SWT 20-378

TEST OF THE AVCO MODEL WS-133A IN THE 20-INCH SUPERSONIC WIND TUNNEL

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SWT 20-378

TEST OF THE AVCO MODEL WS-133A IN THE 20-INCH SUPERSONIC WIND TUNNEL [U]

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U. S. Government Agencies and Contractors Only

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CONTENTS

		Page
I.	Introduction	1
II.	Model Description	2
III.	Wind Tunnel and Instrumentation	3
IV.	Test Procedure	4
V.	Data Reduction	5
VI.	Results	7
	Nomenclature	9
	Tables	11
	Figures	
	Plots	

TABLES

1.	Average Aerodynamic Parameters	11
2.	Balance Range and Repeatability	12
3.	Coefficient Repeatability	13
4.	Run Summary	14
5.	Center of Gravity Location	22
6.	D Local vs X/D	23

FIGURES

1. Models and Dimensions
2. Transition Grit Strip
3. Pressure Port Numbering System
4. Installation Photographs
5. Six-Component Balance
6. Sign Conventions
7. Multi-Pressure Measuring System (MPMS)
8. Schlieren Photographs of Configuration 1
9. Schlieren Photographs of Configuration 7
10. Schlieren Photographs of Configuration 8
11. Summary Plot

PLOTS

Plot No.*	Ordinate	Abscissa	Configuration**	Mach No.	α (deg)
1	C_N	α	1 through 10	1.48	Variable
2	C_X	↓	↓	↓	↓
3	$C_{m_{cg}}$	↓	↓	↓	↓
4	C_L	↓	↓	↓	↓
5	C_D	↓	↓	↓	↓
6	C_N	↓	↓	2.01	↓
7	C_X	↓	↓	↓	↓
8	$C_{m_{cg}}$	↓	↓	↓	↓
9	C_L	↓	↓	↓	↓
10	C_D	↓	↓	↓	↓
11	C_N	↓	↓	3.01	↓
12	C_X	↓	↓	↓	↓
13	$C_{m_{cg}}$	↓	↓	↓	↓
14	C_L	↓	↓	↓	↓
15	C_D	↓	↓	↓	↓
16	C_N	↓	↓	3.98	↓
17	C_X	↓	↓	↓	↓
18	$C_{m_{cg}}$	↓	↓	↓	↓
19	C_L	↓	↓	↓	↓
20	C_D	↓	↓	↓	↓
21	C_N	↓	↓	4.76	↓
22	C_X	↓	↓	↓	↓
23	$C_{m_{cg}}$	↓	↓	↓	↓

PLOTS (Cont'd)

Plot No.*	Ordinate	Abscissa	Configuration**	Mach No.	α (deg)
24	C_L	α	1 through 10	4.76	Variable
25	C_D	α	1 through 10	4.76	Variable
26	C_N (local)	X/D	1, 8, 10	1.48	4,12,20
27	↓	↓	↓	2.01	↓
28				3.01	
29			1, 8	3.98	
30			1	4.76	

*For Plots 1 through 25, a through d is typical; for Plots 26 through 30, a through c is typical.

**See configuration code in Nomenclature for model composition.

I. INTRODUCTION

At the request of the AVCO Corporation, Wilmington, Massachusetts, a test was performed in the 20-in. Supersonic Wind Tunnel (SWT) at the Jet Propulsion Laboratory (JPL) on a family of MINUTEMAN re-entry vehicle configurations. There were two parts to this program: a pressure test using the multi-pressure measuring system, and a three-component force test using the six-component external balance.

There were several purposes involved in running this test. First, it was desired to obtain surface pressure distribution and three-component static force and moment data for configurations utilizing small bluntness ratios. A button nose spike was substituted for the convential forecone in some runs to determine its effectiveness. Another purpose of this test was an evaluation of the effect of varying certain shape parameters on the static force and moment data. Finally, a cone flare with a truncated rear face was investigated as a possible means of providing controllability.

Data were obtained for both the pressure and force tests at Mach numbers 1.48, 2.01, 3.01, 3.98, and 4.76, through an angle-of-attack range of -4 to +20 deg.

The test[1] was performed during the period from September 18 through September 30, 1959, with Messrs. J.H. Grimes, Jr. and J. Fenske representing the AVCO Corporation.

[1]The notation used in this Report is defined in the Nomenclature.

II. MODEL DESCRIPTION

The three pressure models all had cylindrical bodies and conical flare afterbodies. Model and dimensions are shown in Figs. 1a,b,c,d, and transition grit strip is shown in Fig. 2. One of the configurations, shown in Fig. 3a, had a blunt-nose forecone, and the other two, shown in Fig. 3b, had button-nose spikes replacing the forecone. One of the latter had a fusing package attached to the spike.

The ten force models, with the exception of configurations 6 and 7, had cylindrical bodies and conical flare afterbodies. The conical forebodies used on configurations 1 through 5 had varying bluntness ratios as shown in Figs. 1a and 1b. On configurations 8, 9, and 10, the forecones were replaced by button-nose spikes of different lengths, one having a fusing package attached to the spike. This is shown in Fig. 1c. Both configurations 6 and 7 had conical bodies tapering to blunt noses as shown in Fig. 1d. Configuration 6 had a conical flare afterbody, as did configuration 7, but the latter had a truncated rear face.

Several runs were made with grit strips attached to the noses of the models having forecones to effect boundary-layer transition. No. 40 grit was attached to the 0.005-in. brass shim stock by Epoxy (see Fig. 2).

Figure 4 shows a pressure model and a force model installed in the test section.

III. WIND TUNNEL AND INSTRUMENTATION

Design features of the 20-in. wind tunnel permit its continuous operation in either a variable-density closed circuit or an open circuit. For the present test, it was operated as a closed-circuit tunnel. Any value of test-section Mach number between 1.32 and 5.00 may be set remotely; however, normal operation is restricted to the 19 Mach numbers between 1.32 and 5.00, for which flow survey calibrations have been made. Operation at other than calibrated Mach numbers is based upon interpolated nozzle settings and, in some instances, partial calibrations. At all Mach numbers, the test section is 20 in. high and 18 in. wide. During a given run, the air supply is maintained at a constant temperature and kept normally at a dew point sufficiently low to insure that dew-point effects on the data are negligible. The maximum values of dew point at which data were obtained at each Mach number are given in Table 1.

Test-section flow parameters were determined by using the Mach number, the measured supply-section stagnation pressure and temperature, and the assumption of isentropic flow in the nozzle. Table 1 presents representative values of the test-section flow parameters for Mach numbers at which this test was performed.

Flow in the test section may be observed optically by either the shadowgraph or the schlieren technique.

The six-component hydraulic balance and the model support system used for this test are shown in Fig. 5. The models were sting-supported from the crescent-shaped strut carrier, which may be rotated 30 deg in pitch. The angle-of-attack range was -4 to +20 deg for the

straight sting used in this test. The sting and strut carrier are protected from aerodynamic loads by a windshield which is open to the tank surrounding the balance. Flow between the test section and the balance tank is prevented by evacuating the tank to the model base pressure.

The balance system mechanically separates the model lift, drag, and side force and pitching, rolling, and yawing moments. These forces and moments are sensed by hydraulic load cells and are measured by self-balancing beams. The moments, as measured, are referred to a set of orthogonal axes which intersect at a point that is coincident with the center of rotation of the support system and the centerline of the test-section windows.

Based upon the range and repeatability of the balance shown in Table 2 and observation of the test data, the coefficient repeatability is shown in Table 3.

To measure pressures, the Multi-Pressure Measuring System (MPMS) was used with a 15-psi transducer which has an accuracy of ±2 mm.

IV. TEST PROCEDURE

Prior to actual test operations, measurements were made to determine the position of the model, the deflection constants, and the balance tares, as described in Section V.

During test operations, the balance-tank pressure was maintained equal to the model base pressure, and data points were obtained at successive values of angle of attack. The stagnation pressure and model base pressure were recorded for all data points, and the

stagnation and dew-point temperatures were read at least once each run.

Balance readings were plotted vs angle of attack, and any data which appeared questionable were checked before the conclusion of the run; but even if all of the data appeared to be correct, at least one point from each run was checked.

Figure 6 shows the sign conventions used for this test.

Model surface pressures were measured on the MPMS shown in Fig. 7.

Schlieren photographs were made at 0, 4, 12, and 20 deg angle of attack. Figures 8, 9, and 10 are schlieren photographs showing airflow structure.

The test was conducted in the order shown in Table 4.

V. DATA REDUCTION

The force and moment data were reduced to dimensionless coefficients in coordinates specified by the AVCO Corporation, defined as follows:

Wind Axis	Body Axis
$C_L = \frac{L}{q_\infty S}$	$C_N = \frac{N}{q_\infty S}$
$C_D = \frac{\bar{D}}{q_\infty S}$	$C_X = \frac{\bar{X}}{q_\infty S}$
$C_{m_{cg}} = \frac{m}{q_\infty S D}$	$C_{m_{cg}} = \frac{m}{q_\infty S D}$

where

S = reference cross-sectional area:

for configurations 6 and 7, $S = 5.354\ in.^2$

for all others, $S = 2.491\ in.^2$

D = reference diameter:

for configurations 6 and 7, $D = 2.611$ in.

for all others, $D = 1.781$ in.

and the point about which moments are measured is the defined center of gravity (cg) located on the fuselage centerline X_{cg} in. (see Table 5) forward of the model base.

Lift force, L (lb), is positive up, perpendicular to the tunnel longitudinal axis, and perpendicular to the tunnel lateral axis. Drag force, $\bar{D}$ (lb), is positive in the aft direction and parallel to the tunnel longitudinal axis. Normal force, N (lb), is positive up, perpendicular to the model longitudinal axis and perpendicular to the tunnel lateral axis (since roll angle = constant = 0). Axial force, X (lb), is positive in aft direction parallel to model longitudinal axis. Pitching moment, m (in.-lb), is positive nose up and is measured in the tunnel (and model) vertical plane of symmetry ($\varphi = 0$) about the model center of gravity.

The pressure data were reduced to the following pressure coefficients as specified by the AVCO Manufacturing Corporation:

$$C_p = \frac{p - p_\infty}{q_\infty}$$

$$C_{N_L} = \frac{D_L}{S}\left\{\frac{\pi}{2}\left[0.25\left(C_{p_{180°}} - C_{p_{0°}}\right) + 0.3535\left(C_{p_{135°}} - C_{p_{45°}}\right)\right]\right\}$$

where p is static pressure measured at body surface orifices (see Figs. 3a and b); p_∞ and q_∞ (free-stream static and dynamic pressures) are calculated as functions of Mach number and tunnel supply pressure. The local model diameter, D_L, at the orifices vs X/D is given in Table 6.

The coefficients were obtained on an electronic digital computer from the balance data by means of a standardized series of formulae.[2] For this process, measurements were made to determine the position of the model relative to the balance-system orgin. Loads were then applied to the model which simulated the loads expected during the test, and the angular and lateral deflections were measured. Linear expressions derived from these measurements were used to determine the actual position and attitude of the model for each test point, and corrections were applied to the data to compensate for these deviations from the undeflected model settings.

Static tares, produced by unbalanced weight in the system with no air flow through the test section, were evaluated by setting the model to the attitudes to be used during the test and recording the balance readings obtained during the test.

VI. RESULTS

Plot series 1 through 30 give the results of this test.

Plots 1 through 25 present stability and control effectiveness information for the re-entry models tested. These force and moment

[2] Equations for Wind-Tunnel Force-Data Reduction, Internal Memorandum SWT G-T3. Jet Propulsion Laboratory, Pasadena, California, April 19, 1957.

coefficients are not corrected for base pressure. The same coefficients corrected for base pressure have been computed, tabulated, and sent to the AVCO Corporation.

Plots 26 through 30 have local normal force coefficients plotted against dimensionless axial distance at angles of attack of 4, 12, and 20 deg, only as requested by the contractor. Local normal force coefficients for other angles of attack have been tabulated. Pressure coefficients have been tabulated but not plotted.

Pressure runs of configurations 8 and 10 at Mach numbers 3.98 and 4.76 were no good due to a pressure level shift in the MPMS. The shift was corrected, and configuration 8 was rerun at Mach 3.98. There was insufficient time to repeat the other three runs.

Since it was suspected that some pressure tubes may have been pinched in the button nose spike, a leak check was conducted at the conclusion of the test. The following tubes were found to be leaking: Tube No. 2 at the rate of 10 mm Hg/min; tube No. 4 at the rate of 20 mm Hg/min; and tube No. 7 at the rate of 10 mm Hg/min.

Figures 11a and b summarize and verify the consistency of the test data.

It was discovered after the data had been plotted that the external balance was reading in error during the test. The error in drag reading amounted to 0.5%, which is quite small. The lift was in error by a negative 0.2 lb, and the pitching moment by a positive 0.7 in.-lb. This should not affect the slope of the stability curves at all, since it means only a displacement of the curves.

NOMENCLATURE

Data Reduction

C_D = drag coefficient

C_L = lift coefficient

C_{L_α} = slope of lift vs angle of attack

$C_{m_{cg}}$ = pitching moment coefficient about model cg

C_N = normal force coefficient

C_{N_L} = local normal force coefficient

C_p = pressure coefficient

C_X = axial force coefficient

D = reference diameter of model

$\bar{D}$ = drag (lb)

D_L = local model diameter

L = lift (lb)

m = pitching moment about model cg, nose up (in.-lb)

M = Mach number; ratio of local velocity to local sound velocity

N = normal force (lb)

P = local pressure (psi)

P_t = tunnel total pressure

P_∞ = tunnel free-stream static pressure

q_∞ = tunnel free-stream dynamic pressure

S = reference area of model

X_{cg} = model cg measured from base of model (in.)

X = axial distance from nose of model

$\bar{X}$ = axial force (lb)

NOMENCLATURE (Cont'd)

α = model angle of attack, nose up (deg)

φ = model roll angle, right side down (deg)

Configuration Code	Composition	
1	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.277}$	
2	$N^{22.5}_{0.26}\ B^{0.5}\ F^{15}_{1.277}$	
3	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.866}$	(extended flare)
4	$N^{22.5}_{0.8}\ B^{1.0}\ F^{15}_{1.277}$	
5	$N^{22.5}_{0}\ B^{1.0}\ F^{15}_{1.277}$	
6	$N^{10}_{0.33}\ F^{20}_{0.205}$	
7	$N^{10}_{0.33}\ F^{20T}_{0.205}$	(truncated rear face)
8	$S_1\ B^{1.0}\ F^{15}_{1.277}$	(long nose spike)
9	$S_2\ B^{1.0}\ F^{15}_{1.277}$	(short nose spike)
10	$S_3\ B^{1.0}\ F^{15}_{1.77}$	(long nose spike with fusing package)

Configuration Notation

S_n = button nose spike; n corresponds to spike configuration

N^n_m = nose cone; n corresponds to cone half-angle; m corresponds to ratio of nose radius to radius of cylindrical body

B^n = cylindrical body; n corresponds to ratio of cylinder length to cylinder diameter

F^n_m = flare; n corresponds to flare angle (cone frustum vertex half angle); m corresponds to ratio of flare length to cylinder length (except for configurations 6 and 7, where m is ratio of flare length to maximum nose diameter)

TABLE 1. AVERAGE AERODYNAMIC PARAMETERS

Parameter	Mach Number				
	1.48	2.01	3.01	3.98	4.76
Static pressure (psia)	6.20	3.01	0.77	0.33	0.16
Stagnation pressure (psia)	22.14	24.07	28.89	49.11	63.55
Dynamic pressure (psia)	9.52	8.55	4.91	3.66	2.53
Reynolds number (per in. x 10^{-6})	0.513	0.515	0.335	0.340	0.293
Maximum dew point (°F)	0	-20	0	+10	+10
Mach-number variation along centerline	+0.005 -0.006	+0.004 -0.004	+0.003 -0.004	+0.005 -0.006	+0.004 -0.008
Maximum flow-angle variation along centerline (deg)	+0.13 -0.09	+0.08 -0.11	+0.08 -0.03	+0.13 -0.01	-0.01 -0.07
Maximum pressure variation along centerline ($\Delta p/p$)	0.009	0.006	0.006	0.007	0.010

[redacted]

TABLE 2. BALANCE RANGE AND REPEATABILITY

Component	Low Range			High Range		
	Maximum Positive	Maximum Negative	Repeat-ability	Maximum Positive	Maximum Negative	Repeat-ability
Lift (lb)	52	12	±0.05	320	120	±0.2
Drag (lb)	25	20	±0.05	225	325	±0.2
Side force (lb)	30	30	±0.05	30	100	±0.2
Pitching moment (in.-lb)	325	425	±0.50	3500	1100	±2.0
Yawing moment (in.-lb)	200	440	±0.50	1800	2500	±2.0
Rolling moment (in.-lb)	440	200	±0.50	2800	2000	±2.0

[redacted]

TABLE 3. COEFFICIENT REPEATABILITY

Mach No.	Coefficient*				
	C_N	C_X	$C_{M_{cg}}$	C_L	C_D
1.48	0.003	0.005	0.01	0.003	0.005
2.01	0.003	0.004	0.01	0.003	0.004
3.01	0.004	0.006	0.02	0.004	0.006
3.98	0.006	0.006	0.03	0.006	0.006
4.76	0.008	0.008	0.04	0.008	0.008

*Based upon the following reference area and length: S = 2.491 $in.^2$, and d = 1.781 in.

TABLE 4. RUN SUMMARY
A. Pressure Test

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
	1								
9-18	2	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	001	3.01	E		X		
	3		101	3.01	D	X			
	4		101	2.01	D	X			
	5		001	2.01	E		X		
9-19	6		001	4.76	E		X		
	7		101	4.76	D	X			
	8		101	3.98	D	X			
	9		001	3.98	E		X		
	10		001	1.48	E		X		
	11		101	1.48	D	X			
9-21	12	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008	4.76			X		No good
	13	$S_3\ B^{1.0}\ F_{1.277}^{15}$	010	4.76					No good
	14	$S_3\ B^{1.0}\ F_{1.277}^{15}$	010	3.98					No good
	15	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008	3.98					No good
	16	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008	3.01					
	17	$S_3\ B^{1.0}\ F_{1.277}^{15}$	010	3.01					

TABLE 4-A. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-21	18	$S_1\ B^{1.0}\ F^{15}_{1.277}$	008	3.98	D		X		Rerun of 15
↓	19	$S_1\ B^{1.0}\ F^{15}_{1.277}$	008	2.01	↓		↓		P_t = 93 cm
	20	$S_3\ B^{1.0}\ F^{15}_{1.277}$	010	2.01					
	21	$S_3\ B^{1.0}\ F^{15}_{1.277}$	010	1.48					
	22	$S_1\ B^{1.0}\ F^{15}_{1.277}$	008	1.48					

B. Force Test

9-21	23	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.277}$	101						Static tare
9-22	24	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.277}$	101	4.76	D	X			No data taken
9-23	25	$N^{10}_{0.33}\ F^{20}_{0.205}$	006						Static tare; no good
↓	26	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.277}$	101	4.76	D	X		1	
	27	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.277}$	001	4.76	D		X	1	

[redacted]

TABLE 4-B. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9 23	28	$N_{0.26}^{22.5}\ B^{0.5}\ F_{1.277}^{15}$	102	4.76	E	X		1	
	29	$N_{0.8}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	104					1	
	30	$N_{0}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	105					1	
	31	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008				X	3	
	32	$N_{0.33}^{10}\ F_{0.205}^{20}$	006					4	
	33	$S_2\ B^{1.0}\ F_{1.277}^{15}$	009					3	
	34	$N_{0.33}^{10}\ F_{0.205}^{20T}$	007					4	
	35	$S_3\ B^{1.0}\ F_{1.277}^{15}$	010					3	
	36	$N_{0.33}^{10}\ F_{0.205}^{20T}$	007					4	φ = 90 deg
	37	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.866}^{15}$	103			X		2	

[redacted]

TABLE 4-B. (Cont'd)
(Re-Zero Drag at -15 Low Range)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-23	38	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.866}^{15}$	103	3.01	E	X		2	
	39	$N_{0.33}^{10}\ F_{0.205}^{20T}$	007				X	4	φ = 90 deg
	40	$S_3\ B^{1.0}\ F_{1.277}^{15}$	010					3	
	41	$N_{0.33}^{10}\ F_{0.205}^{20T}$	007					4	
	42	$S_2\ B^{1.0}\ F_{1.277}^{15}$	009					3	
	43	$N_{0.33}^{10}\ F_{0.205}^{20}$	006					4	
	44	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008						Static tare
	45	$N_{33}^{10}\ F_{0.205}^{20}$	006						
	46	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.866}^{15}$	003						
	47	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	101						
	48	$S_1\ B^{1.0}\ F_{1.277}^{15}$	008	3.01	E		X	3	

[redacted]

TABLE 4-B. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-23	49	$N_{0}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	105	3.01	E	X		1	
9-28	50	$N_{0.8}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	104	↓	↓	↓		↓	
↓	51	$N_{0.26}^{22.5}\ B^{0.5}\ F_{1.277}^{15}$	102		↓				
	52	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	101		D	↓			
	53	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	001		D		X		
(Re-Zero Drag at -40 Low Range)									
9-28	54	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	001	2.01	D		X	1	
↓	55	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	101	↓	D	X		↓	
	56	$N_{0.26}^{22.5}\ B^{0.5}\ F_{1.277}^{15}$	002		E		X		
	57	$N_{0.8}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	004		↓		↓		
	58	$N_{0}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	005					↓	
	59	$S_{1}\ B^{1.0}\ F_{1.277}^{15}$	008					3	

[redacted]

TABLE 4-B. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-28	60	$N^{10}_{0.33}\ F^{20}_{0.205}$	006	2.01	E		X	4	
9-28	61	$S_2\ B^{1.0}\ F^{15}_{1.277}$	009					3	
9-29	62	$N^{10}_{0.33}\ F^{20T}_{0.205}$	007					4	
	63	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.866}$	003					2	
	64	$N^{10}_{0.33}\ F^{20T}_{0.205}$	007					4	φ = 90 deg
	65	$N^{10}_{0.33}\ F^{20T}_{0.205}$	007	1.48				4	φ = 90 deg
	66	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.866}$	003					2	
	67	$S_3\ B^{1.0}\ F^{15}_{1.277}$	010					3	
	68	$N^{10}_{0.33}\ F^{15}_{0.205}$	007					4	
	69	$S_2\ B^{1.0}\ F^{15}_{1.277}$	009					3	
	70	$N^{10}_{0.33}\ F^{20}_{0.205}$	006					4	
	71	$S_1\ B^{1.0}\ F^{15}_{1.277}$	008					3	

[redacted]

TABLE 4-B. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-29	72	$N_{0}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	005	1.48	E		X	1	
	73	$N_{0.8}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	004						
	74	$N_{0.26}^{22.5}\ B^{0.5}\ F_{1.277}^{15}$	002						
	75	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	001		D				
	76	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	101			X			
	77	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	001	3.98			X		
	78	$N_{0.26}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	101			X			
	79	$N_{0.26}^{22.5}\ B^{0.5}\ F_{1.277}^{15}$	102		E				
	80	$N_{0.8}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	104						
	81	$N_{0}^{22.5}\ B^{1.0}\ F_{1.277}^{15}$	105						
	82	$S_{1}\ B^{1.0}\ F_{1.277}^{15}$	008				X	3	
	83	$N_{0.33}^{10}\ F_{0.205}^{20}$	006				X	4	

[redacted]

[redacted]

TABLE 4-B. (Cont'd)

Date (1959)	Run	Configuration	Code	Mach	α (deg)	Grit On	Grit Off	Tare	Remarks
9-29	84	$S_2\ B^{1.0}\ F^{15}_{1.277}$	009	3.98	E		X		
9-29	85	$N^{10}_{0.33}\ F^{20T}_{0.205}$	007	↓	↓		↓	4	
9-30	86	$N^{10}_{0.33}\ F^{20T}_{0.205}$	007					4	φ = 90 deg
9-30	87	$N^{22.5}_{0.26}\ B^{1.0}\ F^{15}_{1.866}$	103			X		2	

Pressure Test Runs 1 through 22:

α Schedule D: α = -4, -2, 0, 2, 4, 6, 8, 12, 16, 20 deg
α Schedule E: α = -4, 0, 2, 4, 8, 12, 16, 20 deg

Force Test Runs 23 through 87:

α Schedule D: α = -4, -2, 0, 2, 4, 6, 8, 12, 16, 20 deg
α Schedule E: α = -4, 0, 2, 4, 8, 12, 16, 20 deg

P_t = maximum, where not specified

[redacted]

TABLE 5. CENTER OF GRAVITY LOCATION (cg)

Configuration	X_{cg} (in.)
1	2.274
2	2.274
3	3.323
4	2.274
5	2.274
6	5.868
7	5.868
8	2.274
9	↓
10	

TABLE 6. D Local vs X/D

A. Configuration $N_{0.26}^{22.5}$ $B^{1.0}$ $F_{1.277}^{15}$

Tap Number	X/L	X/D	D_L
1, 6, 13, 18	0.0249	0.0814	0.432
2, 7, 14, 19	0.0844	0.2762	0.720
3, 8, 11, 15, 20	0.1440	0.4711	1.008
4, 9, 16, 21	0.2037	0.6665	1.396
5, 10, 12, 17, 22	0.2635	0.8619	1.684
23, 32, 41, 46, 55	0.3776	1.2353	1.781
24, 33, 47, 56	0.4377	1.4318	↓
25, 34, 48, 57	0.4978	1.6283	
26, 35, 42, 49,58	0.5578	1.8248	
27, 36, 43, 50, 59	0.6512	2.130	1.910
28, 37, 51, 60	0.7339	2.401	2.169
29, 38, 44, 52, 61	0.8168	2.672	2.428
30, 39, 53, 62	0.8997	2.943	2.687
31, 40, 45, 54, 63	0.9562	3.128	2.863

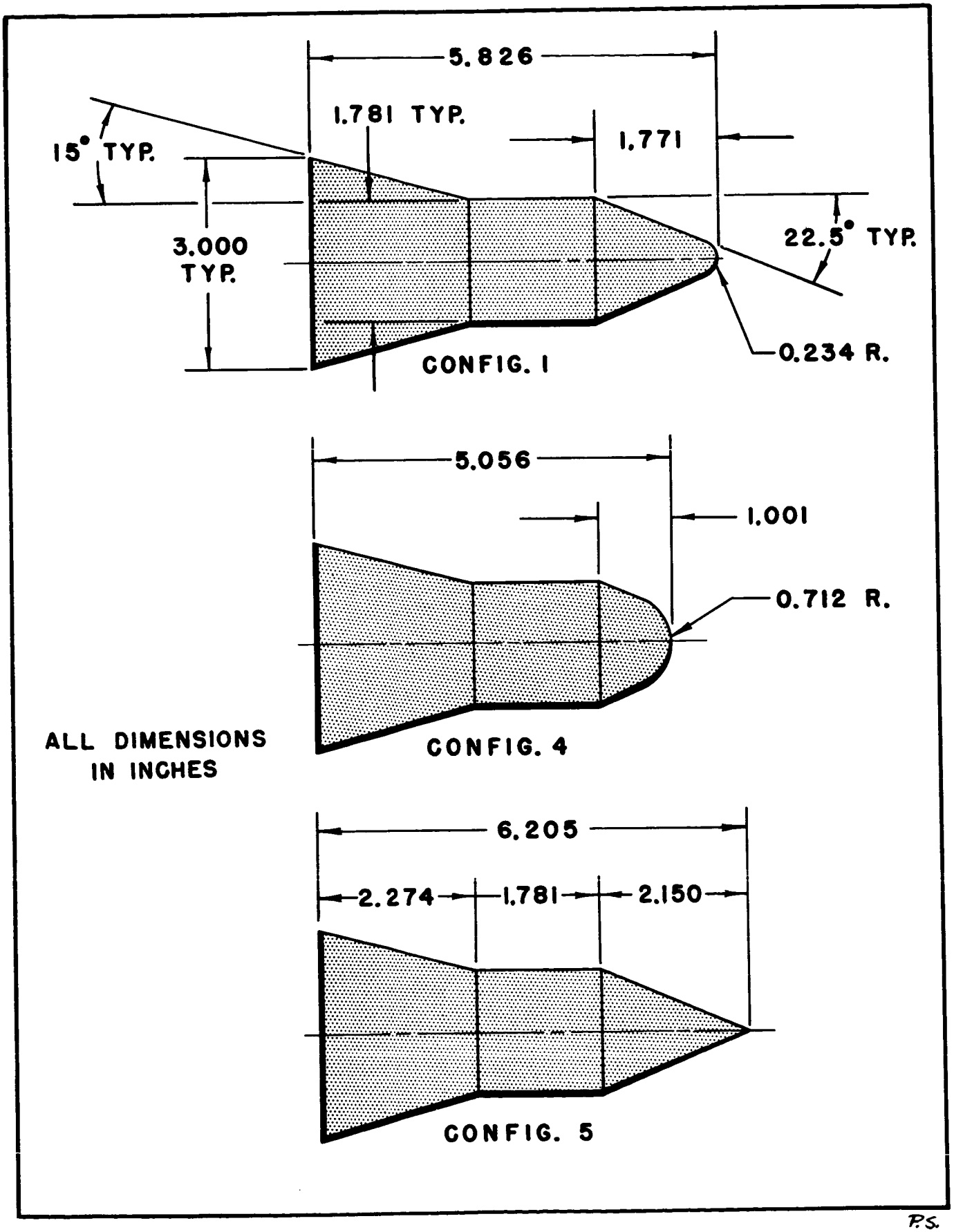
B. Configuration S_1 $B^{1.0}$ $F_{1.277}^{15}$

1*	-	-	-
2*	0.0675	0.2207	0.250
3*	0.1104	0.3610	↓
4*	0.1533	0.5014	

TABLE 6-B. (Cont'd)

Tap Number	X/L	X/D	D_L
5*	0.1962	0.6418	0.250
6*	0.2391	0.7821	↓
7*	0.2820	0.9225	↓
8* through 22**	0.3040	0.9944	1.781

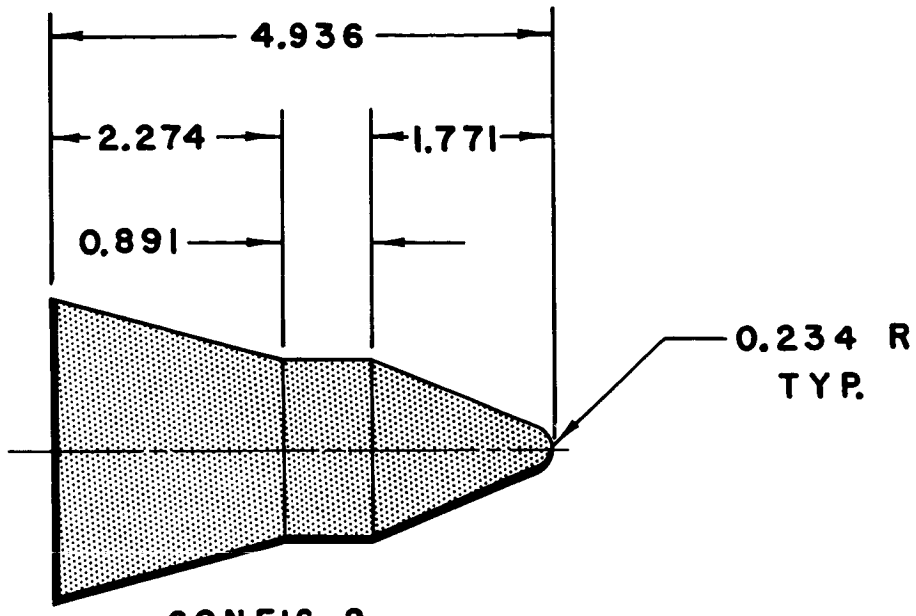
* Taps along cylinder of spike.
** Remainder, same as above (Table 6-A).



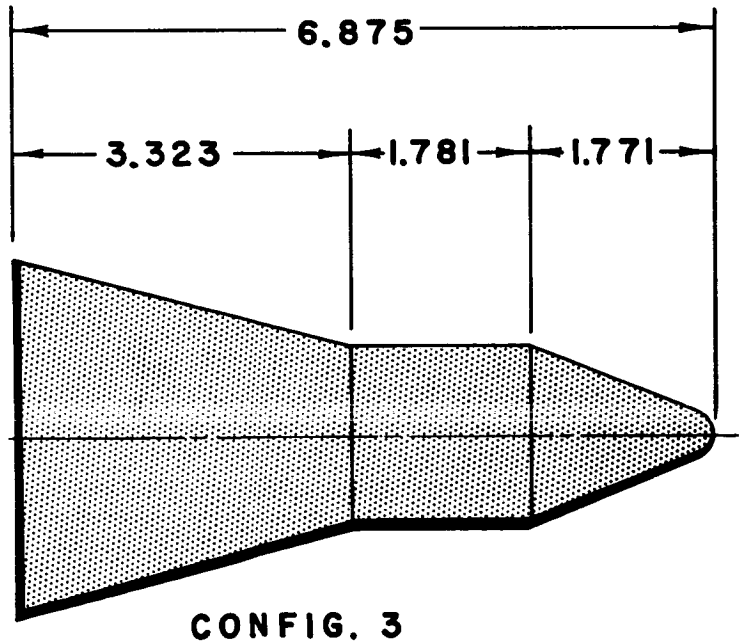
P.S.

FIGURE 1a. [redacted]

MODELS AND DIMENSIONS



CONFIG. 2



CONFIG. 3

ALL DIMENSIONS IN INCHES

P.S.

FIGURE 1b.

[redacted]

MODELS AND DIMENSIONS

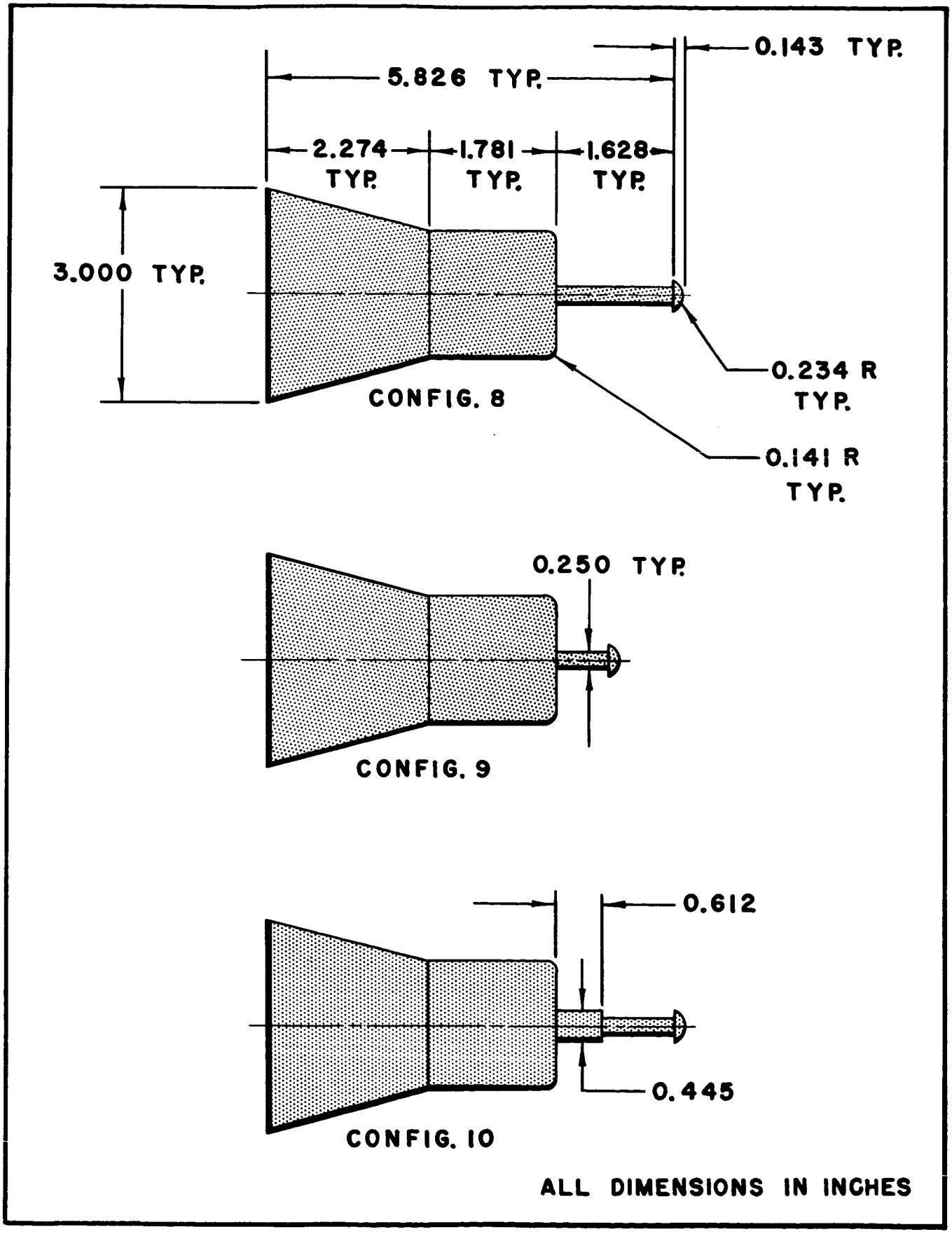
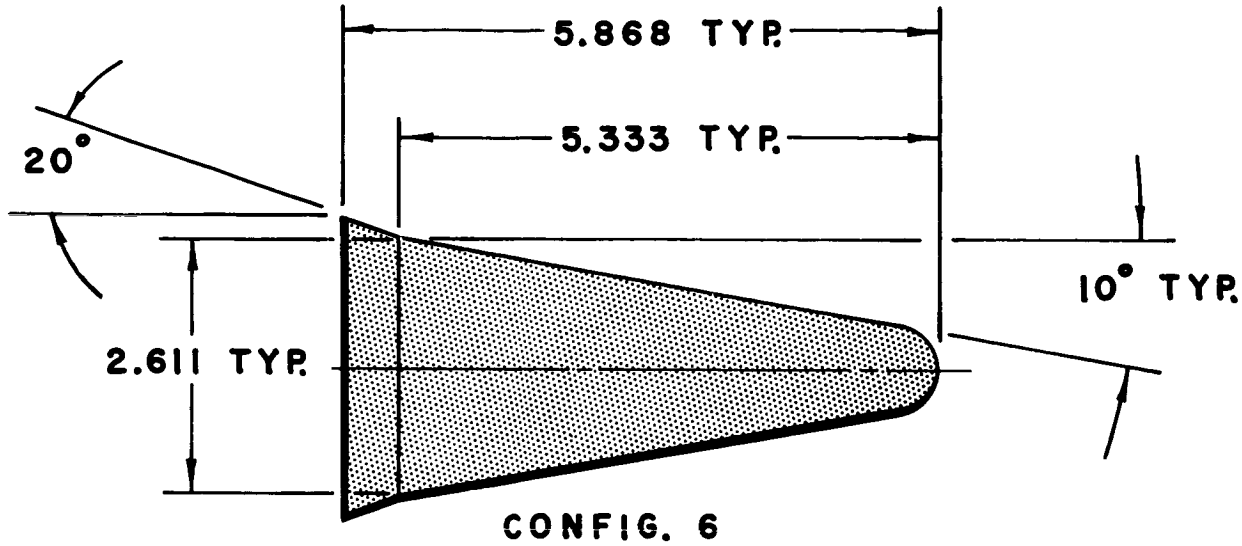


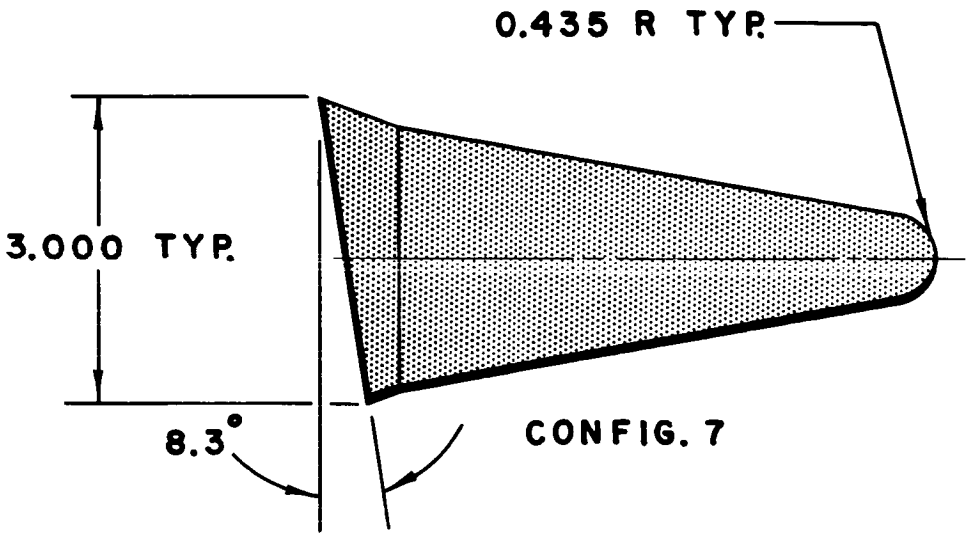
FIGURE 1c.

[redacted]

MODELS AND DIMENSIONS

P.S.





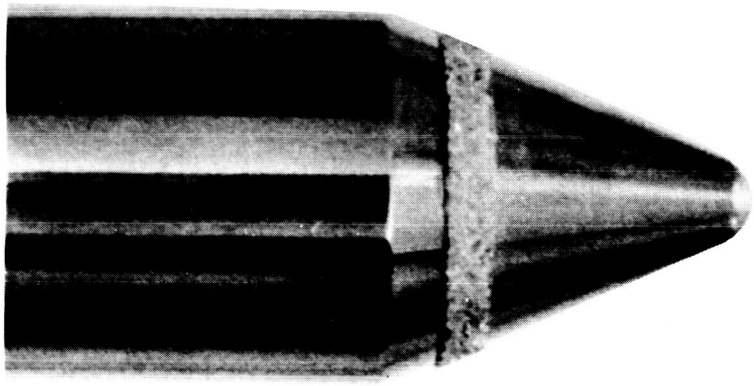
ALL DIMENSIONS IN INCHES

P.S.

FIGURE 1d.

[redacted]

MODELS AND DIMENSIONS



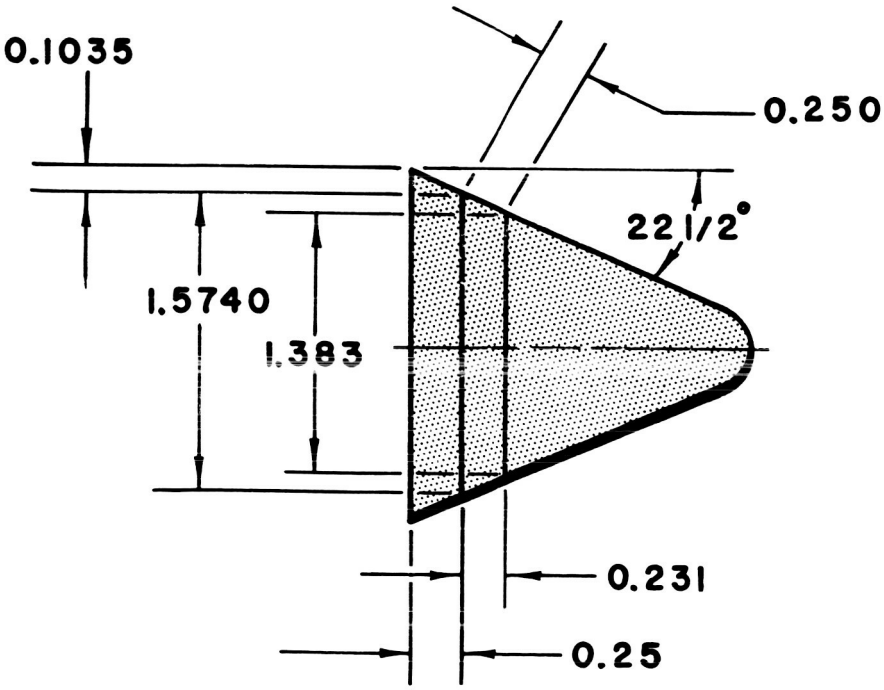
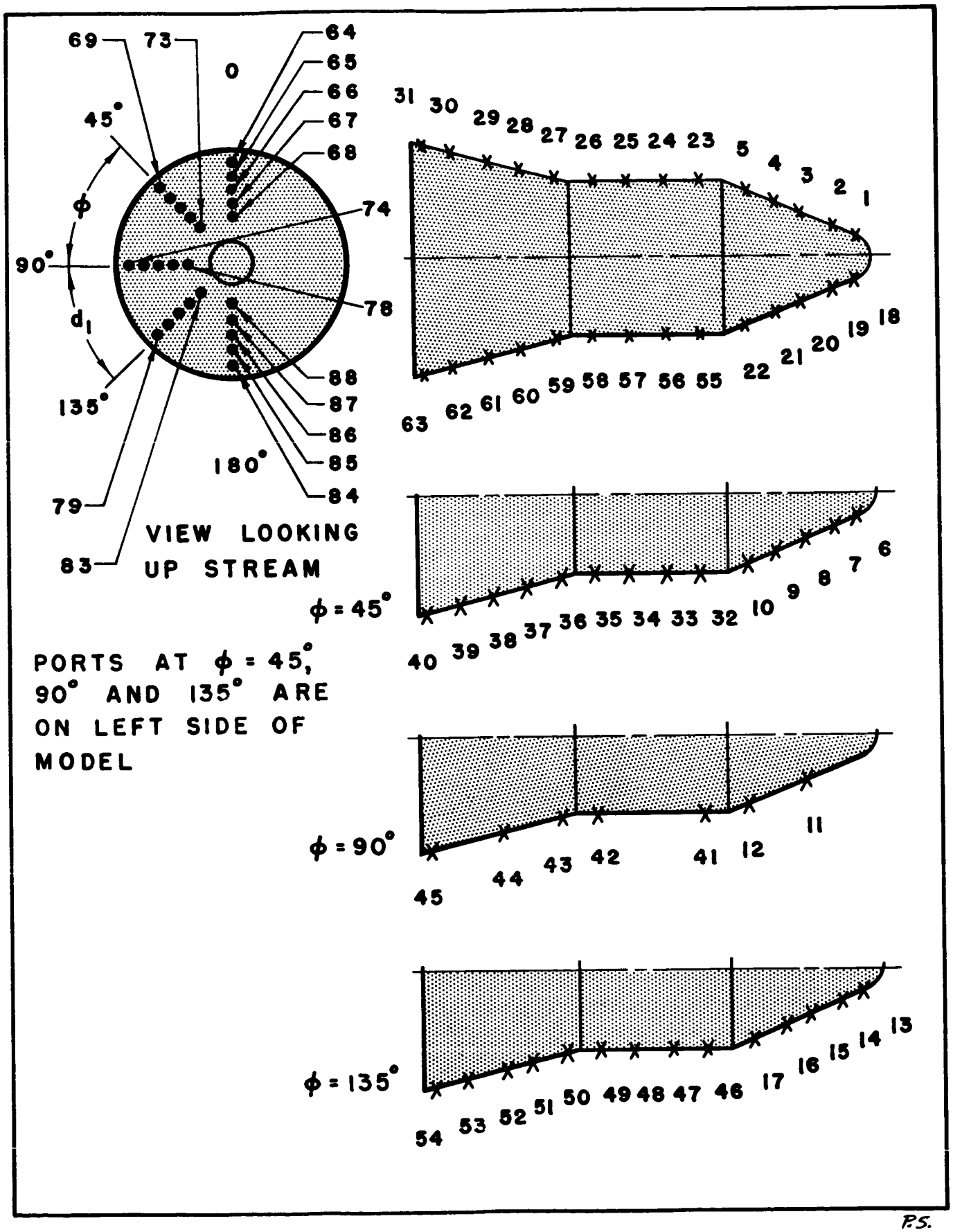


FIGURE 2.

P.S.

TRANSITION GRIT STRIP



P.S.

FIGURE 3a.

[redacted]

PRESSURE PORT NUMBERING SYSTEM OF CONFIGURATION I

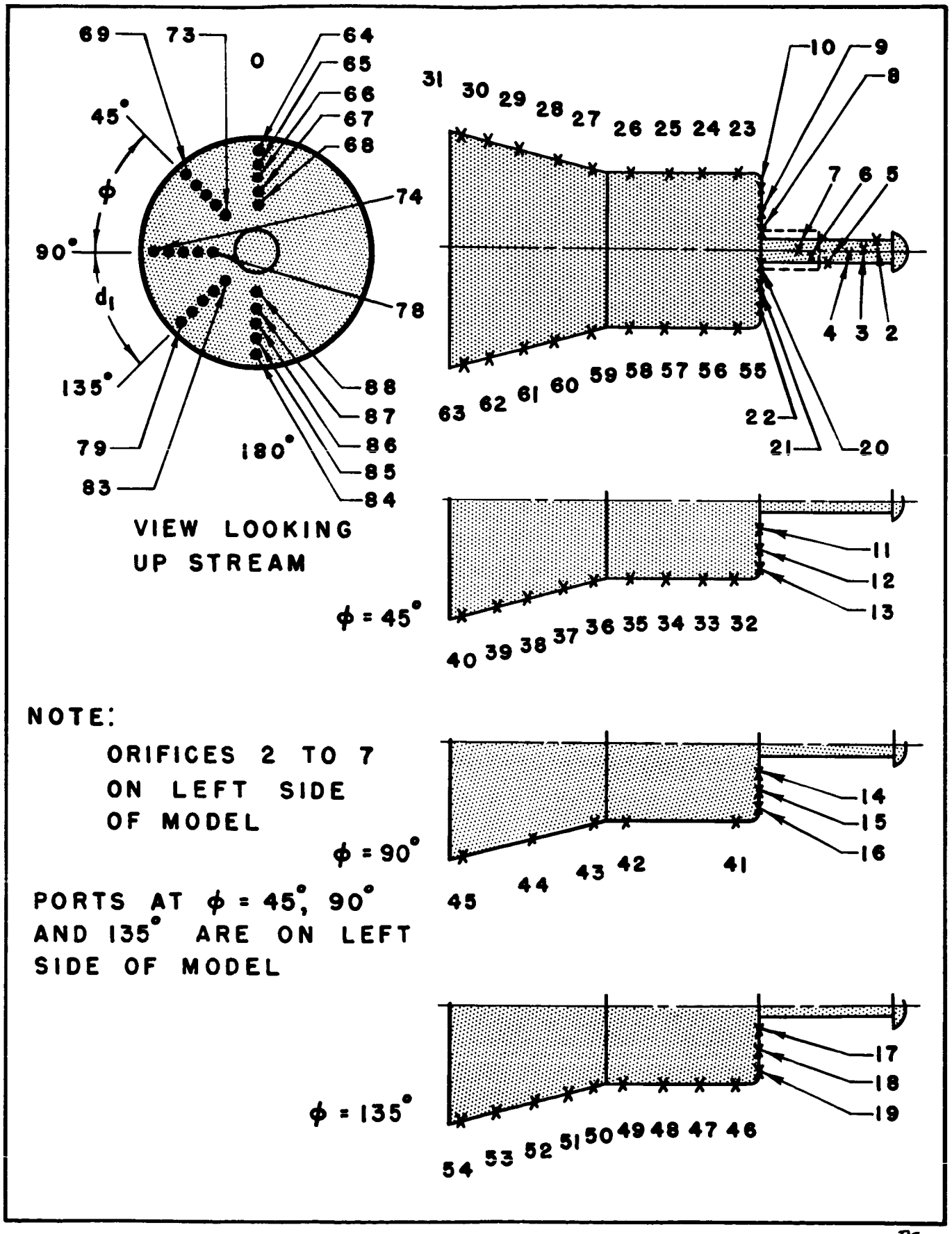
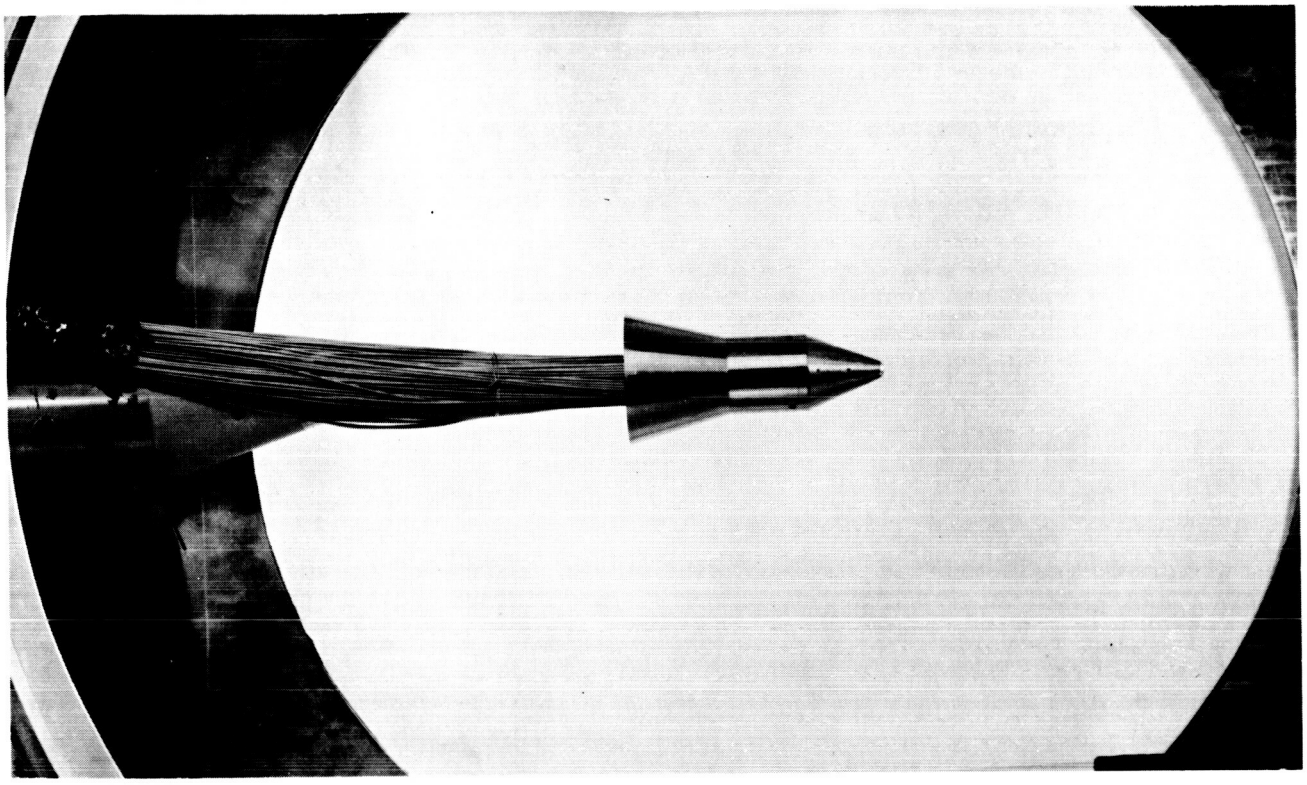


FIGURE 3b.

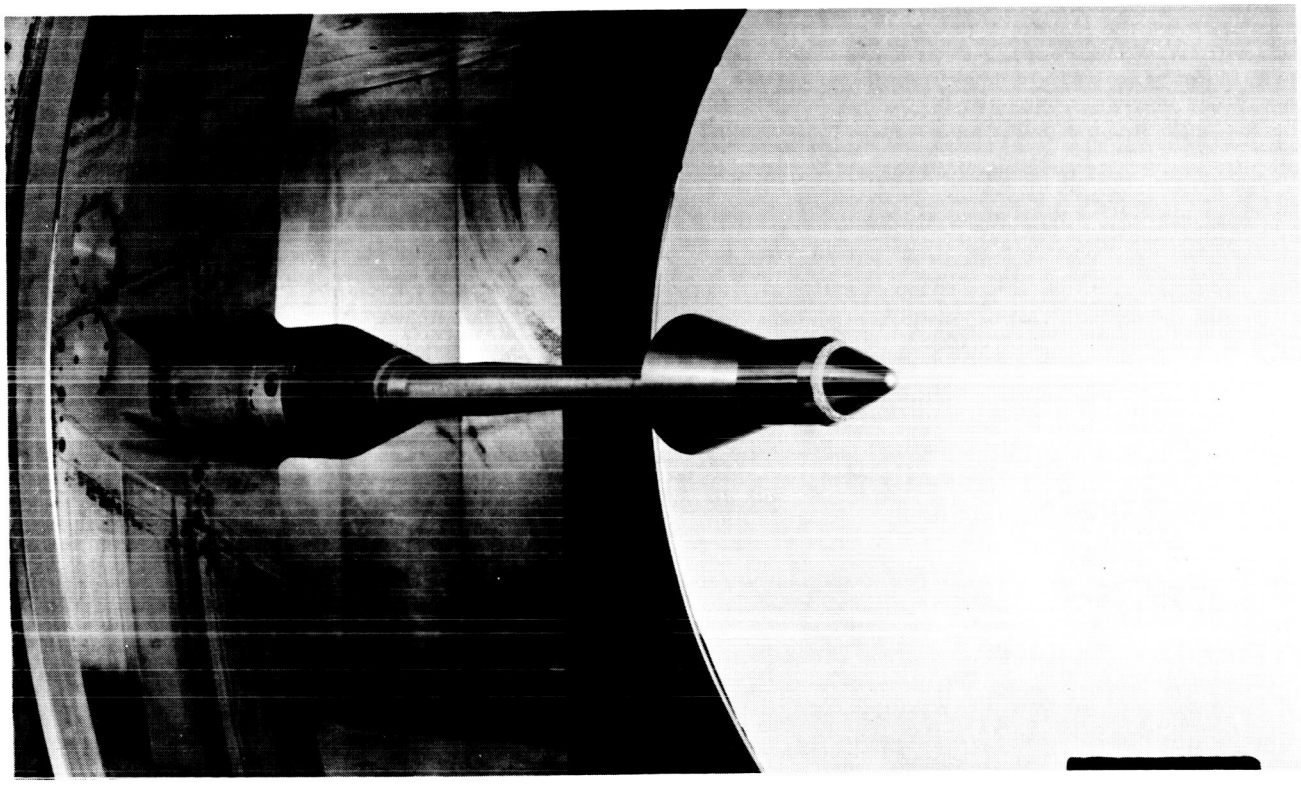
[redacted]

PRESSURE PORT NUMBERING SYSTEM OF CONFIGURATIONS 8 AND 10

P.S.



PRESSURE MODEL



FORCE MODEL WITH GRIT

P.S.

FIGURE 4.

MODEL INSTALLATION IN TUNNEL

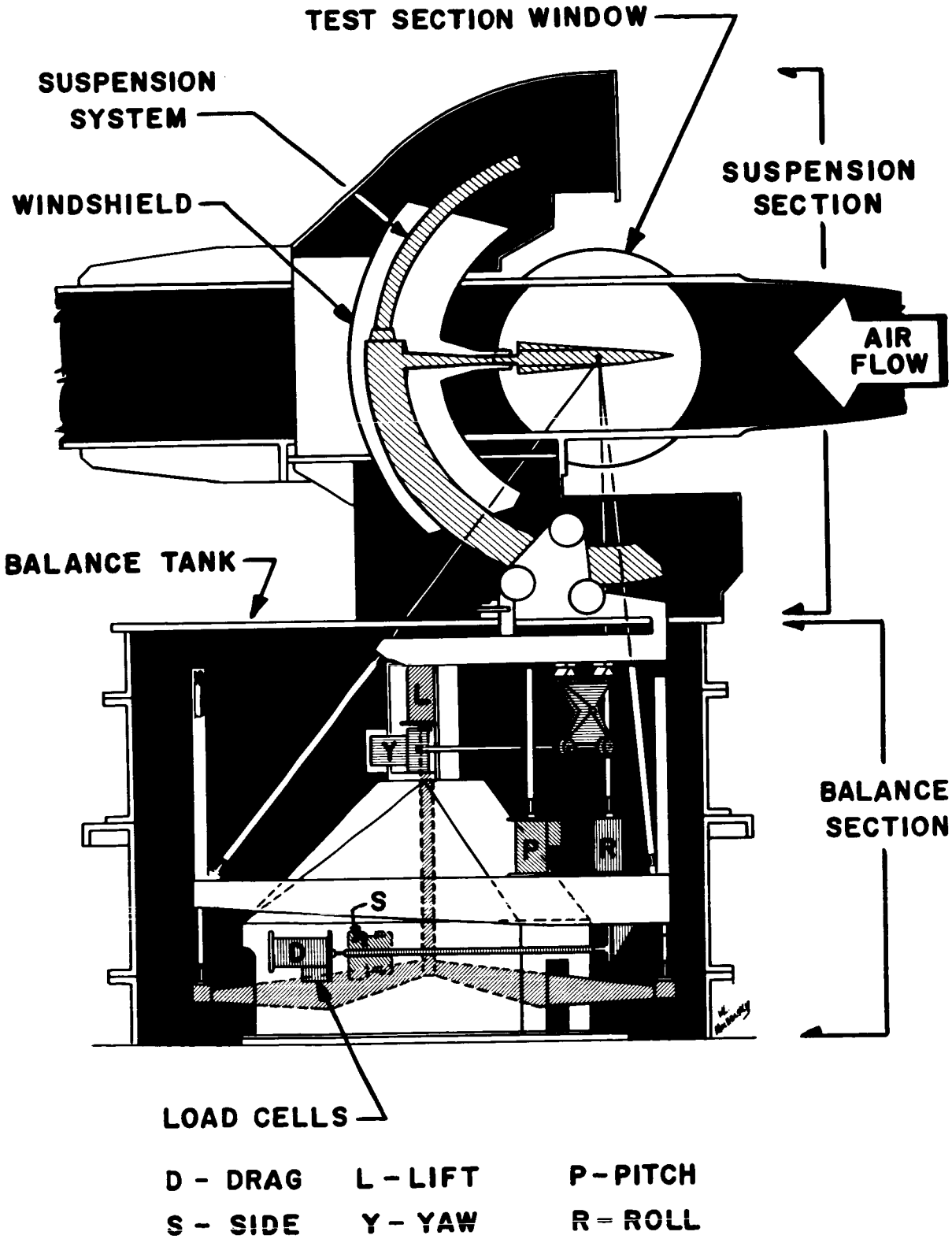


FIGURE [redacted]

THE SIX-COMPONENT EXTERNAL BALANCE AND SUPPORT SYSTEM

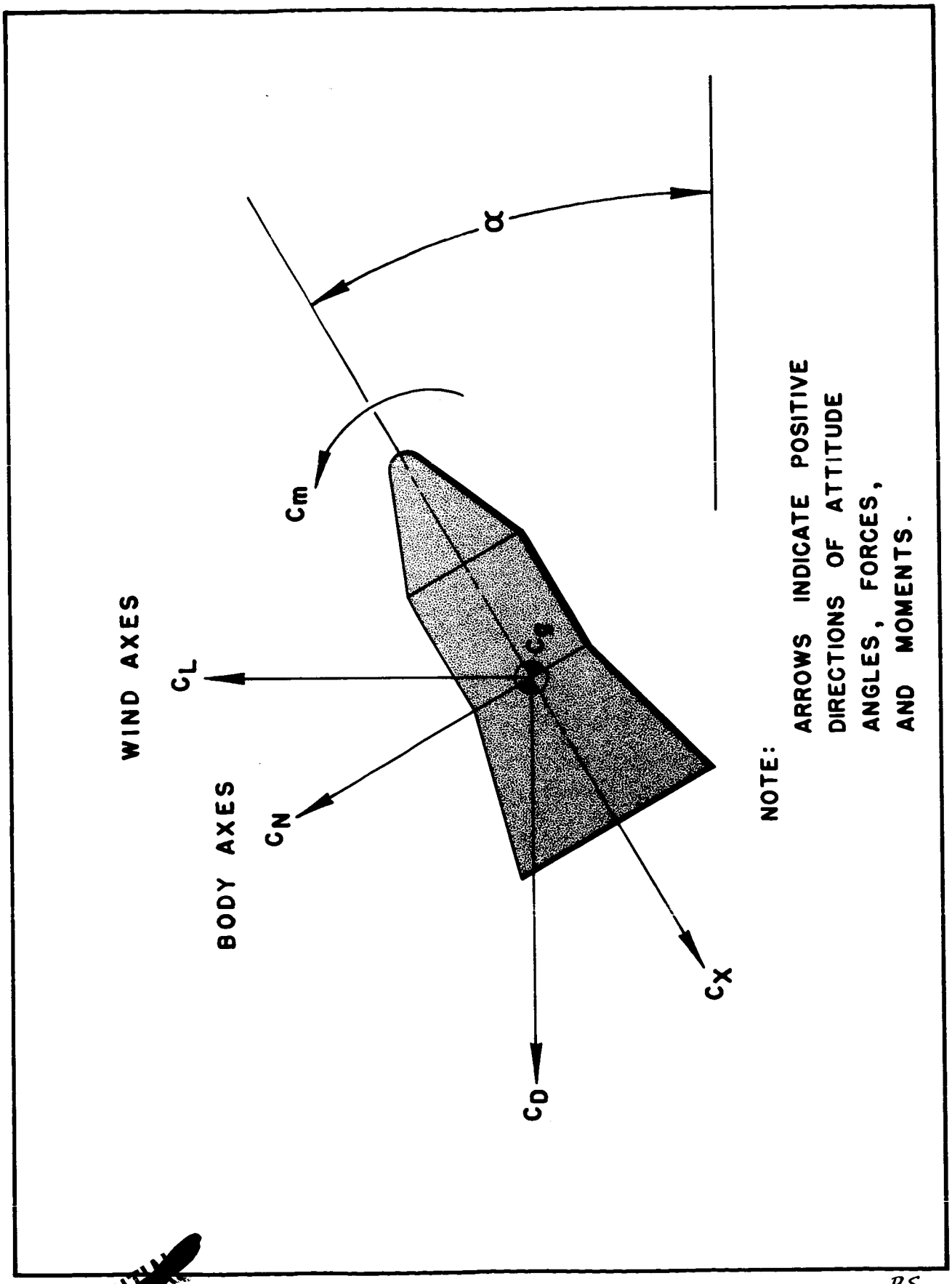


FIGURE 6. SIGN CONVENTIONS

P.S.

[redacted]

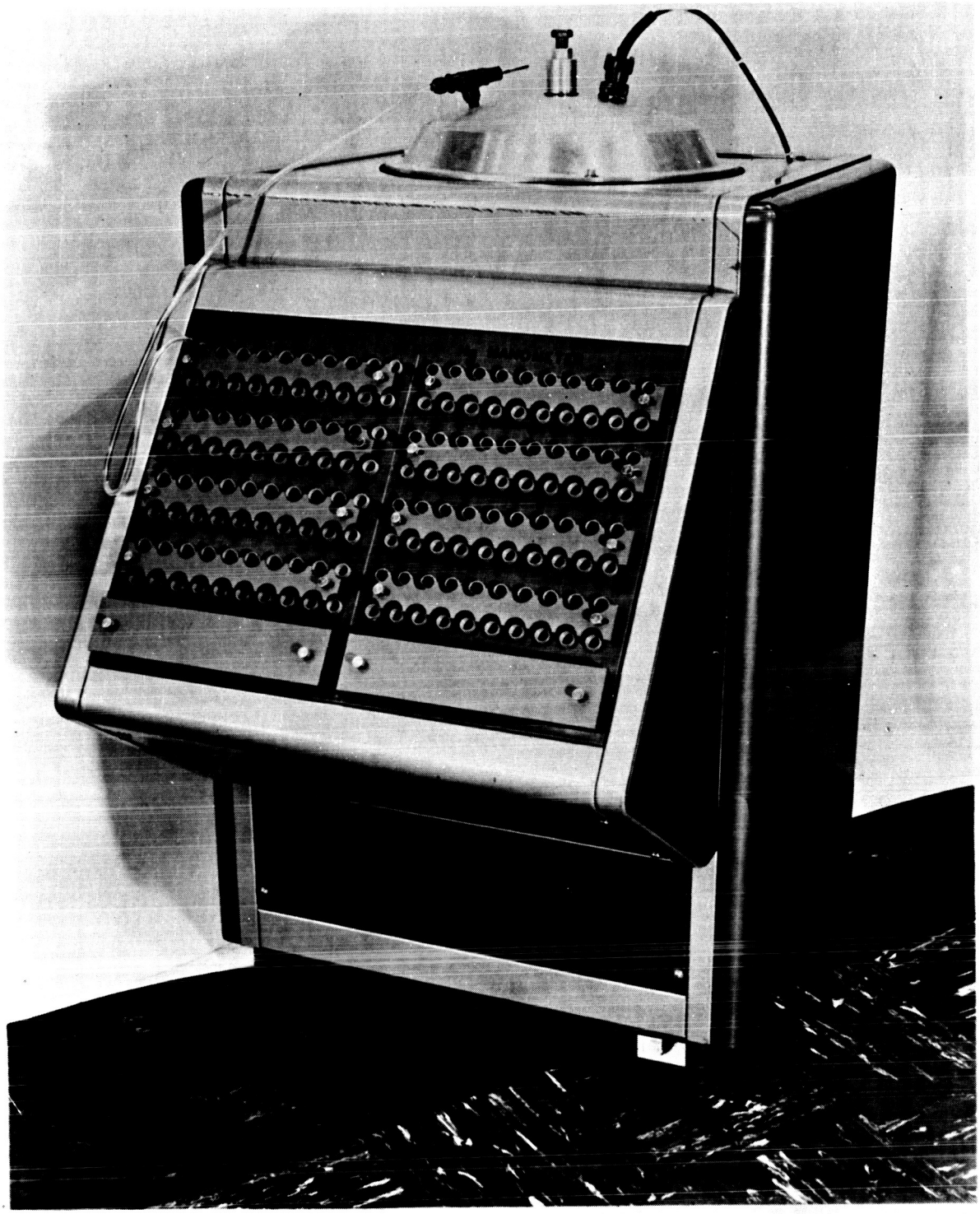


FIGURE 7. MPMS SCANNER UNIT

[redacted]

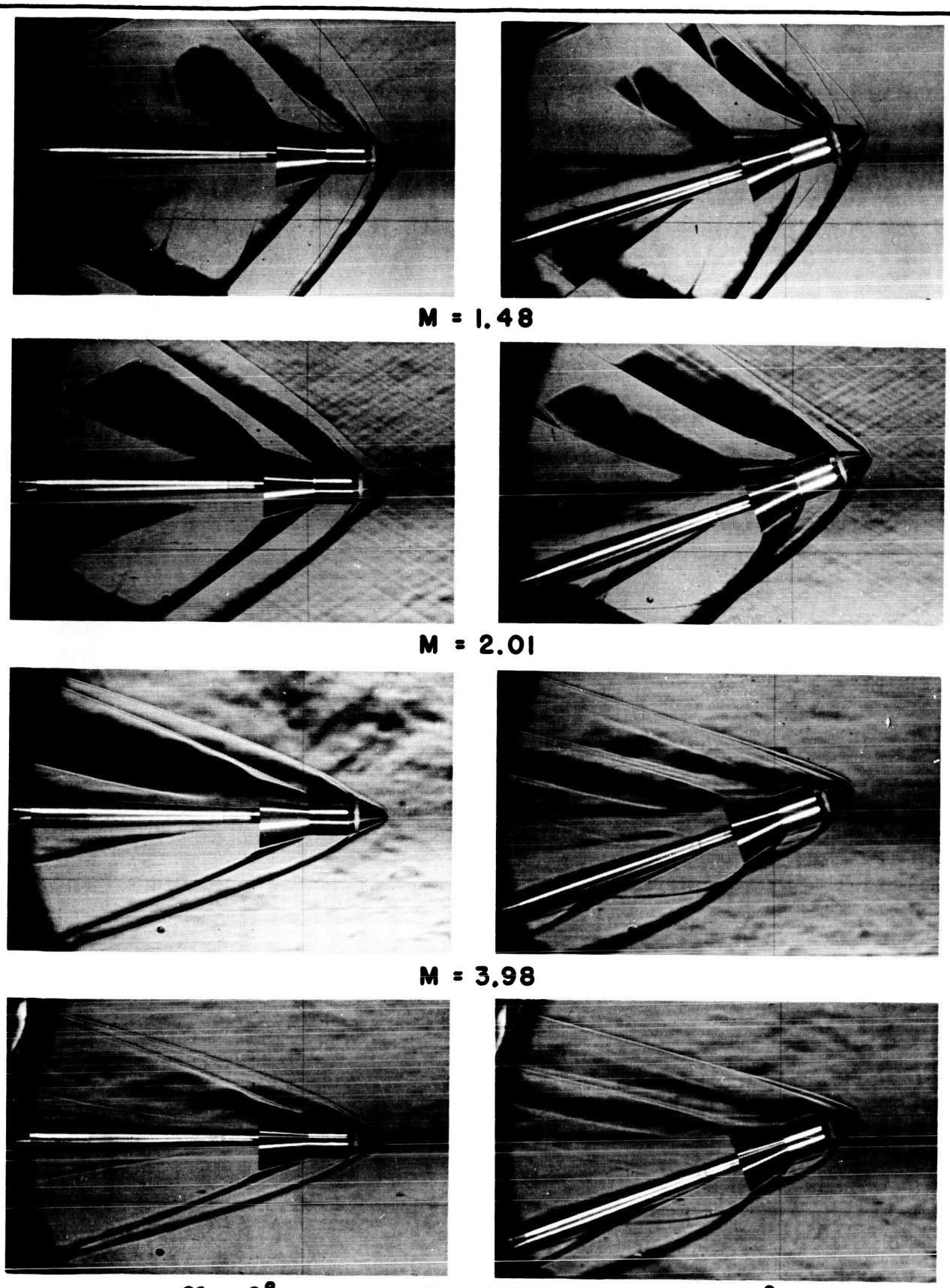


FIGURE 8.

P.S.

SCHLIEREN PHOTOS OF CONFIGURATION I

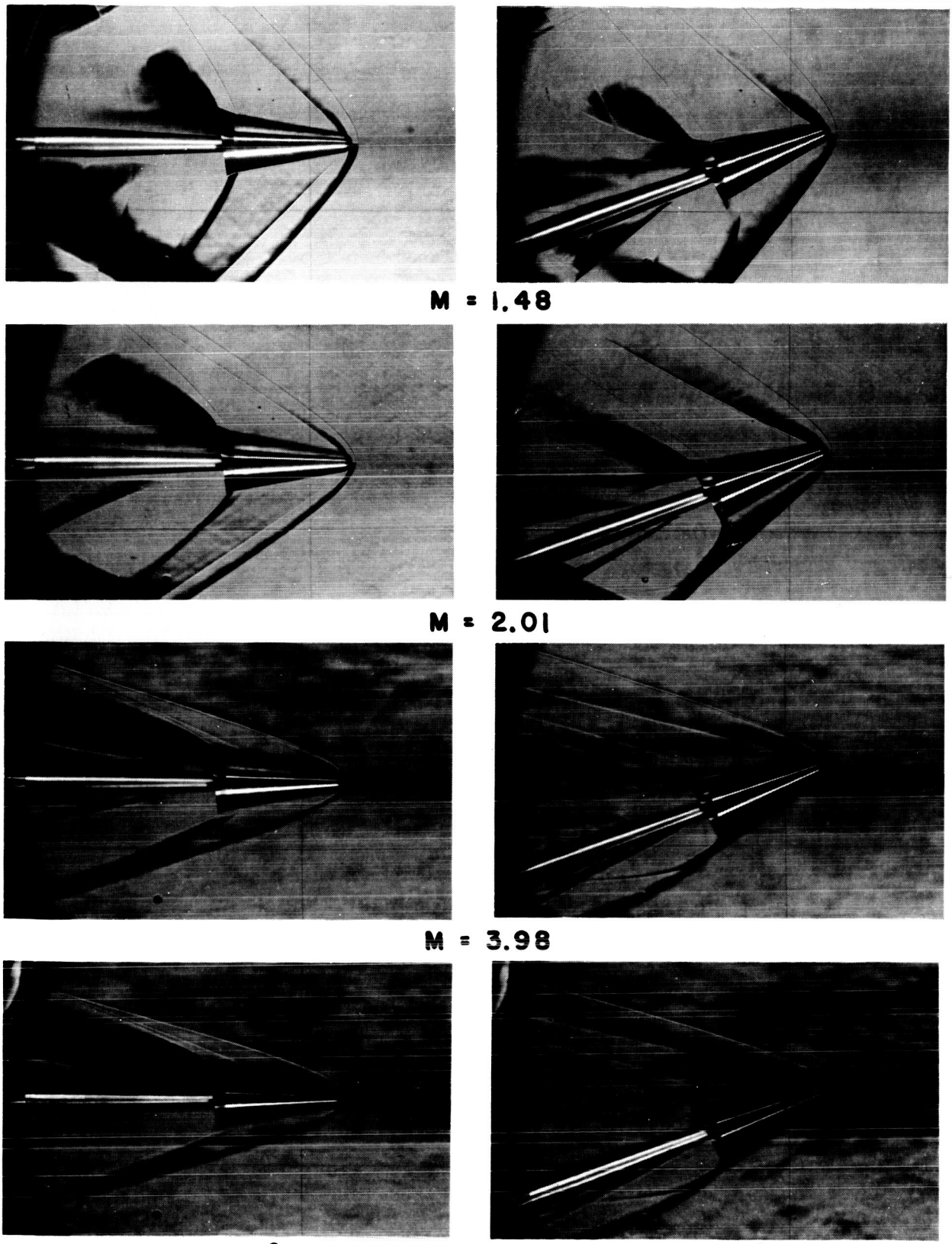


FIGURE 9

P.S.

[redacted]

SCHLIEREN PHOTOS OF CONFIGURATION 7

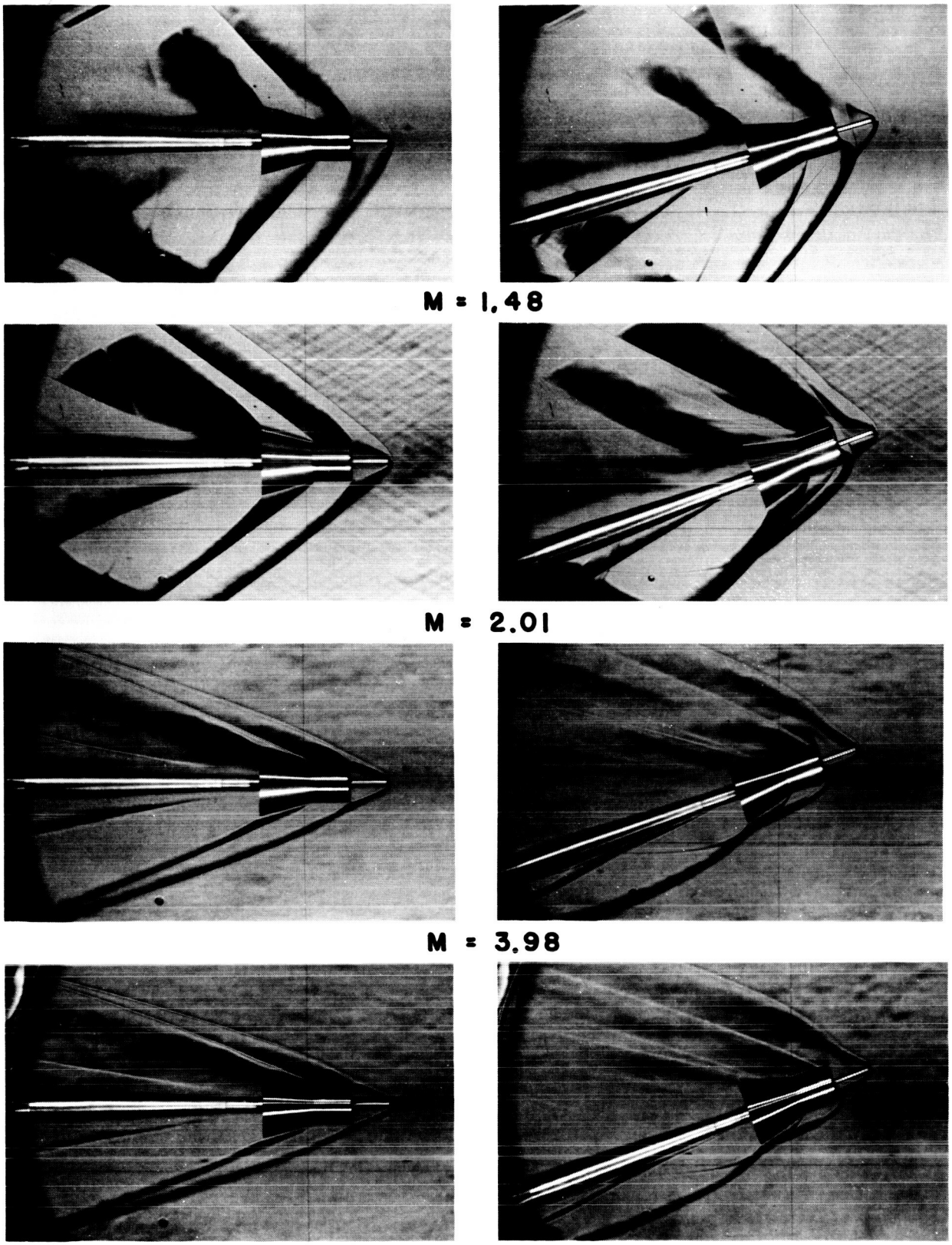


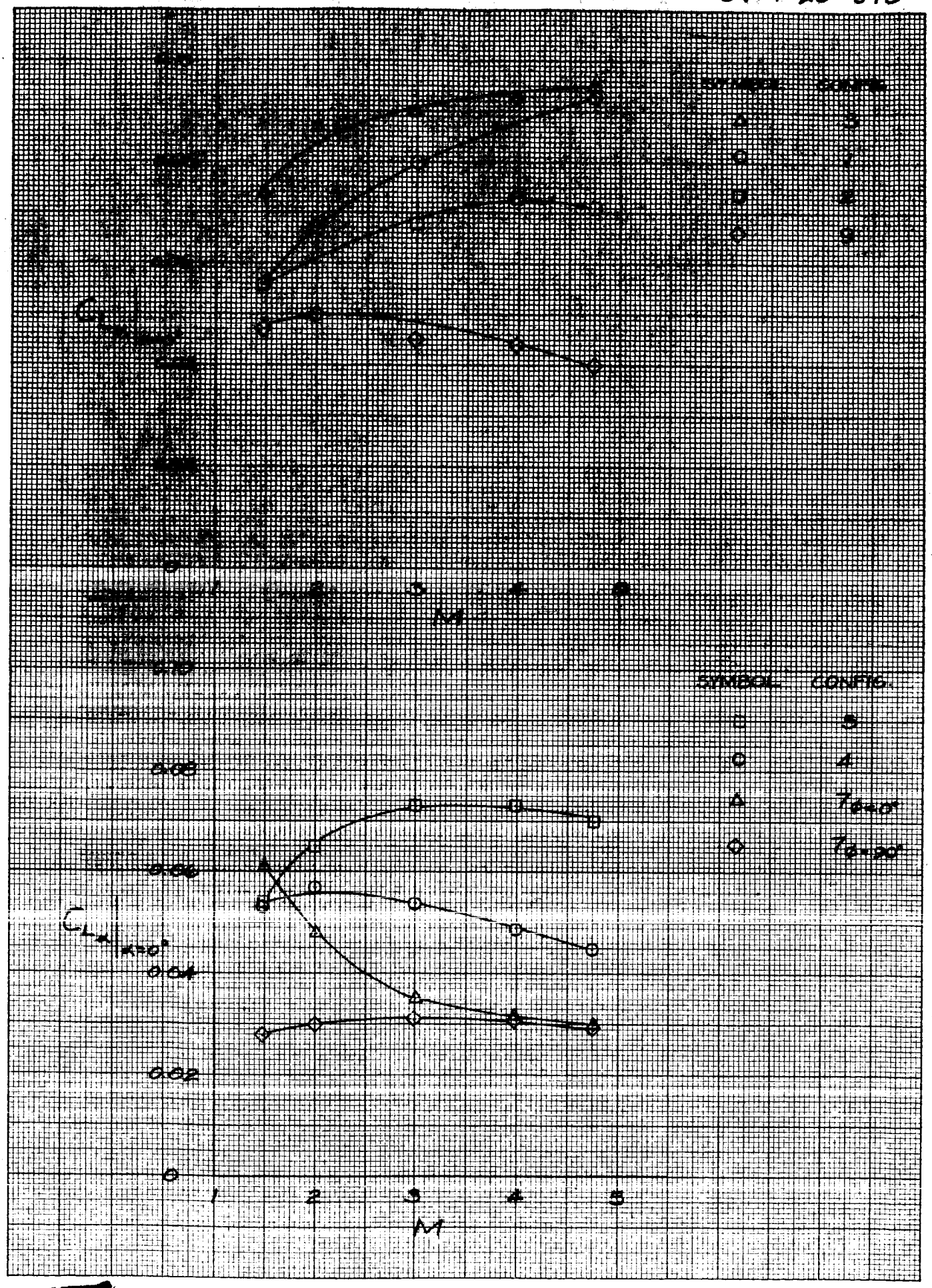
FIGURE 10

P.S.

SCHLIEREN PHOTOS OF CONFIGURATION 8

[redacted]

SWT 20-378



[redacted] FIGURE 11a SUMMARY PLOT

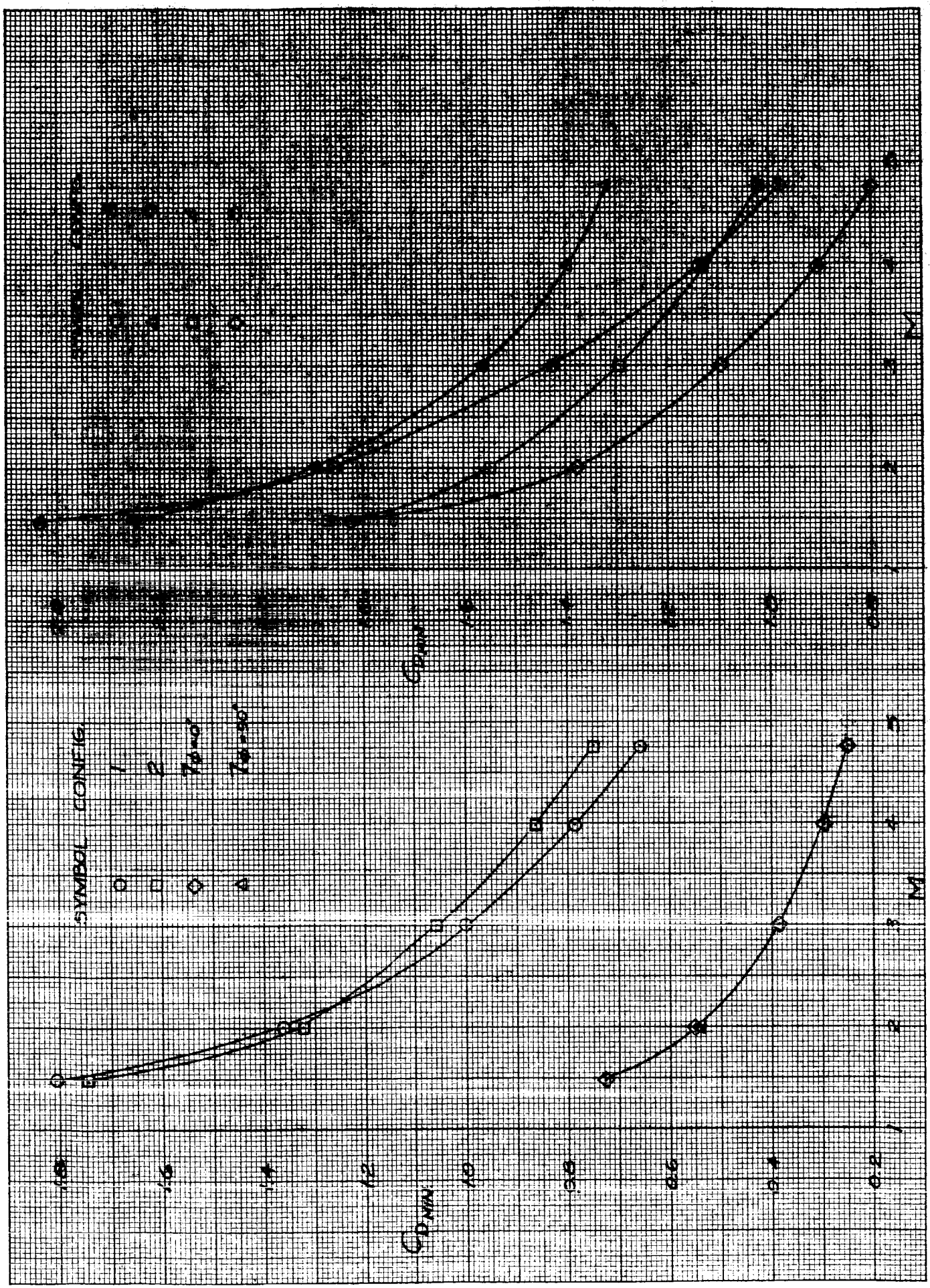
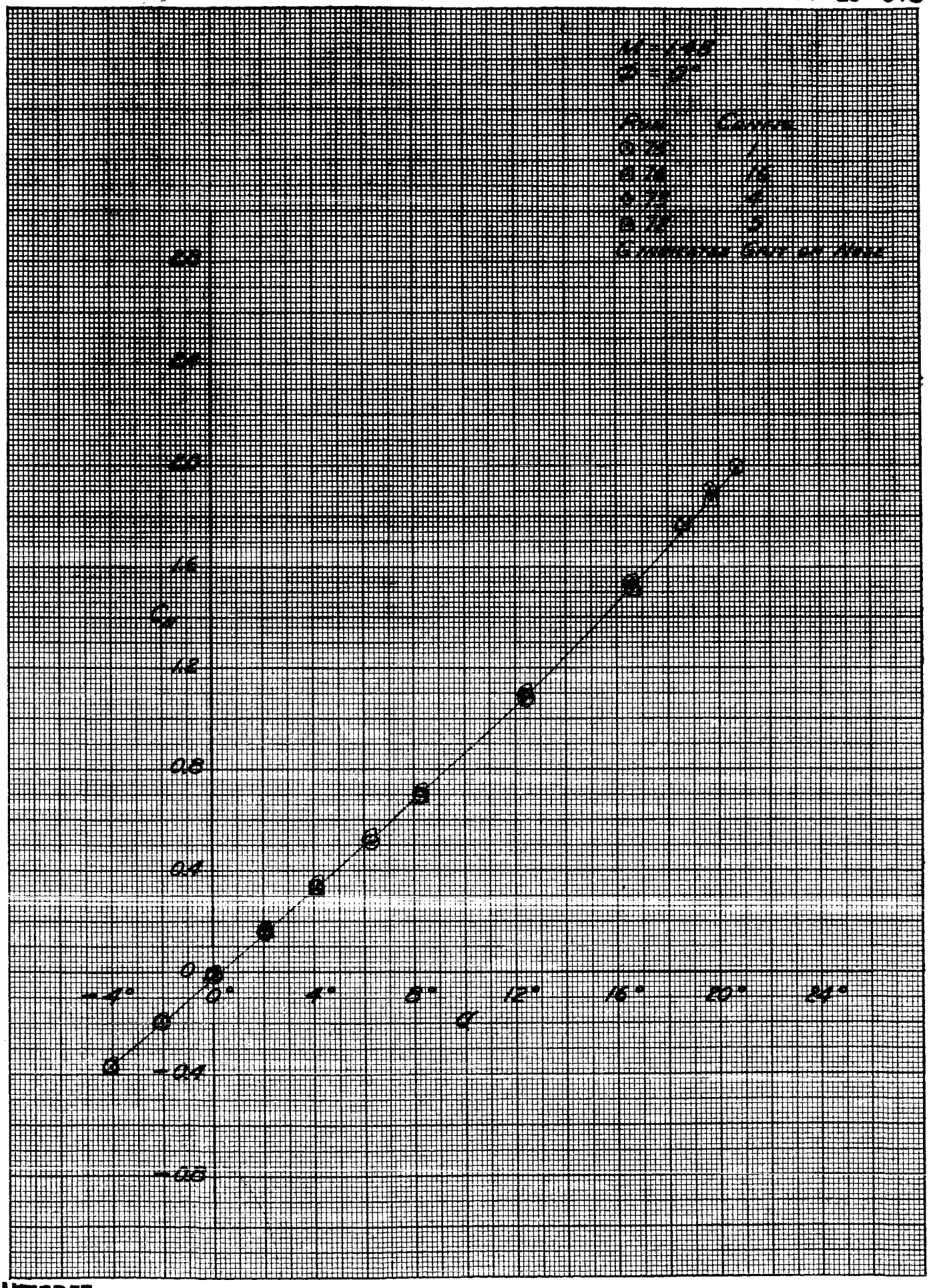
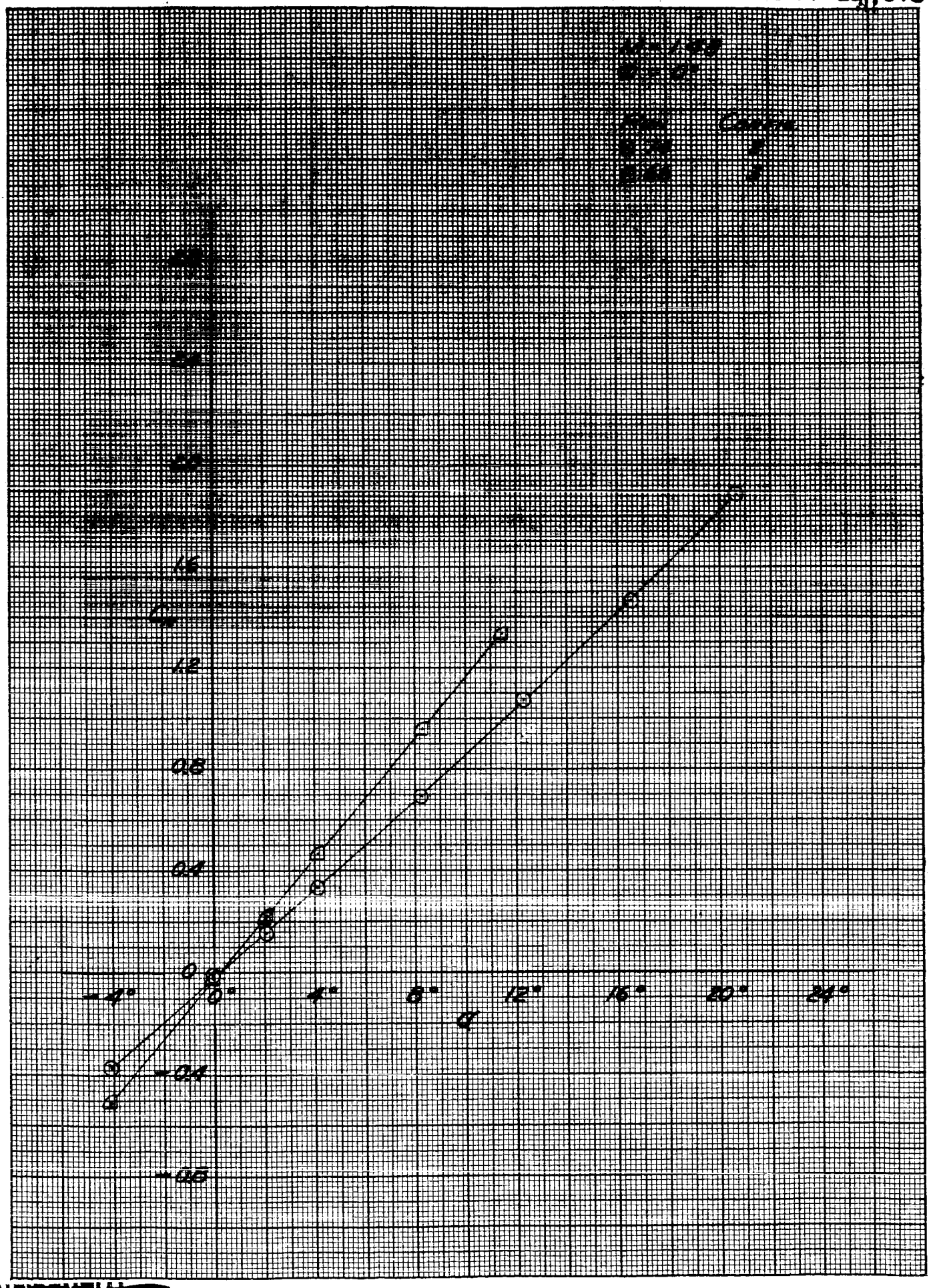
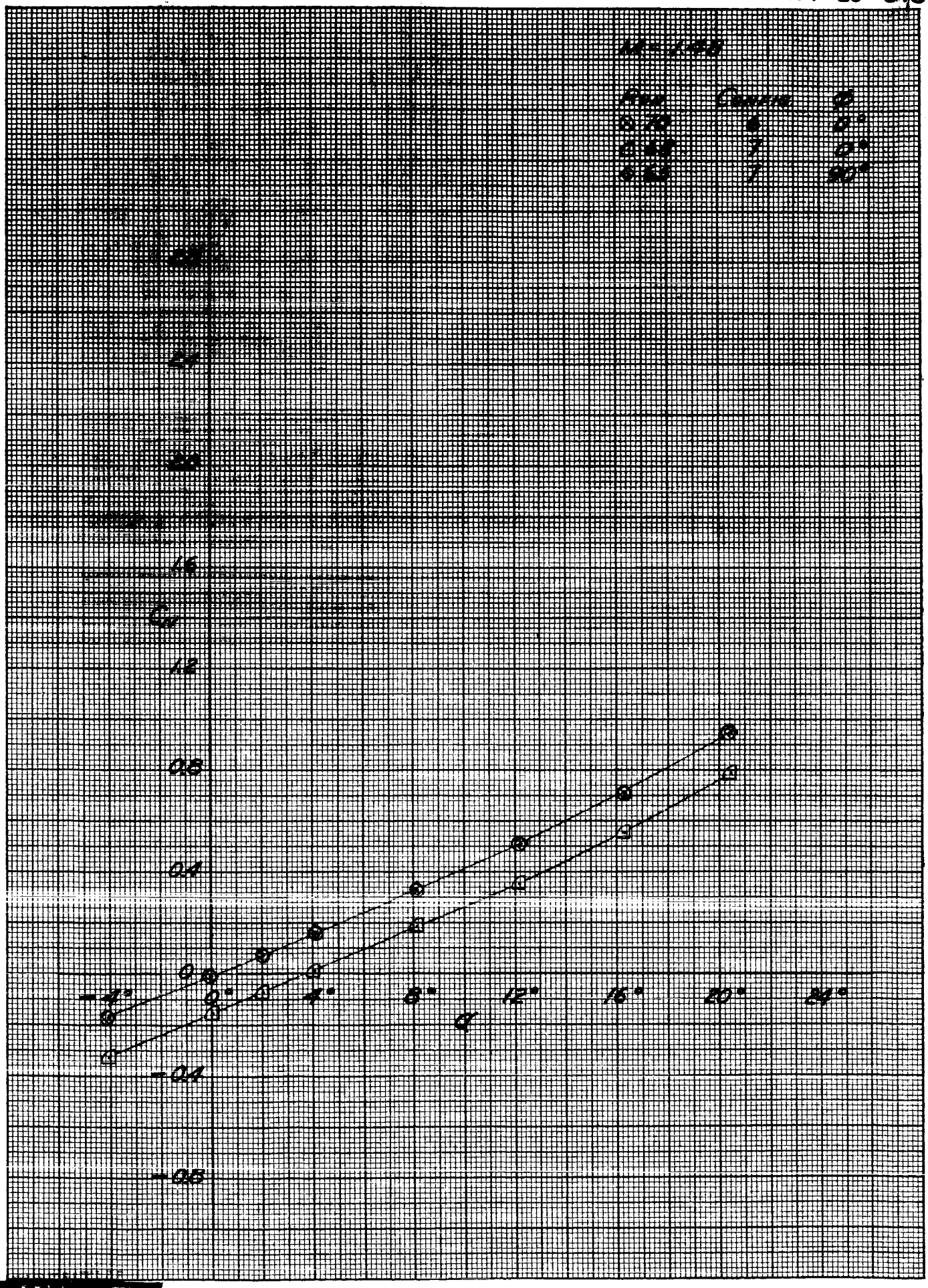


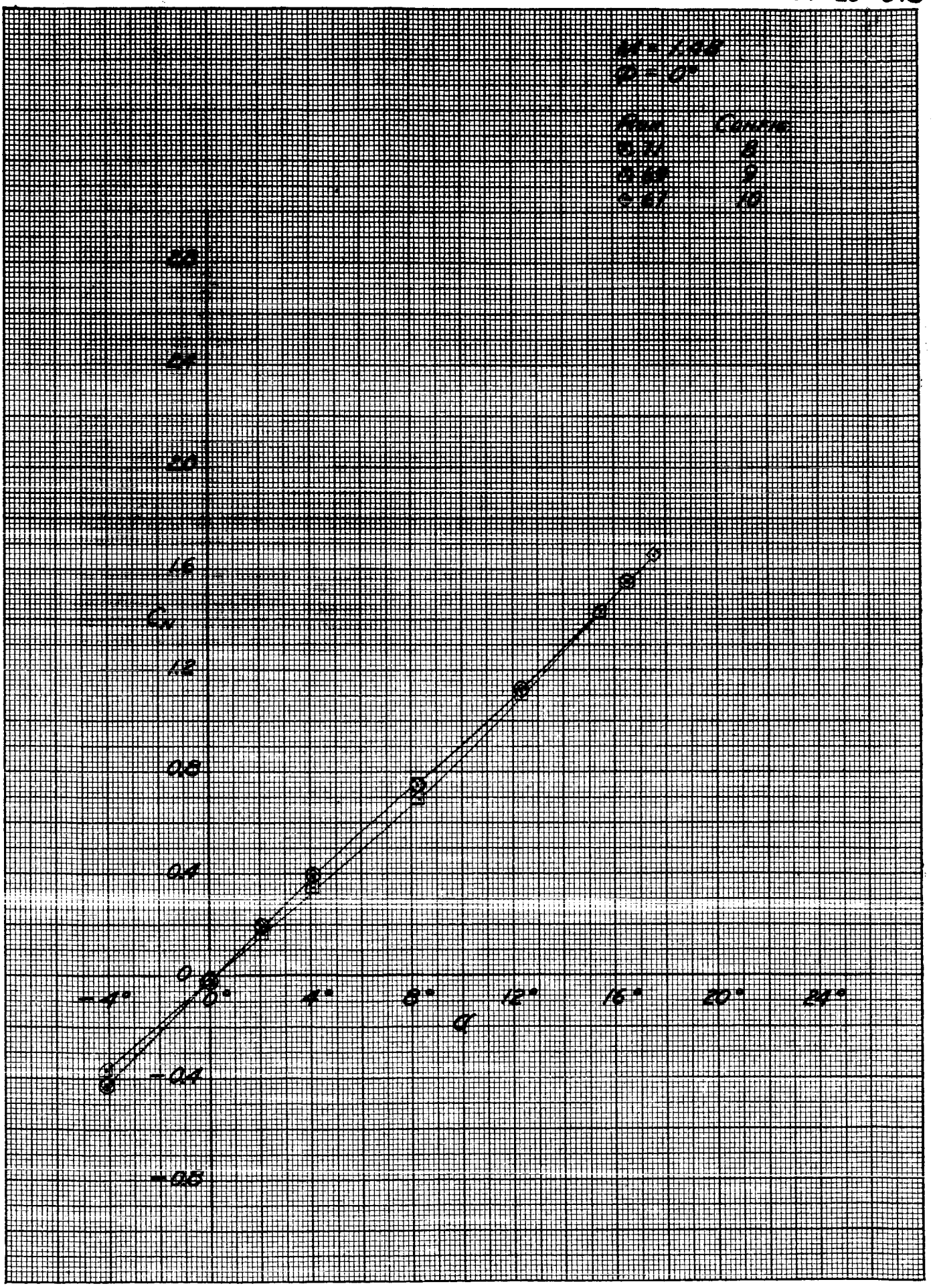
FIGURE 11b SUMMARY PLOT

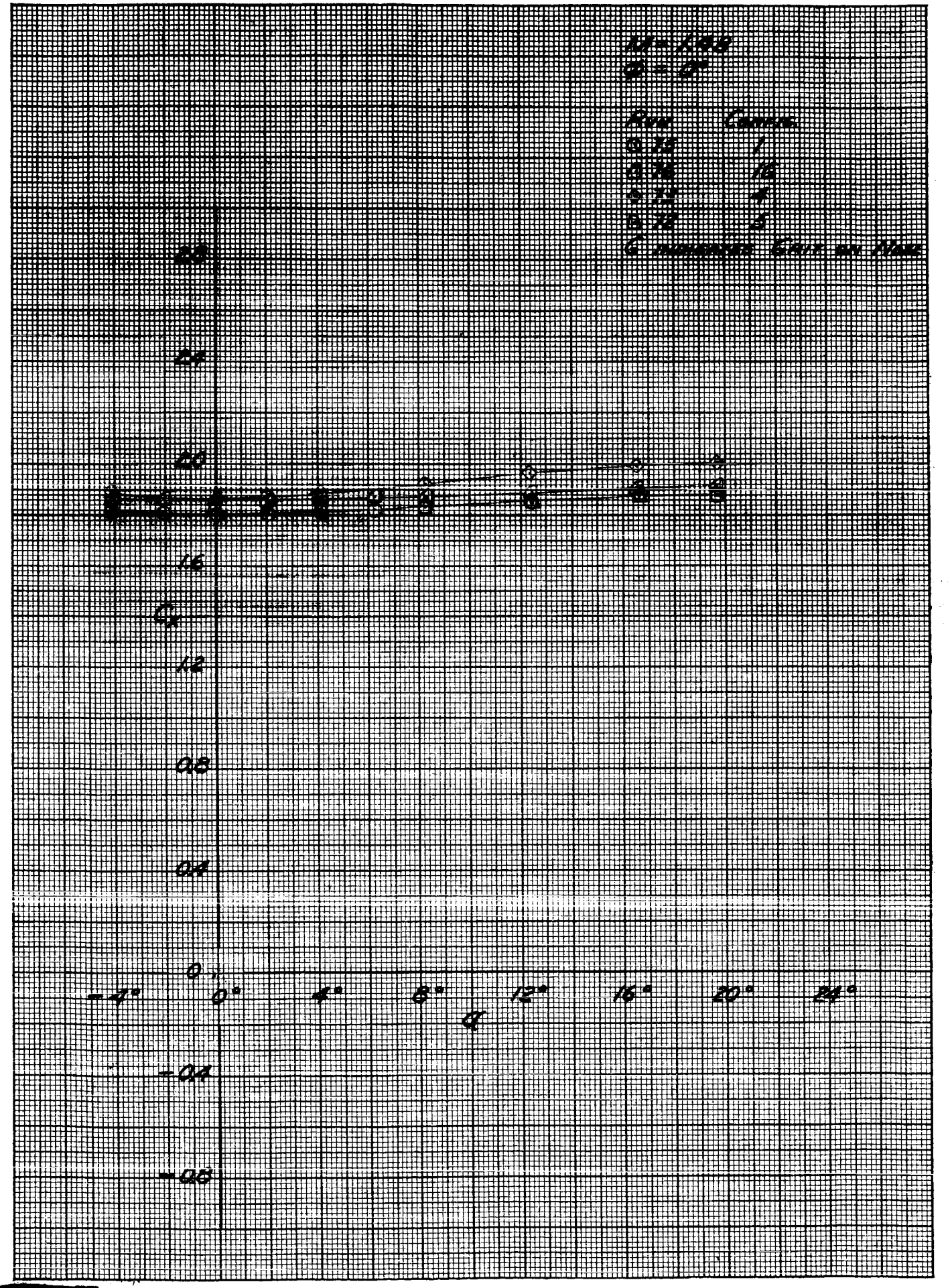
K+E 10 X 10 TO THE CM. KEUFFEL & ESSER CO. MADE IN U.S.A. 359T-14G LIBRARY

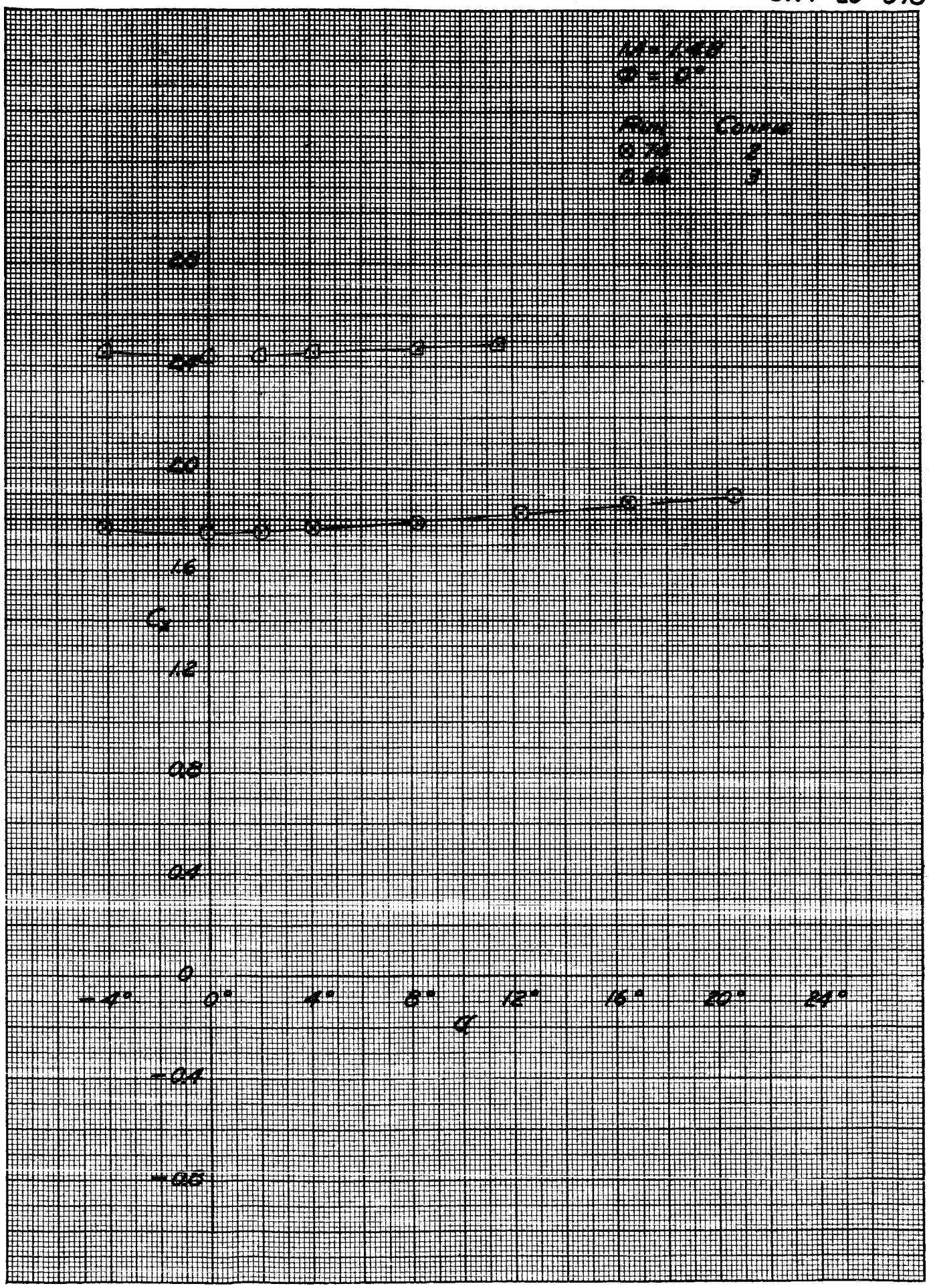

Flap Camber
0.28 1
0.24 .75
0.20 .5
0.16 .25
0.12
0.08
0.04
0
-0.04
-0.08
C_L
-4°
0°
4°
8°
12°
16°
20°
24°
α

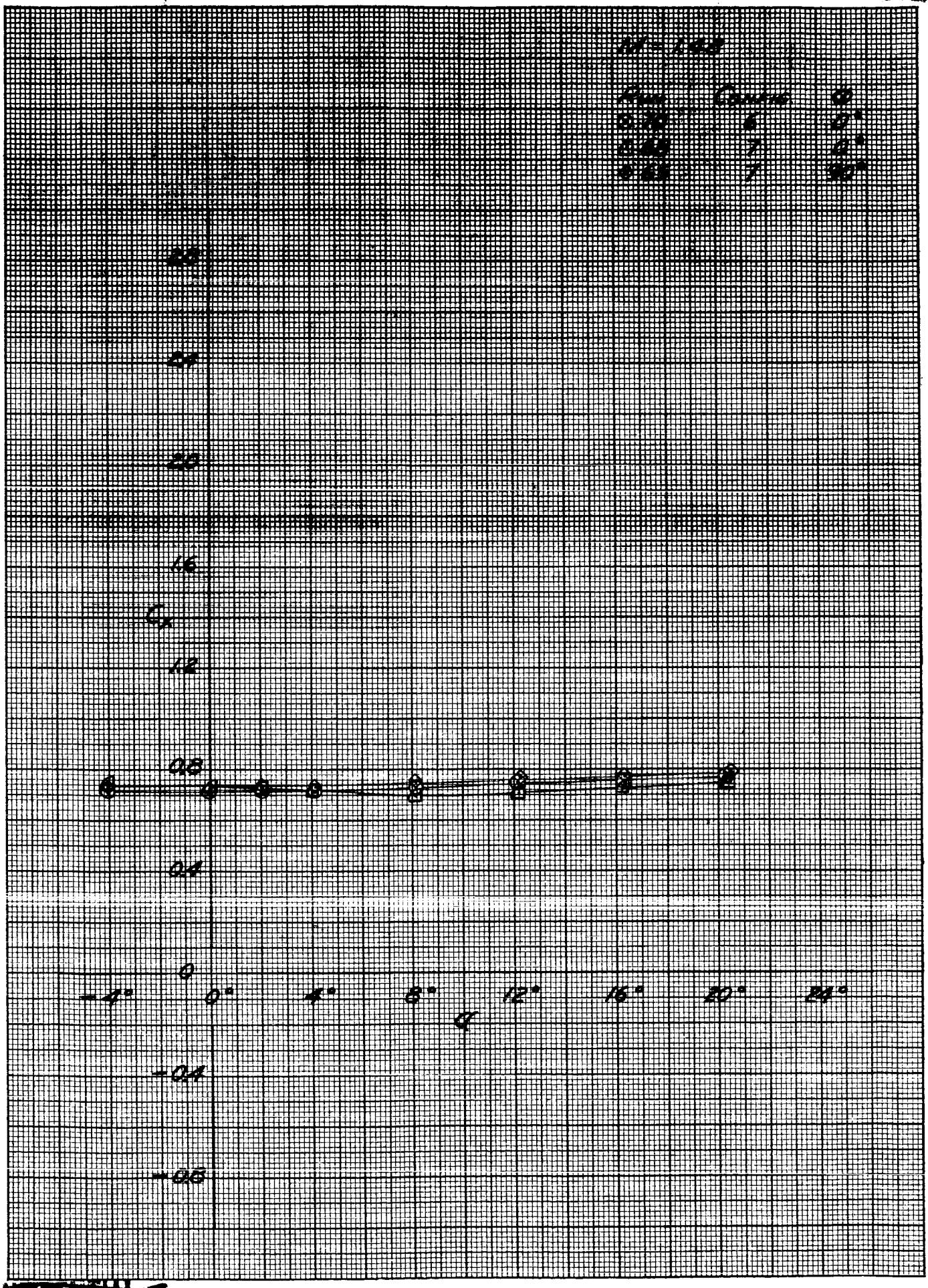

1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

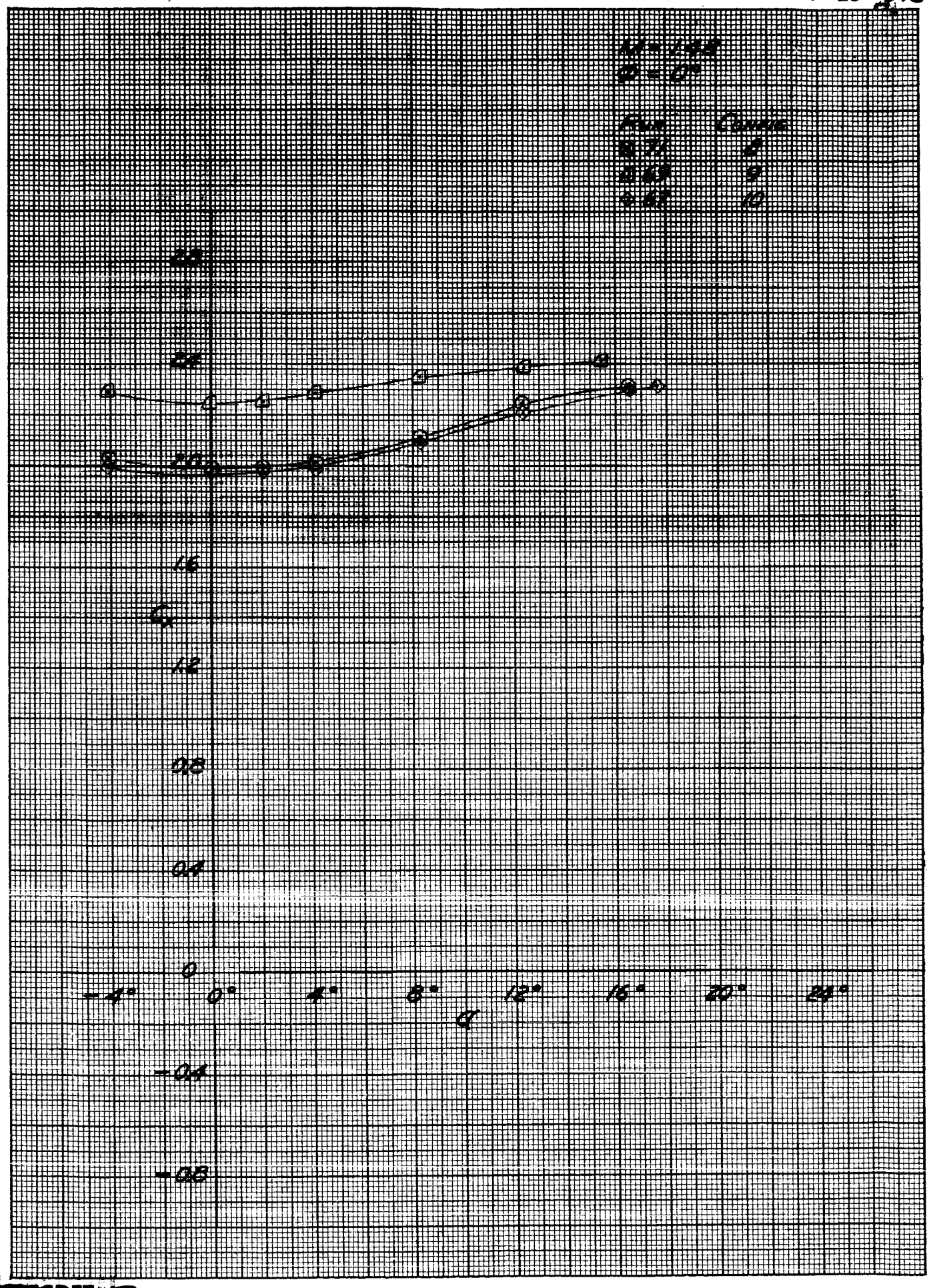

M = 1.48
Flap
0.70
0.48
0.25
Camber
0
1
1
δ
0°
0°
20°
.16
C_L
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

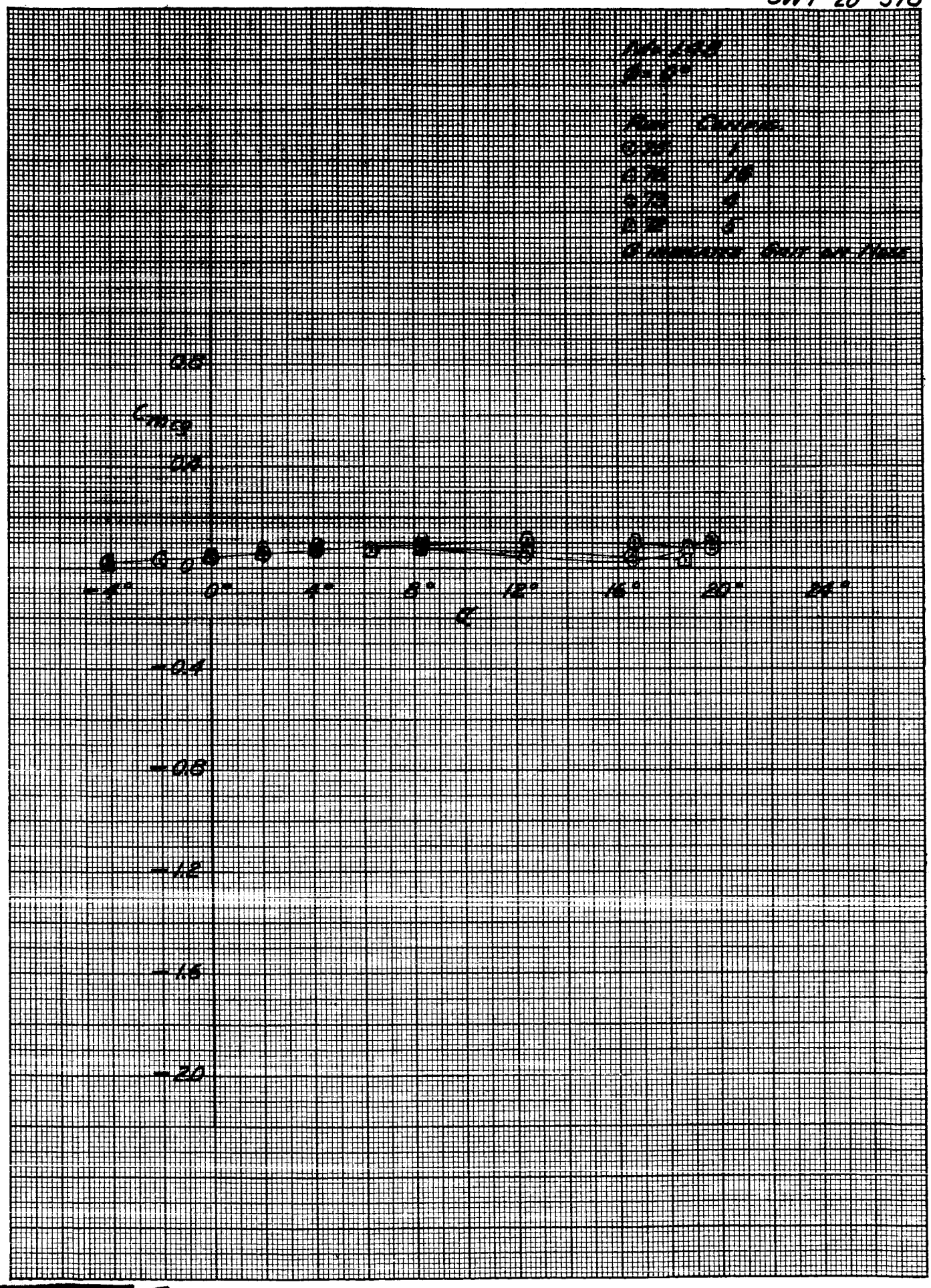

M = 1.48
β = 0°
Run
Curve
0.24
8
0.68
9
0.67
10
0.8
0.4
0
-0.4
-0.8
C_N
-4°
0°
4°
8°
12°
16°
20°
24°
α

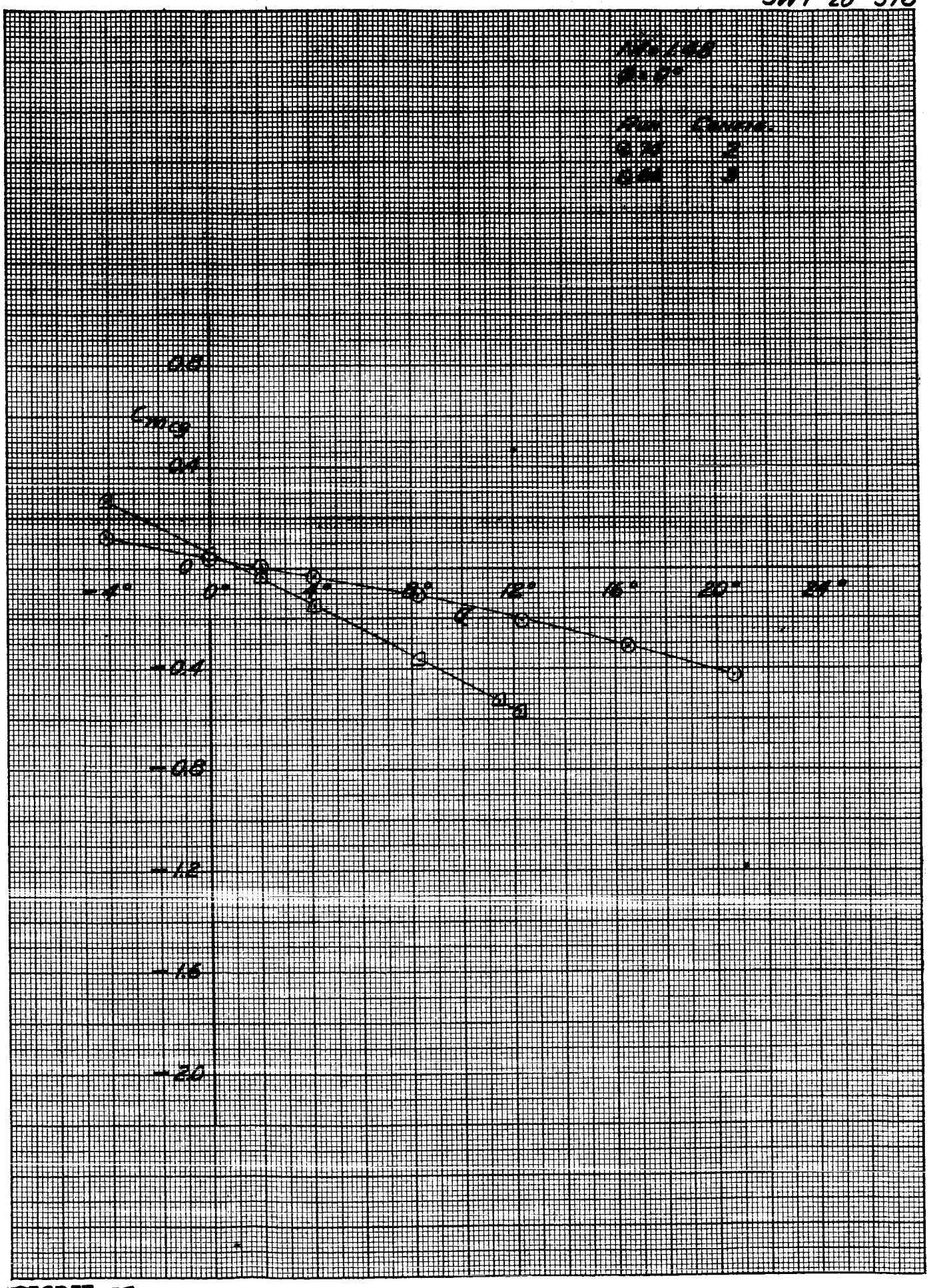

M = 1.48
β = 0°
Run Centers
0.24 1
0.24 16
0.24 4
0.24 3
6 moments taken on Alum
0.28
0.24
0.20
0.16
C_x
0.12
0.08
0.04
0
-0.04
-0.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

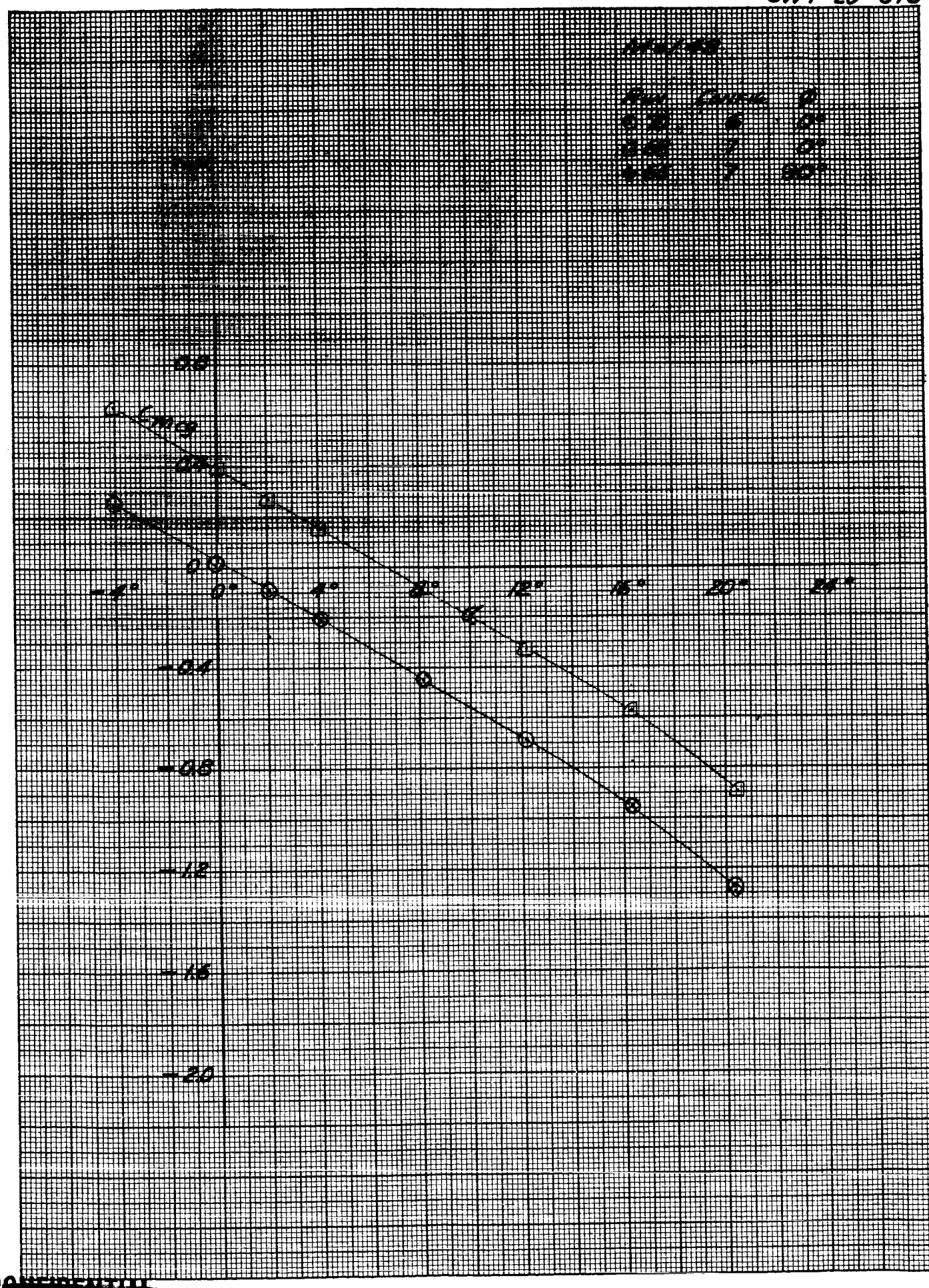

M = 1.48
φ = 0°
Plot Curve
0.78 2
0.88 3
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

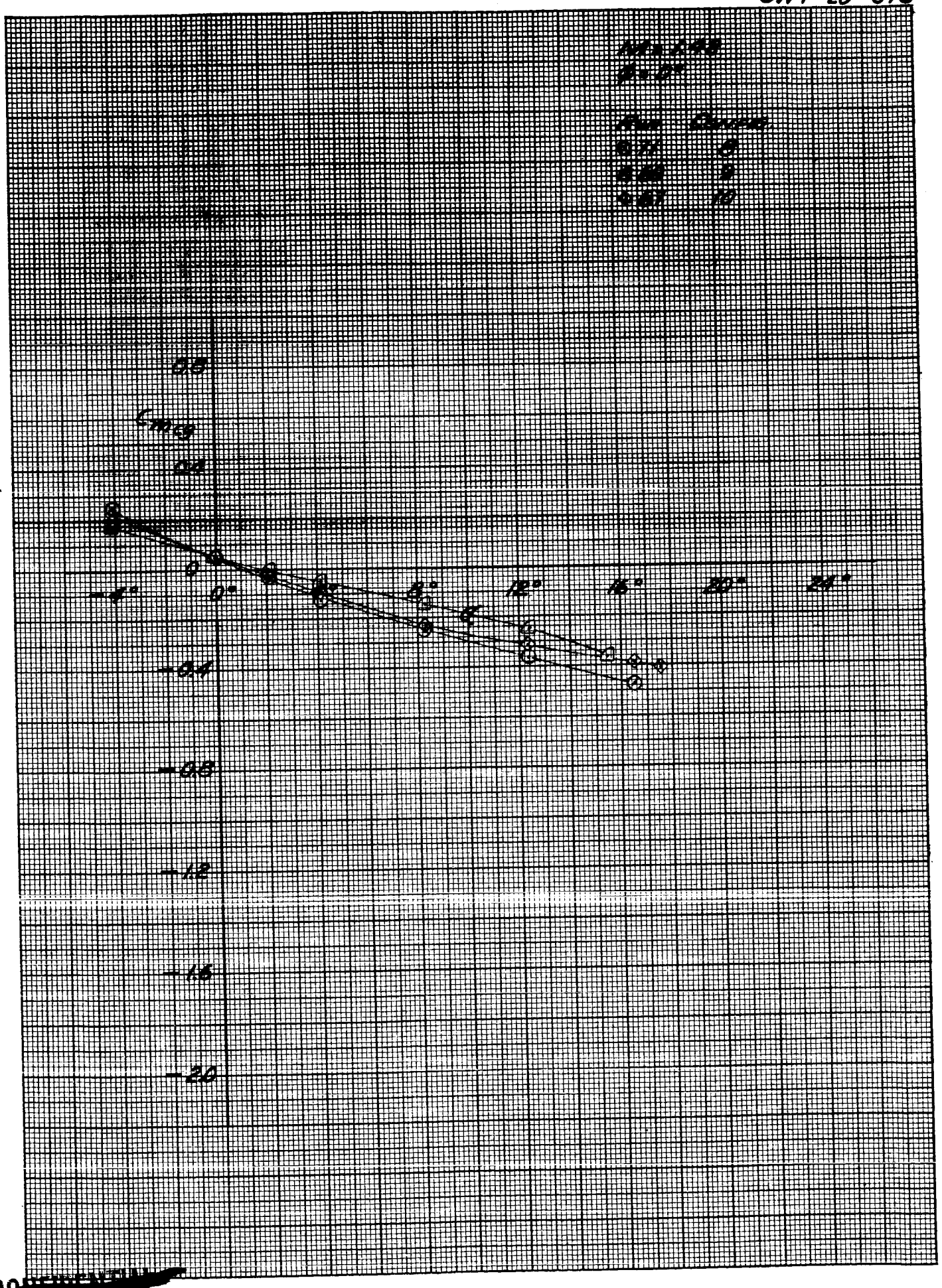

Run Curve
0.28
0.24
0.20
0.16
C_x
0.12
0.08
0.04
0
-0.04
-0.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

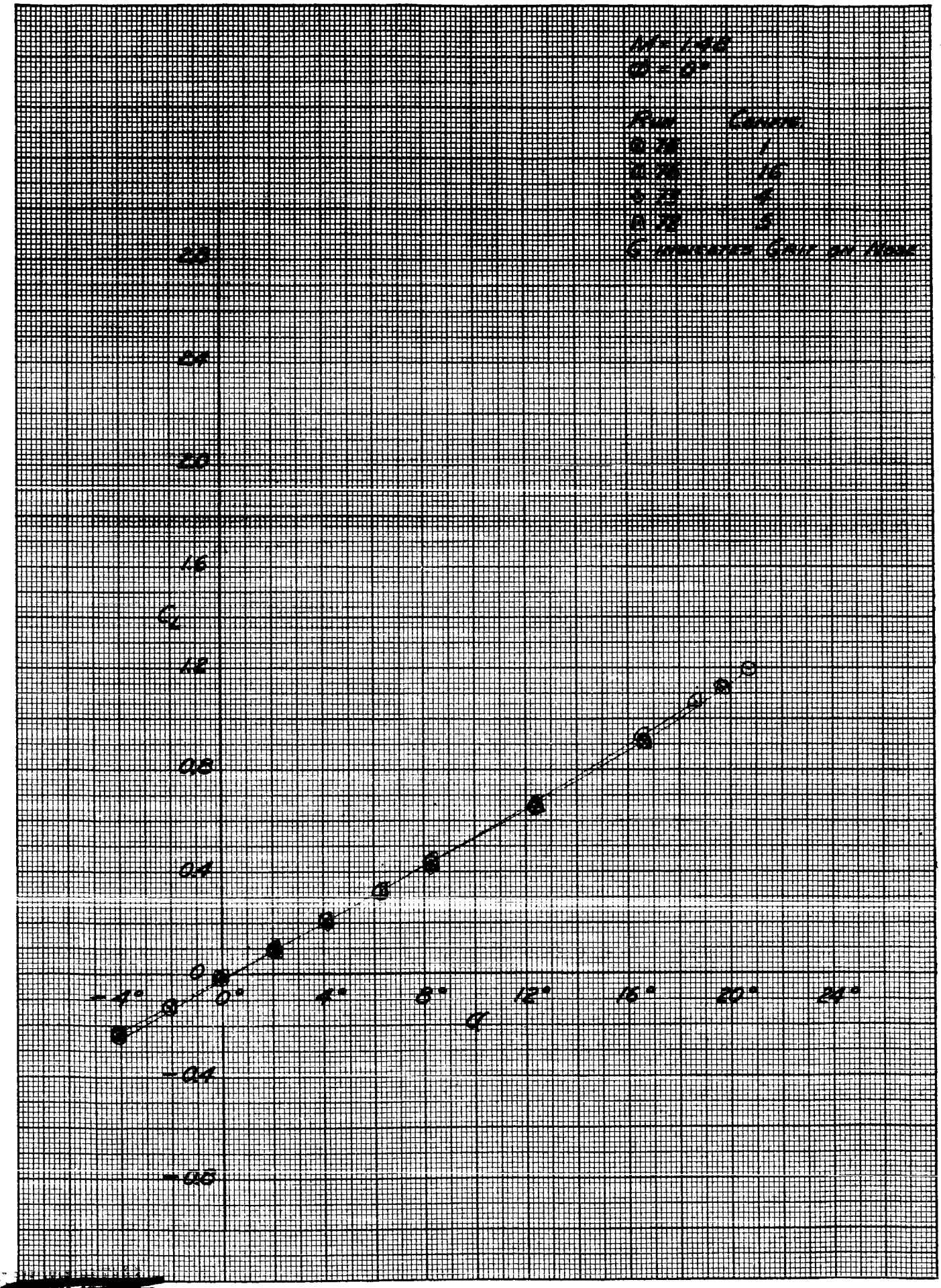

M = 1.45
β = 0°
Run
Curve
71
9
65
10
65
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

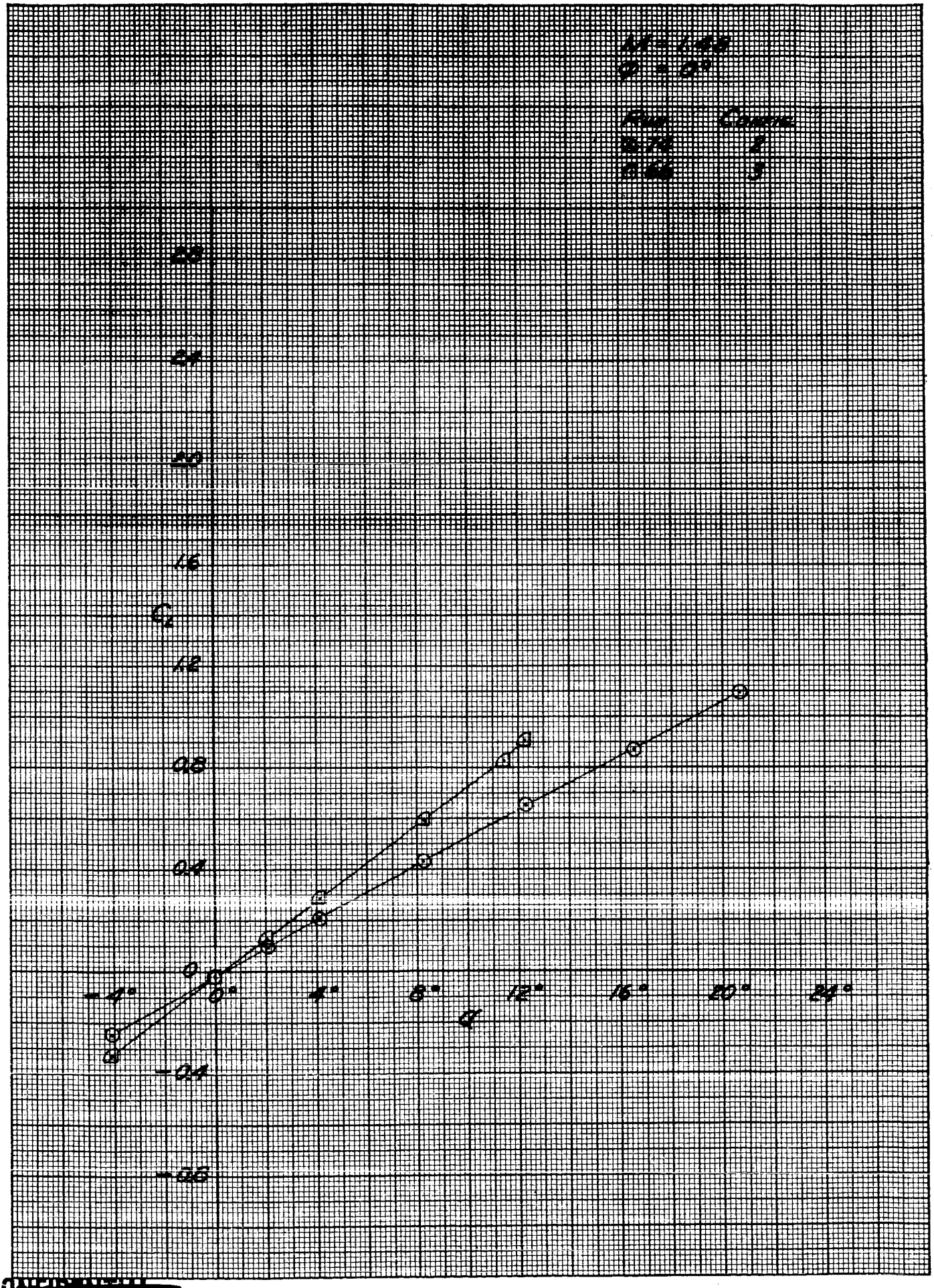

Run Channel
0.28
0.24
$C_{m_{cg}}$
-0.4
-0.8
-1.2
-1.6
-2.0
-4°
0°
4°
8°
12°
16°
20°
24°
α

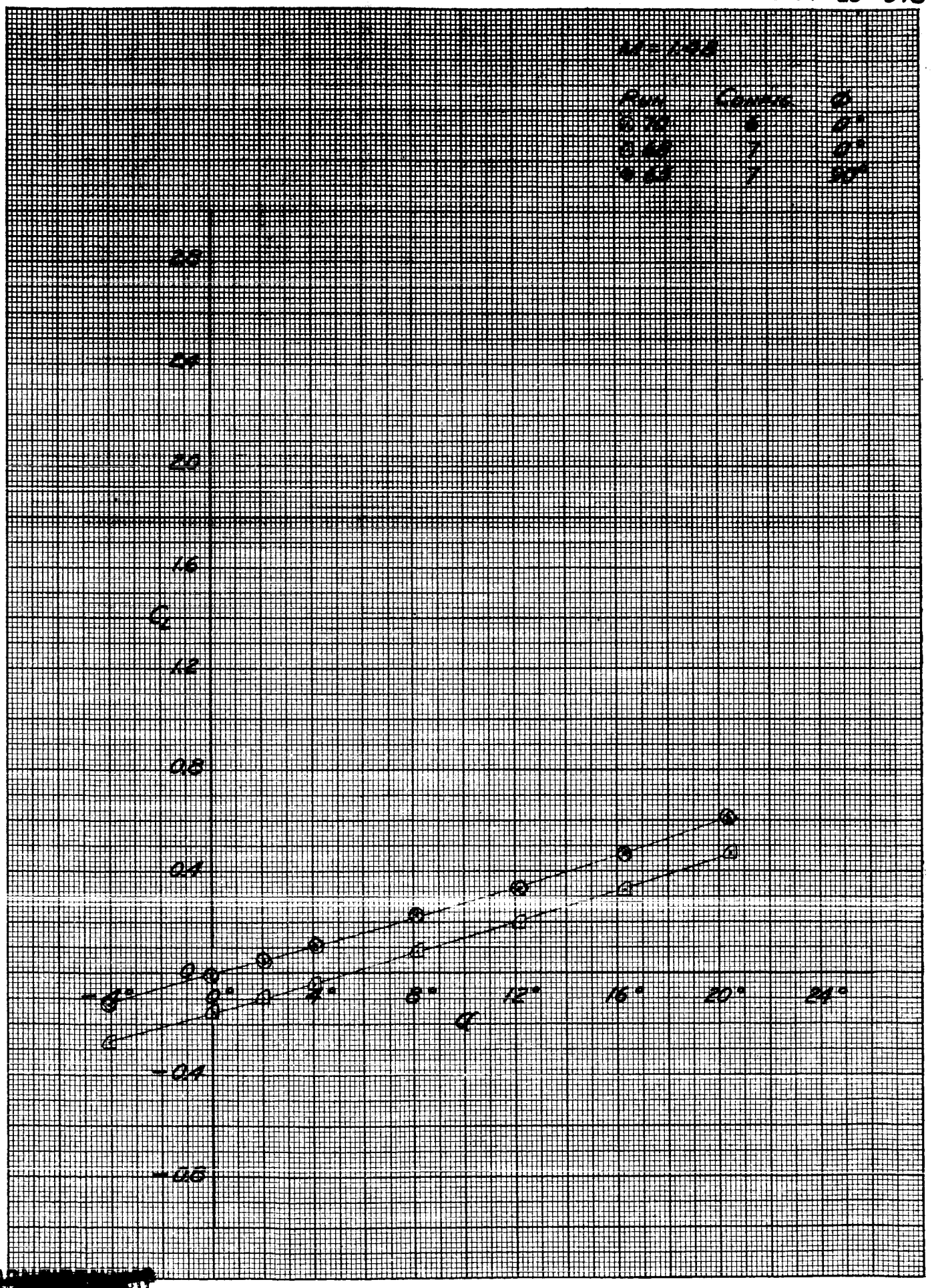

Run Curve
2
3
0.8
C_{m_φ}
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
-0.4
-0.8
-1.2
-1.6
-2.0

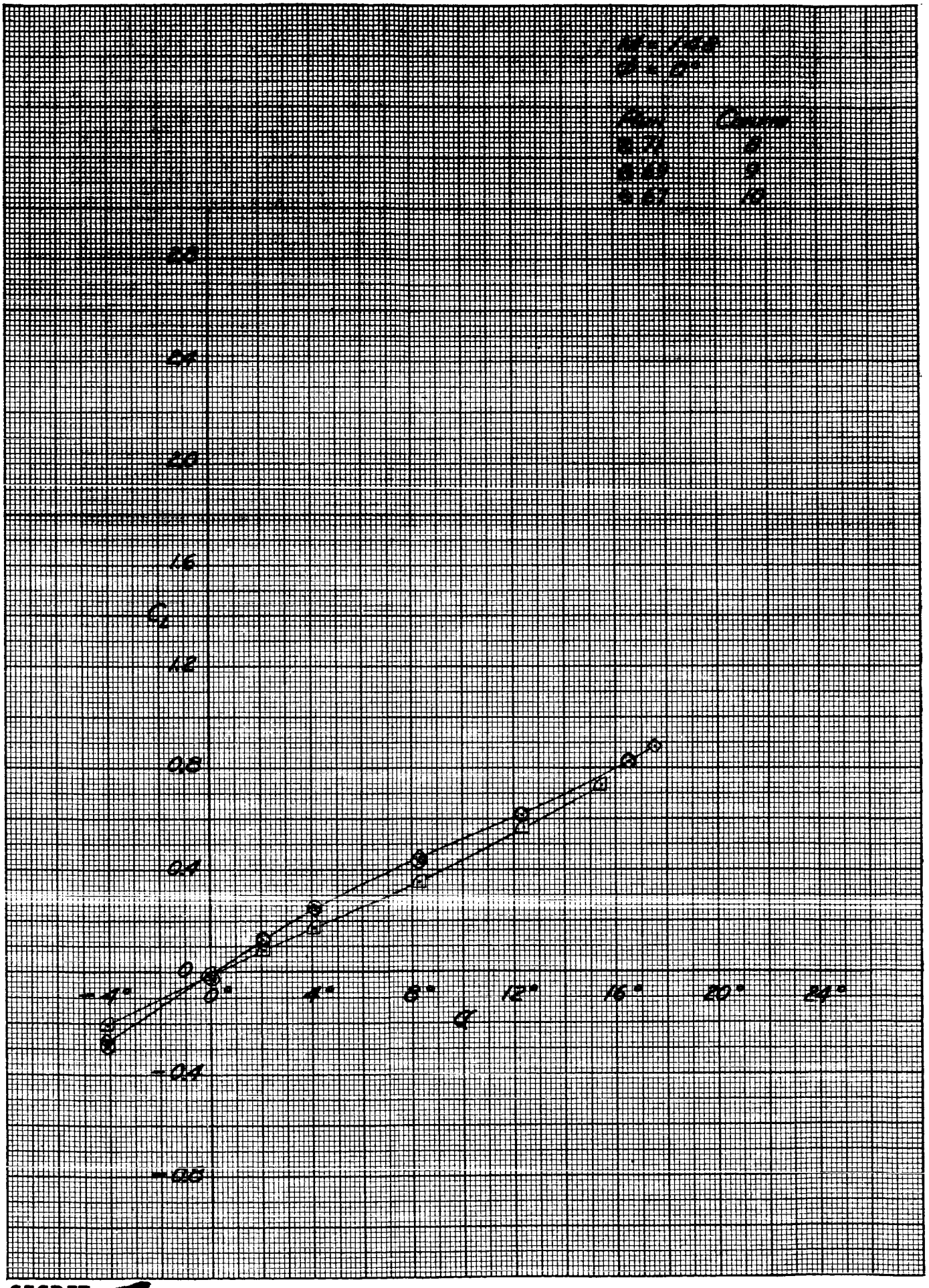

Run Curve
0.08
0.04
0
-0.4°
0°
4°
8°
12°
16°
20°
24°
-0.4
-0.8
-1.2
-1.6
-2.0

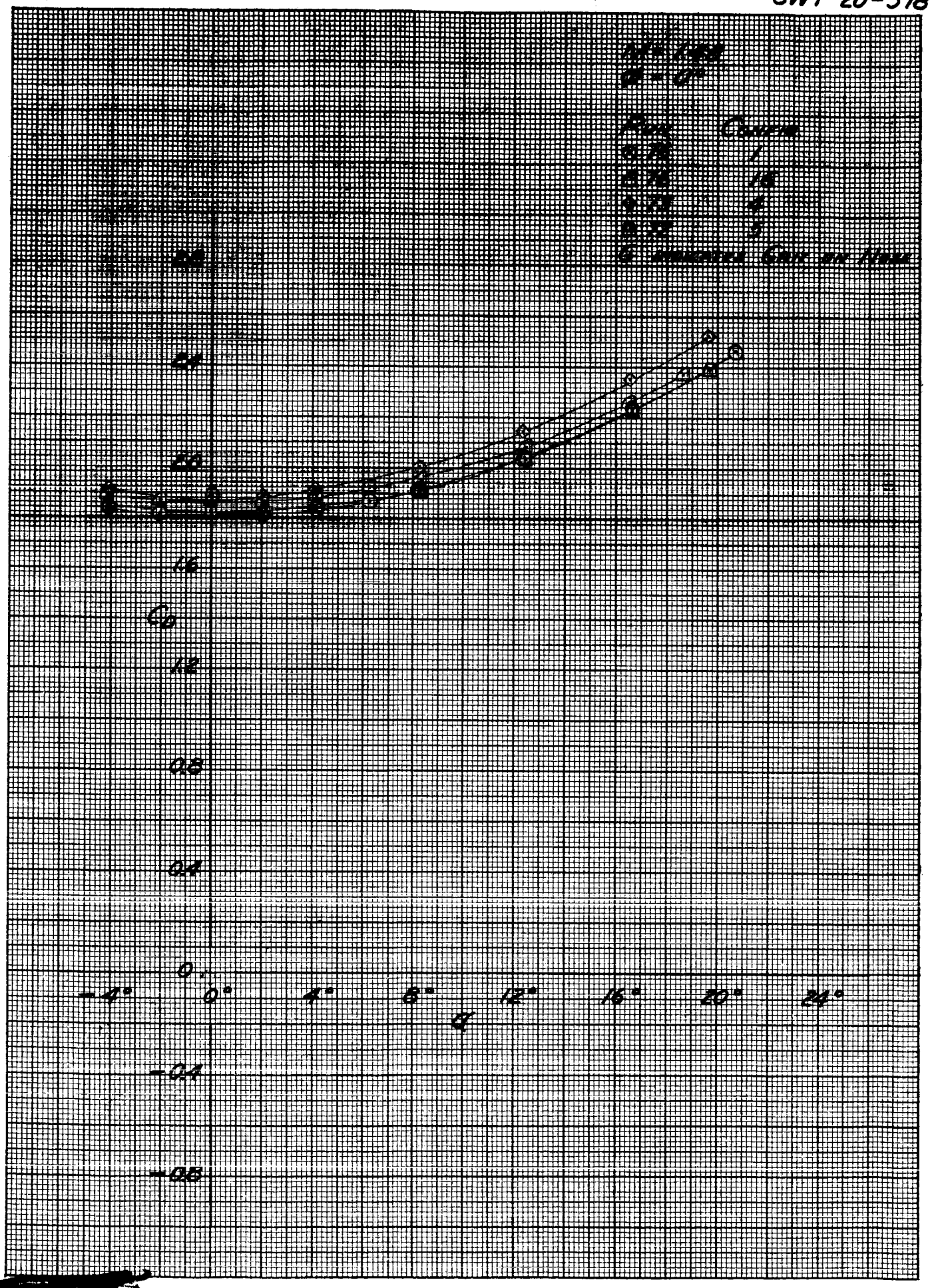

0.08
$C_{m_{cg}}$
0.04
0°
-4°
0°
8°
12°
16°
20°
24°
-0.04
-0.08
-0.12
-0.16
-0.20

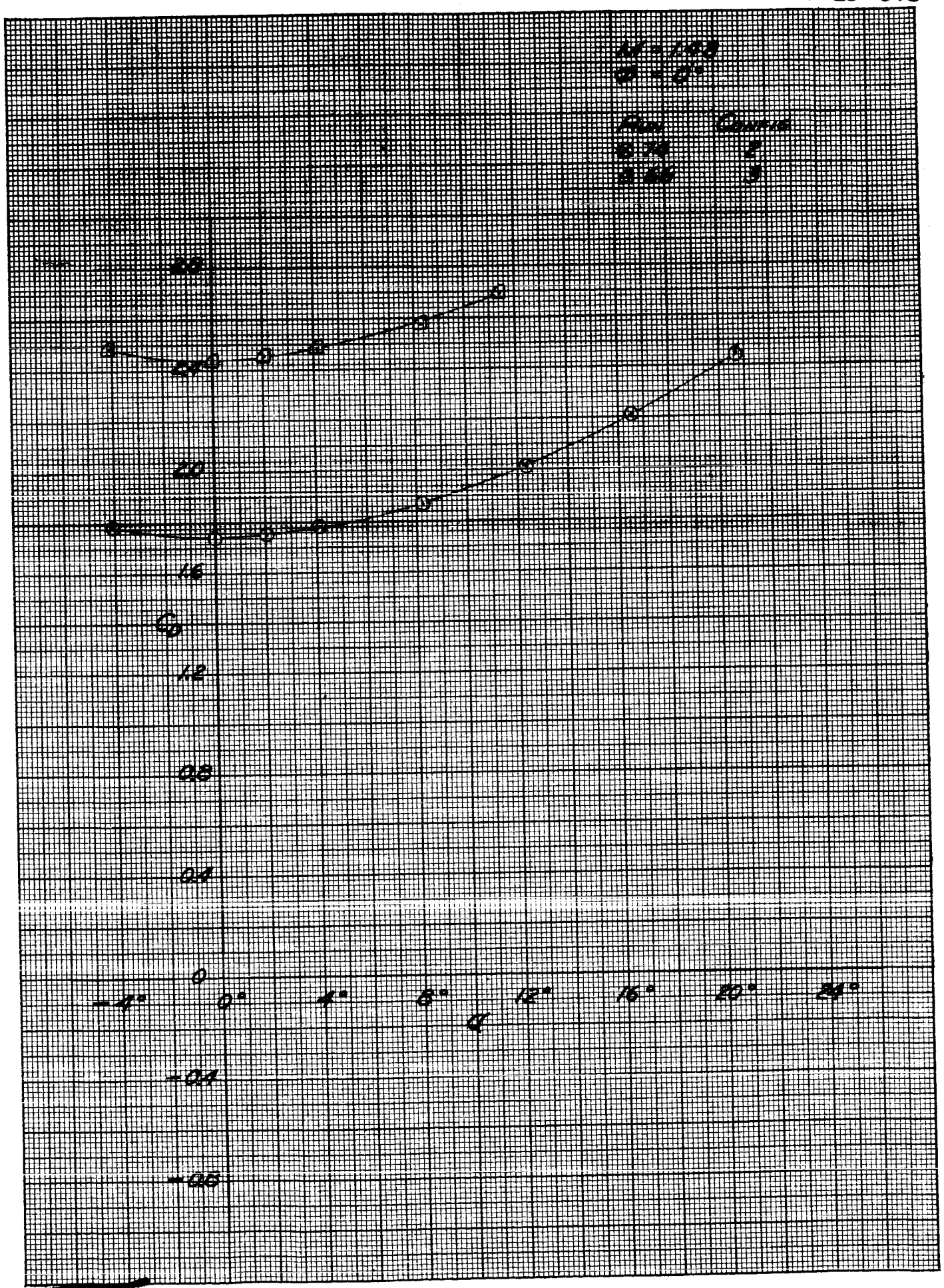

M = 1.48
β = 0°
Run Curve
1
16
24
35
Interference Grid on Nose
.28
.24
.20
.16
C_L
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

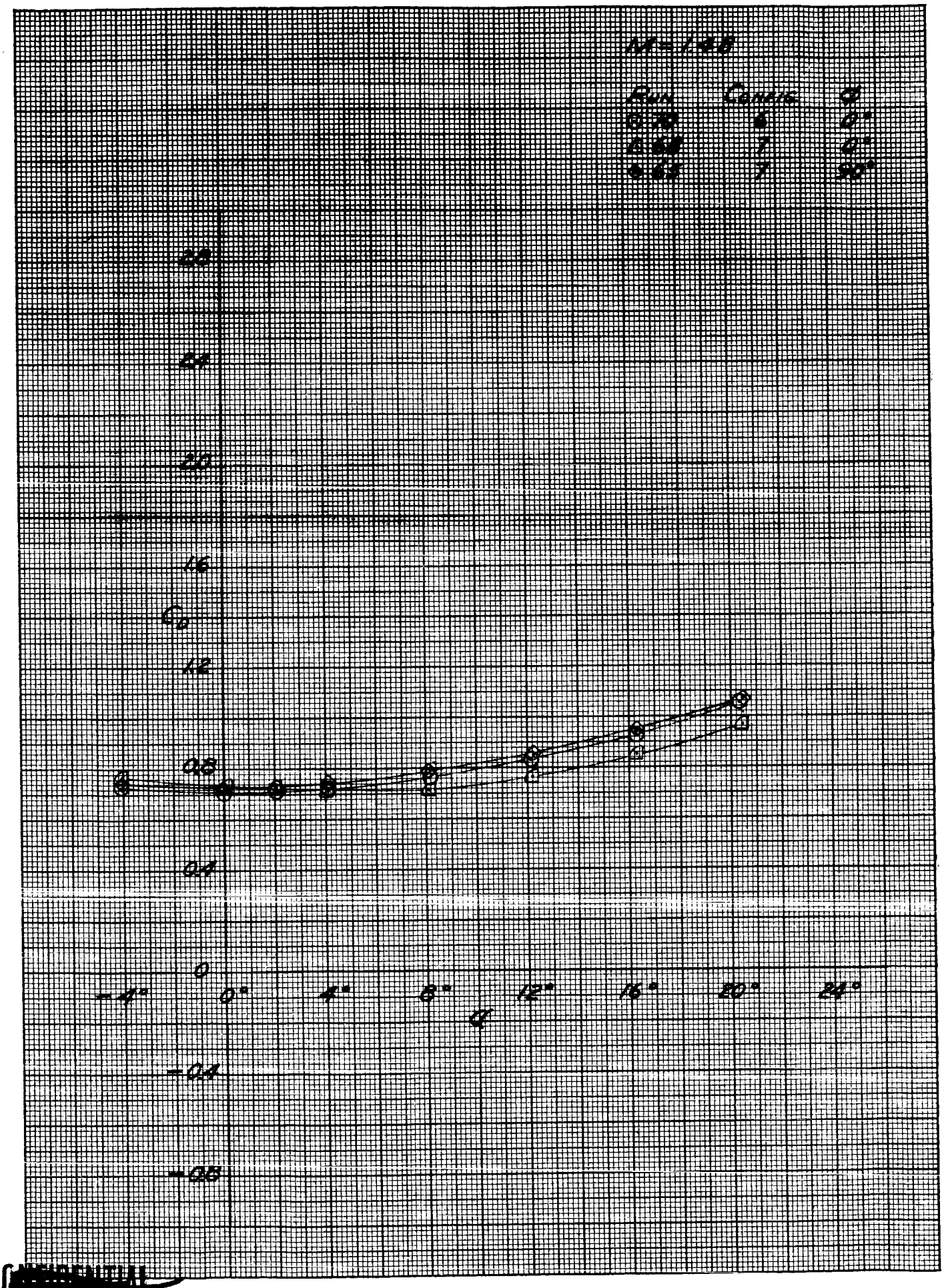

M = 1.48
φ = 0°
Flap Chord
0.75 2
0.60 3
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

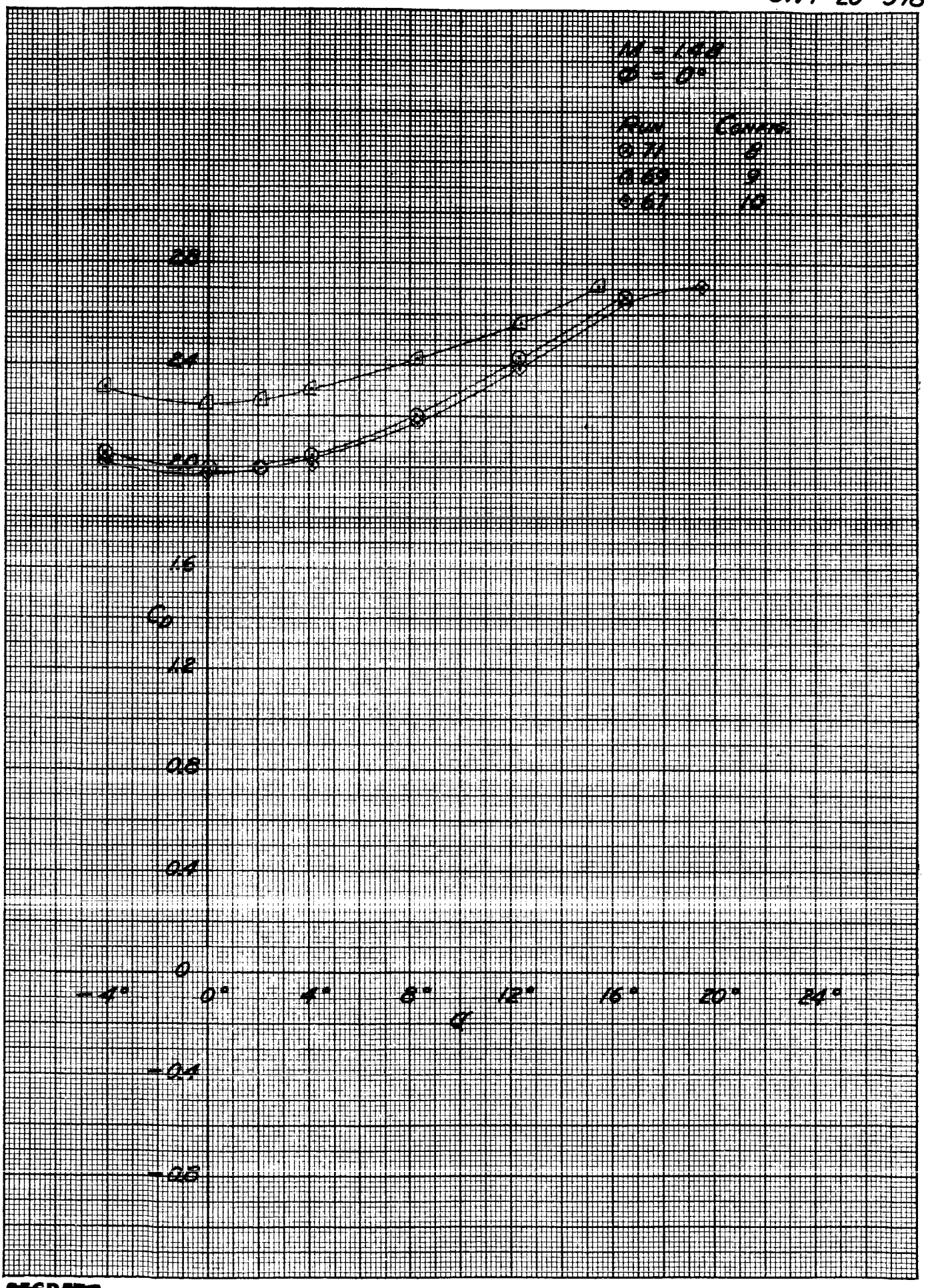

Run
Control
C_L
.28
.24
.20
.16
.12
.08
.04
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

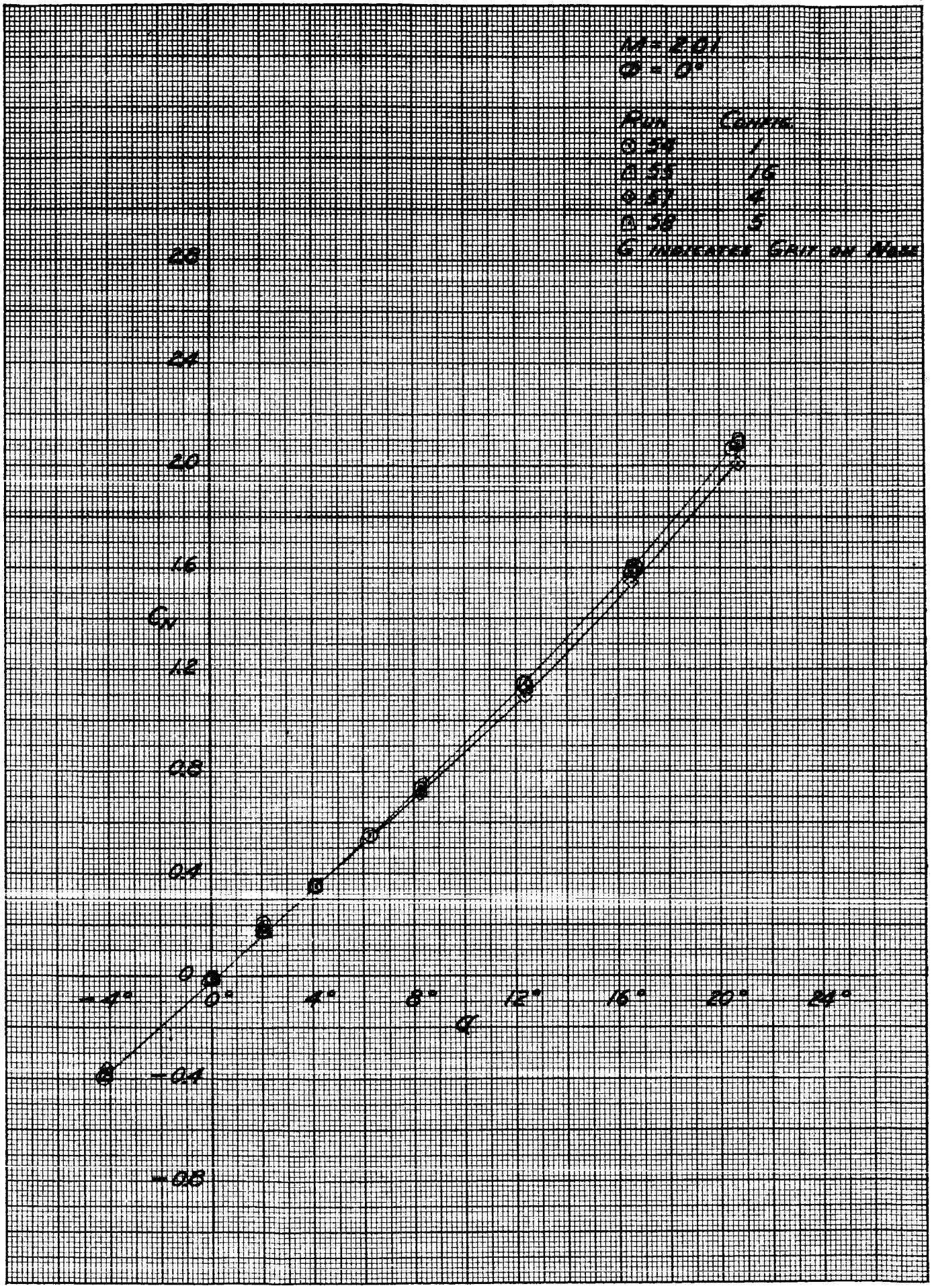

Curve
2.0
1.6
C_L
1.2
0.8
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8

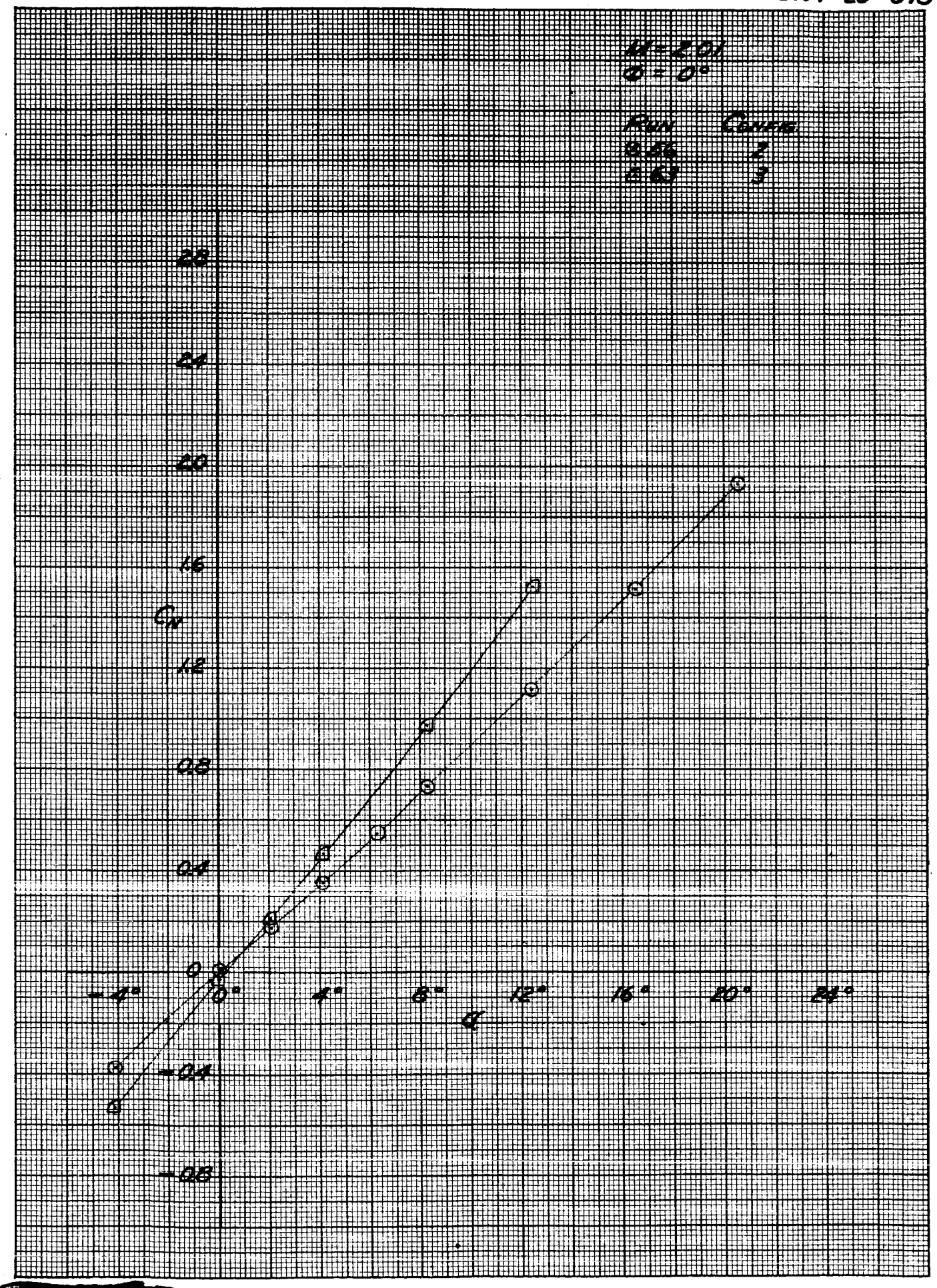

Curve
1
16
4
5
Incidence Gap on Nose
.24
.20
.16
C_D
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

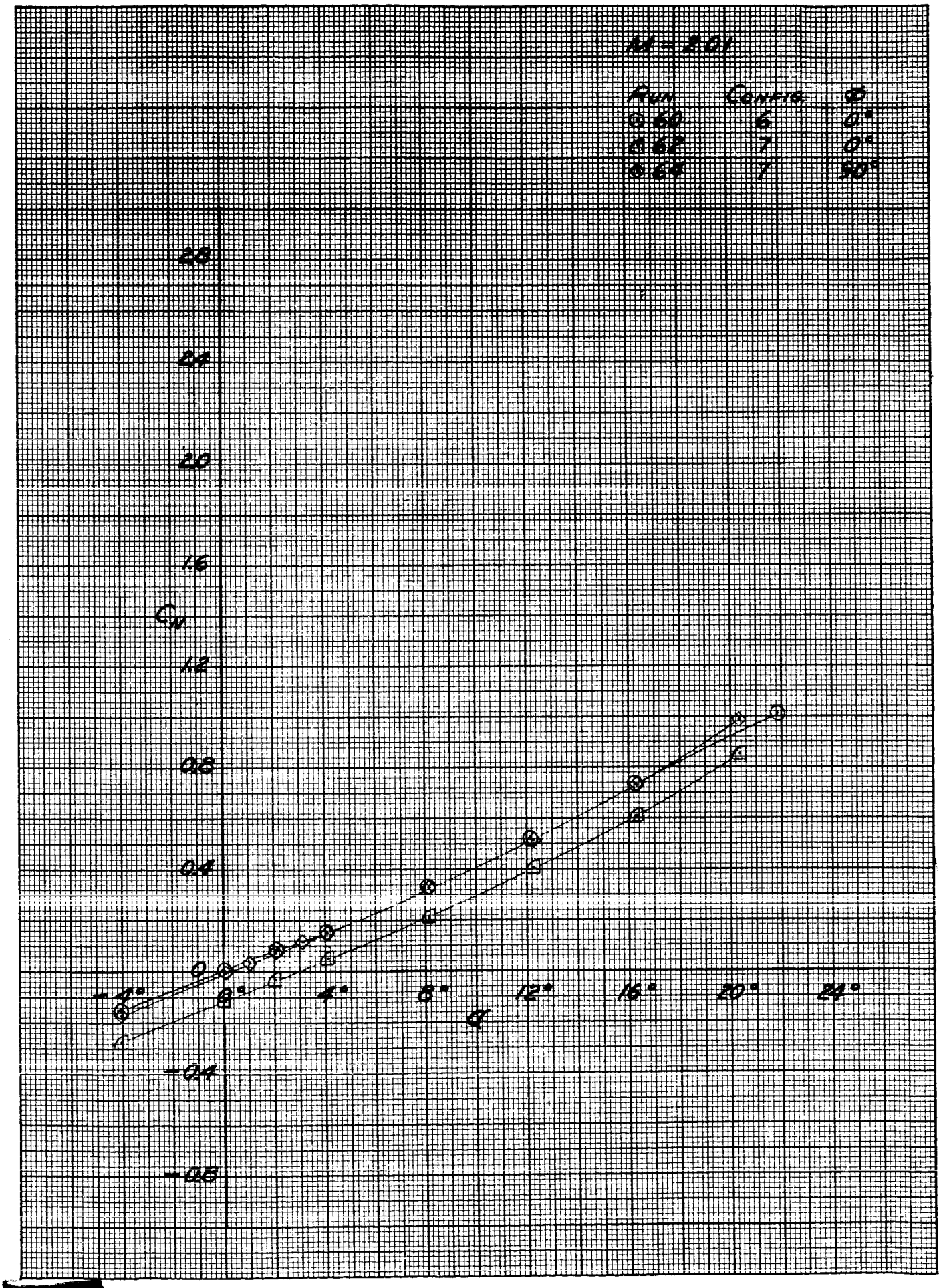

M = 1.98
β = 0°
Run Curve
2
3
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.08
C_D
-4°
0°
4°
8°
12°
16°
20°
24°
α

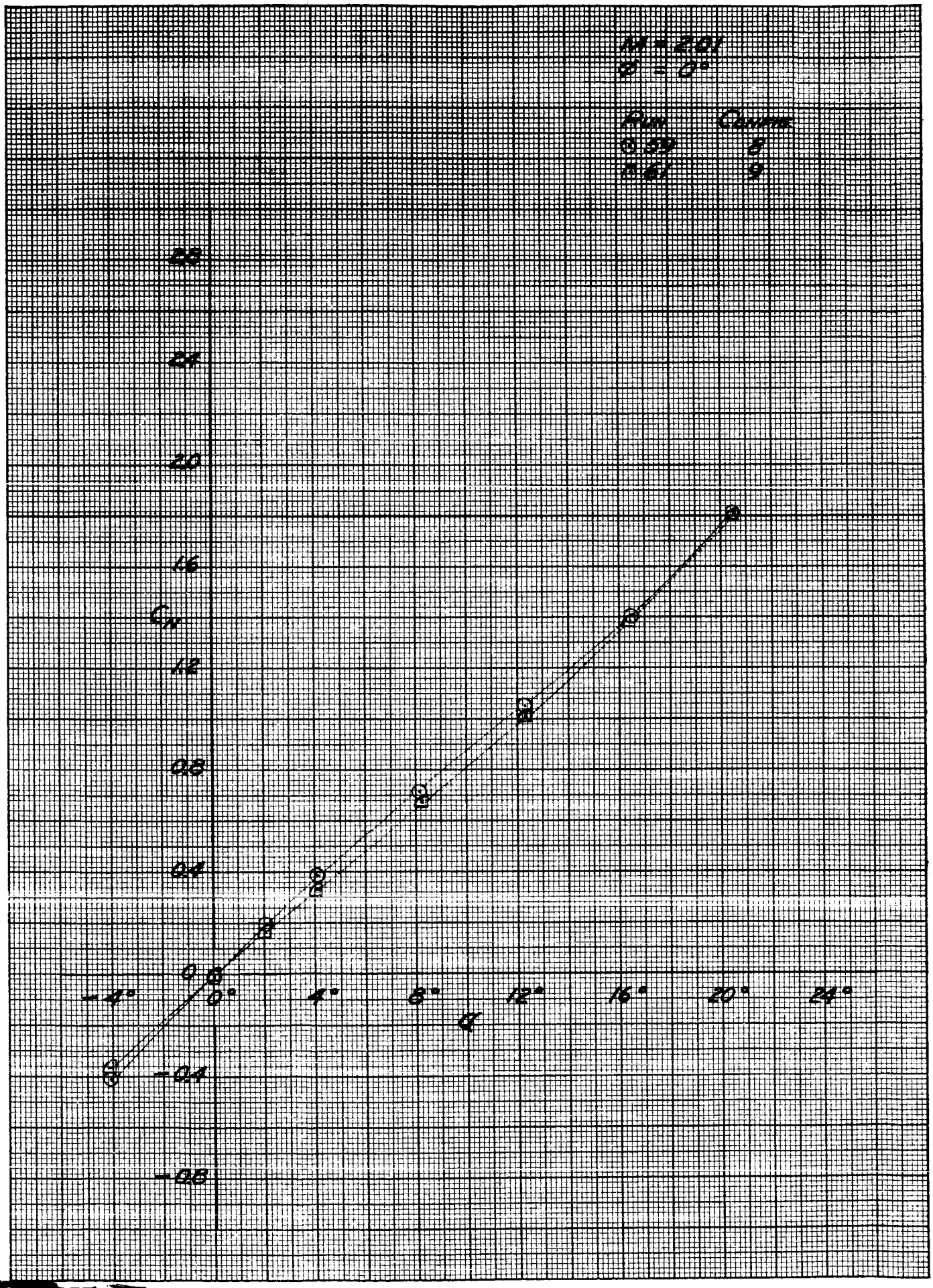

M = 1.48
Run
Config.
β
6
0°
7
0°
7
90°
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

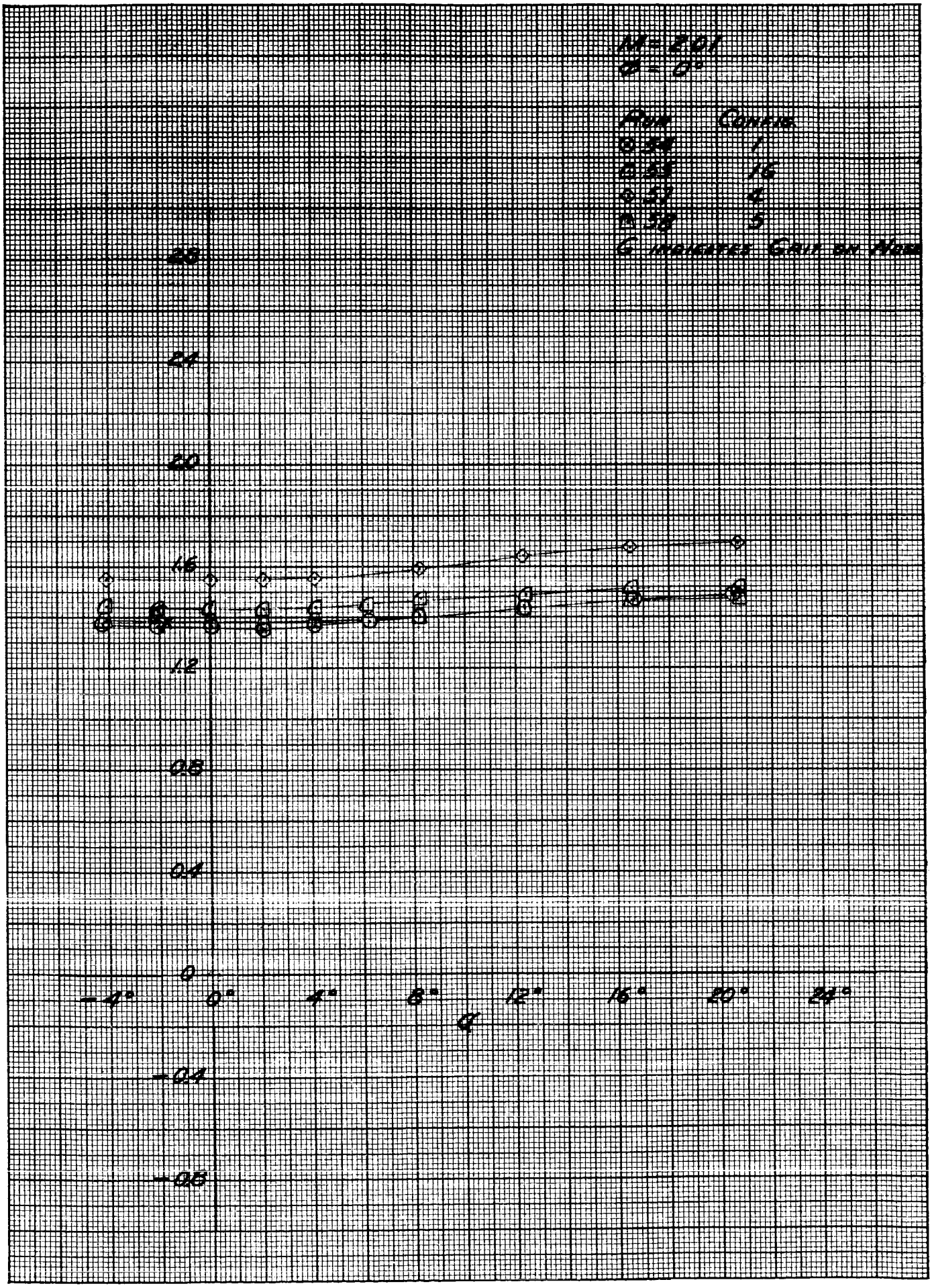

M = 1.42
φ = 0°
Run Comm.
70 8
69 9
67 10
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

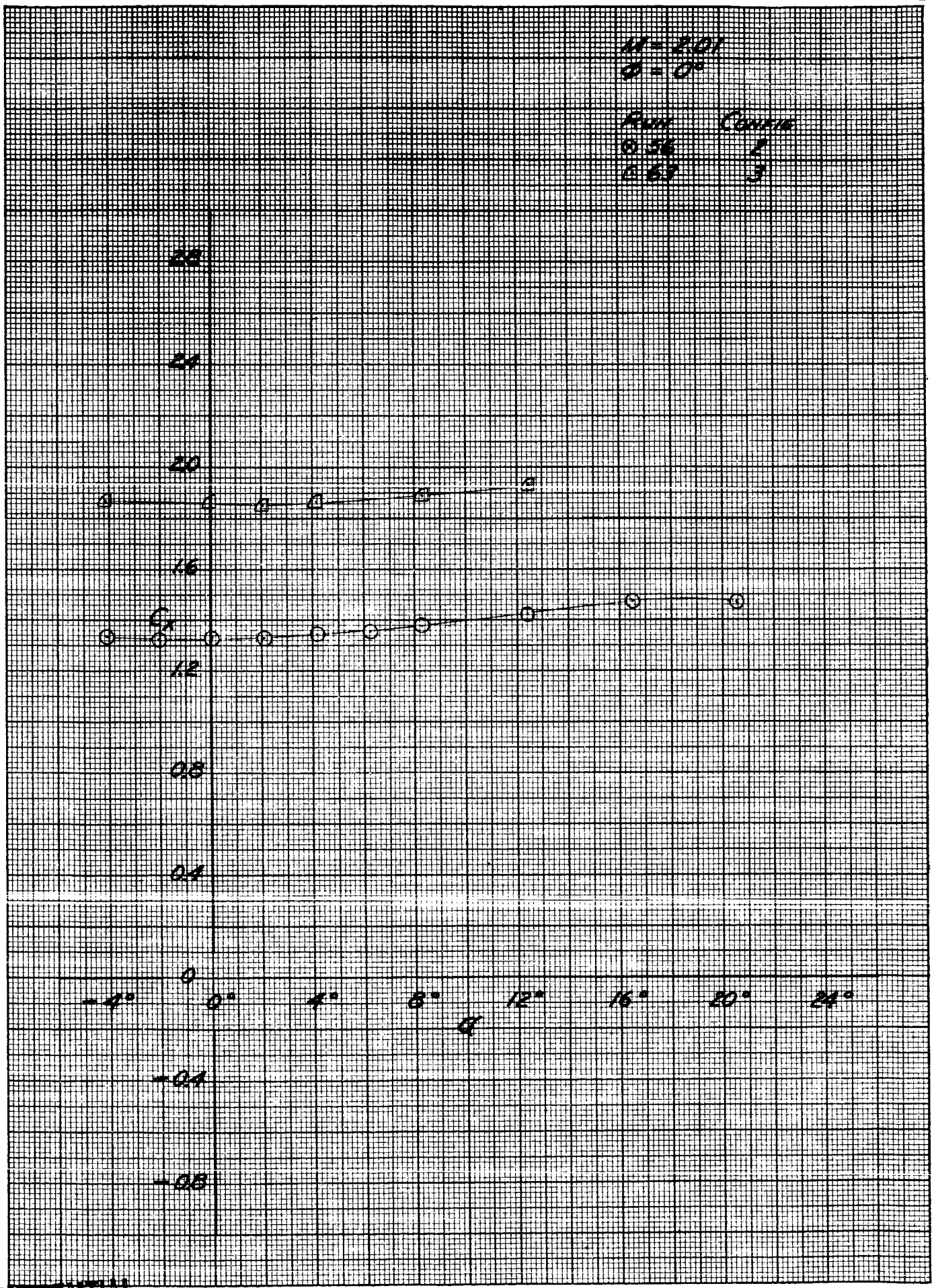

M = 2.01
Φ = 0°
Run Contr.
54 1
55 16
57 4
58 5
G indicates Grit on Nose
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

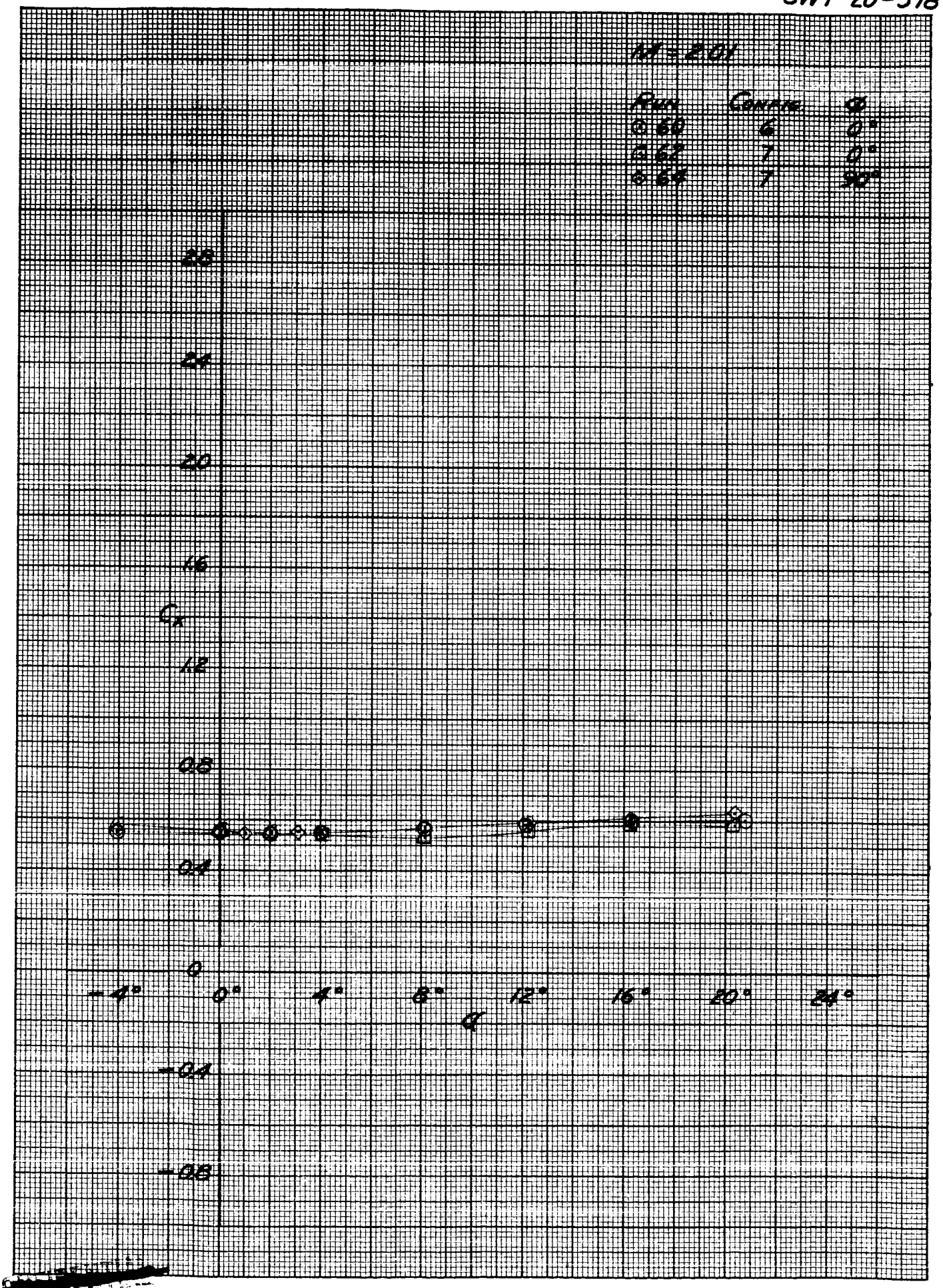

M = 2.01
Φ = 0°
Run Config
0.56 2
0.63 3
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

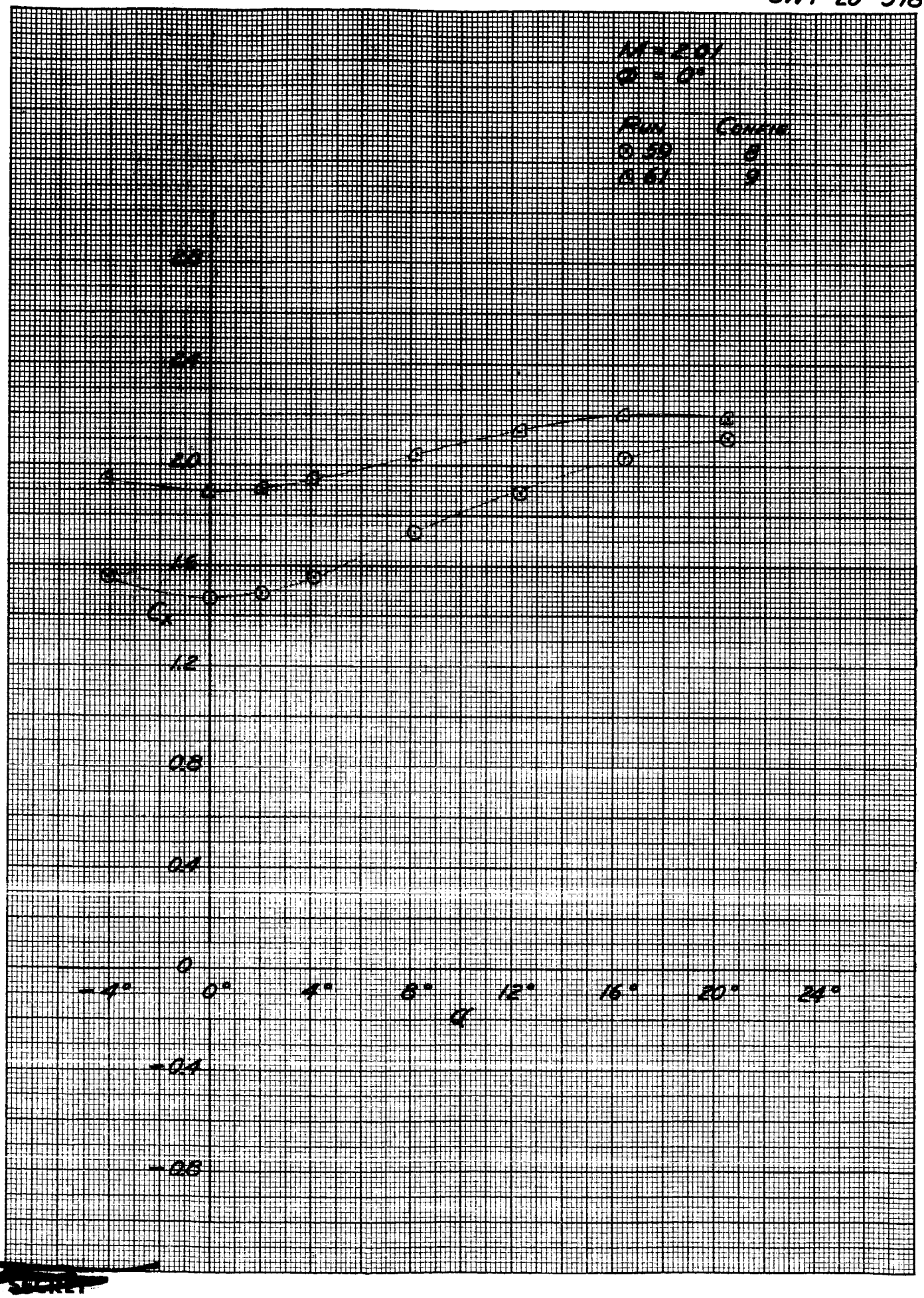

M = 2.01
Run Config φ
60 6 0°
62 7 0°
64 7 90°
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

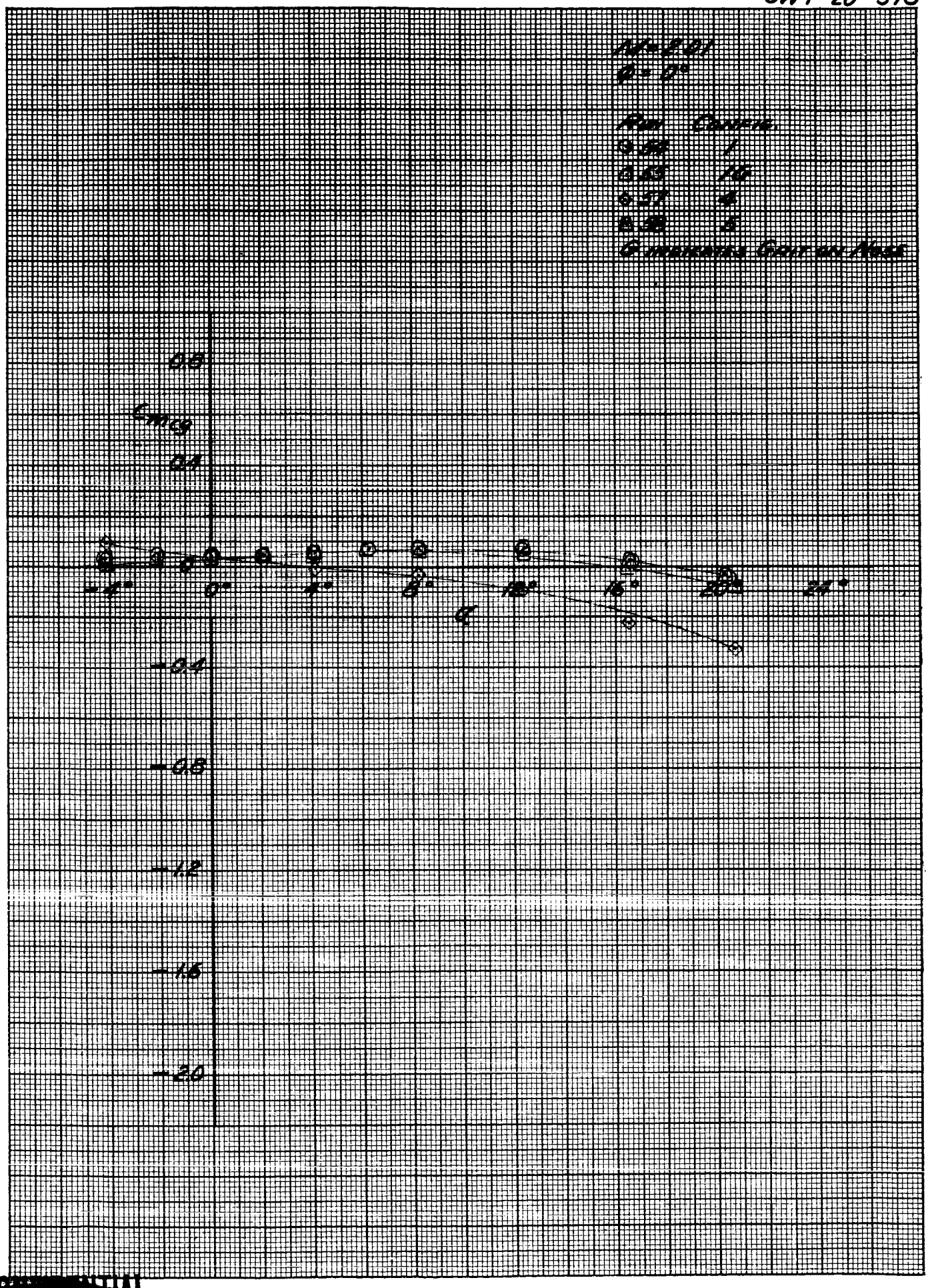

M = 2.01
β = 0°
Run
Camera
39
6
61
9
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

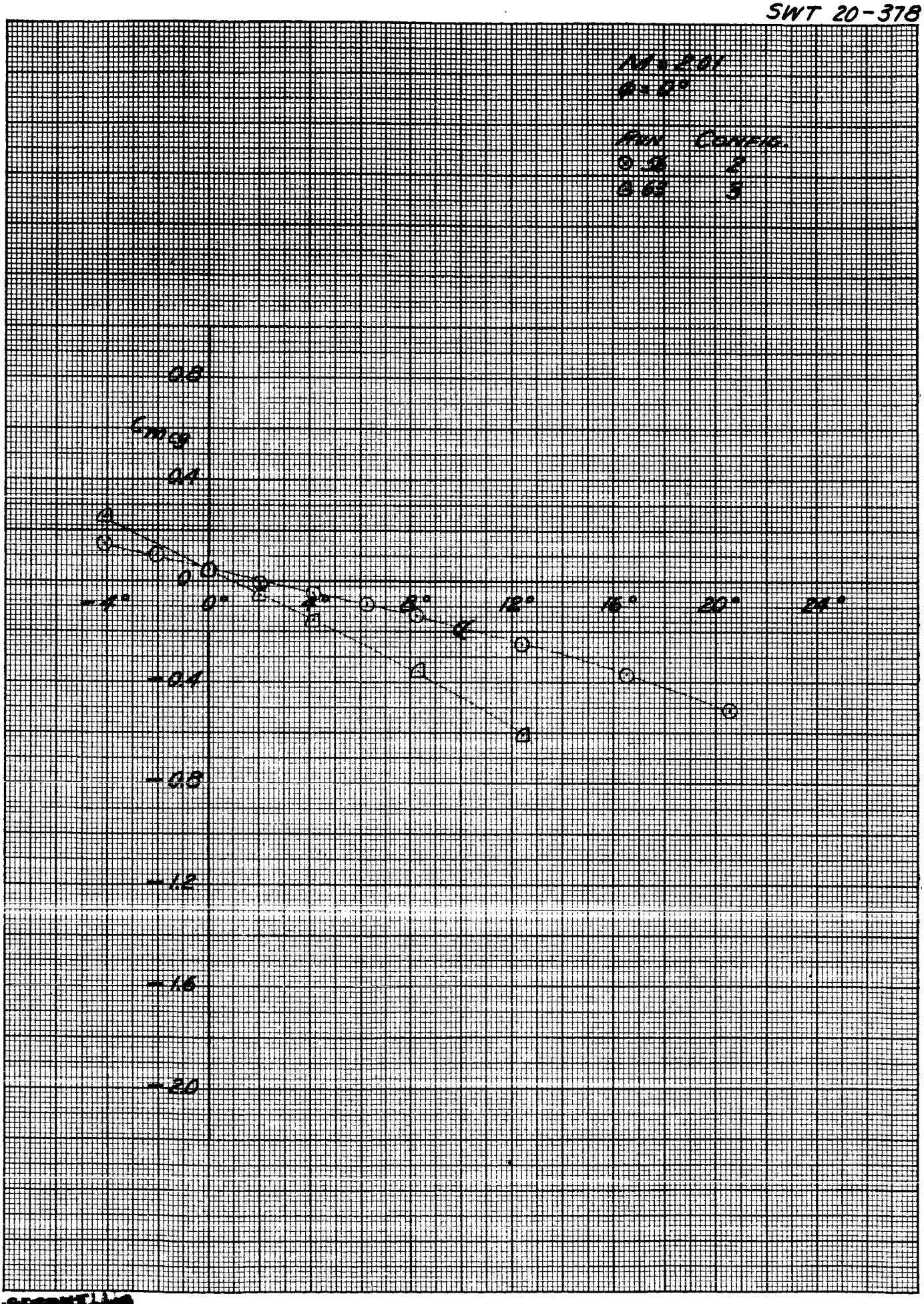

M = 2.01
β = 0°
Mod Configs.
24 1
25 16
27 4
28 5
G indicates Grit on Mod
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

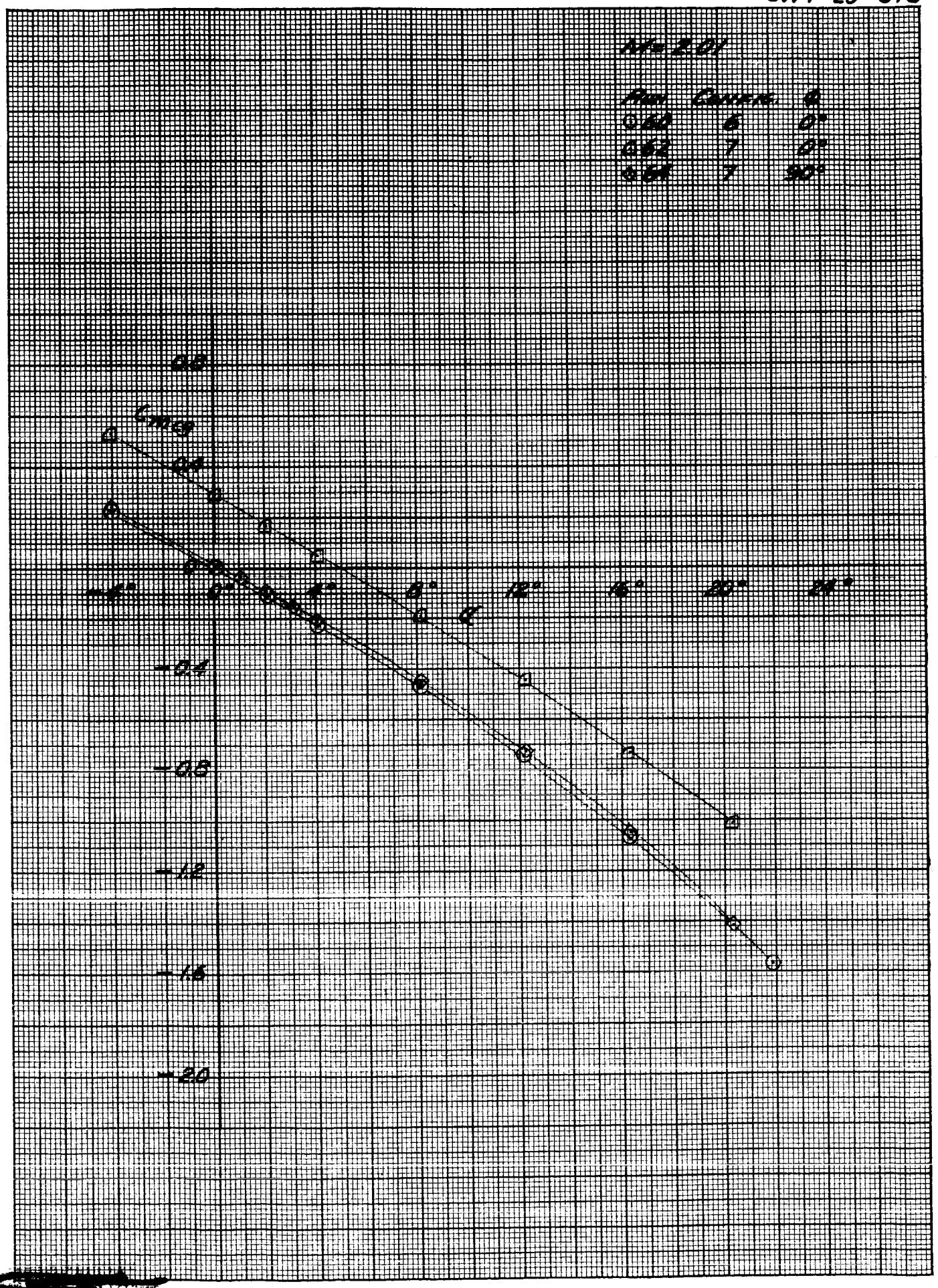

M = 2.01
β = 0°
Run
Curve
⊙ 56
2
△ 63
3
2.8
2.4
2.0
1.6
C_x
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 2.01
Run Configs φ
60 6 0°
62 7 0°
64 7 90°
.28
.24
.20
.16
C_x
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 2.01
β = 0°
Run
Camera
20
16
12
0.8
0.4
0
-0.4
-0.8
C_x
-4°
0°
4°
8°
12°
16°
20°
24°
α

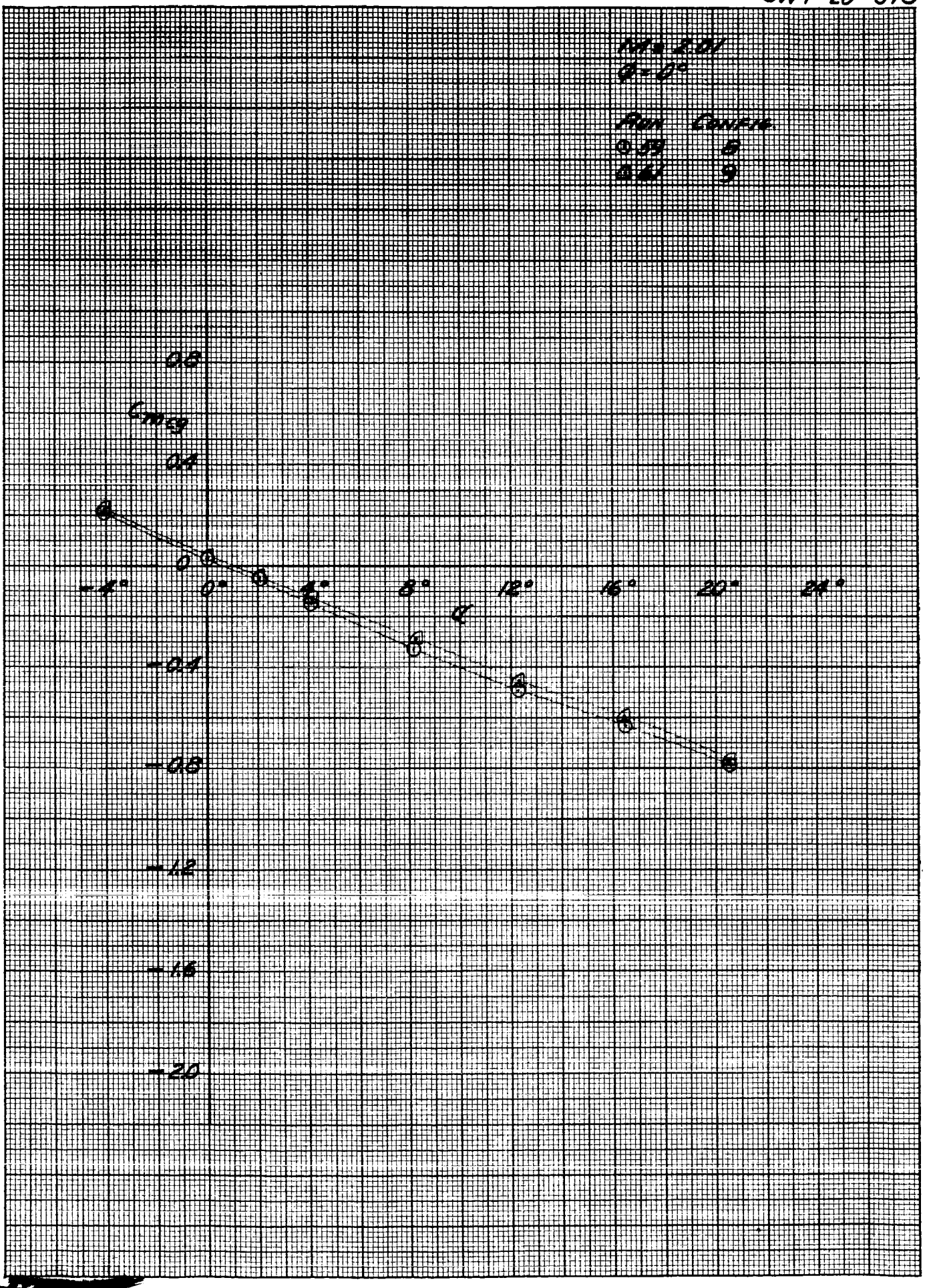

Run Centre
0.8
$C_{m_{CG}}$
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8
-1.2
-1.6
-2.0

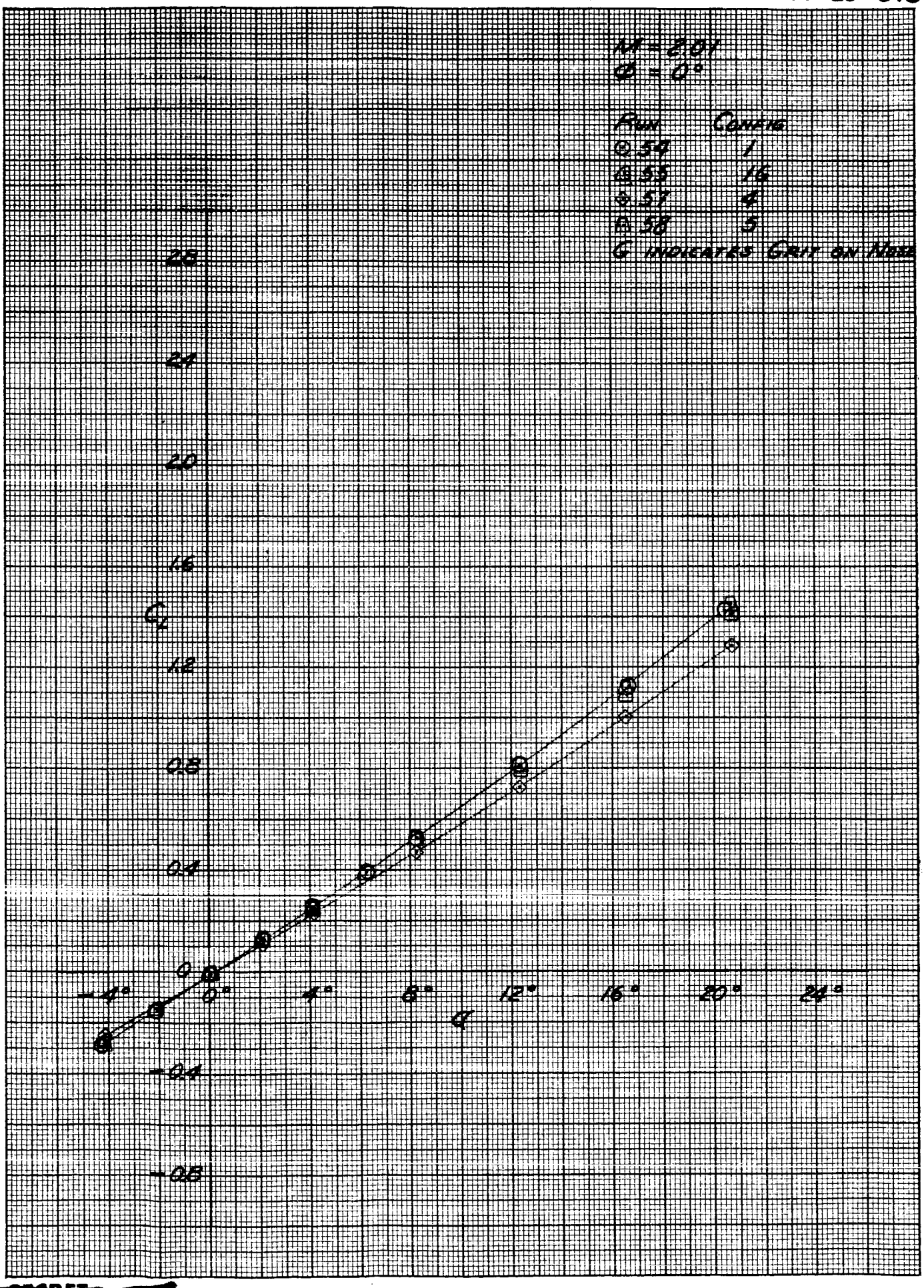

M = 2.01
α = 0°
PIN CONFIG.
56 2
62 3
0.8
C_{m_α}
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8
-1.2
-1.6
-2.0

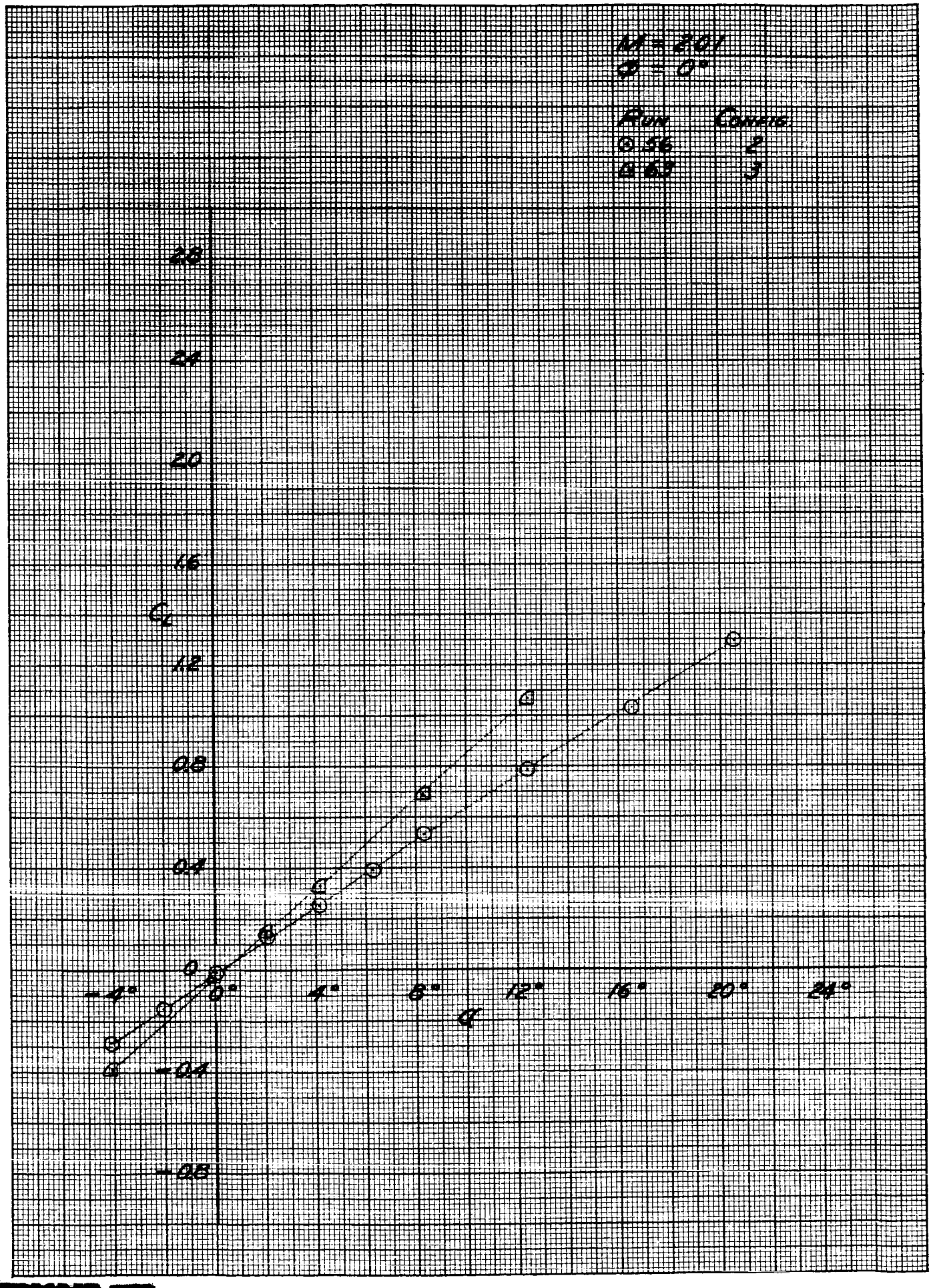


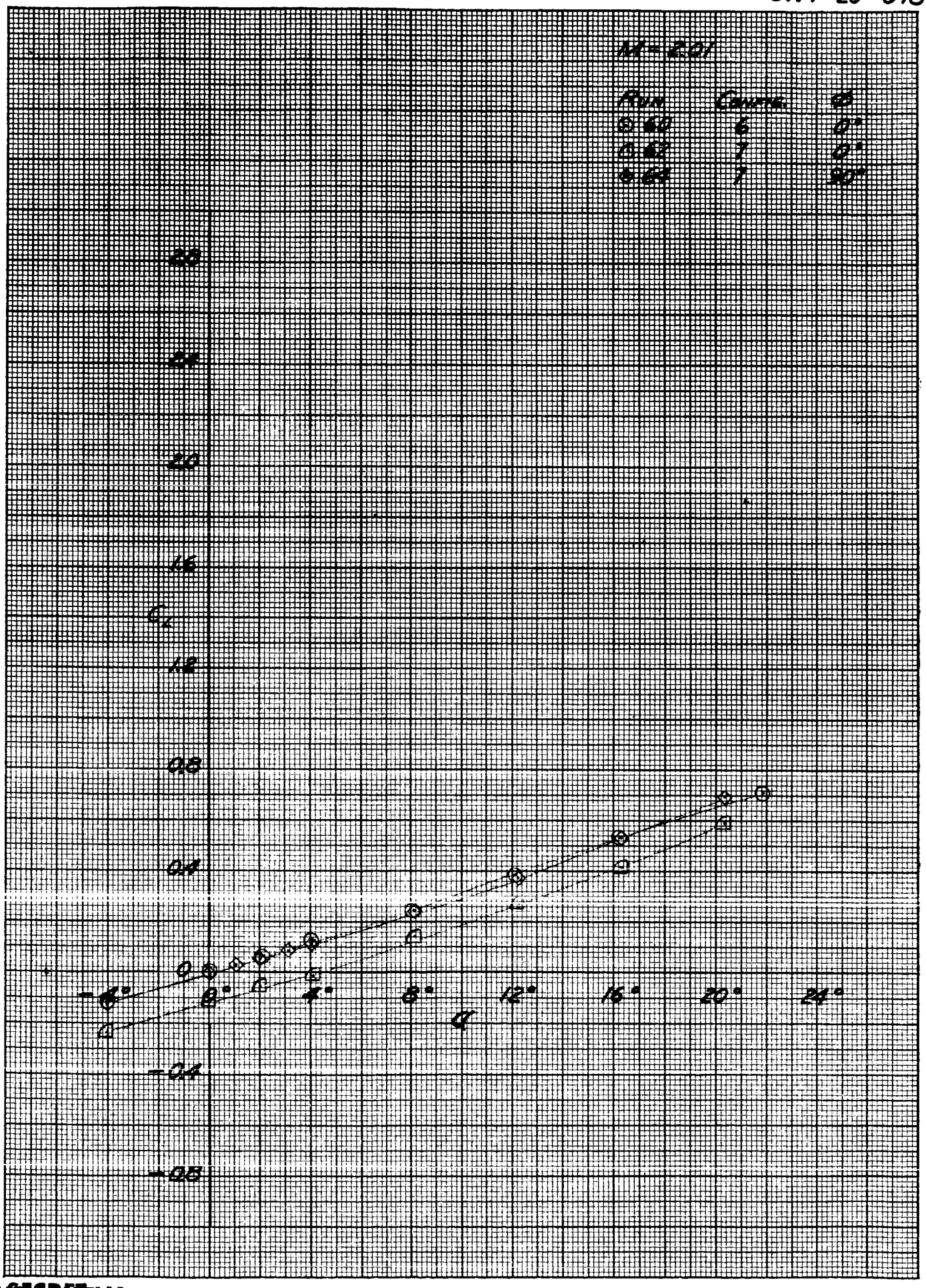
[redacted]

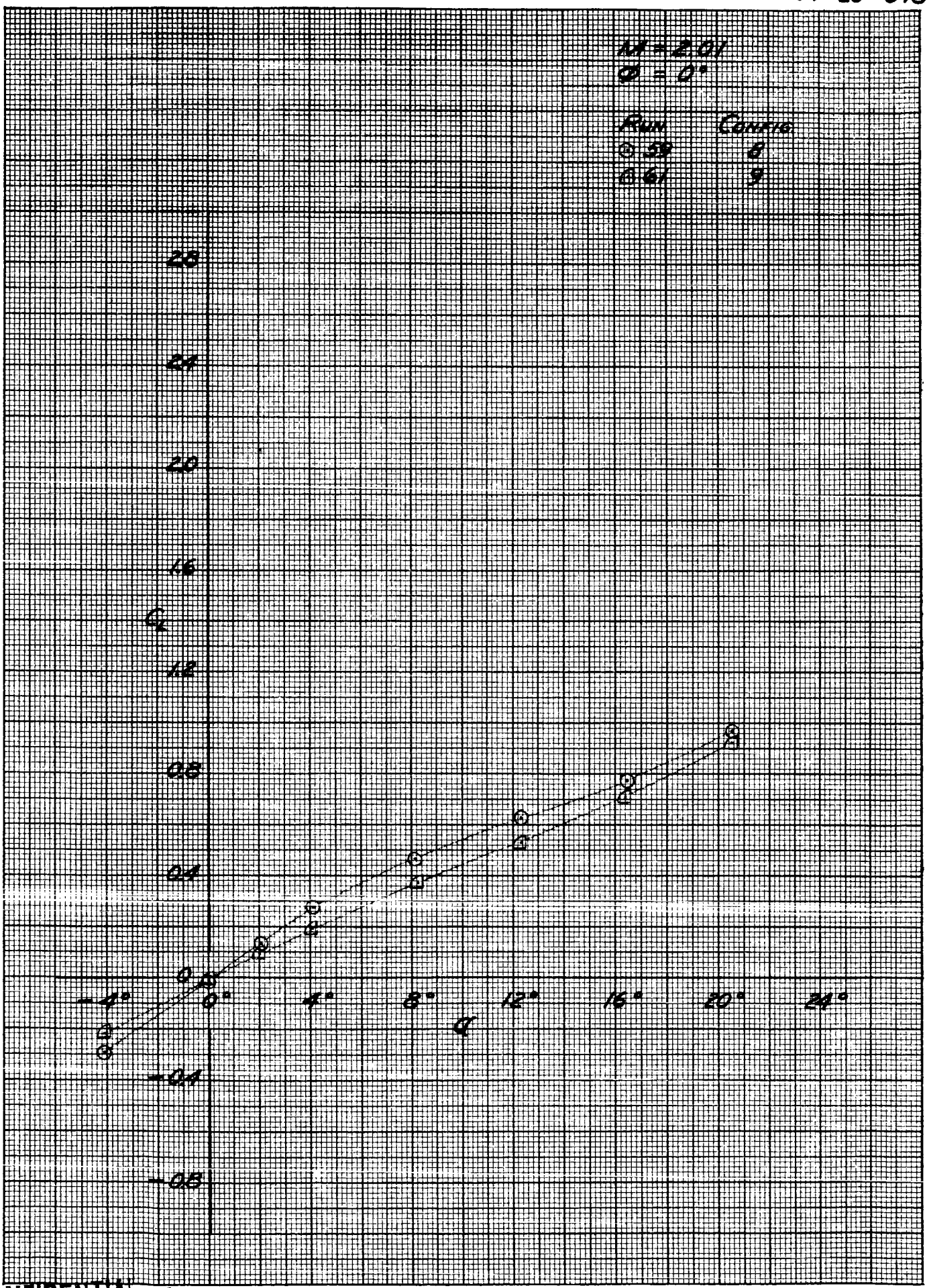
PLOT 8C

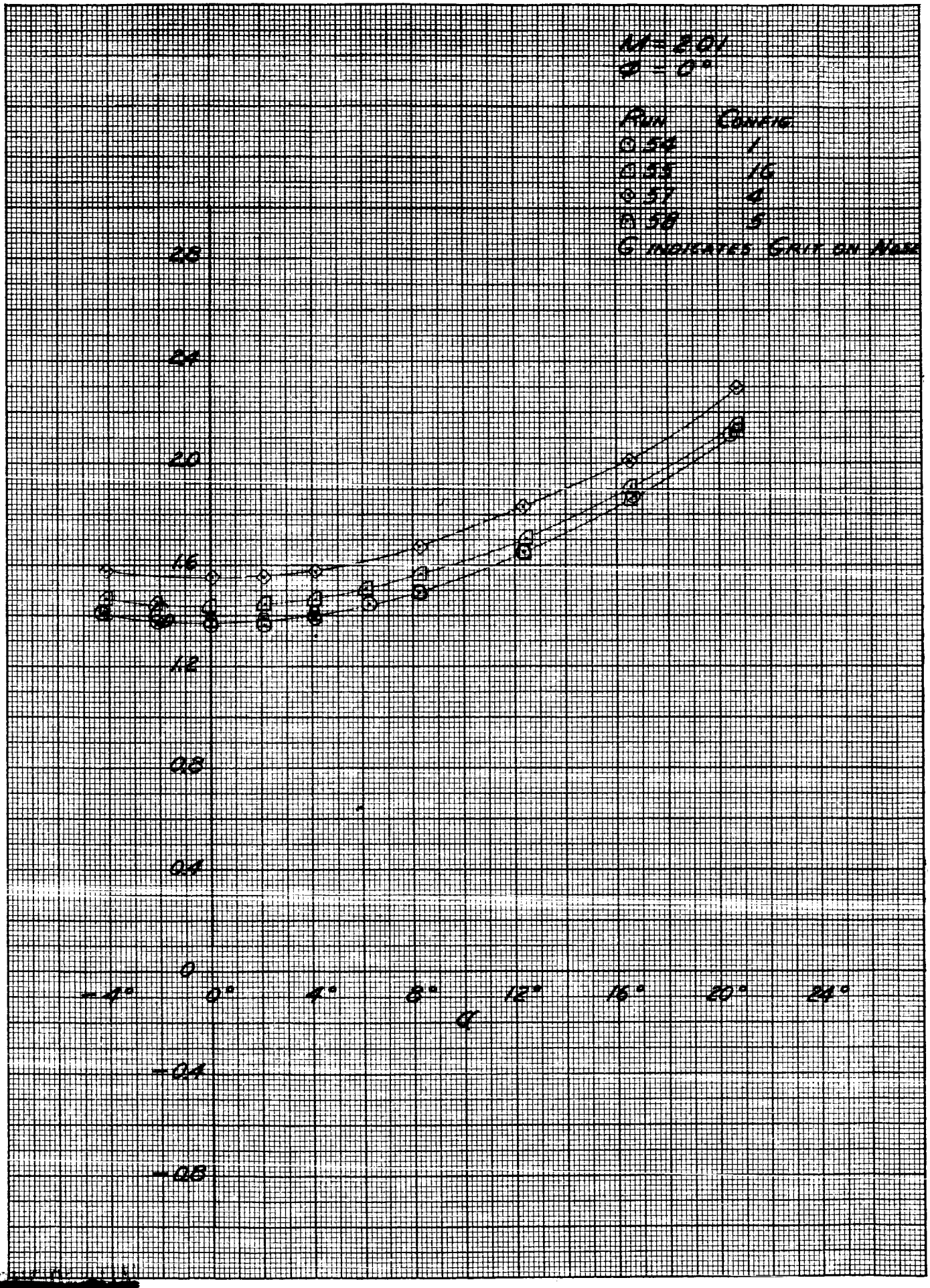

M = 2.01
β = 0°
Run Config.
39 8
41 9
0.8
$C_{m_{cg}}$
0.4
0
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8
-1.2
-1.6
-2.0

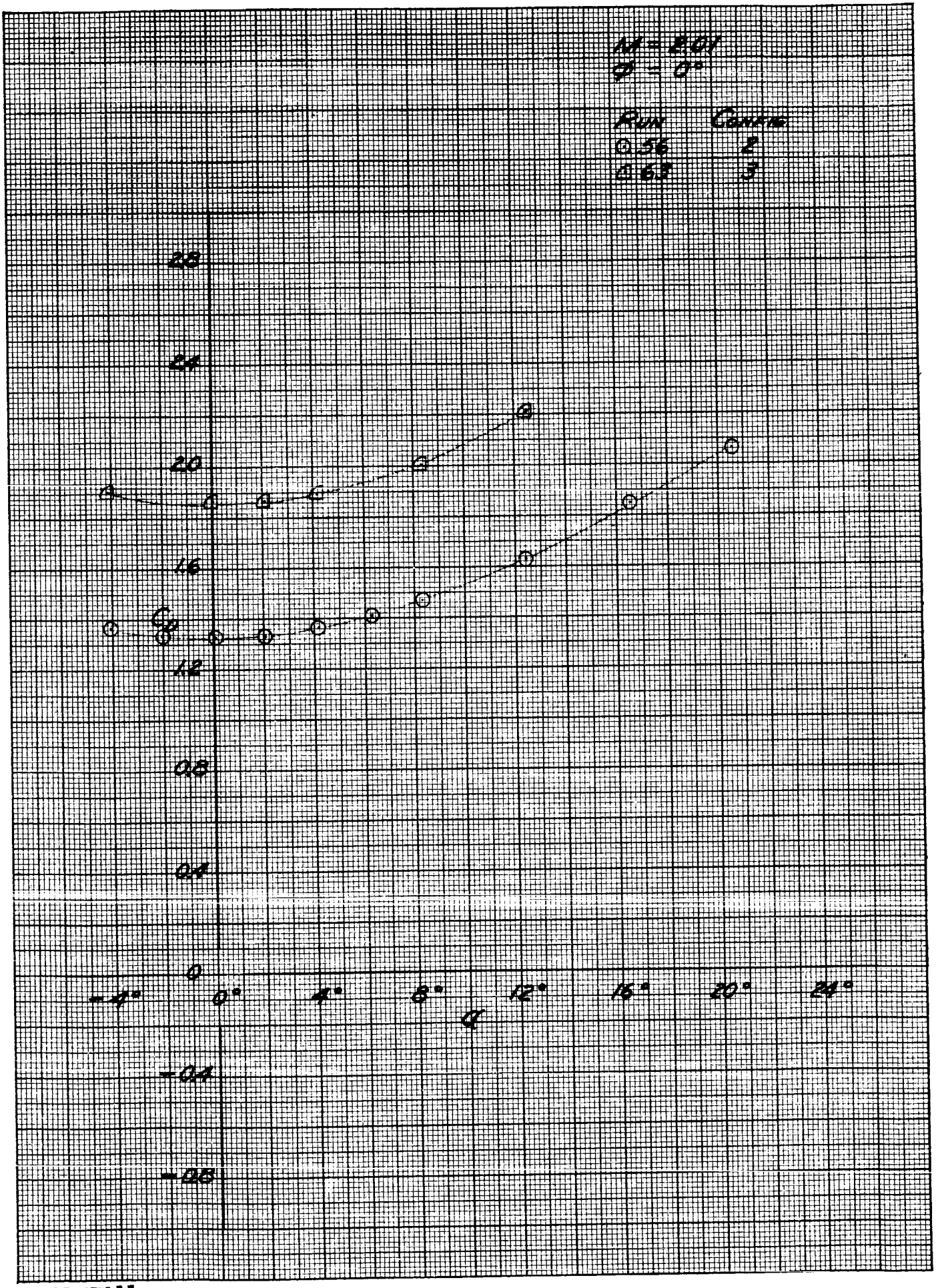

M = 2.01
Φ = 0°
Run Config
54 1
55 16
57 4
58 5
G indicates Grit on Nose
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

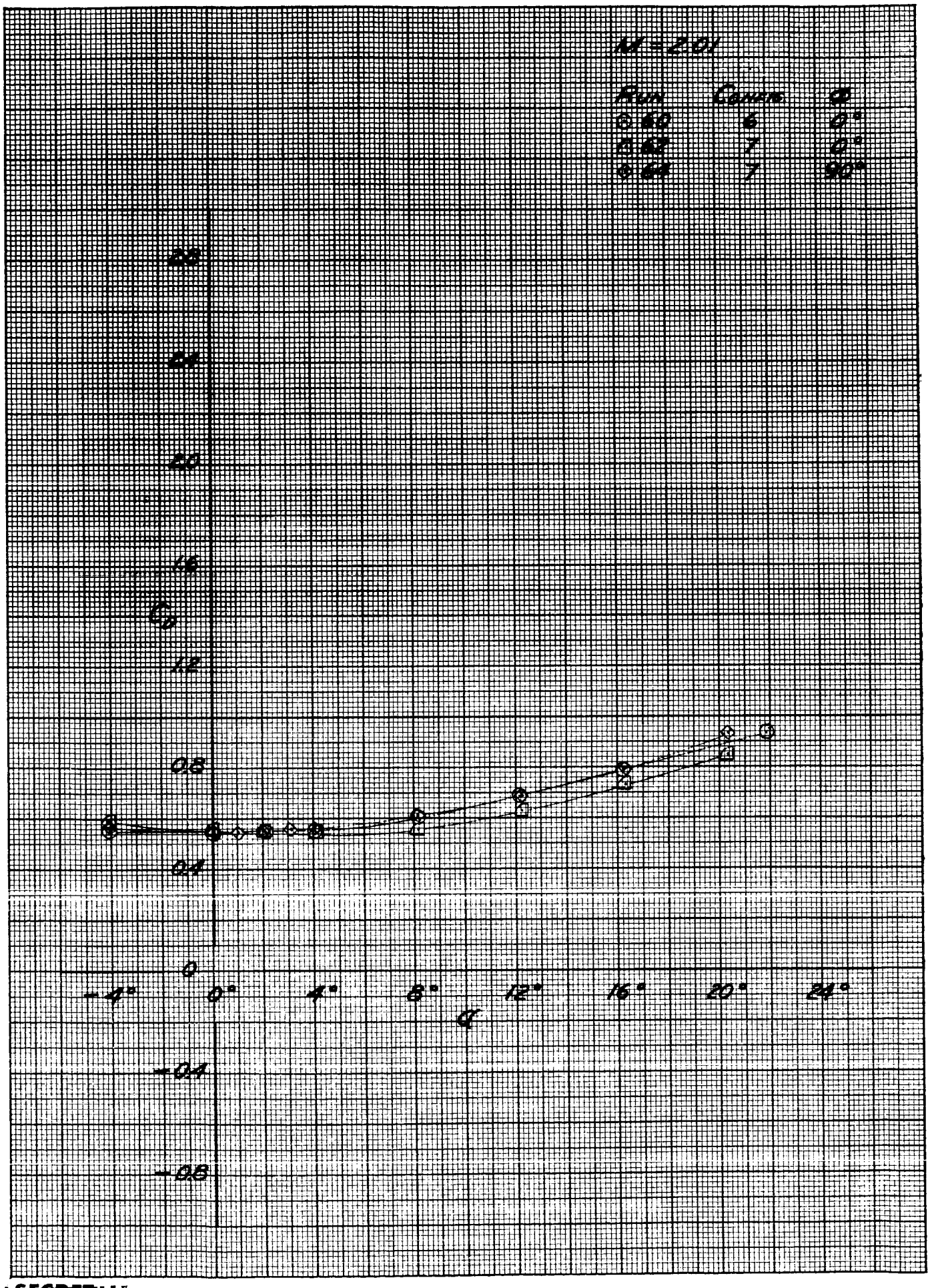

M = 2.01
φ = 0°
Run
Config.
56
2
63
3
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 2.01
Run Configs. φ
60 6 0°
62 7 0°
64 7 90°
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8


M = 2.01
Φ = 0°
Run
Config.
59
8
61
9
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

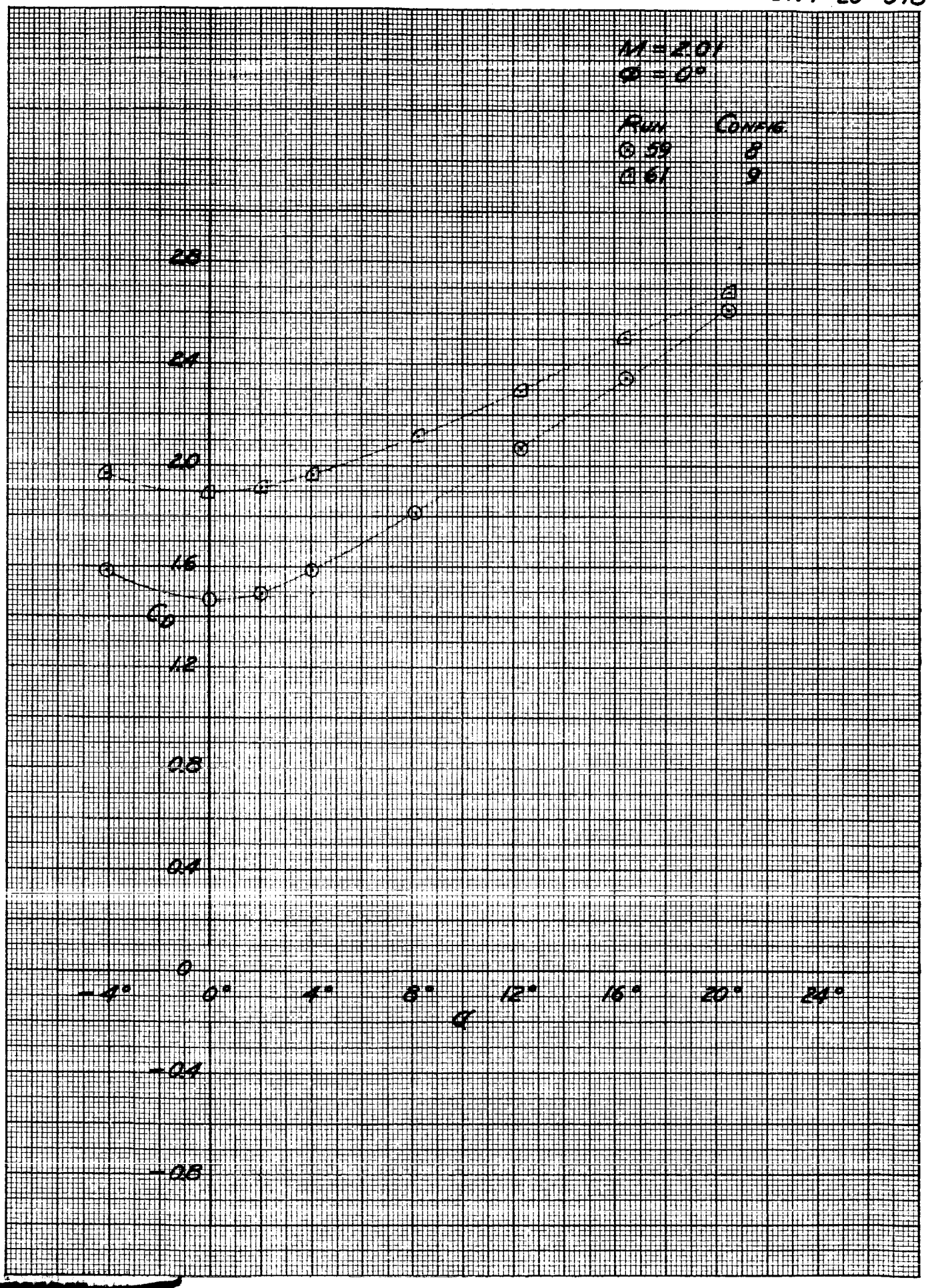

M = 2.01
φ = 0°
Run Config.
○ 54 1
□ 55 16
◇ 57 4
⊕ 58 5
⊕ indicates Grit on Nose
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 2.01
φ = 0°
Run
Configs
56
2
63
3
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

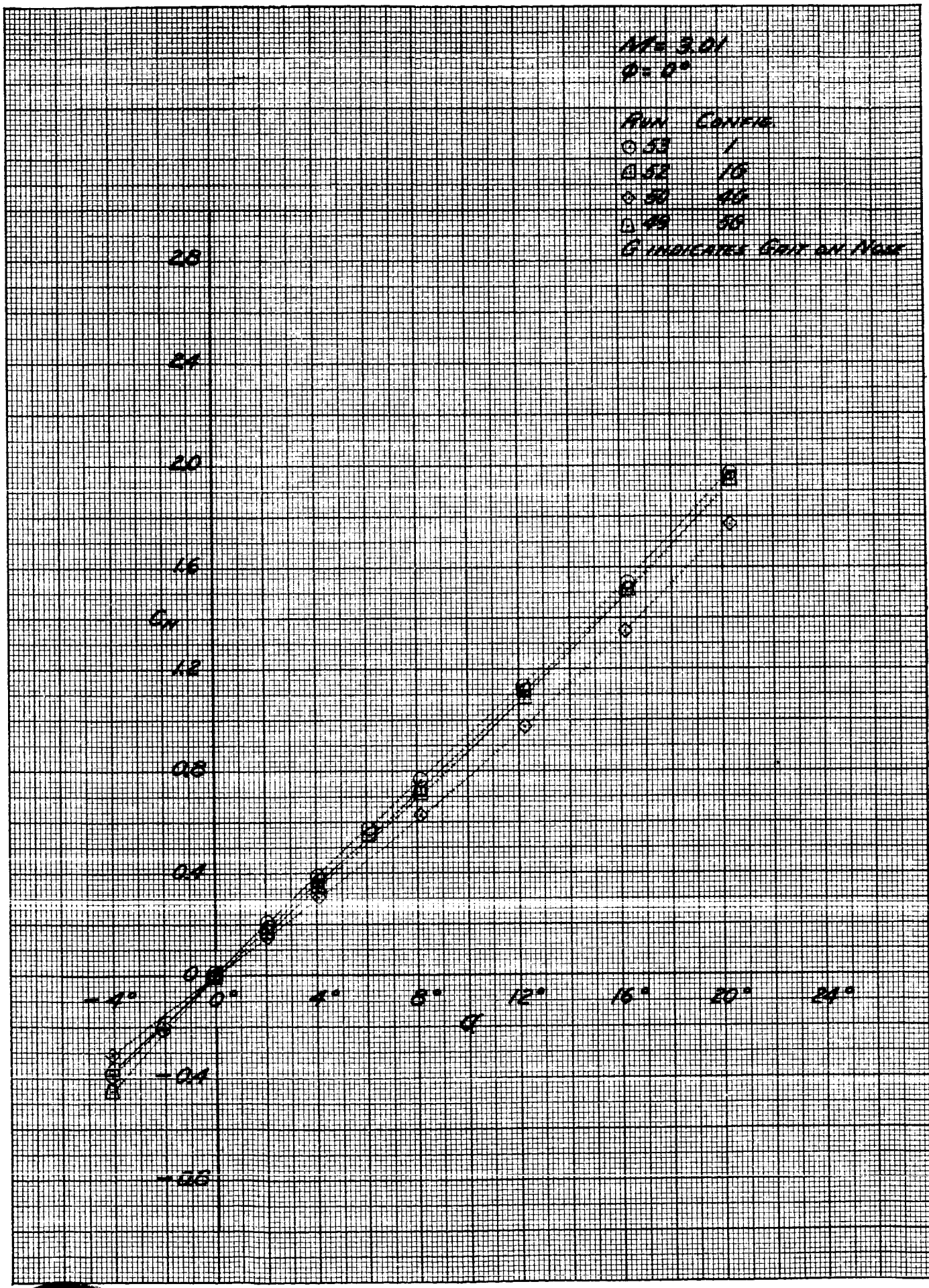

M = 2.01
Run
Contrs.
φ
60
6
0°
62
7
0°
64
7
90°
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

[redacted]

SWT 20-378



[redacted]


M = 3.01
φ = 0°
Run Config
53 1
52 10
50 46
49 56
G indicates Gap on Nose
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

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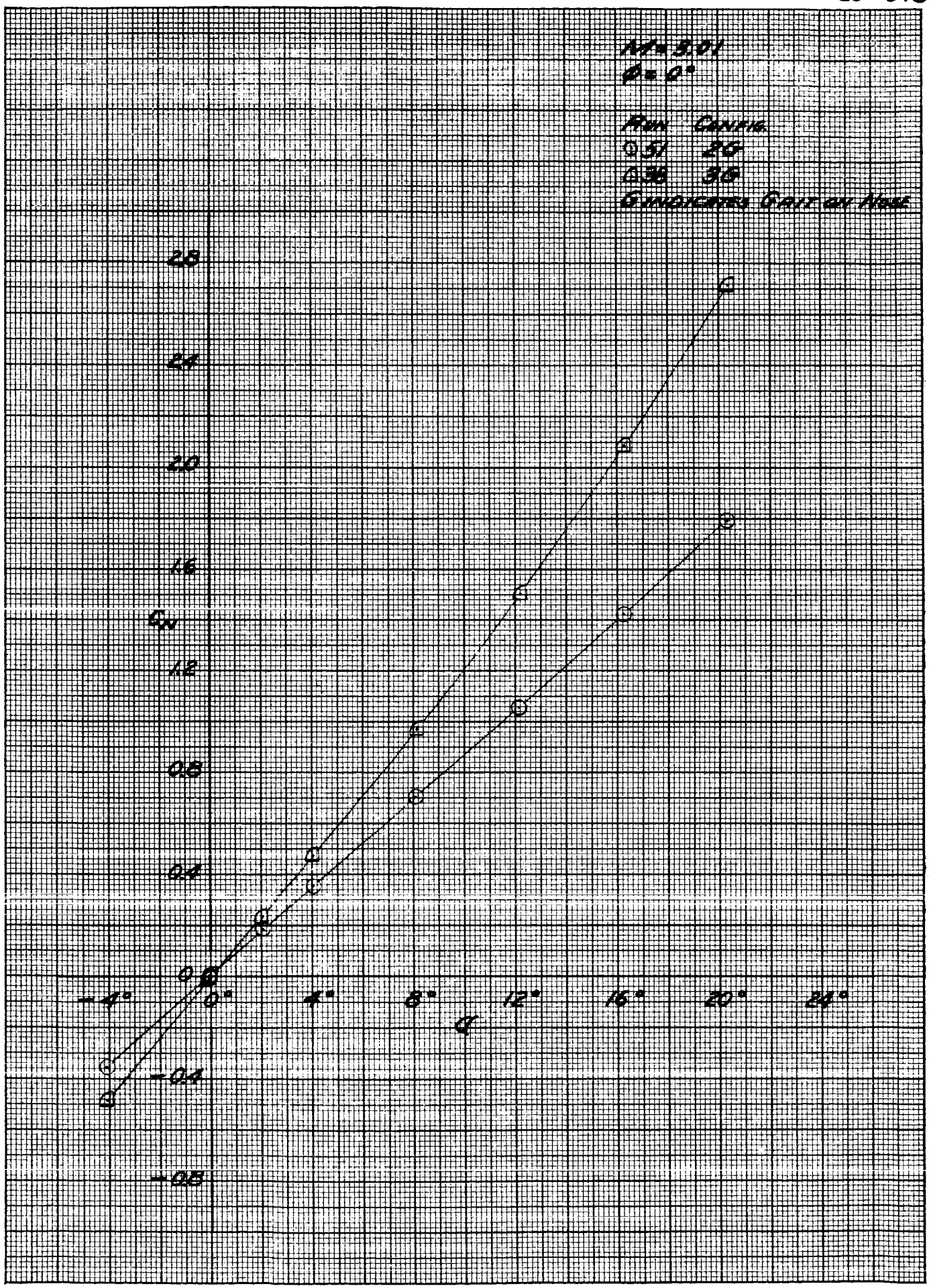
SWT 20-318



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PLOT 11b

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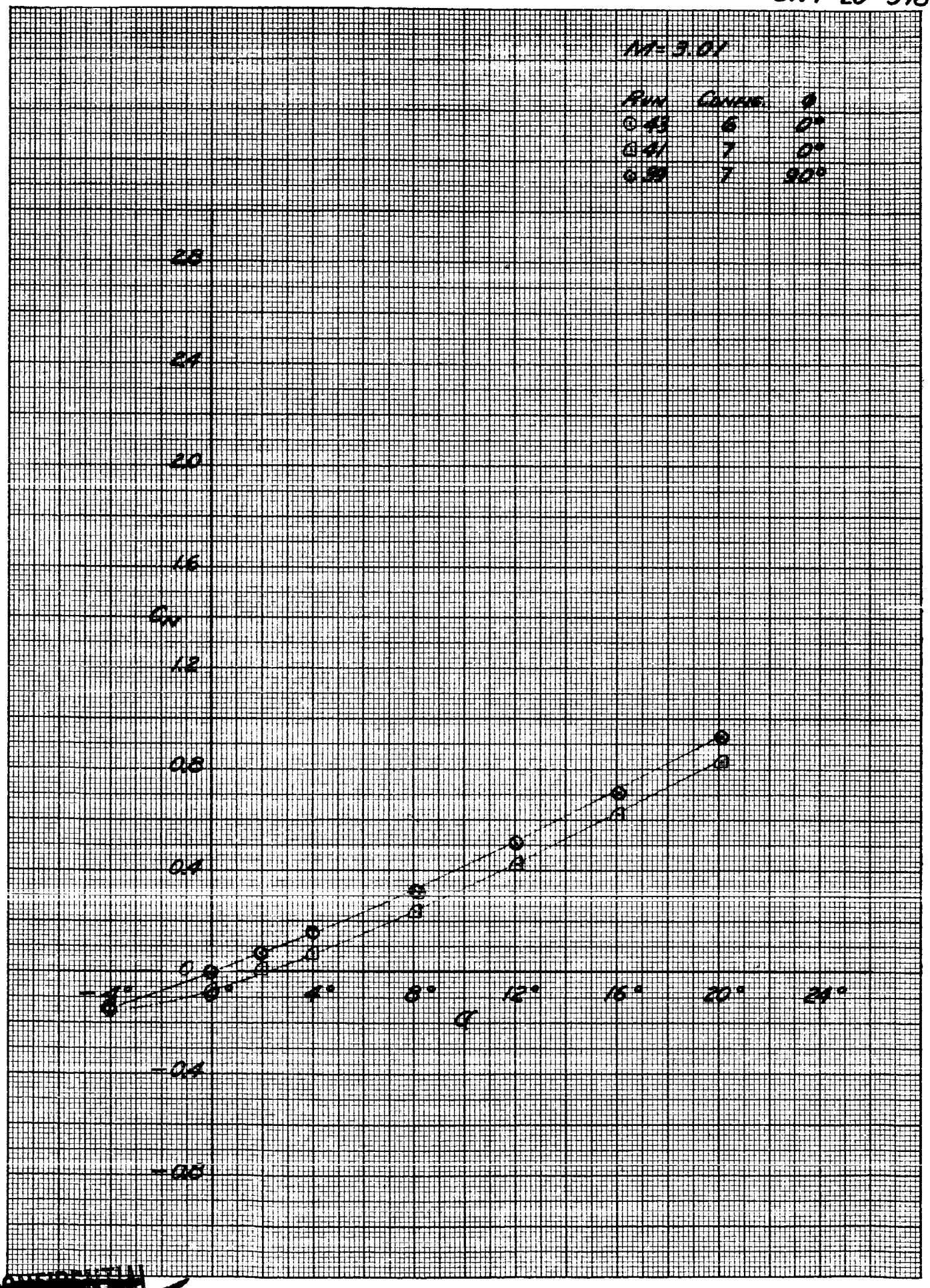
SWT 20-378



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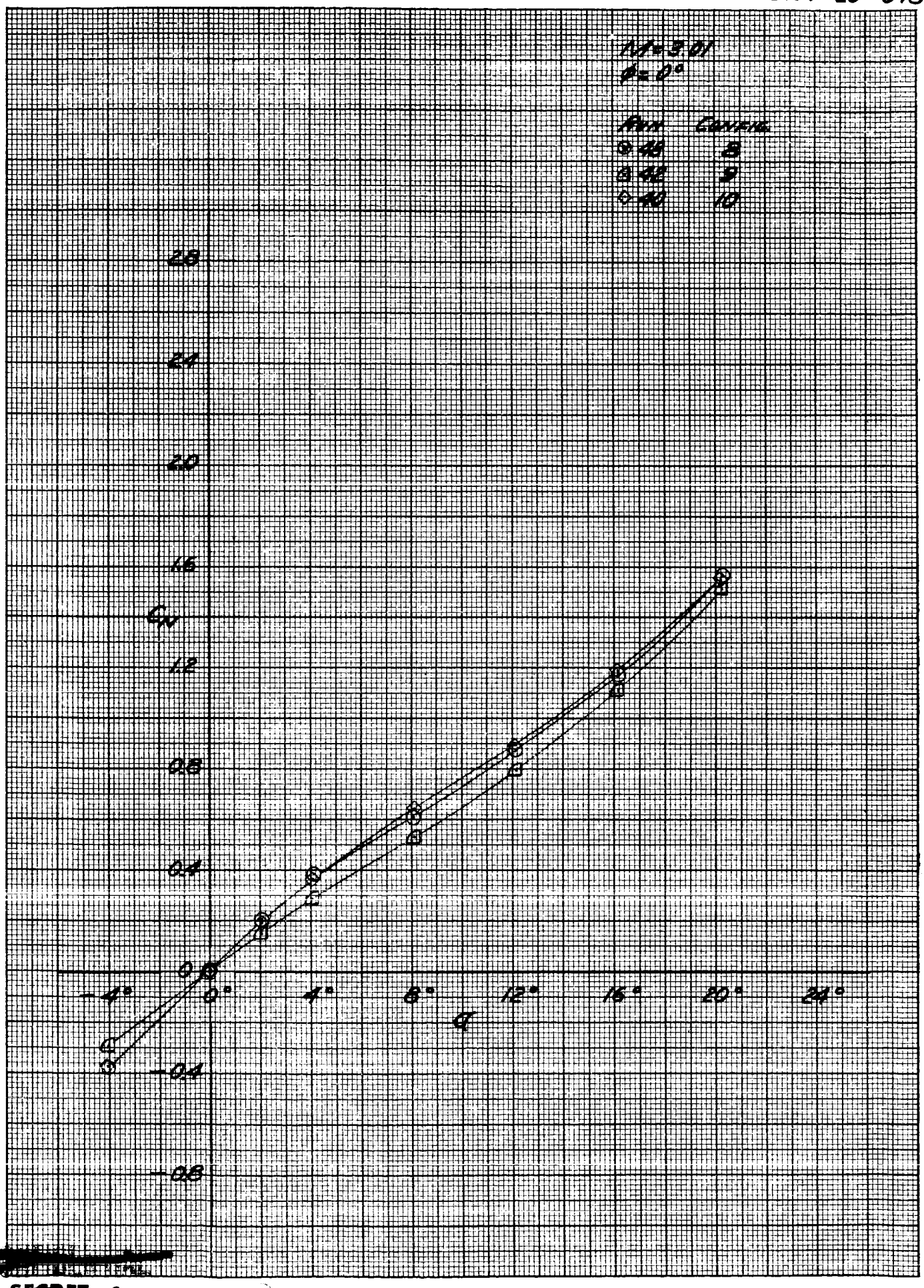
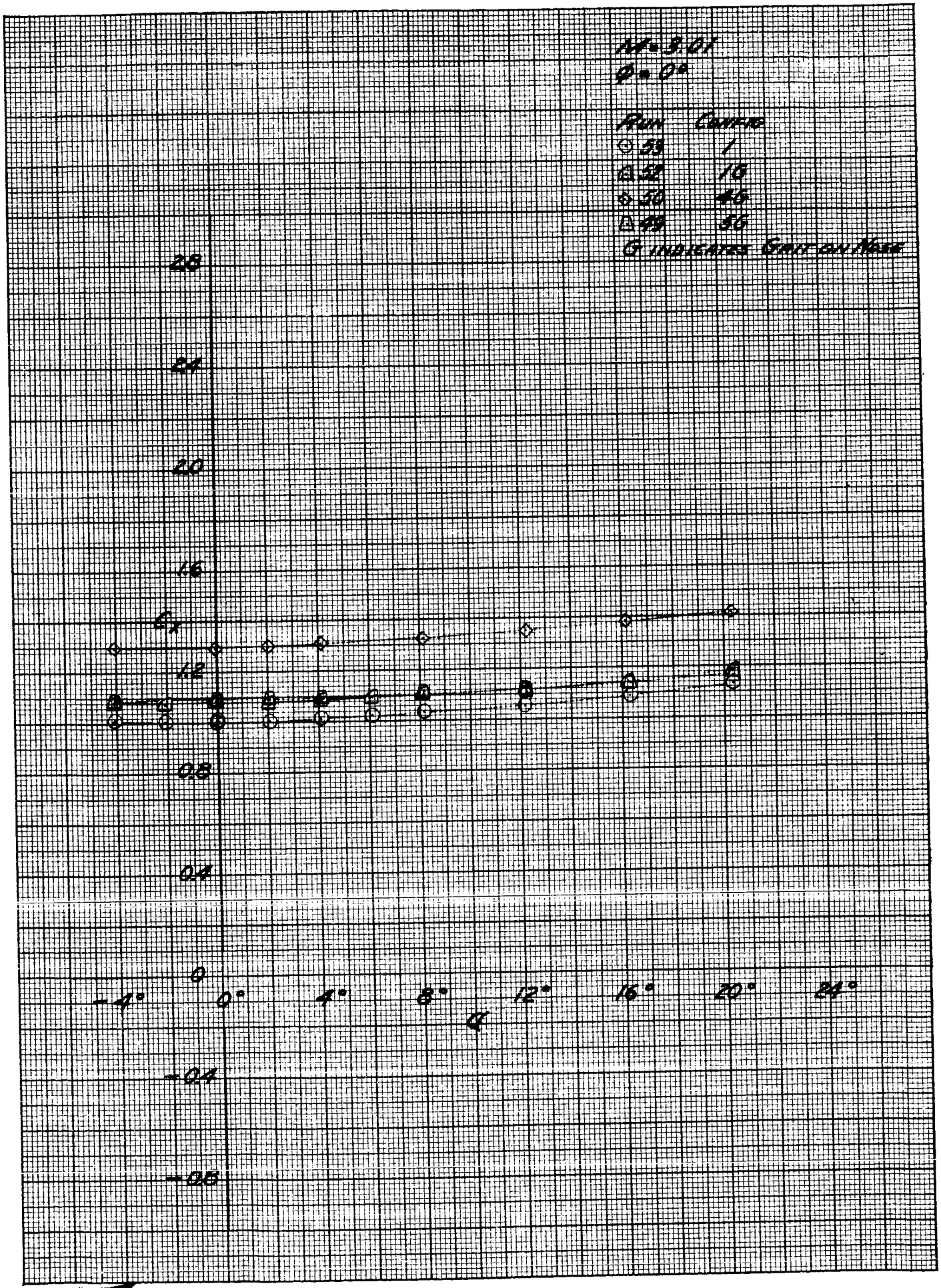
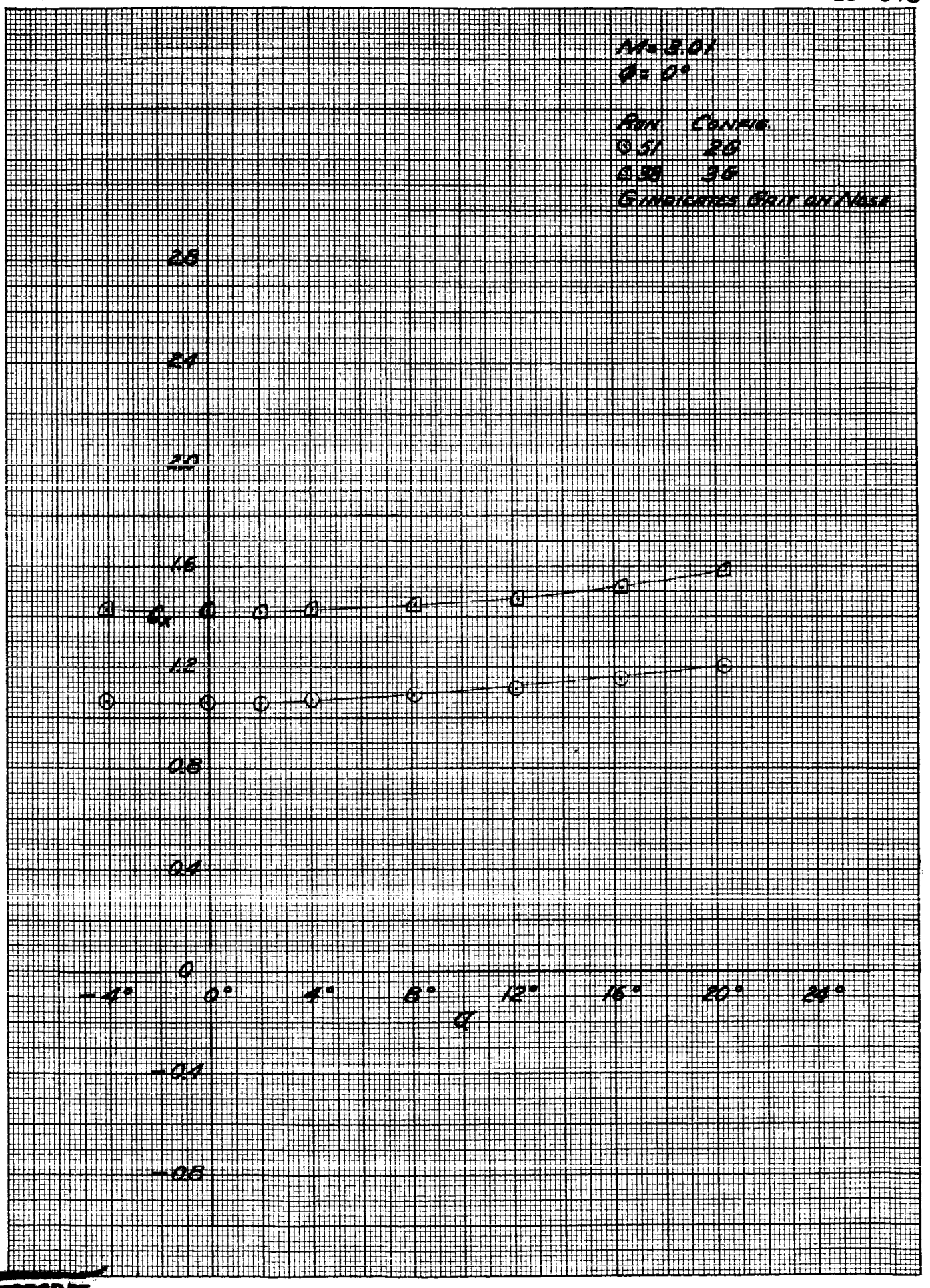
PLOT 11C


M = 3.01
φ = 0°
Run Config.
49 8
42 9
40 10
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.01
Φ = 0°
Run Config.
59 1
52 16
50 46
49 56
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_x
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.01
Φ = 0°
RUN CONFIG.
51 2G
38 3G
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
C_x
-4°
0°
4°
8°
12°
16°
20°
24°
α

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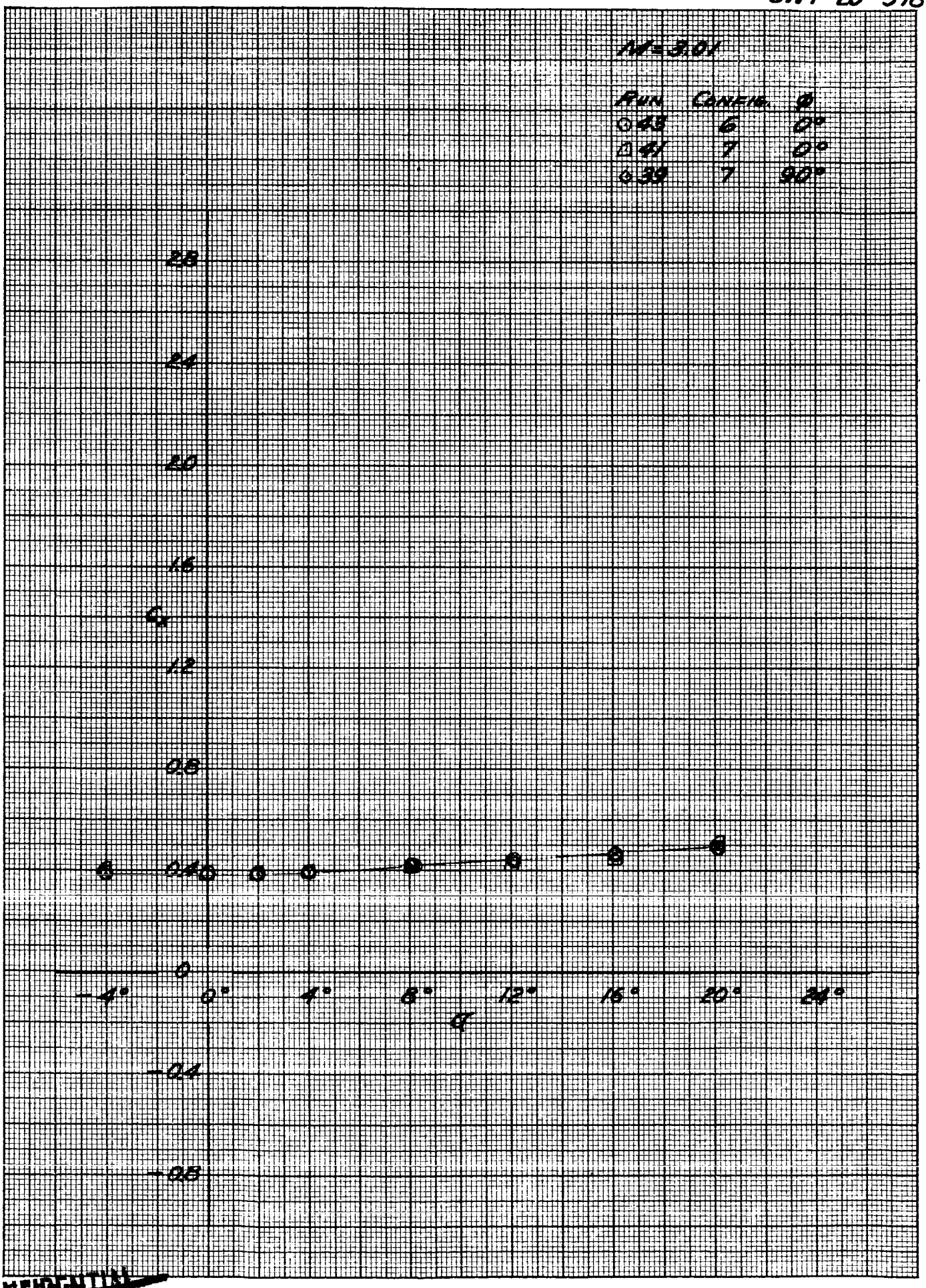
SWT 20-378



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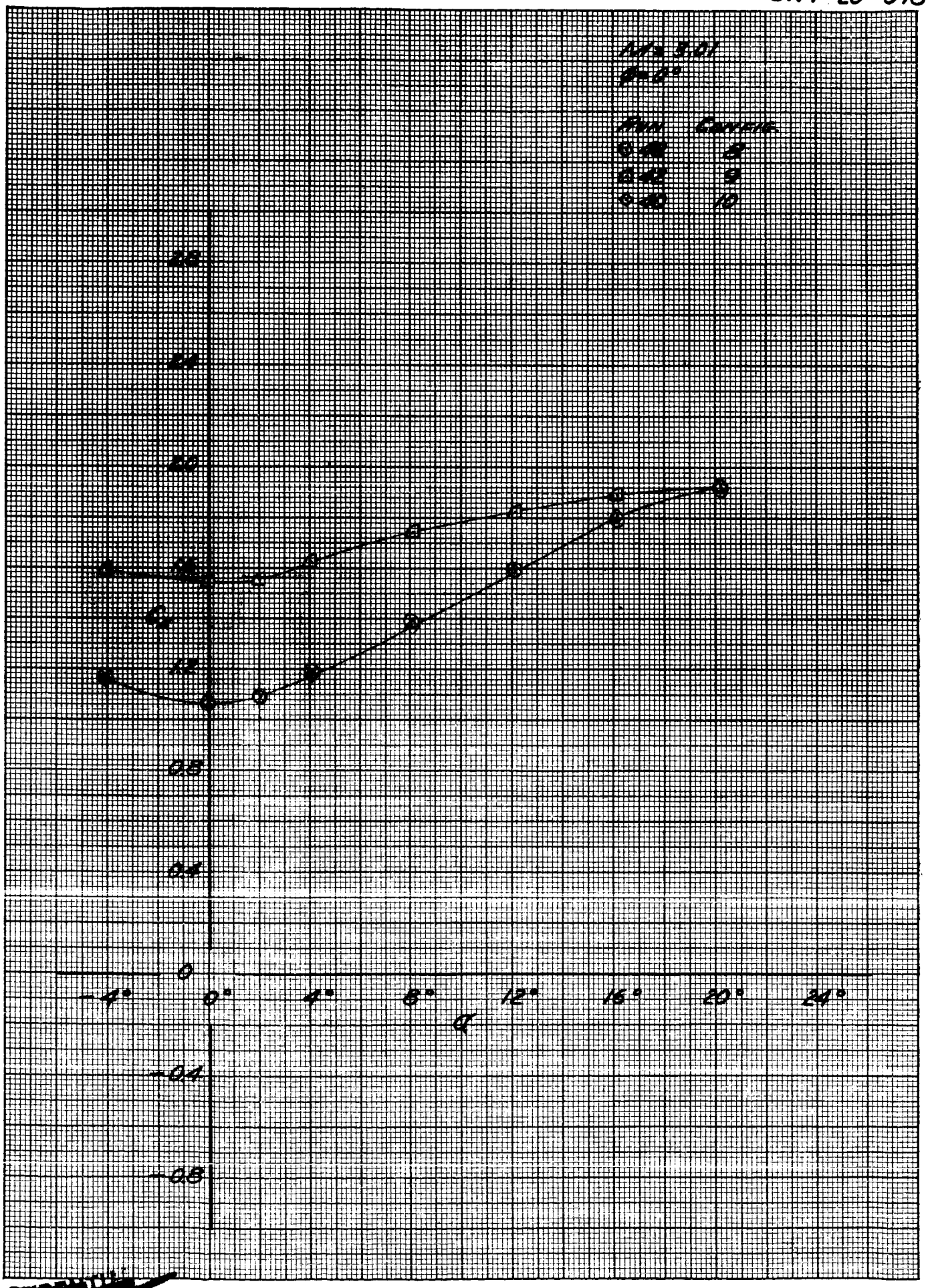
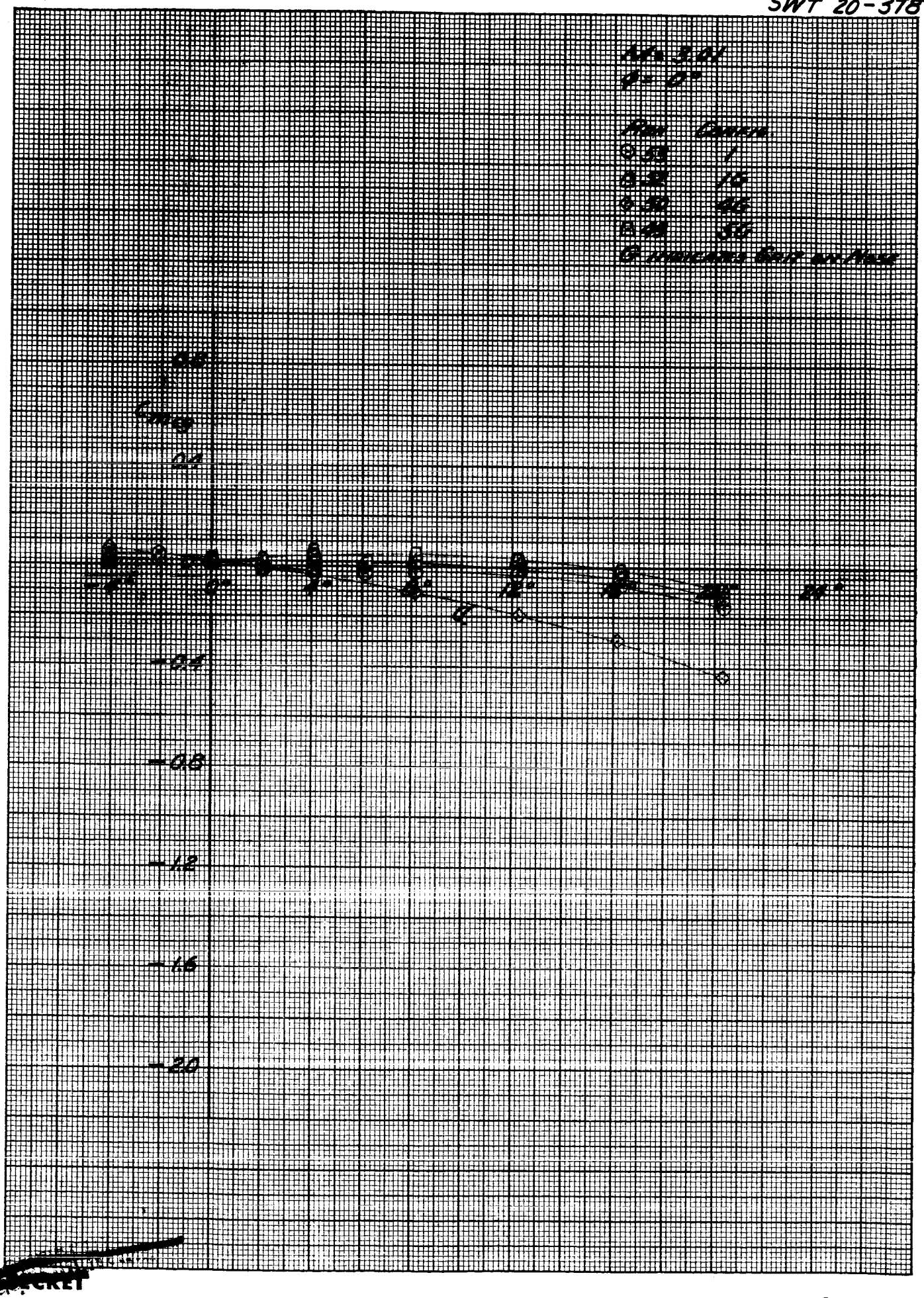
PLOT 12C


M = 3.01
β = 0°
Run Configs.
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

[redacted]

SWT 20-378

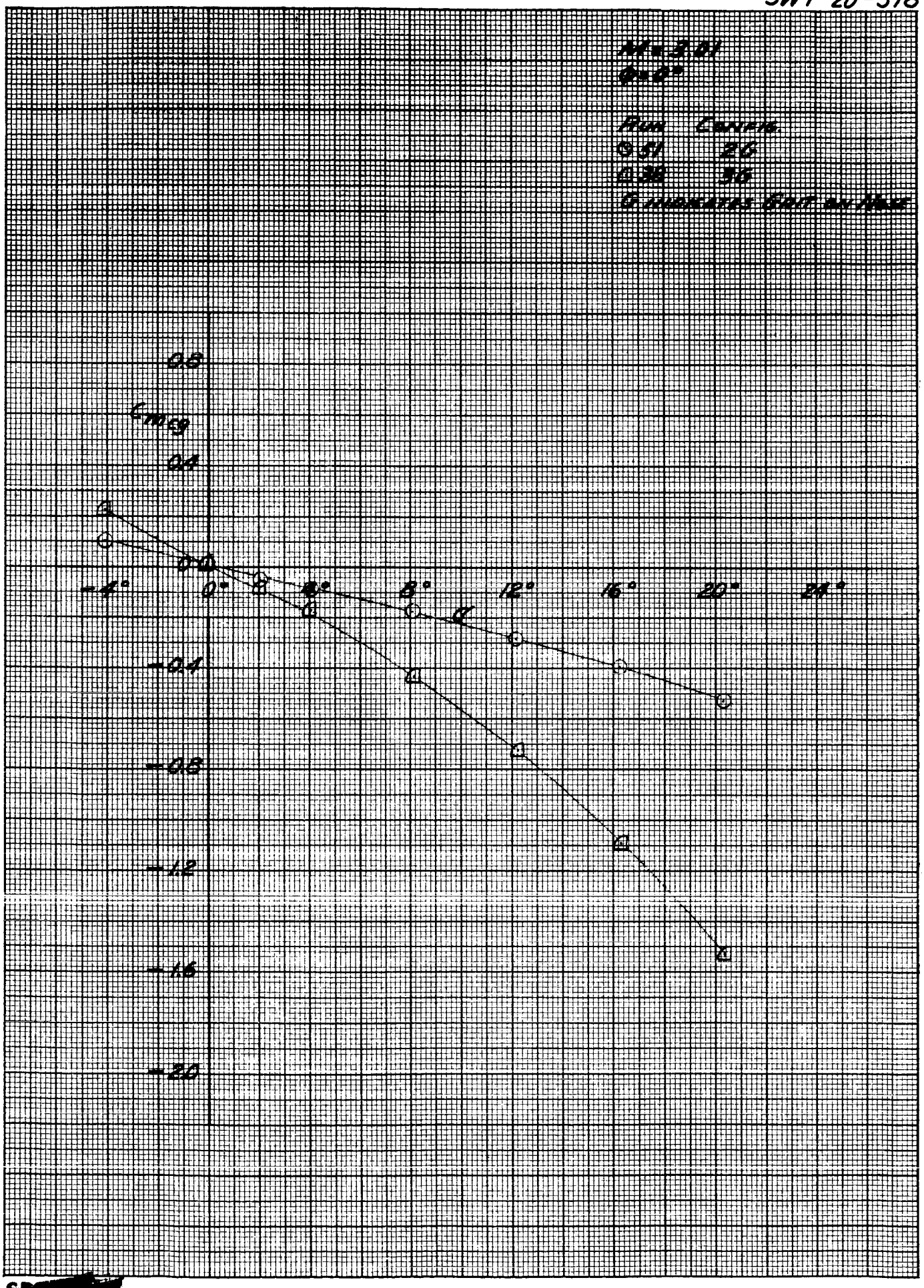


[redacted]

PLOT 13a

[redacted]

SWT 20-378



[redacted]

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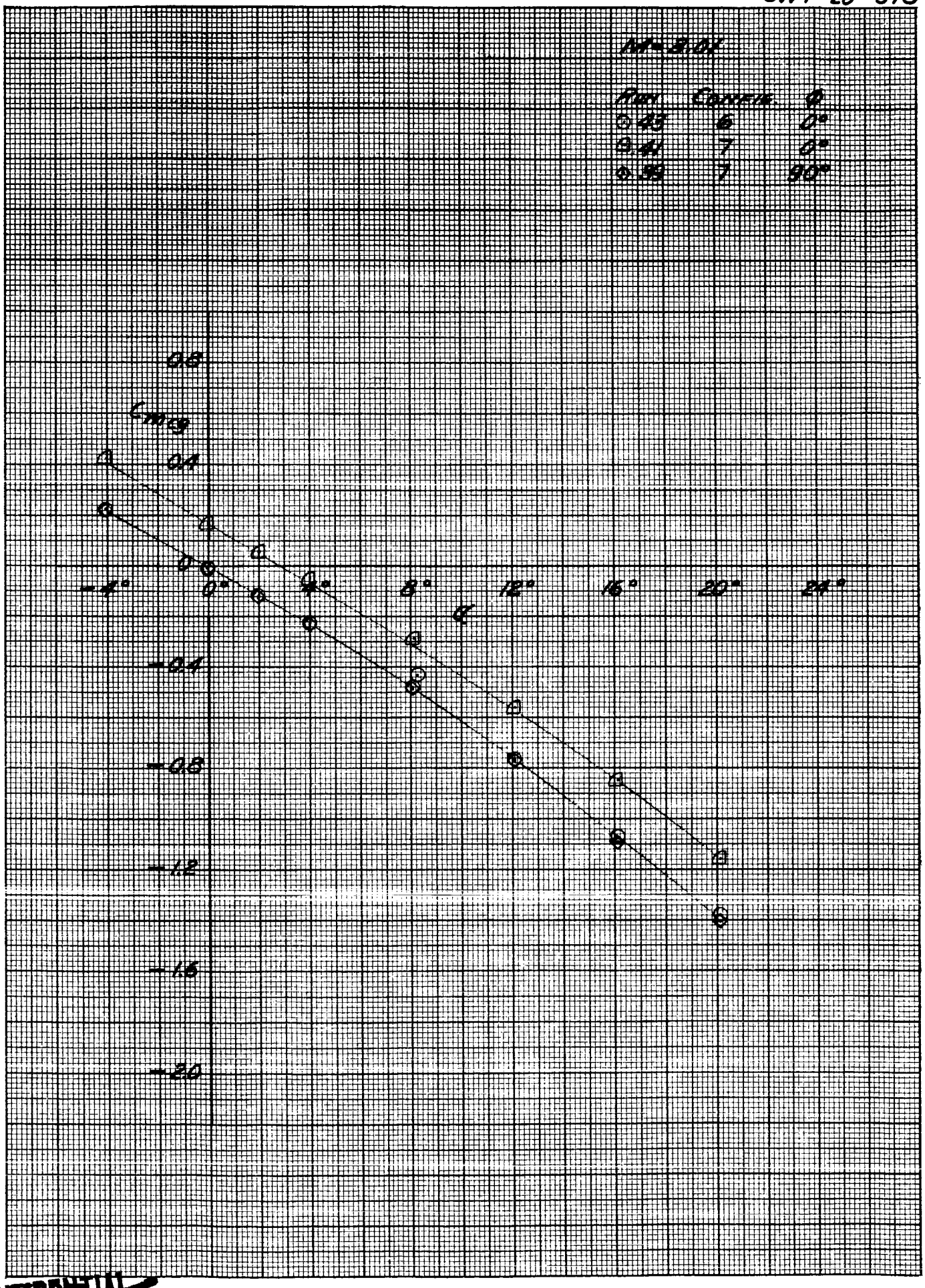
SWT 20-378



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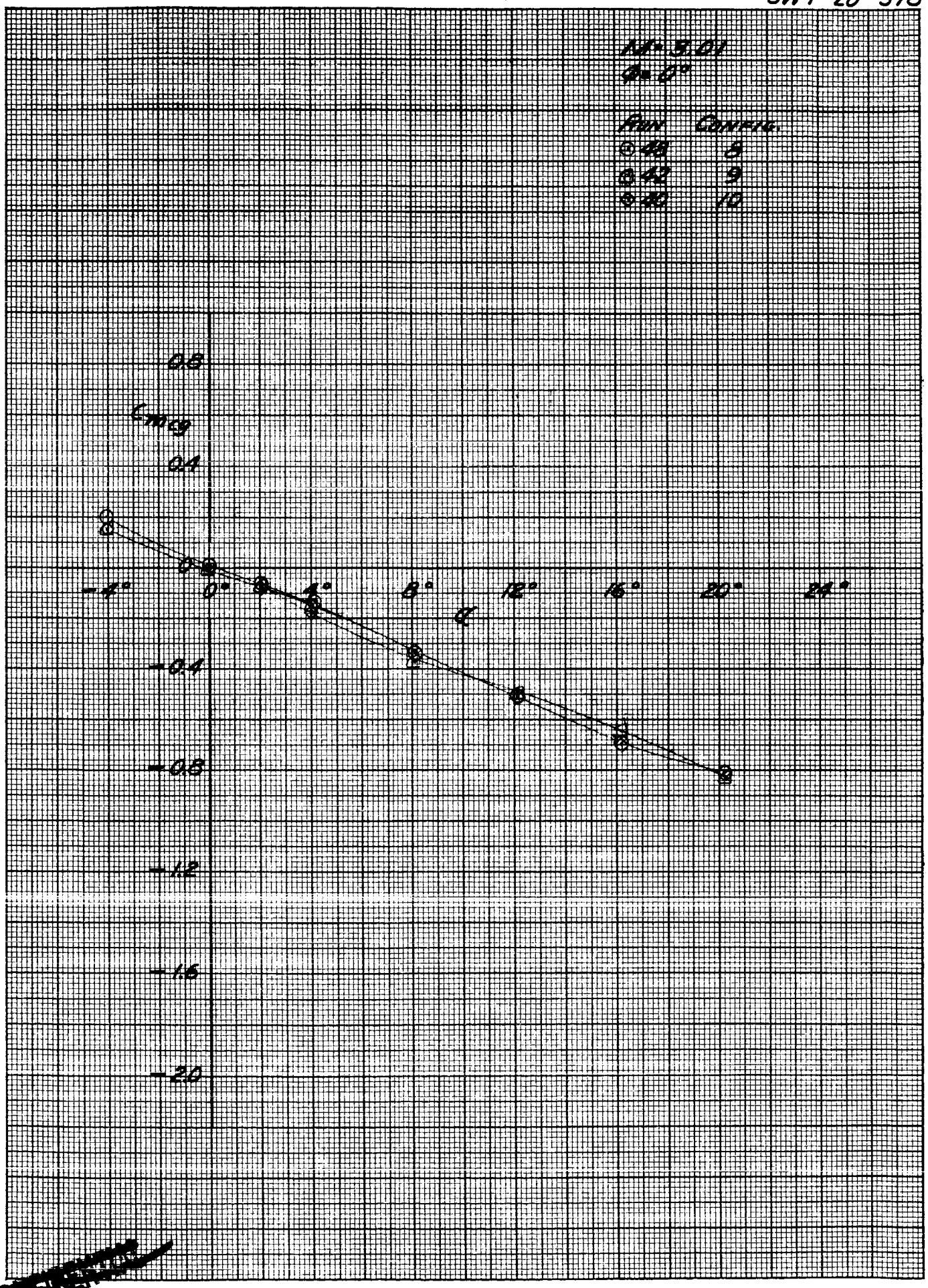
PLOT 13C



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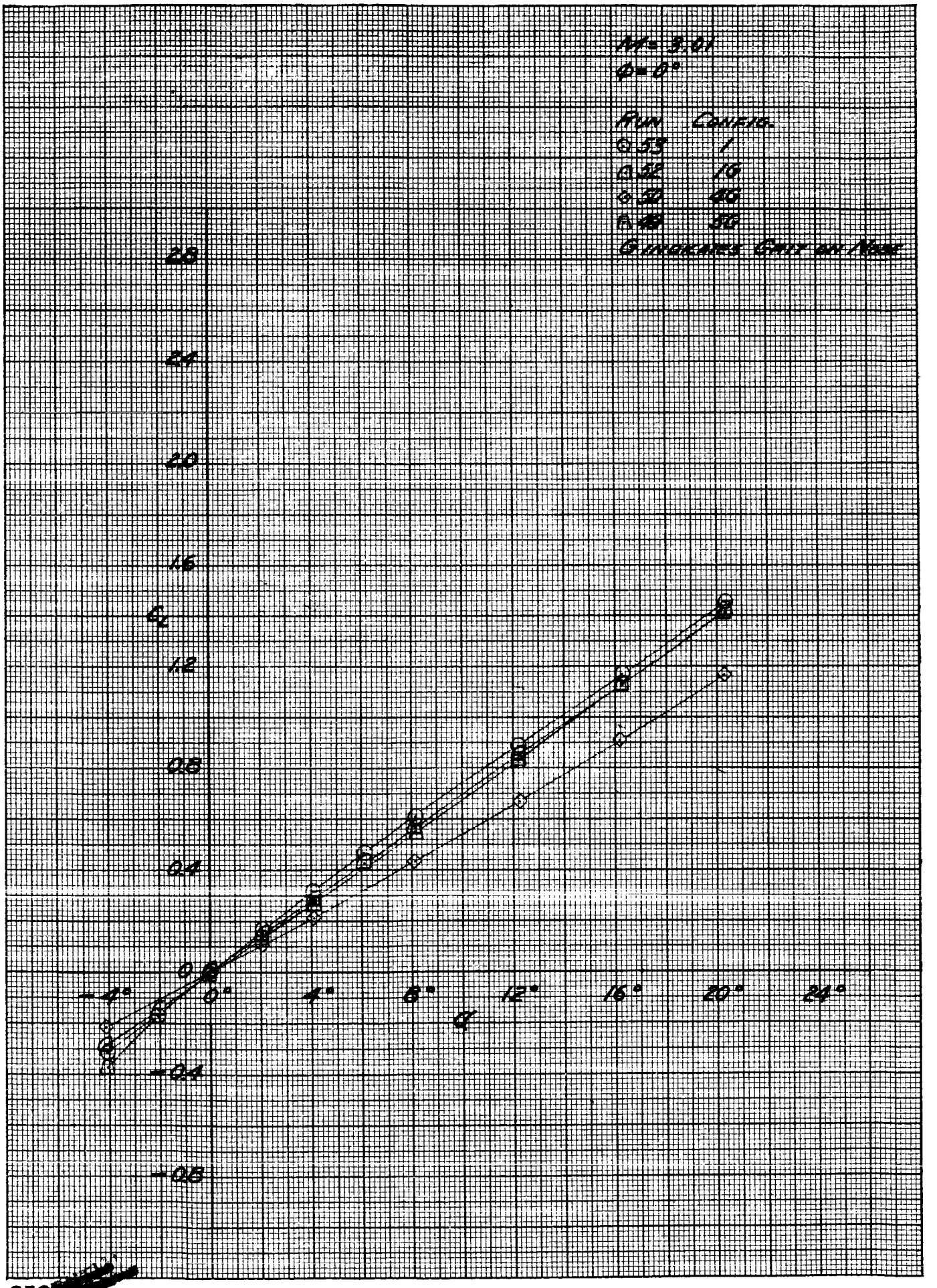
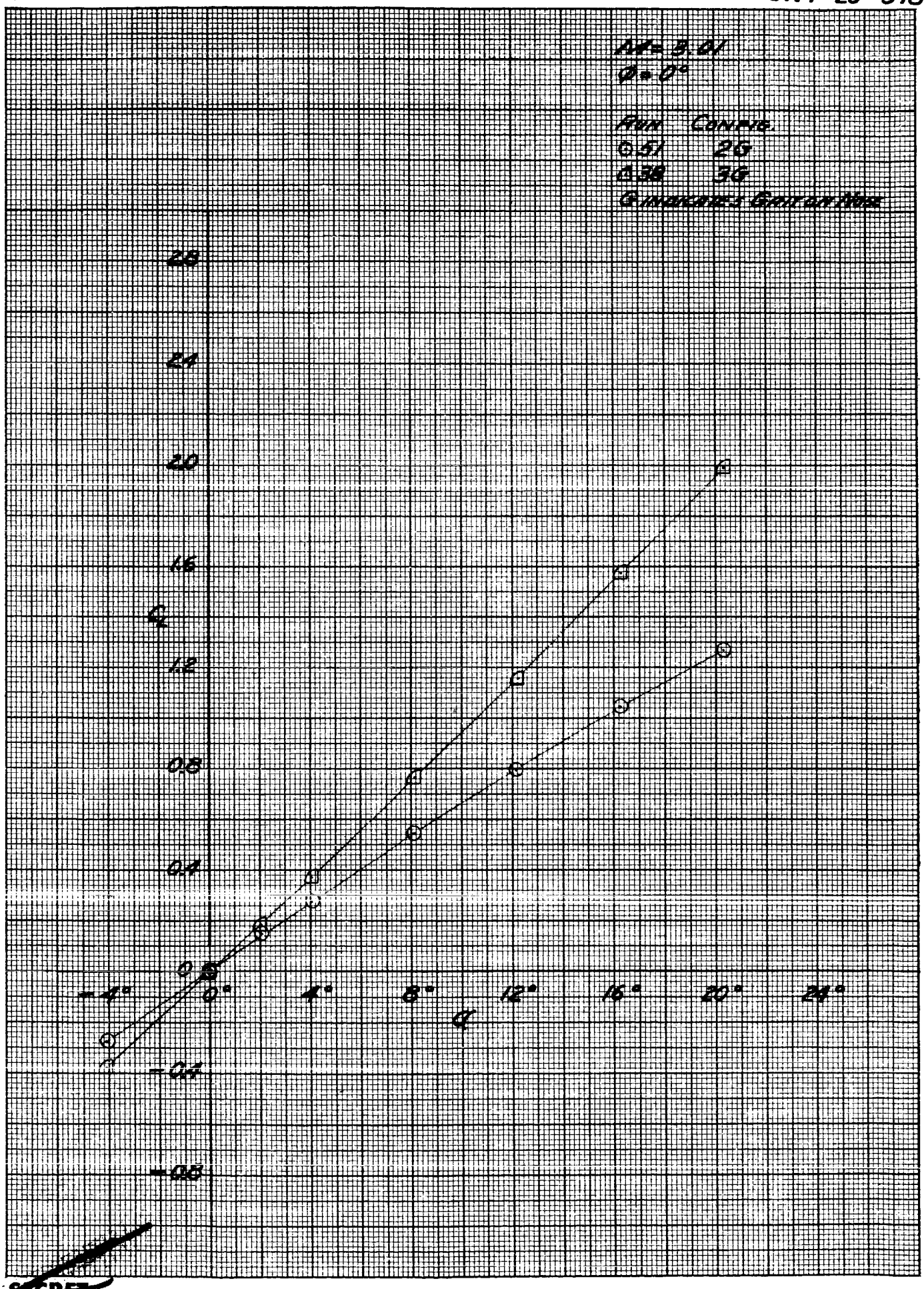
PLOT 13d


M = 5.01
φ = 0°
Run Config.
53 1
52 16
50 40
49 50
Glaukhes Dart on Nose
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

CONFIDENTIAL

SWT 20-378

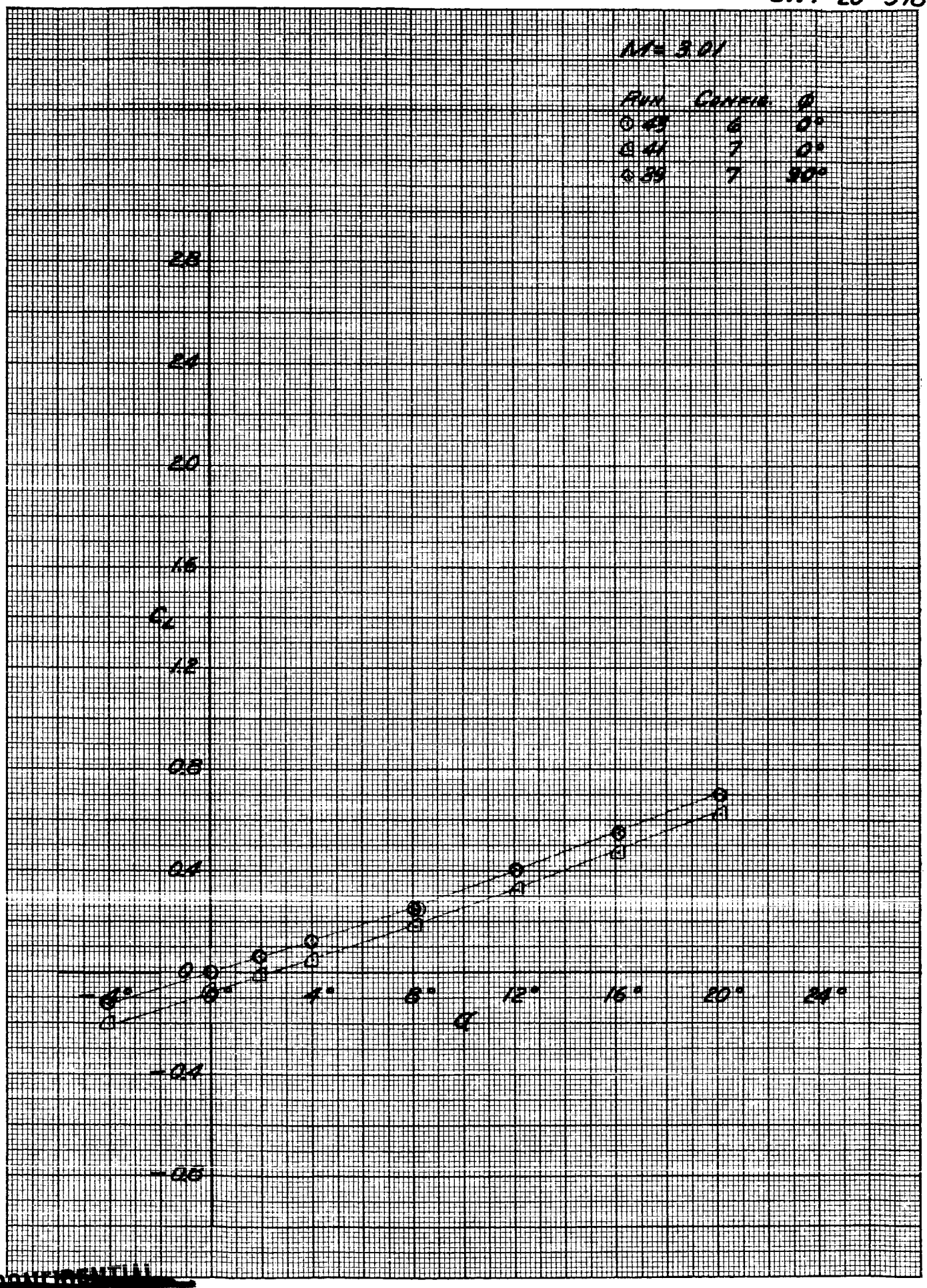


SECRET

PLOT 14b

~~CONFIDENTIAL~~

SWT 20-378



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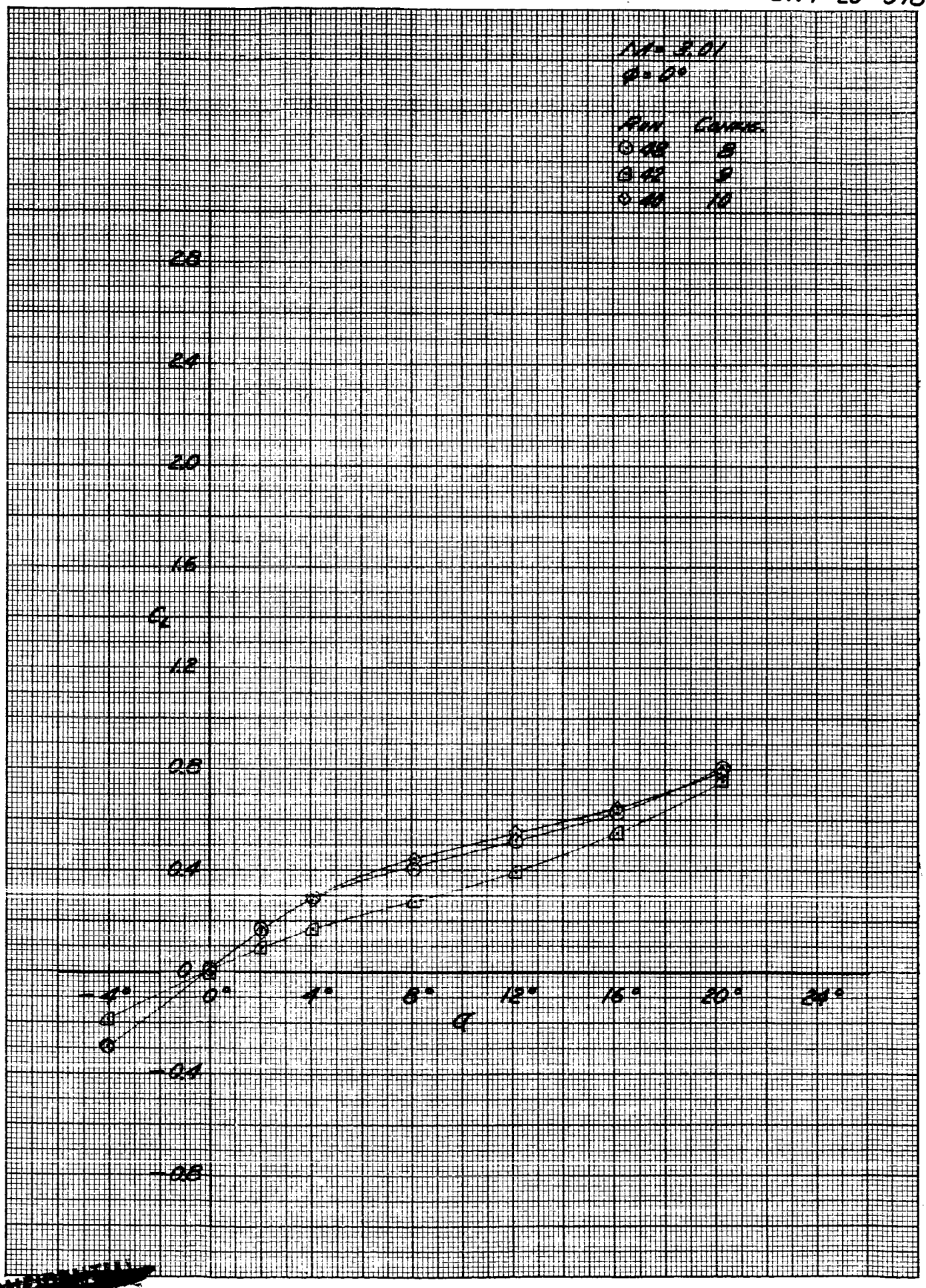
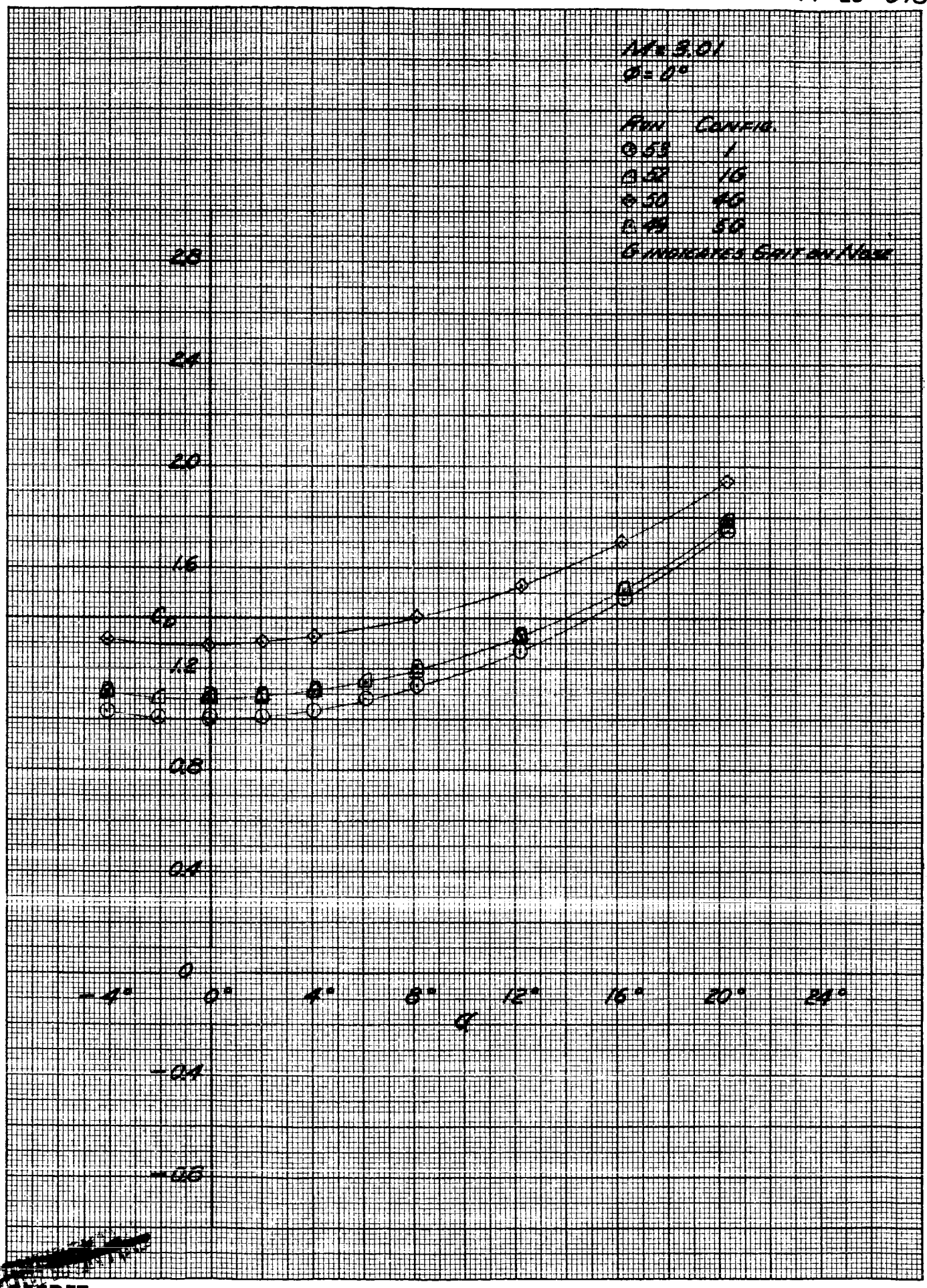
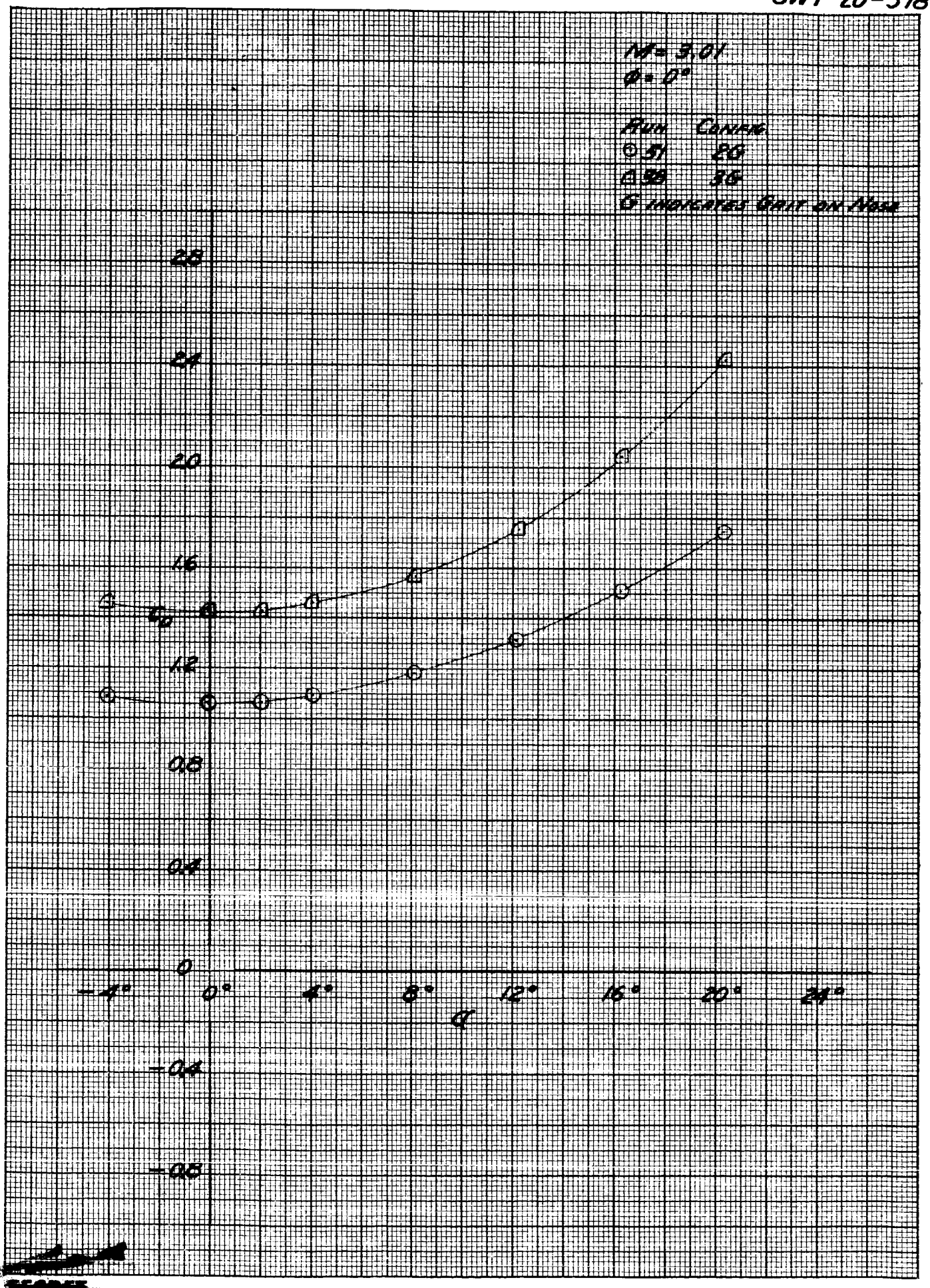
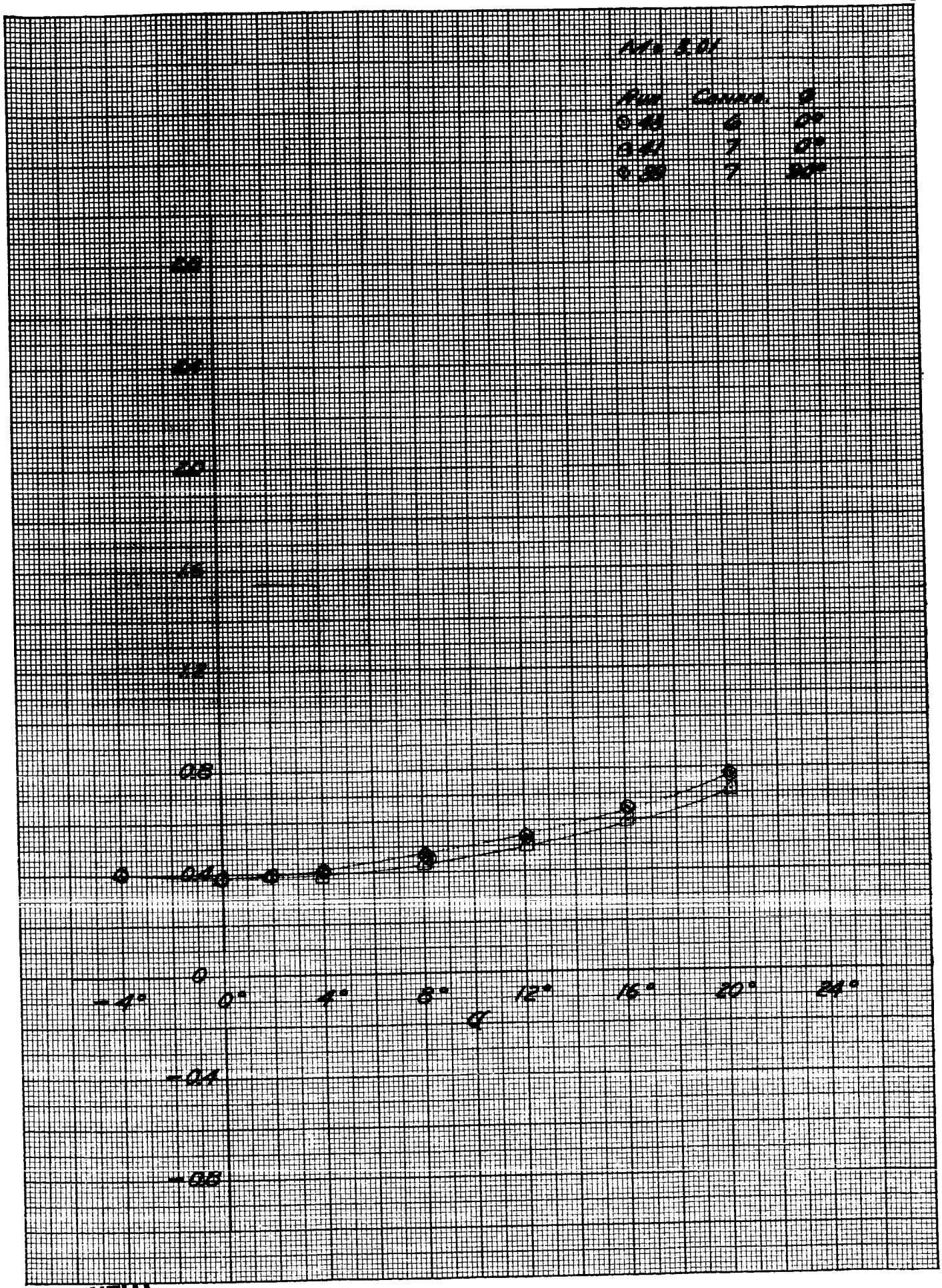
PLOT 14C


M = 2.01
φ = 0°
Fin Camber
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

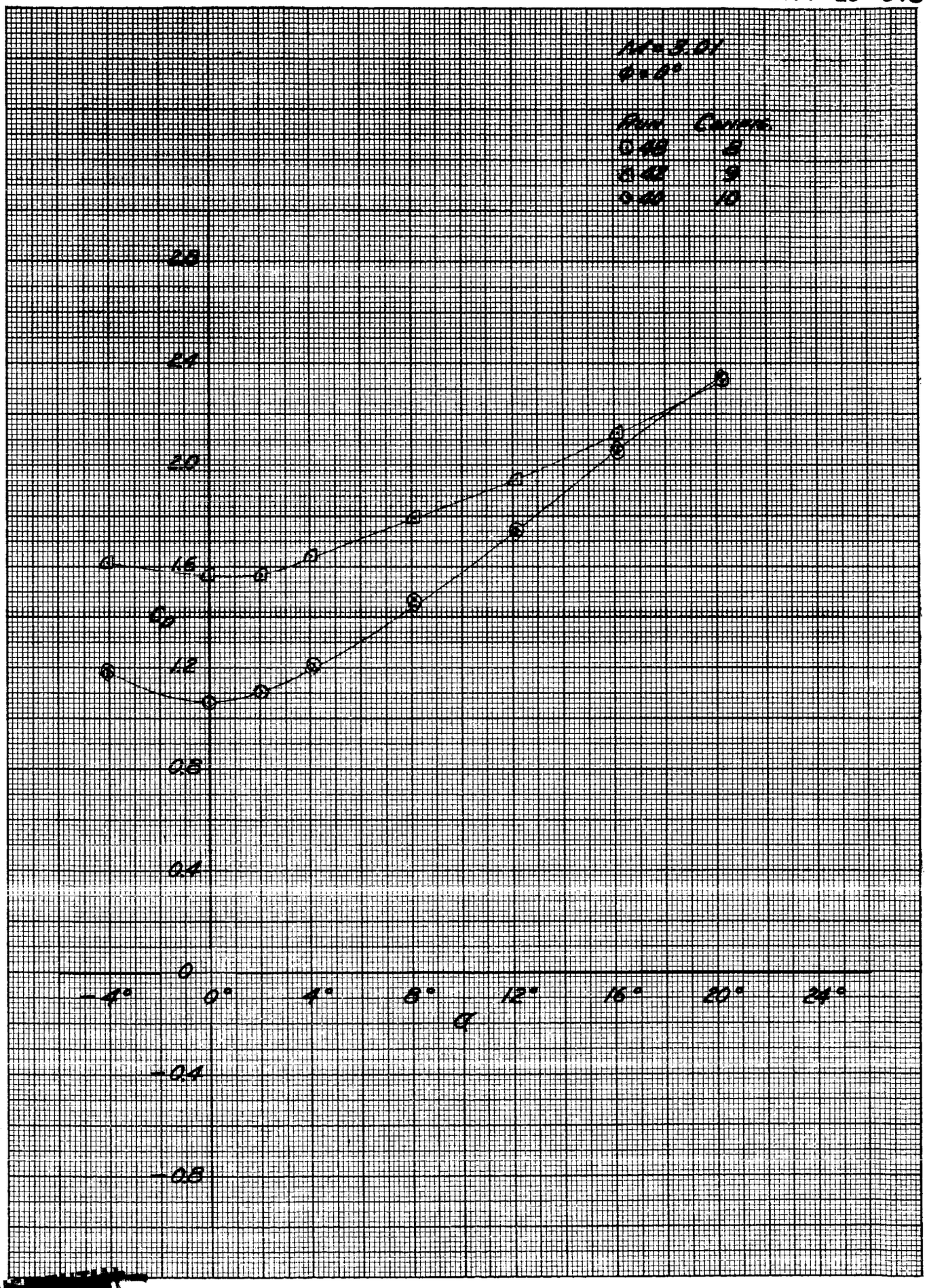

M∞ = 3.01
Φ = 0°
REN CONFIG.
53 1
52 16
50 46
49 50
δ INDICATES SPIT ON NOSE
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
−0.4
−0.8
−4°
0°
4°
8°
12°
16°
20°
24°
α


M∞ = 3.01
φ = 0°
RUN CONFIG.
⊙ 51 2G
△ 98 3G
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


Mach 2.01
Run Camera β
6 0°
7 0°
7 20°
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
-0.04
-0.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

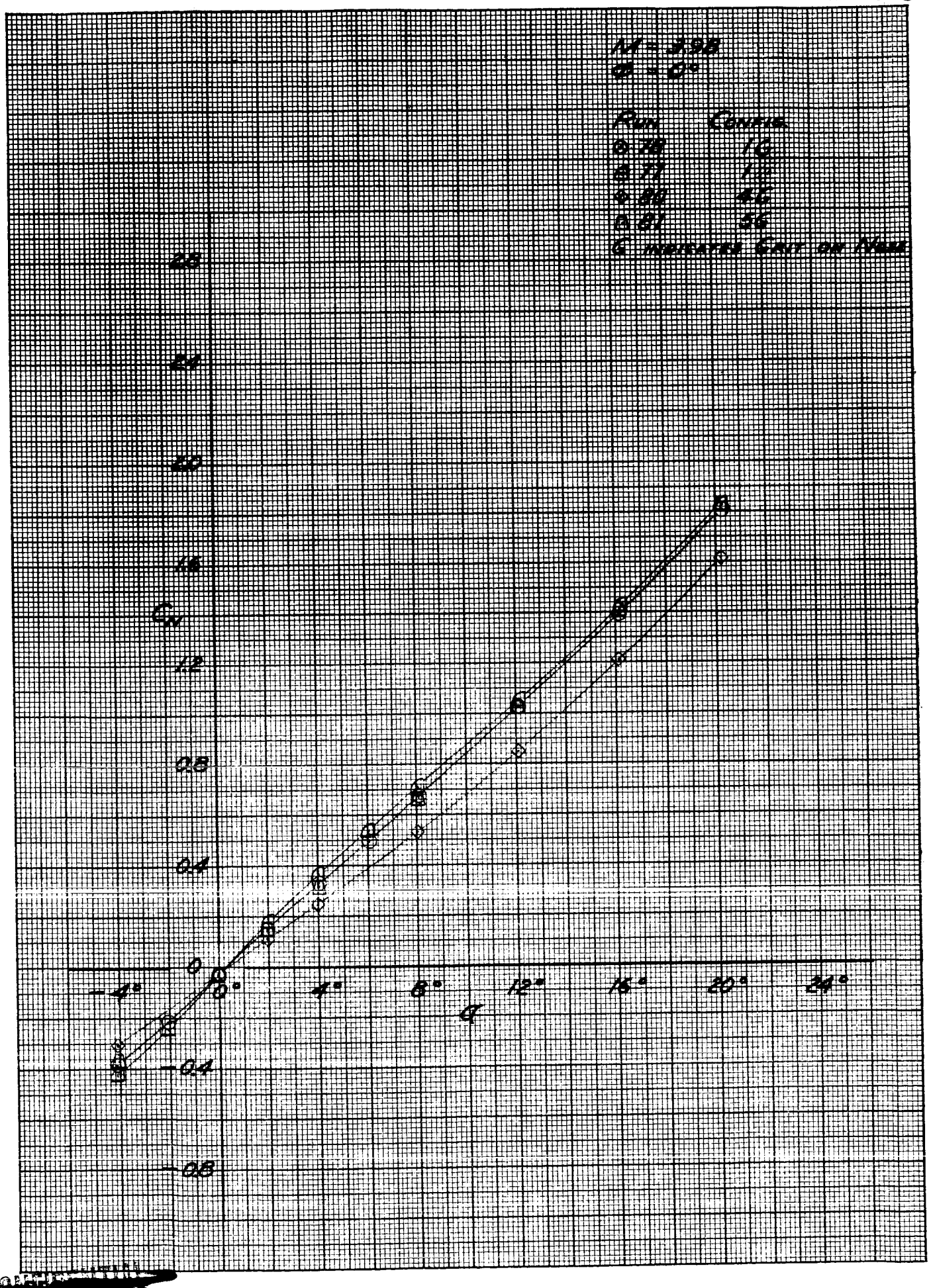
[redacted]

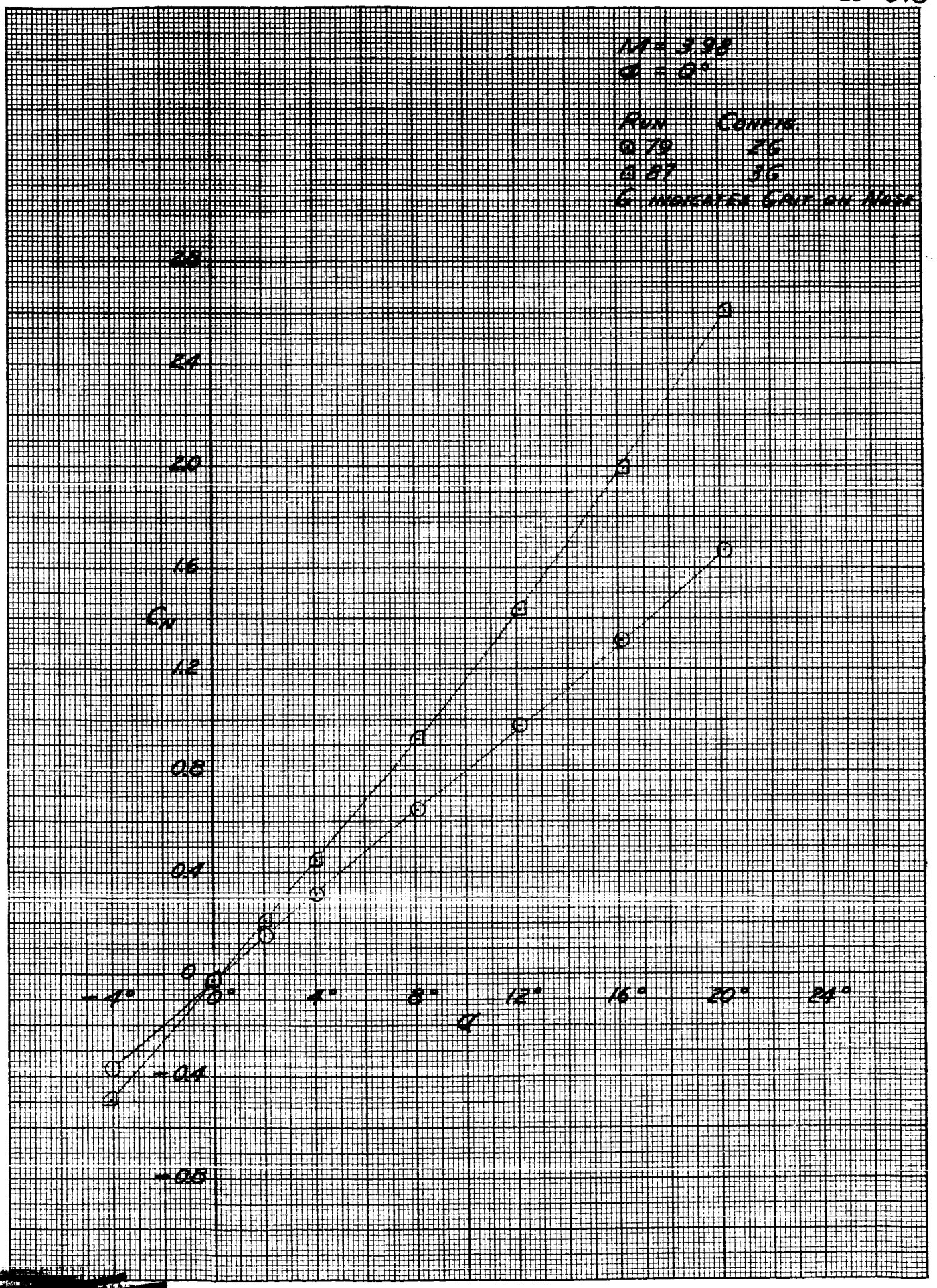
SWT 20-378



[redacted]

PLOT 15d


M = 2.95
β = 0°
Run Contrl.
70 1G
71 1
80 4G
81 5G
G indicates Grit on Nose
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
φ = 0°
Run Config.
79 26
87 36
G indicates Grit on Nose
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

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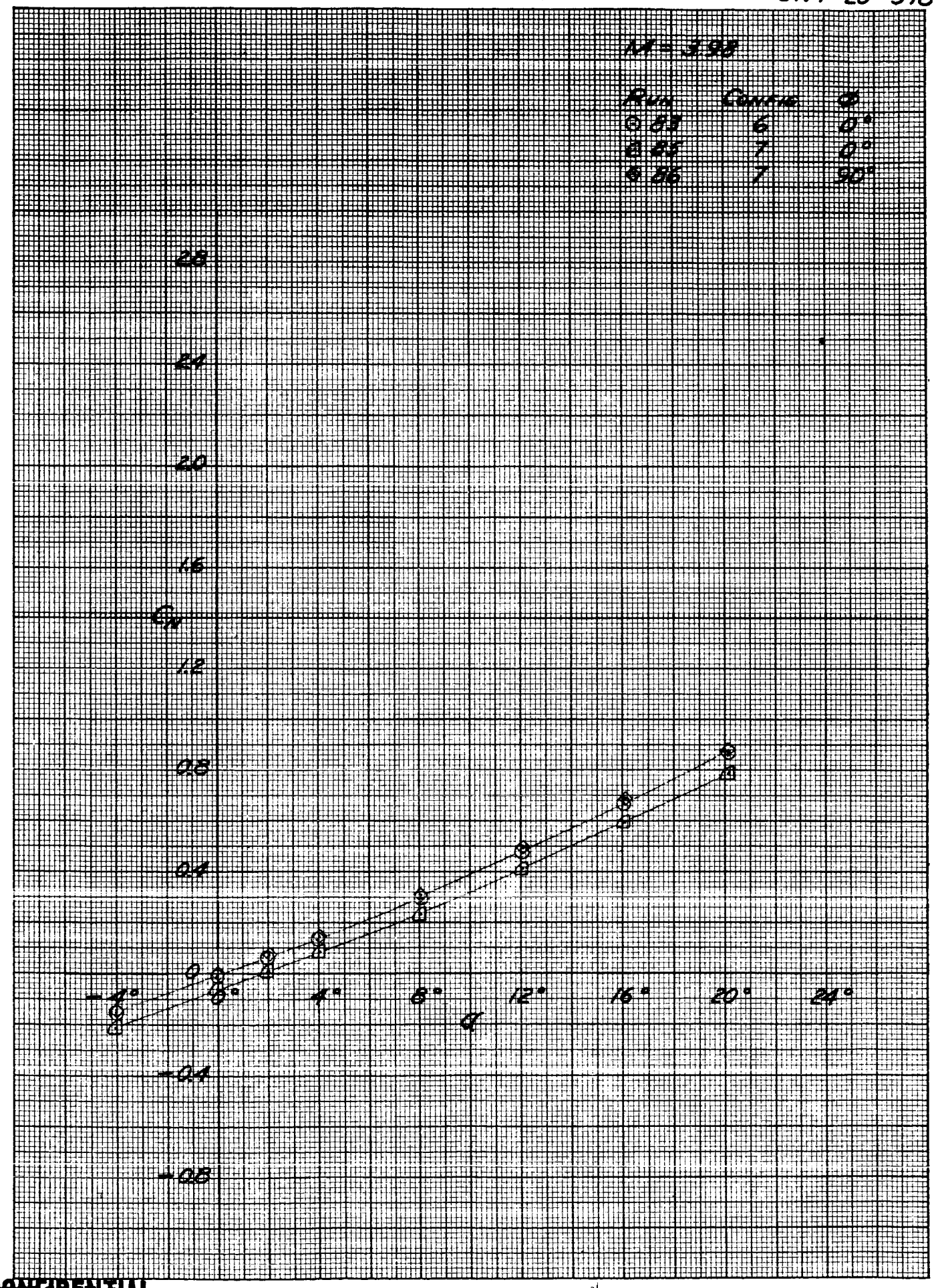
SWT 20-318



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PLOT 16C

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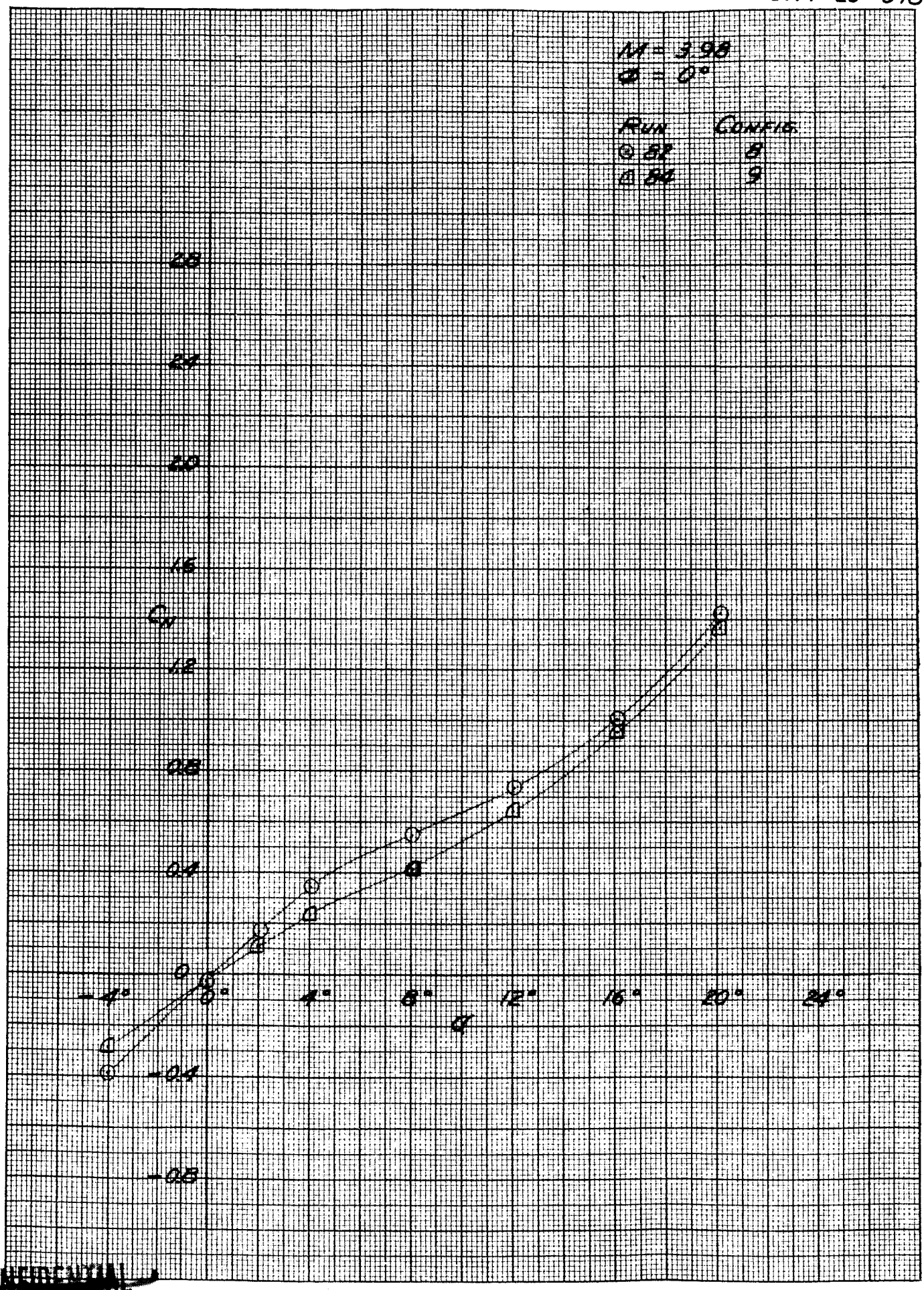
SWT 20-378



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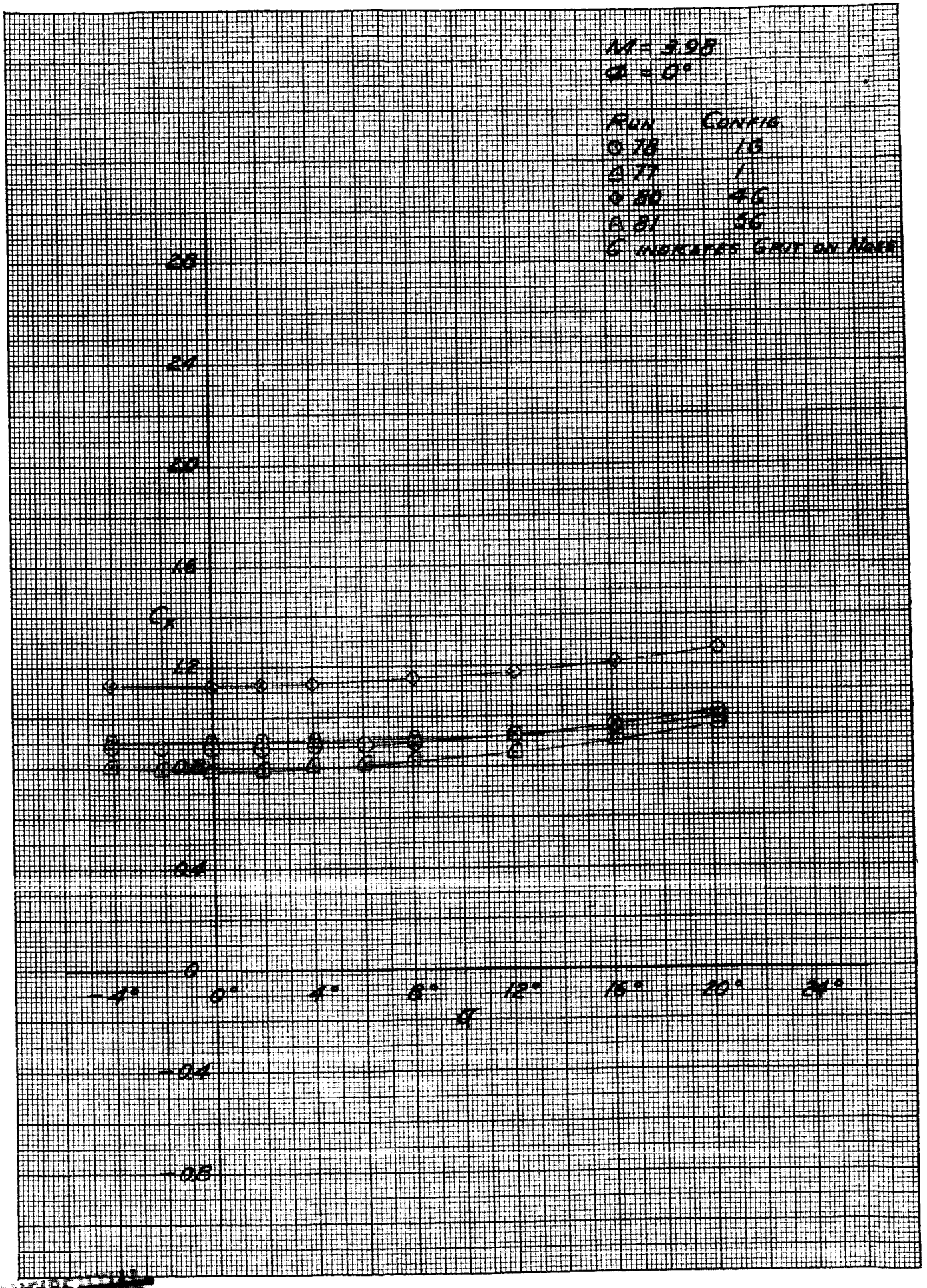
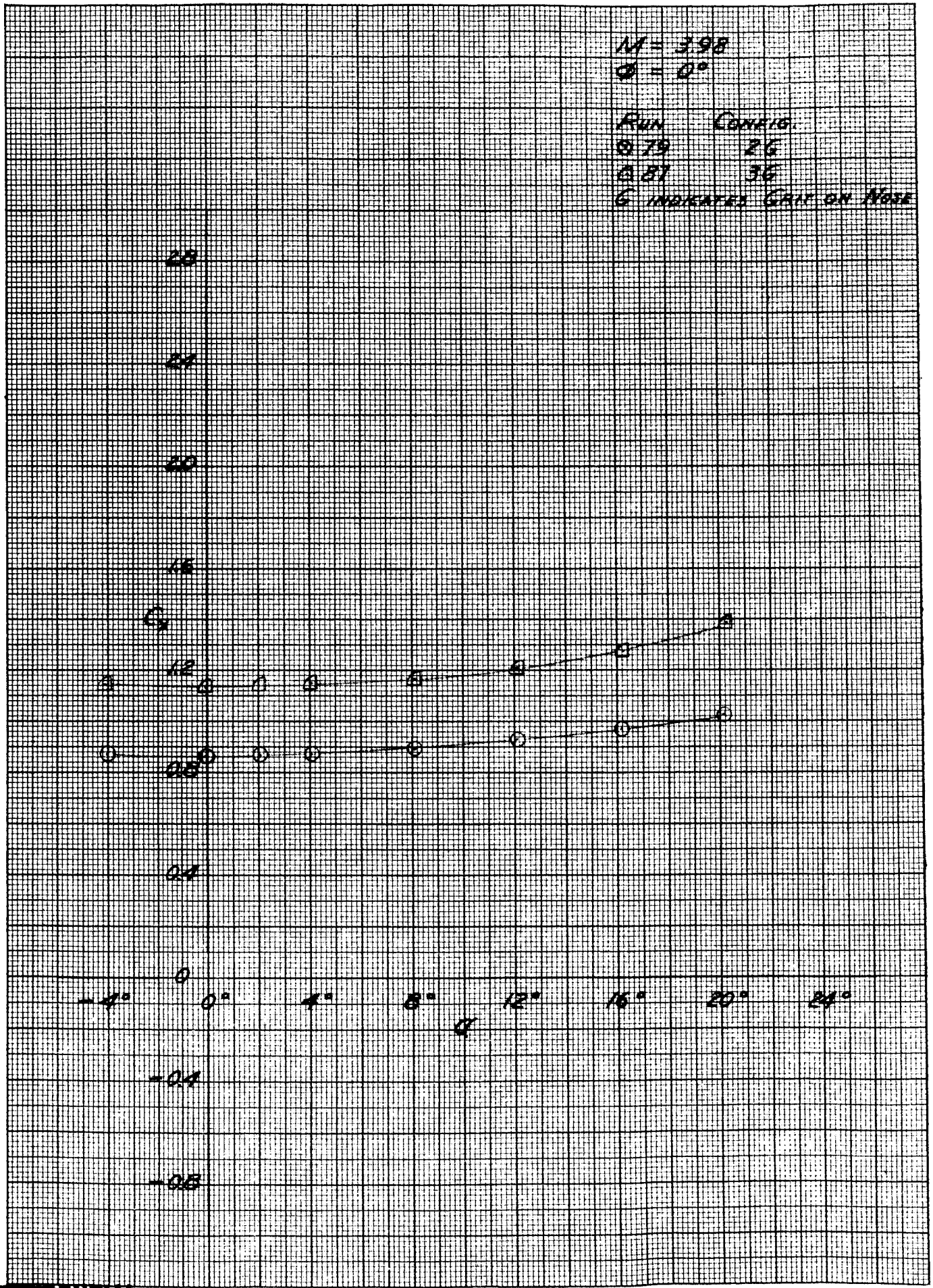
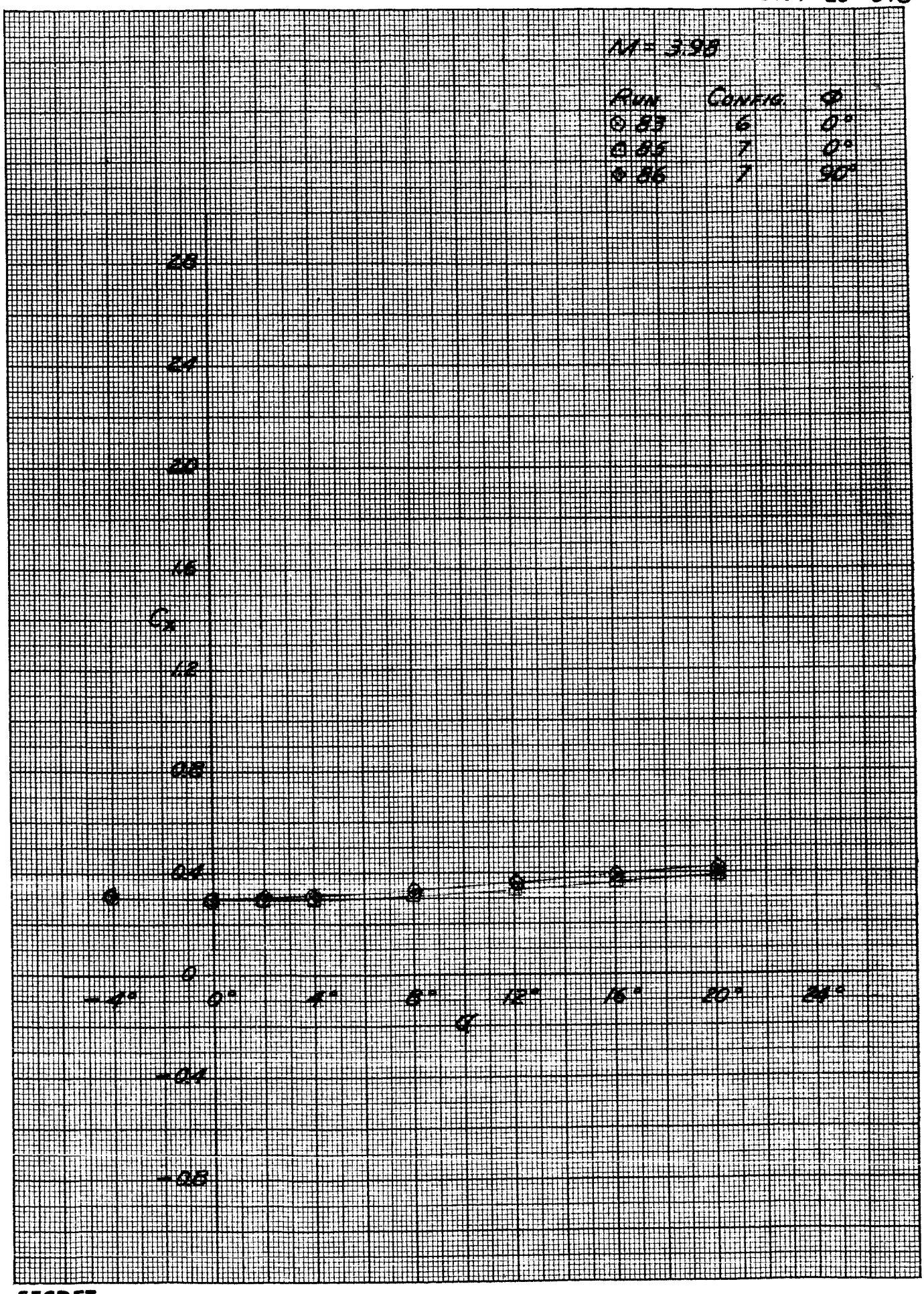
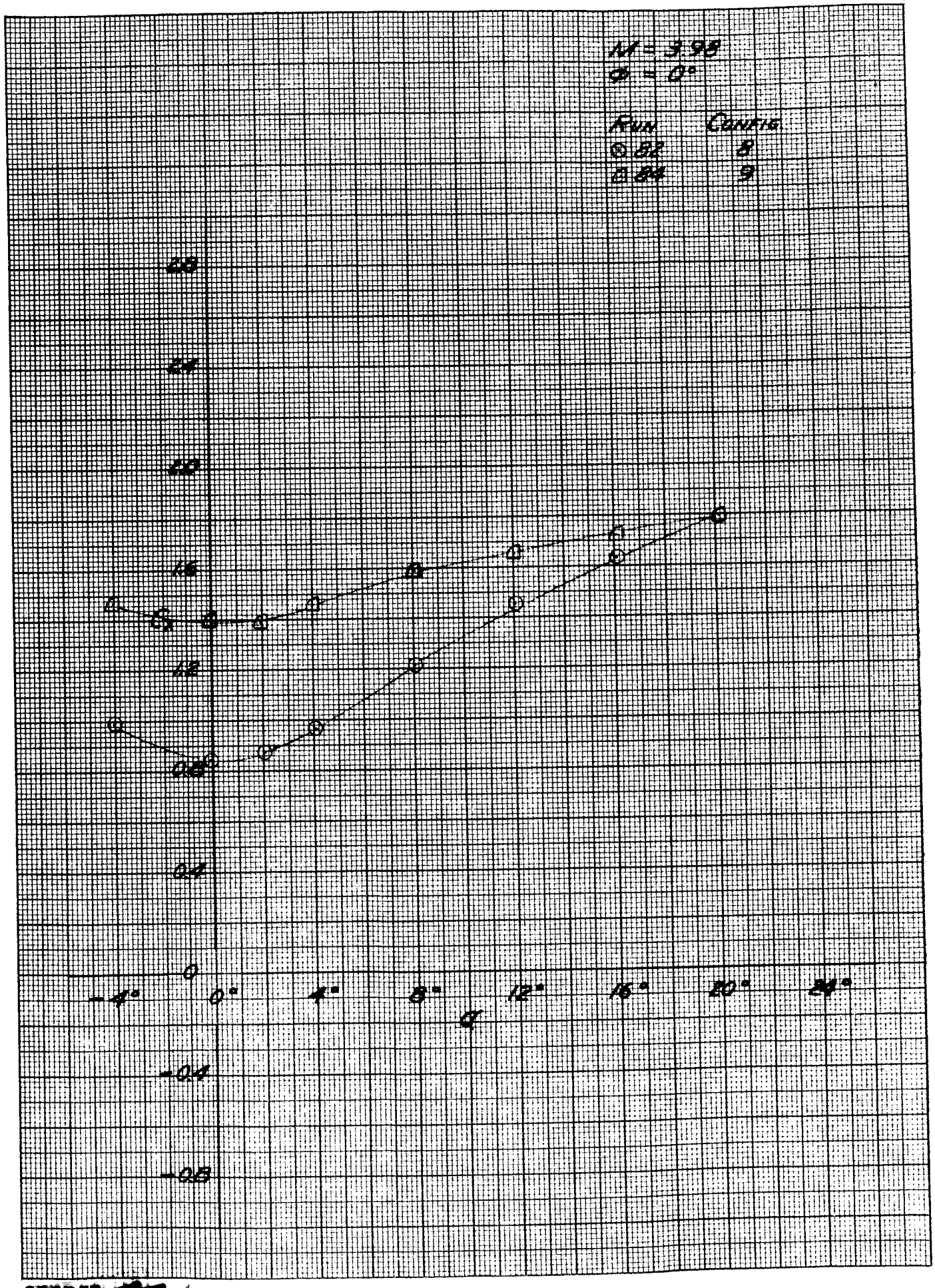
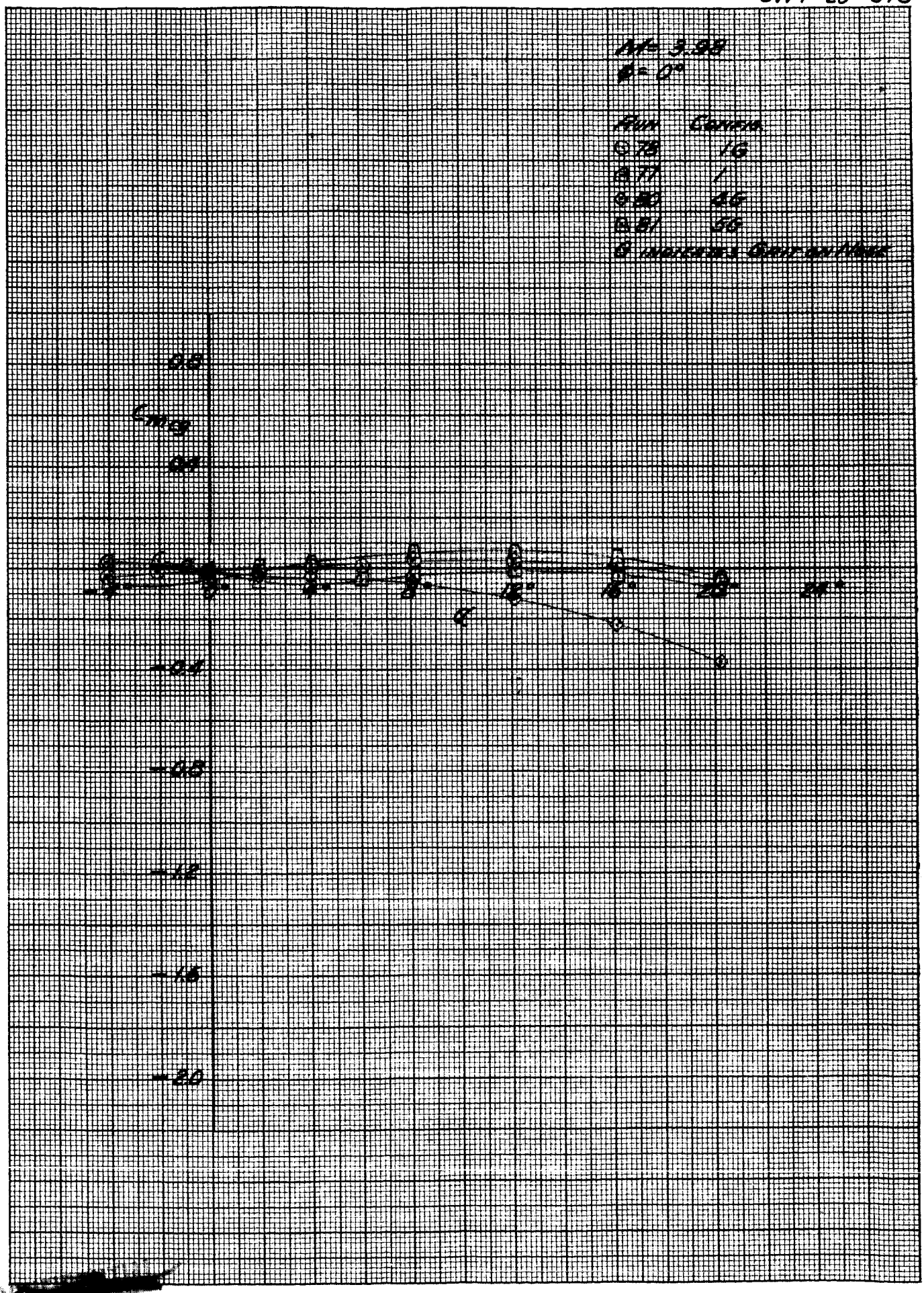
PLOT 16d

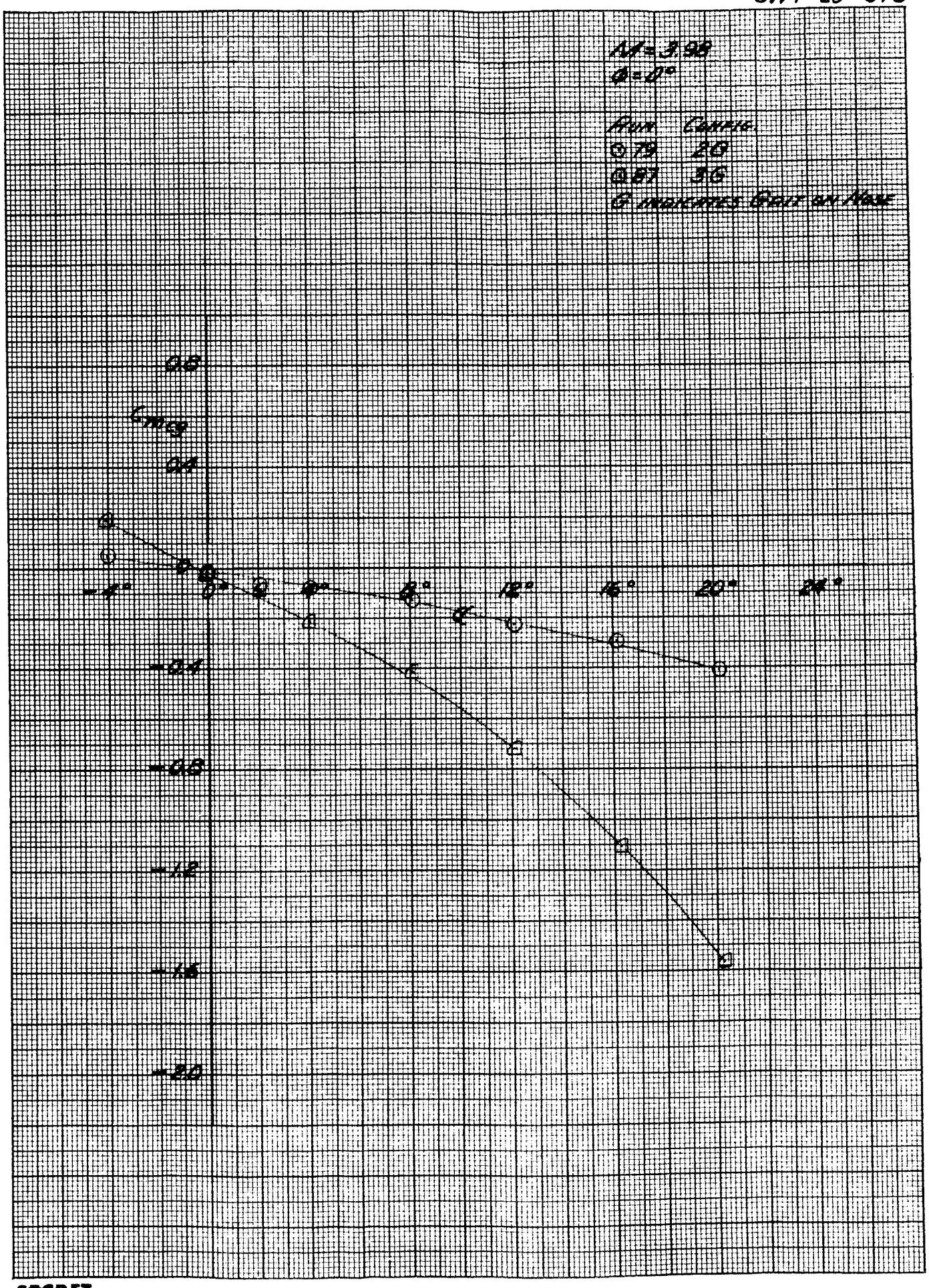

M = 3.95
α = 0°
Run Config
76 16
77 1
80 46
81 56
G indicates Grit on Nose
.28
.24
.20
.16
C_x
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
Φ = 0°
RUN CONFIG.
79 2G
87 3G
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_y
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
Run Config. Φ
83 6 0°
85 7 0°
86 7 90°
.28
.24
.20
.16
C_x
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
Φ = 0°
Run Config.
0.82 8
0.84 9
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
φ = 0°
Run Camera
75 16
77 1
80 46
81 56
8 markers Over on Next
0.8
C_{m_α}
0.4
-0.4
-0.8
-1.2
-1.6
-2.0
α


M = 3.98
φ = 0°
Run Curve.
79 20
87 36
G indicates Foil on Nose
0.8
C_{m_α}
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
-0.4
-0.8
-1.2
-1.6
-2.0

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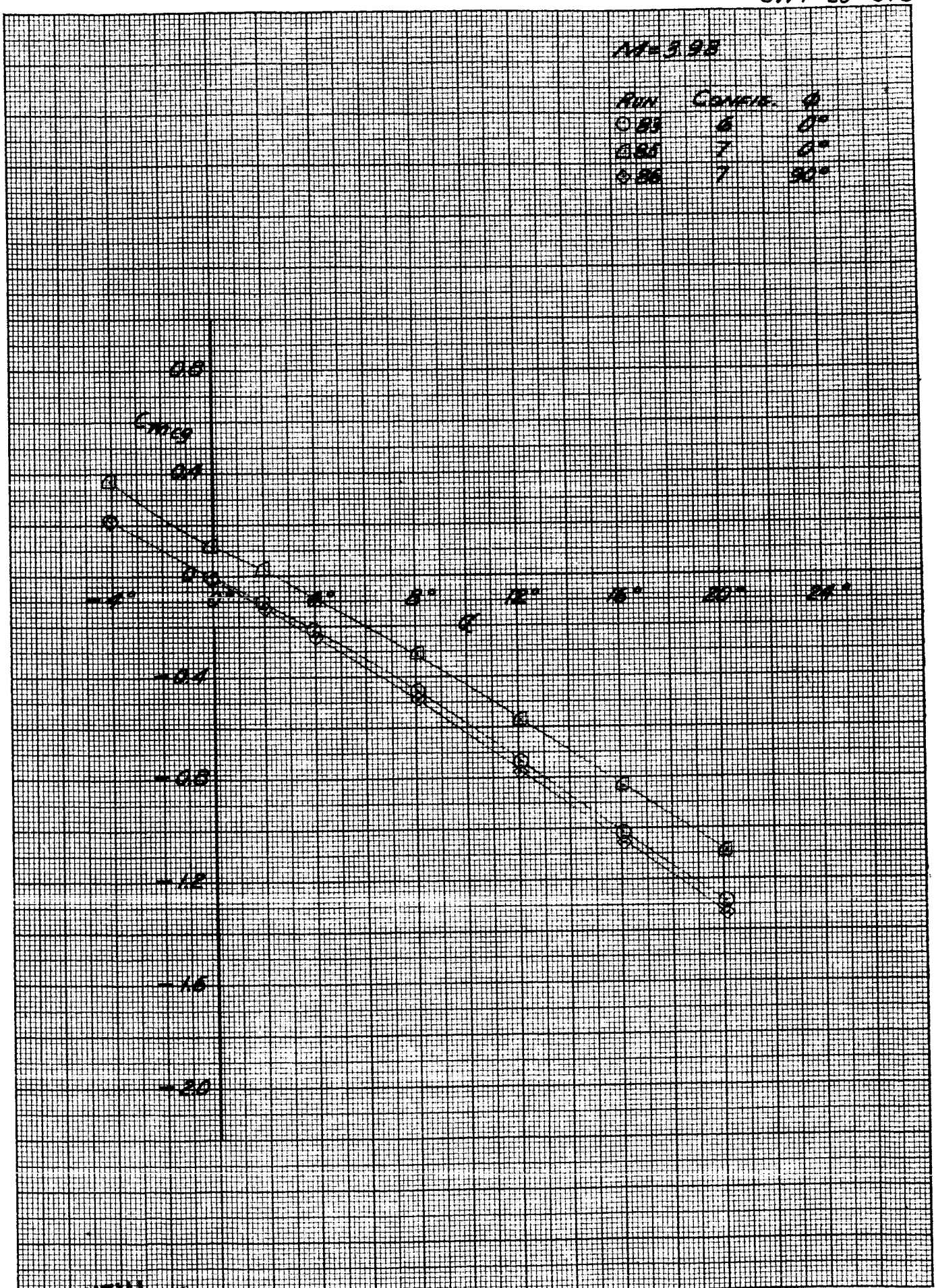
SWT 20-378



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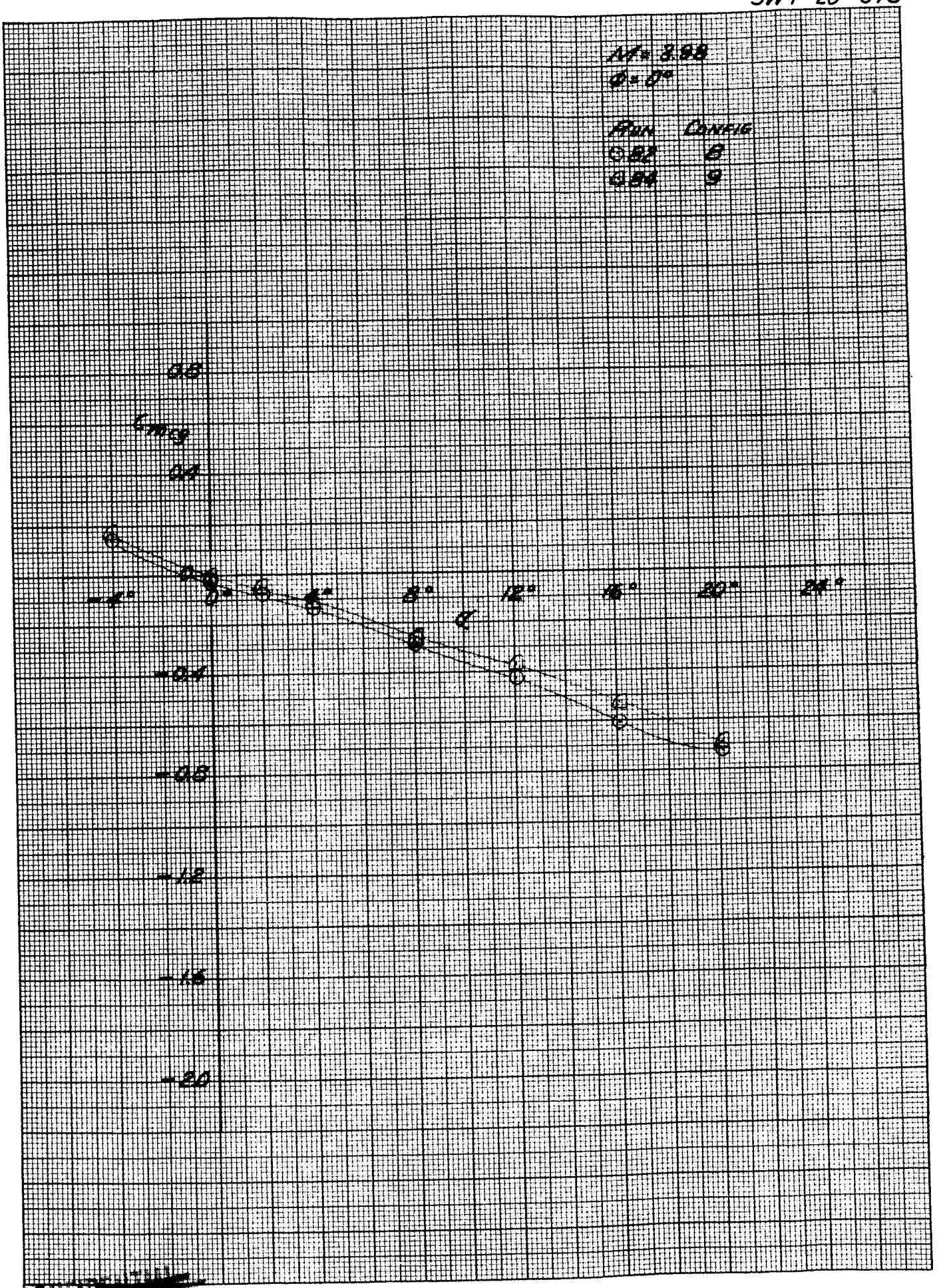
PLOT 18C


M = 3.98
Φ = 0°
Run Config
0.82 8
0.84 9
0.8
$C_{m_{cg}}$
0.4
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8
-1.2
-1.6
-2.0

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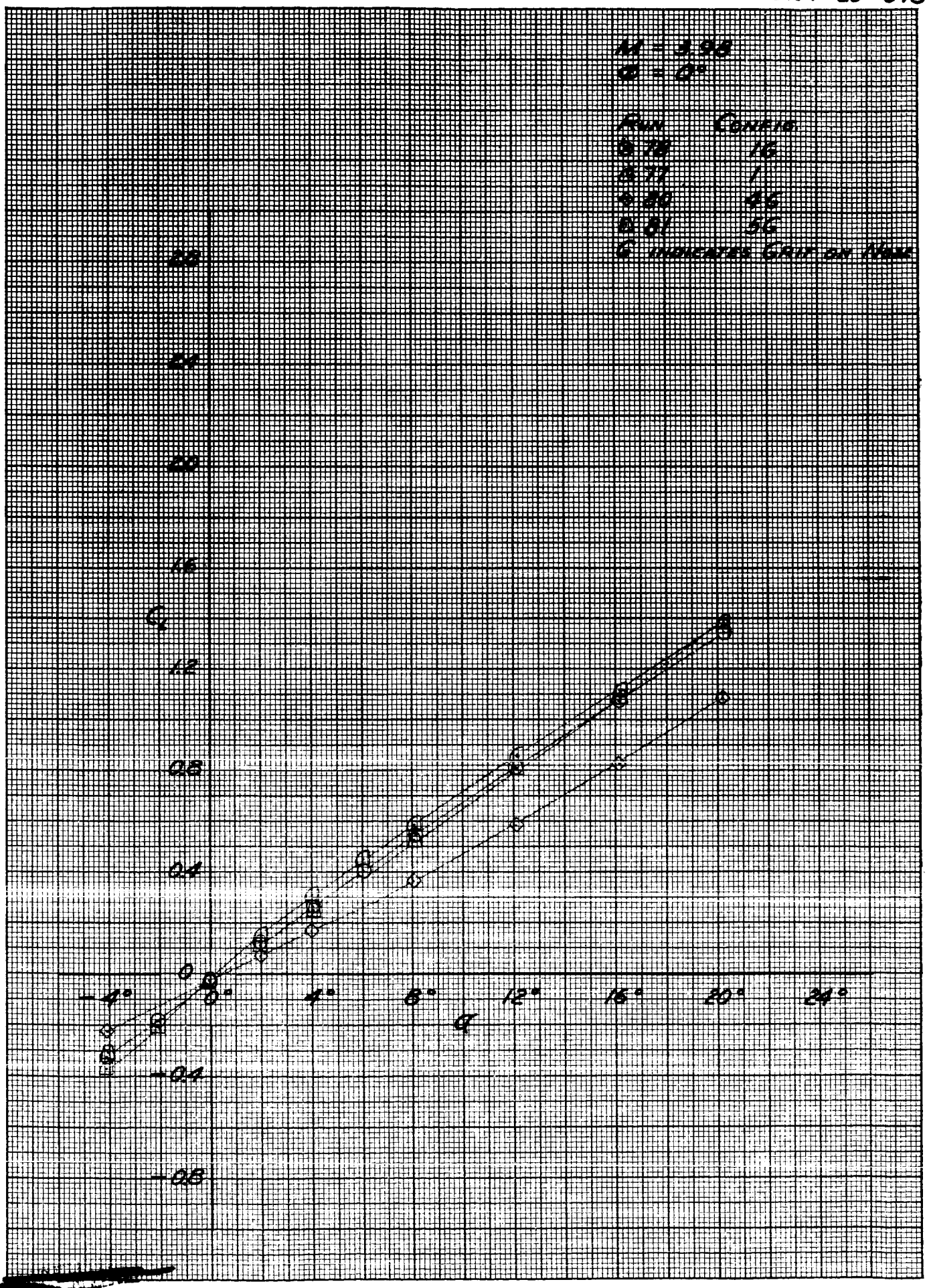
SWT 20-378



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PLOT 19a

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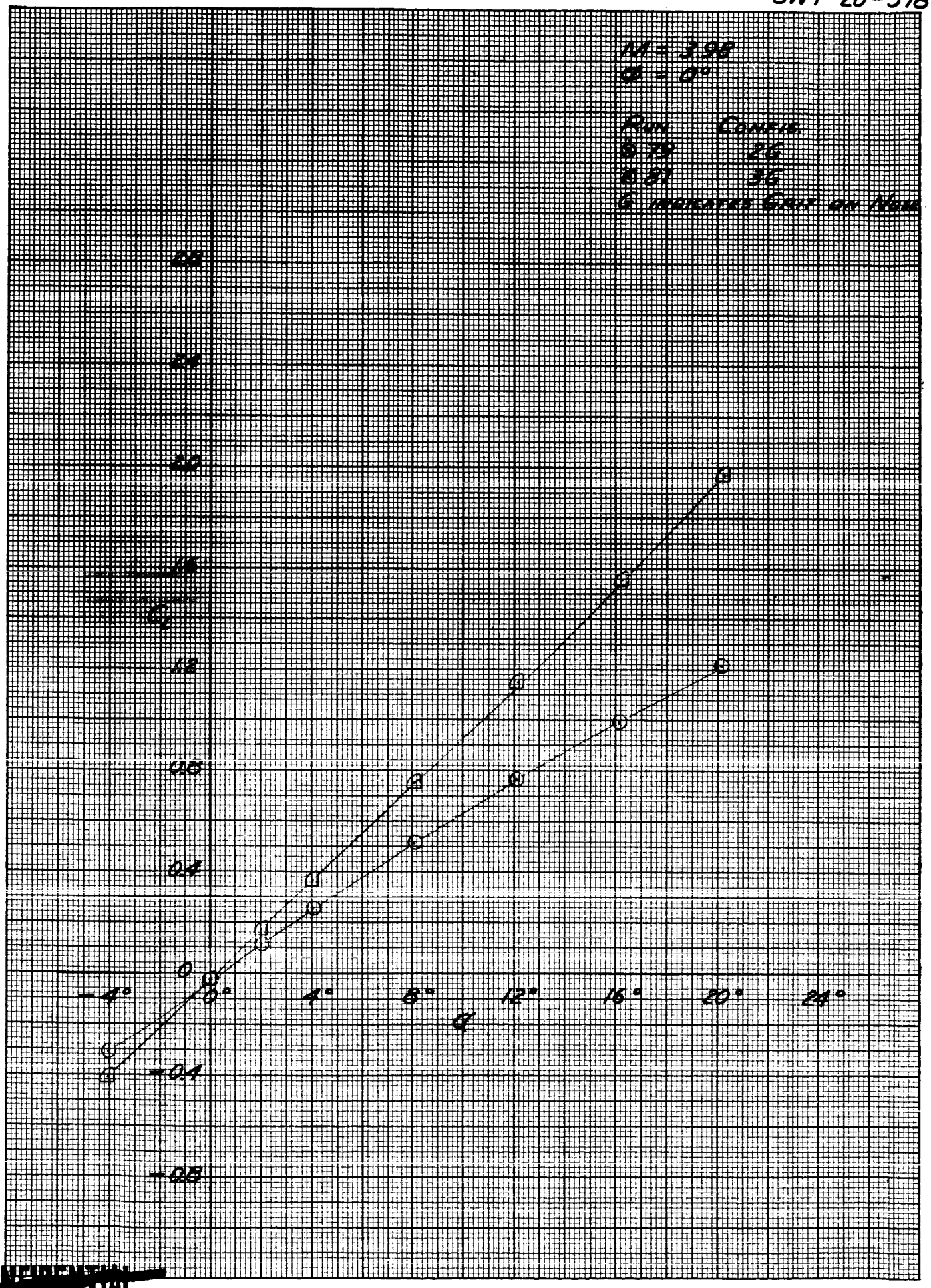
SWT 20-378



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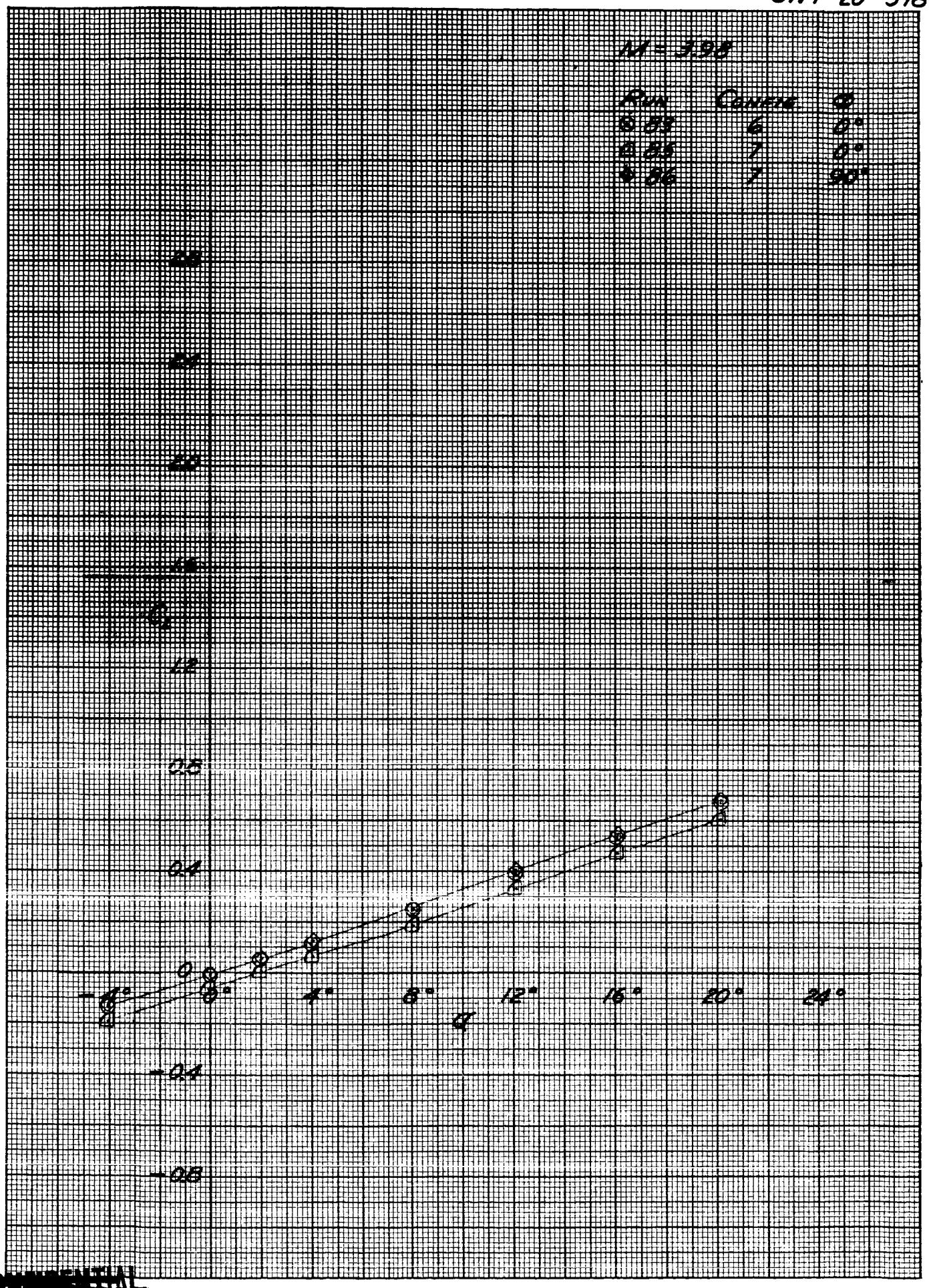
PLOT 19b


M = 3.98
Run Cone No. φ
85 6 0°
85 7 0°
86 7 90°
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

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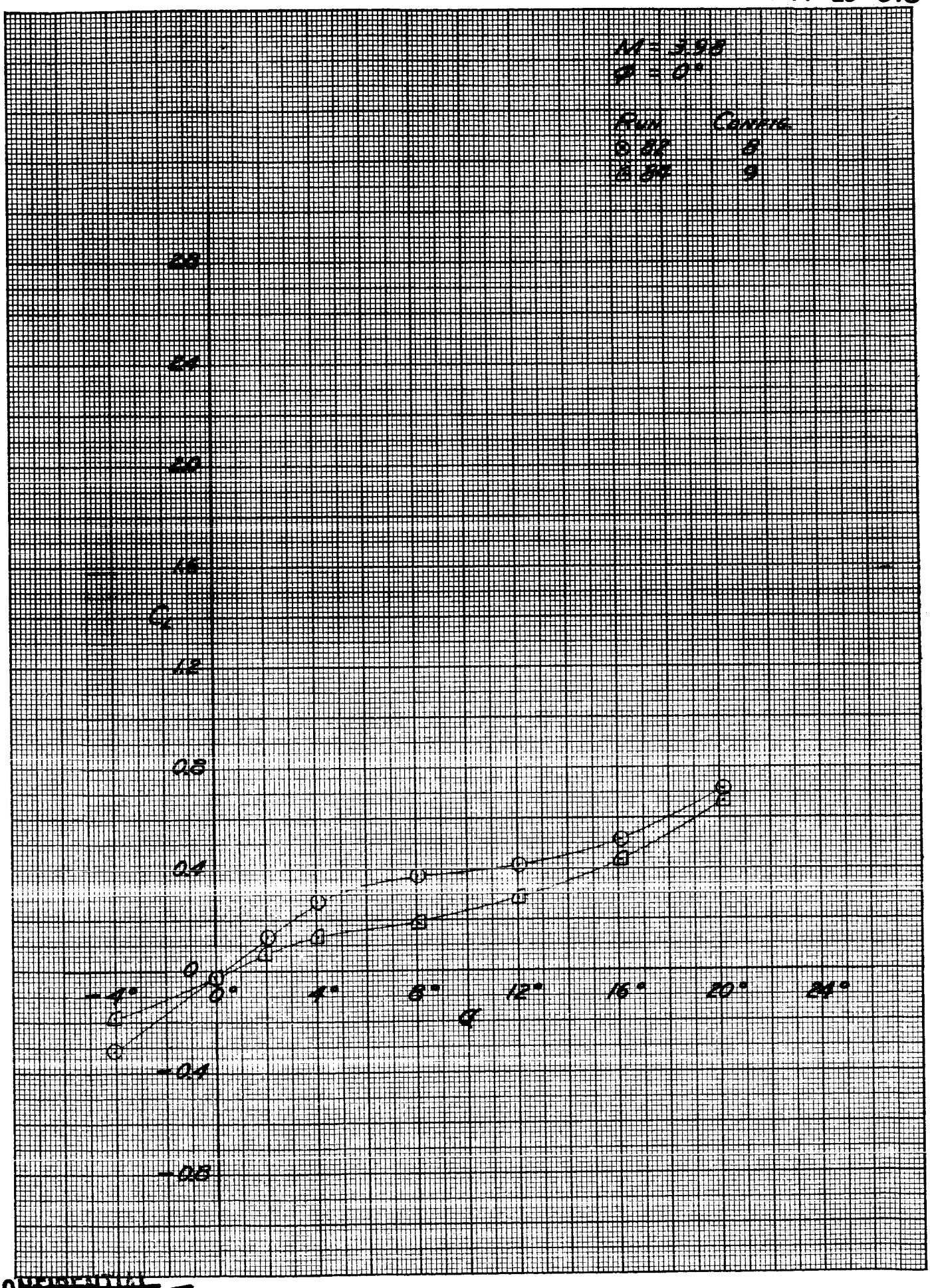
SWT 20-378



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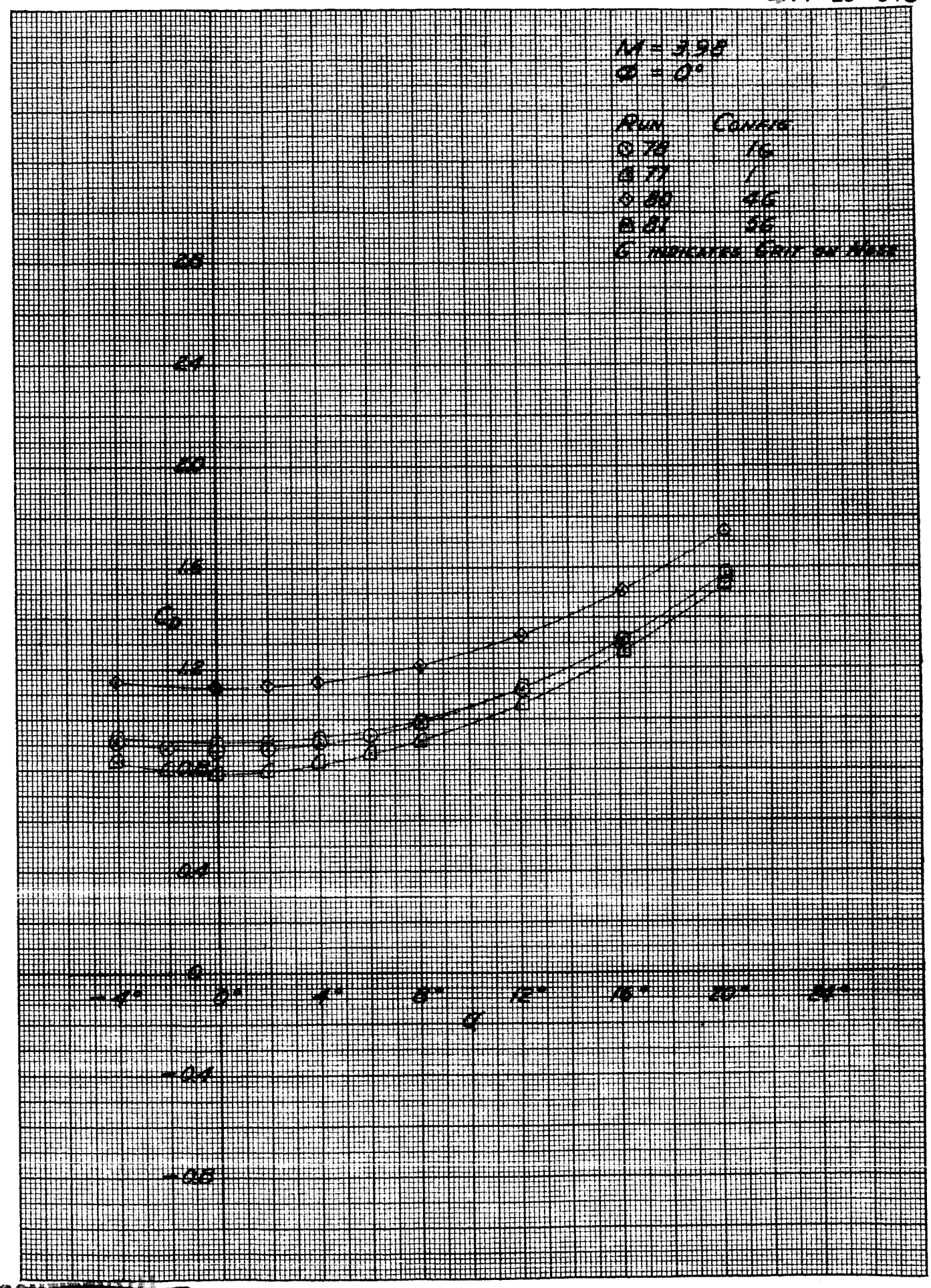
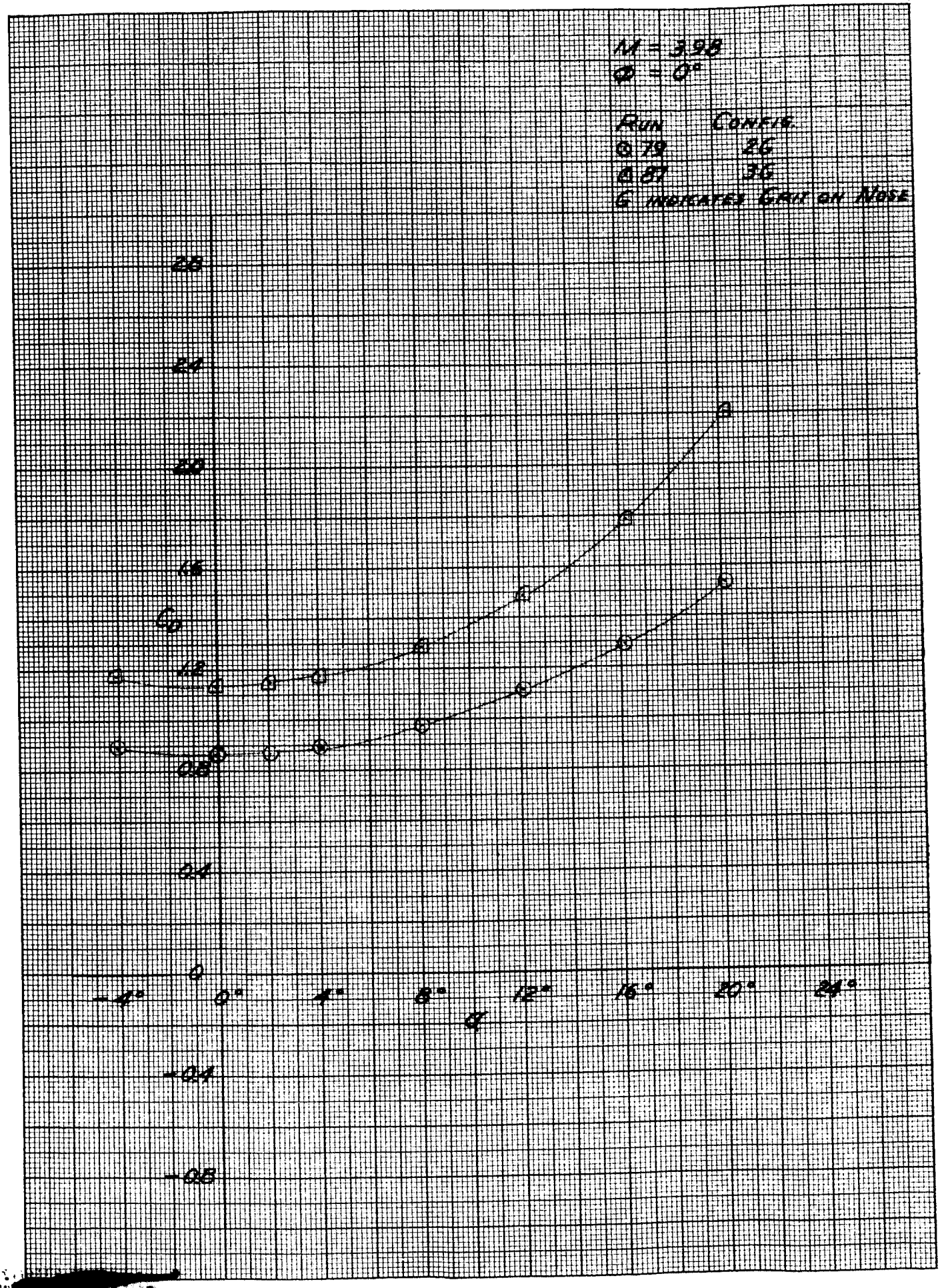
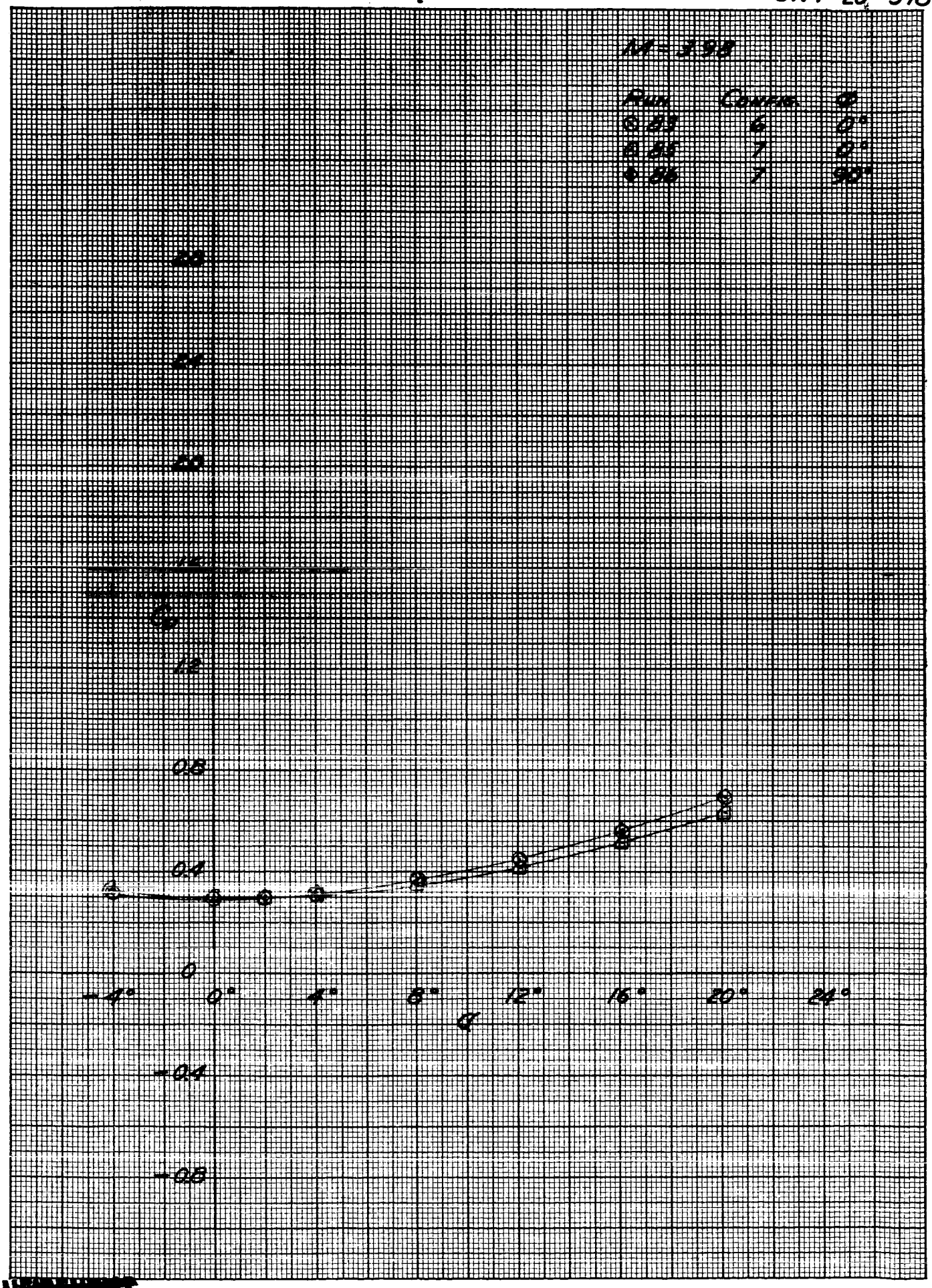
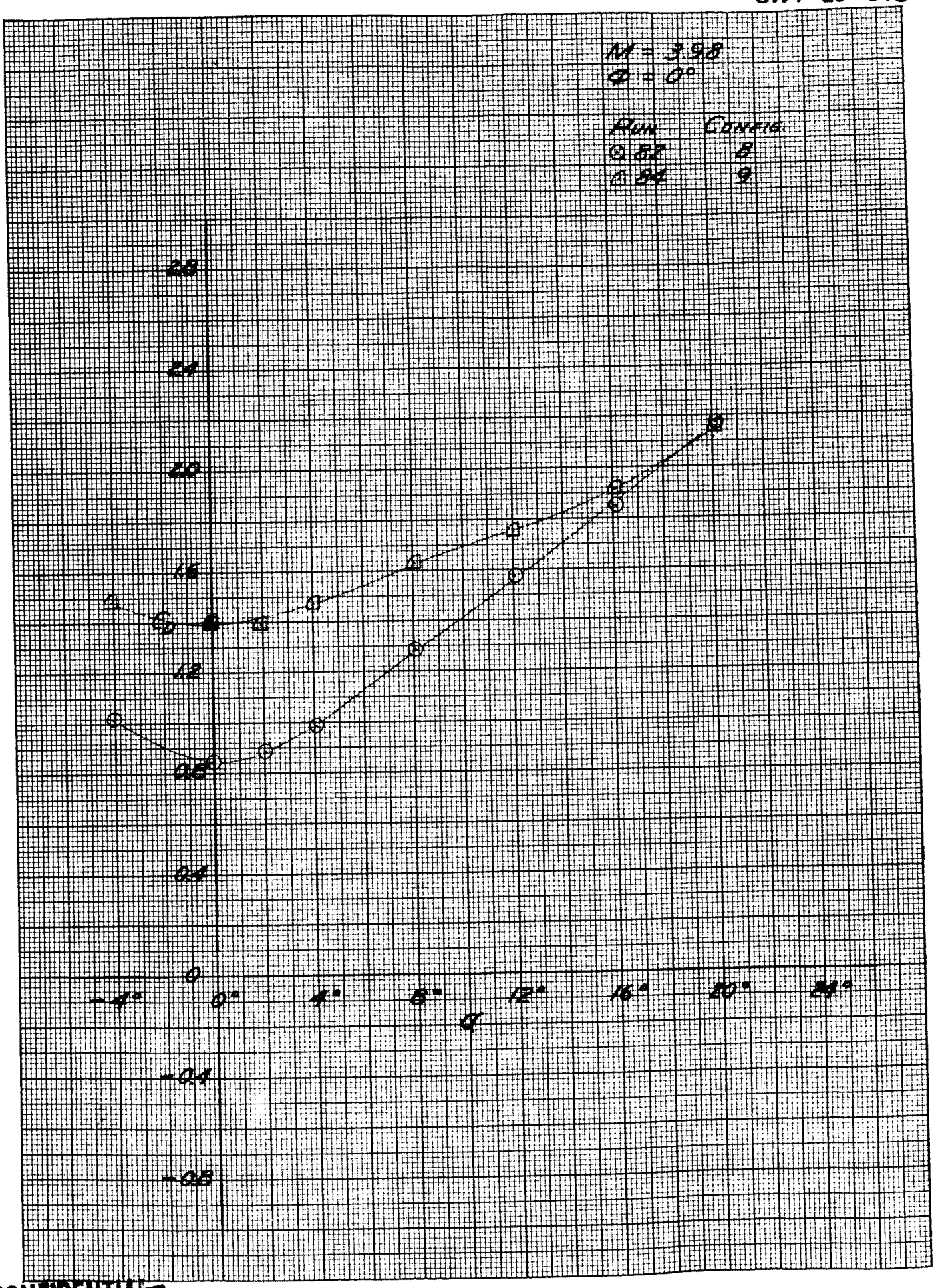
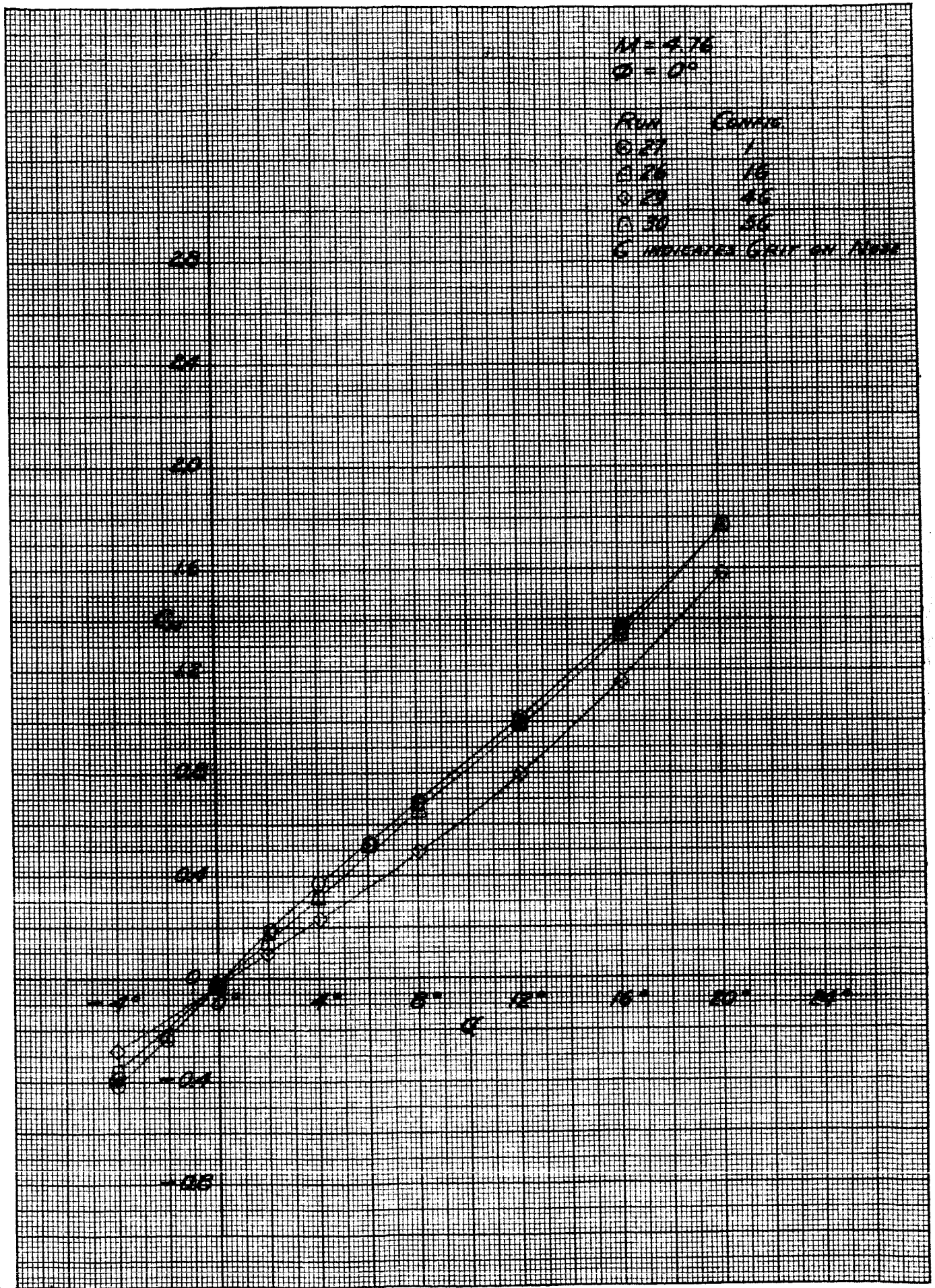
PLOT 19d

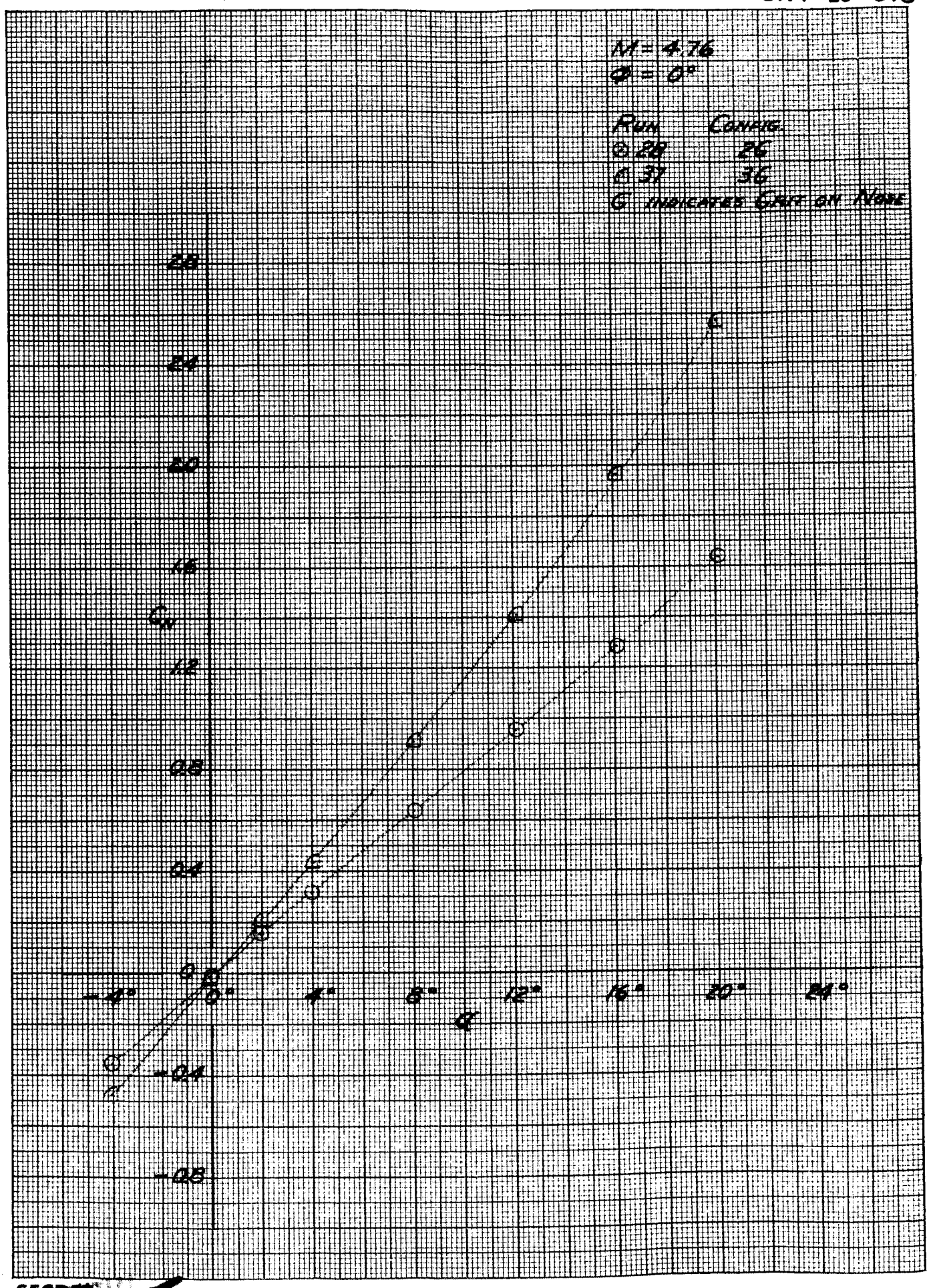

M = 3.98
Φ = 0°
Run Contrails
78 16
77 1
80 46
81 56
G indicates grit on nose
.28
.24
.20
.16
C_D
.12
.08
.04
0
-4°
0°
4°
8°
12°
16°
20°
24°
α
-.04
-.08


M = 3.98
Φ = 0°
RUN CONFIG.
79 2G
87 3G
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
Run Config. φ
25 6 0°
25 7 0°
26 7 90°
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 3.98
φ = 0°
Run
Config.
82
8
84
9
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
Ø = 0°
Run Centro
27 1
26 16
29 46
30 56
G indicates Grit on Nose
.28
.24
.20
.16
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
Φ = 0°
RUN CONFIG.
28 26
37 36
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_N
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

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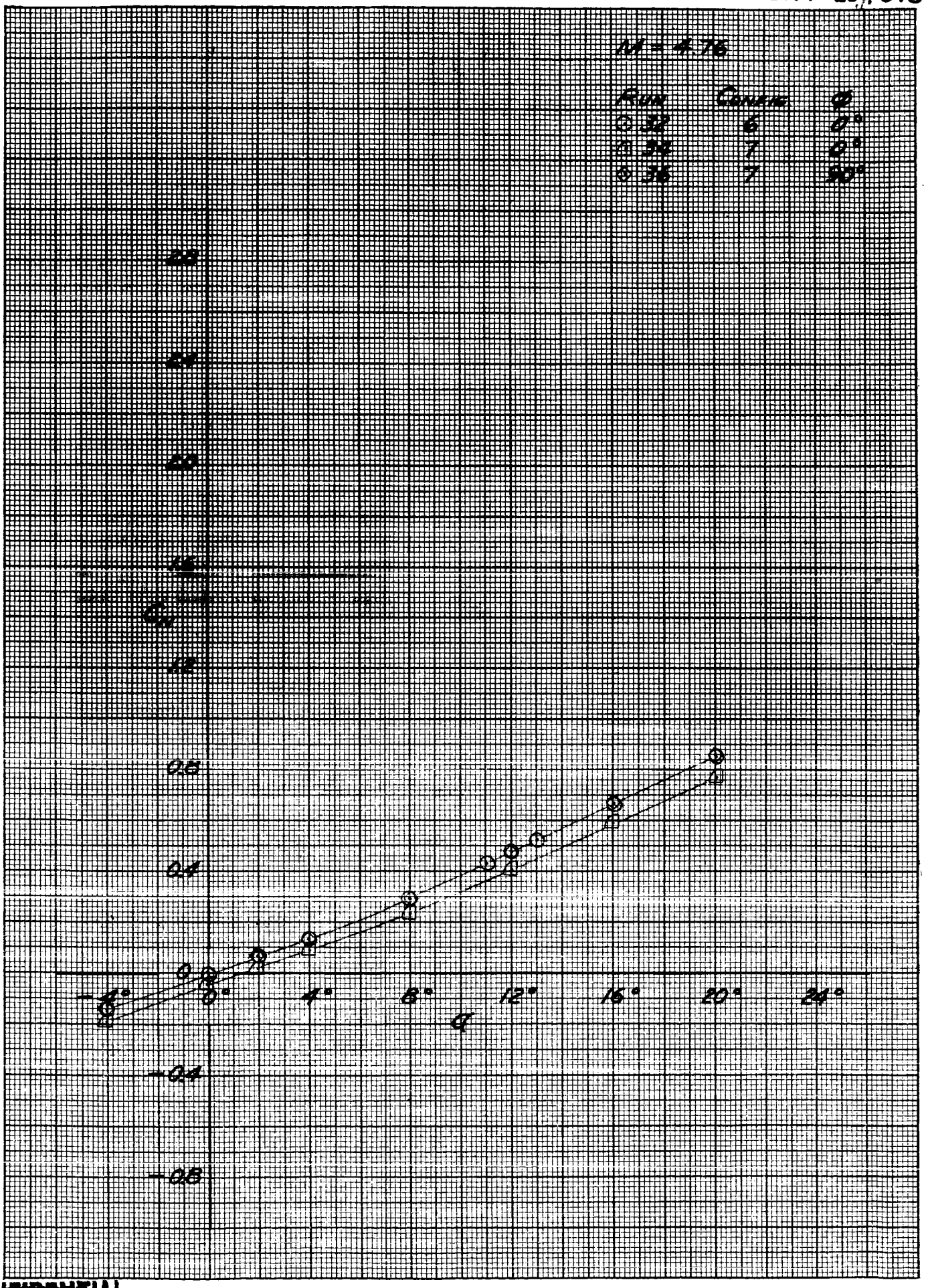
SWT 20 ft 378



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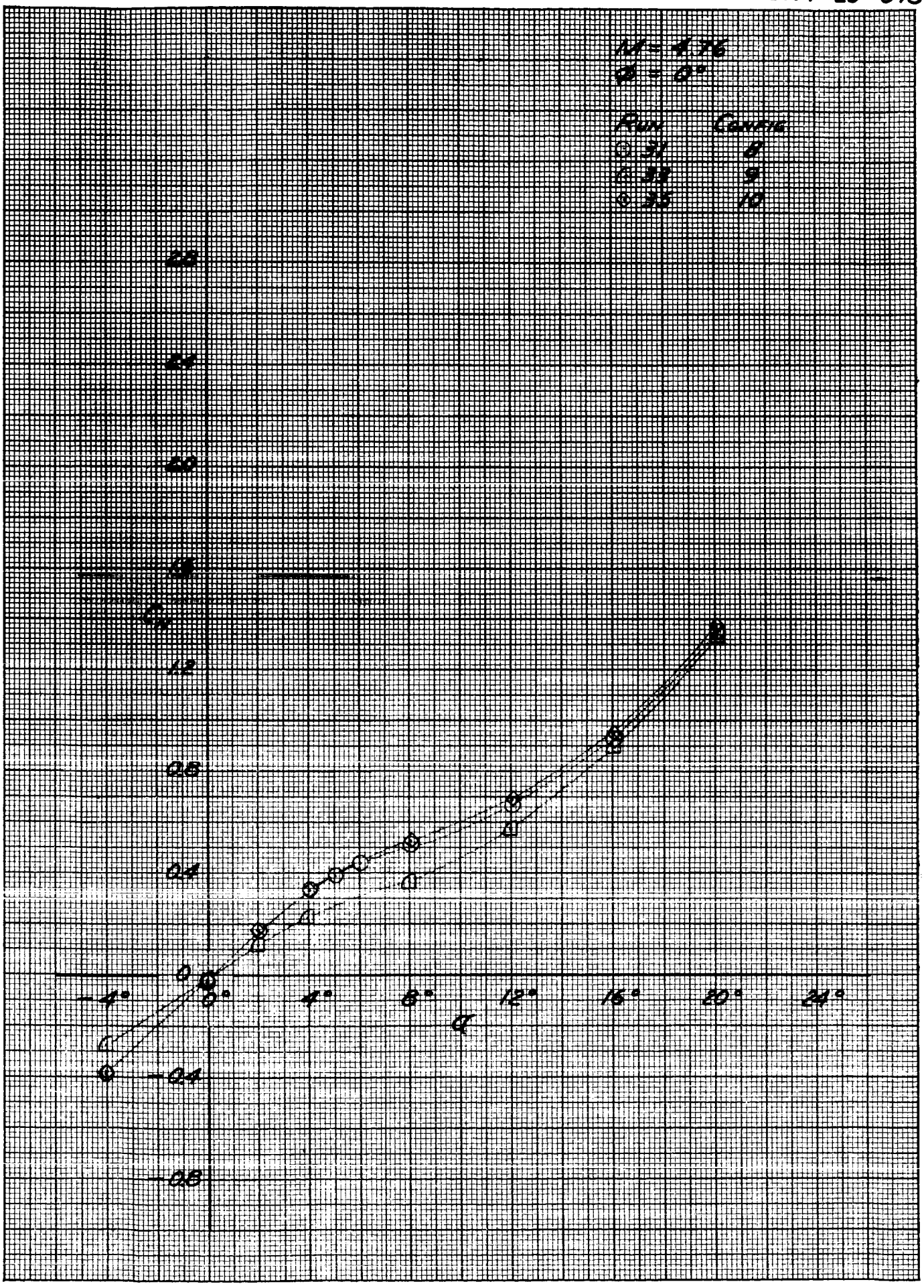
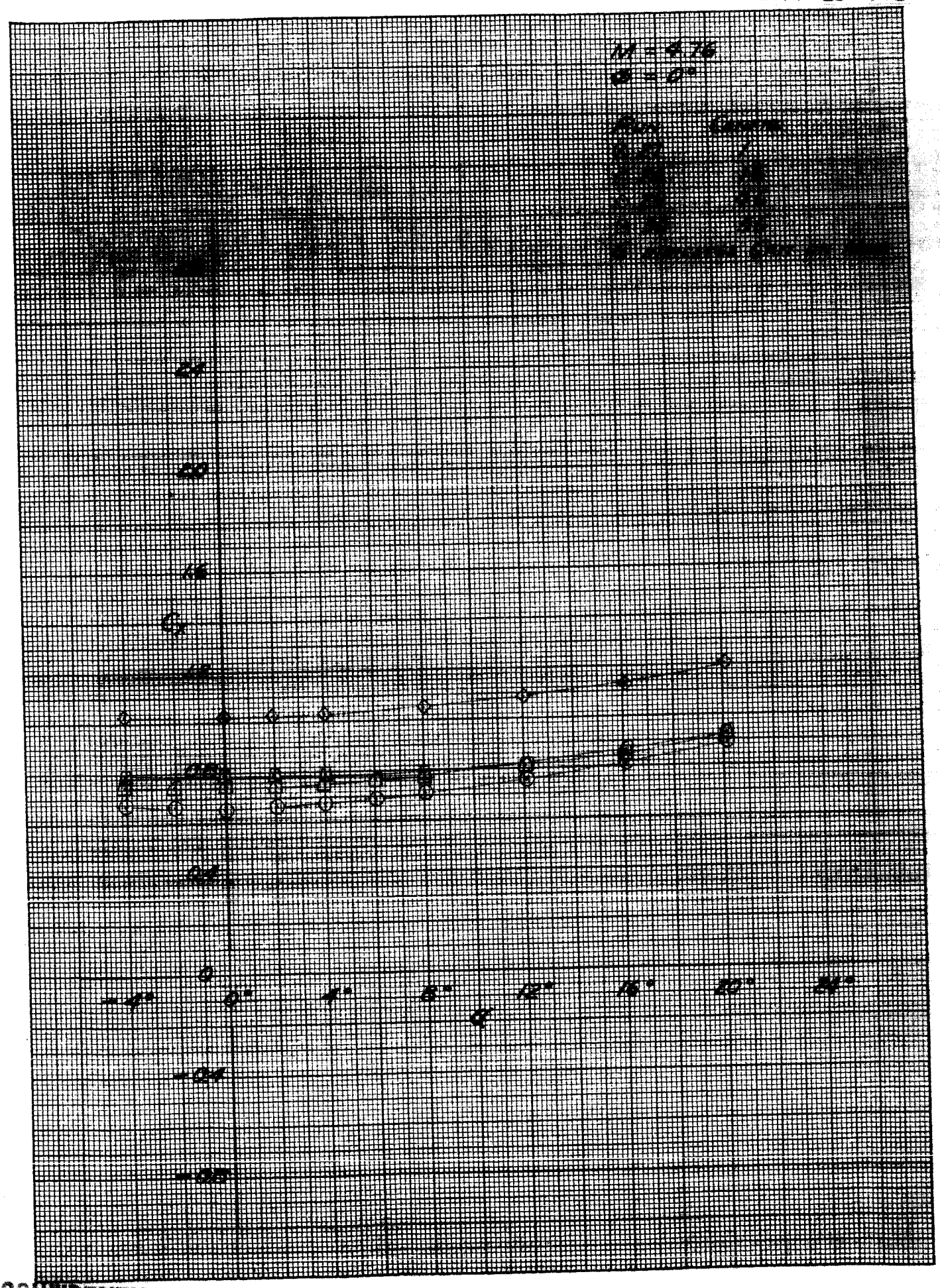
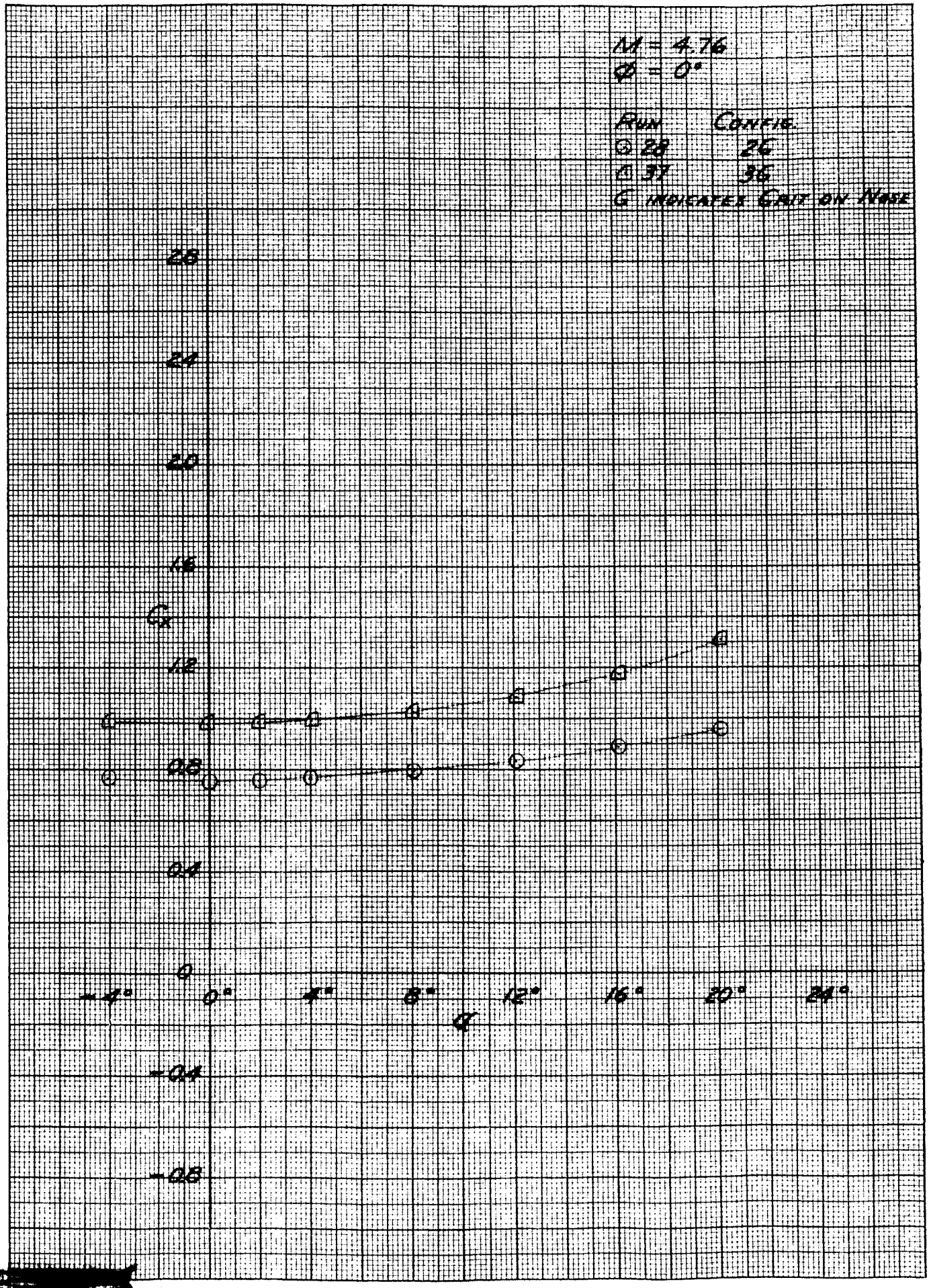
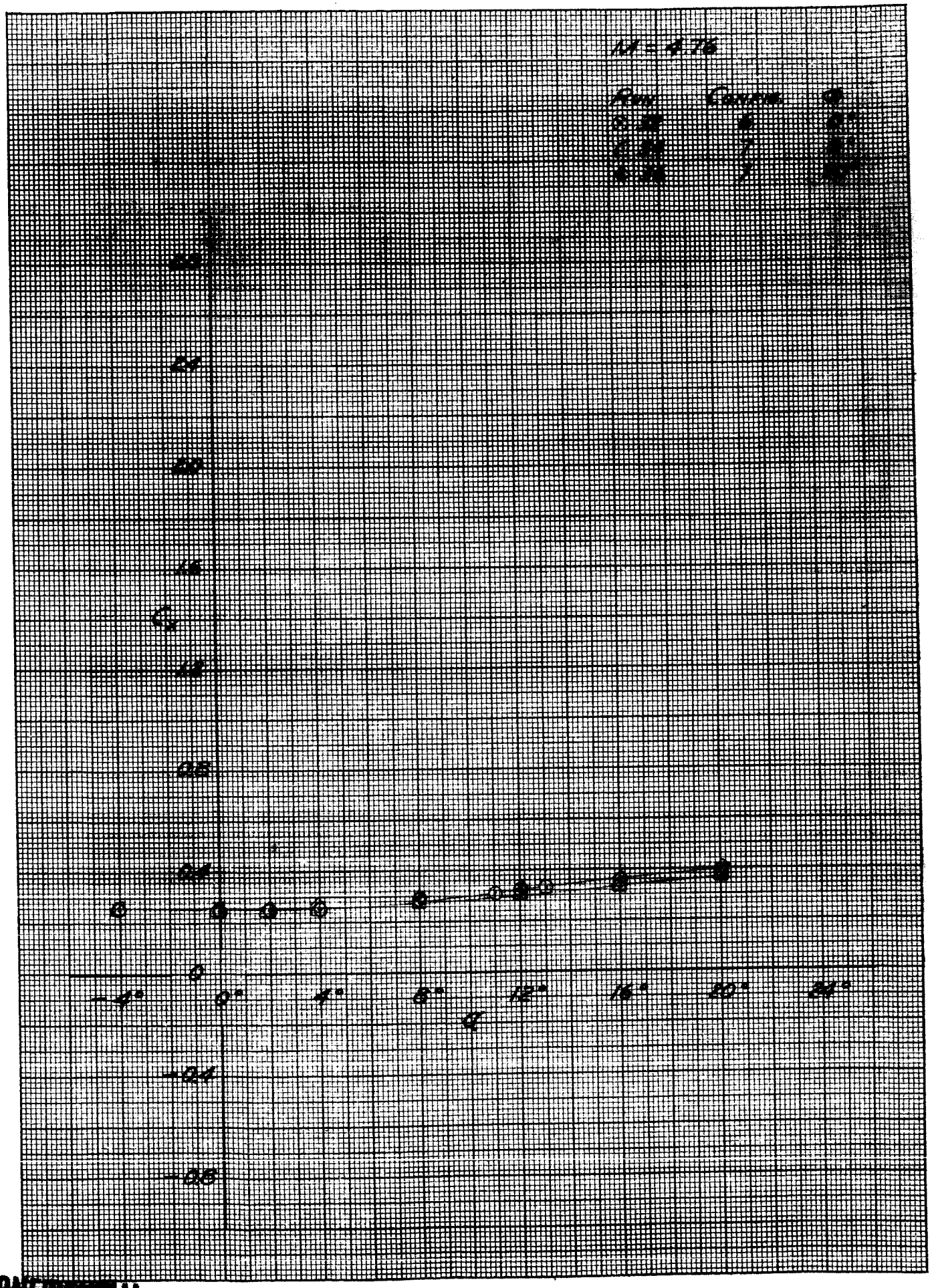
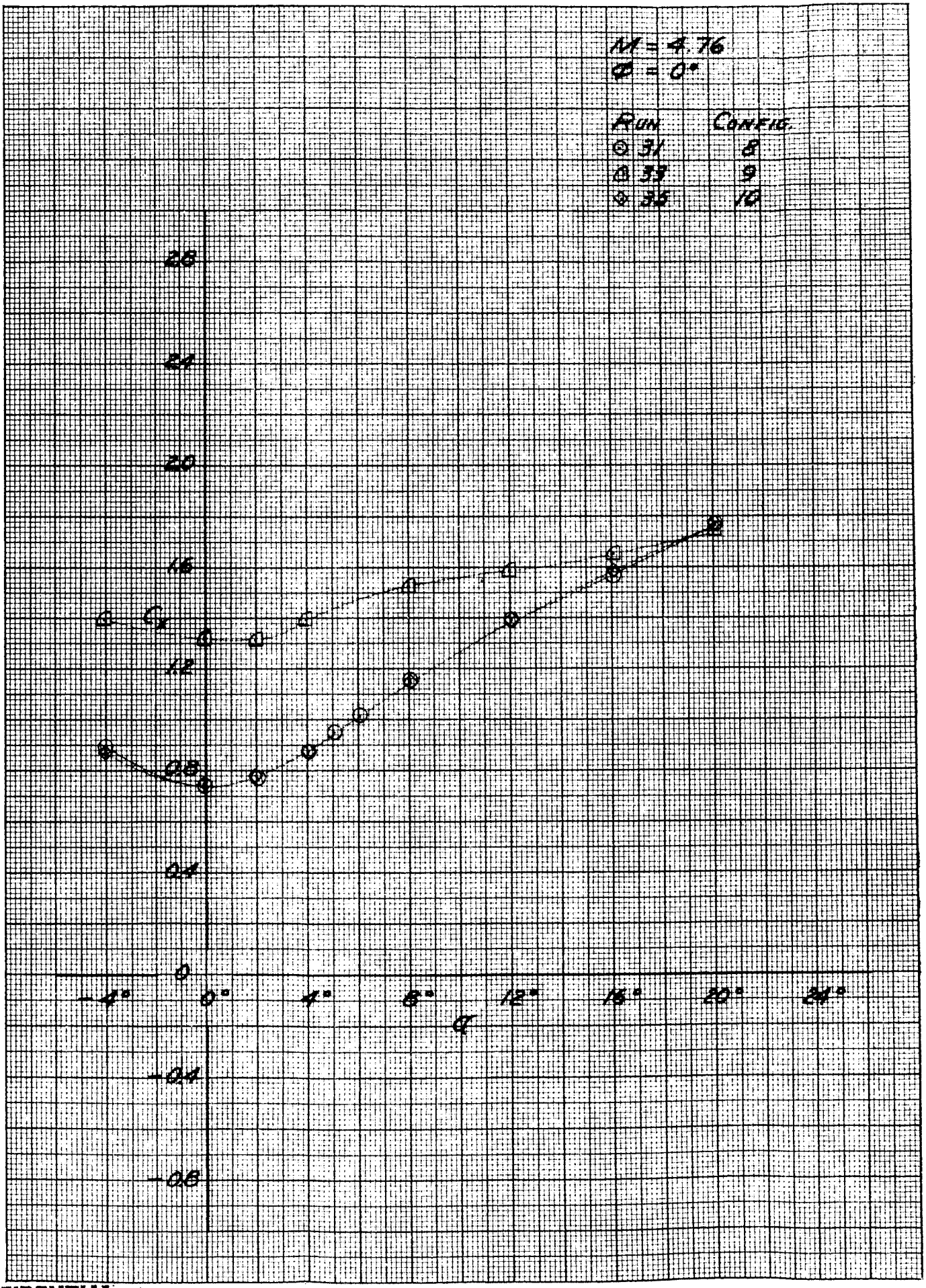
PLOT 21C


M = 4.76
φ = 0°
Run
Config
31
8
32
9
35
10
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
φ = 0°
.24
.20
.16
C_y
.08
0
-.08
-.16
-.24
-.32
-4°
0°
4°
8°
12°
16°
20°
24°
α

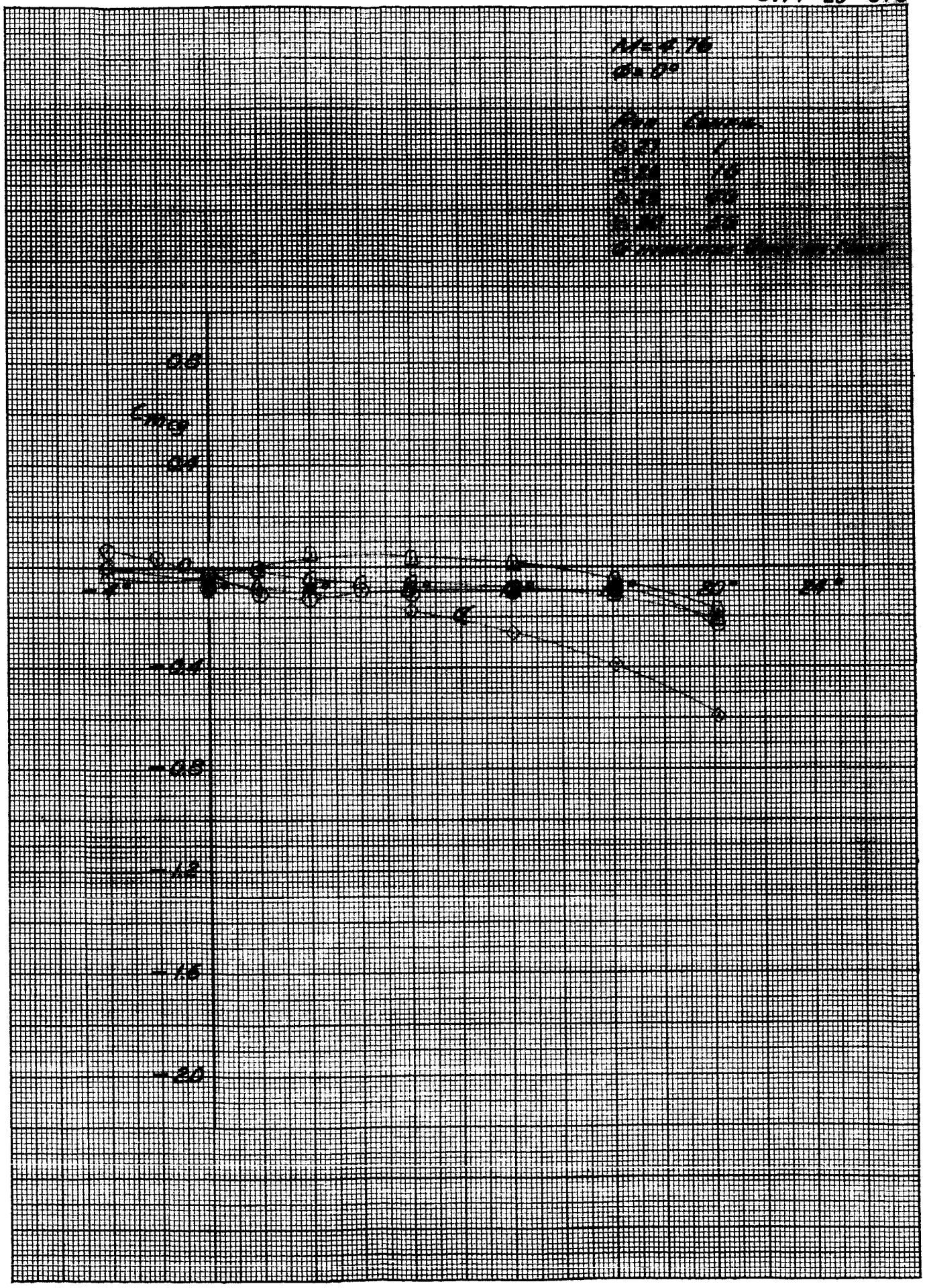

M = 4.76
Φ = 0°
RUN CONFIG.
28 26
37 36
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_x
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
Run
Camera
.08
.04
.00
-.04
C_N
-.08
.08
.04
0
-4°
0°
4°
8°
12°
16°
20°
24°
α
-.04
-.08


M = 4.76
φ = 0°
RUN
CONFIG.
31
8
33
9
35
10
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
C_x
-4°
0°
4°
8°
12°
16°
20°
24°
α

CONFIDENTIAL

SWT 20-378

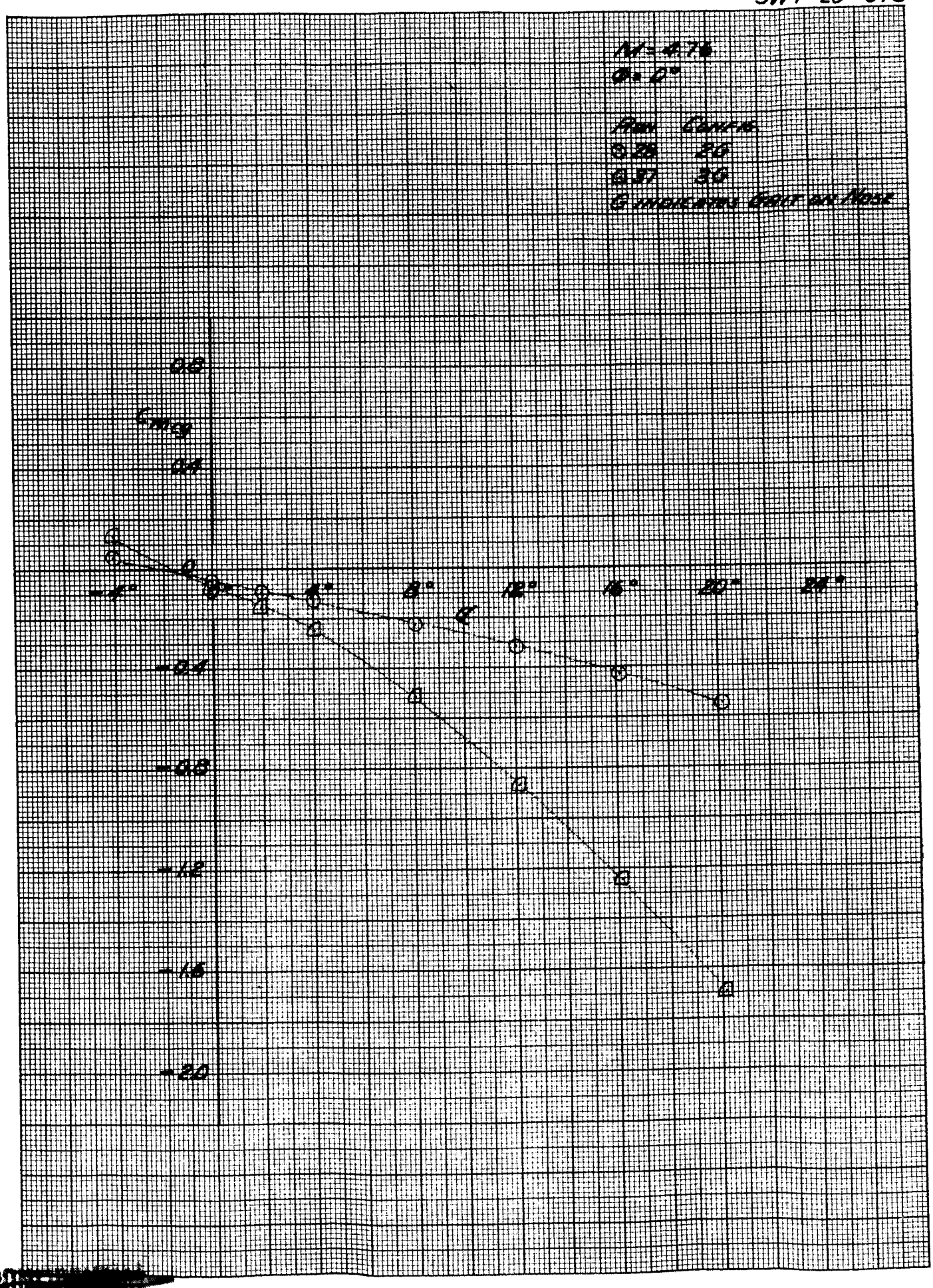


CONFIDENTIAL

PLOT 23a

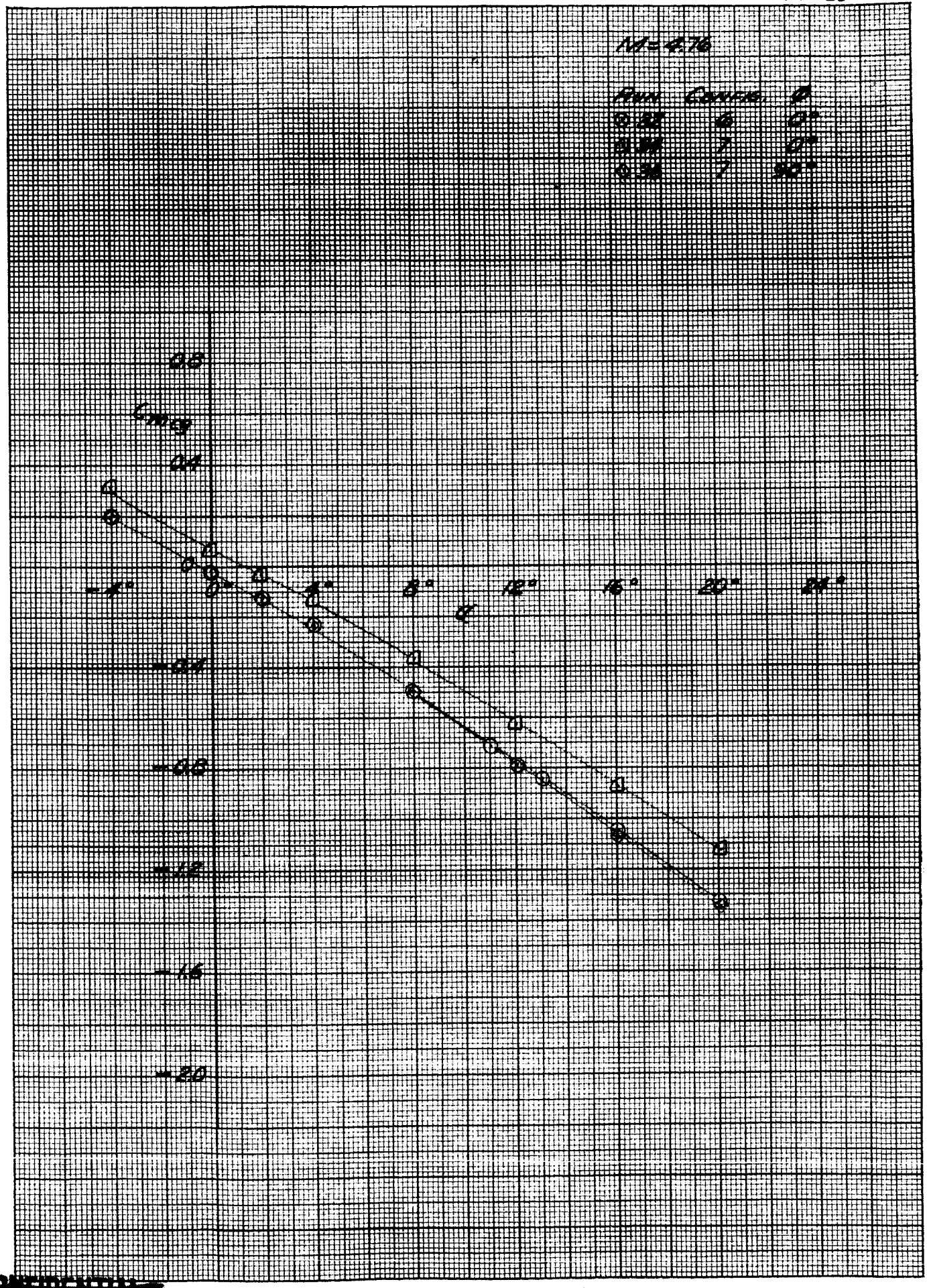
~~CONFIDENTIAL~~

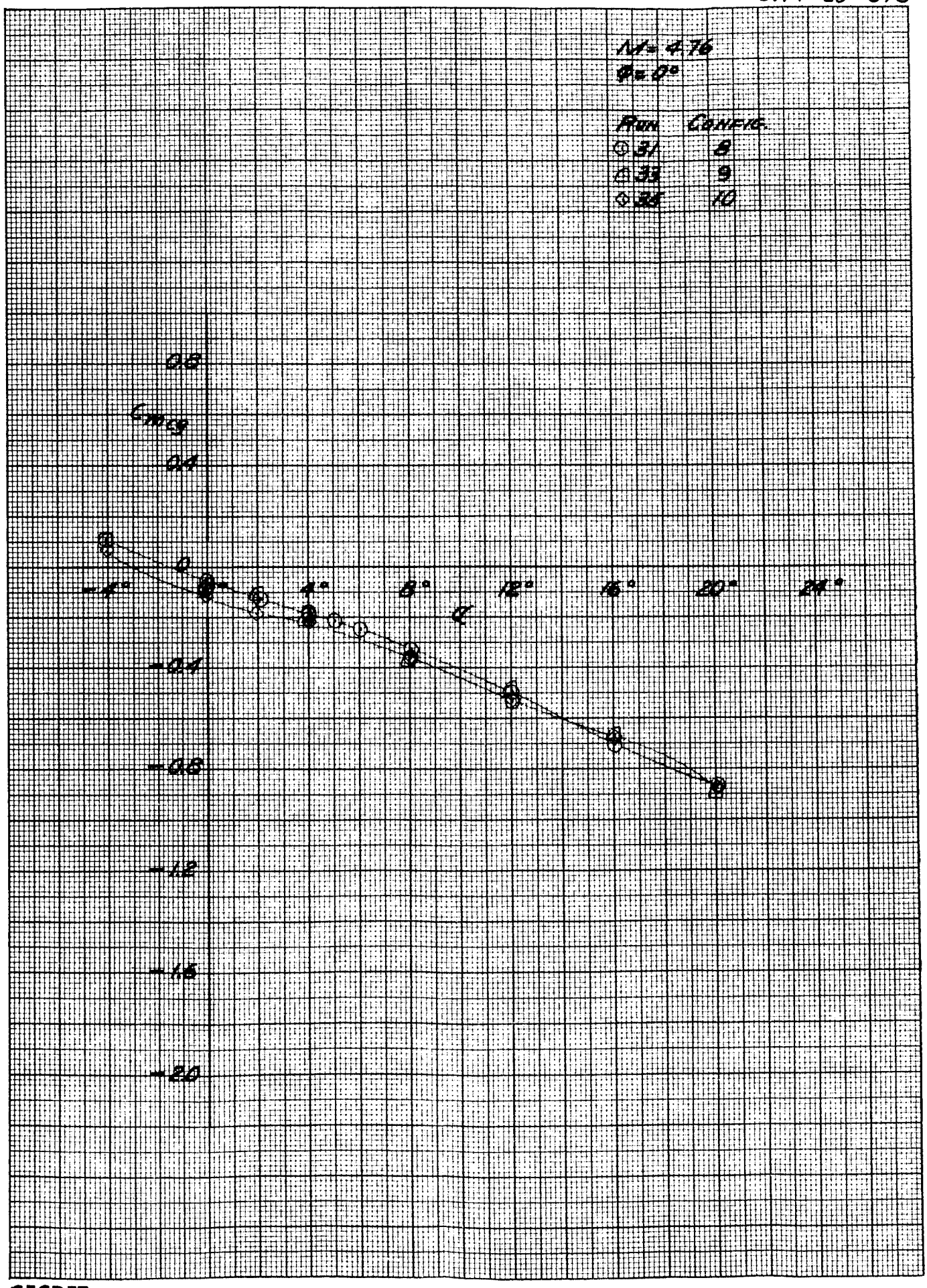
SWT 20-378

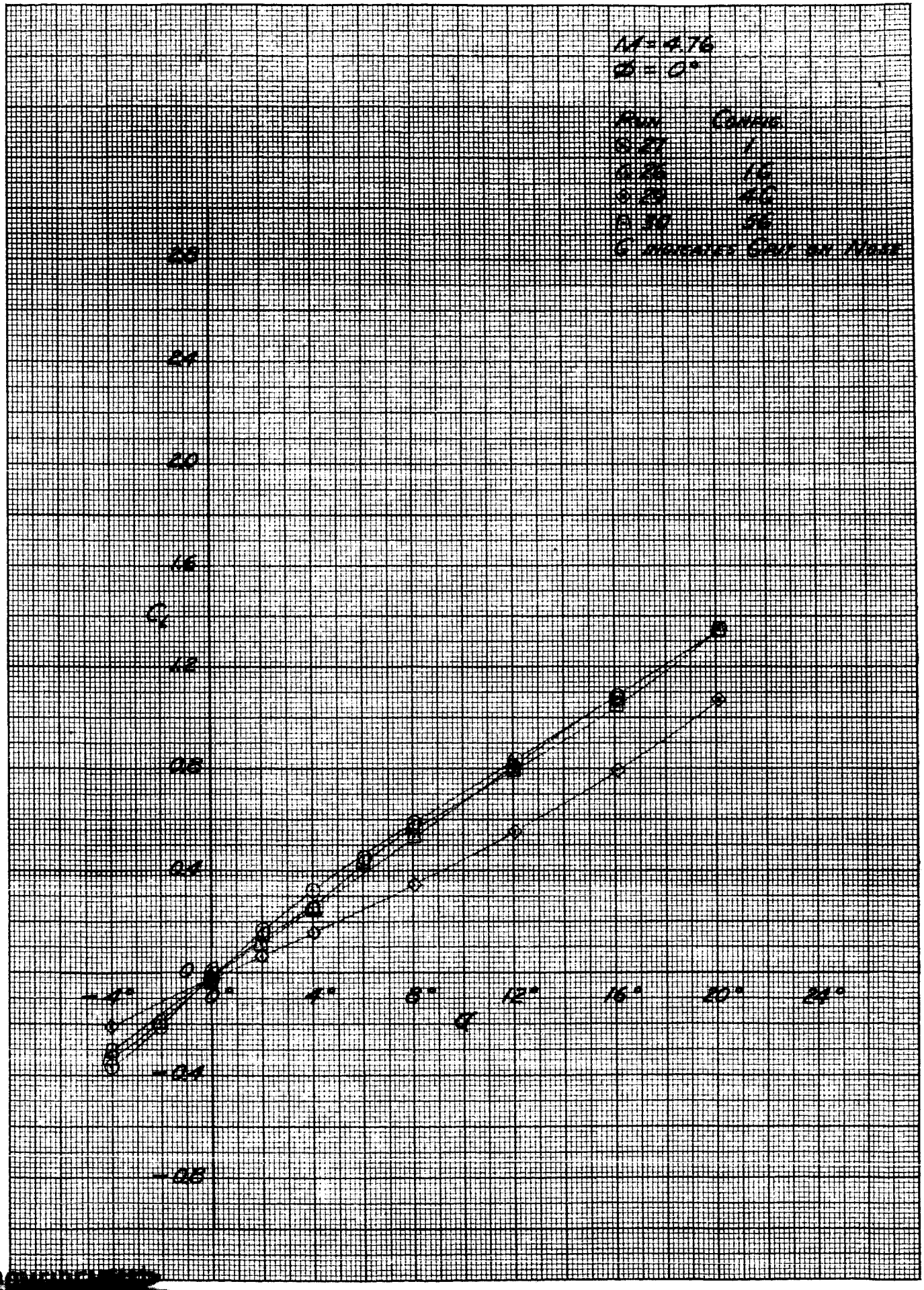


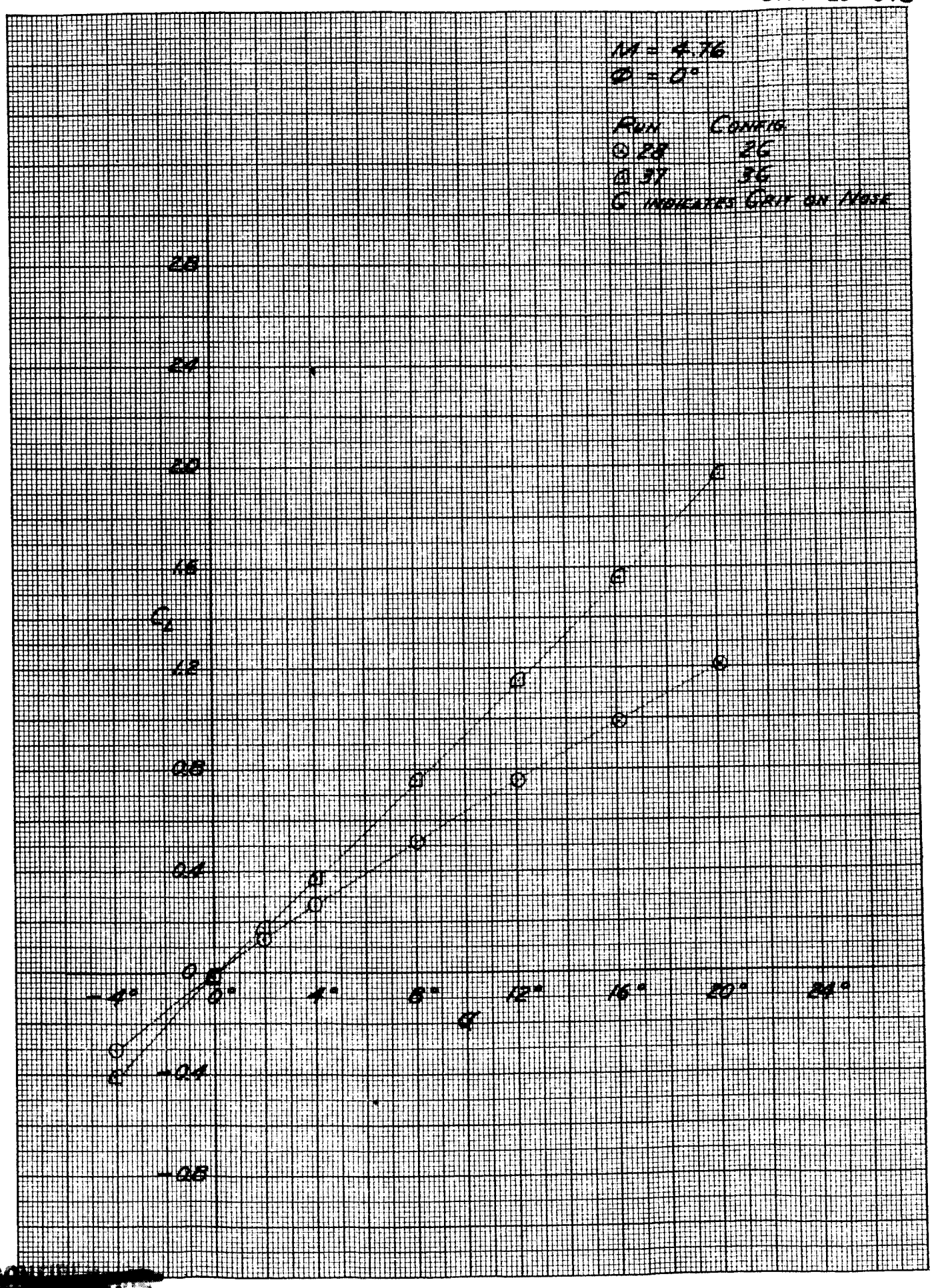
~~CONFIDENTIAL~~

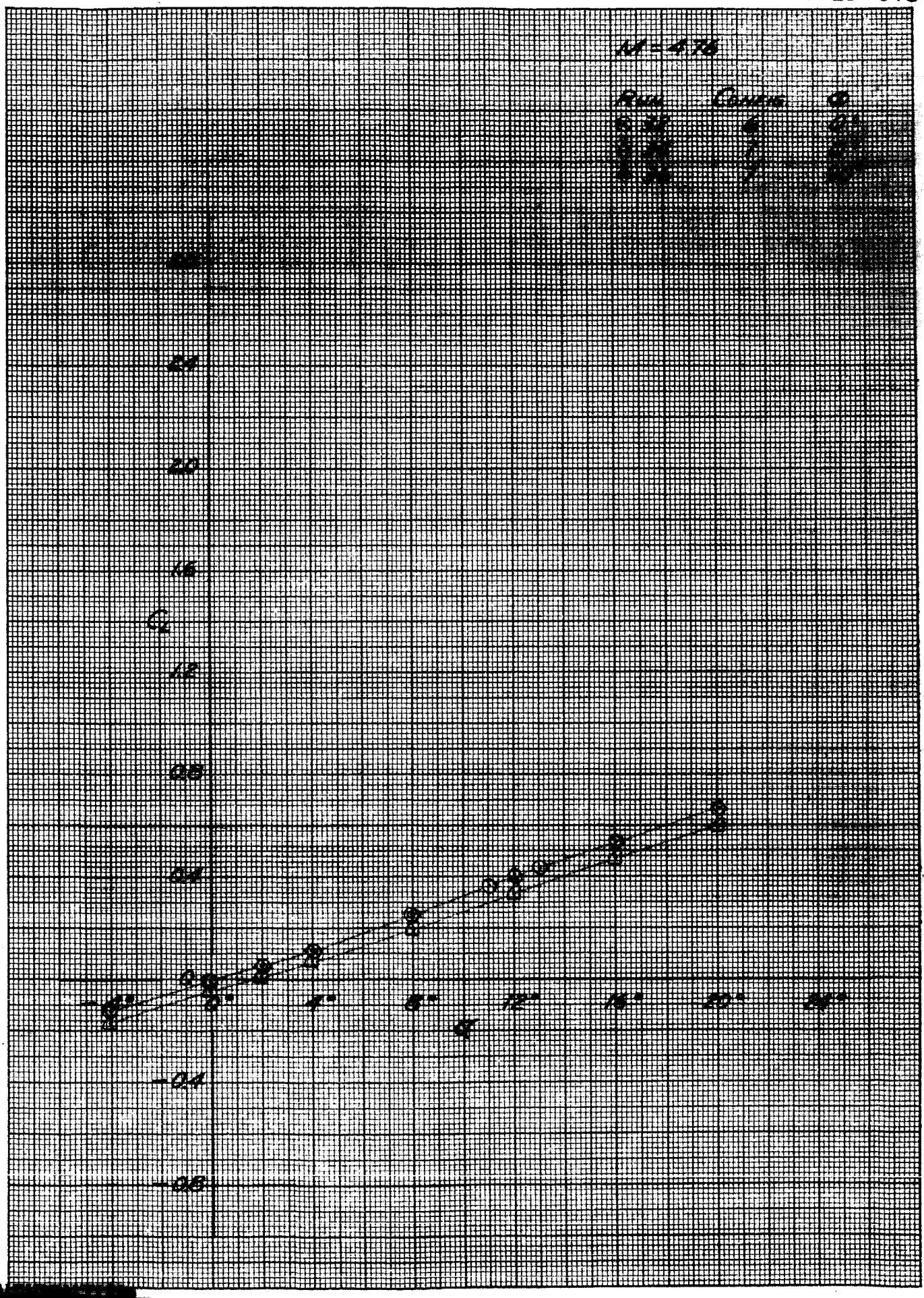
PLOT 236

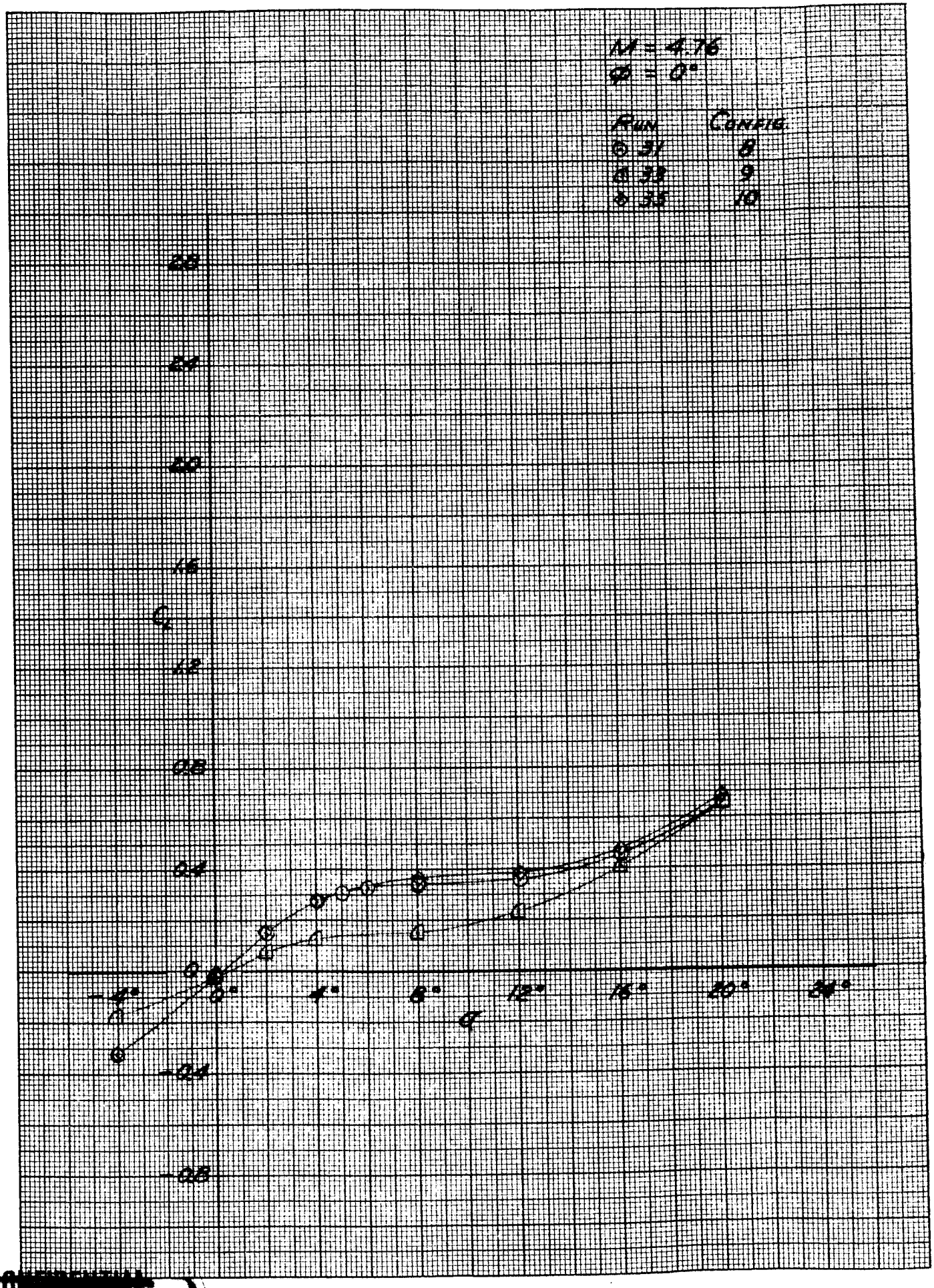

M = 4.76
RUN CONFIG. φ
φ = 0°
φ = 90°
0.08
$C_{m_{cg}}$
0.04
-4°
0°
4°
8°
12°
16°
20°
24°
α
-0.04
-0.08
-0.12
-0.16
-0.20


M = 4.76
φ = 0°
Run Config.
31 8
33 9
34 10
0.8
$C_{m_{cg}}$
0.4
0
-4°
4°
8°
12°
16°
20°
24°
α
-0.4
-0.8
-1.2
-1.6
-2.0


M = 4.76
Φ = 0°
Run Config
27 1
28 16
29 26
30 36
G indicates Grit on Nose
.28
.24
.20
.16
C_L
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

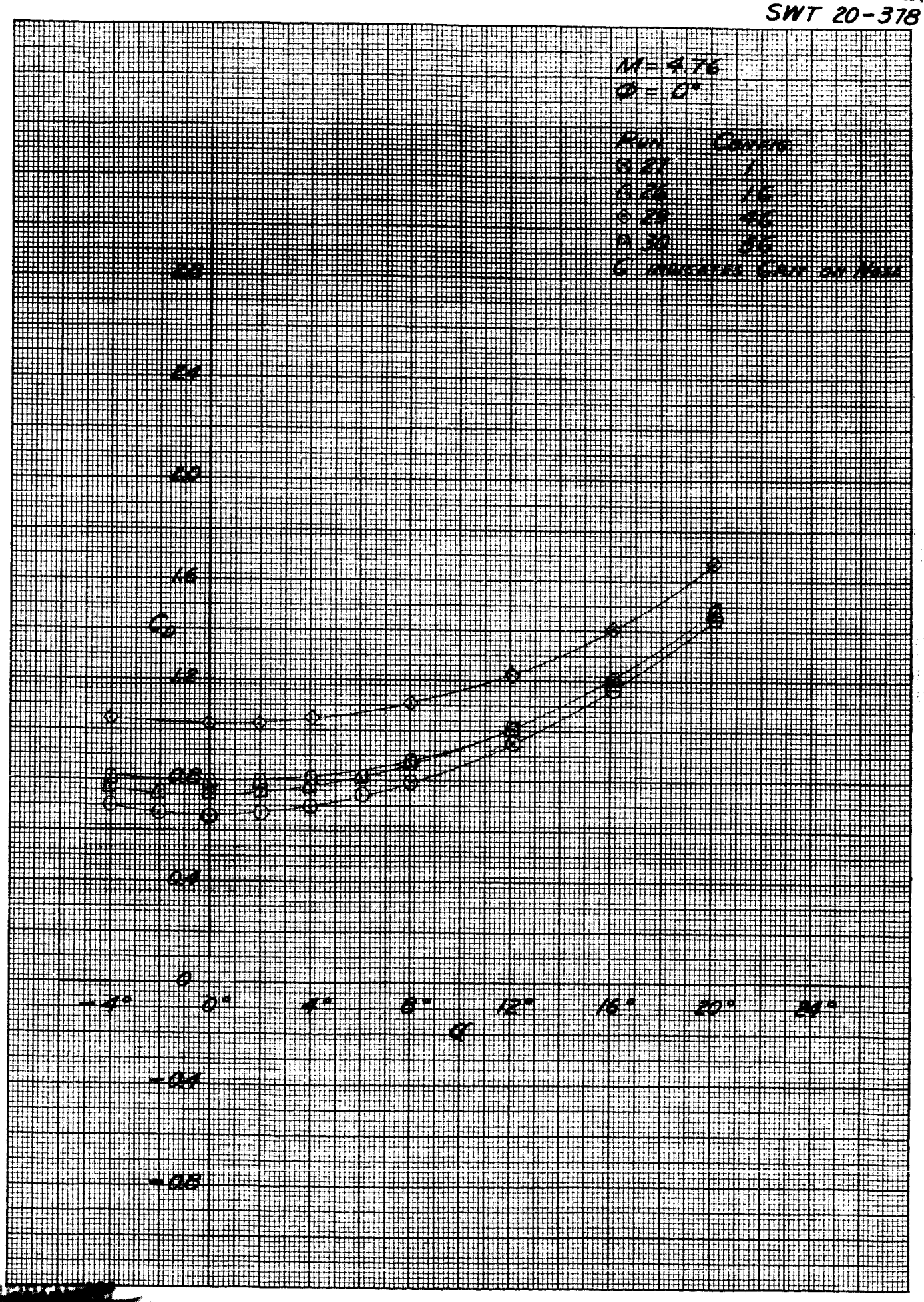

M = 4.76
Φ = 0°
RUN CONFIG.
28 26
37 36
G INDICATES GRIT ON NOSE
2.8
2.4
2.0
1.6
C_L
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
RUN
CONFIG.
C_L
.24
.20
.16
.12
.08
.04
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°

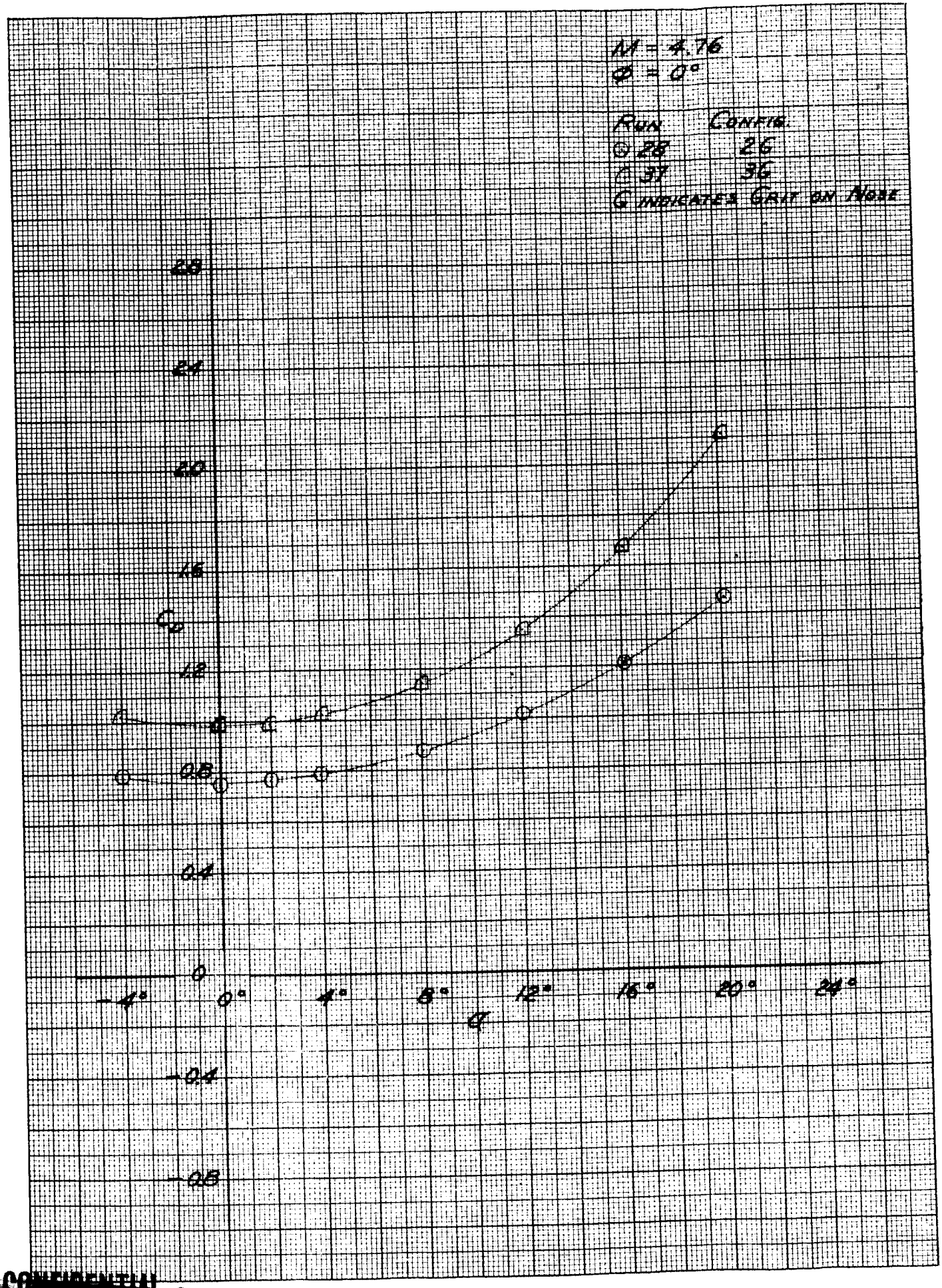

M = 4.76
Φ = 0°
Run
Config.
31
8
33
9
35
10
.28
.24
.20
.16
C_L
.12
.08
.04
0
-.04
-.08
-4°
0°
4°
8°
12°
16°
20°
24°
α

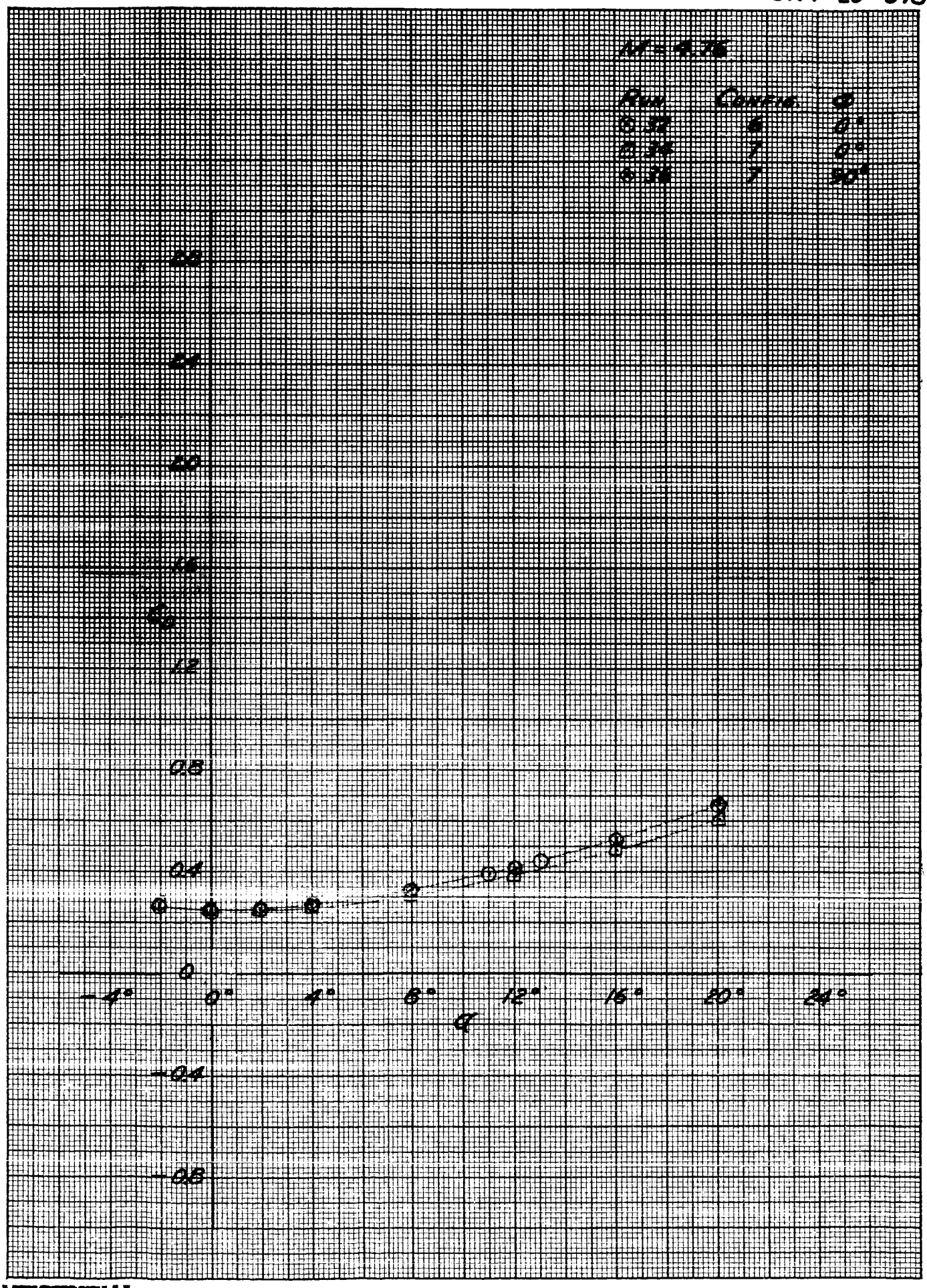
[redacted]

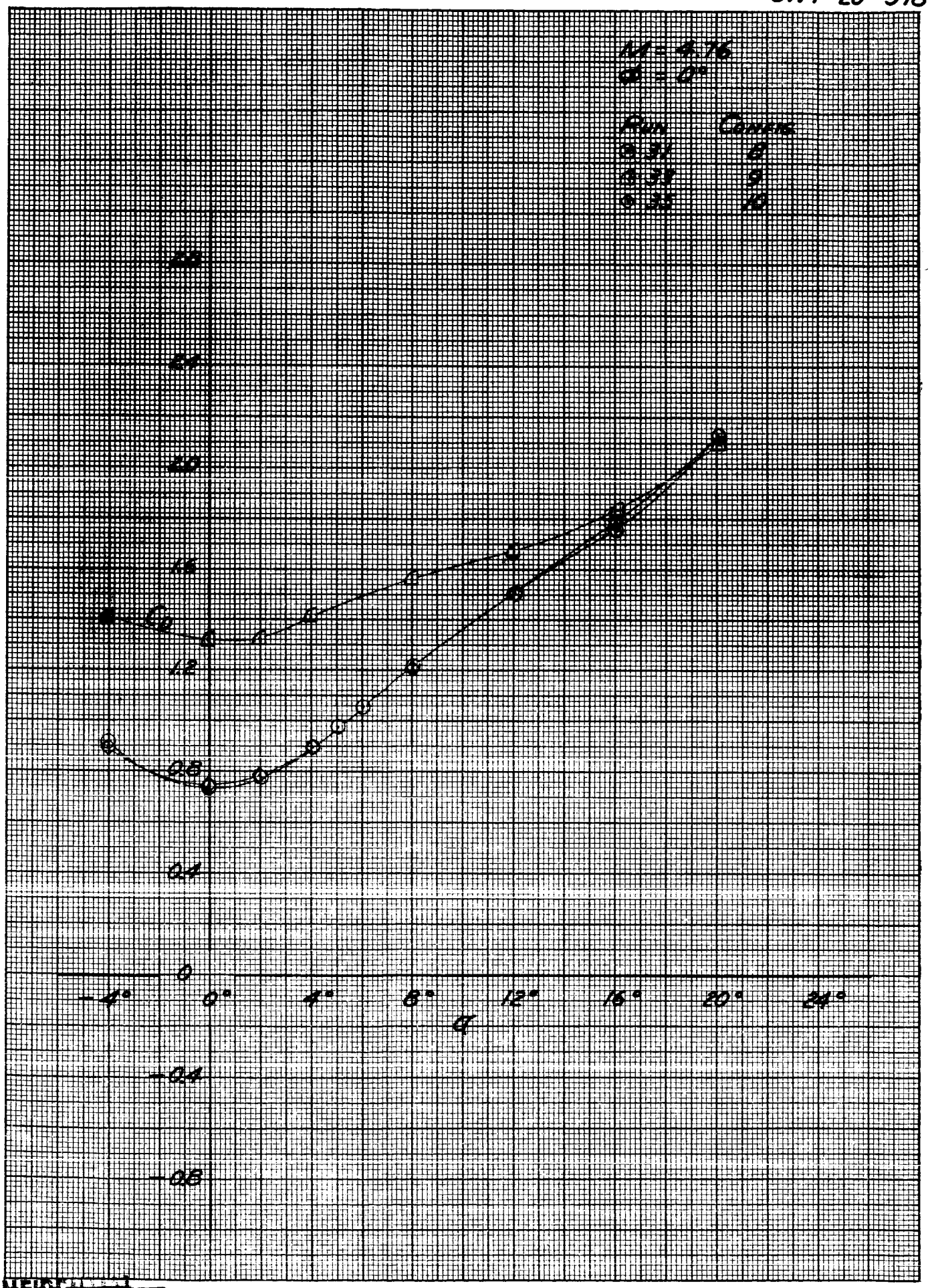
SWT 20-378



[redacted]

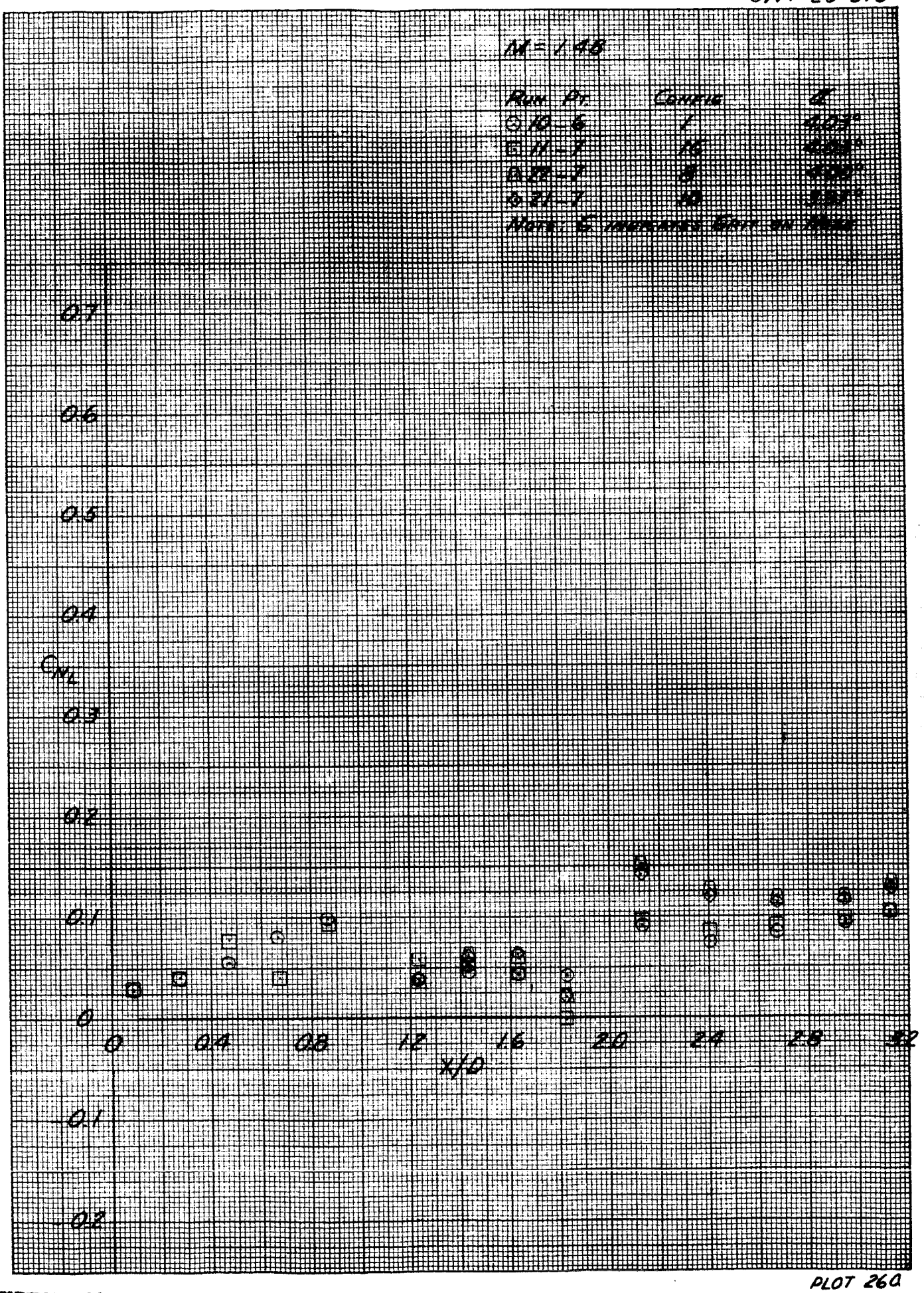

M = 4.76
Φ = 0°
Run Config.
⊙ 28 26
○ 37 36
G indicates Grit on Nose
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
Run Config. φ
32 6 0°
34 7 0°
36 7 90°
2.8
2.4
2.0
1.6
C_D
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α


M = 4.76
β = 0°
Run
Comp.
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-4°
0°
4°
8°
12°
16°
20°
24°
α

[redacted]

SWT 20-378



PLOT 26a

[redacted]

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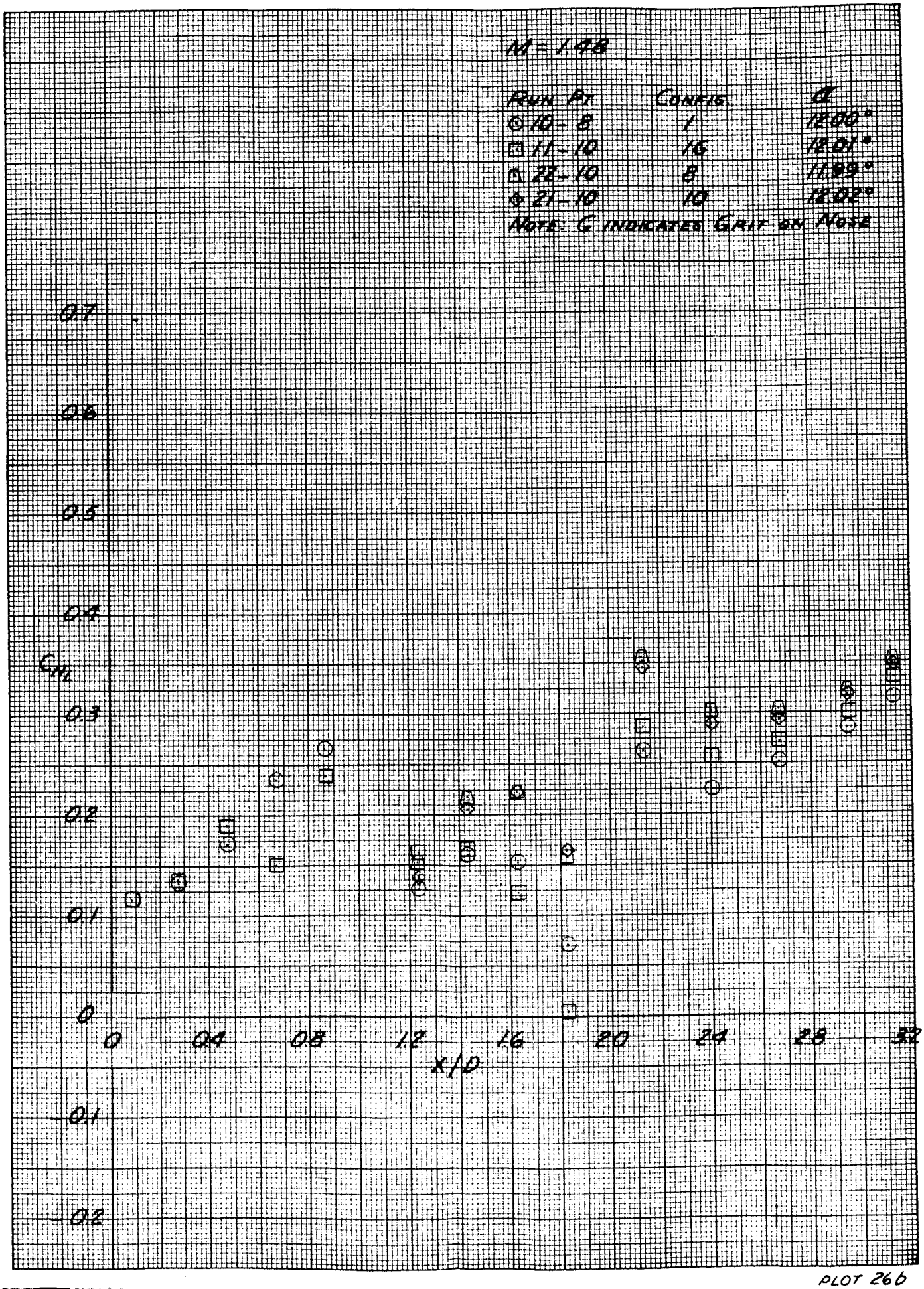
SWT 20-378

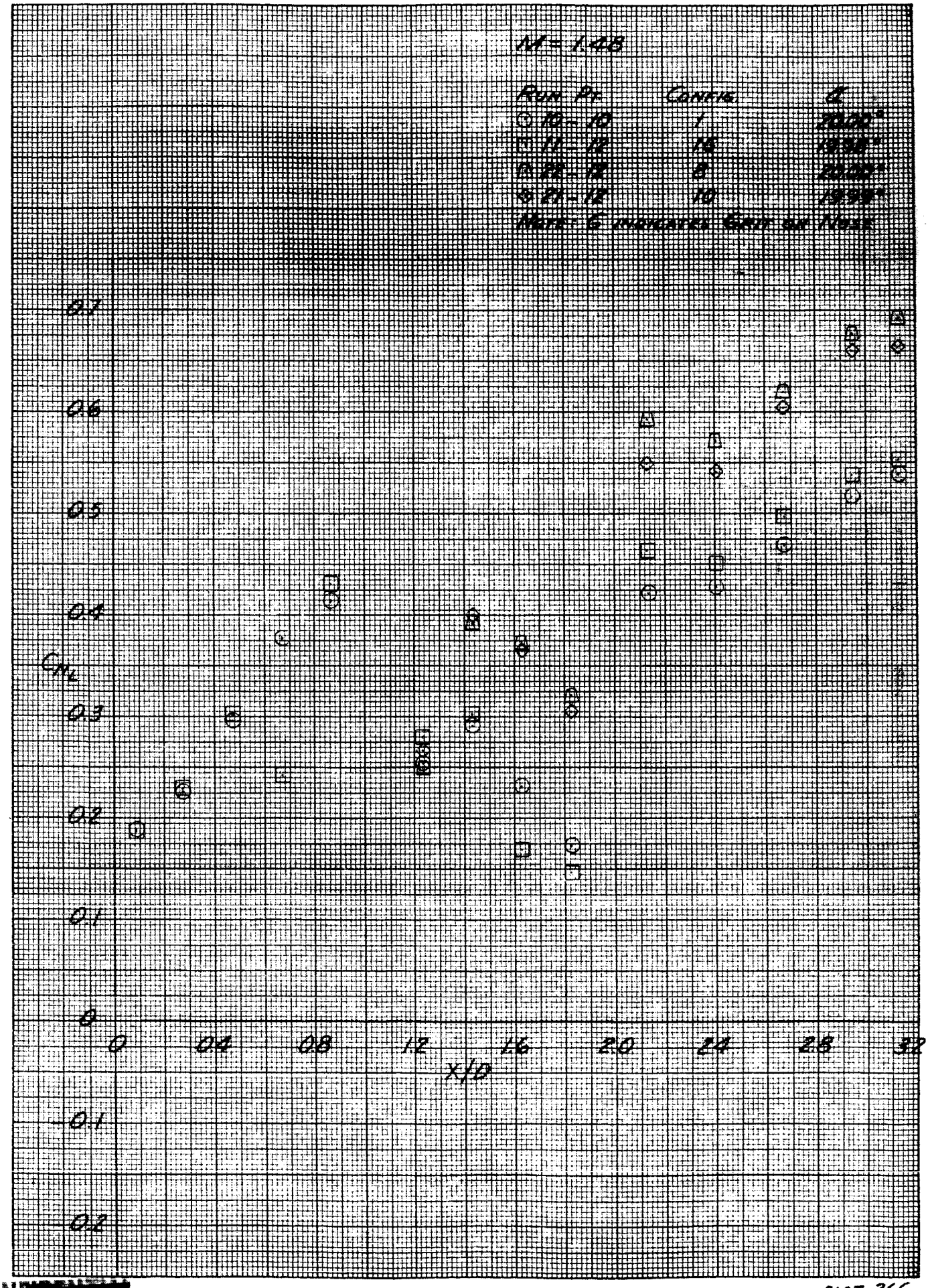


PLOT 26b

~~CONFIDENTIAL~~

[redacted]

SWT 20-378

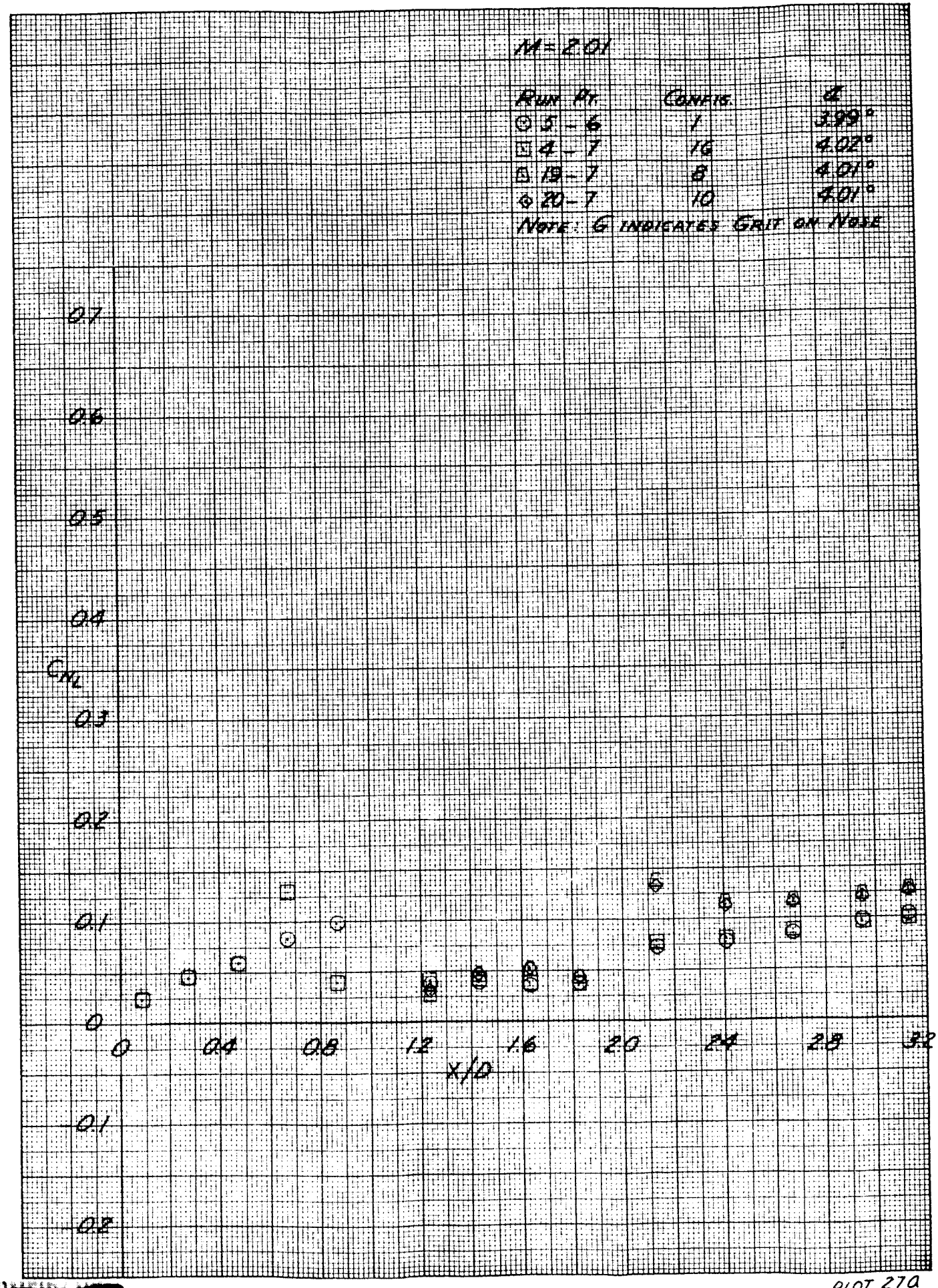


[redacted]

PLOT 26C

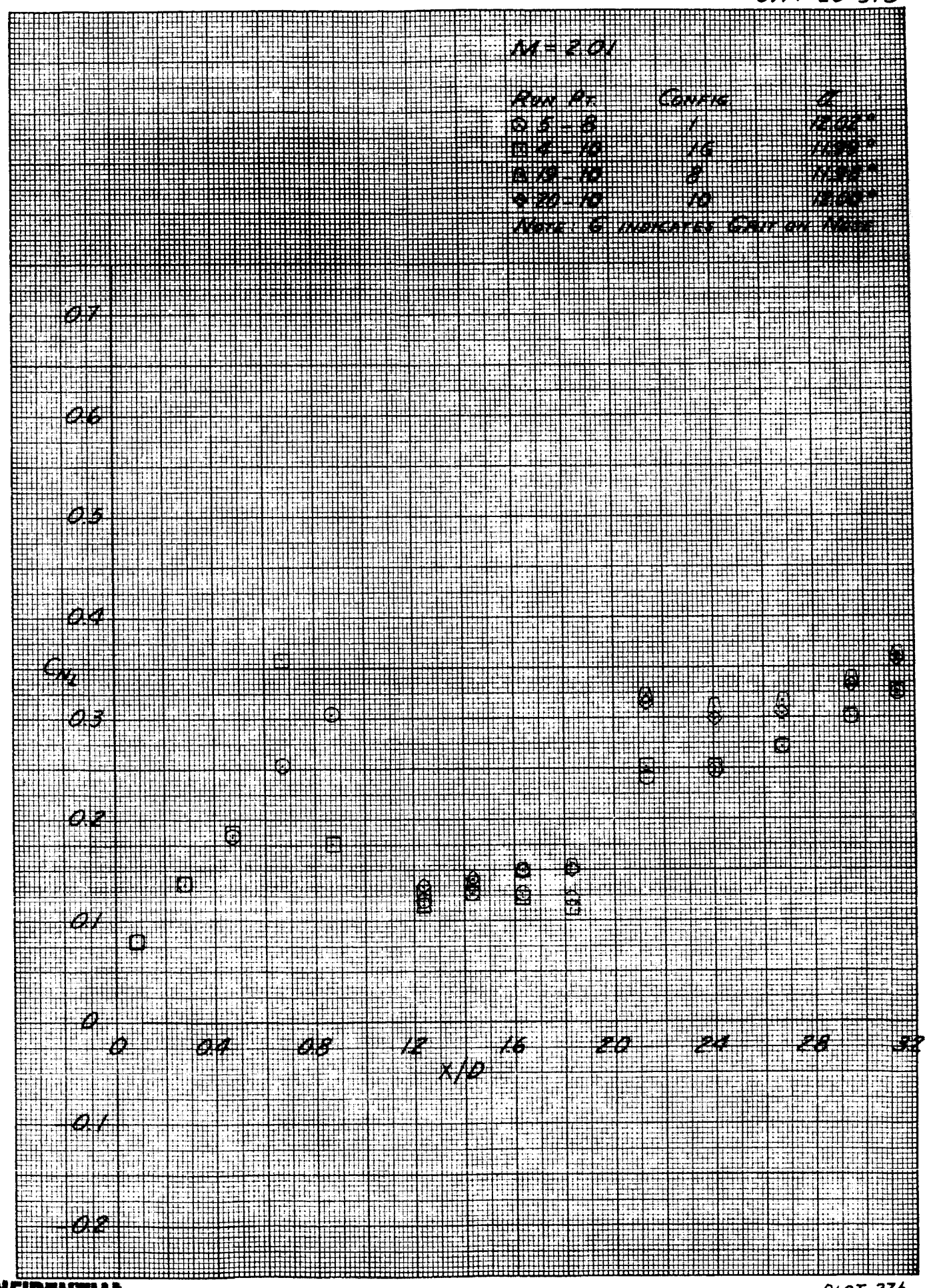
[redacted]

SWT 20-378



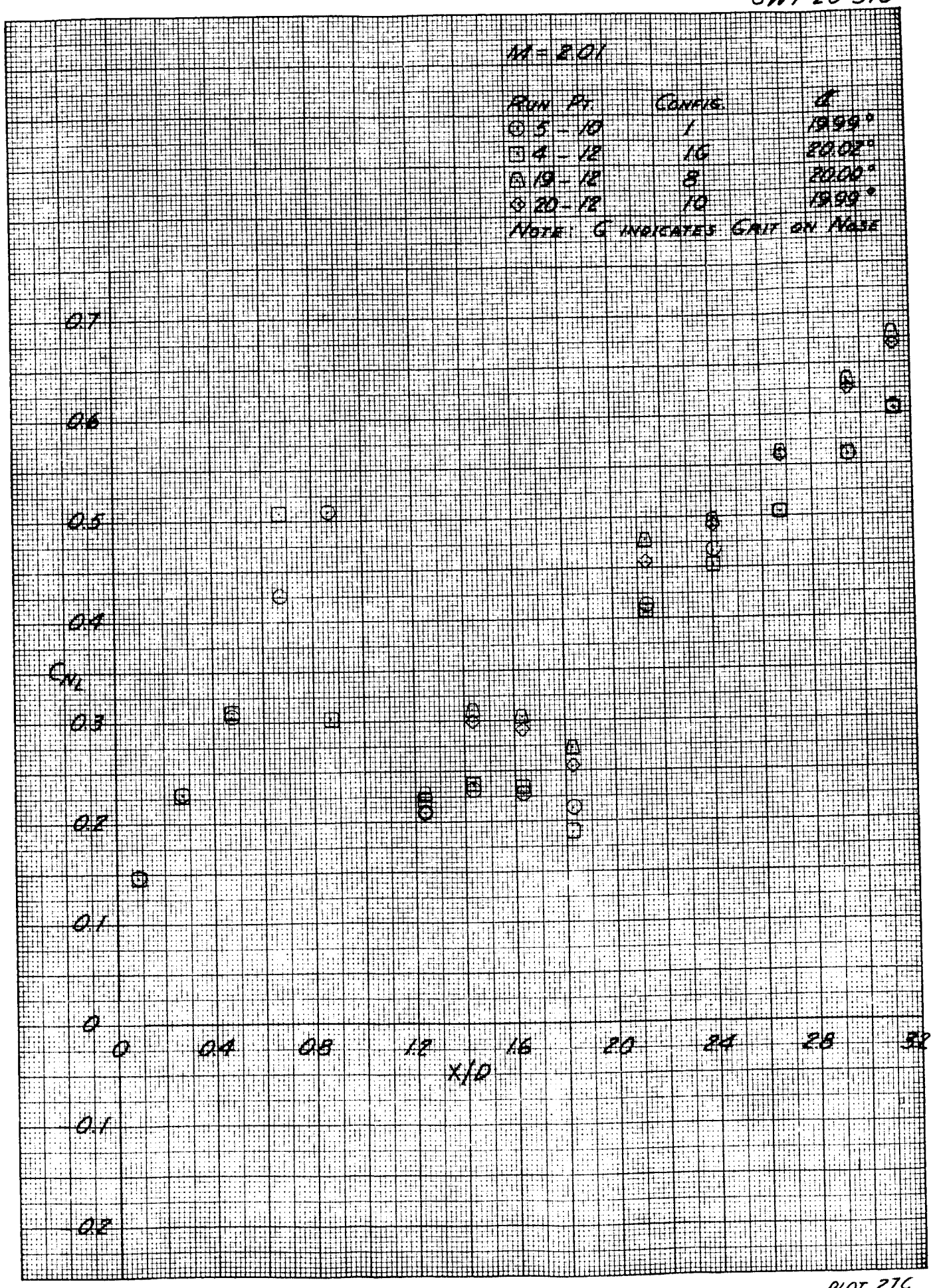
PLOT 27a

[redacted]


M = 2.01
Run Pt Config α
5 – 8 1 12.02°
4 – 10 16 11.99°
12 – 10 8 11.99°
20 – 10 10 12.00°
Note: G indicates Grit on Nose
0.7
0.6
0.5
0.4
C_{N_L}
0.3
0.2
0.1
0
0.1
0.2
0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
X/D

[redacted]

SWT 20-378

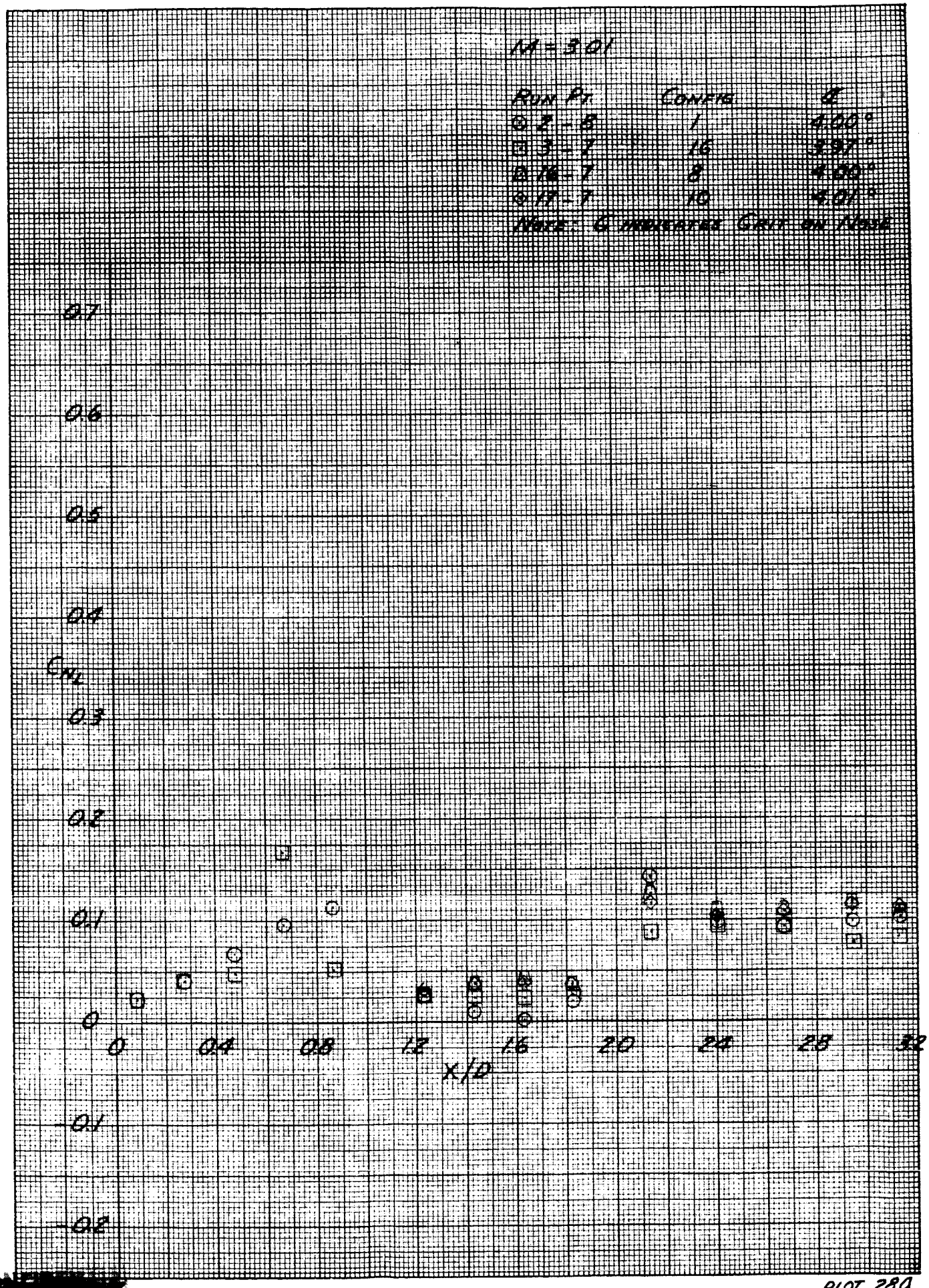


PLOT 27C

[redacted]

[redacted]

SWT 20-378

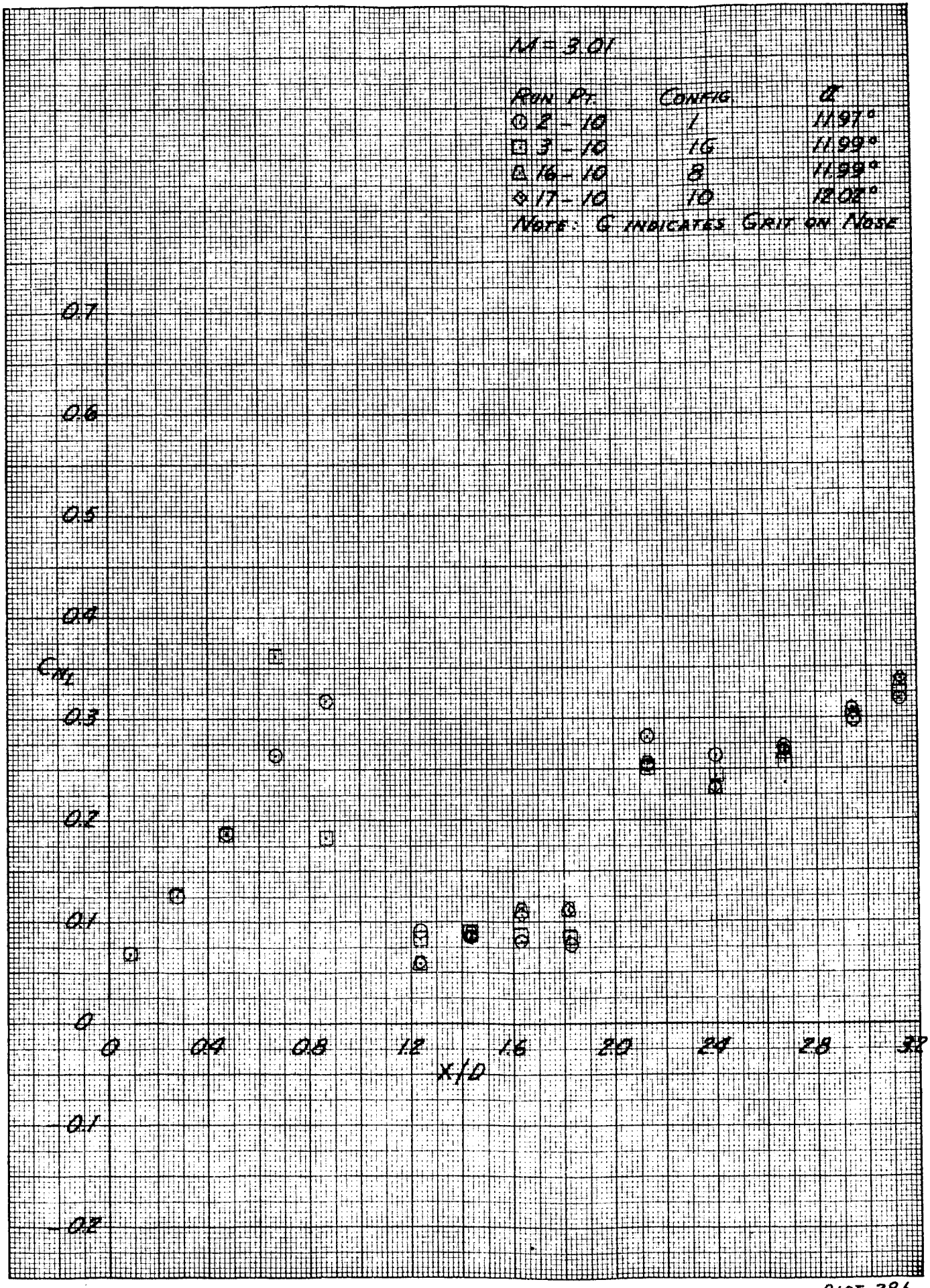


PLOT 28a

[redacted]

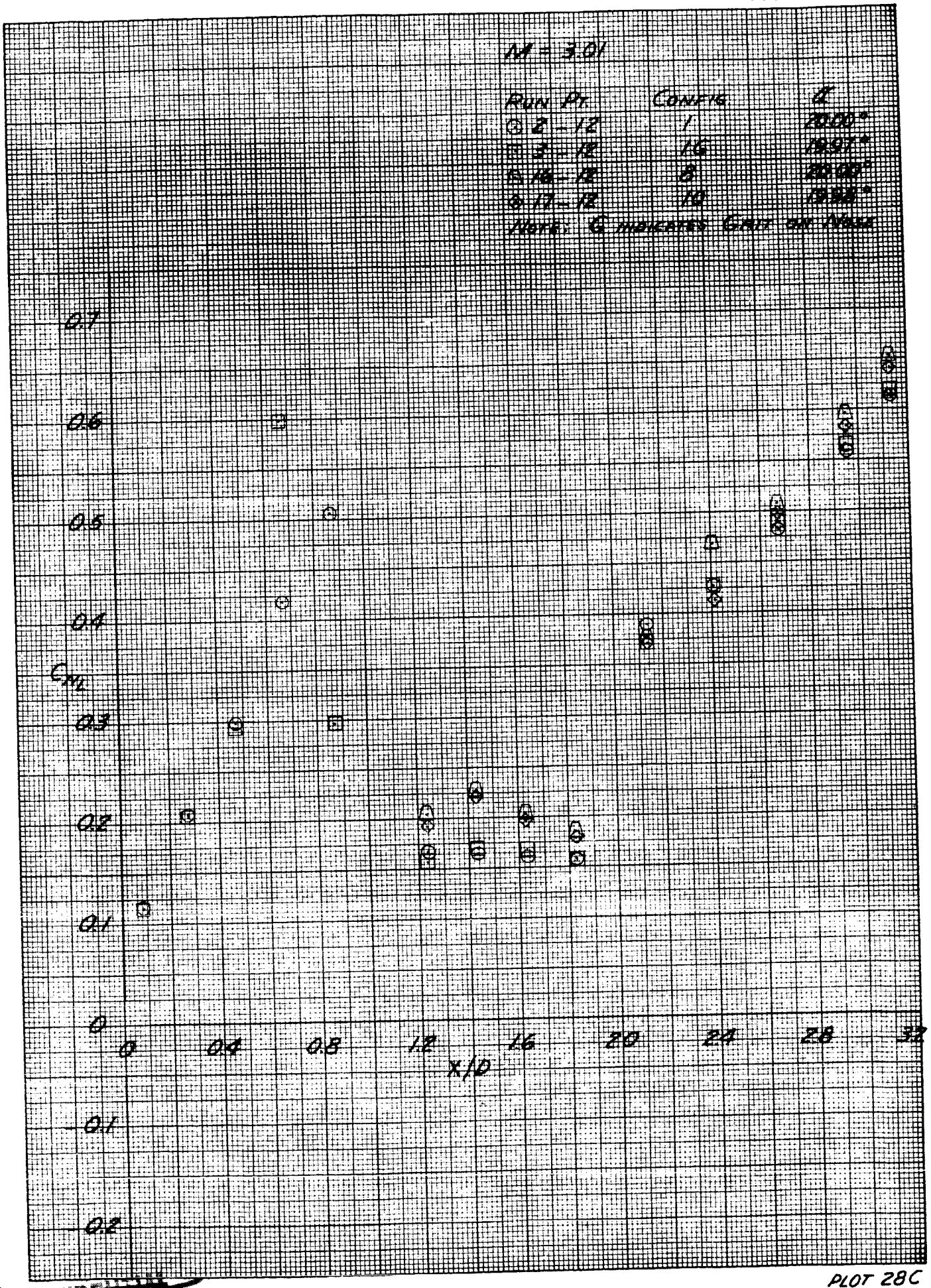
[redacted]

SWT 20-378



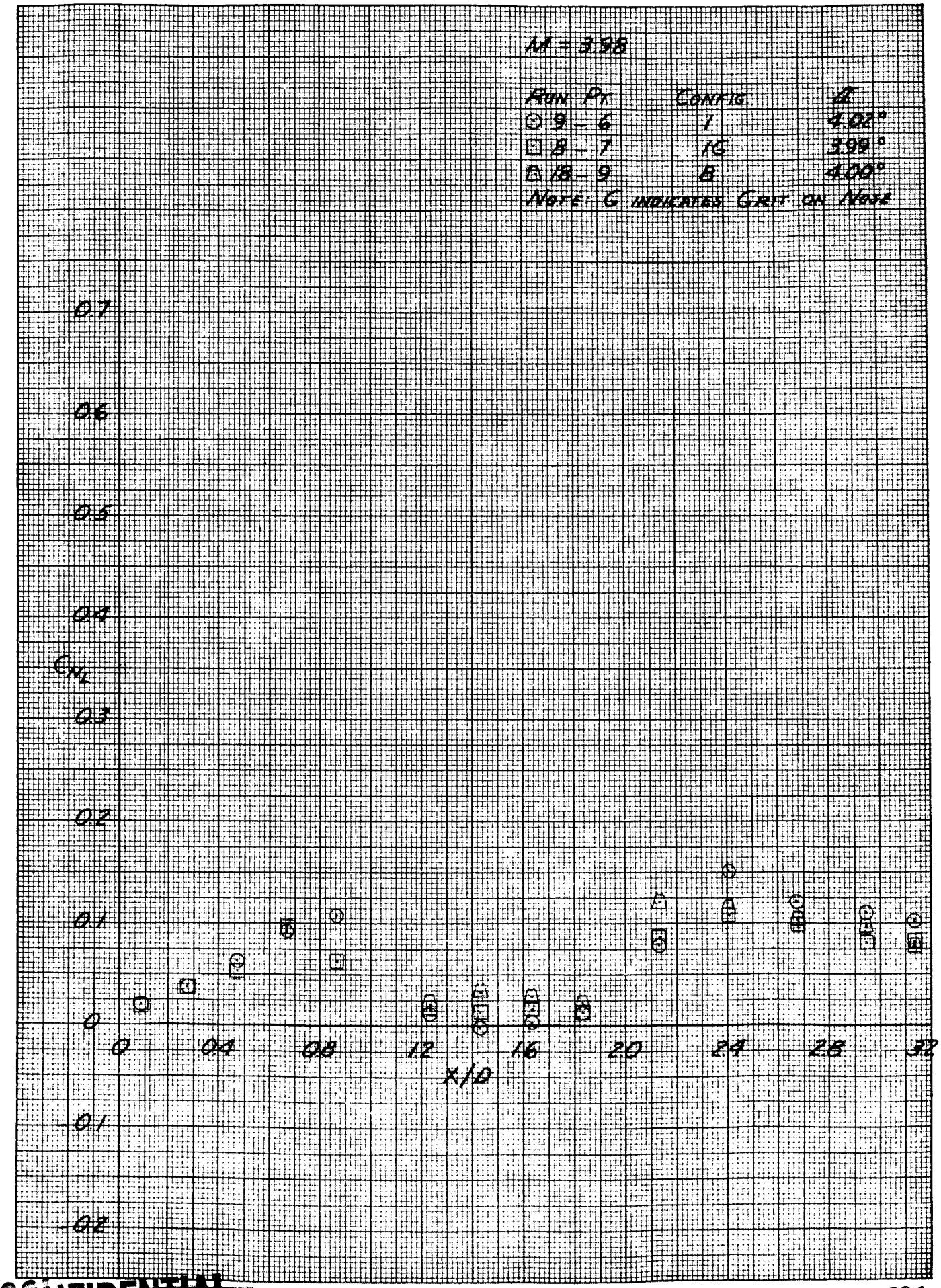
PLOT 28b

[redacted]



PLOT 28C

[redacted]


M = 3.98
Run Pt. Config. α
9 – 6 1 4.02°
8 – 7 1G 3.99°
18 – 9 8 4.00°
Note: G indicates Grit on Nose
0.7
0.6
0.5
0.4
C_{M_L}
0.3
0.2
0.1
0
0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
X/D
0.1
0.2

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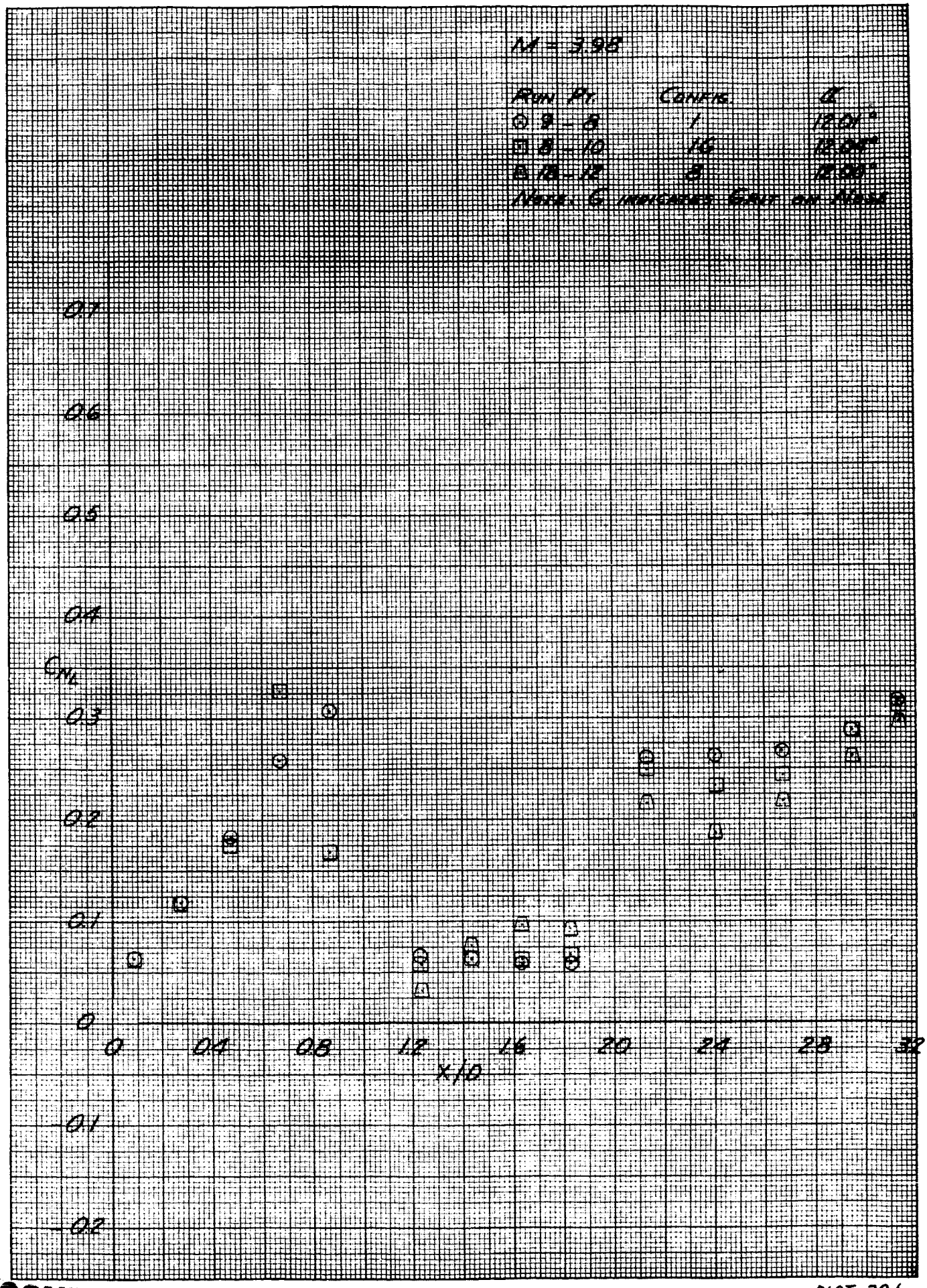
SWT 20-378



PLOT 29b

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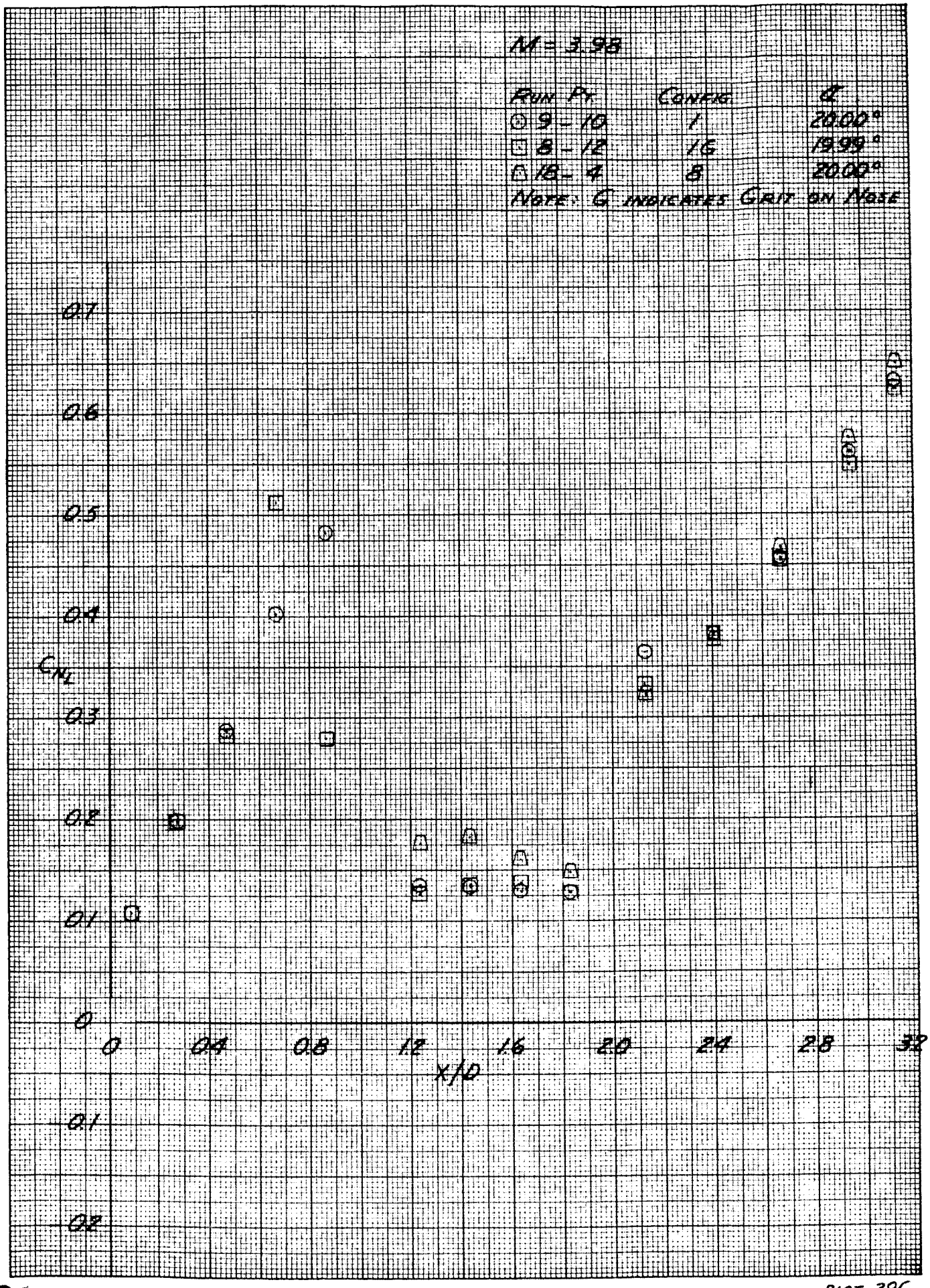
SWT 20-378

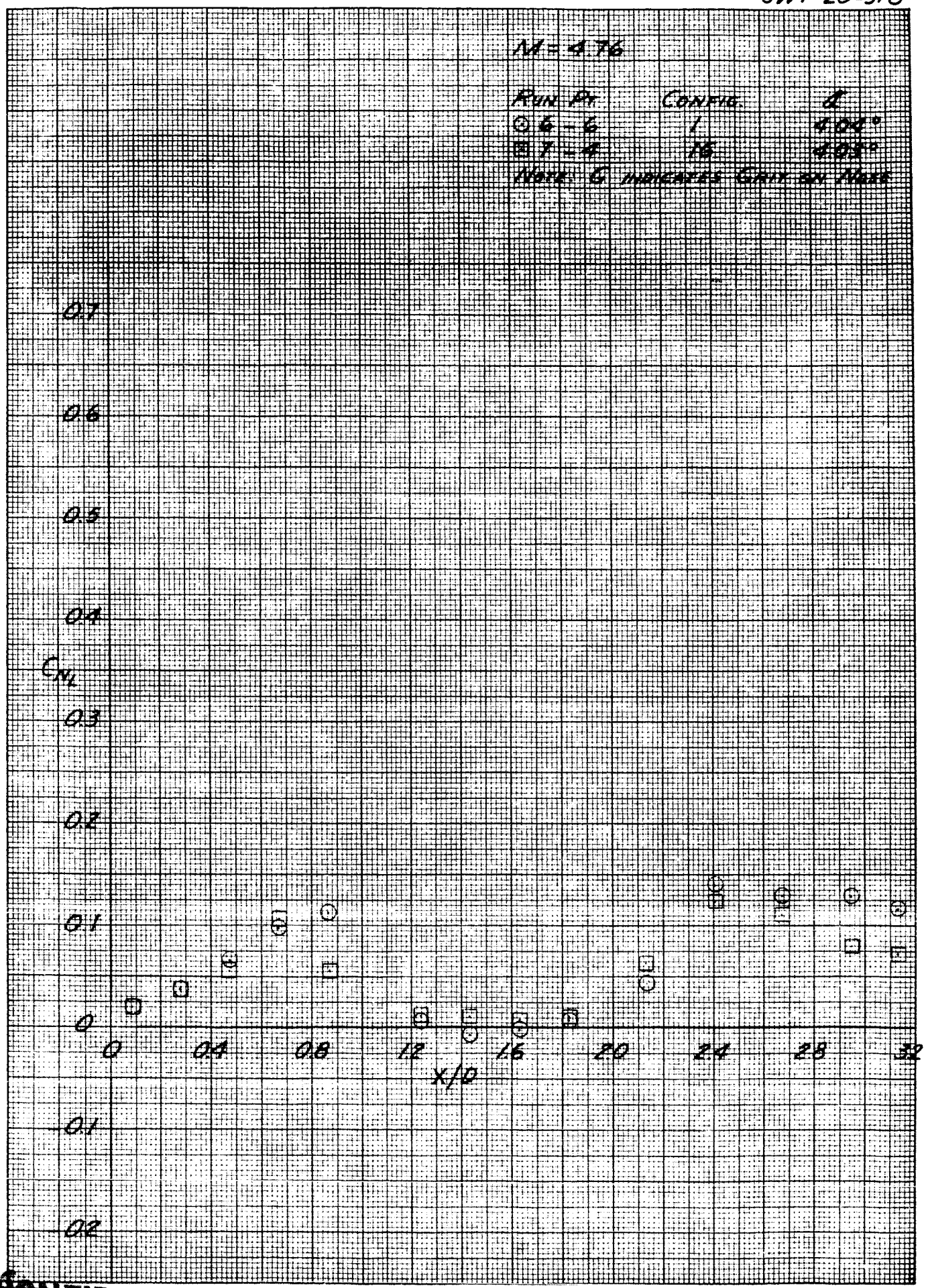


PLOT 29C

~~CONFIDENTIAL~~

CONFIDENTIAL

SWT 20-378



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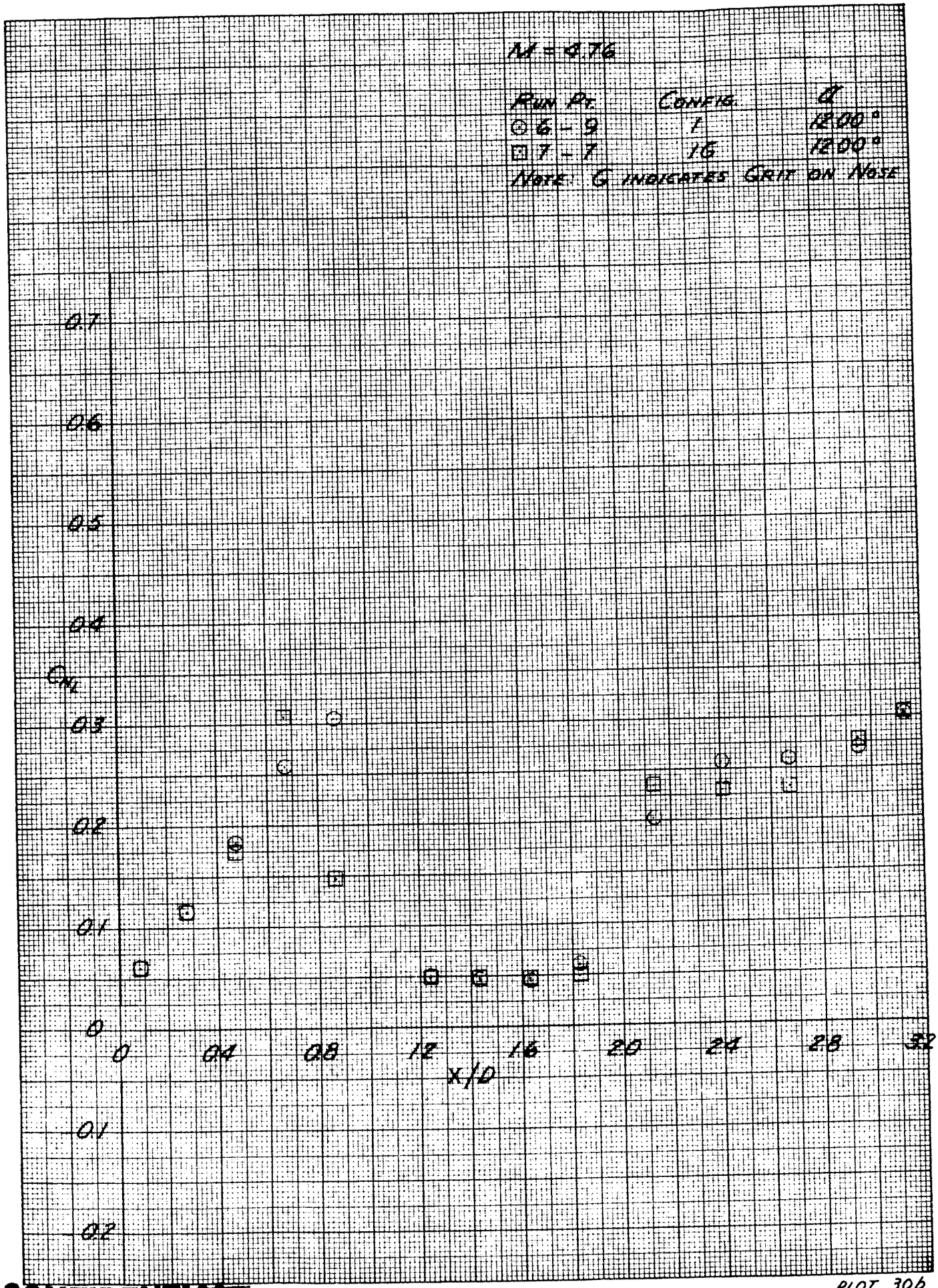
PLOT 30a

~~CONFIDENTIAL~~

SWT 20-378



PLOT 30b

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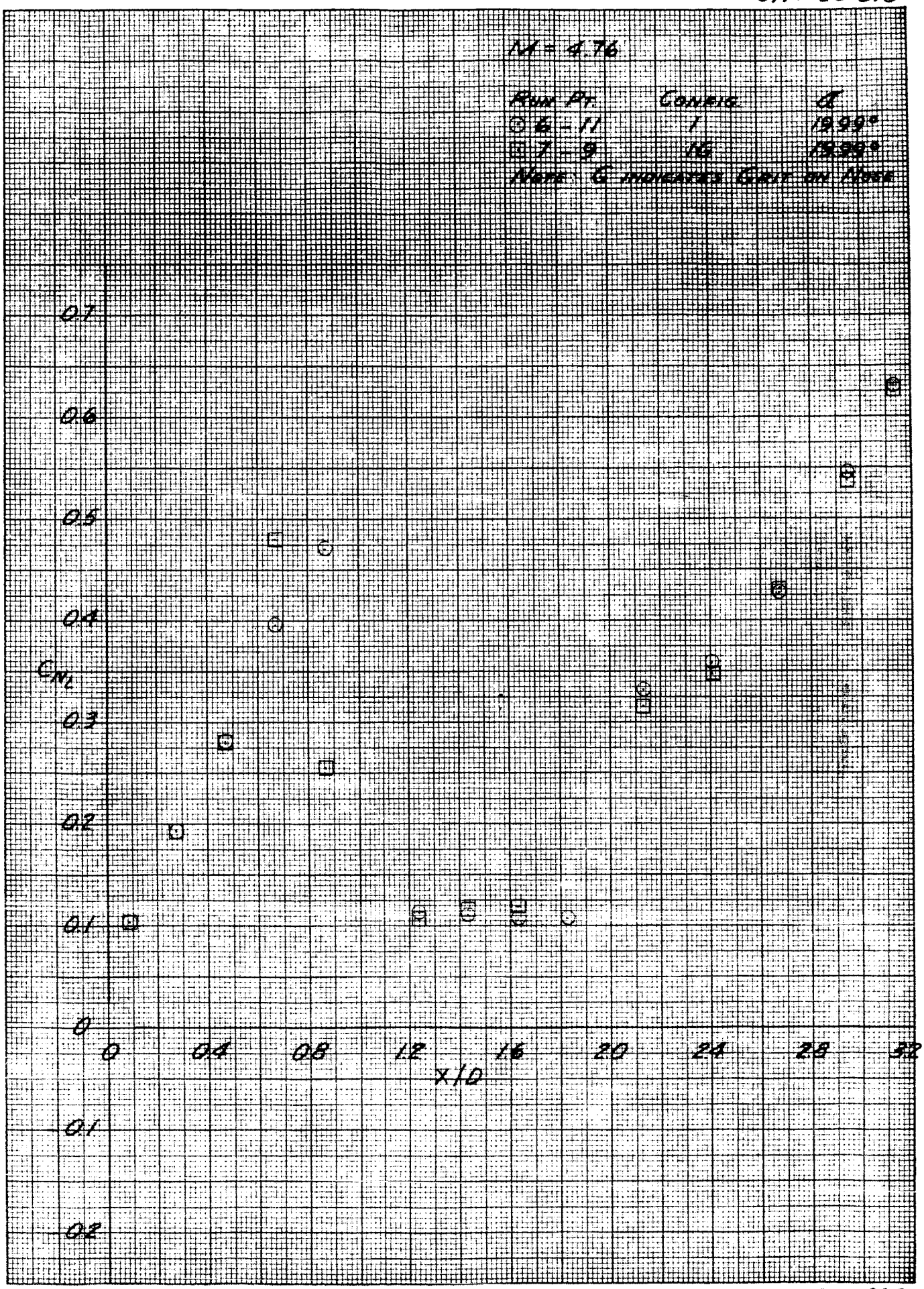
K&E 10 X 10 TO THE CM. 359-1-145
KEUFFEL & ESSER CO. ALBANENE
MADE IN U.S.A.

[redacted]

SWT 20-378



PLOT 30C

[redacted]