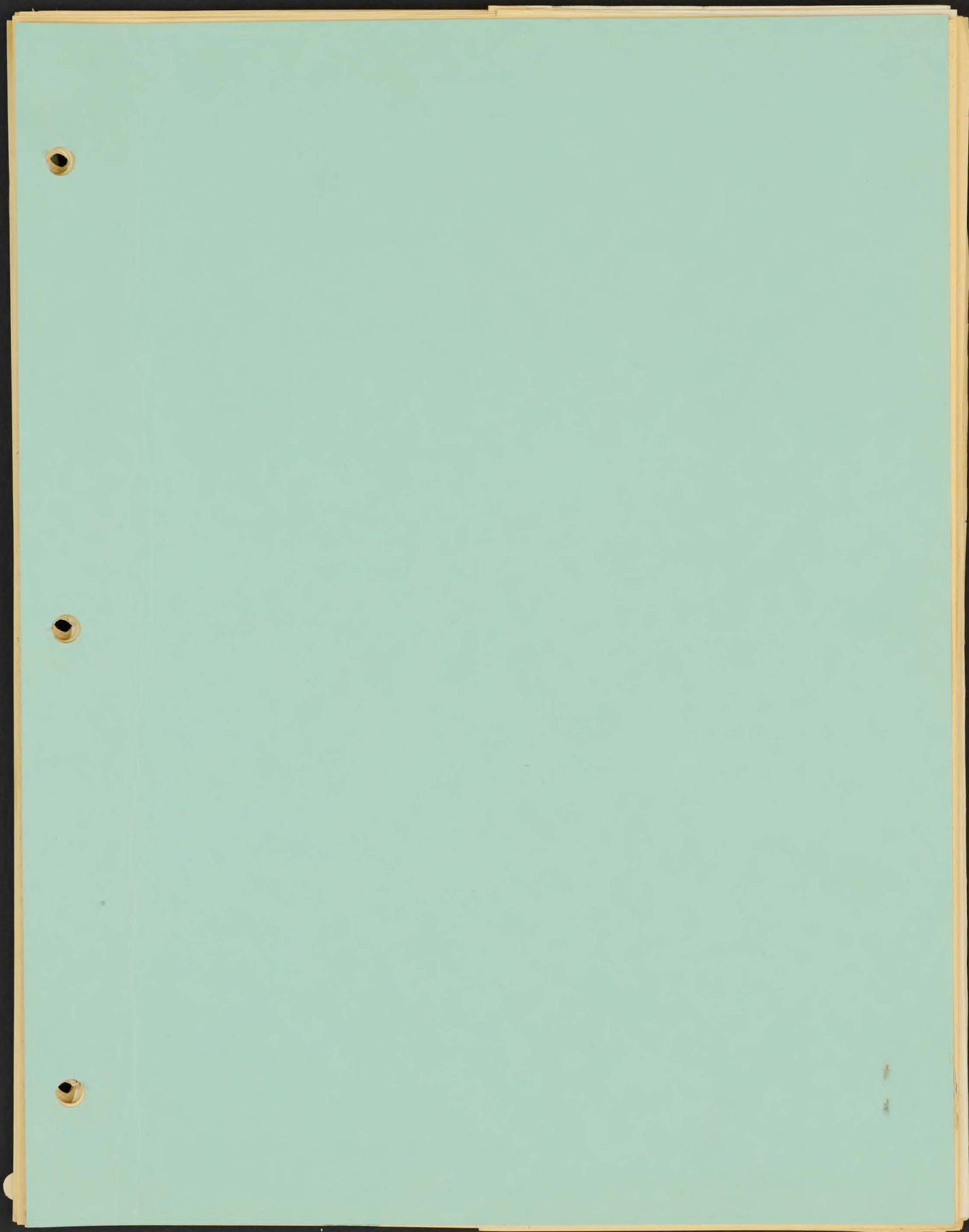


QC  
Avro  
CF105  
P-Control  
105

C-105 ~~CONFIDENTIAL~~ CONTROL/105  
TRIM ANGLES AND FLIGHT ENVELOPE  
LIMITATIONS. (ELASTIC MODE)  
D.B. Garland Copy 28 July 1957

NRC - CISTI  
J. H. PARKIN  
BRANCH  
JUN 8 1995  
ANNEXE  
J. H. PARKIN  
CNRC - ICIST

118





A. V. ROE CANADA LIMITED  
MALTO - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

UNCLASSIFIED

AIRCRAFT C-105

REPORT NO. P/CONTROL/105

FILE NO.

NO. OF SHEETS:

TITLE:



TRIM ANGLES AND FLIGHT ENVELOPE  
LIMITATIONS. (ELASTIC A/C)

UNCLASSIFIED

Classification cancelled/changed to.....

by authority of..... (date).....

Signature..... Rank.....

PREPARED BY D.B. Garland

DATE July 1957

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DATE

SUPERVISED BY

DATE

APPROVED BY

DATE

| ISSUE NO. | REVISION NO. | REVISED BY | APPROVED BY | DATE | REMARKS |
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AVRO AIRCRAFT LIMITED  
MALTON, ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT

C-105

**CONFIDENTIAL**

REPORT No. P/CONTROL/105

SHEET No. \_\_\_\_\_

PREPARED BY

DATE

D.B. Garland

July 1957

CHECKED BY

DATE

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**UNCLASSIFIED**

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AVRO AIRCRAFT LIMITED  
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INTRODUCTION

Basic wind-tunnel test data were used to calculate the rigid aircraft trim angles. No derivatives were used in the calculations and therefore errors due to linearization should be negligible. However, extrapolation of the data was necessary to cover most of the negative, and some of the large positive, lift coefficient cases considered and hence great accuracy cannot be guaranteed in these regions.

Thrust equal to drag was assumed throughout except where the aircraft drag exceeded the maximum available engine plus after burner thrust. In such a case the trimmed state is transient and the aircraft would decelerate unless aided by gravitational acceleration, as when in a dive.

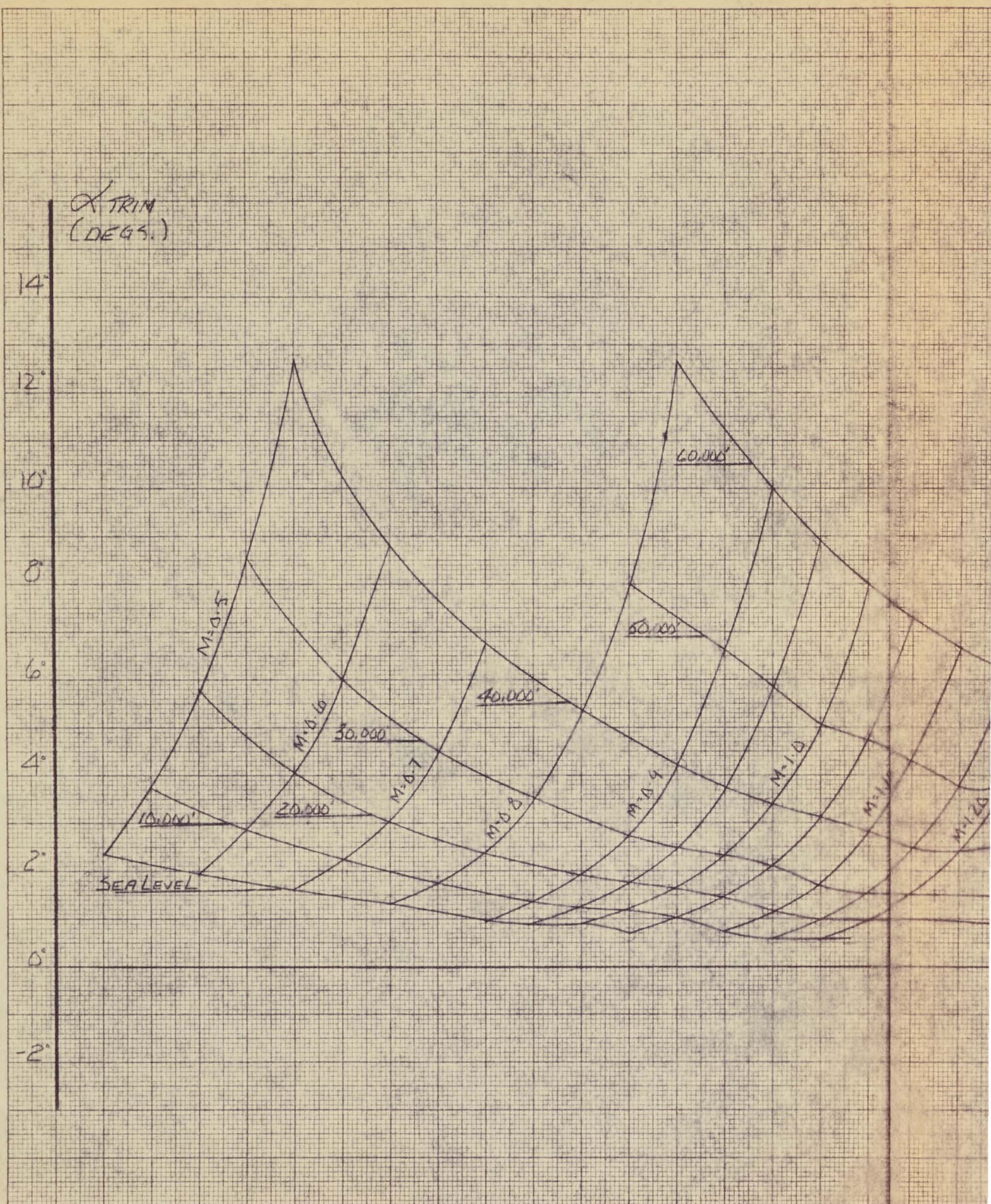
Four degrees of symmetric up-aileron were assumed above 45,000 ft., making the elevator angle to trim less negative but not materially affecting the trim angle of attack.

Increments to the trim angles due to aircraft elasticity were estimated separately and added to the rigid aircraft values. The resulting elastic aircraft trim angles were plotted and used to determine the flight envelope limitations.

Tabulated values of angle of attack to trim are added at the end of the report to increase its usefulness.

Calculations and other information relevant to this report will be found in P/Control/99.









$\alpha_{TRIM}$   
(DEGS)

20°

16°

12°

8°

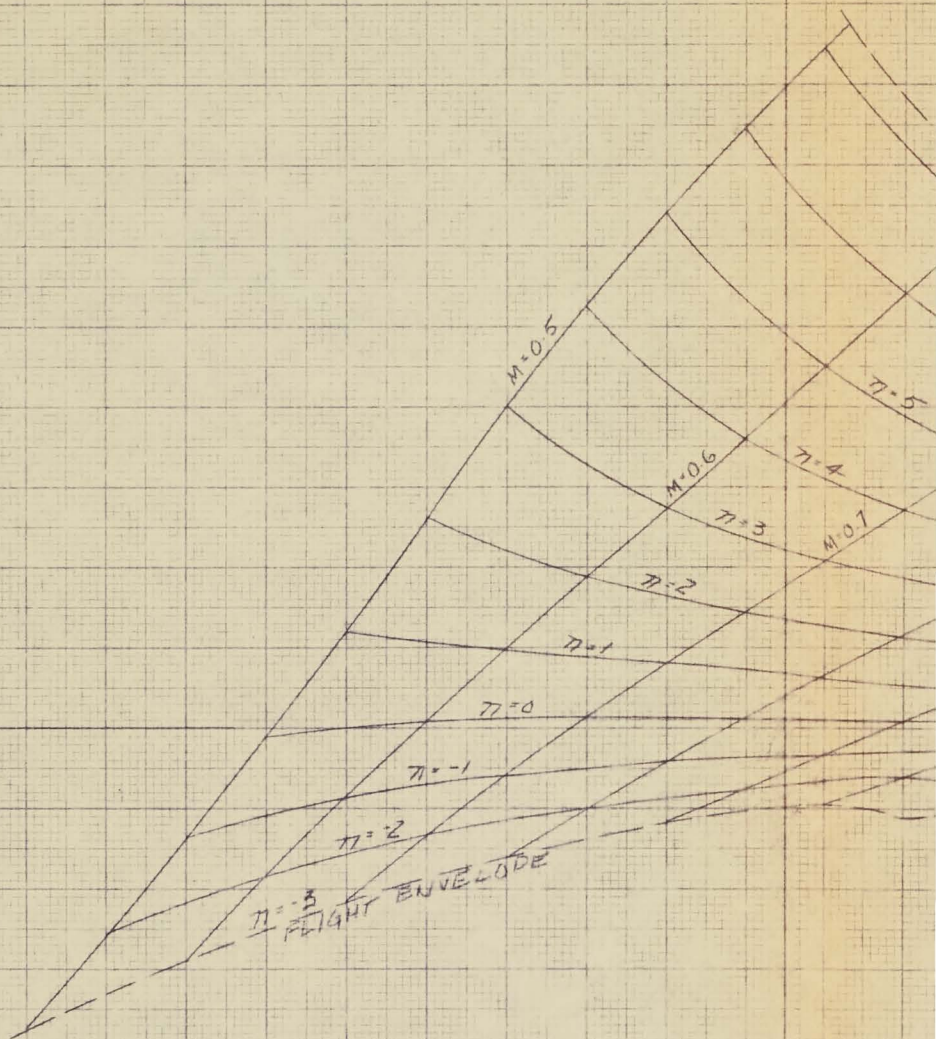
4°

0°

-4°

-8°

-12°





$\alpha$  TRIM  
(DEGS)

20°

16°

12°

8°

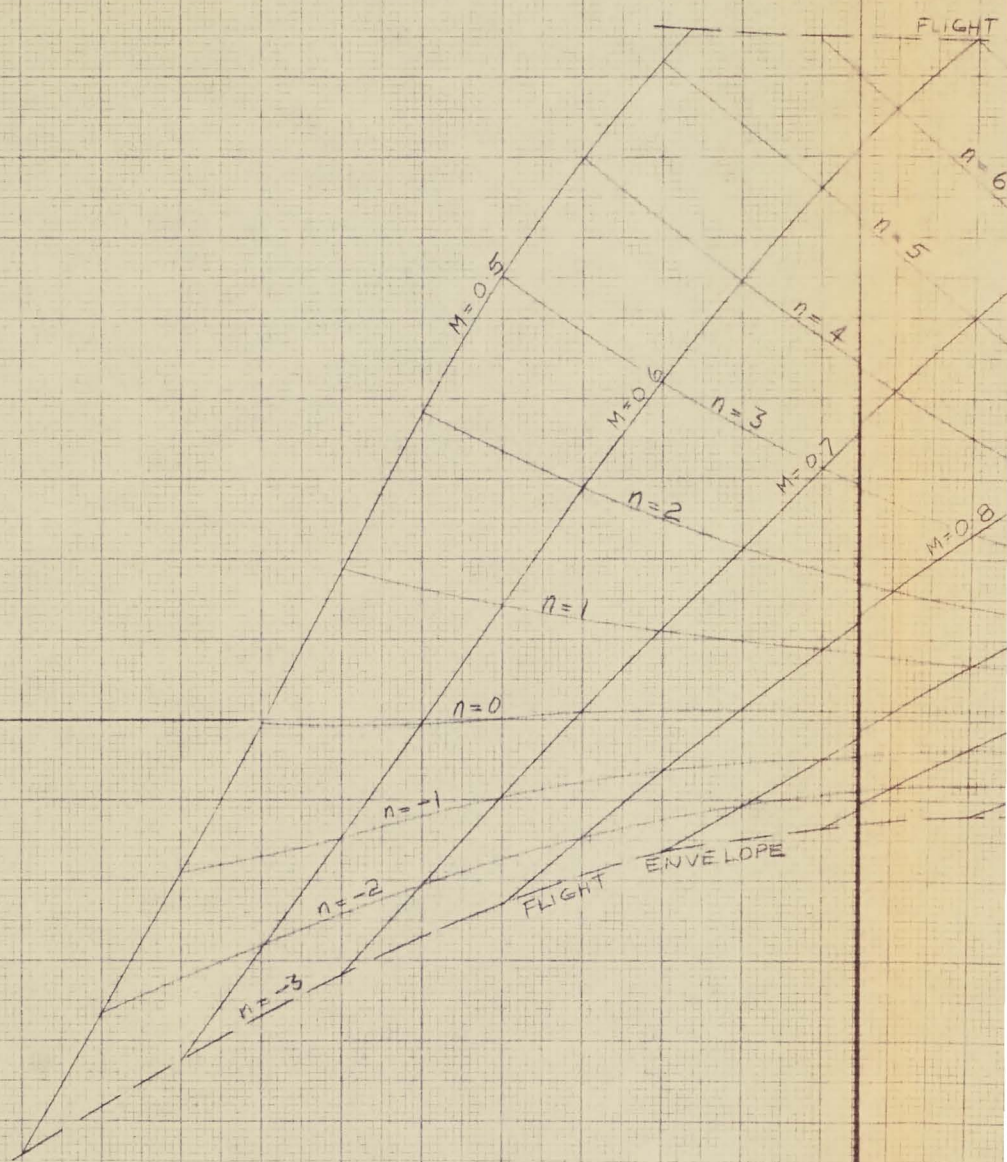
4°

0°

-4°

-8°

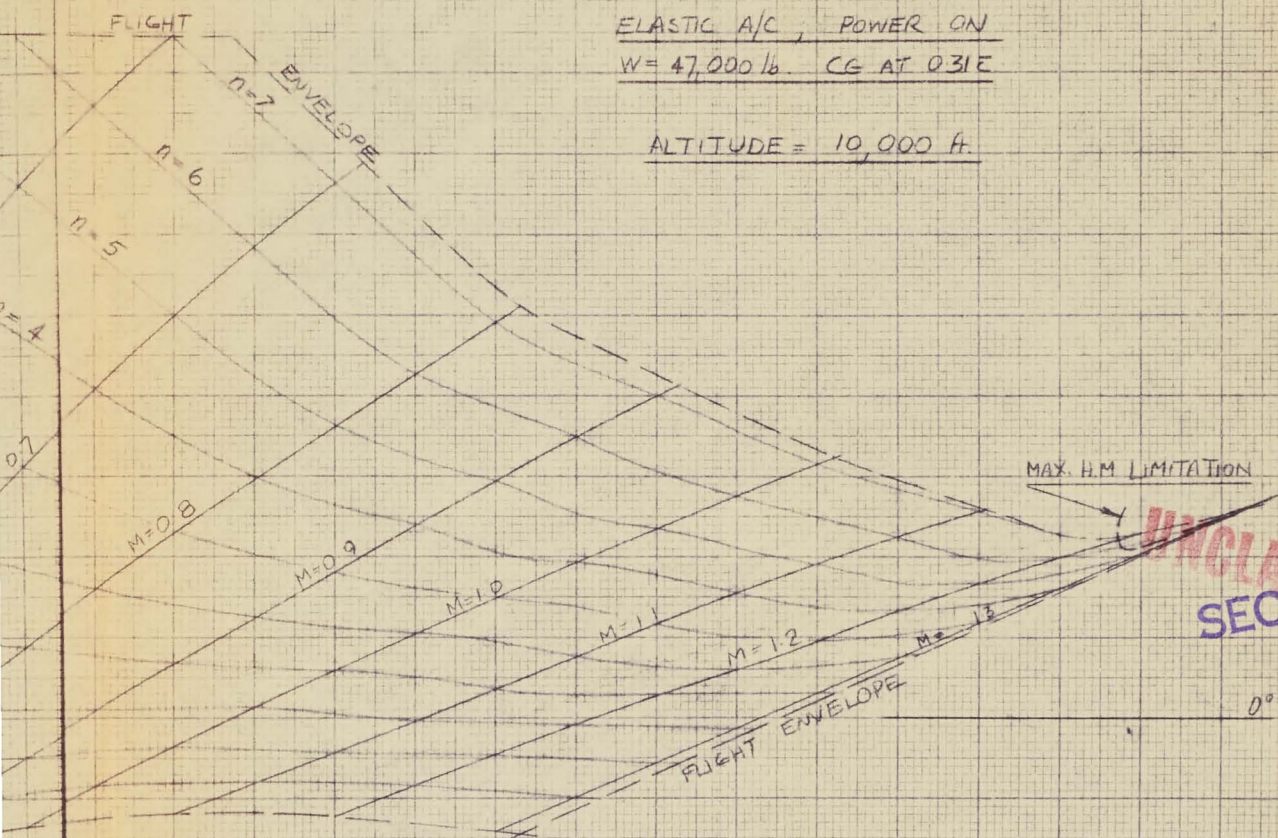
-12°



FLIGHT

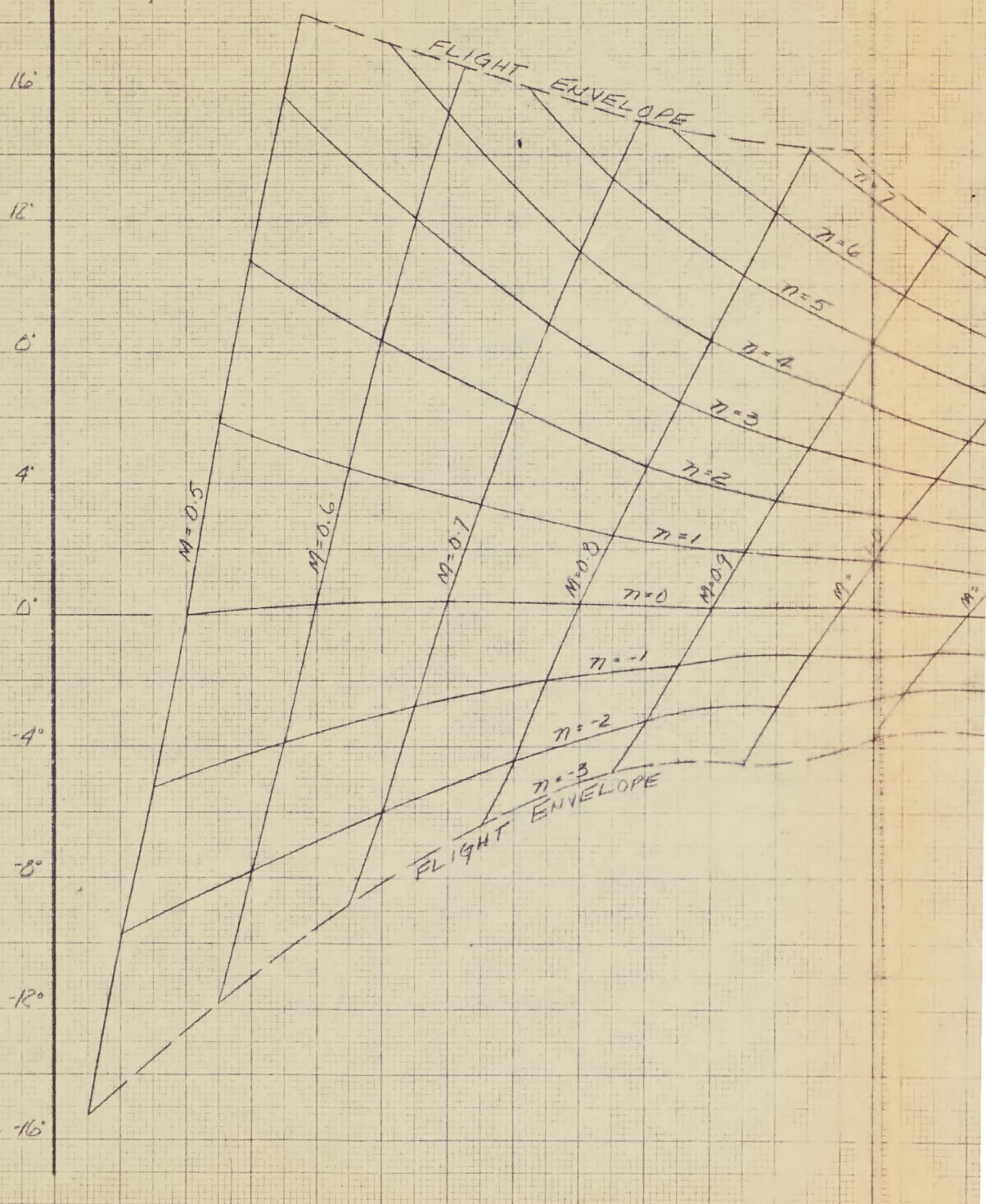


DUG JULY 57

C-105**CONFIDENTIAL**ANGLE OF ATTACK TO TRIM  
VSNORMAL ACC<sup>n</sup> AND MACH N<sup>2</sup>ELASTIC A/C, POWER ON  
W = 47,000 lb. CG AT 0.31EALTITUDE = 10,000 ft.**UNCLASSIFIED**  
**SECRET**

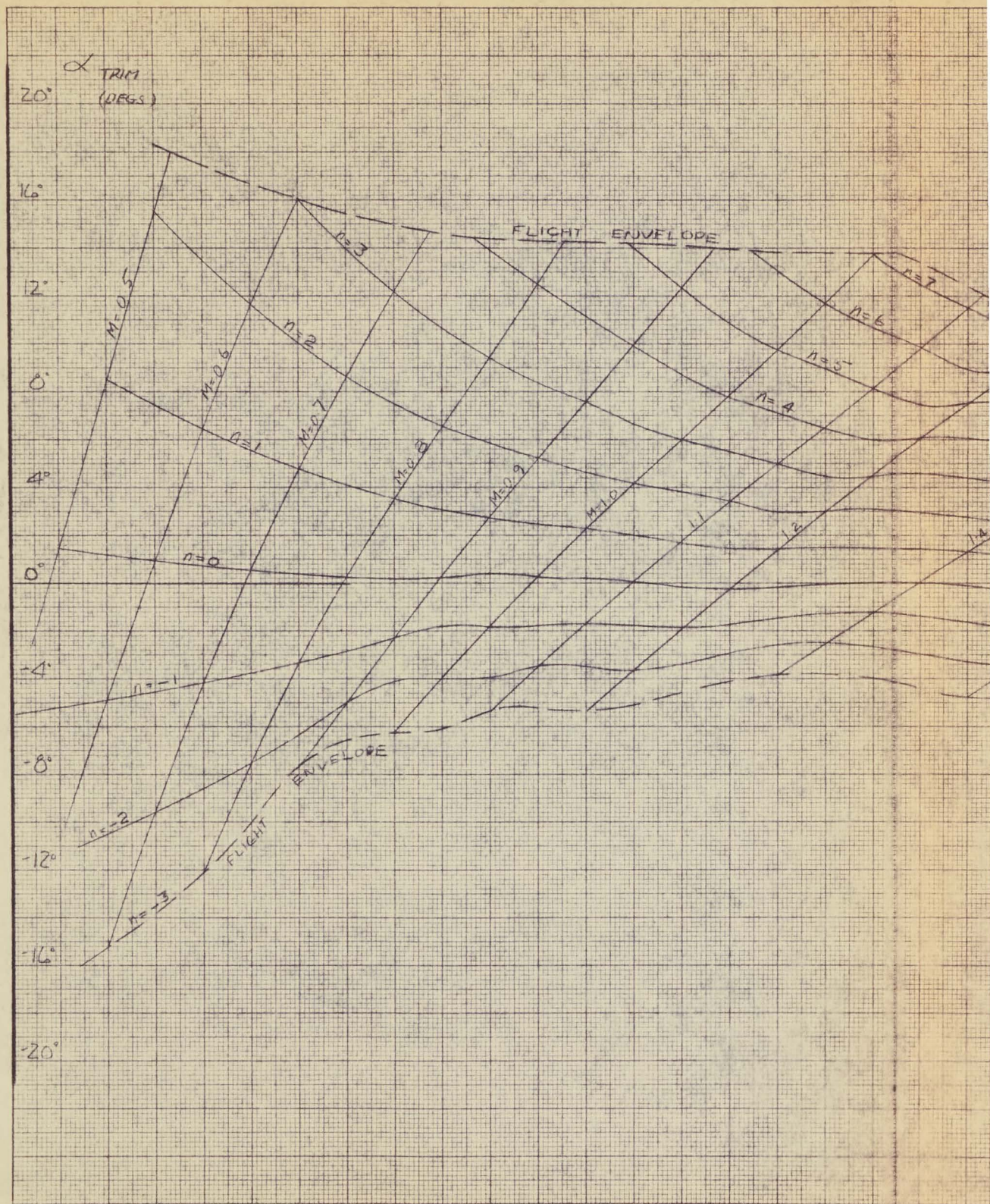


$\alpha$  TRIM  
(DEGS.)











DBG JULY 57

2.5

C-105

~~CONFIDENTIAL~~

ANGLE OF ATTACK TO TRIM

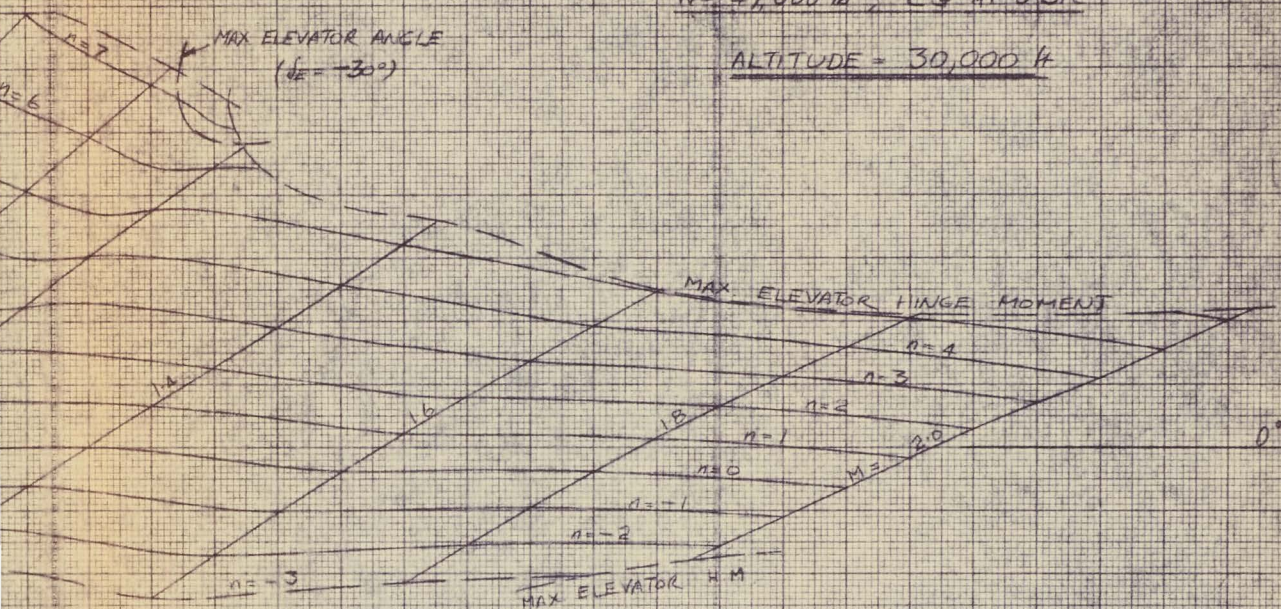
VS

NORMAL ACC<sup>2</sup> AND MACH NR

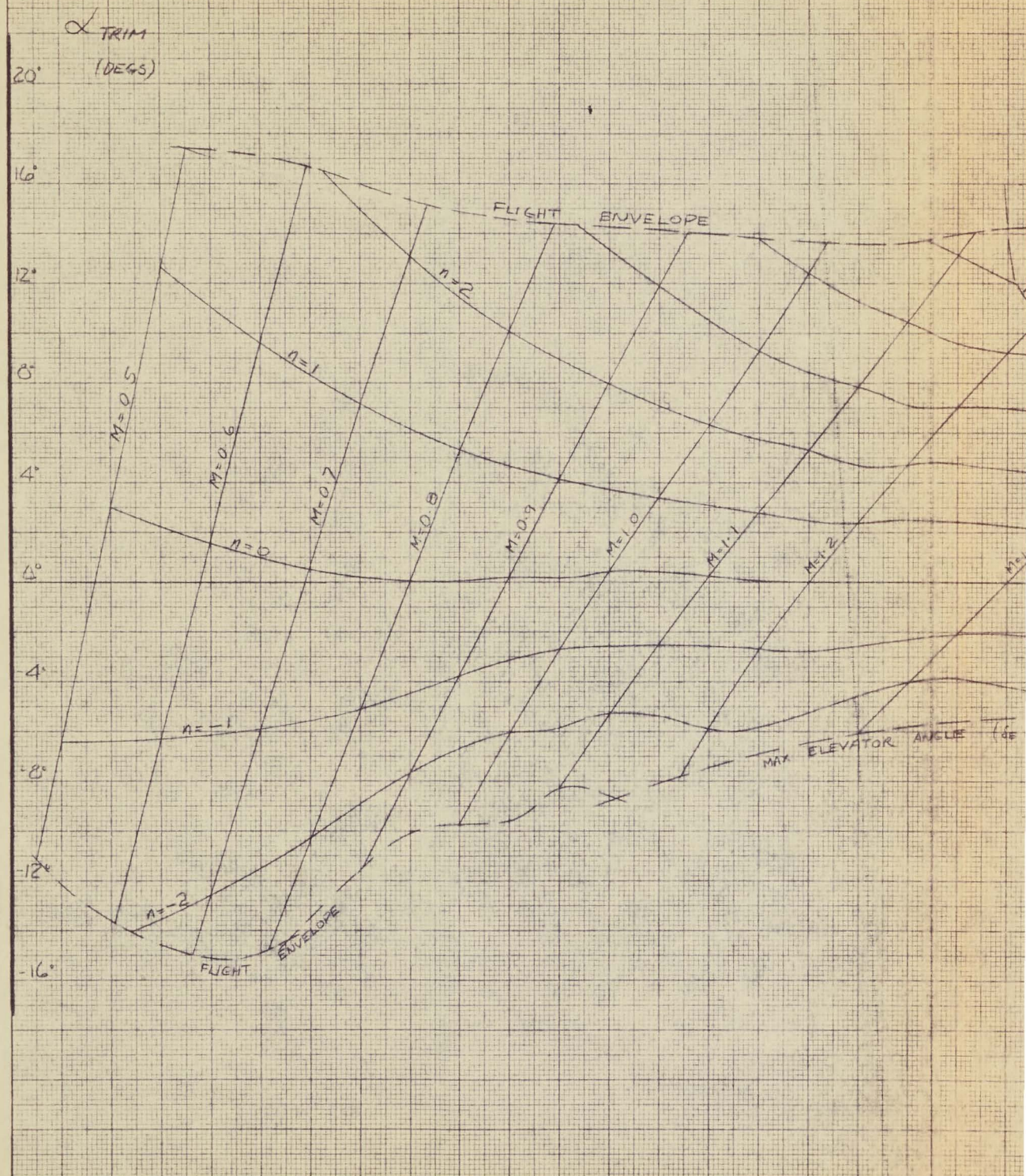
ELASTIC A/C, POWER ON

W = 47,000 lb; CG AT 0.315

ALTITUDE = 30,000 ft

~~SECRET~~









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K&E

$\alpha$  TRIM  
(DEGS)

20°

16°

12°

8°

4°

0°

-4°

-8°

-12°

-16°

FLIGHT ENVELOPE

$M=0.8$

$M=0.9$

$M=1.0$

$M=1.1$

$M=1.2$

$n=3$

$n=2$

$n=1$

$n=0$

$n=-1$

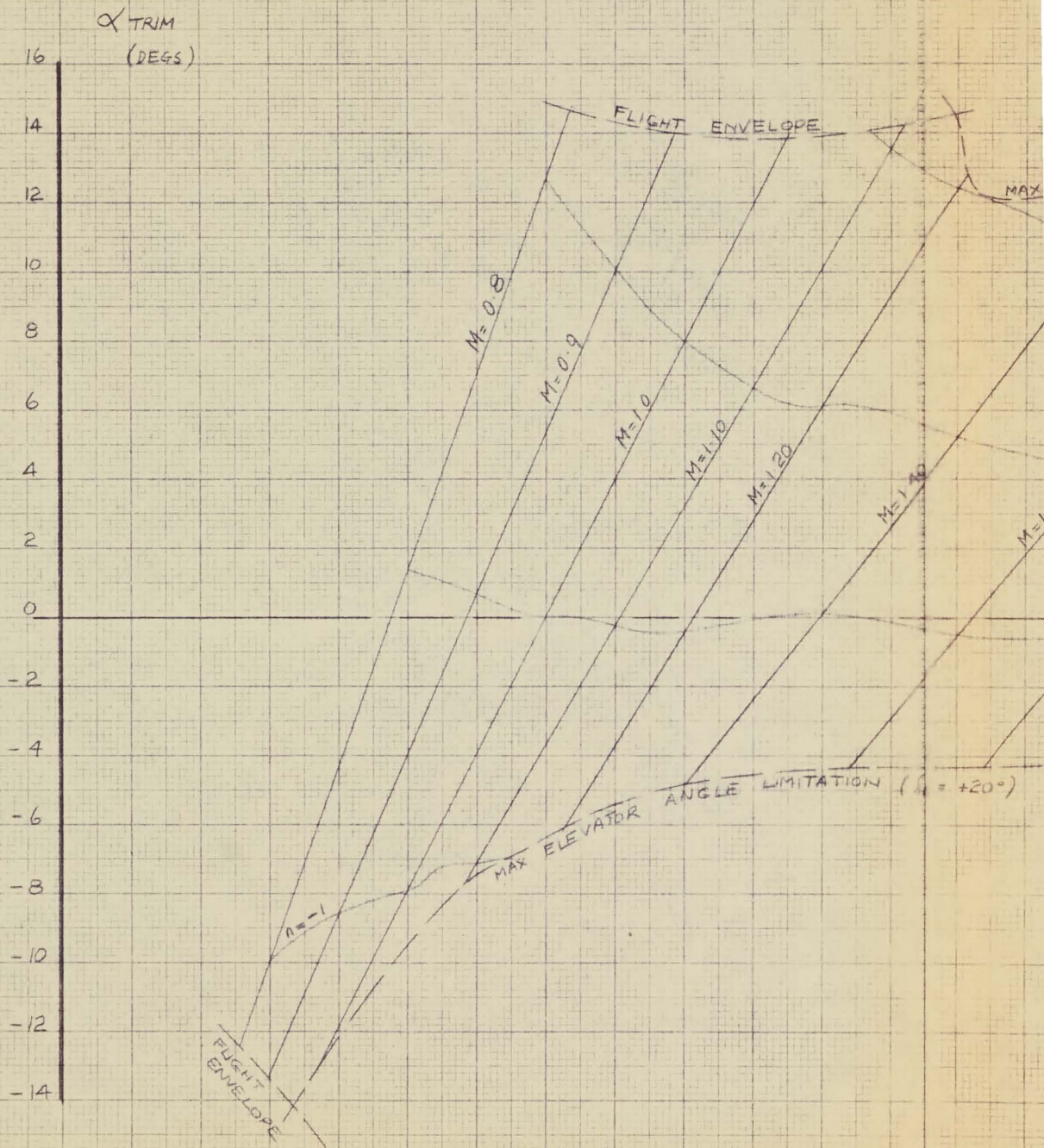
$n=-2$

MAX ELEVATOR ANGLE

FLIGHT ENVELOPE











C-105

ELEVATOR ANGLE TO TRIM vs M

LEVEL FLIGHT / M

ELASTIC A/C : POWER ON / M

SYMMETRIC AILERON DEFLECTION / M

$\delta \epsilon_{TRIM}$   
(DEGREES)

4

3

2

1

0

-1

-2

-3

-4

-5

-6

-7

-8

-9

-10

SEA LEVEL

10,000'

20,000'

M=0.80

M=1.00

M=0.50

30,000'

40,000'

M=1.20

50,000'

M=1.40

M=1.60

M=1.80

M=2.00

M=2.20

M=2.40

M=2.60

M=2.80

M=3.00

M=3.20

M=3.40

M=3.60

M=3.80

M=4.00

M=4.20

M=4.40

M=4.60

M=4.80

M=5.00

M=5.20

M=5.40

M=5.60

M=5.80

M=6.00

M=6.20

M=6.40

M=6.60

M=6.80

M=7.00

M=7.20

M=7.40

M=7.60

M=7.80

M=8.00

M=8.20

M=8.40

M=8.60

M=8.80

M=9.00

M=9.20

M=9.40

M=9.60

M=9.80

M=10.00

M=10.20

M=10.40

M=10.60

M=10.80

M=11.00

M=11.20

M=11.40

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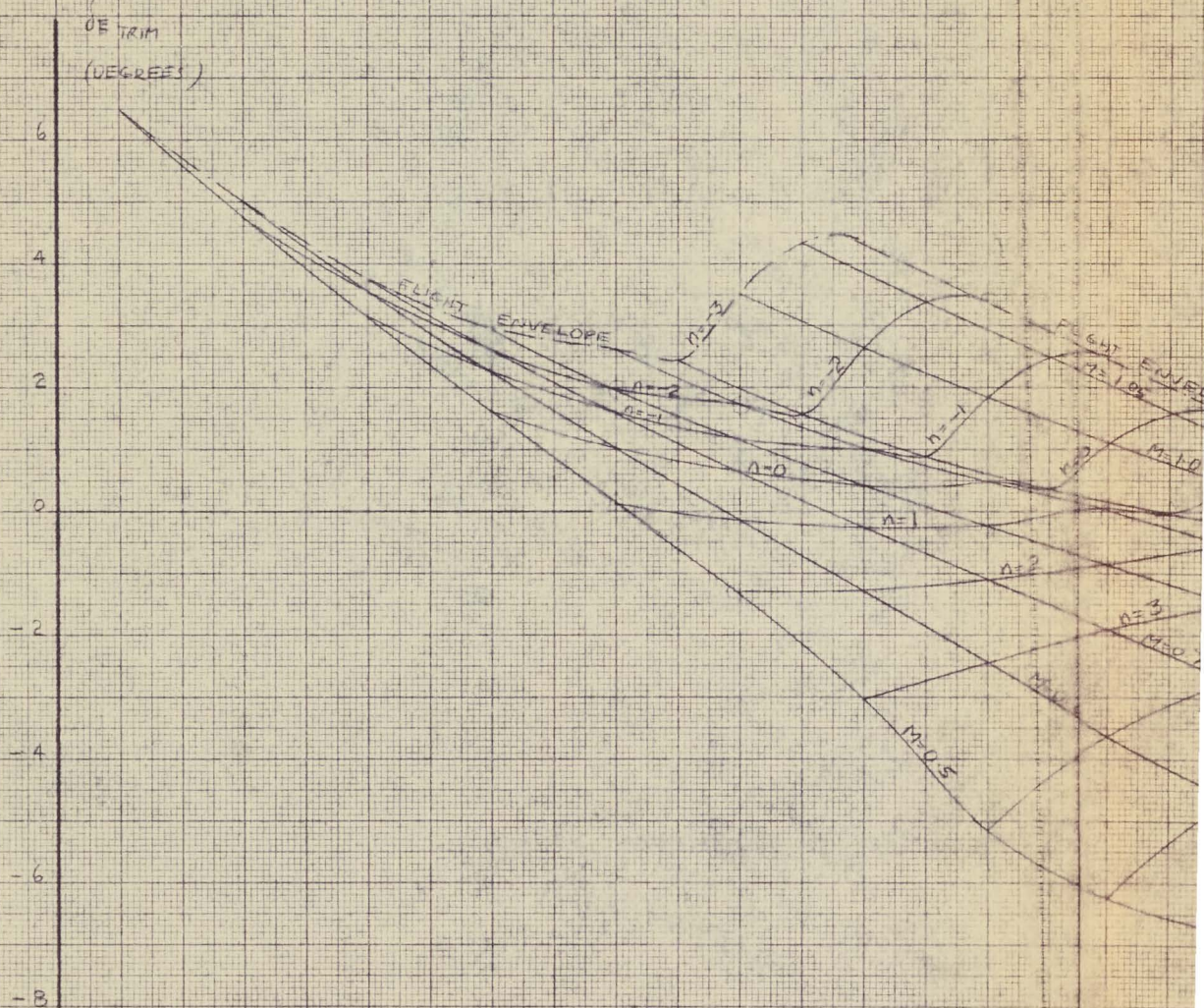




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K.E.

OE TRIM  
(DEGREES)

11°

10°

9°

8°

7°

6°

5°

4°

3°

2°

1°

0°

-1°

-2°

-3°

-4°

-5°

-6°

-7°

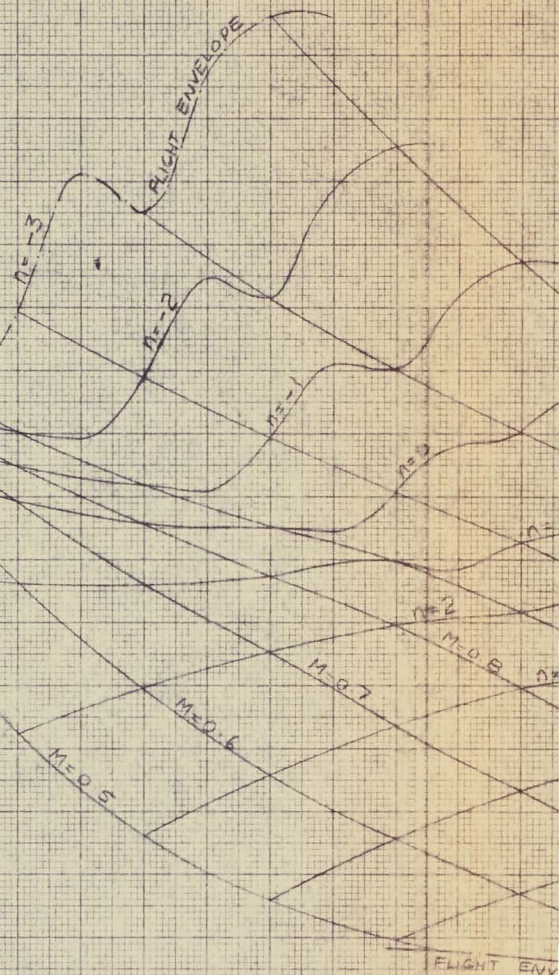
-8°

-9°

-10°

-11°

-12°



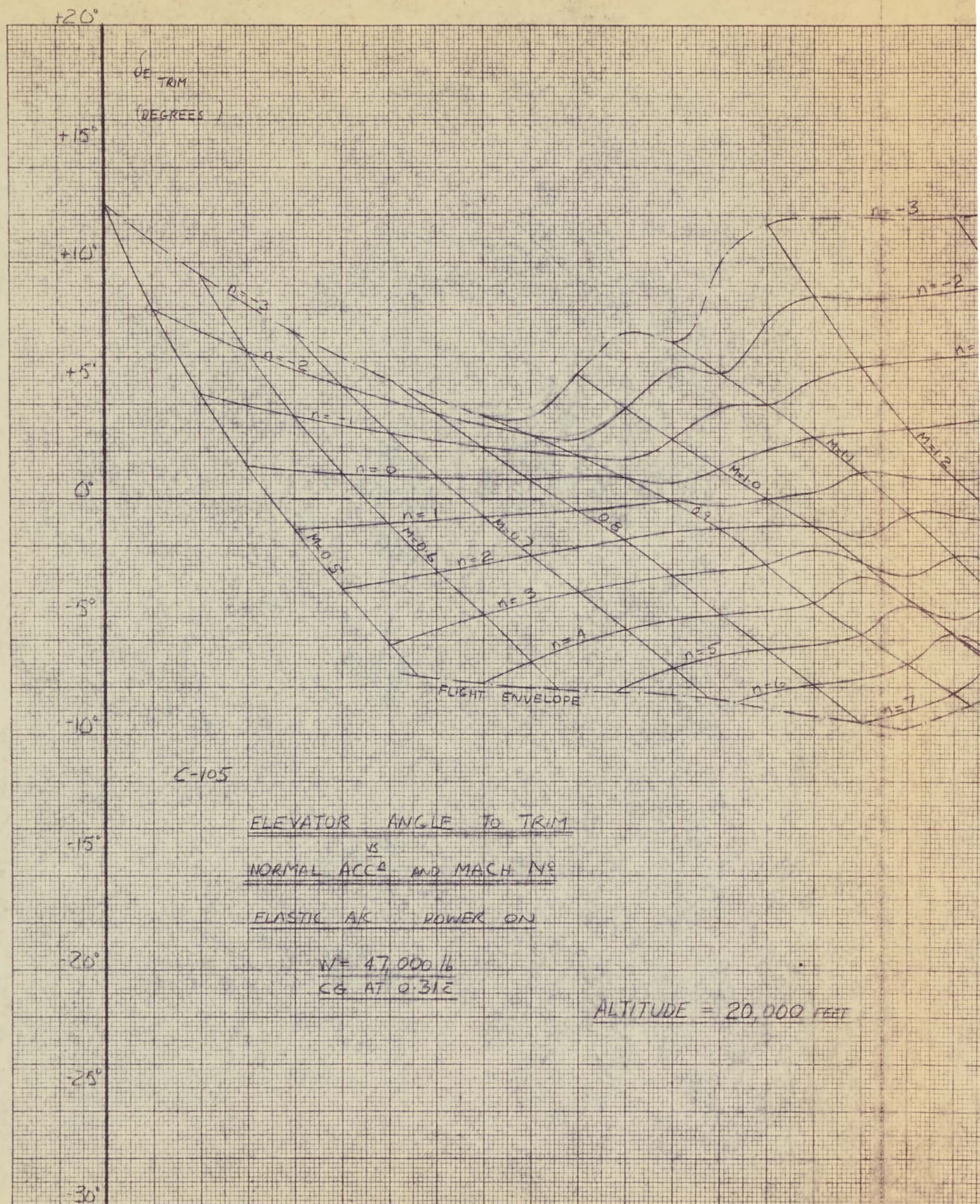




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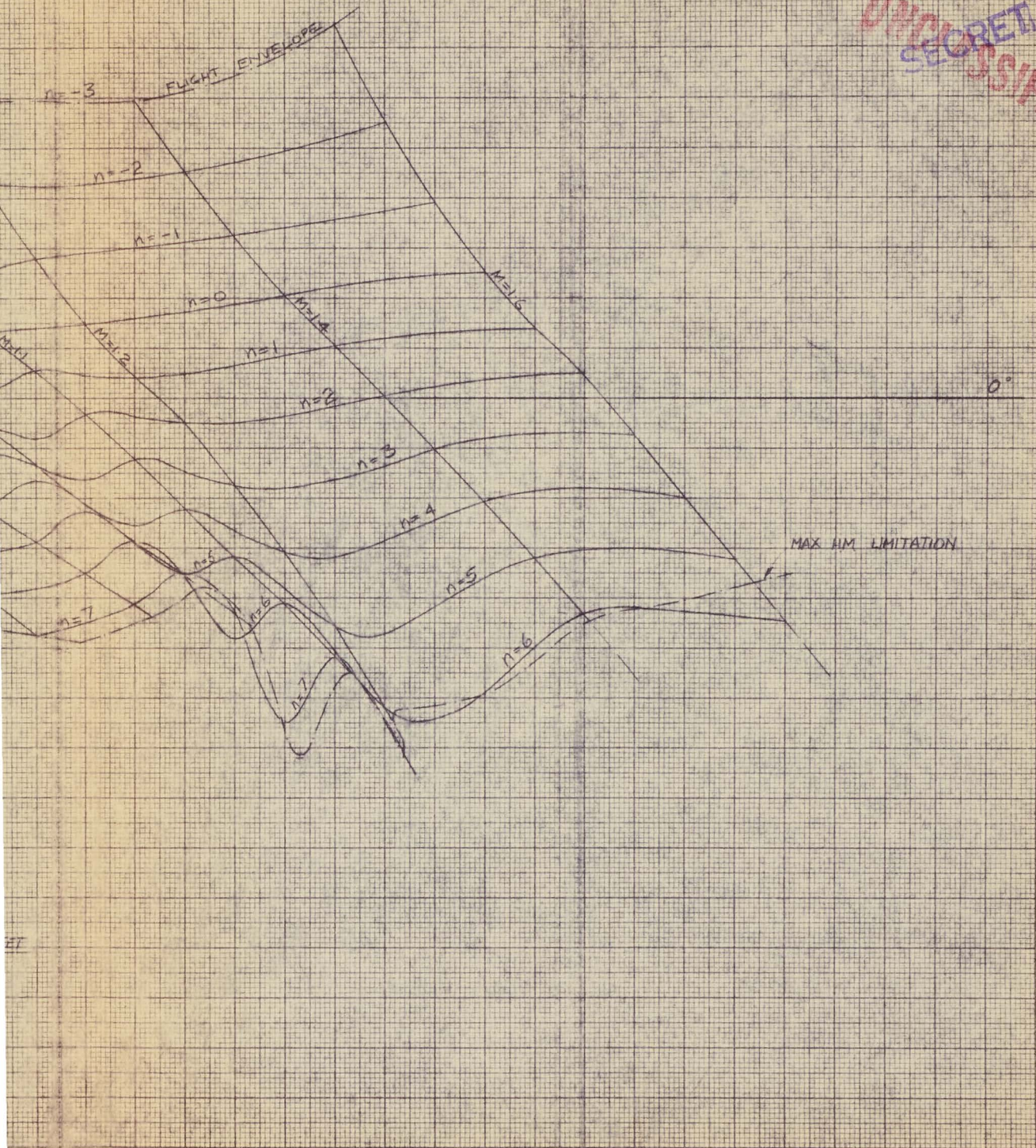
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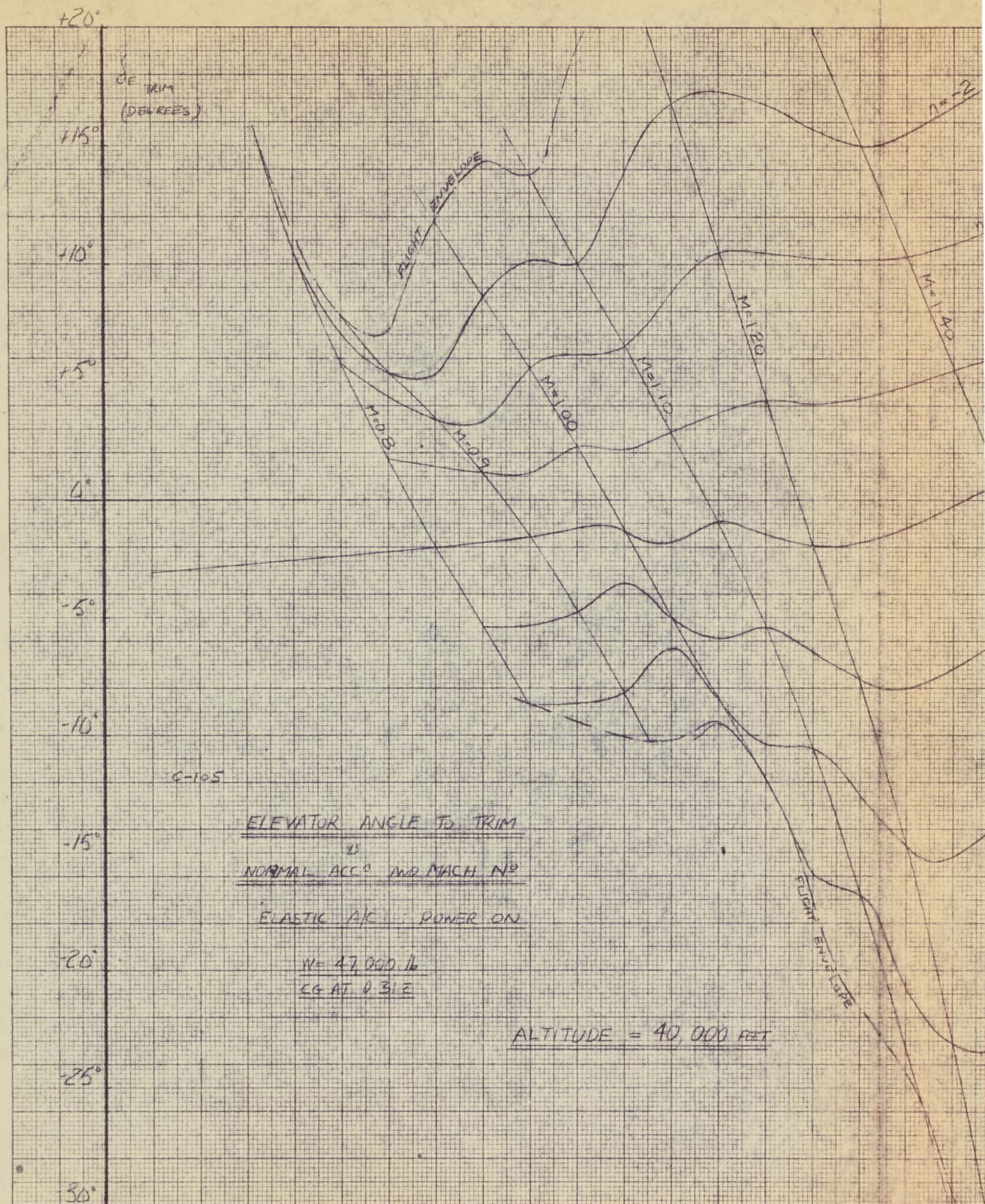




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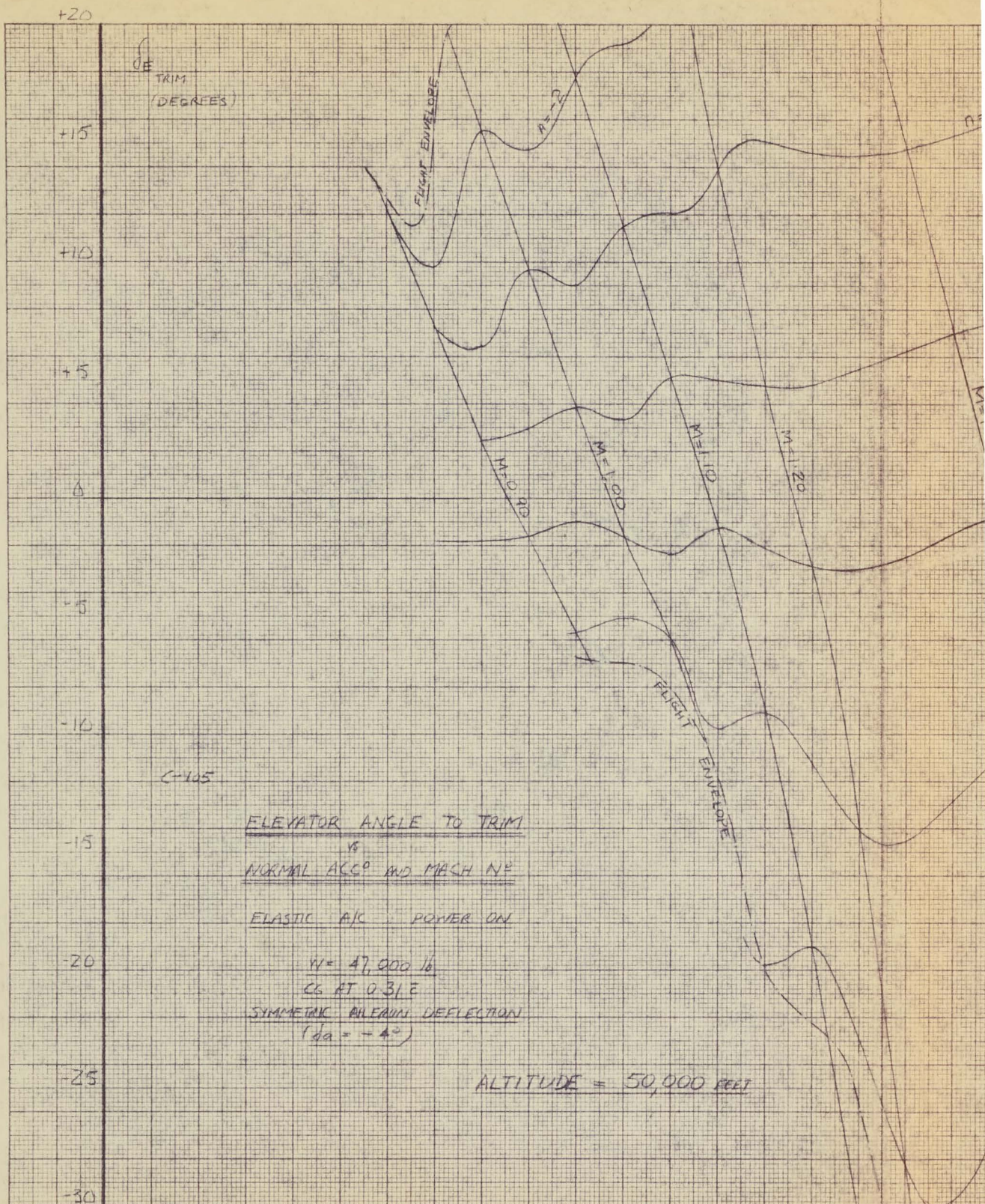




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KE



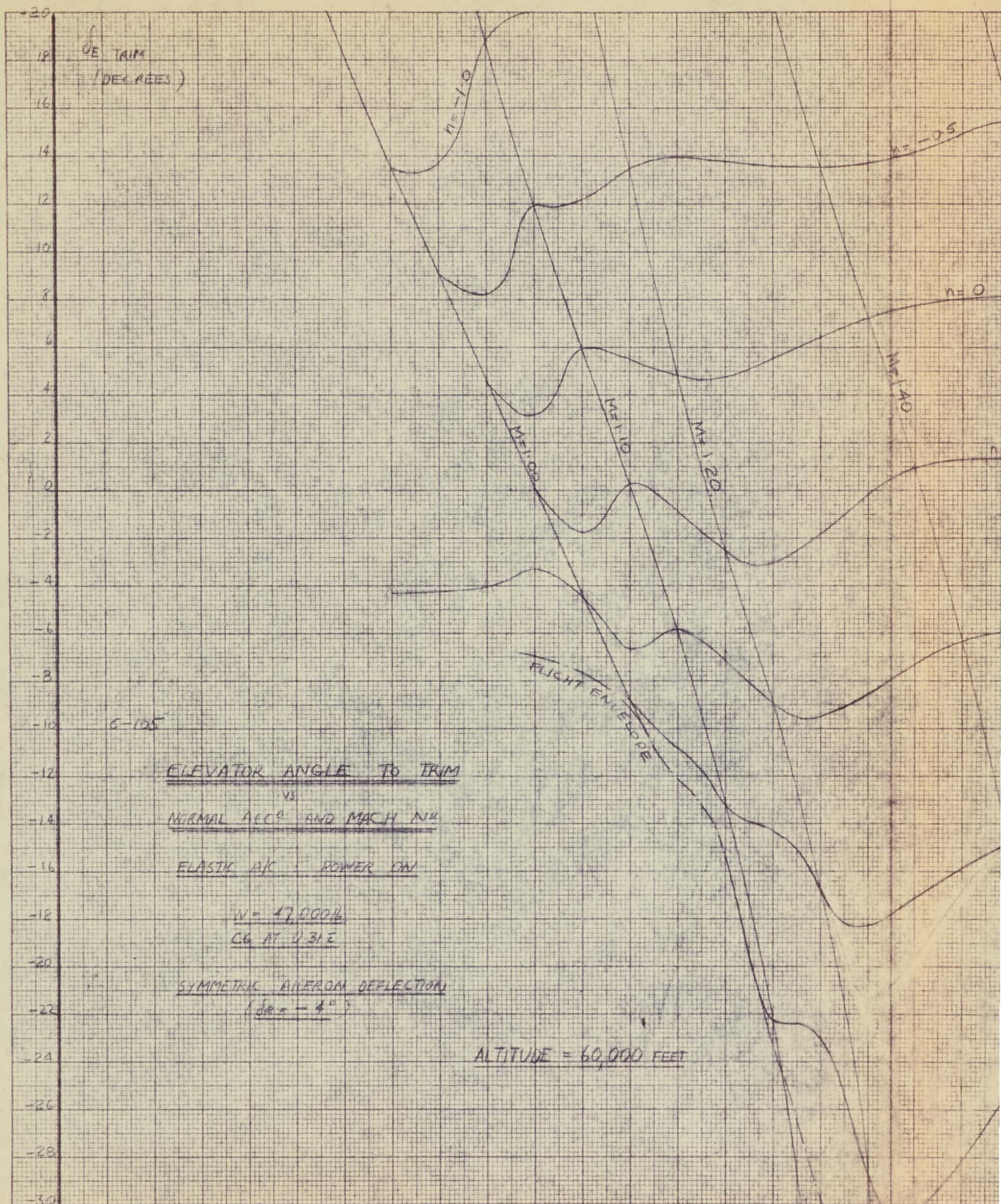




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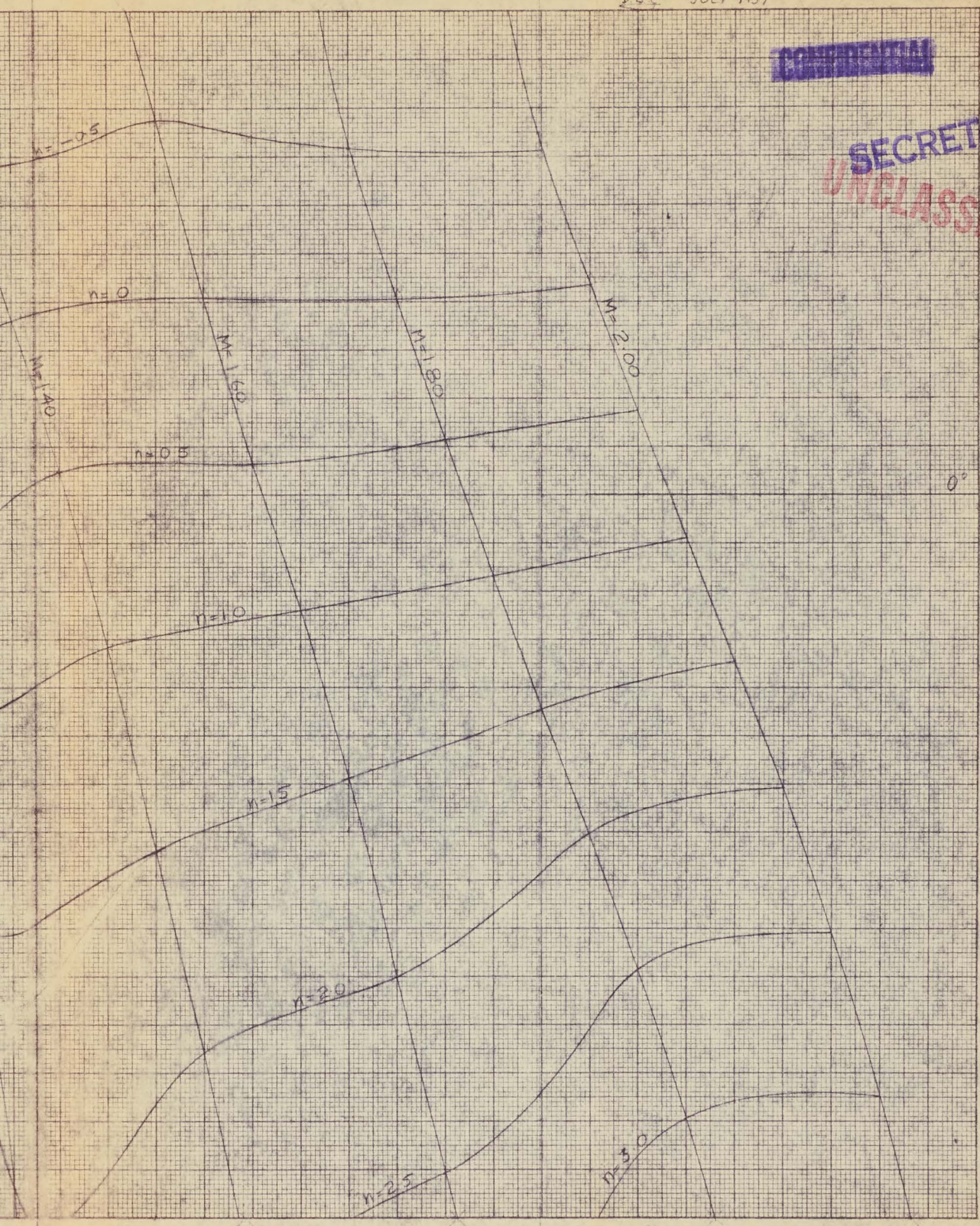
K&E





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C-105

FLIGHT ENVELOPE LIMITATIONS  
ELASTIC AIRCRAFT

POWER ON

ALTITUDE = SEA LEVEL

W = 47,000 lb / 52,500

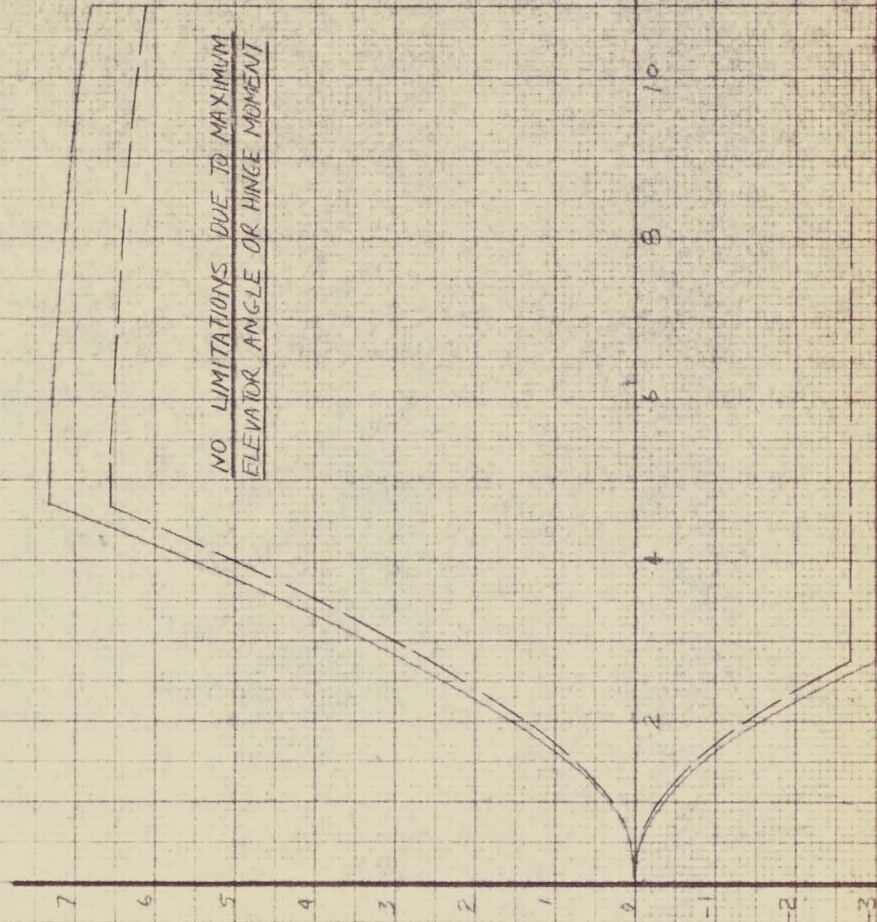
CG AT 0.317

47,000 lb

52,500 lb

NO LIMITATIONS DUE TO MAXIMUM  
ELEVATOR ANGLE OR HINGE MOMENT

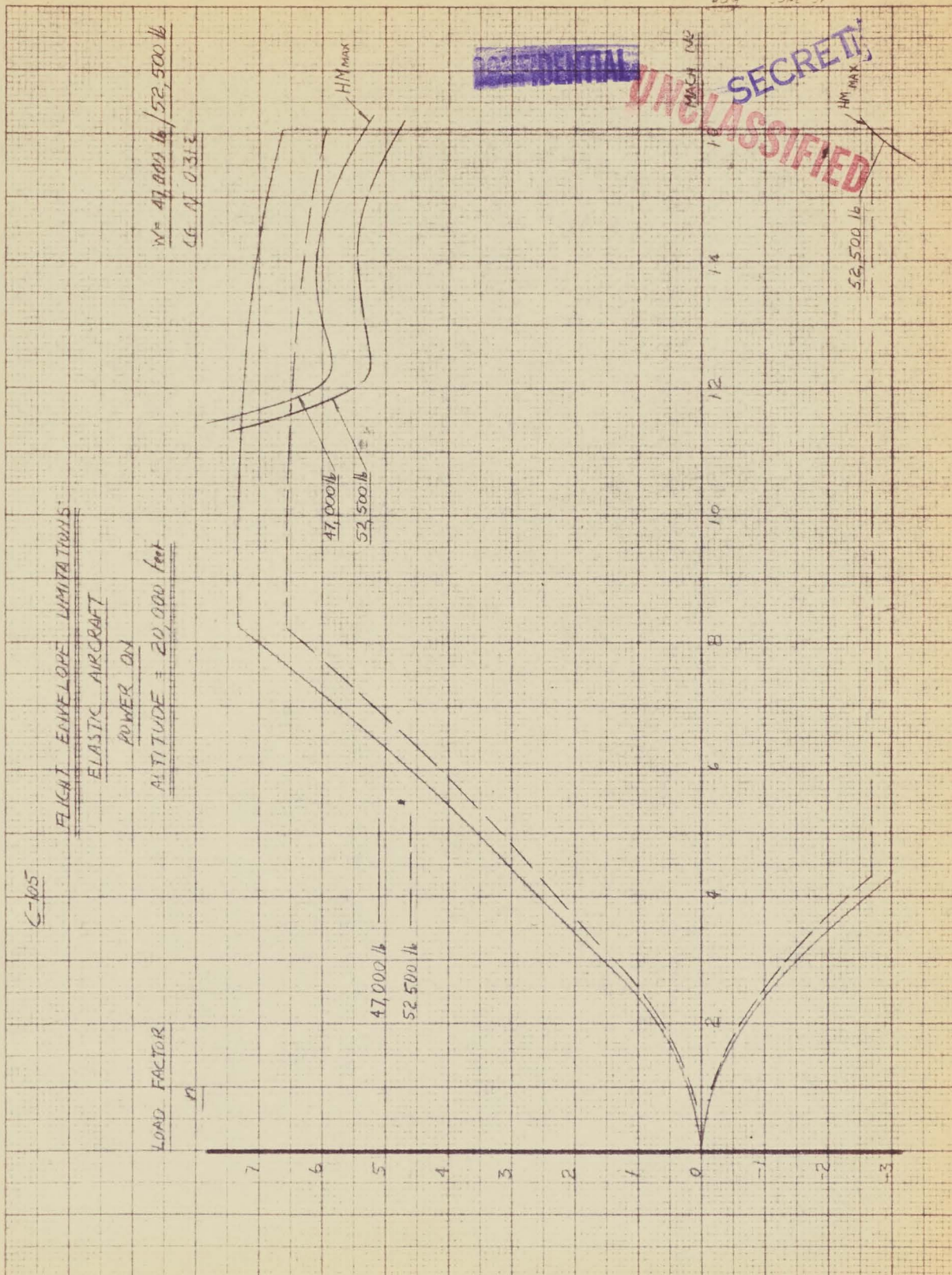
LWD FRACTOR  
 $\eta$



MACH NUMBER









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C-105

FLIGHT ENVELOPE LIMITATIONS  
ELASTIC AIRCRAFT

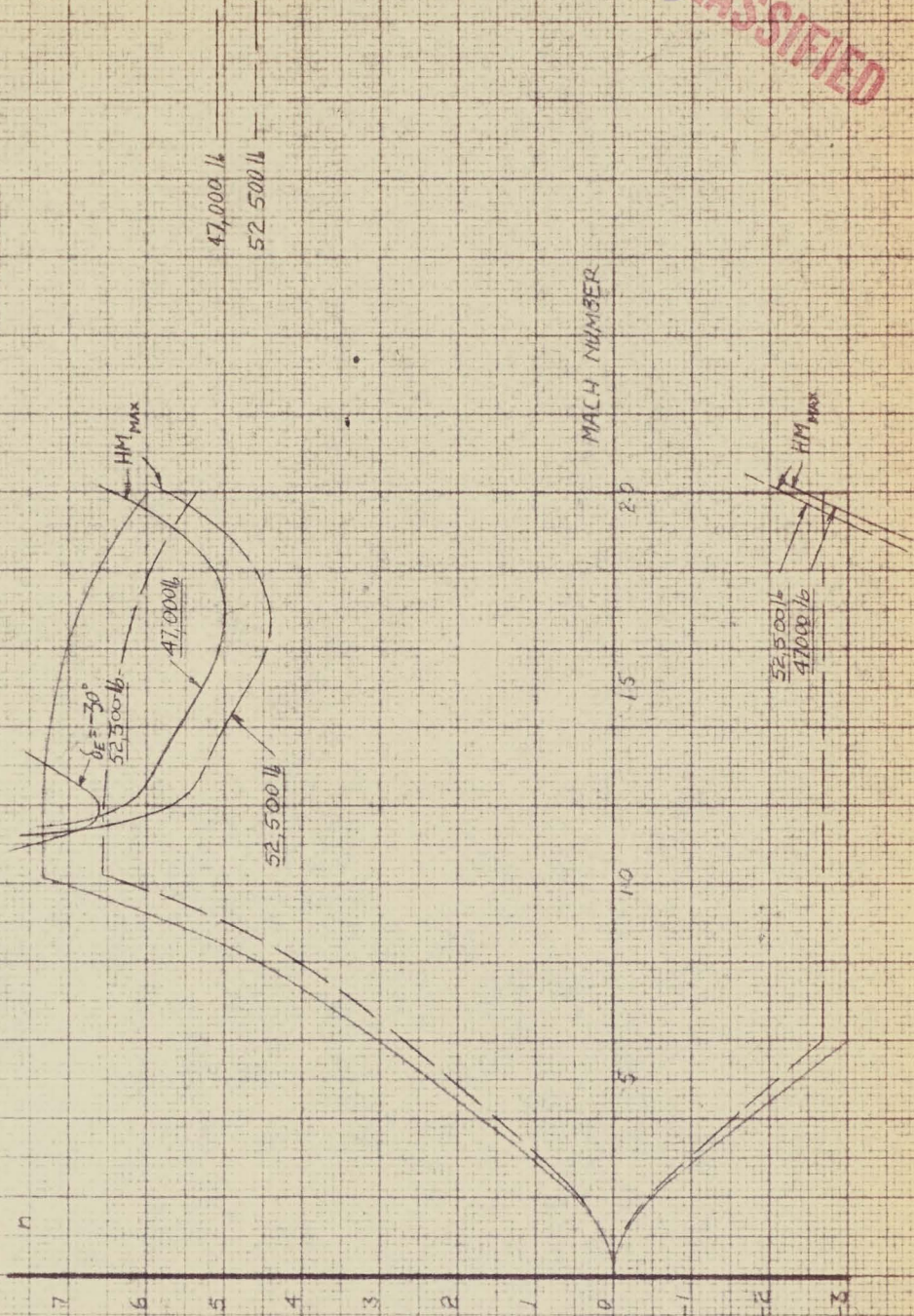
POWER ON

ALTITUDE = 30,000 feet

W = 47,000 lb / 52,500 lb

CG AT 0.315

LOAD FACTOR



















AVRO AIRCRAFT LIMITED  
MALTON - ONTARIO

# TECHNICAL DEPARTMENT

AIRCRAFT:

C-105

**CONFIDENTIAL**

REPORT NO. P/CONTROL/105

SHEET NO. 5.2

PREPARED BY

DATE

D.B. Garland

July 1957

CHECKED BY

DATE

## PREDICTED TRIMMED INCIDENCE IN MANOEUVERING

### FLIGHT FOR THE ELASTIC AIRCRAFT

W = 47000 lbs.

CG = 0.31  $\bar{c}$

POWER ON

h = 30,000 ft.

| M    | $\alpha_{TRIM}$ for n = |       |       |       |       |      |      |       |       |       |       |
|------|-------------------------|-------|-------|-------|-------|------|------|-------|-------|-------|-------|
|      | n = -3                  | -2    | -1    | 0     | 1     | 2    | 3    | 4     | 5     | 6     | 7     |
| .50  | -                       | -     | -5.50 | 1.48  | 8.54  | -    | -    | -     | -     | -     | -     |
| .80  | -12.08                  | -7.53 | -3.32 | 0.25  | 3.53  | 6.60 | 9.45 | 12.48 | -     | -     | -     |
| .90  | - 7.78                  | -4.98 | -2.28 | 0.22  | 2.74  | 5.47 | 7.60 | 9.90  | 12.38 | 14.79 | -     |
| .95  | - 6.58                  | -4.08 | -1.80 | 0.40  | 2.48  | 4.62 | 6.64 | 8.74  | 10.85 | 13.02 | -     |
| 1.00 | - 6.23                  | -3.98 | -1.80 | 0.30  | 2.34  | 4.25 | 6.00 | 7.78  | 9.78  | 11.76 | 13.70 |
| 1.05 | - 6.10                  | -3.93 | -1.78 | 0.20  | 2.13  | 3.82 | 5.52 | 7.16  | 8.98  | 10.67 | 12.48 |
| 1.10 | - 5.35                  | -3.46 | -1.70 | 0.05  | 1.68  | 3.48 | 4.98 | 6.55  | 8.17  | 9.85  | 11.50 |
| 1.15 | - 5.20                  | -3.44 | -1.80 | -0.15 | 1.52  | 2.90 | 4.48 | 5.99  | 7.48  | 8.91  | -     |
| 1.23 | - 5.20                  | -3.56 | -1.80 | -0.20 | 1.50  | 3.11 | 4.60 | 6.15  | 7.59  | 8.84  | -     |
| 1.41 | - 3.80                  | -2.50 | -1.20 | 0     | 1.29  | 2.44 | 3.75 | 5.07  | 6.38  | 7.68  | -     |
| 1.60 | - 4.80                  | -3.39 | -2.02 | -0.75 | 0.46  | 1.59 | 2.78 | 3.86  | 4.92  | 5.98  | -     |
| 1.80 | - 4.28                  | -3.07 | -1.90 | -0.77 | 0.36  | 1.23 | 2.26 | 3.17  | 4.05  | 4.98  | -     |
| 2.00 | -                       | -3.08 | -2.20 | -1.26 | -0.35 | 0.59 | 1.42 | 2.25  | 3.08  | 4.03  | -     |

h = 40,000 ft.

| M    | $\alpha_{TRIM}$ for n = |        |       |       |       |       |       |       |       |      |   |
|------|-------------------------|--------|-------|-------|-------|-------|-------|-------|-------|------|---|
|      | n = -3                  | -2     | -1    | 0     | 1     | 2     | 3     | 4     | 5     | 6    | 7 |
| 0.50 | -                       | -      | -6.42 | 3.00  | 12.70 | -     | -     | -     | -     | -    | - |
| 0.80 | -                       | -12.29 | -5.12 | 0.03  | 5.38  | 10.07 | -     | -     | -     | -    | - |
| 0.90 | -11.58                  | - 7.65 | -3.78 | 0.20  | 4.25  | 8.01  | 11.92 | 15.64 | -     | -    | - |
| 0.95 | -10.05                  | - 6.64 | -3.12 | 0.20  | 3.74  | 7.03  | 10.54 | 13.79 | -     | -    | - |
| 1.00 | - 9.76                  | - 6.03 | -2.70 | 0.42  | 3.43  | 6.34  | 9.28  | 12.49 | -     | -    | - |
| 1.05 | - 9.60                  | - 5.86 | -2.60 | 0.40  | 3.16  | 5.74  | 8.42  | 11.33 | -     | -    | - |
| 1.10 | - 8.30                  | - 5.26 | -2.52 | 0.27  | 2.79  | 5.35  | 7.83  | 10.51 | 13.15 | -    | - |
| 1.15 | - 8.60                  | - 5.36 | -2.58 | 0.05  | 2.47  | 4.72  | 7.10  | 9.62  | 12.12 | -    | - |
| 1.23 | -                       | - 5.96 | -2.80 | 0     | 2.50  | 4.83  | 7.02  | 9.60  | -     | -    | - |
| 1.41 | -                       | - 3.93 | -2.05 | 0     | 1.95  | 3.97  | 6.13  | 8.30  | 10.38 | -    | - |
| 1.60 | -                       | - 4.75 | -2.68 | -0.78 | 1.16  | 2.92  | 4.60  | 6.34  | -     | 9.96 | - |
| 1.80 | - 6.40                  | - 4.38 | -2.55 | -0.80 | 0.85  | 2.45  | 4.00  | 5.46  | 7.00  | 8.51 | - |
| 2.00 | - 5.60                  | - 4.07 | -2.64 | -1.22 | 0.13  | 1.52  | 2.92  | 4.17  | 5.68  | 6.99 | - |

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AVRO AIRCRAFT LIMITED  
MALTON - ONTARIO

TECHNICAL DEPARTMENT

REPORT NO. P/CONTROL/105

SHEET NO. 6.1

AIRCRAFT:

C-105



PREPARED BY

DATE

D.B. Garland

July 1957

CHECKED BY

DATE

UNCLASSIFIED

6. ADDENDUM:

TRIM ANGLES AT LOW SPEED

Some trim angles have been calculated using data from the N.A.E. low speed wind-tunnel, which has a speed of  $M = 0.2$  approximately. The data have been applied at Mach numbers from 0.2 to 0.5, the small compressibility corrections being ignored.

Comparison with trim angles at  $M = 0.5$  calculated from C.A.L. wind-tunnel results, shows a discrepancy of about  $\frac{3}{4}$  degree in angle of attack and about  $1\frac{1}{2}$  degrees in elevator angle. It is thought that these differences can be accounted for by

- (a) different methods of mounting the wind tunnel models
- (b) slight differences in model configurations
- (c) some uncertainty in the calculation and application of wind-tunnel corrections.
- and (d) compressibility effects.

**SECRET**

PRIM

MACH N<sup>o</sup> AND ALTITUDE

$W = 47,000 \text{ lb.}$  CG AT 0.31E

LOW SPEED





C-105

ELEVATOR ANGLE TO TRIM

52

MACH NO AND ALTITUDE

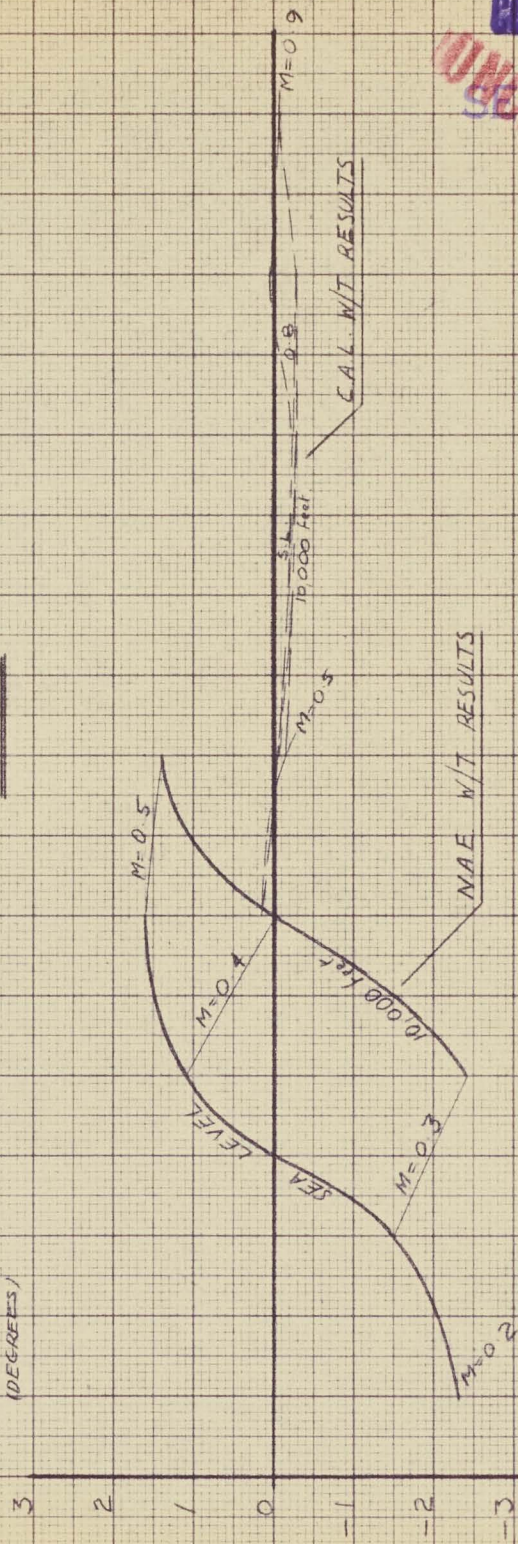
ELASTIC A/C; POWER ON

$W = 47,000 \text{ lb}$ ;  $CG \text{ AT } 0.31 \bar{c}$

LEVEL FLIGHT ( $h=1$ )

LOW SPEED

| $\delta$ TRM | (DEGREES) |
|--------------|-----------|
|--------------|-----------|



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P/CONTROL/105

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6.3





