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REPORT NO. 55A3291

DATE 28 April 1964

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GENERAL DYNAMICS | ASTRONAUTICS

Evaluation Test Report No. 55A3291

Surveyor Nose Fairing Mode Survey

under NAS 3-3232

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APPROVED BY ______

poor quality original

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED

A 700-1 (REV. 1-62)

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INTRODUCTION: The Surveyor Nose Fairing is a fiberglass, cylindrical and conical, split clamshell structure designed to protect the payload from the undesirable effects of passing through the lower atmosphere during launch. Its use terminates 200 seconds after lift off, when it is jettisoned. In performing this designed function, the fairing must withstand the boost generated loads, and the vehicle structure must withstand these loads as modified by the fairing dynamic response.

The fairing response was calculated by theoretical analysis based on available parametric data, such as stiffness, weight, and geometry. This test was performed to verify calculated and assumed parameters and the results of the theoretical analysis.

OBJECTIVE: The main objective of this test was to determine the frequencies, shapes, and damping values of the principle shell modes of the nose fairing under expected flight delta pressure simulation, and to measure rotation of the nose cone tip during the pressure simulation.

CONCLUSIONS: The following shell mode frequencies, shapes, and damping values were determined during this test under a simulated flight delta pressure of 5.5 psid.

m = 1	n = 3	f = 67	ζ = 0.022
m = 1	n = 4	f = 75	ζ = 0.025
m = 1	n = 5	f = 90	ζ = 0.021
m = 1	n = 6	f = 108	ζ = 0.023

The measured rotation of the nose cone tip during the simulated pressure condition was 4 min 45 sec of arc in the Y-Z plane and 1 min 22 sec of arc in the X-Z plane.

This test was started on 17 March 1964 and completed on 31 March 1964.

RECOMMENDATION: The data presented in this report are measured responses. A more thorough examination of the data should be considered since no attempt has been made here to separate bending, torsional, and shell modes.

TEST SPECIMEN: The test was conducted on the 55-0513-2 nose fairing which was essentially identical to the AC-3 fairing except for the following items: (1) no LH_2 vent fin and supporting structure, and (2) no angle of attack mast.

The test article was modified to approximate the uniform tension connection between the AC-3 nose fairing and tank at sta 219. (Ref CIC 28888).

TEST PROCEDURE: The test was performed under the test tower located outside of Building 15, west end. The recording and control instrumentation were located in the portable instrumentation trailer near the tower, figures 46 and 47.

Six Piezoelectric accelerometers were attached to the test specimen at sta 183 with dental cement, figure 9. The outputs of the accelerometers were recorded on direct writing recorders and used to determine frequencies for barrel surface surveys and to record the damping decay curves during that portion of the test. A hand held velocity probe and a vibration meter, figure 51, were used to measure the test specimen response to excitation during the surface survey portion of the test. The output of the vibration meter was connected to the vertical axis input on an oscilloscope so that the phase of the hand probe signal could be compared with the input force signal. An impedance head was used with each vibration exciter and the input force was controlled by a servo system. The force signal at exciter number two at 180°, sta 183, was used as the reference signal and was connected to the horizontal input on the oscilloscope. Accelerometer and hand probe measurements were in a radial direction.

The rotation measurement was made with a microptic clinometer, figures 48 and 49, operated by personnel from Optical Tooling, Dept 451-0. The clinometer was mounted on a flat plate attached to the fairing at three points, which closely simulates the angle of attack mast mounting for AC-4 and on vehicles.

Excitation of the fairing was supplied by two electrodynamic exciters, each having a force rating of 50 pounds vector. The two exciters were located at sta 183, 0° and 180°, as shown in figures 9 and 52. Excitation was applied to the fairing through a stinger which went through a hole in the fairing and was secured with jam nuts on both sides. The stingers were attached to the exciter heads through the impedance head, as shown in figure 50. The fairing was bolted to the test fixture at the missile station 219 ring. A 0.006 inch thick polyethelene bag covered the entire test specimen and was sealed with tape at the base of the fixture. The interior of the fairing was evacuated to 5.5 psid with a vacuum pump, shown in figure 51.

TEST PROCEDURE: (Continued)

Rotation of the nosecone tip was measured during evacuation of the interior of the fairing at 0.5 psid intervals. Measurements were made in the Y-Z and X-Z planes over a period of 2.5 hours.

Initially, two frequency sweeps were made from 5 to 500 cps , one with the exciters in phase, and one with the exciters out of phase. The frequencies at which maximum response from the accelerometers was obtained were selected for barrel section surveys at station 183 with the hand probe. The barrel section response was measured every ten degrees circumferentially. Damping decays were made using one exciter located at sta 183, 180°, to excite the fairing, and recording the accelerometer decay response when the armature circuit of the shaker was opened. Damping values were recorded at 5.5 psid for the principal n modes and at several lower differential pressures for the n = 3 and n = 6 modes.

Complete surface surveys of both the barrel section and the cone section were made at the principal n modes. The barrel section response was measured every 15 degrees circumferentially and at 6 stations. The cone section response was measured every 15 degrees at 11 stations. Only the phase relationship with respect to the input force was recorded at these points. Magnitude as well as phase was recorded at a few selected points.

A search for the higher m modes was conducted by measuring the barrel section response vertically every three inches at 180° and 0°. There was also an attempt made to measure the vertical motion of the sta 219 ring.

TEST RESULTS: The data obtained during the rotation measurement are tabulated in figure 1. The maximum rotation was 4 minutes 45 seconds of arc in the Y-Z plane. At 0.0 psid, there was a gap of approximately 0.03 inch between the two cone halves. Once this gap was closed due to delta pressure, the measured rotation was very small.

There were four shell modes determined for m = 1. They were:

n = 3 at f = 67 cps

n = 4 at f = 75 cps

n = 5 at f = 90 cps

n = 6 at f = 108 cps

TEST RESULTS: (Continued)

The data obtained during the barrel section surveys at sta 183 are plotted in figures 10 thru 26. All surveys were made at 5.5 psid except those plotted in figures 12 and 23 which were made at 2.75 psid, and figures 13 and 24 which were made at 0.0 psid. The results indicate a shift in antinode position with a change in pressure.

The damping decay data are plotted in figures 27 thru 41. Damping factors were determined by plotting the log of the zero to peak amplitude of the decay trace against the number of half cycles and measuring the slope. In cases where a change in decay rate was obvious, two slopes were measured. The results are tabulated in figure 2. The effect of change in pressure on the damping factor is plotted in figure 42 for n = 3 and n = 6. The results indicate a minimum damping factor at 2.5 psid.

Figures 4 thru 8 show surveys of the entire fairing surface. Plus and minus signs were used to indicate in and out of phase relationship with respect to the referenced input force. N was used to indicate a null reading where it was not possible to determine phase relationship. Two exciters were used in all cases and they were located as shown in figure 9. The dotted lines were used to indicate the node lines in the fairing. The locations of the umbilical island cutout and the equipment access doors are shown in figure 3.

Figures 43 thru 45 show the results of the search for higher m modes. There was not time enough to make complete surface surveys at these frequencies. No quantitative data was obtained to describe the vertical motion of the station 219 ring. The hand probe readings were very low. However, there was enough output to indicate that there is a change in phase relationship as the probe is moved around the ring.

TEST EQUIPMENT

Description	MFR	Model	SN	AFN	ESLN
Vacuum Pump	Hereaus	E-70	07001512	--	1036437
Pressure Gage	Wallace-Tiernan	FA-145	FF07562	--	7441044
Exciter System	MB	C-1	379	577712	7701012
Exciter System	MB	C-11	490	945401	7701007
Impedance Head #1	Endevco	2110	FA19	--	--
Impedance Head #2	Endevco	2110	HA25	--	--
Secondary Standard	H - P	400D	13815	--	876306
Velocity Meter	MB	M6	241	907161	7841007
Velocity Pickup	MB	115	10347	--	--
Oscilloscope	Tektronix	RM32	208	911318	7248024
Oscilloscope	Tektronix	531	8493	476266	7515172
Oscilloscope Preamp	Tektronix	CA	1841	911318	7248024
Oscilloscope Preamp	Tektronix	53/54D	2846	905360	7515073
TRMS Meter	Ballantine	320	915	911318	7248024
TRMS Meter	Ballantine	320	--	911317	7248023
Sweep Oscillator	Dynac	DY2200	498	911317	7248023
Dynamonitor	Endevco	2702	AB14	--	1035947
Dynamonitor	Endevco	2702	AB11	--	--
Dynamonitor	Endevco	2702	AB05	--	1037045
Dynamonitor	Endevco	2702	AB04	--	1035945
Frequency Counter	Erie	130	--	911317	7248023
TRMS Meter	MB	N120	1327	905809	7248042
Tape Recorder	Ampex	FR100	459	701442	1035685
Direct Write Recorder	CEC	5-119	1972	902156	7654210
COLA	GD/A	KA564-4	6	--	629297
Servo Oscillator	MB	N572	208	915026	--
Power Supply	CEC	2-105A	575CU6	--	1577010

TEST EQUIPMENT (cont'd)

Description	MFR	Model	SN	AFN	ESLN
Microptic Clinometer	Hilger Watts	TB95	--	906129	--
Visicorder	Honeywell	906A	7022	--	7654691
Linear Integrate Preamps	CEC	1-112-C	11160	--	--
" " "	"	"	10076	--	--
" " "	"	"	497BZ2	--	--
" " "	"	"	652CB3	--	--
" " "	"	"	753CB3	--	--
" " "	"	"	7166	--	--
" " "	"	"	11081	--	--
" " "	"	"	514BZ2	--	--
" " "	"	"	386BZ2	--	--
" " "	"	"	10084	--	--

BIBLIOGRAPHY: The data from which this report was written are recorded in EWB No. 7700, issued to R. L. Radcliffe, Dept. 564-4.

TABULATED DATA FOR NOSE ROTATION MEASUREMENT
SURVEYOR NOSE FAIRING MODE SURVEY

Differential Pressure (PSID)	Angular Position y-z Plane Degrees	Minutes	Seconds	Angular Position x-z Plane Degrees	Minutes	Seconds
0.0	359	53	51	359	56	12
0.5	359	54	32			
1.0	359	55	24	359	56	53
1.5	359	56	12			
2.0	359	56	58	359	57	17
2.5	359	57	30			
3.0	359	57	55	359	57	30
3.5	359	58	13			
4.0	359	58	24	359	57	34
4.5	359	58	27			
5.0	359	58	28			
5.5	359	58	30			
5.0	359	58	36			
4.5	359	58	36			
4.0	359	58	32			
3.5	359	58	25			
3.0	359	58	20			
2.5						
2.0	359	57	48			
1.5						
1.0	359	56	34			
0.5						
0.0	359	54	43			

Figure 1

P psid	n = 3				n = 4				n = 5				n = 6			
	Loc.	f_{cps}	$\mathcal{S}$ 1	$\mathcal{S}$ 2	Loc.	f_{cps}	$\mathcal{S}$ 1	$\mathcal{S}$ 2	Loc.	f_{cps}	$\mathcal{S}$ 1	$\mathcal{S}$ 2	Loc.	f_{cps}	$\mathcal{S}$ 1	$\mathcal{S}$ 2
0.0	6	68	.0183	.0386									5	102.5	.0214	
	6	68	.0183	.033									6	102	.0157	
	5	69	.022	—									3	102	.0244	
	5	68	.0183	.0368												
	6	67	.024	—												
1.5	6	67	.0122	—									5	106	.0174	
	5	68	.0169										6	106	.0169	
													3	105	.0196	
2.75	6	68	.0135	—									5	106	.0187	
	5	68	.0169	—									6	106	.0142	.0196
	6	67	.0147	.0119									3	107	.0191	
3.25	6	69	.0106													
	5	69														
4.0	6	67	.0138										5	107	.0232	
	5	68											6	108	.0124	
													3	108	.0229	
5.5	6	67	.022	—	2	75	.0383	.019	2	88	.020	—	5	110	.0236	
	6	69	.0316	—	2	75.5	.0252	—	6	91	.022	—	6	110	.0318	
	5	67	.0244	—	2	74	.021	—	6	90	.021	—	3	109	.022	
	5	69	.0258	—									6	109	.0176	
	6	67	.022	—												
	6	67	.020	—												

Damping Factors Surveyor Nose Fairing Mode Survey

FIG 2
RLZ 4/22/64

TEST SPECIMEN STRUCTURAL DISCONTINUITIES

SURVEYOR NOSE FAIRING MODE SURVEY

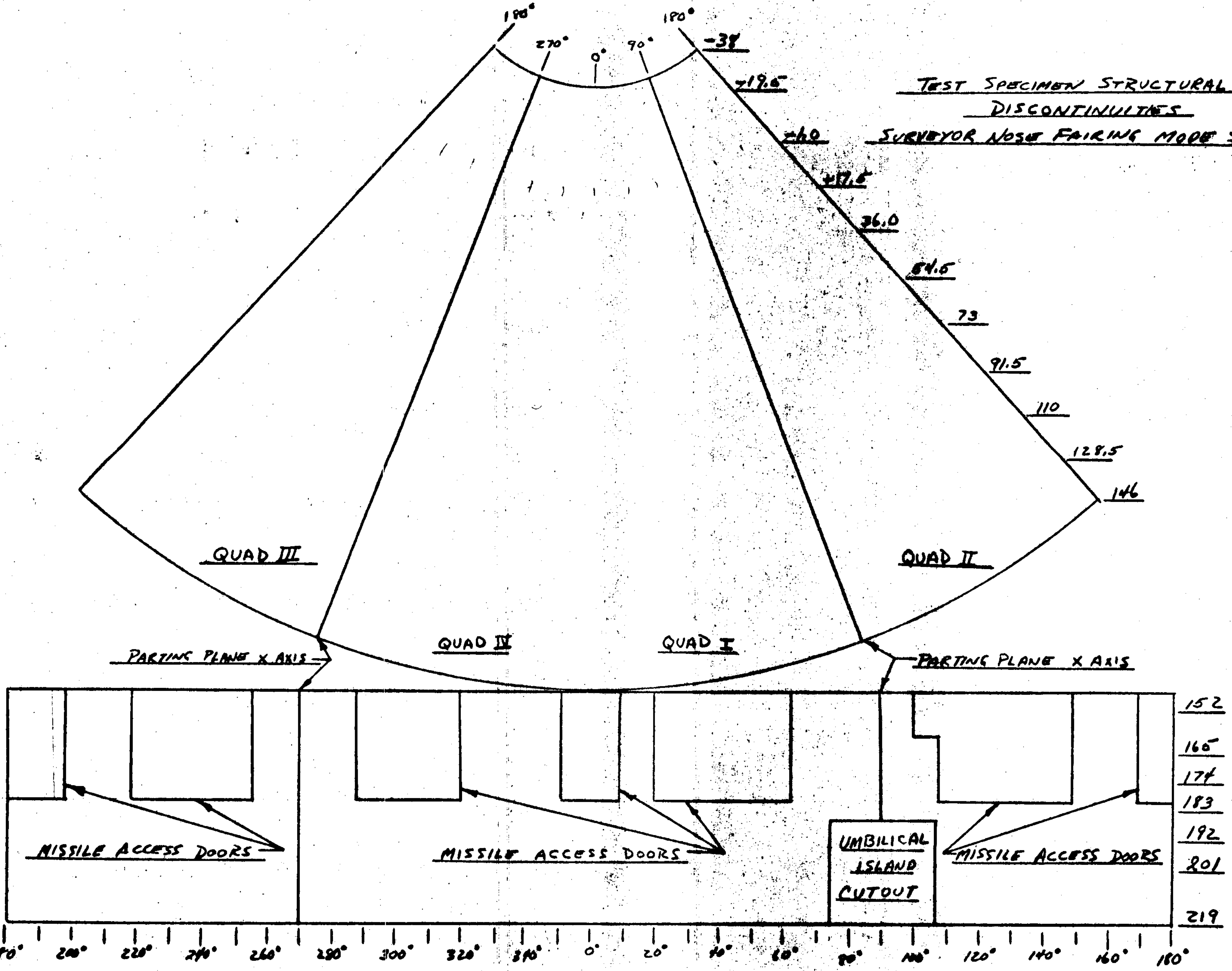


FIG 3

RE 1/14/64

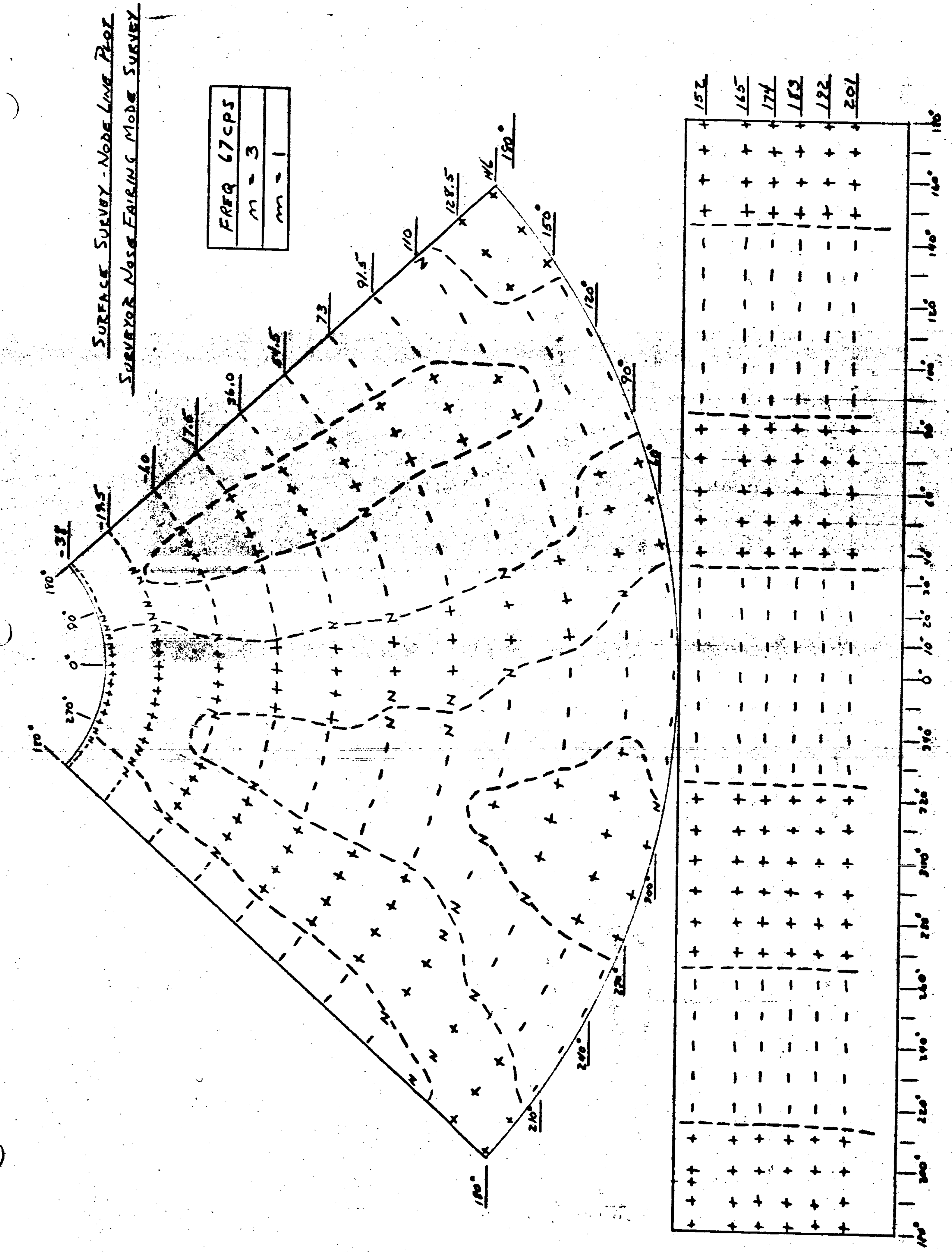


FIG 4
RLB 4/15/64

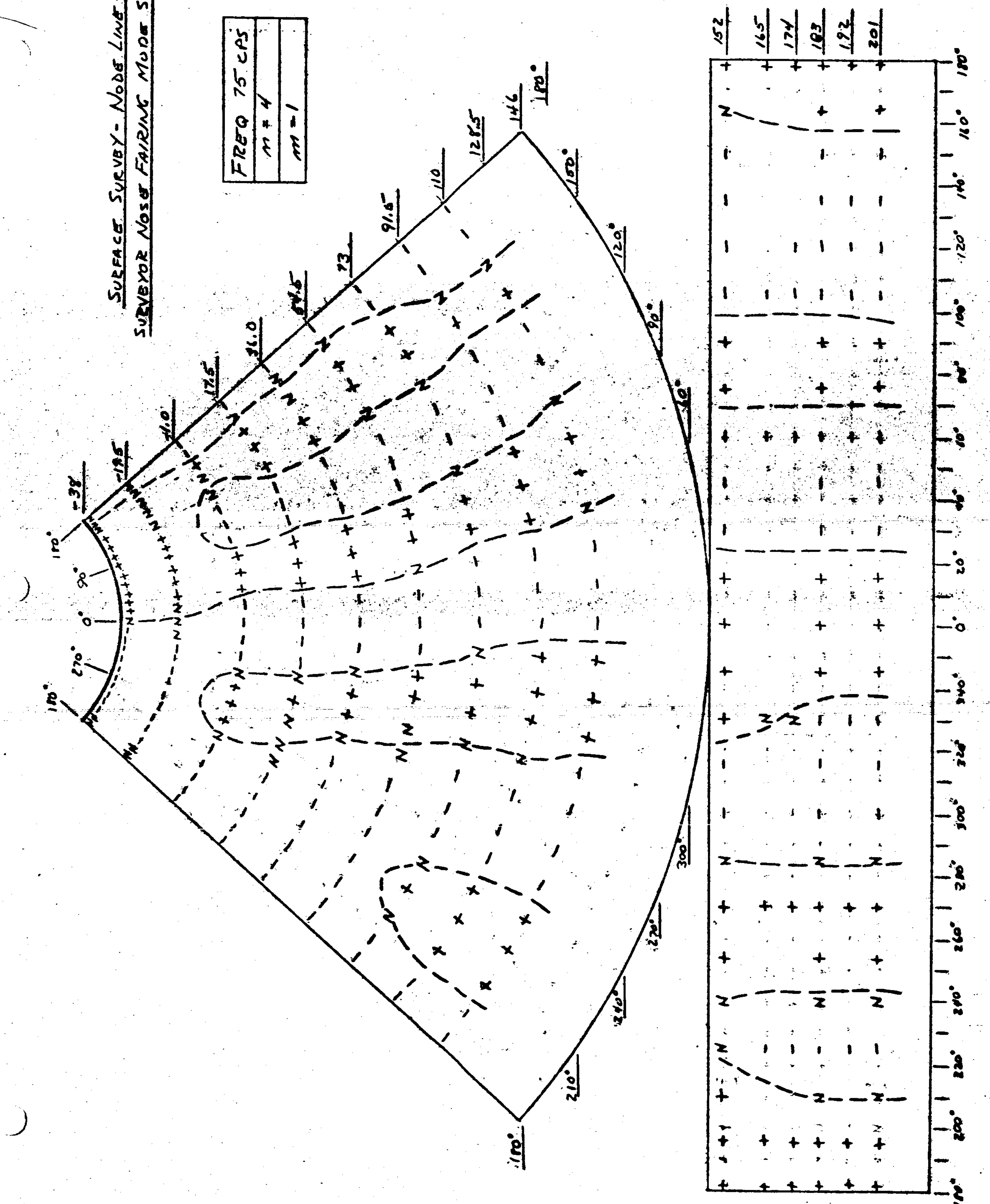


FIG 5
ZLZ 4/15/64

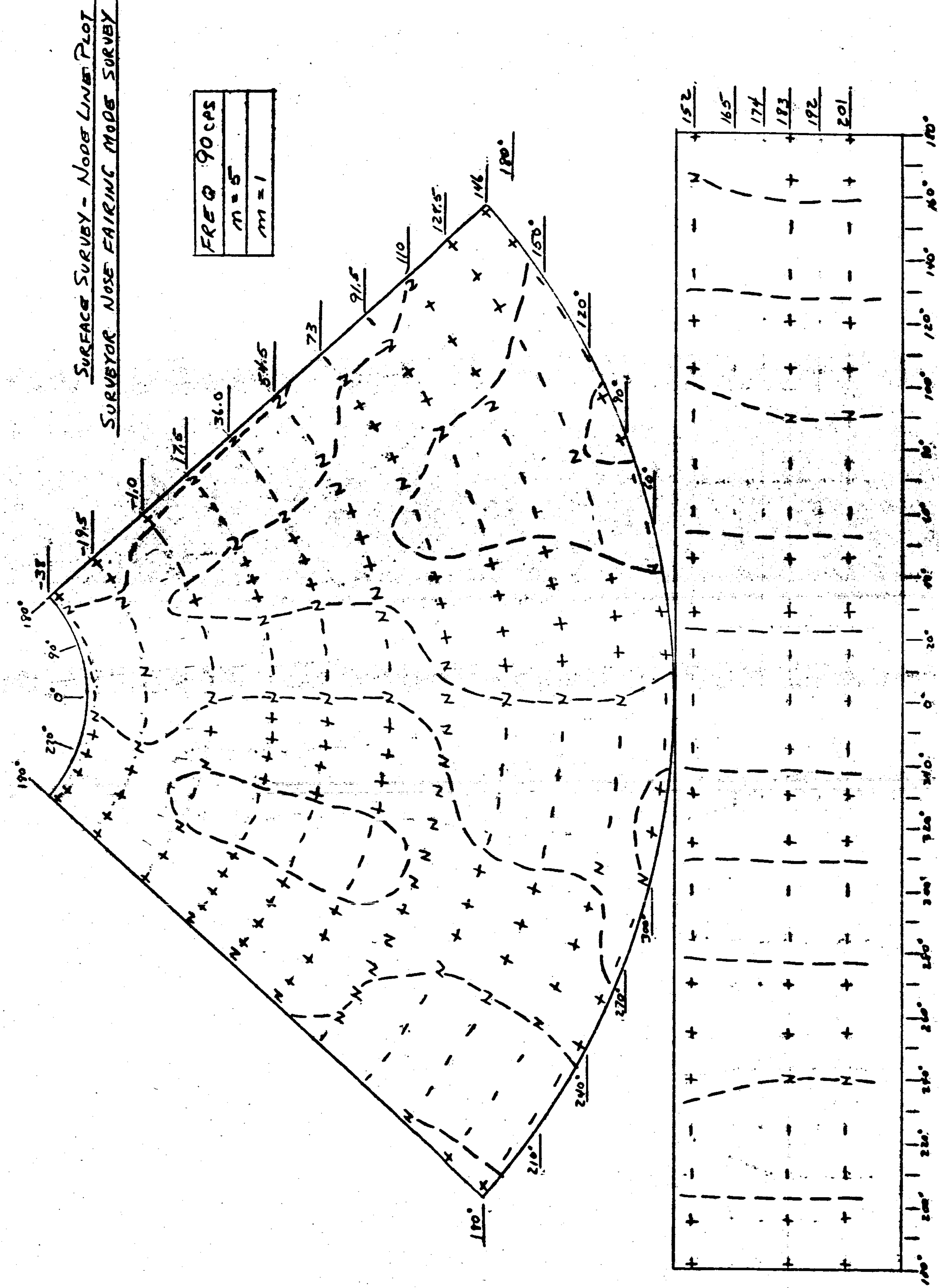


FIG 6
RLR 4/15/64

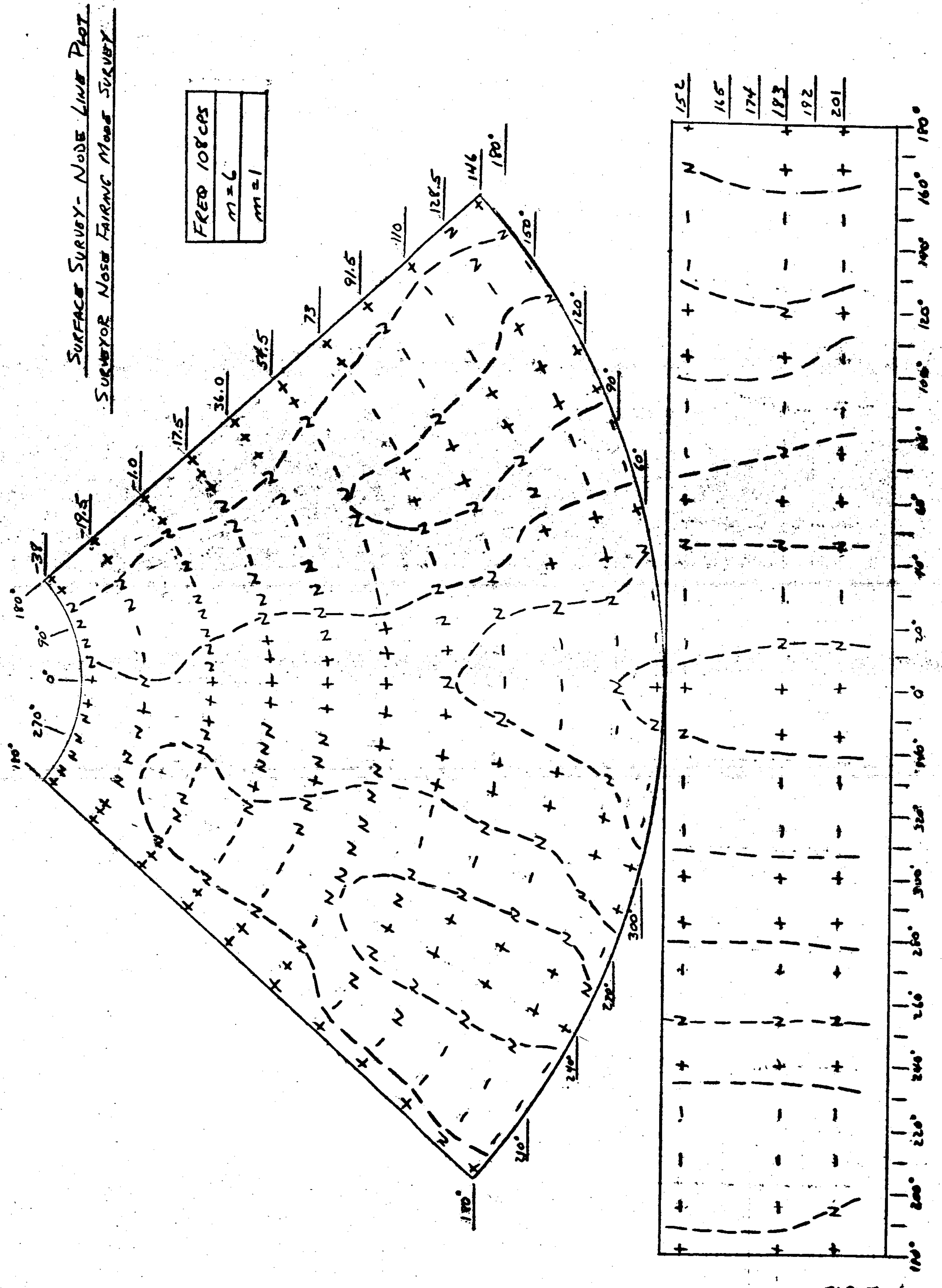

SURFACE SURVEY - NODE LINE PLOT
SURVEYOR NOSE FAIRING MODE SURVEY
FREQ 108 CPS
m = 6
m = 1

FIG 7

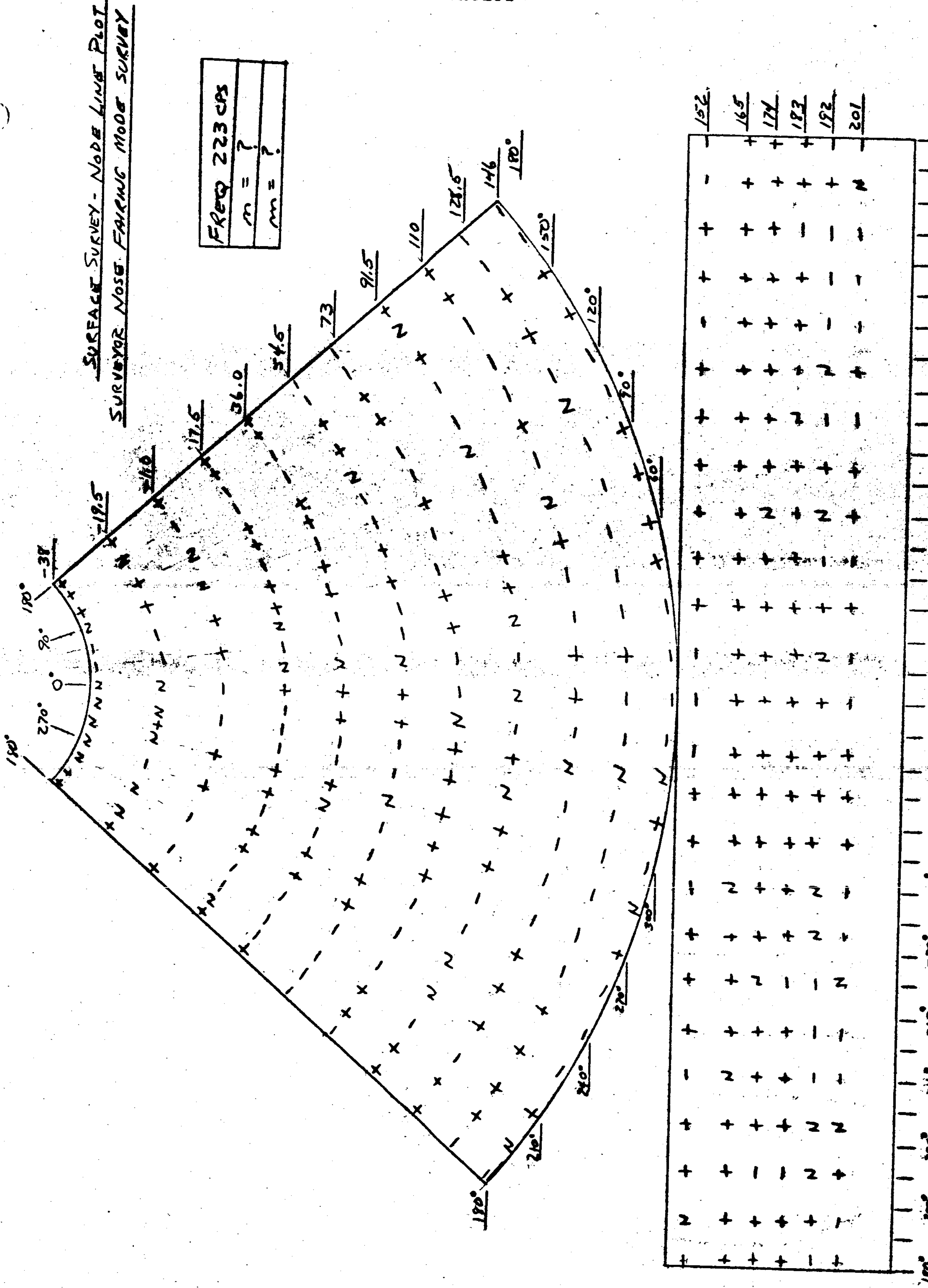
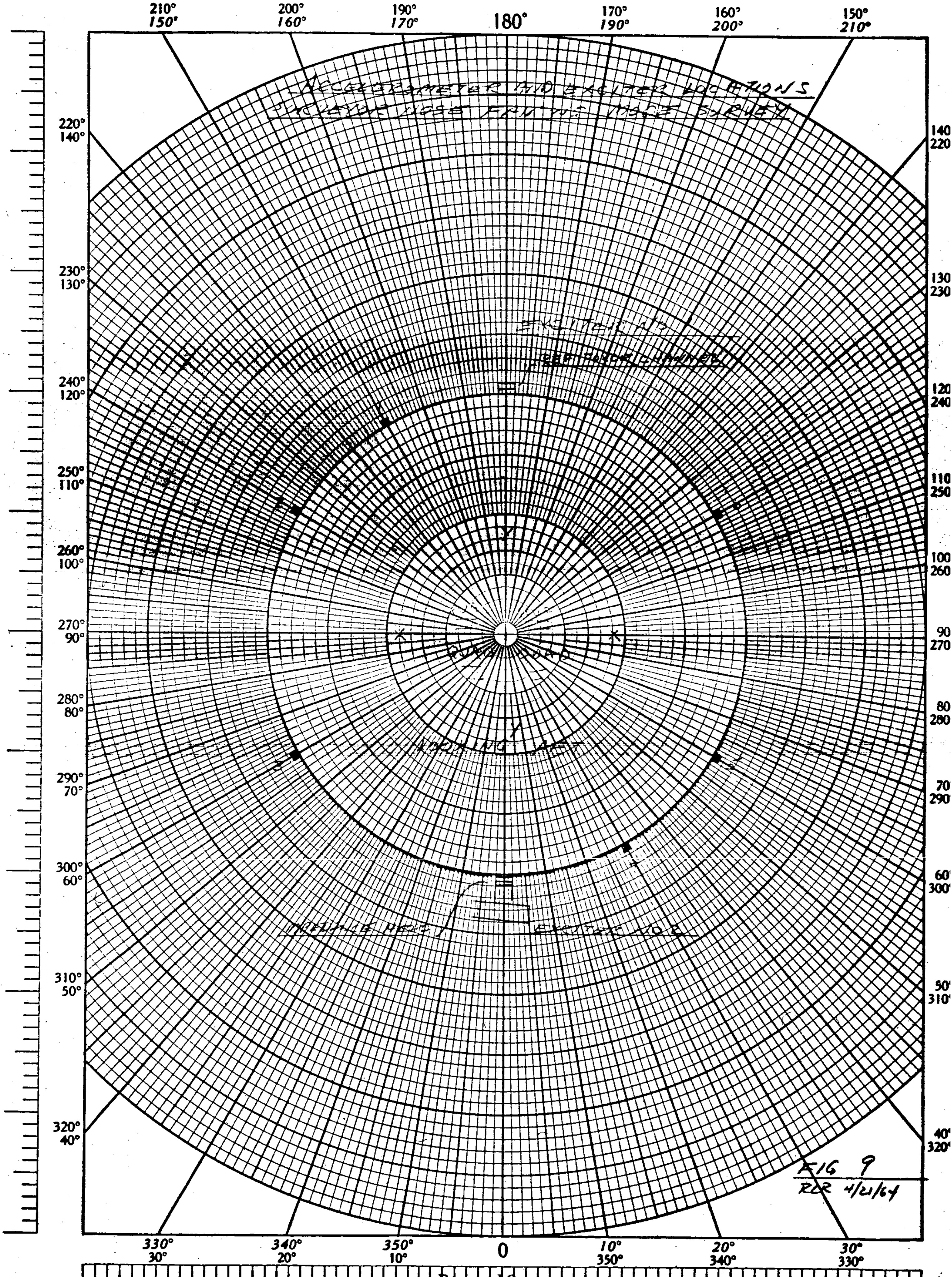
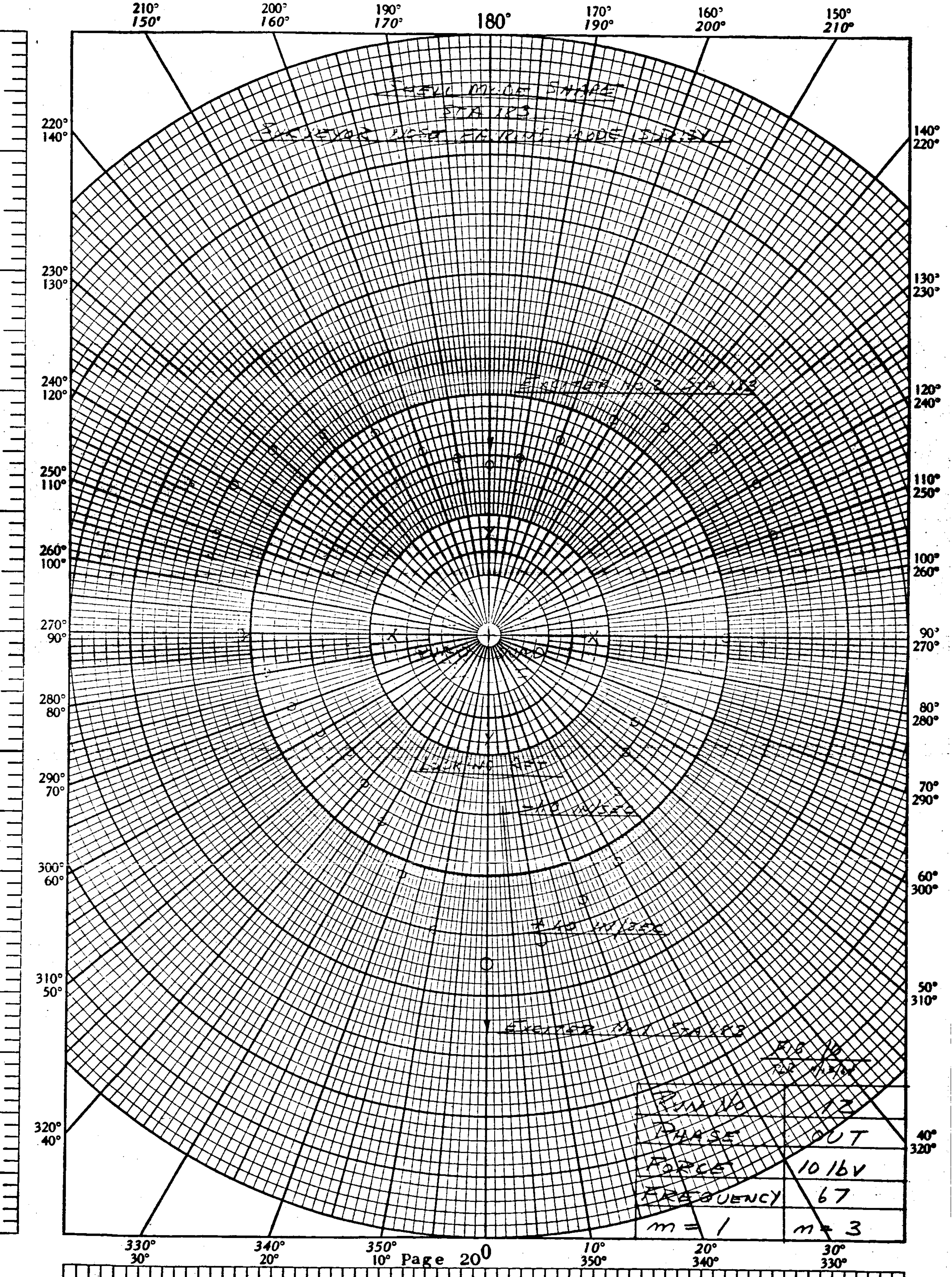
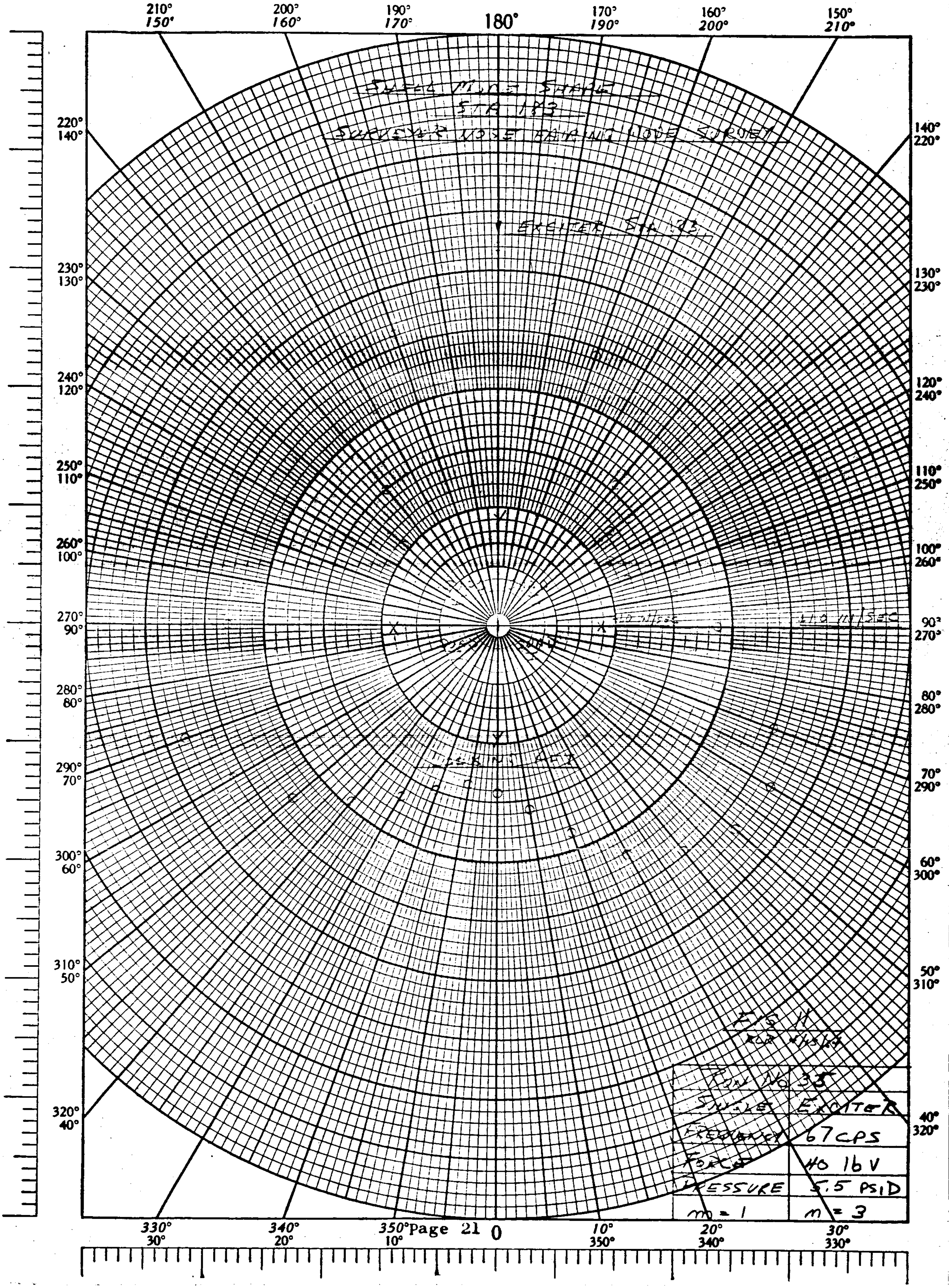

SURFACE SURVEY - NODE LINE PLOT
SURVEYOR NOSE FAIRING MODE SURVEY
FREQ 223 CPS
m = ?
n = ?

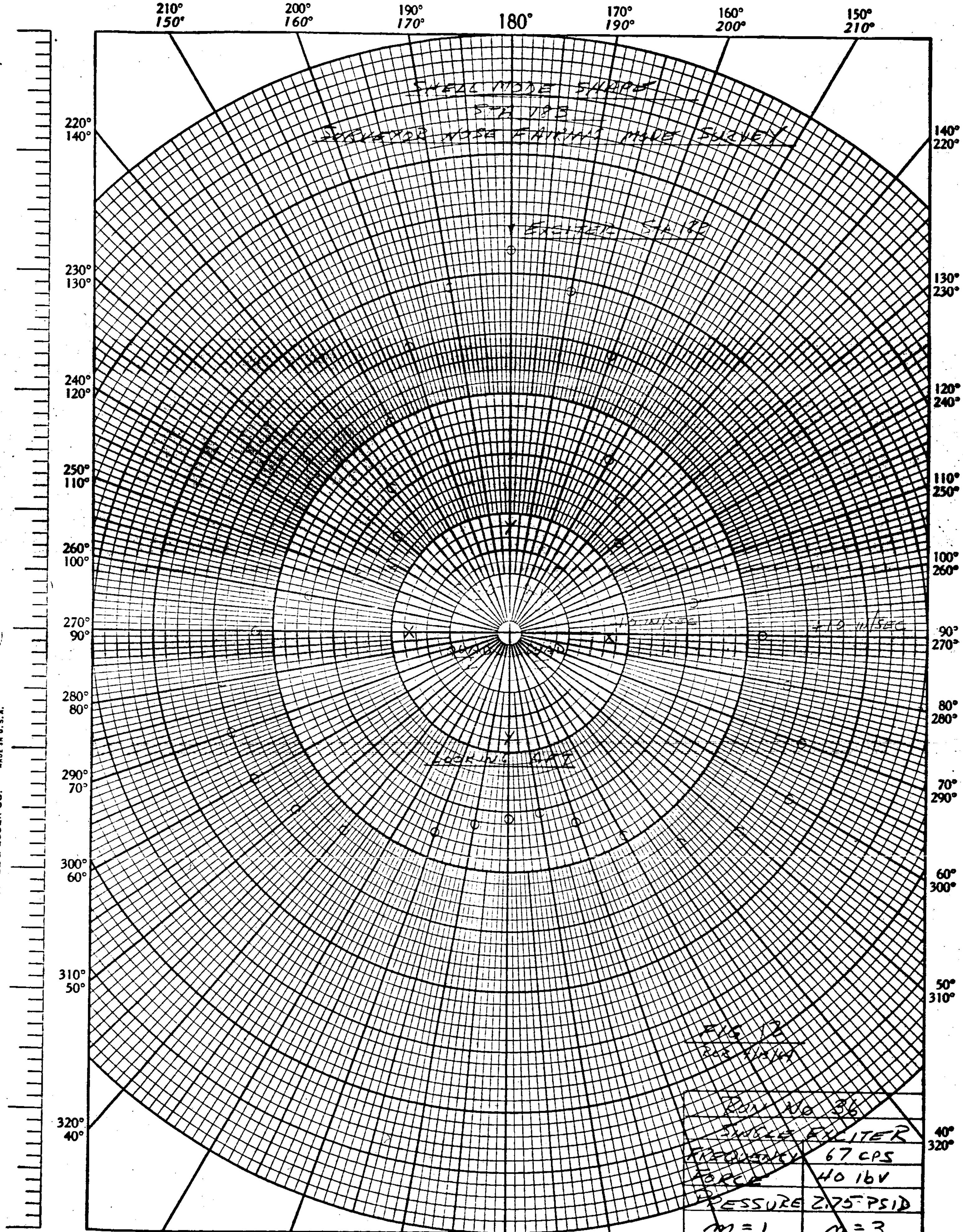
FIG 8


ACCELEROMETER AND EXCITER LOCATIONS
LOOKING AFT
FIG 9
RLR 4/21/64

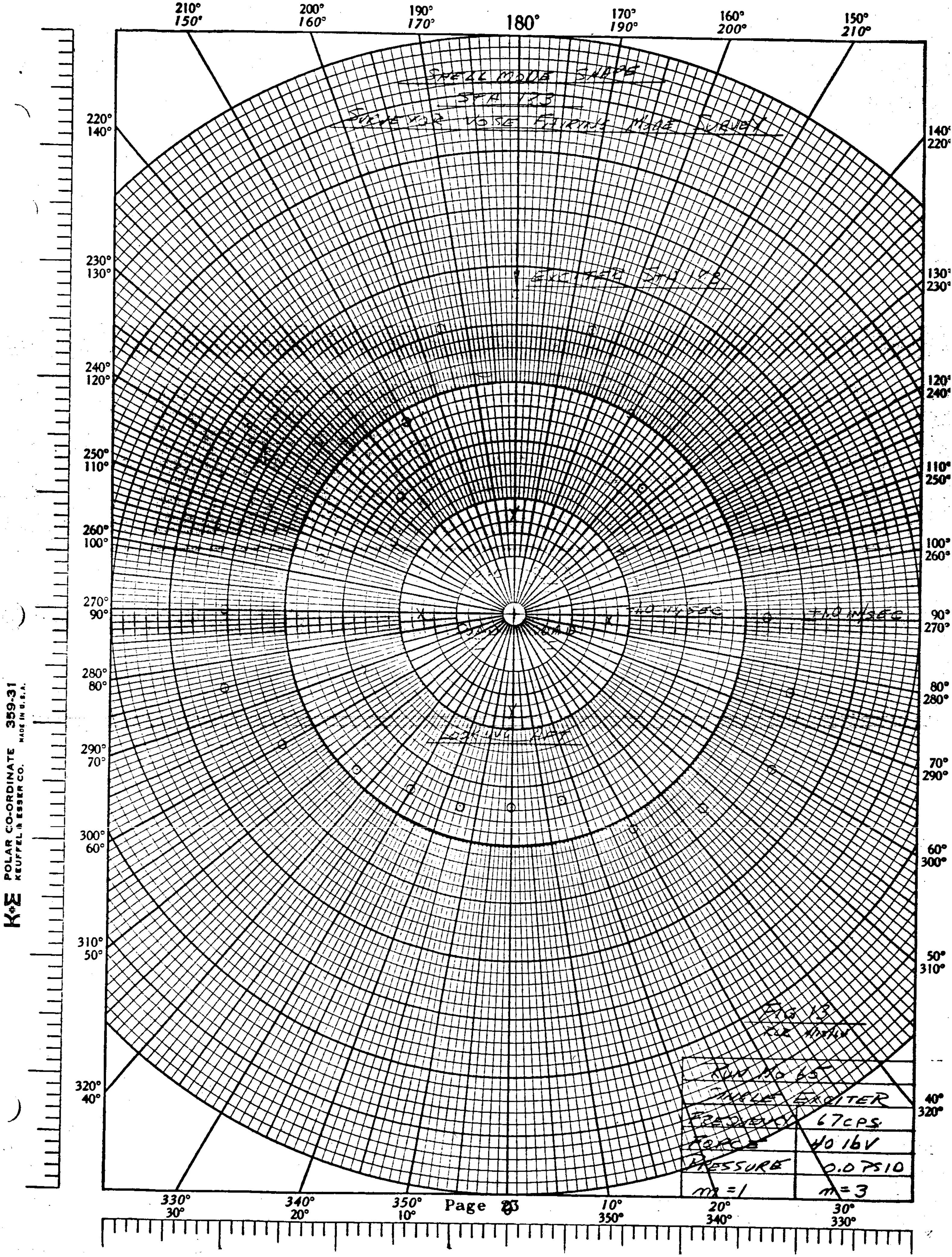


KE POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.

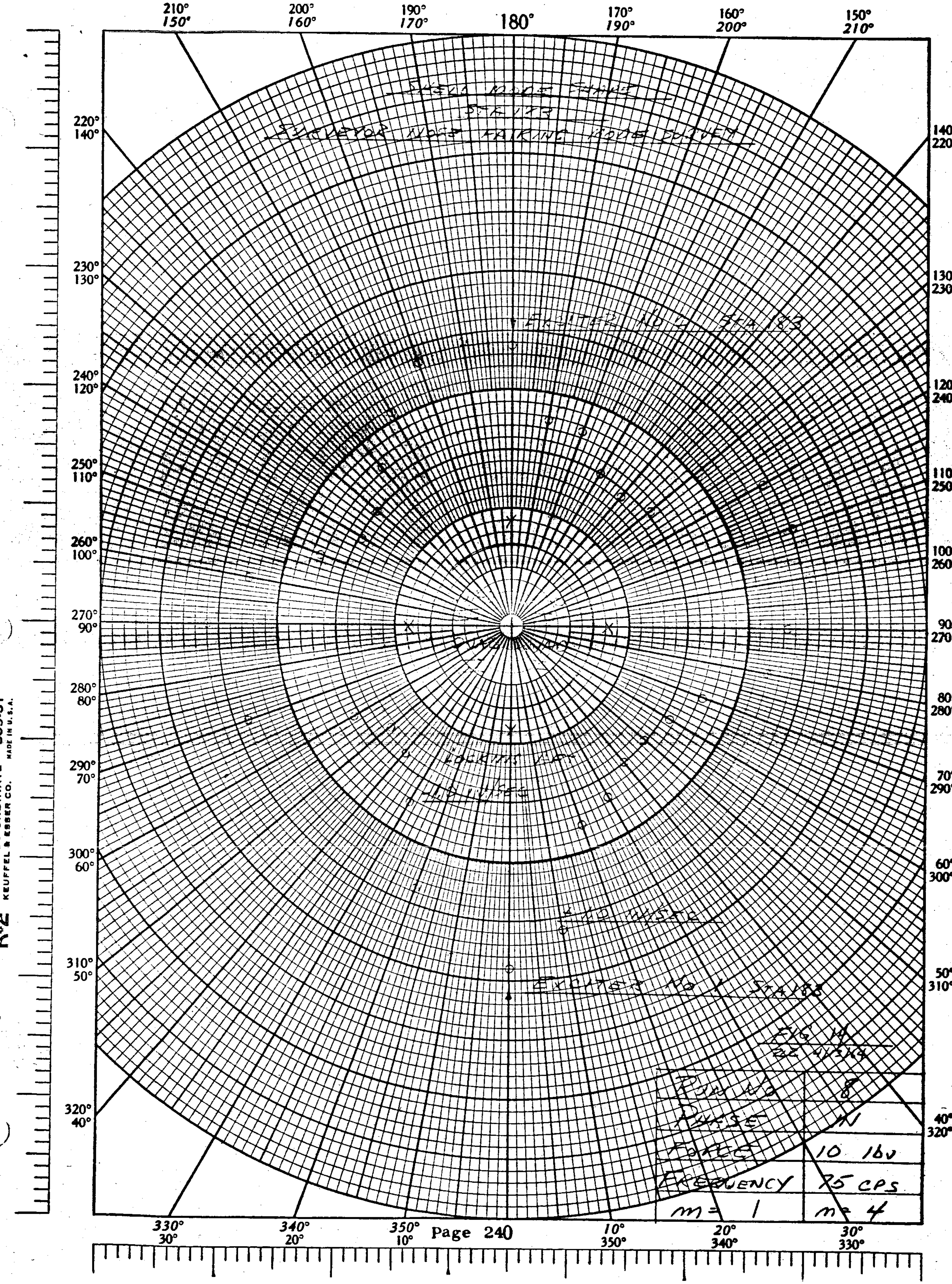

180°
0
EXCITER
PRESSURE
67 CPS
40 lb V
5.5 PSID
m = 1
n = 3

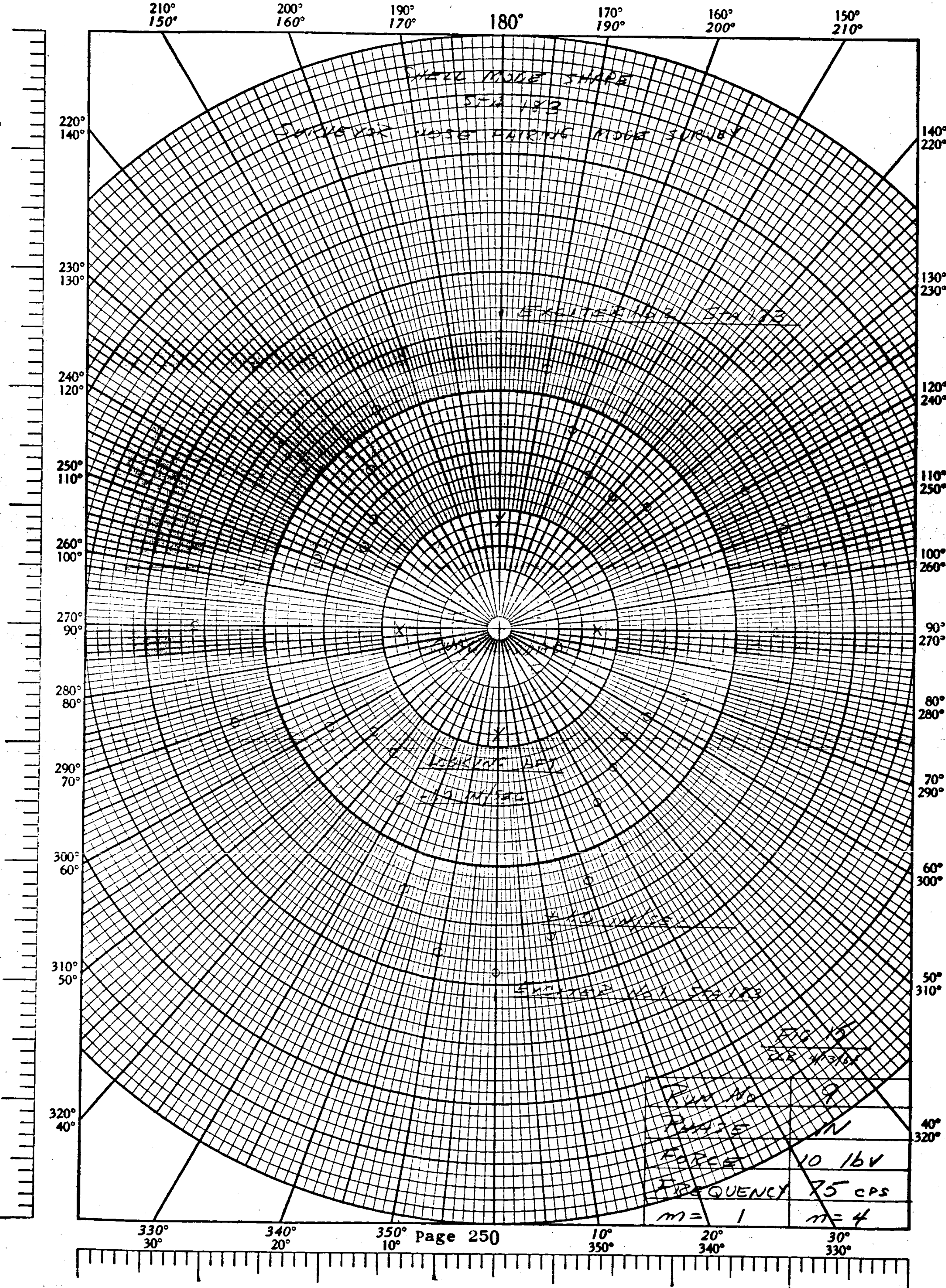

SHELL MODE SHAPE
NOSE FAIRING MODE SURVEY
EXCITER
LOOKING AFT
FIG 12
RUN NO 36
SINGLE EXCITER
FREQUENCY
67 CPS
FORCE
40 lbV
PRESSURE
2.75 PSID
m = 1
n = 3
180°
0
POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO.
MADE IN U.S.A.

55A3291

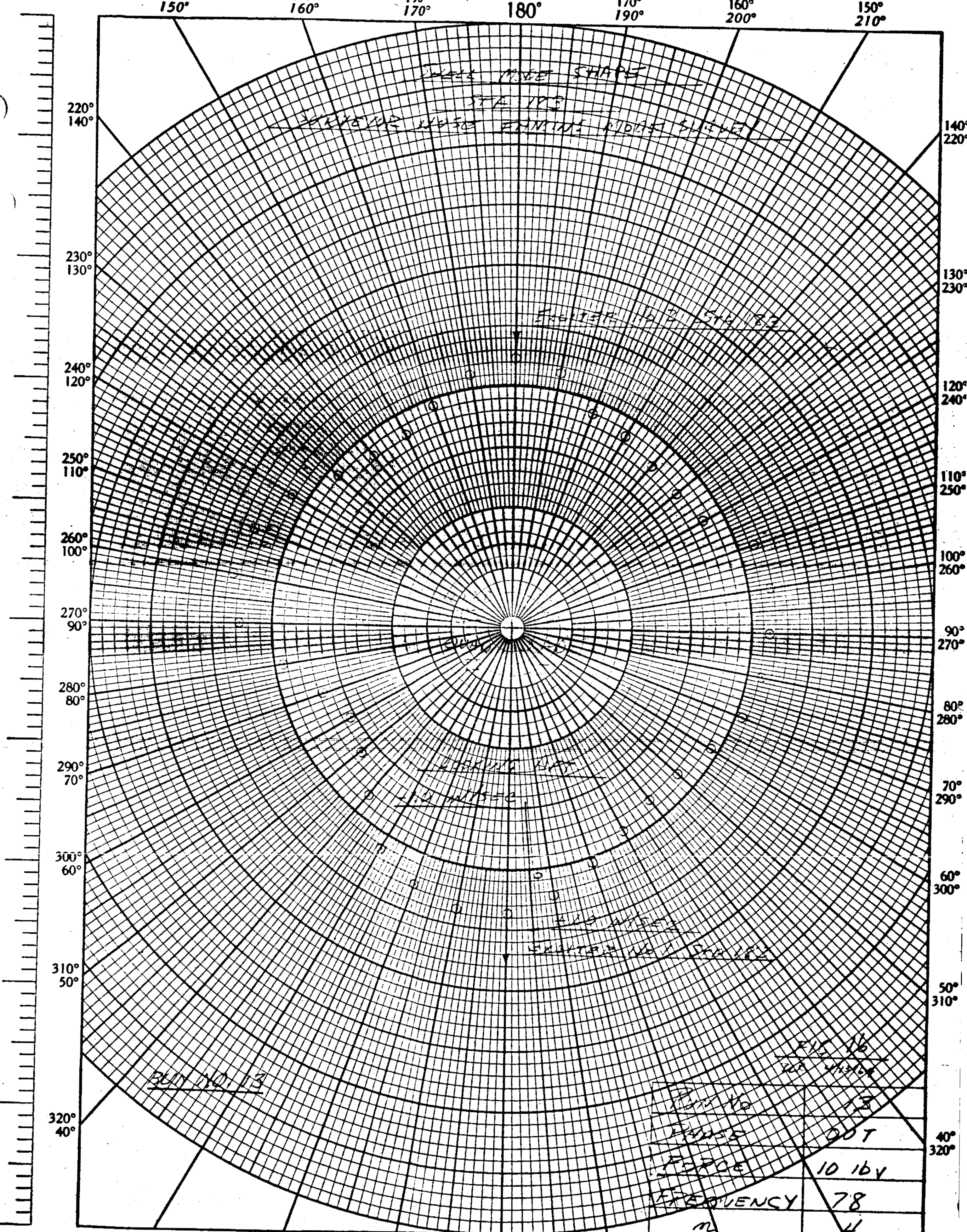


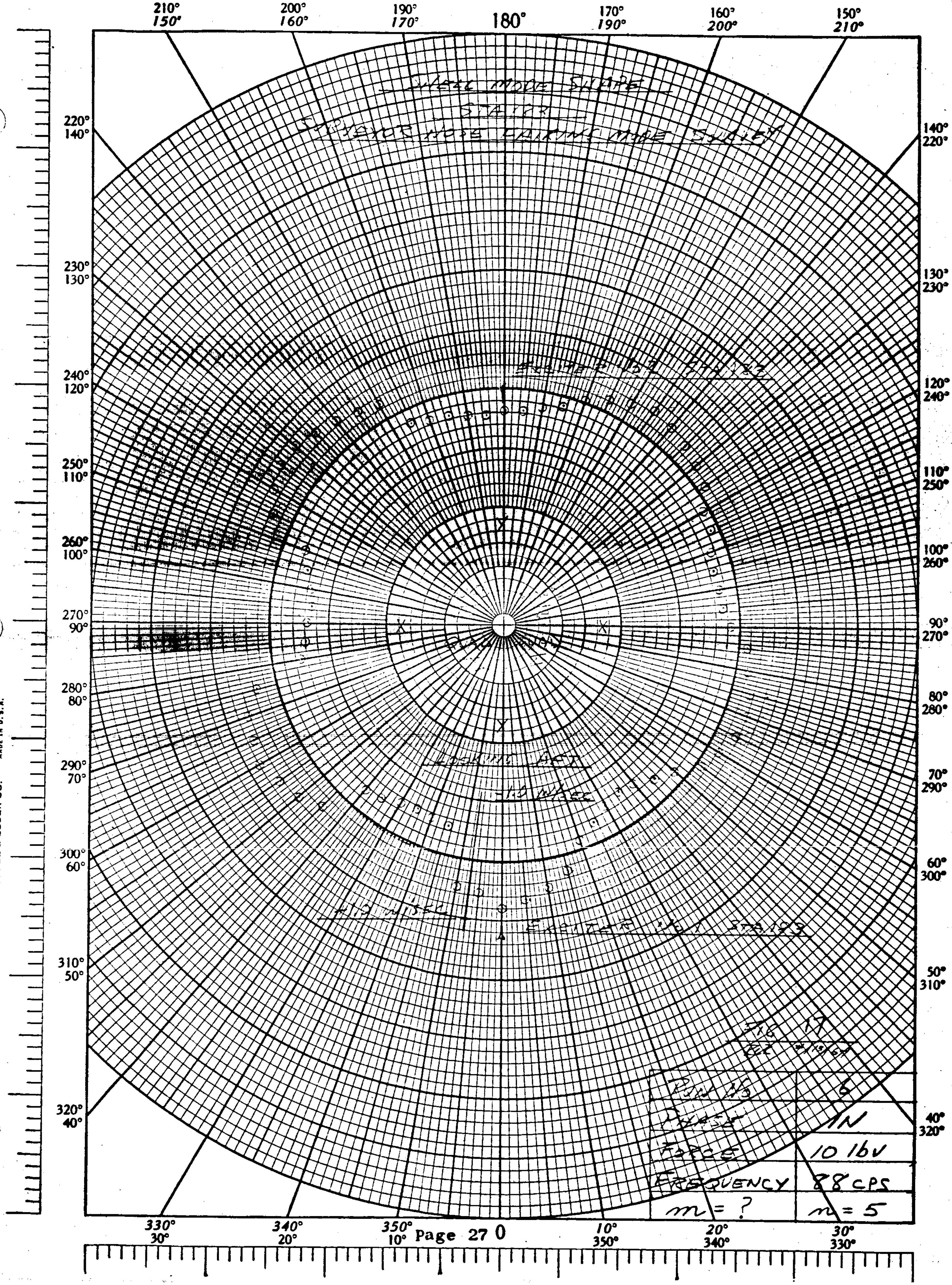
SHELL MODE SHAPES
FIG 13
RUN NO 65
SINGLE EXCITER
67 CPS
PRESSURE
0.0 PSID
m = 1
n = 3
K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO.


SHELL MODE SHAPE
STA 173
SURVEYOR NOSE FAIRING MODE SURVEY
EXCITER NO 2 STA 183
EXCITER NO 1 STA 183
RUN NO 8
PHASE N
FORCE 10 lbv
FREQUENCY 75 CPS
m = 1
m = 4
POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO.
MADE IN U.S.A.

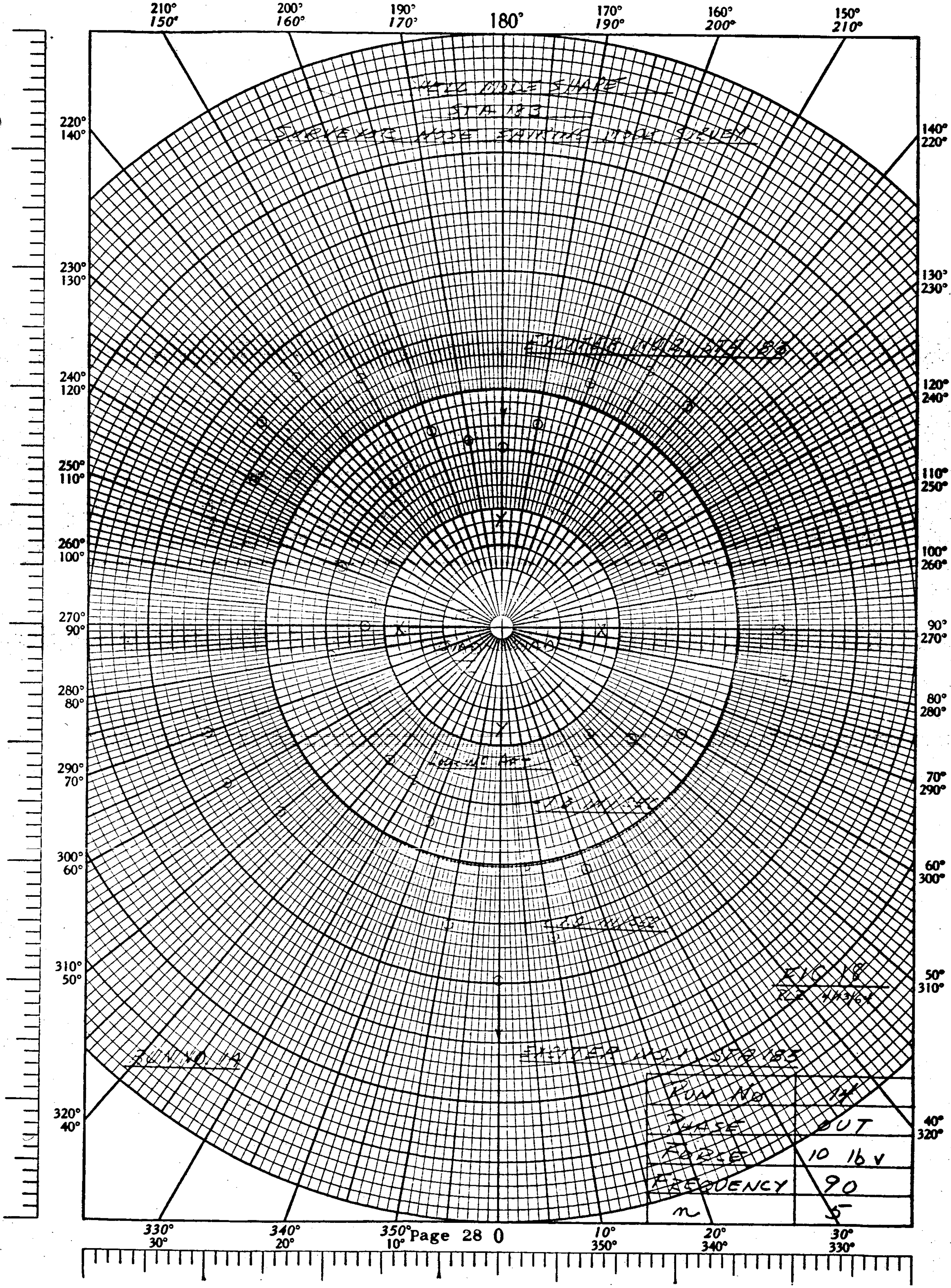


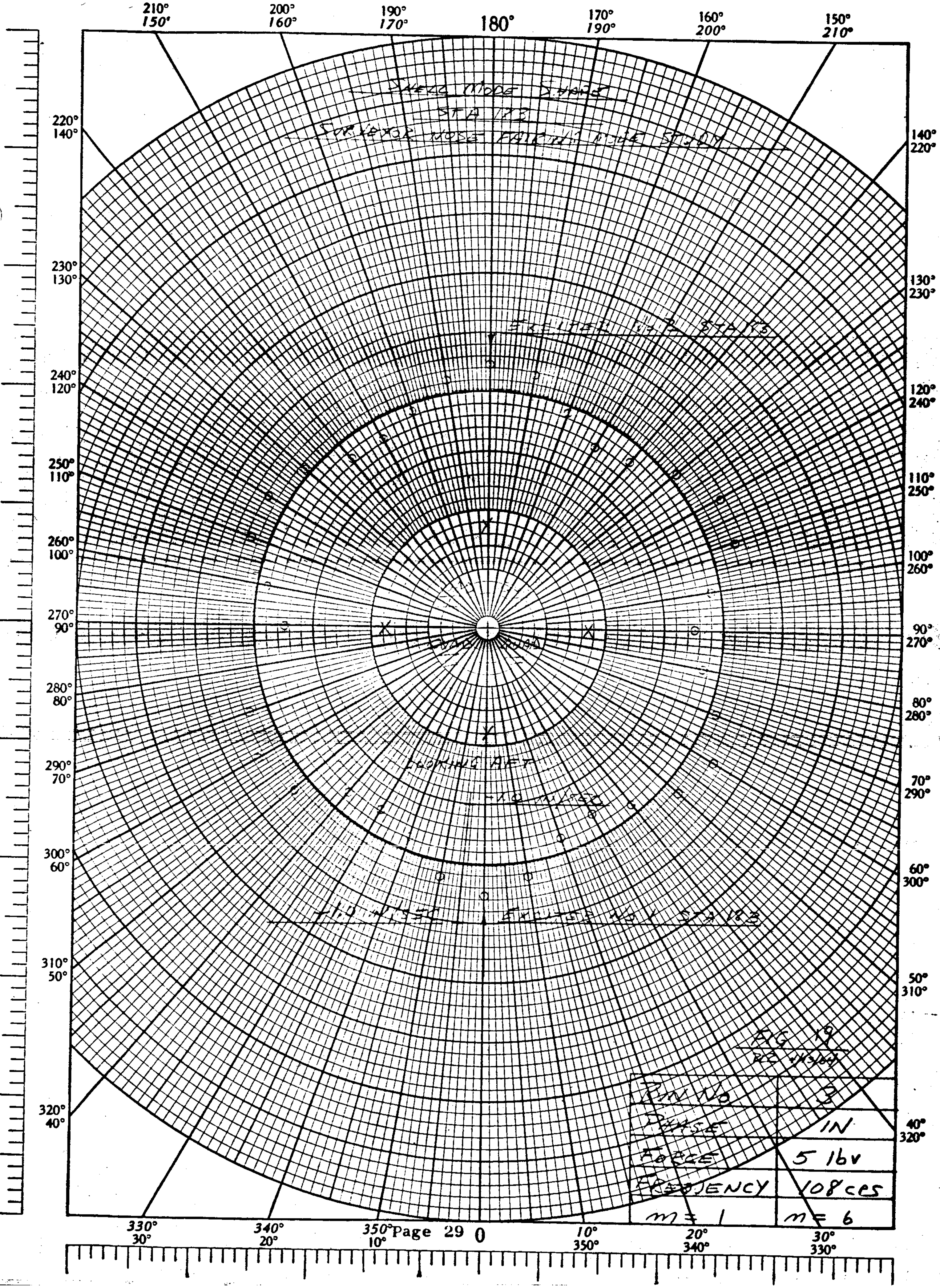
180°
SHELL MODE SHAPE
STA 183
SURVEYOR NOSE FAIRING MODE SURVEY
EXCITER NO 1 STA 183
LOOKING AFT
FIG 15
RUN NO 9
PHASE IN
FORCE 10 lbV
FREQUENCY 75 cps
m = 1
n = 4
K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.

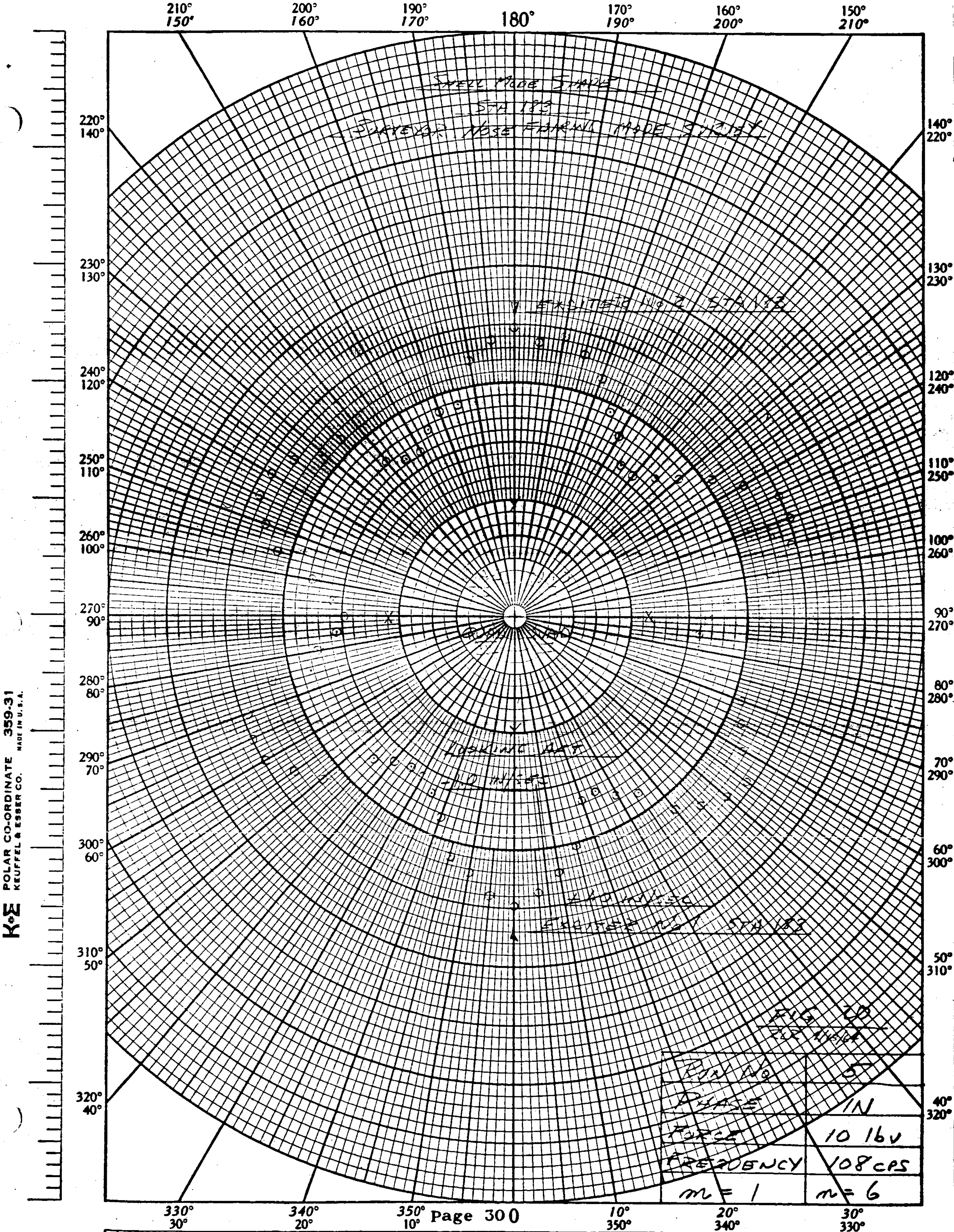

SHAPE
FIG 16
RUN NO. 13
RUN NO 13
PHASE OOT
FORCE 10 lbV
FREQUENCY 78
n 4



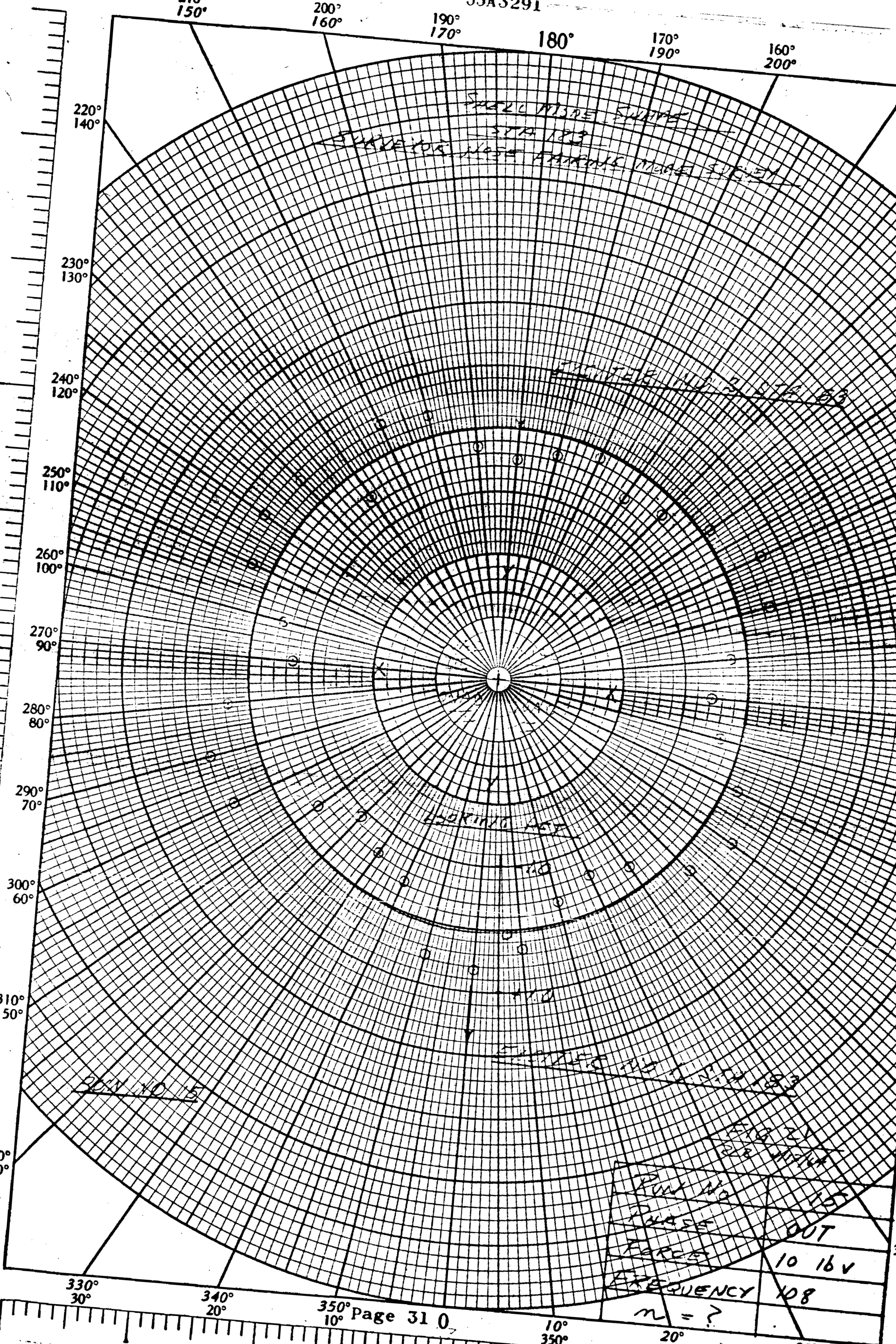
RUN NO	6
PHASE	1N
FORCE	10 lbV
FREQUENCY	88 CPS
m = ?	n = 5


STA 183
FIG 18
RUN NO 14
PHASE OUT
FORCE 10 lb v
FREQUENCY 90
n 5
POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.


SHELL MODE SHAPE
STA 183
SURVEYOR NOSE FAIRING MODE STUDY
EXCITER NO 2 STA 183
UNDEF. ROUND
LOOKING AFT
+10 MILS
+10 MILS
EXCITER NO 1 STA 183
FIG 19
RUN NO 3
PHASE IN
FORCE 5 lbv
FREQUENCY 108 cps
m = 1
n = 6
180°
0
POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO.
MADE IN U.S.A.


SHELL MODE SHAPE
STA 183
SURVEYOR NOSE FAIRING MODE STUDY
EXCITER No 2 STA 182
LOOKING AFT
EXCITER No 1 STA 183
FIG 10
RUN NO 5
PHASE IN
FORCE 10 lbv
FREQUENCY 108 CPS
m = 1
n = 6
POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.

55A3291



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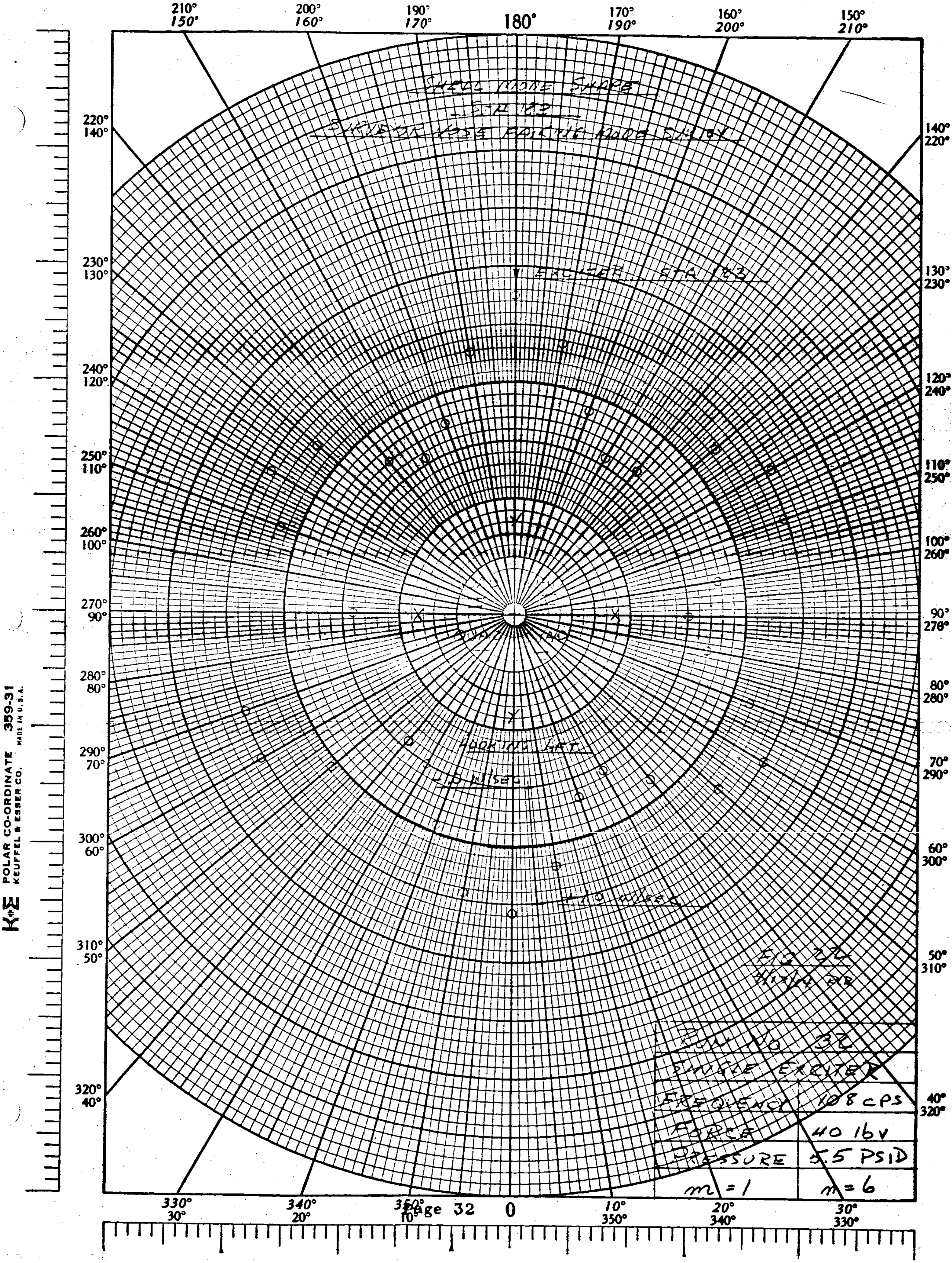
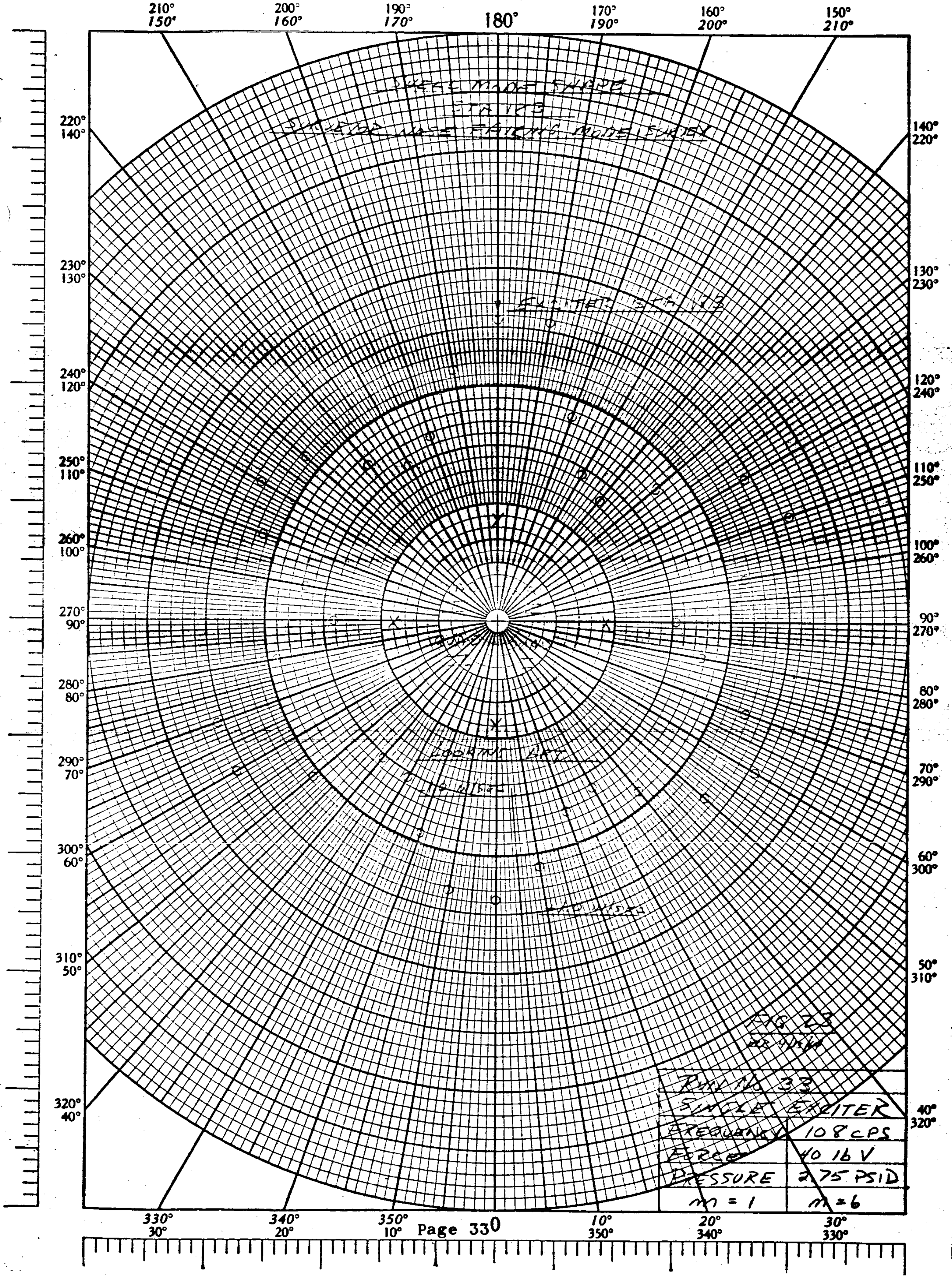
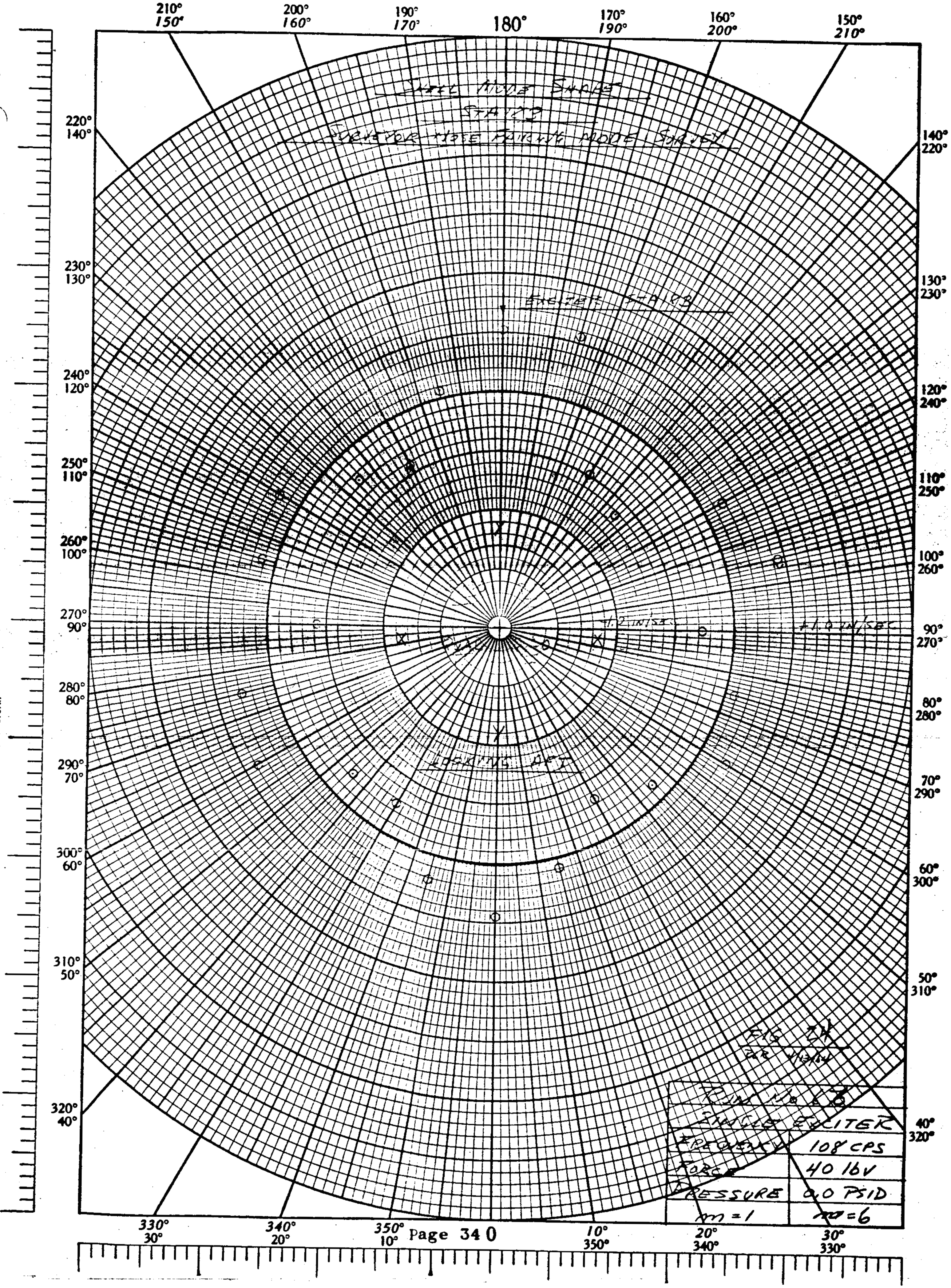
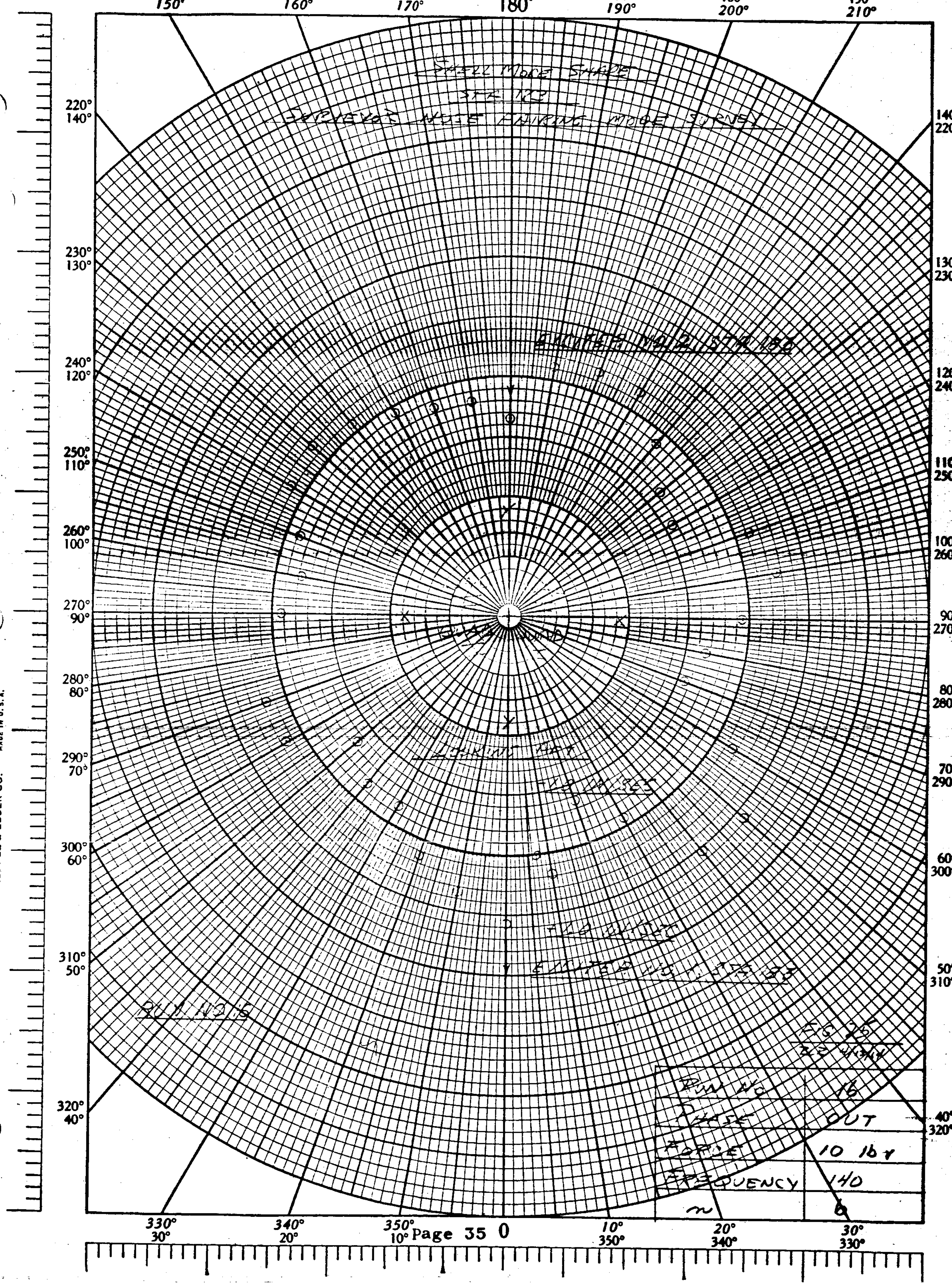
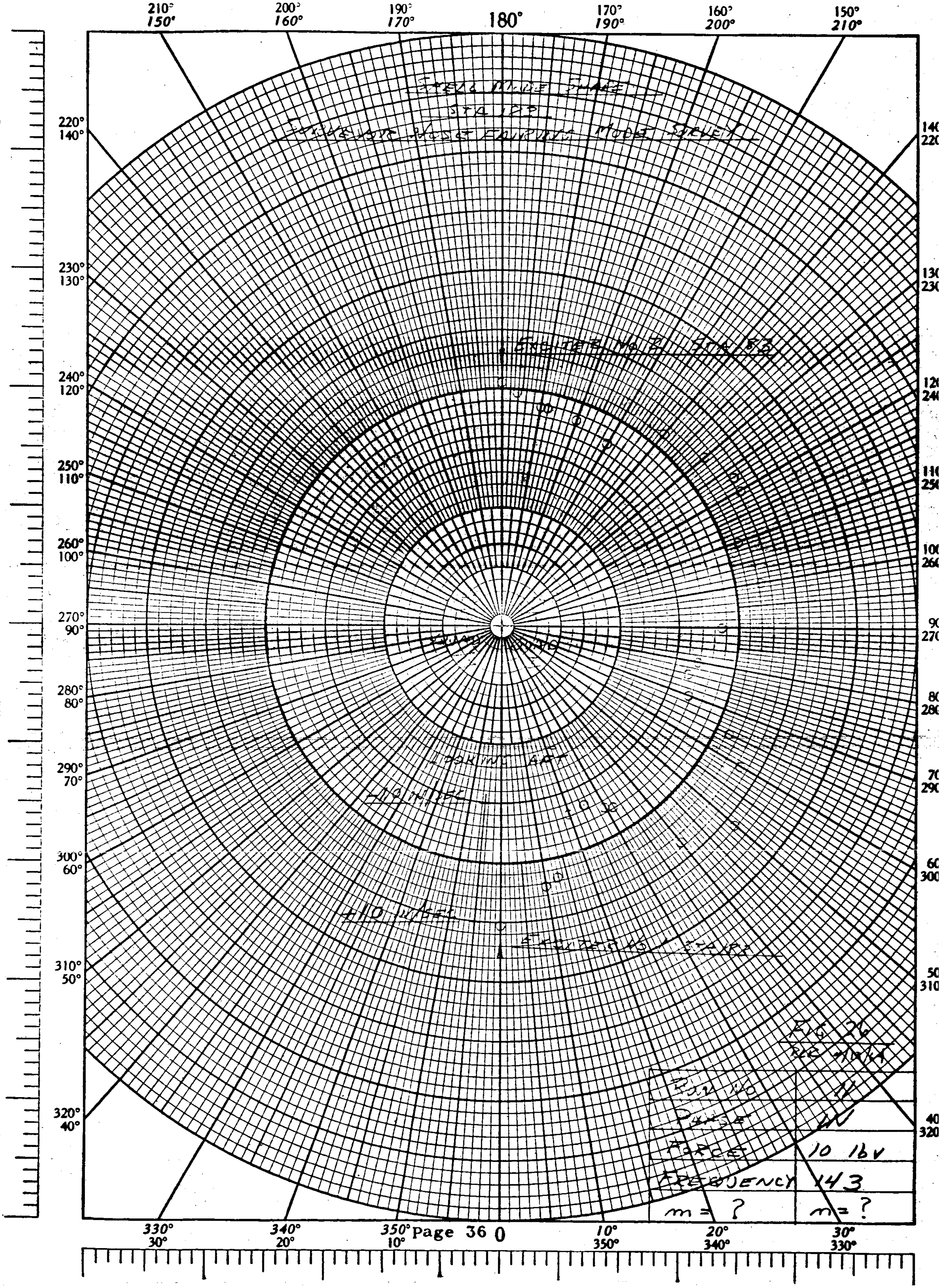
KEUFFEL & ESSER CO. MADE IN U.S.A.

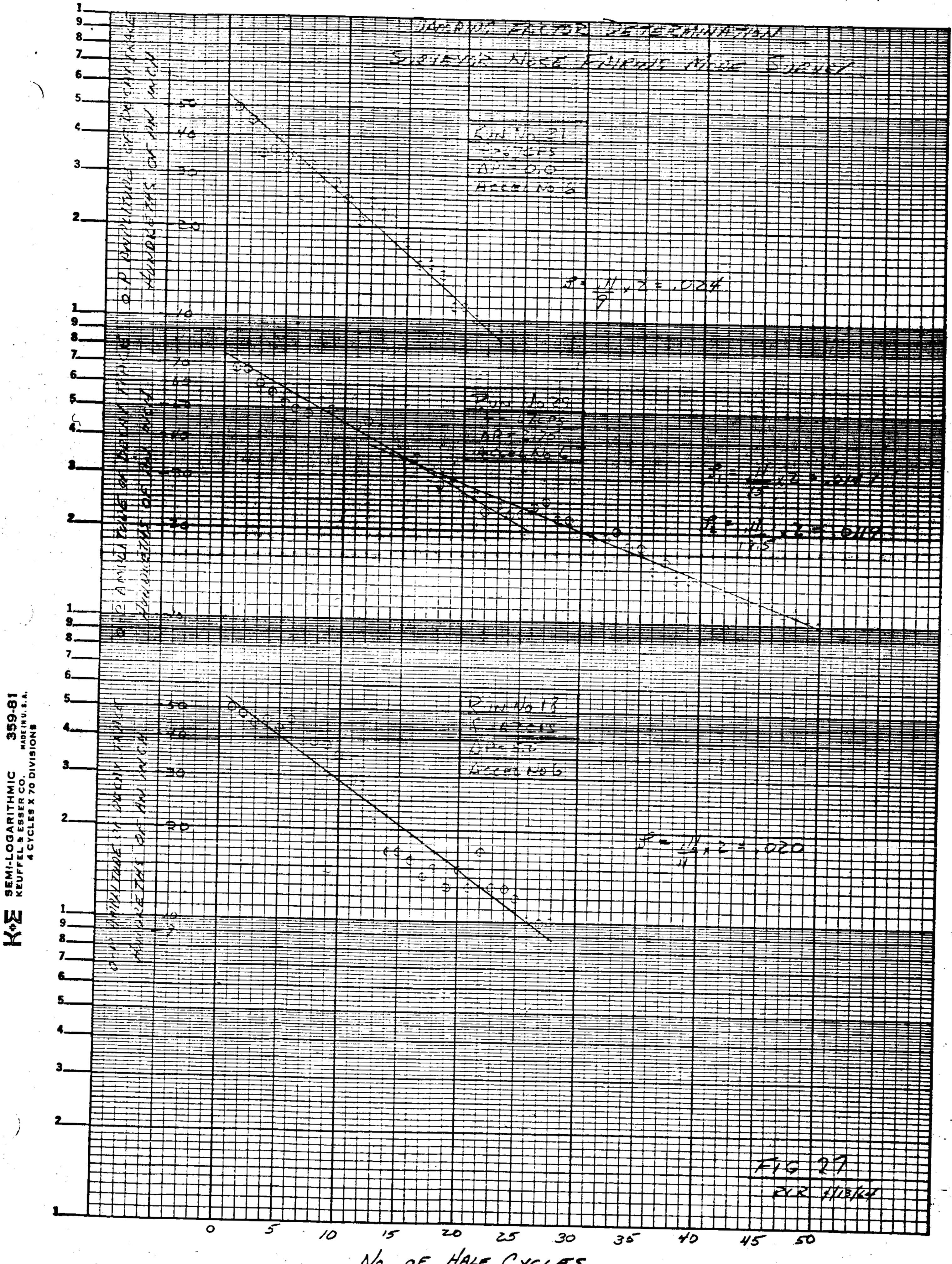

SHELL MODE SHAPE
EXCITER
LOOKING AFT
RUN NO 32
SINGLE EXCITER
FREQUENCY 108 CPS
FORCE 40 lbv
PRESSURE 5.5 PSID
m = 1
n = 6
K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.


K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.
LOOKING AFT
FIG 23
RUN NO. 33
SINGLE EXCITER
FREQUENCY 108 CPS
FORCE 40 lb V
PRESSURE 2.75 PSID
m = 1
m = 6

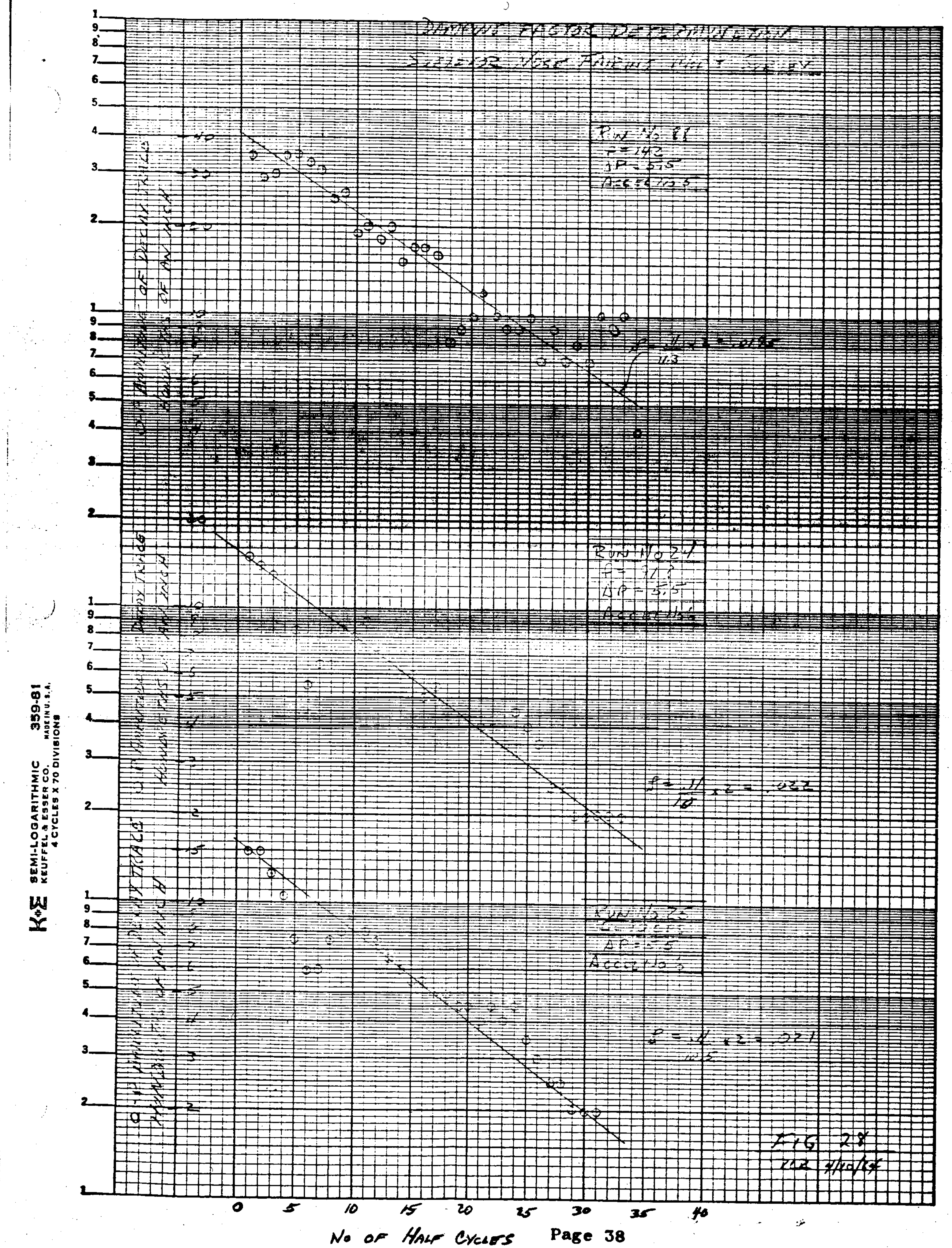

180°
K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.
LOOKING AFT
SINGLE EXCITER
108 CPS
40 lbV
PRESSURE
0.0 PSID
m = 1
= 6


SHELL MODE SHAPE
SURVEYOR NOSE FAIRING MODE SURVEY
LOOKING AFT
RUN NO 16
PHASE OUT
FORCE 10 lb
FREQUENCY 140
n 6
K&E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.

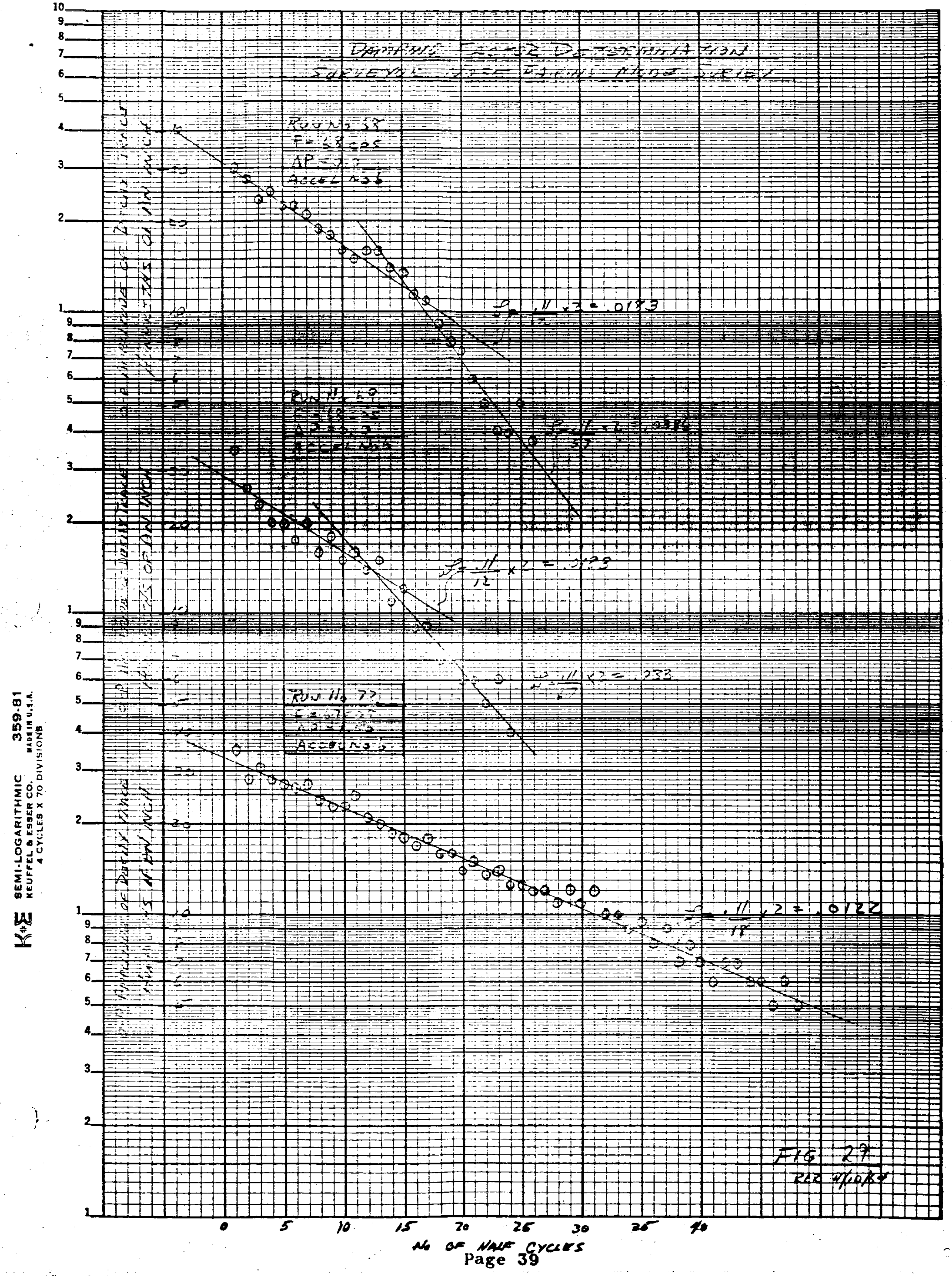

K+E POLAR CO-ORDINATE 359-31
KEUFFEL & ESSER CO. MADE IN U.S.A.
180°
0
FIG 26
RUN NO
PHASE
FORCE
10 lbv
FREQUENCY
143
m = ?
n = ?

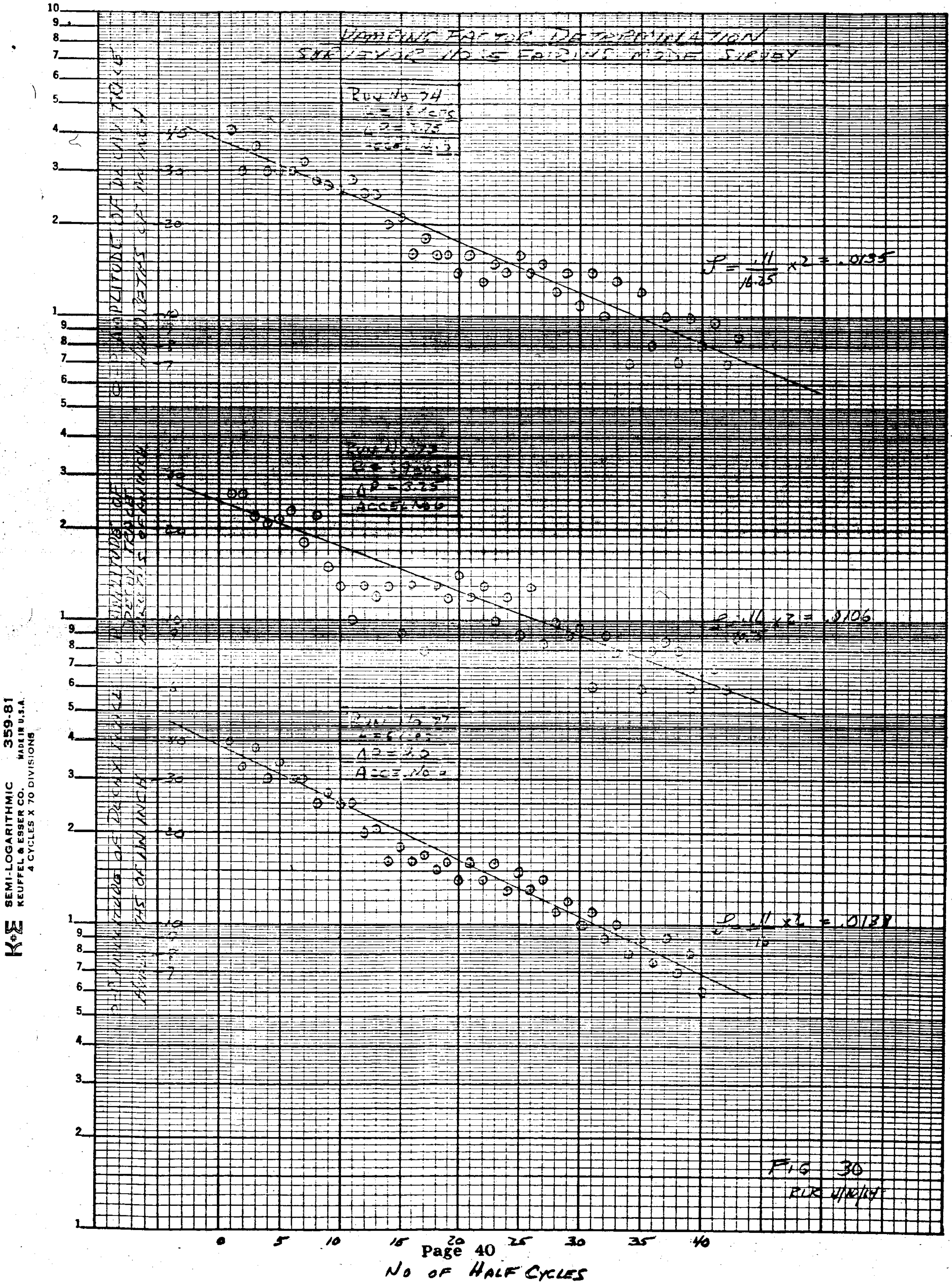


DAMPING FACTOR DETERMINATION
SURVEYOR NOSE FAIRING MODE SURVEY
RUN No 21
ACCEL No 6
RUN No 25
ACCEL No 6
$\delta = \frac{.11}{9} \times 2 = .024$
RUN No 13
ACCEL No 6
$\delta = \frac{.11}{11} \times 2 = .020$
FIG 27
0 5 10 15 20 25 30 35 40 45 50
No OF HALF CYCLES
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS



DAMPING FACTOR DETERMINATION
SUPERIOR NOSE PANEL PITOT SURVEY
RUN NO. 21
RUN NO. 24
RUN NO. 25
FIG 28
No OF HALF CYCLES
K+E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS


SEMI-LOGARITHMIC
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS
359-81
MADE IN U.S.A.
FIG 29
No OF HALF CYCLES


Run No 74
Run No 73
Run No 27
ACCEL No 6
$\rho = \frac{.11}{16.25} \times 2 = .0135$
$\rho = \frac{.11}{16.5} \times 2 = .0106$
$\rho = \frac{.11}{16} \times 2 = .0138$
FIG 30
0 5 10 15 20 25 30 35 40
NO OF HALF CYCLES
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS

55A3291

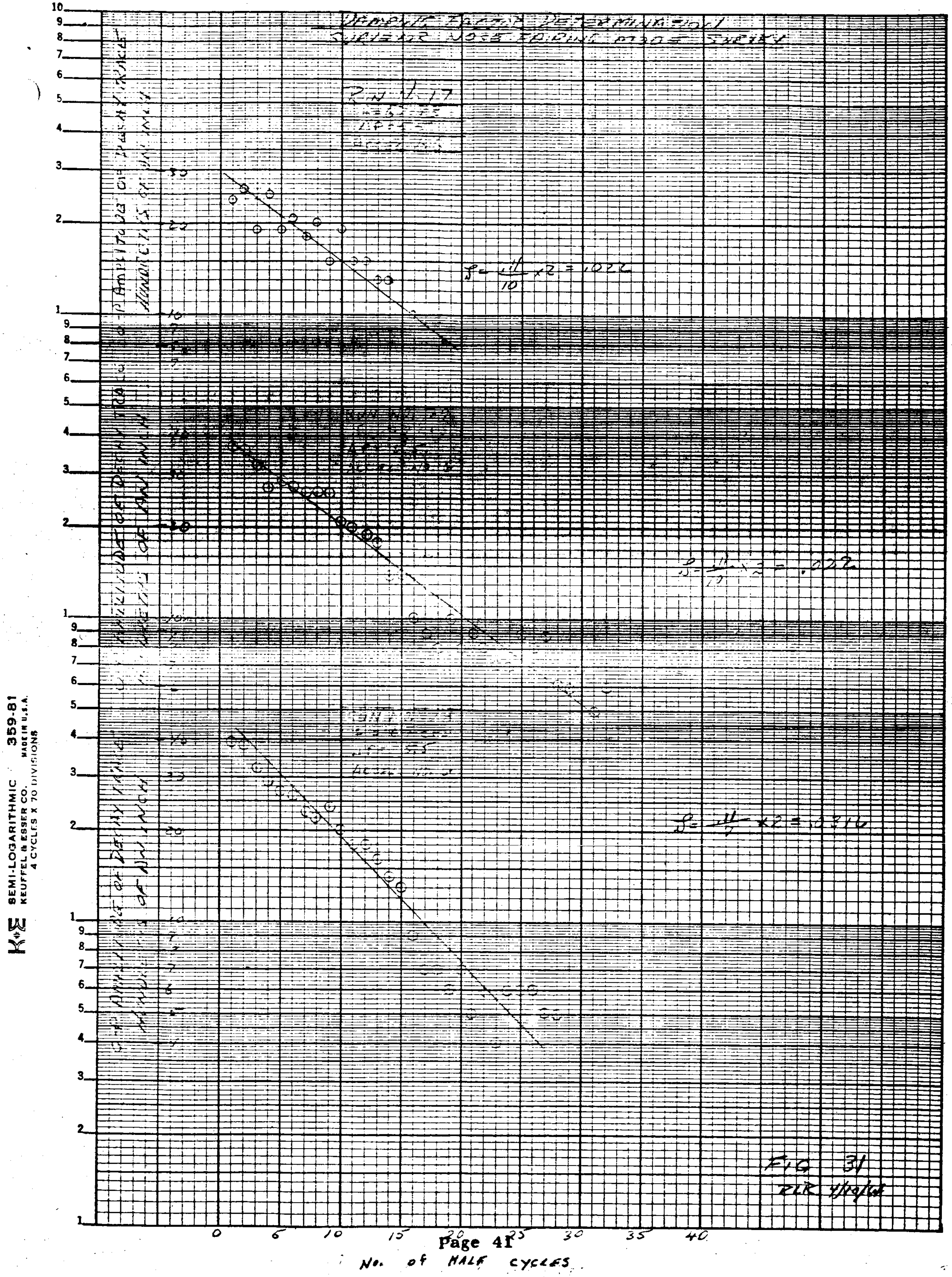
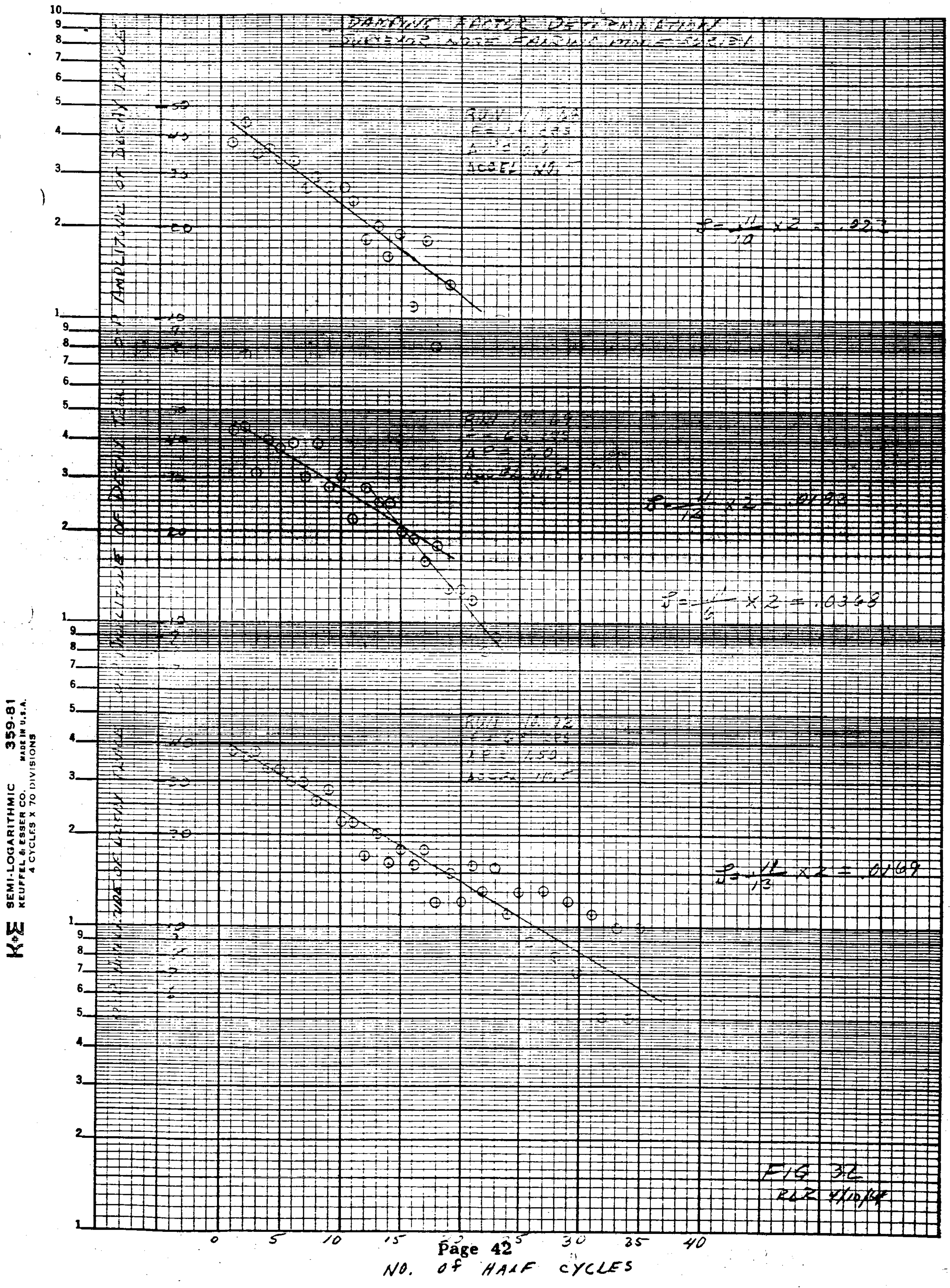
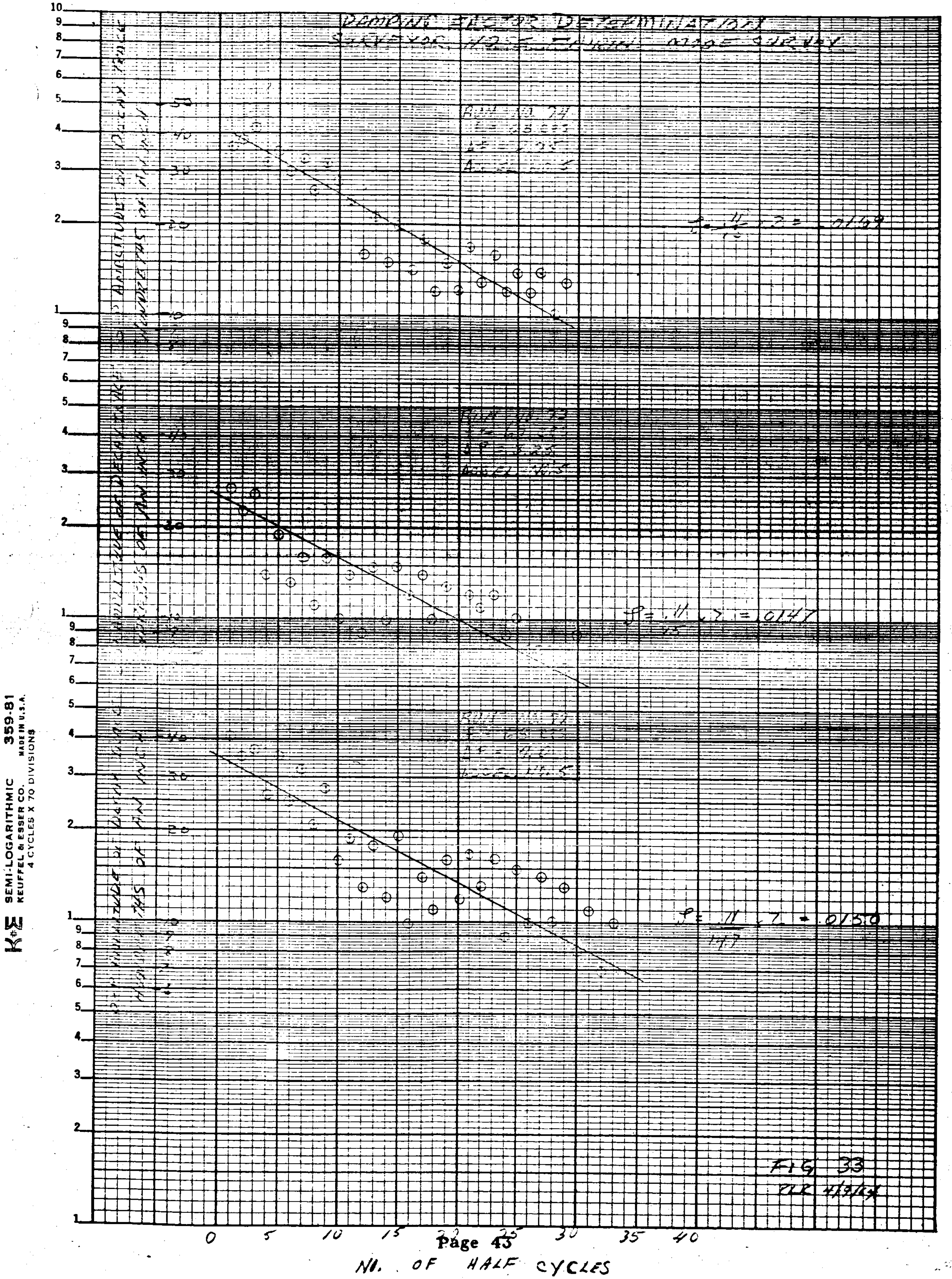
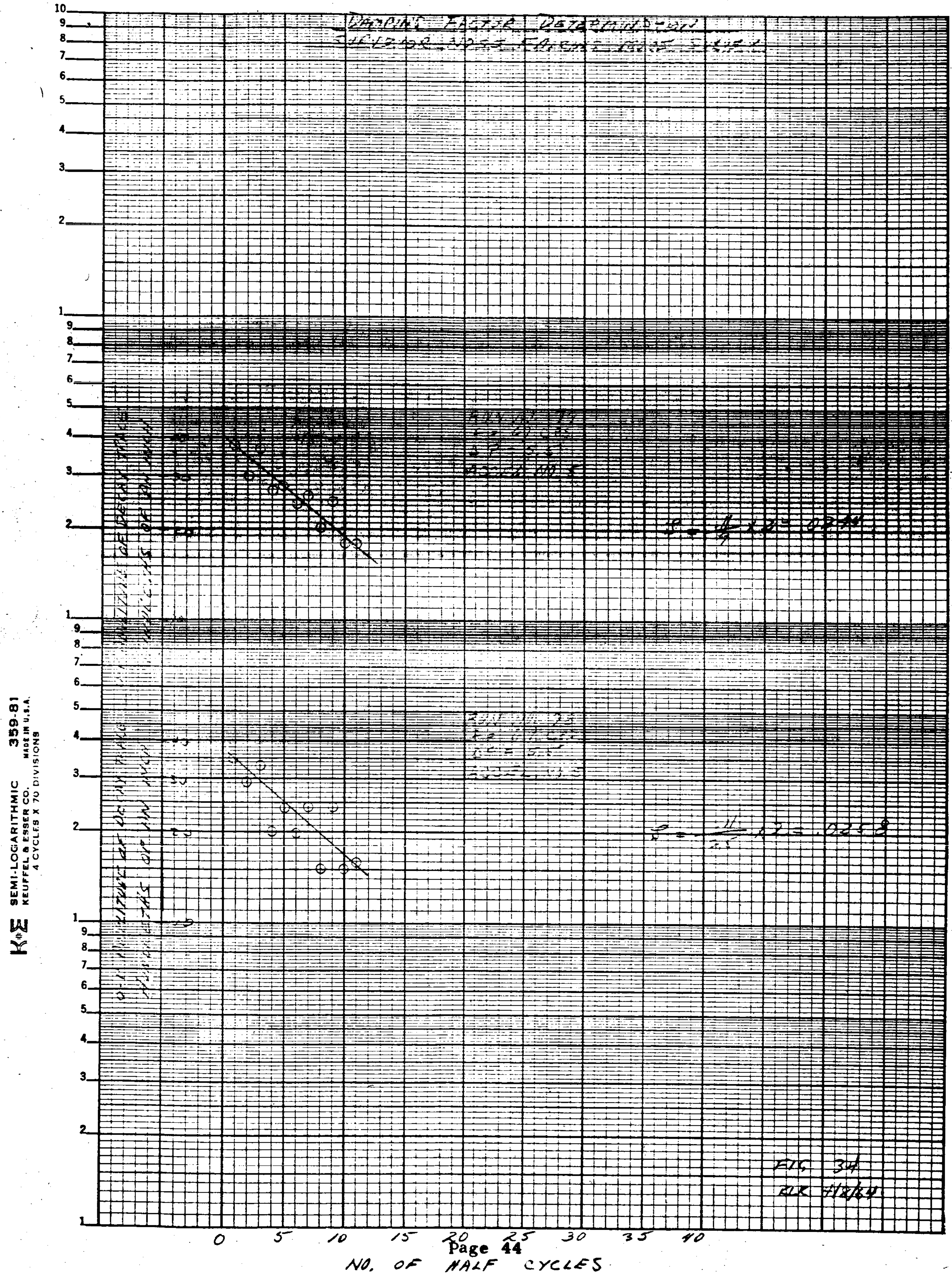


FIG 31

DLR 4/10/64


DAMPING FACTOR DETERMINATION
NO. OF HALF CYCLES
FIG 32
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS


SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
FIG 33
0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES



SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES
FIG 34

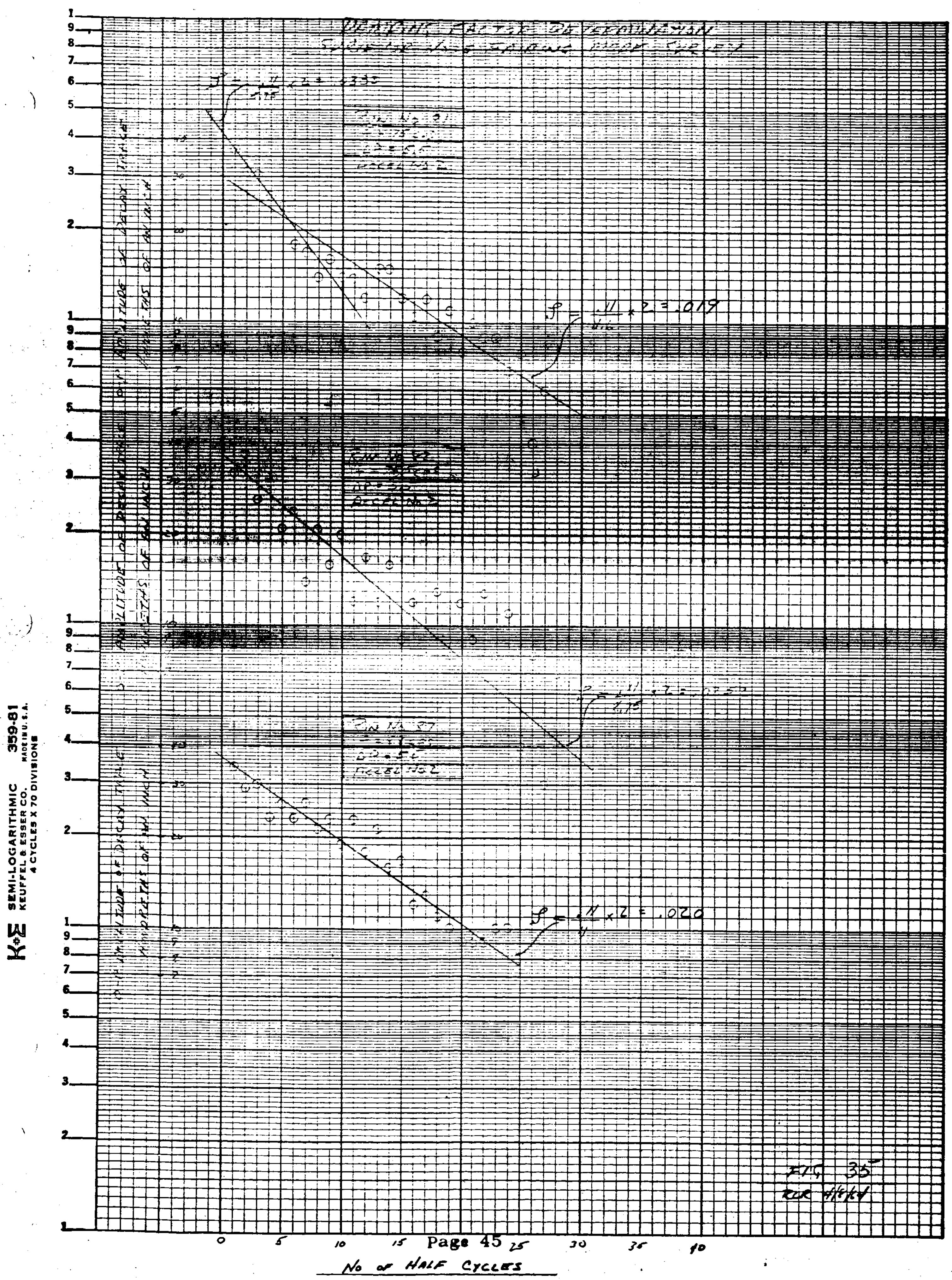
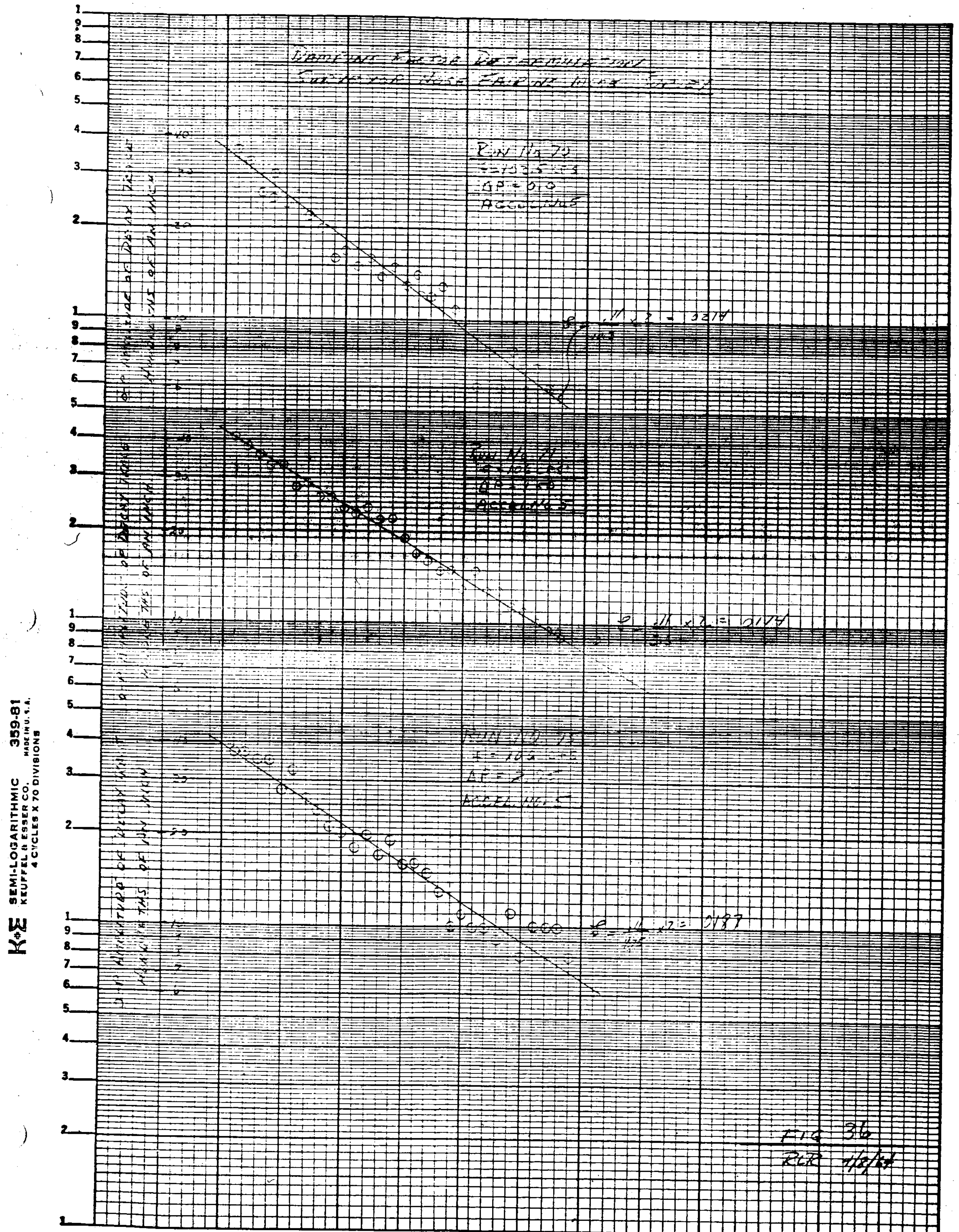
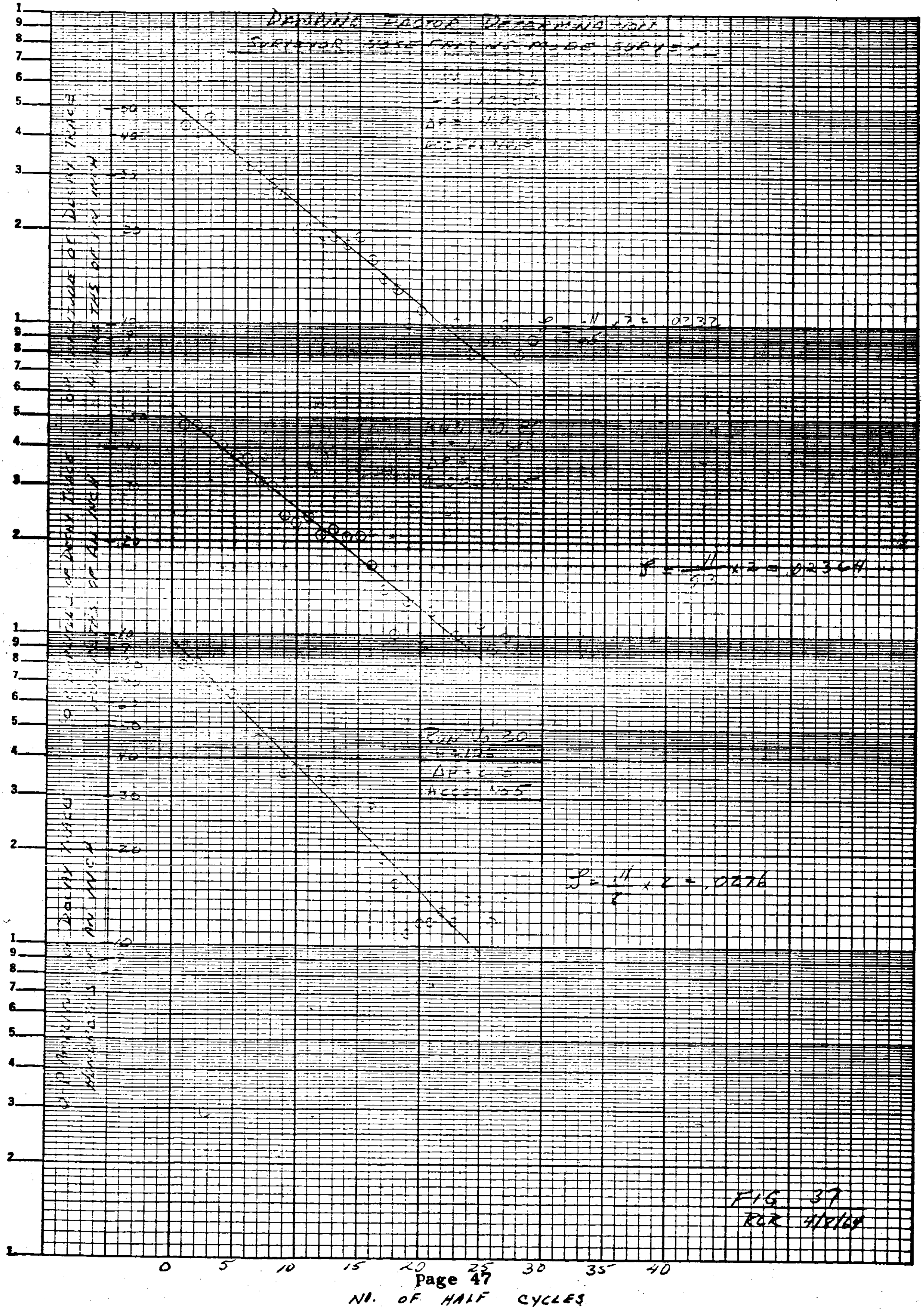
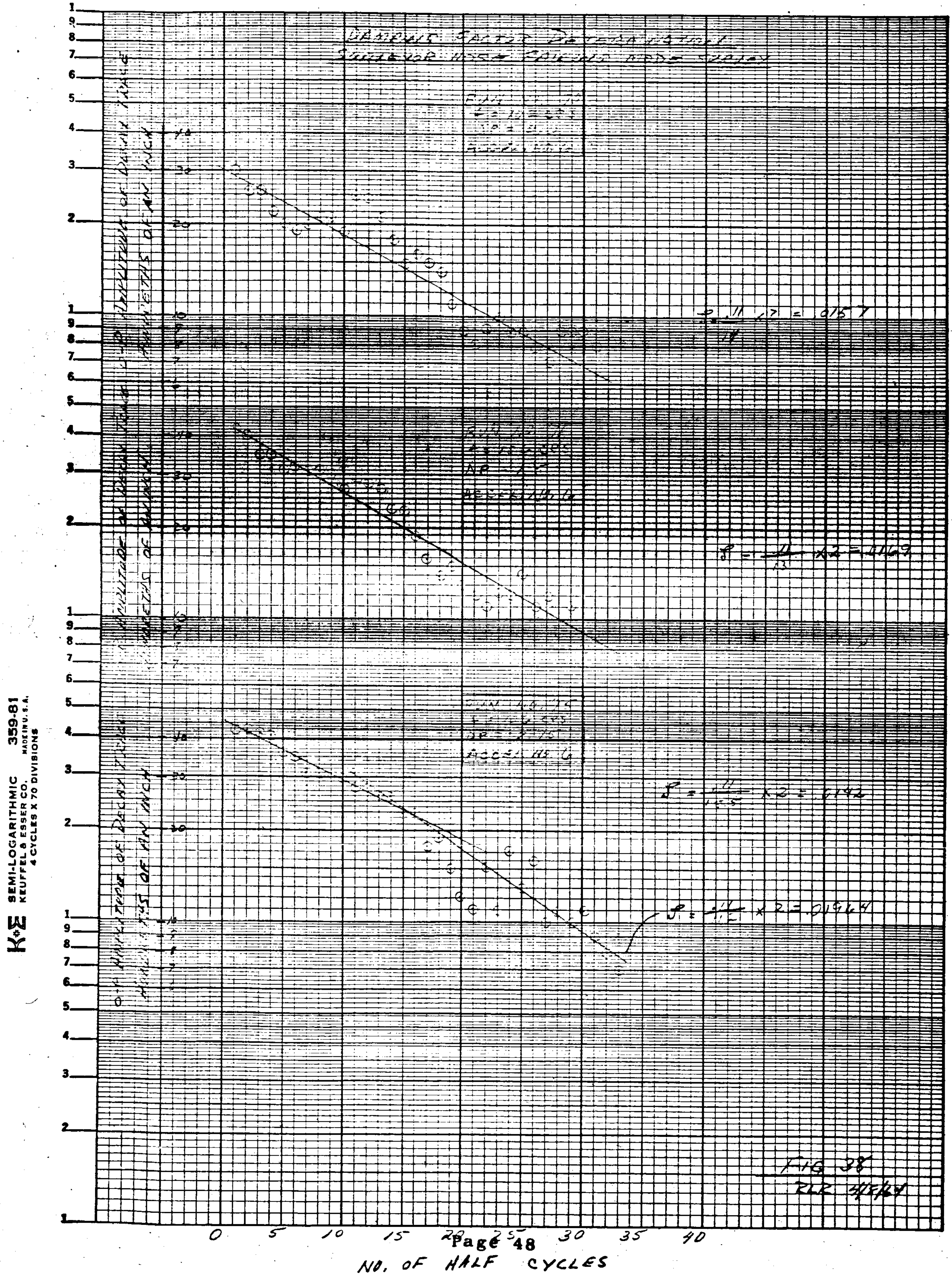

SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
0 5 10 15 20 25 30 35 40
No of HALF CYCLES

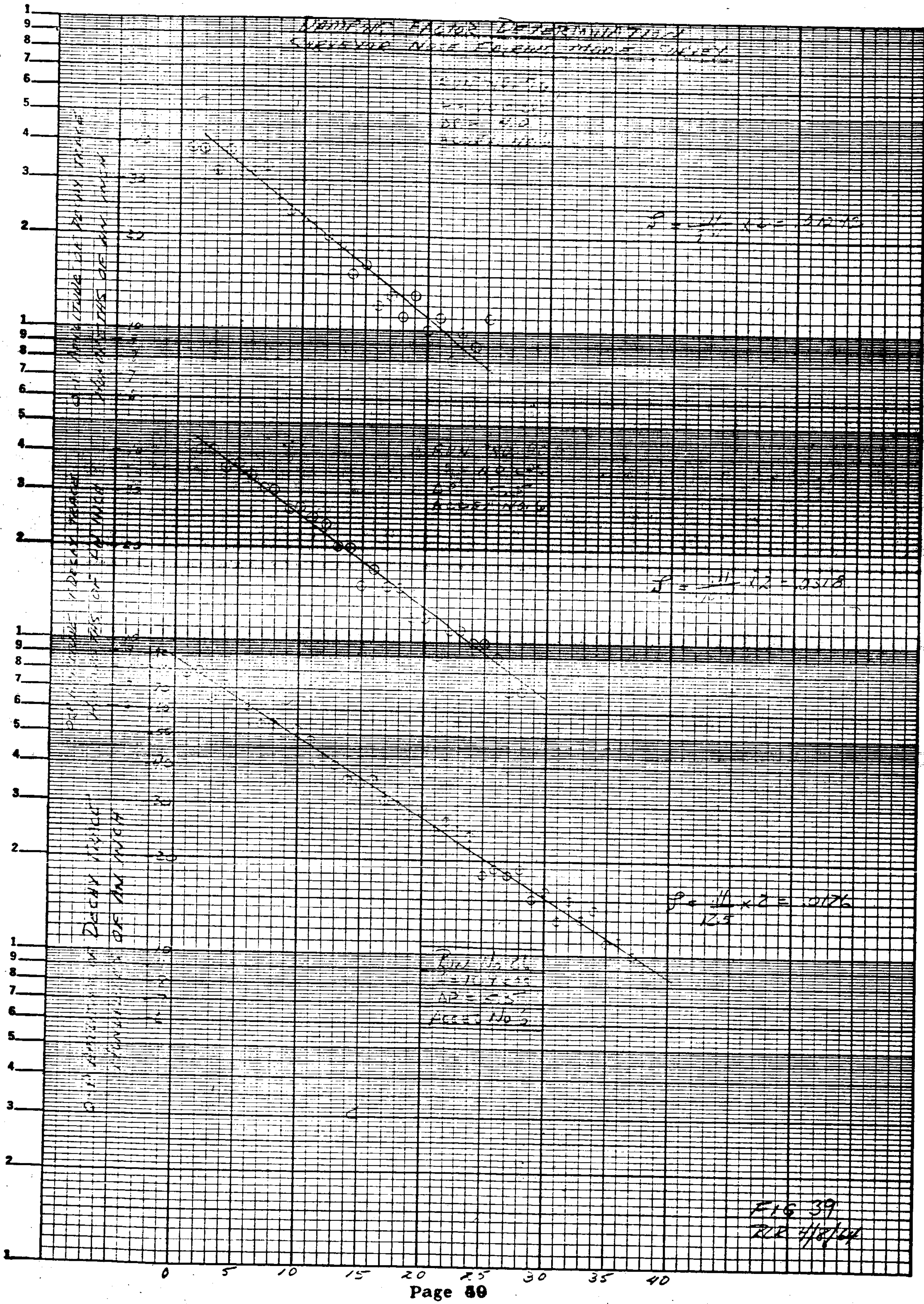
FIG 35


SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
0
5
10
15
20
25
30
35
40
No OF HALF CYCLES
FIG 36

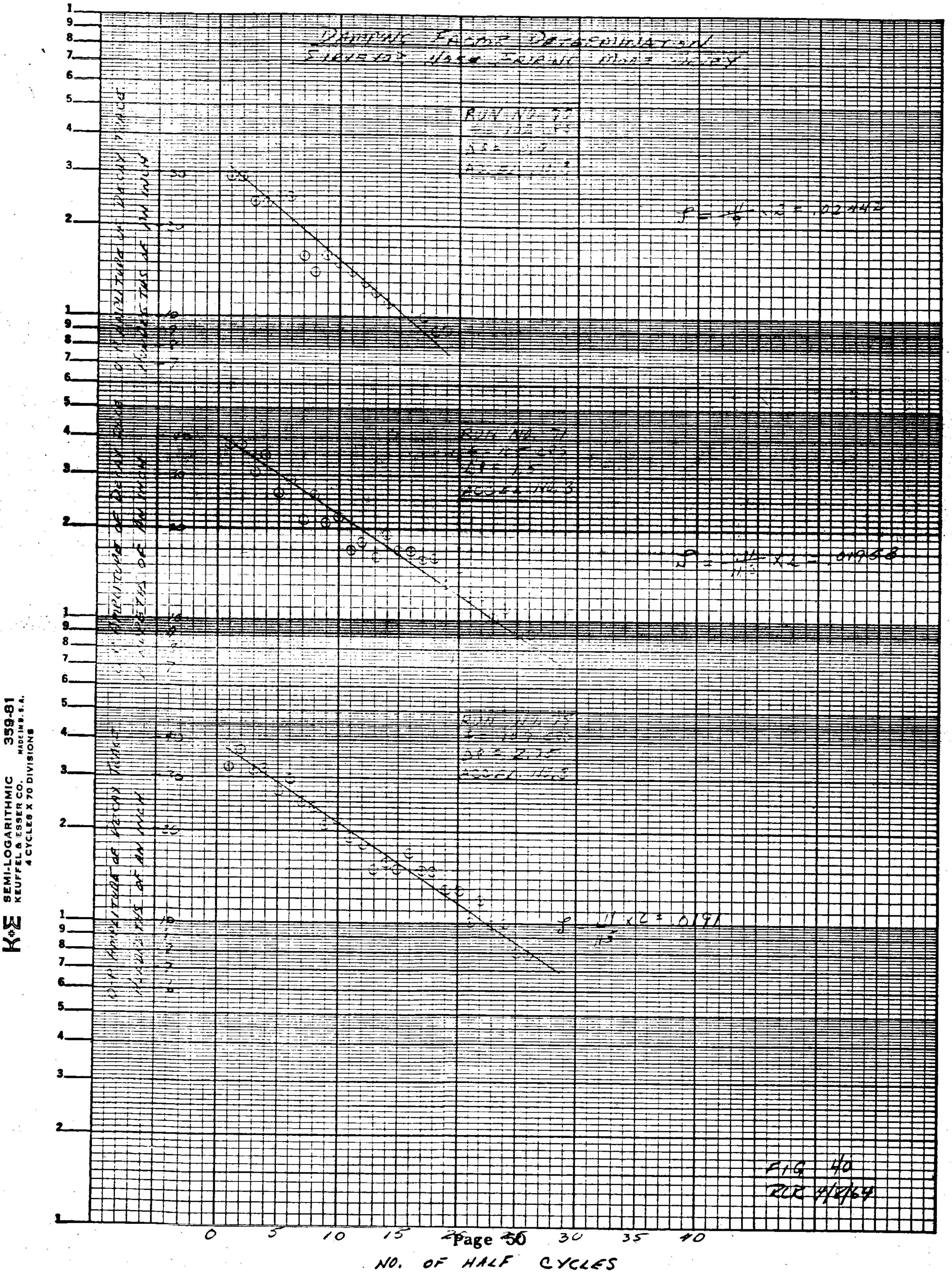


0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES
FIG 37

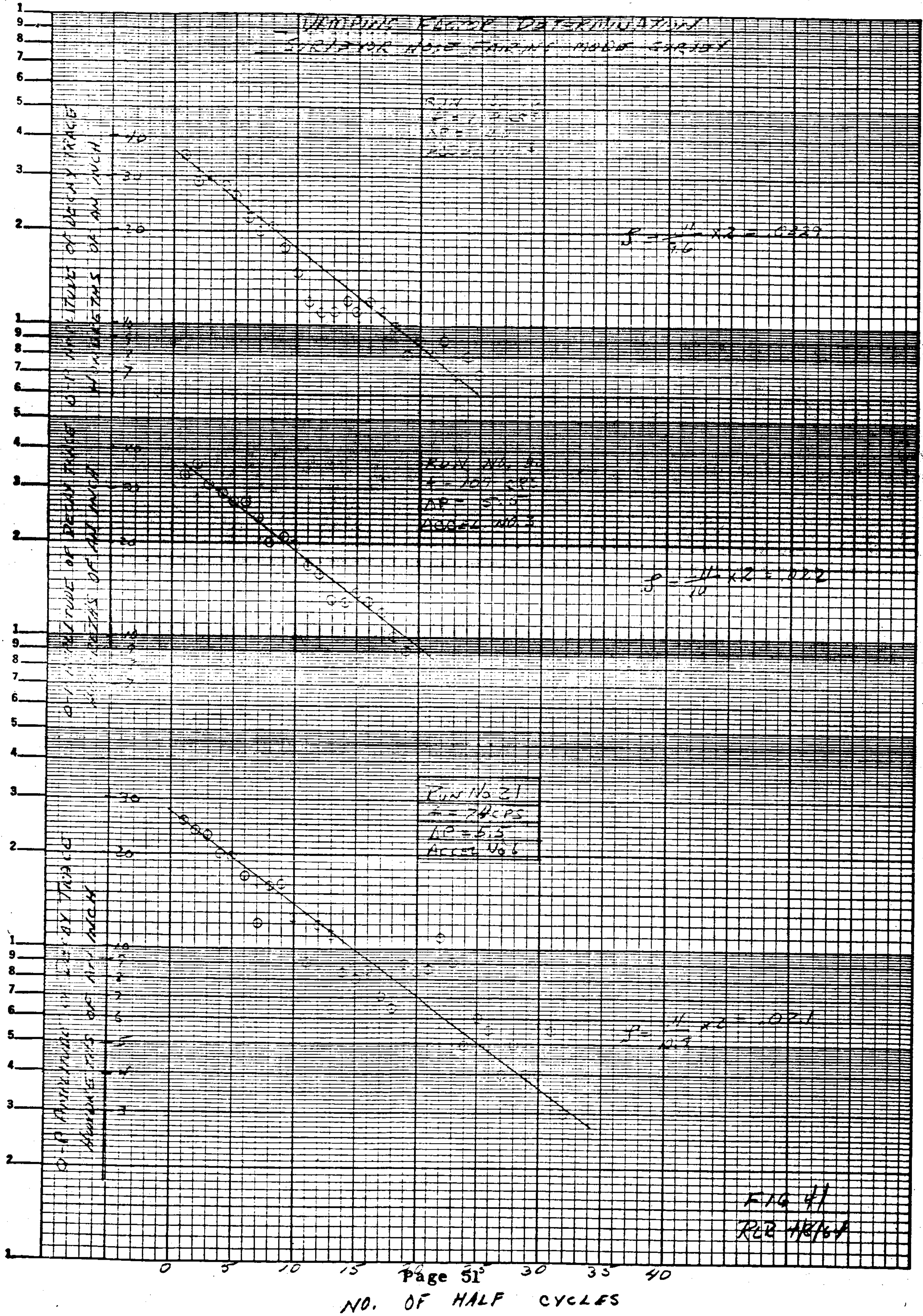

SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES
FIG 38



0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES
FIG 39



SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
0 5 10 15 20 25 30 35 40
NO. OF HALF CYCLES
FIG 40
RCR 4/8/64


DAMPING FACTOR DETERMINATION
Run No. 21
f = 74 CPS
ΔP = 5.5
Accel No 6
NO. OF HALF CYCLES
FIG 41
RLR 4/8/64
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS

EFFECT ON DAMPING DUE TO CHANGE IN PRESSURE

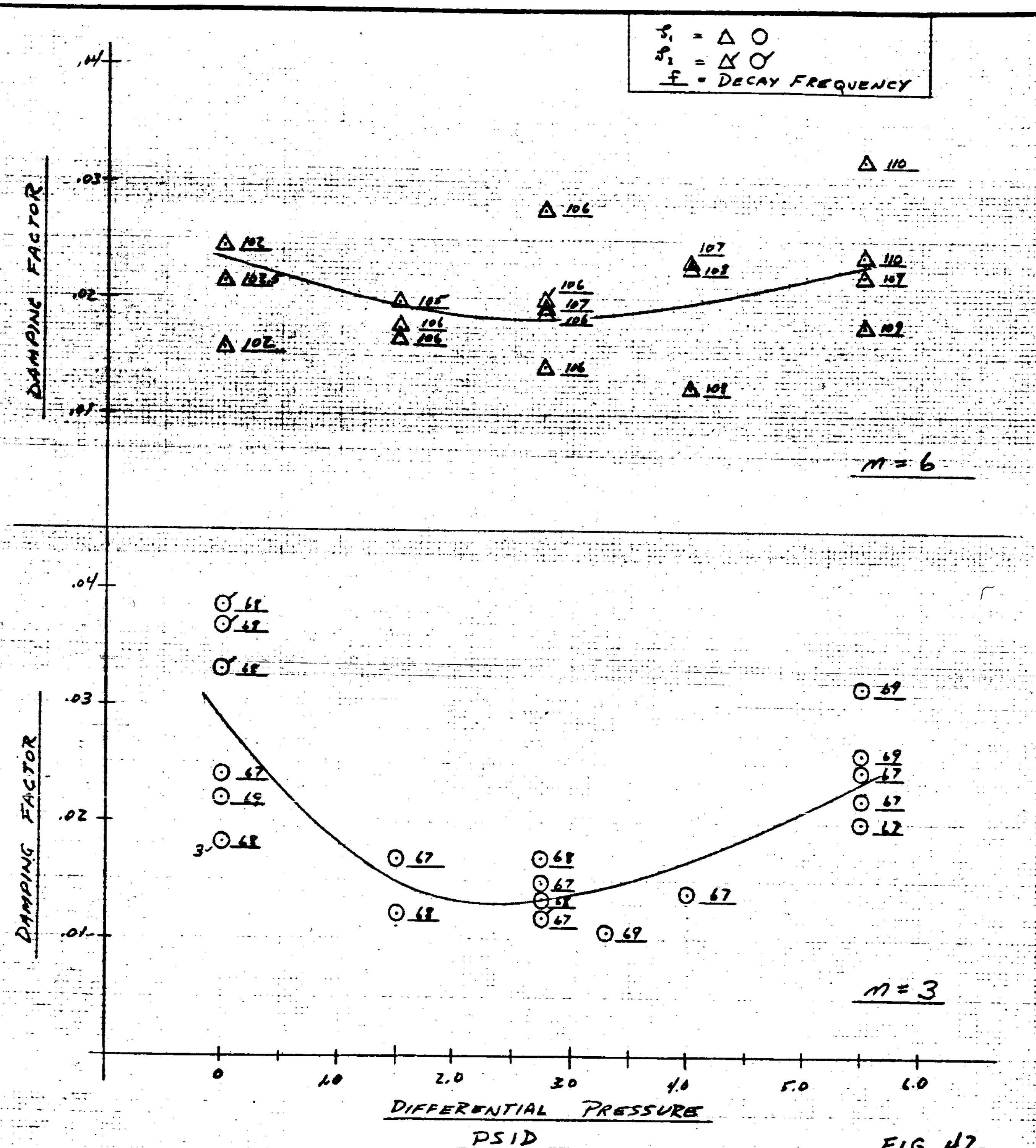
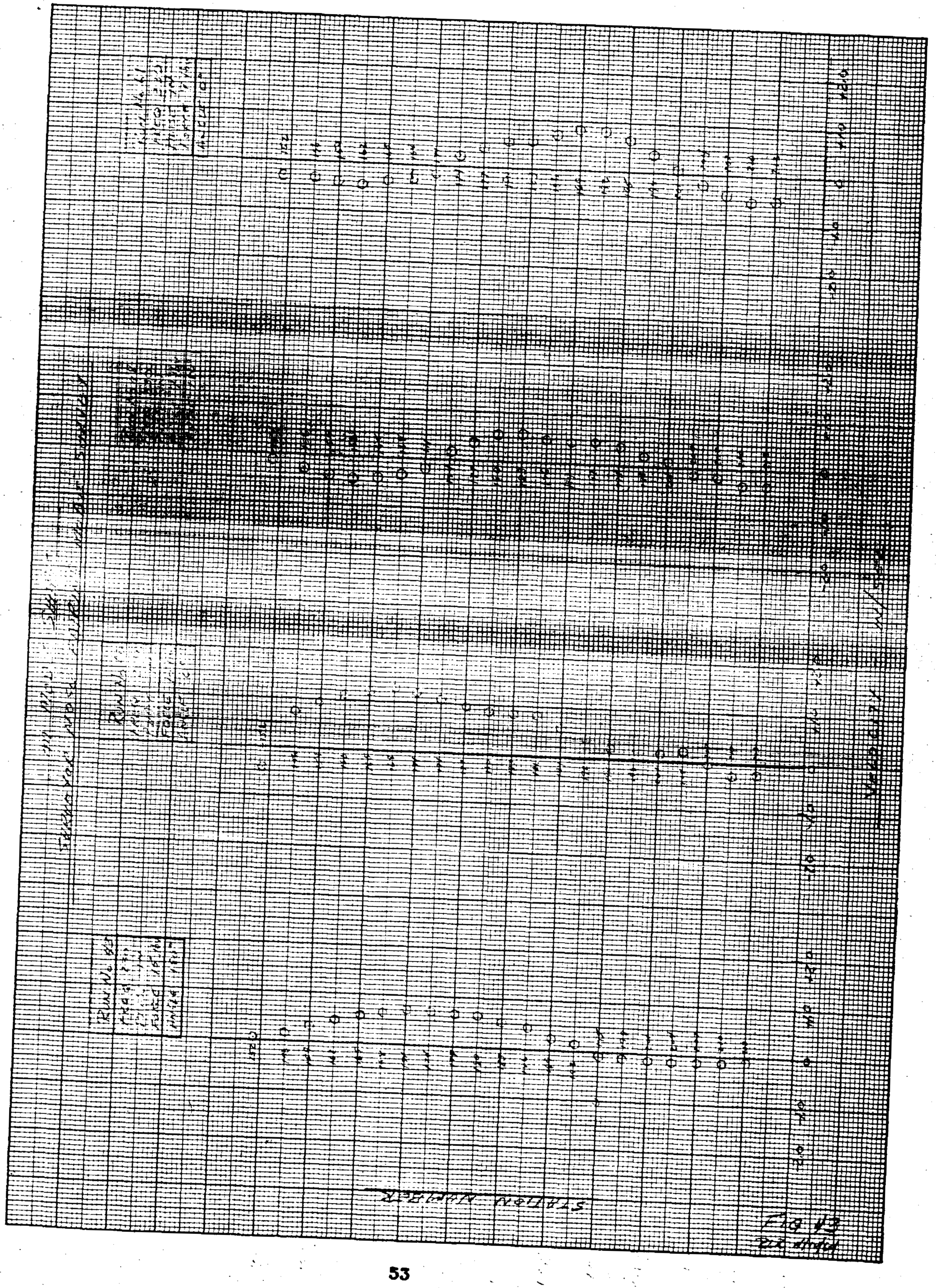
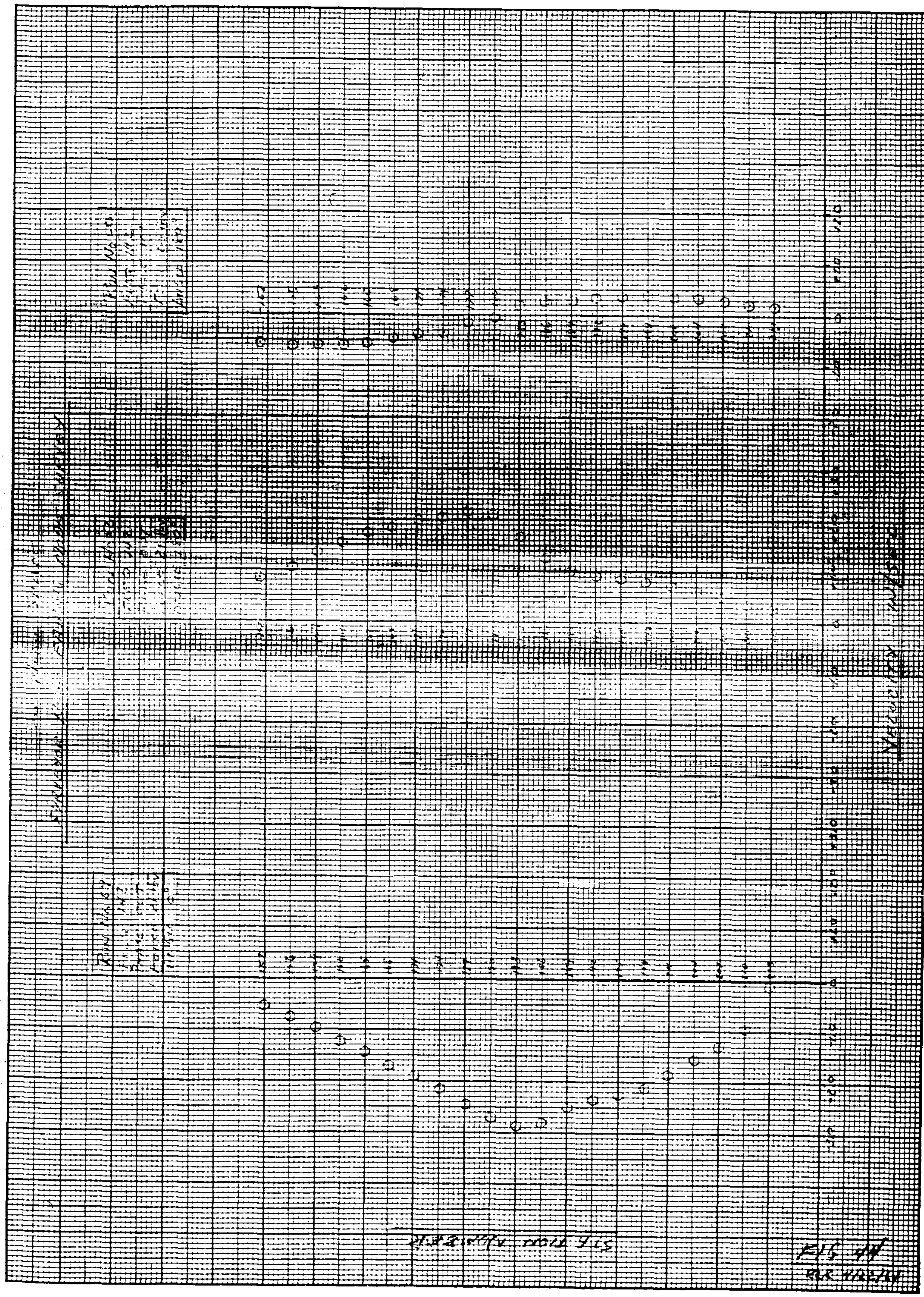
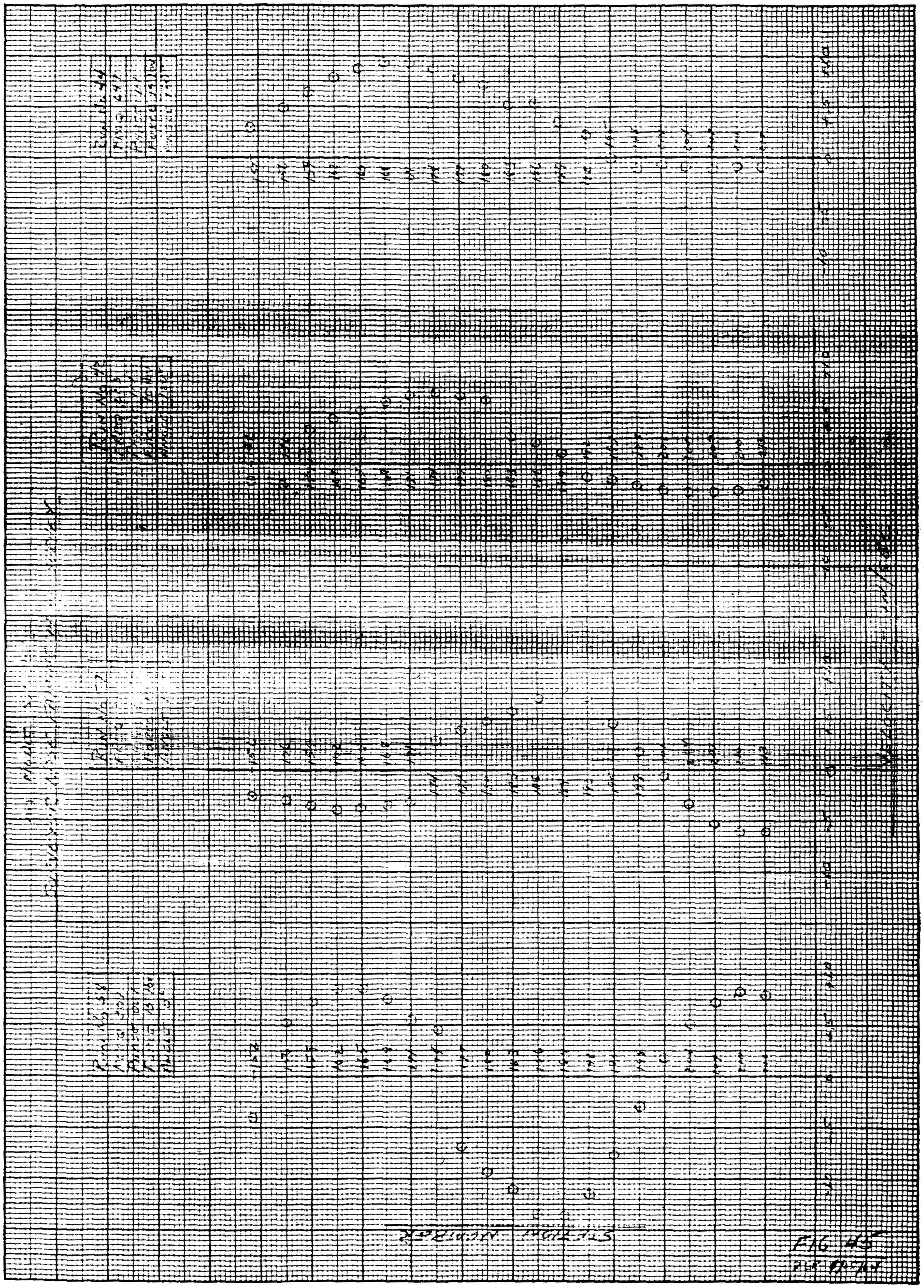


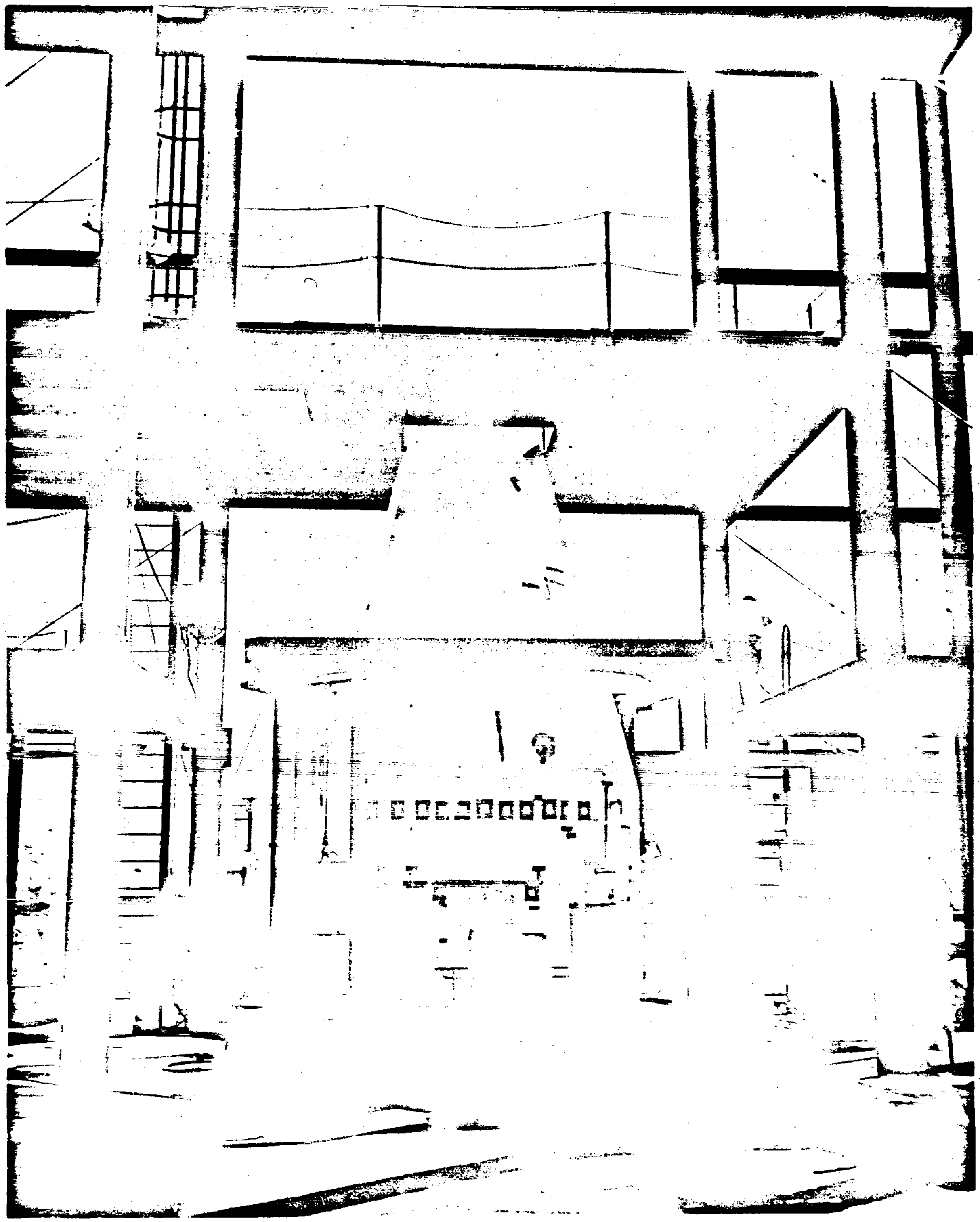
FIG 42

PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
				RLR	4/8/64


STATION NUMBER
Fig #3



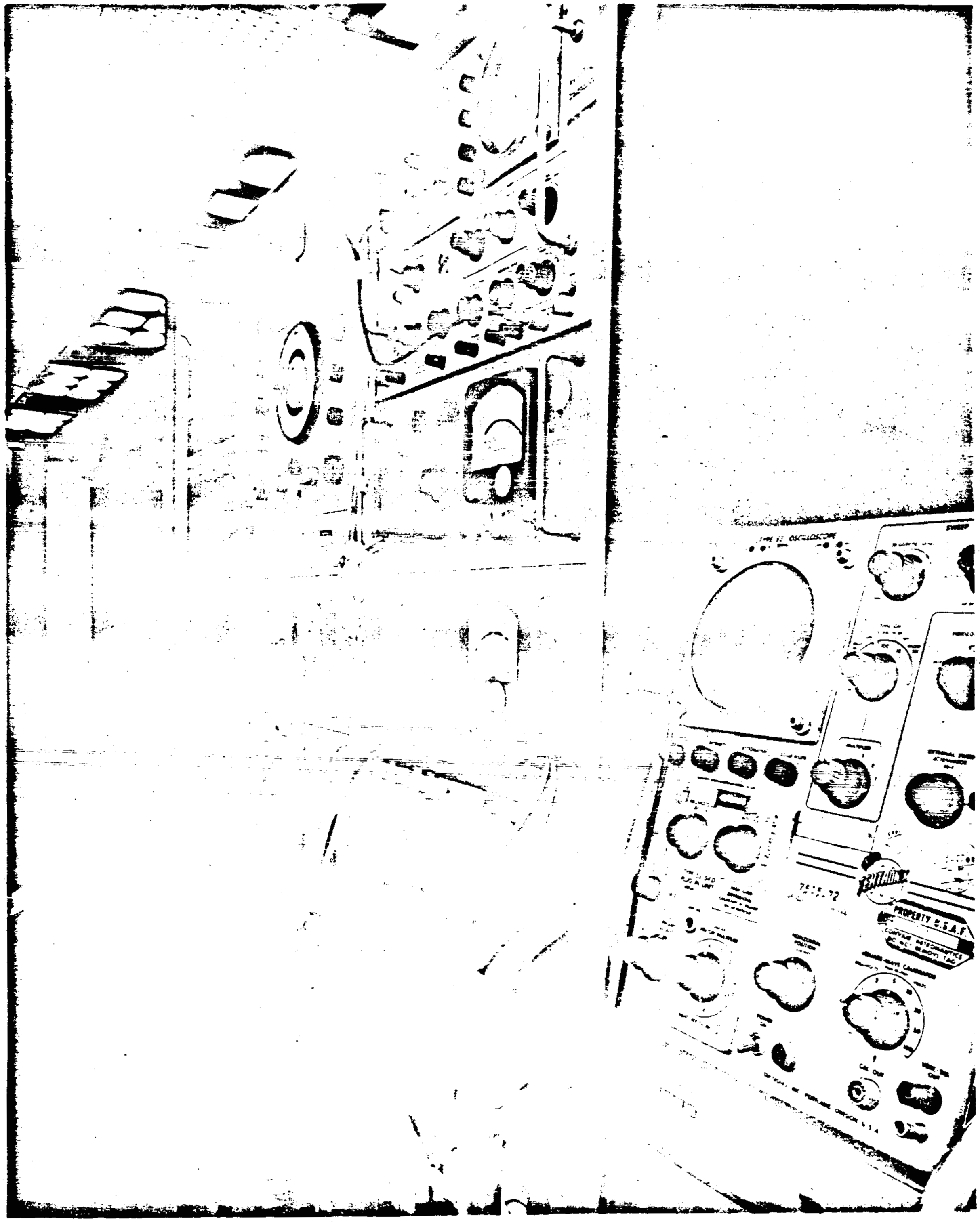




GD/A Photo No. 29987B

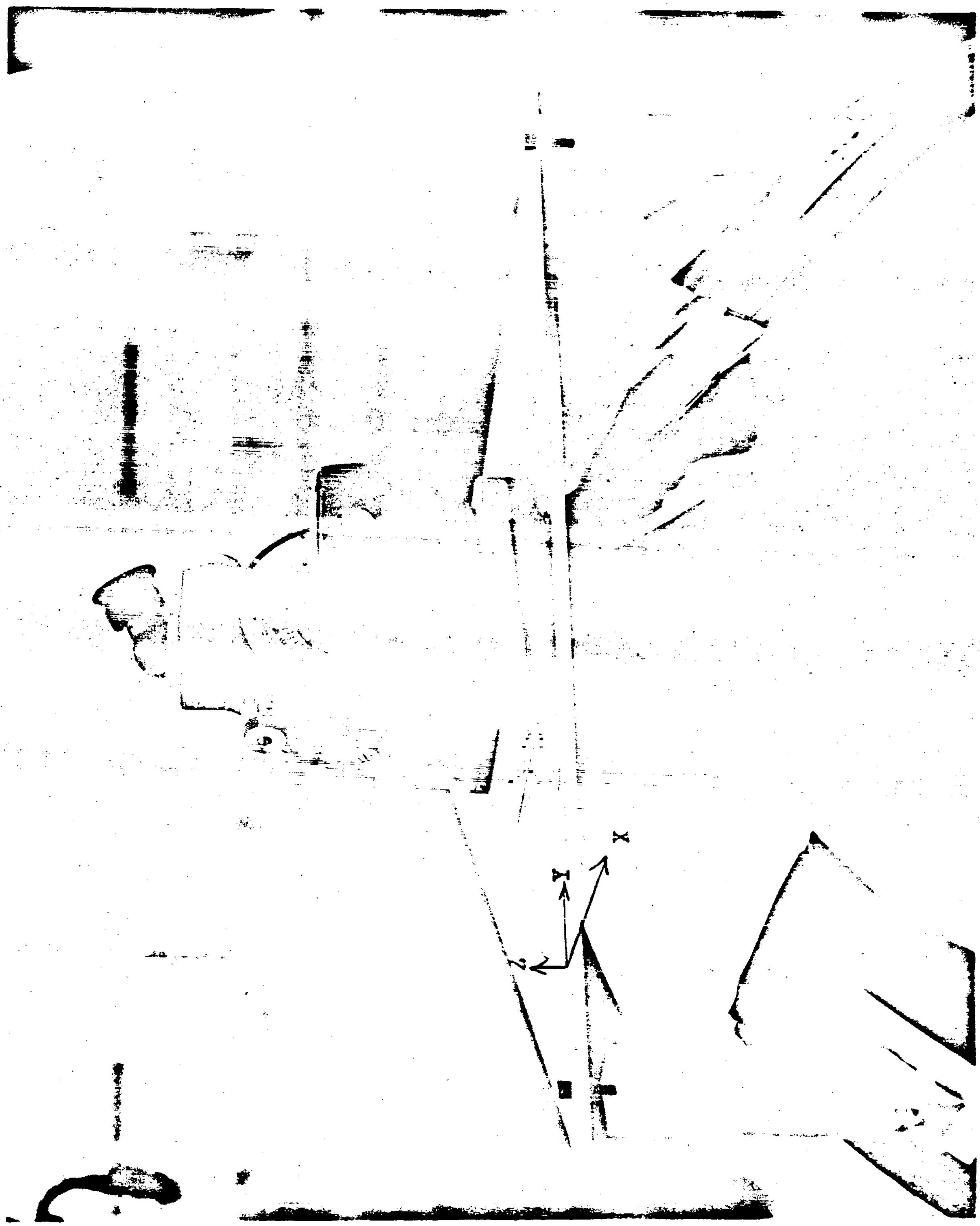
Test Setup
Surveyor Nose Fairing Mode Survey

Figure 46



GD/A Photo No. 30697B

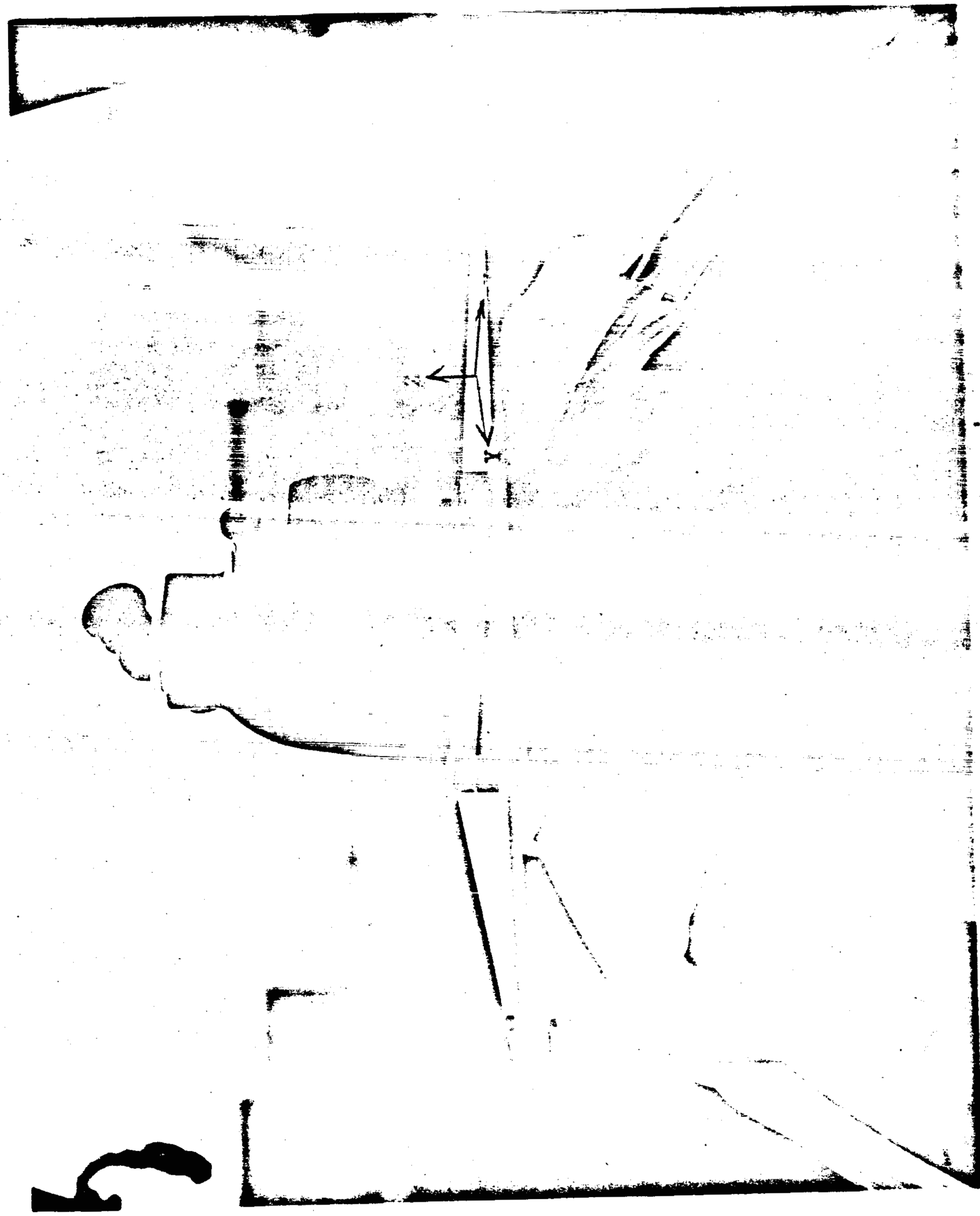
Instrumentation System
Surveyor Nose Fairing Mode Survey



Rotation Measurement - Microptic Clinometer
Y - Z Plane

GD/A Photo No. 30695B

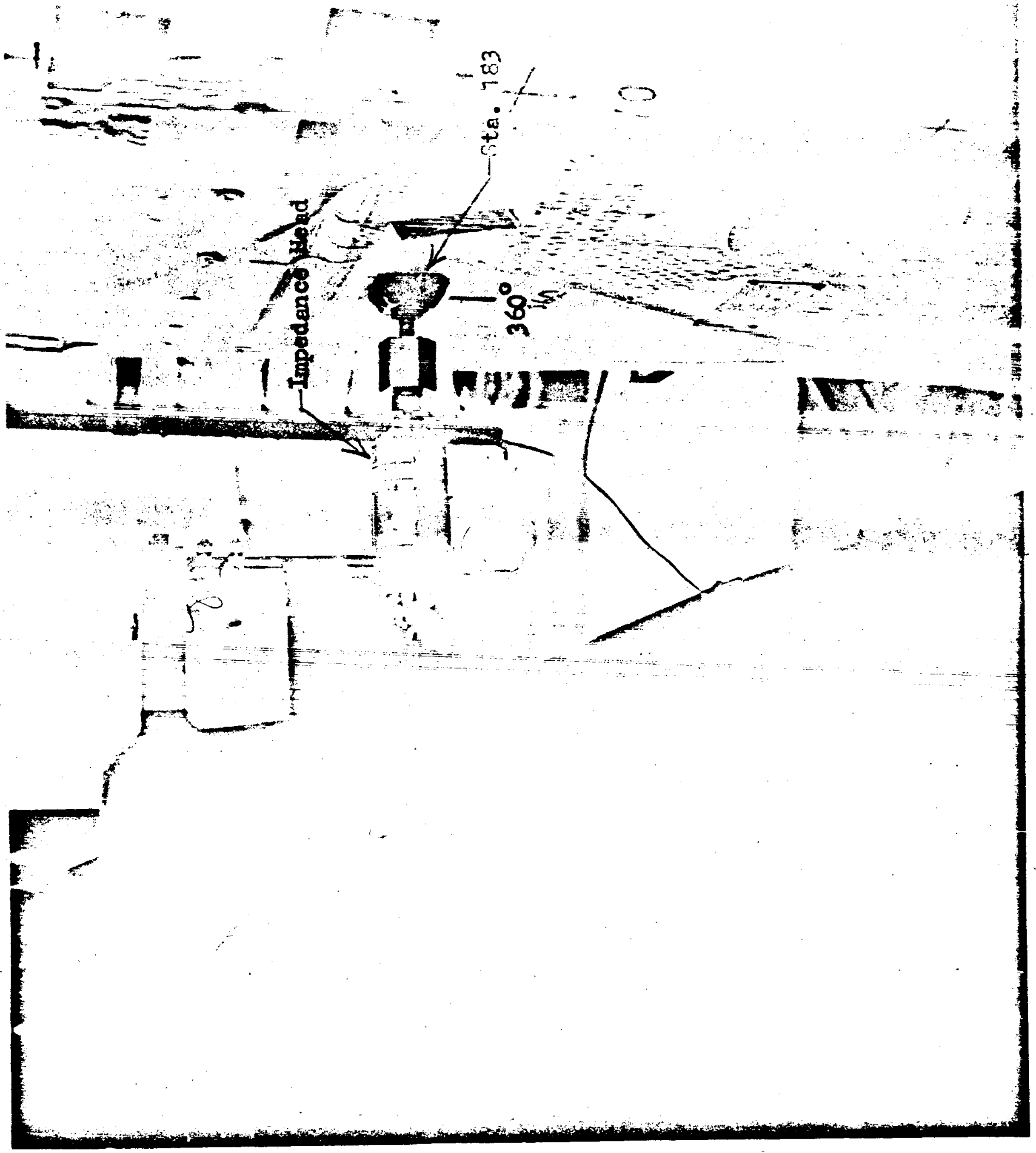
Figure 48



Rotation Measurement - Microptic Clinometer
X - Z Plane

GD/A Photo No. 30696B

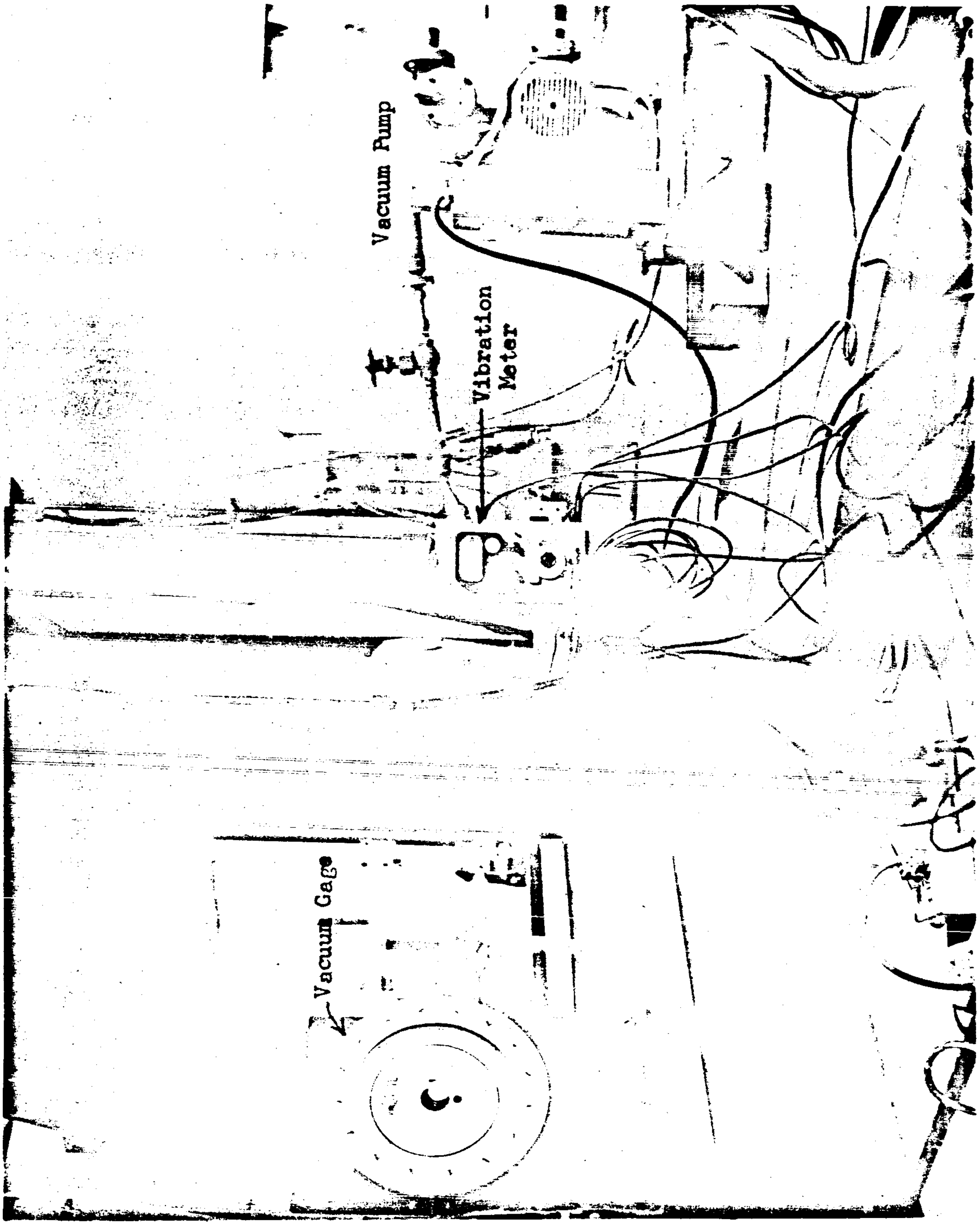
Figure 49



Exciter Attachment and Stinger

GD/A Photo No. 29990B

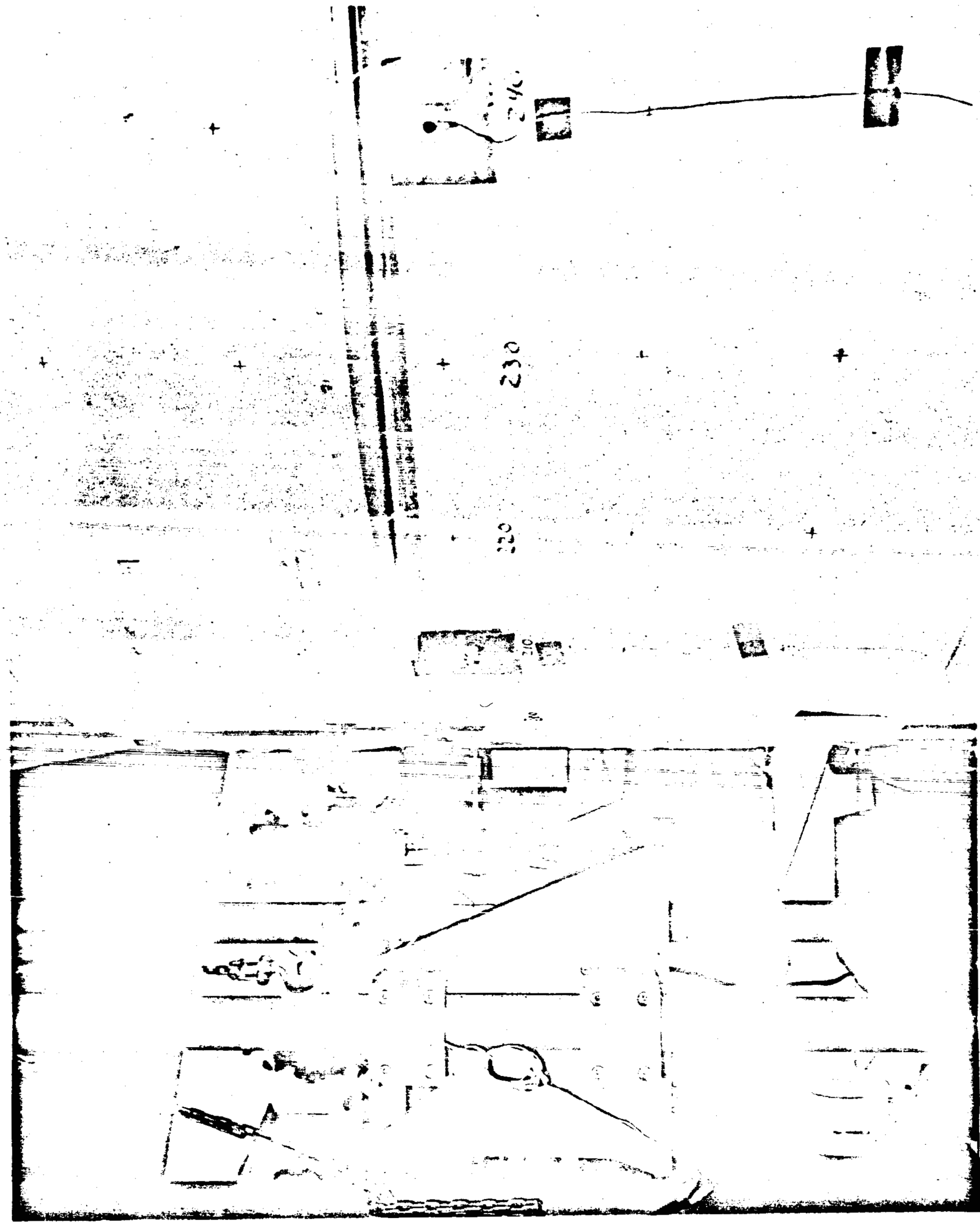
Figure 50



Vacuum Gage - Vibration Meter - Vacuum Pump

GD/A Photo No. 29988B

Figure 51



Exciter Setup

GD/A Photo No. 29989B

Figure 52