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TRANSONIC AIRCRAFT DRAG TECHNIQUE APPLIED TO MILITARY AIRCRAFT

VOLUME II

(NASA-CR-151791) TRANSONIC AIRCRAFT DRAG TECHNIQUE APPLIED TO MILITARY AIRCRAFT, VOLUME 2 (Lockheed-California Co.) 197 p

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by R. C. Feagin

March 1977
Revised December 1978

Prepared Under Contract No. NAS2-8612, Mod. 6

for

Ames Research Center
National Aeronautics and Space Administration

by

Lockheed-California Company
Burbank, California

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FOREWORD

This document appendices the study summarized by Reference (1) which was performed by the Lockheed-California Company for the National Aeronautics and Space Administration, Ames Research Center, under Contract No. NAS2-8612, Mod. 6. Mr. Gary C. Hill was the technical monitor. Messrs. R. C. Feagin and W. D. Morrison, Jr. were the principal investigators.

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INTRODUCTION

The Lockheed-California Company, under NASA Contract No. NAS2-8612, Mod. 6, has evaluated referenced information on 19 subsonic and supersonic military aircraft for the purpose of developing empirical correlation techniques for total drag estimation which can be applied in future preliminary design activities. The resulting method is discussed in Reference (1).

This volume presents the data packages for each of the subject aircraft from which the method presented in Reference (1) was derived.

AIRCRAFT DATA PRESENTATION

Presented herein are the data packages for each of the subject aircraft which form the basis for the drag correlation discussed in Reference (1). The methods outlined in Reference (1) have been used to develop the data as shown. The base for this information is flight test correlated data as presented in References (2) through (22).

The subject aircraft are the T-2B, T-37B, KA-3B, A-4F, TA-4F, RA-5C, A-6A, A-7A, F-4E, F-5A, F-8C, F-11F, F-100, F-101, F-104G, F-105B, F-106A, XB-70, and S-3A.

Depending on availability of information, each data package consists of:

* Three-view
* Fuselage area distribution
* Limit lift characteristics
* Drag characterisitics
* M(L/D) versus Mach number
* Design lift coefficient and Mach number
* Three dimensional Mach divergence characteristics
* Minimum drag breakdown
* Compressibility drag
* Wing pressure drag variation

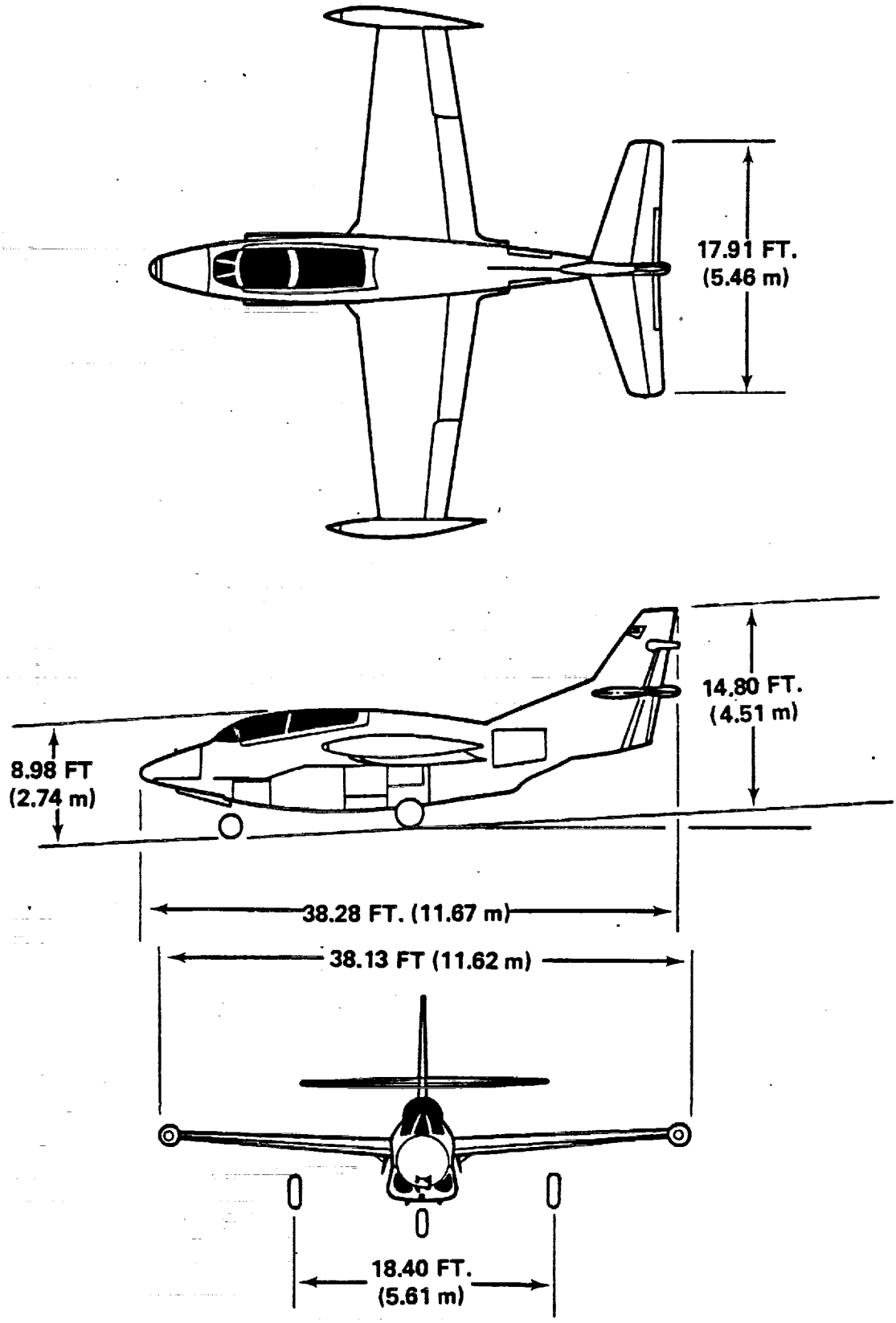

FIGURE 1. THREE-VIEW, T-2B

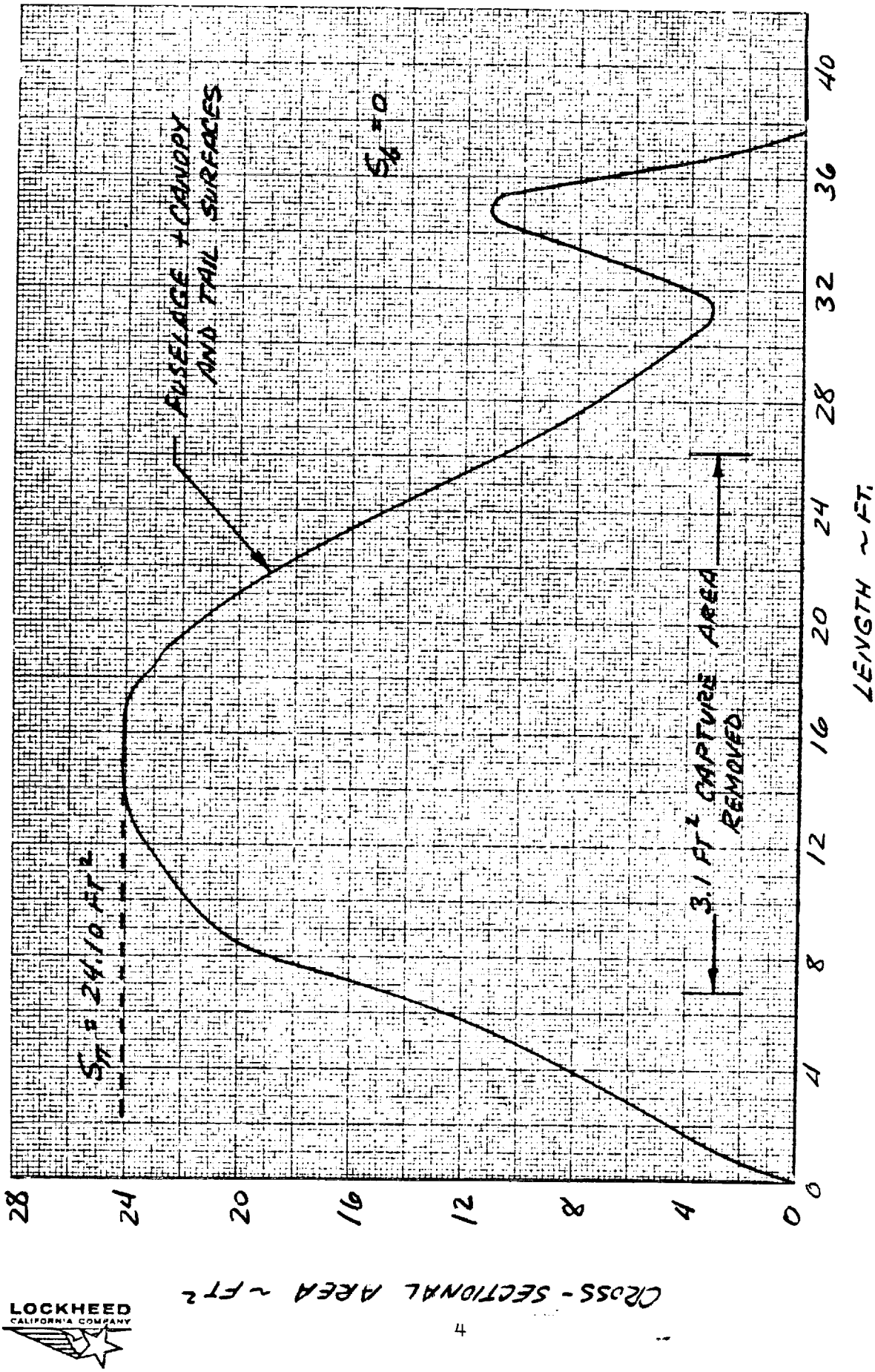

FIG. 2 T-28 FUSELAGE AREA DISTRIBUTION

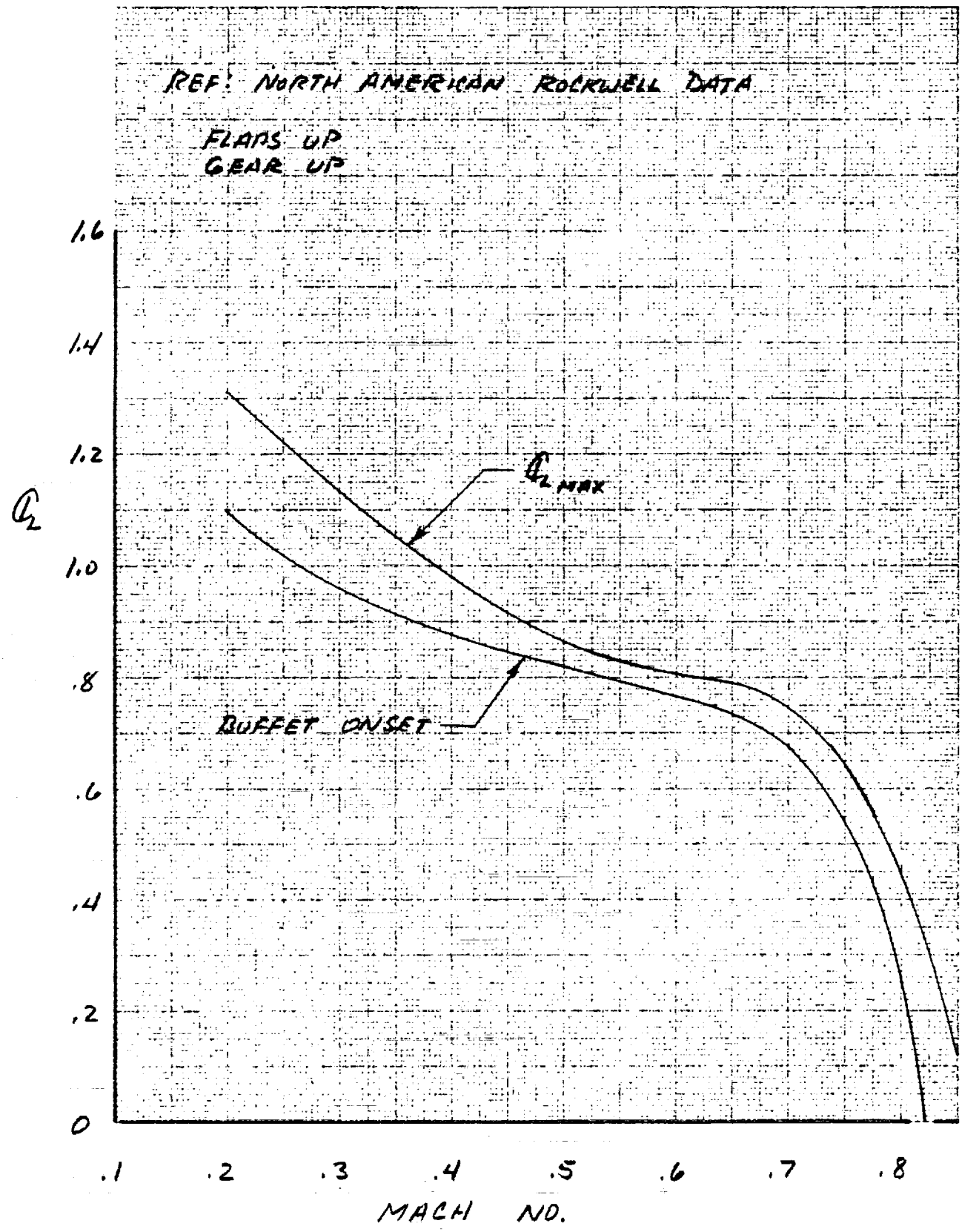

FIG. 3 LIMIT LIFT CHARACTERISTICS, T-2B

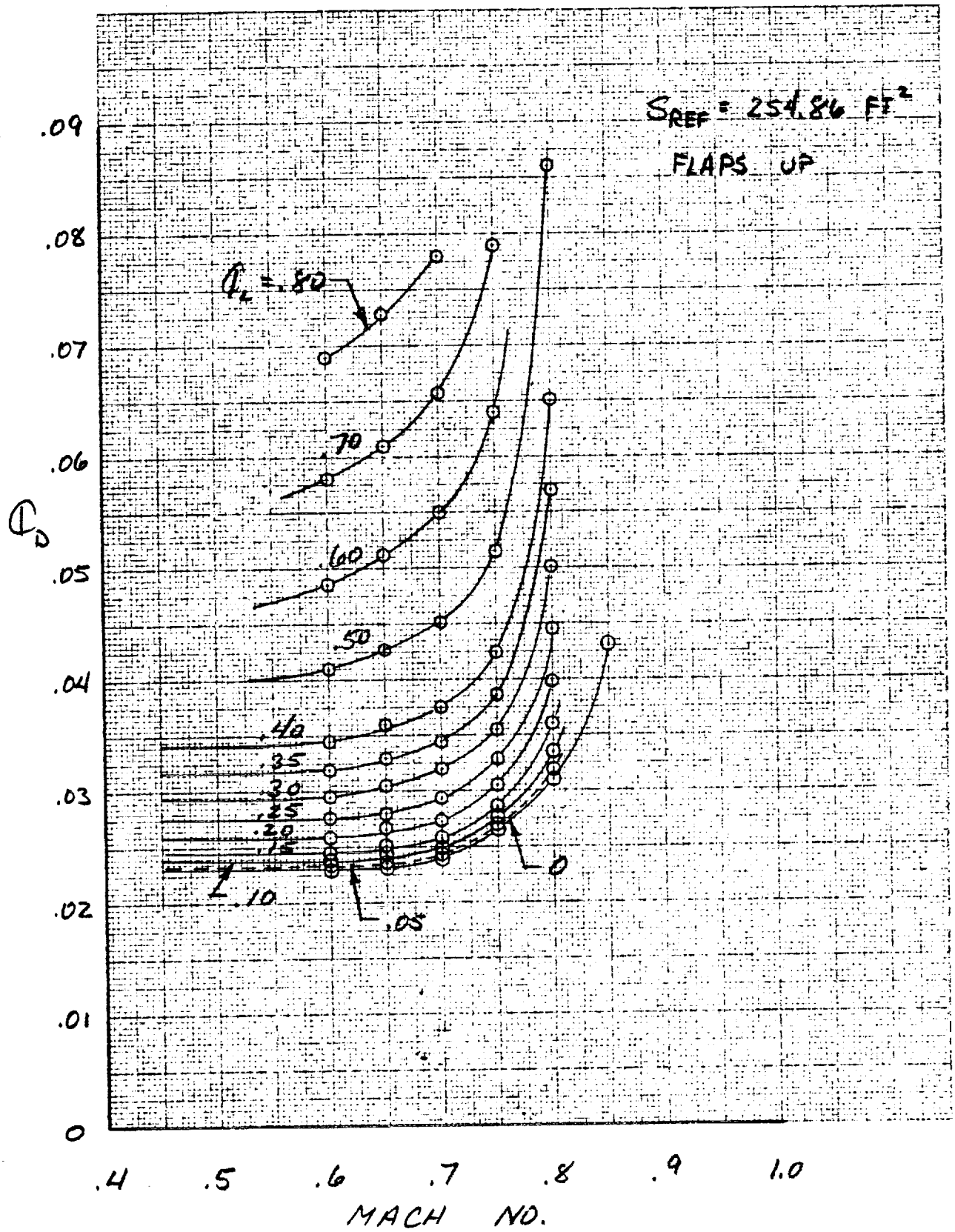

FIG. 4 T-2B DRAG CHARACTERICS

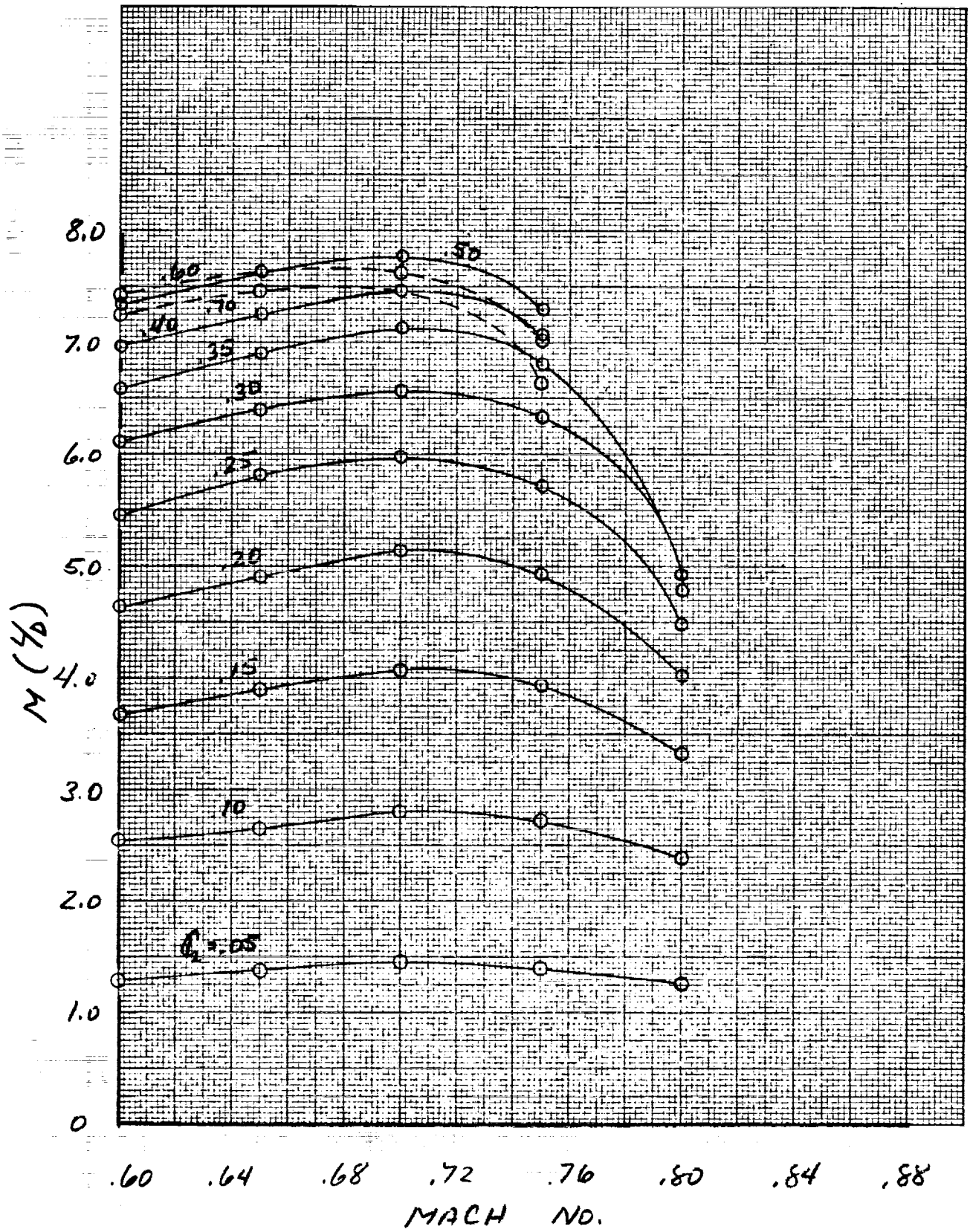

FIG. 5 M(L/D) VS. MACH NUMBER, T-2B

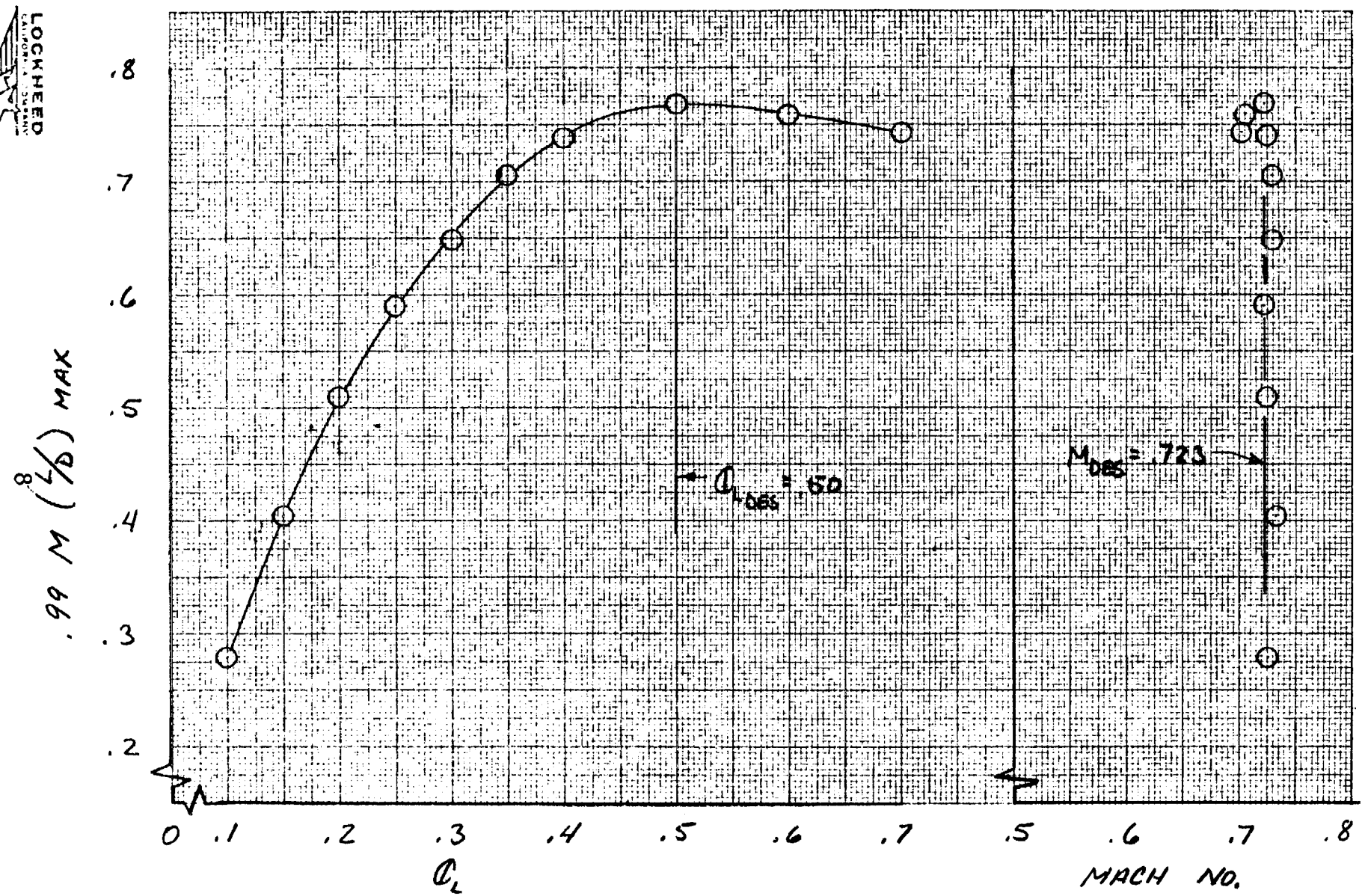

FIG. 6 $C_{L_{DES}}$ AND M_{DES} FOR T-2B

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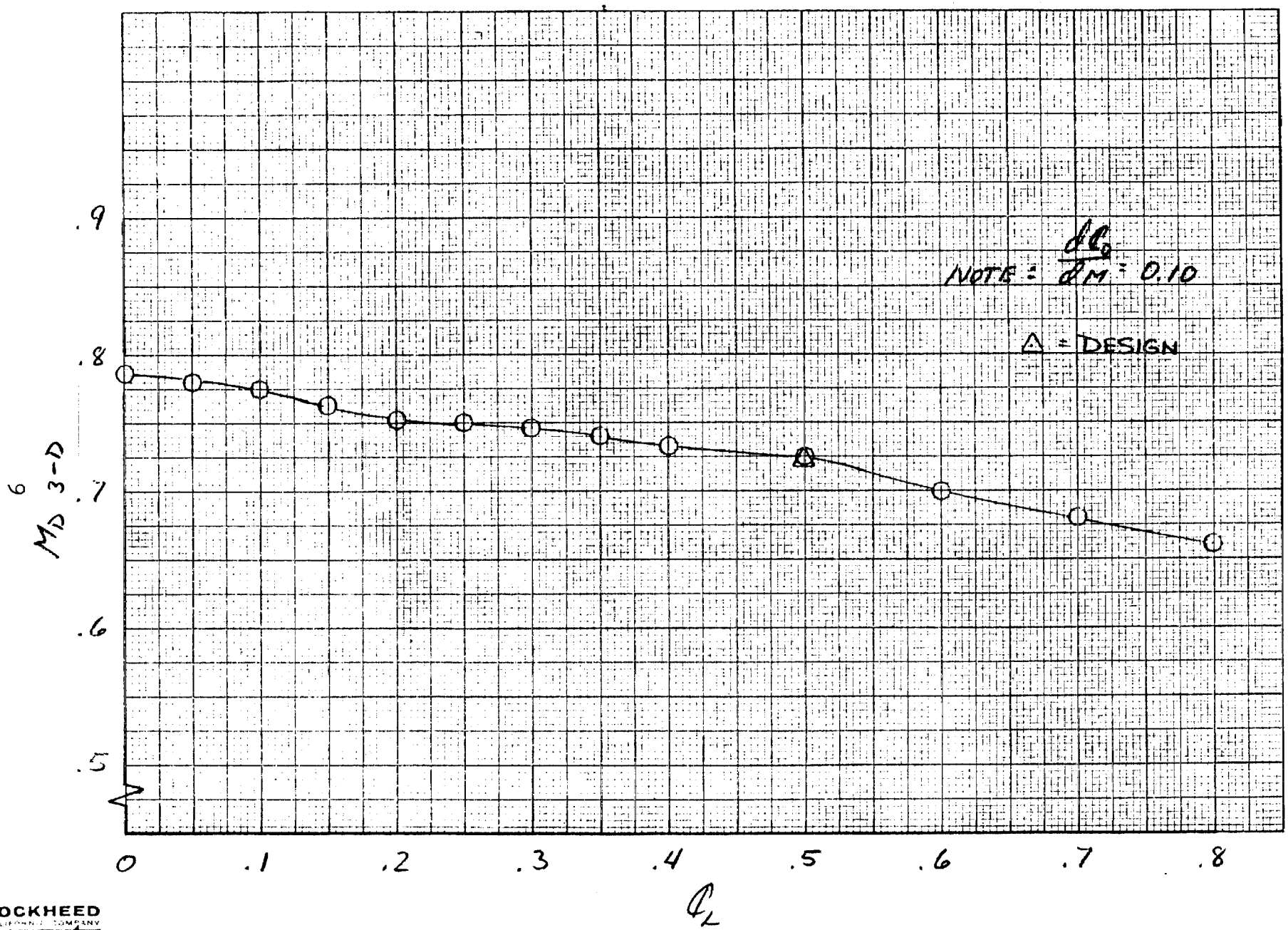

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FIG. 7 DRAG DIVERGENCE CHARACTERISTICS, T-2B

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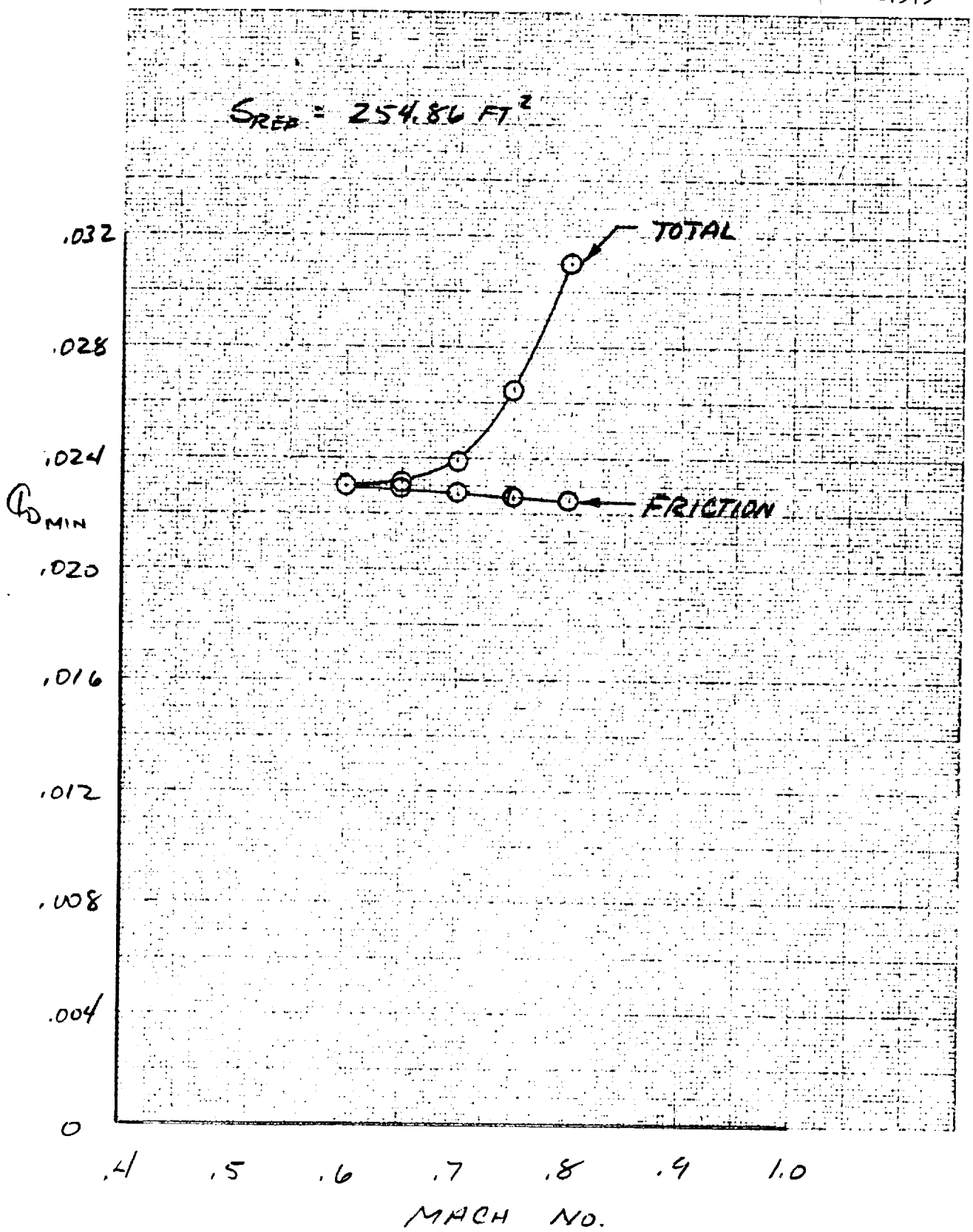

FIG. 8 MINIMUM DRAG BREAKDOWN, T-2B

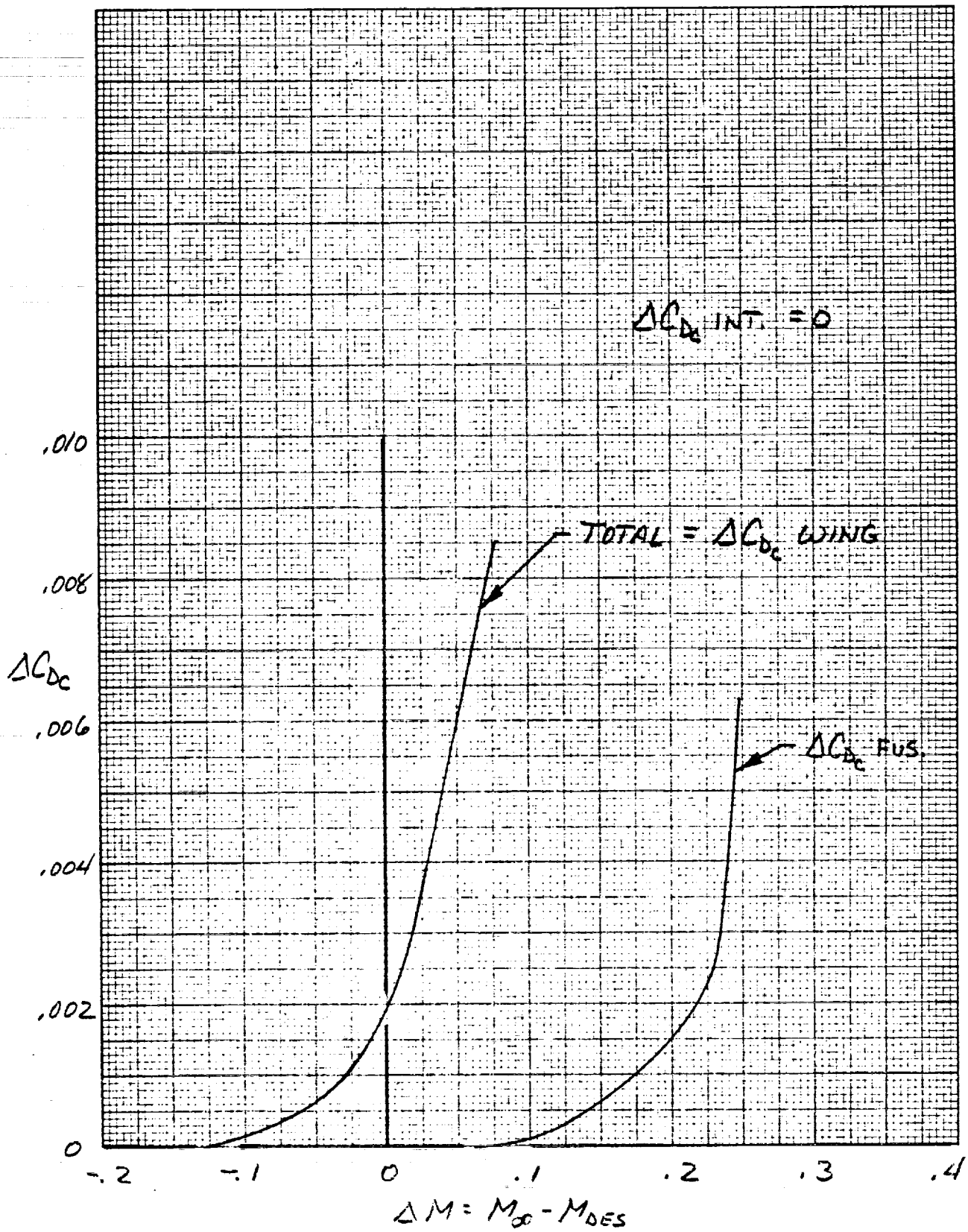

FIG. 9 COMPRESSIBILITY DRAG, T-2B

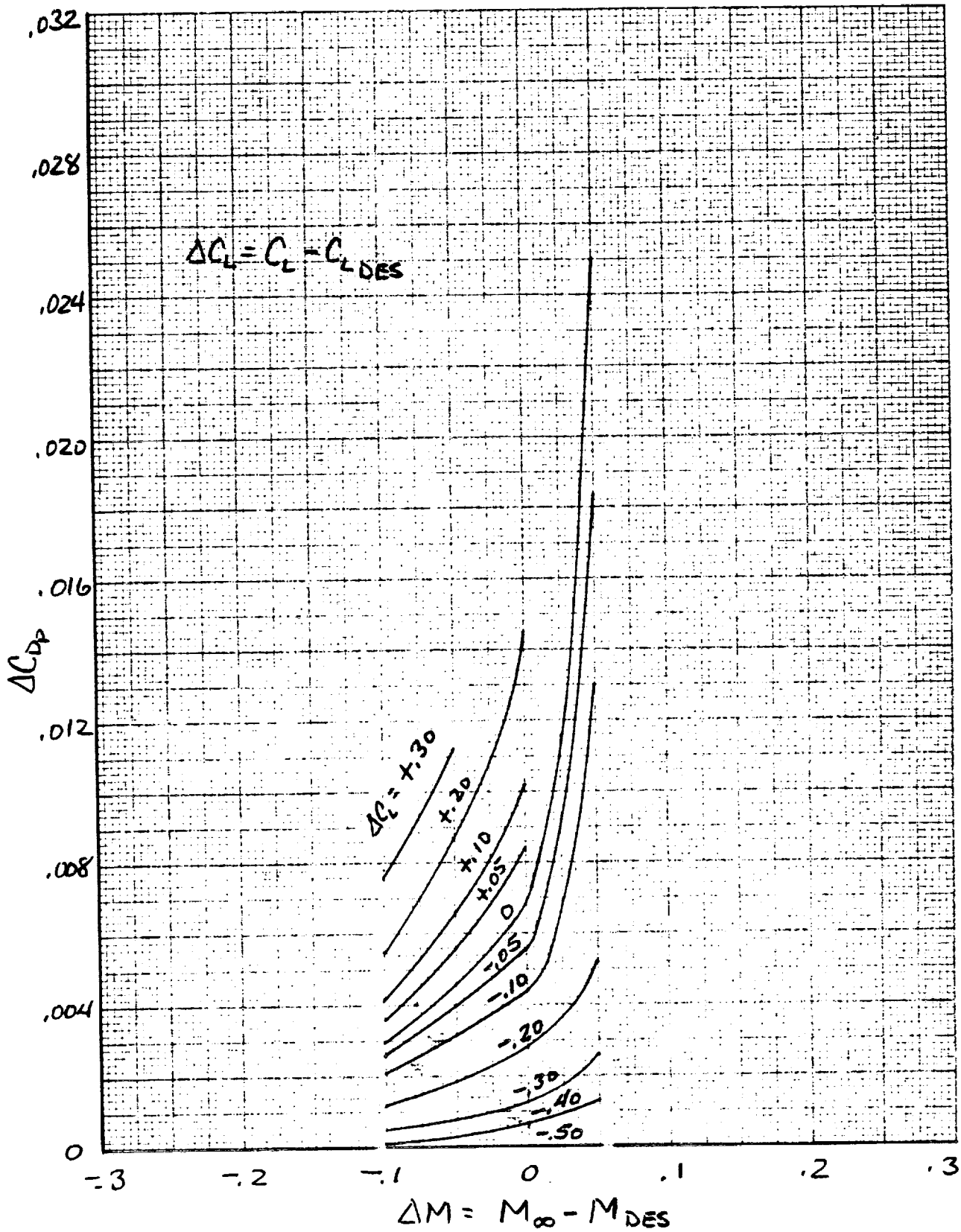

FIG. 10 WING PRESSURE DRAG VARIATION, T-2B

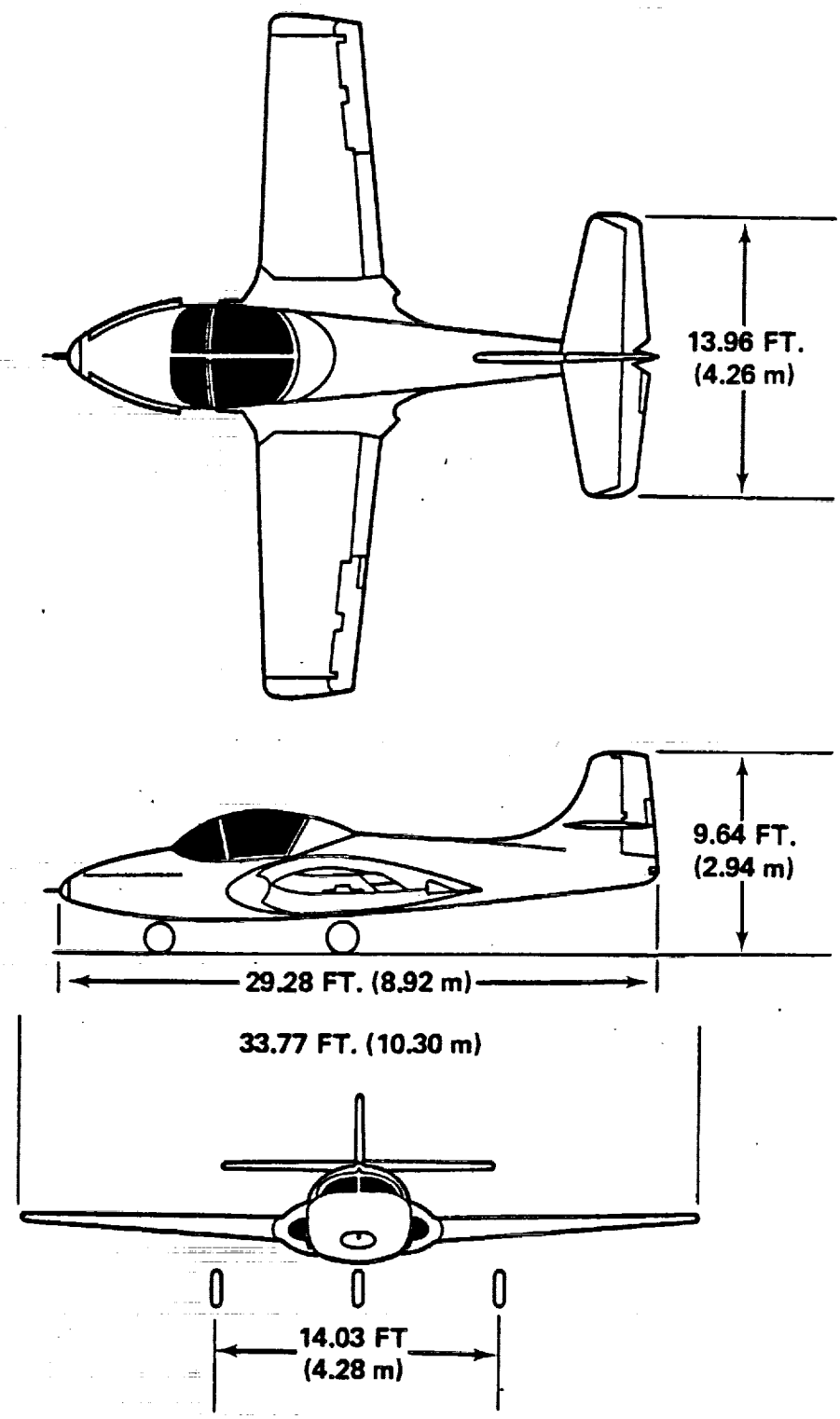

FIGURE 11. THREE-VIEW, T-37B

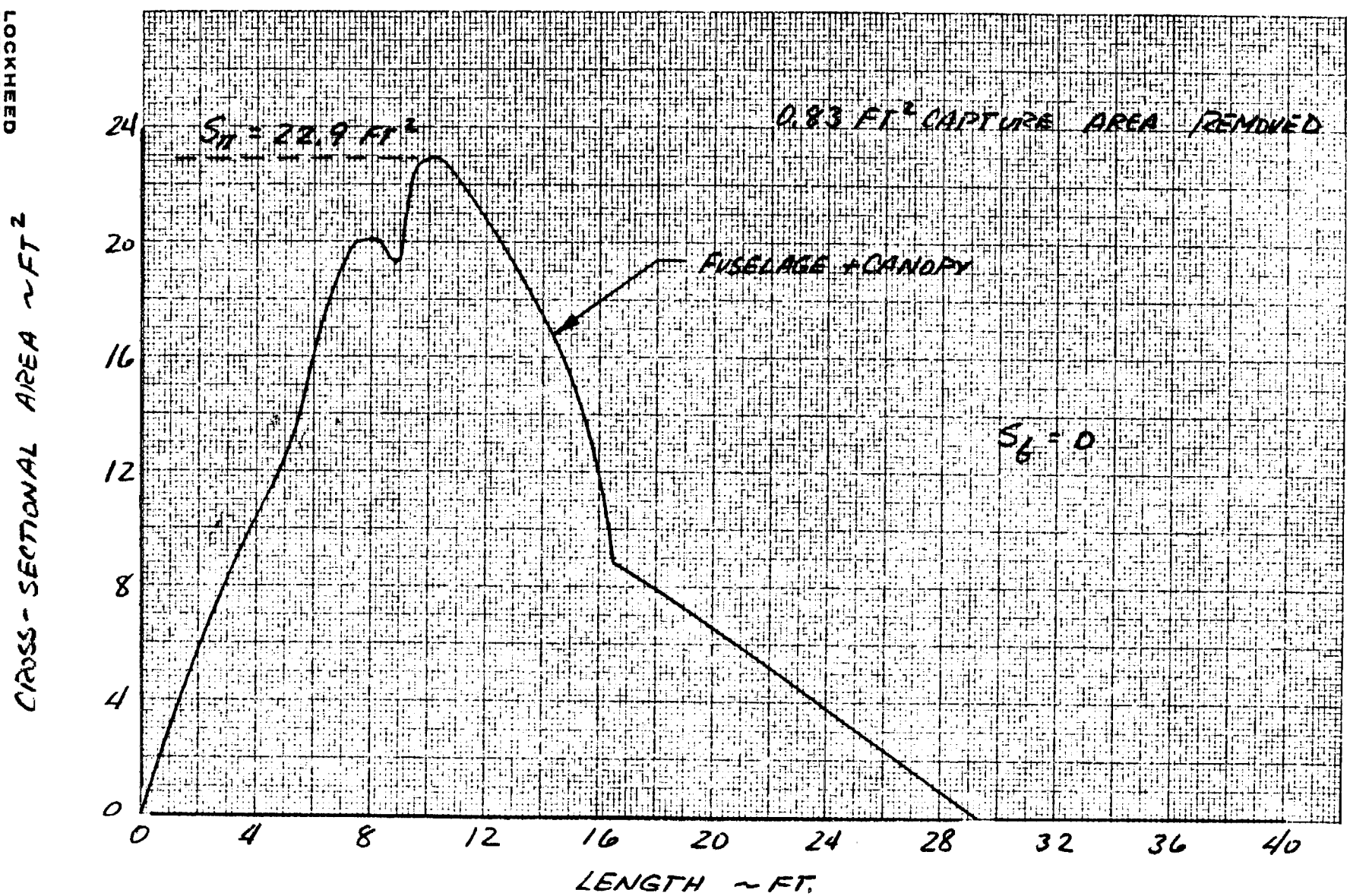

FIG. 12 T-37B FUSELAGE AREA DISTRIBUTION

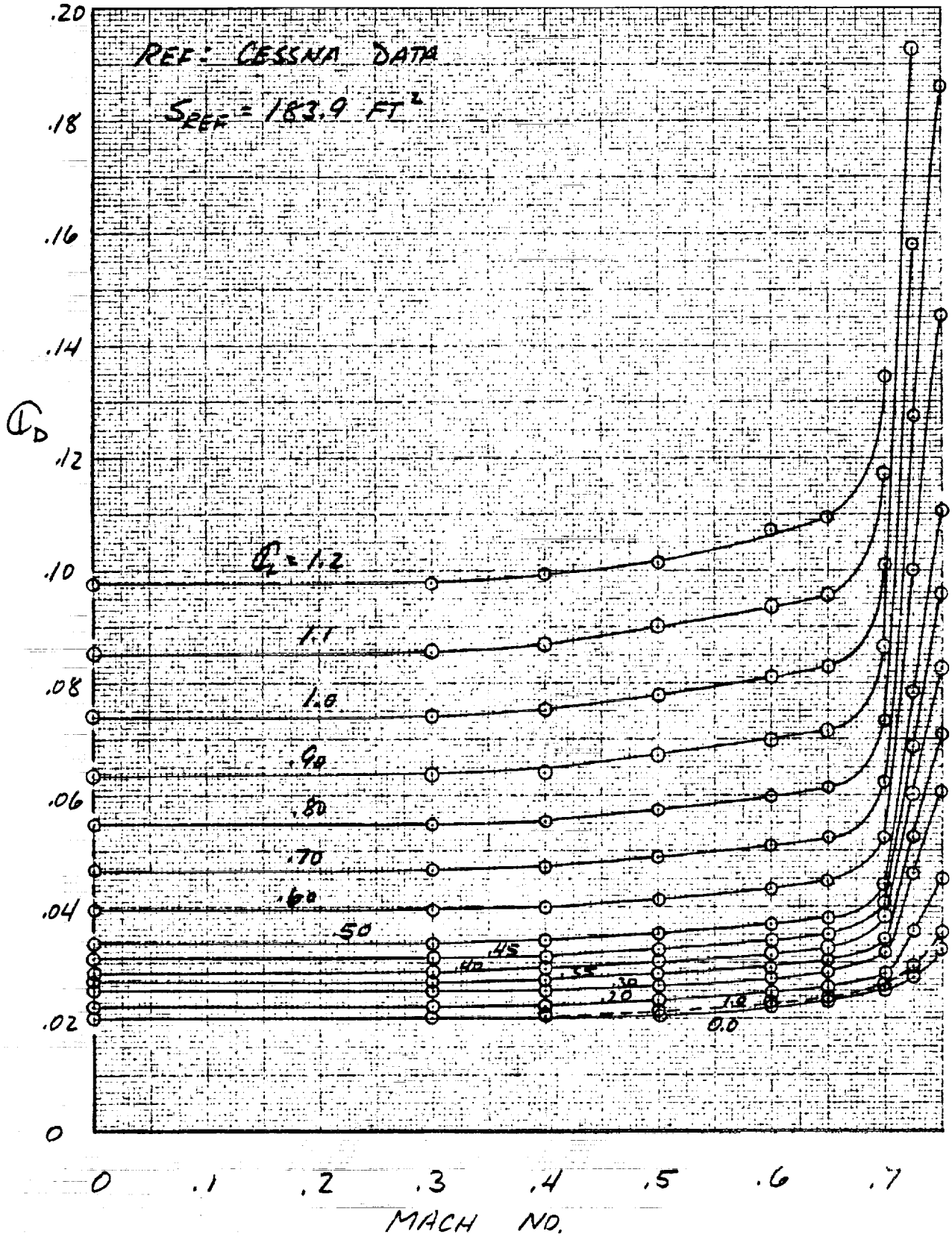

FIG. 13 T-37B DRAG CHARACTERISTICS

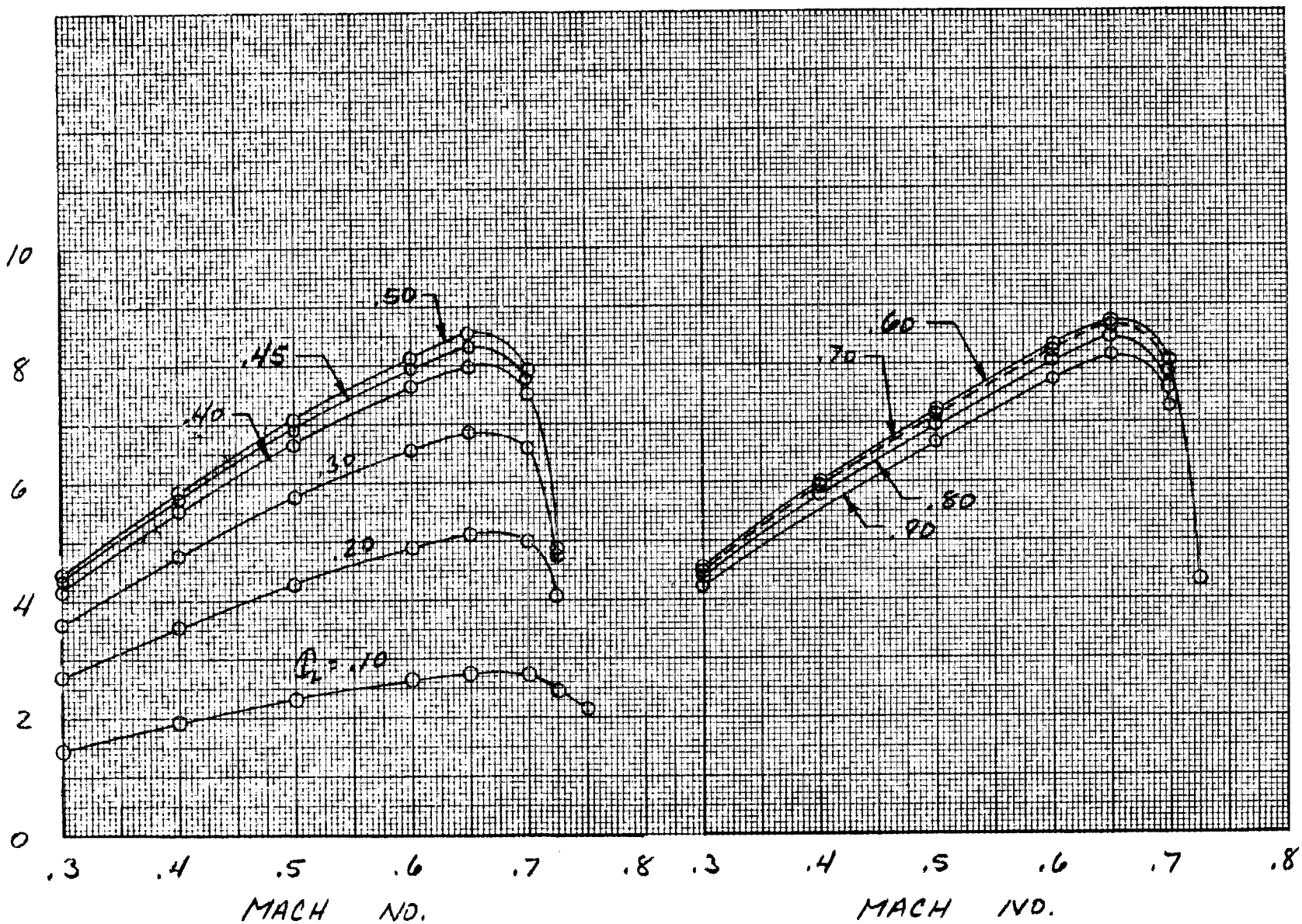

FIG. 14 M (L/D) VS. MACH NUMBER, T-37B

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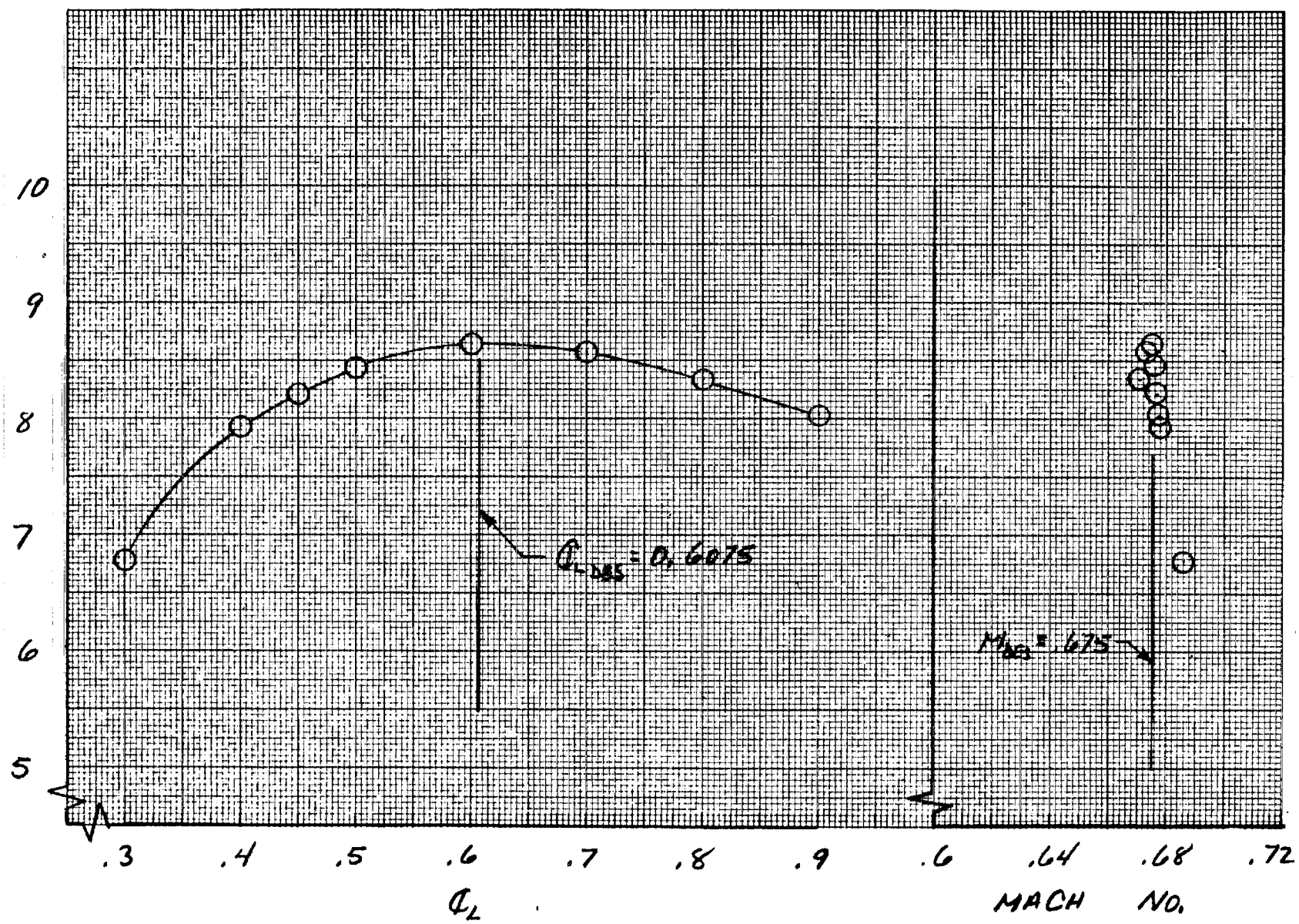

FIG. 15 $C_{L_{DES}}$ AND M_{DES} FOR T-37B

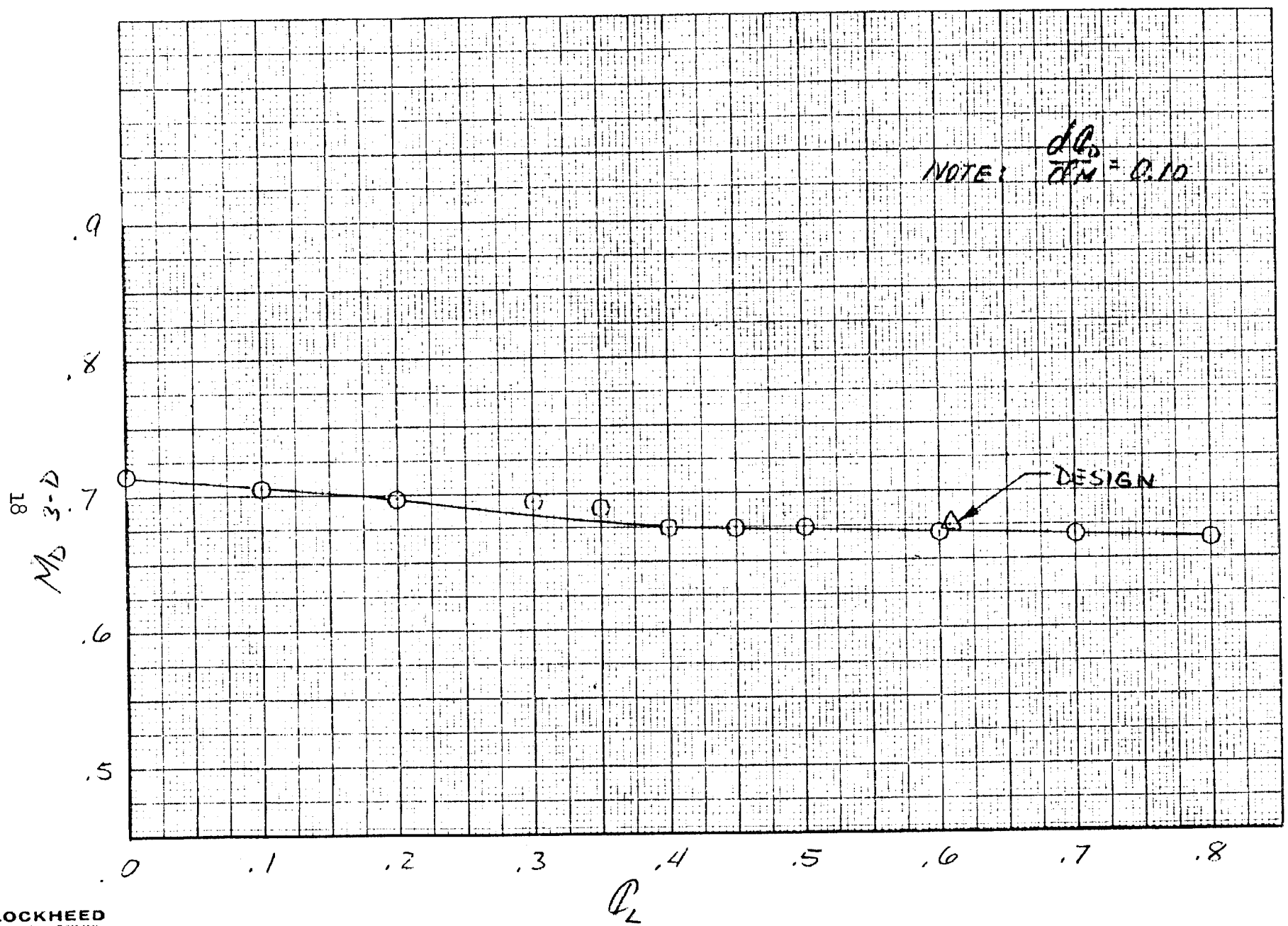

FIG. 16. DRAG DIVERGENCE CHARACTERISTICS, T-37B.

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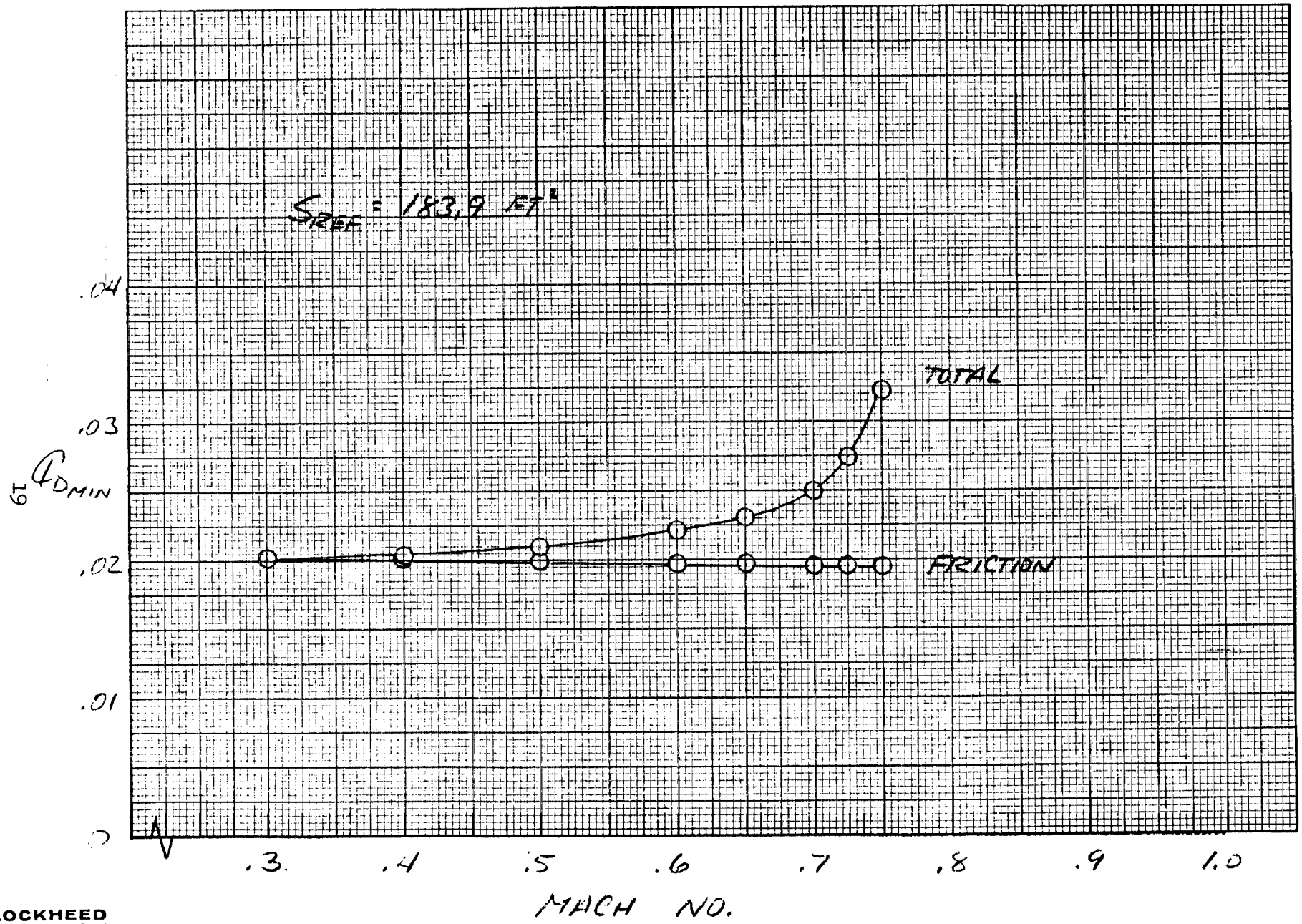

FIG. 17 MINIMUM DRAG BREAKDOWN, T-37B

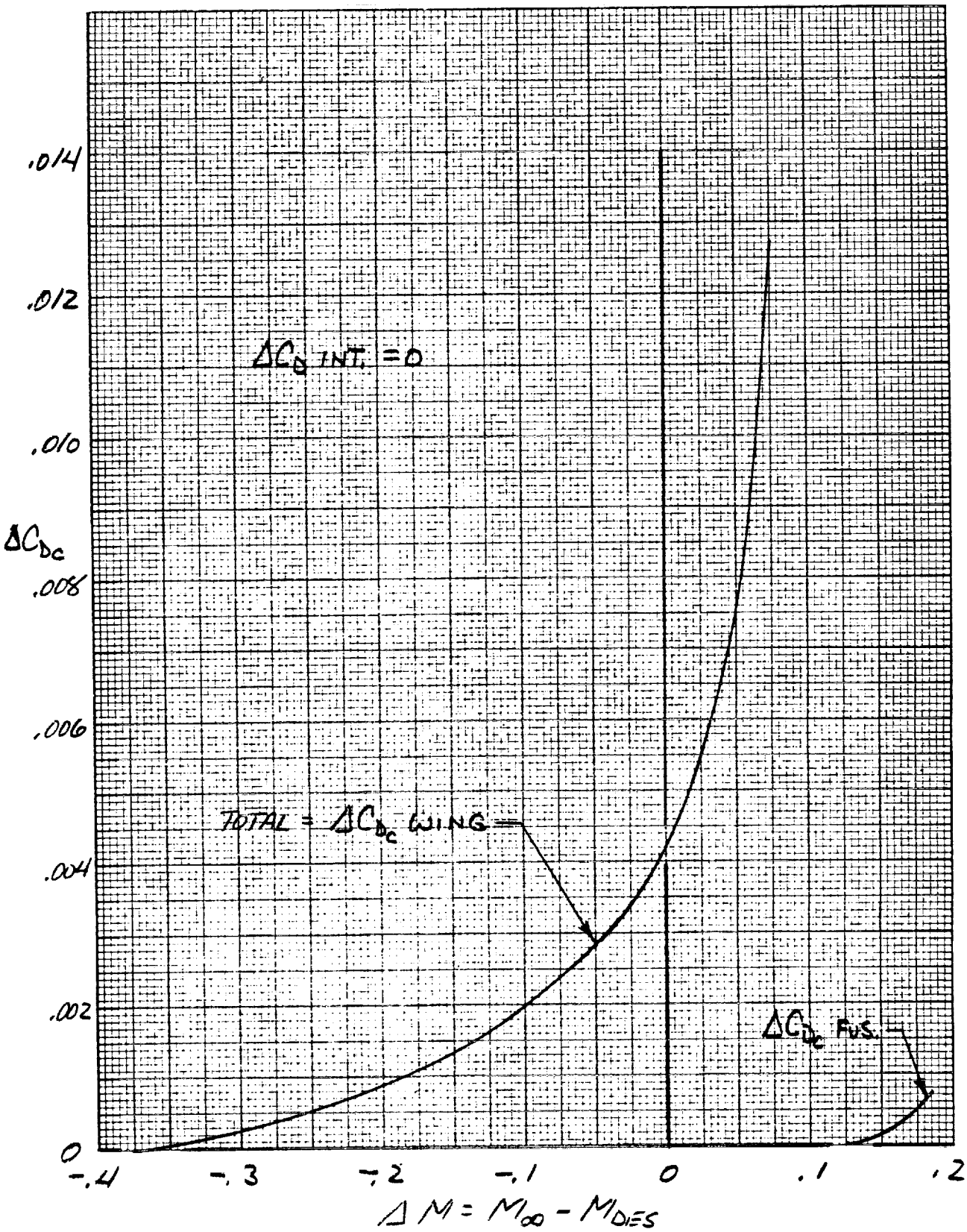

FIG. 18 COMPRESSIBILITY DRAG, T-37B

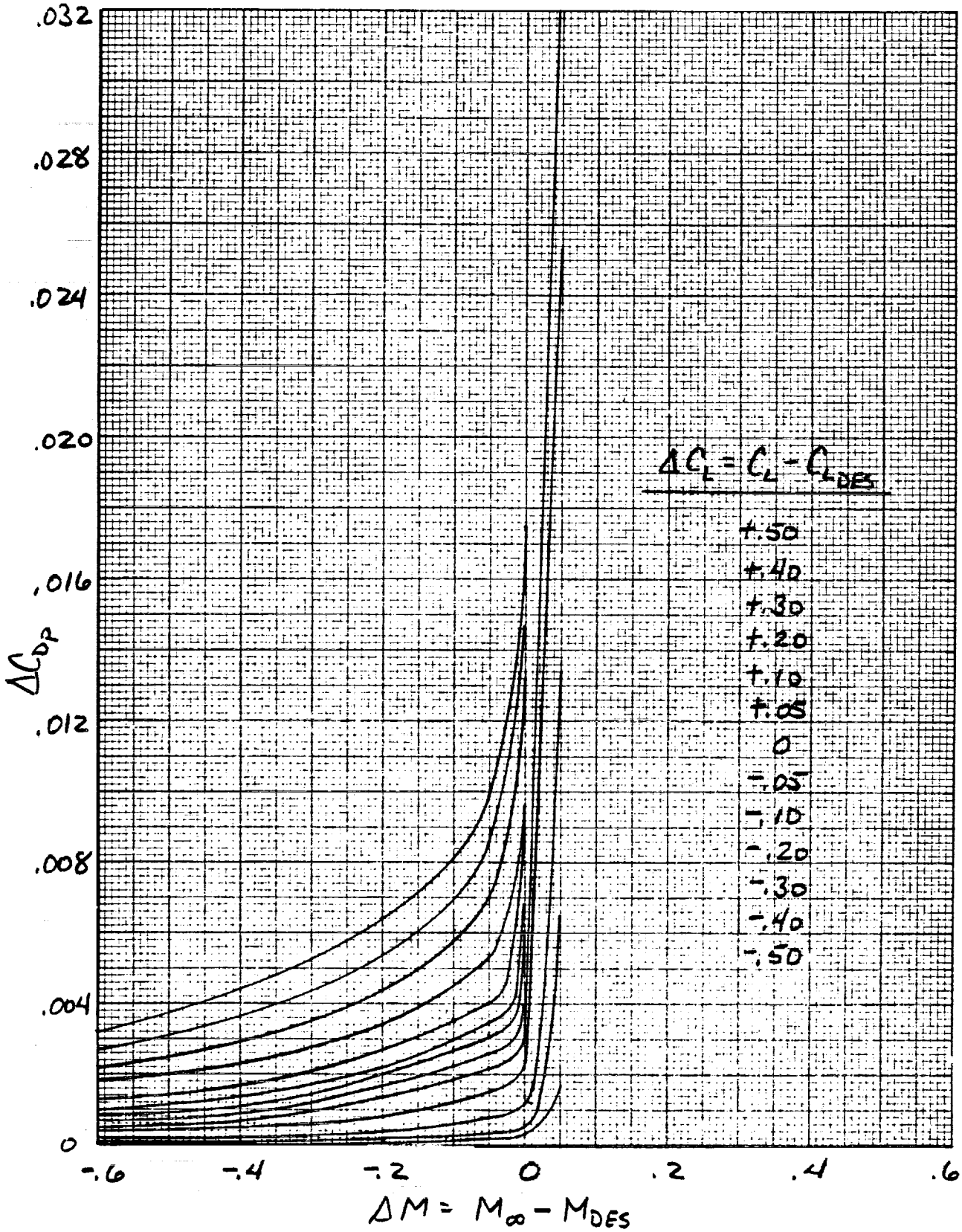

FIG. 19 WING PRESSURE DRAG VARIATION, T-37B

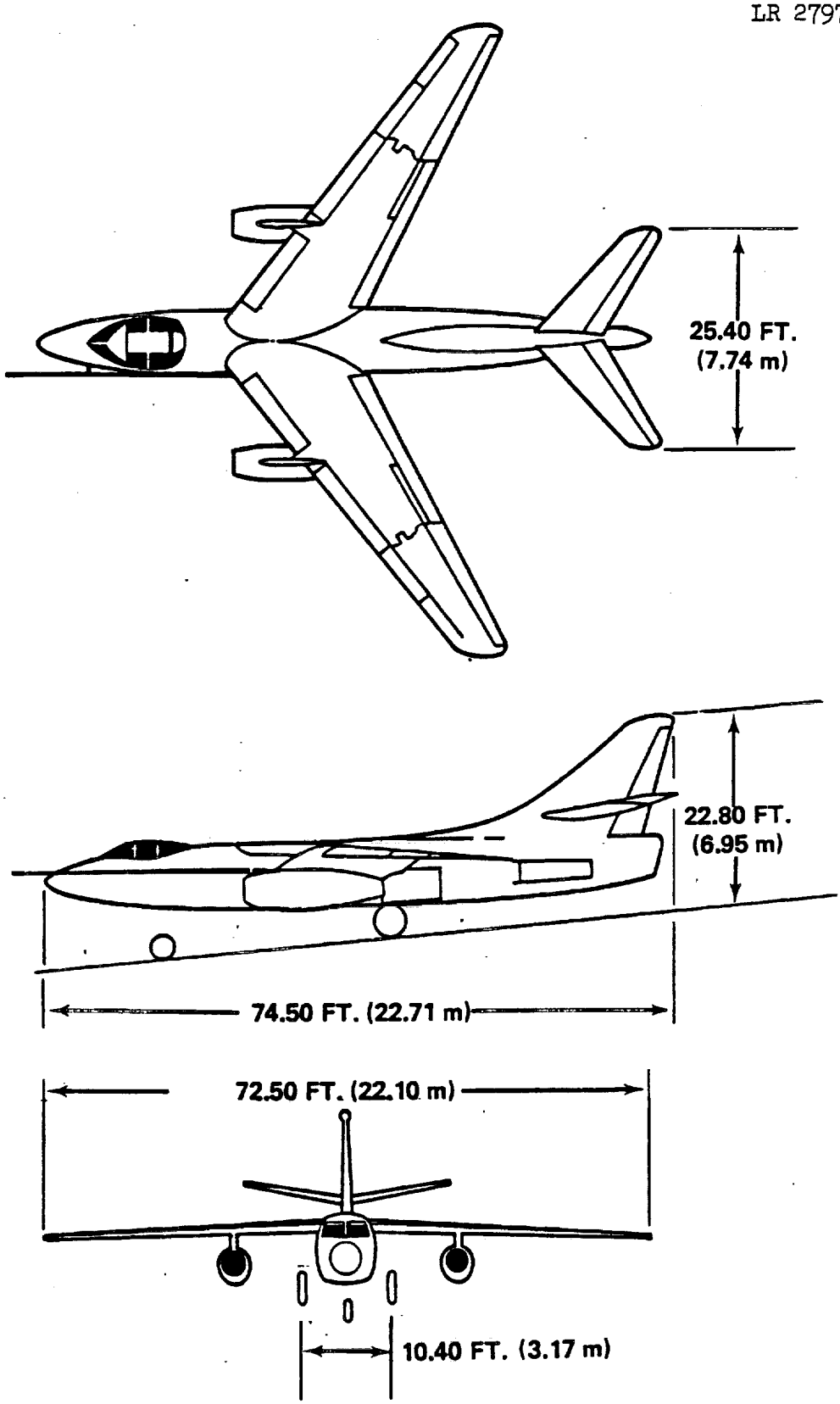

FIGURE 20. THREE-VIEW, KA-3B

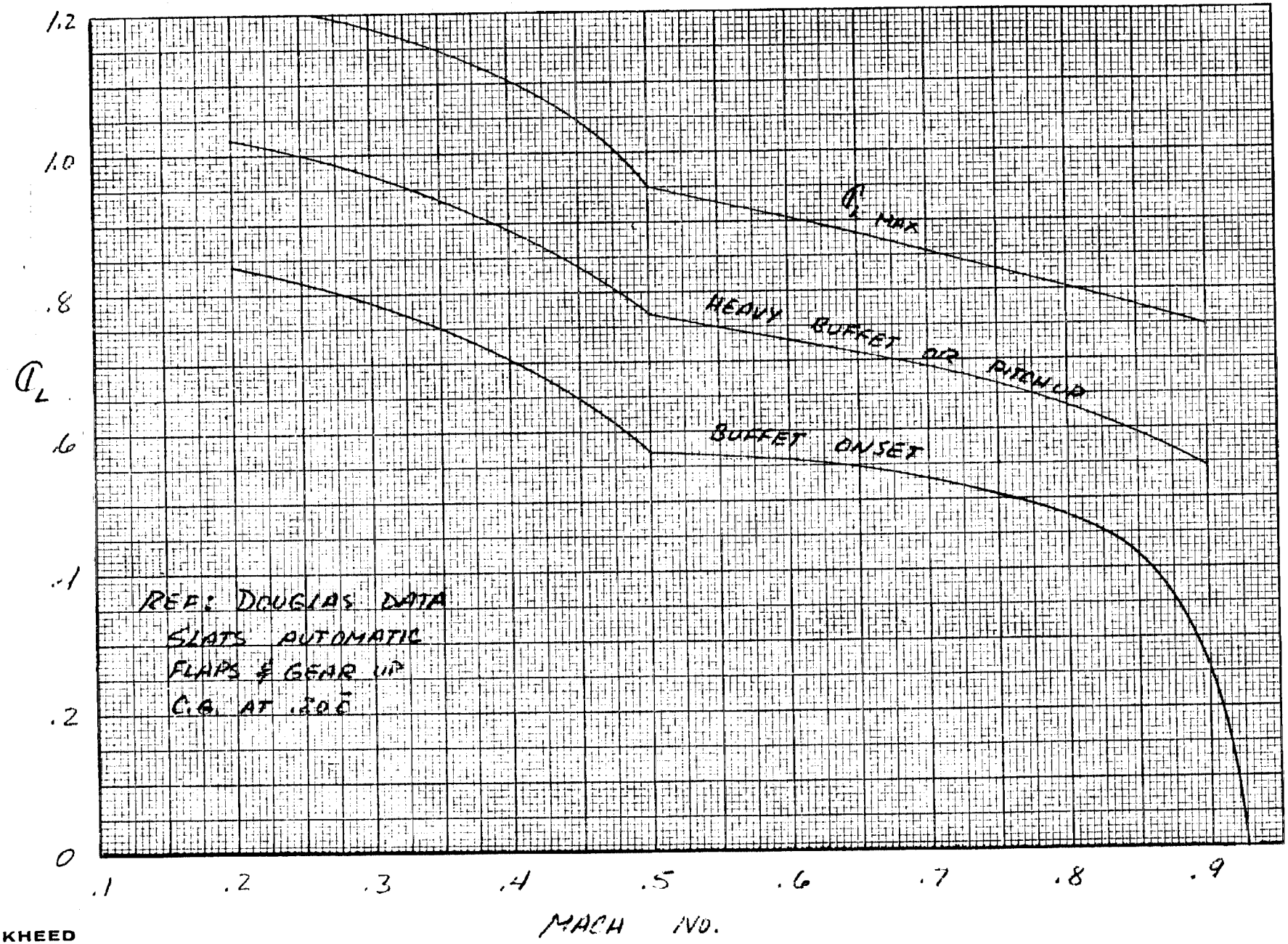

FIG. 21 LIMIT LIFT CHARACTERISTICS, KA-3B

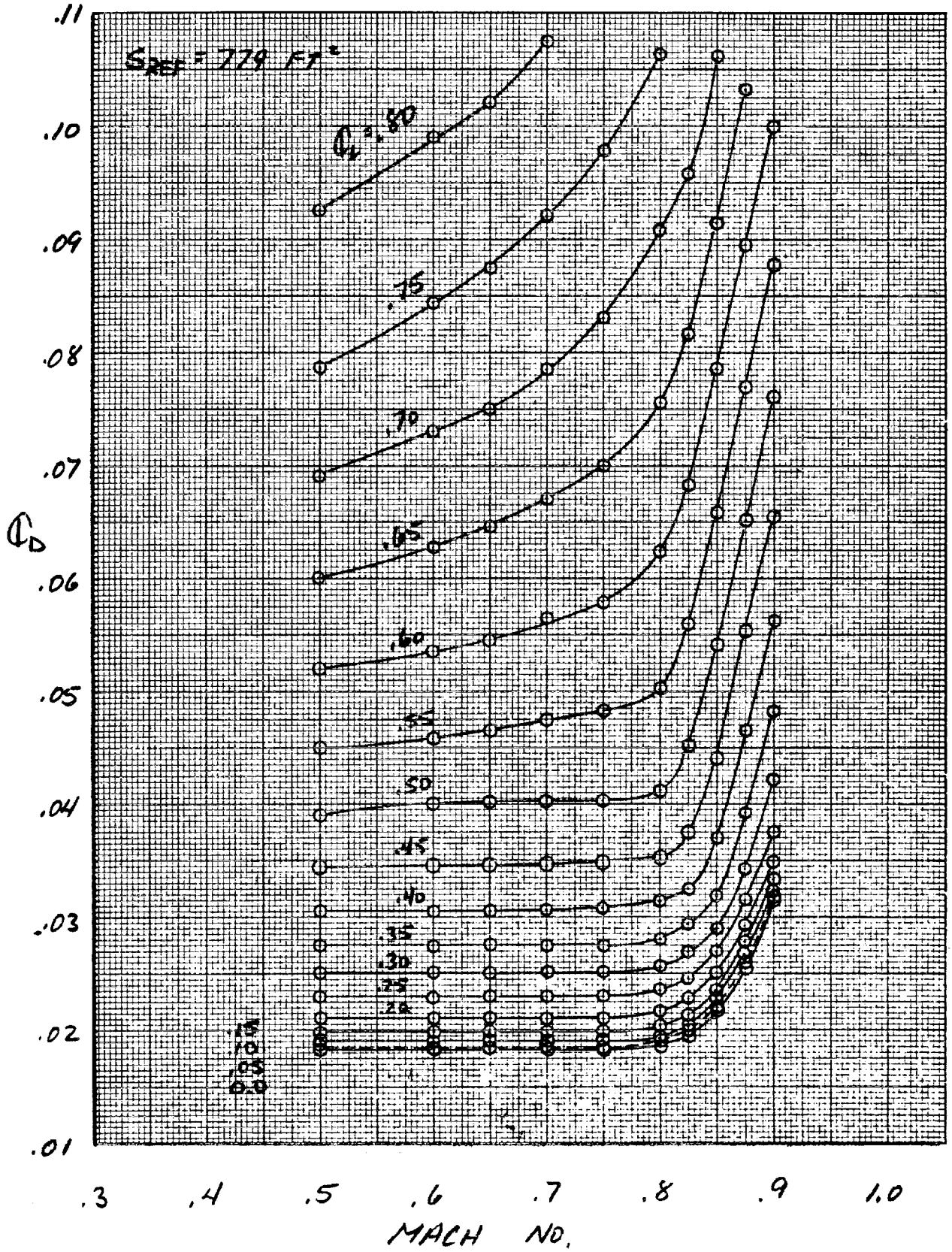

FIG. 22 KA-3B DRAG CHARACTERISTICS

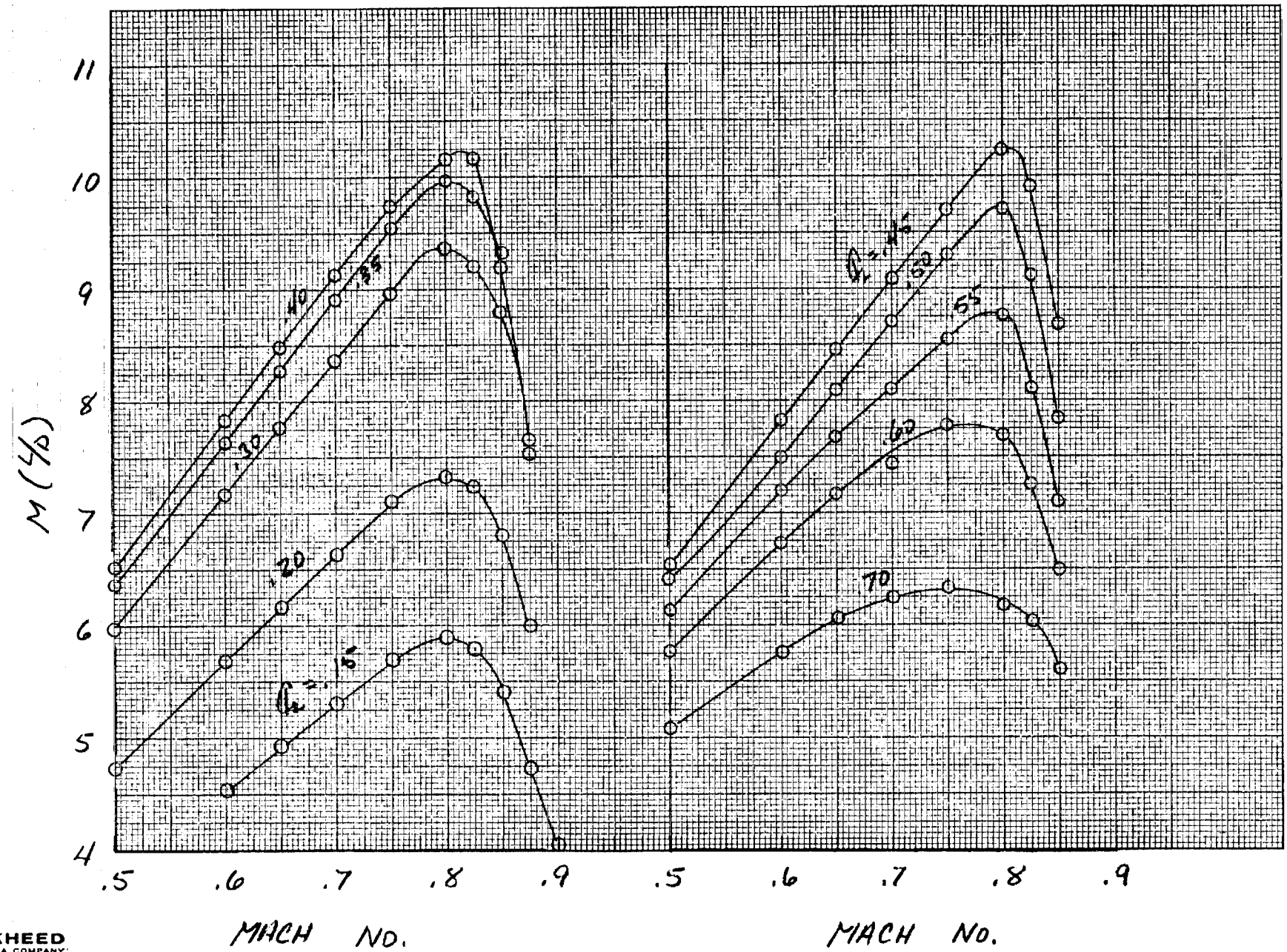

FIG. 23 M(L/D) VS. MACH NO., KA-3B

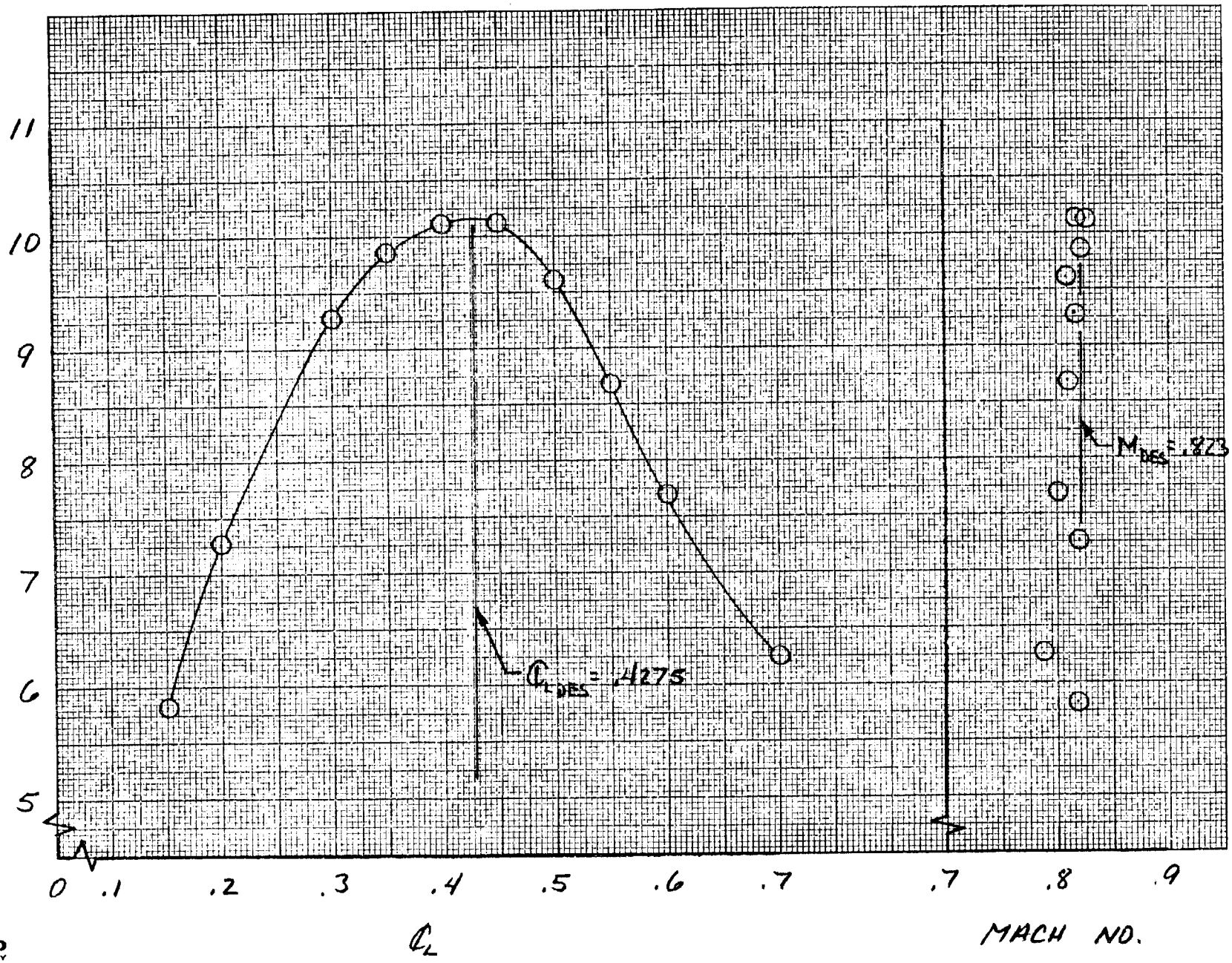

FIG. 24 $C_{L\,DES}$ AND M_{DES} FOR KA-3B

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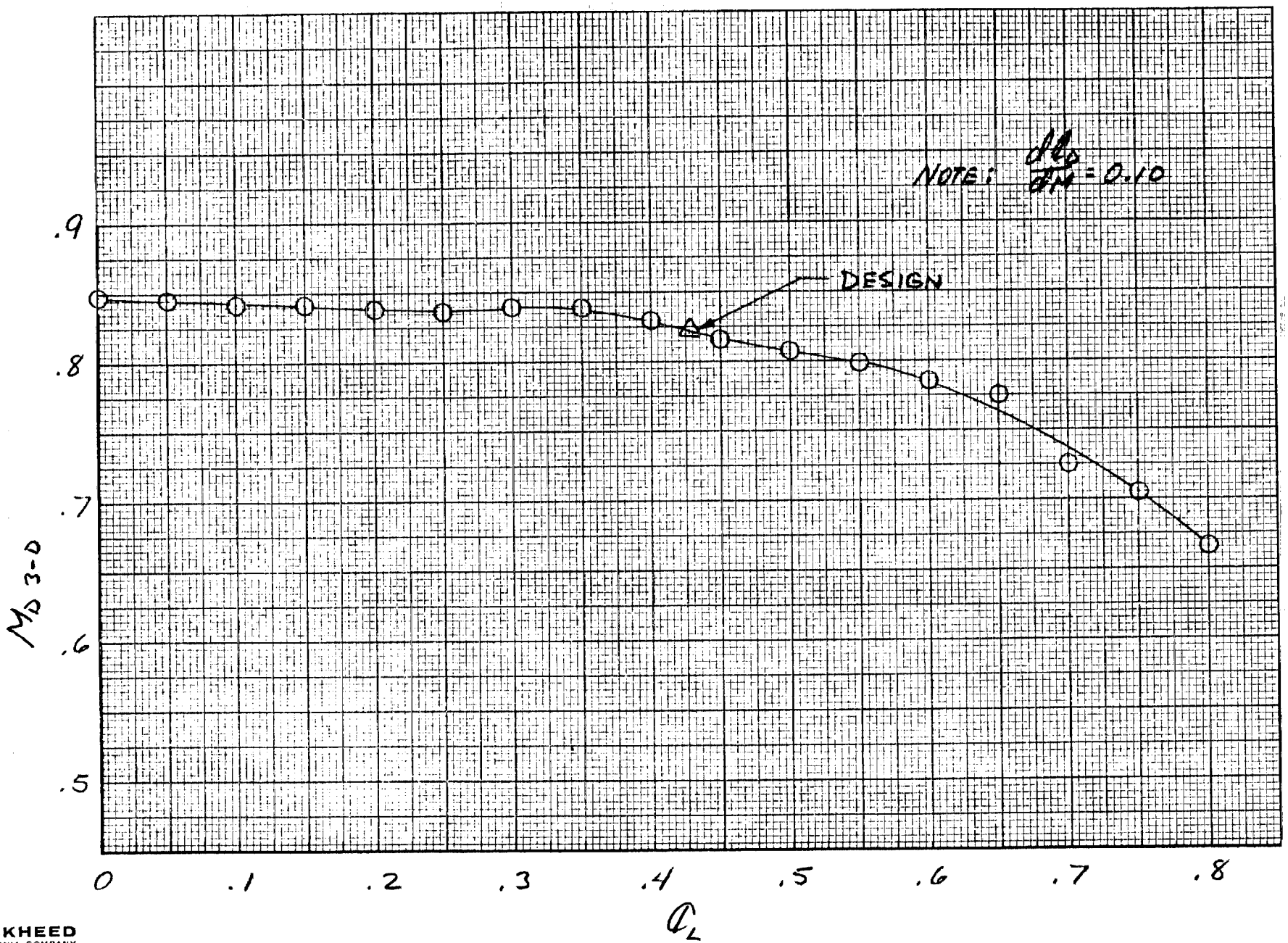

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FIG. 25 DRAG DIVERENCE CHARACTERISTICS, KA-3B

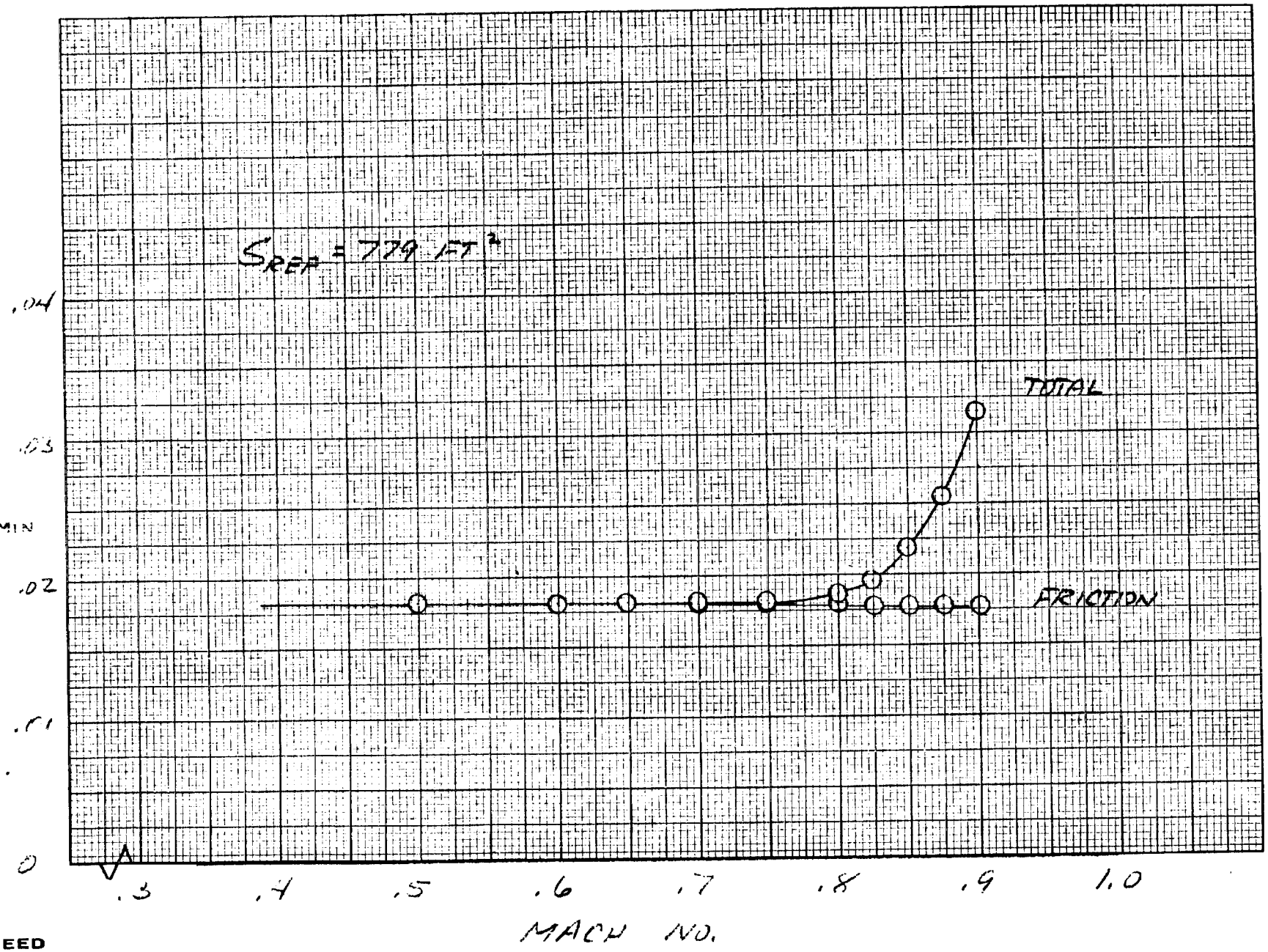

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FIG. 26 MINIMUM DRAG BREAKDOWN, KA-3B

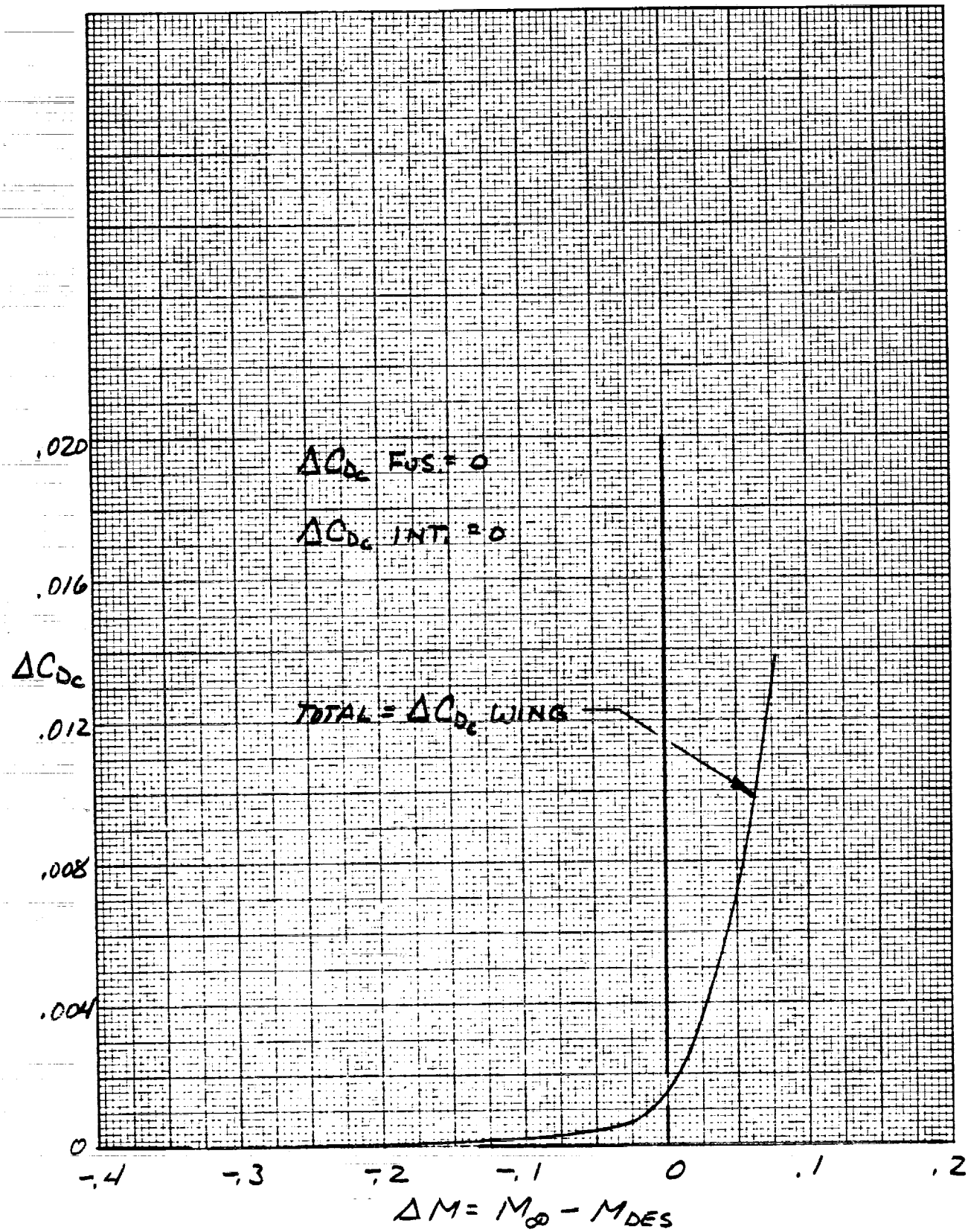

FIG. 27 COMPRESSIBILITY DRAG, KA-3B

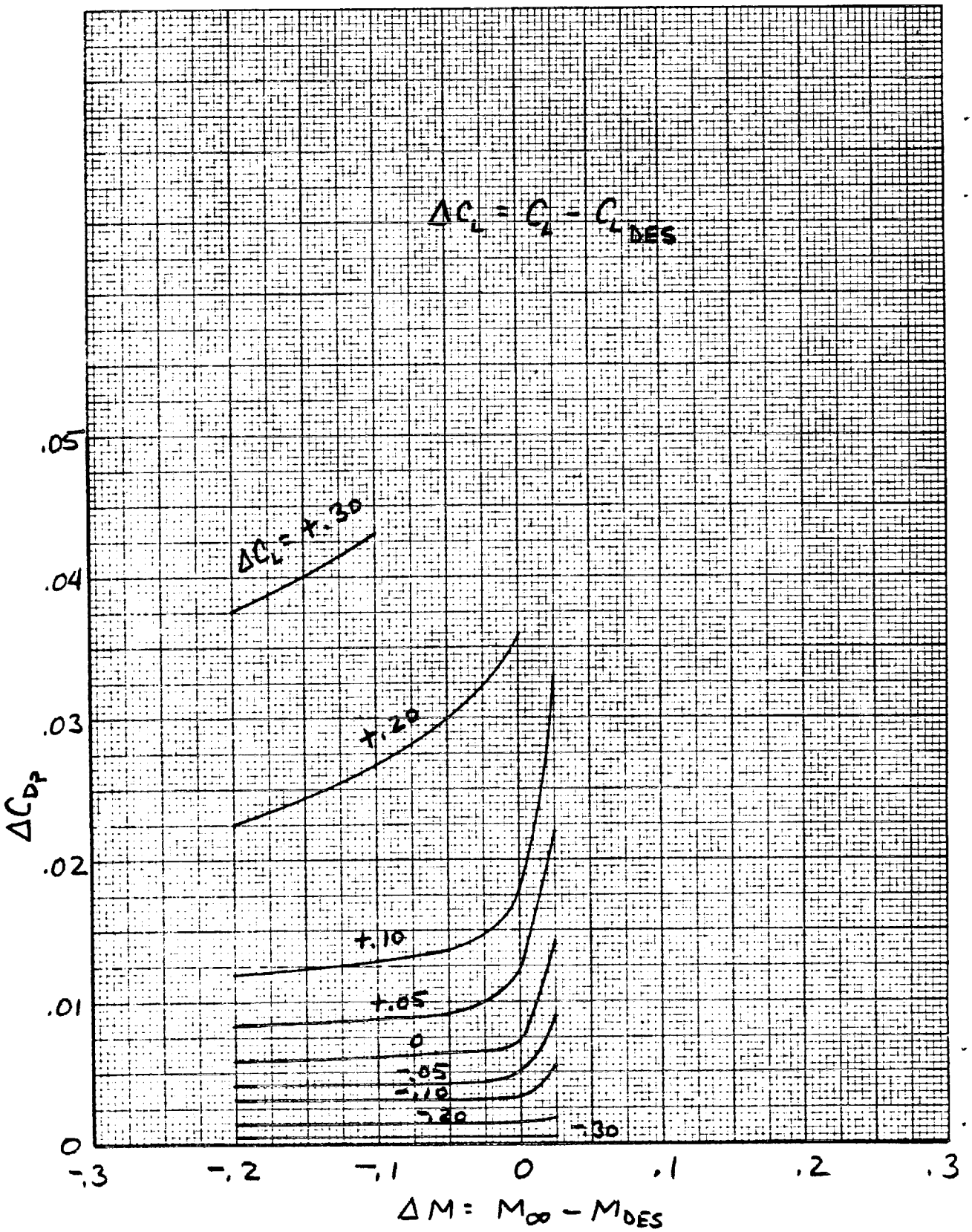

FIG. 28 WING PRESSURE DRAG VARIATION, KA-3B

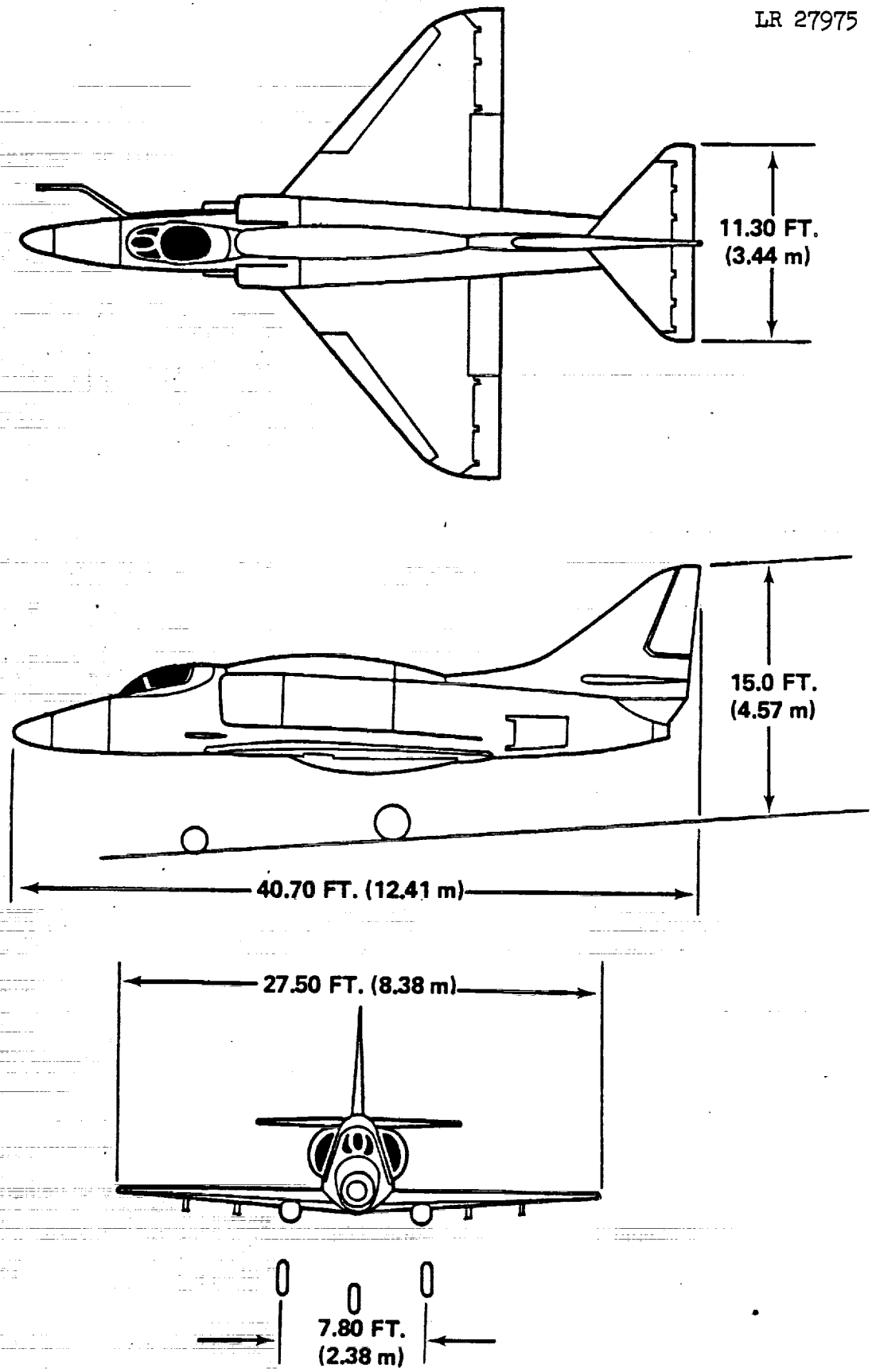

FIGURE 29. THREE-VIEW, A-4F

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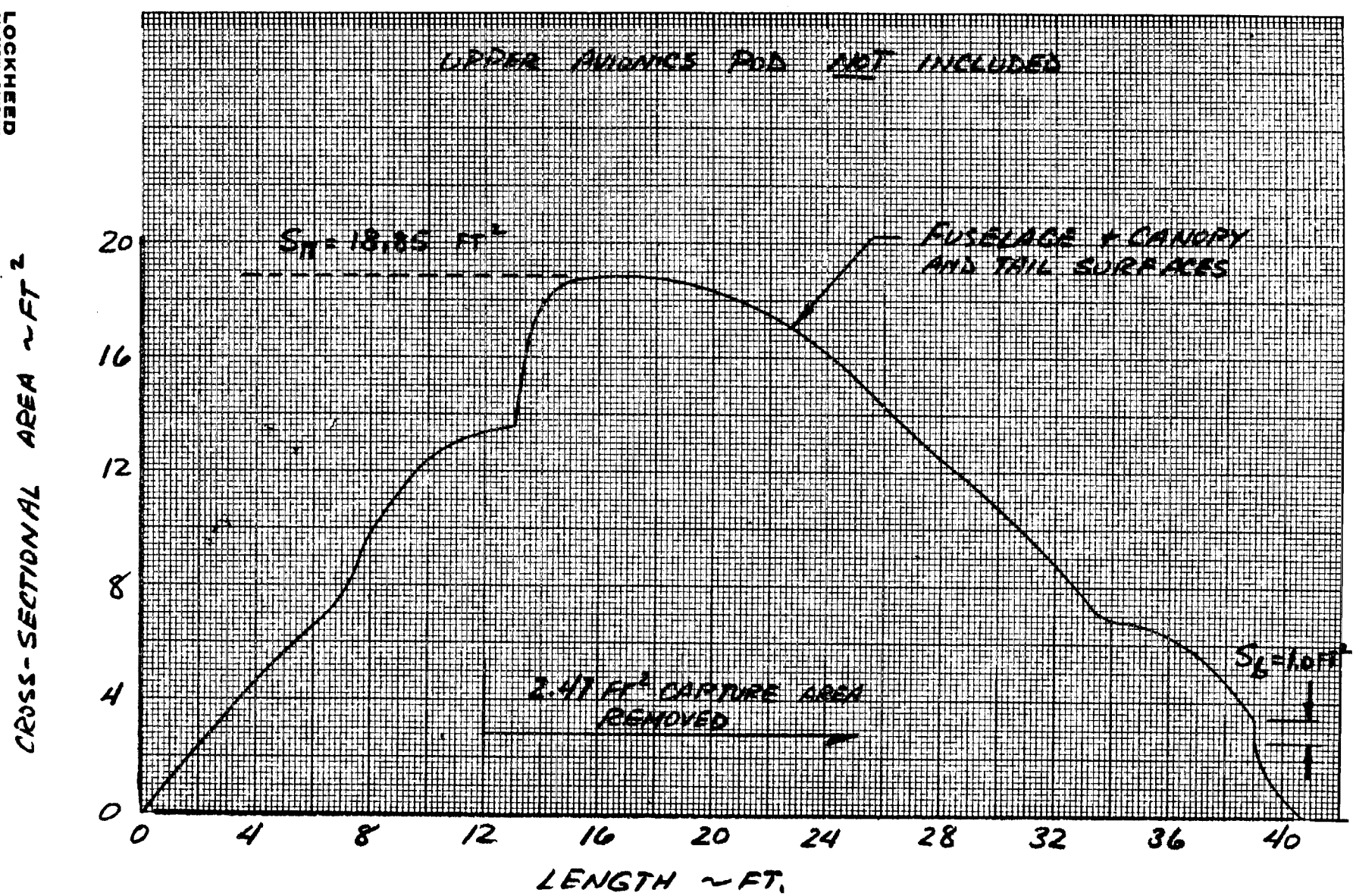

FIG. 30 A-4F FUSELAGE AREA DISTRIBUTION

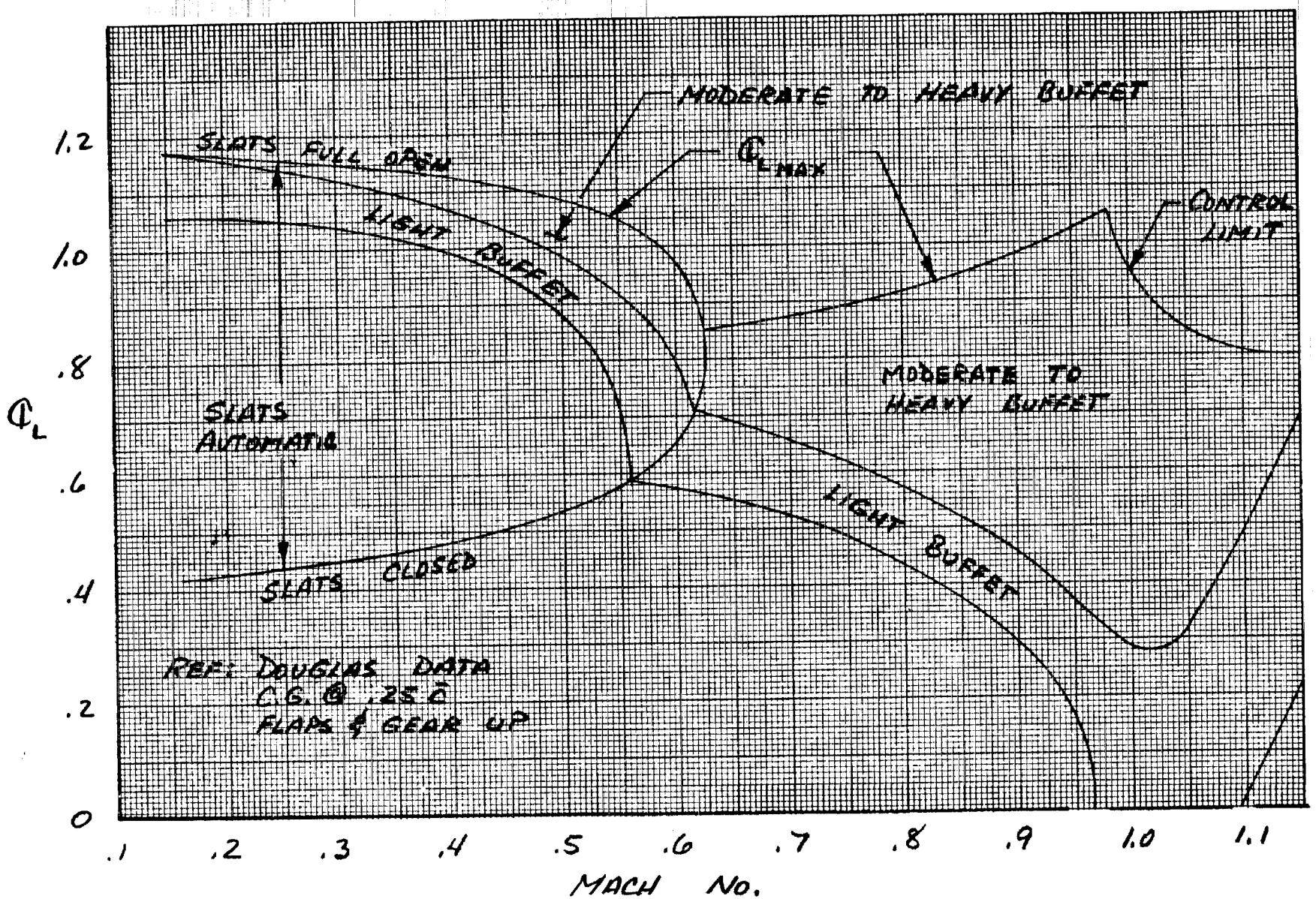

FIG. 31 LIMIT LIFT CHARACTERISTICS ~ A-4F/TA-4F

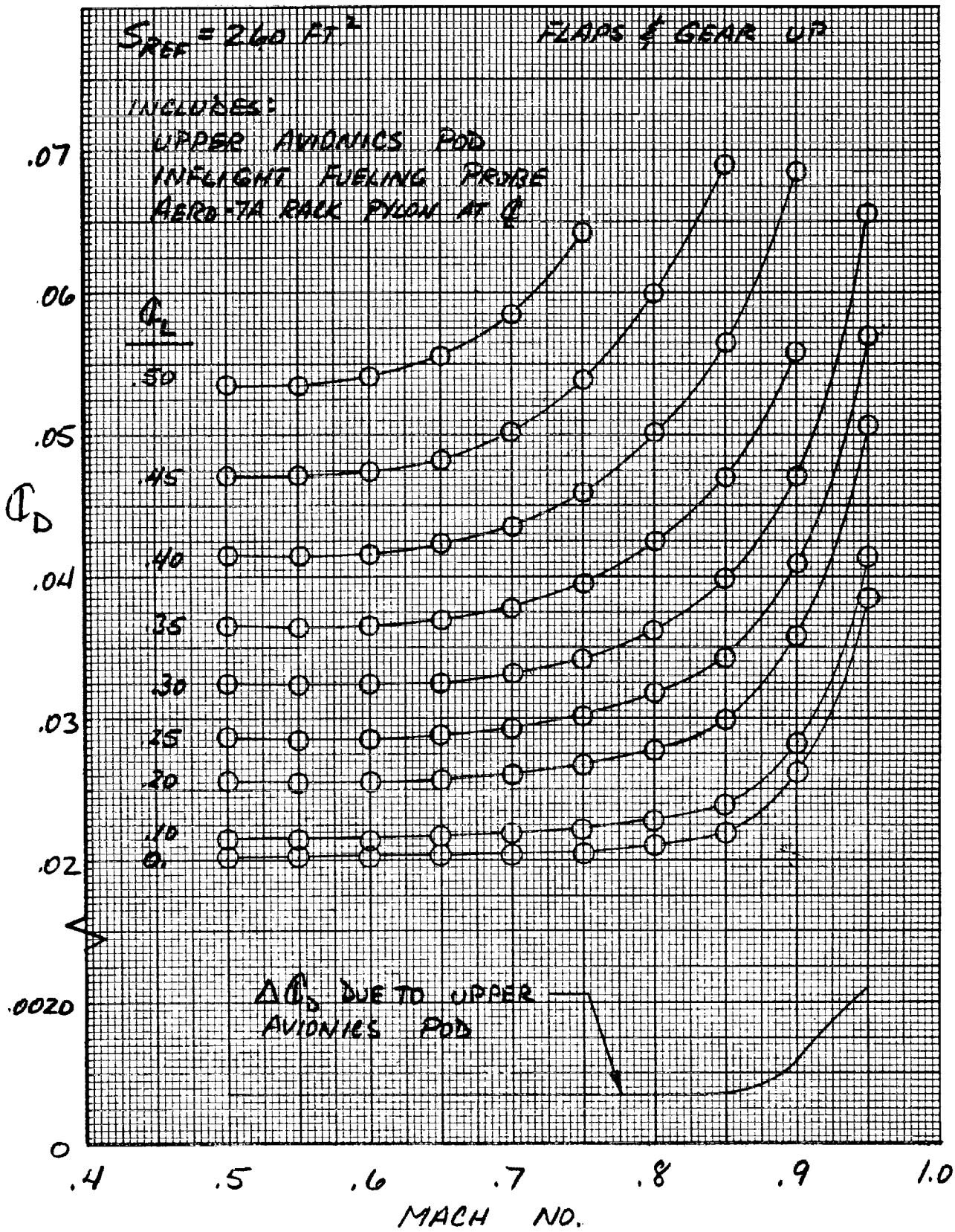

FIG. 32 A-4F DRAG CHARACTERISTICS

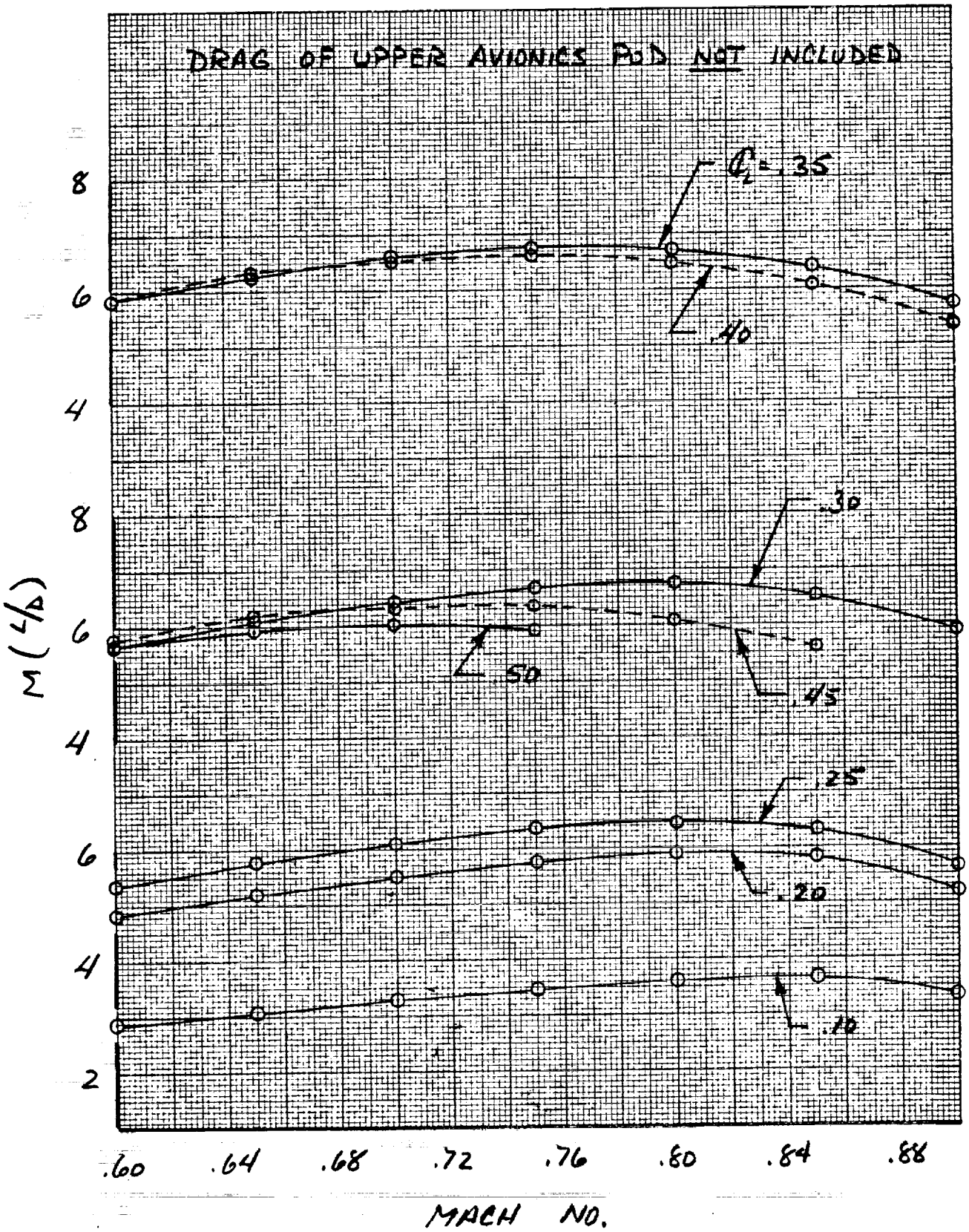

FIG. 33, M (L/D) VS. MACH NO. ~ A-4F

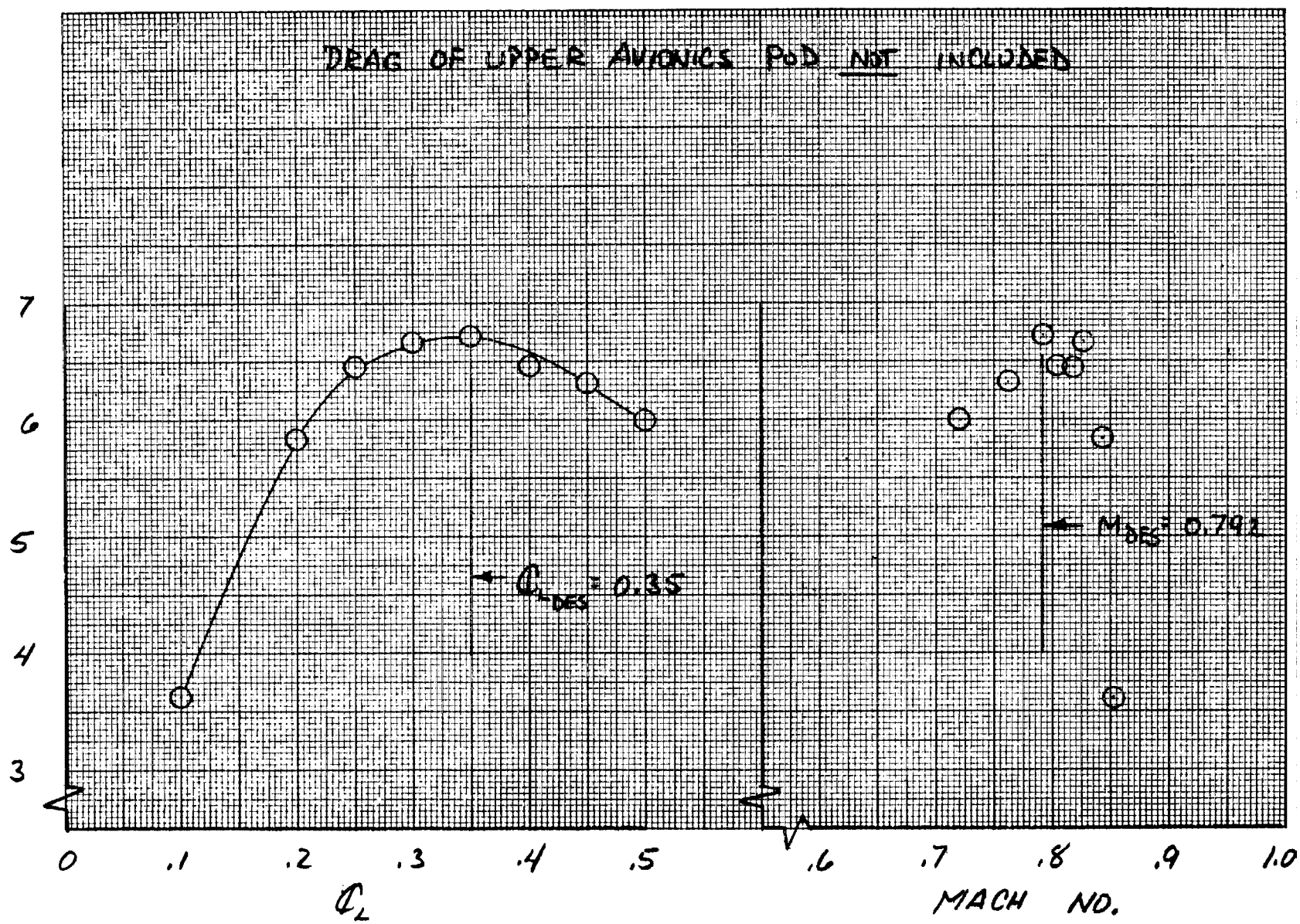

FIG. 34 $C_{L_{DES}}$ AND M_{DES} FOR A-4F

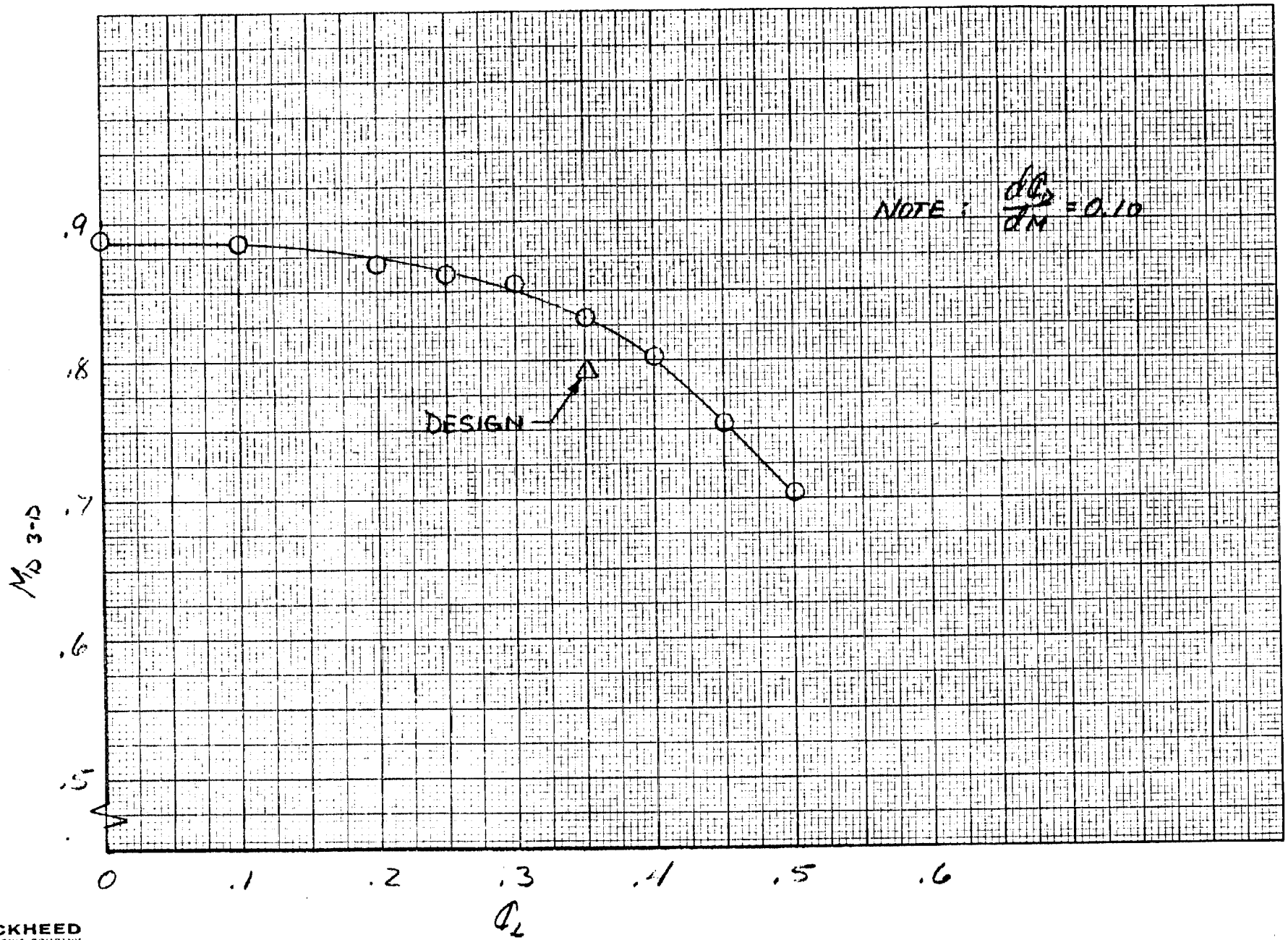

FIG. 35 DRAG DIVERGENCE CHARACTERISTICS, A-4F

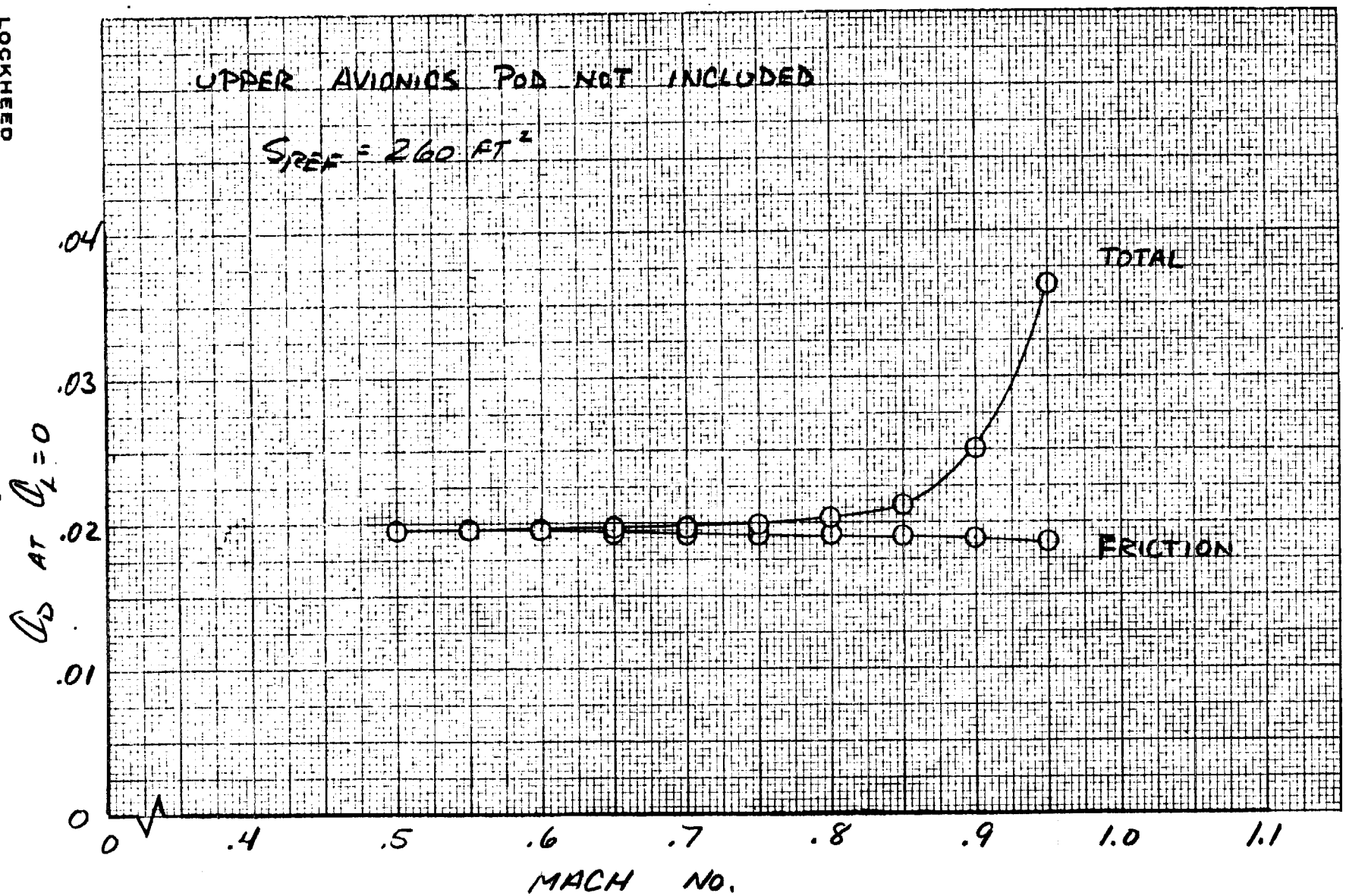

FIG. 36 MINIMUM DRAG BREAKDOWN, A-4F

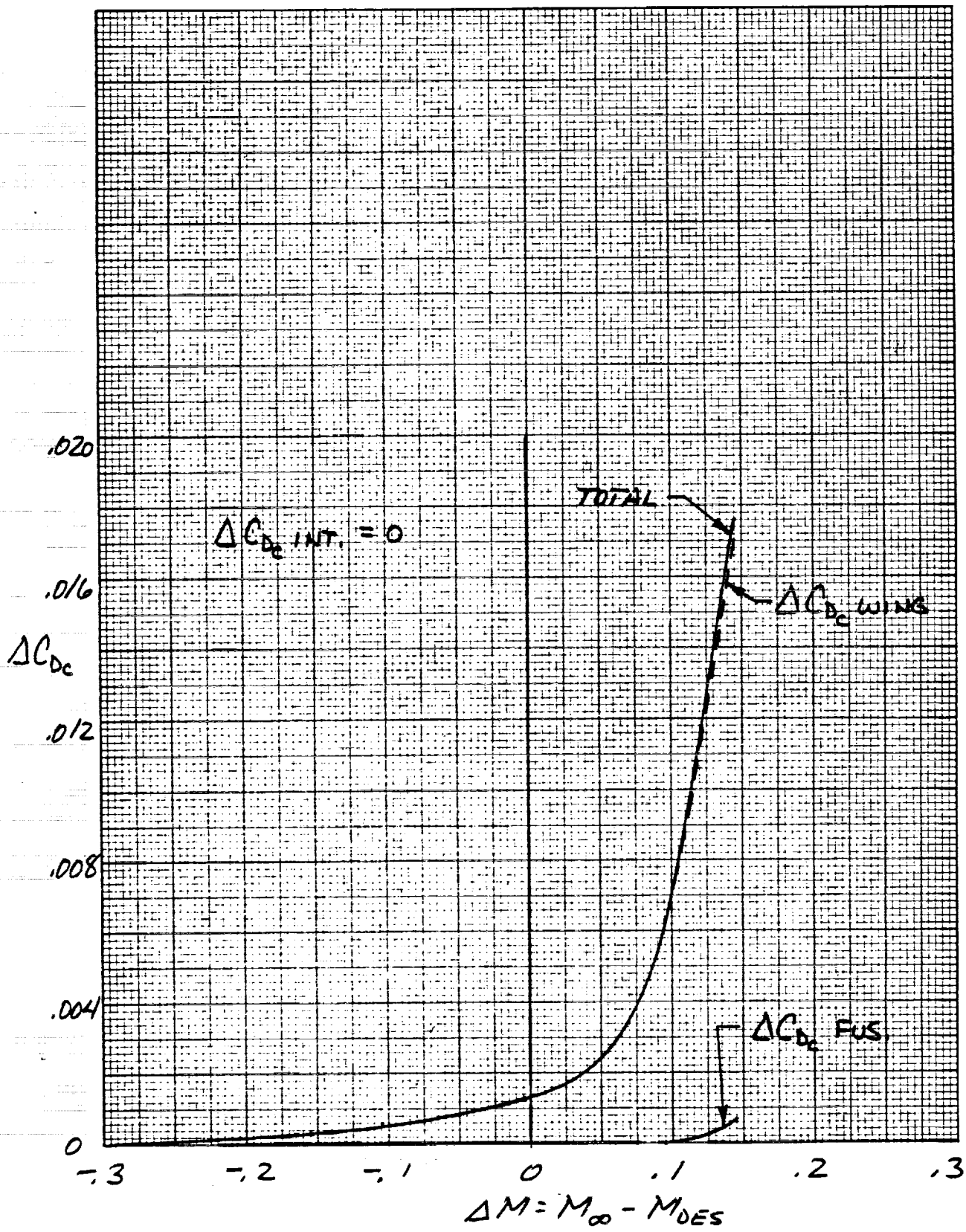

FIG. 37 COMPRESSIBILITY DRAG, A-4F

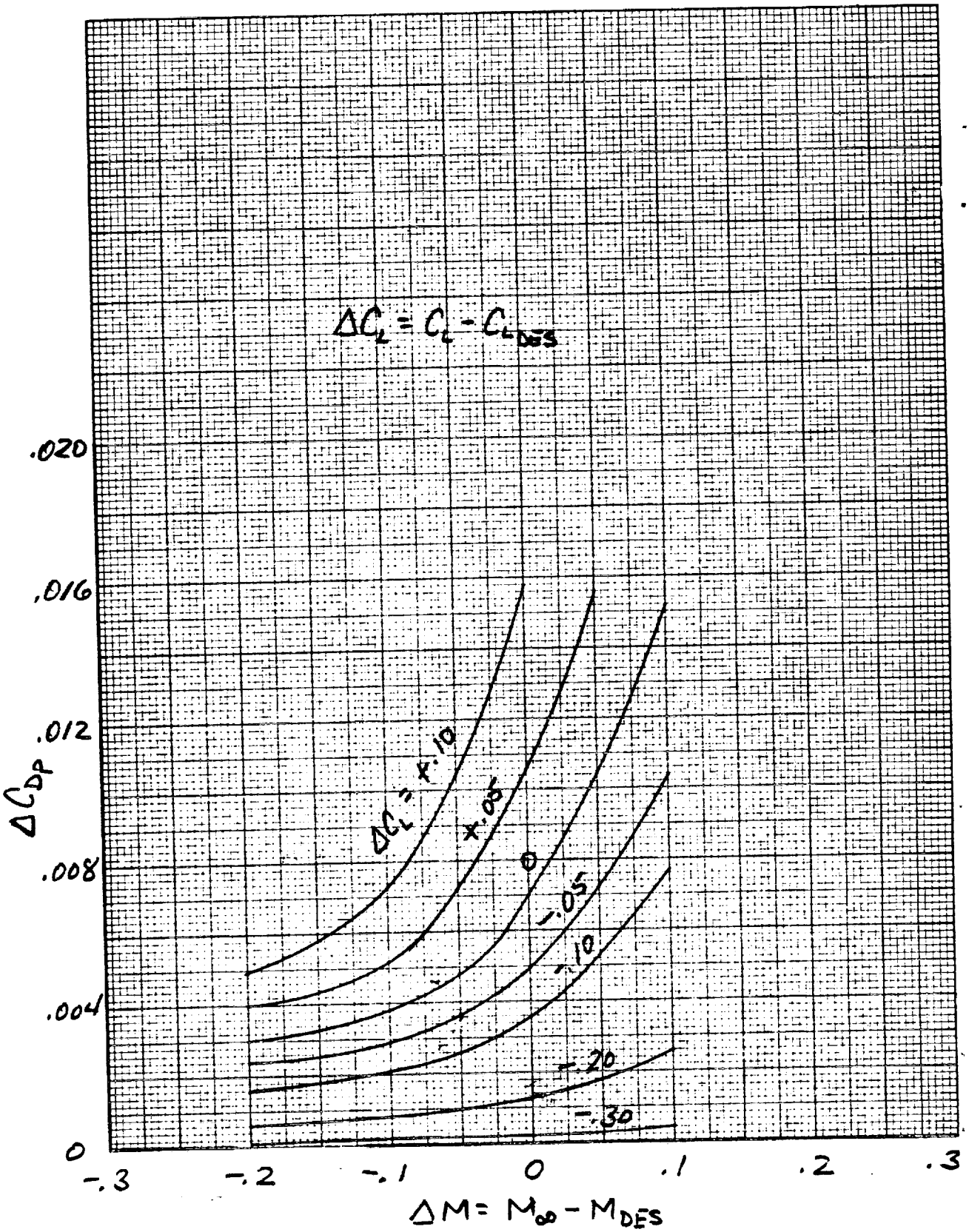

FIG. 38 WING PRESSURE DRAG VARIATION, A-4F

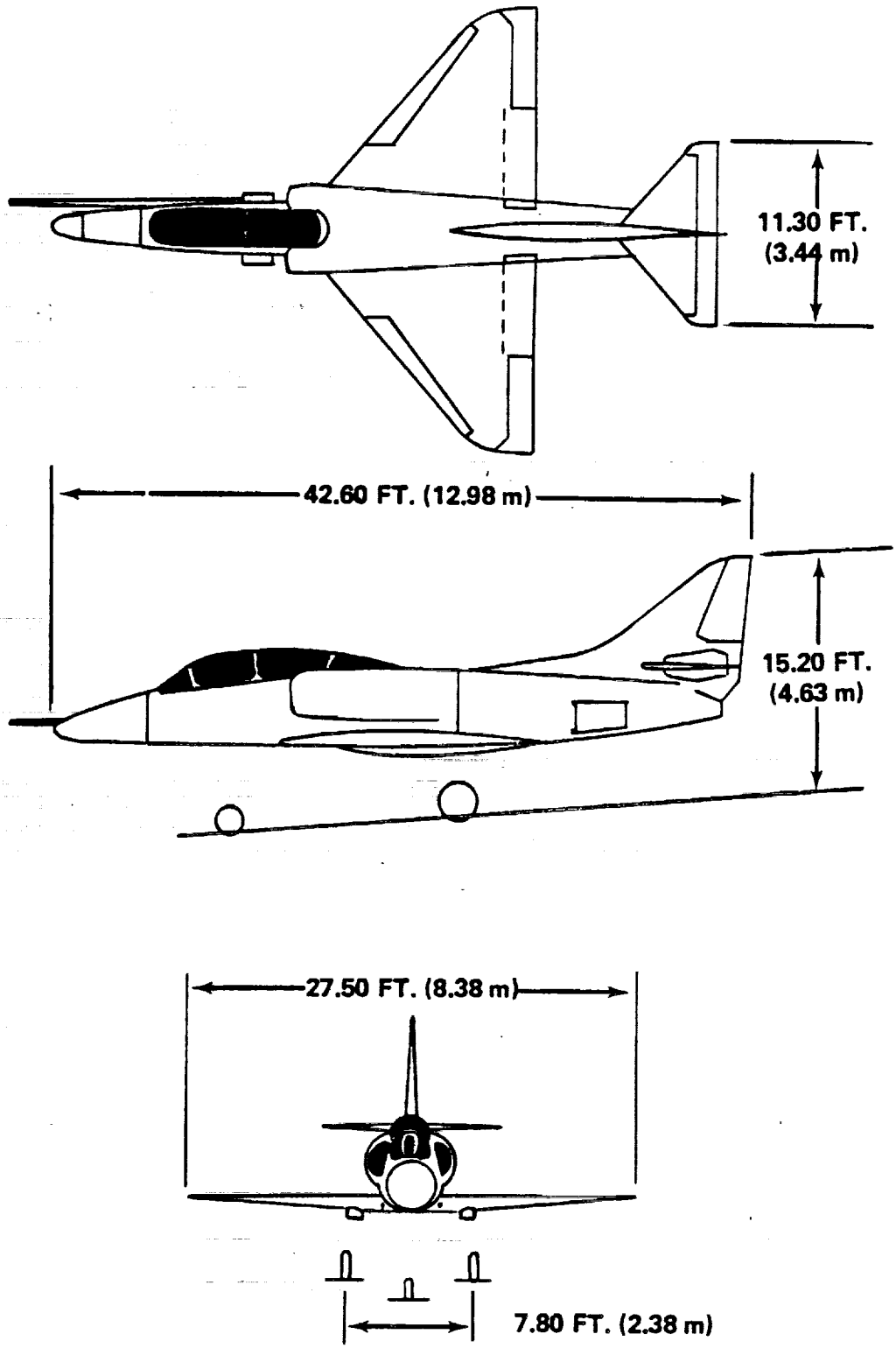

FIGURE 39. THREE-VIEW, TA-4F

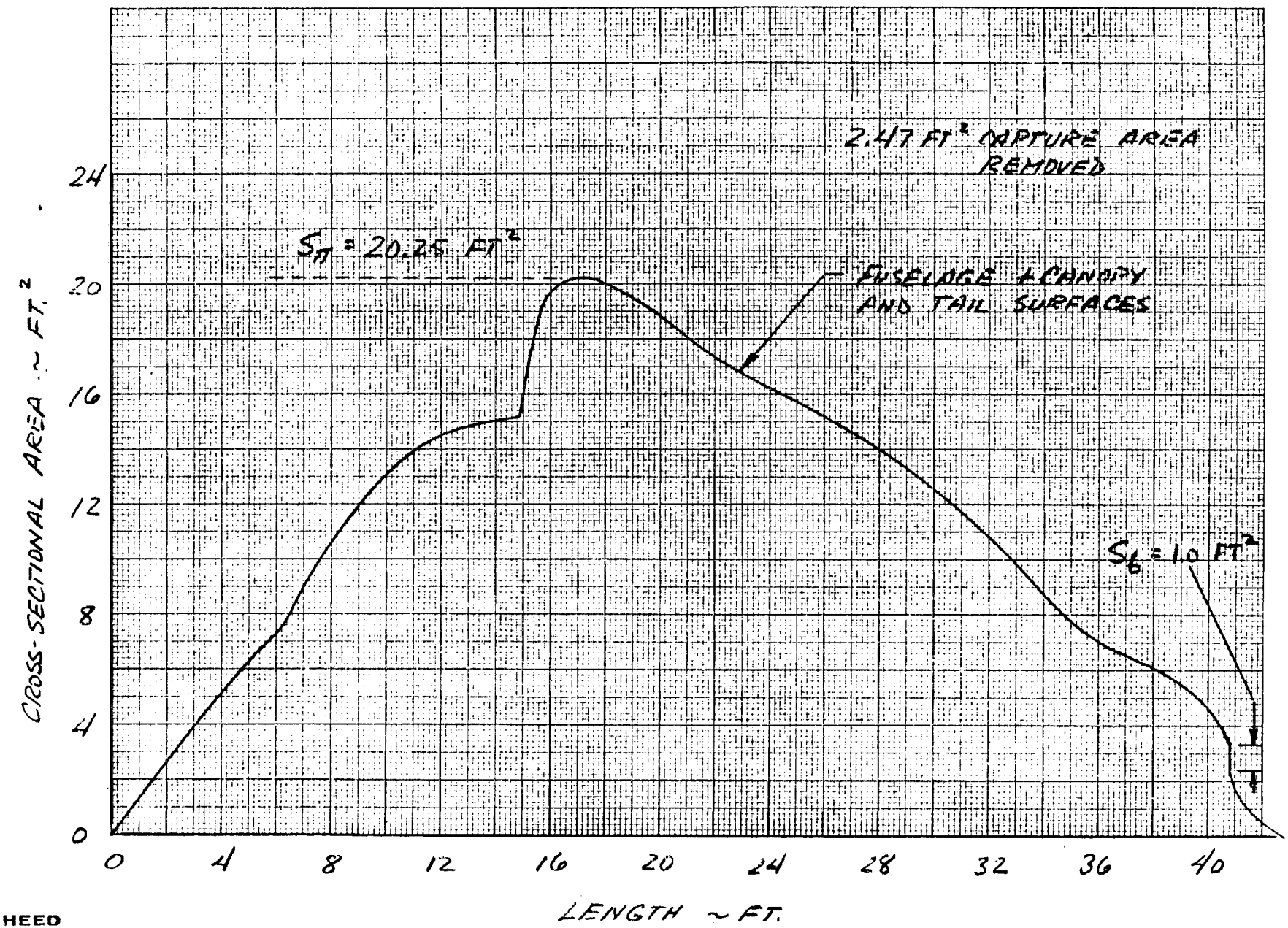

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FIG. 40 TA-4F FUSELAGE AREA DISTRIBUTION

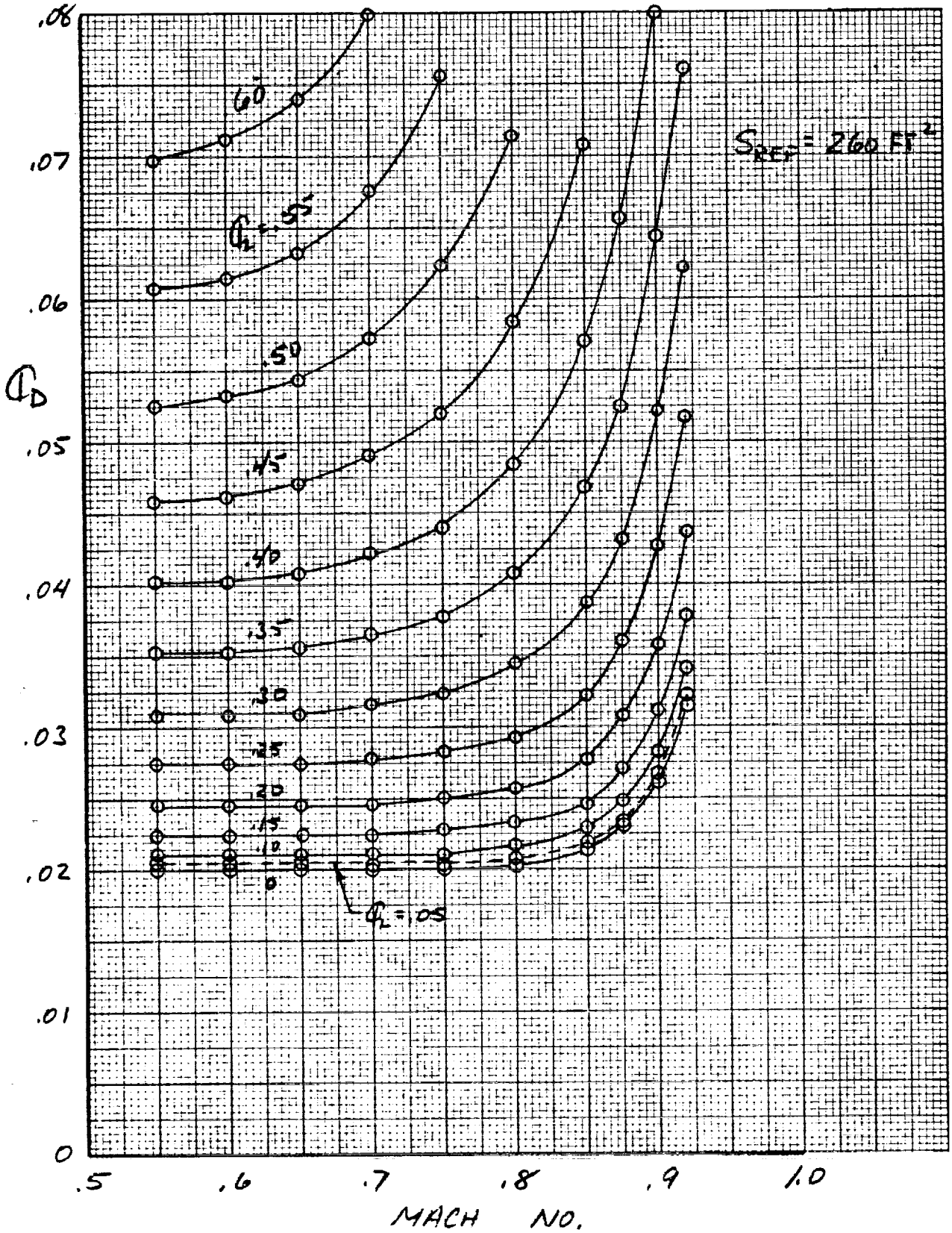

FIG. 41 TA-4F DRAG CHARACTERISTICS

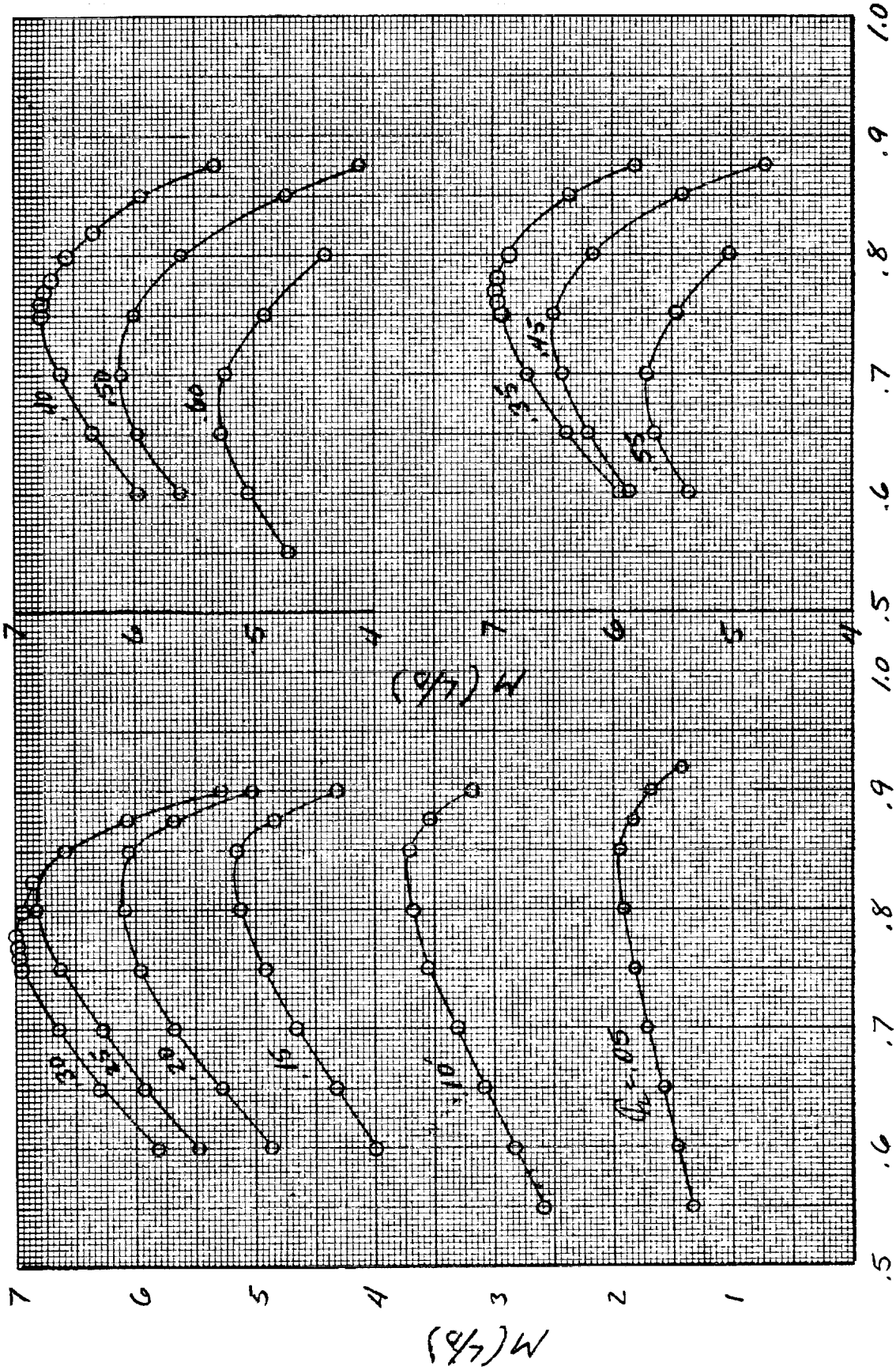

FIG. 42 M(L/D) VS. MACH NUMBER, TA-41F

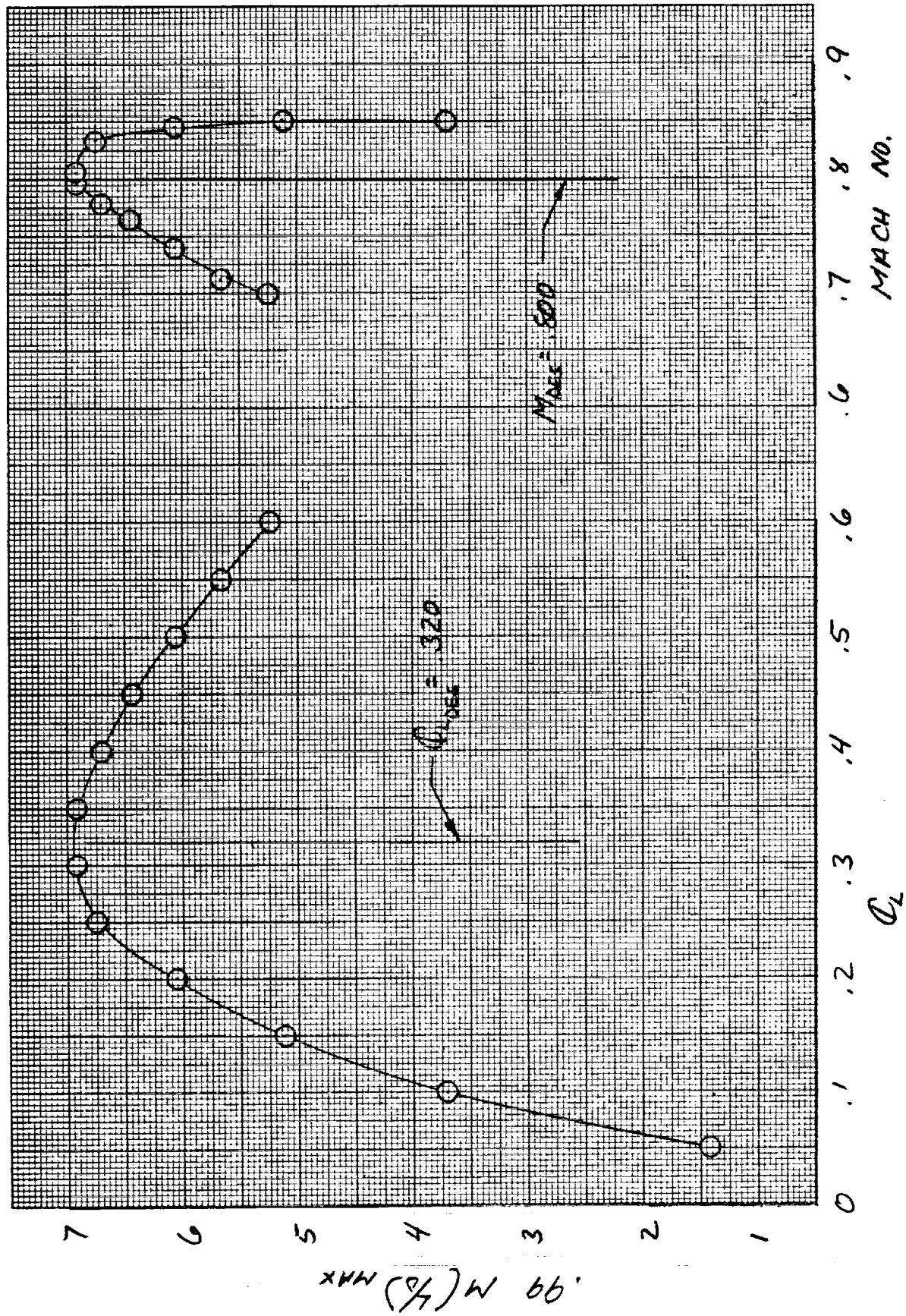

FIG. 43 $C_{L_{DES}}$ AND M_{DES} FOR TA-4F

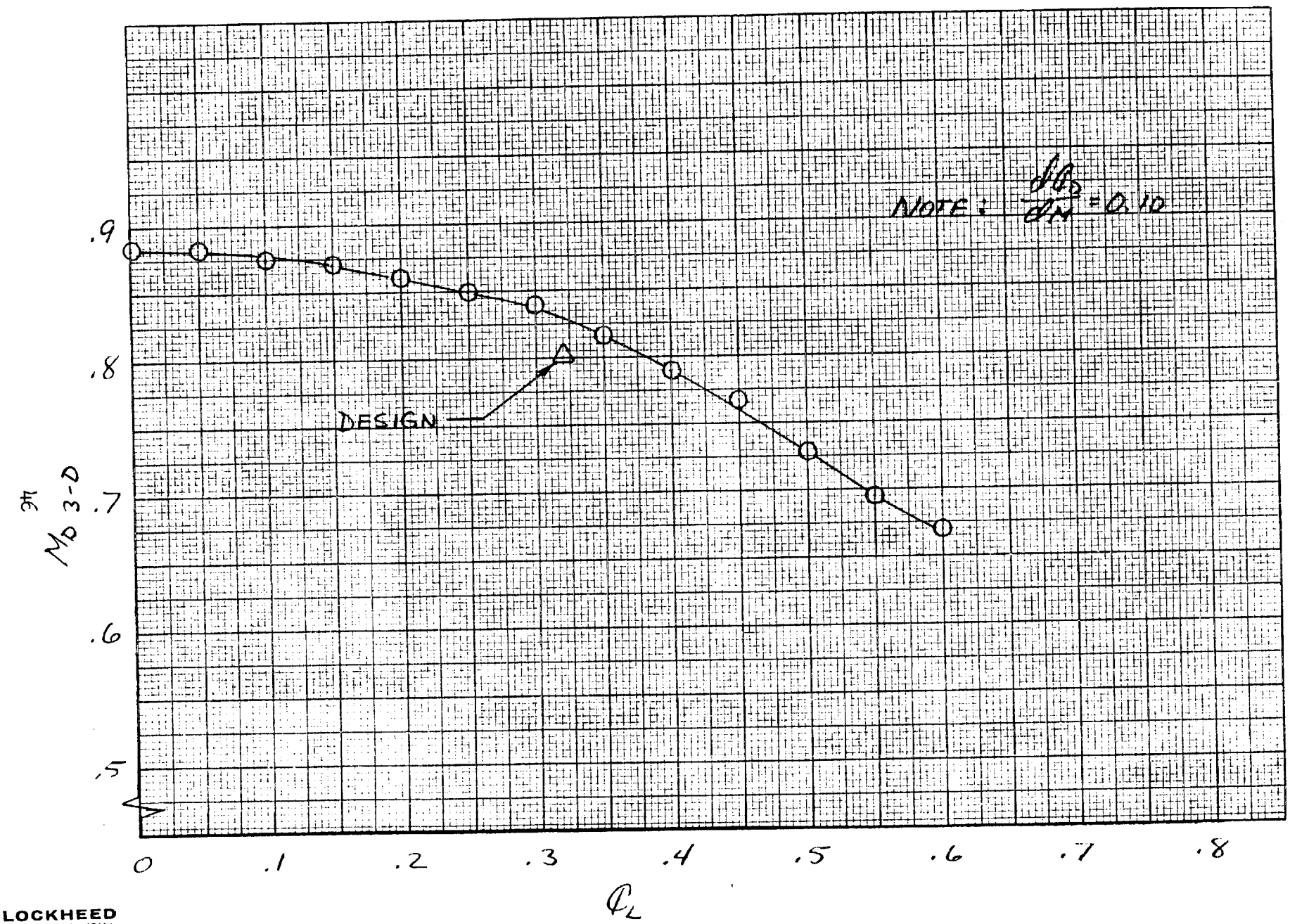

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FIG. 44 DRAG DIVERGENCE CHARACTERISTICS FOR TA-4F

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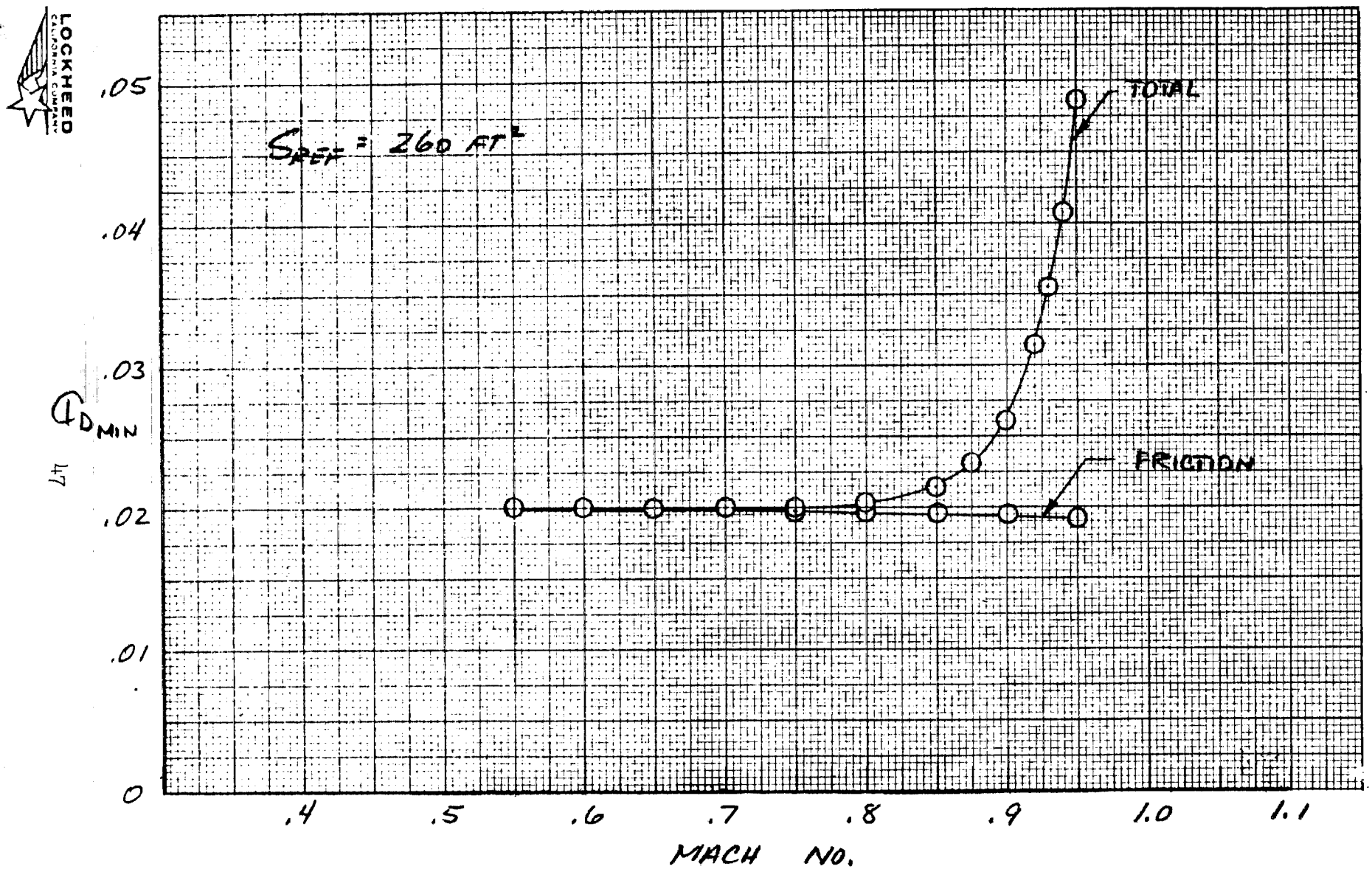

FIG. 45 MINIMUM DRAG BREAKDOWN, TA-4F

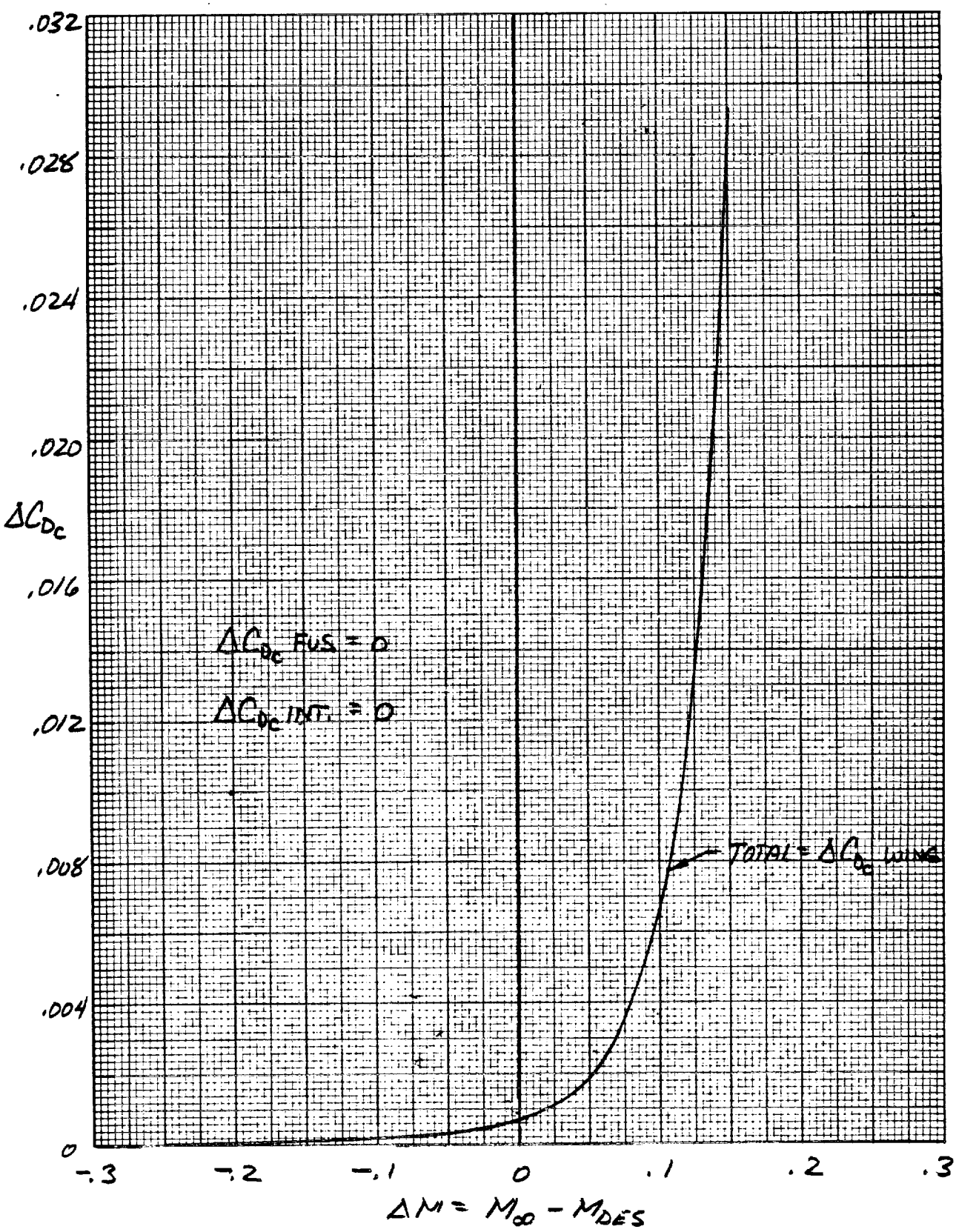

FIG. 46 COMPRESSIBILITY DRAG, TA-4F

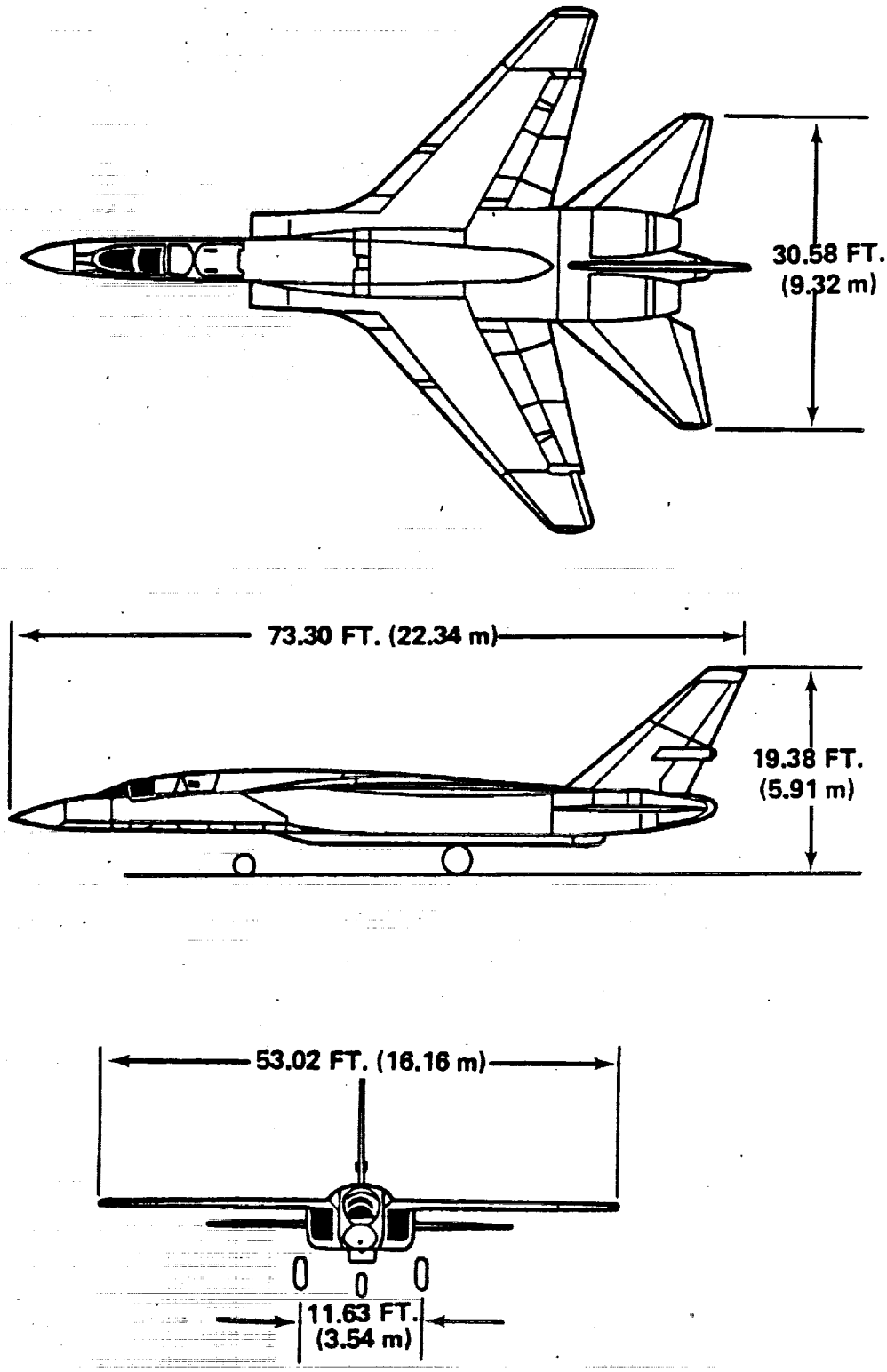

FIGURE 47. THREE-VIEW, RA-5C

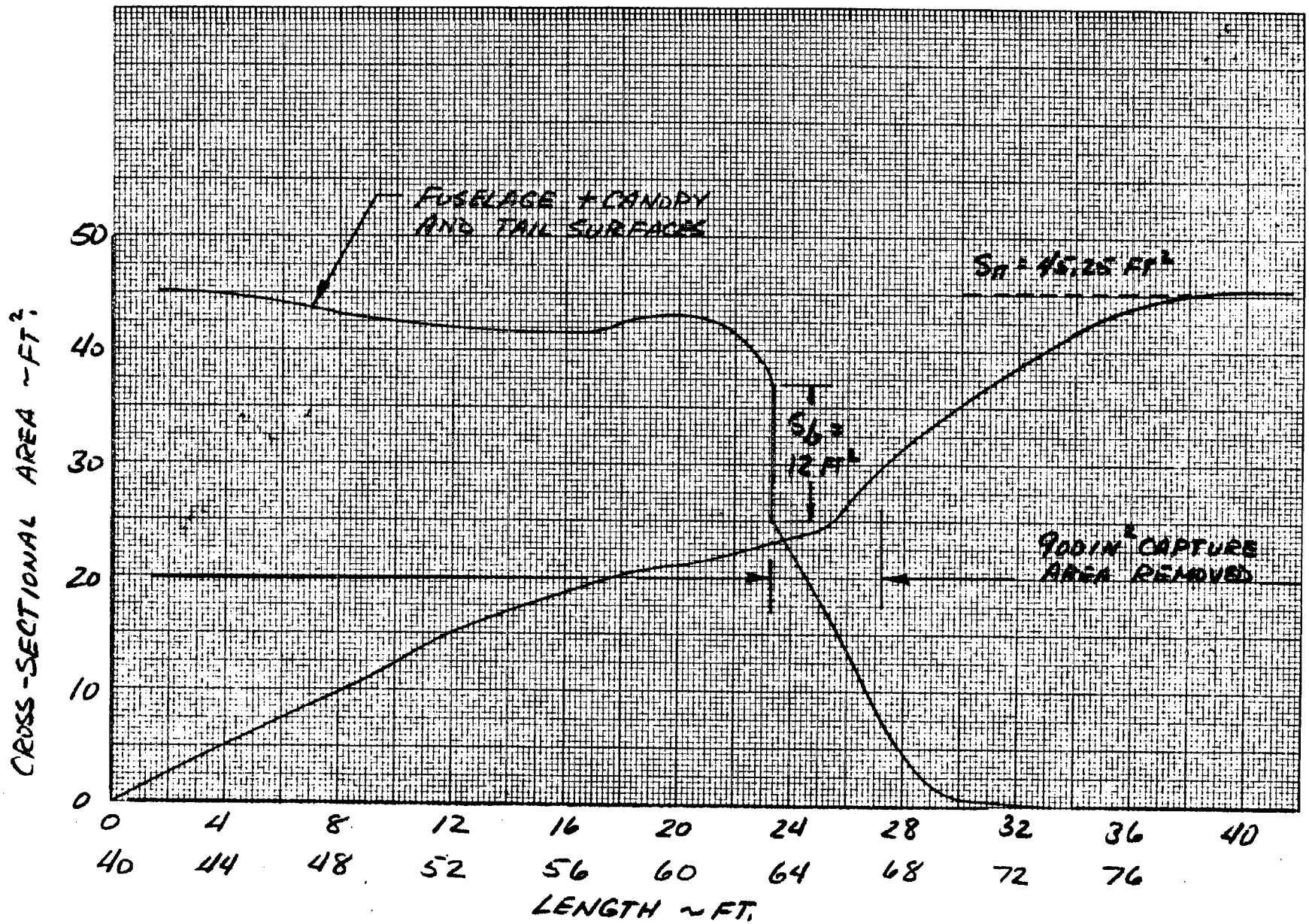

FIG. 48 RA-5C FUSELAGE AREA DISTRIBUTION

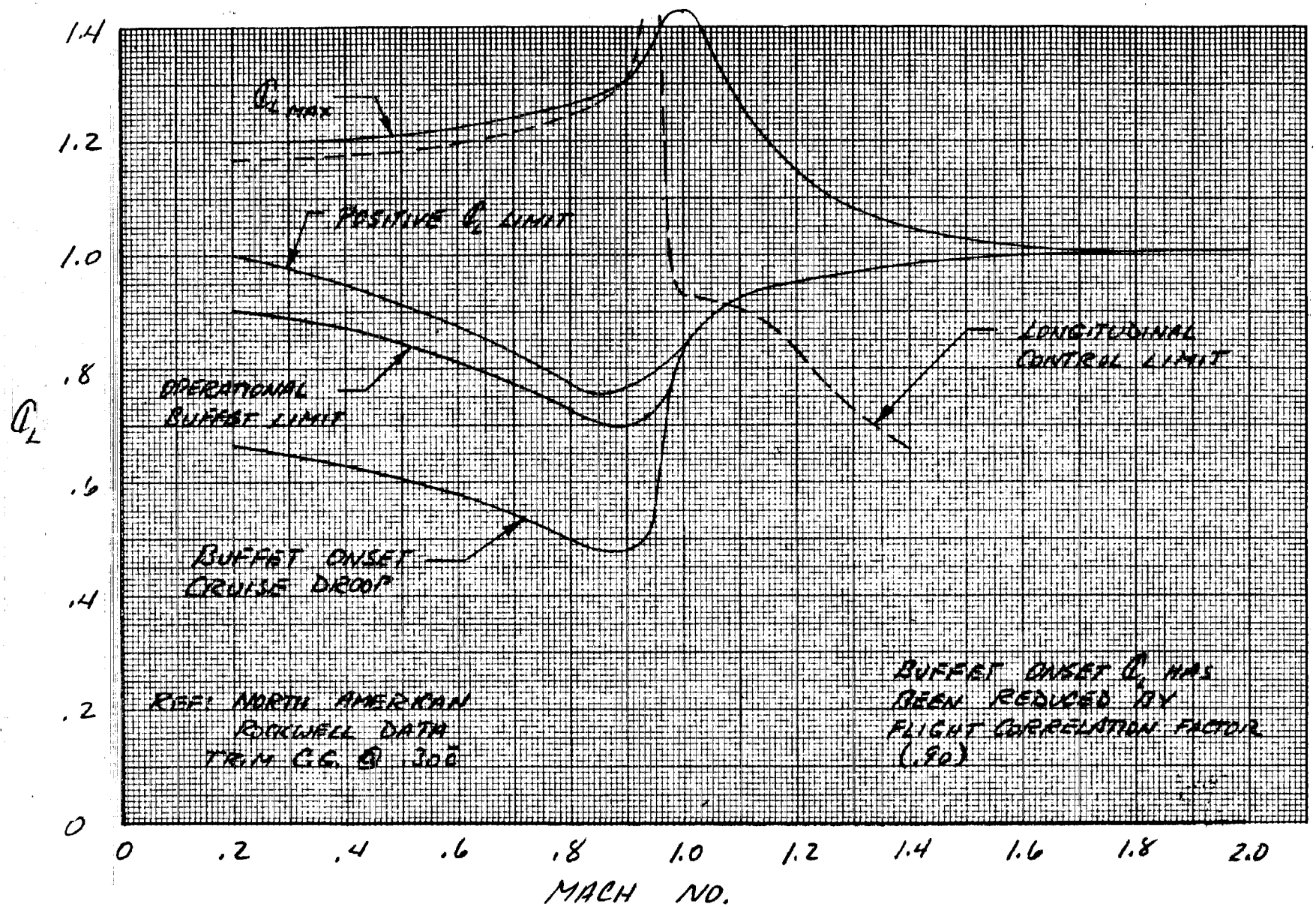

FIG. 49 LIMIT LIFT CHARACTERISTICS, RA-5C

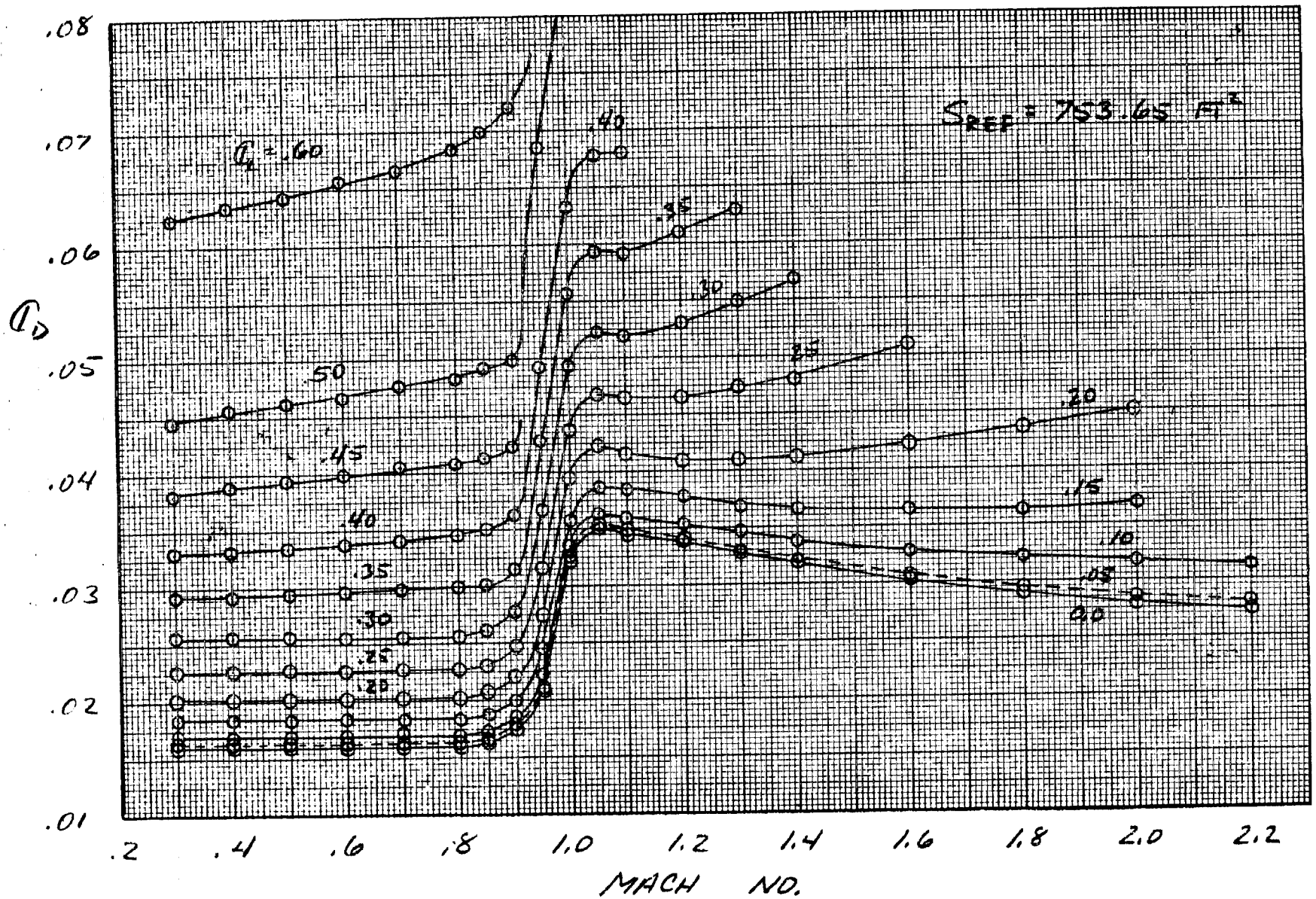

FIG. 50 RA-5C DRAG CHARACTERISTICS

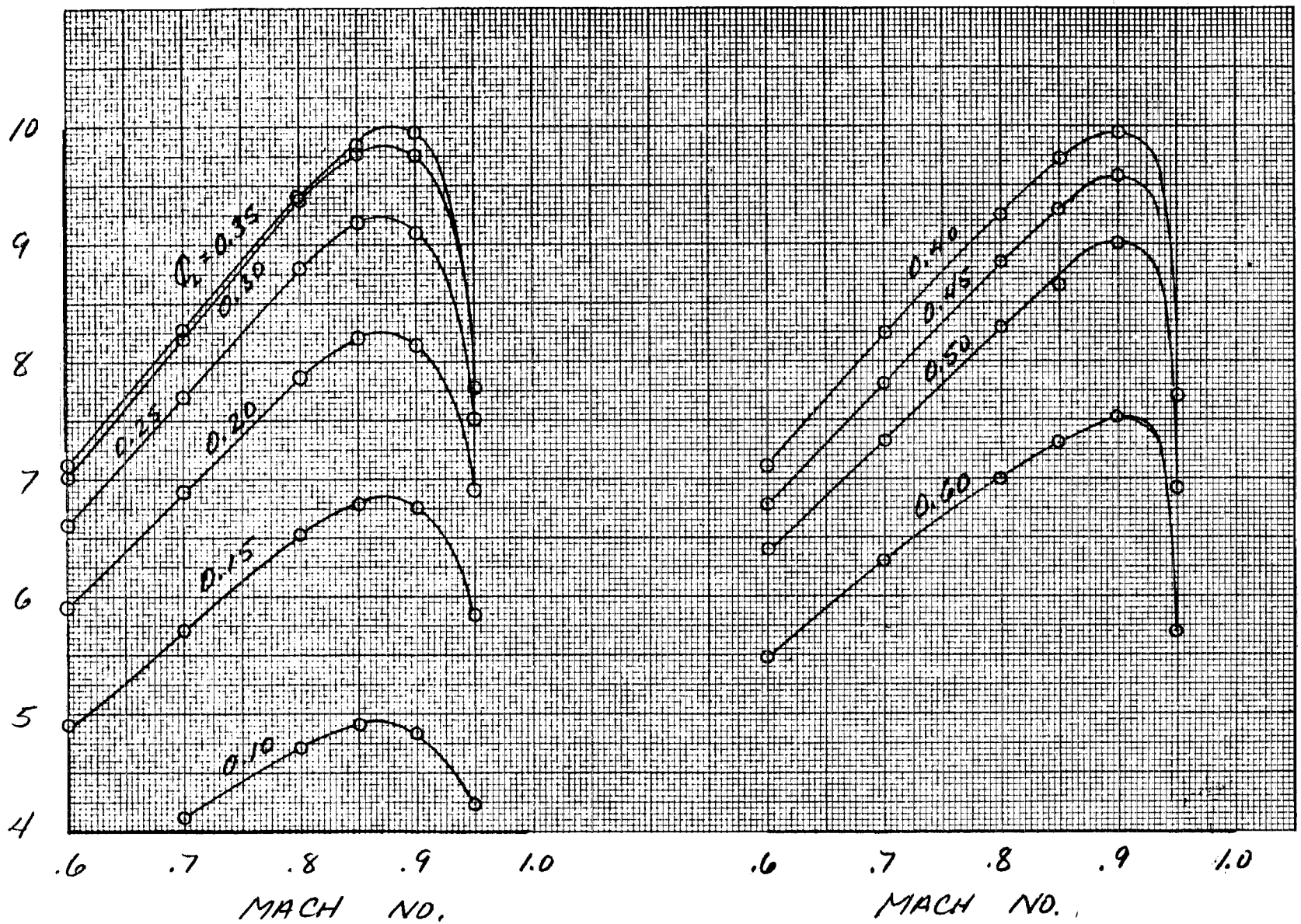

FIG. 51 M(L/D) VS. MACH NUMBER, RA-5C

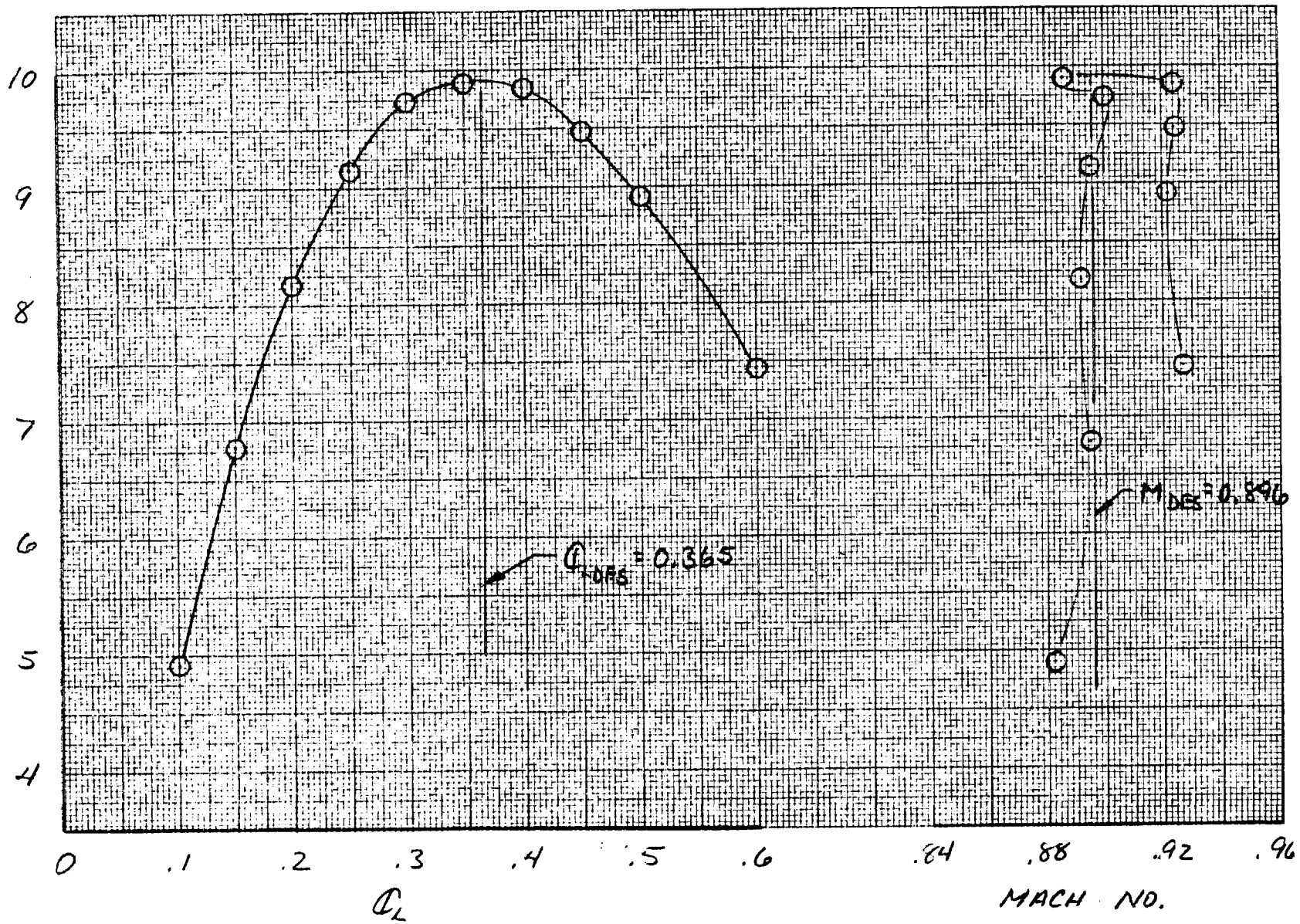

FIG. 52 $C_{L_{DES}}$ AND M_{DES} FOR RA-5C

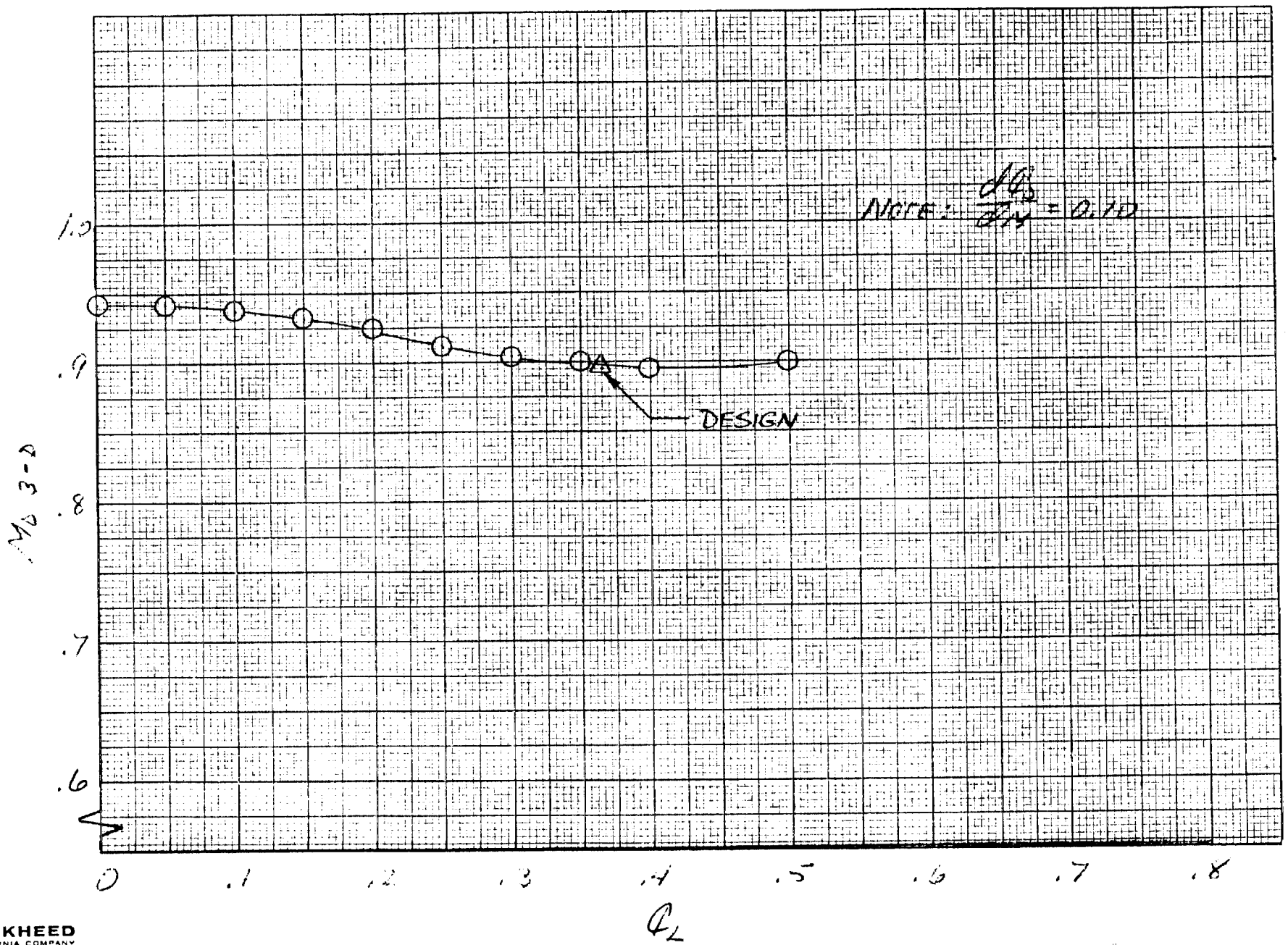

FIG. 53 DRAG DIVERGENCE CHARACTERISTICS, RA-5C

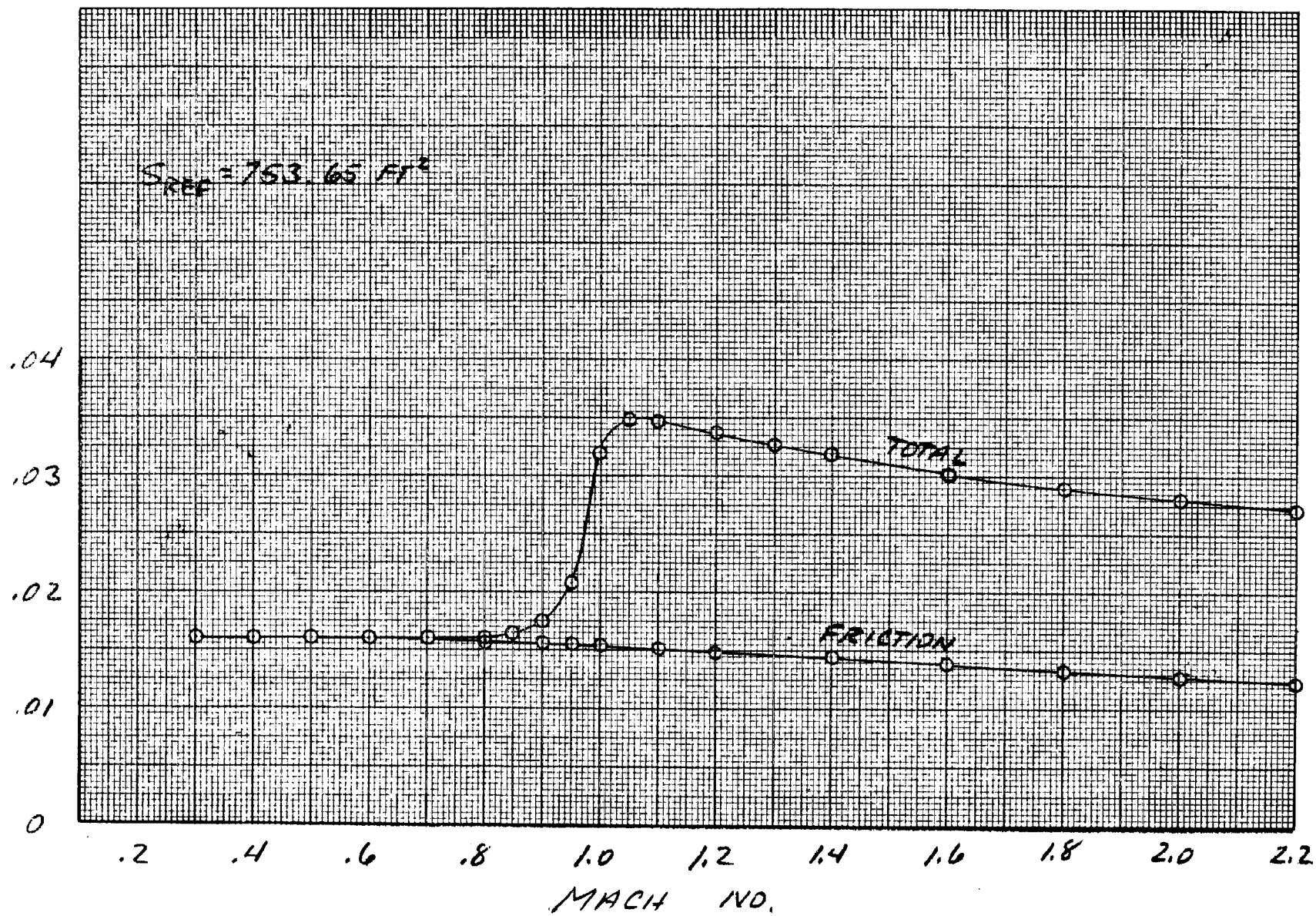

FIG. 54 MINIMUM DRAG BREAKDOWN, RA-5C

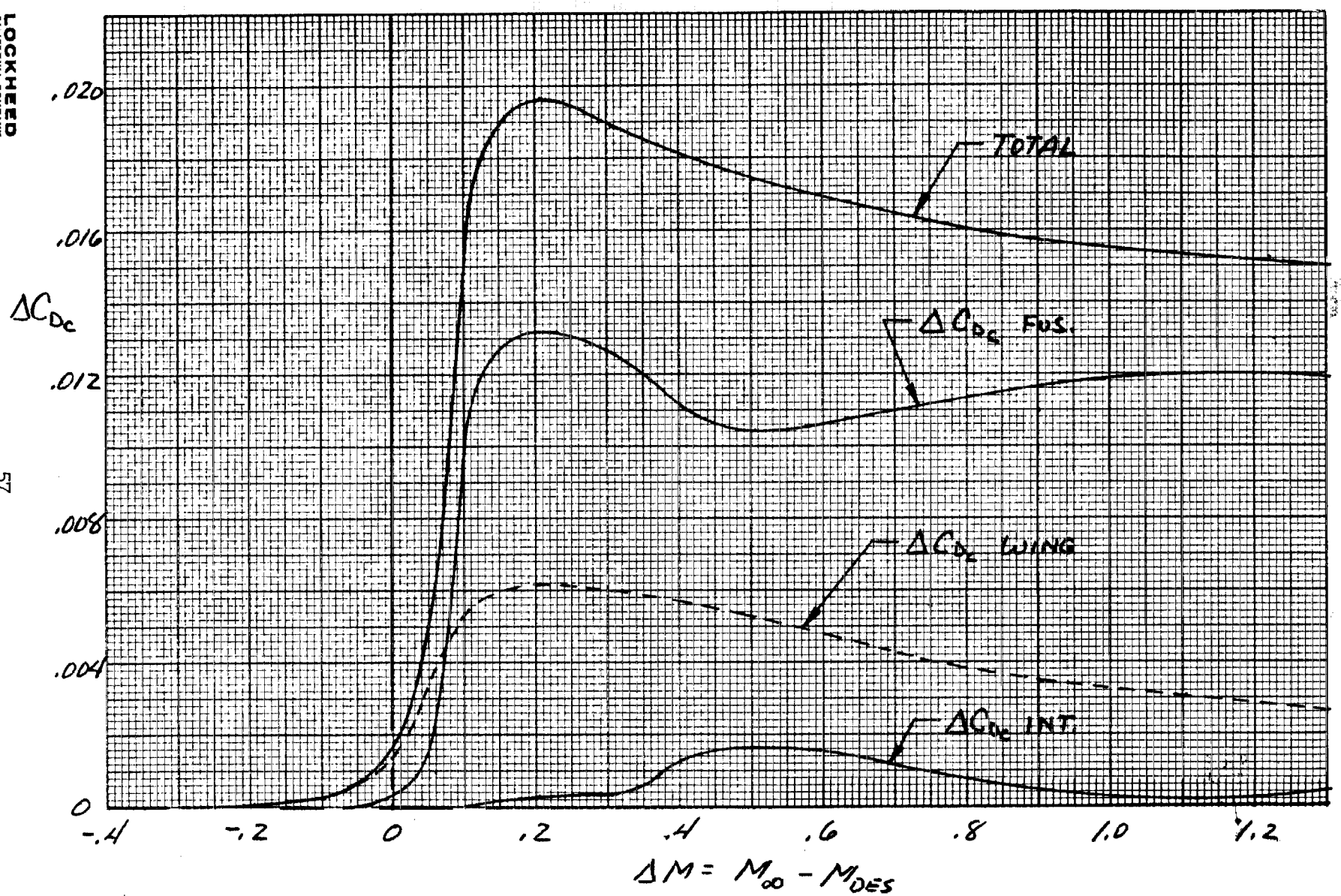

FIG. 55 COMPRESSIBILITY DRAG, RA-5C

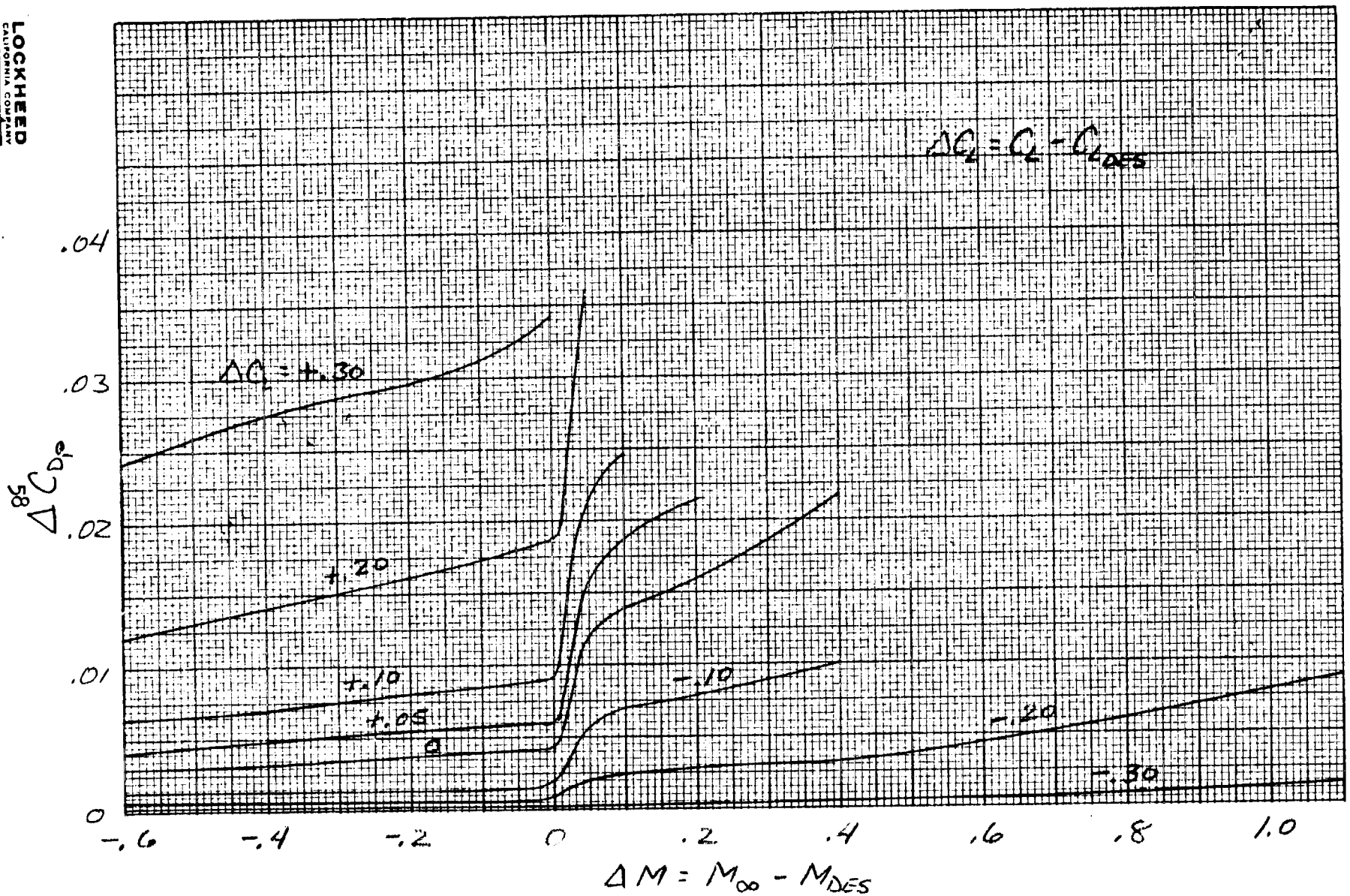

FIG. 56 WING PRESSURE DRAG VARIATION, RA-5C

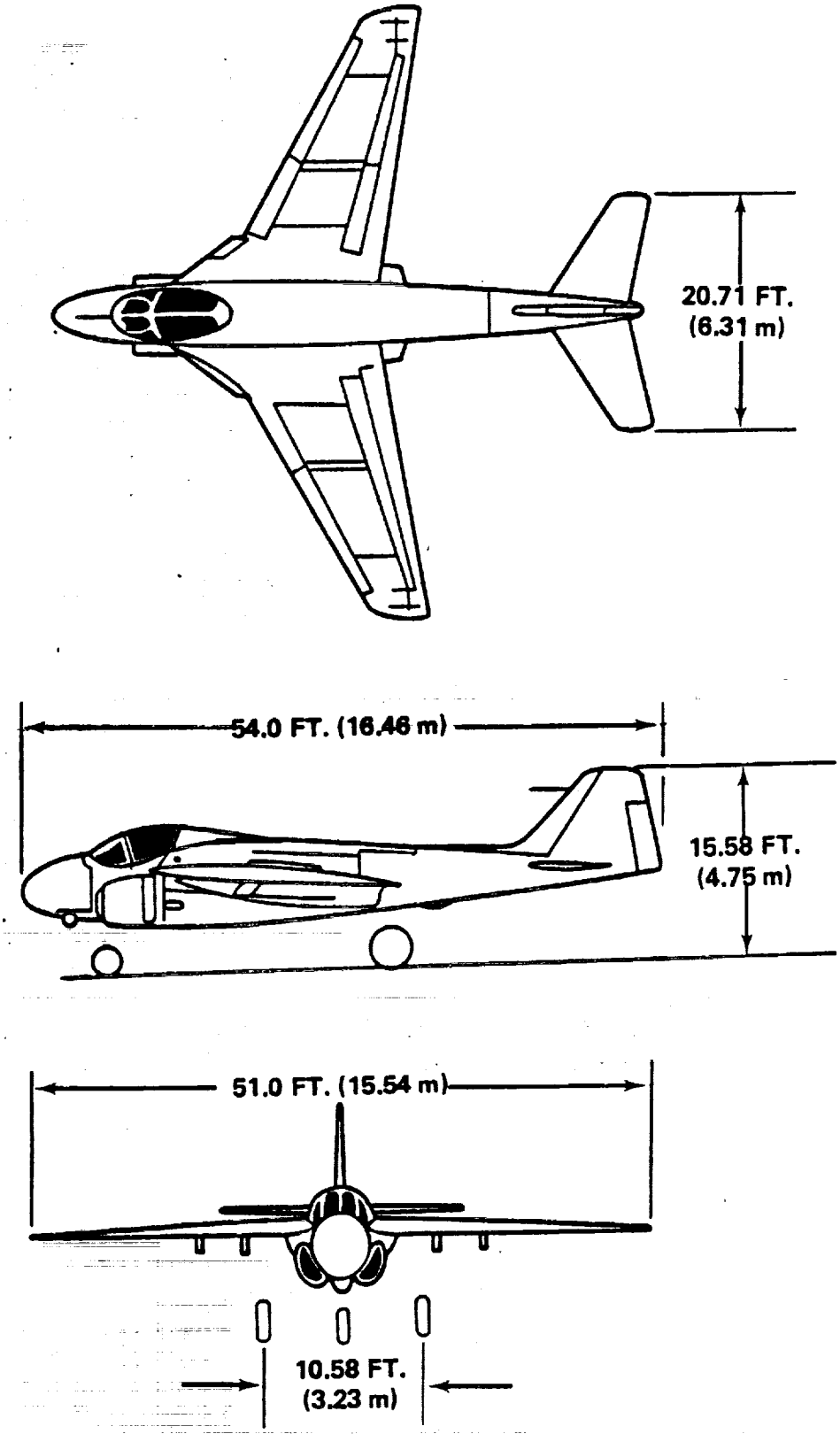

FIGURE 57. THREE-VIEW, A-6A

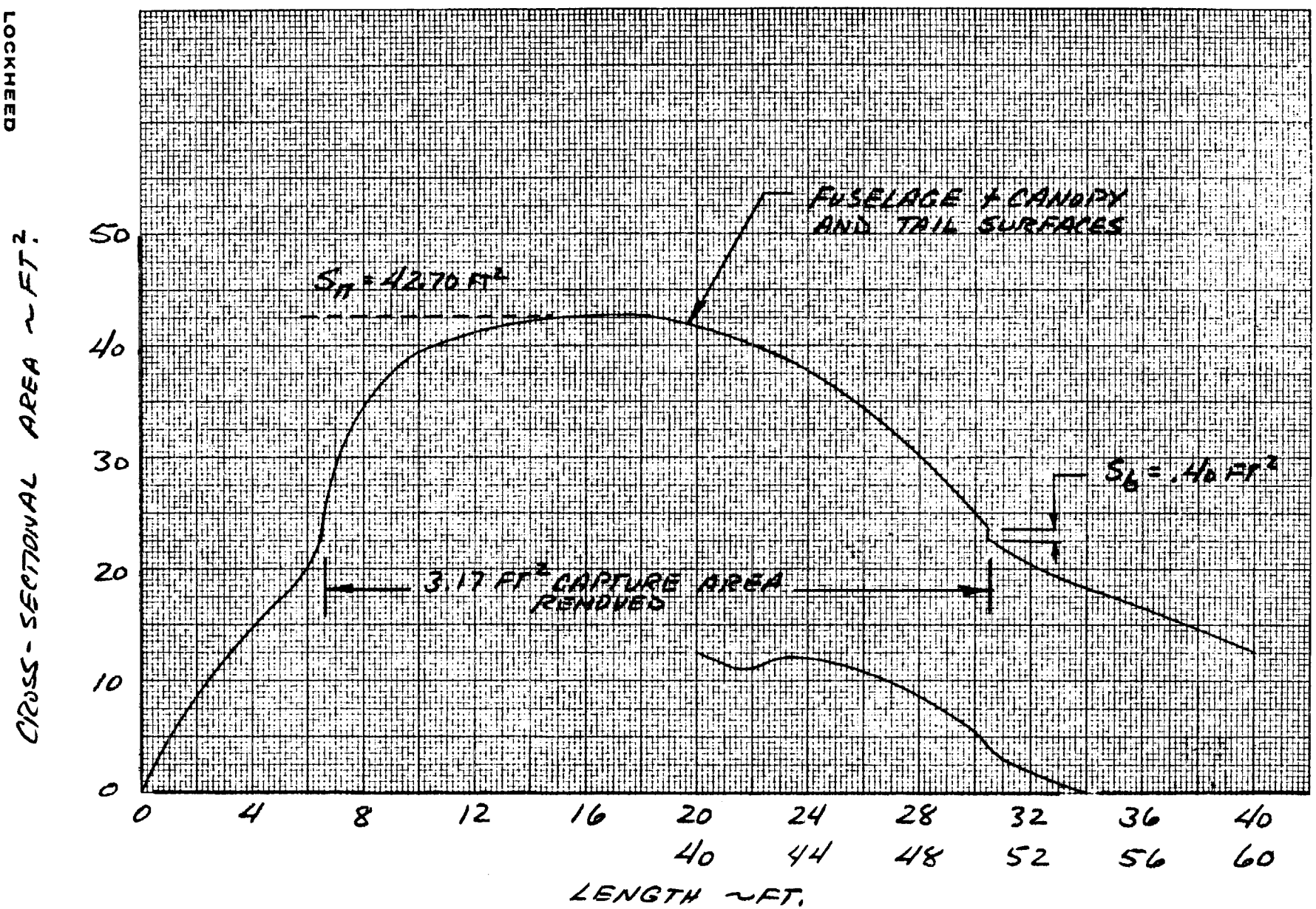

FIG. 58 A-6A FUSELAGE AREA DISTRIBUTION, A-6A

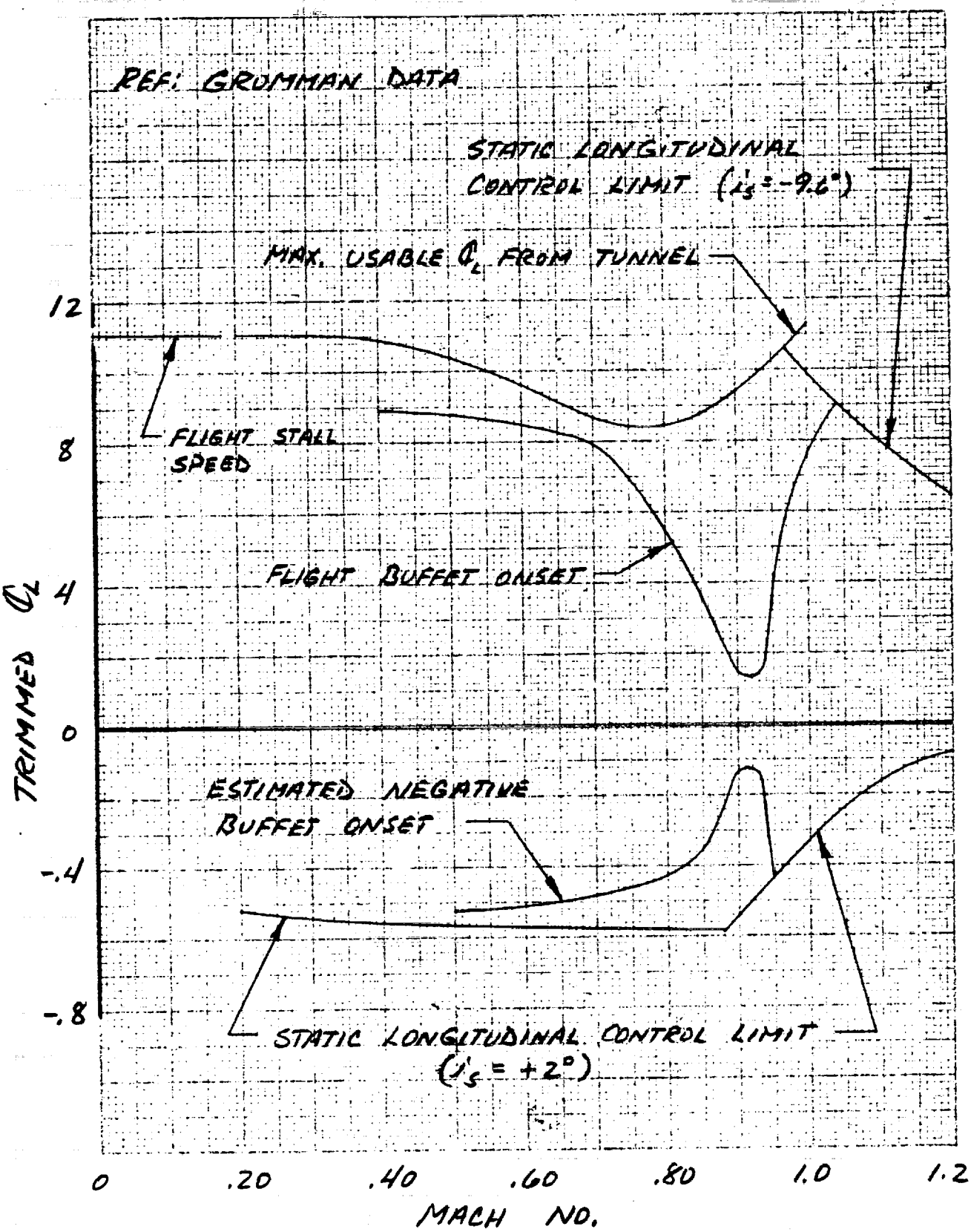

FIG. 59 LIMIT LIFT CHARACTERISTICS, A-6A

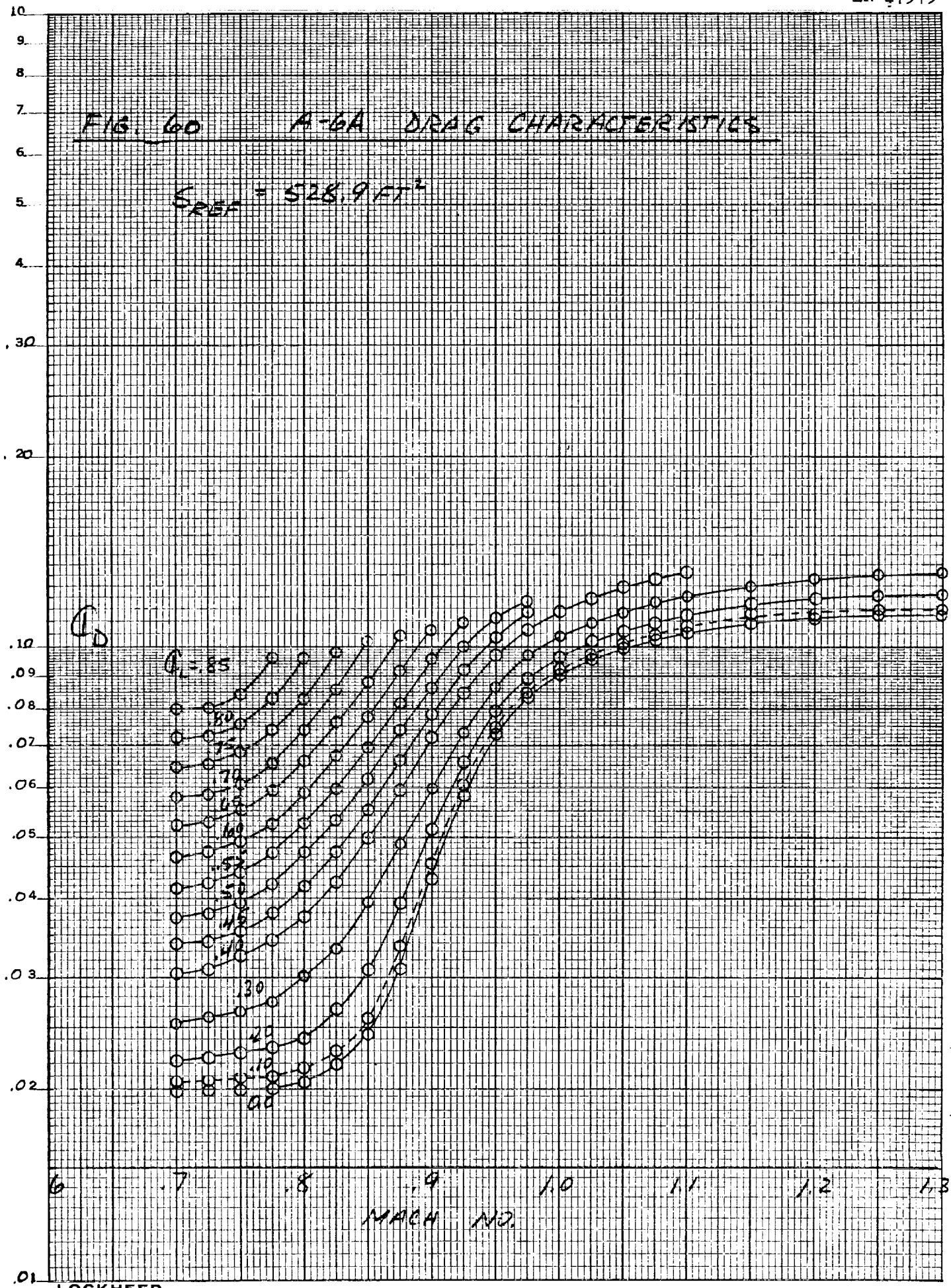
FIG. 60 A-6A DRAG CHARACTERISTICS
S_{REF} = 528.9 FT²
C_D
C_L = .85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.30
.20
.10
.00
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.6
.7
.8
.9
1.0
1.1
1.2
1.3
MACH NO.

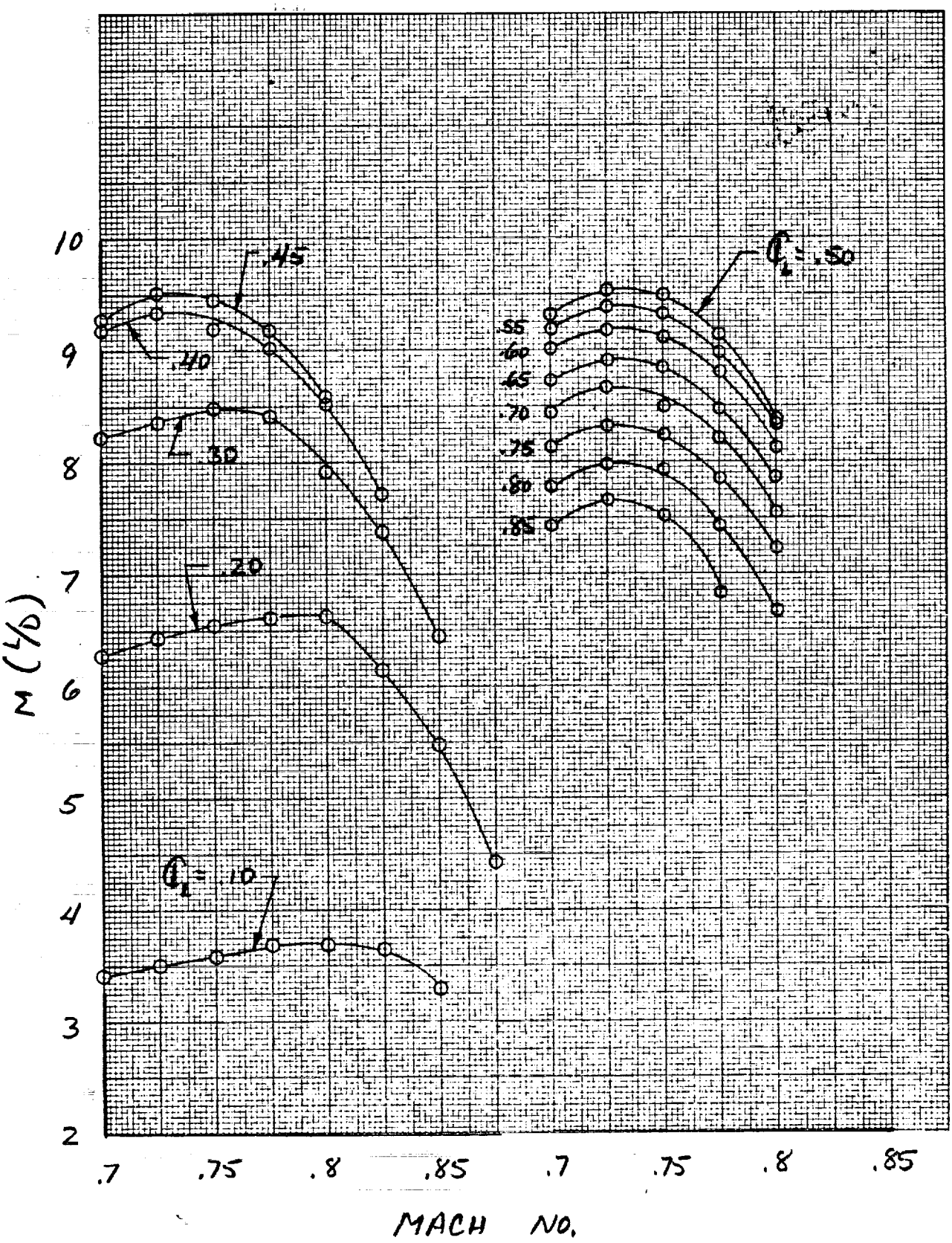

FIG. 61 M (L/D) VS. MACH NUMBER, A-6A

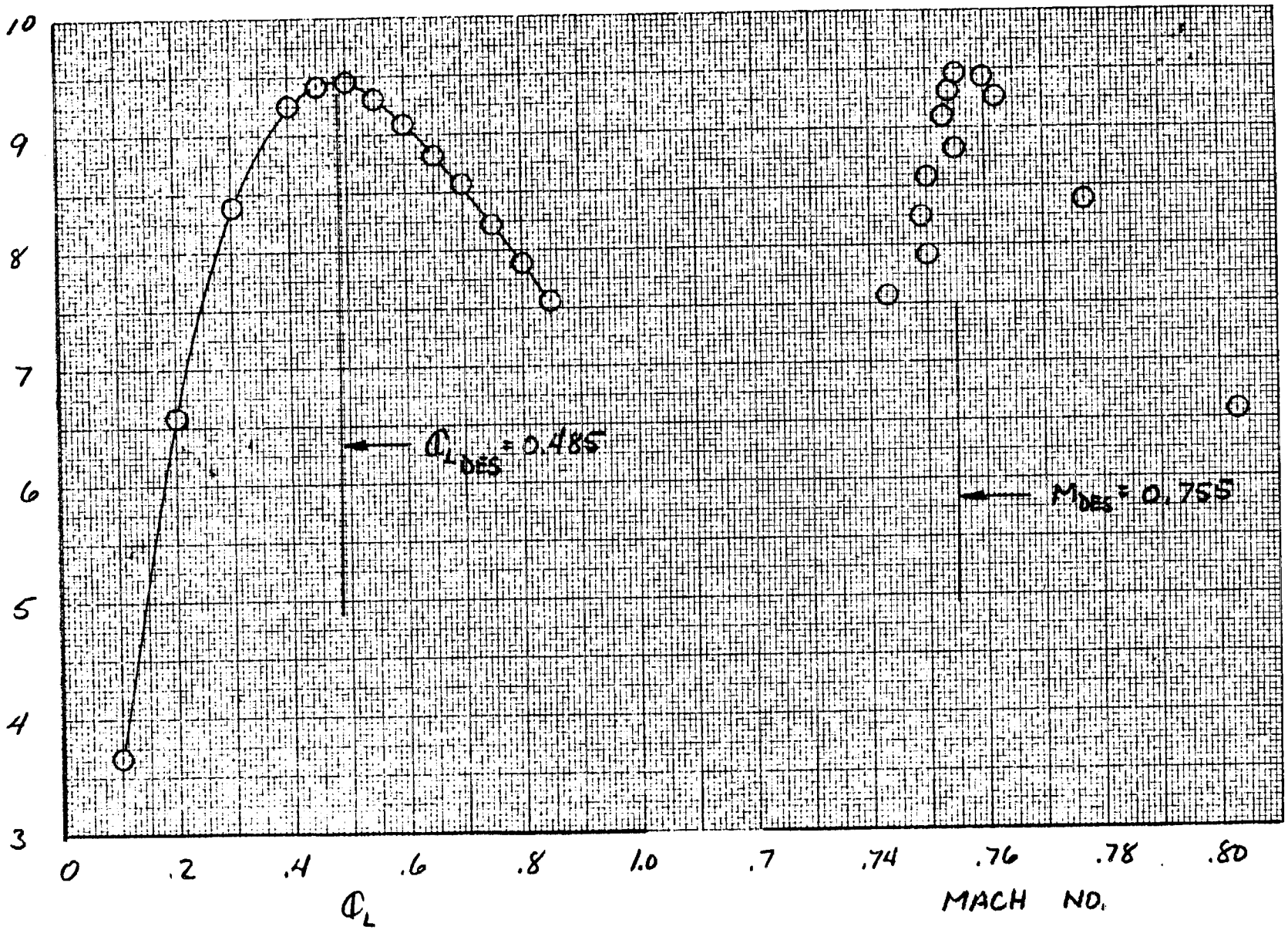

FIG. 62 $C_{L_{DES}}$ AND M_{DES} FOR A-6A

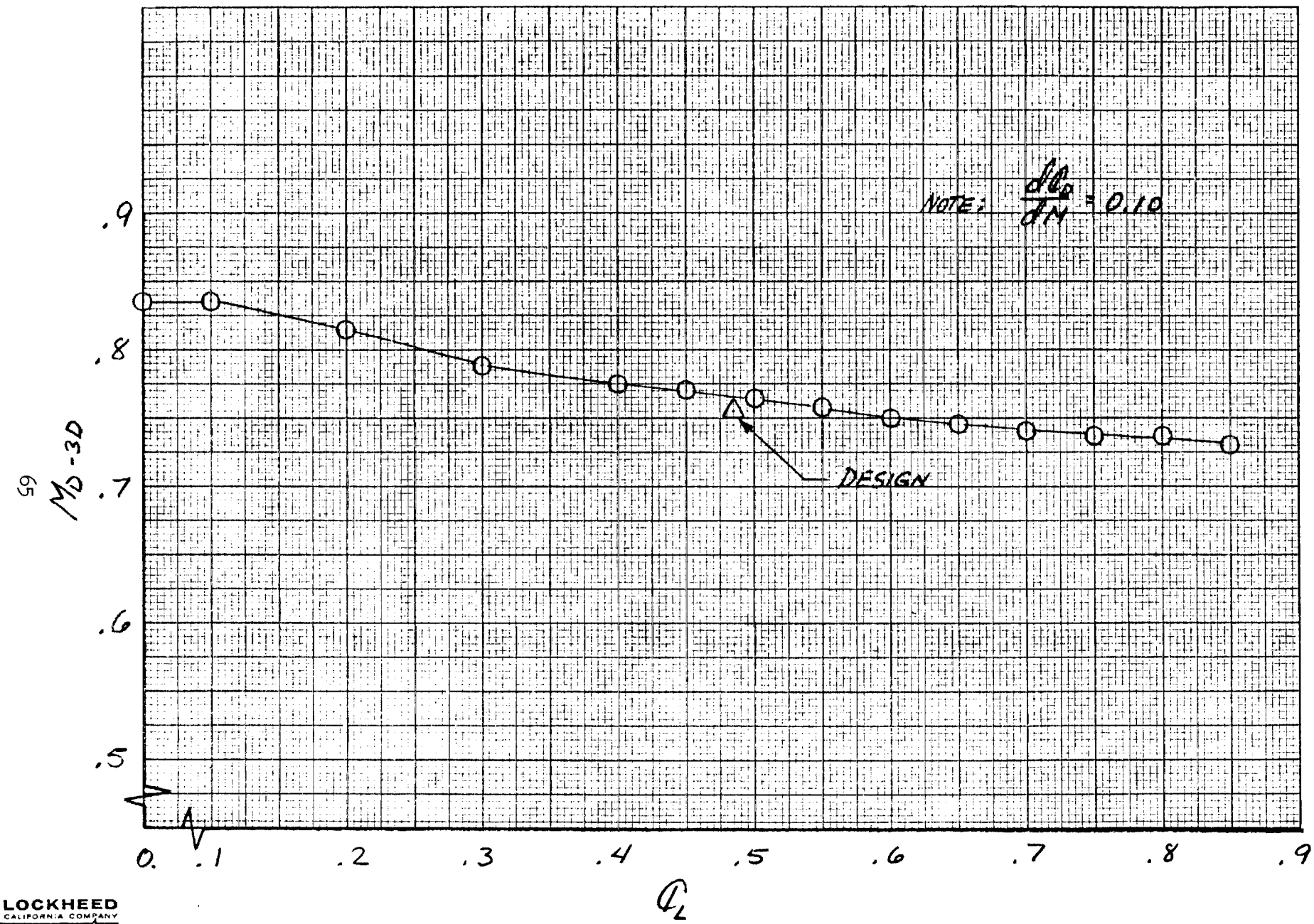

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FIG. 63 DRAG DIVERGENCE CHARACTERISTICS, A-6A

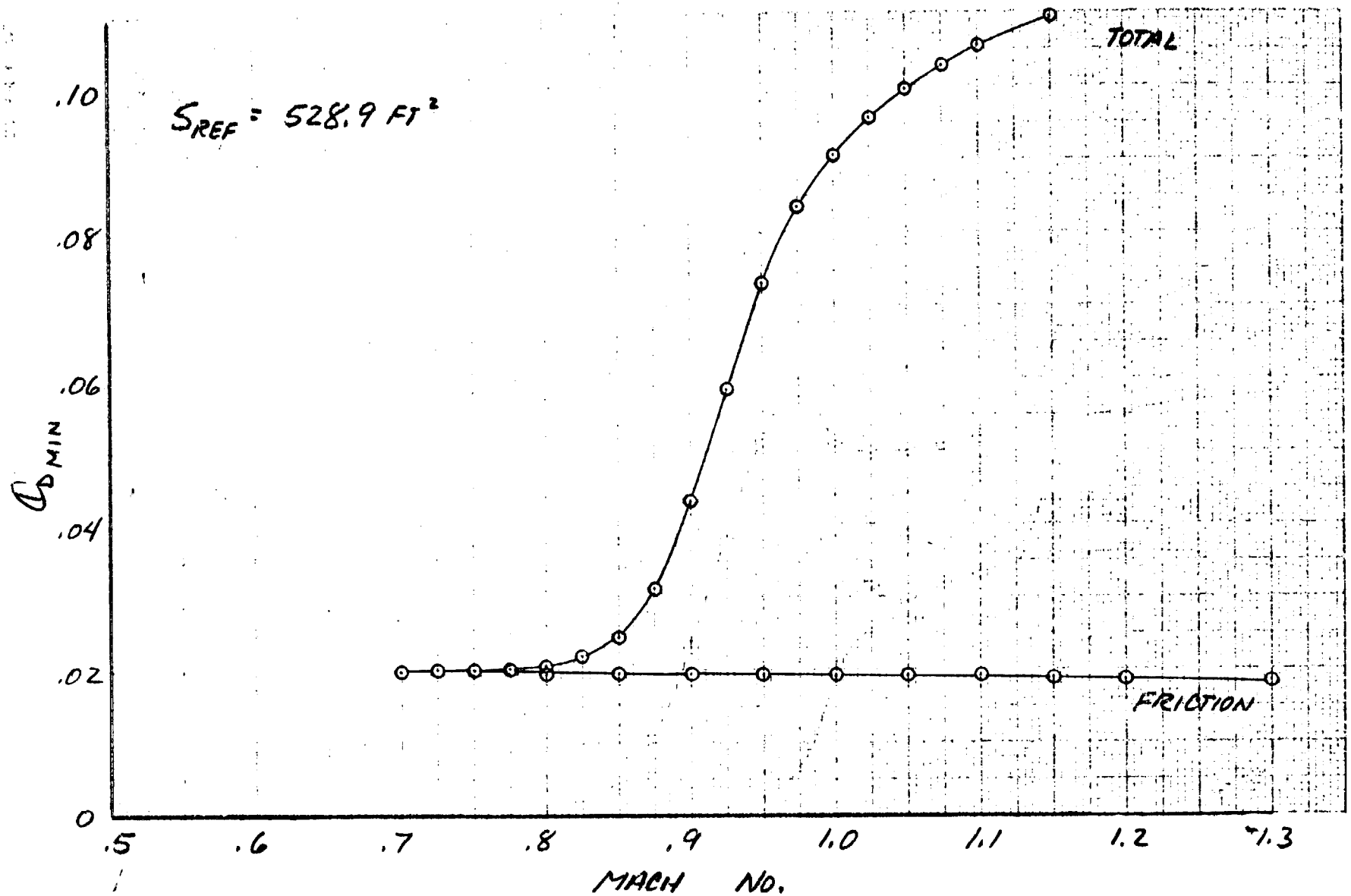

FIG. 64 MINIMUM DRAG BREAKDOWN, A-6A

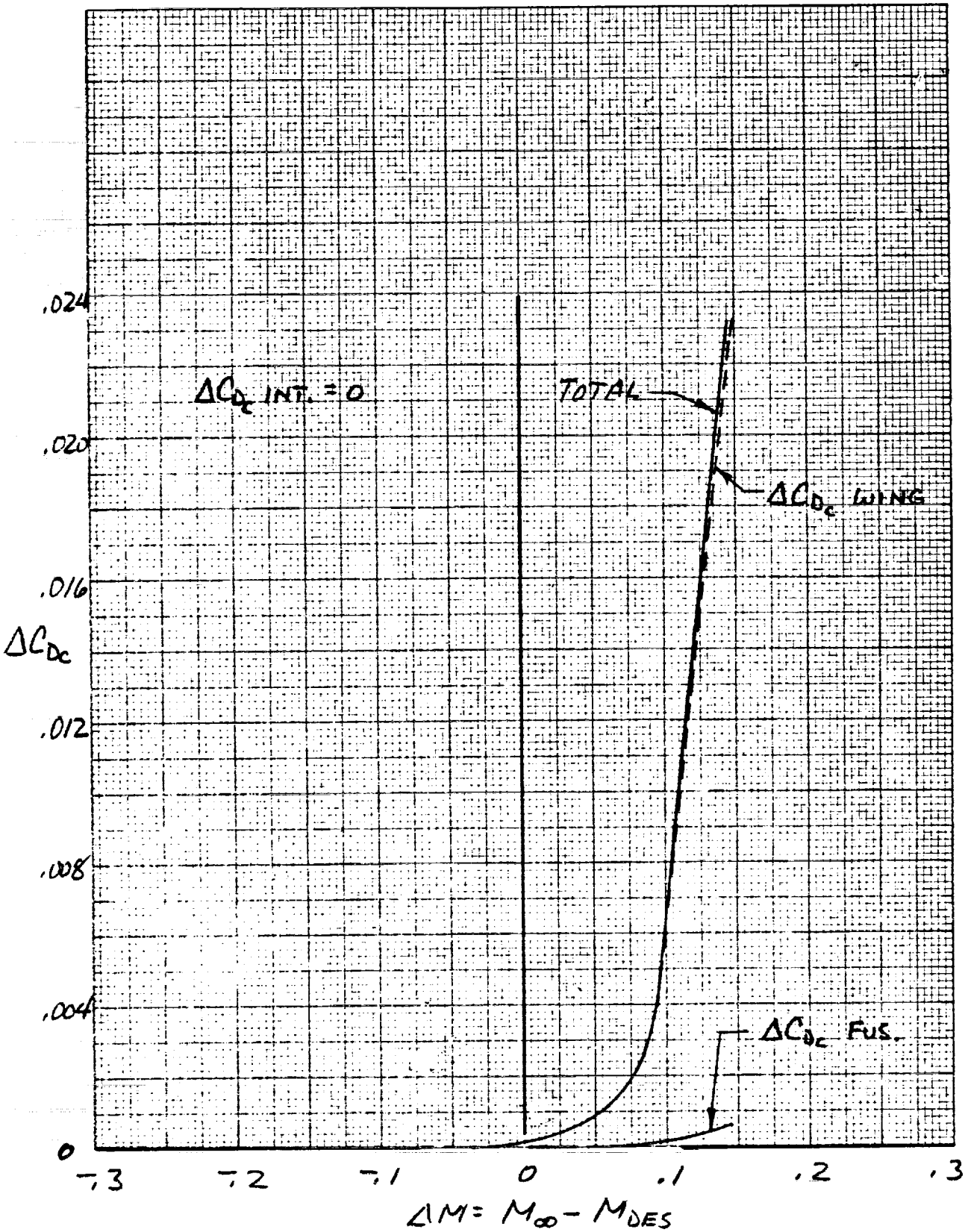

FIG. 65 COMPRESSIBILITY DRAG, A-6A

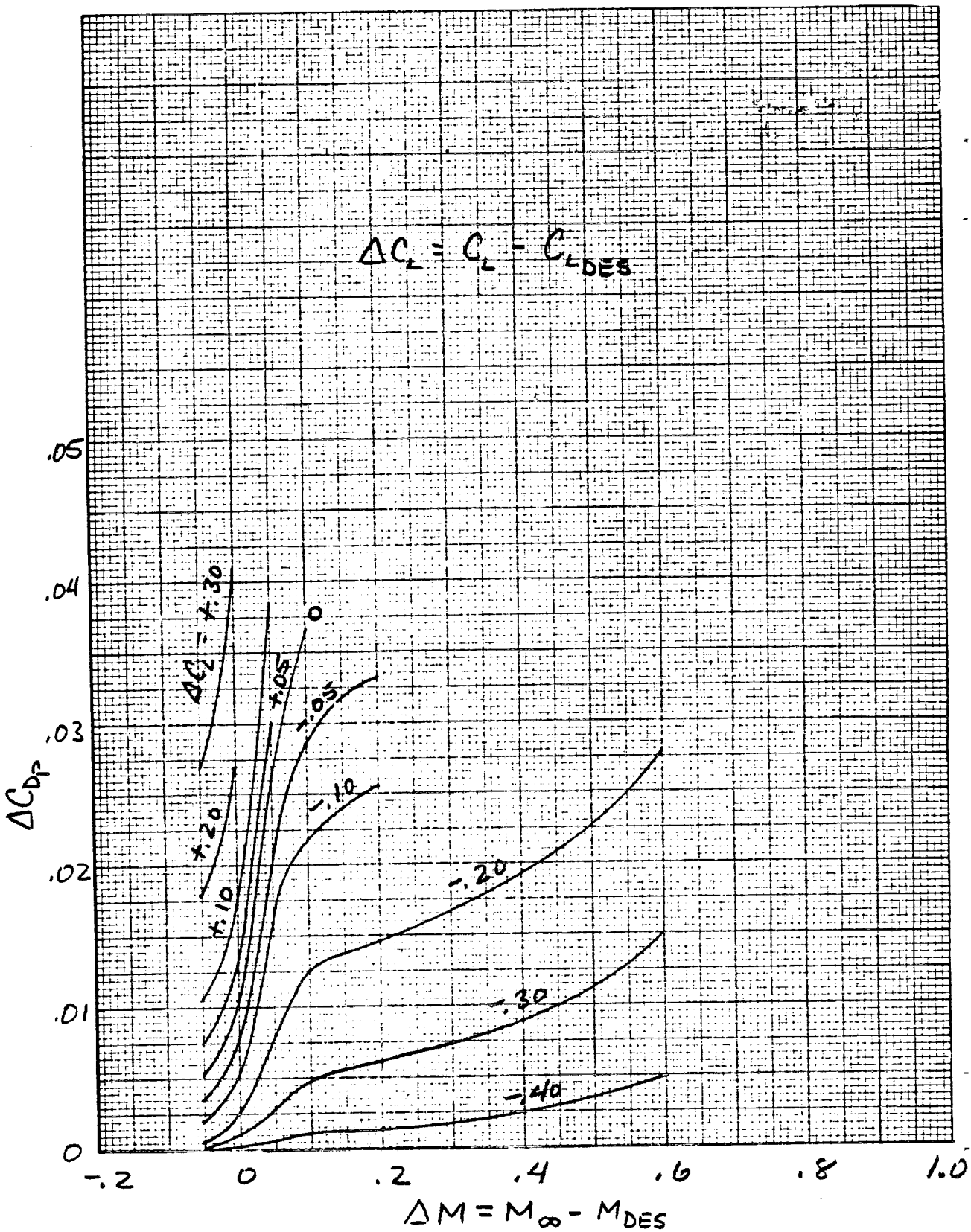

FIG. 66 WING PRESSURE DRAG VARIATION, A-6A

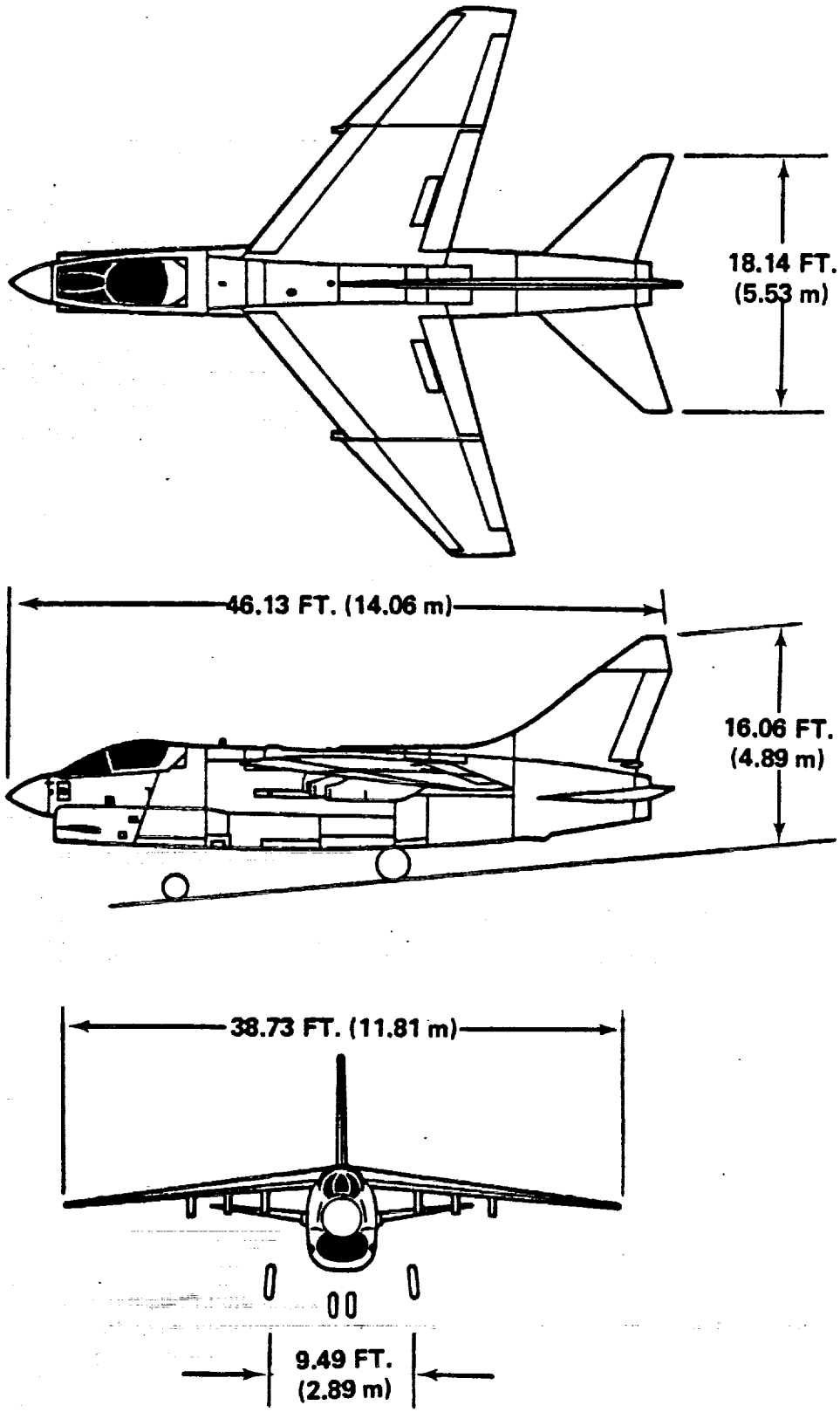

FIGURE 67. THREE-VIEW, A-7A

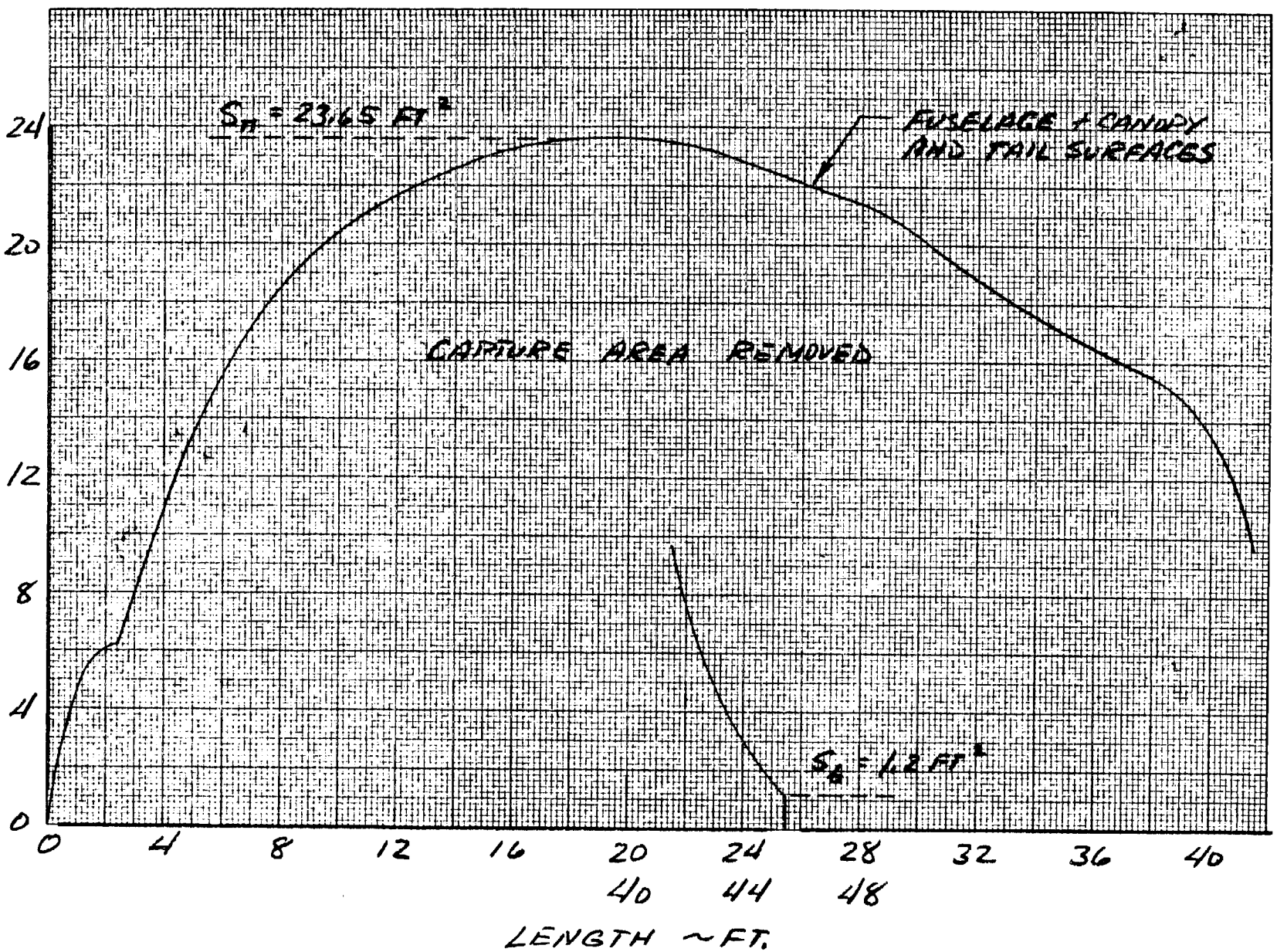

FIG. 68 A-7A FUSELAGE AREA DISTRIBUTION

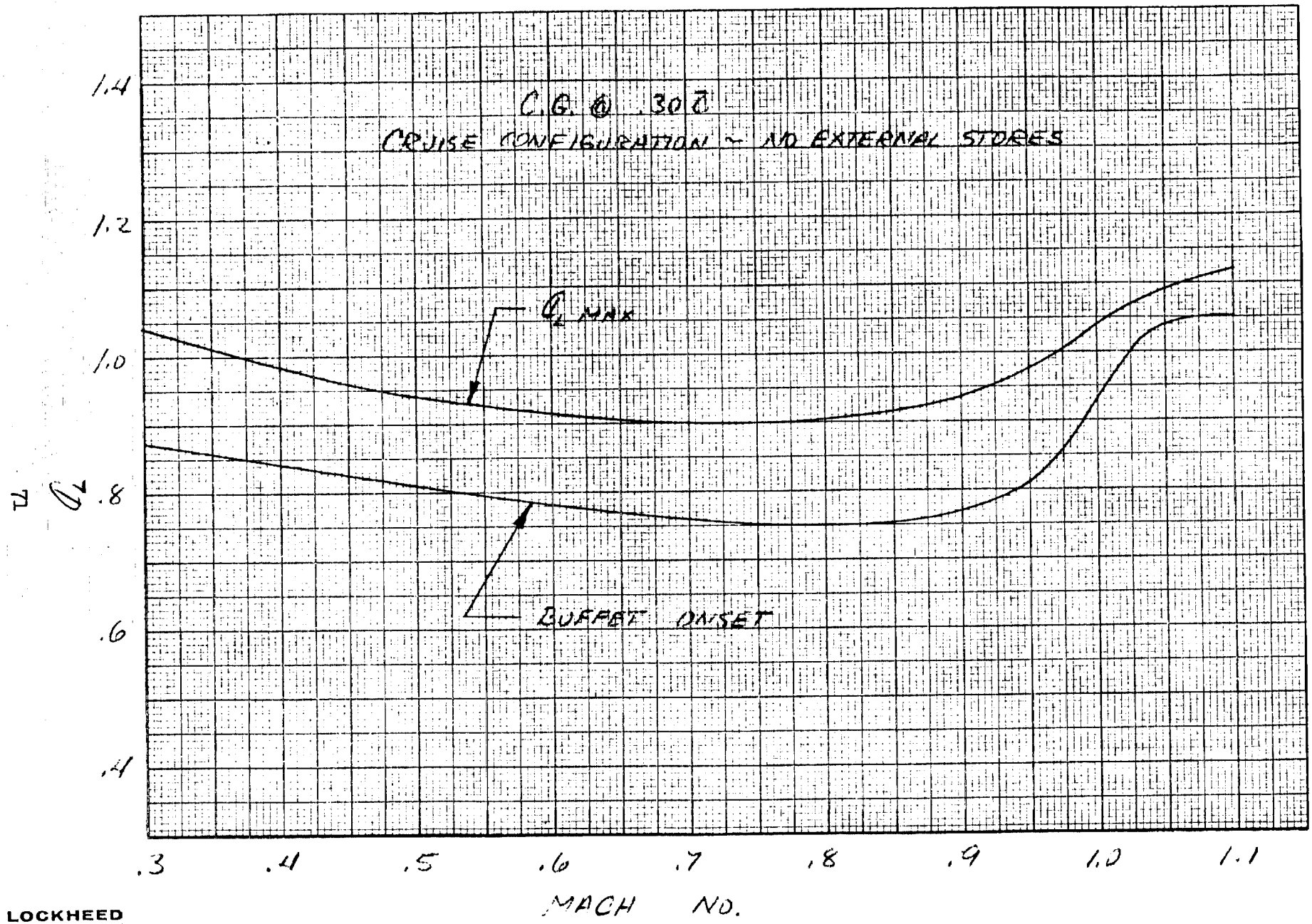

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FIG. 69 LIMIT LIFT CHARACTERISTICS, A-7A

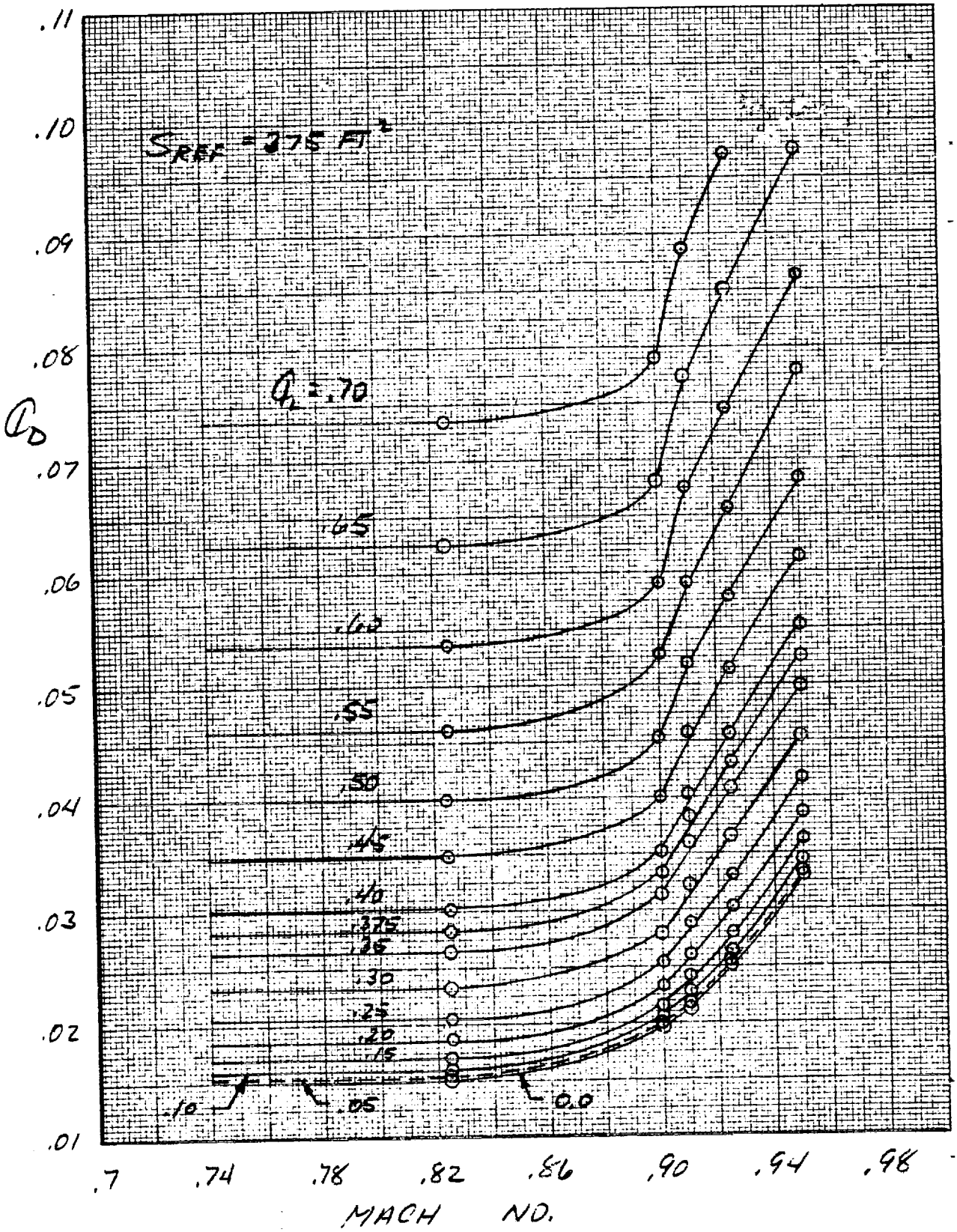

FIG. 70 A-7A DRAG CHARACTERISTICS

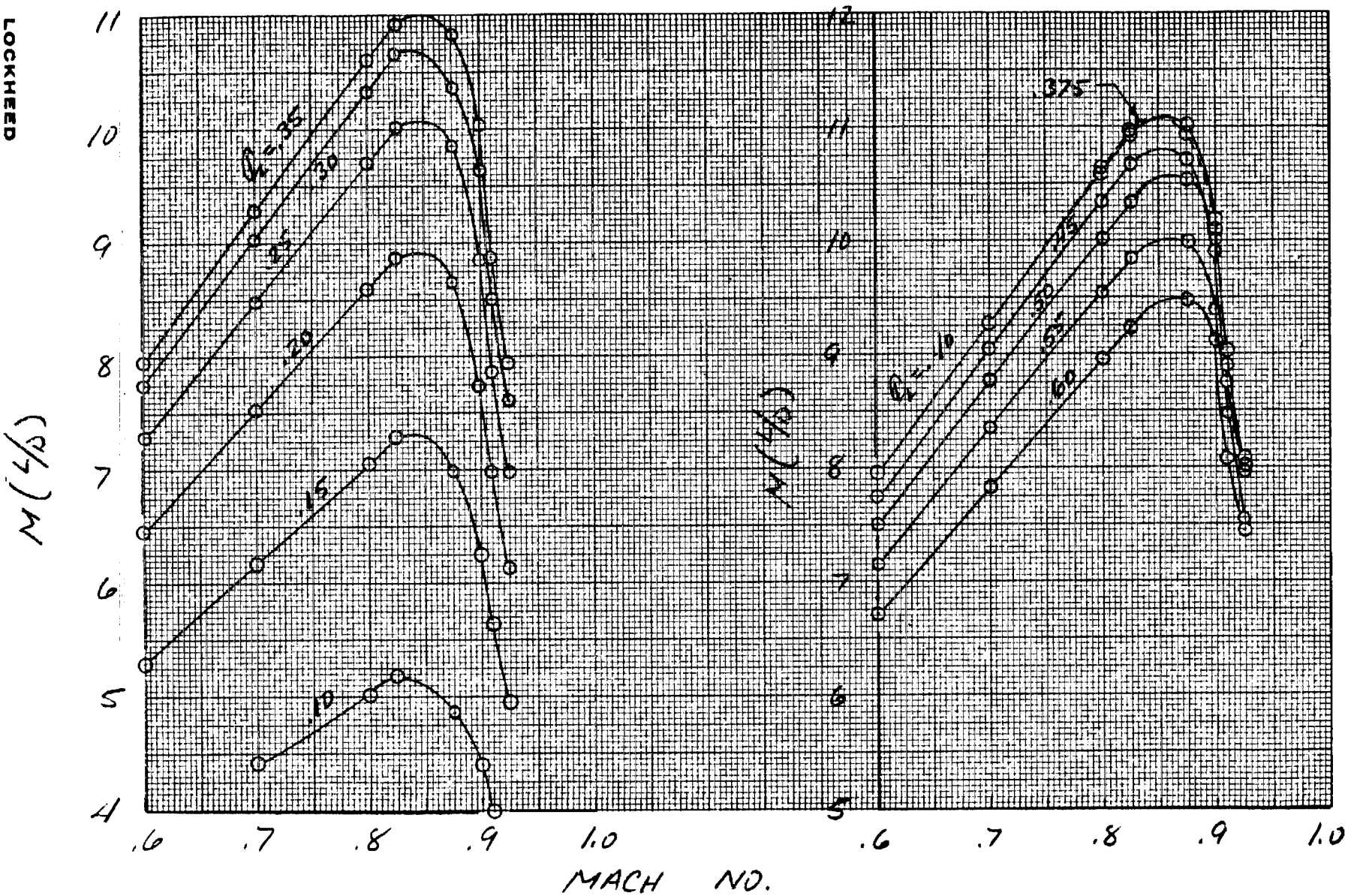

FIG. 71 M(L/D) vs. MACH NO., A-7A

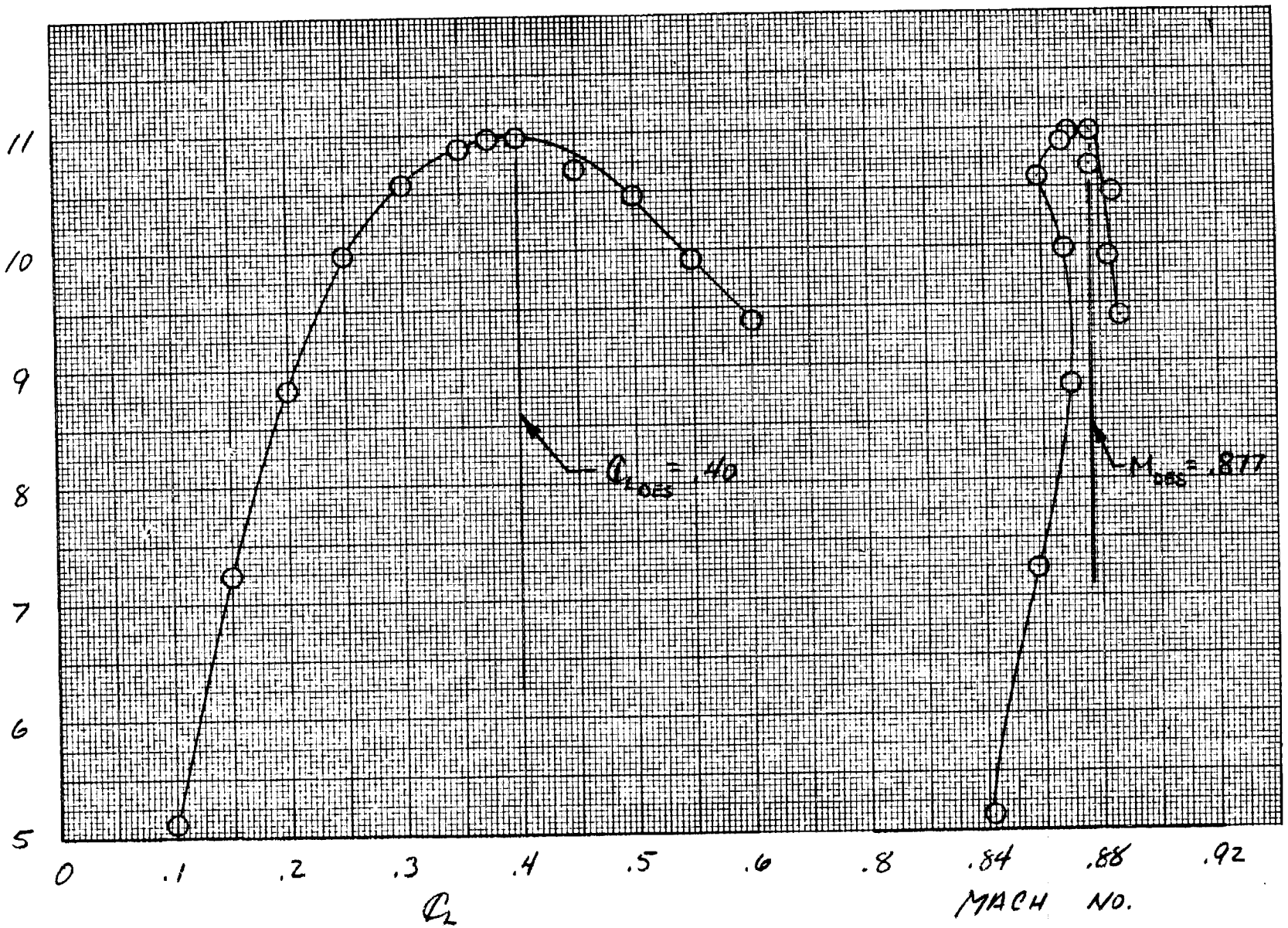

FIG. 72 $C_{L_{DES}}$ AND M_{DES} FOR A-7A

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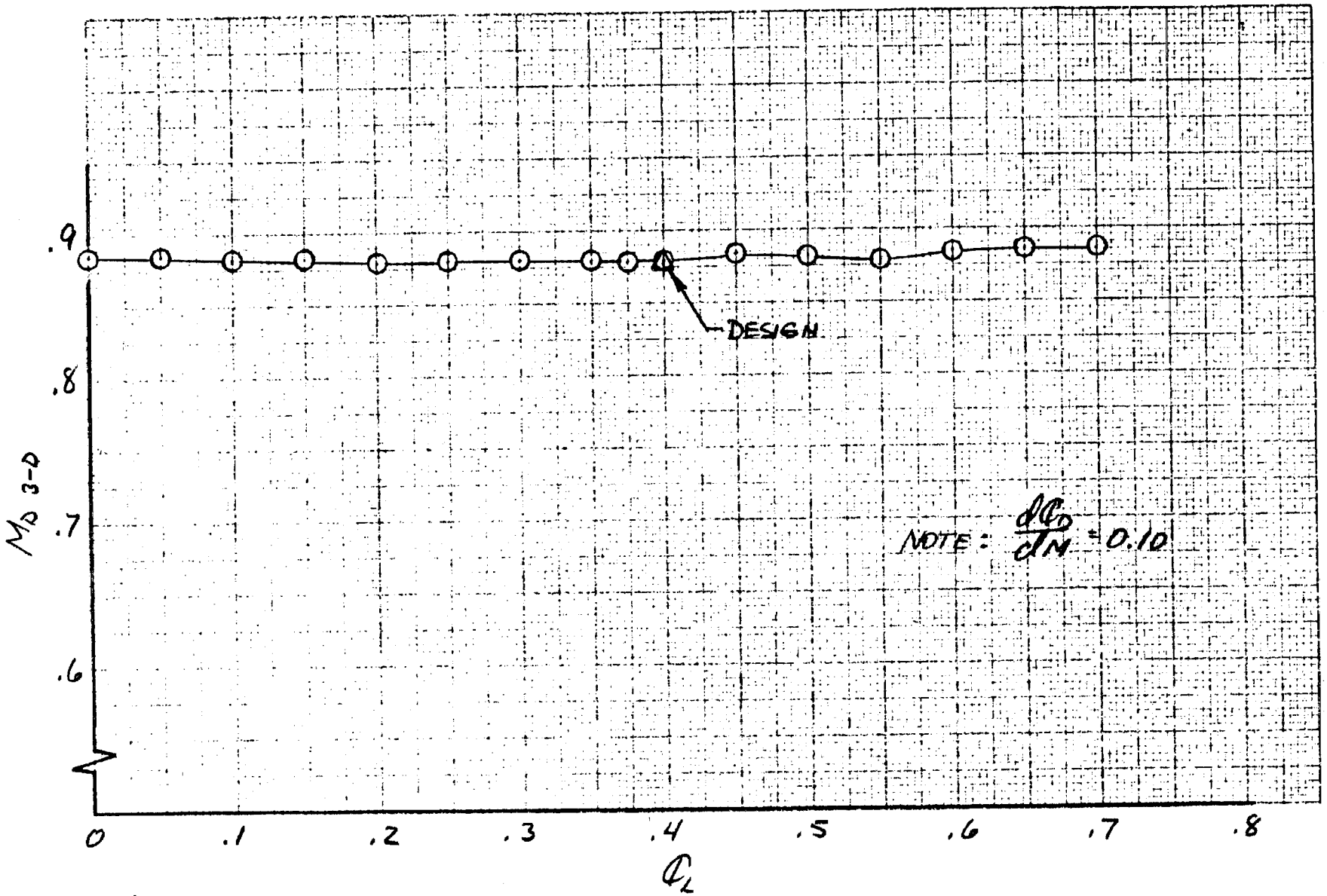

FIG. 73 DRAG DIVERGENCE CHARACTERISTICS, A-7A

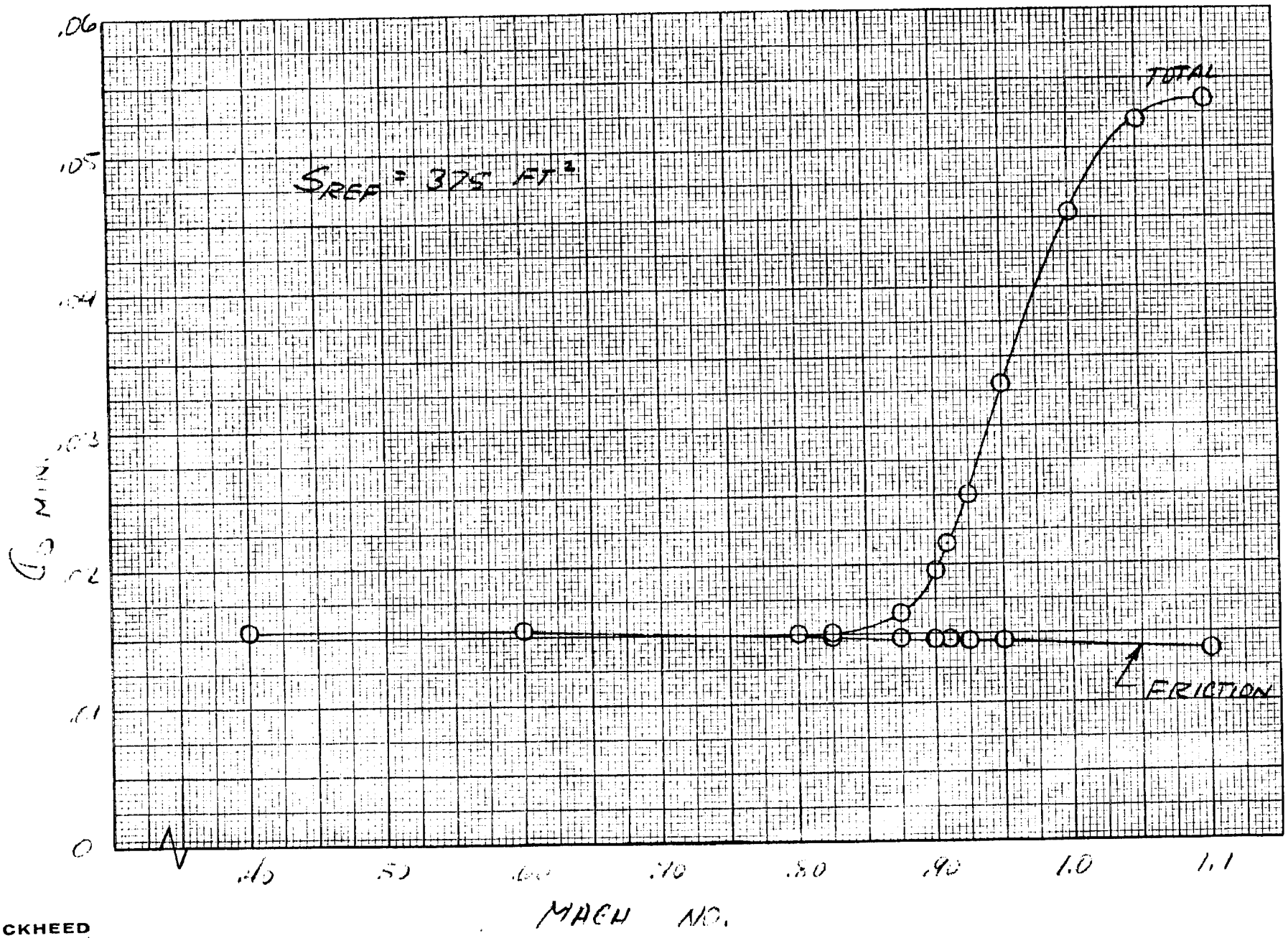

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FIG. 74 MINIMUM DRAG BREAKDOWN, A-7A

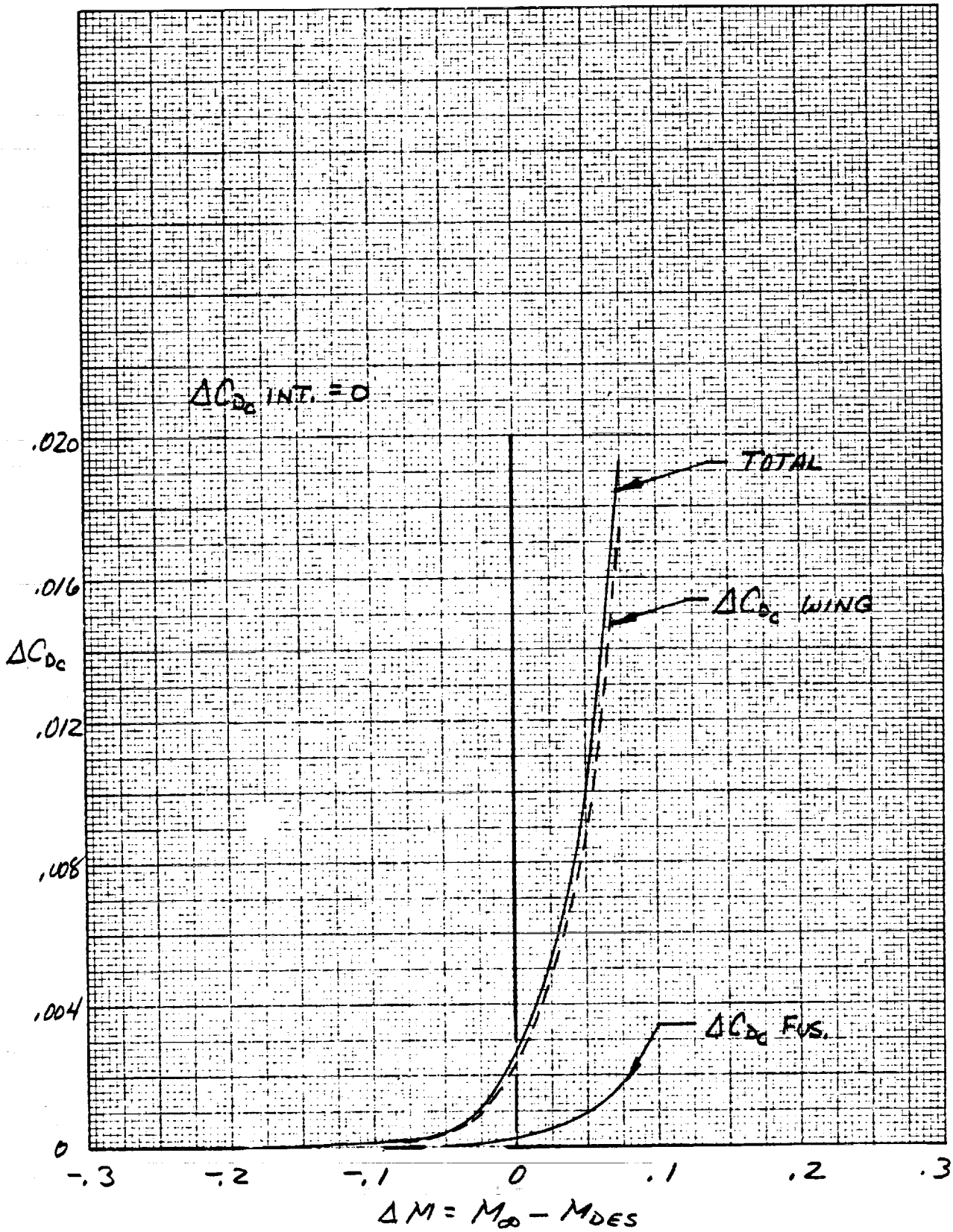


FIG. 75 COMPRESSIBILITY DRAG, A-7A

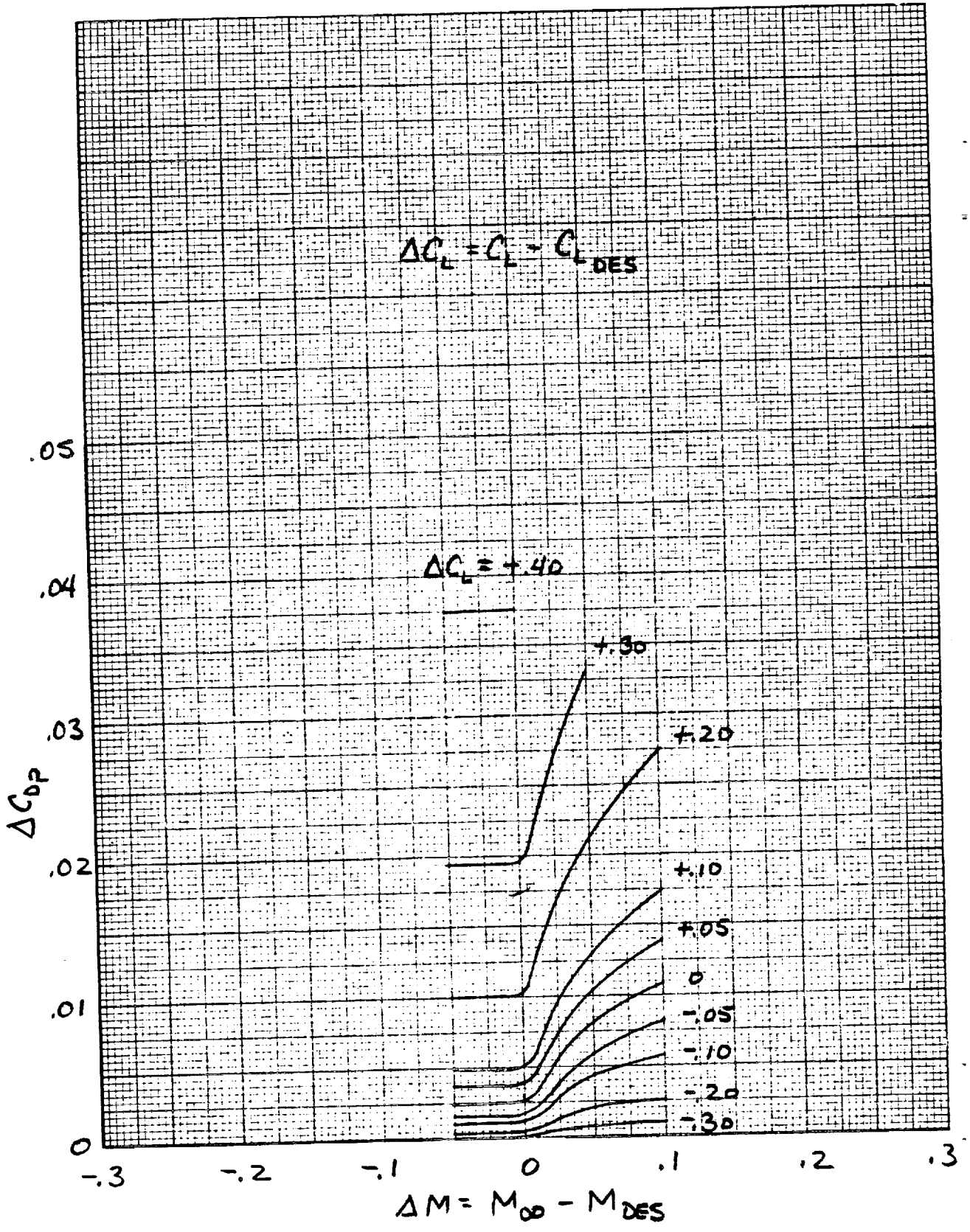


FIG. 76 WING PRESSURE DRAG VARIATION, A-7A

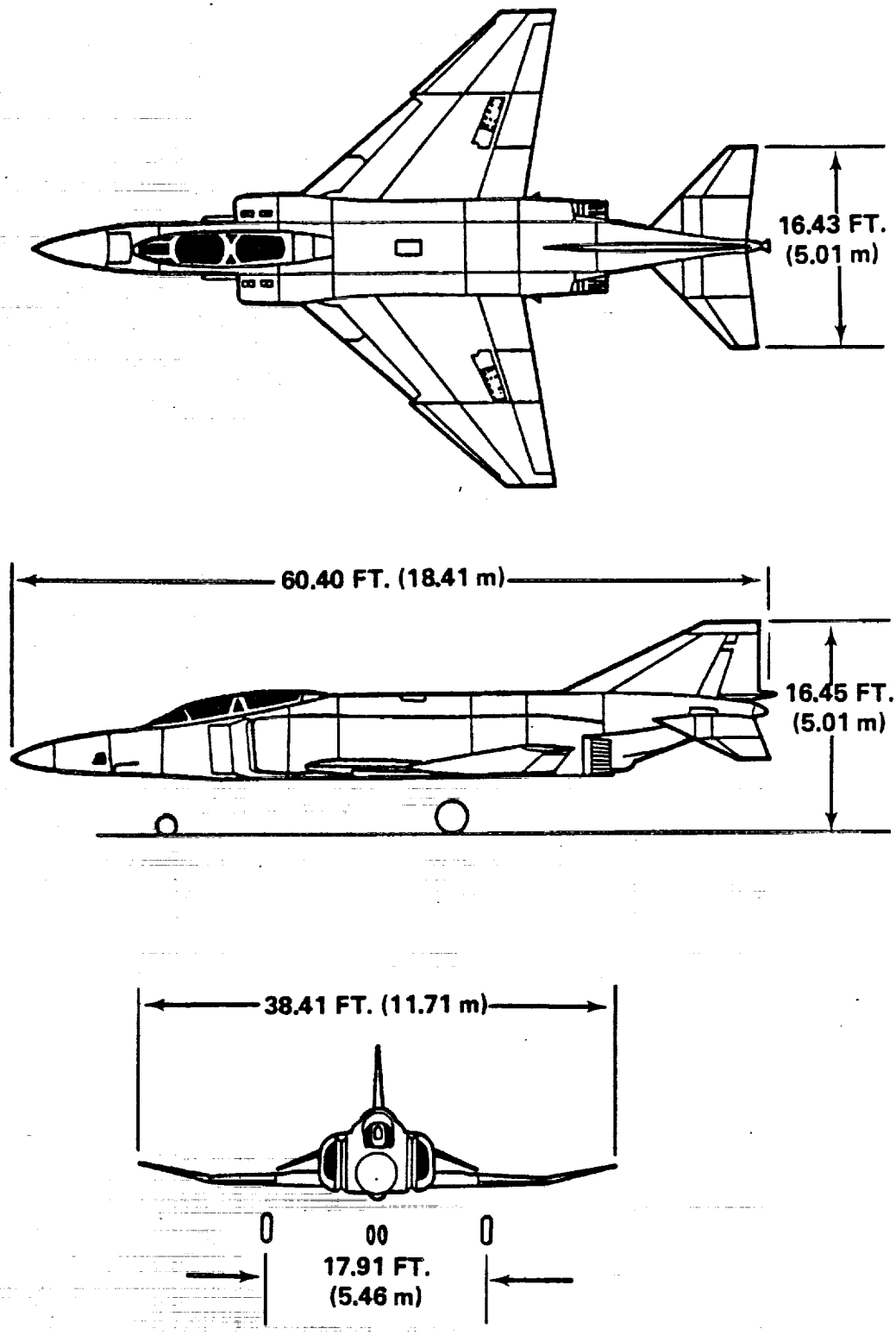


FIGURE 77. THREE-VIEW, F-4E

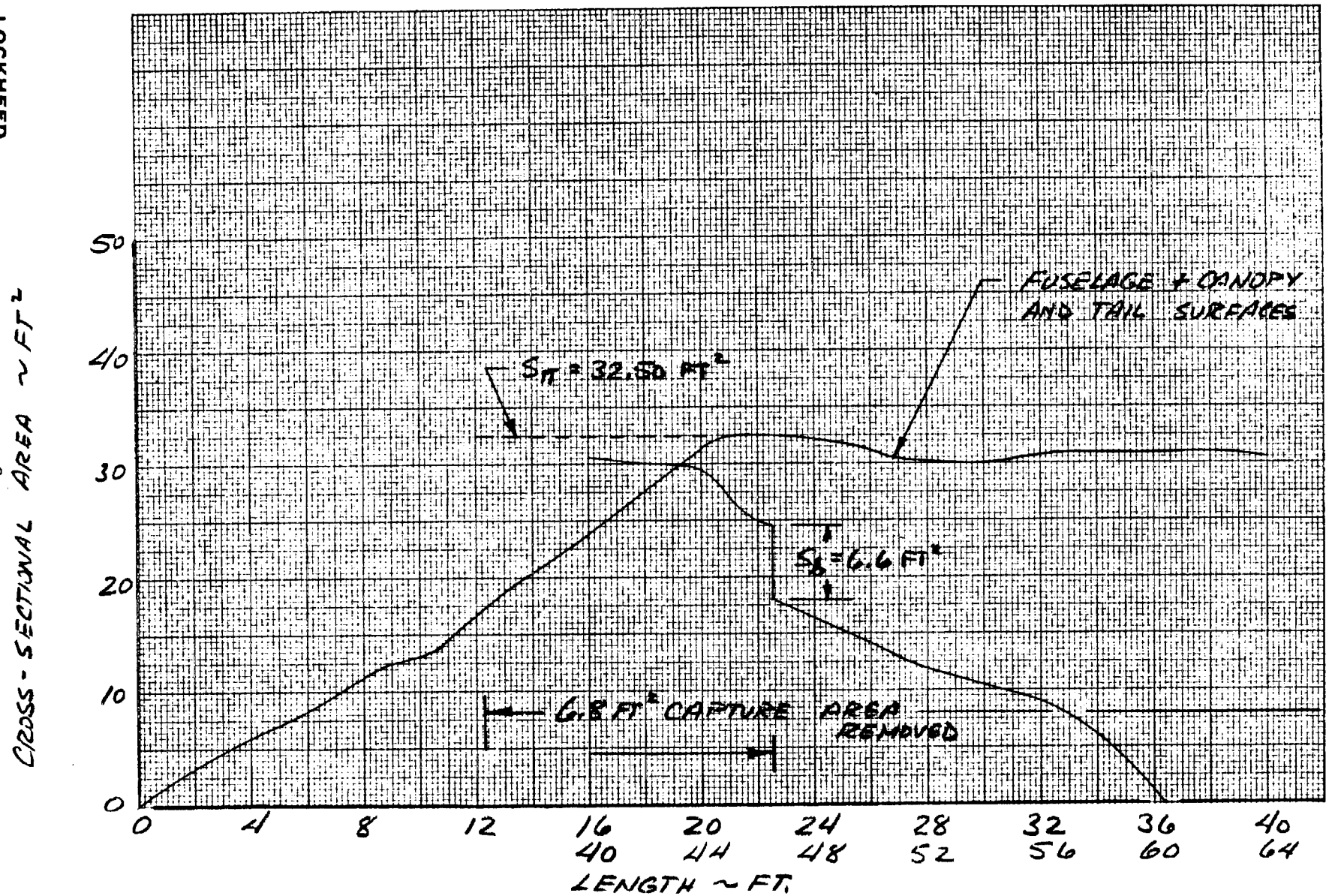


FIG. 78 F-4E FUSELAGE AREA DISTRIBUTION

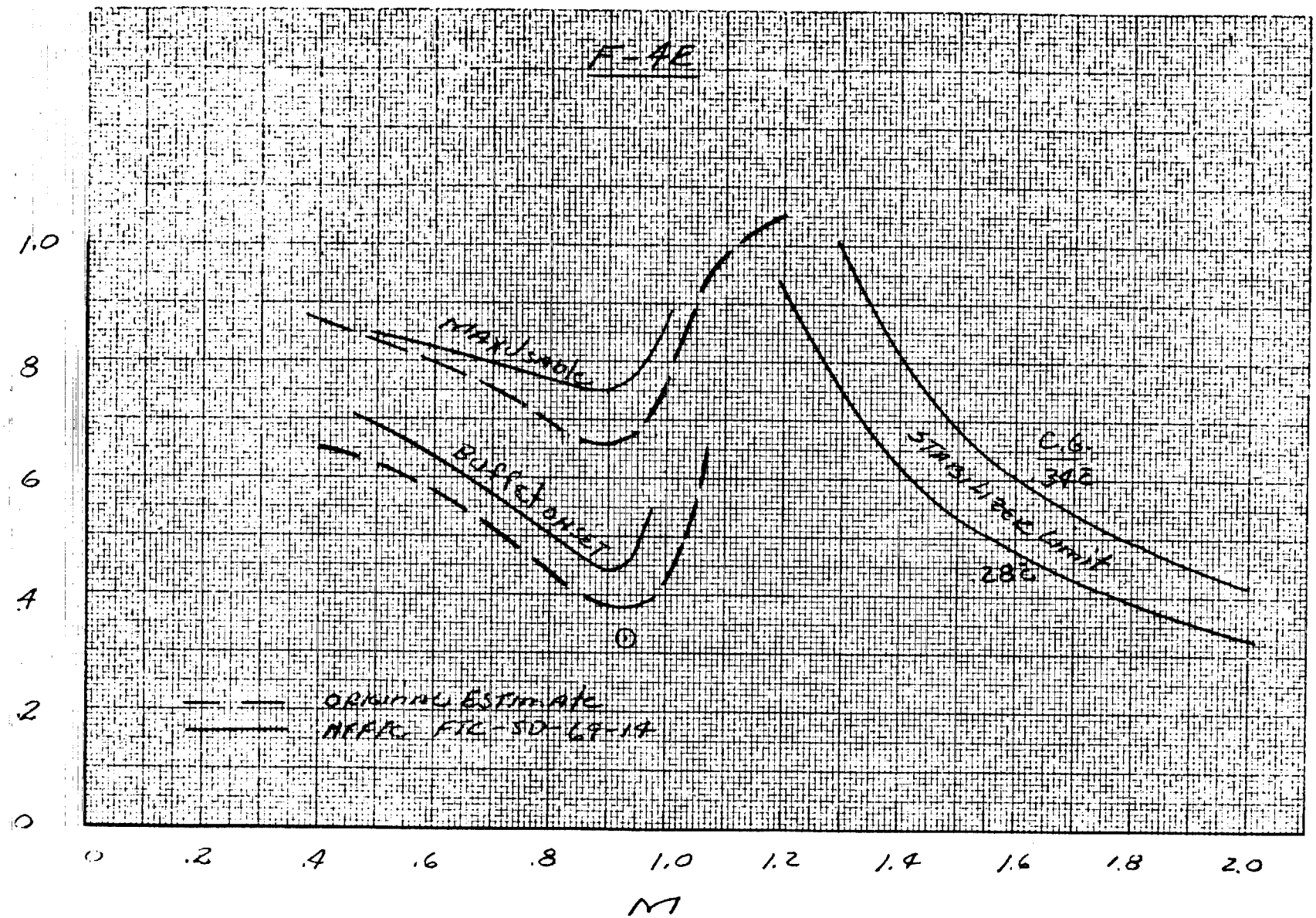
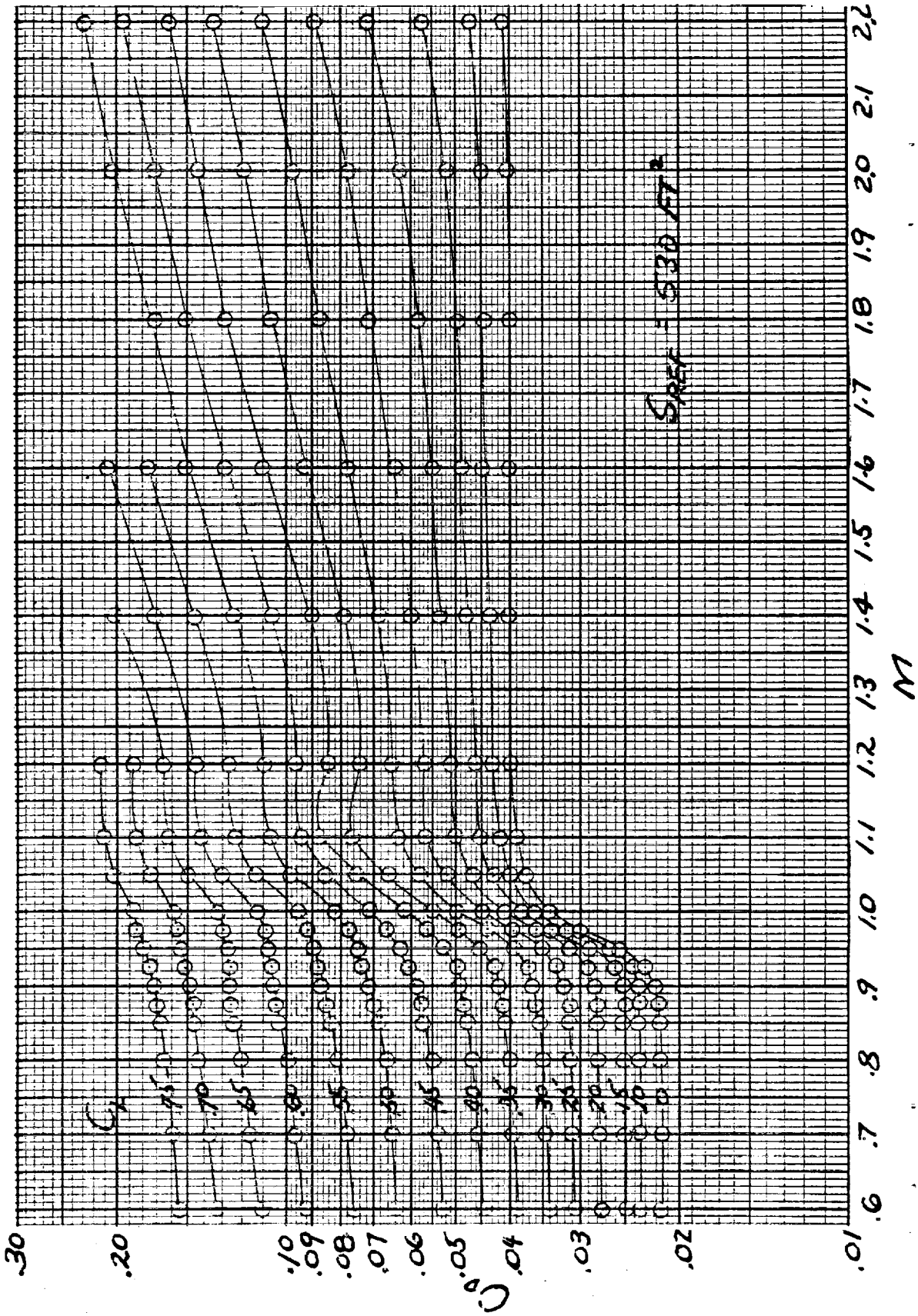


FIG. 79 LIMIT LIFT CHARACTERISTICS, F-4E



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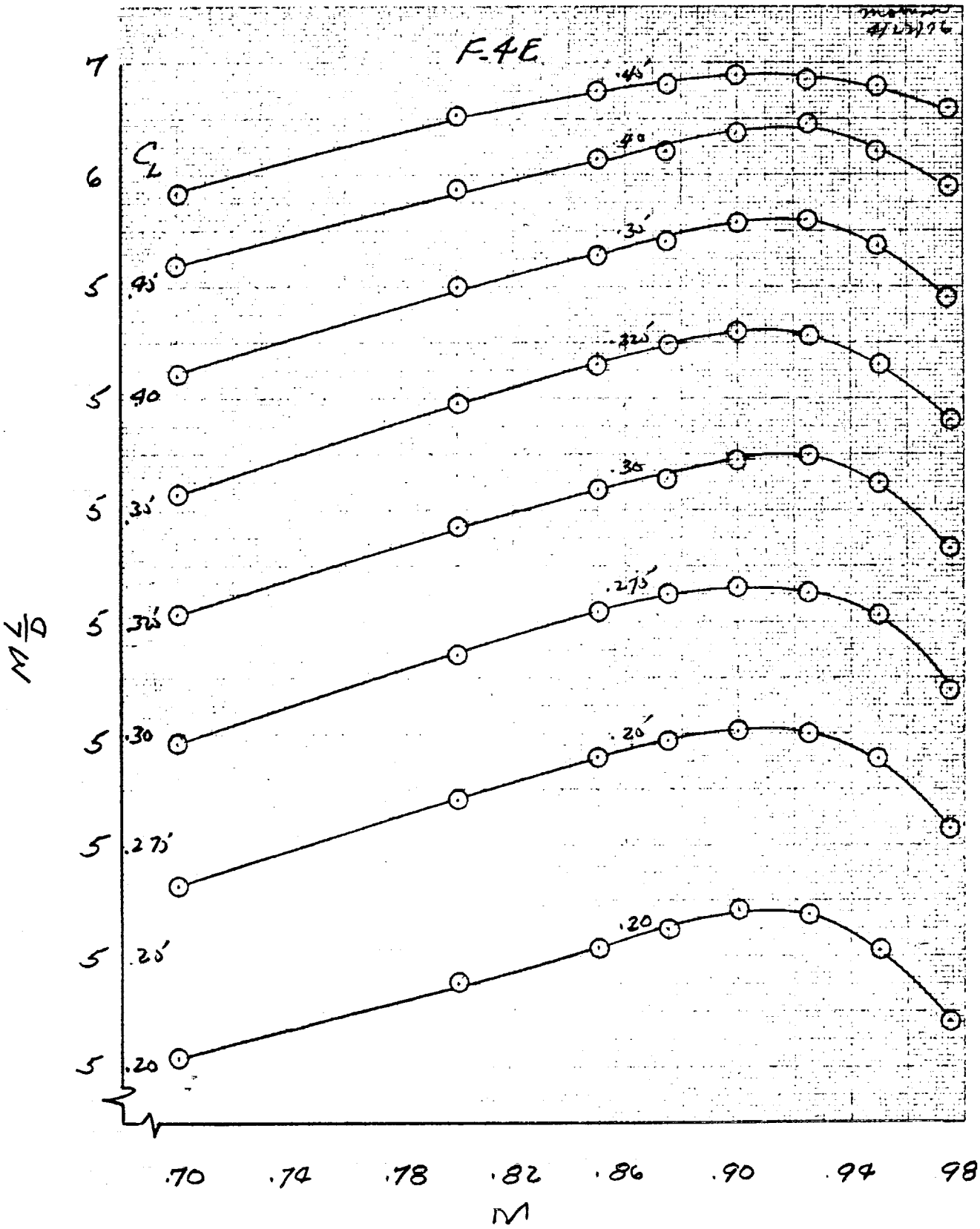

FIG. 81 $M\left(\frac{L}{D}\right)$ VS. MACH NUMBER, F-4E

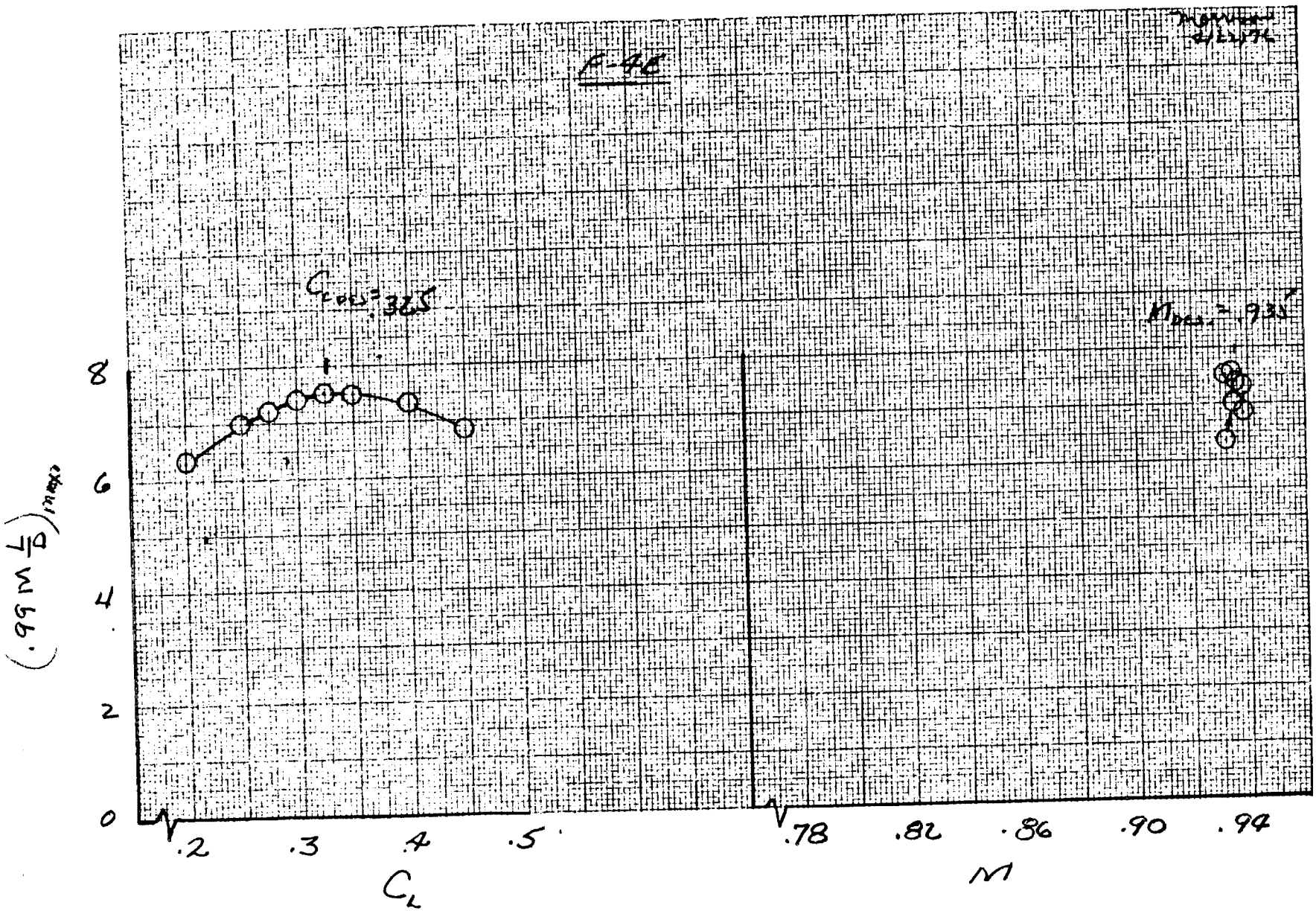

FIG. 82 $C_{L_{DES}}$ AND M_{DES} FOR F-4E

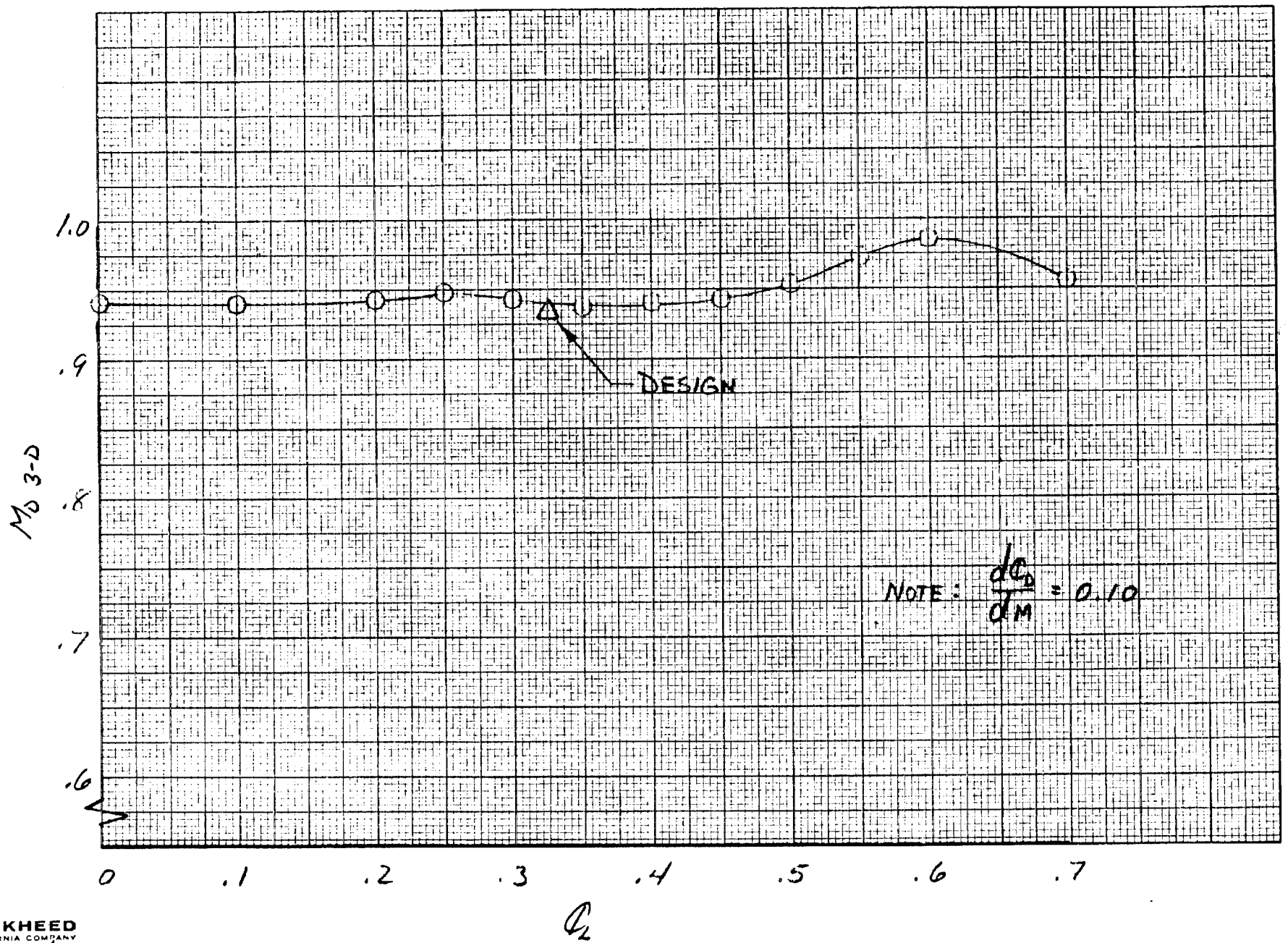

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FIG. 83 DRAG DIVERGENCE CHARACTERISTICS, F-4E

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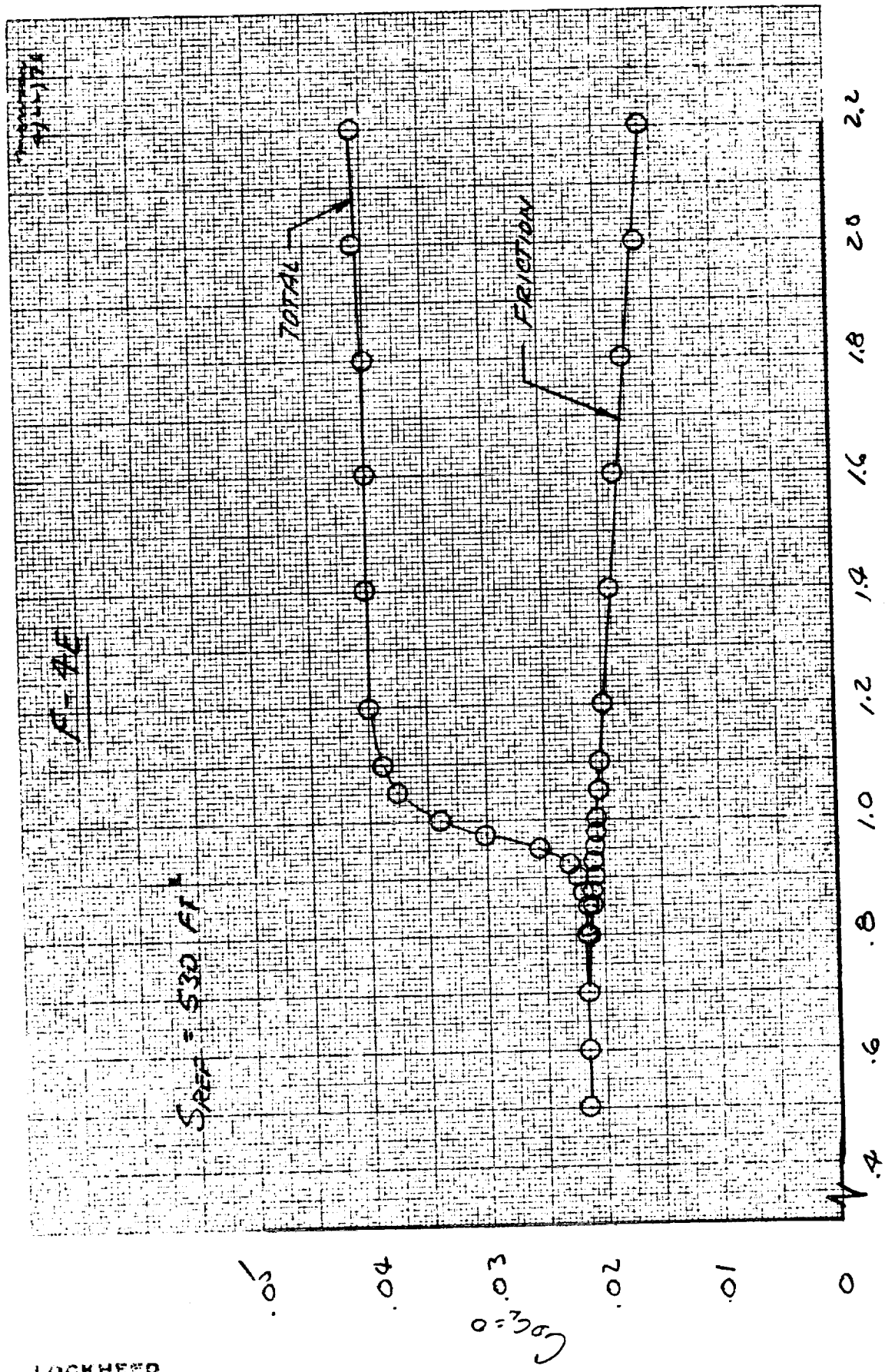

FIG. 84 MINIMUM DRAG BREAKDOWN, F-4E

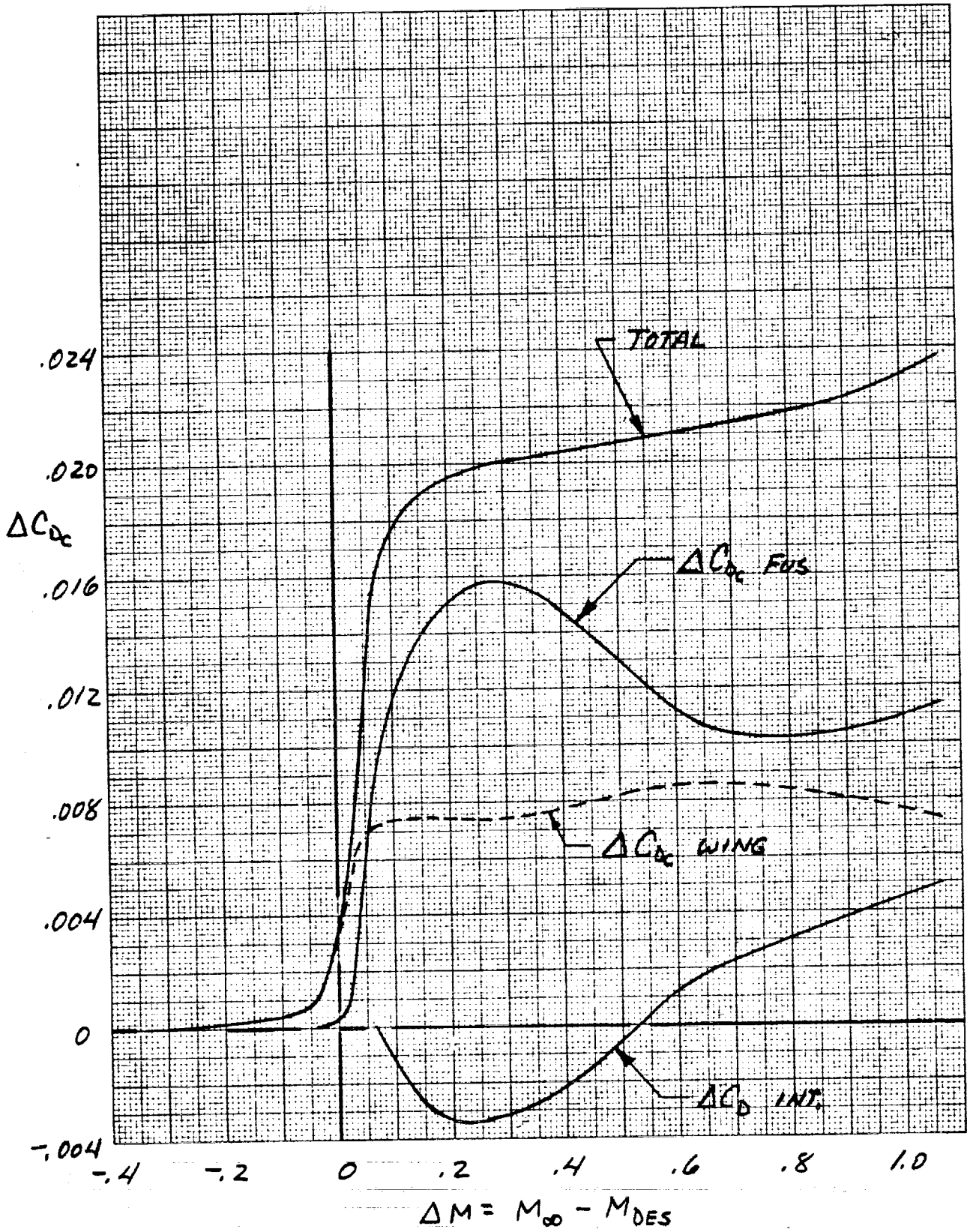

FIG. 85 COMPRESSIBILITY DRAG, F-4E

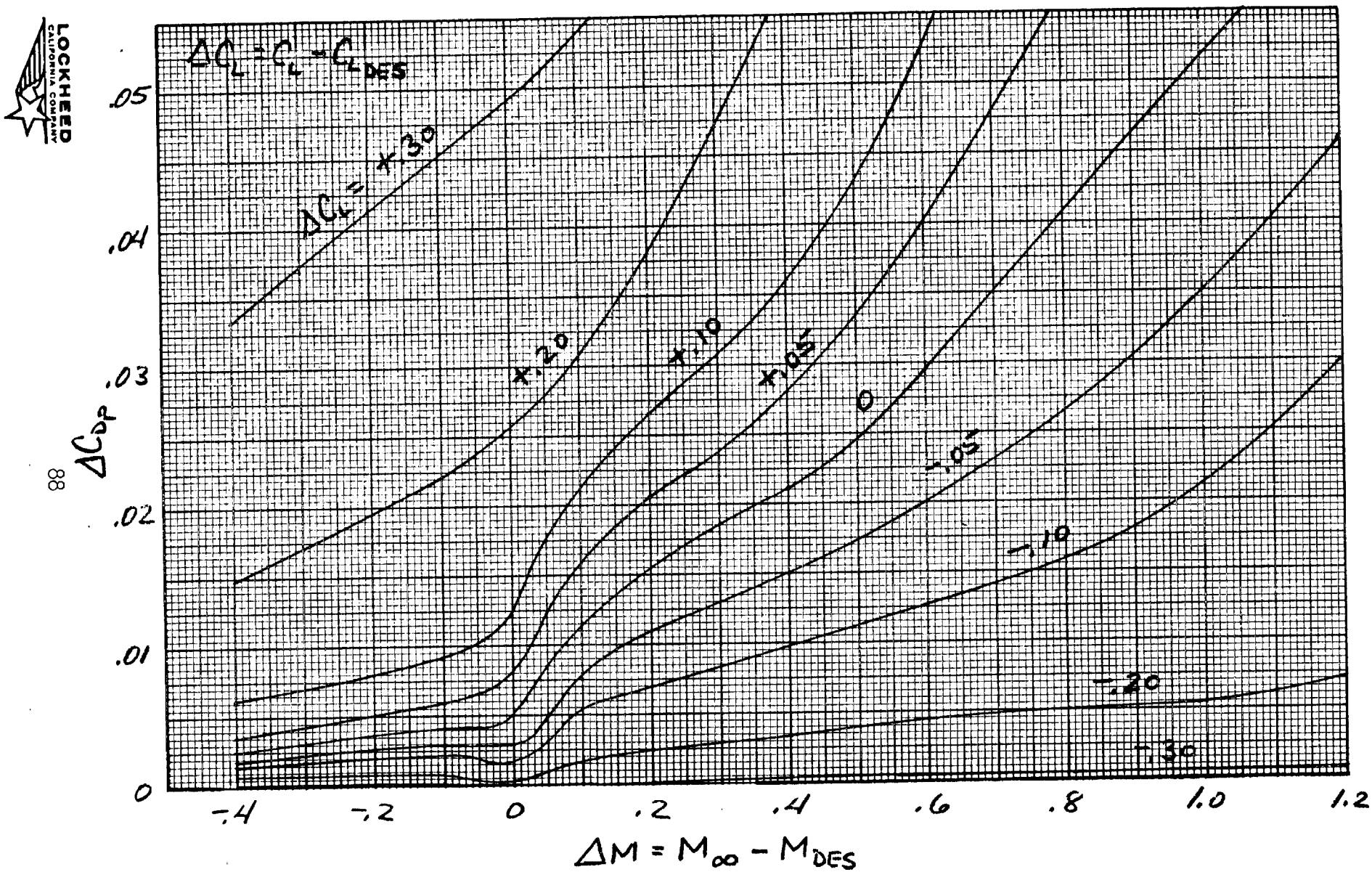

FIG. 86 WING PRESSURE DRAG VARIATION, F-4E

(1 OF 2)

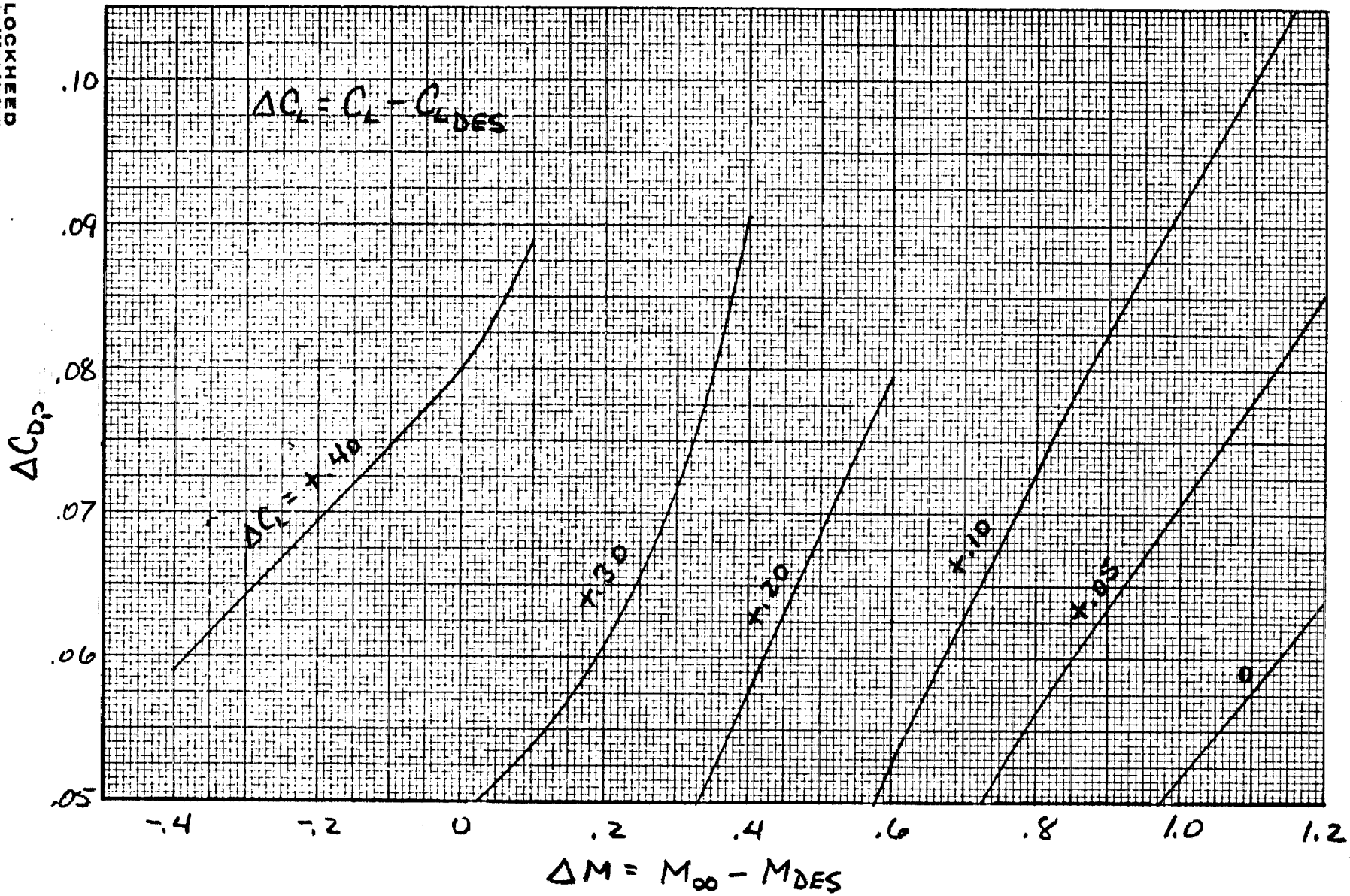

FIG. 86 WING PRESSURE DRAG VARIATION, F-4E

(2 OF 2)

LK 27975

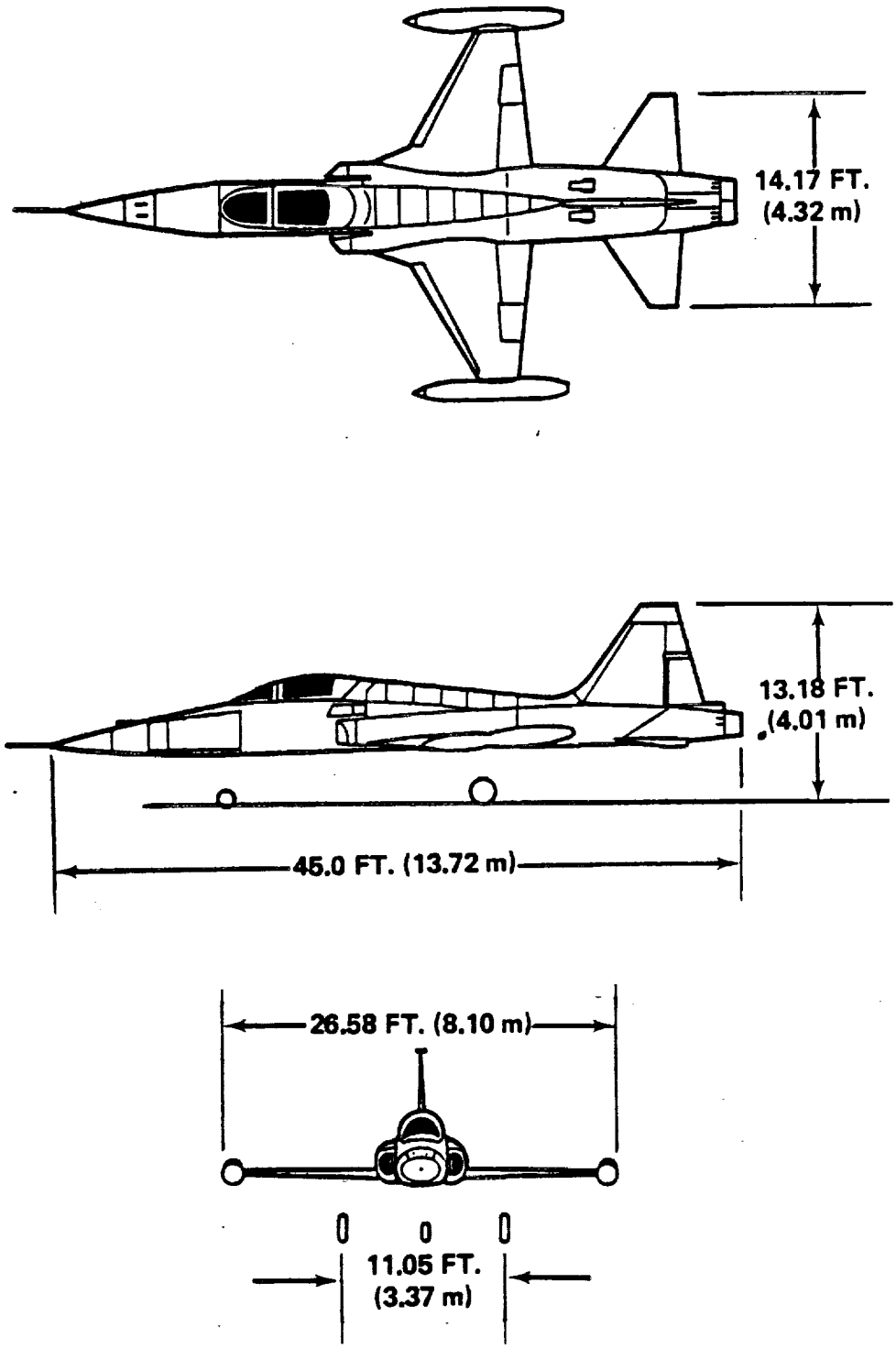

FIGURE 87. THREE-VIEW, F-5A

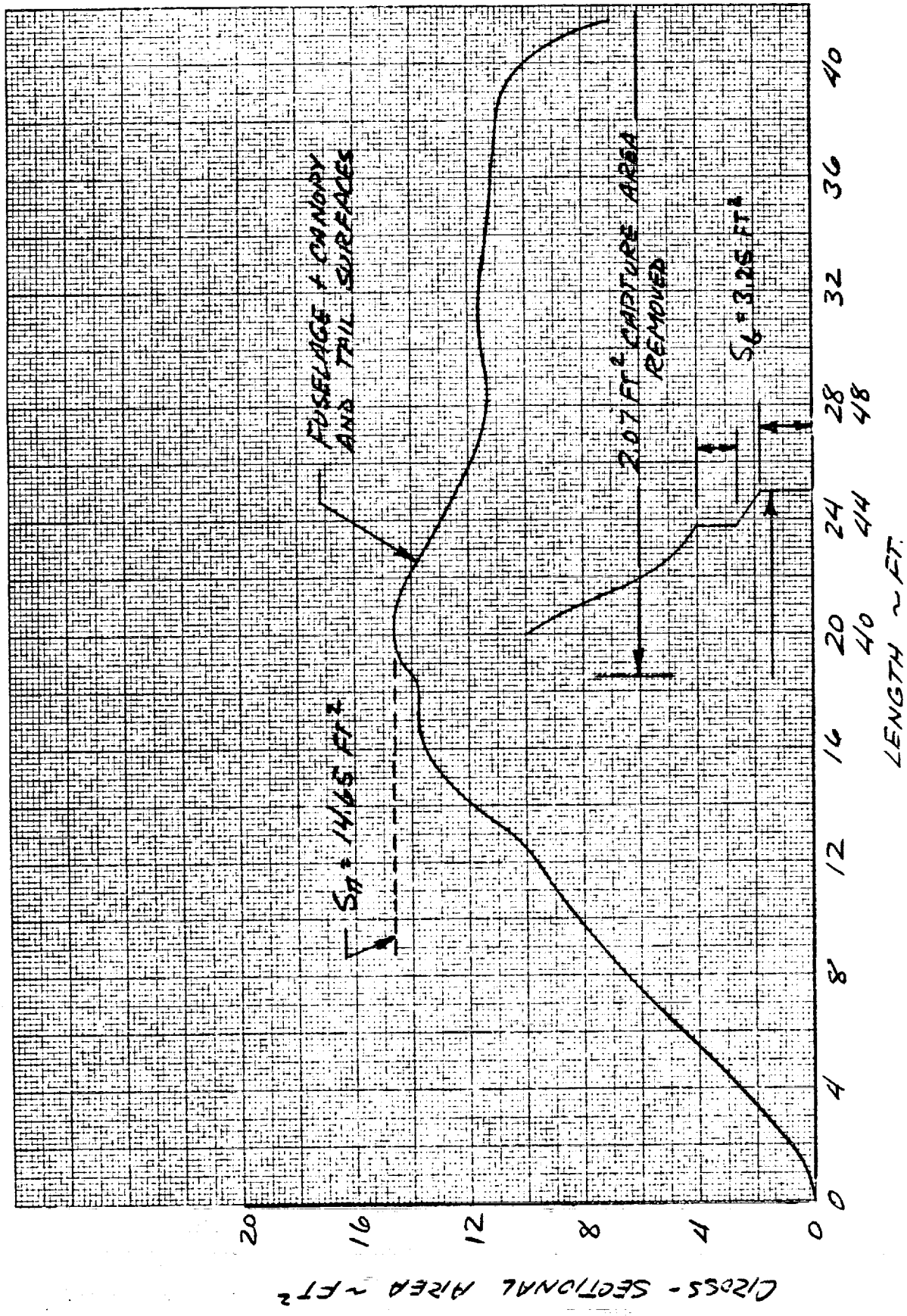

FIG. 88 F-5A FUSELAGE AREA DISTRIBUTION

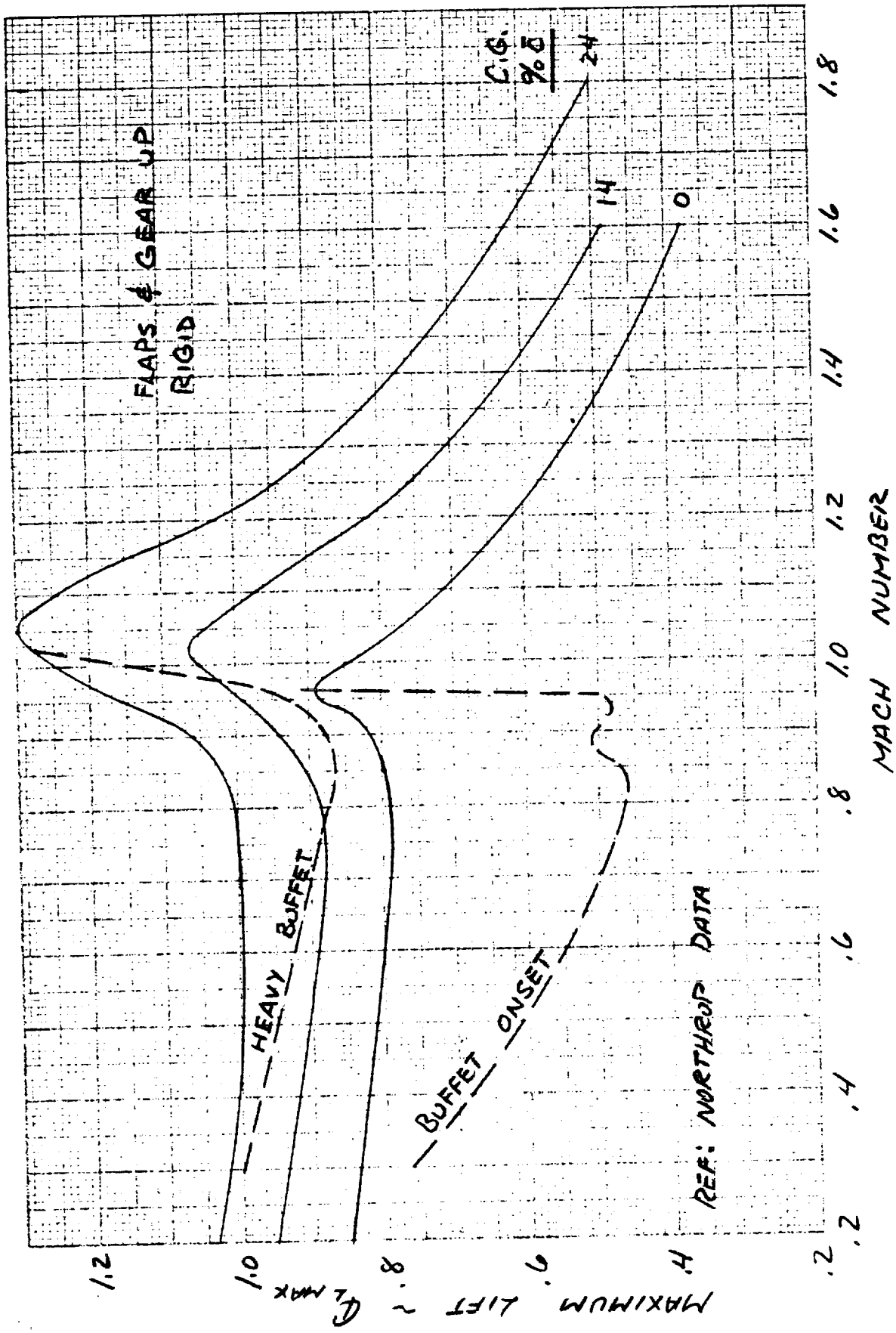

FIG. 89 LIMIT LIFT CHARACTERISTICS, F-5A

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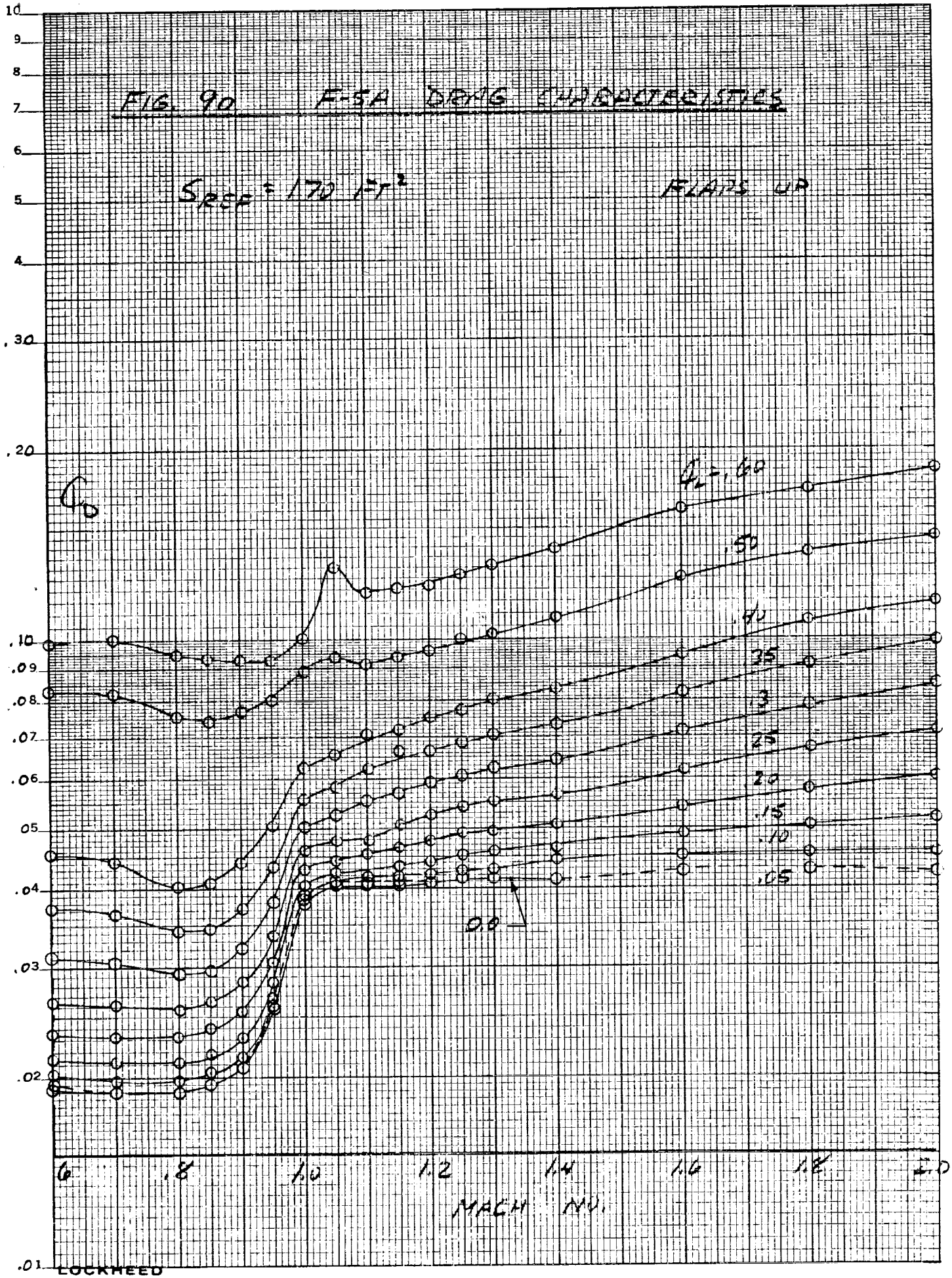
FIG. 90 F-5A DRAG CHARACTERISTICS
S_{REF} = 170 FT²
FLAPS UP
C_D
C_L = .60
.50
.40
.35
.3
.25
.20
.15
.10
.05
0.0
10
9
8
7
6
5
4
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
MACH NO.

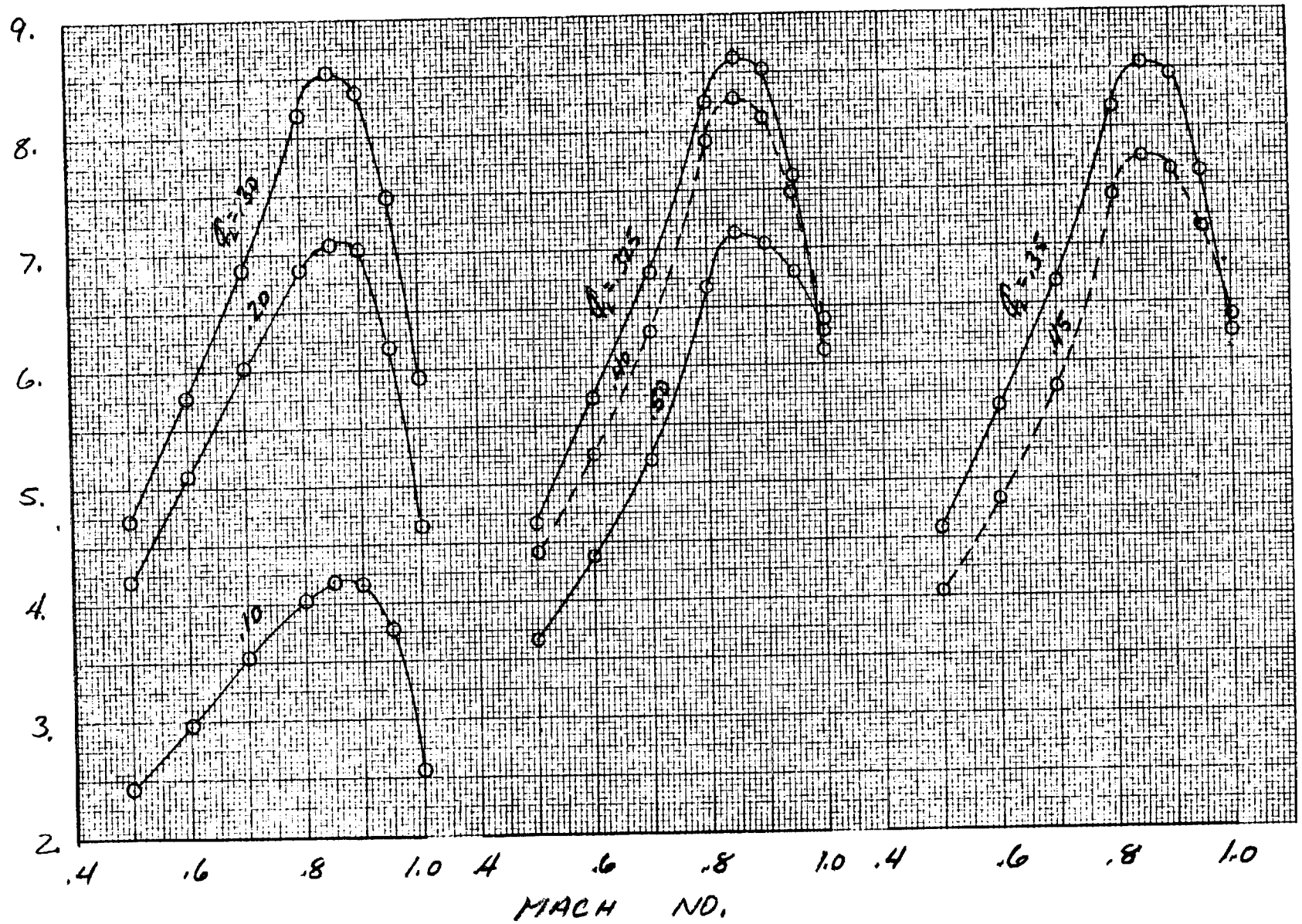

FIG. 91 M(L/D) VS. MACH NUMBER, F-5A

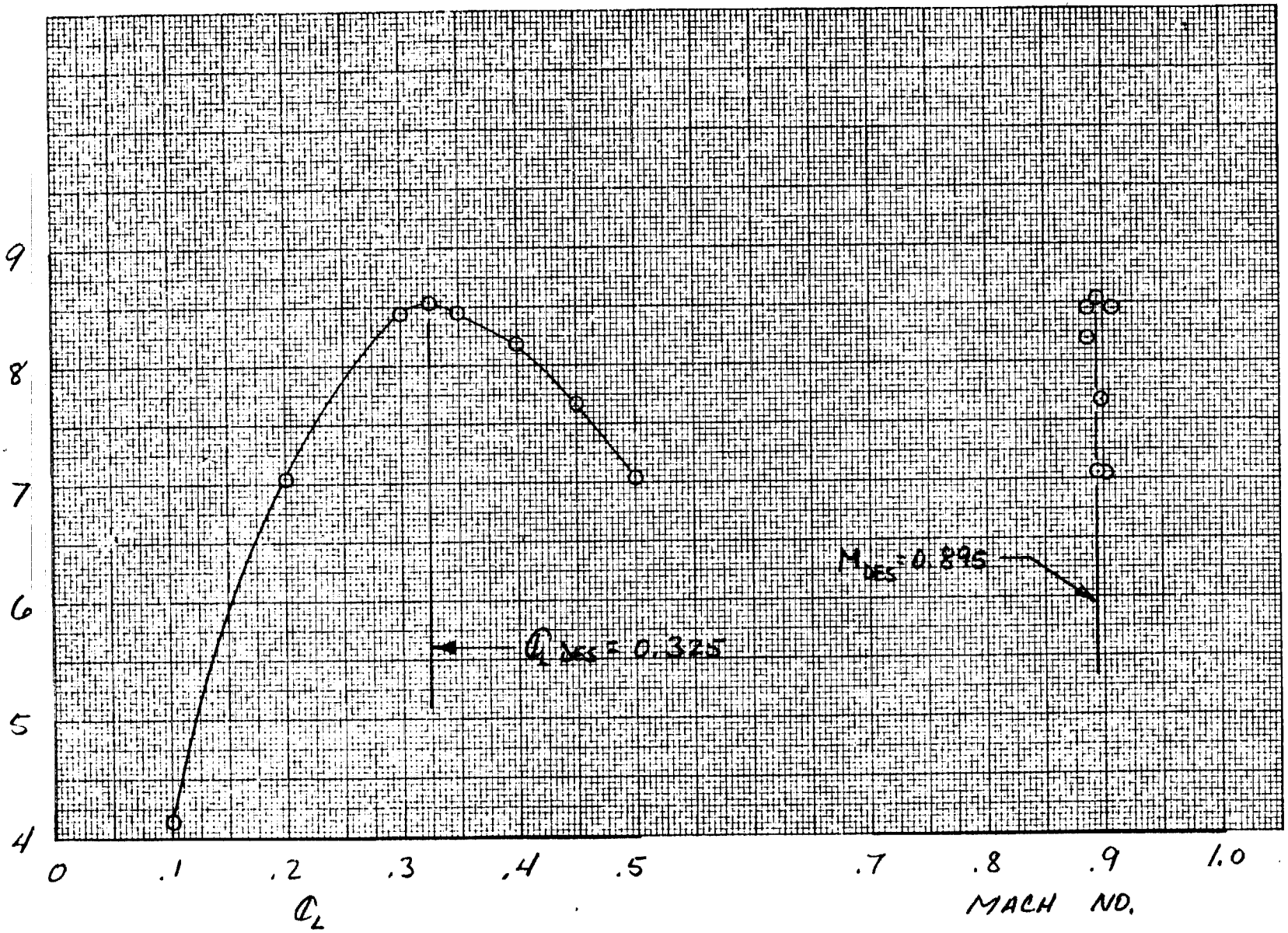

FIG. 92 $C_{L\,DES}$ AND M_{DES} FOR F-5A

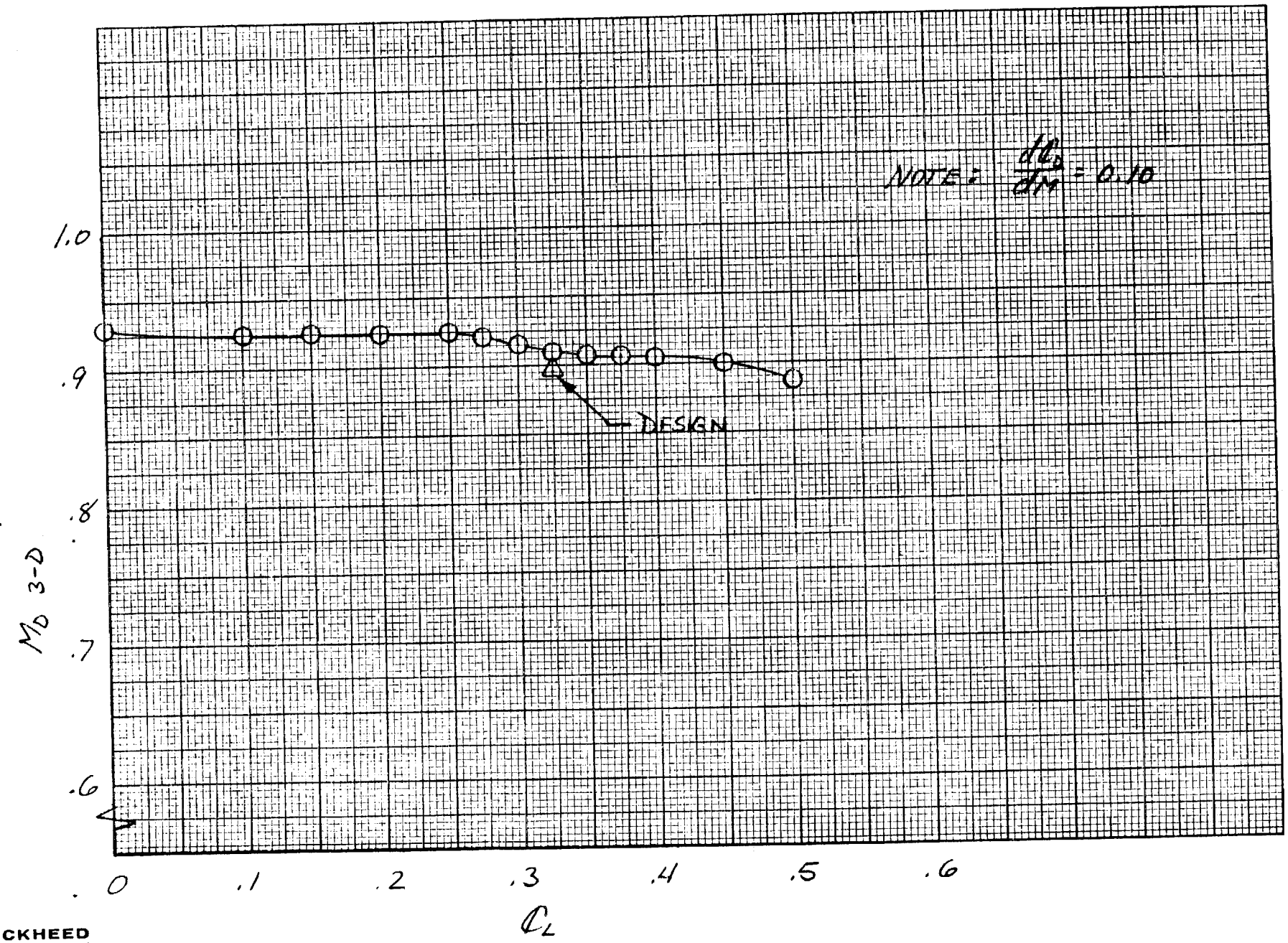

FIG. 93 DRAG DIVERGENCE CHARACTERISTICS, F-5A.

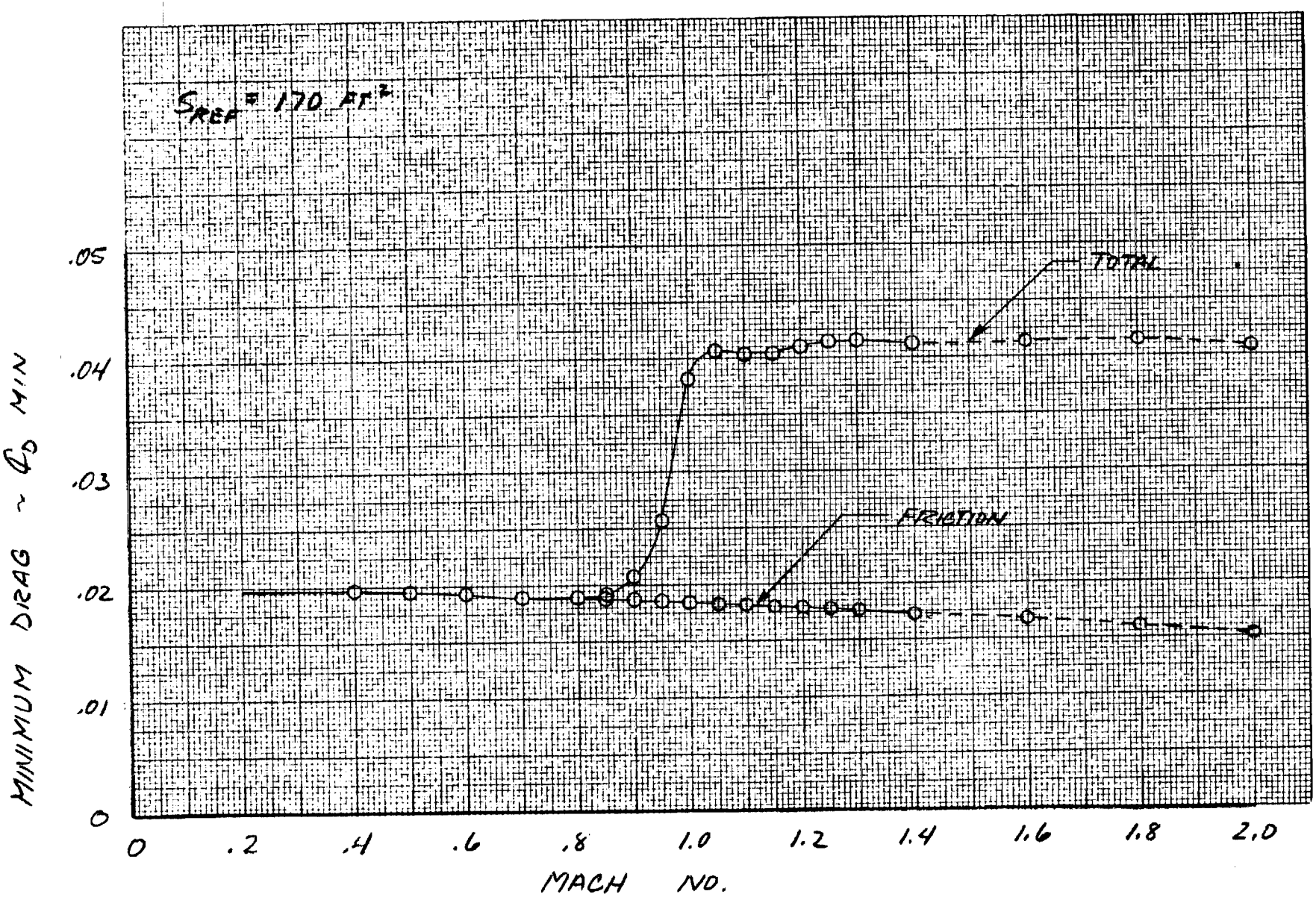

FIG. 94 MINIMUM DRAG BREAKDOWN, F-5A

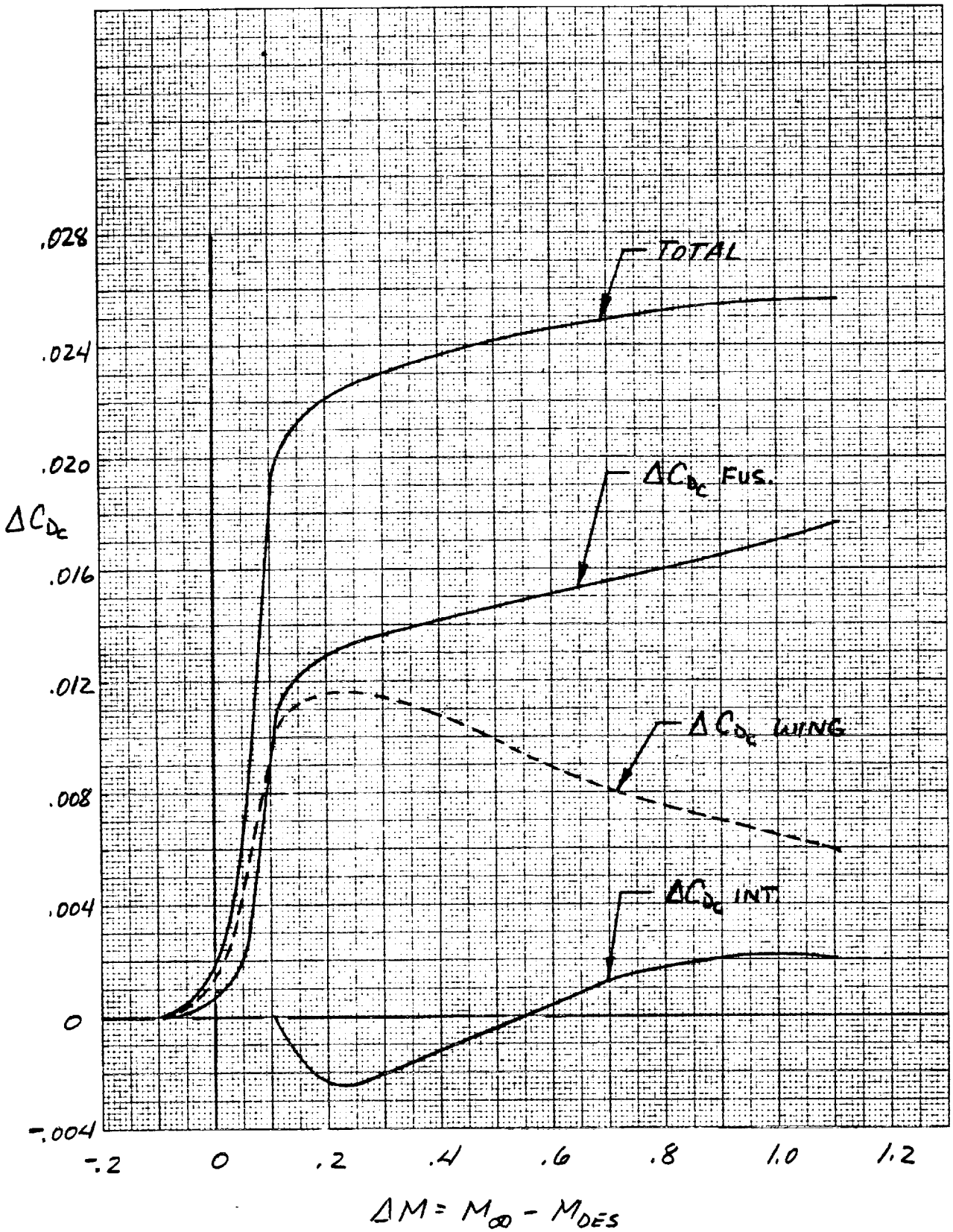

FIG. 95 COMPRESSIBILITY DRAG, F-5A

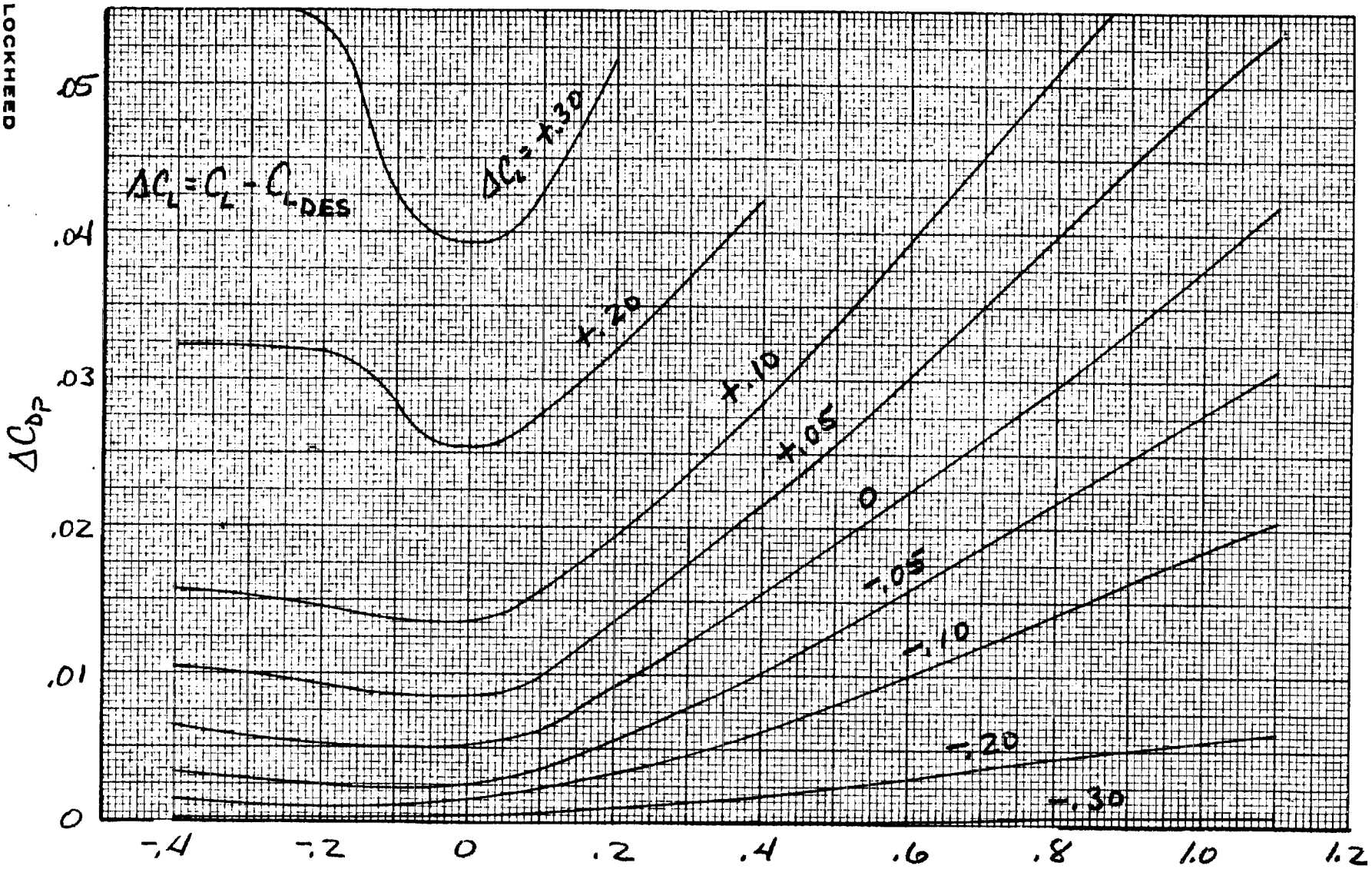

FIG. 96 WING PRESSURE DRAG VARIATION, F-5A

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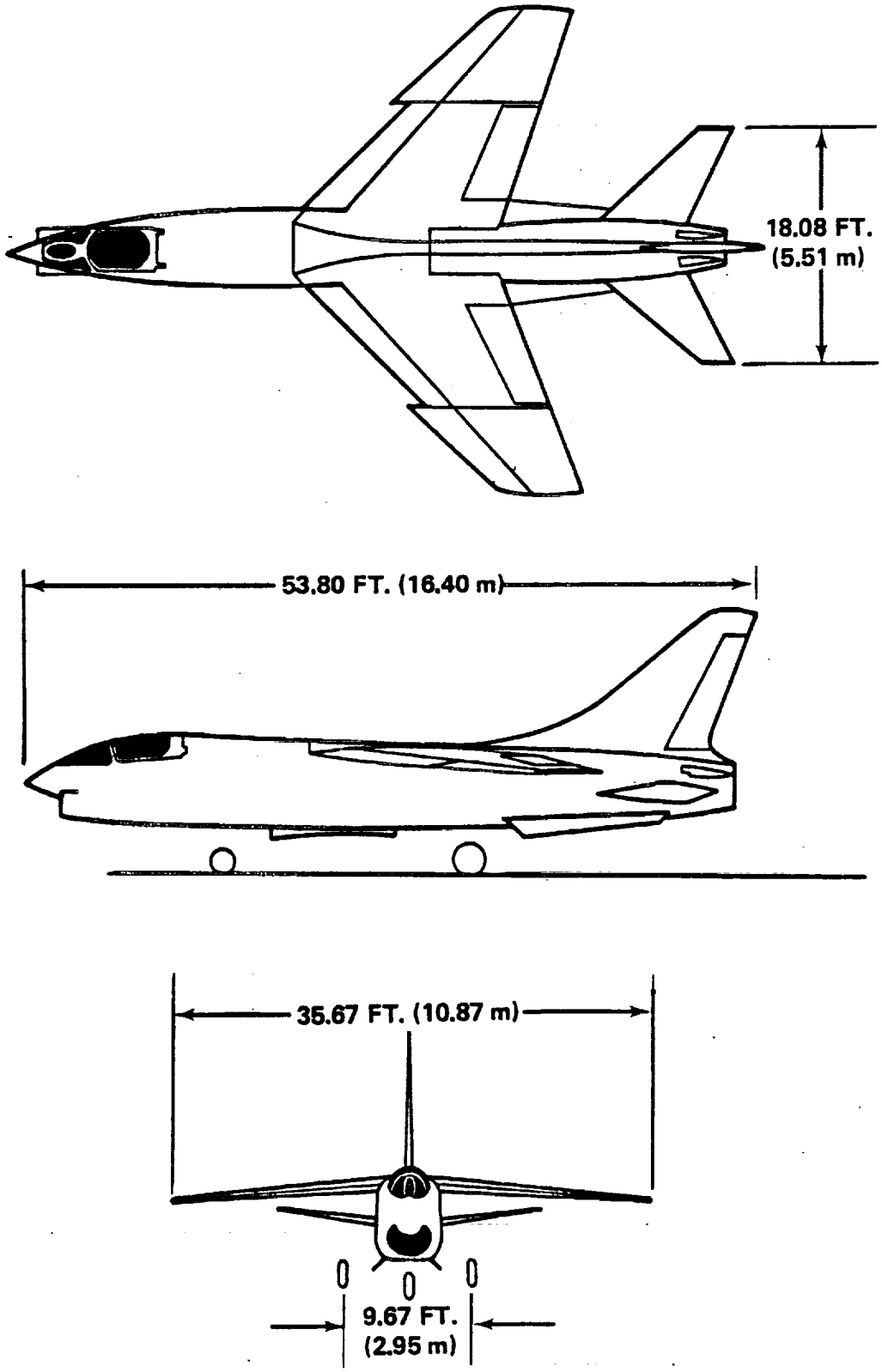

FIGURE 97. THREE-VIEW, F-8C

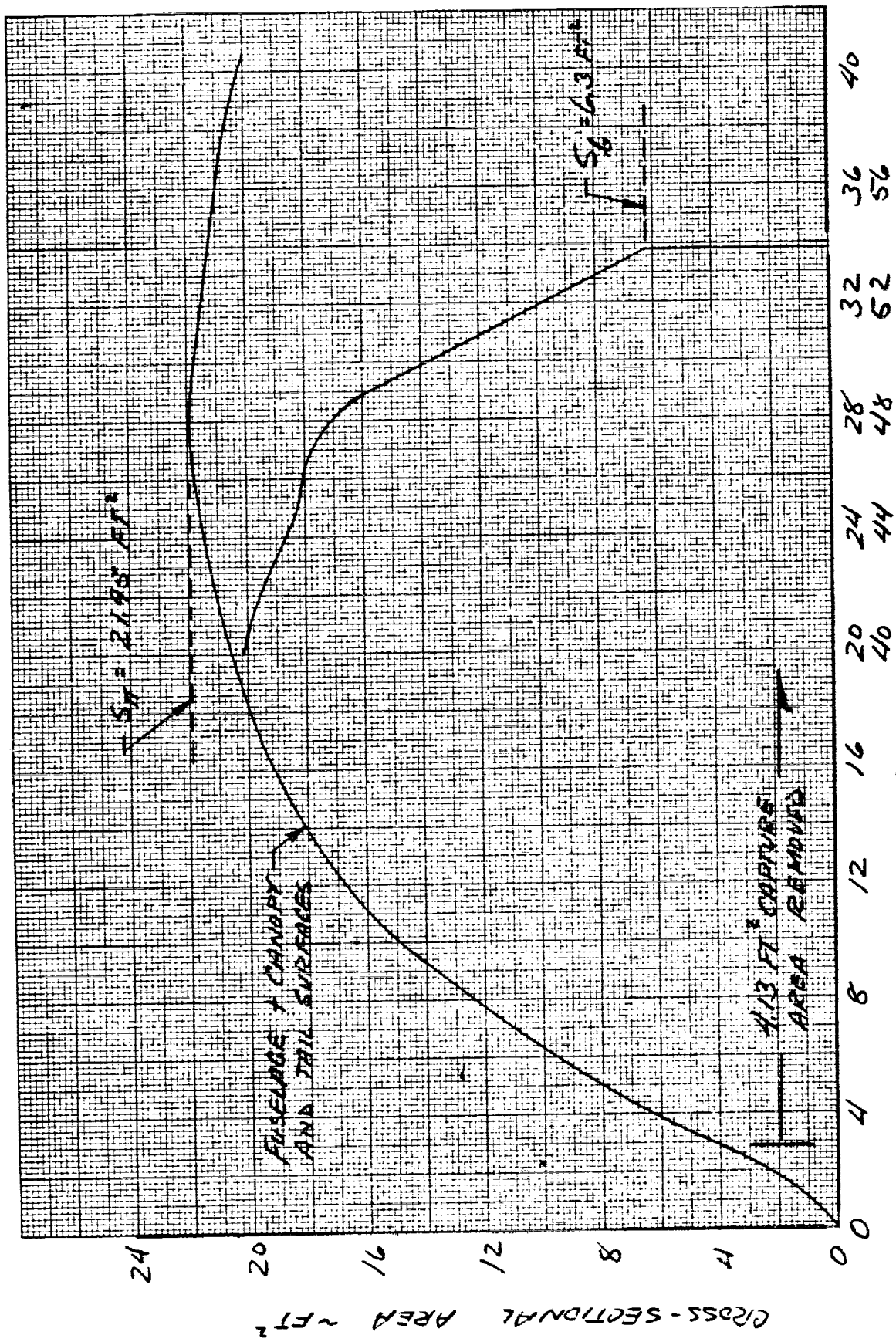

FIG. 98 F-8C FUSELAGE AREA DISTRIBUTION

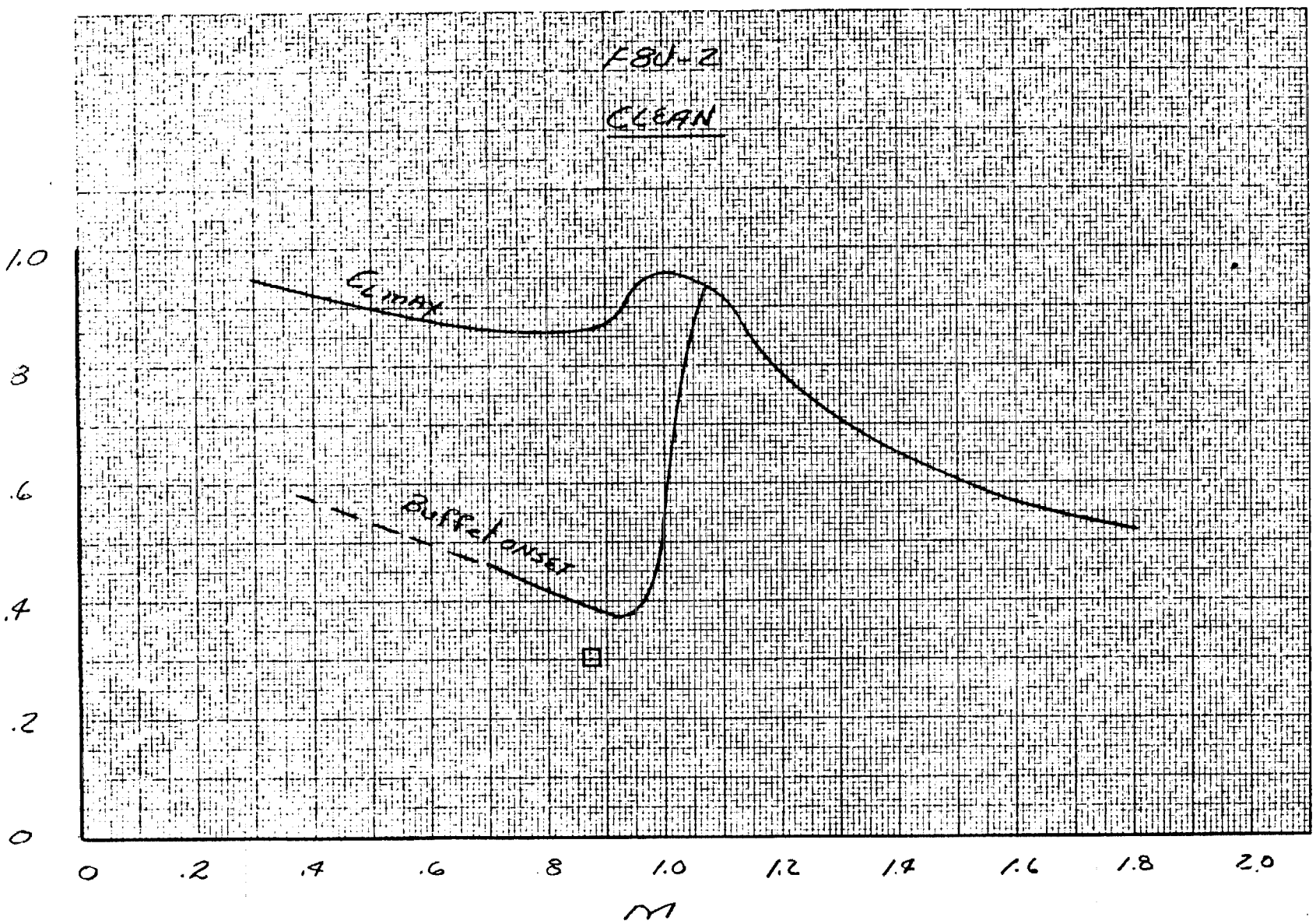

FIG. 99 LIMIT LIFT CHARACTERISTICS, F-8C

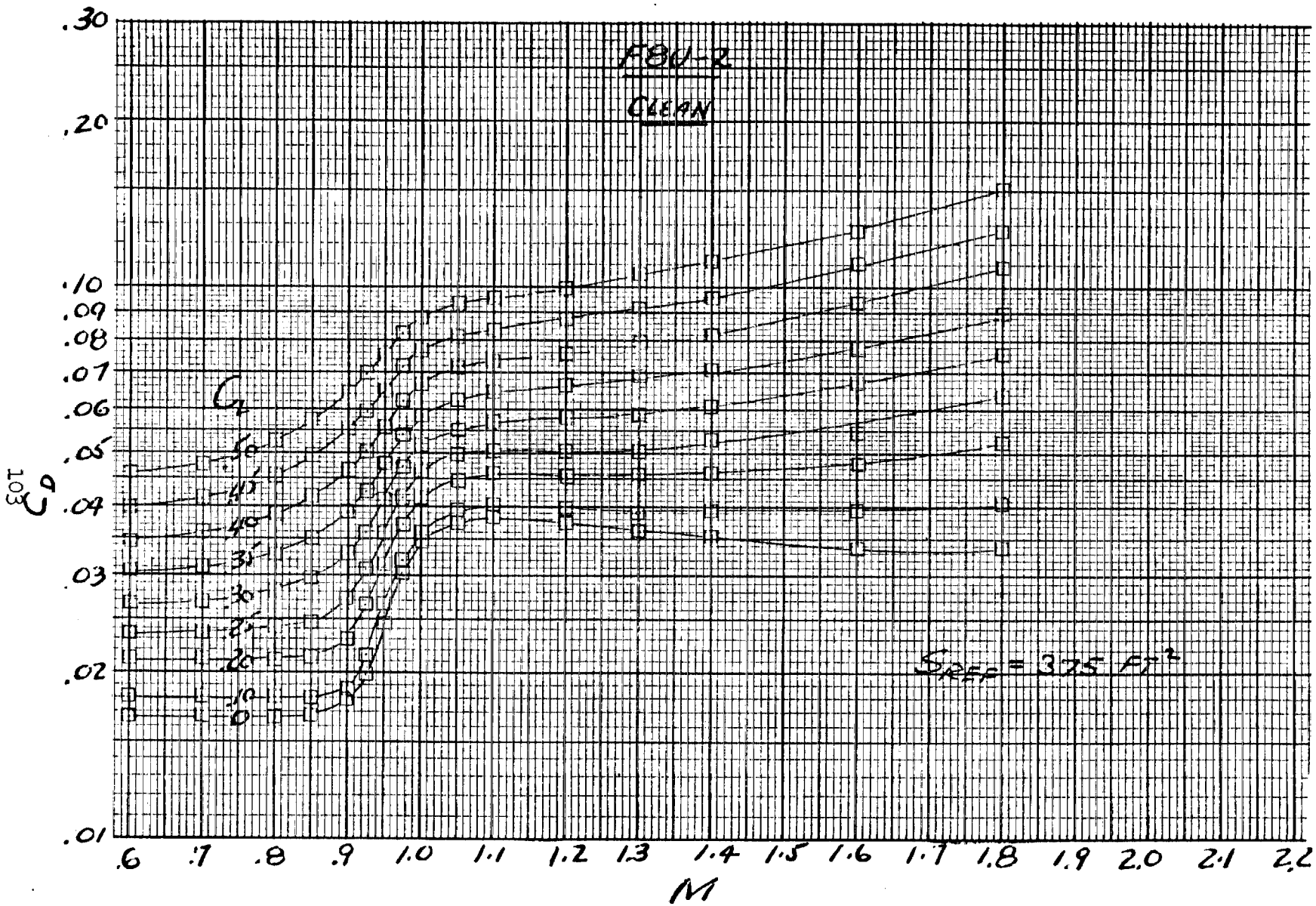

Figure 100. F-8C DRAG CHARACTERISTICS

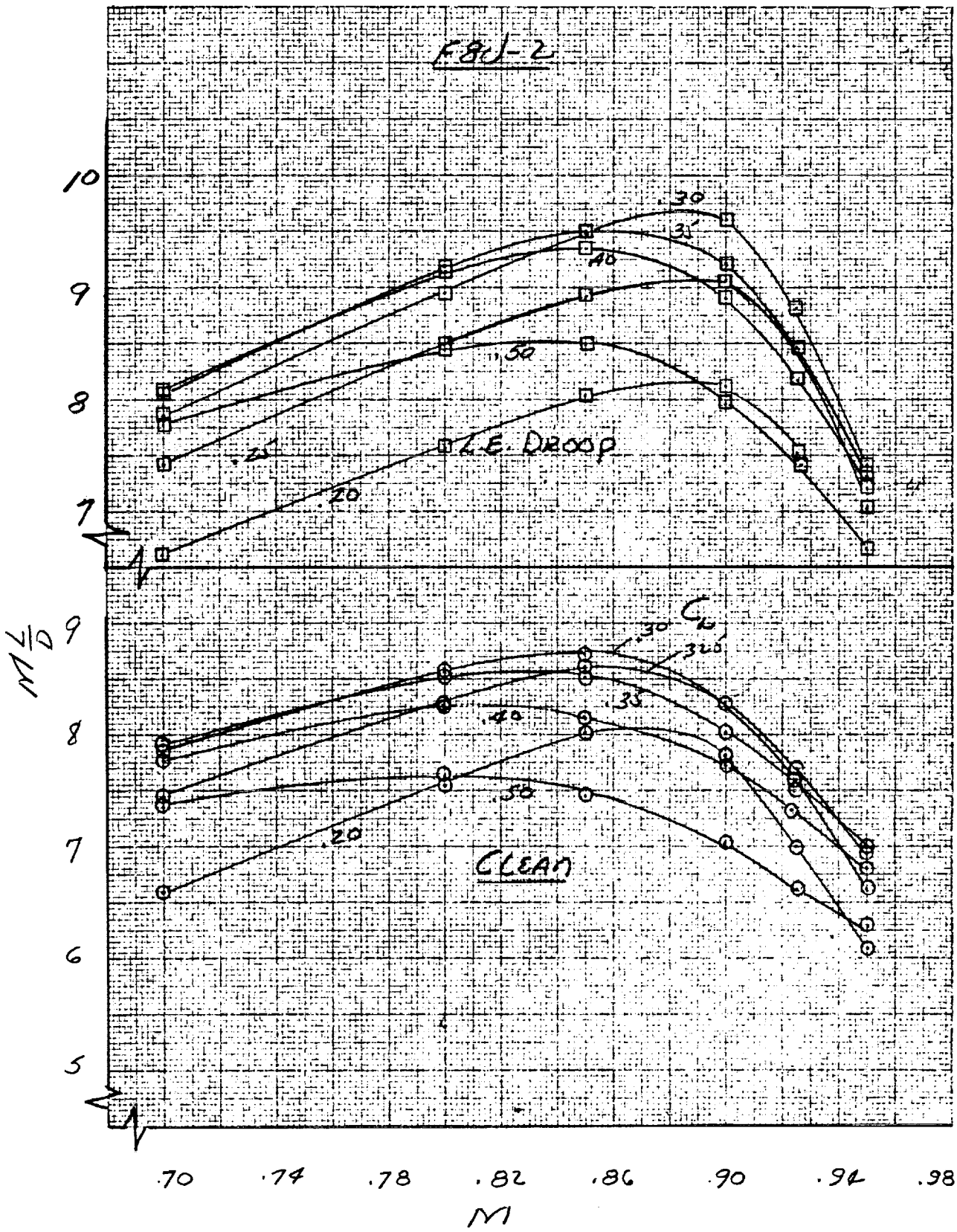

FIG. 101 $M(L/D)$ VS. MACH NUMBER, F-8C

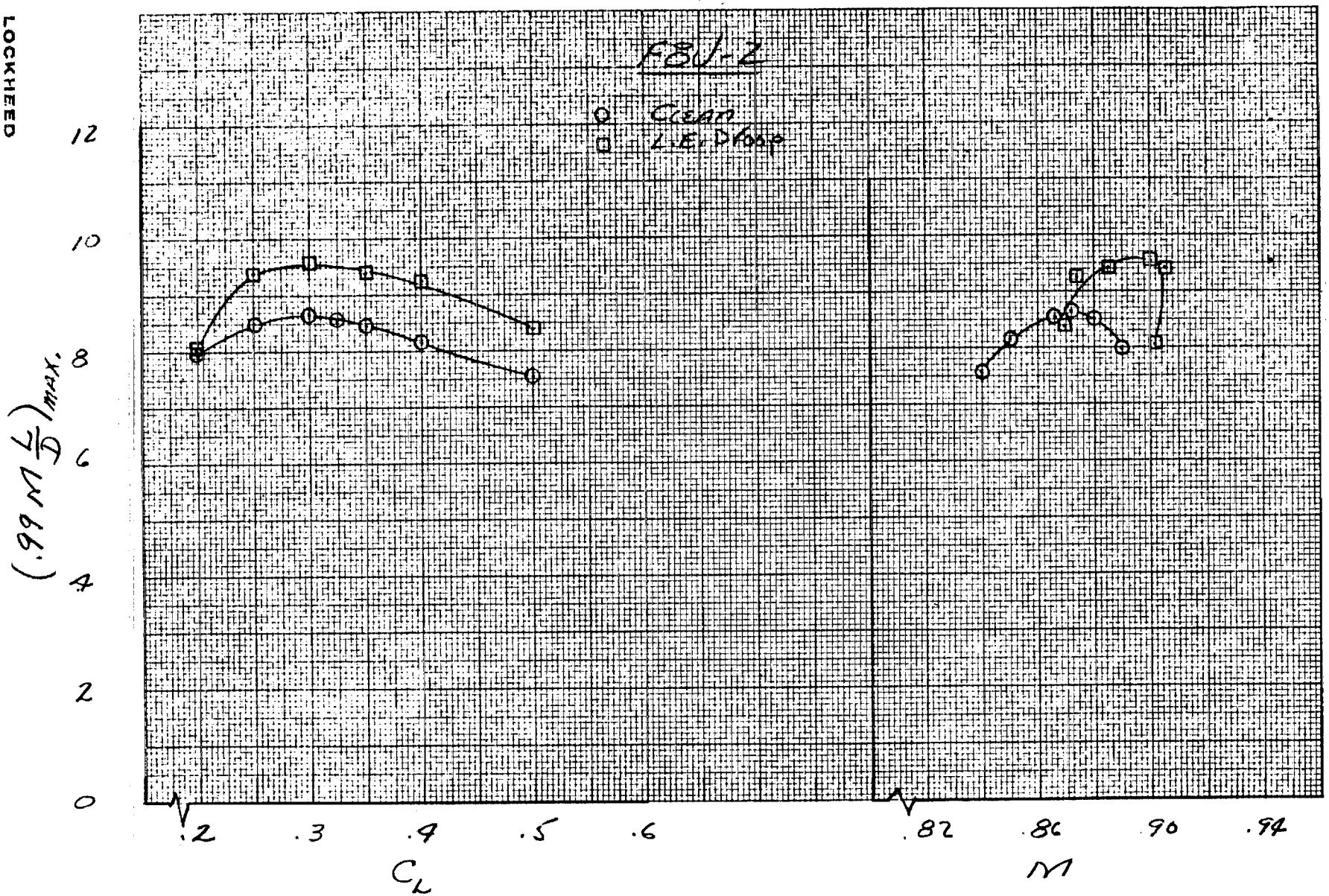

FIG. 102 $C_{L_{DES}}$ AND M_{DES} FOR F-8C

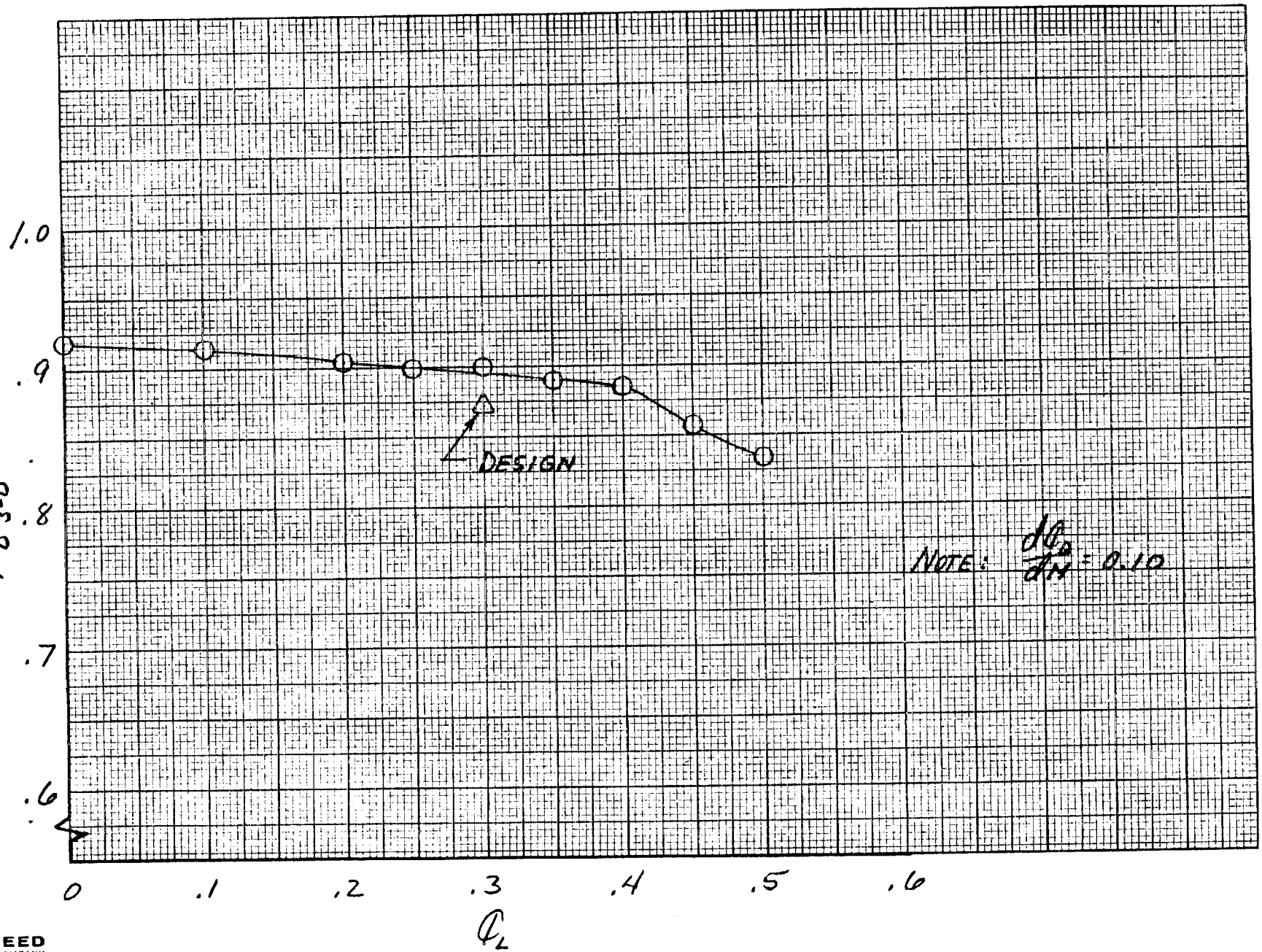

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FIG. 103 DRAG DIVERGENCE CHARACTERISTICS, F-8C

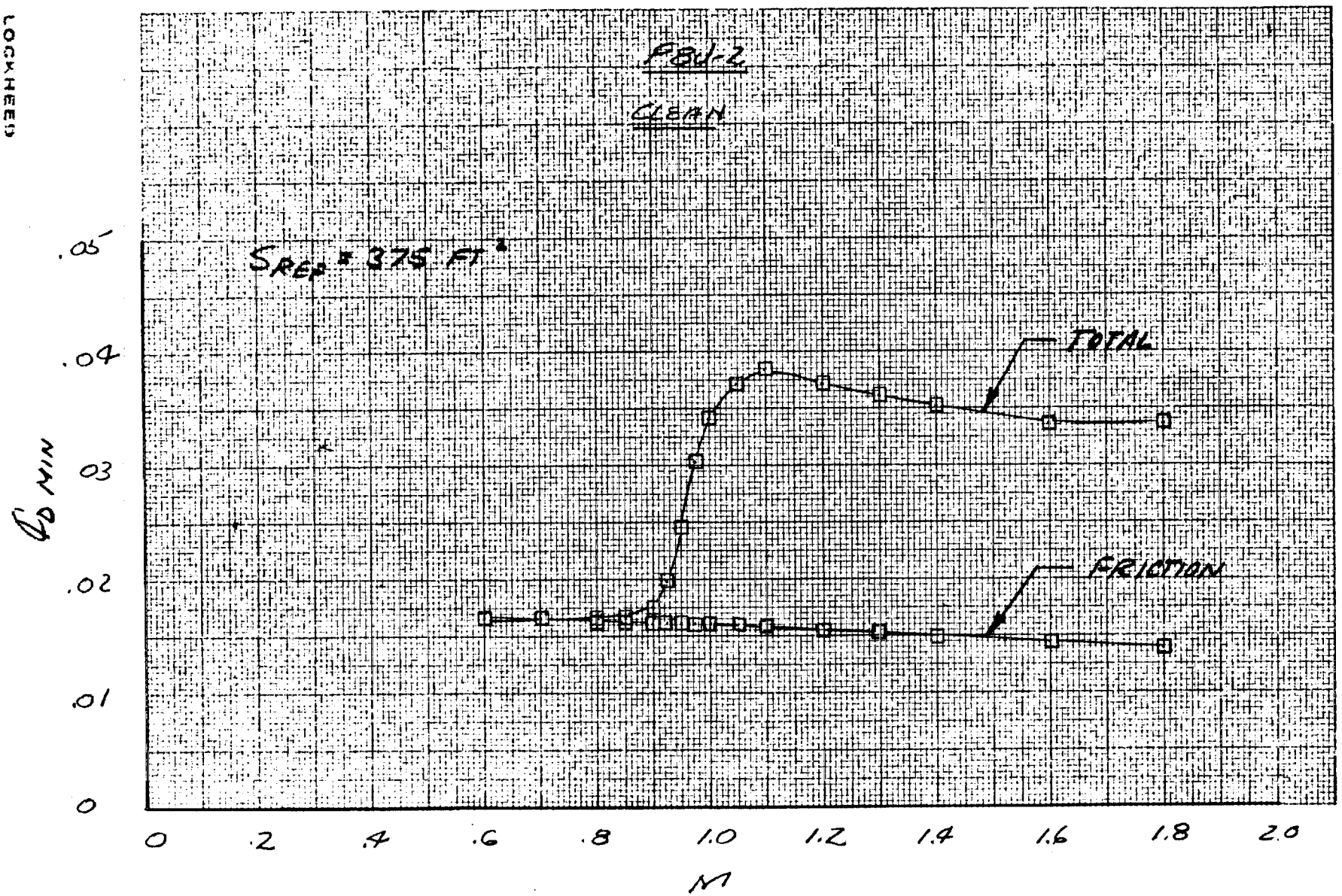

FIG. 104 MINIMUM DRAG BREAKDOWN, F-8C

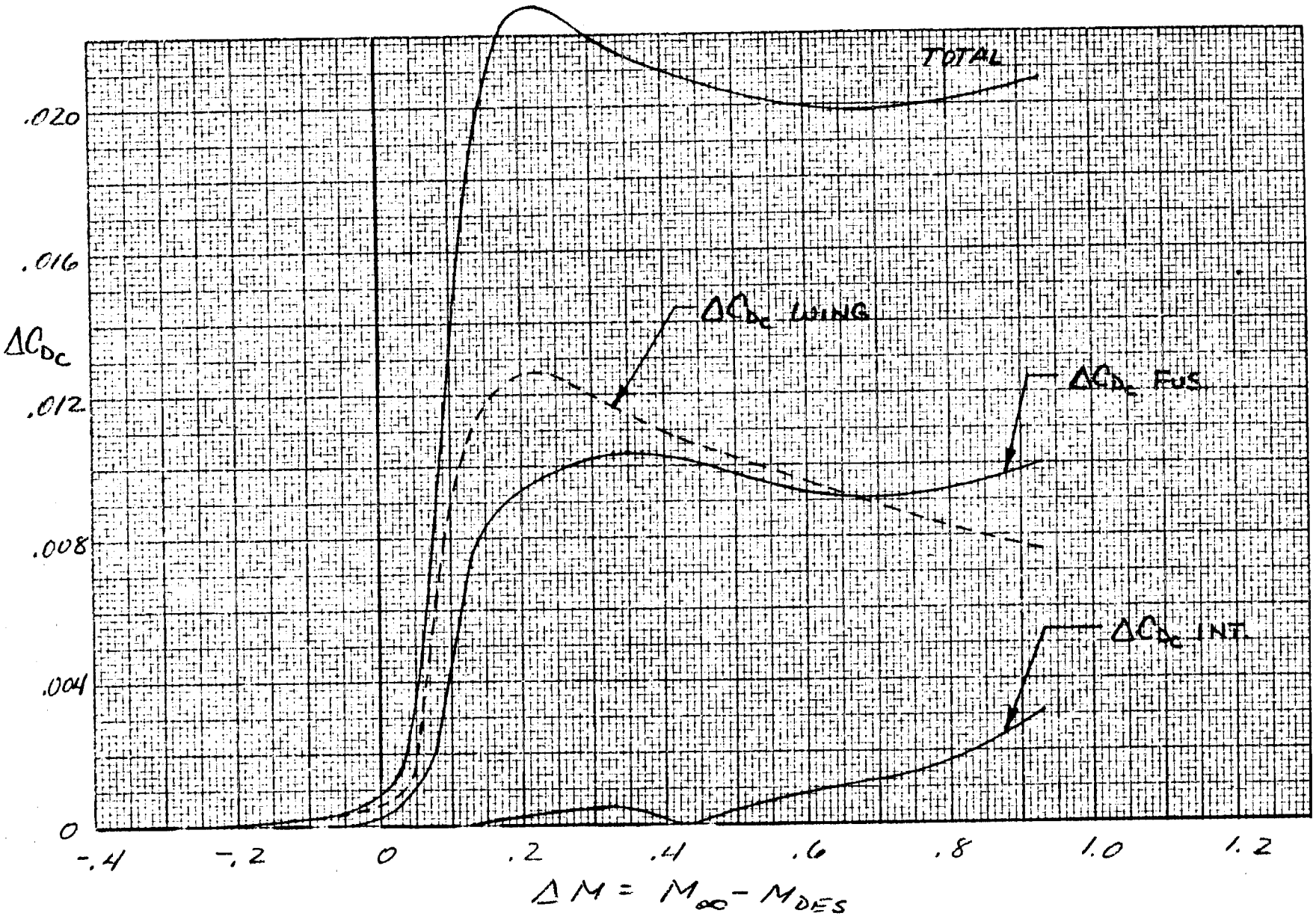

FIG. 105 COMPRESSIBILITY DRAG, F-8C

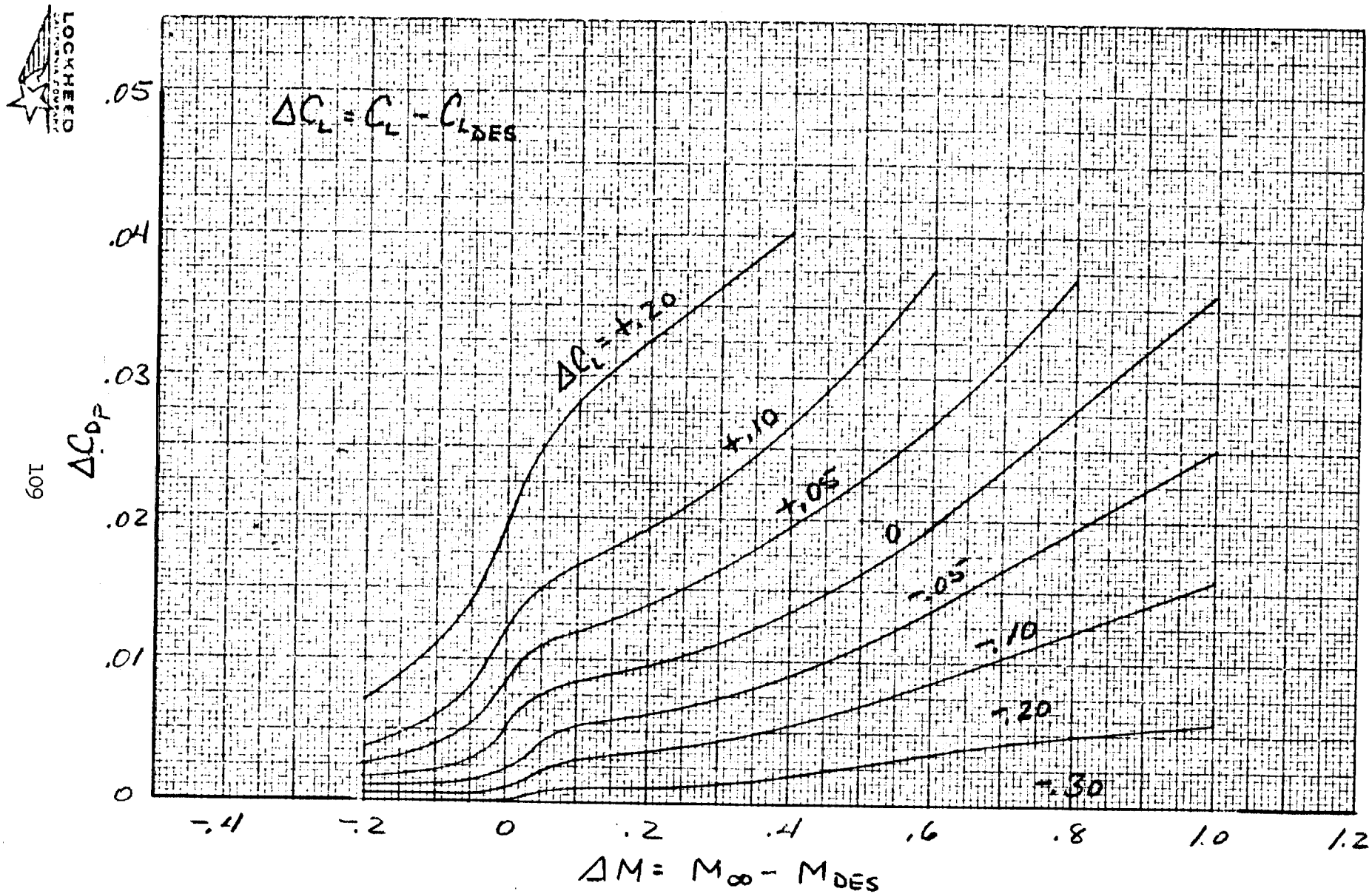

FIG. 106 WING PRESSURE DRAG VARIATION, F-8C

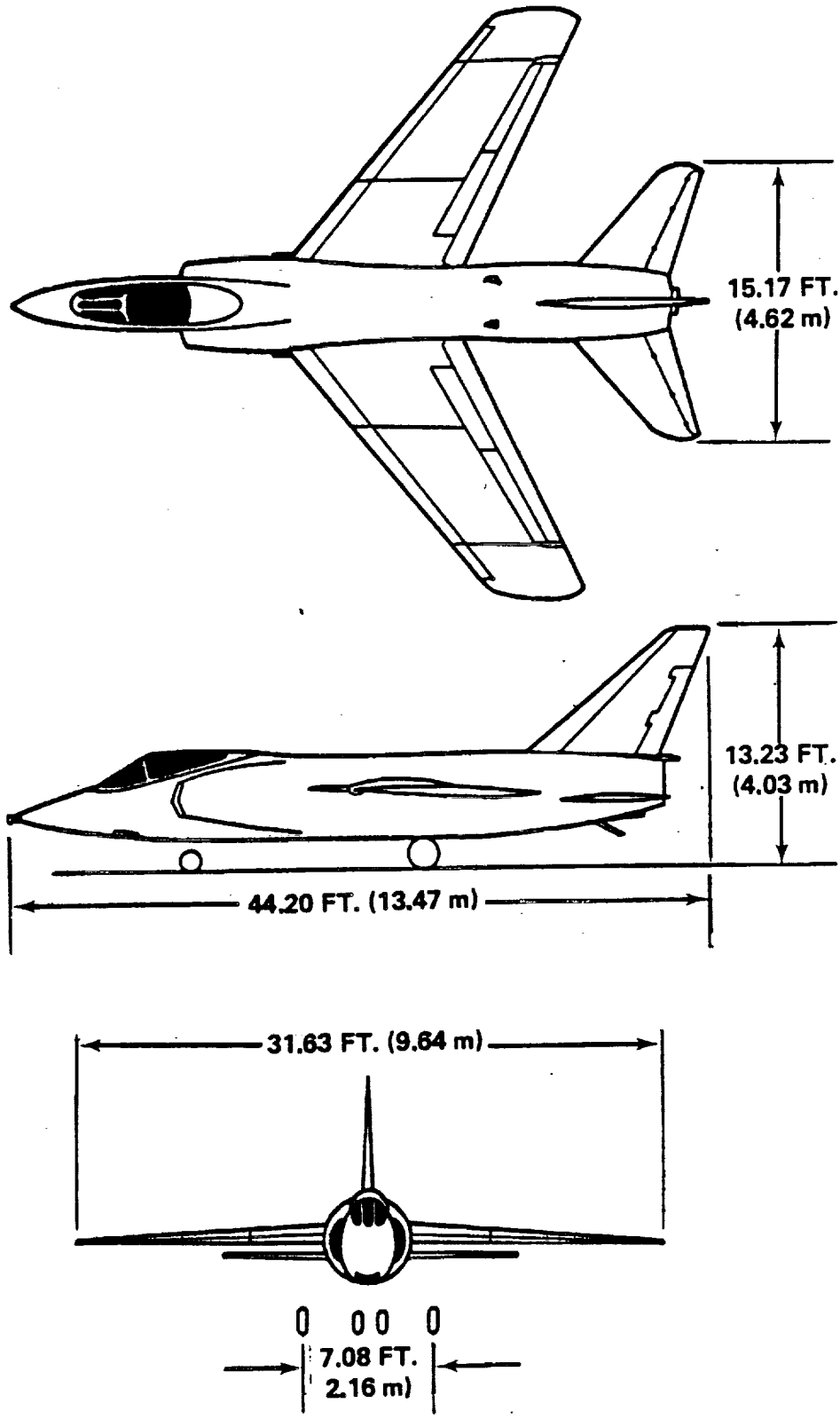

FIGURE 107. THREE-VIEW, F-11F

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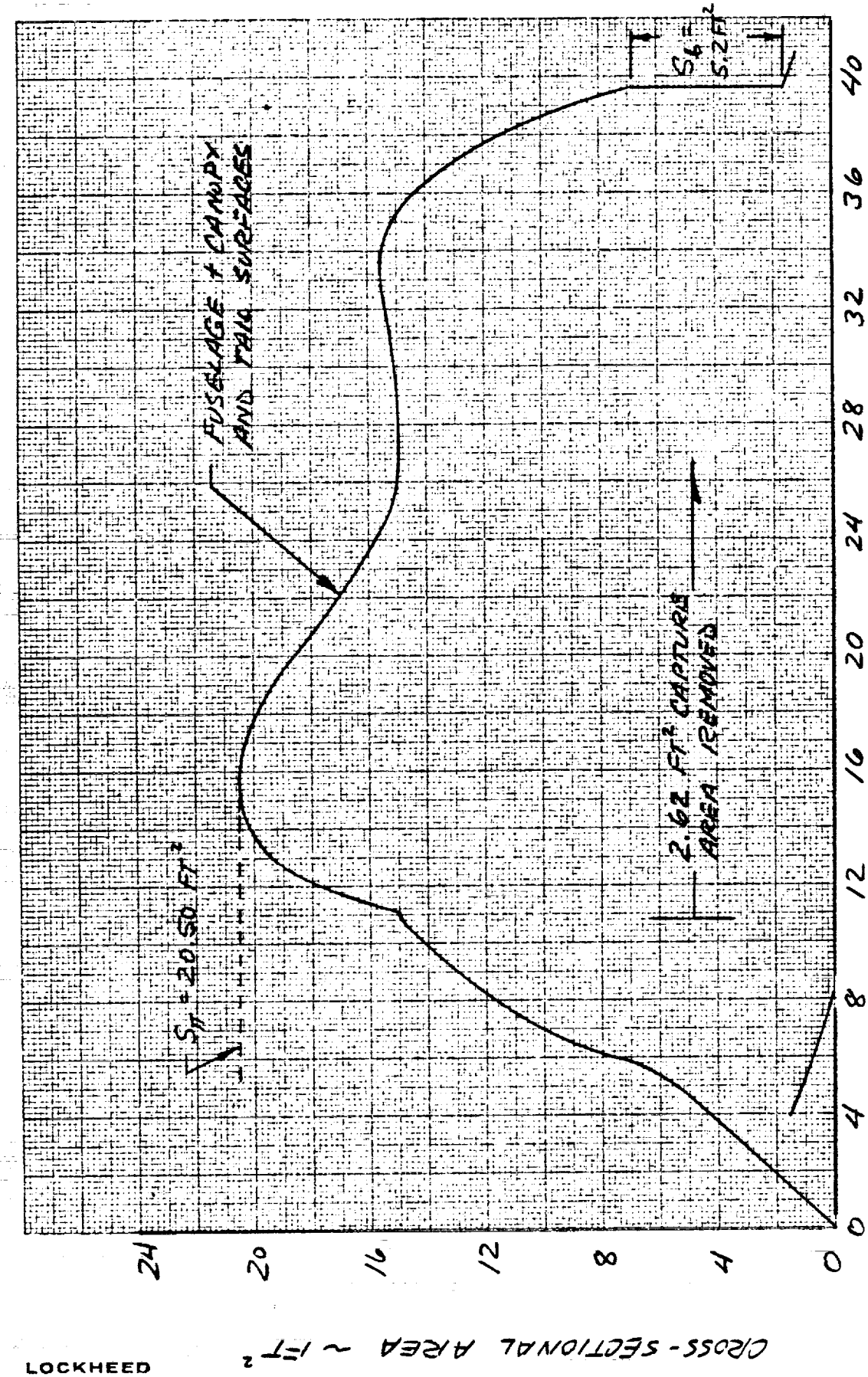

FIG. 108 F-111F FUSELAGE AREA DISTRIBUTION

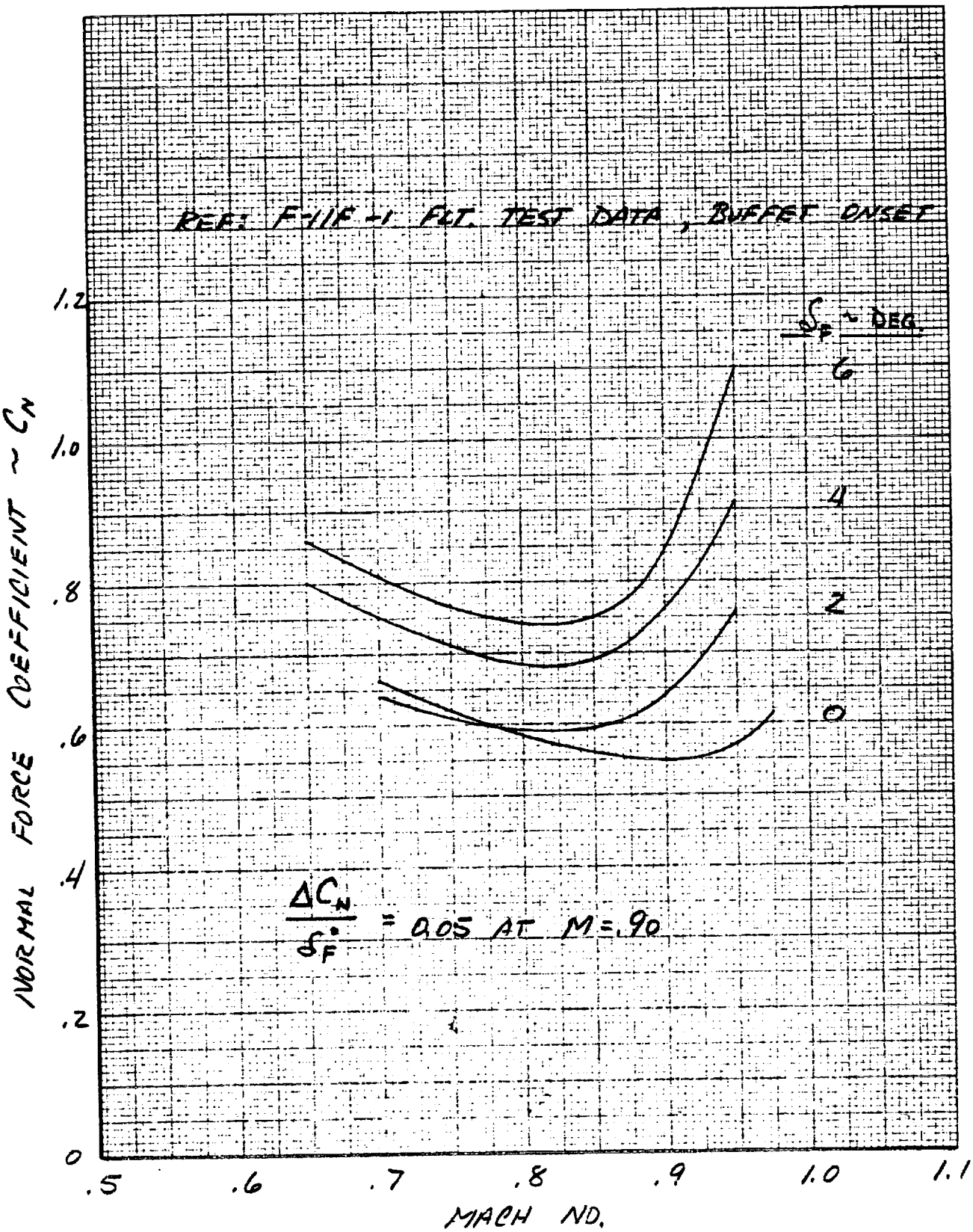

FIG. 109 LIMIT LIFT CHARACTERISTICS, F-11F

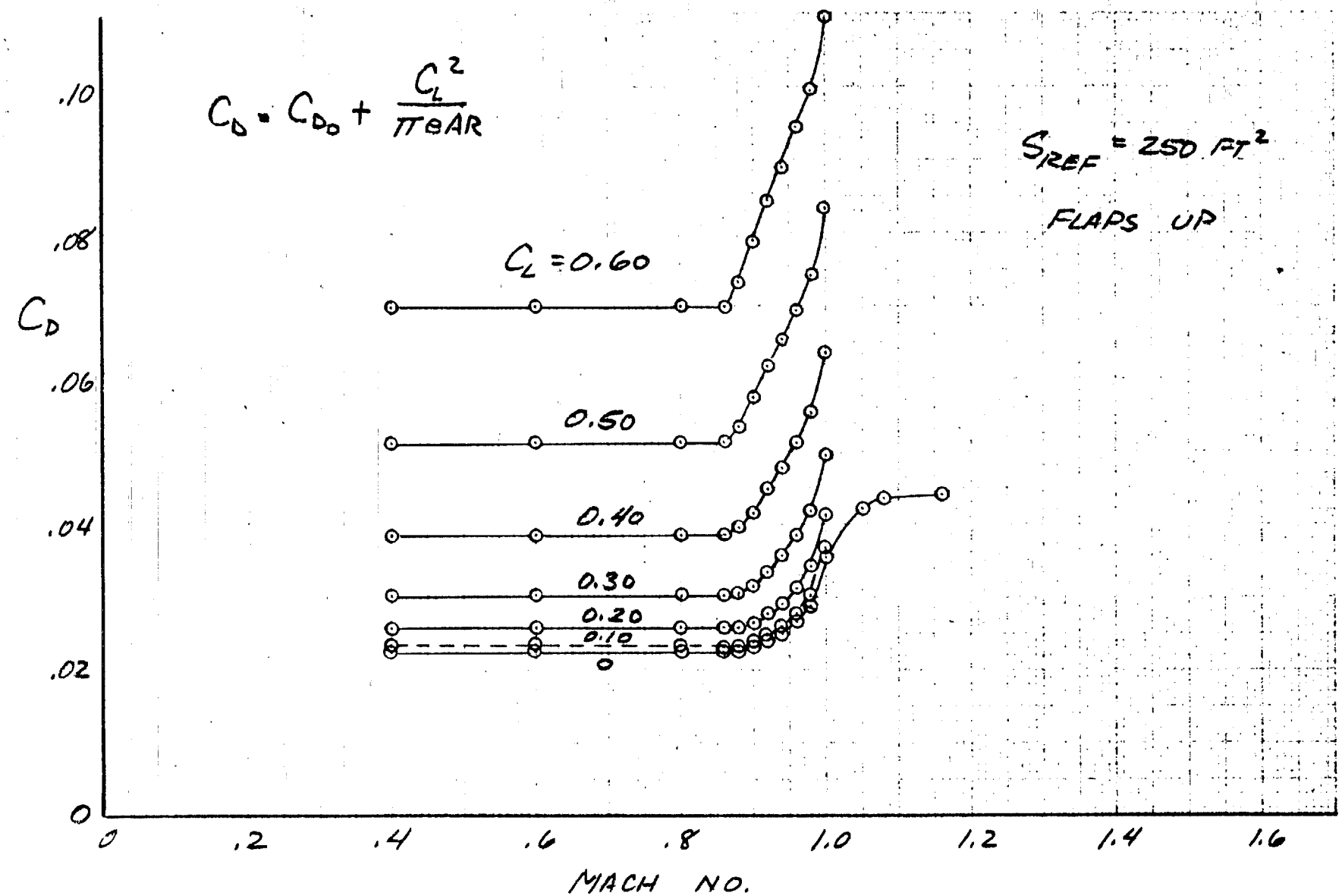

FIG. 110 F-11F DRAG CHARACTERISTICS

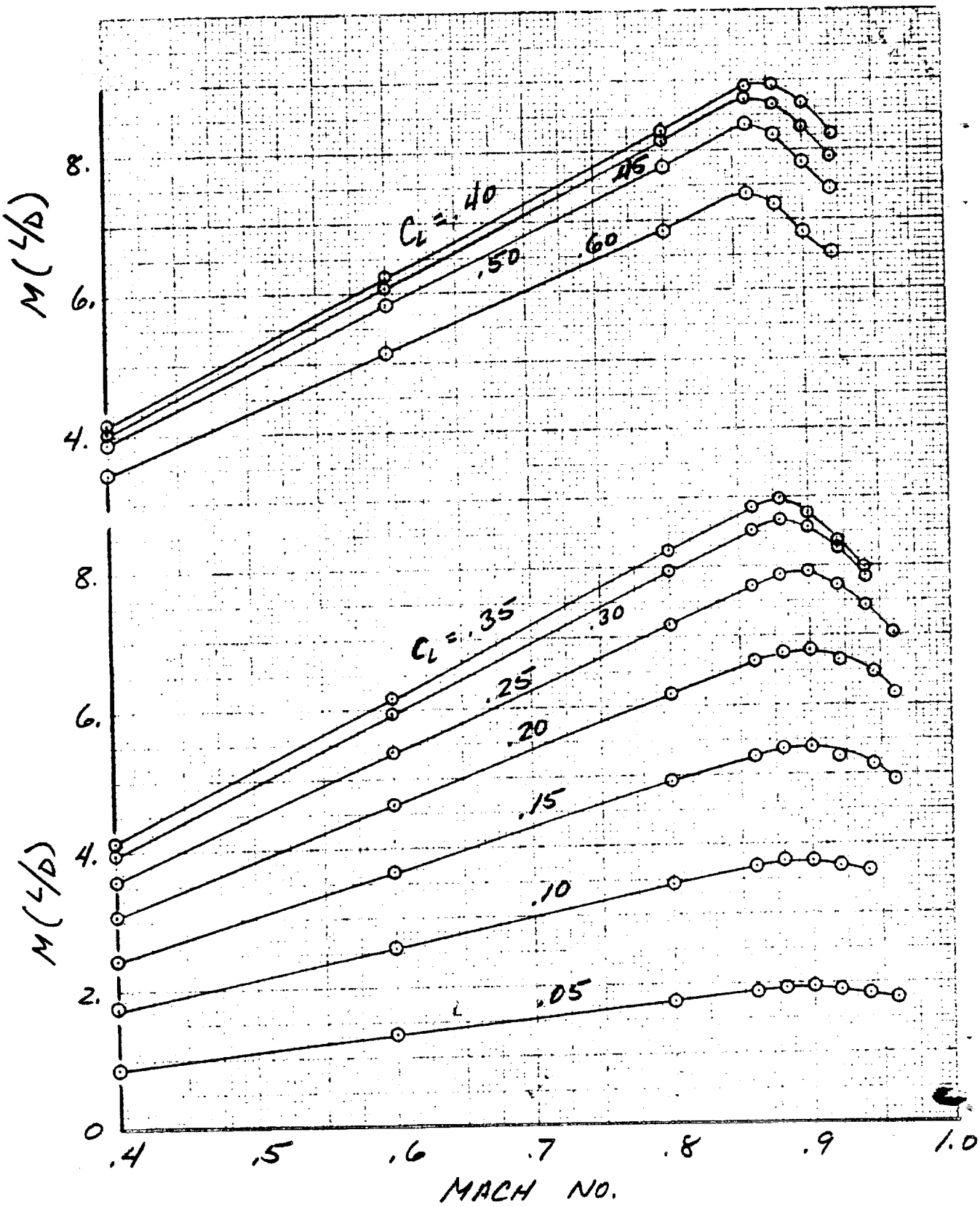

FIG. 111 M(L/D) VS. MACH NUMBER, F-11F

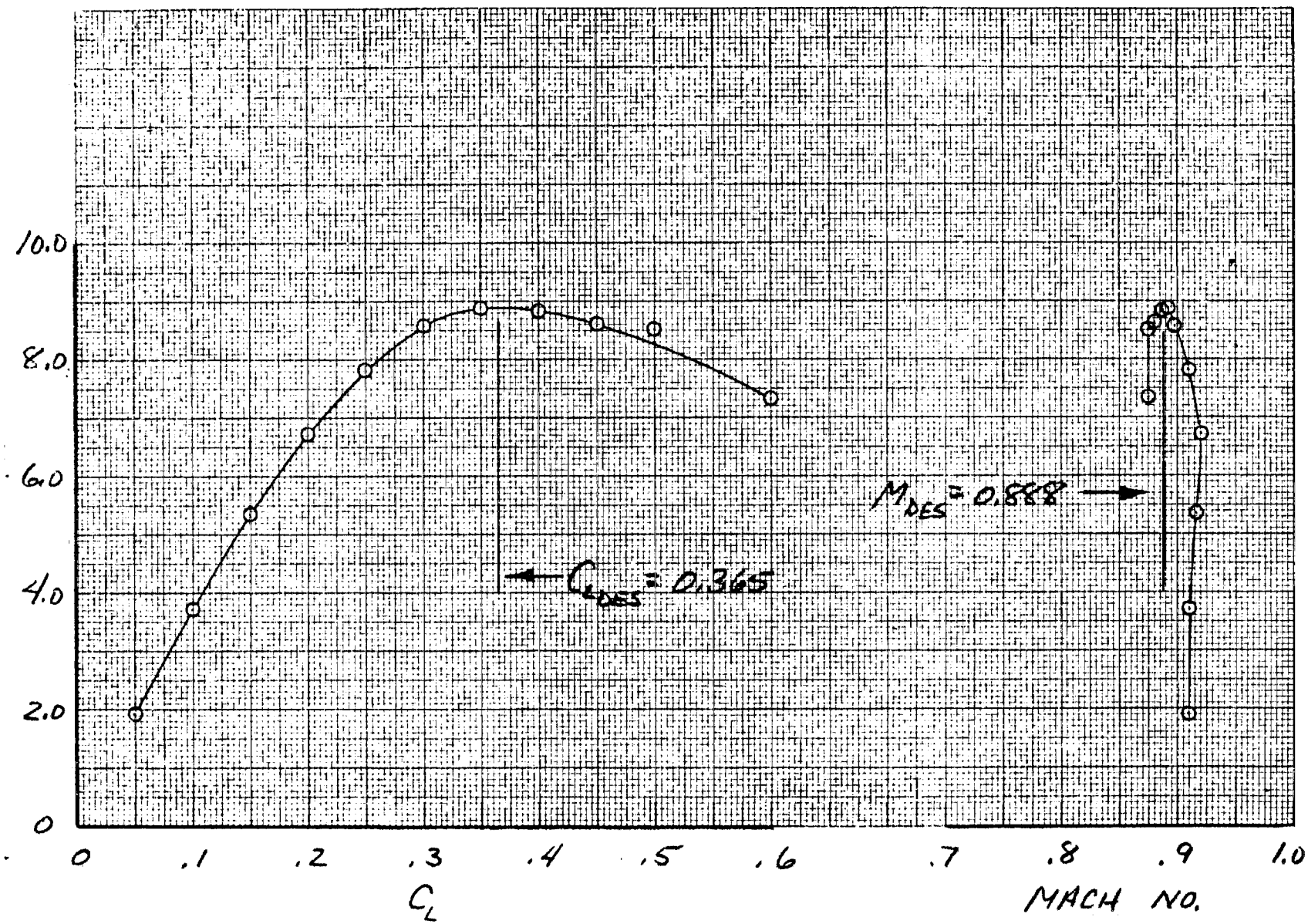

FIG. 112 $C_{L_{DES}}$ AND M_{DES} FOR F-11F

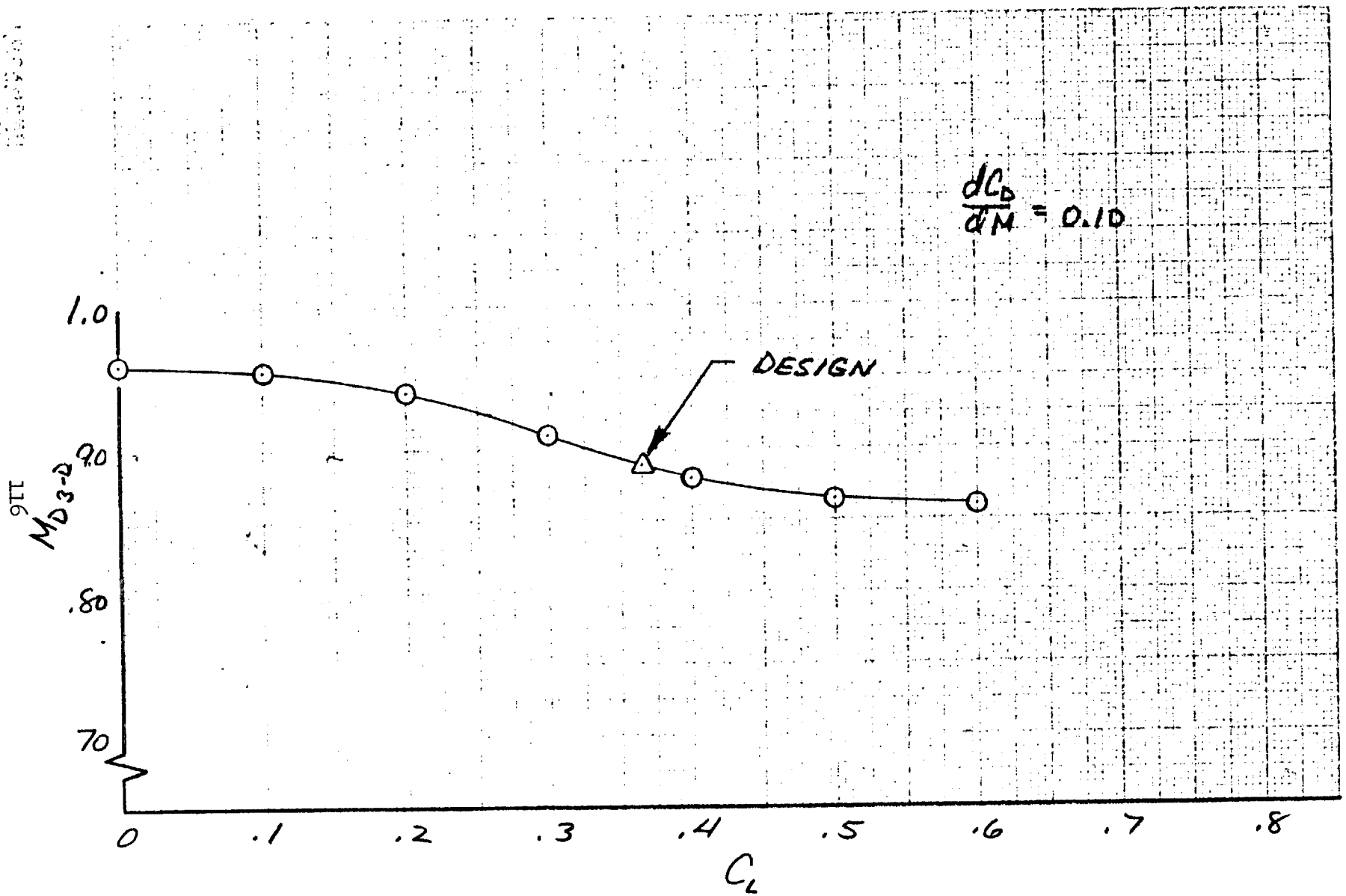

FIG. 113 DRAG DIVERGENCE CHARACTERISTICS, F-11F

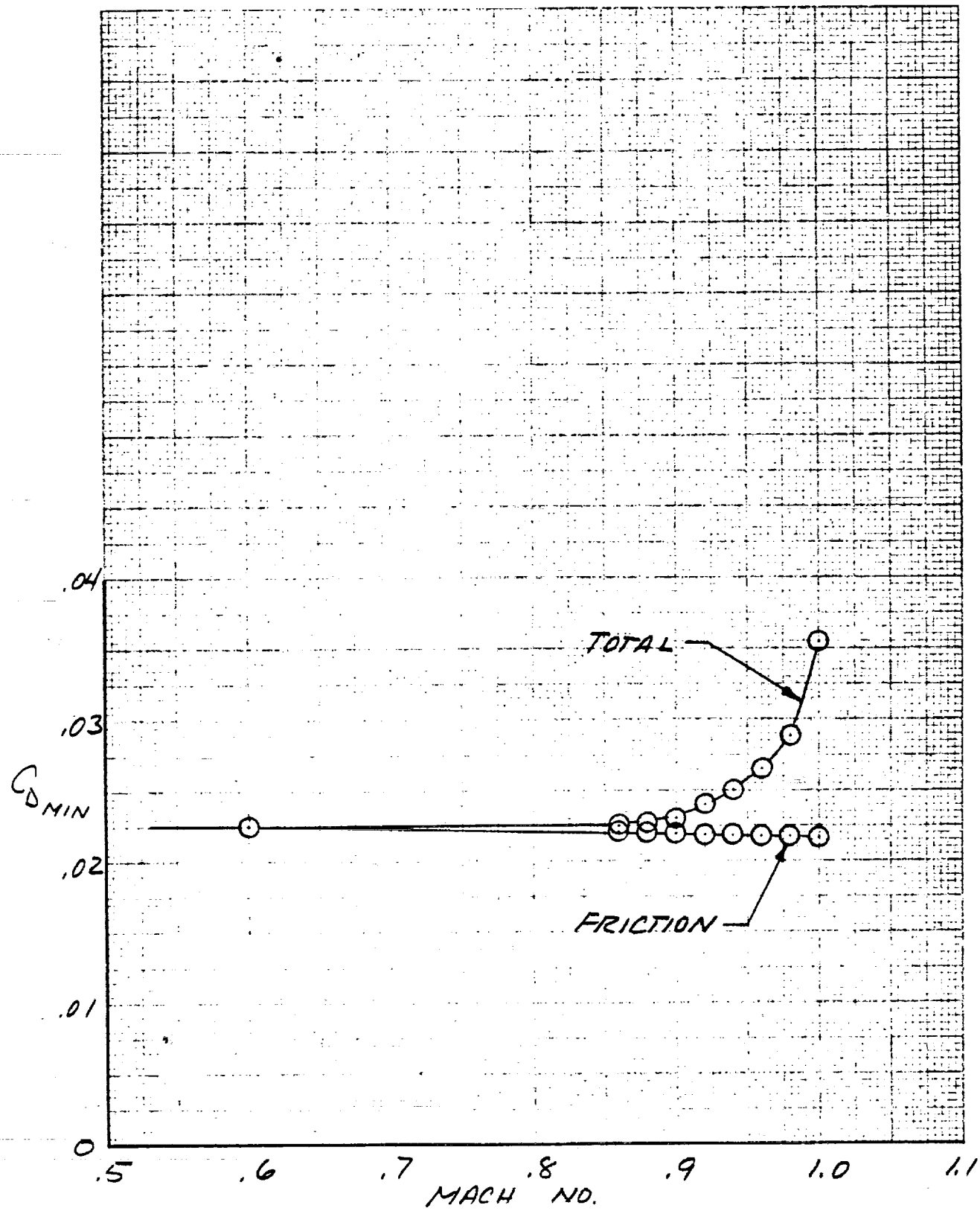

FIG. 114 MINIMUM DRAG BREAKDOWN, F-111F

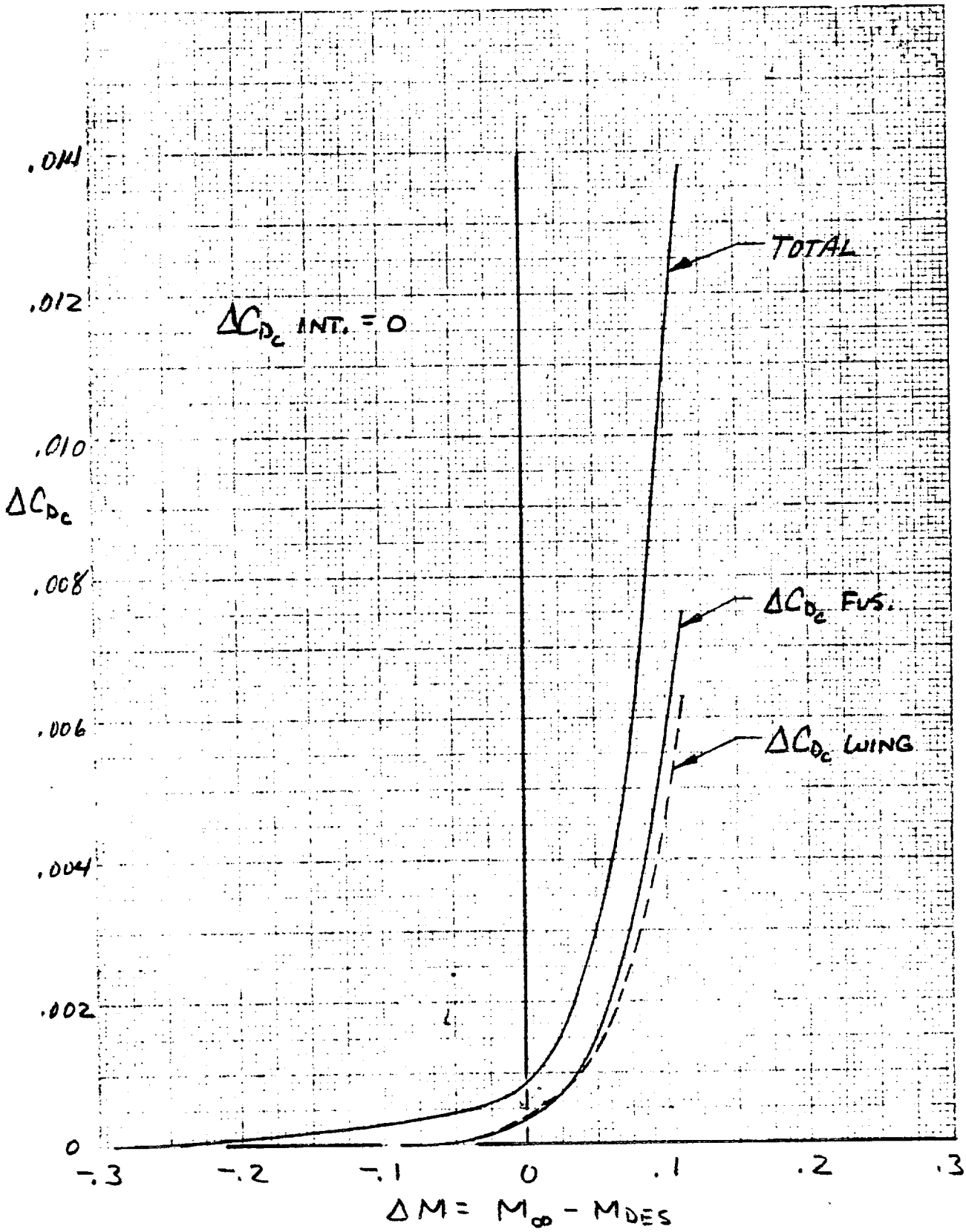

FIG. 115 COMPRESSIBILITY DRAG, F-11F

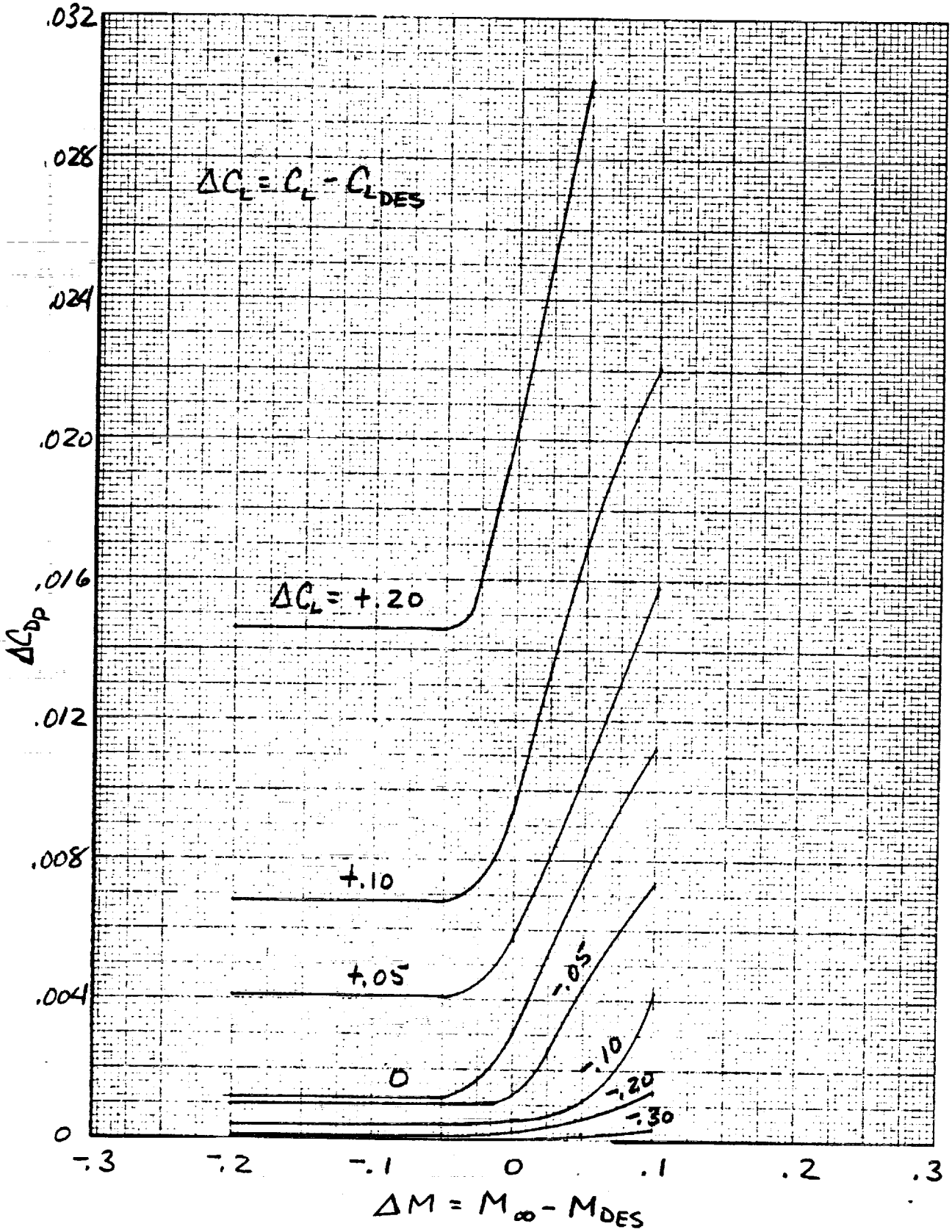

FIG. 116 WING PRESSURE DRAG VARIATION, F-11F

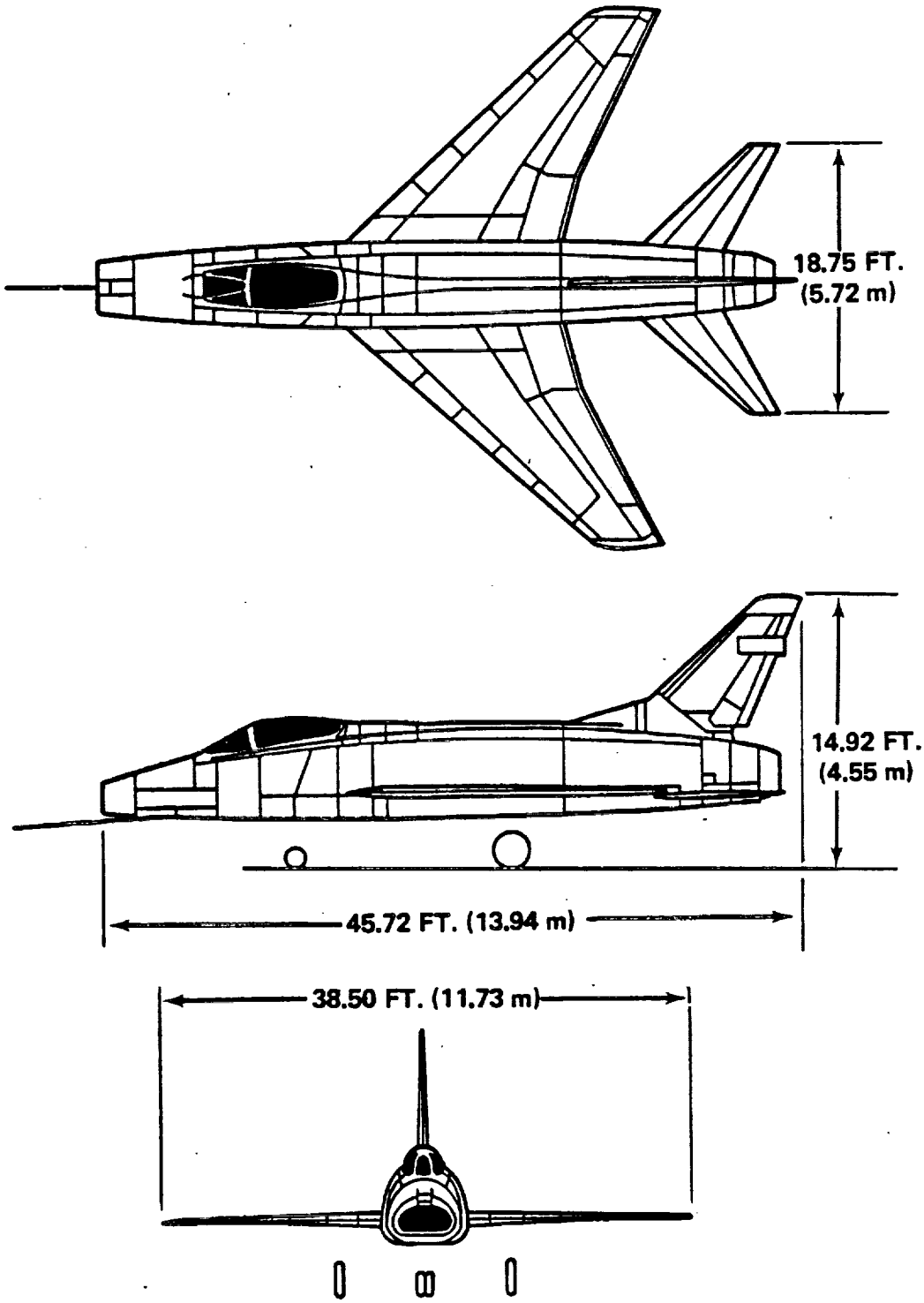

FIGURE 117. THREE-VIEW, F-100

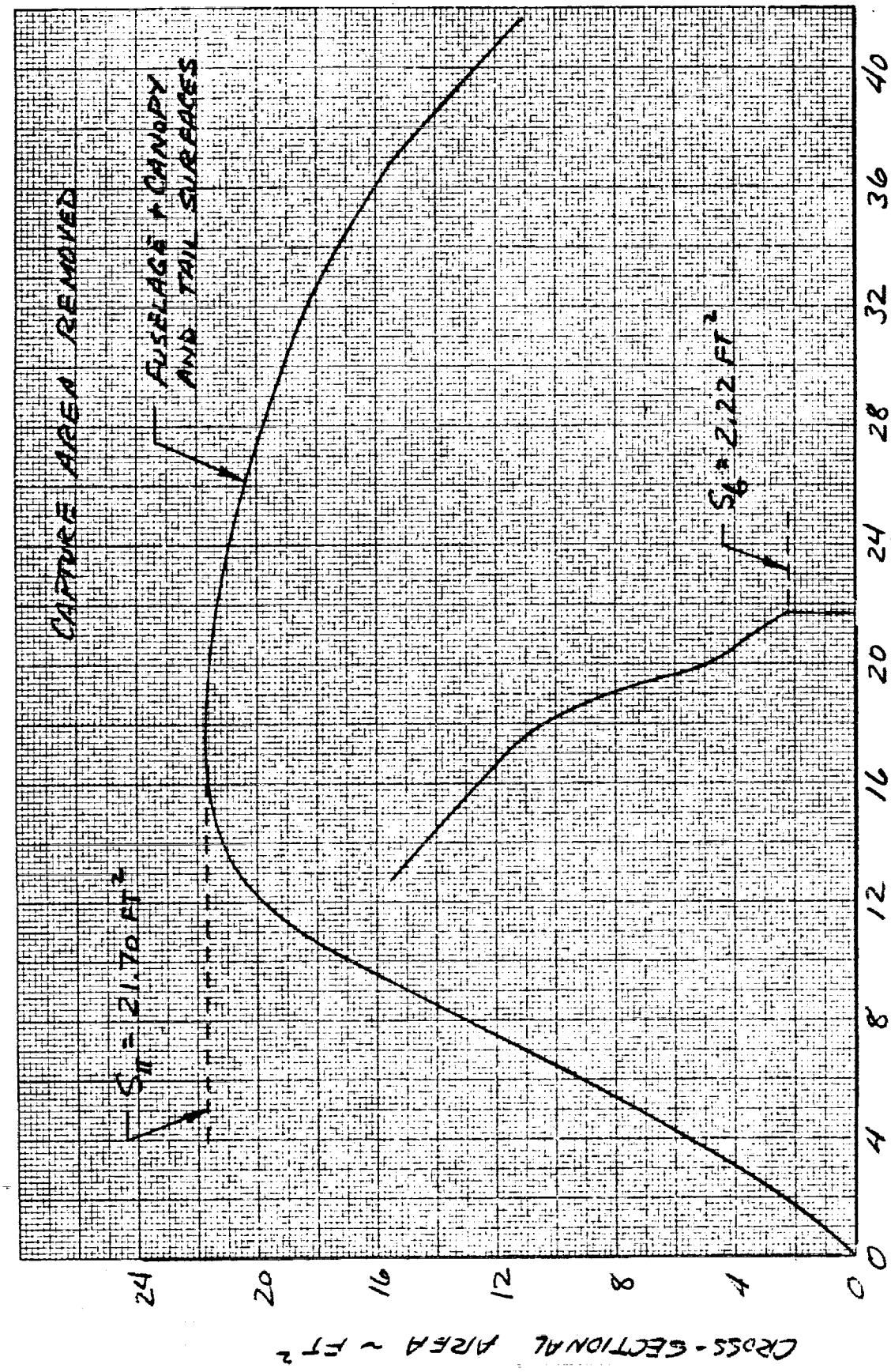

FIG. 118 F-100 FUSELAGE AREA DISTRIBUTION

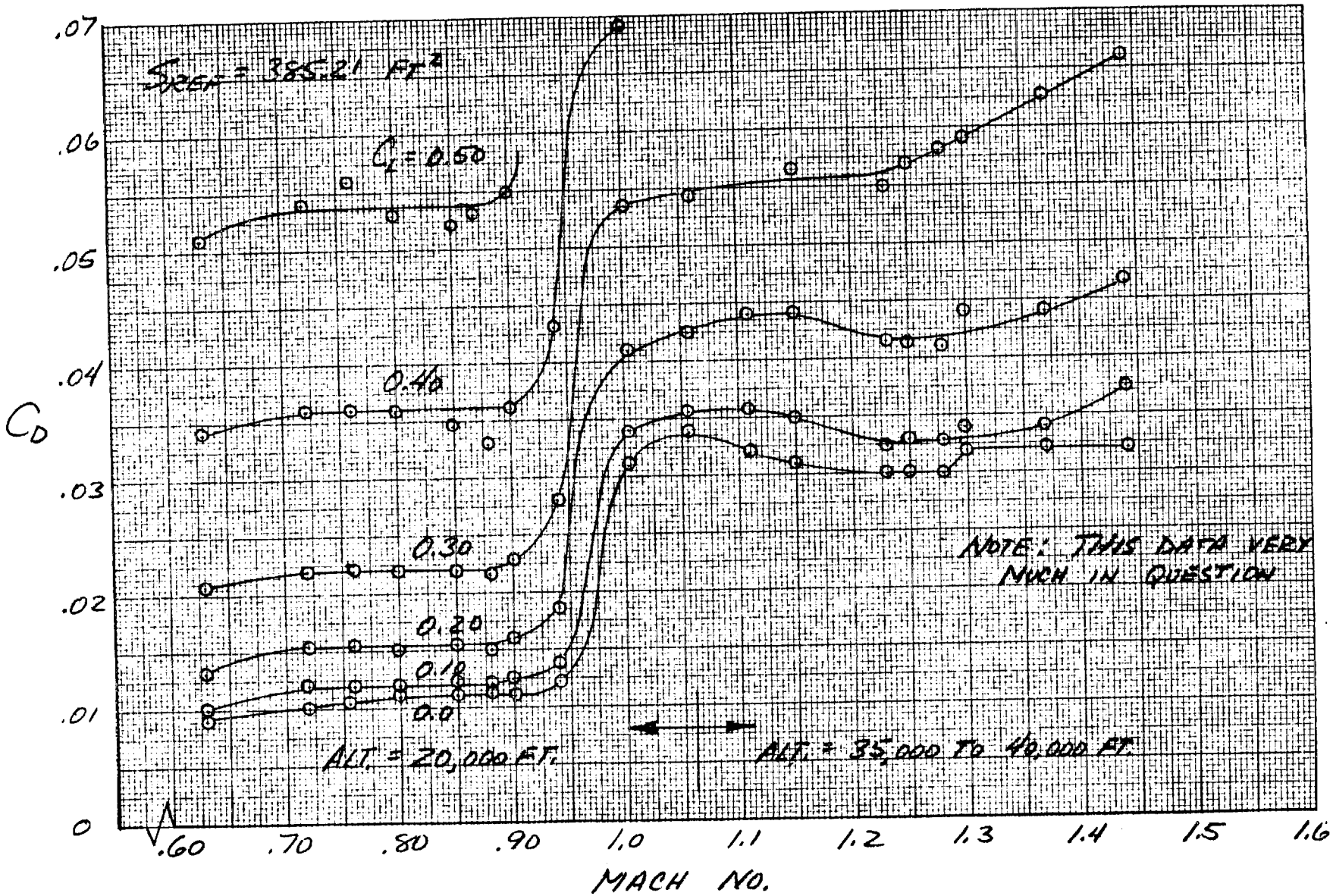

FIG. 119 F-100 DRAG CHARACTERISTICS

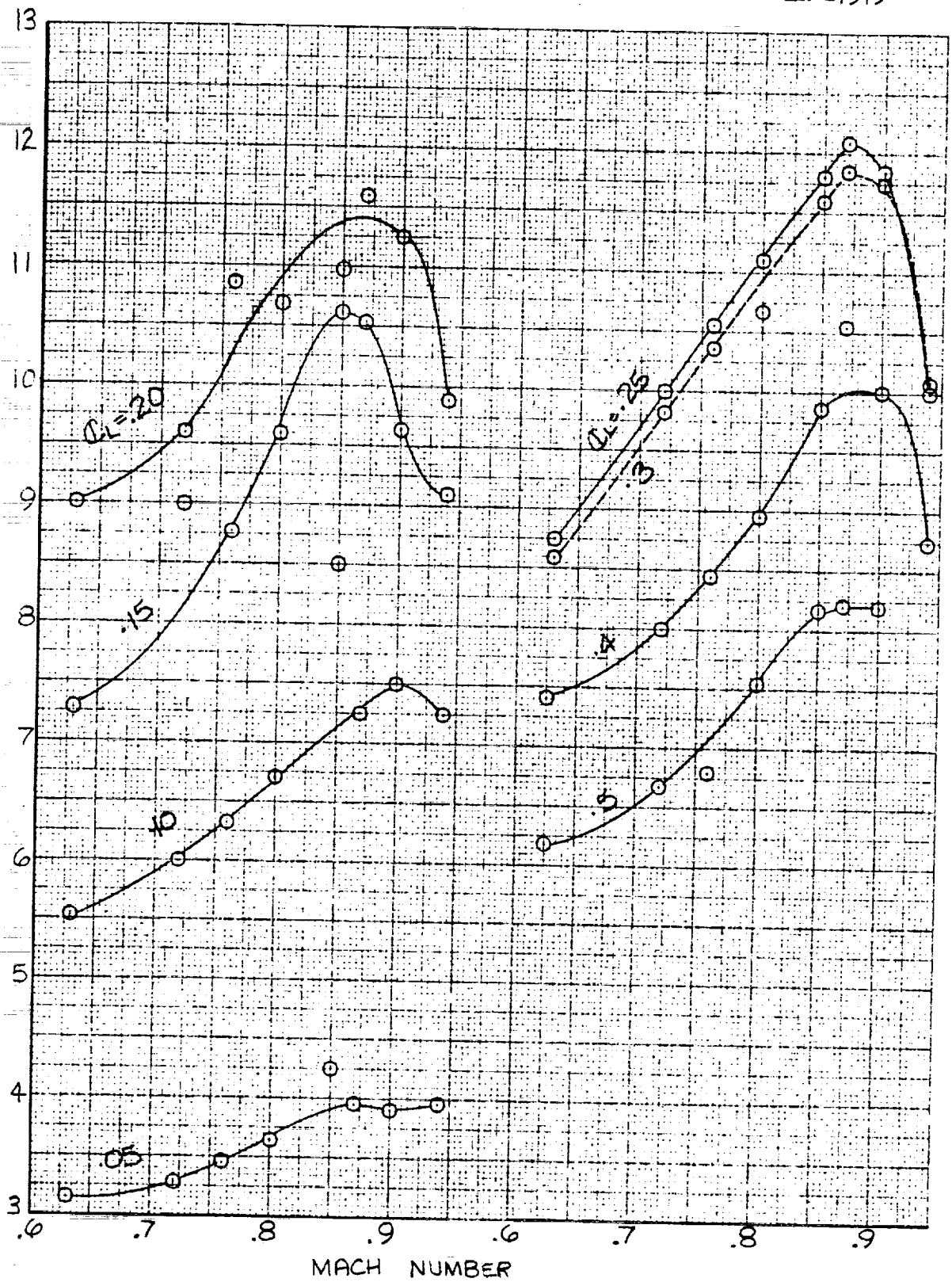

FIG. 120 $M\left(\frac{L}{D}\right)$ VS. MACH NUMBER, F-100

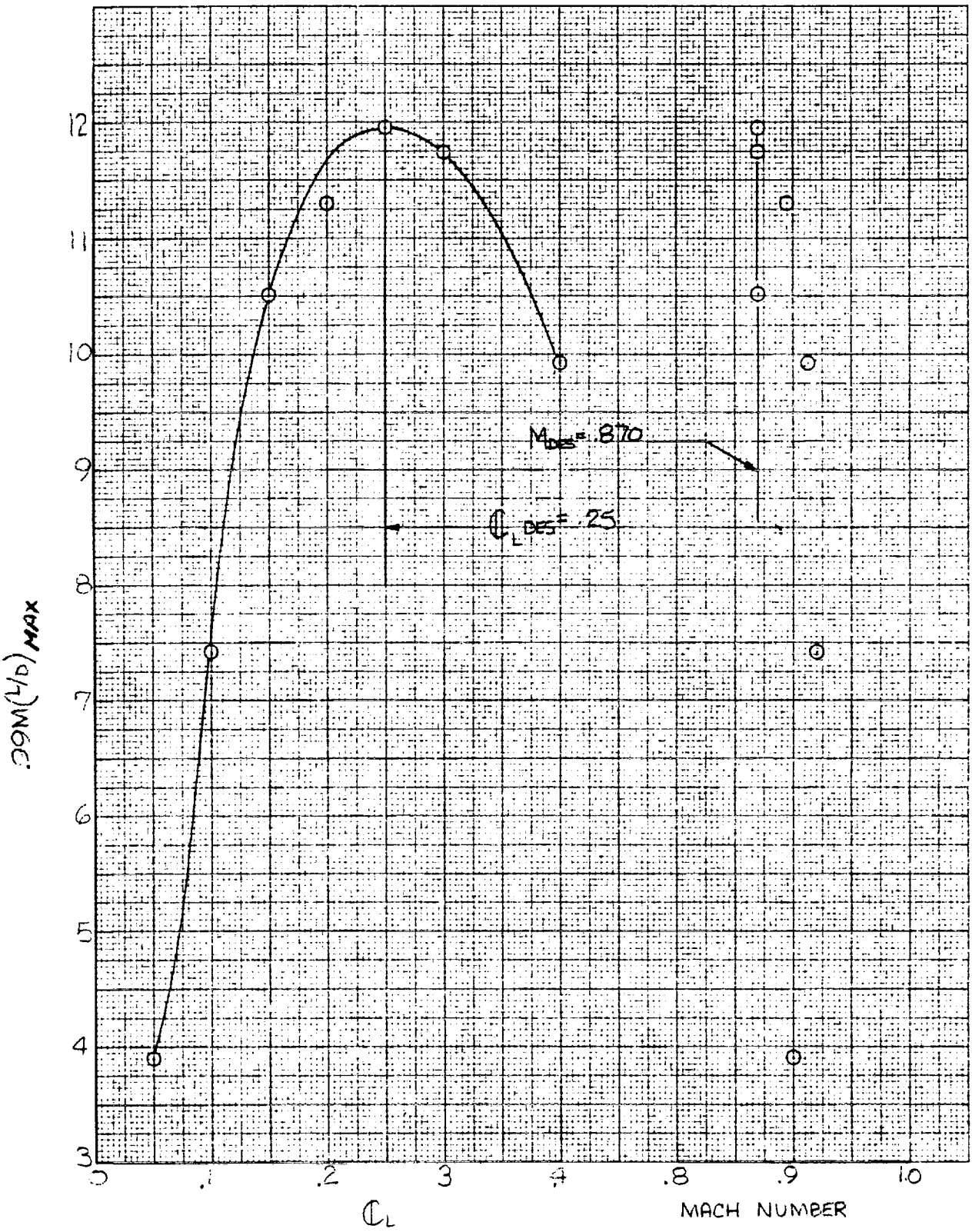

FIG. 121 $C_{L\,DES}$ AND M_{DES} FOR F-100

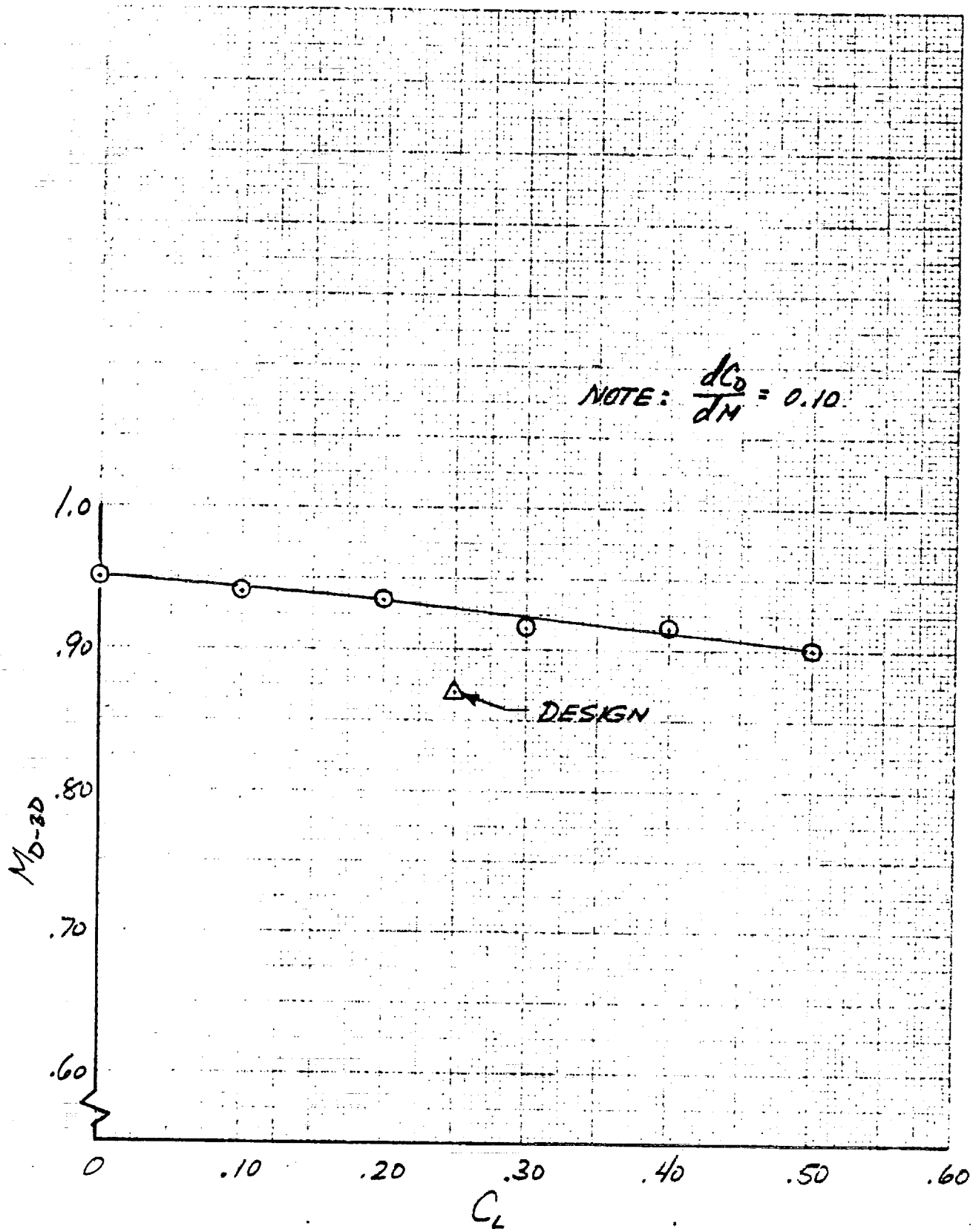

FIG. 122 DRAG DIVERGENCE CHARACTERISTICS, F-100

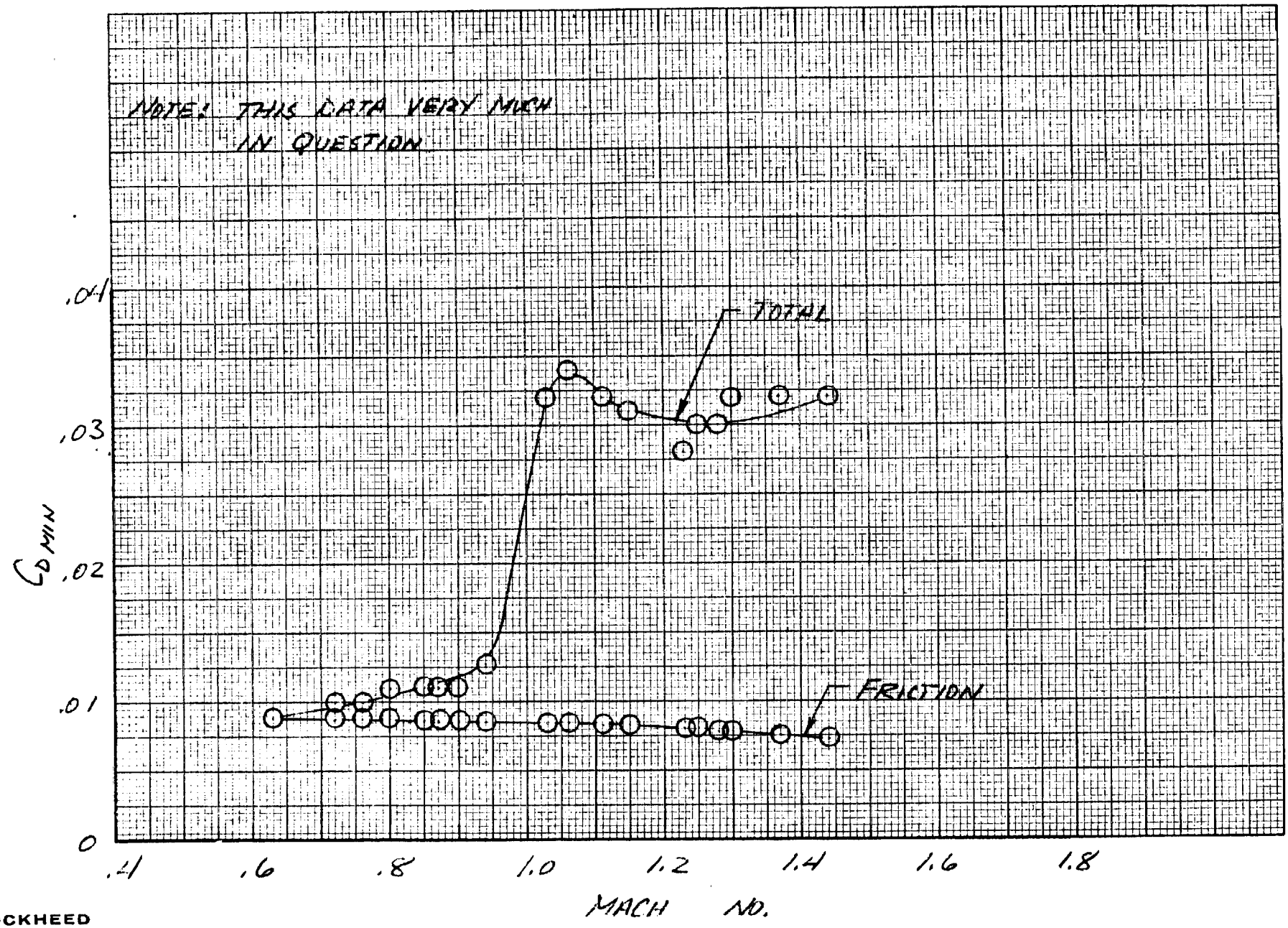

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FIG. 123 MINIMUM DRAG BREAKDOWN, F-100

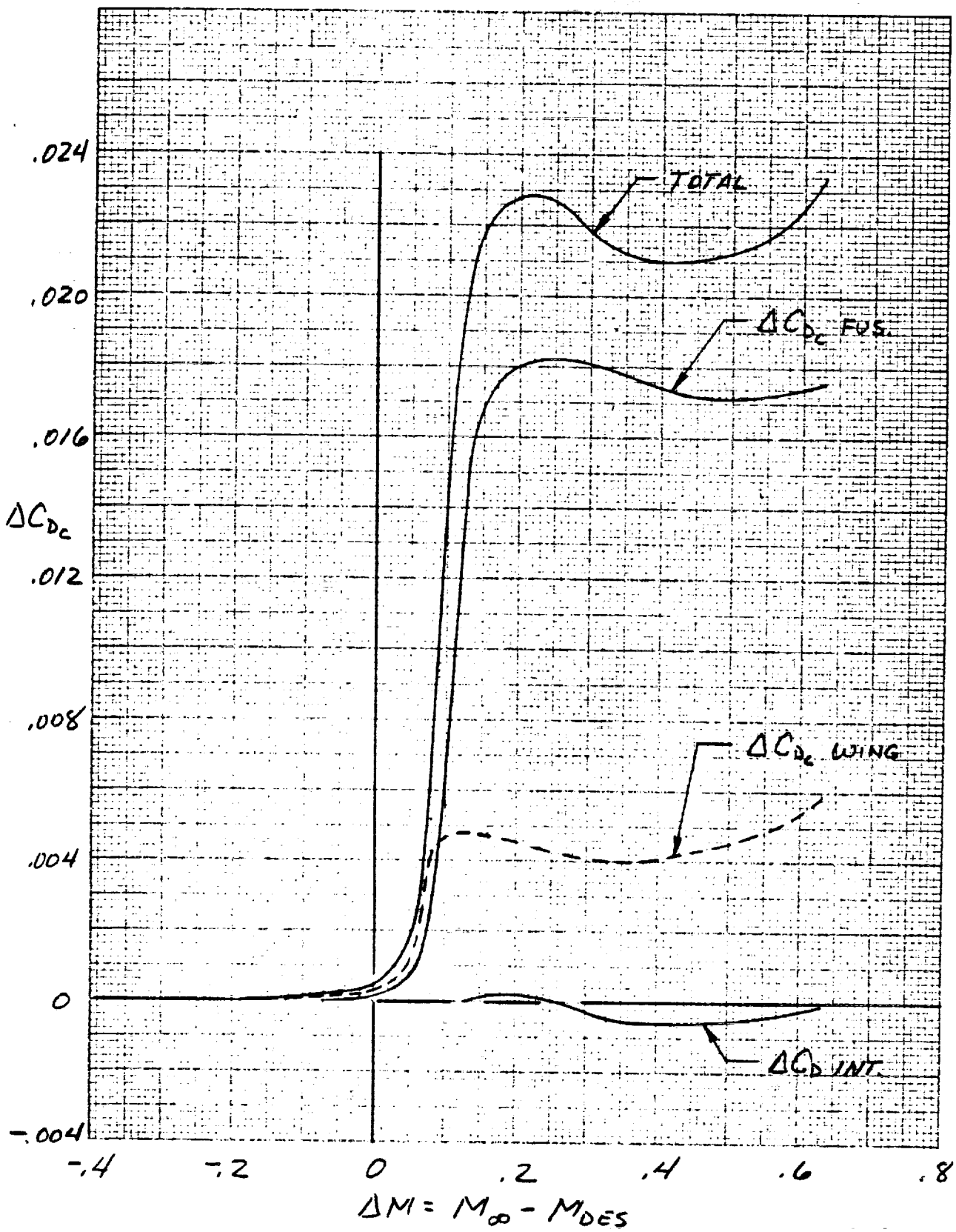

FIG. 124 COMPRESSIBILITY DRAG, F-100

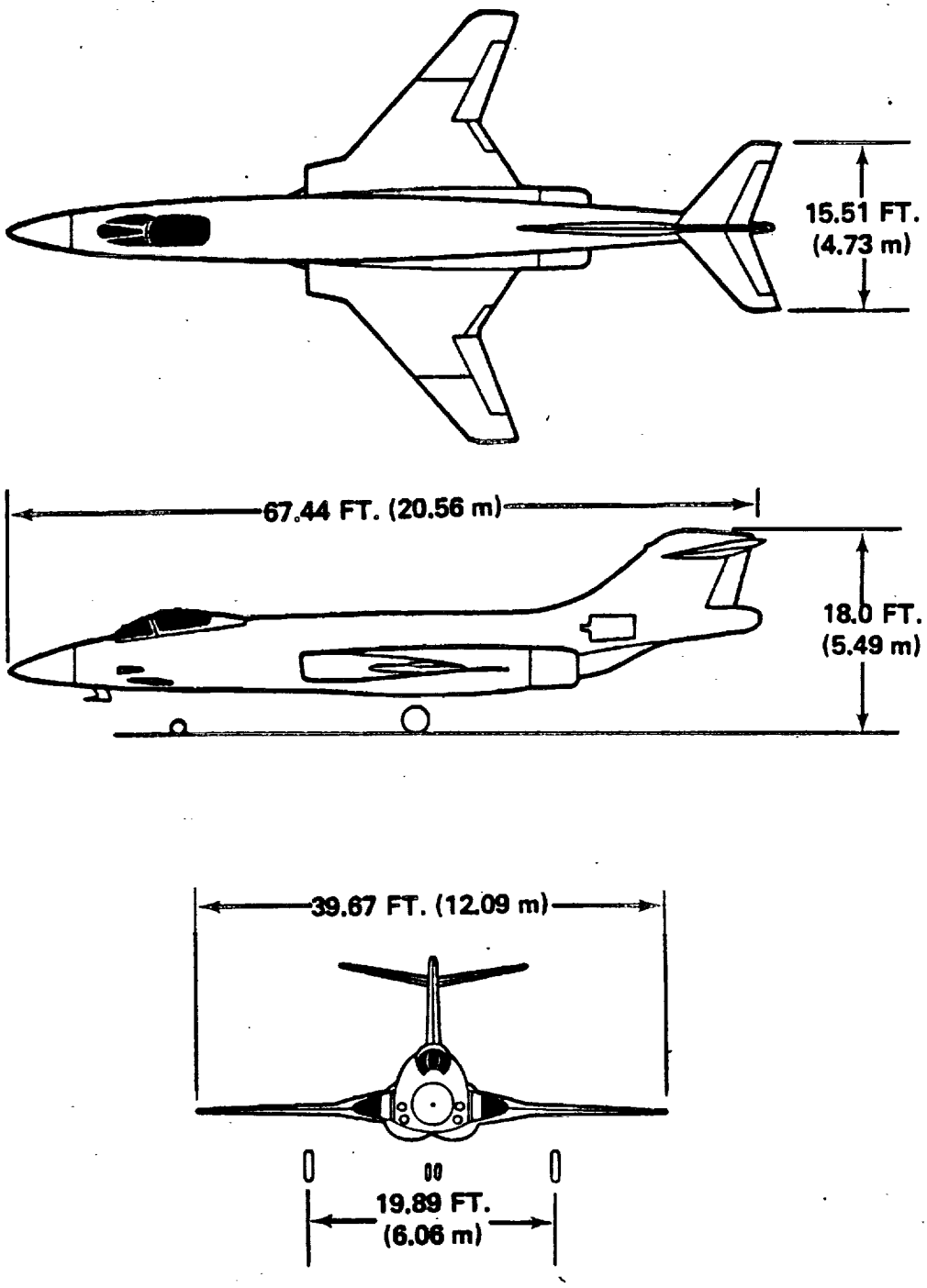

FIGURE 125. THREE-VIEW, F-101

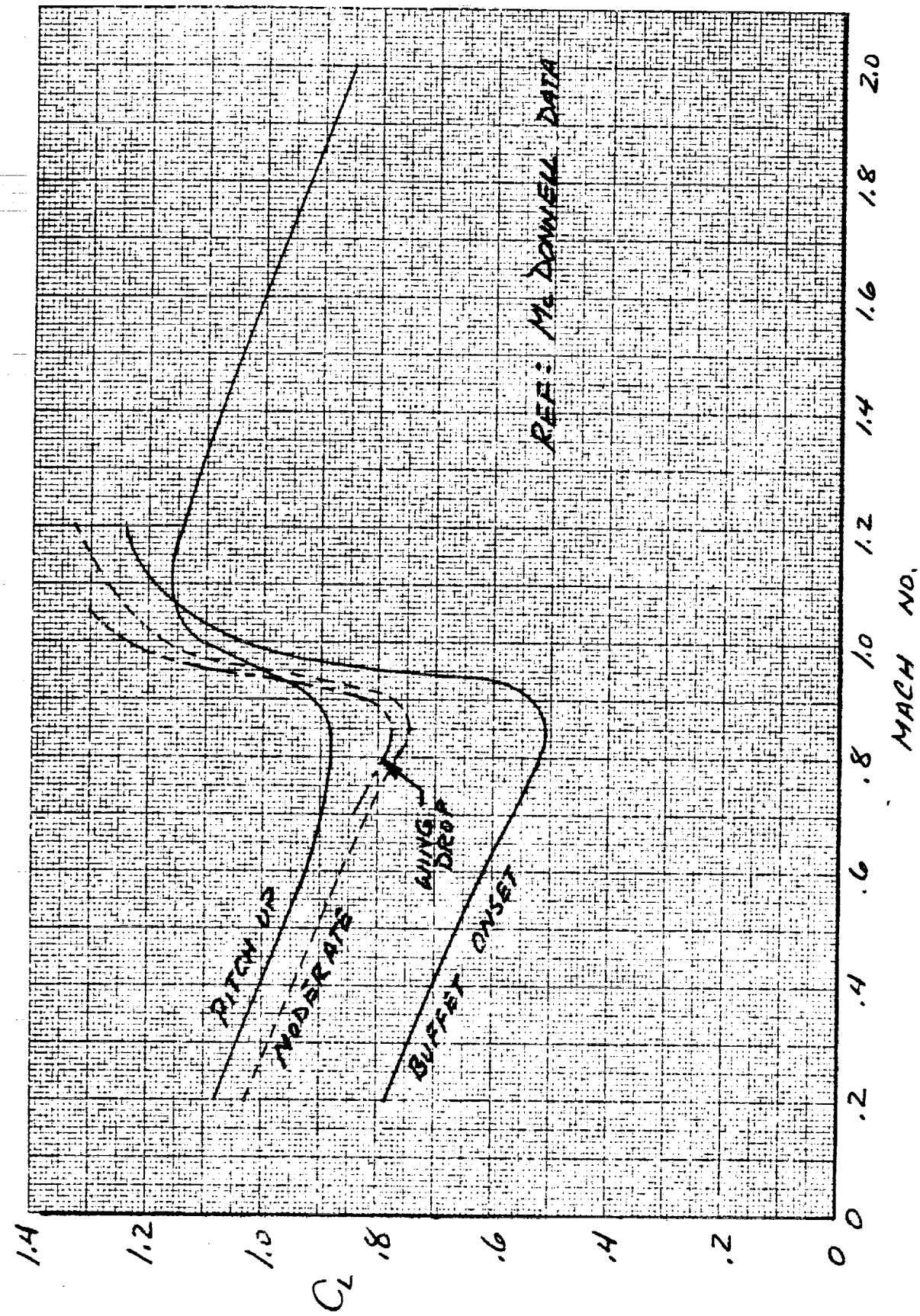

FIG. 126 LIMIT LIFT CHARACTERISTICS, F-101

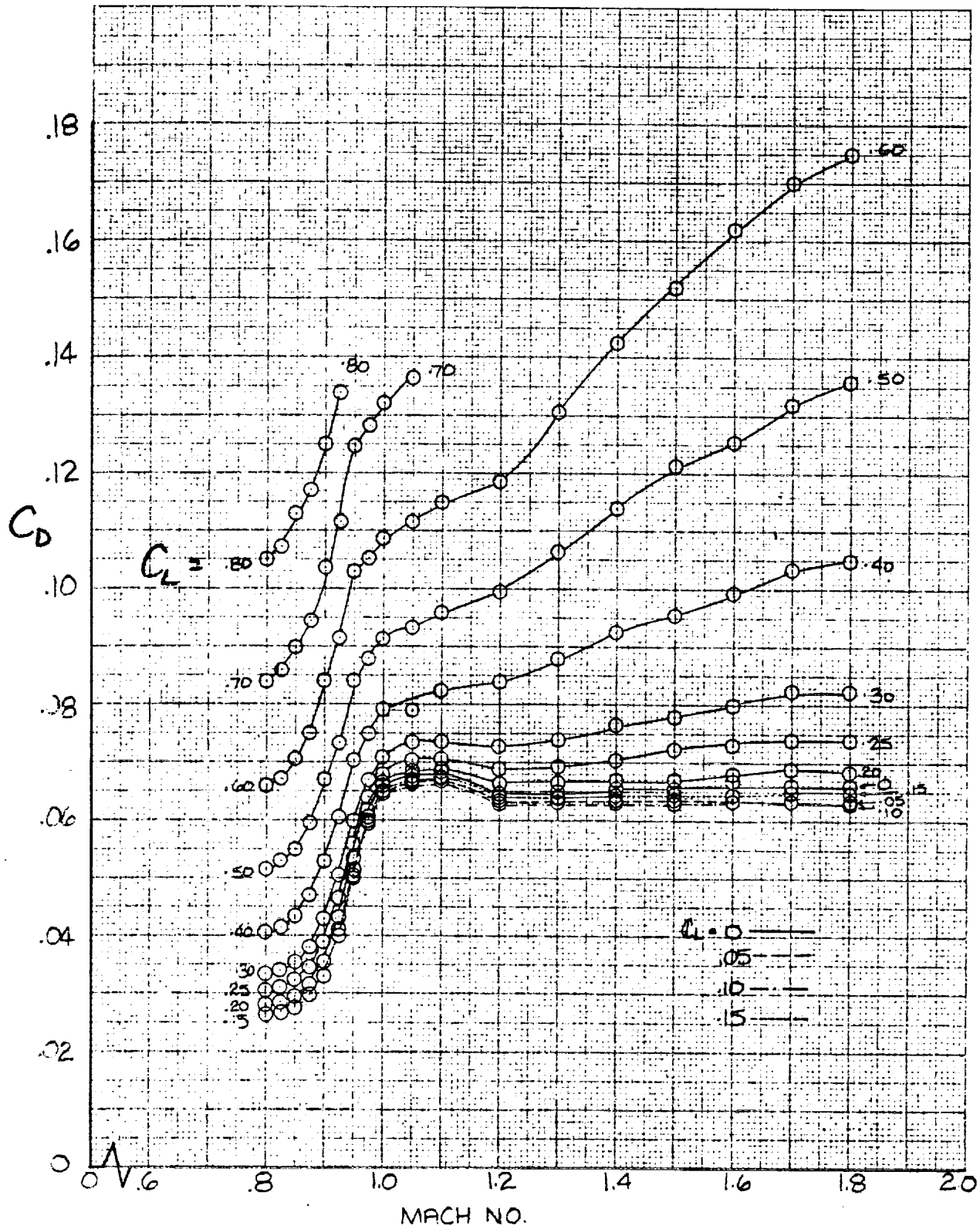

FIG. 127 F-101 DRAG CHARACTERISTICS

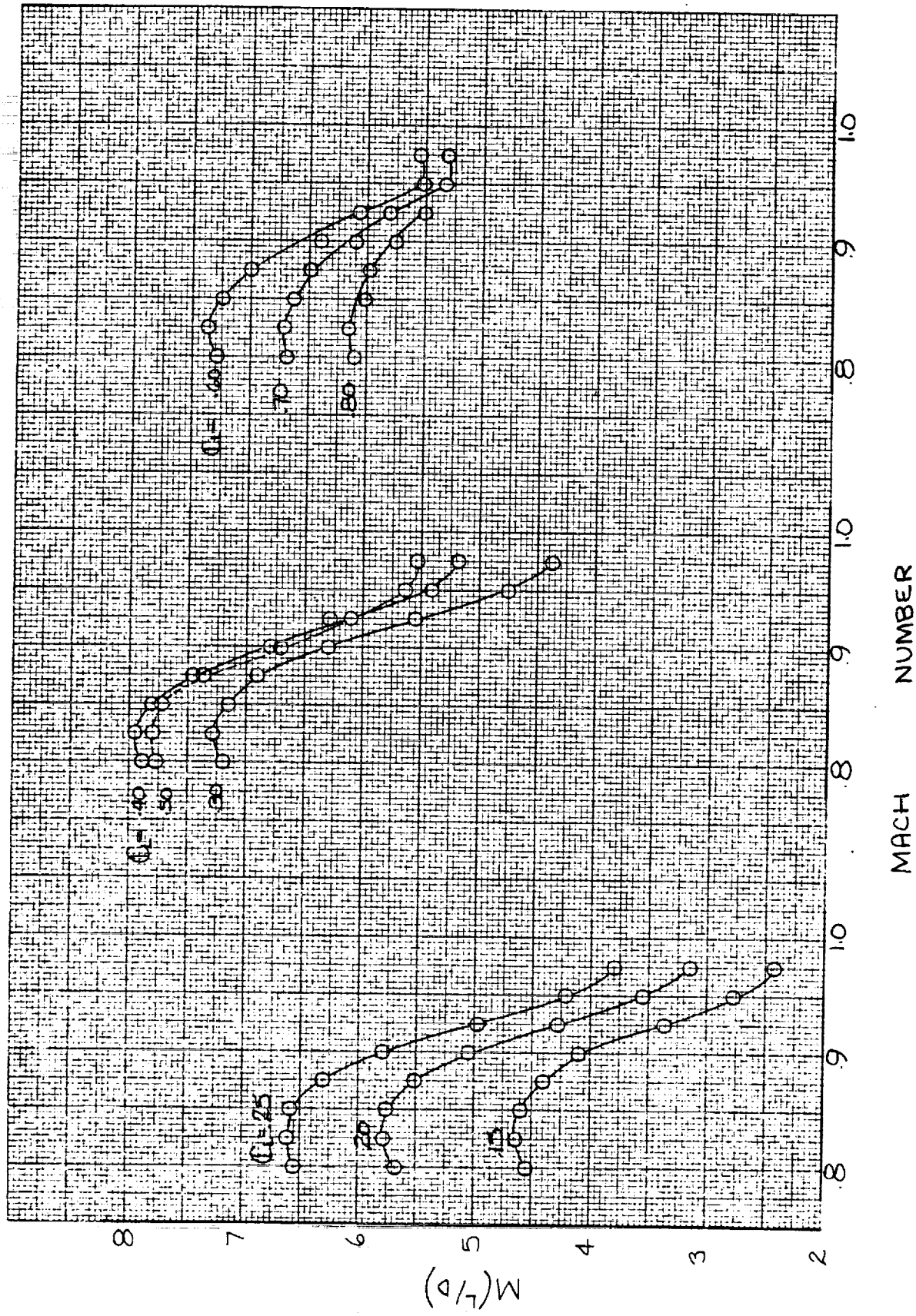

FIG. 128 M(L/D) vs. MACH NUMBER, F-101

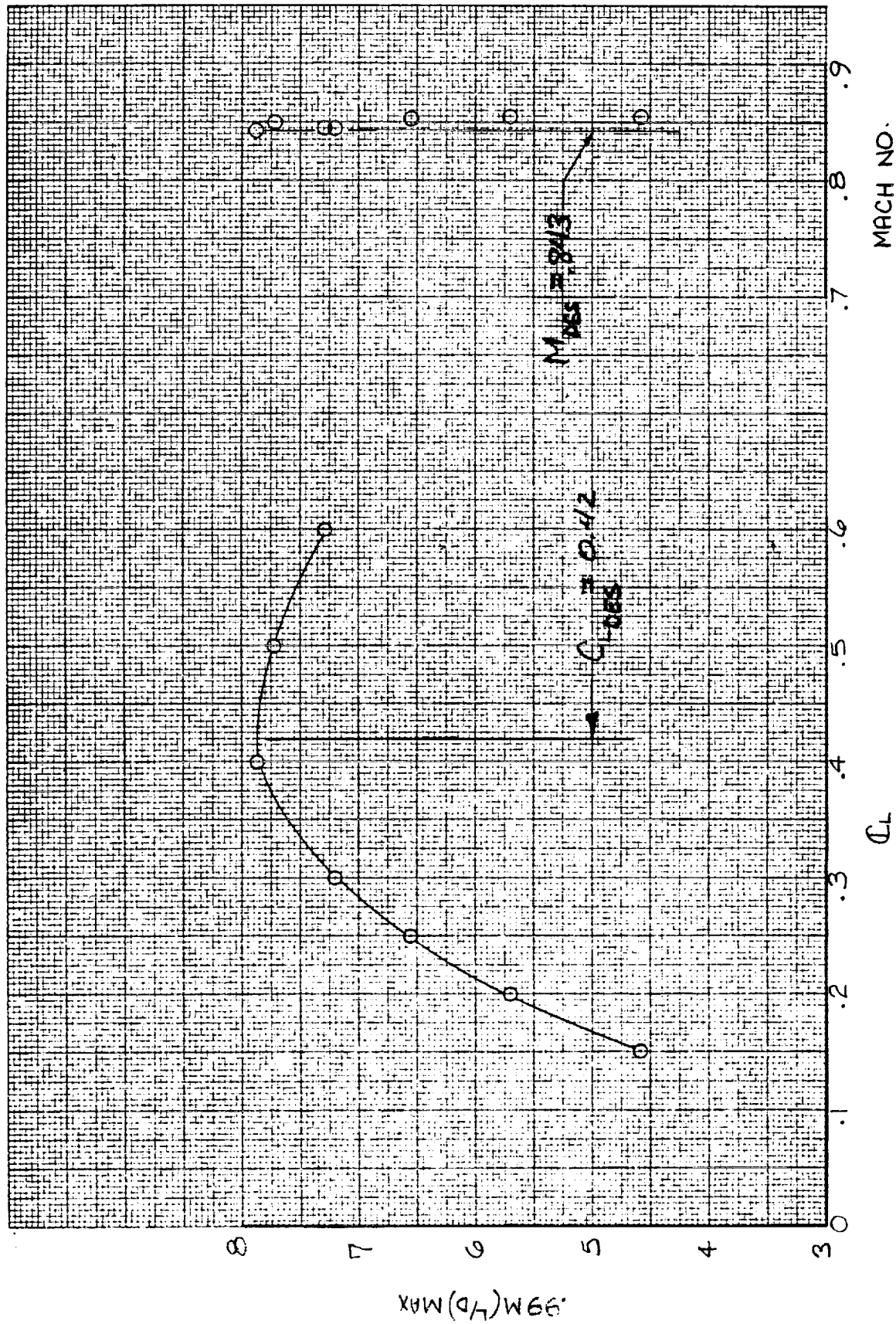

FIG. 129 $C_{L_{DES}}$ AND M_{DES} FOR F-101

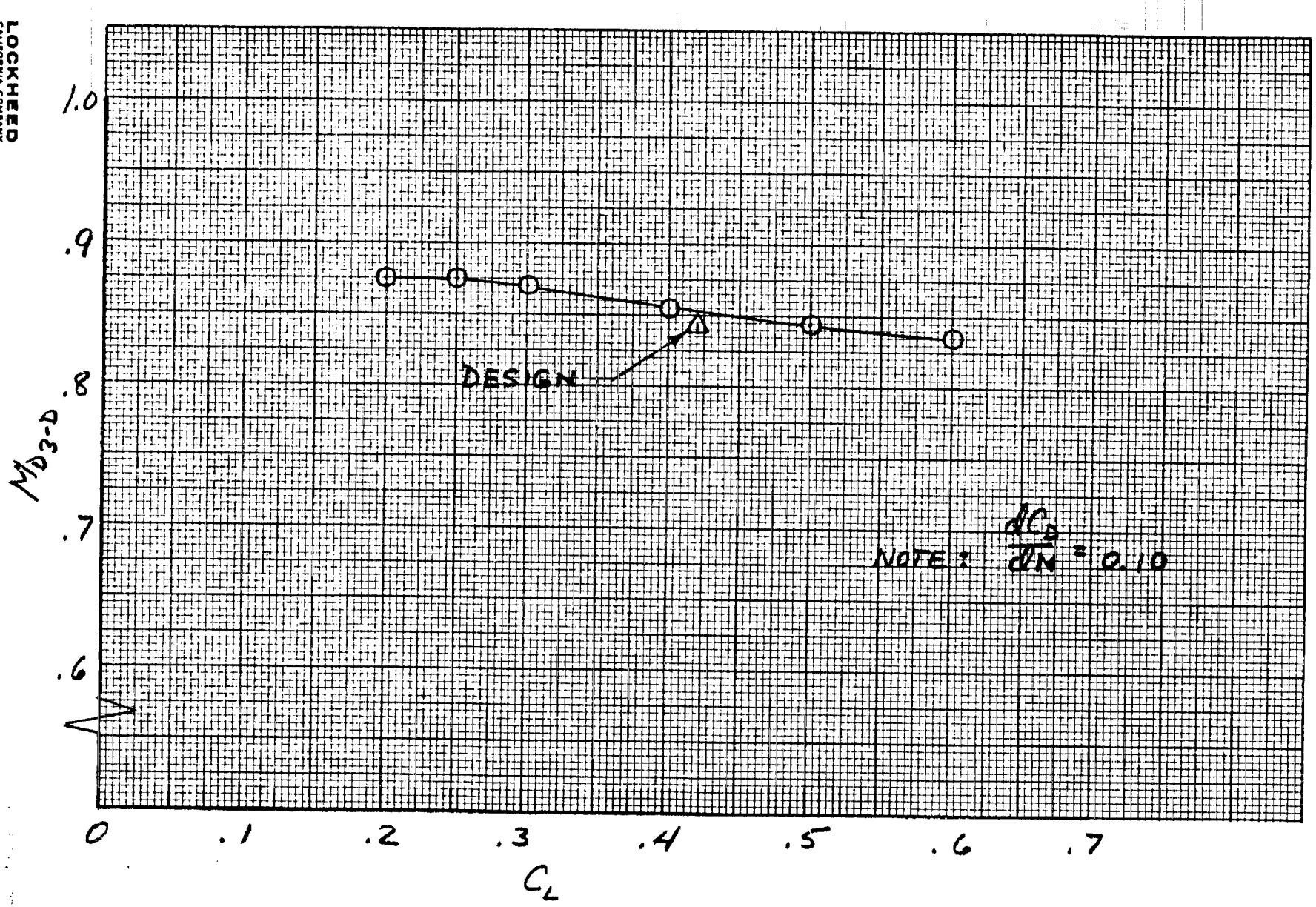

FIG. 130 DRAG DIVERGENCE CHARACTERISTICS, F-101

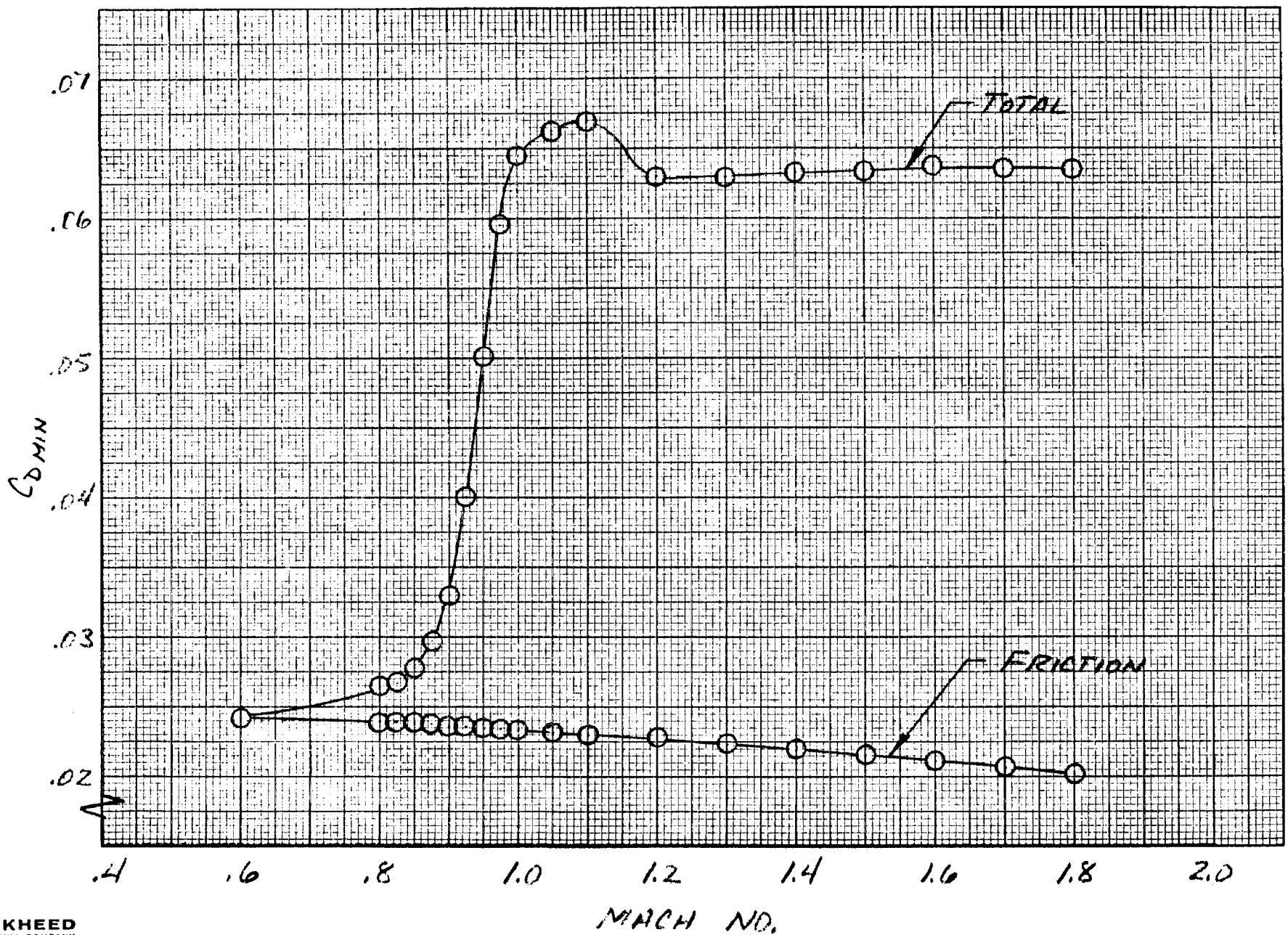

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FIG. 131 MINIMUM DRAG BREAKDOWN, F-101

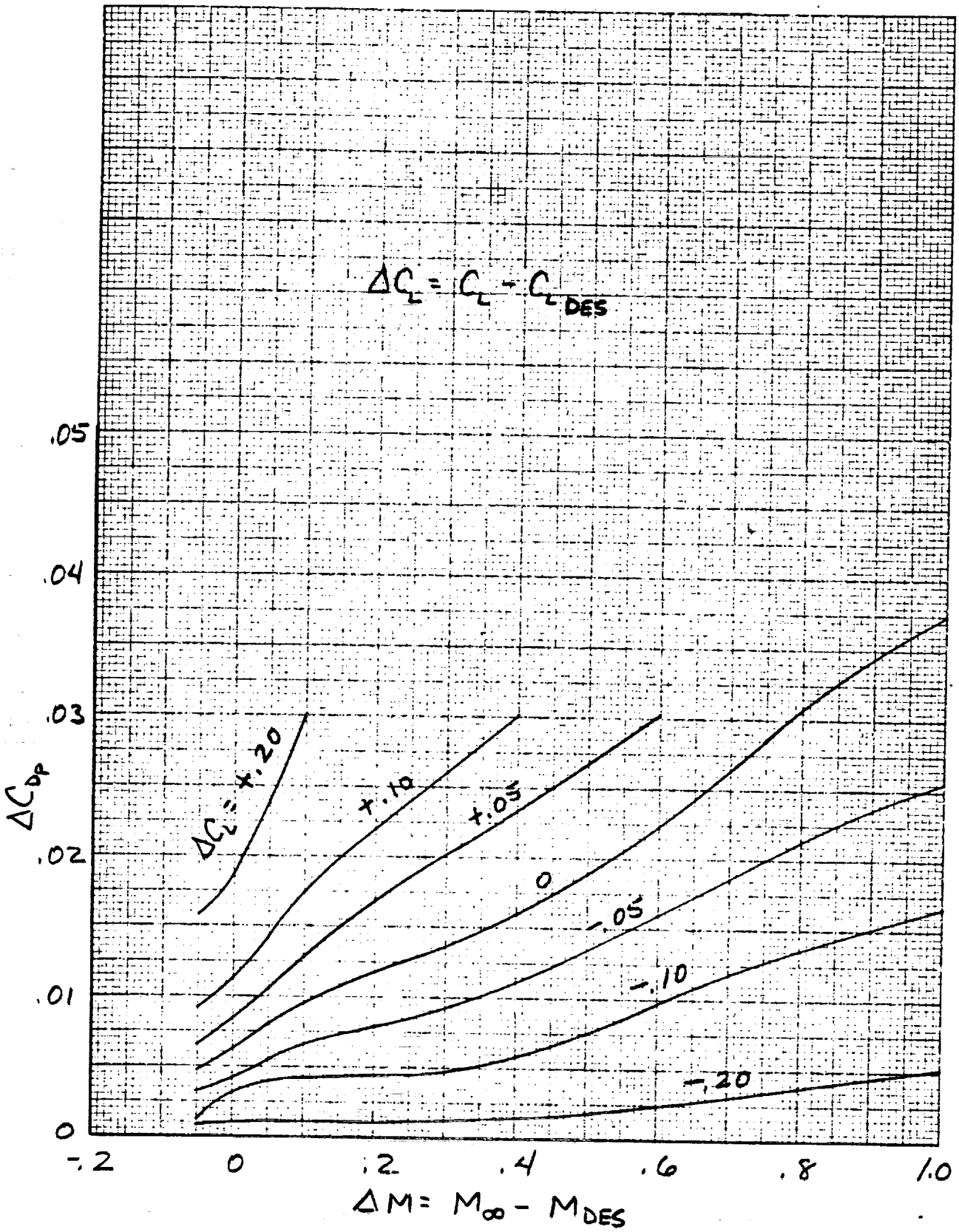

FIG. 132 WING PRESSURE DRAG VARIATION, F-101

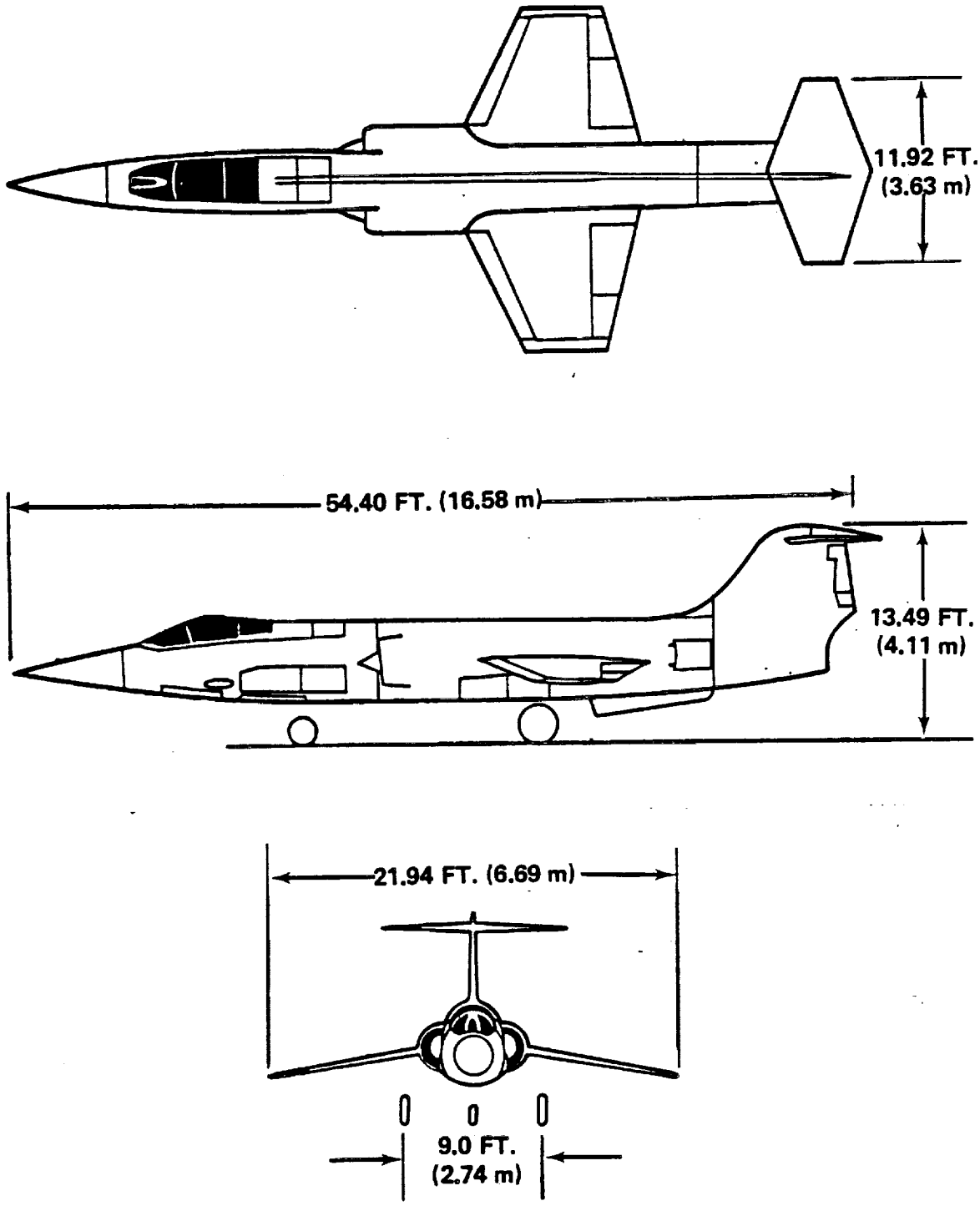

FIGURE 133. THREE-VIEW, F-104G

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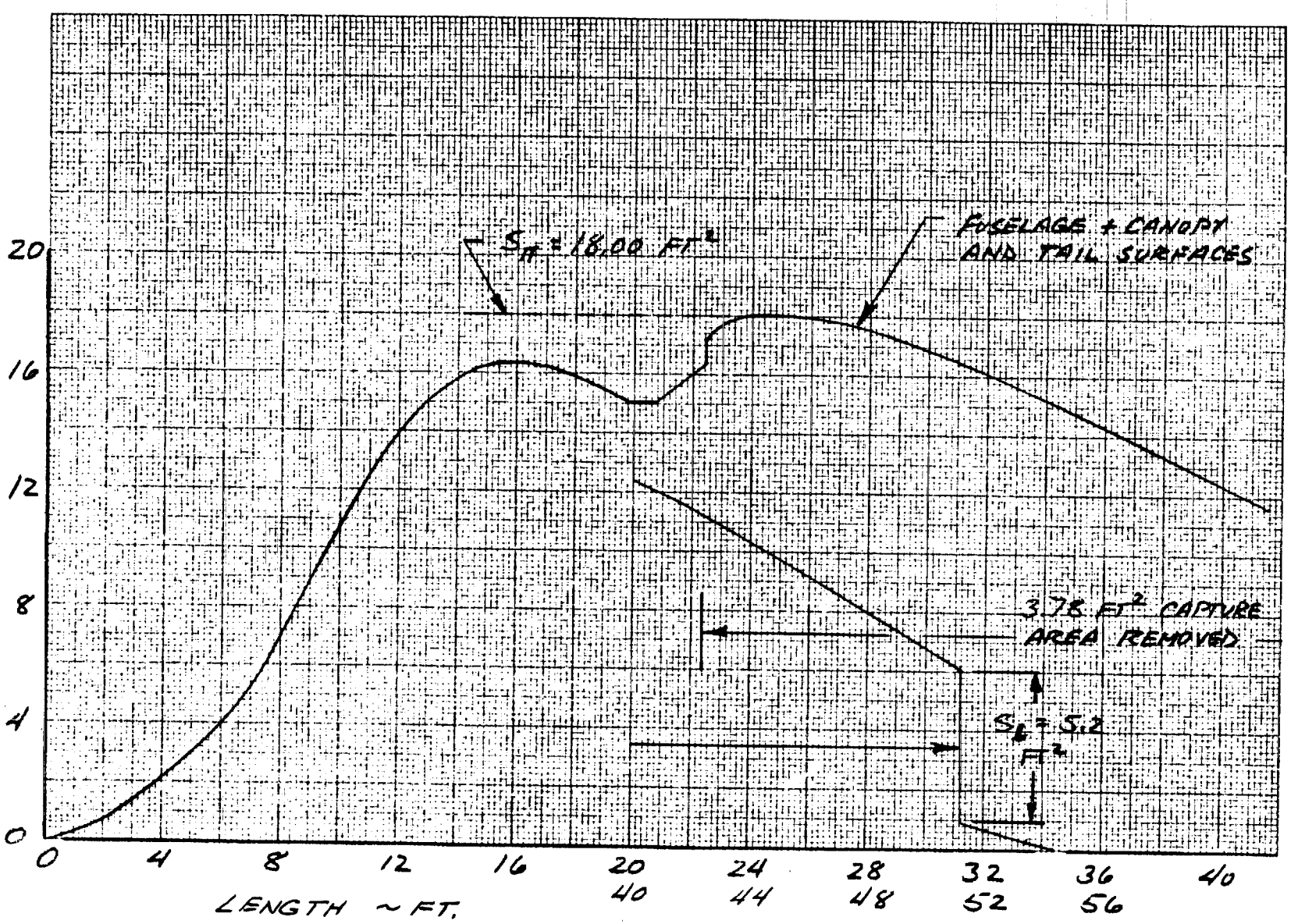


FIG. 134 F-104G FUSELAGE AREA DISTRIBUTION

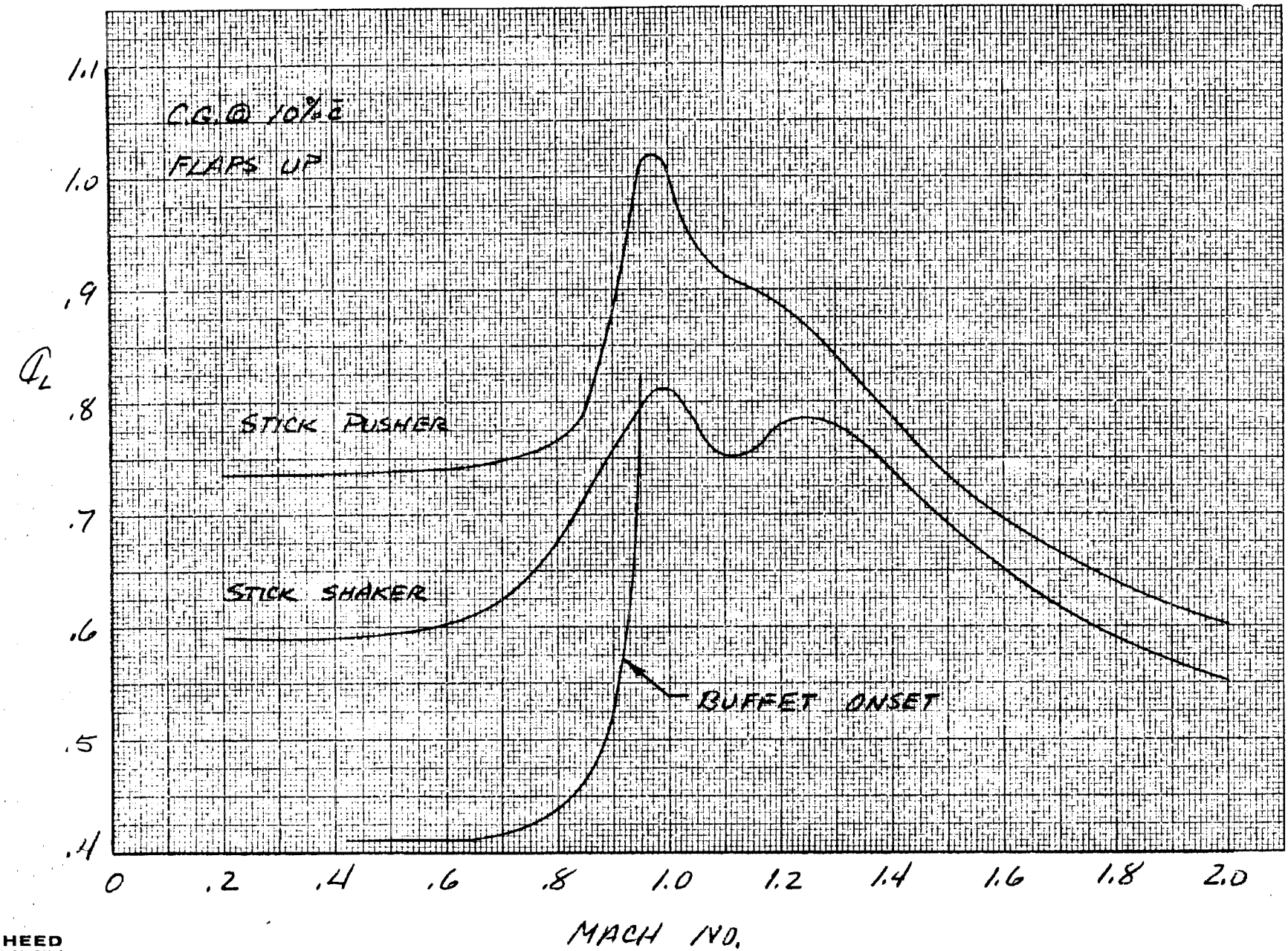
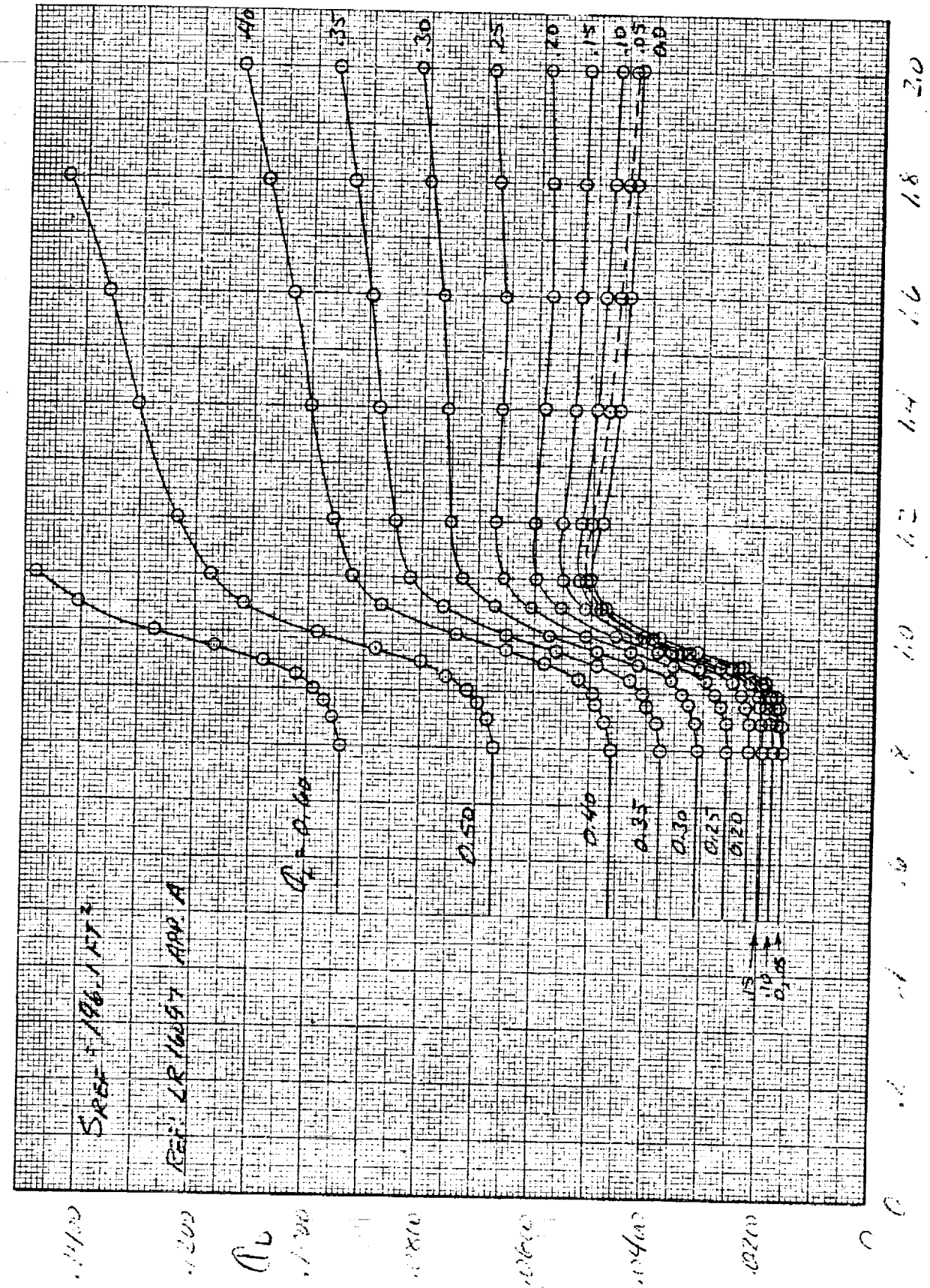


FIG. 135 LIMIT LIFT CHARACTERISTICS, F-104G

LOCKHEED
CALIFORNIA COMPANY



MACH NO.

FIG. 136 F-104G DRAG CHARACTERISTICS

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CALIFORNIA COMPANY

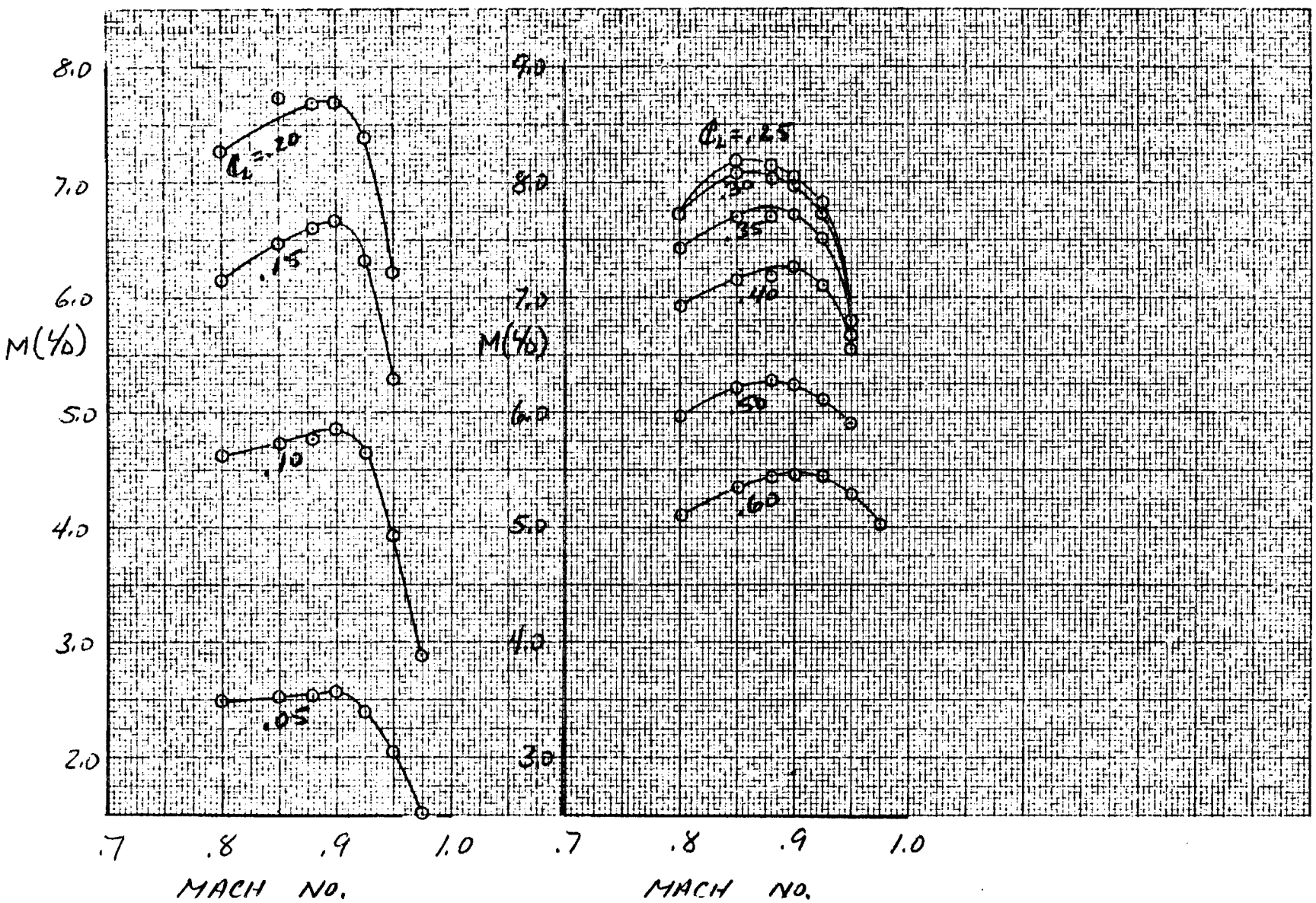

FIG. 137 M(L/D) VS. MACH NUMBER, F-104G

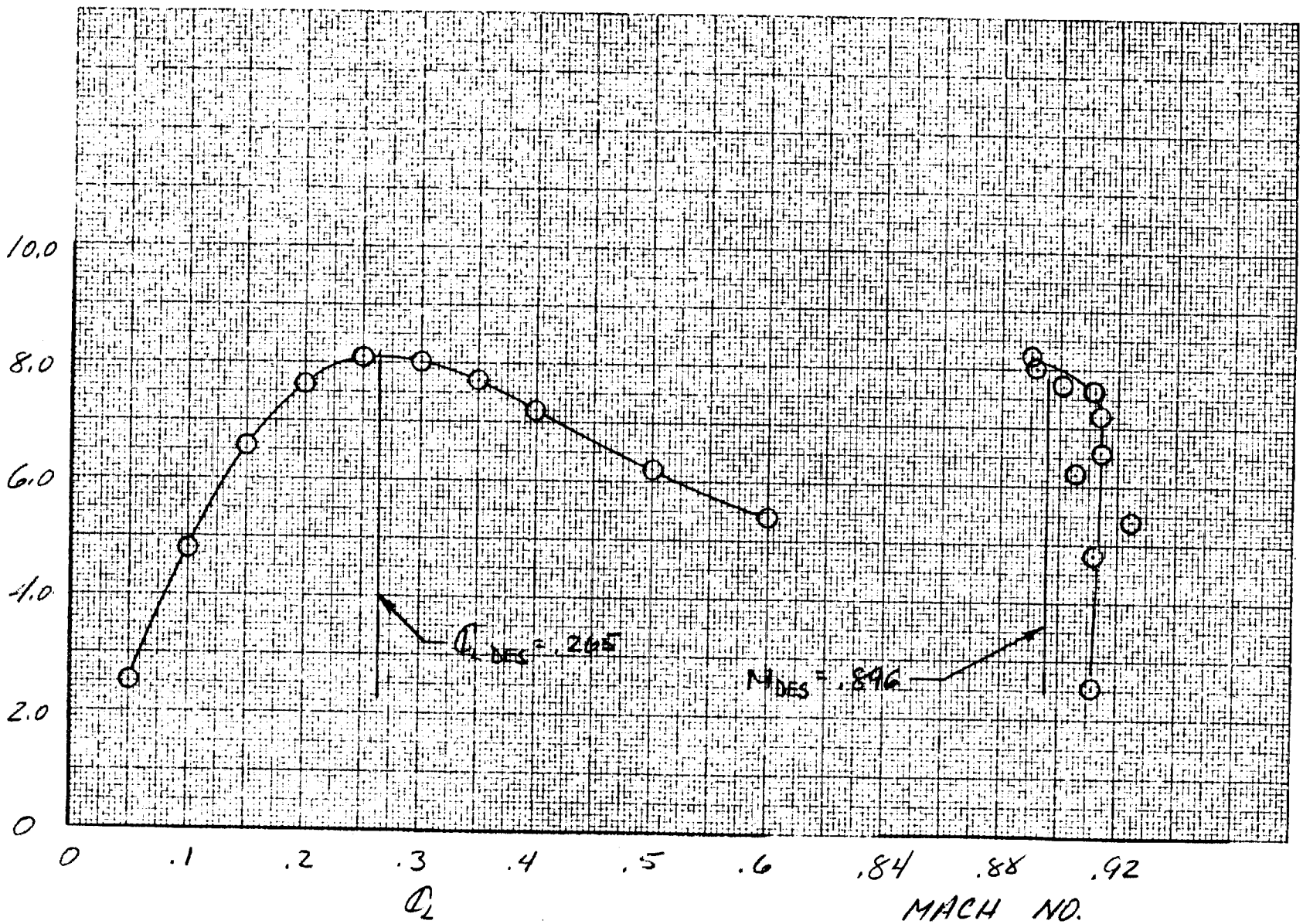

FIG. 138 $C_{L\,DES}$ AND M_{DES} FOR F-104G

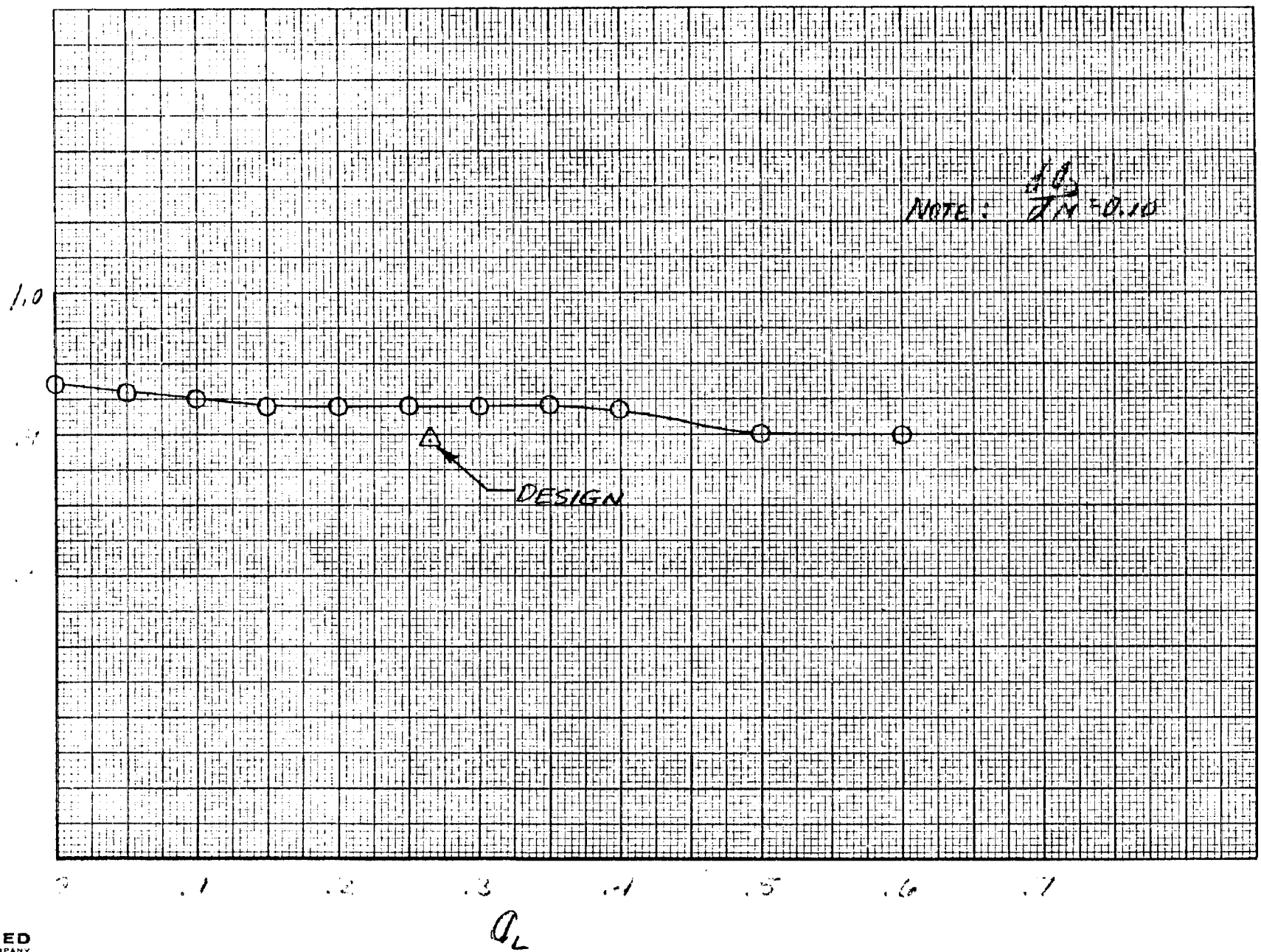

FIG. 139 DRAG DIVERGENCE CHARACTERISTICS, F-104G

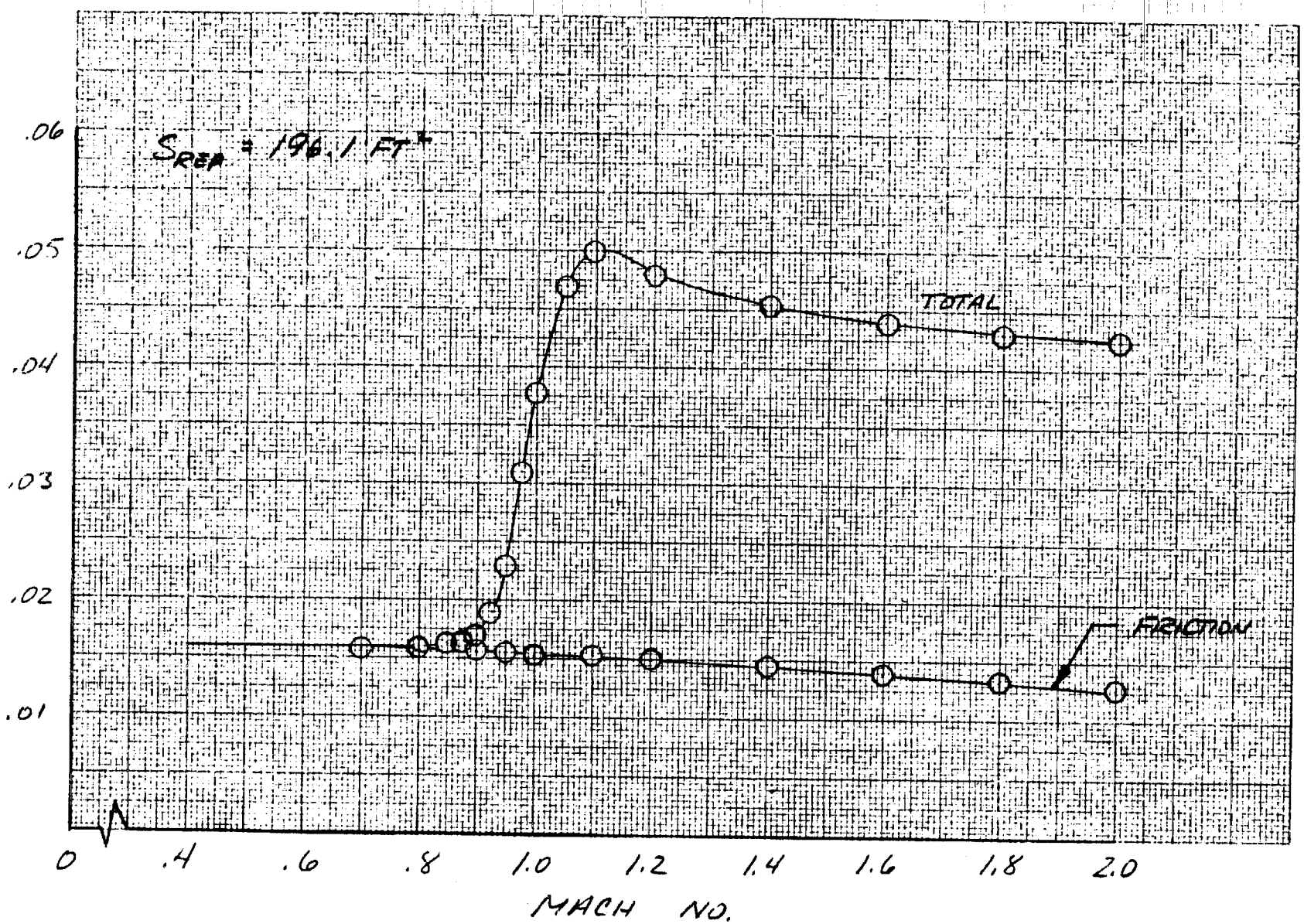

FIG. 140 MINIMUM DRAG BREAKDOWN, F-104G

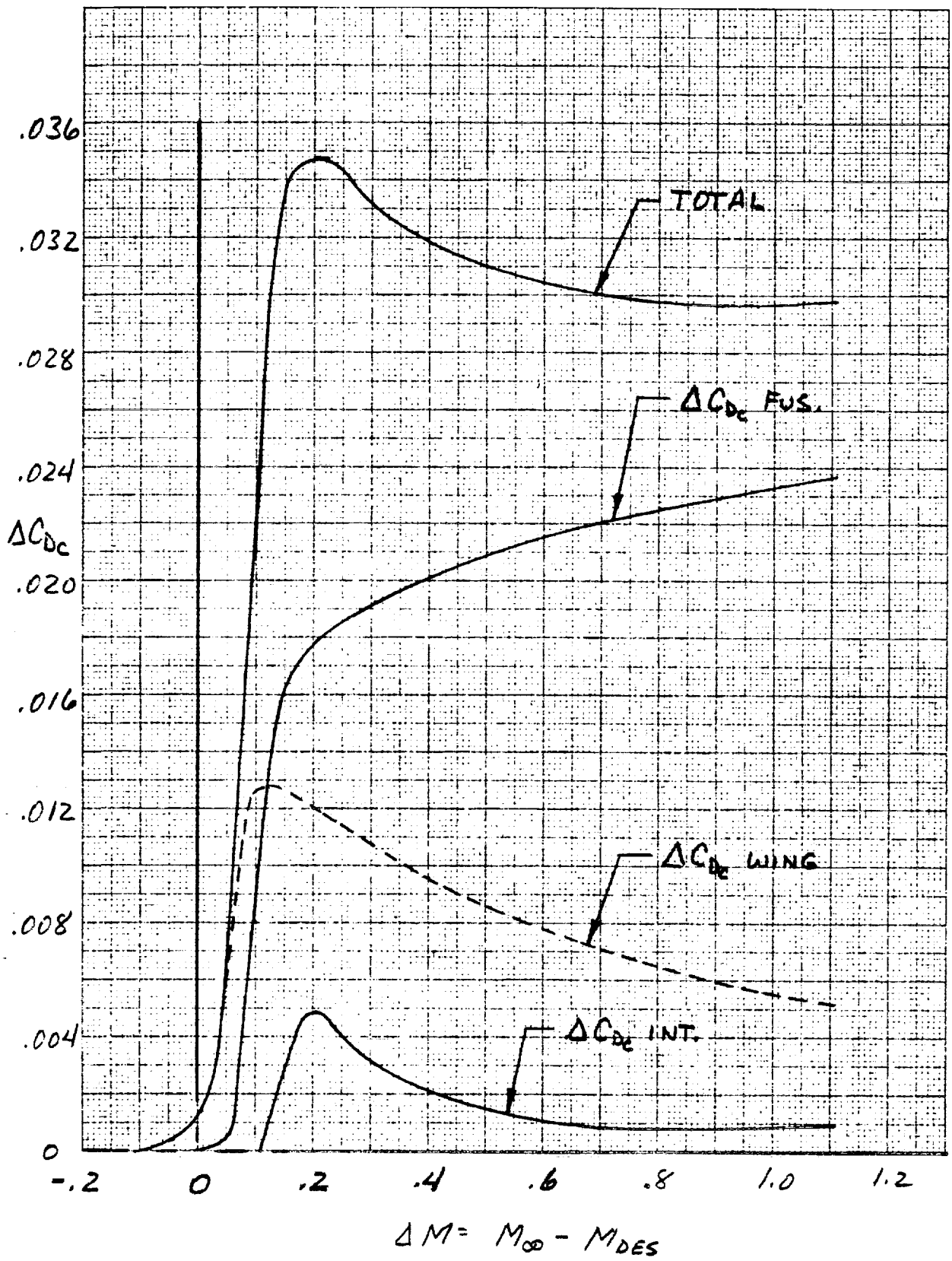

FIG. 141 COMPRESSIBILITY DRAG, F-104G

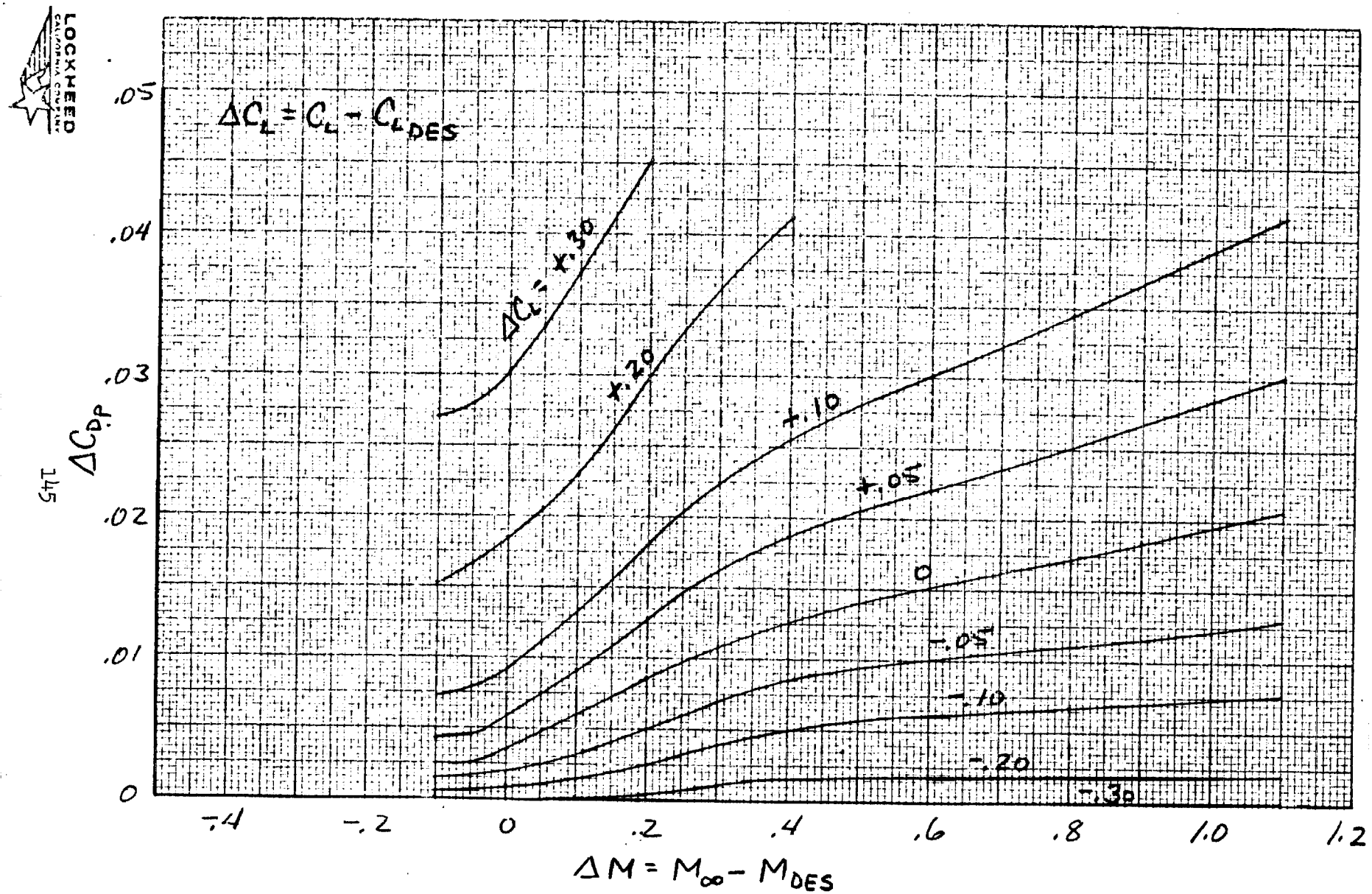

FIG. 142 WING PRESSURE DRAG VARIATION, F-104G

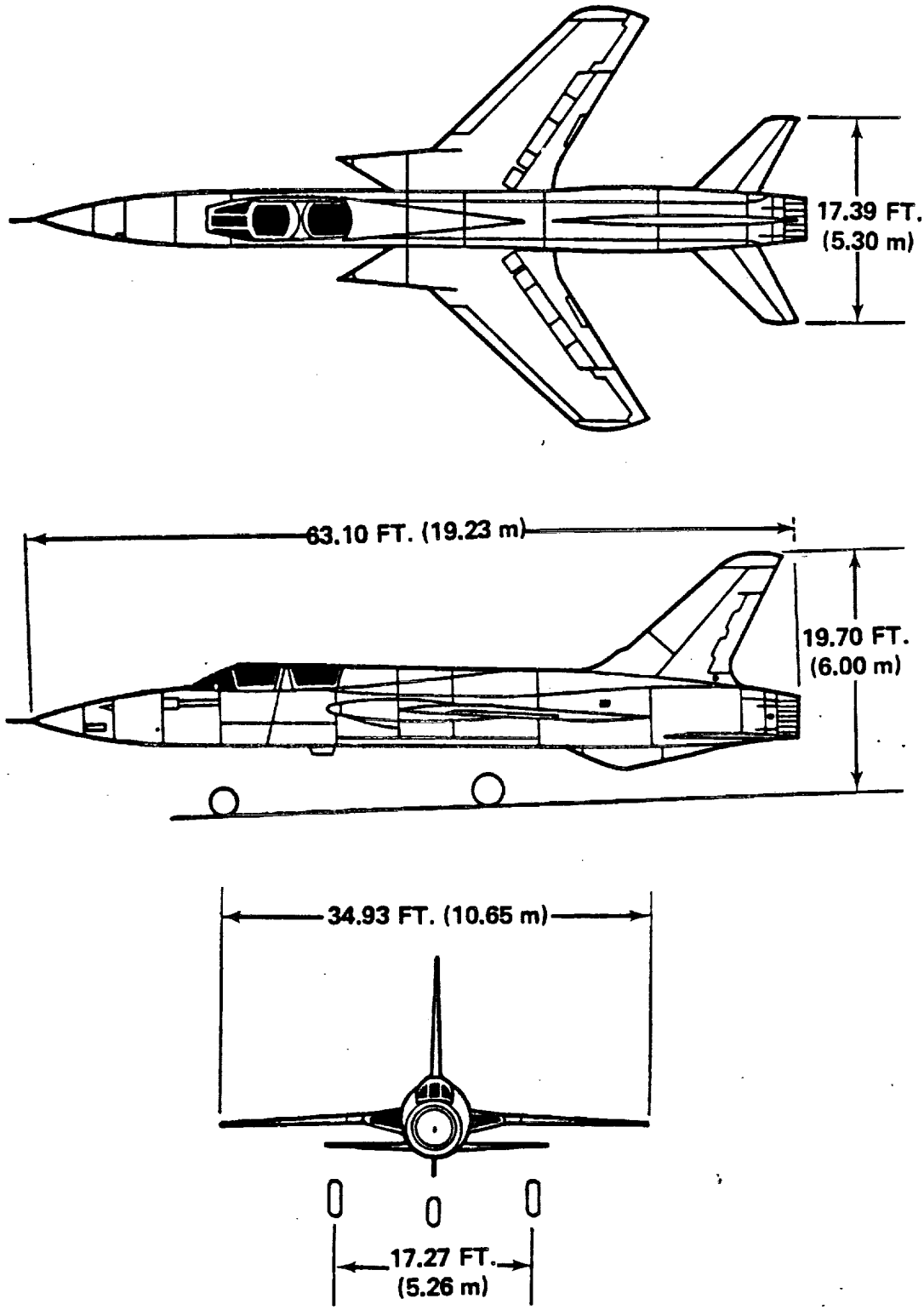

FIGURE 143. THREE-VIEW, F-105B

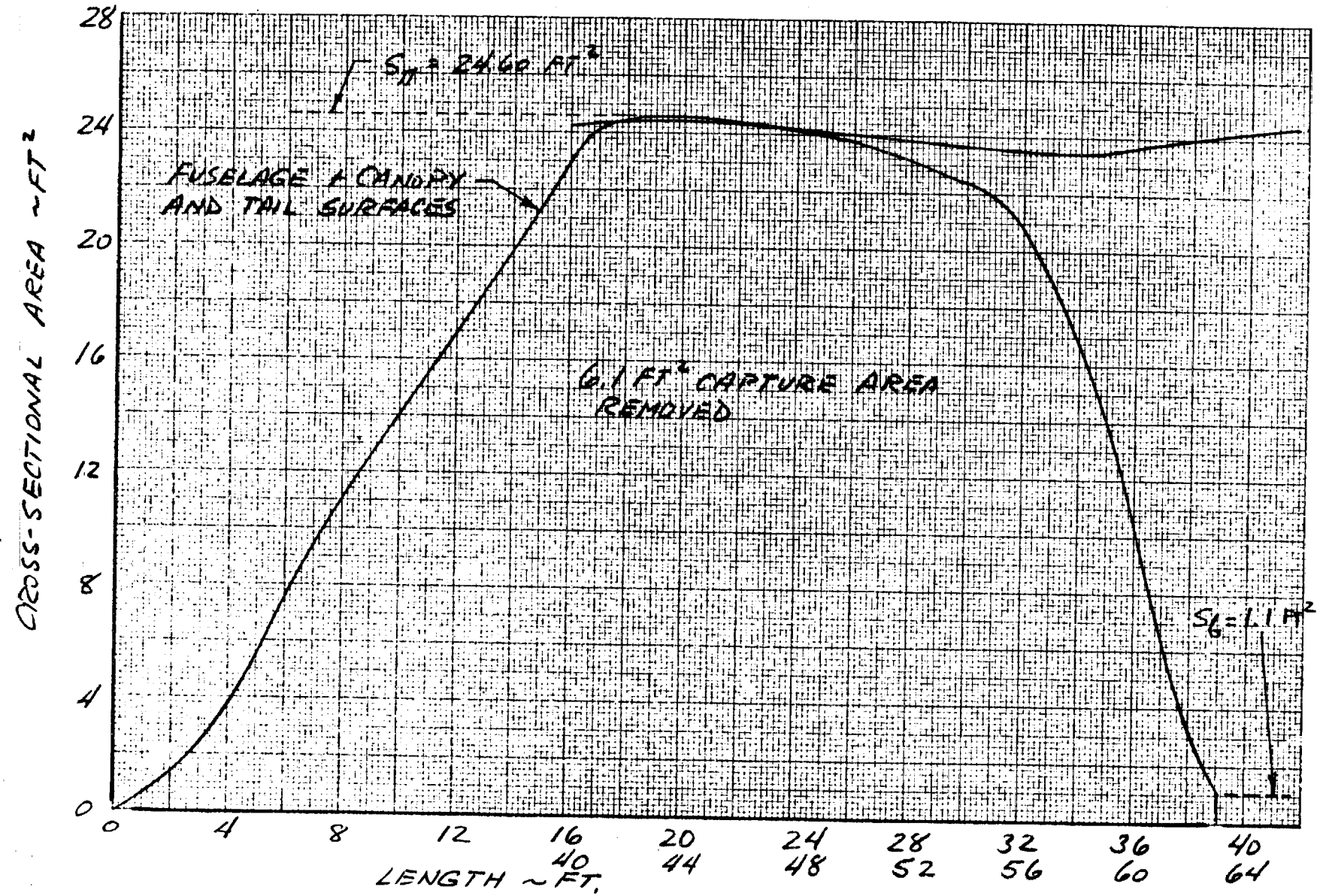

FIG. 144 F-105B FUSELAGE AREA DISTRIBUTION

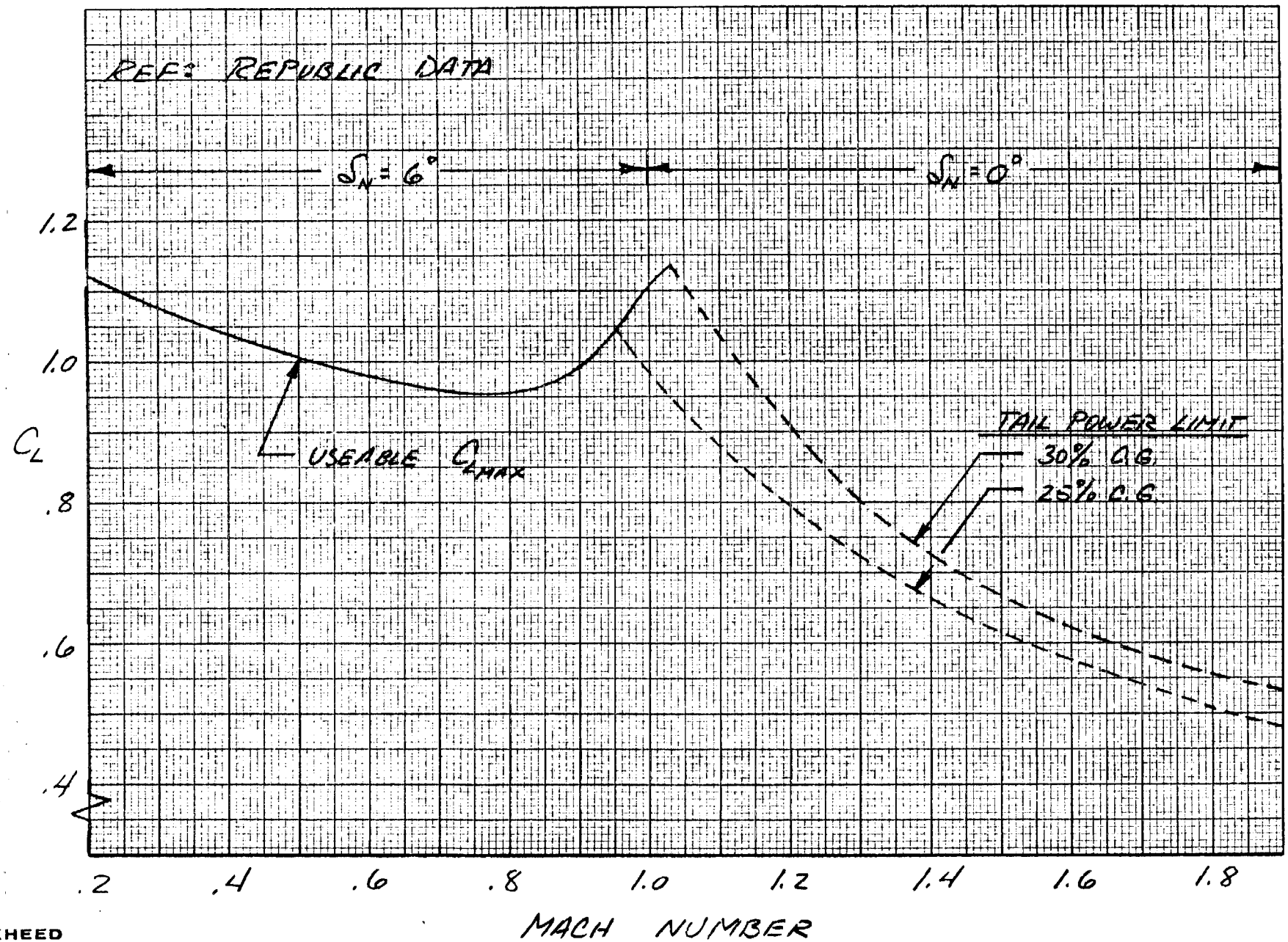

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FIG. 145 LIMIT LIFT CHARACTERISTICS, F-105B

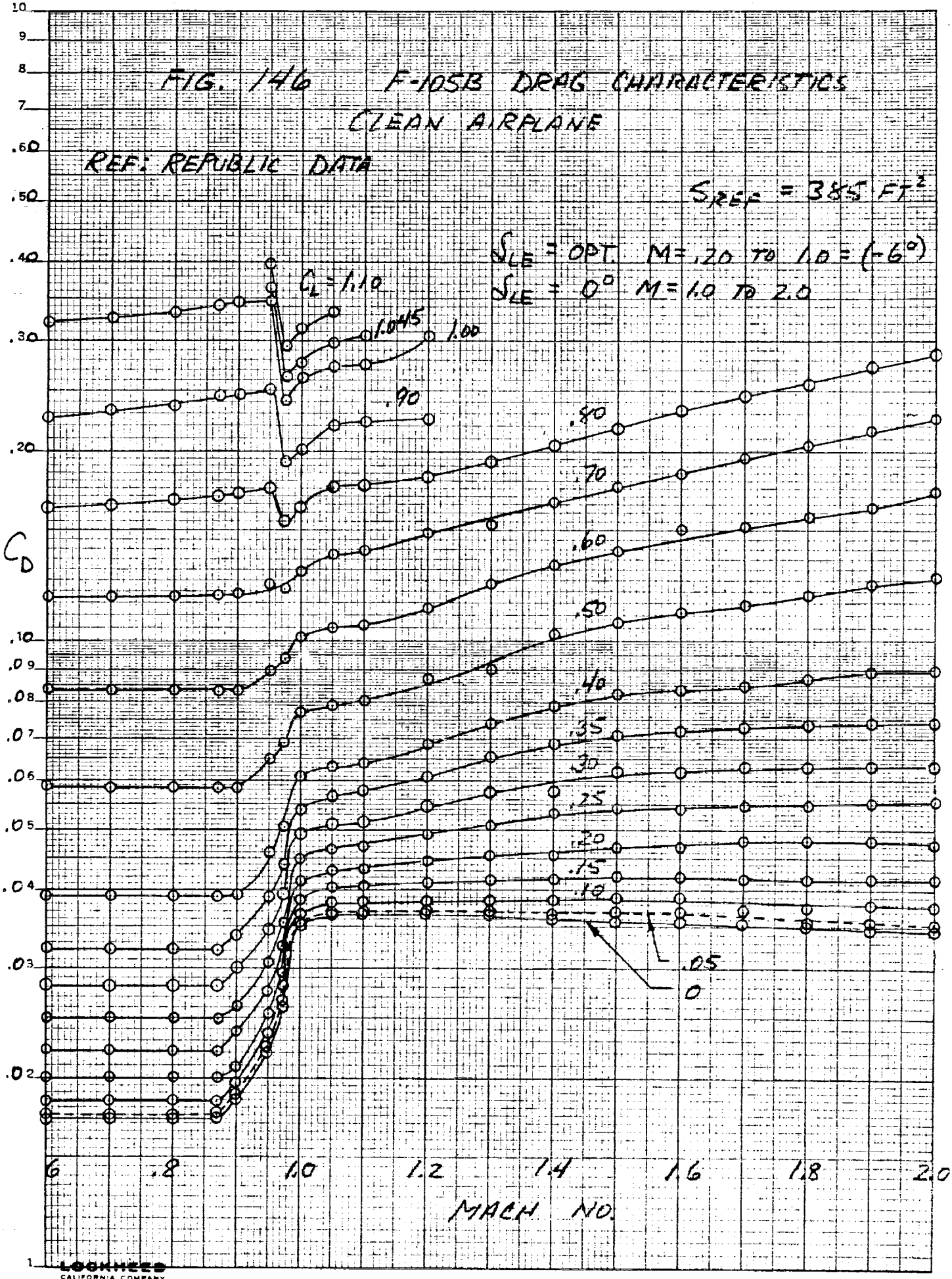
FIG. 146 F-105B DRAG CHARACTERISTICS
CLEAN AIRPLANE
REF: REPUBLIC DATA
S_{REF} = 385 FT²
δ_{LE} = OPT. M = .20 TO 1.0 = (-6°)
δ_{LE} = 0° M = 1.0 TO 2.0
C_L = 1.10
1.0445
1.00
.90
.80
.70
.60
.50
.40
.35
.30
.25
.20
.15
.10
.05
0
C_D
MACH NO.
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0

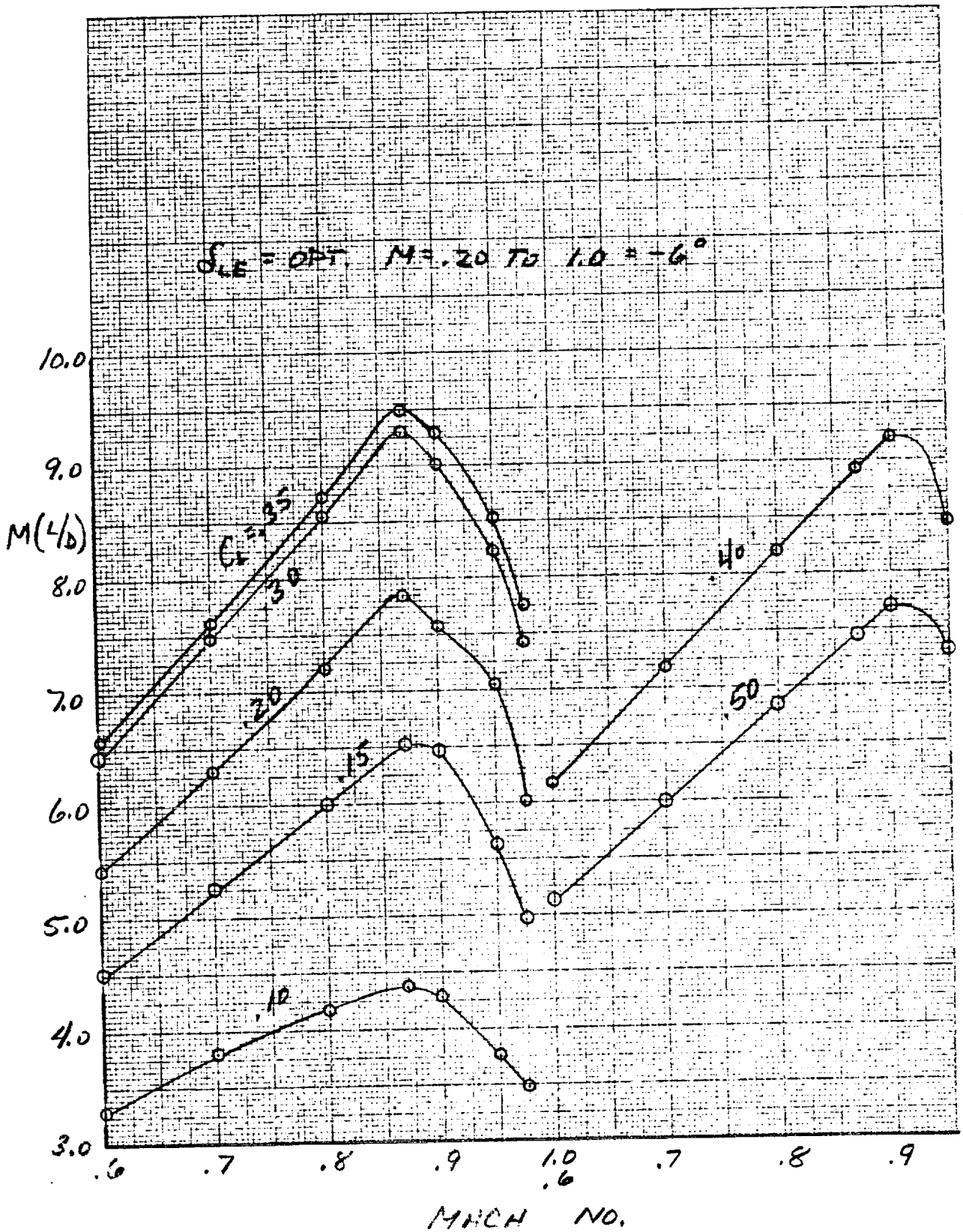

FIG. 147 M(L/D) VS. MACH NUMBER, F-105 B

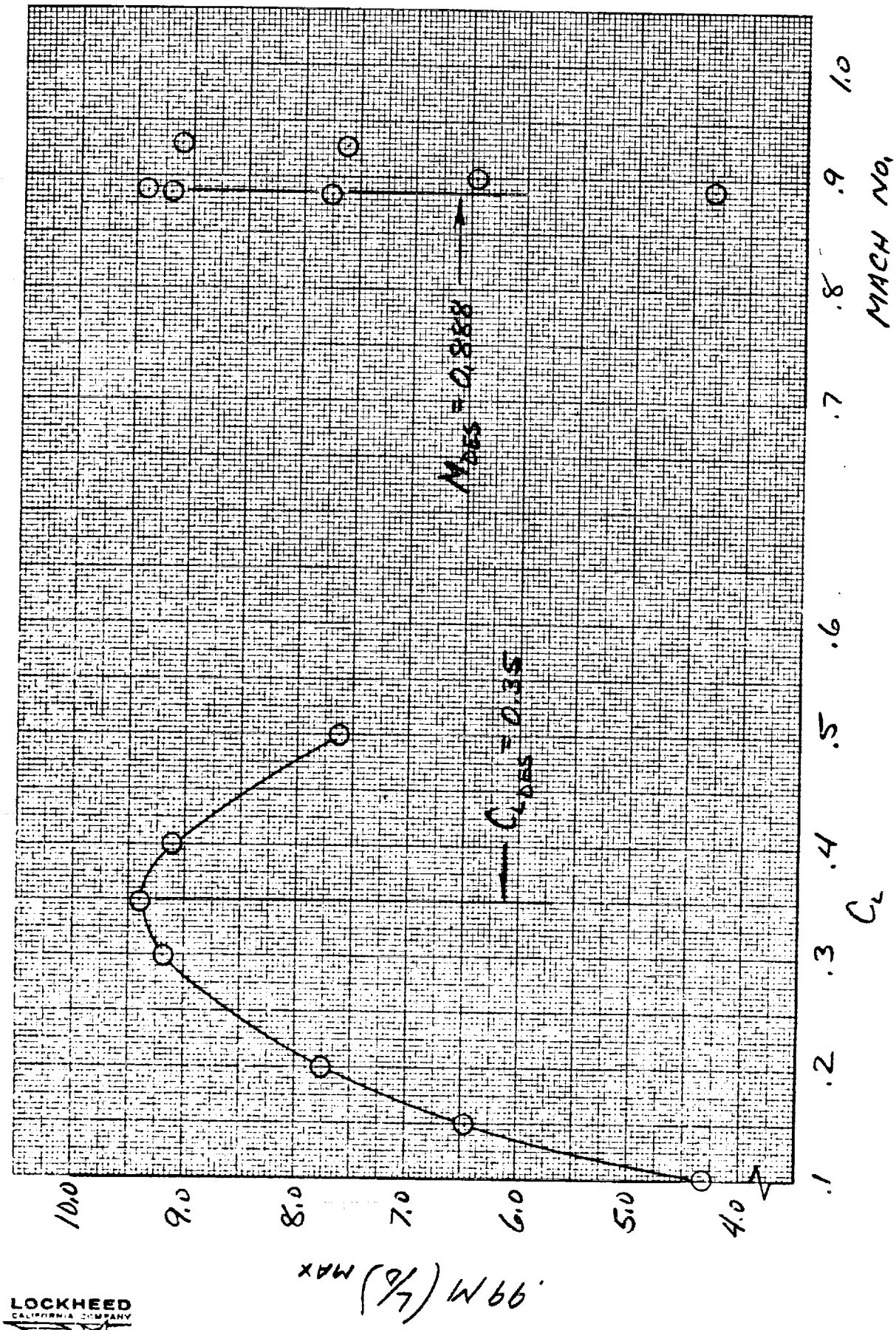

FIG. 148 $C_{L_{DES}}$ AND M_{DES} FOR F-105B

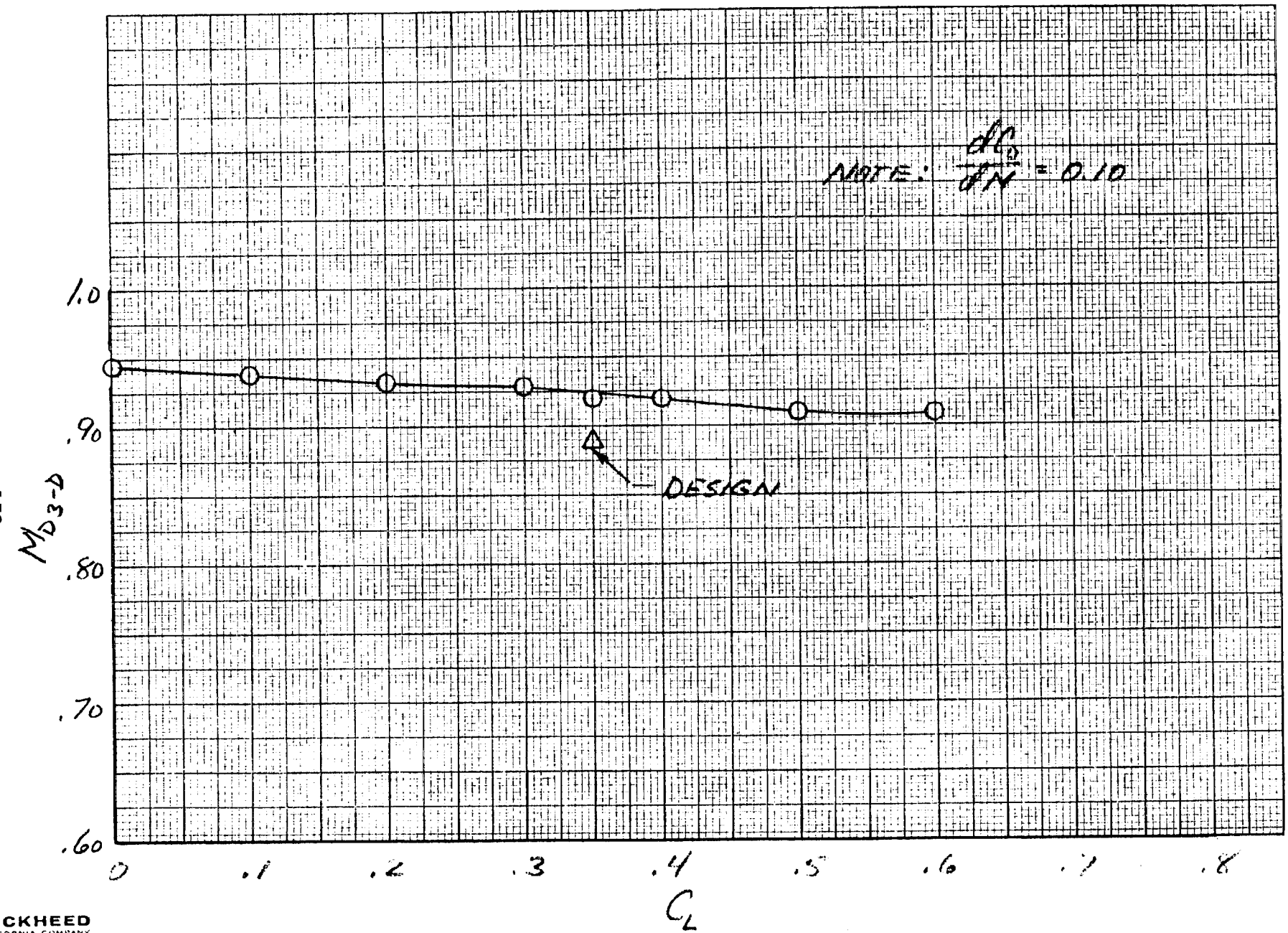

FIG. 149 DRAG DIVERGENCE CHARACTERISTICS, F-105B

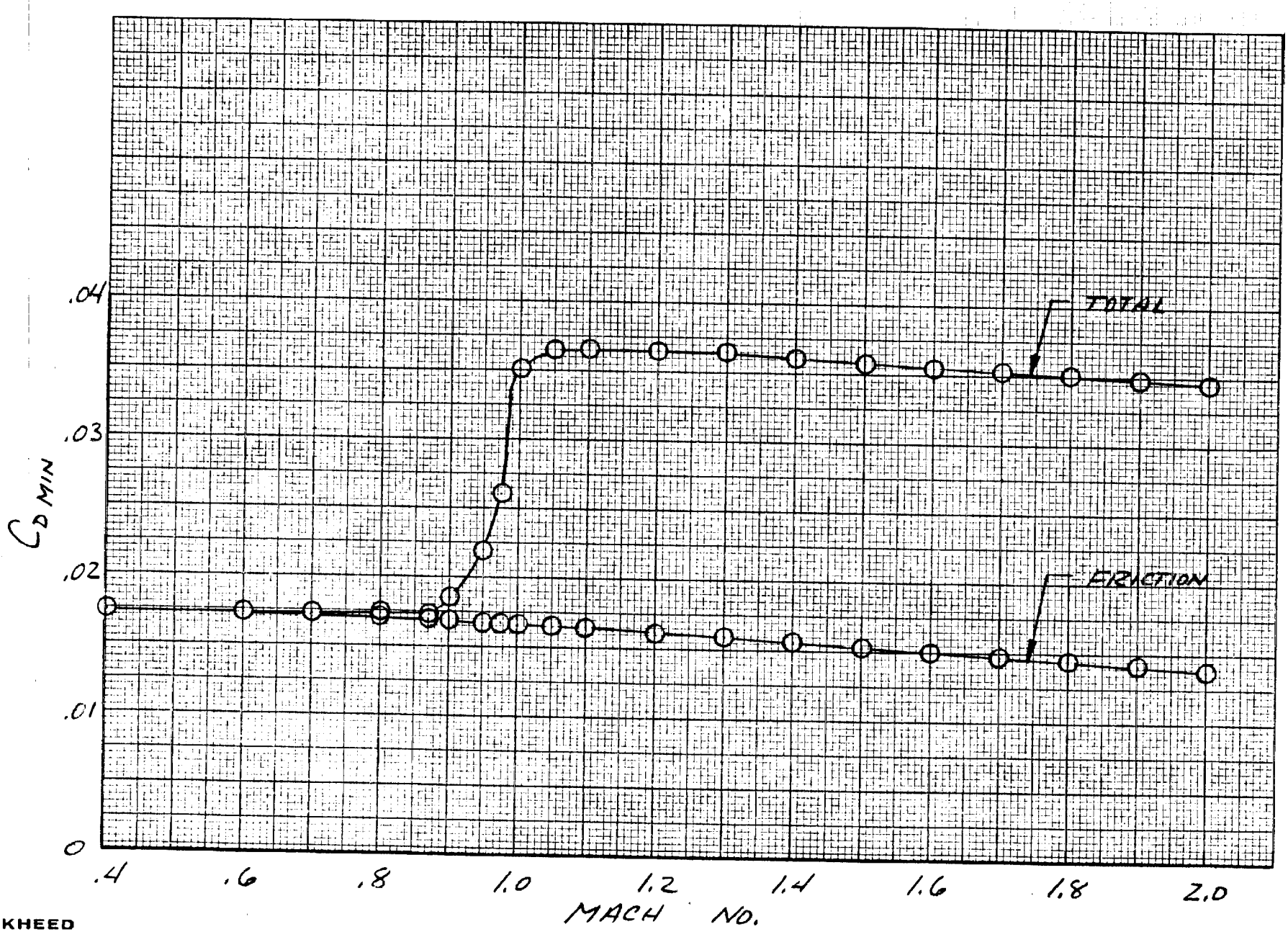

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FIG. 150 MINIMUM DRAG BREAKDOWN, F-105B

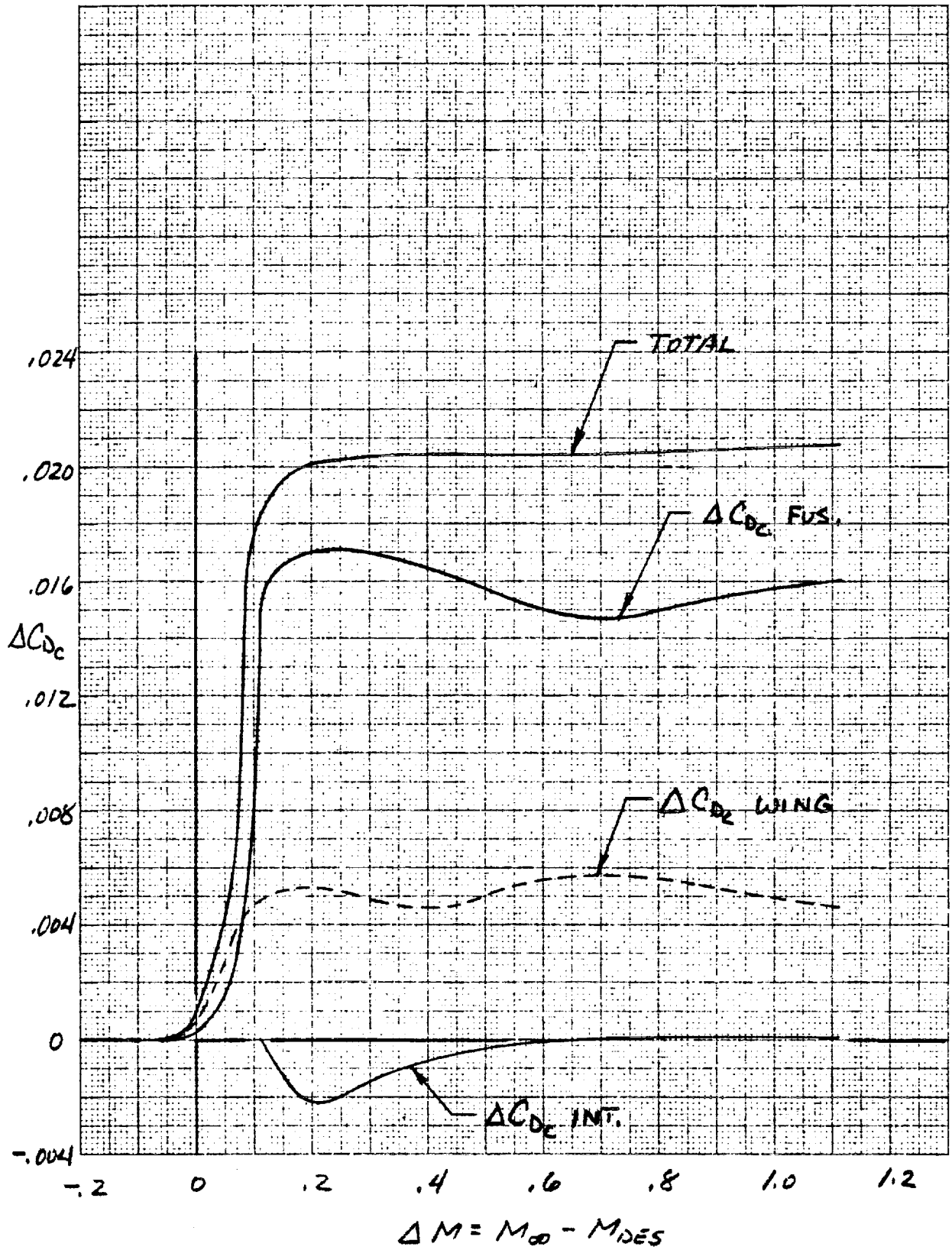

FIG. 151 COMPRESSIBILITY DRAG, F-105B

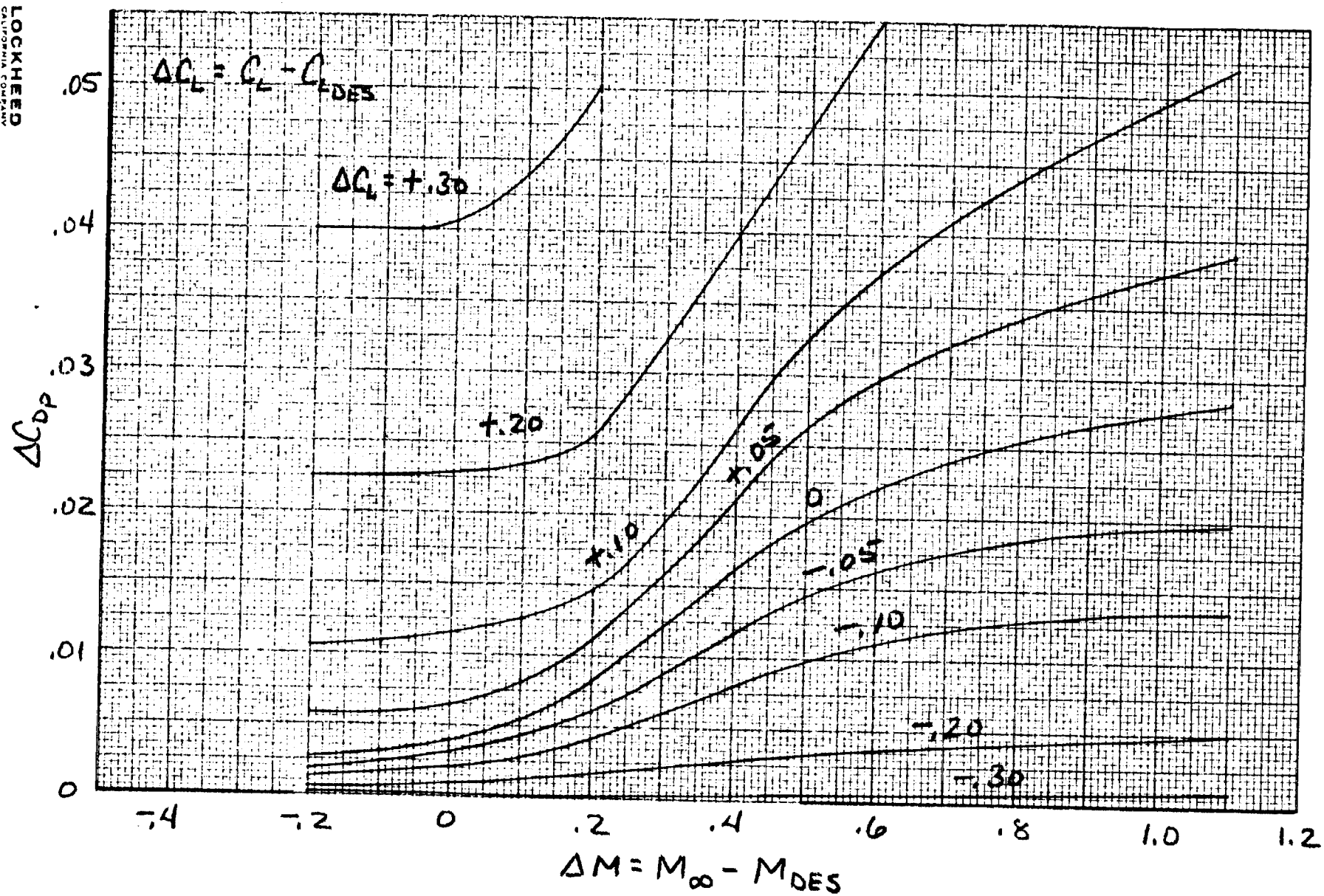

FIG. 152 WING PRESSURE DRAG VARIATION, F-105B

LR 27978

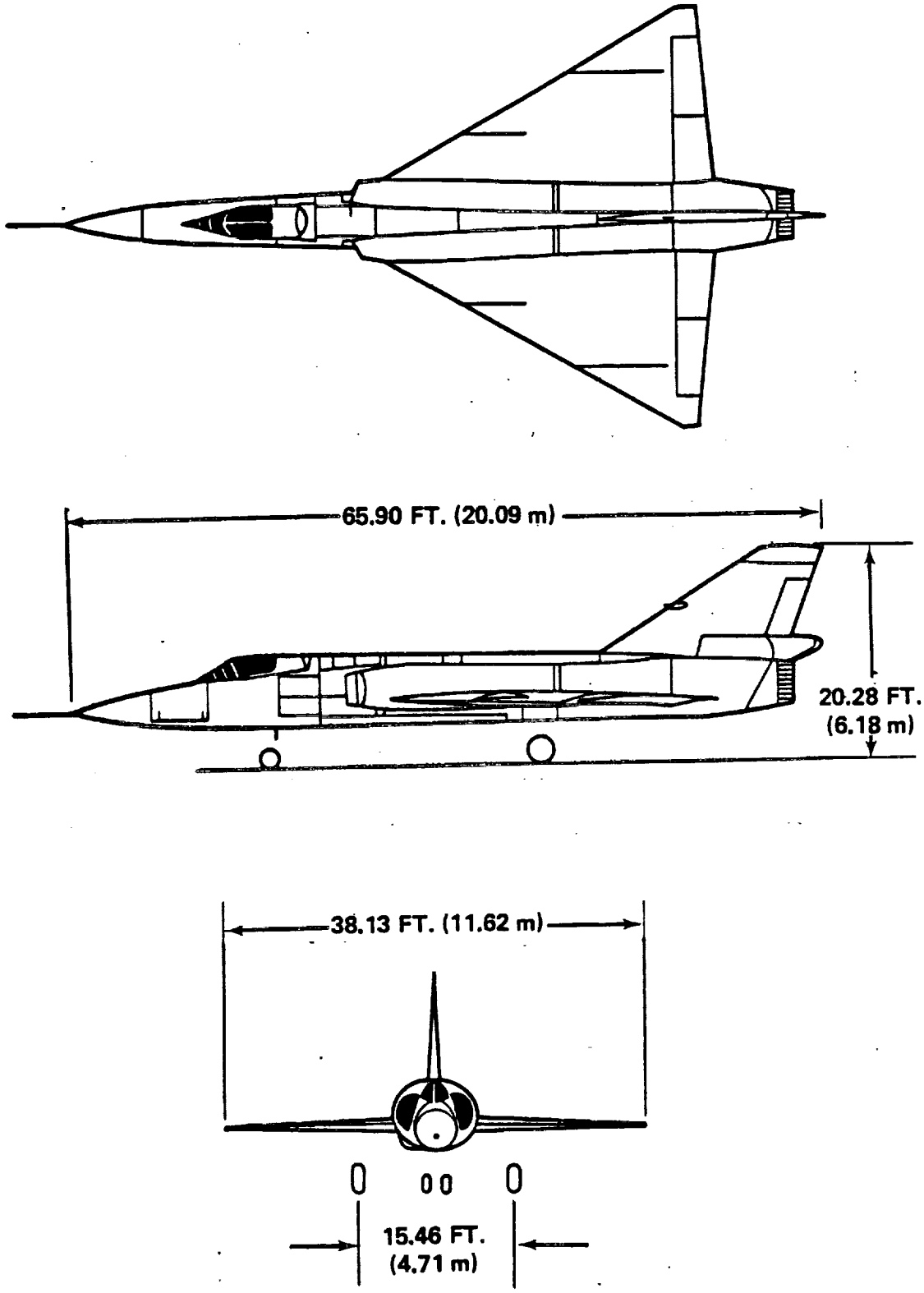

FIGURE 153. THREE-VIEW, F-106A

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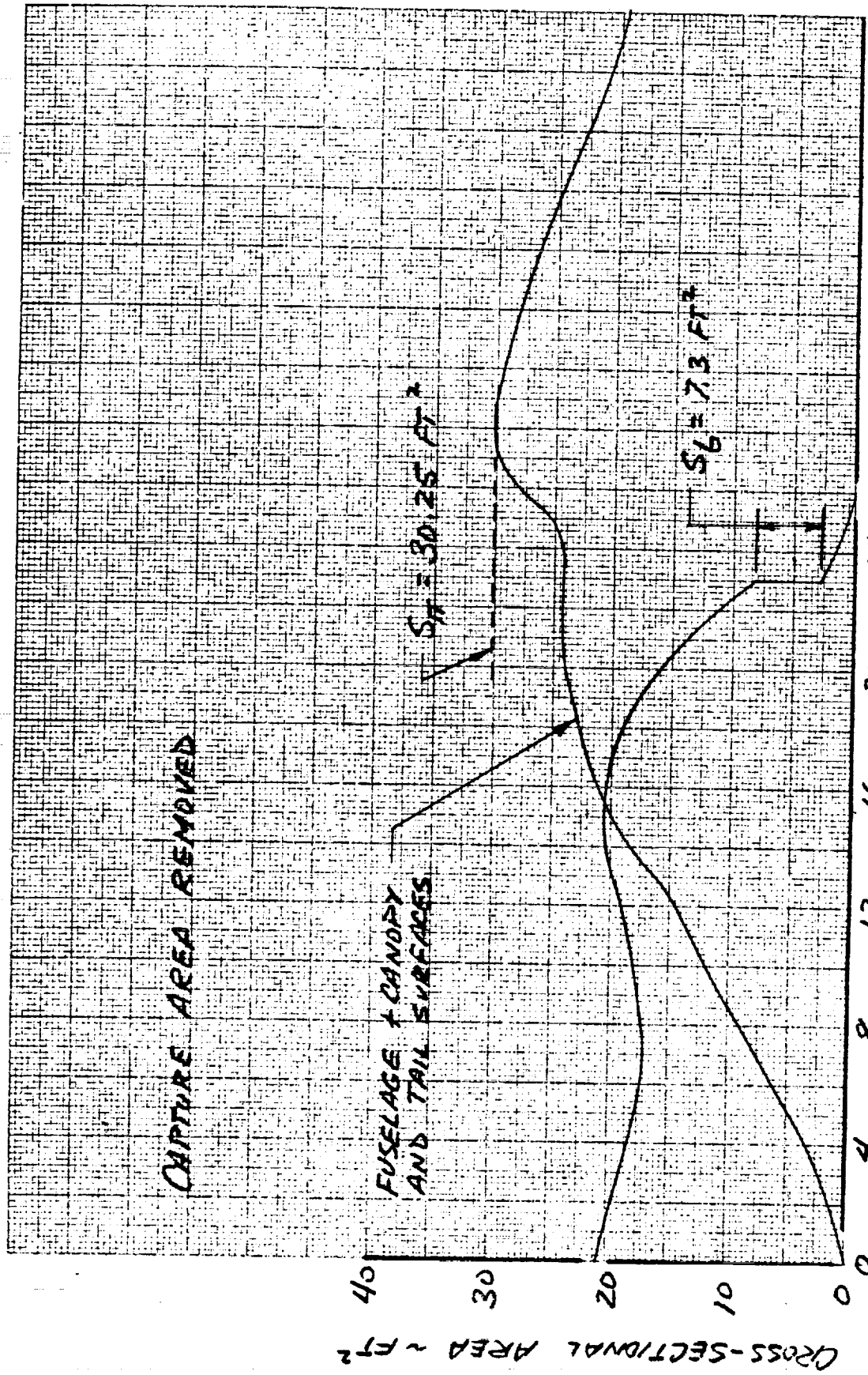

FIG. 154 F-106A FUSELAGE AREA DISTRIBUTION

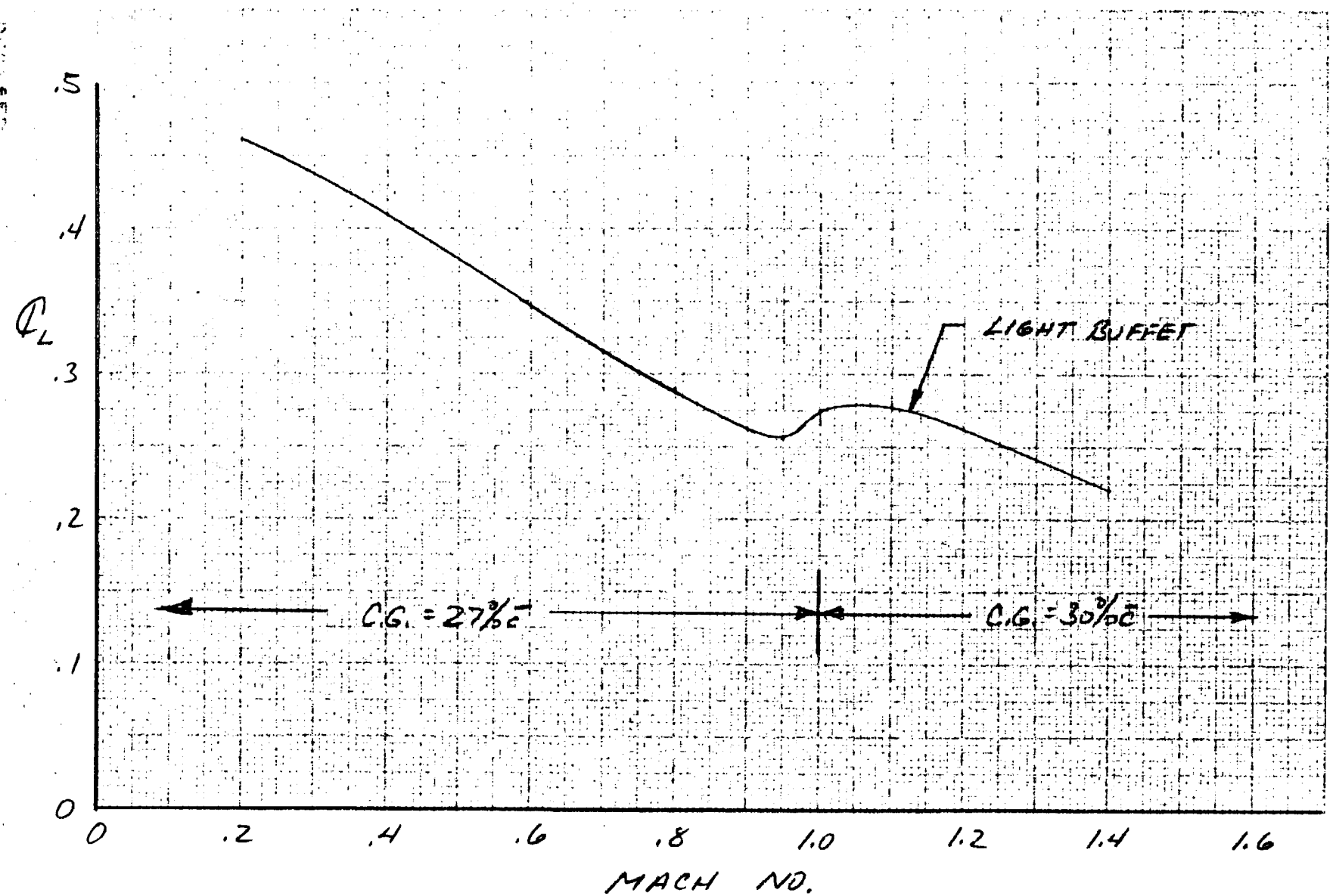

FIG. 155 LIMIT LIFT CHARACTERICS, F-106A

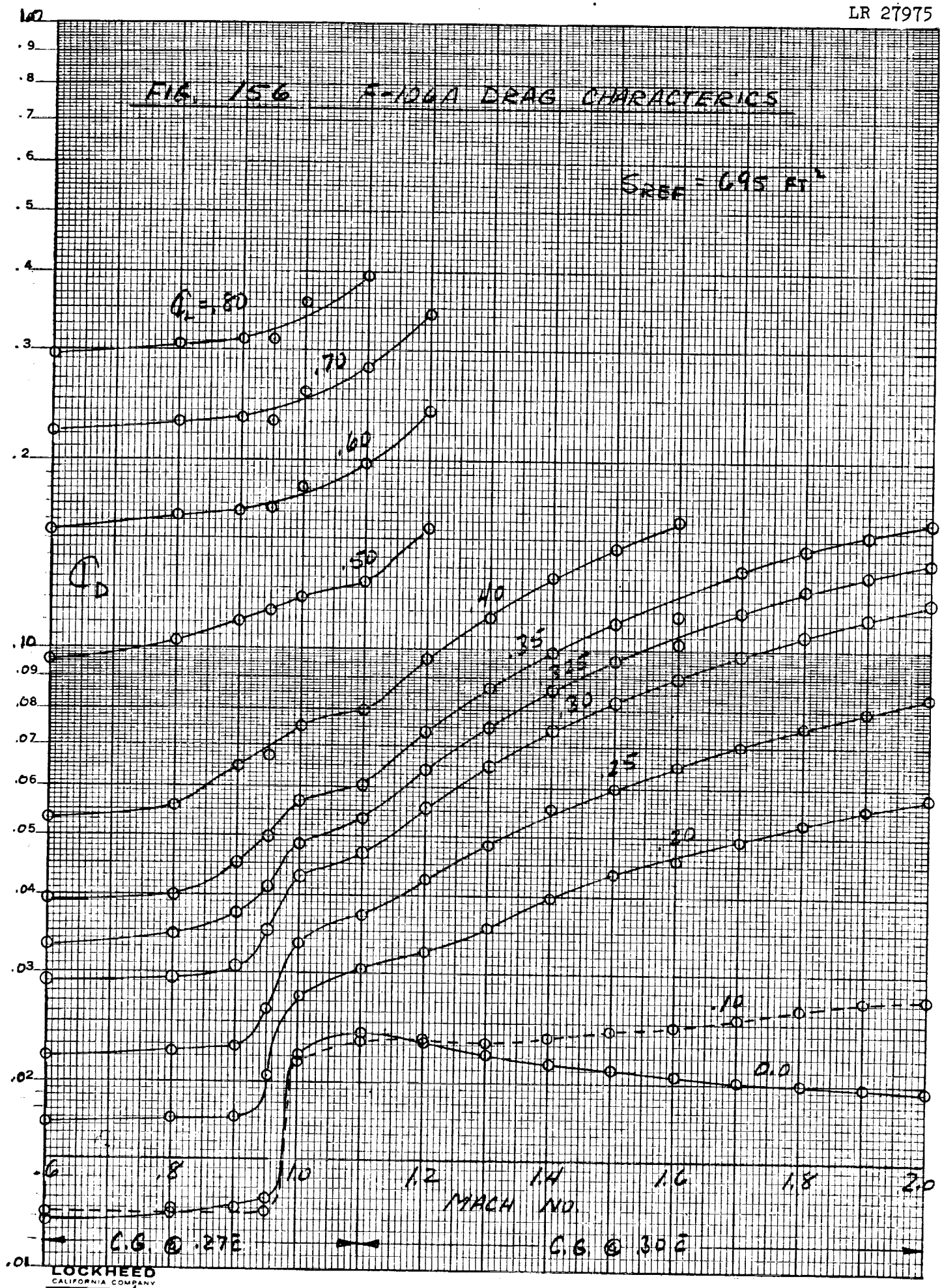
FIG. 156 F-104A DRAG CHARACTERICS
SREF = 6.95 FT²
CL = .80
.70
.60
.50
.40
.35
.325
.30
.25
.20
.10
0.0
CD
MACH NO.
C.G. @ .272
C.G. @ .302
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
.2
.3
.4
.5
.6
.7
.8
.9
1.0
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0

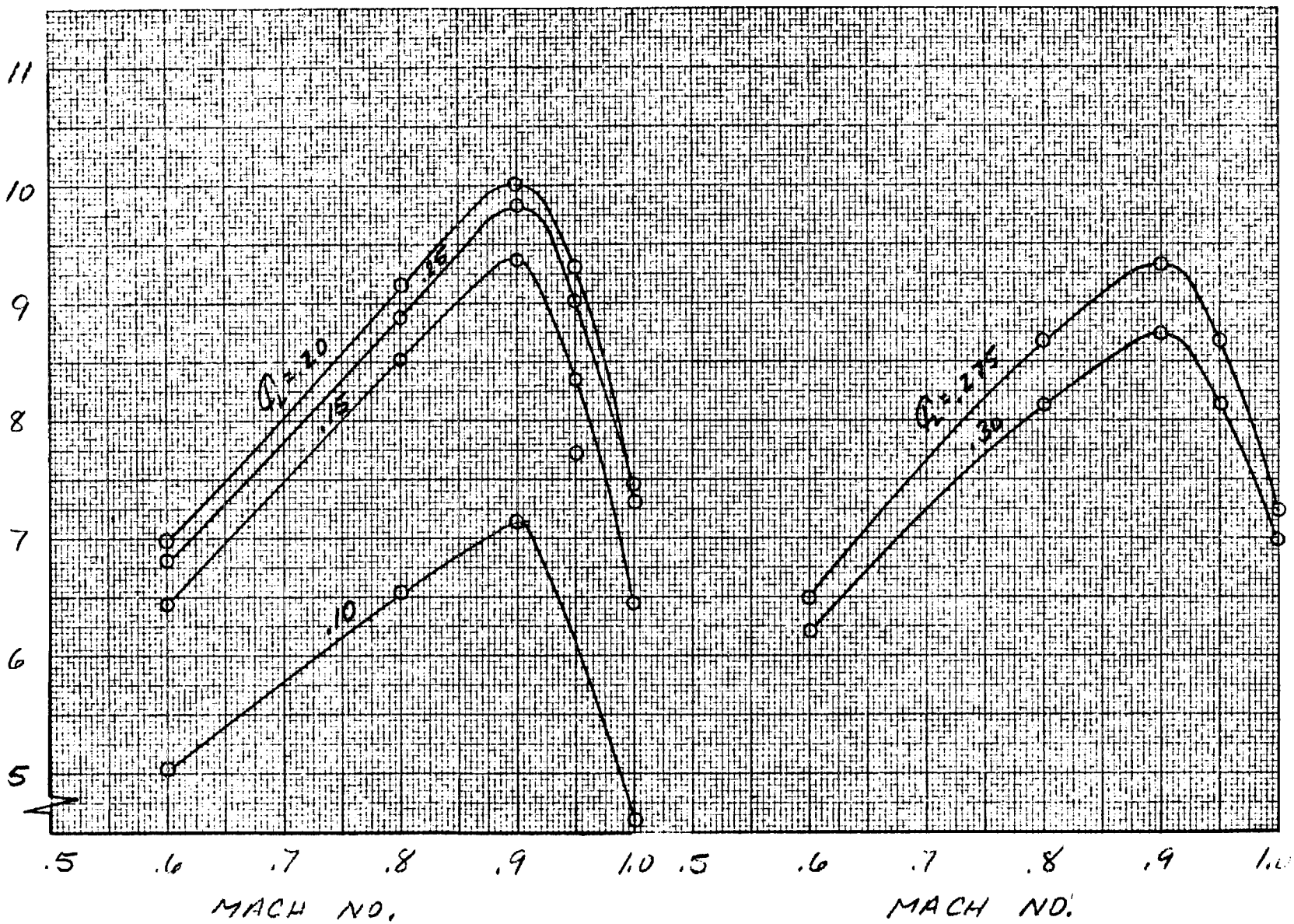

FIG. 157 M(L/D) VS. MACH NUMBER, F-106A

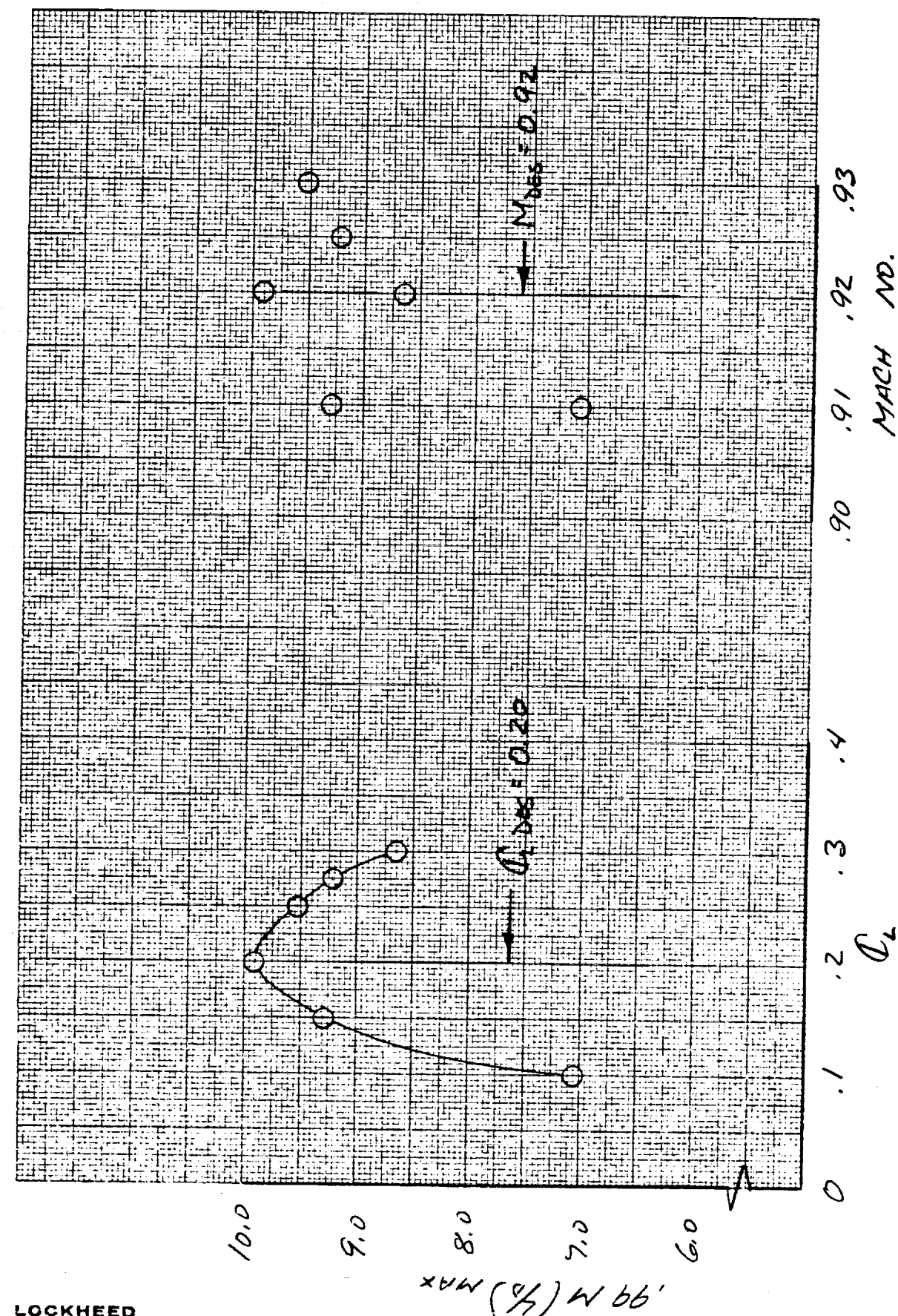

FIG. 158 $C_{L_{DES}}$ AND M_{DES} FOR F-106A

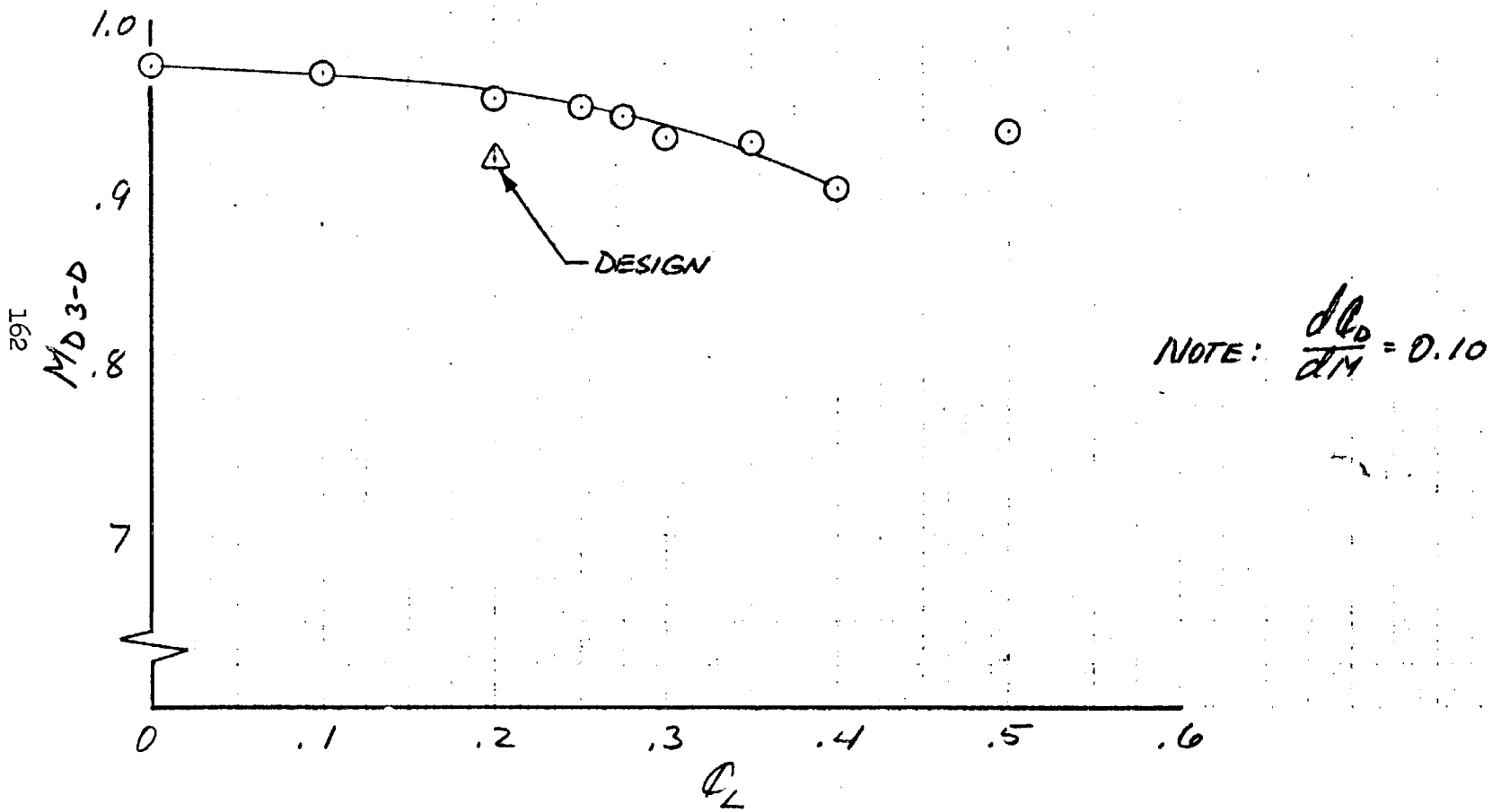

FIG. 159 DRAG DIVERGENCE CHRACTERISTICS, F-106A

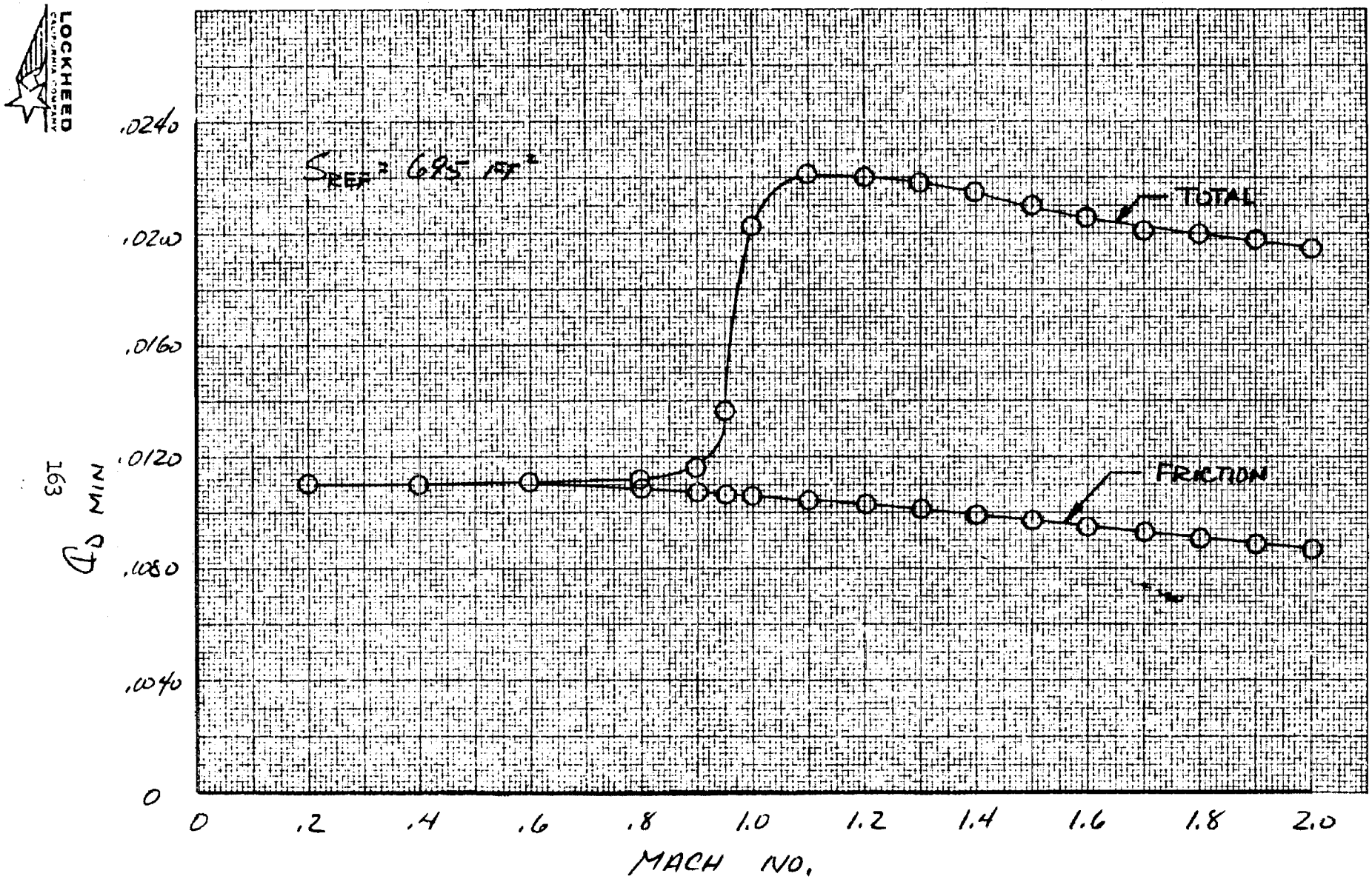

FIG. 160 MINIMUM DRAG BREAKDOWN, F-106A

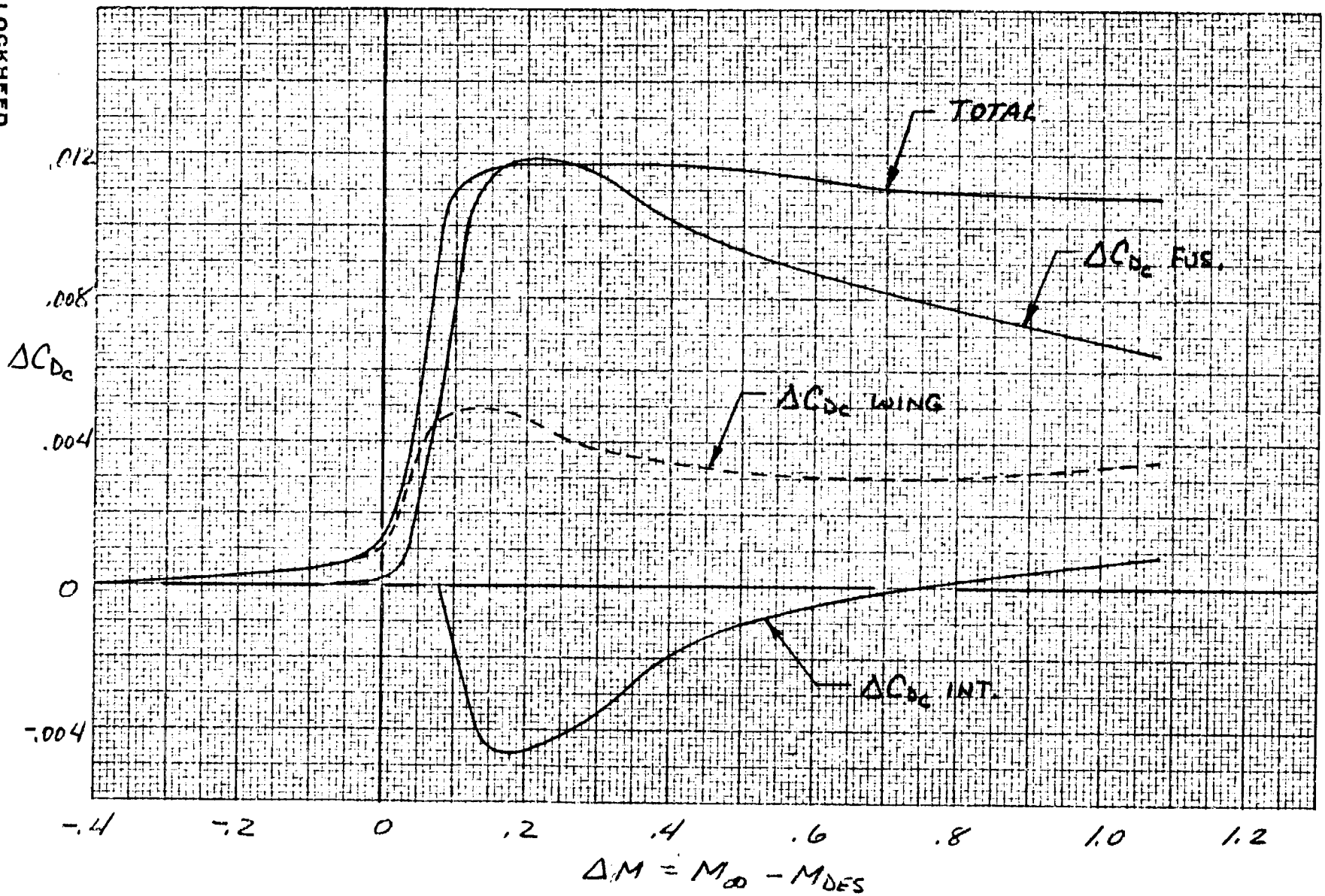

FIG. 161 COMPRESSIBILITY DRAG, F-106A

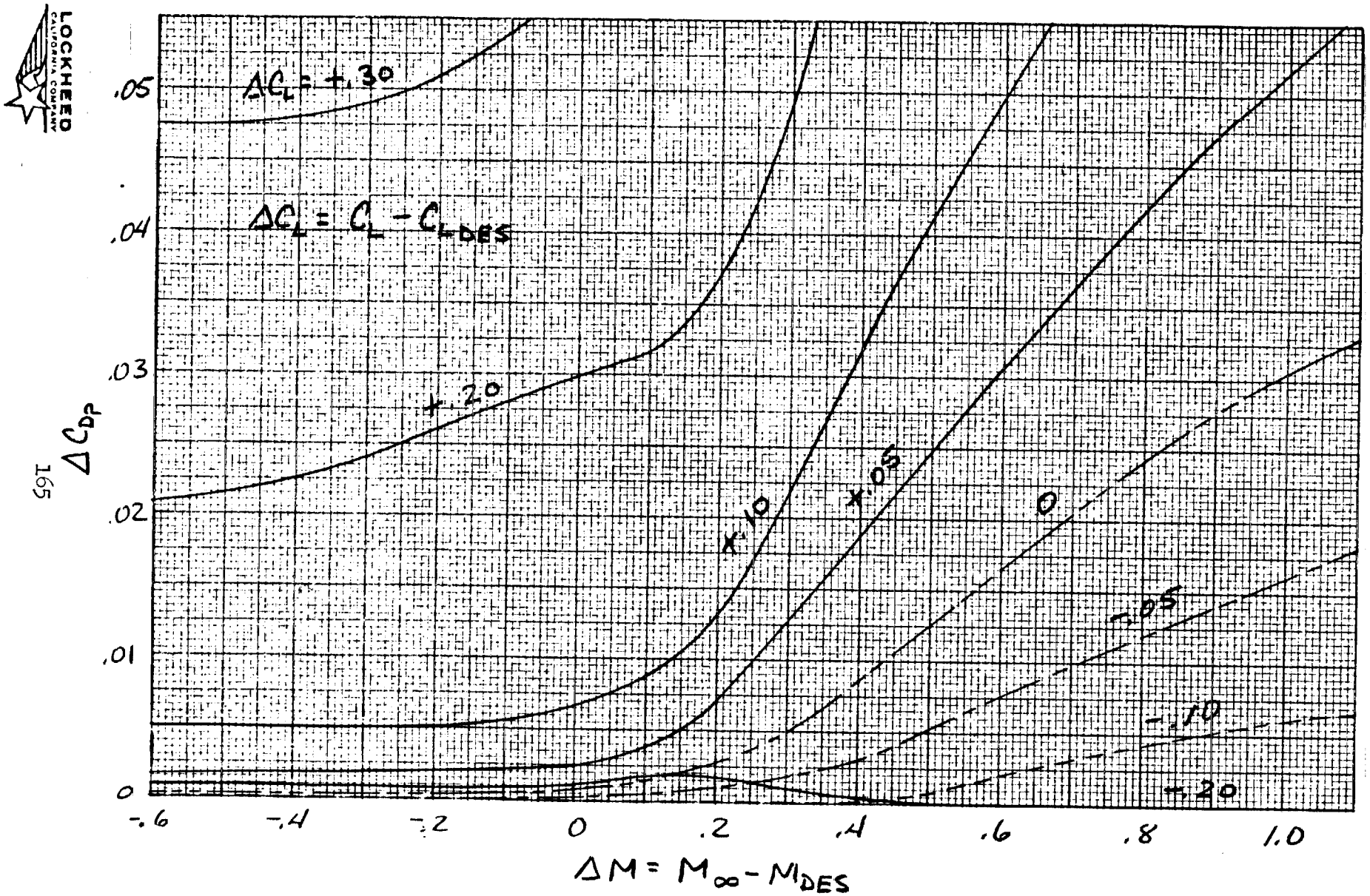

FIG. 162 WING PRESSURE DRAG VARIATION, F-106A

(1 OF 2)

LR 27975

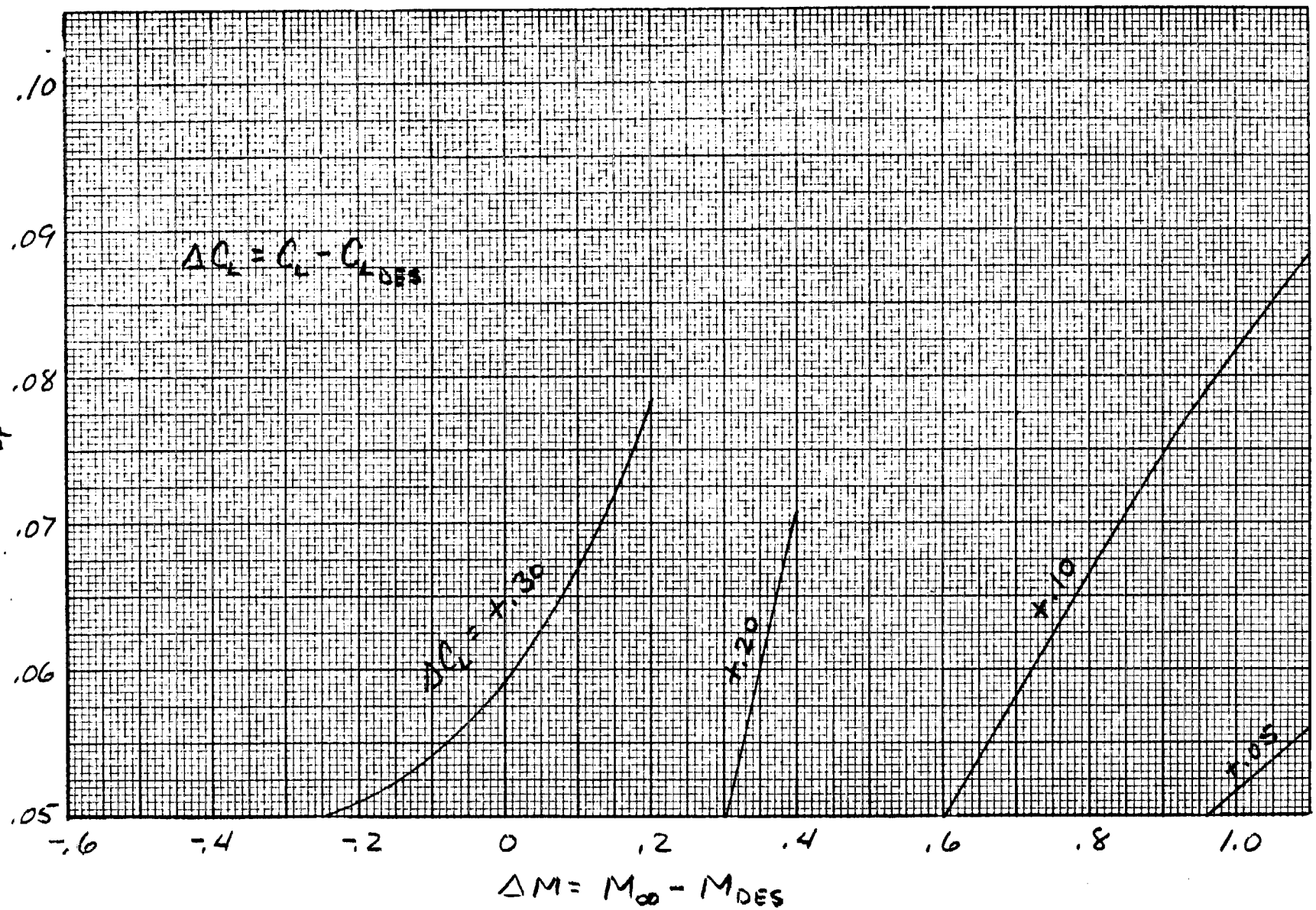

FIG. 162 WING PRESSURE DRAG VARIATION, F-106A

(2 OF 2)

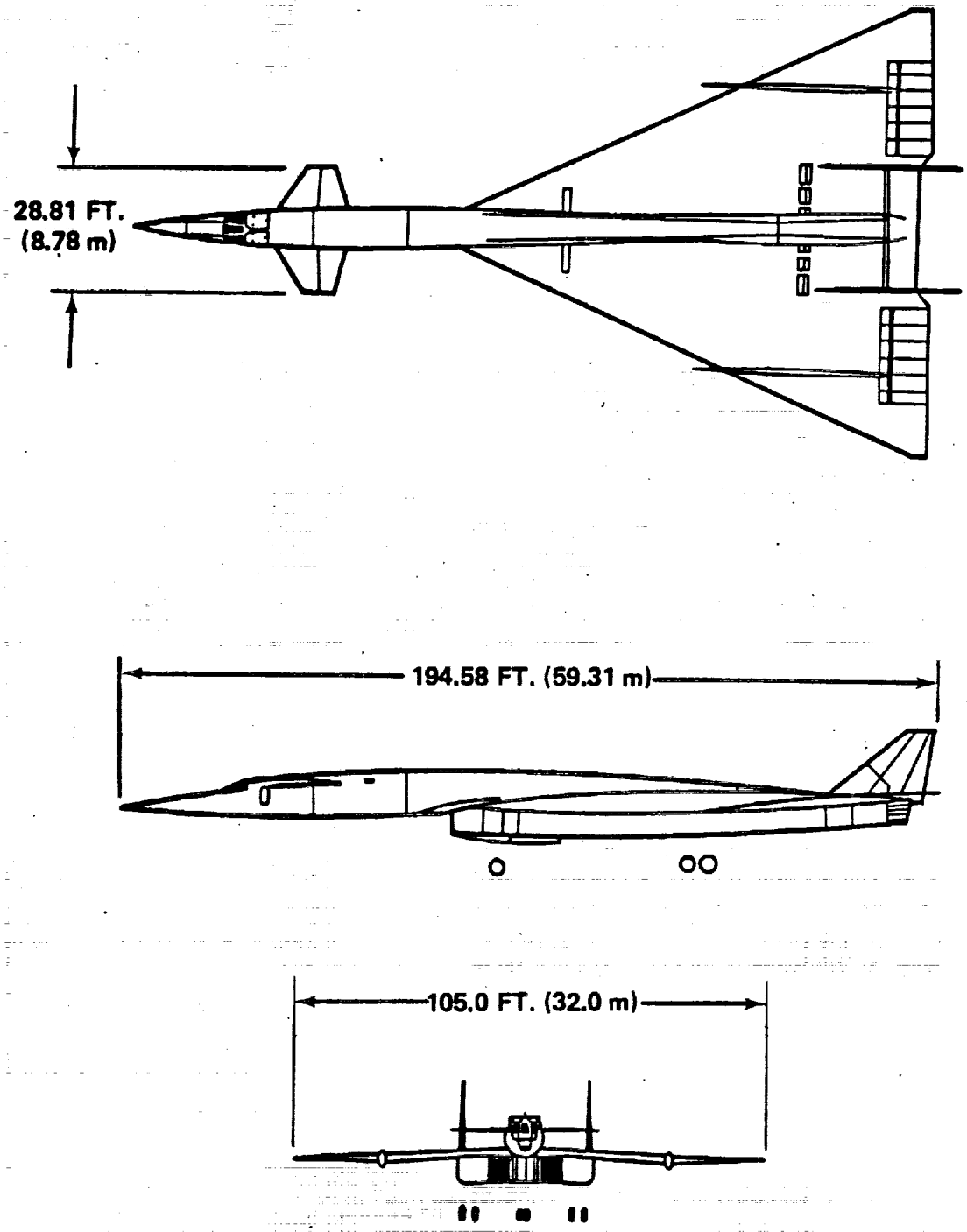

FIGURE 163. THREE-VIEW, XB-70

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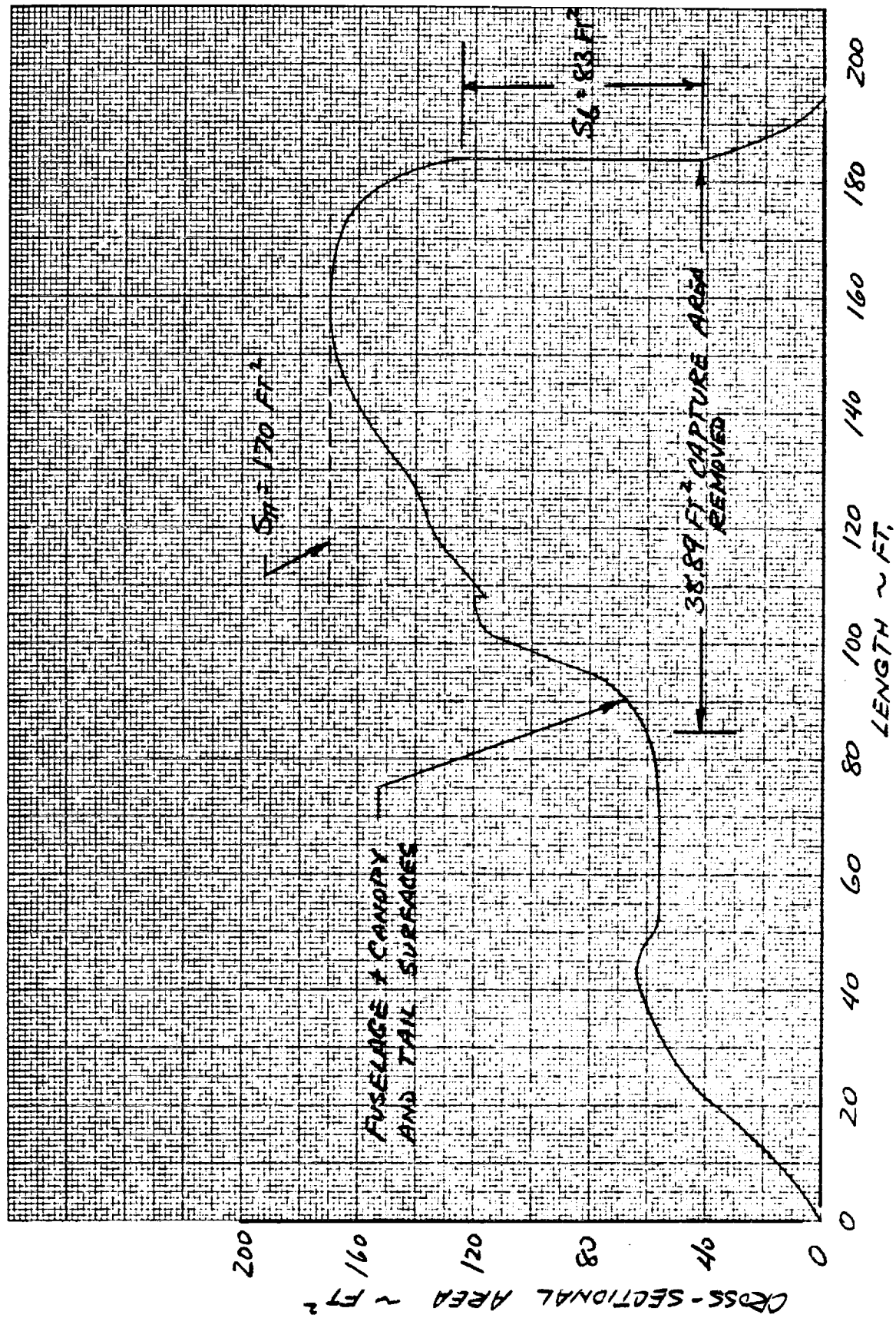


FIG. 164 XB-70 FUSELAGE AREA DISTRIBUTION

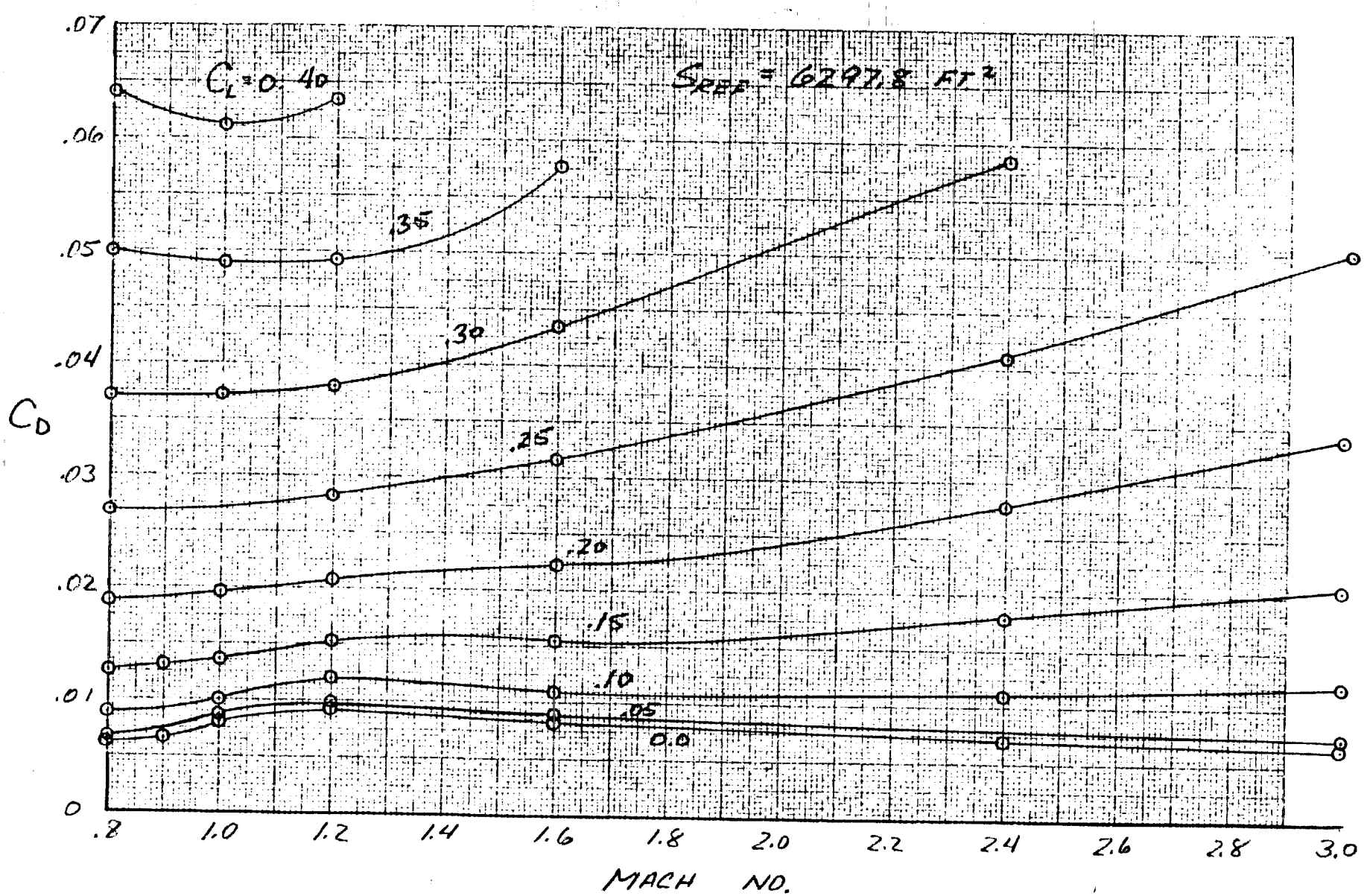
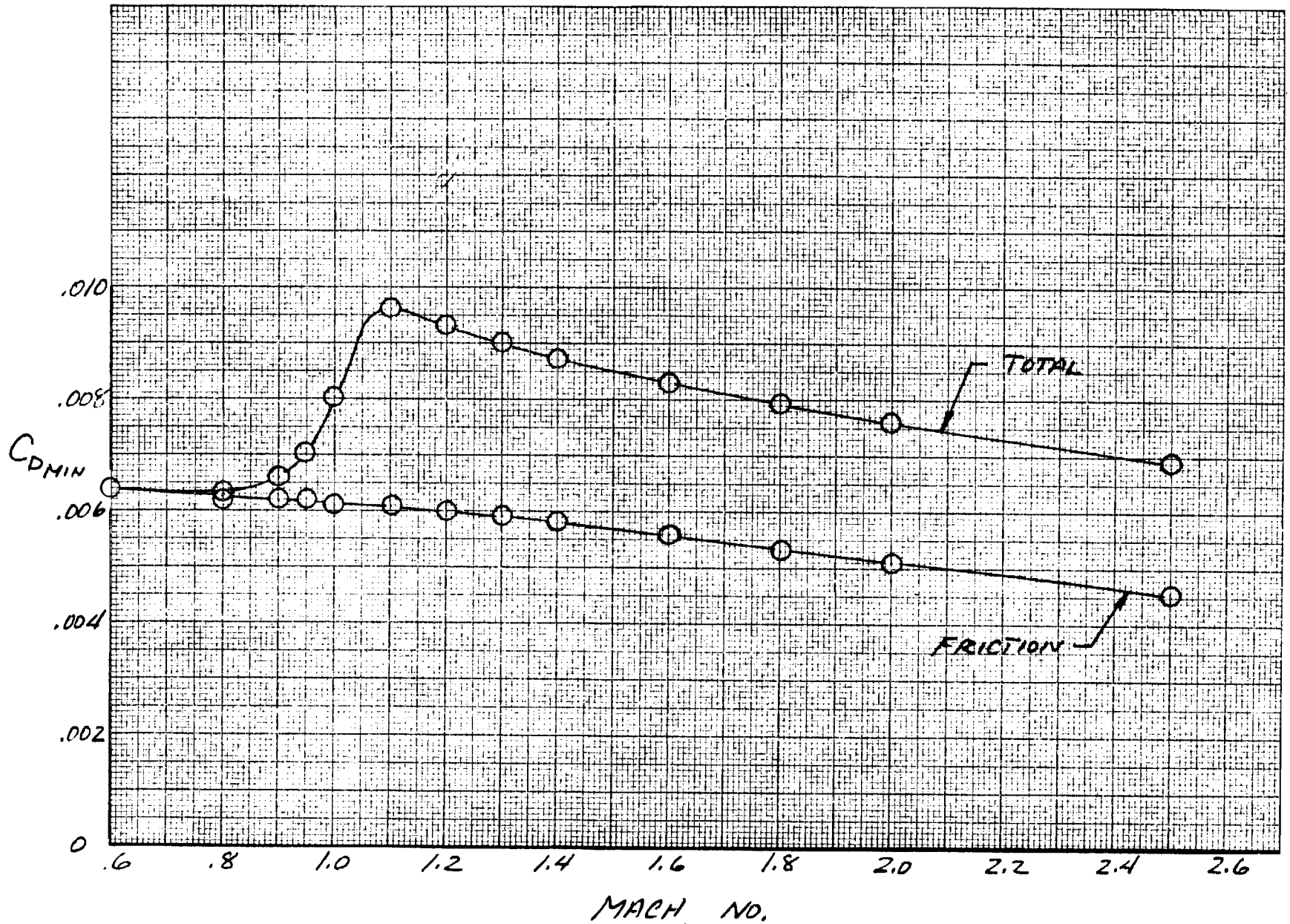


FIG. 165 XB-70A DRAG CHARACTERISTICS



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CALIFORNIA COMPANY

FIG. 166 MINIMUM DRAG BREAKDOWN, XB-70

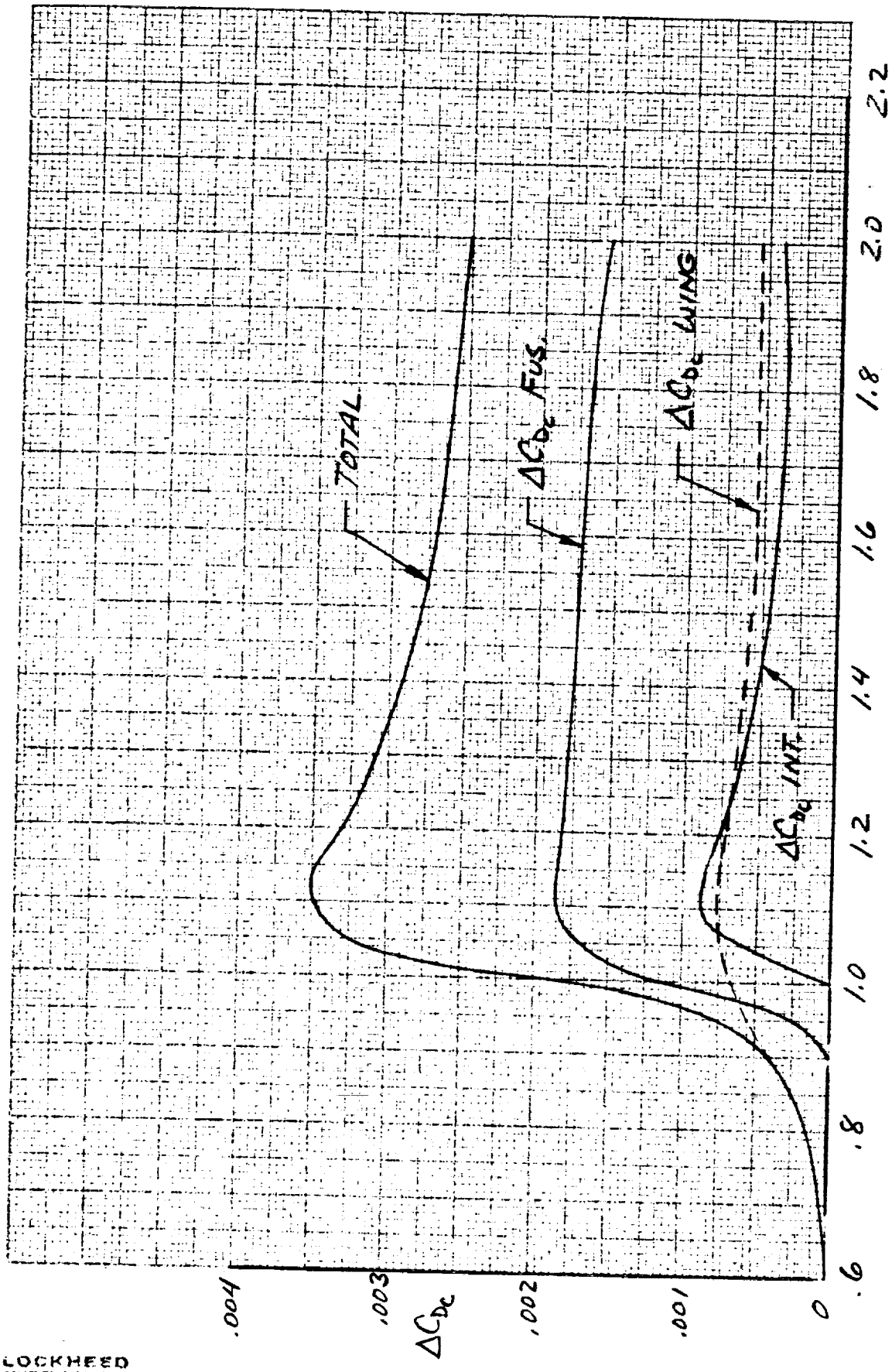

FIG. 167 COMPRESSIBILITY DRAG, XB-70

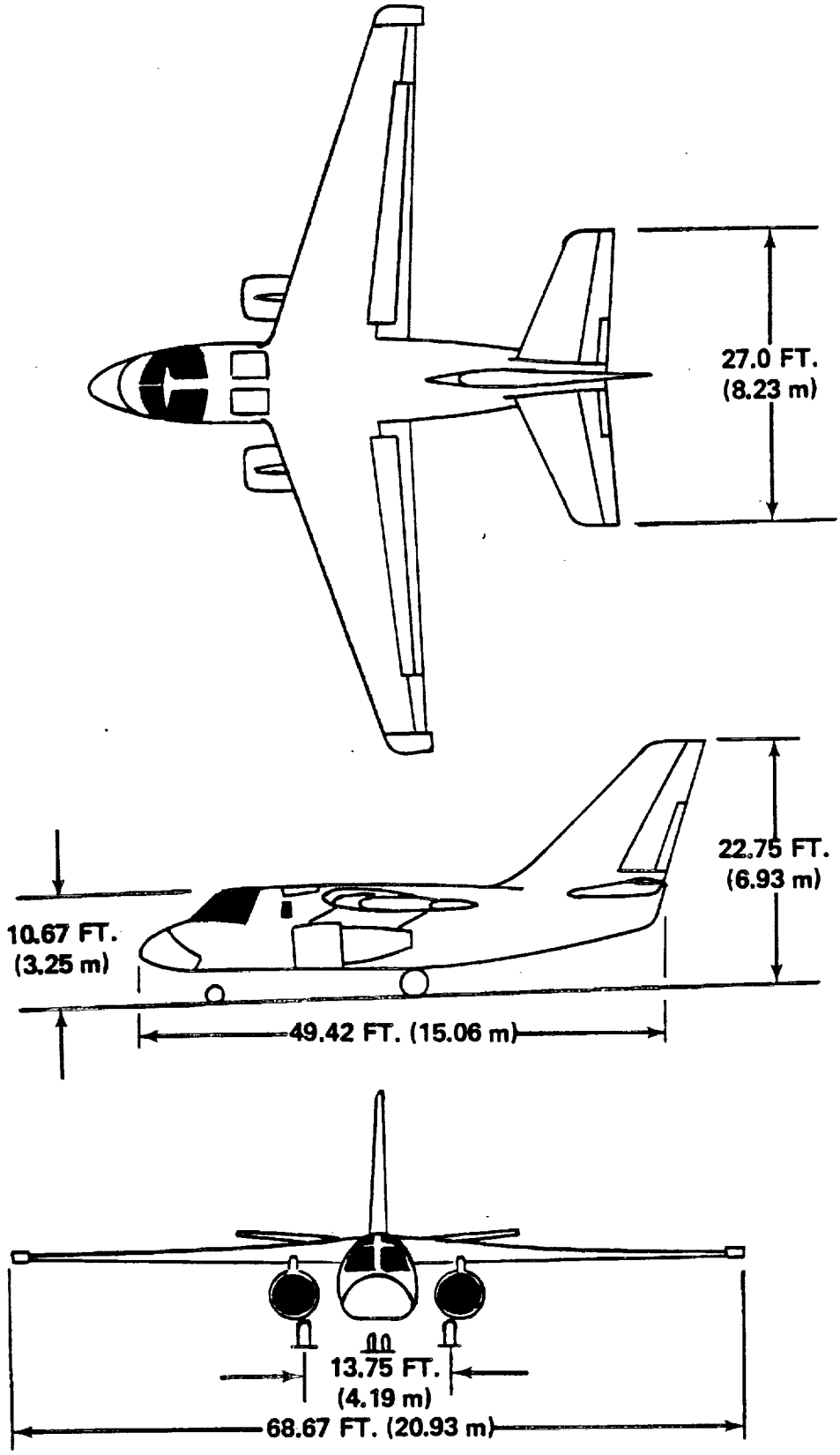

FIGURE 168. THREE-VIEW, S-3A

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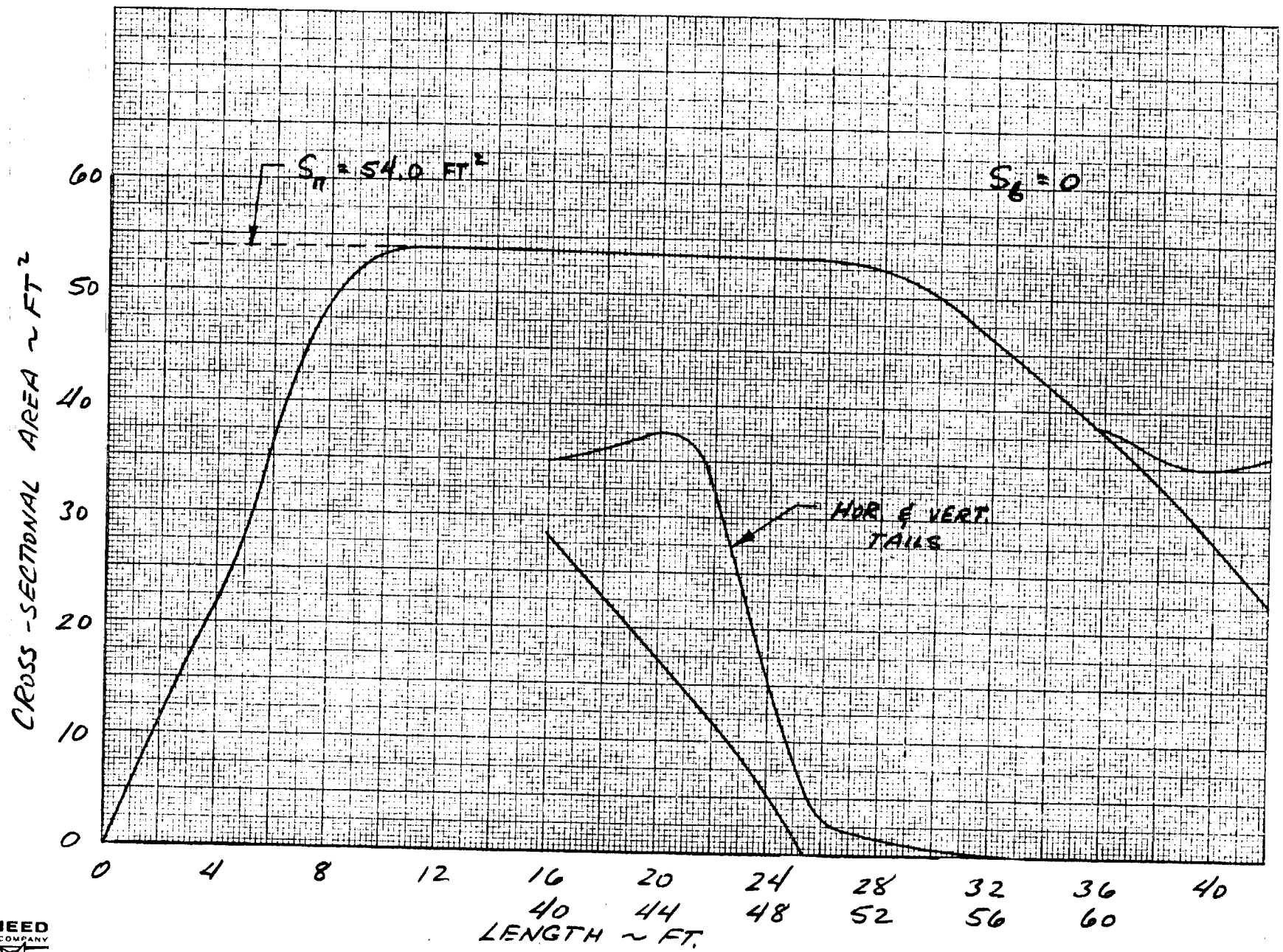

FIG. 169 S-3A FUSELAGE AREA DISTRIBUTION

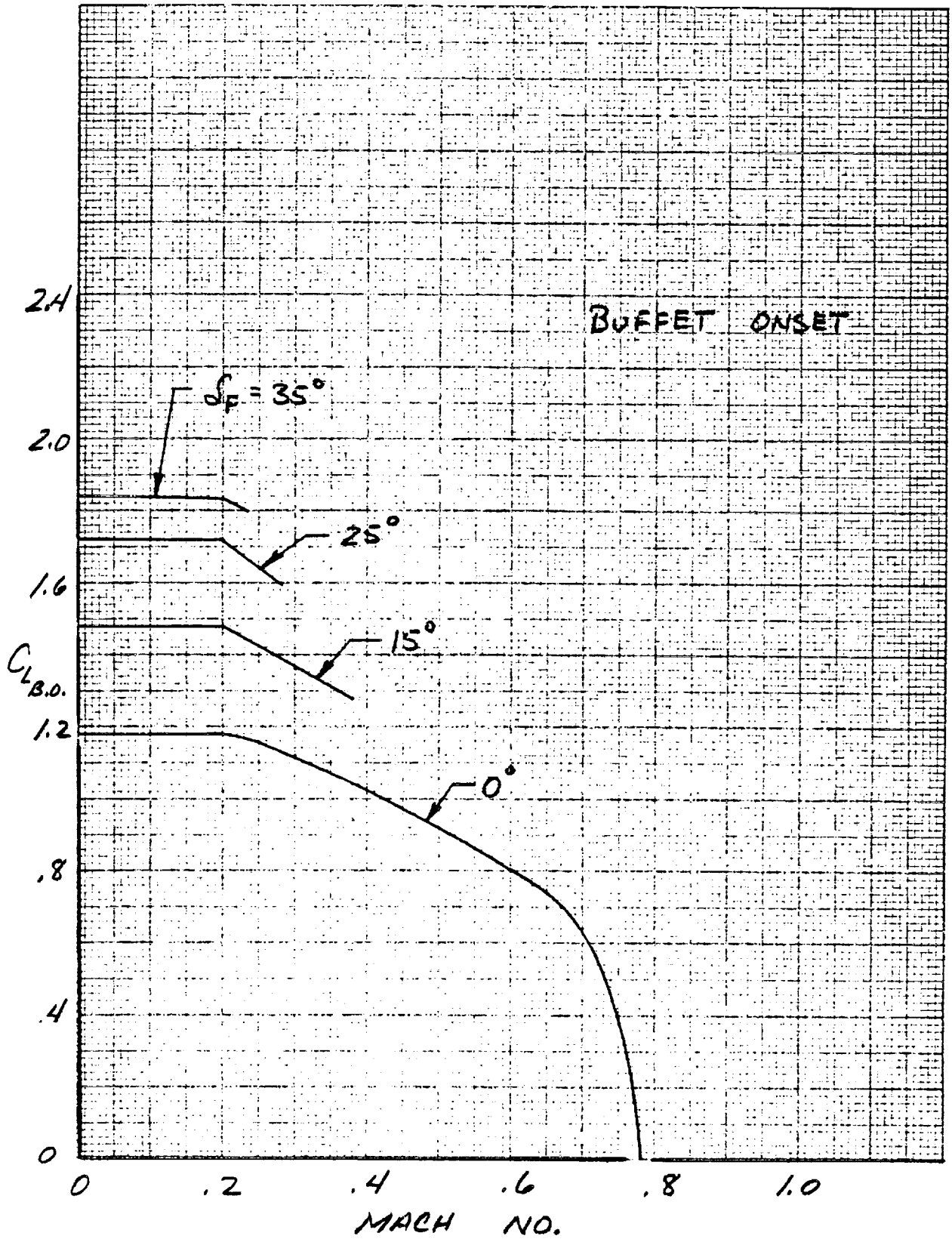

FIG. 170 LIMIT LIFT CHARACTERISTICS, S-3A

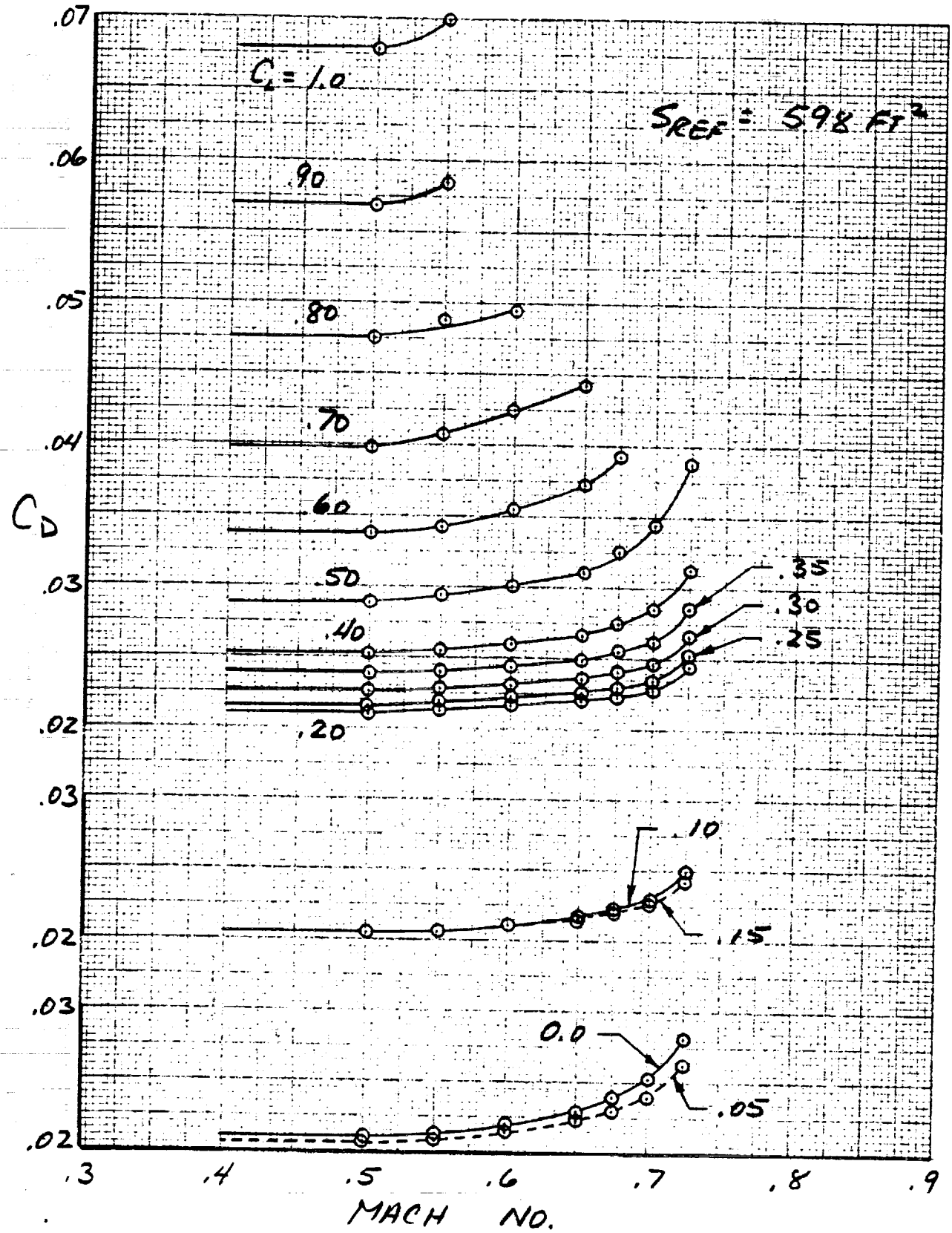

FIG. 171 S-3A DRAG CHARACTERISTICS

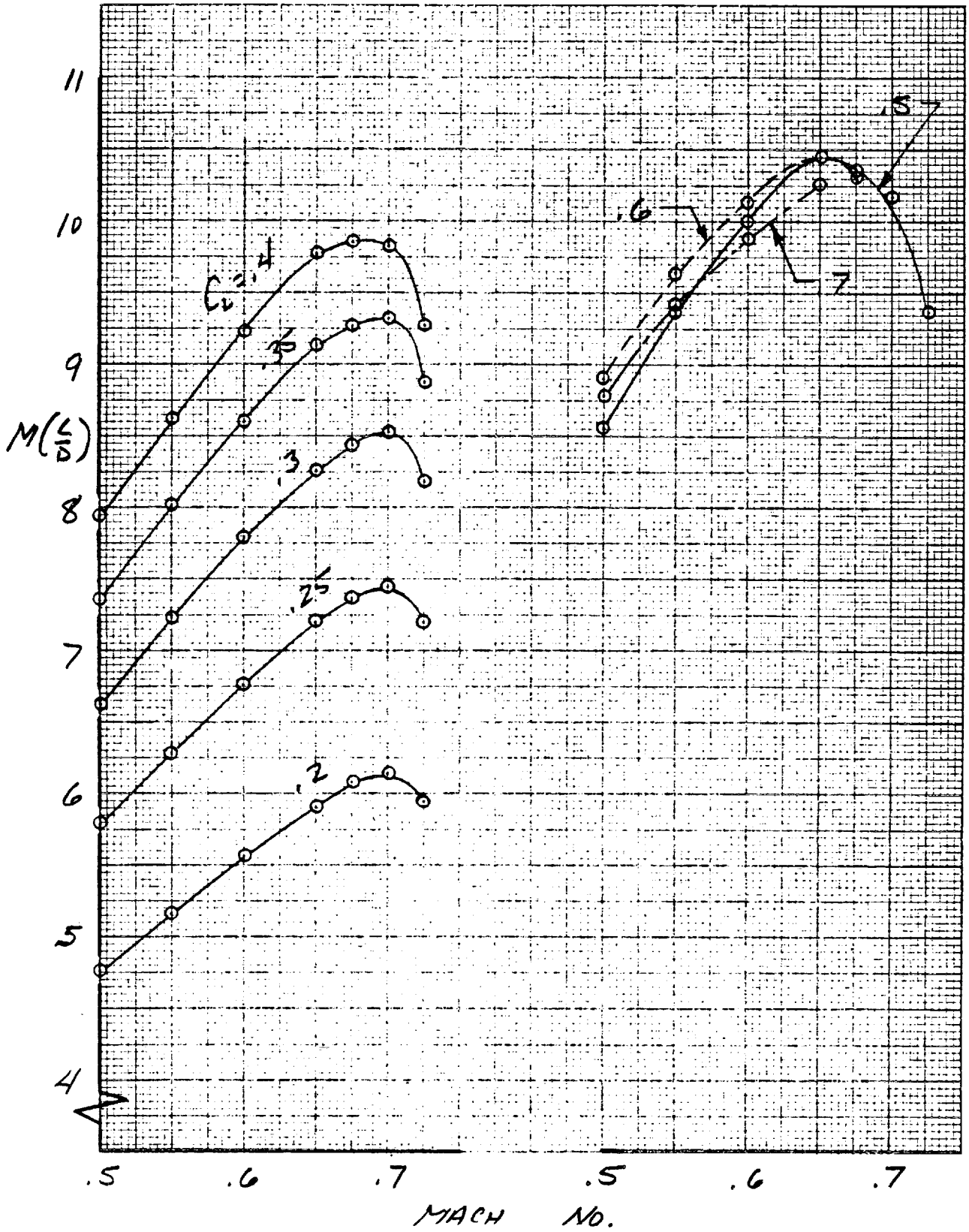

FIG. 172 M(L/D) VS. MACH NUMBER, S-3A

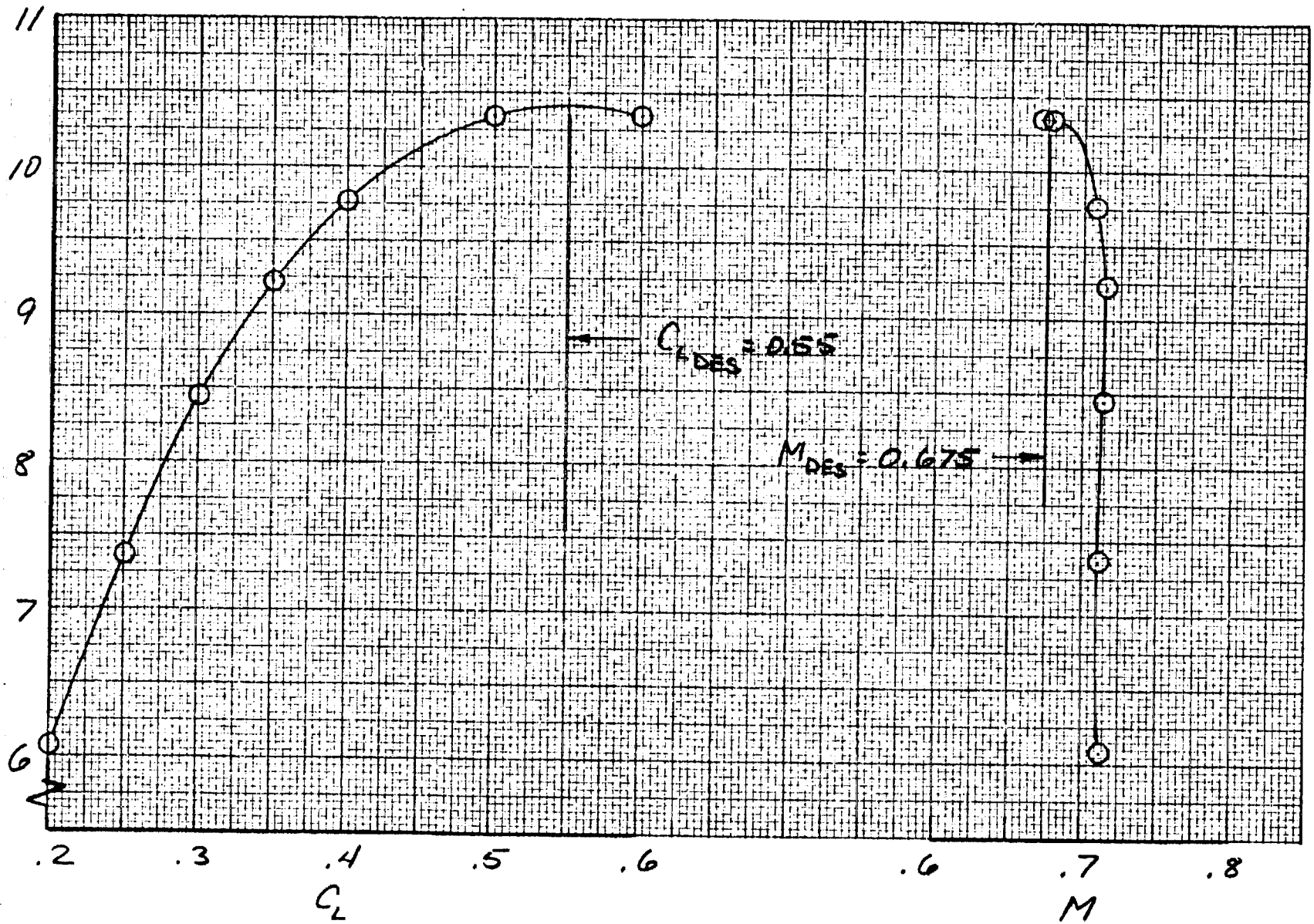

FIG. 173 $C_{L_{DES}}$ AND M_{DES} FOR S-3A

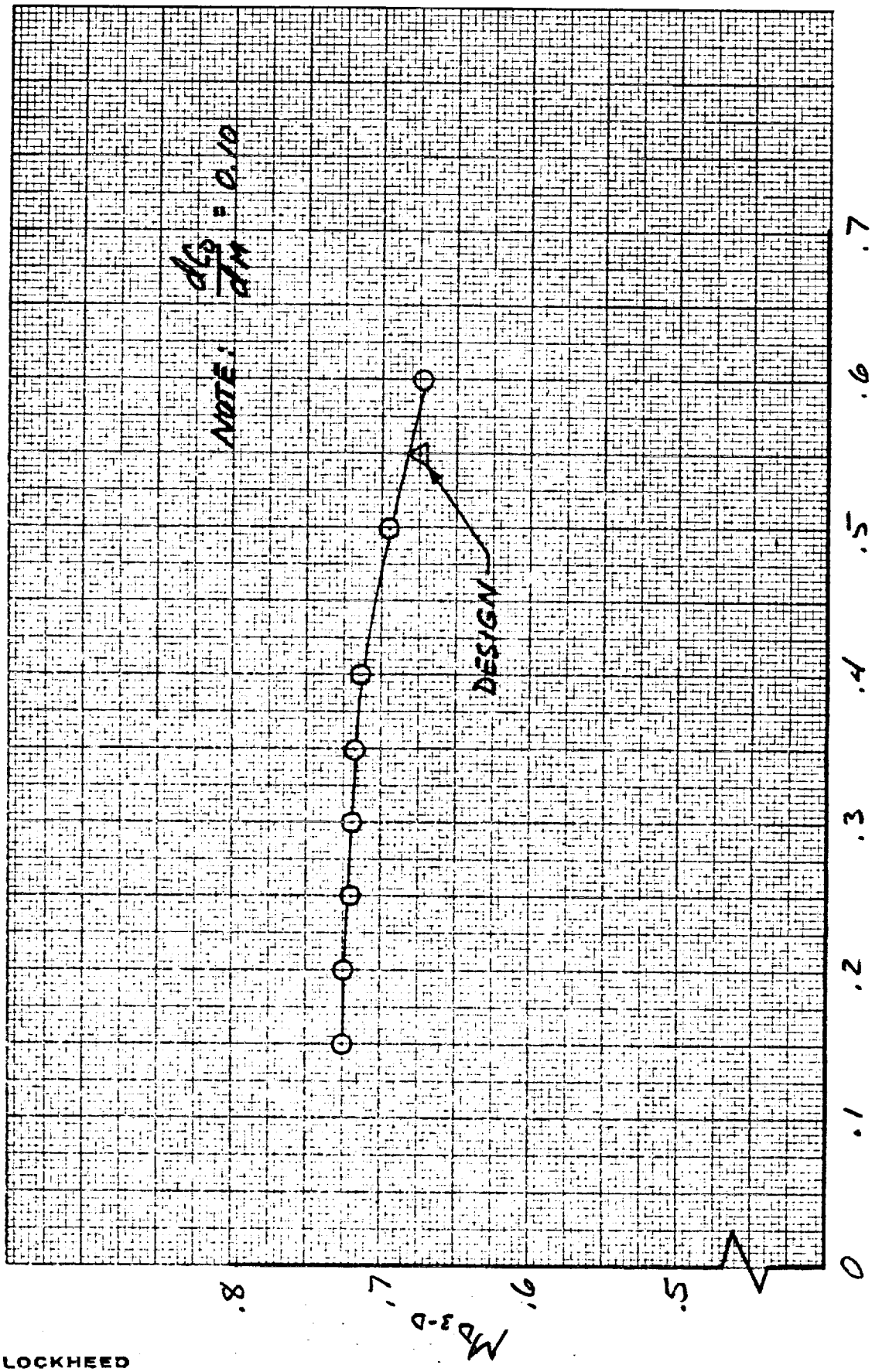

FIG. 174 DRAG DIVERGENCE CHARACTERISTICS, S-3A

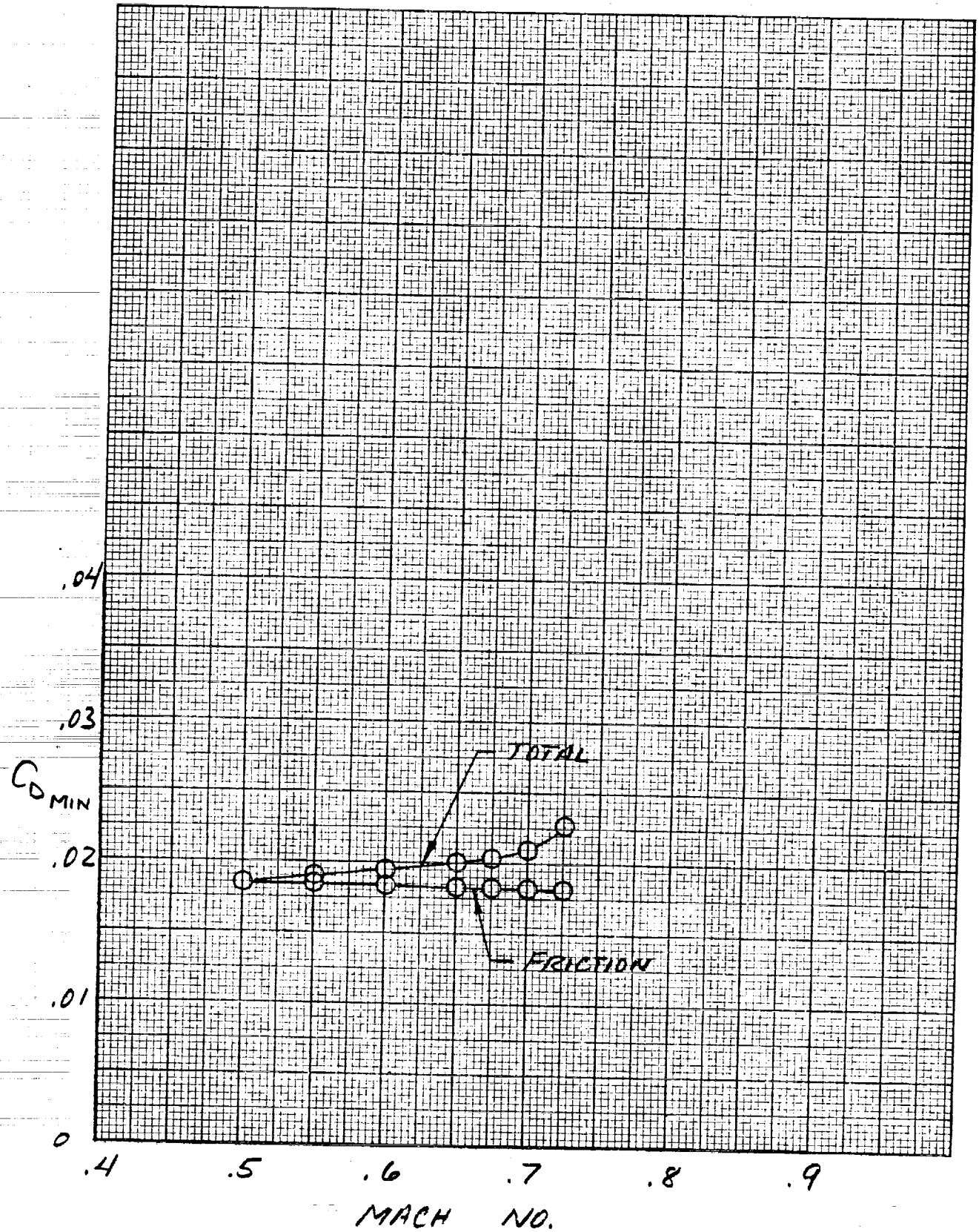

FIG. 175 MINIMUM DRAG BREAKDOWN, S-3A

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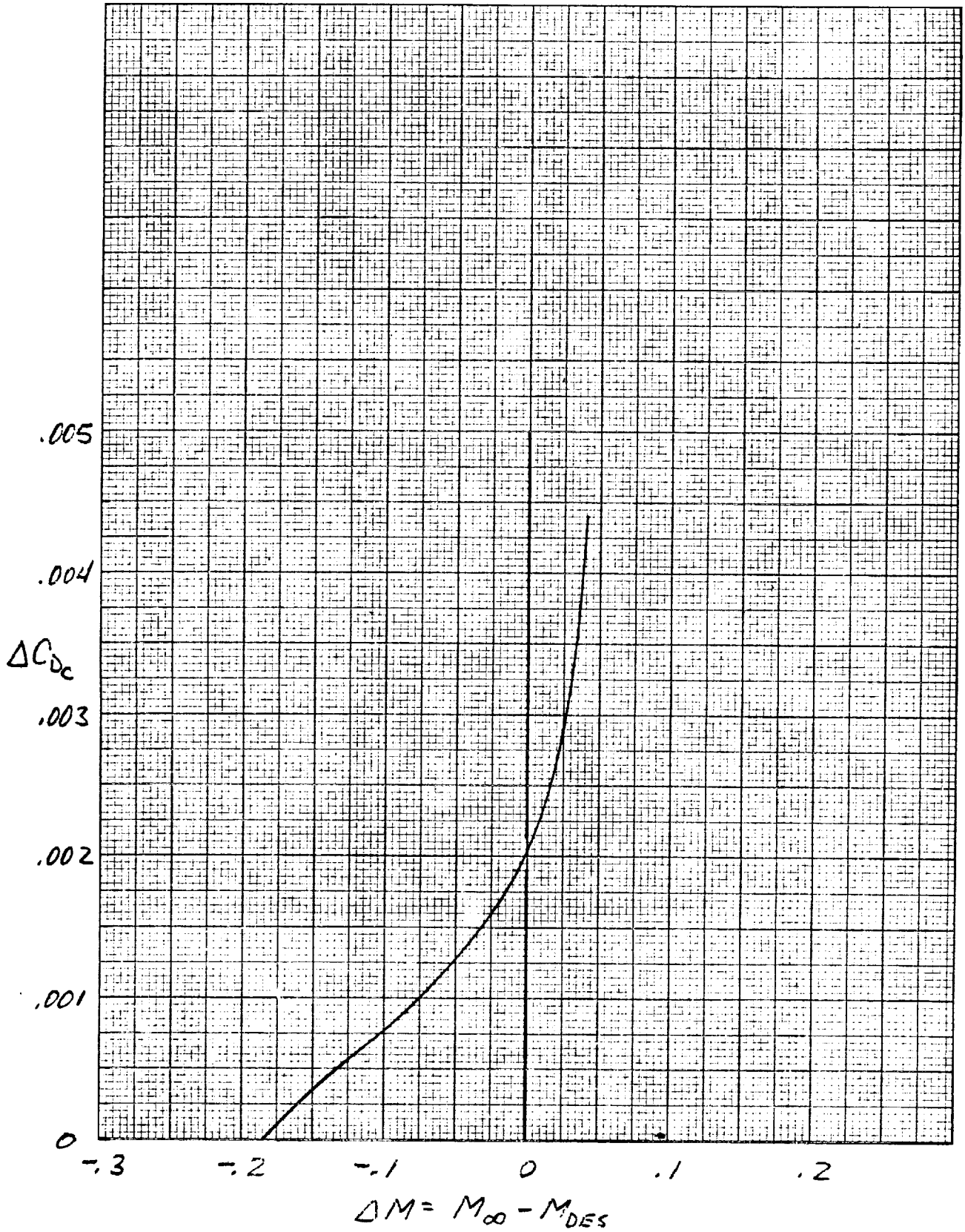

FIG. 176 COMPRESSIBILITY DRAG, S-3A

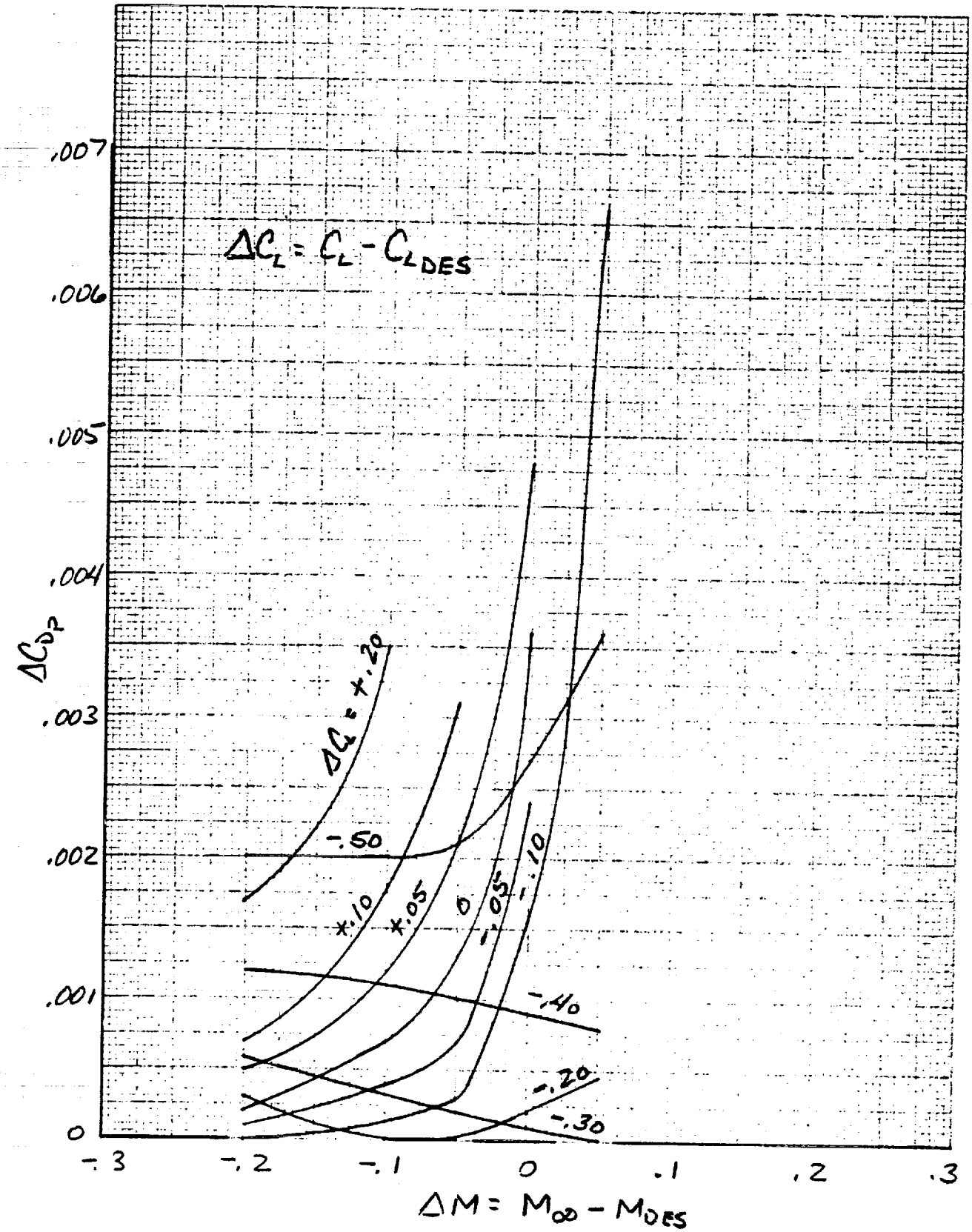

FIG. 177, WING PRESSURE DRAG VARIATION, S-3A

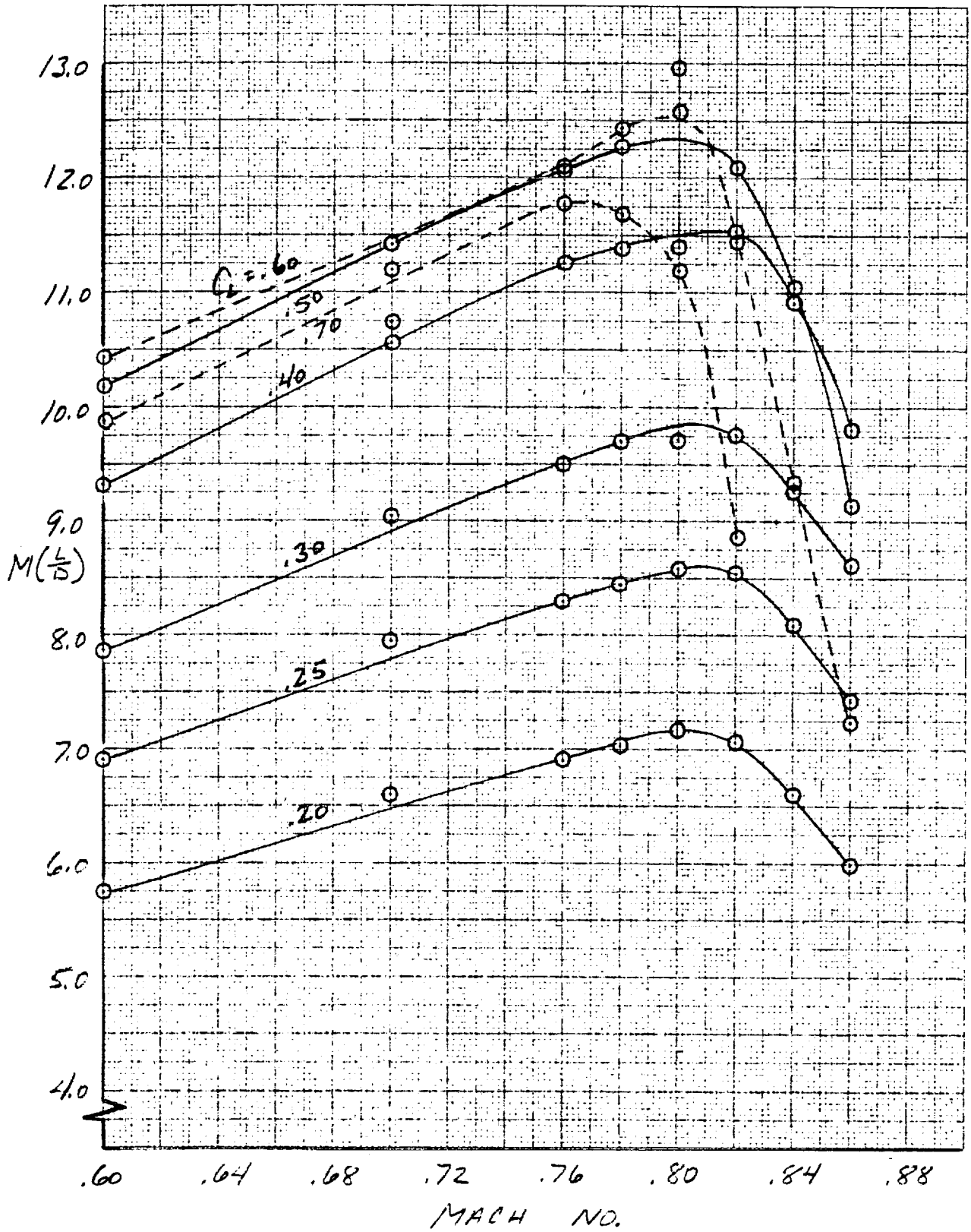

FIG. 178 $M\left(\frac{L}{D}\right)$ VS. MACH NUMBER, WING 51

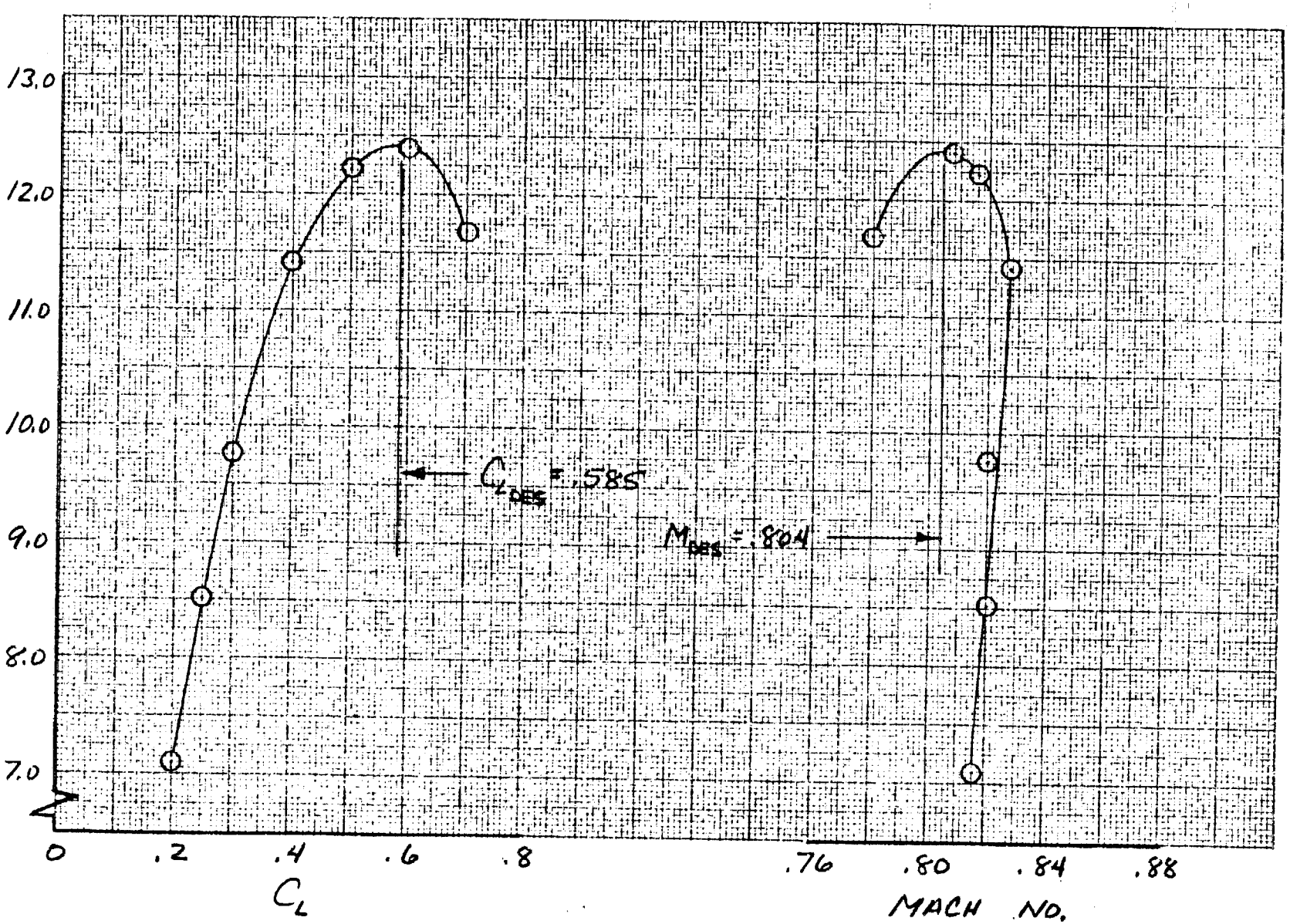

FIG. 179 $C_{L_{DES}}$ AND M_{DES} FOR WING 51

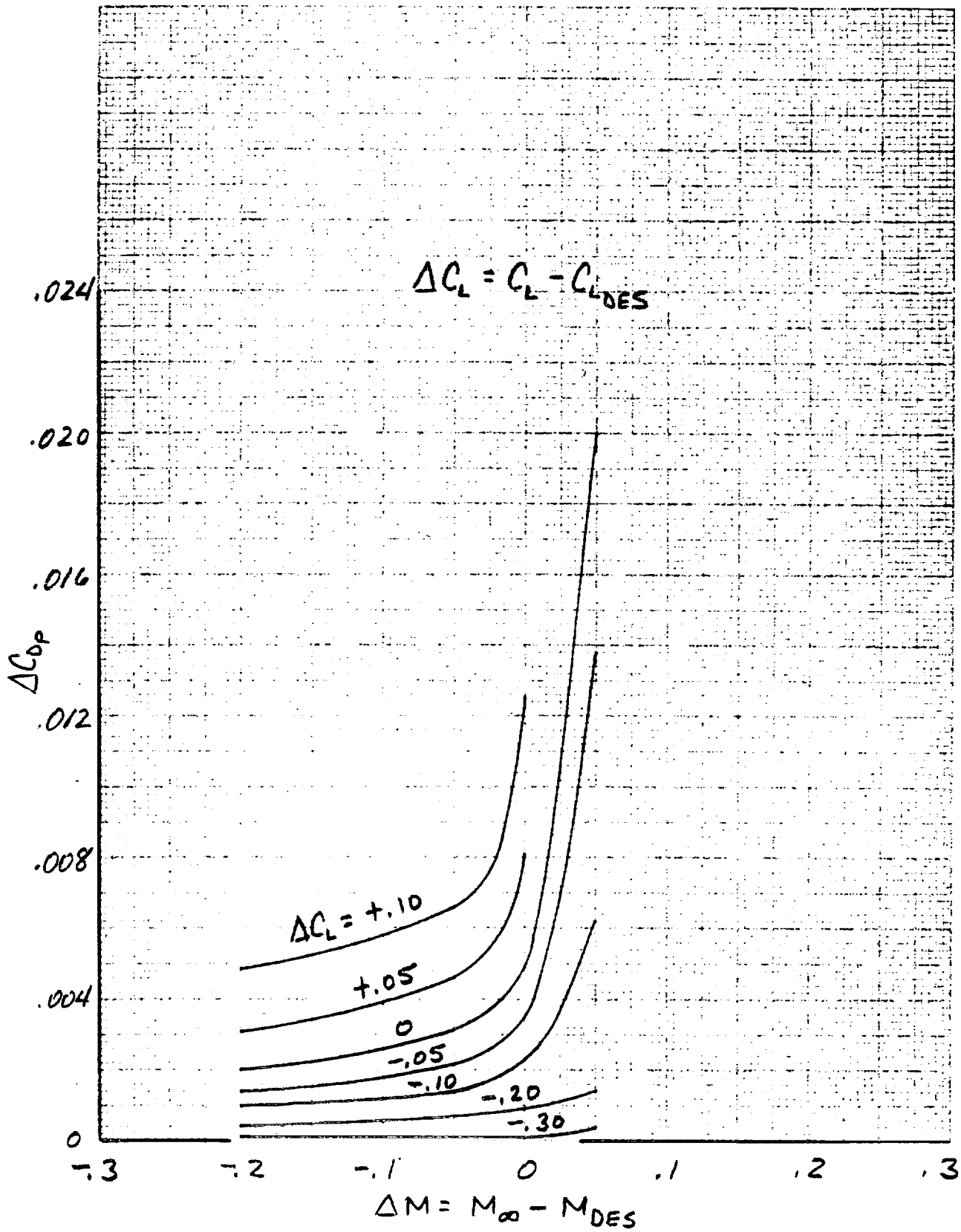

FIG. 180 WING PRESSURE DRAG VARIATION, WING 51

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2. Elliott, D. W.: Substantiating Data Report Based on Flight Test Data for the T-2B Trainer Power with Two T60-P-6 Engines. North American Aviation, Inc. NA64H-536, 7 June 1964.

3. Wong, F. T.: Model T-37B Substantiating Data for Standard Aircraft Characteristics Charts, Based on Category II Flight Test Data. Cessna Aircraft Company, 31813-7003-120, 21 December 1970.

4. Anon.: Performance Data for the Model A3D-2, 2P and 2Q, (KA-3B) Airplanes Based on Flight Test Data. Douglas Aircraft Company, Inc. 29 April 1960.

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