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SC-TM-27-53-12

RESULTS OF WIND TUNNEL TESTS OF FULL-SCALE SINGLE FIN PANELS FOR TX-7

Douglas Aircraft Company, Inc.

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW DOWNGRADING OR DECLASSIFICATION STAMP	
CLASSIFICATION CHANGED TO: U Emelda Selph 4/21/97 CHANGING MARKING & DATE 5/5/97 Carmela M Gallegos PERSON VERIFYING MARKING & DATE	AUTHORITY: R. B Craner RECORD ID: 97SN1100 DATED: 3/26/97

ABSTRACT

This report shows the results of tests performed to determine if modifications to the trailing edge of the airfoil section of the fin would increase the fin effectiveness and therefore, the static stability of the TX-7X1.

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW	
1st Review Date: 3-25-97 Authority: CLASS X ADD Name: W. Layne 2nd Review Date: 3/26/97 Authority: ADD Name: RB Craner	Determination (Circle Number): 1 Classification Retained 2 Classification Changed to: U 3 Contains No DOE Classified Information 4 Contains With: 5 Contains UCAI? 6 Comments: OK for Openness

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March 11, 1953

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DOUGLAS AIRCRAFT COMPANY, INC.

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Engineering DEPARTMENT

DOUGLAS

REPORT NUMBER

ES 17183

RESULTS OF WIND TUNNEL TESTS

OF

FULL-SCALE SINGLE FIN PANELS FOR TX-7

CONTRACT NO. BD-461, S.O. 6789-5

REPORT DATE Dec. 19, 1952

MODEL External Stores

CLASSIFICATION Confidential-Restr.Data

PREPARED BY L. E. Sattler

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APPROVED BY [signature]
for Chief Engineer

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1.0 SUMMARY

This report presents the results of wind tunnel tests conducted on full-scale single-fin panels of the TX-7X1 special weapon. The purpose of these tests was to determine if modifications to the trailing edge of the airfoil section of the fin would increase the fin effectiveness and therefore, the static stability of the TX-7X1.

The fin panels tested consisted of the production fin incorporating 35-degrees of sweepback, and a straight fin with zero sweepback. The tests were conducted on the single-fin panels rather than a scale model of the complete store because of the small changes involved in the fin contour.

The tests were conducted in the Southern California Cooperative Wind Tunnel and covered a Mach Number range of 0.70 to 0.95.

The results of these tests indicate that on both the sweptback and straight fin replacing the sharp trailing edge with straight sides and a bluff trailing edge increased the lift-curve slope approximately 12-percent. However, the drag increases were comparatively larger.

It was found on the sweptback fin that this drag increase of the bluff trailing edge could be reduced one-half without losing the improvement in lift-curve slope by beveling the last five percent of the airfoil chord to a sharp edge. On the straight fin this change did not give any significant drag reduction.

A boat-tailed trailing edge section which was tested did not give any worthwhile improvement in the lift curve slope of the basic sharp trailing edge section. The effects of the 12-percent increase in lift curve slope on the static stability of the TX7-X1 are estimated to be approximately 3.5 percent at a Mach number of 0.7 and 5.0 percent at a Mach number of 0.95.

All data presented in this report show the comparison of the sweptback and straight fin. In general, the results indicate that up to a Mach number of 0.95 the stability of the sweptback and straight fin are essentially the same, but the drag of the straight fin with either the bluff or beveled trailing edges is appreciably higher than the corresponding configuration of the sweptback fin.

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3.0 INTRODUCTION

A previous study of possible modification to the fin on the TX-7 special weapon (Reference 1) indicated that substantial increases in the static stability might be obtained by modifying the fin airfoil contour to incorporate slab sides and bluff or boat-tailed trailing edges. Wind tunnel tests were therefore conducted on a full-scale single-fin panel for the TX-7 X1 special weapon.

In order to compare the effect of the sweepback on the drag and stability a special fin was fabricated with zero sweep. The semi-span was maintained the same as the sweptback fin, but the chord was increased and the root leading edge was assumed three inches further back on the body in order to maintain the static stability at low Mach numbers at the same value as with the sweptback fin. Sketches of the fins and the trailing edge modifications tested are shown in Figures 1 and 2.

4.0 DESCRIPTION OF MODELS

The swept-fin model used in these tests was an actual full-scale fin for the TX7-X1 store. The basic airfoil was a modified diamond with the chord divided into thirds consisting of leading and trailing edges and a flat parallel sided central section. The airfoil contour is further modified as the fin thickness is tapered in the spanwise direction after the basic division into thirds is made. This results in the leading and trailing edge sections each being one-third of the chord only at the fin root and tapering to zero percent of the chord at the theoretical tip.

The straight fin used was a specially manufactured fin with the same airfoil contour as the swept-fin, but with zero sweepback angle of the leading and trailing edges. Both fins were made from a 1" thick aluminum plate with straight plane machine cuts forming the airfoil contour and thickness taper. The modifications to the trailing edge were made by gluing mahogany blocks to the metal fin.

A single base fairing of mahogany was used to mount both models to the wind tunnel floor. This fairing matched the contour and radius of the TX-7 special weapon in the area of the fins. The ordinates of this fairing are given in Figure 3.

The pertinent dimensional data of the two fins are in the following table.

		Swept Fin	Straight Fin
Sweepback	(deg)	35	0
Span	(in)	29	29
Chord (1)	(in)	19	17
Area	(ft^2)	3.545	3.425
Exposed Area	(ft^2)	2.805	2.82
Aspect Ratio (2)		3.31	3.4
Root Thickness	(in/%)	1.0/5.25	1.0/5.5
Tip Thickness	(in/%)	.125/.67	.125/.73

(1) Parallel to store centerline
(2) Based on two fins in same plane

5.0 DISCUSSION OF RESULTS

5.1 Lift Curve Slope

The curves of lift coefficient vs. angle of attack are shown on Figures 4 and 5 for the sweptback and straight fin respectively. Curves are shown for the bluff, beveled and sharp trailing edges. The boat-tail trailing edge data have been omitted from these curves for purposes of clarity as the results were essentially identical to the sharp trailing edge fin.

The values of lift curve slope vs. Mach number are shown on Figure 6. For the sweptback fin the lift curve slope of the bluff and beveled trailing edge are identical, but for the straight fin, the beveled trailing edge is not quite as effective as the bluff trailing edge above a Mach number of 0.90. The increase of the lift curve slope for the modified trailing edges compared to the sharp trailing edge is approximately 11.5% at M = 0.70 and 12.0% at M = 0.95.

The effect of this increase in lift curve slope on the static stability margin of the TX-7X1 is discussed in Section 5.4.

5.2 Drag

The curves of drag coefficient vs. angle of attack are shown on Figures 7 and 8 for the sweptback and straight fin respectively. The summary of the drag coefficient at zero angle of attack vs. Mach number is presented on Figure 9.

The drag level of the straight fin is consistently higher than that of the sweptback fin at all Mach numbers. With the sharp trailing edges the drag difference is quite small. However, with the bluff or beveled trailing edges, the drag difference becomes quite large. It should also be noted that on the straight fin the drag of the beveled trailing edge fin is identical to the bluff trailing edge, both of which have approximately three times the drag of the sharp trailing edge fin. In the sweptback fin the beveled trailing edge has only about one-half the drag increase of the bluff trailing edge over the sharp trailing edge fin. The drag of the beveled trailing edge fin being only 1.9 times the drag of the drag of the sharp trailing edge fin and the bluff trailing edge being 2.7 times the sharp trailing edge.

Figure 10 presents the drag of the various three fin installations on the TX-7X1; the drag coefficient is based on the store frontal area. Figure 11 shows the total drag of the TX-7X1 with various fin installations. With the sharp trailing edge sweptback fins the total drag coefficient is .050, adding the

5.2 Drag - continued:

beveled trailing edge to the fins increases the drag to .061 or an increase of 22%. Adding the straight fin with either the bluff or beveled trailing edges would increase the drag to .080 or an increase of 60%.

5.3 Center of Pressure

The location of the center of pressure of the fins as the percent of the root chord vs Mach number is shown in Figure 12. The center of pressure moves aft with the bluff or boat-tailed trailing edges as compared to the sharp trailing edges. This aft movement for the sweptback fin is about 2.5% at all Mach numbers up to M = 0.95. For the straight fin the difference is a little larger, being about 3.5% at low Mach numbers and about 6.5% at M = 0.95.

The important aspect of the center of pressure location of the fin in determining its effect on the static stability margin of a store is the distance between the store c.g. to the fin center of pressure. This distance in the form of a ratio of this distance to the store length is presented on Figure 13. The fin leading edge-body contour intersection for the straight fin is assumed to be 3" further aft than the swept fin so that the low speed stability equals that of the swept fin.

5.4 Effect on Static Stability of TX7-X1

The effect of the bluff and beveled trailing edges on the static stability margin of the TX-7 X1 is shown on Figure 14. These curves indicate that the static stability with either the straight or sweptback fin is essentially the same.

The static stability margin was computed by adding the fin characteristic to the body alone characteristics. The body alone C_{m_α} and C_{L_α} were obtained from Reference 1. When the fin parameters were added directly to the body parameters, the static margin was much greater than actually measured by wind tunnel tests of a scale model store with sharp trailing edge fins. Therefore, a reduction factor was calculated for the sharp trailing edge fins to make it correlate and these factors were then used for the other fin configurations.

6.0 CONCLUSION

As a result of these tests the following conclusions are presented:

1. The static stability margin of the TX7-X1 is increased approximately 3.5 percent at a Mach number of 0.7 and 5.0 percent at a Mach number of 0.95 if the sharp trailing edge of the fin is changed to one with straight sides and either a bluff trailing edge or a bevel on the aft 5-percent of the chord. The beveled trailing edge has about one-half the drag increase of the bluff trailing edge and is therefore recommended on this basis.

2. The static stability of the TX7-X1 is essentially the same with either the 35 degree sweptback or straight fin provided the straight fin is located further aft so that it intersects the store contour three inches aft of the sweptback fin-body contour intersection.

3. Improvement in the static stability characteristics of the straight fin by use of either bluff or beveled trailing edges results in much higher drag increase than with swept-fins. Beveling the aft five percent of the chord does not reduce significantly the drag of the bluff trailing edge straight fins.

7.0 REFERENCES

1. Douglas Aircraft Company, Inc. Report No. ES 16115, "Study of Alternate Fin Arrangements for TX-7 Special Weapon", by L. E. Sattler, dated May 23, 1952. Confidential.

2. Southern California Cooperative Wind Tunnel Report No. CWT 295 "Report on High Speed Wind Tunnel Tests of Two Douglas El Segundo Fins", by W. H. Stuth, dated Sept. 19, 1952. Confidential.

Figure 1.

SWEPT-BACK FIN CONFIGURATION

SEMI-SPAN = 29 INCHES
CHORD = 18 INCHES (PARALLEL TO CENTER LINE)
ROOT THICKNESS = 1.0 INCHES

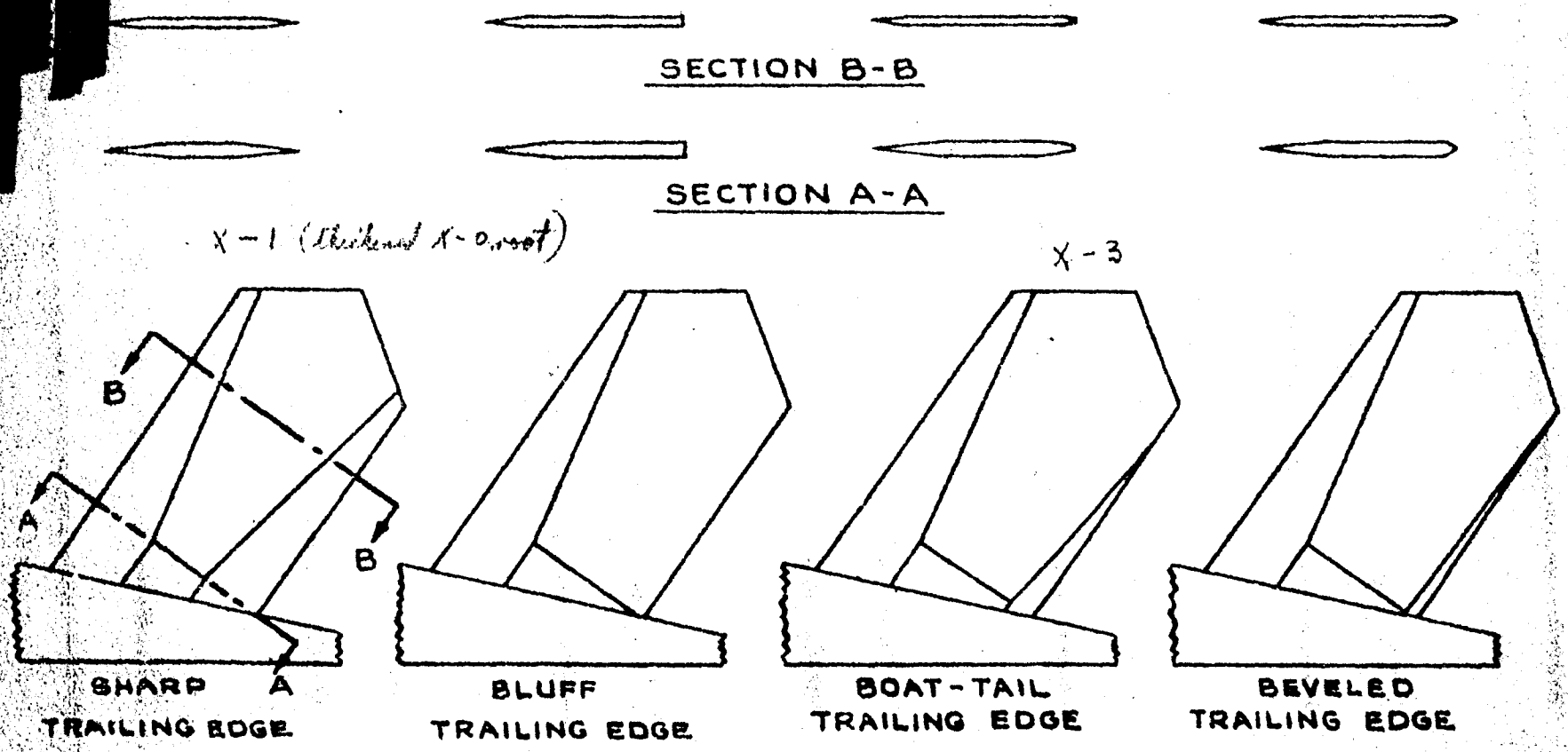

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Figure 2

DOUGLAS AIRCRAFT COMPANY, INC. EL SEGUNDO DIVISION EL SEGUNDO, CALIFORNIA

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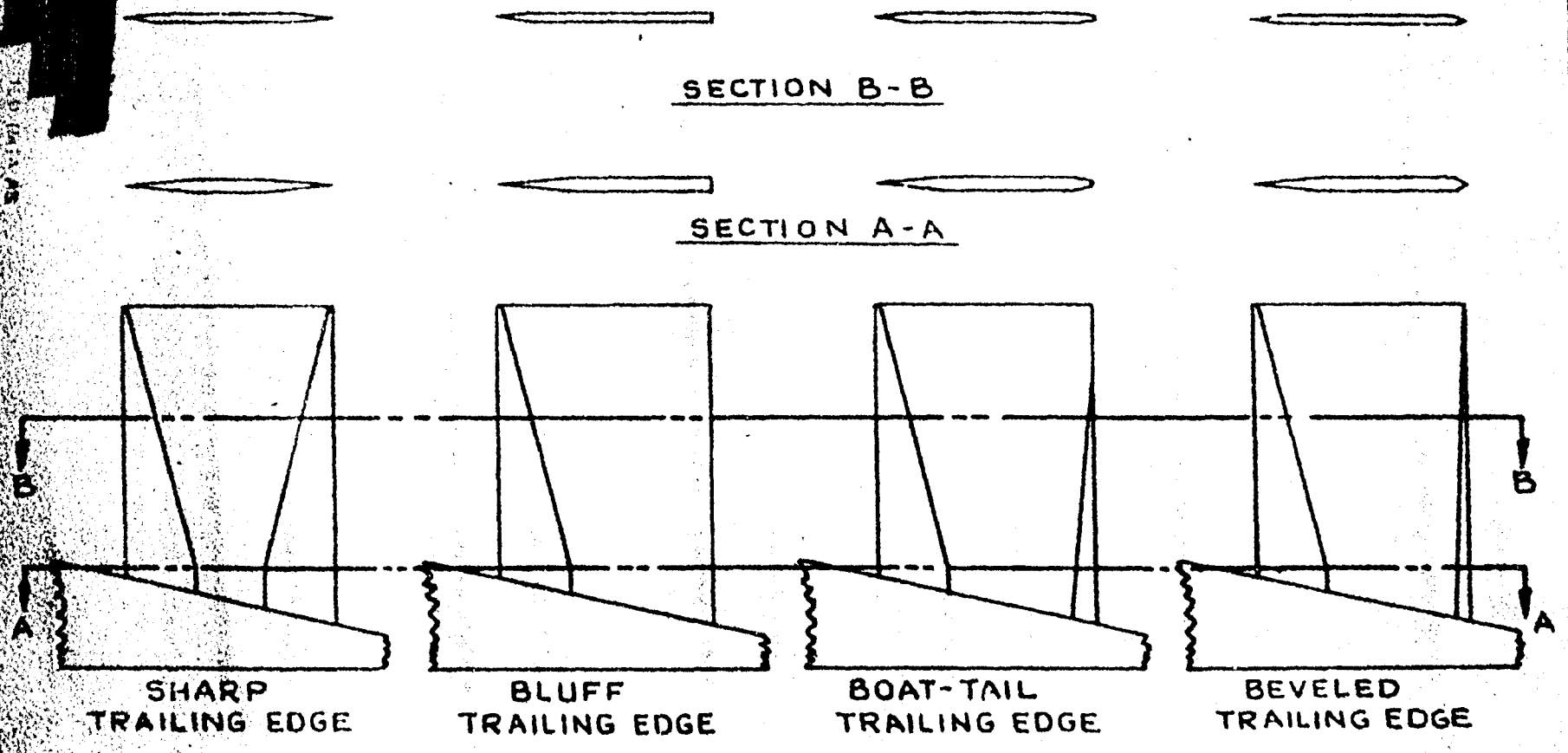
Ref. Sym.

STRAIGHT FIN CONFIGURATION

SEMI-SPAN = 29 INCHES

CHORD = 17 INCHES

ROOT THICKNESS = 1.0 INCHES



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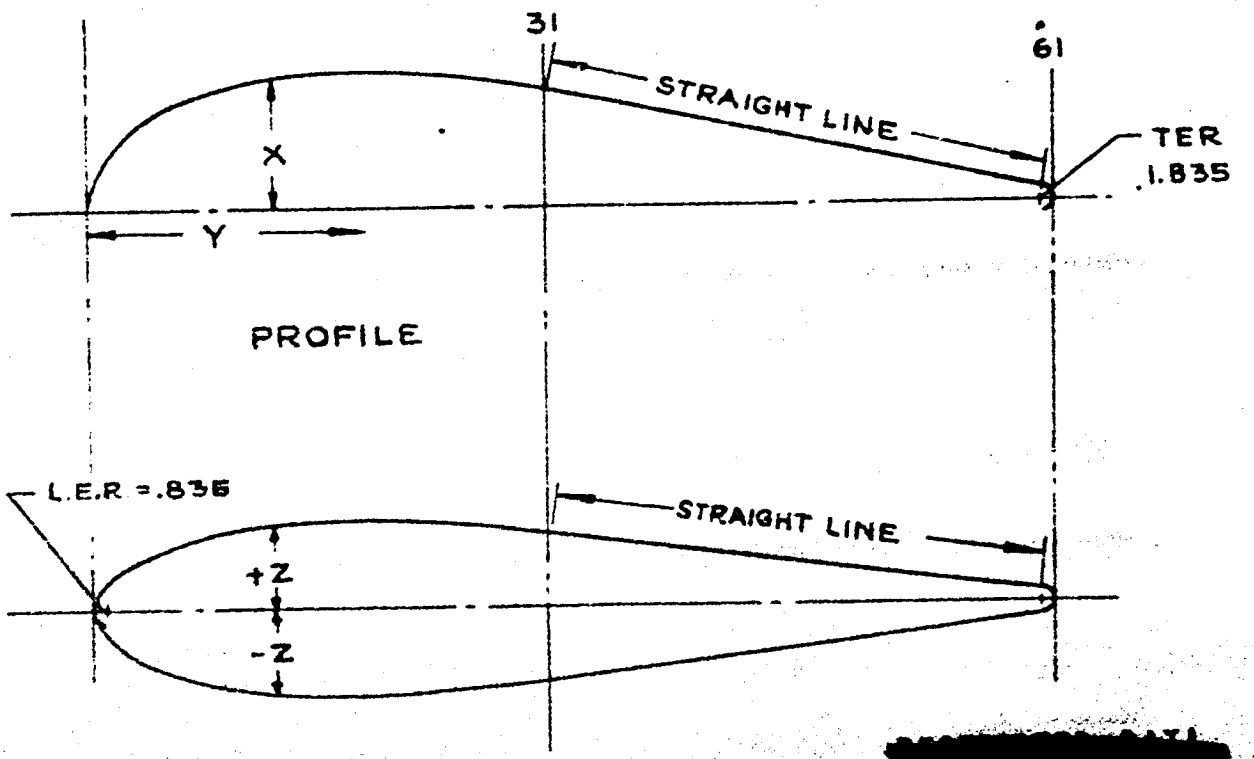
FIN INSTALLATION
F.S. WITH EXTERNAL STORE SINGLE
FWD. FAIRING

Y	X	± Z
0	0	0
.838	2.950	1.170
1.675	4.030	1.655
3.350	5.440	2.311
5.025	6.390	2.775
6.700	7.080	3.124
10.050	8.050	3.595
13.400	8.560	3.860
16.750	8.800	3.987
20.100	8.770	4.020
23.400	8.560	4.000
26.800	8.110	3.917
31.000	7.350	3.750
61.000	0	0



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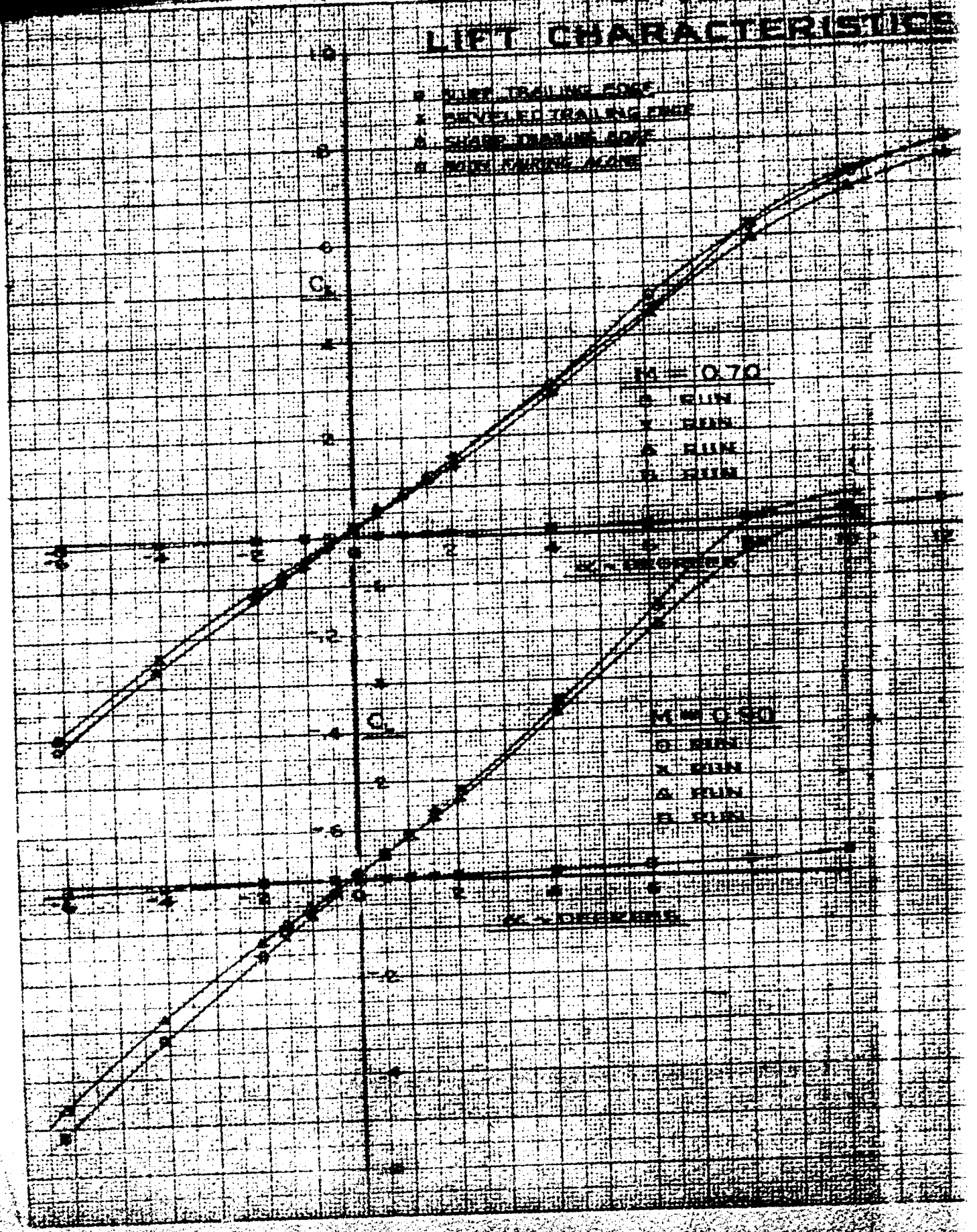
LIFT CHARACTERISTICS



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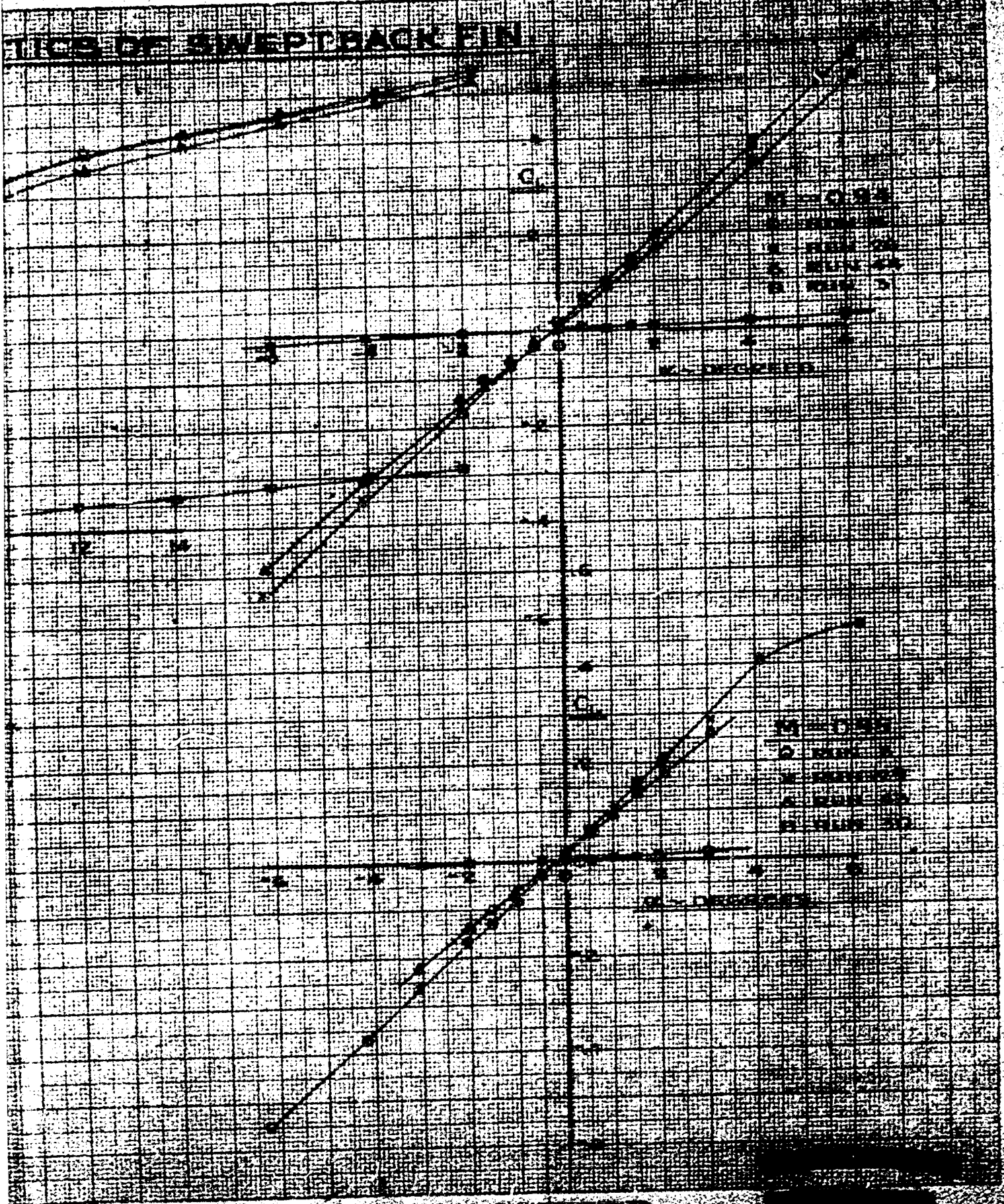
TICS OF SWEPTBACK FIN
C_L
C_L
12
14

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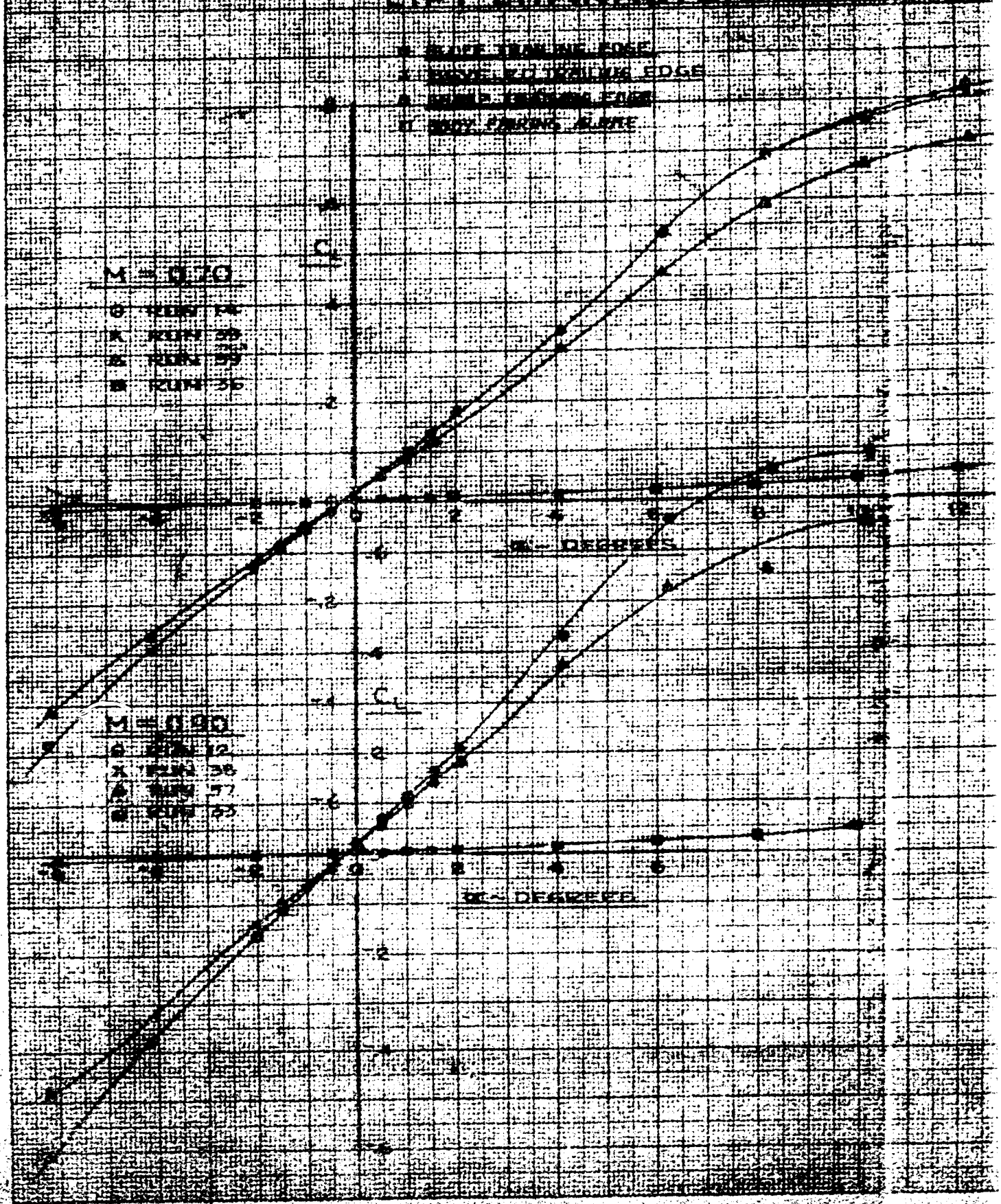
LIFT CHARACTERISTICS OF



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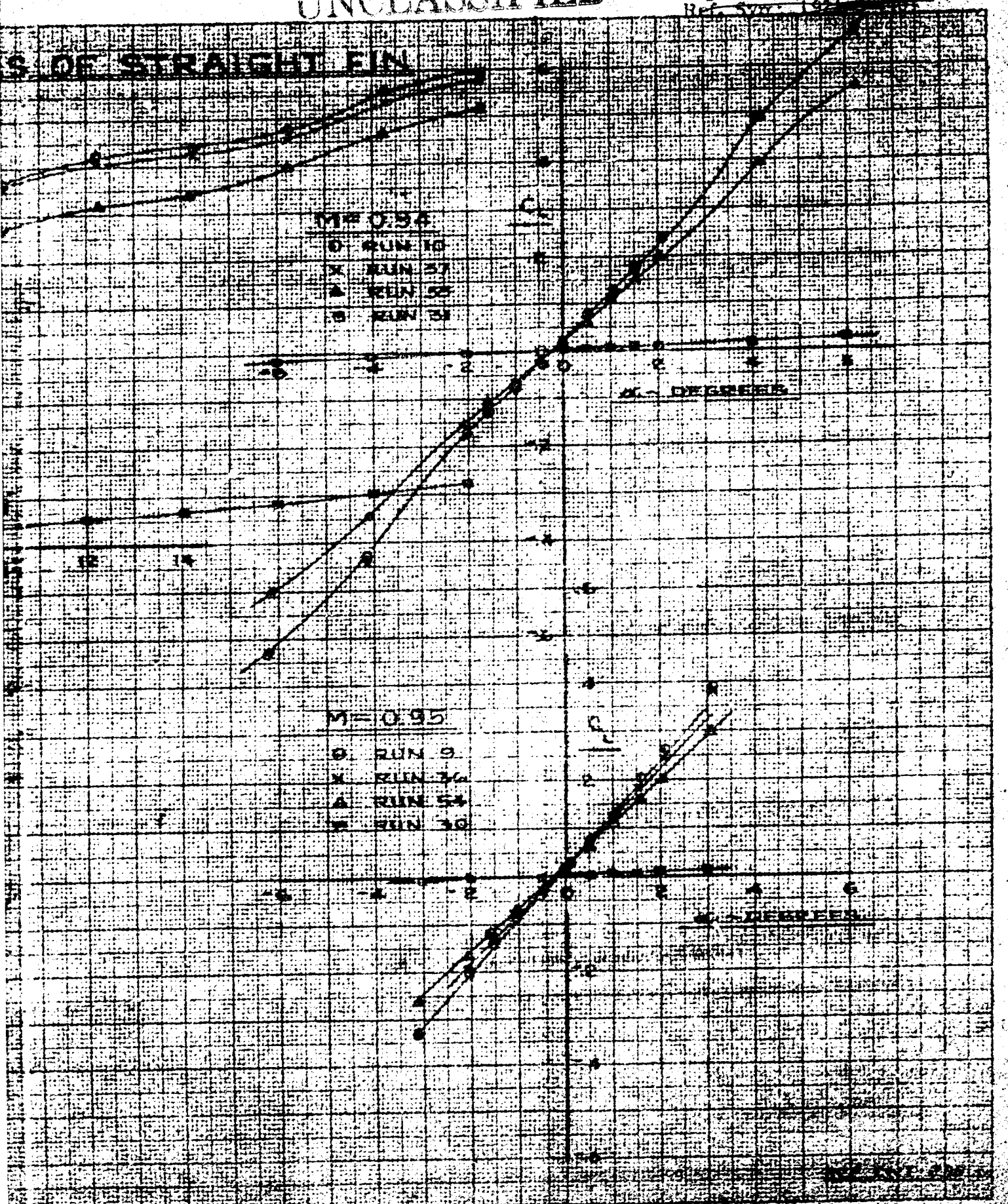
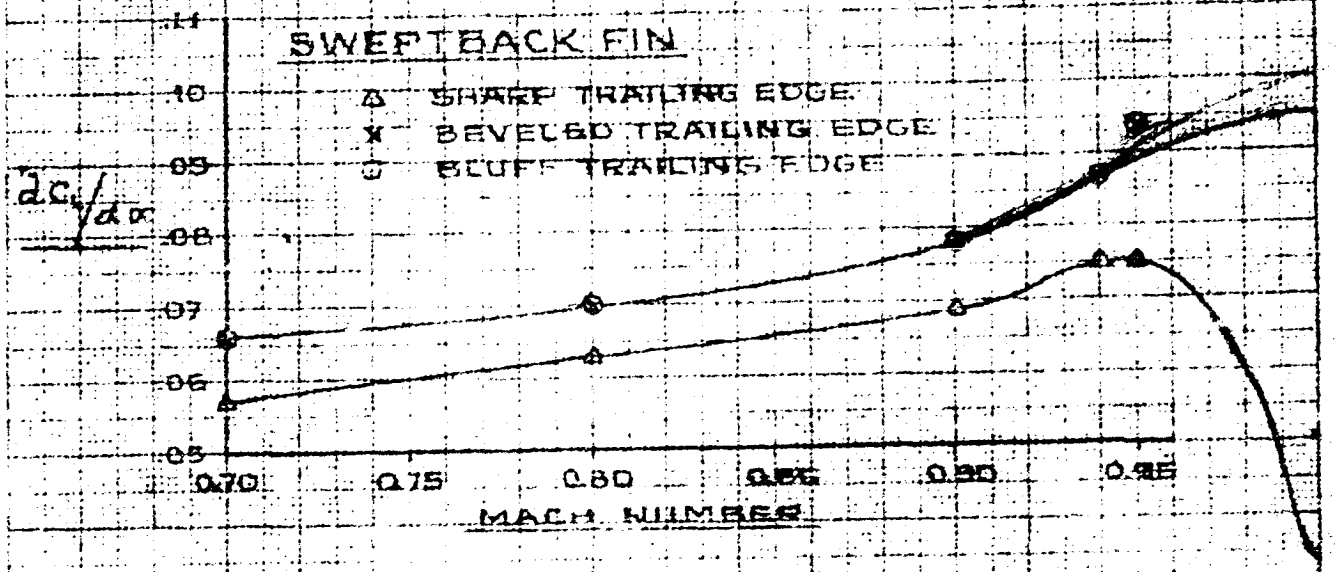
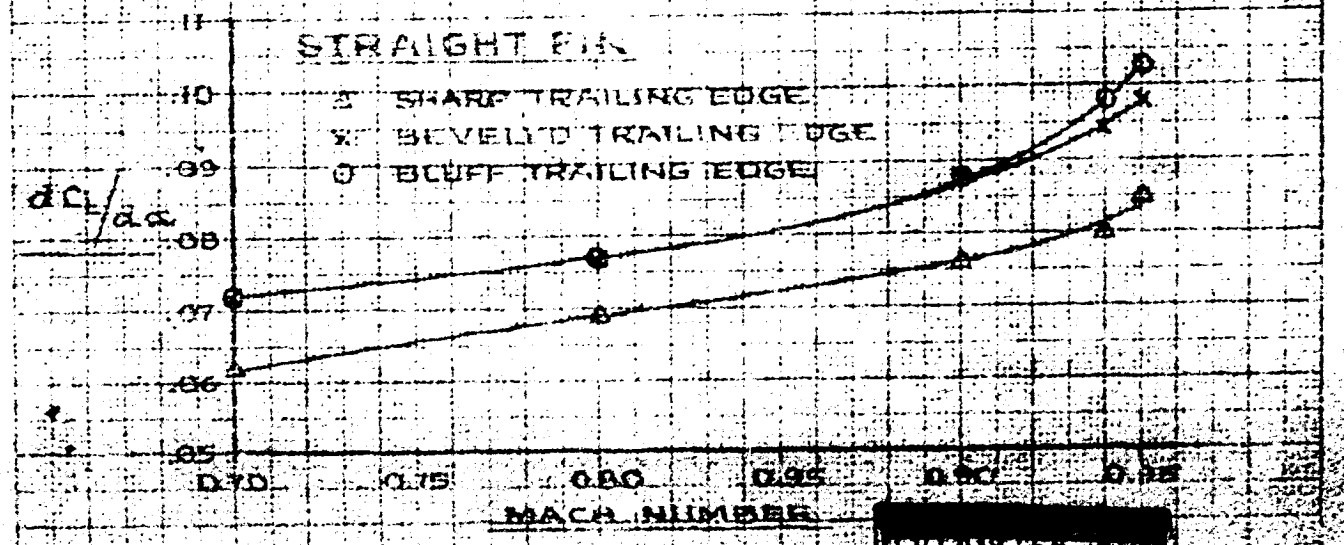

S OF STRAIGHT FIN
M = 0.94
RUN 10
RUN 37
RUN 53
RUN 31
C_L
α - DEGREES
M = 0.95
RUN 9
RUN 36
RUN 54
RUN 30
C_L
α - DEGREES

LIFT CURVE SLOPE

ALL COEFFICIENTS BASED ON TOTAL FIN AREA

X .7 to change to S_π





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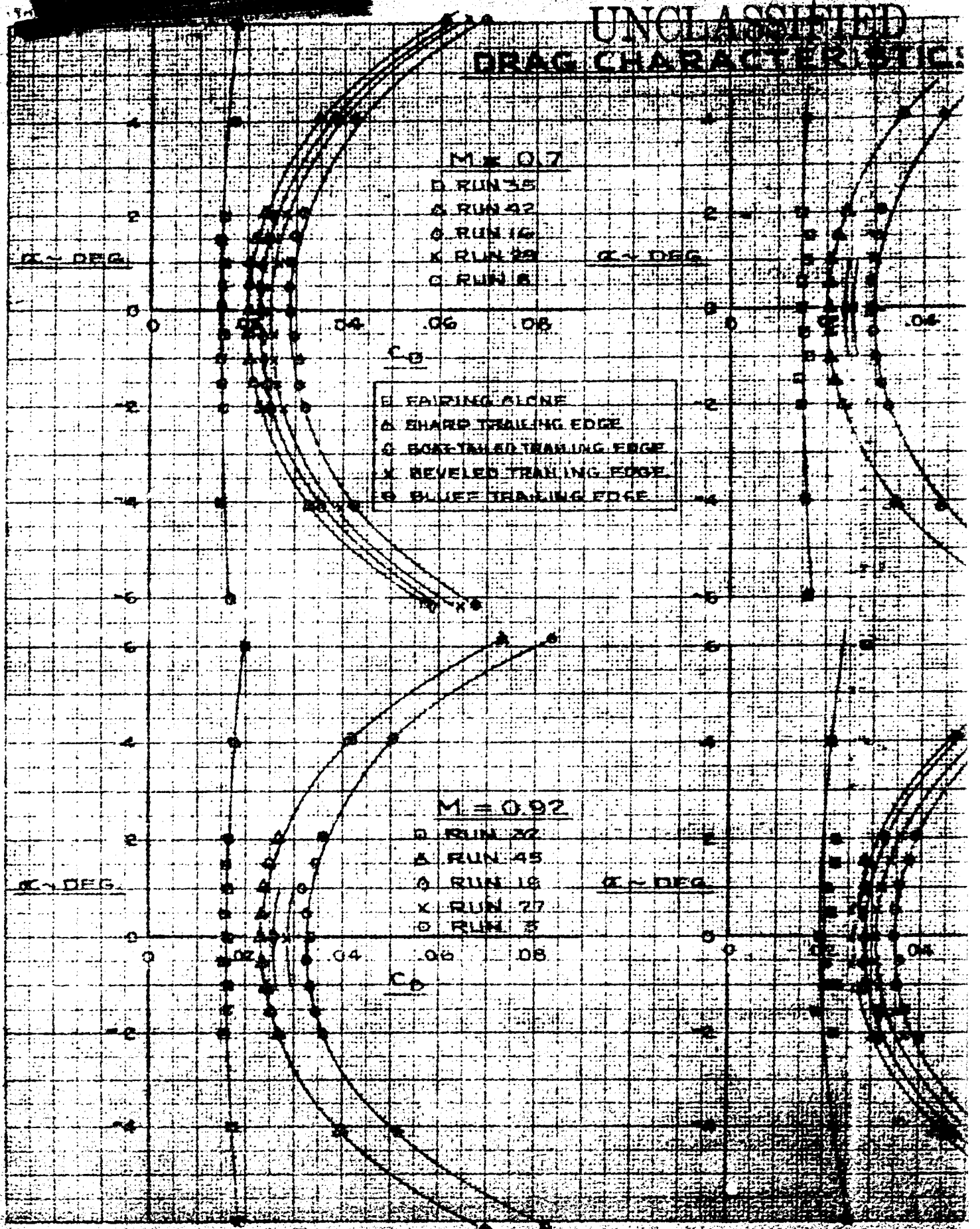
DRAG CHARACTERISTICS



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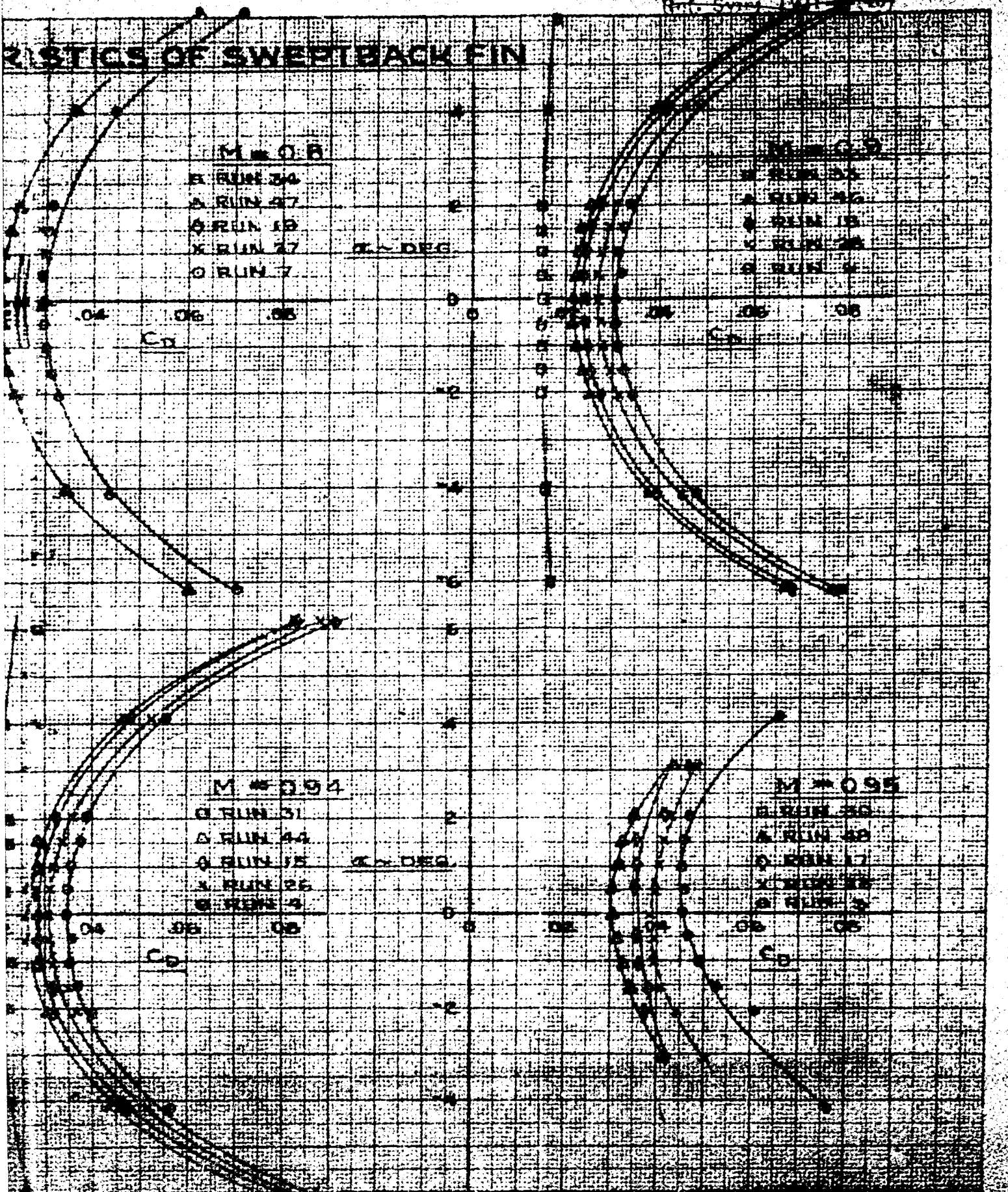
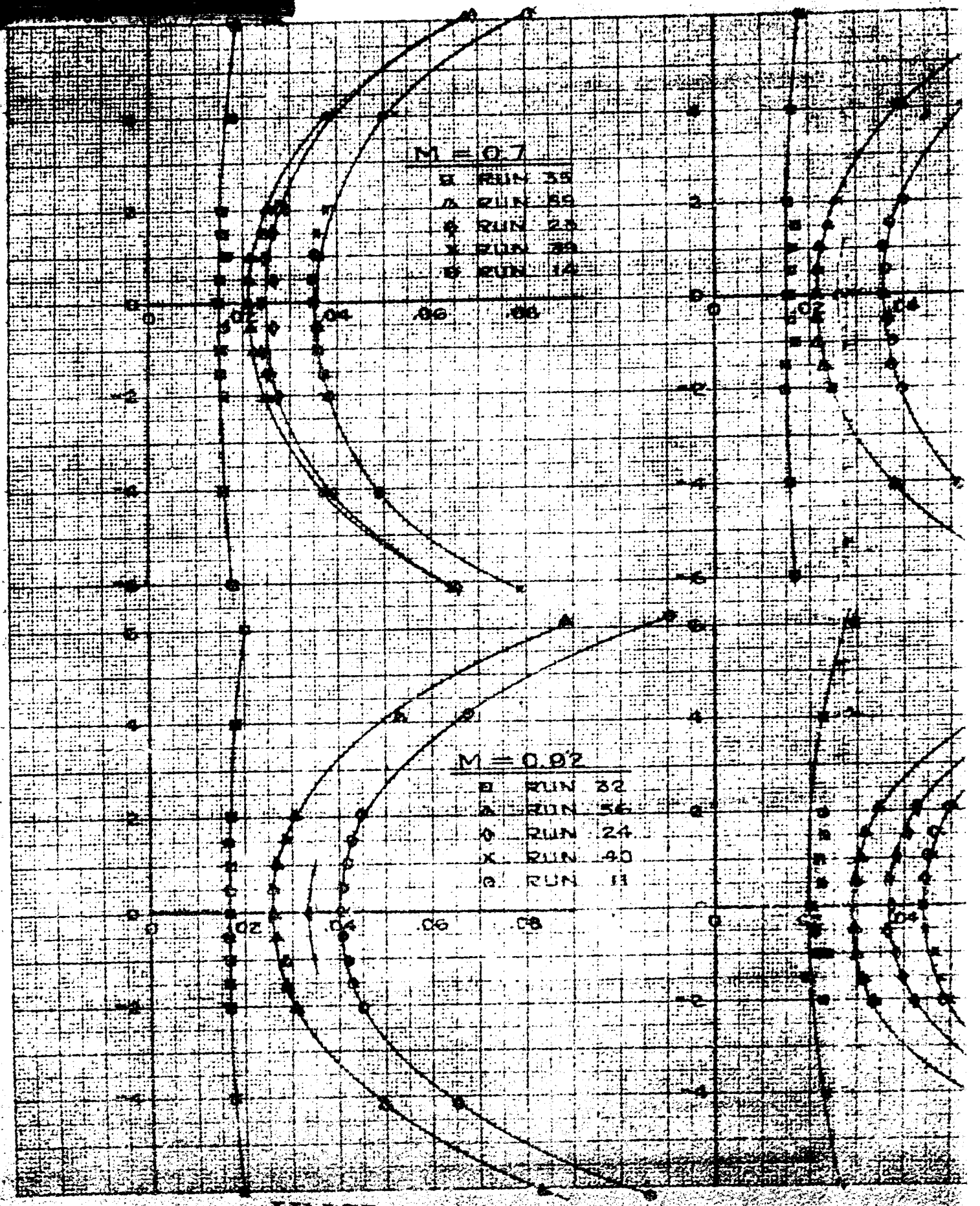
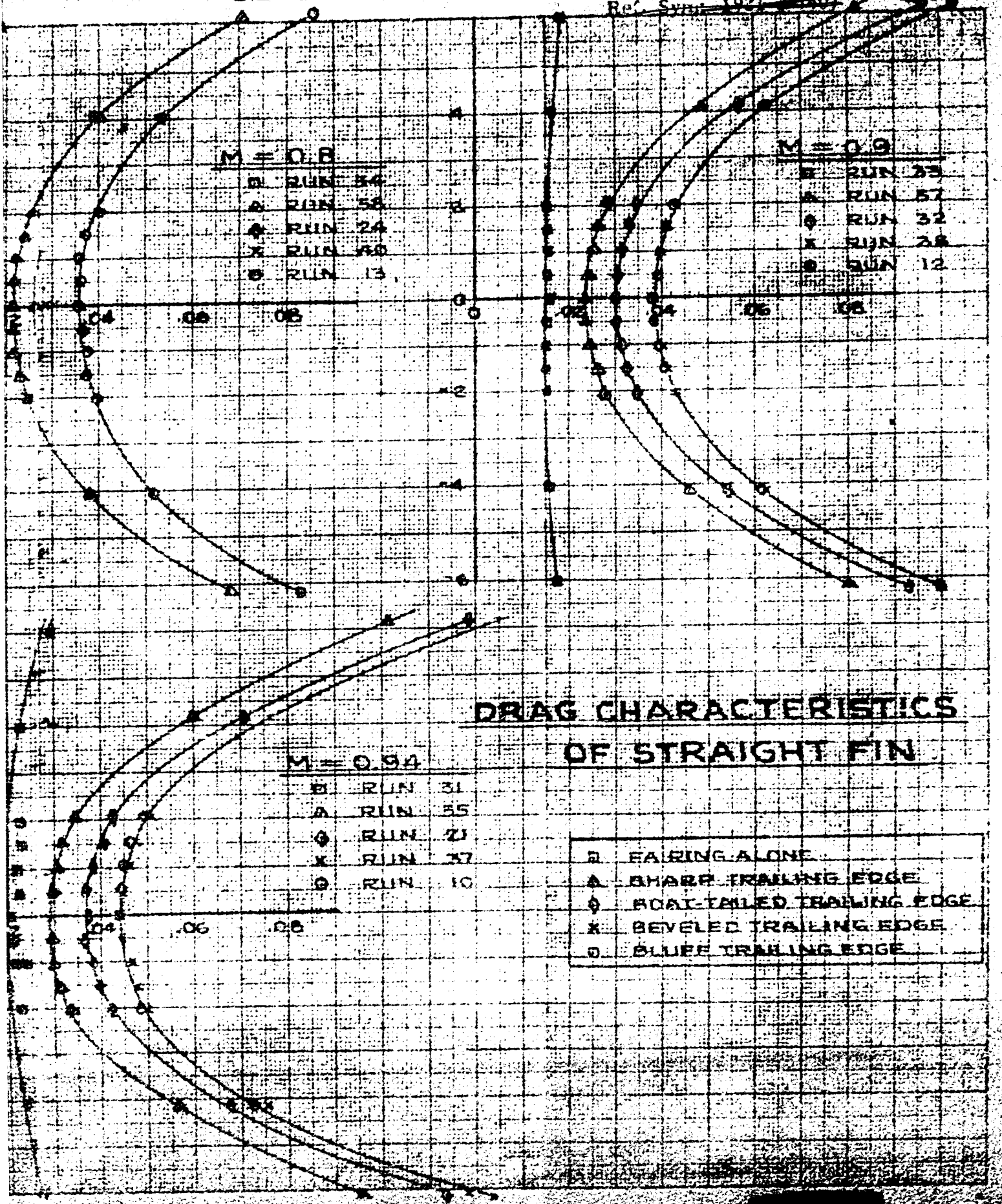

RISTICS OF SWEPTBACK FIN
M = 0.8
RUN 34
RUN 47
RUN 19
RUN 27
RUN 7
α ~ DEG
C_D
M = 0.9
M = 0.94
RUN 31
RUN 44
RUN 15
RUN 26
RUN 4
M = 0.95
RUN 30
RUN 48
RUN 17


M = 0.7
RUN 35
RUN 59
RUN 23
RUN 39
RUN 14
M = 0.92
RUN 32
RUN 56
RUN 24
RUN 40
RUN 11
.02
.04
.06
.08



DRAG CHARACTERISTICS OF STRAIGHT FIN

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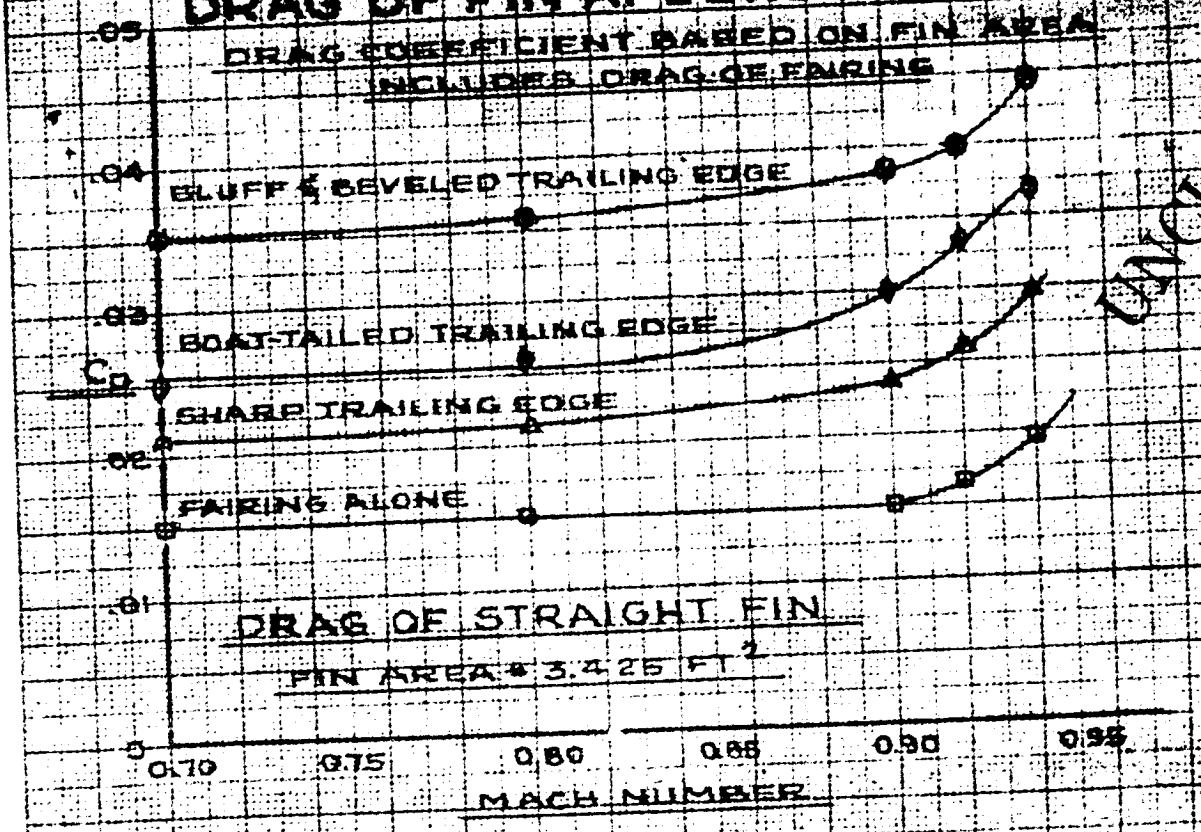
Page 17
Figure 9
Ref. [redacted]

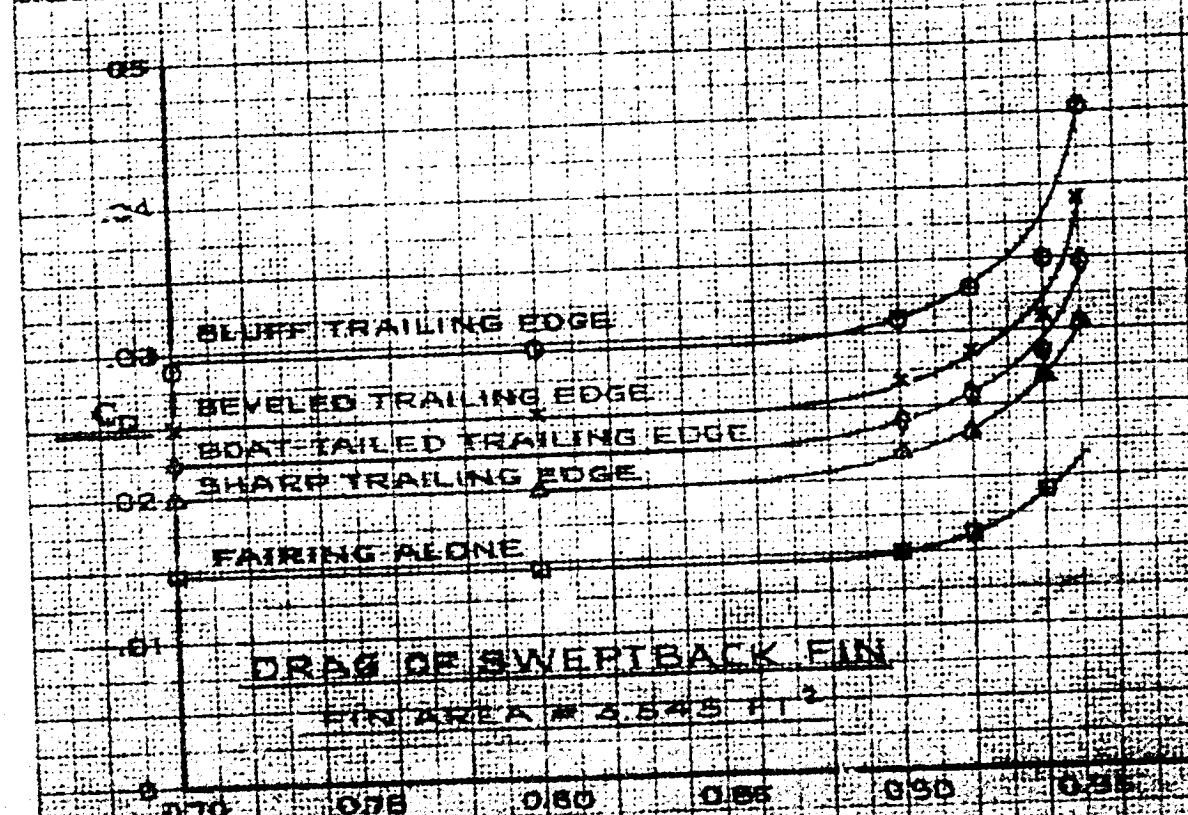
DRAG OF FIN AT ZERO ANGLE OF ATTACK

DRAG COEFFICIENT BASED ON FIN AREA
INCLUDES DRAG OF FAIRING



DRAG OF STRAIGHT FIN

FIN AREA = 3.425 FT^2



DRAG OF SWEPTBACK FIN

FIN AREA = 3.845 FT^2

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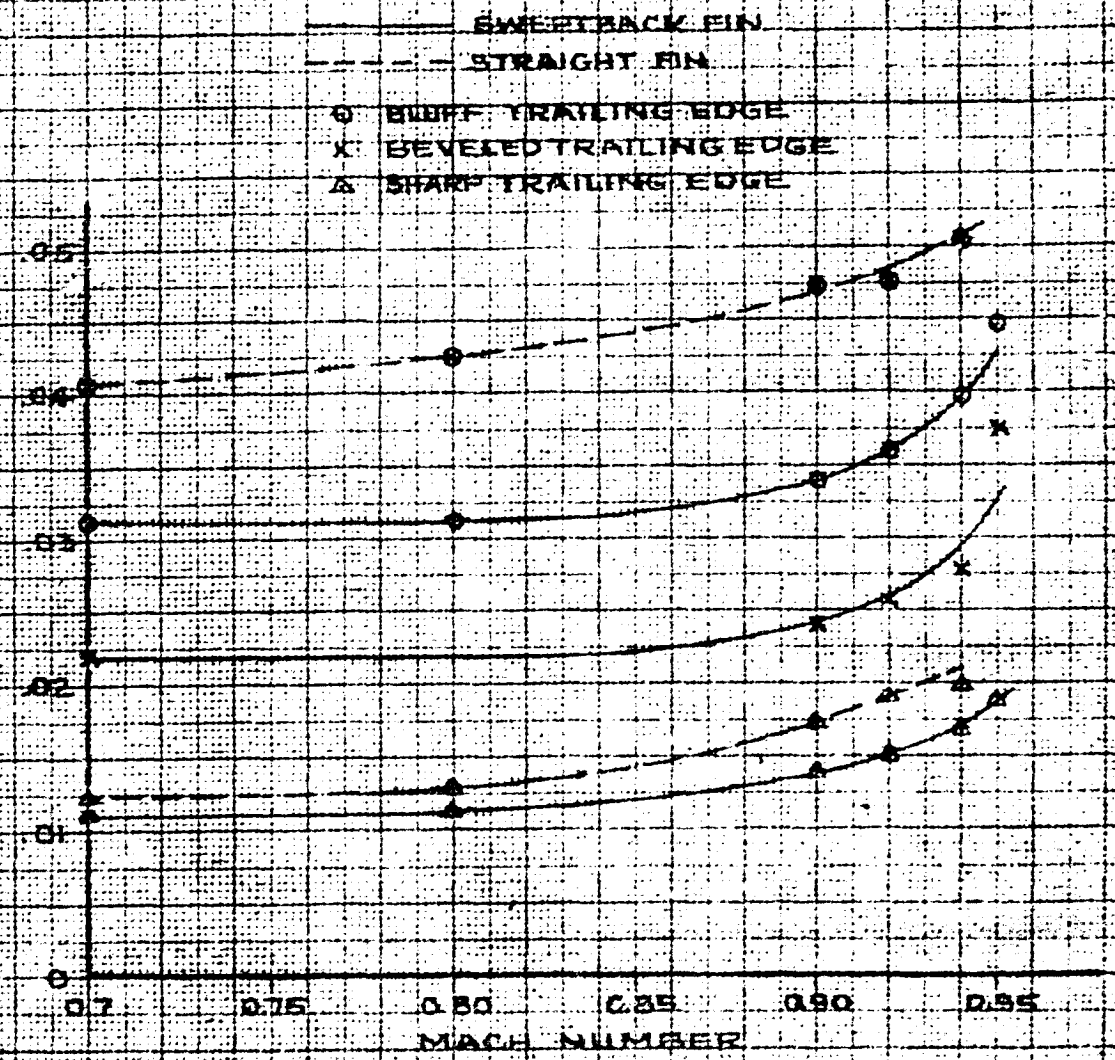
DRAG OF THREE FINS INSTALLED ON TX-7

DRAG COEFFICIENT BASED ON STORE FRONTAL AREA

$S_{\gamma} = 5.07\ FT^2$



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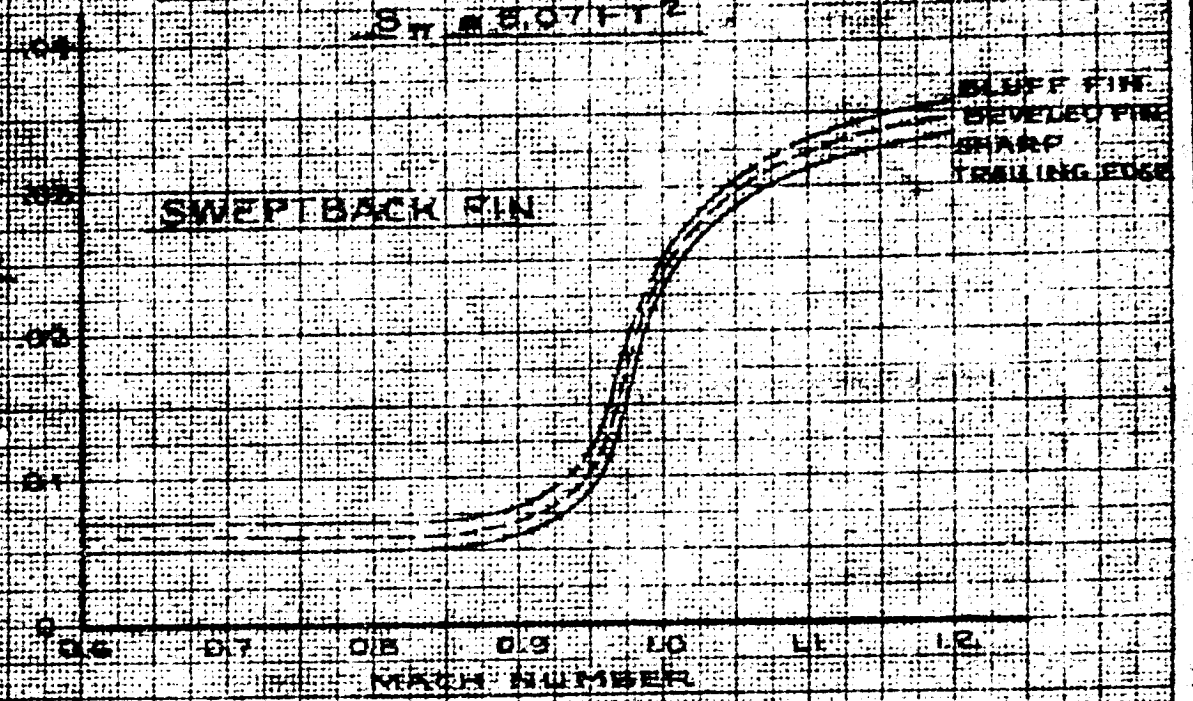
ESTIMATED DRAG OF TX-7 XI WITH VARIOUS FIN MODIFICATIONS

DRAG COEFFICIENT IS BASED ON $S_T = 5.07 FT^2$



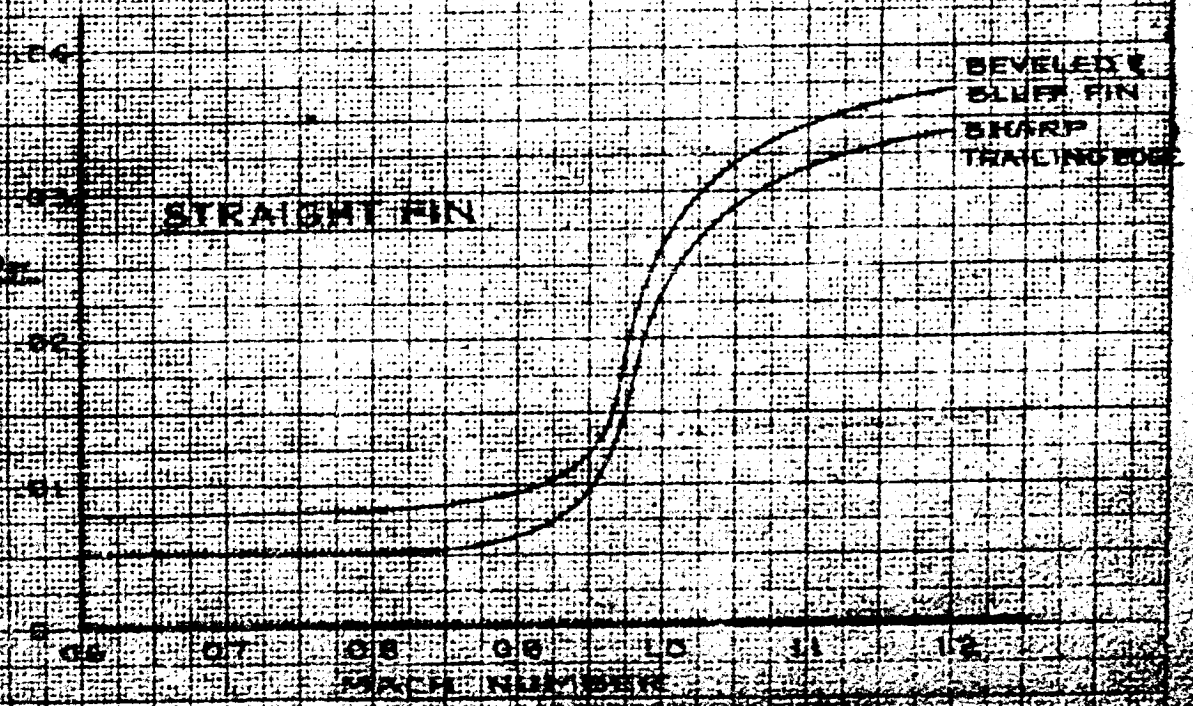


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Figure 12

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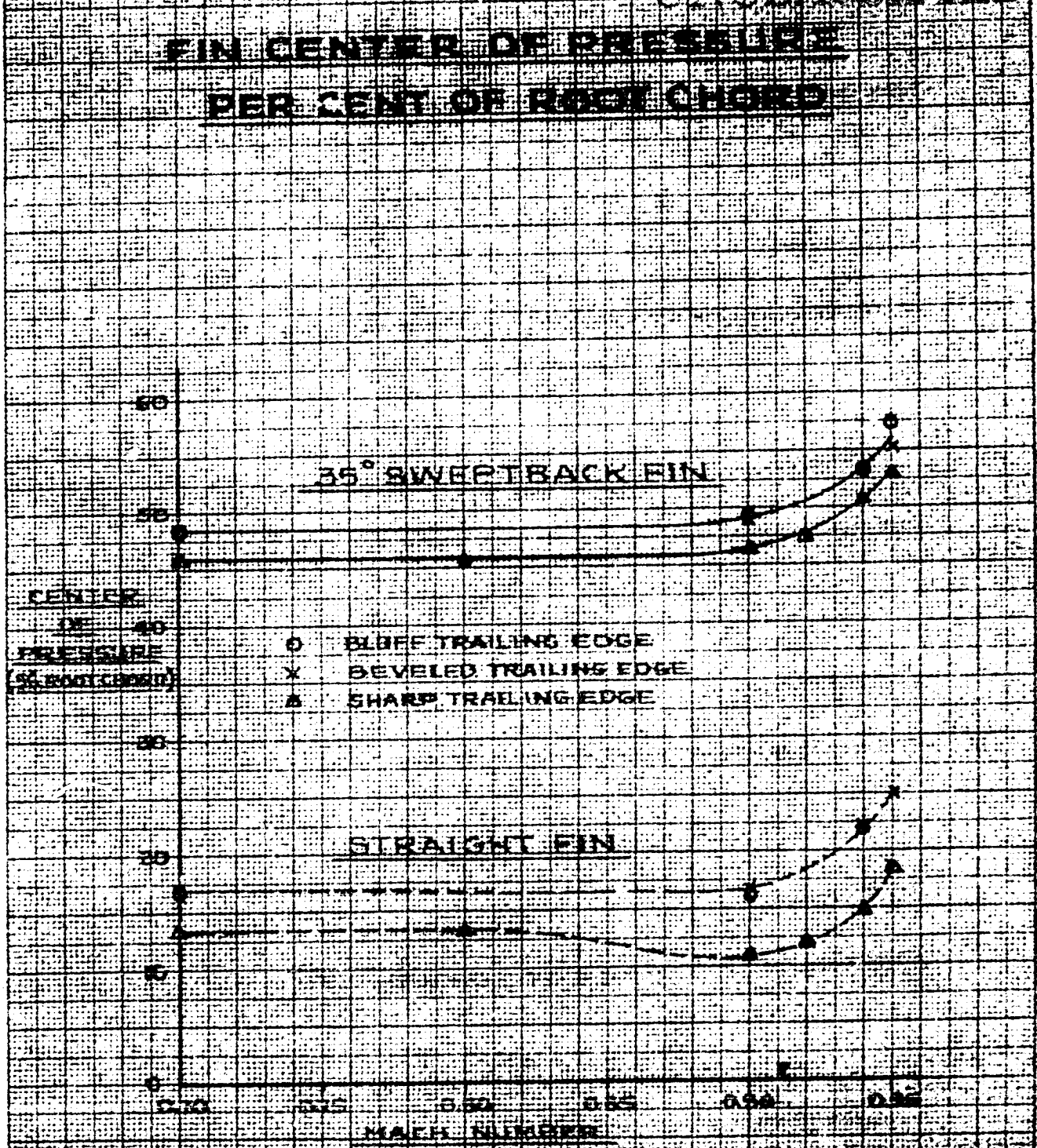

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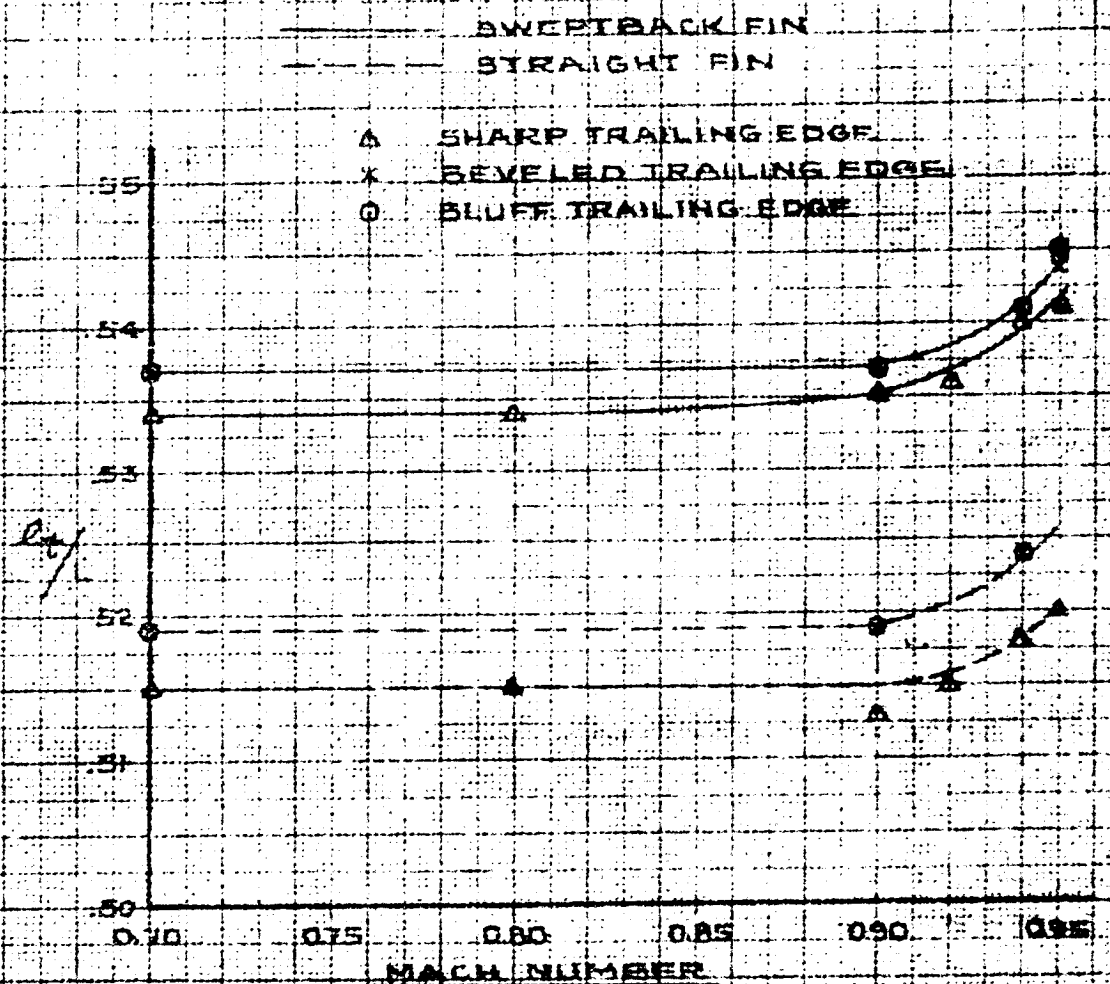
EFFECTIVE TAIL LENGTH OF FINS

ℓ_t/L

ℓ_t = DISTANCE FROM STORE C.g TO FIN CENTER OF PRESSURE

L = STORE LENGTH



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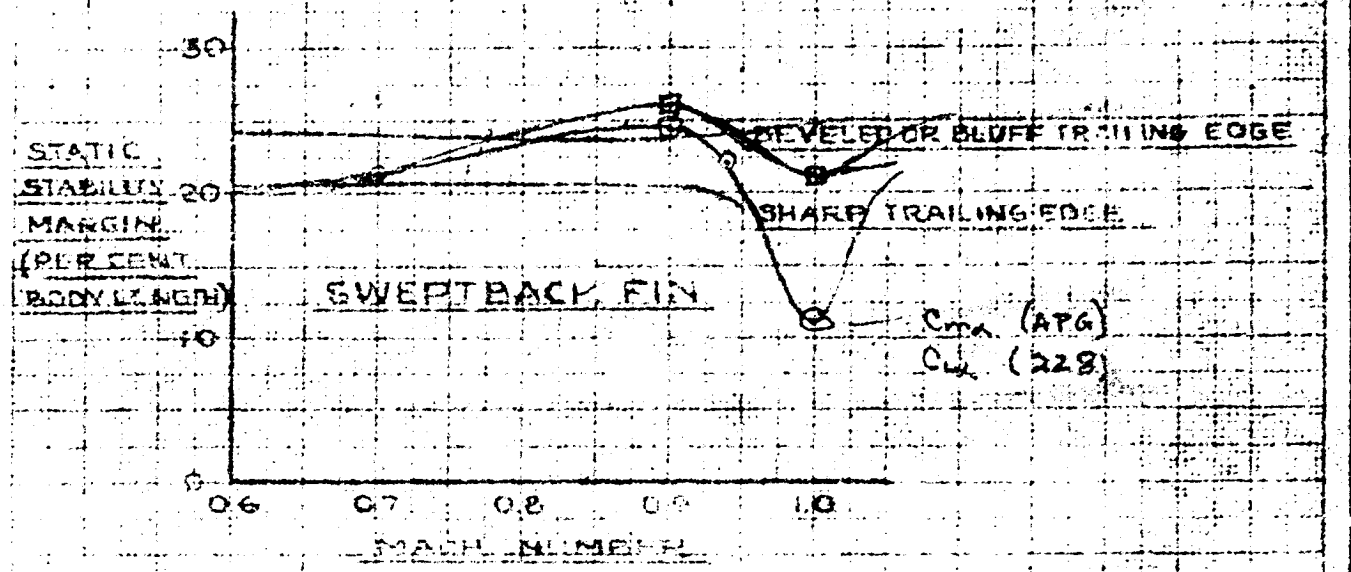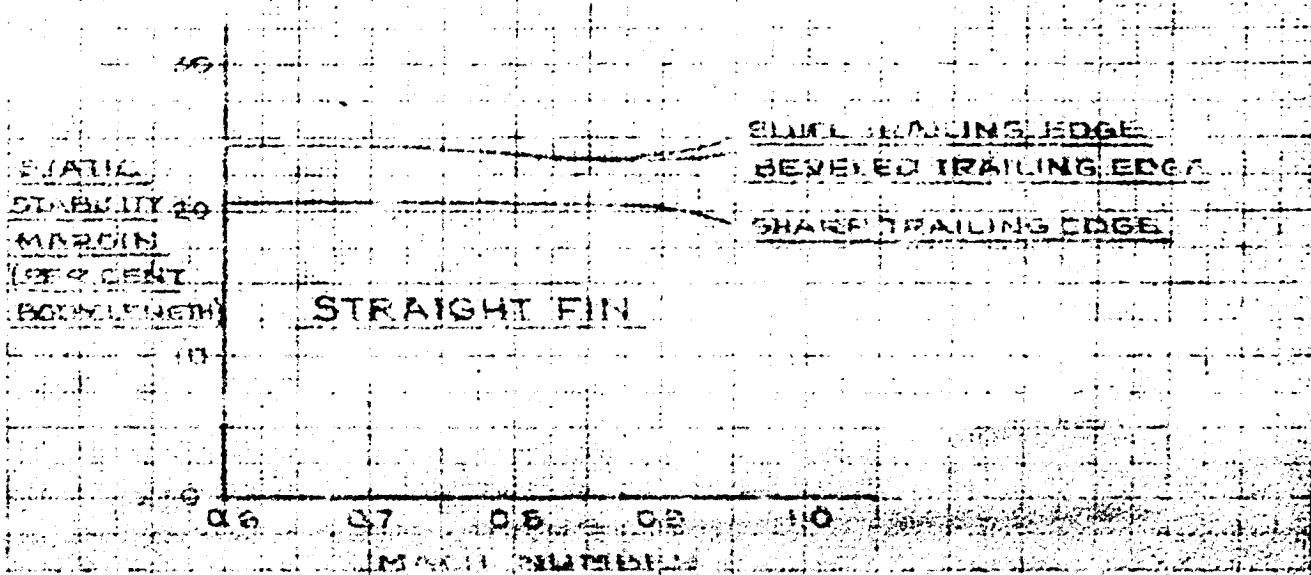
ESTIMATED EFFECT OF FIN MODIFICATIONS ON TX-7 STATIC STABILITY MARGIN