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WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF  
ATTACK UP TO 70 DEGREES (U)

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U. S. NAVAL ORDNANCE LABORATORY  
WHITE OAK, MARYLAND

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NAVWEPS REPORT 7291

Aerodynamics Research Report 125

WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT  
ANGLES OF ATTACK UP TO 70 DEGREES

Prepared by

V. L. Schermerhorn  
F. J. LeMeritte

ABSTRACT: This report presents the results of an investigation in the NOL Supersonic Tunnel No. 1 to measure the static stability and drag of the Navy low-drag bomb at angles of attack up to 70 degrees. These data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

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4 October 1960

The purpose of this investigation was to obtain stability and drag data at high angles of attack on the Navy low-drag bomb for trajectory calculations. The wind-tunnel test was performed at the request of the Naval Weapons Laboratory (reference (a)), under Task Number 526. Other reports on the low-drag bomb shape are given in references (b) through (m).

W. D. COLEMAN  
Captain, USN  
Commander

R. KENNETH LOBB  
By direction

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WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT  
ANGLES OF ATTACK UP TO 70 DEGREES

INTRODUCTION

1. The low-drag bomb is a standard Navy external store carried by high speed aircraft. The MK 81, 82, 83, and 84 bombs use the low-drag bomb shape as tested in this investigation.
2. This report gives the results of a wind-tunnel investigation to determine the stability and drag coefficients at high angles of attack (up to 70 degrees). The coefficients are necessary for trajectory calculations. The data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

AERODYNAMIC SYMBOLS

A	reference area (based on maximum body diameter)
c.g.	center of gravity, 3.64 calibers forward from the base
$C_A$	axial force coefficient ( $F_A/qA$ )
$C_\theta$	pitching moment coefficient ( $M_\theta/qAd$ )
$C_N$	normal force coefficient ( $F_N/qA$ )
$C_Y$	side force coefficient ( $F_Y/qA$ )
$C_\phi$	rolling moment coefficient ( $M_\phi/qAd$ )
$C_\psi$	yawing moment coefficient ( $M_\psi/qAd$ )
d	reference diameter (maximum body diameter - caliber) (1.5 in)
$F_A$	axial force (lbs)
$F_N$	normal force (lbs)
$F_Y$	side force (lbs)
$M_\theta$	pitching moment (in-lbs)
$M_\phi$	rolling moment (in-lbs)
$M_\psi$	yawing moment (in-lbs)
q	dynamic pressure (psi)

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- $\alpha$  angle of attack (deg)
- $\phi$  angle of roll ( $\phi = 0^\circ$  with fins in horizontal and vertical planes respectively) (deg)

MODEL, TEST TECHNIQUES, AND DATA REDUCTION

3. A sketch of the model is shown as Figure 1. The data were obtained using a six-component internal strain-gage balance (reference (n)). These data were recorded on IBM cards using the automatic data recording system explained in reference (o). The IBM 704 machine was used to reduce the wind-tunnel data to coefficient form. A correction was made to the data for the elastic deflection of the sting due to the aerodynamic loading.

DISCUSSION

4. Six-component data were desired over a Mach number range from 0.40 to 2.03 at angles of attack up to 70 degrees. At the supersonic Mach numbers the model size restricted the maximum angle of attack. At a Mach number of 1.53, the maximum angle of attack was 10 degrees, Mach number 1.76 the maximum angle of attack, 12 degrees, and at Mach number 2.03 the maximum angle of attack, 30 degrees.

5. The data are plotted in coefficient form versus angle of attack in Figures 2 through 37. An index of the plotted data is presented in Table I.

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### REFERENCES

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- (n) Shantz, I., Gilbert, B. D., and White, C. E., "NOL Wind-Tunnel Internal Strain-Gage Balance System," NAVORD Report 2972, Unclassified, (1953)
- (o) Gilbert, B. D., "Automatic Data Processing System (ADAPS) for the Supersonic Wind Tunnels," NAVORD Report 2813, Unclassified, (1953)

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TABLE I  
INDEX OF PLOTTED DATA

Figure No.	Run Number	Mach No.	$\theta$ deg	$\alpha$ deg	Coefficients Plotted
2	8	1.53	-45	0-10	$C_N, C_\theta, C_Y, C_\psi$
3	8	1.53	-45	0-10	$C_\theta, C_A$
4	9	1.53	-22.5	0-10	$C_N, C_\theta, C_Y, C_\psi$
5	9	1.53	-22.5	0-10	$C_\theta, C_A$
6	10	1.53	0	0-10	$C_N, C_\theta, C_Y, C_\psi$
7	10	1.53	0	0-10	$C_\theta, C_A$
8	7	1.76	-45	0-12	$C_N, C_\theta, C_Y, C_\psi$
9	7	1.76	-45	0-12	$C_\theta, C_A$
10	6	1.76	-22.5	0-12	$C_N, C_\theta, C_Y, C_\psi$
11	6	1.76	-22.5	0-12	$C_\theta, C_A$
12	5	1.76	0	0-12	$C_N, C_\theta, C_Y, C_\psi$
13	5	1.76	0	0-12	$C_\theta, C_A$
14	18, 20, 21	0.40	-45	0-70	$C_N, C_\theta, C_Y, C_\psi$
15	18, 20, 21	0.40	-45	0-70	$C_\theta, C_A$
16	19, 22	0.40	-22.5	0-70	$C_N, C_\theta, C_Y, C_\psi$
17	19, 22	0.40	-22.5	0-70	$C_\theta, C_A$
18	23	0.40	0	30-70	$C_N, C_\theta, C_Y, C_\psi$



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TABLE I (Cont.d)

Figure No.	Run Number	Mach No.	$\theta$ deg	$\alpha$ deg	Coefficients Plotted
19	23	0.40	0	30-70	$C_{\theta}$ , $C_A$
20	17,27,34	0.60	-45	0-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
21	17,27,34	0.60	-45	0-70	$C_{\theta}$ , $C_A$
22	16,26	0.60	-22.5	0-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
23	16,26	0.60	-22.5	0-70	$C_{\theta}$ , $C_A$
24	15,24,25, 33	0.60	0	0-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
25	15,24,25 33	0.60	0	0-70	$C_{\theta}$ , $C_A$
26	28,31	0.80	-45	29-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
27	28,31	0.80	-45	29-70	$C_{\theta}$ , $C_A$
28	12,29	0.80	-22.5	0-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
29	12,29	0.80	-22.5	0-70	$C_{\theta}$ , $C_A$
30	11,13,14, 30,32	0.80	0	0-70	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
31	11,13,14, 30,32	0.80	0	0-70	$C_{\theta}$ , $C_A$
32	1,2	2.03	-45	-6-30	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
33	1,2	2.03	-45	-6-30	$C_{\theta}$ , $C_A$
34	3	2.03	-22.5	-0-30	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
35	3	2.03	-22.5	-0-30	$C_{\theta}$ , $C_A$
36	4	2.03	0	-0-30	$C_N$ , $C_{\theta}$ , $C_Y$ , $C_{\psi}$
37	4	2.03	0	-0-30	$C_{\theta}$ , $C_A$

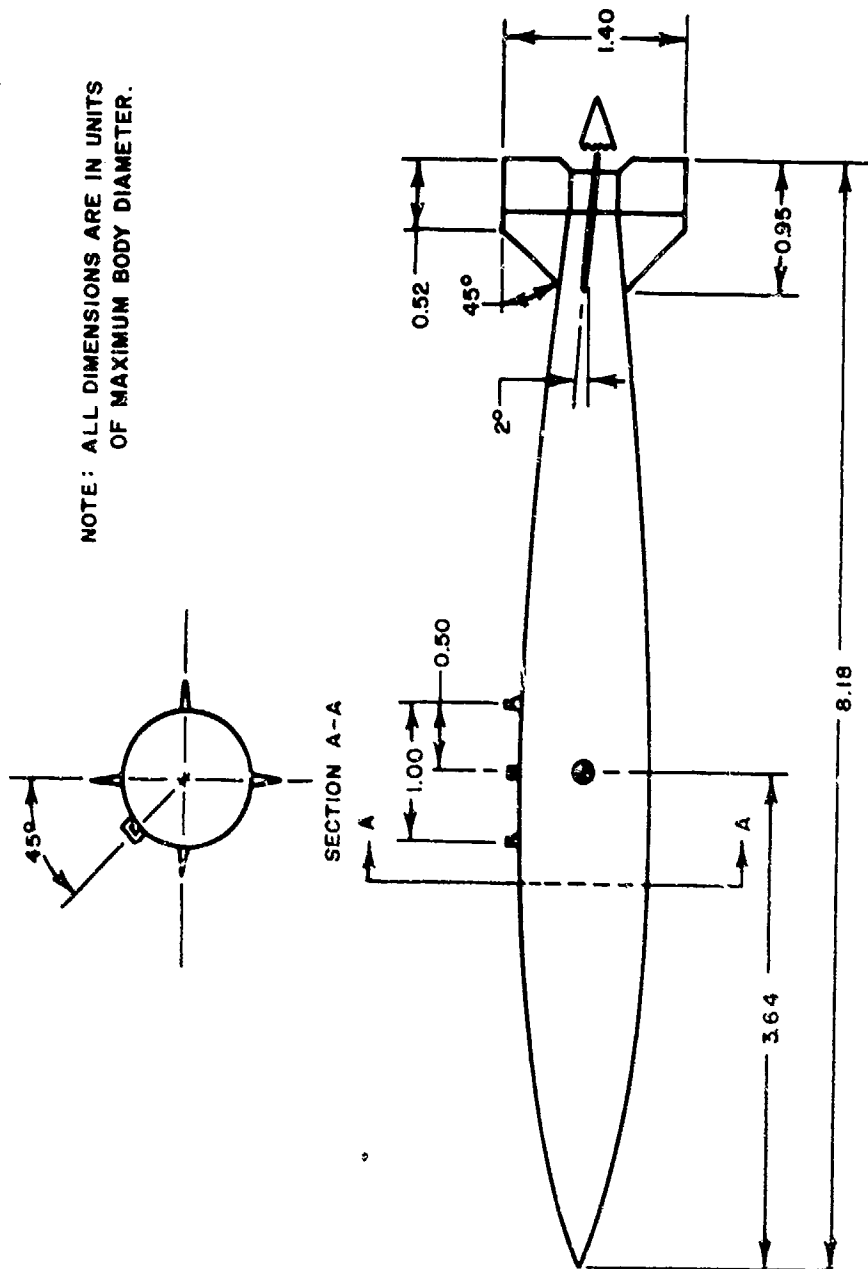


FIG. 1 U.S. NAVY GENERAL PURPOSE LOW DRAG BOMB

LOW DRAG BOMB

$\theta = -45$

$M = 1.53$

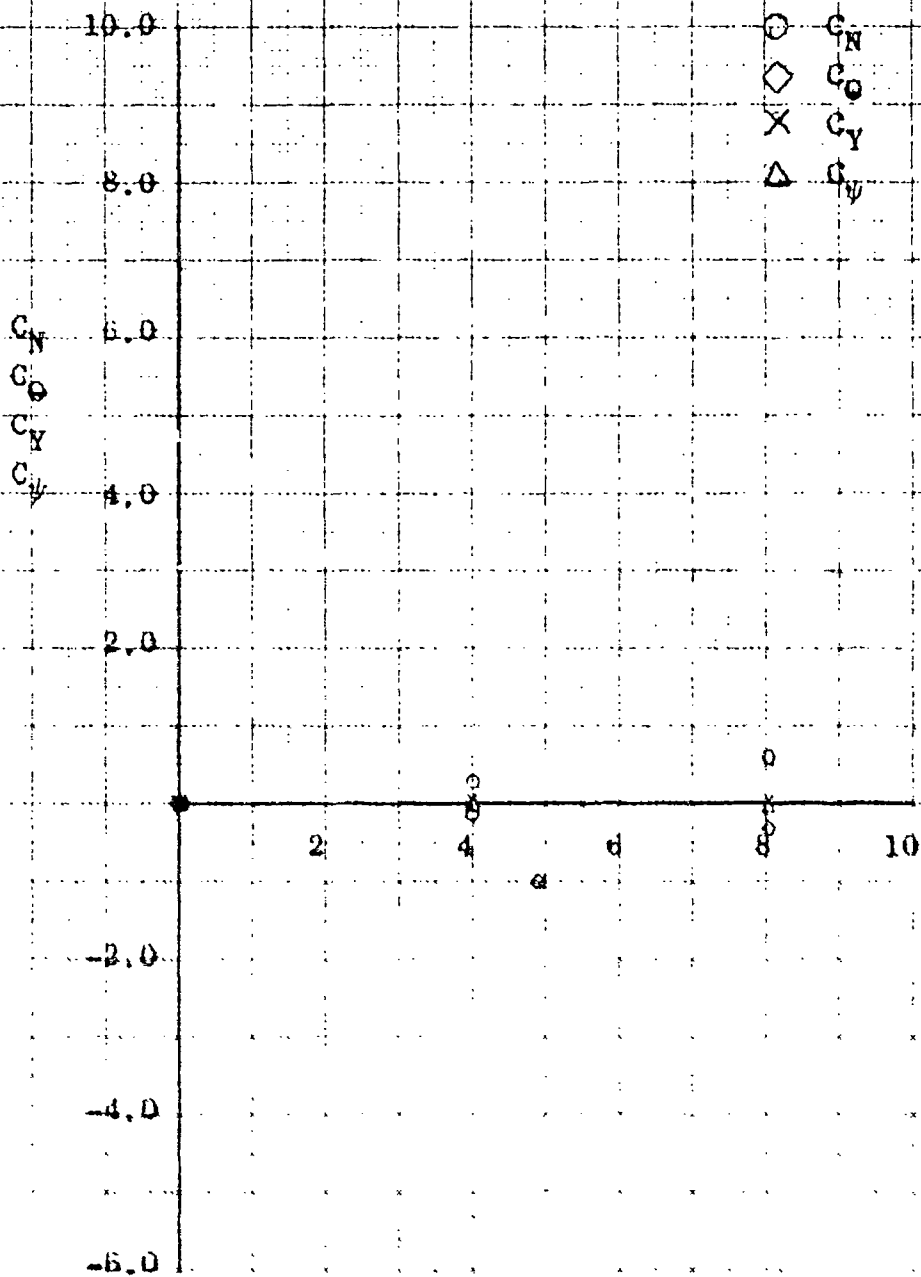


FIG. 2  $C_N, C_D, C_Y, C_Z$  vs.  $\alpha$

LOW DRAG BOMB

$\theta = -45$   
 $M = 1.53$

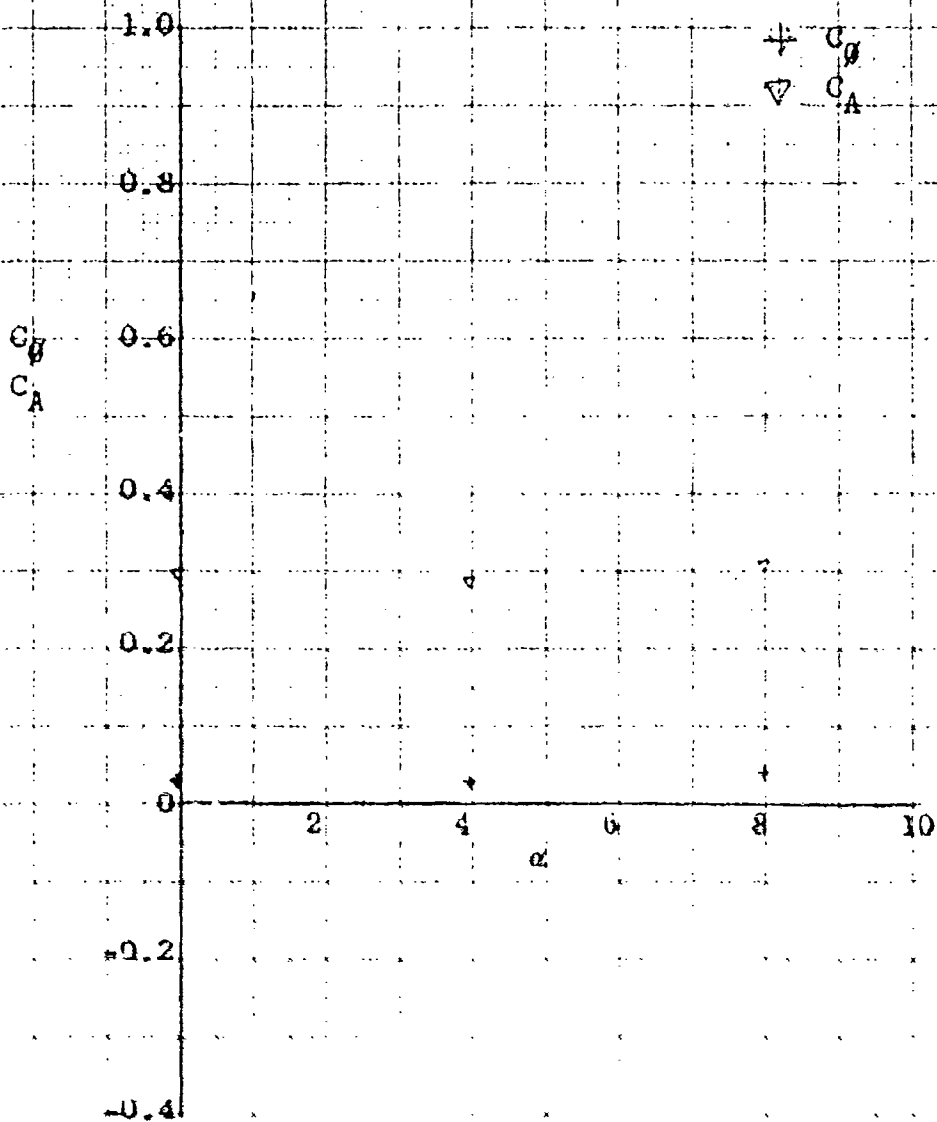


FIG. 3  $C_g, C_A$  vs.  $\alpha$

NAVWEPS REPORT 7291

LOW FRAG BOMB

$\theta = -22.5$

$M = 1.53$

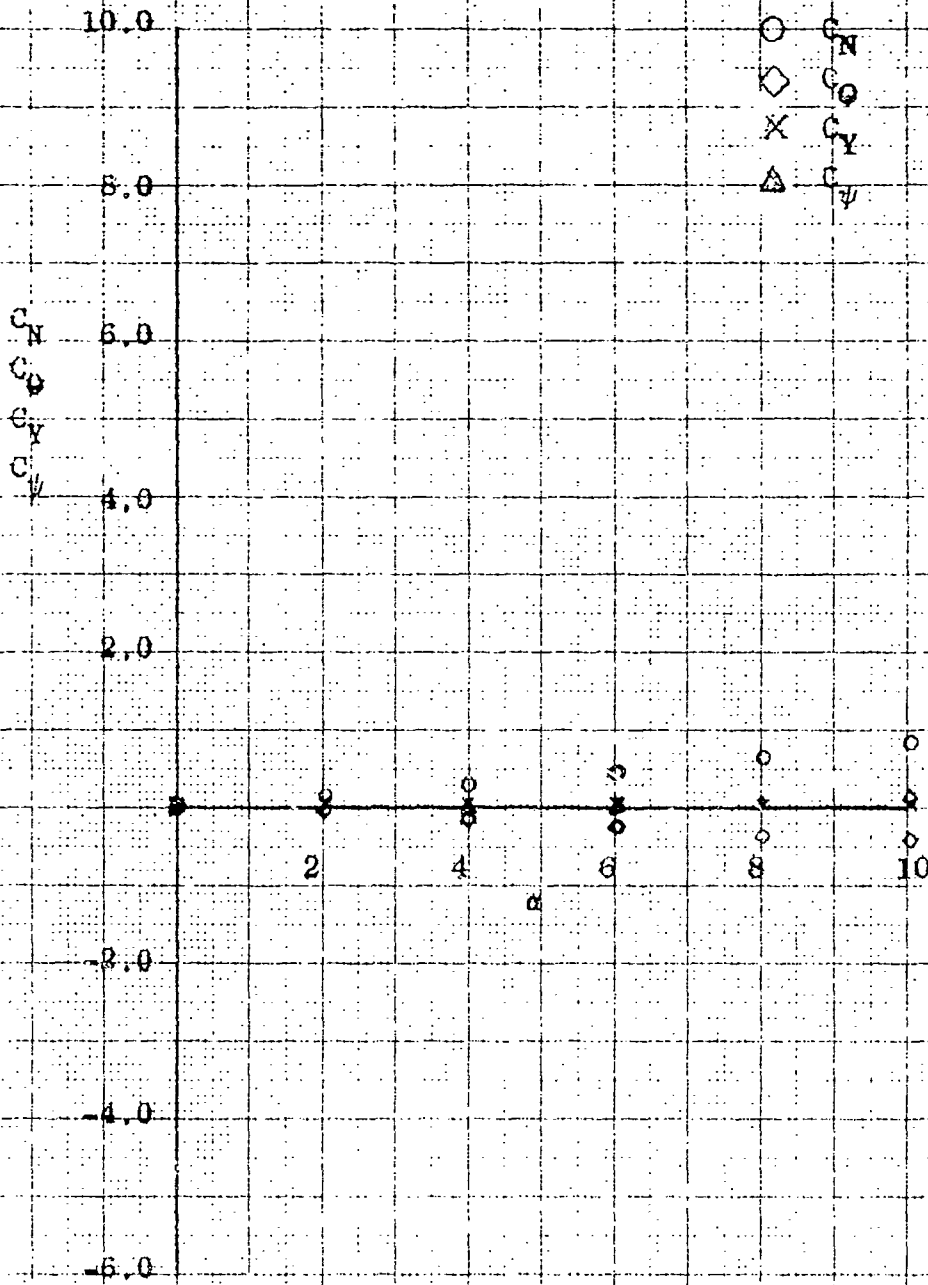


FIG. 4  $C_N, C_Q, C_Y, C_W$  vs.  $\alpha$

LOW DRAG BOMB

$\theta = 0$   
 $M = 1.53$

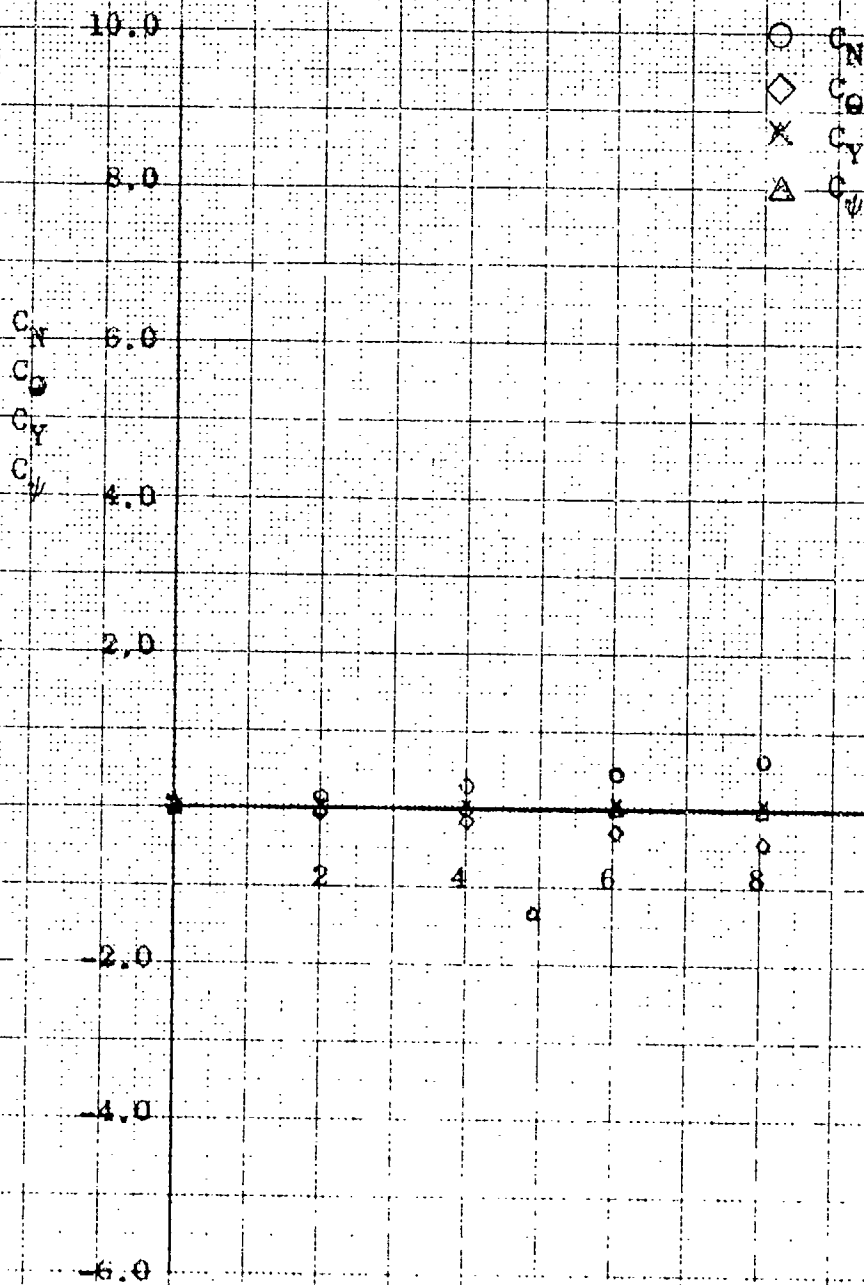


FIG. 6  $C_L, C_D, C_Y, C_{Y'}$  vs.  $\alpha$

LOW DRAG BOMB

$\theta = 0$   
 $M = 1.53$

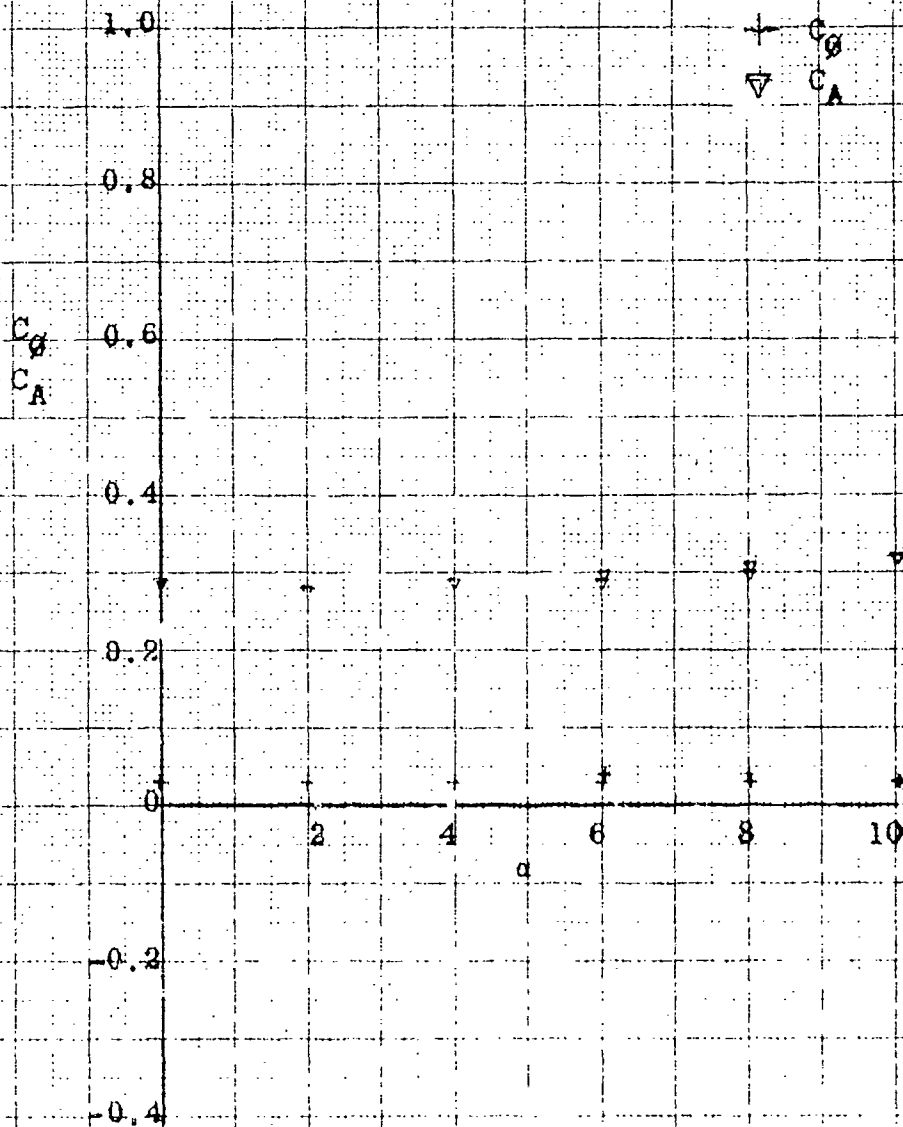


FIG. 7  $C_D, C_A$  vs.  $\alpha$

NAVWEPS REPORT 7291

LOW DRAG BOMB

$\theta = -45$   
 $M = 1.76$

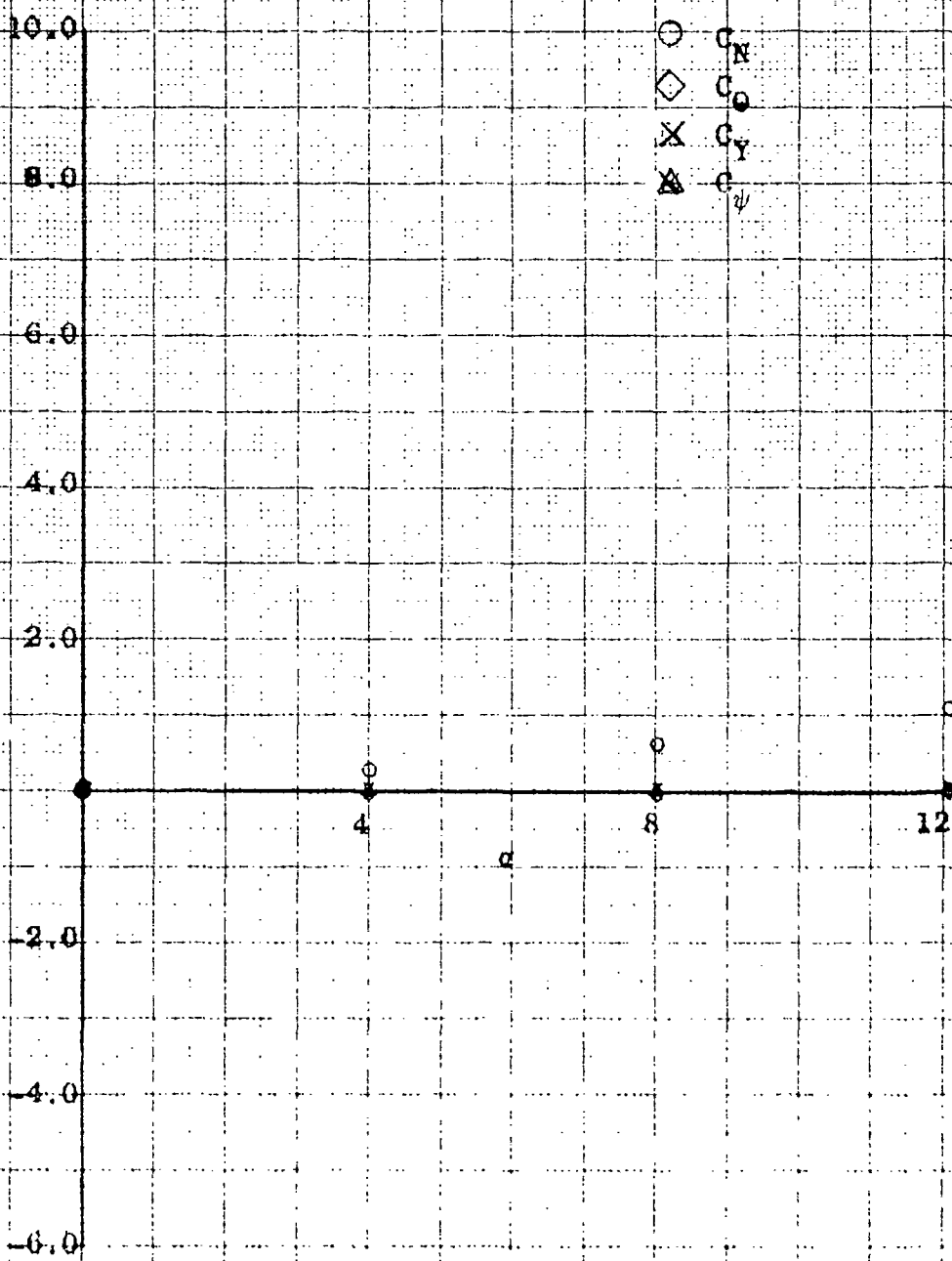


FIG. 8  $C_N, C_D, C_Y, C_V$  vs.  $\alpha$



LOW DRAG BOMB

$\theta = -45$

$M = 1.76$

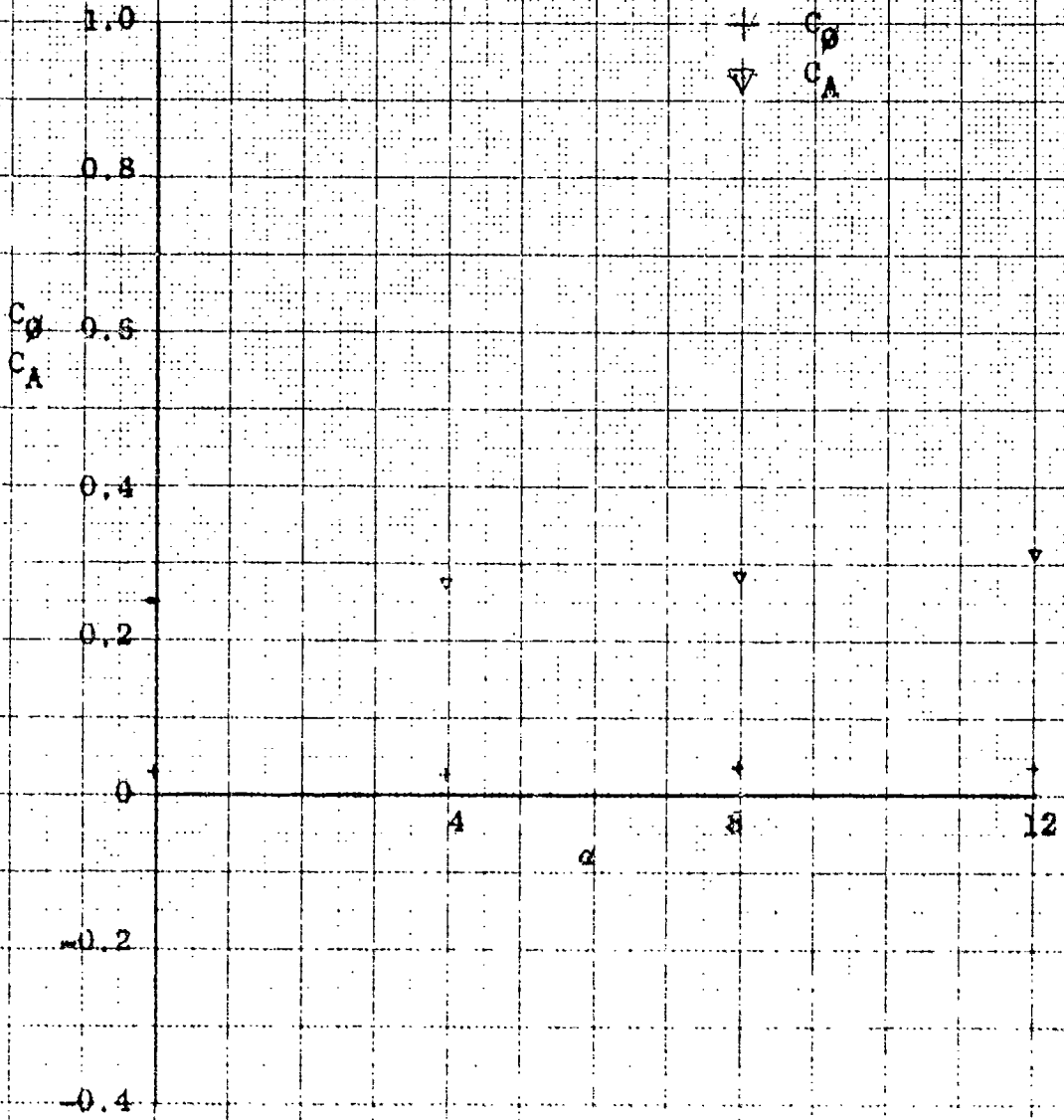


FIG. 9  $C_D, C_A$  vs.  $\alpha$

NAYWEPS REPORT 7291

LOW DRAG BOMB

$\theta = -22.5$   
 $M = 1.76$

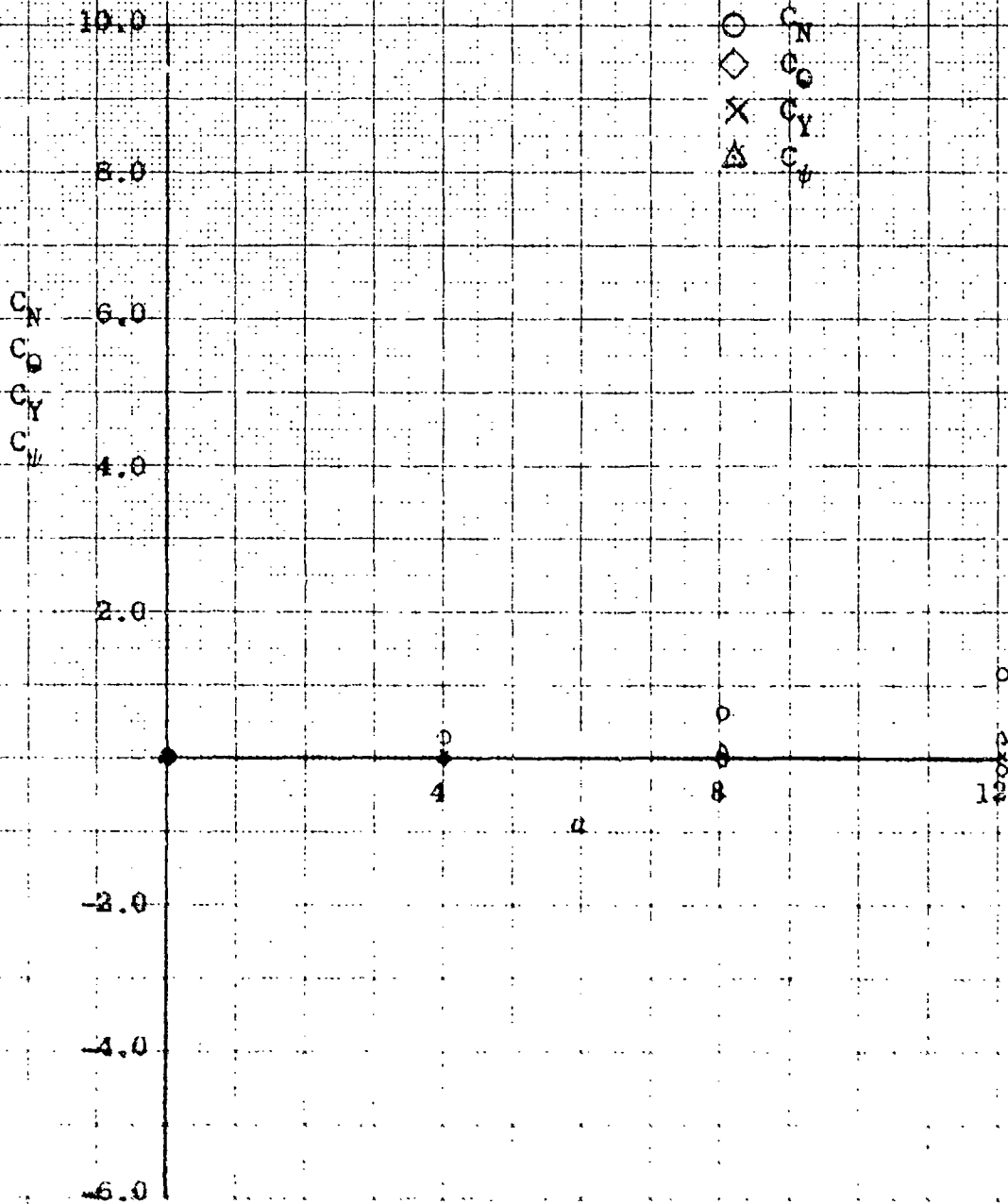


FIG. 10  $C_N, C_D, C_Y, C_W$  vs:  $\alpha$

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LOW DRAG BOMB

$\theta = -22.5$   
 $M = 1.76$

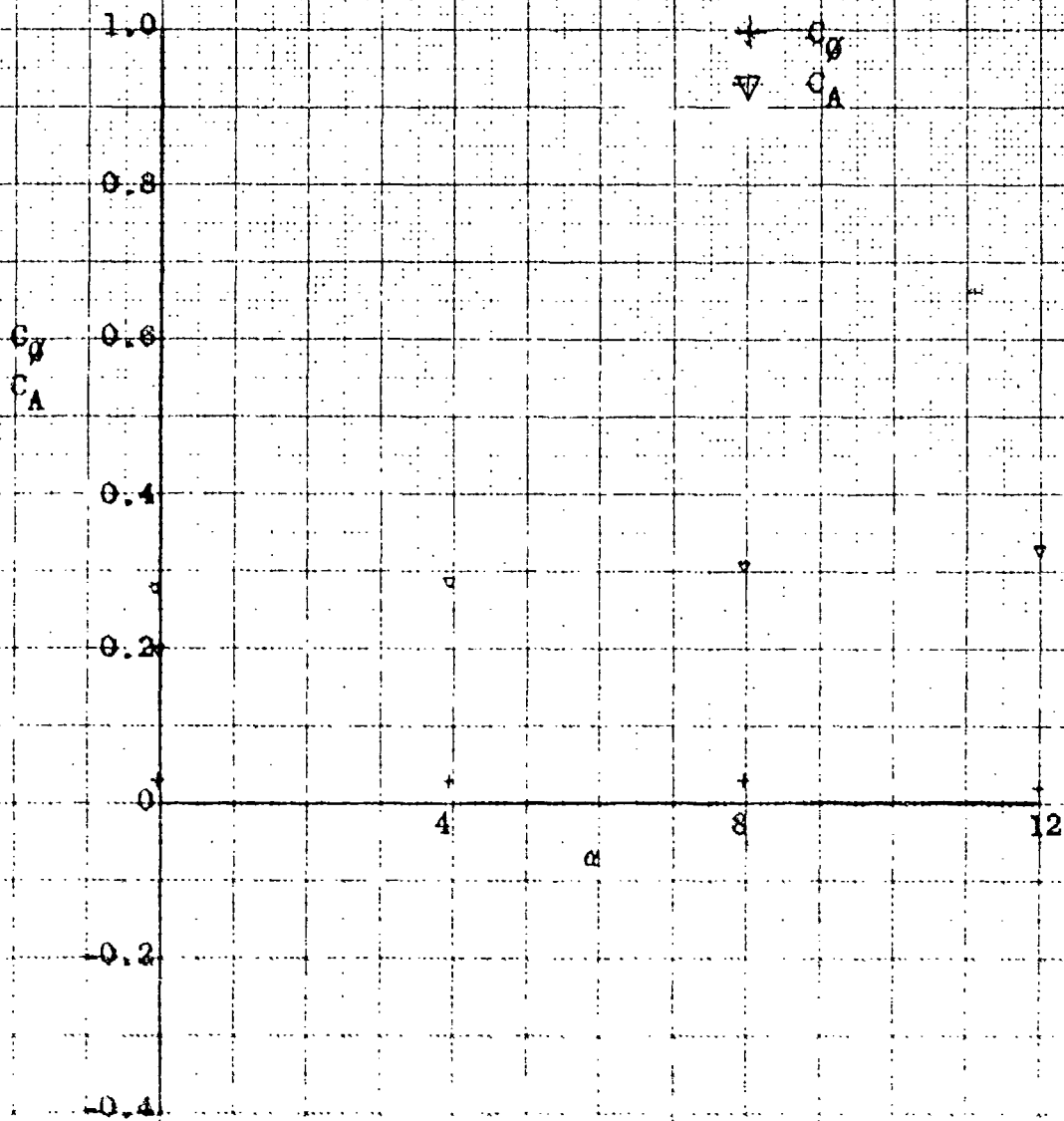


FIG. 11.  $C_D, C_A$  vs.  $\alpha$

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LOW DRAG BOMB

$\theta = 0$

$M = 1.76$

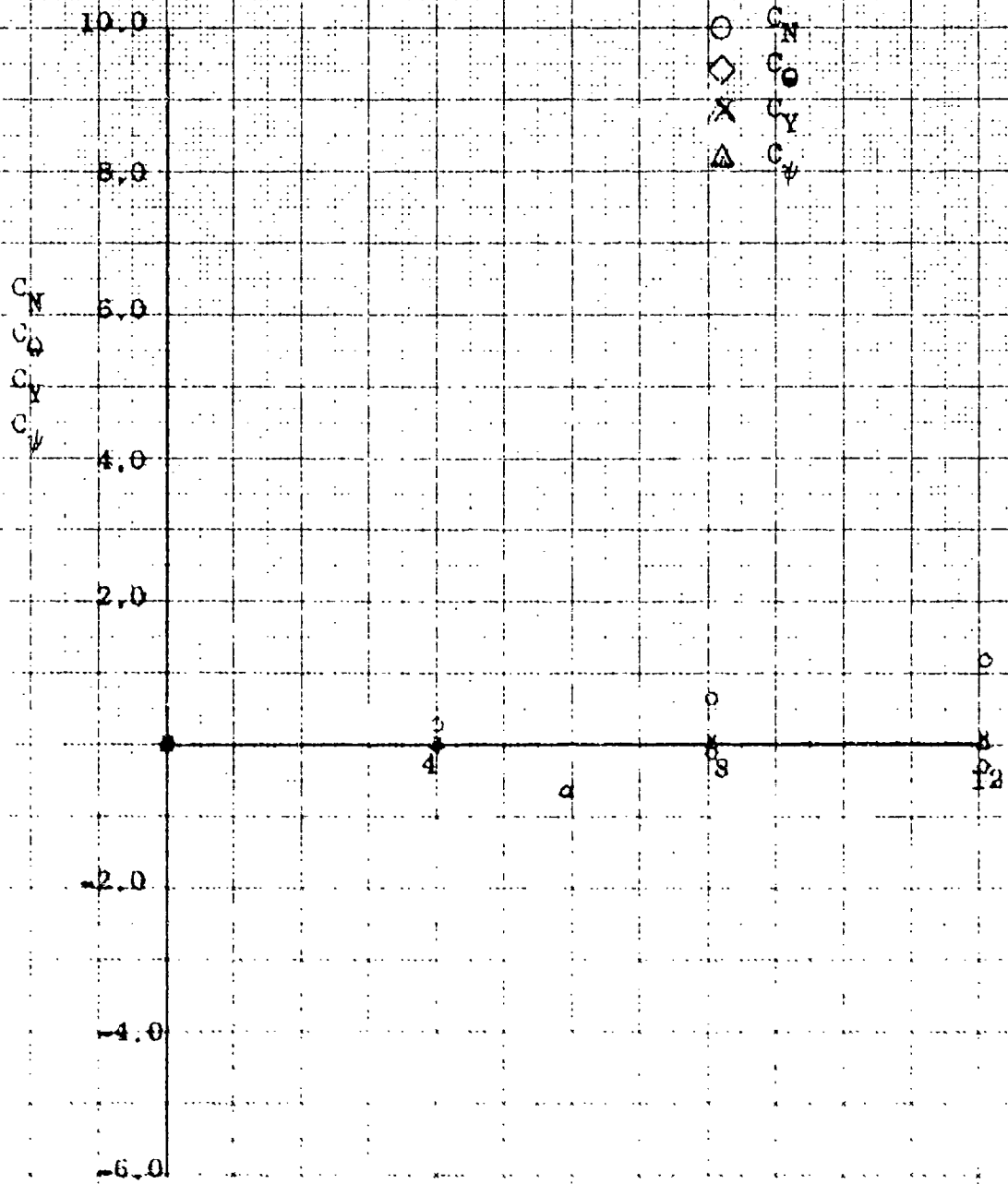


FIG. 12  $C_N, C_D, C_Y, C_Z$  vs.  $\alpha$

NAVWERS REPORT 7291

LOW DRAG BOMB

$\beta = 0$   
 $M = 1.76$

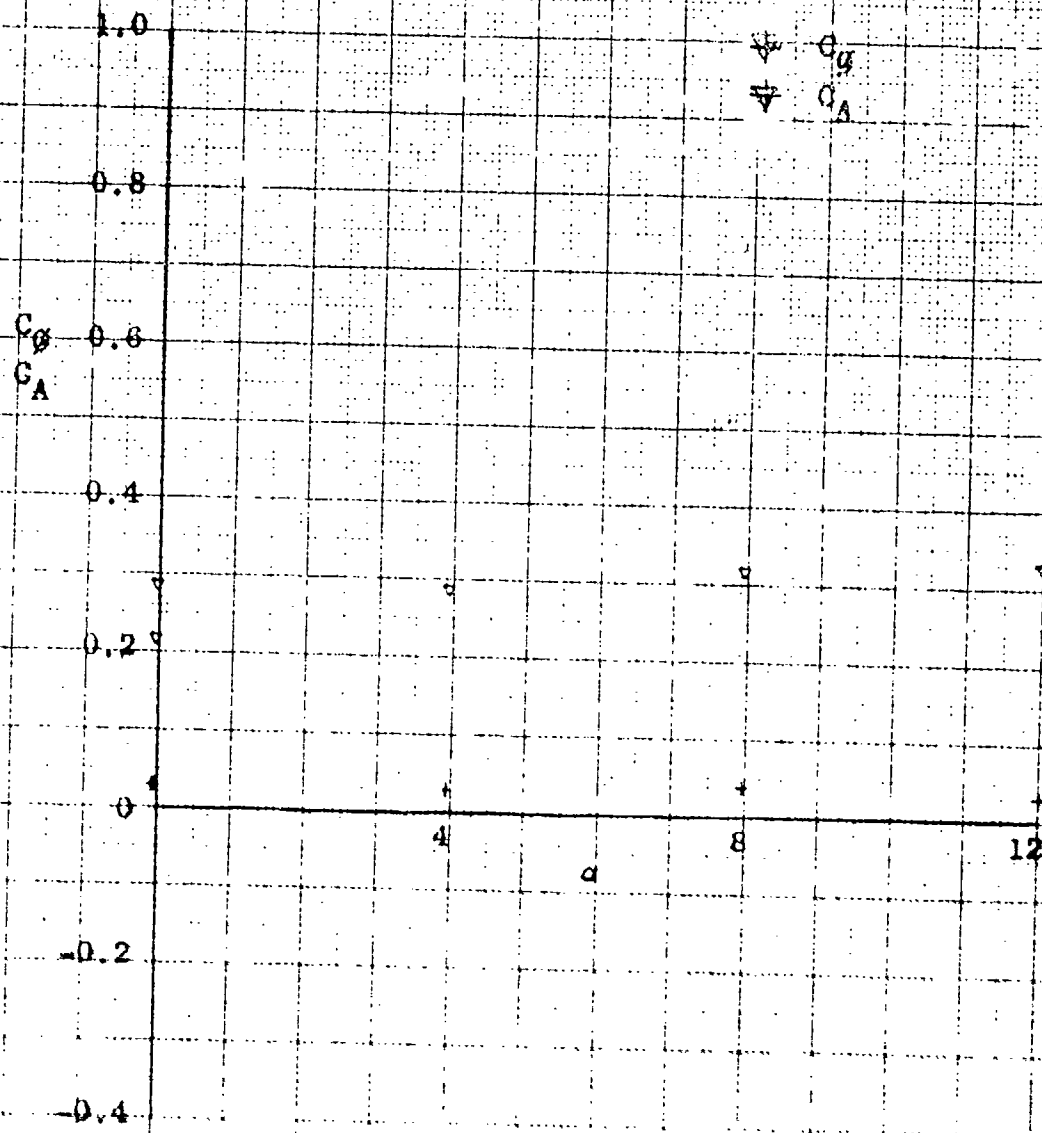
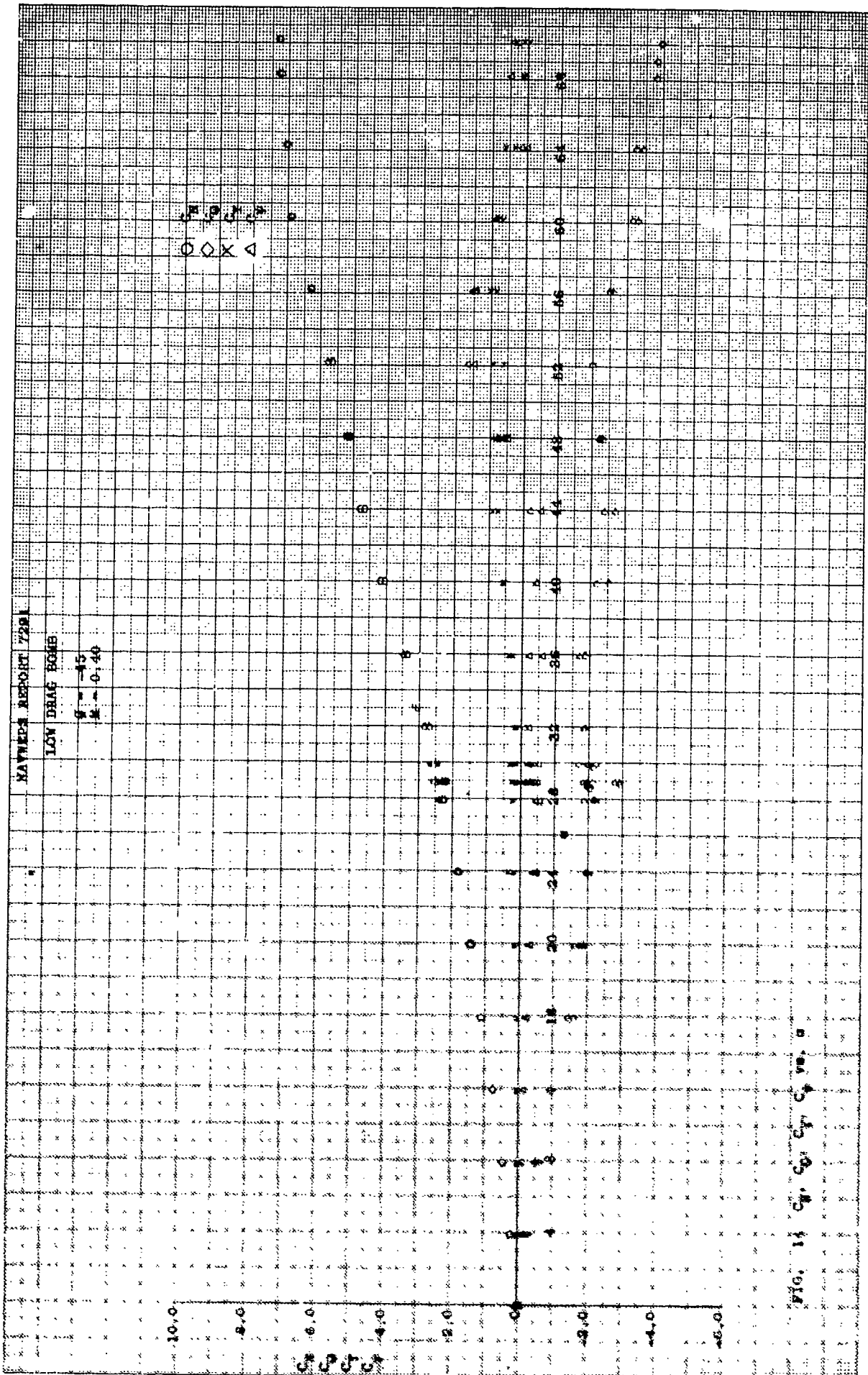


FIG. 13  $C_D, C_A$  vs.  $\alpha$

NAVY REPORT 7291

LOY DRAG BOGS

$\sigma = .45$   
 $\mu = 0.40$



MAYWIFE REPORT 72881

LOW DRAG BOMB

$g = 45$

$M = 0.40$

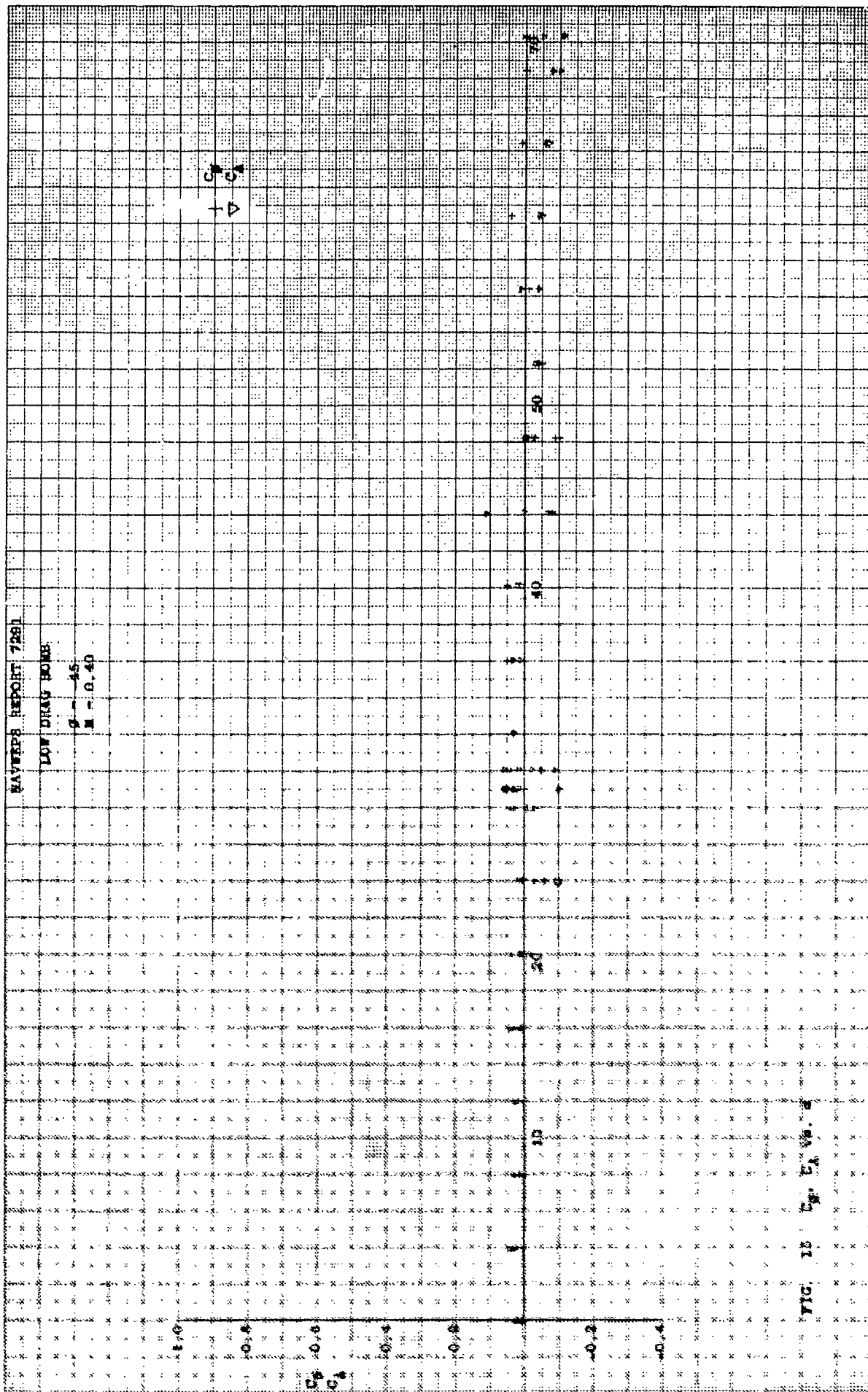
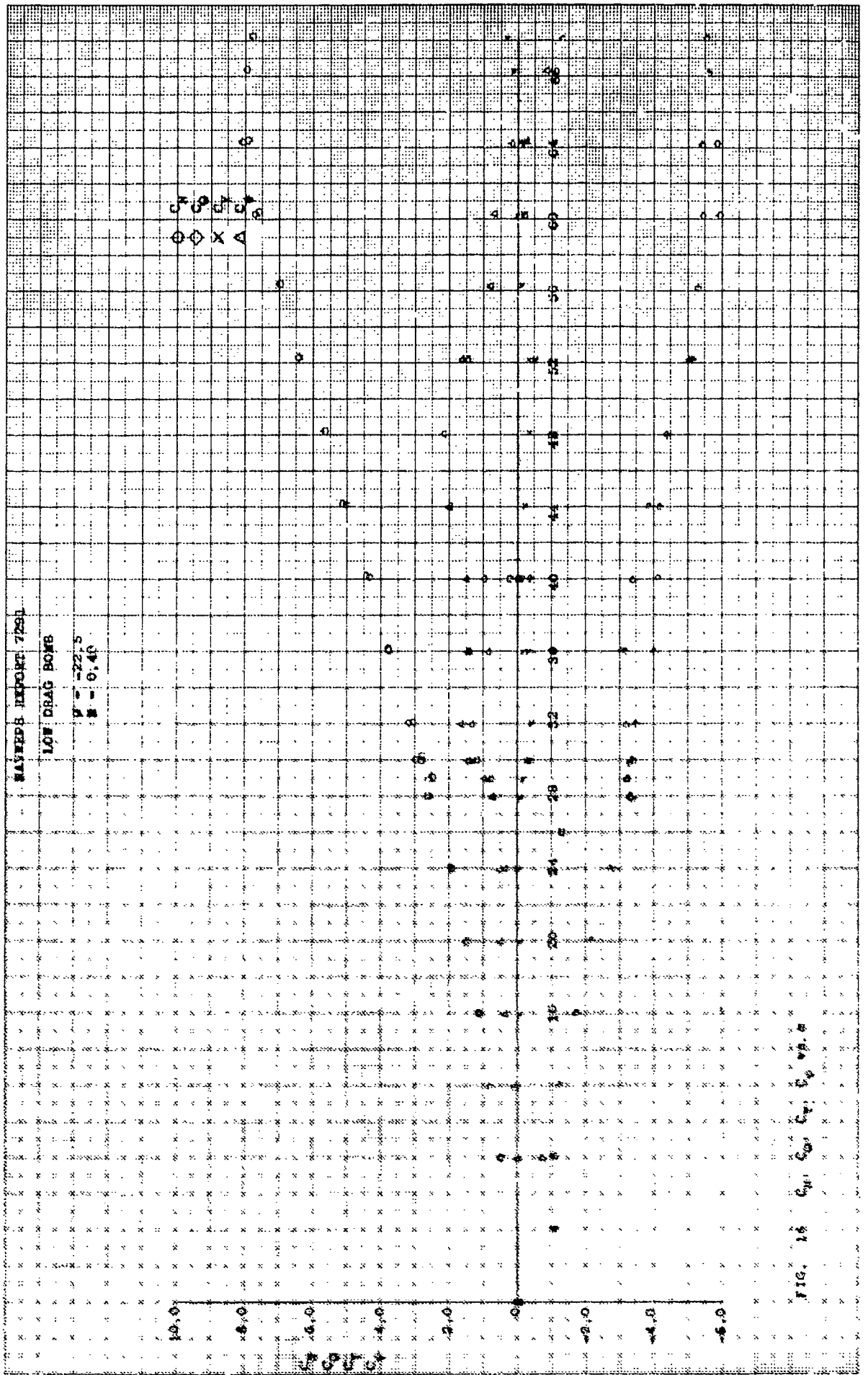


FIG. 15 Cp vs Cm





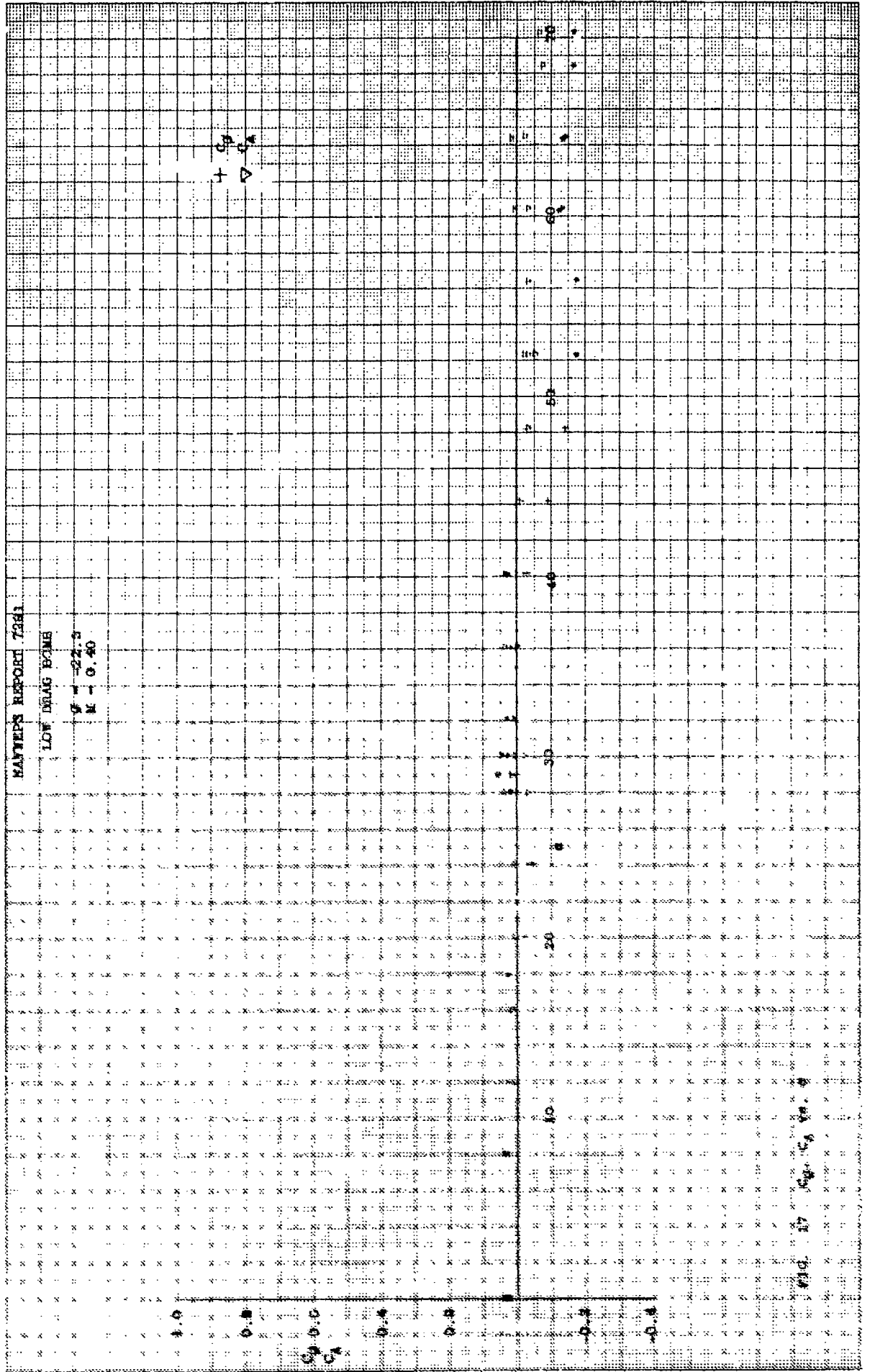
HAYTER'S REPORT 7241

LOW DRAG BOMB

$\gamma = -22.5$

$\mu = 0.40$

$\Delta$   
+ 0.5



17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

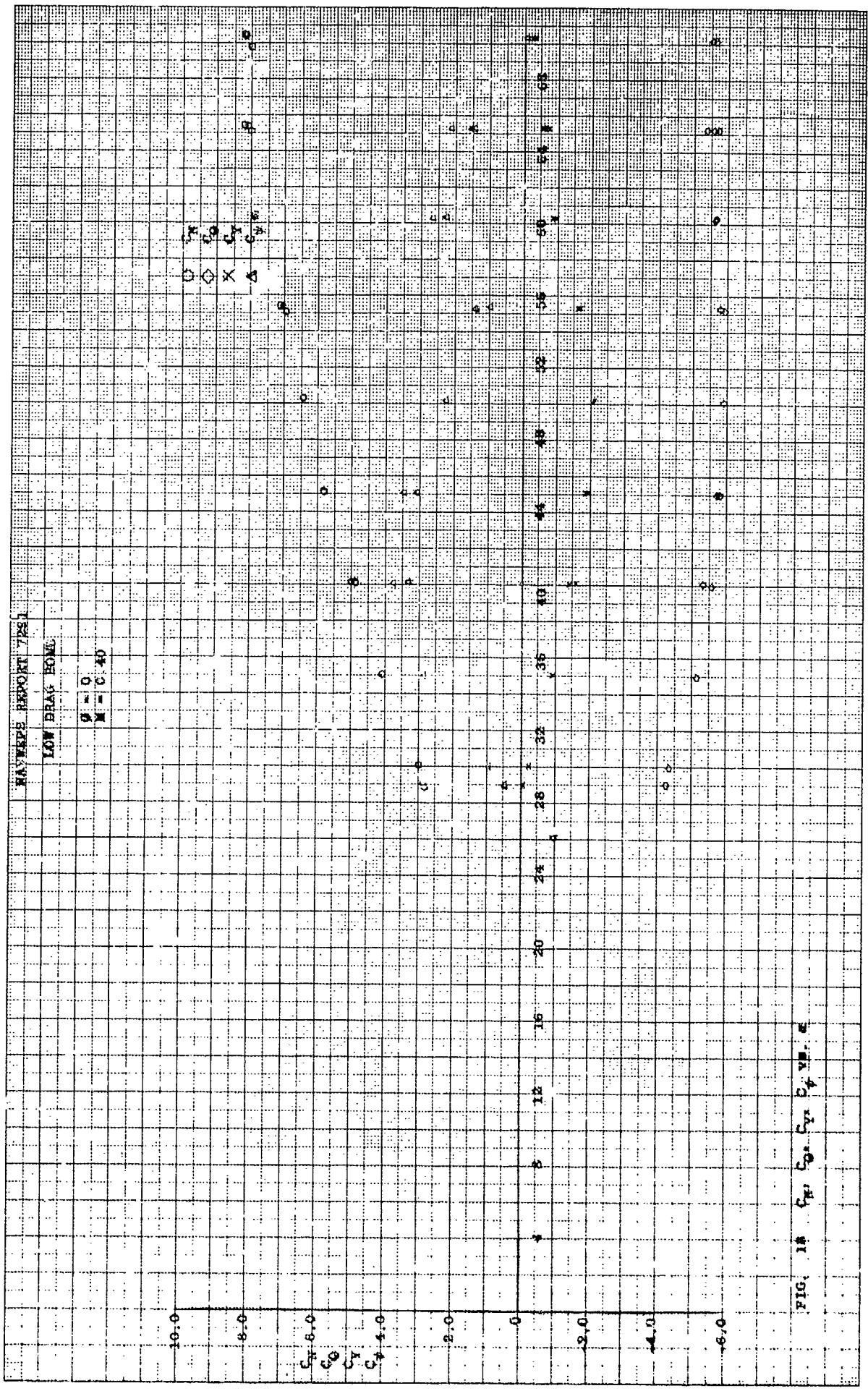


FIG. 14  $C_p, C_x, C_y, C_z$  vs.  $\alpha$

NAVY'S REPORT 722

LOW DRAG BOMB

$\beta = 0$

$\mu = 0.40$

1.0

0.8

0.6

$C_D$

0.4

0.2

0.0

-0.2

-0.4

$\Delta$   $C_D$   
 $\square$   $C_A$

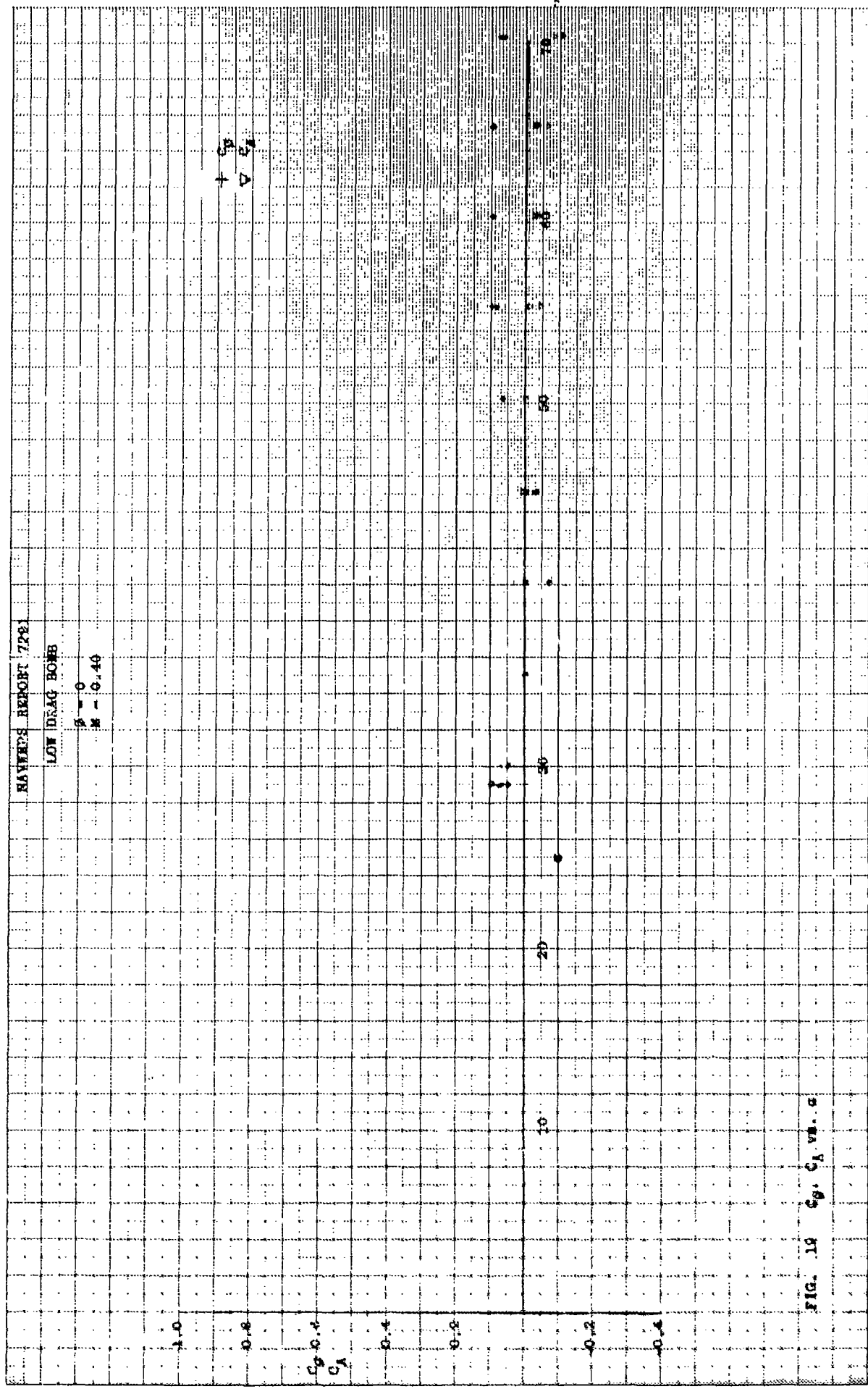


FIG. 19  $C_D$ ,  $C_A$  vs.  $V$

NAVY'S REPORT 722

RAYWING REPORT 7891

LOW DRAG BOBB

$\beta = -45$

$M = 0.60$

10.0

6.0

2.0

0.0

-2.0

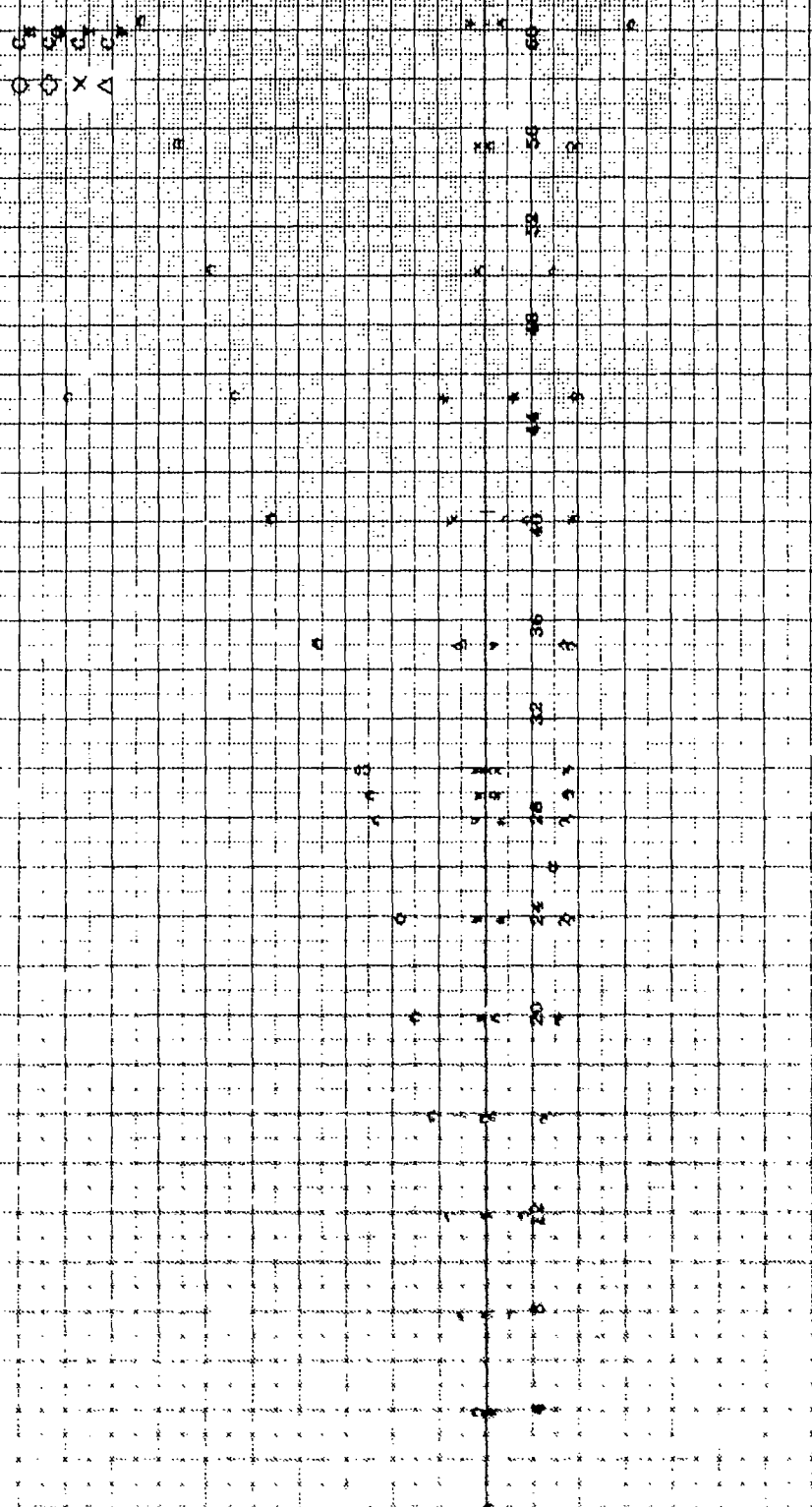
-4.0

-6.0

-8.0

-10.0

FIG. 26  $C_D$ ,  $C_L$ ,  $C_M$  vs.  $\alpha$



K.M. 2007 141

SAMCO'S PATENT 2281

DAN IRLE MONTE

W. 100  
H. 100

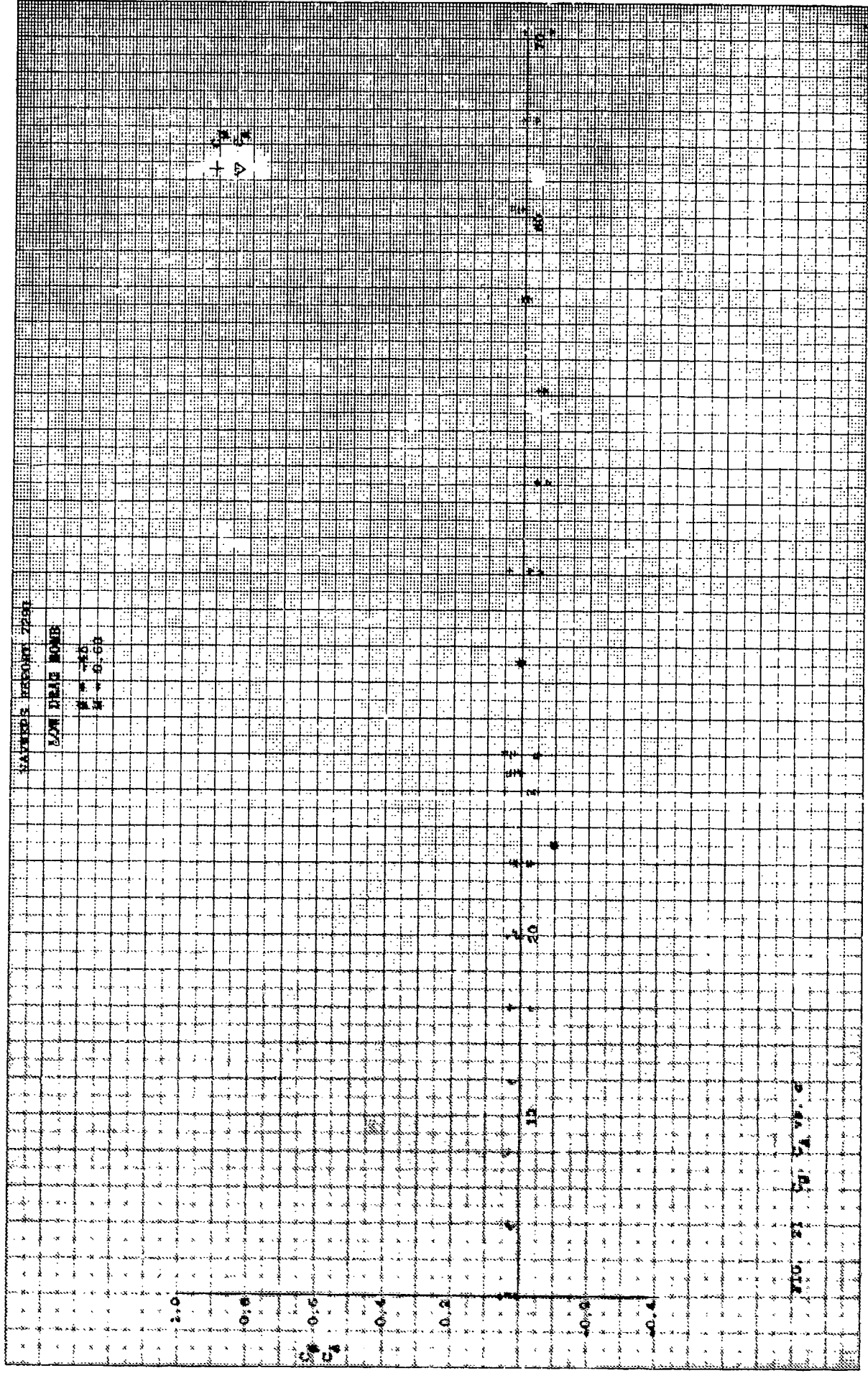


FIG. 12 U.S. PAT. 2,281,281

WATERS REPORT 7281

LOW BRAG BOMB

$\theta = 22.5$   
 $\lambda = 0.60$

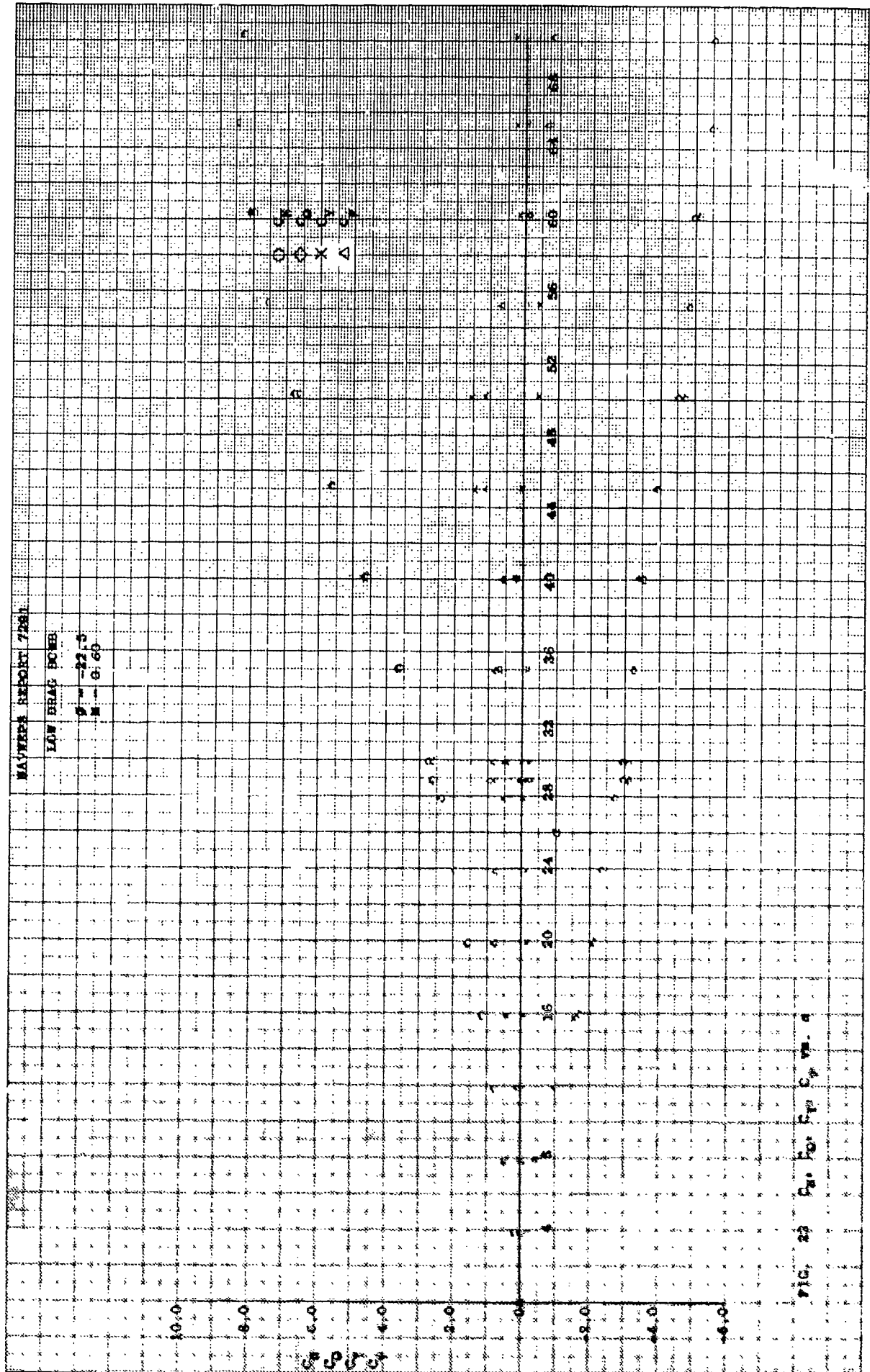
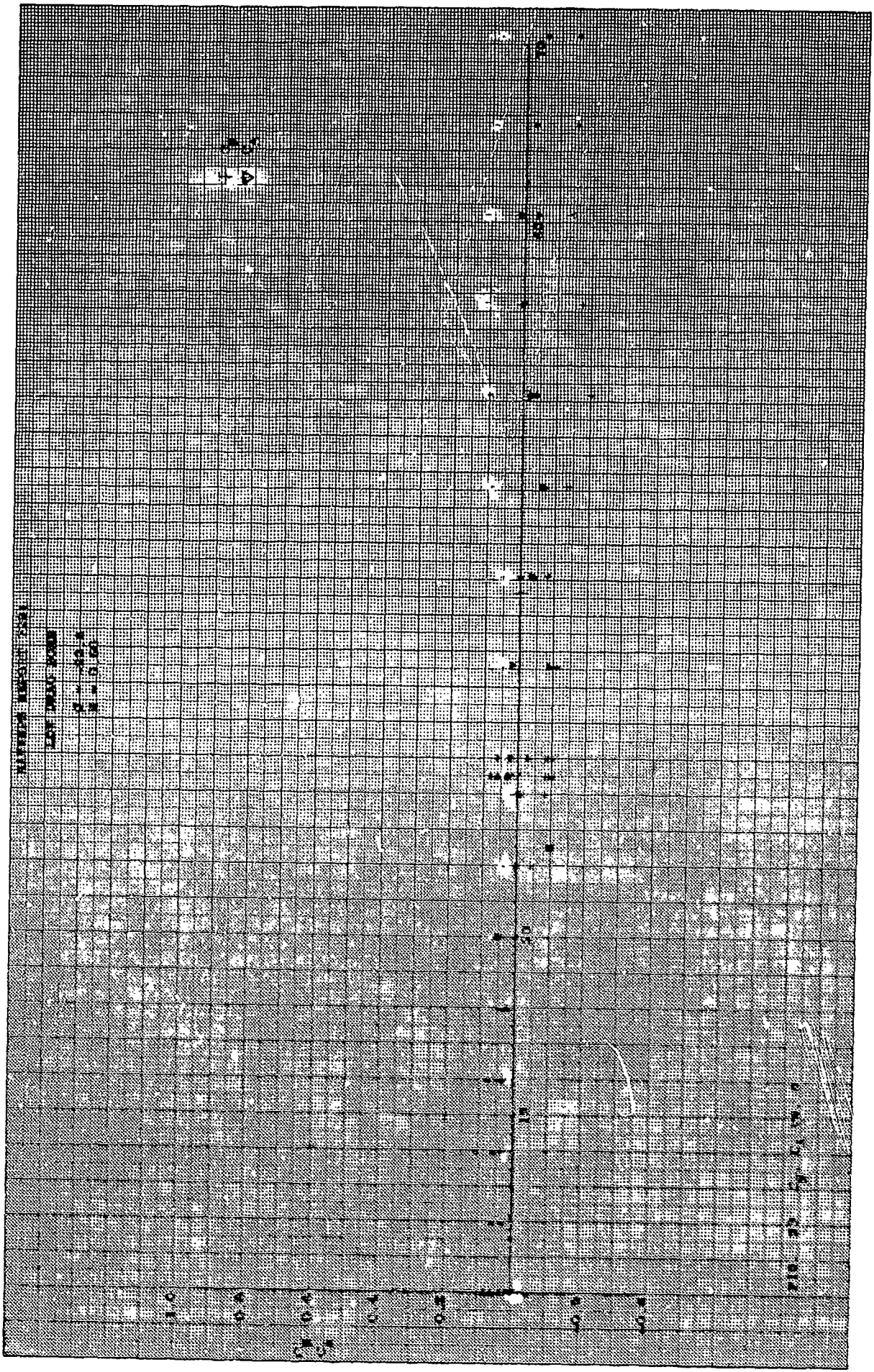


FIG. 23 Pa. For C<sub>10</sub>H<sub>8</sub>

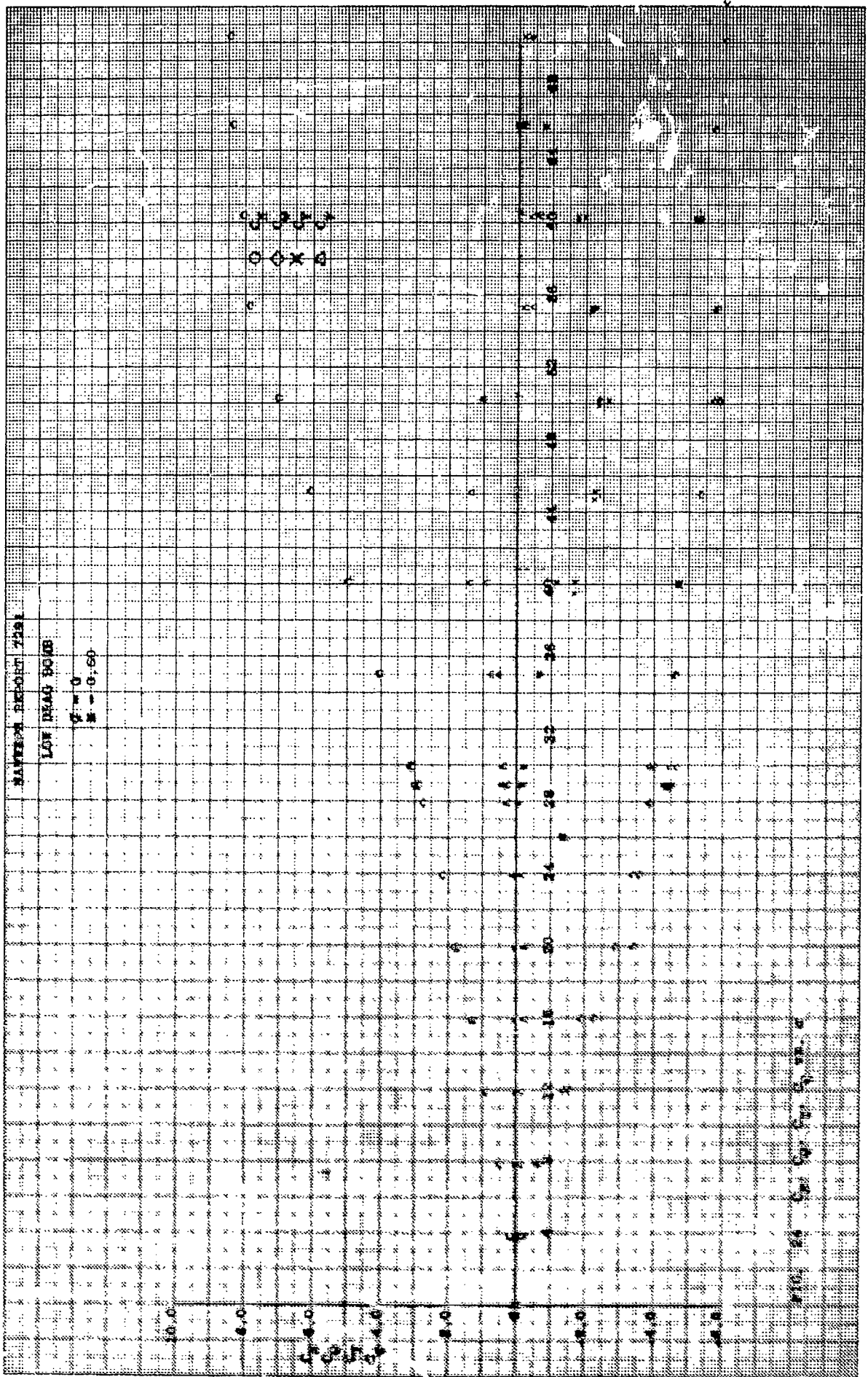


NAUTICAL REPORT FORM

LOG DRAG POINT

$\gamma = 0$

$\delta = 0.50$





NAVIER'S REPORT 7281

LOW DRAG BOMB

$\beta = 0$

$M = 0.60$

$\Delta$   
CA  
CA

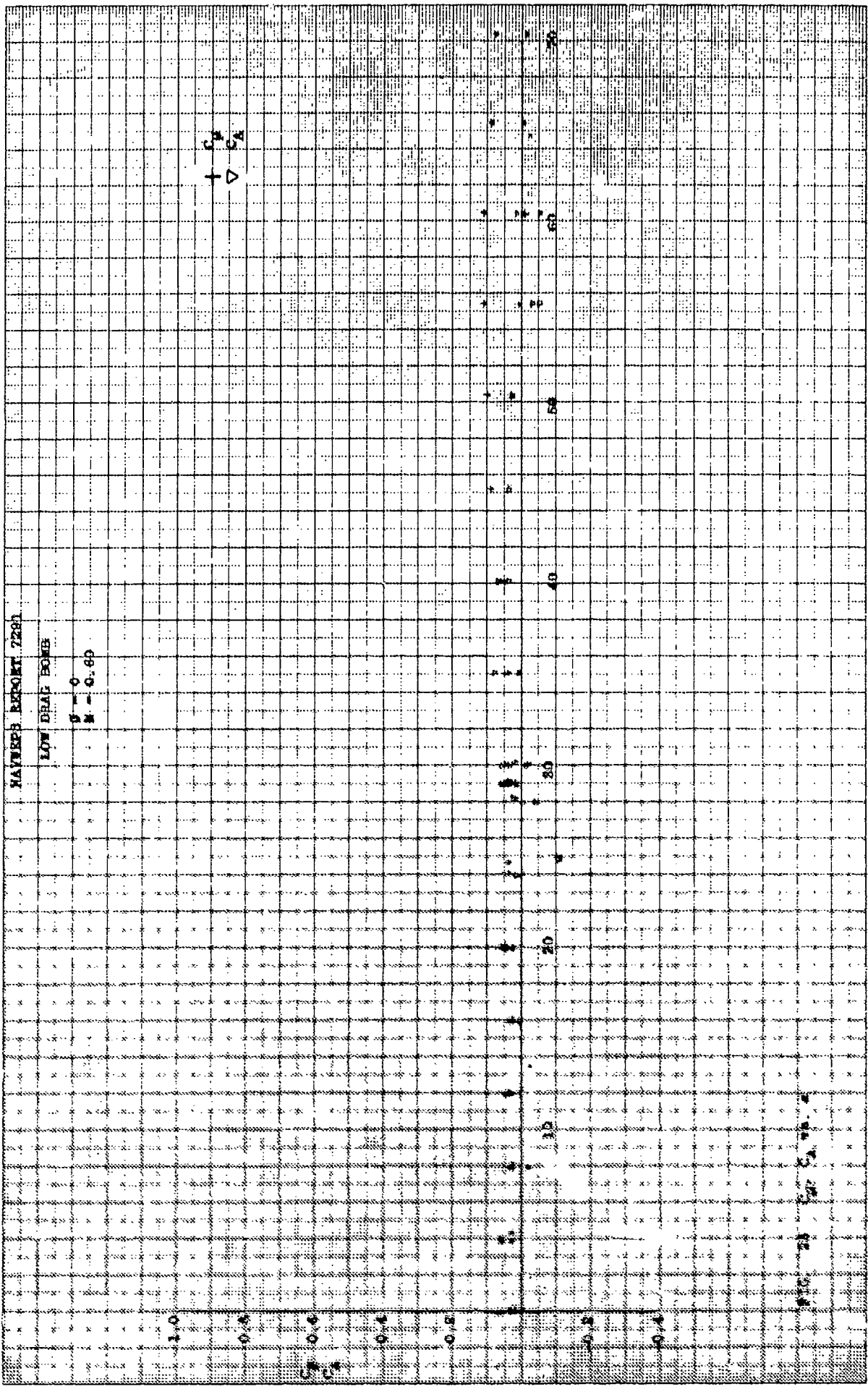
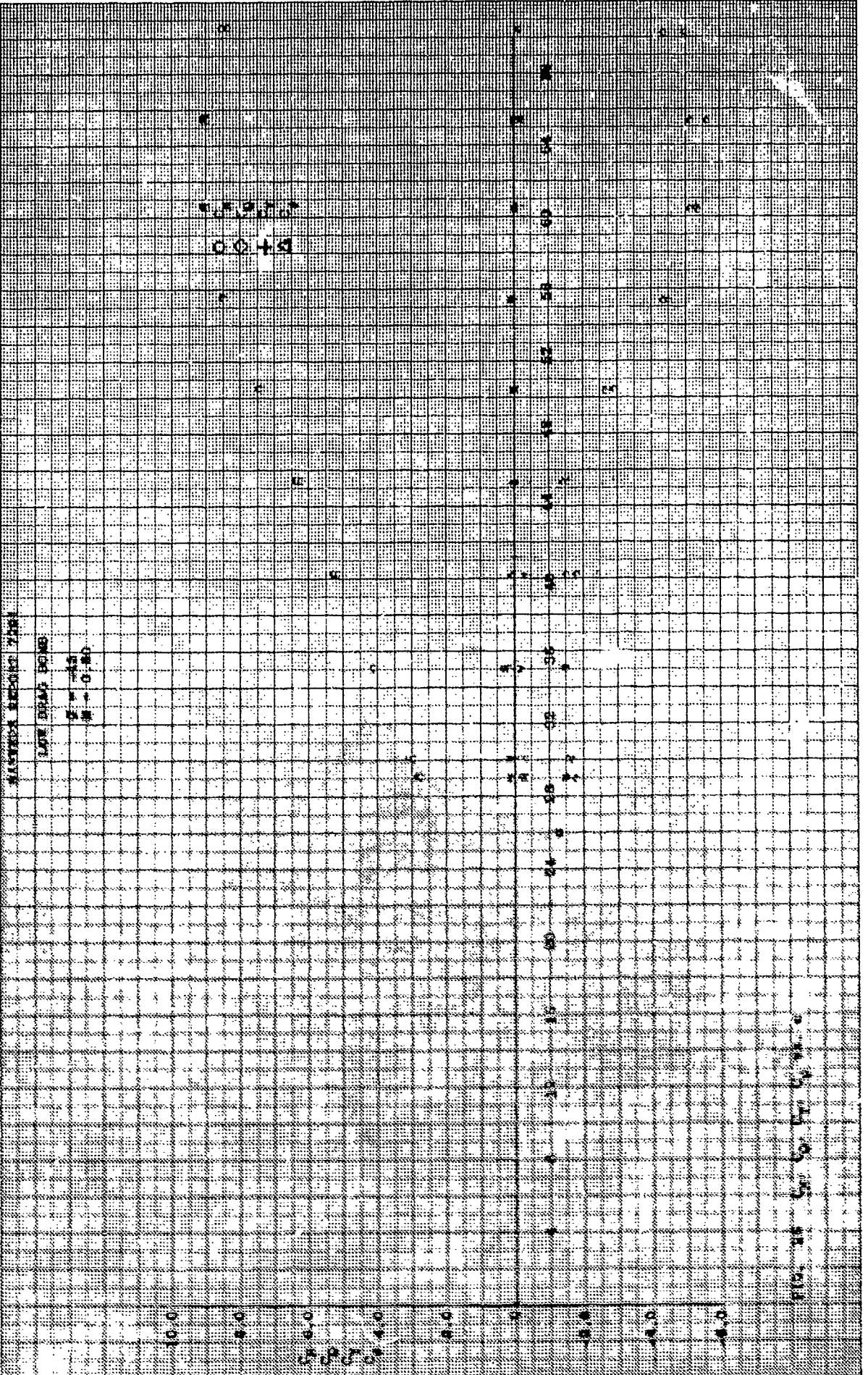


FIG. 23 - LOW DRAG BOMB



MISSILE REPORT TIME

LOW BRAD BOMB

21-15

11-0-00

HAYWARD REPORT 72891

LOW DRAG BOMB

$V = 125$

$K = 0.80$

1.0

0.8

0.6

0.4

0.2

0.0

0.0

0.0

0.0

0.0

0.0

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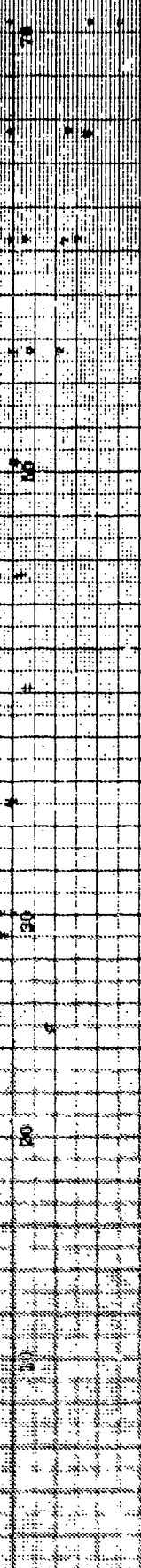
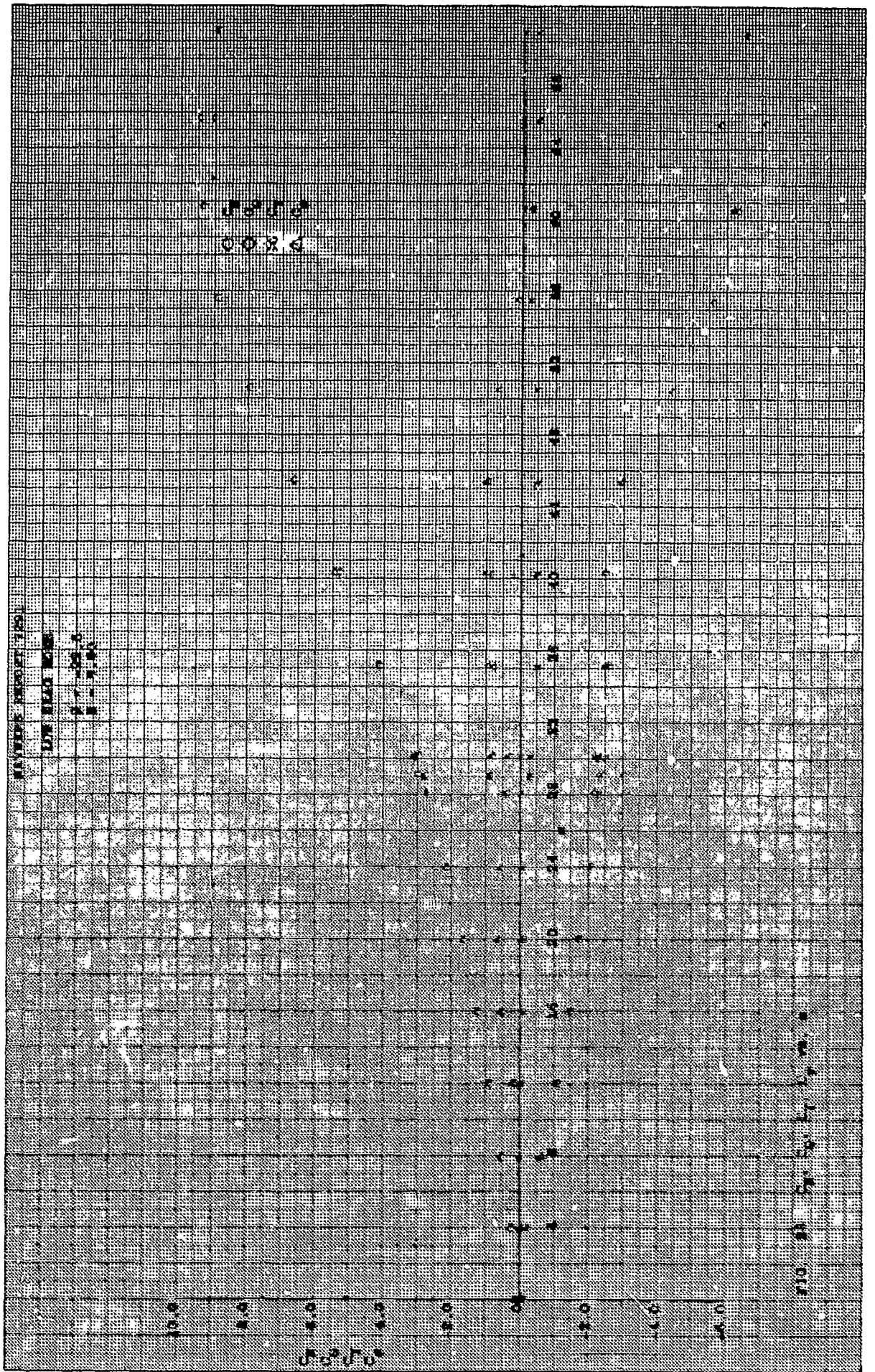


FIG. 11 (W. S. A. 1957)

K-E



PERCENT  
DAYS

0.0  
0.0

100 80 60 40 20 0

0 2 4 6 8 10

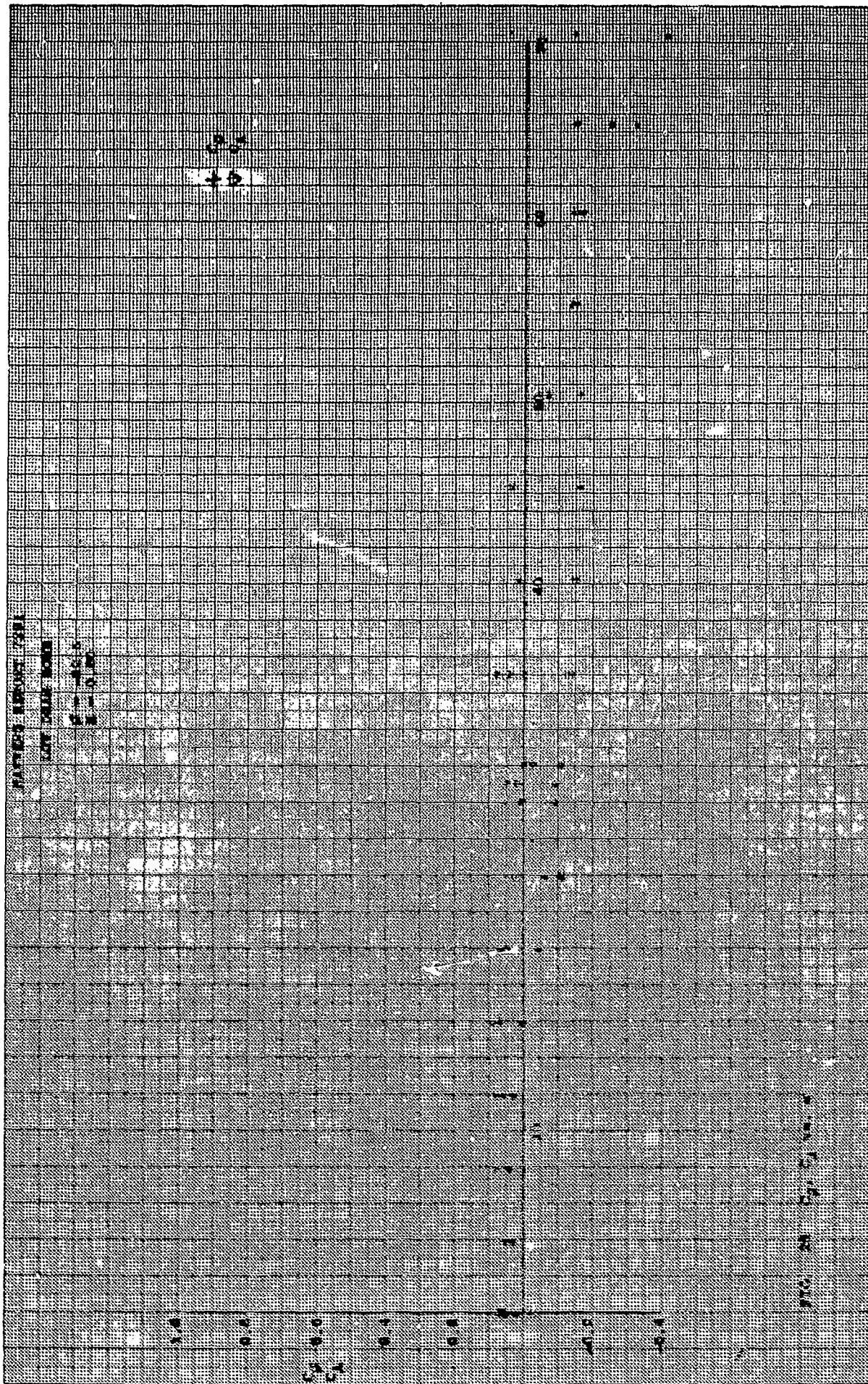


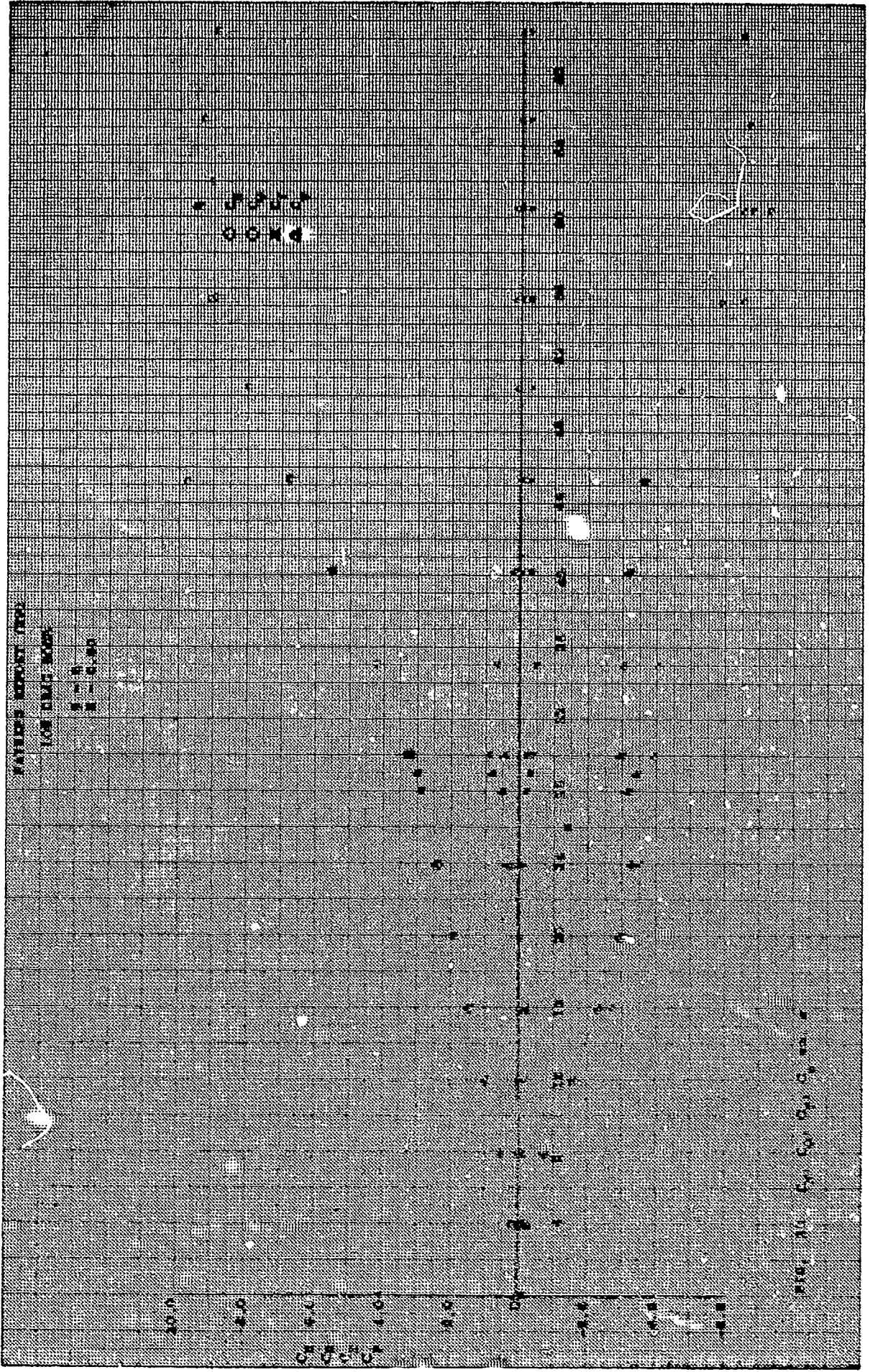
PLATE 1000000000

COY. 1000000000

1000000000

1000000000

K-2  
1000000000

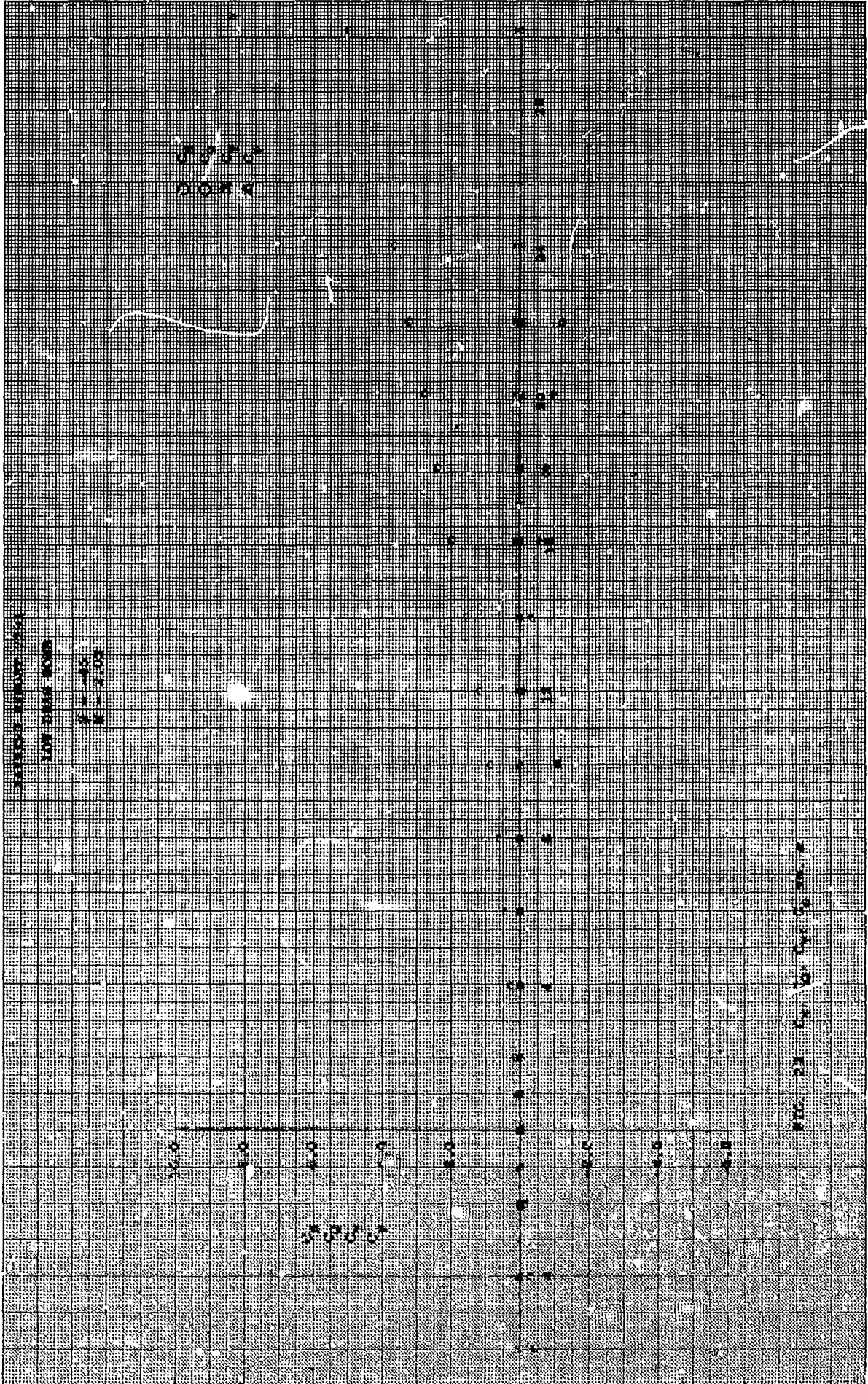


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 1-44  
 1-45  
 1-46  
 1-47  
 1-48  
 1-49  
 1-50

FACTORY AND/OR SHOP  
LOW VOLT BOARD  
P-1  
M-2-2.40

1.0  
0.8  
0.6  
0.4  
0.2  
0.0

FIG. 10



STATION NUMBER 100

DATE 10/10/50

9 3-40

11-2100







NAVY REPORT 7891

LOW DRAG BOMB

$\beta = -22.5$

$\mu = 2.08$

1.0

0.8

0.6

$C_D$

$C_L$

0.4

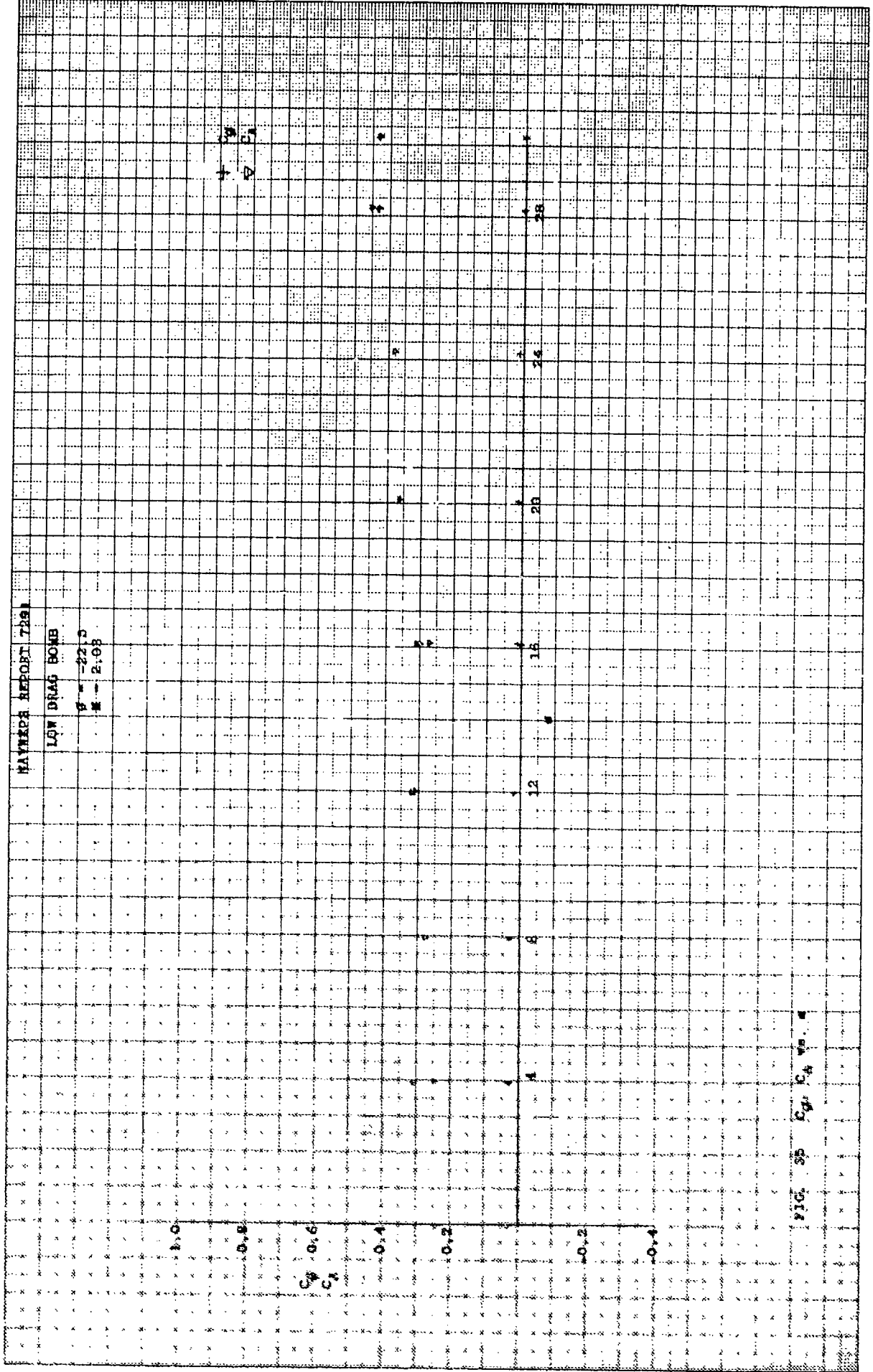
0.2

0.2

0.4

FIG. 35  $C_D$ ,  $C_L$  vs  $\alpha$

K-11 10-11-54



NAVY REPORT 7201

LOW DRAG BOMB

V -- 0

M -- 0.63

○ ●  
◇ ○  
X X  
△ △

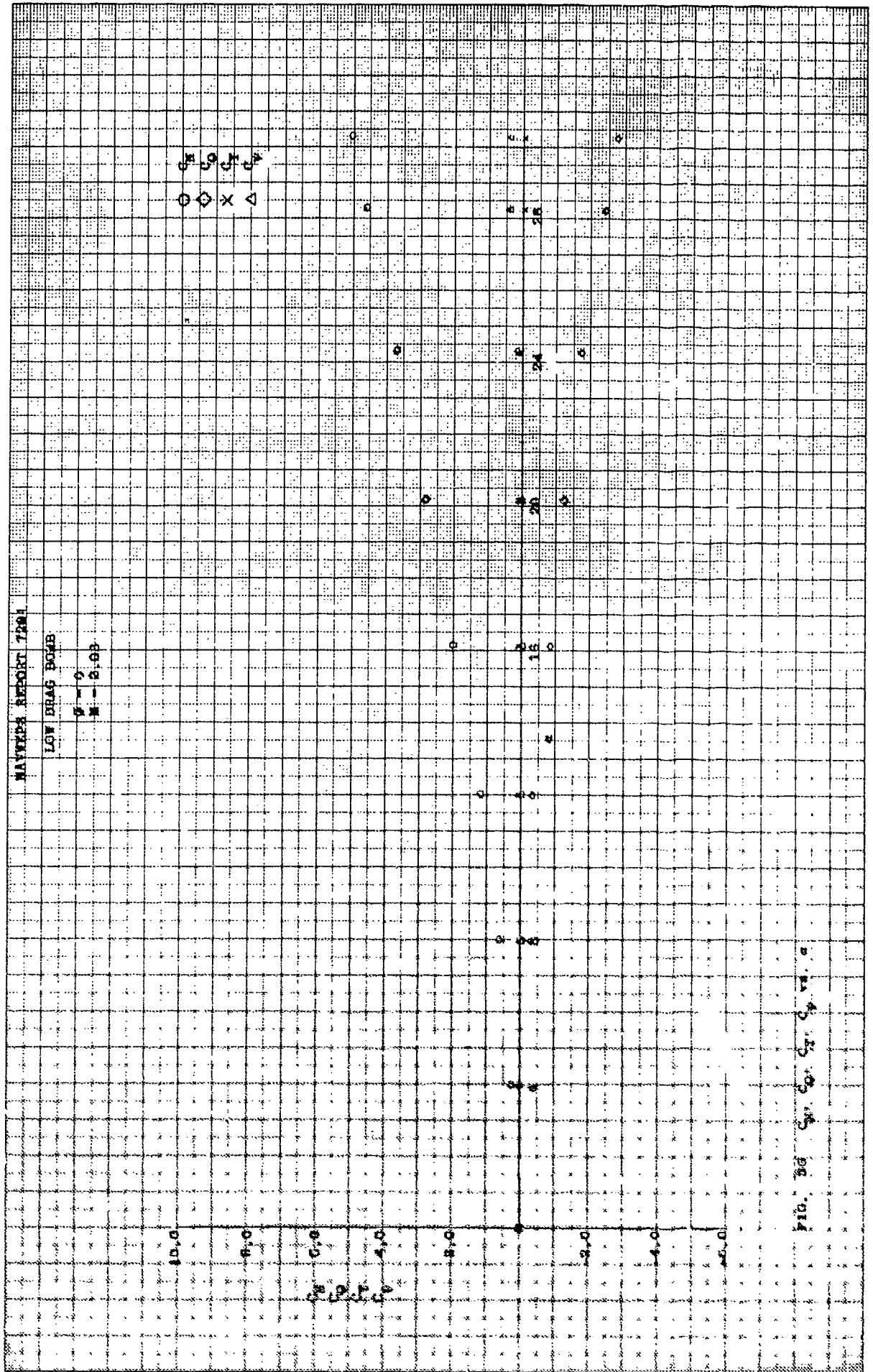


FIG. 36 Sp. Gr. 0.98

NAVY REPORT REPORT 7284

LOW DRAG BOMB

$\rho = 0$   
 $M = 2.03$

$C_D$   
 $C_L$

$C_D$  vs  $C_L$

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