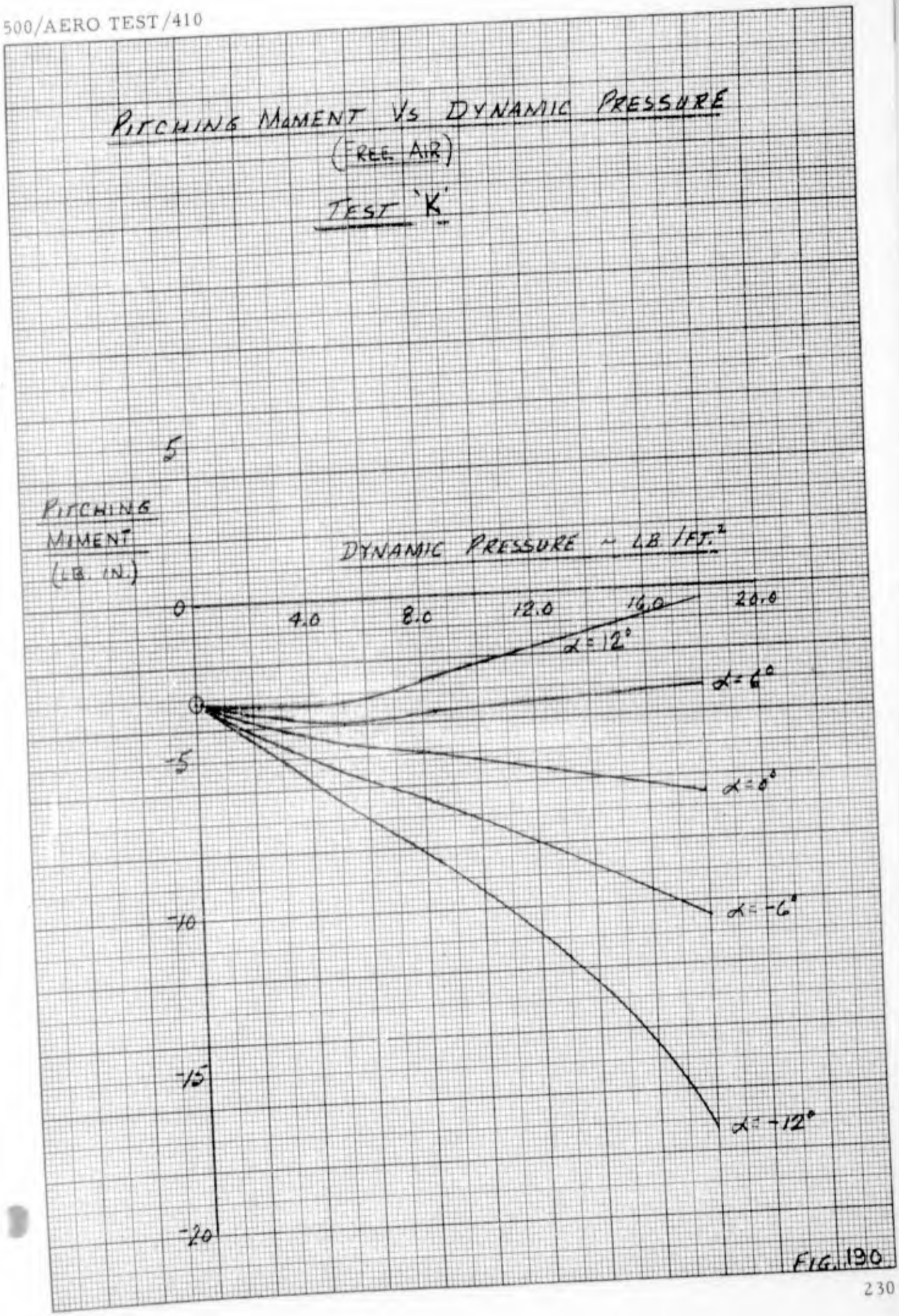

PITCHING MOMENT Vs DYNAMIC PRESSURE
(FREE AIR)
TEST 'K'
PITCHING MOMENT (LB. IN.)
DYNAMIC PRESSURE ~ LB. /FT.²
5
0
-5
-10
-15
-20
4.0
8.0
12.0
16.0
20.0
α = 12°
α = 6°
α = 0°
α = -6°
α = +12°

FIG. 190

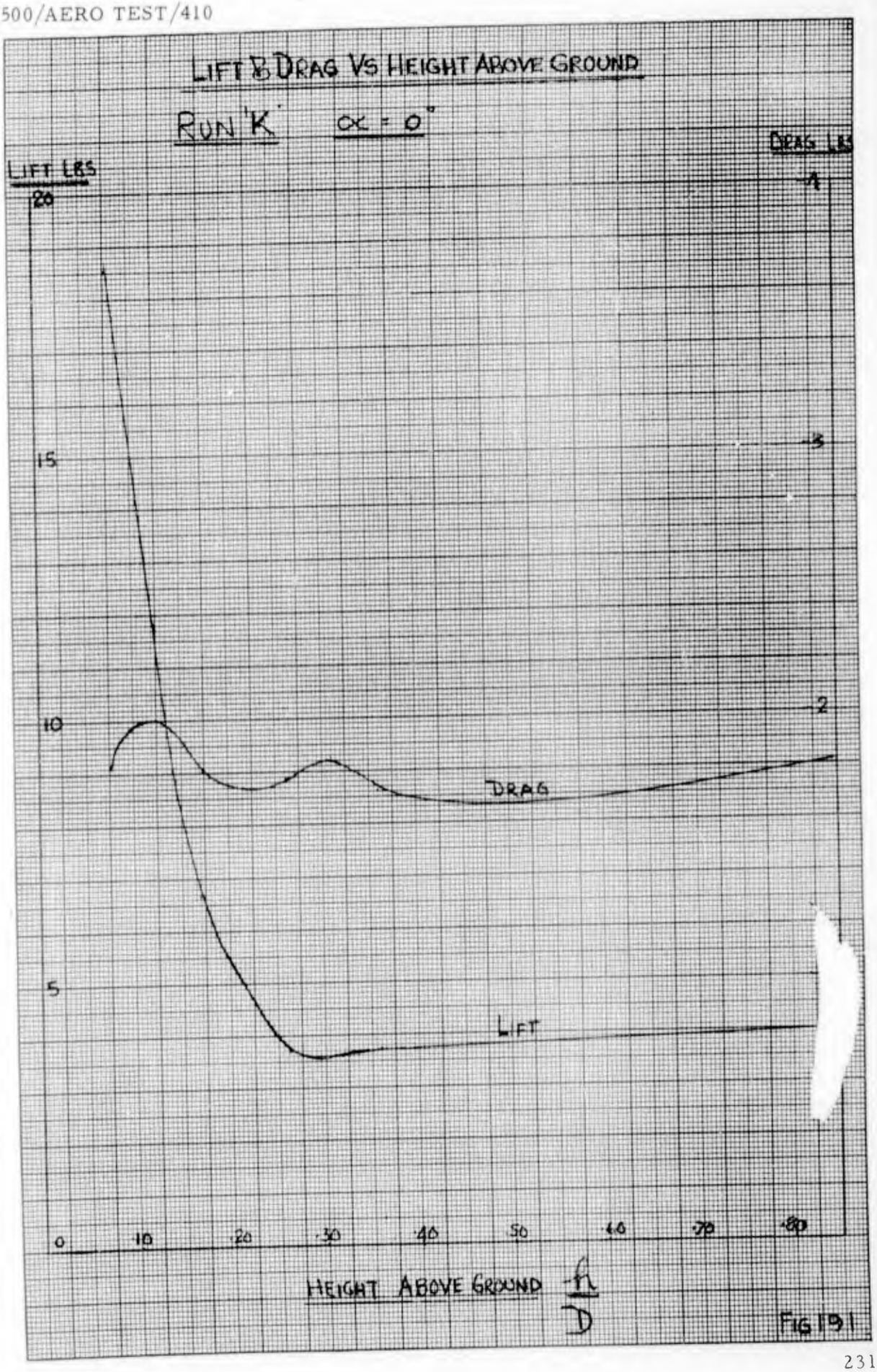
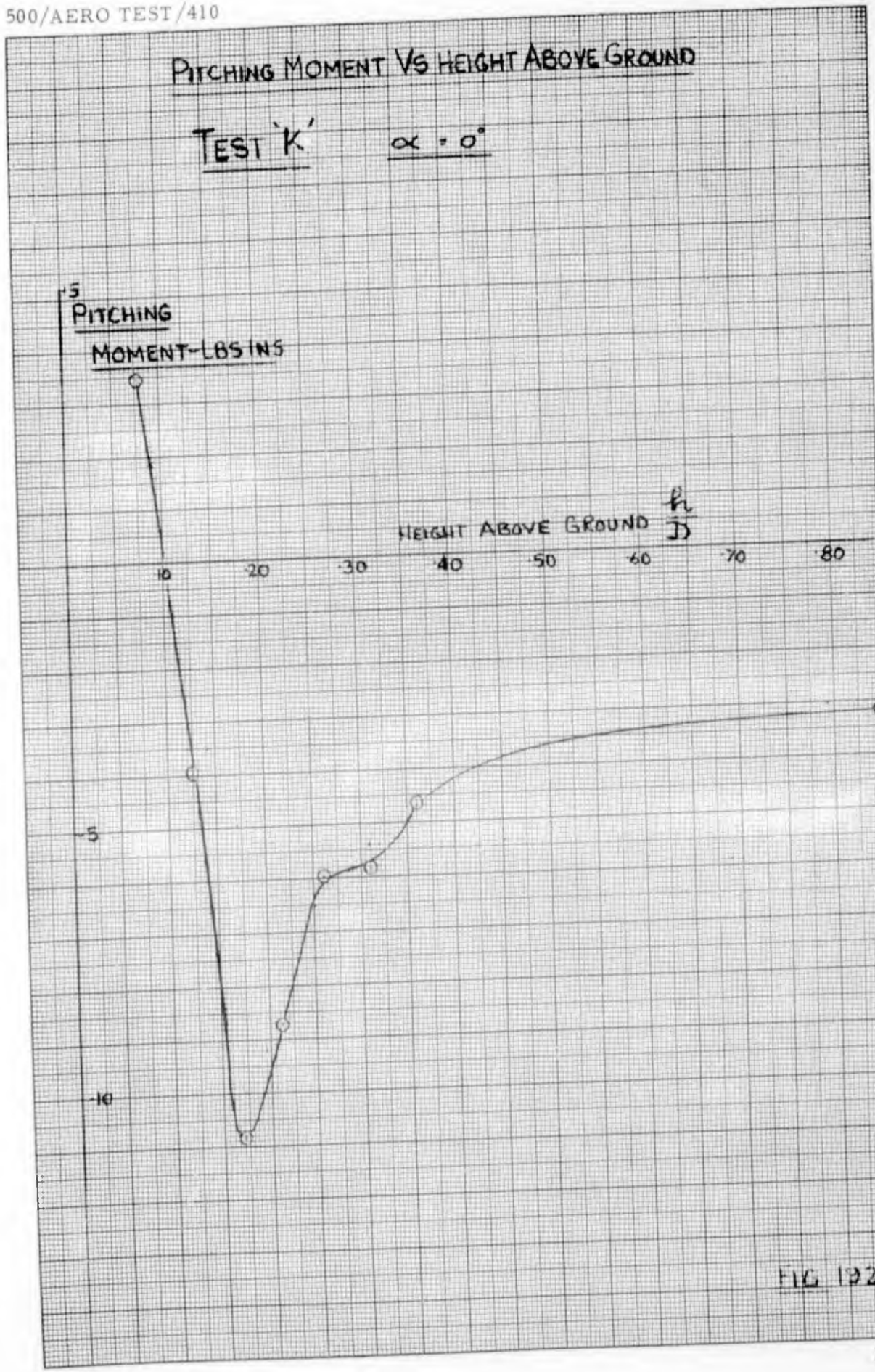

LIFT & DRAG VS HEIGHT ABOVE GROUND
RUN 'K' α = 0°
LIFT LBS
DRAG LBS
20
15
10
5
4
3
2
DRAG
LIFT
0
10
20
30
40
50
60
70
80
HEIGHT ABOVE GROUND h/D

FIG 19


PITCHING MOMENT VS HEIGHT ABOVE GROUND
TEST 'K' α = 0°
+5
PITCHING
MOMENT-LBS INS
HEIGHT ABOVE GROUND h/D
10
20
30
40
50
60
70
80
-5
-10
FIG 192

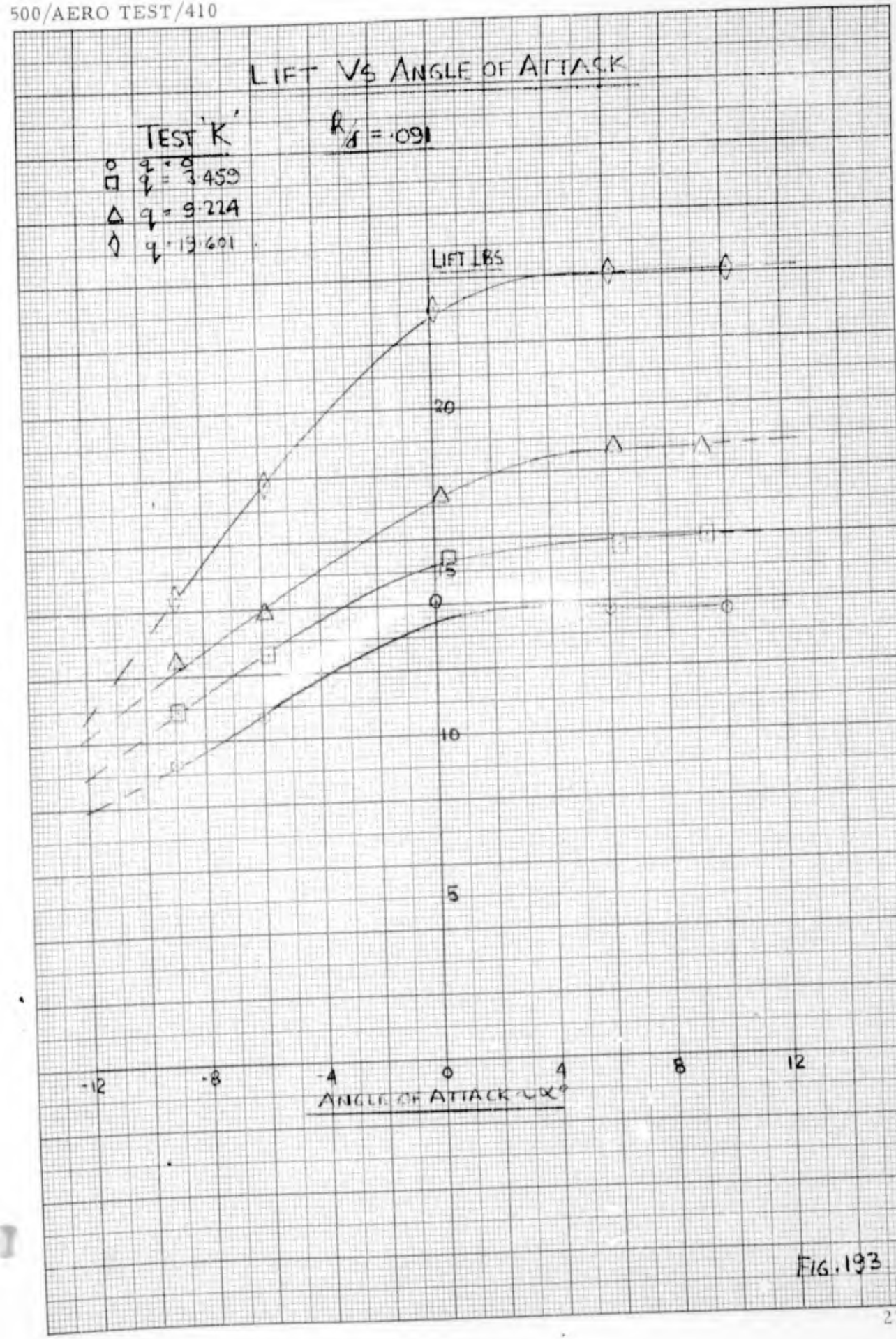

LIFT VS ANGLE OF ATTACK
TEST 'K'
h/d = .091
q = 0
q = 3.459
q = 9.224
q = 19.601
LIFT LBS
20
15
10
5
0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK (α°)

FIG. 193

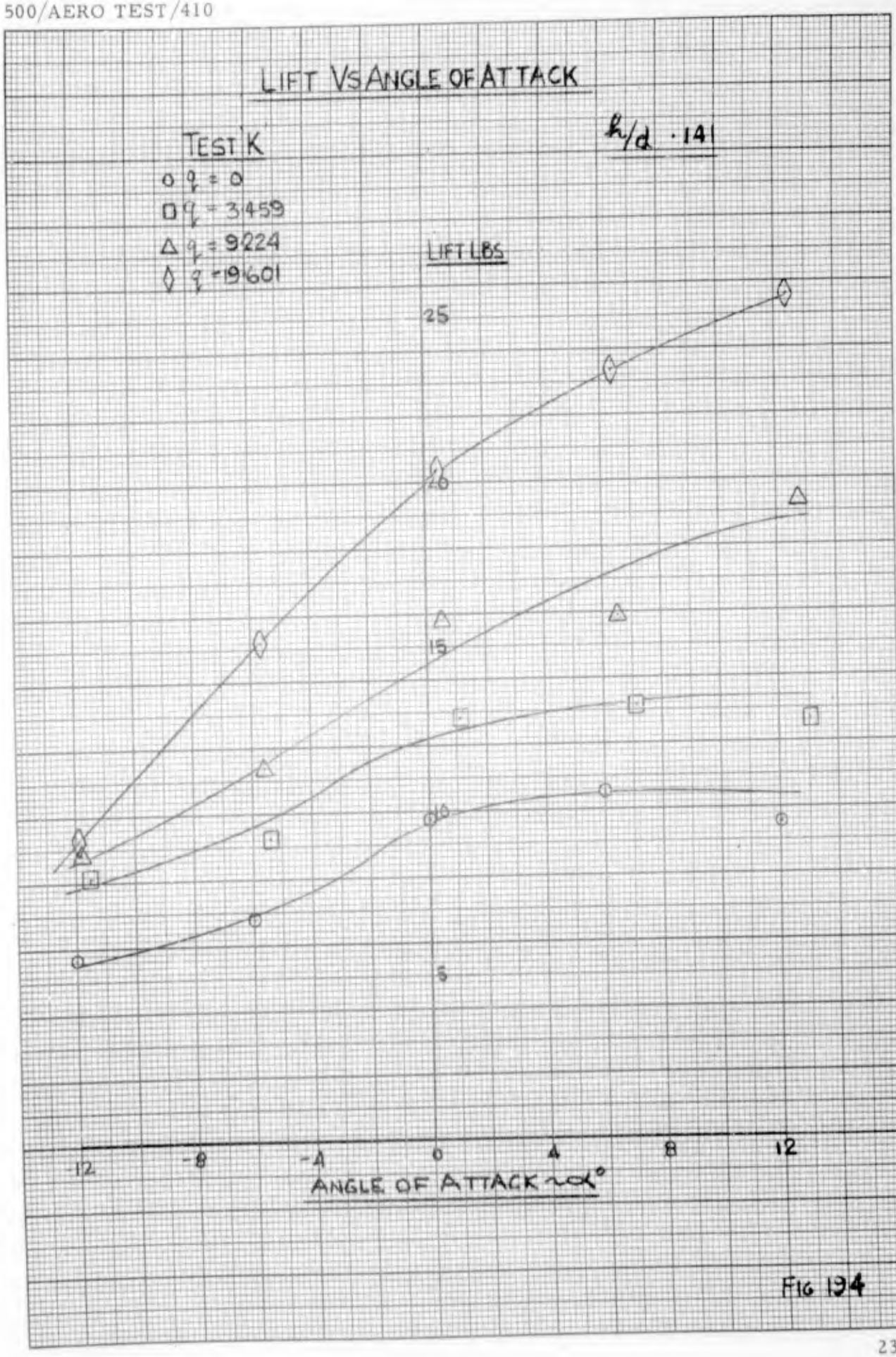
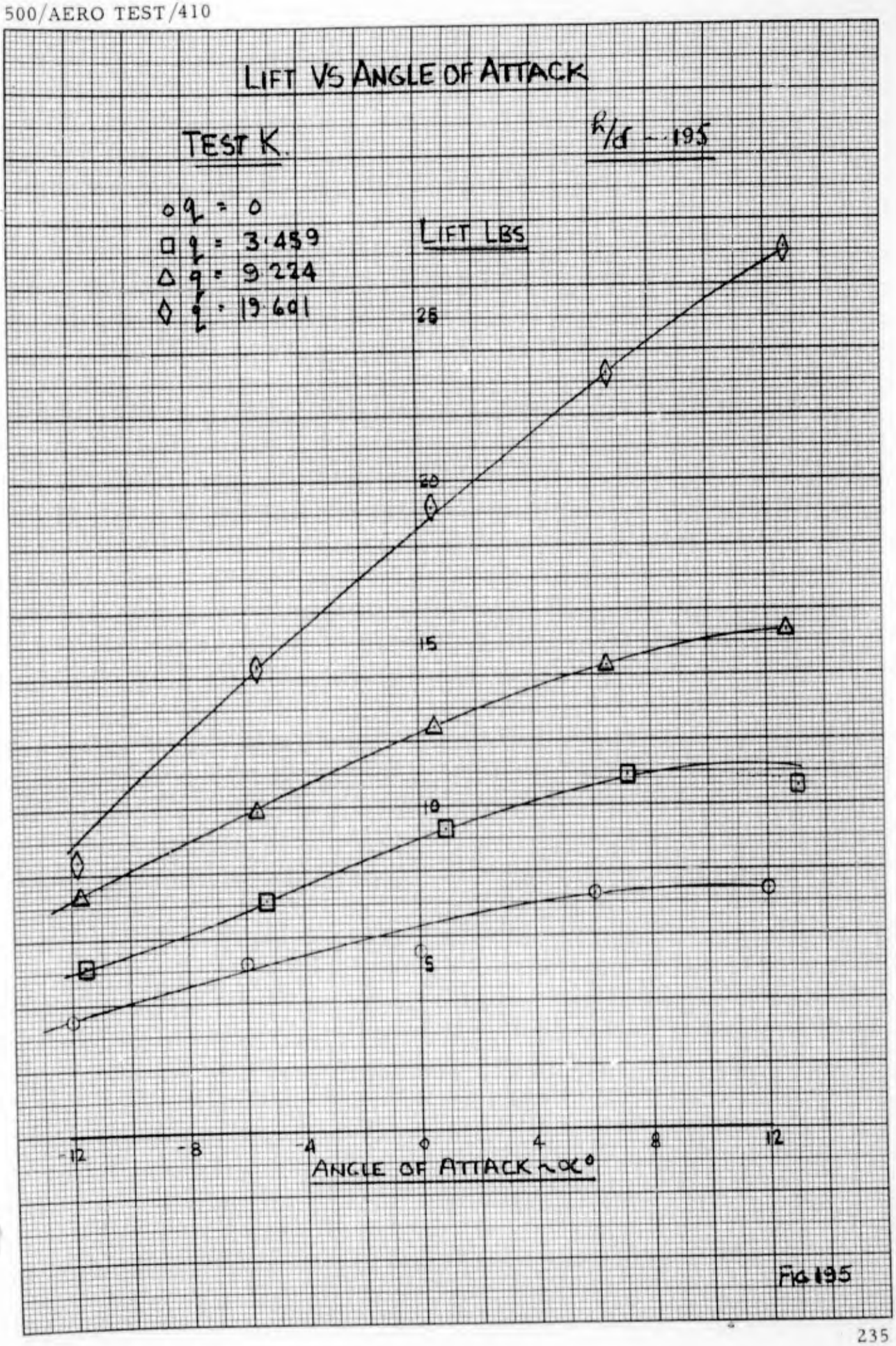

LIFT VS ANGLE OF ATTACK
TEST K
h/d .14
o q = 0
□ q = 3459
△ q = 9224
◊ q = 19601
LIFT LBS
25
20
15
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK α°

FIG 194


LIFT VS ANGLE OF ATTACK
TEST K.
h/d = .195
q = 0
q = 3.459
q = 9.224
q = 19.601
LIFT LBS
25
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
Fig 195

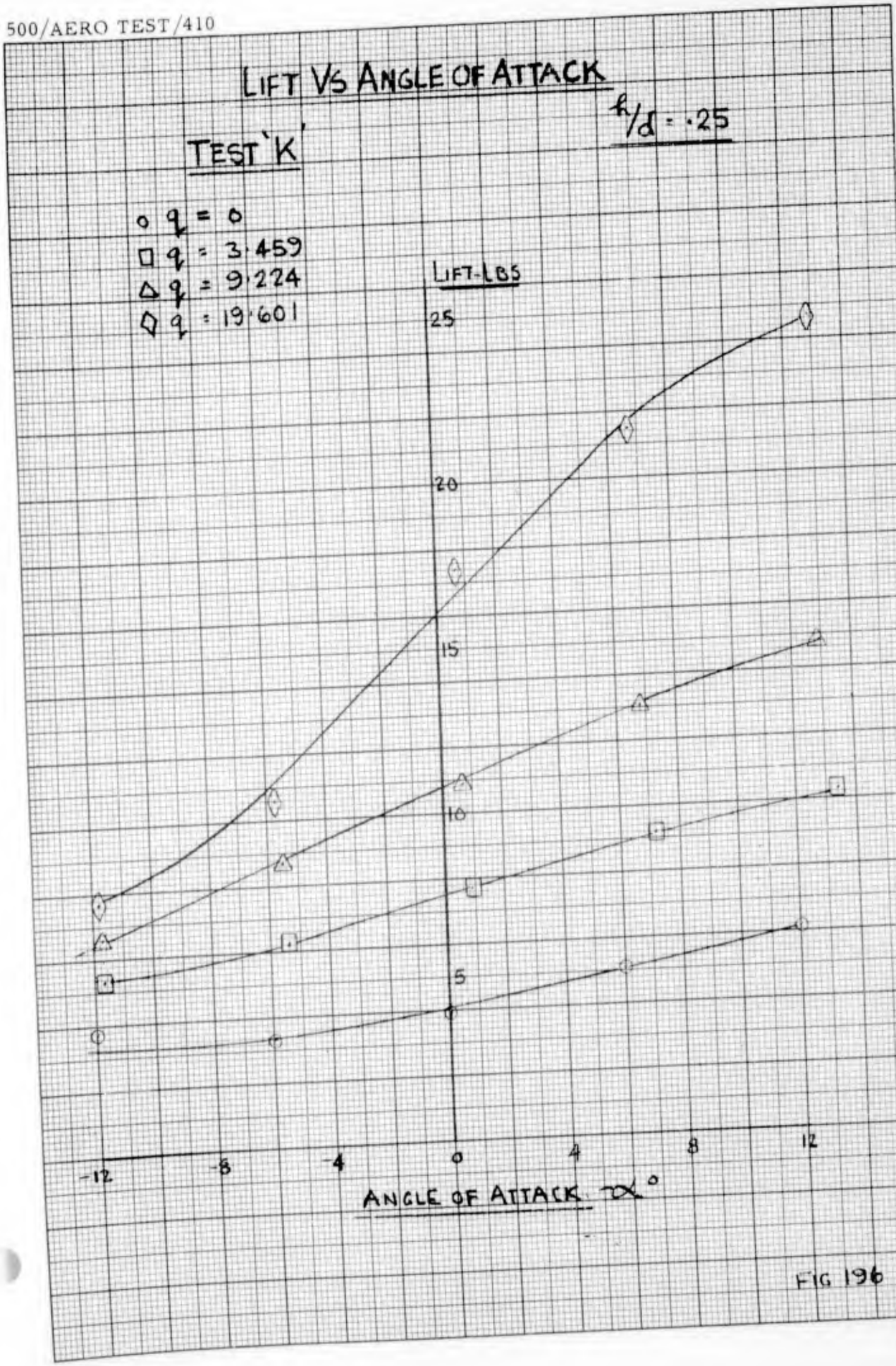

LIFT VS ANGLE OF ATTACK
h/d = .25
TEST 'K'
○ q = 0
□ q = 3.459
△ q = 9.224
◇ q = 19.601
LIFT-LBS
25
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK α°

FIG 196

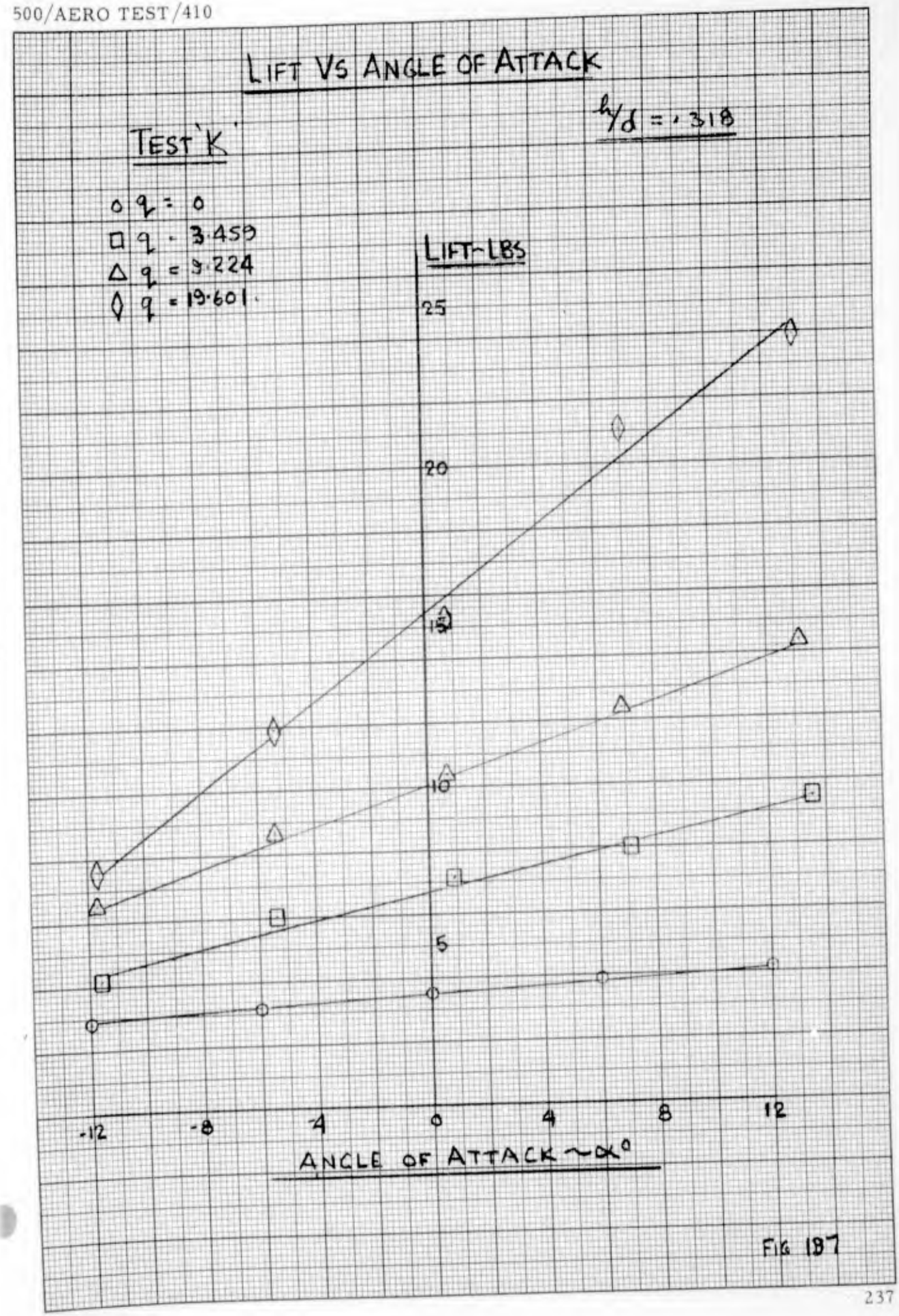

LIFT VS ANGLE OF ATTACK
h/d = .318
TEST 'K'
○ q = 0
□ q = 3.459
△ q = 9.224
◊ q = 19.601
LIFT-LBS
25
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~α°

FIG 187

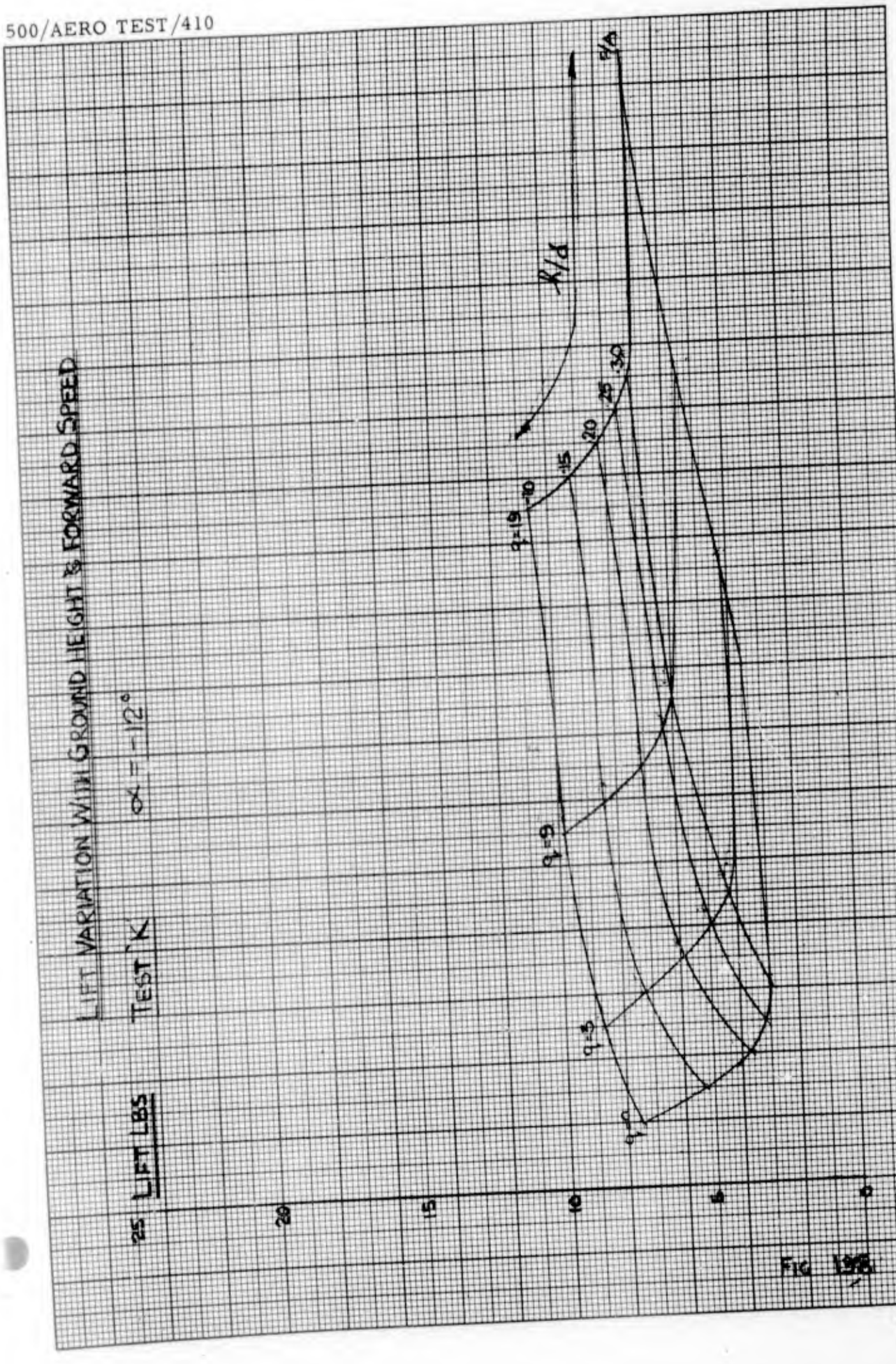

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'K'
α = -12°
LIFT LBS
25
20
15
10
5
0
h/d
.30
.25
.20
.15
.10
q=19
q=9
q=5
q=1

FIG 195

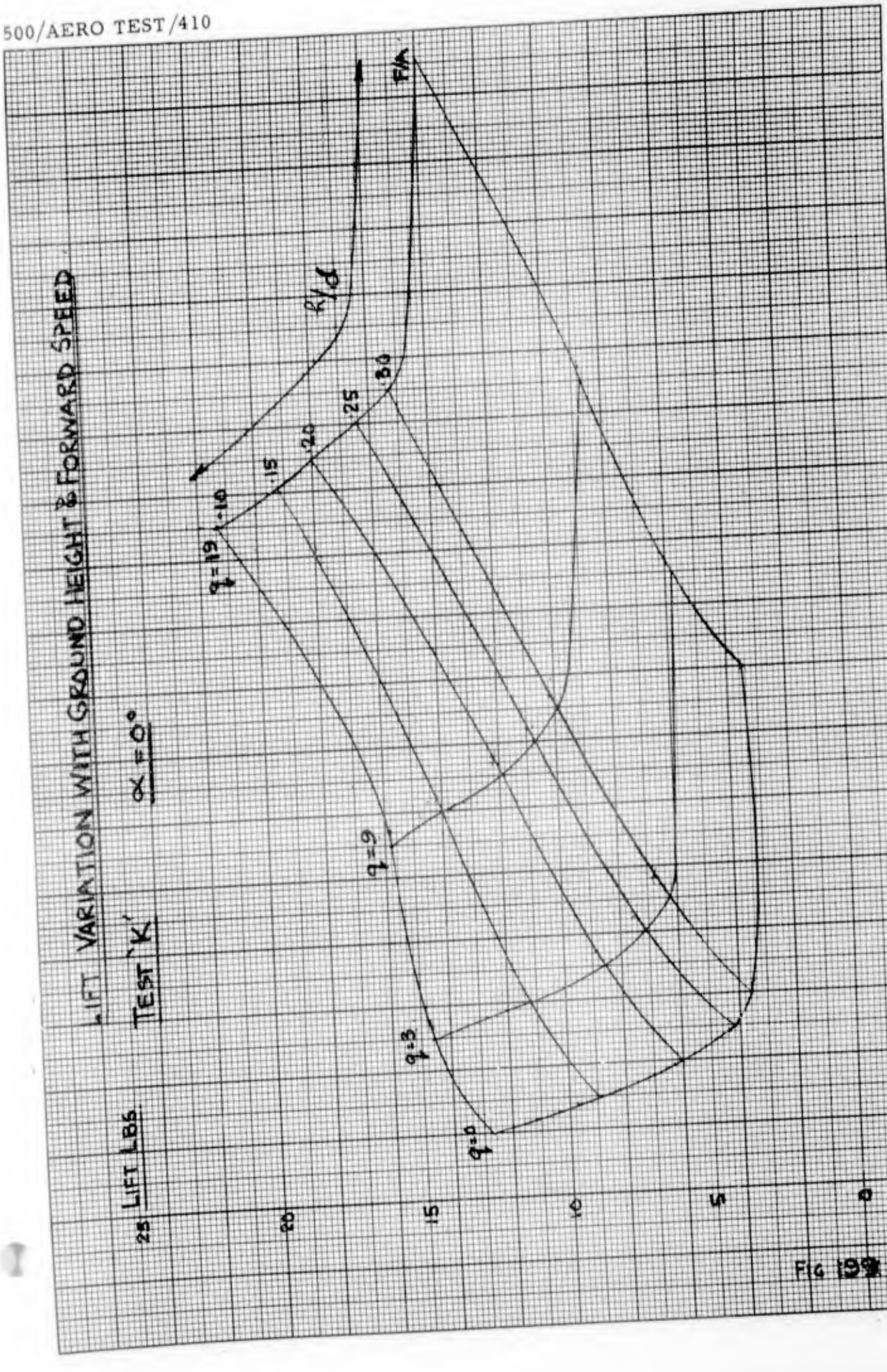

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'K'
α = 0°
LIFT LBS.
25
20
15
10
5
0
F/A
R/d
.10
.15
.20
.25
.30
q=19
q=9
q=3
q=0

Fig 19

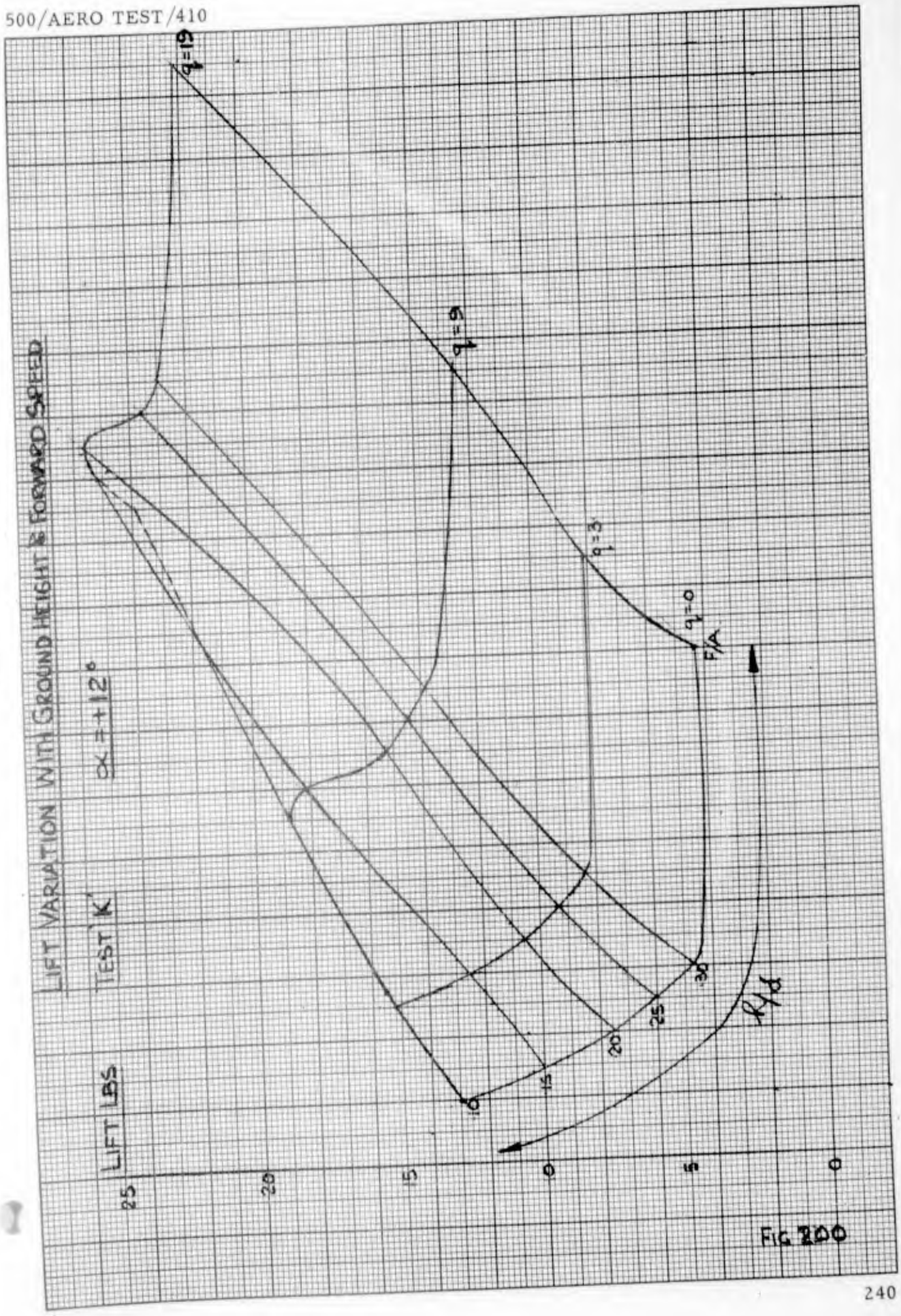

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'K'
α = +12°
LIFT LBS
25
20
15
10
5
0
5
0
h/d
h=19
h=9
h=3
h=1
h=0
F/A
30
25
20
15
10

Fig 200

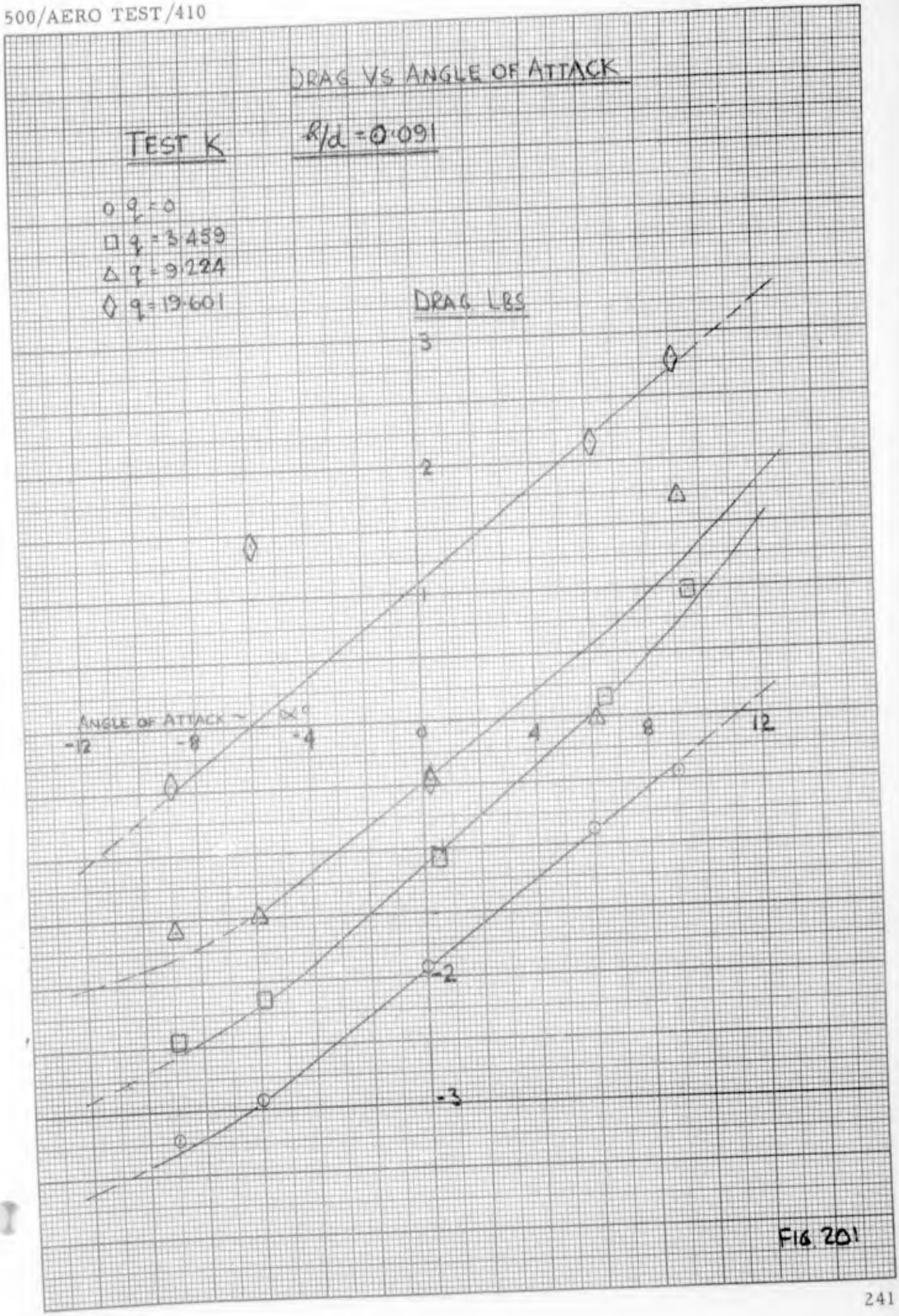

DRAG VS ANGLE OF ATTACK
TEST K
R/d = 0·091
○ q = 0
□ q = 3·459
△ q = 9·224
◊ q = 19·601
DRAG LBS
3
2
1
-2
-3
ANGLE OF ATTACK ~ ∝°
-12
-8
-4
0
4
8
12

FIG 201

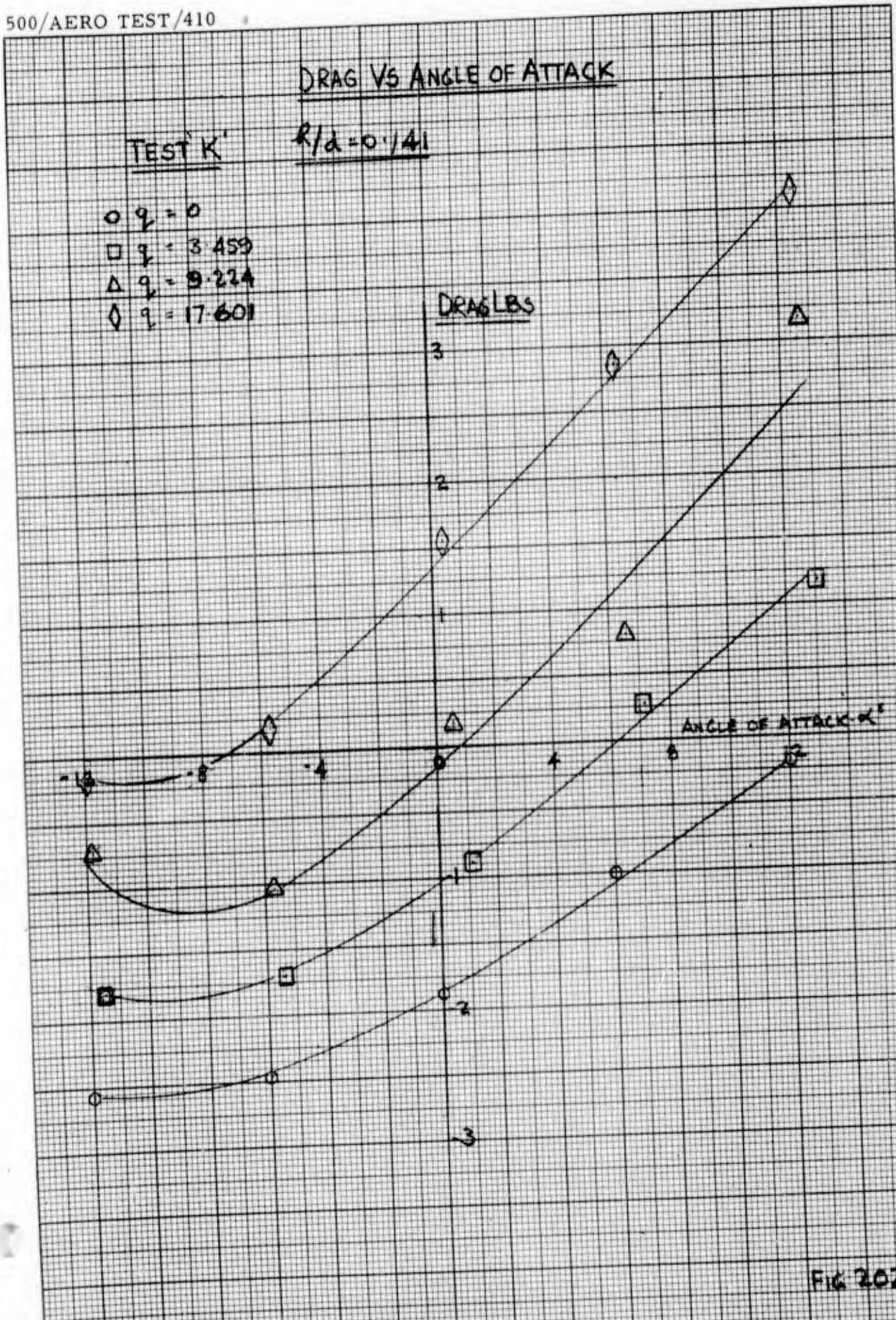

DRAG VS ANGLE OF ATTACK
TEST K'
R/d = 0.141
o q = 0
□ q = 3.459
Δ q = 9.224
◊ q = 17.601
DRAG LBS
ANGLE OF ATTACK - K'
3
2
1
-1
-2
-3
-8
-4
4
8

FIG 202

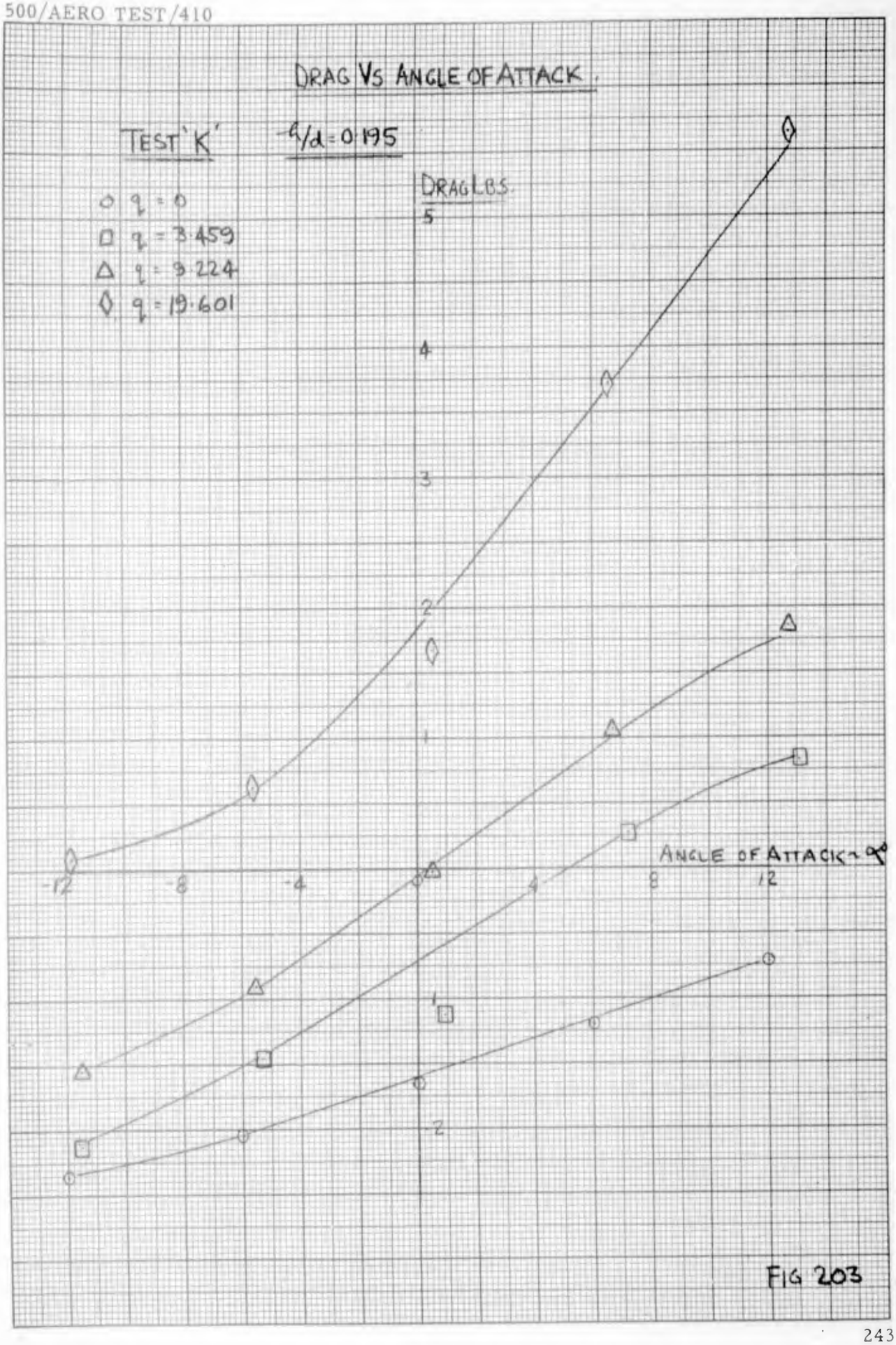

DRAG VS ANGLE OF ATTACK.
TEST 'K'
-q/d = 0.195
○ q = 0
□ q = 3.459
△ q = 9.224
◇ q = 19.601
DRAG LBS.
5
4
3
2
1
-12
-8
-4
4
8
12
ANGLE OF ATTACK - α°

FIG 203

DRAG VS ANGLE OF ATTACK

TEST K $\ell/d = 0.25$

○ $q = 0$
□ $q = 3.459$
△ $q = 9.224$
◇ $q = 19.601$

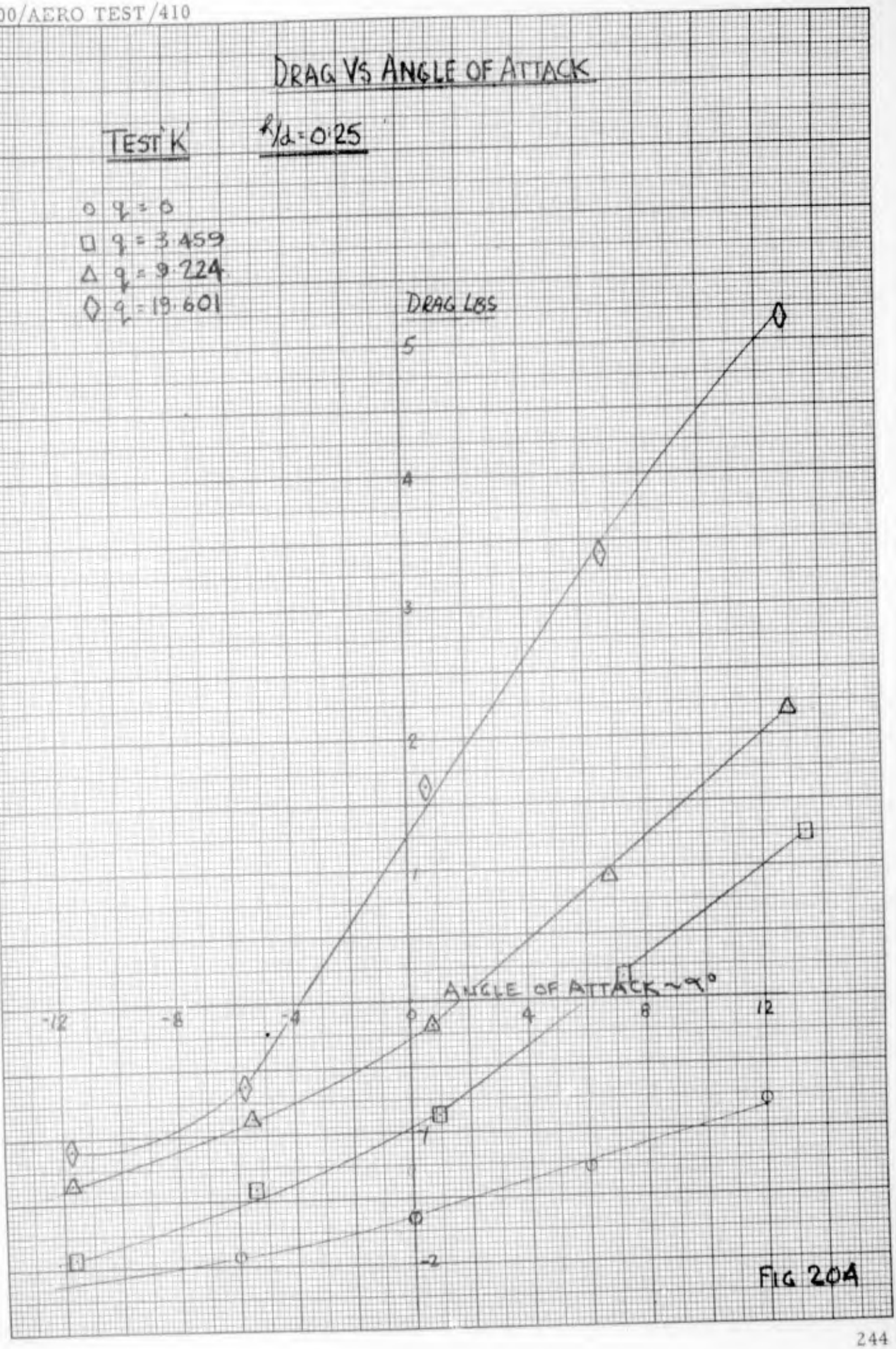
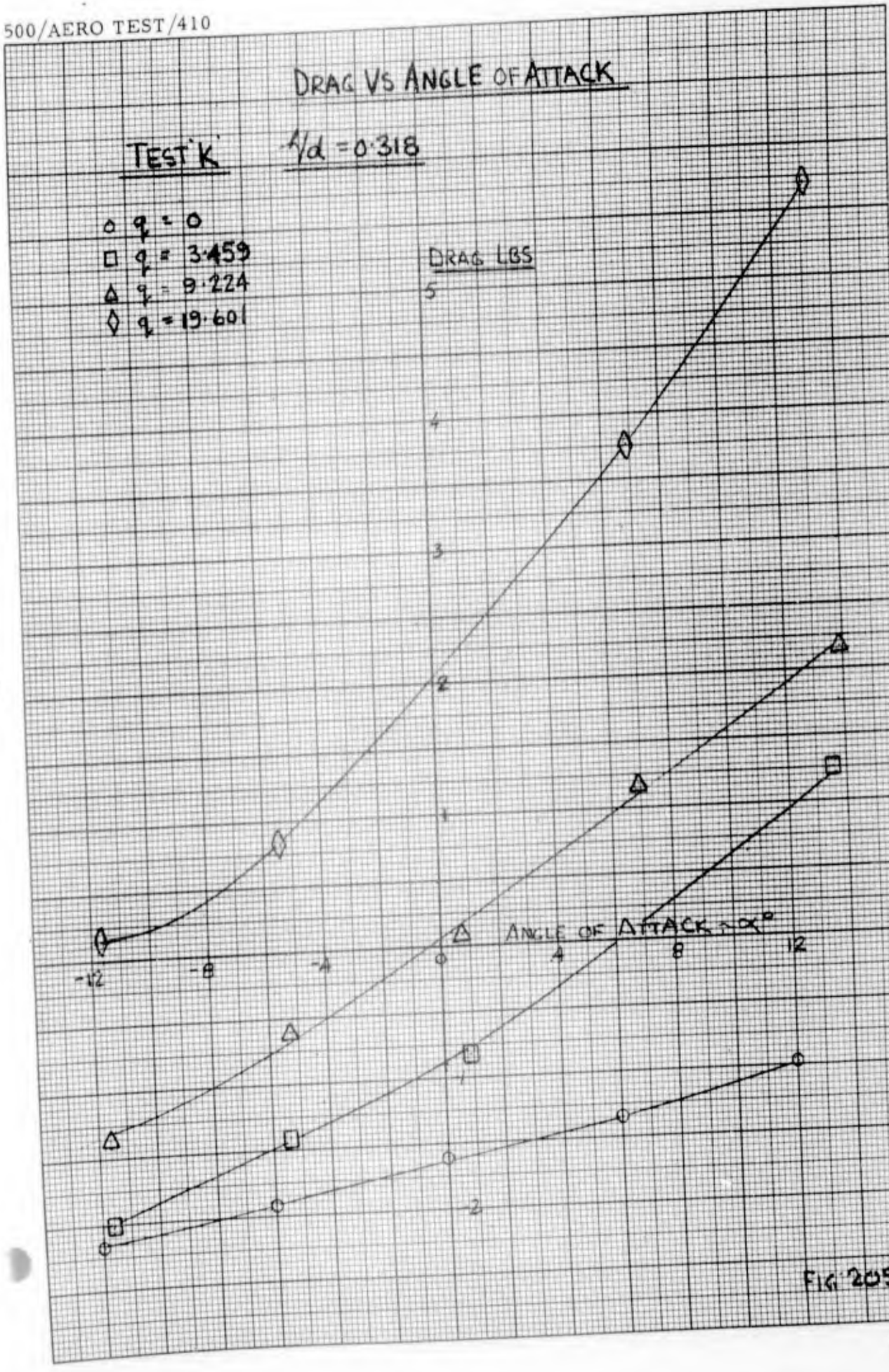


FIG 204


DRAG VS ANGLE OF ATTACK
TEST K
1/d = 0.318
○ q = 0
□ q = 3.459
△ q = 9.224
◇ q = 19.601
DRAG LBS
5
4
3
2
1
ANGLE OF ATTACK = α°
-12
-8
-4
4
8
12
FIG 205

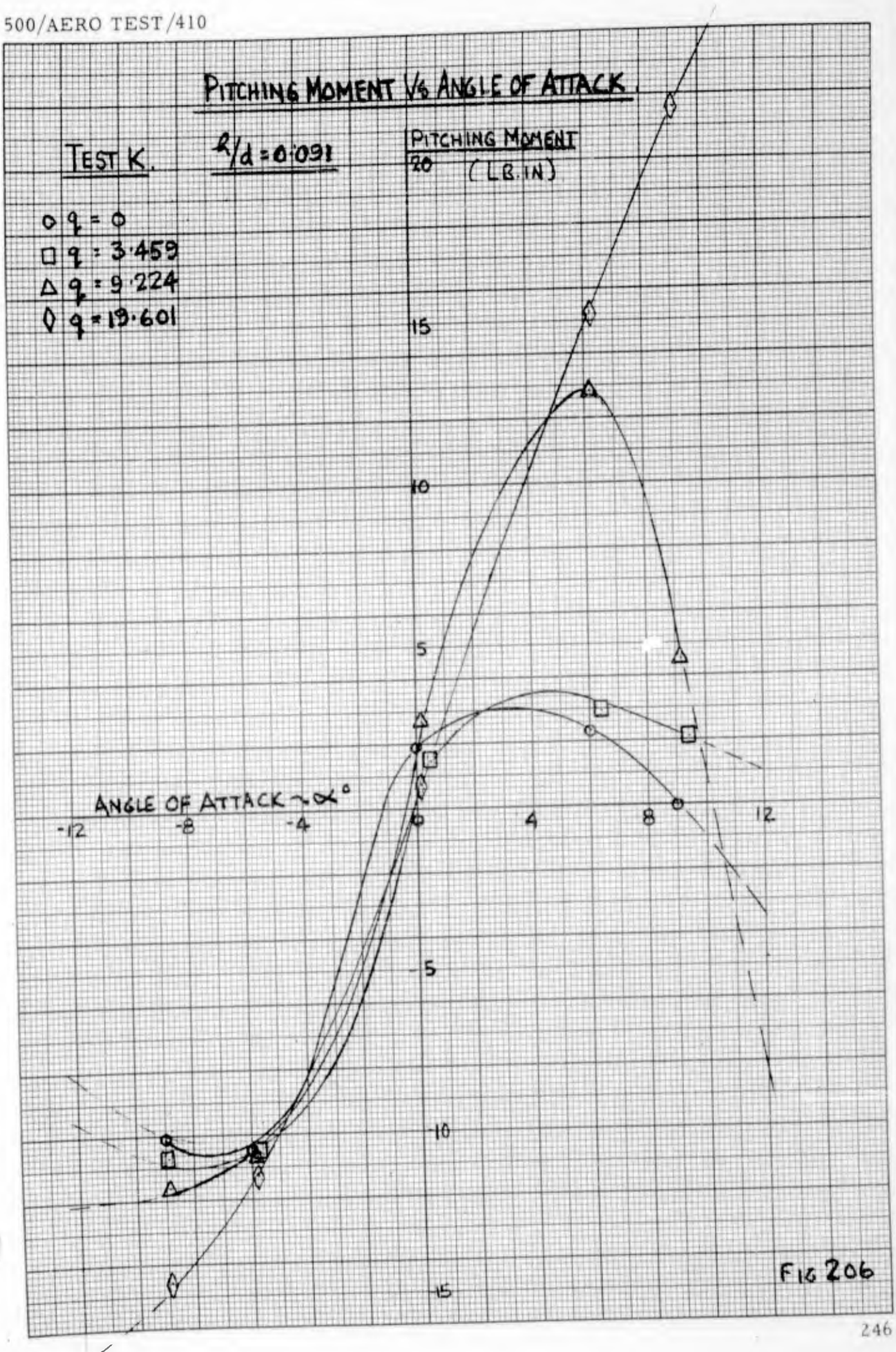

PITCHING MOMENT Vs ANGLE OF ATTACK.
TEST K.
ℓ/d = 0·091
○ q = 0
□ q = 3·459
△ q = 9·224
◊ q = 19·601
PITCHING MOMENT (LB.IN)
20
15
10
5
-5
10
15
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12

FIG 206

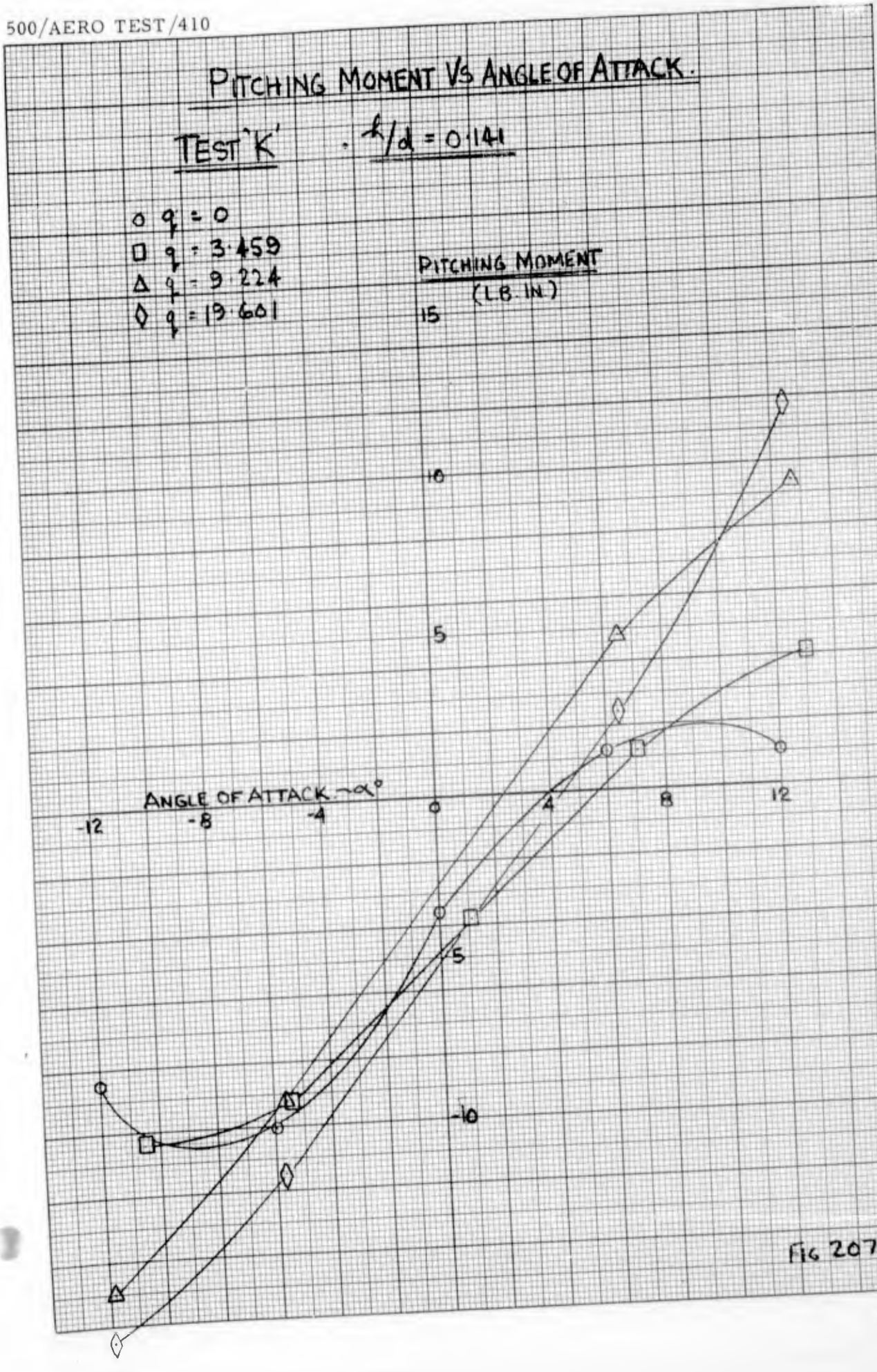

PITCHING MOMENT VS ANGLE OF ATTACK.
TEST 'K' . k/d = 0·141
○ q = 0
□ q = 3·459
△ q = 9·224
◇ q = 19·601
PITCHING MOMENT (LB. IN)
15
10
5
-5
-10
ANGLE OF ATTACK -α°
-12
-8
-4
0
4
8
12

Fig 207

PITCHING MOMENT VS ANGLE OF ATTACK.

TEST 'K' $\ell/d = 0.195$

○ $q = 0$
□ $q = 3.459$
△ $q = 9.224$
◇ $q = 19.601$

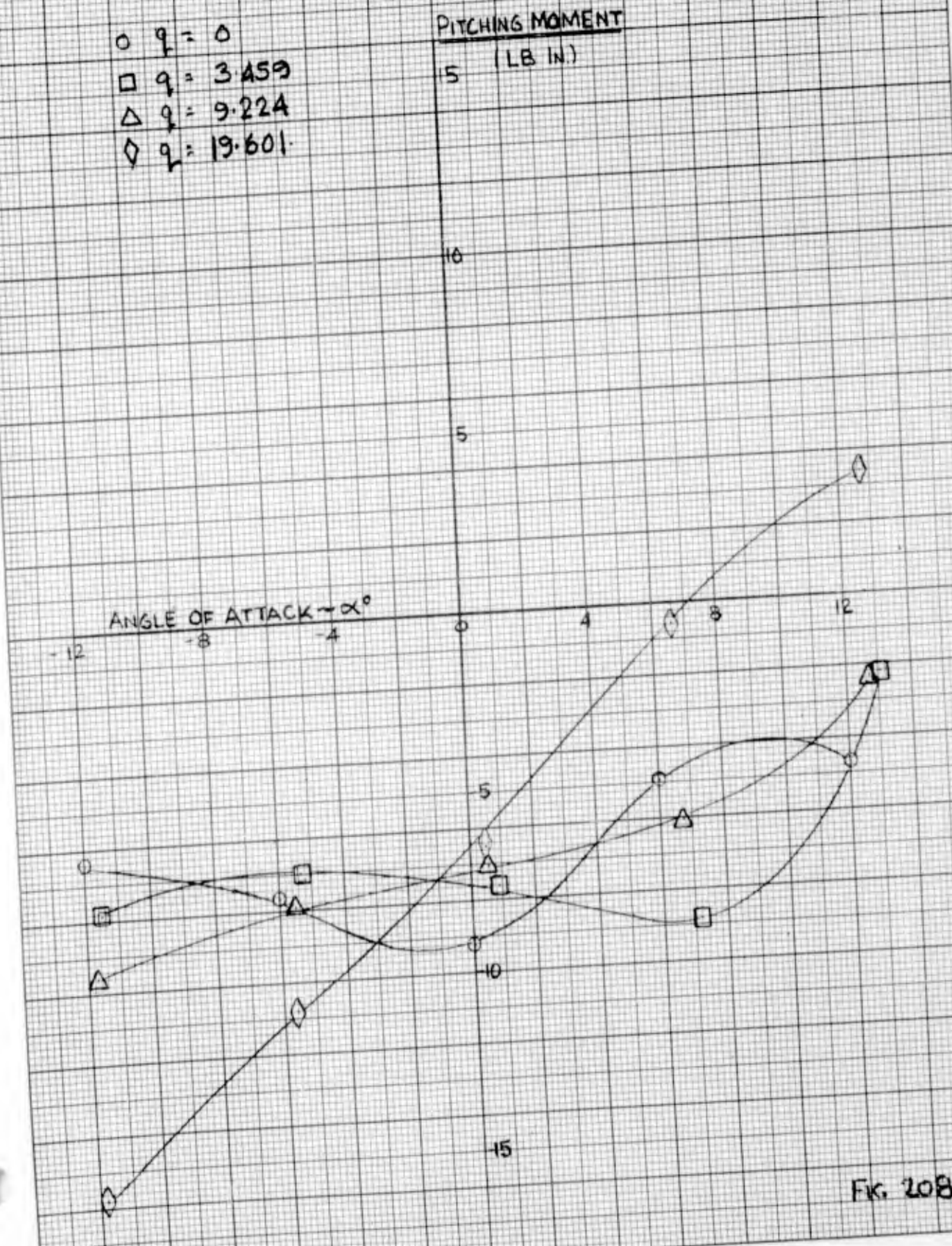


FIG. 208

PITCHING MOMENT VS ANGLE OF ATTACK.

TESK K. $\ell/d = 0.25$

- ○ $q = 0$
- □ $q = 3.459$
- △ $q = 9.224$
- ◇ $q = 19.601$

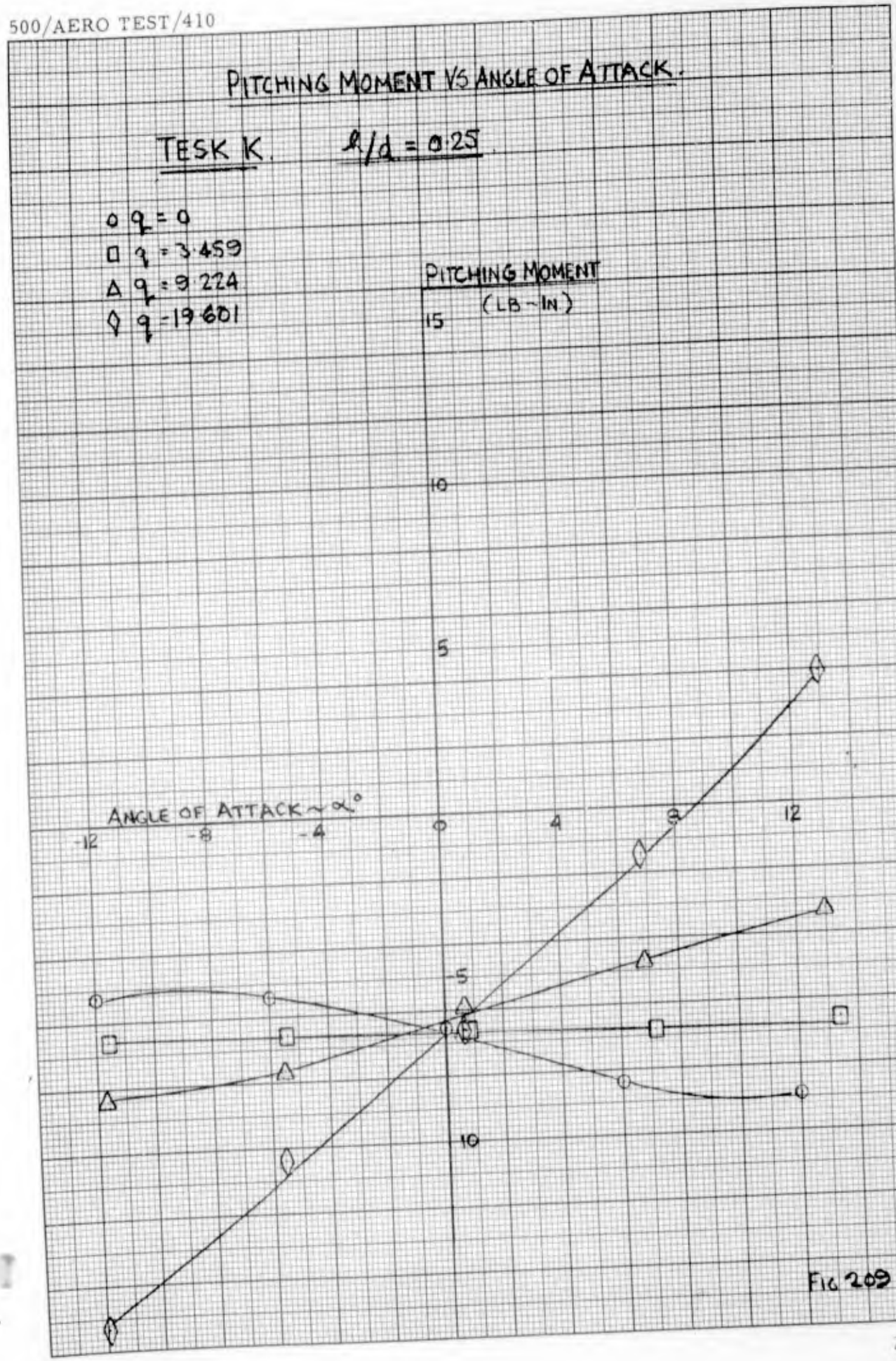


FIG 209

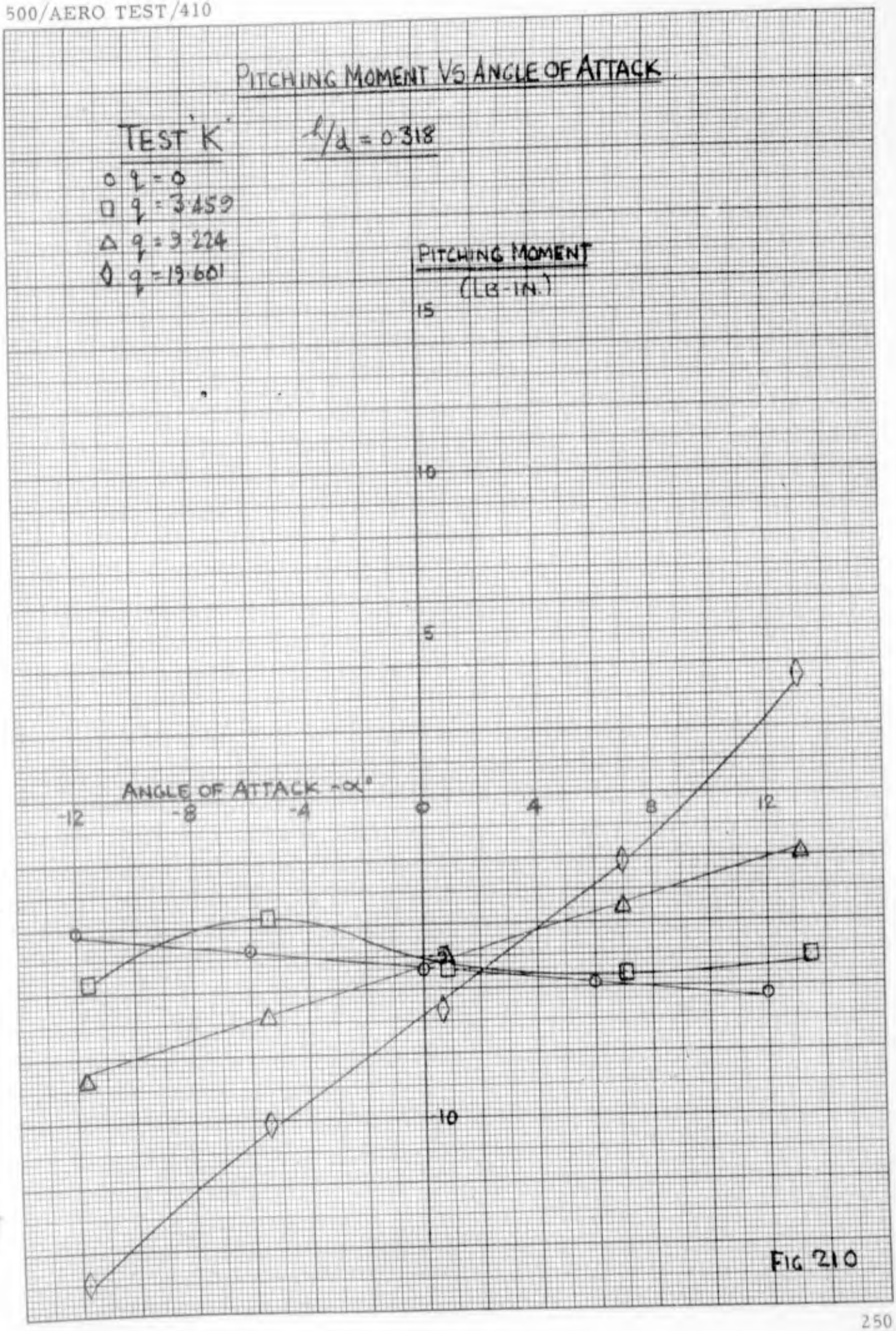

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'K'
l/d = 0.318
○ q = 0
□ q = 3.459
△ q = 3.224
◊ q = 19.601
PITCHING MOMENT
(LB-IN.)
15
10
5
10
ANGLE OF ATTACK -α°
-12
-8
-4
0
4
8
12

FIG 210

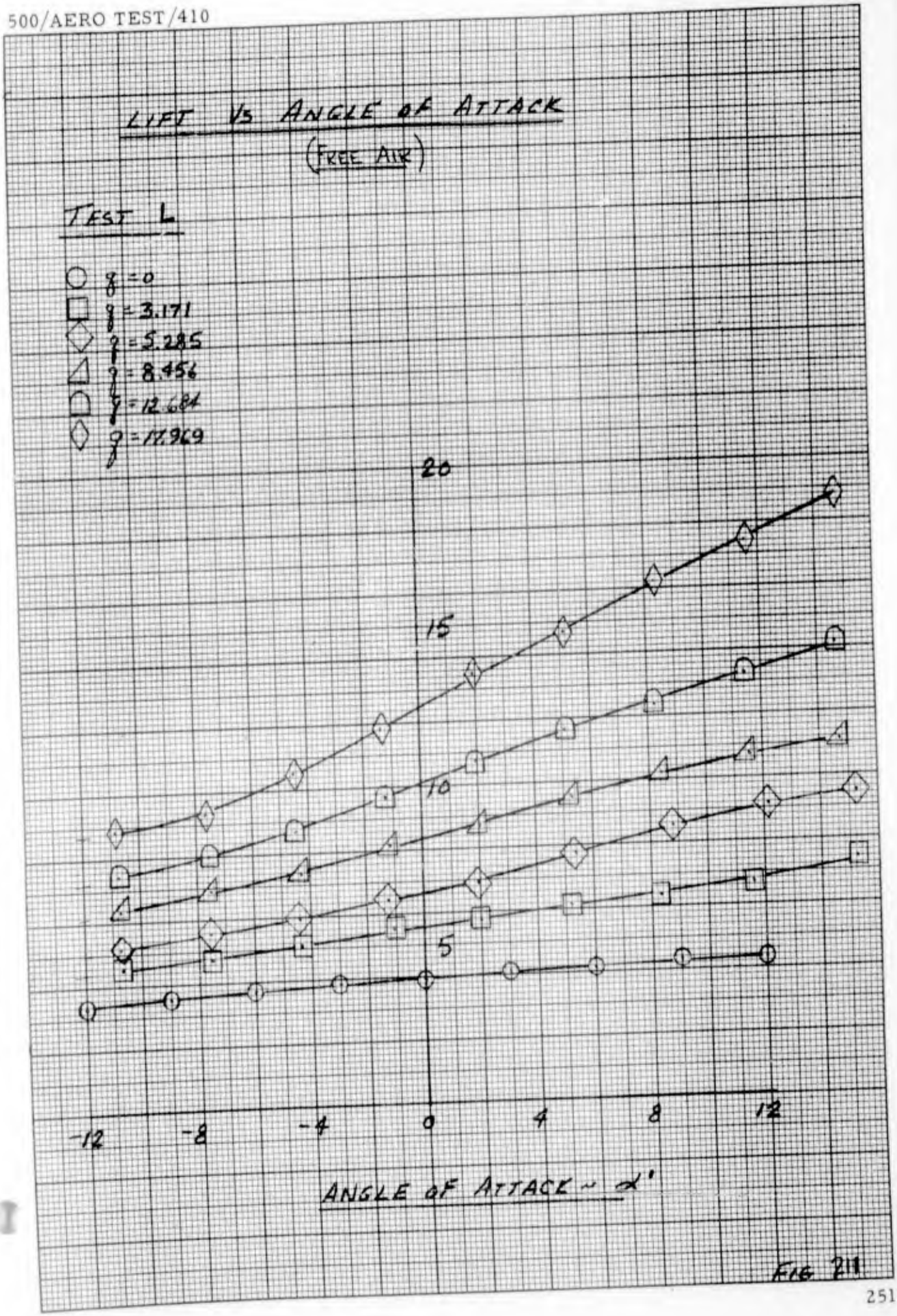

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST L
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α'

FIG 211

DRAG VS ANGLE OF ATTACK

(FREE AIR)

TEST L

- ○ $q = 0$
- □ $q = 3.171$
- ◇ $q = 5.285$
- △ $q = 8.456$
- ⌂ $q = 12.684$
- ◇ $q = 17.969$

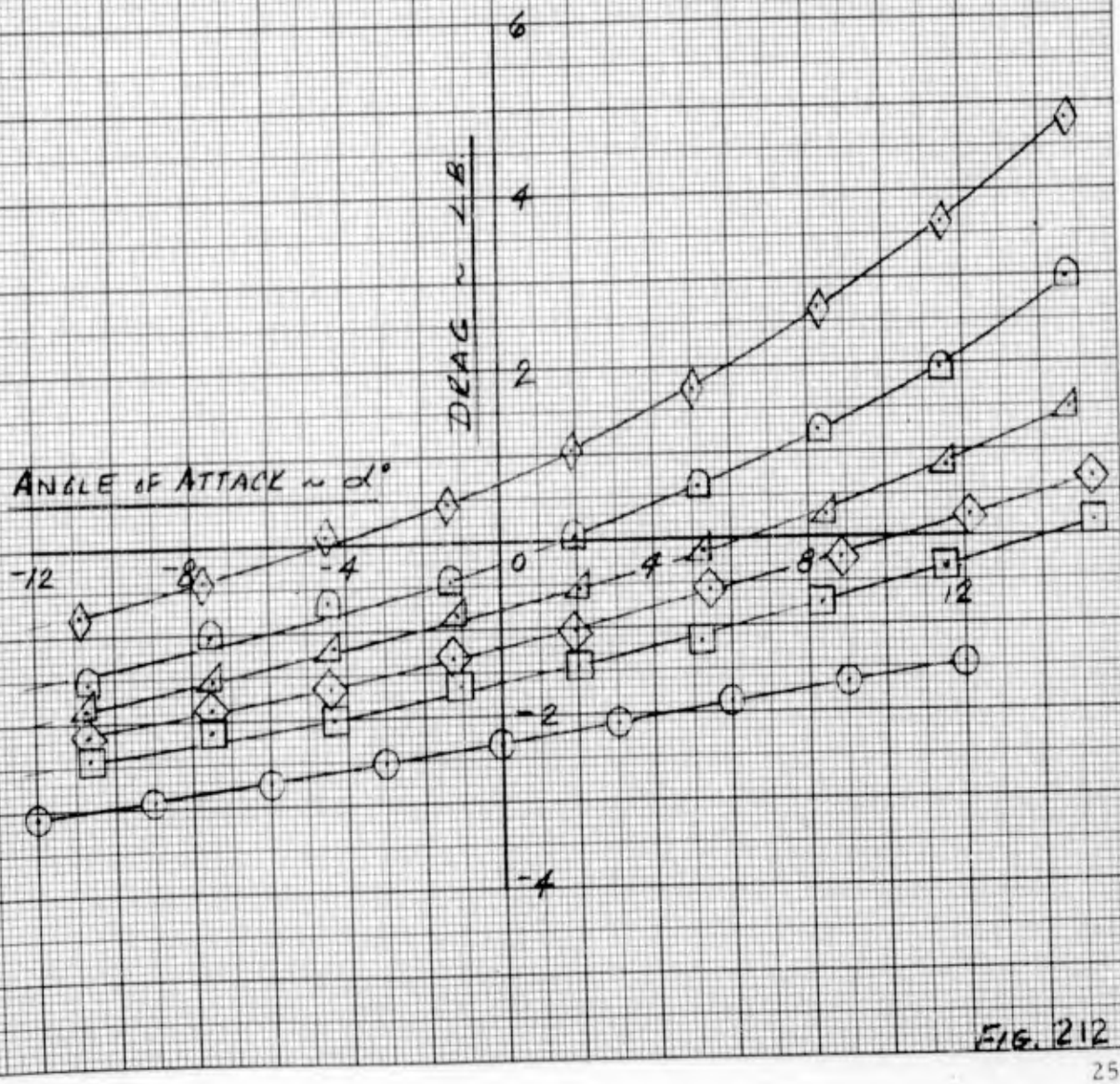


FIG. 212

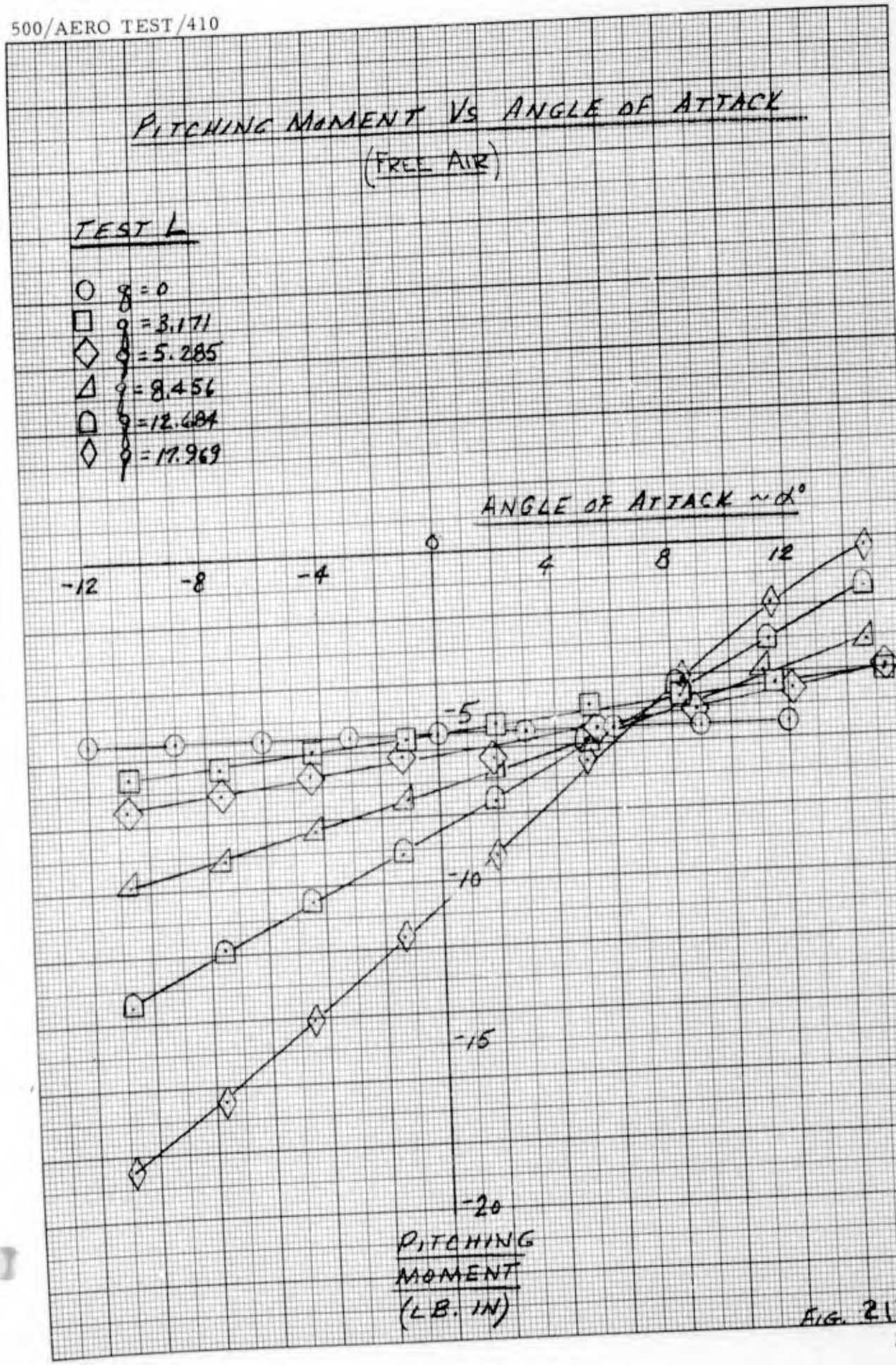

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST L
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
ANGLE OF ATTACK ~ α°
0
4
8
12
-12
-8
-4
-5
-10
-15
-20
PITCHING MOMENT (LB. IN)

FIG. 213

LIFT COEFFICIENT Vs ANGLE of ATTACK

(FREE AIR)

TEST L

- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ∩ q = 12.684
- ◇ q = 17.969

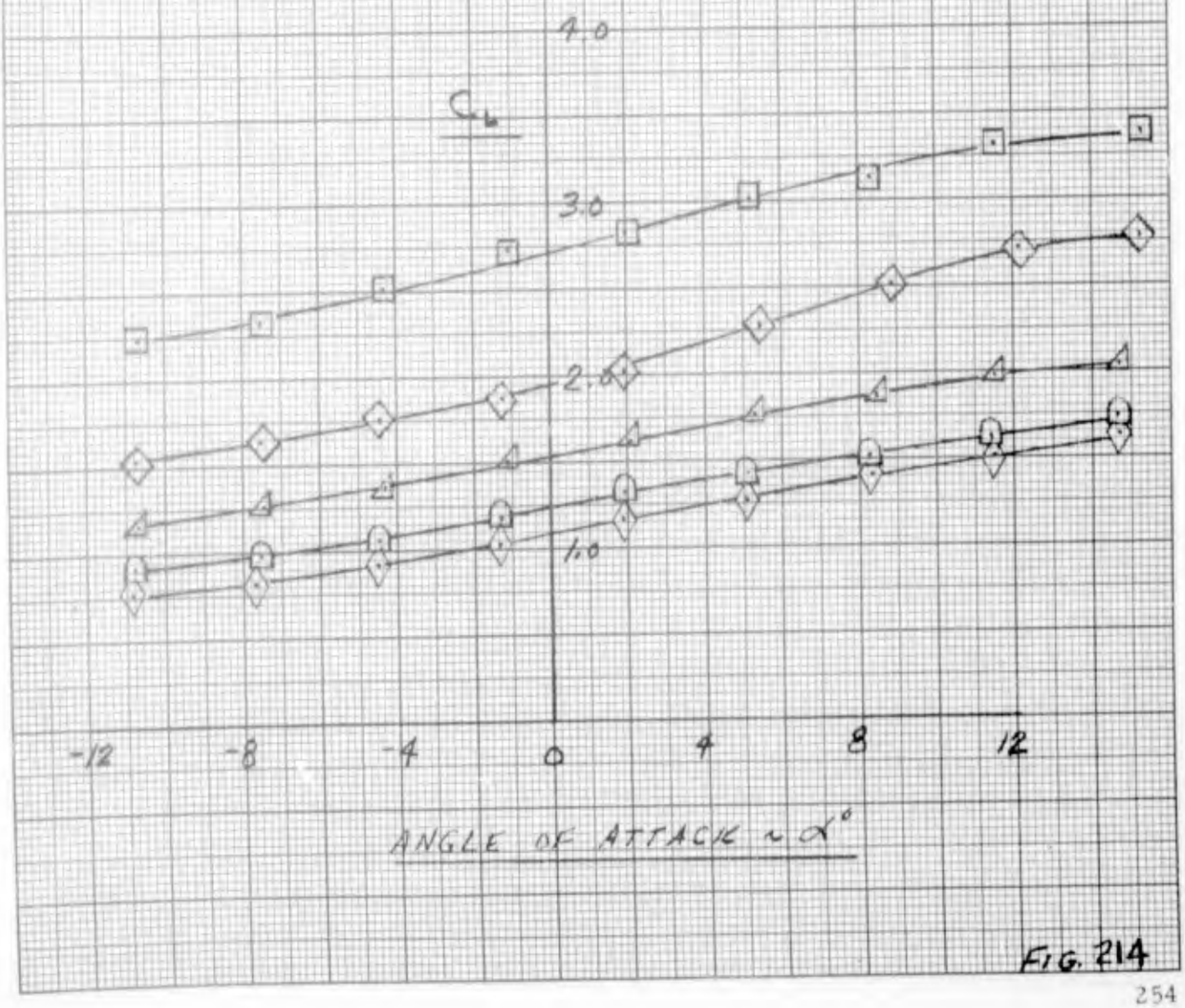


FIG. 214

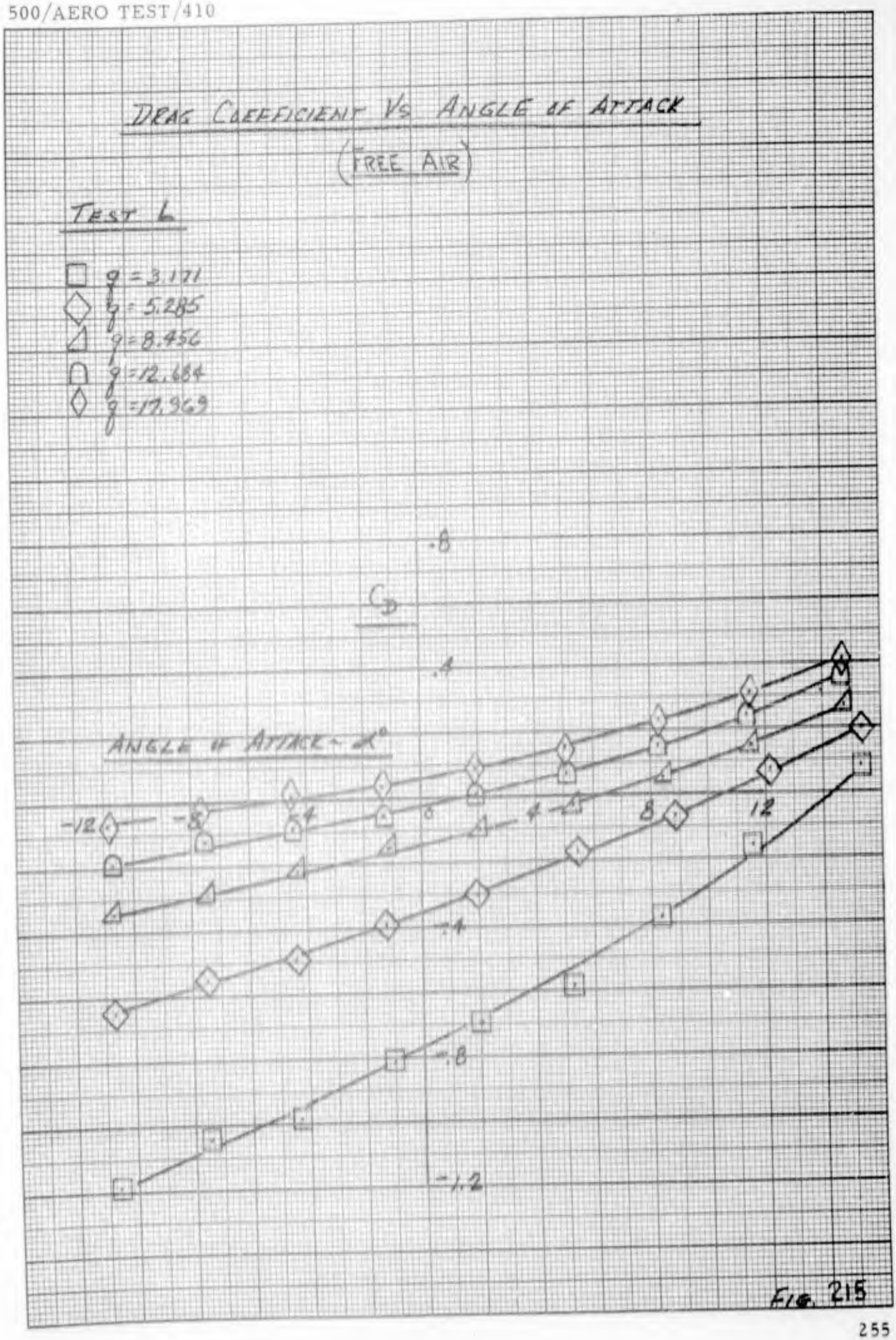

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST L
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
.8
C_D
.4
ANGLE OF ATTACK = α°
-12
-8
-4
0
4
8
12
-.4
-.8
-1.2

FIG. 215

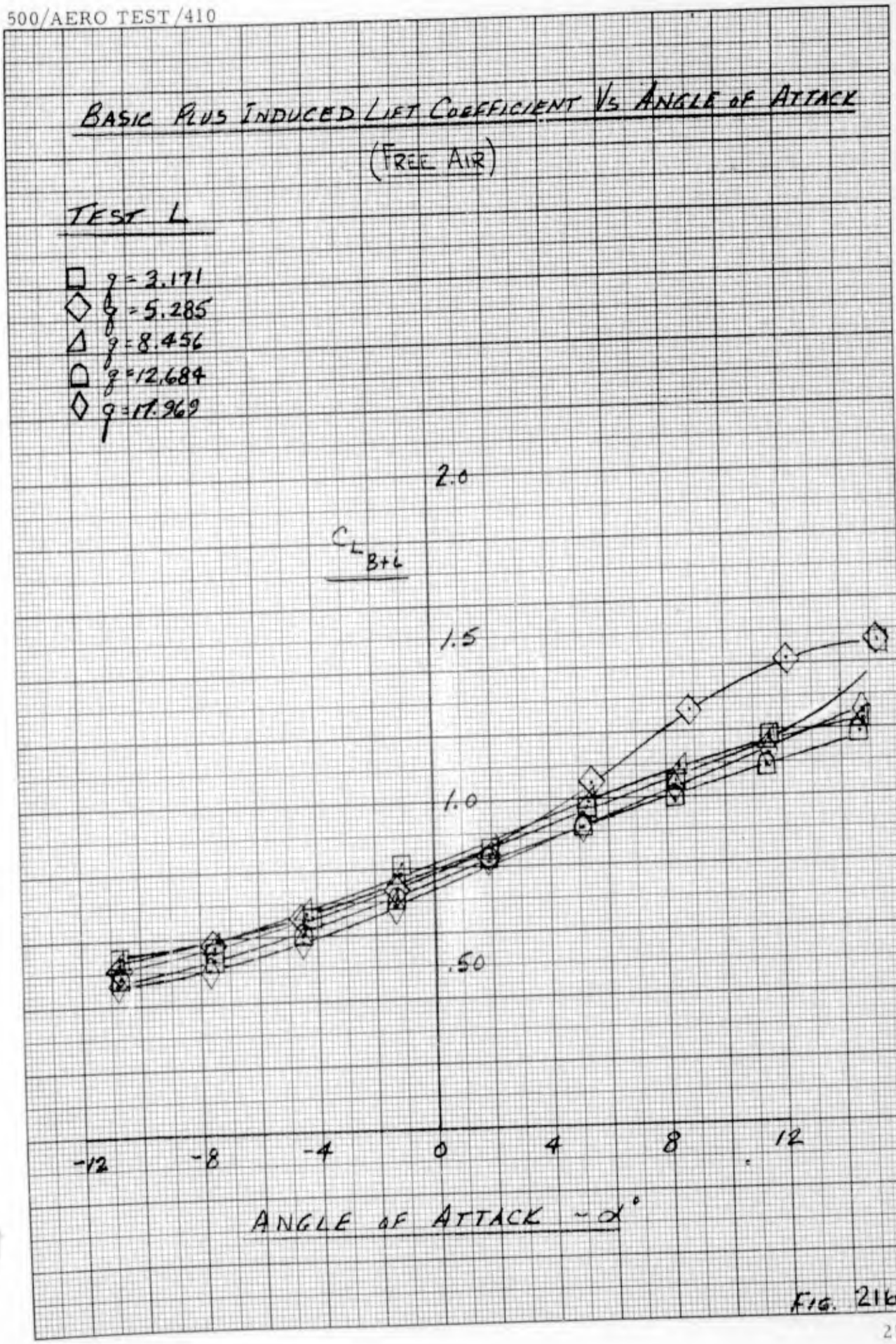

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST L
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
2.0
$C_{L_{B+i}}$
1.5
1.0
.50
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

FIG. 216

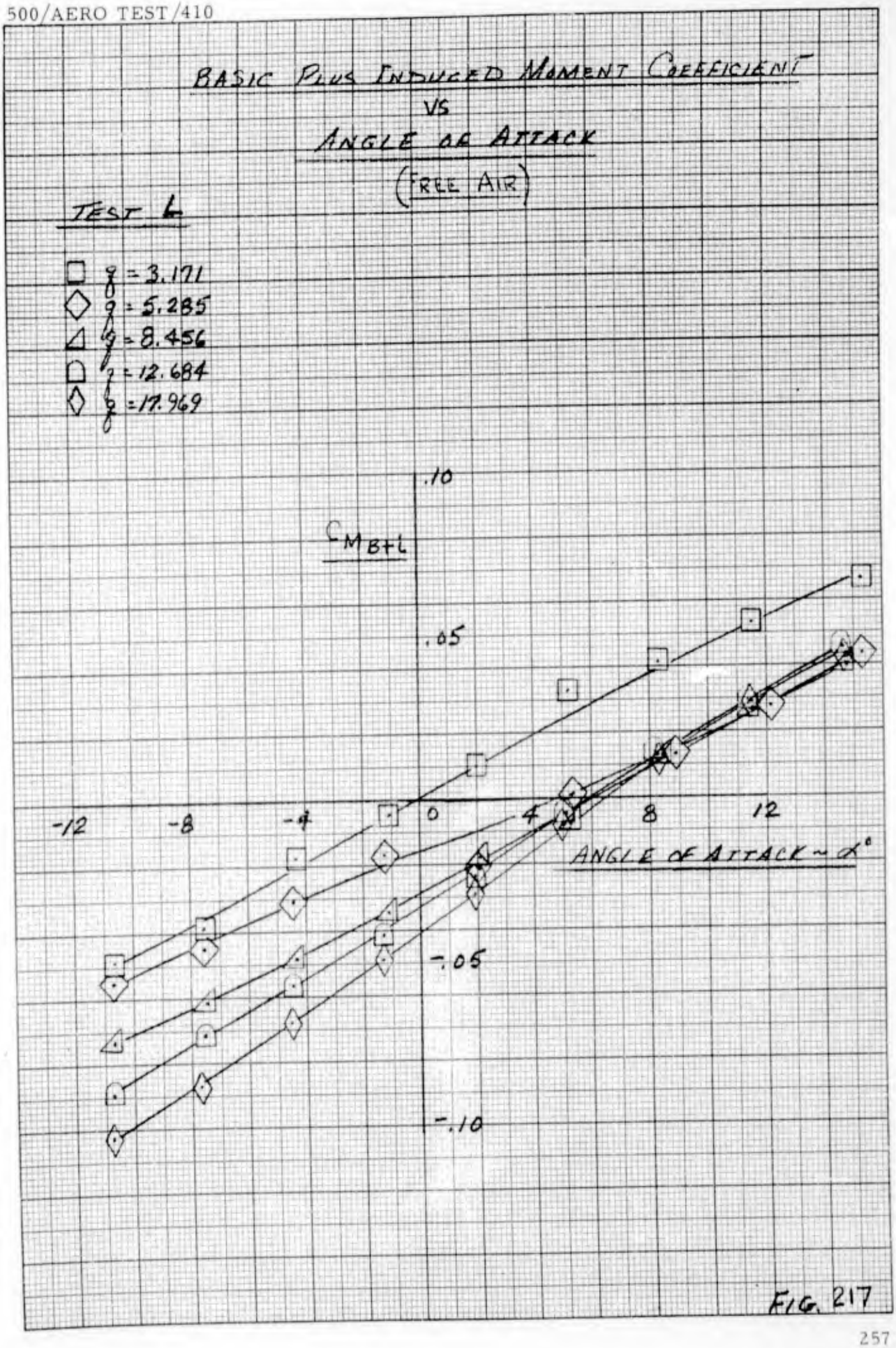

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
ANGLE OF ATTACK
(FREE AIR)
TEST L
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
.10
$C_{M_{B+L}}$
.05
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
-.05
-.10

FIG. 217

BASIC PLUS INDUCED MOMENT COEFFICIENT VS BASIC PLUS INDUCED LIFT COEFFICIENT (FREE AIR)

TEST L

- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ⌒ q = 12.684
- ◇ q = 17.969

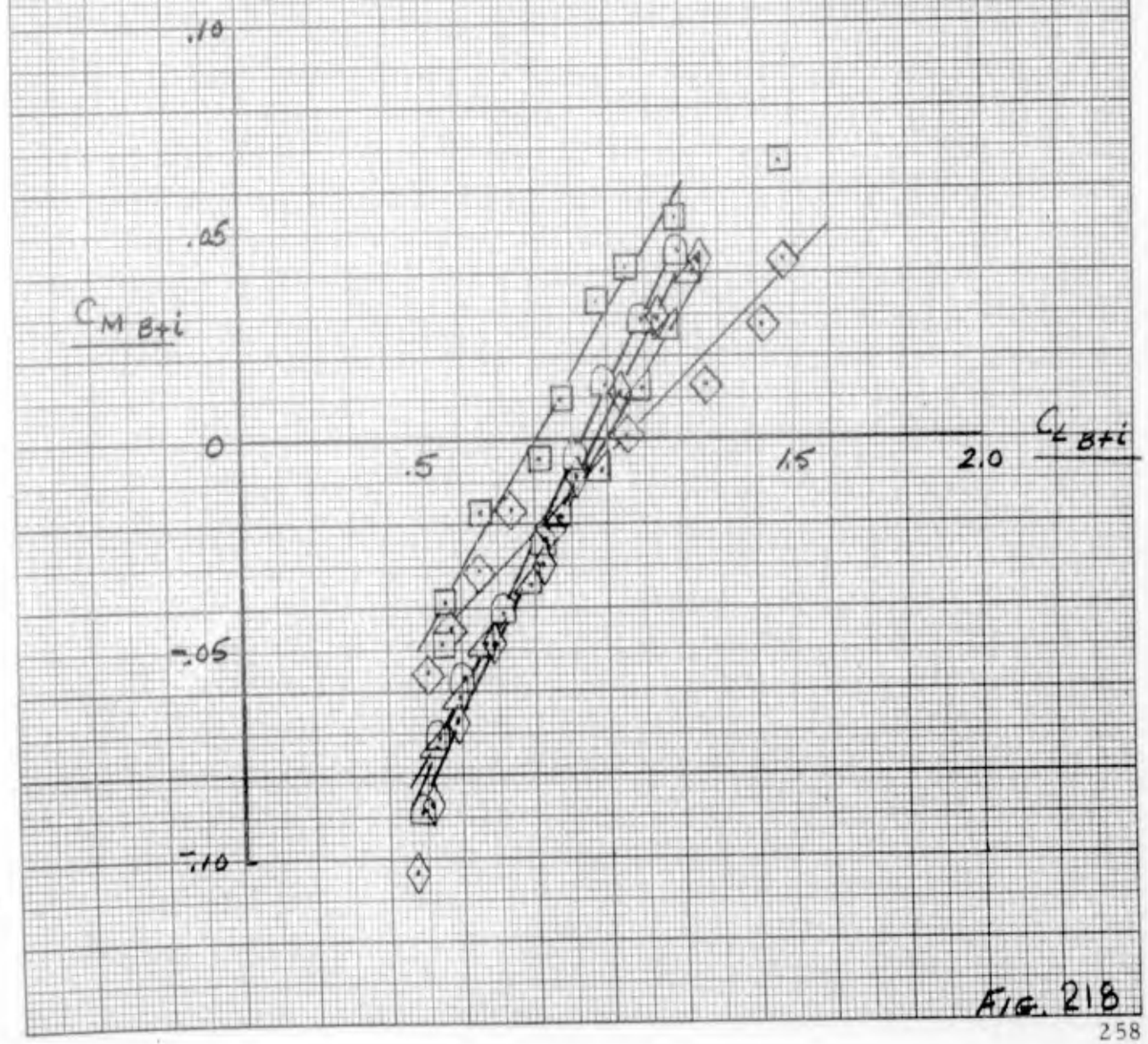


FIG. 218

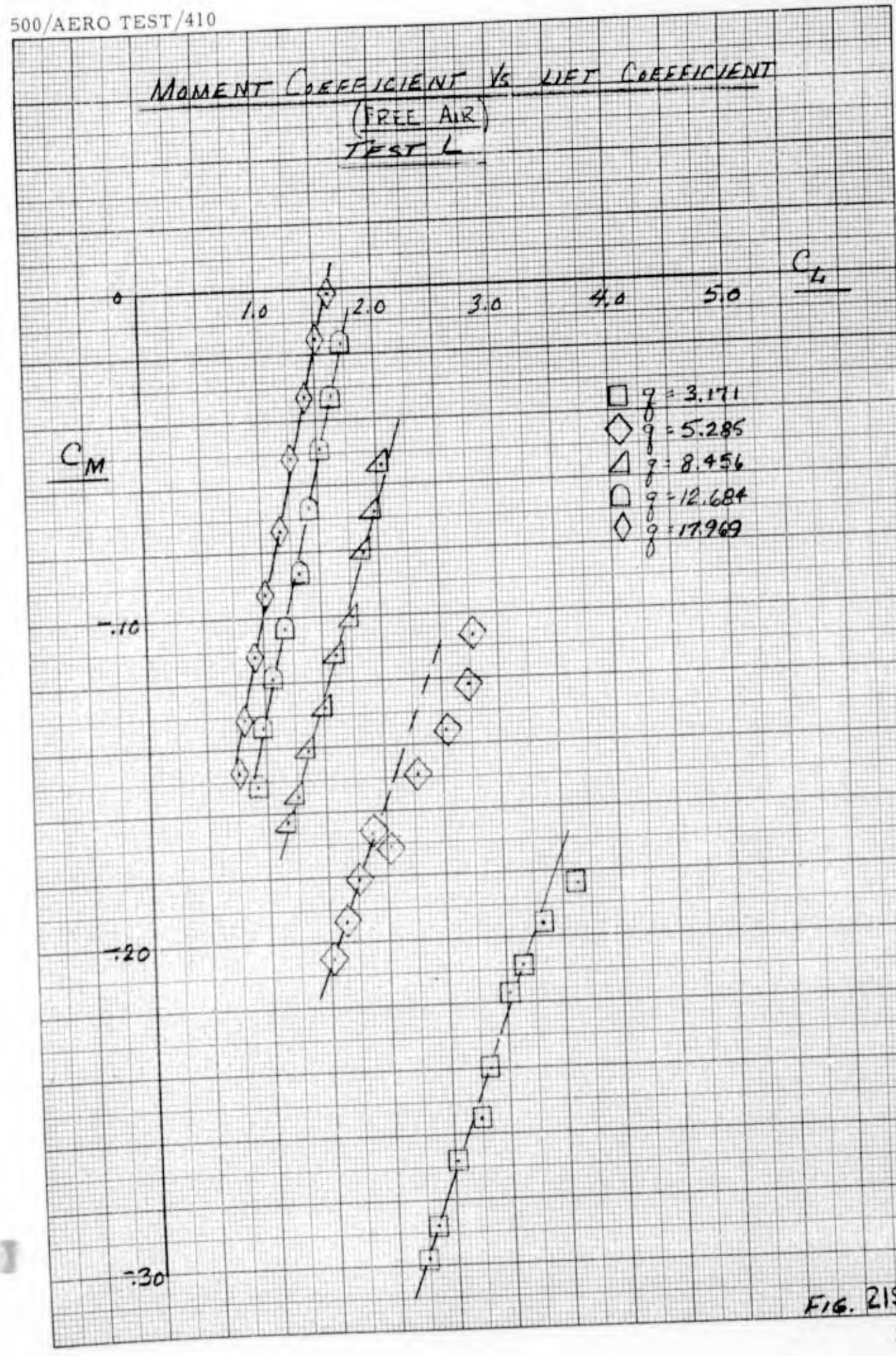

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST L
C_L
0
1.0
2.0
3.0
4.0
5.0
C_M
-.10
-.20
-.30
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969

FIG. 219

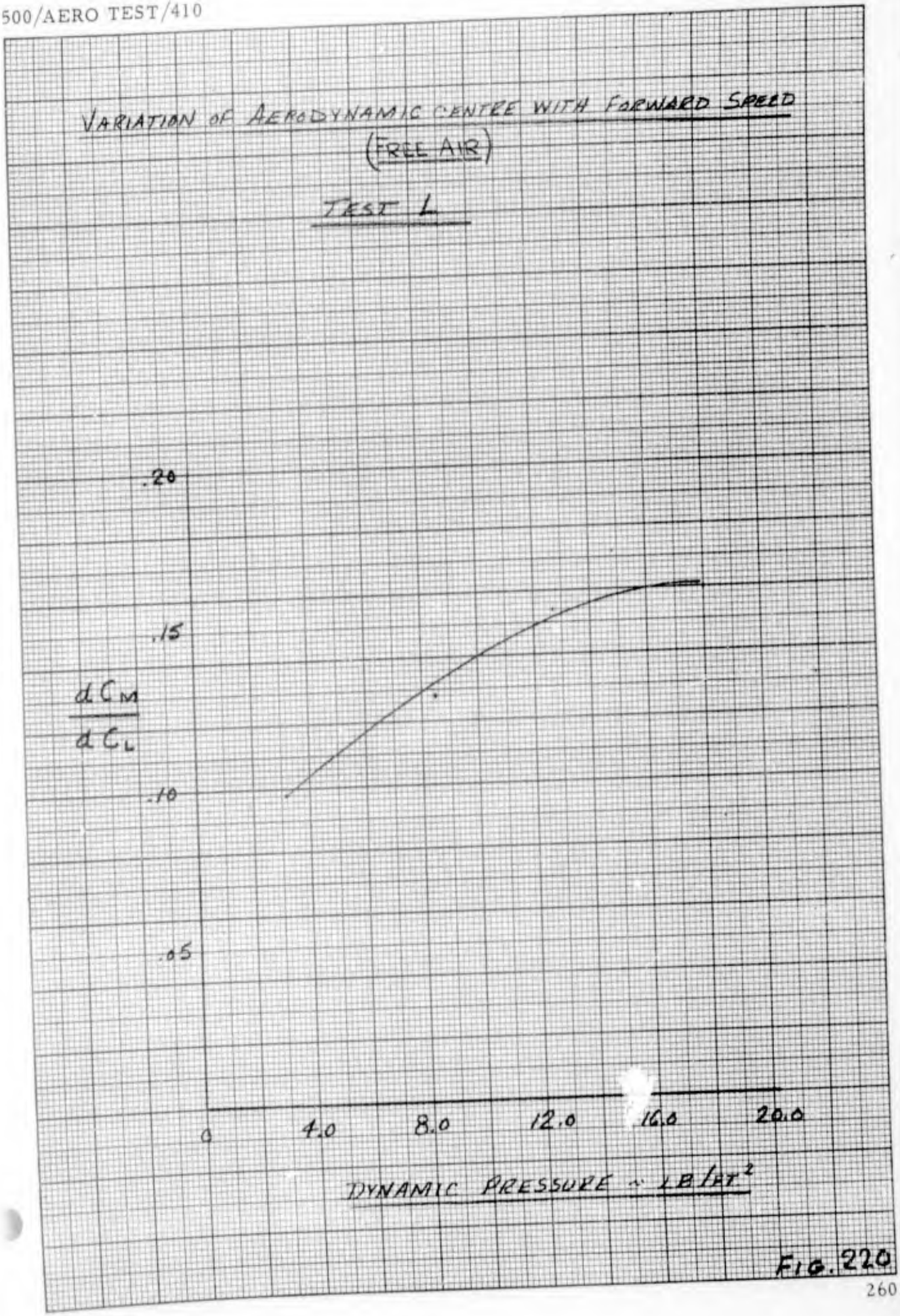

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)
TEST L
.20
.15
$\frac{dC_M}{dC_L}$
.10
.05
0
4.0
8.0
12.0
16.0
20.0
DYNAMIC PRESSURE = LB/FT²

FIG. 220

LIFT CURVE SLOPE VS DYNAMIC PRESSURE

(FREE AIR)

TEST L

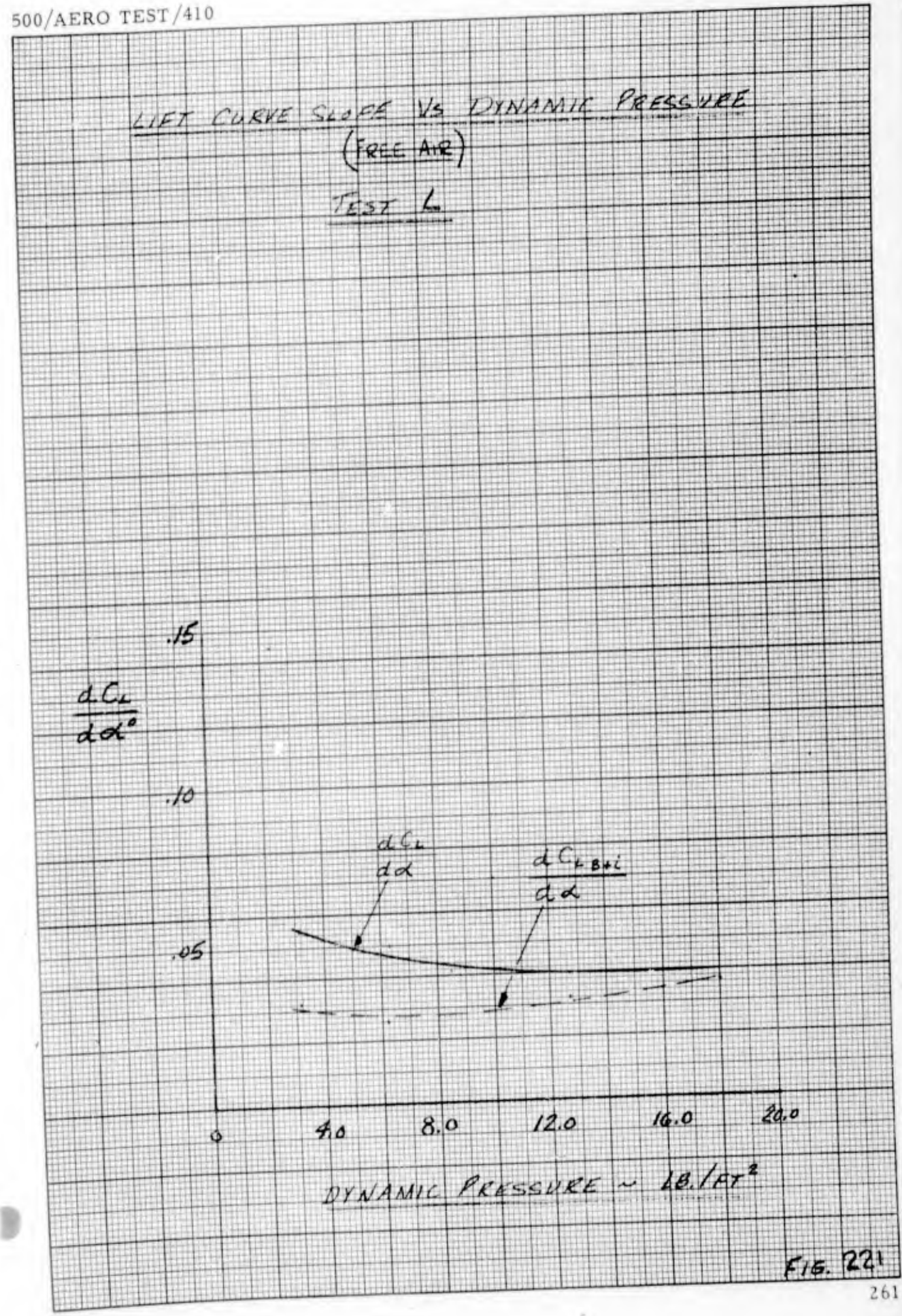


FIG. 221

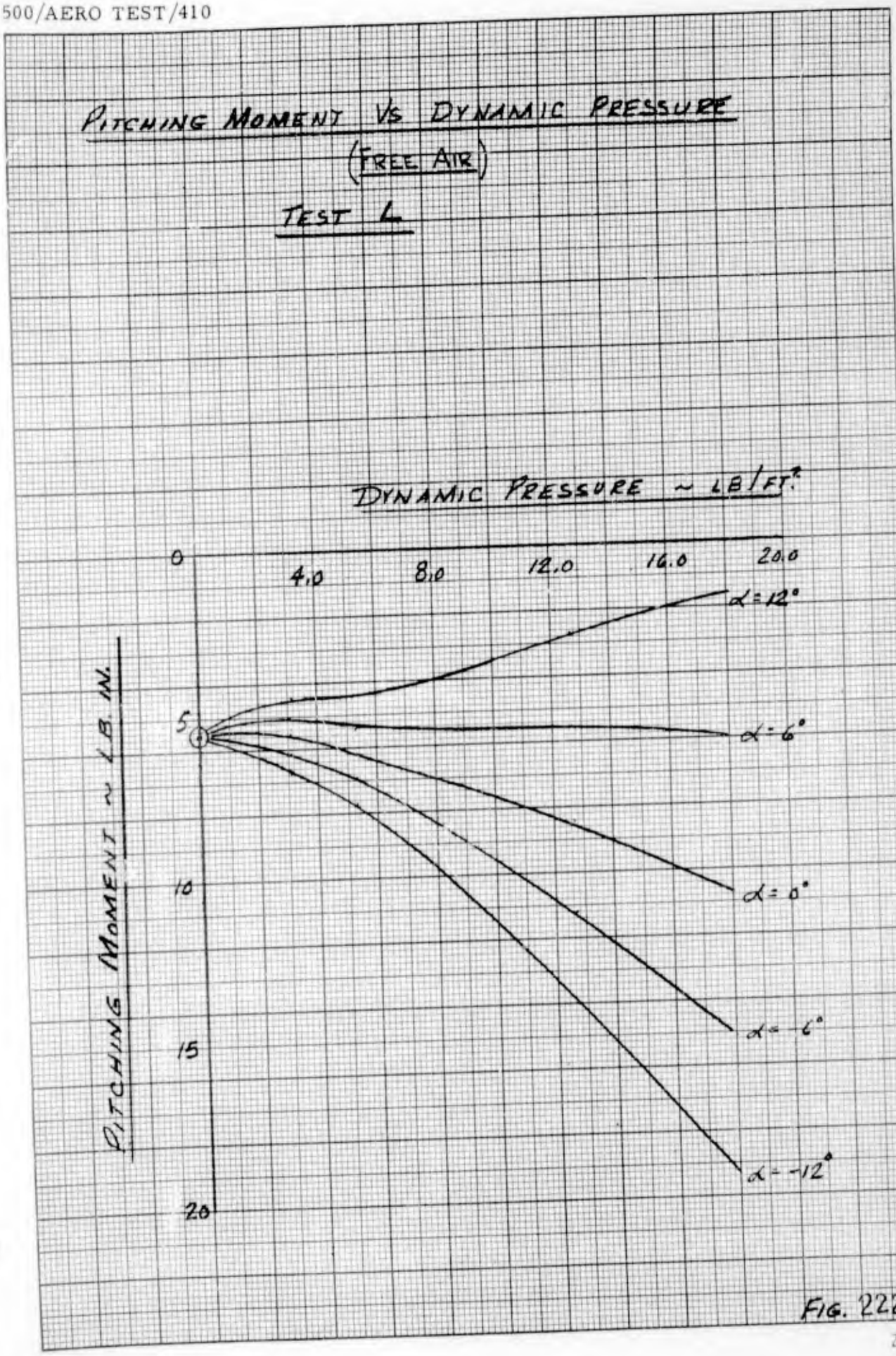

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 4
DYNAMIC PRESSURE ~ LB/FT.²
0
4.0
8.0
12.0
16.0
20.0
PITCHING MOMENT ~ LB. IN.
5
10
15
20
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG. 222

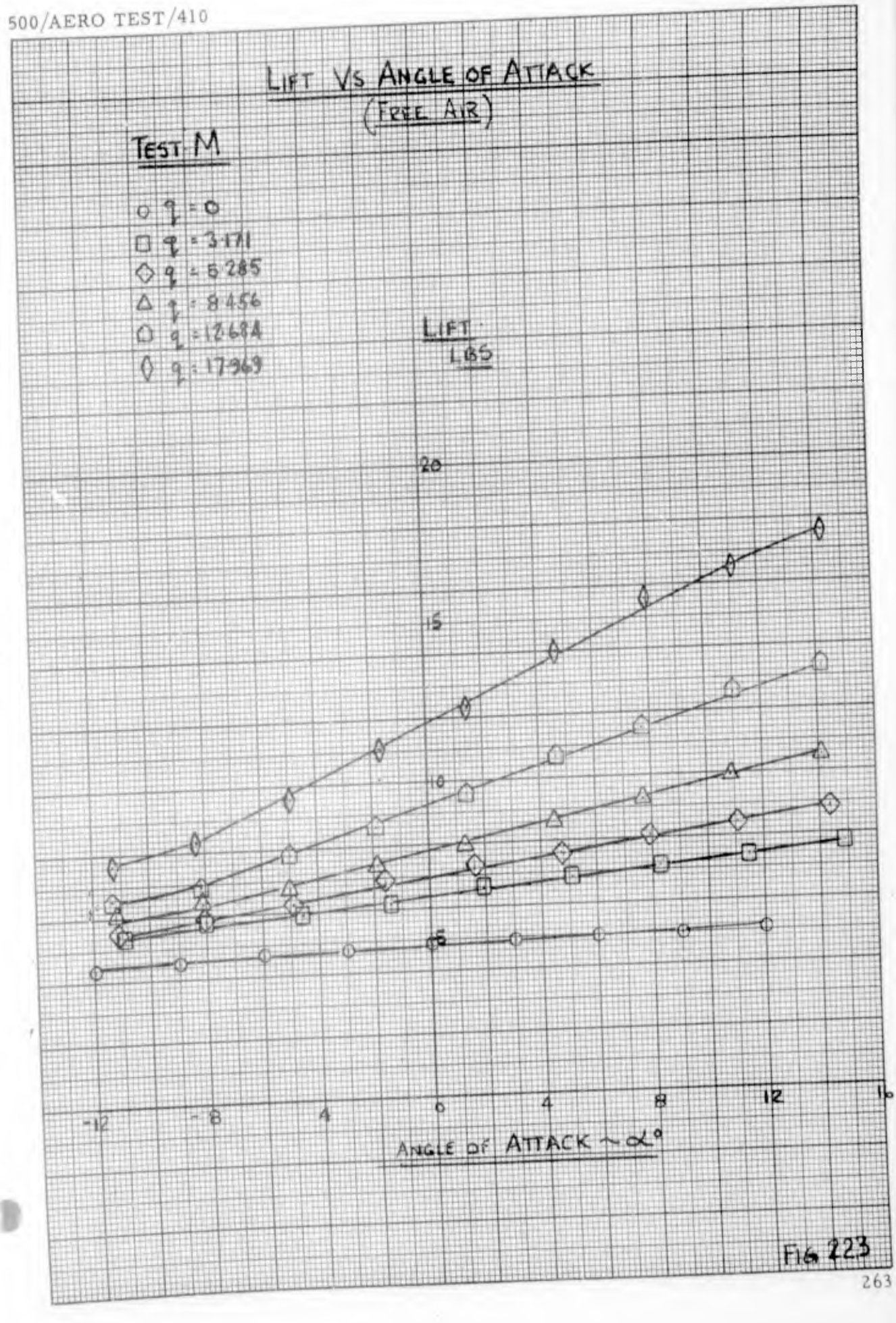

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST M
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
LIFT
LBS
20
15
10
5
-12
-8
4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

Fig 223

DRAG VS ANGLE OF ATTACK
(FREE AIR)

TEST M

- ○ $q = 0$
- □ $q = 3.171$
- ◇ $q = 5.285$
- △ $q = 8.456$
- ▭ $q = 12.684$
- ◊ $q = 17.969$

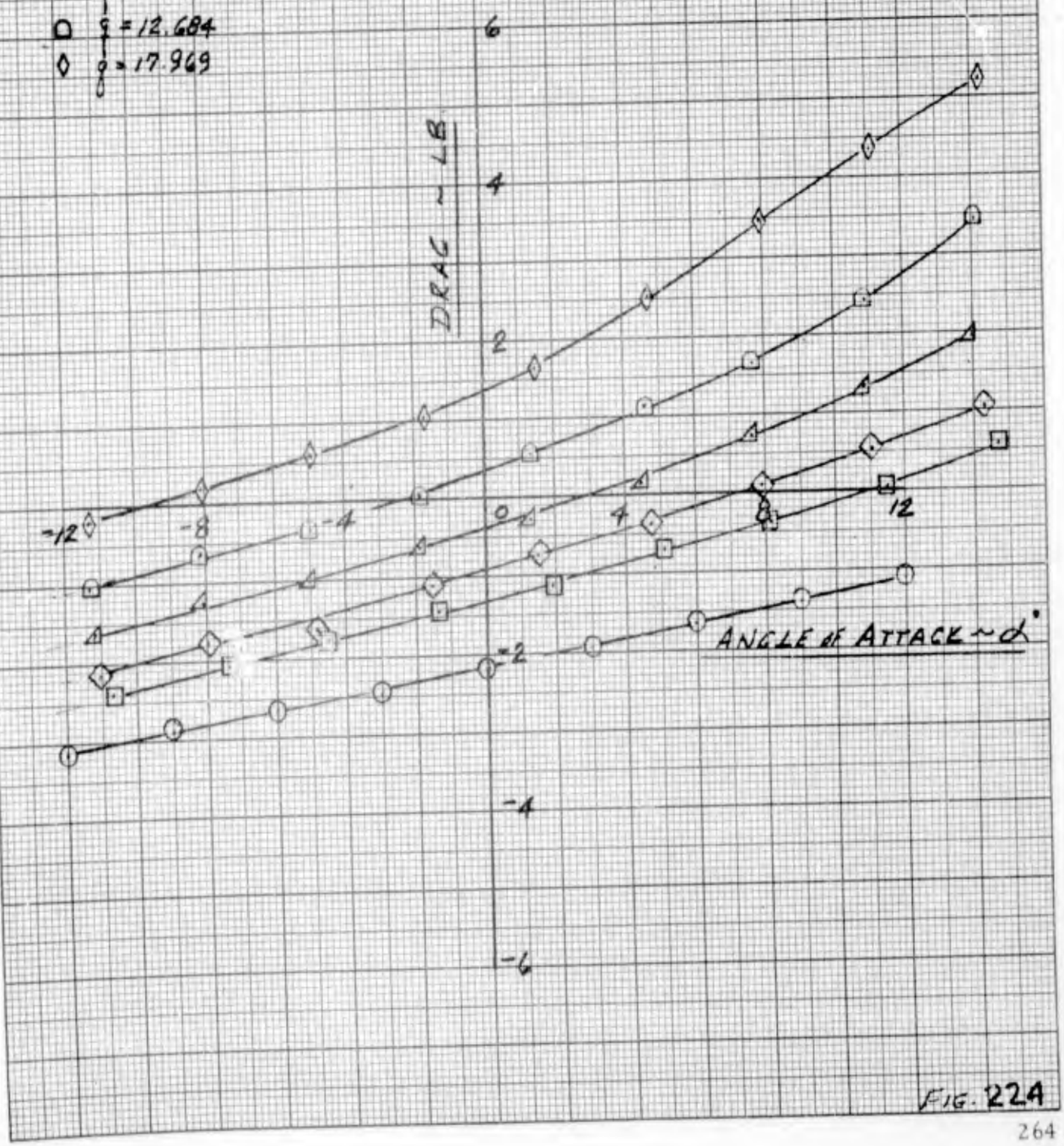


FIG. 224

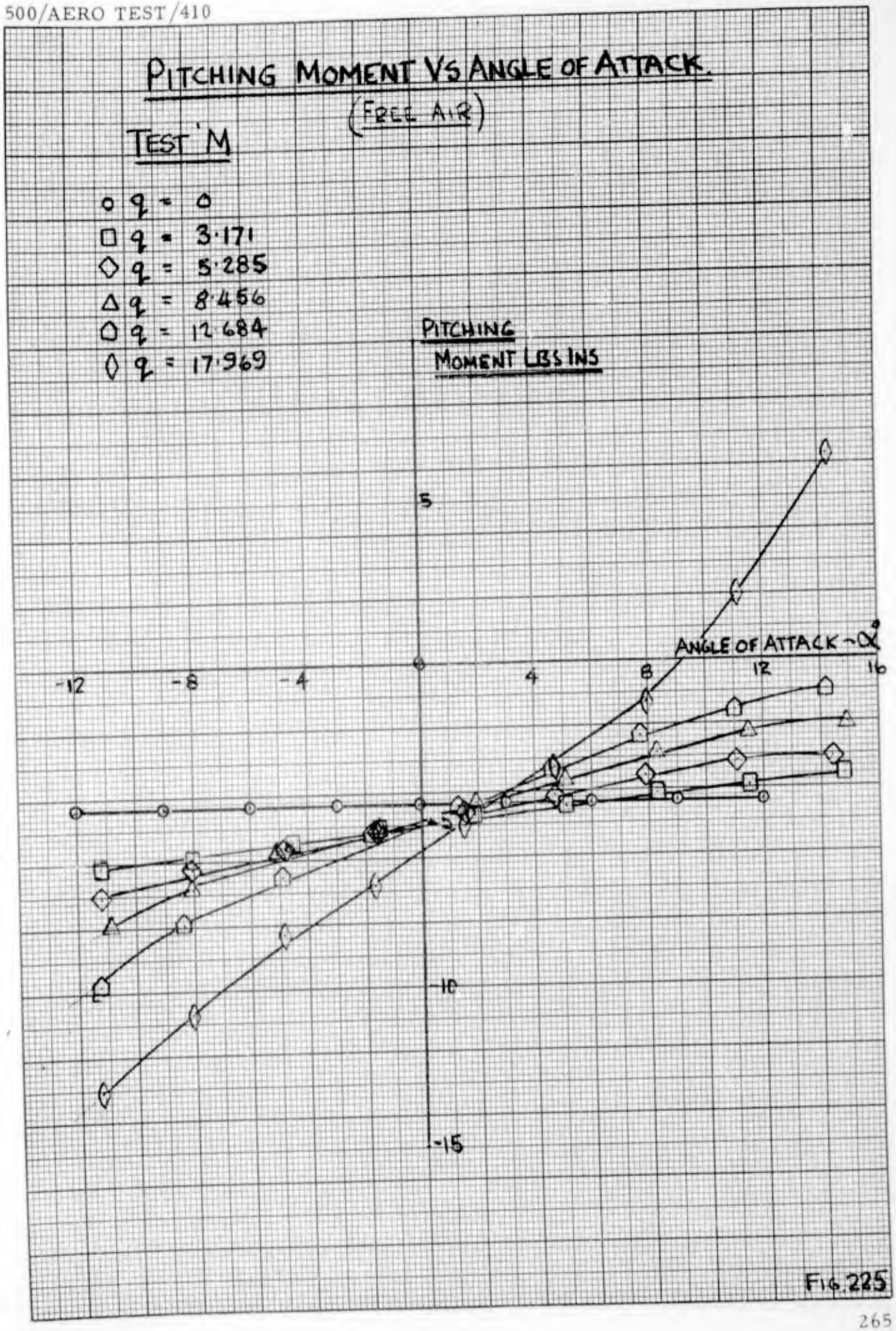

PITCHING MOMENT VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'M
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
PITCHING
MOMENT LBS INS
5
ANGLE OF ATTACK -α°
-12
-8
-4
4
8
12
16
-10
-15

Fig. 225

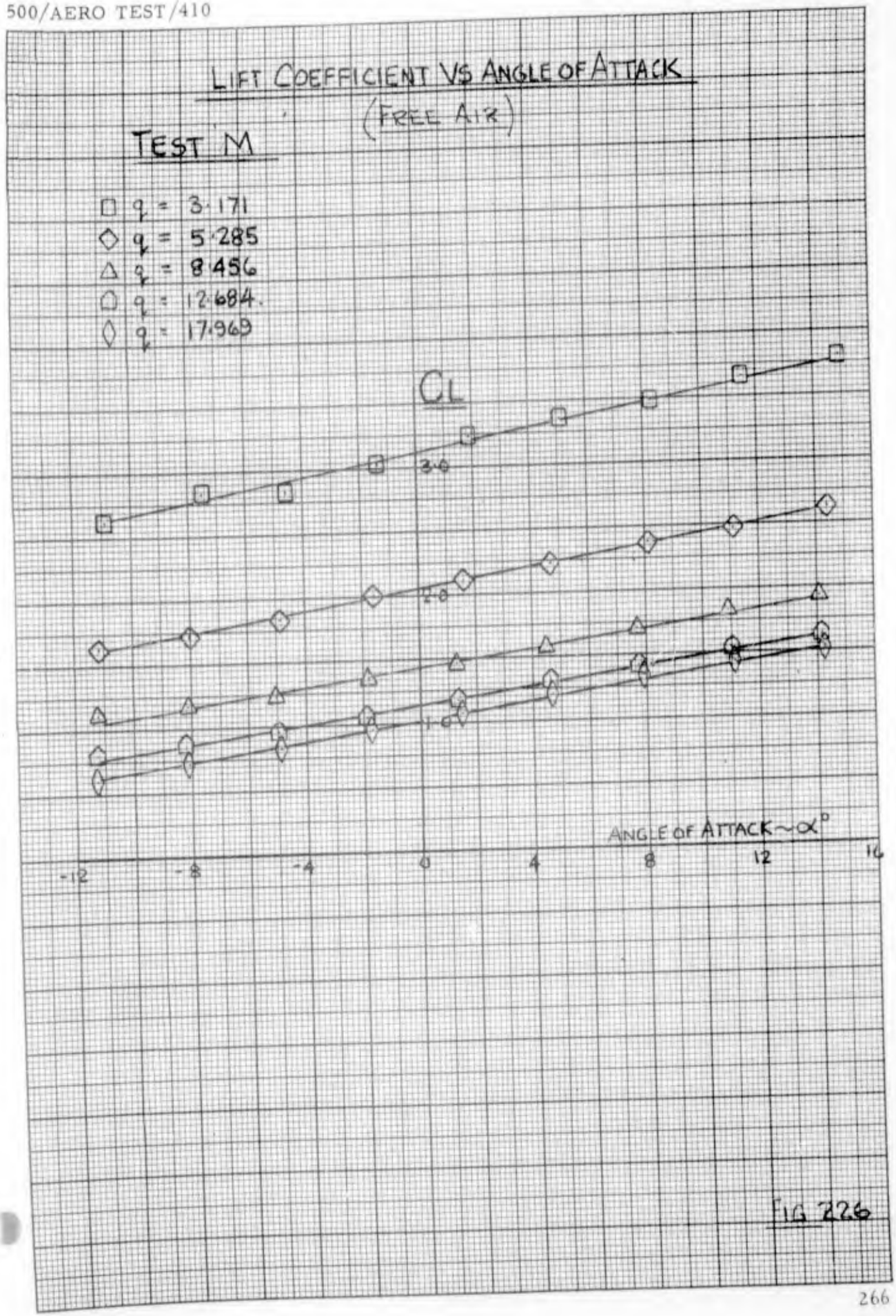
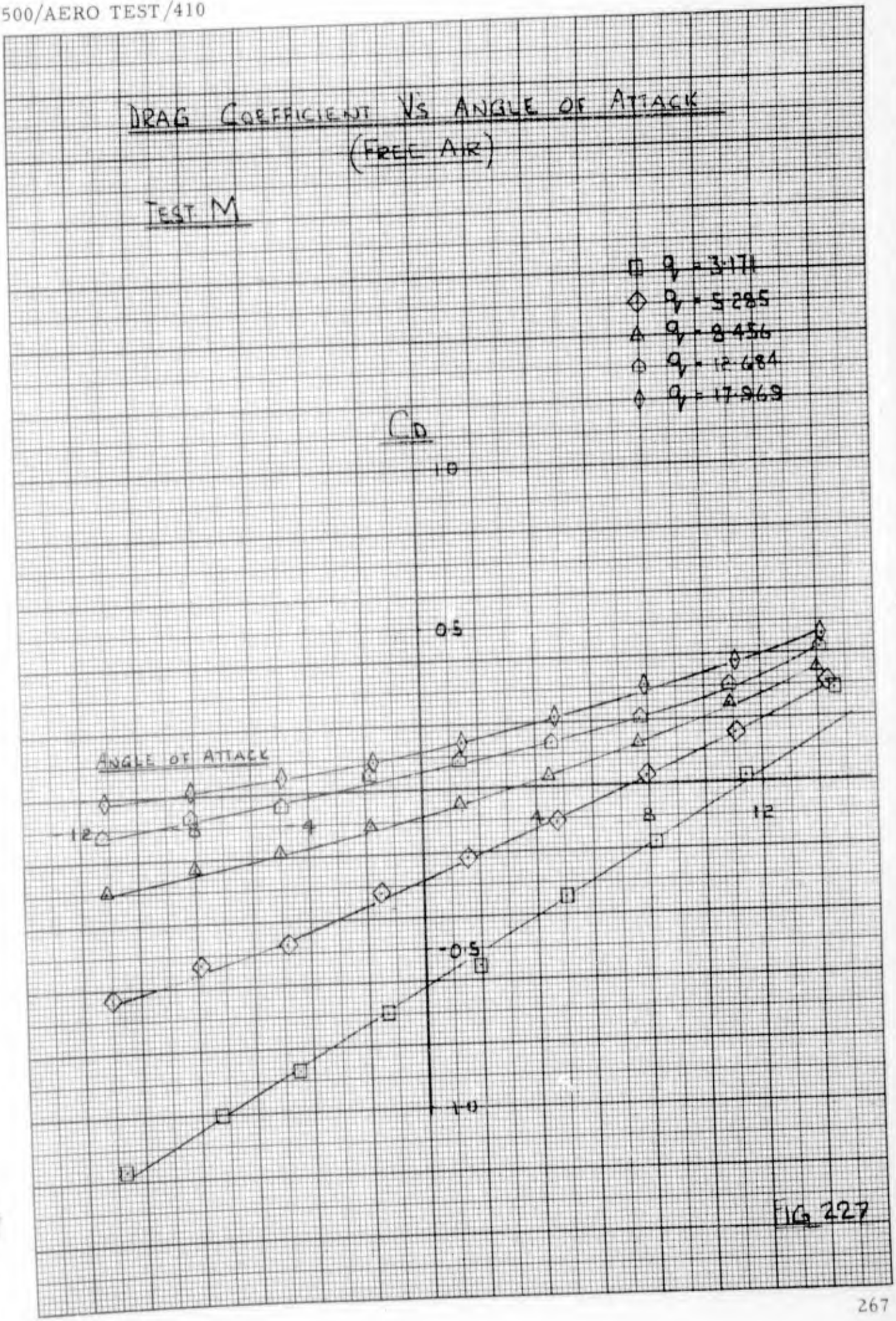

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST M
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CL
3.0
2.0
1.0
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 22.6


DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST M
q_v = 3.171
q_v = 5.285
q_v = 8.456
q_v = 12.684
q_v = 17.963
C_D
1.0
0.5
-0.5
-1.0
ANGLE OF ATTACK
-12
-4
4
8
12
FIG 227

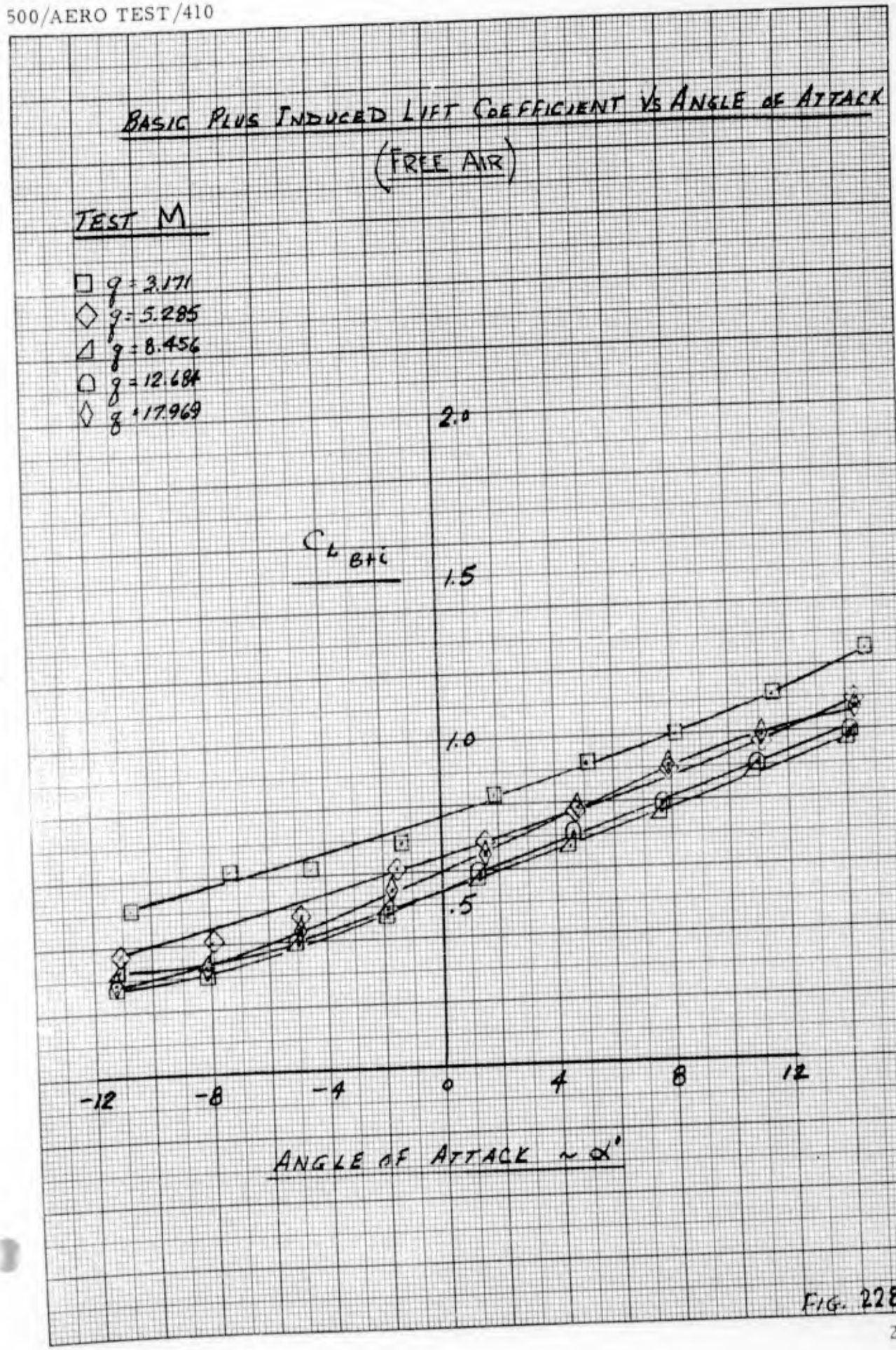

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST M
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⌂ q = 12.684
◊ q = 17.969
$C_{L_{BAI}}$
2.0
1.5
1.0
.5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG. 228

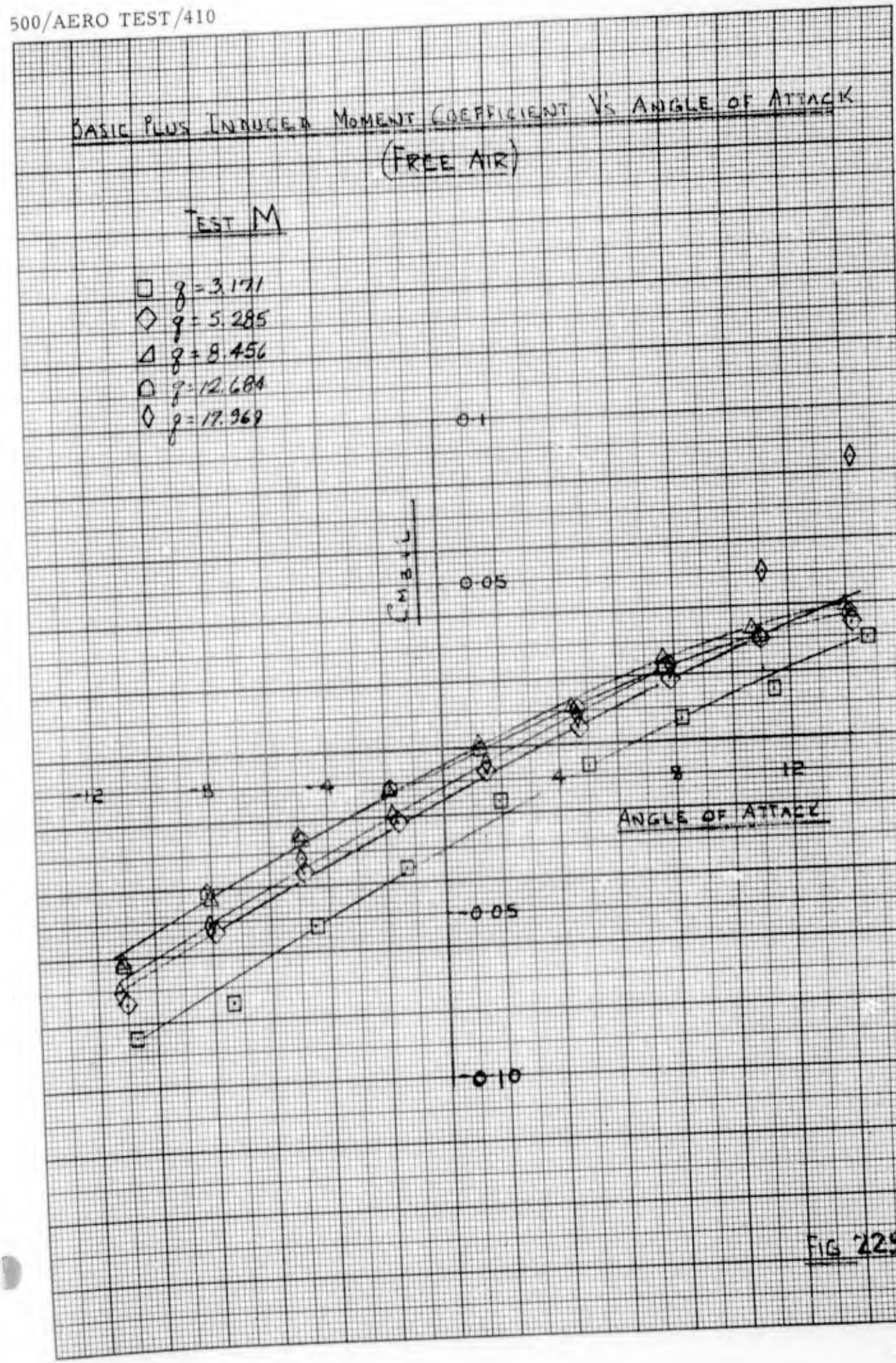

BASIC PLUS INDUCED MOMENT COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST M
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
0.1
0.05
-0.05
-0.10
-12
-8
-4
4
8
12
ANGLE OF ATTACK

FIG 229

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)

TEST M

□ $q = 3.171$
◇ $q = 5.285$
△ $q = 8.456$
⬠ $q = 12.684$
◊ $q = 17.969$

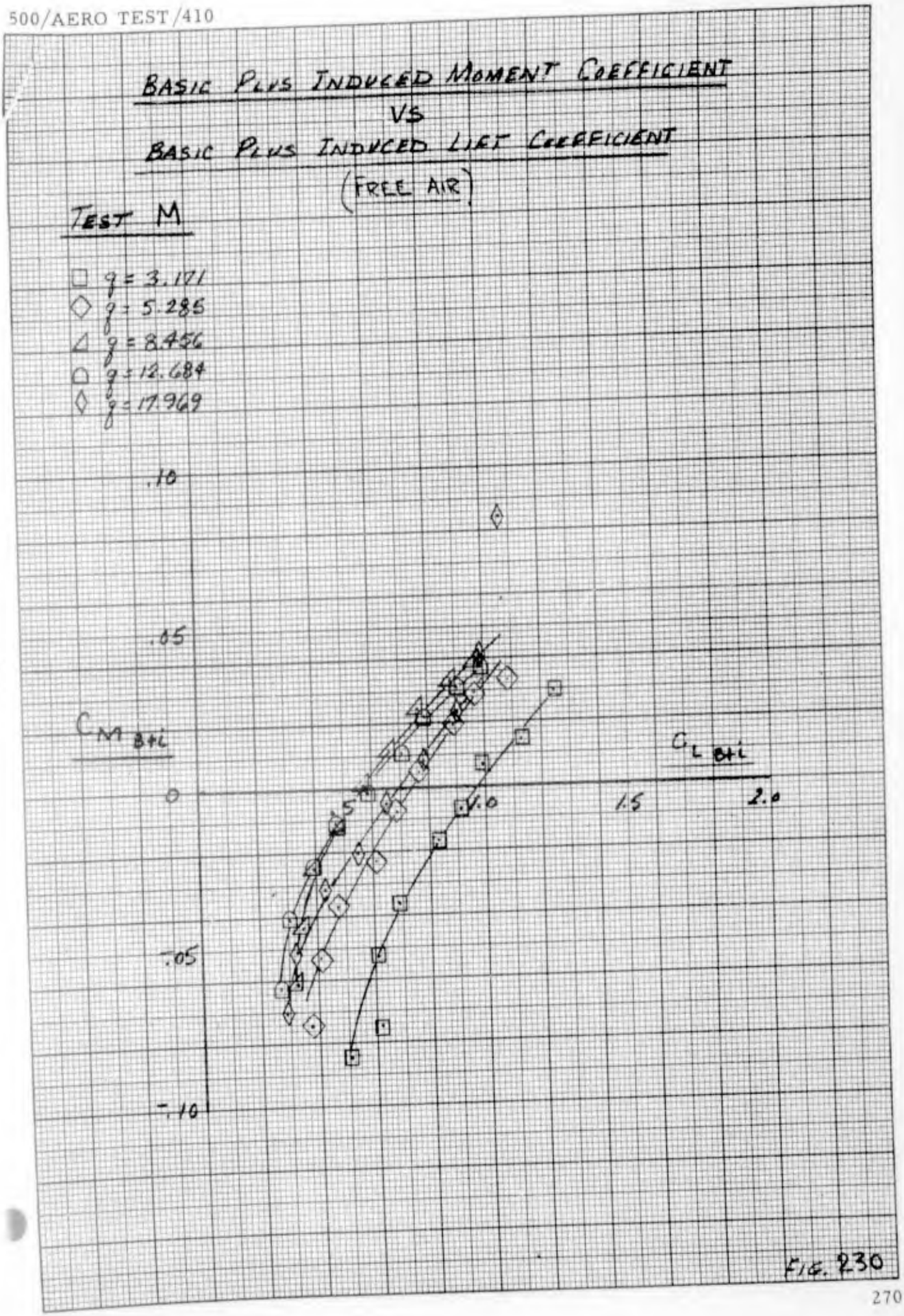
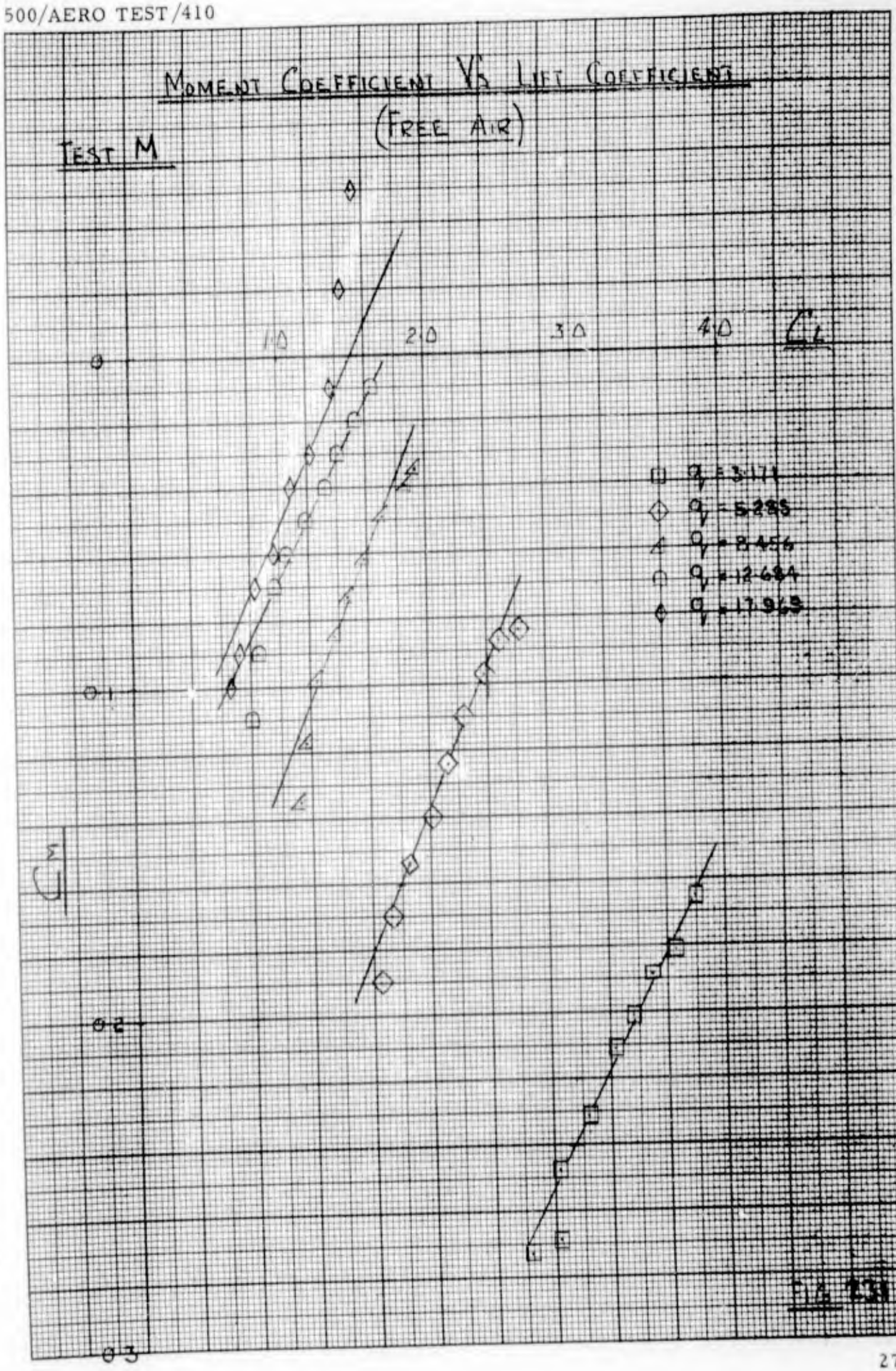


FIG. 230


MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST M
10
20
30
40
C_L
0
-0.1
-0.2
-0.3
C_m
q_v = 3.171
q_v = 5.285
q_v = 8.456
q_v = 12.684
q_v = 17.969
M 131

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED
(FREE AIR)

TEST M

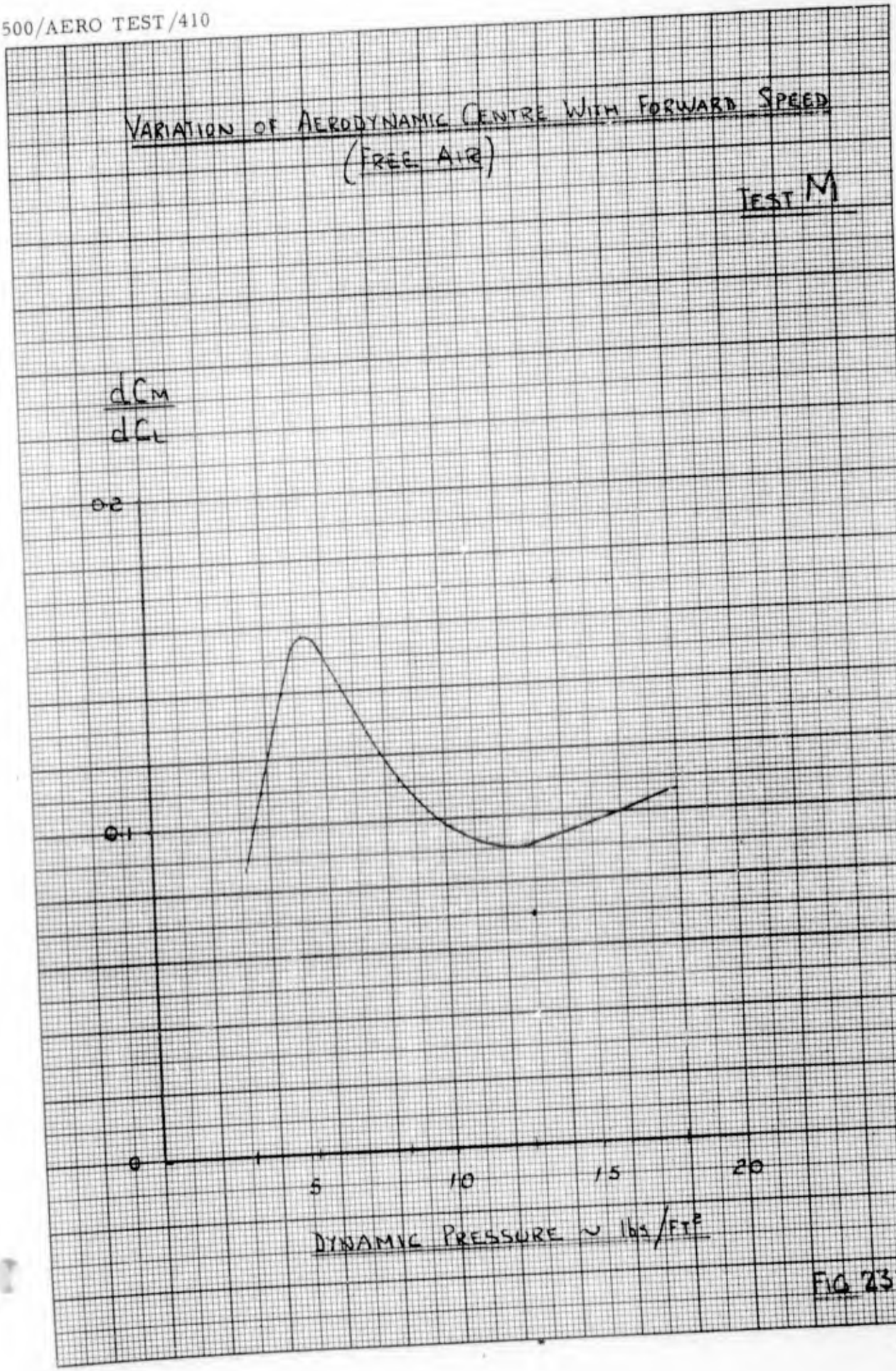


FIG 232

LIFT CURVE SLOPE Vs FORWARD SPEED
(FREE AIR)

TEST M

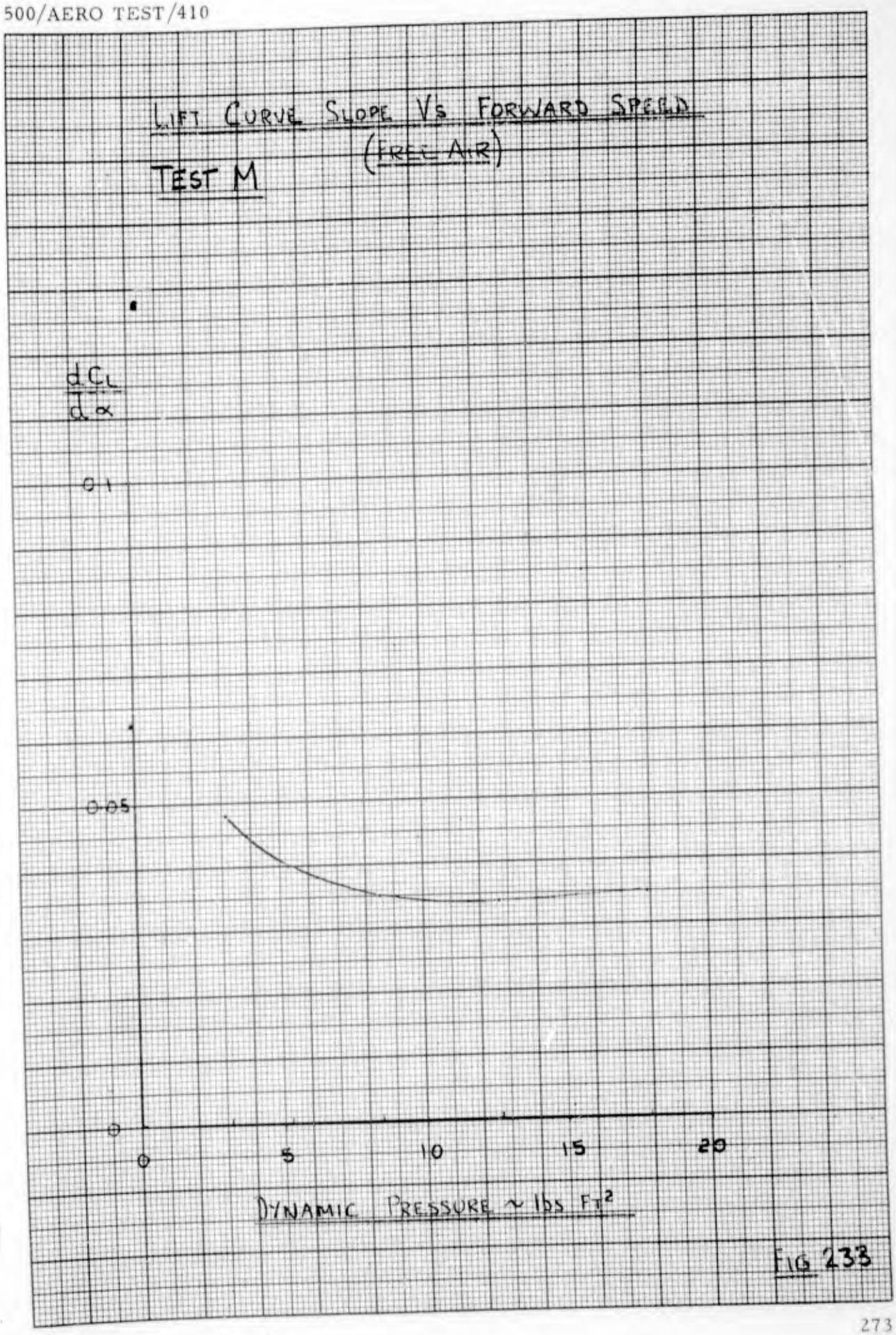


FIG 233

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST M (FREE AIR)

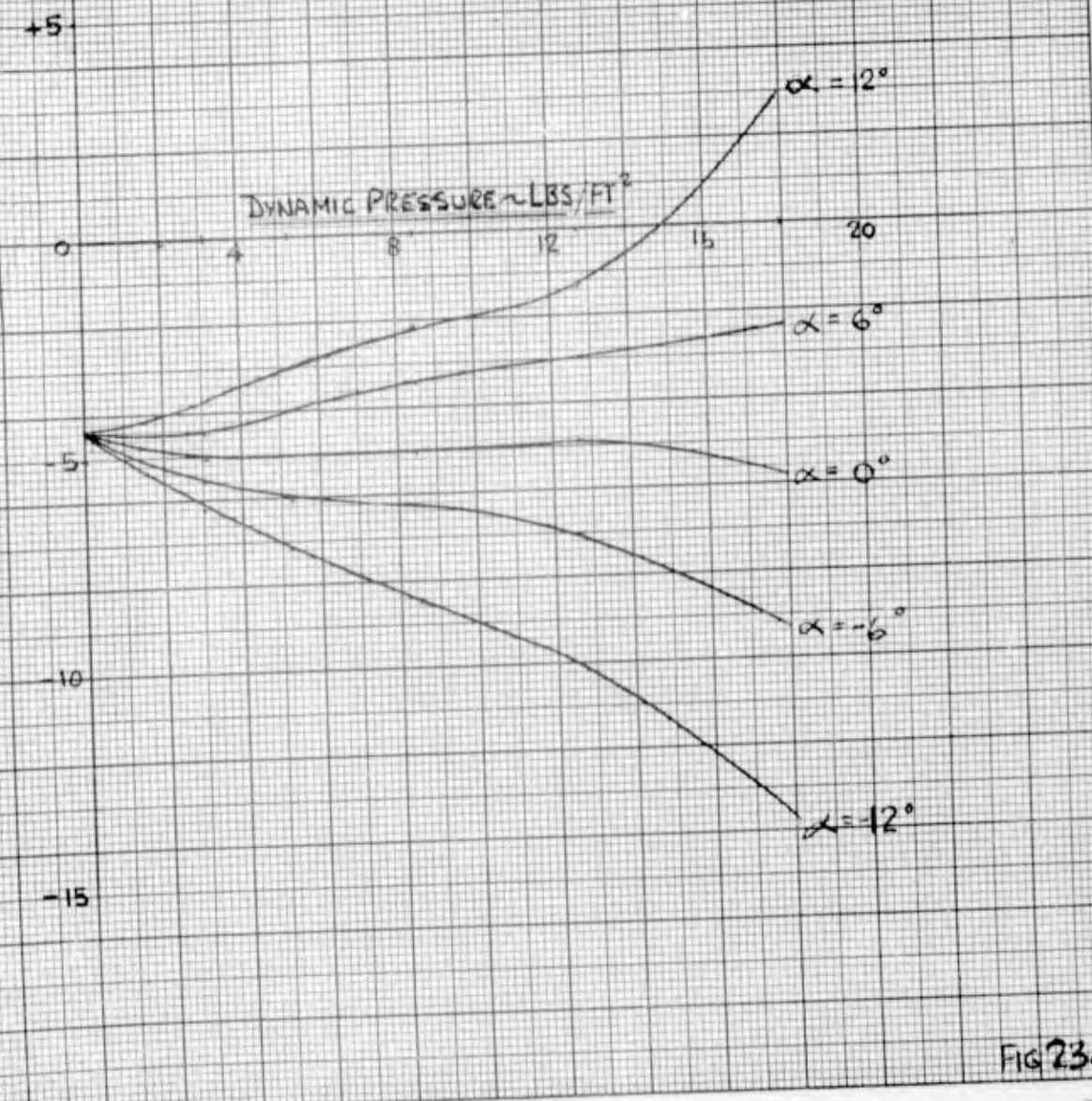


FIG 234

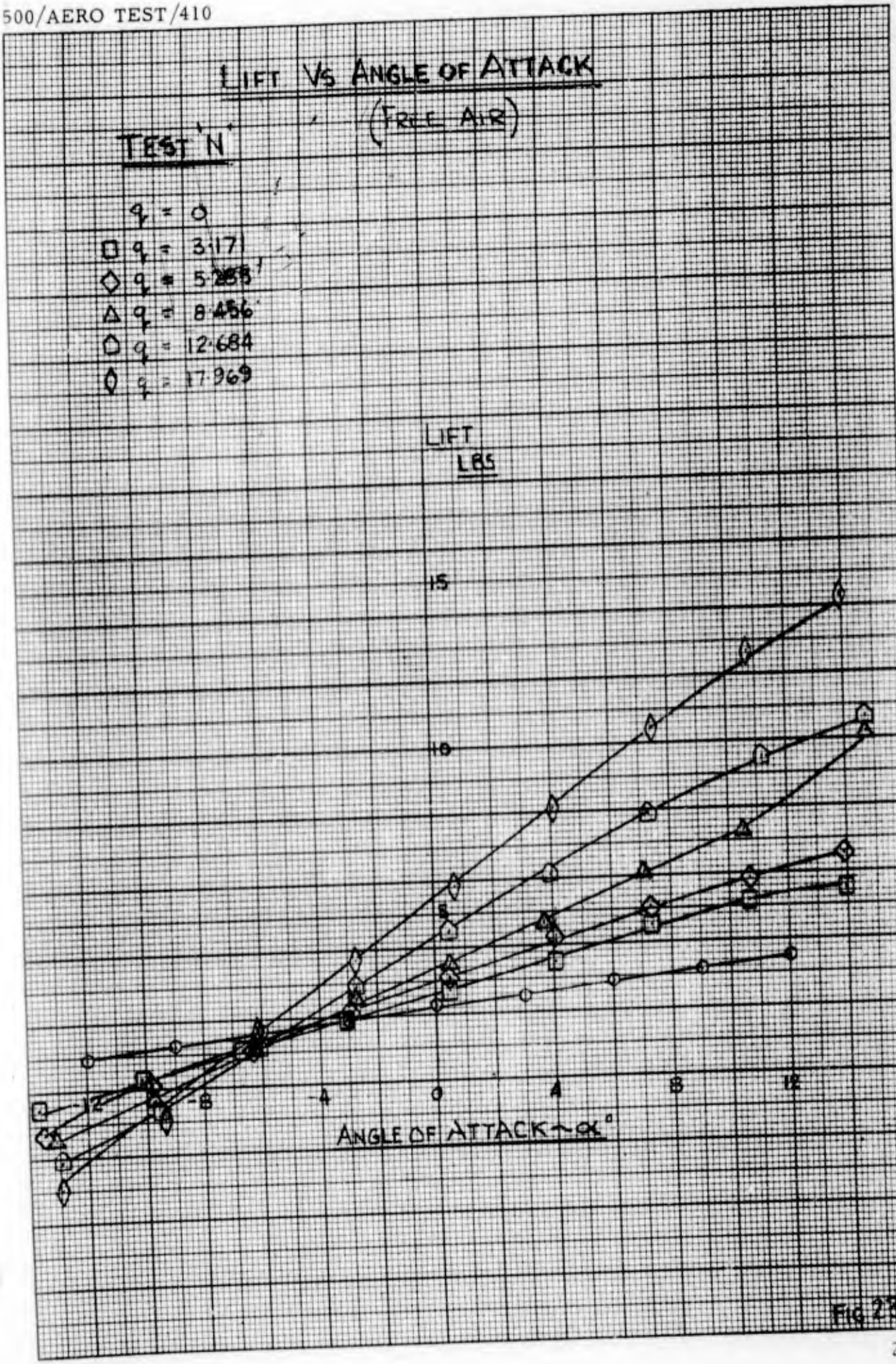
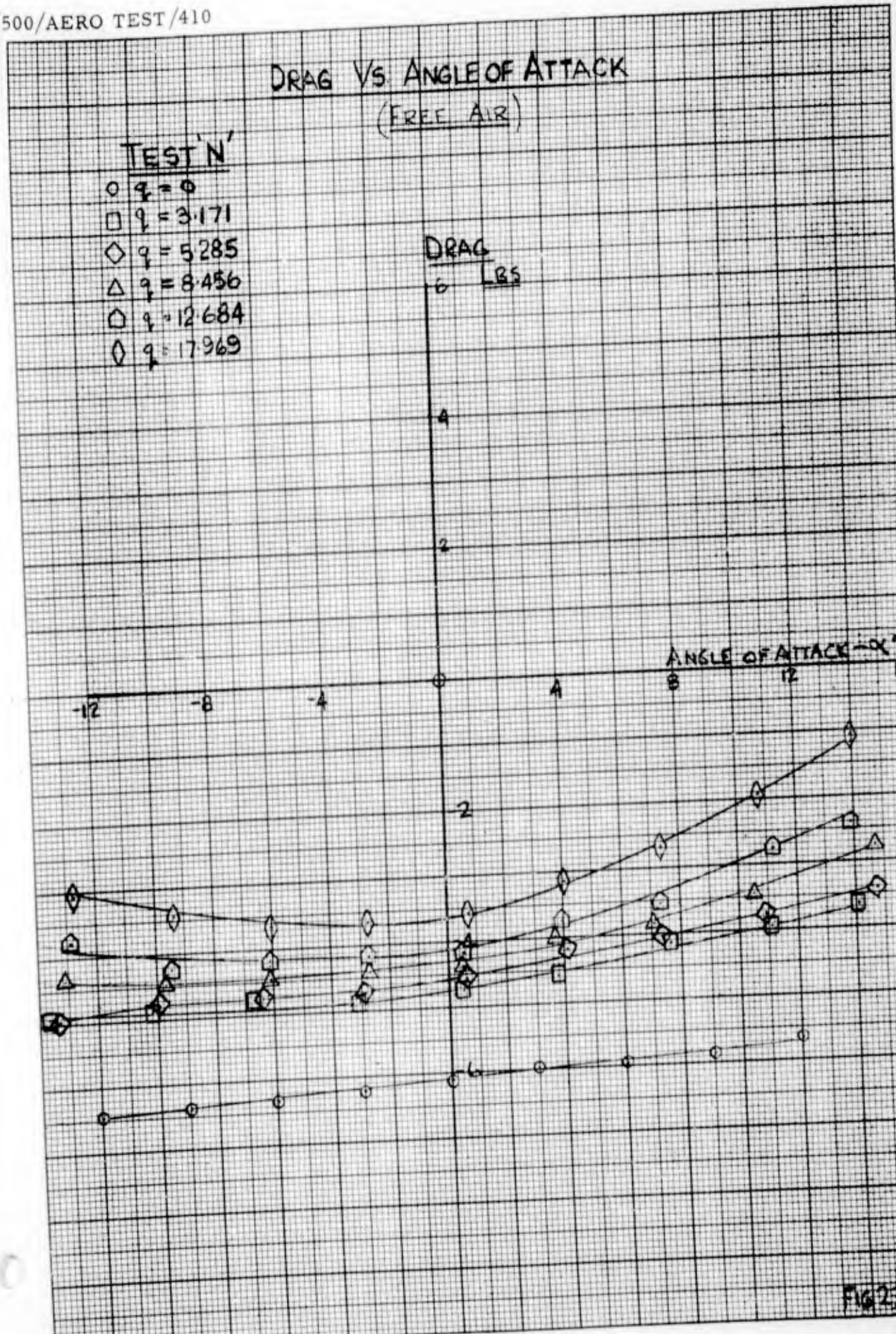

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'N'
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
LIFT
LBS
15
10
5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG 285


DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'N'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
DRAG
LBS
6
4
2
ANGLE OF ATTACK = α°
-12
-8
-4
4
8
12
16
-2
-6
FIG 23b

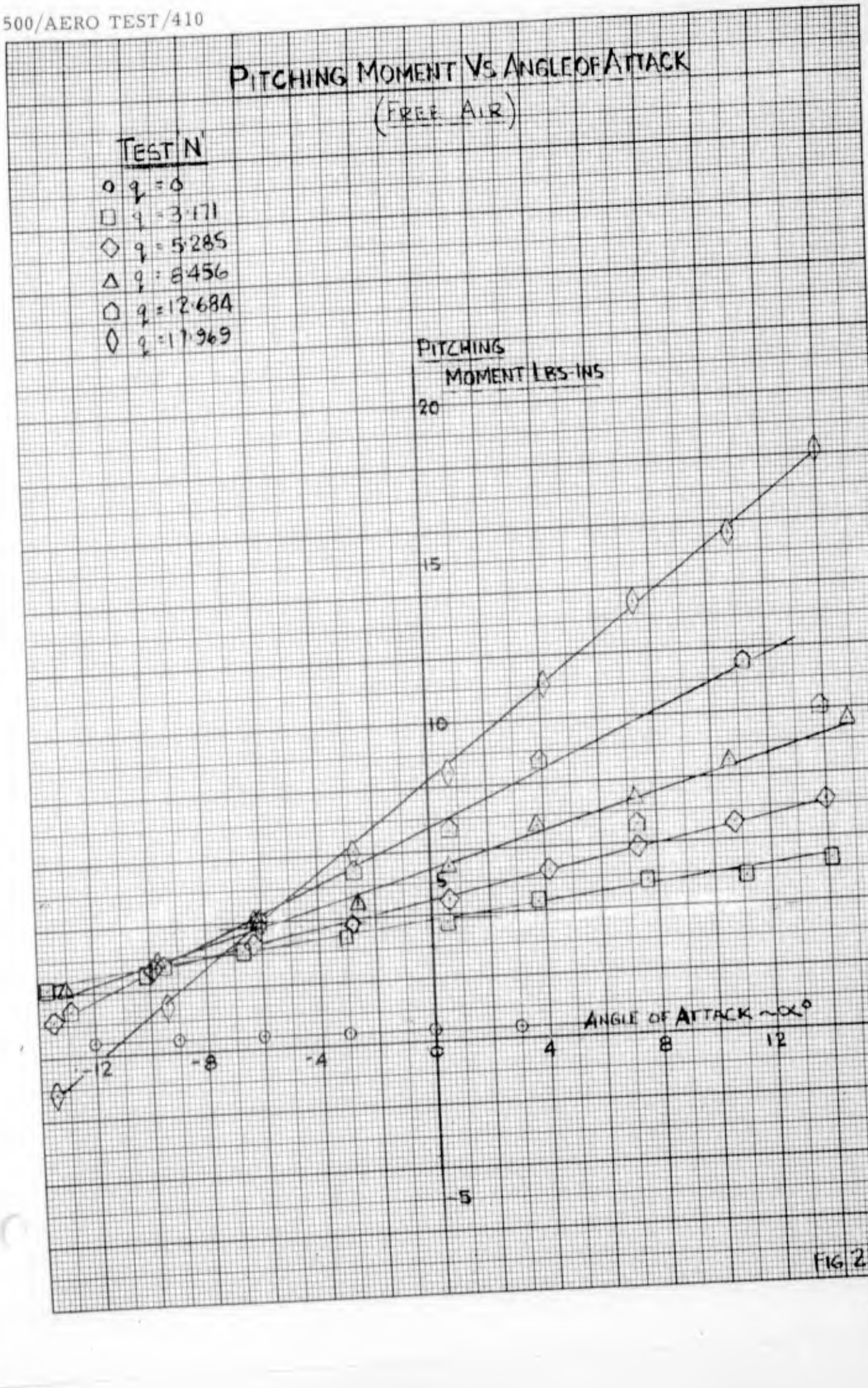

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST N
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
PITCHING MOMENT LBS-INS
20
15
10
5
-5
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~α°

FIG 23

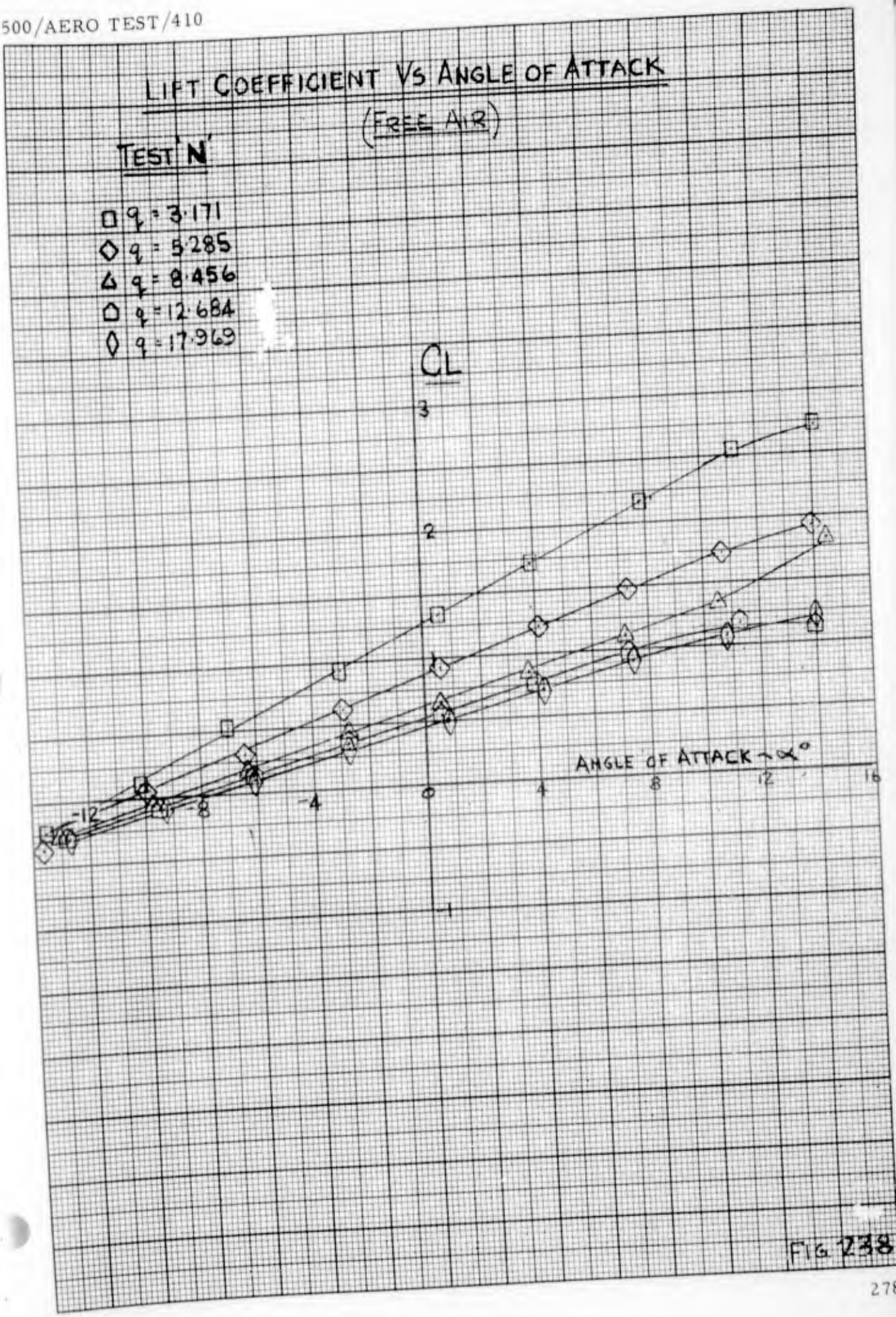

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'N'
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
CL
3
2
1
ANGLE OF ATTACK → α°
-12
-8
-4
0
4
8
12
16

FIG. 238

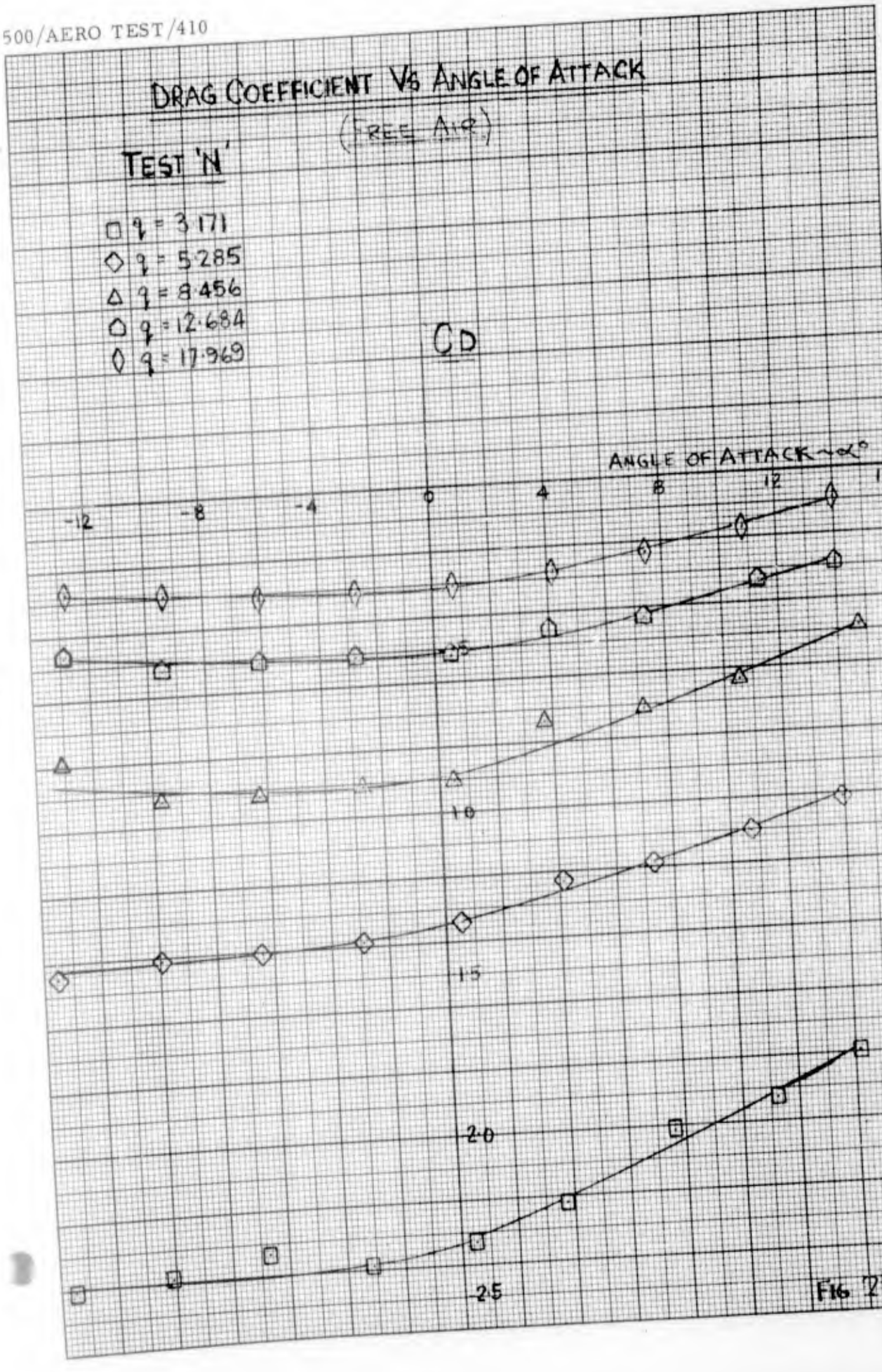

DRAG COEFFICIENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'N'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CD
ANGLE OF ATTACK → α°
-12
-8
-4
0
4
8
12
16
1.0
1.5
2.0
2.5

Fig 239

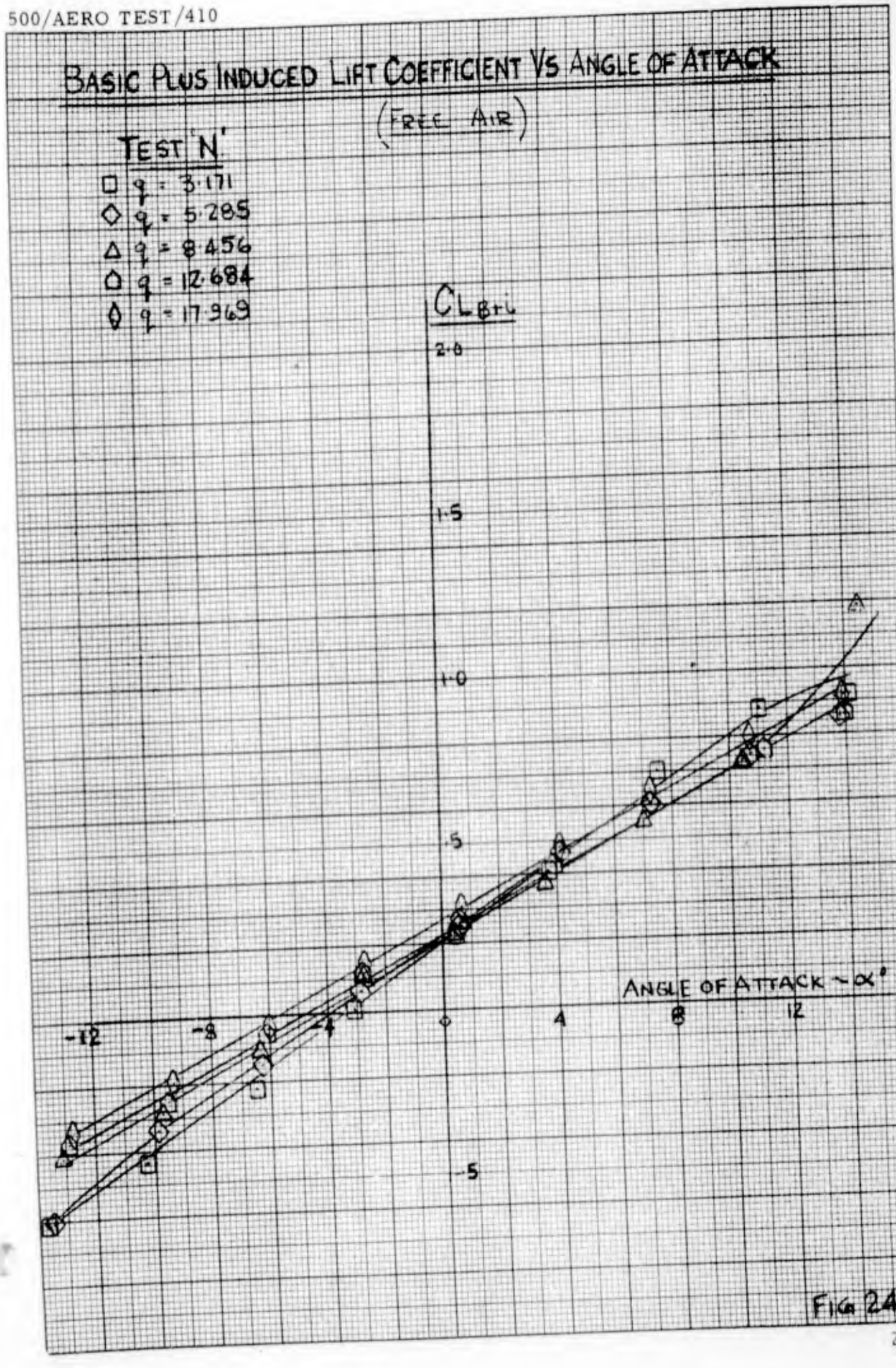

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'N'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CL Bri
2.0
1.5
1.0
.5
-5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 240

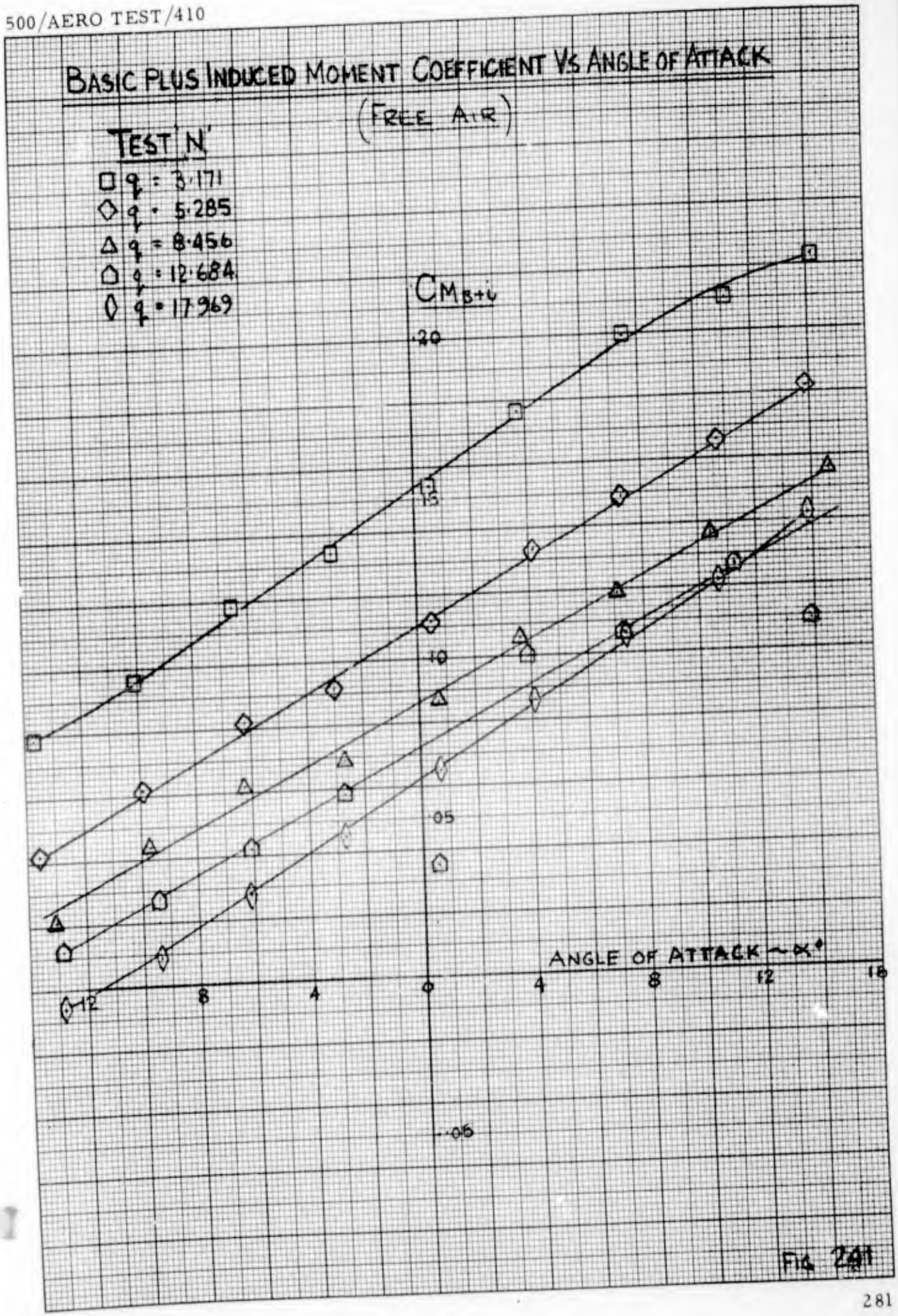

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST N'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CM B+i
·20
15
10
05
·05
ANGLE OF ATTACK ~ α°
12
8
4
0
4
8
12
16

FIG 241

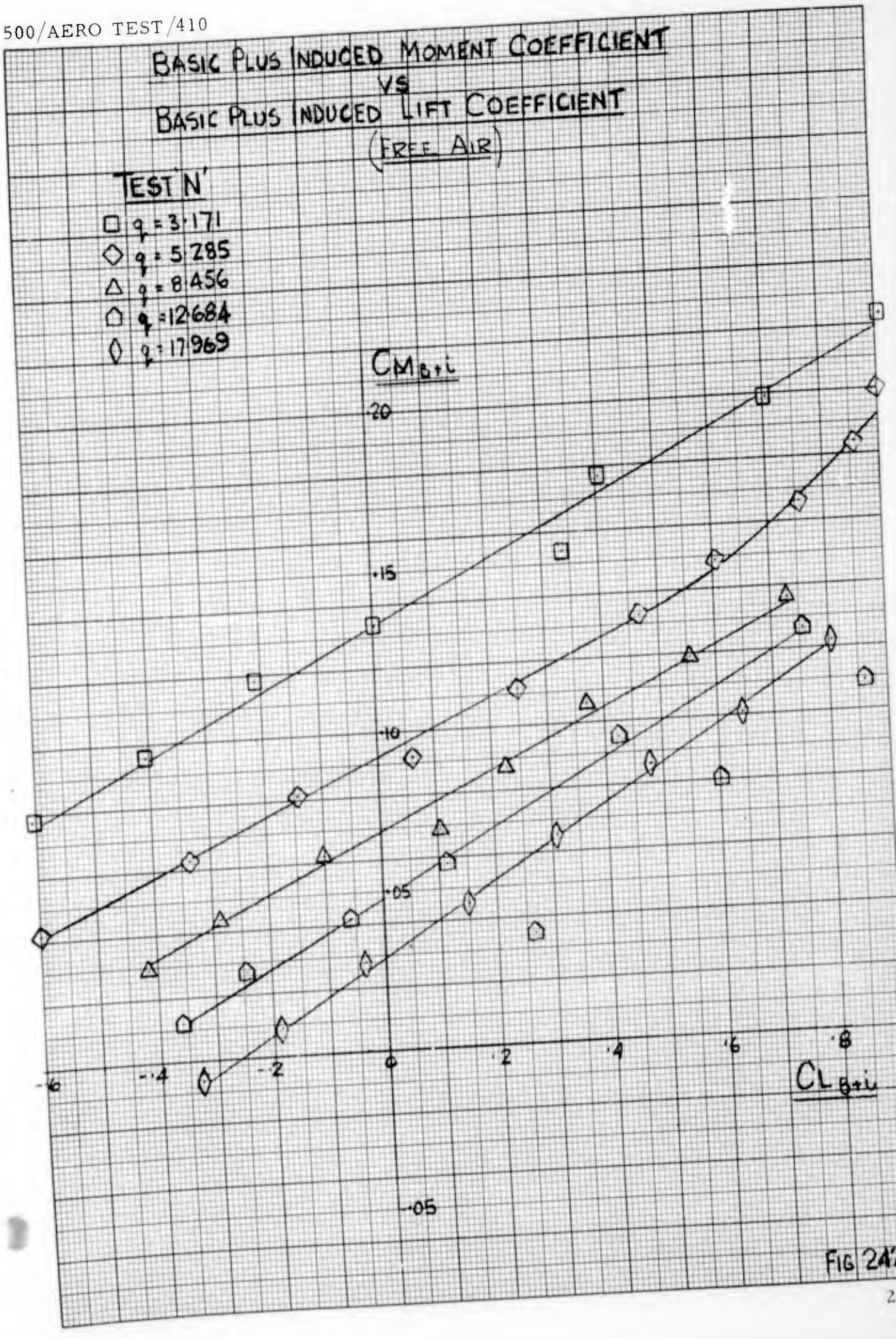

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST N'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CM B+i
.20
.15
.10
.05
-.05
-.6
-.4
-.2
0
.2
.4
.6
.8
CL B+i

FIG 24

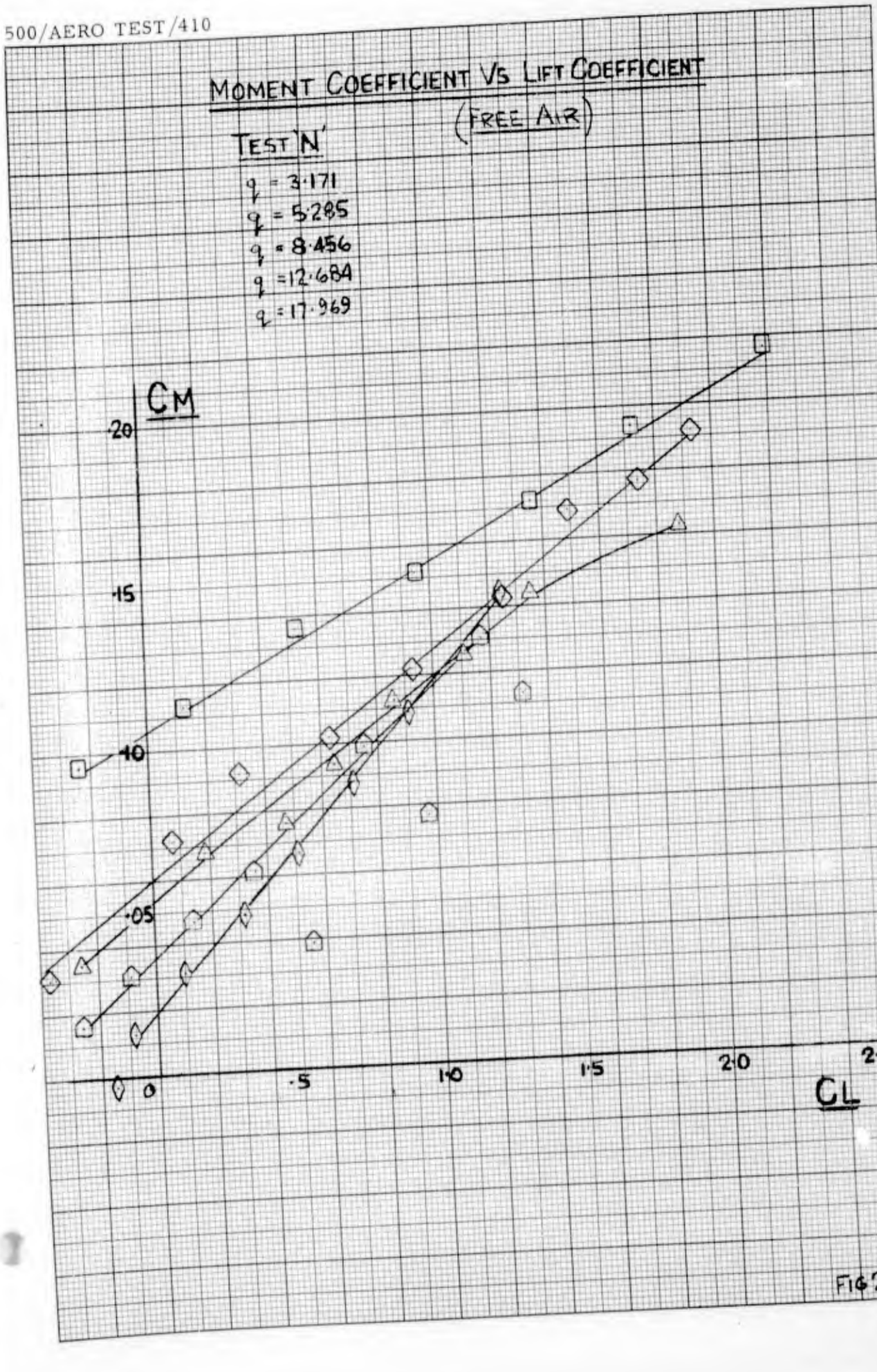

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'N'
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
CM
·20
·15
·10
·05
0
·5
1·0
1·5
2·0
2·5
CL

Fig 243

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED.
(FREE AIR)

TEST 'N'

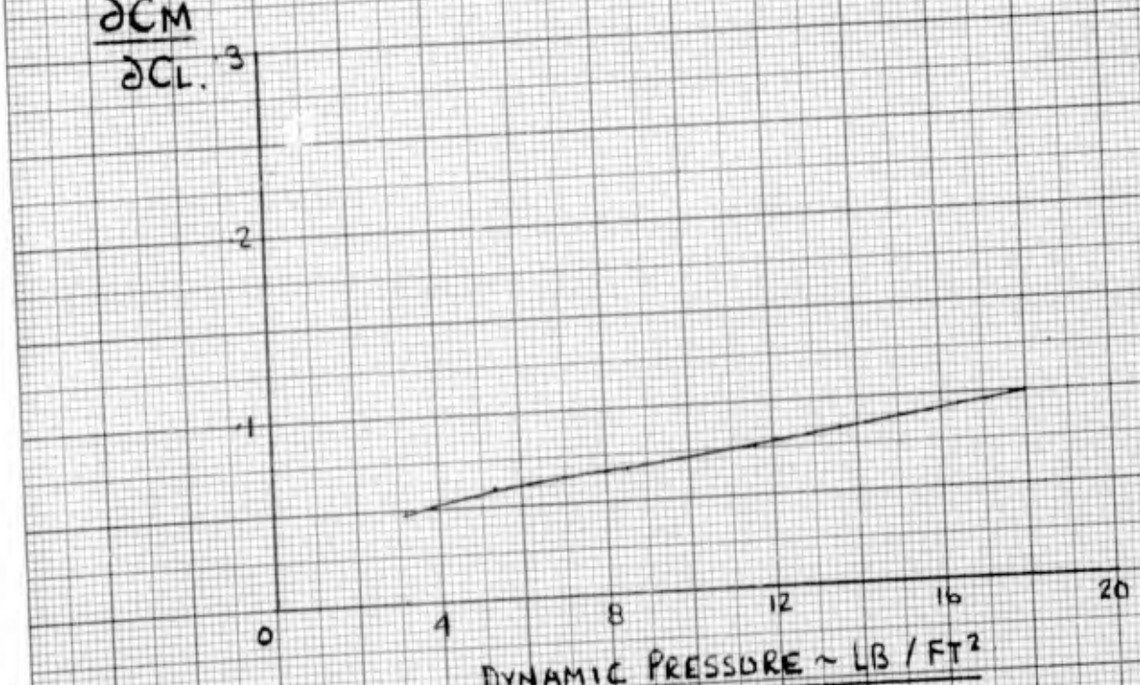


FIG 24

LIFT CURVE SLOPE VS FORWARD SPEED

TEST 'N' (FREE AIR)

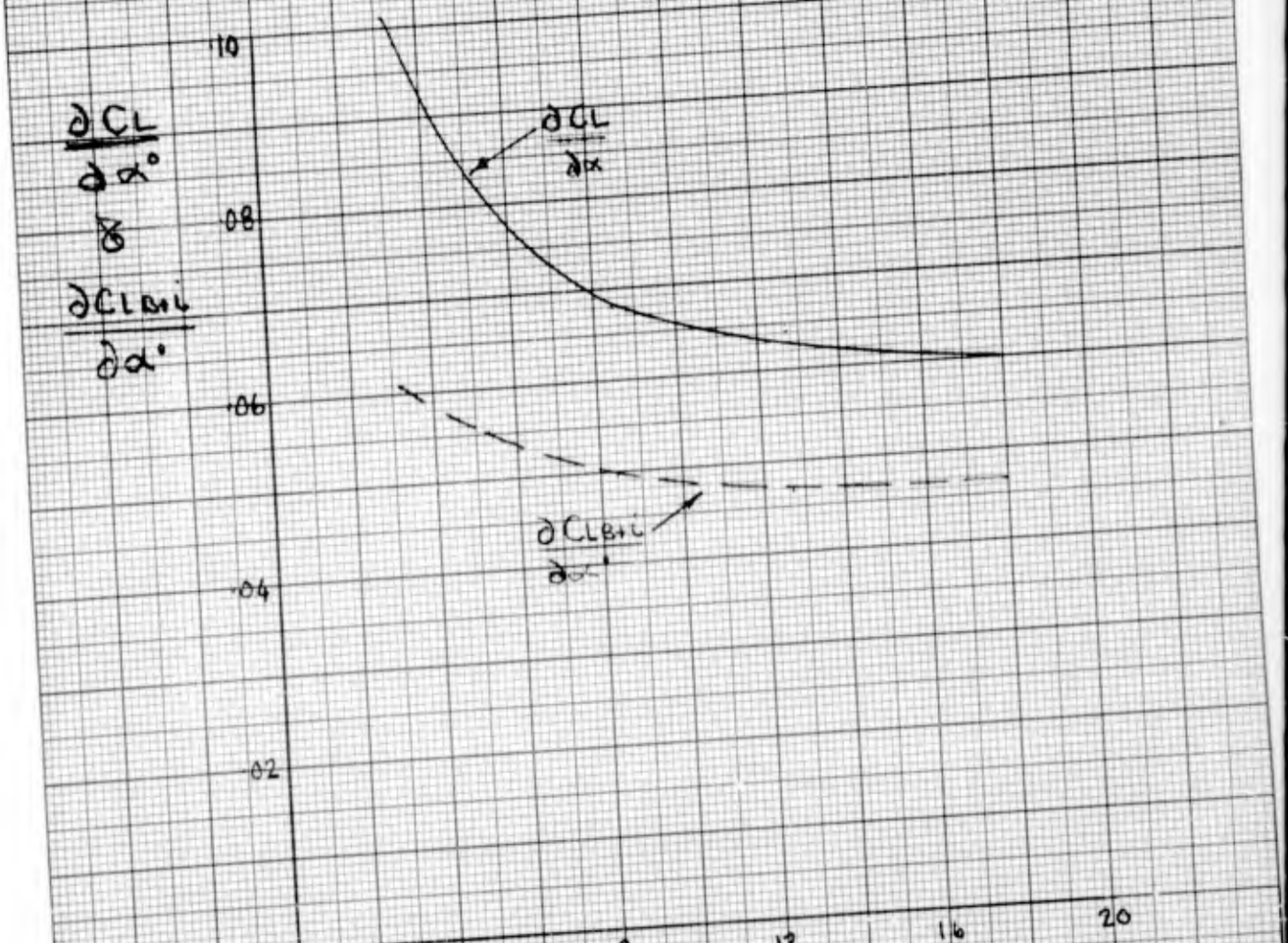


FIG 24

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST 'N' (FREE AIR)

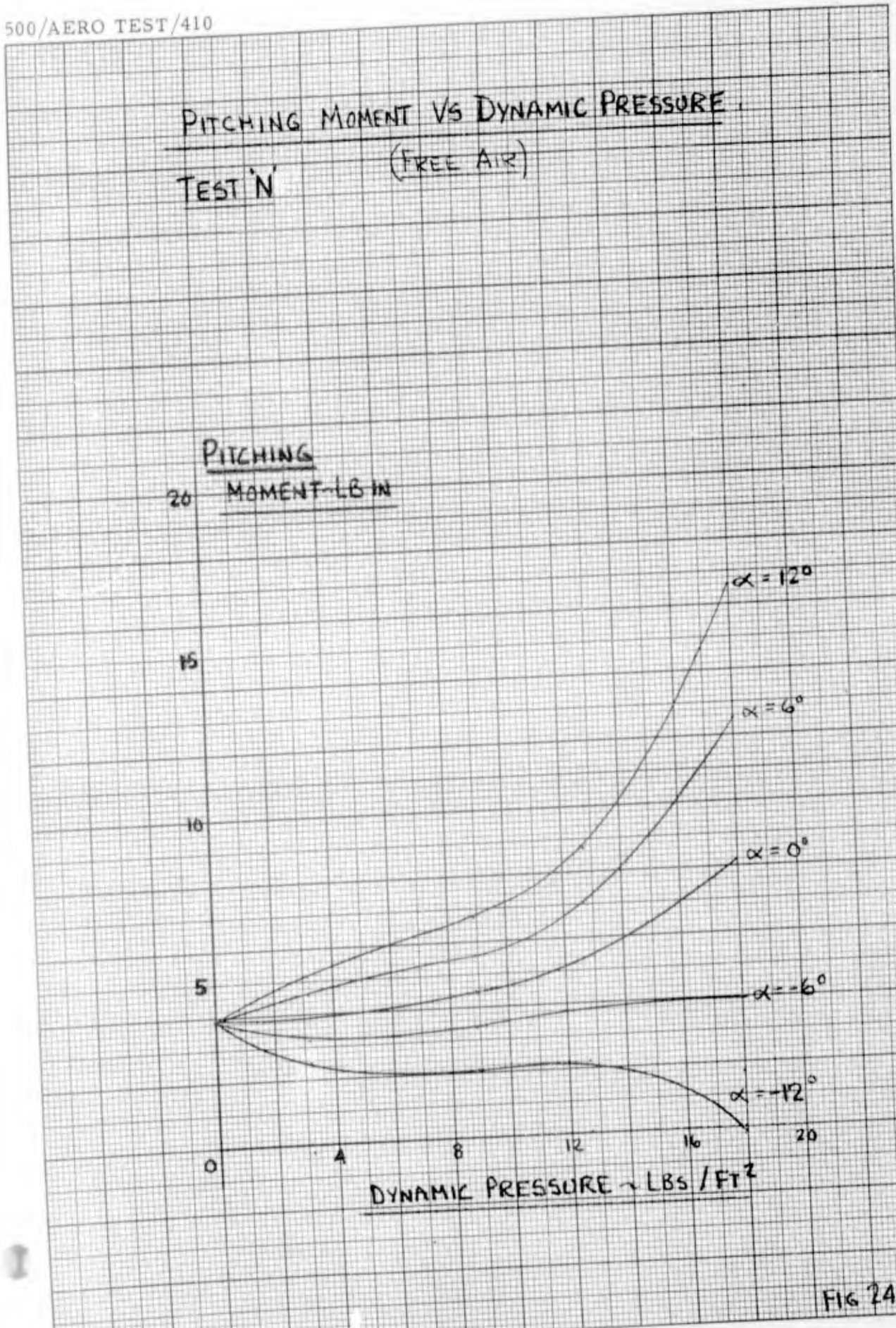


FIG 246

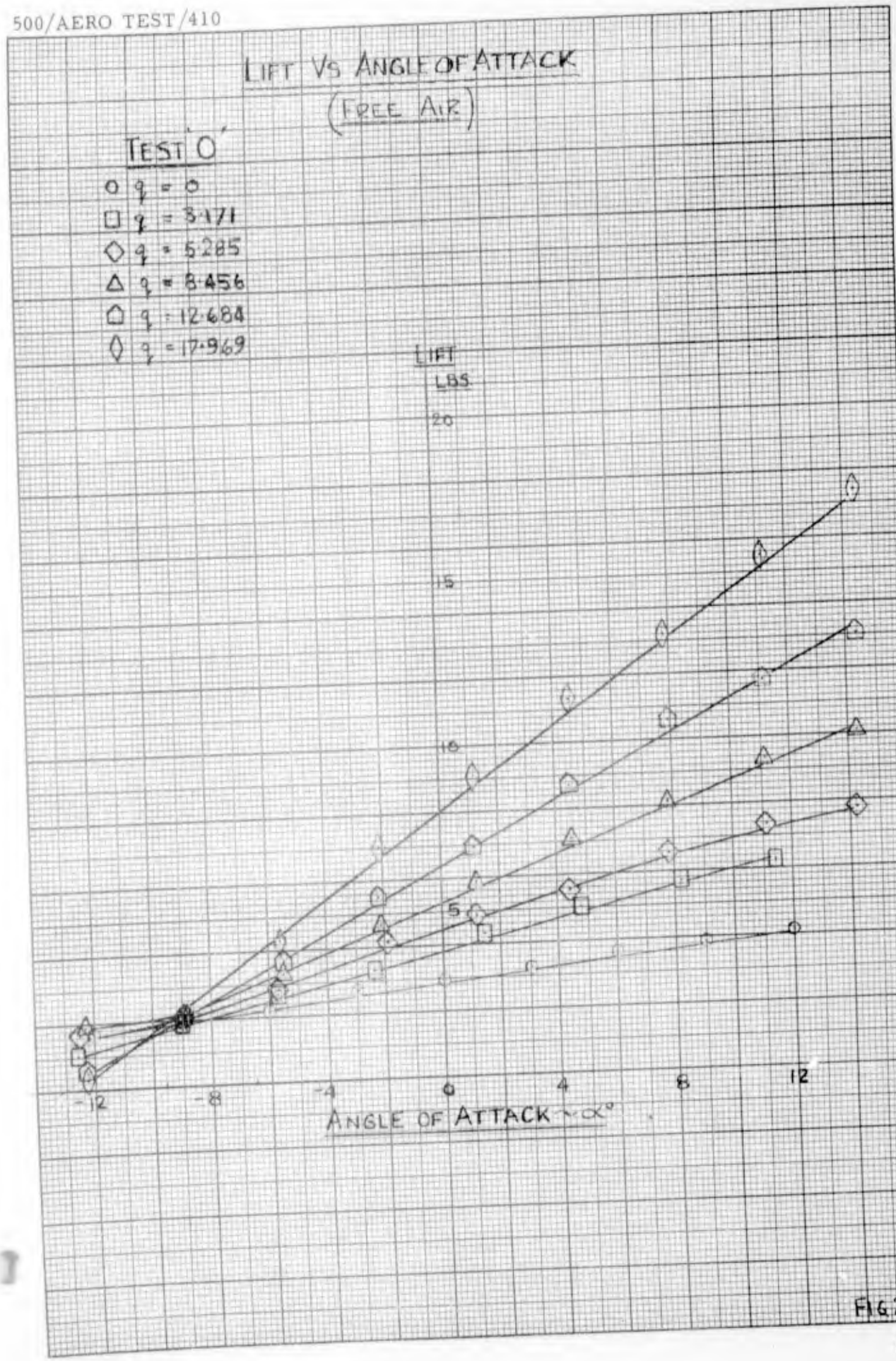

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 0'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
LIFT
LBS
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 247

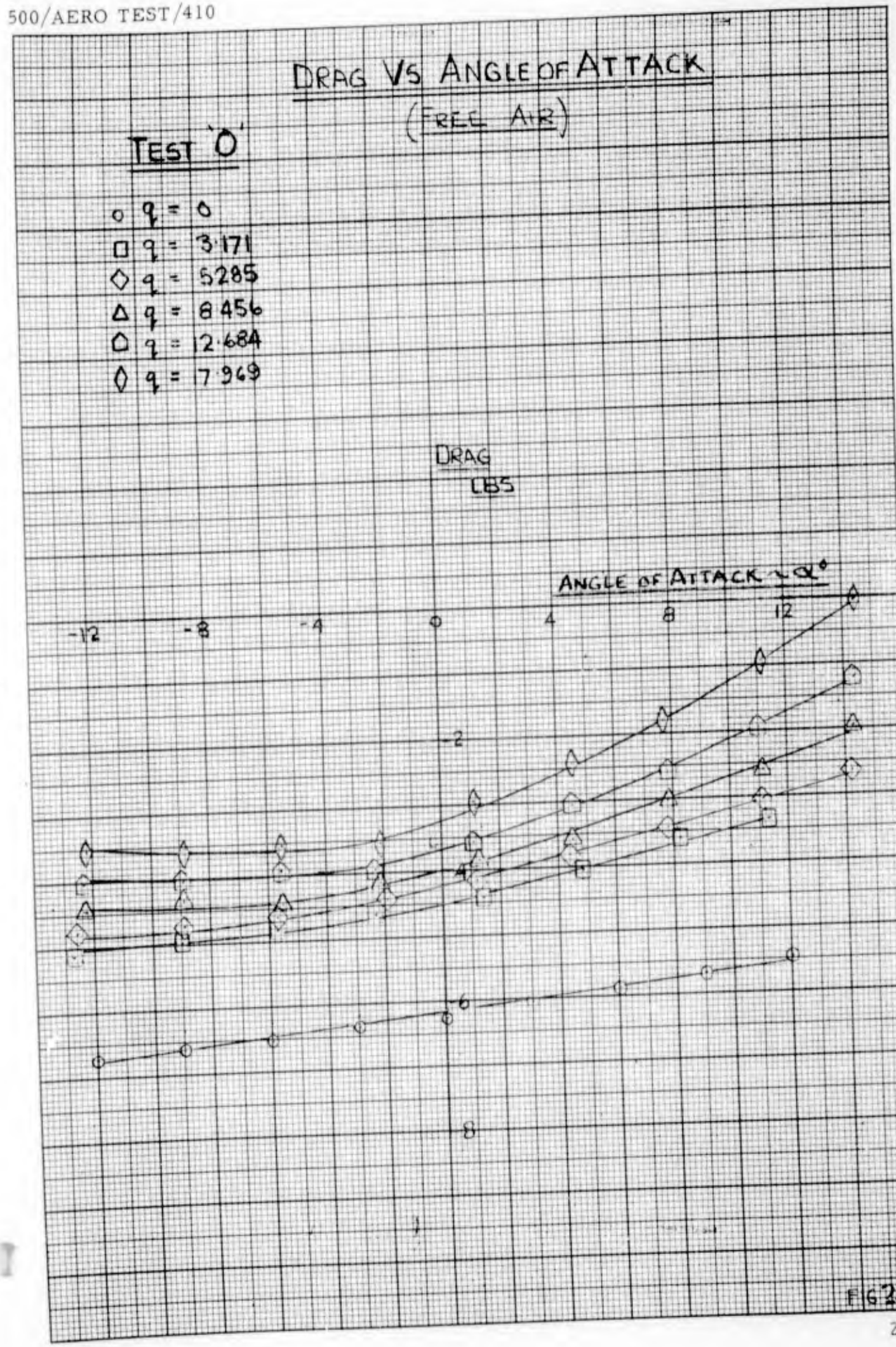

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'O'
o q = 0
□ q = 3.171
◇ q = 5285
△ q = 8456
⬠ q = 12.684
◊ q = 7.969
DRAG
LBS
ANGLE OF ATTACK = α°
-12
-8
-4
0
4
8
12
-2
4
6
8

FIG 24B

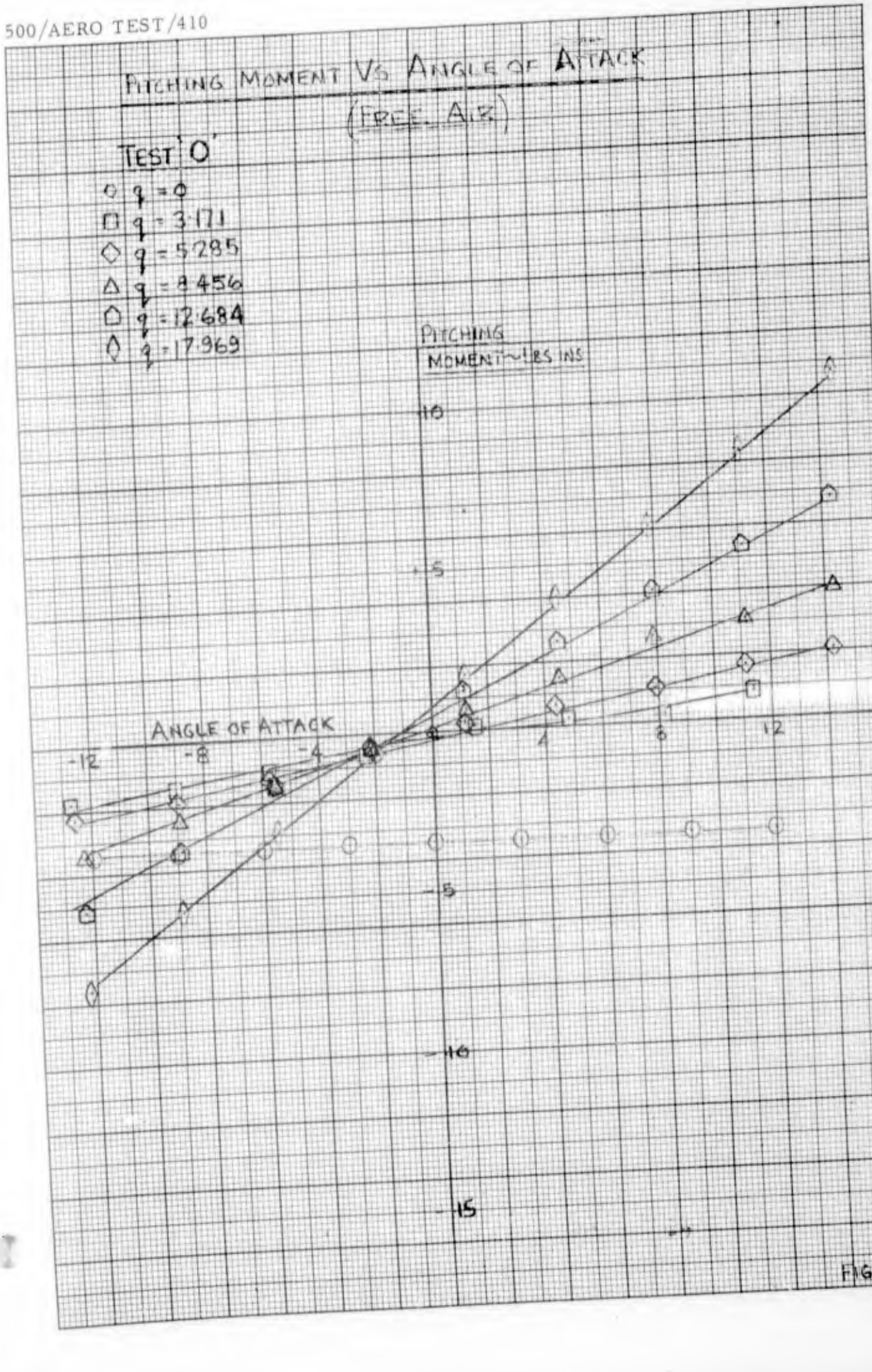

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'O'
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
⬡ q = 17·969
PITCHING MOMENT-LBS INS
ANGLE OF ATTACK
-12
-8
-4
4
8
12
16
10
5
-5
-10
-15

FIG 24

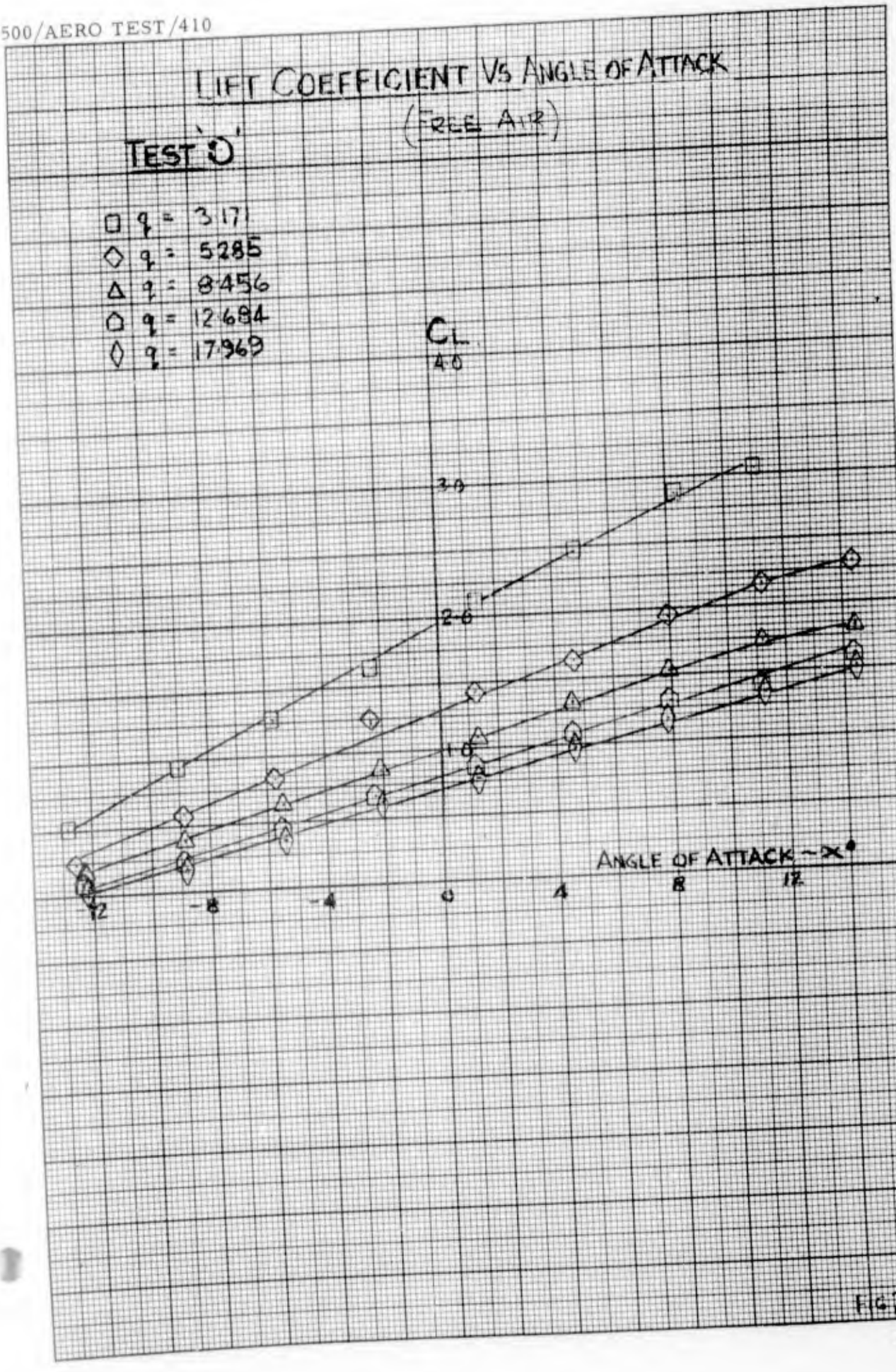

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'O'
□ q = 3171
◇ q = 5285
△ q = 8456
⬠ q = 12684
◊ q = 17969
C_L
4.0
3.0
2.0
1.0
ANGLE OF ATTACK - α°
-12
-8
-4
0
4
8
12
16

FIG 250

DRAG COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

TEST 'O'

□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969

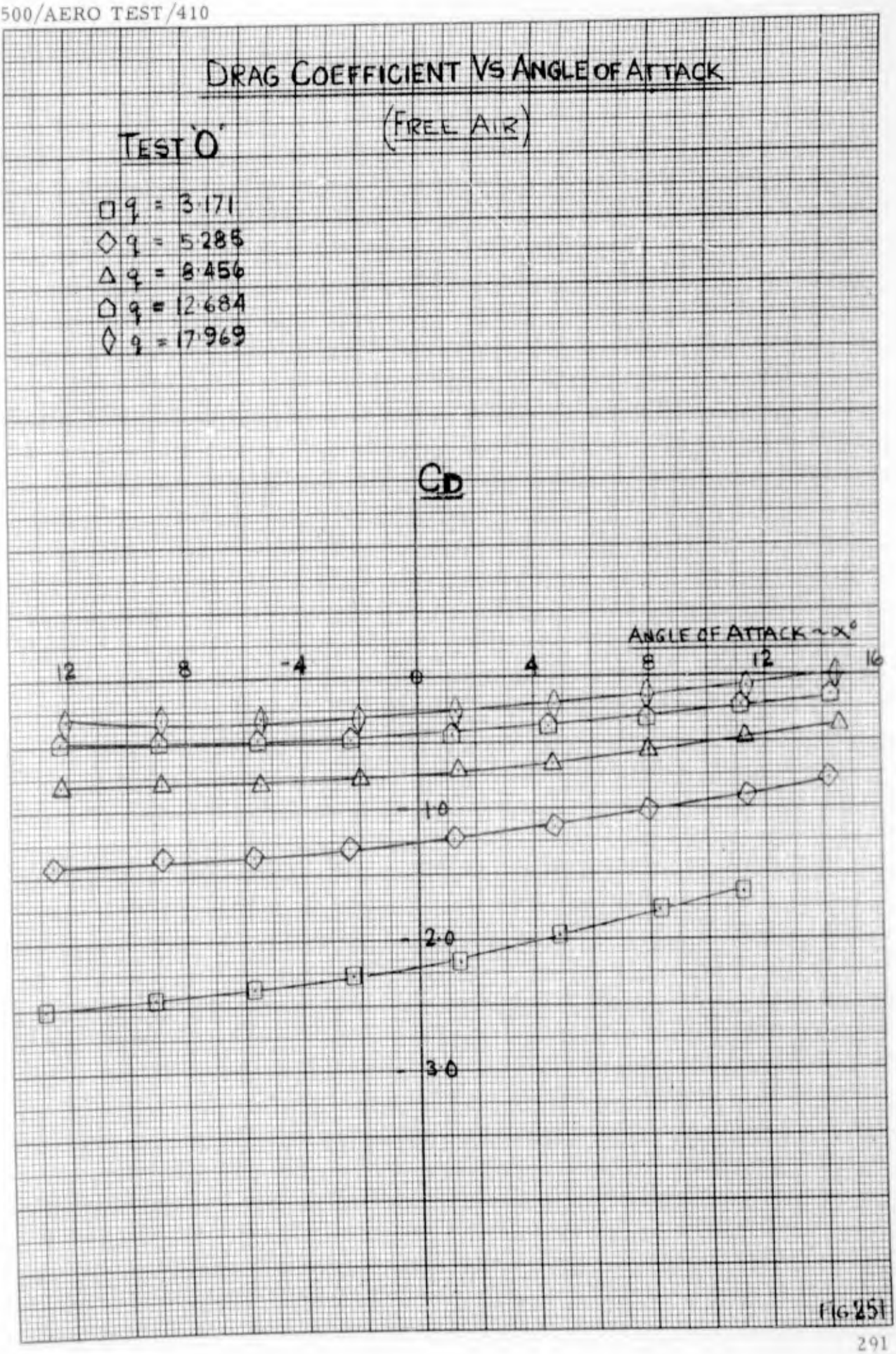


FIG 251

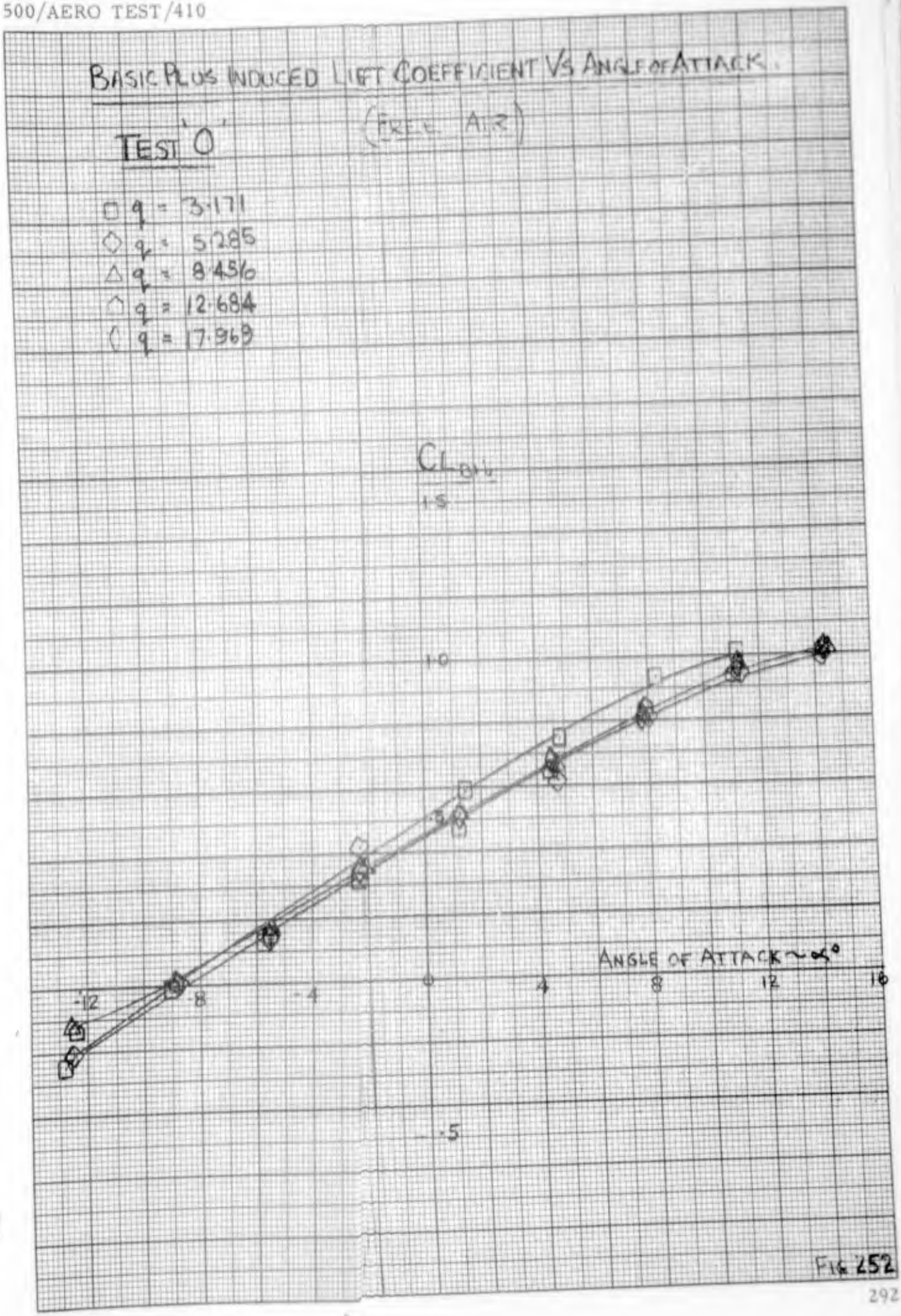

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK.
TEST 'O'
(FREE AIR)
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⌒ q = 12.684
(q = 17.969
$C_{L_{BW}}$
1.5
1.0
.5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 252

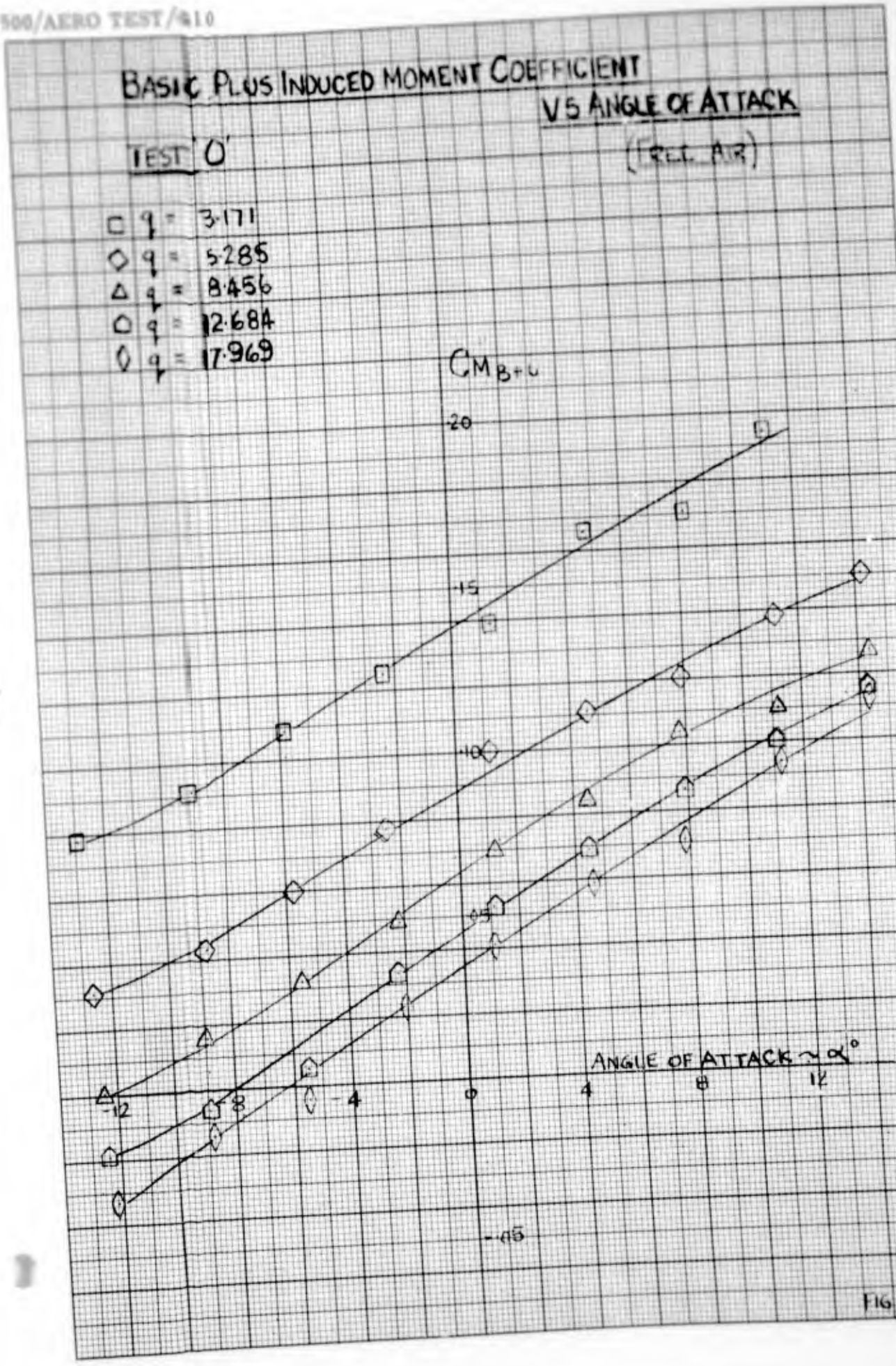

BASIC PLUS INDUCED MOMENT COEFFICIENT
V5 ANGLE OF ATTACK
TEST 'O'
(REF. AIR)
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
$C_{M_{B+U}}$
·20
·15
·10
·05
-·05
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12

FIG 25

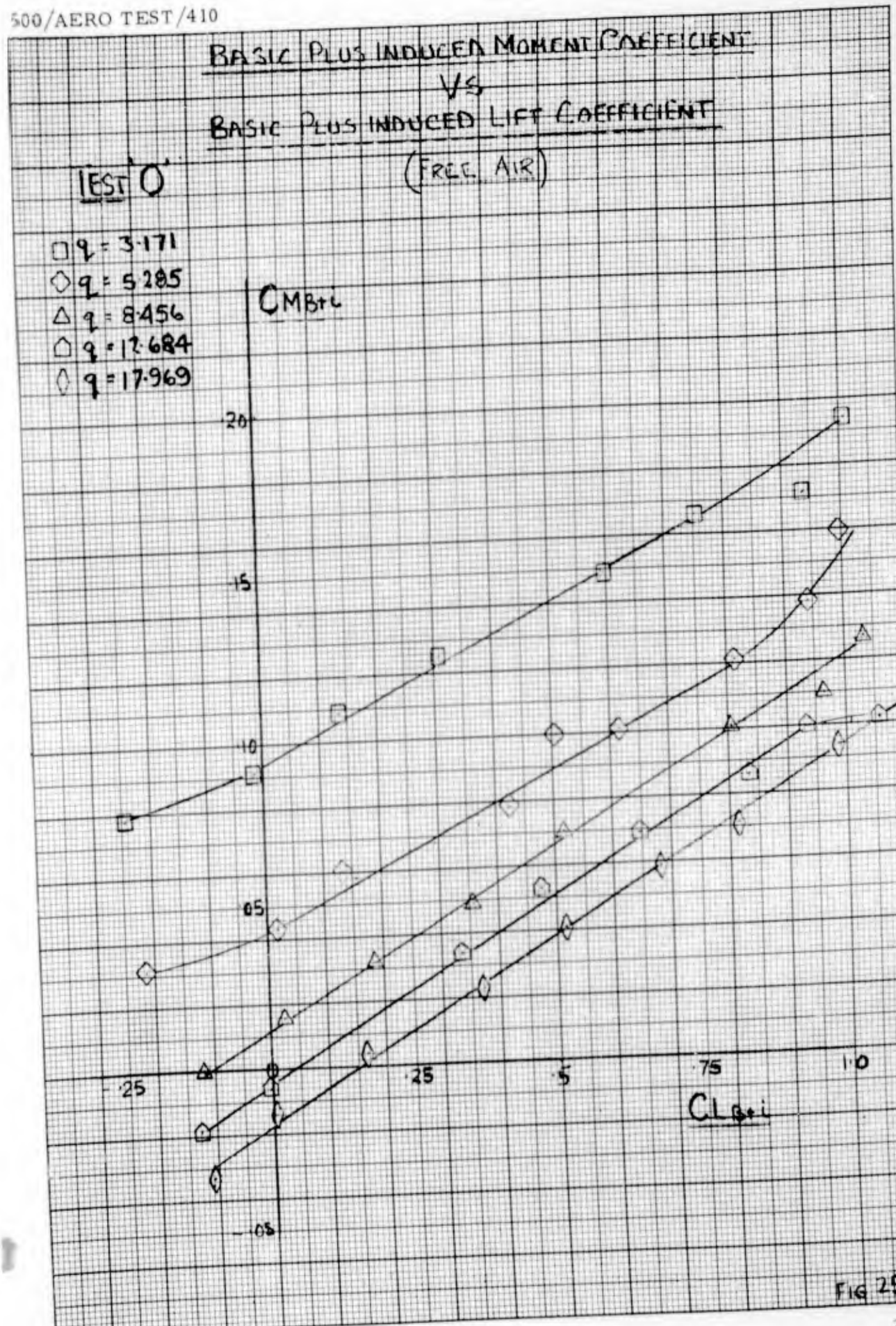

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'O'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CMB+i
20
15
10
05
-.08
-.25
0
.25
.5
.75
1.0
CLB+i

FIG 254

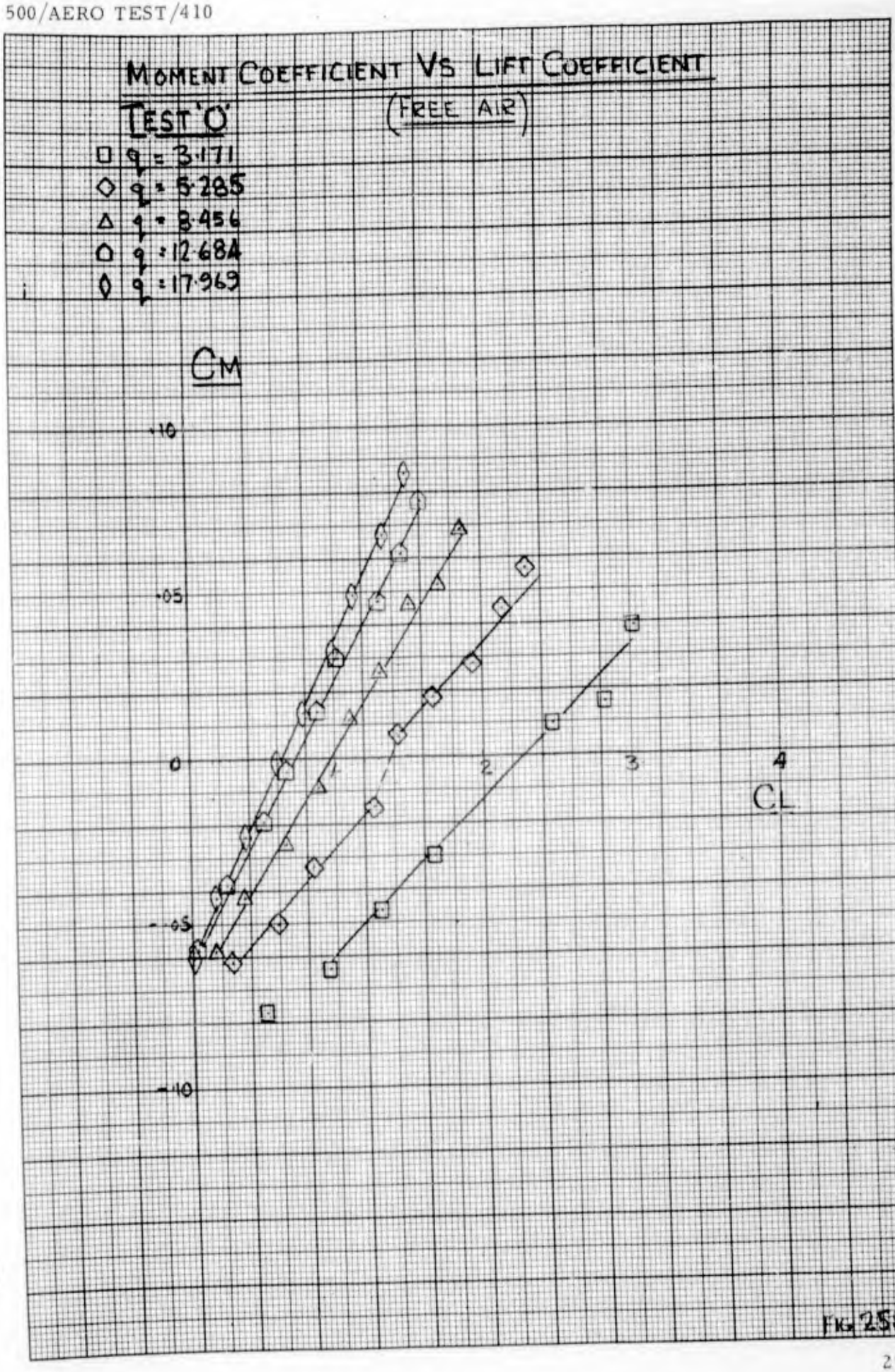

MOMENT COEFFICIENT VS LIFT COEFFICIENT
TEST 'O'
(FREE AIR)
□ q = 3.171
◇ q = 5.285
△ q = 8.456
○ q = 12.684
◊ q = 17.969
CM
.10
.05
0
-.05
-.10
1
2
3
4
CL

FIG 256

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 'O'

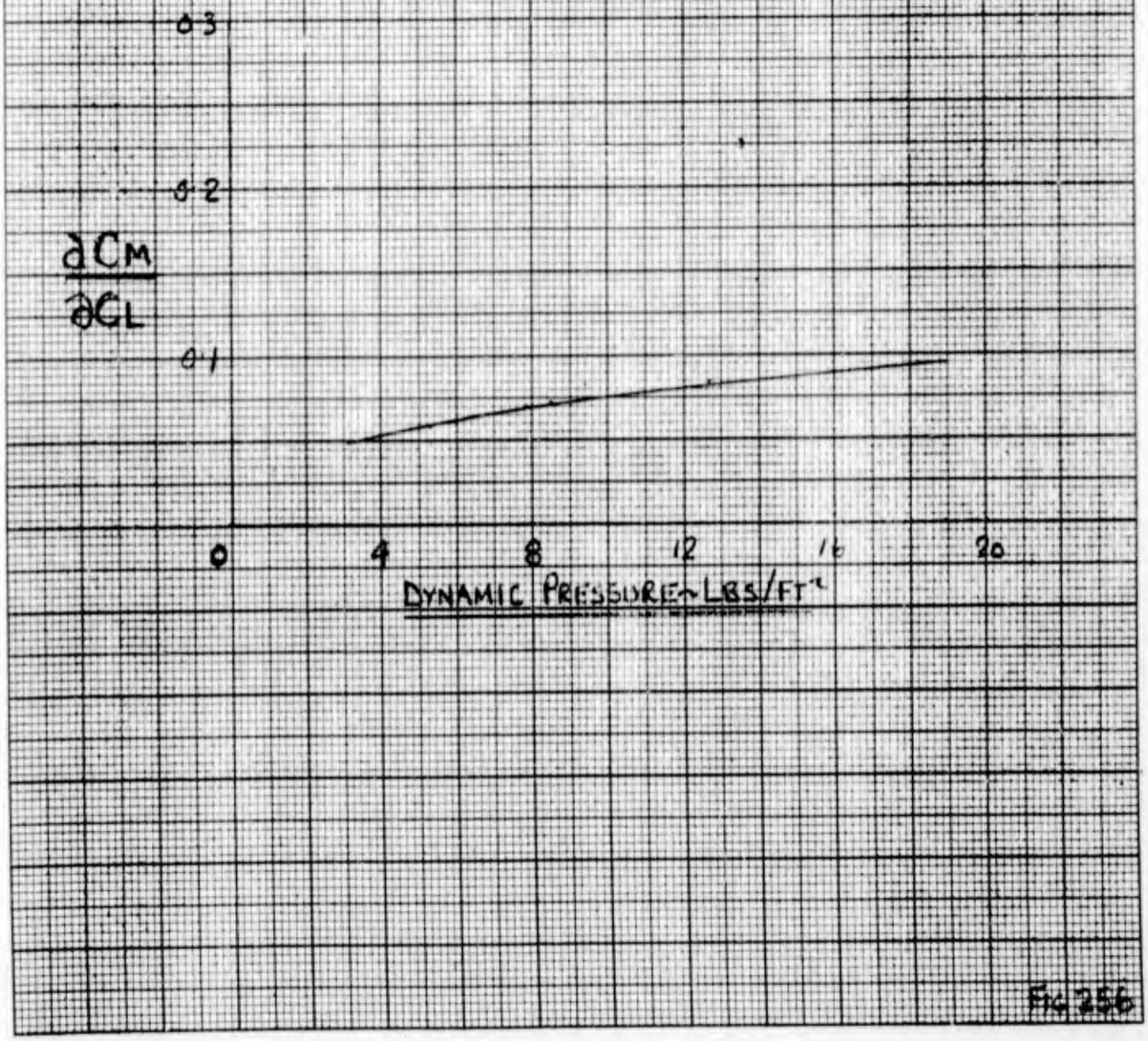


FIG 256

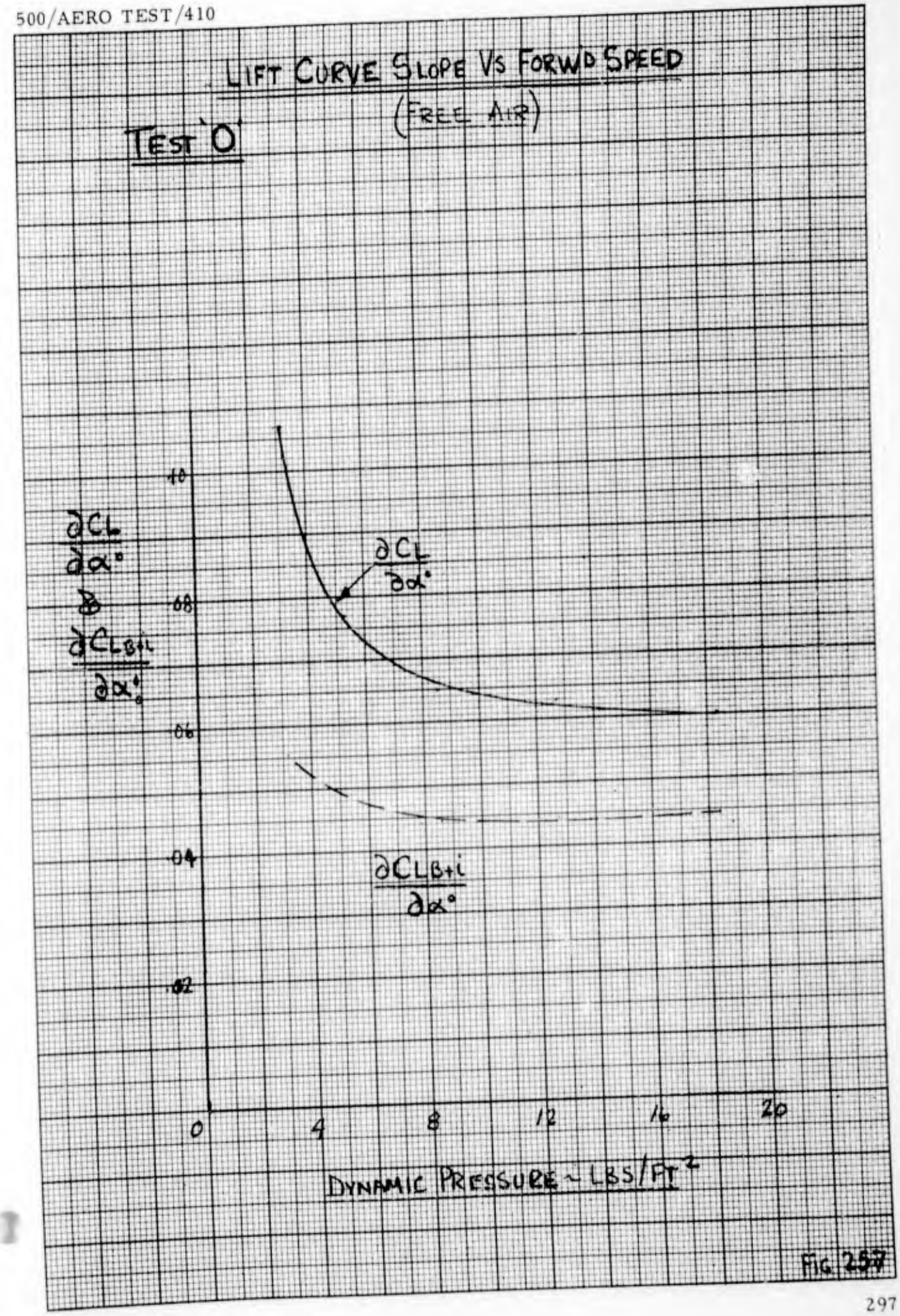

LIFT CURVE SLOPE VS FORWD SPEED
(FREE AIR)
TEST 'O'
$\frac{\partial C_L}{\partial \alpha^\circ}$
&
$\frac{\partial C_{L_{B+i}}}{\partial \alpha^\circ}$
1.0
.8
.6
.4
.2
$\frac{\partial C_L}{\partial \alpha^\circ}$
$\frac{\partial C_{L_{B+i}}}{\partial \alpha^\circ}$
0
4
8
12
16
20
DYNAMIC PRESSURE ~ LBS/FT²

FIG 257

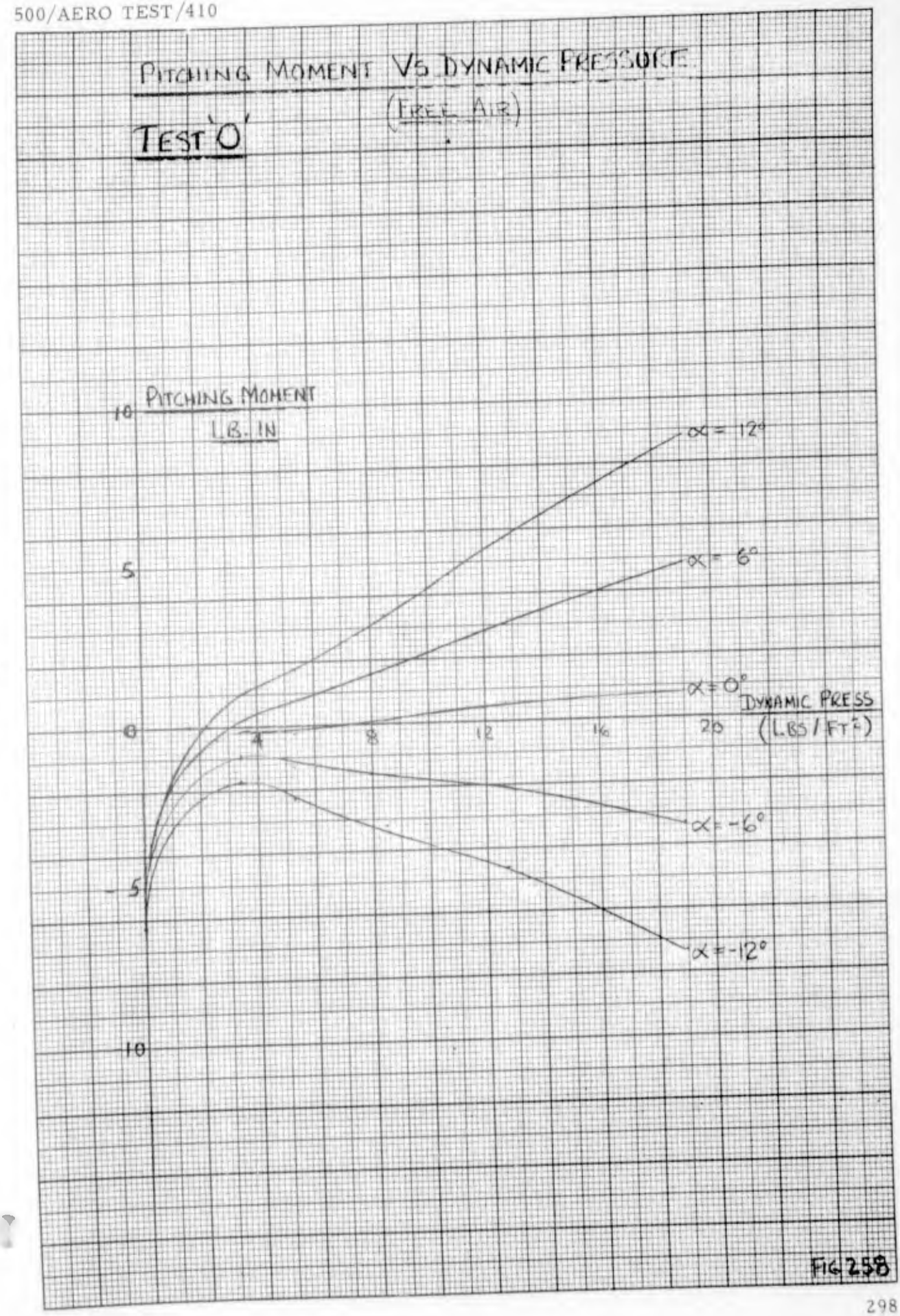

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 'O'
PITCHING MOMENT
LB. IN
10
5
0
5
10
4
8
12
16
20
DYNAMIC PRESS
(LBS / FT²)
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 258

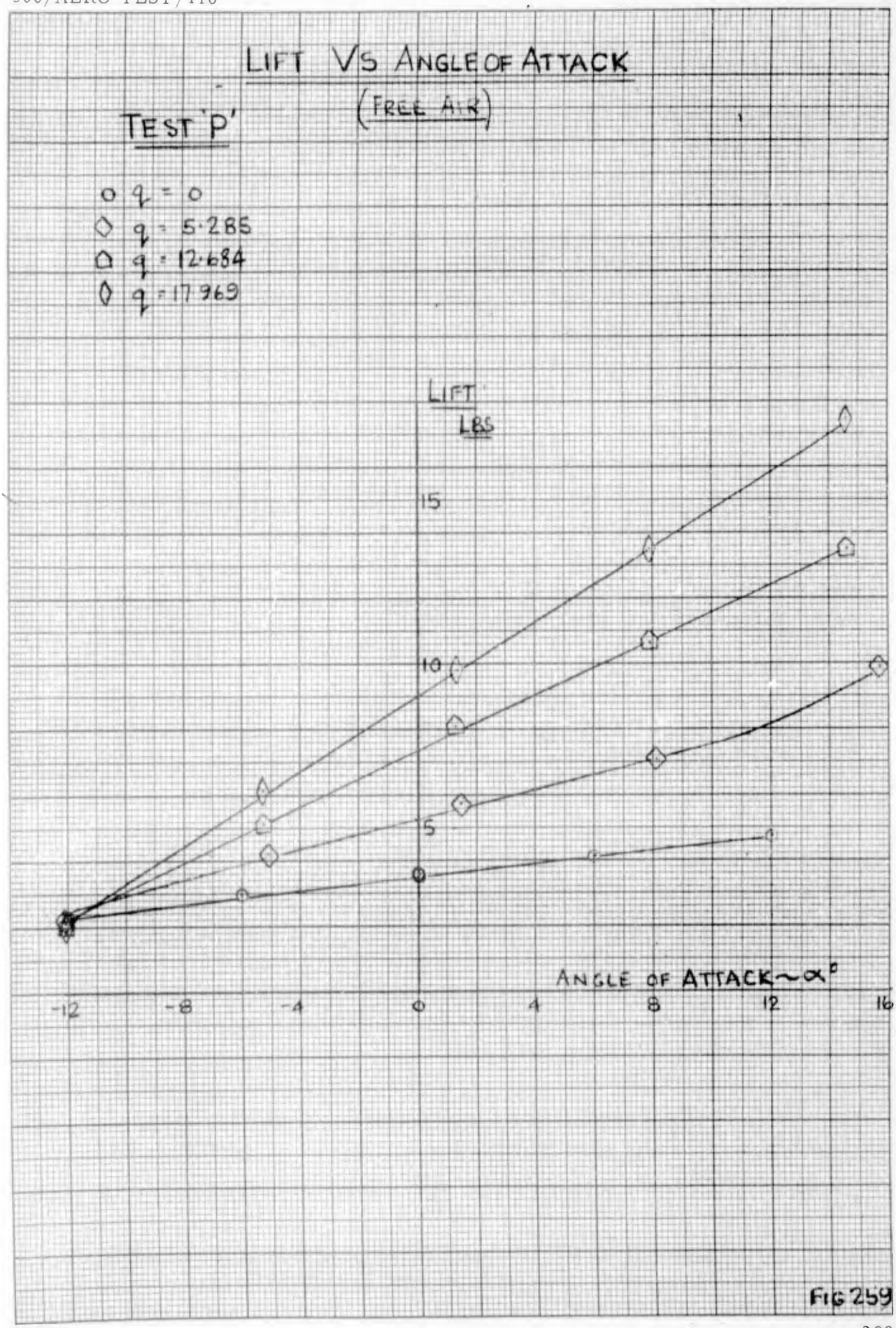

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'P'
o q = 0
◇ q = 5·285
△ q = 12·684
◊ q = 17·969
LIFT
LBS
15
10
5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 259

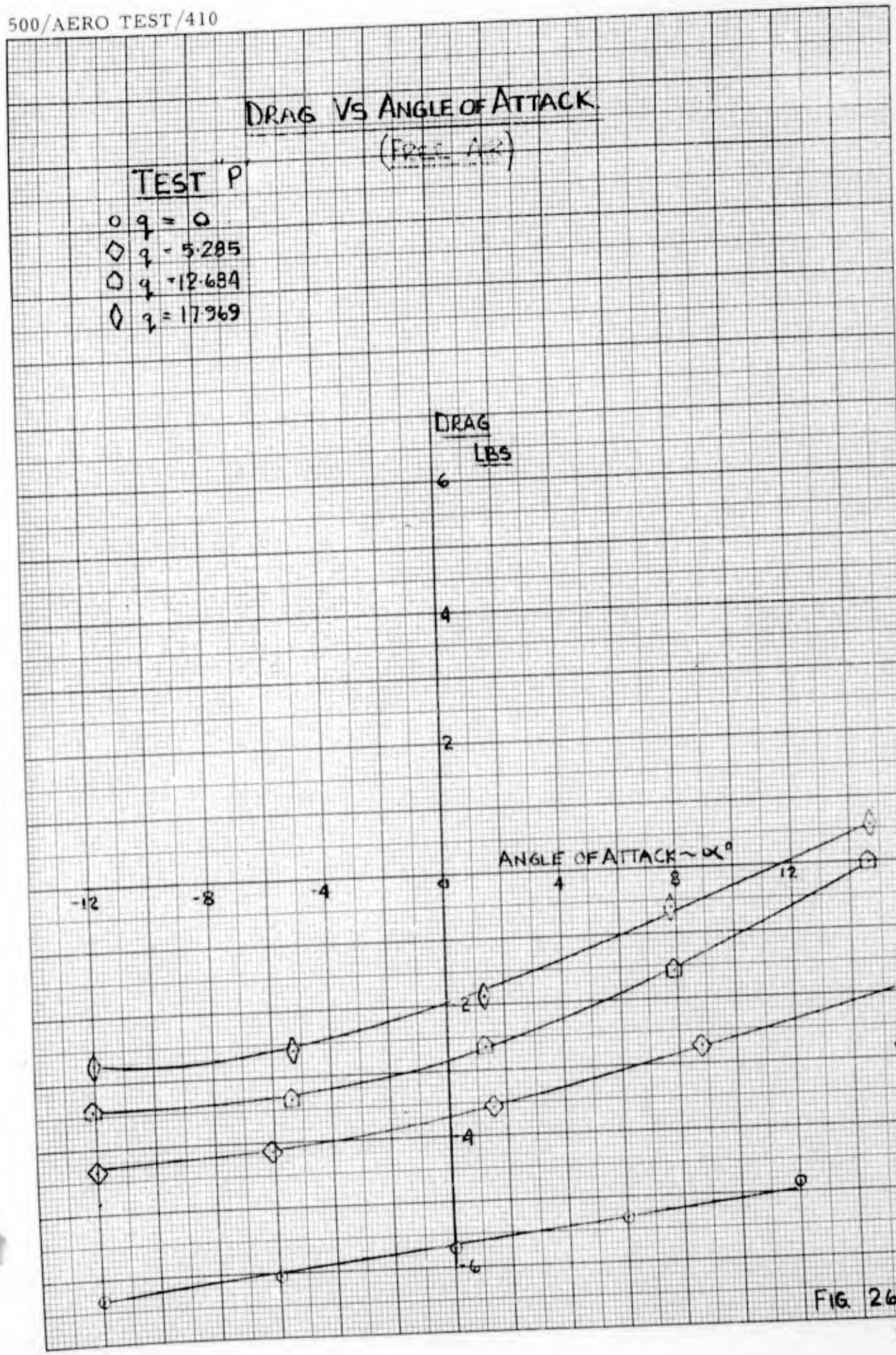
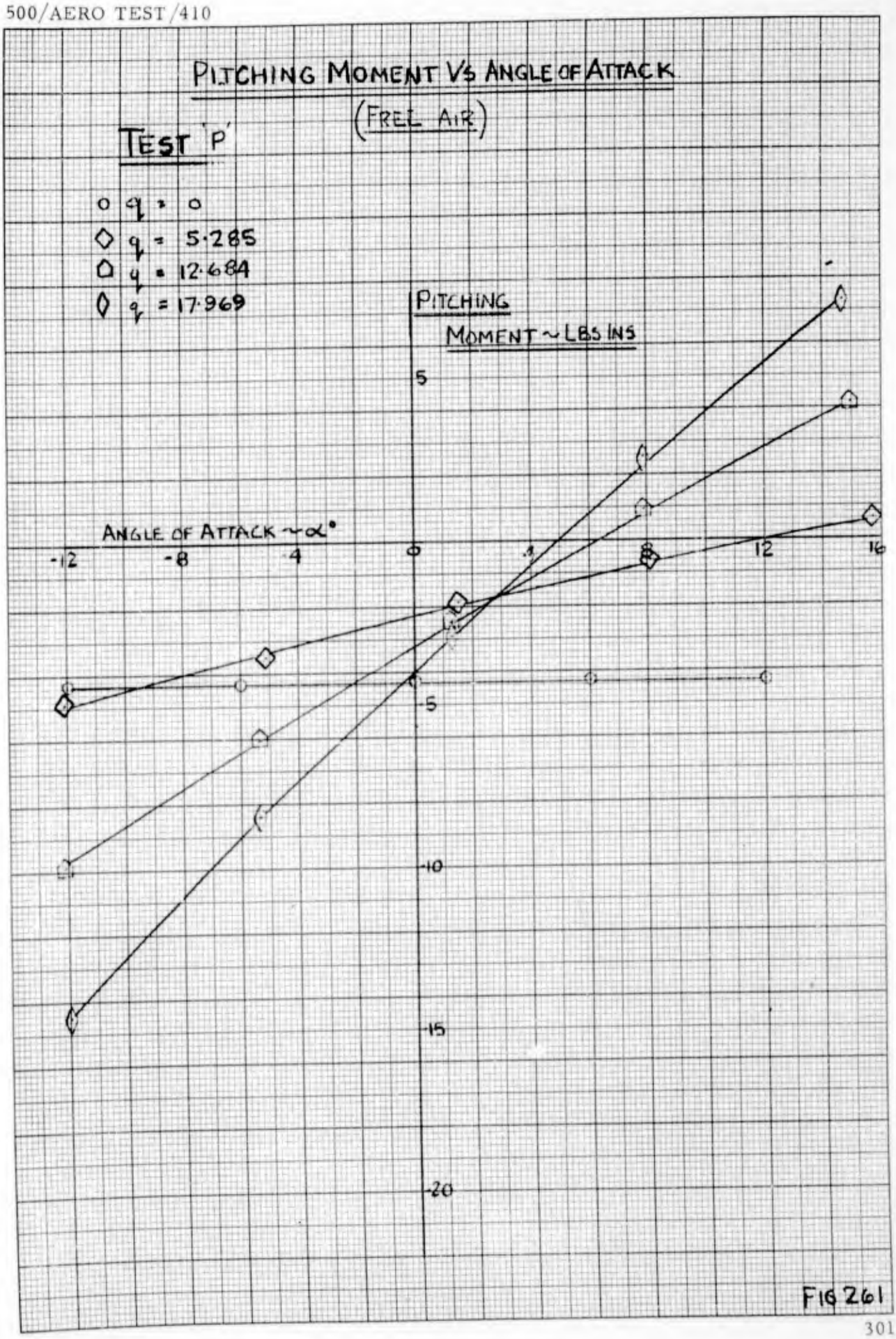

DRAG VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'P'
o q = 0
◇ q = 5.285
⬡ q = 12.684
◊ q = 17.969
DRAG
LBS
6
4
2
-2
-4
-6
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG 260


PITCHING MOMENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'P'
o q = o
◇ q = 5·285
⬠ q = 12·684
◊ q = 17·969
PITCHING
MOMENT ~ LBS INS
5
-5
-10
-15
-20
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16
FIG 261

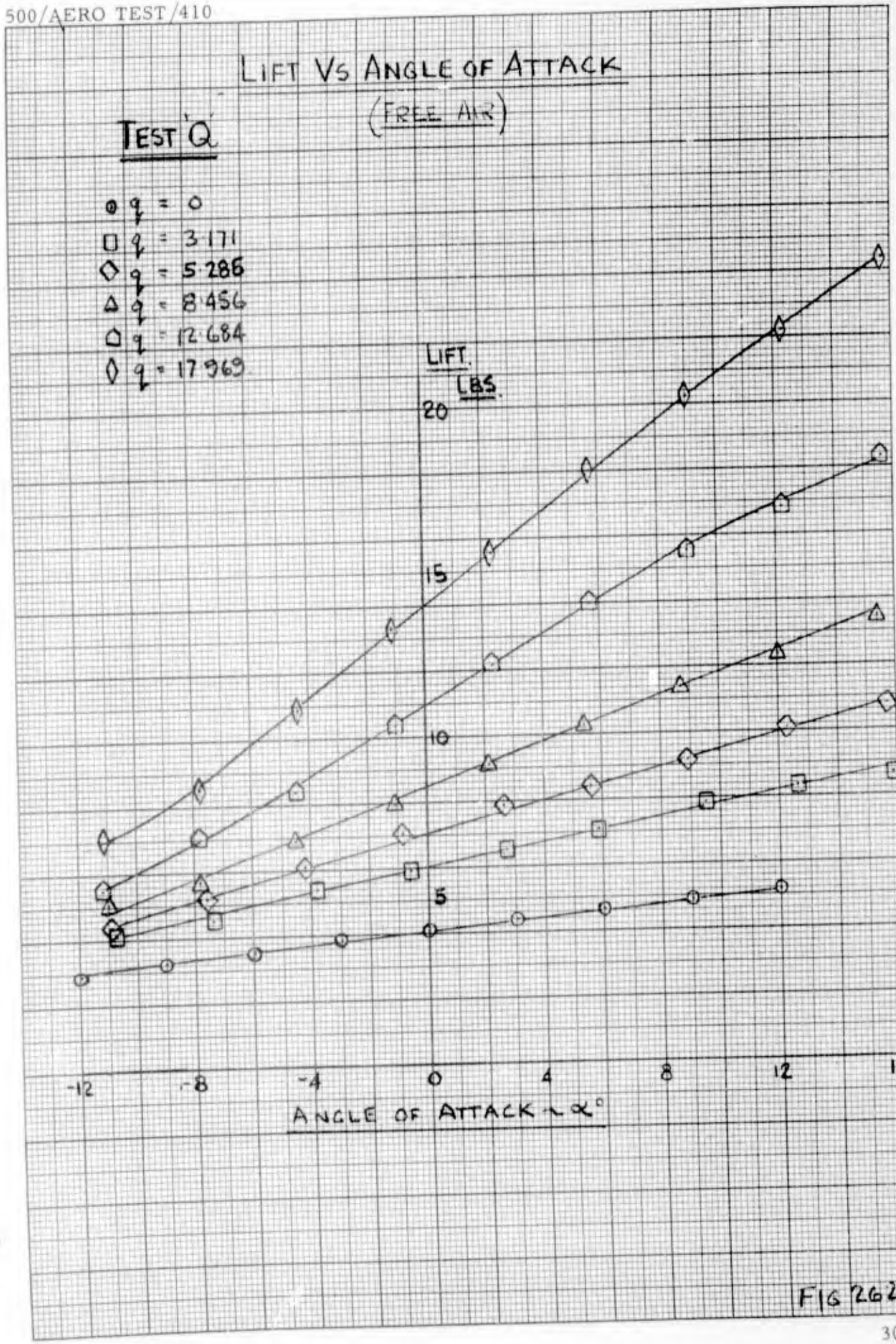
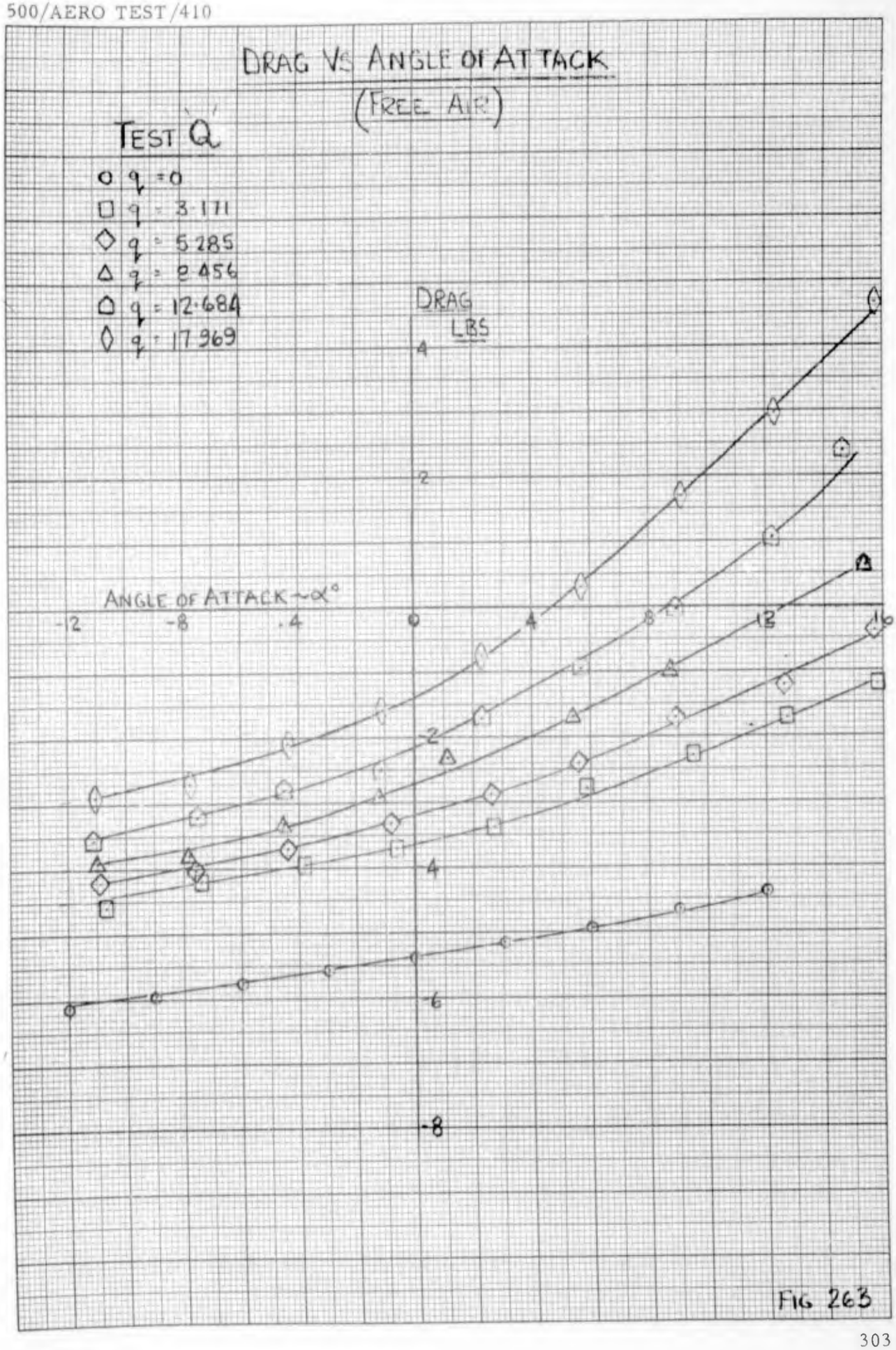

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST Q
q = 0
q = 3.171
q = 5.286
q = 8.456
q = 12.684
q = 17.969
LIFT
LBS.
20
15
10
5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ∠ α°

FIG 262


DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST Q
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 9.456
⬠ q = 12.684
◊ q = 17.969
DRAG
LBS
ANGLE OF ATTACK ~ α°
-2
-8
4
0
4
8
12
16
2
-2
4
-6
-8
FIG 263

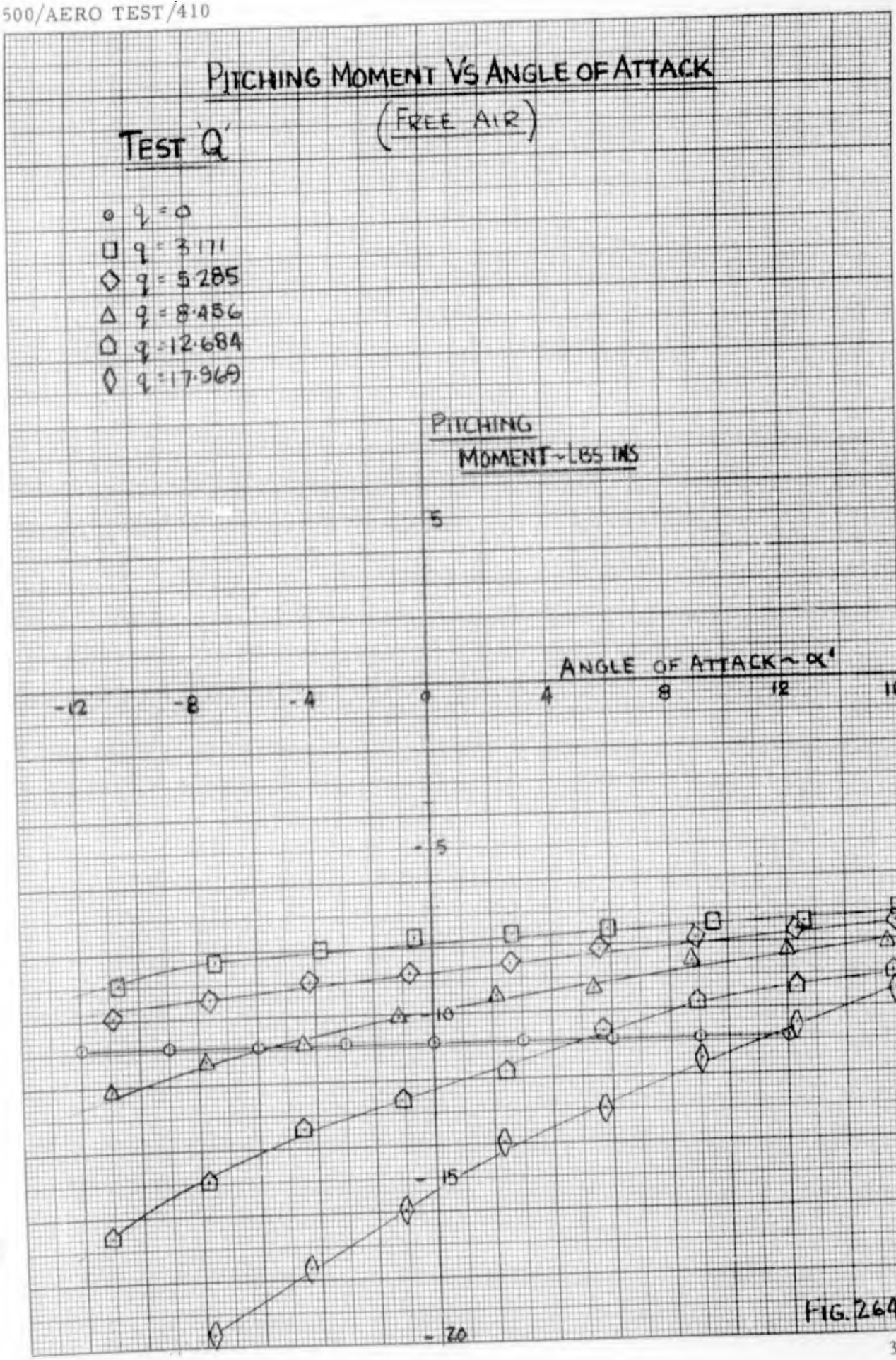

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Q'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
PITCHING MOMENT ~ LBS INS
5
ANGLE OF ATTACK ~ α'
-12
-8
-4
0
4
8
12
16
-5
-10
-15
-20

FIG. 264

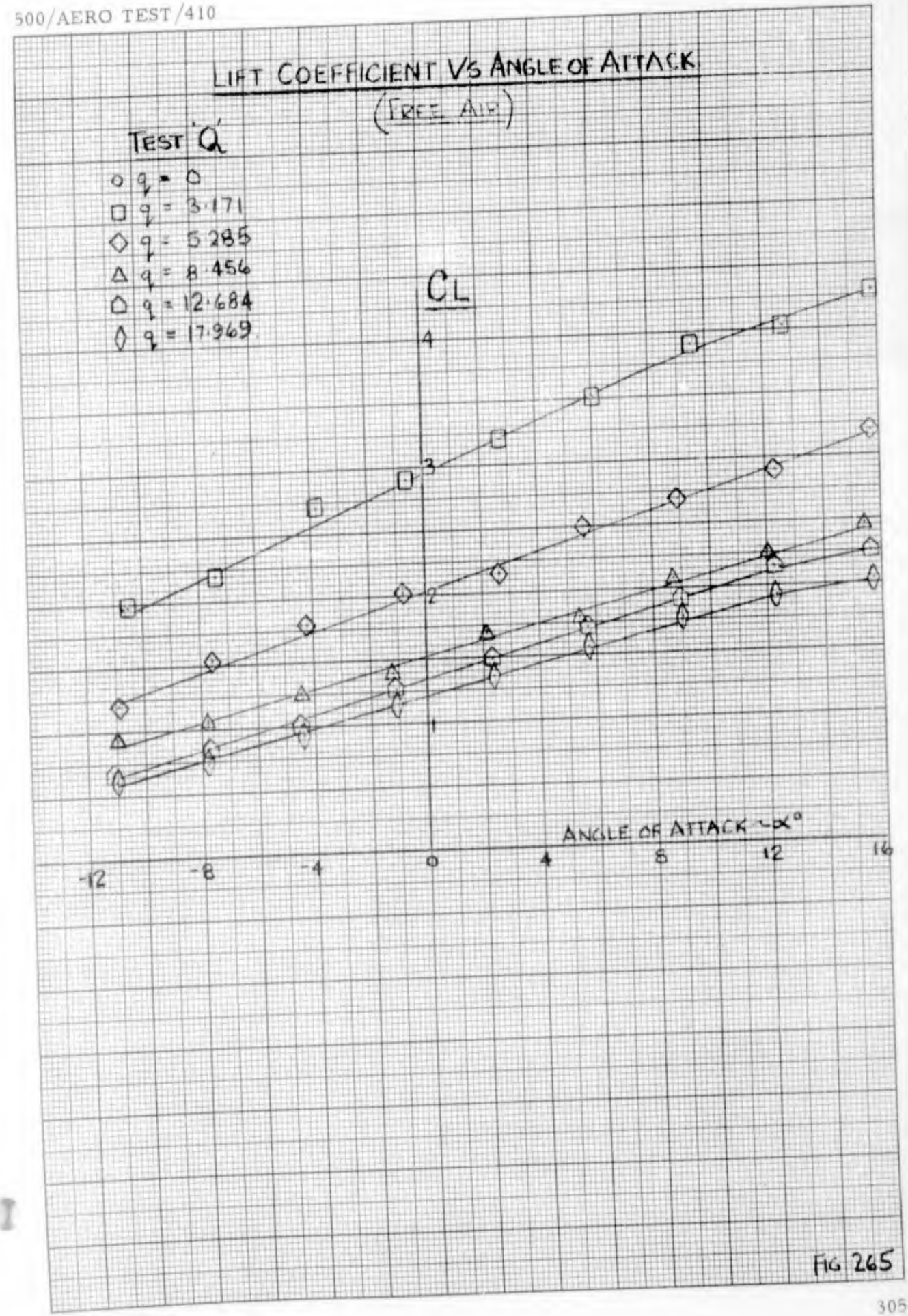

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Q'
q = 0
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
CL
4
3
2
1
ANGLE OF ATTACK -α°
-12
-8
-4
0
4
8
12
16

FIG 265

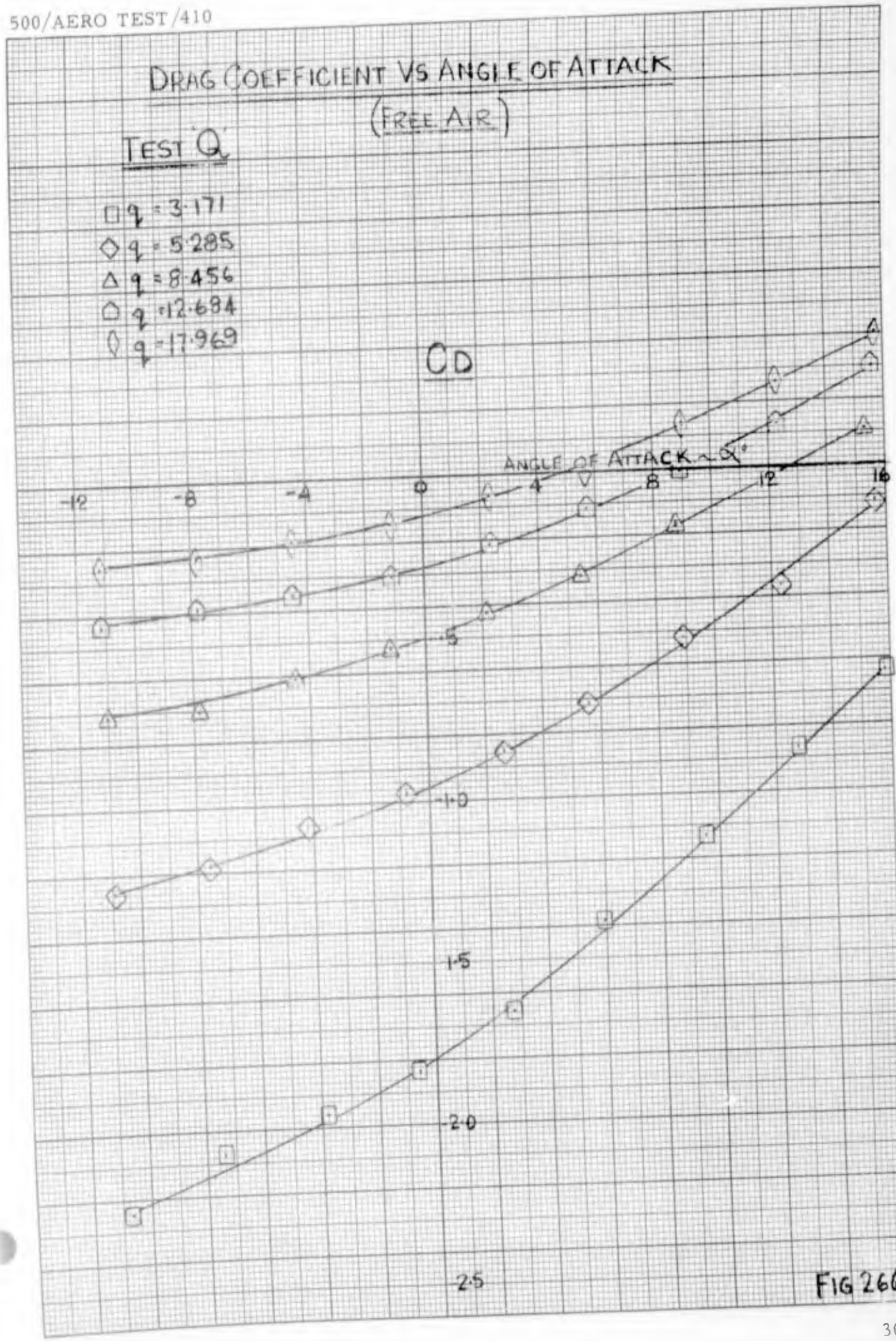

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST Q
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CD
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16
-5
-1·0
-1·5
-2·0
-2·5

FIG 266

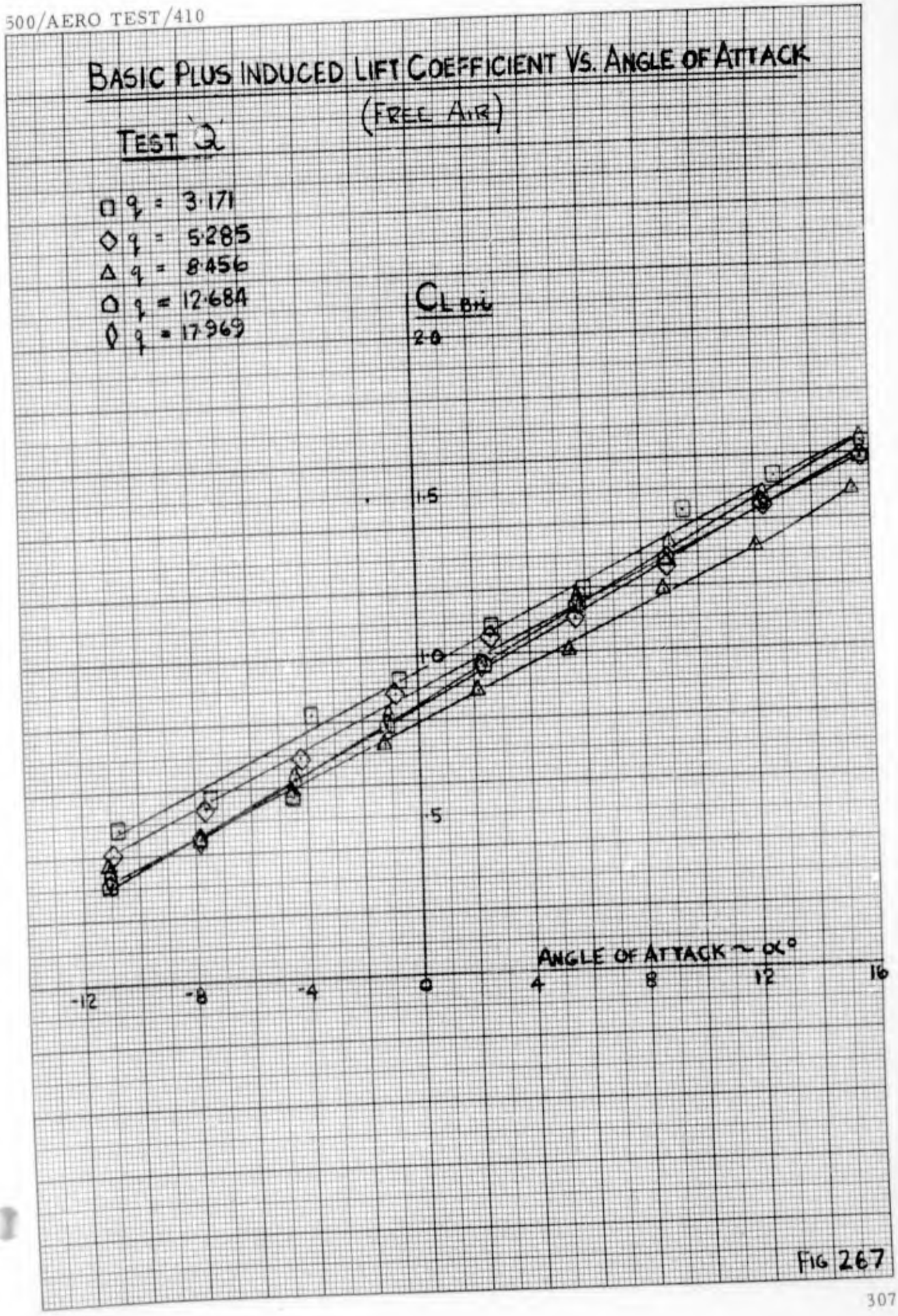

BASIC PLUS INDUCED LIFT COEFFICIENT VS. ANGLE OF ATTACK
(FREE AIR)
TEST 2
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CL Bw
2.0
1.5
1.0
.5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 267

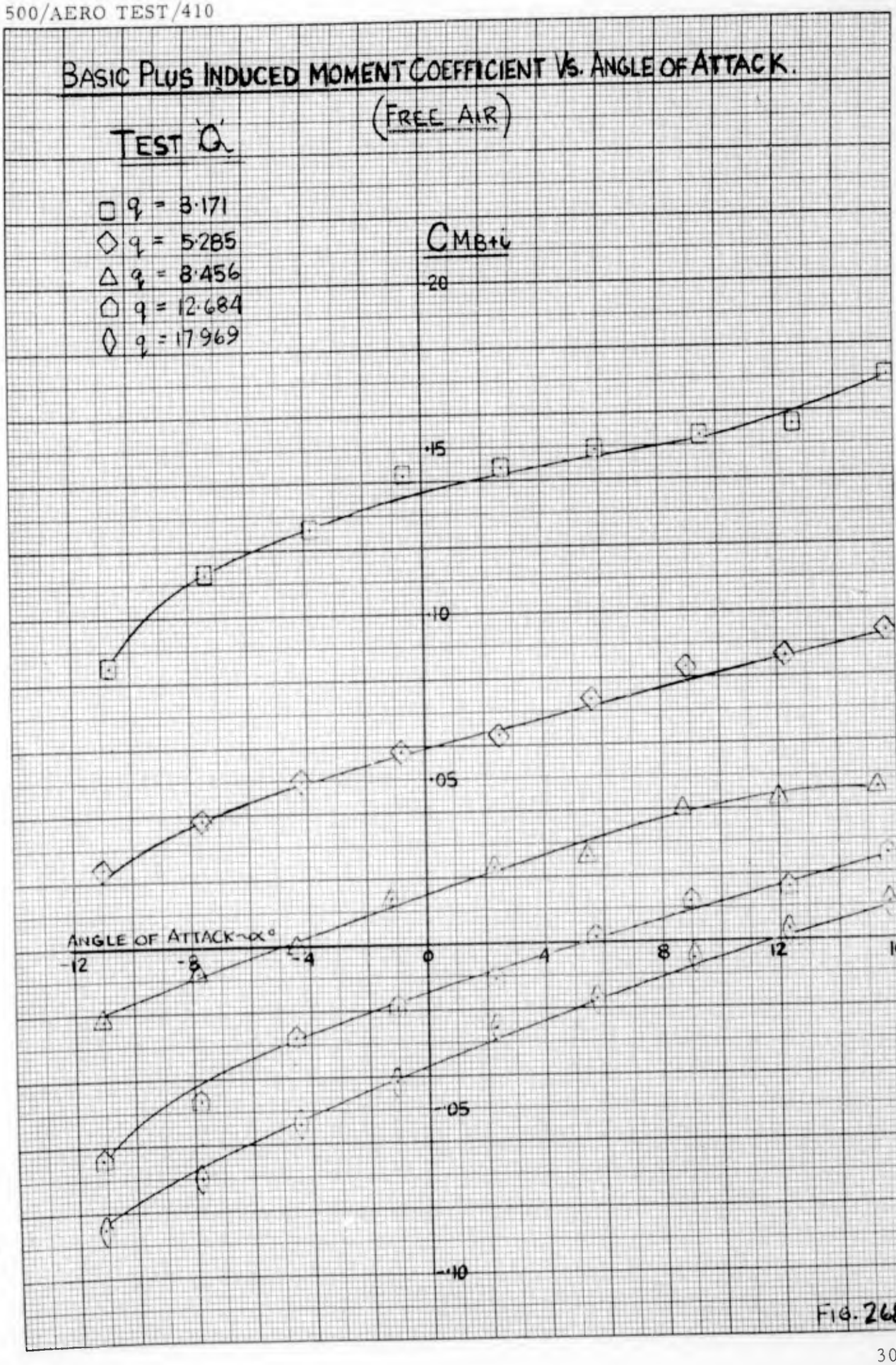

BASIC PLUS INDUCED MOMENT COEFFICIENT VS. ANGLE OF ATTACK.
(FREE AIR)
TEST 'Q'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CMB+i
·20
·15
·10
·05
-·05
-·10
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG. 268

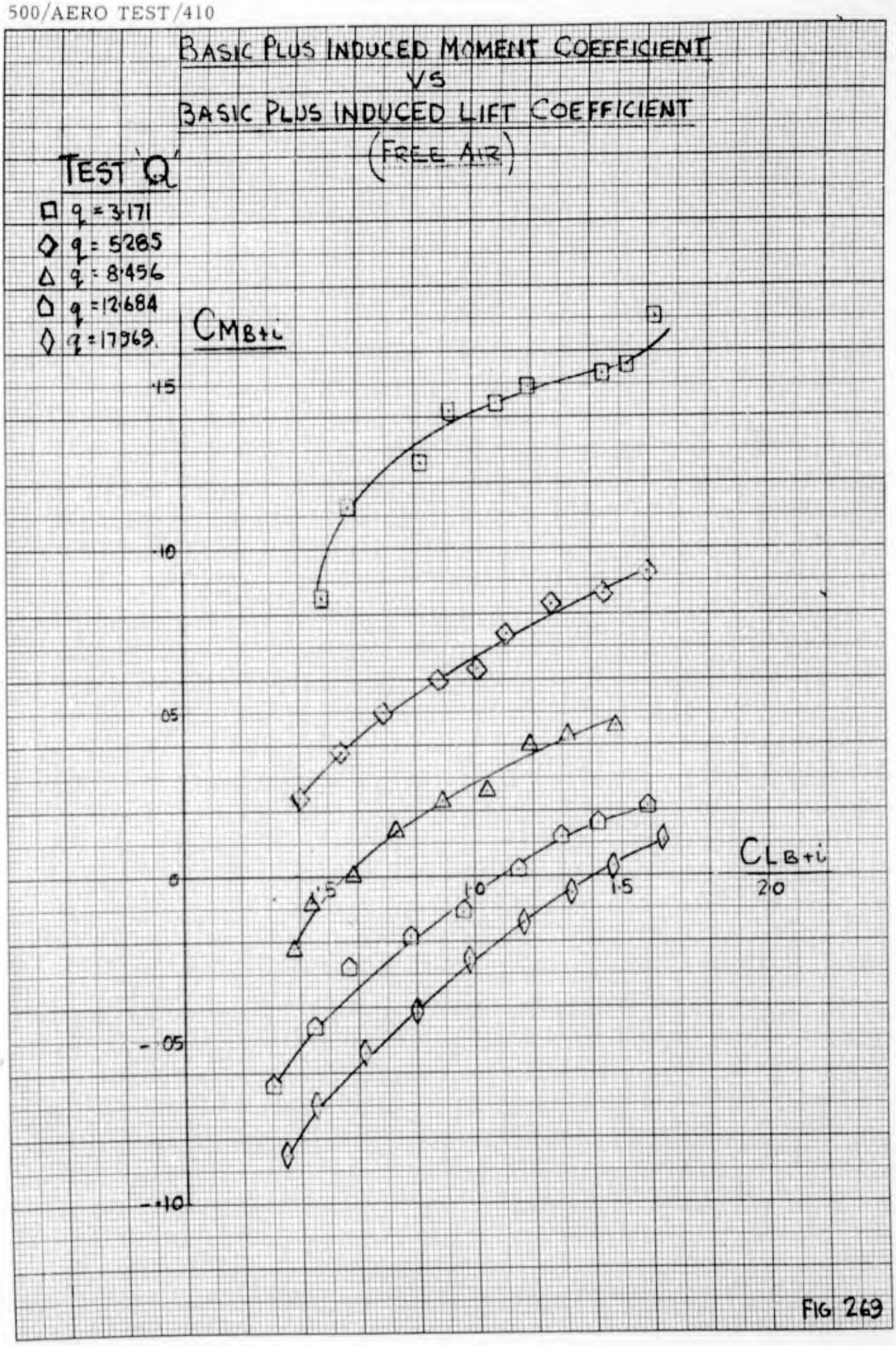

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'Q'
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
CMB+i
·15
·10
·05
0
-·05
-·10
1·5
1·0
1·5
CLB+i
20

FIG 269

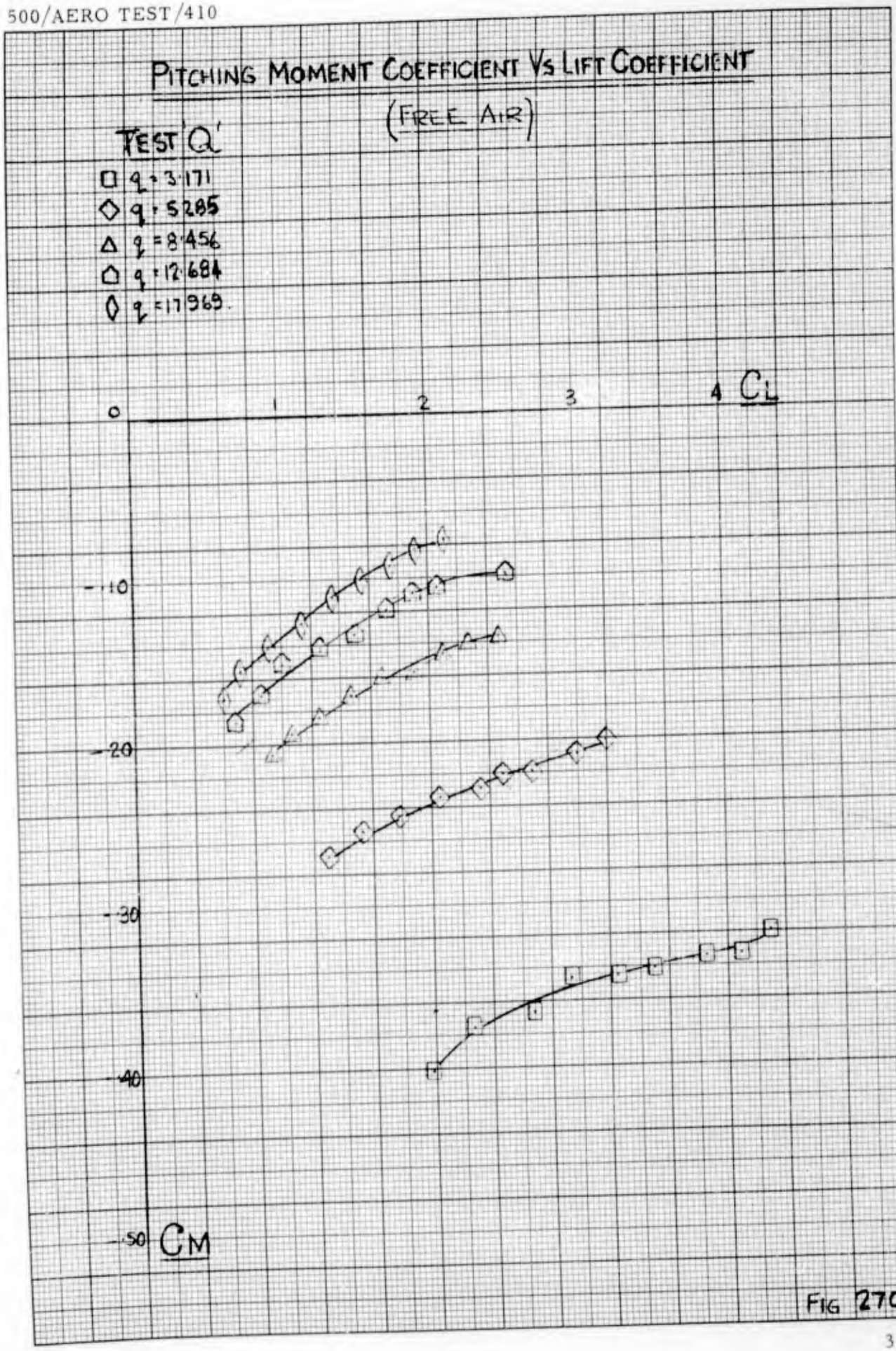

PITCHING MOMENT COEFFICIENT Vs LIFT COEFFICIENT
(FREE AIR)
TEST 'Q'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
0
1
2
3
4 CL
-10
-20
-30
-40
-50 CM

FIG 270

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 'Q'

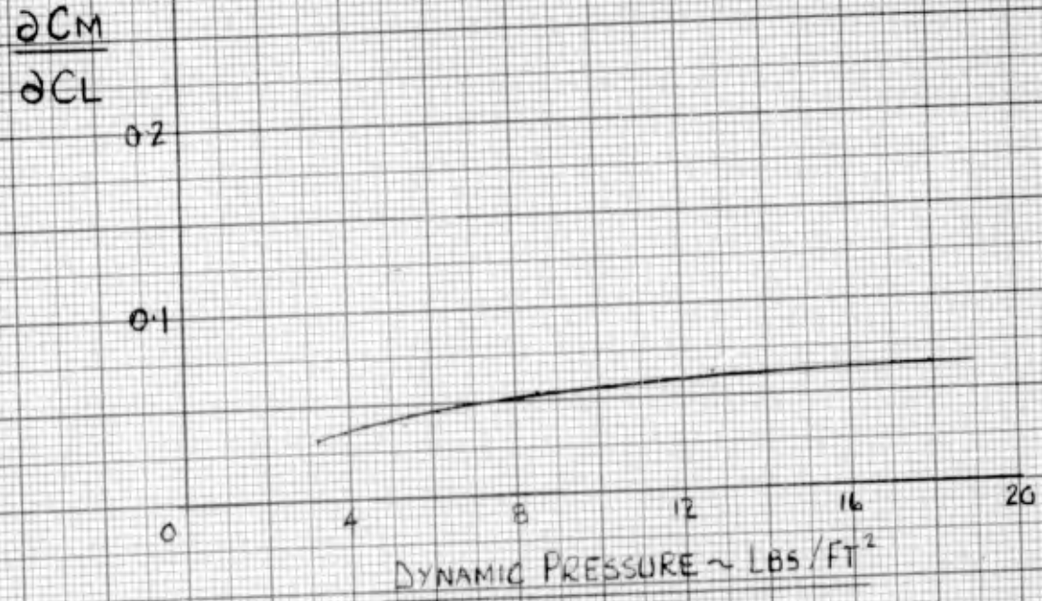


FIG. 271

LIFT CURVE SLOPE VS FORWARD SPEED

(FREE AIR)

TEST 'Q'

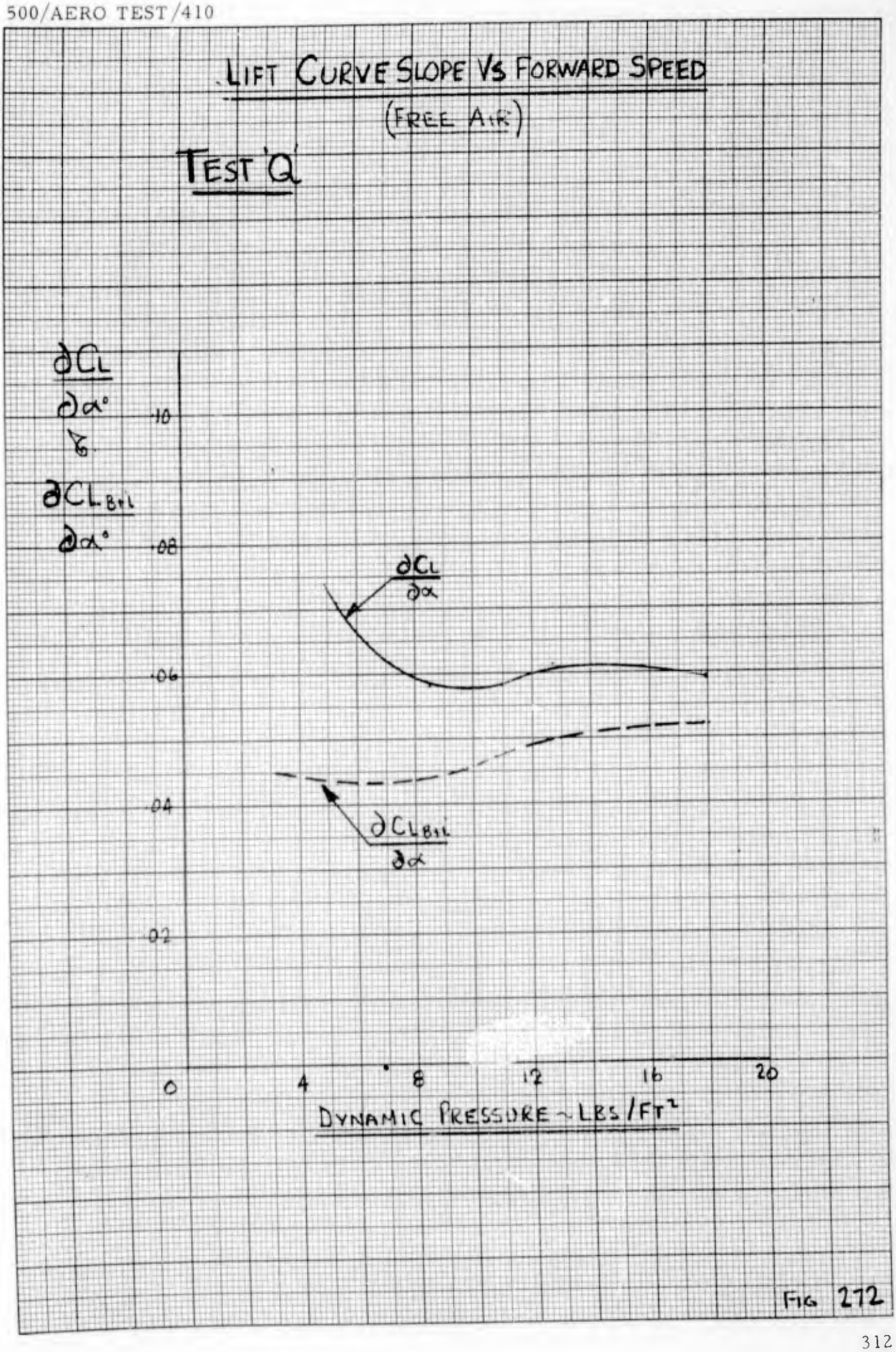


FIG 272

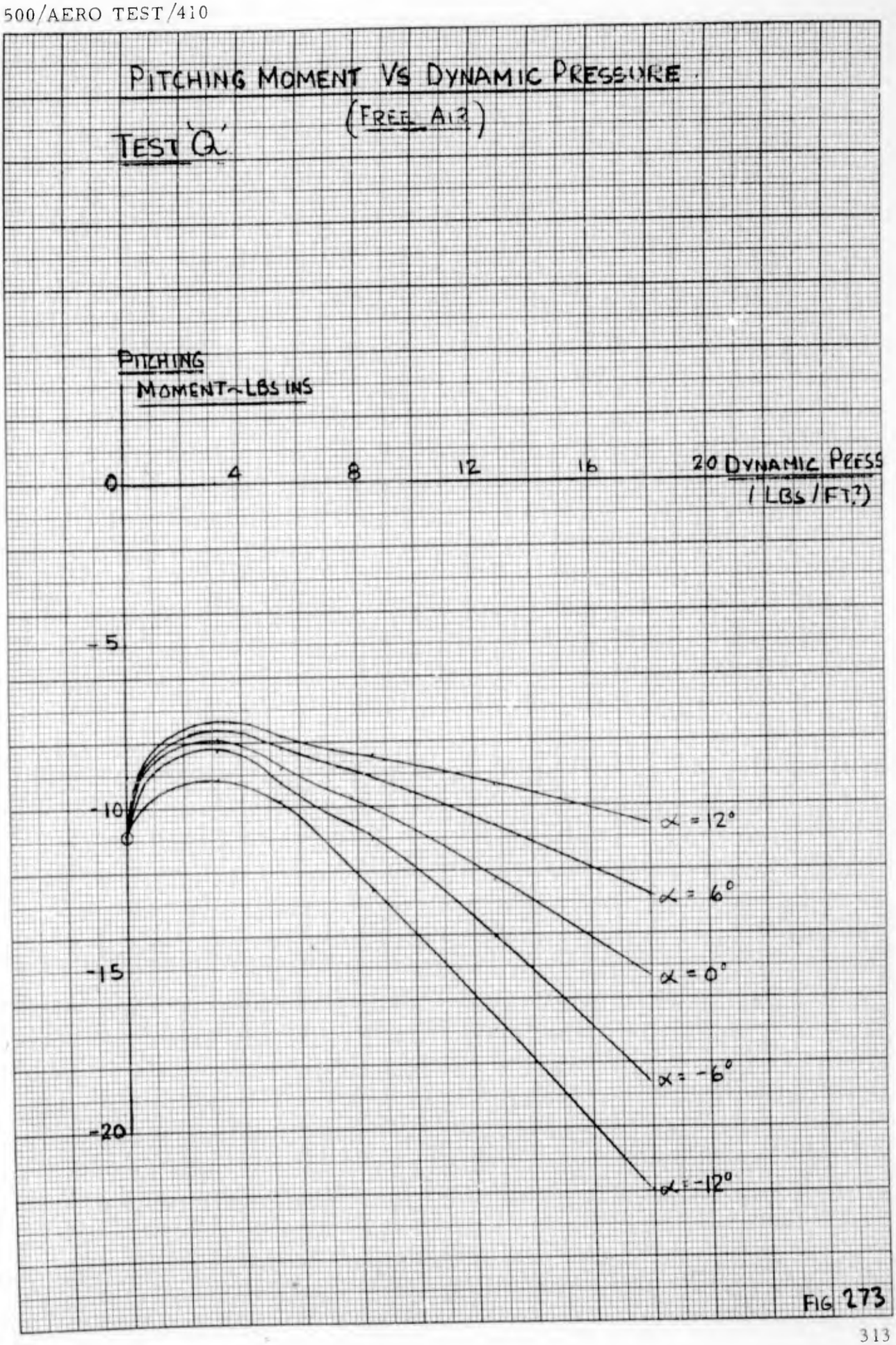

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST 'Q'
PITCHING MOMENT-LBS INS
0
4
8
12
16
20 DYNAMIC PRESS (LBS/FT.²)
-5
-10
-15
-20
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 273

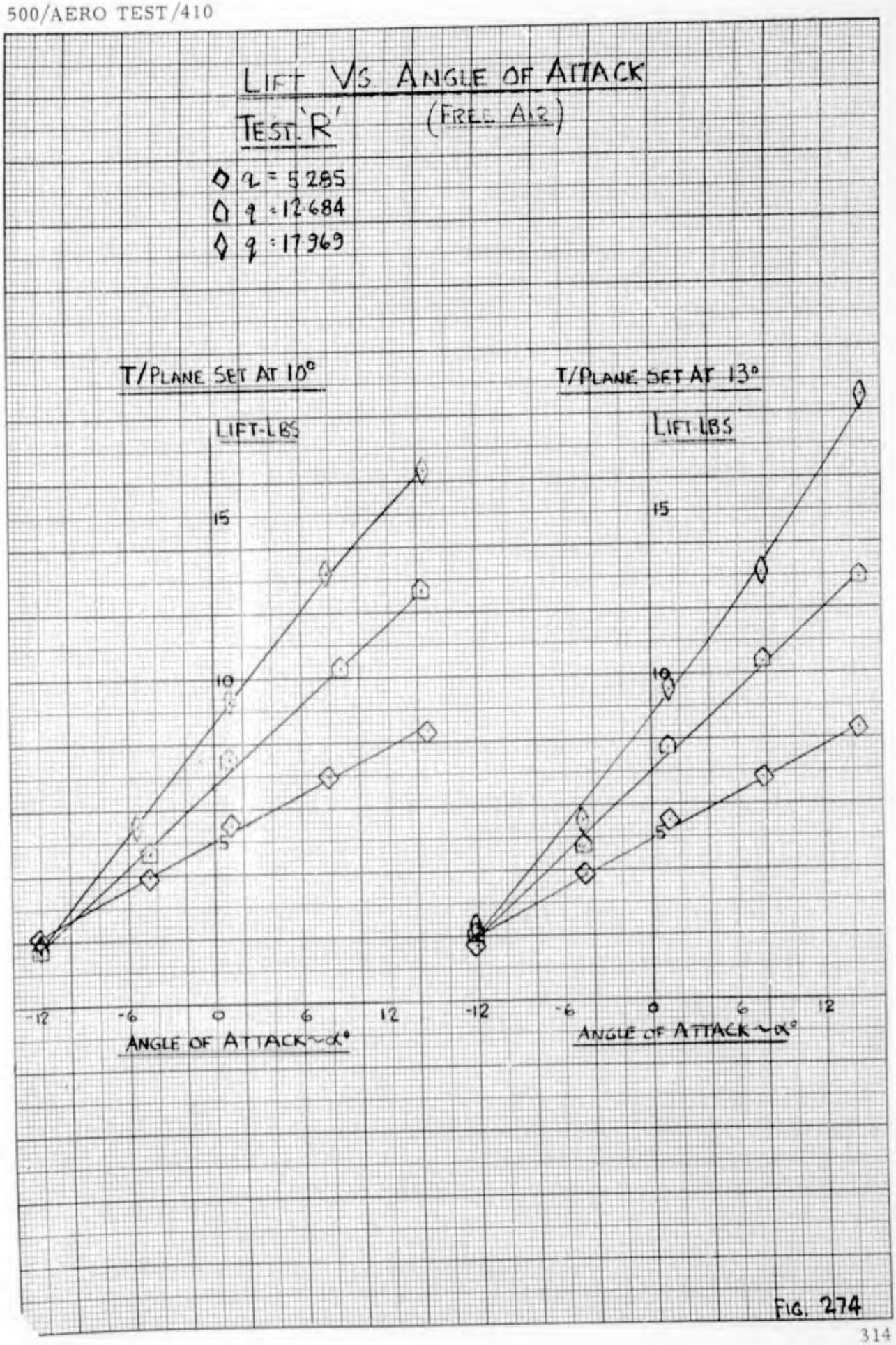

LIFT VS ANGLE OF ATTACK
TEST 'R' (FREE AIR)
◇ q = 5285
◇ q = 12684
◇ q = 17969
T/PLANE SET AT 10°
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK ~ α°
T/PLANE SET AT 13°
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK ~ α°

FIG. 274

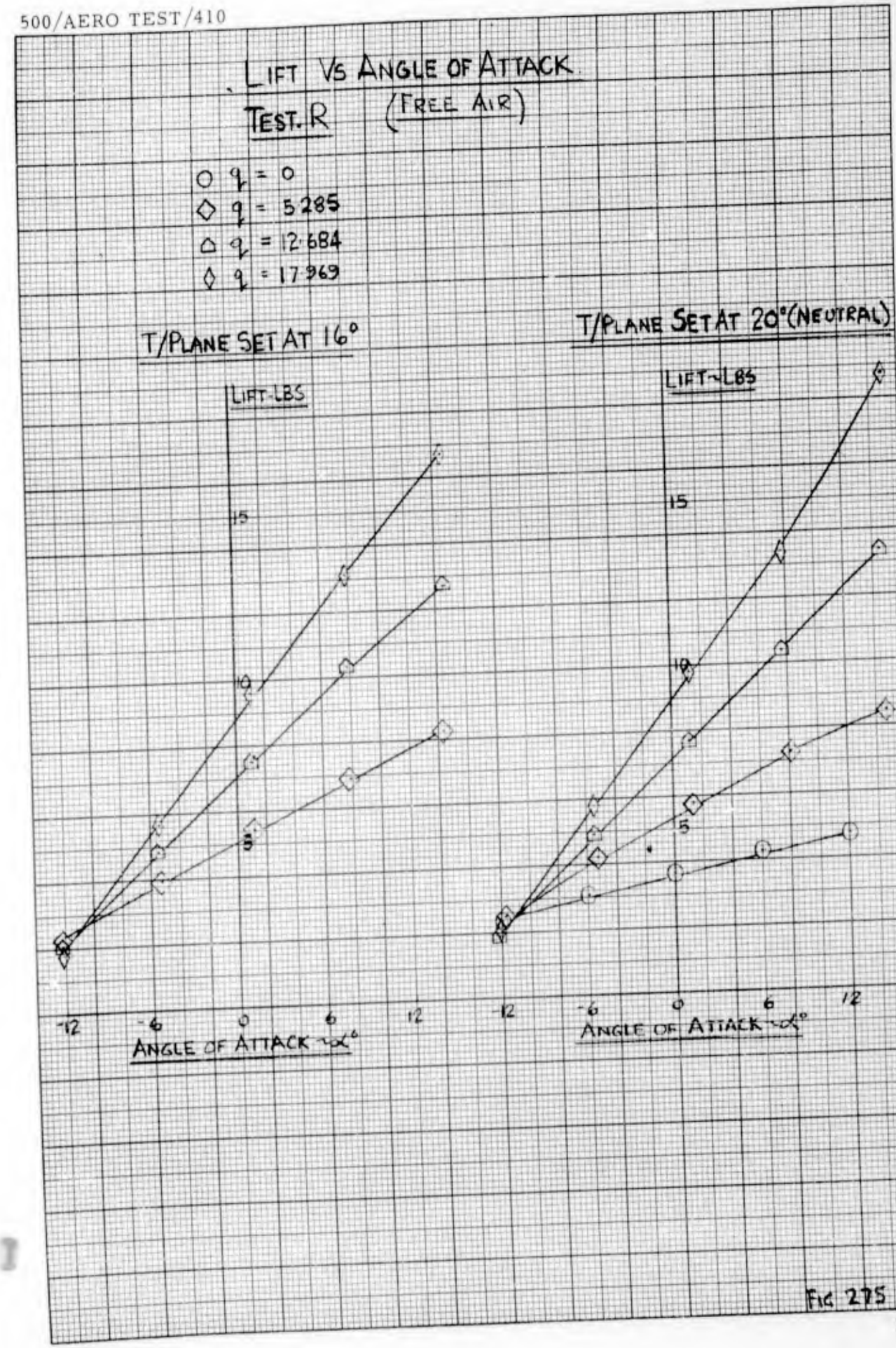

LIFT VS ANGLE OF ATTACK
TEST. R (FREE AIR)
○ q = 0
◇ q = 5285
△ q = 12·684
◊ q = 17969
T/PLANE SET AT 16°
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK - α°
T/PLANE SET AT 20°(NEUTRAL)
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK - α°

FIG 275

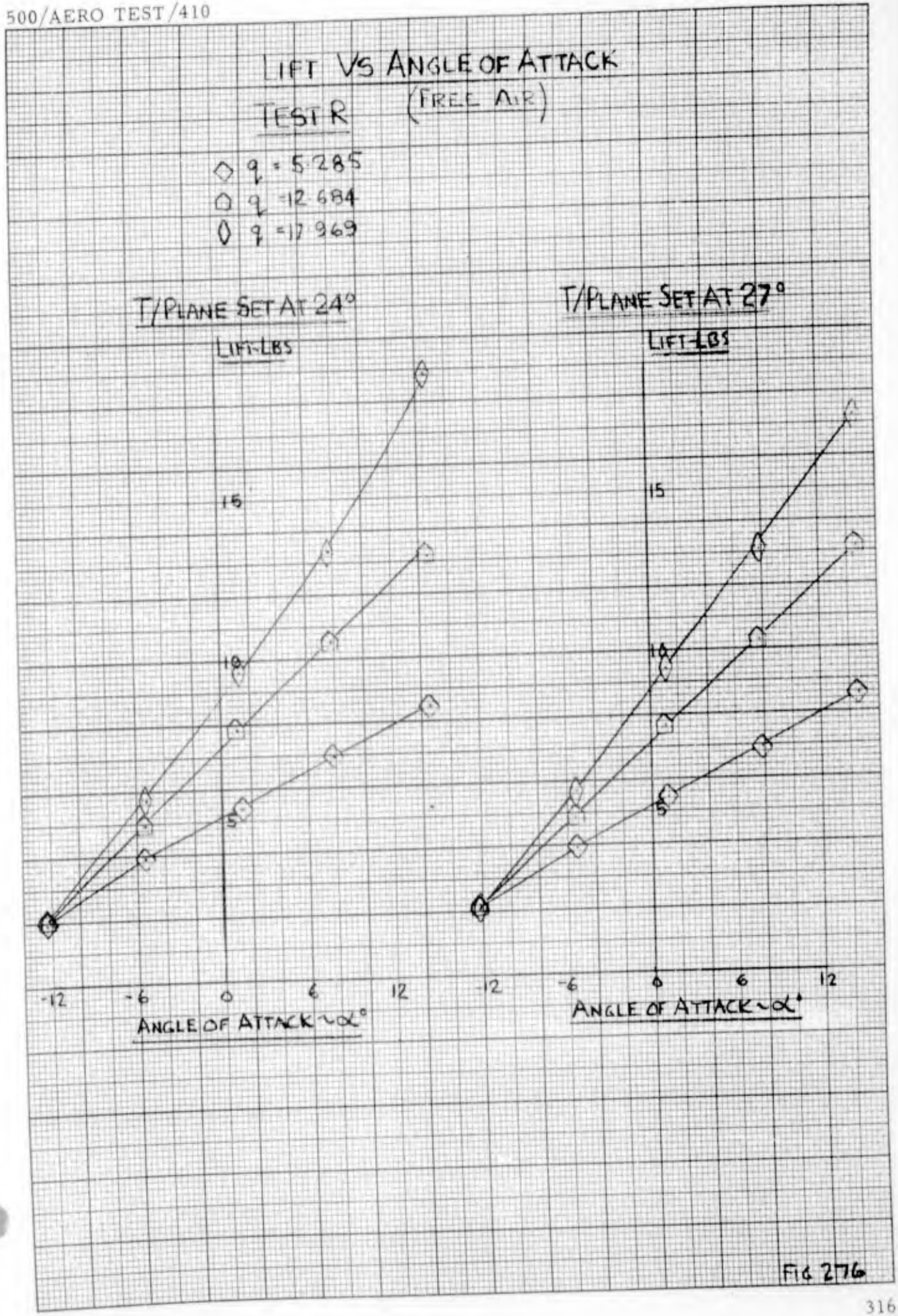

LIFT VS ANGLE OF ATTACK
TEST R (FREE AIR)
◇ q = 5.285
⬠ q = 12.684
◊ q = 17.969
T/PLANE SET AT 24°
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK ~α°
T/PLANE SET AT 27°
LIFT-LBS
15
10
5
-12
-6
0
6
12
ANGLE OF ATTACK ~α°

Fig 276

LIFT VS ANGLE OF ATTACK.

TEST 'R' (FREE AIR)

◇ q = 5 285
△ q = 12 684
◊ q = 17 969

T/PLANE SET AT 30°

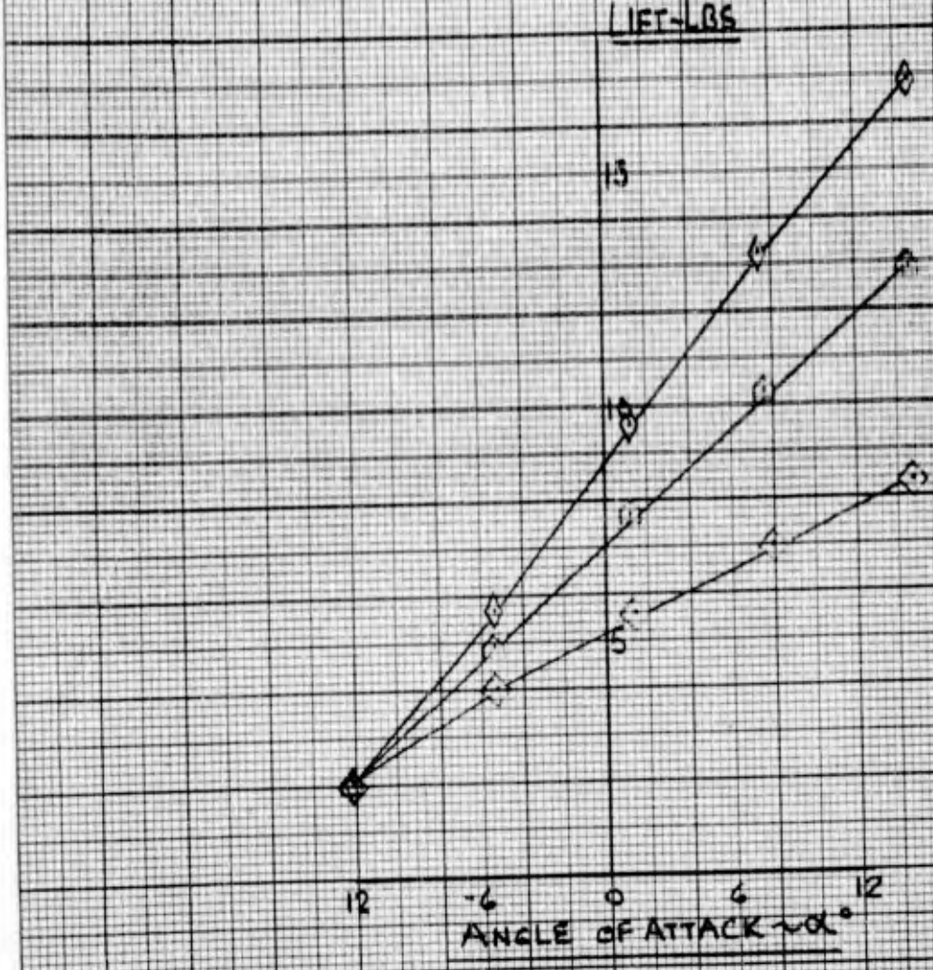


Fig 277

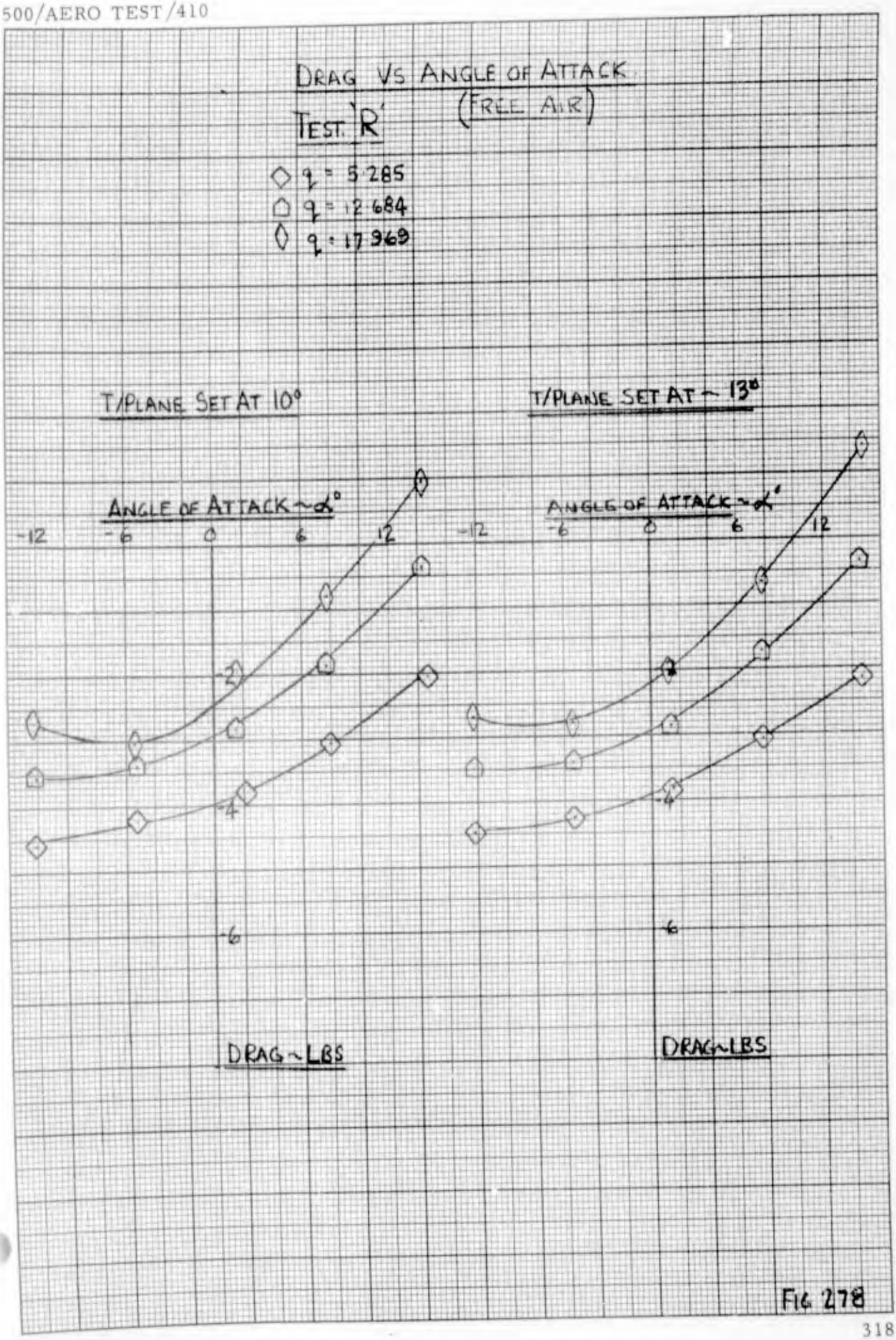
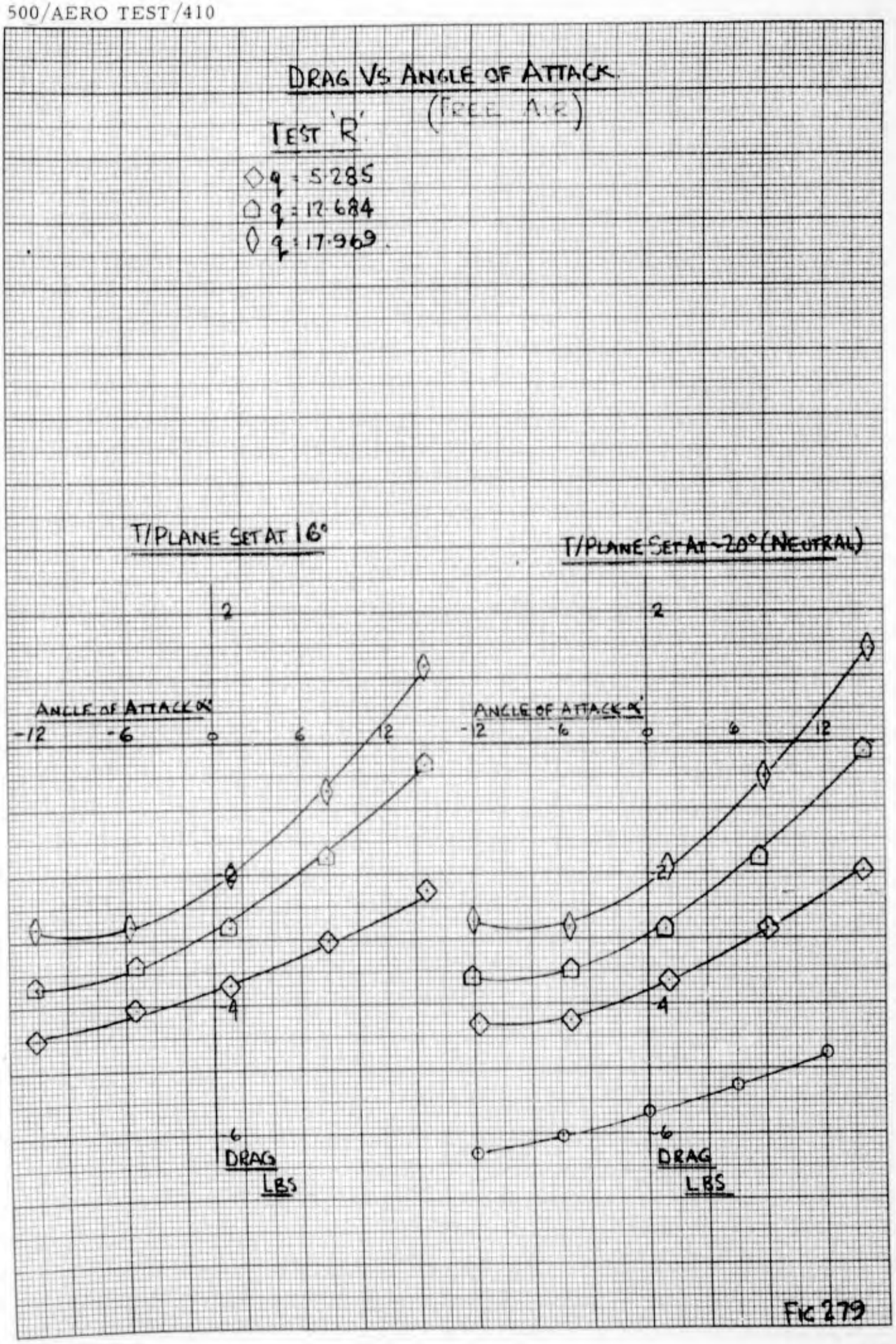
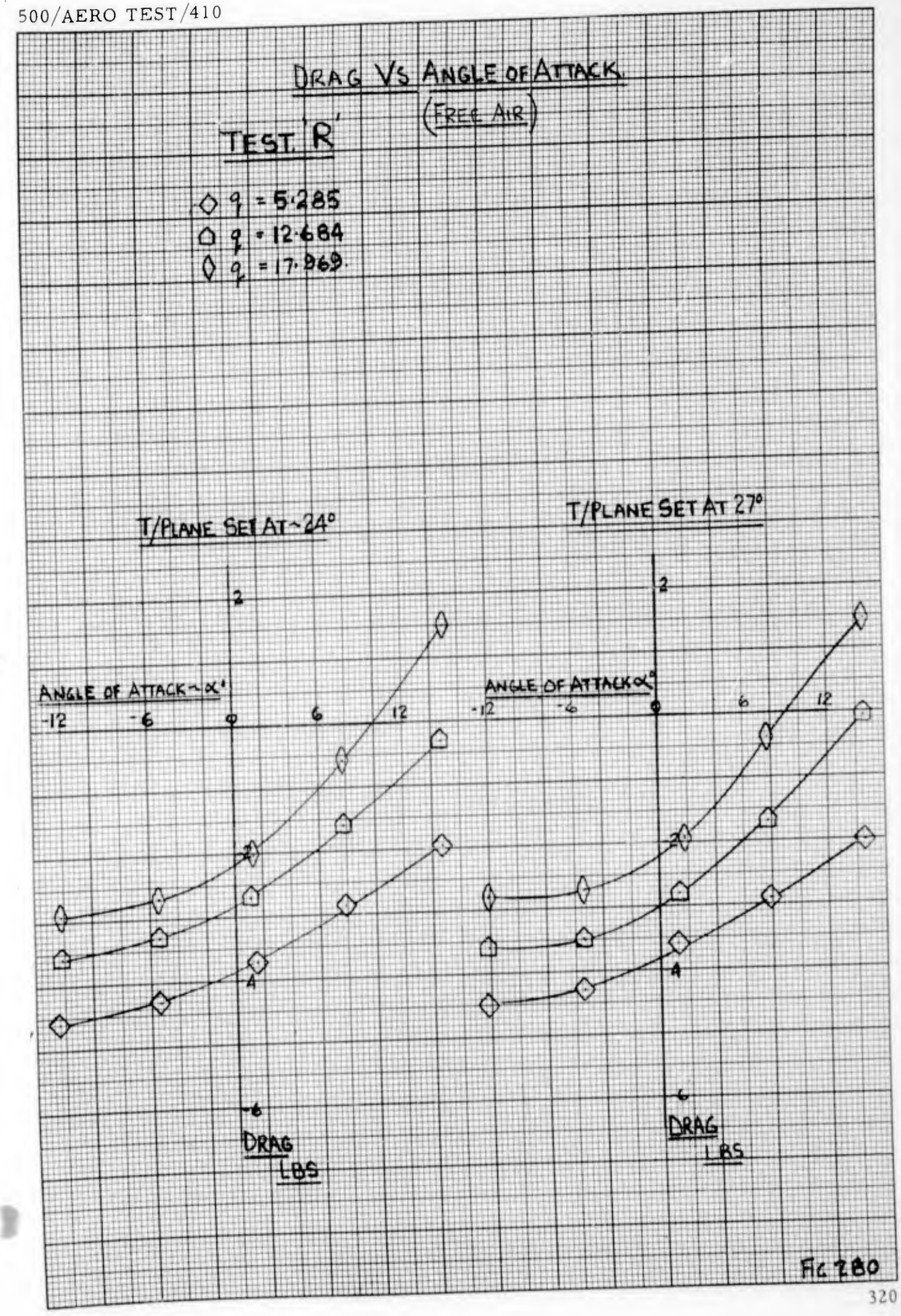

DRAG VS ANGLE OF ATTACK
TEST 'R' (FREE AIR)
◇ q = 5 285
⬠ q = 12 684
◊ q = 17 969
T/PLANE SET AT 10°
T/PLANE SET AT ~ 13°
ANGLE OF ATTACK ~ α°
ANGLE OF ATTACK ~ α°
-12
-6
0
6
12
-12
-6
0
6
12
-2
-4
-6
-4
-6
DRAG ~ LBS
DRAG ~ LBS

Fig 278


DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'R'
◇ q = 5·285
△ q = 17·684
◇ q = 17·969
T/PLANE SET AT 16°
T/PLANE SET AT -20° (NEUTRAL)
ANGLE OF ATTACK α°
-12
-6
0
6
12
2
0
-2
-4
-6
DRAG LBS
ANGLE OF ATTACK α°
-12
-6
0
6
12
2
0
-2
-4
-6
DRAG LBS
FIG 279


DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'R'
◇ q = 5.285
⬠ q = 12.684
◊ q = 17.969
T/PLANE SET AT -24°
T/PLANE SET AT 27°
ANGLE OF ATTACK -α°
ANGLE OF ATTACK α°
-12
-6
0
6
12
2
4
6
DRAG
LBS
FIG 280

DRAG VS ANGLE OF ATTACK

TEST 'R' (FREE AIR)

◇ q = 5·285
⬠ q = 2·684
◊ q = 17·969

T/PLANE SET AT ~30°

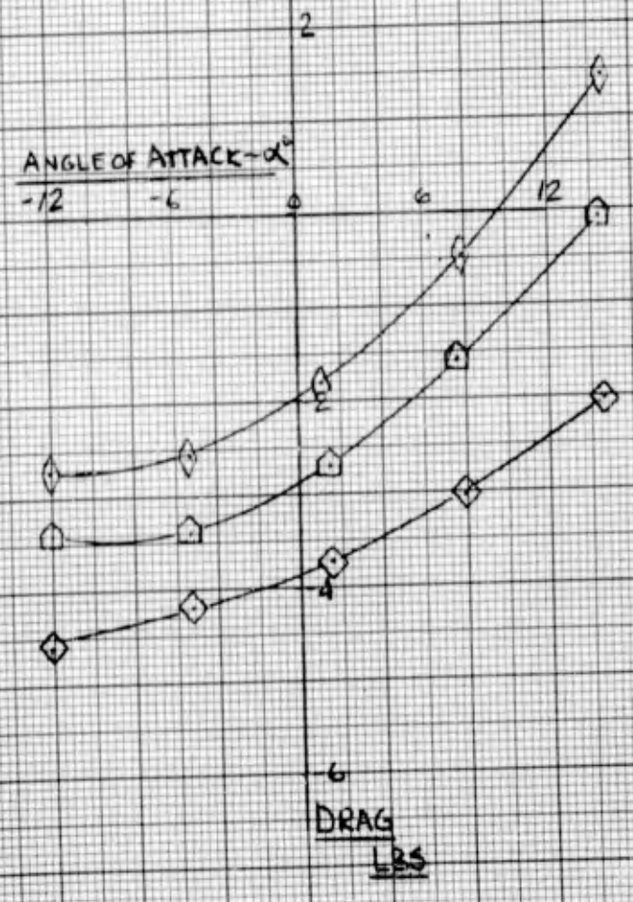


Fig 281

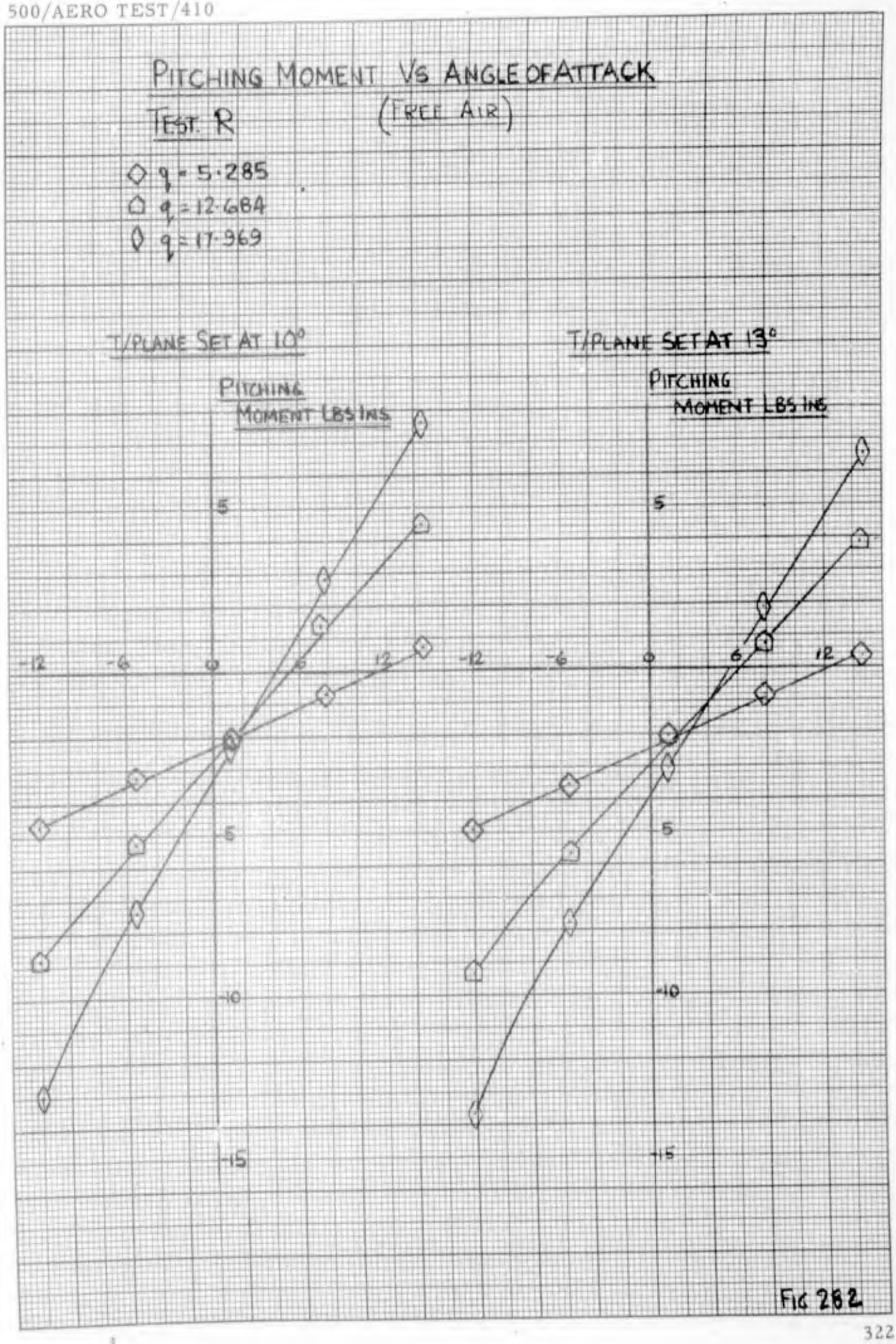

PITCHING MOMENT VS ANGLE OF ATTACK
TEST R
(FREE AIR)
◇ q = 5·285
⬠ q = 12·684
◊ q = 17·969
T/PLANE SET AT 10°
PITCHING MOMENT LBS INS
T/PLANE SET AT 13°
PITCHING MOMENT LBS INS
-12
-6
0
6
12
5
-5
-10
-15

FIG 282

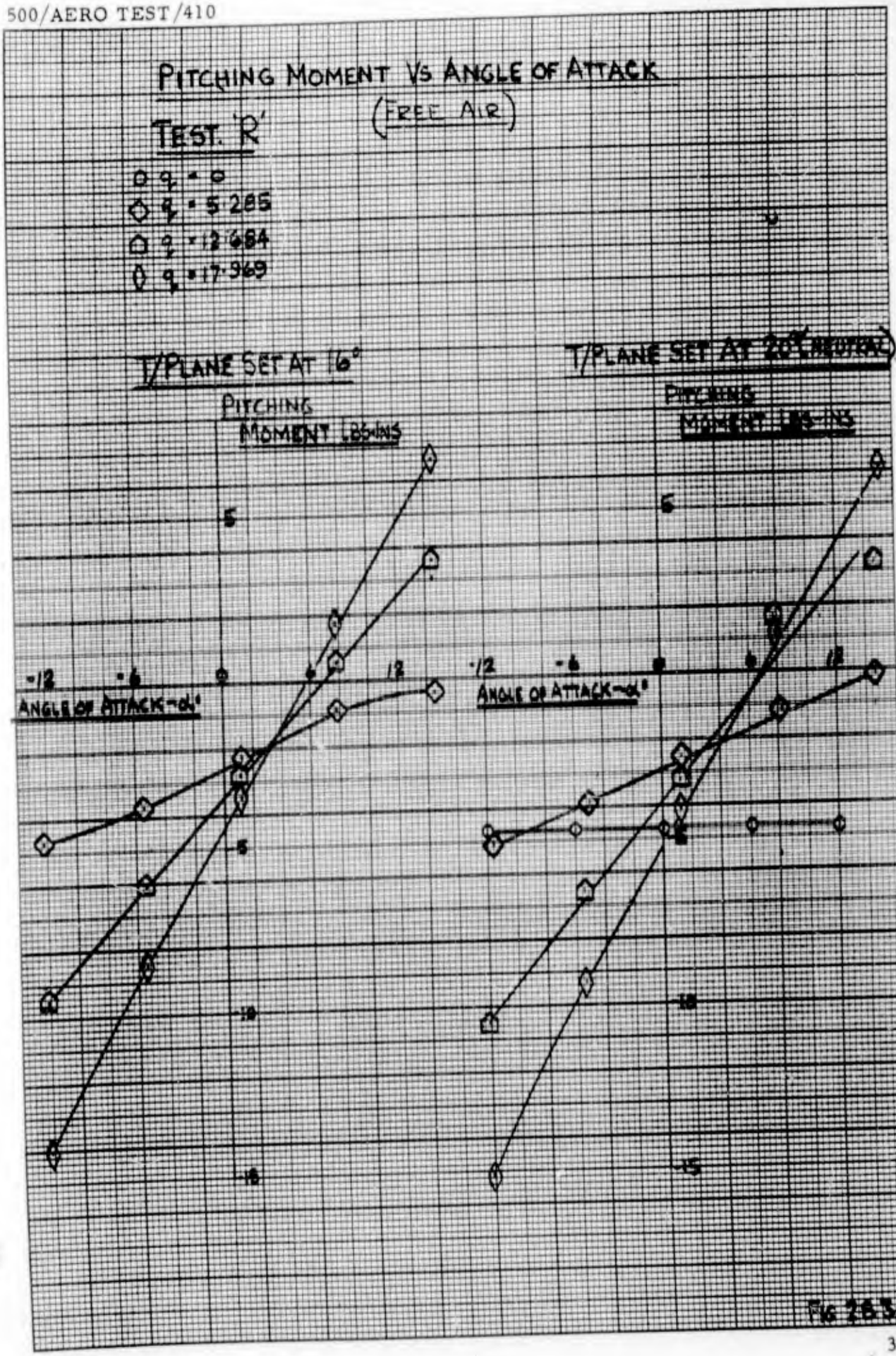

PITCHING MOMENT Vs ANGLE OF ATTACK
(FREE AIR)
TEST 'R'
○ q = 0
◇ q = 5·285
□ q = 12·684
◊ q = 17·969
T/PLANE SET AT 16°
PITCHING MOMENT LBS-INS
ANGLE OF ATTACK-α°
T/PLANE SET AT 20° (NEUTRAL)
PITCHING MOMENT LBS-INS
ANGLE OF ATTACK-α°
5
-5
-10
-15
-12
-6
0
6
12

Fig 263

PITCHING MOMENT VS ANGLE OF ATTACK

TEST R. (FREE AIR)

$q = 5.285$

$q = 12.684$

$q = 17.969$

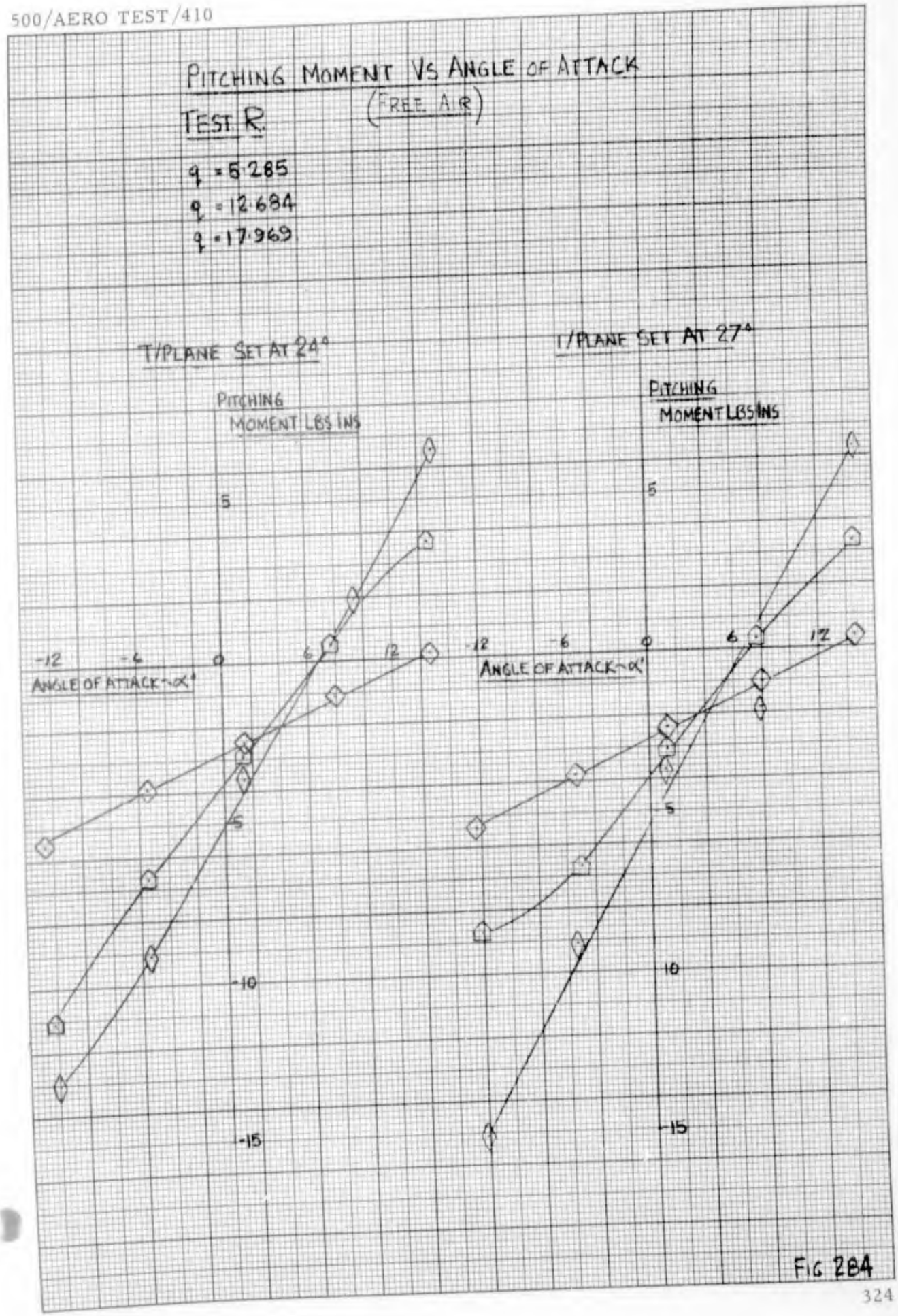


FIG 284

PITCHING MOMENT VS ANGLE OF ATTACK

TEST 'R' (FREE AIR)

◇ q = 5285
⌂ q = 12684
◊ q = 17369

T./PLANE SET AT ~ 30°

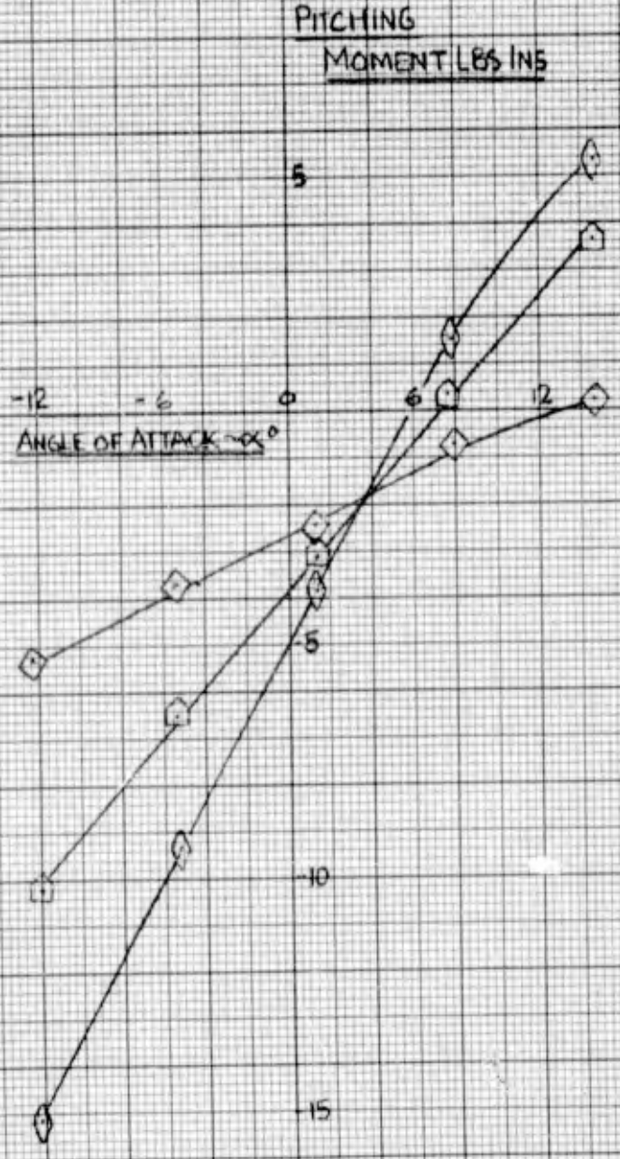


FIG 285

LIFT VS ANGLE OF ATTACK

(FREE AIR)

TEST 'S'

- ○ q = 0
- □ q = 3·171
- ◇ q = 5·285
- △ q = 8·456
- ⬠ q = 12·684
- ◊ q = 17·369

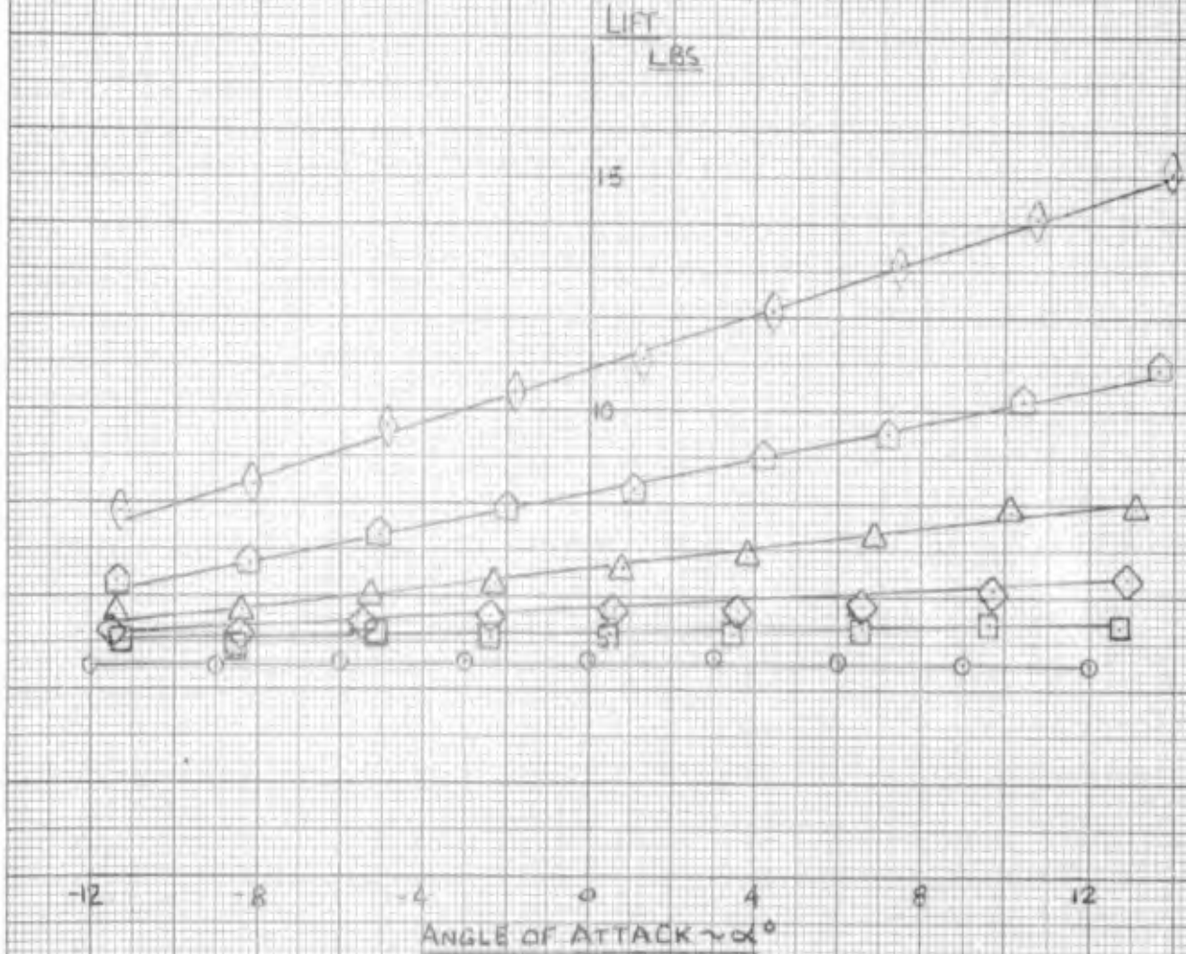


FIG 286

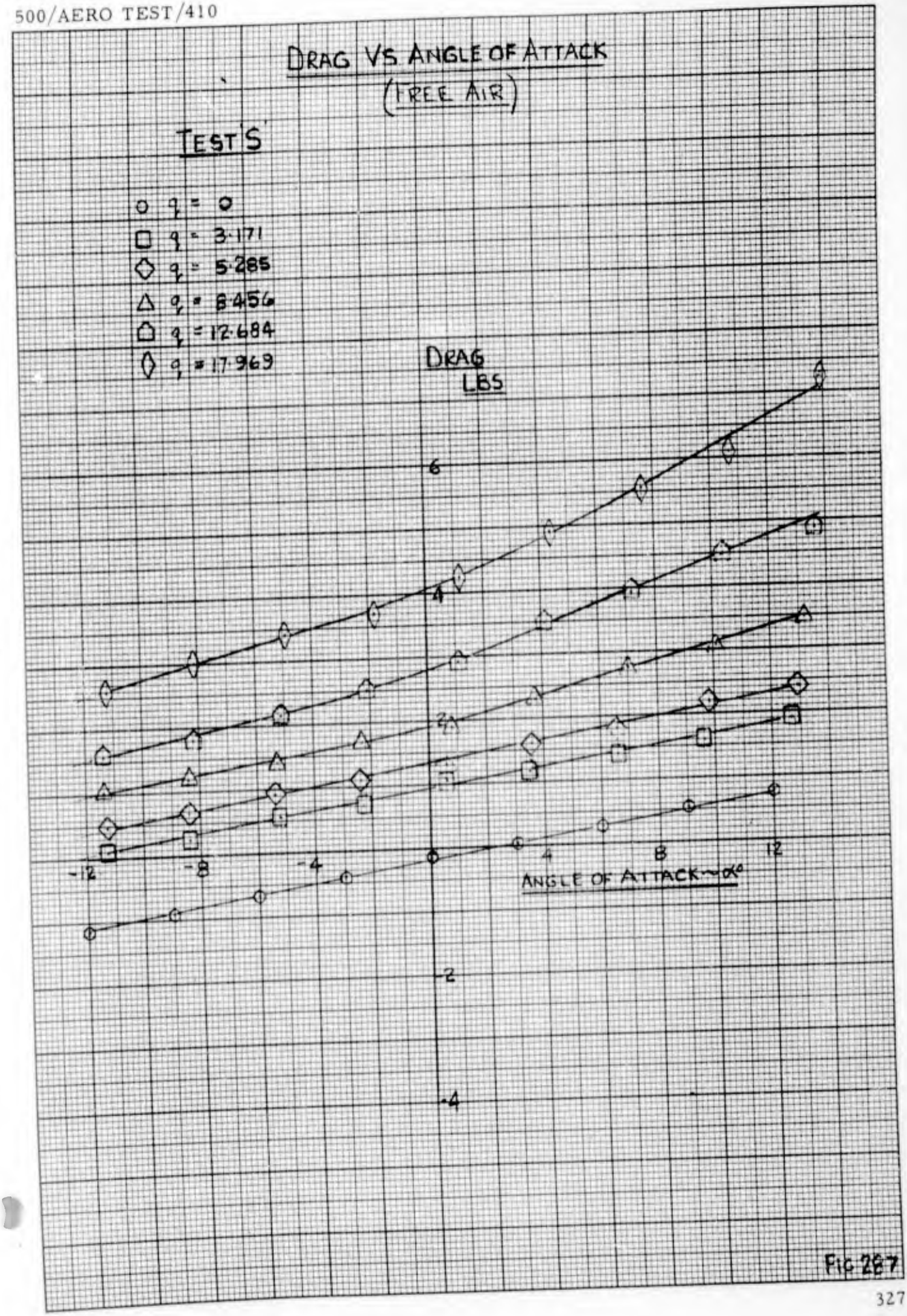

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST'S
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
DRAG
LBS
6
4
2
-2
-4
-12
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°

Fig 287

PITCHING MOMENT VS ANGLE OF ATTACK

(FREE AIR)

TEST 'S'

- ○ q = 0
- □ q = 3·171
- ◇ q = 5·285
- △ q = 8·456
- ⌂ q = 12·684
- ◊ q = 17·969

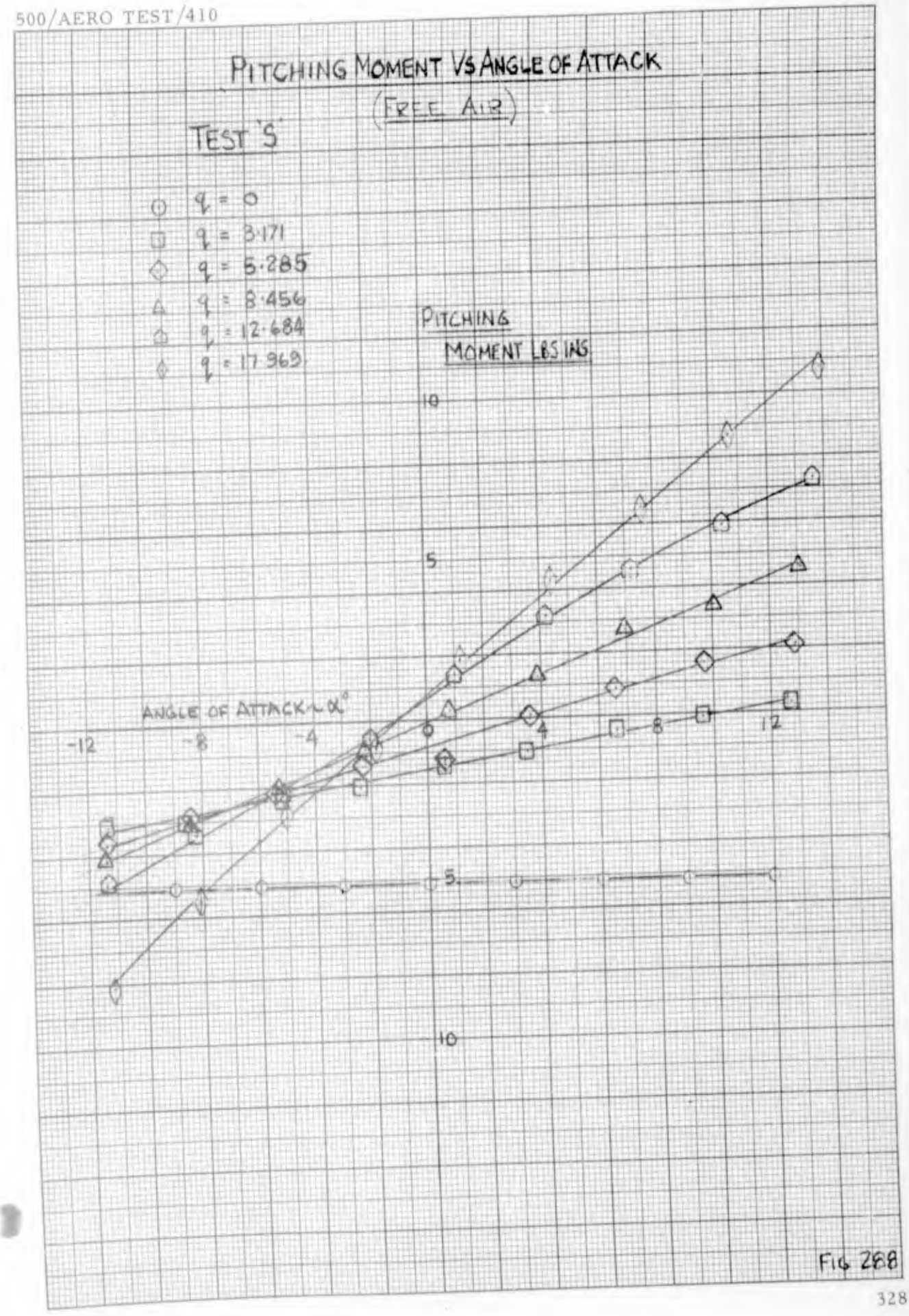


Fig 288

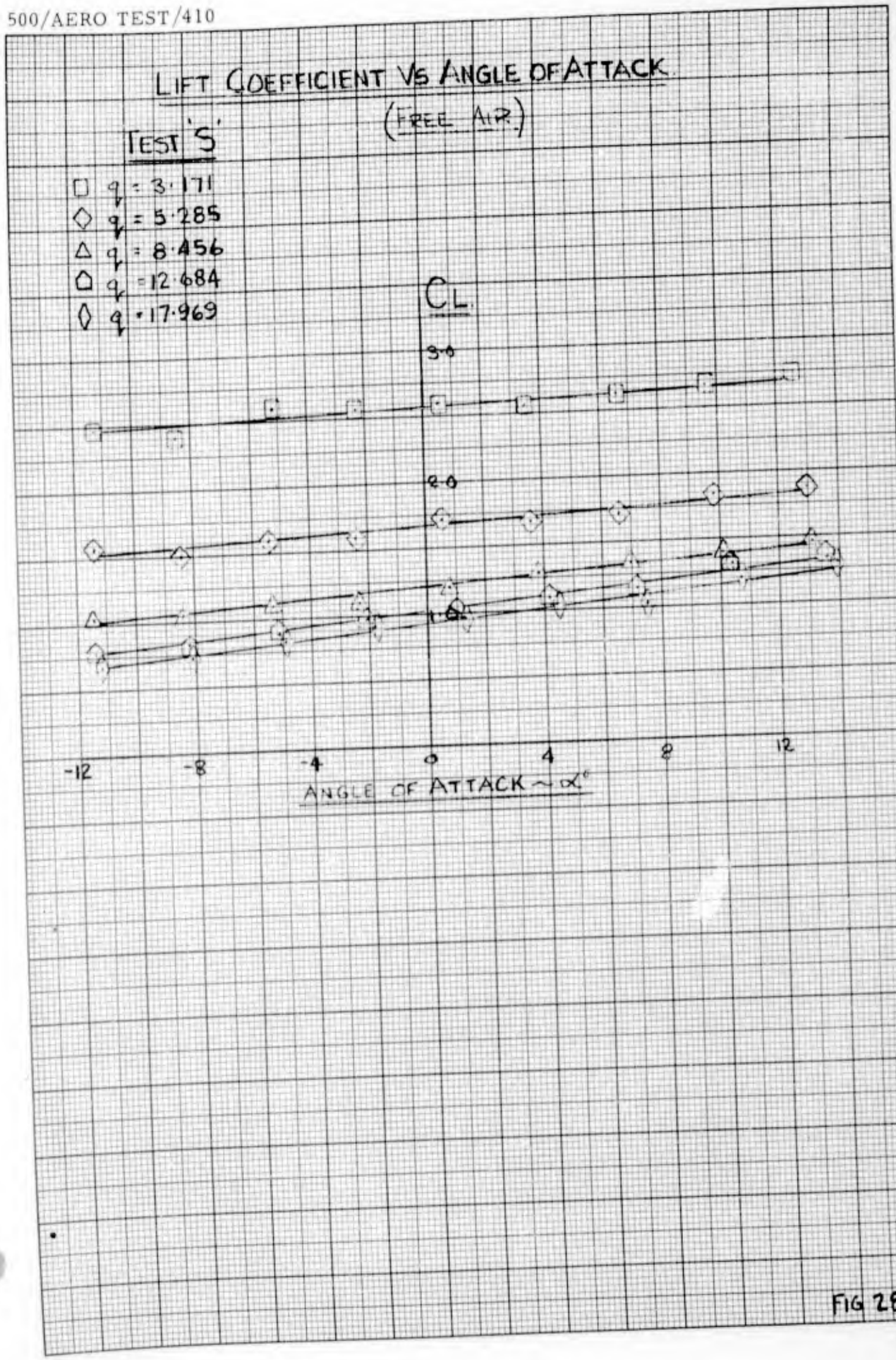

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'S'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CL
3·0
2·0
1·0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 289

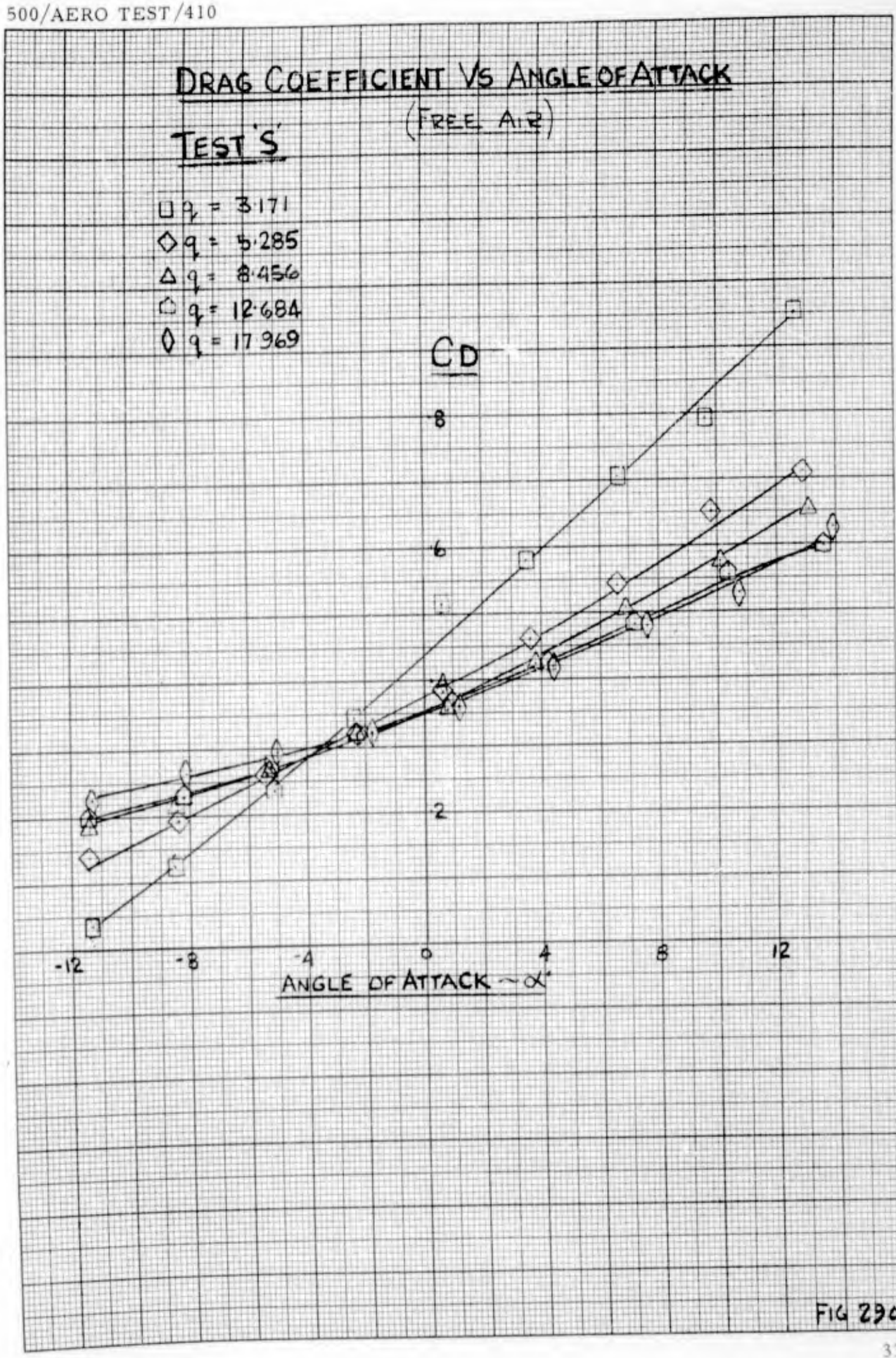

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST S
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CD
8
6
2
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 290

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

TEST S.

□ q = 3·171
◇ q = 5·285
△ q = 8·456
○ q = 12·684
◊ q = 17·969.

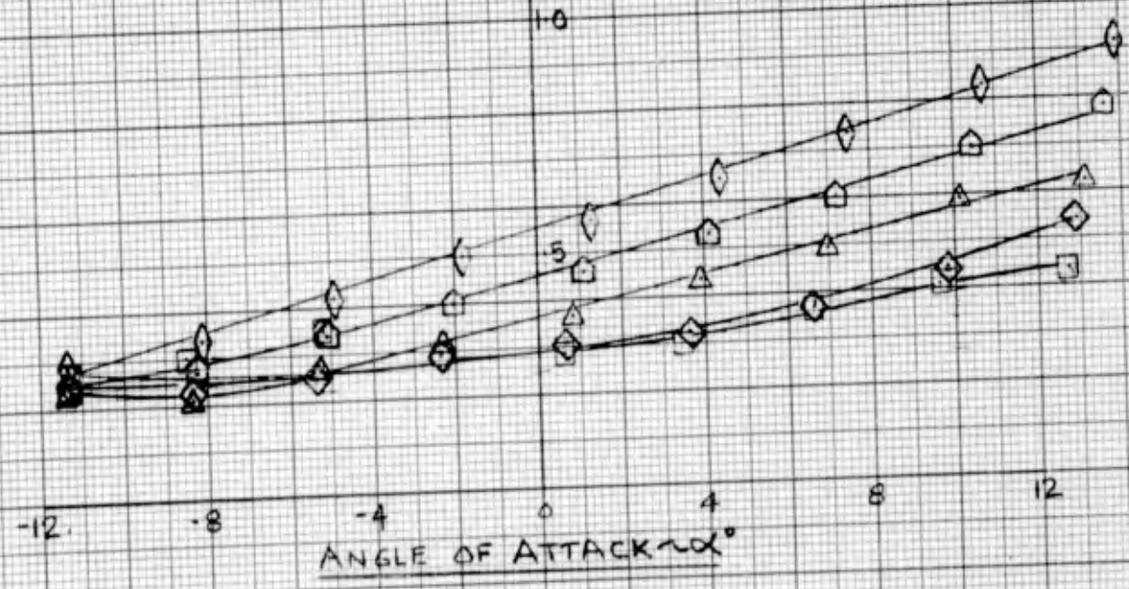


FIG 291

BASIC PLUS INDUCED PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK

(FREE AIR)

TEST S

□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969

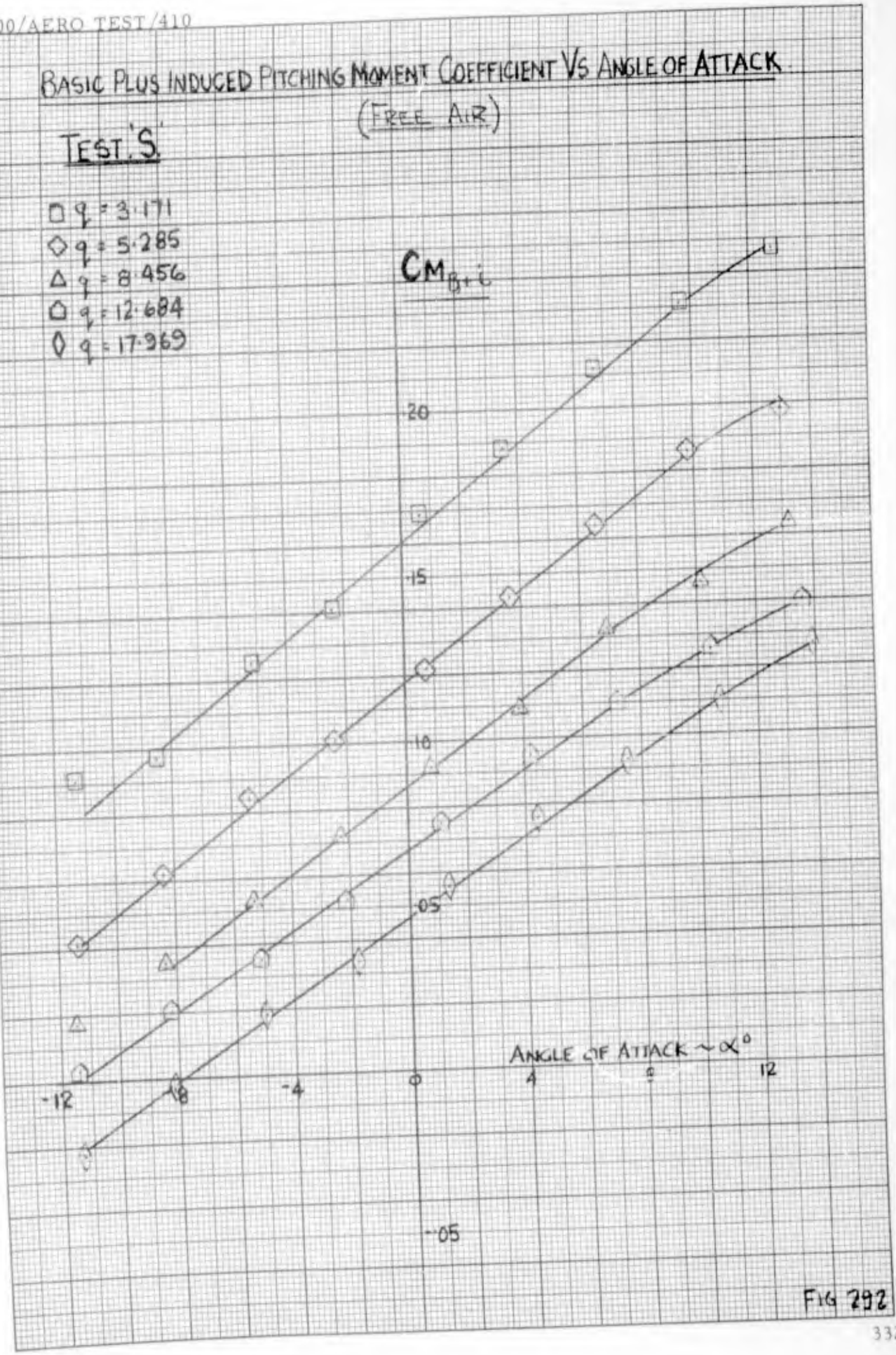


FIG 292

BASIC PLUS INDUCED MOMENT COEFFICIENT VS BASIC PLUS INDUCED LIFT COEFFICIENT.

(FREE AIR)

TEST S

$q = 3.171$
$q = 5.285$
$q = 8.456$
$q = 12.684$
$q = 17.969$

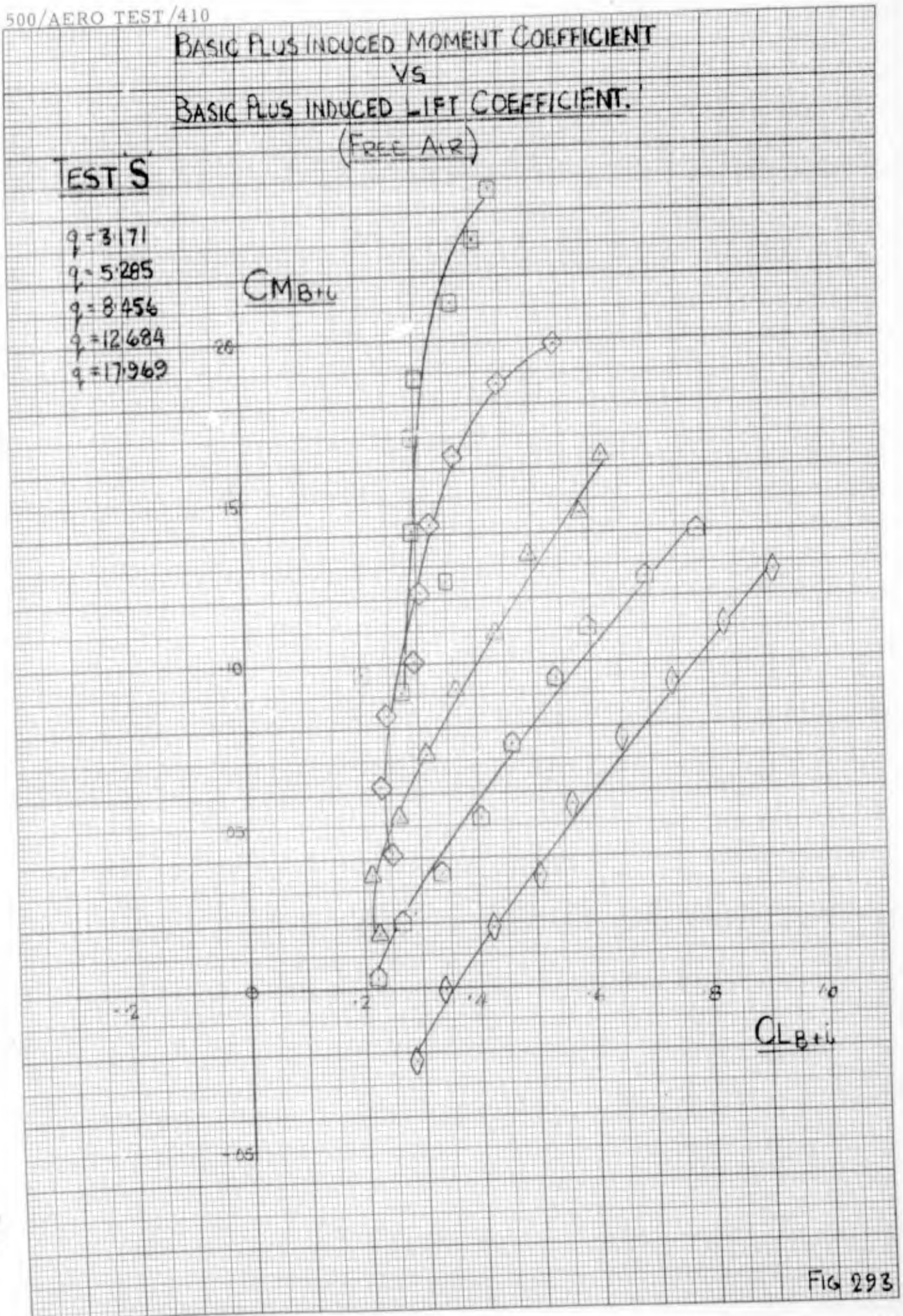


FIG 293

MOMENT COEFFICIENT VS LIFT COEFFICIENT

(FREE AIR)

TEST 'S'

- □ $\frac{1}{2}$ = 3·171
- ◇ $\frac{1}{2}$ = 5·285
- △ $\frac{1}{2}$ = 8·456
- ⬠ $\frac{1}{2}$ = 12·684
- ◊ $\frac{1}{2}$ = 17·969

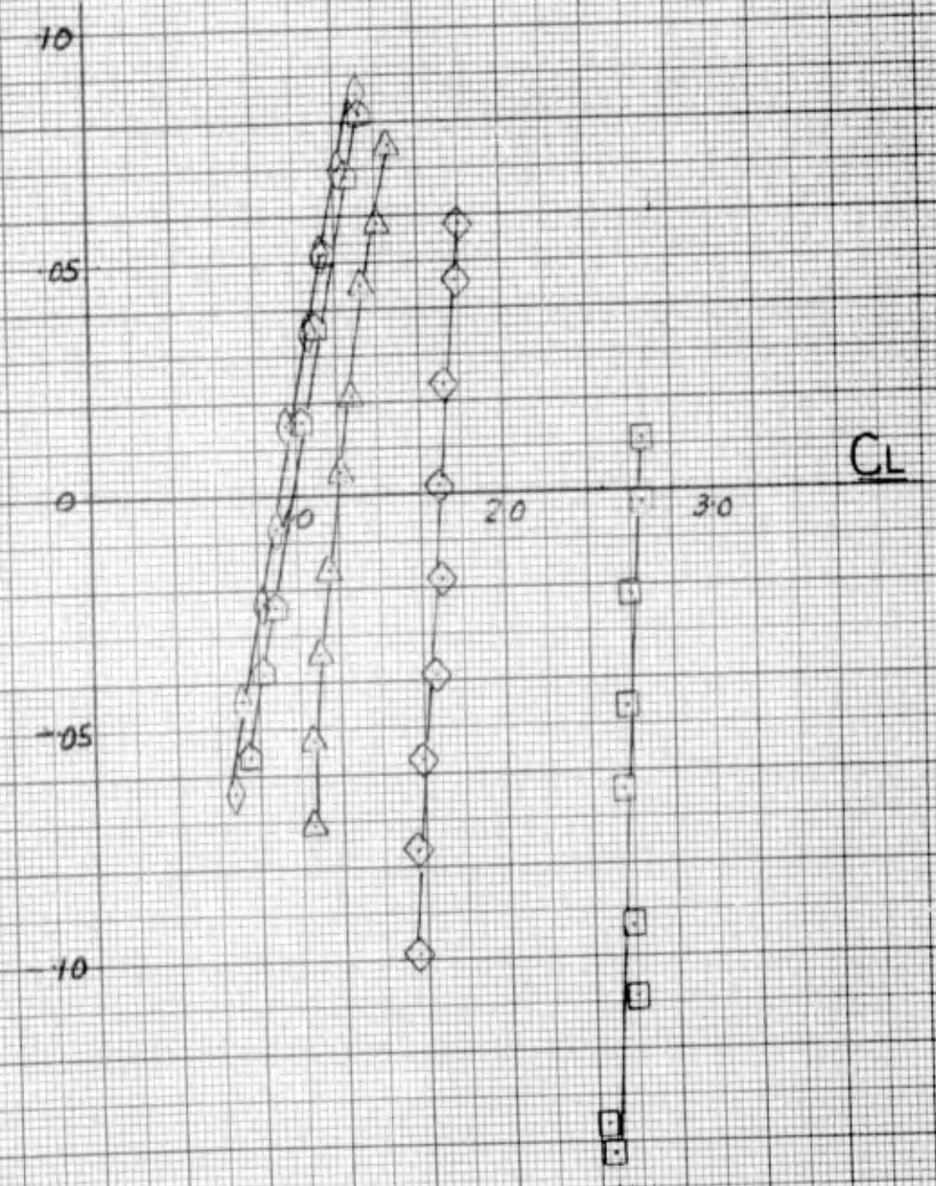


FIG 294

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 5

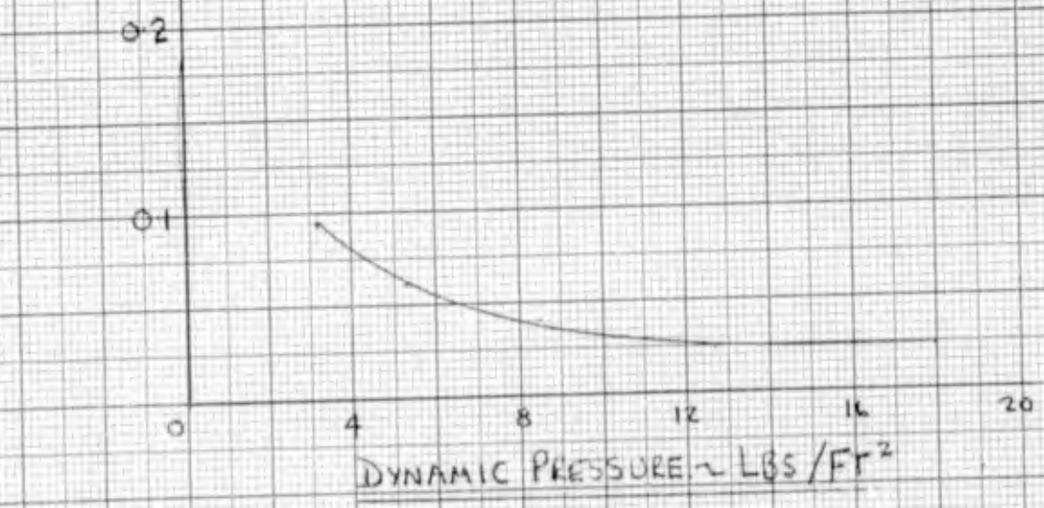


FIG. 295

LIFT CURVE SLOPE VS FORWARD SPEED

TEST S (FREE AIR)

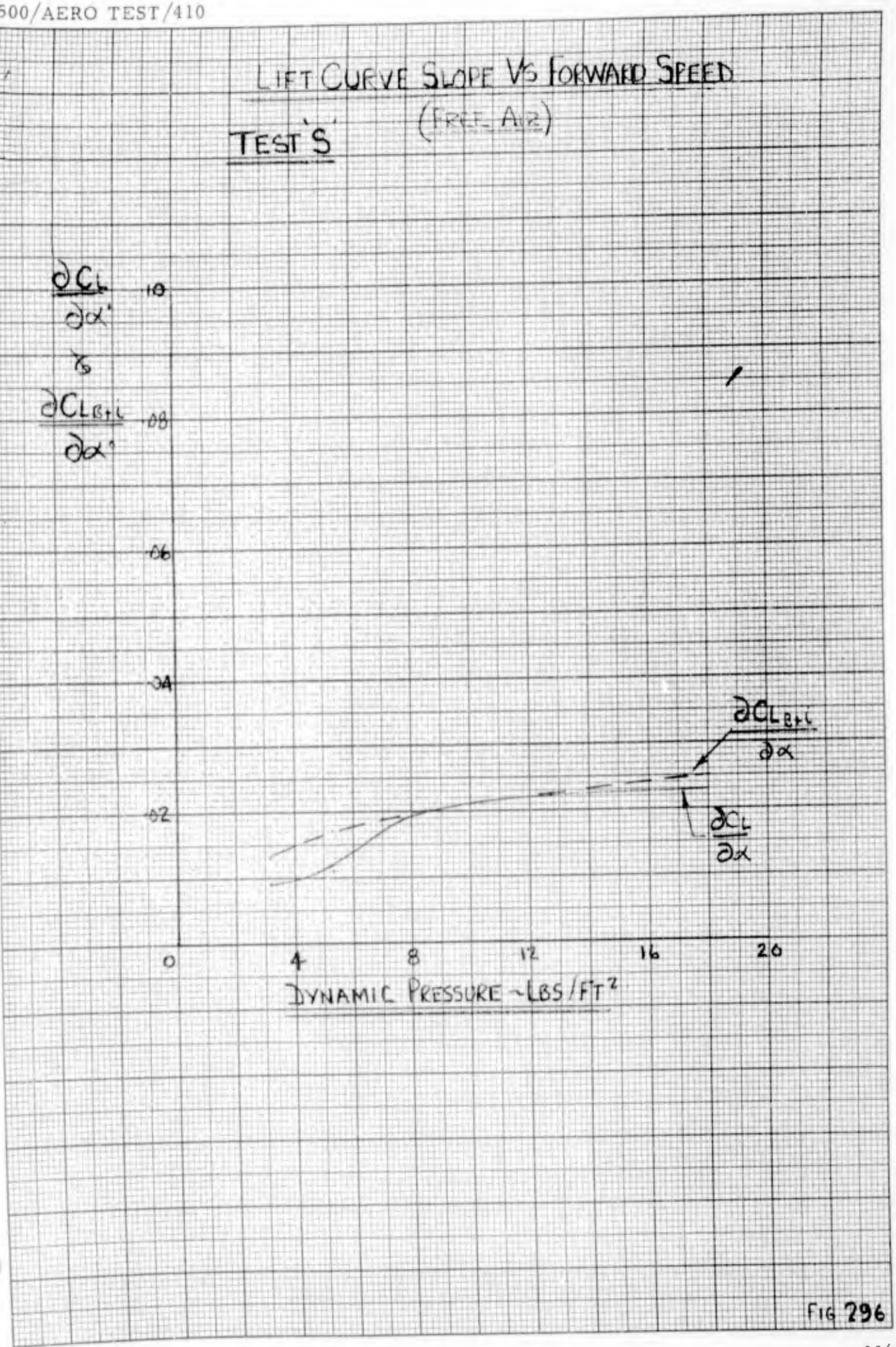


FIG 296

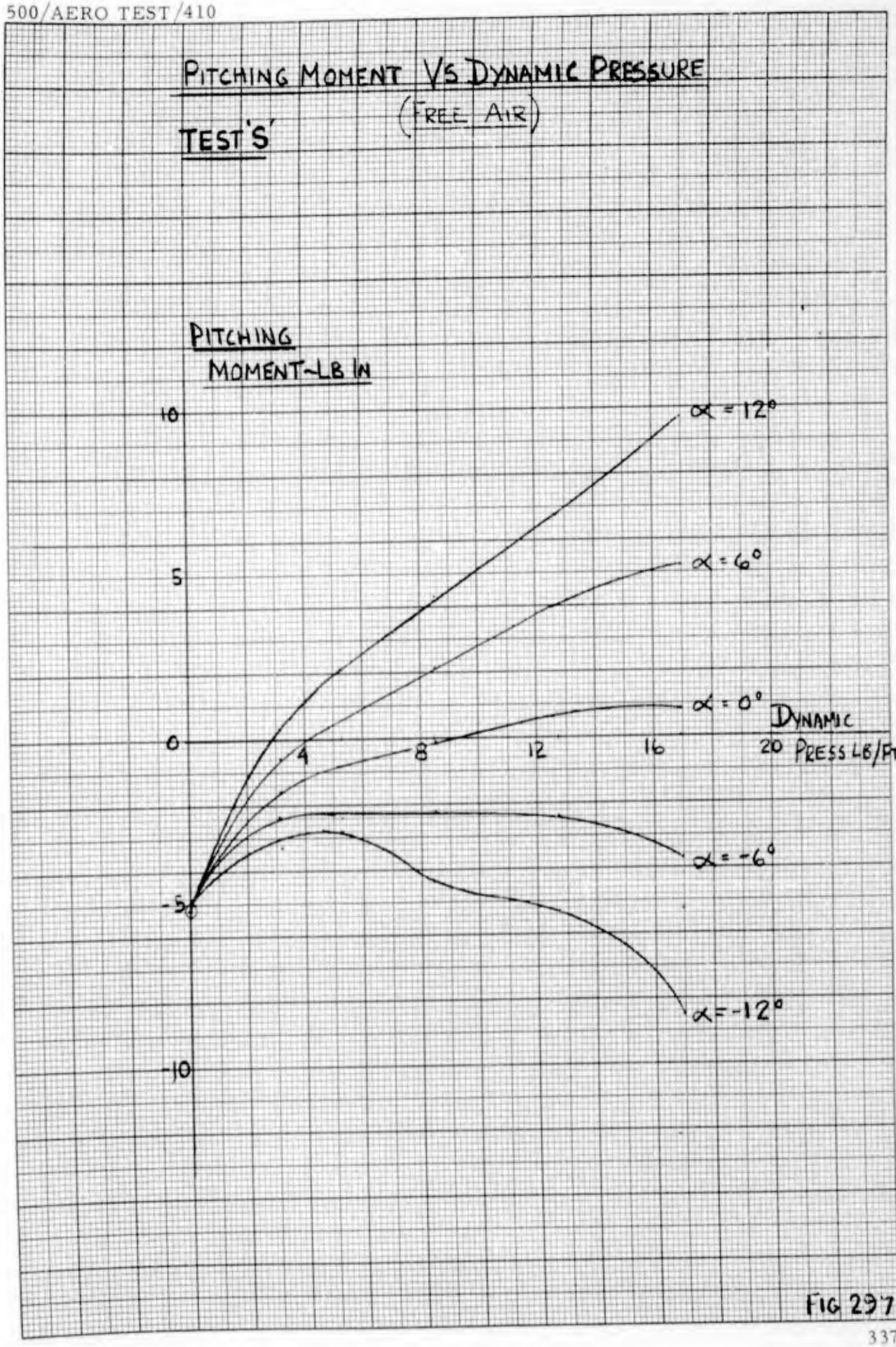

PITCHING MOMENT VS DYNAMIC PRESSURE
(FREE AIR)
TEST'S'
PITCHING MOMENT-LB IN
10
5
0
-5
-10
4
8
12
16
20
DYNAMIC PRESS LB/FT²
α = 12°
α = 6°
α = 0°
α = -6°
α = -12°

FIG 297

LIFT VS. ANGLE OF ATTACK.

(FREE AIR)

TEST 'T'

- ○ q = 0
- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ⬠ q = 12.684
- ◊ q = 11.969

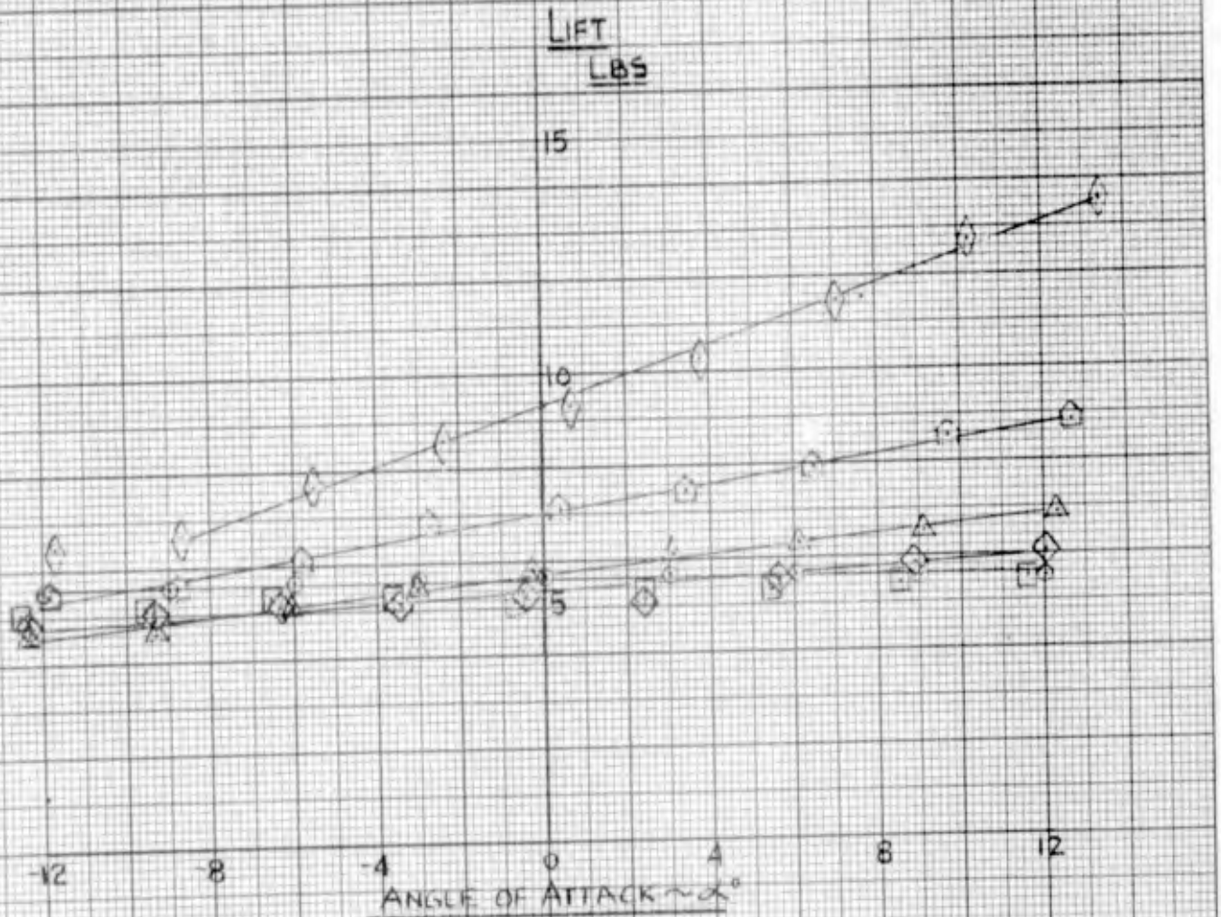


FIG 298

DRAG VS ANGLE OF ATTACK.

(FREE AIR)

TEST T

- ○ q = 0
- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ⬠ q = 12.684
- ◊ q = 17.969

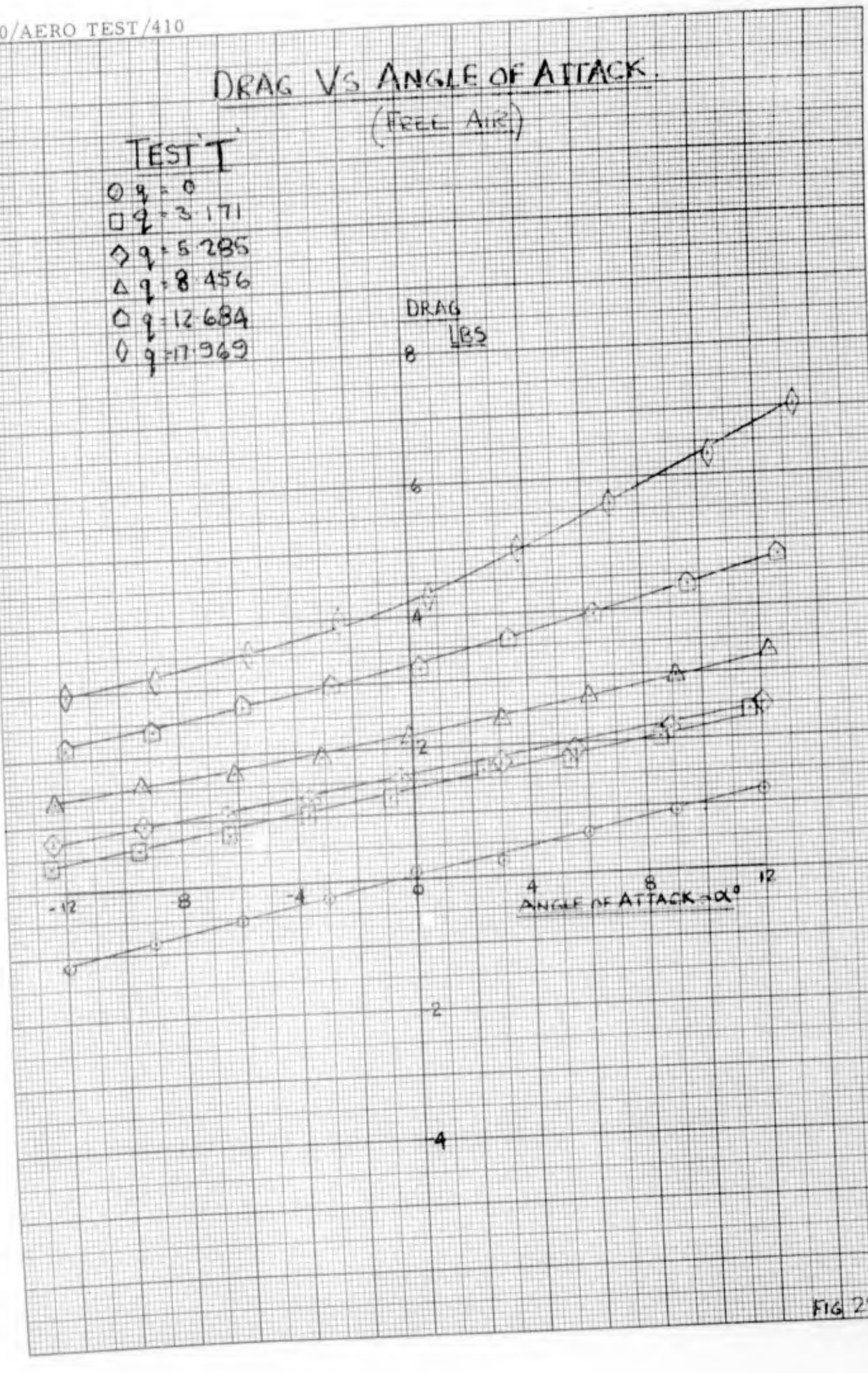


FIG 299

PITCHING MOMENT VS ANGLE OF ATTACK.

(FREE AIR)

TEST 'T'

- ○ q = 0
- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ○ q = 12.684
- ◇ q = 17.969

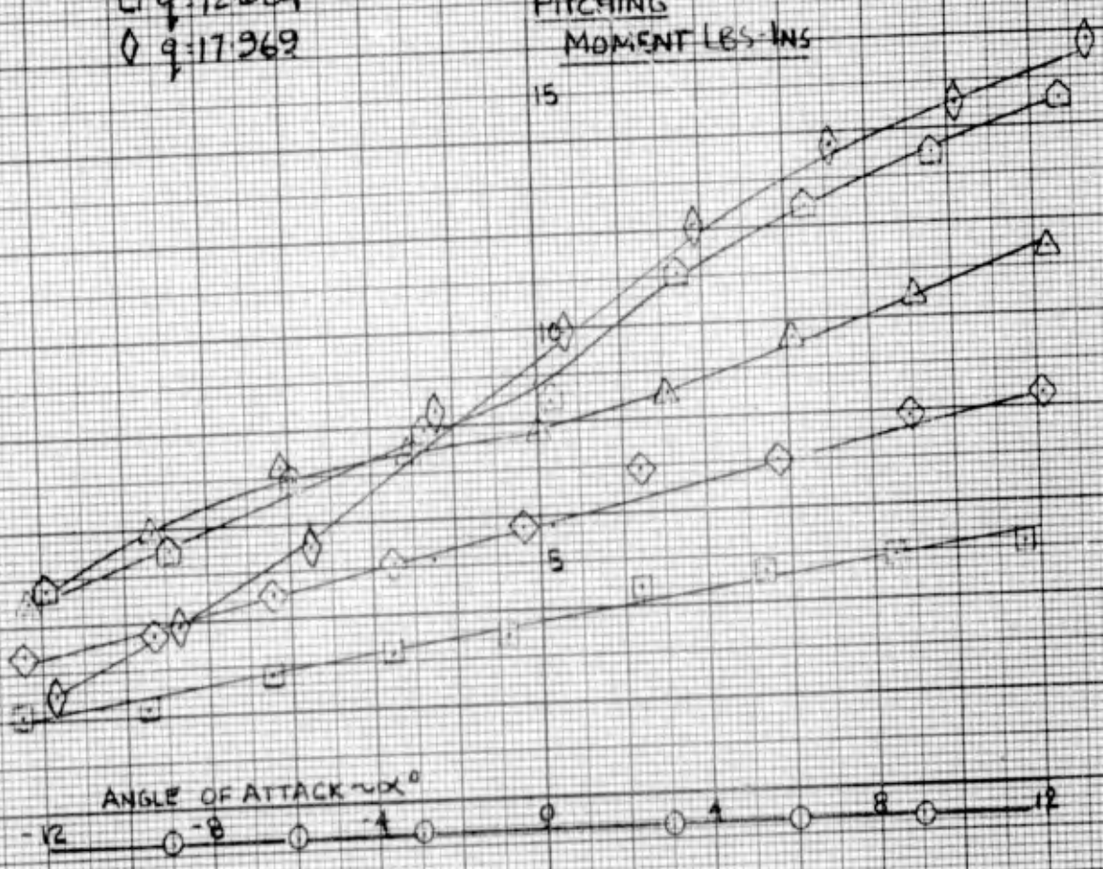


FIG 300

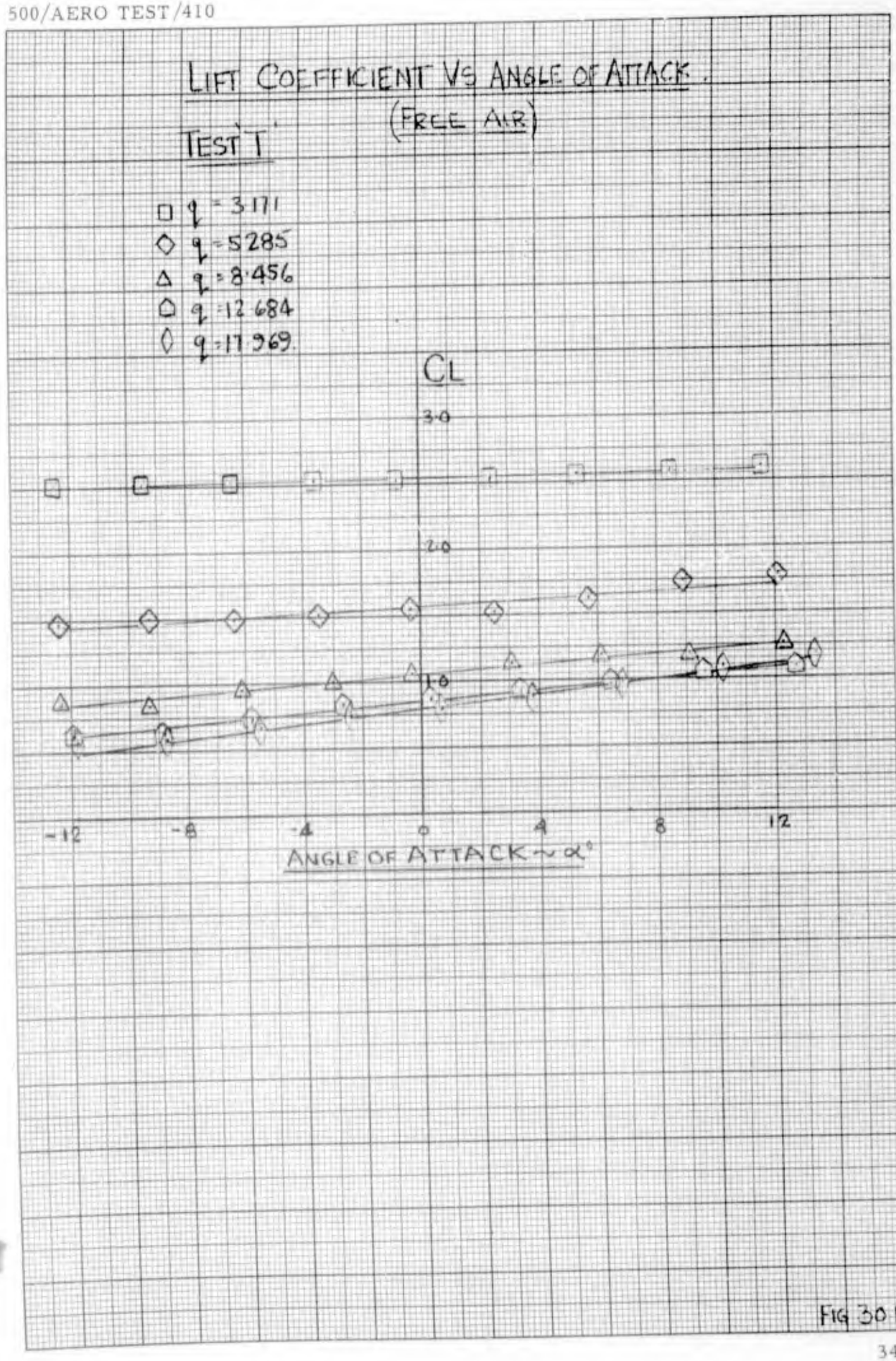

LIFT COEFFICIENT VS ANGLE OF ATTACK.
(FREE AIR)
TEST T
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
CL
3.0
2.0
1.0
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 30.1

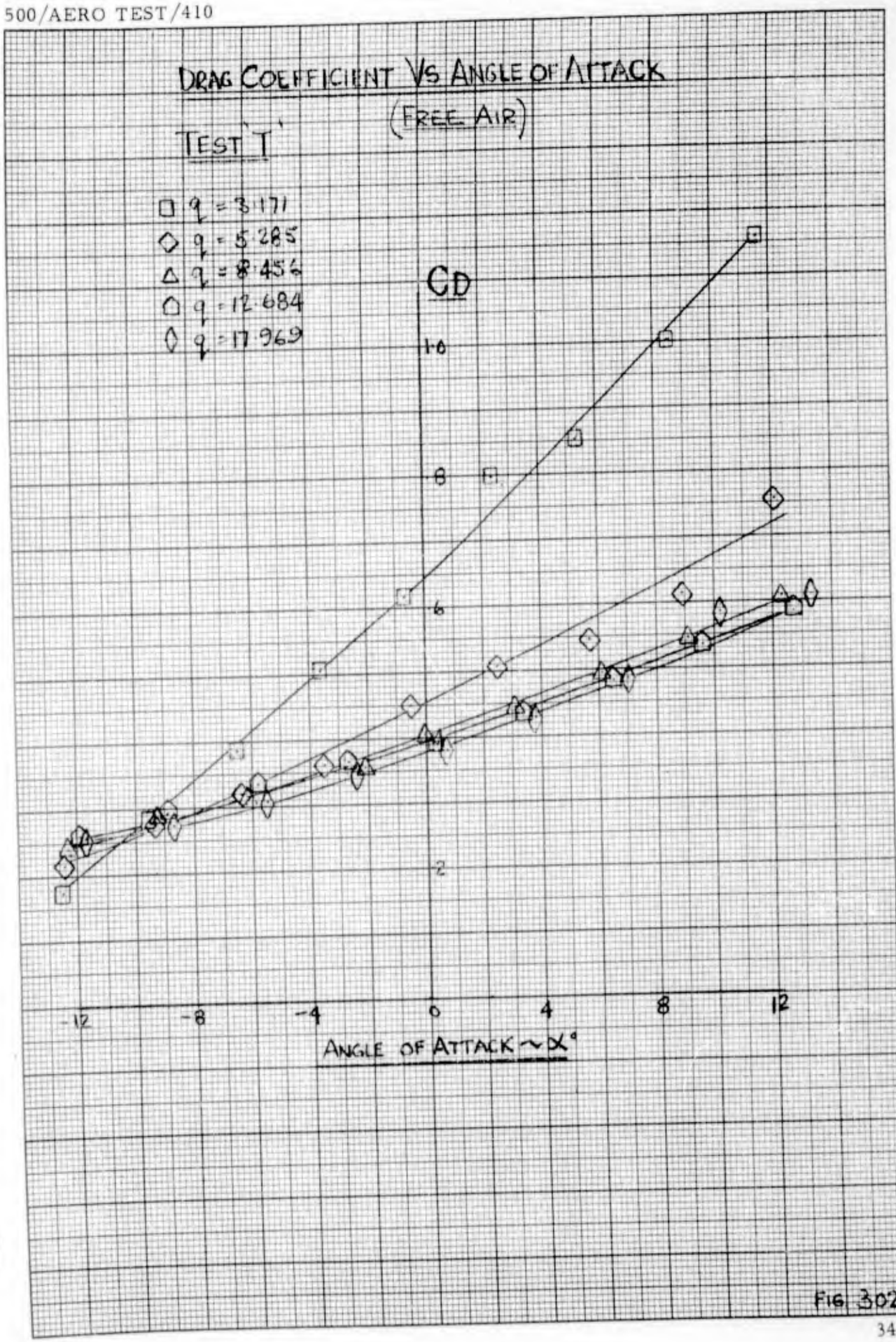

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'T'
□ q = 3.171
◇ q = 5.285
△ q = 8.454
⬠ q = 12.684
◊ q = 17.969
CD
10
8
6
2
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 302

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK.

(FREE AIR)

TEST T

□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·062

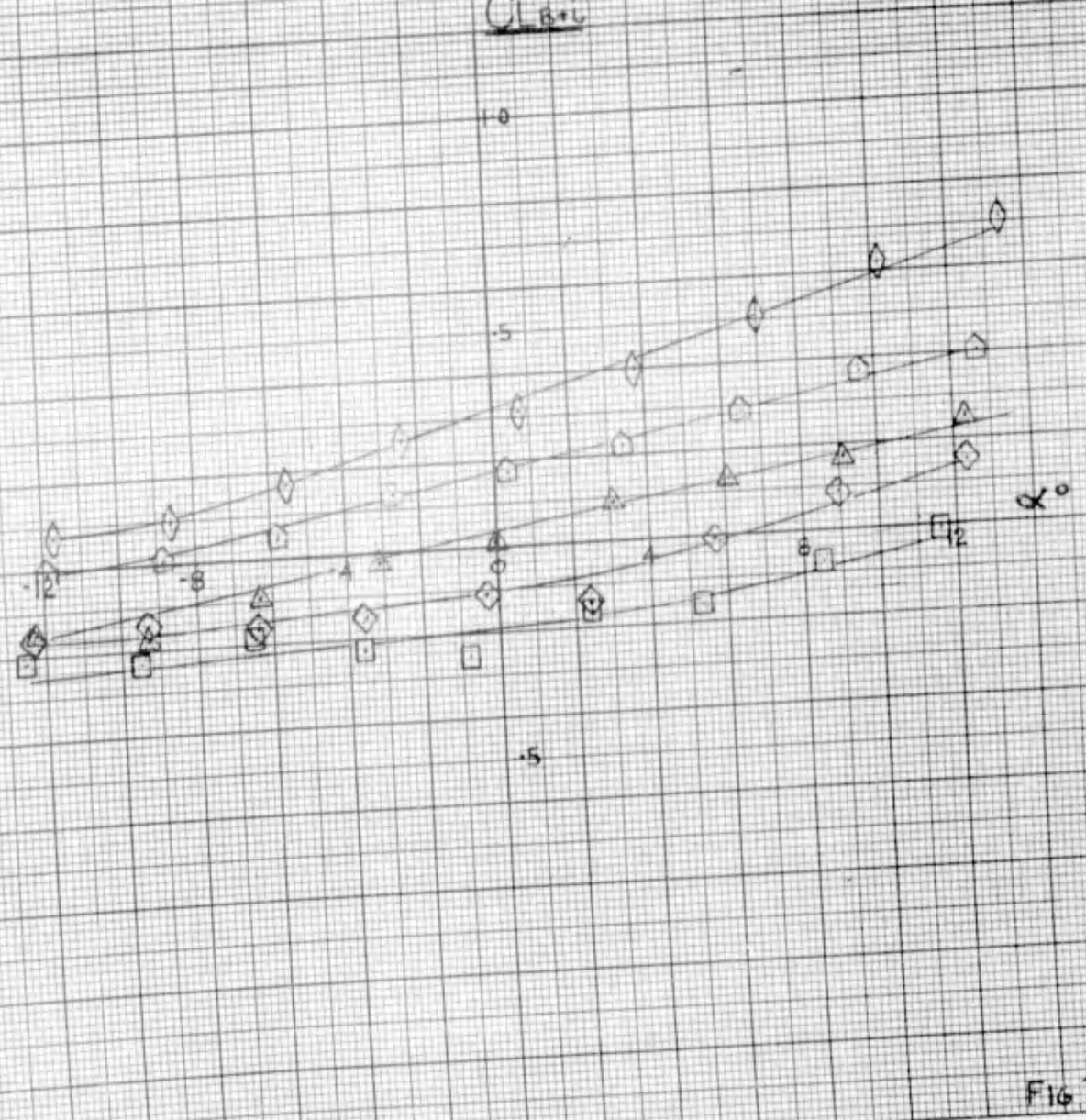


Fig 303

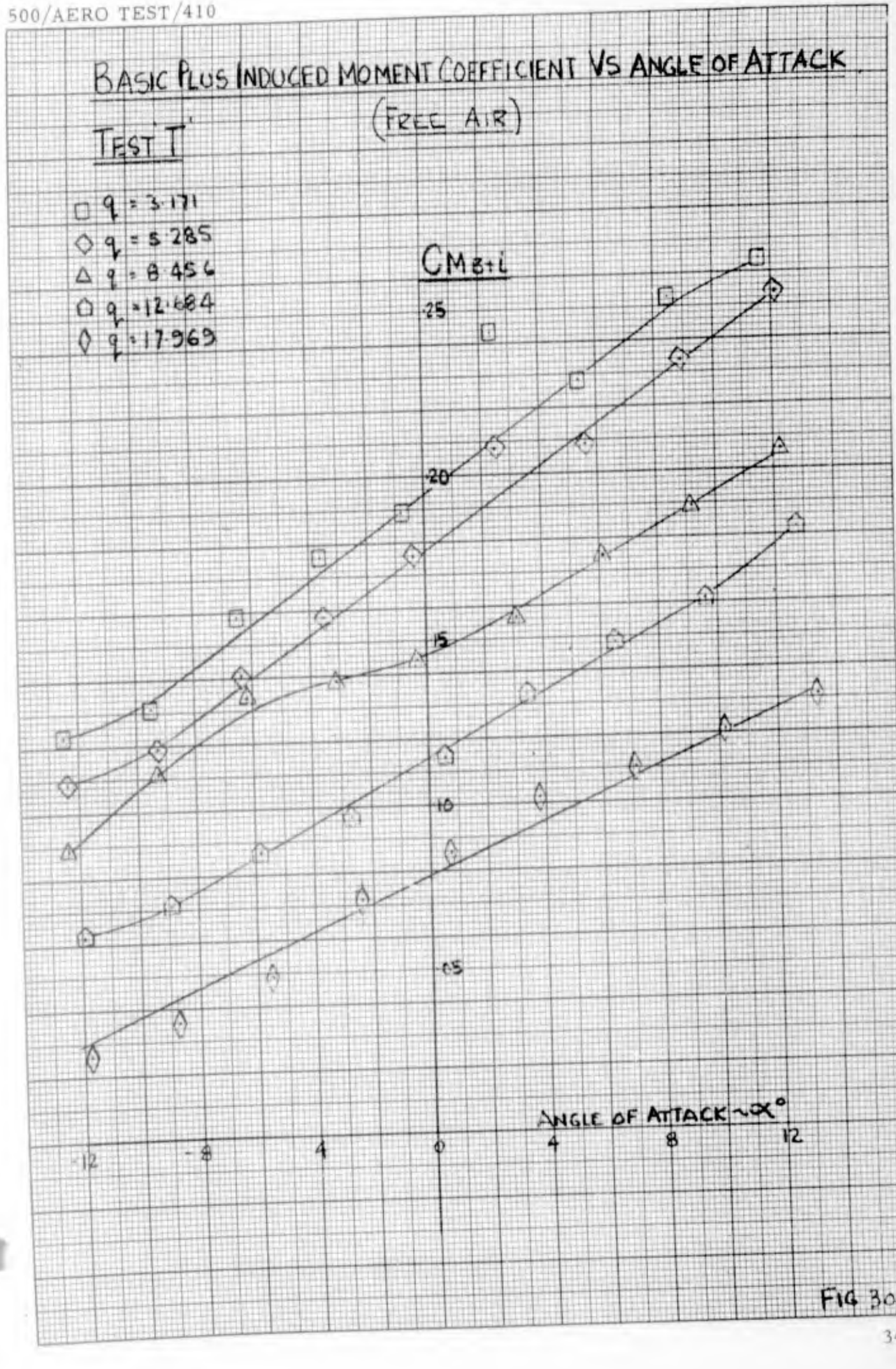

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST T'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
CMB+L
·25
·20
·15
·10
·05
ANGLE OF ATTACK ~α°
-12
-8
4
0
4
8
12

FIG 304

BASIC PLUS INDUCED AERODYNAMIC MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED AERODYNAMIC LIFT COEFFICIENT
(FREE AIR)

TEST 'T'

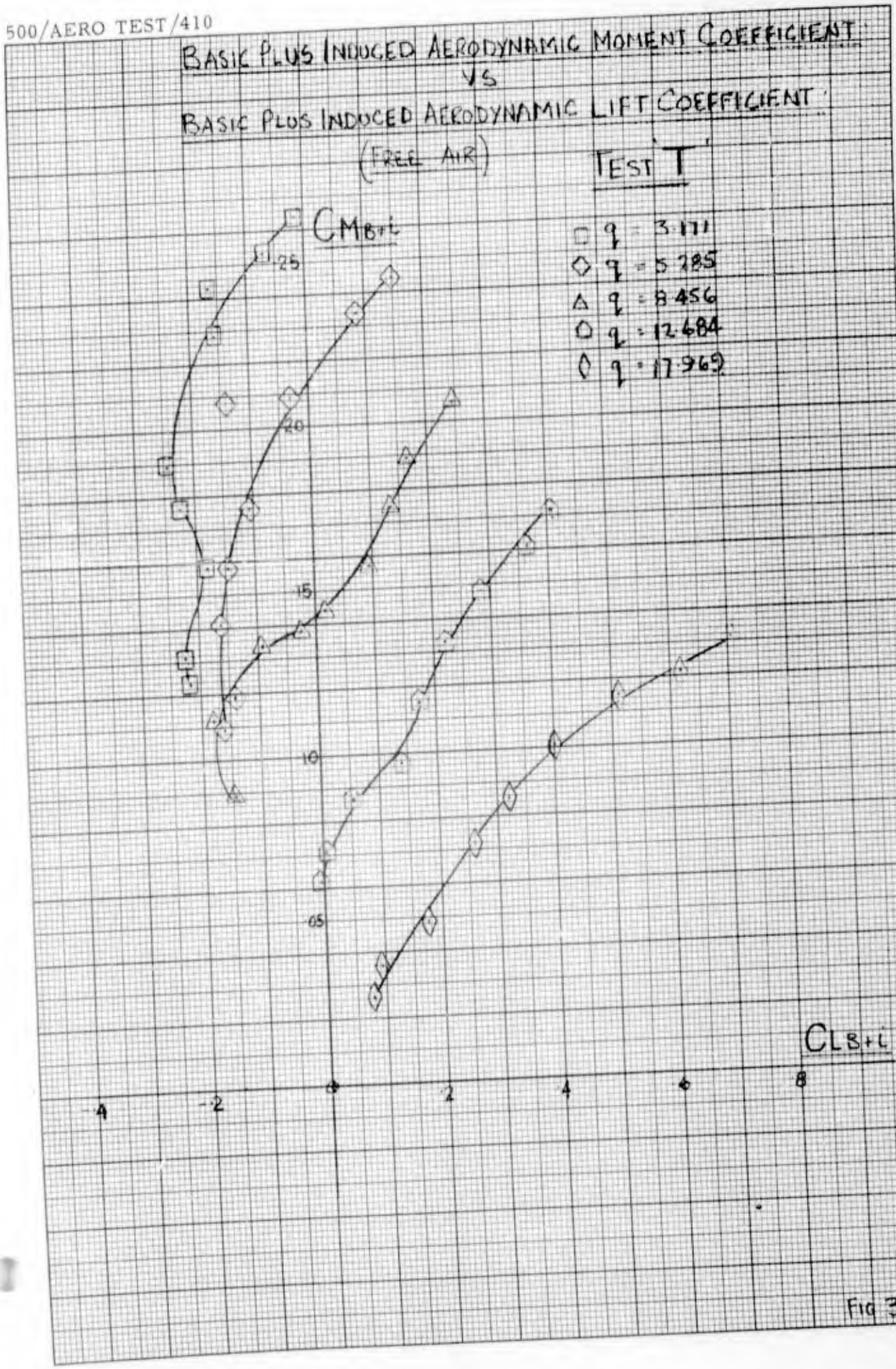


Fig 305

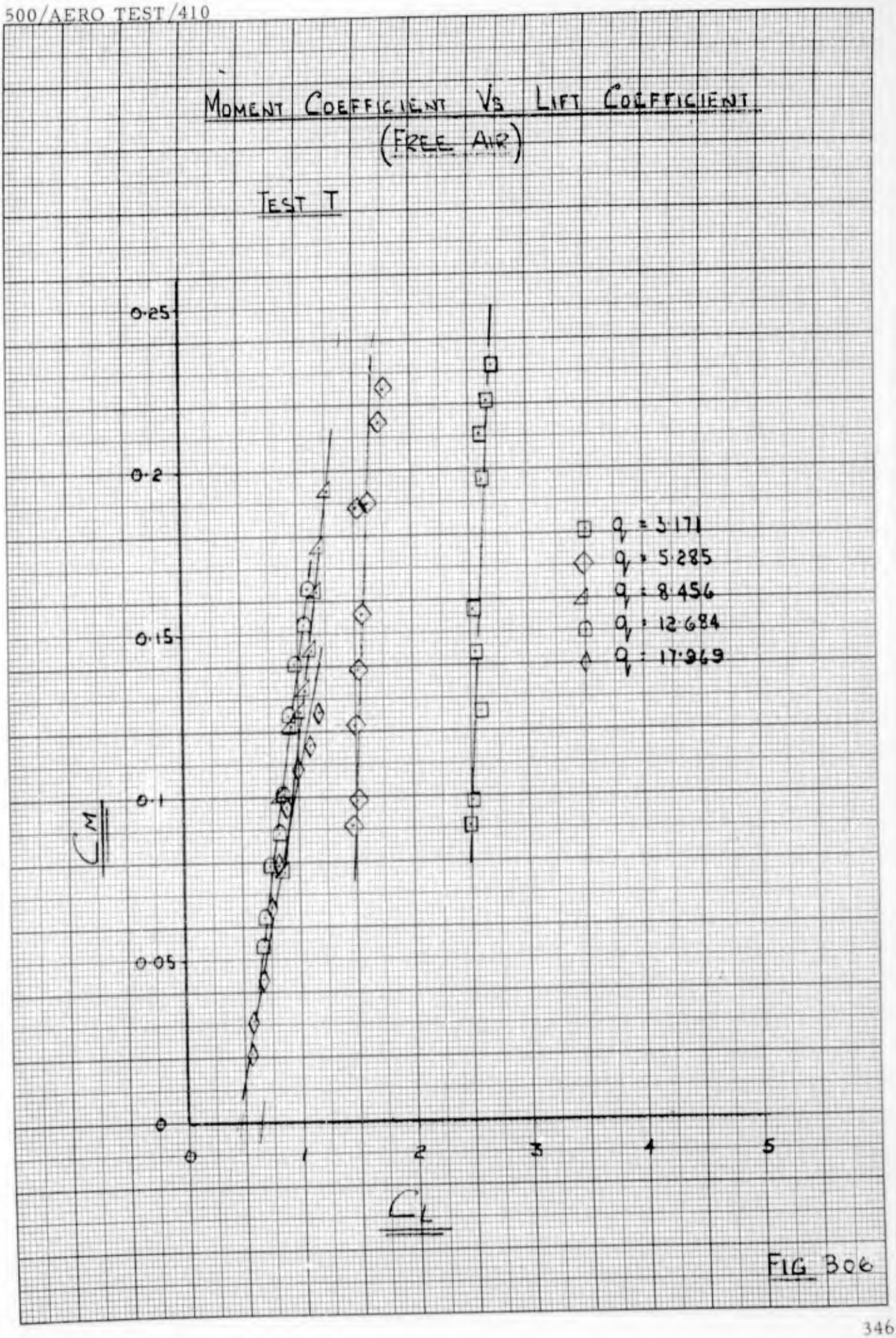

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST T
0·25
0·2
0·15
0·1
0·05
0
C_M
0
1
2
3
4
5
C_L
q_v = 3·171
q_v = 5·285
q_v = 8·456
q_v = 12·684
q_v = 17·969

FIG 306

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 'T'

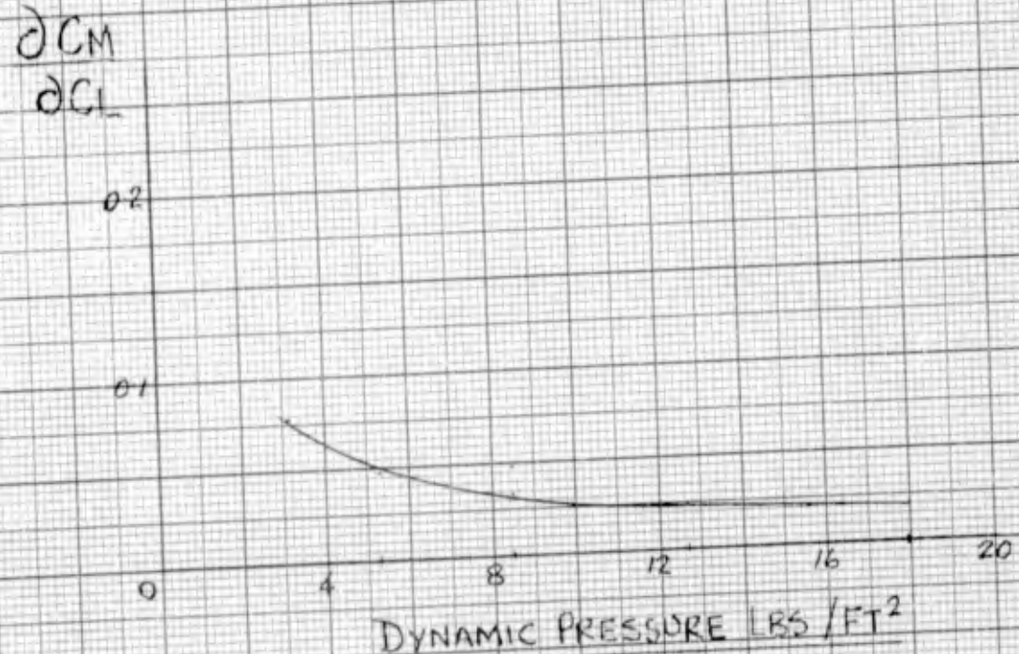


FIG 307

LIFT CURVE SLOPE VS FORWARD SPEED

(FREE AIR)

TEST T

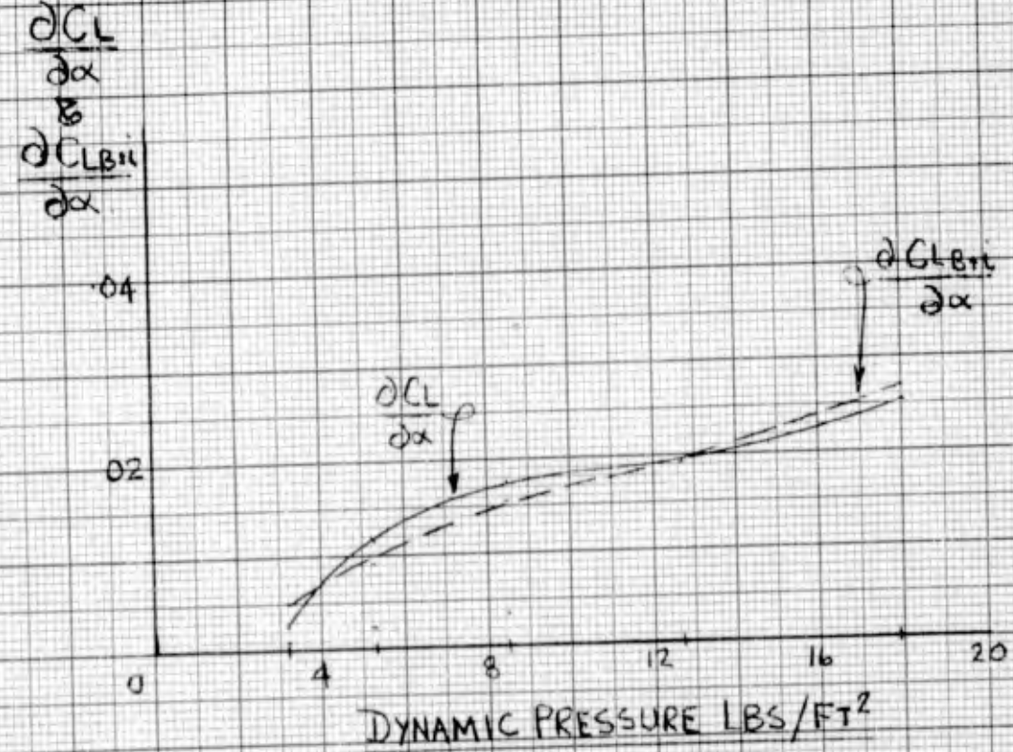


FIG. 308

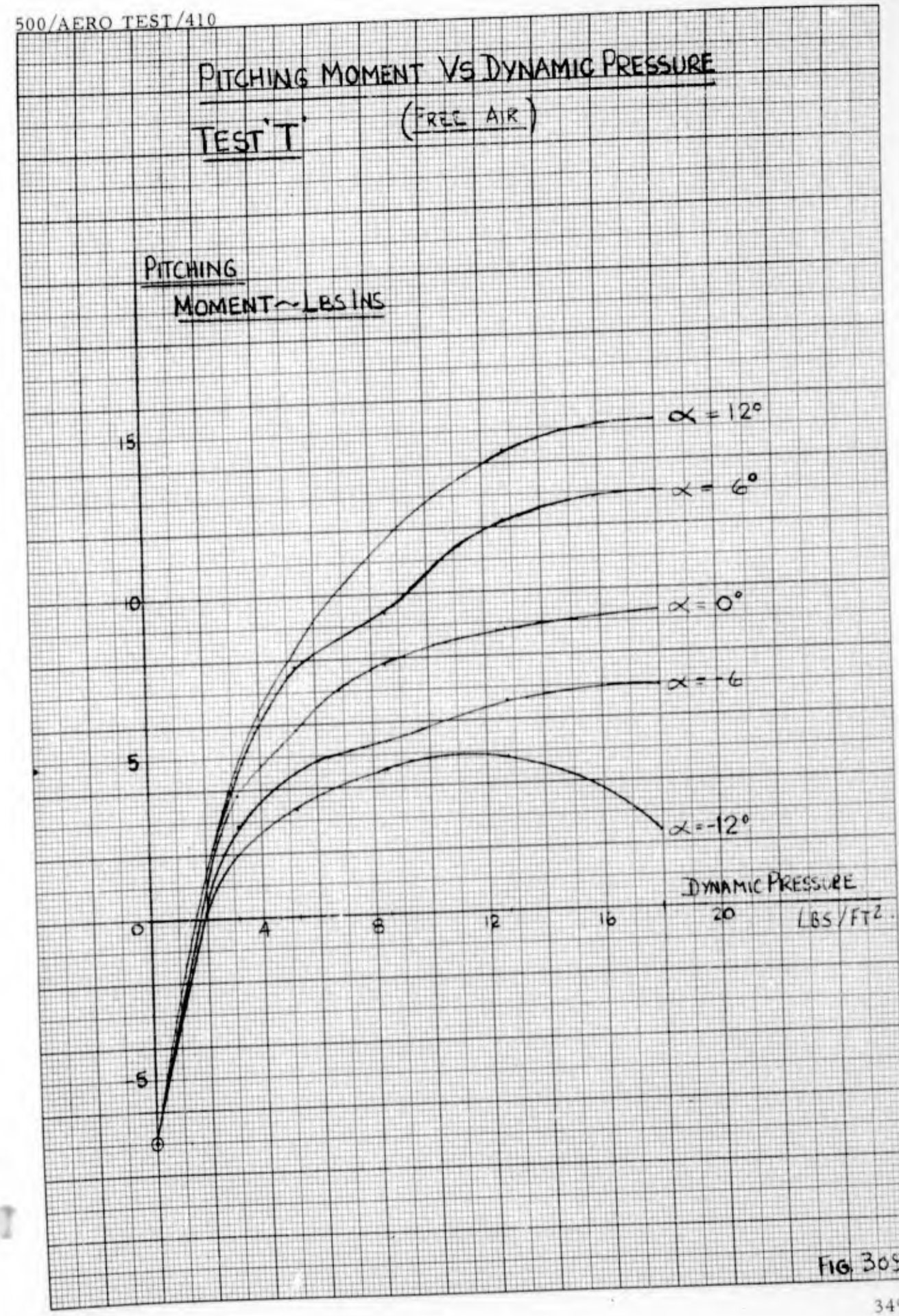

PITCHING MOMENT VS DYNAMIC PRESSURE
TEST 'T' (FREE AIR)
PITCHING MOMENT ~ LBS INS
15
10
5
0
-5
4
8
12
16
20
DYNAMIC PRESSURE LBS/FT²
α = 12°
α = 6°
α = 0°
α = -6
α = -12°

FIG. 309

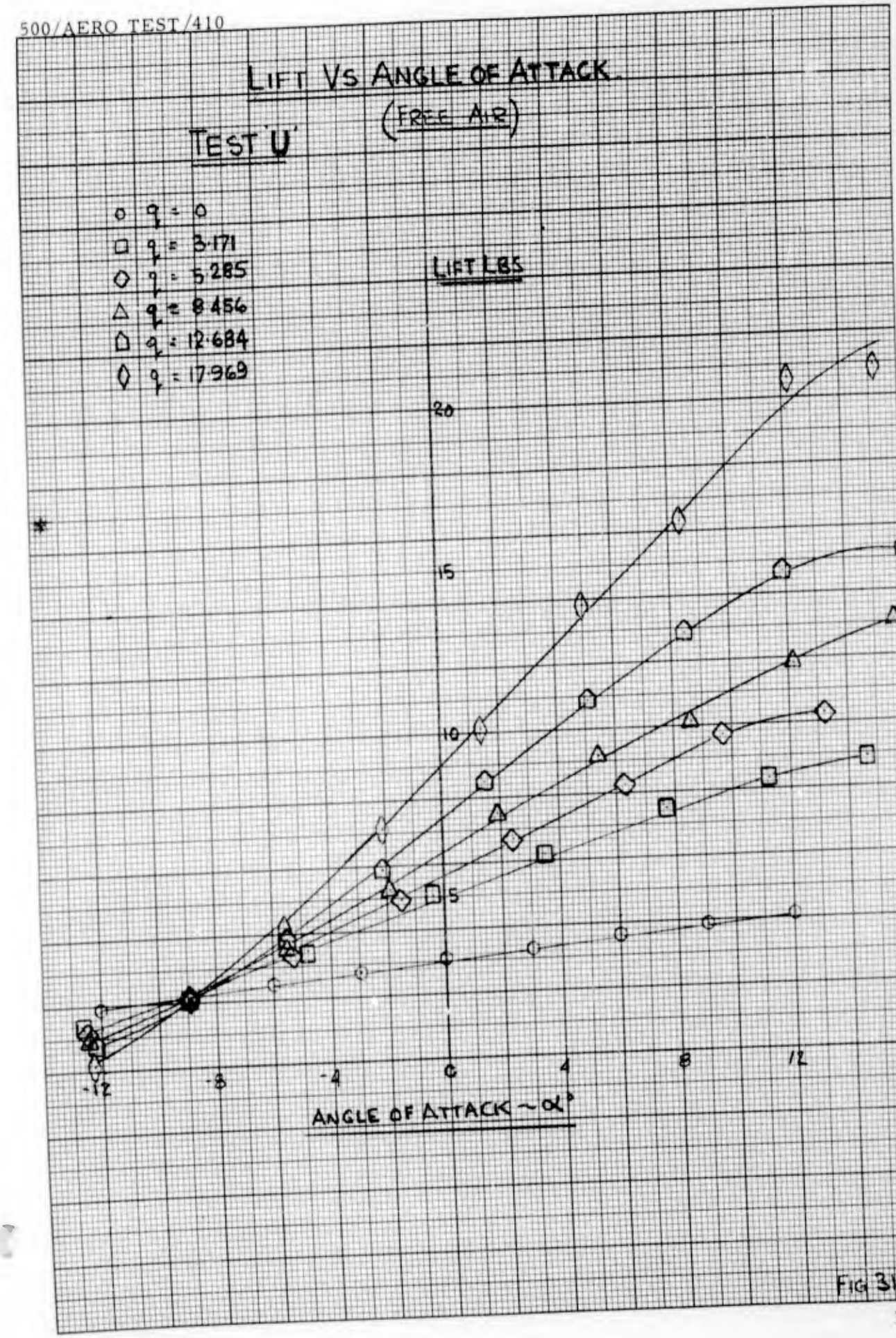

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
o q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 12.684
◊ q = 17.969
LIFT LBS
20
15
10
5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG 310

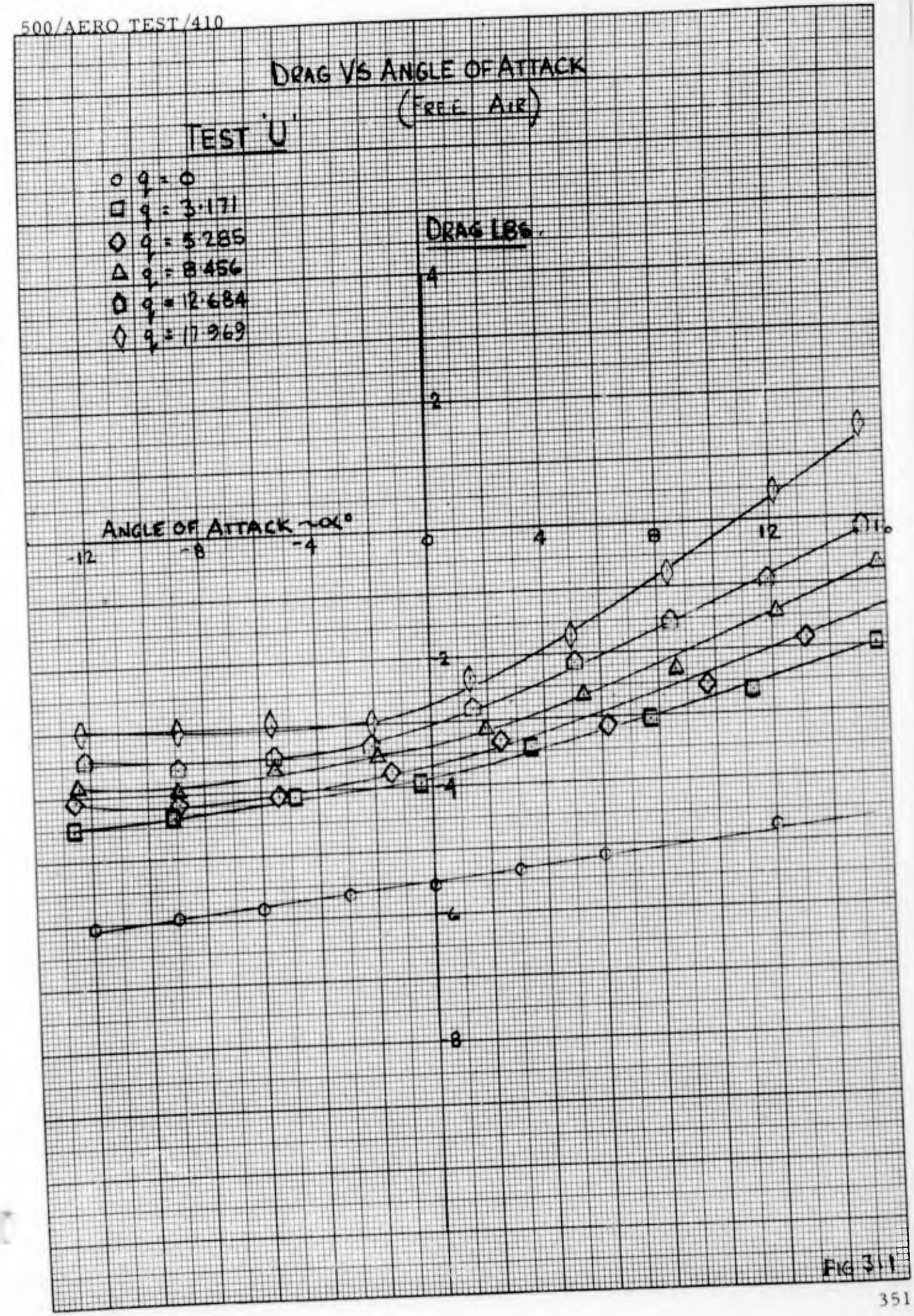

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
q = 0
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
DRAG LBS.
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
16
2
4
6
8

FIG 311

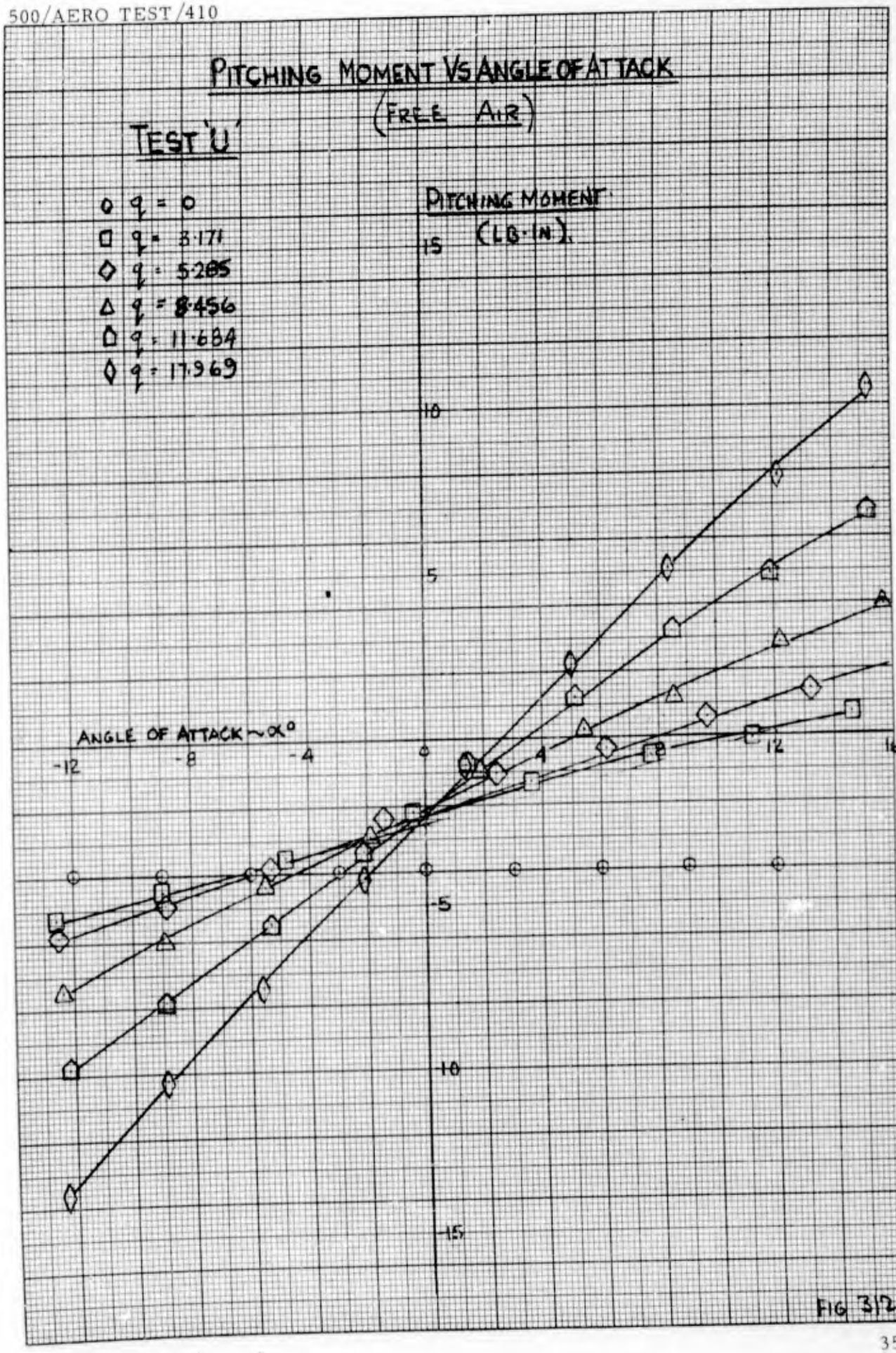

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
○ q = 0
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬠ q = 11.684
◊ q = 17.969
PITCHING MOMENT
(LB·IN).
15
10
5
-5
-10
-15
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
16

FIG 312

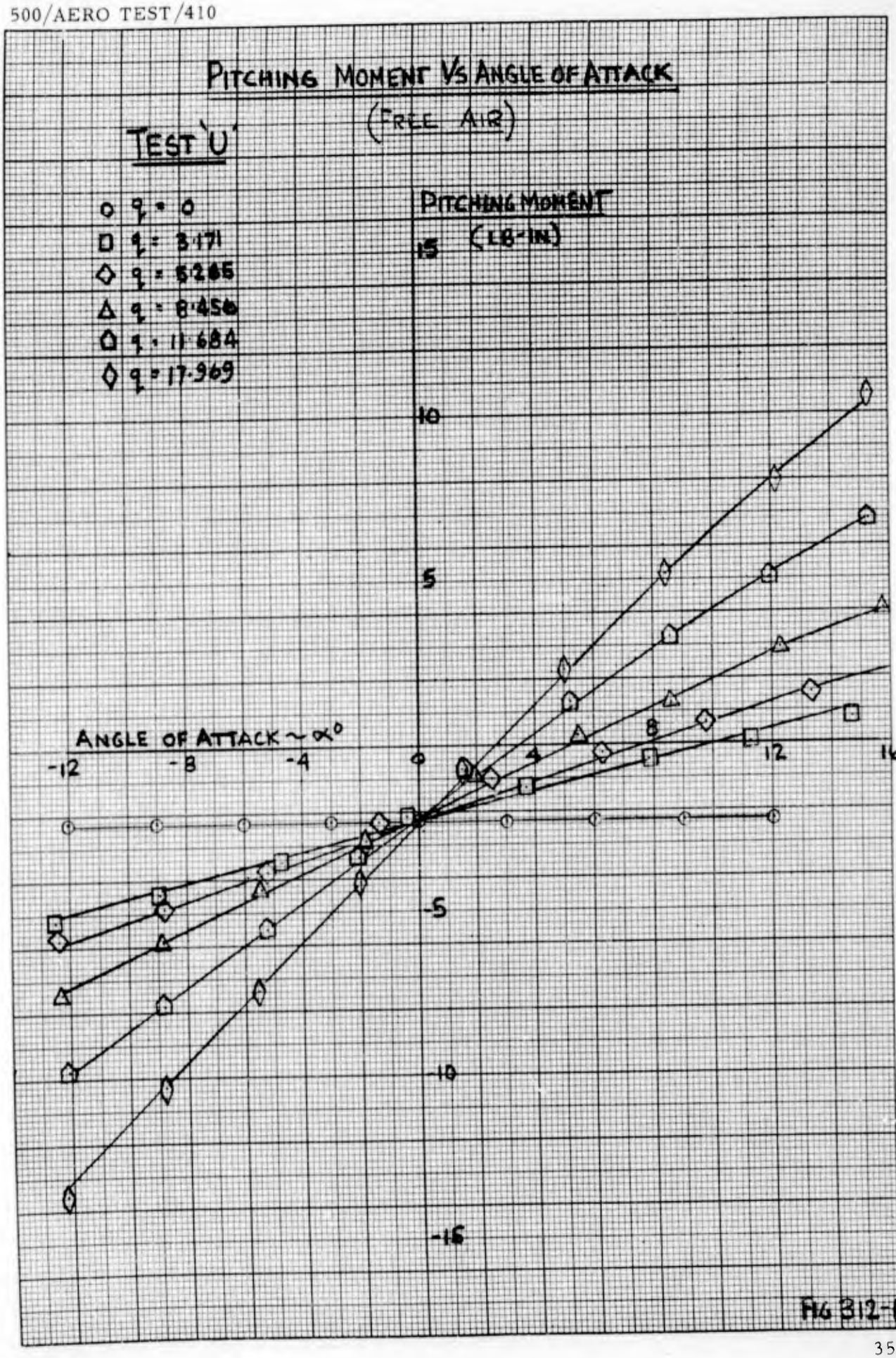

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 11·684
◊ q = 17·969
PITCHING MOMENT
(LB-IN)
15
10
5
-5
-10
-15
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 312-1

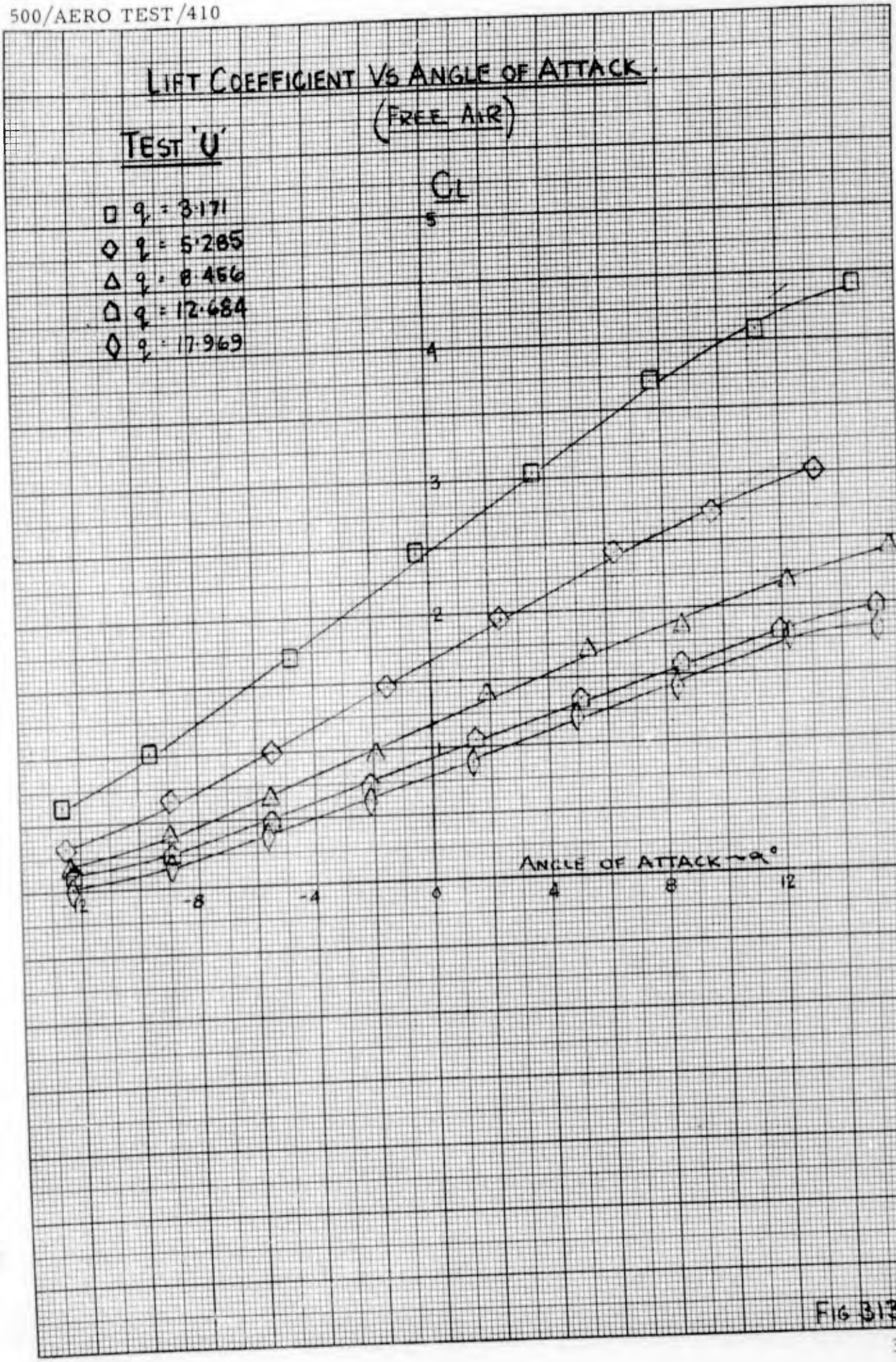

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
□ q = 3·171
◇ q = 5·285
△ q = 8·466
⌂ q = 12·484
◊ q = 17·969
CL
5
4
3
2
1
½
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG 313

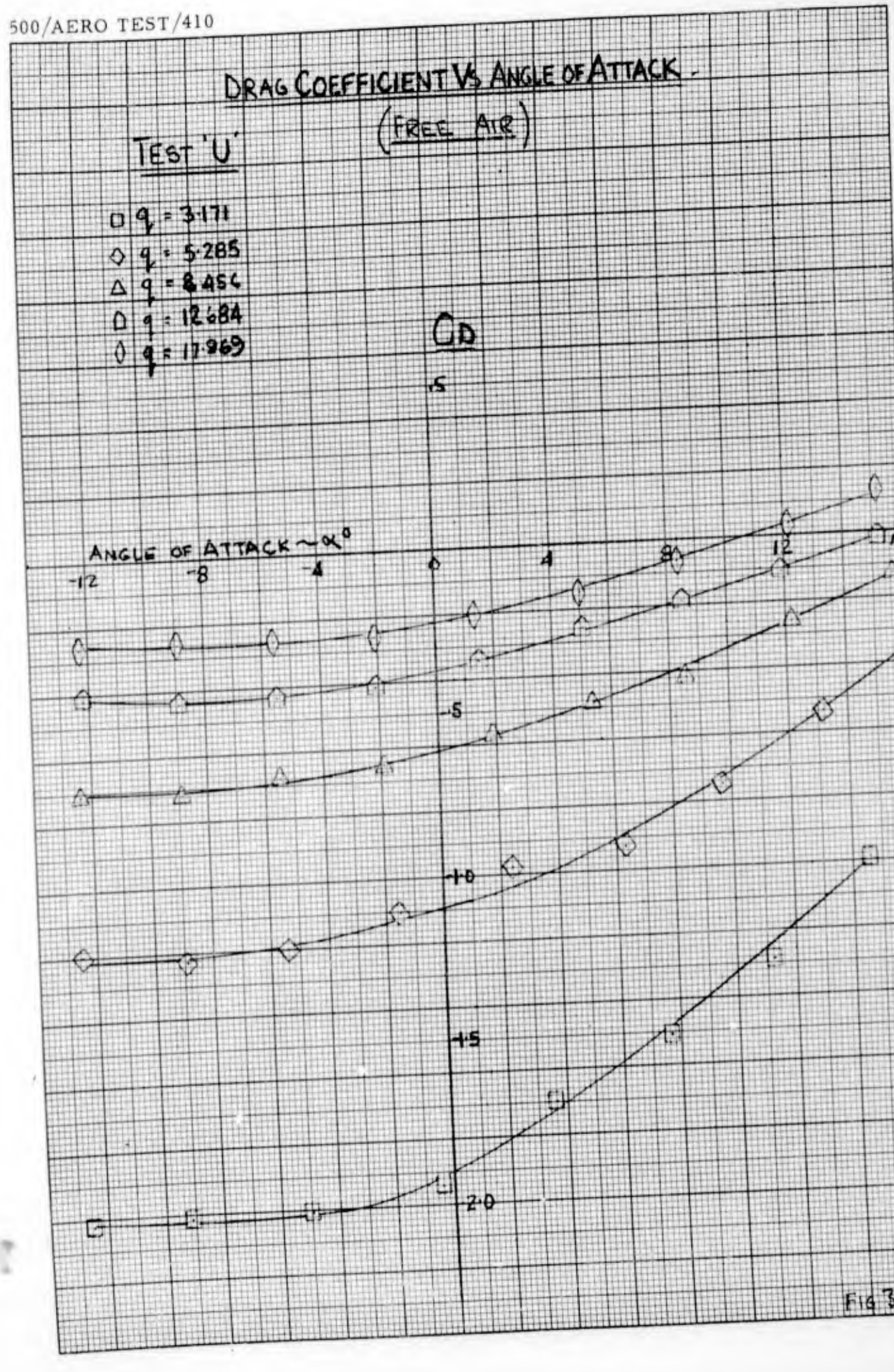

DRAG COEFFICIENT VS ANGLE OF ATTACK -
(FREE AIR)
TEST 'U'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
○ q = 12·684
◊ q = 17·969
CD
·5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16
-5
-10
-15
-20

Fig 314

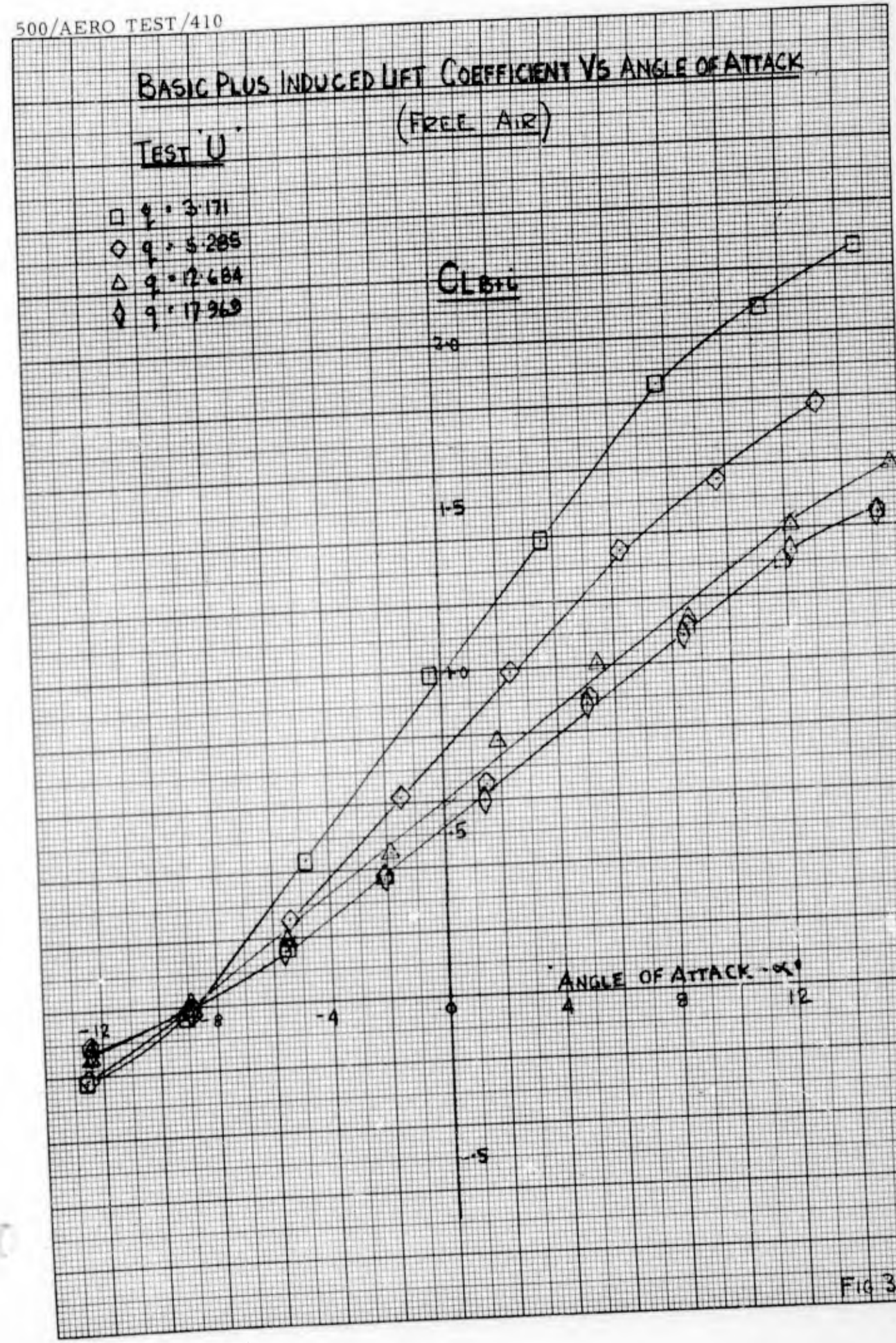

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST "U"
q = 3.171
q = 5.285
q = 12.684
q = 17.969
CL BTG
2.0
1.5
1.0
.5
-.5
ANGLE OF ATTACK - α°
-12
-8
-4
4
8
12
16

Fig 3.5

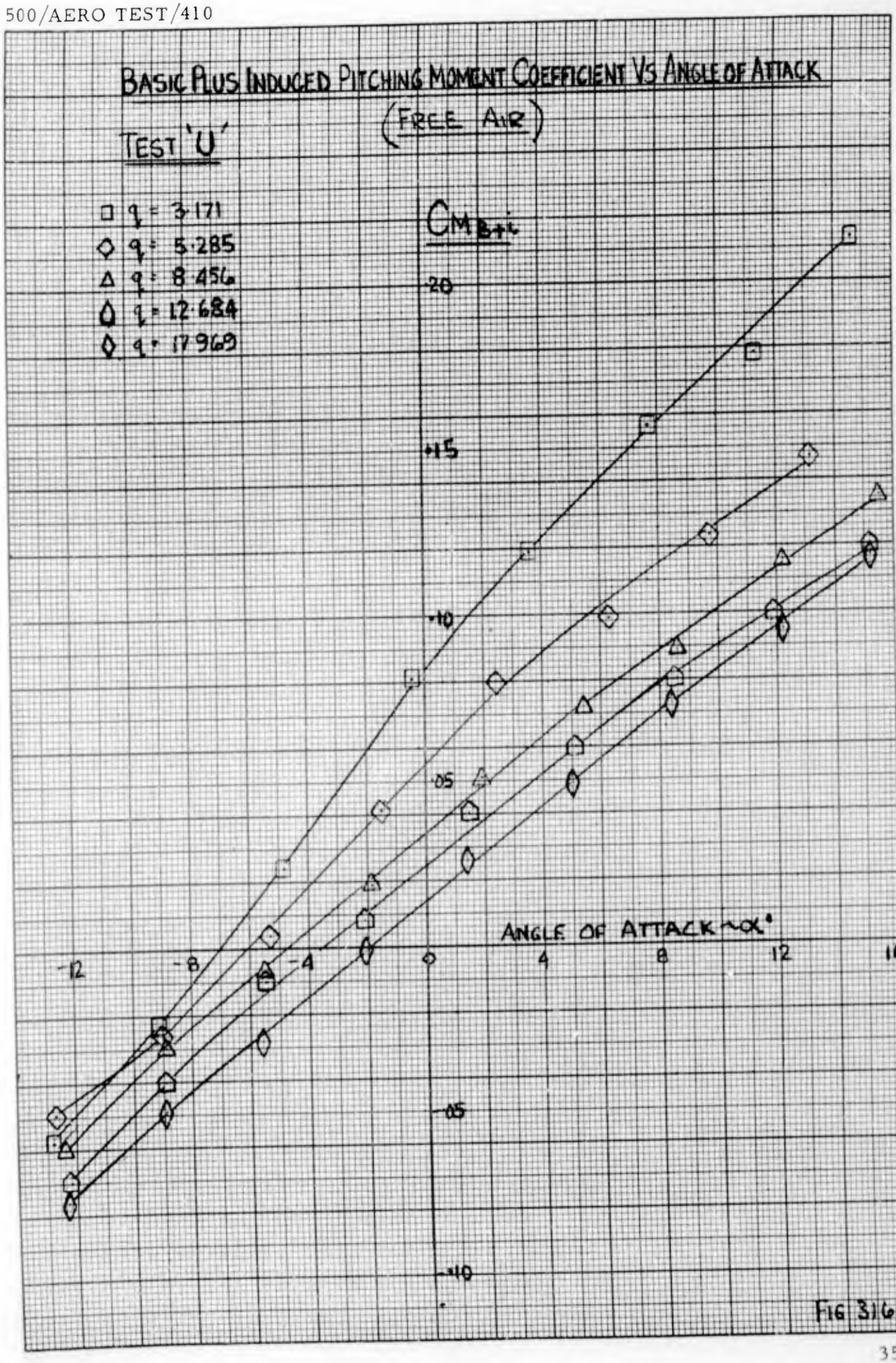

BASIC PLUS INDUCED PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
□ q = 3·171
◇ q = 5·285
△ q = 8·456
○ q = 12·684
◇ q = 17·969
CM B+i
·20
·15
·10
·05
-·05
-·10
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
16

FIG 316

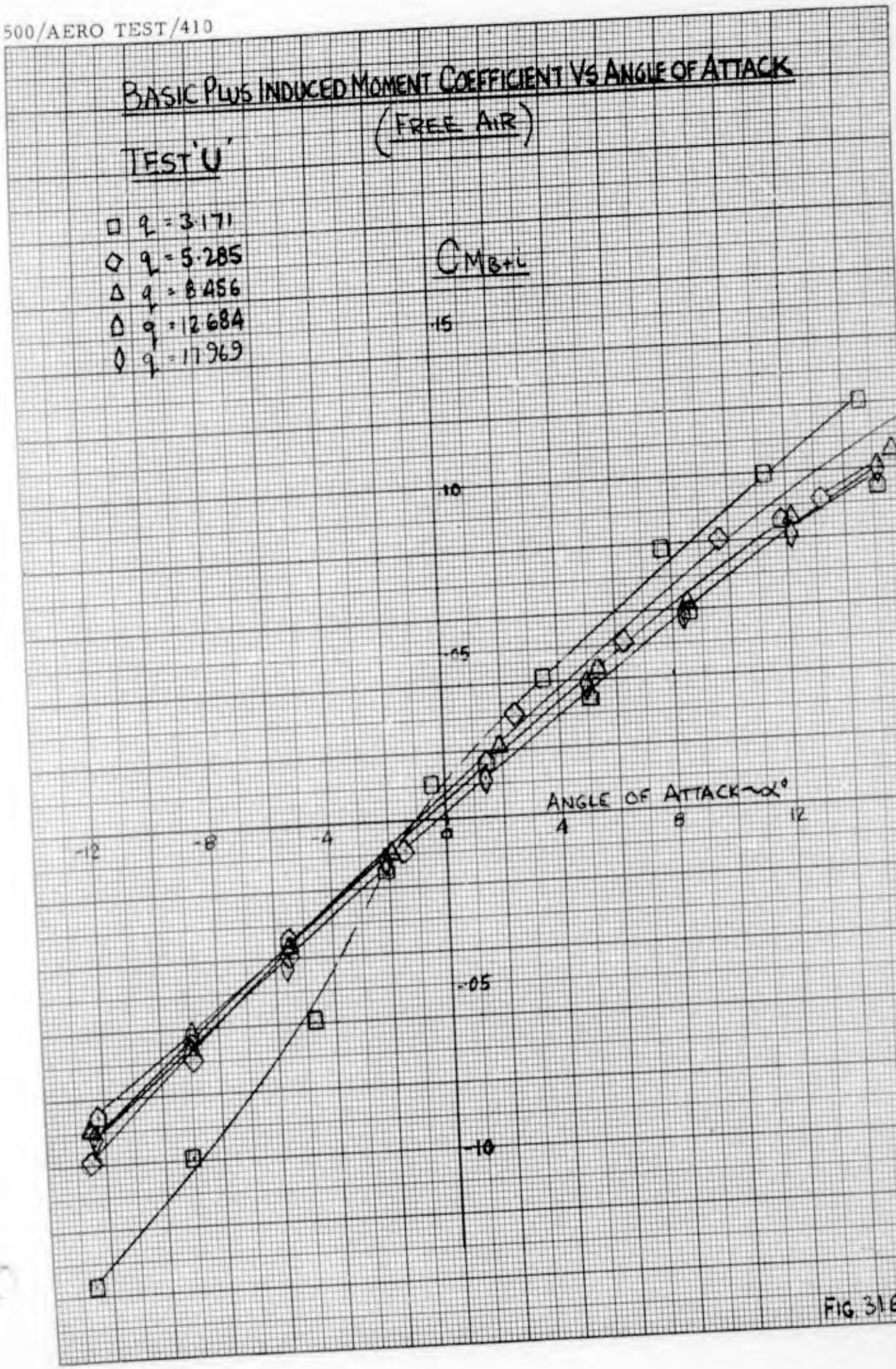

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'U'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
△ q = 12.684
◇ q = 17.969
$C_{M_{B+L}}$
.15
.10
.05
-.05
-.10
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
16

FIG. 3.16

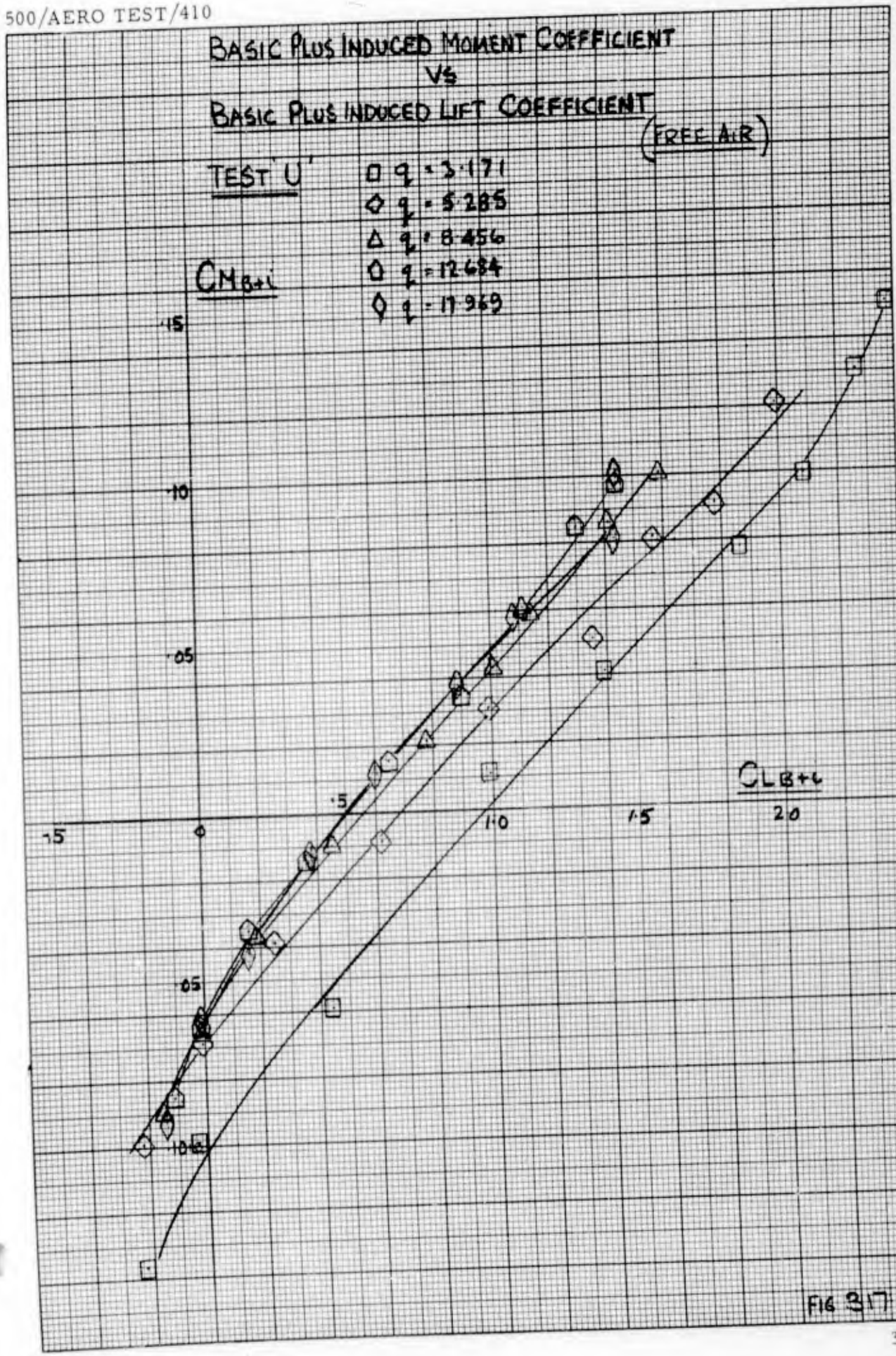

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST U'
q = 3.171
q = 5.285
q = 8.456
q = 12.684
q = 17.969
CMB+L
CLB+L
.15
.10
.05
.5
1.0
1.5
2.0

FIG 317

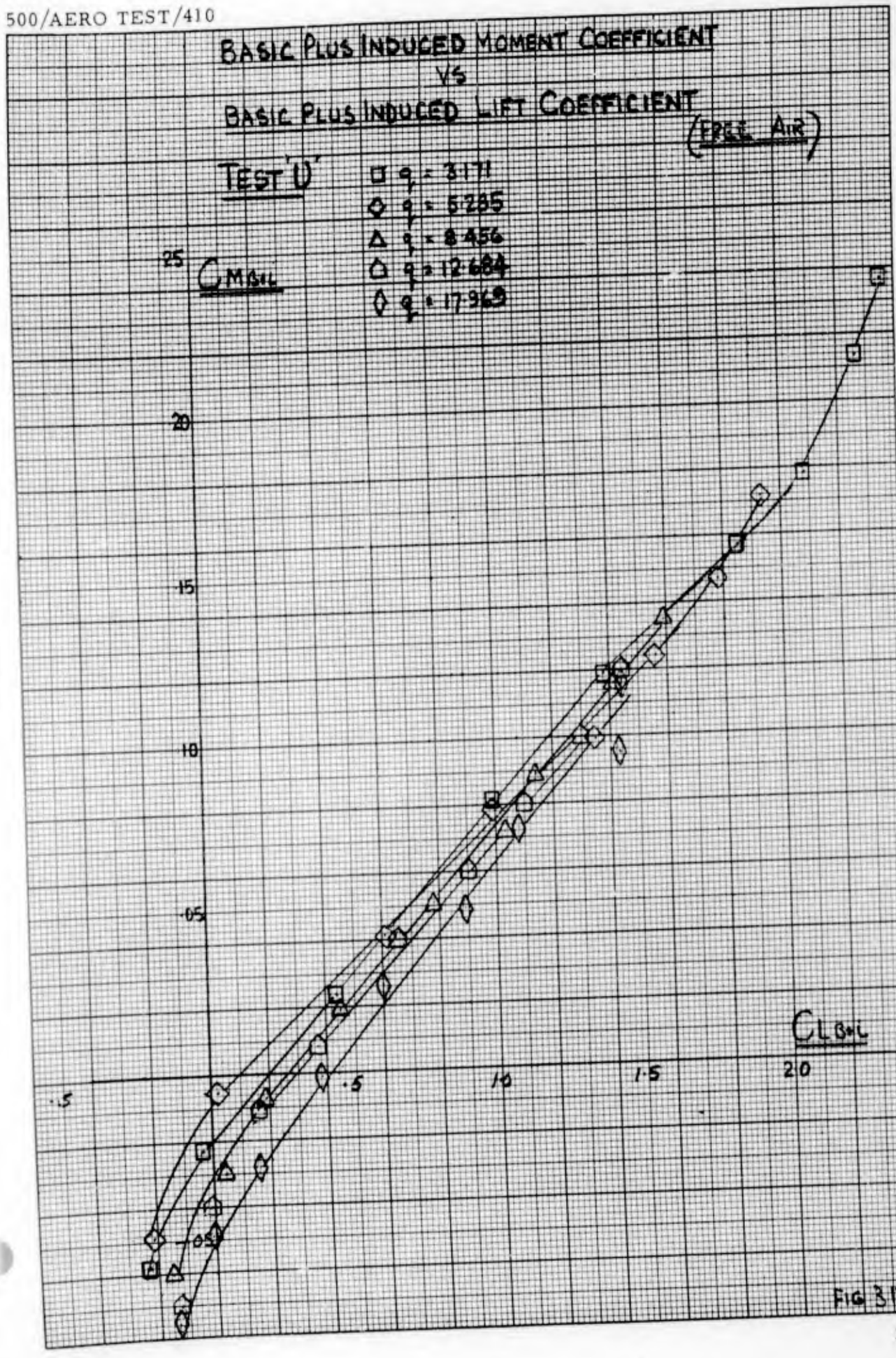

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST 'U'
q = 3171
q = 5285
q = 8456
q = 12684
q = 17969
CMB&L
CLB&L
25
20
15
10
05
-.5
.5
1.0
1.5
2.0
-.05

FIG 3.17.1

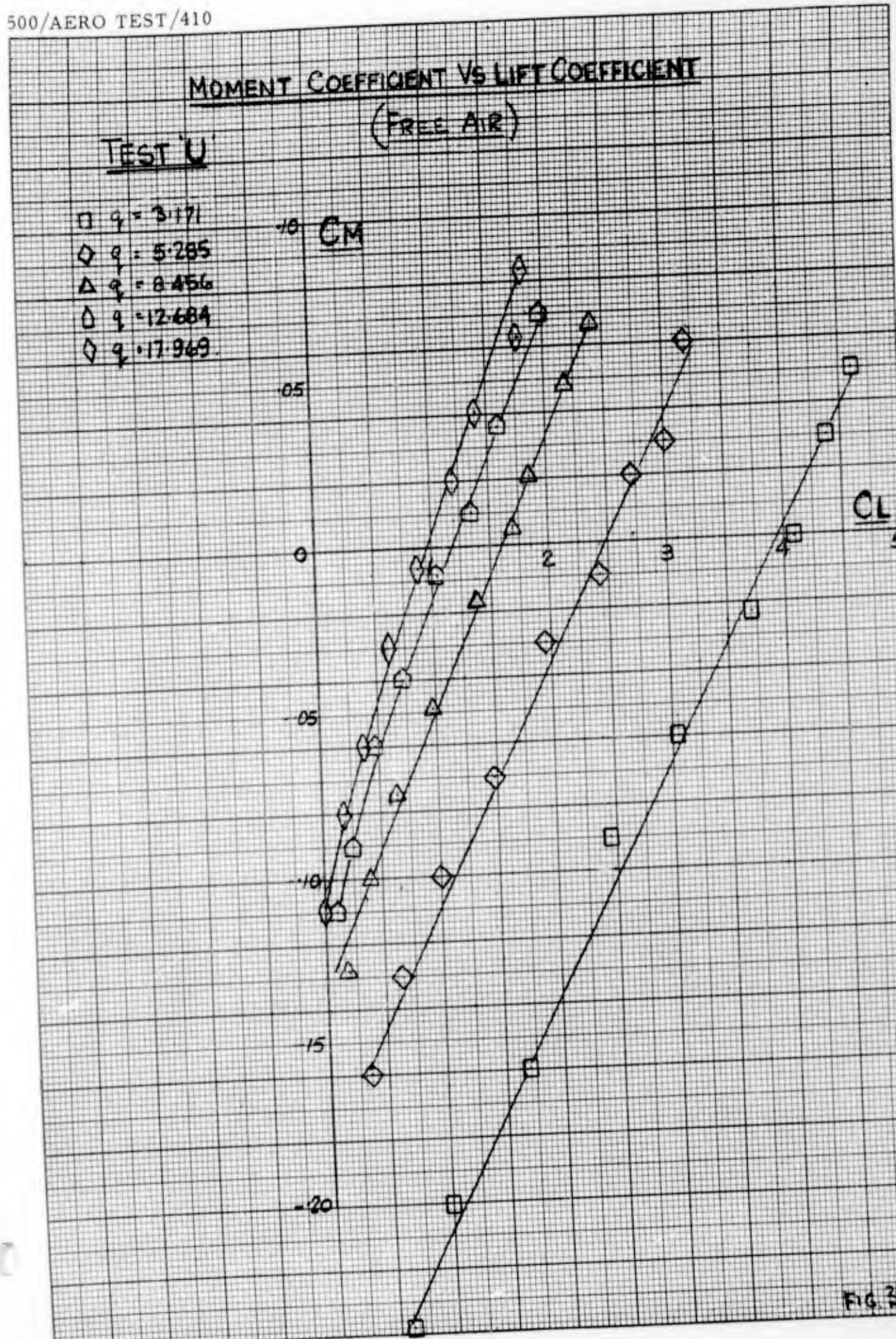

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'U'
□ q = 3.171
◇ q = 5.285
△ q = 8.456
⬡ q = 12.684
◇ q = 17.969
CM
CL
.10
.05
0
.05
.10
.15
.20
2
3
4
5

FIG. 318

VARIATION OF AERODYNAMIC CENTRE WITH FORWARD SPEED

(FREE AIR)

TEST 'U'

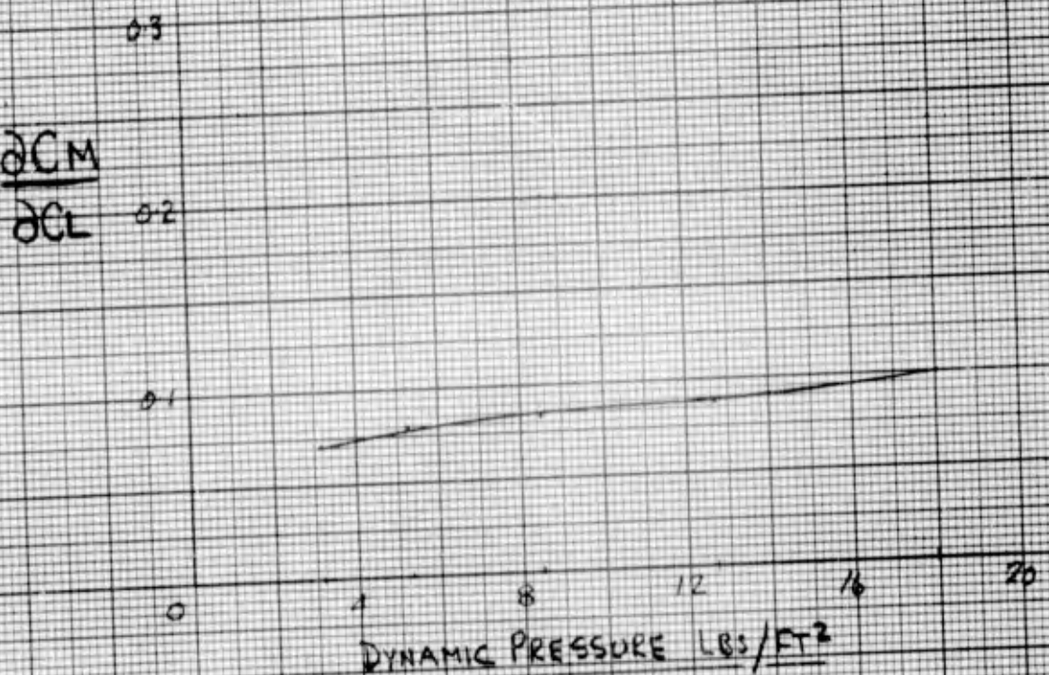


FIG 319

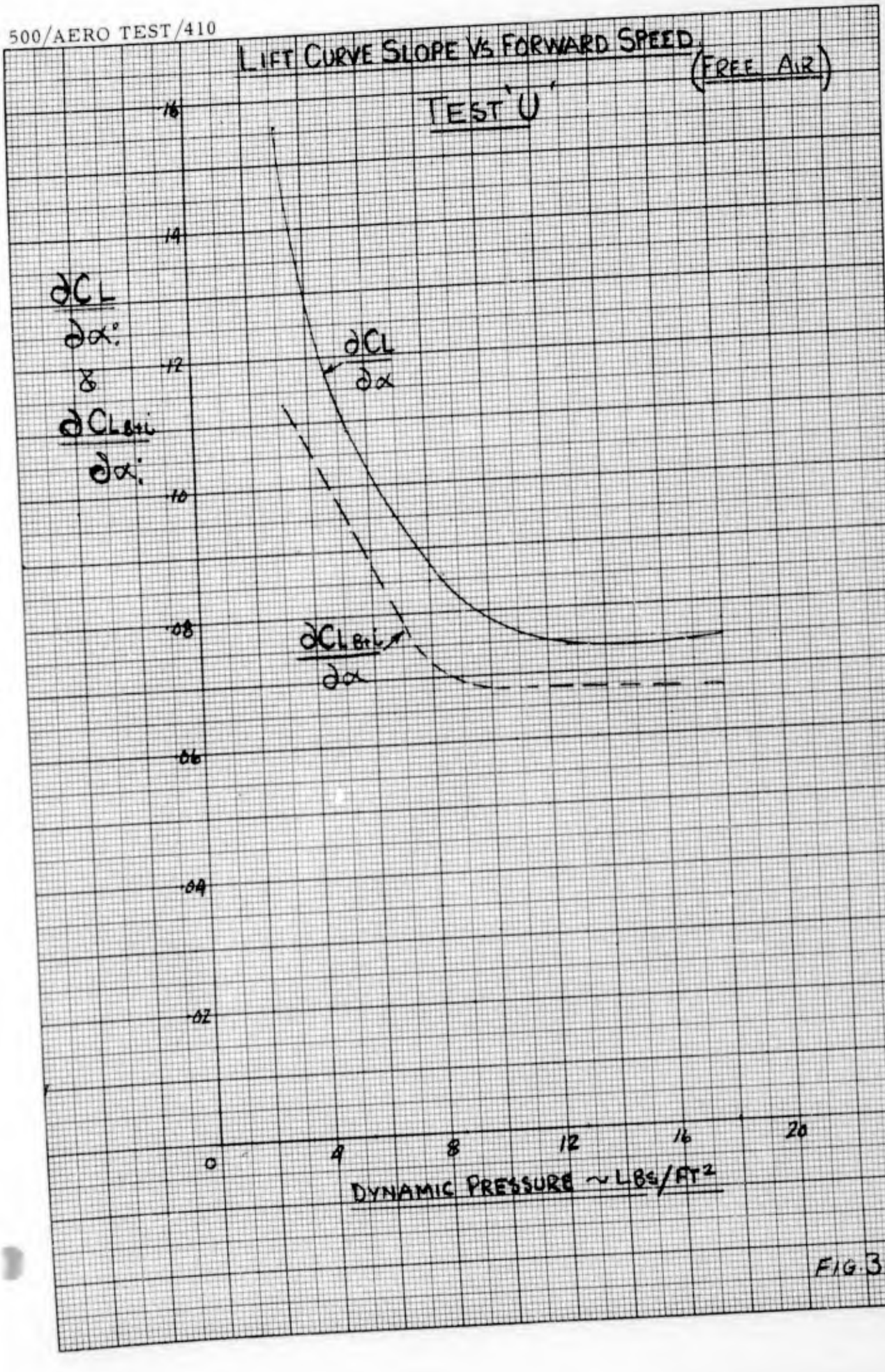

LIFT CURVE SLOPE VS FORWARD SPEED (FREE AIR)
TEST 'U'
∂CL/∂α°
&
∂CL Bkt/∂α°
∂CL/∂α
∂CL Bkt/∂α
16
14
12
10
·08
·06
·04
·02
0
4
8
12
16
20
DYNAMIC PRESSURE ~ LBS/FT²

FIG. 320

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST 'U' (FREE AIR)

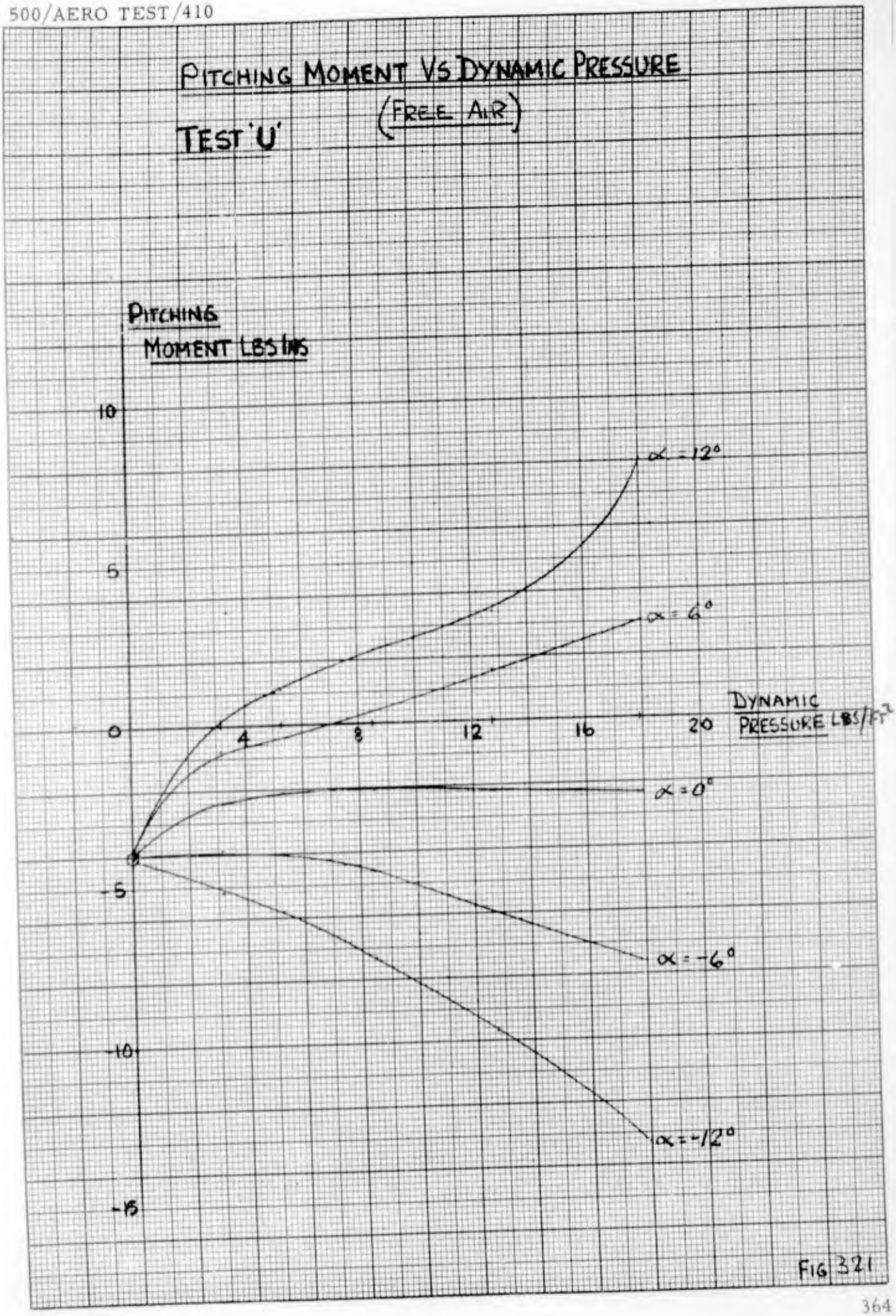


FIG 321

PITCHING MOMENT VS DYNAMIC PRESSURE

TEST 'U' (FREE AIR)

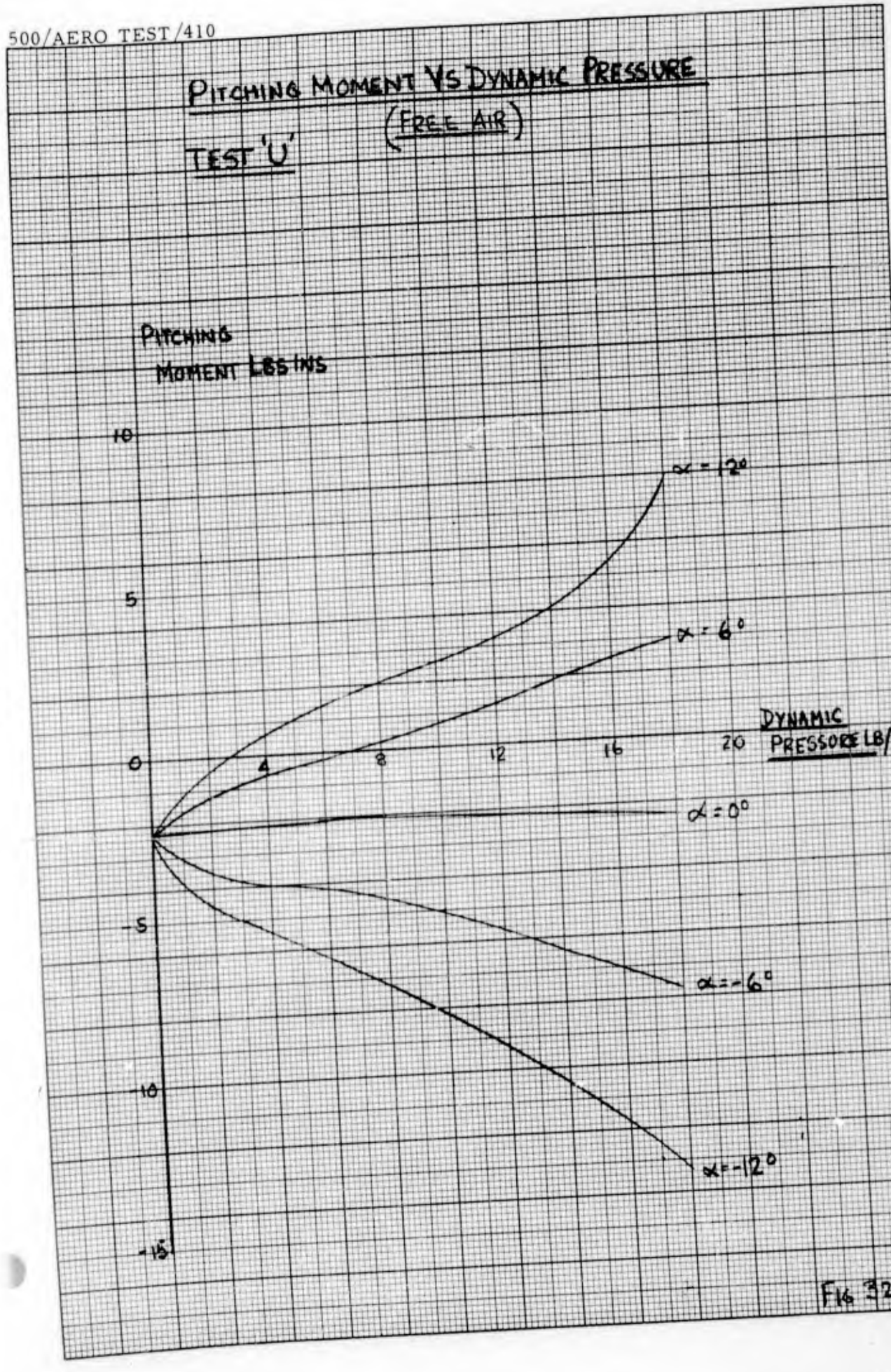


FIG 321-

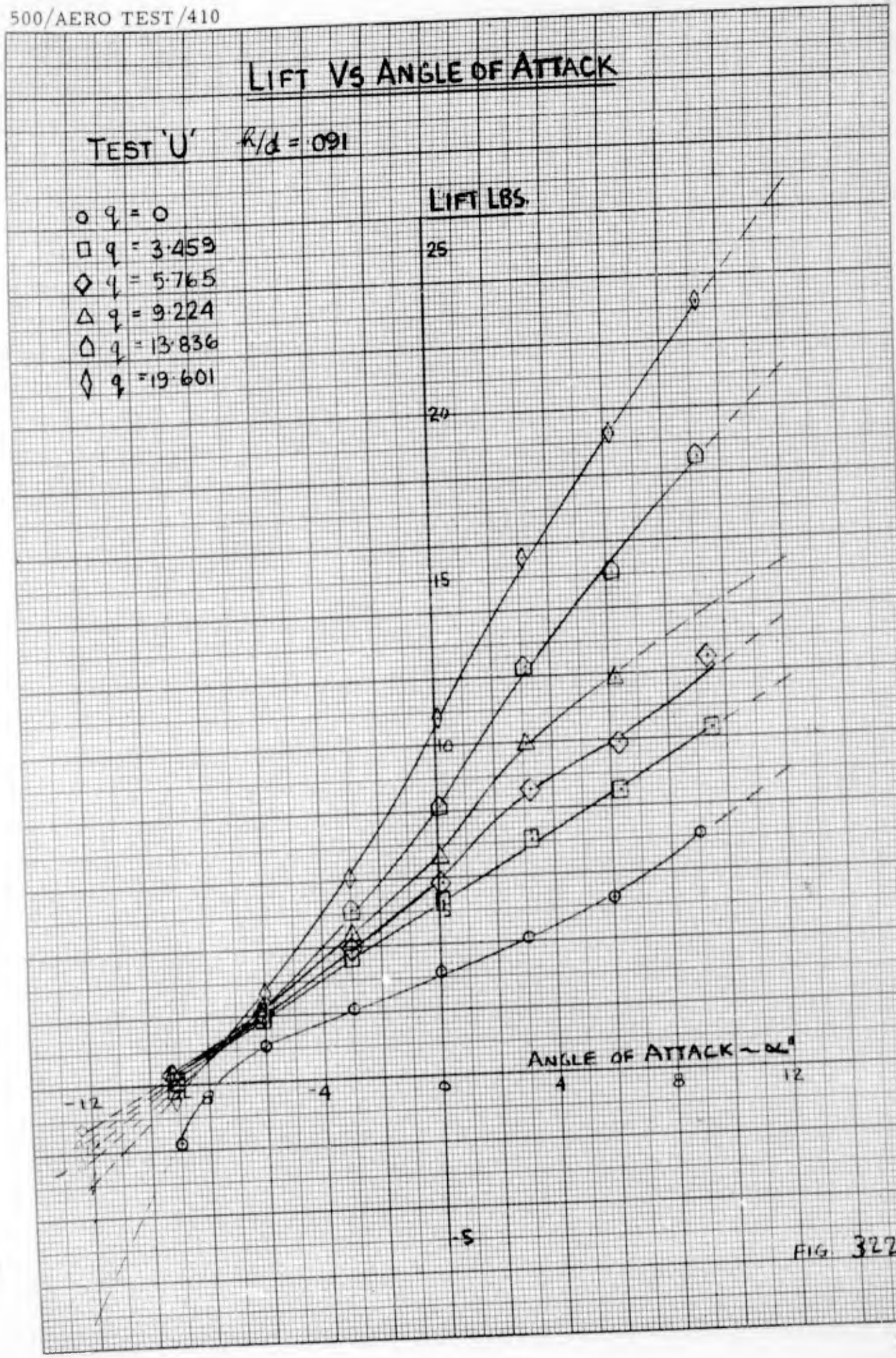

LIFT VS ANGLE OF ATTACK
TEST 'U' K/d = .091
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 19.601
LIFT LBS.
25
20
15
10
5
-5
ANGLE OF ATTACK ~ α°
-12
-4
4
8
12

FIG. 322

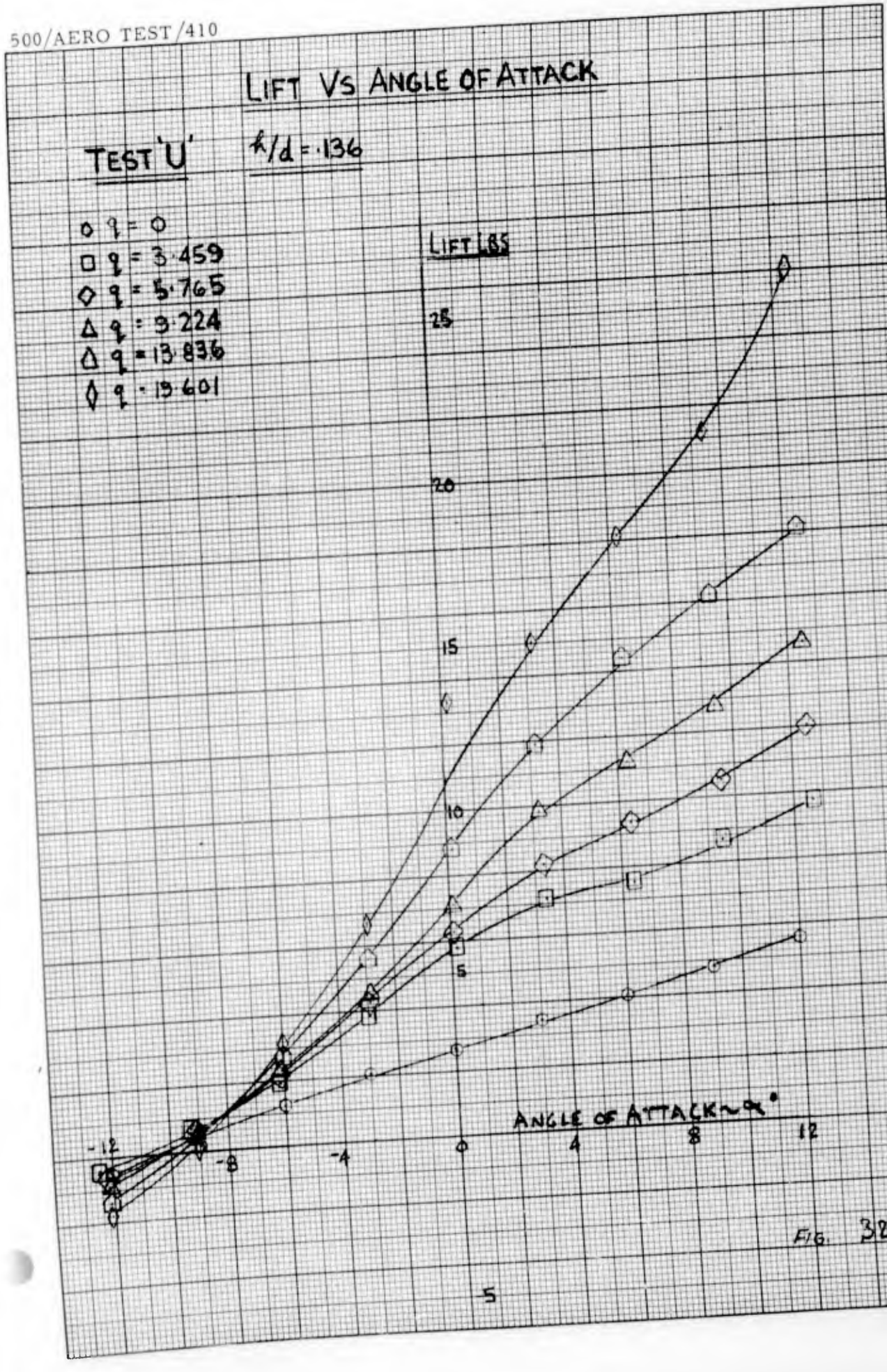

LIFT VS ANGLE OF ATTACK
TEST 'U'
k/d = .136
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⏢ q = 13.836
◊ q = 19.601
LIFT LBS
25
20
15
10
5
-5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG. 323

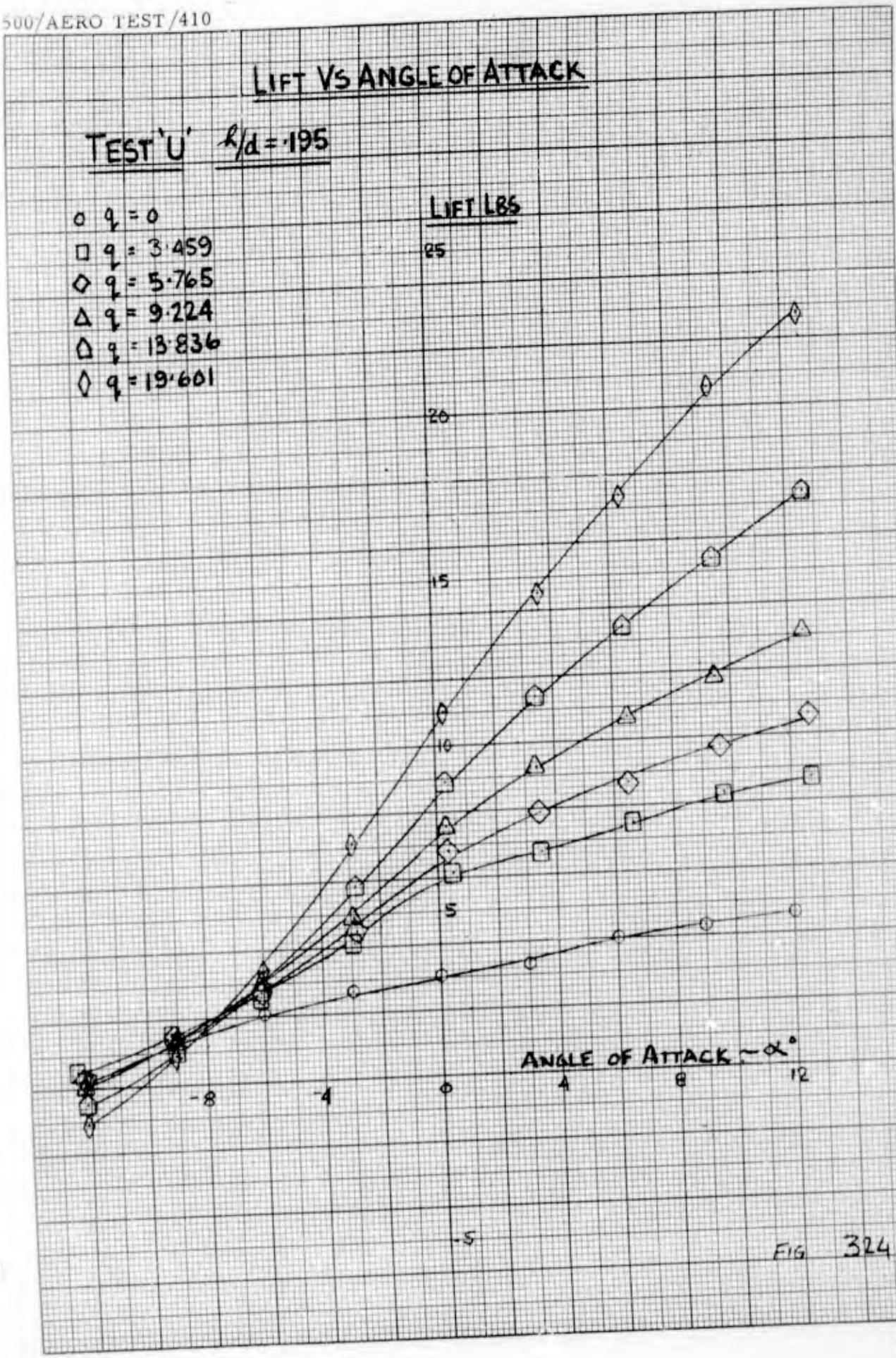
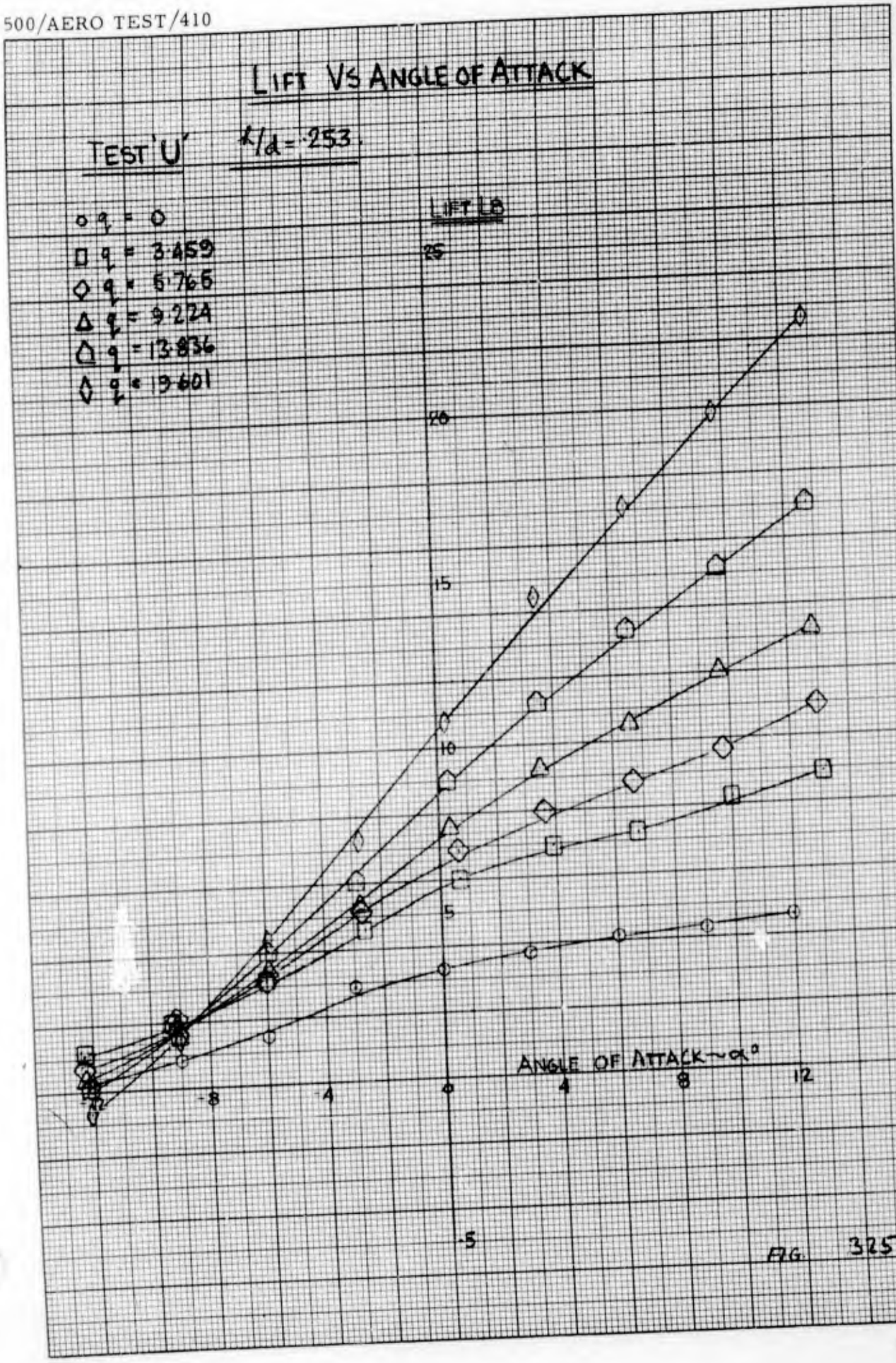

LIFT VS ANGLE OF ATTACK
TEST 'U' ℓ/d = .195
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬠ q = 13.836
◊ q = 19.601
LIFT LBS
25
20
15
10
5
-5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 324


LIFT VS ANGLE OF ATTACK
TEST 'U' k/d = .253
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 19.601
LIFT LB
25
20
15
10
5
-5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
AG 325

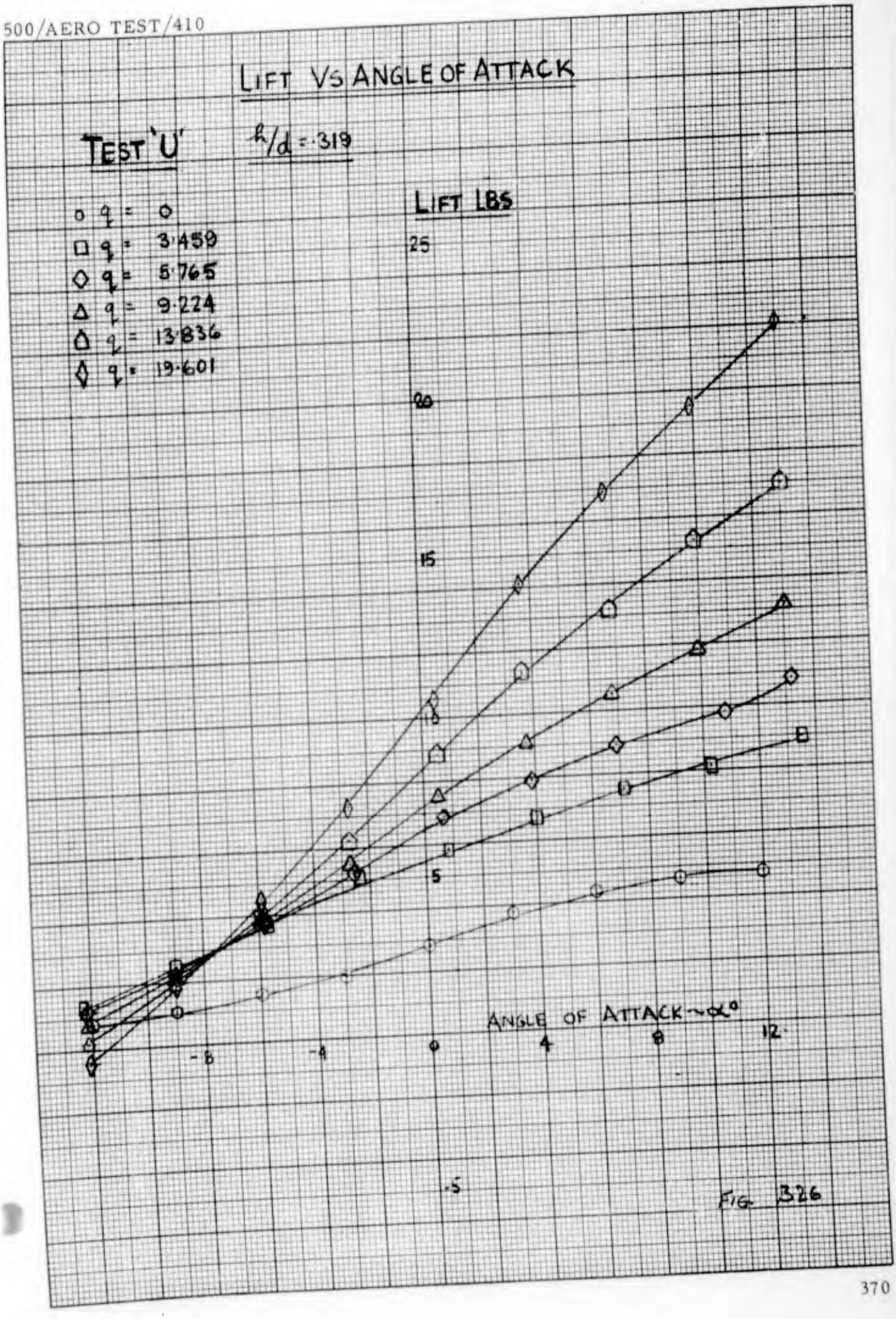
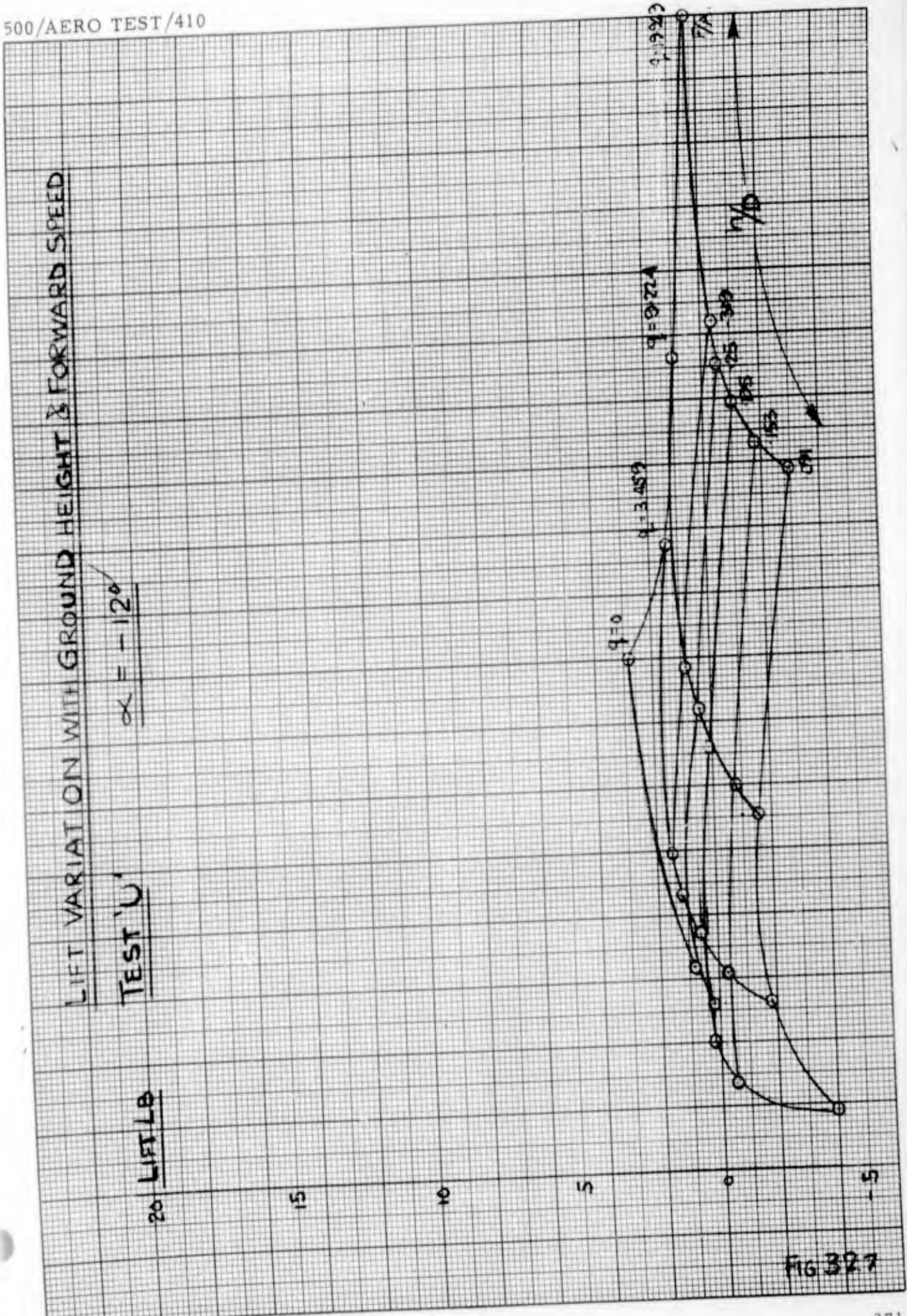

LIFT VS ANGLE OF ATTACK
TEST 'U'
h/d = .319
LIFT LBS
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬠ q = 13.836
◊ q = 19.601
25
20
15
5
-5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG. 326


LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'U'
α = -12°
LIFT LB
20
15
10
5
0
-5
h/D
V/√gD
q=0
q=3·459
q=6·224
25
36
15
6
FIG 327

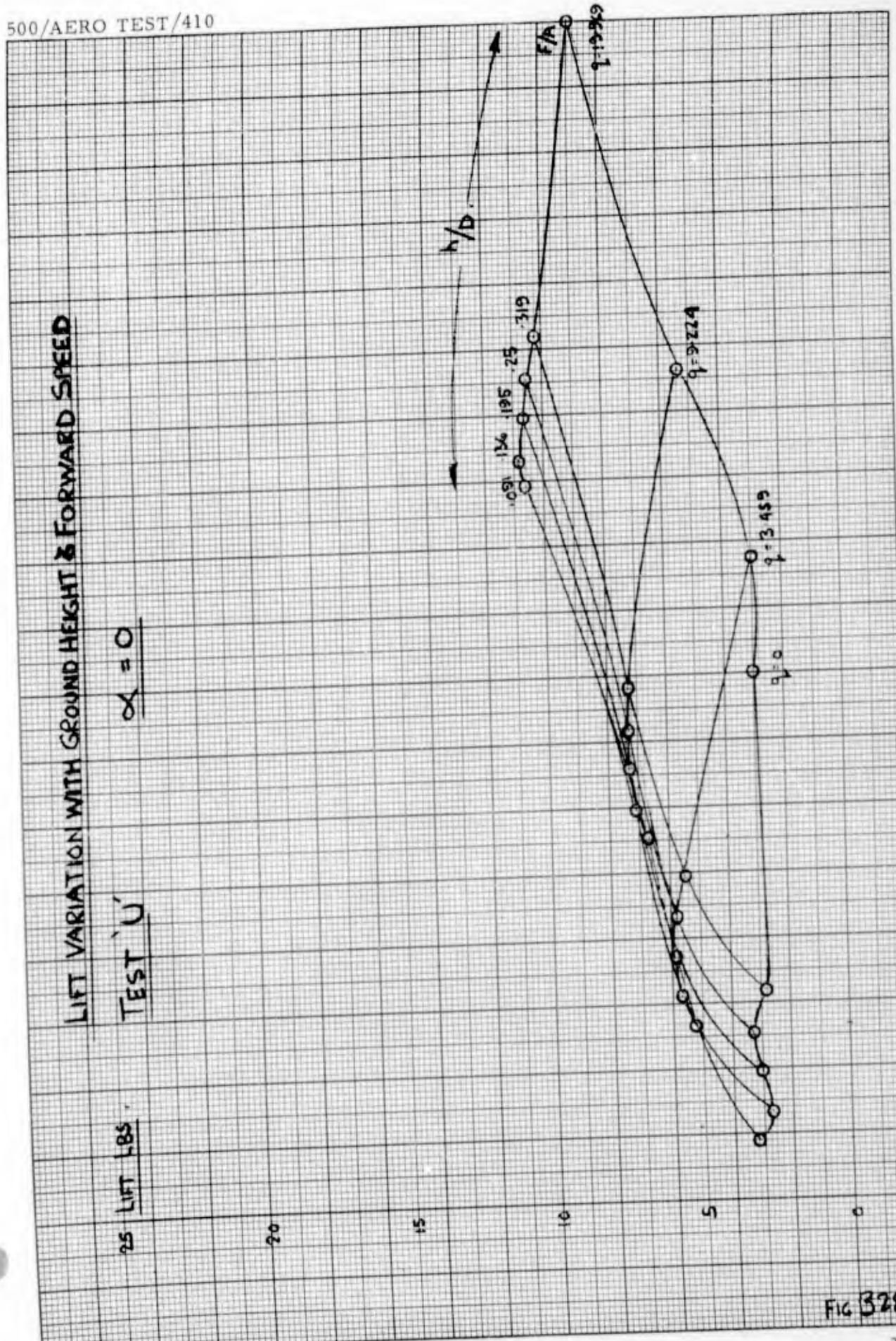

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'U'
α = 0
LIFT LBS
25
20
15
10
5
0
h/D
F/A
.613
.525
.195
.141
.100
9.2-6.4
9.2-6.4
9.2-3.459
9.2-0

FIG 328

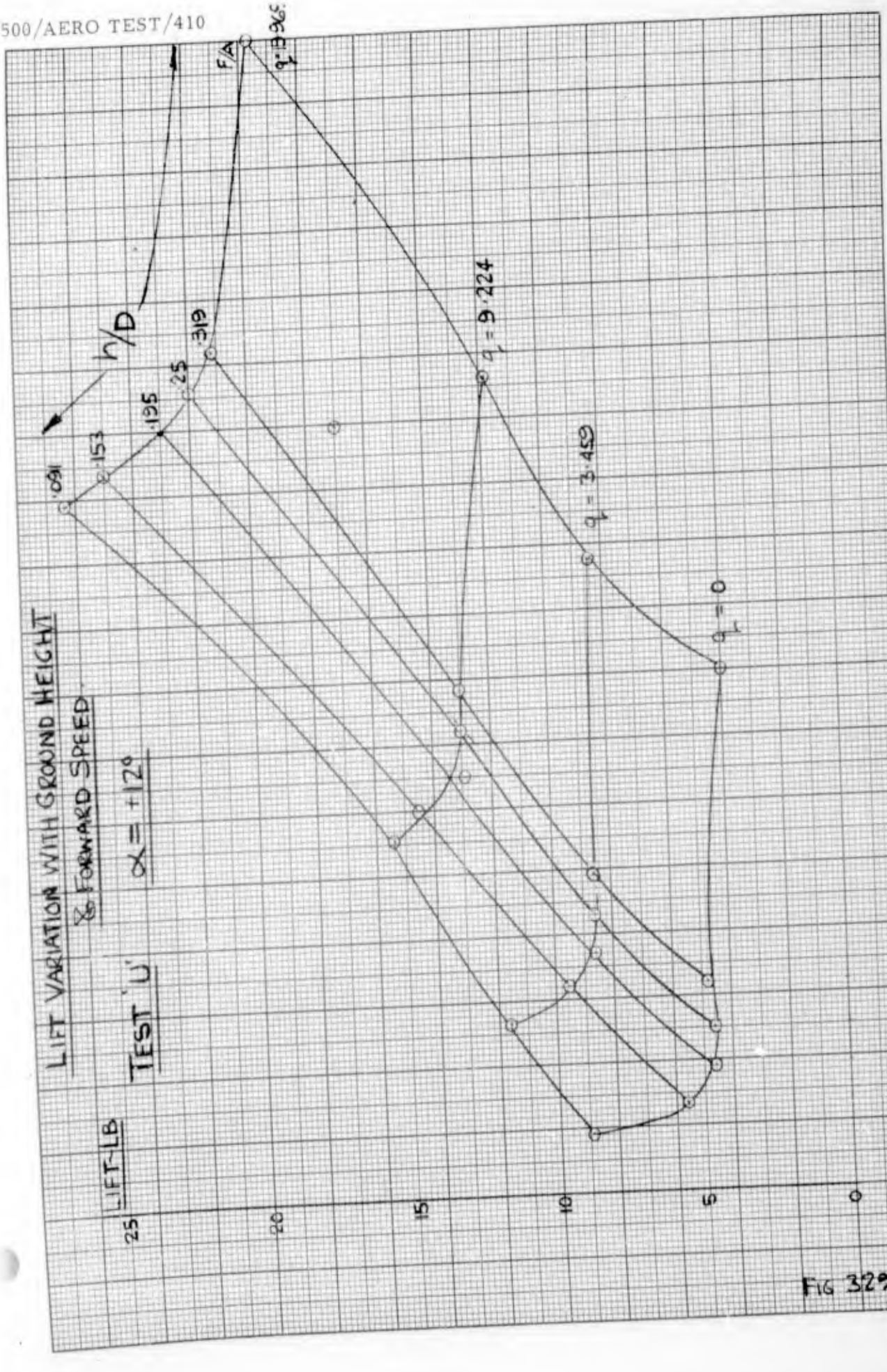

LIFT VARIATION WITH GROUND HEIGHT
& FORWARD SPEED
TEST 'U' α = +12°
LIFT-LB
25
20
15
10
5
0
h/D
.031
.153
.195
.25
.319
F/A
q = 0
q = 3.459
q = 9.224
q = 13.365

FIG 329

DRAG VS ANGLE OF ATTACK

TEST 'U' $\ell/d = .091$

- ○ $q = 0$
- □ $q = 3.459$
- ◇ $q = 5.765$
- △ $q = 9.224$
- ⌂ $q = 13.836$
- ◊ $q = 19.601$

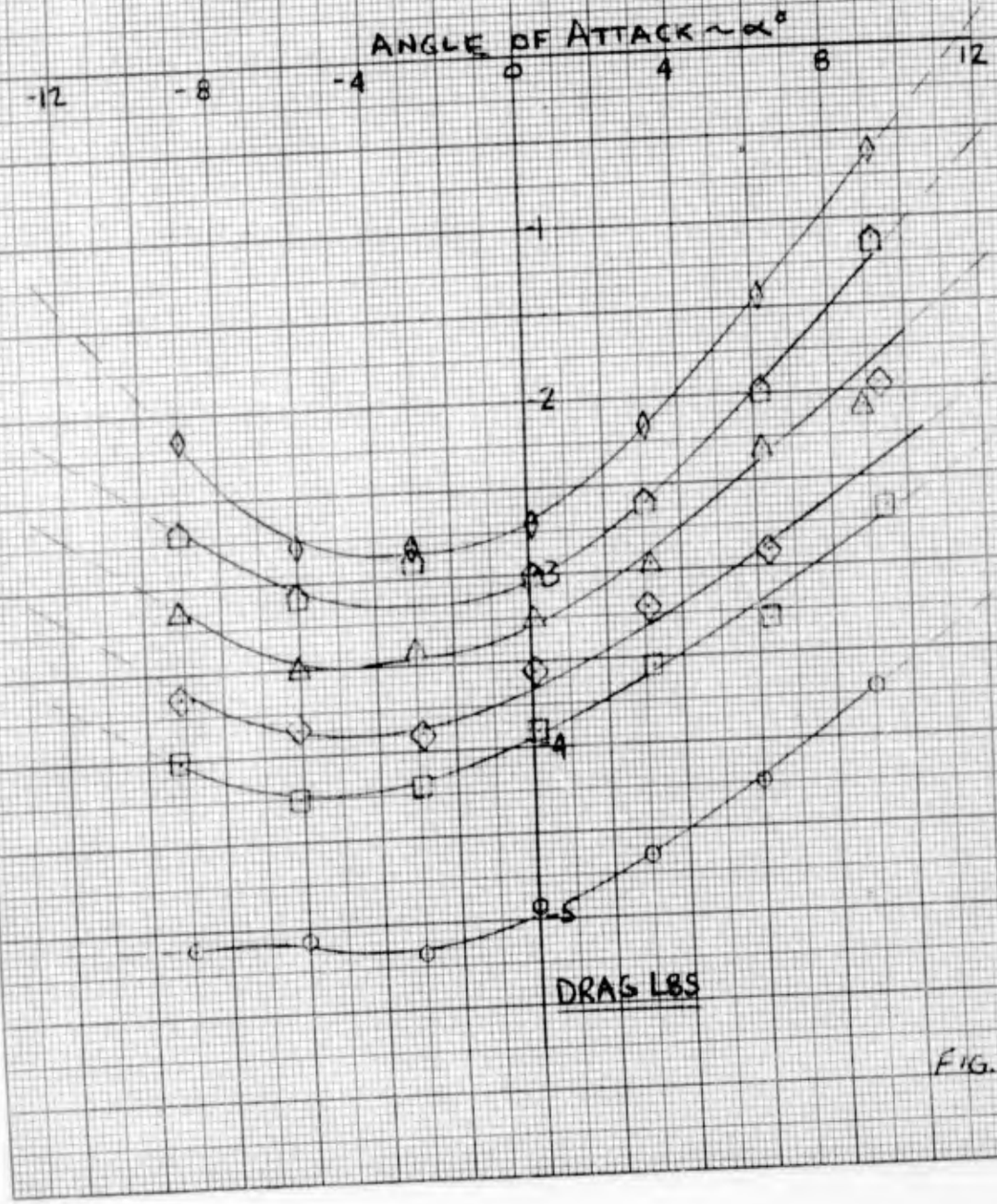


FIG. 330

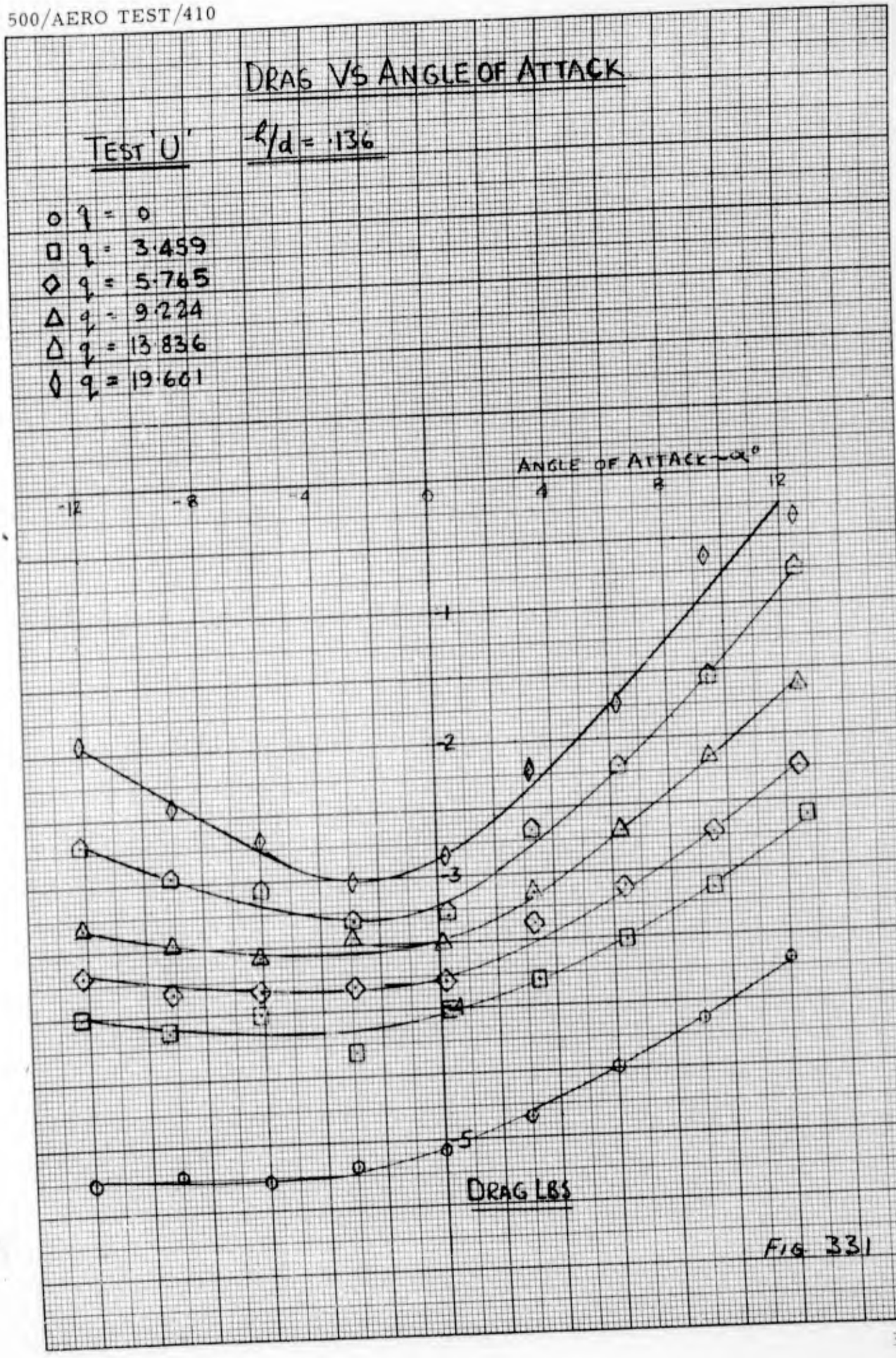

DRAG VS ANGLE OF ATTACK
TEST 'U'
ℓ/d = .136
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
△ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
-1
-2
-3
-5
DRAG LBS

FIG 331

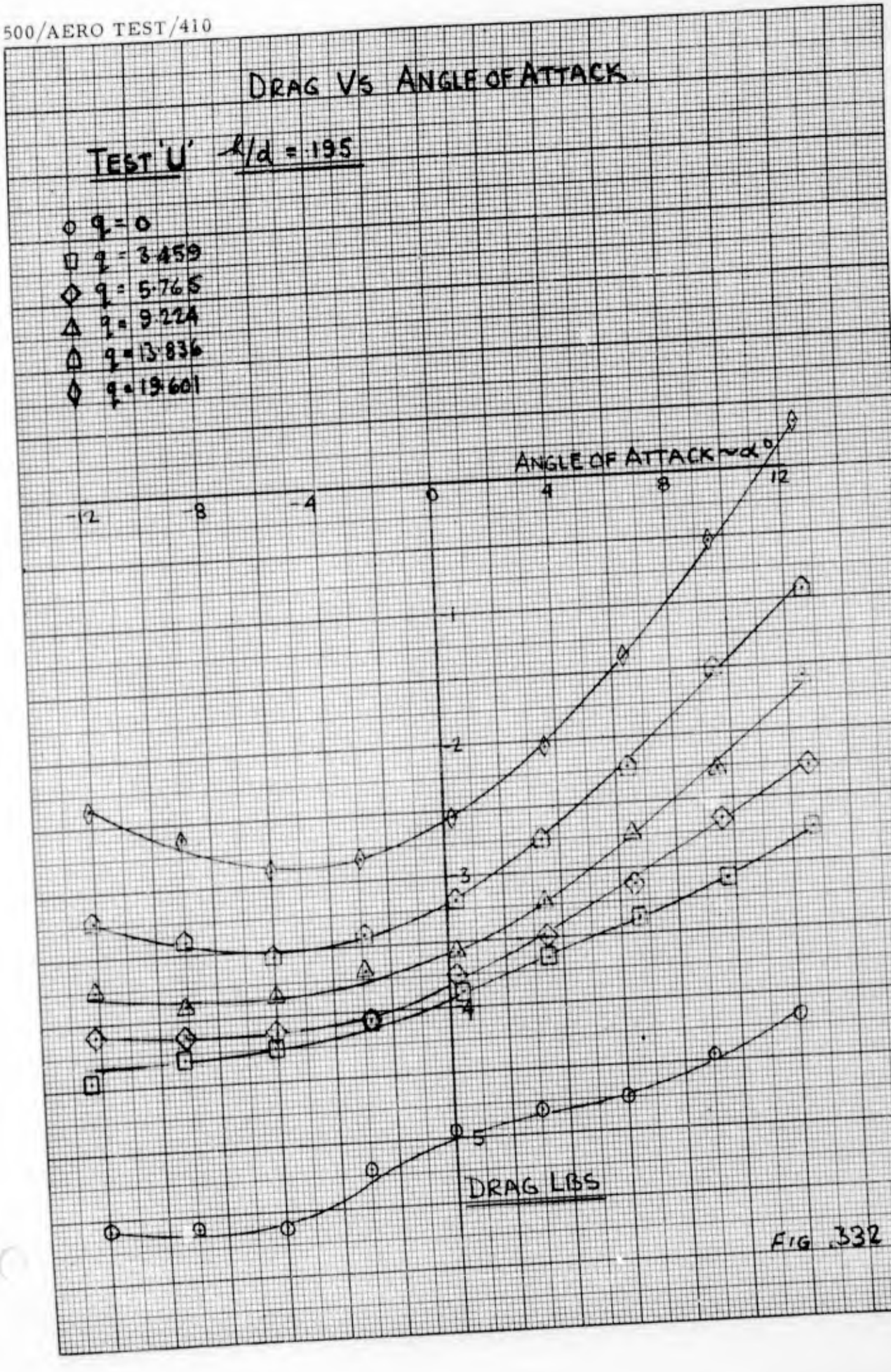

DRAG VS ANGLE OF ATTACK.
TEST 'U' ℓ/d = 1.95
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
1
2
3
4
5
DRAG LBS

FIG. 332

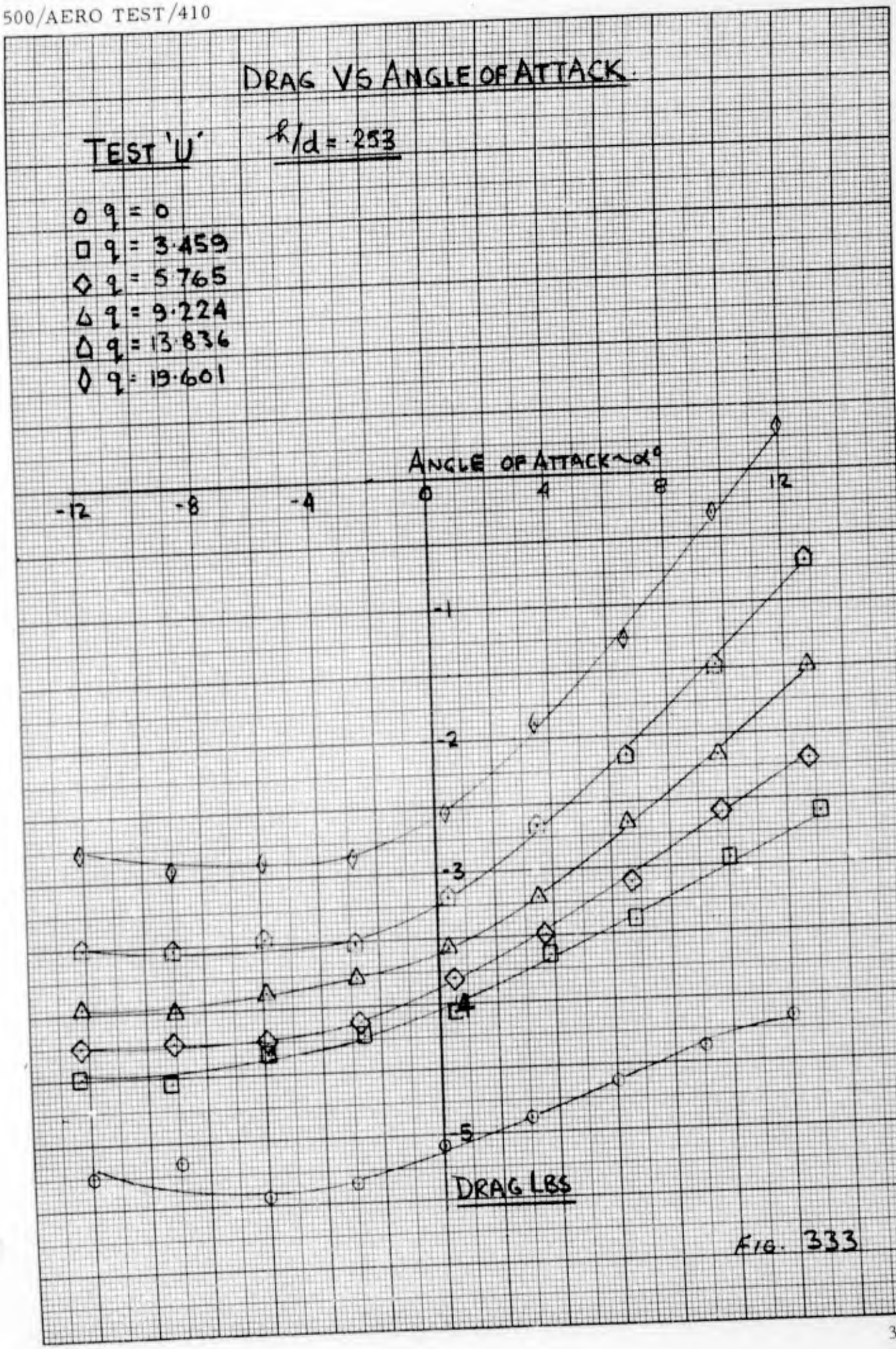
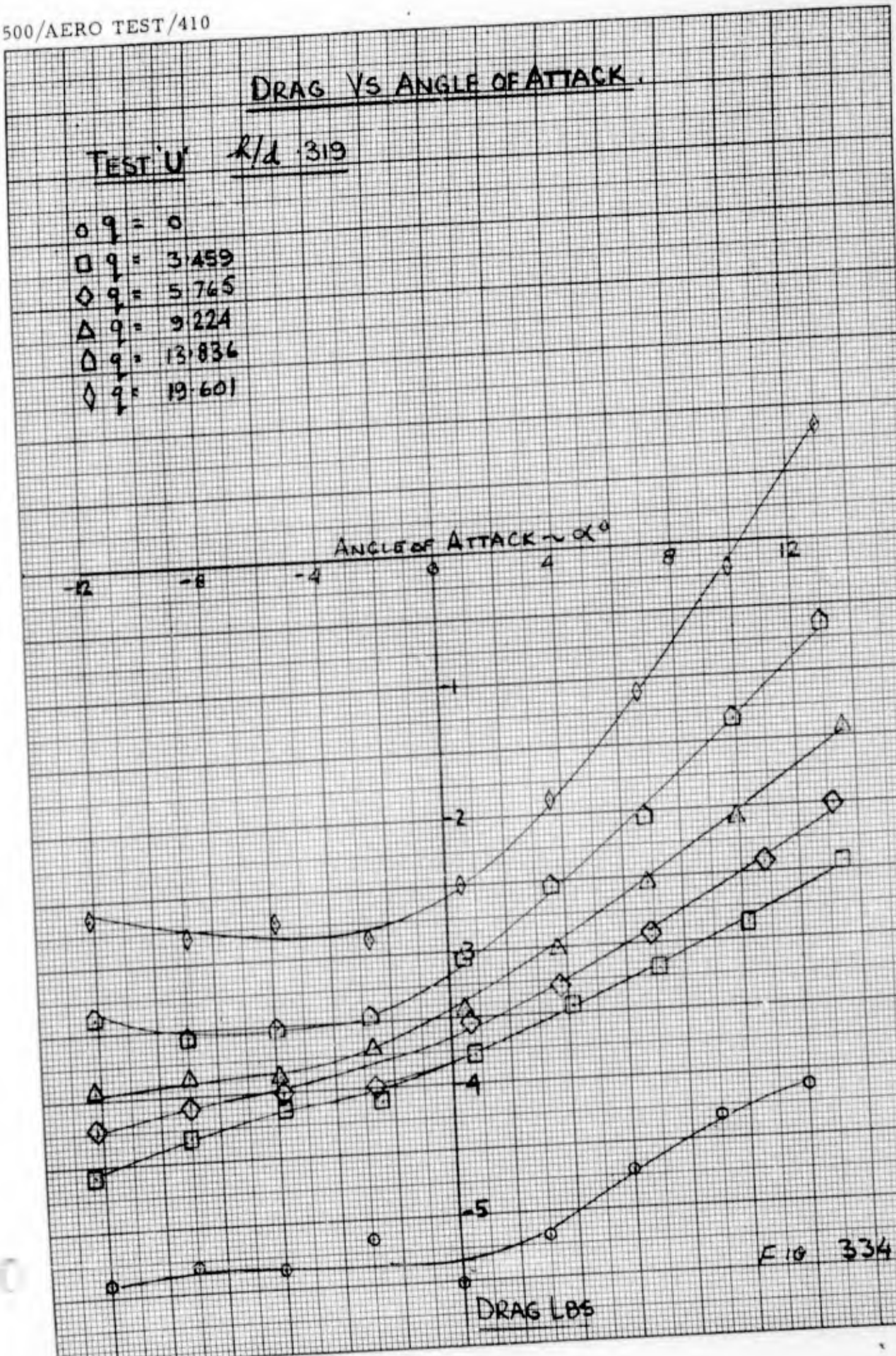

DRAG VS ANGLE OF ATTACK.
TEST 'U'
ℓ/d = .253
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
△ q = 13.836
◇ q = 19.601
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-1
-2
-3
-4
-5
DRAG LBS

FIG. 333


DRAG VS ANGLE OF ATTACK.
TEST 'U' R/d .319
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬠ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-1
-2
-3
-4
-5
DRAG LBS
E 10 334

PITCHING MOMENT VS ANGLE OF ATTACK

TEST 'U' ℓ/d .091

- ○ q = 0
- □ q = 3.459
- ◇ q = 5.765
- △ q = 9.224
- ⬠ q = 13.836
- ◊ q = 19.601

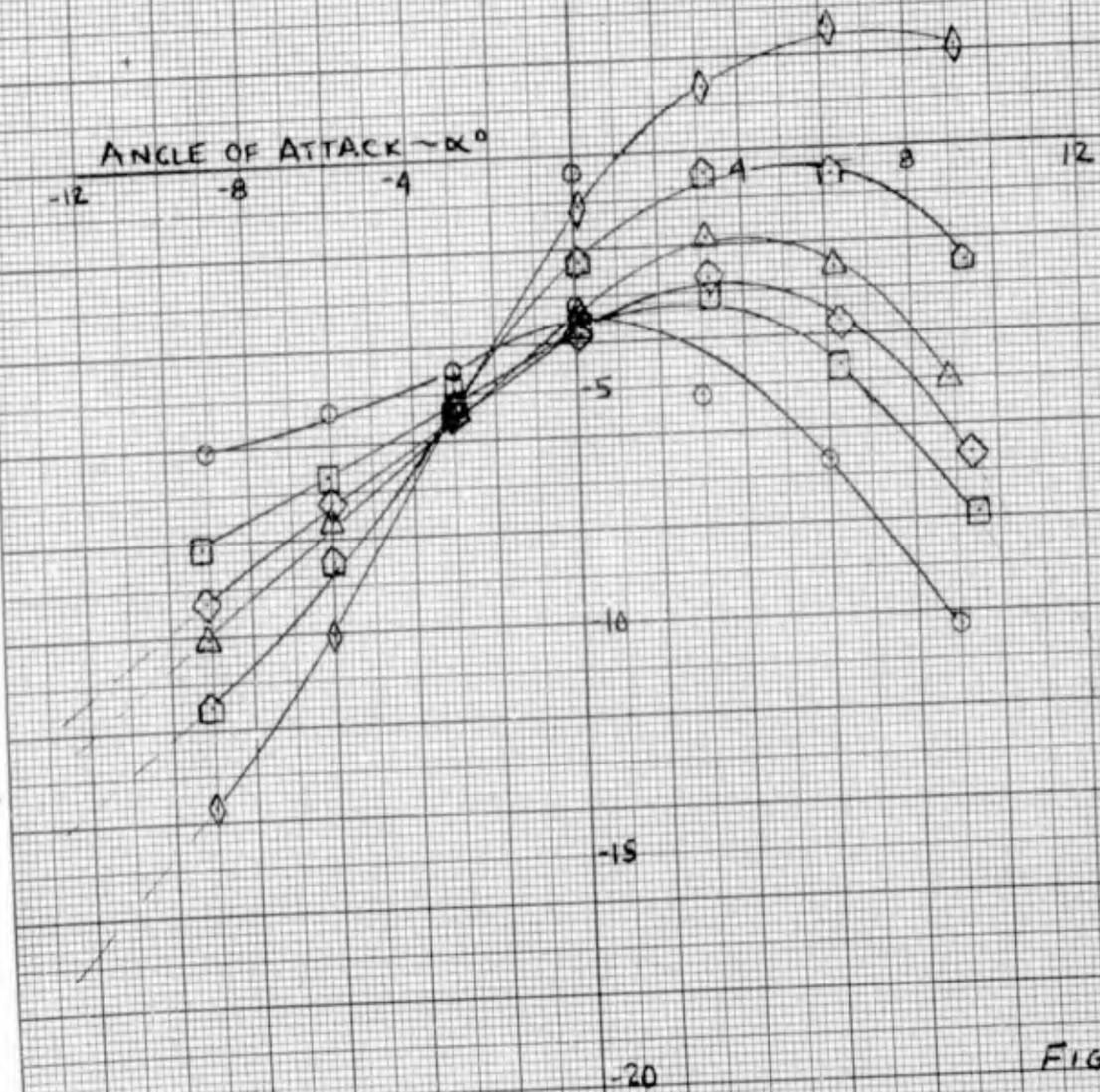


FIG. 335

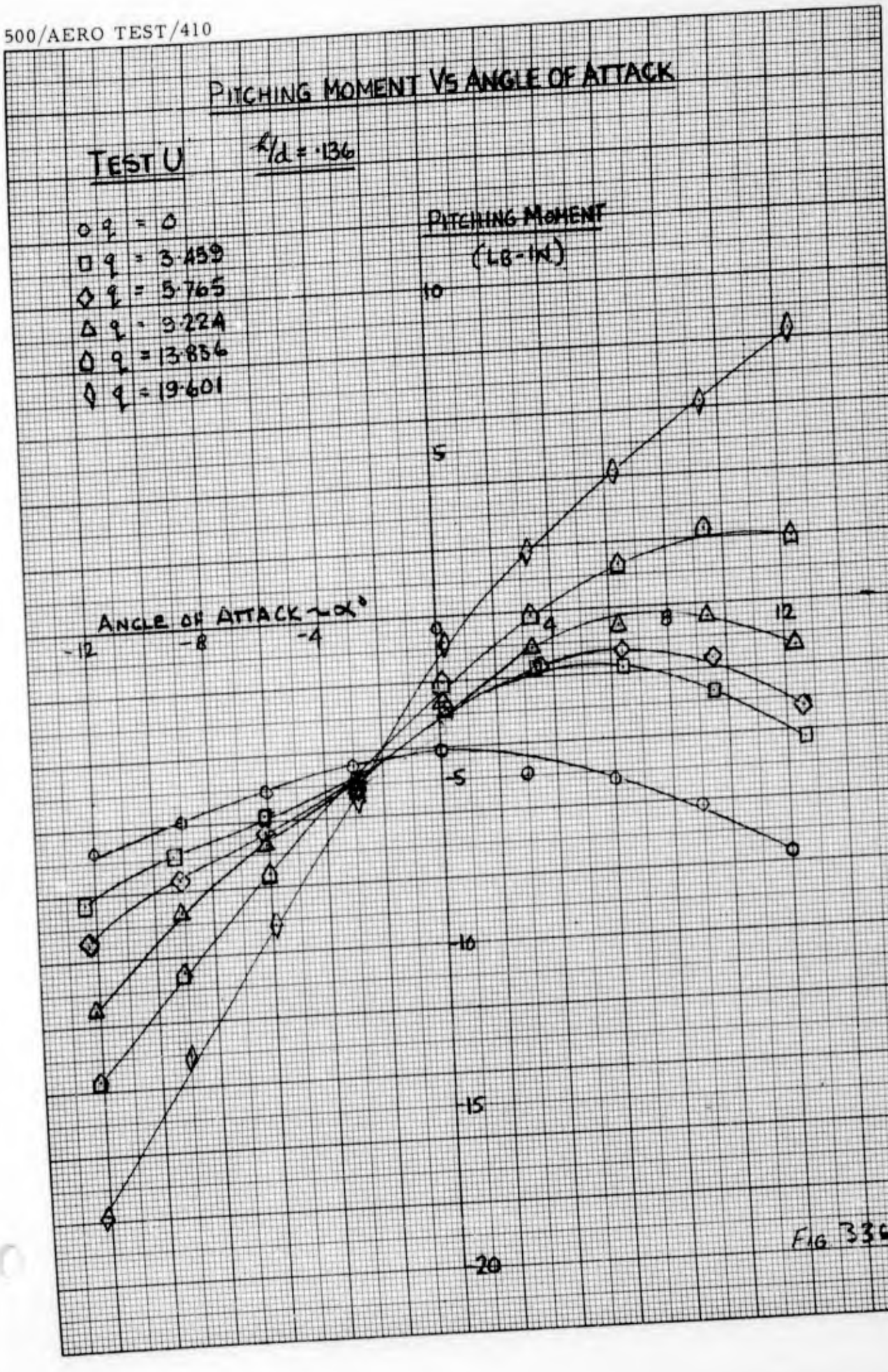
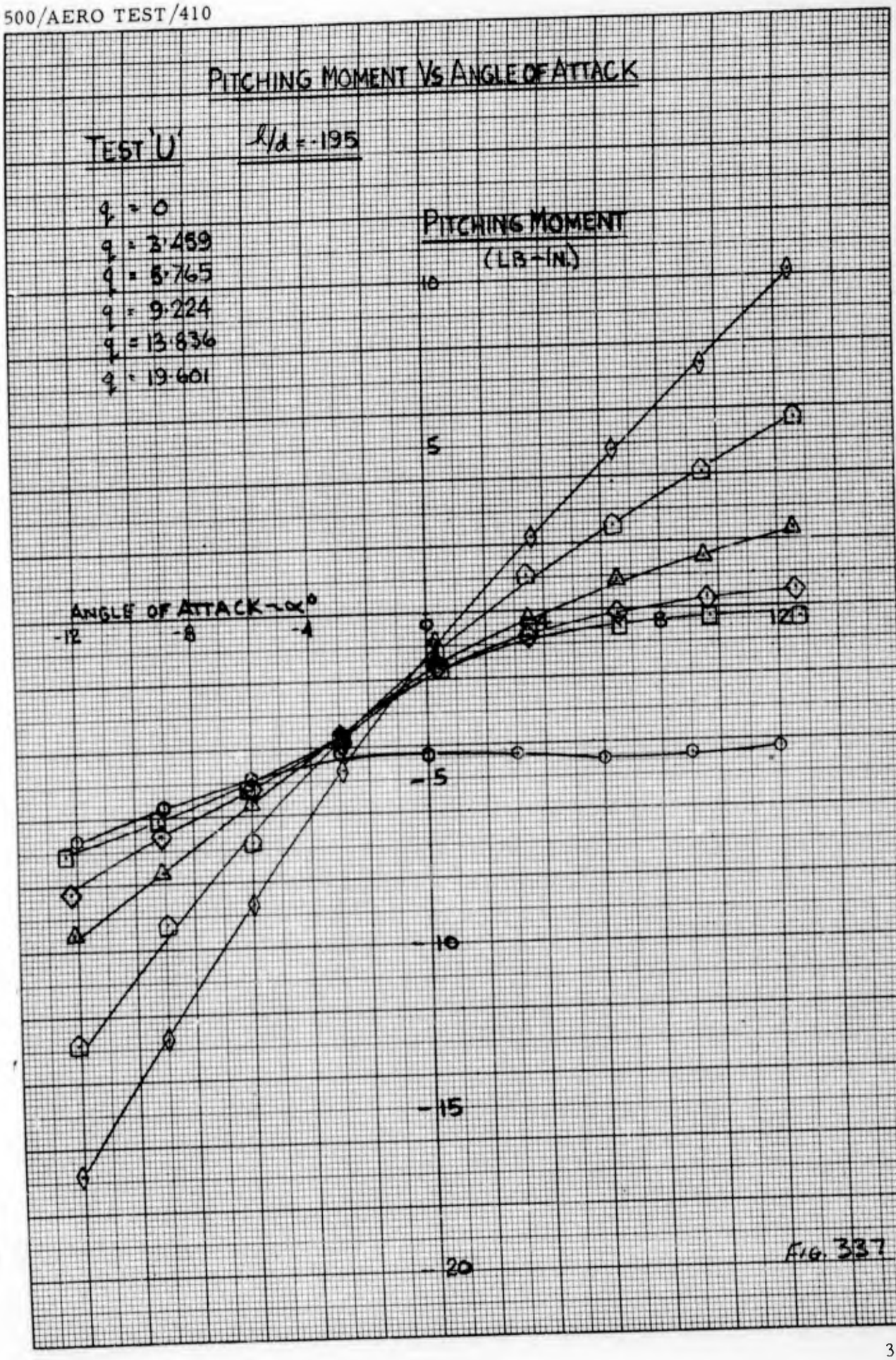
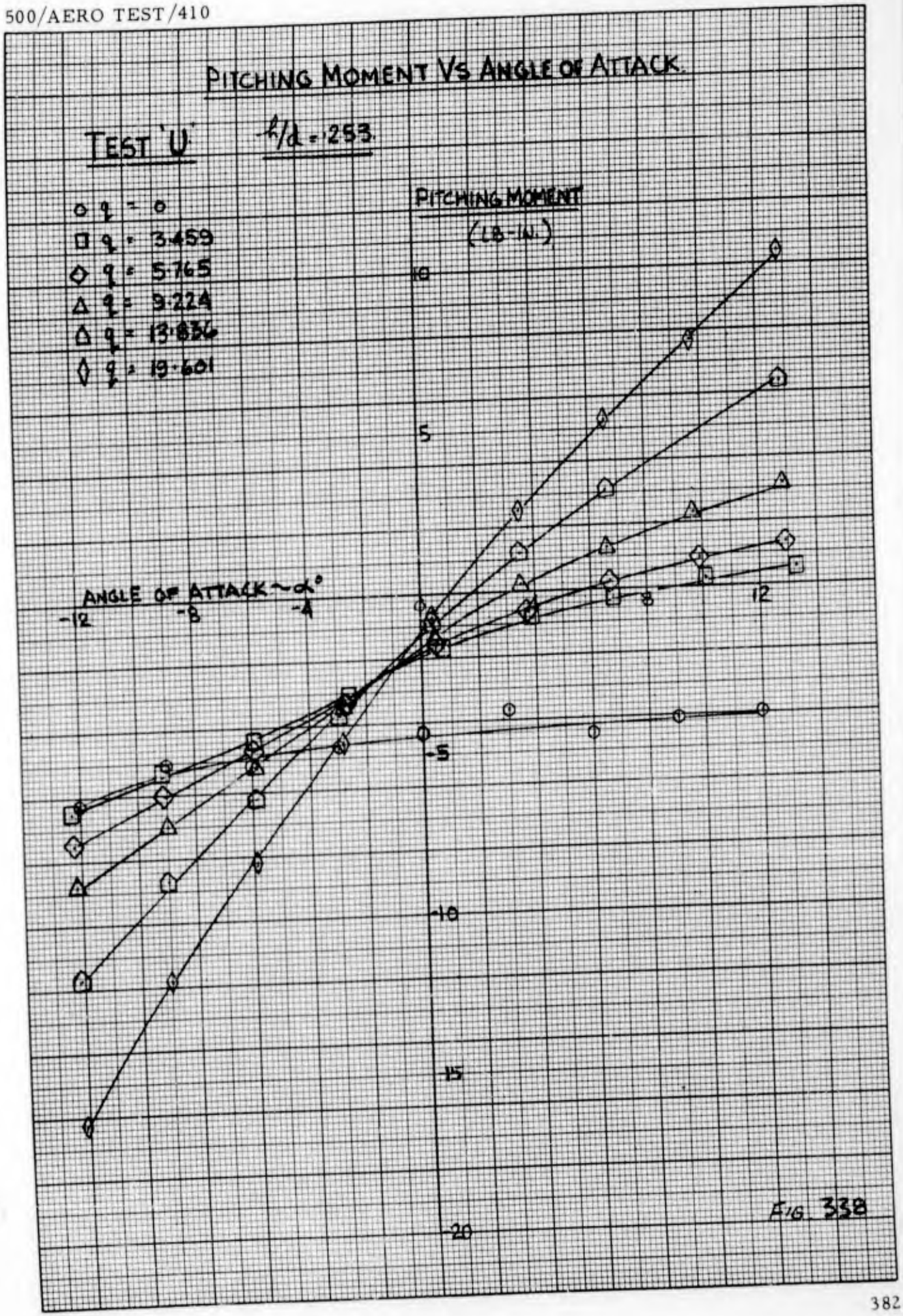

PITCHING MOMENT VS ANGLE OF ATTACK
TEST U
R/d = .136
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬠ q = 13.836
◊ q = 19.601
PITCHING MOMENT (LB-IN)
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
10
5
-5
-10
-15
-20

FIG 336


PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'U'
ℓ/d = .195
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
PITCHING MOMENT
(LB-IN.)
10
5
-5
-10
-15
-20
ANGLE OF ATTACK - α°
-12
-8
-4
12
FIG. 337


PITCHING MOMENT VS ANGLE OF ATTACK.
TEST 'U'
ℓ/d = .253
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
PITCHING MOMENT
(LB-IN.)
10
5
-5
-10
15
20
ANGLE OF ATTACK ~ α°
-12
-8
-4
8
12
FIG 338

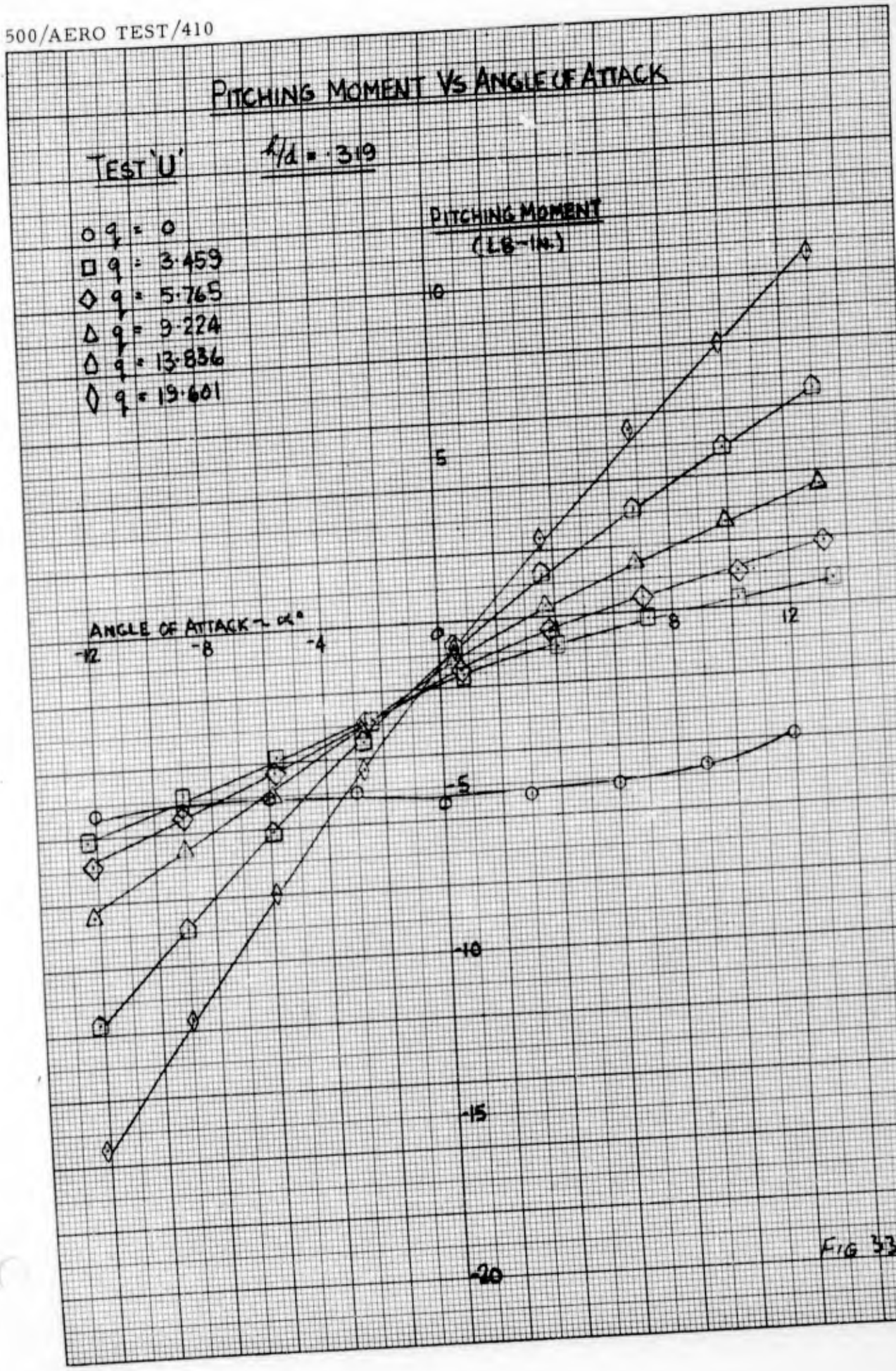

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'U'
ℓ/d = .319
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬠ q = 13.836
◊ q = 19.601
PITCHING MOMENT (LB-IN.)
10
5
-5
-10
-15
-20
ANGLE OF ATTACK - α°
-12
-8
-4
8
12

FIG 339

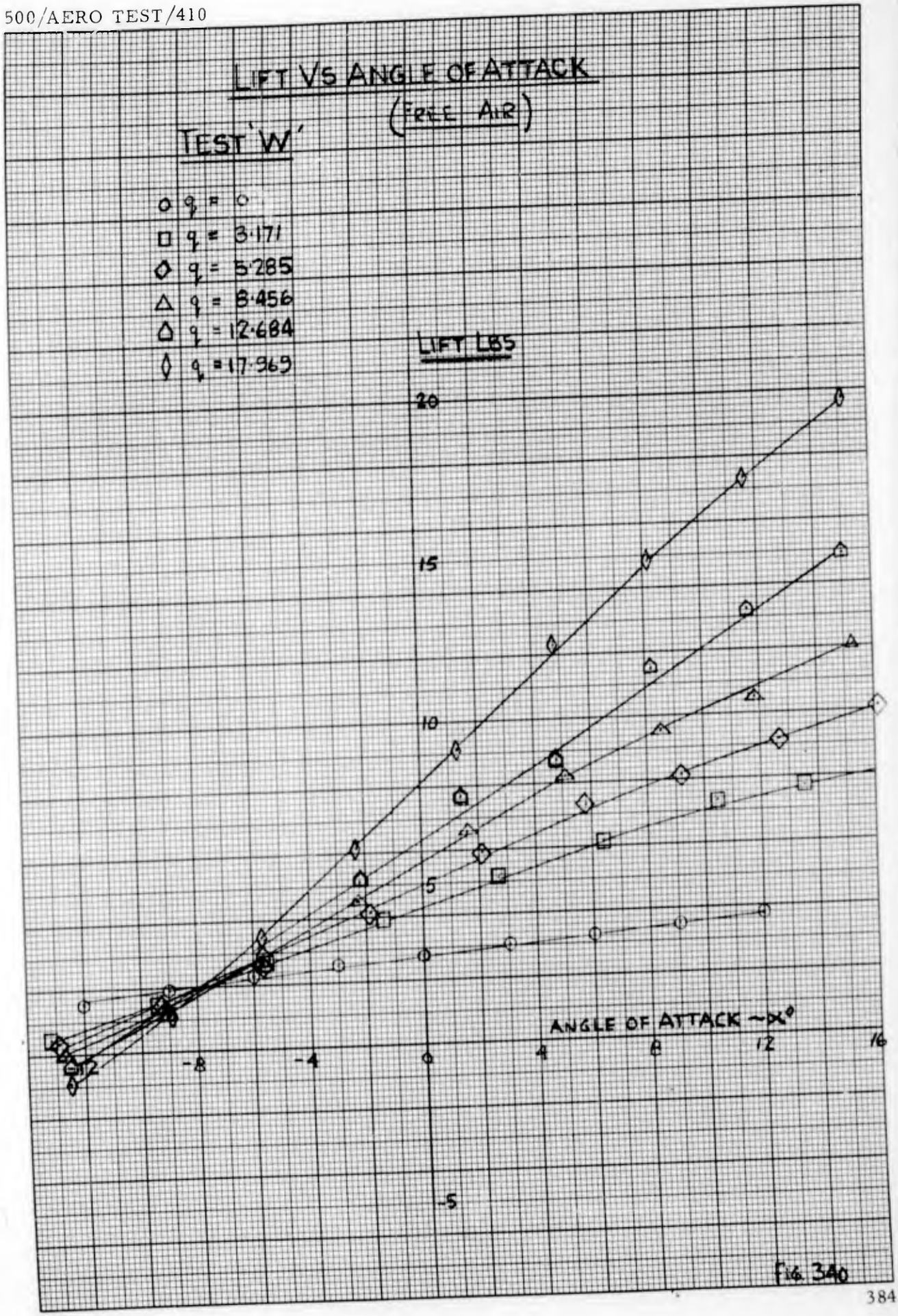

LIFT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'W'
q = 0
q = 3·171
q = 5·285
q = 8·456
q = 12·684
q = 17·969
LIFT LBS
20
15
10
5
-5
-8
-4
4
8
12
16
ANGLE OF ATTACK ~α°

Fig 340

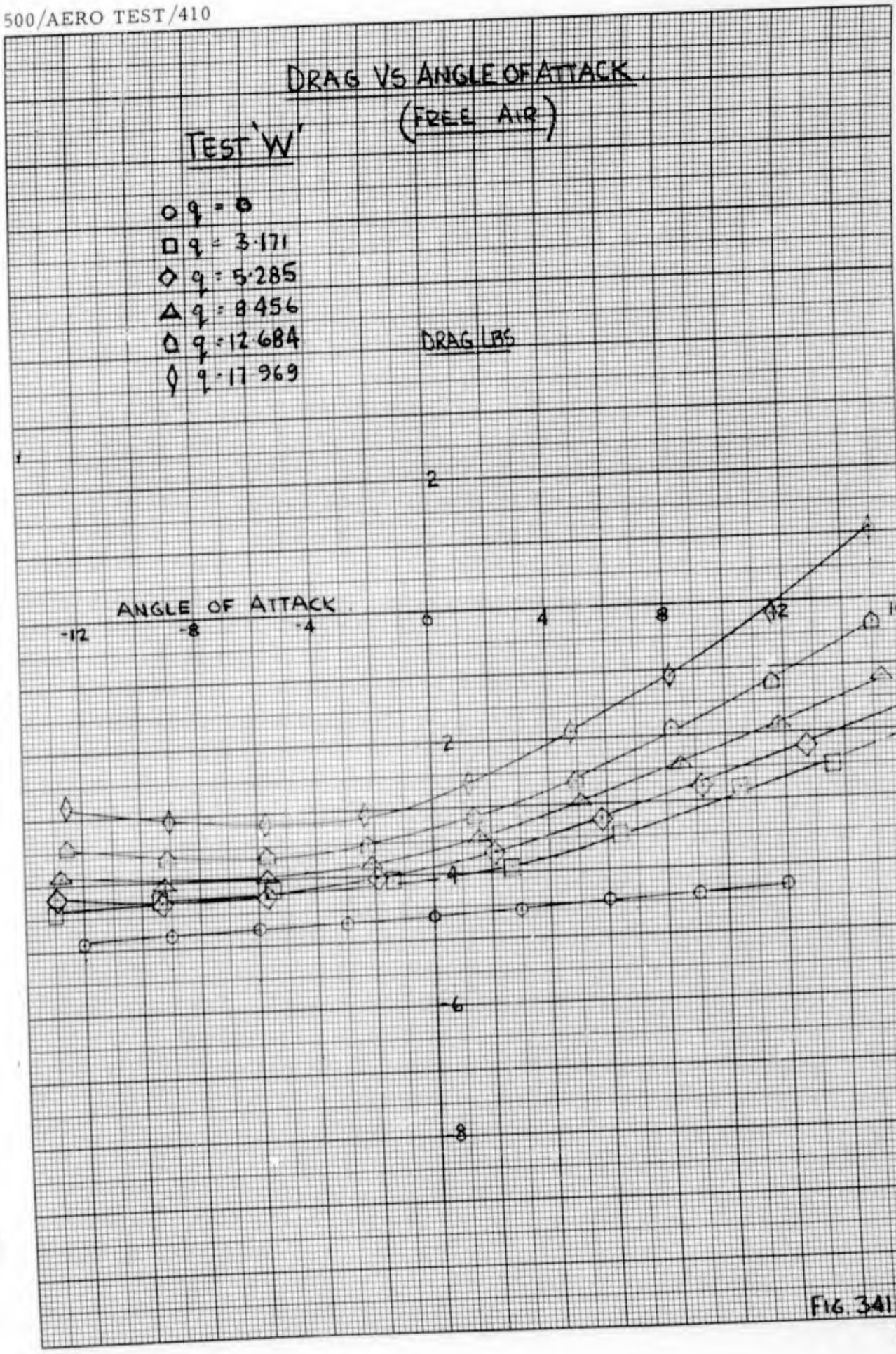

DRAG VS ANGLE OF ATTACK.
(FREE AIR)
TEST 'W'
○ q = 0
□ q = 3·171
◇ q = 5·285
△ q = 8·456
⬠ q = 12·684
◊ q = 17·969
DRAG LBS
2
ANGLE OF ATTACK.
-12
-8
-4
0
4
8
12
16
2
4
6
8

FIG. 341.

PITCHING MOMENT VS ANGLE OF ATTACK.

(FREE AIR)

TEST 'W'

- ○ q = 0
- □ q = 3.171
- ◇ q = 5.285
- △ q = 8.456
- ⬠ q = 12.684
- ◊ q = 17.969

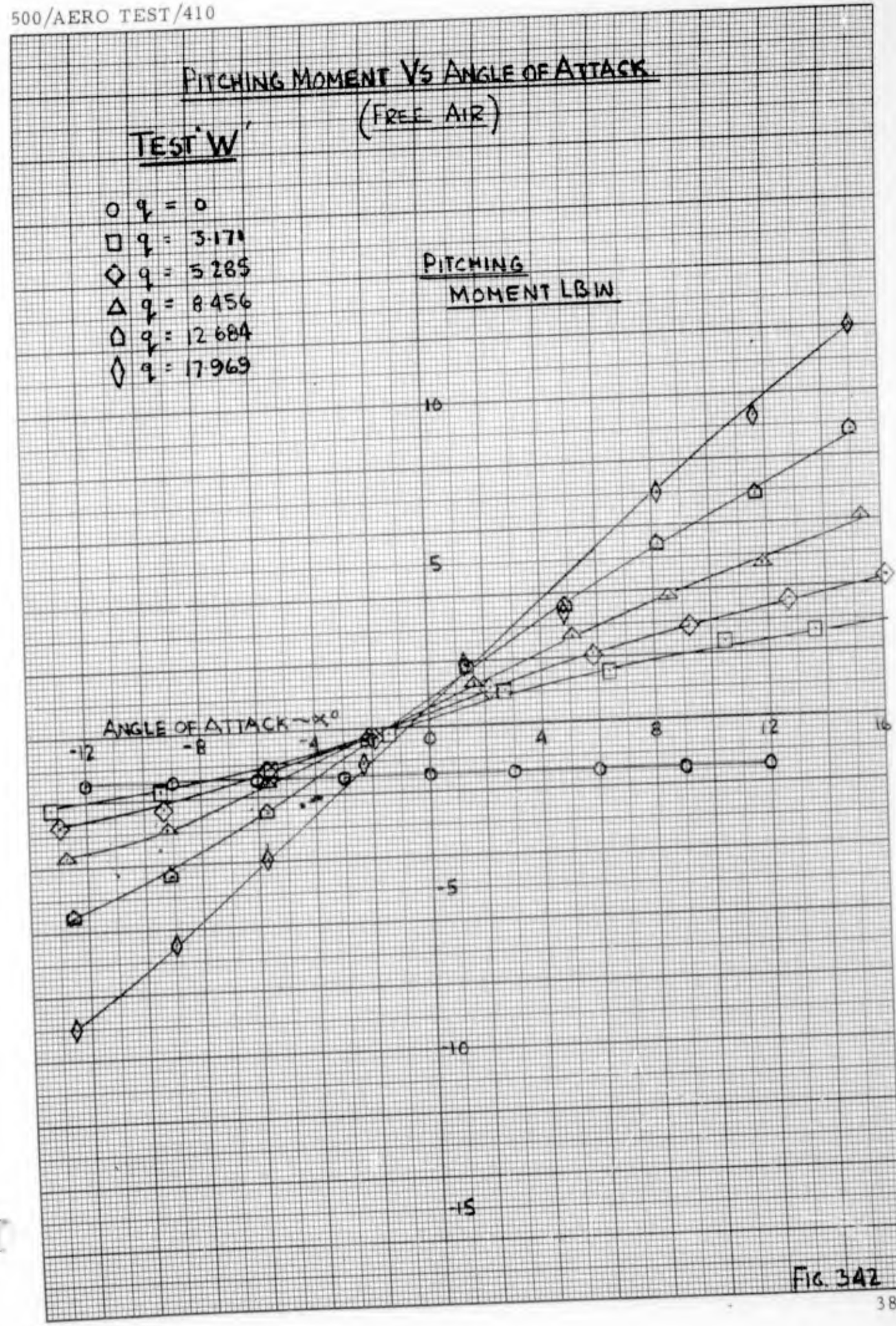


FIG. 342

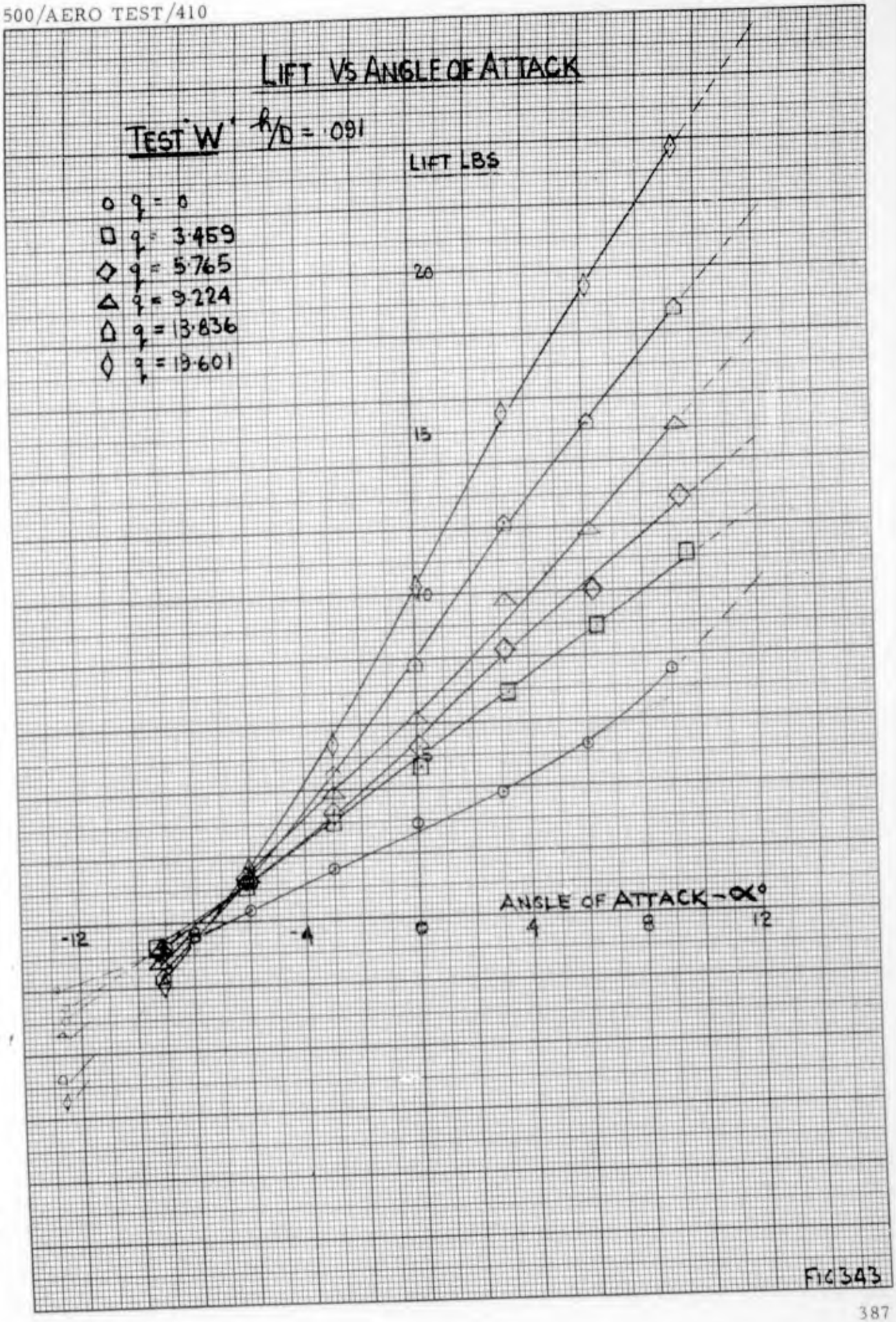

LIFT VS ANGLE OF ATTACK
TEST W h/D = .091
LIFT LBS
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 18.601
20
15
10
5
ANGLE OF ATTACK - α°
-12
-8
-4
0
4
8
12

Fig 343

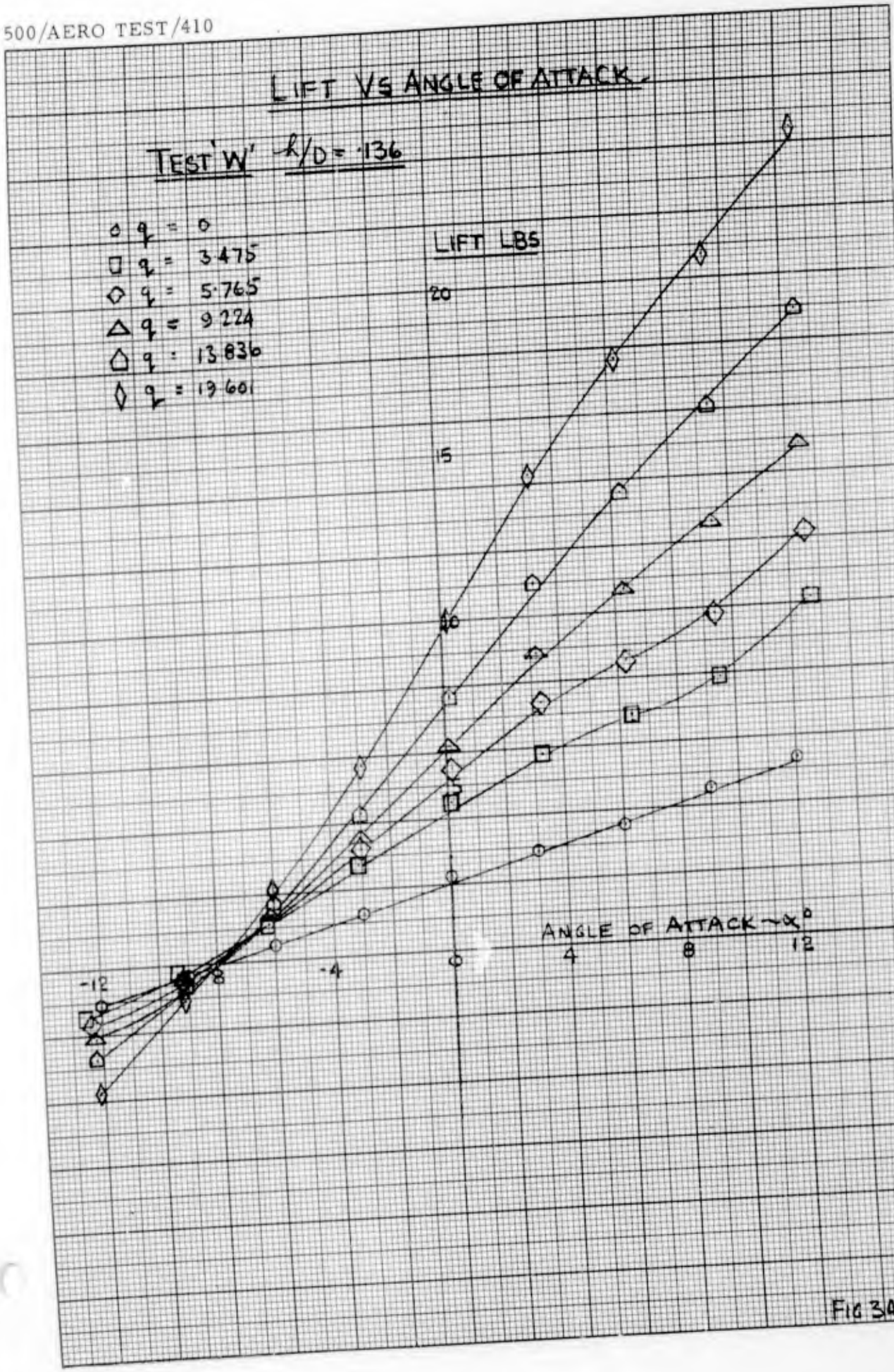

LIFT VS ANGLE OF ATTACK
TEST 'W' ℓ/D = ·136
q = 0
q = 3·475
q = 5·765
q = 9·224
q = 13·836
q = 19·601
LIFT LBS
20
15
10
5
ANGLE OF ATTACK → α°
-12
-8
-4
0
4
8
12

Fig 3.44

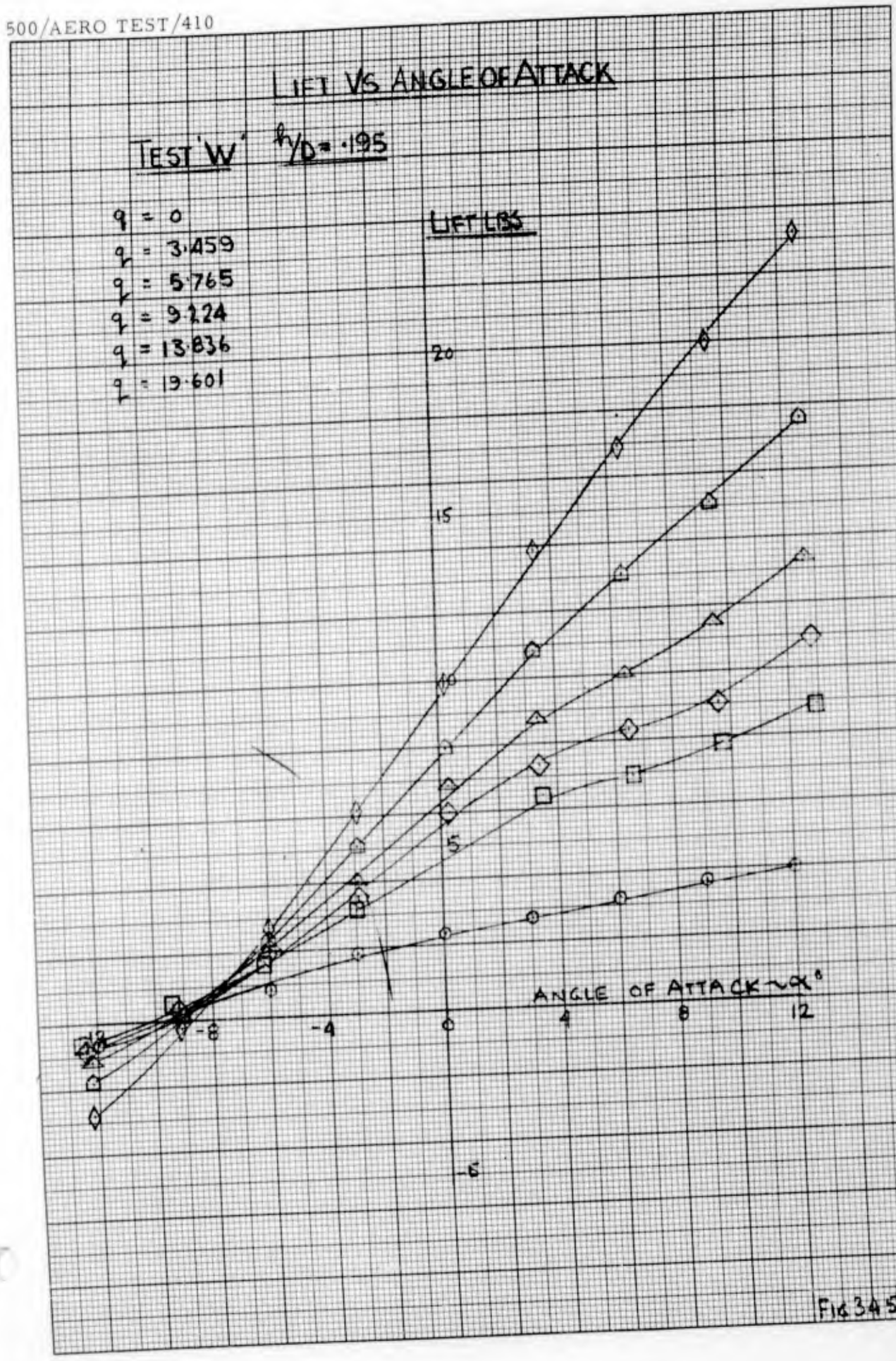

LIFT VS ANGLE OF ATTACK
TEST 'W' h/D = .195
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
LIFT LBS
20
15
10
5
-5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~α°

FIG 345

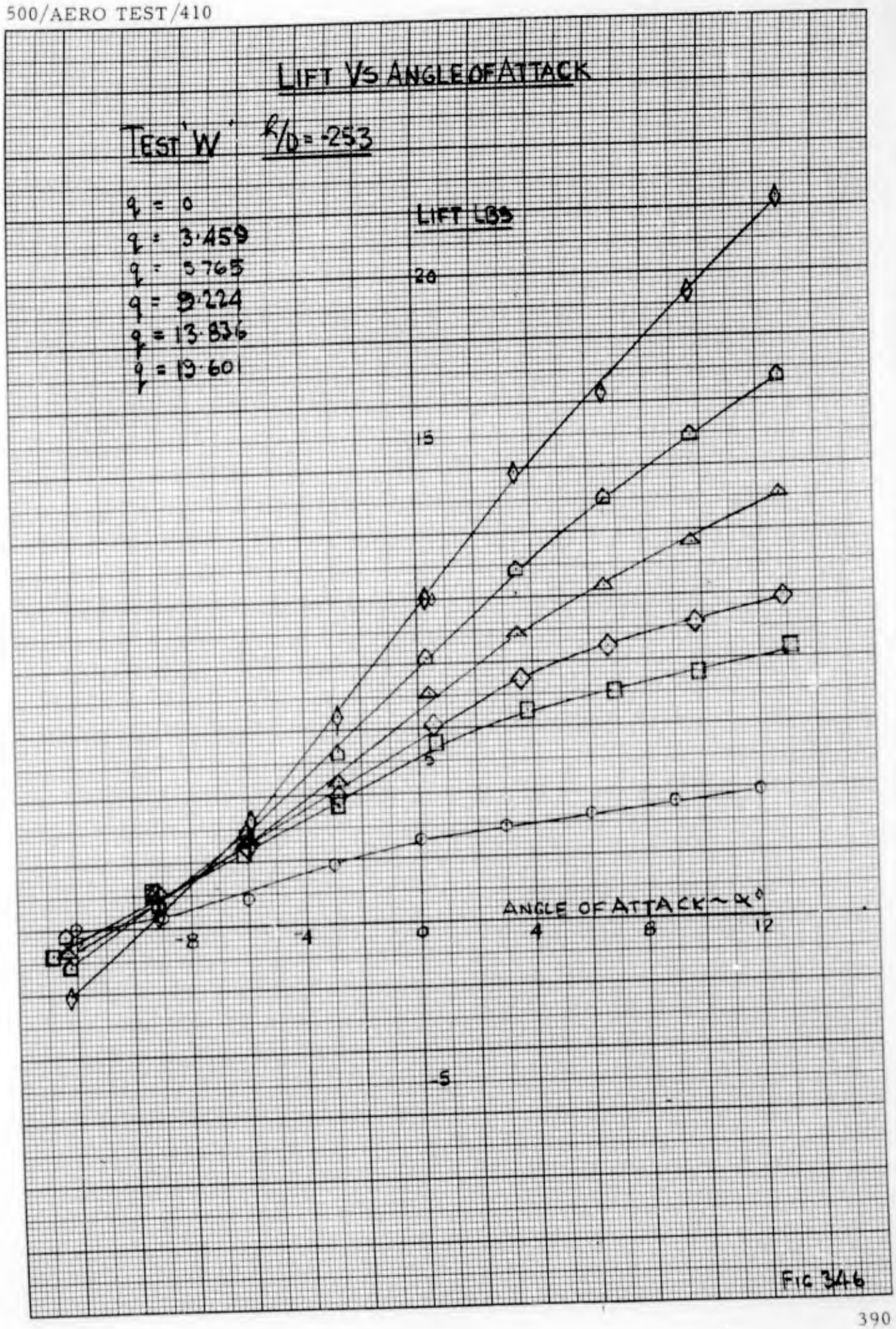

LIFT VS ANGLE OF ATTACK
TEST 'W' R/D = .253
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.60
LIFT LBS
20
15
5
-5
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 346

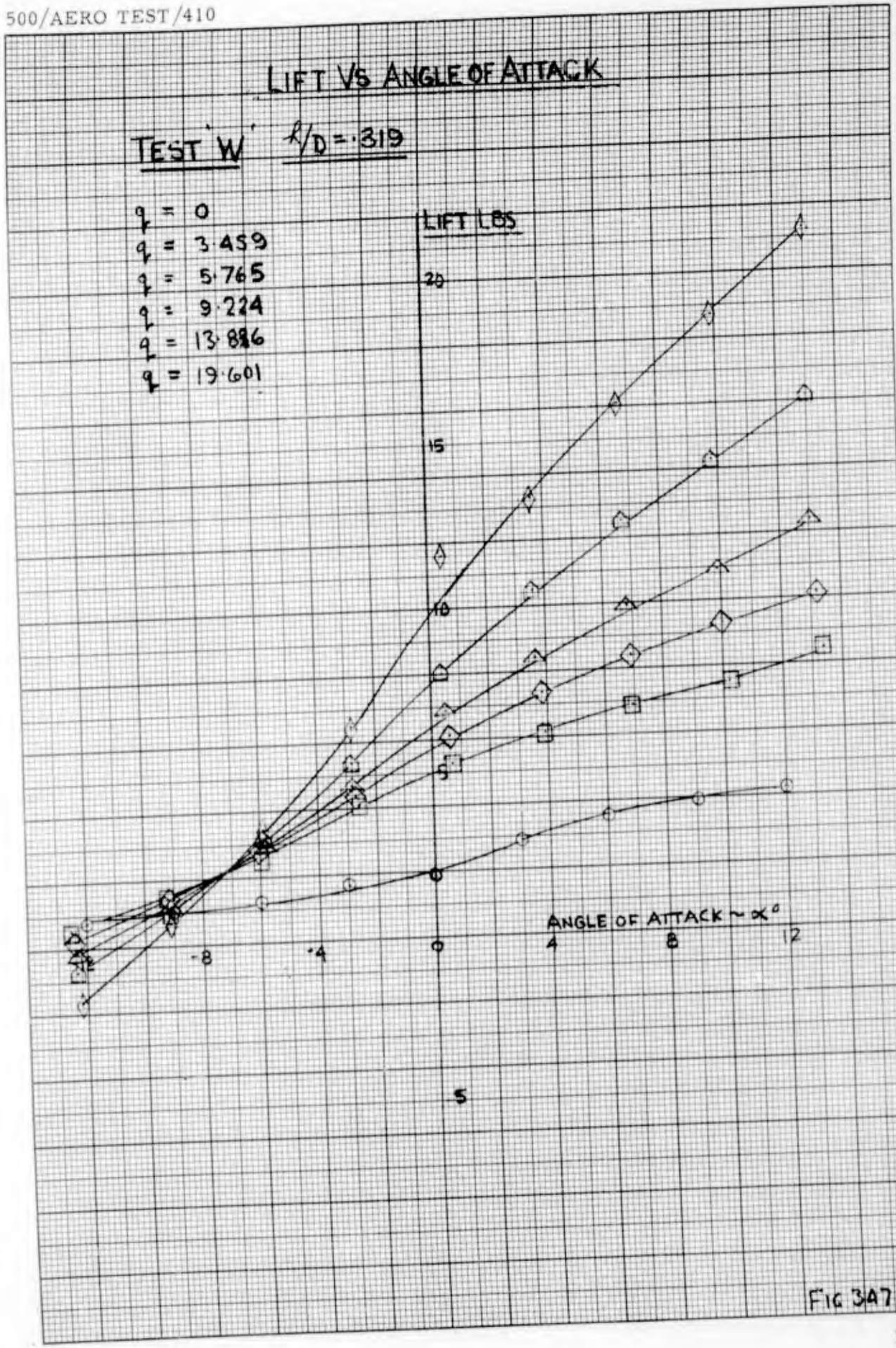

LIFT VS ANGLE OF ATTACK
TEST W
$\ell/D = .319$
$q = 0$
$q = 3.459$
$q = 5.765$
$q = 9.224$
$q = 13.886$
$q = 19.601$
LIFT LBS
20
15
10
5
0
-8
-4
4
8
12
ANGLE OF ATTACK ~ α°

FIG 347

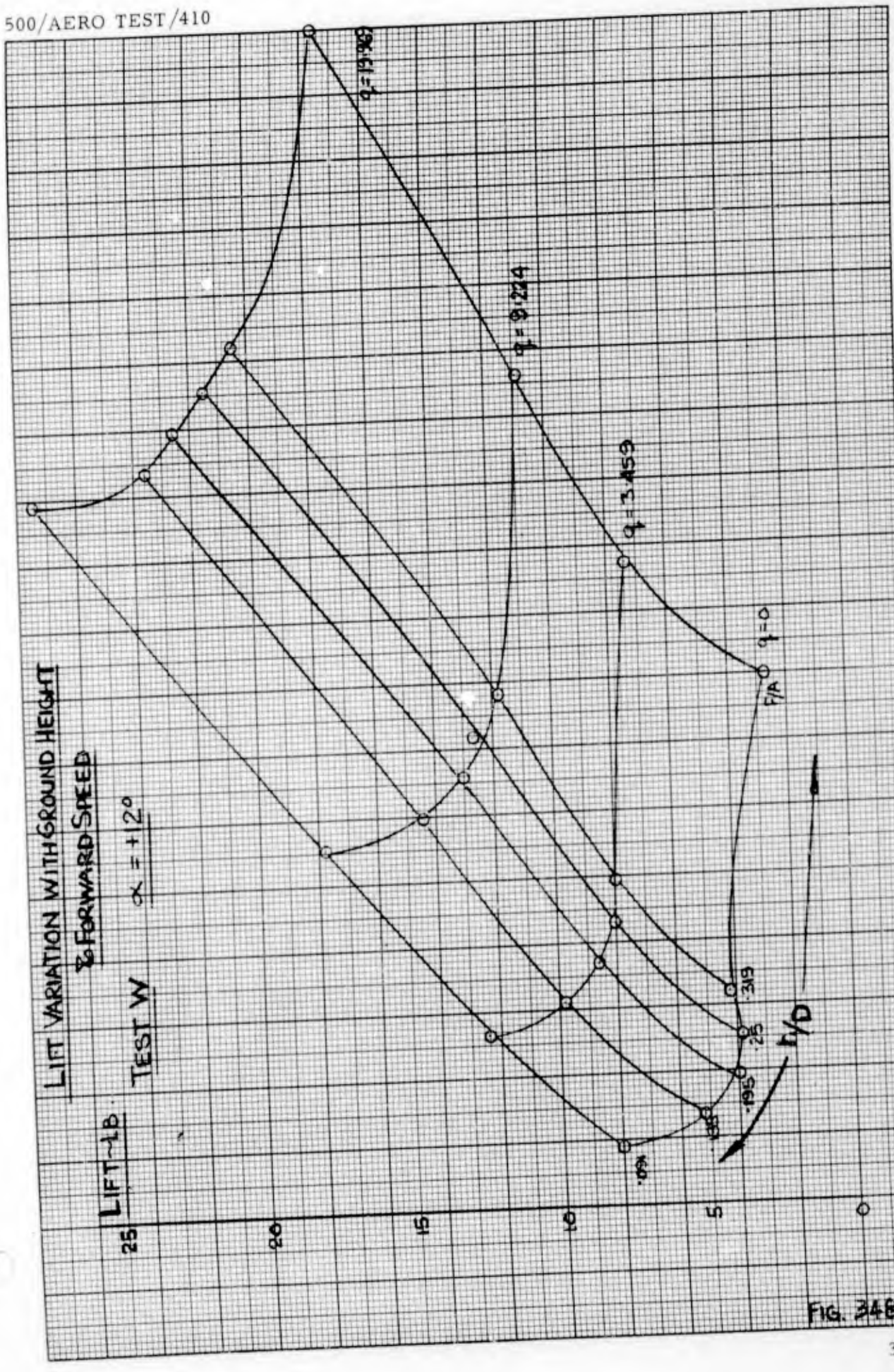

LIFT VARIATION WITH GROUND HEIGHT
& FORWARD SPEED
TEST W
α = +12°
LIFT~LB.
25
20
15
10
5
0
q=19.969
q=9.274
q=3.459
q=0
F/A
.319
.25
.195
.156
.69
h/D

FIG. 346

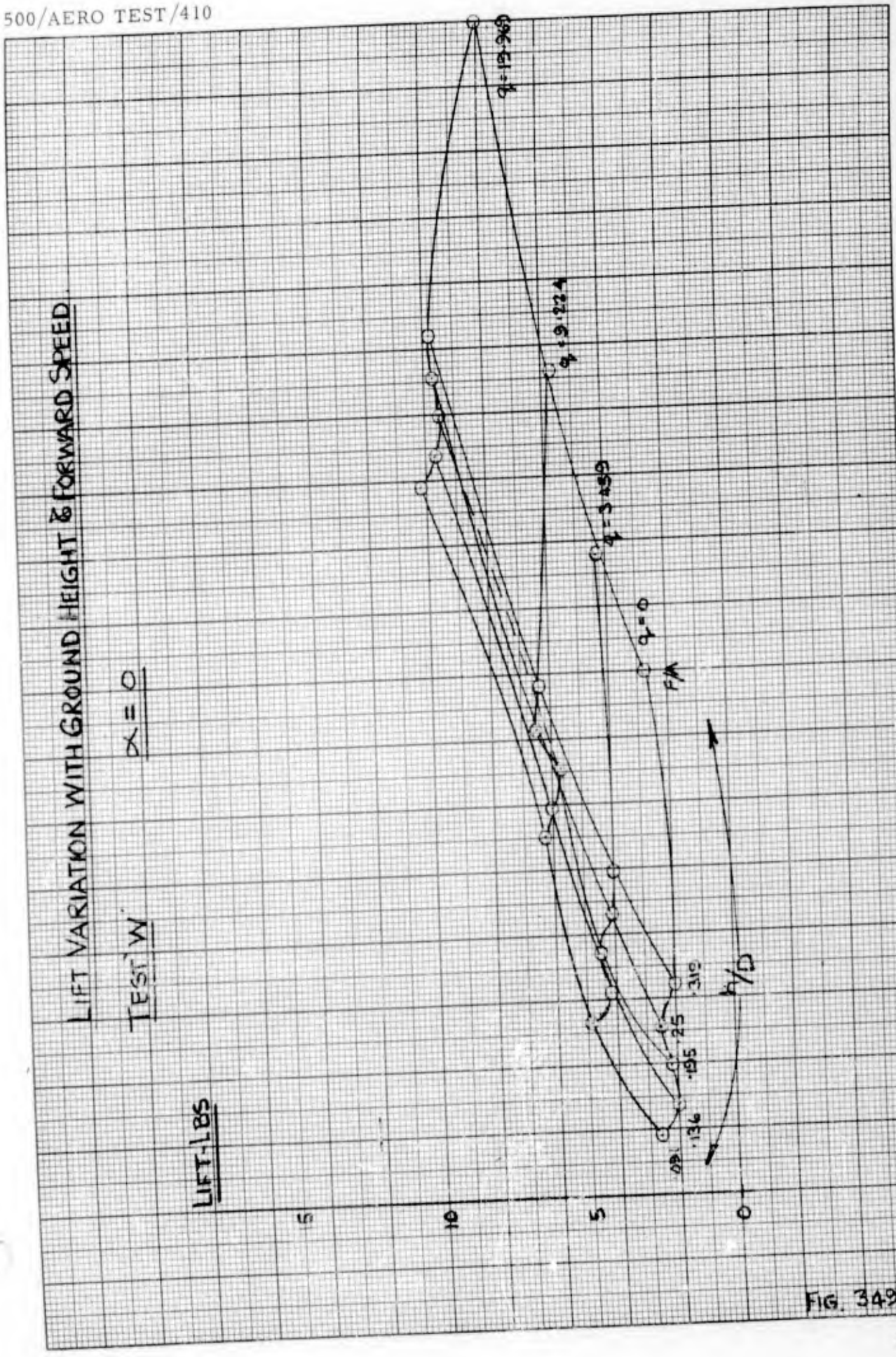
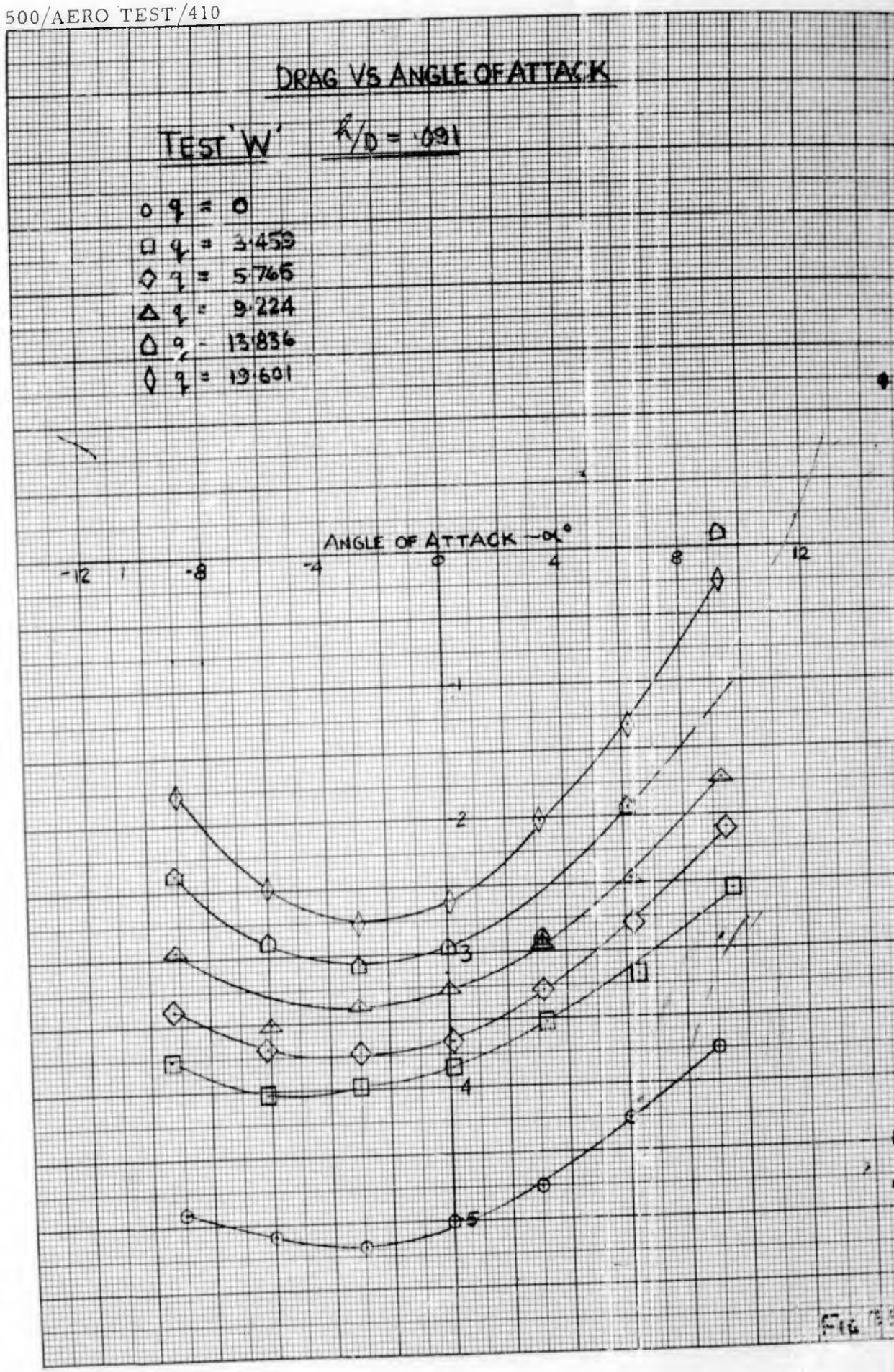

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED.
TEST W
α = 0
LIFT-LBS
q = 151.9
q = 9.22.4
q = 3.39
q = 0
FWD
h/D
.319
.25
.195
.136
.081
15
10
5
0

FIG. 349

LIFT VARIATION WITH GROUND HEIGHT & FORWARD SPEED
TEST 'W'
α = -12
LIFT LBS
+10
+5
0
-5
q=0
q=3459
q=9224
q=13,969
F/A
h/D

FIG 350


DRAG VS ANGLE OF ATTACK
TEST 'W' K/D = .091
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬡ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK -α°
-12
-8
-4
0
4
8
12
1
2
3
4
5

Fig

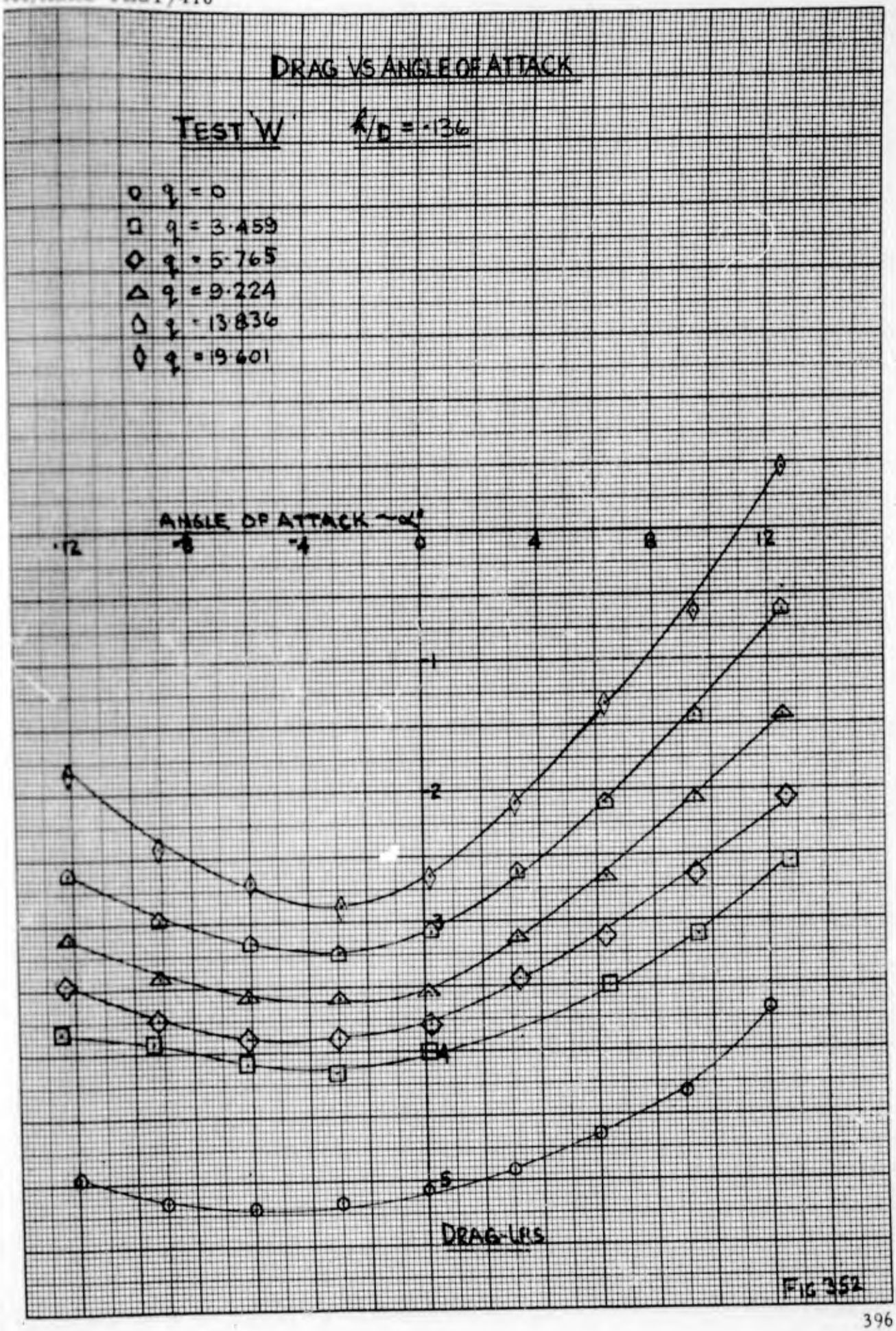

DRAG VS ANGLE OF ATTACK
TEST W
h/D = .136
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
1
2
3
4
5
DRAG-LBS

FIG 352

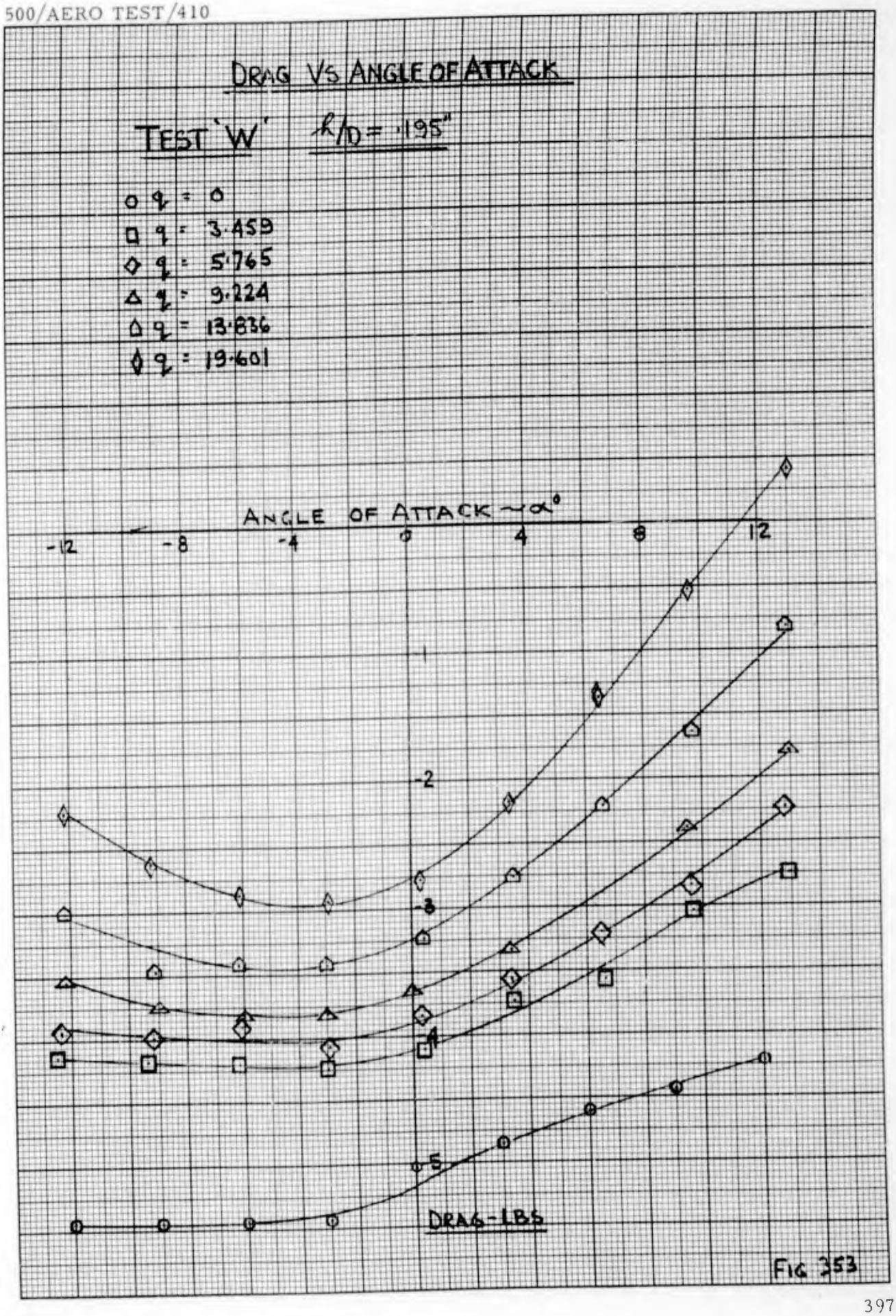

DRAG VS ANGLE OF ATTACK
TEST 'W' R/D = .195"
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-1
-2
-3
-4
-5
DRAG-LBS

FIG 353

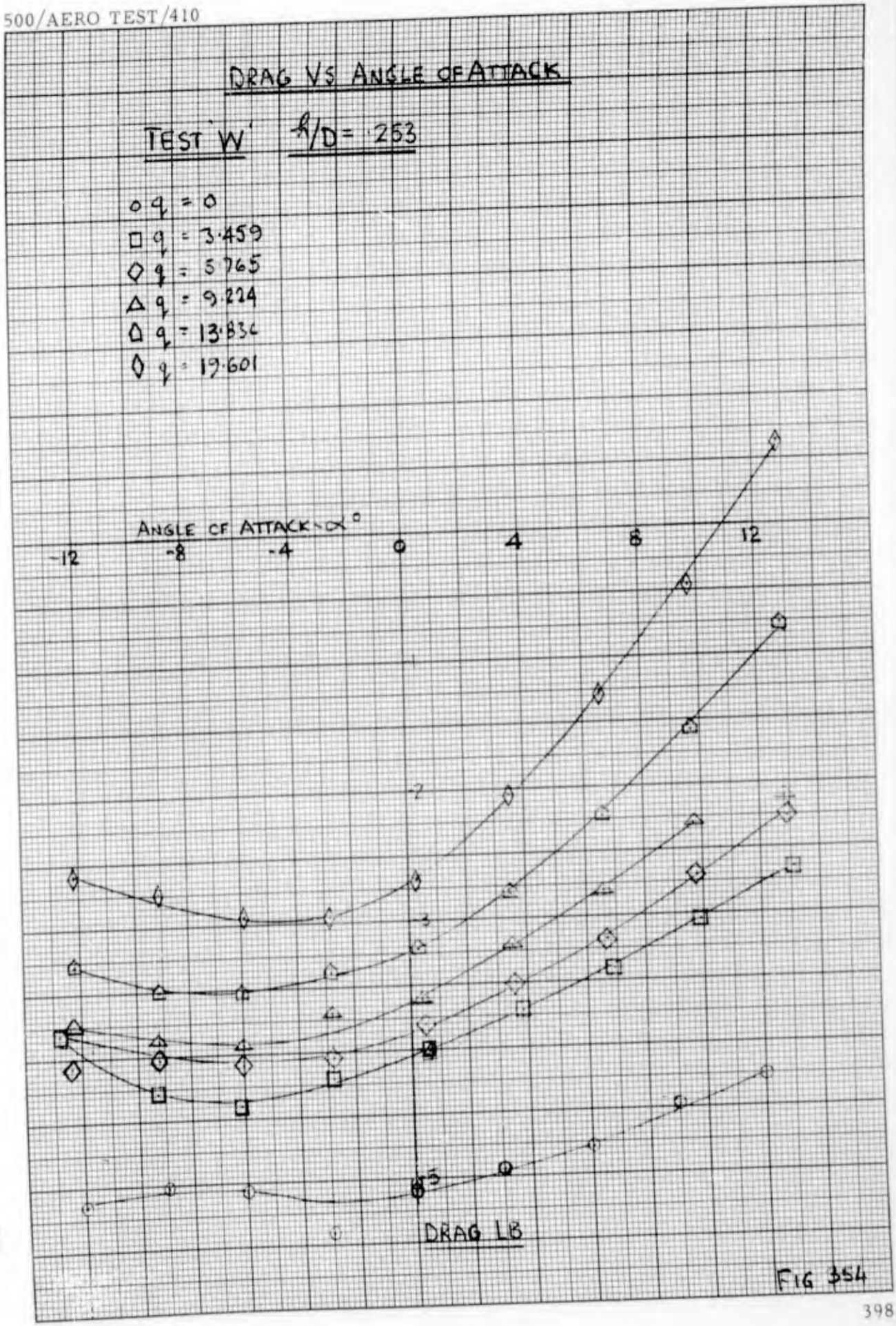
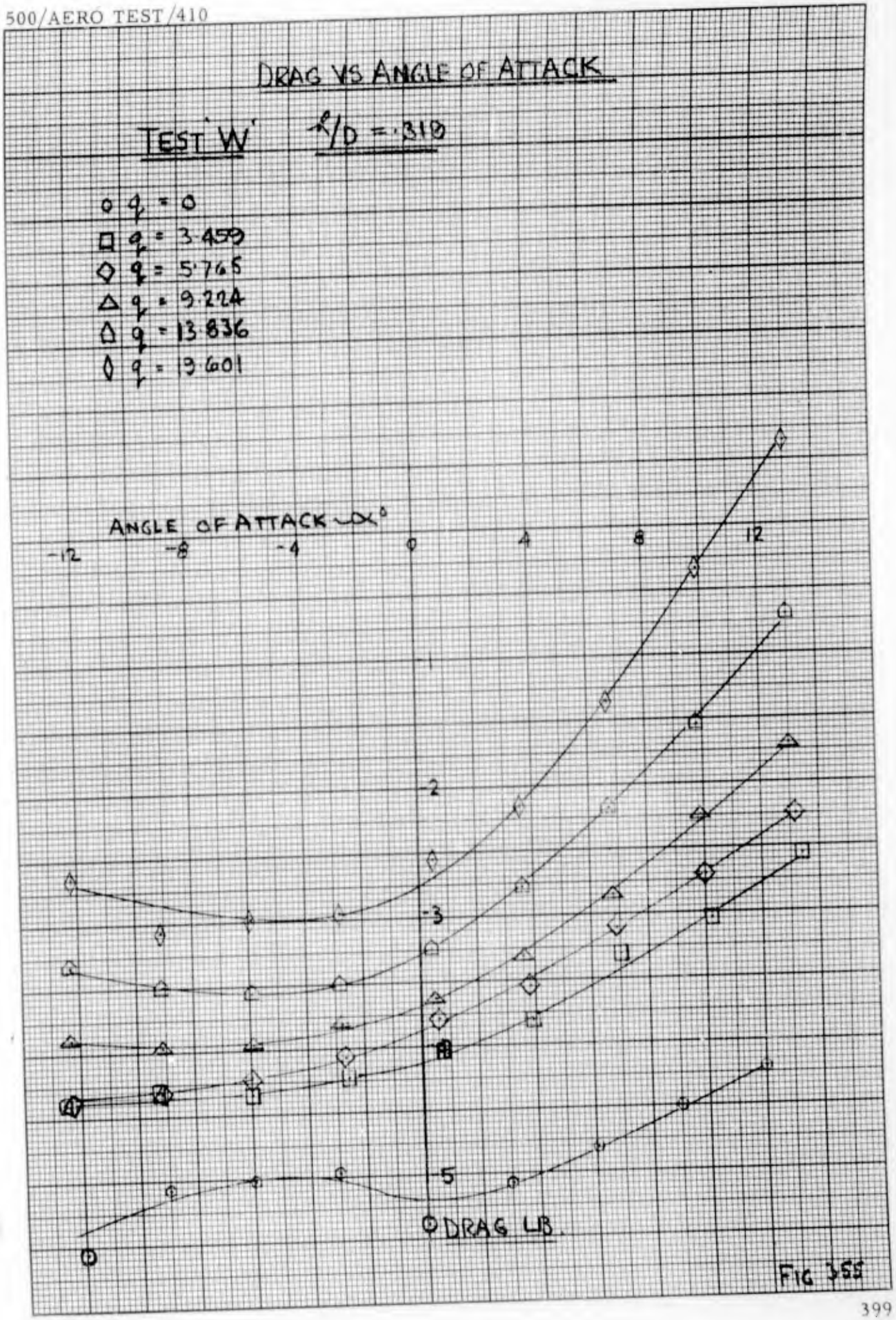

DRAG VS ANGLE OF ATTACK
TEST W' A/D = .253
o q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
-2
3
5
DRAG LB

FIG 354


DRAG VS ANGLE OF ATTACK
TEST W
$\frac{s}{D}$ = .310
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⌂ q = 13.836
◊ q = 19.601
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
-1
-2
-3
-5
DRAG LB.
FIG 355

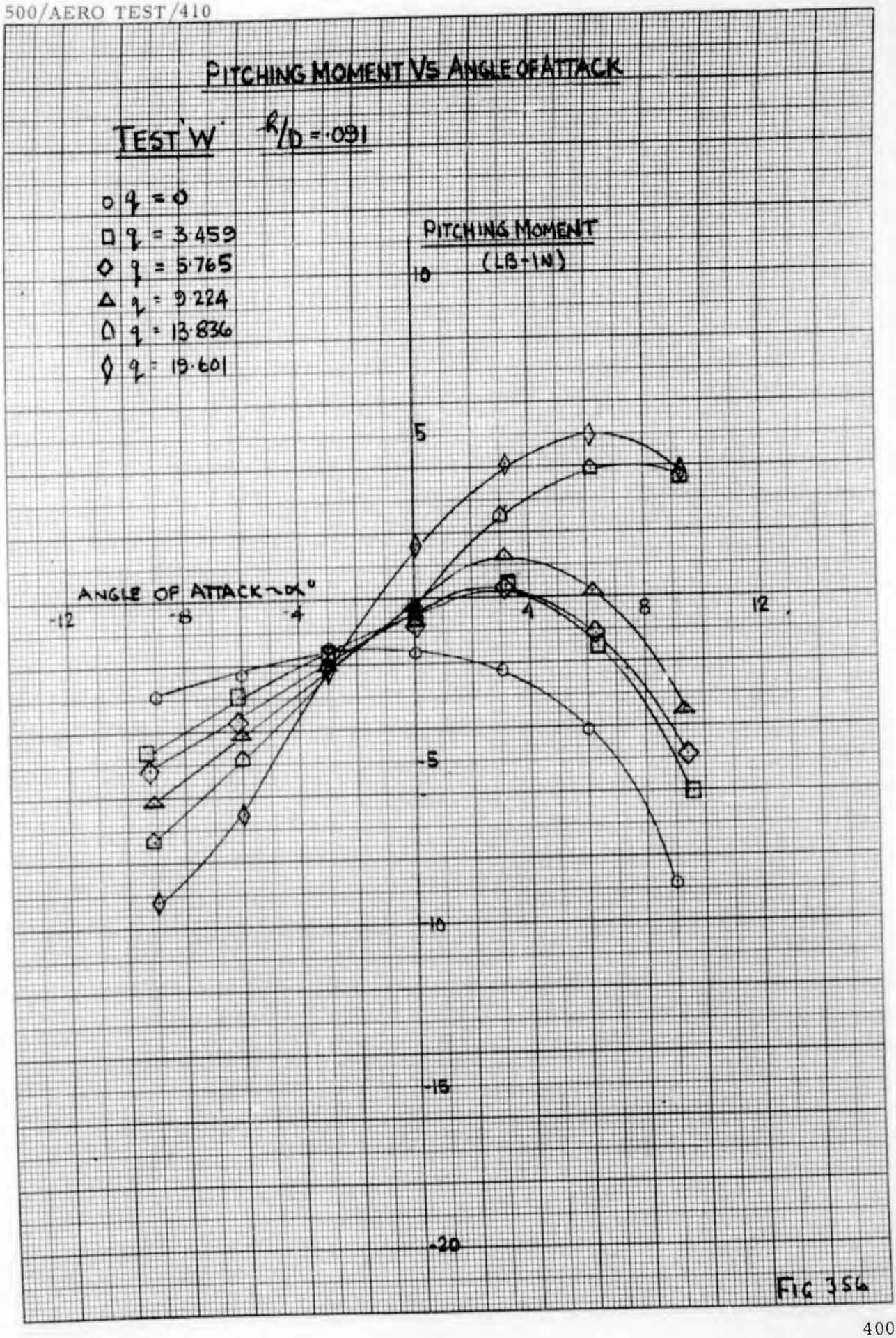
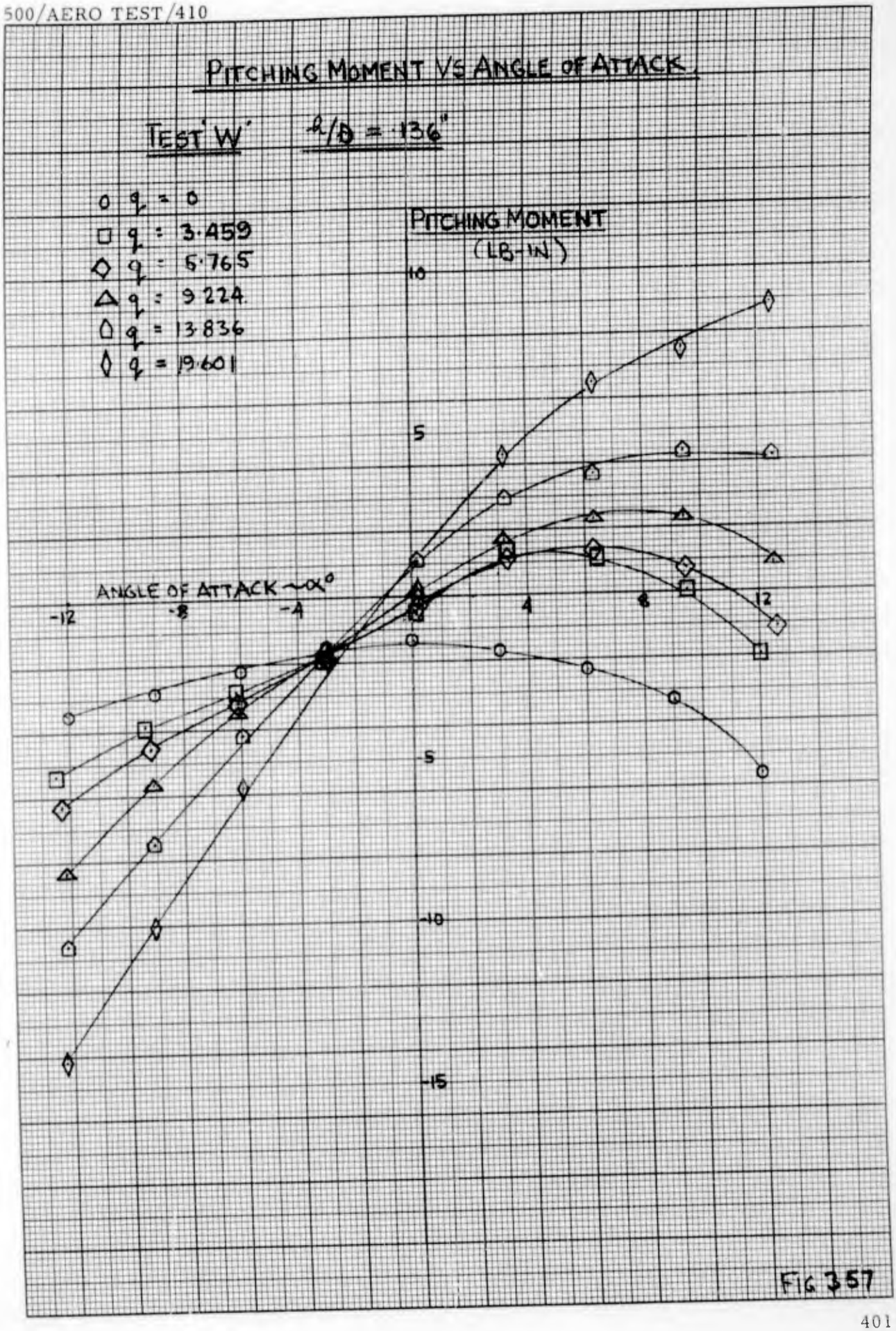

PITCHING MOMENT VS ANGLE OF ATTACK
TEST W
R/D = .091
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
⬡ q = 13.836
◊ q = 19.601
PITCHING MOMENT
(LB-IN)
10
5
-5
-10
-15
-20
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12

FIG 356


PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'W' ℓ/D = .136"
q = 0
q = 3.459
q = 5.765
q = 9.224
q = 13.836
q = 19.601
PITCHING MOMENT (LB-IN)
10
5
-5
-10
-15
ANGLE OF ATTACK ~α°
-12
-8
-4
4
8
12
FIG 357

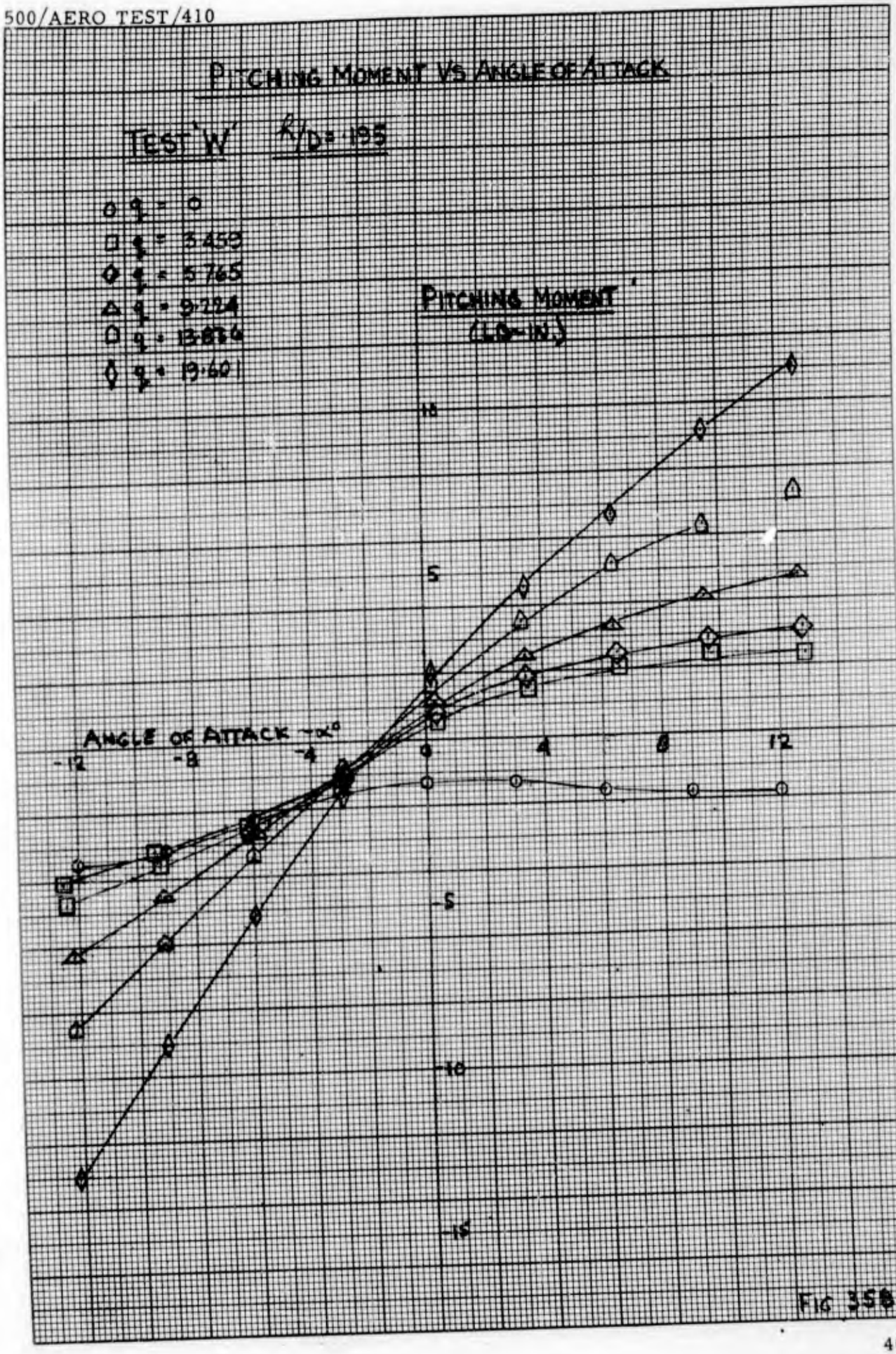

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'W' R/D = .195
○ q = 0
□ q = 3.459
◇ q = 5.765
△ q = 9.224
○ q = 13.836
◇ q = 19.601
PITCHING MOMENT (LB-IN.)
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
10
5
-5
-10
-15

FIG 358

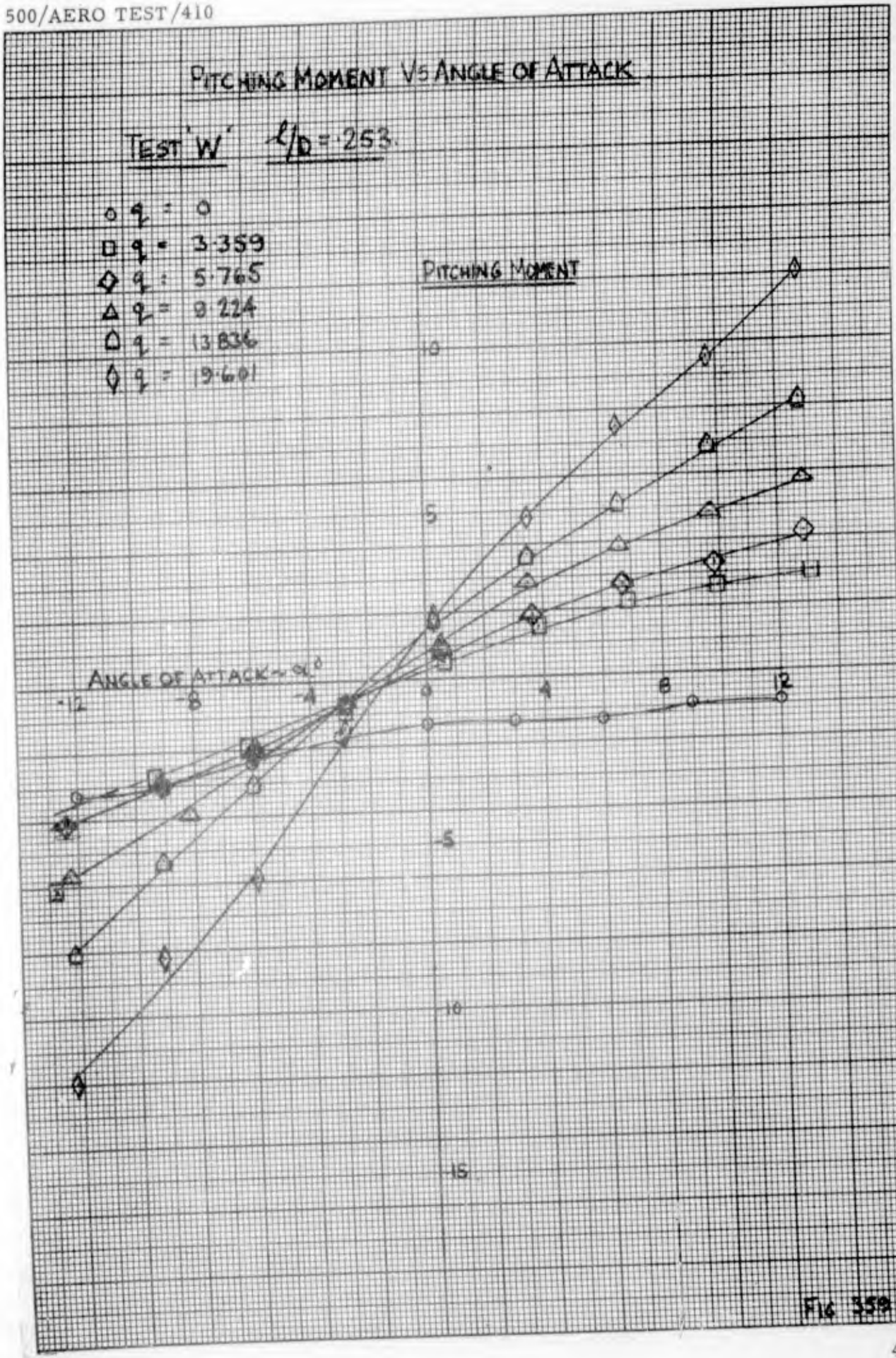

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'W' ℓ/D = ·253
○ q = 0
□ q = 3·359
◇ q = 5·765
△ q = 8·224
⬡ q = 13·836
◊ q = 19·601
PITCHING MOMENT
ANGLE OF ATTACK = α°
-12
-8
-4
0
4
8
12
10
5
-5
-10
-15

FIG 358

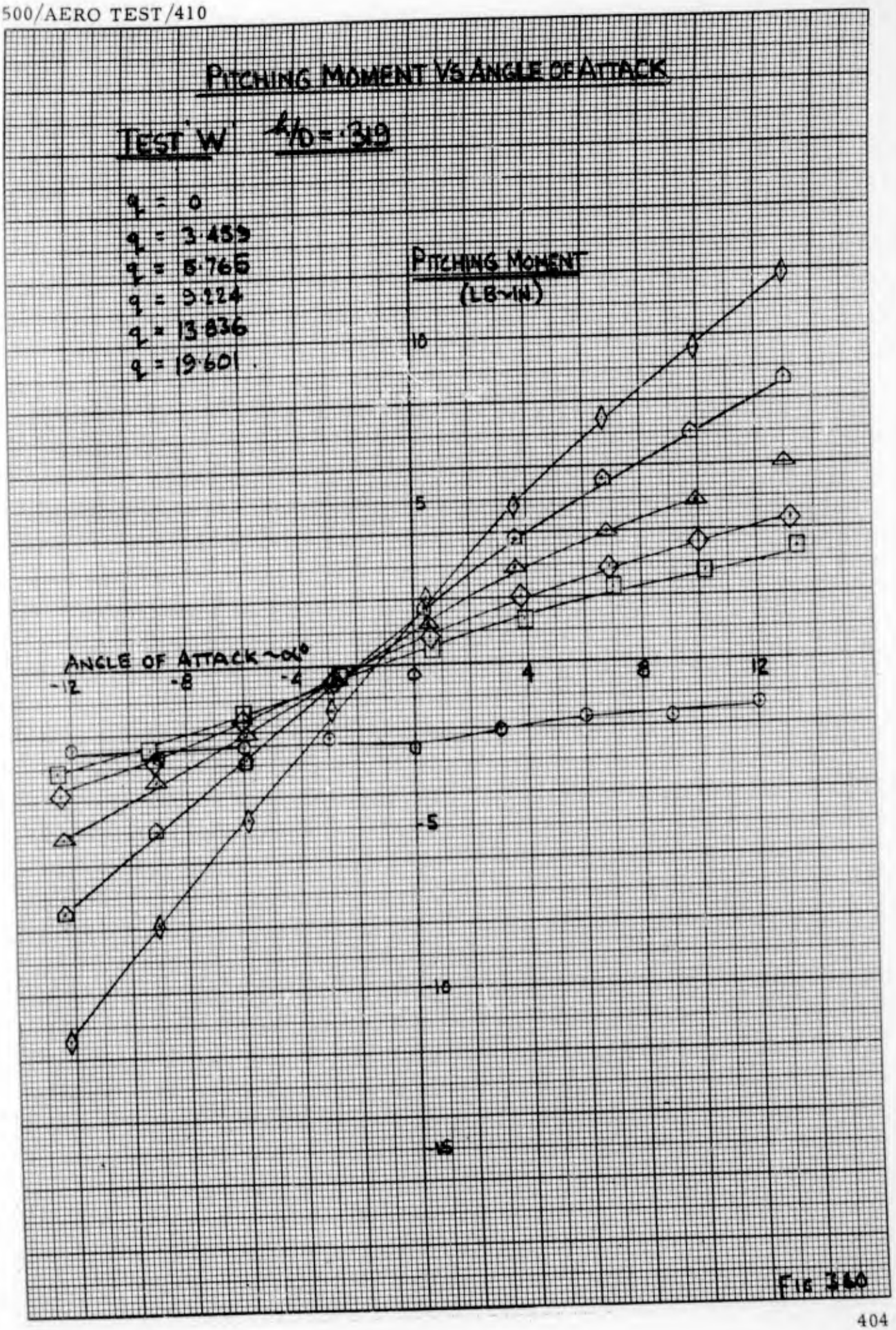

PITCHING MOMENT VS ANGLE OF ATTACK
TEST W
$\ell/D = .319$
$q = 0$
$q = 3.459$
$q = 5.765$
$q = 9.224$
$q = 13.836$
$q = 19.601$
PITCHING MOMENT
(LB-IN)
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
10
5
-5
-10
-15

FIG 360

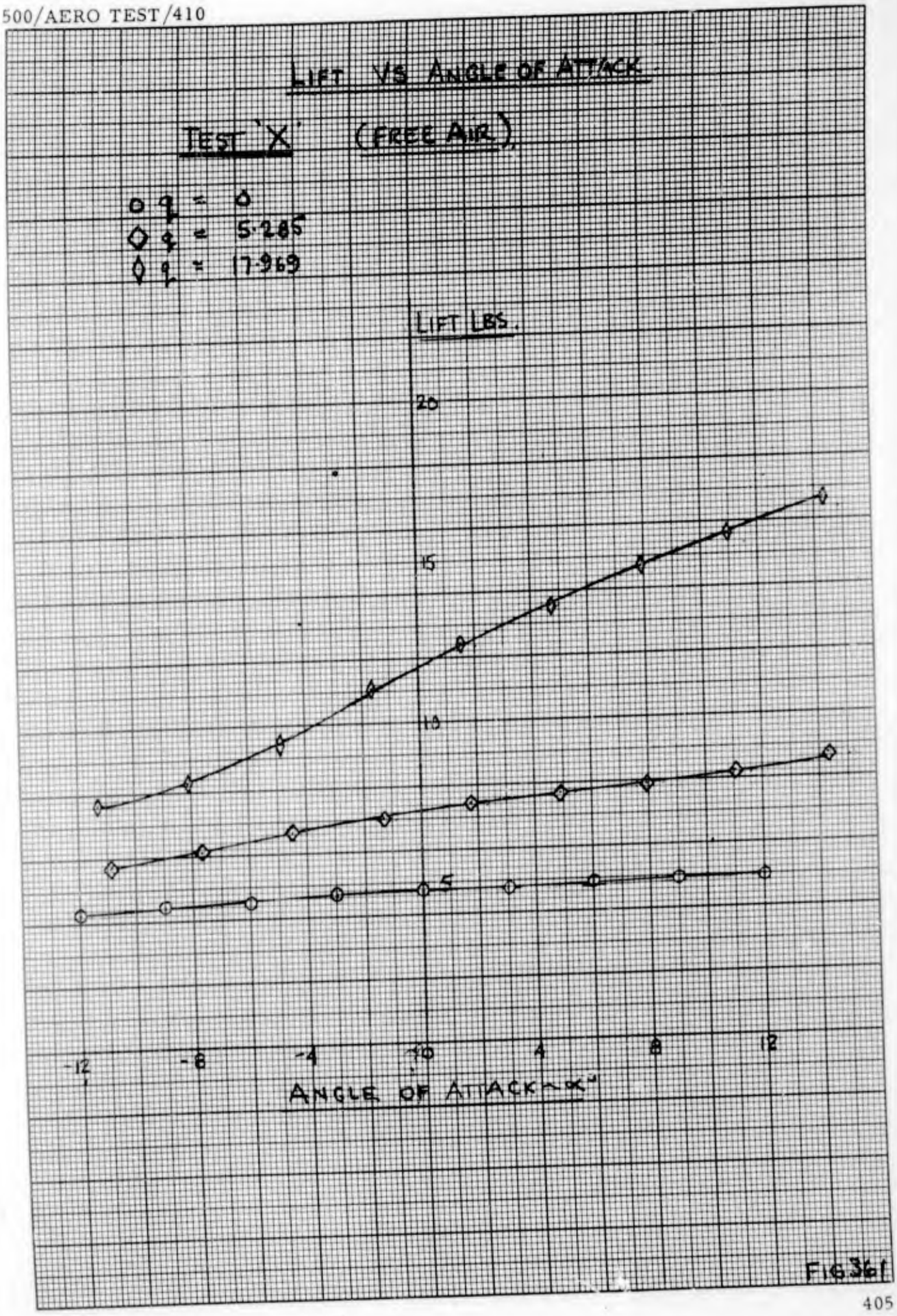

LIFT VS ANGLE OF ATTACK
TEST 'X' (FREE AIR)
q = 0
q = 5.285
q = 17.969
LIFT LBS.
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

Fig 36f

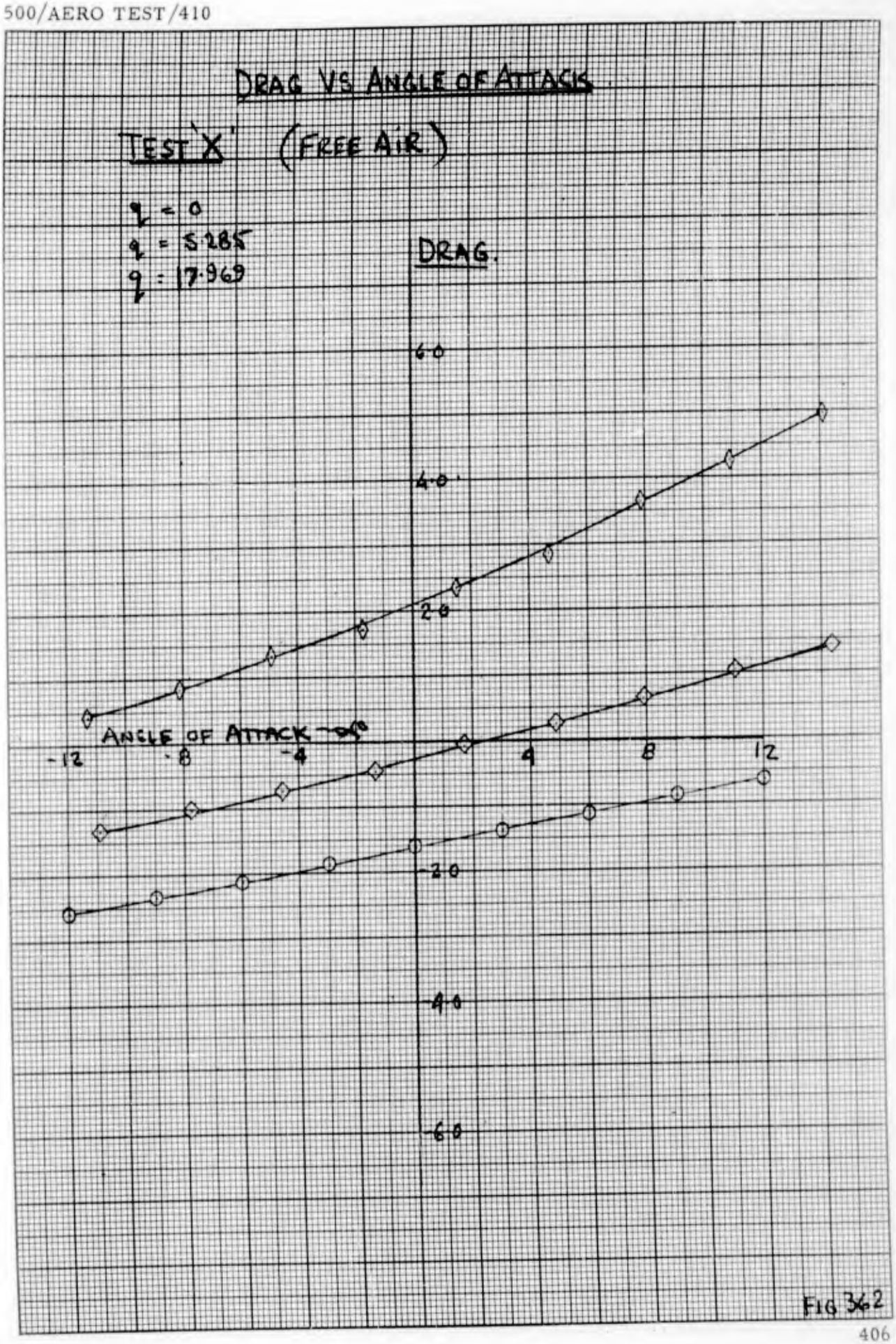

DRAG VS ANGLE OF ATTACK
TEST 'X' (FREE AIR)
γ = 0
ϕ = 5·285
q = 17·969
DRAG.
6·0
4·0
2·0
ANGLE OF ATTACK
-12
-8
-4
4
8
12
2·0
4·0
6·0

FIG 3.62

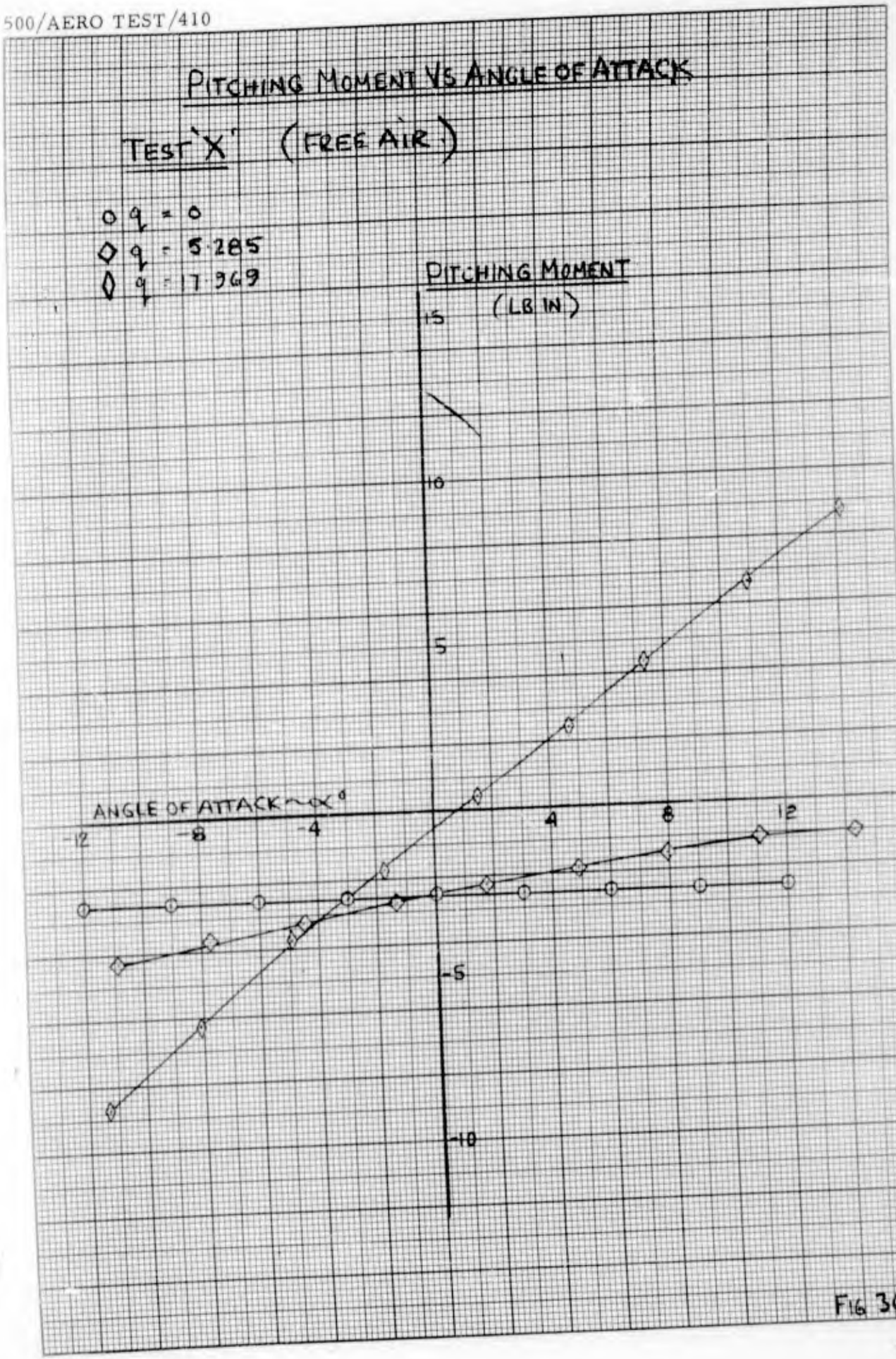

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'X' (FREE AIR)
○ q = 0
◇ q = 5·285
◊ q = 17·969
PITCHING MOMENT
(LB IN)
15
10
5
-5
-10
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12

Fig 363

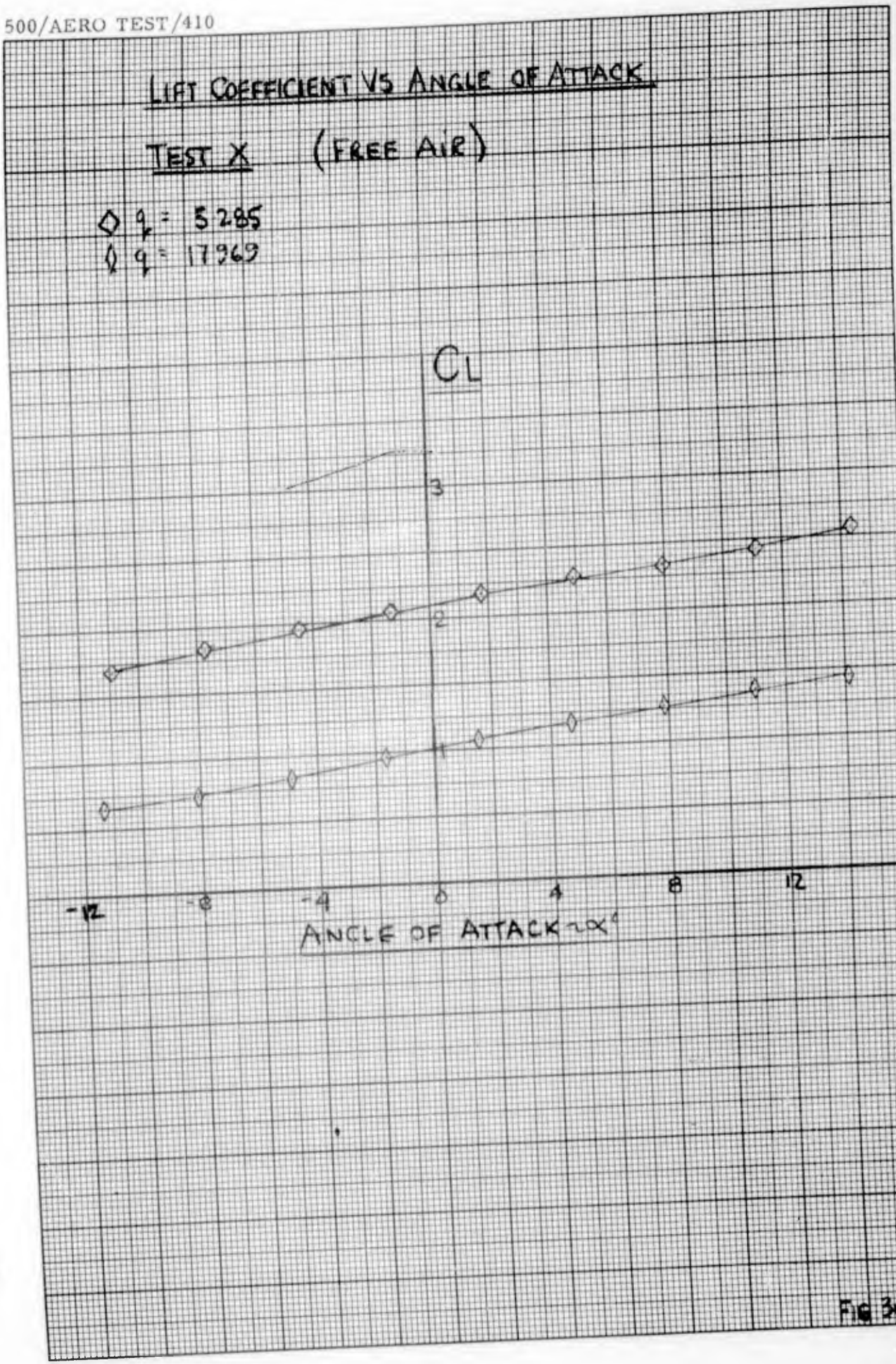

LIFT COEFFICIENT VS ANGLE OF ATTACK
TEST X (FREE AIR)
◇ q = 5285
◇ q = 17969
CL
3
2
1
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK - α°

FIG 364

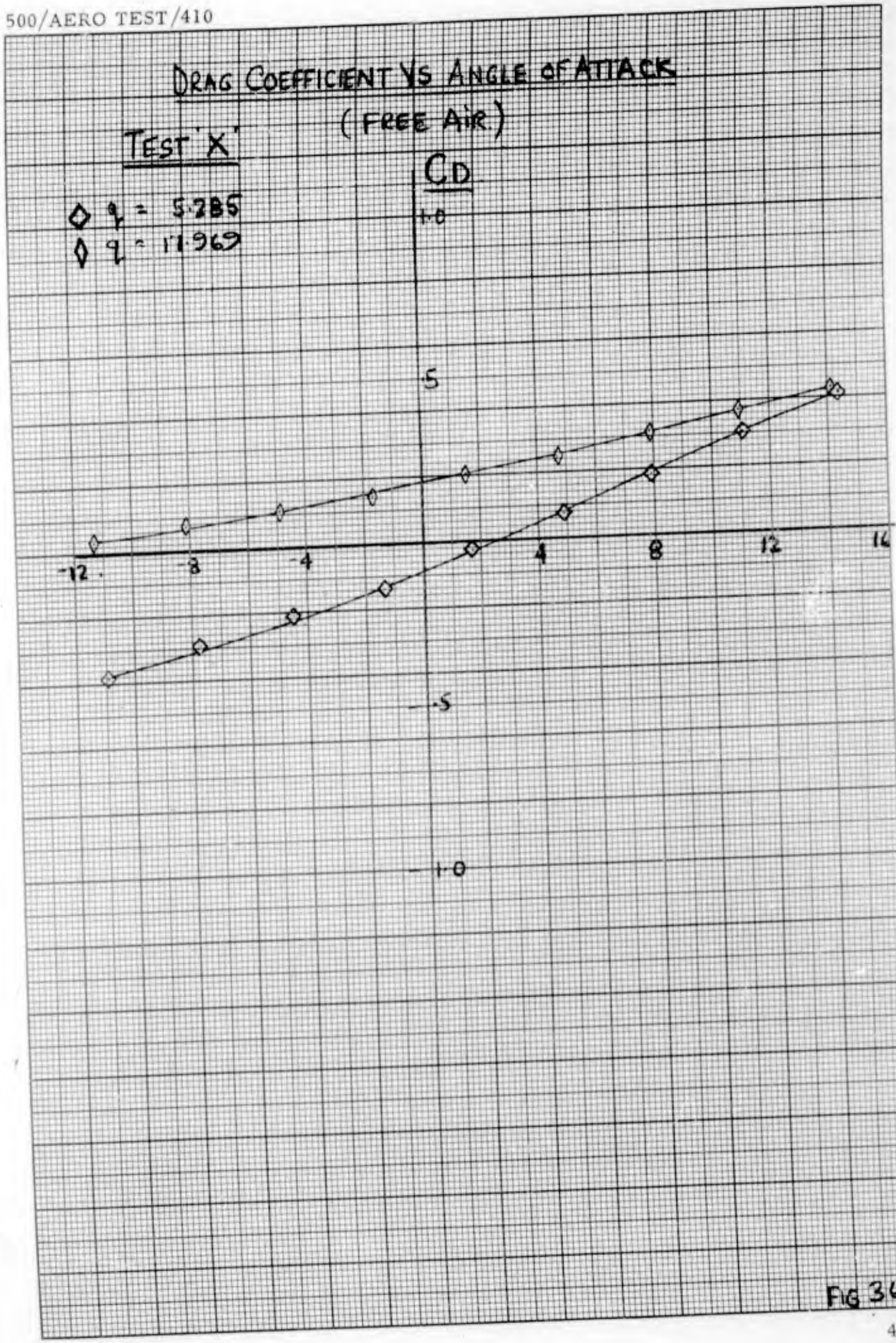

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'X'
◇ q = 5.285
◇ q = 11.969
CD
1.0
.5
-12
-8
-4
4
8
12
16
-.5
-1.0

FIG 365

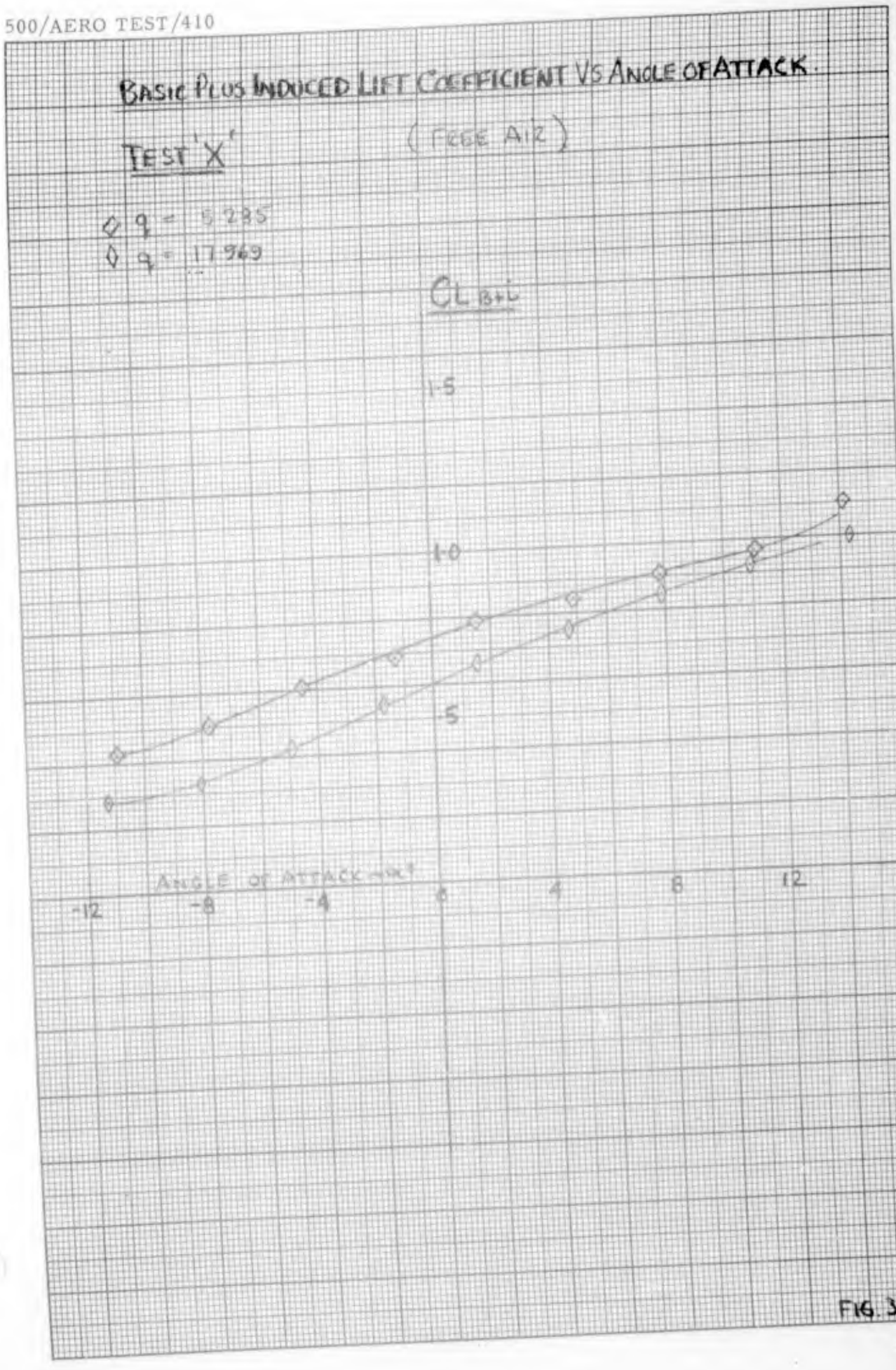

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK.
TEST 'X'
(FREE AIR)
◇ q = 5285
◇ q = 17969
CL B+i
1·5
1·0
·5
ANGLE OF ATTACK α°
-12
-8
-4
0
4
8
12
16

FIG. 366

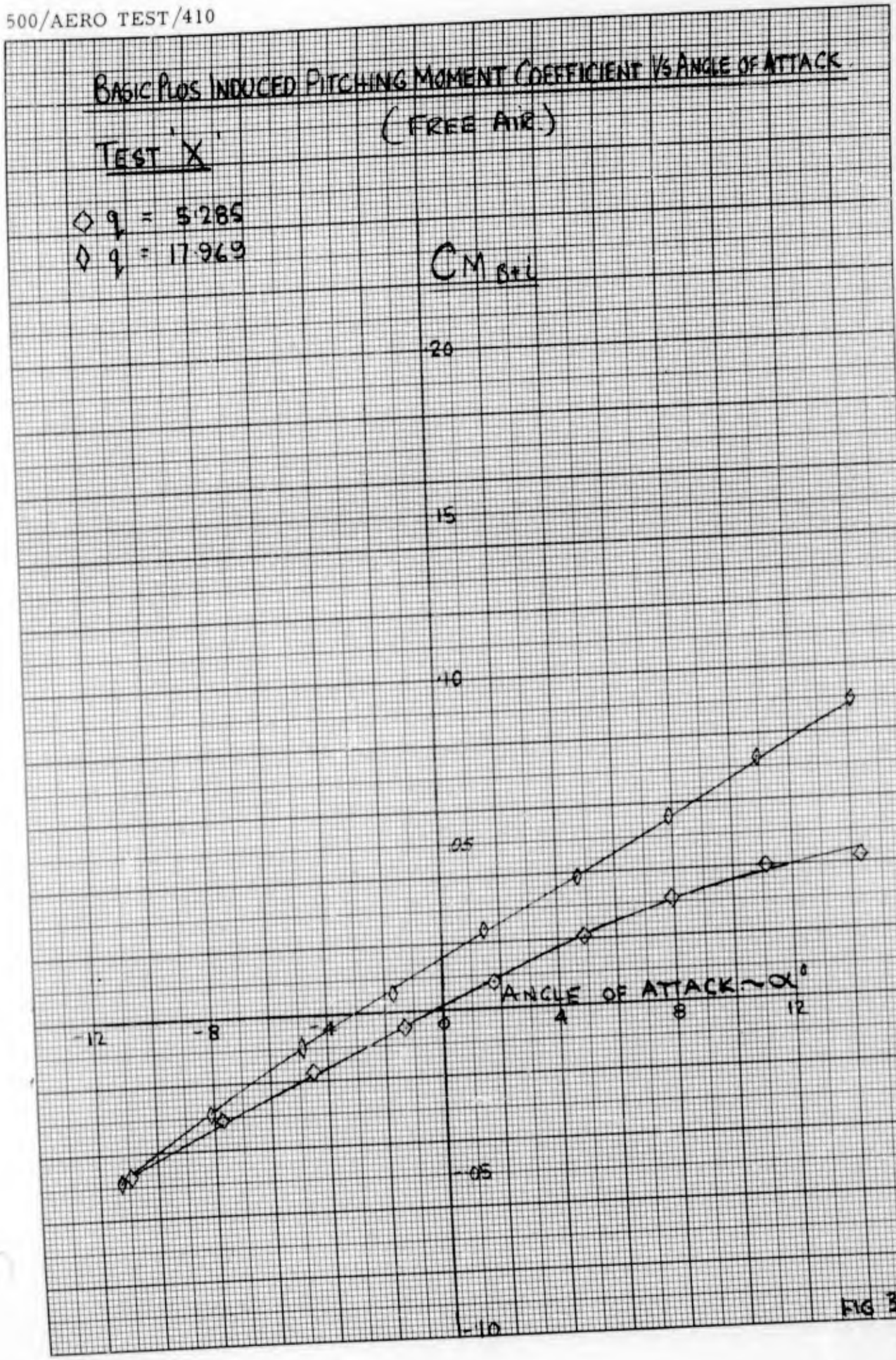

BASIC PLOS INDUCED PITCHING MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'X'
◇ q = 5.285
◇ q = 17.969
CM B+L
20
15
10
.05
-.05
-.10
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG 367

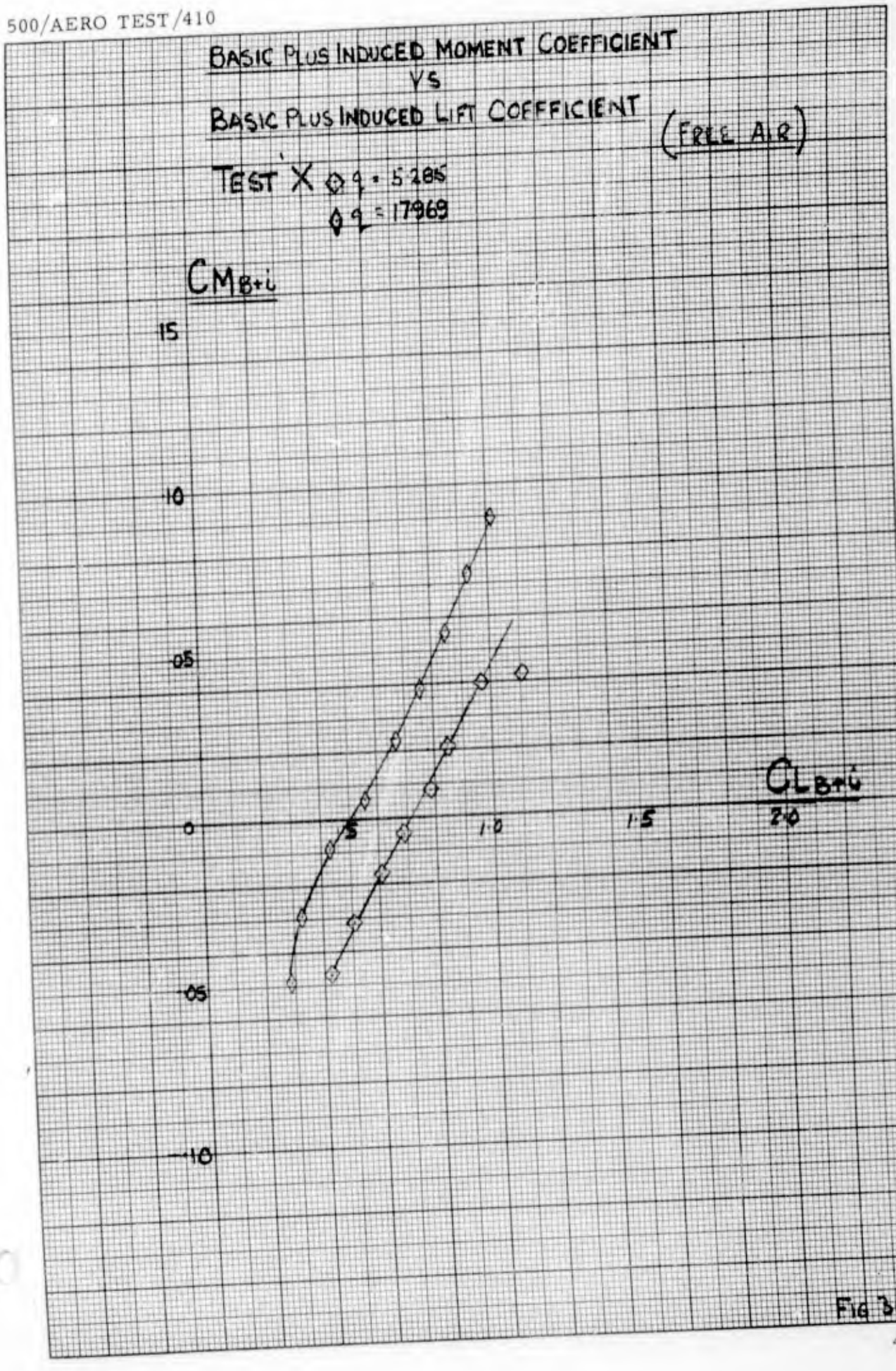

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS
BASIC PLUS INDUCED LIFT COEFFICIENT
(FREE AIR)
TEST X ◇ q = 5285
◇ q = 17969
CMB+i
15
10
05
0
05
10
CLB+i
5
1.0
1.5
2.0

Fig 368

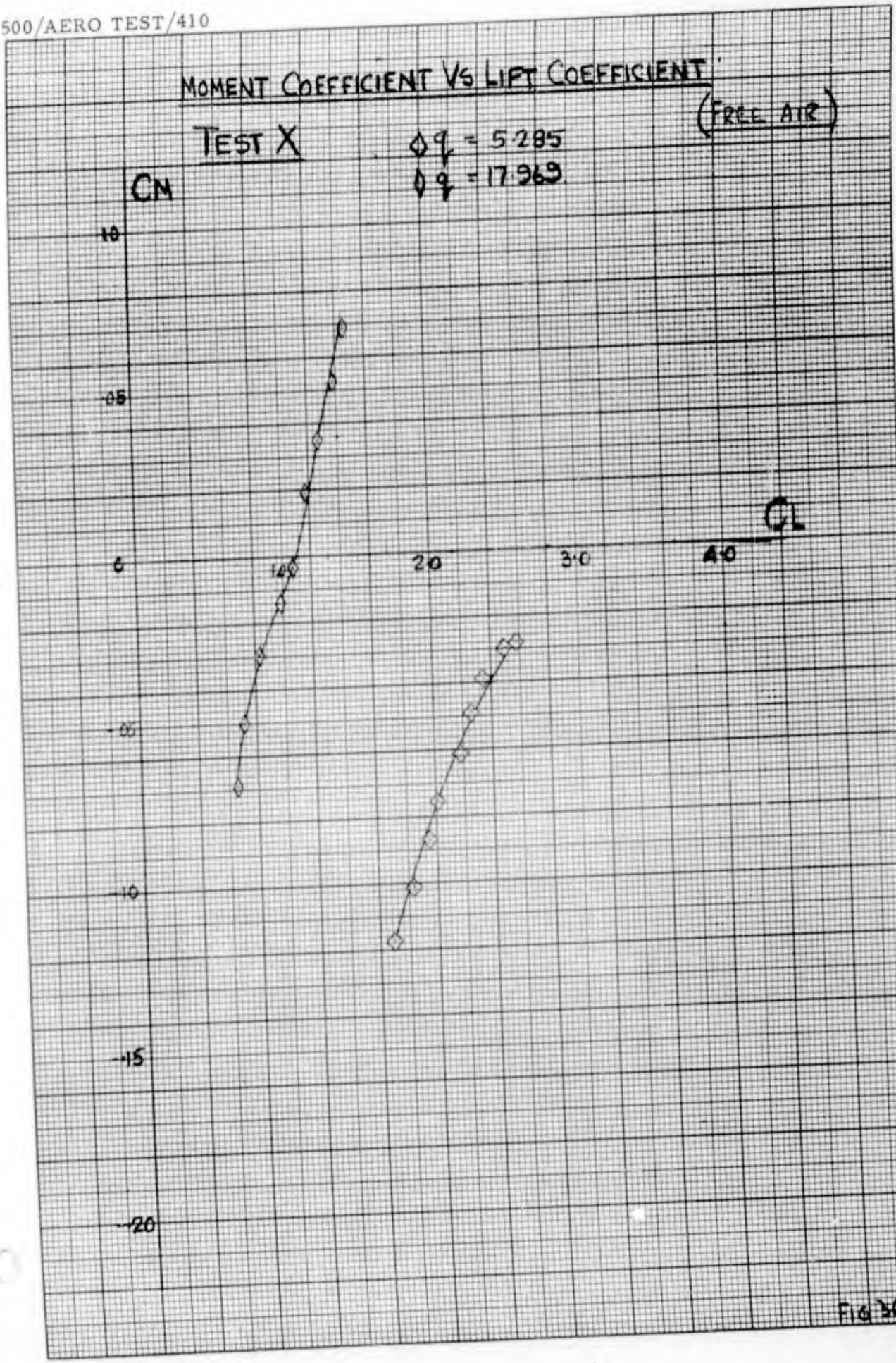

MOMENT COEFFICIENT Vs LIFT COEFFICIENT
(FREE AIR)
TEST X
Φ_q = 5.285
Φ_q = 17.969
CM
CL
10
05
0
-05
-10
-15
-20
10
20
30
40

FIG 369

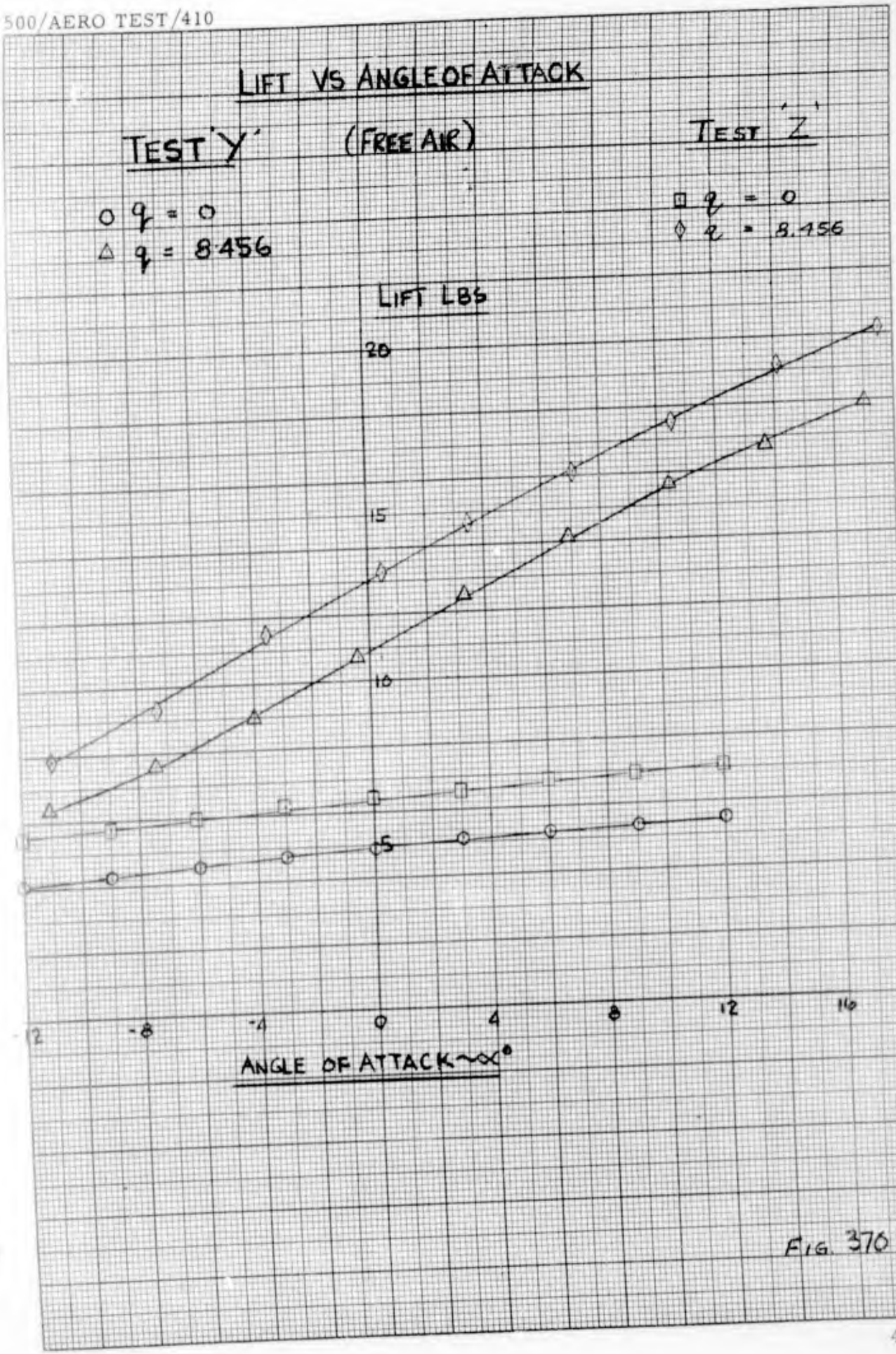

LIFT VS ANGLE OF ATTACK
TEST 'Y' (FREE AIR)
TEST 'Z'
○ q = 0
△ q = 8.456
□ q = 0
◇ q = 8.456
LIFT LBS
20
15
10
5
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK ~α°

FIG. 370

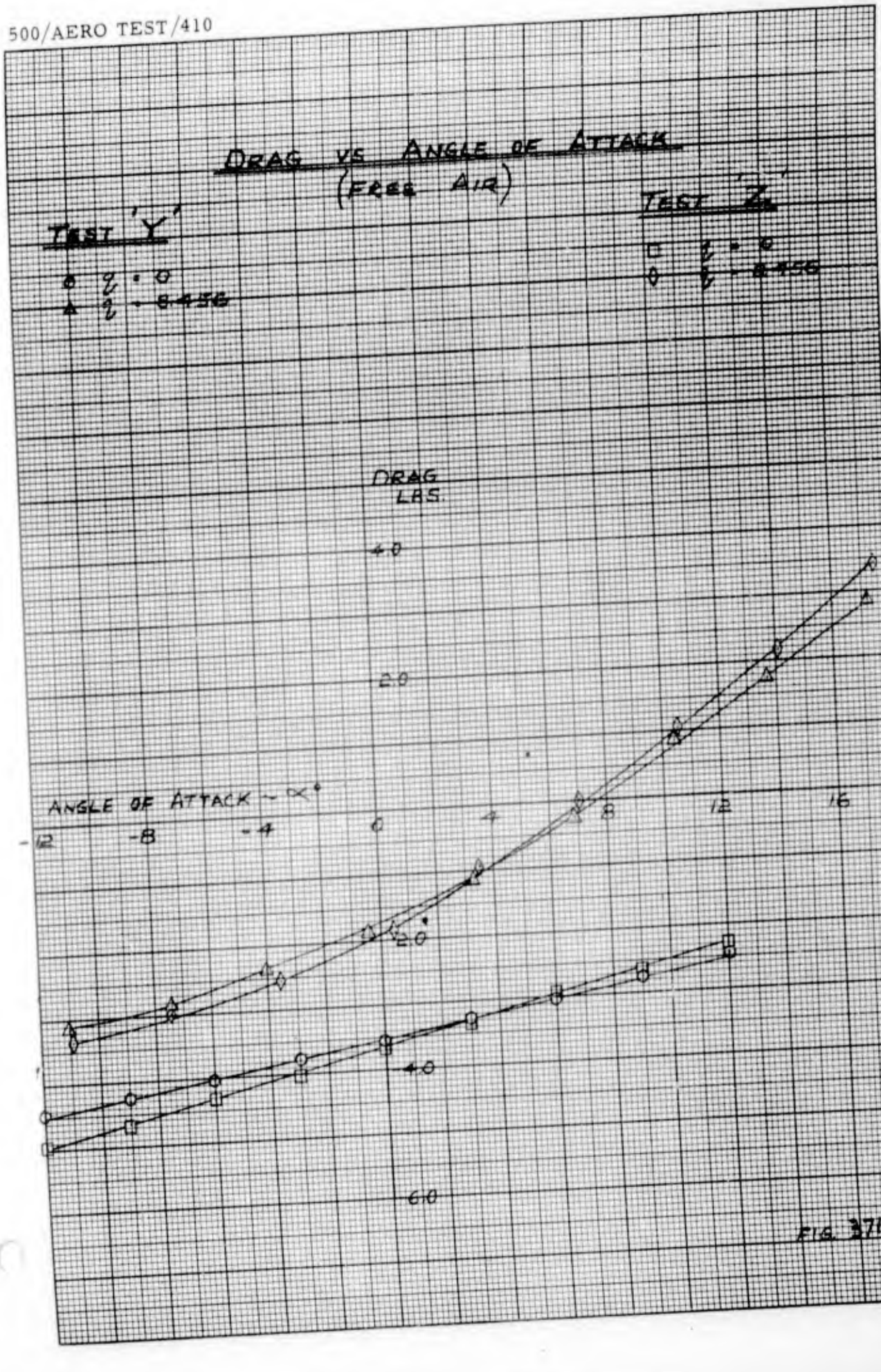

DRAG VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Y'
TEST 'Z'
DRAG
LBS.
4.0
2.0
ANGLE OF ATTACK ~ ∝°
-12
-8
-4
0
4
8
12
16
2.0
4.0
6.0

FIG. 371

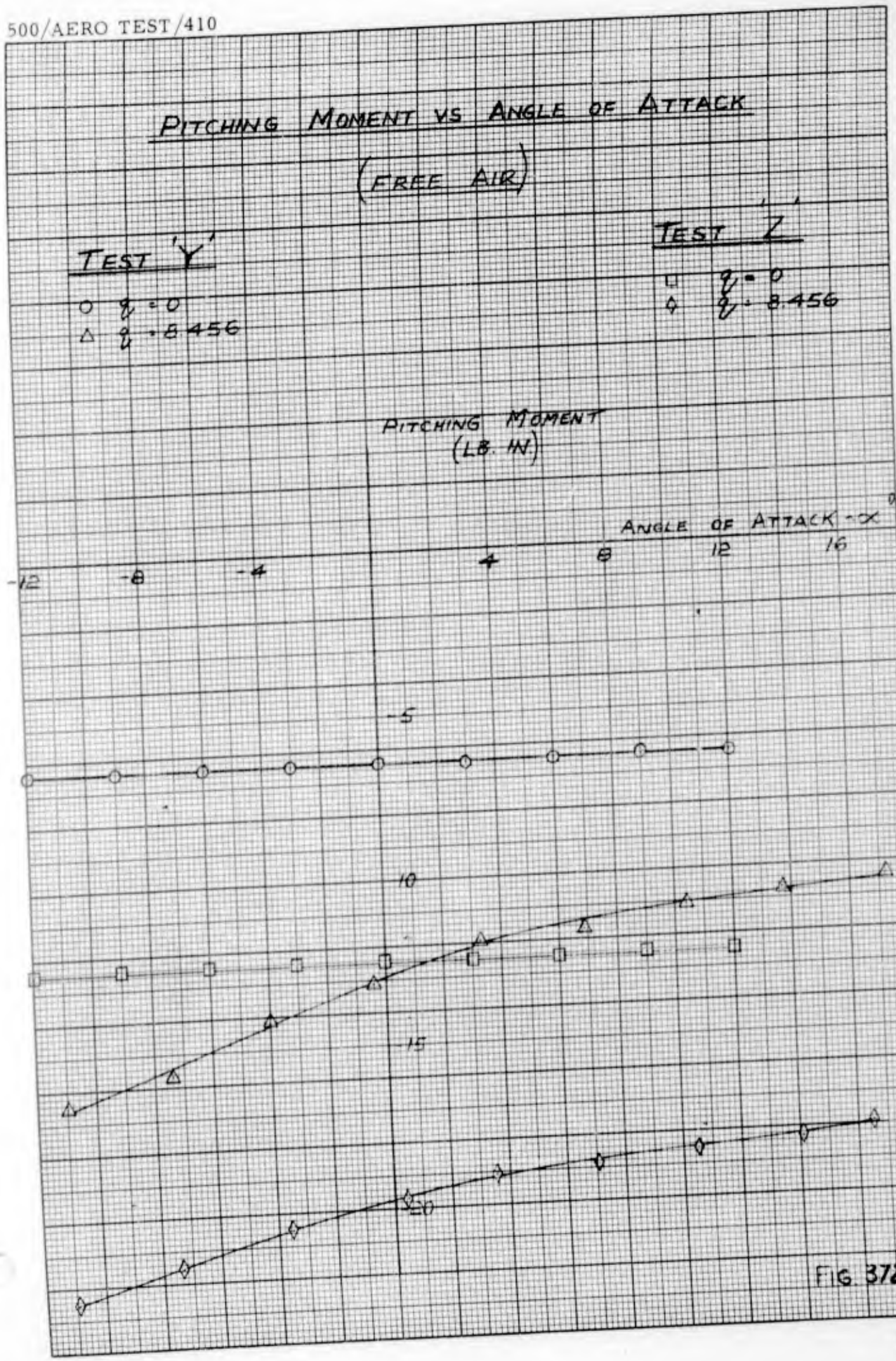

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Y'
○ q = 0
△ q = 8.456
TEST 'Z'
□ q = 0
◇ q = 8.456
PITCHING MOMENT
(LB. IN.)
ANGLE OF ATTACK - α°
-12
-8
-4
4
8
12
16
-5
10
15
20

FIG. 372

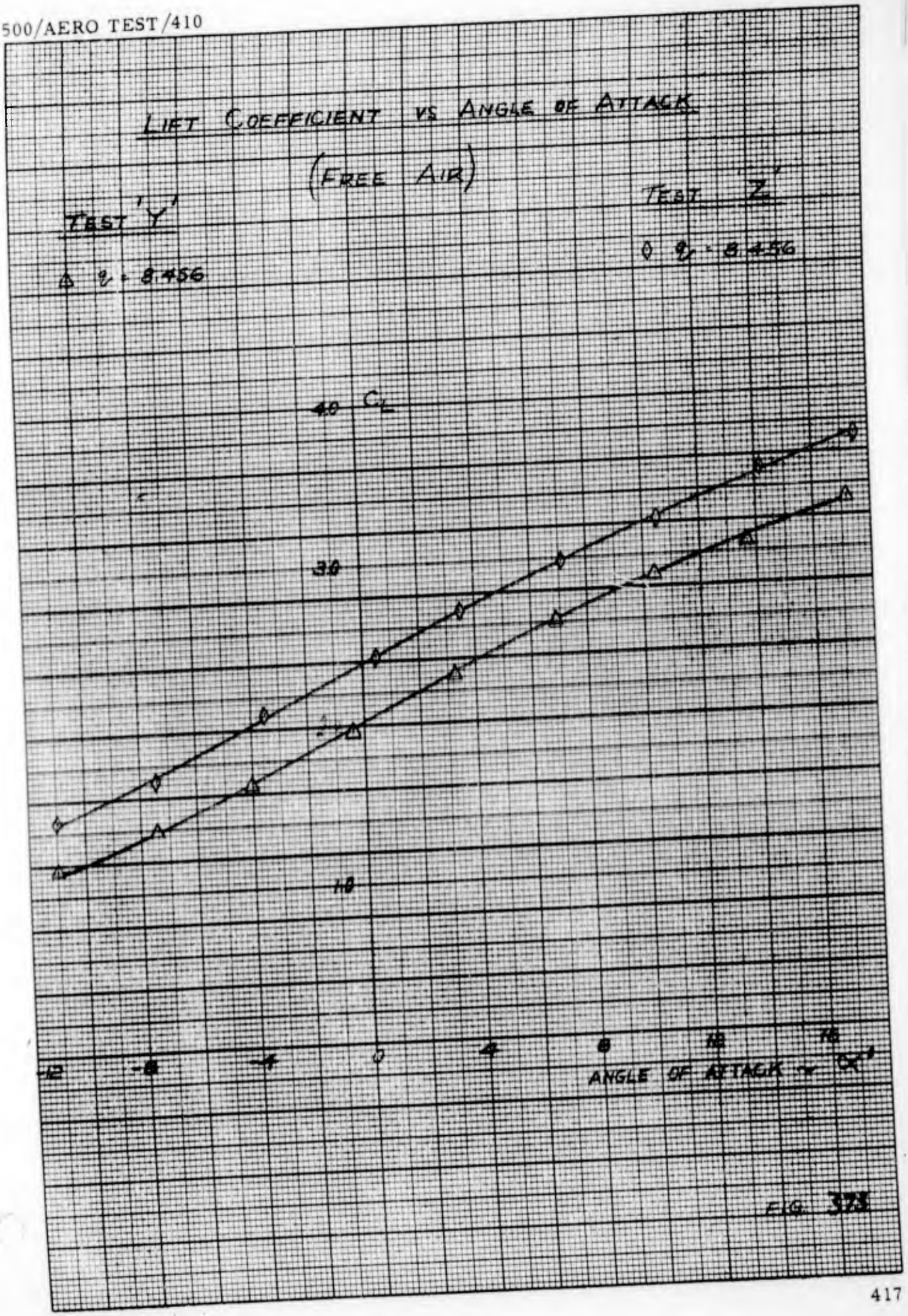

LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Y'
△ q = 8.456
TEST 'Z'
◊ q = 8.456
4.0 C_L
3.0
2.0
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK - α°

FIG. 375

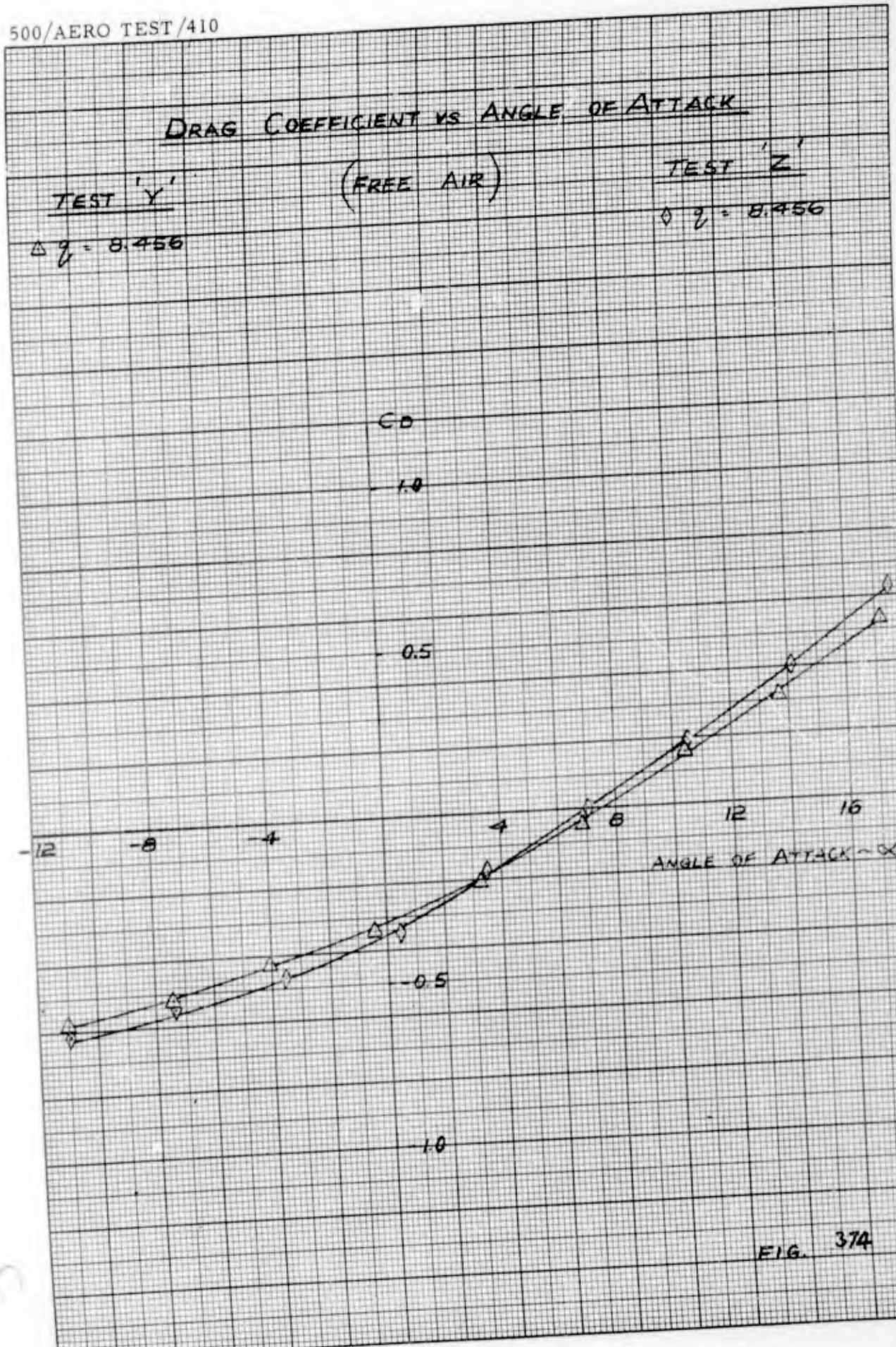

DRAG COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Y'
△ q = 8.456
TEST 'Z'
◇ q = 8.456
CD
1.0
0.5
-0.5
-1.0
-12
-8
-4
4
8
12
16
ANGLE OF ATTACK ~ α°

FIG. 374

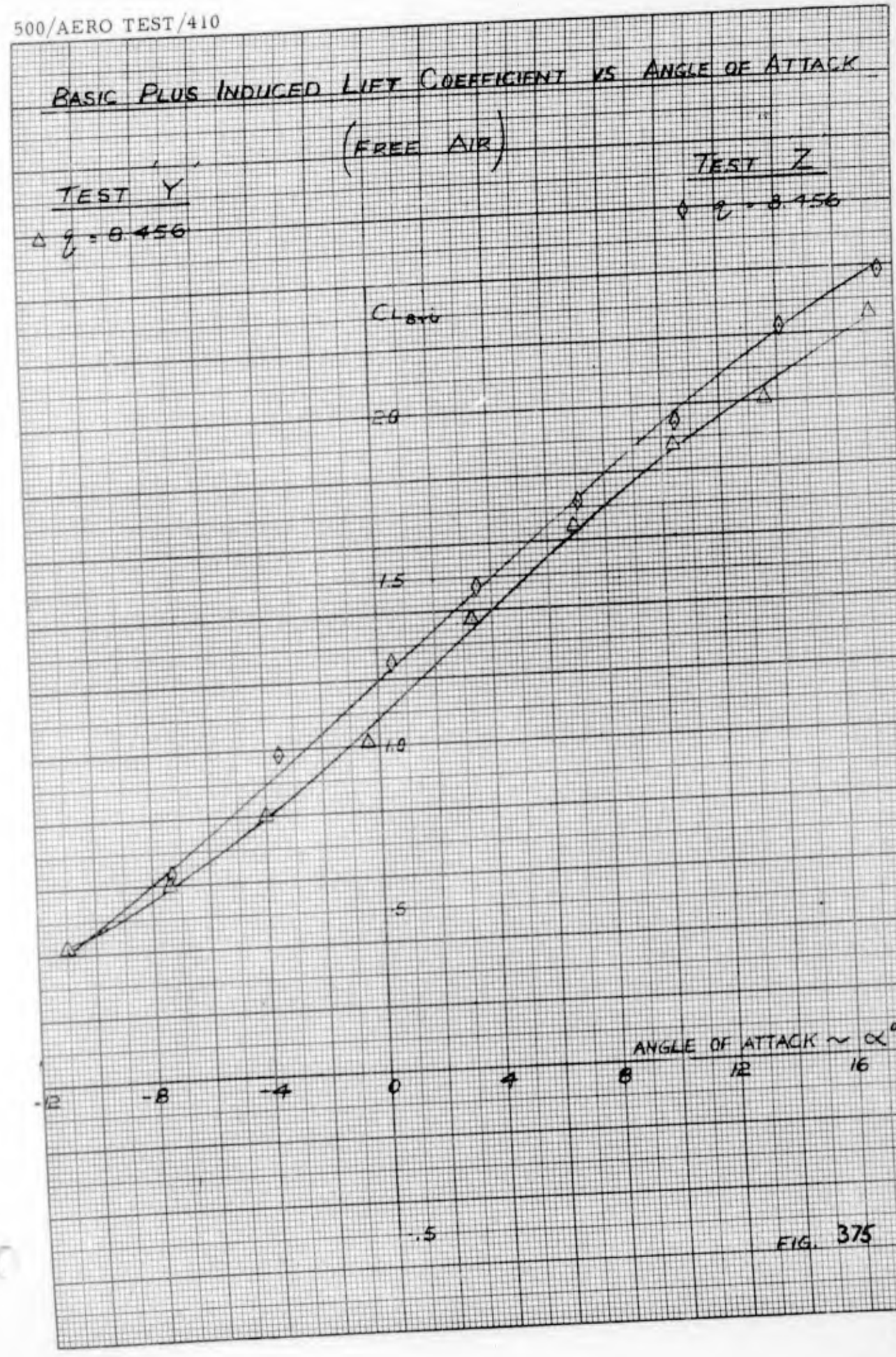

BASIC PLUS INDUCED LIFT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST Y
△ q = 8.456
TEST Z
◇ q = 8.456
$C_{L_{BIG}}$
2.0
1.5
1.0
.5
-.5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
16

FIG. 375

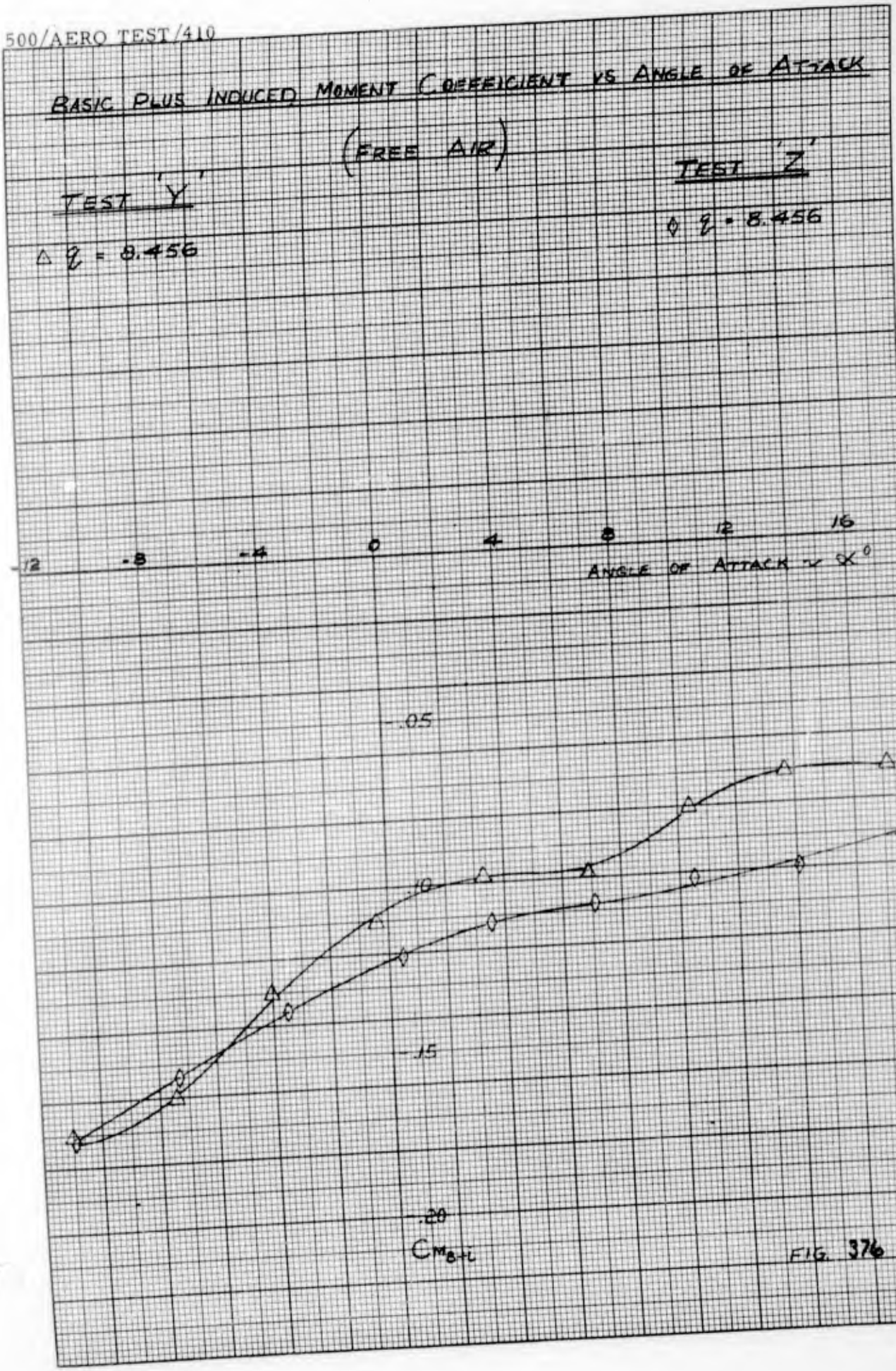

BASIC PLUS INDUCED MOMENT COEFFICIENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'Y'
Δ q = 8.456
TEST 'Z'
◊ q = 8.456
-12
-8
-4
0
4
8
12
16
ANGLE OF ATTACK α°
-.05
-.10
-.15
-.20
CM8+L

FIG. 376

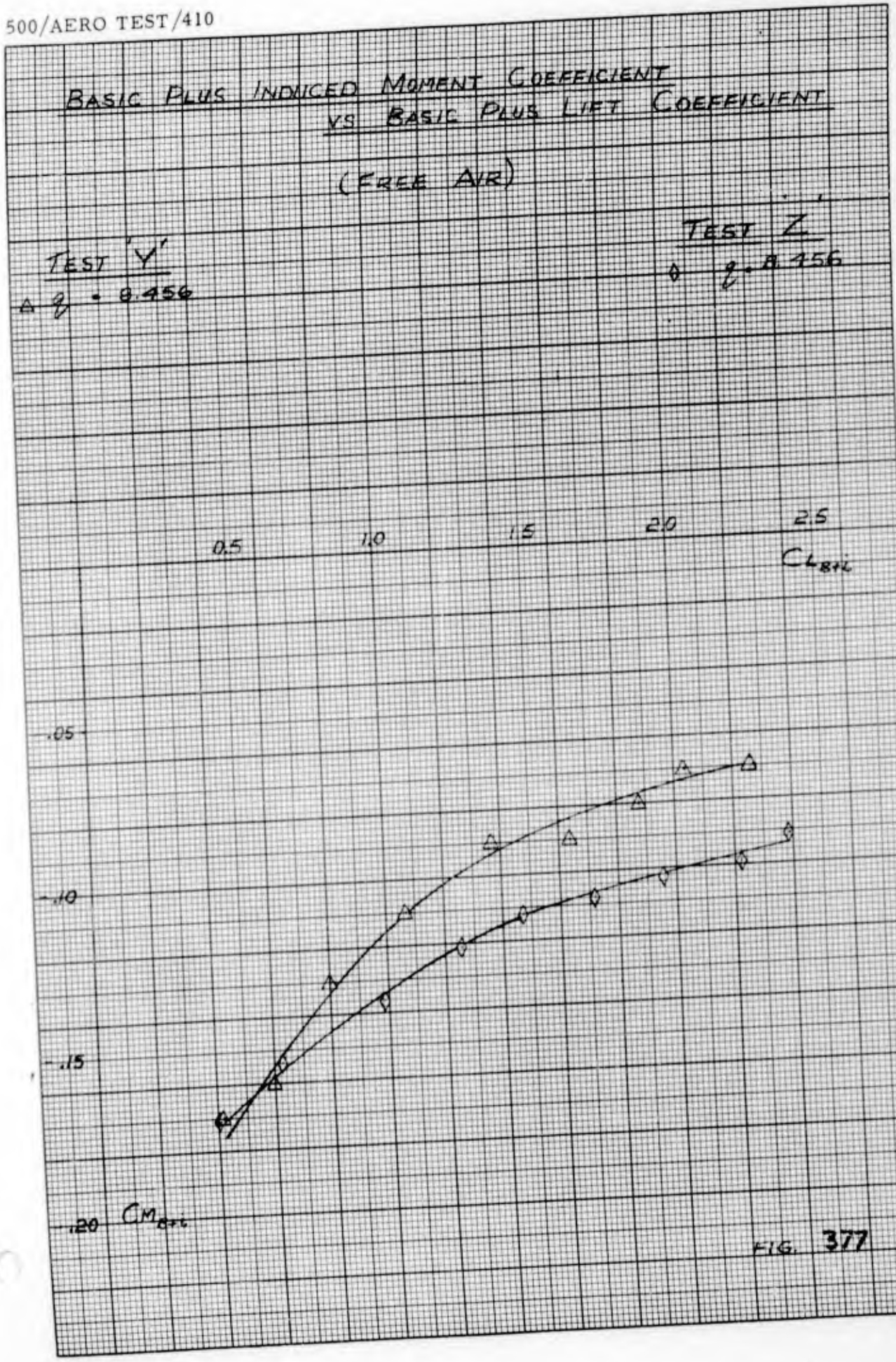

BASIC PLUS INDUCED MOMENT COEFFICIENT
VS BASIC PLUS LIFT COEFFICIENT
(FREE AIR)
TEST 'Y'
△ q = 8.456
TEST 'Z'
◇ q = 8.456
0.5
1.0
1.5
2.0
2.5
$C_{L_{B+i}}$
.05
.10
.15
.20
$C_{M_{B+i}}$

FIG. 377

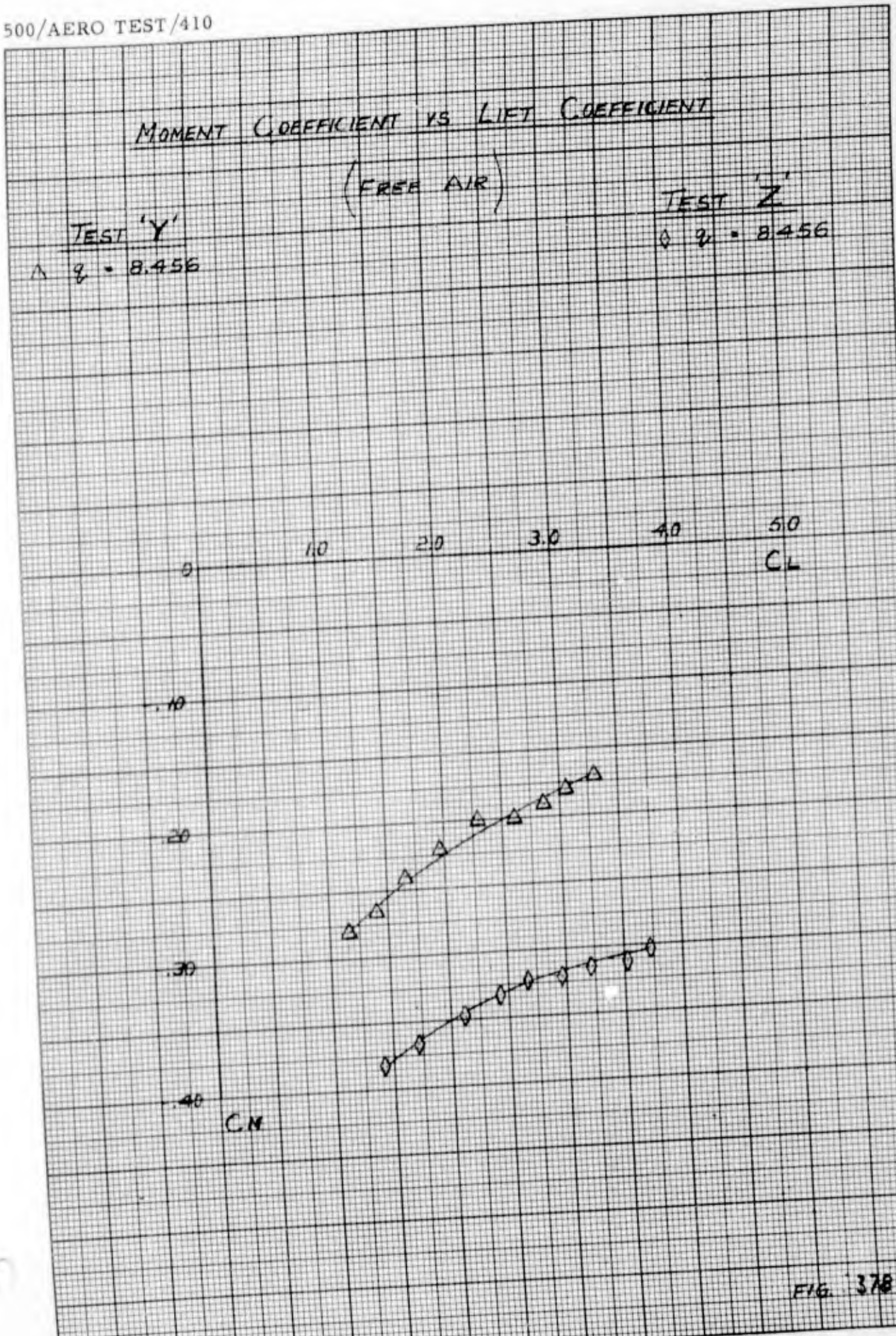

MOMENT COEFFICIENT VS LIFT COEFFICIENT
(FREE AIR)
TEST 'Y'
△ q = 8.456
TEST 'Z'
◇ q = 8.456
1.0
2.0
3.0
4.0
5.0
CL
0
-.10
-.20
-.30
-.40
CM

FIG. 378

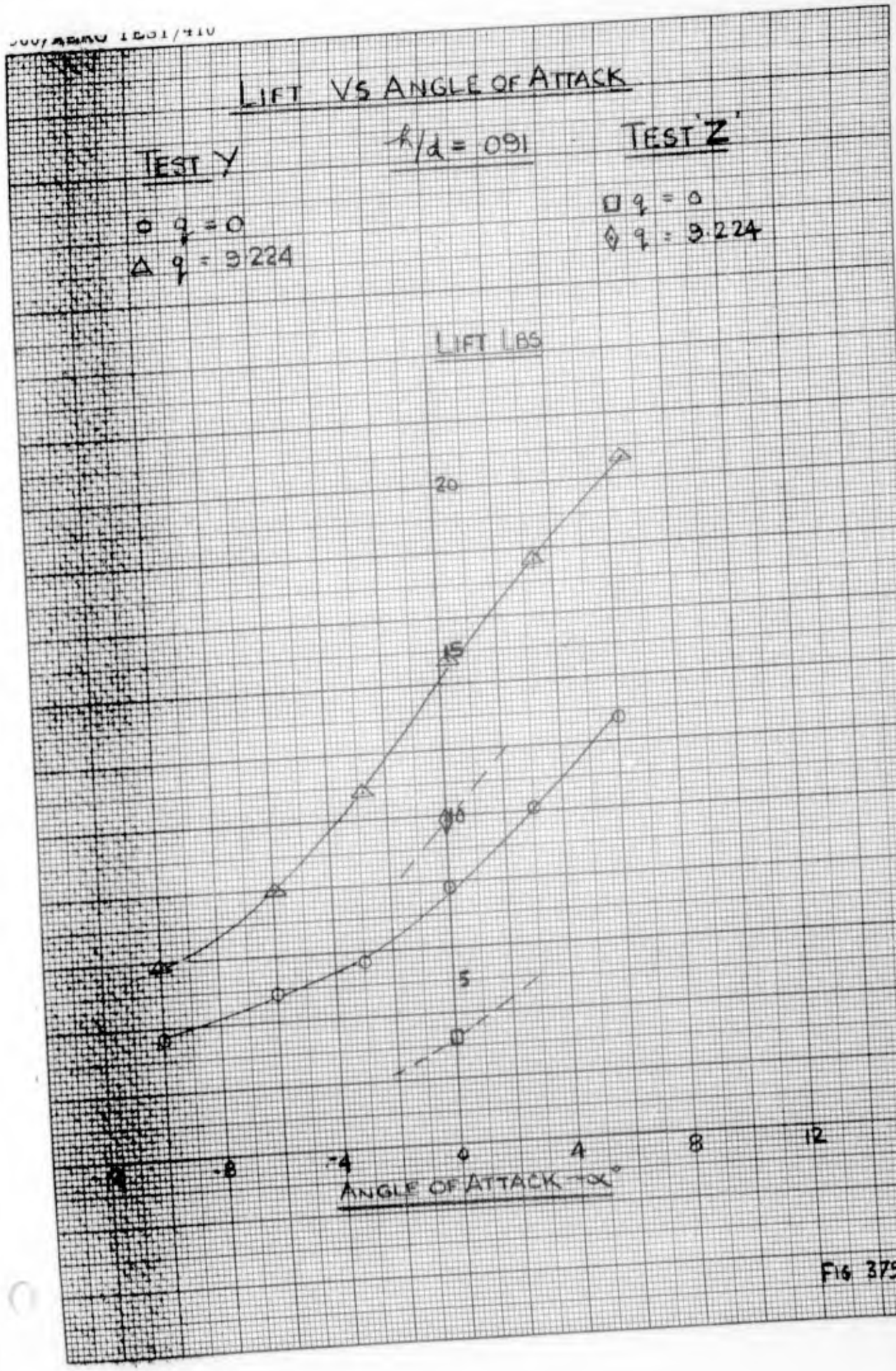

LIFT VS ANGLE OF ATTACK
TEST 'Y'
h/d = 091
TEST 'Z'
○ q = 0
△ q = 9.224
□ q = 0
◇ q = 9.224
LIFT LBS
20
15
10
5
-8
-4
0
4
8
12
ANGLE OF ATTACK "α"

FIG 379

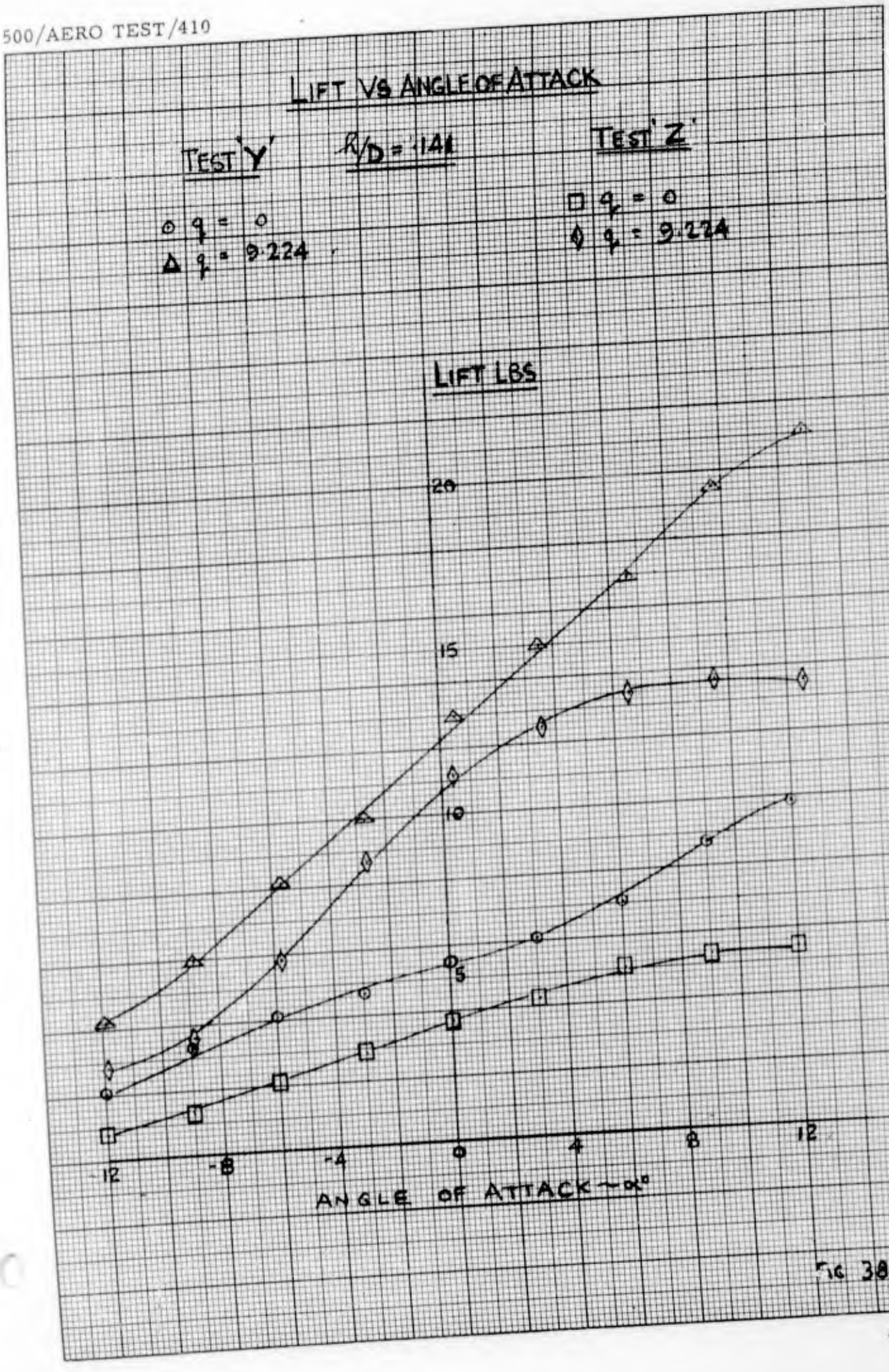

LIFT VS ANGLE OF ATTACK
TEST 'Y'
R/D = .141
TEST 'Z'
○ q = 0
△ q = 9.224
□ q = 0
◇ q = 9.224
LIFT LBS
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 380

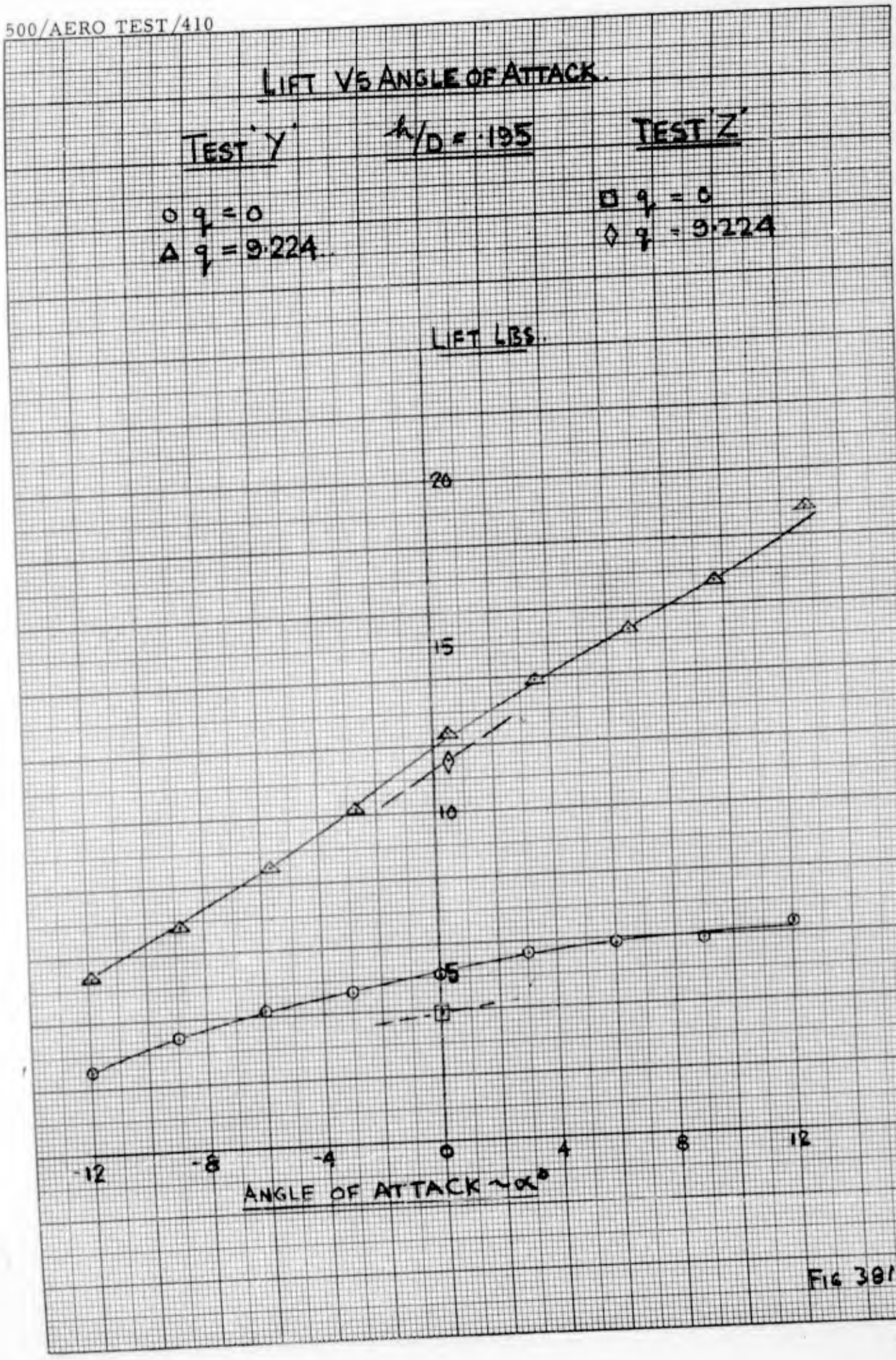

LIFT VS ANGLE OF ATTACK.
TEST 'Y' h/D = .195 TEST 'Z'
○ q = 0
△ q = 9.224
□ q = 0
◇ q = 9.224
LIFT LBS.
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~α°

FIG 381

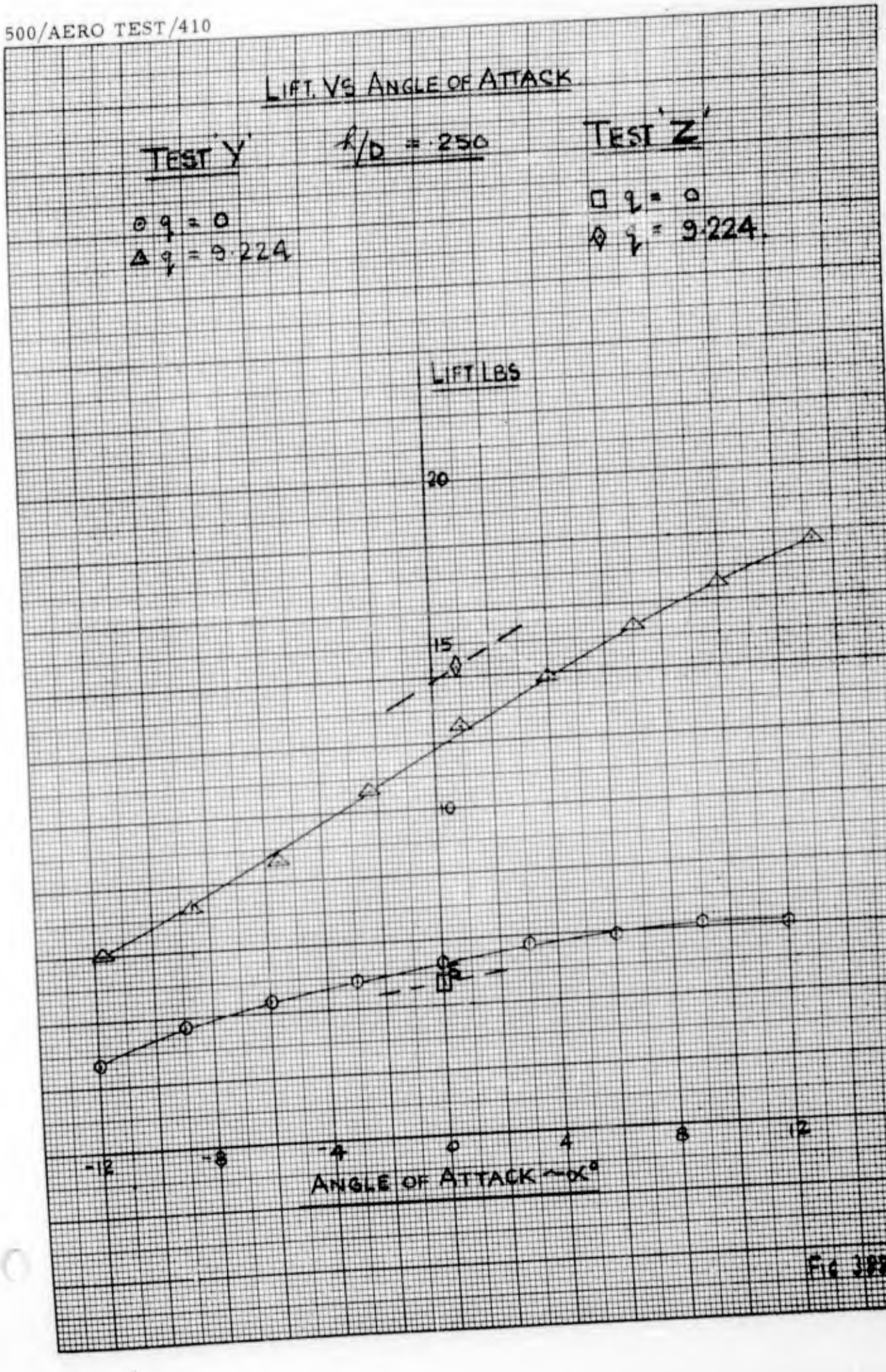

LIFT VS ANGLE OF ATTACK
TEST 'Y'
f/D = .250
TEST 'Z'
○ q = 0
△ q = 9.224
□ q = 0
◇ q = 9.224
LIFT LBS
20
15
10
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~α°

Fig 388

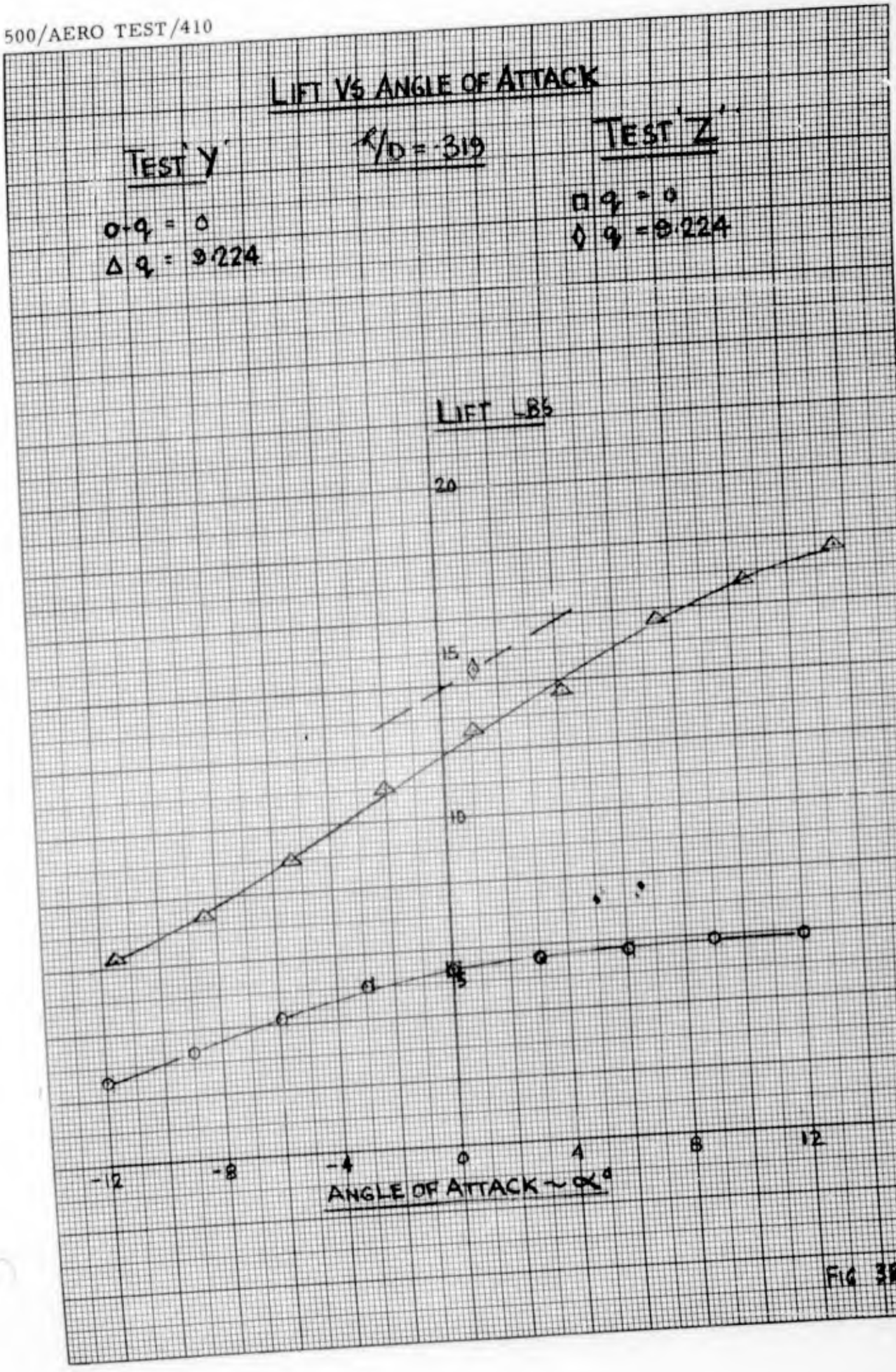

LIFT VS ANGLE OF ATTACK
TEST 'Y'
$\bar{x}/D = .319$
TEST 'Z'
o q = 0
Δ q = 0.224
□ q = 0
◊ q = 0.224
LIFT LBS
20
15
10
5
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°

FIG 3B3

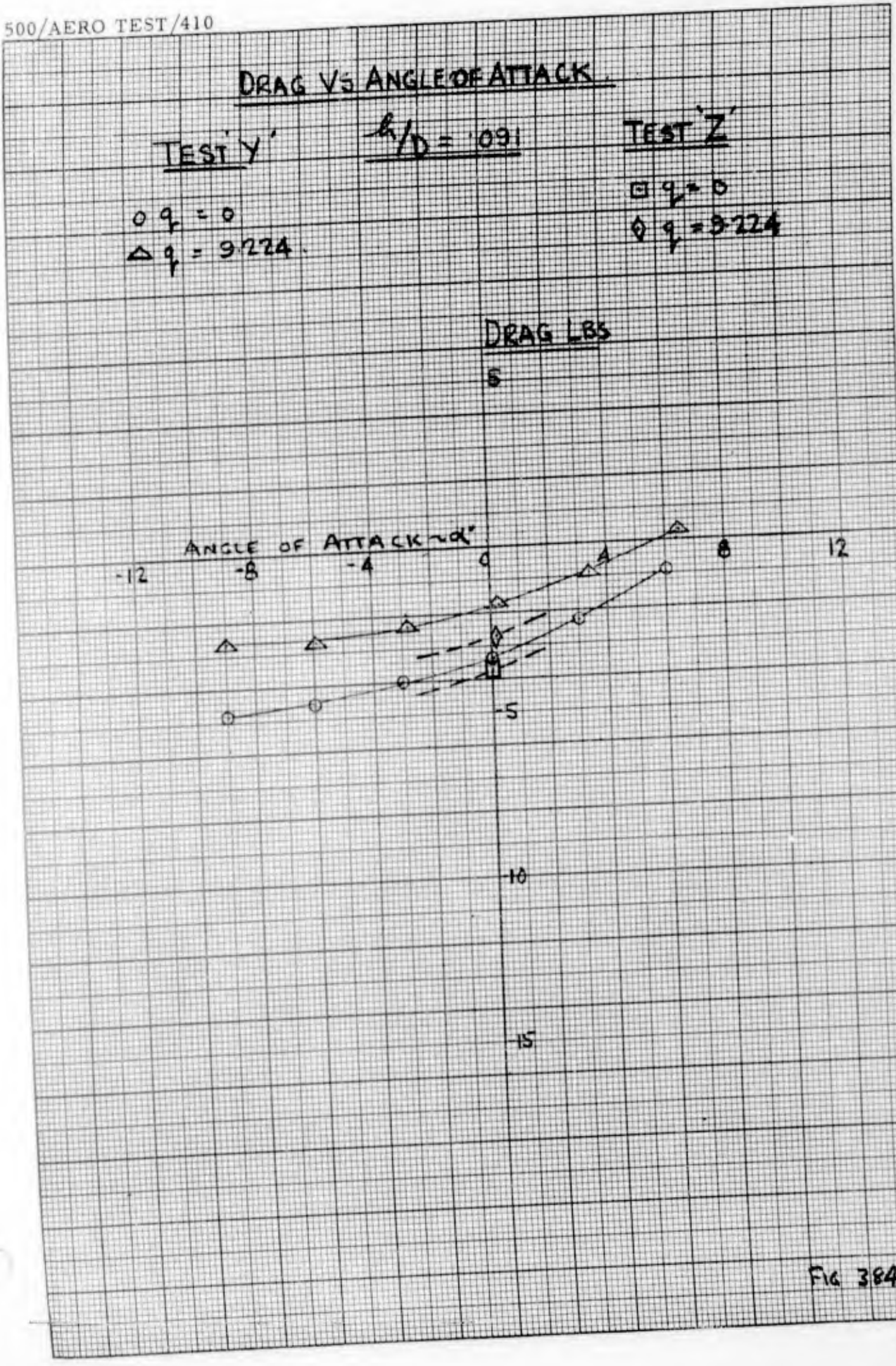

DRAG VS ANGLE OF ATTACK
TEST 'Y'
h/D = .091
TEST 'Z'
○ q = 0
△ q = 9.224
□ q = 0
◇ q = 8.224
DRAG LBS
5
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-5
10
15

Fig 384

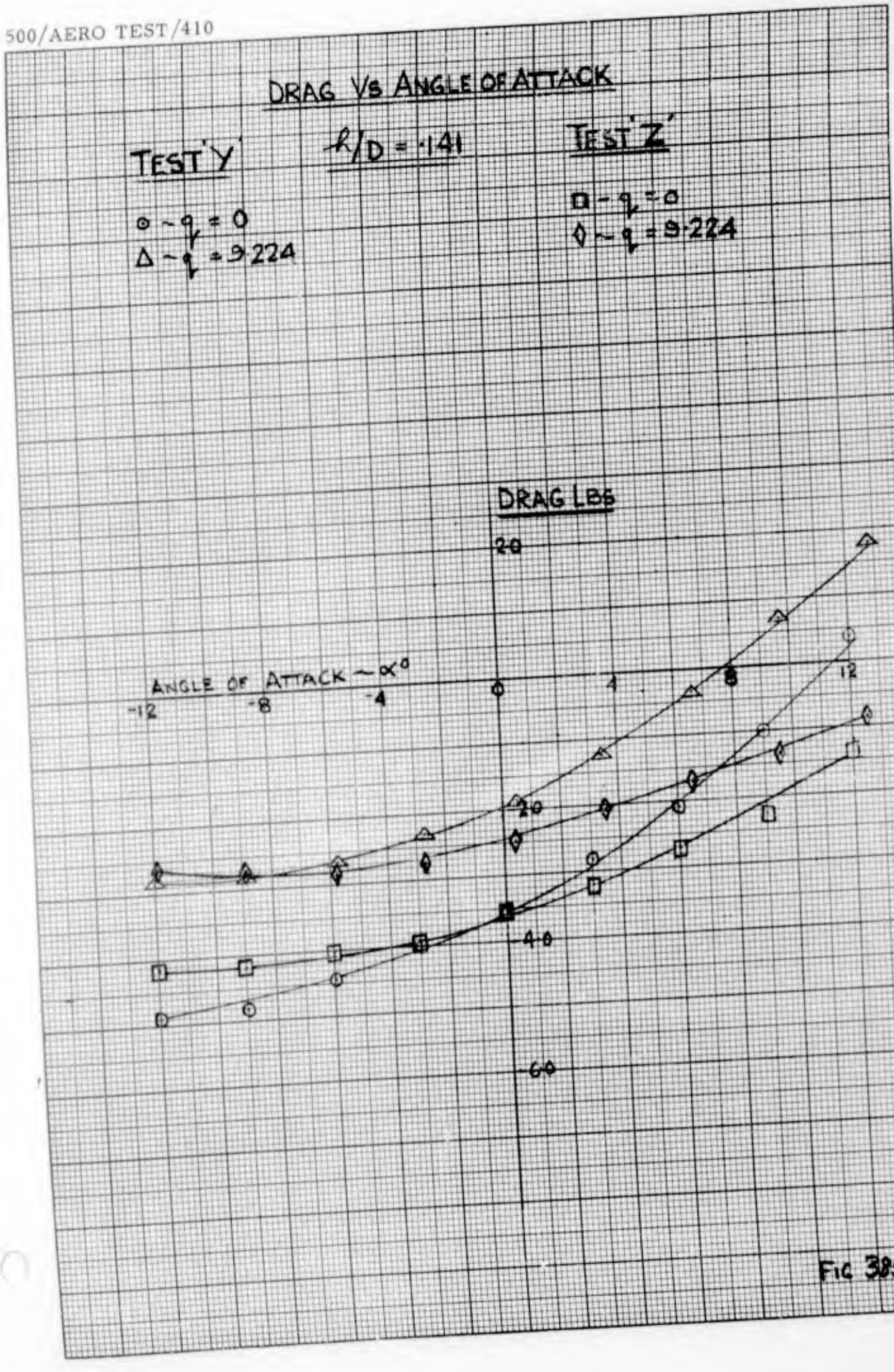

DRAG Vs ANGLE OF ATTACK
TEST 'Y'
R/D = .141
TEST 'Z'
⊙ - q = 0
Δ - q = 9.224
□ - q = 0
◊ - q = 9.224
DRAG LBS
20
ANGLE OF ATTACK ~ α°
-12
-8
-4
4
8
12
20
40
60

FIG 385

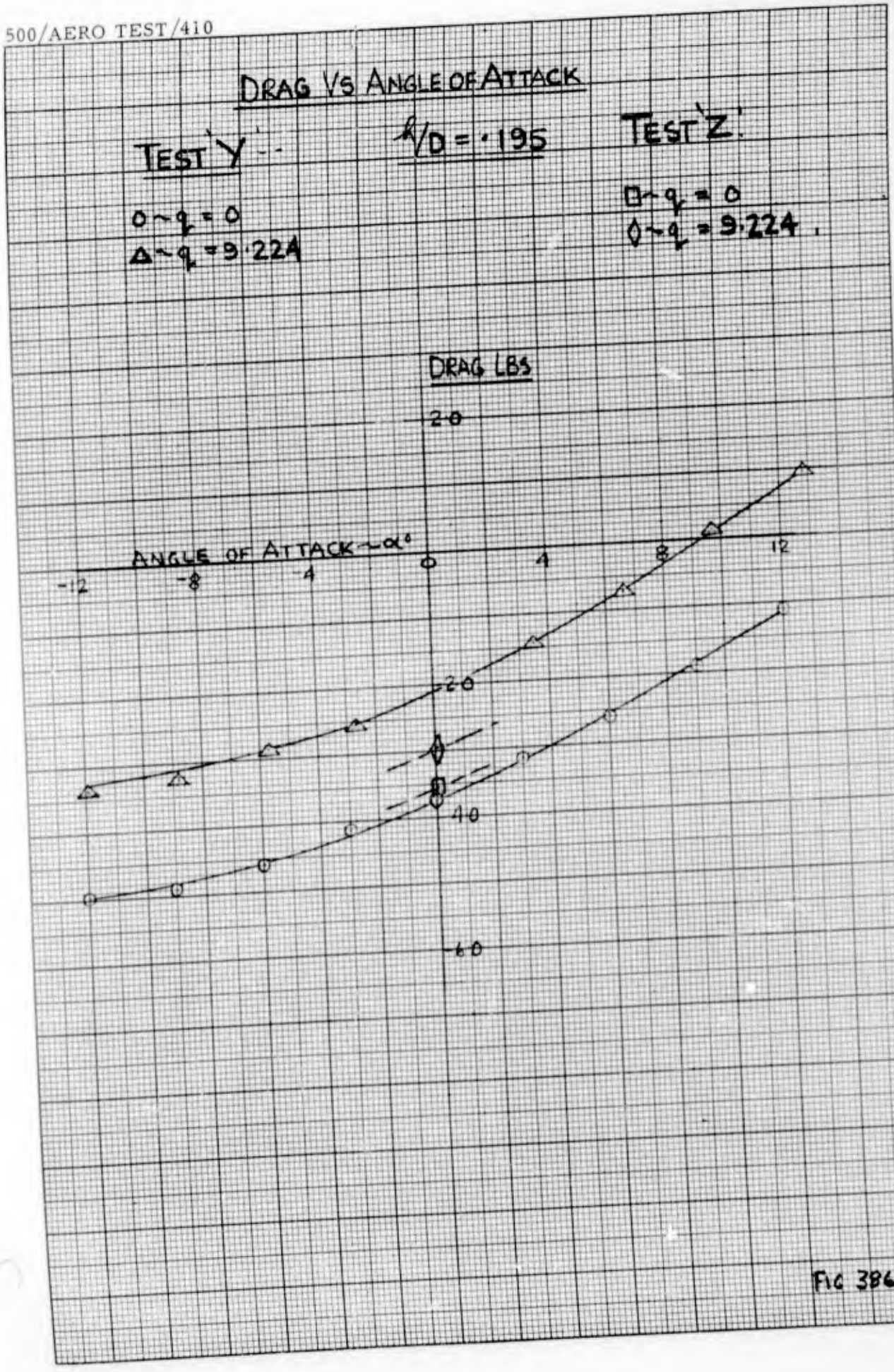

DRAG VS ANGLE OF ATTACK
TEST 'Y'
k/D = .195
TEST 'Z'
○ ~ q = 0
△ ~ q = 9.224
□ ~ q = 0
◊ ~ q = 9.224
DRAG LBS
20
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
20
40
60

FIG 386

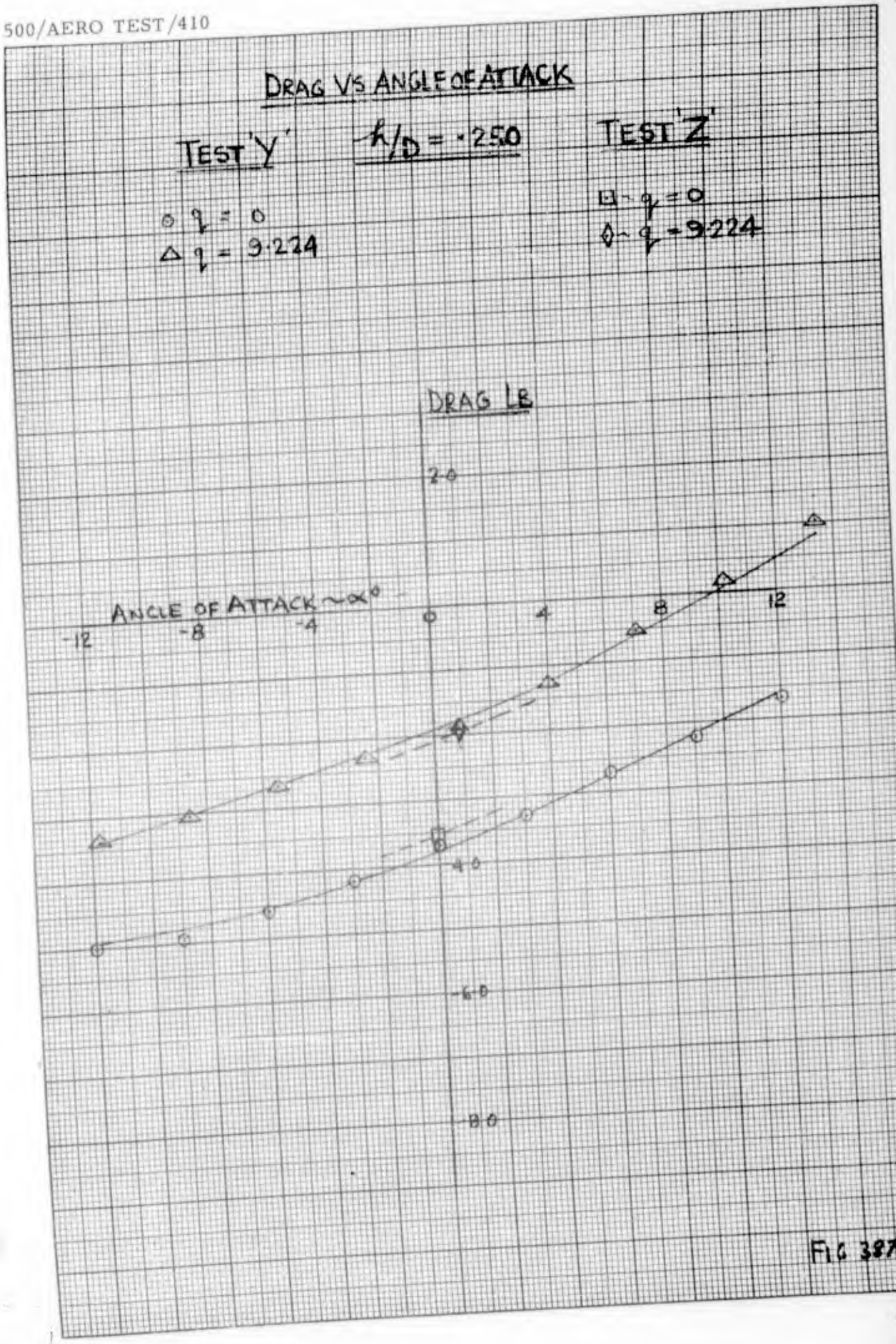

DRAG VS ANGLE OF ATTACK
TEST 'Y'
h/D = .250
TEST 'Z'
○ q = 0
△ q = 9.224
□ - q = 0
◊ - q = 9.224
DRAG LB
2.0
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
4.0
-6.0
-8.0

FIG 387

DRAG VS ANGLE OF ATTACK

$\ell/D = .319$.

TEST 'Y'

o $q = 0$

Δ $q = 9224$

TEST 'Z'

□ $q = 0$

◊ $q = 9224$

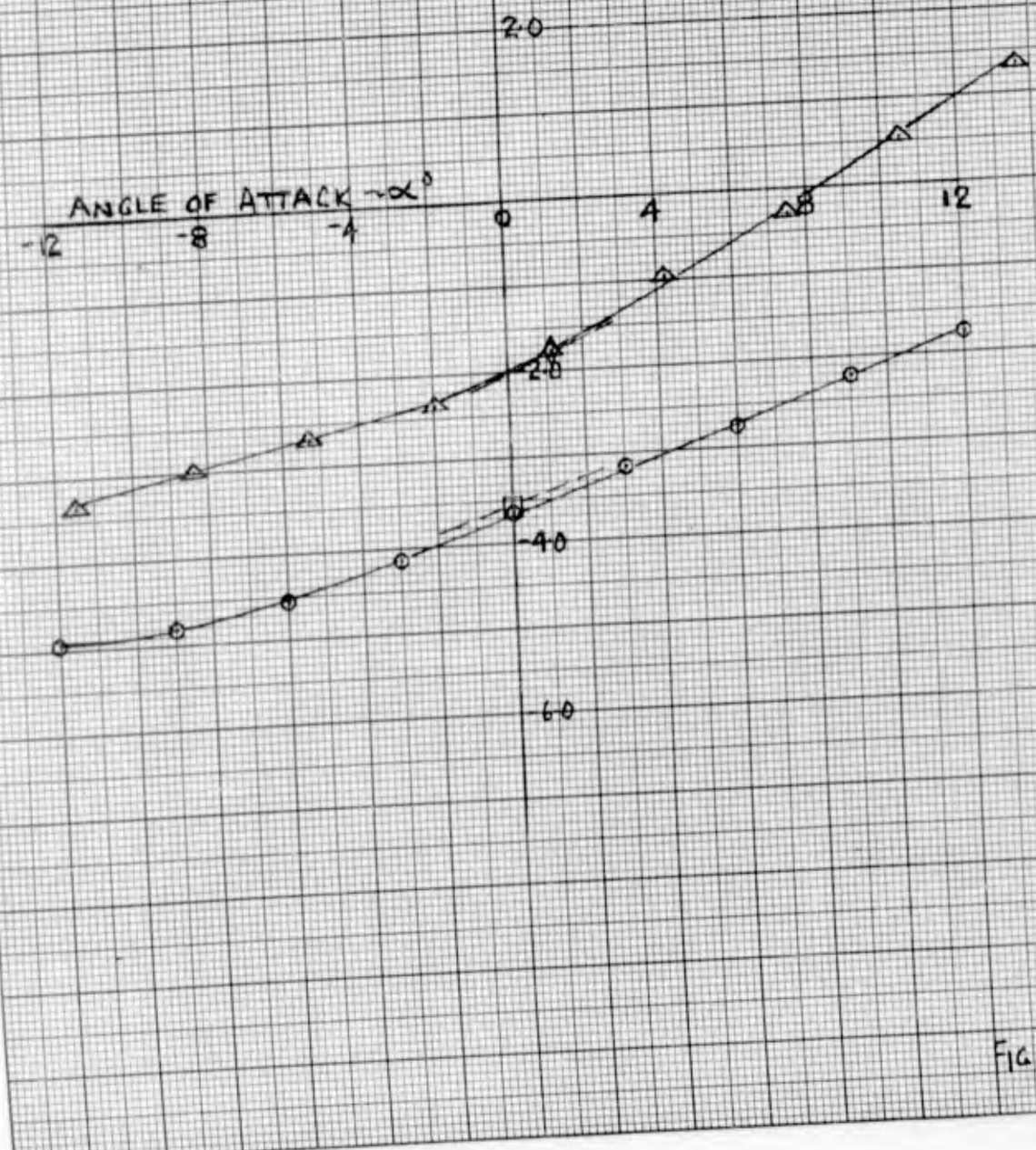


FIG 388

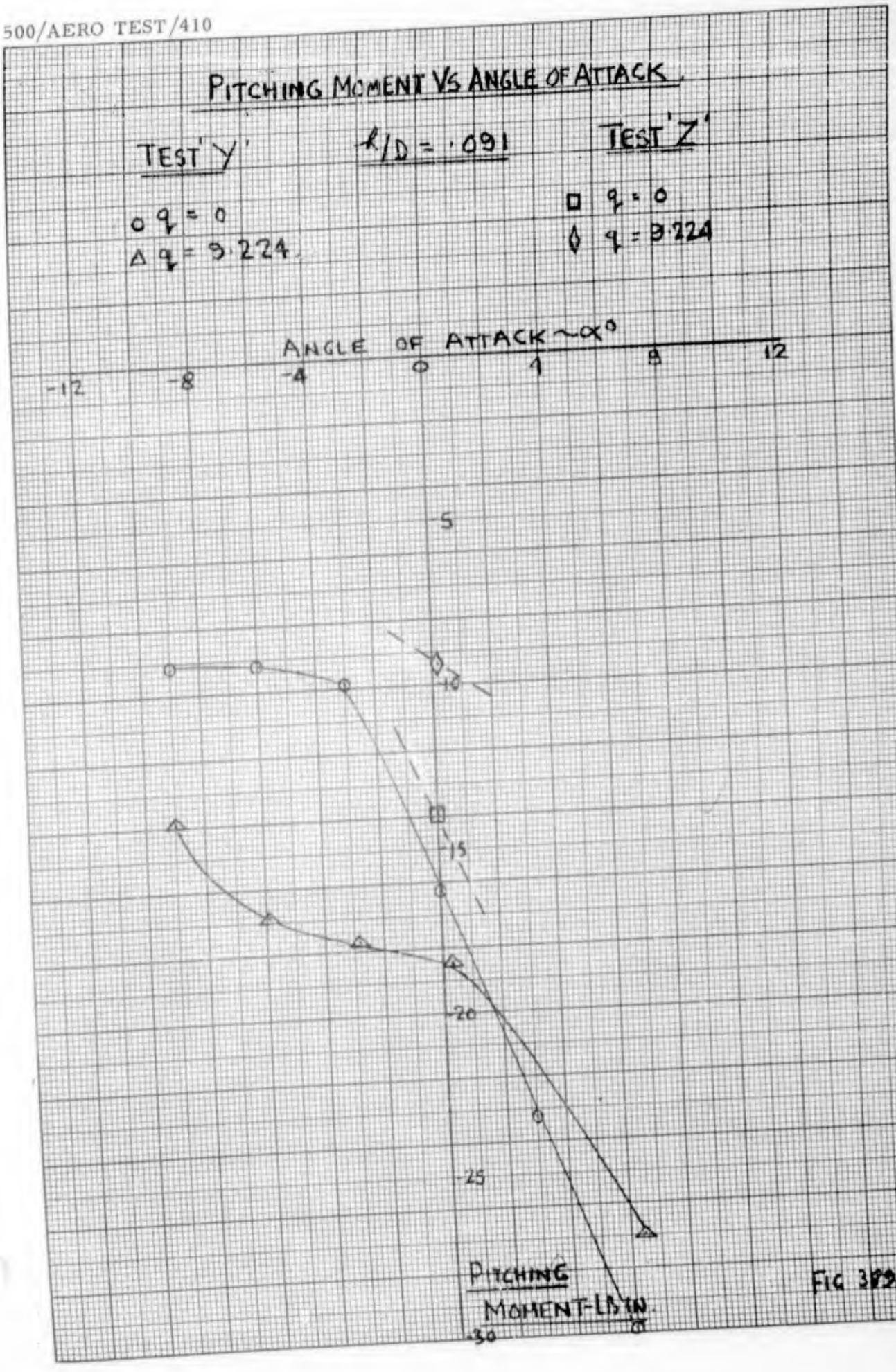

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'Y'
ℓ/D = .091
TEST 'Z'
○ q = 0
Δ q = 9.224
□ q = 0
◊ q = 9.224
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
-5
-10
-15
-20
-25
-30
PITCHING MOMENT-LB-IN.

FIG 389

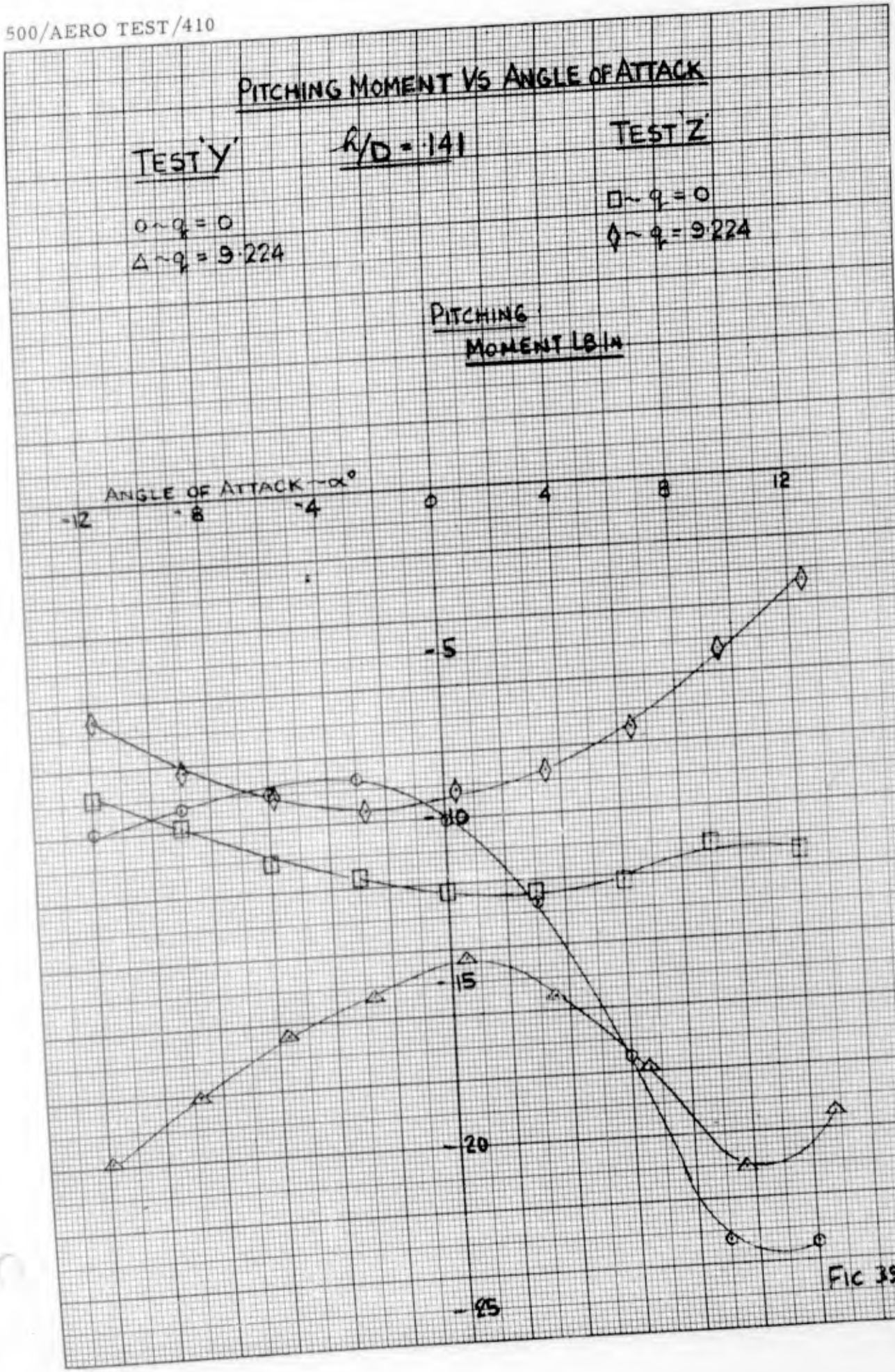

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'Y'
R/D = .141
TEST 'Z'
○ ~ q = 0
△ ~ q = 9·224
□ ~ q = 0
◇ ~ q = 9·224
PITCHING MOMENT LB IN
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-5
-10
-15
-20
-25

FIG 390

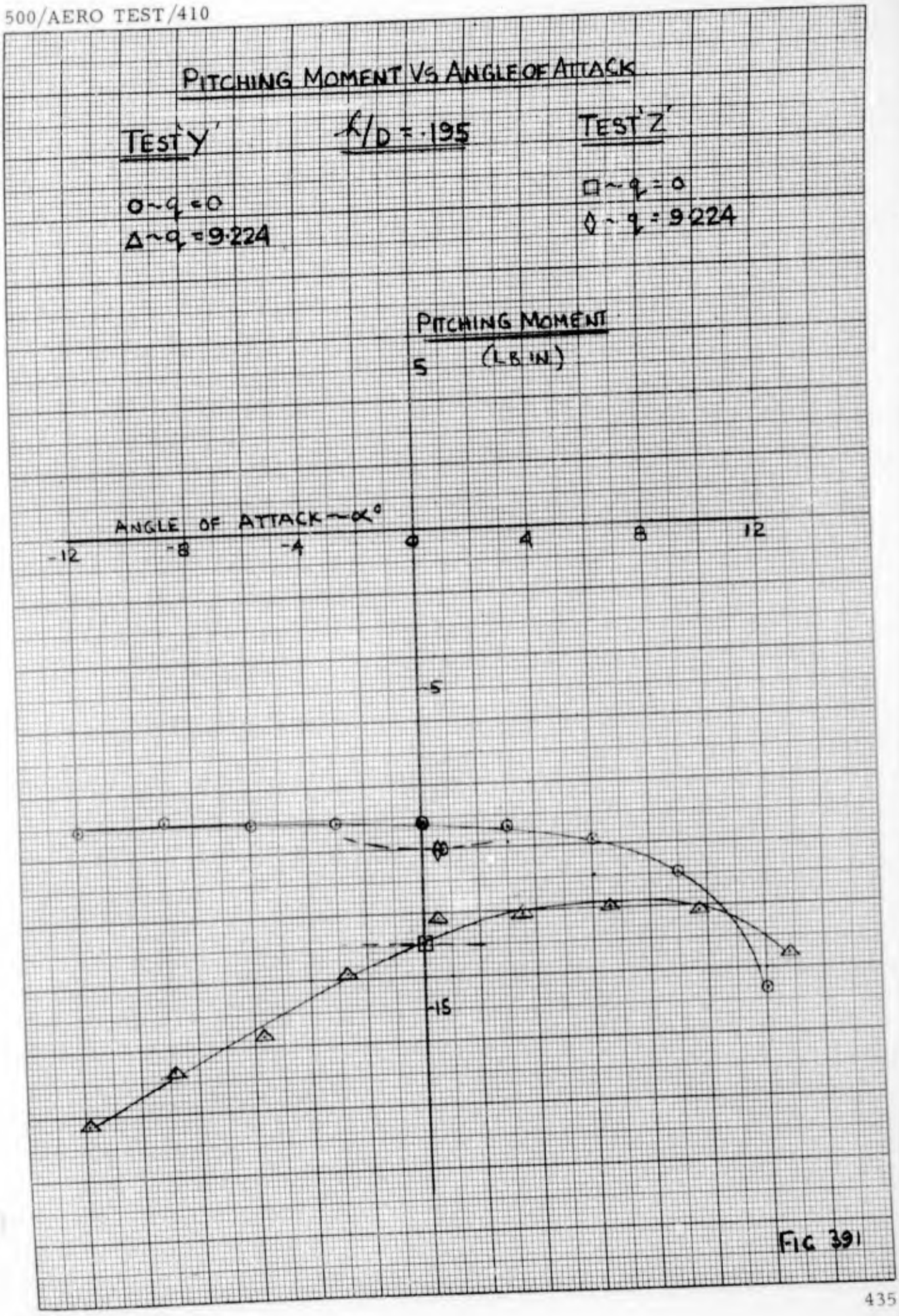

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'Y'
ℓ/D = .195
TEST 'Z'
o ~ q = 0
Δ ~ q = 9.224
□ ~ q = 0
◊ ~ q = 9.224
PITCHING MOMENT
(LB IN.)
ANGLE OF ATTACK ~ α°
-12
-8
-4
0
4
8
12
-5
-15

FIG 391

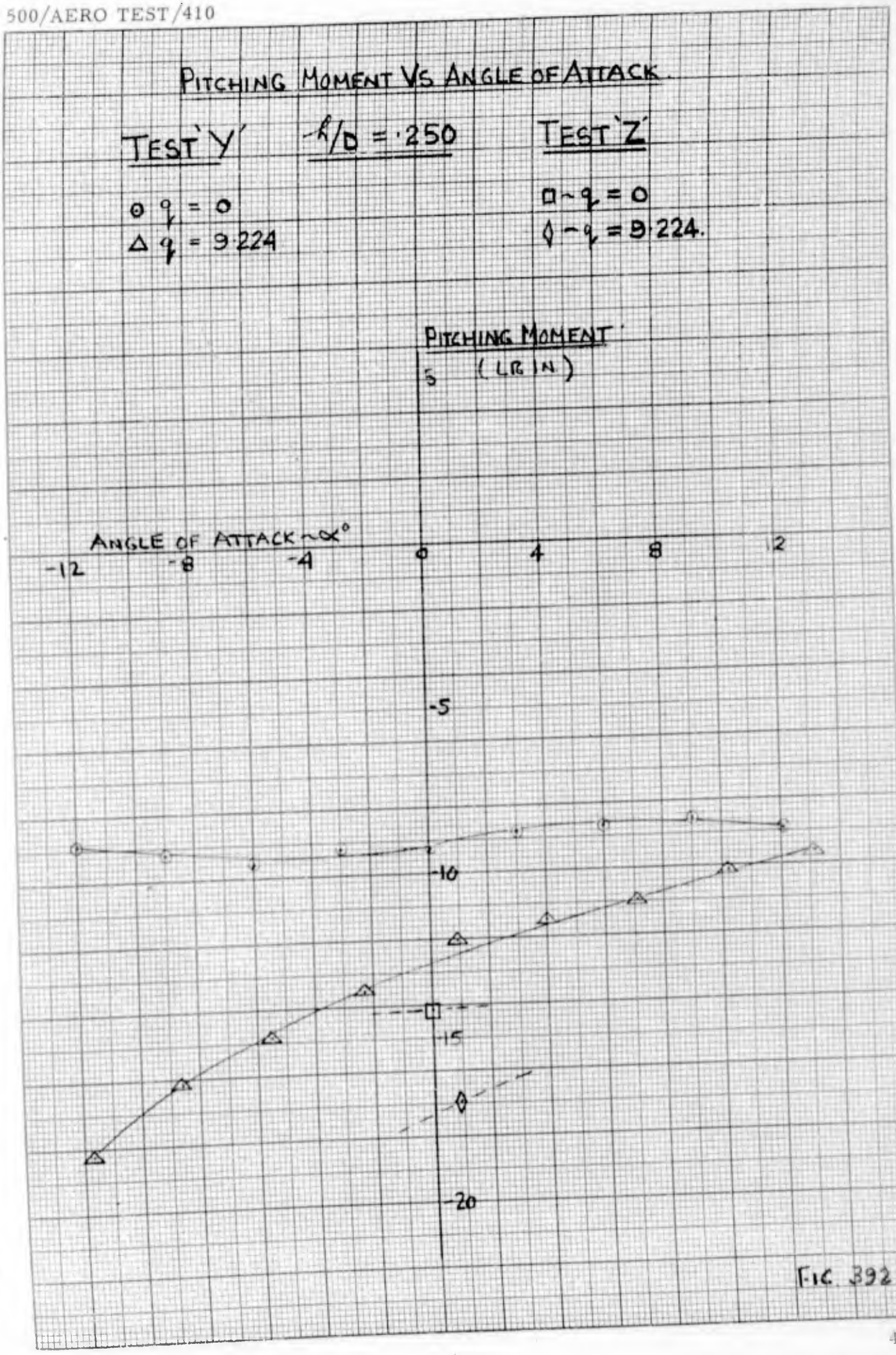

PITCHING MOMENT VS ANGLE OF ATTACK.
TEST 'Y' $\ell/D = .250$ TEST 'Z'
○ $q = 0$
△ $q = 9.224$
□ $-q = 0$
◇ $-q = 9.224$.
PITCHING MOMENT
(LB IN)
ANGLE OF ATTACK $\sim\alpha°$
-12
-8
-4
0
4
8
12
-5
-10
-15
-20

FIG. 392

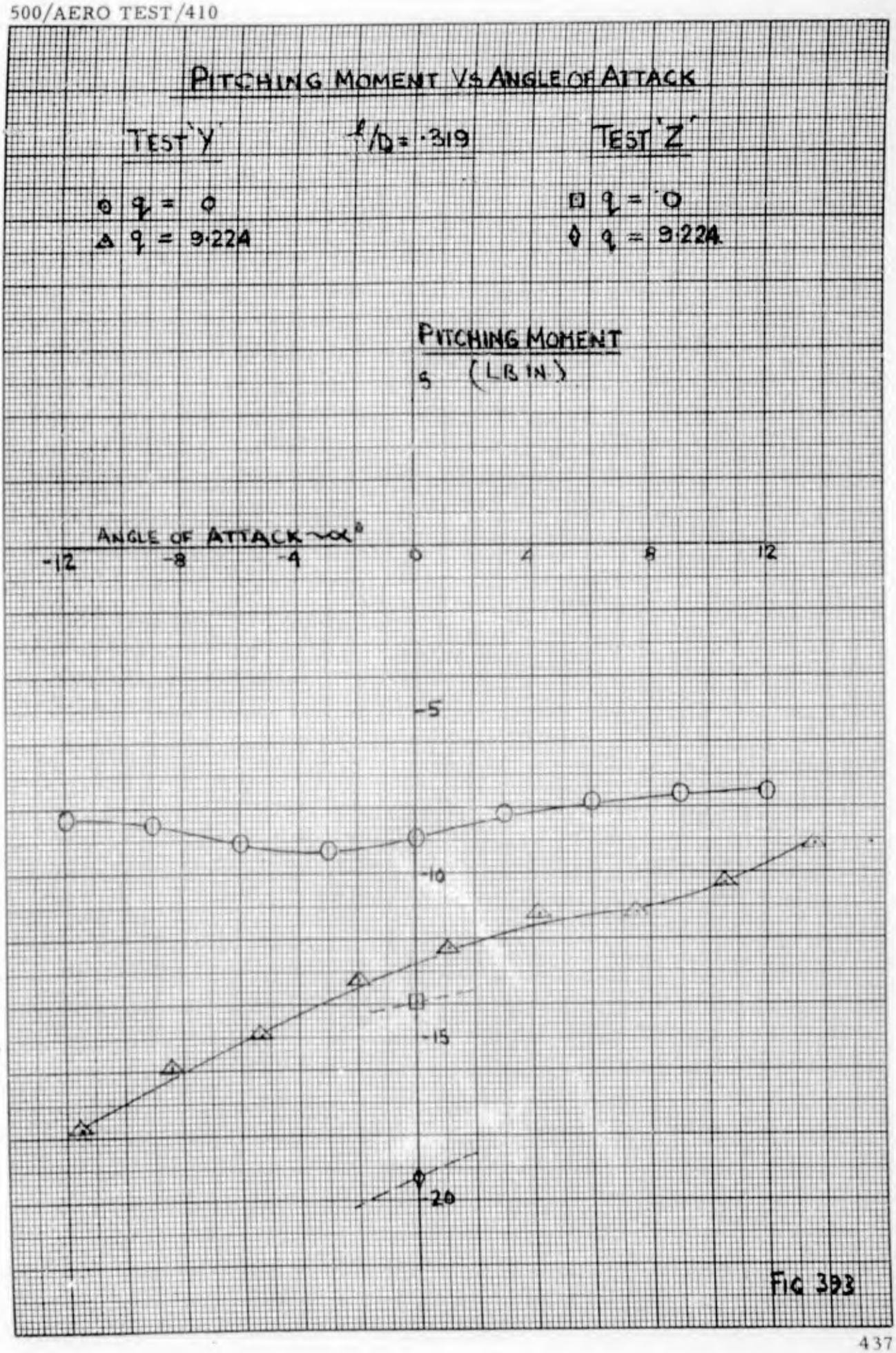

PITCHING MOMENT VS ANGLE OF ATTACK
TEST 'Y'
ℓ/D = ·319
TEST 'Z'
○ q = 0
△ q = 9·224
□ q = 0
◇ q = 9·224
PITCHING MOMENT
(LB IN)
ANGLE OF ATTACK ~α°
-12
-8
-4
0
4
8
12
-5
-10
-15
-20

FIG 393

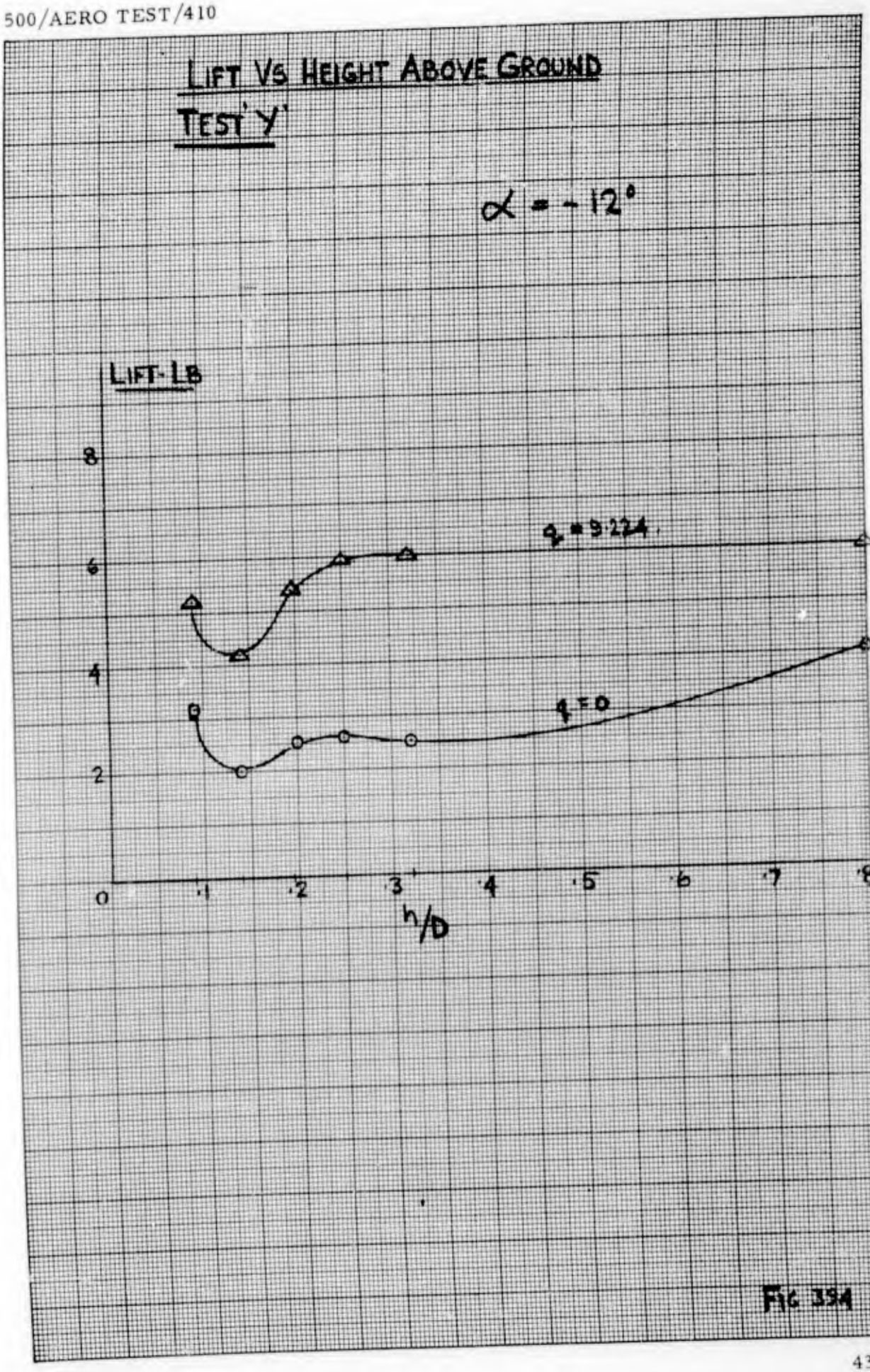
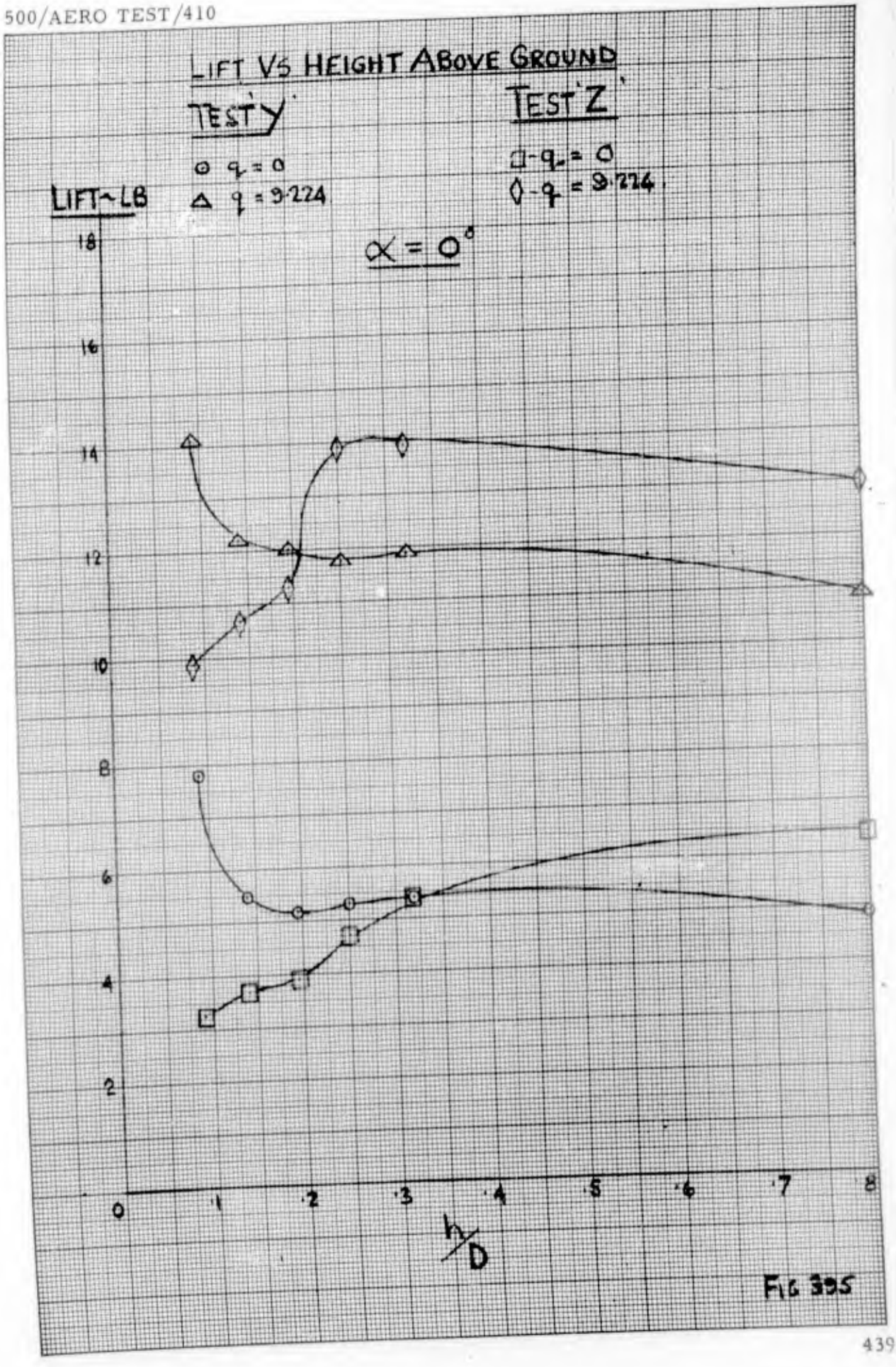
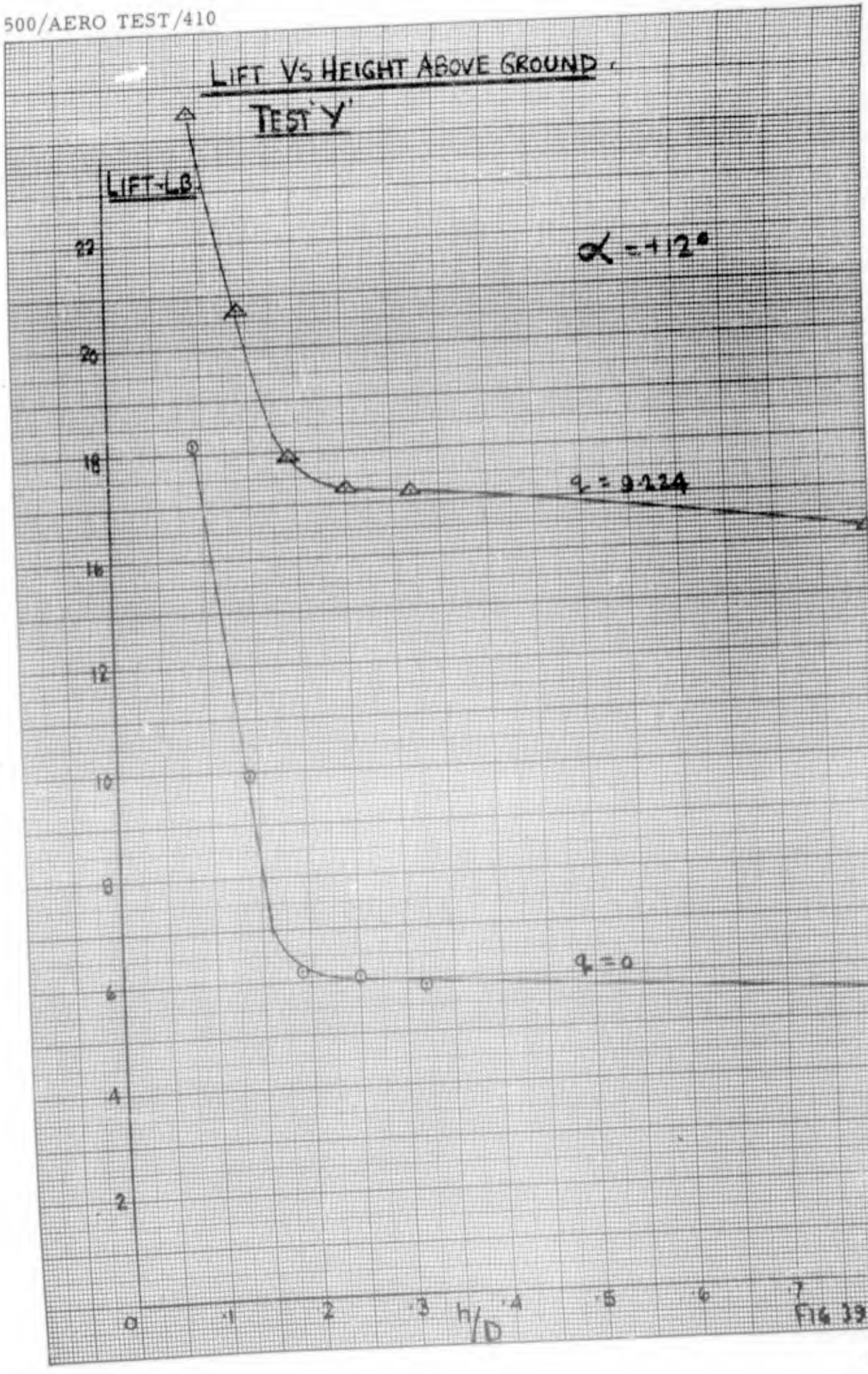

LIFT VS HEIGHT ABOVE GROUND
TEST 'Y'
α = -12°
LIFT-LB
8
6
4
2
0
q = 9.224
q = 0
.1
.2
.3
.4
.5
.6
.7
.8
h/D

FIG 334


LIFT VS HEIGHT ABOVE GROUND
TEST Y
TEST Z
⊙ q = 0
△ q = 9.224
□ - q = 0
◊ - q = 9.224
LIFT ~ LB
α = 0°
18
16
14
12
10
8
6
4
2
0
·1
·2
·3
·4
·5
·6
·7
·8
h/D
FIG 395


LIFT VS HEIGHT ABOVE GROUND
TEST 'Y'
LIFT-LB
22
20
18
16
12
10
8
6
4
2
0
·1
2
·3
h/D
·4
·5
6
7
α = +12°
q = 9.224
q = 0
FIG 336

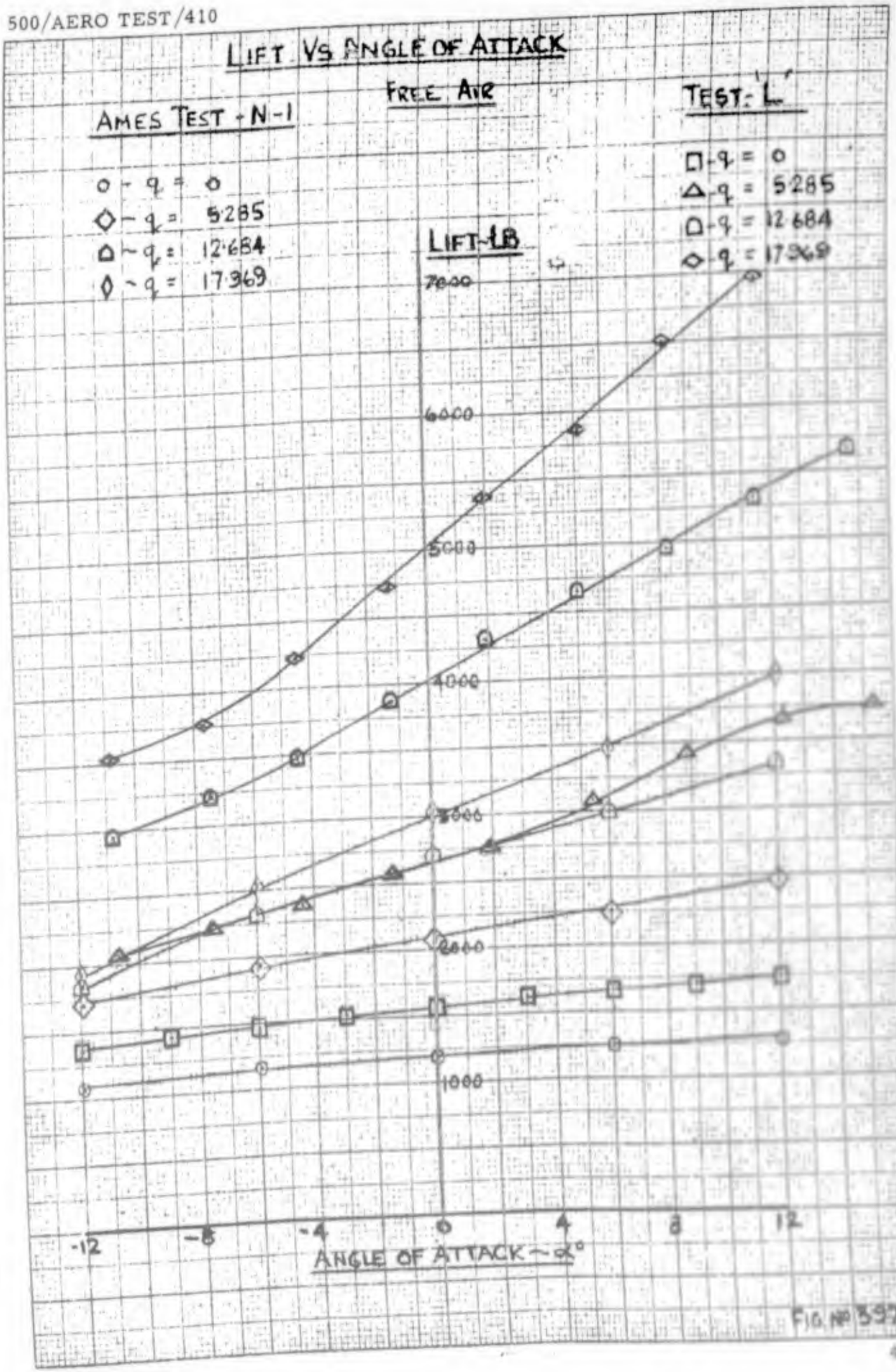

LIFT VS ANGLE OF ATTACK
FREE AIR
AMES TEST - N-1
TEST: 'L'
○ - q = 0
◇ - q = 5285
△ - q = 12684
◊ - q = 17369
□ - q = 0
△ - q = 5285
□ - q = 12684
◇ - q = 17369
LIFT-LB
7000
6000
5000
4000
3000
2000
1000
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

FIG. № 397

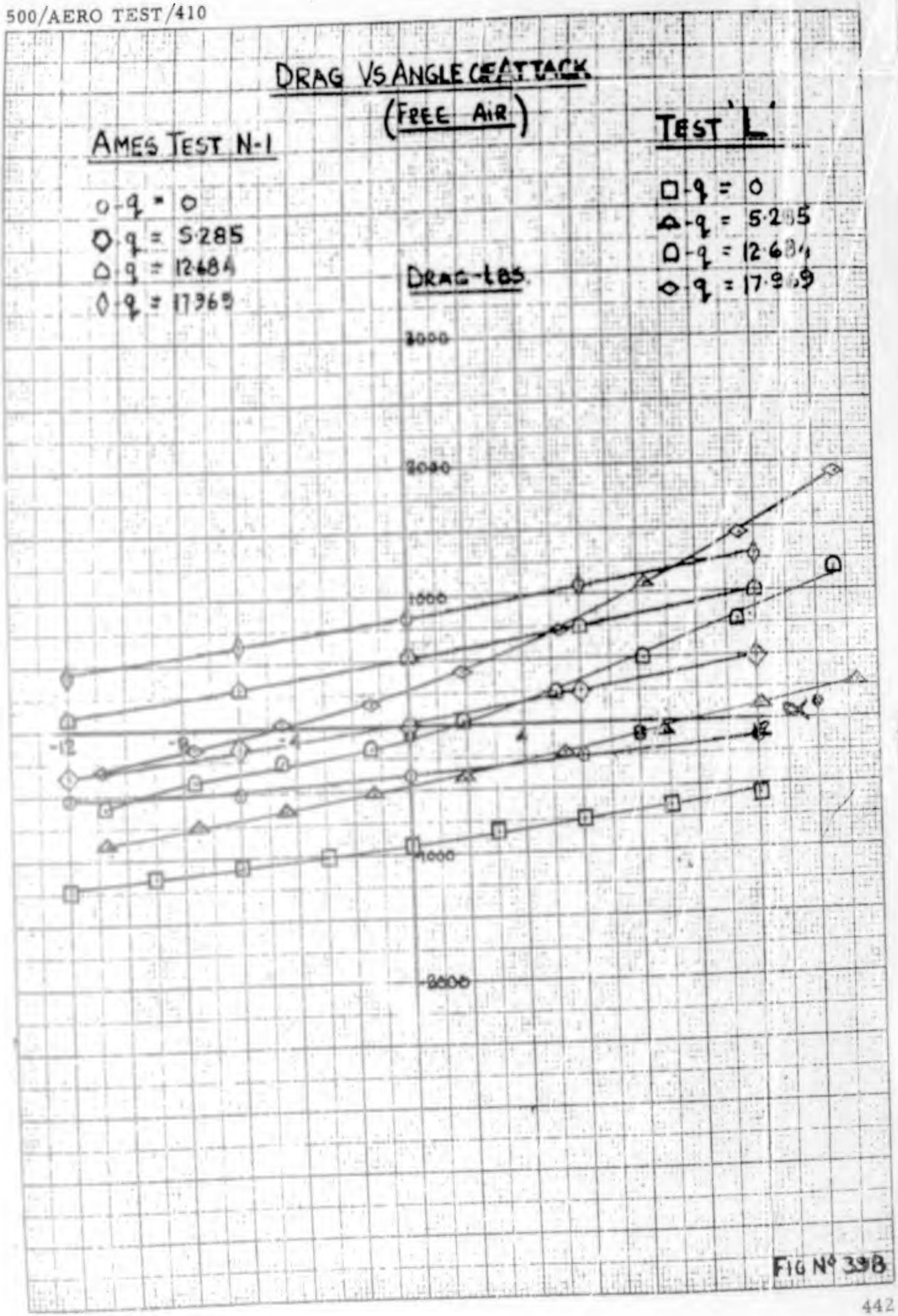

DRAG VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST N-1
o-q = 0
q = 5·285
q = 12·684
q = 17·969
TEST 'L'
□-q = 0
q = 5·285
q = 12·684
q = 17·969
DRAG-LBS.
3000
2000
1000
-1000
-2000
-12
-8
-4
4
8
12

FIG Nº 39B

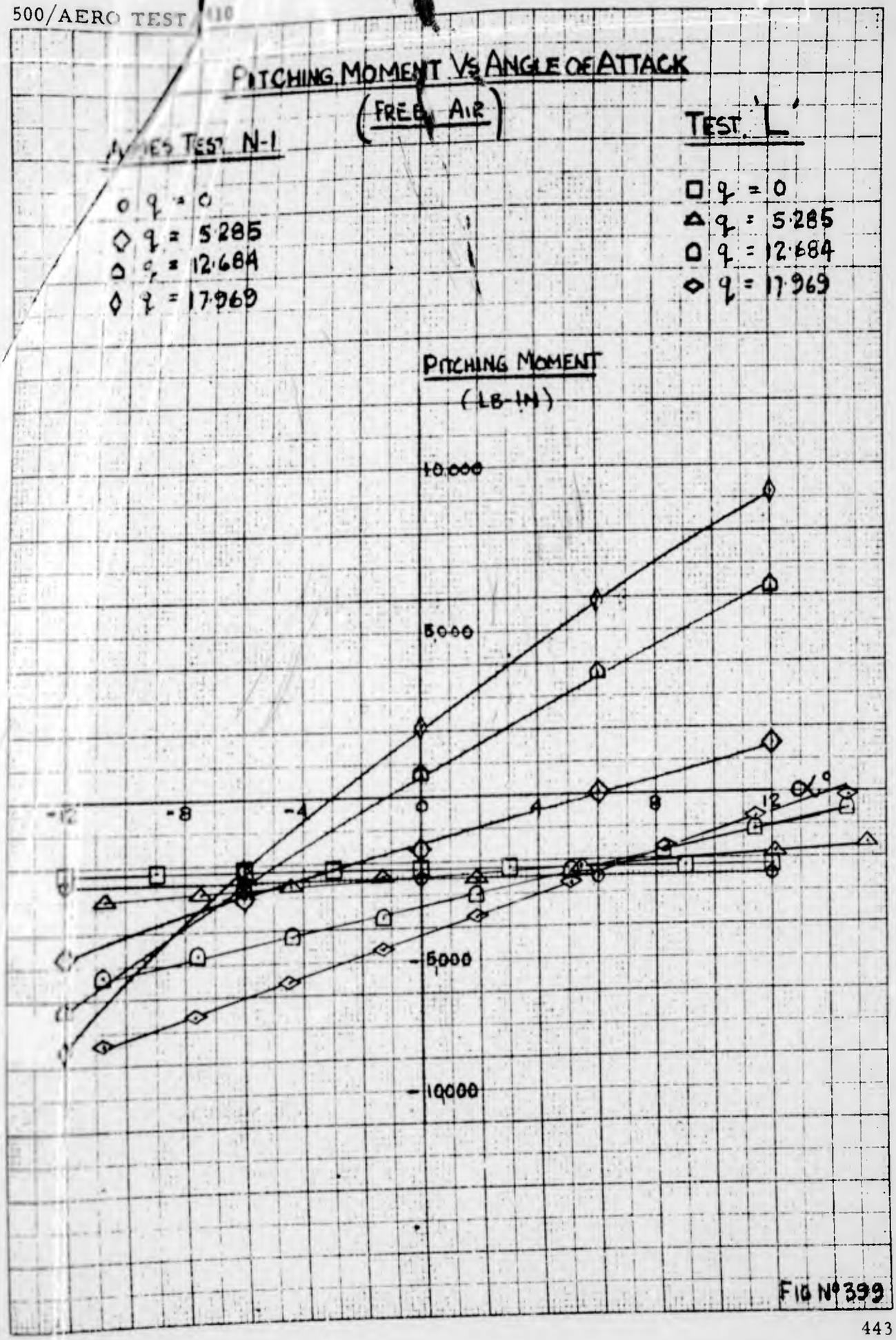
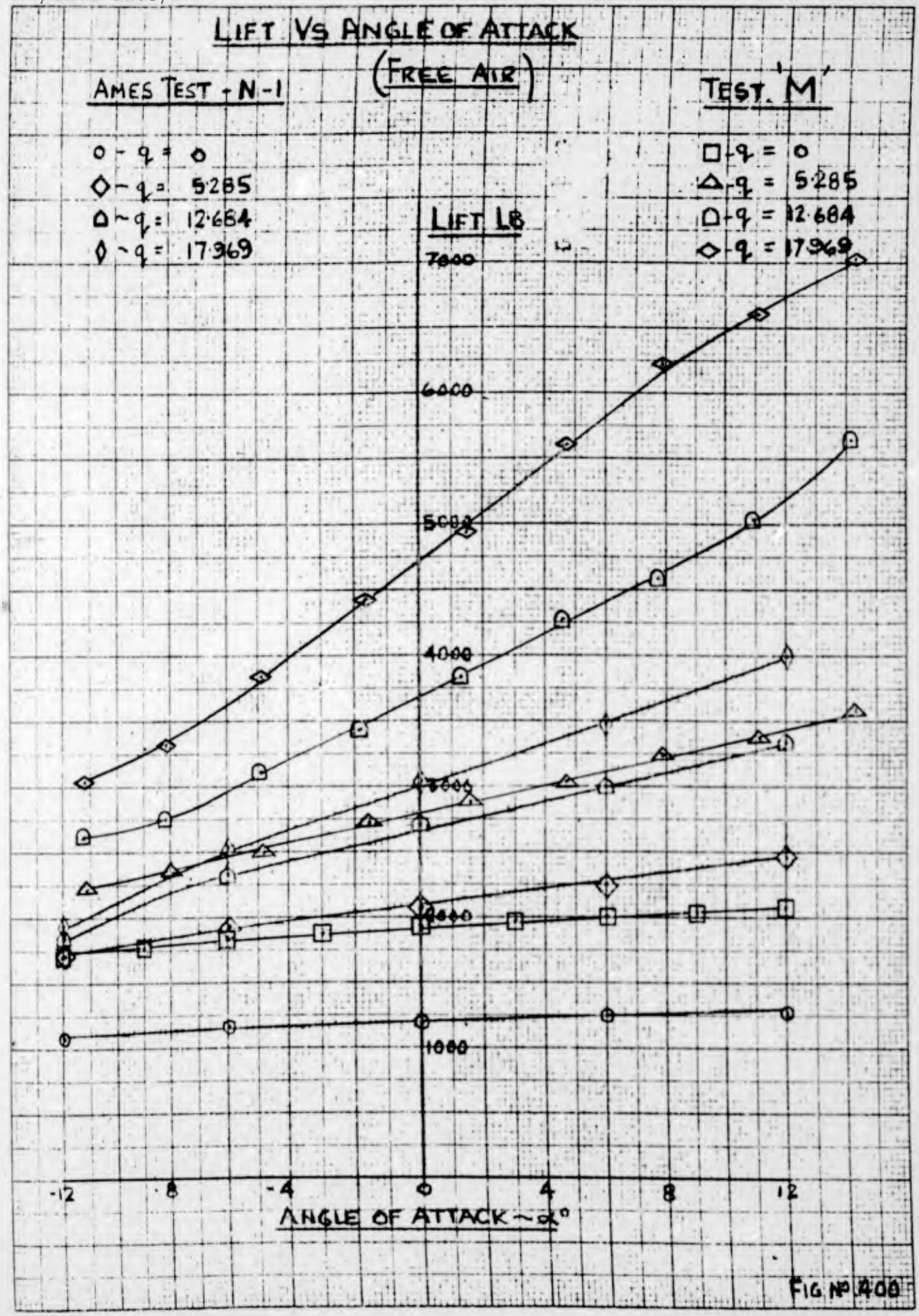

PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
TEST 'L'
□ q = 0
△ q = 5·285
○ q = 12·684
◇ q = 17·969
PITCHING MOMENT
(LB-IN)
10,000
5000
-5000
-10000
-12
-8
-4
0
4
8
12
α°

FIG N°399


LIFT VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST - N-1
TEST 'M'
○ - q = 0
◇ - q = 5285
△ - q = 12684
◊ - q = 17969
□ - q = 0
△ - q = 5285
□ - q = 12684
◇ - q = 17969
LIFT LB
7000
6000
5000
4000
3000
2000
1000
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK ~ α°
FIG Nº 400

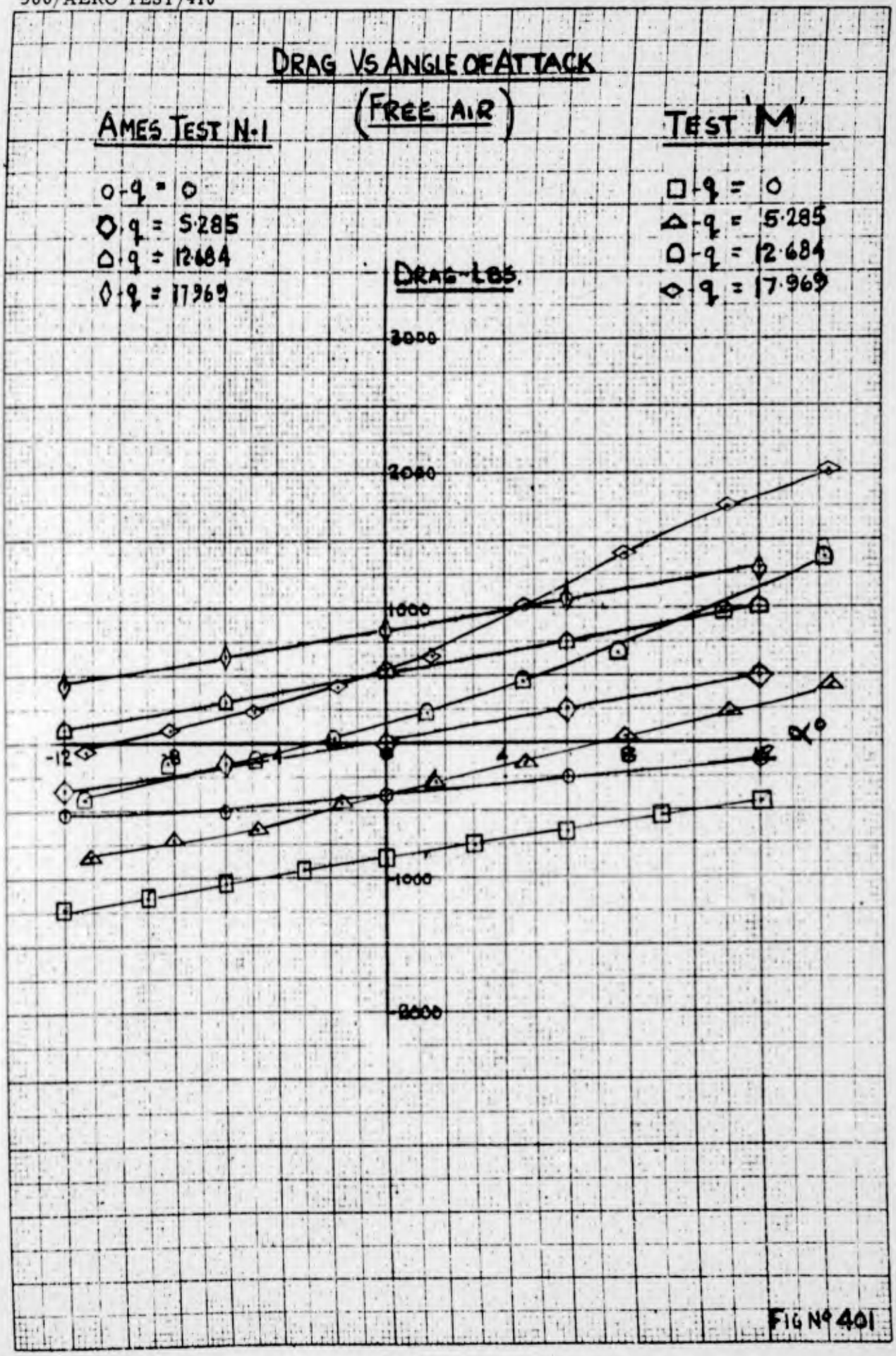
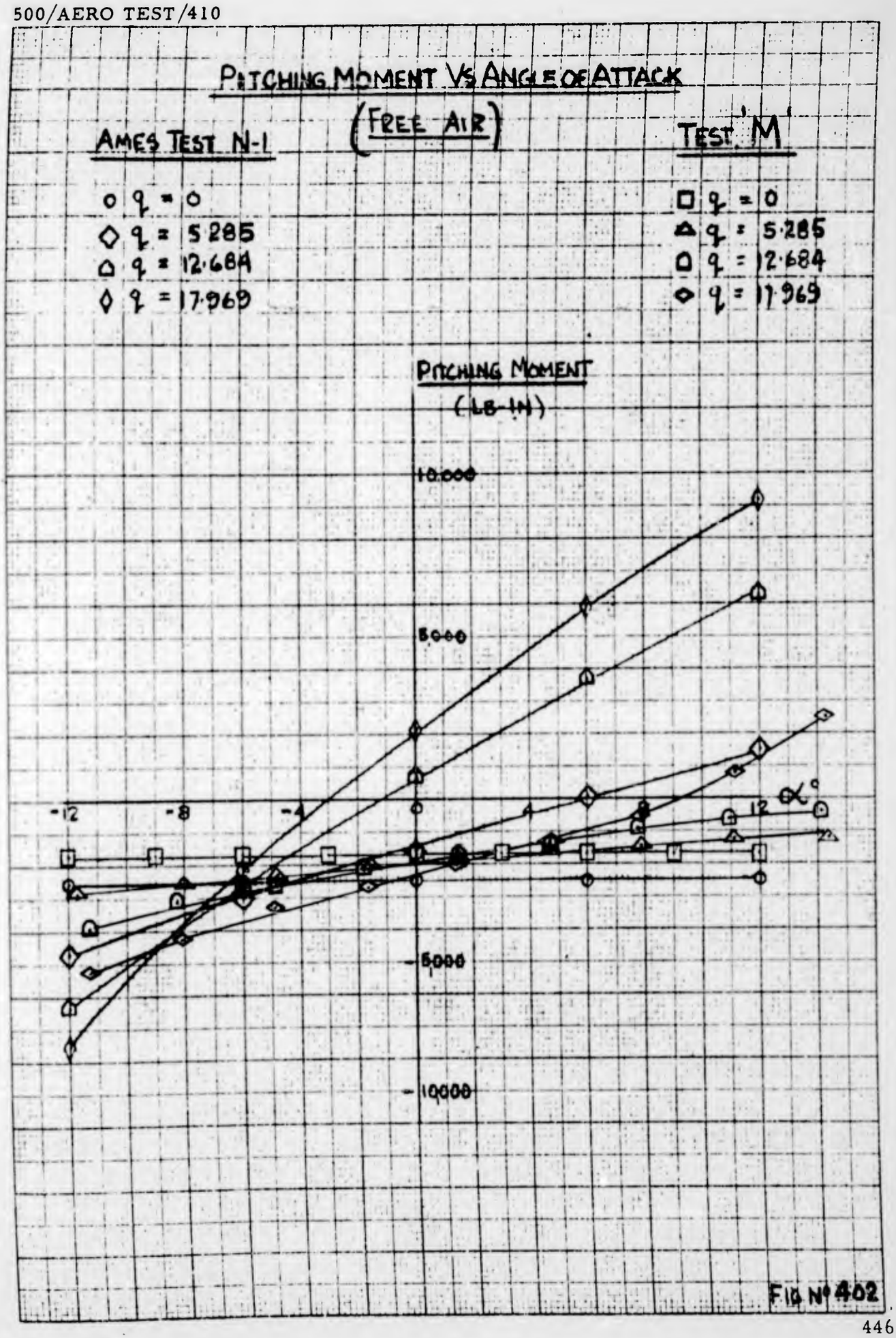

DRAG VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST N-1
TEST 'M'
○ q = 0
◯ q = 5·285
△ q = 12·684
◇ q = 17·969
□ q = 0
△ q = 5·285
○ q = 12·684
◇ q = 17·969
DRAG-LBS.
3000
2000
1000
1000
3000
-12
-8
-4
4
8
12
α°

FIG Nº 401


PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST N-1
o q = 0
◇ q = 5.285
△ q = 12.684
◊ q = 17.969
TEST 'M'
□ q = 0
△ q = 5.285
○ q = 12.684
◇ q = 17.969
PITCHING MOMENT
(LB-IN)
10,000
5000
-5000
-10000
-12
-8
-4
12
α°
FIG N° 402

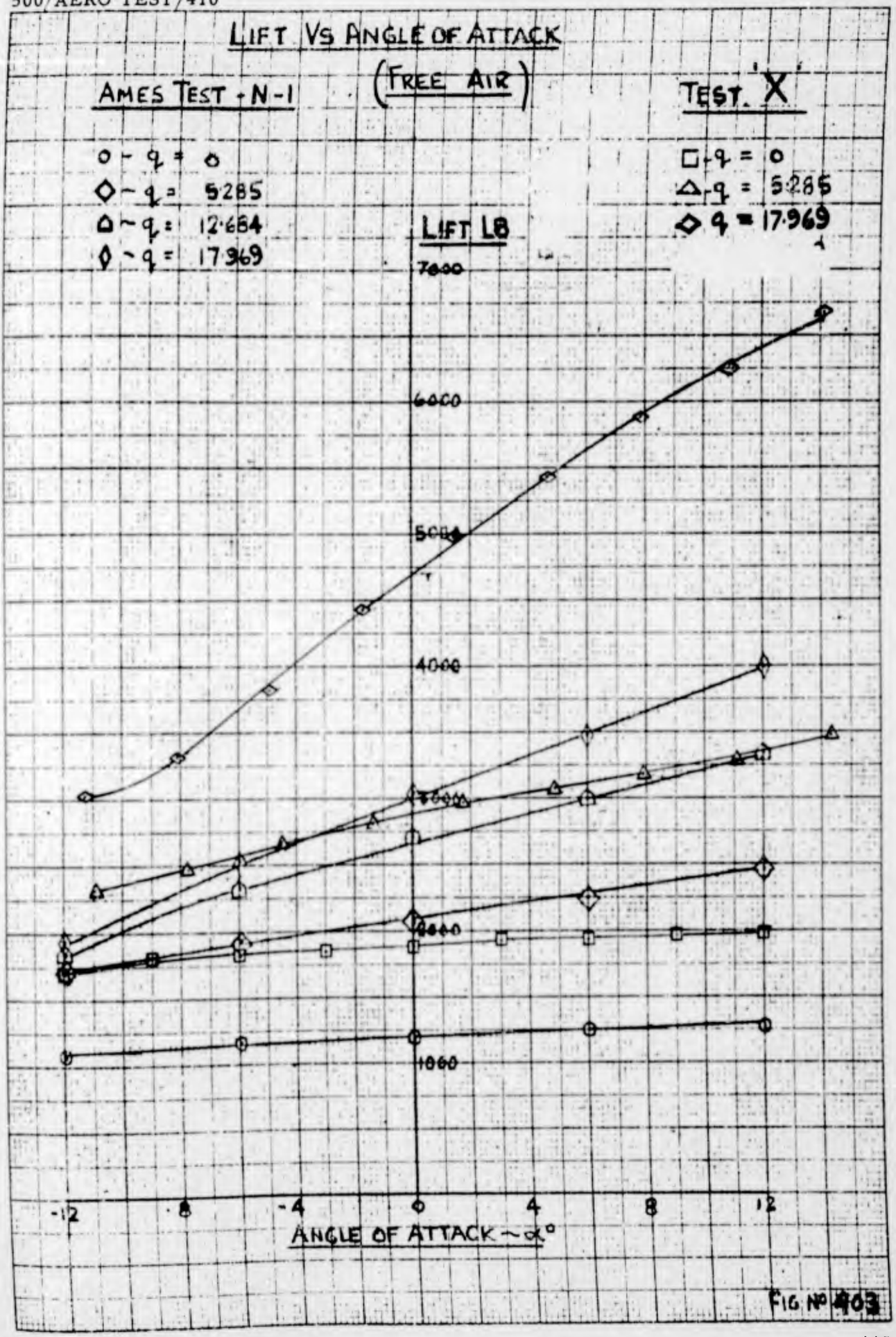

LIFT VS ANGLE OF ATTACK
AMES TEST - N-1
(FREE AIR)
TEST. X
○ - q = 0
◇ - q = 5285
△ - q = 12·684
◊ - q = 17·369
□ - q = 0
△ - q = 5·285
◇ q = 17·969
LIFT LB
7000
6000
5000
4000
3000
2000
1000
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK - α°

FIG Nº 403

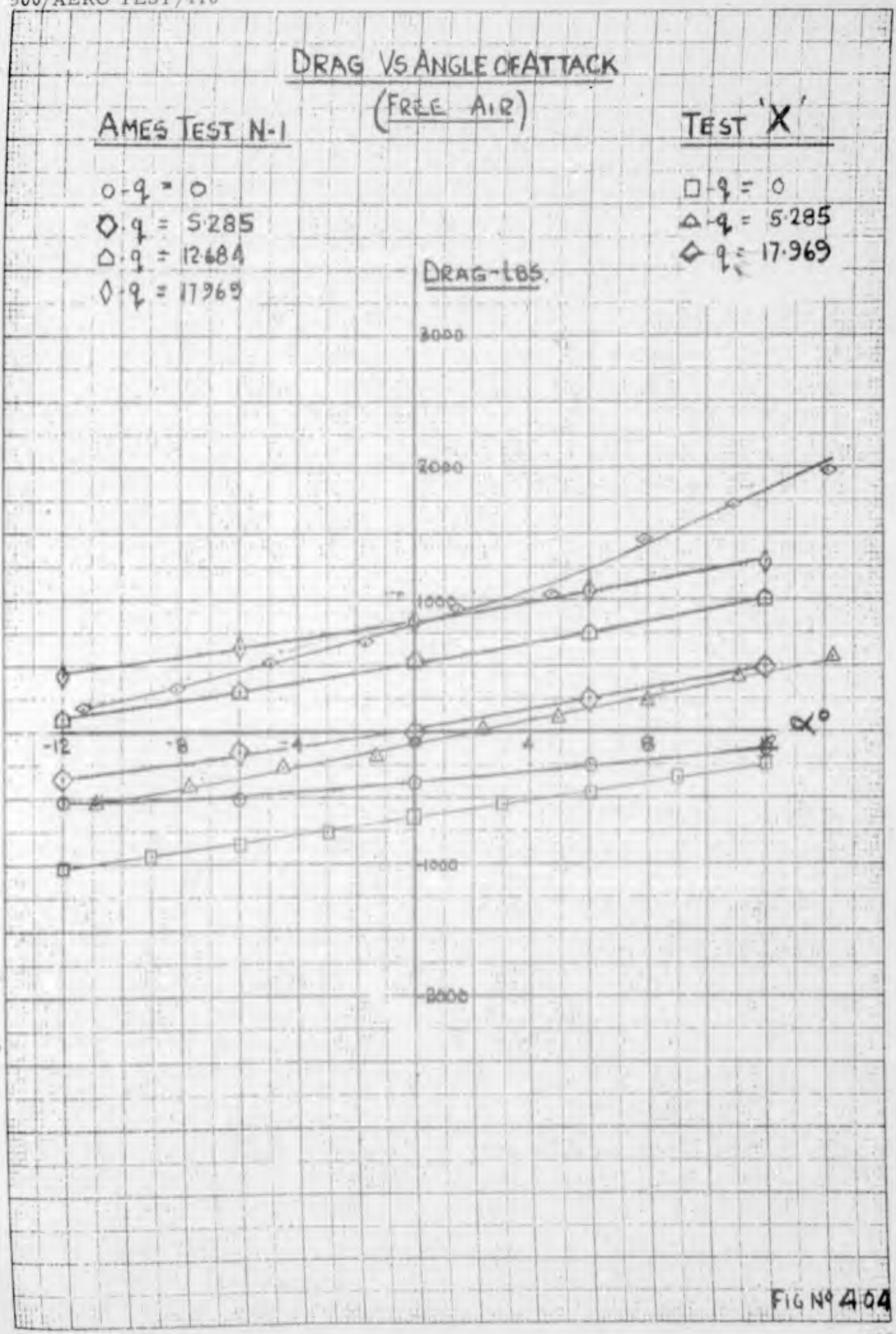
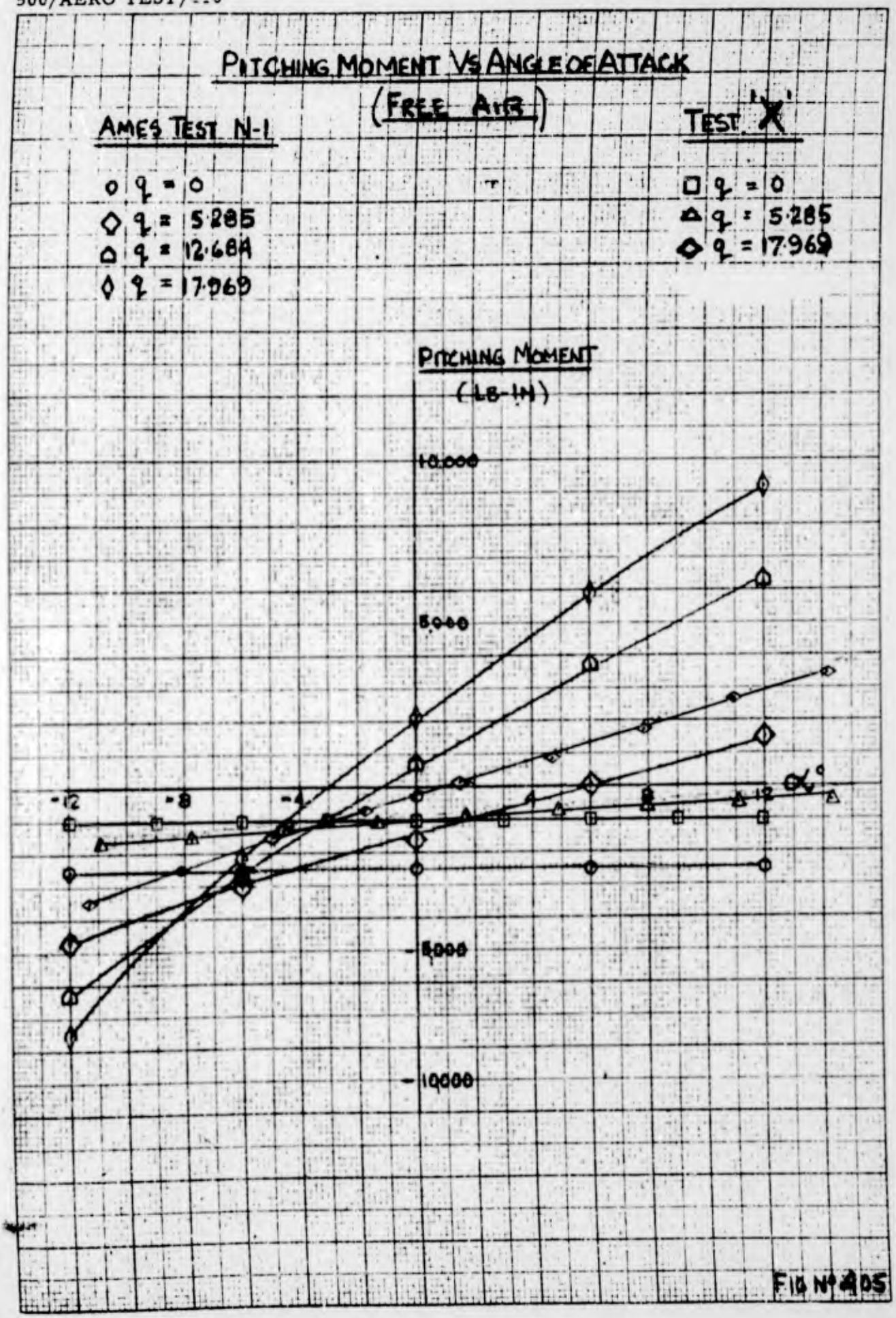

DRAG VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST N-1
o-q = 0
◇-q = 5·285
△-q = 12·684
◊-q = 17·969
TEST 'X'
□-q = 0
△-q = 5·285
◇ q = 17·969
DRAG-LBS.
3000
2000
1000
1000
2000
-12
-8
-4
4
8
α°

FIG Nº 4.04


PITCHING MOMENT VS ANGLE OF ATTACK
(FREE AIR)
AMES TEST N-1
o q = 0
◇ q = 5.285
△ q = 12.684
◊ q = 17.969
TEST 'X'
□ q = 0
△ q = 5.285
◇ q = 17.969
PITCHING MOMENT
(LB-IN)
10,000
5,000
-5,000
-10,000
-12
-8
-4
4
8
12
α°
FIG N° 405

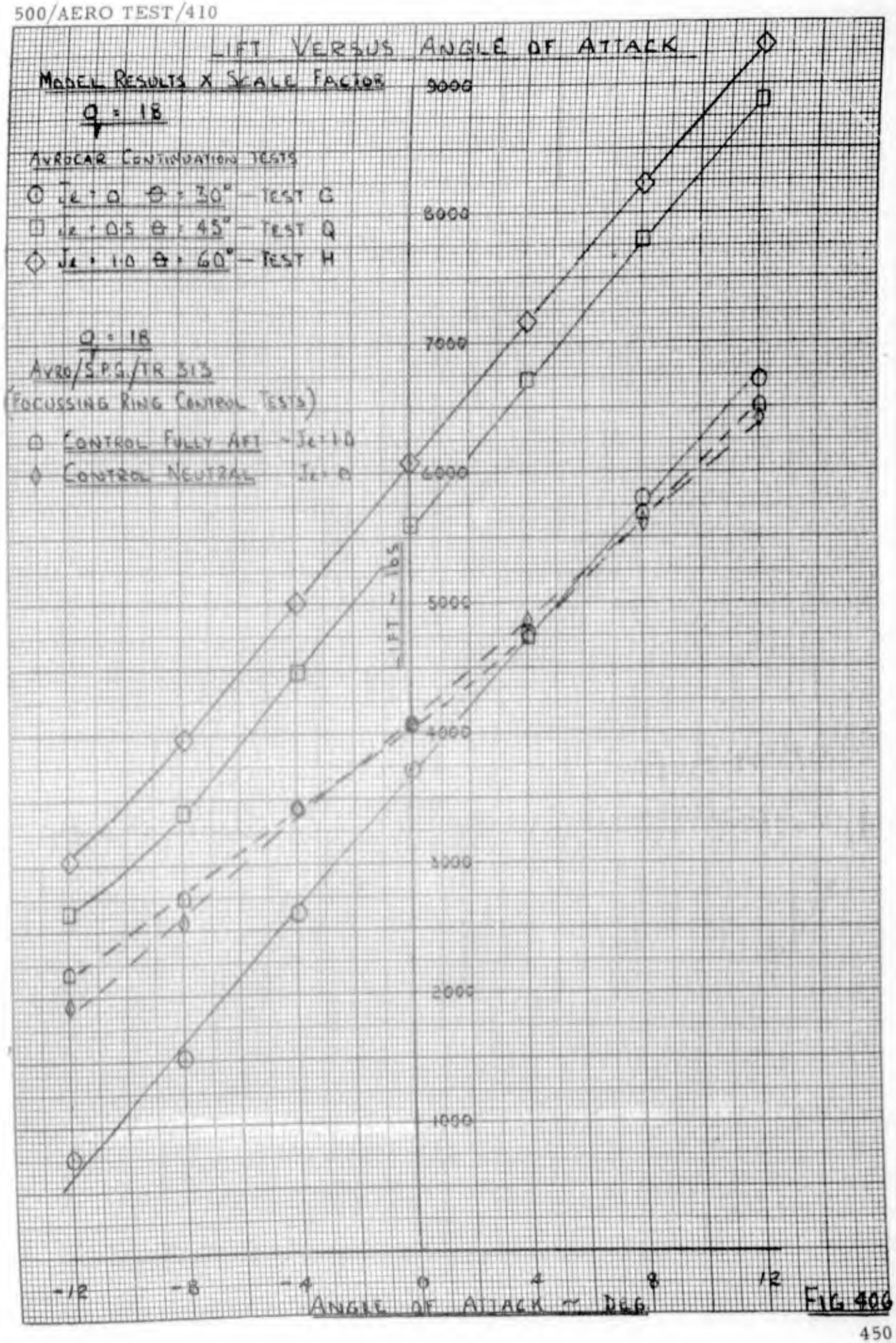

LIFT VERSUS ANGLE OF ATTACK
MODEL RESULTS X SCALE FACTOR
Q = 18
AVROCAR CONTINUATION TESTS
① Je = 0 θ = 30° — TEST G
□ Je = 0.5 θ = 45° — TEST Q
◇ Je = 1.0 θ = 60° — TEST H
Q = 18
AVRO/S.P.G./TR 313
(FOCUSSING RING CONTROL TESTS)
□ CONTROL FULLY AFT Je = 1.0
◇ CONTROL NEUTRAL Je = 0
LIFT — LBS
9000
8000
7000
6000
5000
4000
3000
2000
1000
-12
-8
-4
0
4
8
12
ANGLE OF ATTACK — DEG.

FIG 406

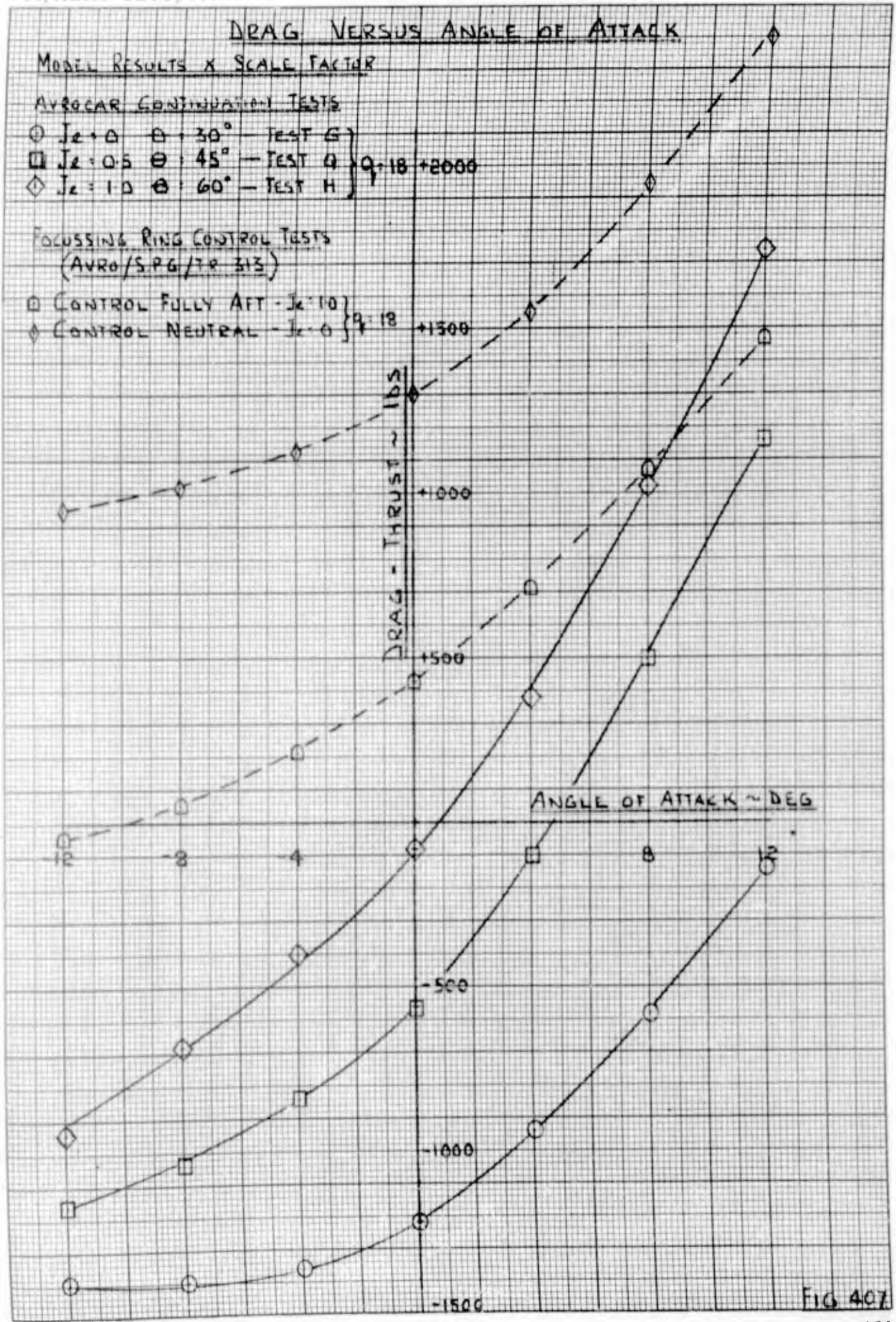

DRAG VERSUS ANGLE OF ATTACK
MODEL RESULTS X SCALE FACTOR
AVROCAR CONTINUATION TESTS
Je = 0 θ = 30° — TEST G
Je = 0.5 θ = 45° — TEST A
Je = 1.0 θ = 60° — TEST H
q = 18 +2000
FOCUSSING RING CONTROL TESTS
(AVRO/SPG/TP 313)
CONTROL FULLY AFT - Je = 1.0
CONTROL NEUTRAL - Je = 0
q = 18 +1300
DRAG - THRUST - LBS
+1000
+500
-500
-1000
-1500
ANGLE OF ATTACK ~ DEG
-12
-8
-4
8
12

FIG 407

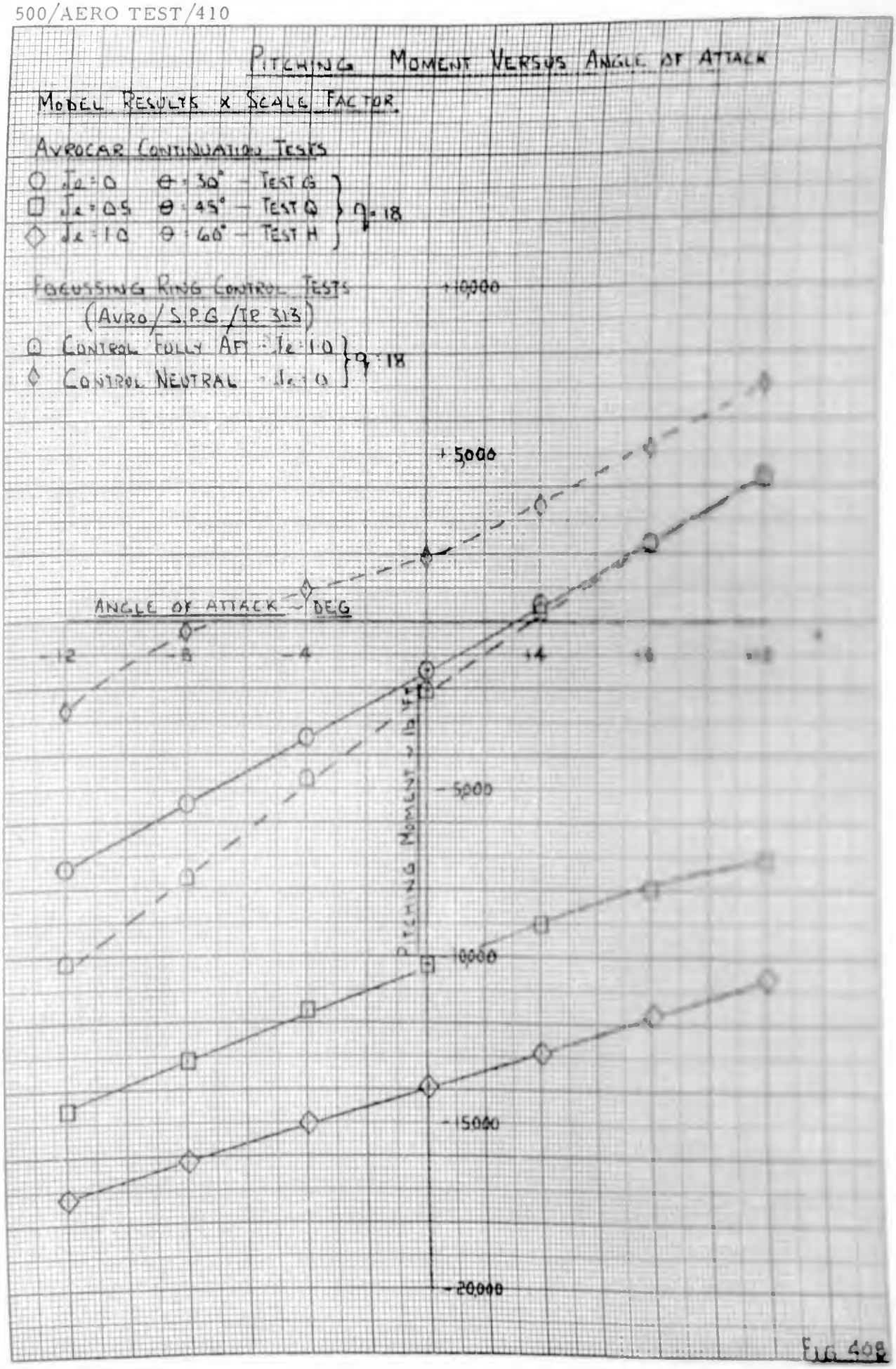

PITCHING MOMENT VERSUS ANGLE OF ATTACK
MODEL RESULTS x SCALE FACTOR
AVROCAR CONTINUOUS TESTS
○ Je = 0 θ = 30° – TEST G
□ Je = 0.5 θ = 45° – TEST Q
◇ Je = 1.0 θ = 60° – TEST H
q = 18
FOCUSSING RING CONTROL TESTS
(AVRO/S.P.G./TP 313)
Control Fully Aft Je = 1.0
Control Neutral Je = 0
q = 18
+10,000
+5000
-5000
-10000
-15000
-20,000
ANGLE OF ATTACK – DEG
-12
-8
-4
+4
PITCHING MOMENT – lb ft

Fig 408

UNCLASSIFIED

UNCLASSIFIED