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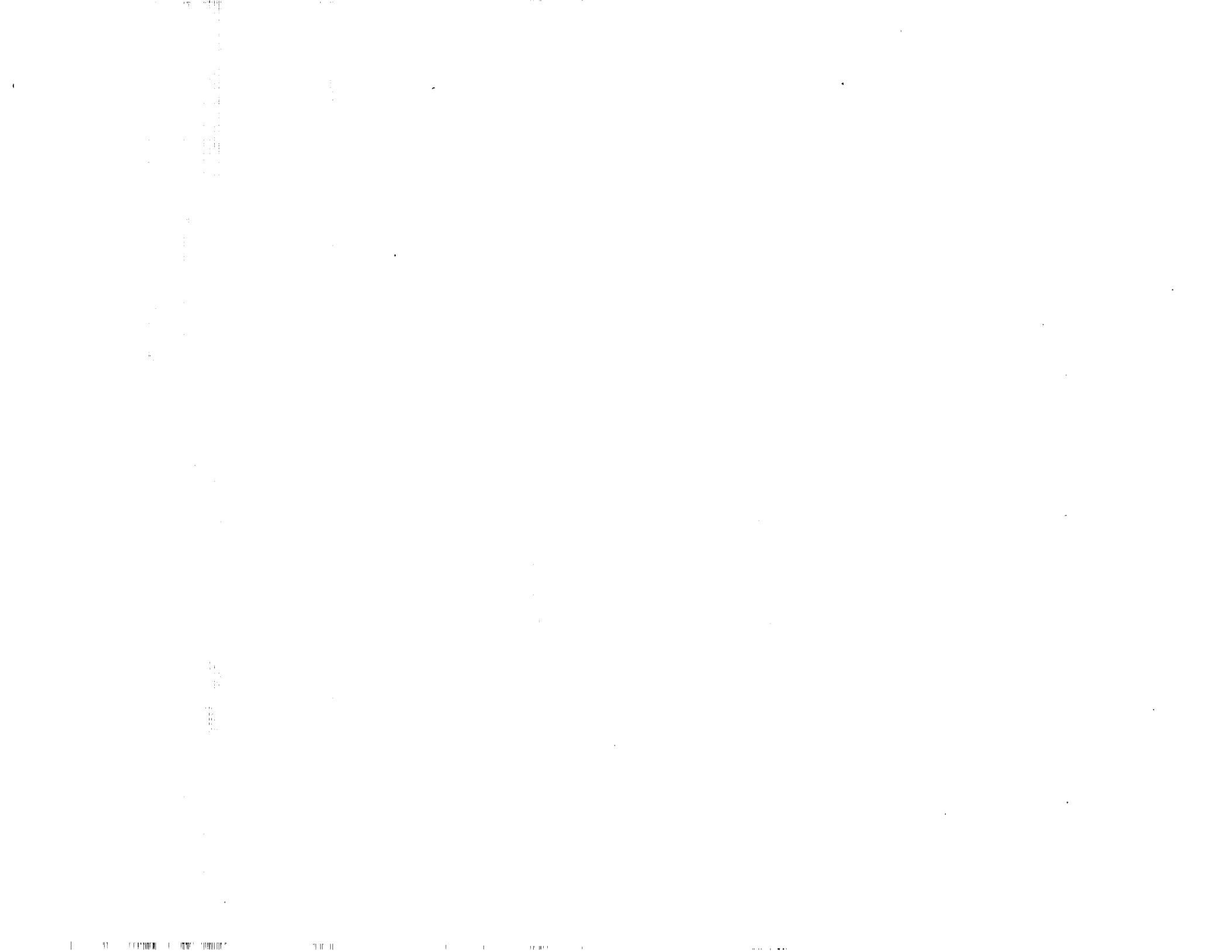
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AERODYNAMIC CHARACTERISTICS OF AN A-4B AIRCRAFT WITH
SIMULATED AND ACTUAL GUNFIRE DAMAGE TO ONE WING

Mark D. Betzina and David H. Brown

Ames Research Center
and
Ames Directorate, USAAMRDL
Moffett Field, California 94035

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16. Abstract The aerodynamic characteristics of a damaged McDonnell Douglas A-4B aircraft were studied in the Ames Research Center's 40- by 80-Foot Wind Tunnel. A standard fuselage and three different wings were used. The first wing tested was an undamaged one in which holes had been cut and detachable cover plates installed. Removal of one or more cover plates gave one of fourteen different simulated damage cases. The other two wings tested were damaged by actual gunfire at an Air Force range.			
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NOTATION

A	Aspect ratio
ALPHA	Plotter Notation for α
b	Wing span, meters (feet)
\bar{c}	Mean aerodynamic chord, meters (feet)
C_D	Drag coefficient, $\frac{D}{qS}$
C_{D_u}	Uncorrected C_D
C_D	Plotter notation for C_D
C_L	Lift Coefficient, $\frac{L}{qS}$
C_{L_u}	Uncorrected C_L
C_L	Plotter notation for C_L
C_m	Pitching moment coefficient, $\frac{M}{qSc}$
C_{m_u}	Uncorrected C_m
C_m	Plotter notation for C_m
CN	Plotter notation for yawing moment coefficient, $\frac{N}{qSb}$
CRL	Plotter notation for rolling moment coefficient, $\frac{l}{qSb}$
D	Drag force, N(lb)
i_H	Horizontal tail incidence angle, degrees
i	Rolling moment, m-N (ft-lb)
L	Total lift on aircraft, N(lb)

M	Pitching moment, $\text{lb}\cdot\text{ft}$
N	Yawing moment, $\text{lb}\cdot\text{ft}$
q	Free-stream dynamic pressure, lb/ft^2
q_u	Uncorrected q
S	Wing area, ft^2
α	Angle of attack of wing chord plane, degrees
α_u	Uncorrected α , degrees
Γ	Geometric dihedral angle, degrees
δ_a	Aileron deflection, degrees (positive for right roll)
δ_f	Flap deflection, degrees
$\Lambda_{c/4}$	Sweep angle of quarter chord line, degrees
λ	Taper ratio

**Aerodynamic Characteristics of an A-4B
Aircraft with Simulated and Actual
Gunfire Damage to One Wing**

David H. Brown and Mark D. Betzina

U.S. Army Air Mobility R&D Laboratory

The aerodynamic characteristics of a damaged McDonnell Douglas A-4B aircraft were studied in the Ames Research Center's 40- by 80-Foot Wind Tunnel. A standard fuselage and three different wings were used. The first wing tested was an undamaged one in which holes had been cut and detachable cover plates installed. Removal of one or more cover plates gave one of fourteen different simulated damage cases. The other two wings tested were damaged by actual gunfire at an Air Force range.

Introduction

The Air Force Armament Laboratory is currently studying the effectiveness of its air to air gun fired projectiles. The objective of this test was to obtain the necessary data that would allow an aerodynamic analysis, by McDonnell Douglas Corporation, of an A-4 aircraft that has been hit by 25mm and 30mm projectiles.

Model Description

The model used in this test was a McDonnell Douglas A-4B aircraft. Basic aircraft data is tabulated below.

	Wing	Hor. Stab.	Vert. Stab.
$S, m^2 (ft^2)$	24.15(260)	4.260(45.85)	4.641(49.95)
A	2.91	2.80	1.24
$c, m (ft)$	3.292(10.8)	1.420(4.66)	2.249(7.38)
$b, m (ft)$	8.382(27.5)	3.453(11.33)	2.396(7.86)
$\Lambda_{c/4}, deg$	33.21	34.37	42.0
λ	0.226	0.225	0.205
Γ, deg	2.68	0	-----

The aircraft is shown mounted in the Ames 40- by 80-Foot Wind Tunnel in Figures 1 and 2.

A single fuselage and three different wings were used during the test. The first wing used was an undamaged one on which several panels had been removed on the upper and lower surfaces of the right wing and easily detachable cover plates of aluminum installed. By removing one or more of the cover plates, various simulated damage configurations could be obtained. These panels and hole configurations are shown in Figures 3 through 17 with the removed panels being shaded. Note that in configurations 1 and 5 an optional plate could be installed to simulate petaled metal.

Also tested were two wings that were damaged by actual gunfire at an Eglin Air Force Base gunfire range. These are shown in Figures 18 through 21. One was damaged by a 25mm projectile and the other by a 30mm

projectile. Both were hit between the front and intermediate spars and above the right landing gear fairing from an angle of 15° ~~degrees~~ - above and behind the wing. The 25mm projectile created a large hole on the upper surface between the front and intermediate spars and from the fuselage to wing station 90. On the lower surface, the explosion made a small hole and blew off part of the landing gear fairing. The wing hit by the 30mm projectile was damaged mainly on the lower surface where the landing gear fairing was torn off and a hole was produced between the front and intermediate spars.

Electric drive actuators were installed in the undamaged wing and fuselage tail so that the ailerons and horizontal stabilizer could be operated remotely during running. The elevator was locked at zero deflection. During part of the test, the flaps were locked in the landing configuration by a bar attached to the flap control linkage of the aircraft. The leading edge slats were fastened either in the closed or open position and were not allowed to float free aerodynamically due to worn and binding tracks.

Testing and Procedures

Aerodynamic force and moment data were taken for each undamaged and simulated damage configuration by performing angle of attack sweeps (polars) from -4 to $+26^{\circ}$ with all other variables held constant. Tail incidence, aileron, flap and slat settings were varied between polars. Some data were taken with the horizontal tail removed from the aircraft.

For the actual damage cases, polars were conducted in the tail off configuration only, with ailerons and flaps at zero and slats closed.

Several baseline runs were repeated for checks on data repeatability and others were repeated with only a variation in dynamic pressure for an indication of Reynolds number effects.

Corrections

Force and moment data obtained in the test were corrected for the effects of the wind tunnel walls. The data were corrected as follows:

$$\alpha = \alpha_u + .6025 C_{L_u}$$

$$C_D = C_{D_u} + .01051 C_{I_u}^2$$

$$C_m = C_{m_u} + .00571 C_{L_u} \quad \text{(applies to tail on only)}$$

The data were also corrected for strut effects.

Results

The aerodynamic data obtained in this test are presented without analysis in Figures 22 through 88. All moments were computed about the quarter chord point of the mean aerodynamic chord. An index of all plots is given in Table 1.

Table 1
Index of Plots

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u N/m^2 (lb/ft^2)
Reynolds Number Effects							
22	undamaged	1	0	0	0	closed	1197(25)
		3	0	0	0	closed	2394(50)
23	undamaged	7	-8	0	0	closed	1197(25)
		5	-8	0	0	closed	2394(50)
24	undamaged	58	-4	0	50	open	1197(25)
		59	-4	0	50	open	2394(50)
25	#1	10	0	0	0	closed	1197(25)
		11	0	0	0	closed	2394(50)
26	#15	128	Off	0	0	closed	1197(25)
		129	Off	0	0	closed	2394(50)
27	#16	131	Off	0	0	closed	1197(25)
		132	Off	0	0	closed	2394(50)
Repeatability							
28	undamaged	1,8,70	0	0	0	closed	1197(25)
29	undamaged	51,69	0	0	0	assymmetric	1197(25)
30	#3	77,79	Off	0	50	open	1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u N/m^2 (lb/ft^2)
Undamaged Wing							
31	undamaged	3	0	0	0	closed	2394(50)
		4	-4	0	0	closed	2394(50)
		5	-8	0	0	closed	2394(50)
		71	Off	0	0	closed	1197(25)
32	undamaged	3	0	0	0	closed	2394(50)
		6	0	+10	0	closed	2394(50)
		9	0	-10	0	closed	1197(25)
33	undamaged	51	0	0	0	assymmetric	1197(25)
		52	-4	0	0	assymmetric	1197(25)
		53	-8	0	0	assymmetric	1197(25)
		72	Off	0	0	assymmetric	1197(25)
34	undamaged	51	0	0	0	assymmetric	1197(25)
		54	0	+10	0	assymmetric	1197(25)
		55	0	-10	0	assymmetric	1197(25)
35	undamaged	56	0	0	50	open	1197(25)
		58	-4	0	50	open	1197(25)
		60	-8	0	50	open	1197(25)
		61	-11	0	50	open	1197(25)
		83	Off	0	50	open	1197(25)
36	undamaged	58	-4	0	50	open	1197(25)
		62	-4	+10	50	open	1197(25)
		63	-4	-10	50	open	1197(25)
Simulated Damage							
37	undamaged #1	70	0	0	0	closed	1197(25)
		10	0	0	0	closed	1197(25)
38	undamaged #1 + Petaling	70	0	0	0	closed	1197(25)
		16	0	0	0	closed	1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u N/m^2 (lb/ft^2)
39	#1	10	0	0	0	closed	1197(25)
		12	-4	0	0	closed	1197(25)
		13	-8	0	0	closed	1197(25)
		73	Off	0	0	closed	1197(25)
40	#1	10	0	0	0	closed	1197(25)
		14	0	+10	0	closed	1197(25)
		15	0	-10	0	closed	1197(25)
41	#1 + Petaling	16	0	0	0	closed	1197(25)
		17	-4	0	0	closed	1197(25)
		18	-8	0	0	closed	1197(25)
		74	Off	0	0	closed	1197(25)
42	#1 + Petaling	16	0	0	0	closed	1197(25)
		19	0	+10	0	closed	1197(25)
		20	0	-10	0	closed	1197(25)
43	undamaged #2	70	0	0	0	closed	1197(25)
		21	0	0	0	closed	1197(25)
44	#2	21	0	0	0	closed	1197(25)
		22	-4	0	0	closed	1197(25)
		23	-8	0	0	closed	1197(25)
		75	Off	0	0	closed	1197(25)
45	#2	21	0	0	0	closed	1197(25)
		24	0	+10	0	closed	1197(25)
		25	0	-10	0	closed	1197(25)
46	undamaged #3	70	0	0	0	closed	1197(25)
		26	0	0	0	closed	1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u N/m^2 (lb/ft^2)
47	undamaged #3	58	-4	0	50	open	1197(25)
		64	-4	0	50	open	1197(25)
48	#3	26	0	0	0	closed	1197(25)
		27	-4	0	0	closed	1197(25)
		28	-8	0	0	closed	1197(25)
		76	Off	0	0	closed	1197(25)
49	#3	26	0	0	0	closed	1197(25)
		29	0	+10	0	closed	1197(25)
		30	0	-10	0	closed	1197(25)
50	#3	64	-4	0	50	open	1197(25)
		65	-8	0	50	open	1197(25)
		66	-11	0	50	open	1197(25)
		77	Off	0	50	open	1197(25)
51	#3	64	-4	0	50	open	1197(25)
		67	-4	+10	50	open	1197(25)
		68	-4	-10	50	open	1197(25)
52	undamaged #4	70	0	0	0	closed	1197(25)
		31	0	0	0	closed	1197(25)
53	#4	31	0	0	0	closed	1197(25)
		32	-4	0	0	closed	1197(25)
		33	-8	0	0	closed	1197(25)
		78	Off	0	0	closed	1197(25)
54	#4	31	0	0	0	closed	1197(25)
		34	0	+10	0	closed	1197(25)
		35	0	-10	0	closed	1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u^2 $N/m^2 (lb/ft^2)$
55	undamaged #5	70 36	0 0	0 0	0 0	closed closed	1197(25) 1197(25)
56	undamaged #5 + Petaling	70 41	0 0	0 0	0 0	closed closed	1197(25) 1197(25)
57	#5	36 37 38	0 -4 -8	0 0 0	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)
58	#5	36 39 40	0 0 0	0 +10 -10	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)
59	#5 + Petaling	41 42 43 80	0 -4 -8 Off	0 0 0 0	0 0 0 0	closed closed closed closed	1197(25) 1197(25) 1197(25) 1197(25)
60	#5 + Petaling	41 44 45	0 0 0	0 +10 -10	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)
61	undamaged #6	70 46	0 0	0 0	0 0	closed closed	1197(25) 1197(25)
62	#6	46 47 48 81	0 -4 -8 Off	0 0 0 0	0 0 0 0	closed closed closed closed	1197(25) 1197(25) 1197(25) 1197(25)
63	#6	46 49 50	0 0 0	0 +10 -10	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u N/m^2 (lb/ft^2)
64	undamaged #7	70 123	0 0	0 0	0 0	closed closed	1197(25) 1197(25)
65	#7	123 124 125 84	0 -4 -8 Off	0 0 0 0	0 0 0 0	closed closed closed closed	1197(25) 1197(25) 1197(25) 1197(25)
66	#7	123 126 127	0 0 0	0 +10 -10	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)
67	undamaged #8	70 115	0 0	0 0	0 0	closed closed	1197(25) 1197(25)
68	undamaged #8	82 86	Off Off	0 0	0 0	open open	1197(25) 1197(25)
69	#8	115 116 117 85	0 -4 -8 Off	0 0 0 0	0 0 0 0	closed closed closed closed	1197(25) 1197(25) 1197(25) 1197(25)
70	#8	115 118 119	0 0 0	0 +10 -10	0 0 0	closed closed closed	1197(25) 1197(25) 1197(25)
71	#8	120 121 122	0 0 0	0 +10 -10	0 0 0	open open open	1197(25) 1197(25) 1197(25)
72	undamaged #9	70 110	0 0	0 0	0 0	closed closed	1197(25) 1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u^2 N/m^2 (lb/ft^2)
73	#9	110	0	0	0	closed	1197(25)
		111	-4	0	0	closed	1197(25)
		112	-8	0	0	closed	1197(25)
		87	Off	0	0	closed	1197(25)
74	#9	110	0	0	0	closed	1197(25)
		113	0	+10	0	closed	1197(25)
		114	0	-10	0	closed	1197(25)
75	undamaged #10	70	0	0	0	closed	1197(25)
		107	0	0	0	closed	1197(25)
76	#10	107	0	0	0	closed	1197(25)
		108	-4	0	0	closed	1197(25)
		109	-8	0	0	closed	1197(25)
		88	Off	0	0	closed	1197(25)
77	undamaged #11	70	0	0	0	closed	1197(25)
		104	0	0	0	closed	1197(25)
78	#11	104	0	0	0	closed	1197(25)
		105	-4	0	0	closed	1197(25)
		106	-8	0	0	closed	1197(25)
		89	Off	0	0	closed	1197(25)
79	undamaged #12	70	0	0	0	closed	1197(25)
		101	0	0	0	closed	1197(25)
80	#12	101	0	0	0	closed	1197(25)
		102	-4	0	0	closed	1197(25)
		103	-8	0	0	closed	1197(25)
		90	Off	0	0	closed	1197(25)

Index of Plots, Continued

Fig.	Hole Config.	Runs	i_H deg.	δ_a deg.	δ_f deg.	Slats	q_u^2 (lb/ft ²)
81	undamaged	70	0	0	0	closed	1197(25)
	#13	98	0	0	0	closed	1197(25)
82	#13	98	0	0	0	closed	1197(25)
		99	-4	0	0	closed	1197(25)
		100	-8	0	0	closed	1197(25)
		91	Off	0	0	closed	1197(25)
83	undamaged	70	0	0	0	closed	1197(25)
	#14	93	0	0	0	closed	1197(25)
84	#14	93	0	0	0	closed	1197(25)
		94	-4	0	0	closed	1197(25)
		95	-8	0	0	closed	1197(25)
		92	Off	0	0	closed	1197(25)
85	#14	93	0	0	0	closed	1197(25)
		96	0	+10	0	closed	1197(25)
		97	0	-10	0	closed	1197(25)
25mm Wing Damage Case							
86	undamaged	71	Off	0	0	closed	1197(25)
	#15	128	Off	0	0	closed	1197(25)
	#15	130	Off	0	0	closed	1197(25)
30mm Wing Damage Case							
87	undamaged	71	Off	0	0	closed	1197(25)
	#16	131	Off	0	0	closed	1197(25)
	#16	133	Off	0	0	closed	1197(25)
25mm/30mm Comparison							
88	#15	128	Off	0	0	closed	1197(25)
	#16	131	Off	0	0	closed	1197(25)

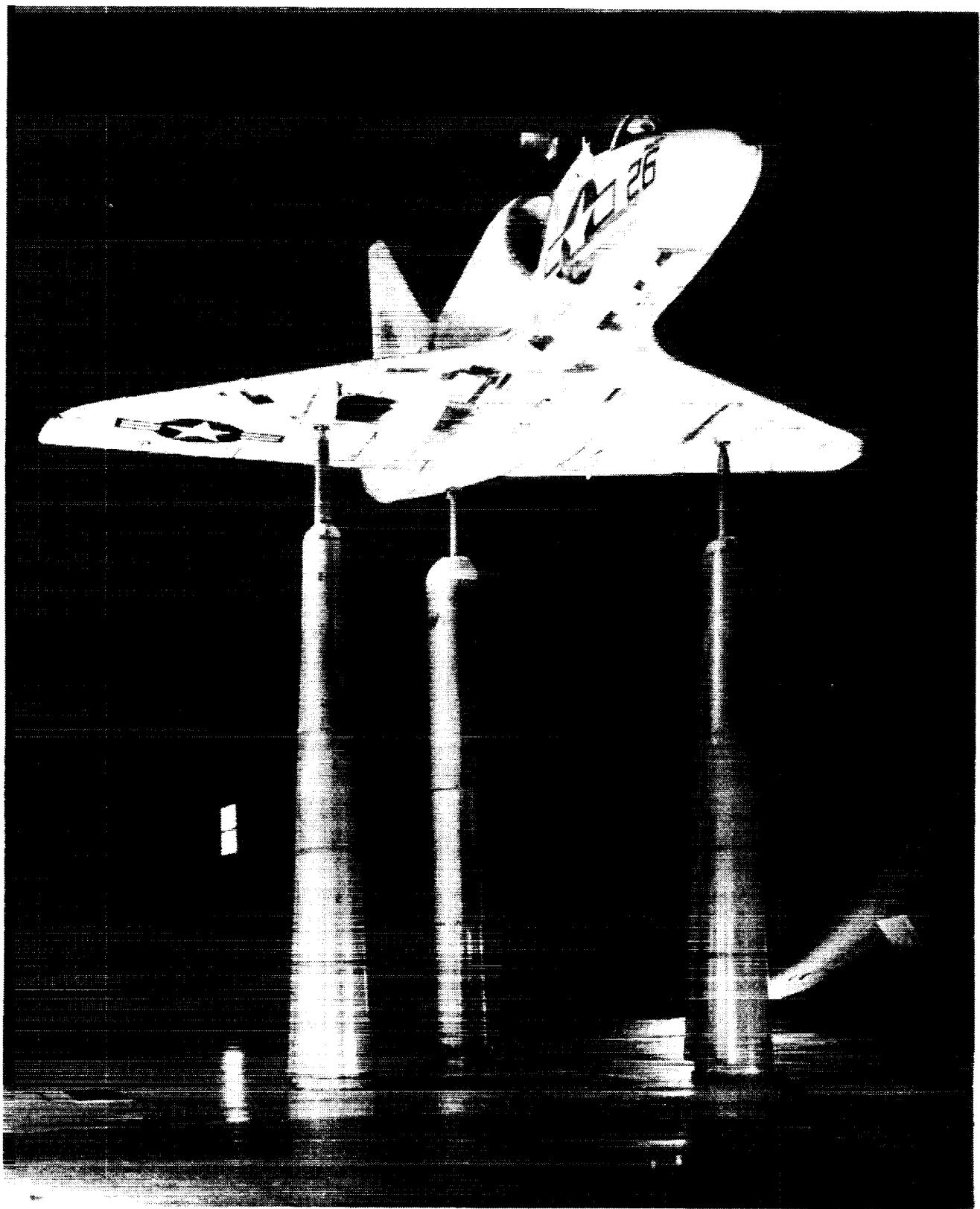


Fig. 1.- A-4B IN THE AMES 40 X 80 FOOT WIND TUNNEL
WITH HOLE CONFIGURATION #5

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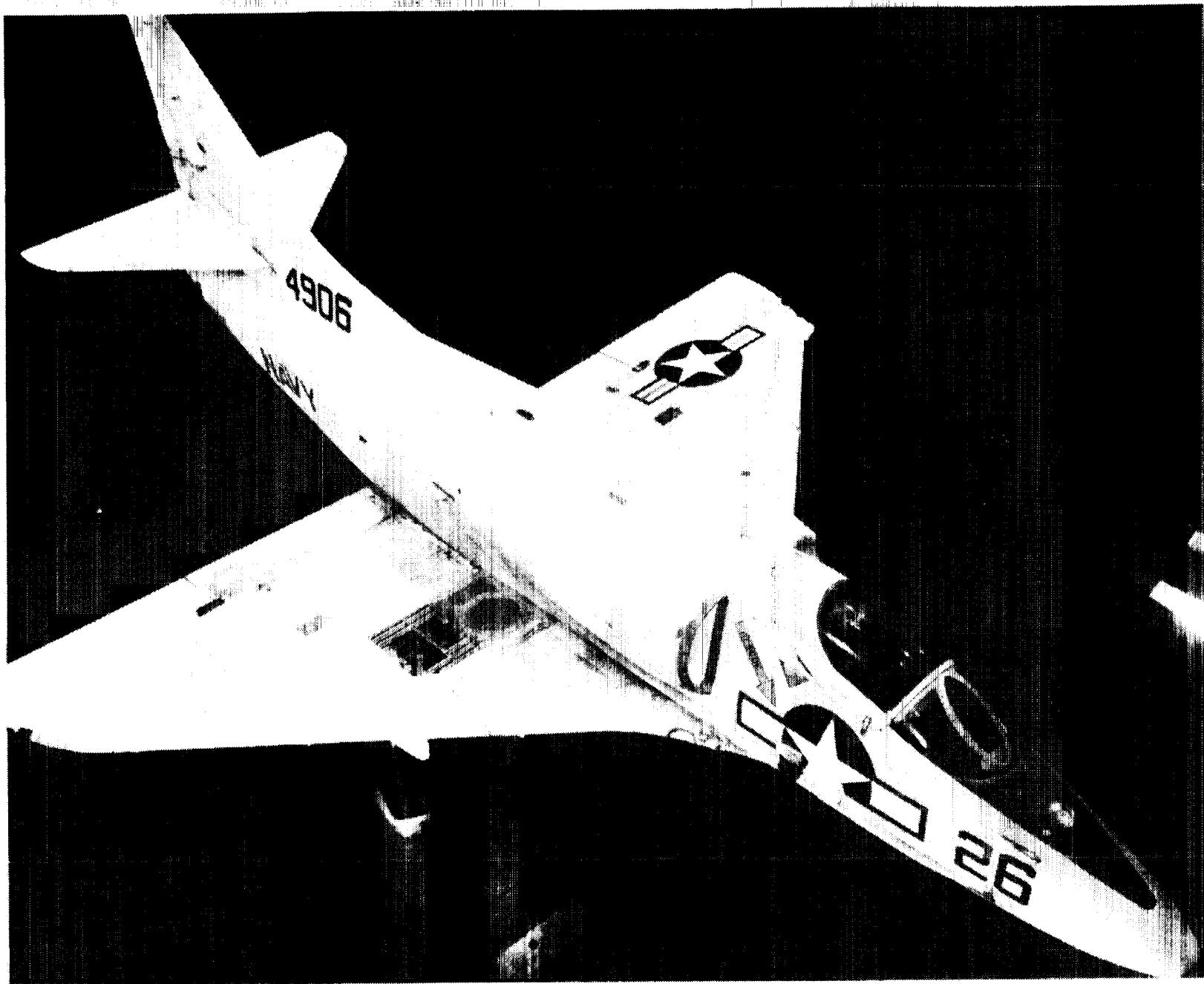


Fig. 2.- OVERHEAD VIEW OF A-4B WITH HOLE CONFIGURATION #5

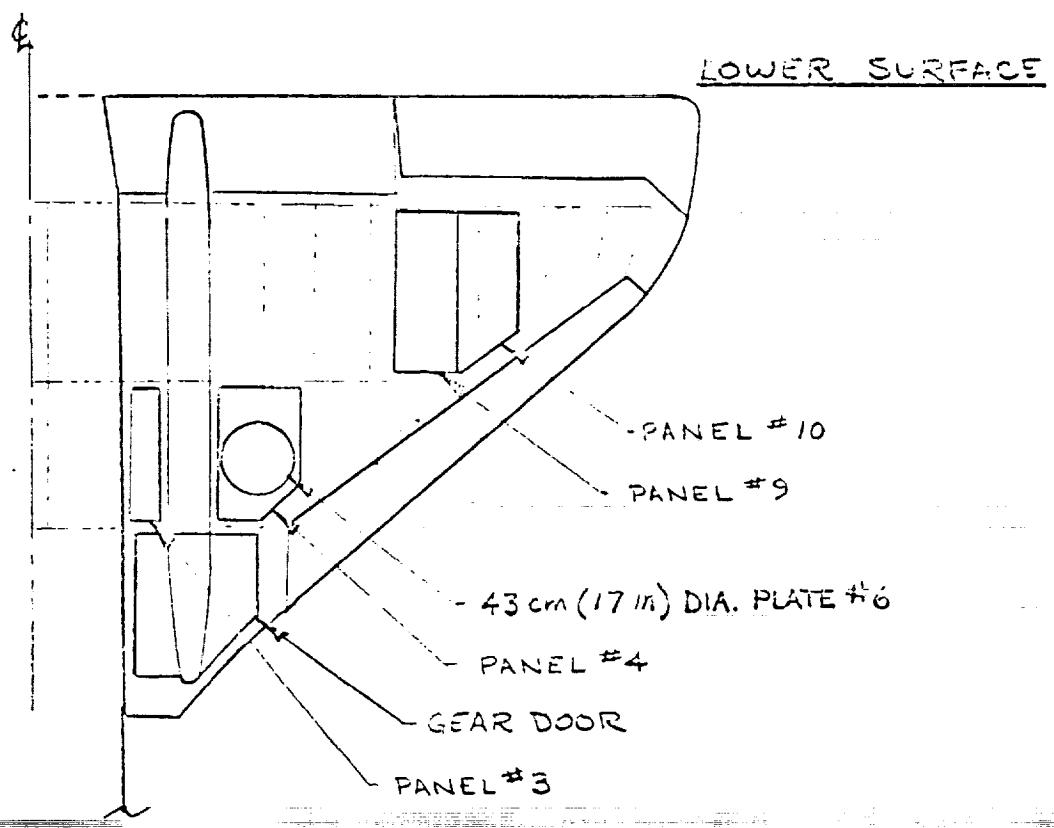
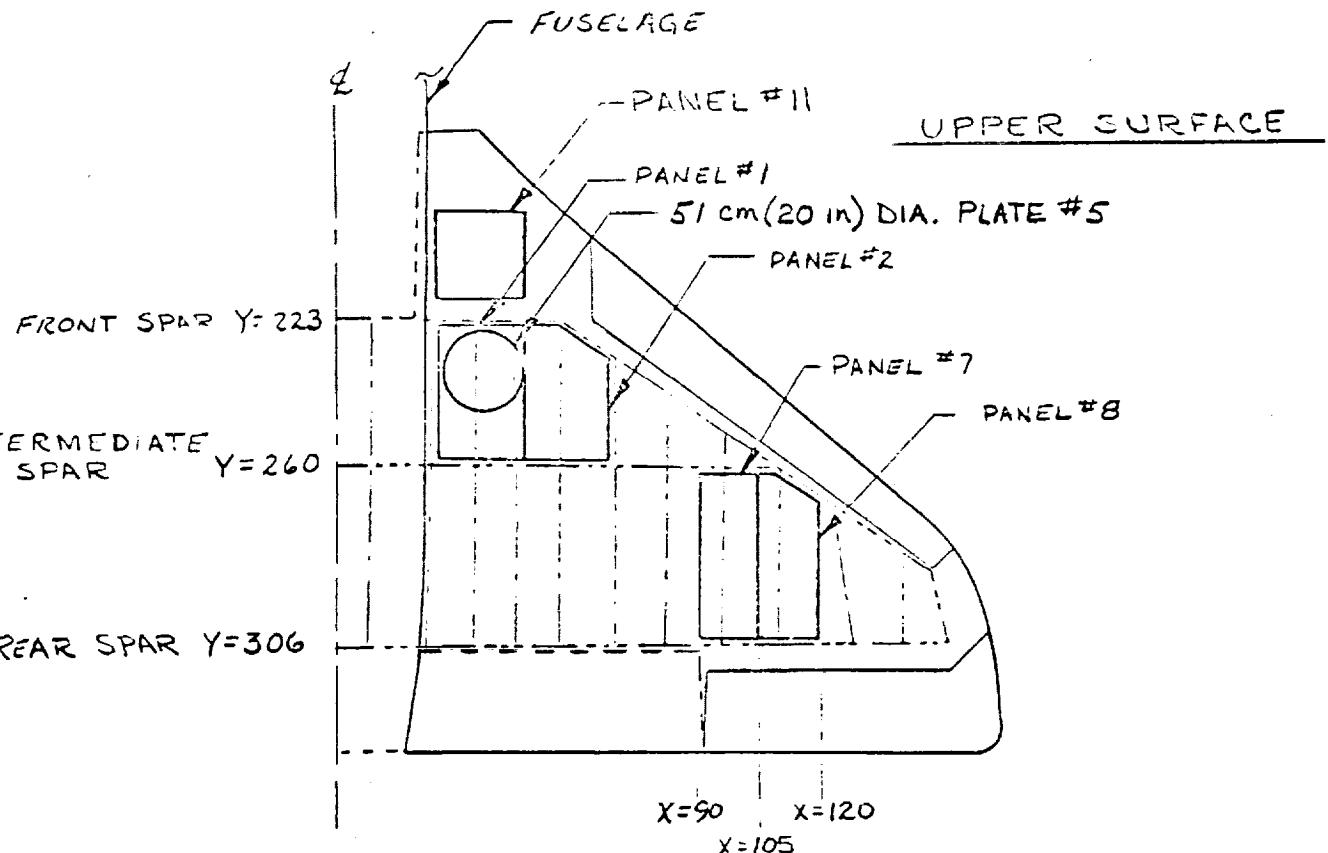


Fig. 3.- UNDAMAGED WING - ALL PANELS IN PLACE

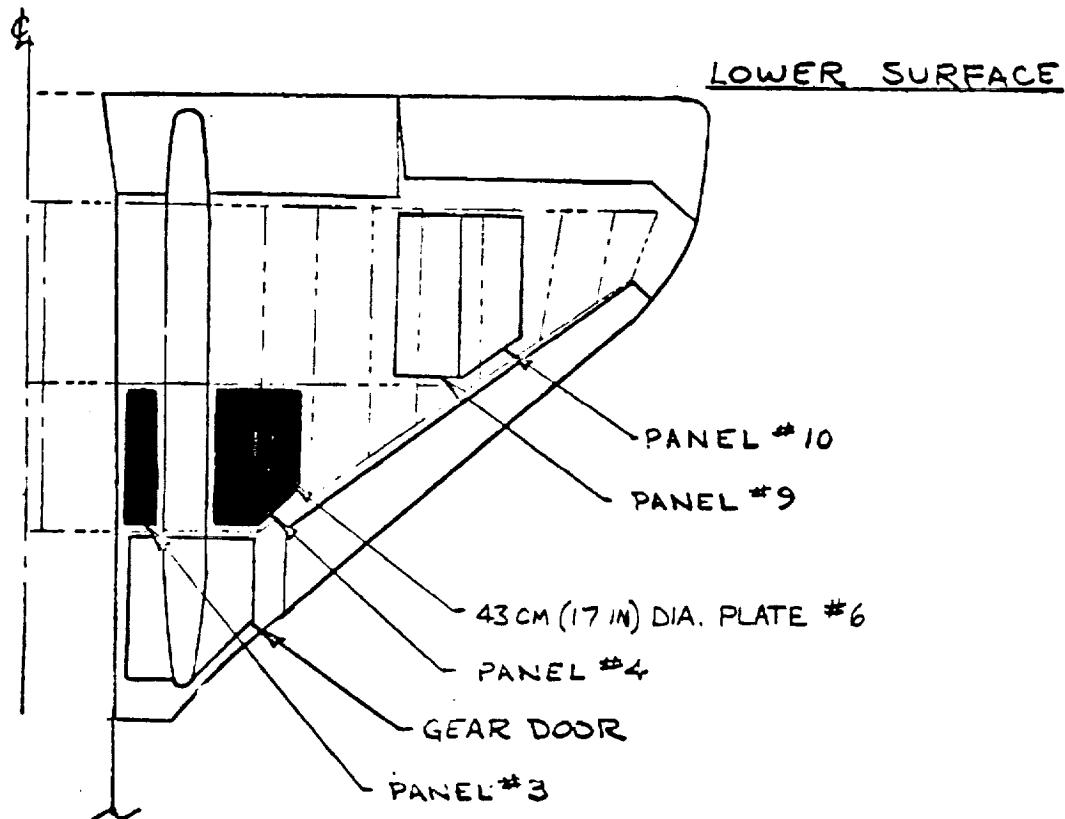
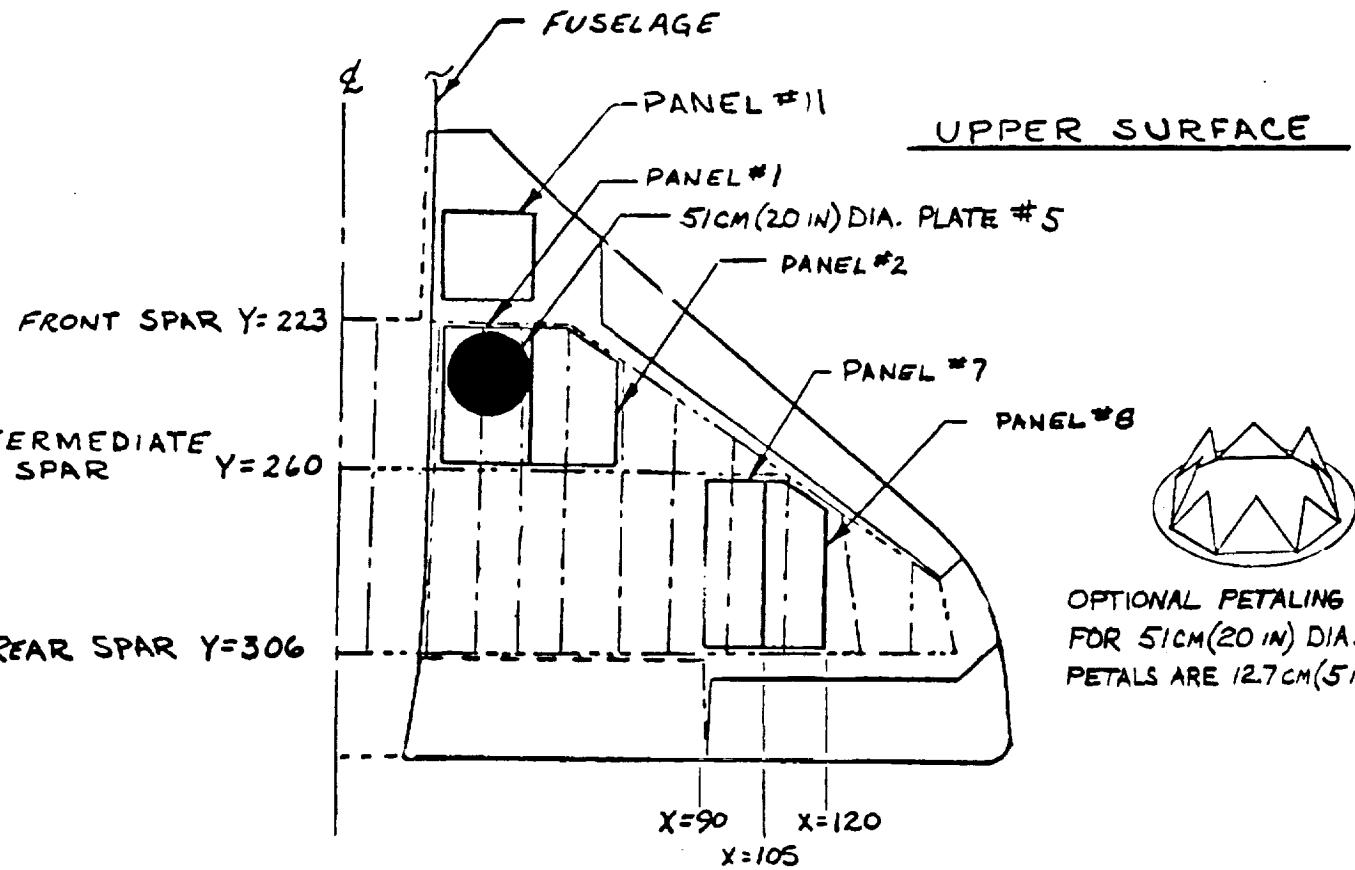


Fig. 4.- HOLE CONFIGURATION #1. PANELS 3&4 AND PLATES 5&6 REMOVED

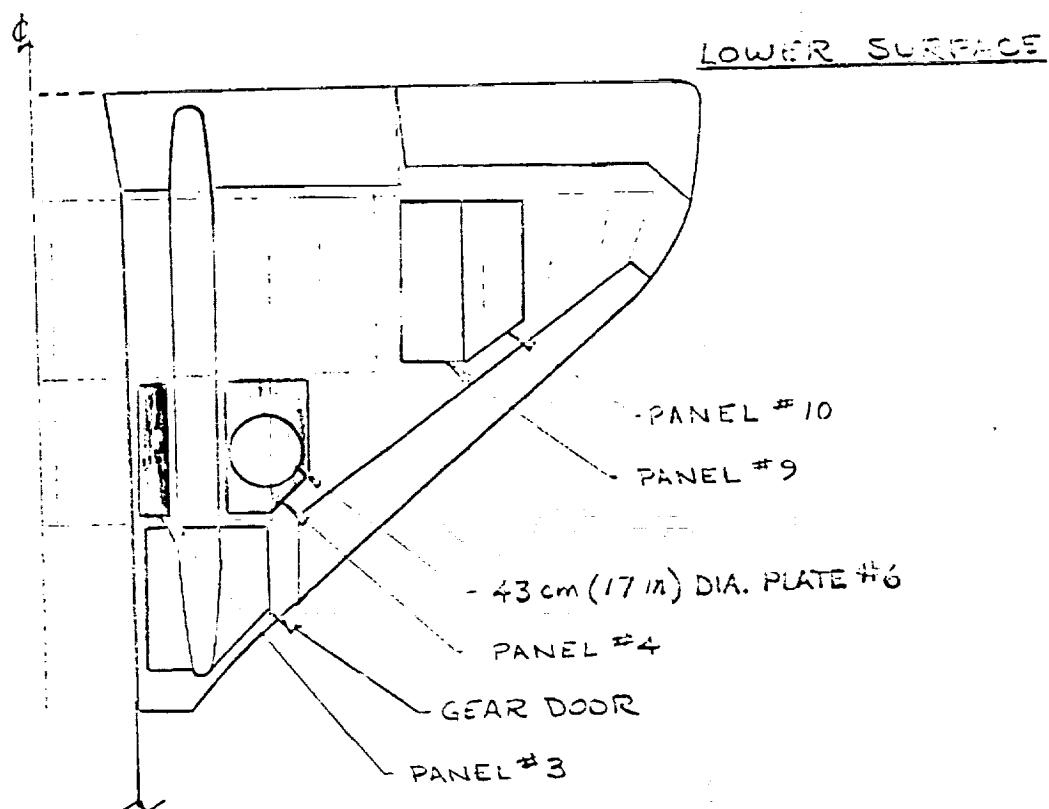
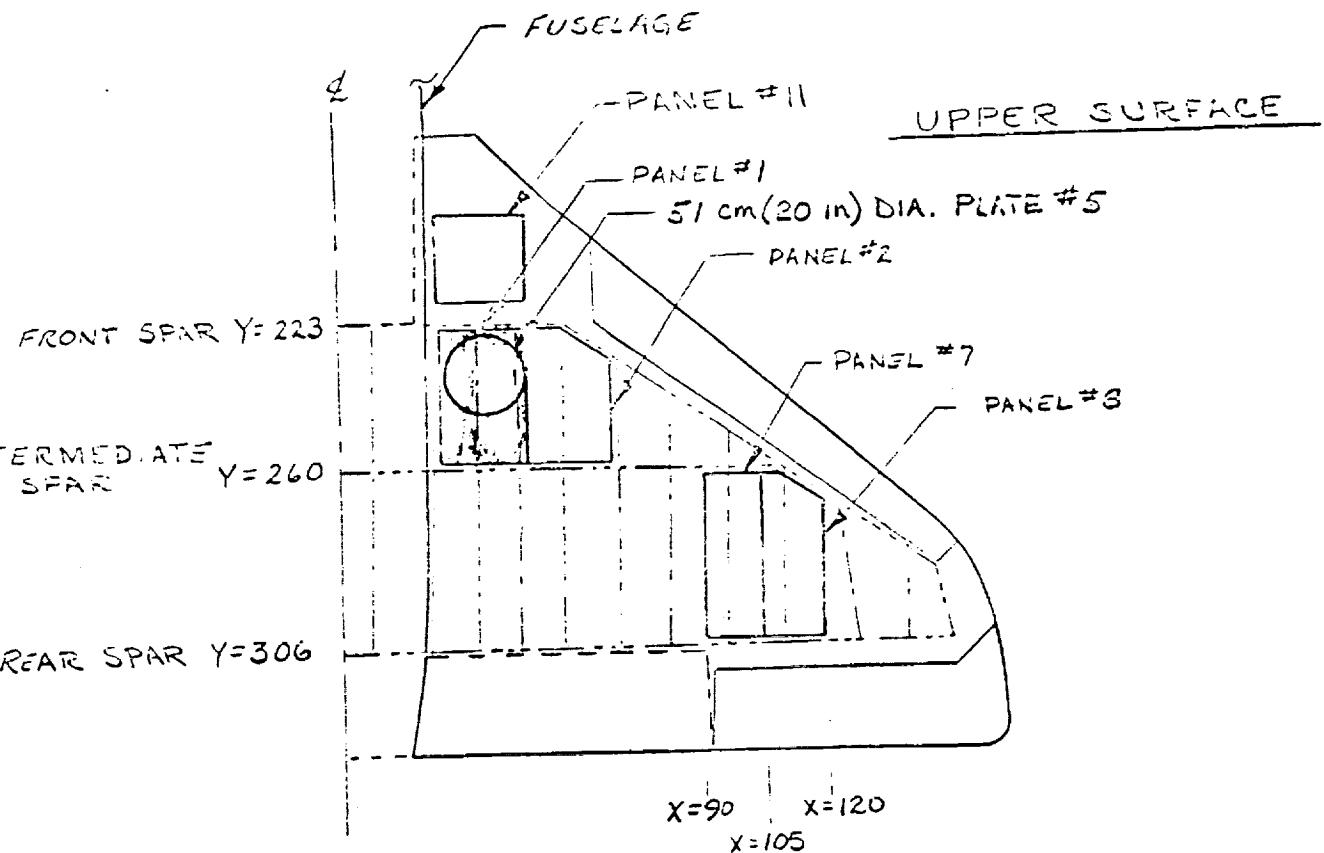


Fig. 5.- HOLE CONFIGURATION #2. PANELS 1,3,4 AND PLATES 5&6 REMOVED

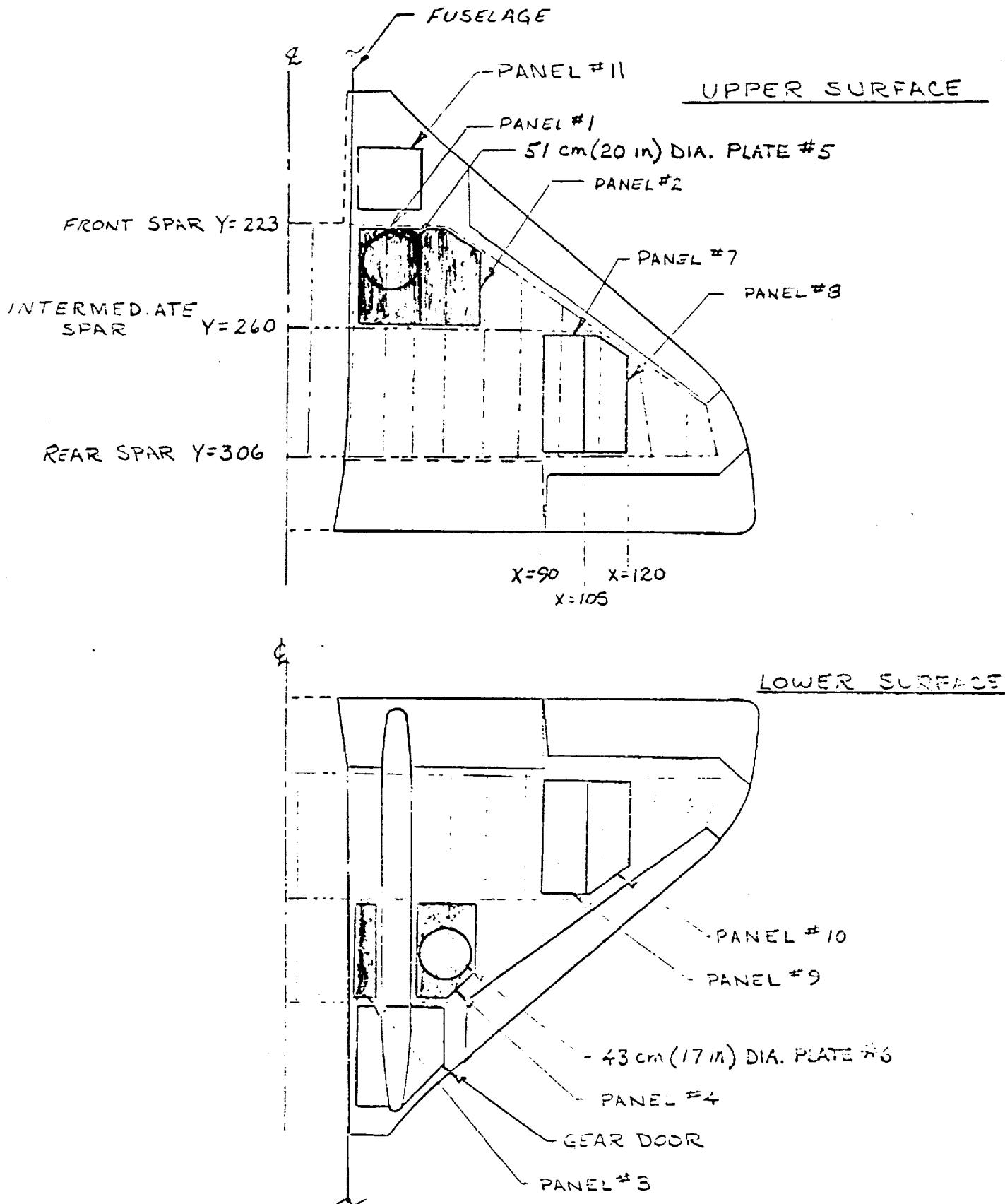


Fig. 6.- HOLE CONFIGURATION #3. PANELS 1,2,3,&4 AND PLATES 5&6 REMOVED

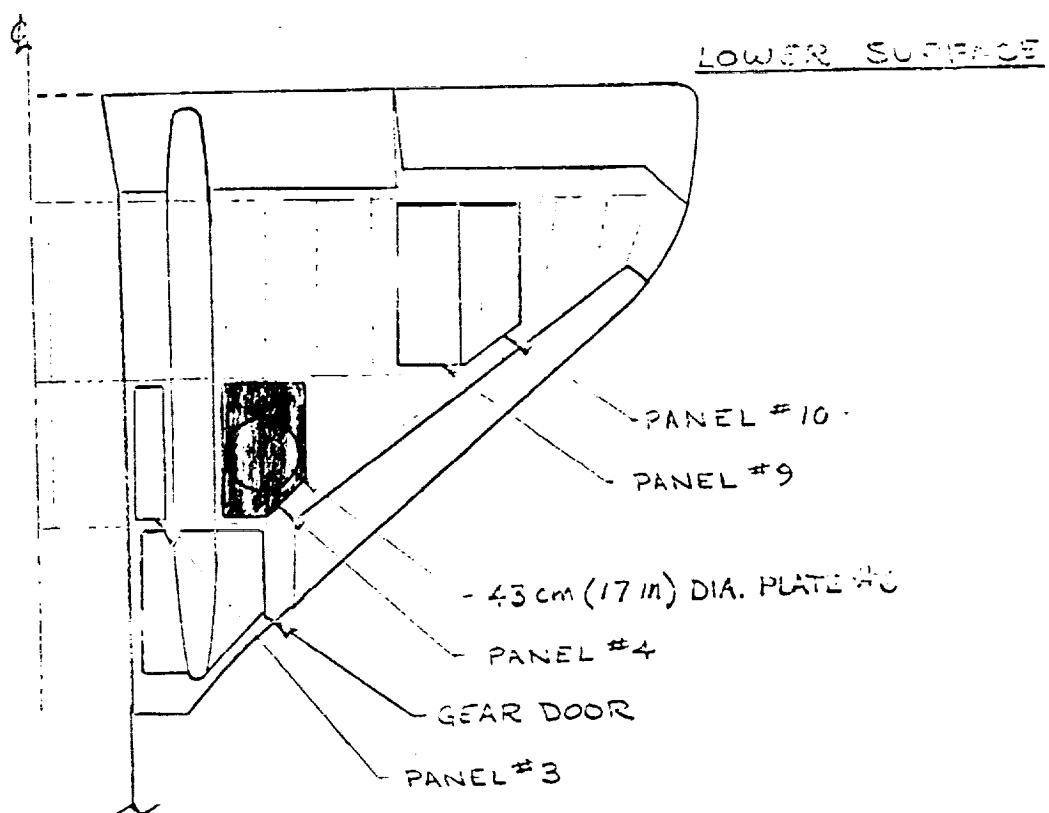
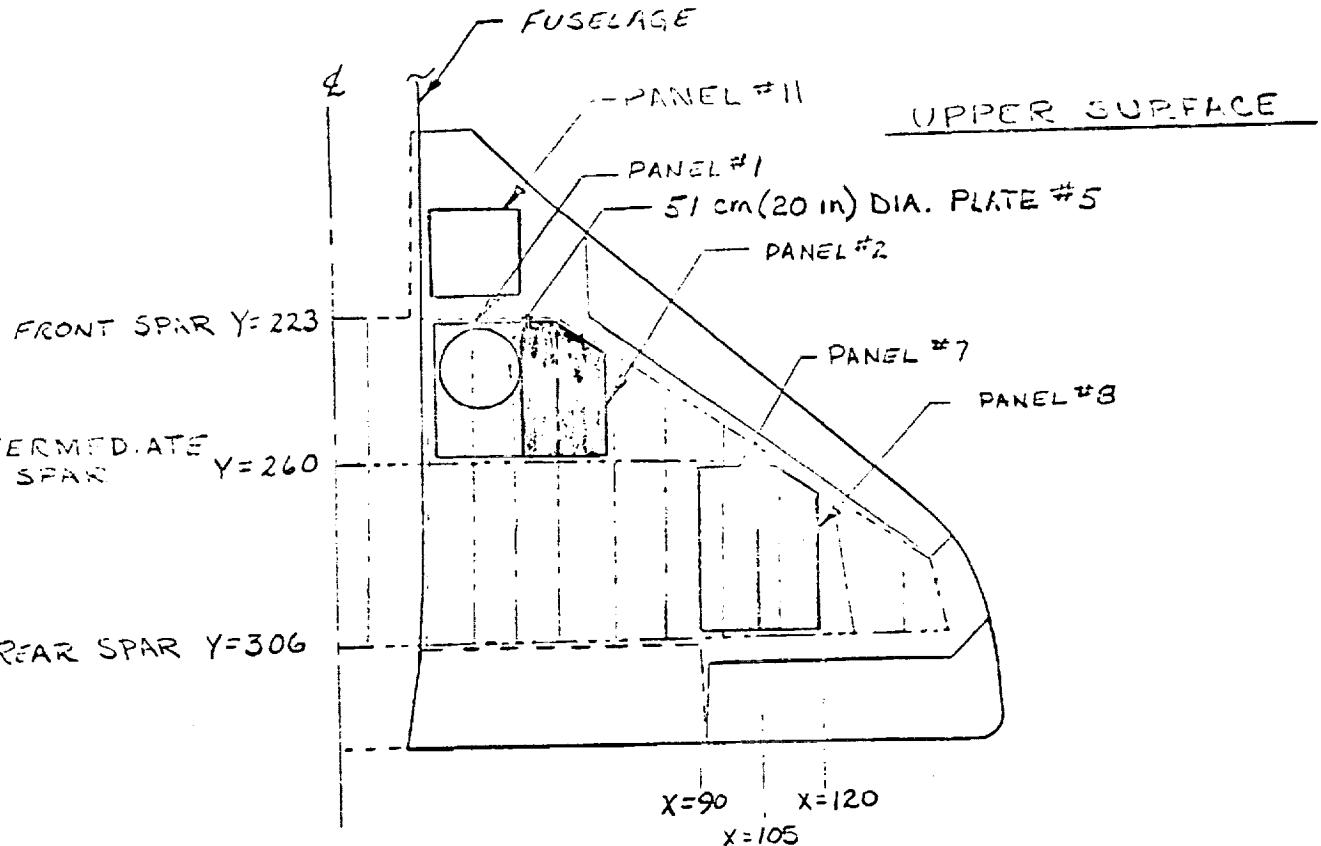


Fig. 7.- HOLE CONFIGURATION #4. PANELS 2&4 AND PLATE 6 REMOVED

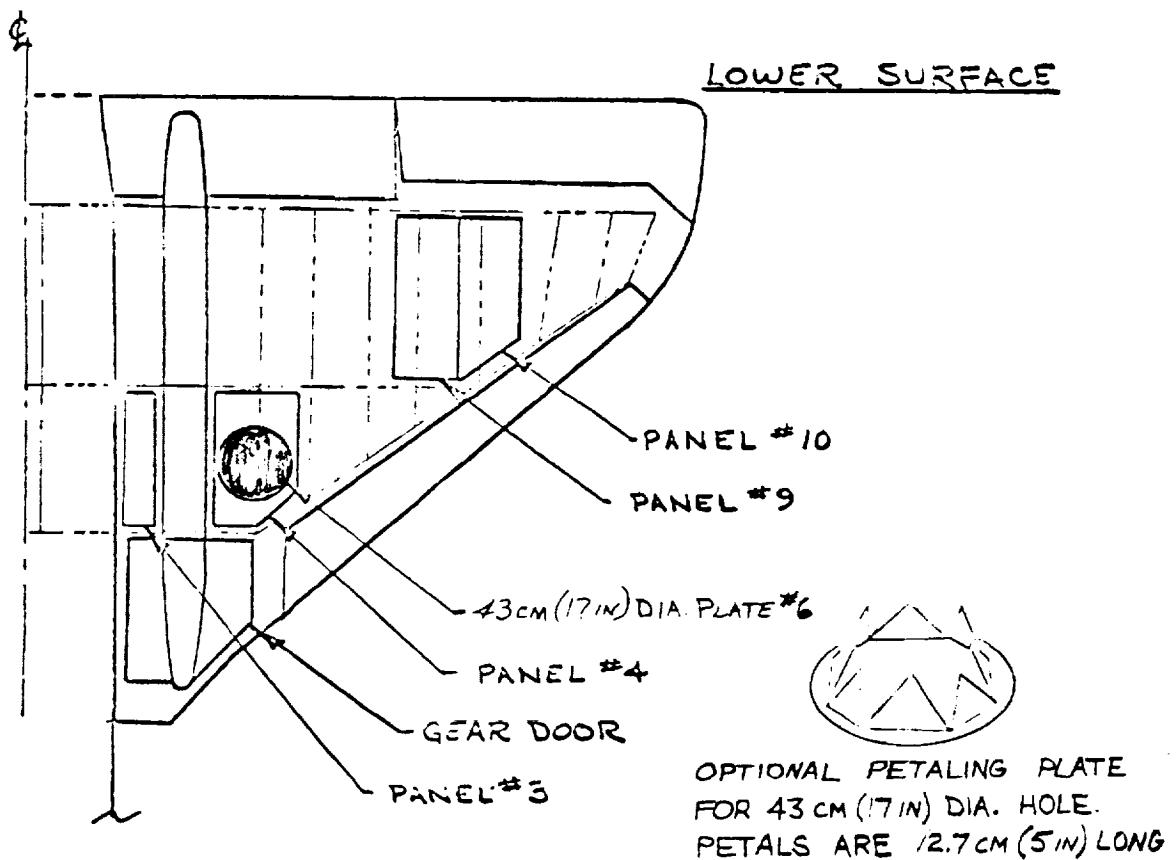
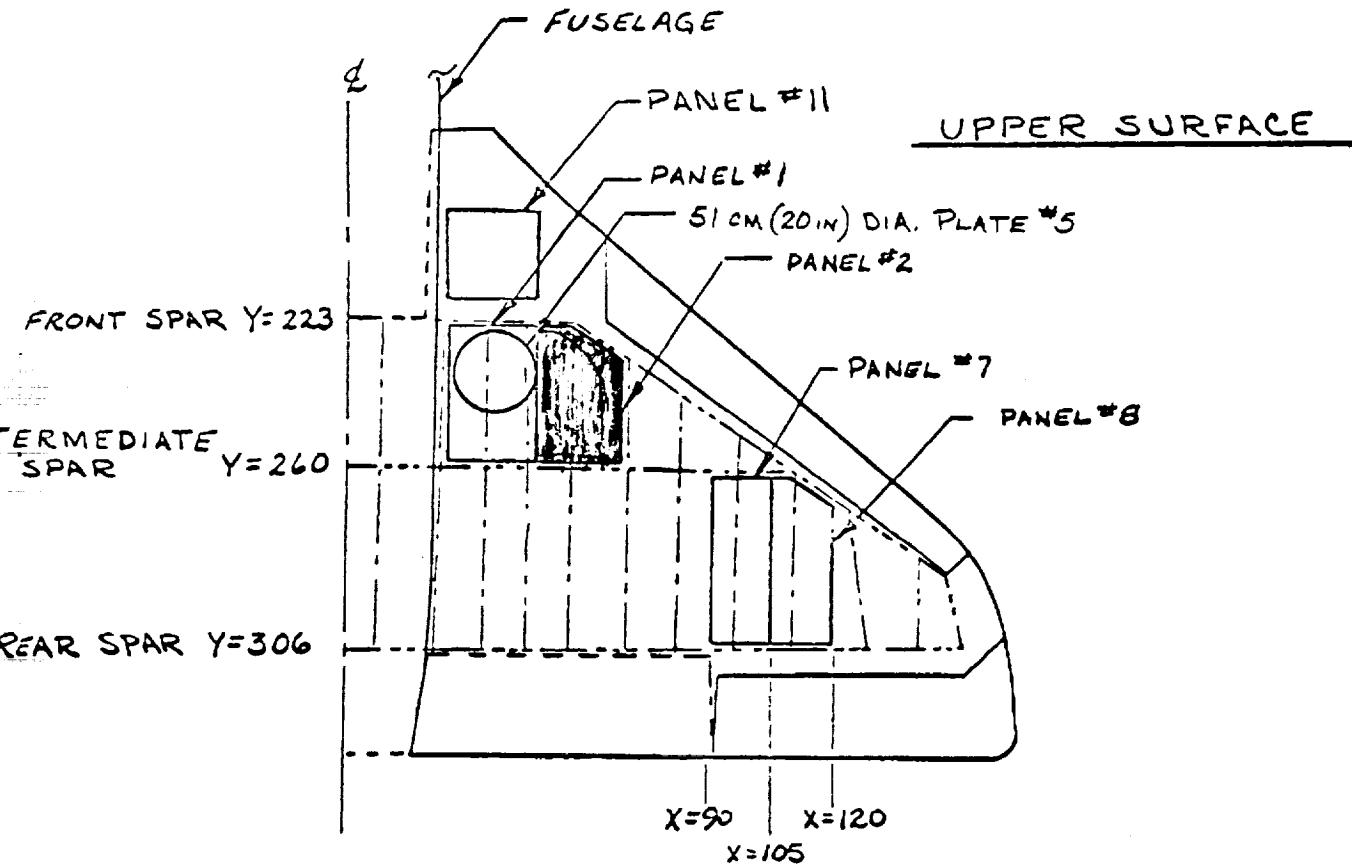
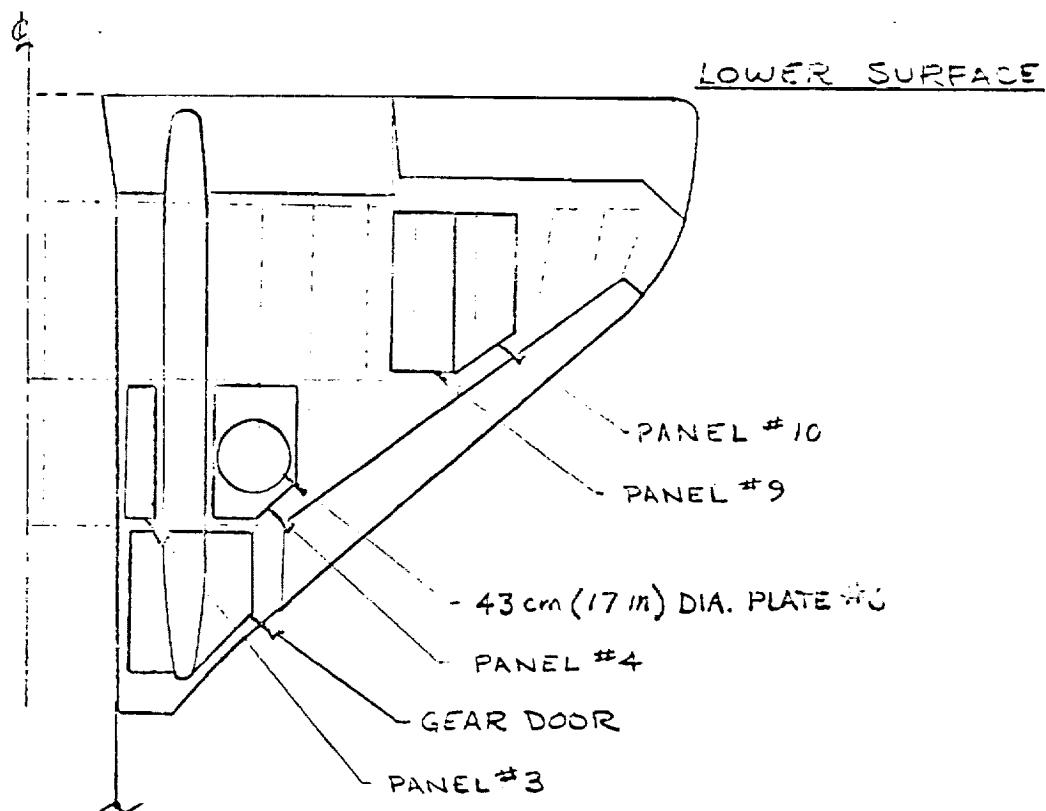
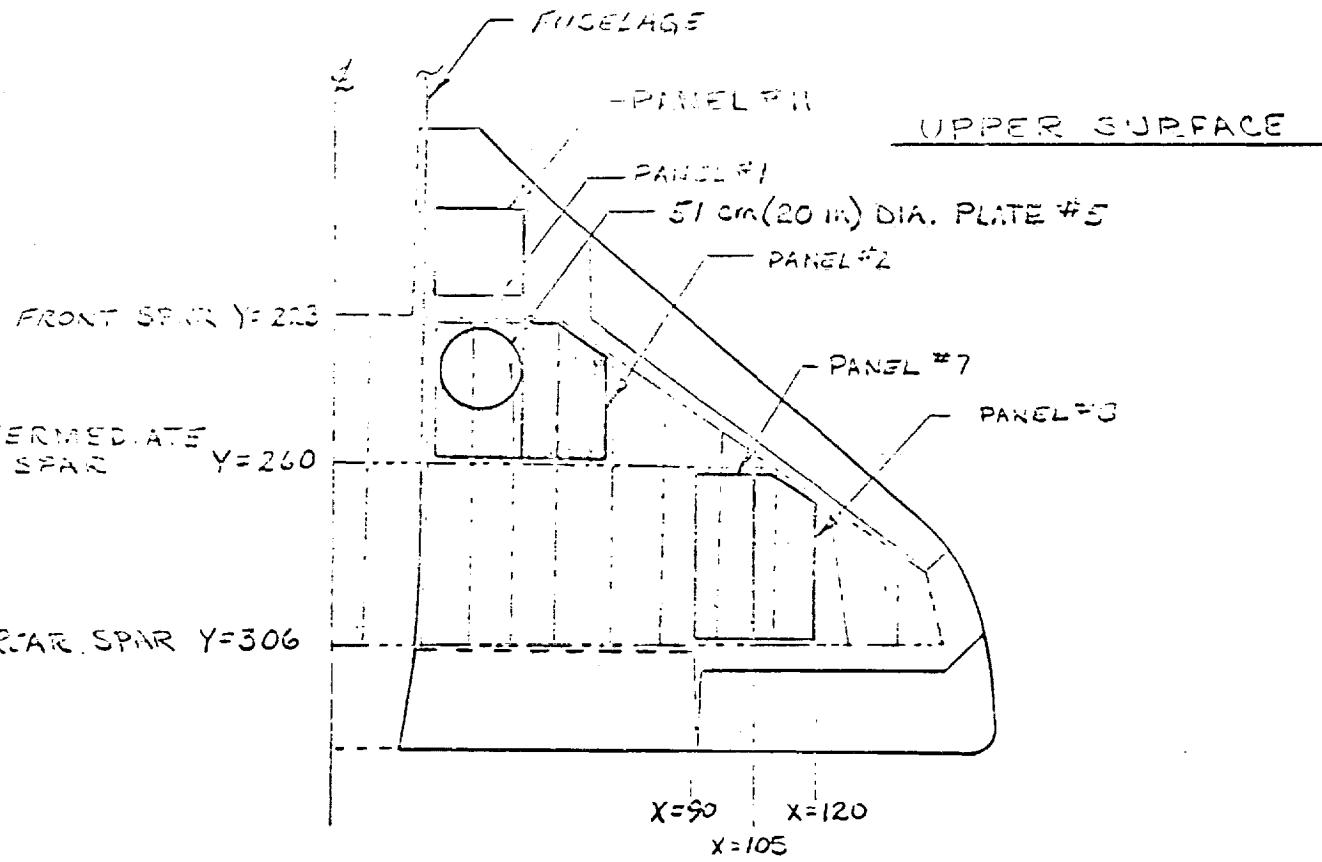


Fig. 8.- HOLE CONFIGURATION #5. PANEL 2 AND PLATE 6 REMOVED



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Fig. 9.- HOLE CONFIGURATION #6. PANELS 1&2 AND PLATE 5 REMOVED

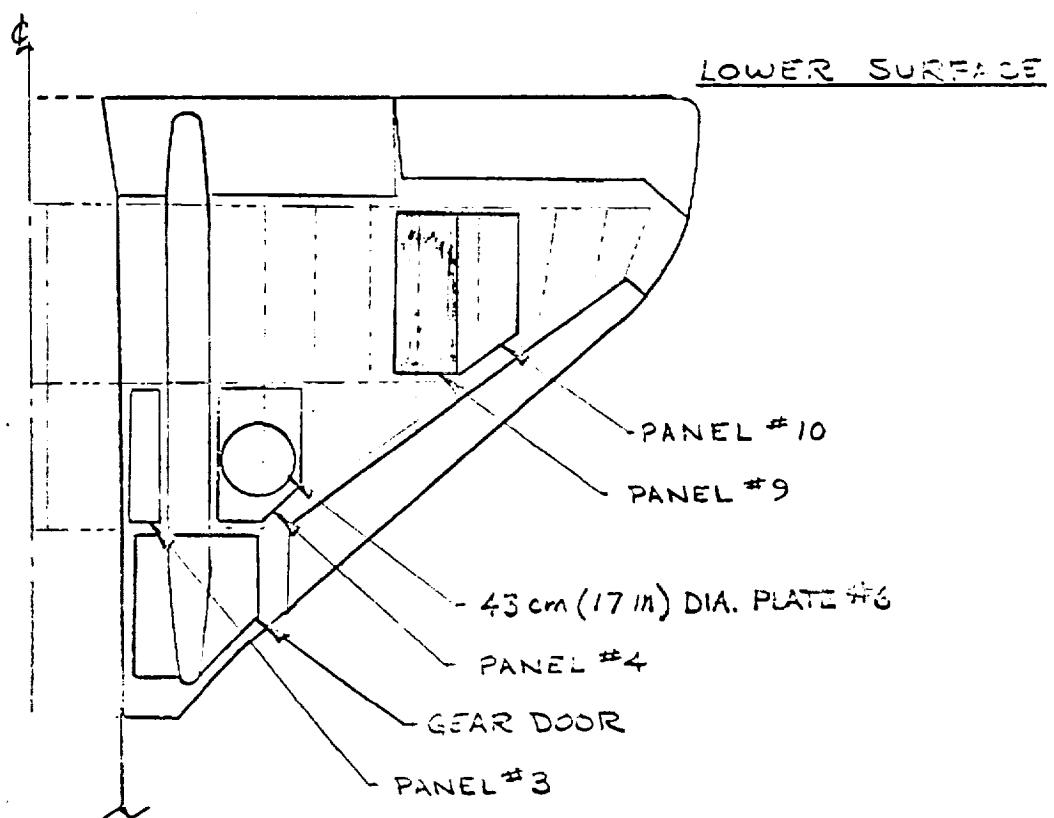
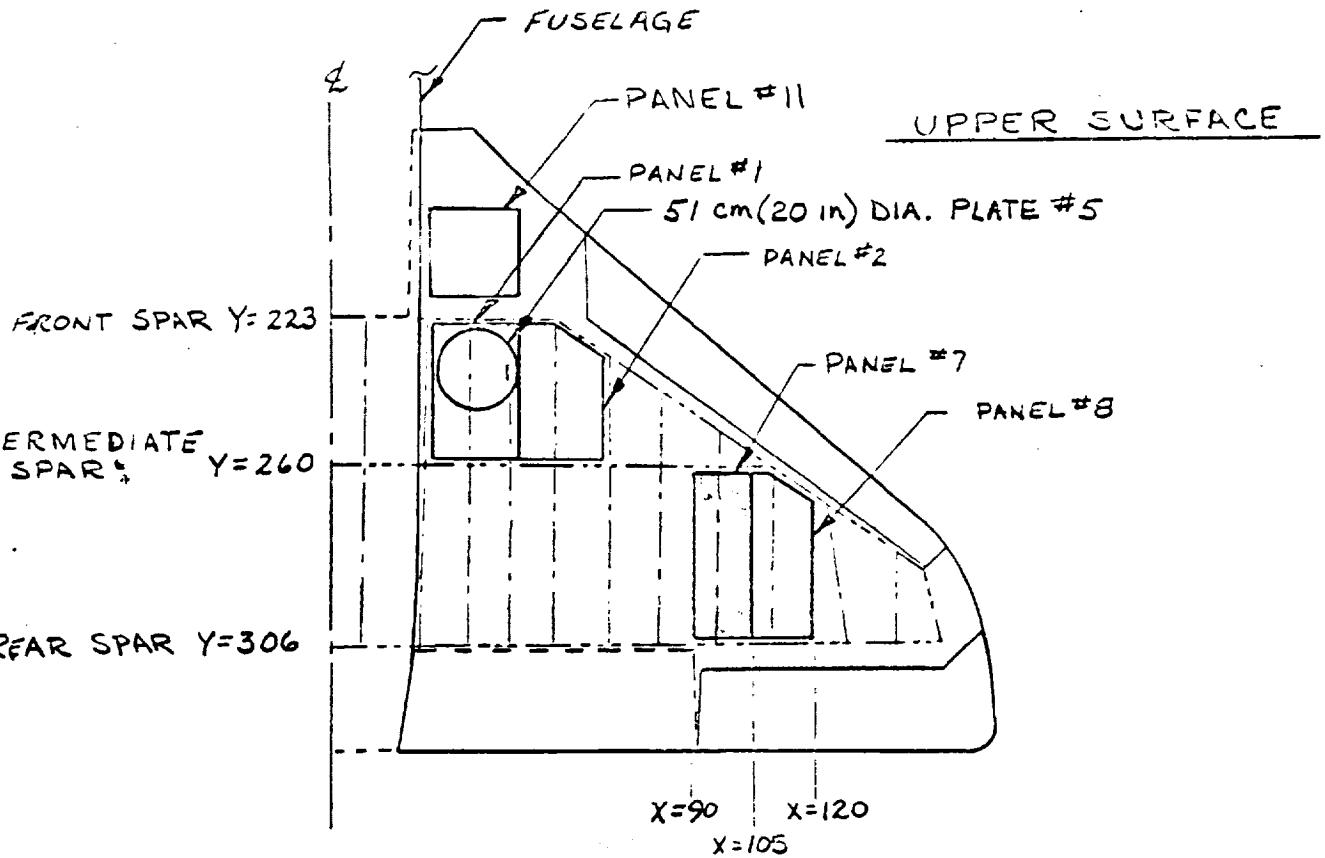


Fig. 10.- HOLE CONFIGURATION #7. PANELS 7&9 REMOVED

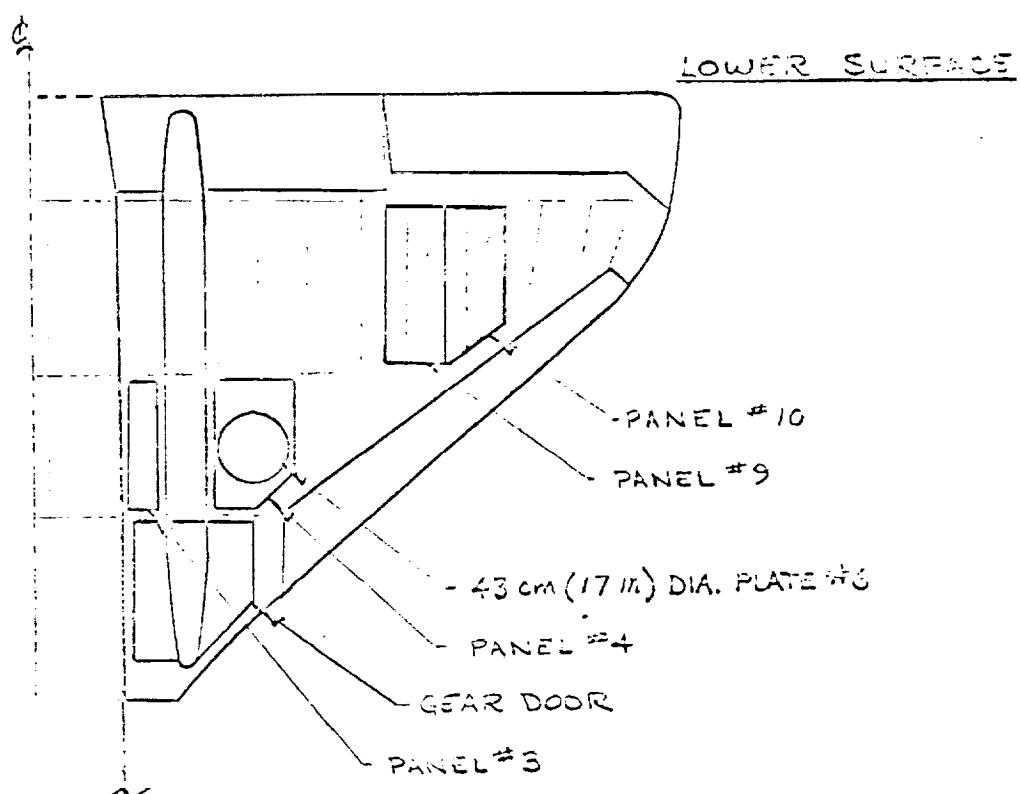
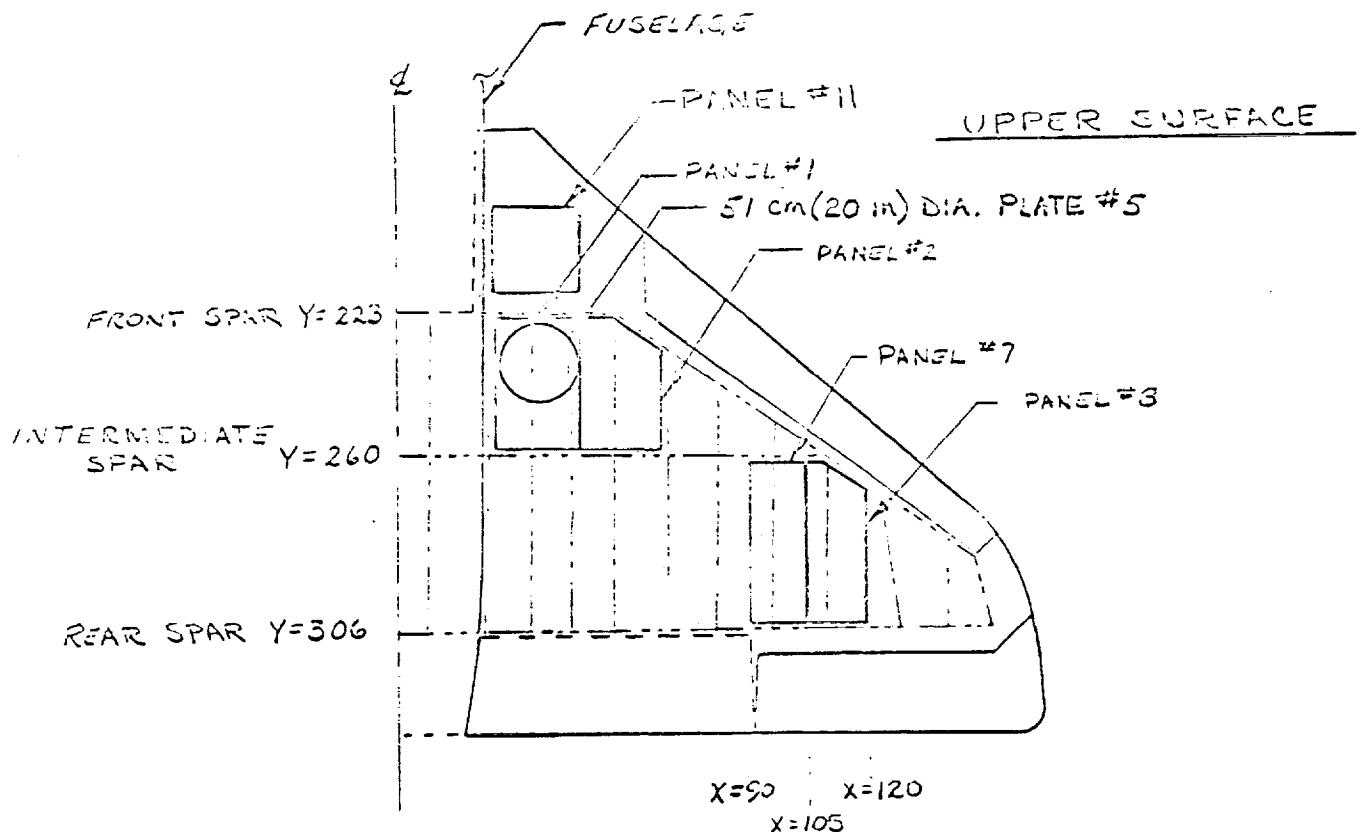
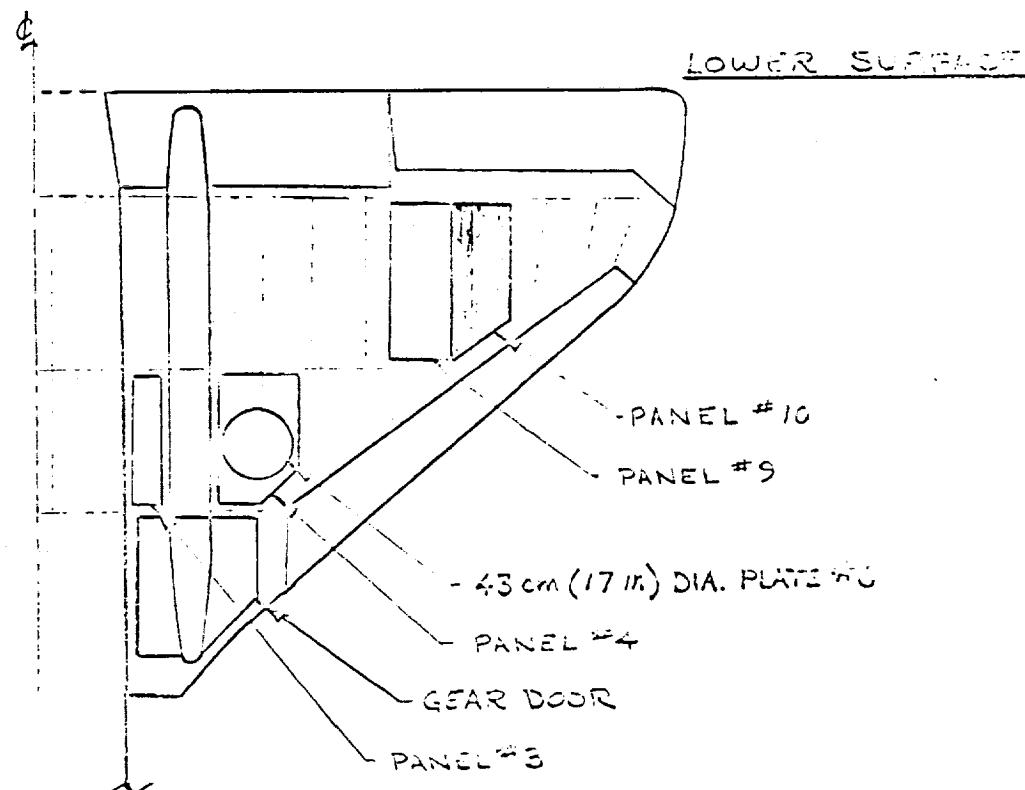
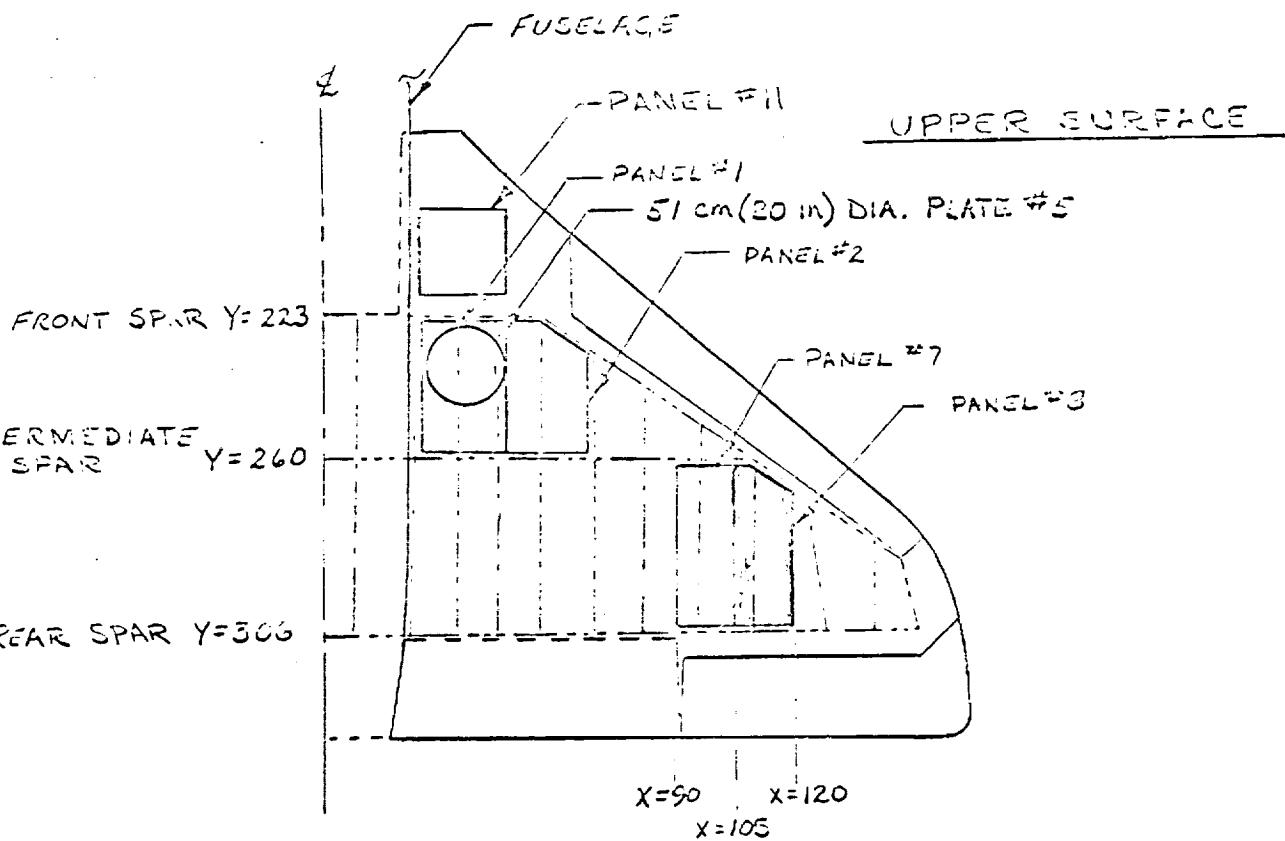


Fig. 11.- HOLE CONFIGURATION #8. PANELS 7,8,9,&10 REMOVED



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OF POOR QUALITY

Fig. 12.- HOLE CONFIGURATION #9. PANELS 8&10 REMOVED.

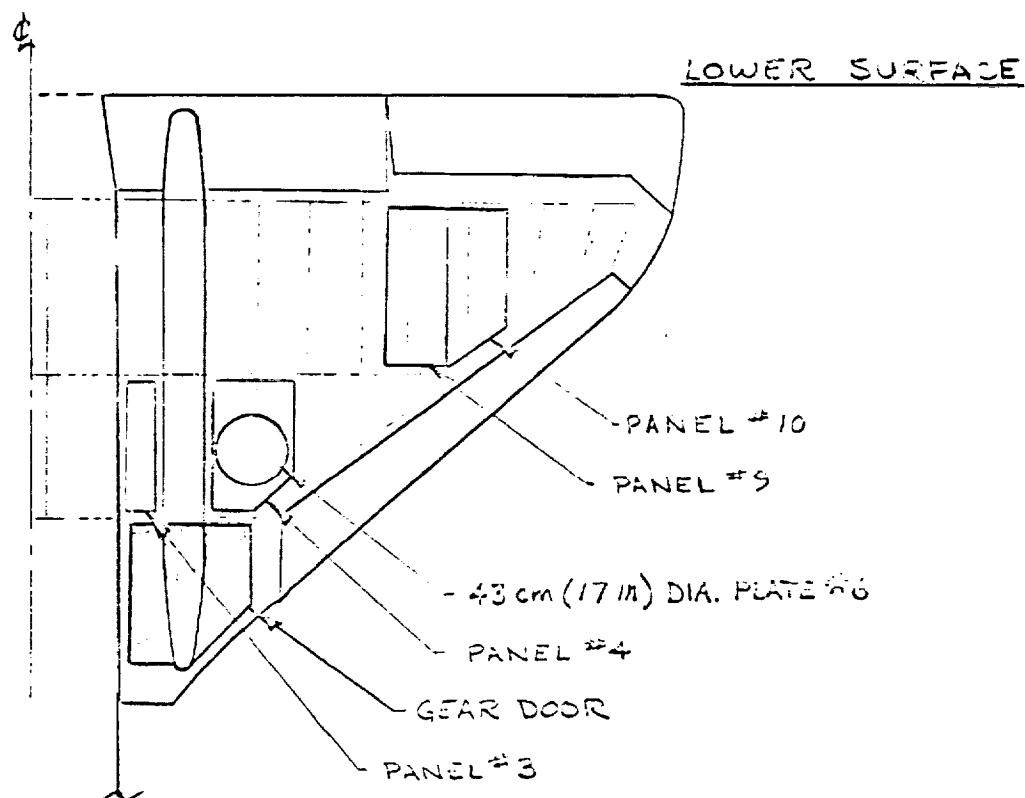
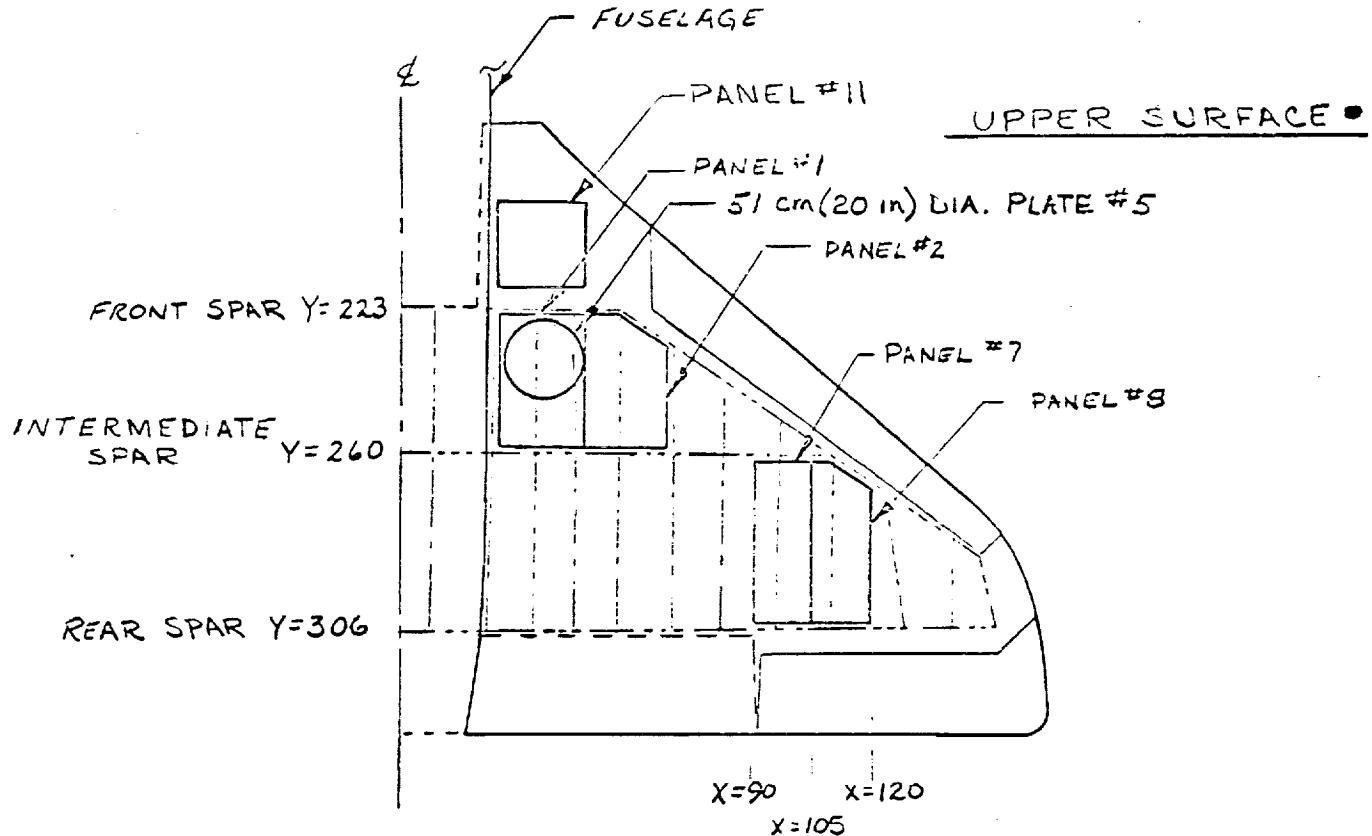


Fig. 13.- HOLE CONFIGURATION #10. GEAR DOOR LOCKED OPEN

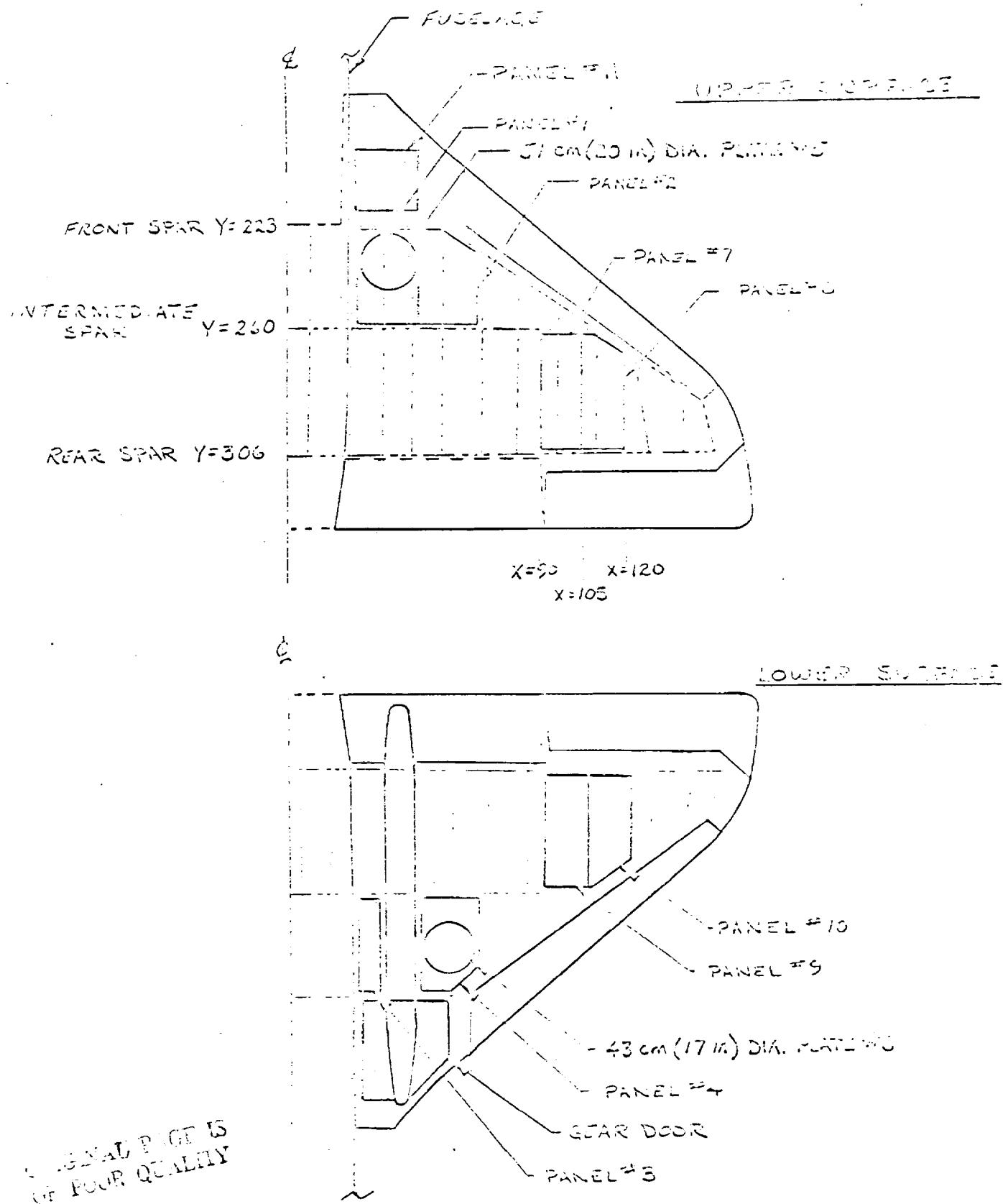


Fig. 14.- HOLE CONFIGURATION #11. PANEL 11 REMOVED AND GEAR DOOR OPEN

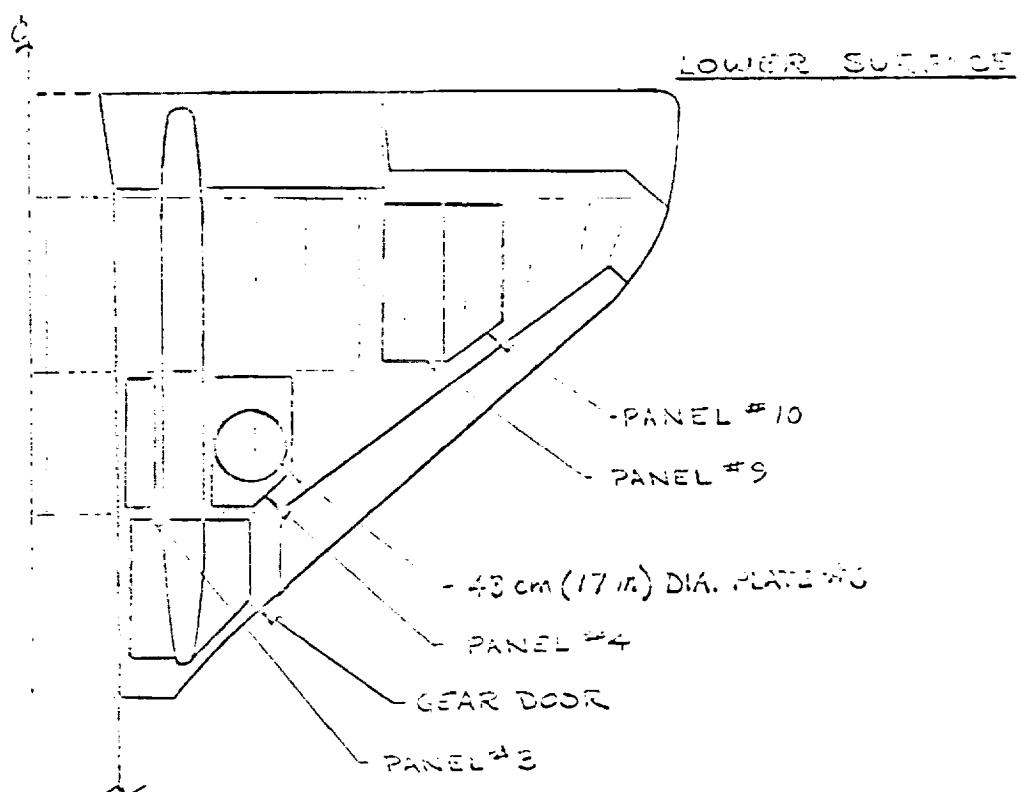
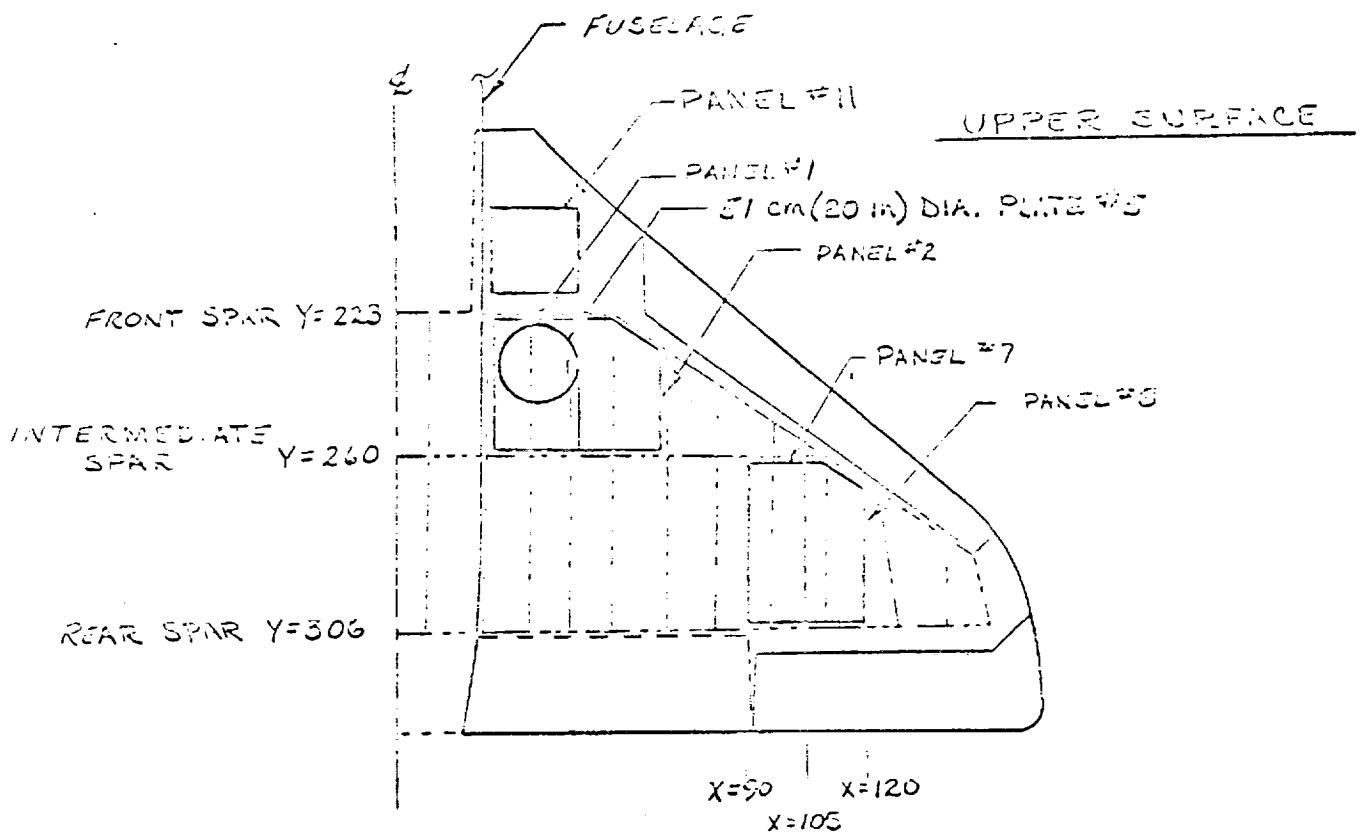


Fig. 15.- HOLE CONFIGURATION #12. PANELS 1, 3, 4, & 11 AND PLATES 5&6 REMOVED; GEAR DOOR LOCKED OPEN

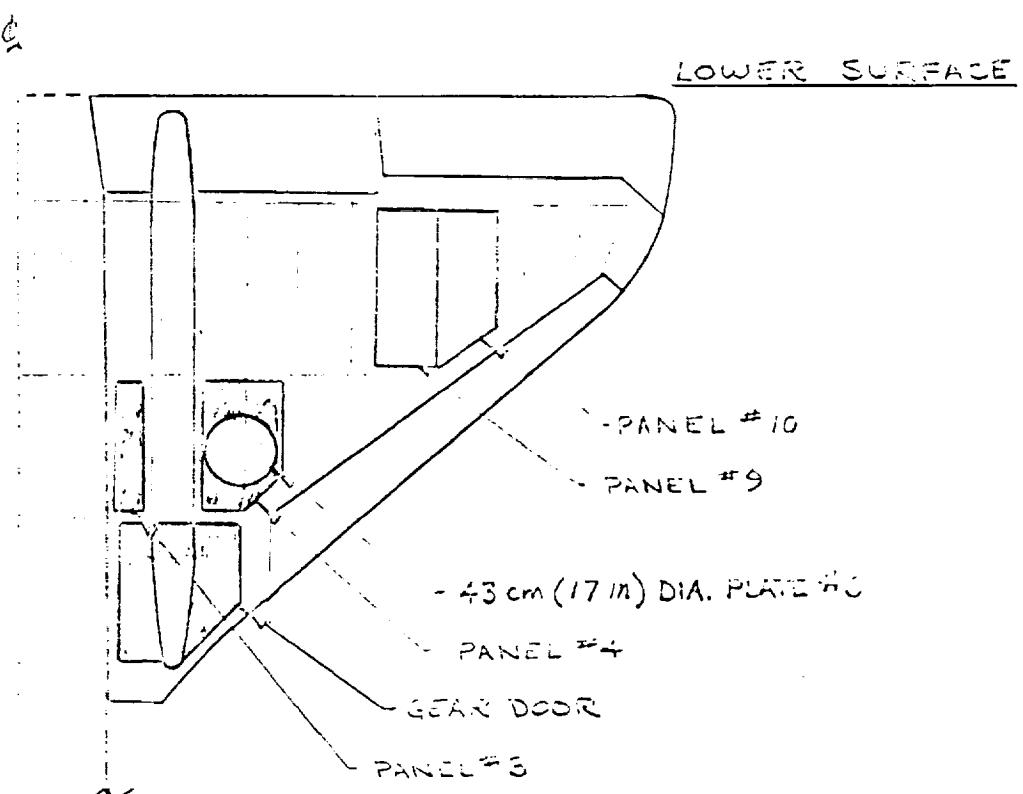
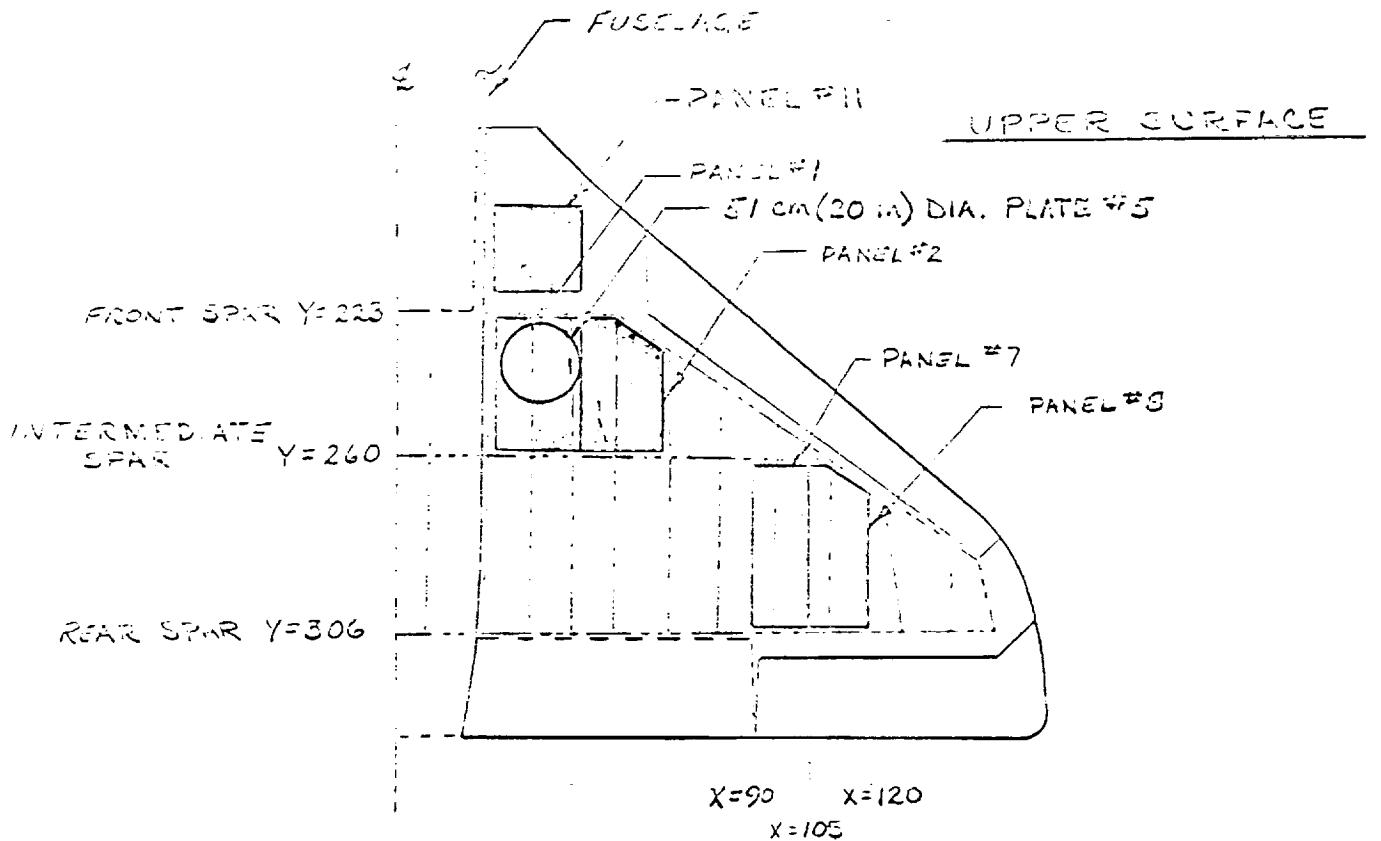


Fig. 16.- HOLE CONFIGURATION #13. ALL INBOARD PANELS & PLATES REMOVED;
GEAR DOOR OPEN

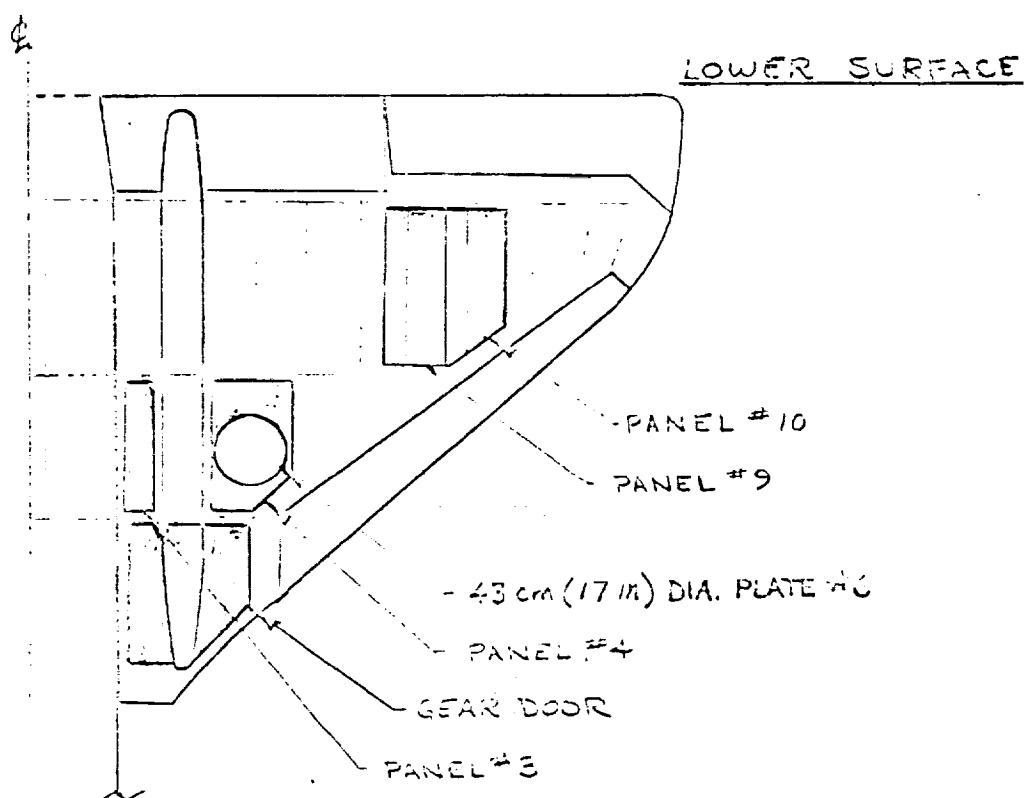
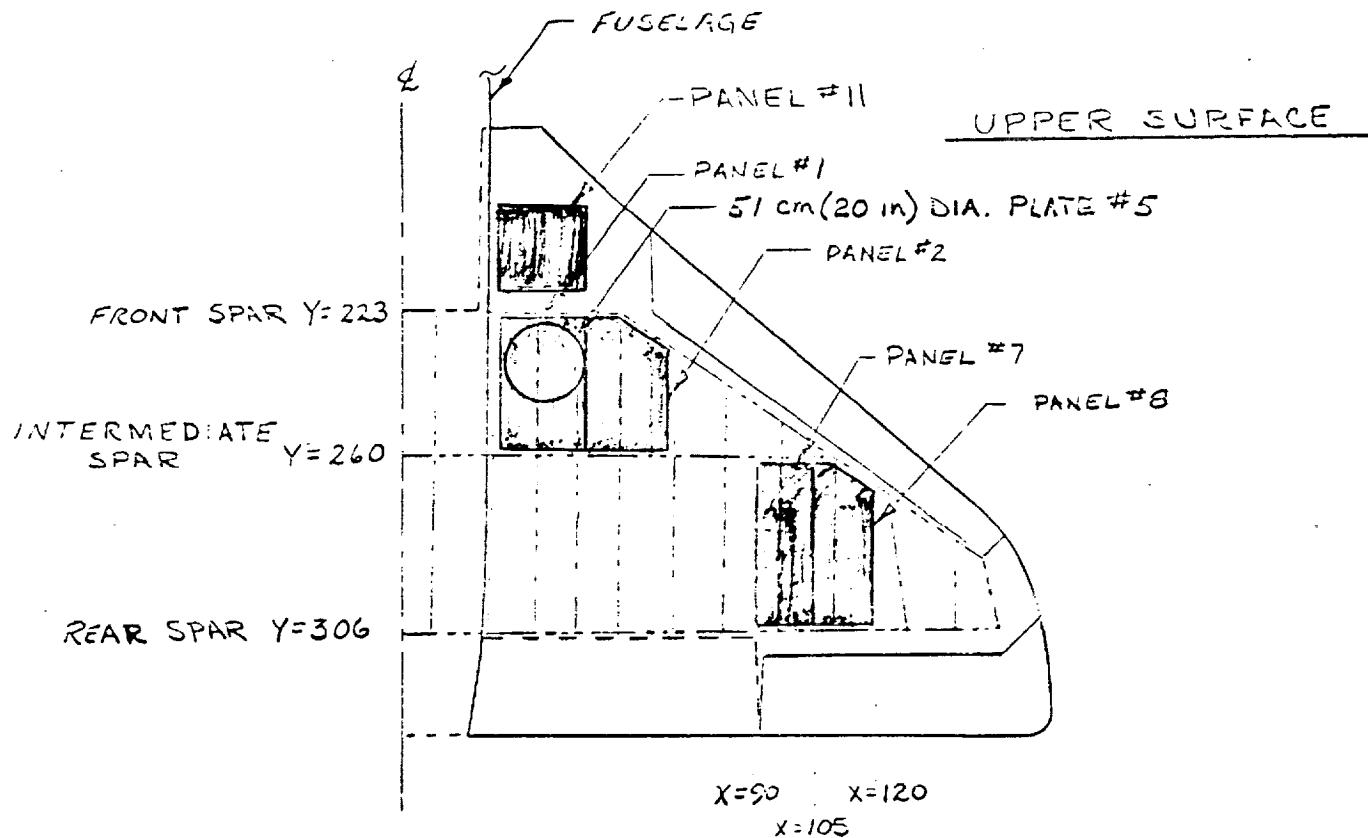


Fig. 17.- HOLE CONFIGURATION #14. ALL PLATES & PANELS REMOVED;
GEAR DOOR LOCKED OPEN

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33

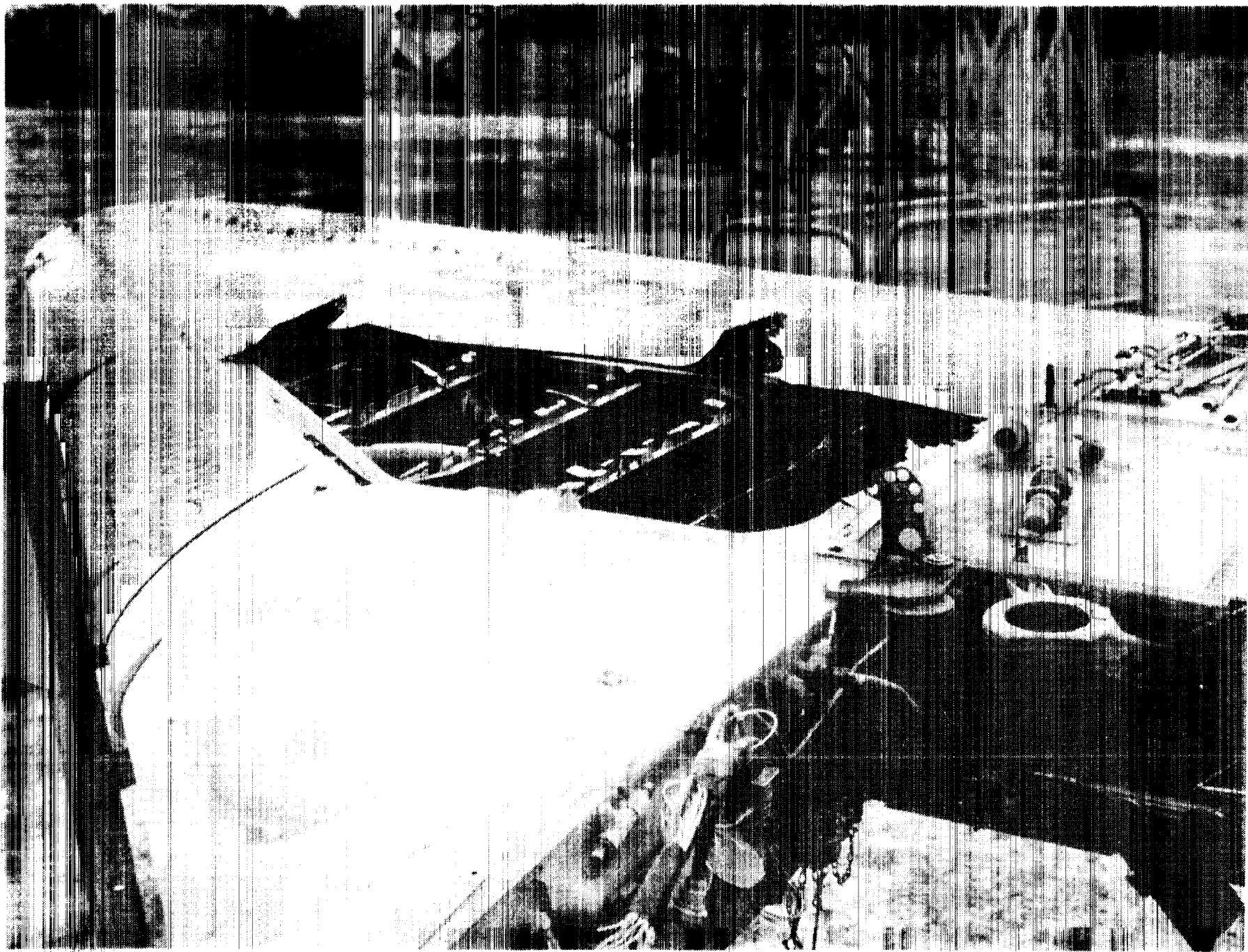


Fig. 18.- TOP SURFACE OF 25mm DAMAGED WING.
LEADING EDGE IS IN LEFT FOREGROUND

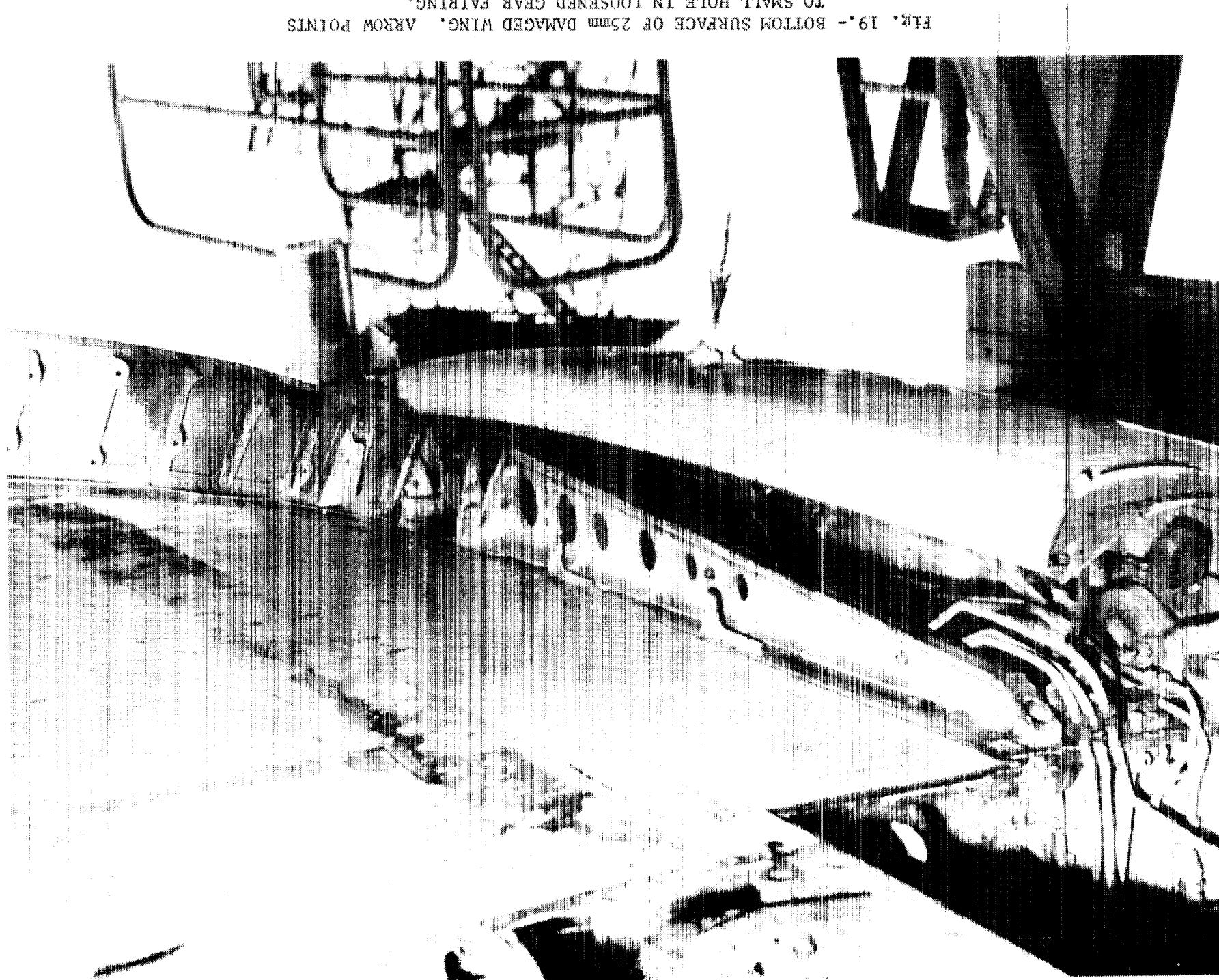


FIG. 19.- BOTTOM SURFACE OF 25mm DAMAGED WING. ARROW POINTS
TO SMALL HOLE IN LOOSEND GEAR FAIRING.

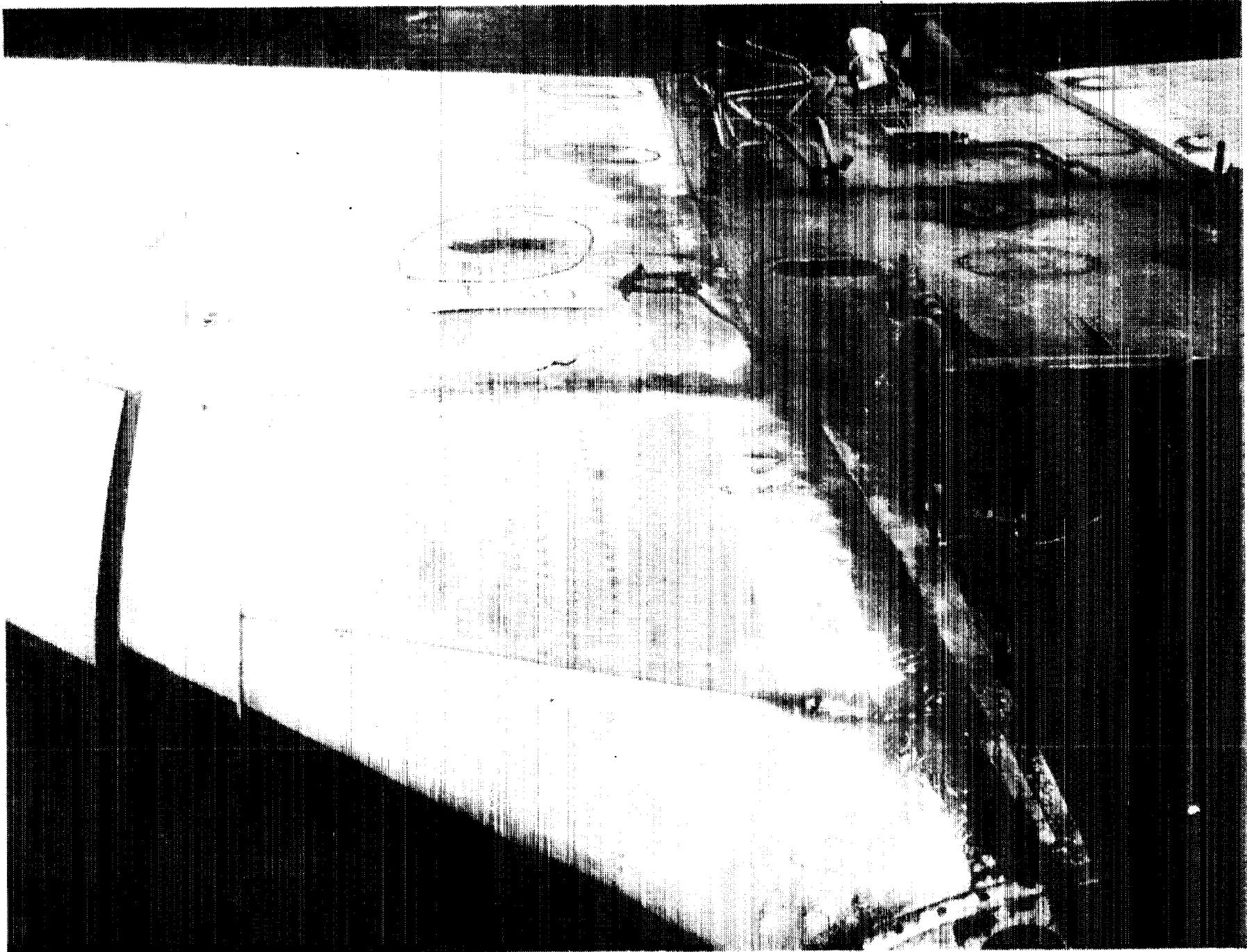


Fig. 20.- TOP SURFACE OF 30mm DAMAGED WING.

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OF POOR
QUALITY

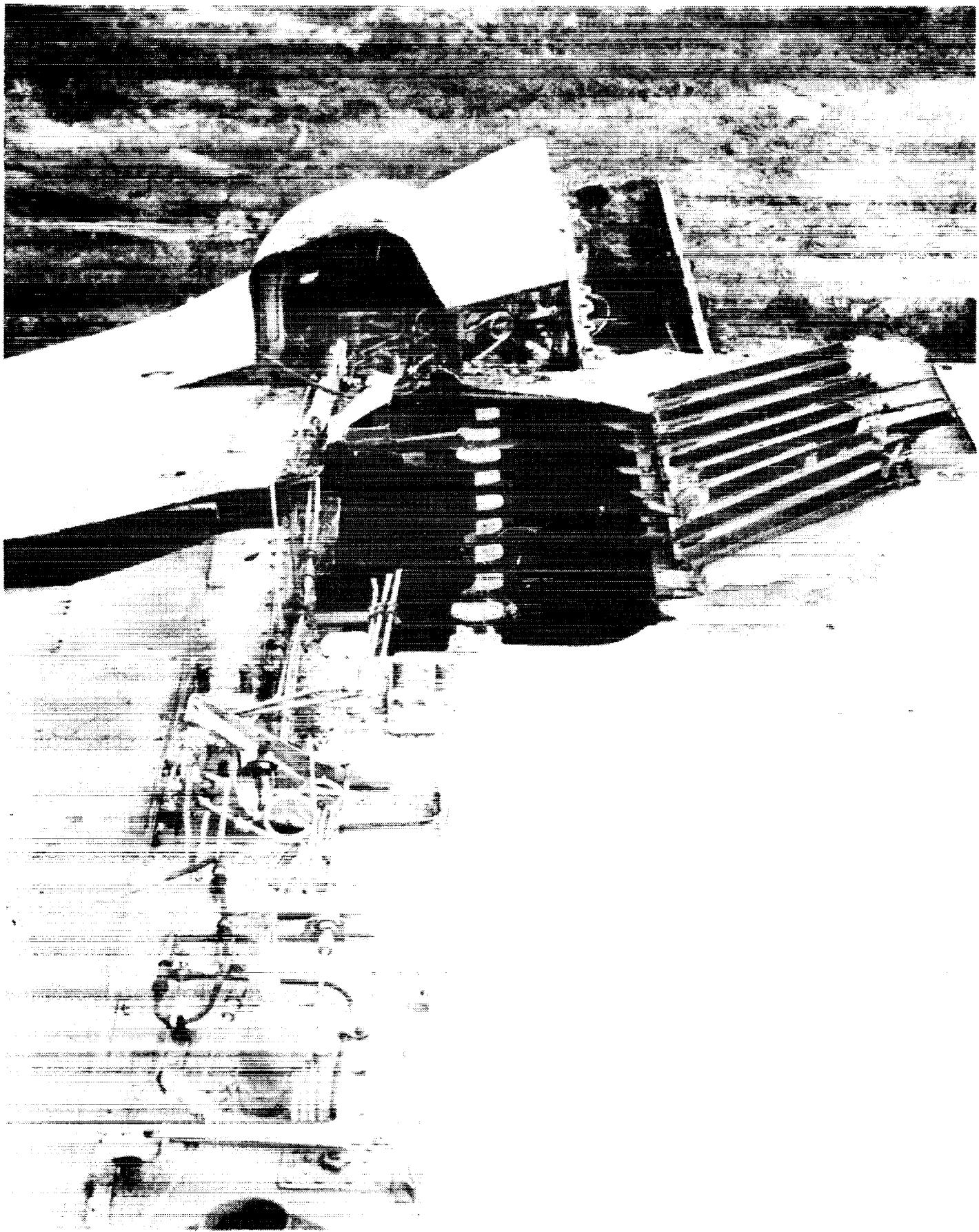


Fig. 21.- BOTTOM SURFACE OF 30mm DAMAGED WING.
LEADING EDGE IS IN LEFT BACKGROUND

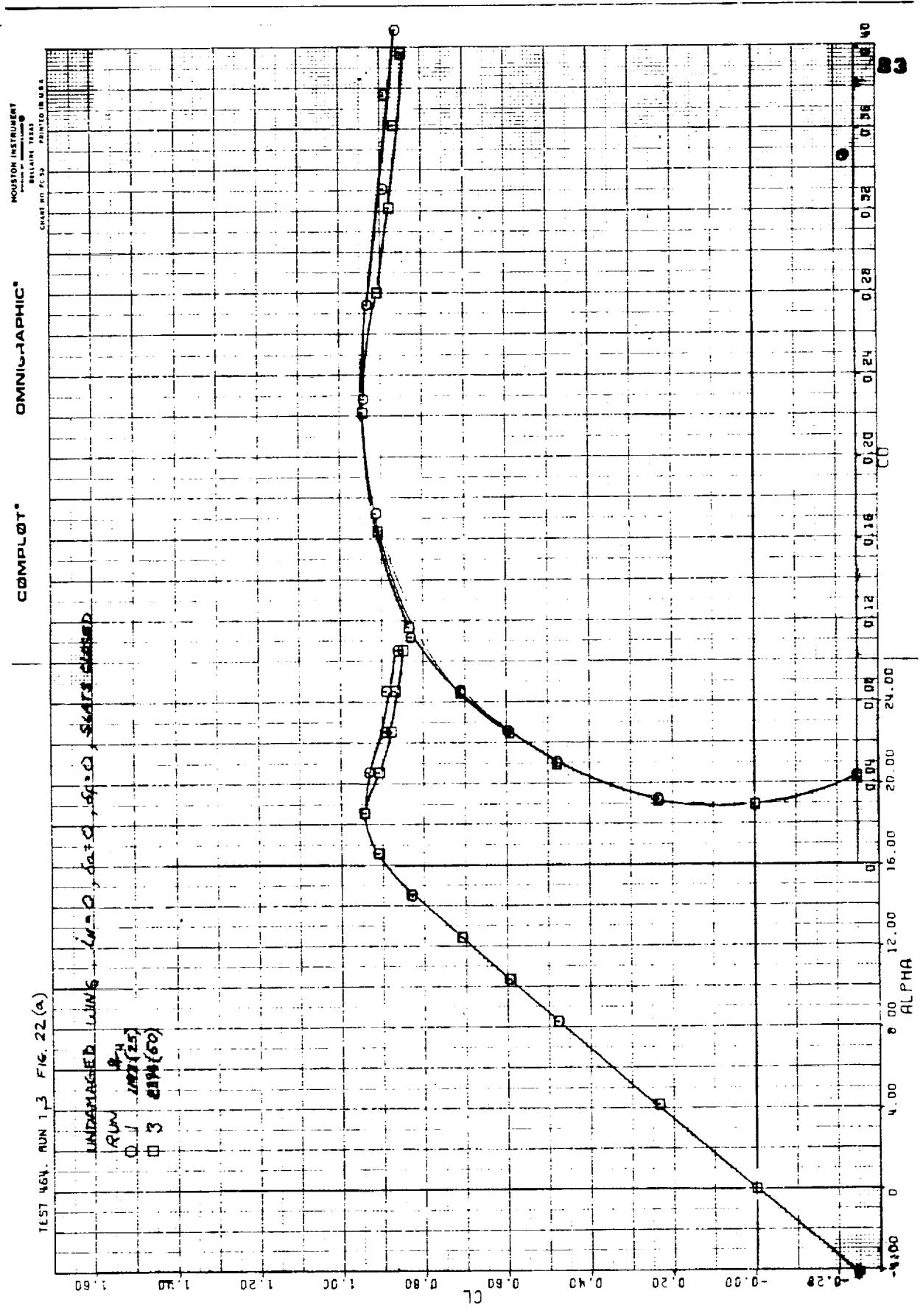


Figure 22(a)

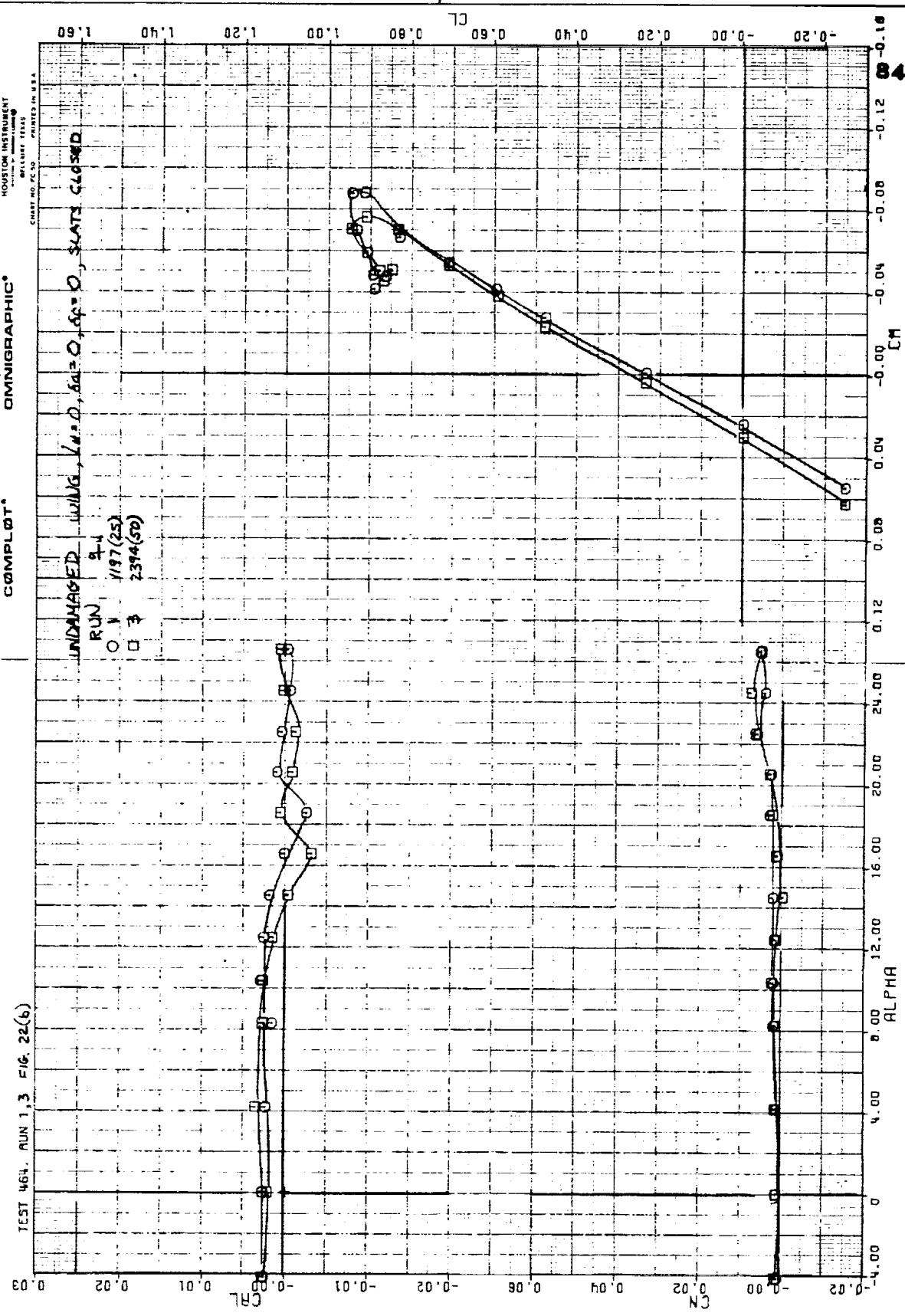


Figure 22(b)

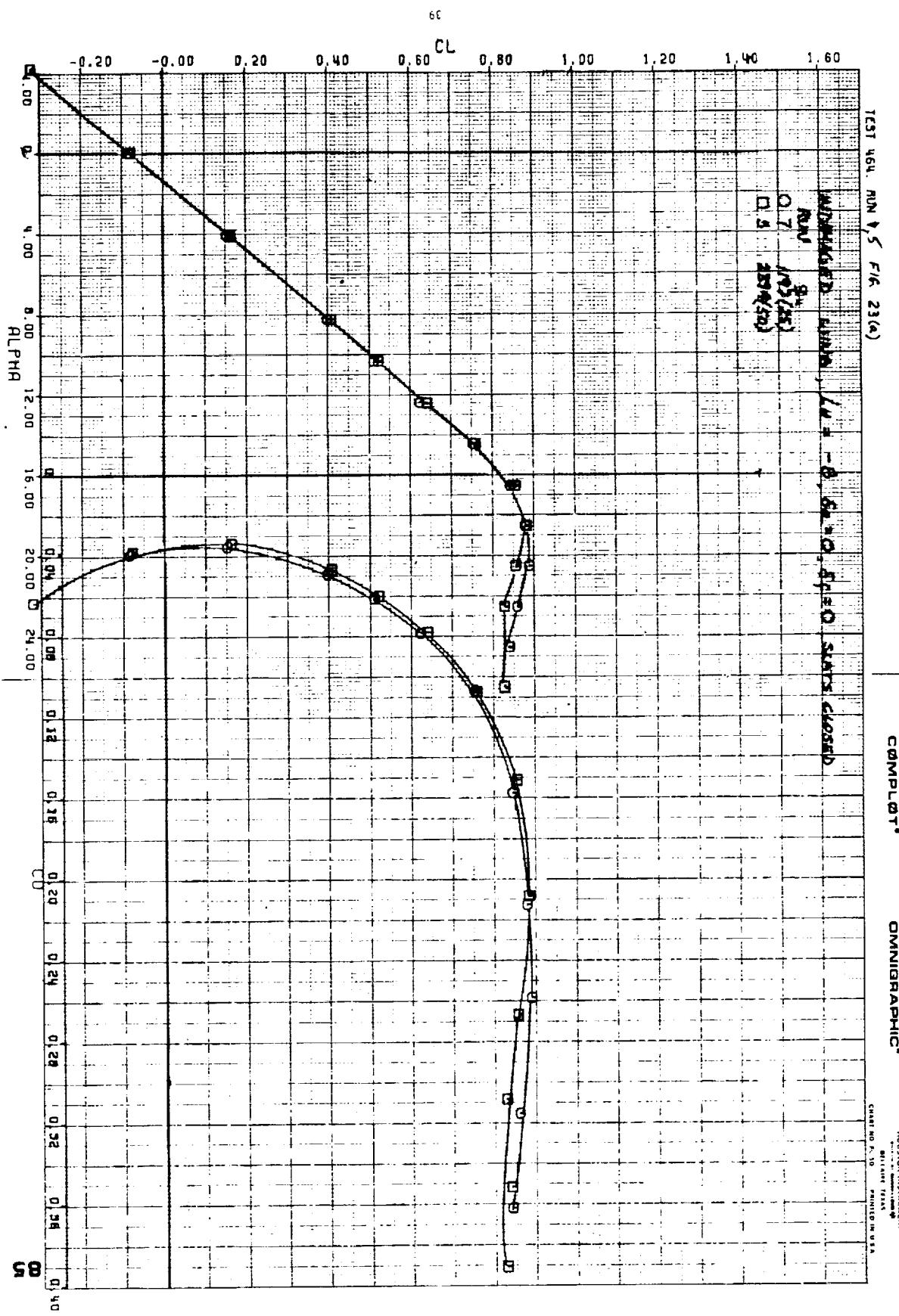


Figure 23(a)

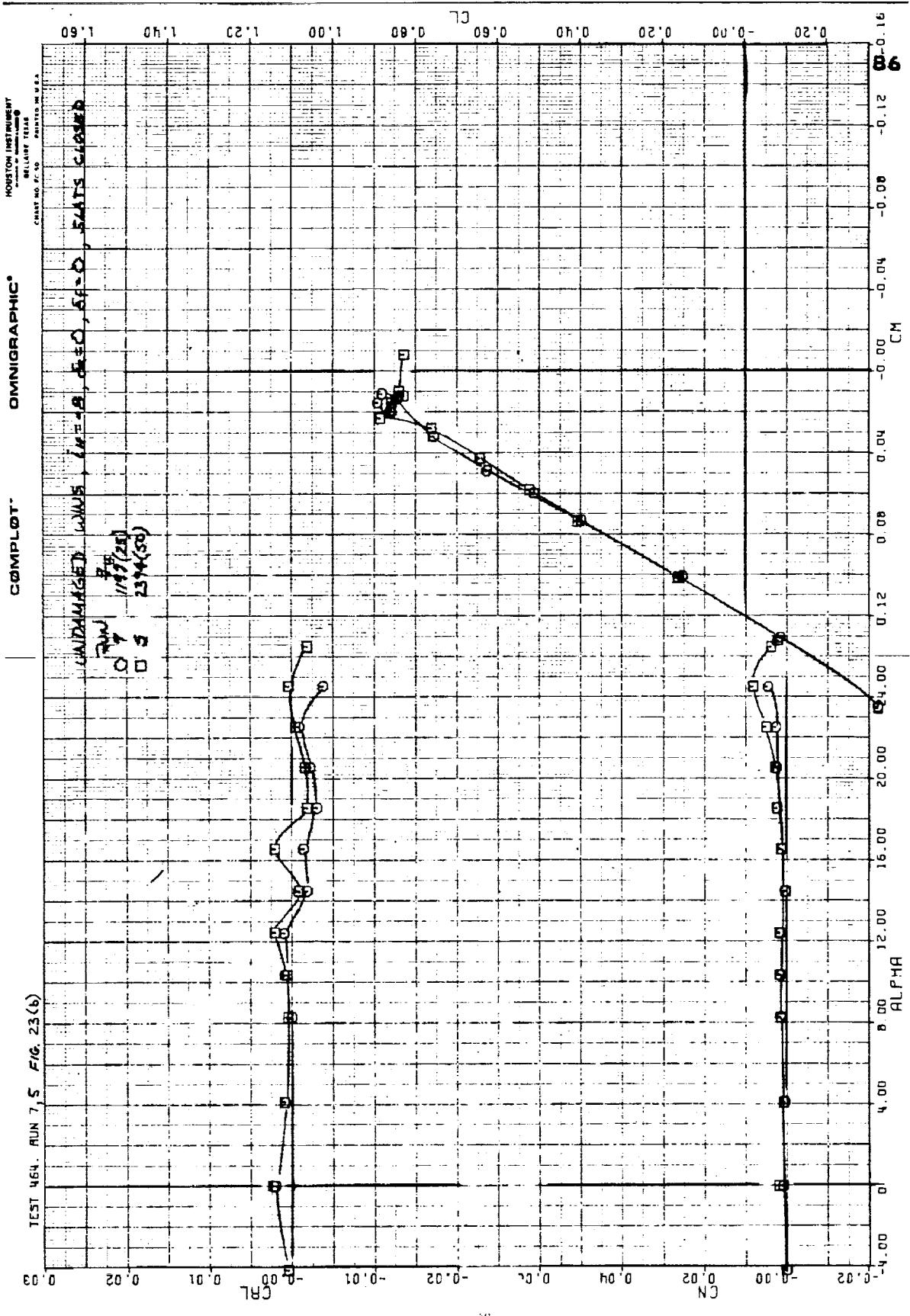


Figure 23(b)

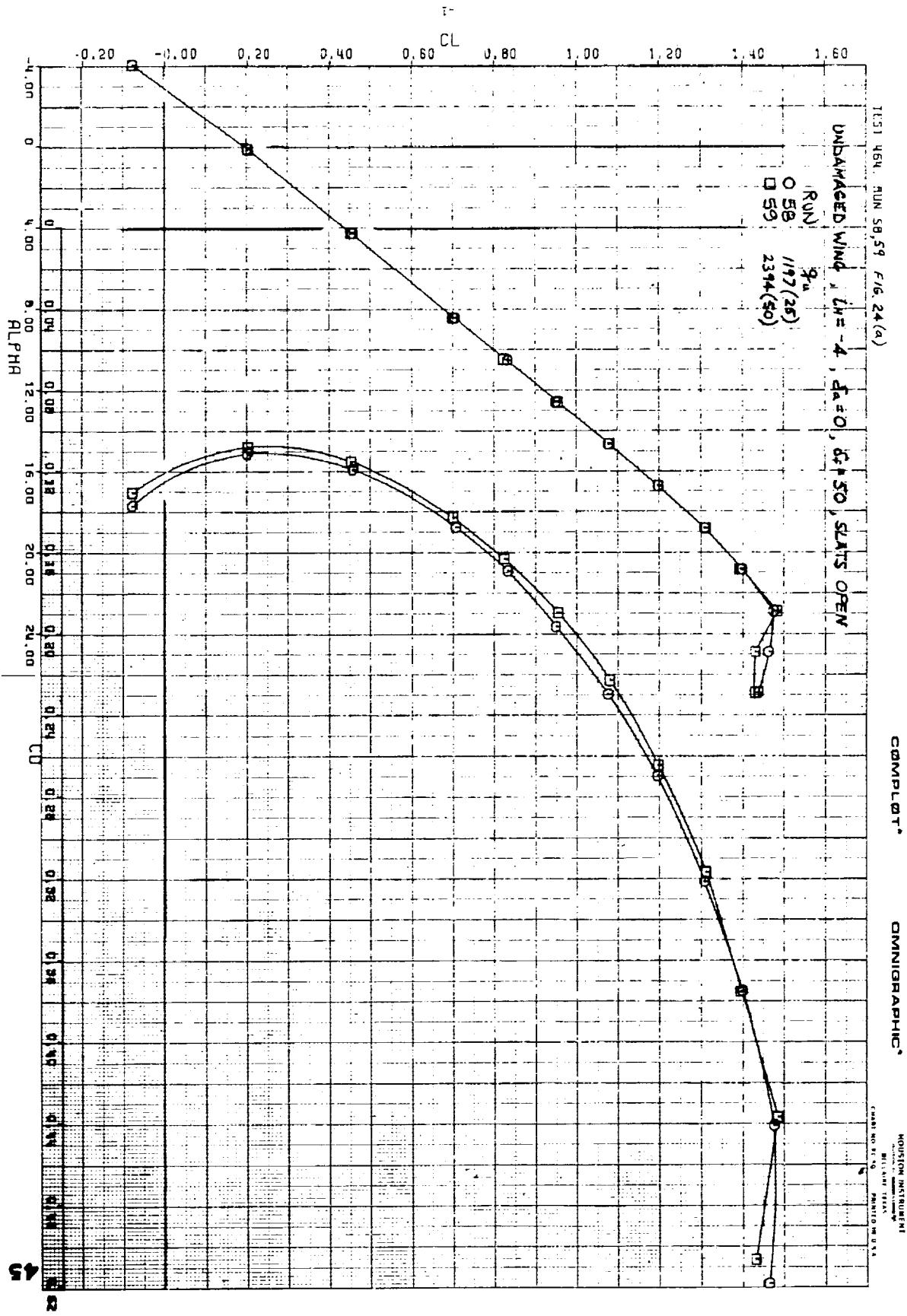


Figure 24(a)

TEST 464. RUN 58,59 FIG. 24-(b)

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DIVISION OF OMNIGRAPHIC
BELLVILLE, TEXAS
CHART NO. PC-60 PRINTED IN U.S.A.

ENDAMAGED WING, $\alpha_0 = -4^\circ$, $\delta_a = 0^\circ$, $S_F = 30^\circ$, SEATBELT OPEN

RUN
58 227(15)
59 259(30)

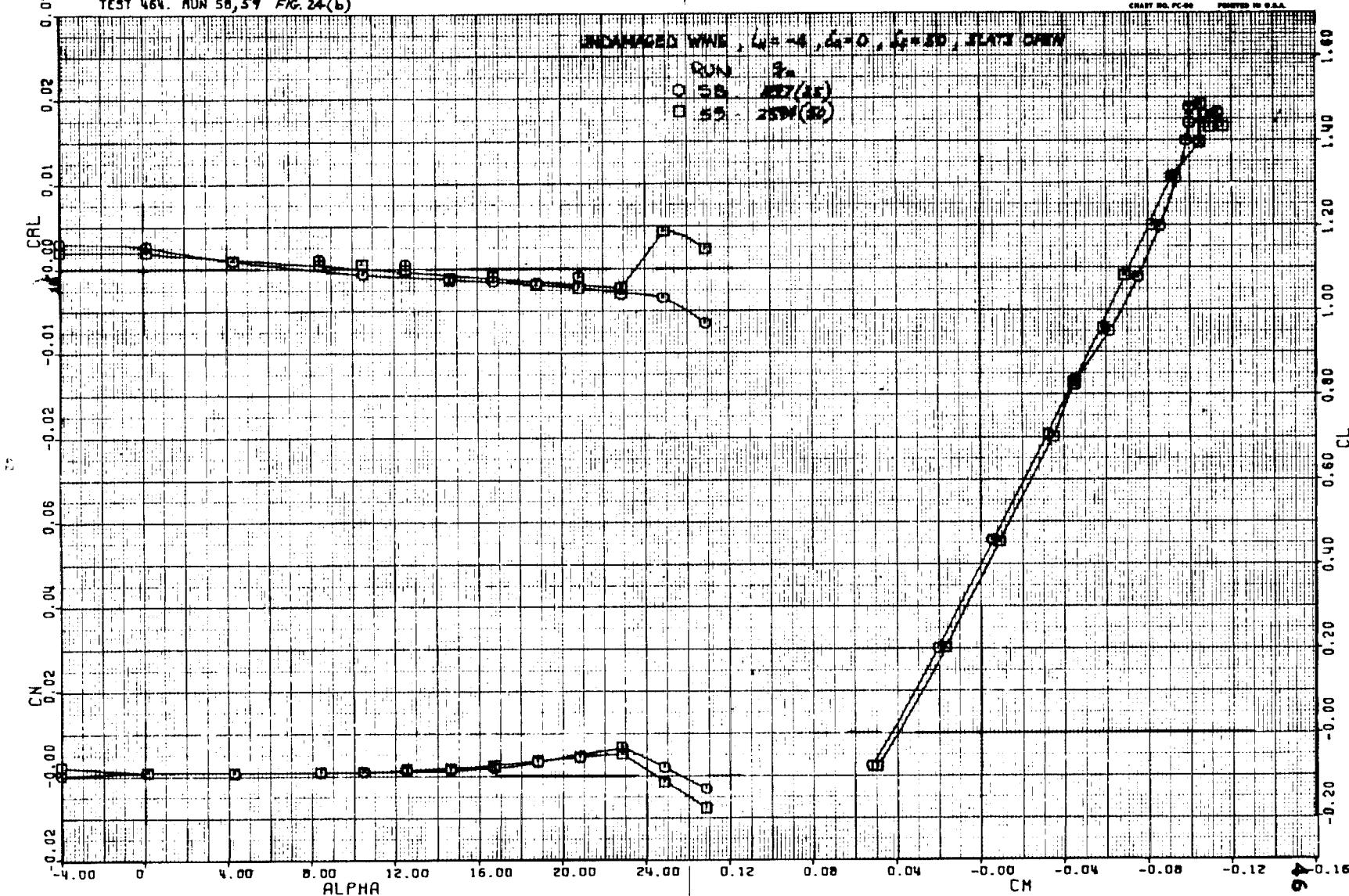


Figure 24(b)

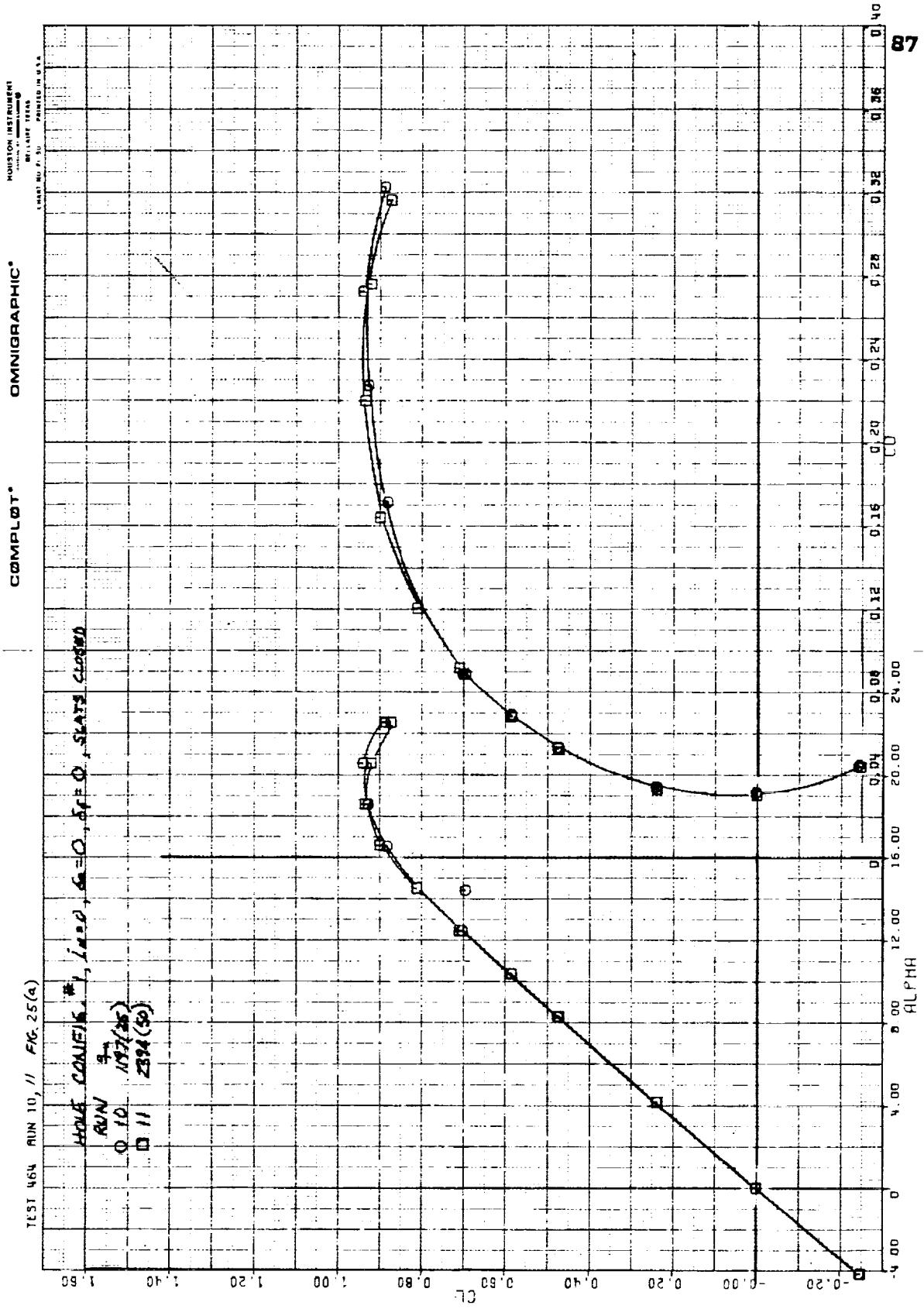
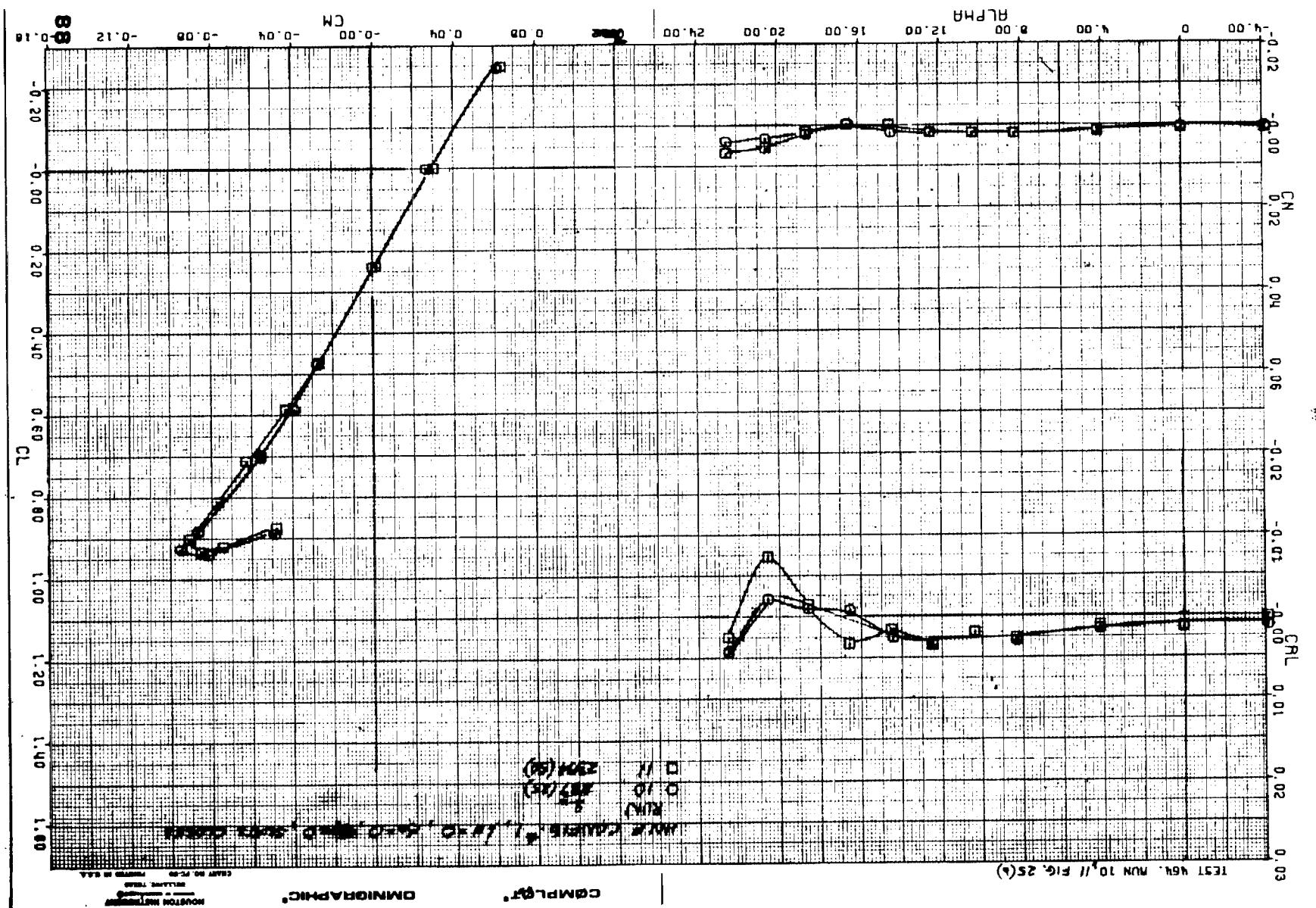


Figure 25(a)

Figure 25(b)



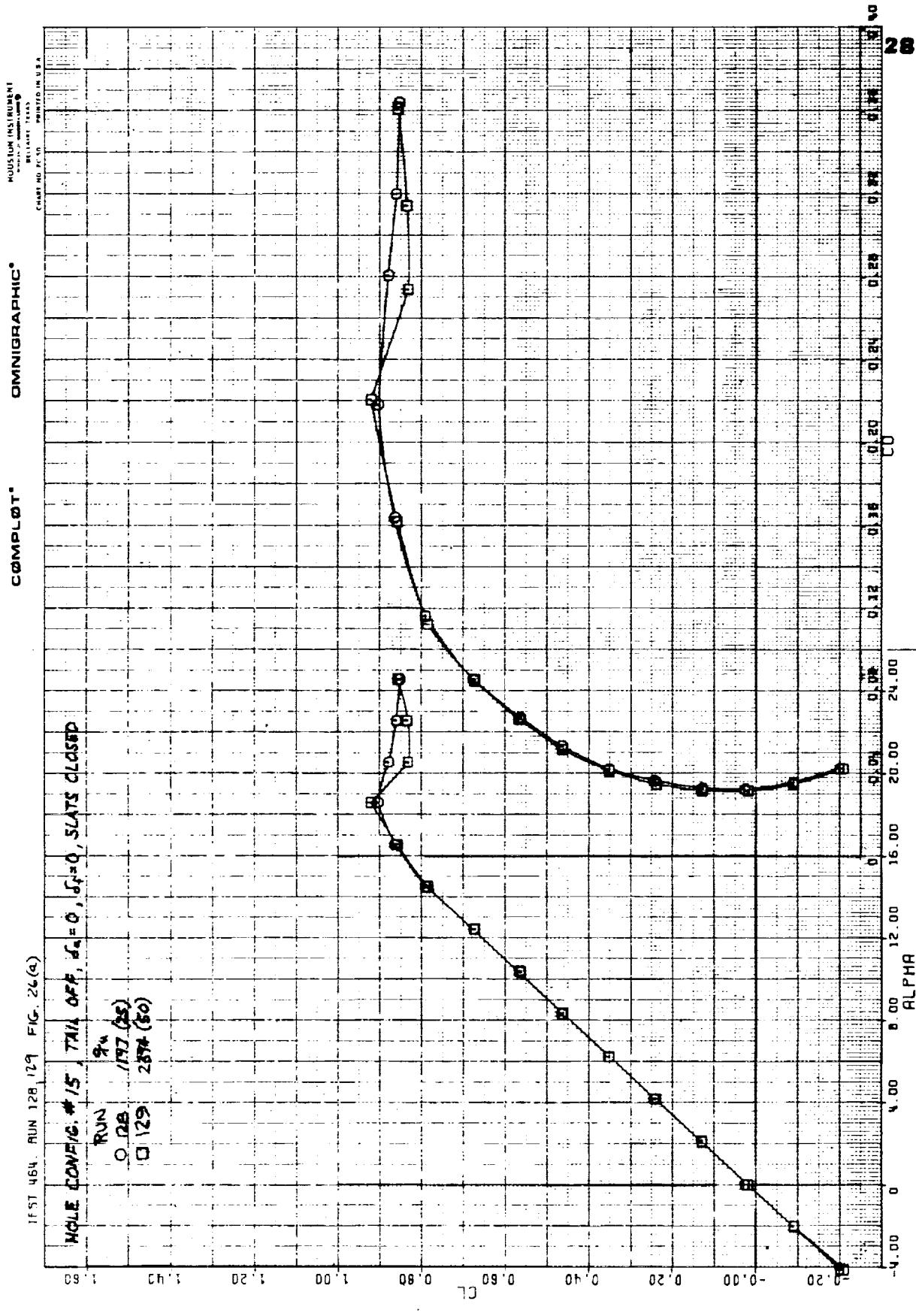


Figure 26(a)

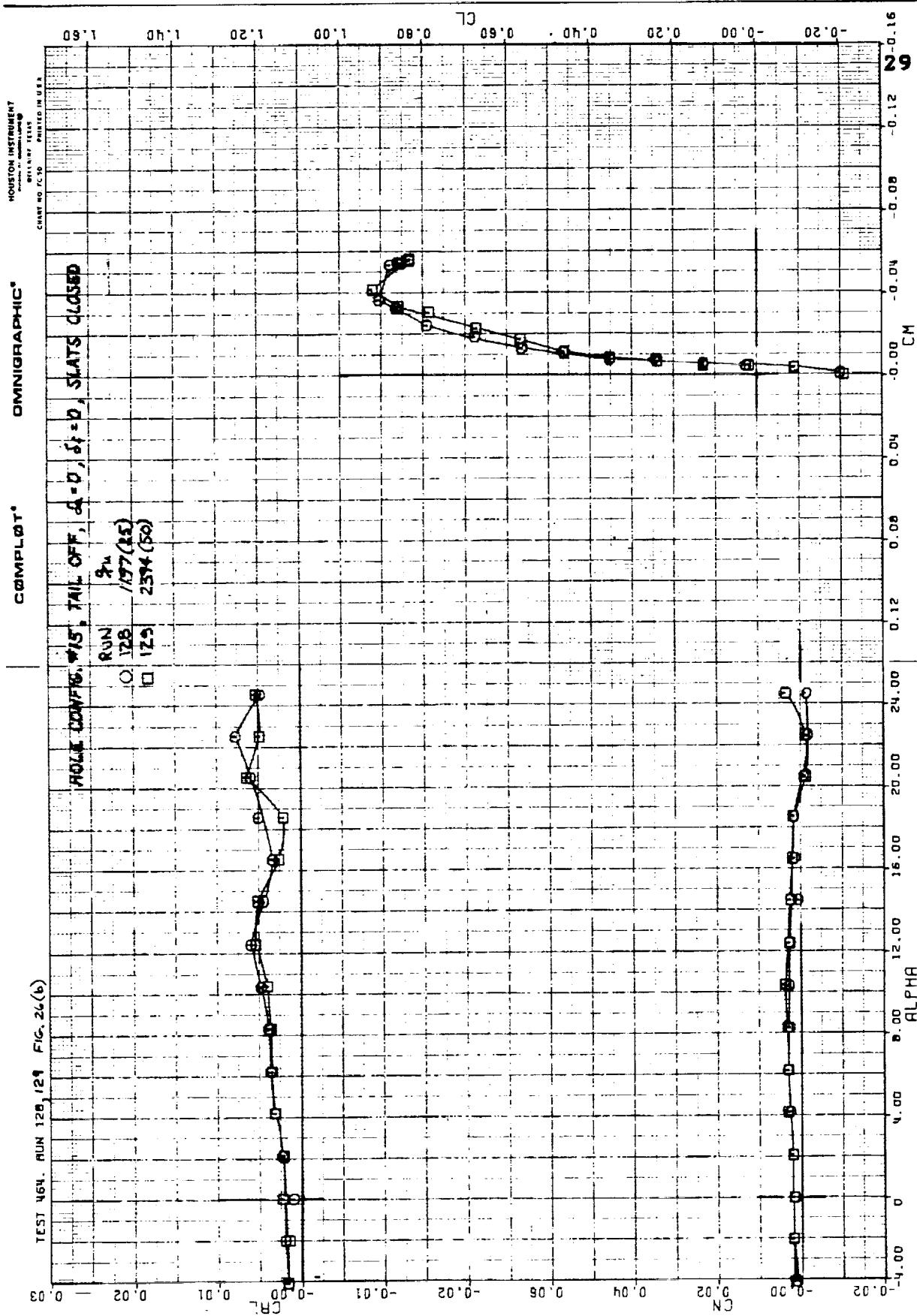


Figure 26(b)

TEST 464 RUN 131, 132 FIG. 27(a)

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HAWAII
GILLINGS, TEXAS
CHART NO. PC-20 PRINTED IN U.S.A.

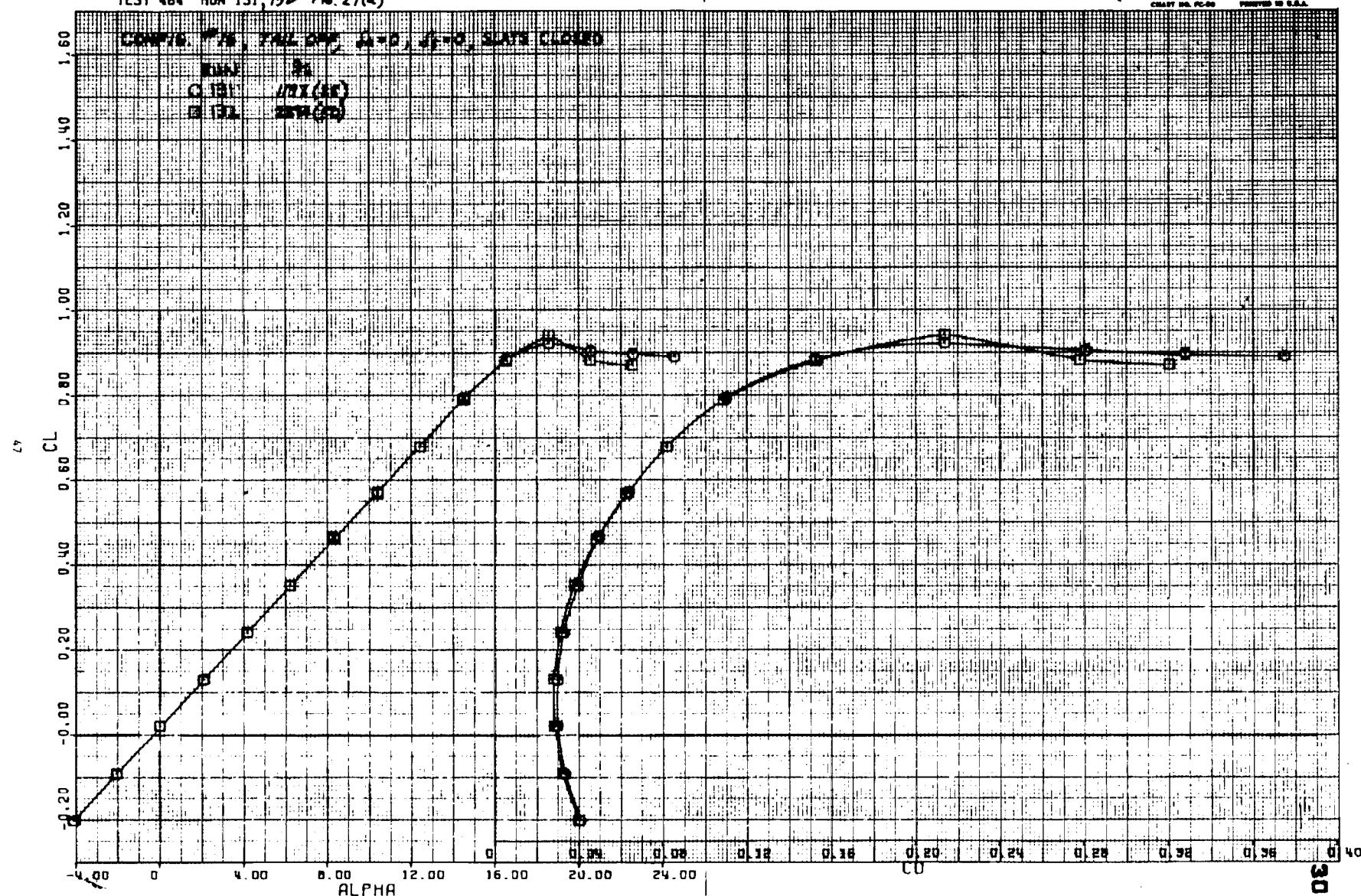


Figure 27(a)

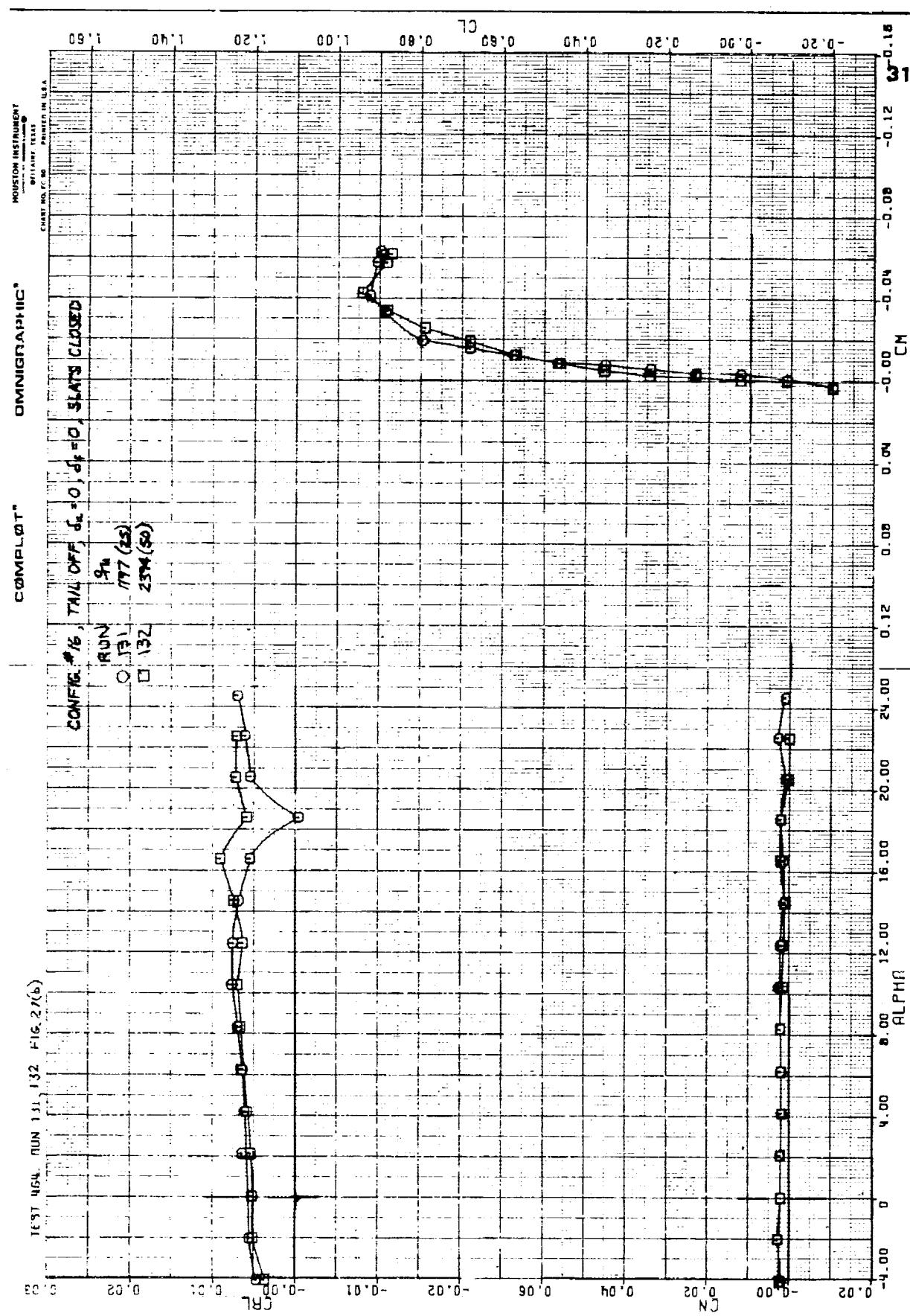


Figure 27(b)

TEST NSL. RUN 1, 5/70 FIG. 28(a)

COMPLATE

OMNIGRAPHIC

HOUSTRON INSTRUMENT

BELLAIR, TEXAS

PRINTED IN U.S.A.

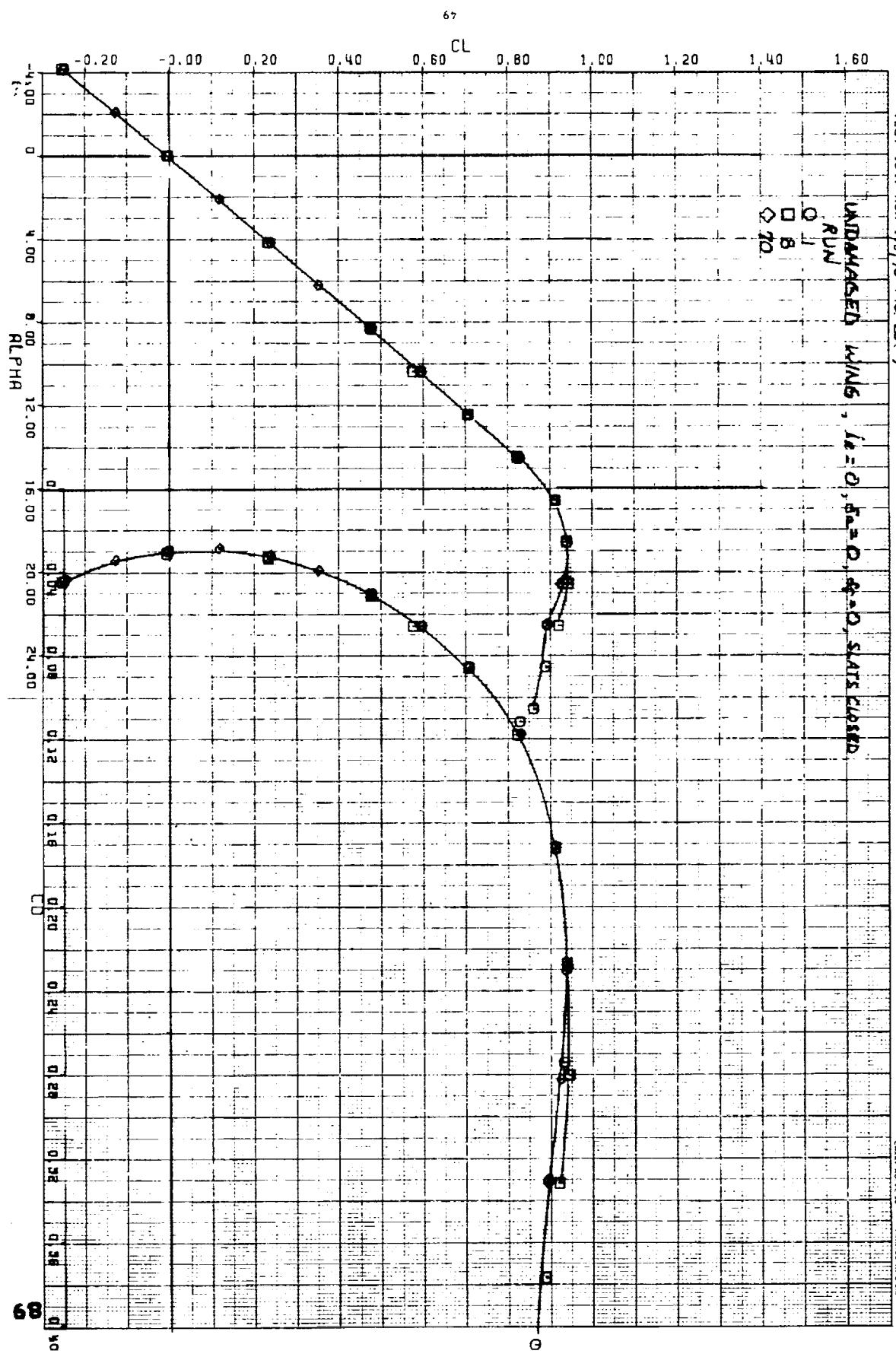


Figure 28(a)

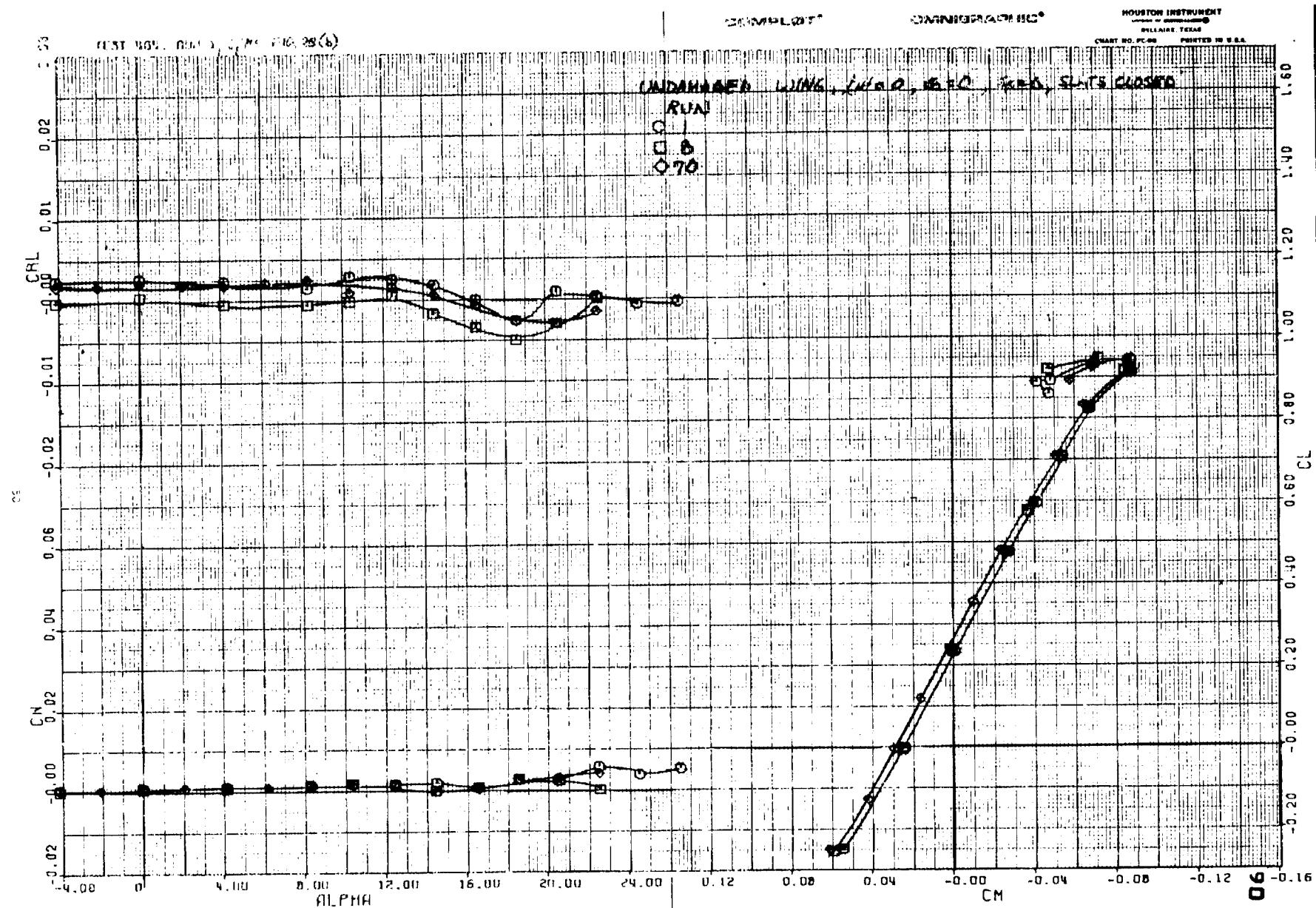


Figure 28(b)

TEST 464, RUN 51, ω^2 FIG. 29(a)

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OMNIGRAPHIC®

HOUSTON INSTRUMENT
BELLARY TEXAS

CHART NO FC 50 PRINTED IN U.S.A.

UNDAMAGED WING, $L_0 = 0$, $S_0 = 0$, $S_f = 0$,
L.H. SLAT OPEN, R.H. SLAT CLOSED

RUN
O 51
□ 68

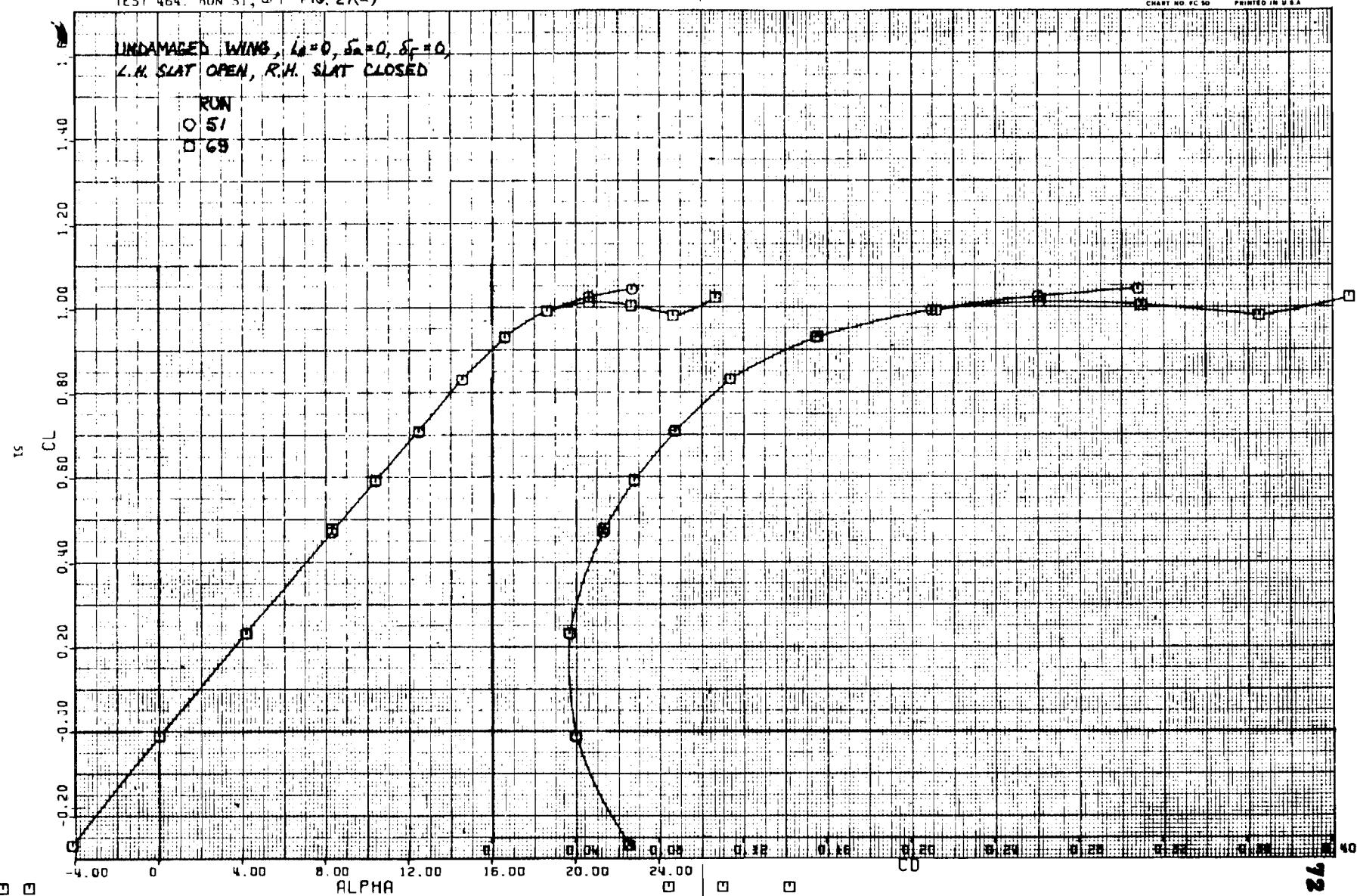


Figure 29(a)

EST 464. RUN S1, C7 FIG. 29(b)

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HOUSTON INSTRUMENT

SELLING TIME

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CHART NO. FCC 50

PRINTED IN U.S.A.

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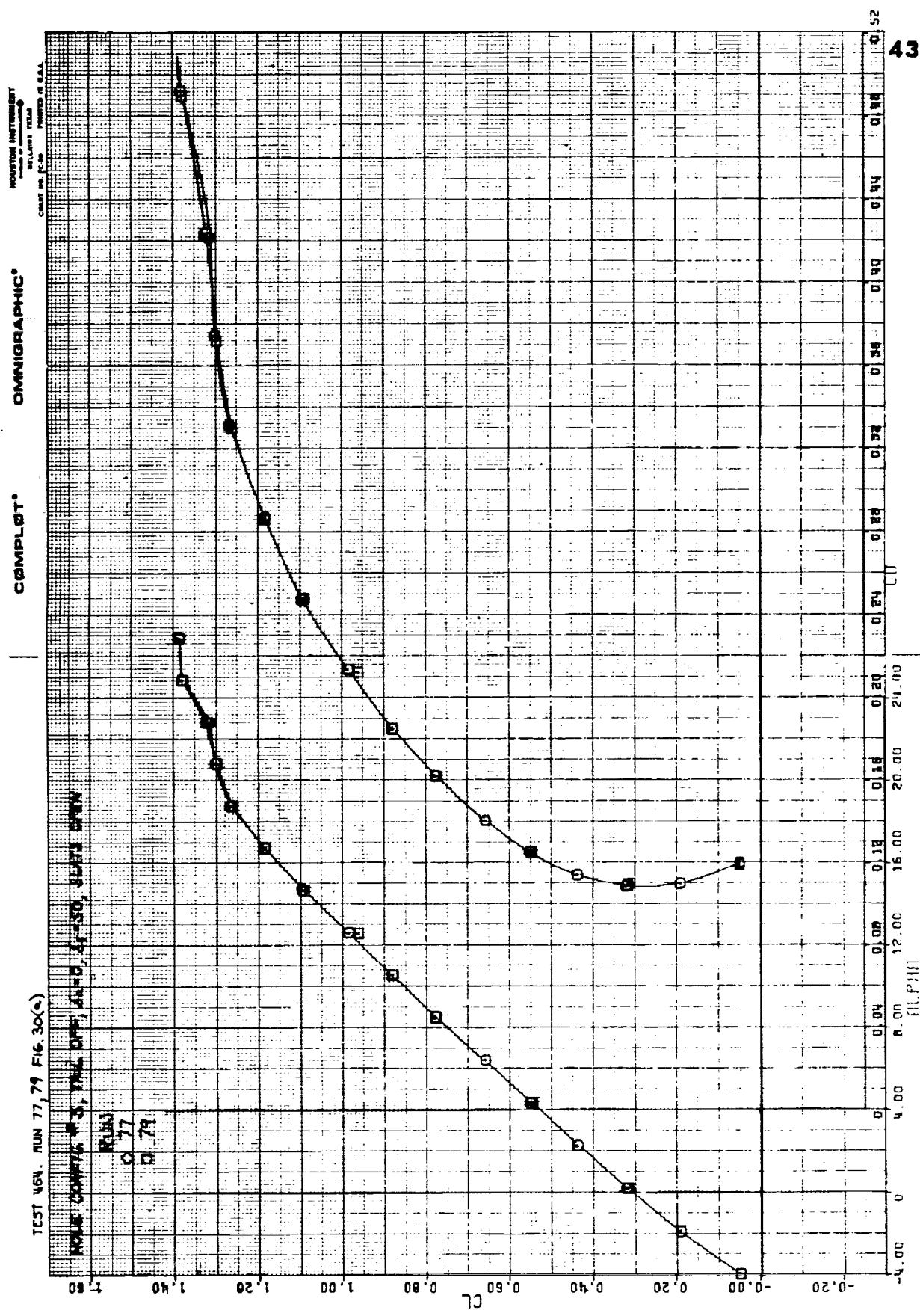
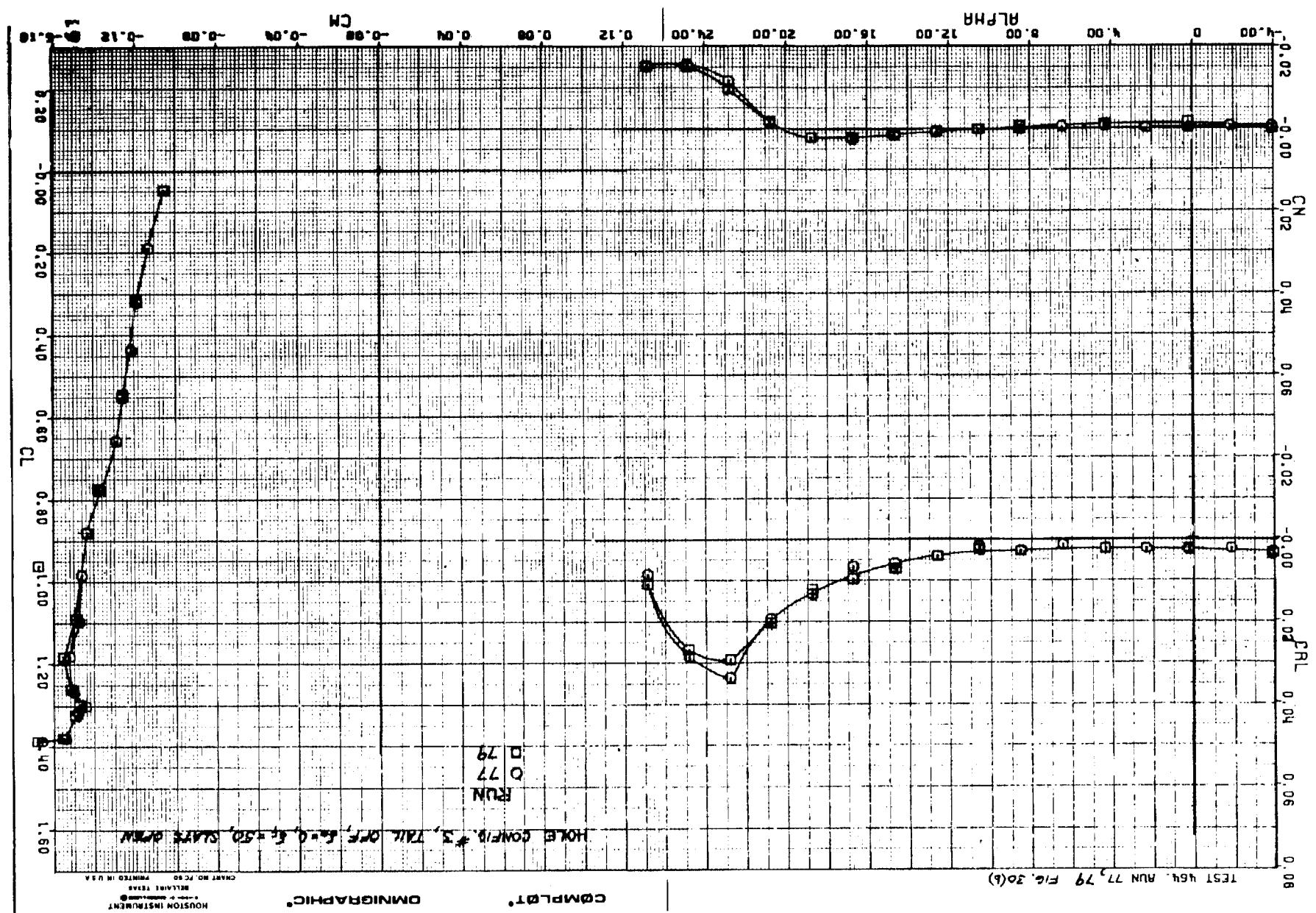


Figure 30(a)

Figure 30(b)



TEST 464. RUN 3,4,5,71 FIG. 31(a)

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CHART NO. FC-50 PRINTED IN U.S.A.

UNBALANCED WING, 100% S. P. E., SLATS CLOSED

RUN 3 5
4 2370(30)
5 -
71 OFF 1197(35)

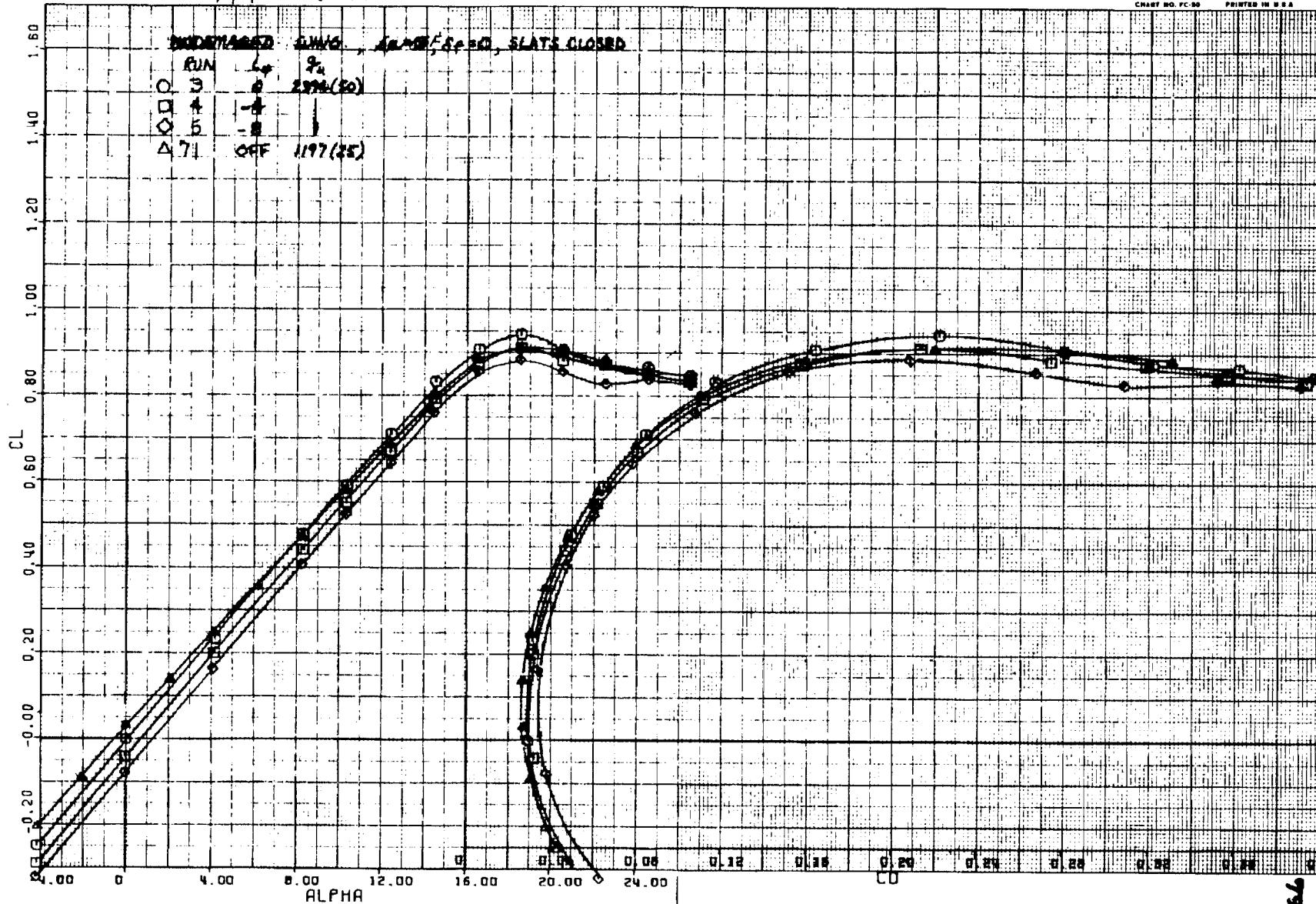
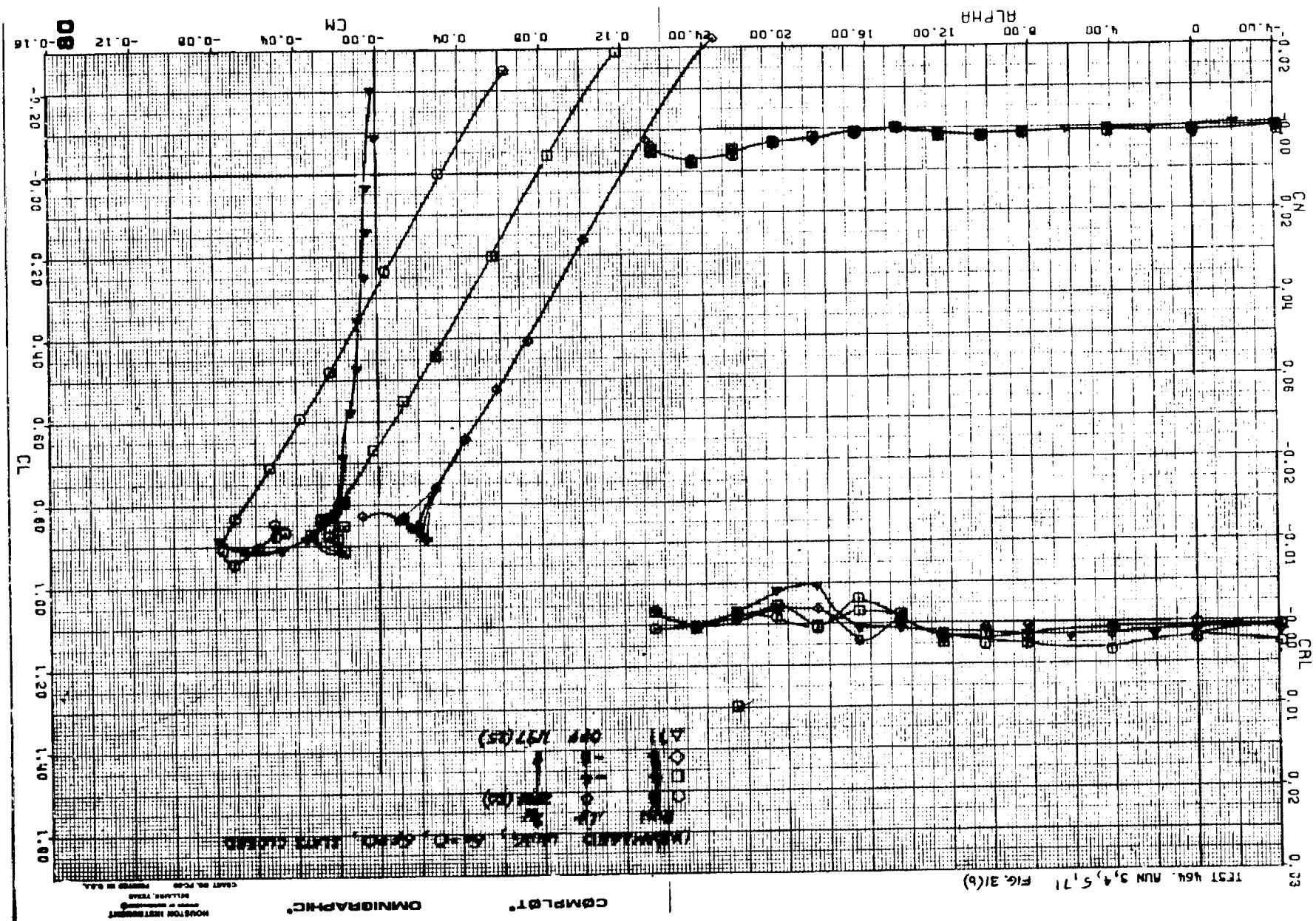


Figure 31(a)

Figure 31(b)



TEST 464. RUN 3, 6, 7 FIG. 32(a)

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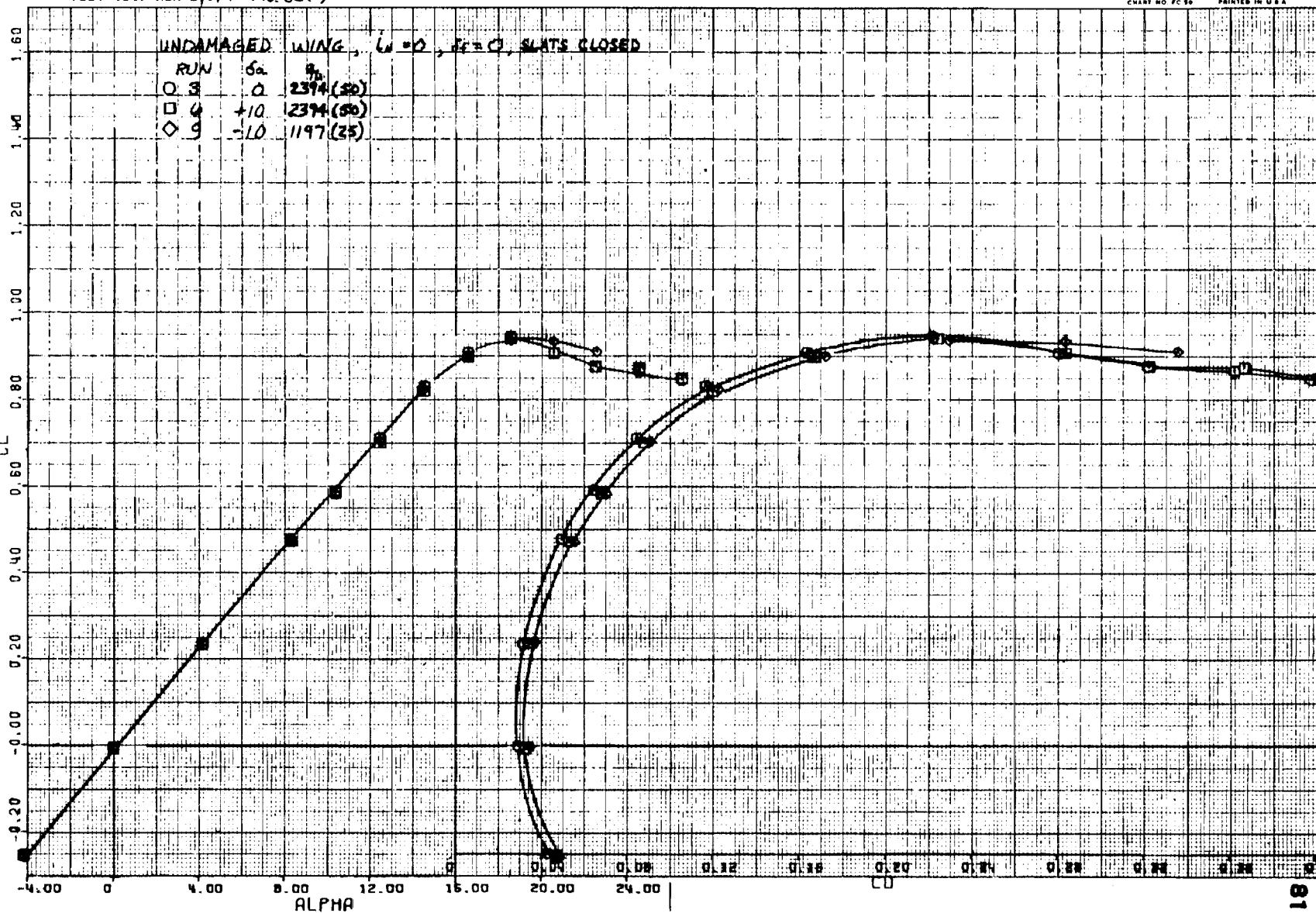


Figure 32(a)

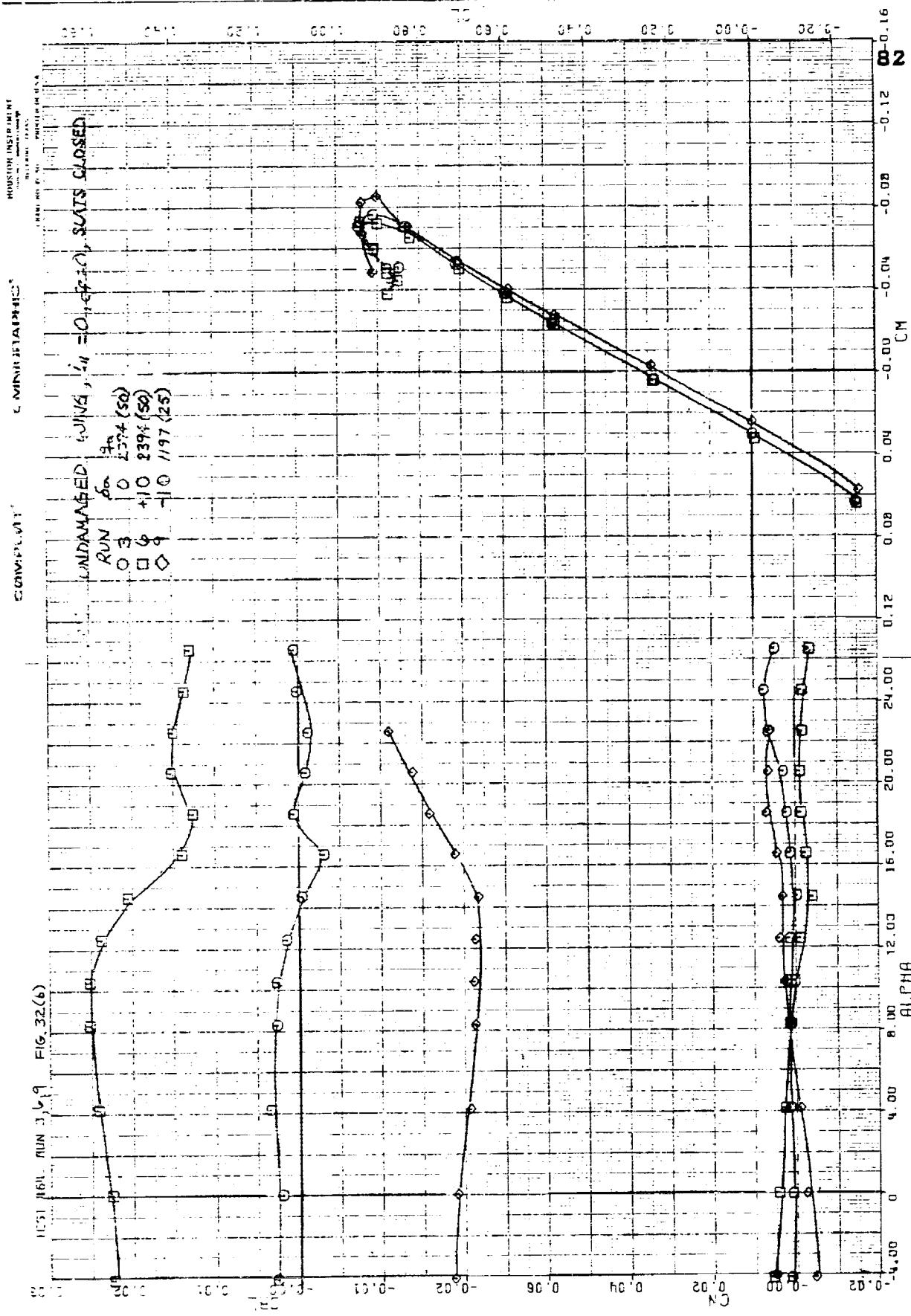
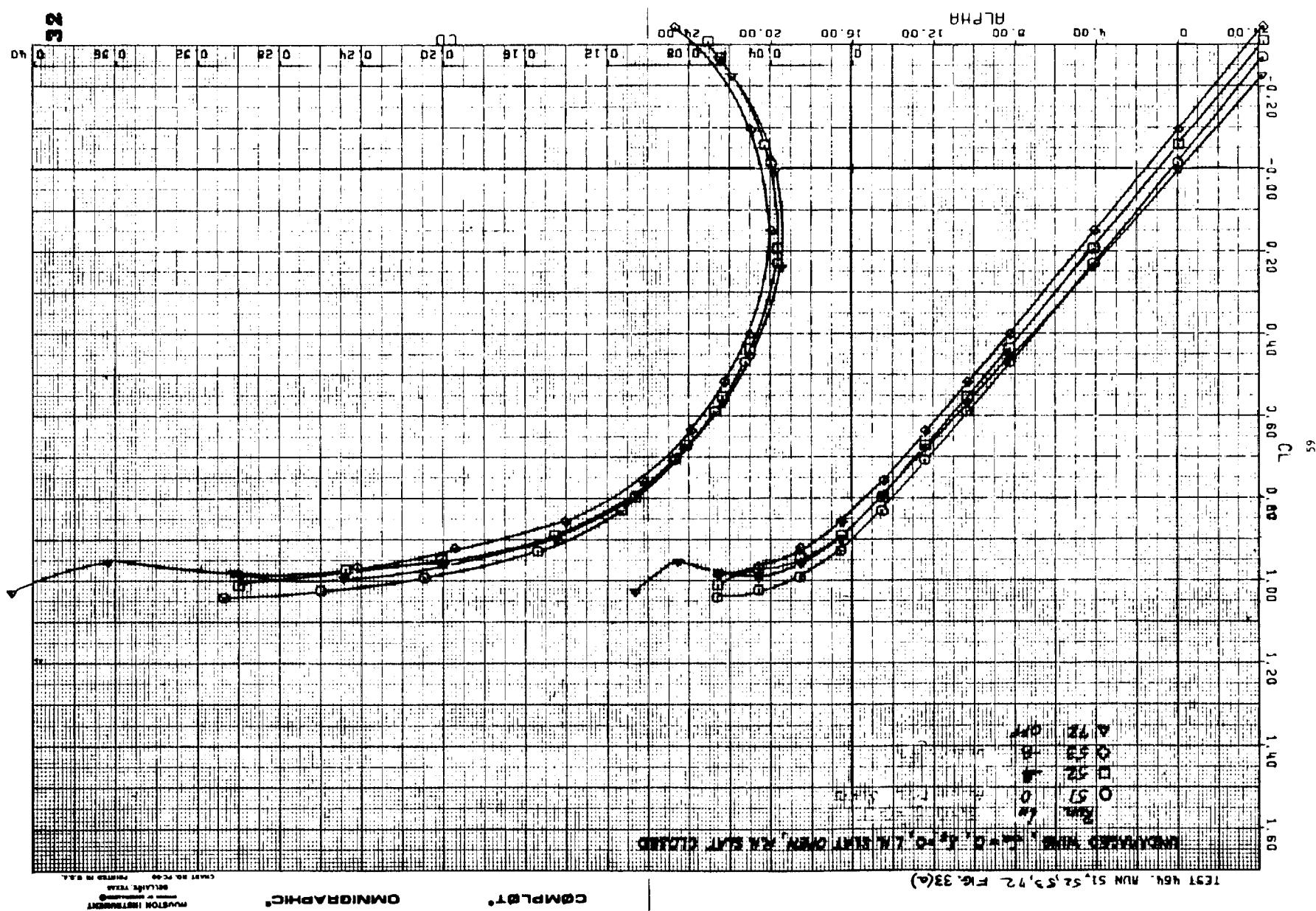


Figure 32(b)

Figure 33(a)



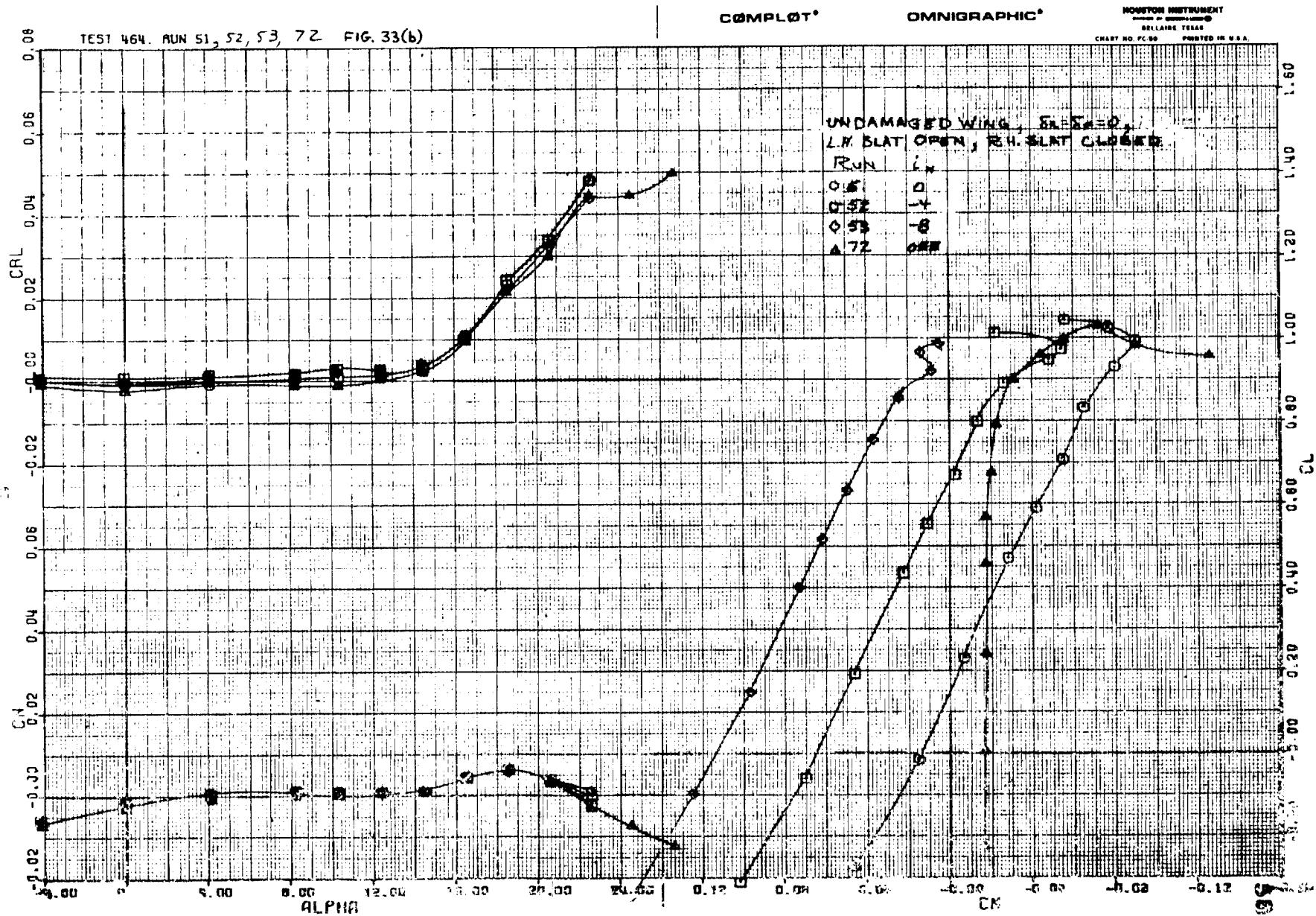


Figure 33(b)

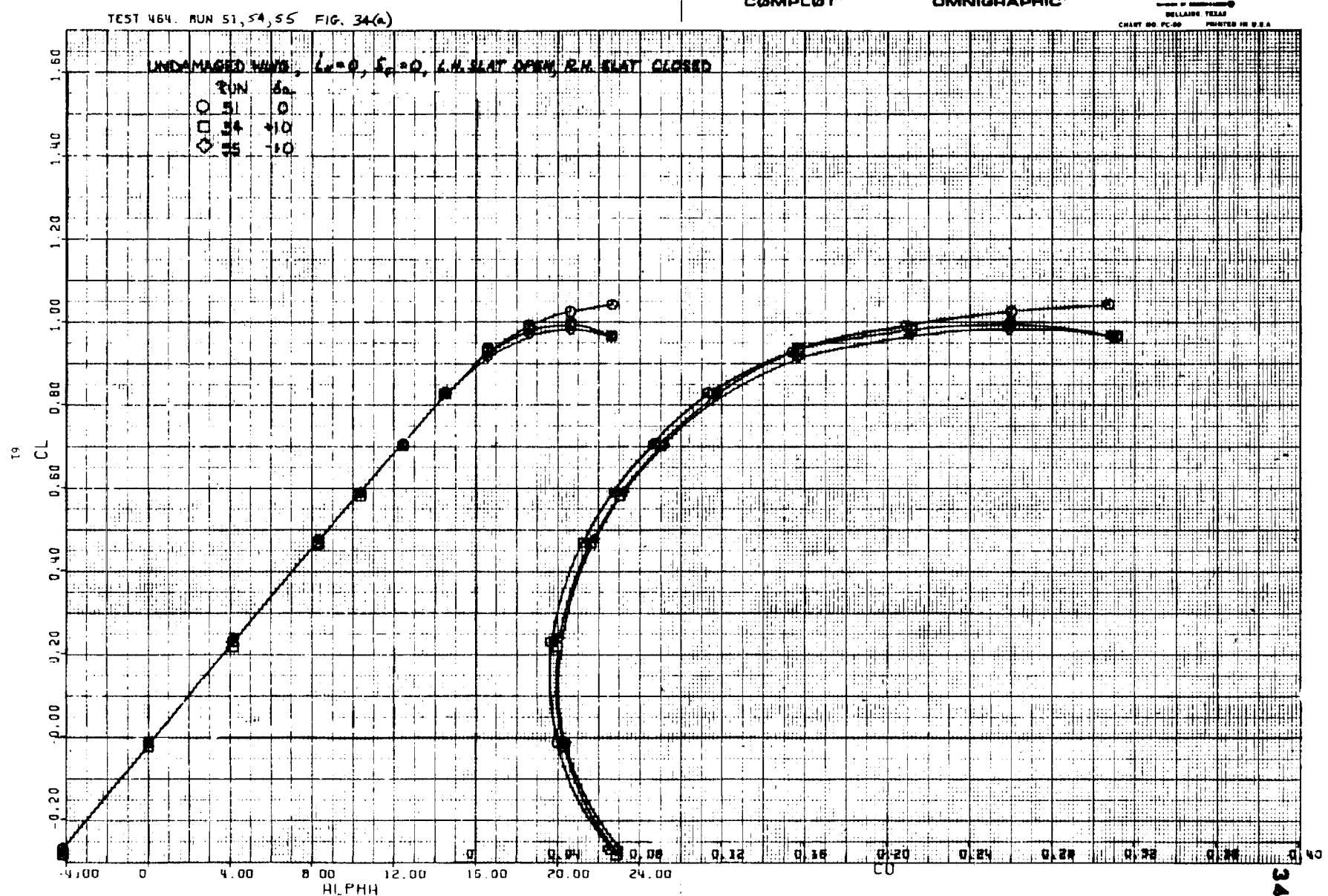


Figure 34(a)

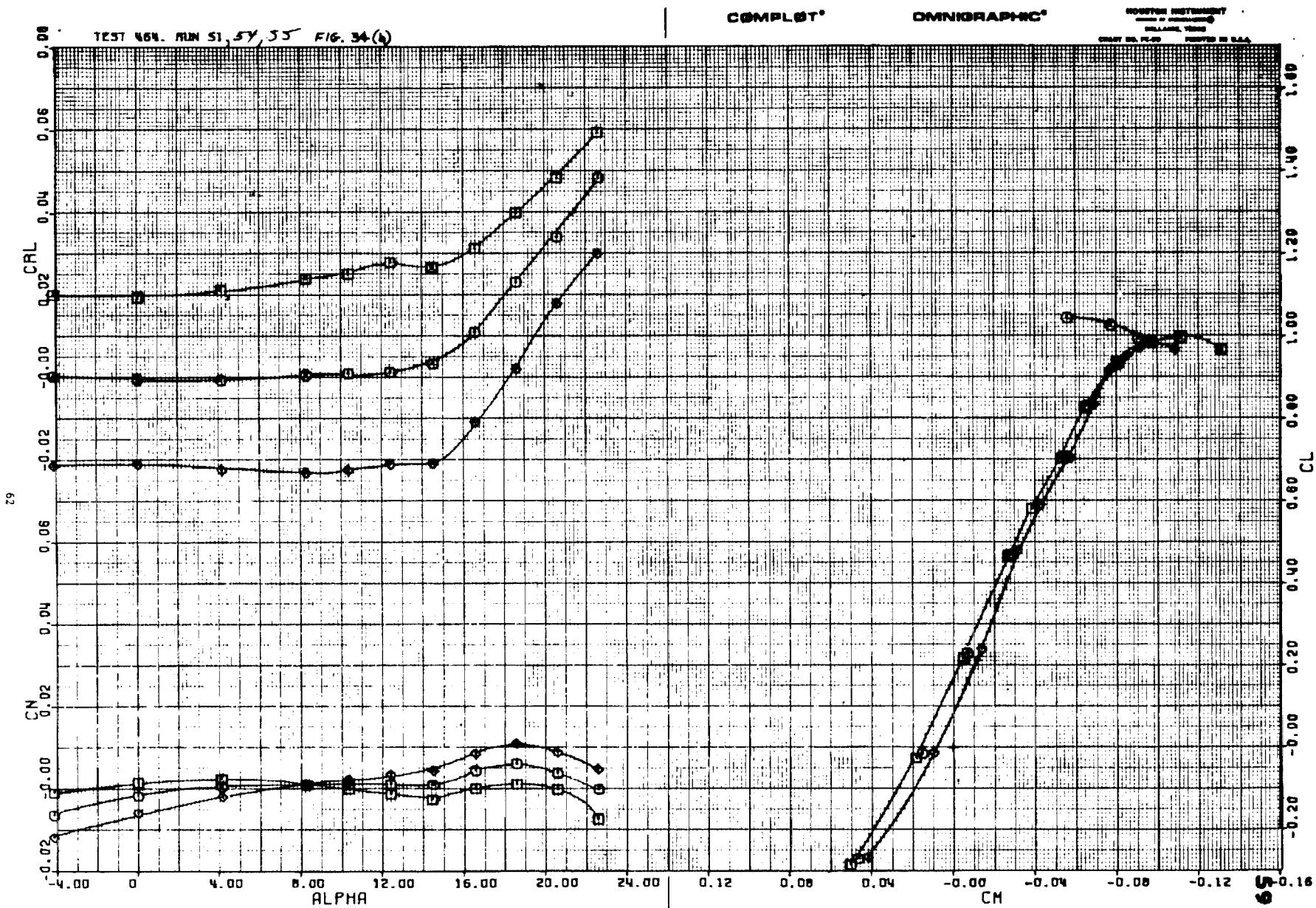


Figure 34(b)

TEST 464. RUNS 56, 58, 60, 61, 73 FIG. 35(a)

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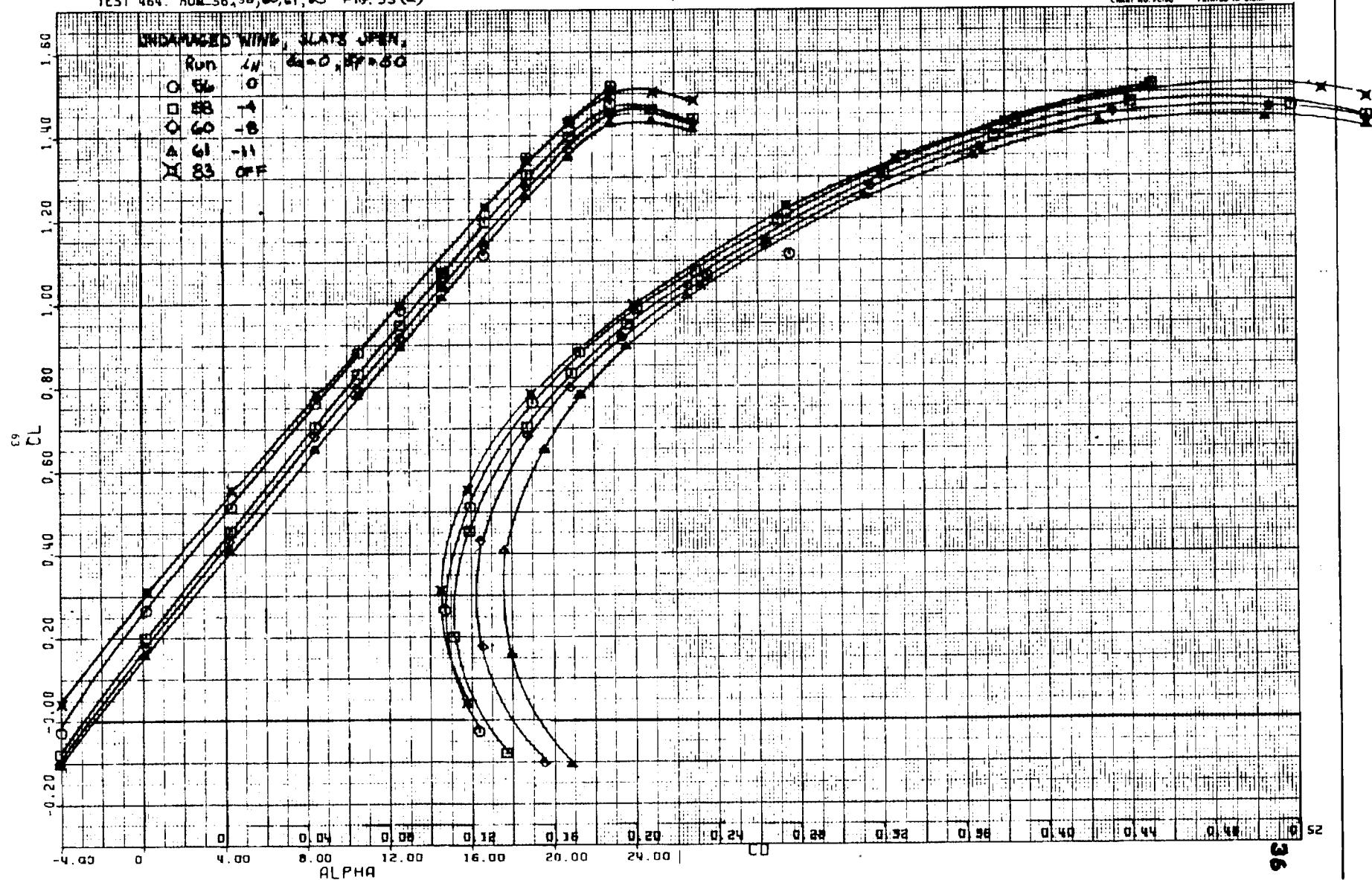


Figure 35(a)

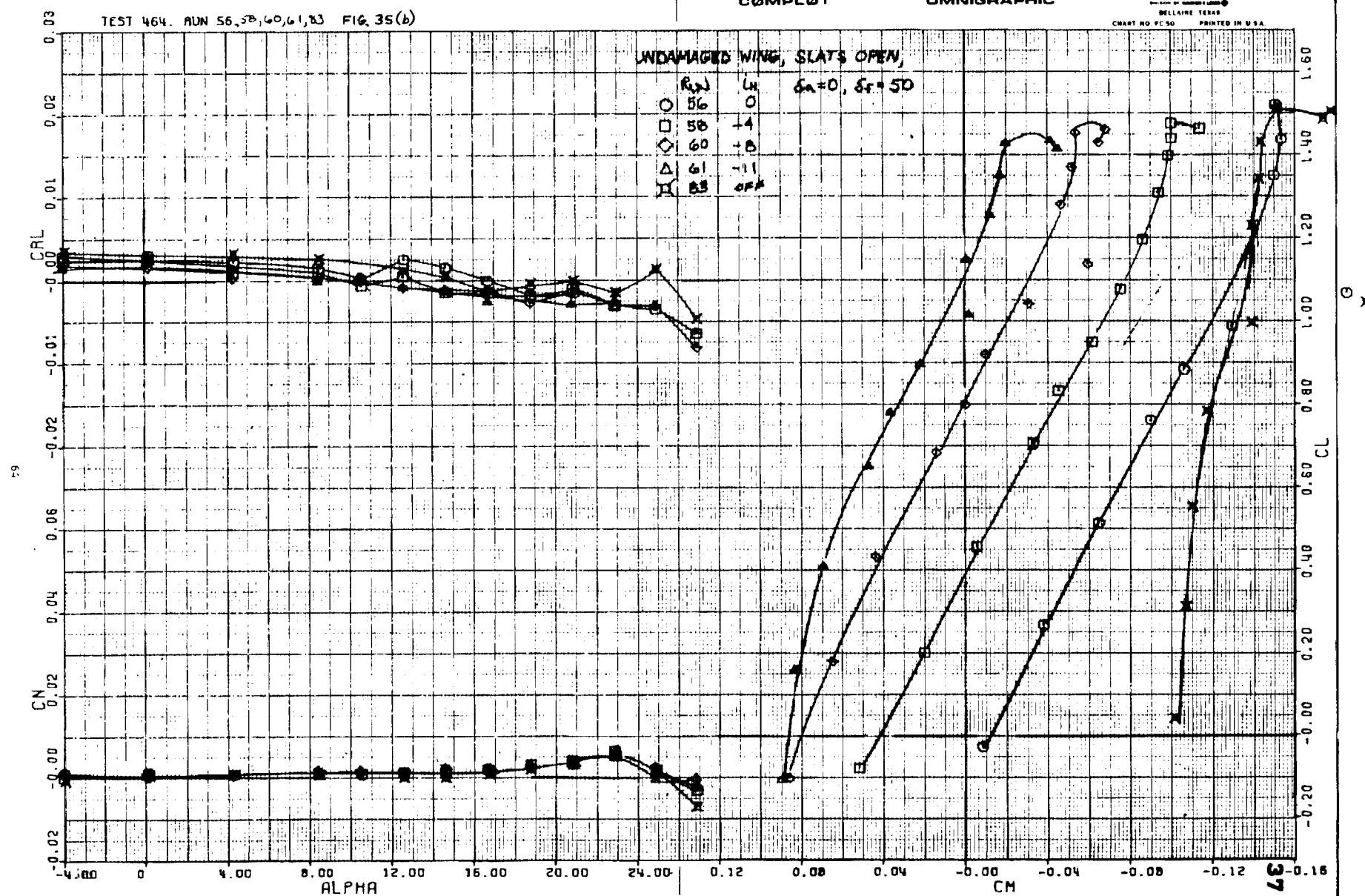


Figure 35(b)

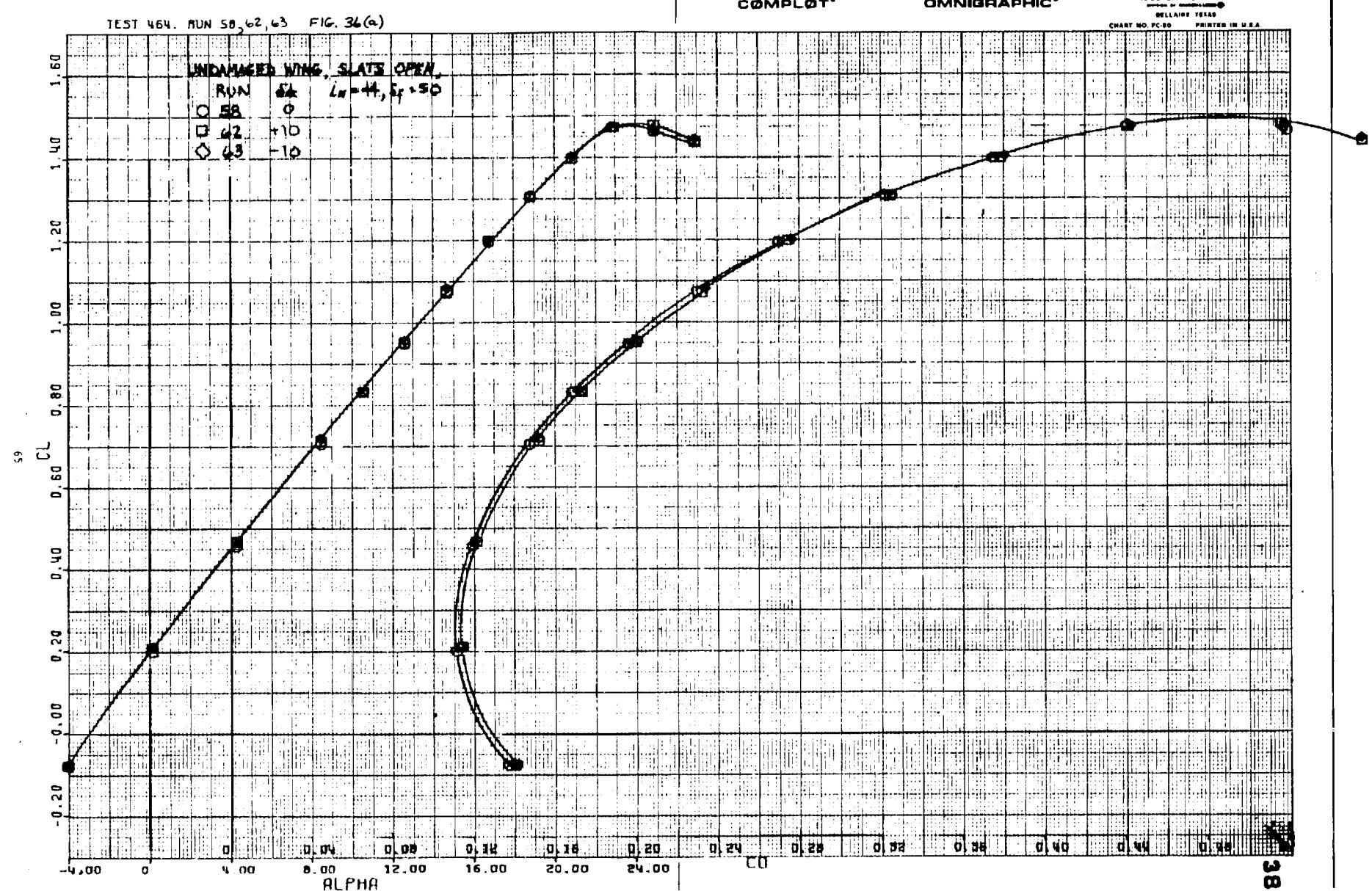
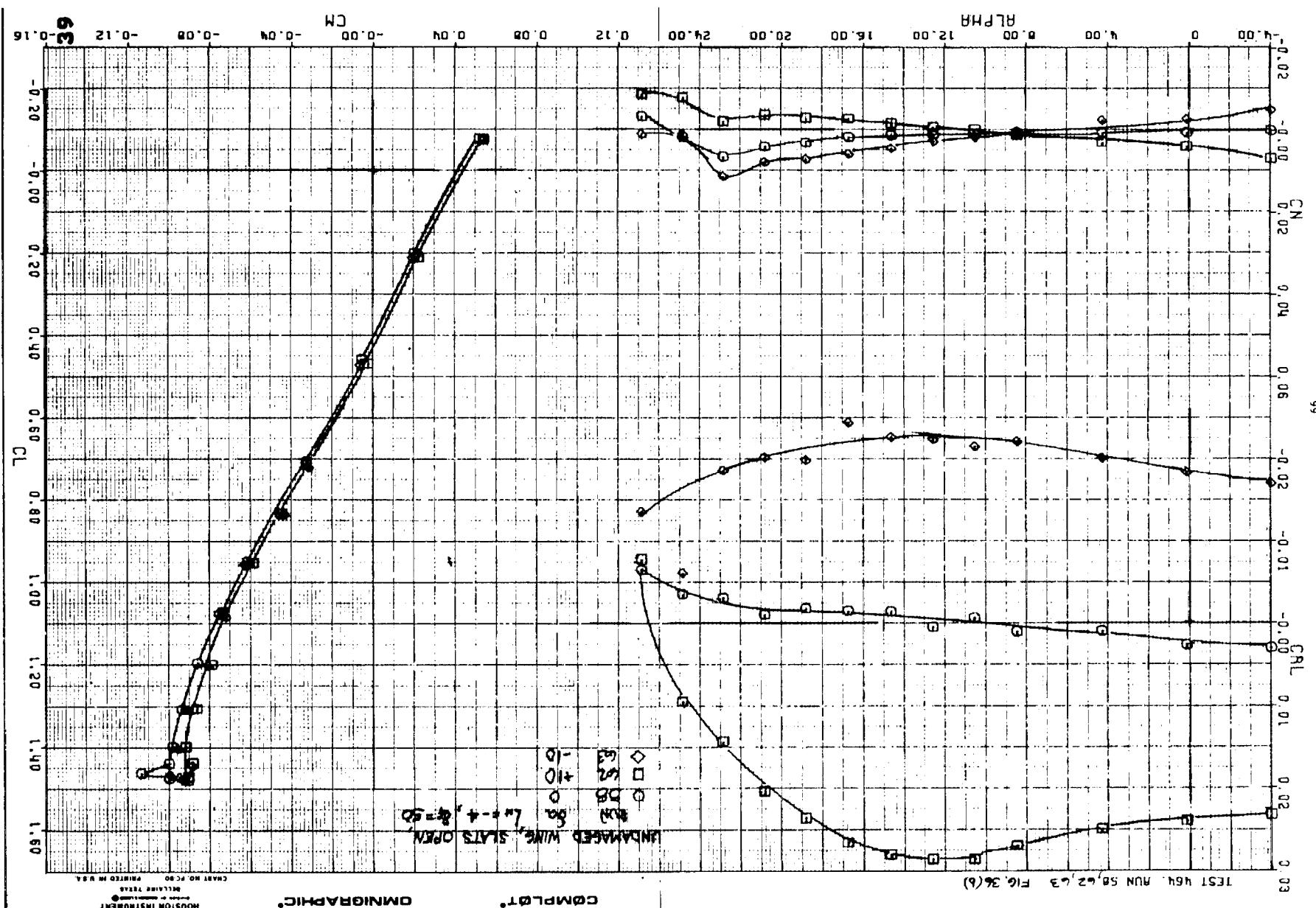


Figure 36(a)

Figure 36(b)



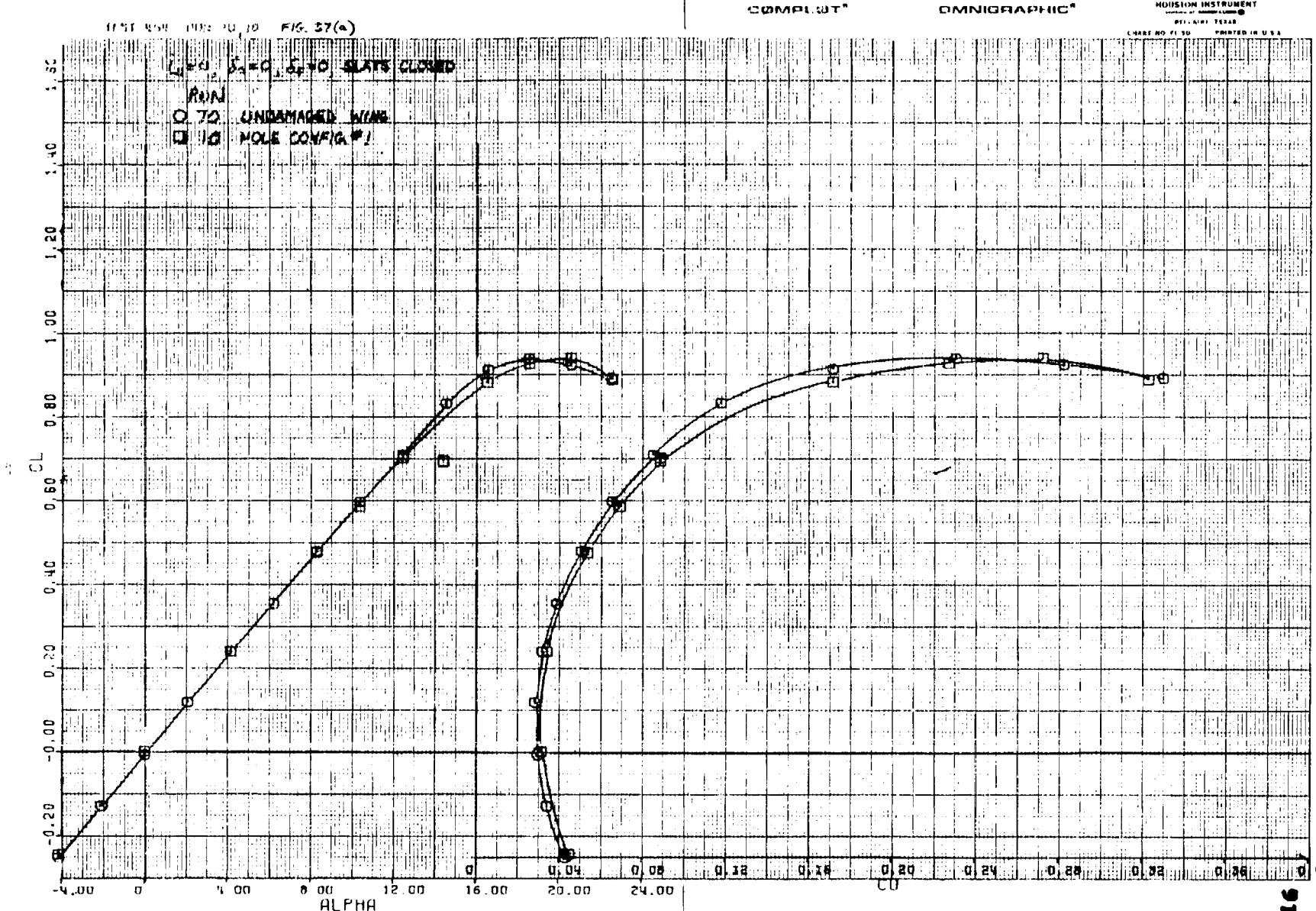


Figure 37(a)

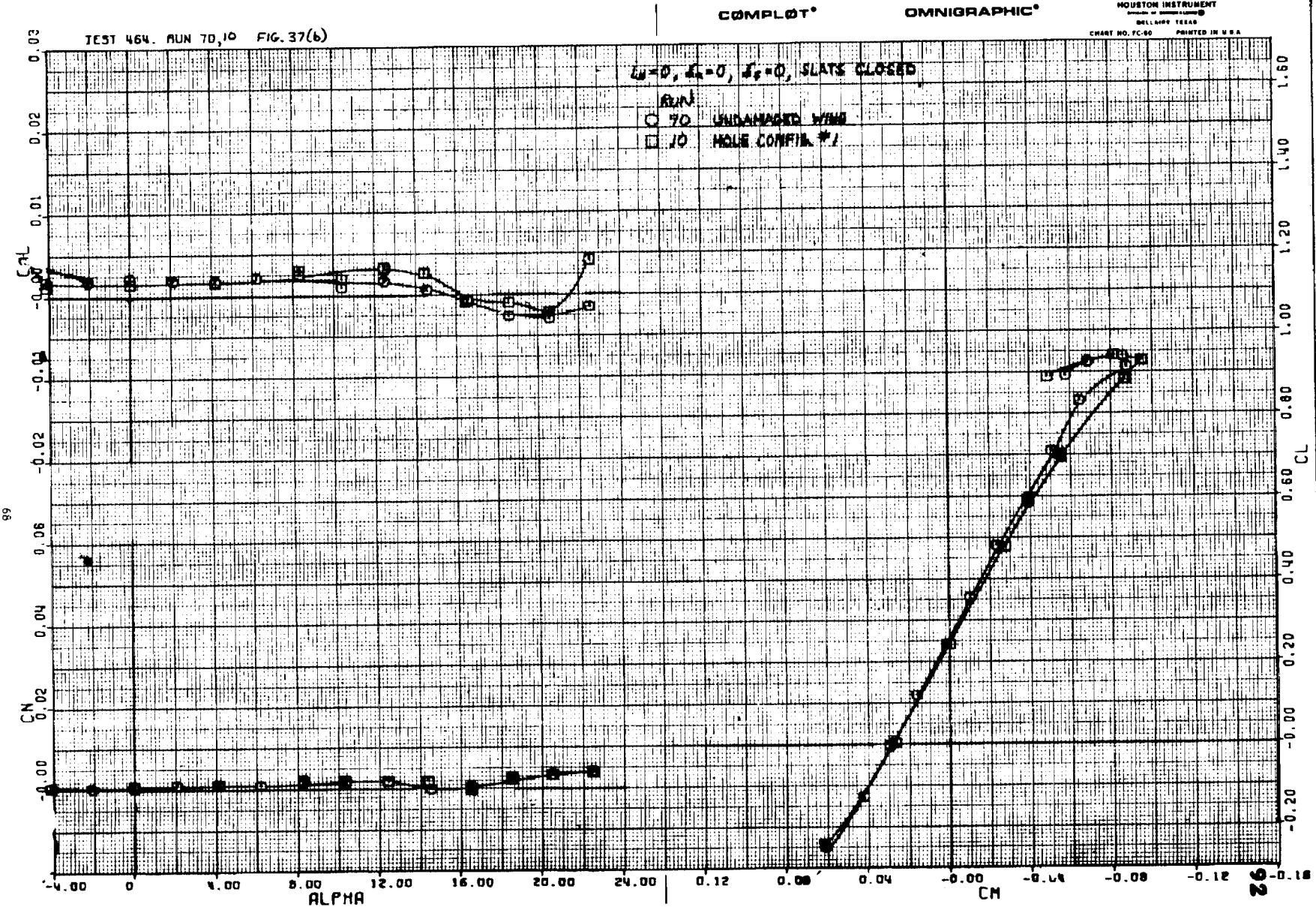


Figure 37(b)

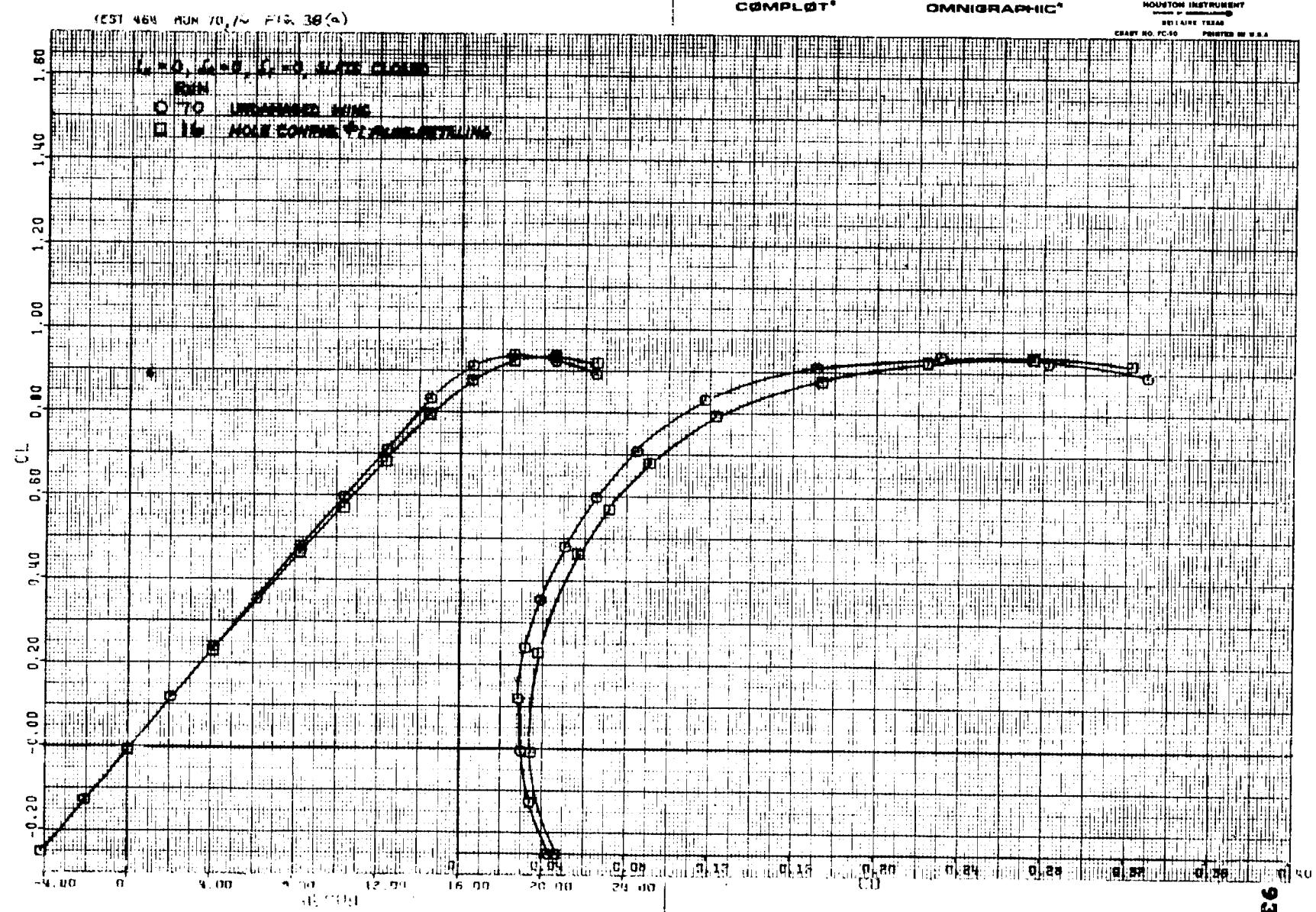


Figure 38(a)

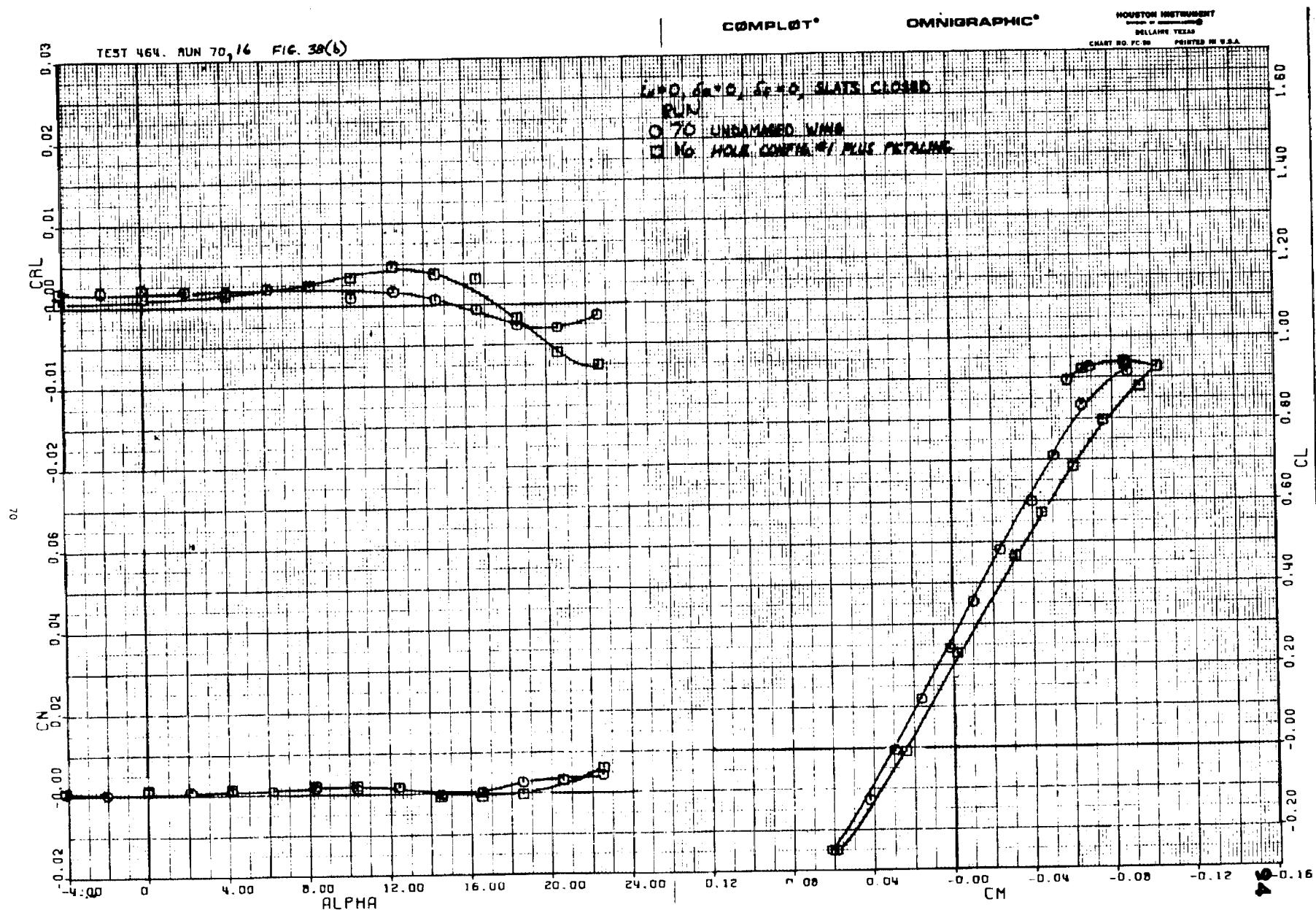


Figure 38(b)

TEST 464, RUN 10, 12, 13, 73 FIG. 39(a)

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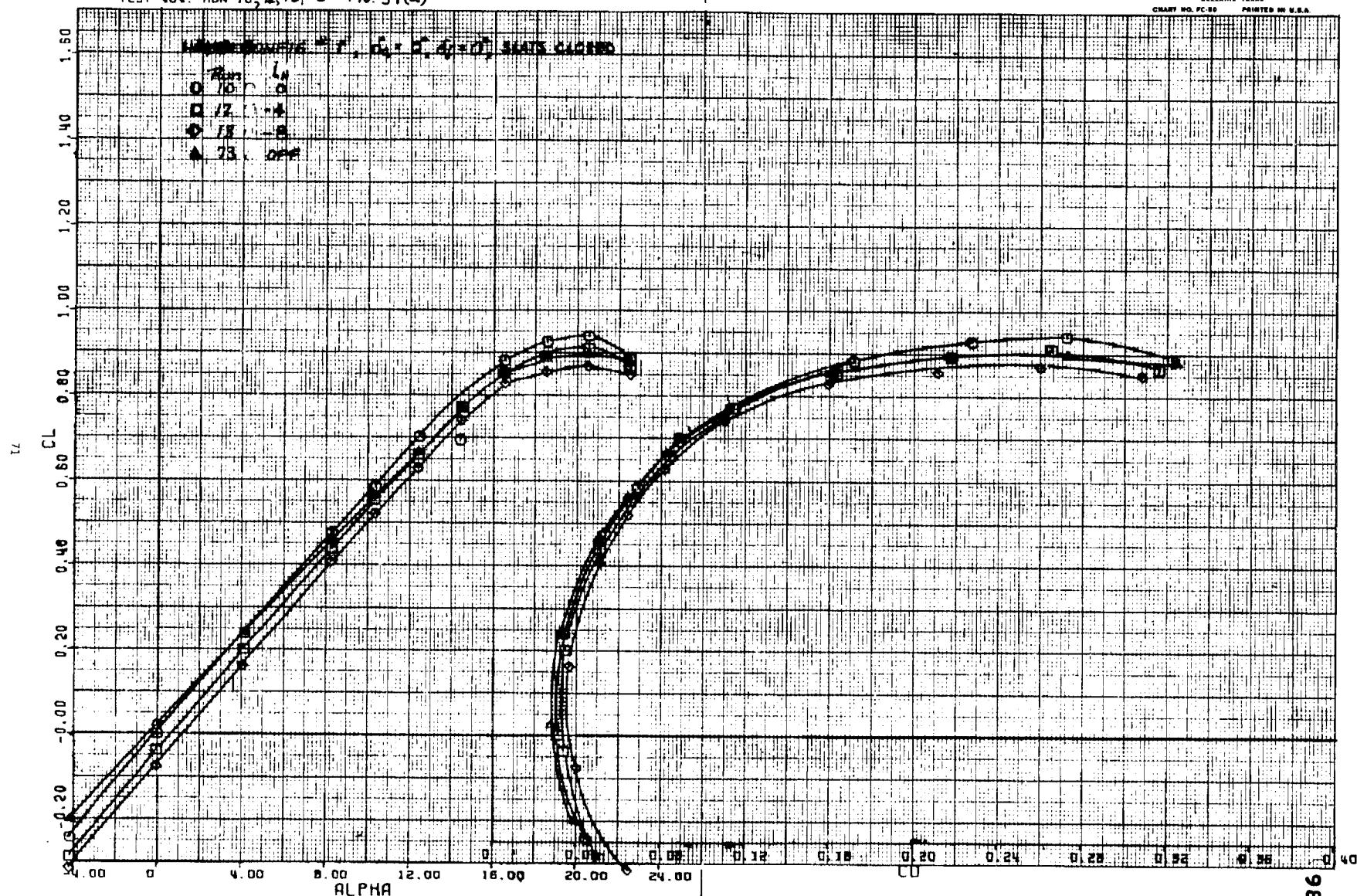


Figure 39(a)

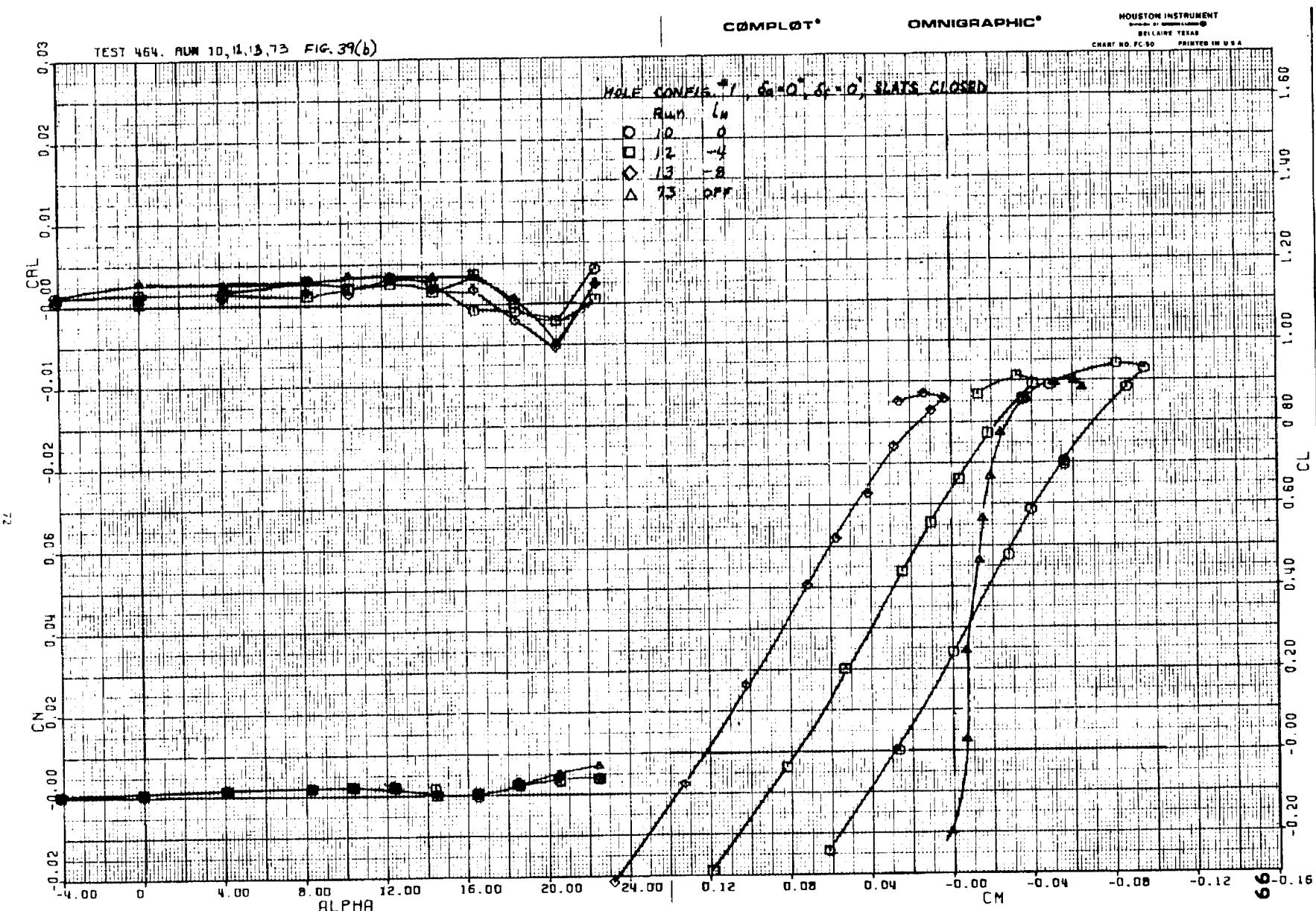


Figure 39(b)

TEST 464. RUN 10,14,15 FIG. 40(a)

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BELLAIR TEXAS
CHART NO. PC 88 PRINTED IN U.S.A.

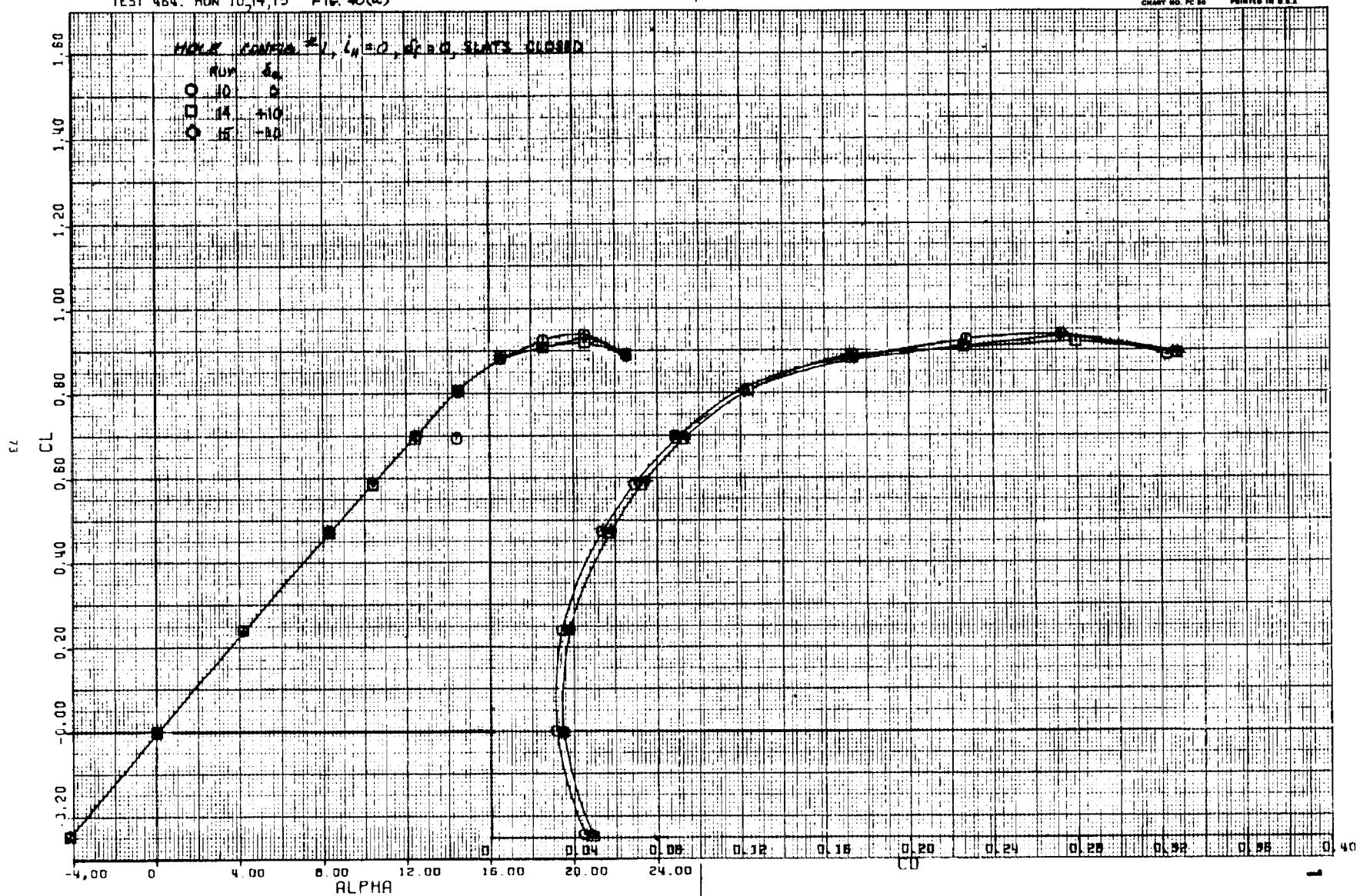


Figure 40(a)

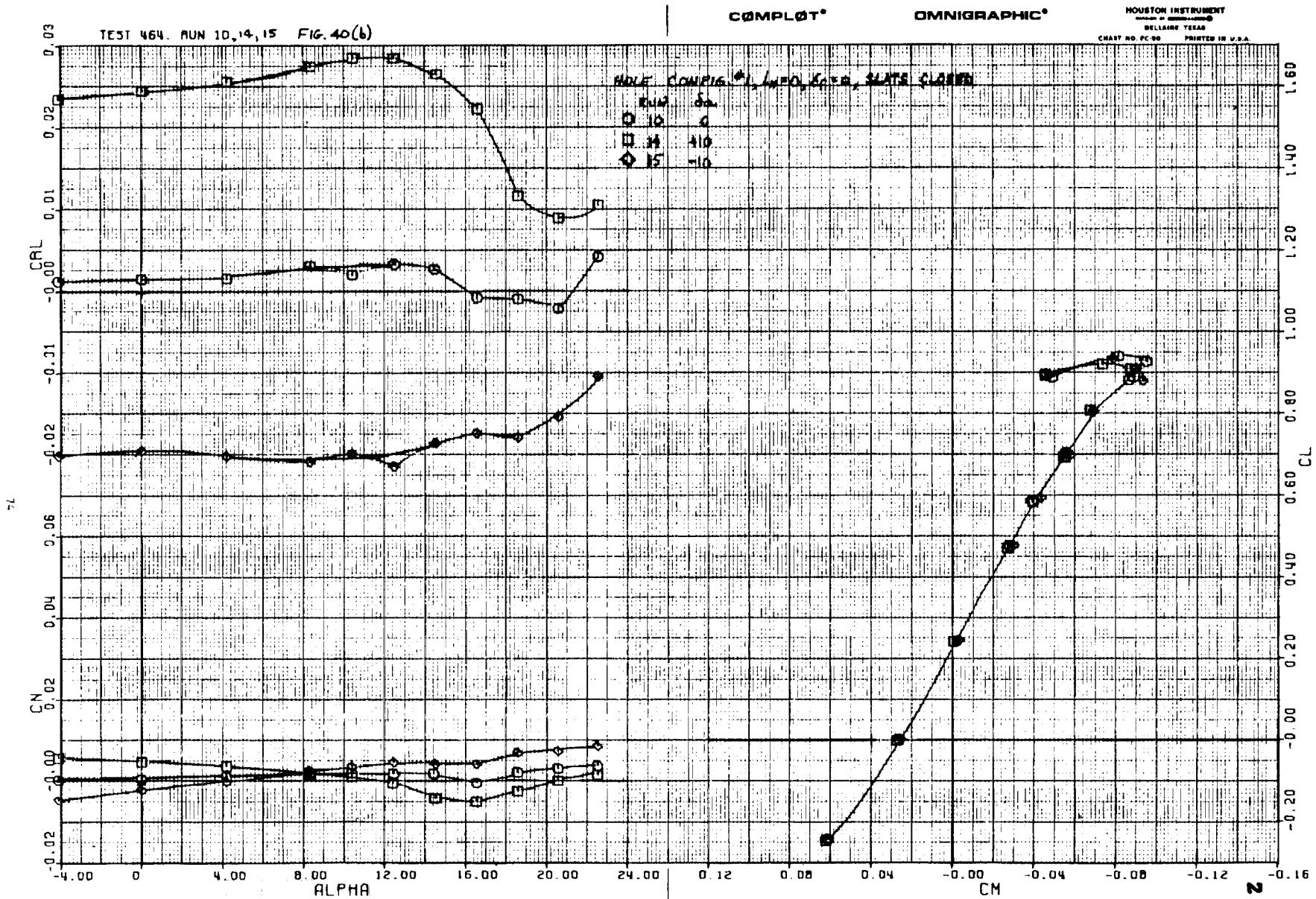


Figure 40(b)

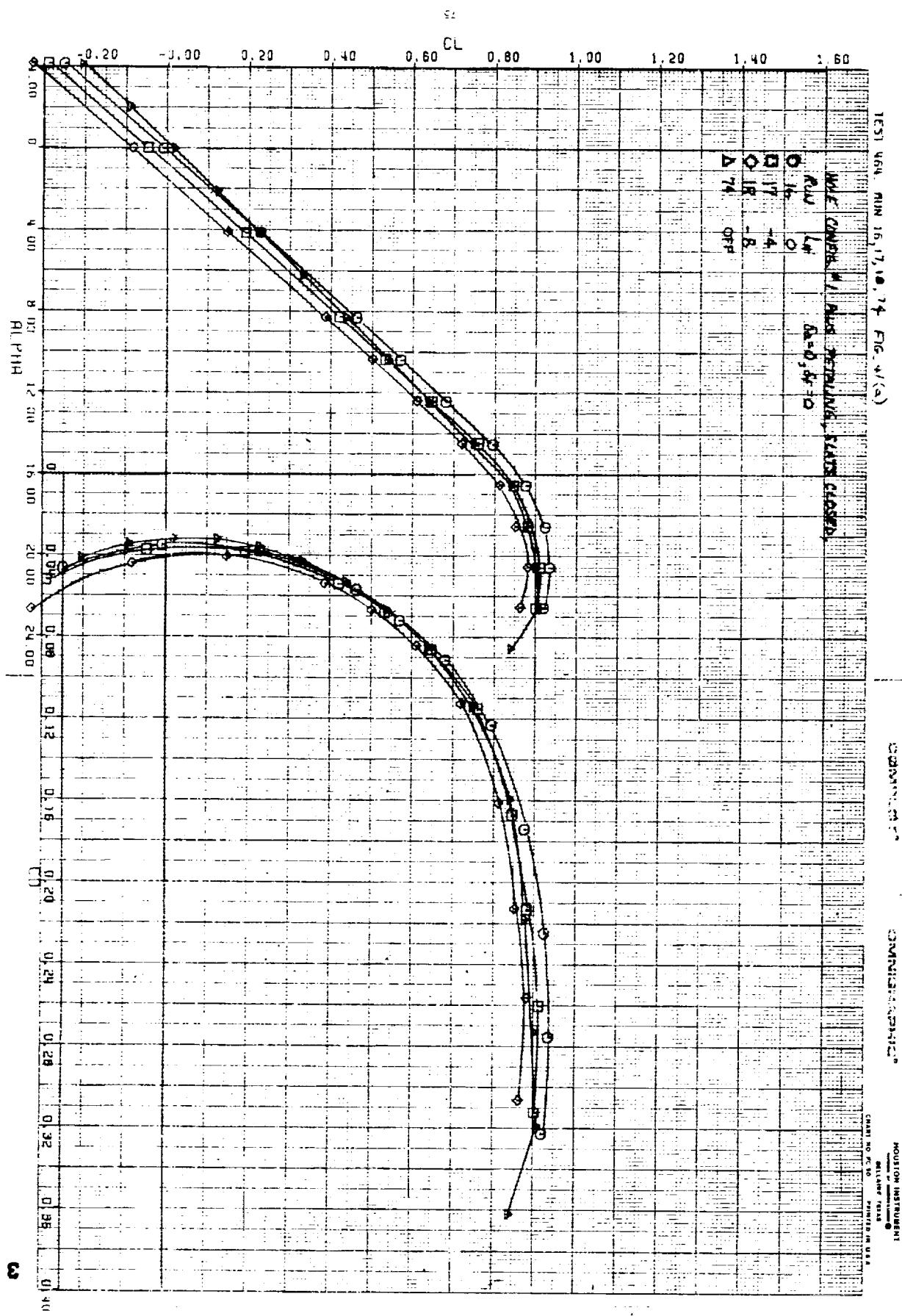


Figure 41(a)

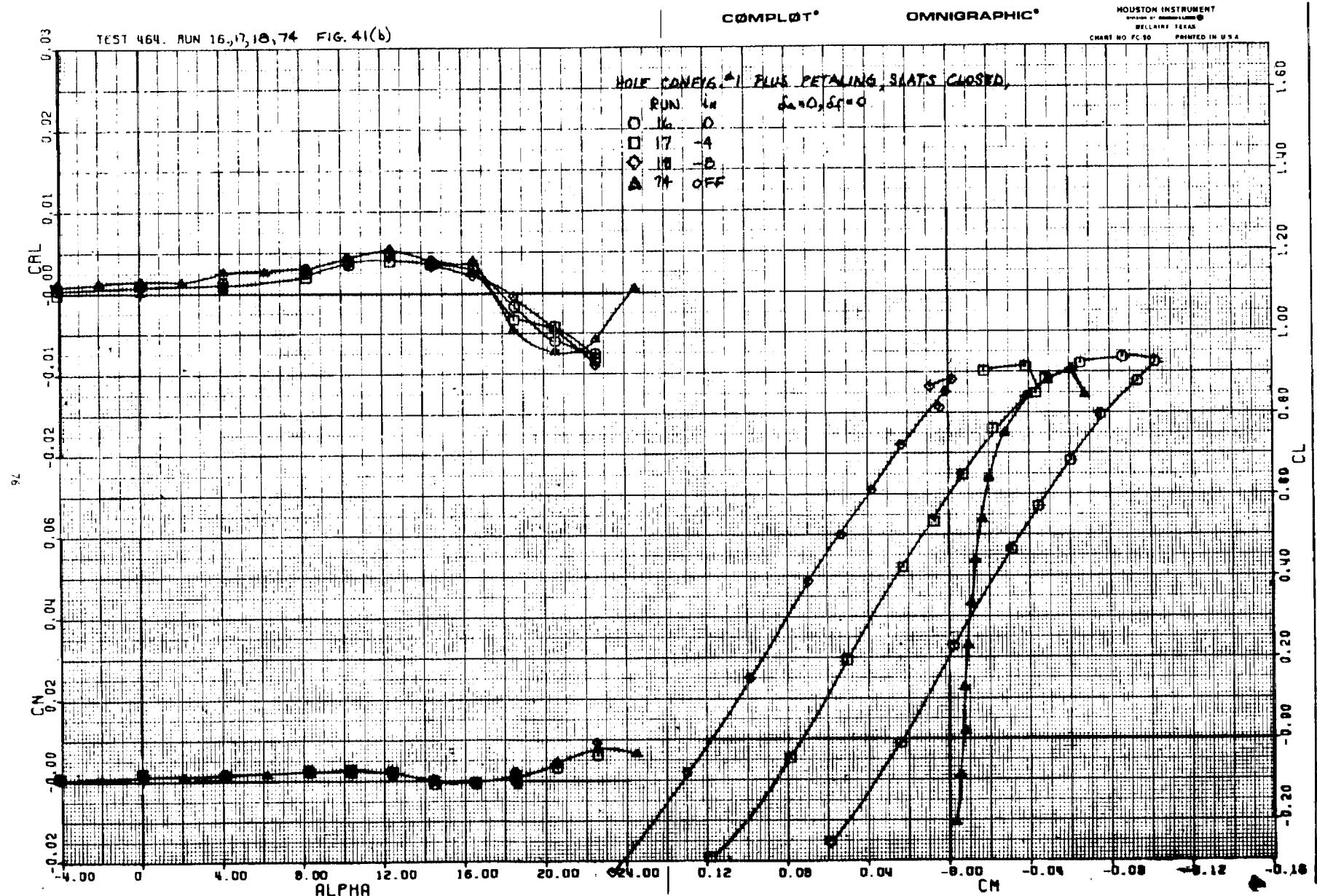


Figure 41(b)

TR-SI USA RUN 15, 19, 20 FIG. 42(a)

COMPARATOR

CINEMATOGRAPHIC

WILHELM INSTRUMENTS

Sheet No. 10

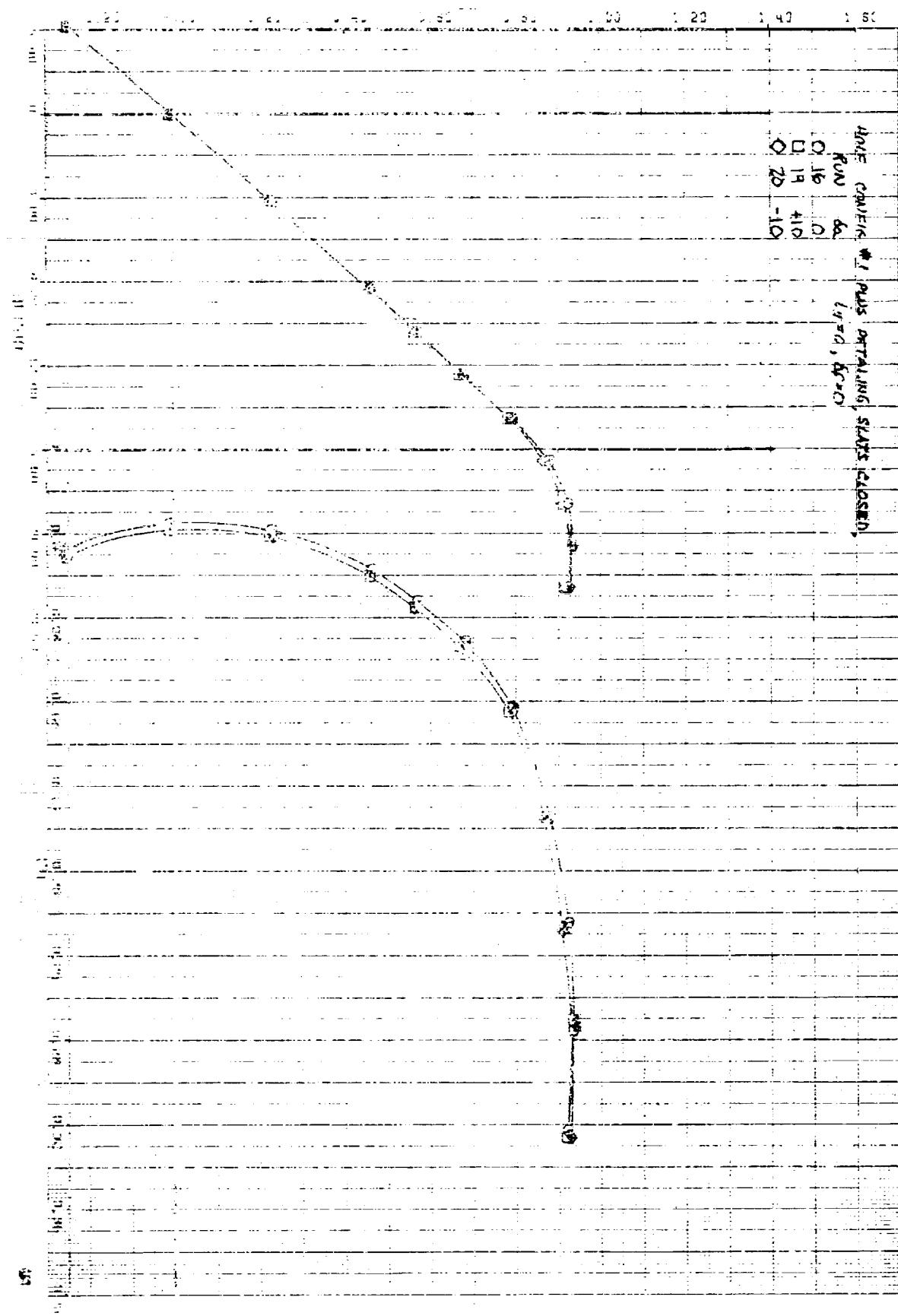
Revised Date

Printed in U.S.A.

WING CAVES #1
RUN 16
O 16
O 19
O 20
-10

WING CAVES #1
RUN 19
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O 19
O 20
-10

WING CAVES #1
RUN 20
O 16
O 19
O 20
-10



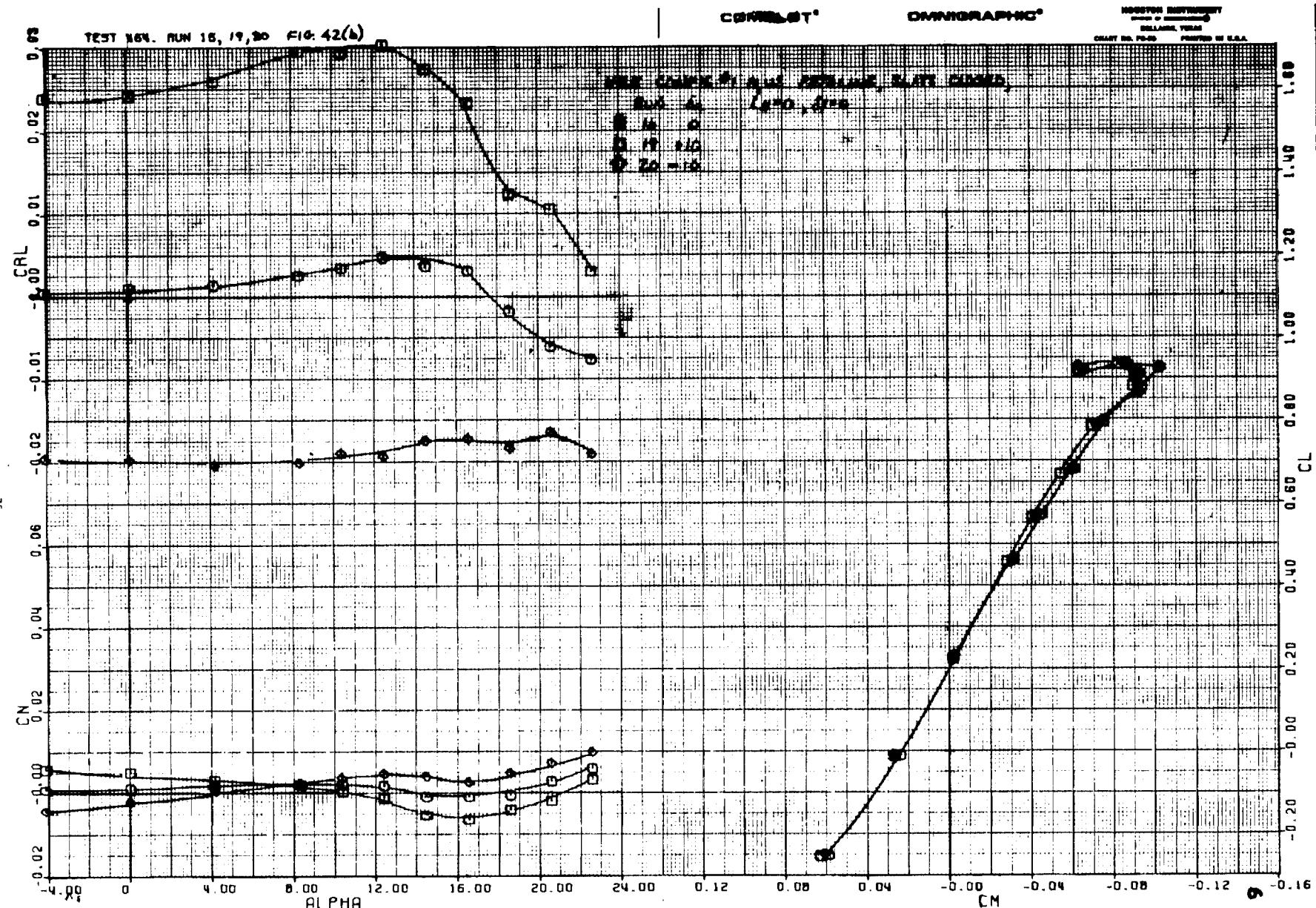


Figure 42(b)

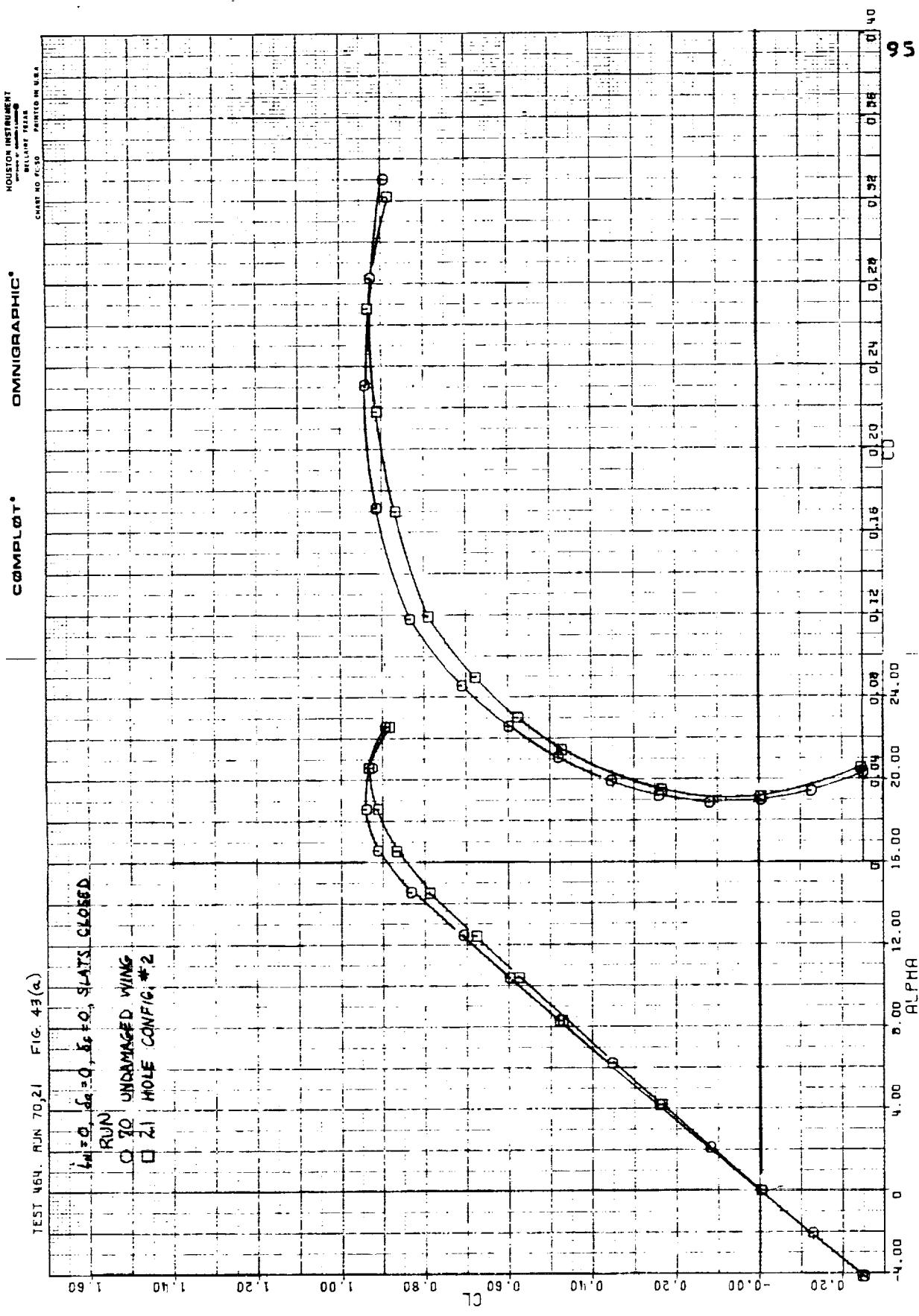


Figure 43(a)

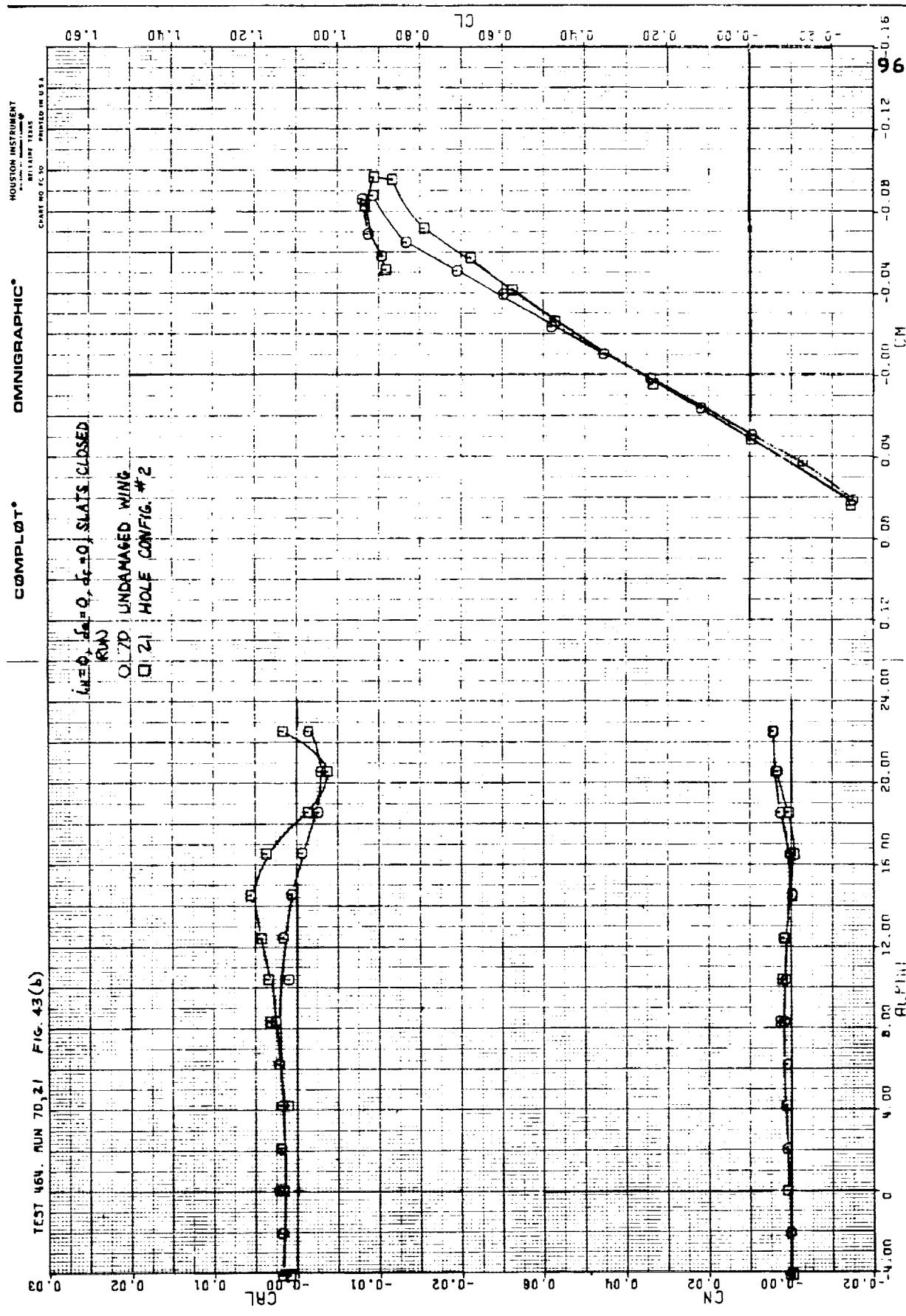


Figure 43(b)

TEST 464 RUN 21, 22, 23, 75 FIG. 44(a)

HOLE DOWNGEAD 2, SLATS OPEN, SLATS CLOSED

RUN
21 O
22 □
23 △
75 Δ

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BELLAIRE, TEXAS

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CHART NO FC 50

7

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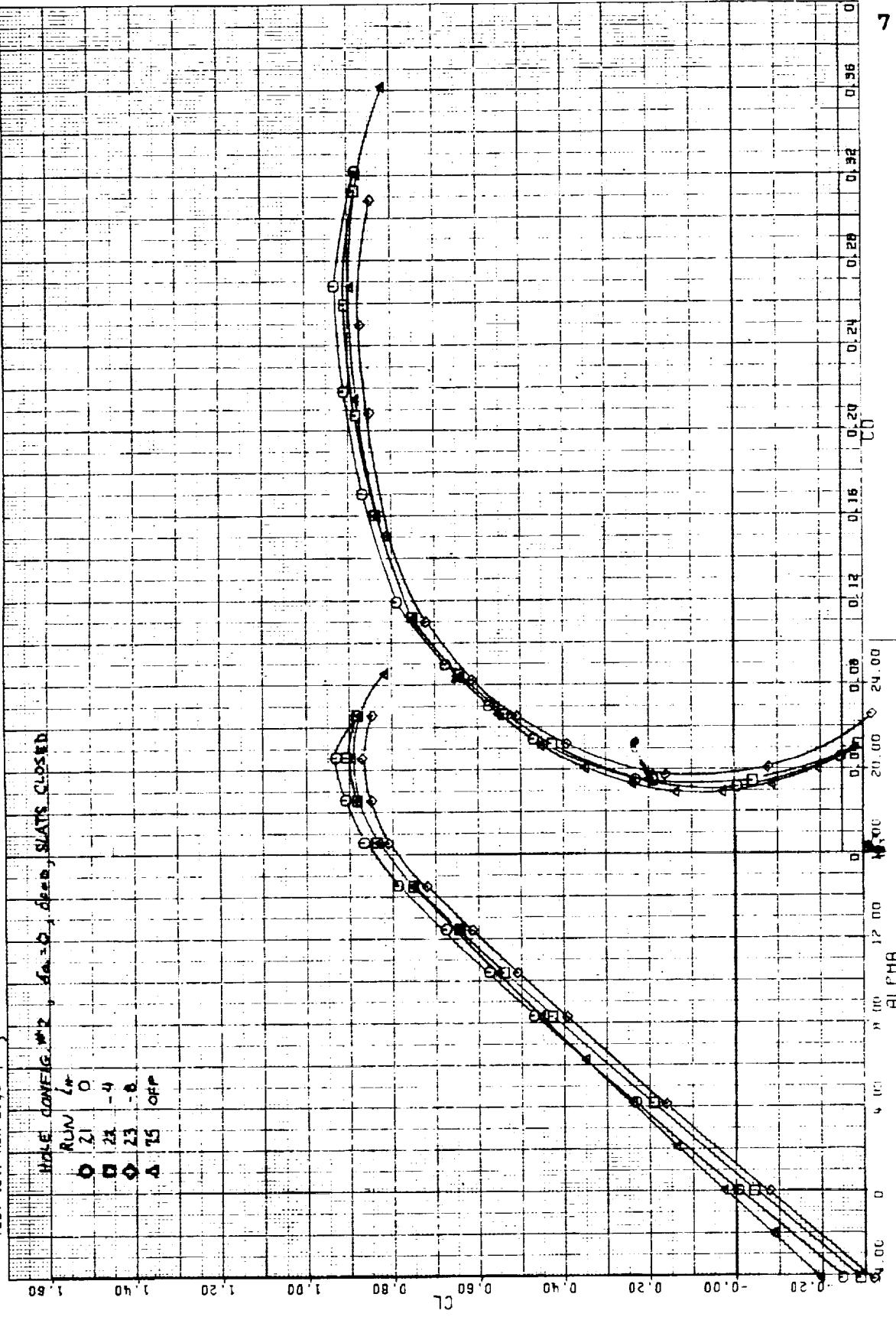


Figure 44(a)

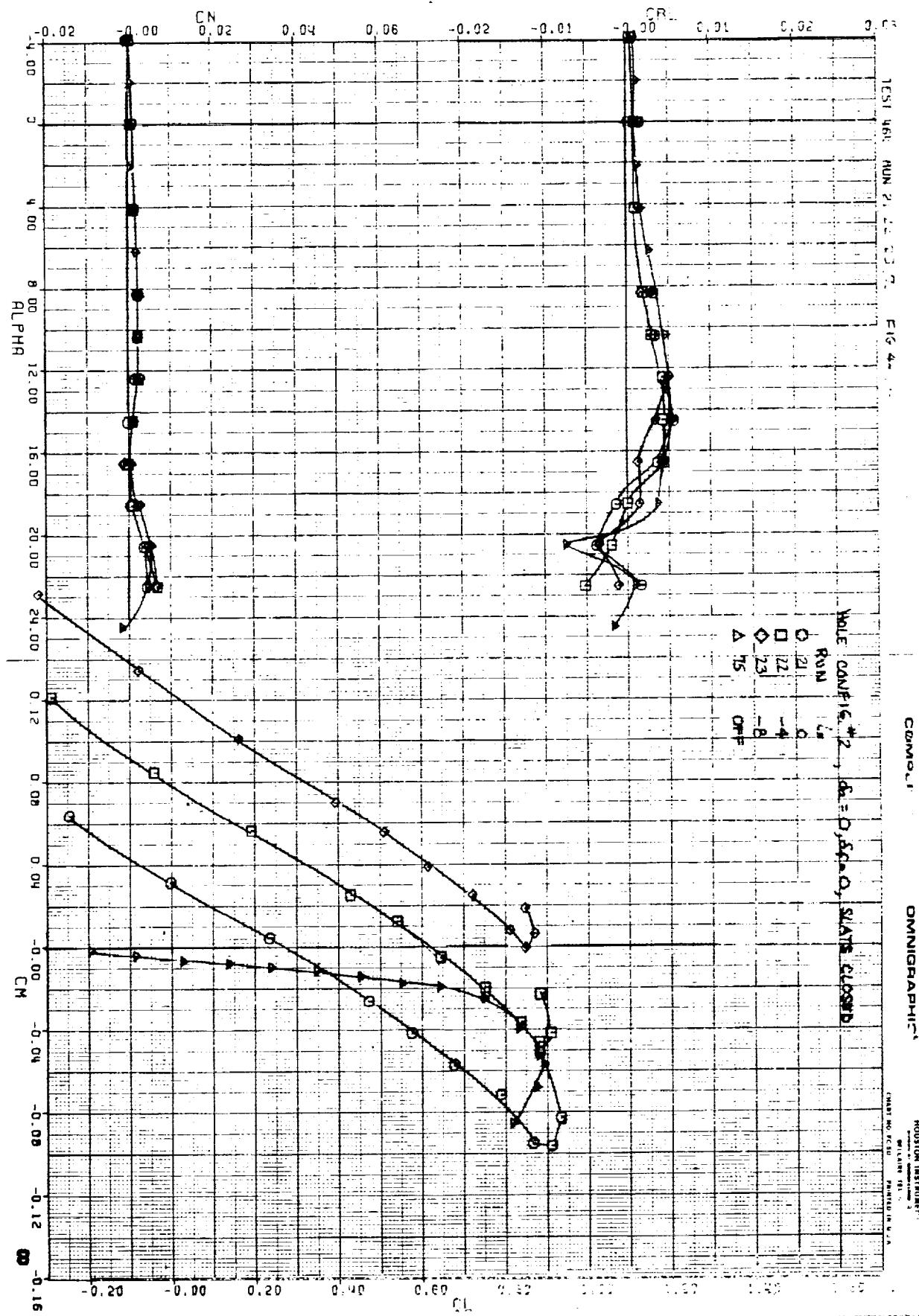


Figure 44(b)

TEST 454. RUN 21, 24, 25 FIG. 45(a)

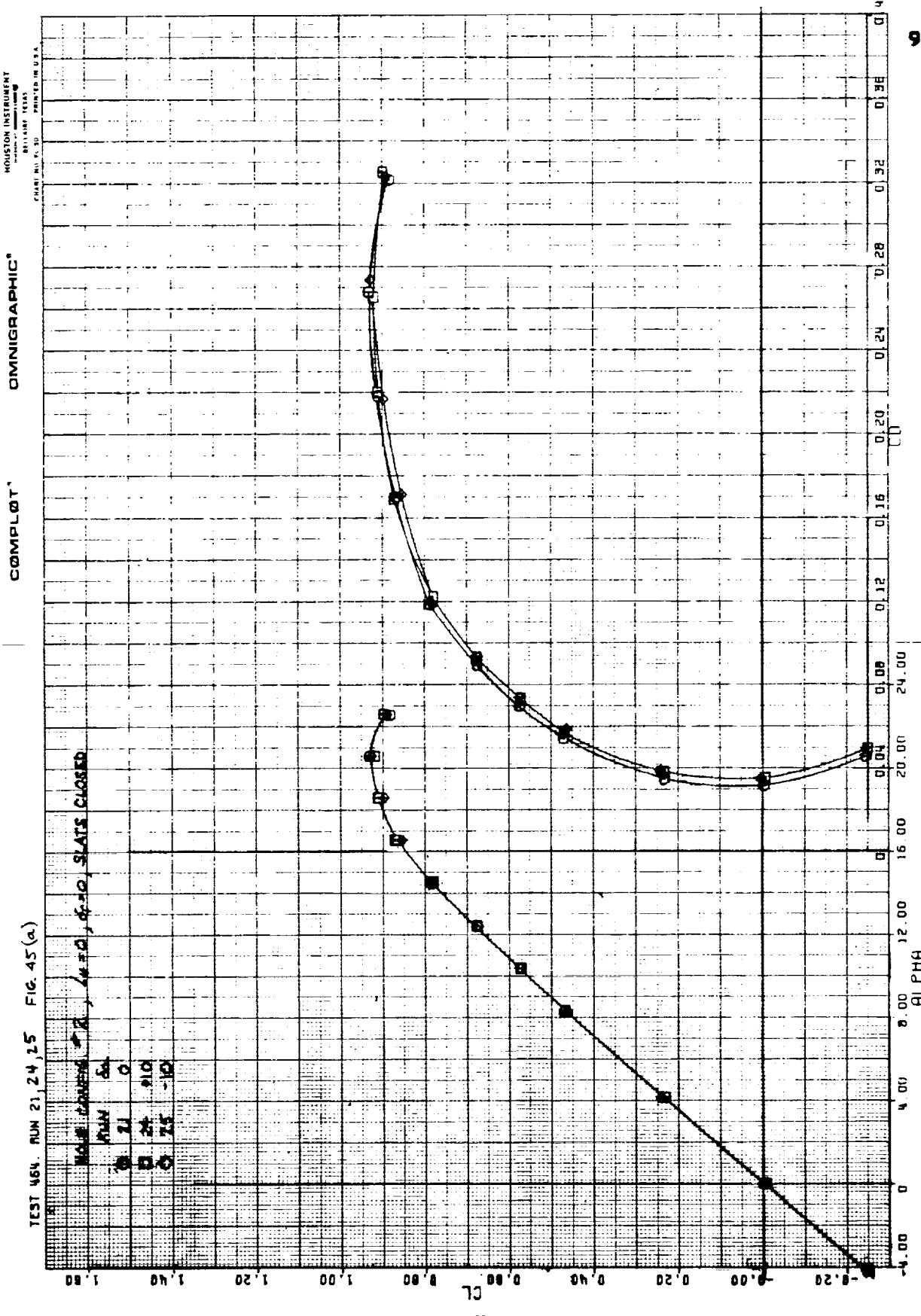


Figure 45(a)

TEST NO. 45, RUN 21, 24, 25 FIG. 45(a)

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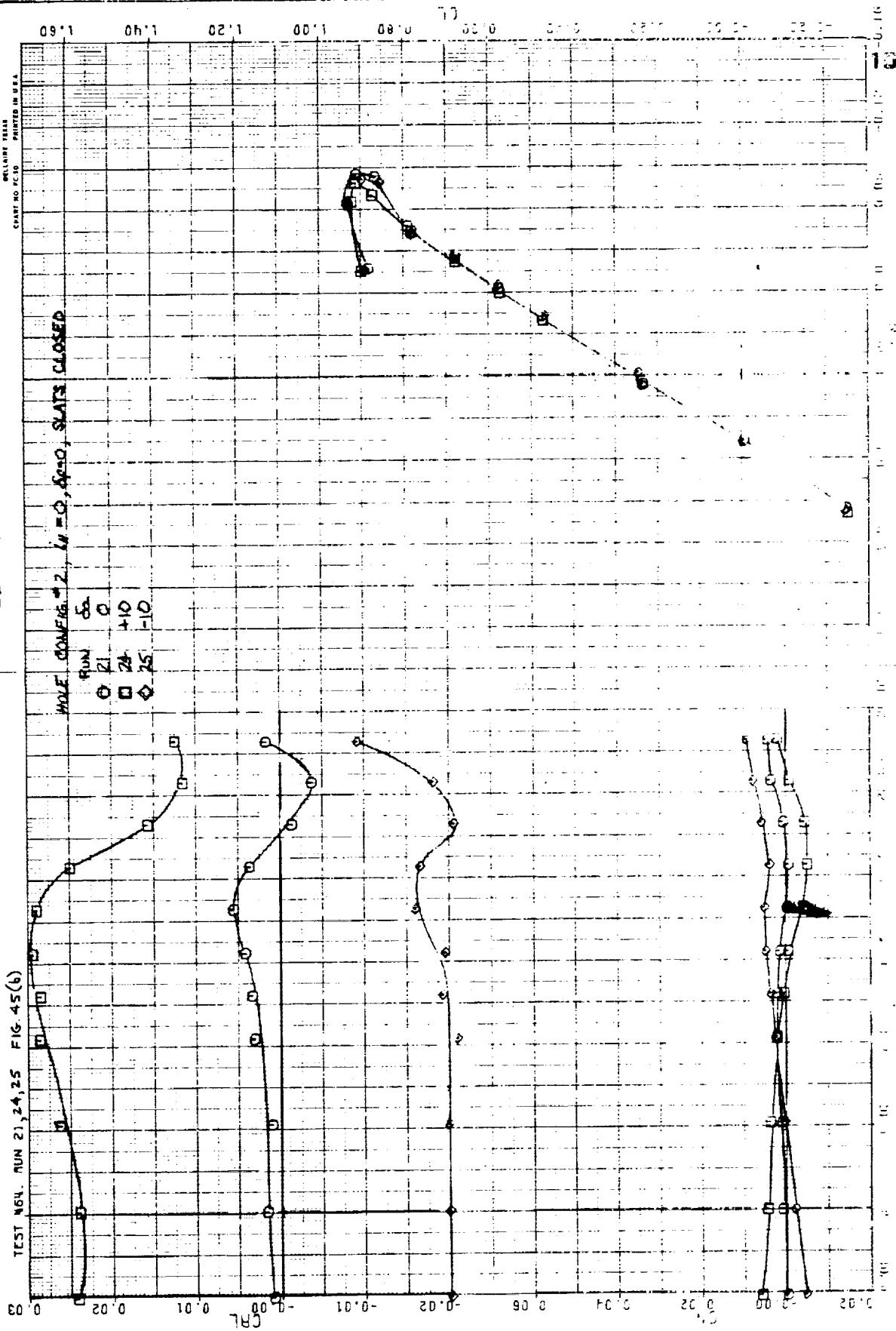
HOUSTON INSTRUMENT[®]

SELLERY TEST CHART

CHART NO. FC10 PRINTED IN U.S.A.

HOLE COUPLES #2, IN = 0, 640, SLATS CLOSED

RUN 52
○ 21
□ 24
◇ 25



TEST 404 RUN 70,26 FIG 46(a)

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OMNIGRAPHIC®

HOUSTON INSTRUMENT

BELLAIR TEXAS

CHART NO FL 50 PRINTED IN U.S.A.

$L_0 = 0$, $\delta_2 = \phi$, $\delta_3 = 0$, SLATS CLOSED

RUN

○ 70 UNDAMAGED WING

□ 26 HOLE CONFIG. #3

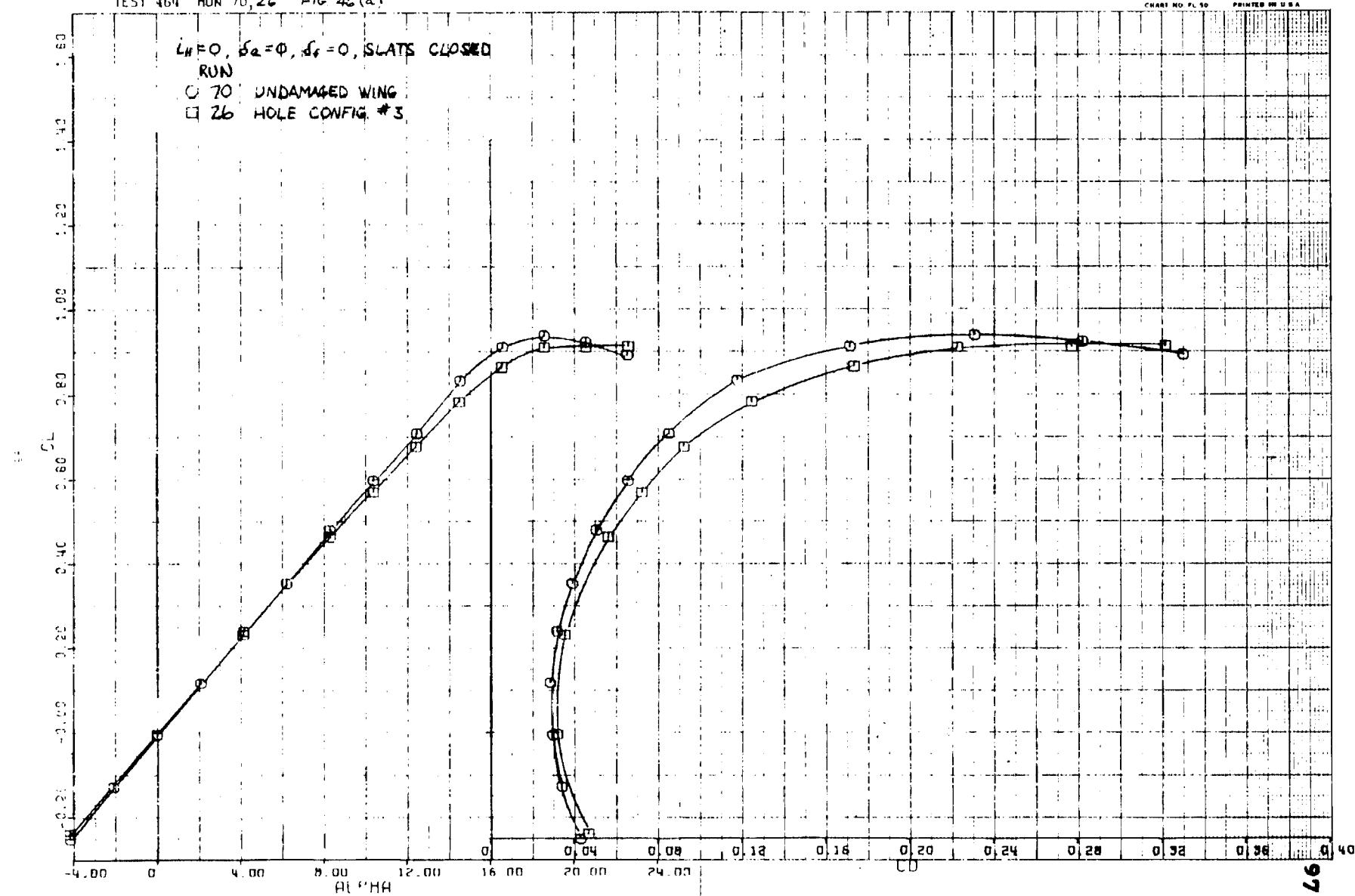


Figure 46(a)

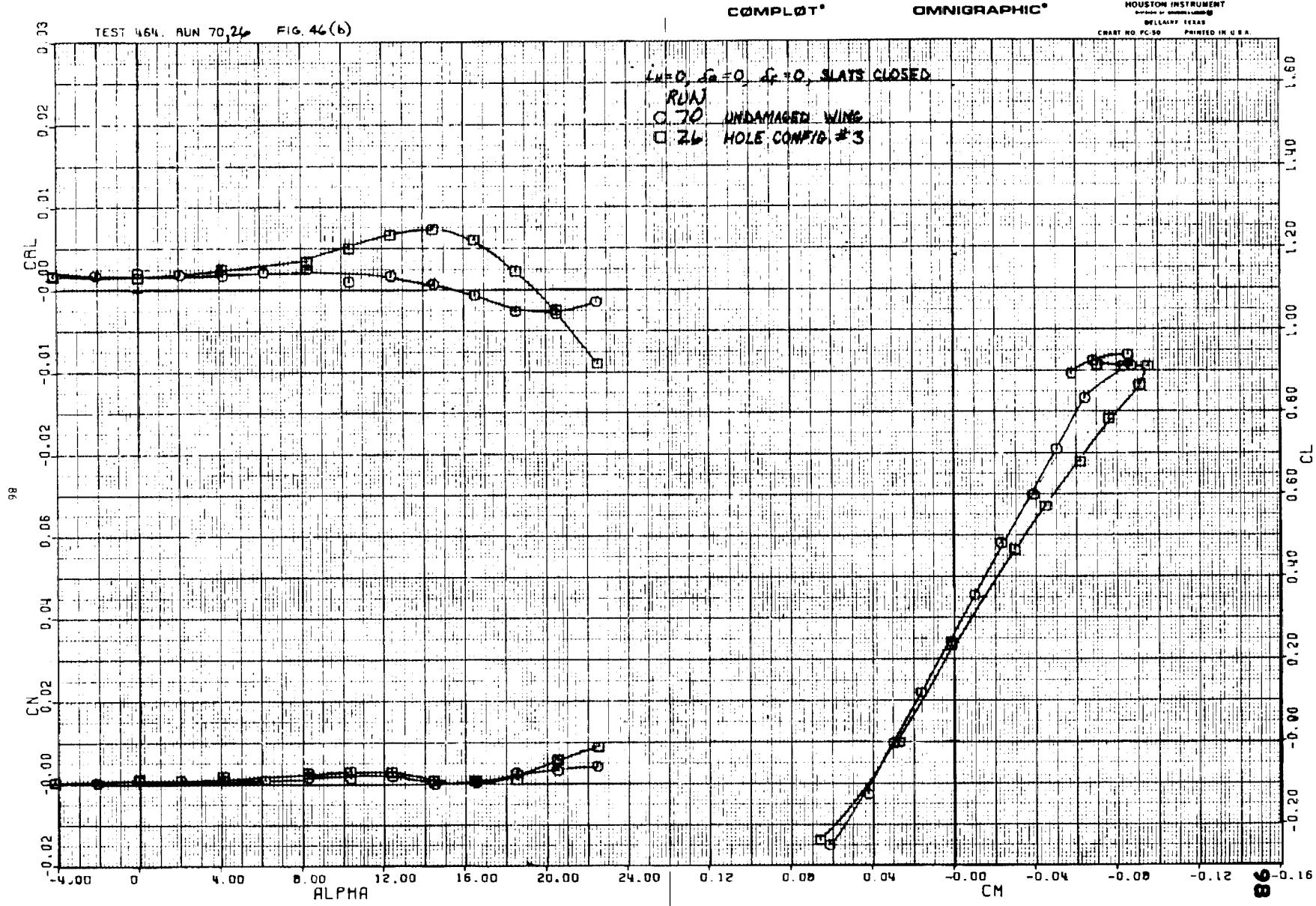


Figure 46(b)

TEST 464. RUN 5B, 64 FIG. 47(a)

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HOUSTON INSTRUMENT
DELLAIRE TEXAS
CHART NO. FC 30 PRINTED IN U.S.A.

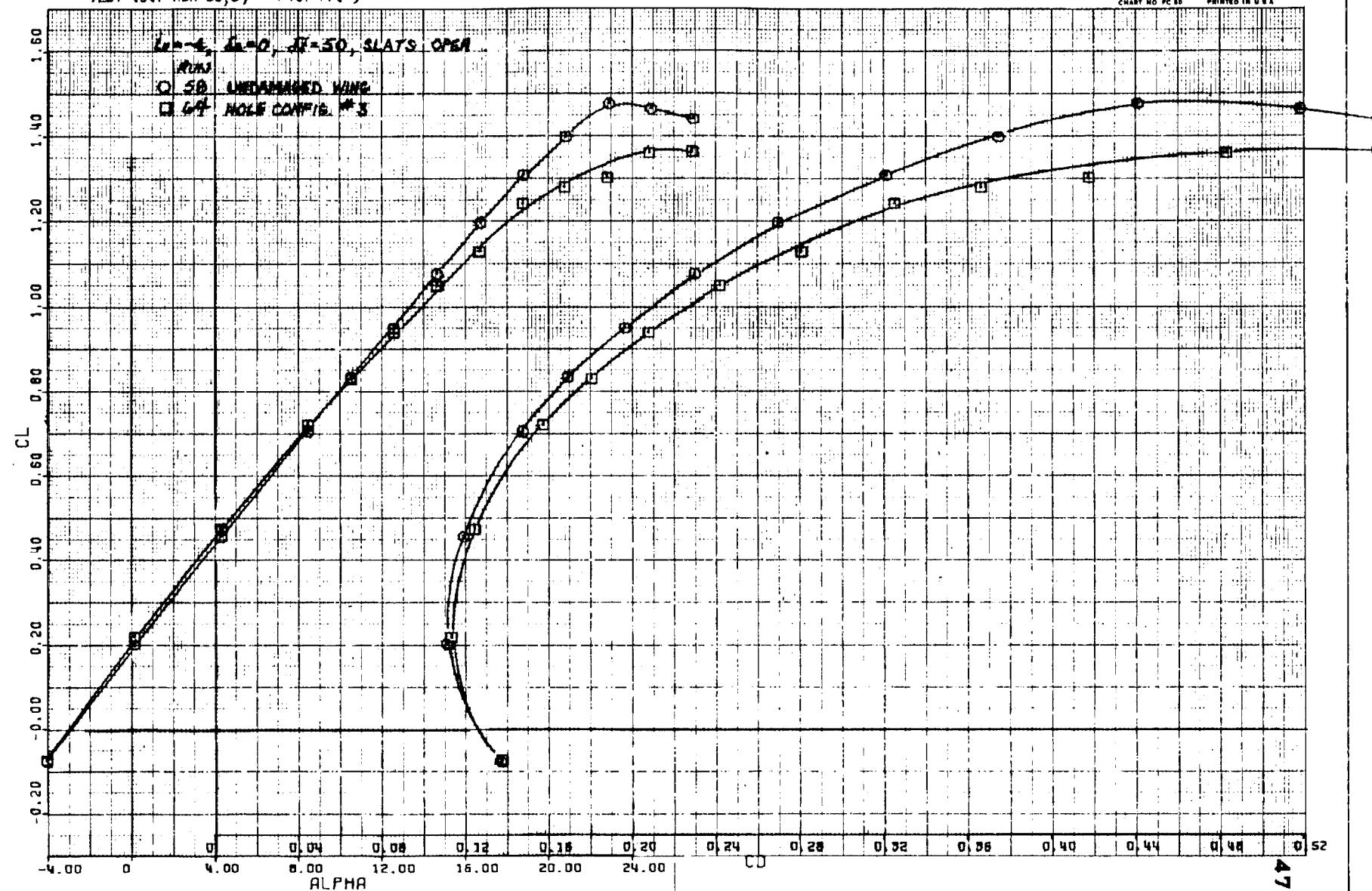


Figure 47(a)

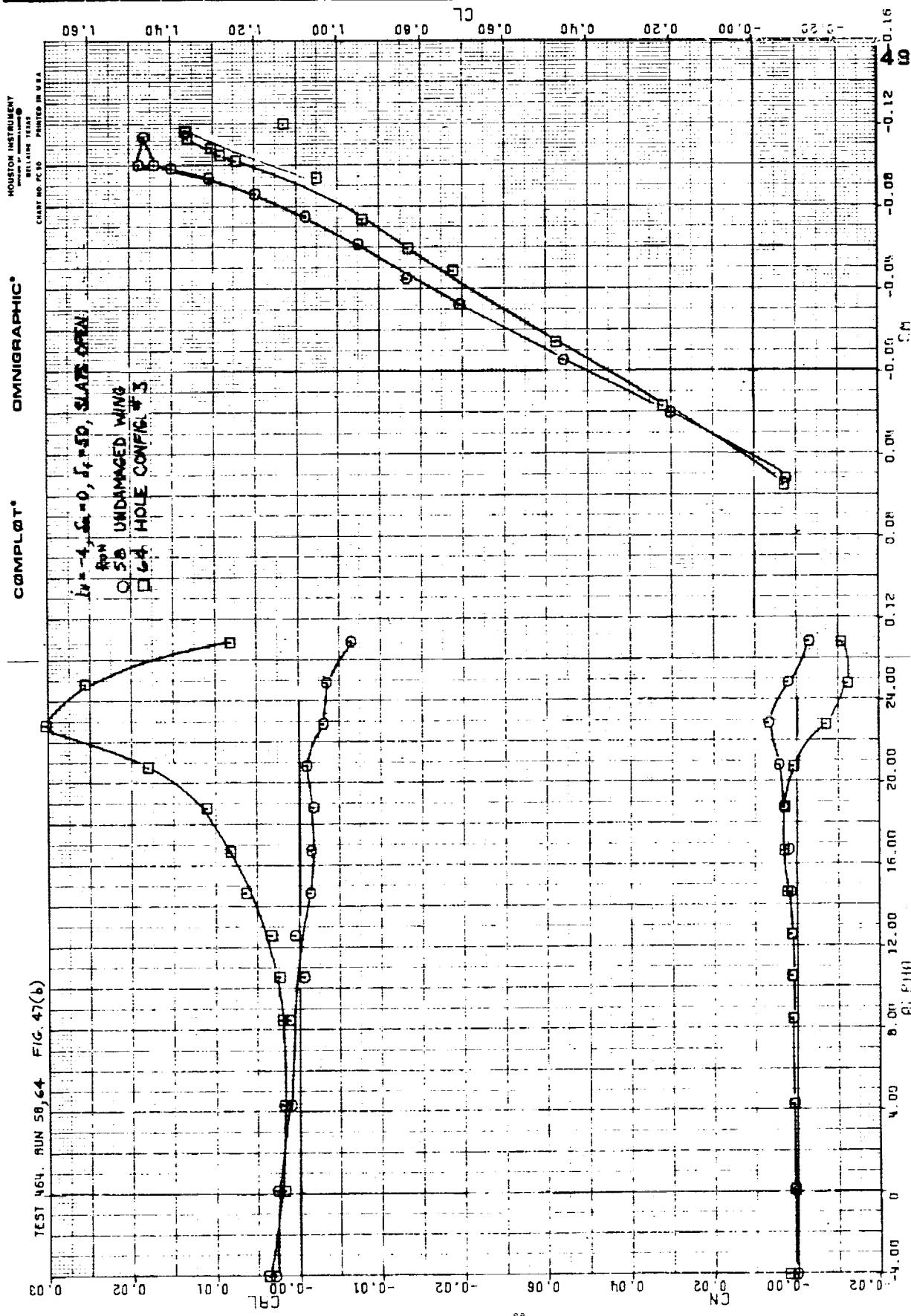


Figure 47(b)

TEST 464. RUN 26,27,28,76 FIG. 48(a)

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OMNIGRAPHIC®

HOUSTON INSTRUMENT
BELLING TEXAS

CHART NO. FL10 PRINTED IN U.S.A.

MOTOR COMPOUND, $S_0 = 0.5 = 0$, SLATS CLOSED

RUN 14
○ 26 ○
□ 27 □
○ 28 △
△ 76 OPEN

68

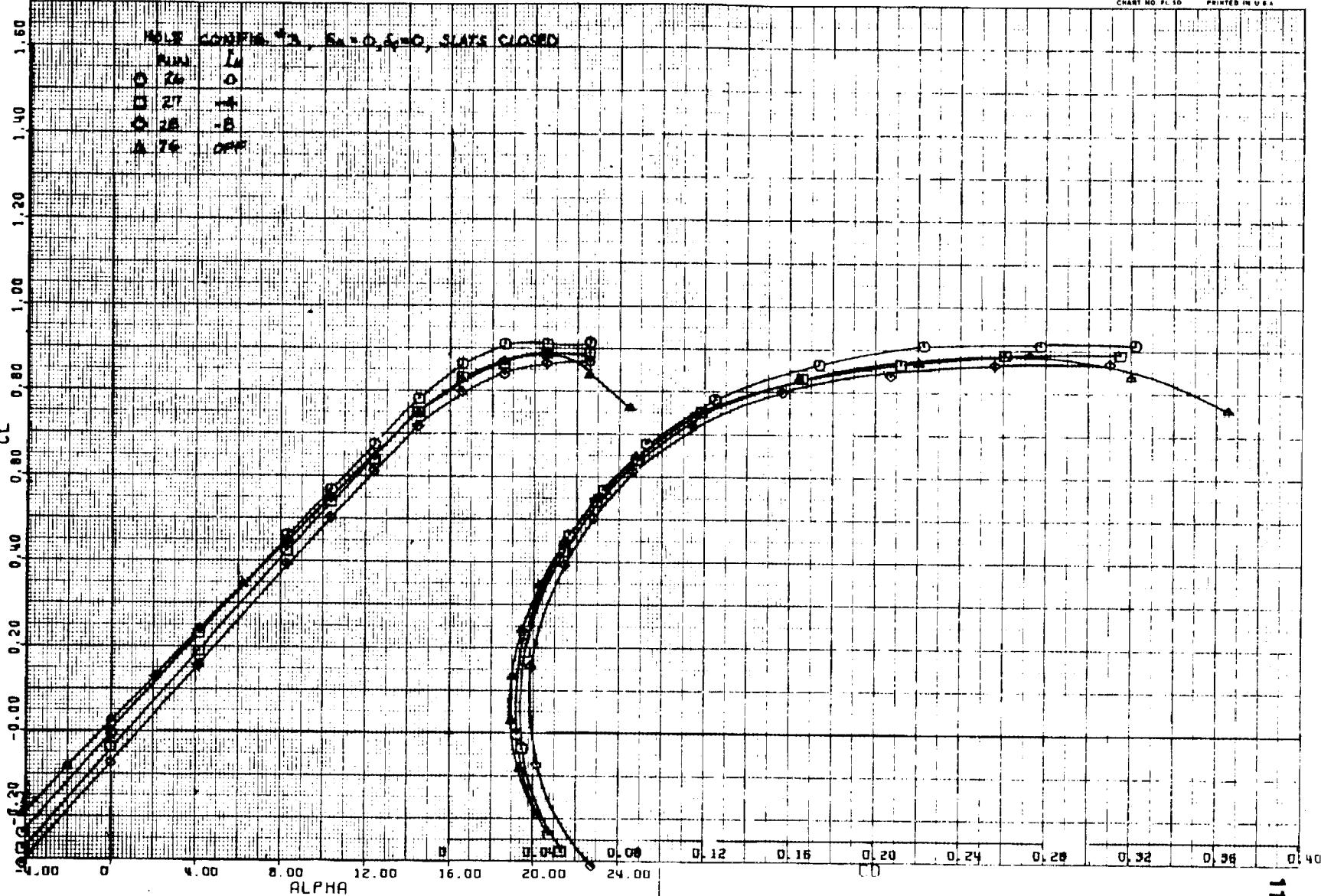


Figure 48(a)

11

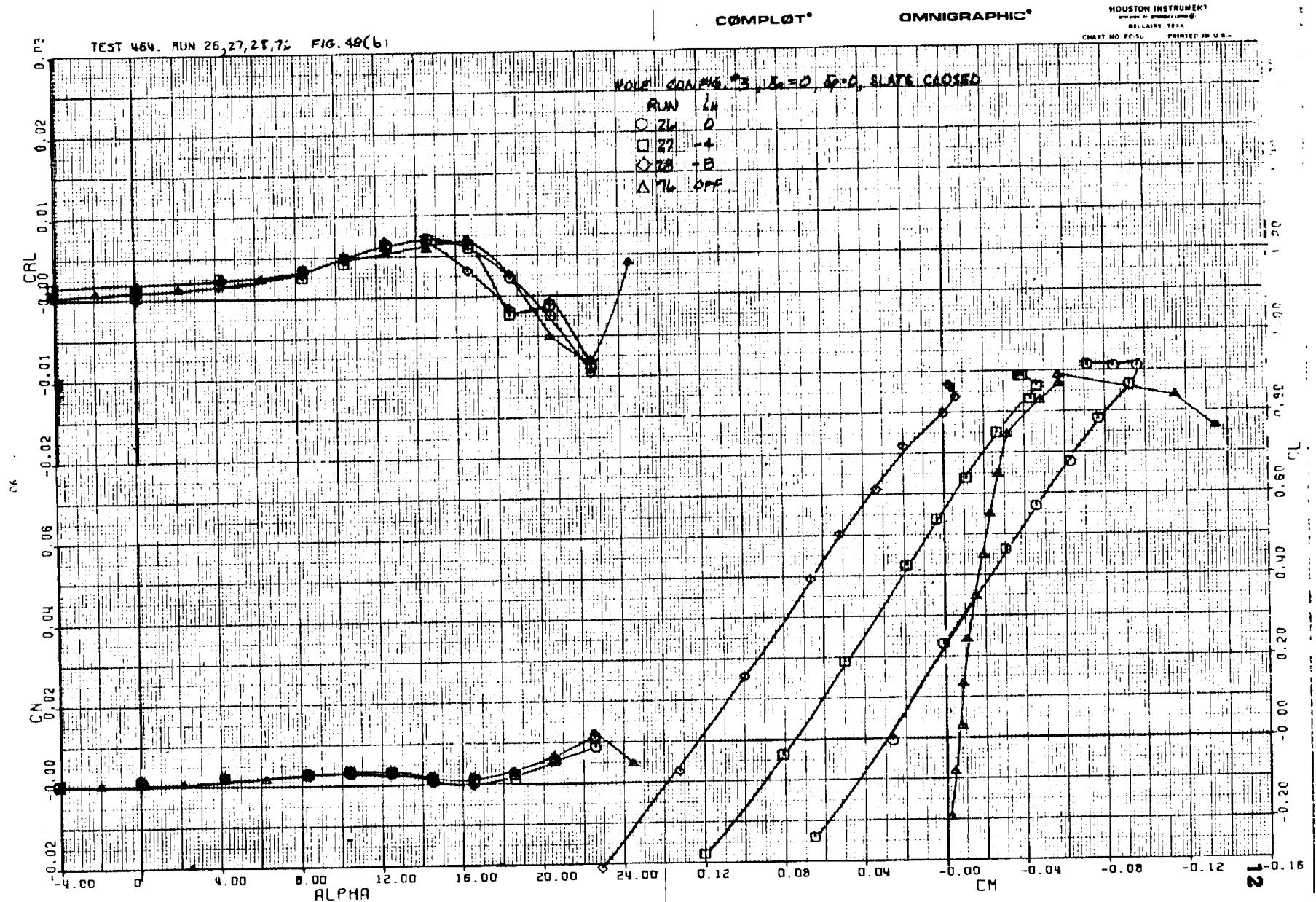


Figure 48(b)

TEST 461. RUN 26, 29, 30 FIG. 49(a)

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HOUSTON INSTRUMENT

MILLIVOLT TAHS

CHART NO. FC-60 PRINTED IN U.S.A.

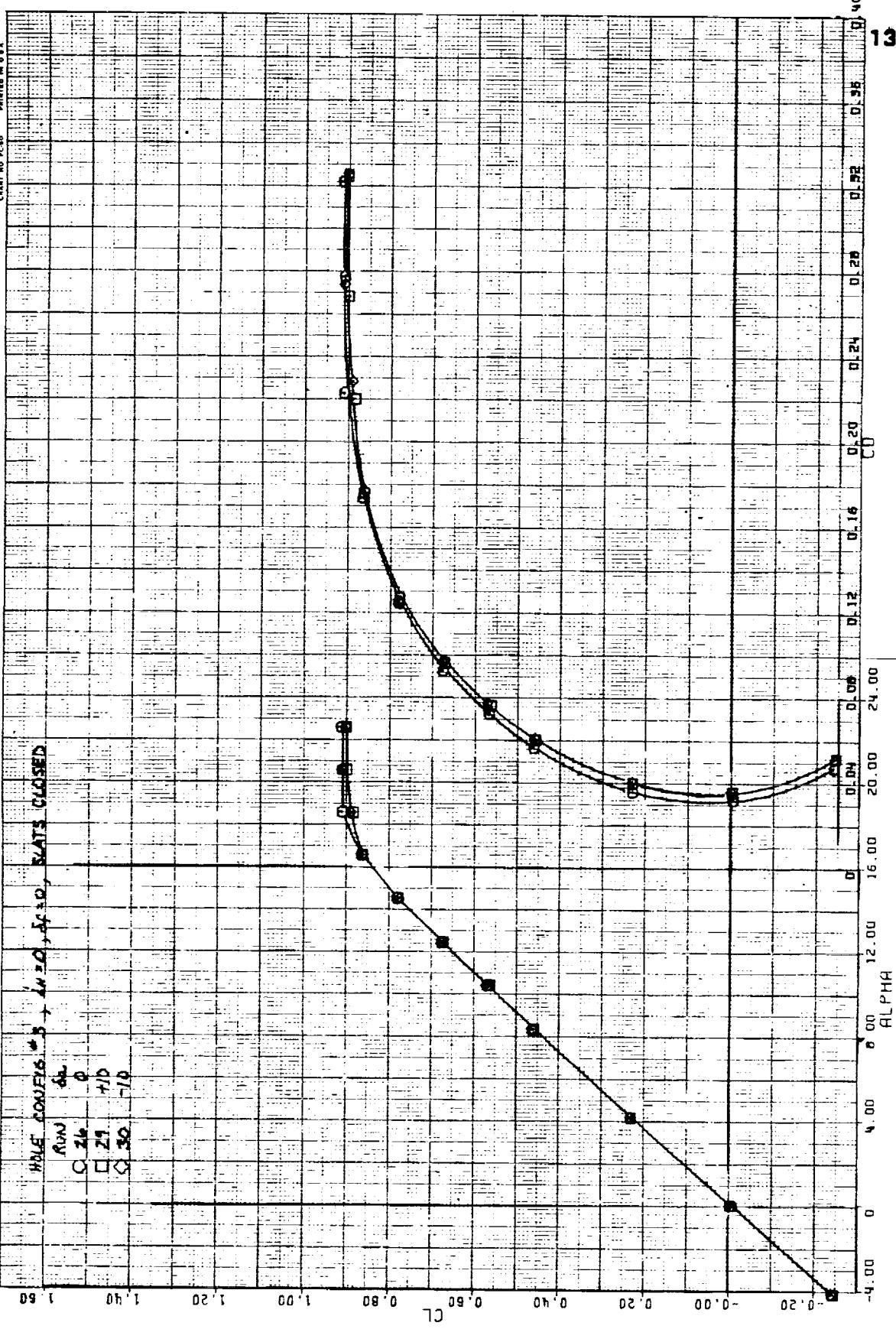


Figure 49(a)

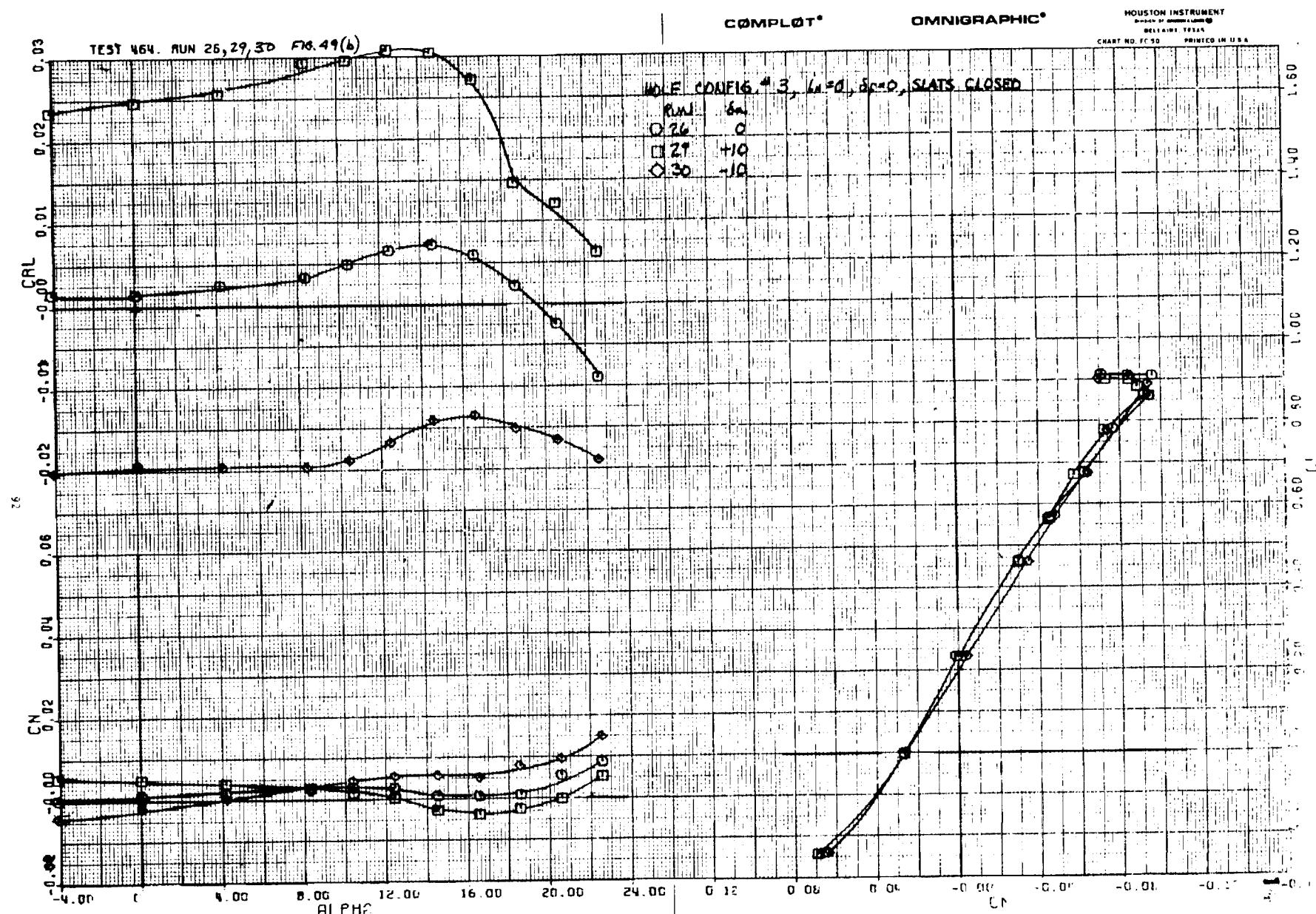


Figure 49(b)

TEST 464 RUN 64, 5, 6, 7 FIG. 50(a)

COMPLATE

OMNIGRAPHIC

HOUSETON INSTRUMENT
MILITARY TEST

CHART NO. PL 10 PRINTED IN U.S.A.

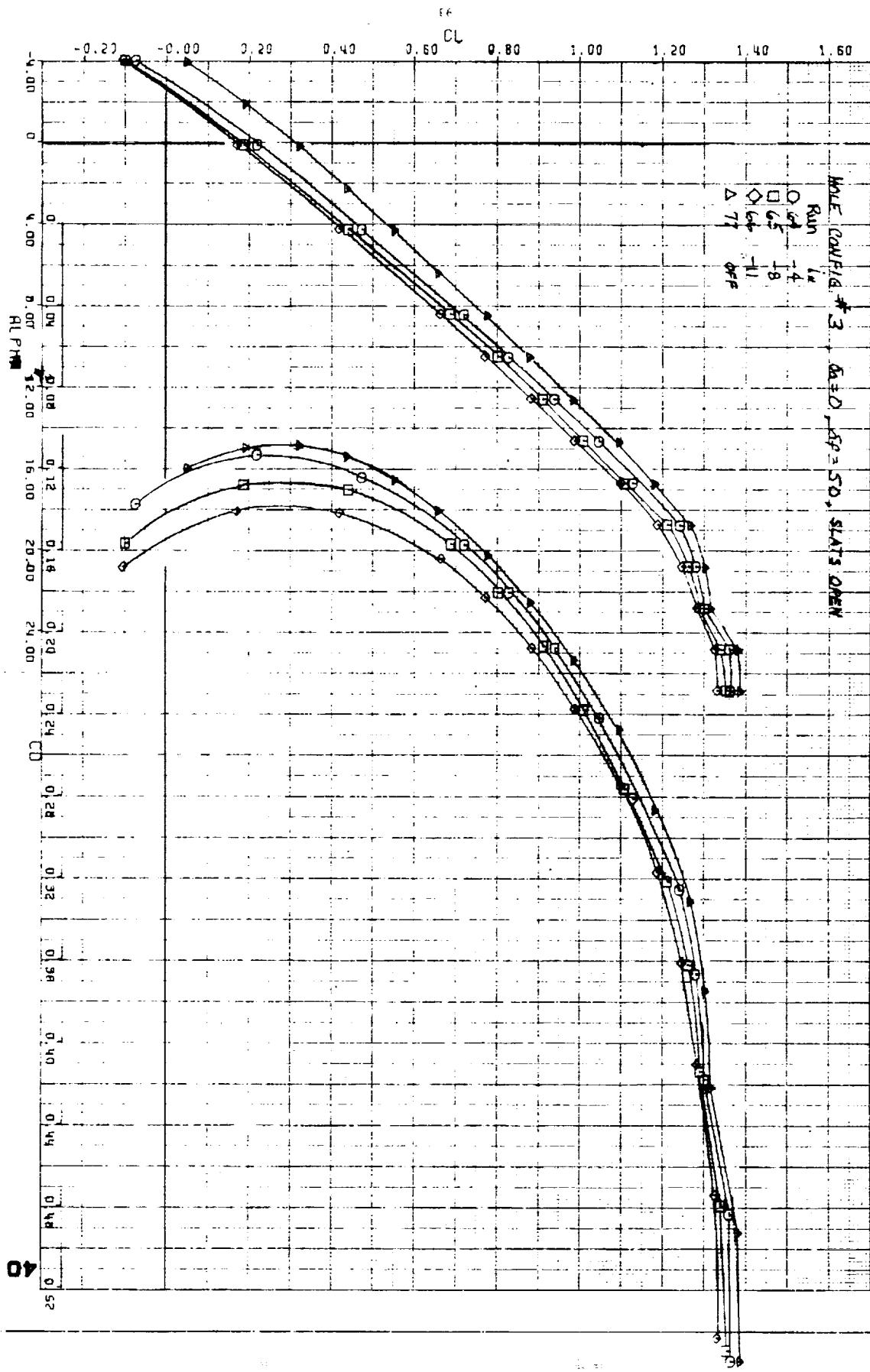


Figure 50(a)

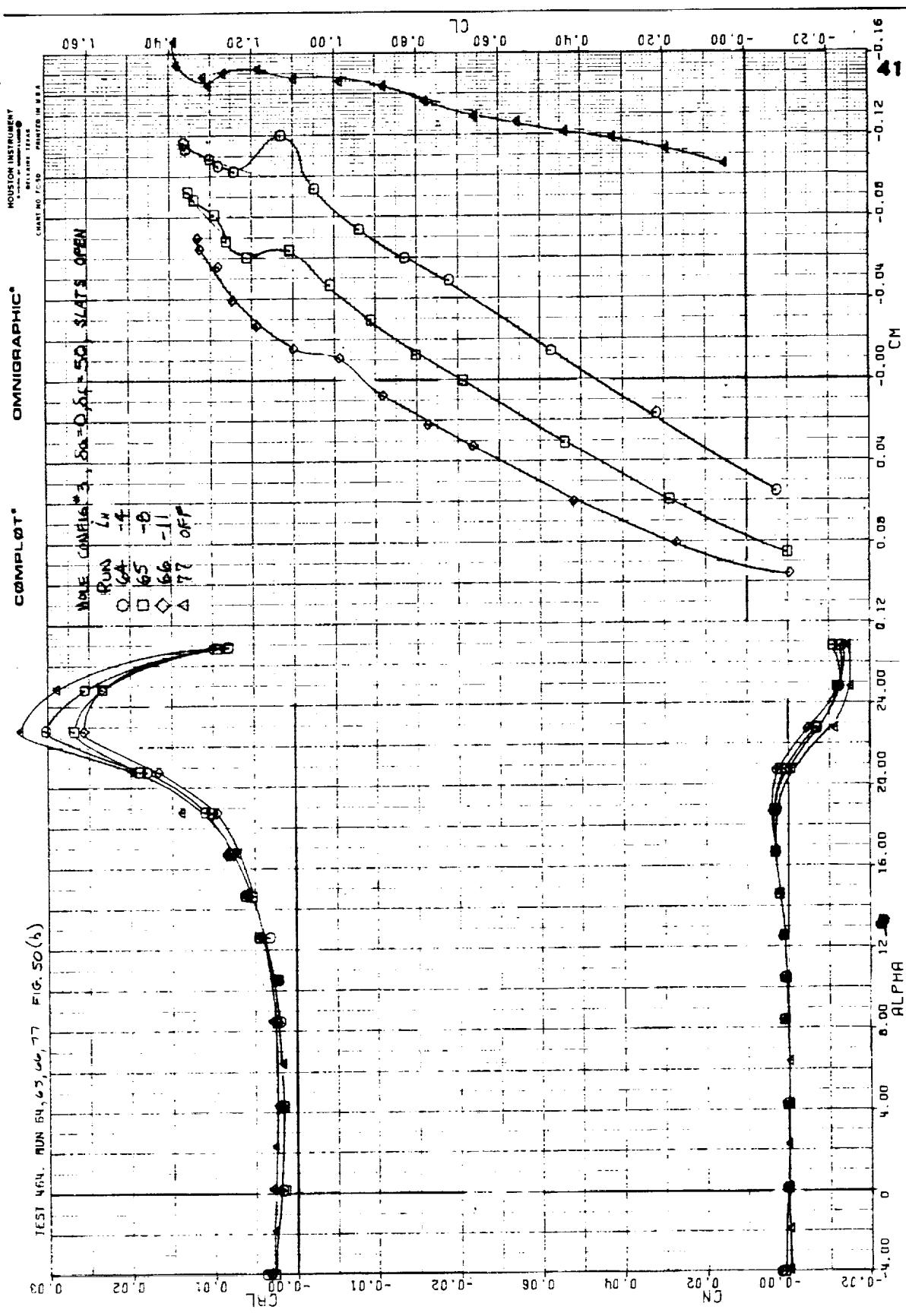


Figure 50(b)

C.2

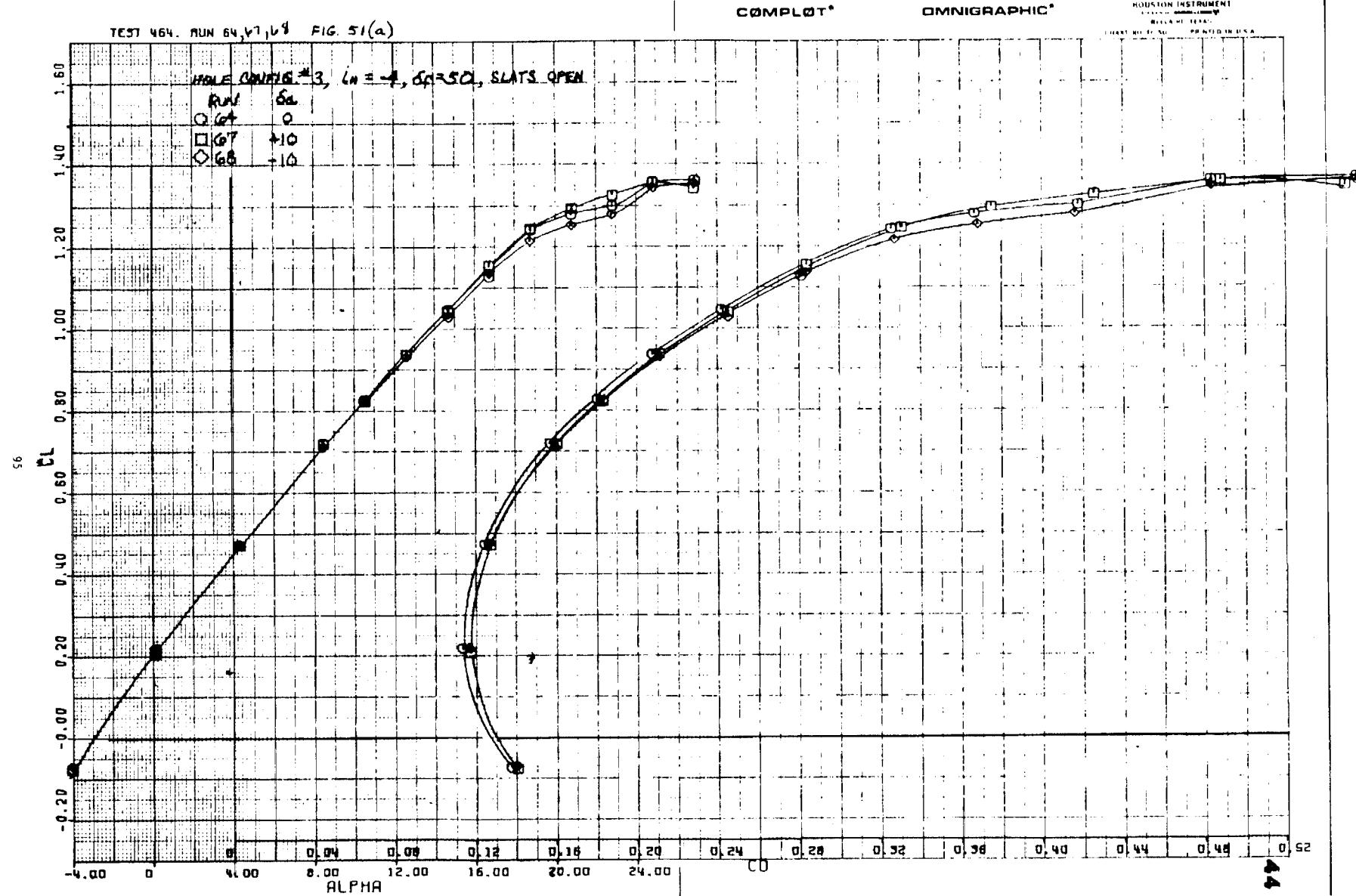


Figure 51(a)

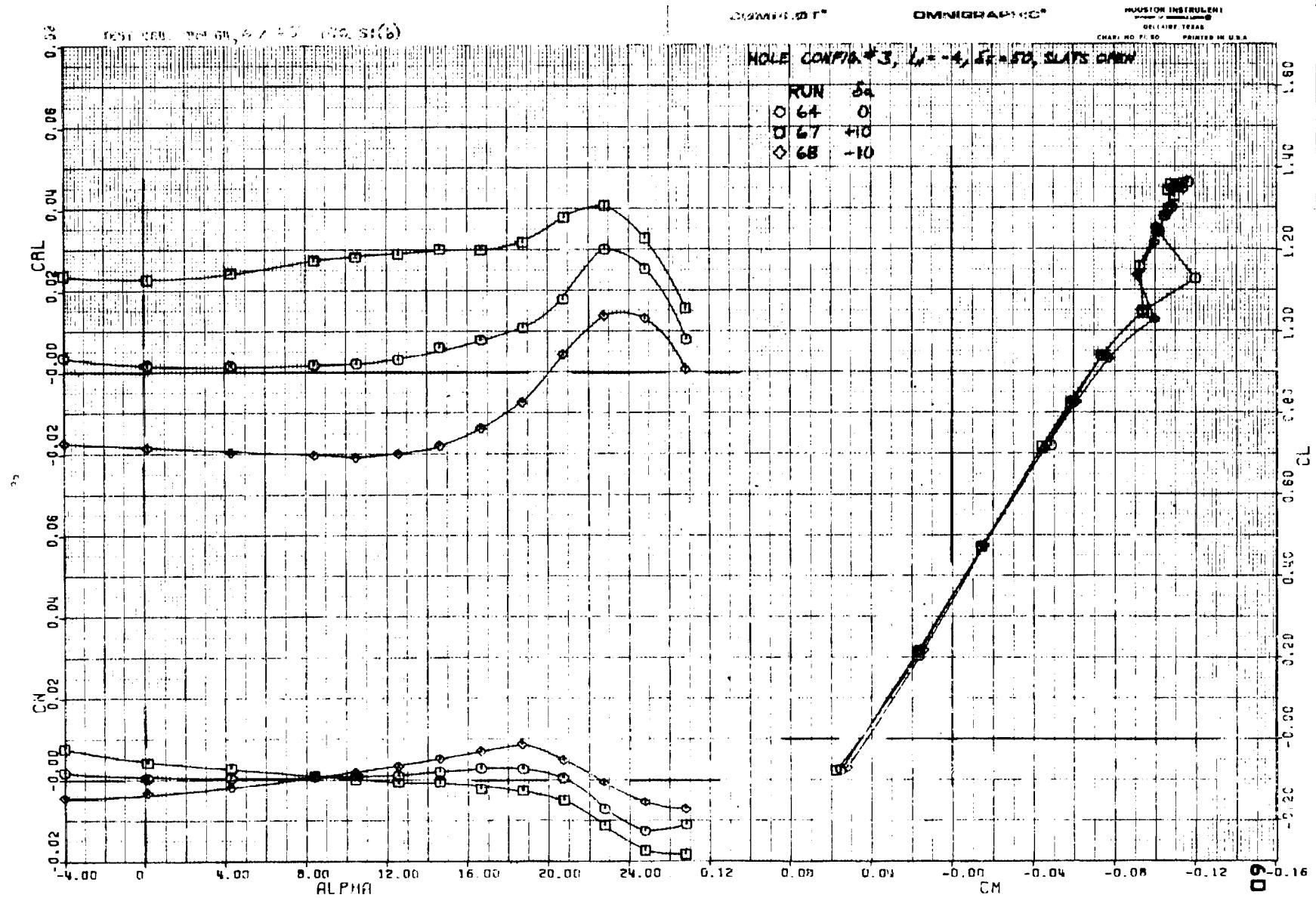


Figure 51(b)

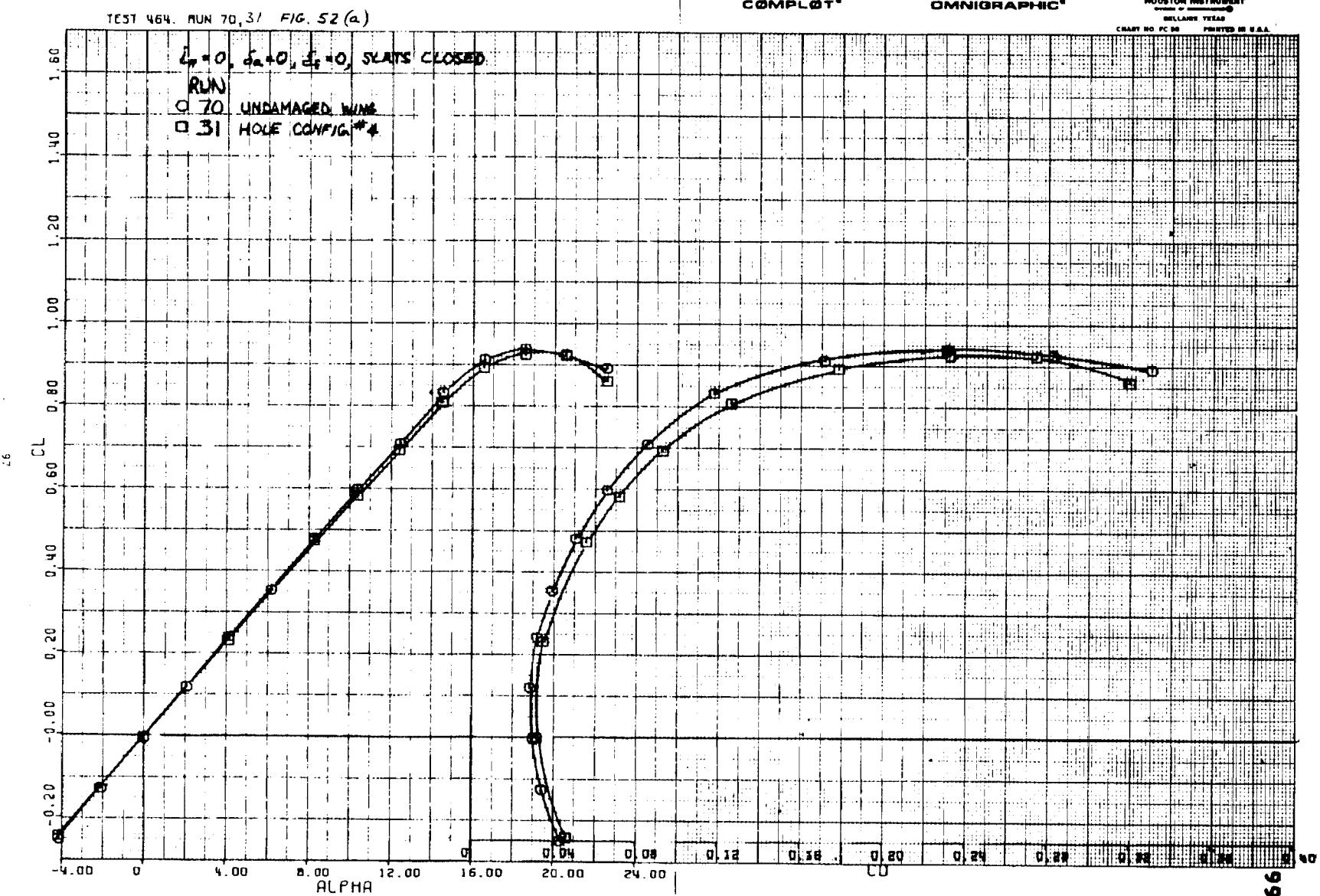


Figure 52(a)

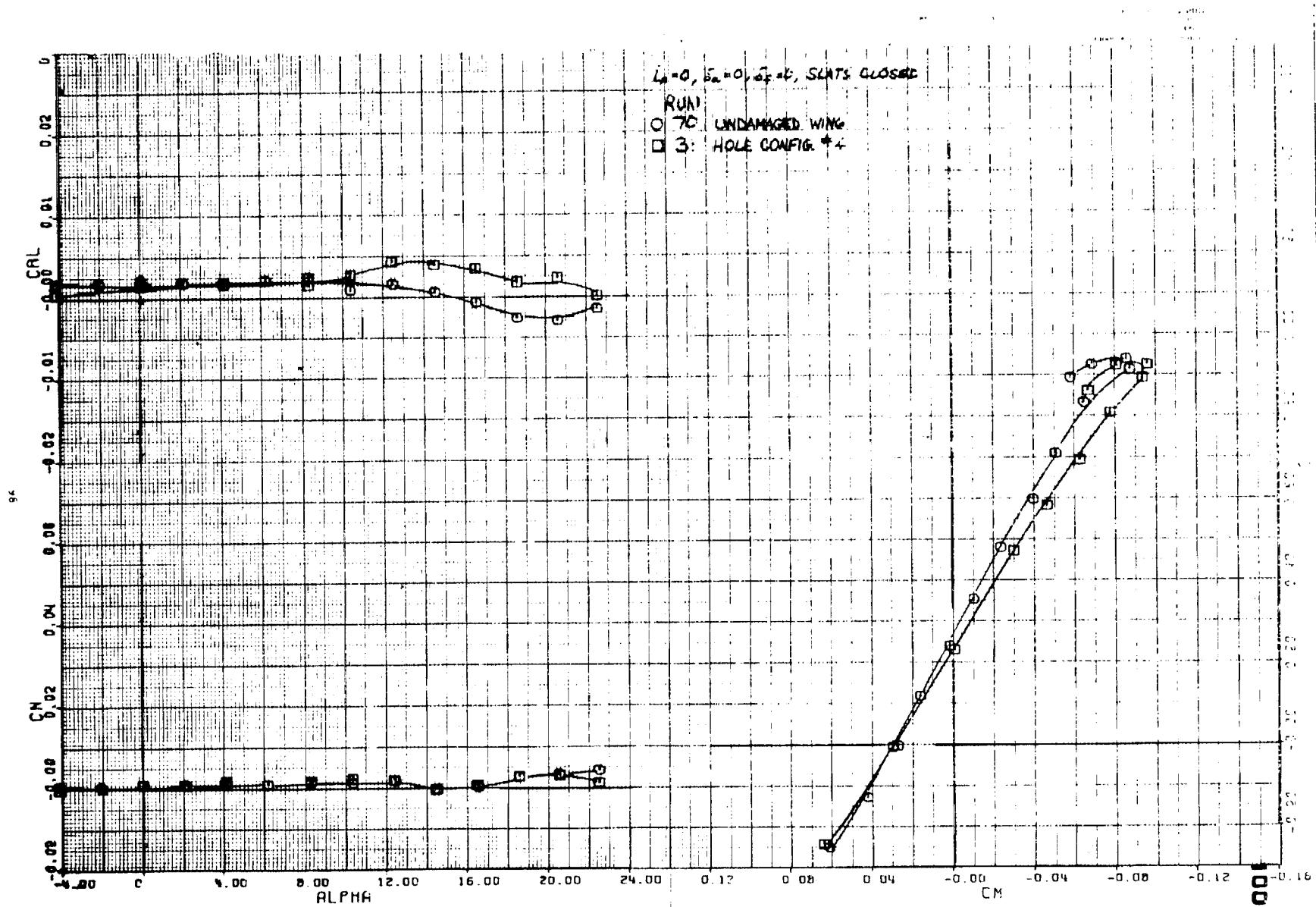


Figure 52(b)

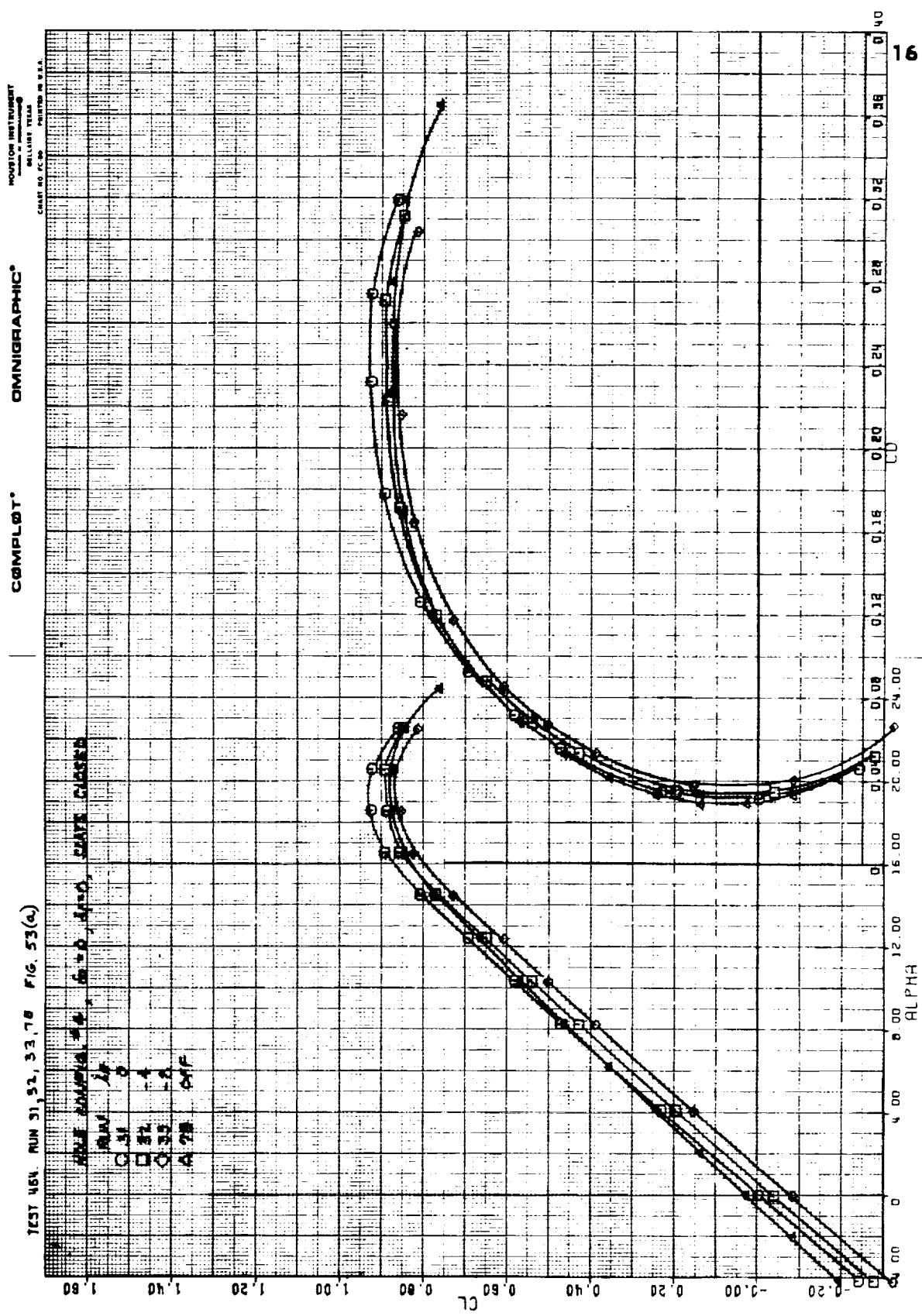


Figure 53(a)

5. 1951 May 1000-1010 hrs. 1000 ft. S.E. of 53(6)

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• 187 •

HOUSTON INSTRUMENT

SEARCHED INDEXED SERIALIZED FILED

400E COUPING - 8-0-80-30. SEATS CLOSED

1

TEST 46N. RUN 31, 34, 35 FIG. 54(a)

WIND DIRECTION, DEGREES FROM NORTH

RUNS

31

34

35

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MUNISON INSTRUMENTS

BELLEVUE

WA 98005

101

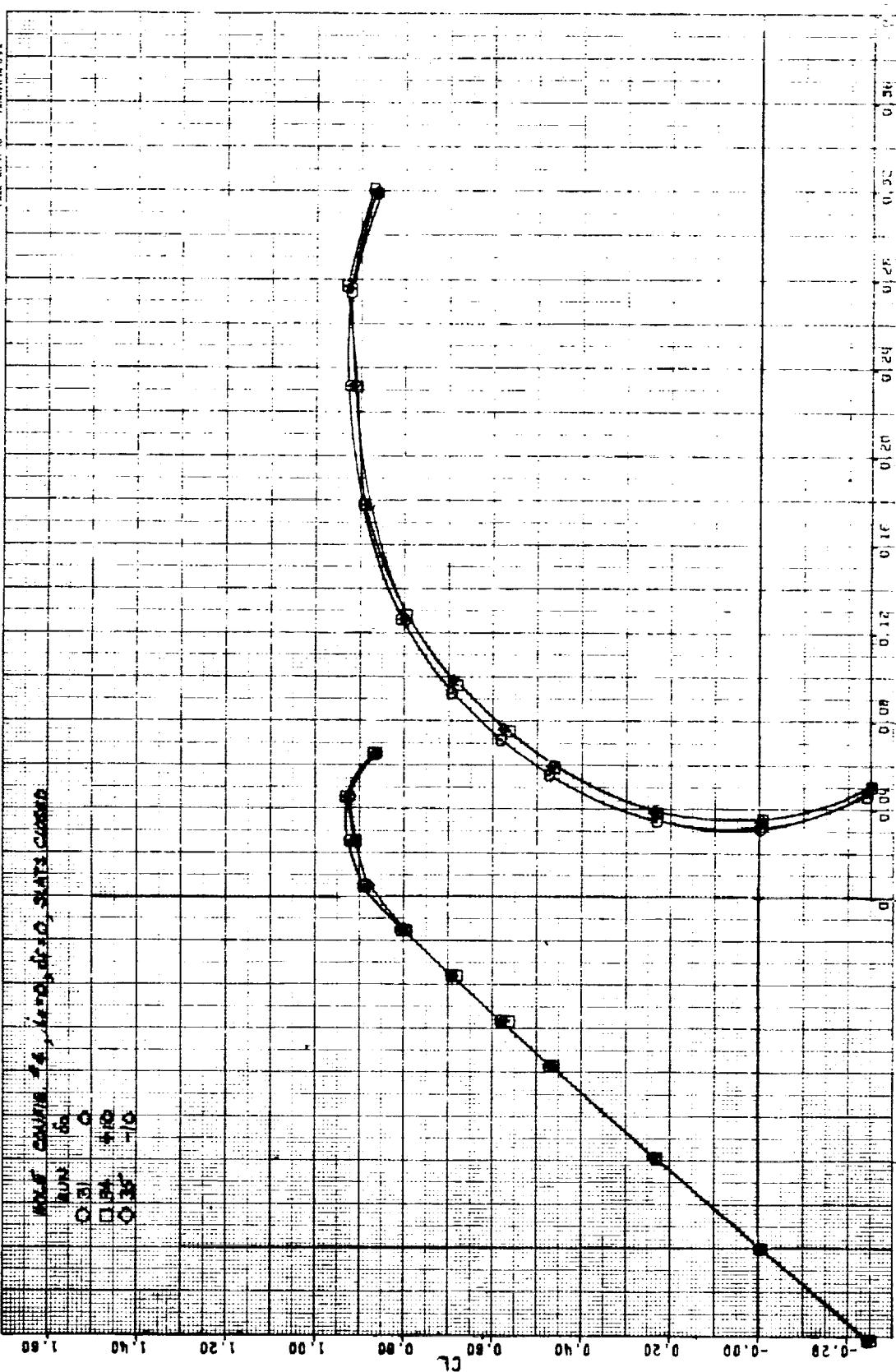




Figure 54(b)

TEST 464, RUN 70, 34 FIG. 55(a)

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HOUSTON INSTRUMENT
BELLAME TEXAS
CHART NO. FC 50 PRINTED IN U.S.A.

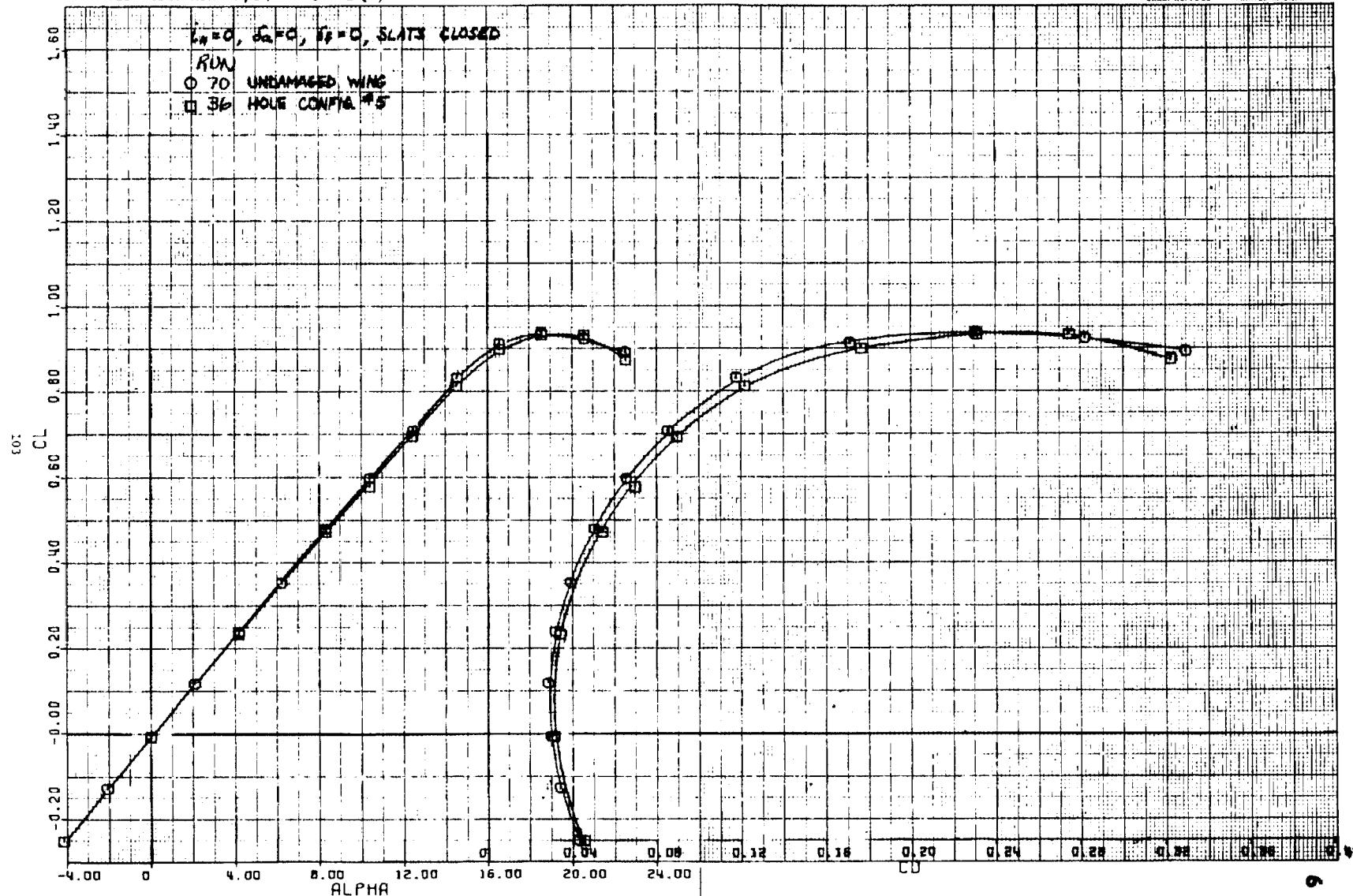


Figure 55(a)

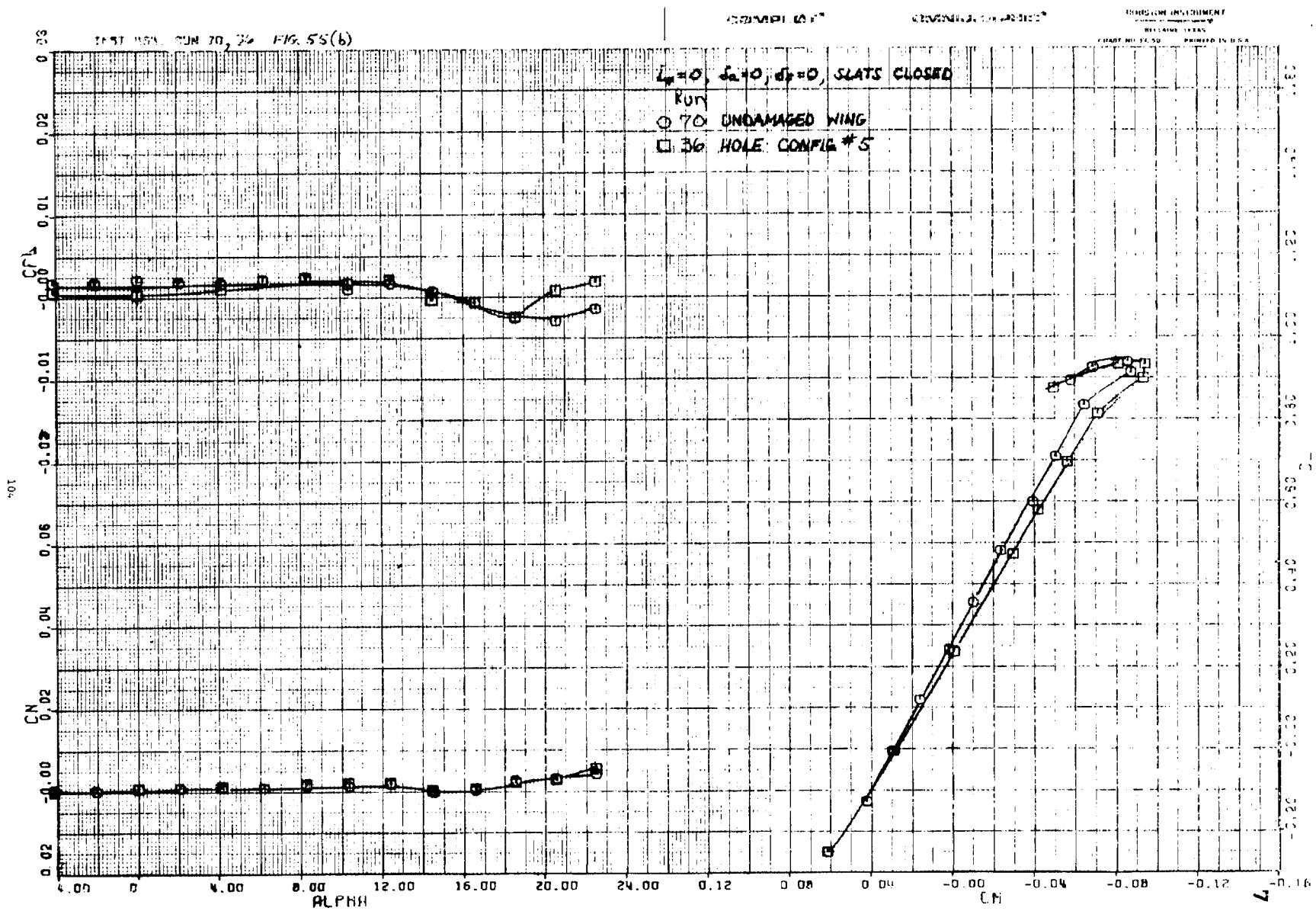


Figure 55(b)

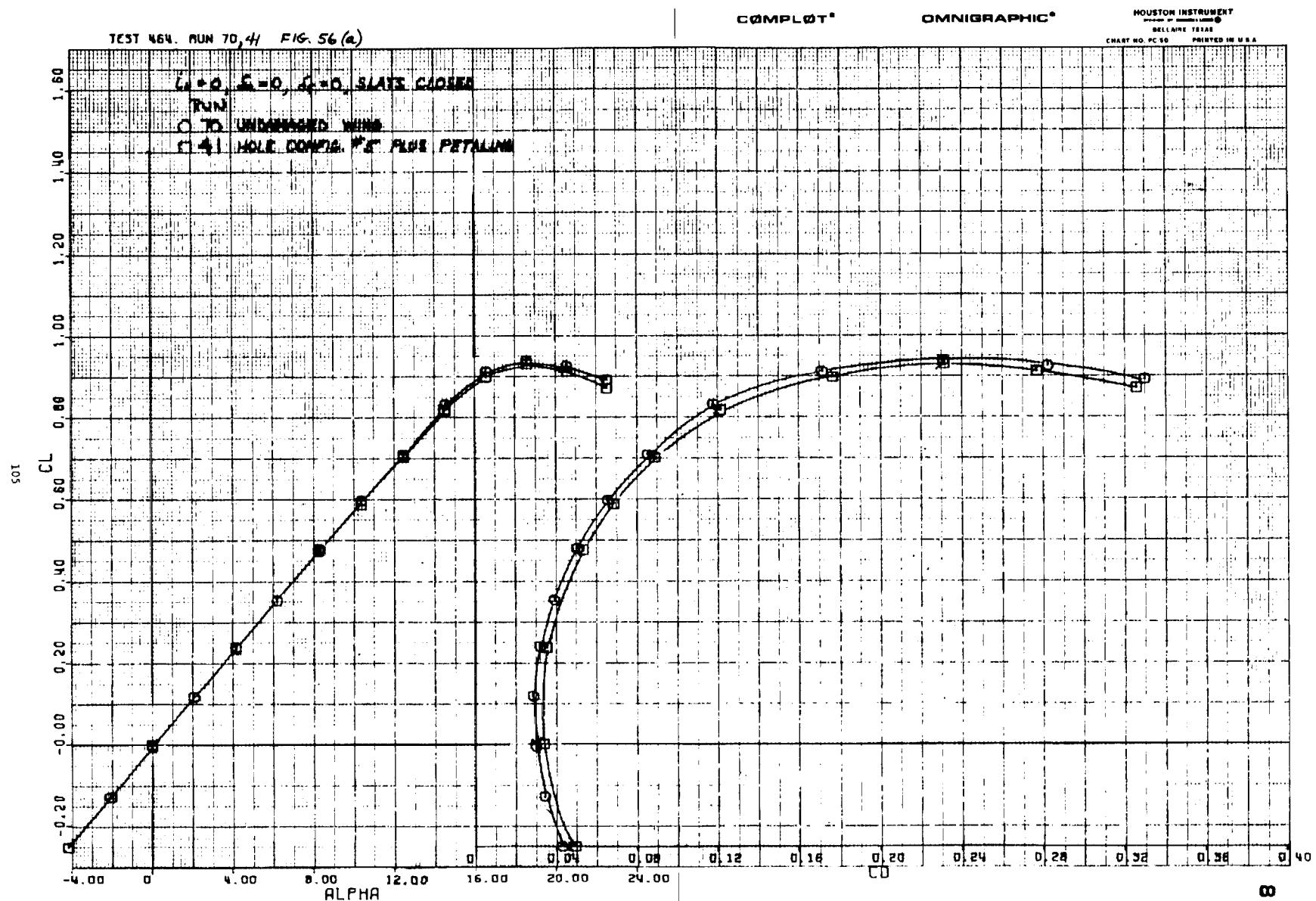
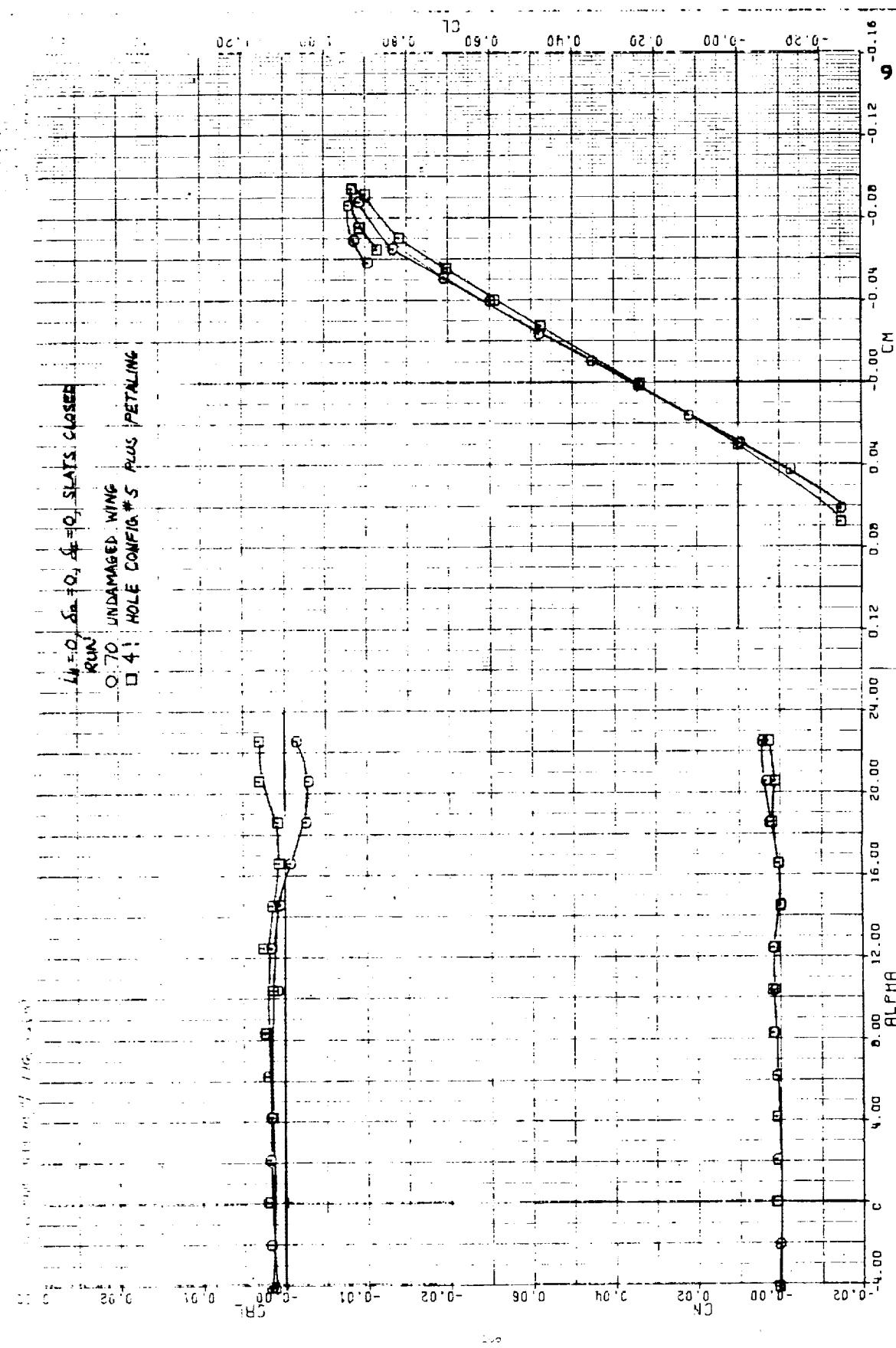


Figure 56(a)

Figure 56(b)



TEST 464, RUN 36, 37, 38 FIG. 57(a)

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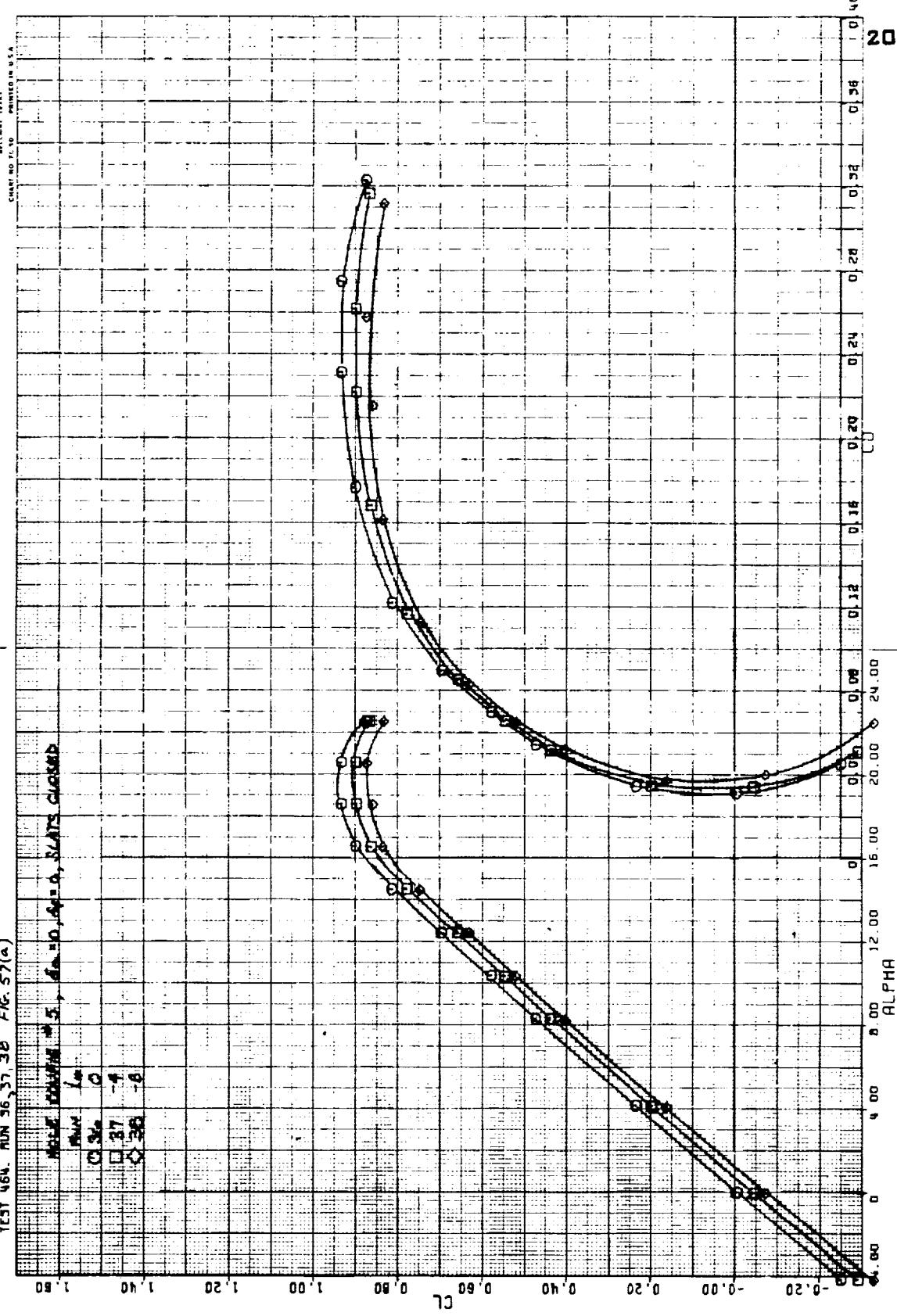


Figure 57(a)

TEST 1060 RUN 36 27.36 FIG. 57(6)

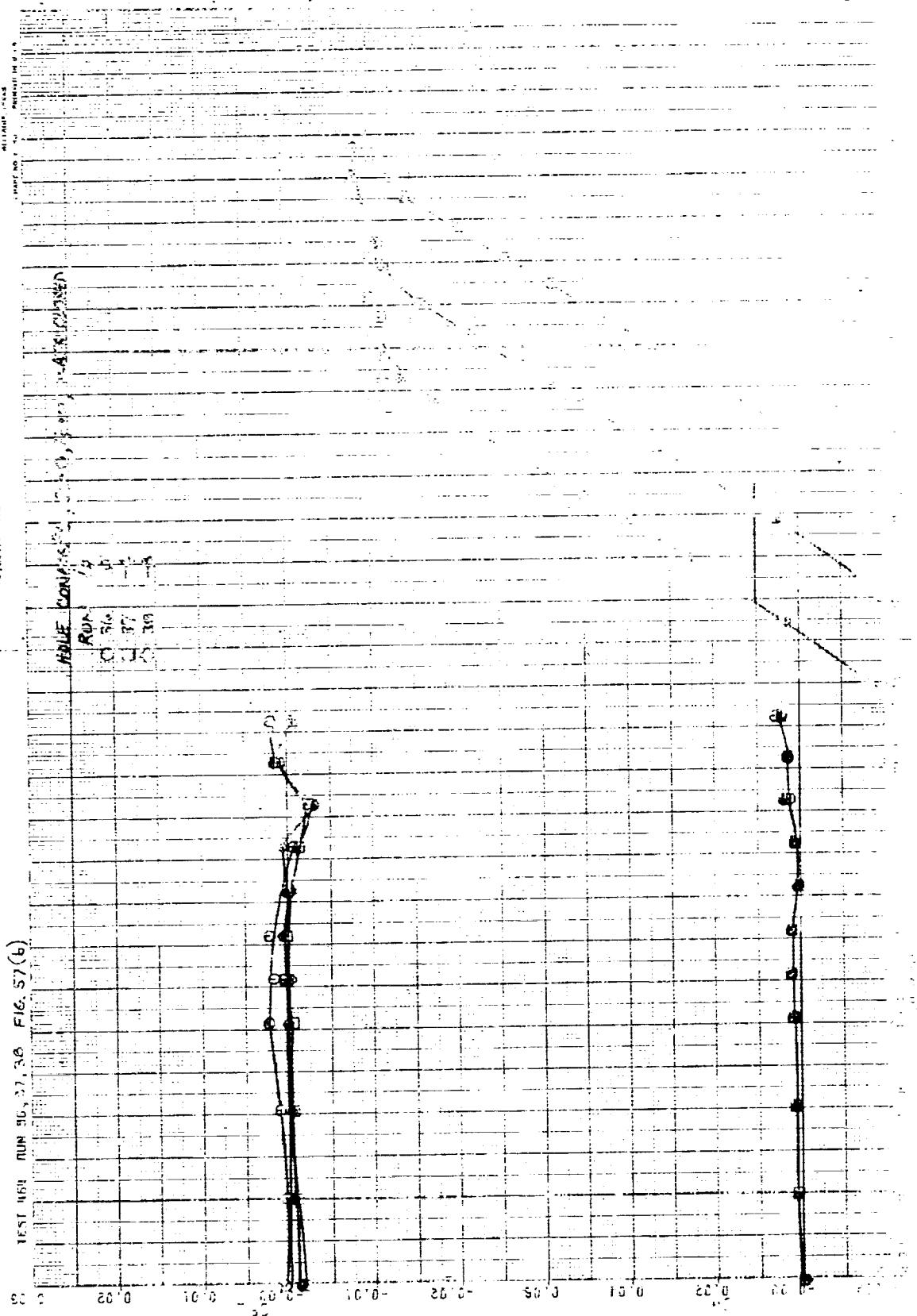
INSTITUTE INSTRUMENTS

DATA ACQUISITION

DYNAMIC LOAD TEST

CHAMBER 10°C

HOLE CONVENTIONAL
RUN C 36 m



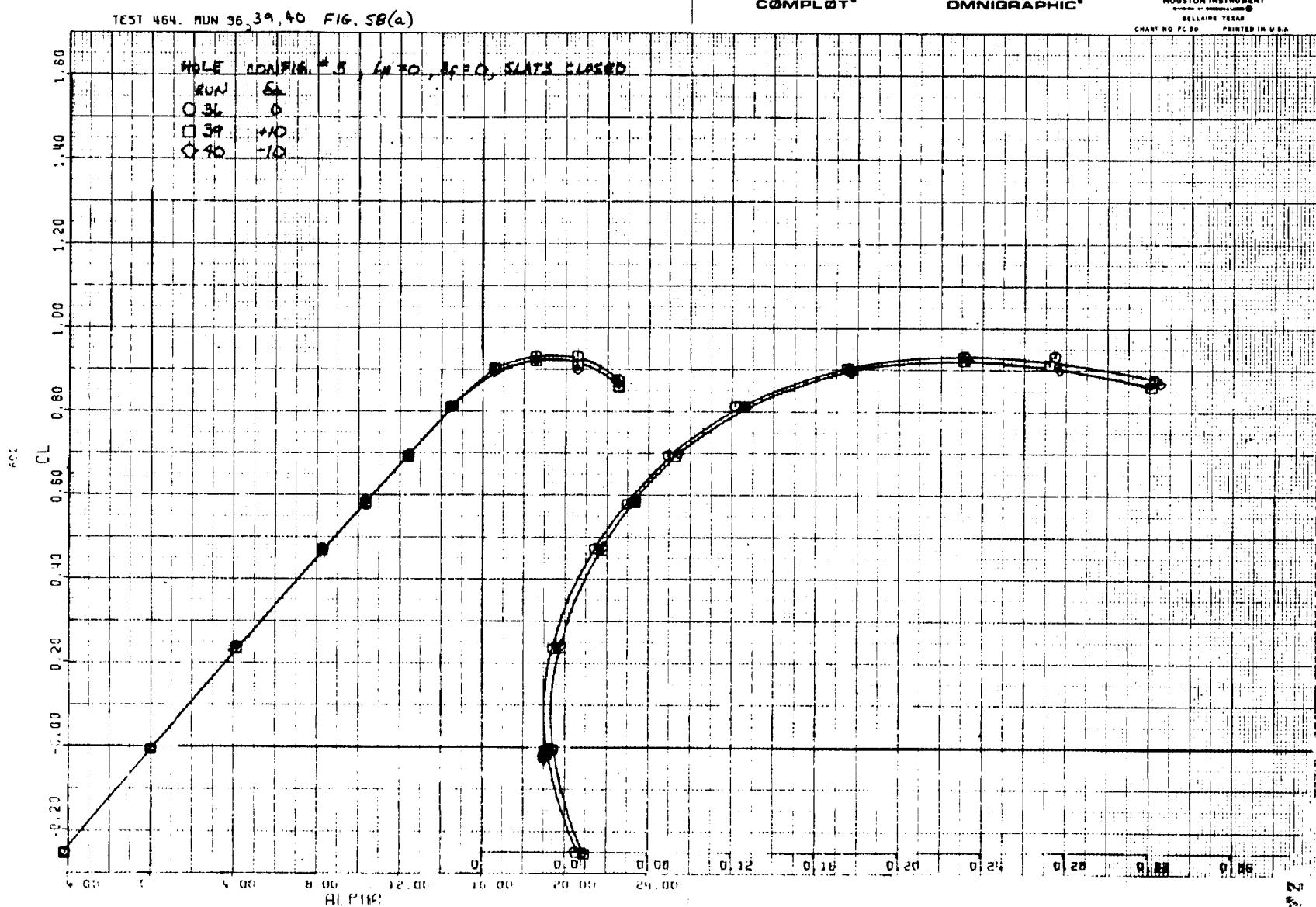


Figure 58(a)

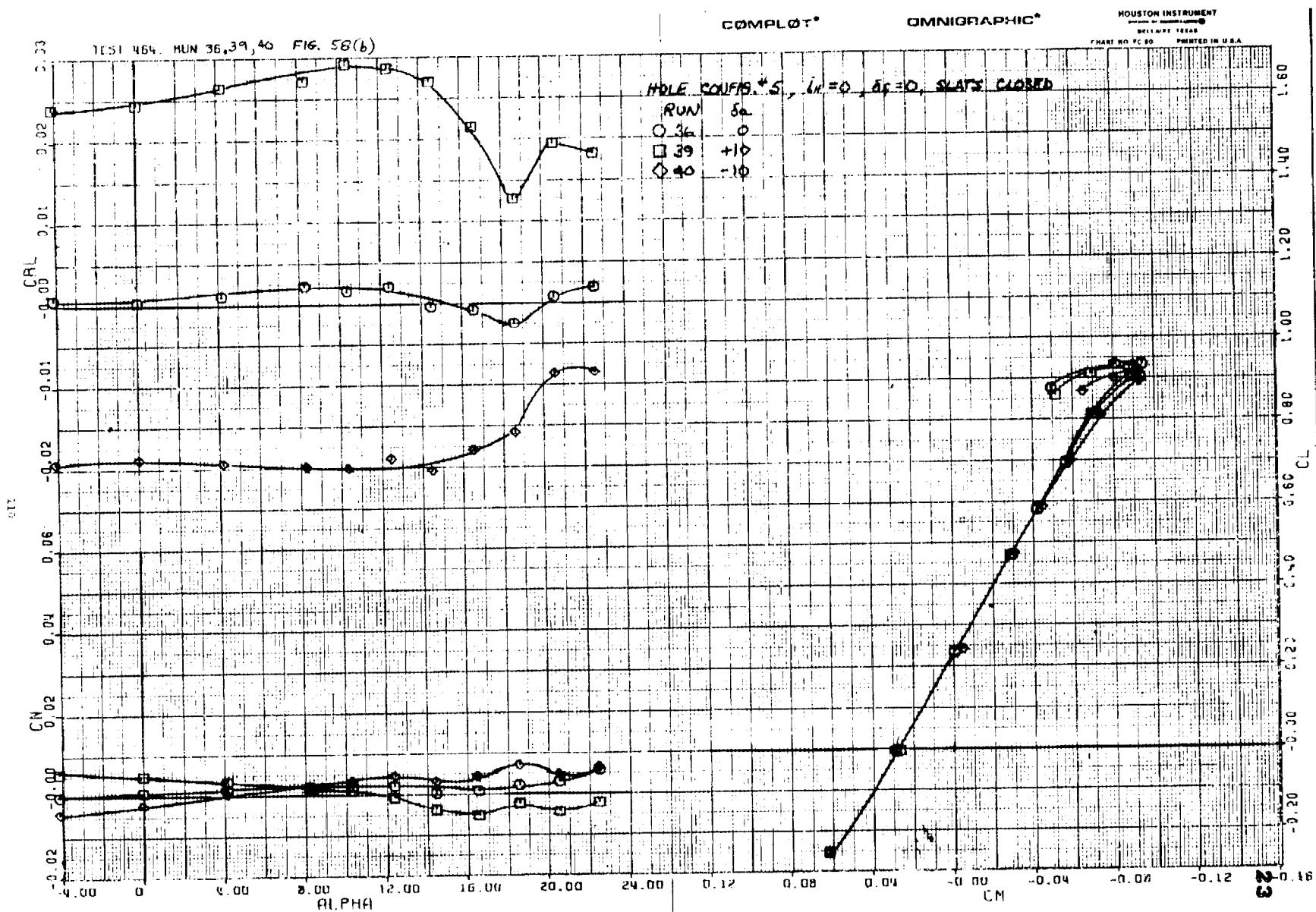


Figure 58(b)

TEST 46B, RUN 41,42,43,80 FIG. 59(a)

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HOUSTON INSTRUMENT
DELLRIVE TEXAS
CHART NO PC 80 PRINTED IN U.S.A.

BALL CONFINING 5 AIR METALINE, SLATS CLOSED

RUN 41 0 $\delta_x = 0, \delta_y = 0$

□ 42 -4

○ 43 -8

△ 80 OFF

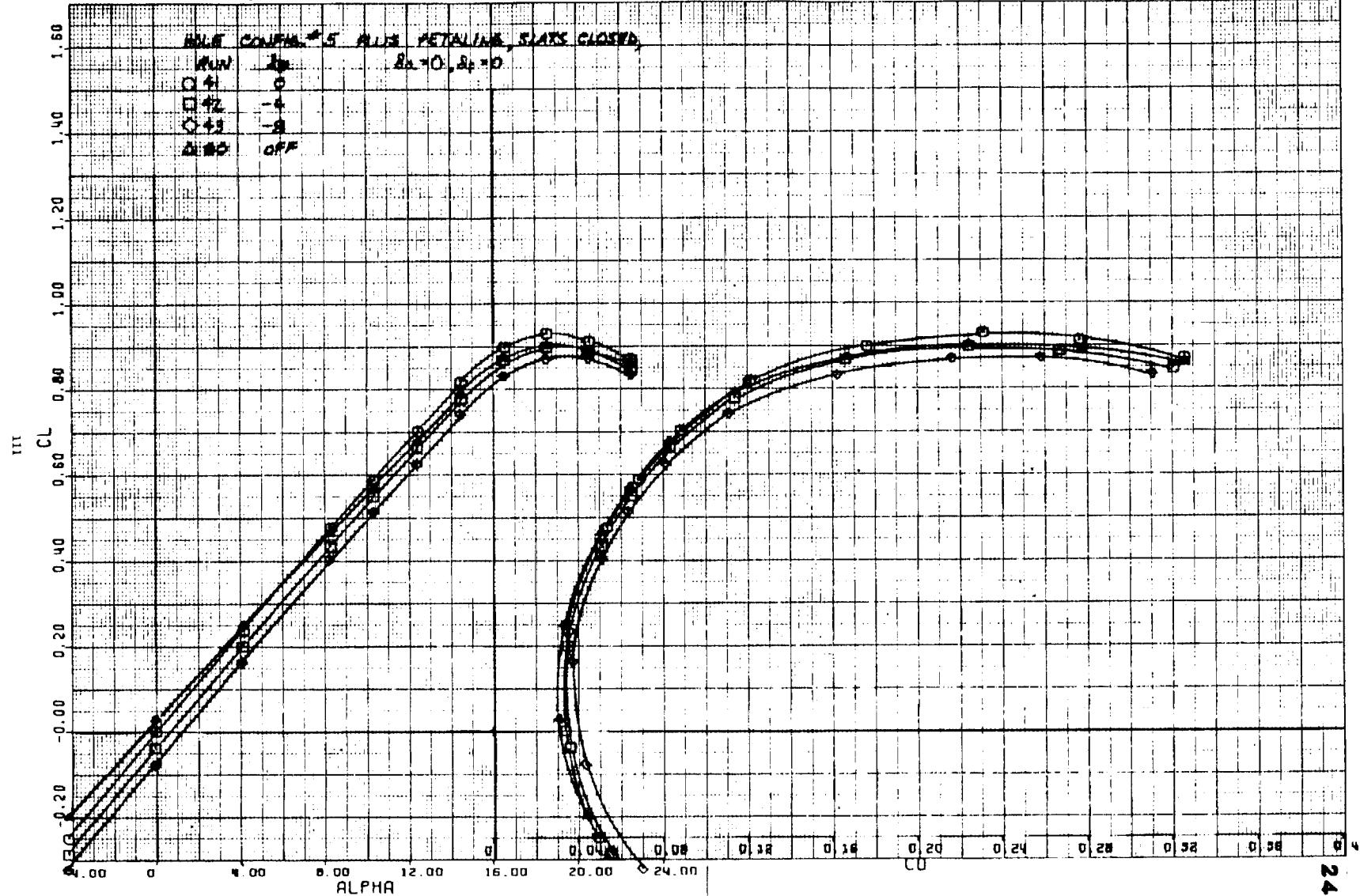
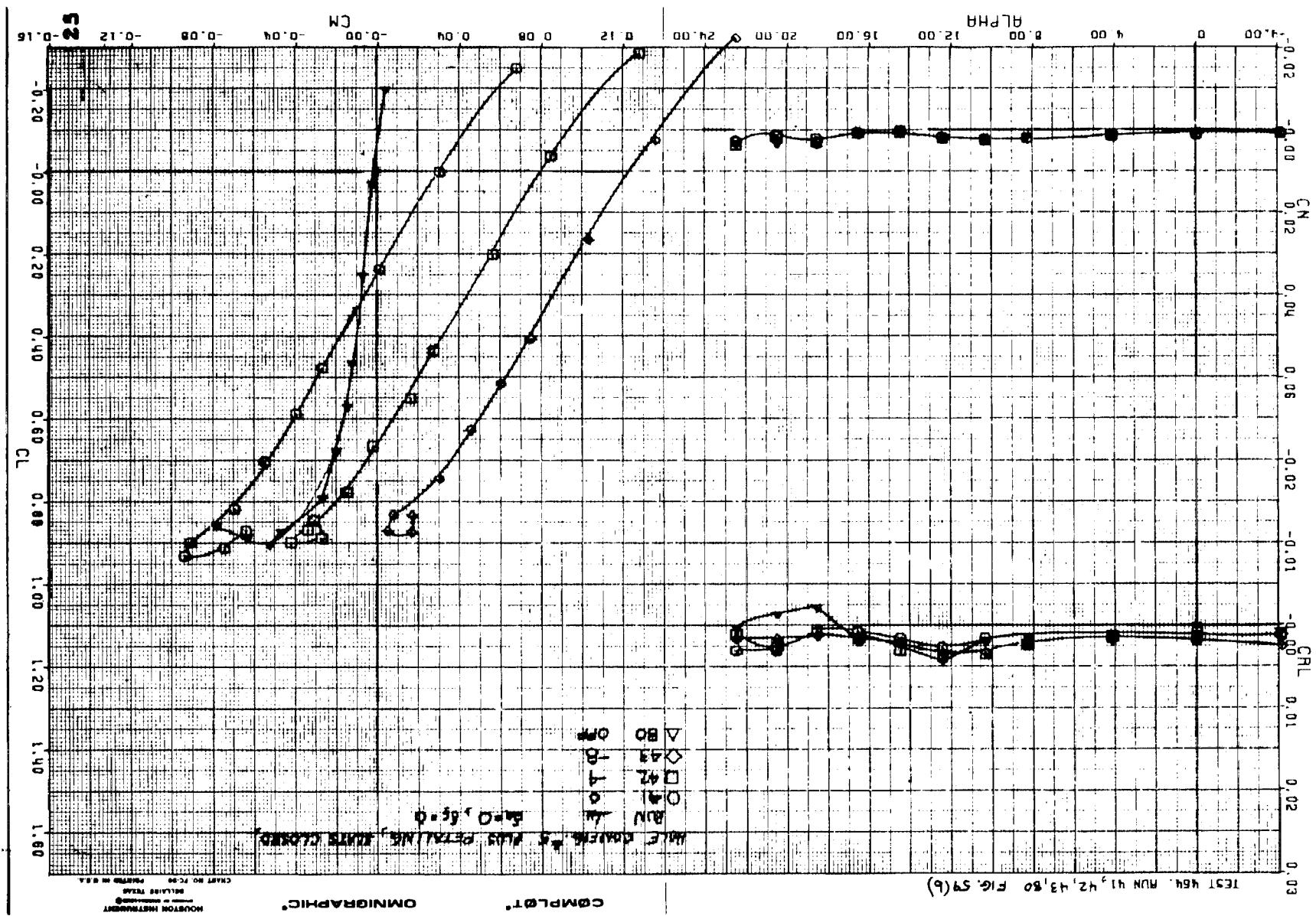


Figure 59(a)

Figure 59(b)



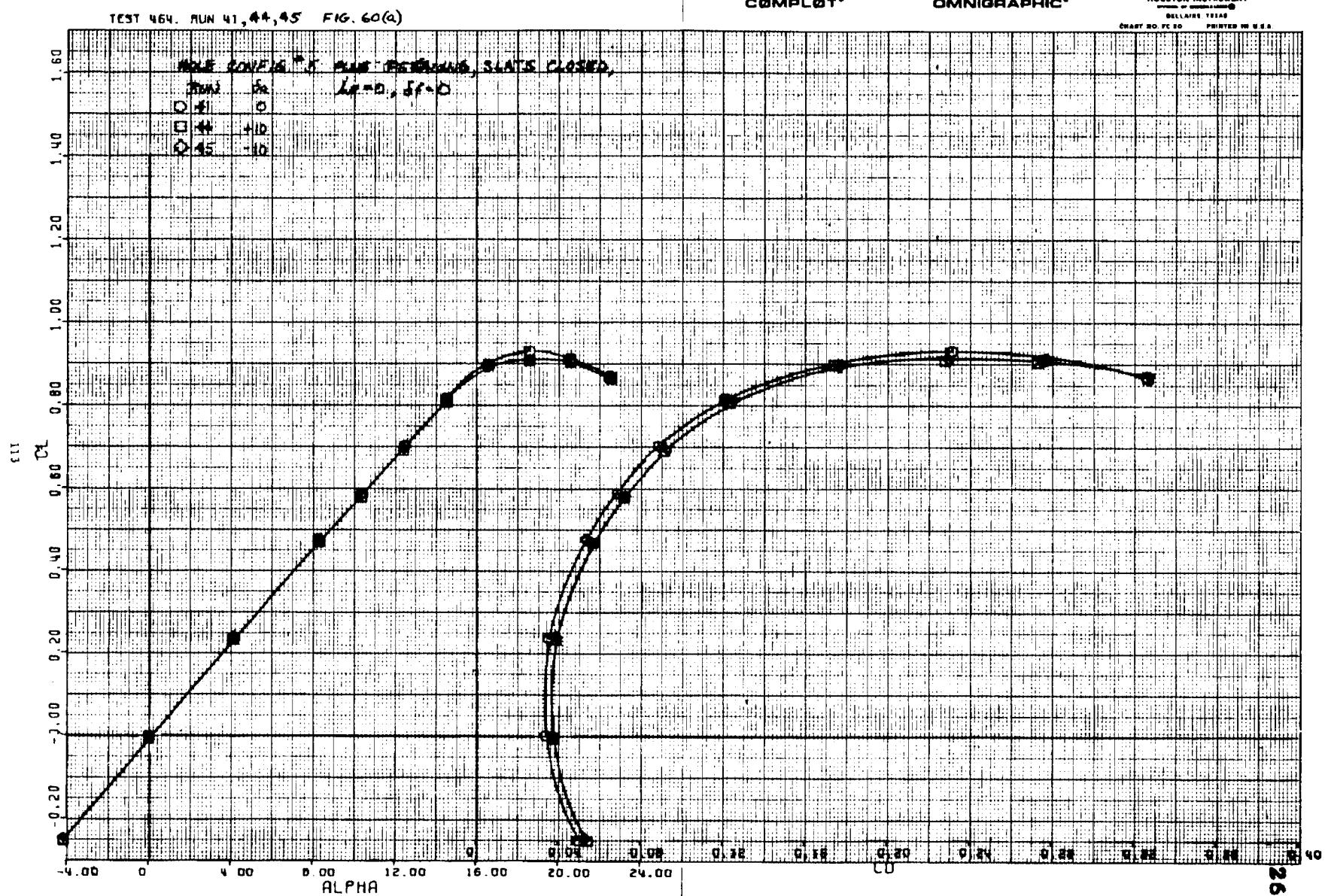


Figure 60(a)

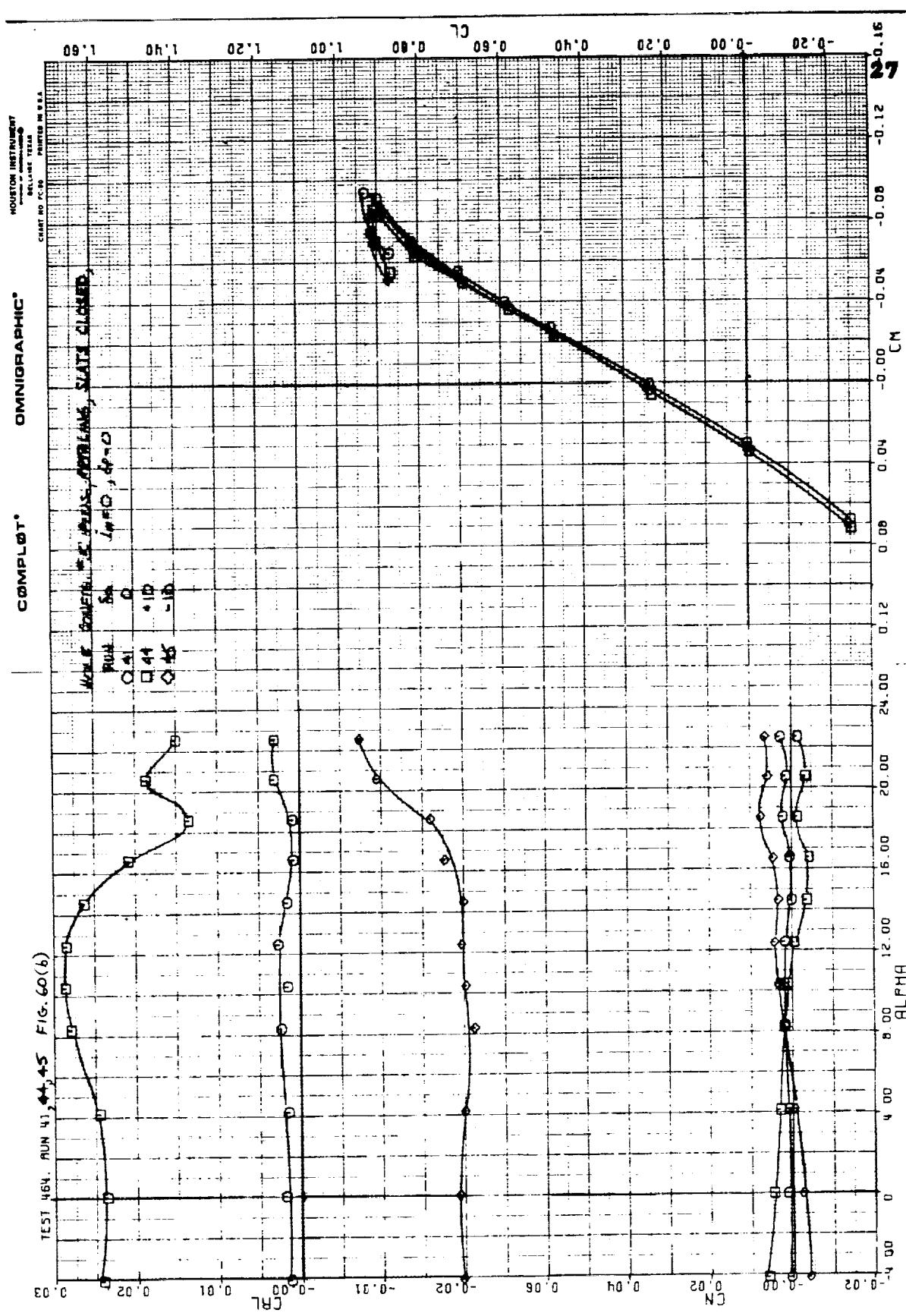


Figure 60(b)

TEST 464, RUN 7D, FIG. 61(a)

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BE LAURE TEXAS

CHART NO. FC 30 PRINTED IN U.S.A.

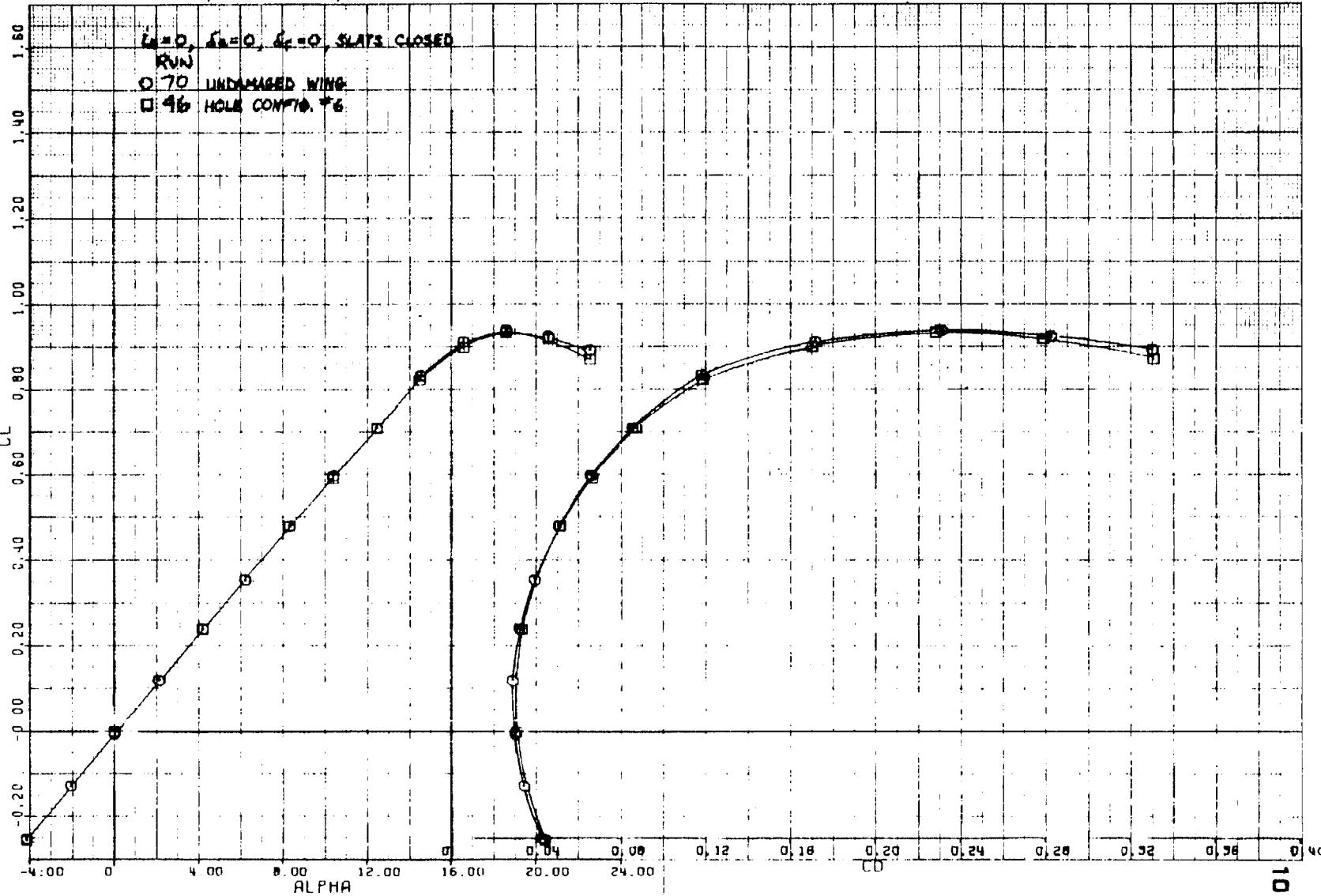


Figure 61(a)

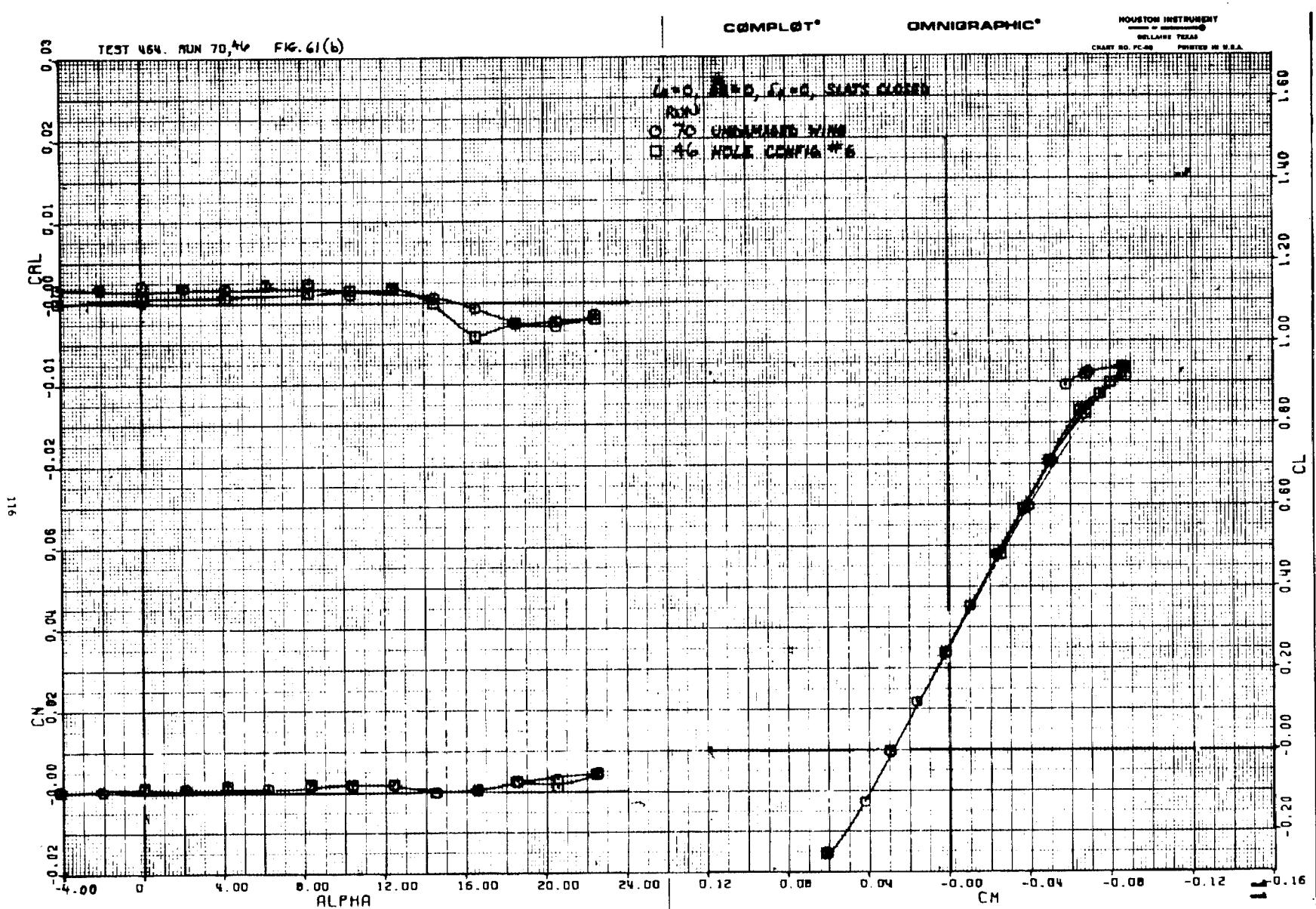


Figure 61(b)

1631 46N. RUN 46.41.44.81

FIG. 62(a)

COMPLAT

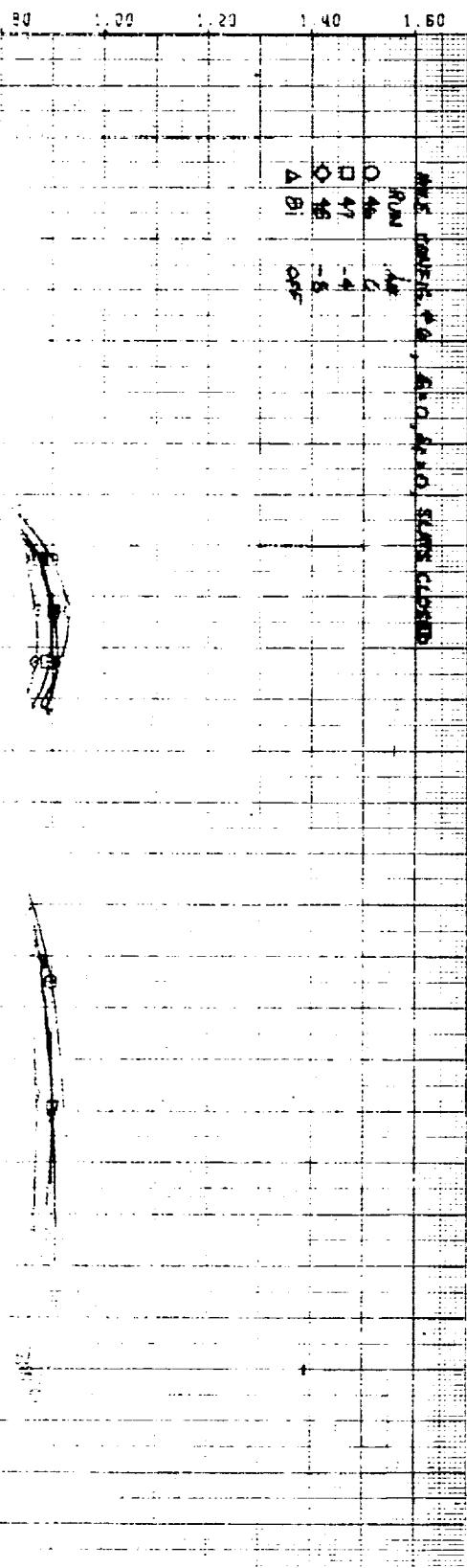
OMNIGRAPHIC

HOUSETON INSTRUMENTS

Chart No. 62

Rev. 1/10

Printed 1/10



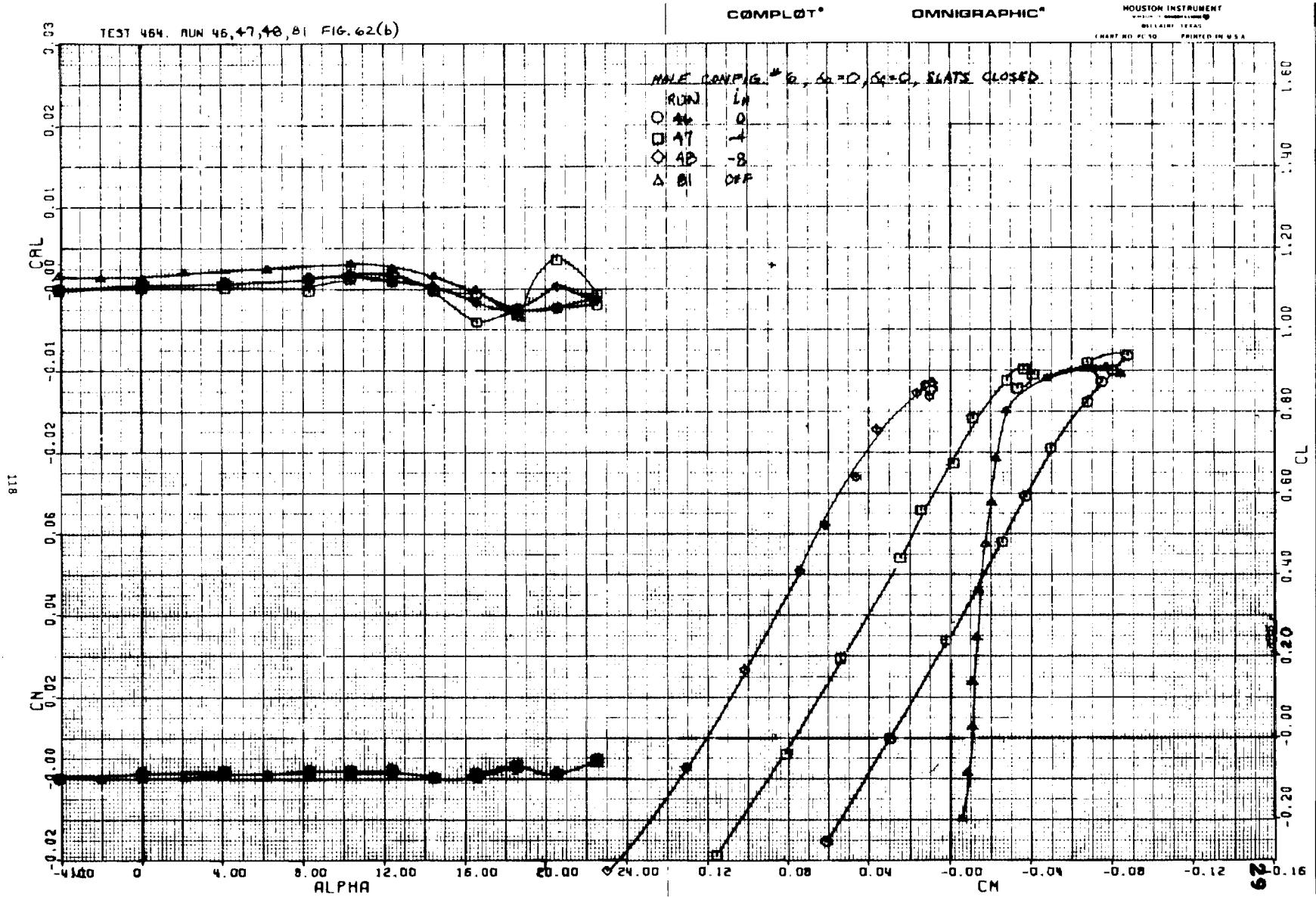


Figure 62(b)

TEST 464, RUN 46,49,50 FIG. 63(a)

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HOUSTON INSTRUMENT
MADE BY AMERICAN LOGIC®
BELLAIR TEXAS
CHART NO FC 50 PRINTED IN U.S.A.

NOTE CONFIG. #6, $L_e=0$, $\delta_r=0$, SLATS CLOSED

RUN 50
○ 46 0
□ 49 +10
◇ 50 -10

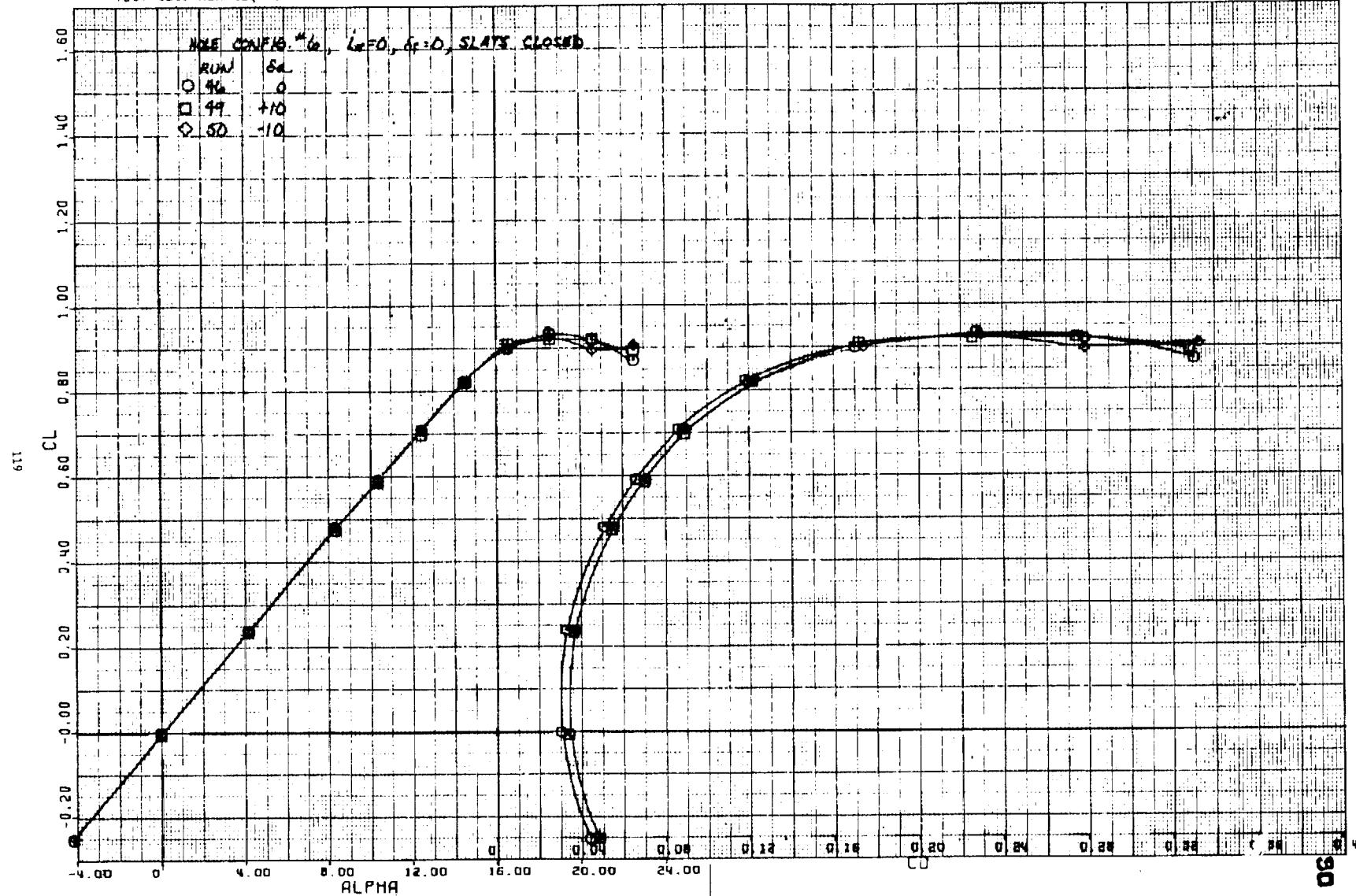


Figure 63(a)

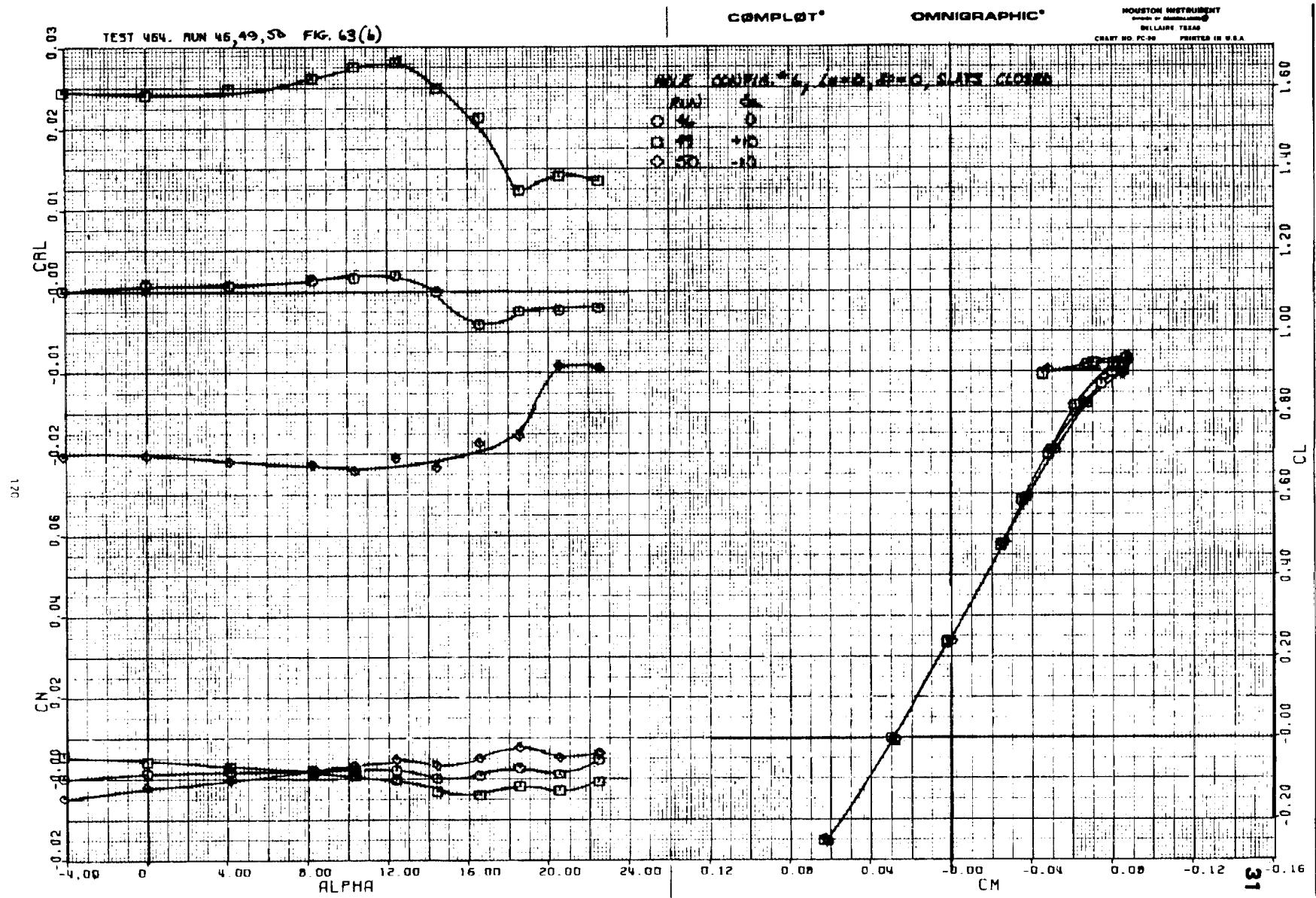


Figure 63(b)

TEST 464, RUN 70, 123 FIG. 64(a)

WIND, $\delta_a = 0$, $\delta_r = 0$, SLATS CLOSED

TRAIL

O TO UNDAMAGED WING
□ 123 HOLE CONFG. # 7

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CHART NO FC 30 PRINTED IN U.S.A.

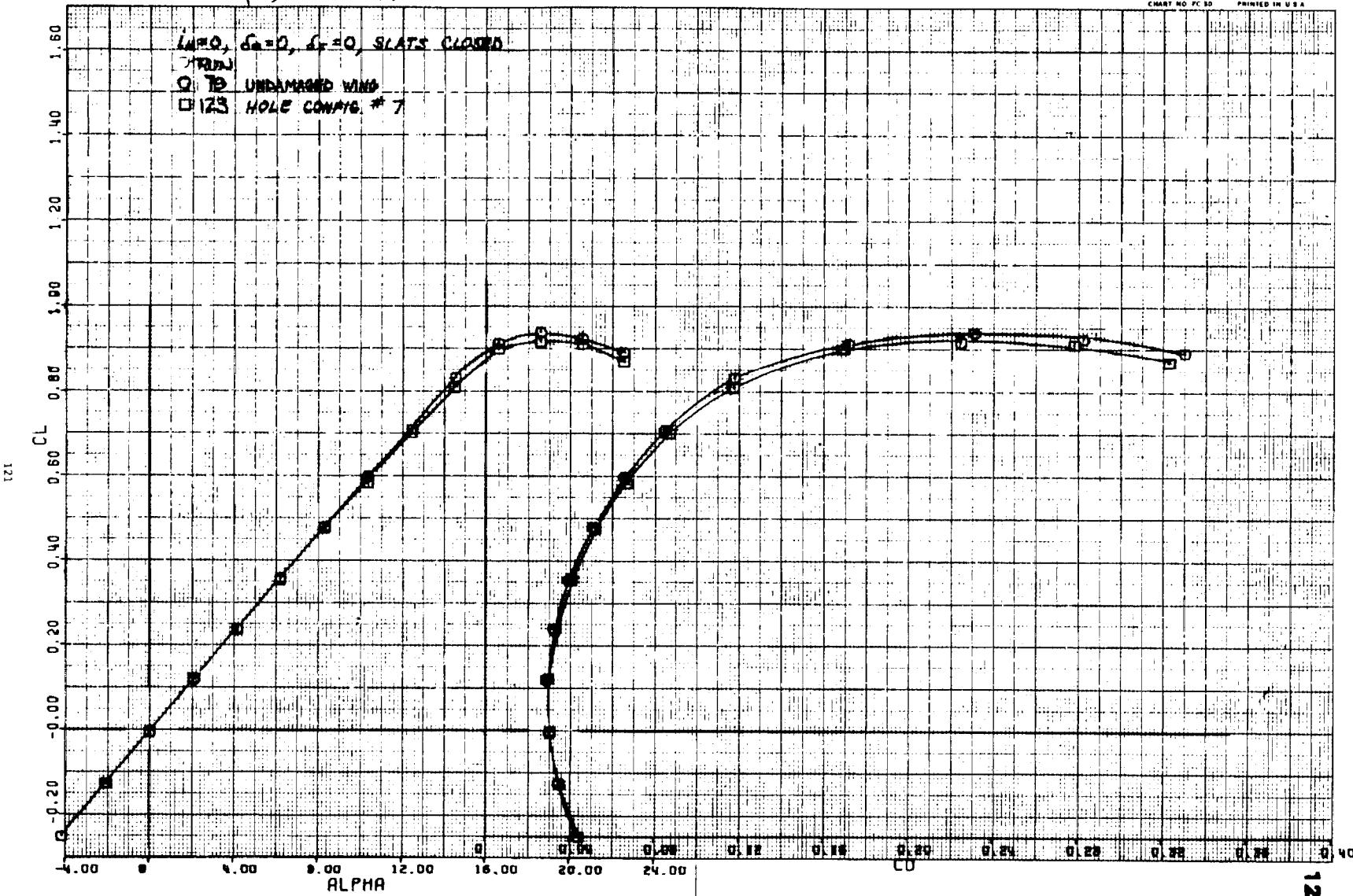


Figure 64(a)

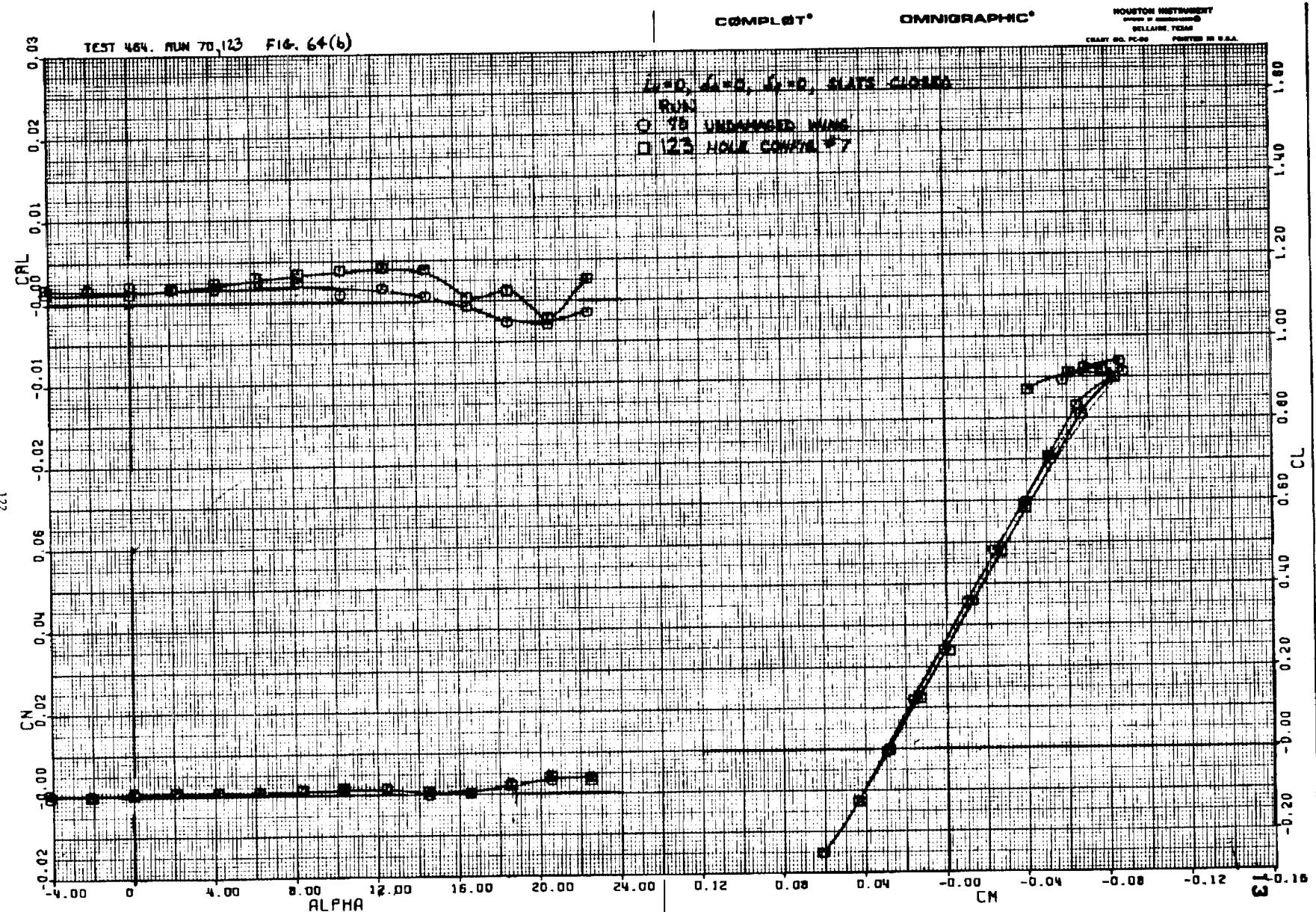


Figure 64(b)

TEST 464. RUN 123, 124, 125, 84 FIG. 65(a)

СОМПЛЕКТ*

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HOUSTON INSTRUMENT
DIVISION OF AMERICAN
BELLAIRE, TEXAS
PART NO. PC-50 PRINTED IN U.S.A.

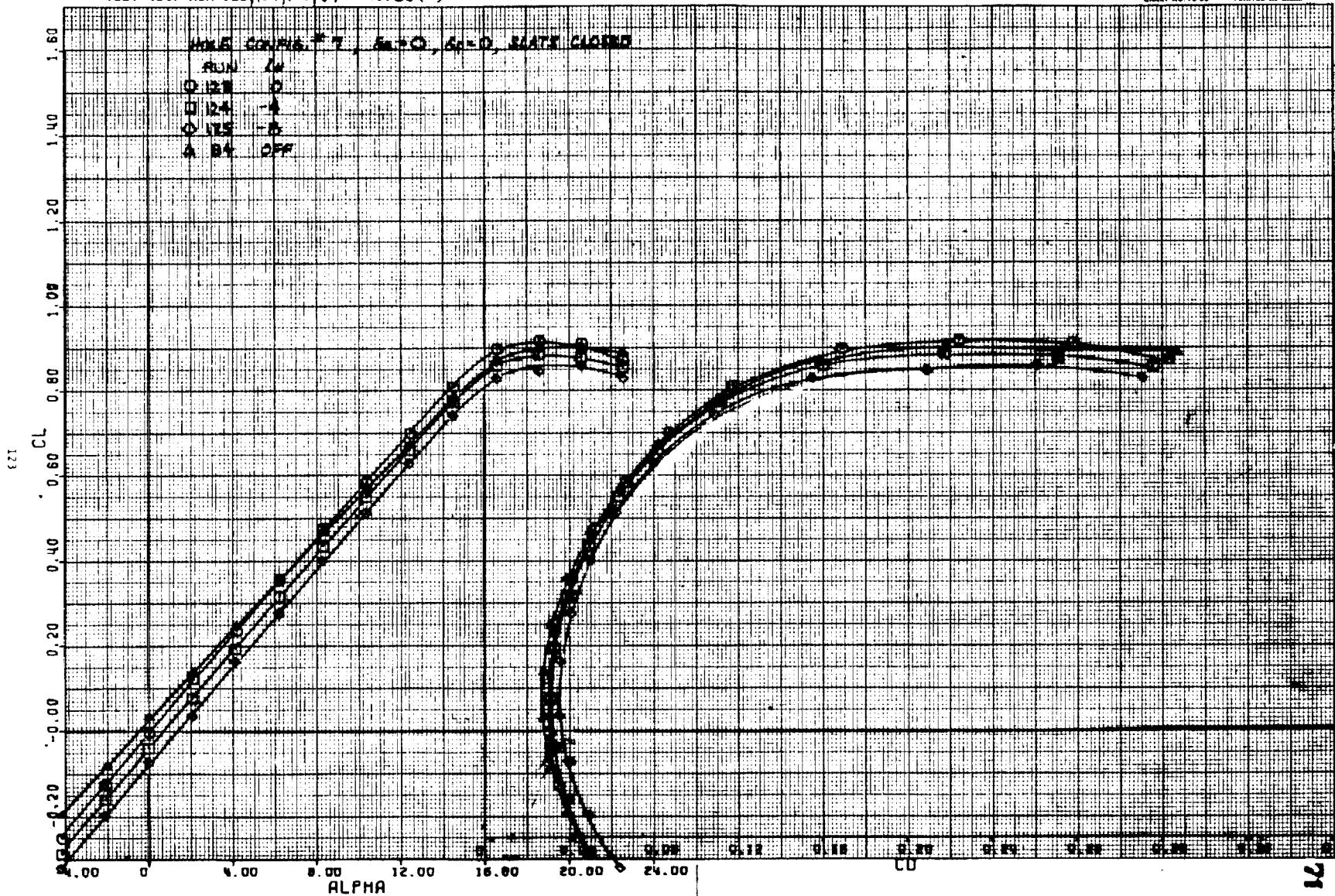


Figure 65(a)

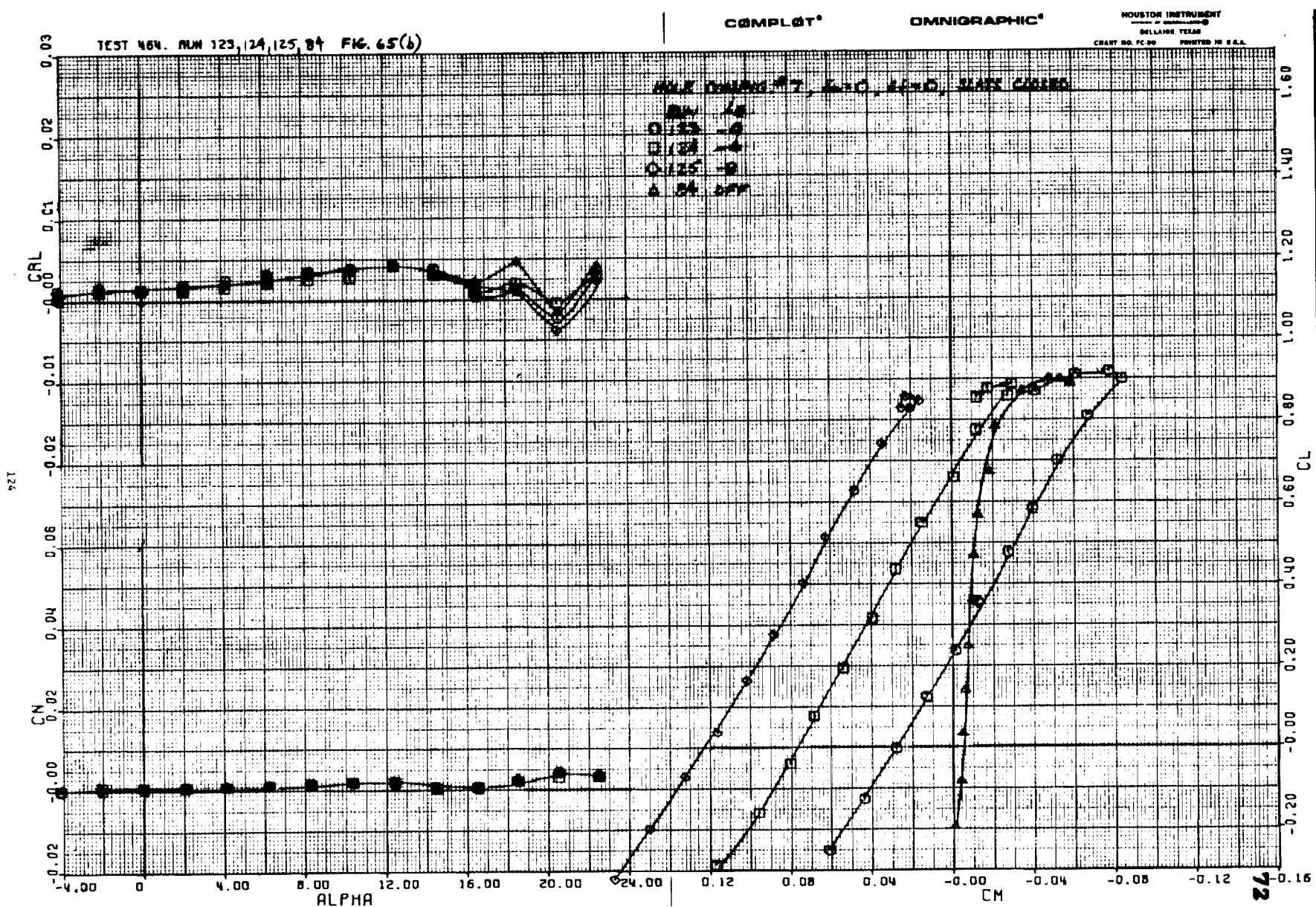


Figure 65(b)

TEST 460, RUN 123, 126(2) FIG. 6(a)

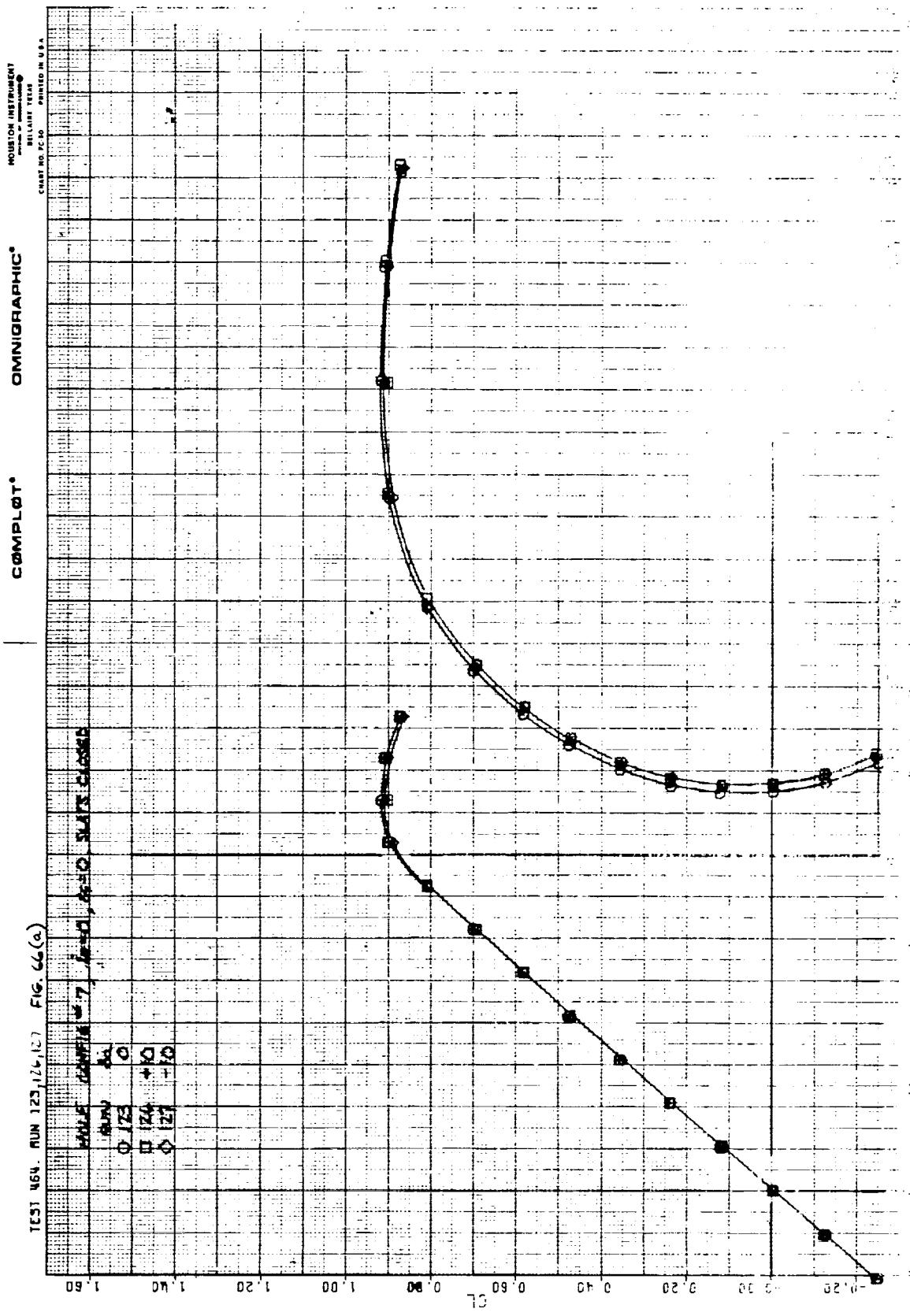
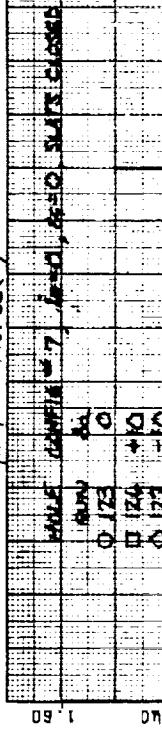
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RELIABLE TEST

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CHART NO. 100



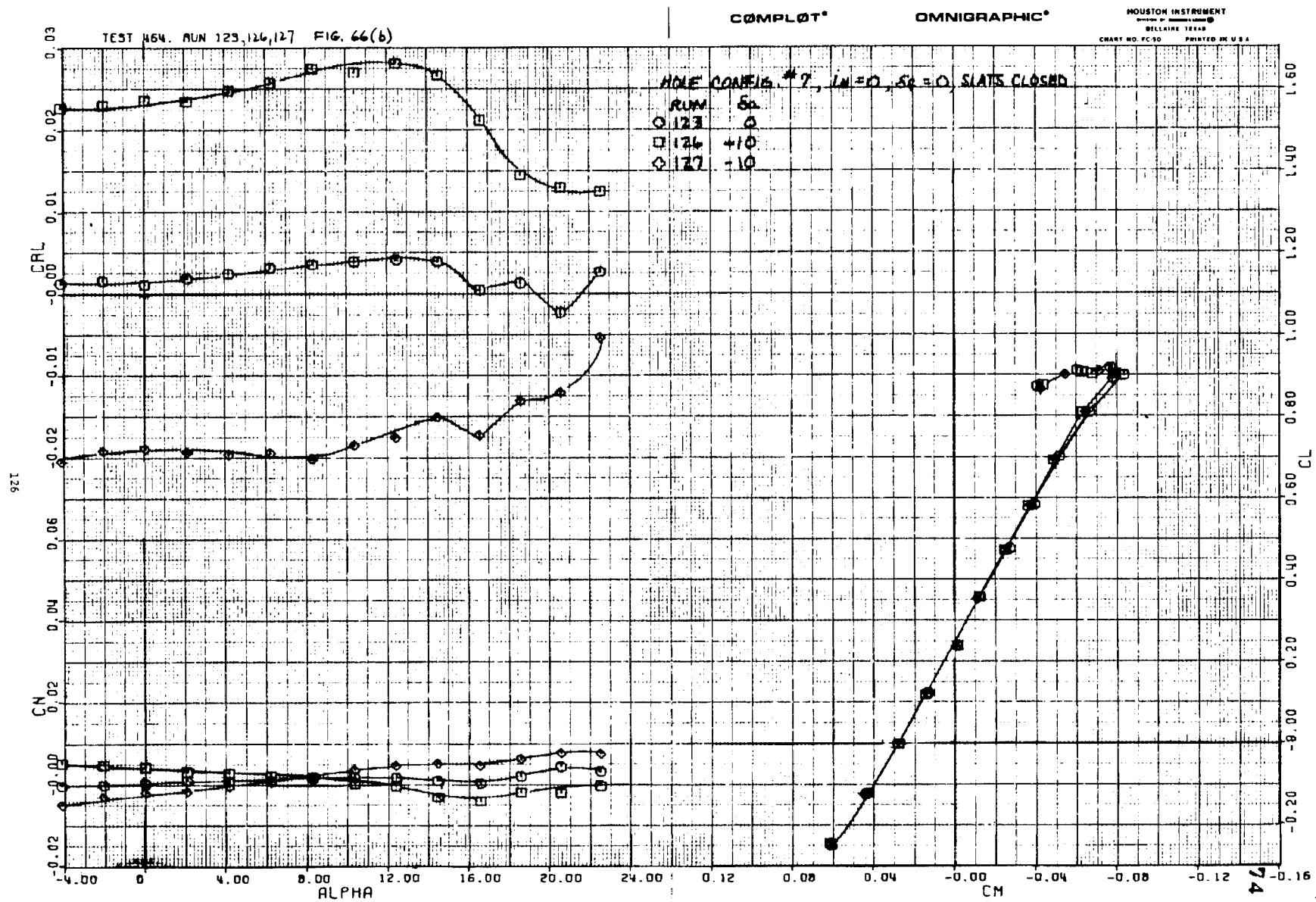
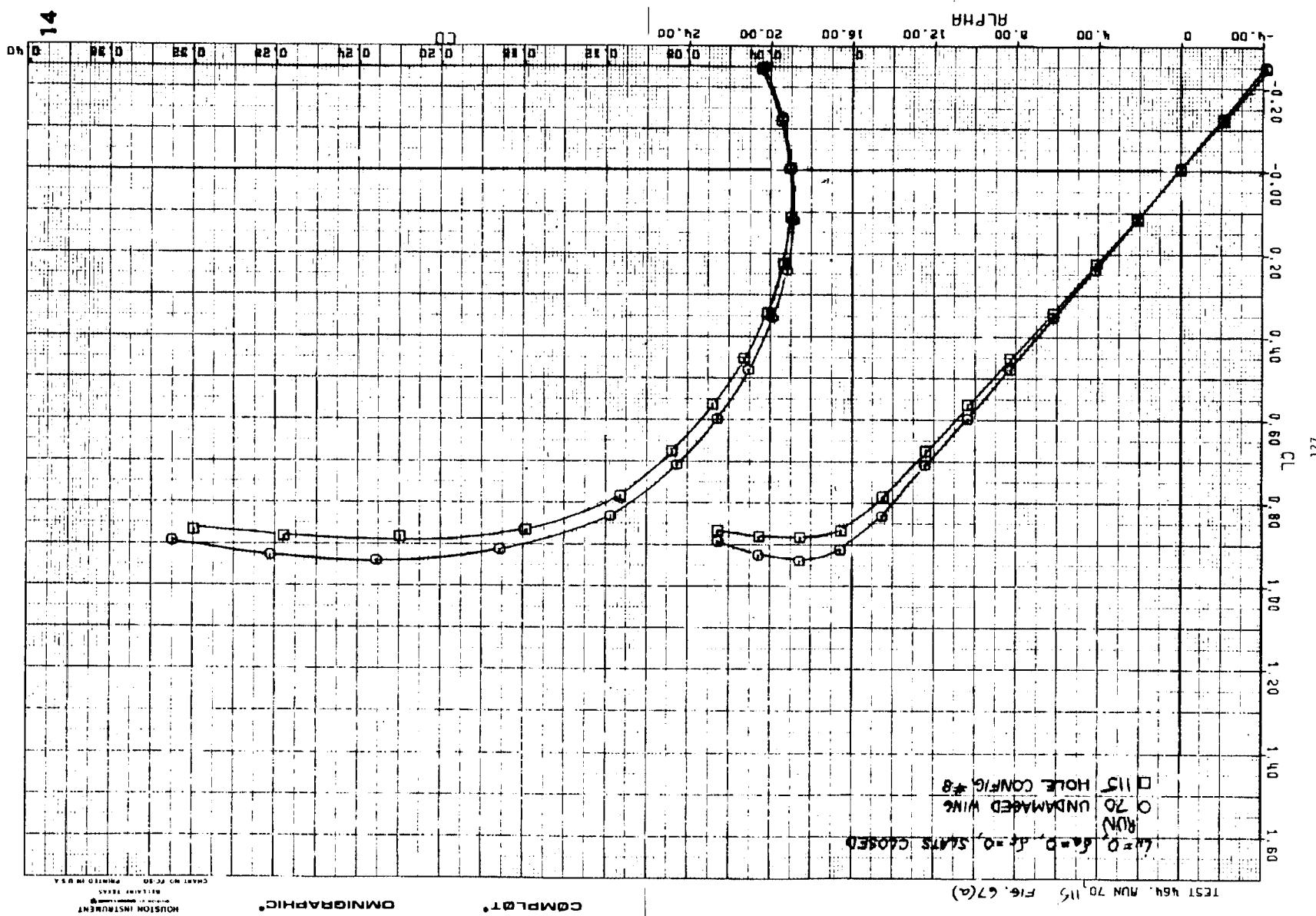


Figure 66(b)

Figure 67(a)



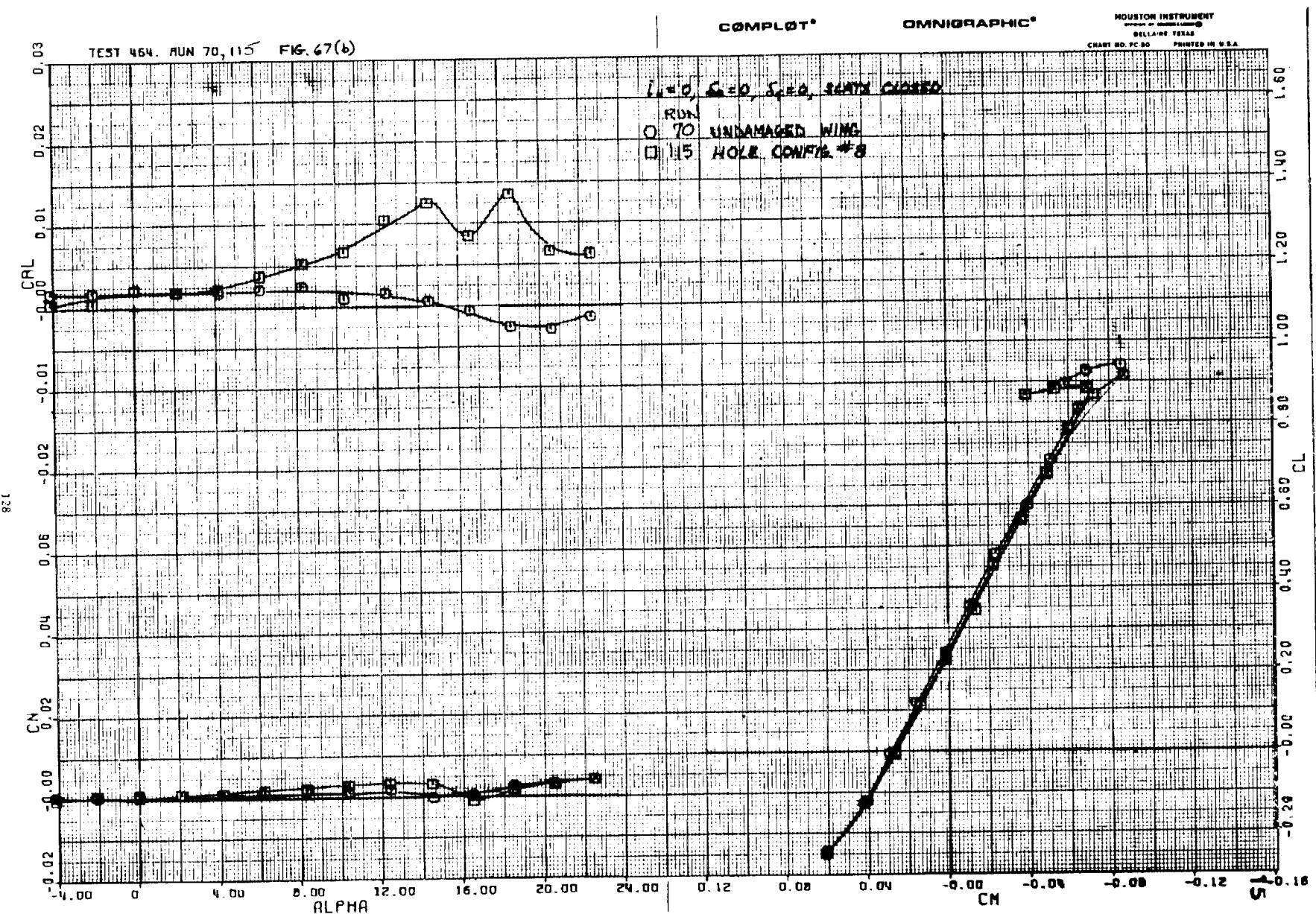


Figure 67(b)

TEST 464, RUN 82, FIG. 68(a)

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DELLAIRE, TEXAS
CRAFT NO. PC-60 PRINTED IN U.S.A.

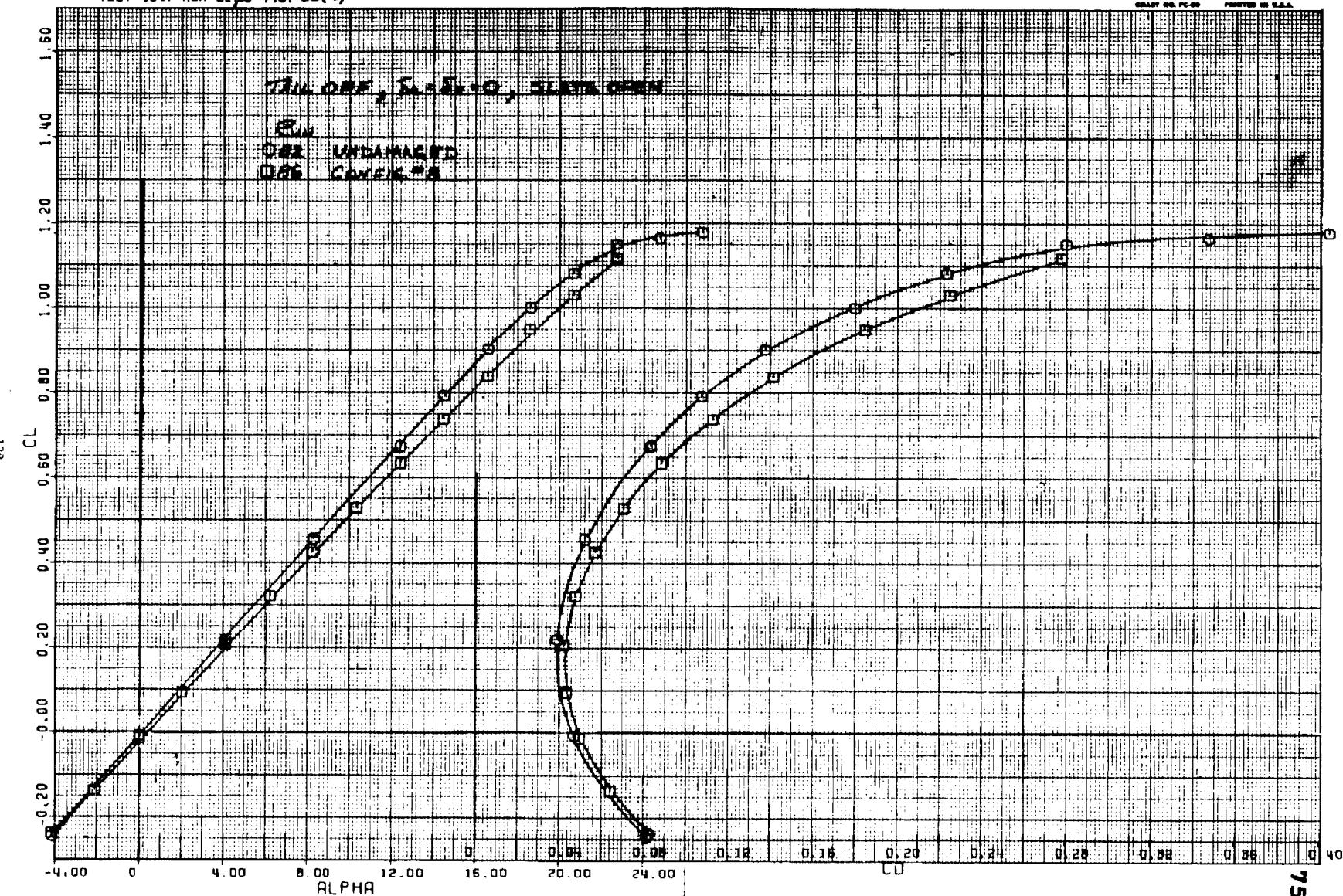


Figure 68(a)

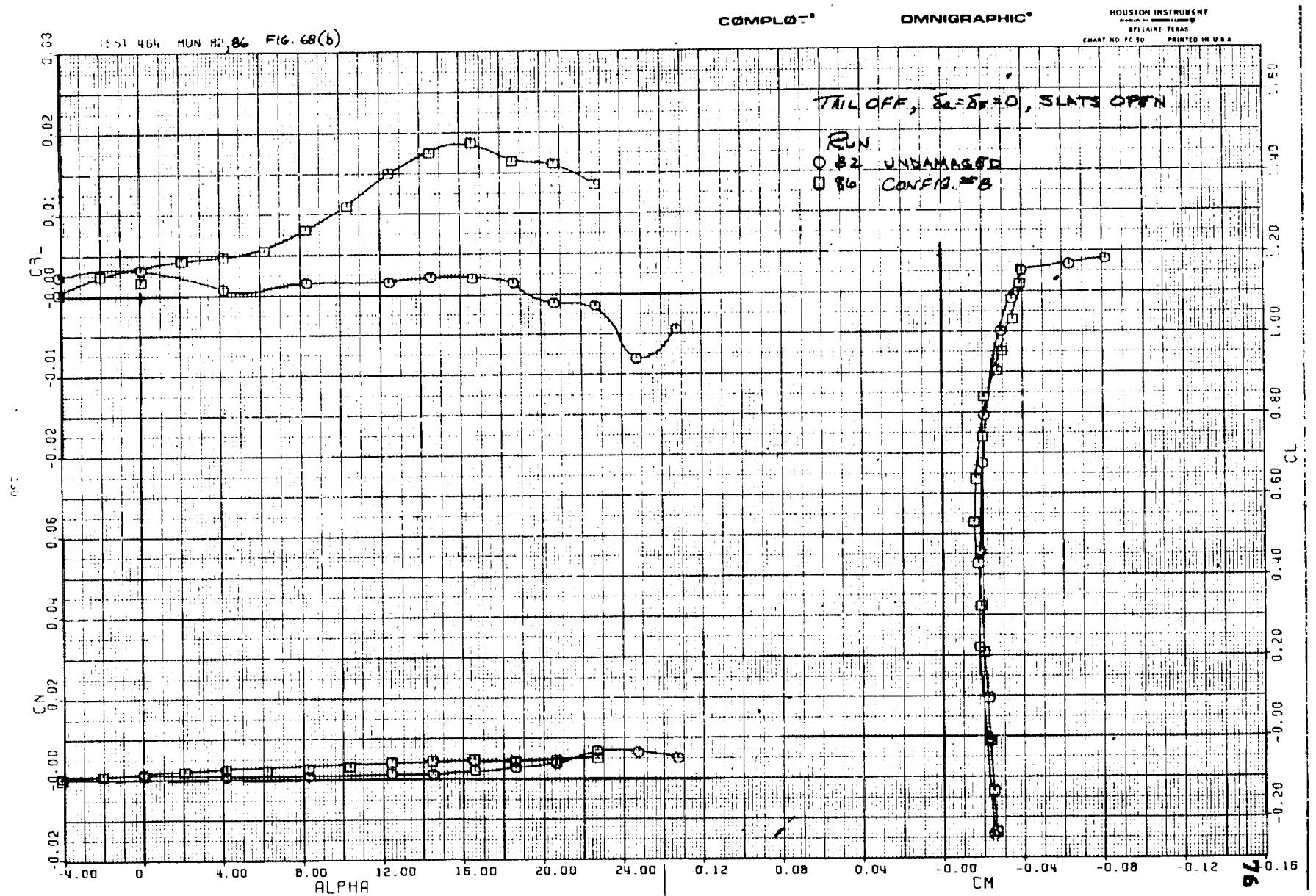


Figure 68(b)

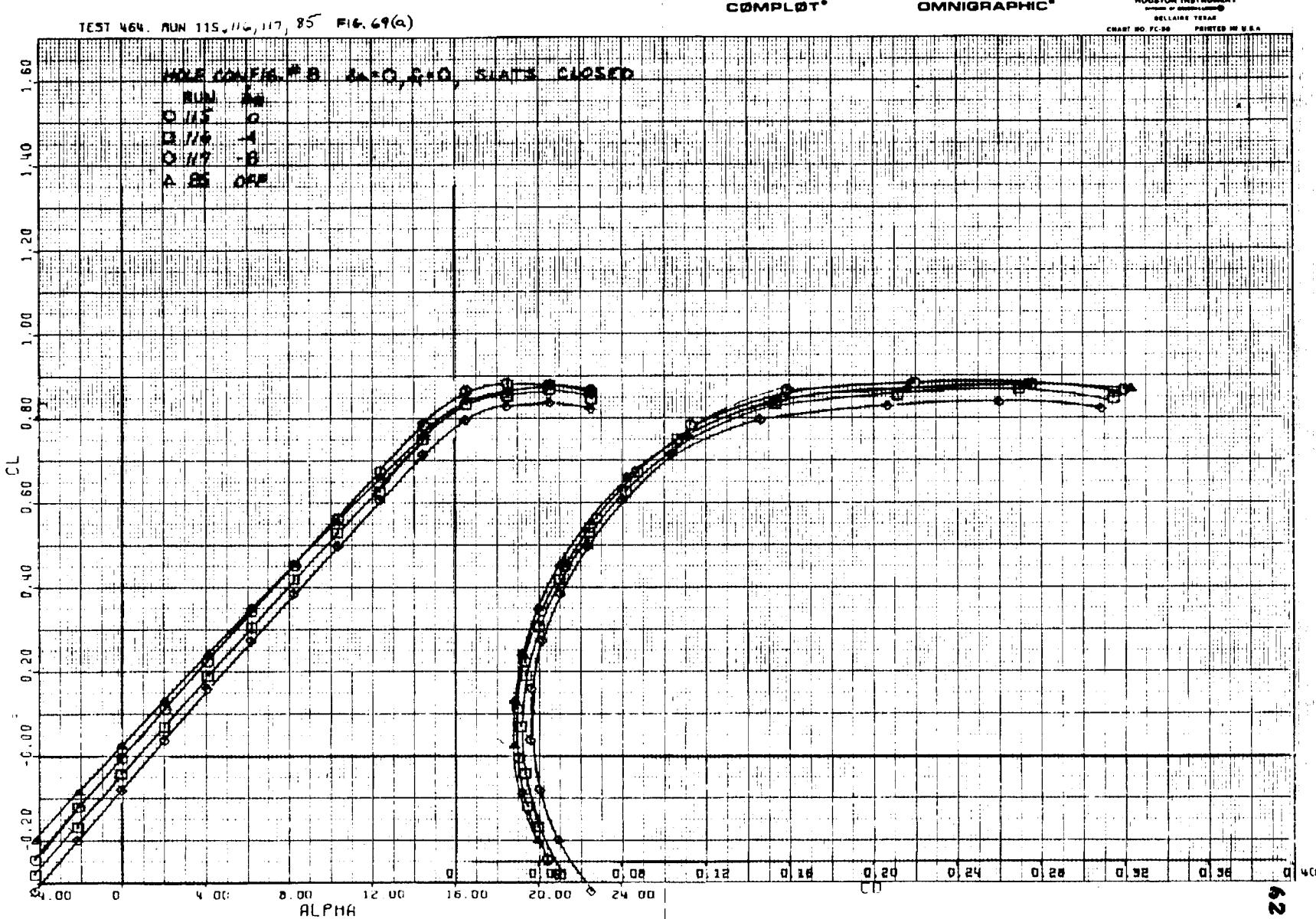


Figure 69(a)

TEST 464. RUN : 15, 116, 117, 85 FIG. 69(b)

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HOUSTON INSTRUMENT

Division of Allis-Chalmers

BELAIRE, TEXAS

CHART NO. FC 50 PRINTED IN U.S.A.

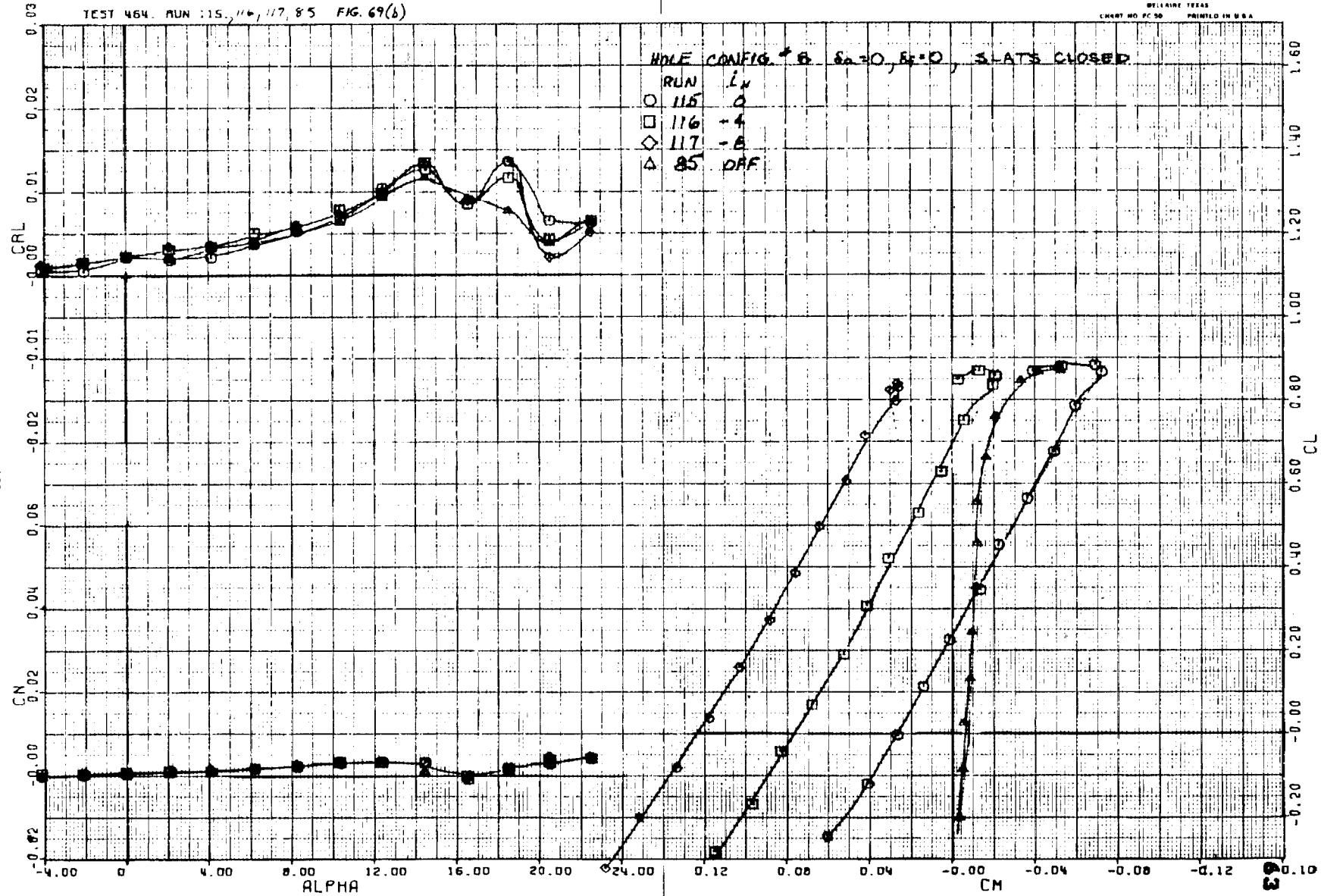


Figure 69(b)

NAME CONVENTIONAL SKATE CROSSED

9

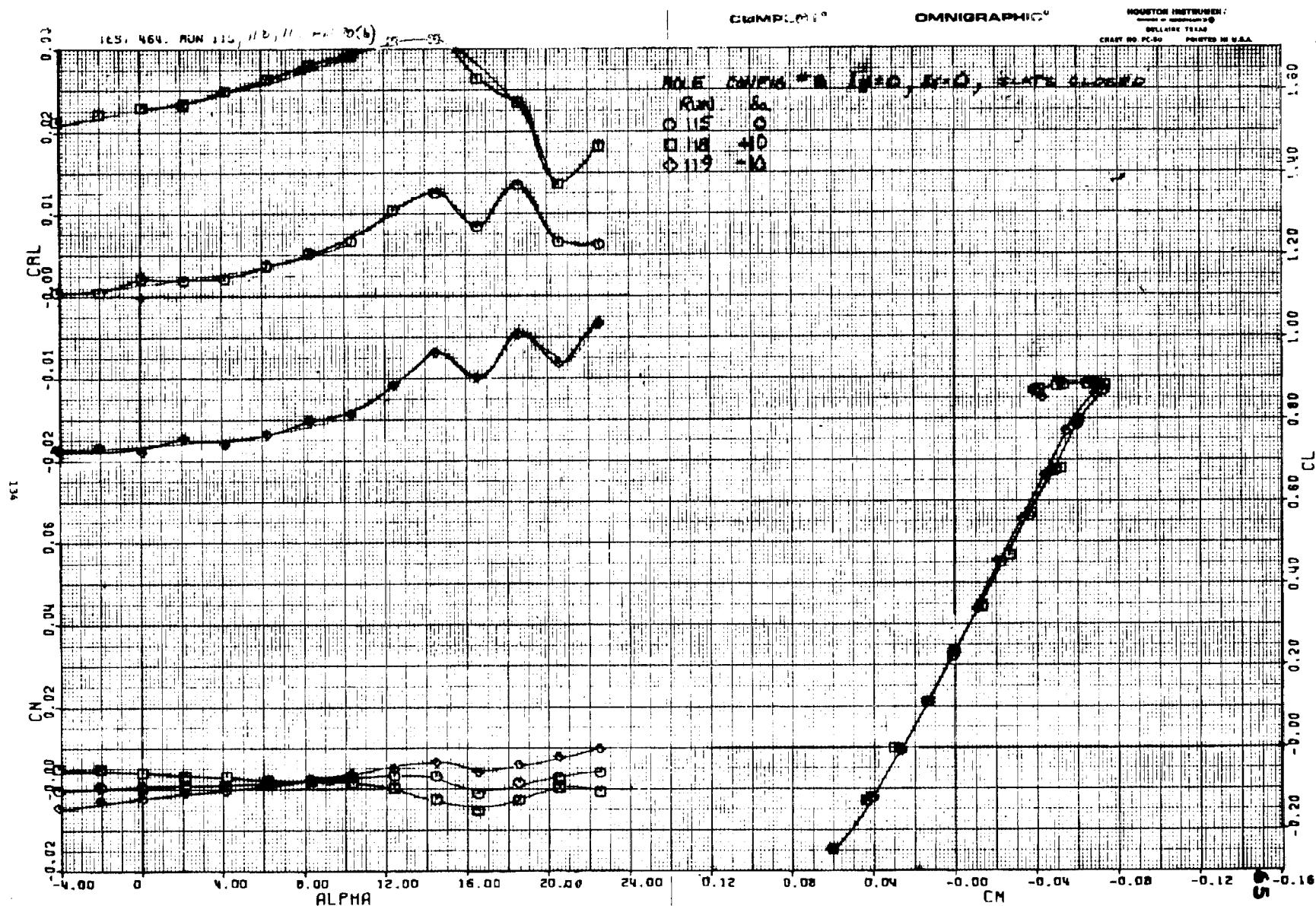


Figure 70(b)

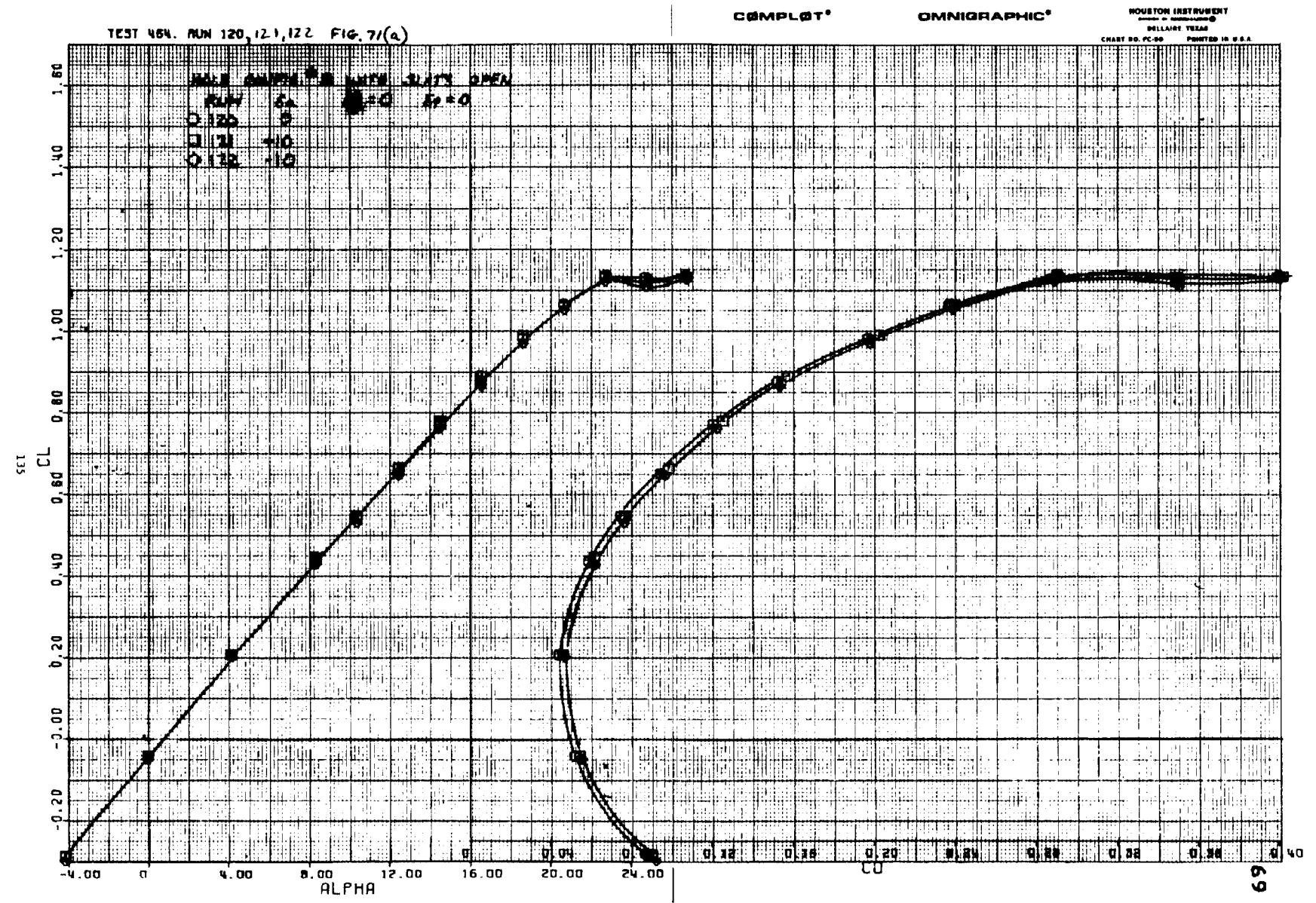


Figure 71(a)

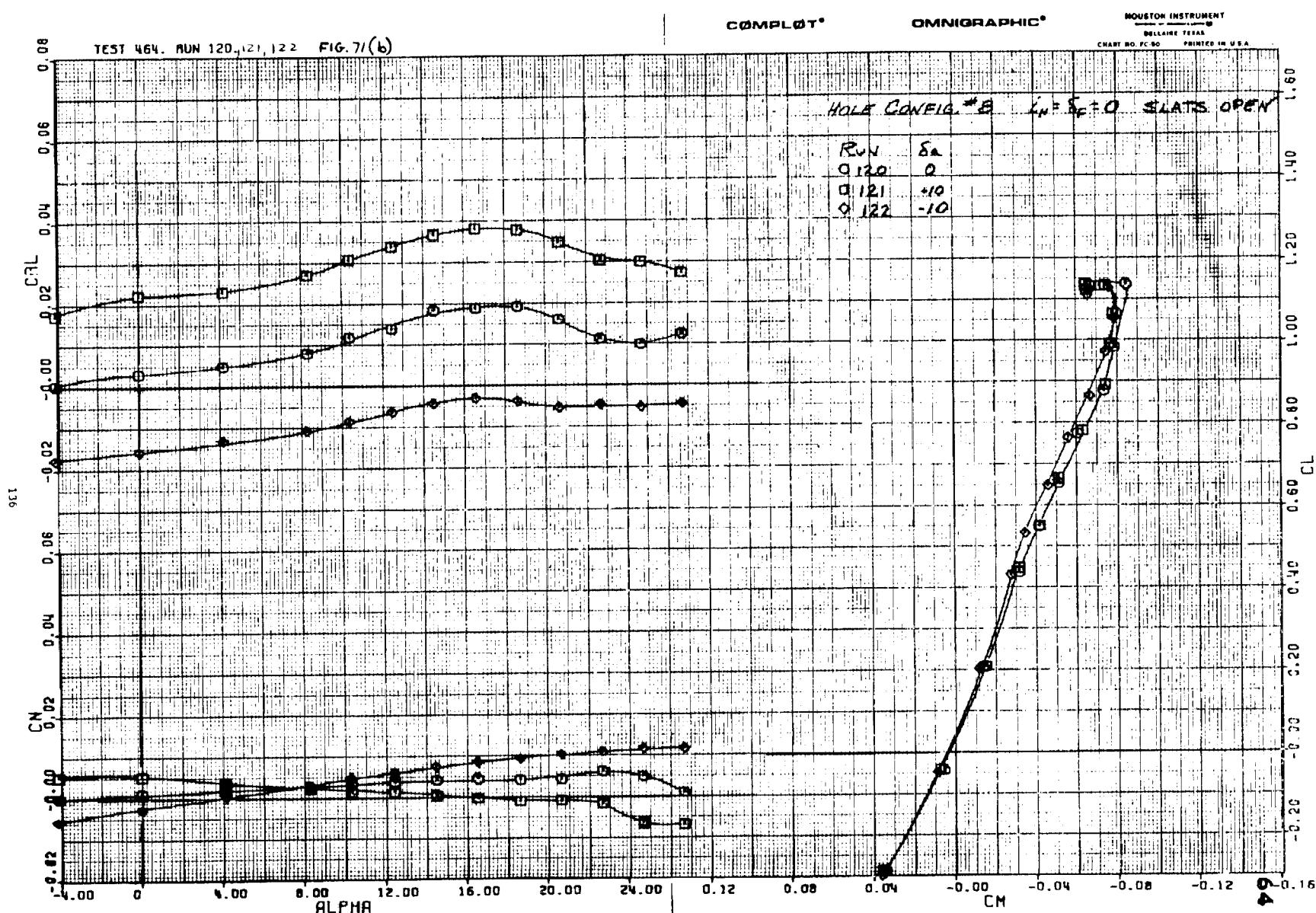
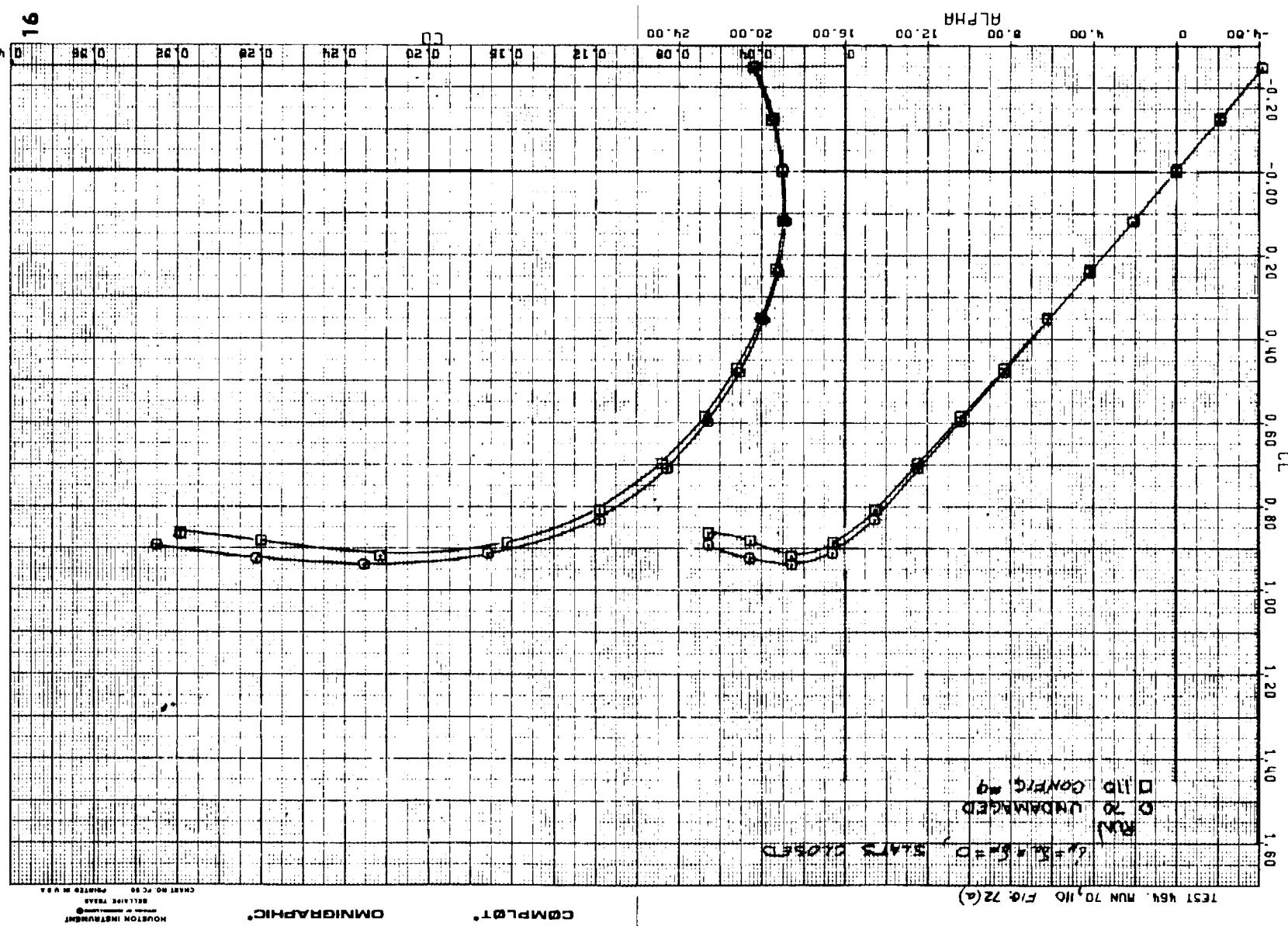


Figure 71(b)

Figure 72(a)



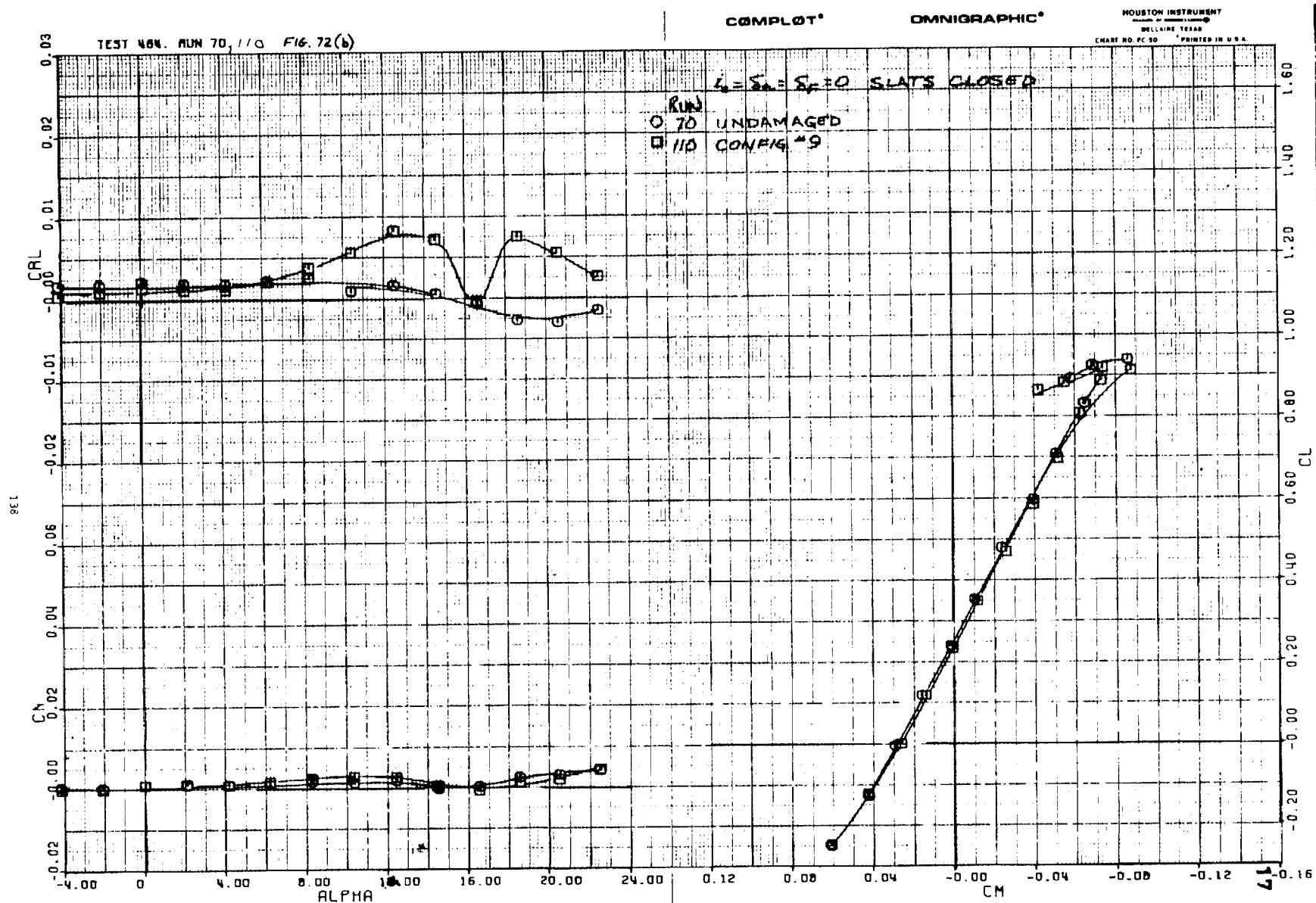


Figure 72(b)

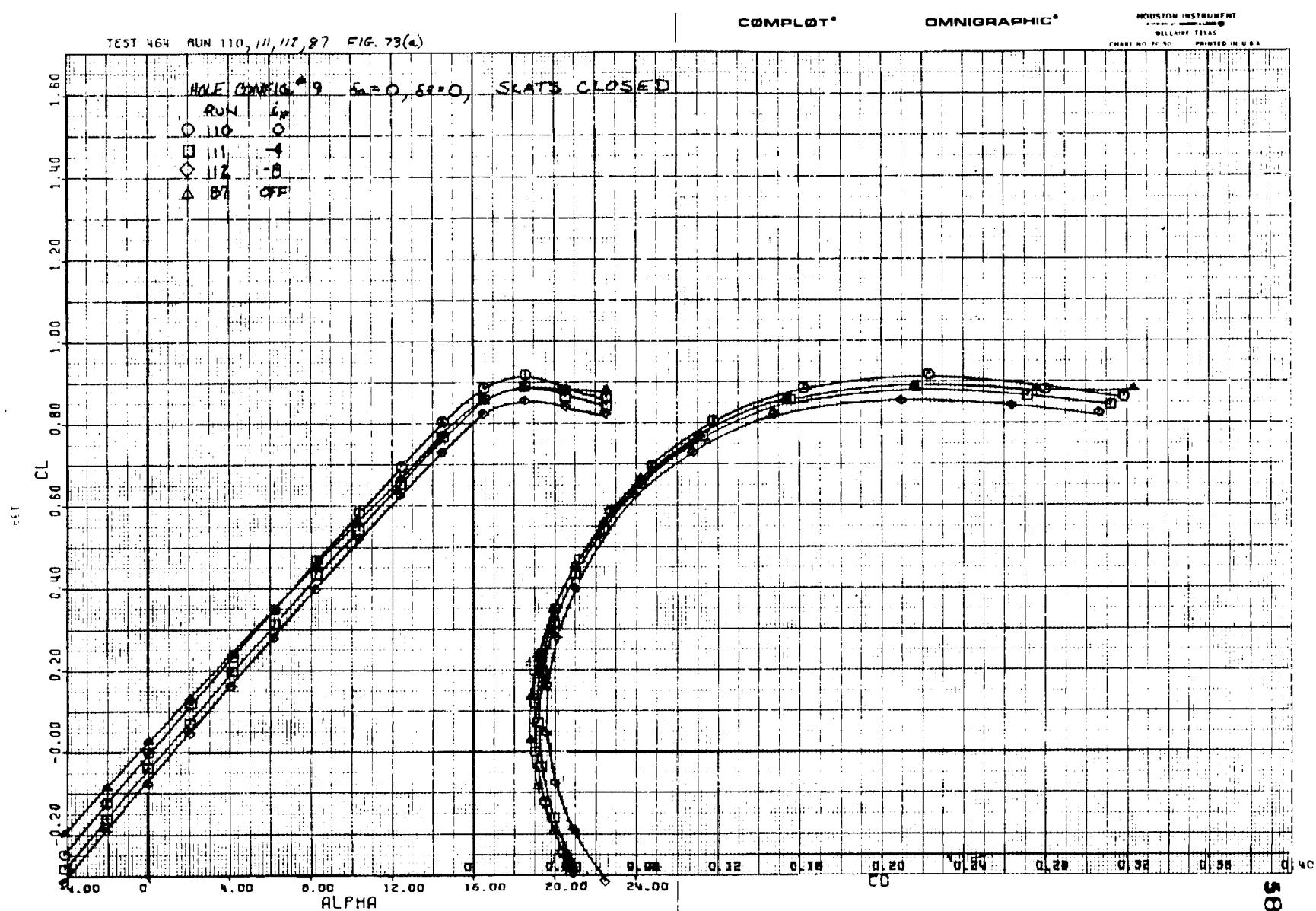


Figure 73(a)

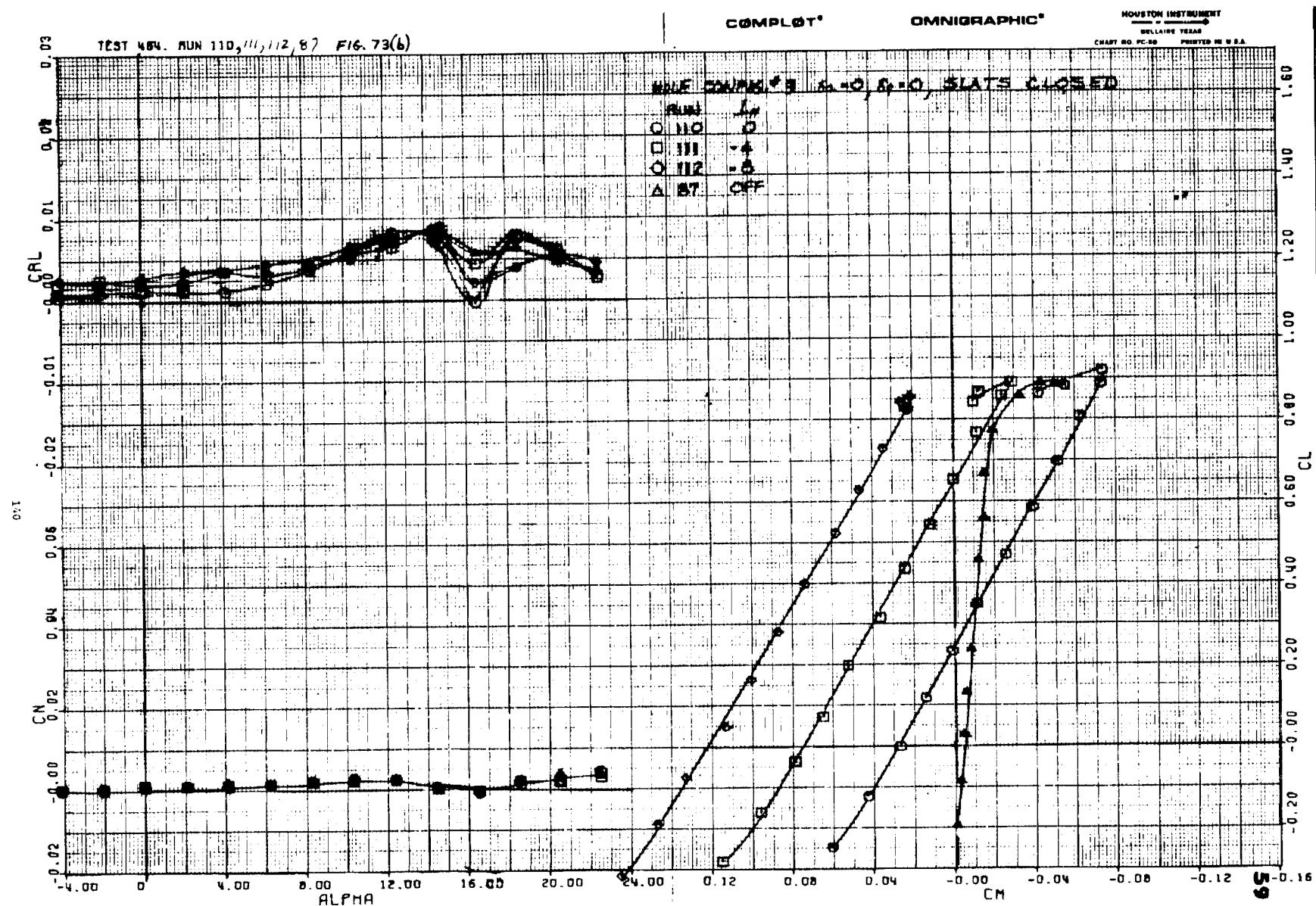


Figure 73(b)

COTTON		Wool		SILK	
Yarn	Color	Yarn	Color	Yarn	Color
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60
1.60	1.40	1.20	1.00	0.80	0.60

SOLE draped 1.60 1.40 1.20 1.00 0.80 0.60

0.40

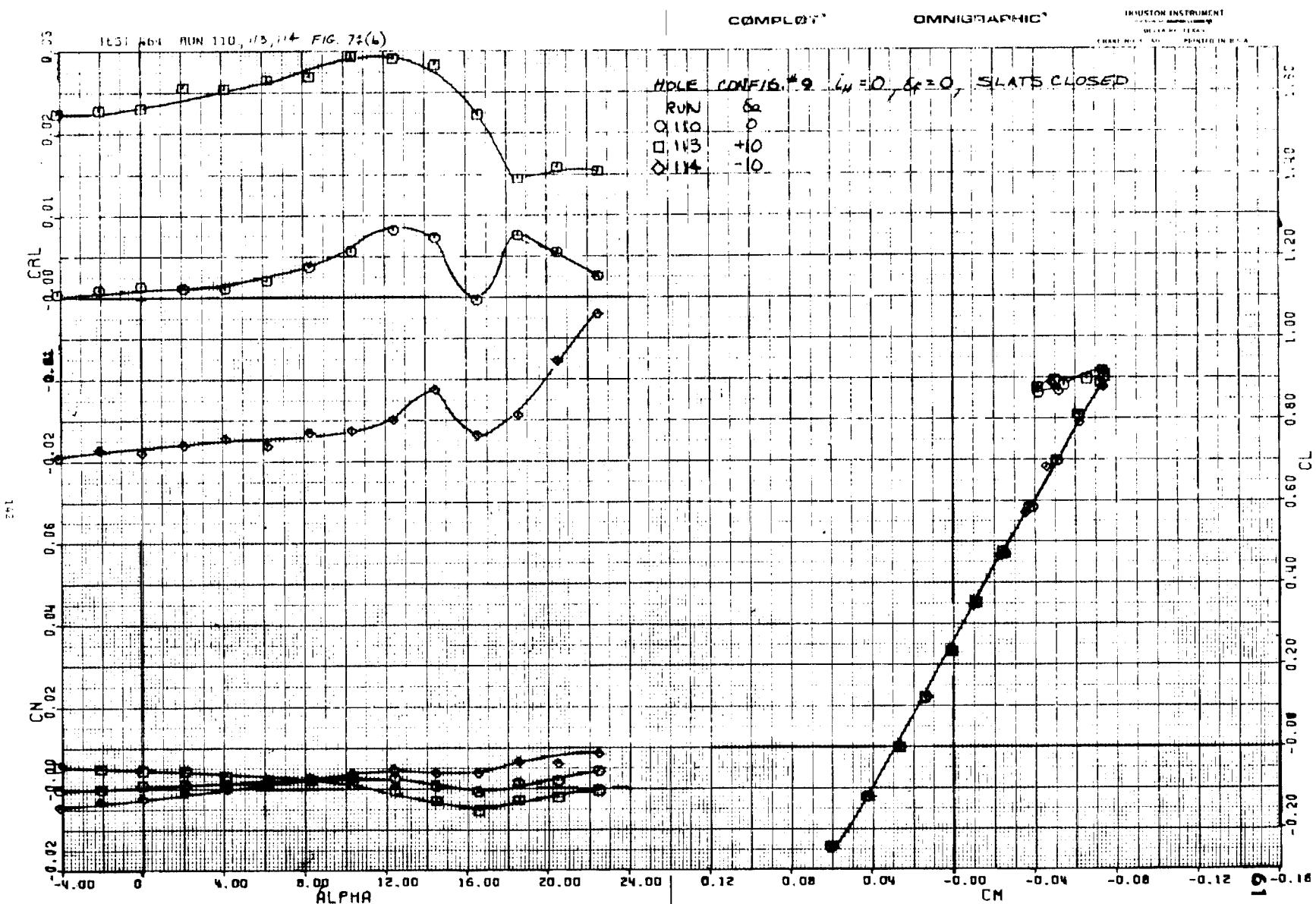


Figure 74(b)

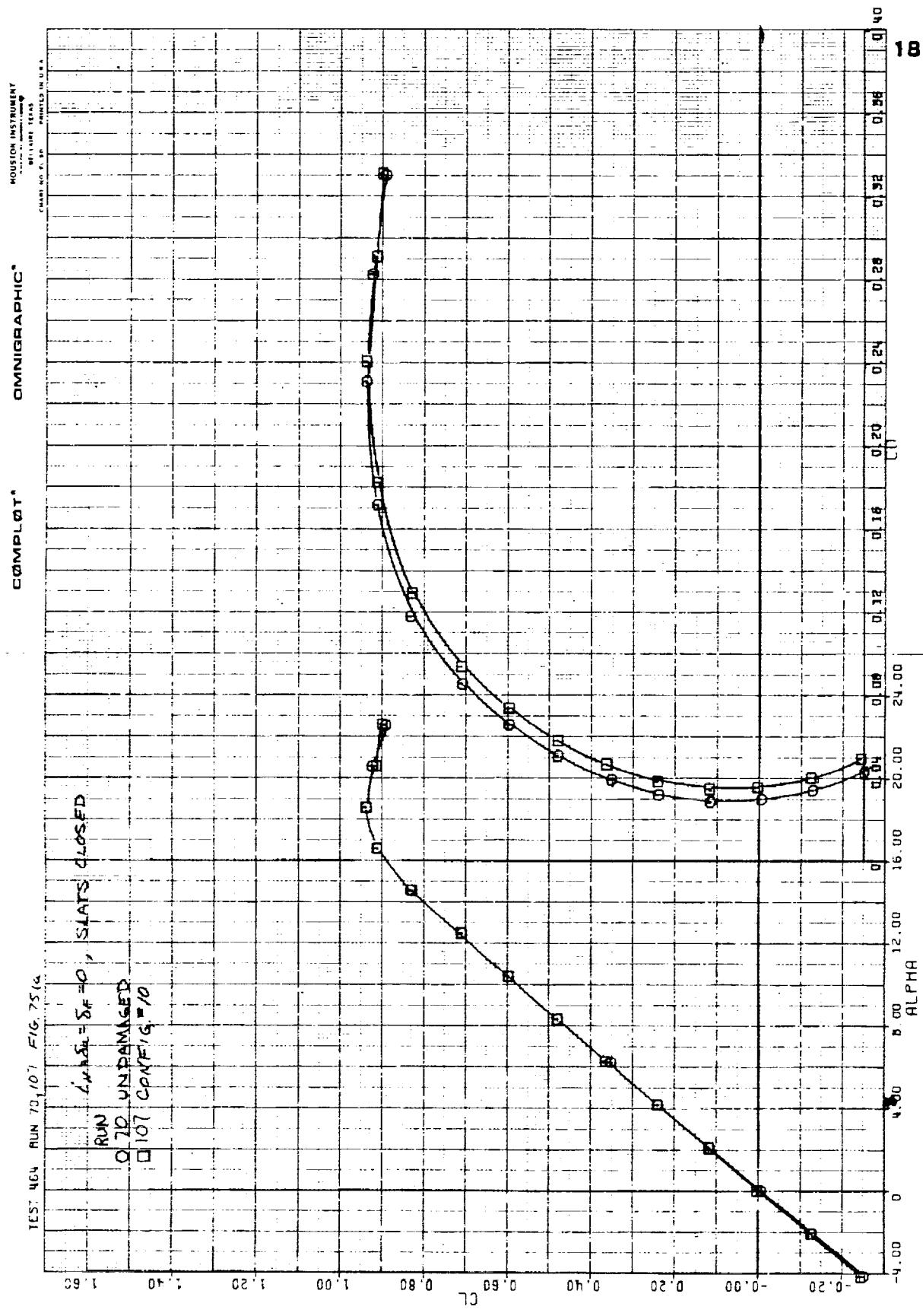
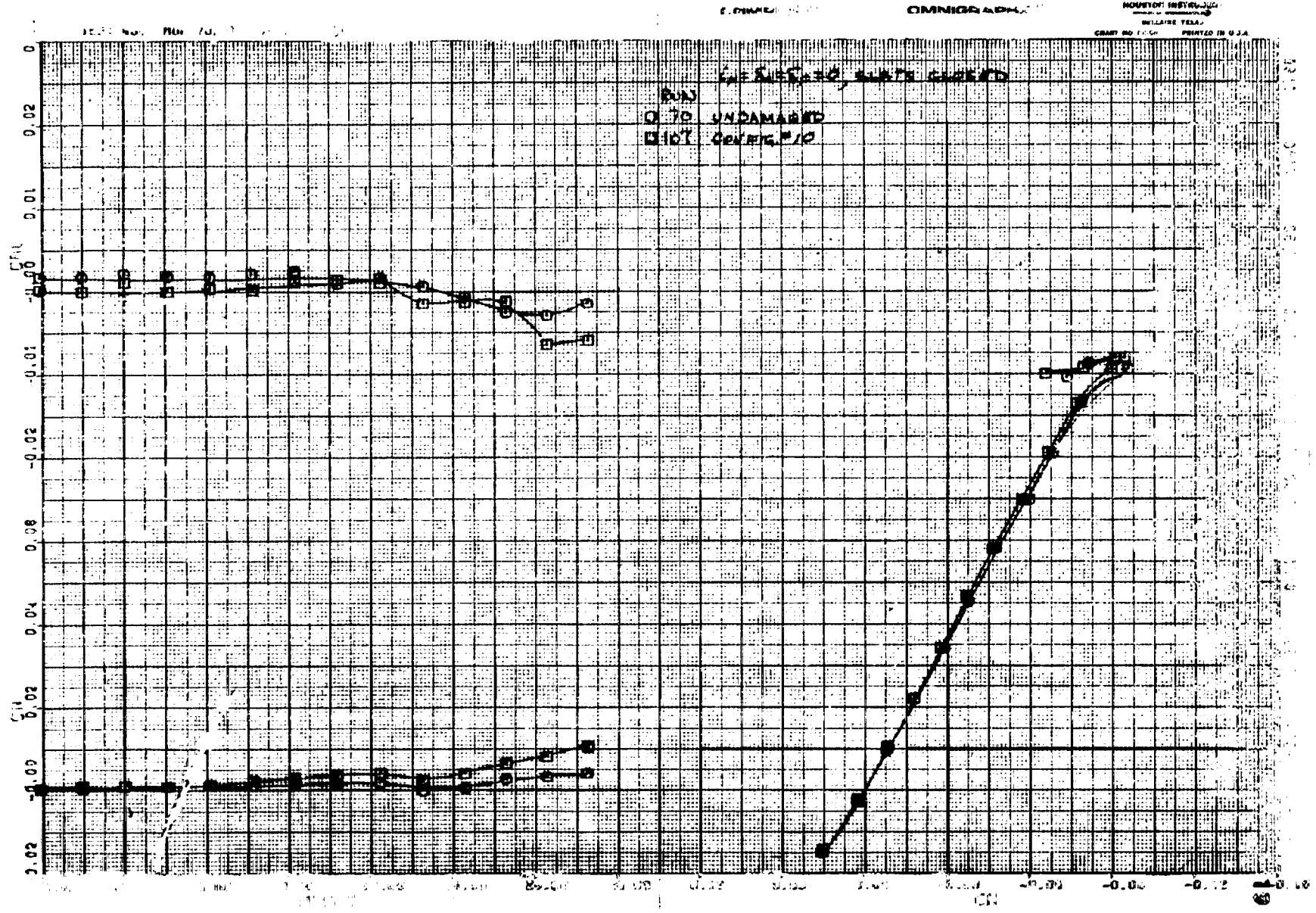


Figure 75(a)



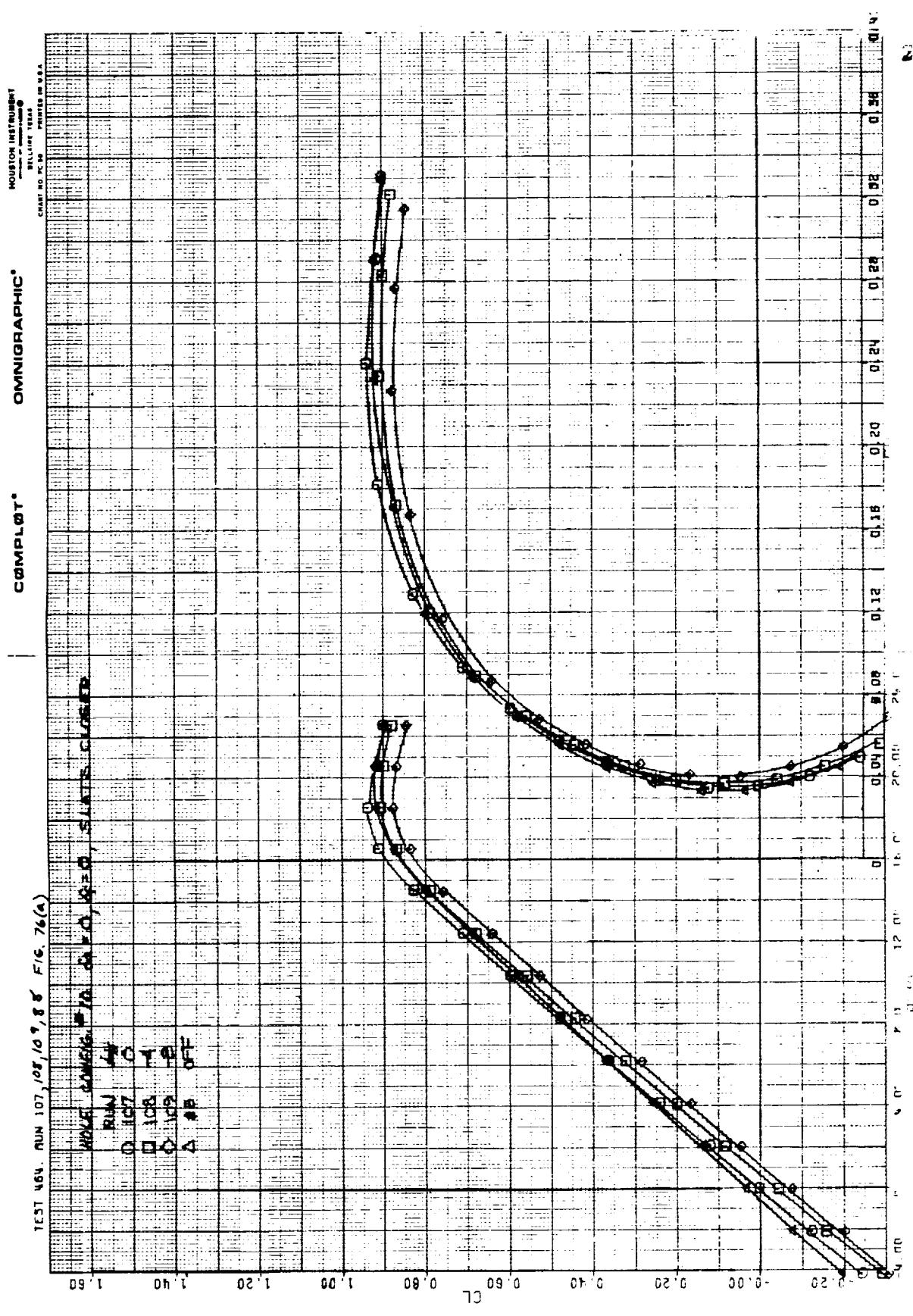
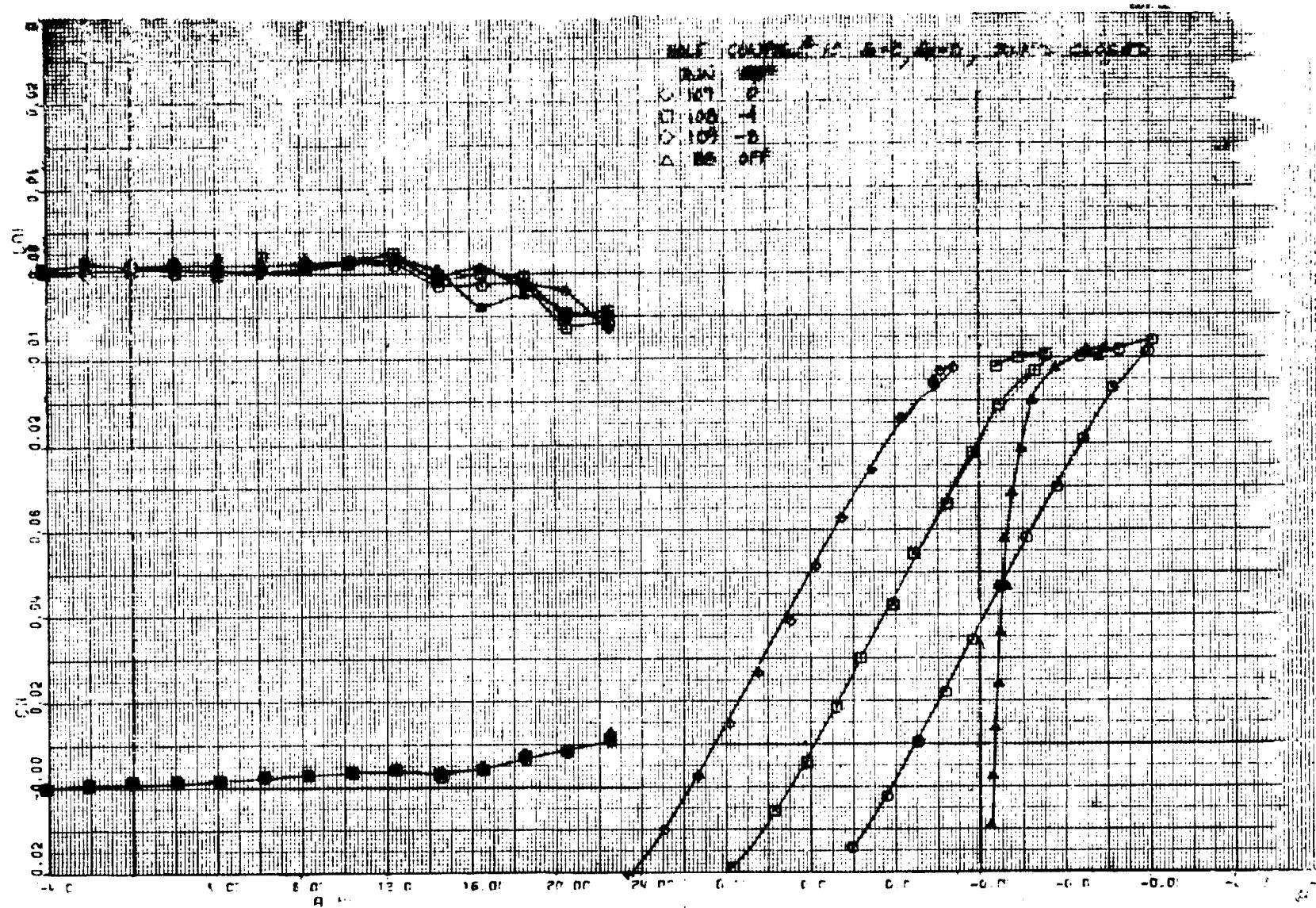


Figure 1b.



118110

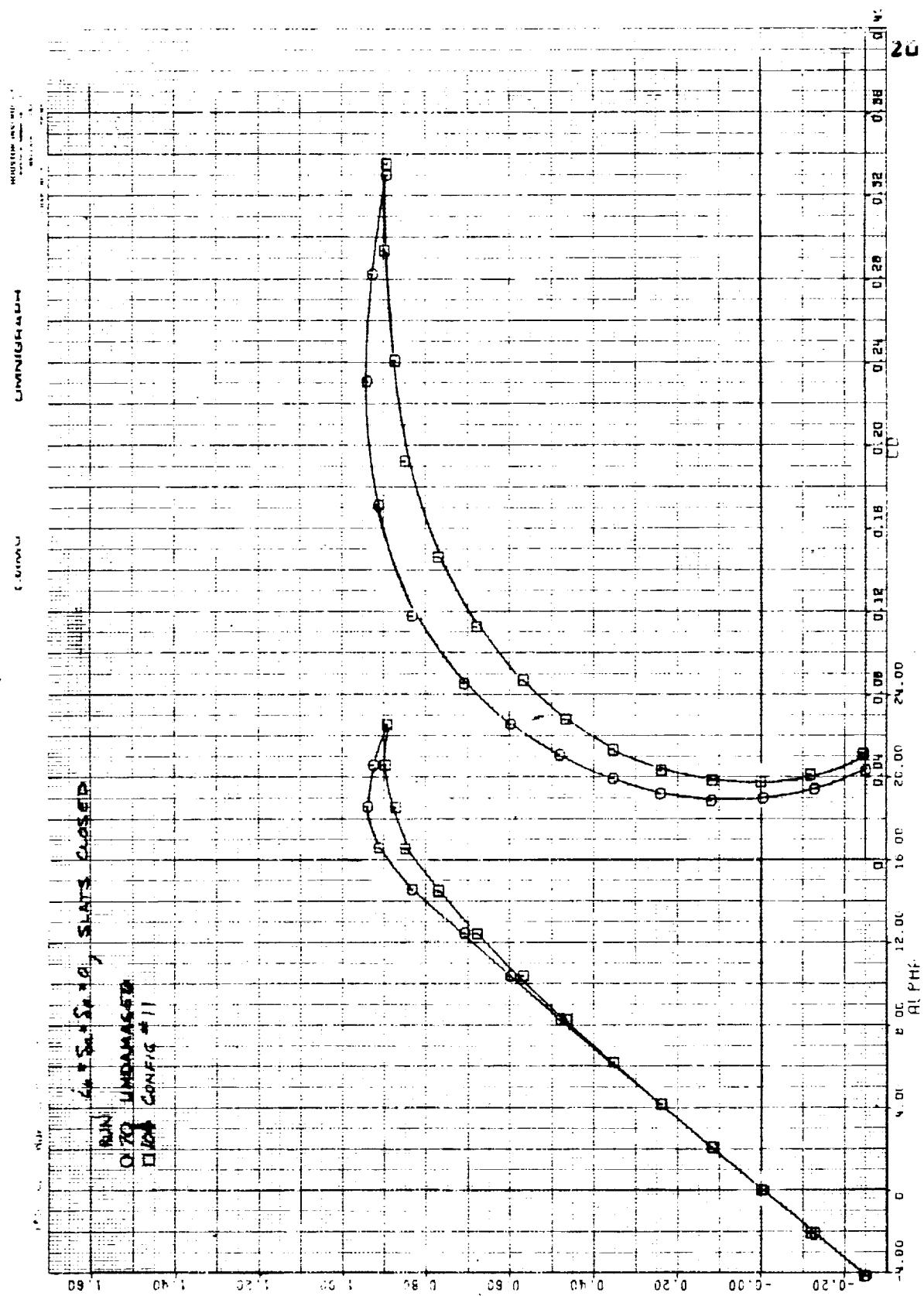
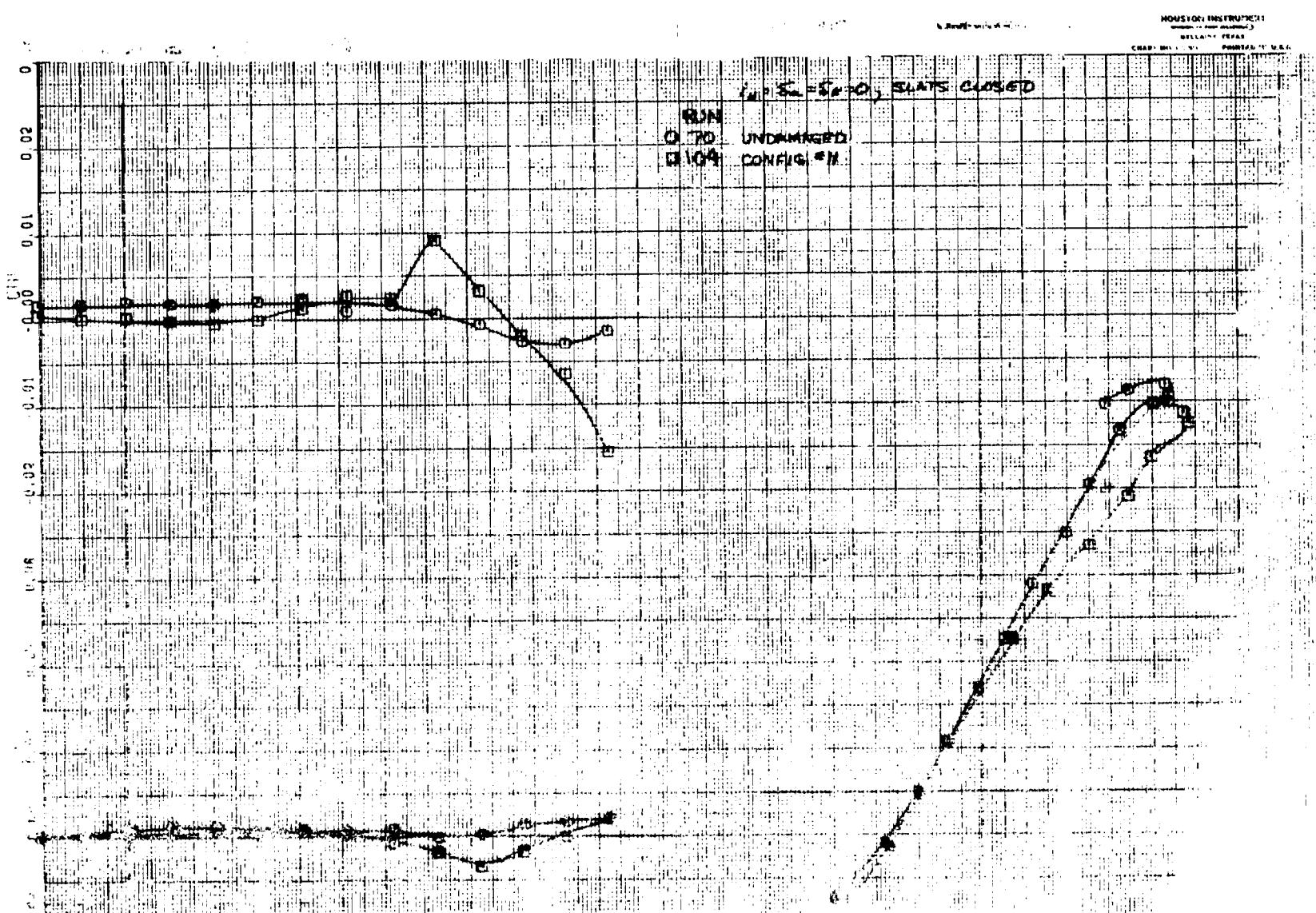
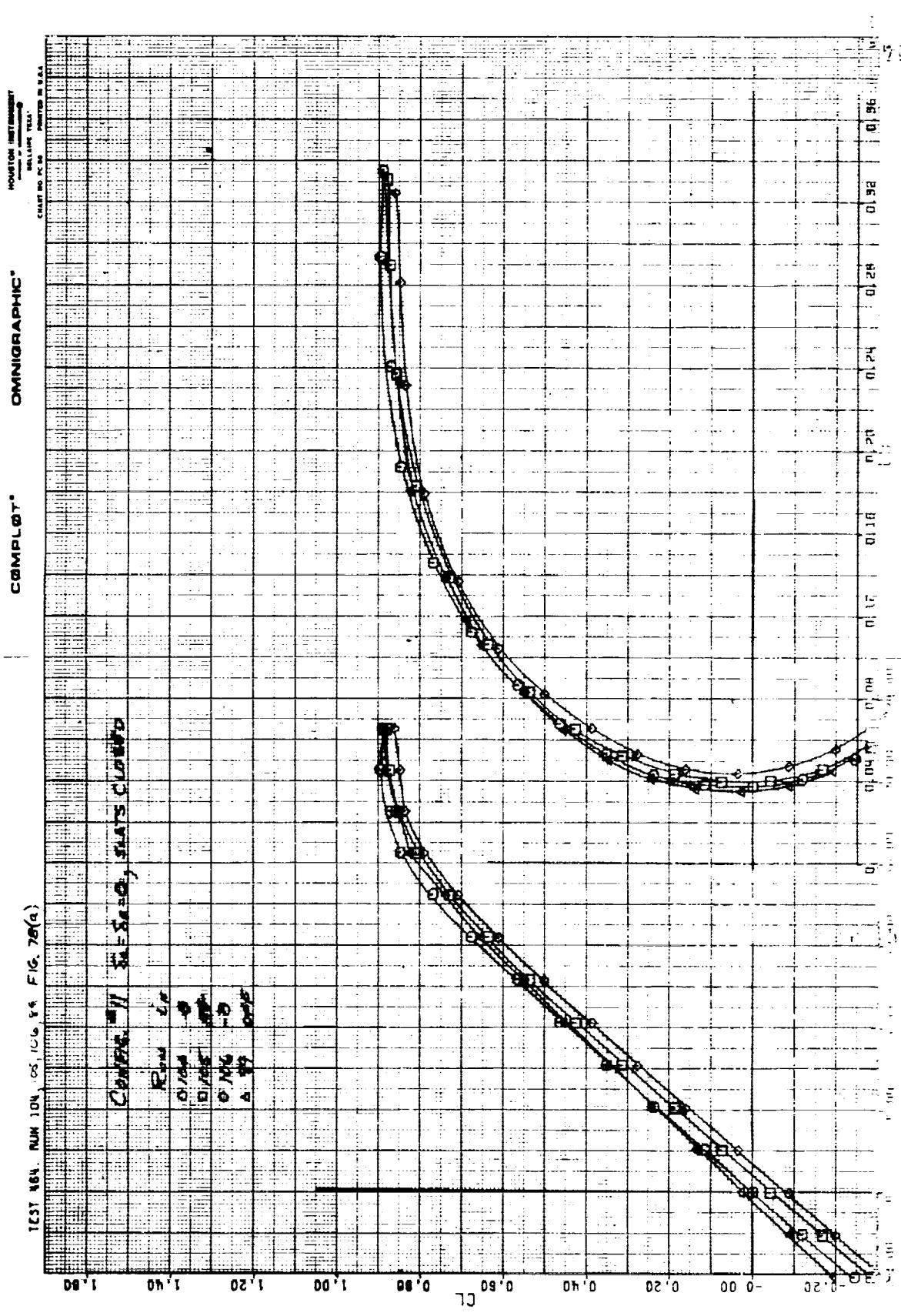


Figure 77(a)



TEST 484 NUMBER OS-116 FIG. 78(a)



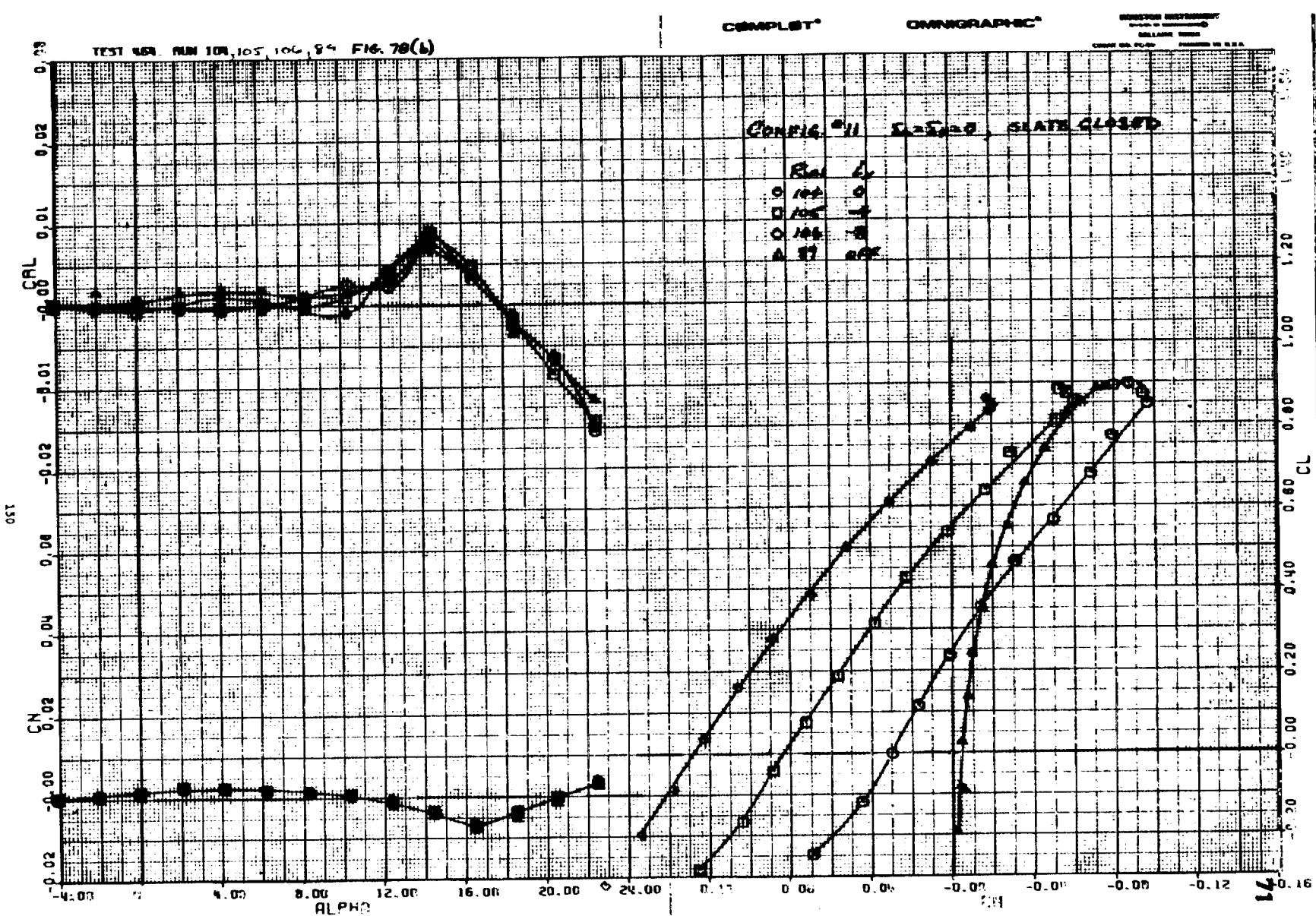


Figure 7B(b)

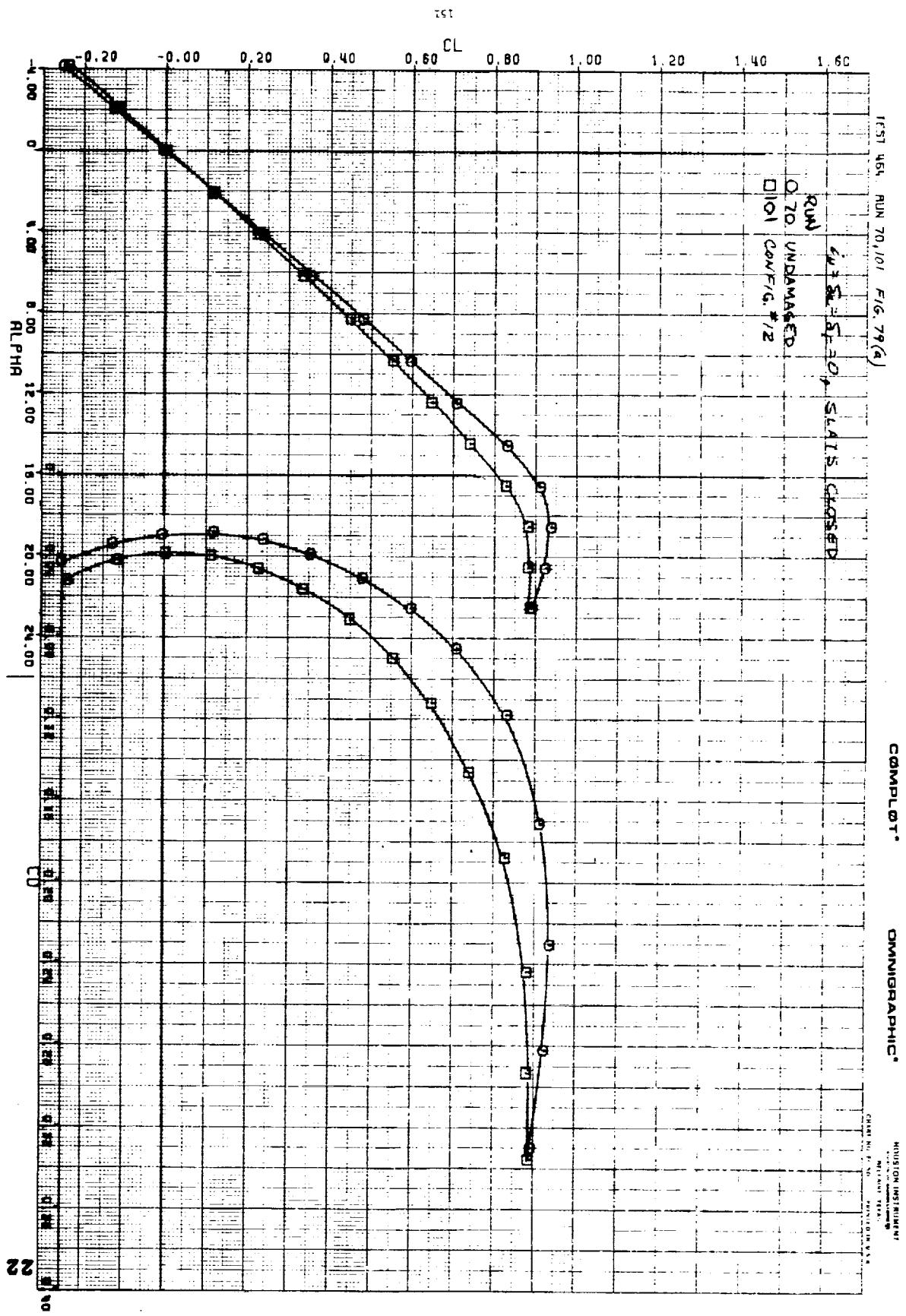
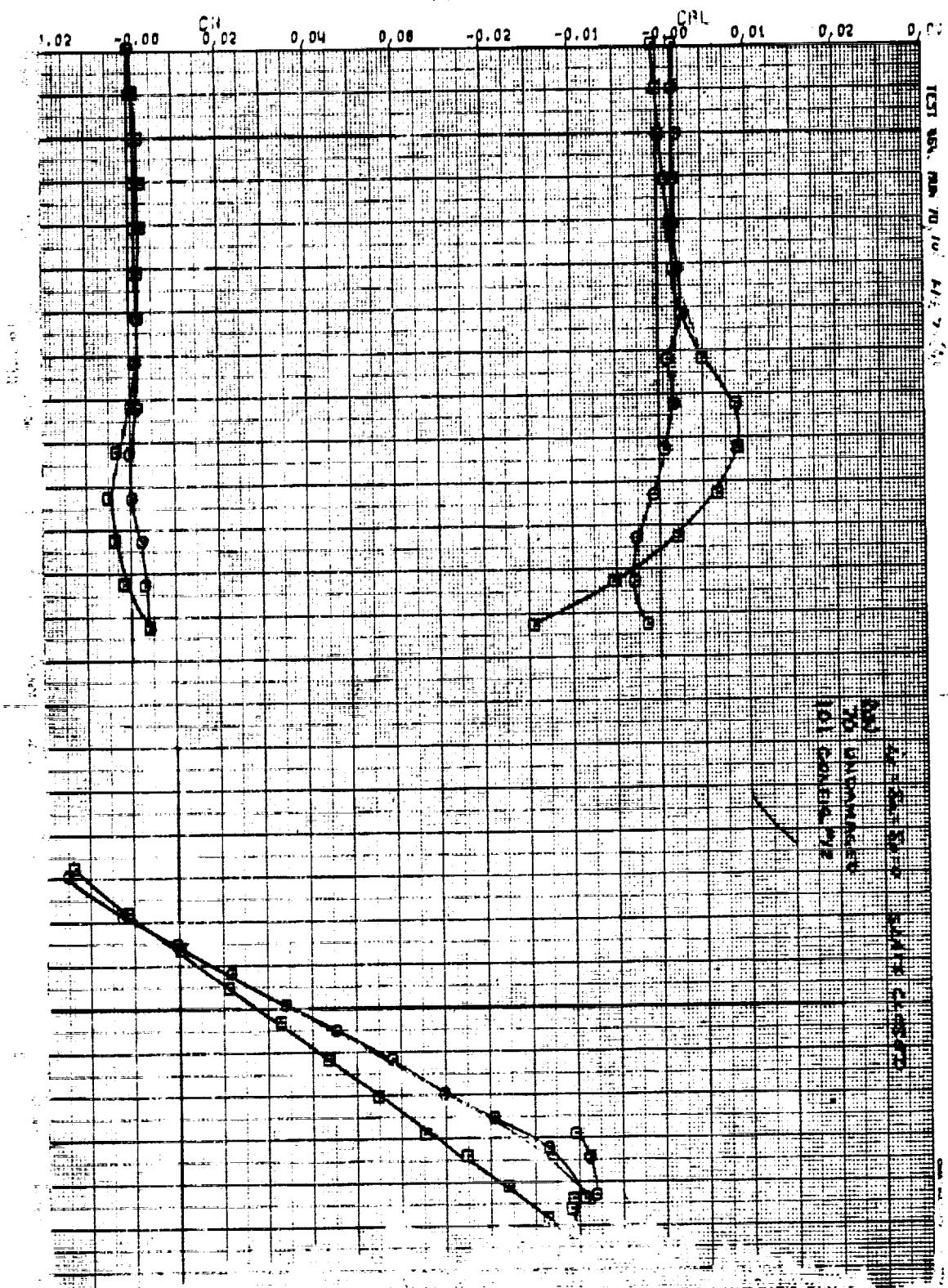


Figure 79(a)



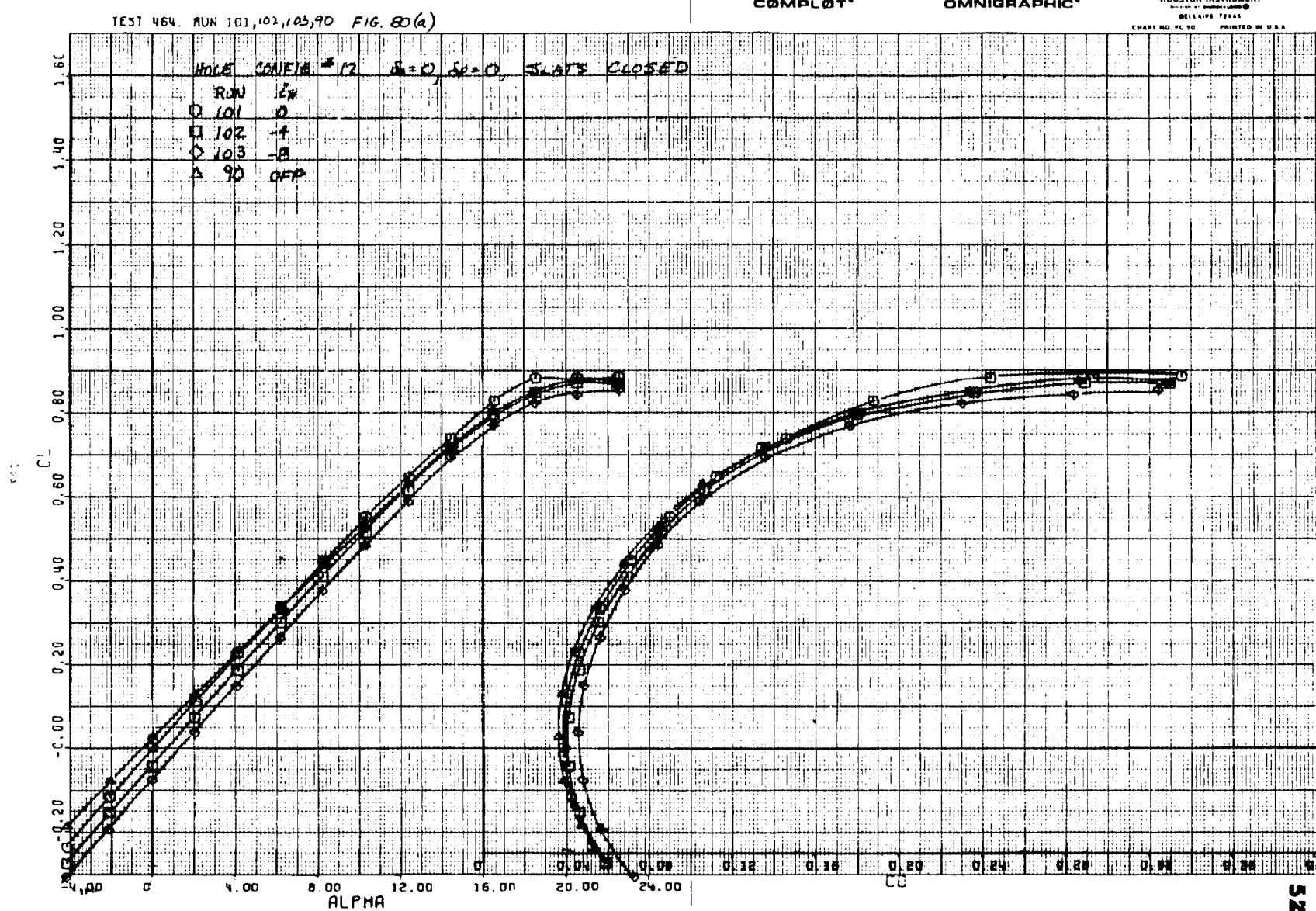


Figure 80(a).

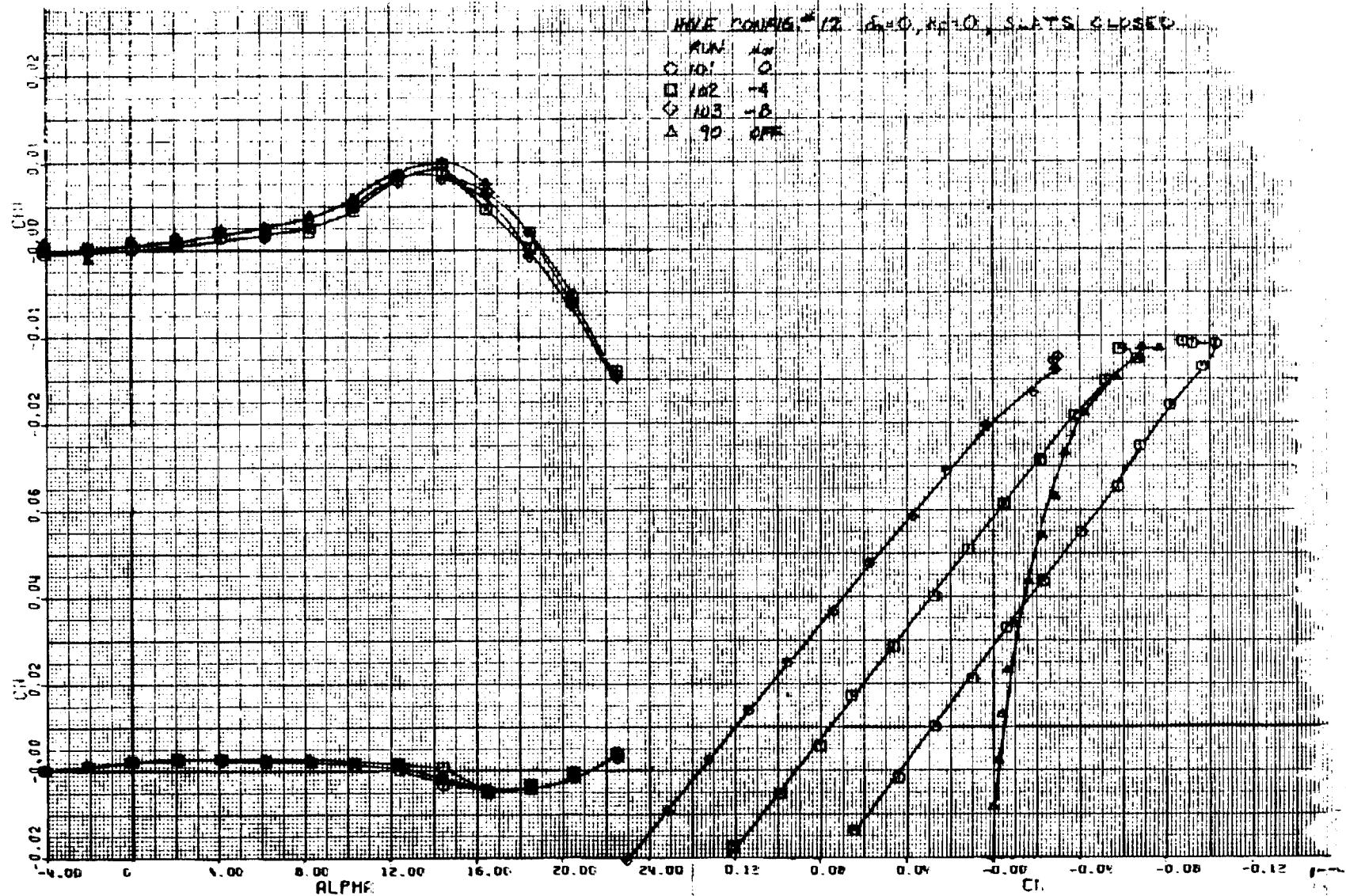


Figure 80(b)

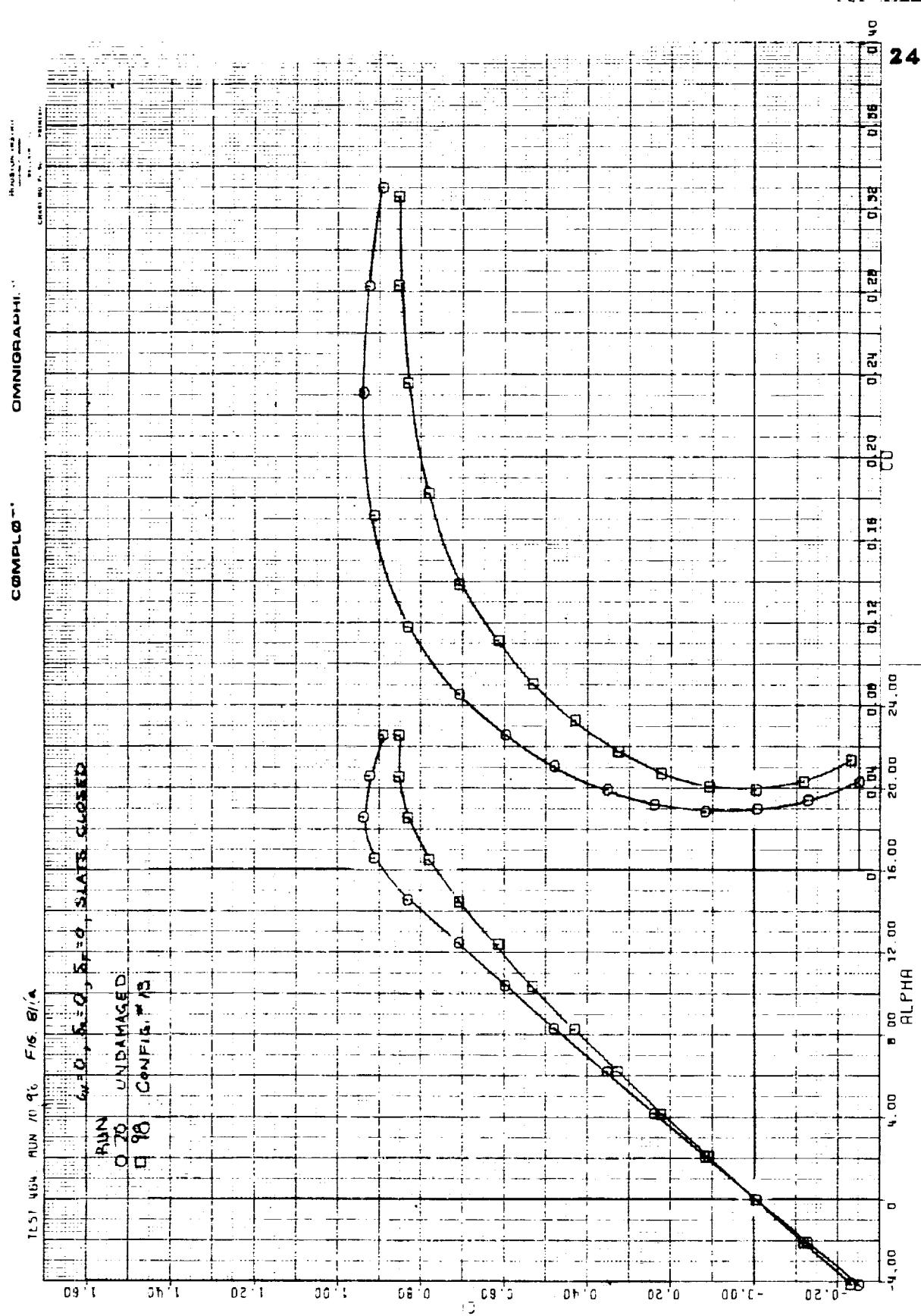
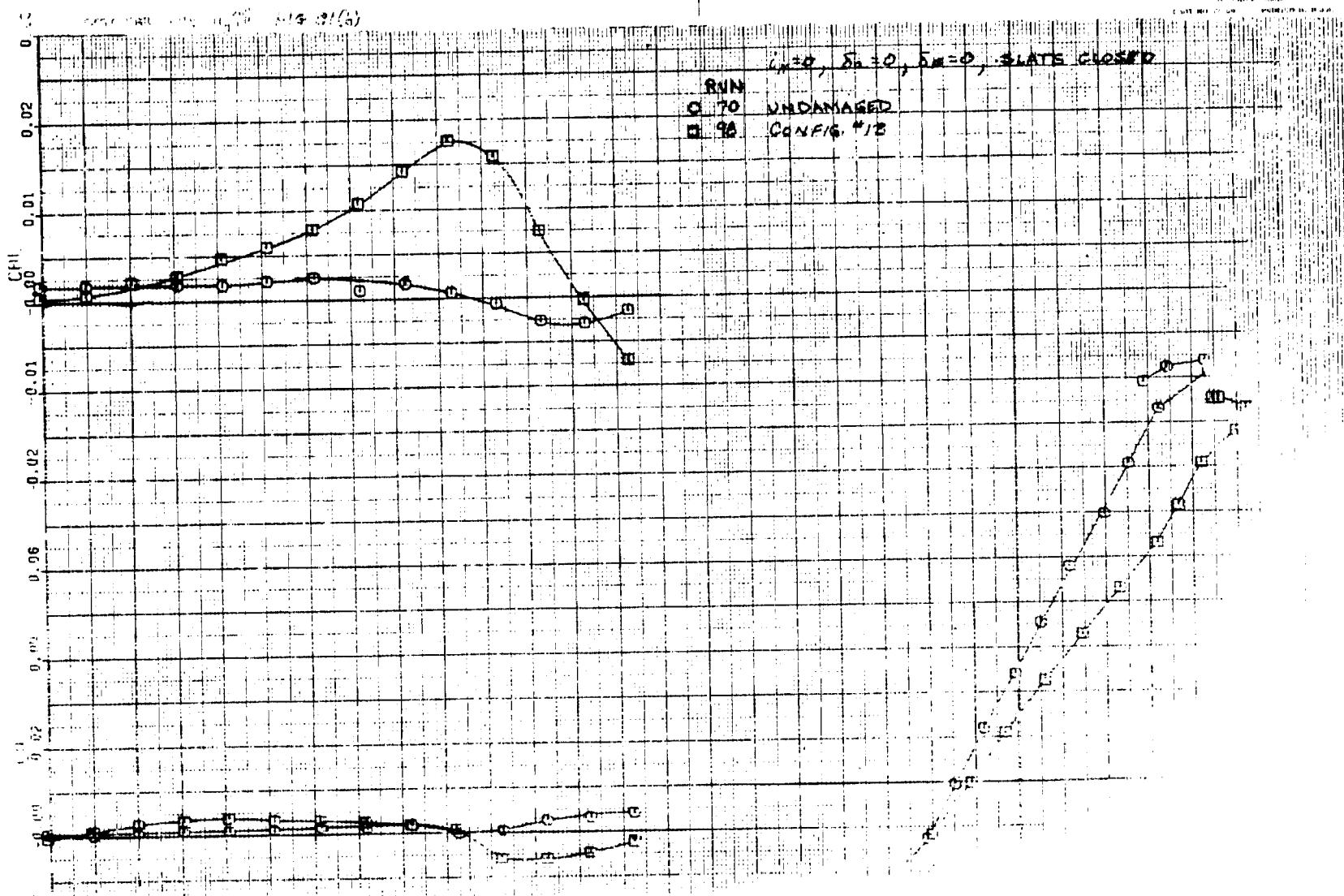


Figure 81(a)



TEST 464, RUN 98, 99, 100, 111 FIG. 82(a)

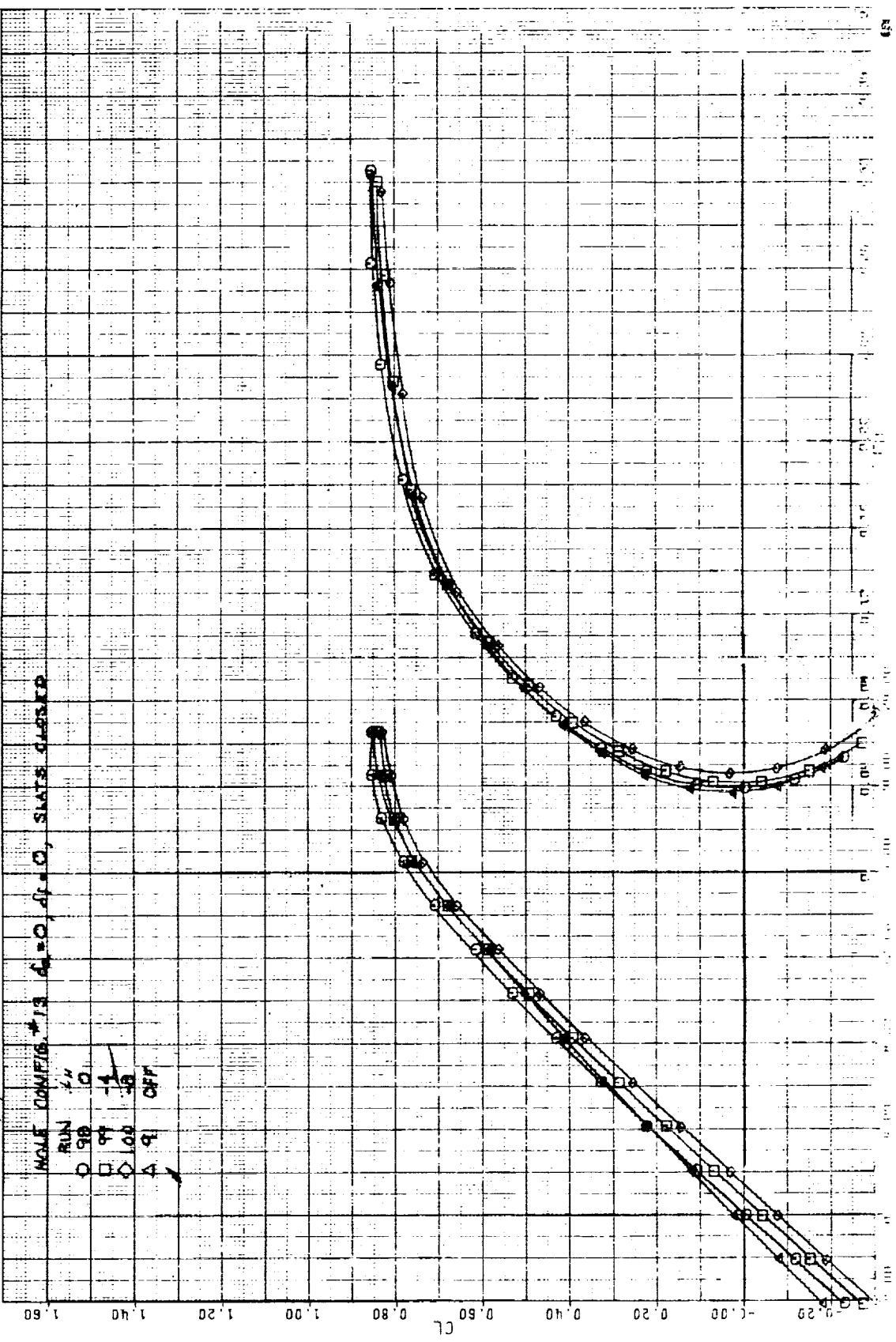
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HOUSTON INSTRUMENT

Divisions of General Electric

MIDLAND, TEXAS 79701 U.S.A.

Chart No. PC 50



TEST 464. RUN 98, 99, 100, 91 FIG. 82(b)

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OMNIGRAPHIC[®]

HOBTON INSTRUMENT
OIL & GAS
DEALER TEST
CHART NO. PC-40
PRINTED IN U.S.A.

MOLE CONCNS + 10 A=O, Spool, SEATES CLOSED

RUN
98
99
100
91
OFF

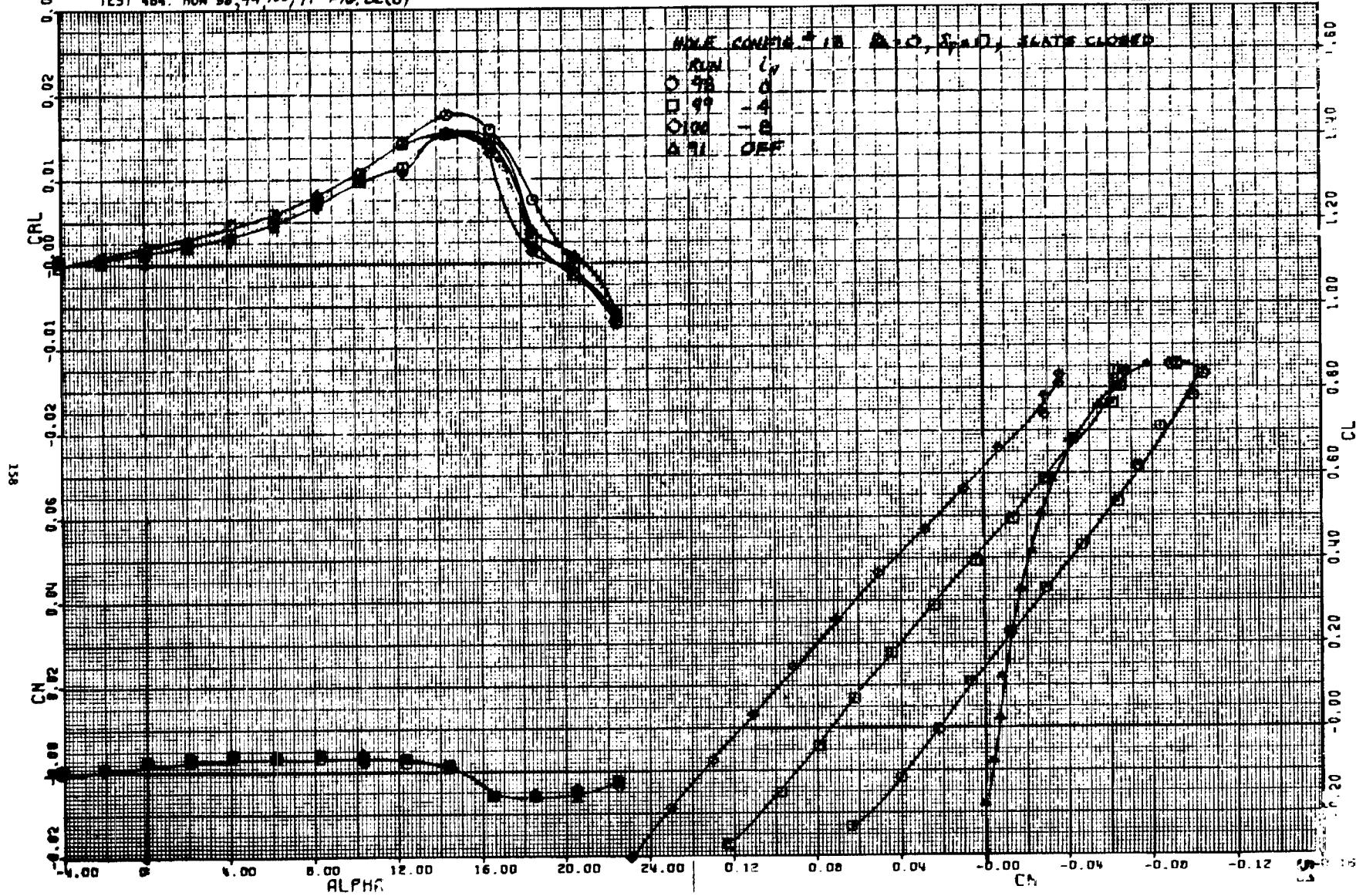


FIGURE 82(b)

TEST 464, RUN 70, 93 FIG. 83(a)

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OMNIGRAPHIC[®]

HOUSTON INSTRUMENT
SYSTEMS INCORPORATED
BELLAIR, TEXAS
CHART NO. FC 30 PRINTED IN U.S.A.

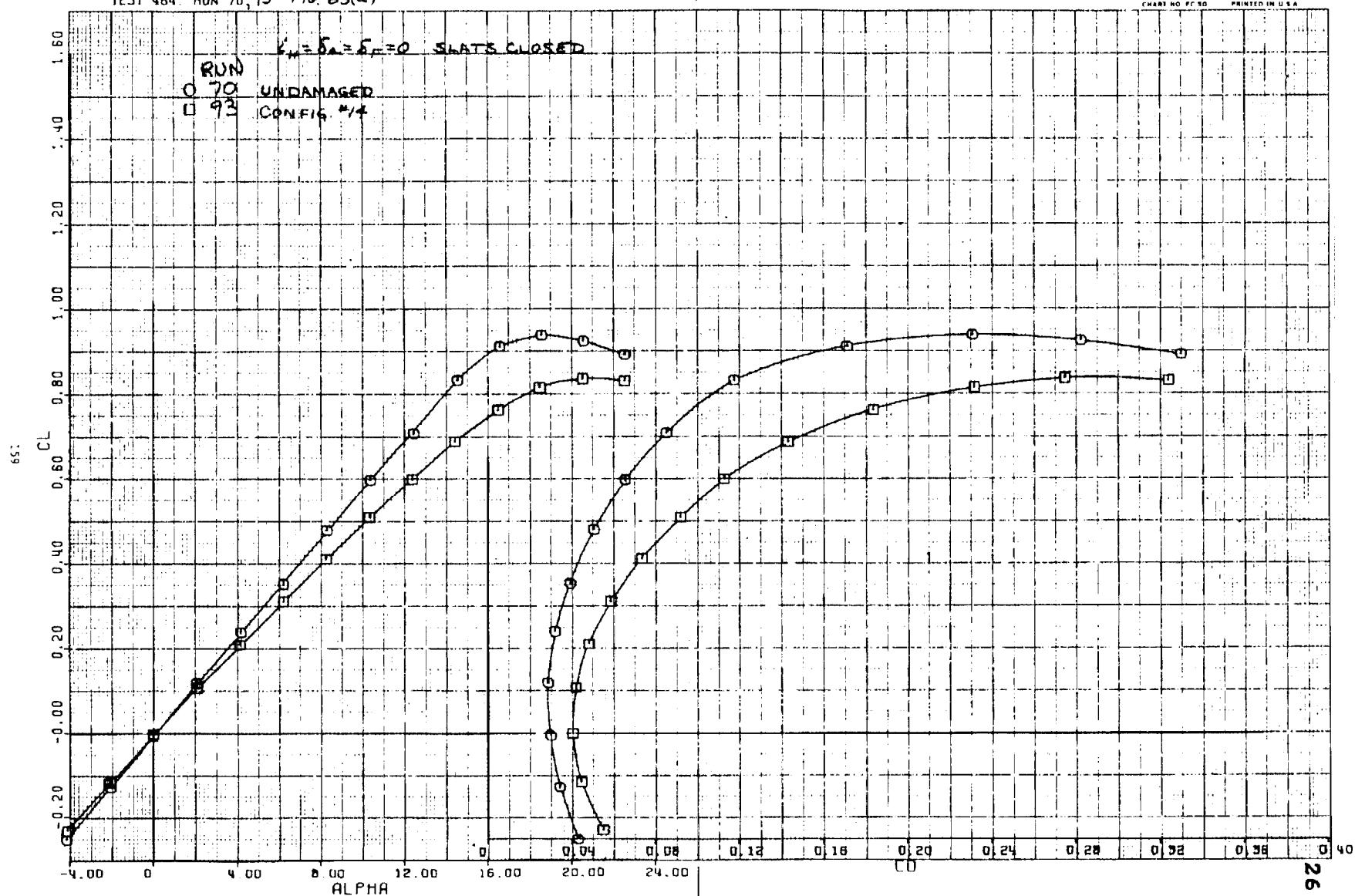
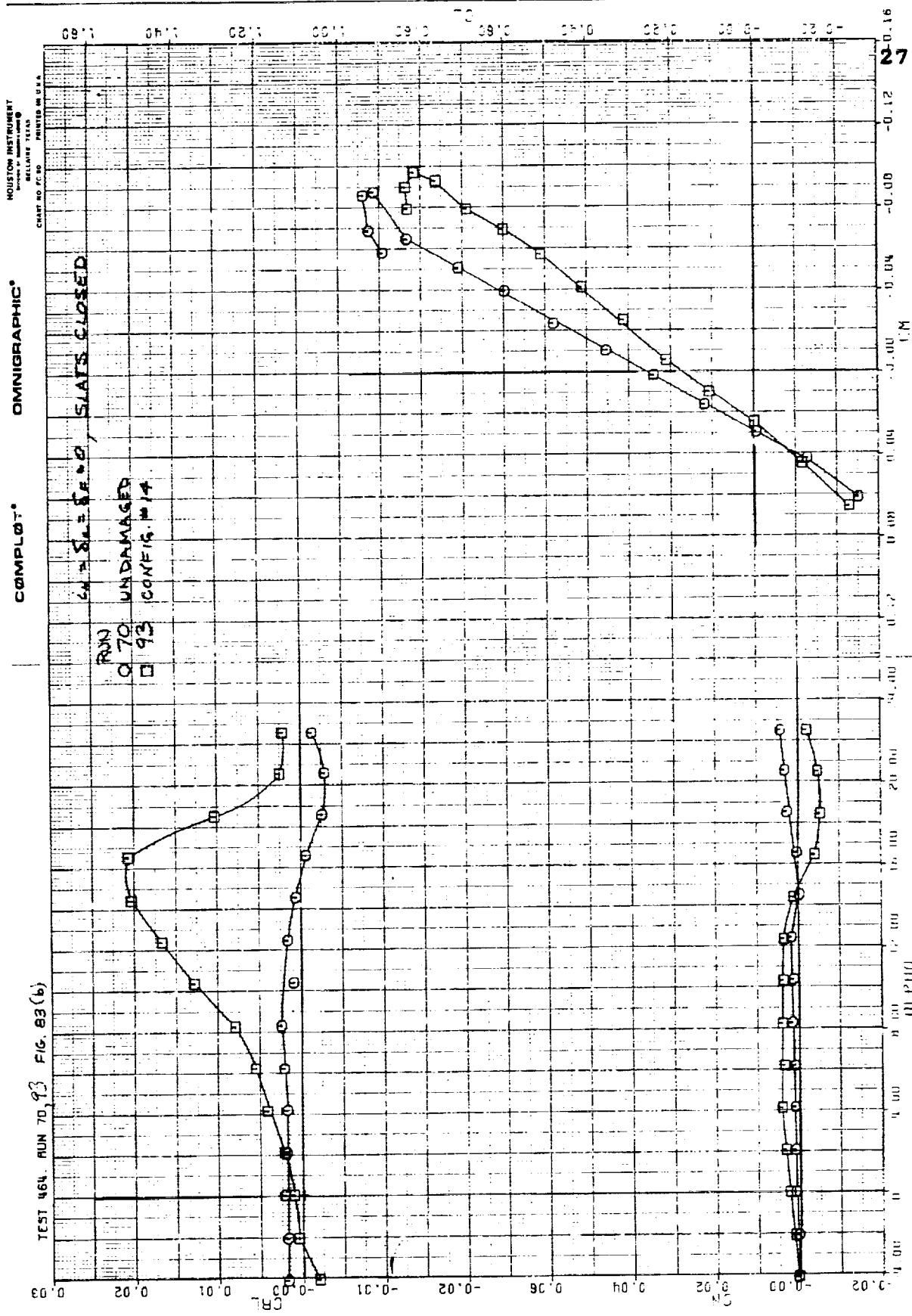


Figure 83(a)



TEST 464, RUN 93,94,95,92, FIG. B4(a)

COMPLOT®

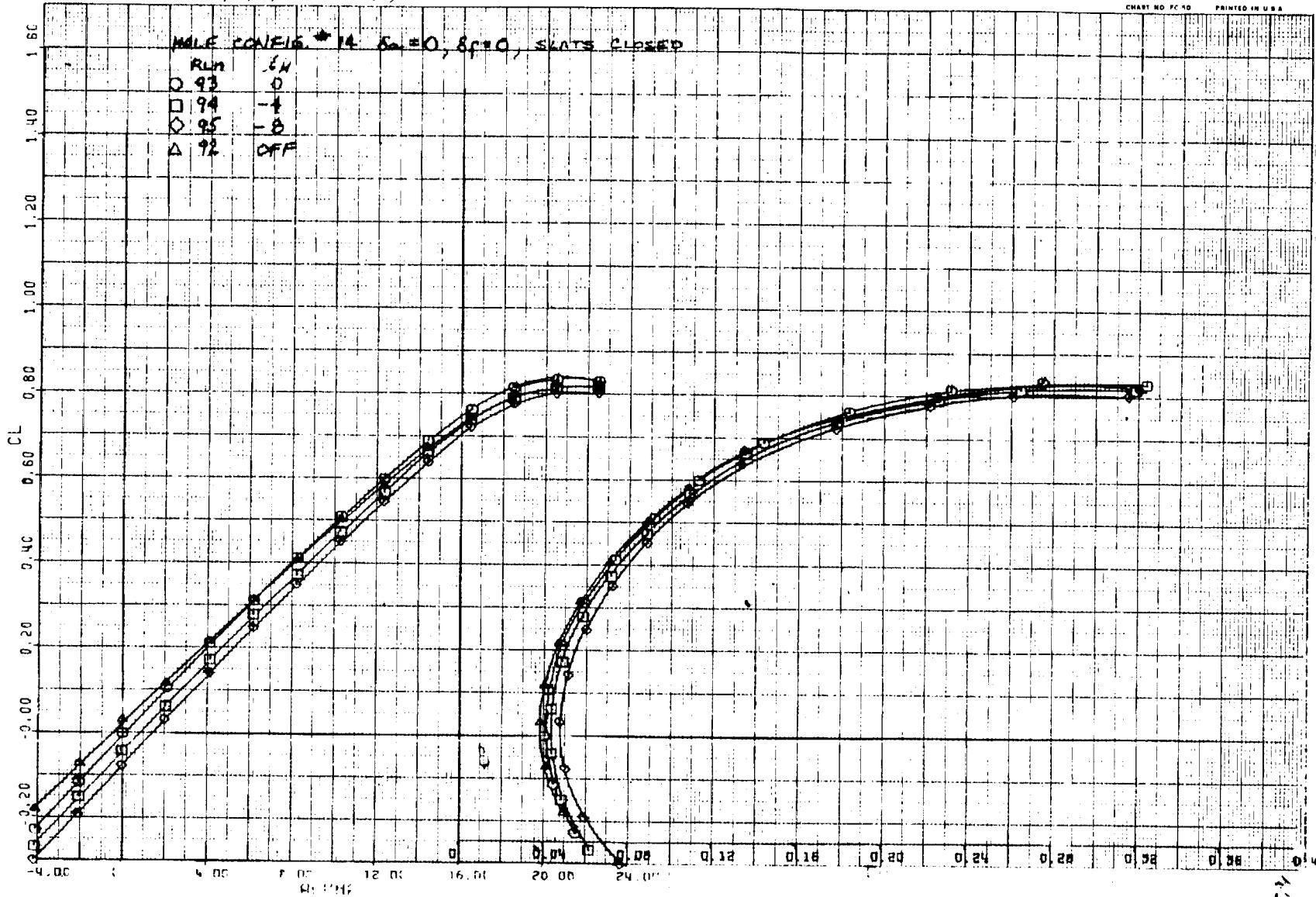
OMNIGRAPHIC®

HOUSTON INSTRUMENT
BY OMNIGRAPHIC
BELLAIR TEXAS

CHART NO FC 40 PRINTED IN U.S.A.

WING CONFIG #14 $\delta_a = 0$, $\delta_r = 0$, SKIDS CLOSED

RUN 64
○ 93 0
□ 94 -4
○ 95 -8
△ 92 OFF



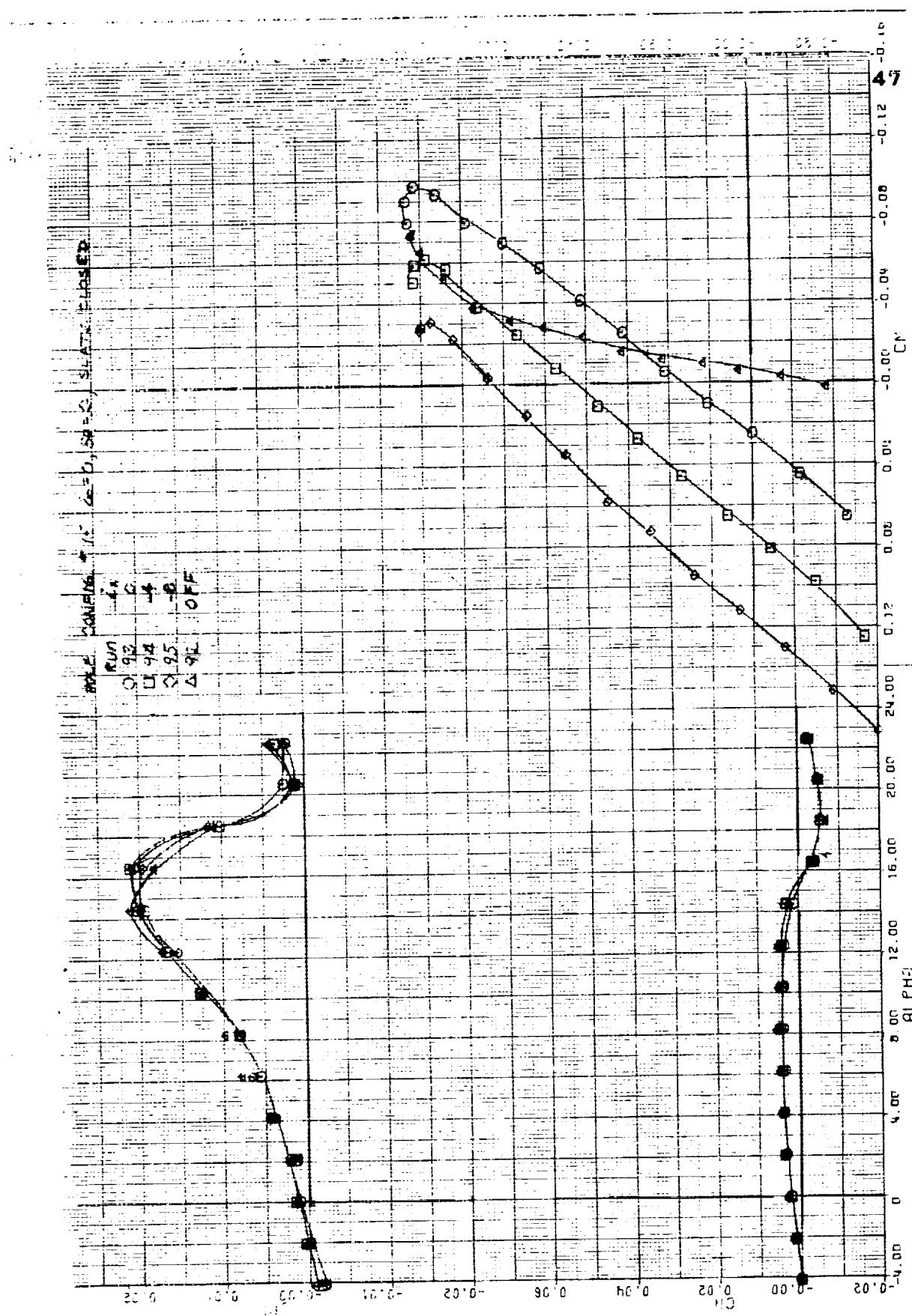


Figure 84(b)

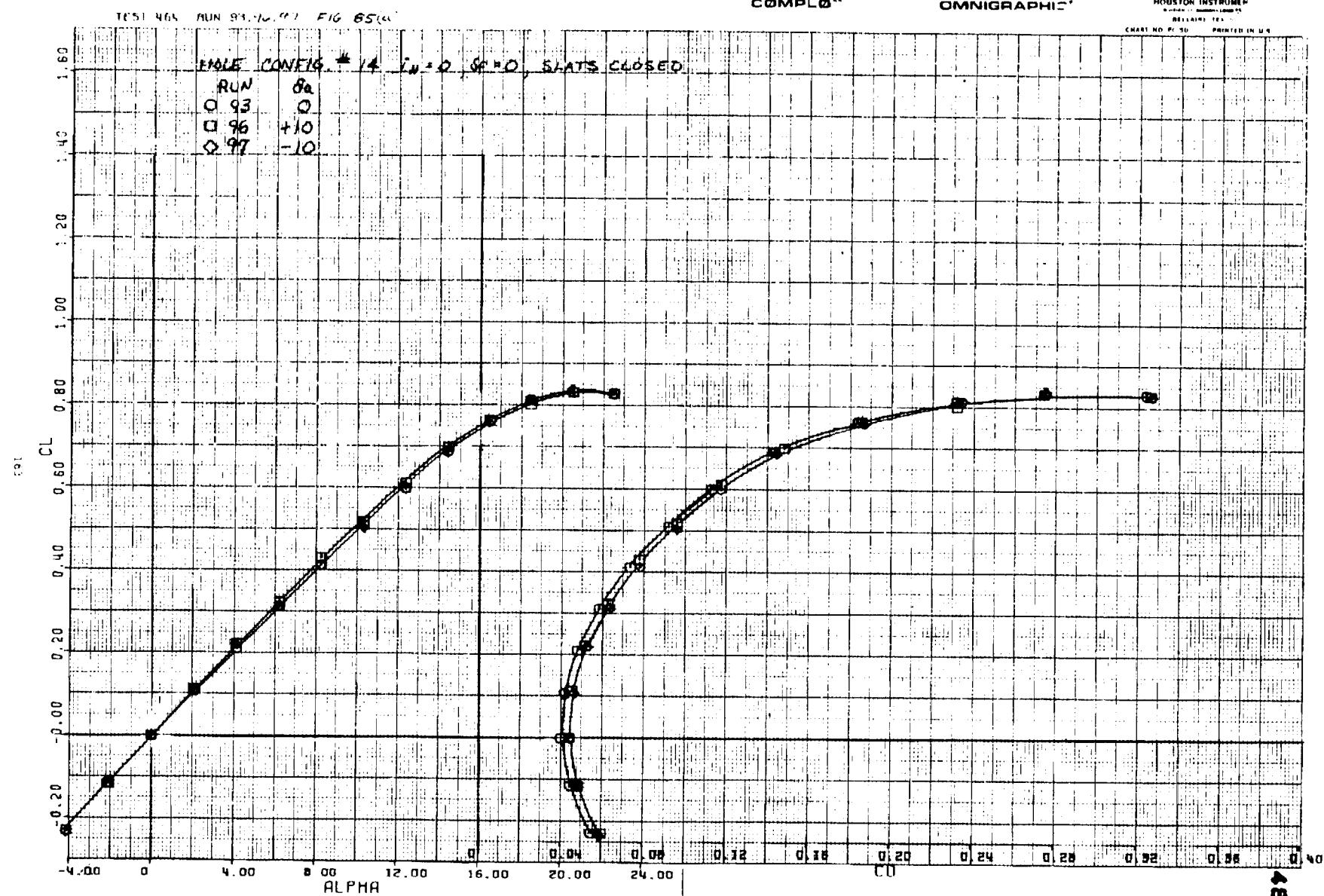


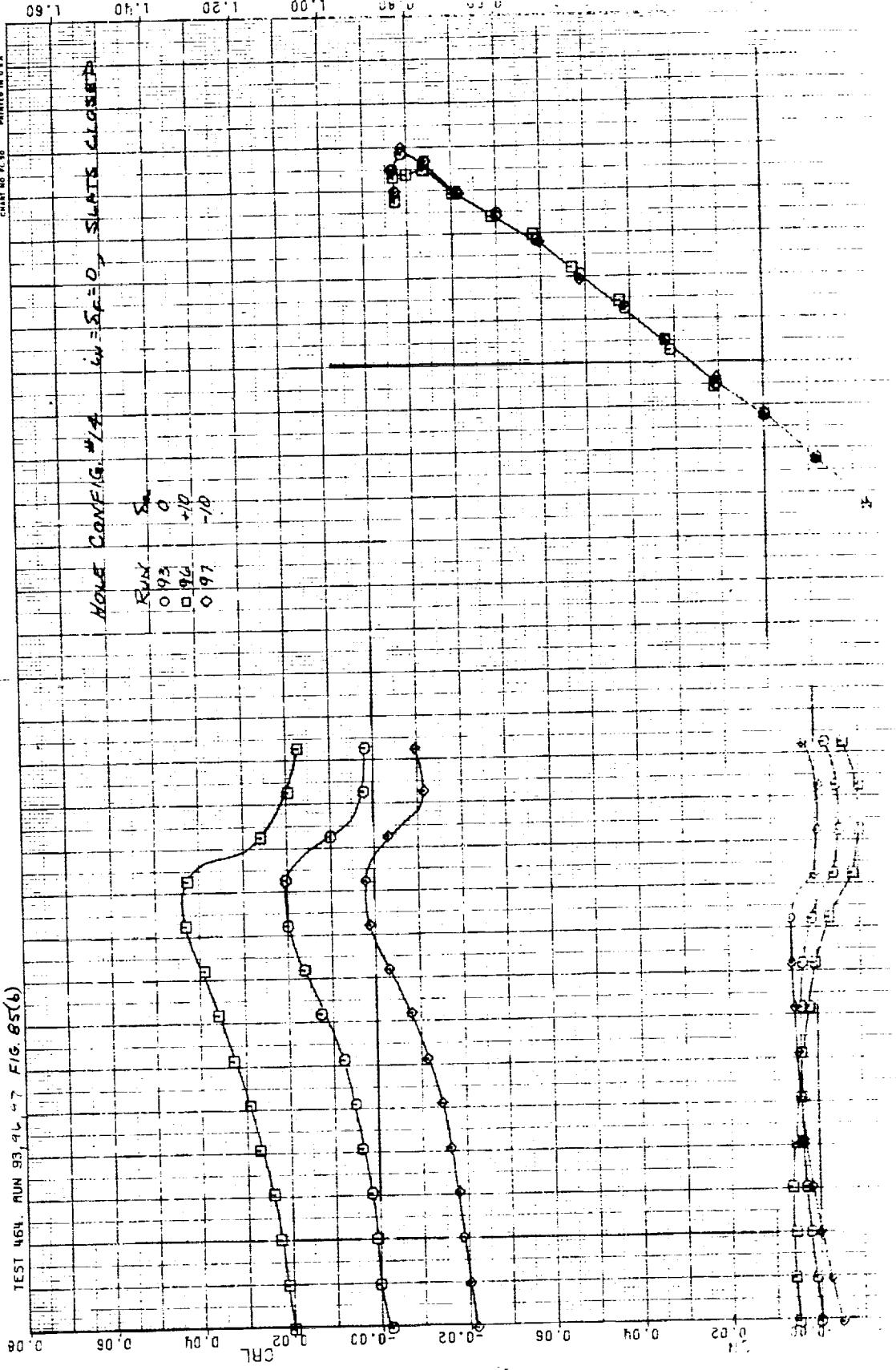
Figure 85(a)

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HOUSTON INSTRUMENT

WILMINGTON, TEXAS

PRINTED IN U.S.A.



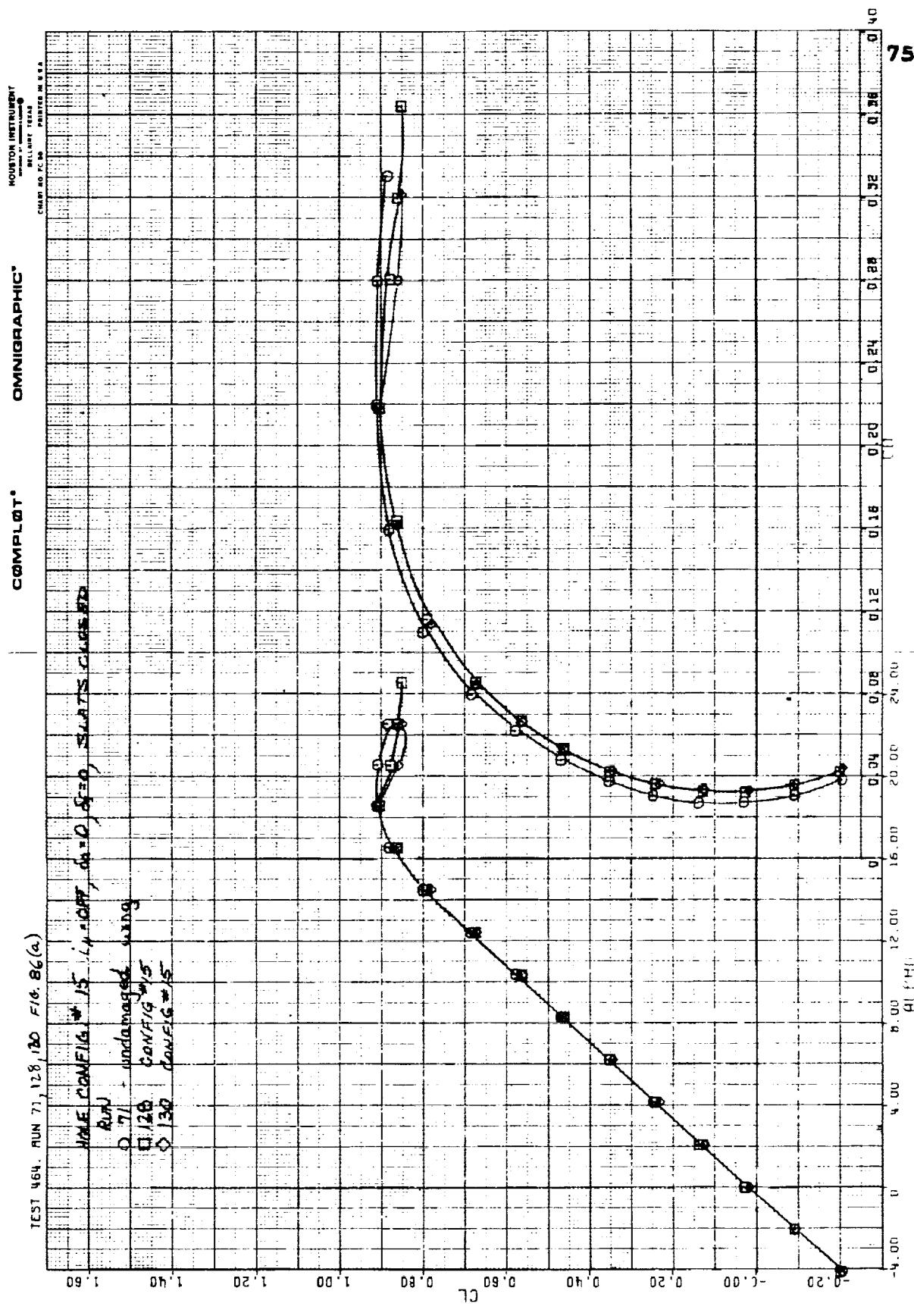
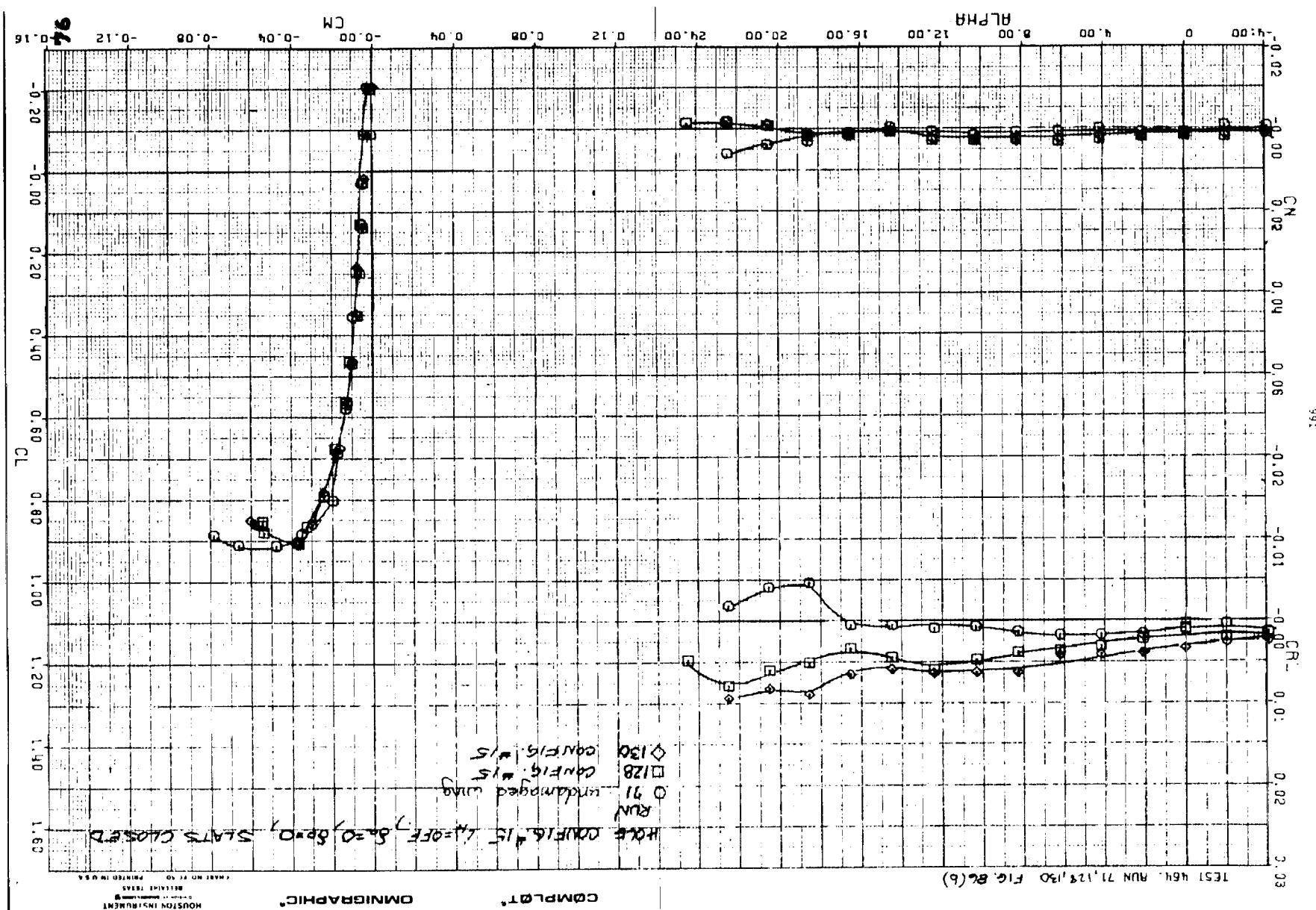


Figure 86(b)



TEST 464. RUN 71, 131, /33 FIG. 87(a)

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OMNIGRAPHIC®

HOUSTON INSTRUMENT
DIVISION OF OMNIGRAPHIC
BELLAIR TEXAS
CHART NO FC 30 PRINTED IN U.S.A.

HOLE CONFIG. #1/16 HOLE OFF, 50%O, 50%O, SLATS CLOSED

RUN

- 71 undamaged wing
- 131 CONFIG #1/16
- ◇ 132 CONFIG #1/16

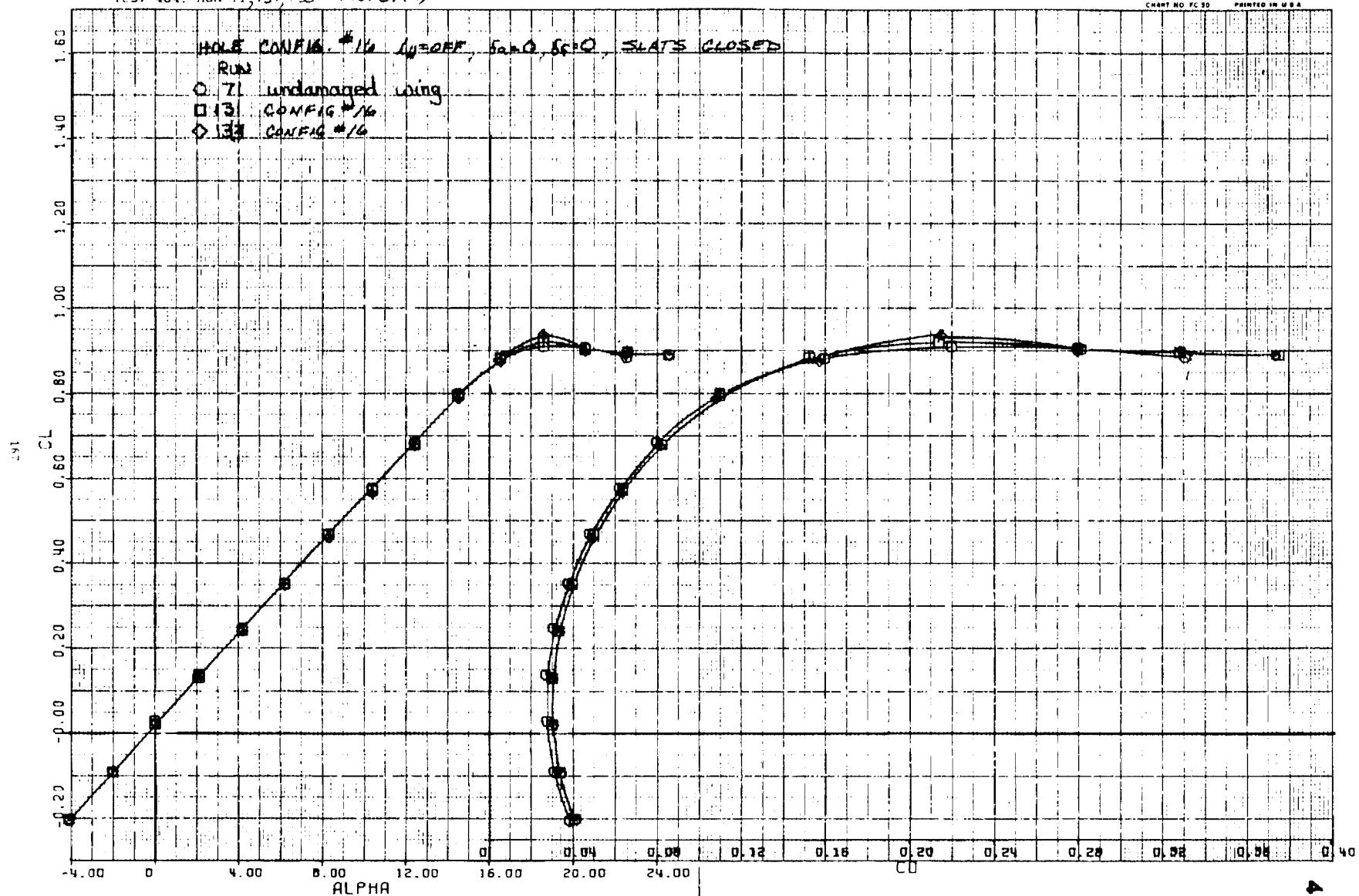


Figure 87(a)

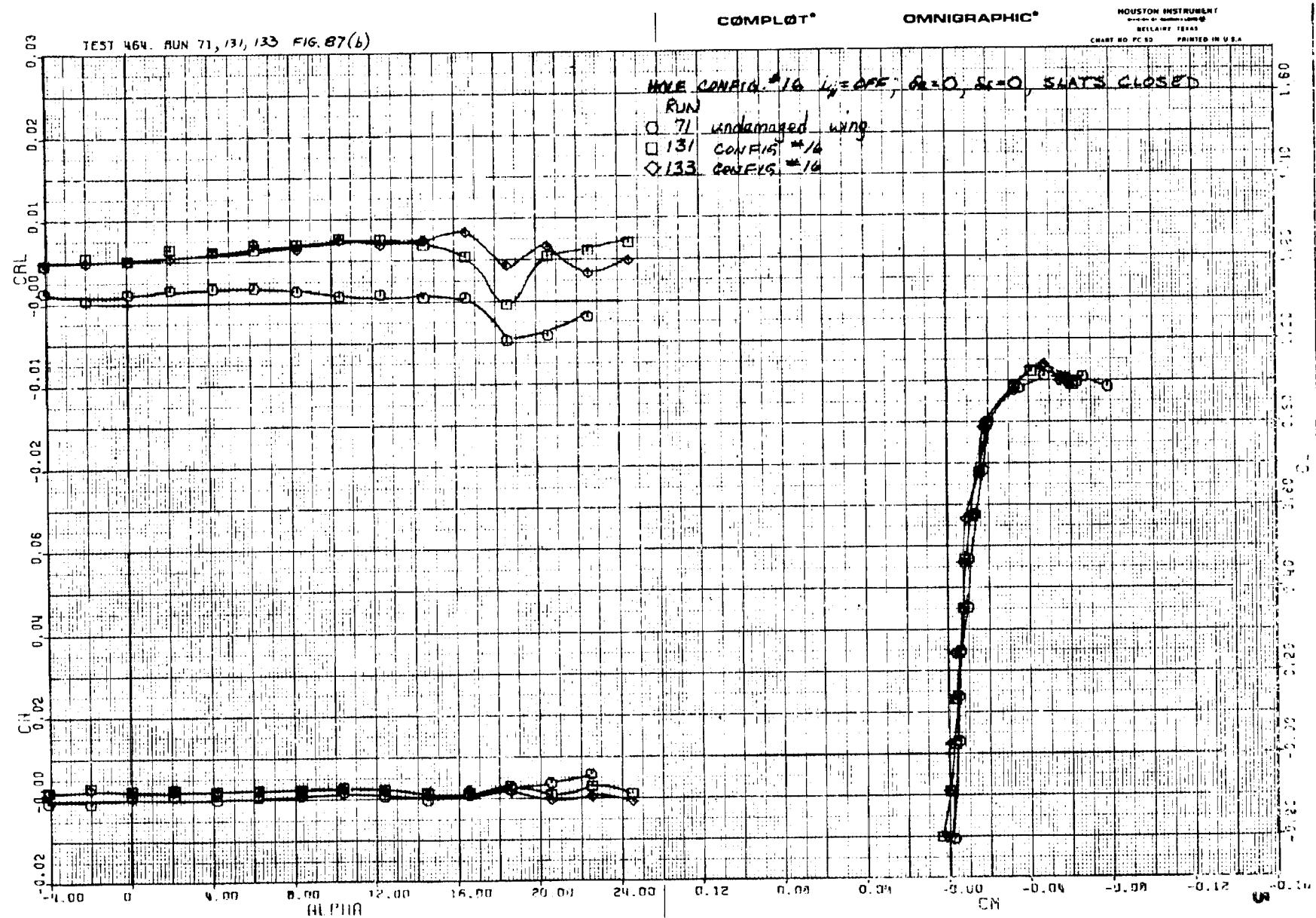
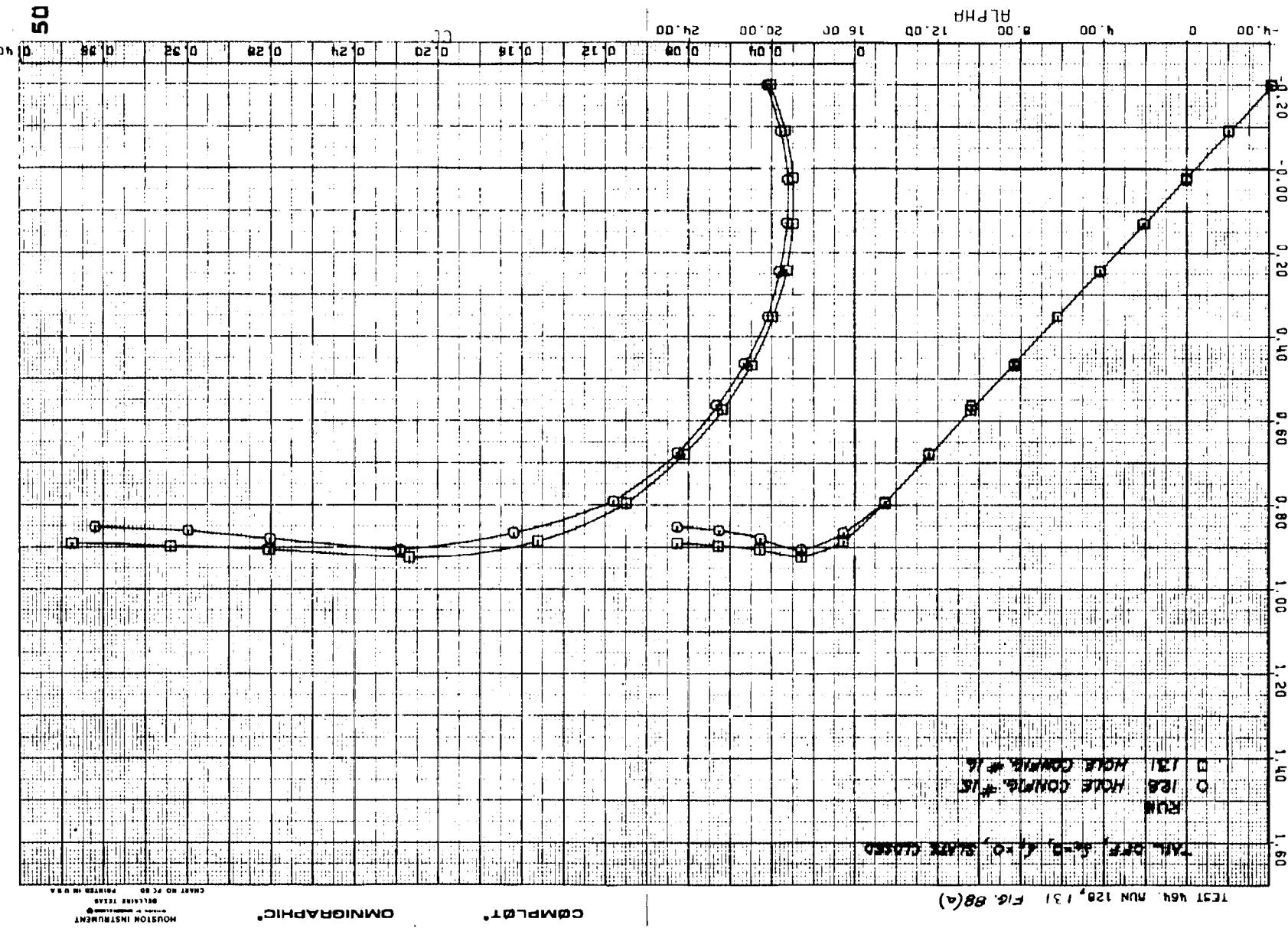


Figure 87(b)

FIGURE 88(a)



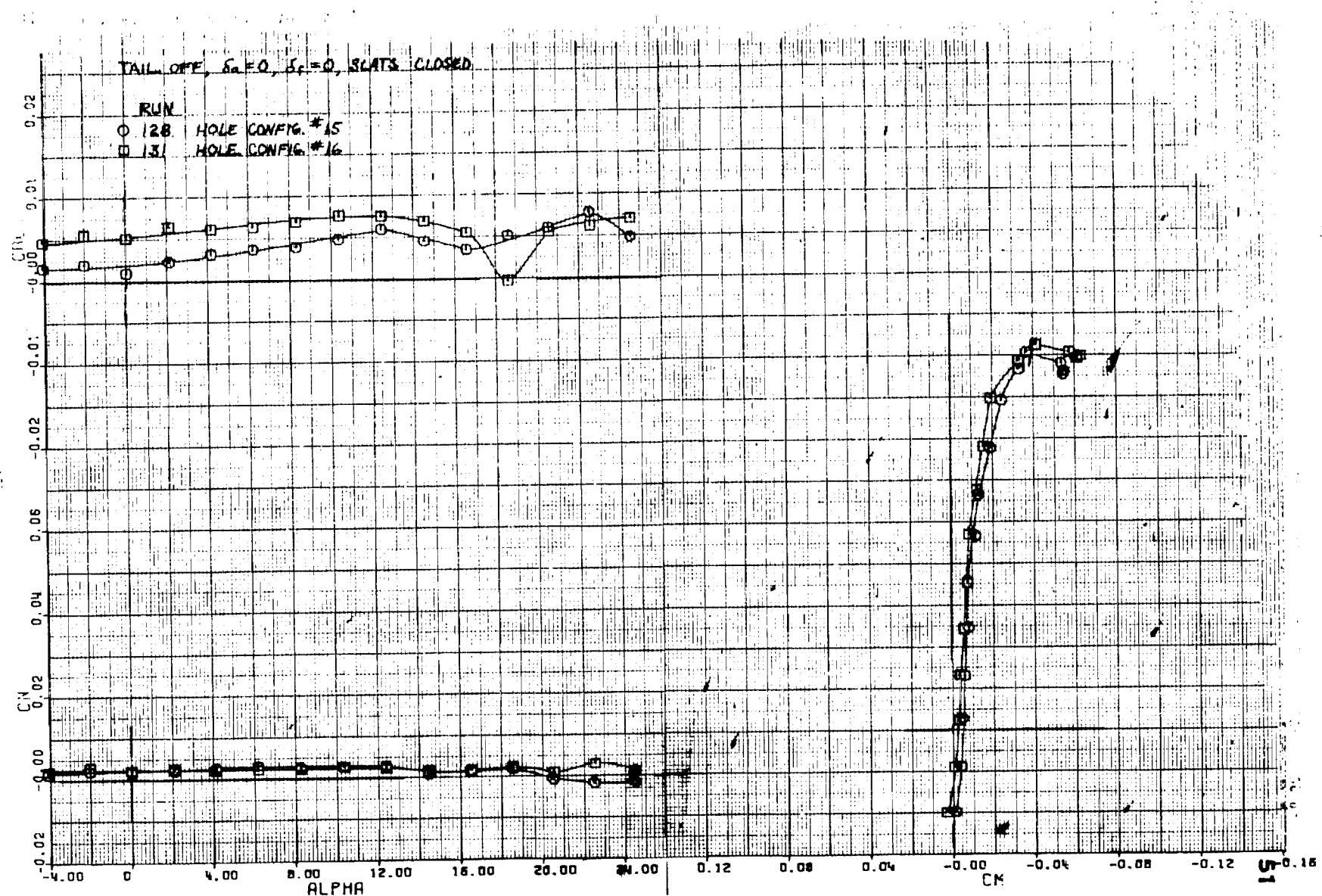


Figure 88(b)