

QC
Avro
CF105
P-AD-82

CF105 /ero Data/82

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ELASTIC LONGITUDINAL

DERIVATIVES.

V. Baddeley

Nov. 1956

~~27~~
27

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Classification cancelled/changed to.....

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(date).....

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MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

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AIRCRAFT: CF-105

REPORT NO. P/Aero Data/82

FILE NO.

NO. OF SHEETS

TITLE:

ELASTIC LONGITUDINAL

DERIVATIVES.

PREPARED BY V. Baddeley

DATE Nov. 1956

CHECKED BY

DATE

SUPERVISED BY

DATE

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ISSUE NO.	REVISION NO.	REVISED BY	APPROVED BY	DATE	REMARKS



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

REPORT No. P/Aero Data/82

SHEET No. _____

AIRCRAFT

CF-105

PREPARED BY

DATE

V. Baddeley

Nov. 1956

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ELASTIC LONGITUDINAL DERIVATIVES

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★ Derivatives Modified Due To Elastics

CONTENTS

	<u>Section Reference</u>	<u>No. of Sheets</u>
1. <u>Stability Derivatives</u>		
★ Aerodynamic Centre	1.1	1
★ $C_{L\alpha}$	1.2	2
C_{Lq}	1.3	1
$C_{L\dot{\alpha}}$	1.4	1
C_{M_0}	1.5	2
α_0	1.6	1
★ $C_{M\alpha}$	1.7	2
C_{Mq}	1.8	1
$C_{M\dot{\alpha}}$	1.9	1
★ $\Delta C_{L(C_{M_0})/C_{M_0}}$	1.10	2
★ C.P. (C_{M_0})	1.11	2

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2. Control Derivatives

Section Reference

No. Of Sheets

* $C_{L\delta R}$, $C_{L\delta E}/C_{L\delta R}$, and $C_{L\delta E}$ for

1 'g', c.g. at .31 A.M.C.
Weight = 47,000 lb.

2.1

5

* C_{PR} , $\Delta CP(C_L)$, $\Delta CP(\alpha)$

2.2

6

* $C_{M\delta(C_L)}$, 1 'g' c.g. at .31 A.M.C.

Weight = 47,000 lb.

2.3

1

* $C_{M\delta(\alpha)}$ 1 'g' c.g. at .31 A.M.C.

Weight = 47,000 lb.

2.4

1

$C_{h\alpha}$

2.5

1

$C_{h\delta_e}$

2.6

1

$C_{h\delta}$

2.7

1

3. Appendix

α_{TR} , 1 'g', c.g. at .31 A.M.C.

Weight = 47,000 lb.

3.1

1

δ_{TR} , 1 'g', c.g. at .31 A.M.C.

Weight = 47,000 lb.

3.2

1

N.B. $C_{M\delta(C_L)} = C_{L\delta Rigid} (a.c. - cp_E(C_L))$

$C_{M\delta(\alpha)} = C_{L\delta Rigid} (h - cp_E(\alpha))$

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REMARKS

One general remark, it is assumed that the effects of elasticity, on all derivatives are felt immediately some small disturbance is made. This is obviously not correct for high frequency oscillations, but corrections for this are beyond the scope of this report.

Apart from this Section 1 is self explanatory with the following minor comments.

- (a) $\Delta C_{L_{C_{M_0}}}$ could have been expressed as a change in α_0

$$\text{viz. } \Delta \alpha_0 = \frac{-\Delta C_{L_{C_{M_0}}}}{C_{M_0}}$$

- (b) Similarly a change in C_{M_0} due to C_{M_0} with the revised α_0 could have been given

$$\text{viz. } \Delta C_{M_0 C_{M_0}} = C_{L_{C_{M_0}}} \text{ (a.c. - c.p. } C_{M_0} \text{)}$$

However the more fundamental treatment of figs. 1.10, & 1.11 was considered more desirable, but it should be remembered that basically all the effects are, is a change in α_0 & C_{M_0} .

- (c) The change in C_{M_0} shown in fig. 1.5.2 is for c.g. at .31 A.M.C. However since most of this change is due to the vertical shift of c.g., from test model to aircraft the curve could be used for other c.g.'s with very little loss of accuracy.

Section 2

- (a) It is most important that in estimating C_{M_δ} at constant $\alpha = C_{L_\delta}$ (h - c.p.)

$$C_{M_\delta} \text{ at constant lift} = C_{L_\delta} \text{ (a.c. - c.p.)}$$

that the RIGID values of C_{L_δ} be used since the changes in c.p. due to elastics are based on the rigid values of C_{L_δ} .

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Section 2 (Continued)

- (b) In obtaining c.p. elastic from figs 2.2.1 - 2.2.6, it will be noted that Δ c.p. due to elastics is shown positive forwards, and hence $c.p._E = c.p._R$ from (2.2.1, 2.2.2)
- Δ c.p. from 2.2.3 - 2.2.6.

Section 3

The values of α_{TR} , and δ_{TR} for 1 'g', were obtained by adding the increments due to elastics, from calculations using the derivatives, to the rigid values obtained directly from $C_M \sim C_L \sim \delta$ plots.

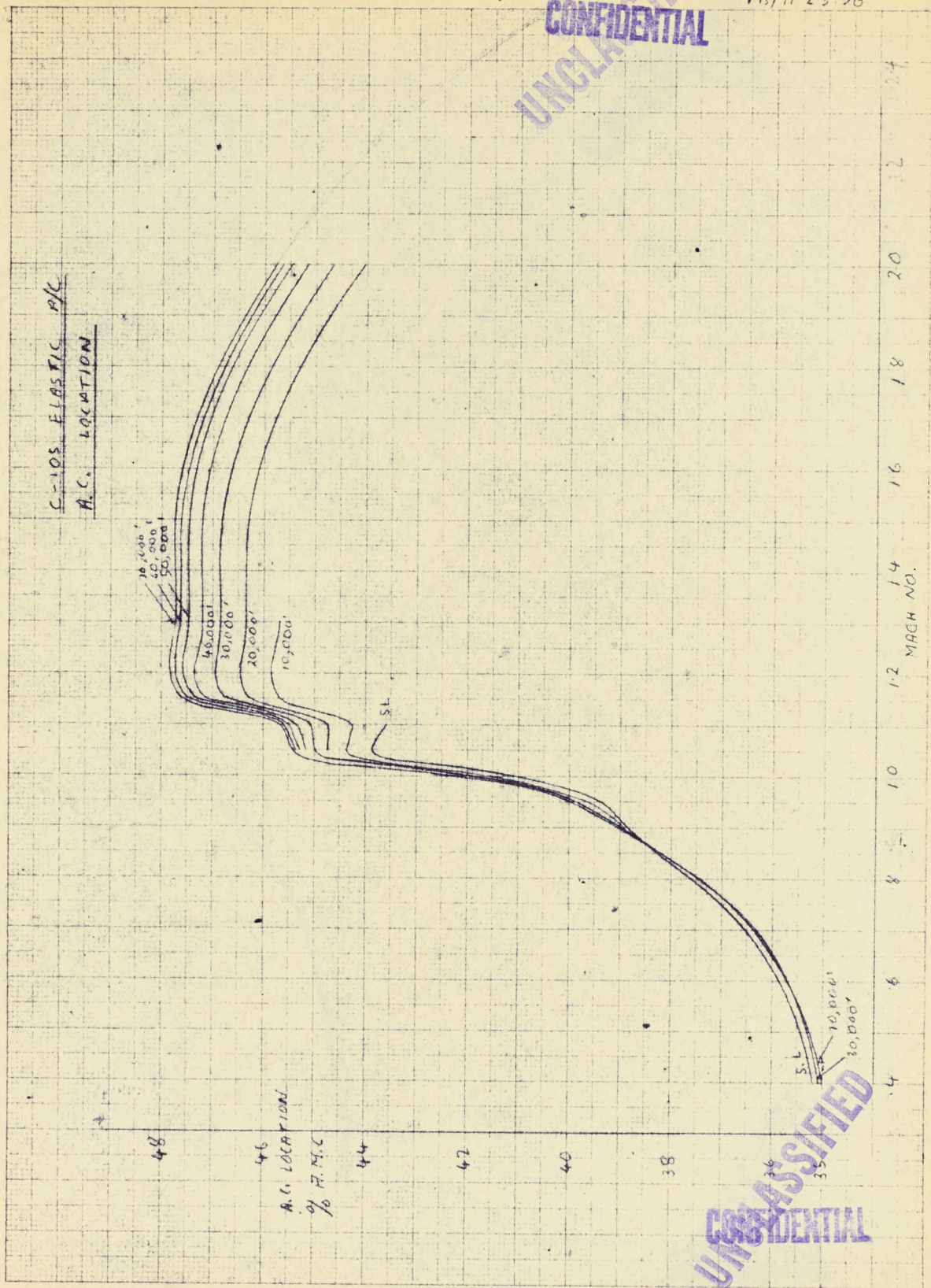
In this manner errors due to linearization were minimized. However this does mean, that calculations using the derivatives of the report will not agree exactly with the values of α_{TR} and δ_{TR} quoted.

It will also be noted, that the α_{TR} curve is for the rigid aircraft. This is because the change in α due to elastics at 1 'g' is so small as to be not significant, hence the rigid curve.

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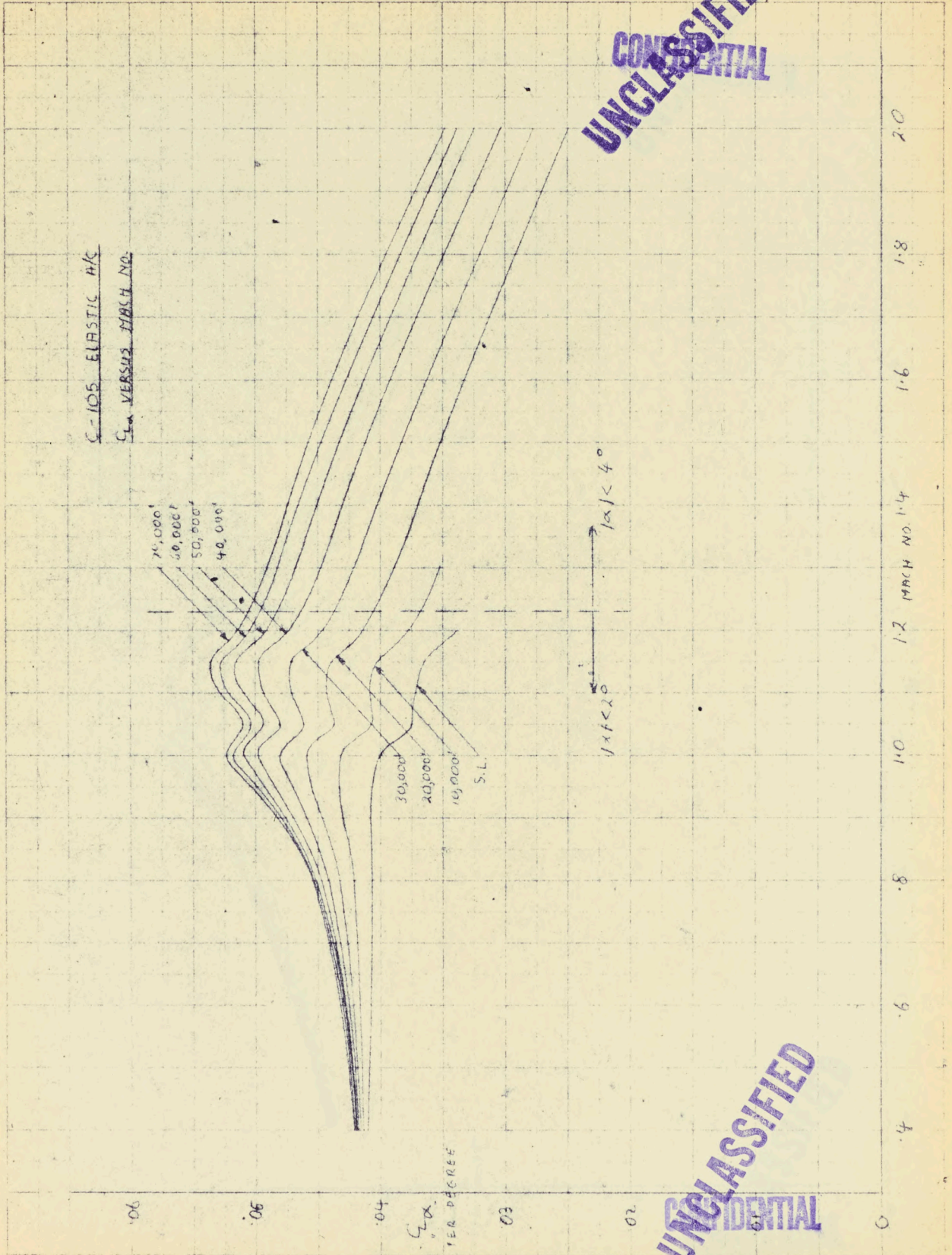
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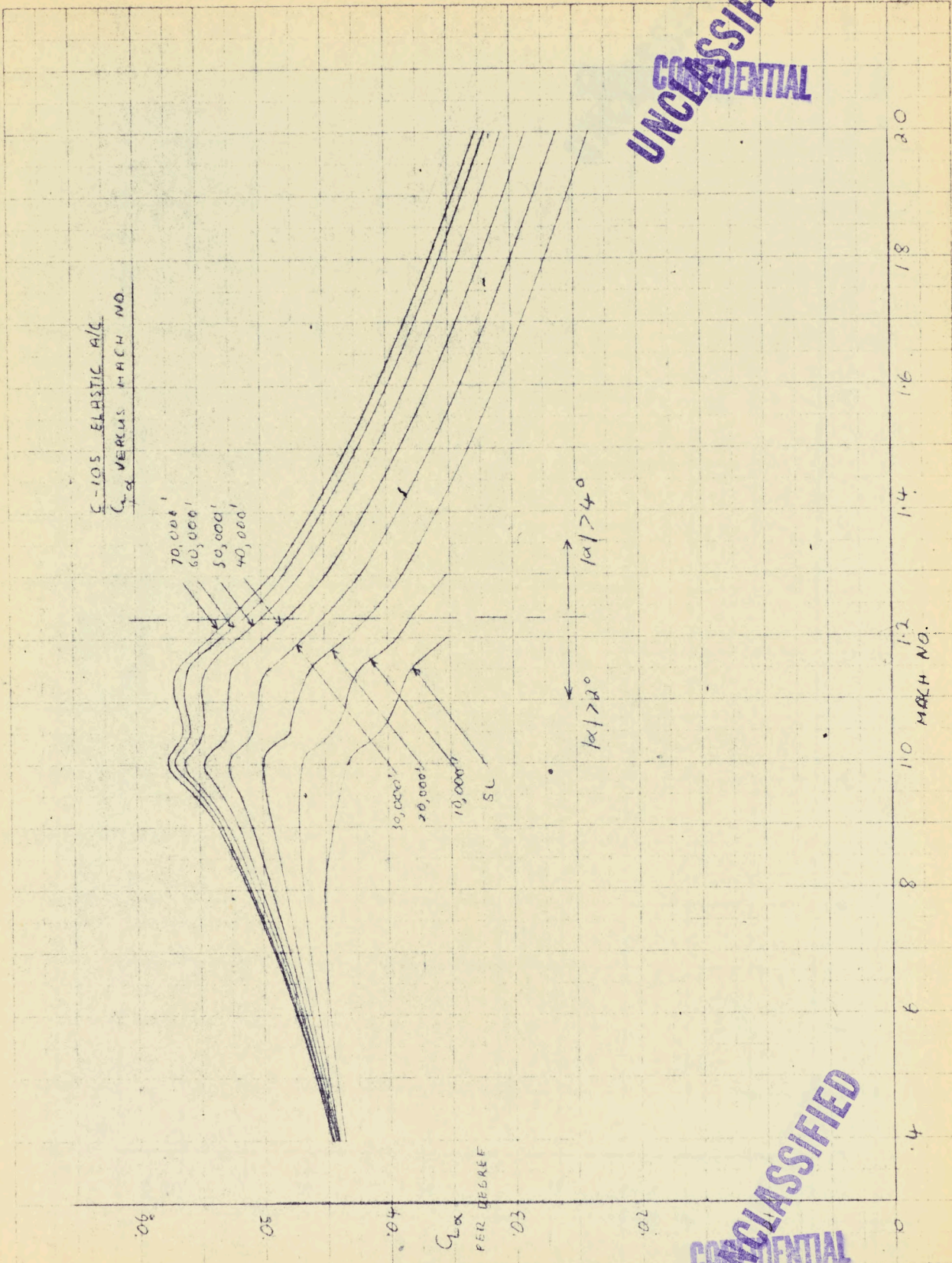
C₁₀₅ ELASTIC A/C
C₁₀₅ VERSUS MACH NO.



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C-105 ELASTIC A/C
C_α VERSUS MACH NO

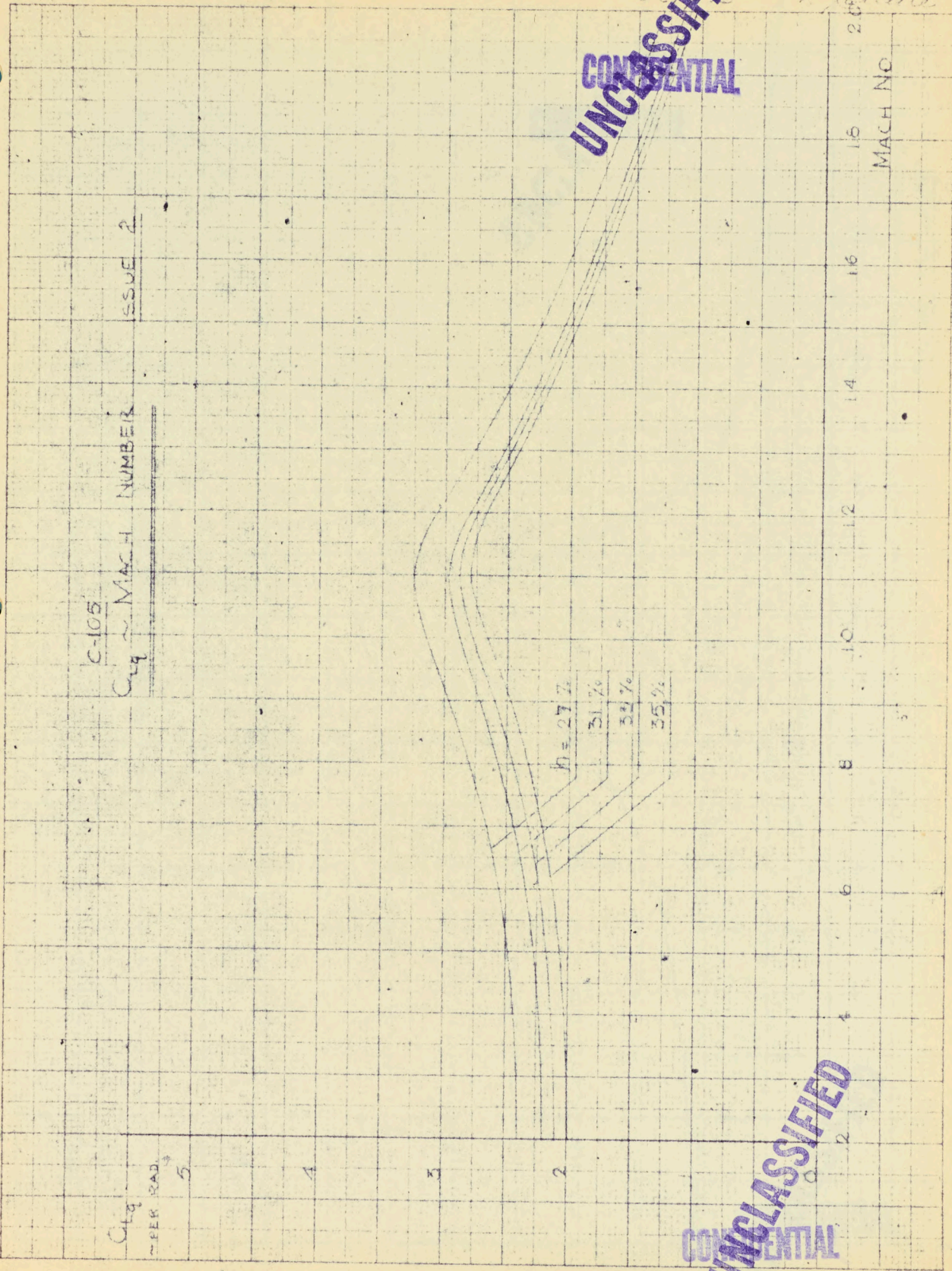


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FILE TO THE... 355 12

Orlando K. Little

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K&E 10 X 10 TO THE 1/4 INCH 359-12
KUPPEL & EMBE CO. MADE IN U.S.A.

Plot
1/2 1/2 1/2 1/2 1/2

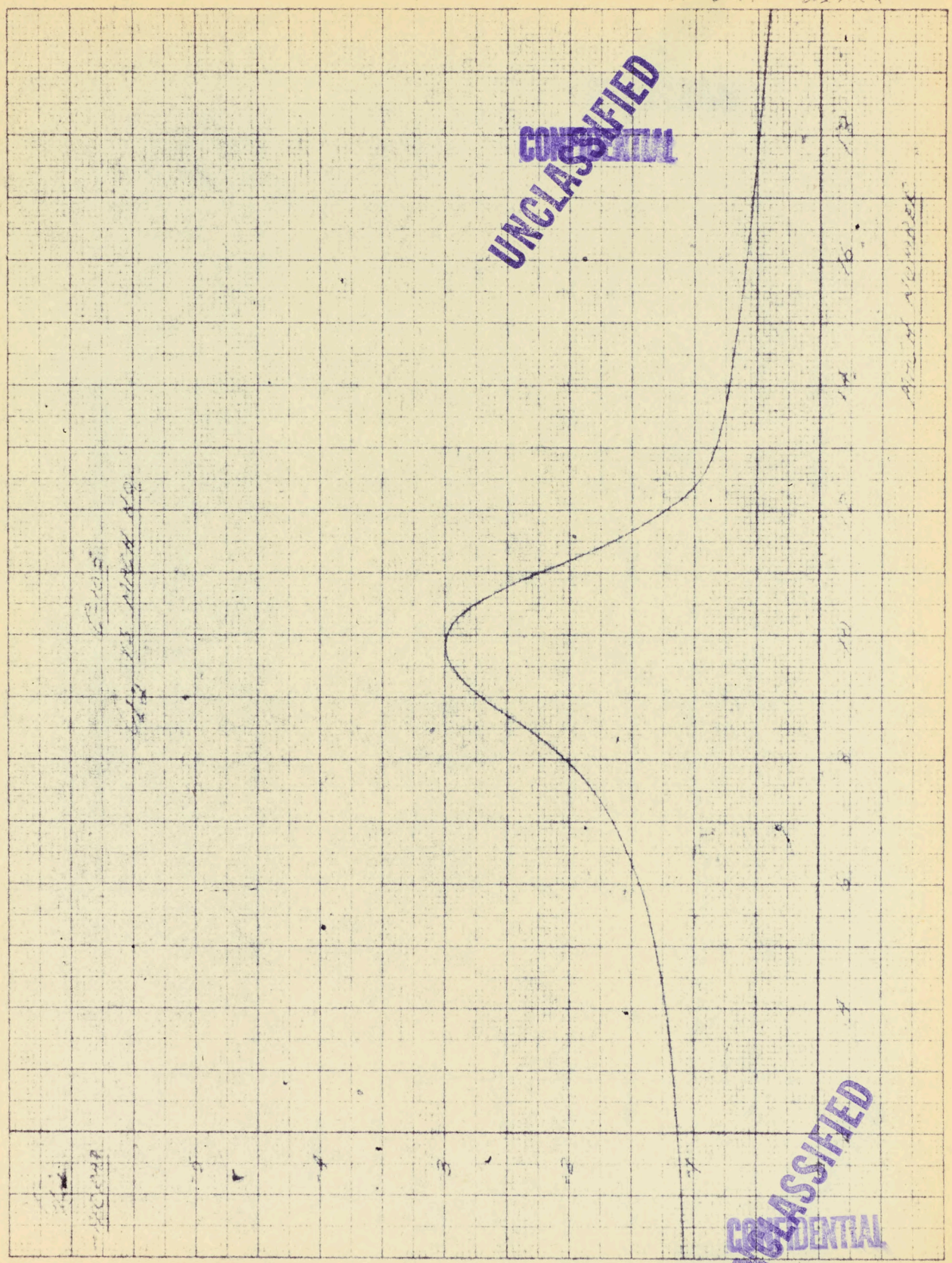
1/2 1/2 1/2 1/2 1/2

P. 17 AB 51

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Area Number



C-105

SUBMODEL CAL AND LANGLEY W/I TESTS

C_{mo} vs MACH NO.

CONFIG. B, V, W, E, M, S, D₄

C_{mo}

0.3

0.2

0.1

0

2

4

6

8

10

12

14

16

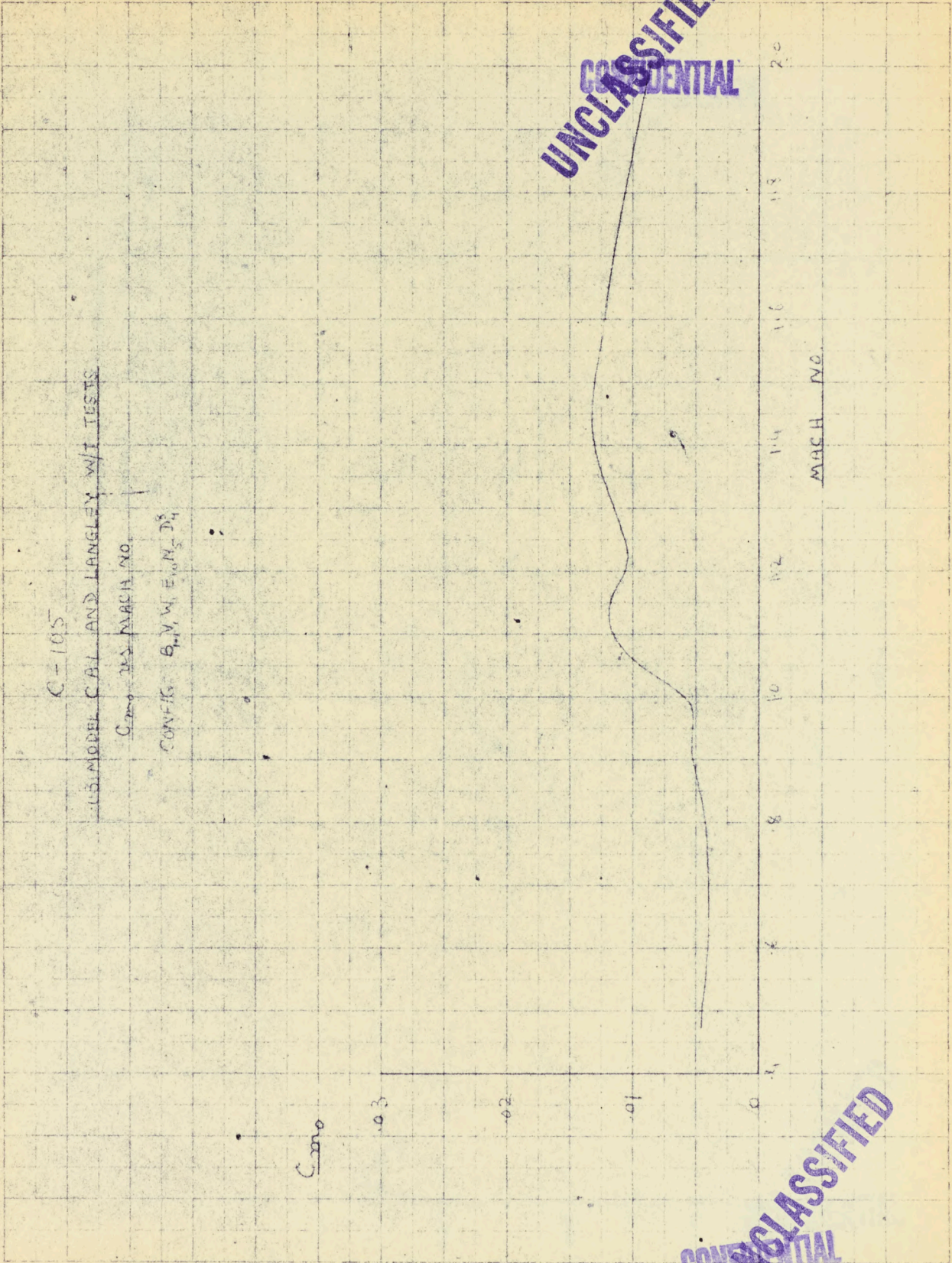
18

20

MACH NO.

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16-000 10 X 10 TO THE 1/8 INCH 359-12
MILITARY STANDARD 100

C-105

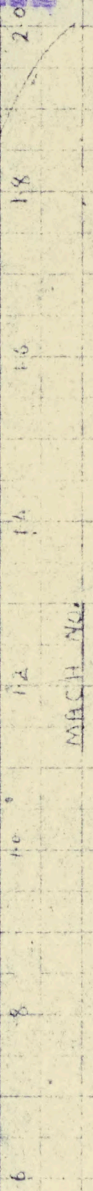
33 MODELS A1 AND LANGLEY WJT TESTS

20 vs MACH NO.

CONFIG. C₂X, W₁E, A₁C, B₁

α

DEGREES

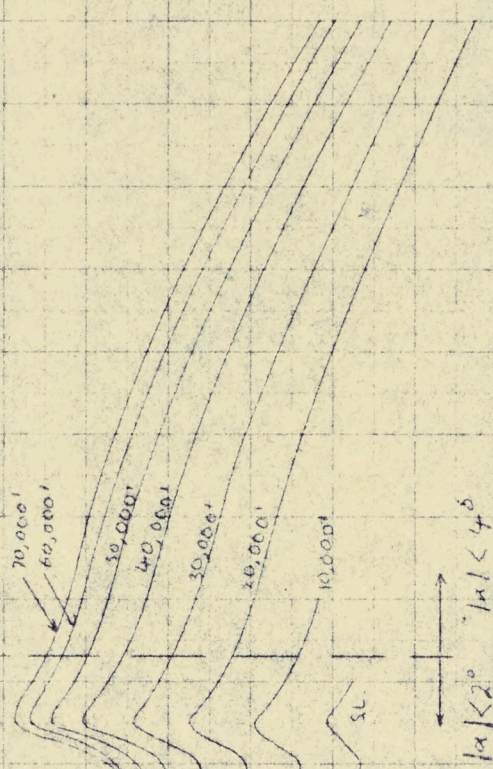


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18/11/56

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C-106 ELASTIC A/C
C_{max}
19 @ 31% A.M.C



2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0

0
4
8
10
12
14
16
18
20

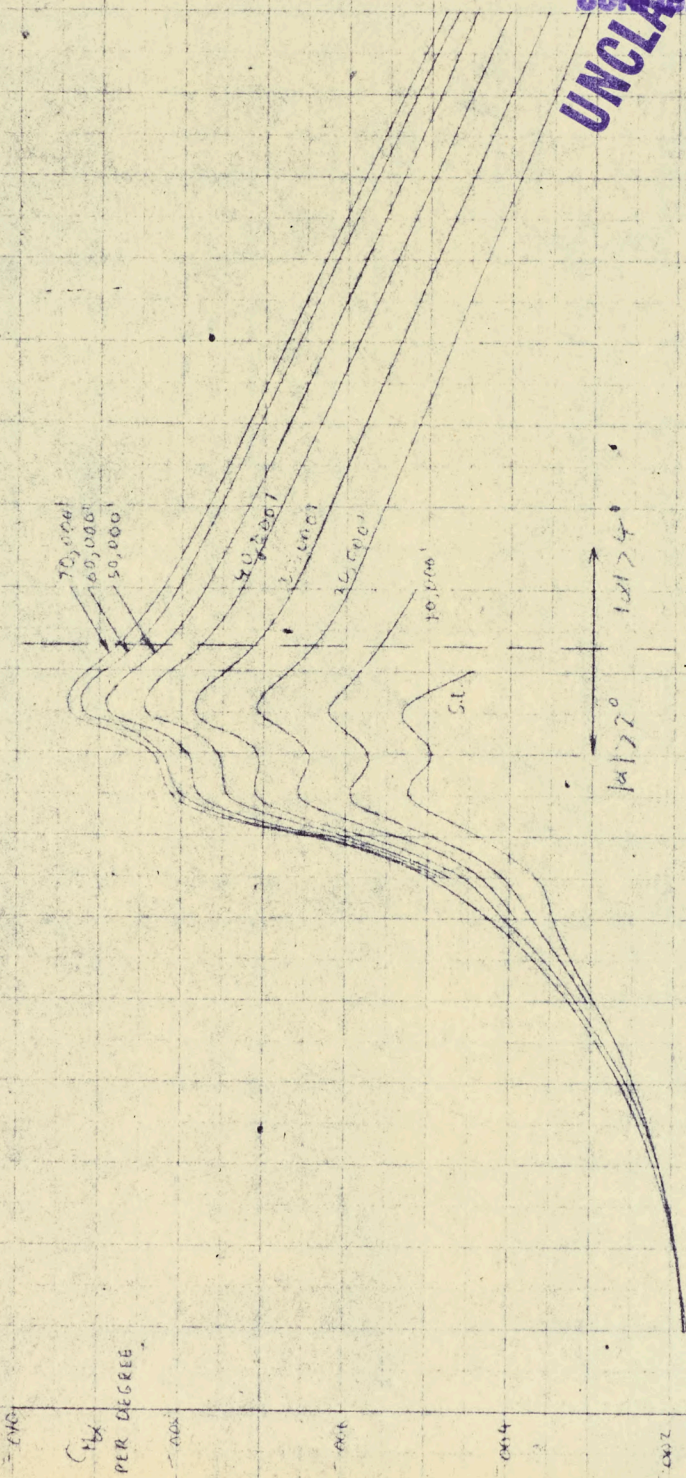
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1000 TO THE 1 INCH 359.12

18/11 23 56

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S-105 ELASTIC PK
C_{max}
c.g. @ 31% A.M.C.

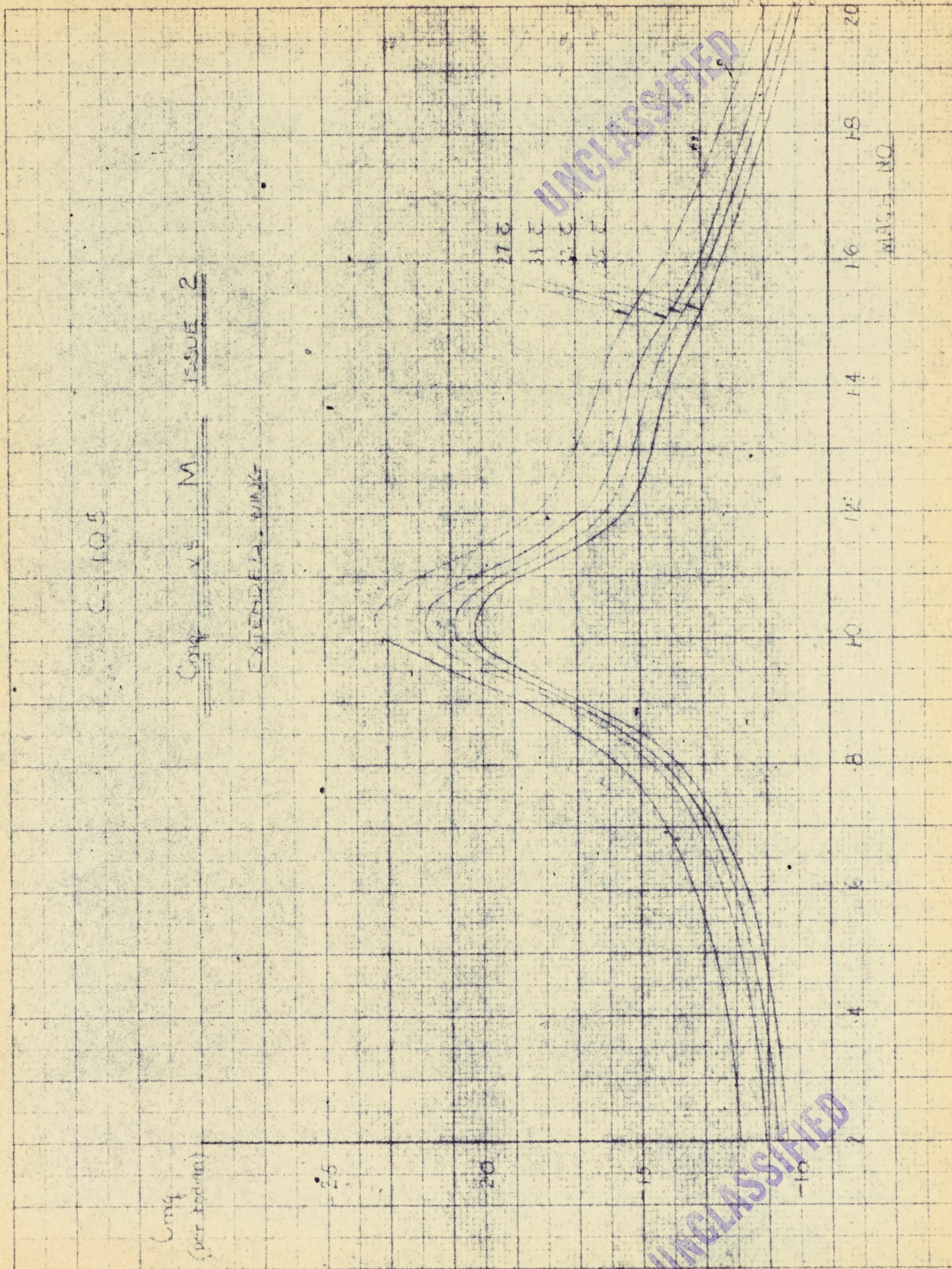


MACH NO
6 8 10 12 14 16 18 20

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10 X 10 TO THE INCH 359 12

APR 1976



C-105

ISSUE 2

M

x 4

Cmg

EXTENDED RANGE

C_{mg}
(per Rod/min)

MAGE NO

10X TO 10X TO THE INCH 350112

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8056018

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10-11 TO THE ENGINE 350-12

C-105

C_{Mx} vs MACH NUMBER
ISSUE 2

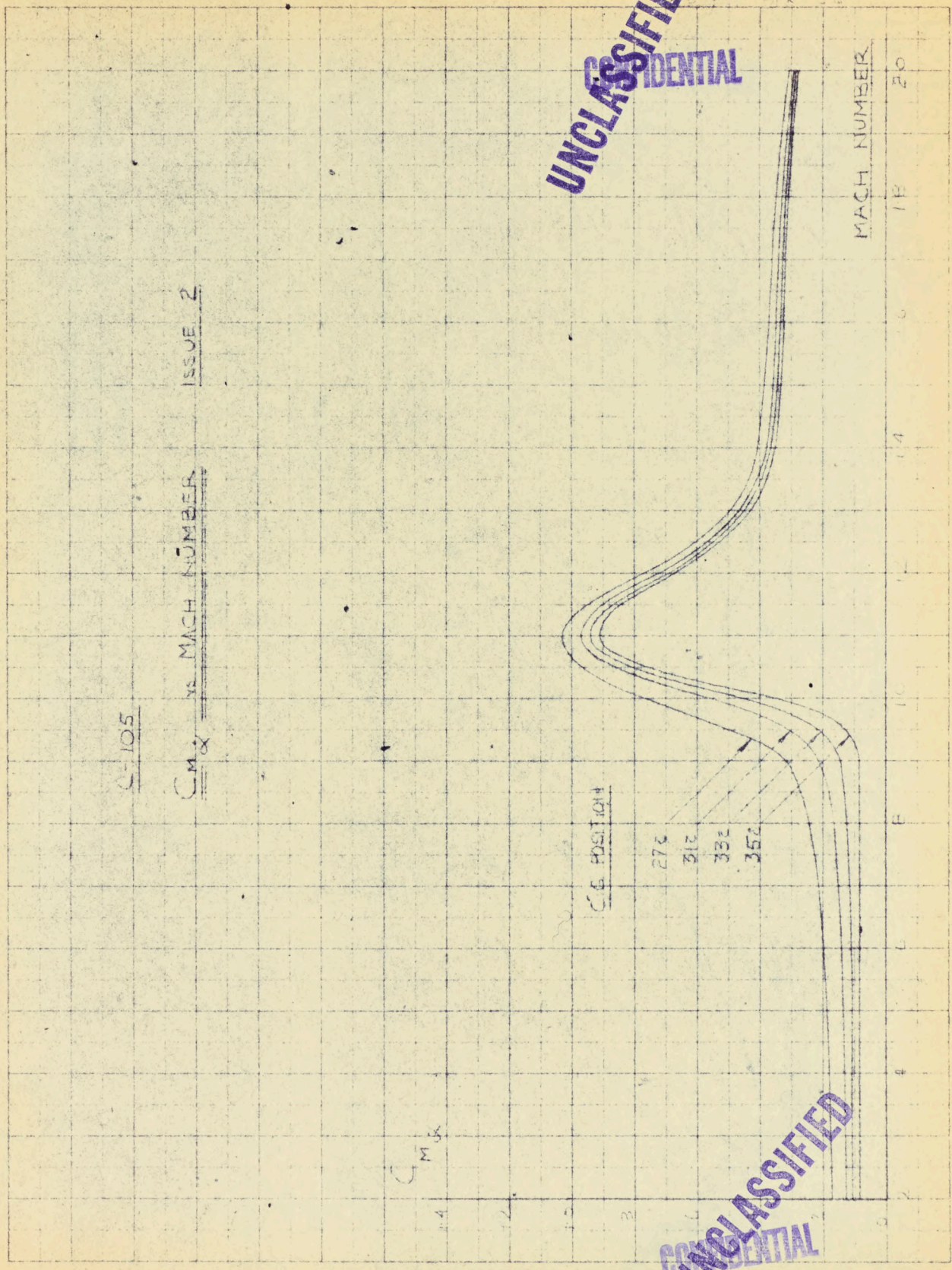
C_{Mx}
1.4
1.2
1.0
0.8

C_{LE} POSITION

276
312
331
352

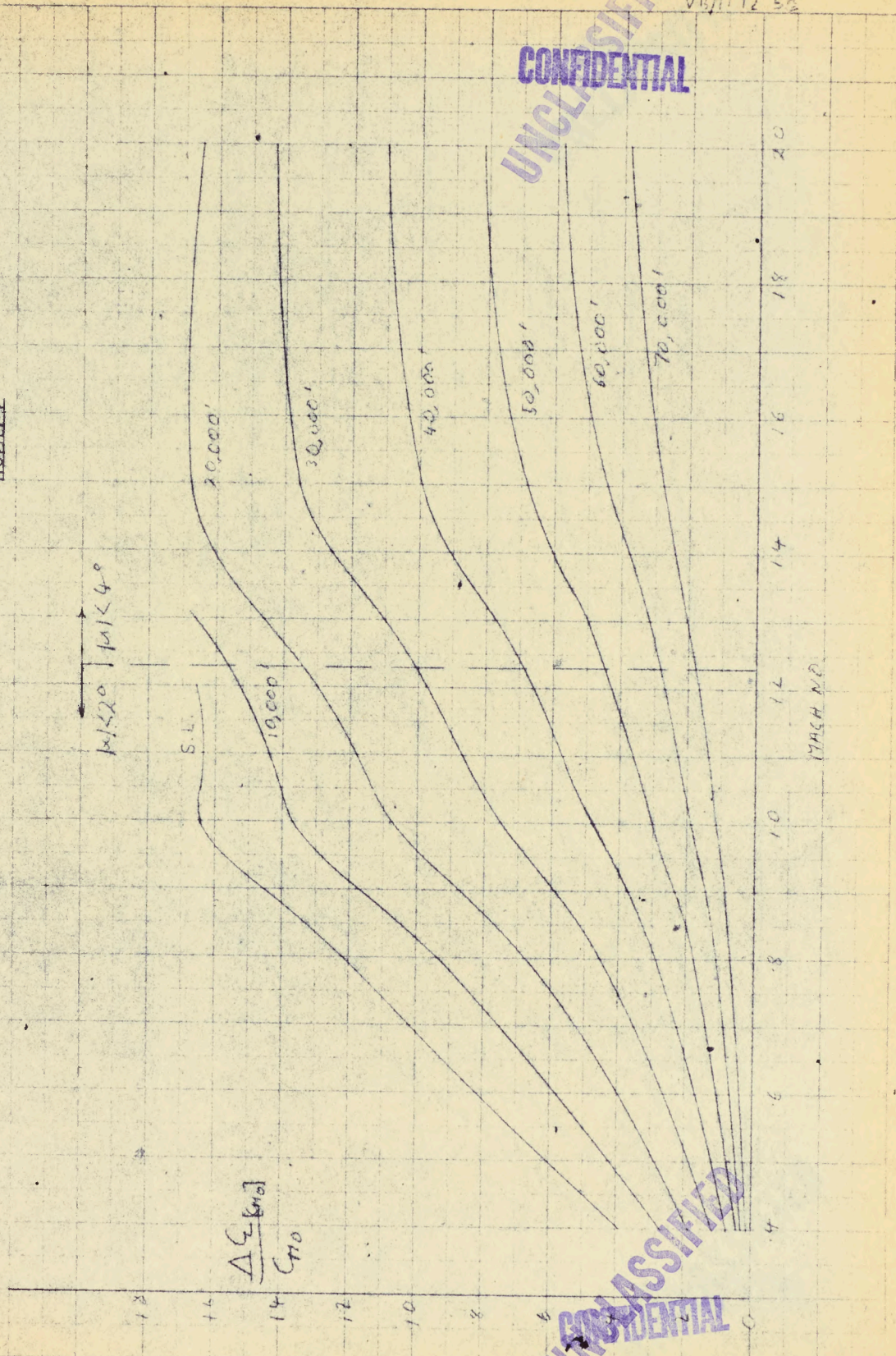
MACH NUMBER

0 2 4 6 8 10 12 14 16 18 20



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LIFT DUE TO APPLIED PITCHING
MOMENT

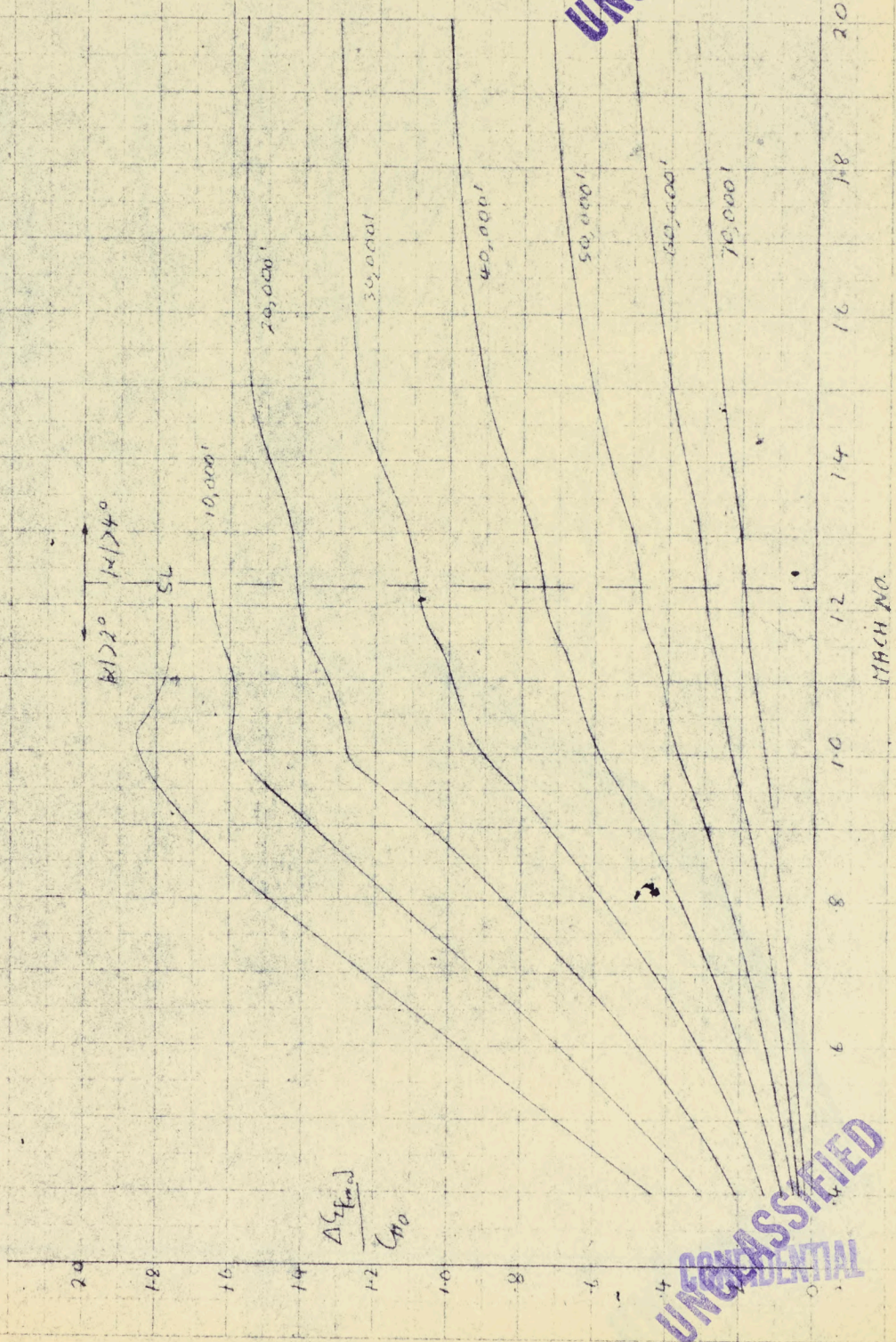


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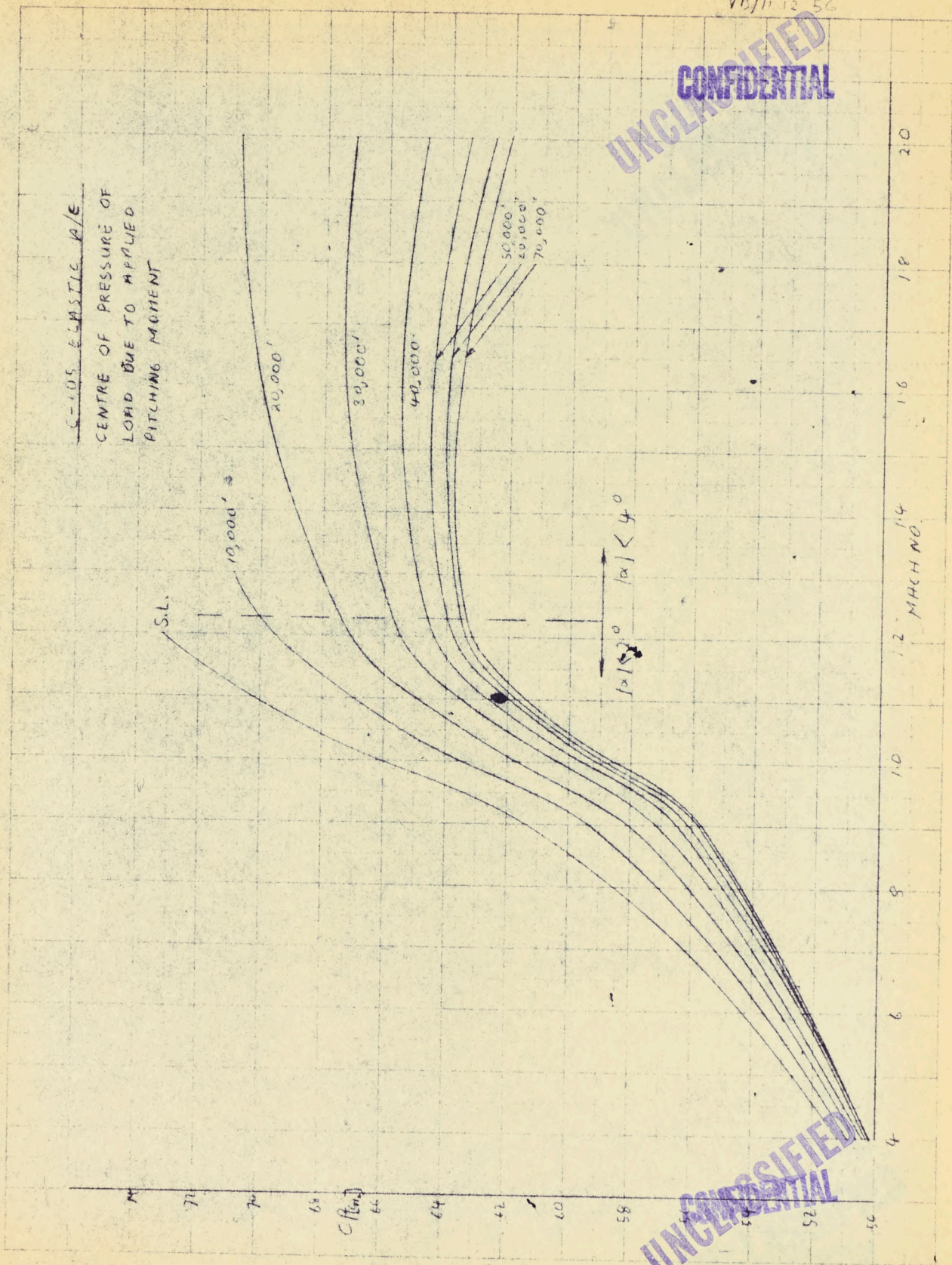
S-105 ELASTIC AIRCRAFT
LIFT DUE TO HAPPIER PITCHING MOMENT



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S-105 ELASTIC P/ϵ
CENTRE OF PRESSURE OF
LOAD DUE TO APPLIED
PITCHING MOMENT

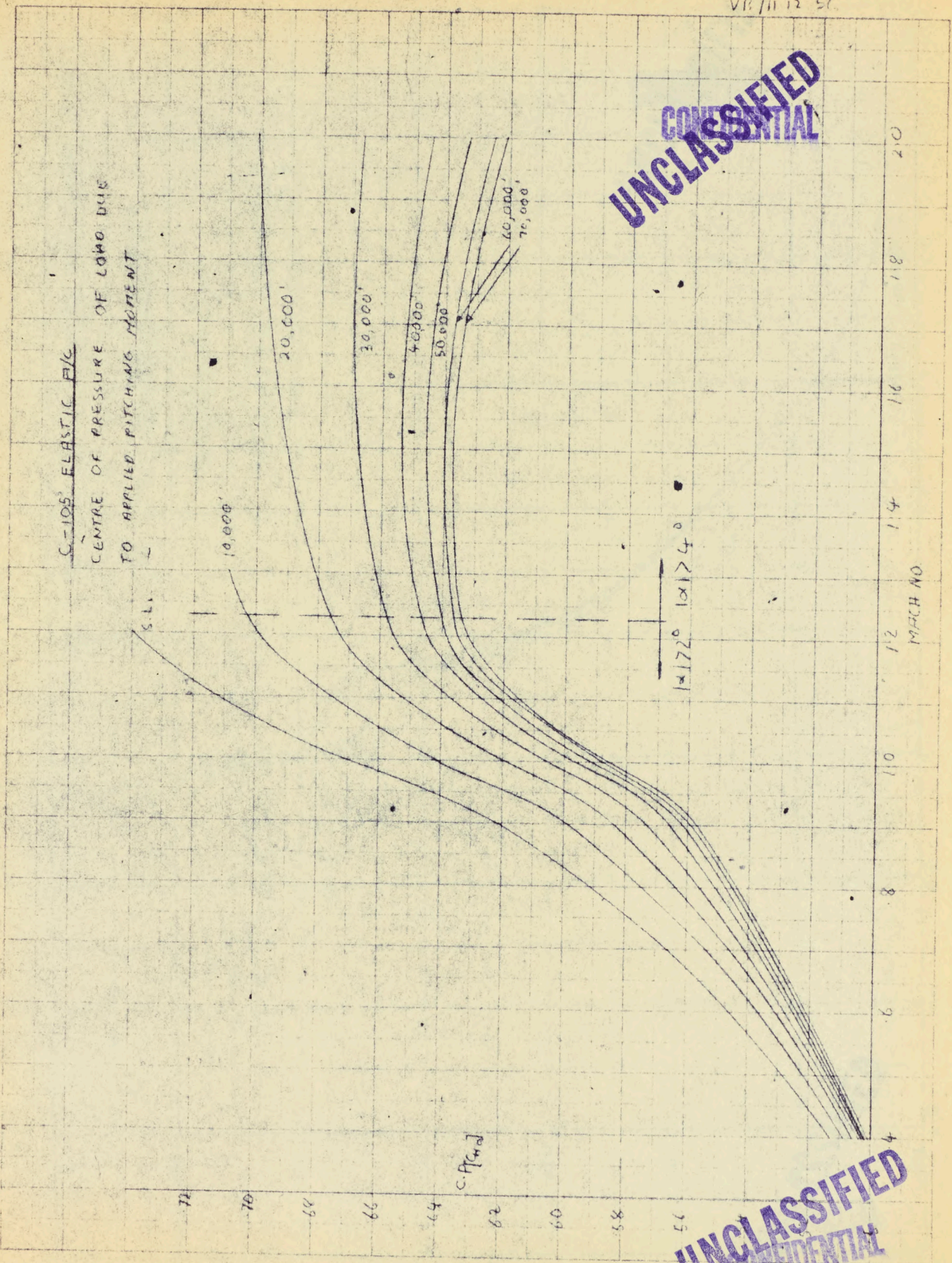


10 X 60 TITANUM N.M. 250 12

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C_{105} ELASTIC P/C
CENTRE OF PRESSURE OF LOW DUE
TO APPLIED PITCHING MOMENT



10 X 10 TO THE 13 N-14 359/12

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C-105 03 SCALE CAL & LANGLEY WIND TUNNEL TESTS

$C_{L_{de}}$ vs MACH NUMBER

B_{11}, V, W, E, N, D, S

-10° < α < 0° FOR $M > 1.3$

-5° < α < 10° FOR $M < 1.3$

$C_{L_{de}}$ (per degree)

0.14

0.12

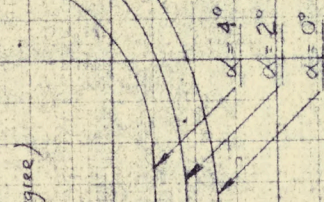
0.10

0.08

0.06

0.04

0.02



MACH NUMBER

2.0

1.8

1.6

1.4

1.2

1.0

0.8

0.6

0.4

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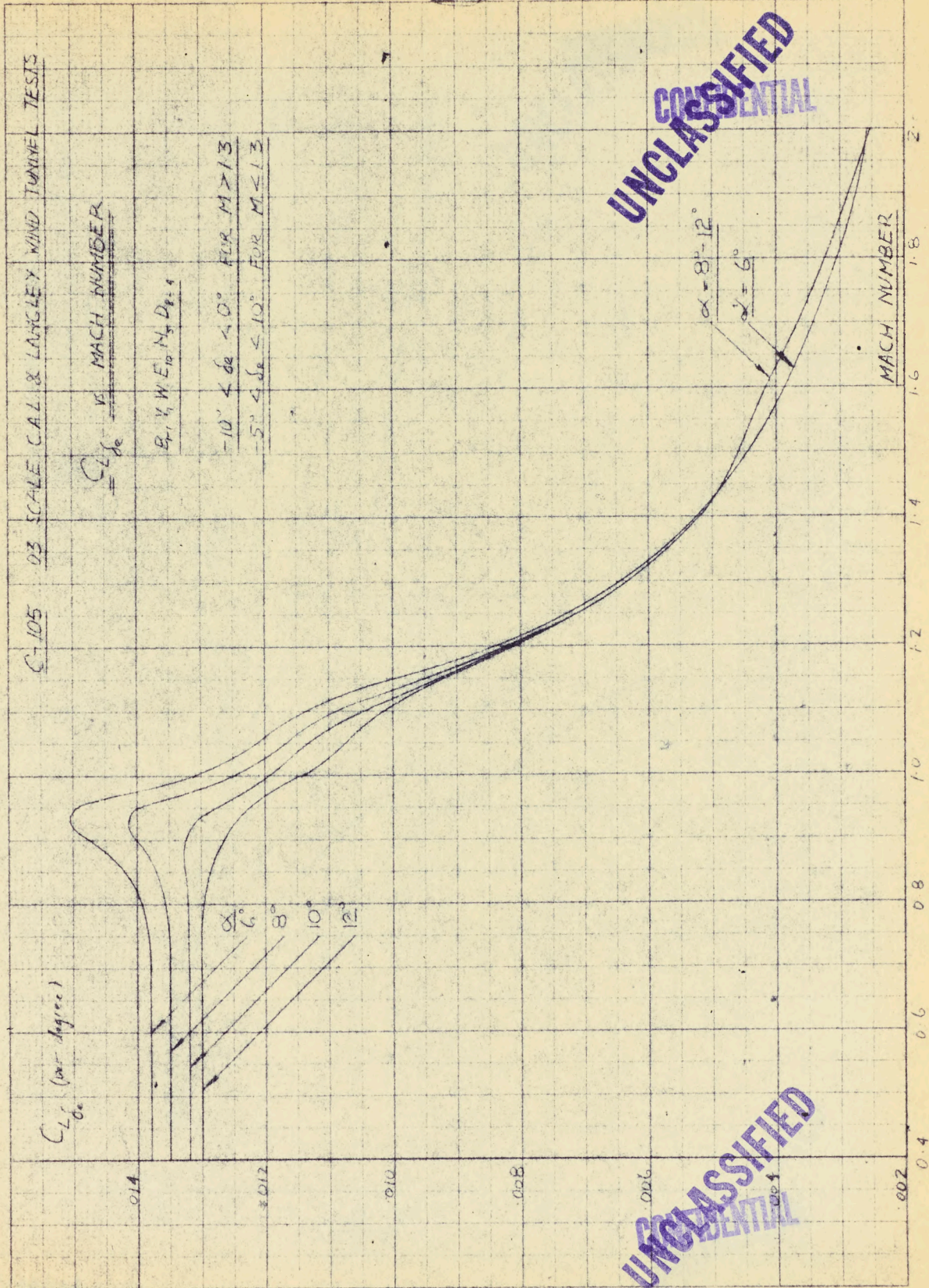
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20 X 20 PER INCH



C-105 03 SCALE CAL & LANGLEY WIND TUNNEL TESTS

$C_{L\alpha}$ vs MACH NUMBER

$R_1, V, W, E_0, M_T, D_{e,0}$

$-10^\circ < \alpha < 0^\circ$ FOR $M > 1.3$

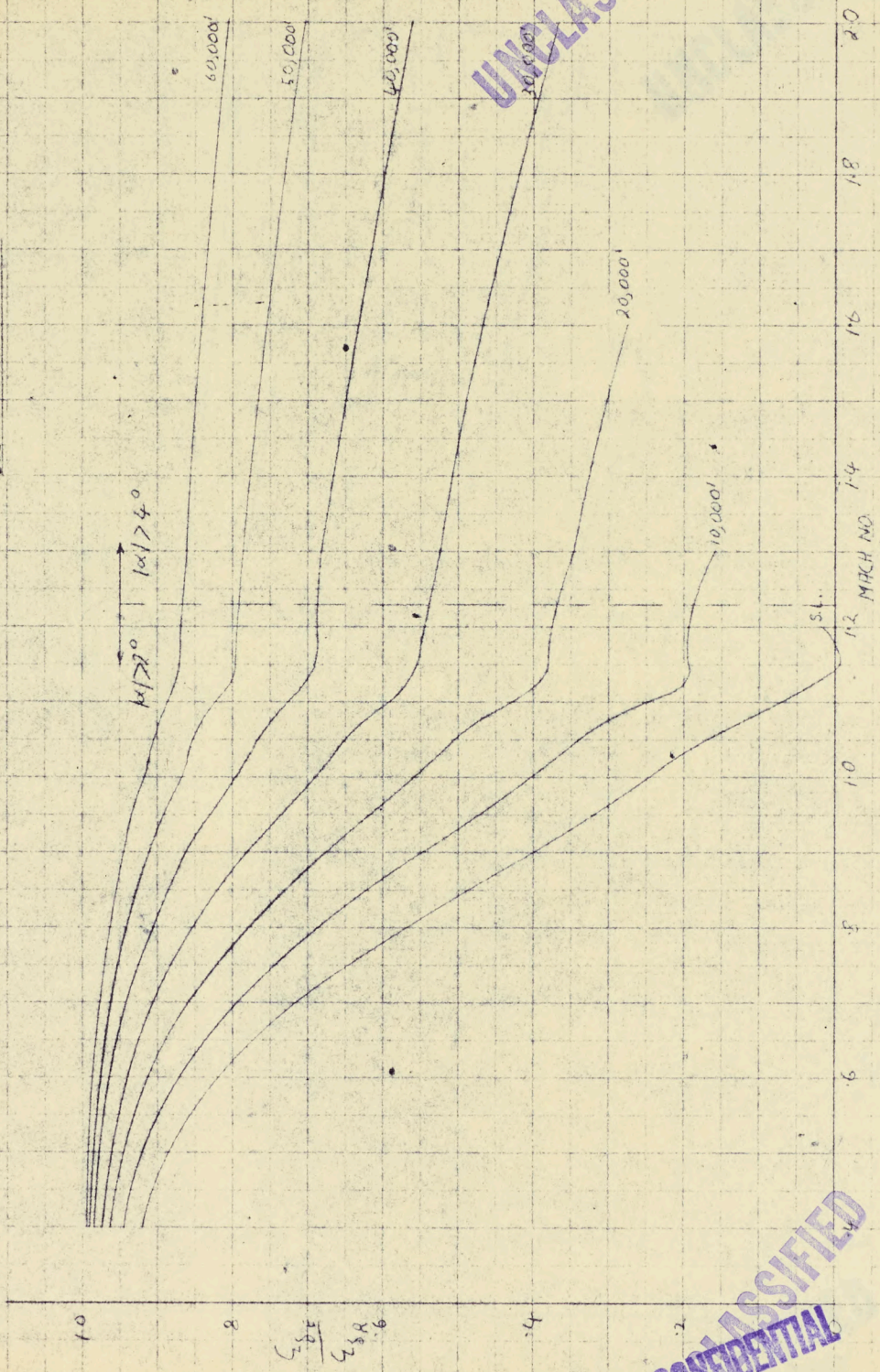
$-5^\circ < \alpha < 10^\circ$ FOR $M < 1.3$

$C_{L\alpha}$ (per degree)

MACH NUMBER

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C-105 ELASTIC AIRCRAFT
EFFECT OF ELASTICS ON LIFT DUE TO
ELEVATOR DEFLECTION



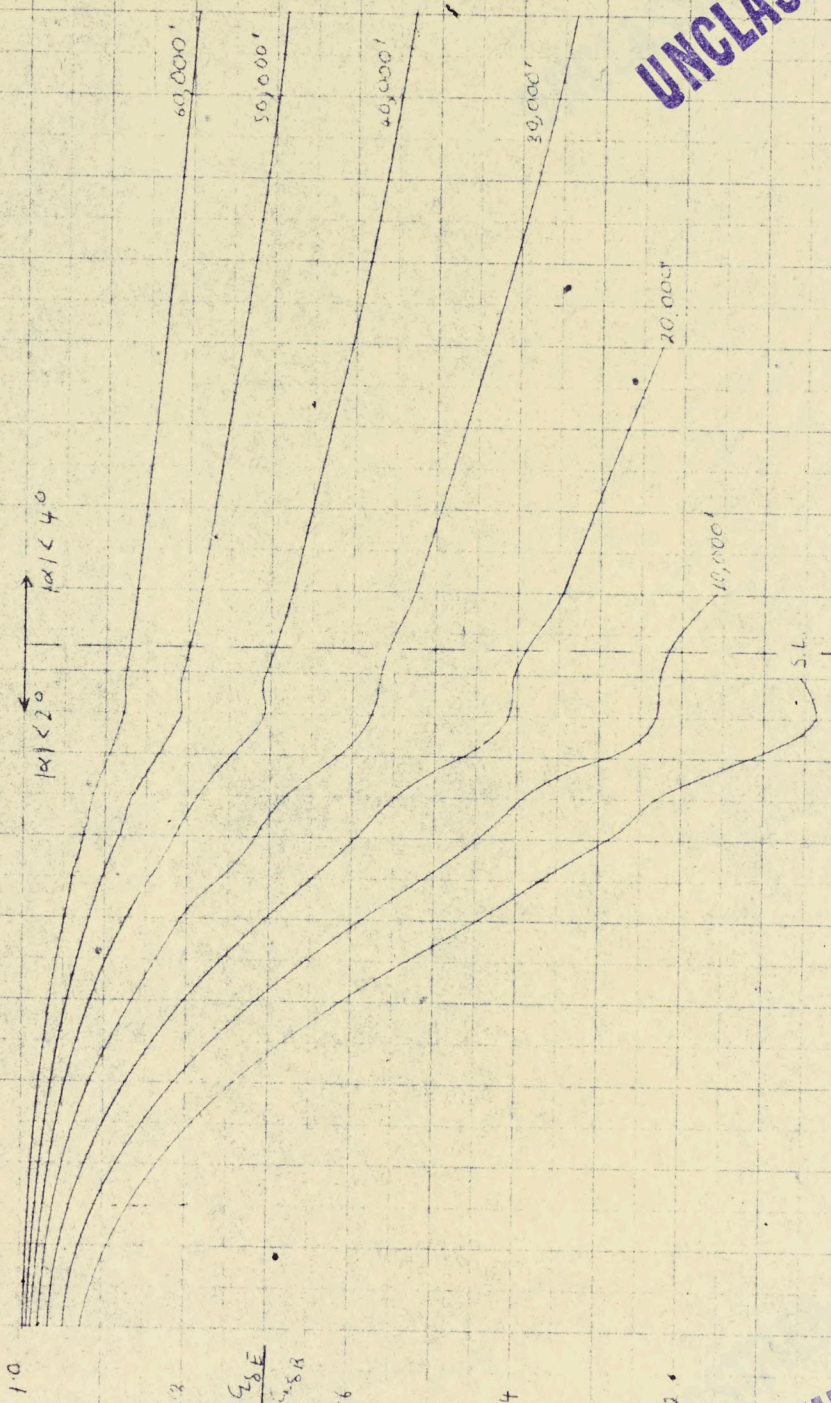
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SCALE 1/8" TO THE 1/4" INCH 359.12

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C-105 ELASTIC PIC
EFFECT OF ELASTIC DEFORMATION LIFT DUE TO ELEVATOR DEFLECTION



4 6 8 10 12 MACH NO. 14 16 18 20

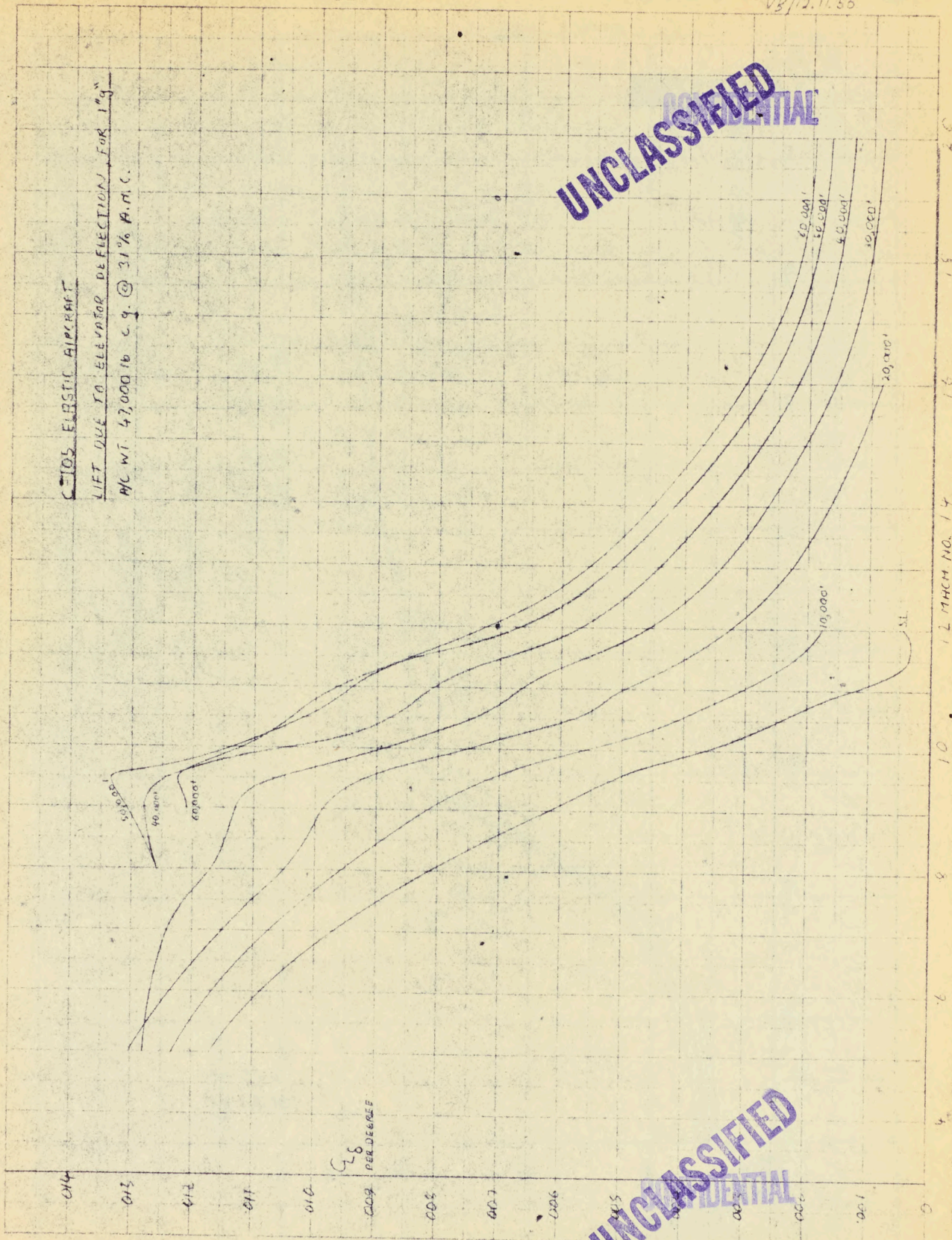
10 X 10 TO THE 10 INCH 35912

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C-105 ELASTIC AIRCRAFT

LIFT DUE TO ELEVATOR DEFLECTION FOR 1"q

M/C WT. 47,000 lb c.g. @ 31% P.M.C.



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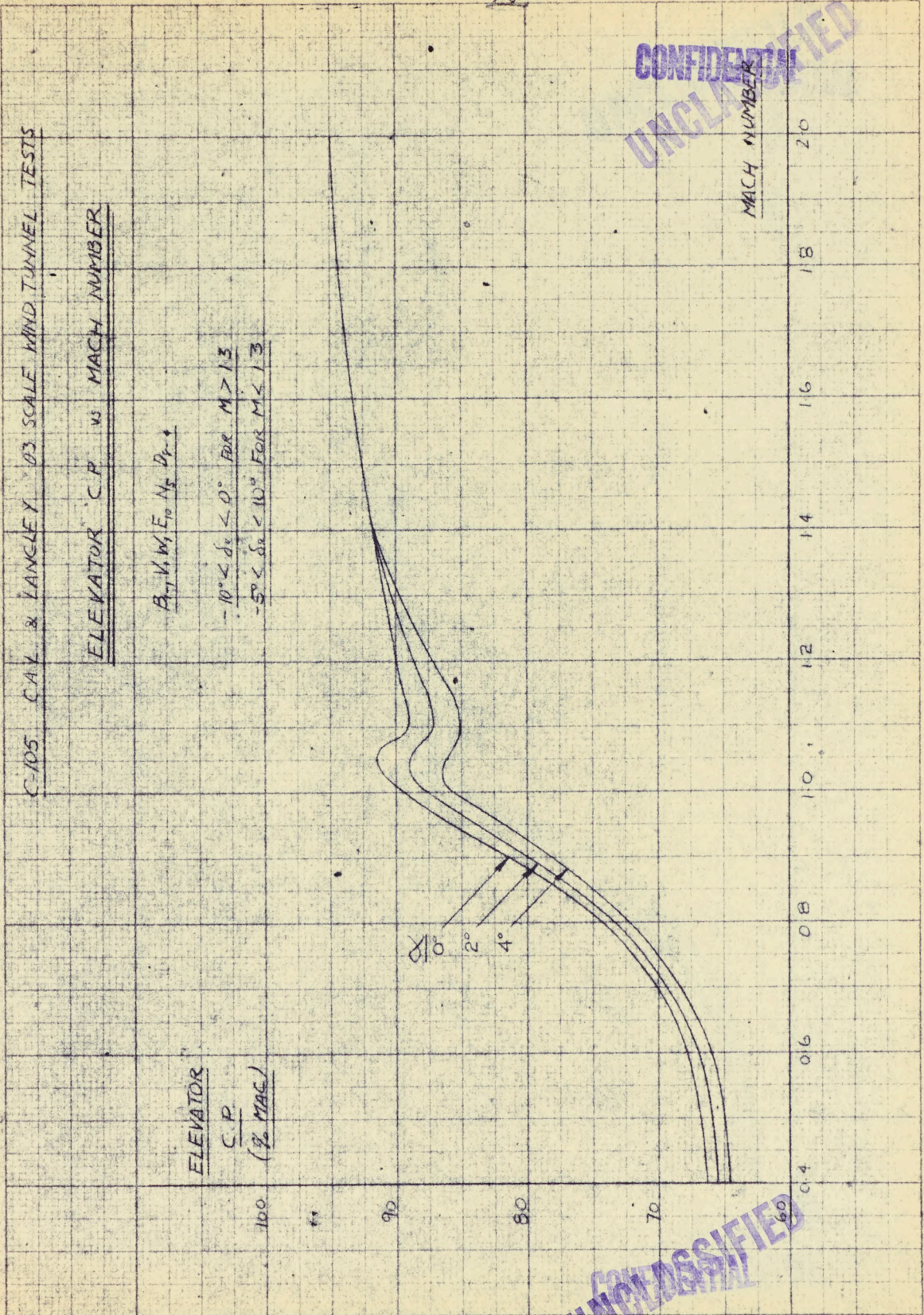
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10X TO THE 1/2 INCH 359-12

P/STAB/123

12 MACH NO. 14

RPG 5 NOV 52



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C-105 03 SCALE CAL & LANGLEY WIND TUNNEL TESTS

ELEVATOR C.P. v. MACH NUMBER

B_{12} M E_{12} N_{12} D_{12}
 $-10^\circ < \delta < 0^\circ$ FOR $M > 1.3$
 $-5^\circ < \delta < 10^\circ$ FOR $M < 1.3$

ELEVATOR
 C.P.
 (% MAC)

100

90

80

70

$\alpha = 6^\circ$

$\alpha = 8^\circ - 12^\circ$

α 6° 8° 10° 12°

MACH NUMBER

2.0

1.8

1.6

1.4

1.2

1.0

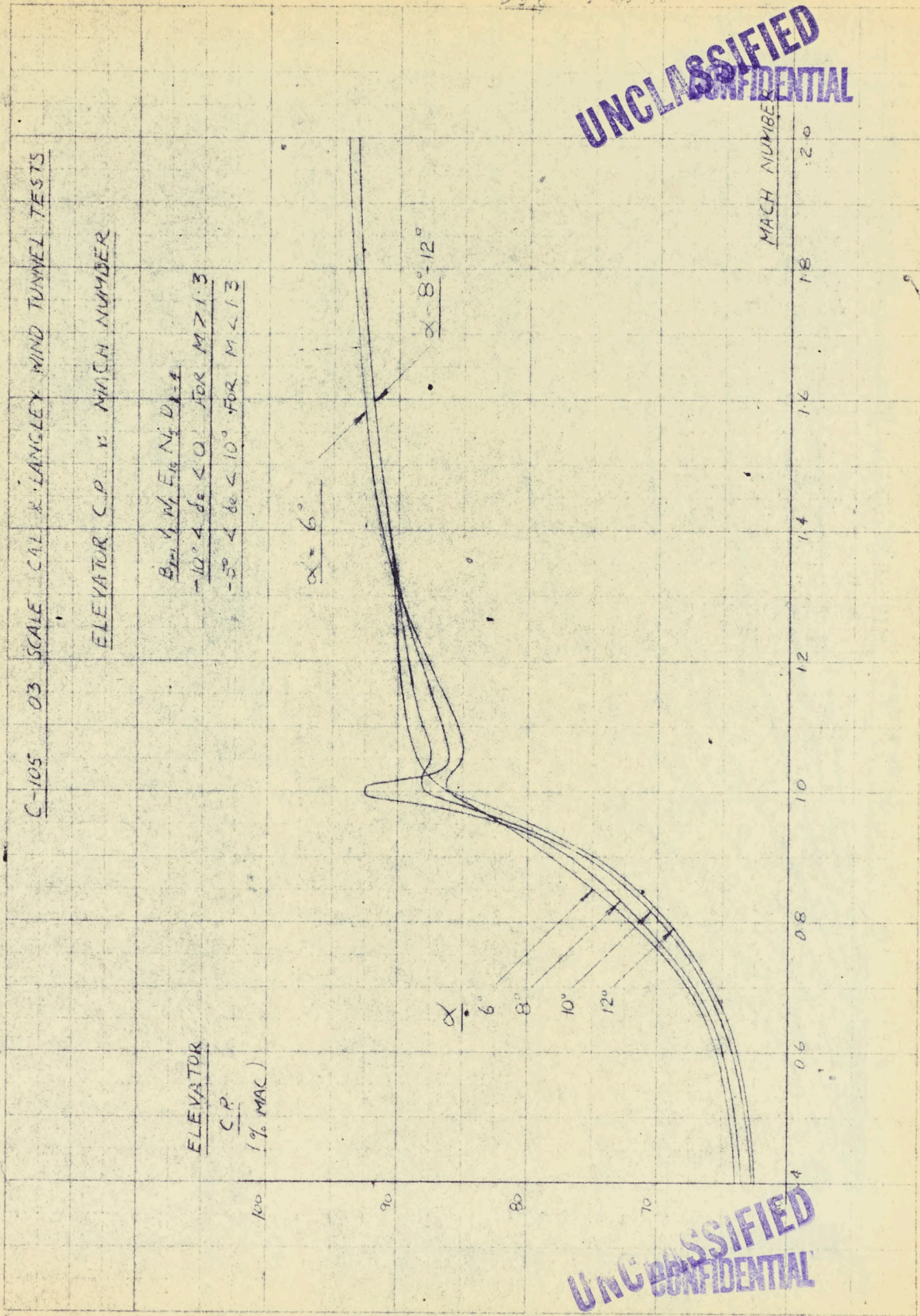
0.8

0.6

0.4

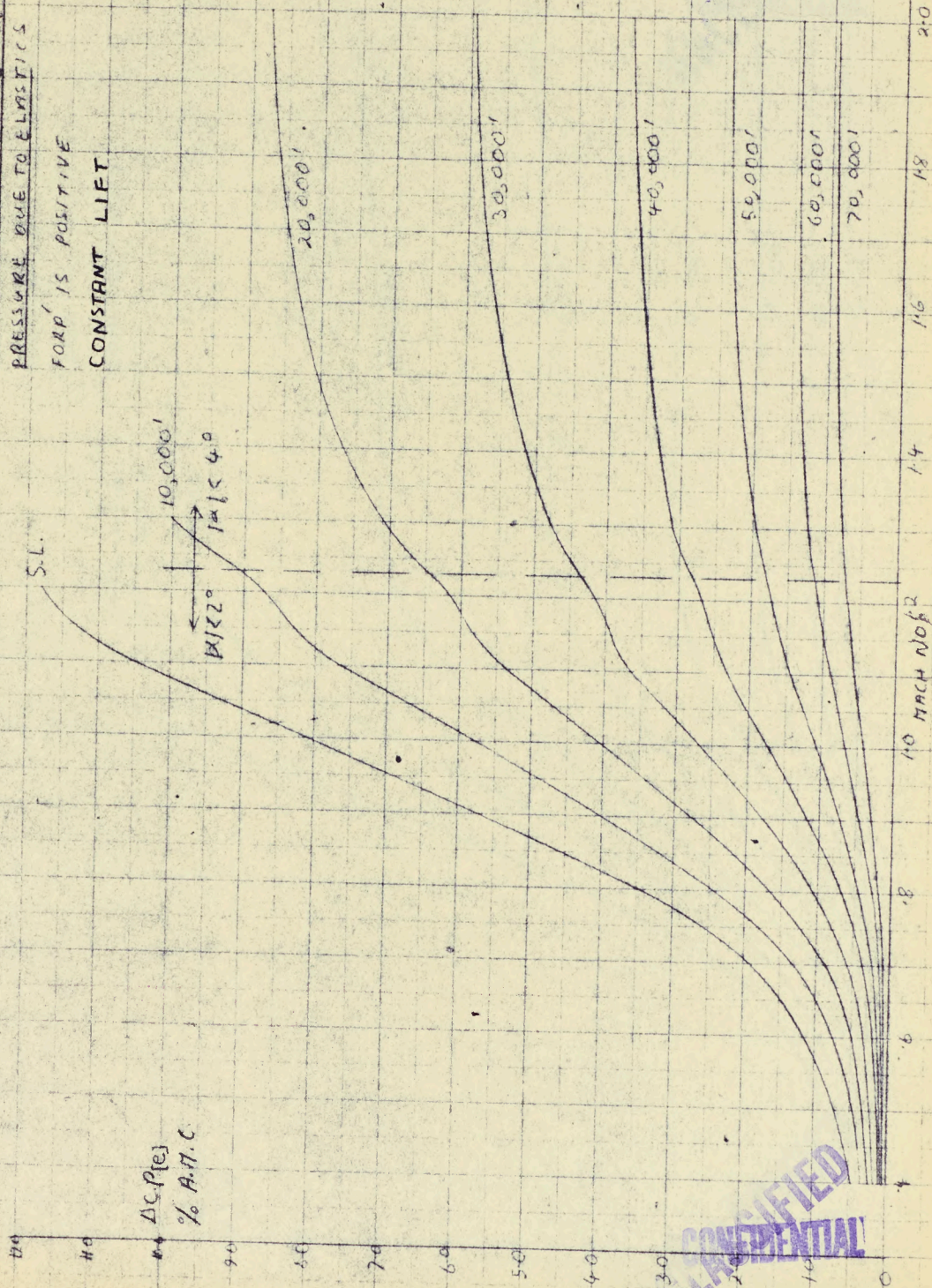
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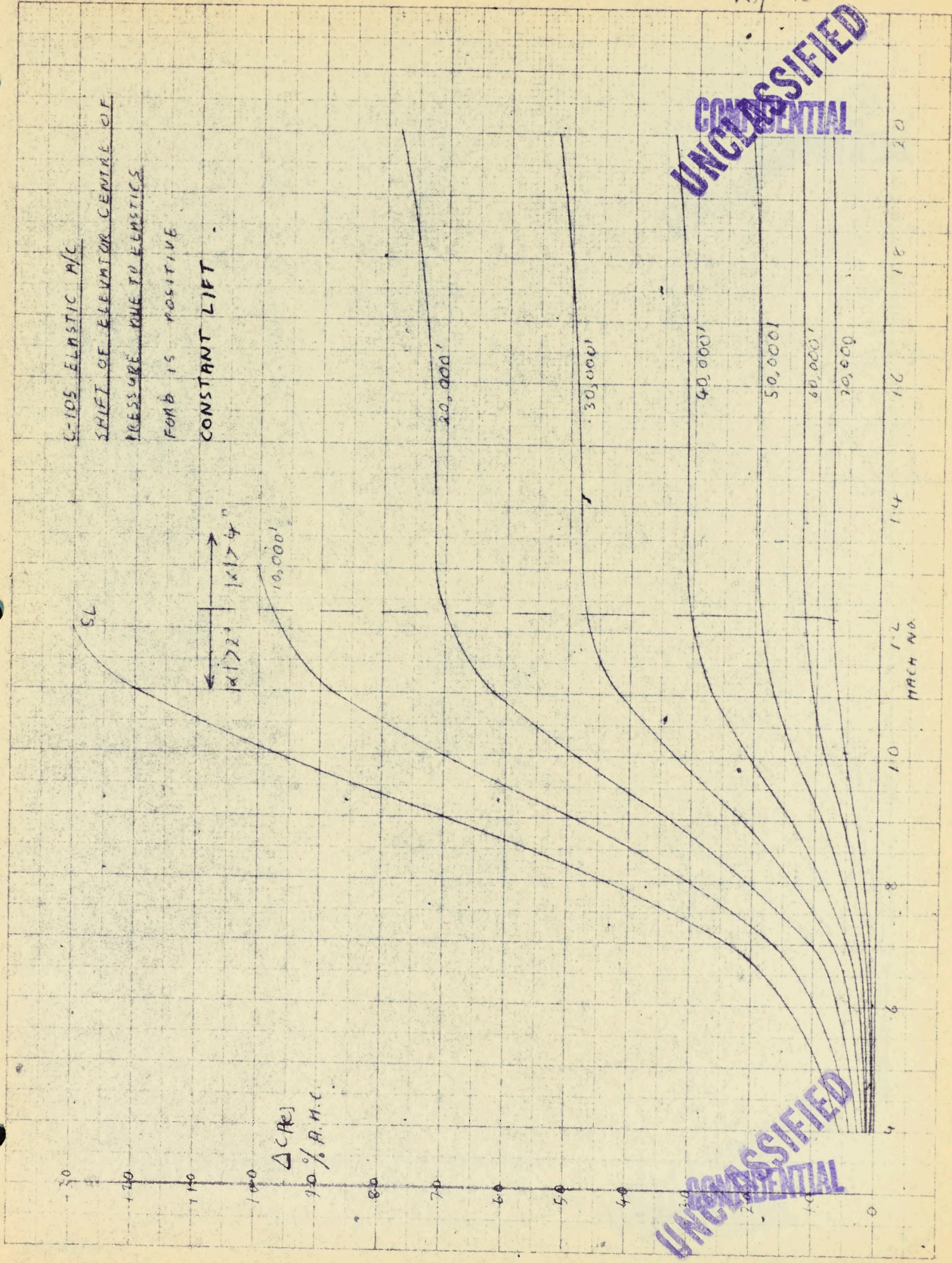


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C-105 ELASTIC ΔC
SHIFT OF ELEVATOR CENTER OF
PRESSURE DUE TO ELASTICS
FOR δ IS POSITIVE
CONSTANT LIFT

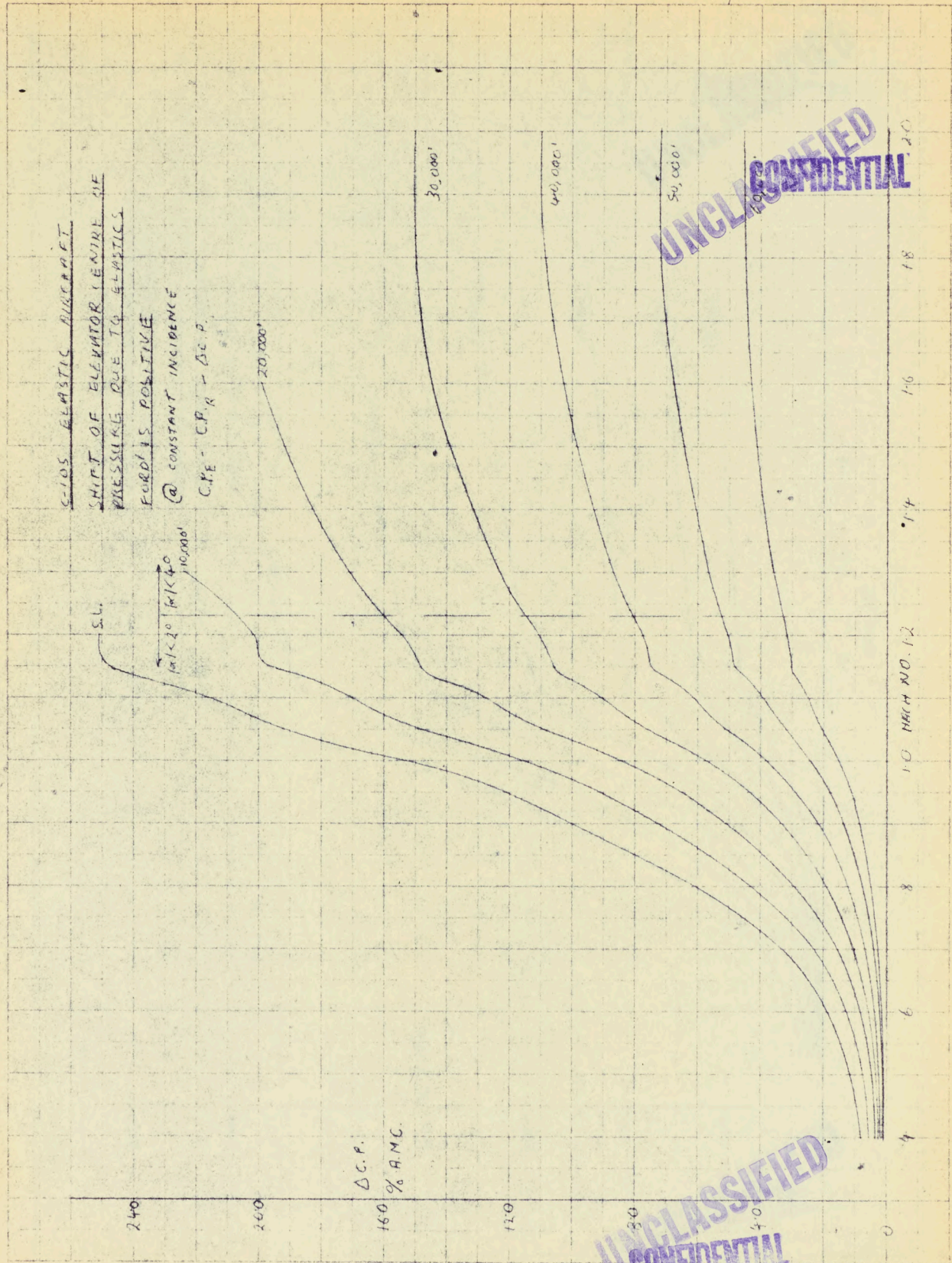


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NO. 10 TO THE INCH 310-12

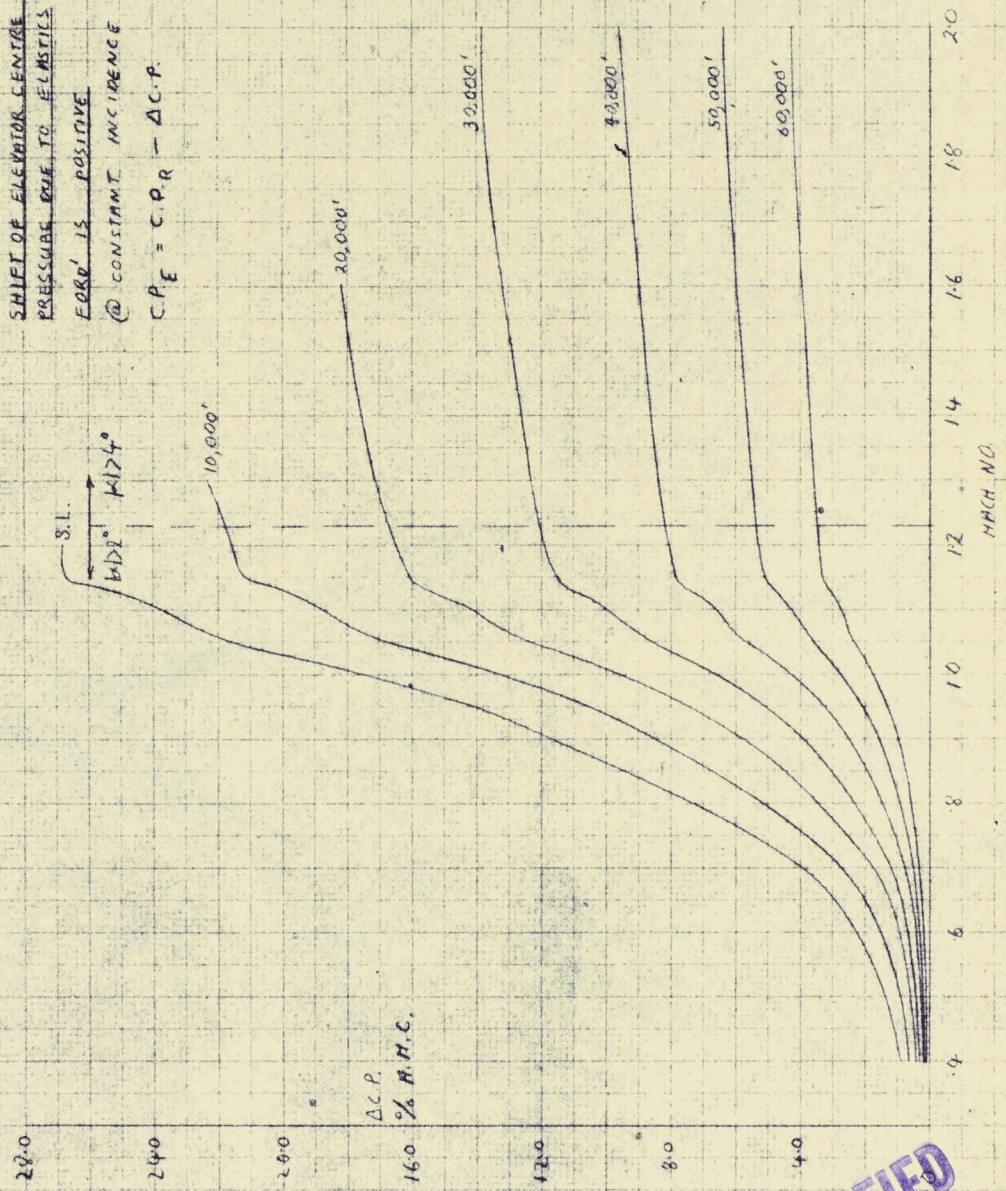
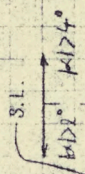
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C-105 ELASTIC AIRCRAFT
SHIFT OF ELEVATOR CENTRE OF
PRESSURE DUE TO ELASTICS
EORD' IS POSITIVE
@ CONSTANT INCIDENCE
C.P.E = C.P.R - ΔC.P.

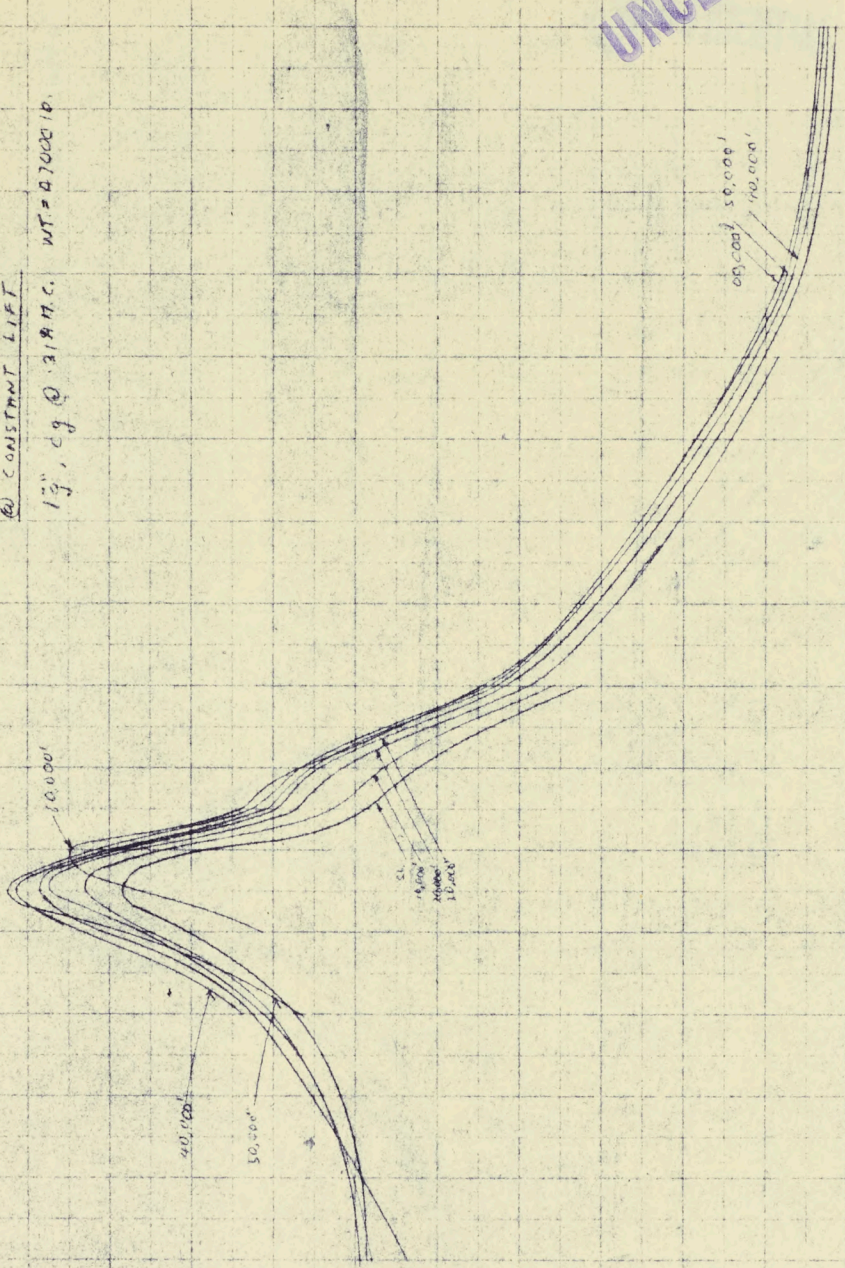


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12/17/56

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S-105 ELASTIC AIRCRAFT
PITCHING MOMENT DUE TO ELEVATOR DEFLECTION
(a) CONSTANT LIFT
13" CG @ 318 MC. WT = 47000 LB.



20
18
16
14
12 MACH NO. 14
10
8
6
4

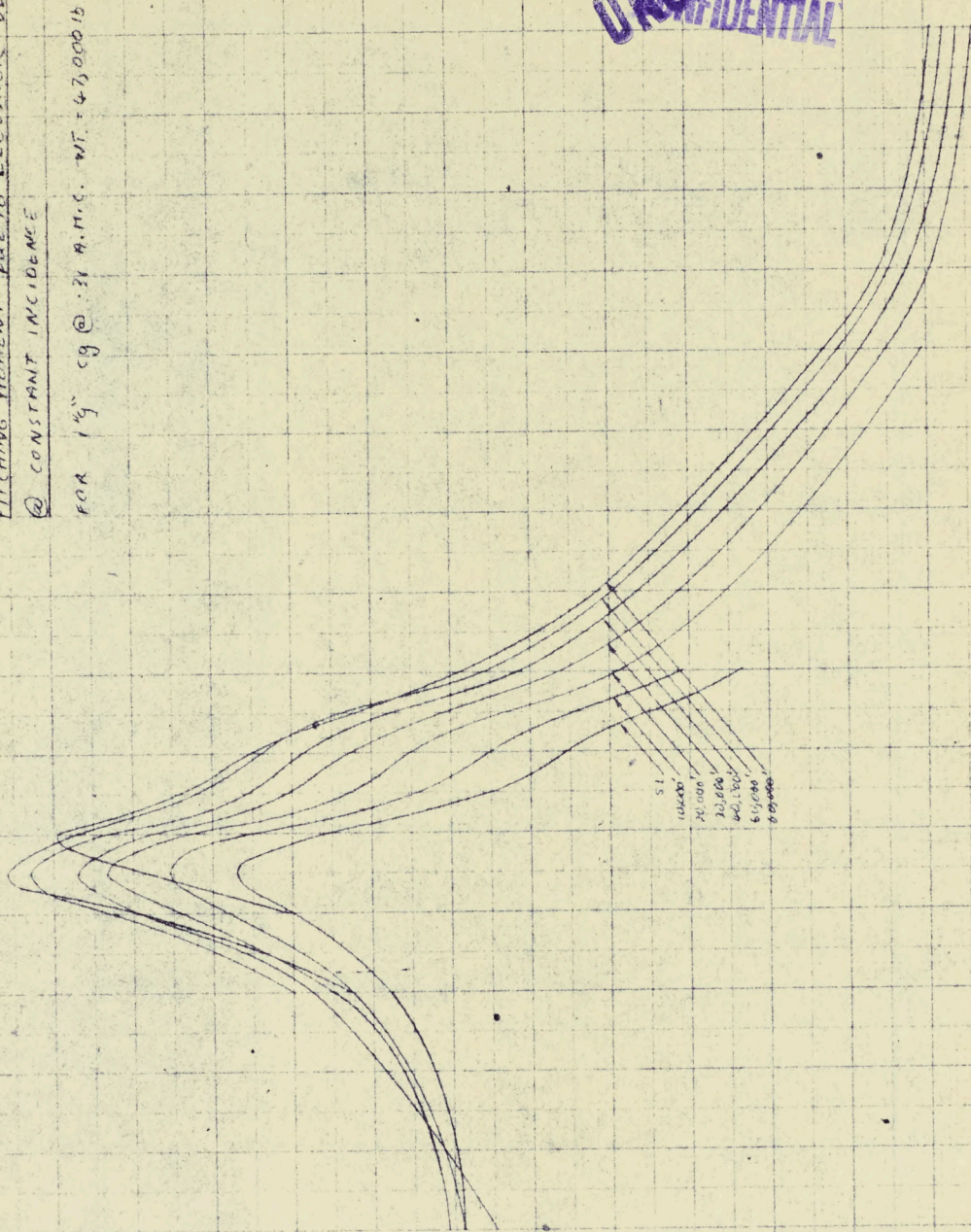
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A-13 P.O. BOX 3048 CO. 19113

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VR/12 14.56.

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C-105 ELASTIC AIRCRAFT
PITCHING MOMENT PUE TO ELEVATOR DEFLECTION
@ CONSTANT INCIDENCE
FOR 1 1/2 DEG @ 31 A.M.C. WT = 43,000 LB



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SCALE 1/8" TO THE 1" INCH 355 12

-0.07

-0.06

-0.05 $C_m [-]$

-0.04

-0.03

-0.02

-0.01

20

18

16

14

12 MARCH NO. 14

10

8

6

4

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03 SCALE CAL. & LANGLEY WIND TUNNEL TESTS

C-105

$C_{he\alpha}$ vs. MACH NUMBER

B-1, V, M, E₁₀, N₅, D₄-4

$|\alpha| < 4^\circ$
 $\delta_e = 0^\circ$

ELEVATOR

$C_{he\alpha}$ (per degree)

MACH NUMBER

0.016

0.014

0.012

0.010

0.008

0.006

0.004

0.002

0

0.4

0.6

0.8

1.0

1.2

1.4

1.6

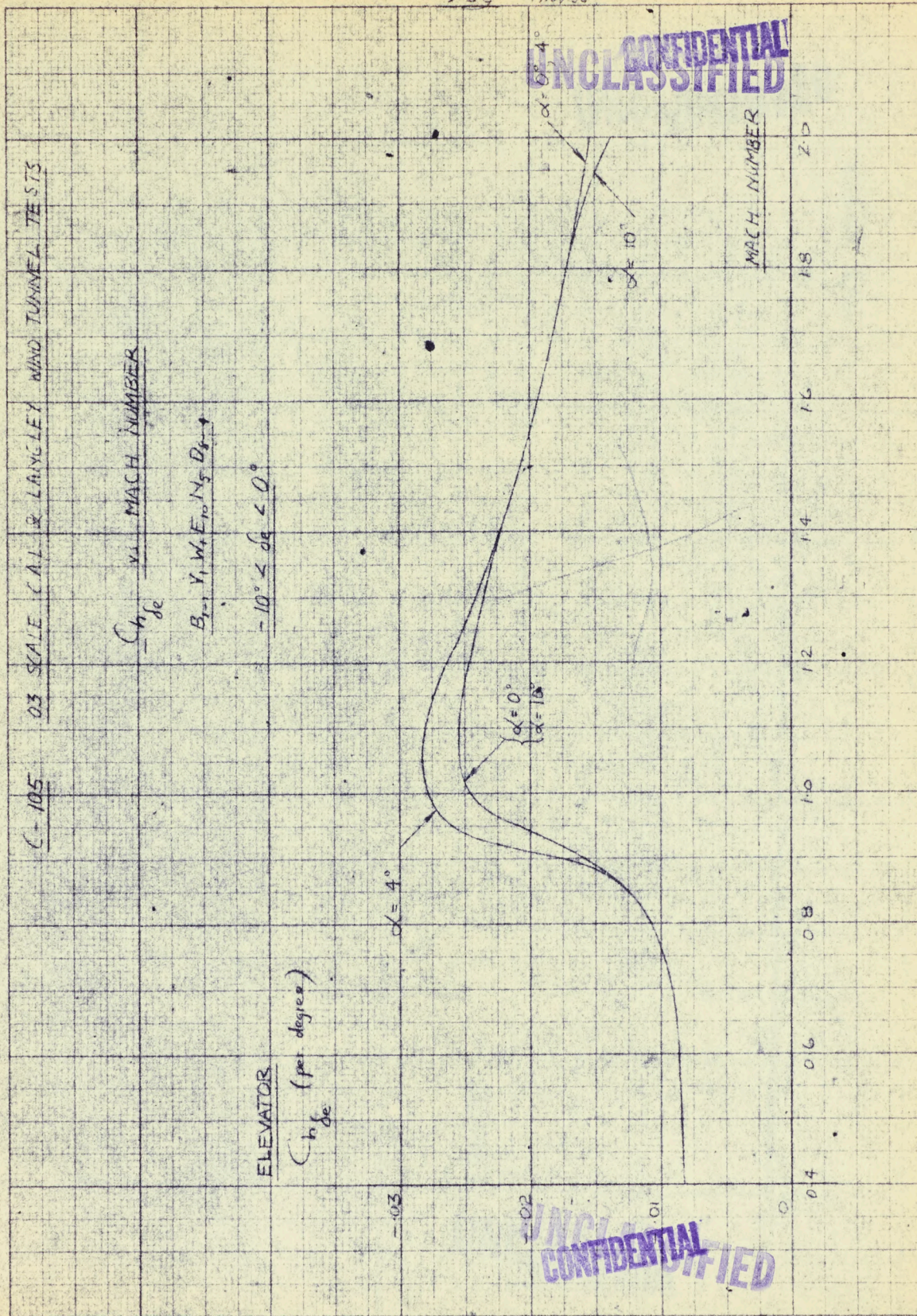
1.8

2.0

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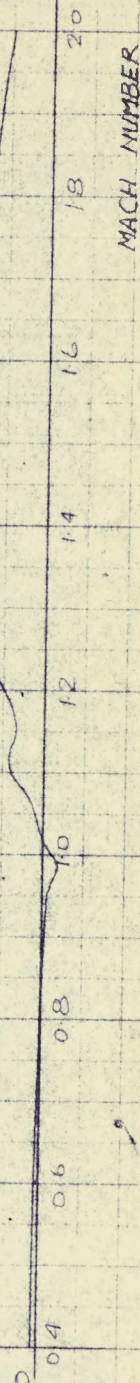
C-105 .03 SCALE CAL & LANGLEY WIND TUNNEL TESTS

ELEVATOR C_{h_0} VS MACH NUMBER

$B_{h_0} = \frac{V}{M} E_{h_0} N_2 D_{h_0}$

$(\alpha = 0^\circ, \delta_e = 0^\circ)$

ELEVATOR
 C_{h_0}



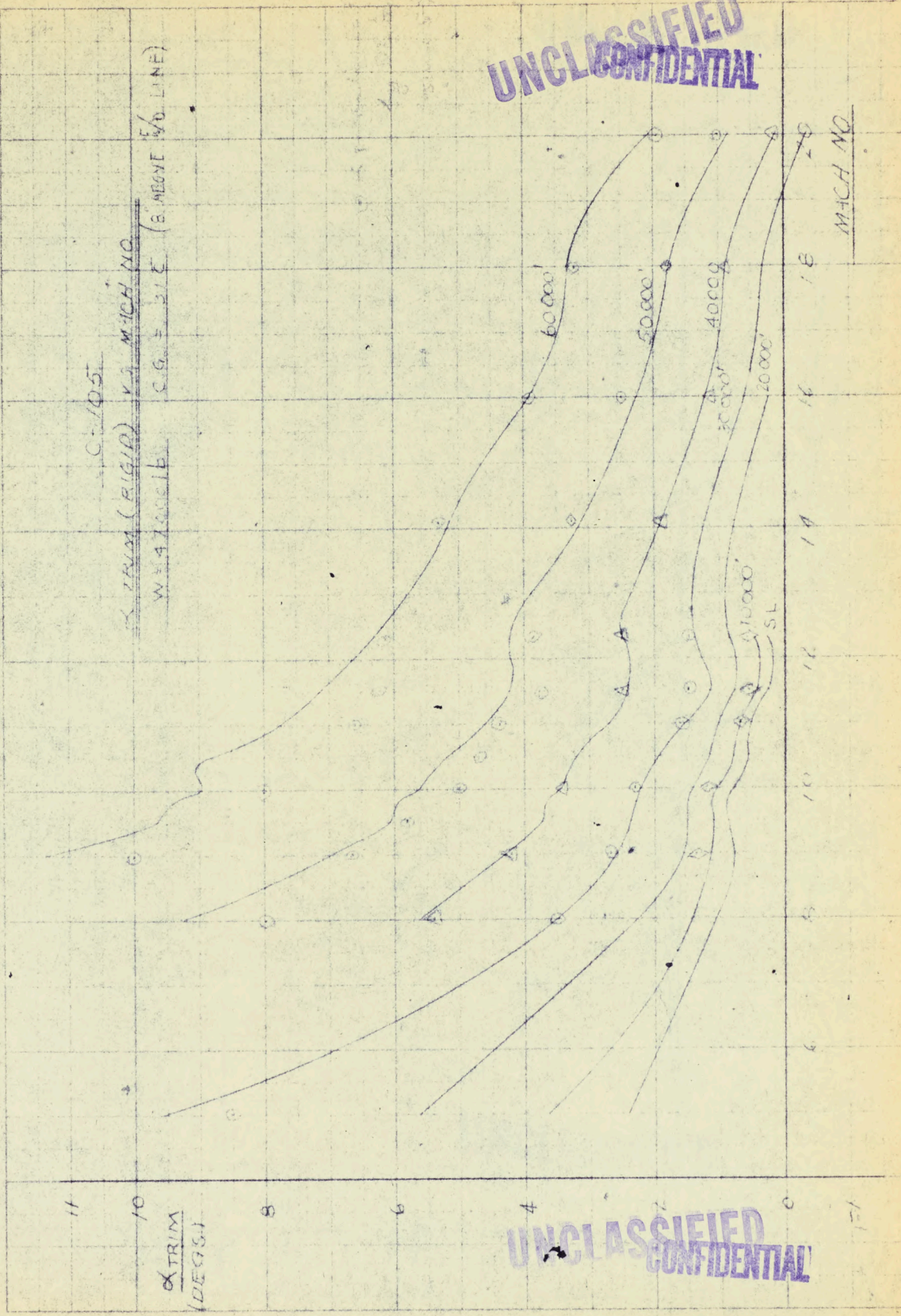
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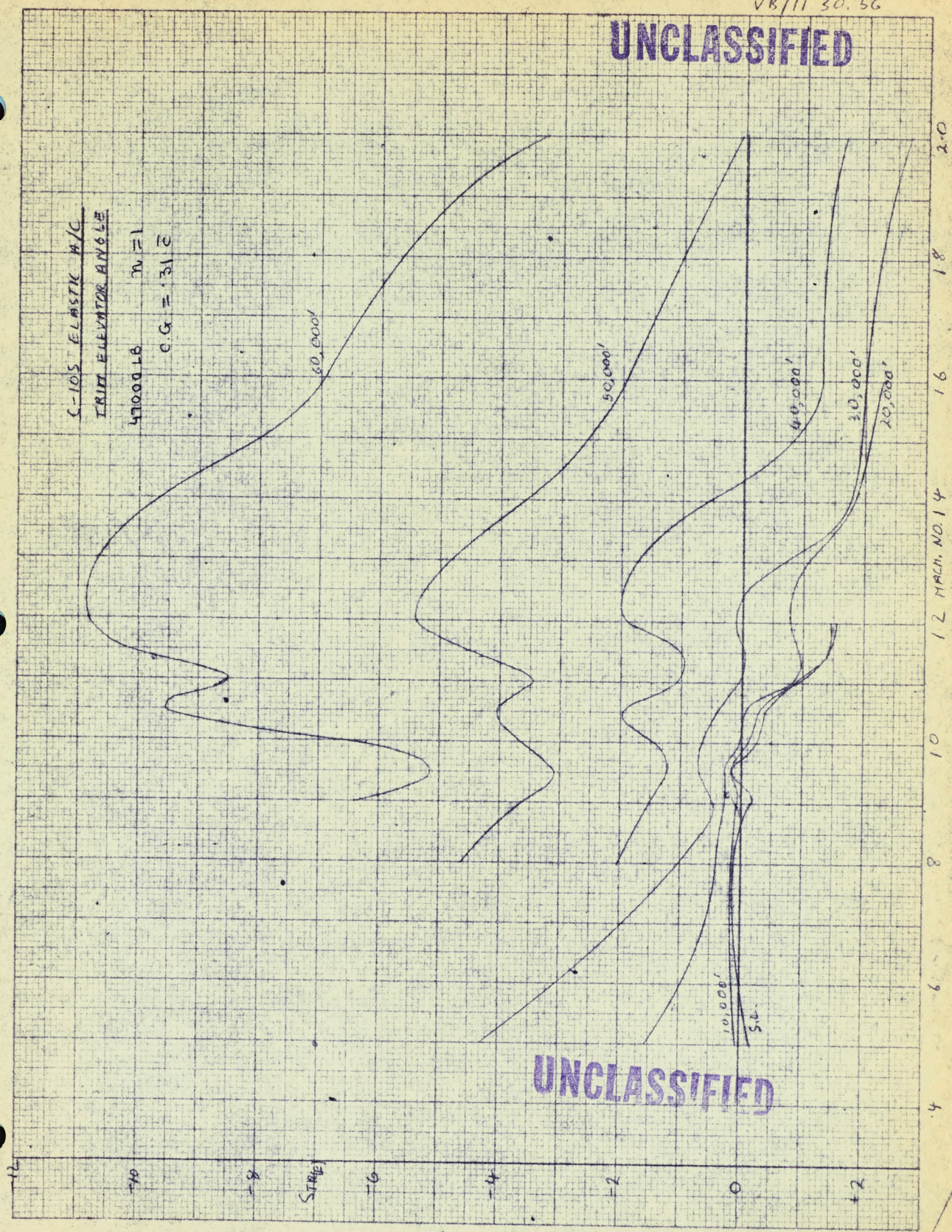
C-105
TRIM (RIGID) vs MACH NO
W = 47000 LB S.G. = 2.15 (B. MEANE W/O LINE)



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C-105 ELASTIC H/C
TRIM ELEVATOR ANGLE
47000 LB $\eta = 1$
C.G. = 131.2



UNCLASSIFIED

K&E 10 X TO THE 1/8 INCH 359-12
KEUFFEL & ESSER CO. MADE IN U.S.A.

