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(NASA-CR-101236) DISTRIBUTION OF AERODYNAMIC LOADS ON THE PROJECT MERCURY VEHICLE (TRW Systems, Redondo Beach, Calif.) 67 p

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(6) DISTRIBUTION OF AERODYNAMIC LOADS ON THE PROJECT MERCURY VEHICLE (U), (8)

[U]

(10) by R. H. Adams

(14) Rept. no. TN-59-0000-00304

(11) 17 August 1959,

APR 7 1963

APPROVED: J. R. Sellars

(5) TRW SPACE TECHNOLOGY LABORATORIES, INC.
P.O. Box 95001
Los Angeles 45, California

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DISTRIBUTION OF AERODYNAMIC LOADS ON THE PROJECT MERCURY VEHICLE

Wind tunnel tests were conducted ~~for McDonnell Aircraft~~ by ~~the~~ NASA at their Ames Unitary Plan Wind Tunnel on a 7% scale model of Project Mercury. These tests provided force data, ~~reported in References (1) and (2)~~ and surface pressure data ~~presented herein.~~

Two configurations were tested. One consisted of the ATLAS booster and the MIS capsule; the other consisted of the ATLAS booster and the MIS capsule and escape tower with rocket. The escape rocket, tower and capsule are shown in Figure 1 mounted in position on the ATLAS booster.

Zero angle of attack pressure distributions for Mach numbers of M = 1.55, 2.00, 2.30, 3.02, and 3.49 on the capsule without tower are shown in Figures 2 and 3. Comparable pressure distributions for the vehicle with tower are shown in Figures 4 through 8. Note that the tower-off plots are presented as single test points and the tower-on plots are presented as a band of data. Test data revealed that with the tower off, at $\alpha = 0^{\circ}$, the circumferential variation of the pressure coefficient, C_p, at a particular axial station was within experimental error (within $C_p = \pm .02$). However, the tower-on data showed a random circumferential variation of the pressure coefficient within the bands shown in Figures 4 through 8, evidently due to the high degree of turbulence caused by the tower. Another notable effect on the $\alpha = 0^{\circ}$ pressure distribution, caused by the presence of the tower, is the increase of C_p at station 366 along with a decrease of C_p at station 370. That is, with the tower off a peak pressure, quite normal for supersonic flow, occurs on the face of the step at station 370. With the tower on, a peak pressure occurs 4 inches

ahead of the step at station 366 and the pressure coefficient on the face is very nearly zero. Shadowgraphs revealed a high degree of subsonic turbulence in this region. Shifting of the peak C_p is evidently due to the feedback of pressure through this subsonic layer. The zero angle of attack pressure distributions over the escape rocket (essentially a spiked cylinder with a flange) are shown in Figure 9.

The circumferential distributions of pressure coefficients for various axial stations on the capsule are shown in Figures 10 through 27 for the vehicle without the tower at M = 1.55 (approximately maximum dynamic pressure) and $\alpha = 2^{\circ}, 4.1^{\circ}, 6.1^{\circ}$. The corresponding plots for the tower-on configuration for various axial stations on the escape rocket and the capsule are shown in Figures 28 through 57.

Integrating the circumferential pressure distributions led to the normal force distributions shown in Figures 58 through 60. Comparison of Figures 58 and 59 (the tower-off and tower-on configurations, respectively) reveals that there is a higher degree of linearity of normal force for the tower-on configuration than there is for the tower-off configuration, particularly on the cone frustrum of the capsule (station 380 to 450). This effect is attributed to the fact that for the tower-on configuration the capsule is immersed in a turbulent wake which is relatively unaffected by angle of attack whereas without the tower the blunt nose and step of the capsule are directly exposed to the airstream, no doubt resulting in separation and vorticity effects downstream. The normal force distribution over the escape rocket is shown in Figure 60 to be fairly linear. Note that the total normal force (obtained by integrating under the curves) of Figure 58 and the total normal force of Figures 59 and 60 are approximately equal as was revealed in the normal force data of the force tests reported in Reference (2).

REFERENCES:

(1) GM-59-7540-59; "Measured Aerodynamic Force Characteristics on Project Mercury - Addendum I," R. H. Adams to D. C. Bakeman, 21 May 1959 - Confidential

(2) GM-59-7540.3-59; "Measured Aerodynamic Force Characteristics on Project Mercury - Addendum II," R. H. Adams to D. C Bakeman, 3 June 1959 - Confidential

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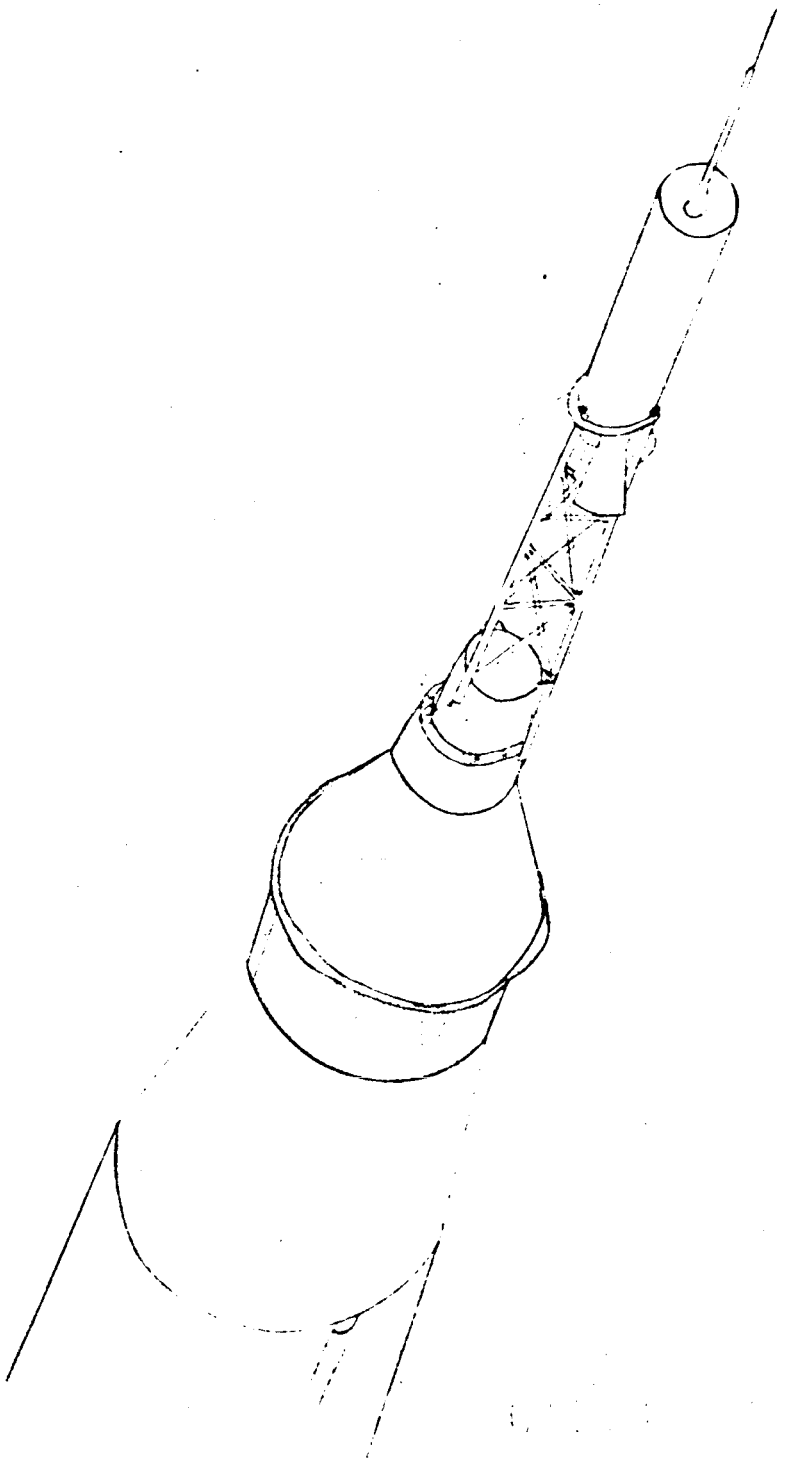

ESCAPE ROCKET, TOWER AND MIS CAPSULE
MOUNTED ON THE ATLAS BOOSTER

Figure 1

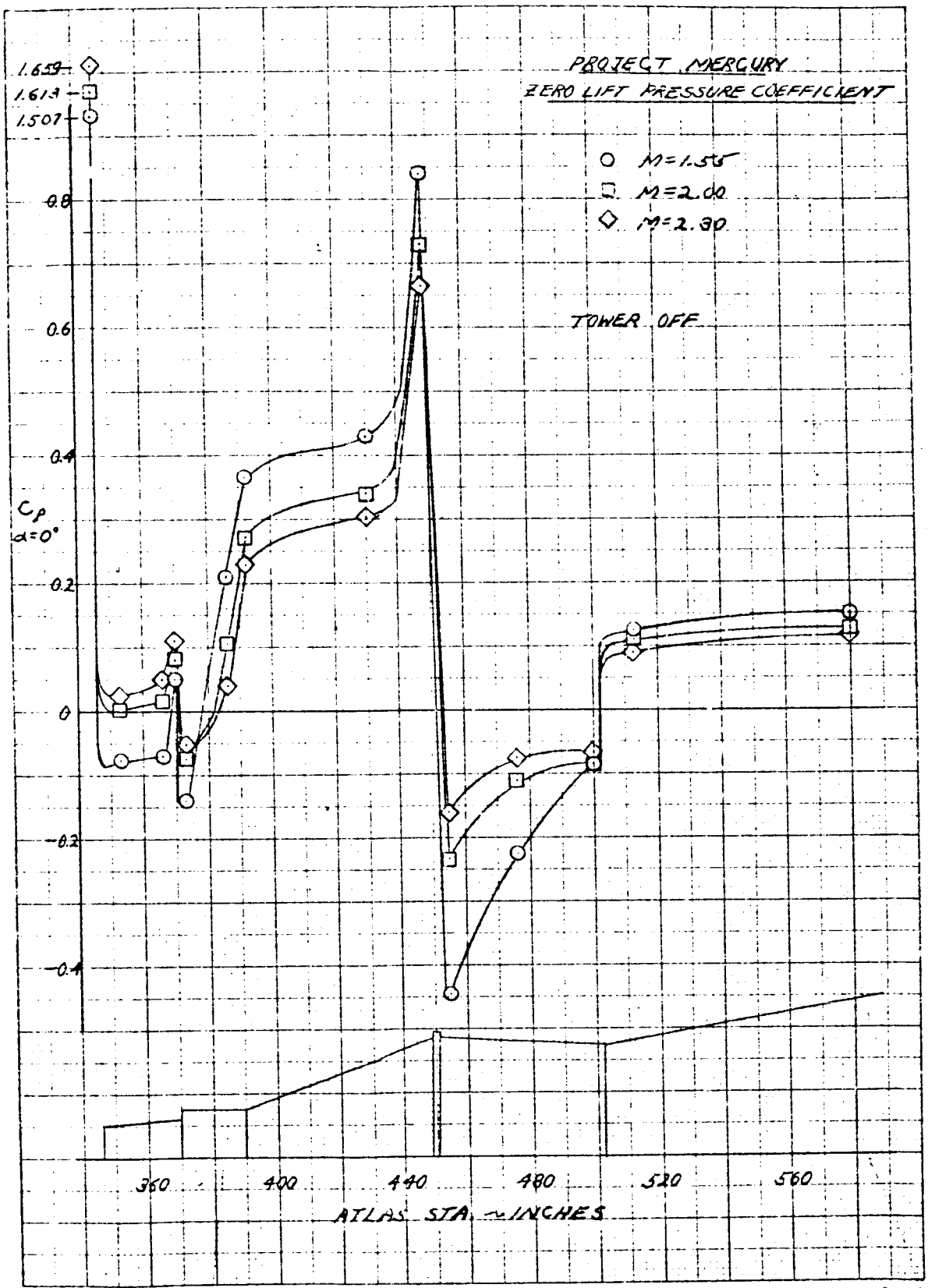
PROJECT MERCURY
ZERO LIFT PRESSURE COEFFICIENT
M=1.55
M=2.00
M=2.30
TOWER OFF
1.659
1.613
1.507
0.8
0.6
0.4
0.2
0
-0.2
-0.4
C_p
$\alpha=0°$
360
400
440
480
520
560
ATLAS STA. ~ INCHES

Figure 2

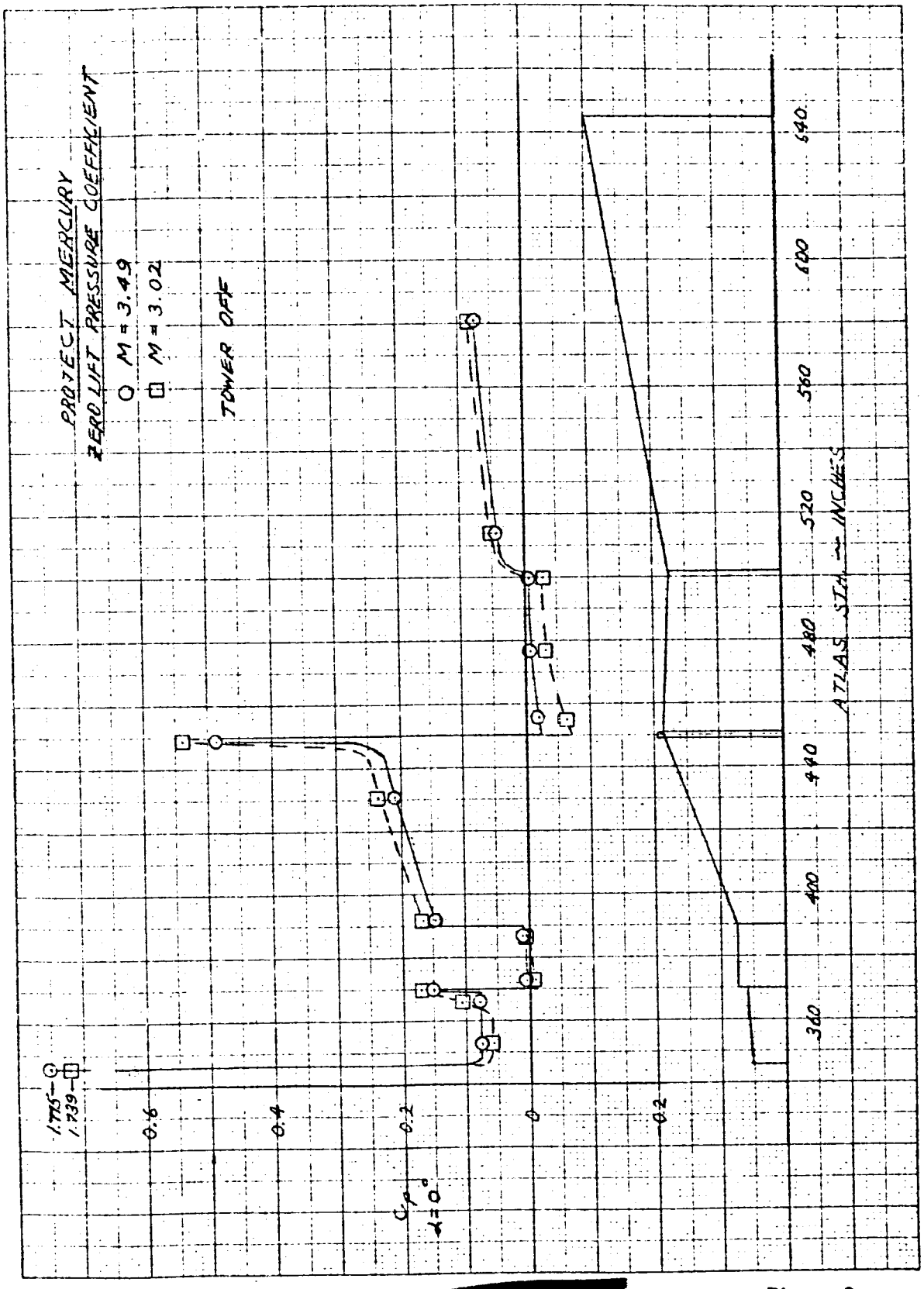
PROJECT MERCURY
ZERO LIFT PRESSURE COEFFICIENT
○ M = 3.49
□ M = 3.02
TOWER OFF
1.775
1.739
0.6
0.4
0.2
0
-0.2
C_p
$\alpha = 0°$
360
400
440
480
520
560
600
640
ATLAS STA. ~ INCHES

Figure 3

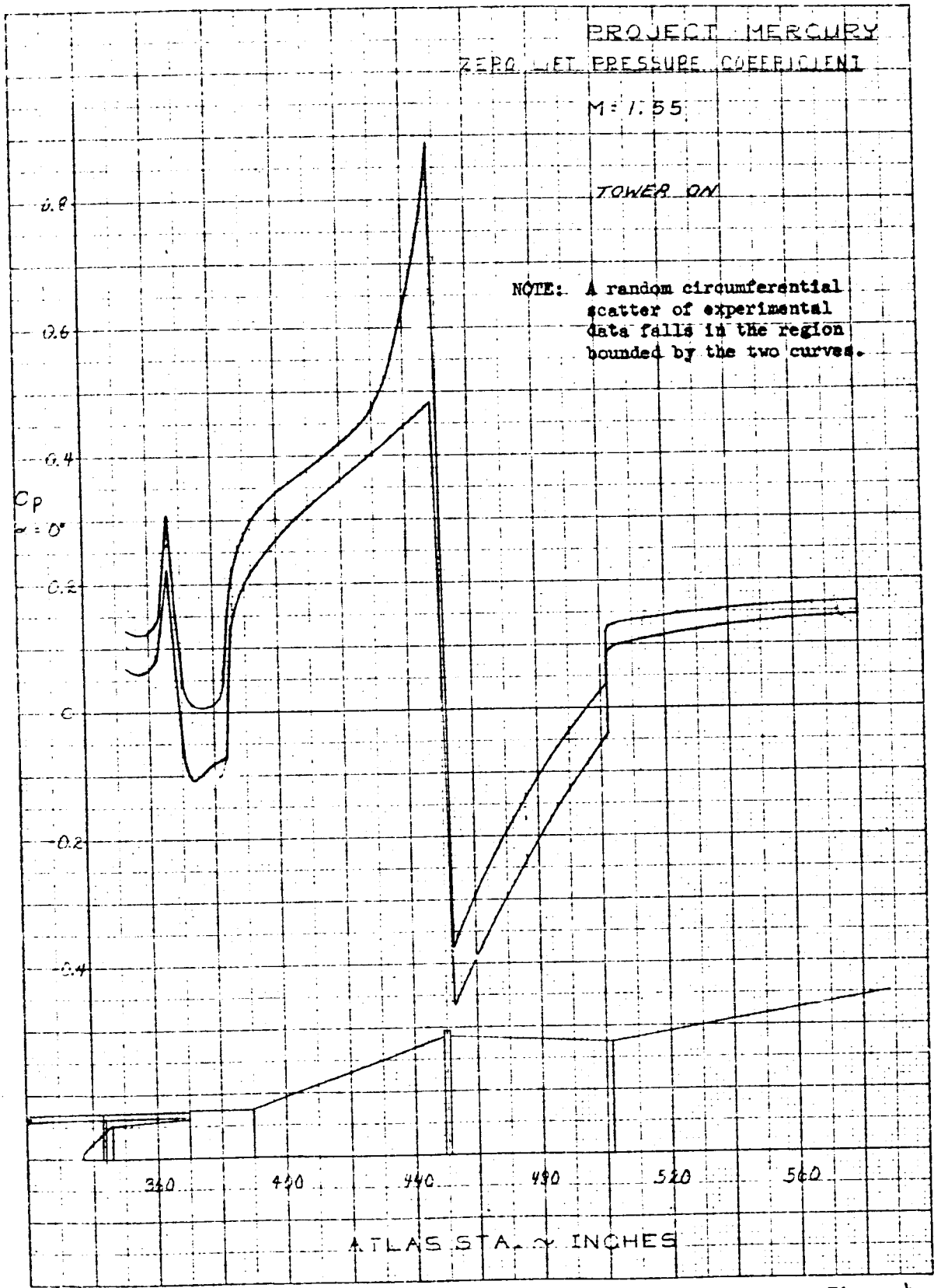

Figure 4

[redacted]

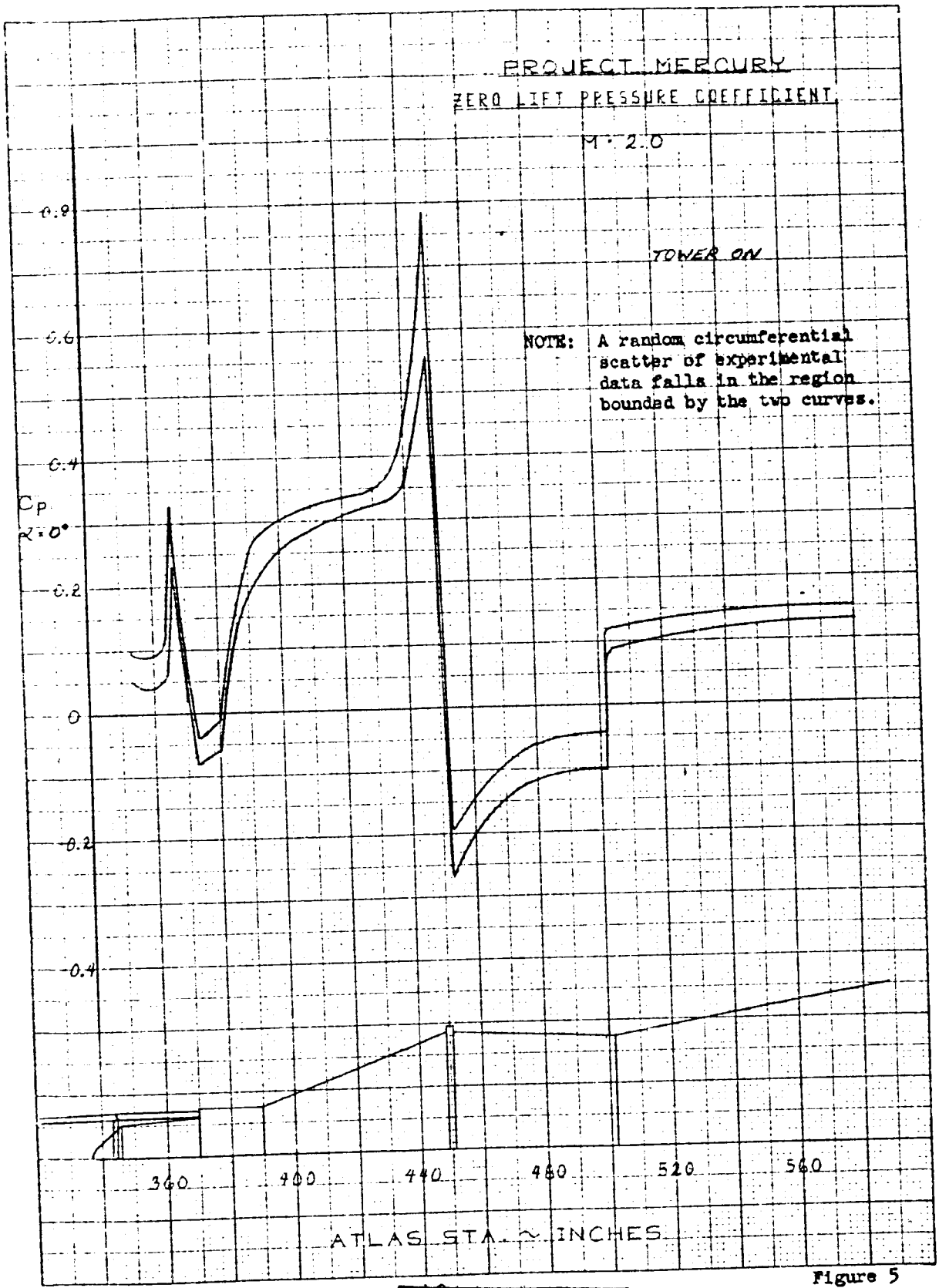

Figure 5

[redacted]

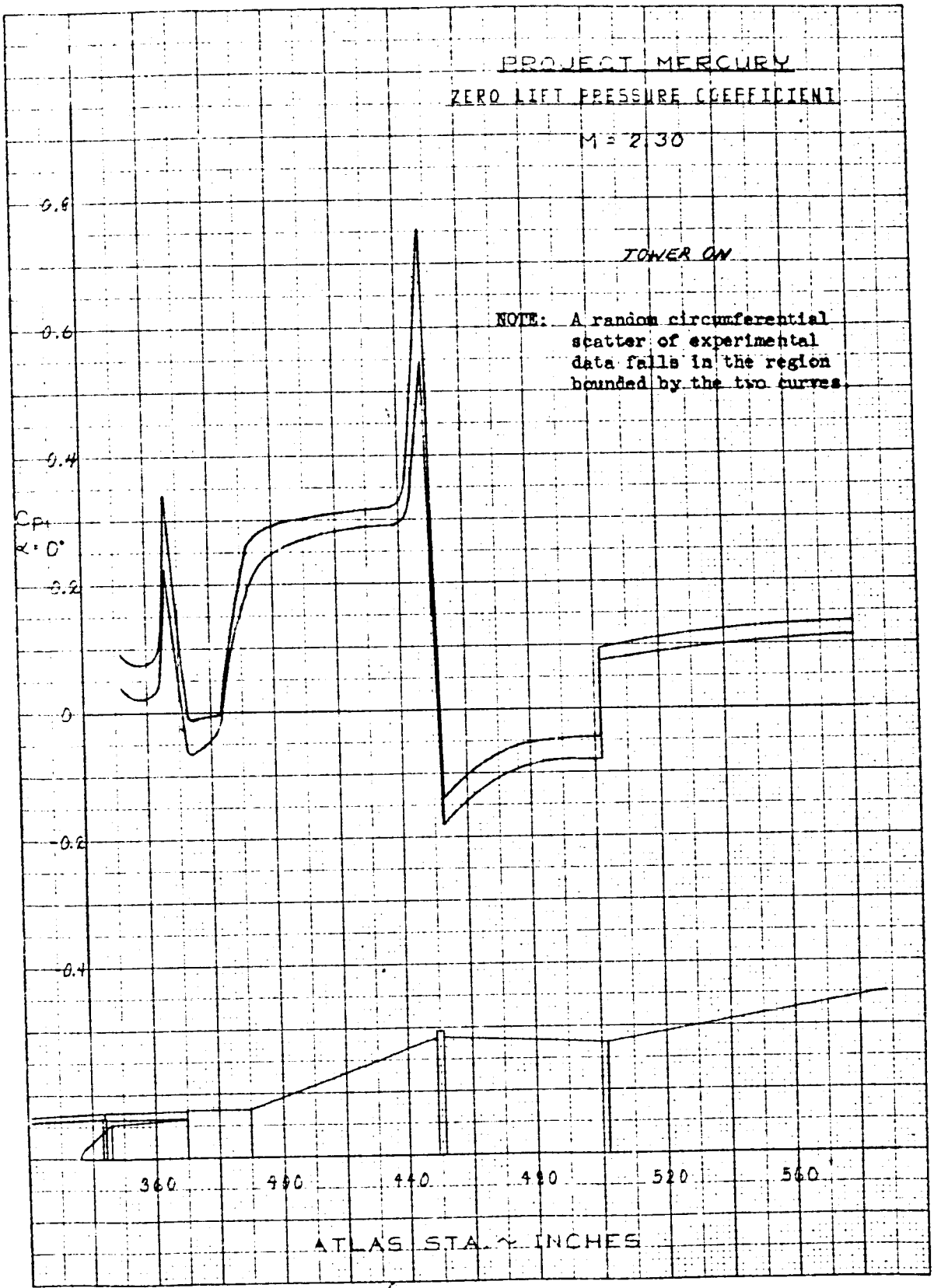

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Figure 6

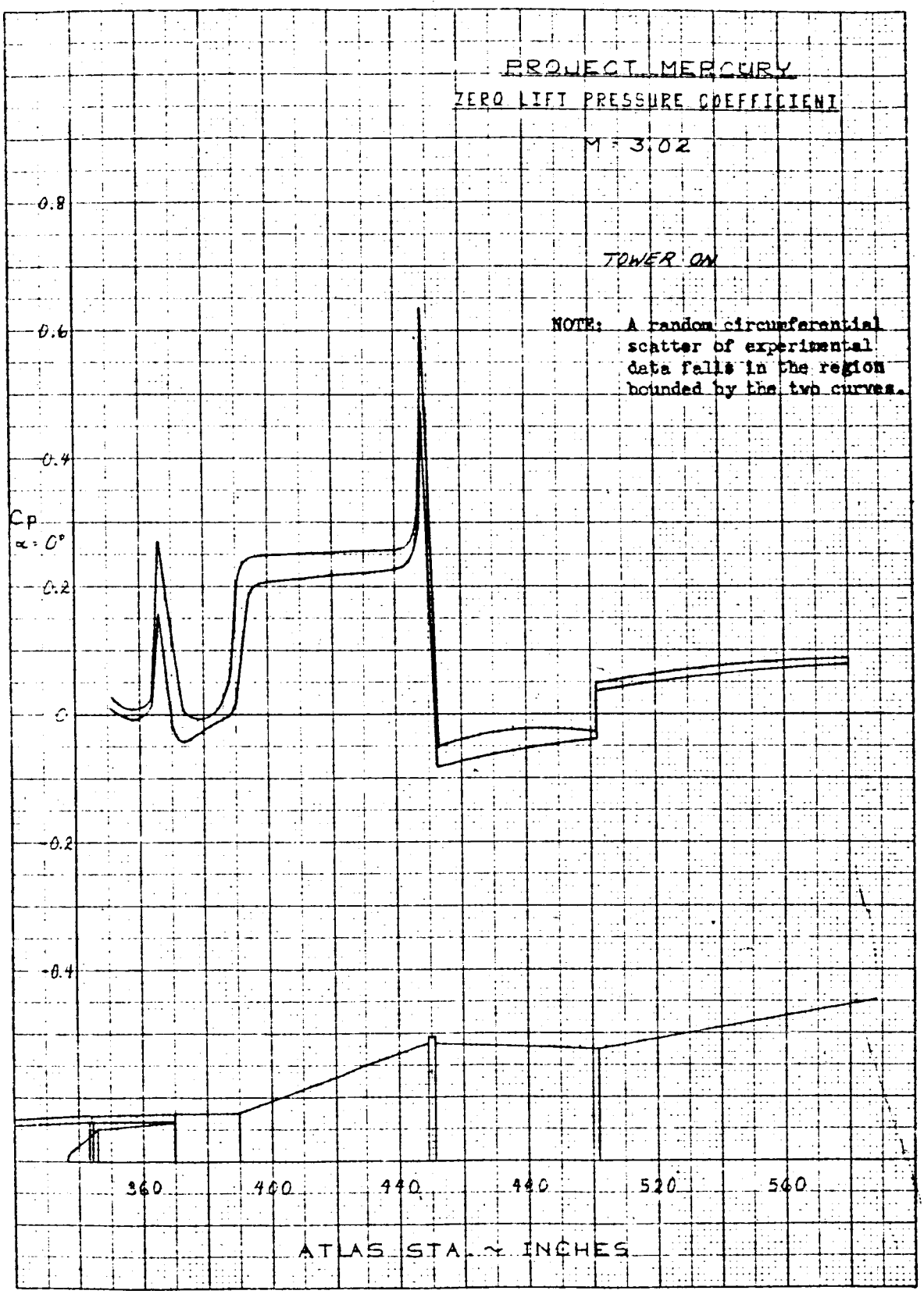

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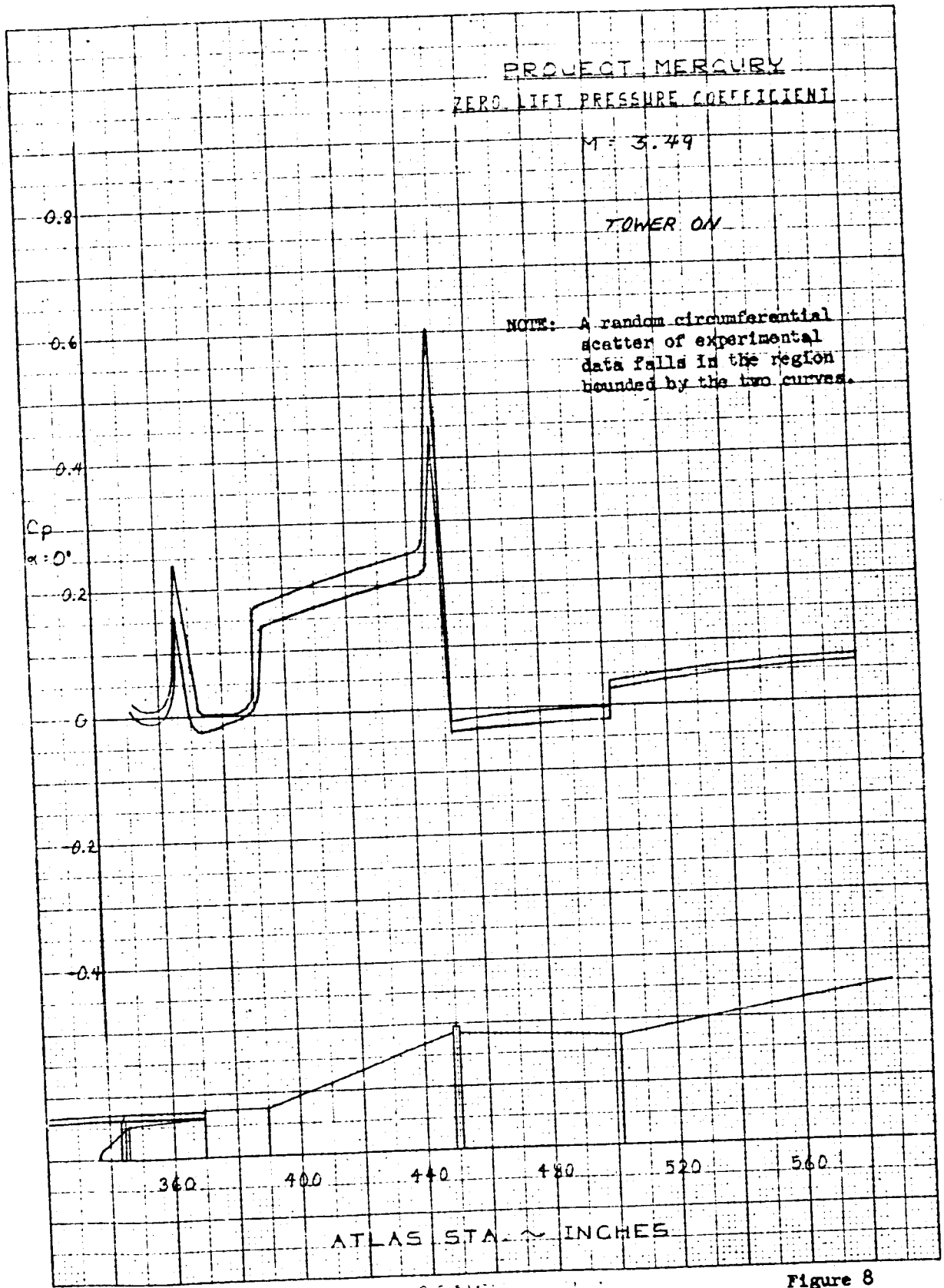
Figure 7



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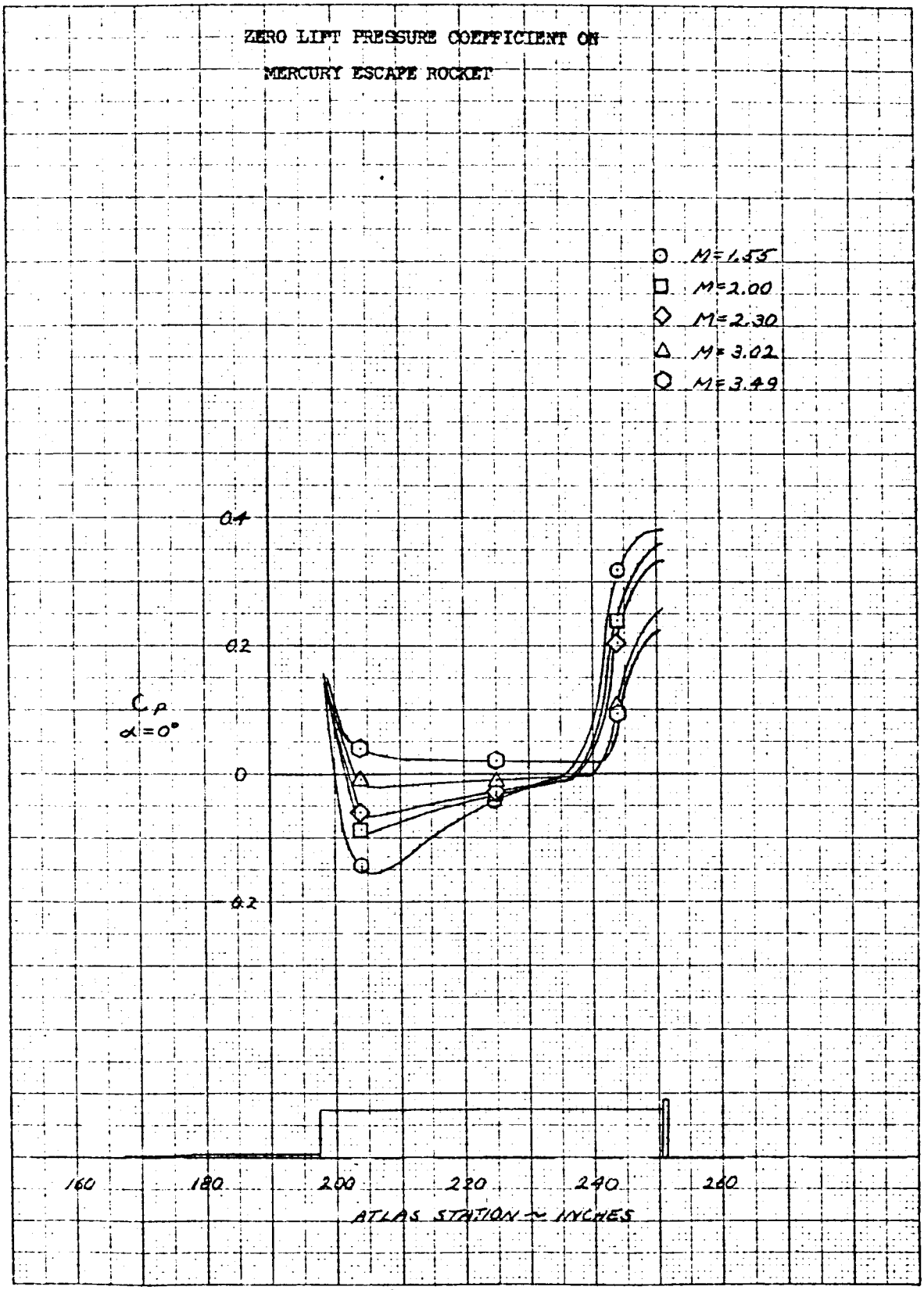

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Figure 9

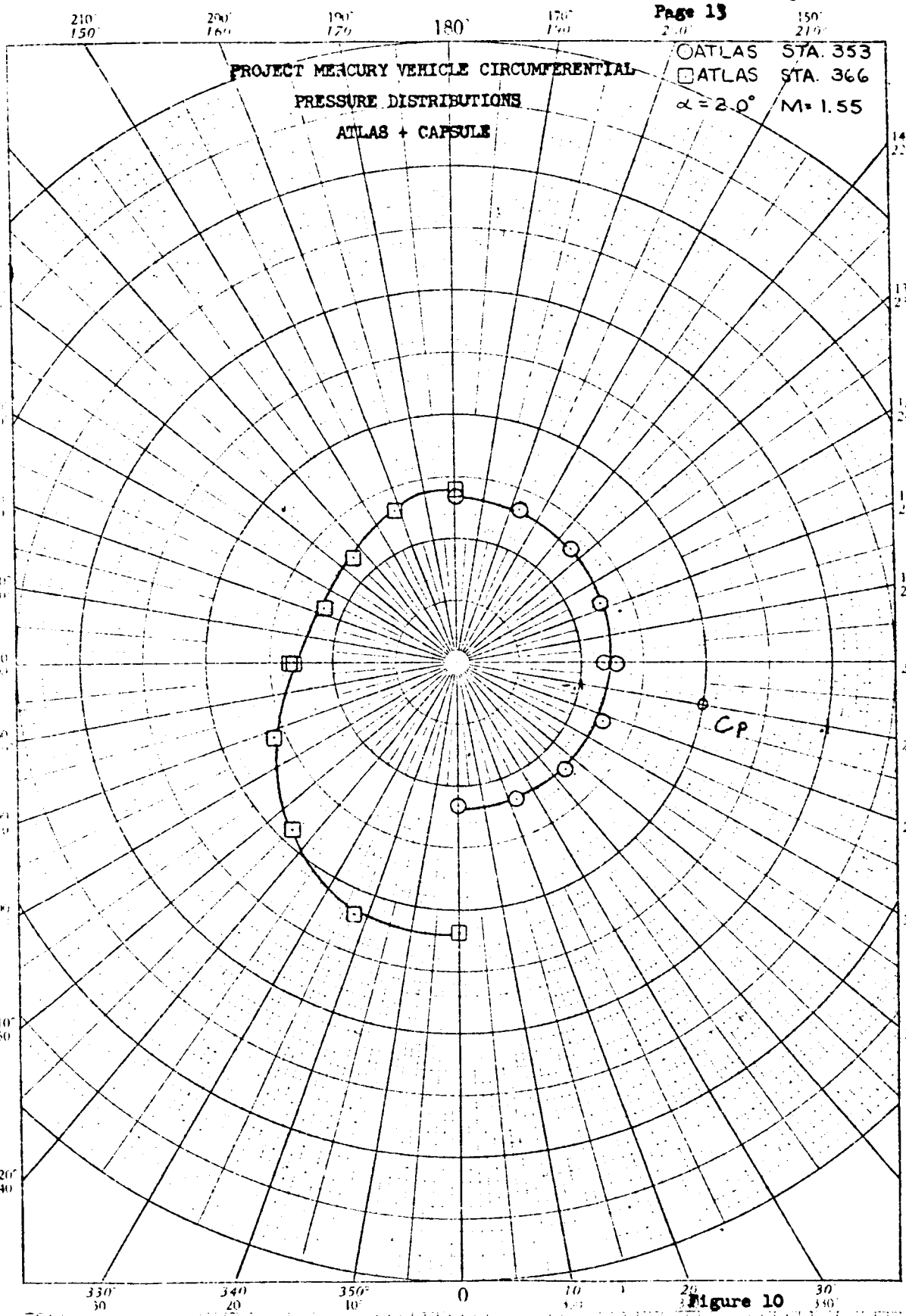

Figure 10

POLAR COORDINATE 359-31

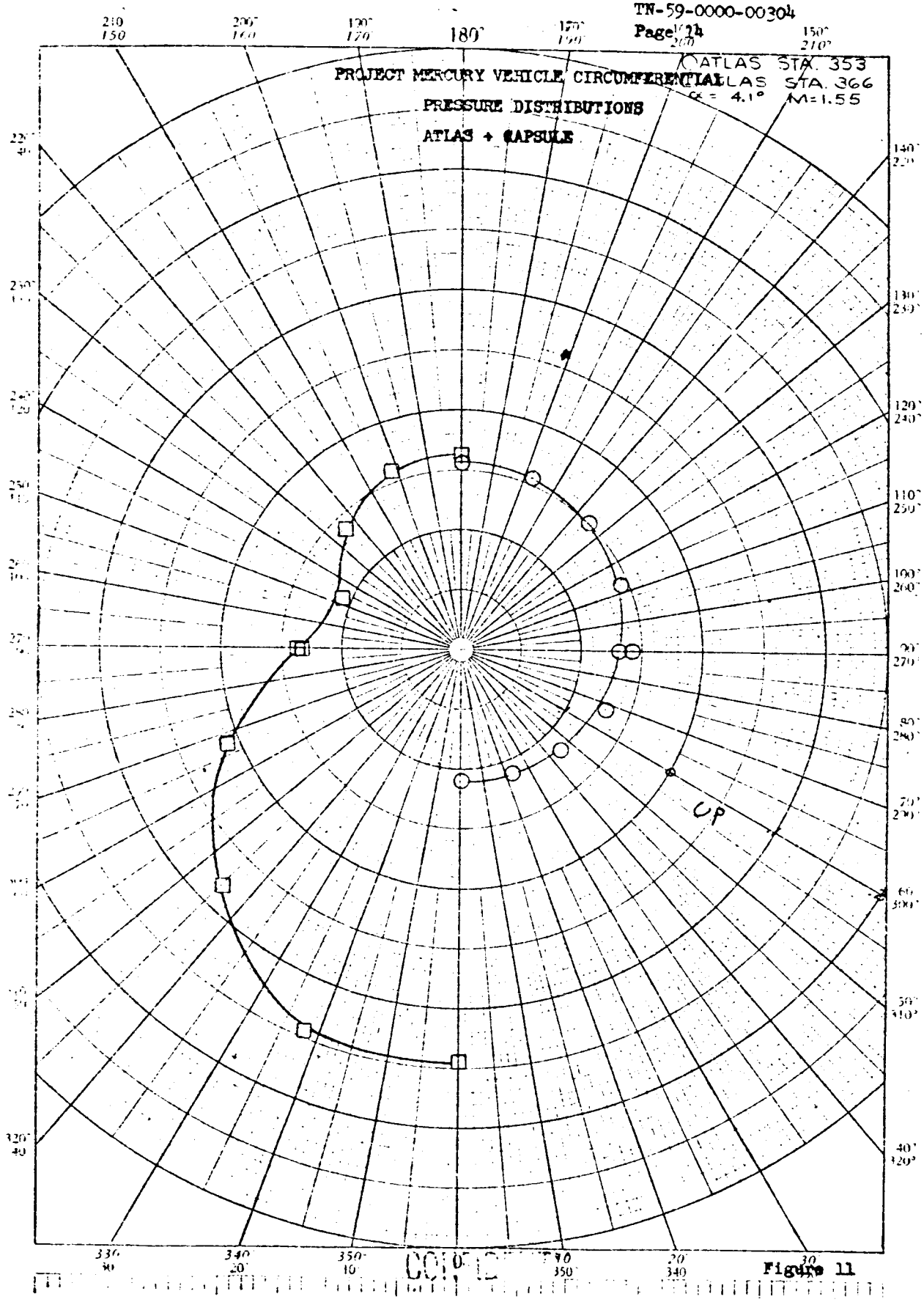
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA. 353
ATLAS STA. 366
α = 4.1°
M=1.55
UP
180°

Figure 11

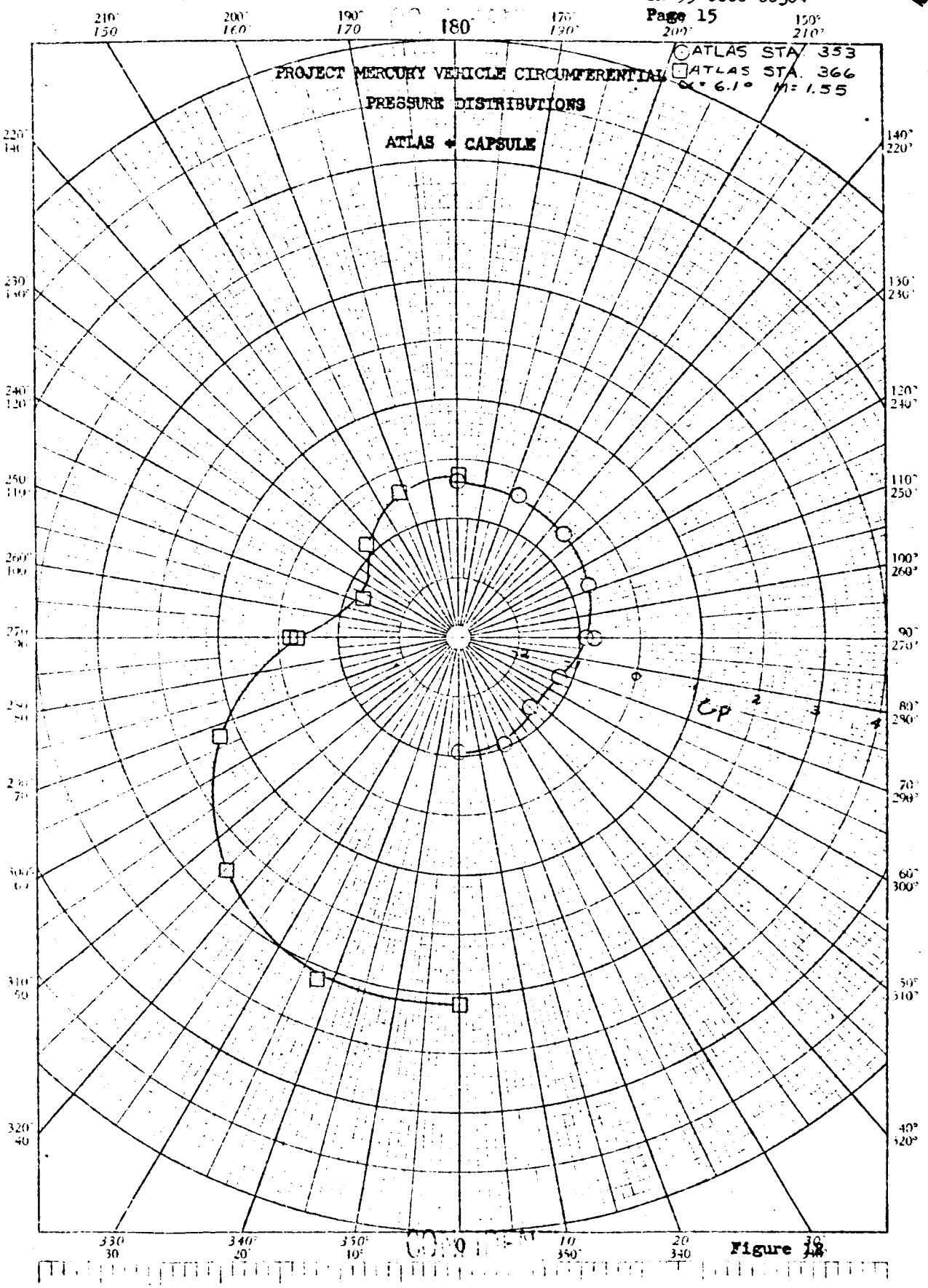
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA. 353
ATLAS STA. 366
α = 6.1° M = 1.55
Cp
180°
0

Figure 12

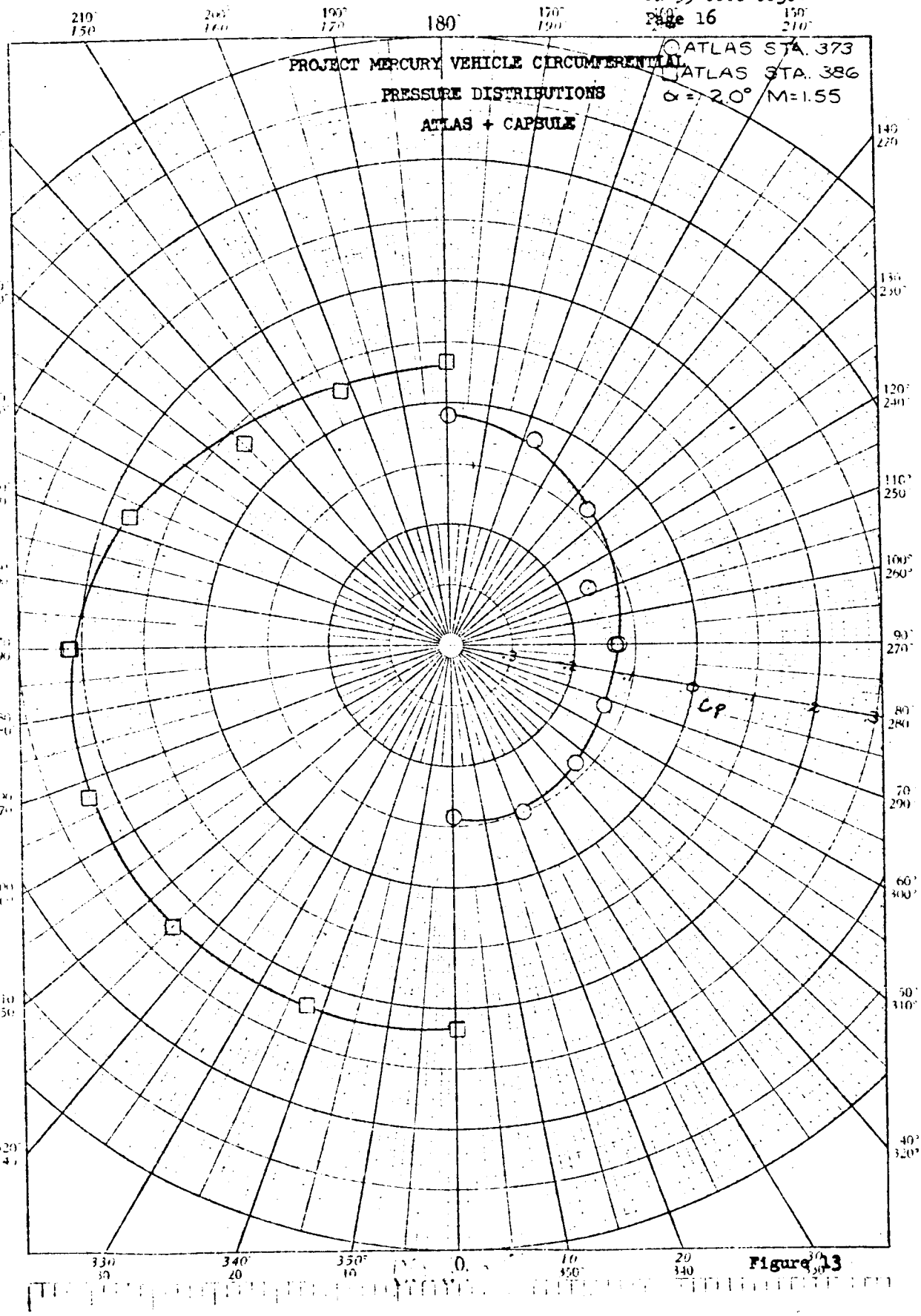
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA. 373
ATLAS STA. 386
α = 2.0° M=1.55
Cp
180°
0.

Figure 13

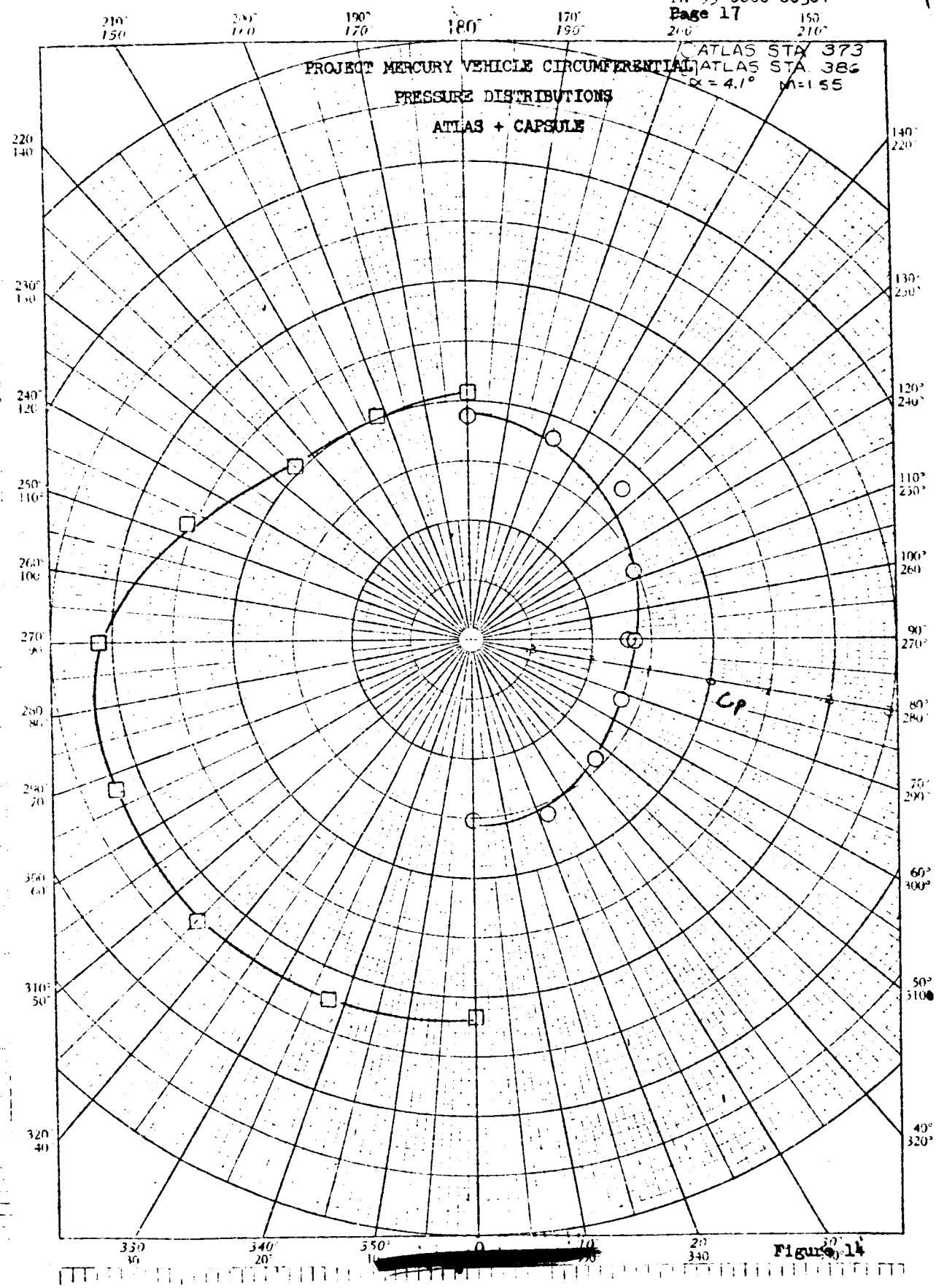
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA 373
ATLAS STA 386
α = 4.1°
M=1.55
Cp
POLAR CO-ORDINATE 359-31

Figure 14

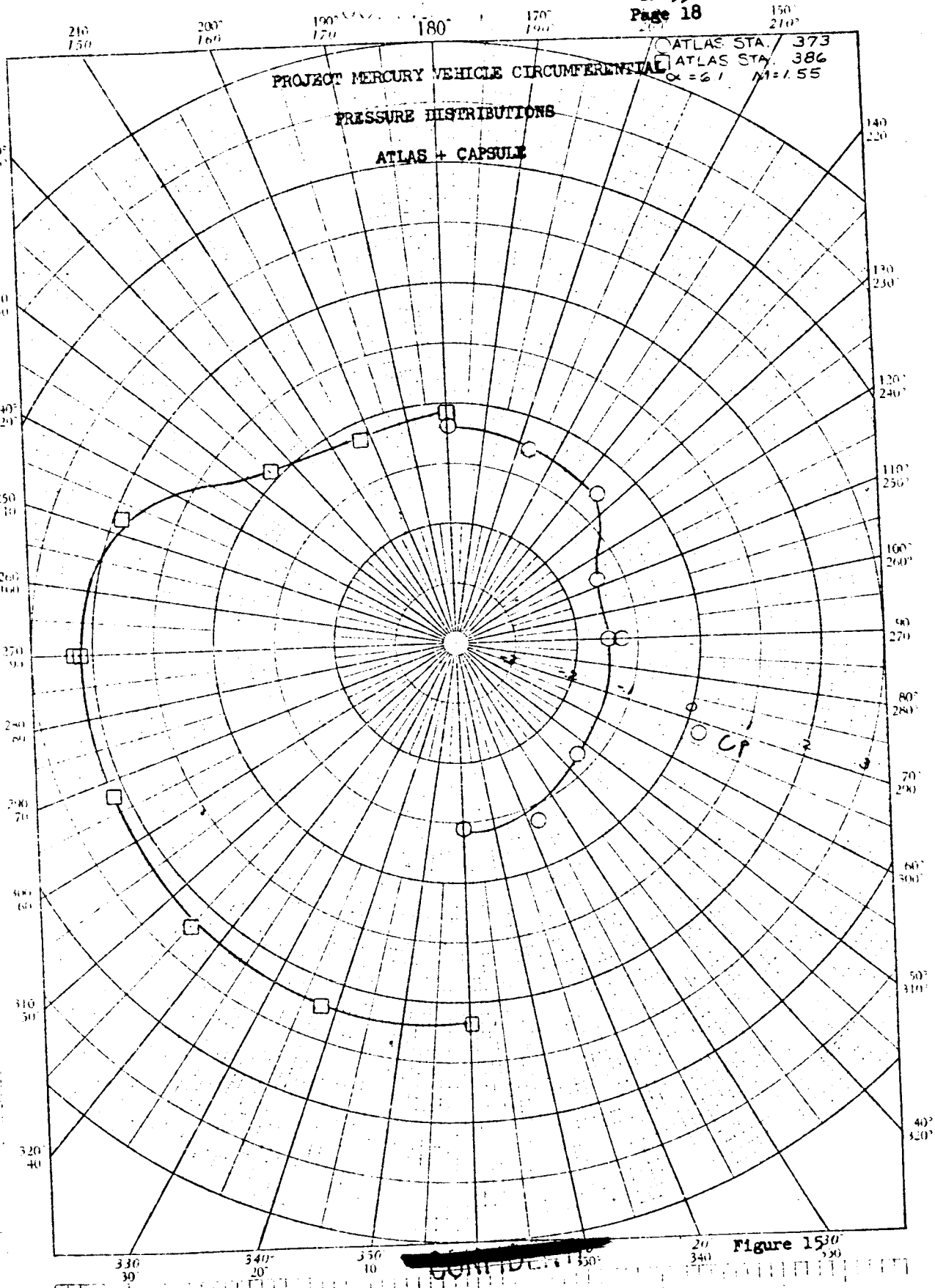

Figure 15

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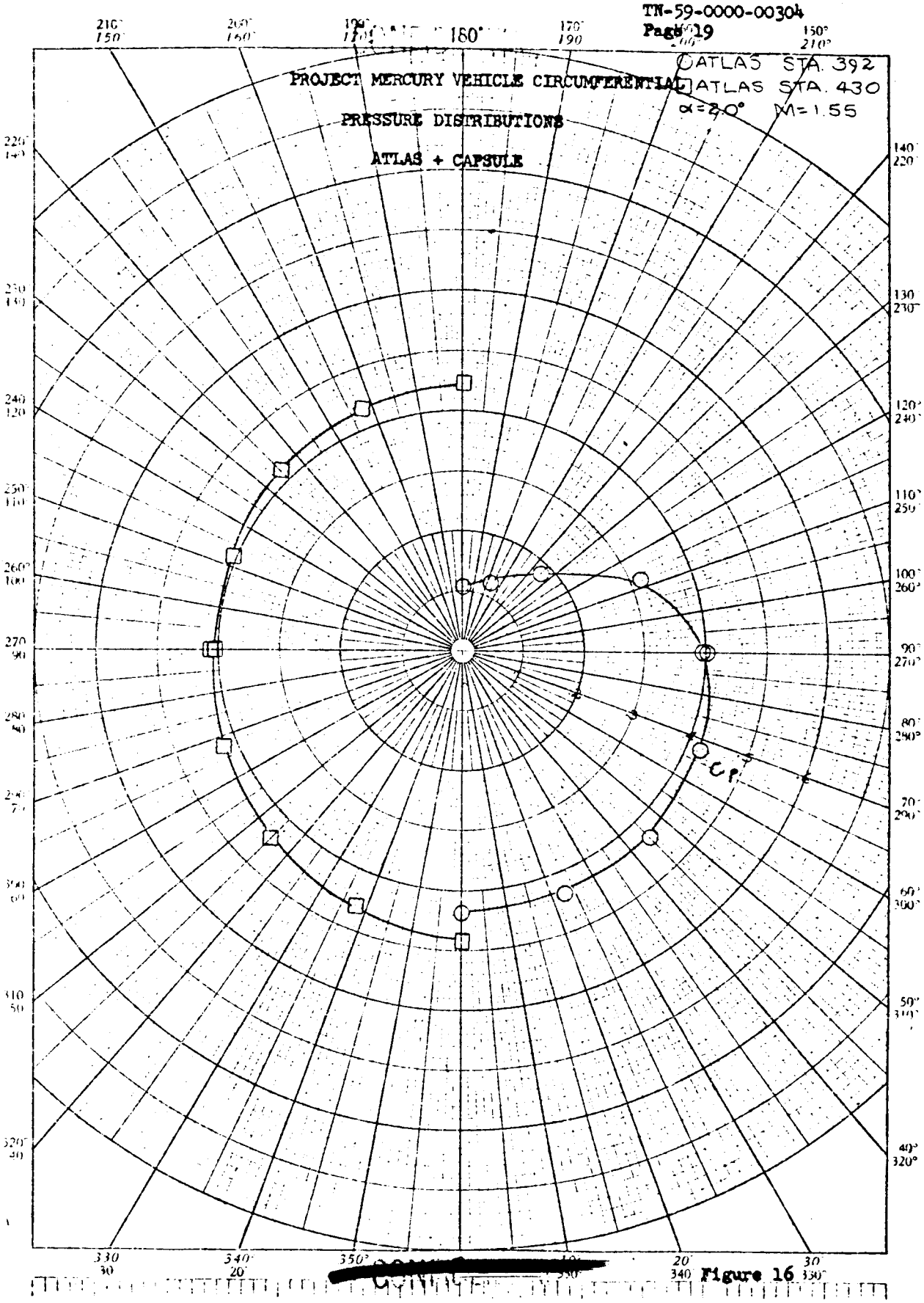

Figure 16

POLAR COORDINATE 339-31

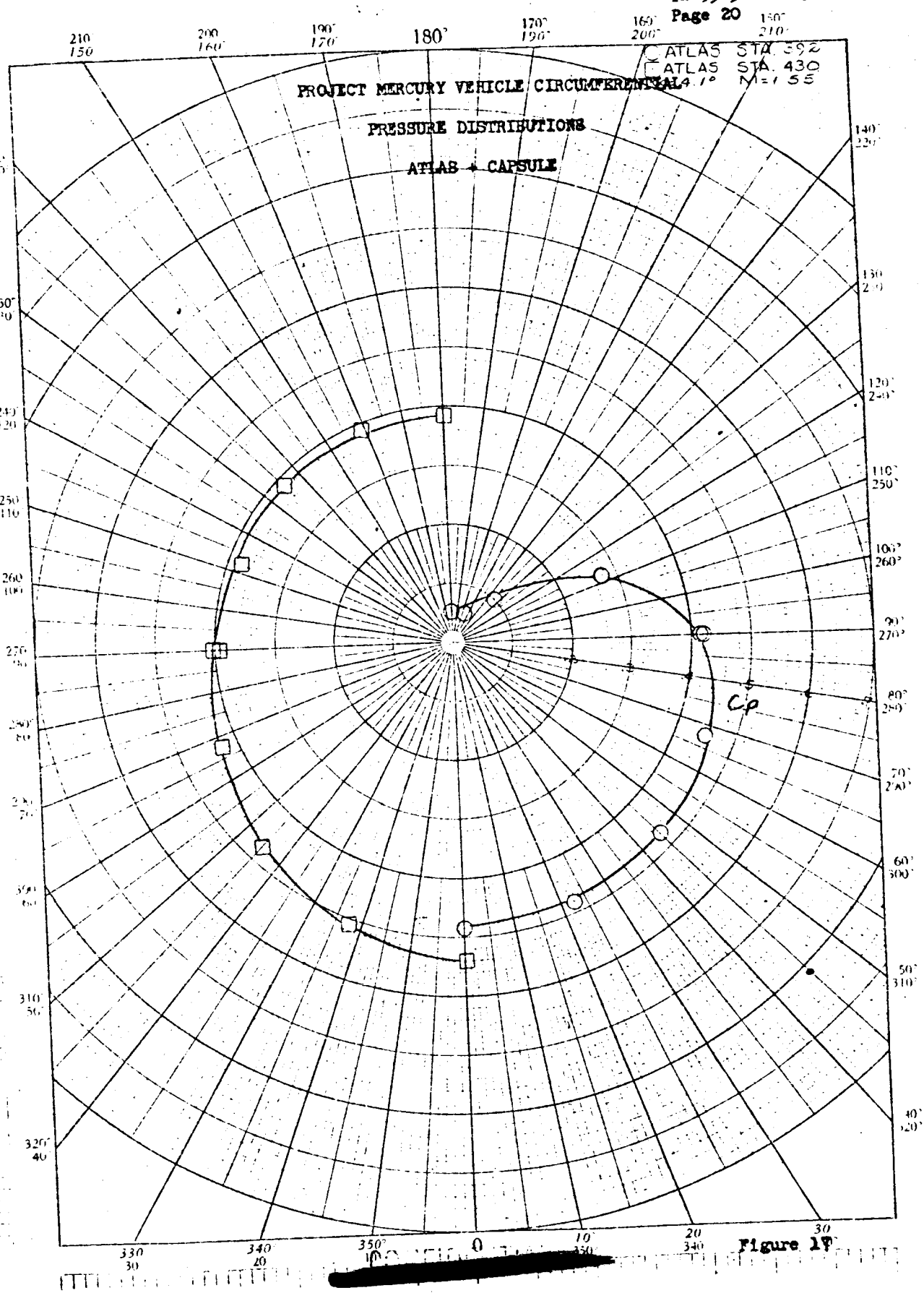

Figure 17

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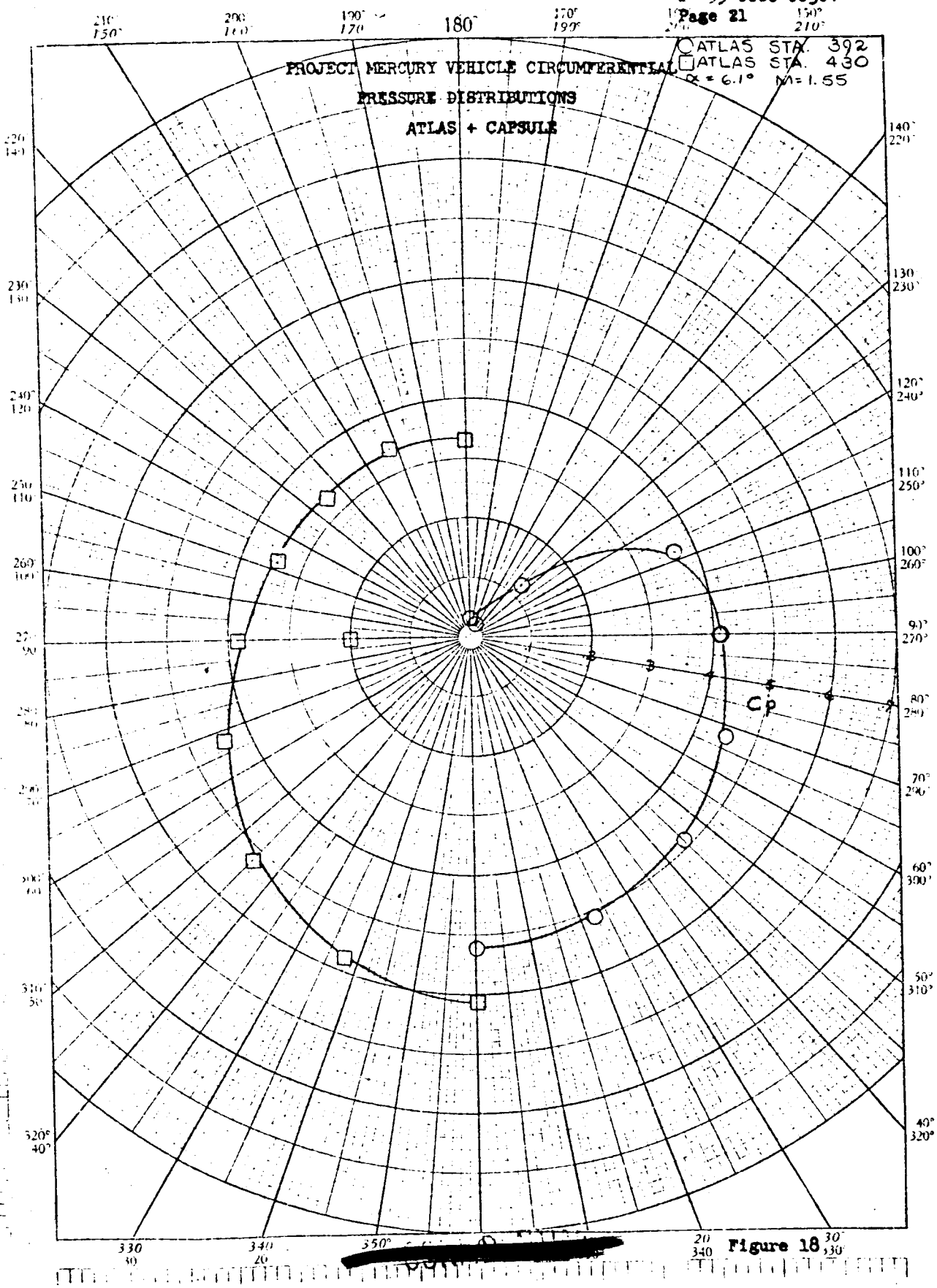
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA. 392
ATLAS STA. 430
α = 6.1° M = 1.55
Cp
180°
POLAR CO-ORDINATE 350-31

Figure 18

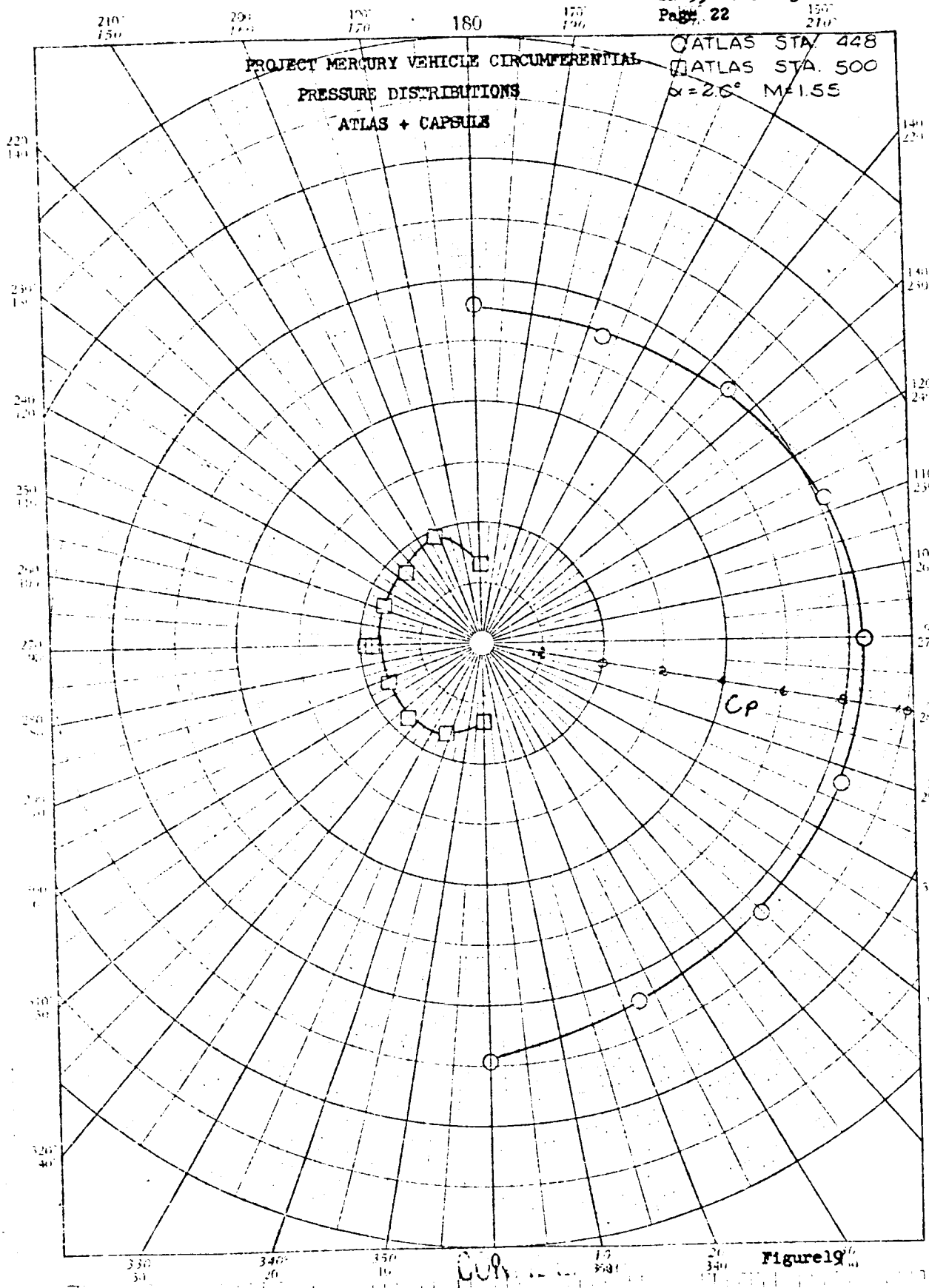
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA. 448
ATLAS STA. 500
α = 2.6° M = 1.55
180
Cp

Figure 19

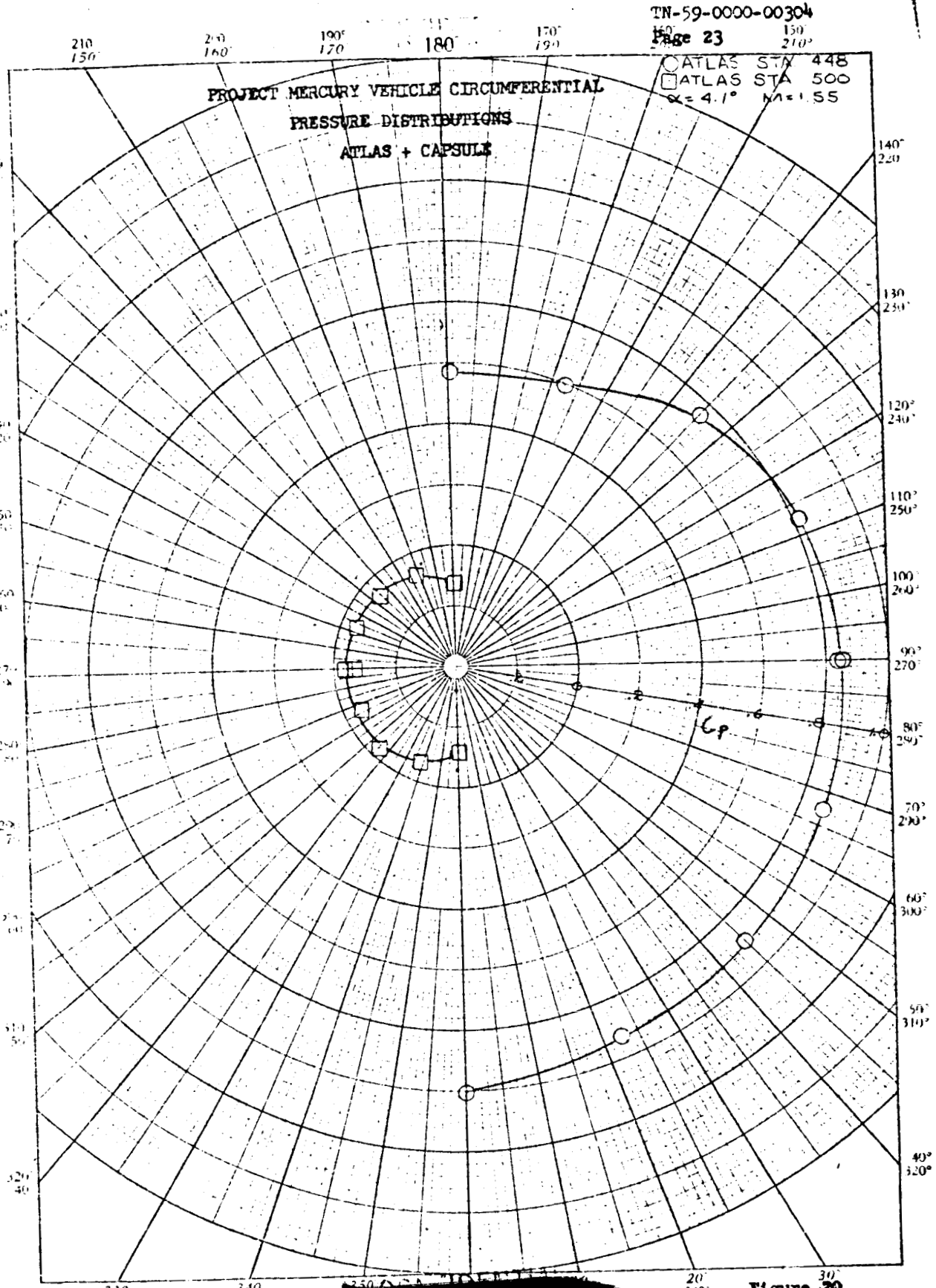
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA 448
ATLAS STA 500
α = 4.1°
M = 1.55
180°
210 150
200 160
190 170
170 190
150 210
140 220
130 230
120 240
110 250
100 260
90 270
80 280
70 290
60 300
50 310
40 320
330 0
340 20
20 340
30 330
Cp

Figure 20

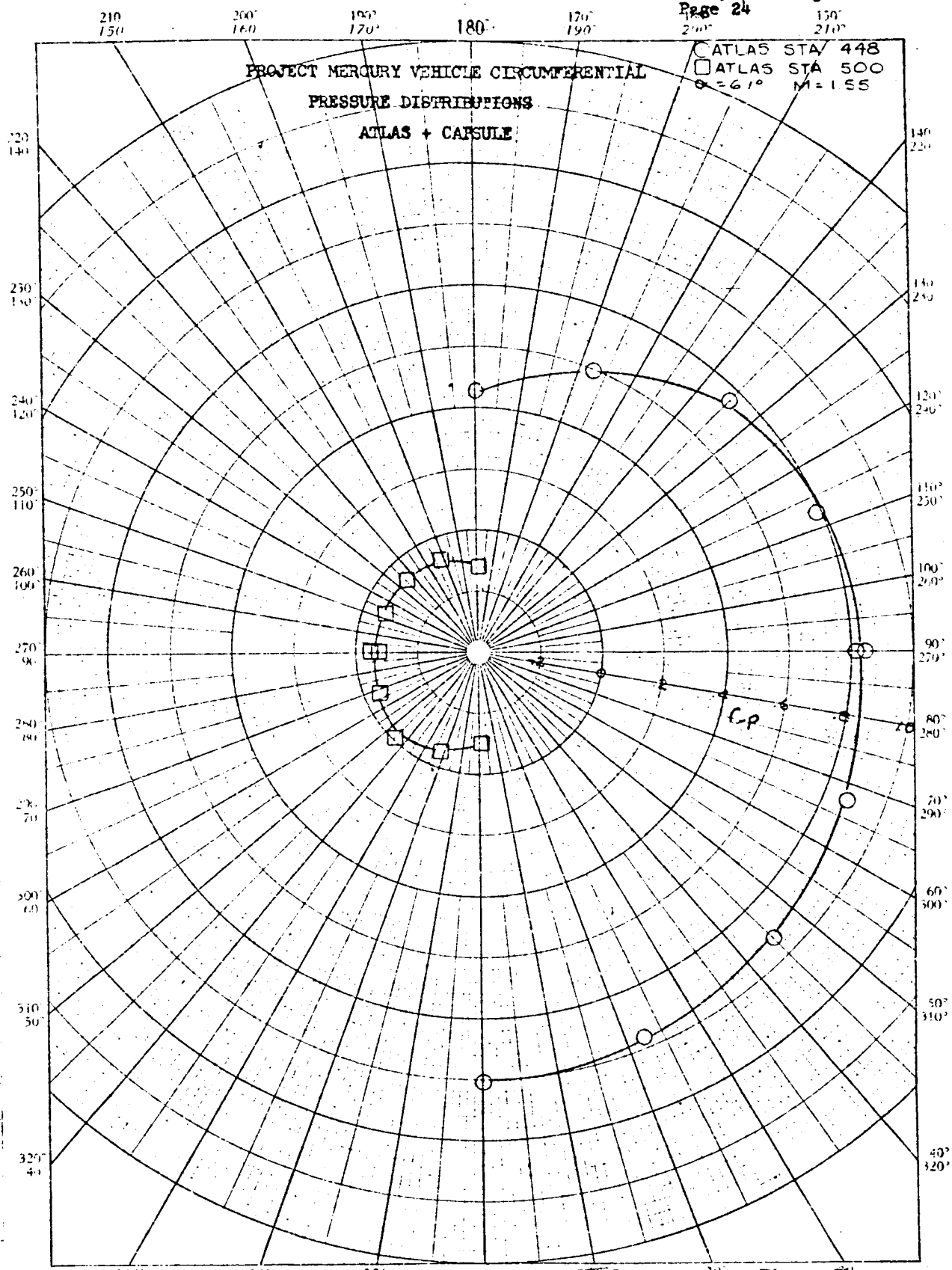

Figure 21

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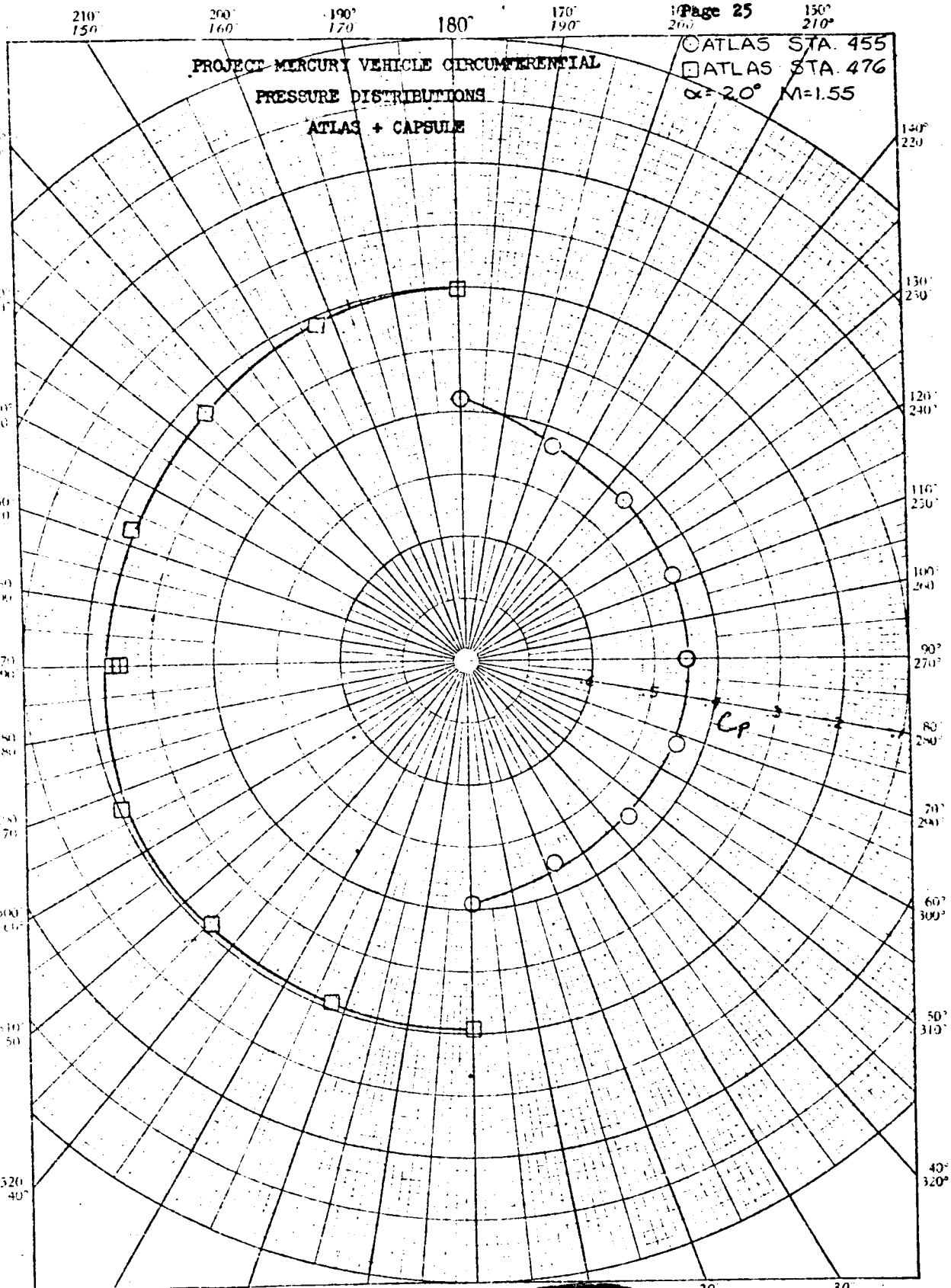

Figure 22

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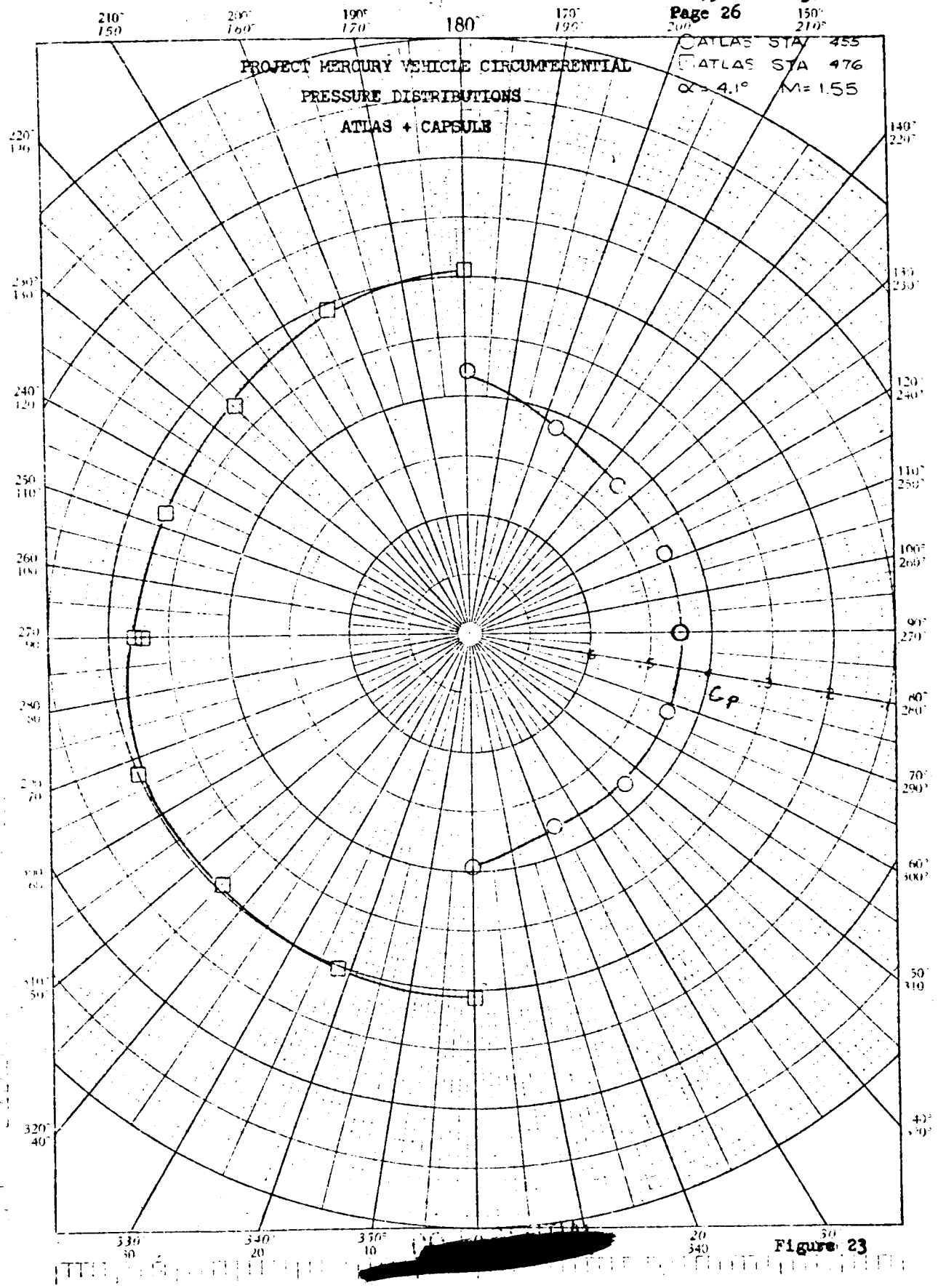
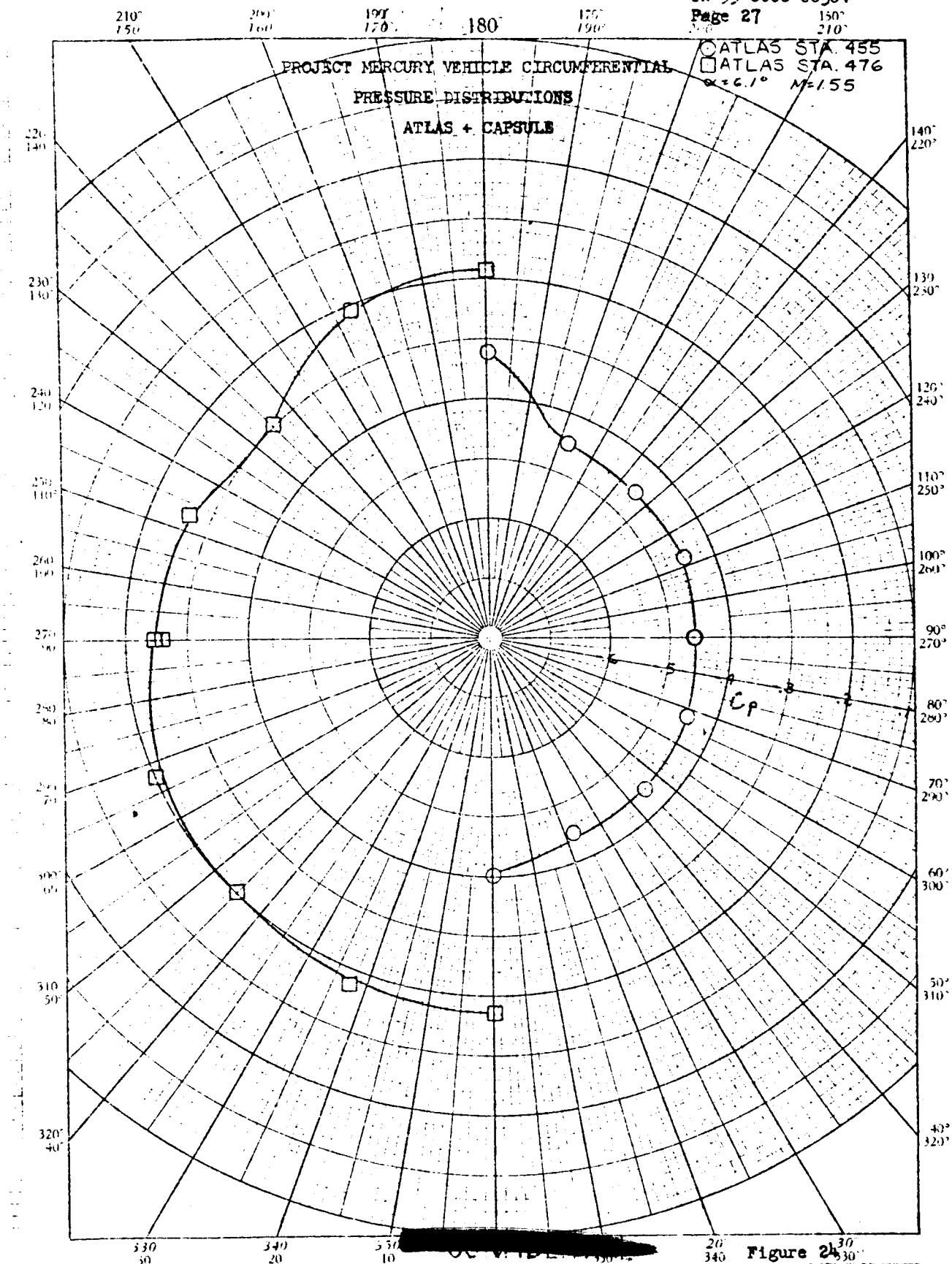

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE
ATLAS STA 455
ATLAS STA 476
α = 4.1°
M = 1.55
180°
Cp
POLAR CO-ORDINATE

Figure 23



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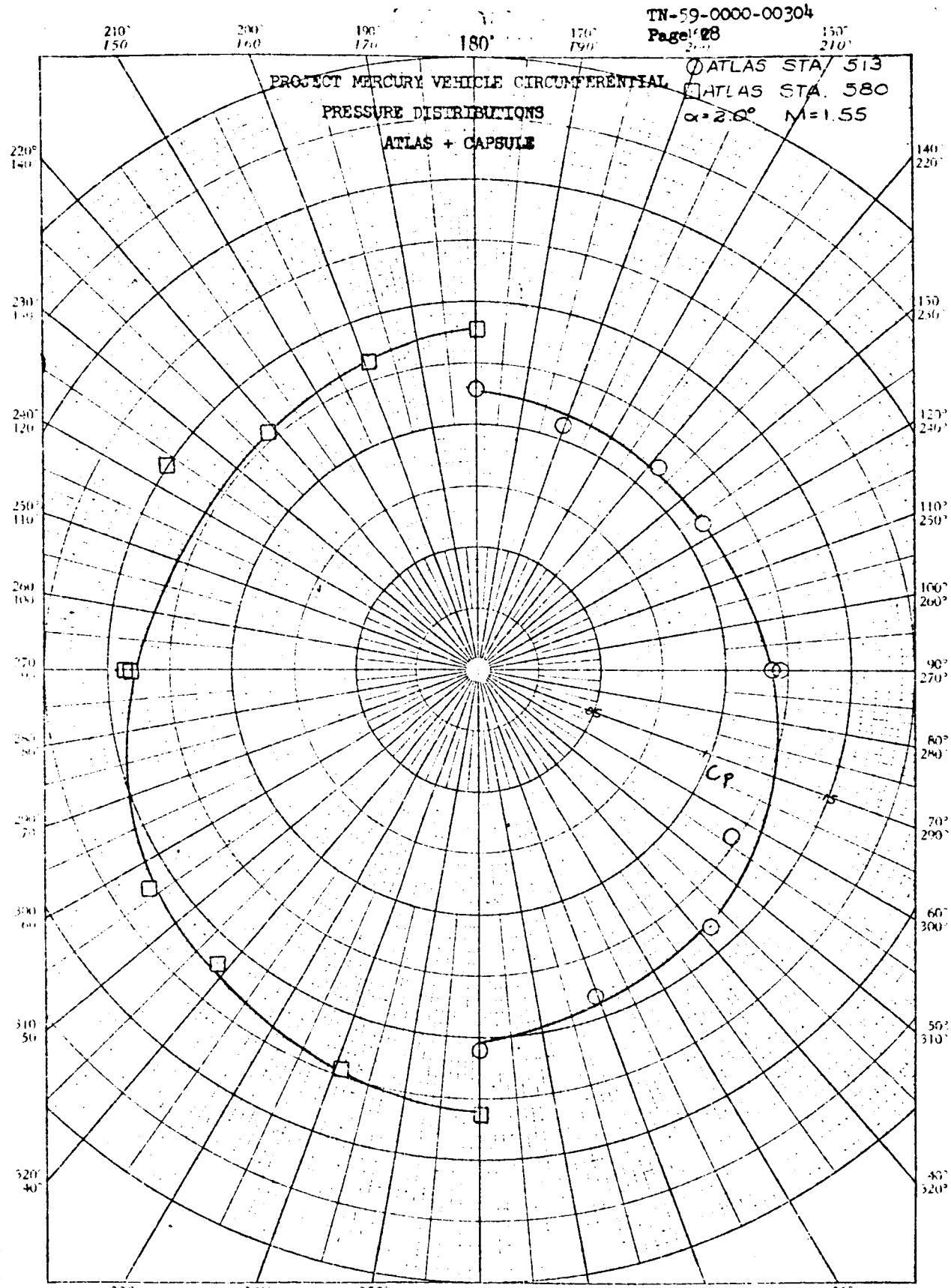

Figure 25

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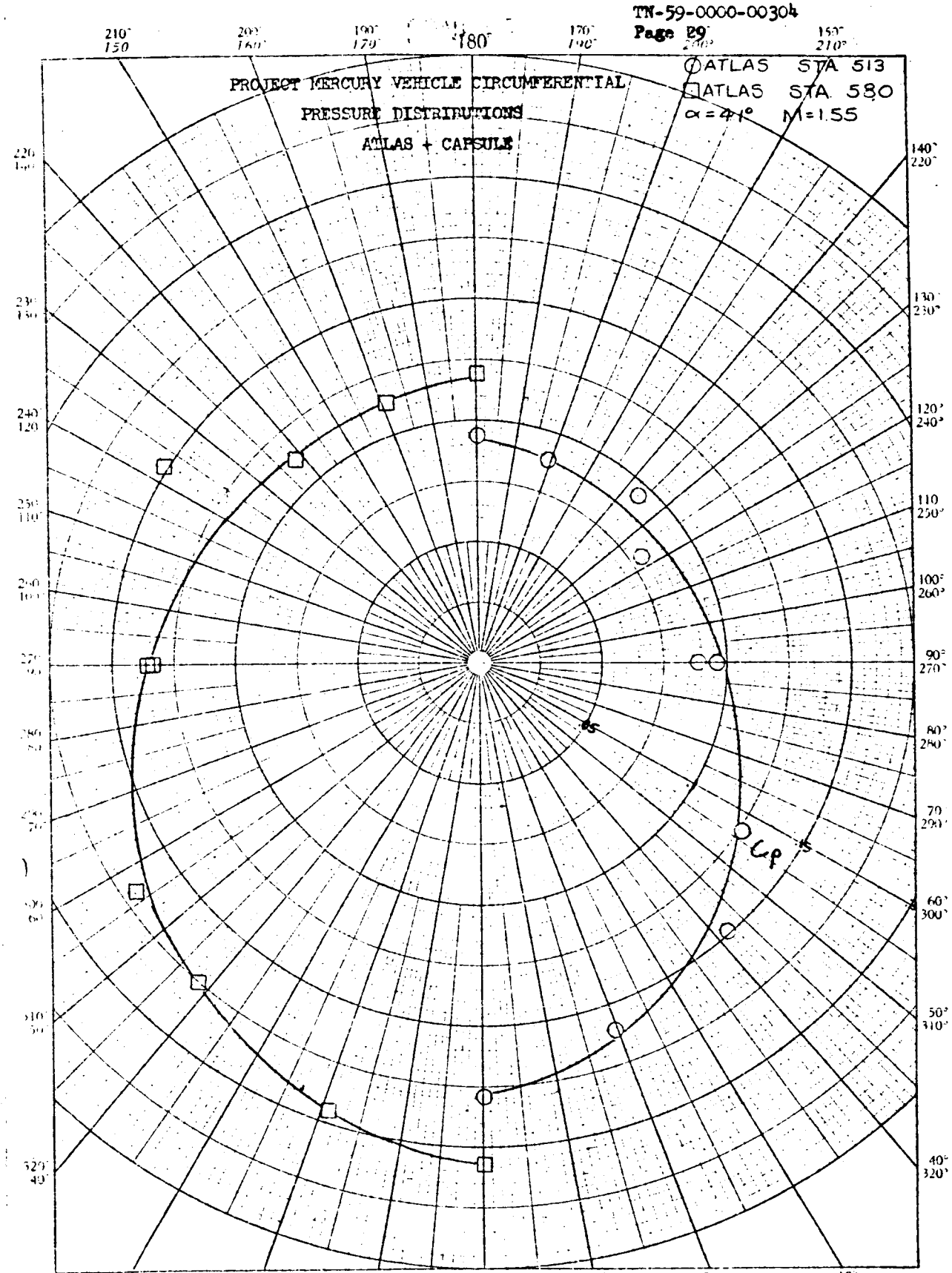

Figure 26

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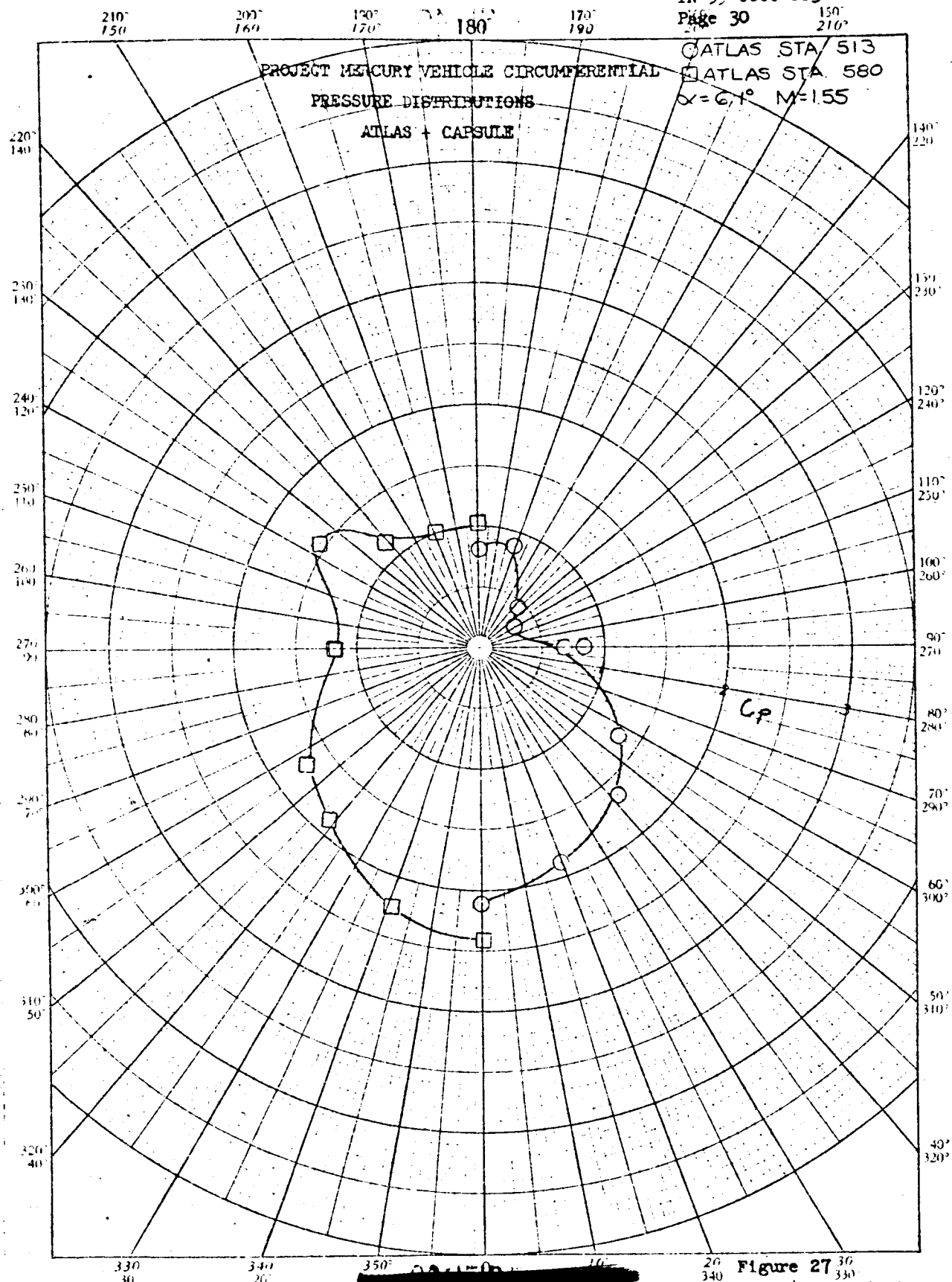

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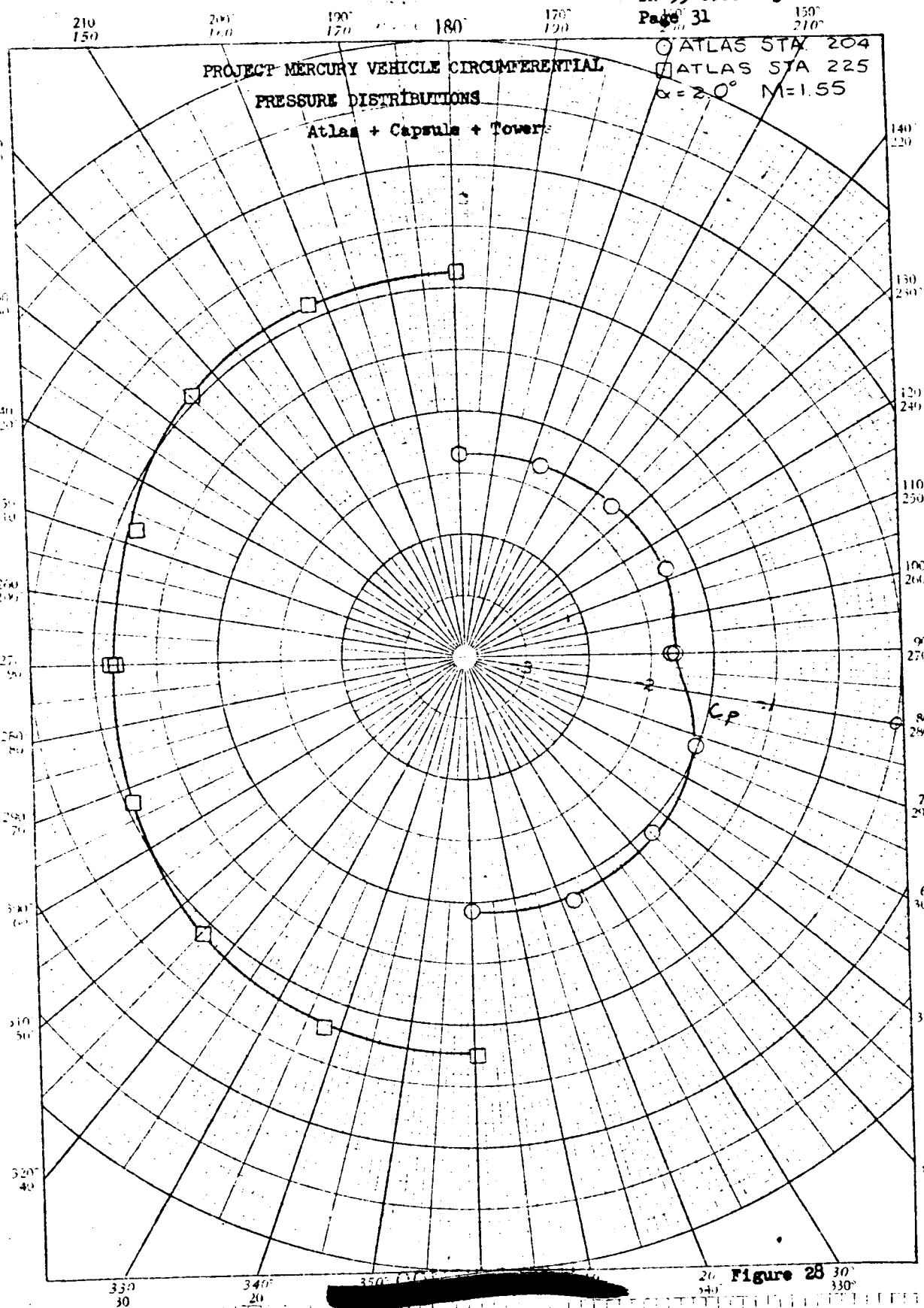

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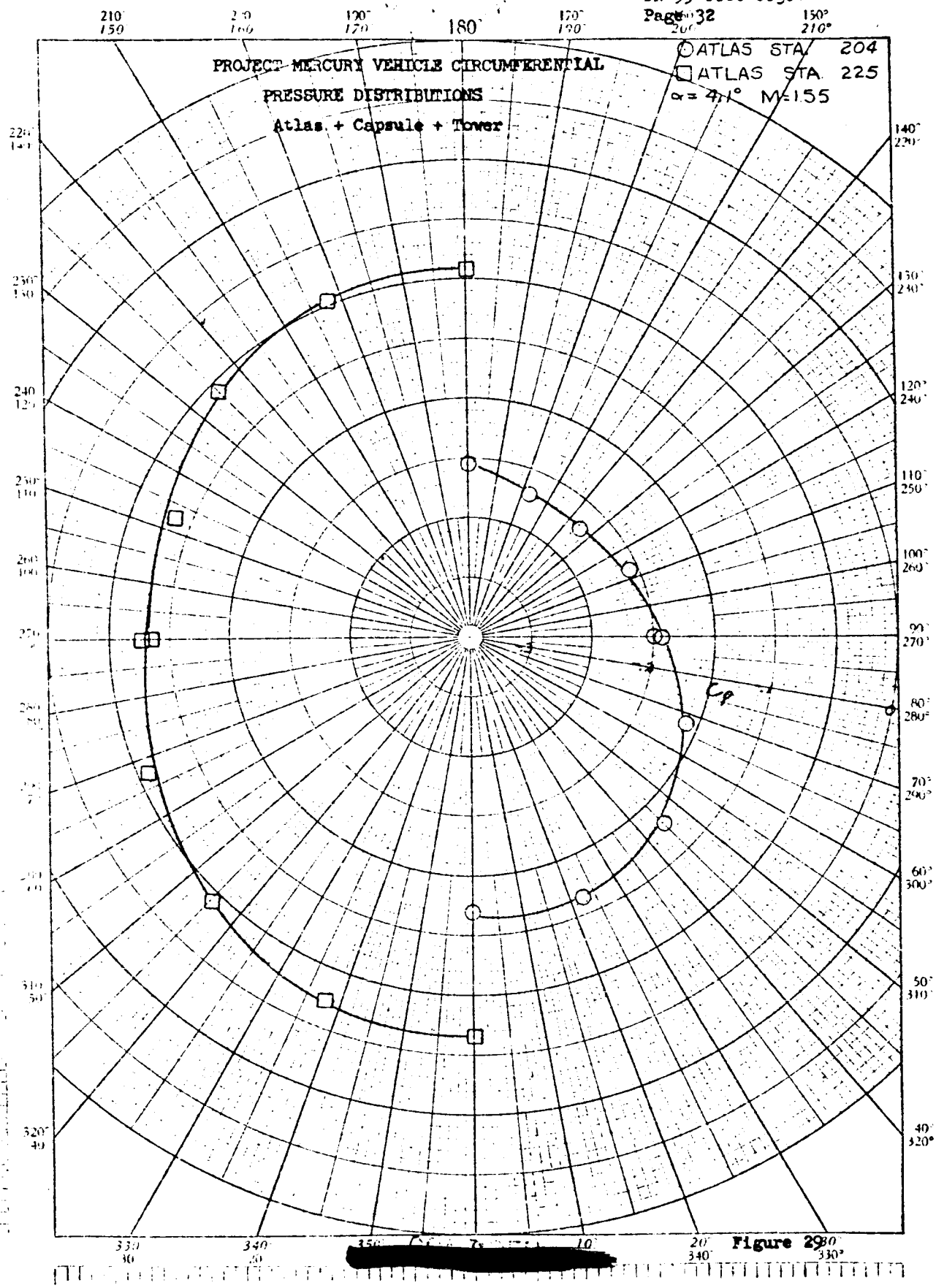

Figure 29

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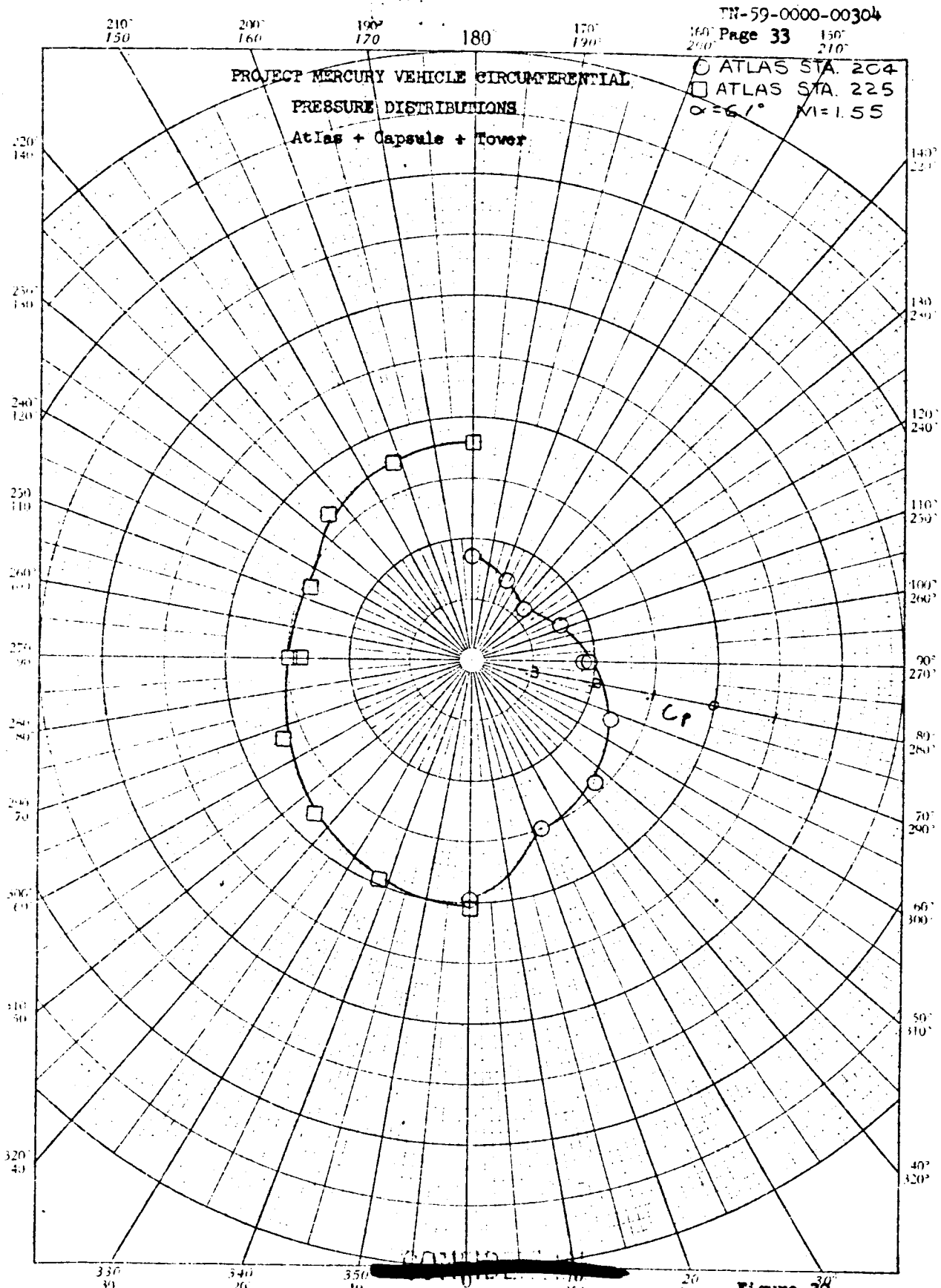

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Figure 30

POLAR COORDINATE 359-31

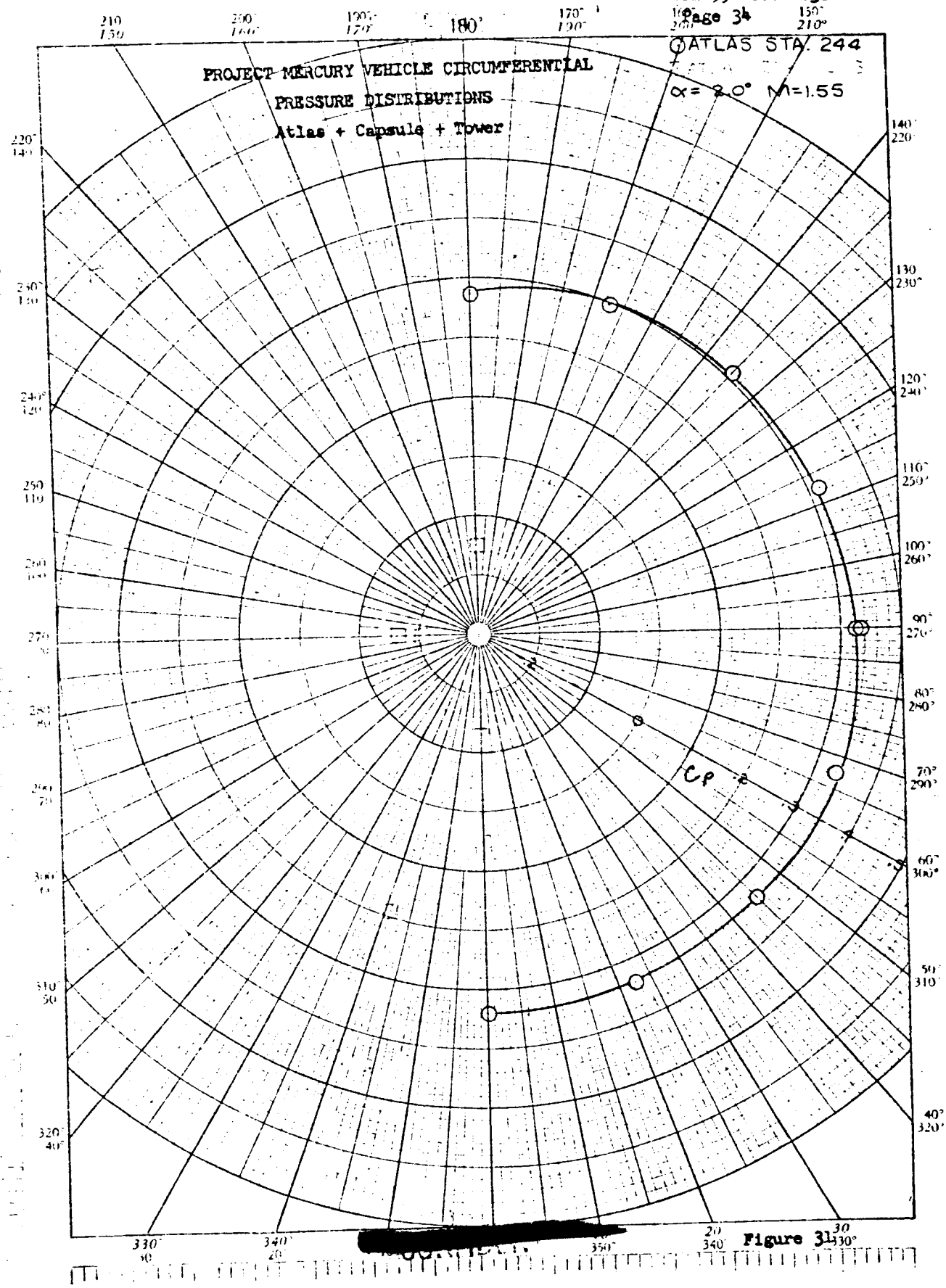

Figure 31

[redacted]

POLAR CO-ORDINATE 359-31

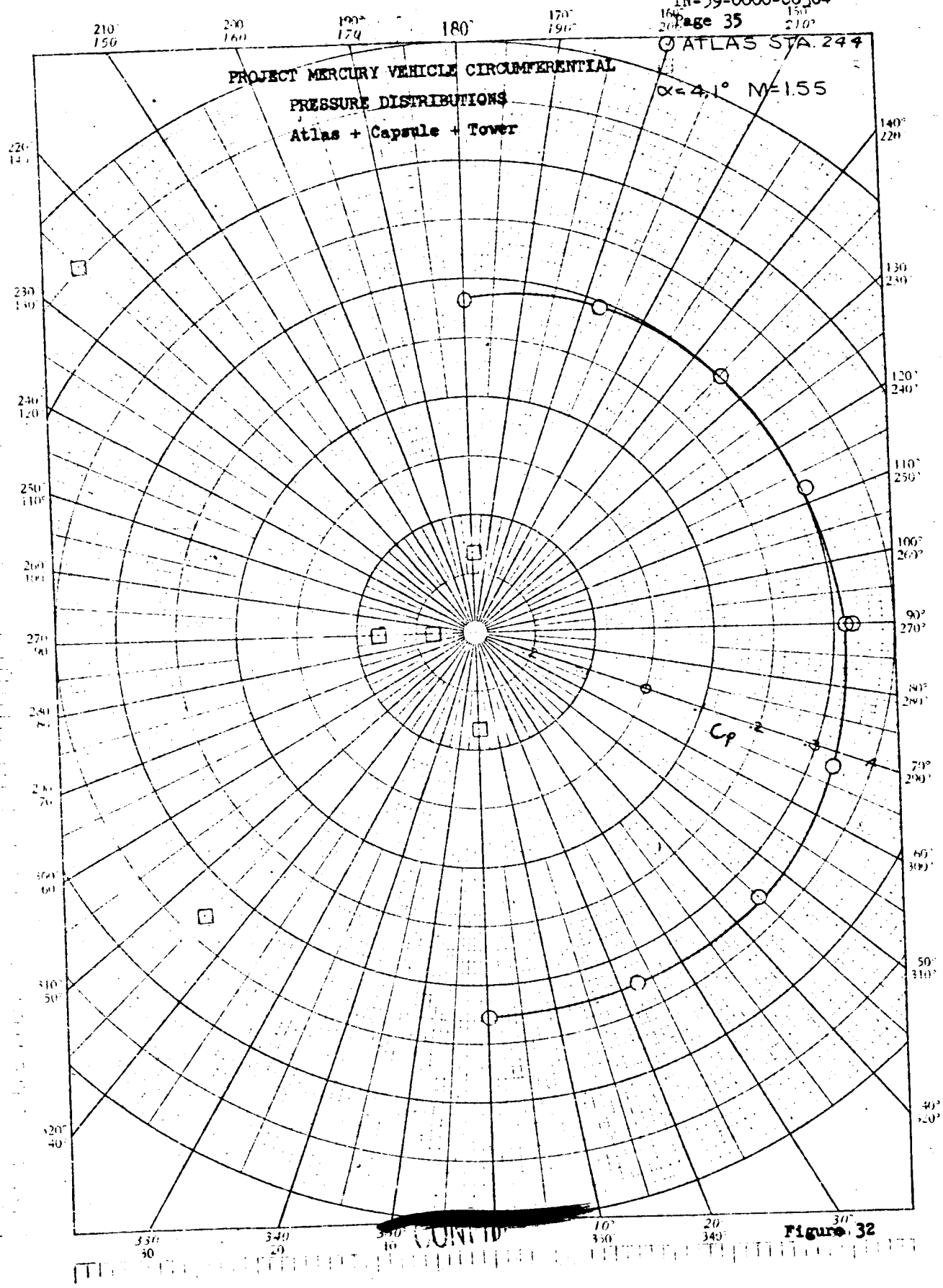
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA. 244
α=4.1° M=1.55
Cp
.2
.3
.4
180°
90° 270°
70° 290°
60° 300°
50° 310°
40° 320°
30°
20° 340°
10° 350°
330° 30°
340° 20°
350° 10°
POLAR CO-ORDINATE 359-31

Figure 32

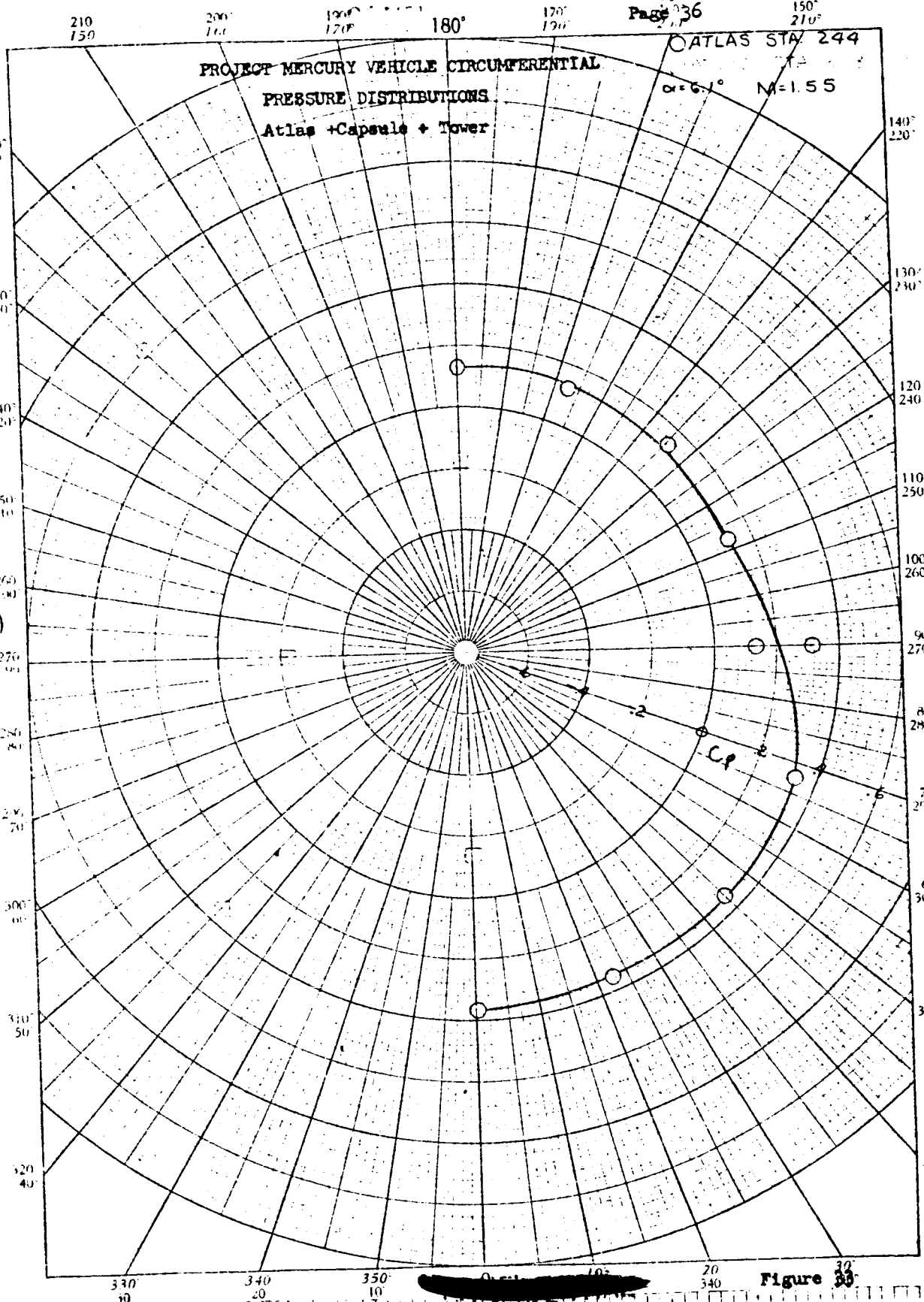
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas +Capsule + Tower
ATLAS STA 244
α = 6.1°
M = 1.55
180°
C_p
-.2
-.4
-.6

Figure 33

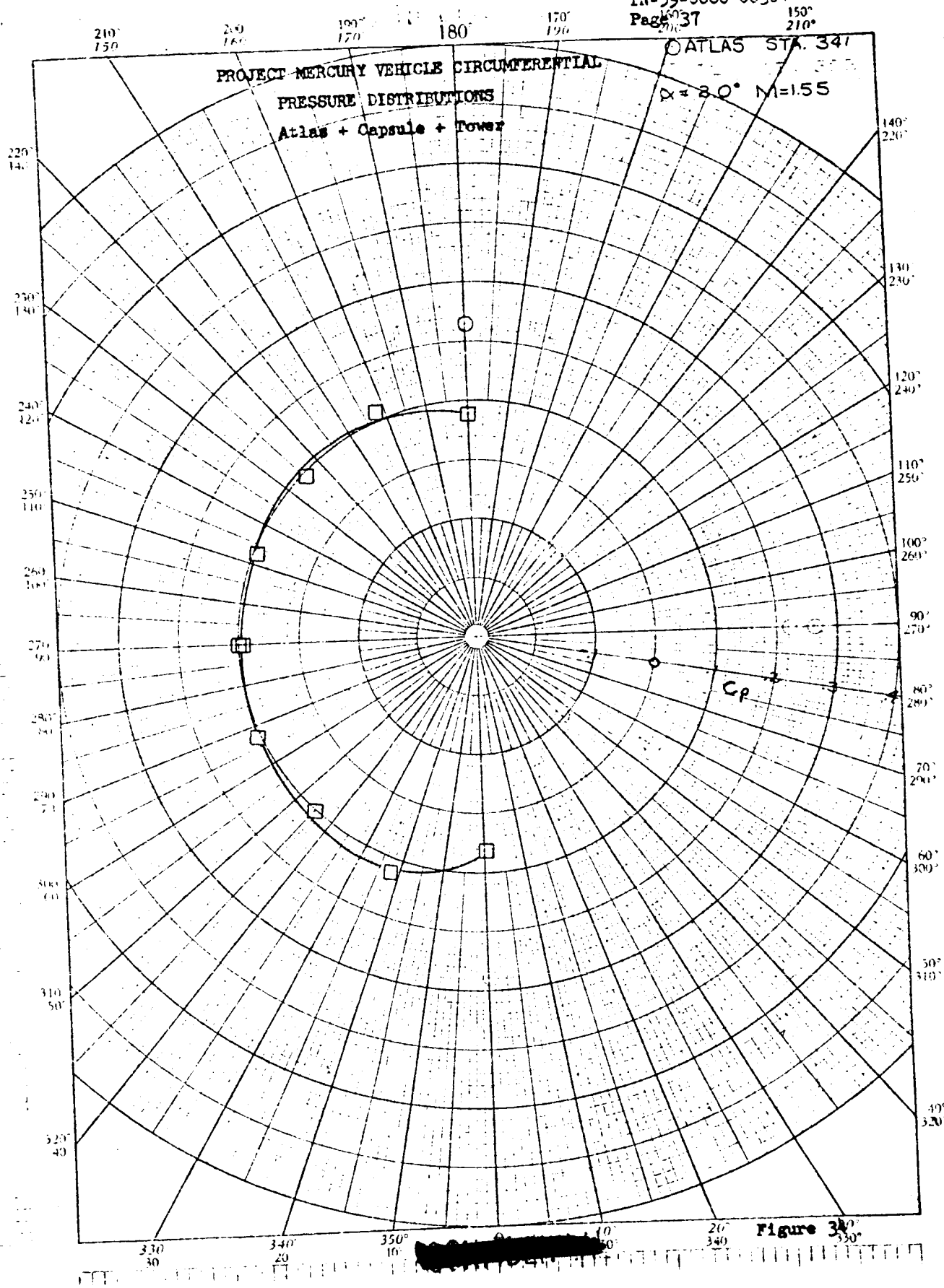

Figure 34

[redacted]

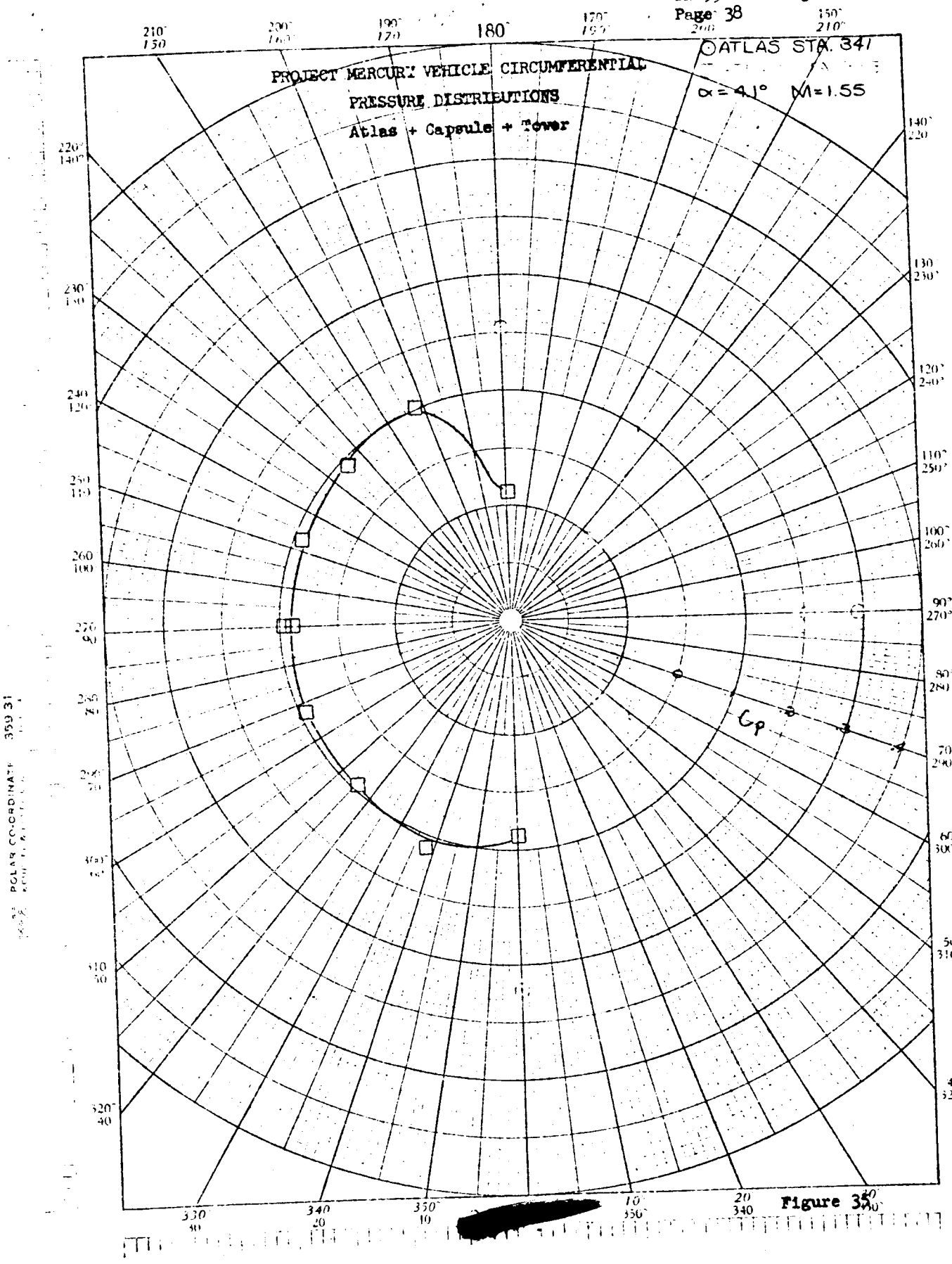
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA. 341
α = 4.1° M = 1.55
180°
Cp
POLAR CO-ORDINATE 359 31

Figure 35

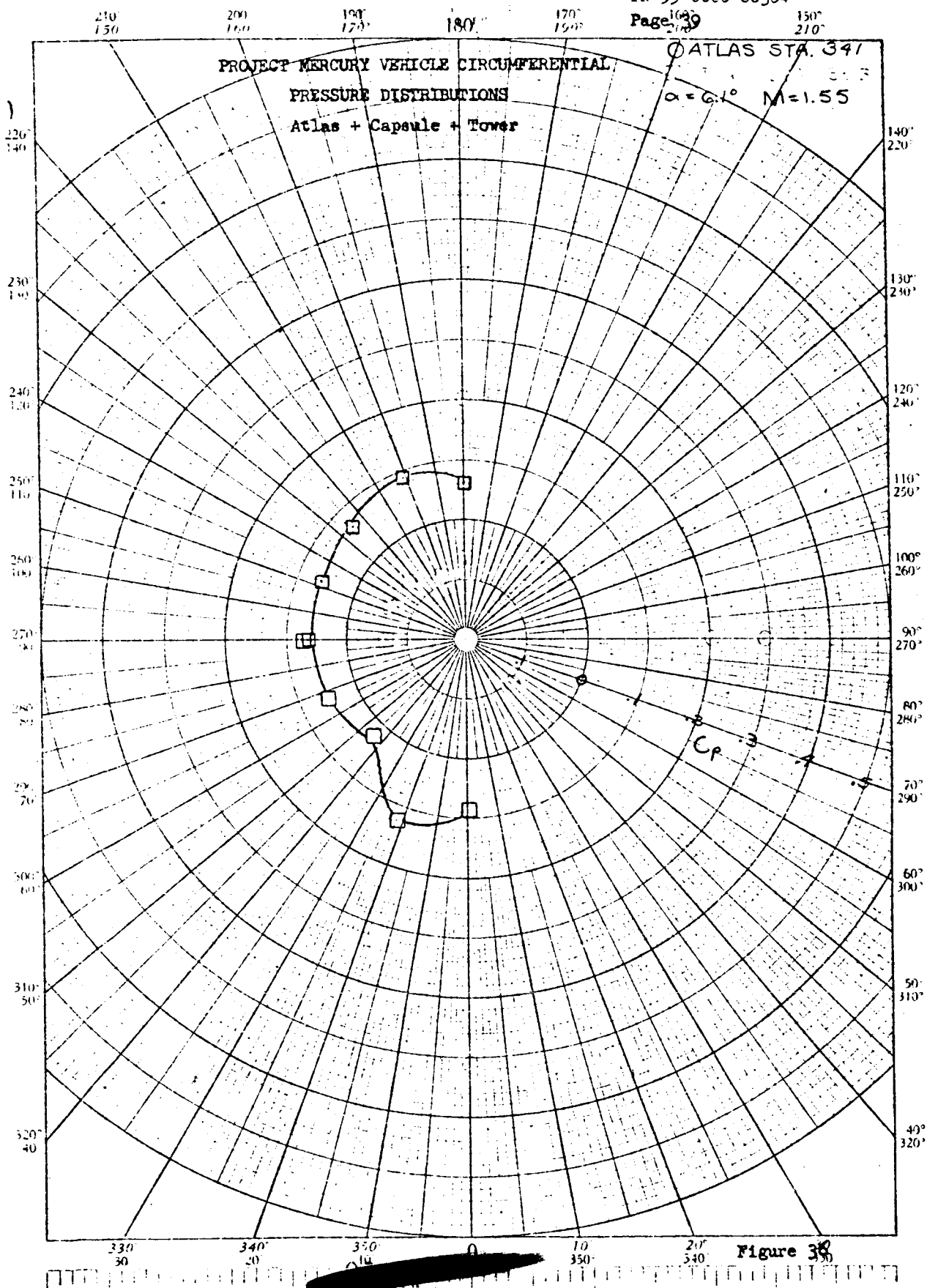

Figure 38

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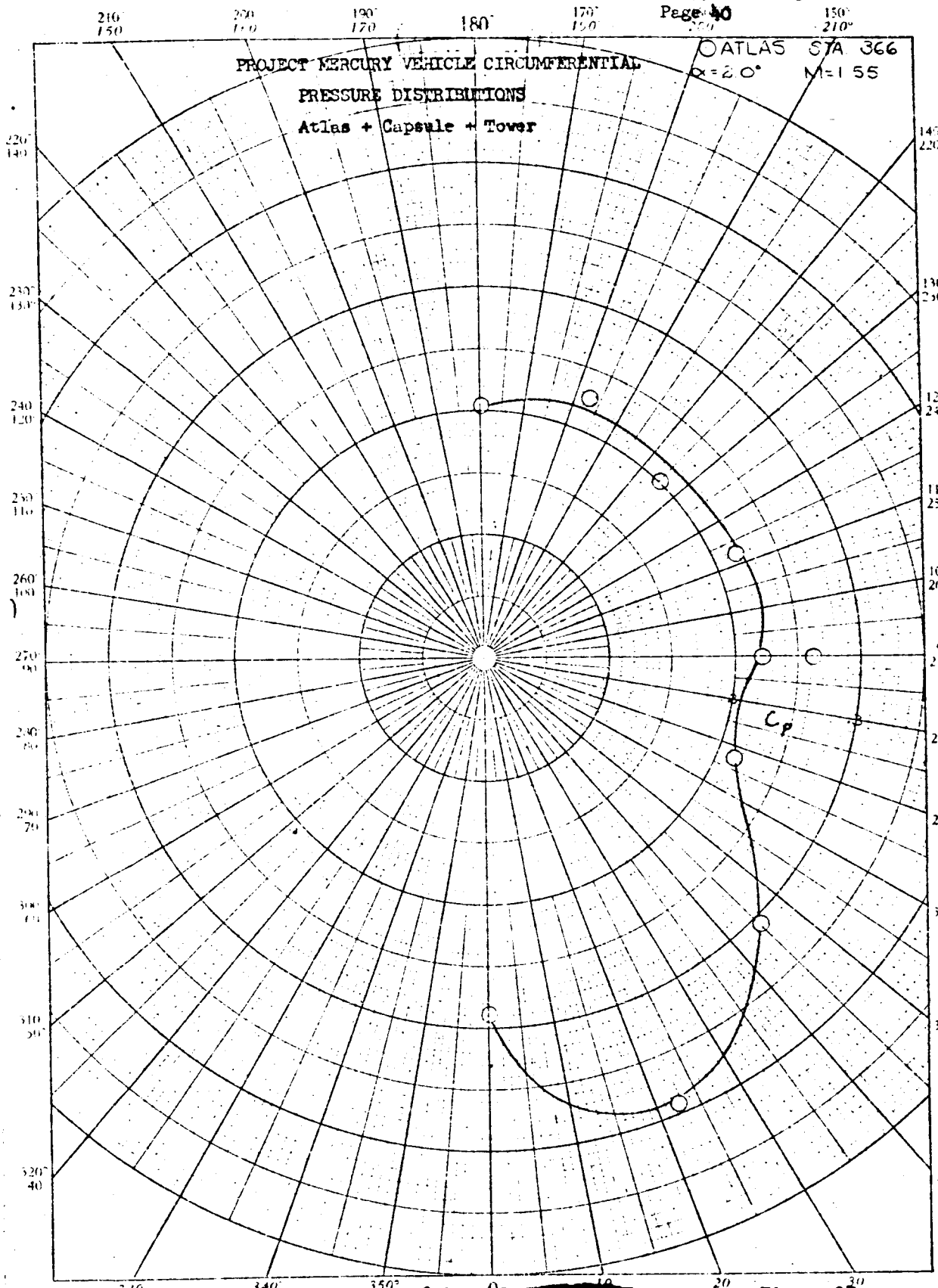


Figure 37

POLAR CO-ORDINATE 359-21

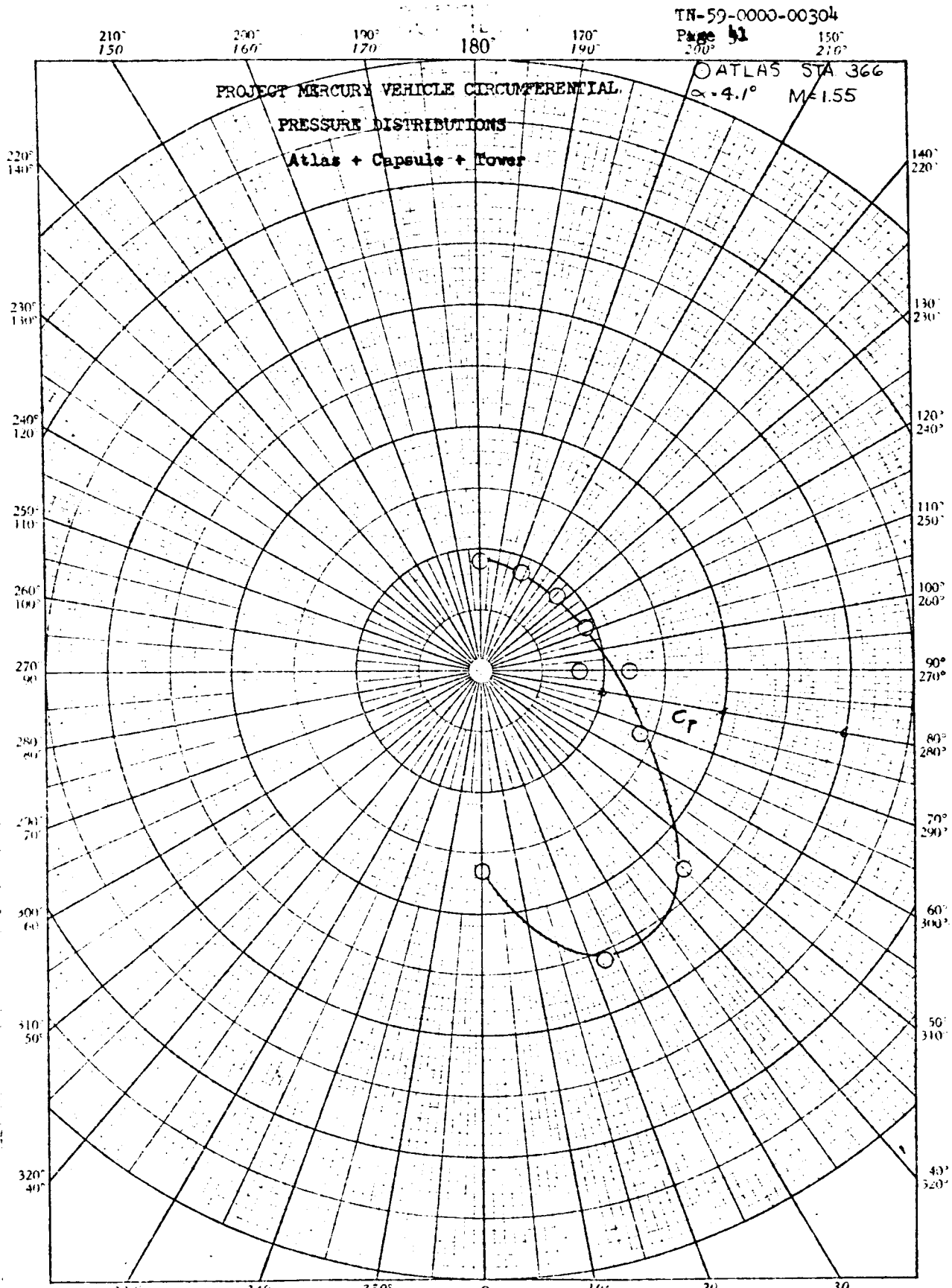


Figure 38

CONFIDENTIAL

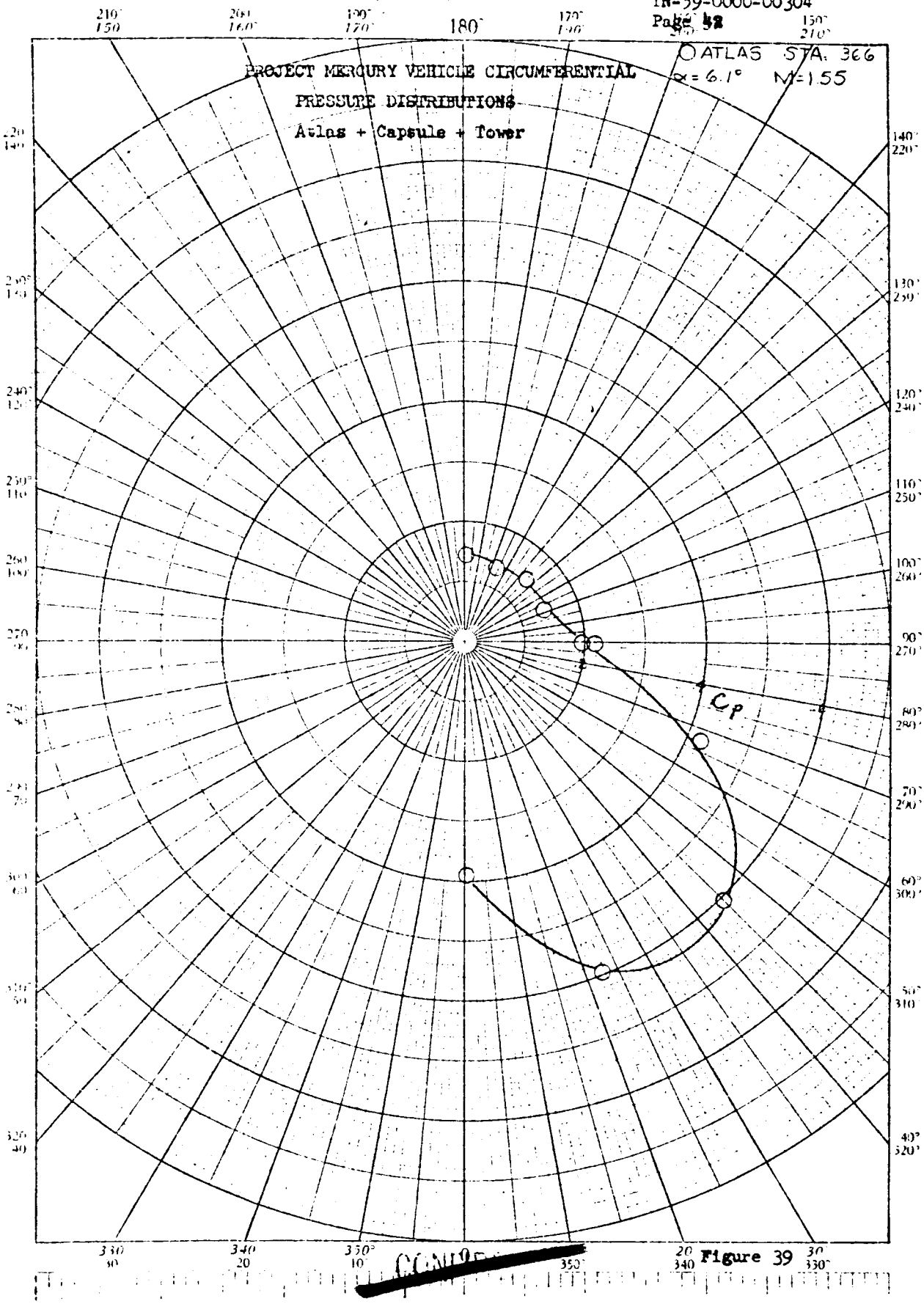


Figure 39

CONFIDENTIAL

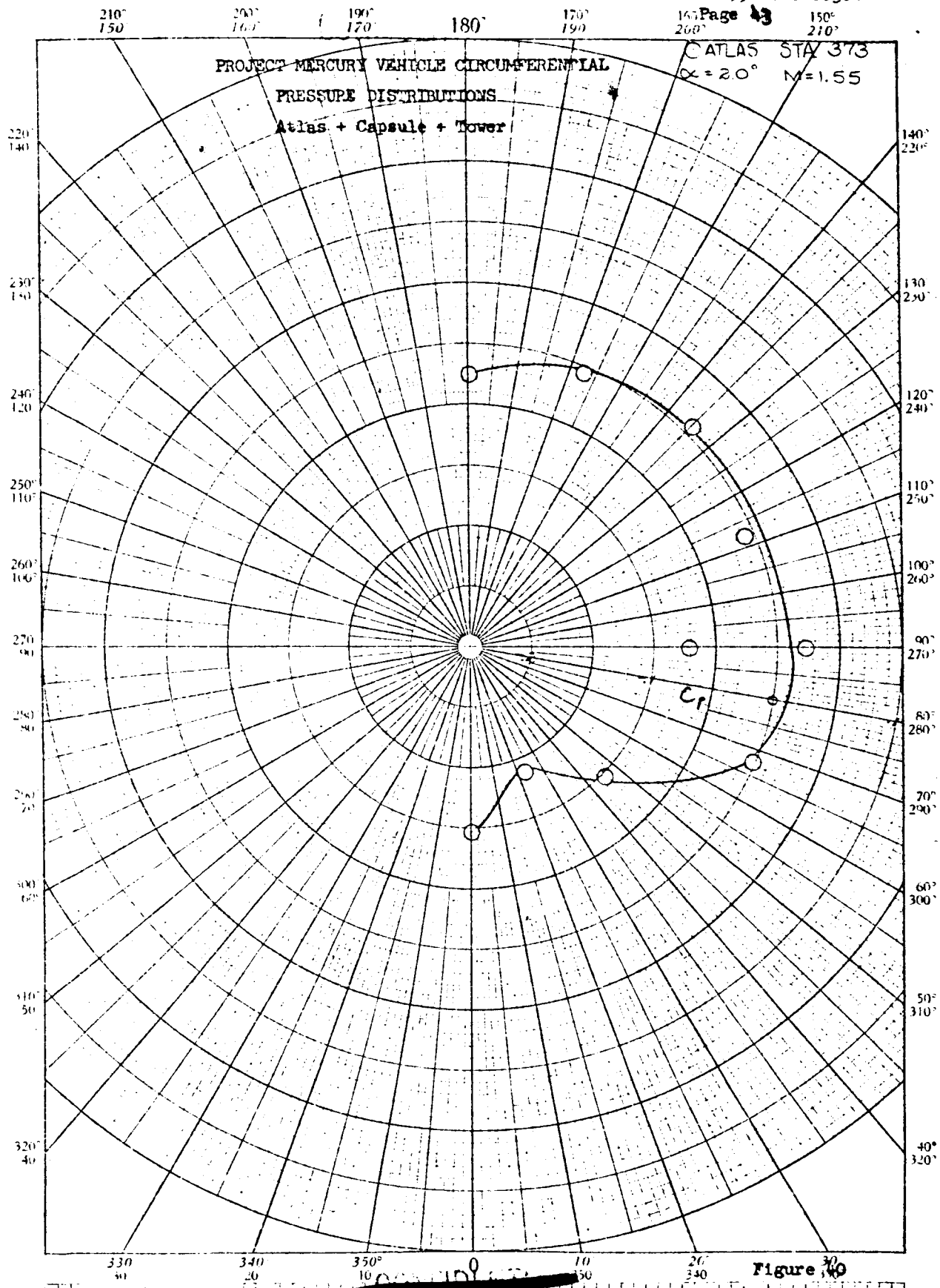


Figure 40

POLAR CO-ORDINATE 359-31

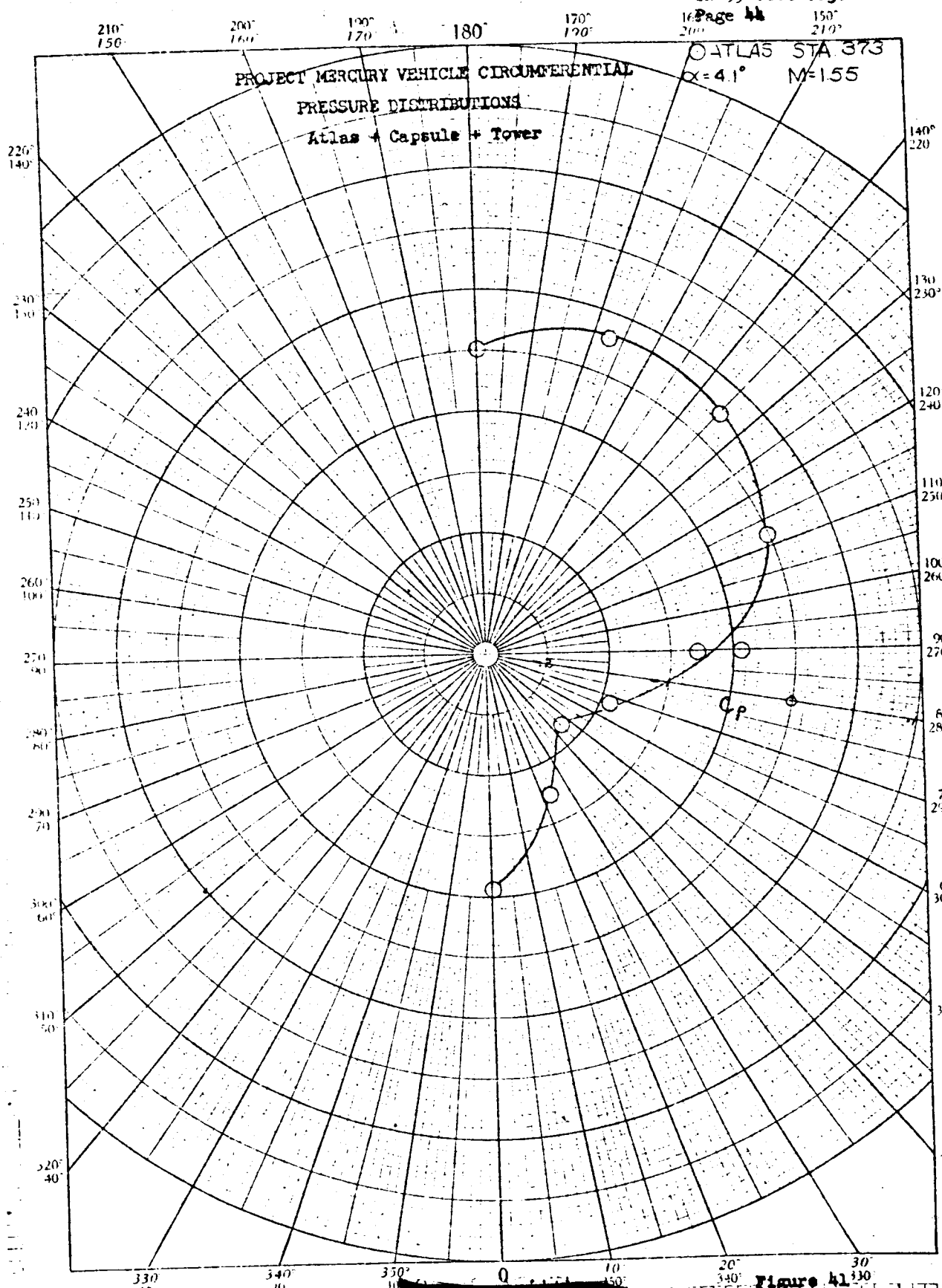


Figure 41

POLAR COORDINATE 359-31

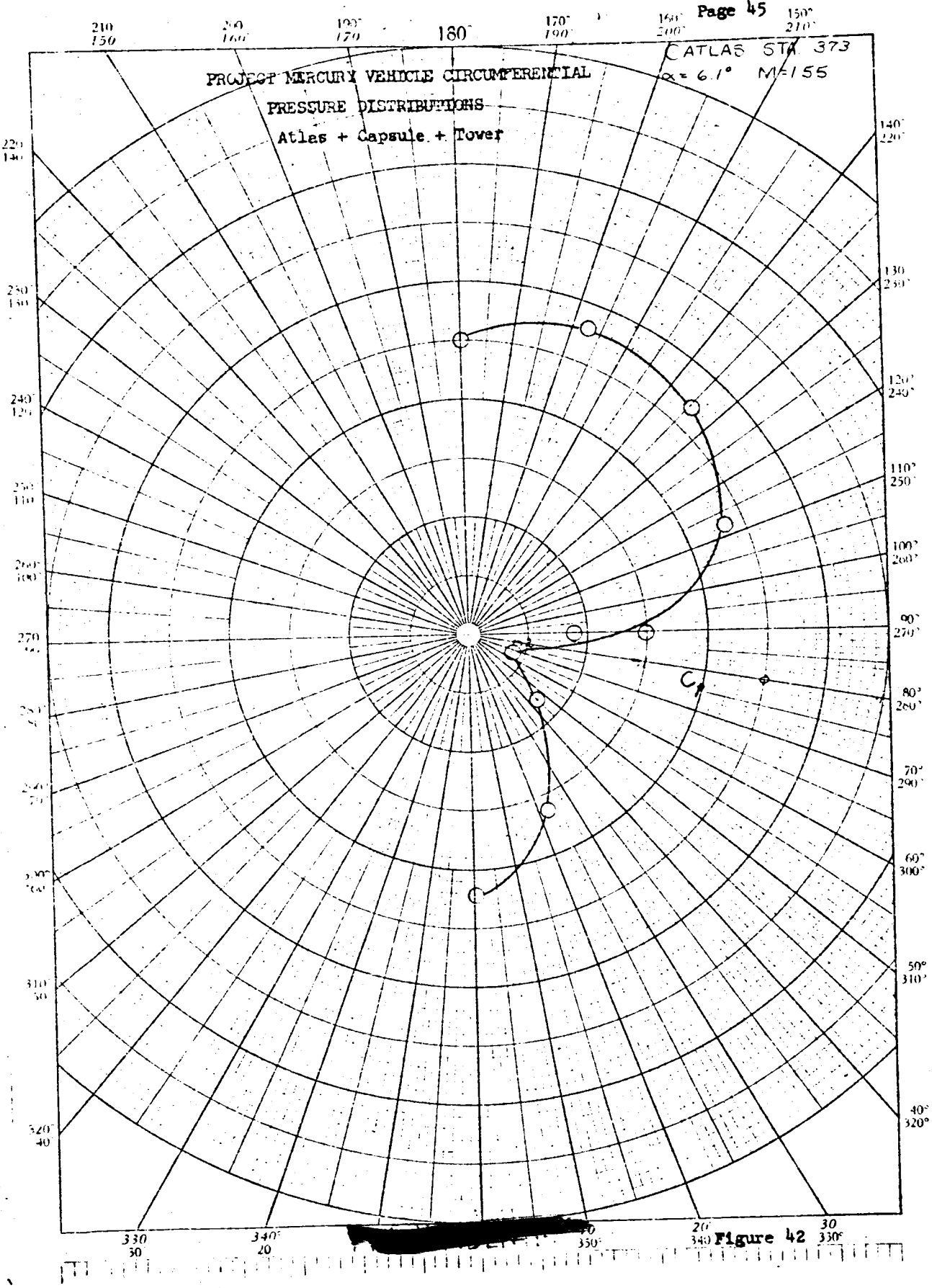


Figure 42

POLAR COORDINATE 359-31

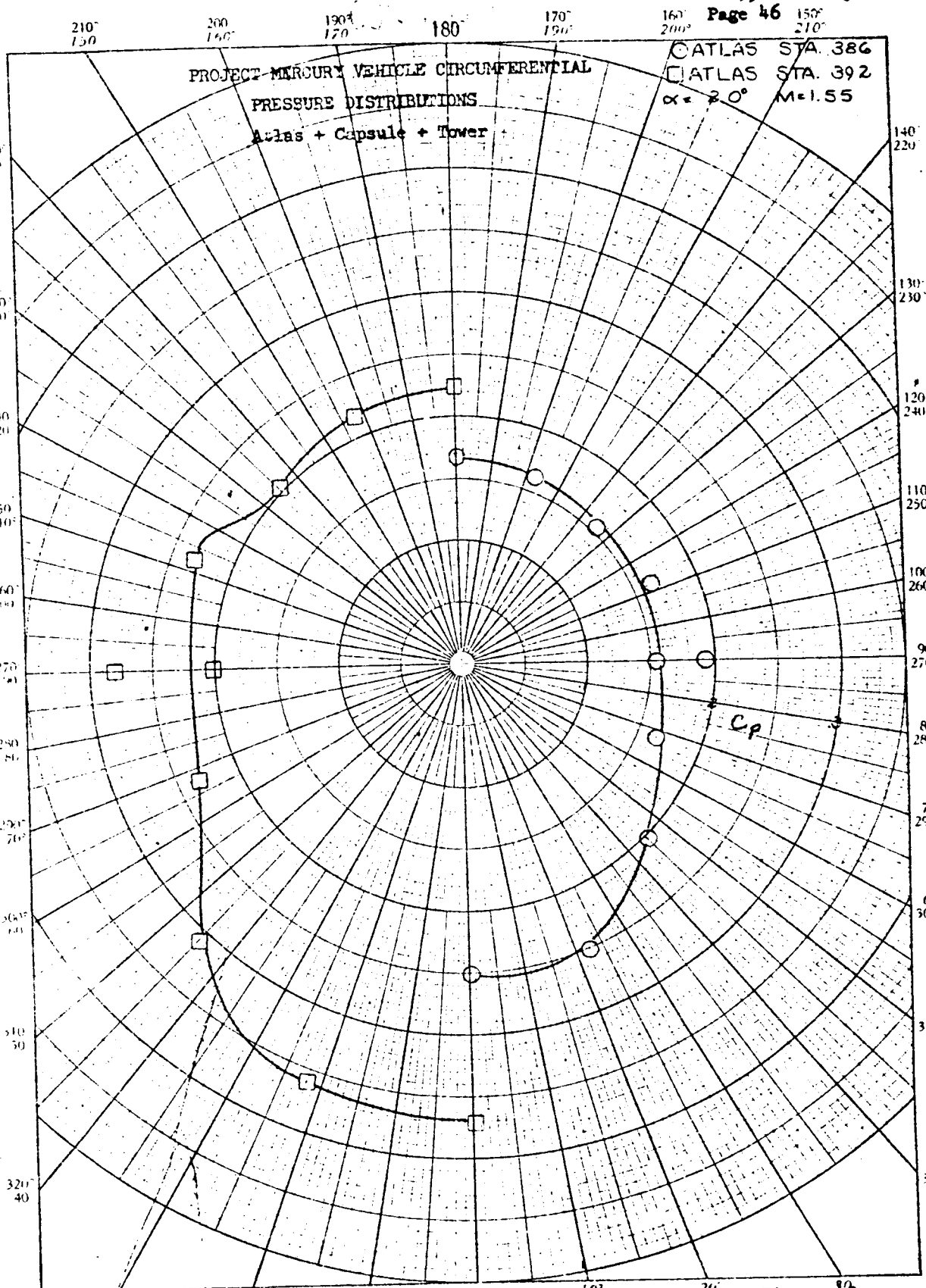


Figure 43

[redacted]

POLAR COORDINATE 359-31

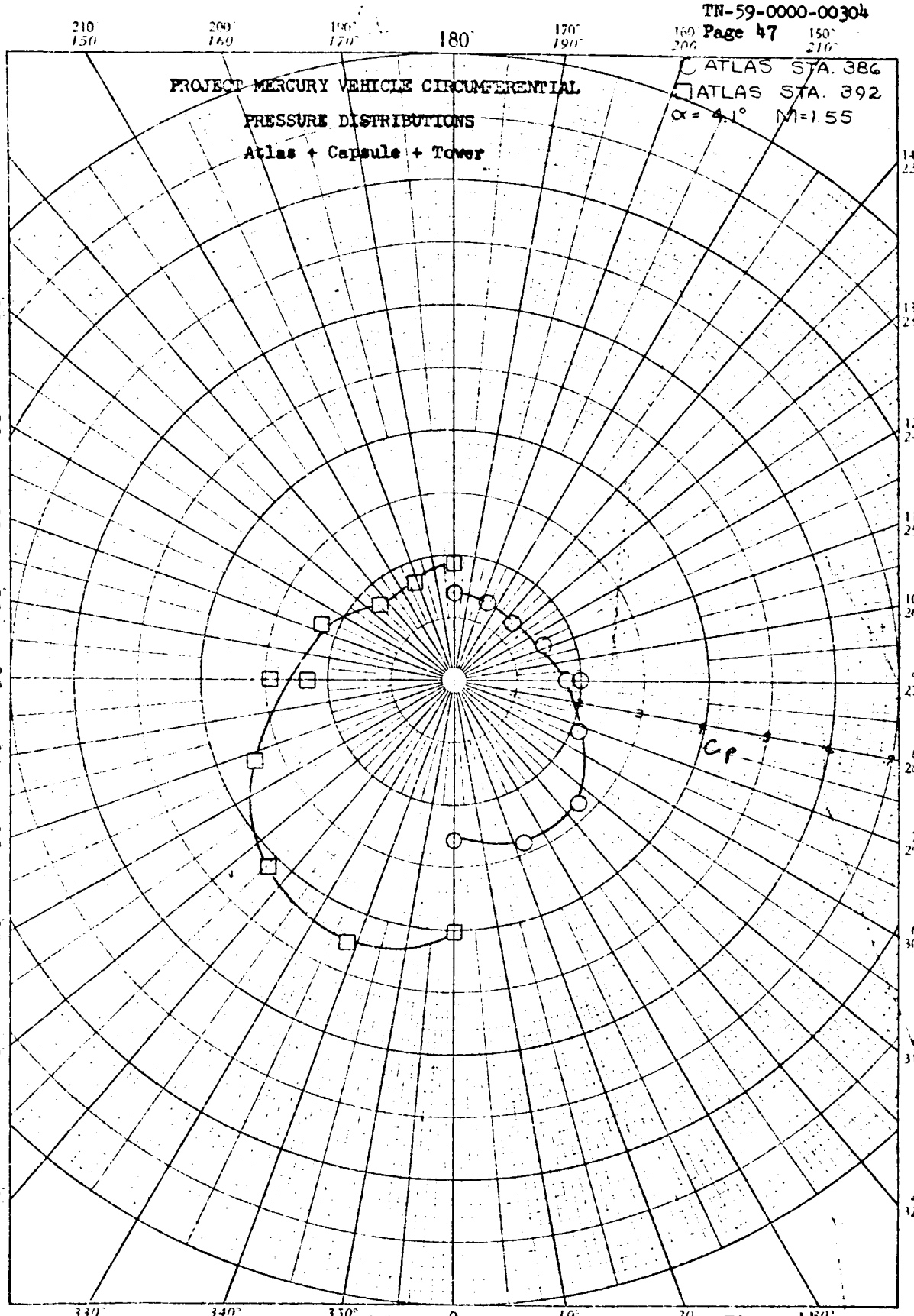


Figure 44

POLAR COORDINATE 359-31

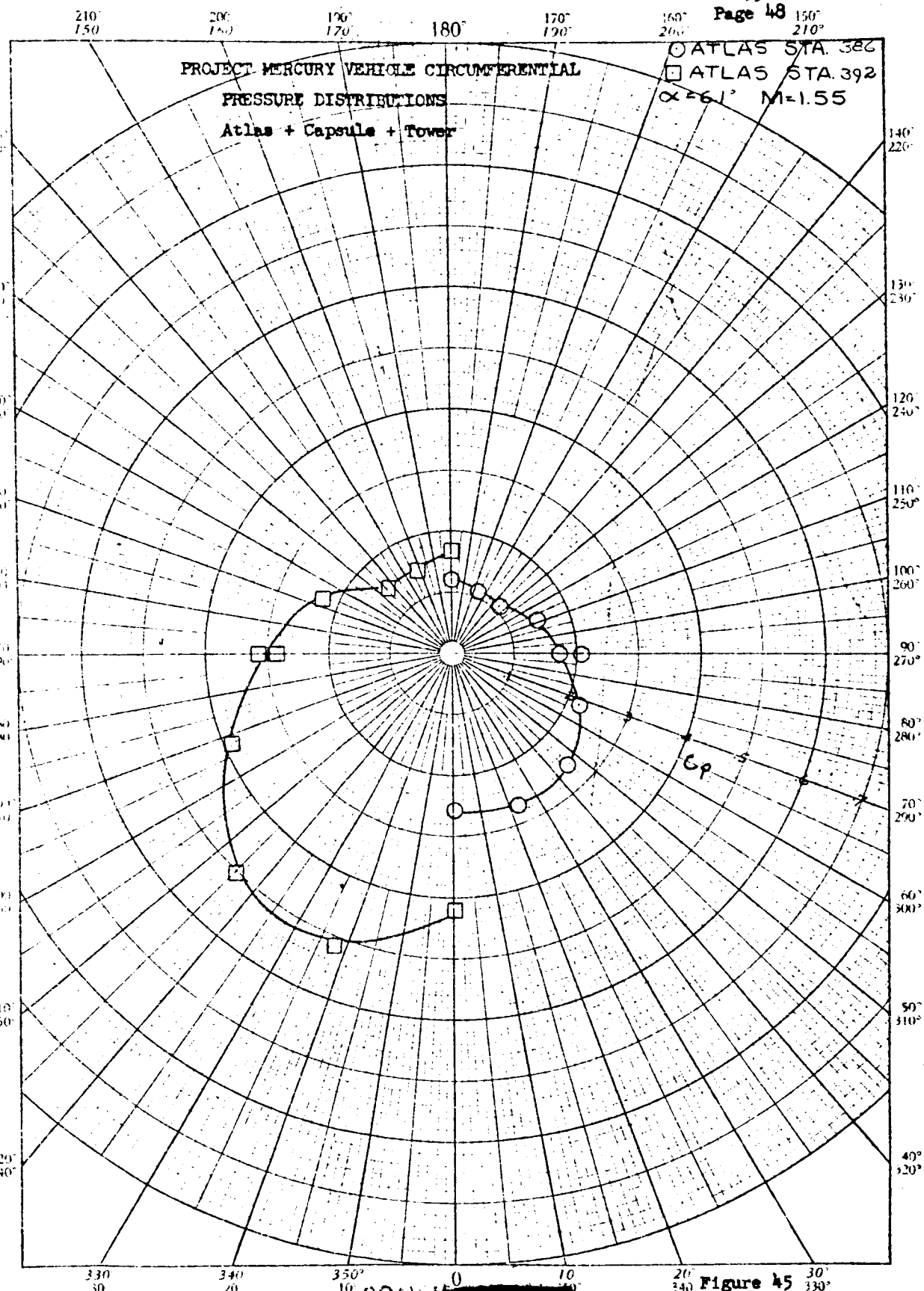


Figure 45

POLAR CO-ORDINATE 359-31

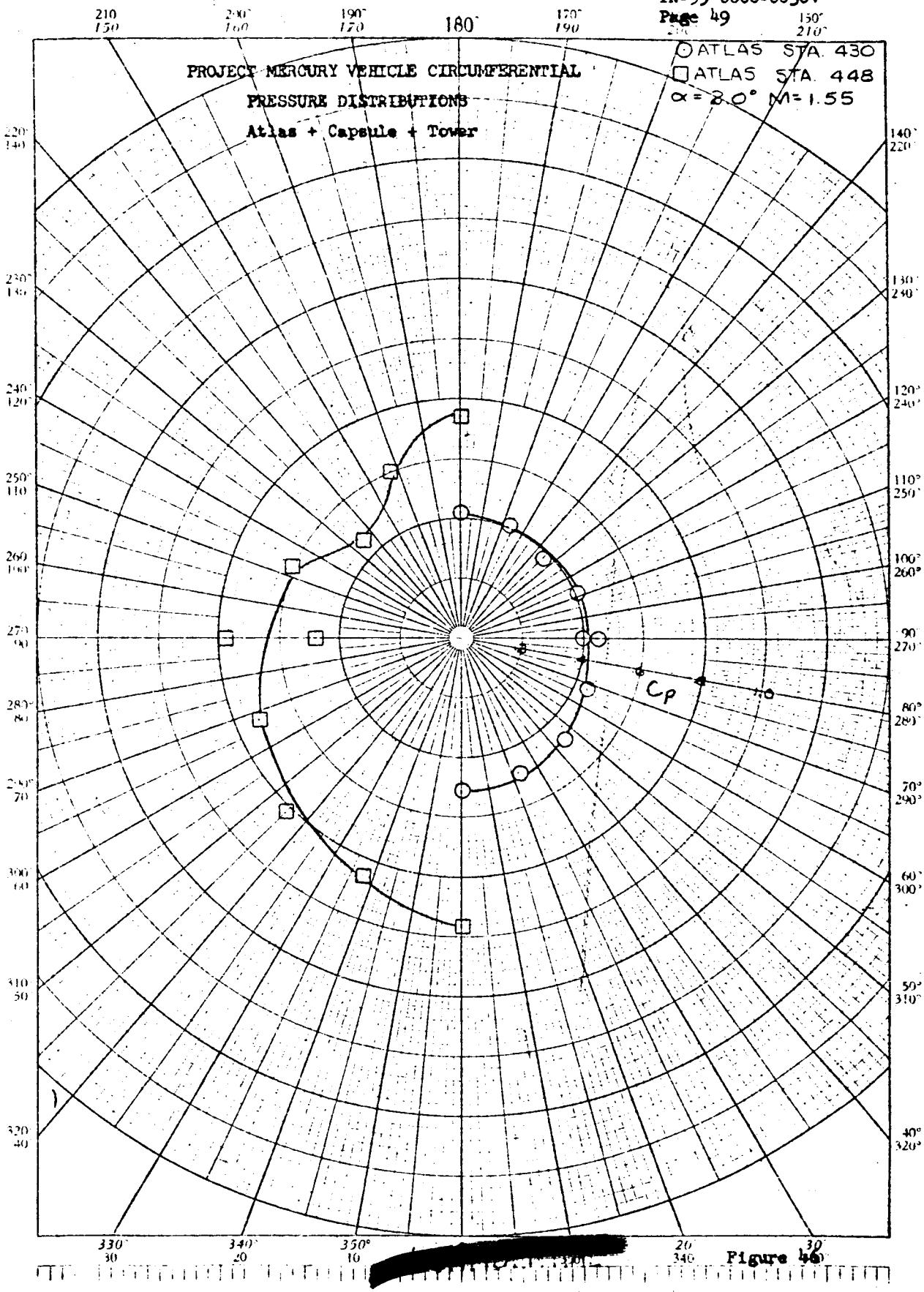

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA. 430
ATLAS STA. 448
α = 2.0° M = 1.55
Cp
180°
POLAR COORDINATE

Figure 46

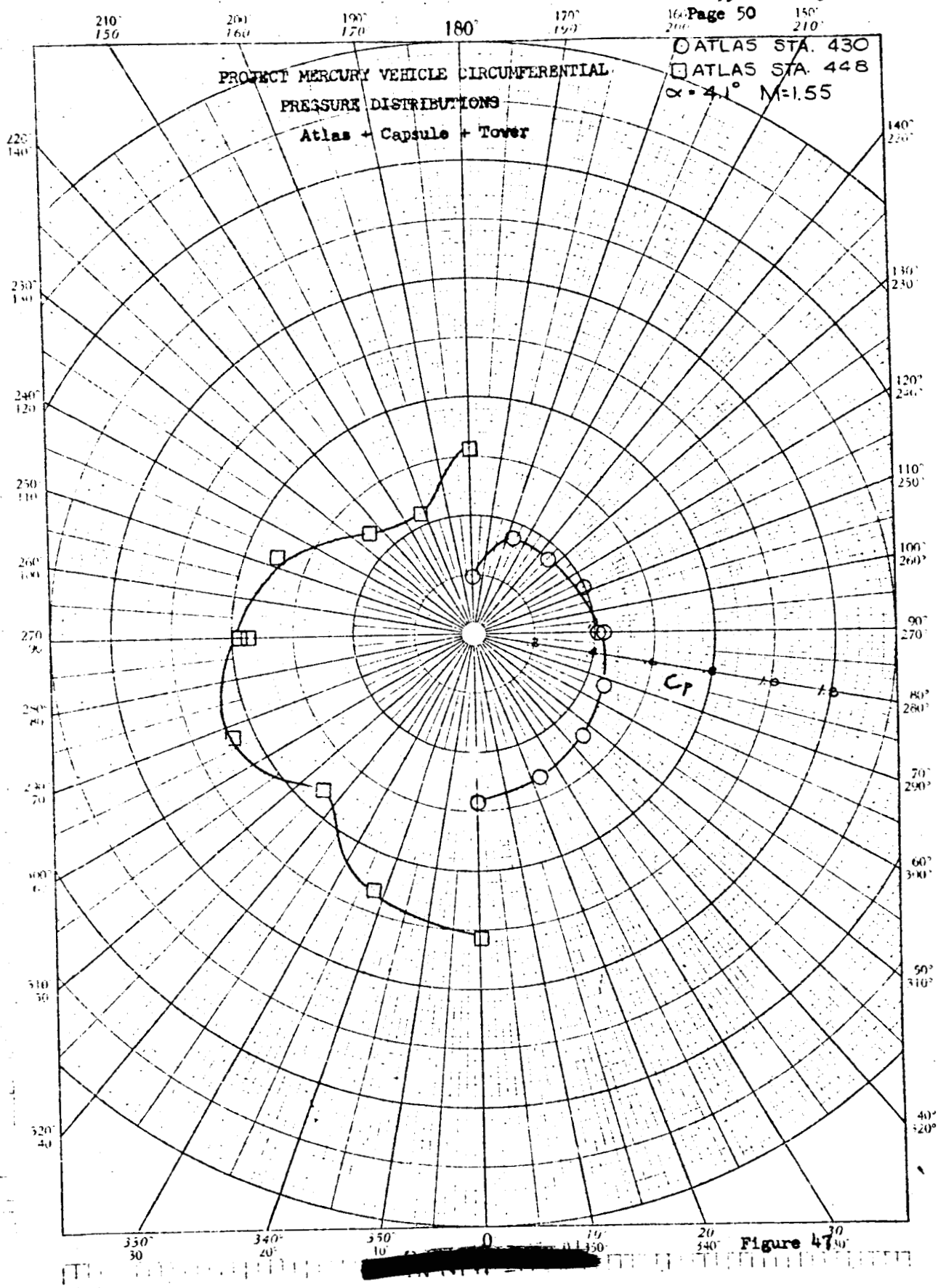


Figure 47

[redacted]

POLAR CO-ORDINATE 359-31

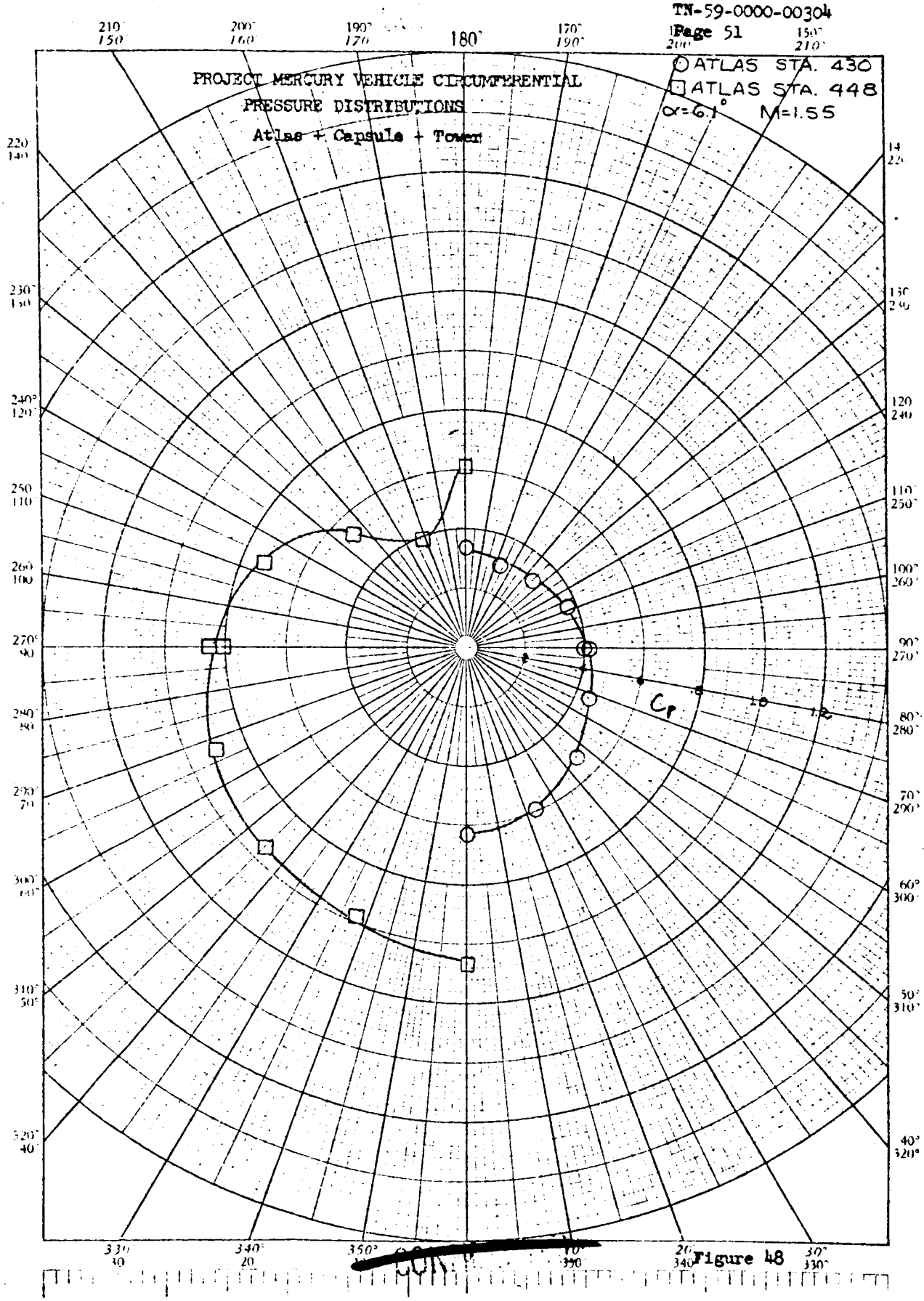


Figure 48

POLAR CO-ORDINATE 359.31

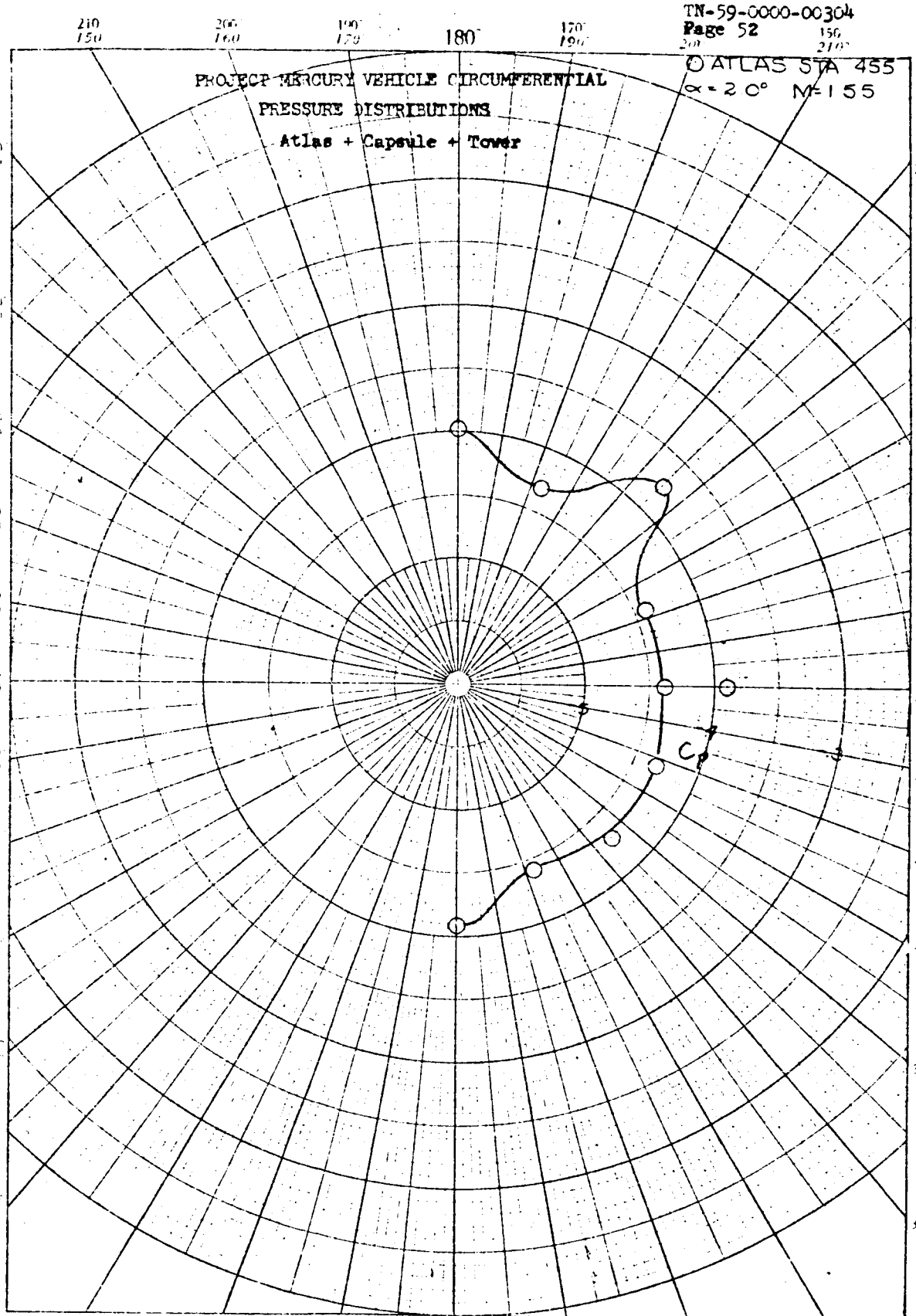


Figure 49

[redacted]

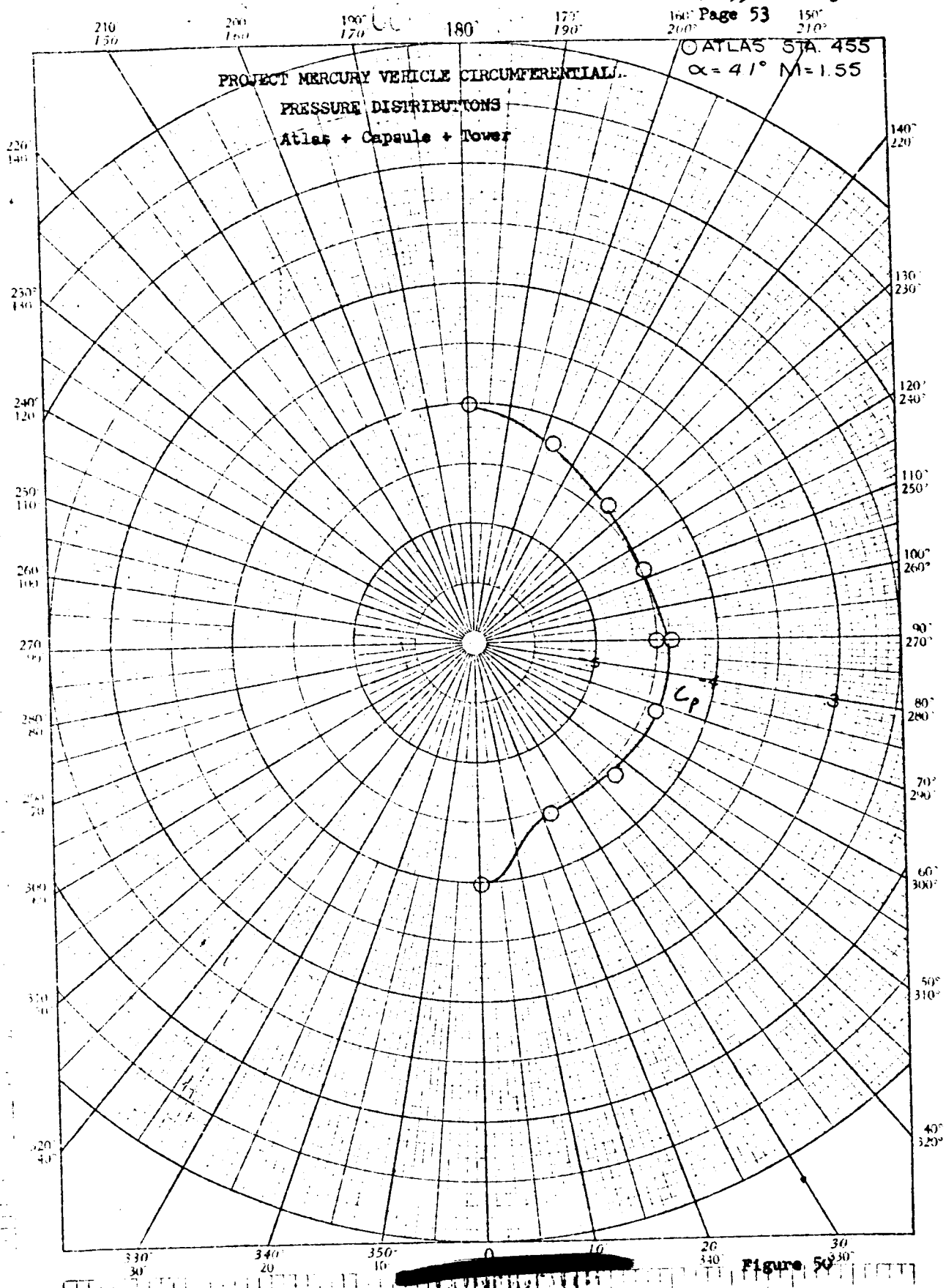


Figure 50

[redacted]

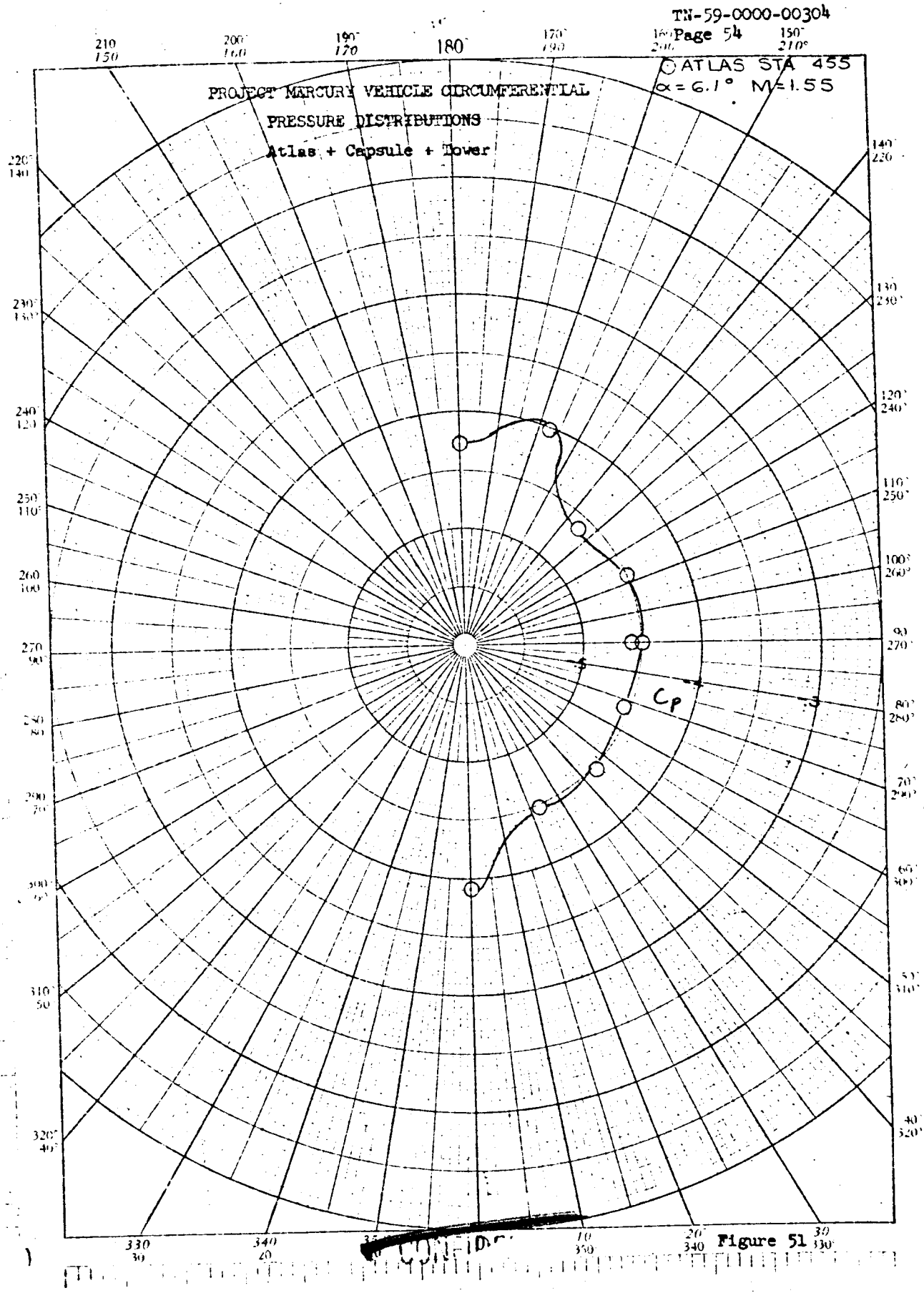

PROJECT MARCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA 455
α = 6.1° M=1.55
Cp
POLAR COORDINATE

Figure 51

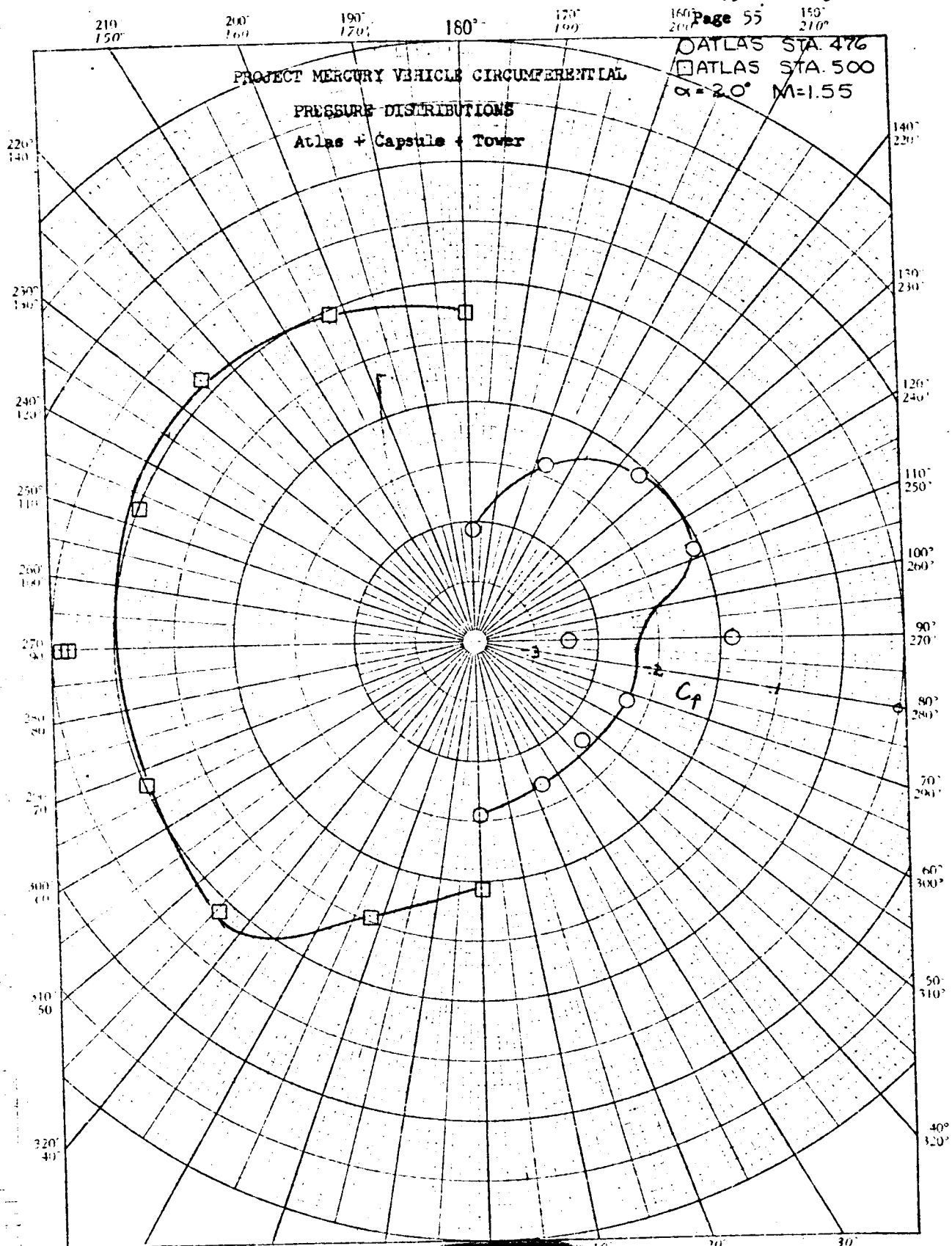

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA. 476
ATLAS STA. 500
α = 2.0° M=1.55
180°
-3
-2
-1
C_p

Figure 52

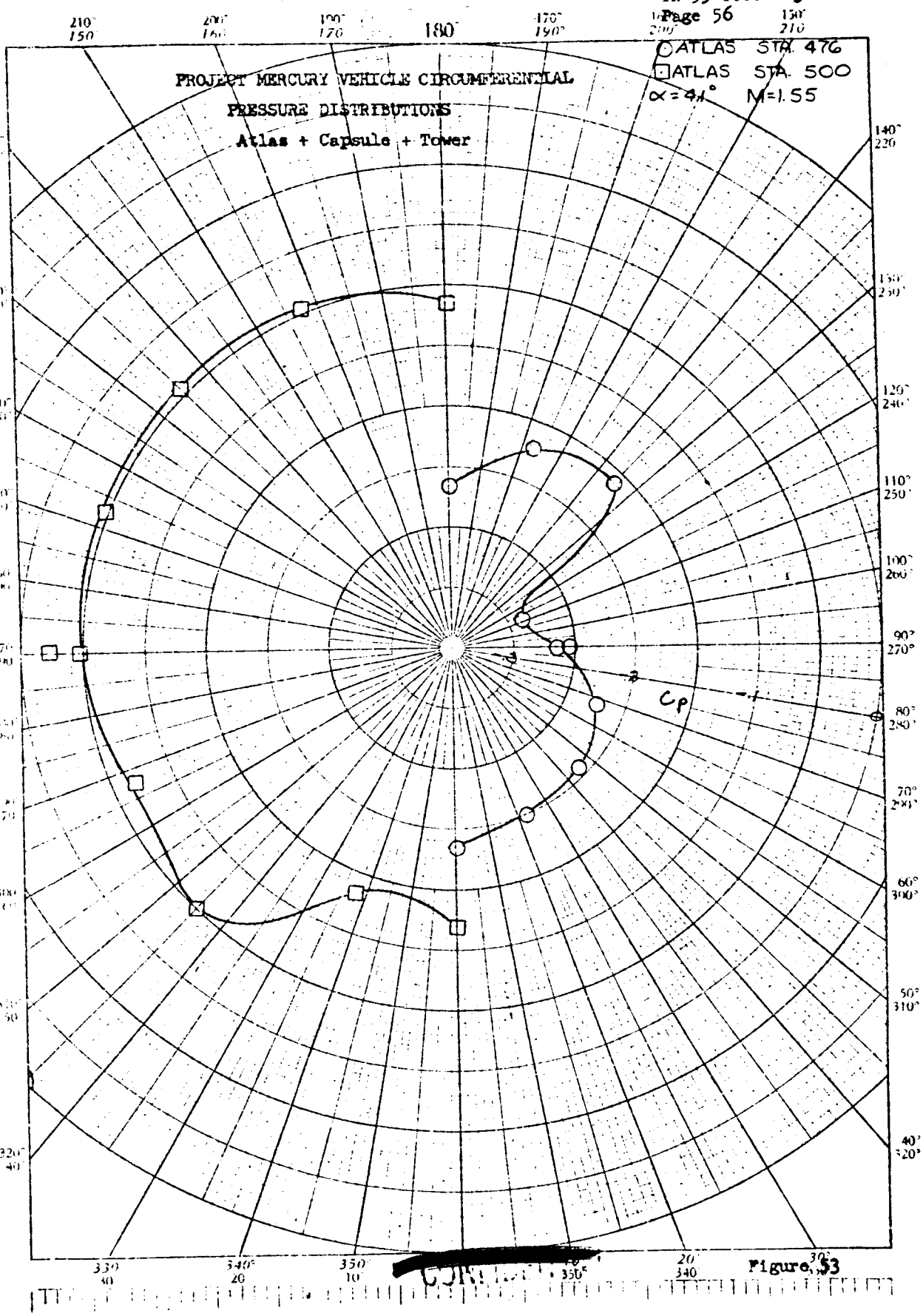

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA. 476
ATLAS STA. 500
α = 4.1°
M = 1.55
Cp
180°
POLAR CO-ORDINATE 359-31

Figure 53

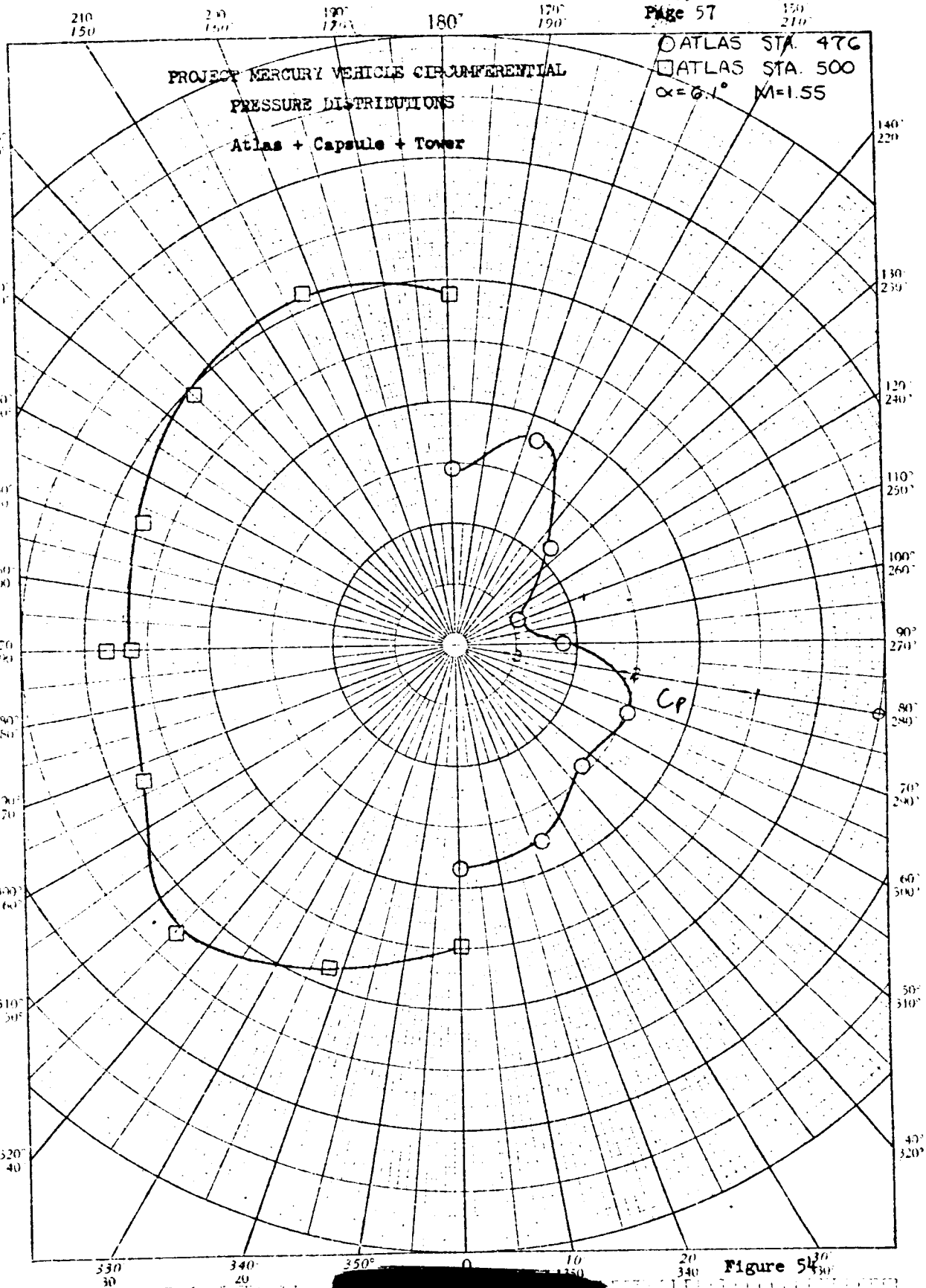


Figure 54

[redacted]

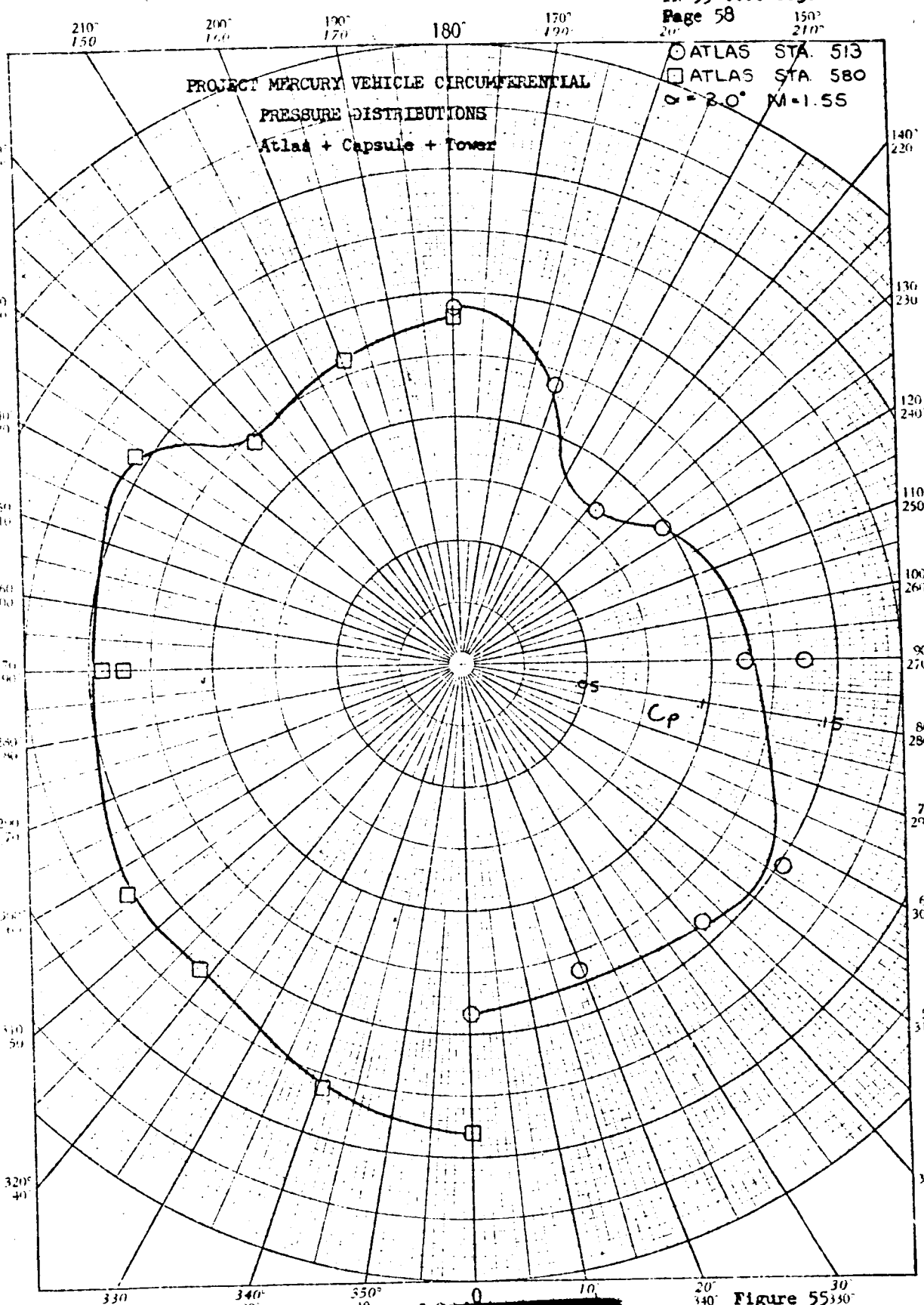


Figure 55

[redacted]

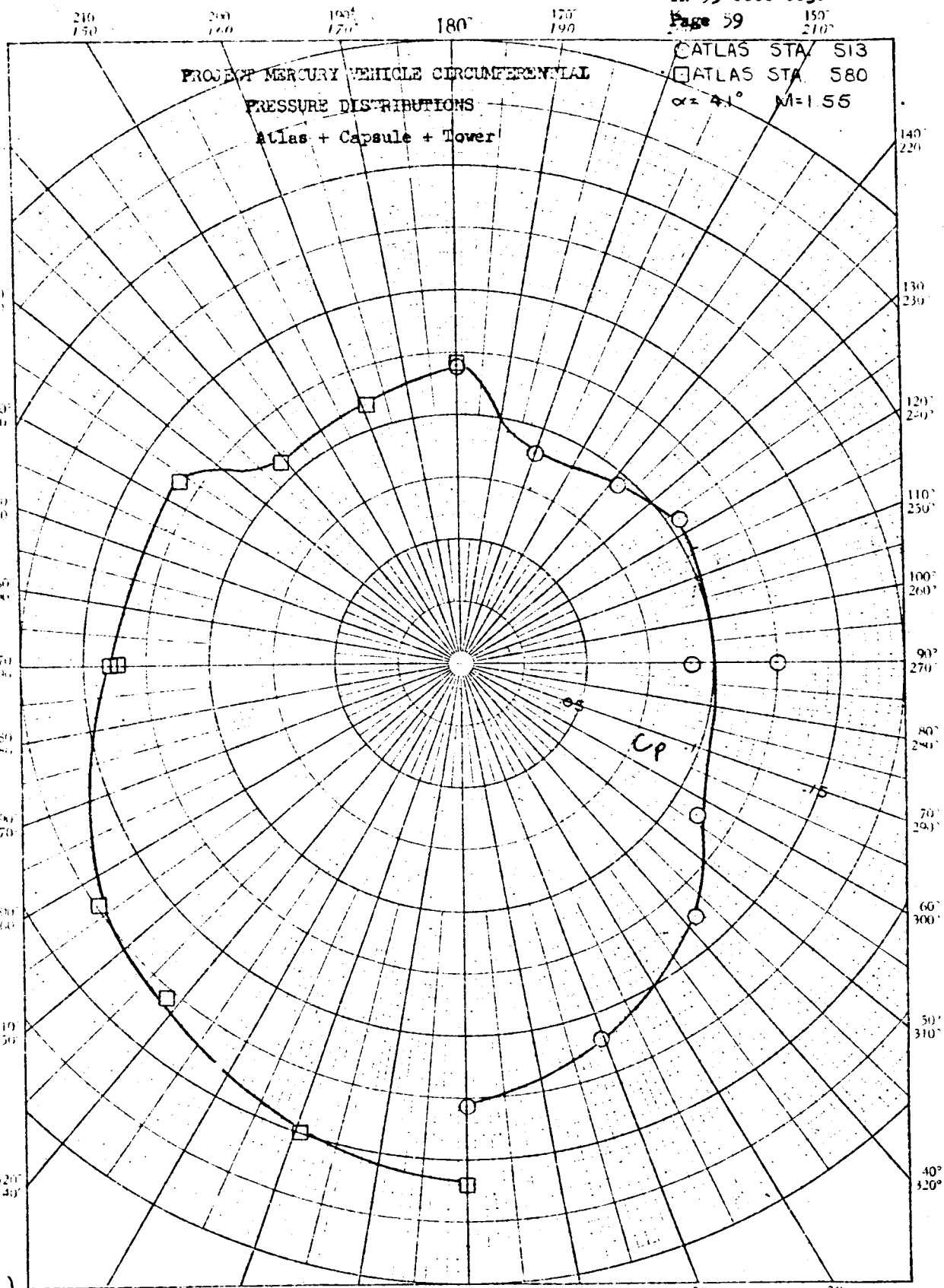

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower
ATLAS STA 513
ATLAS STA 580
α = 41° M=1.55
Cp
.05
.15
180°
0
POLAR CO-ORDINATE 350-31

Figure 56

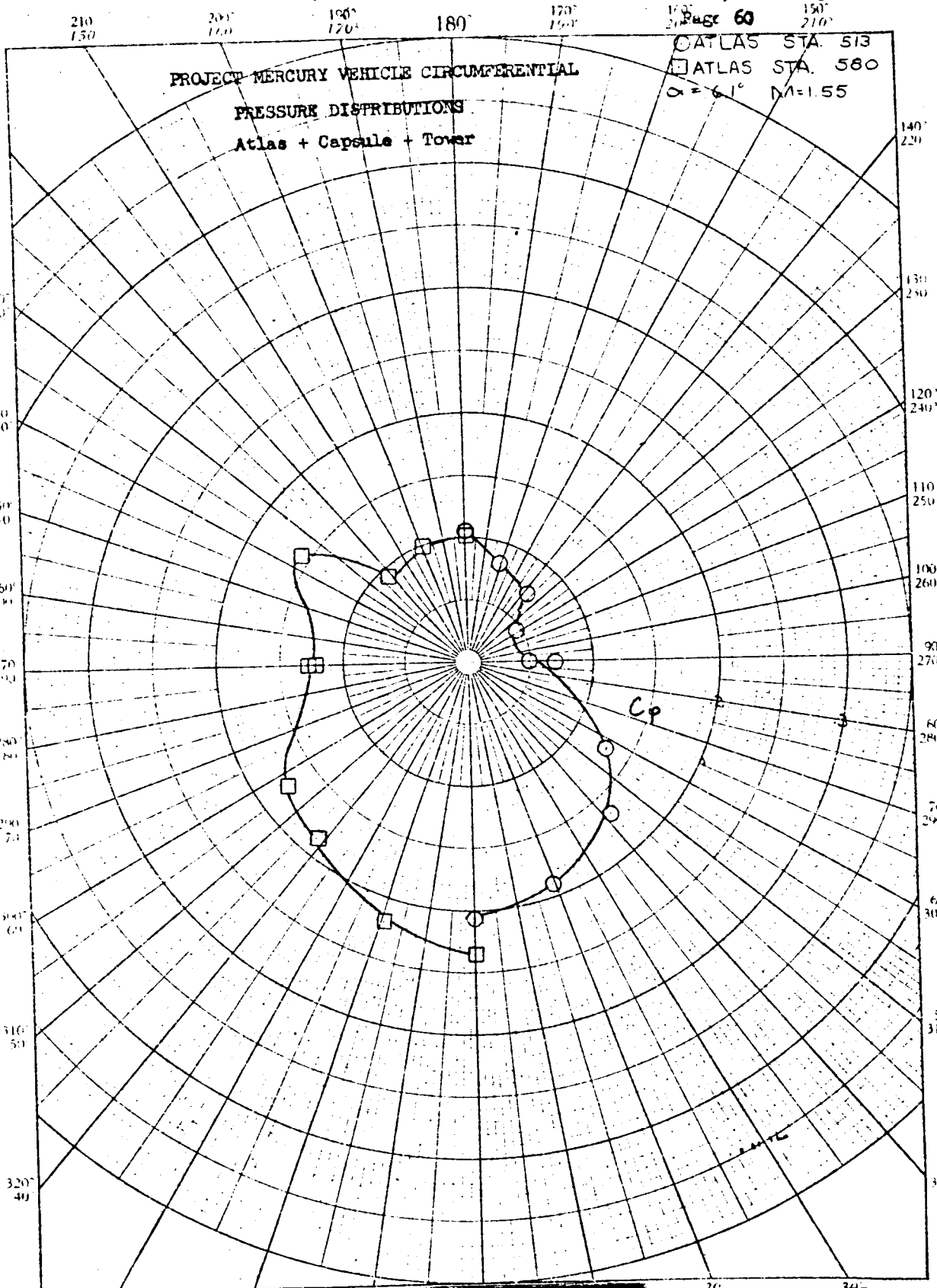


Figure 37

POLAR COORDINATE 359-31

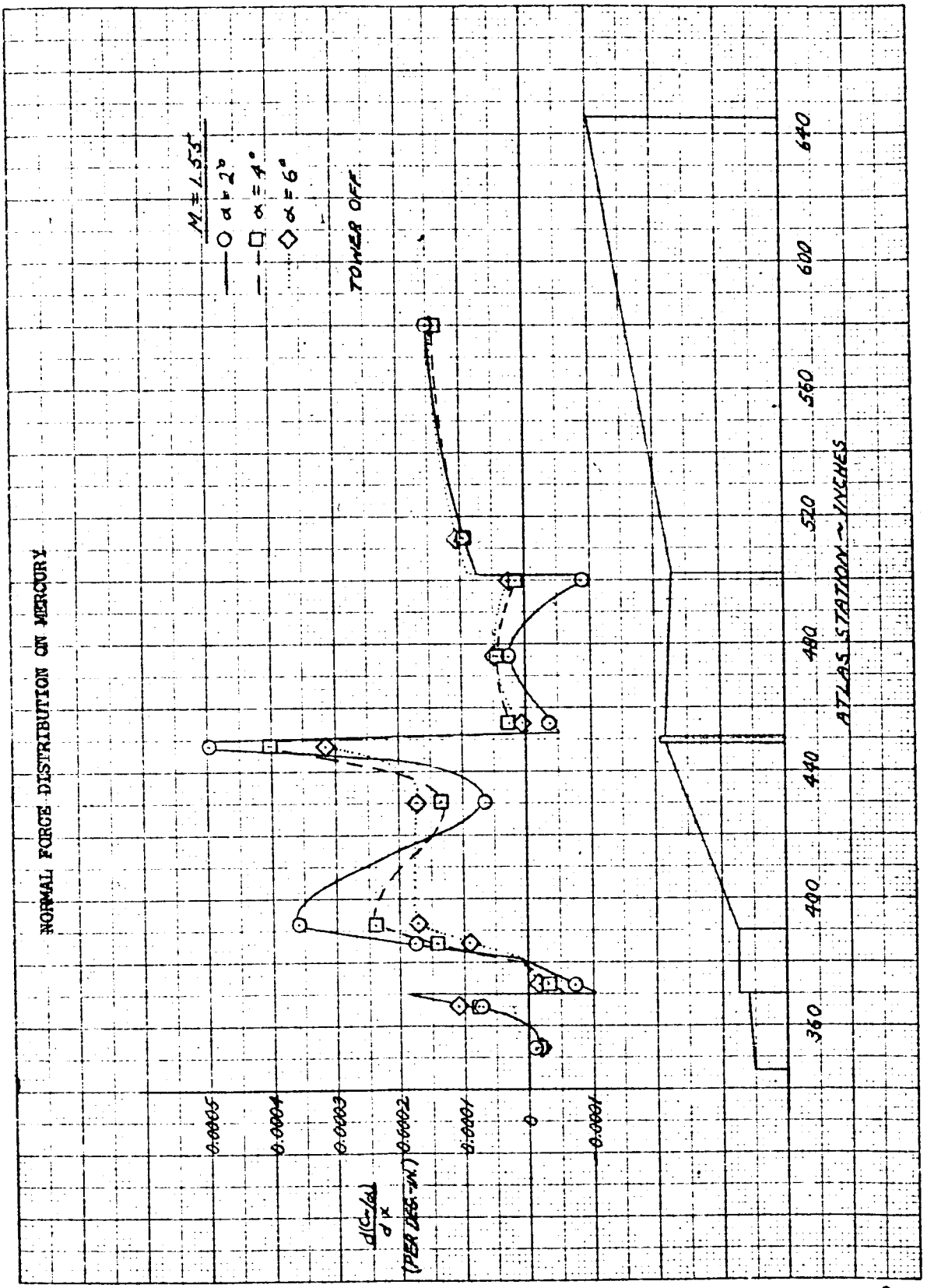
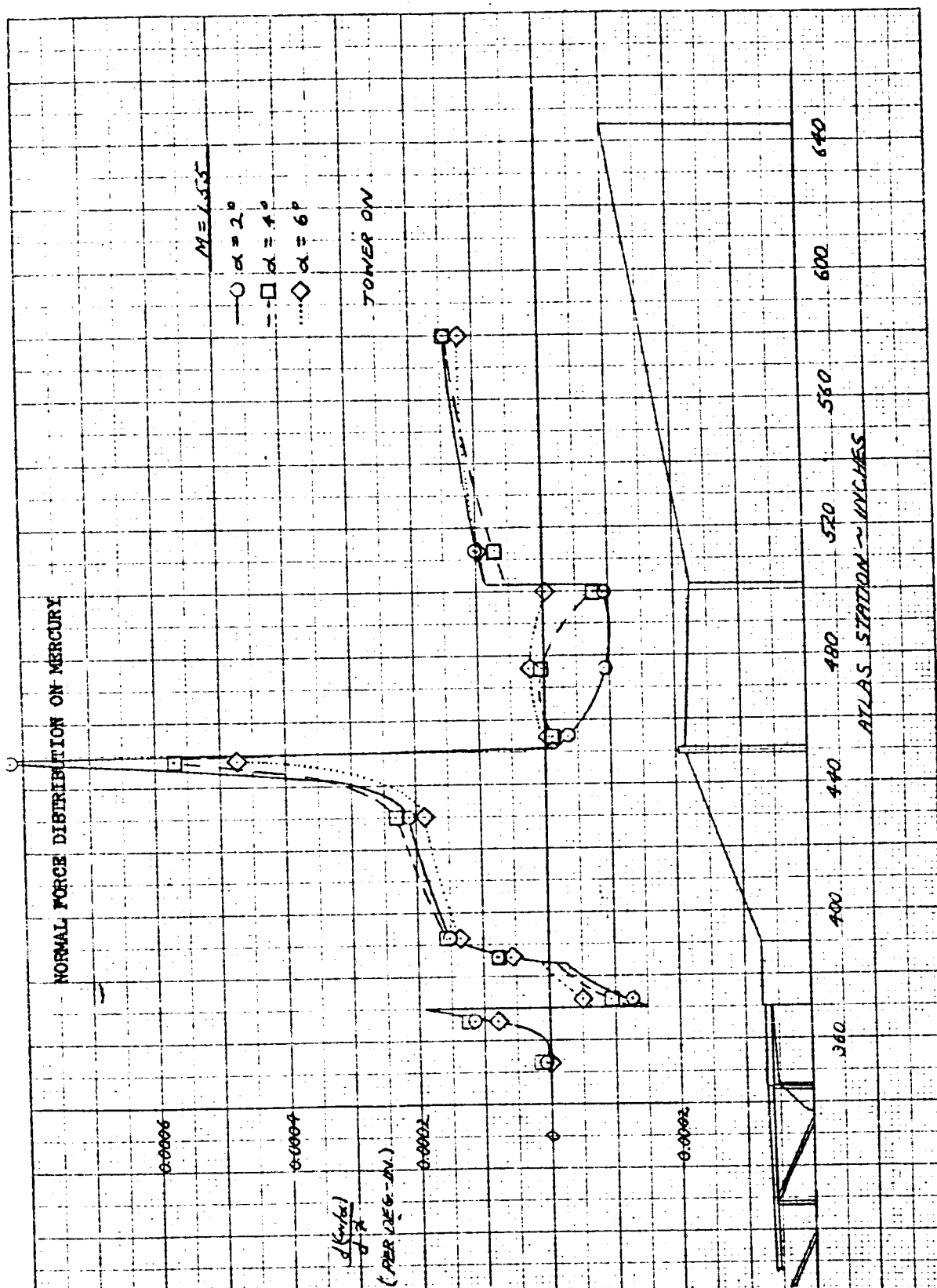

NORMAL FORCE DISTRIBUTION ON MERCURY
M = 1.55
α = 2°
α = 4°
α = 6°
TOWER OFF
0.0005
0.0004
0.0003
0.0002
0.0001
0
-0.0001
d(C_N/α)/dx
(PER DEG-IN.)
360
400
440
480
520
560
600
640
ATLAS STATION ~ INCHES

Figure 58



[redacted]

Figure 59

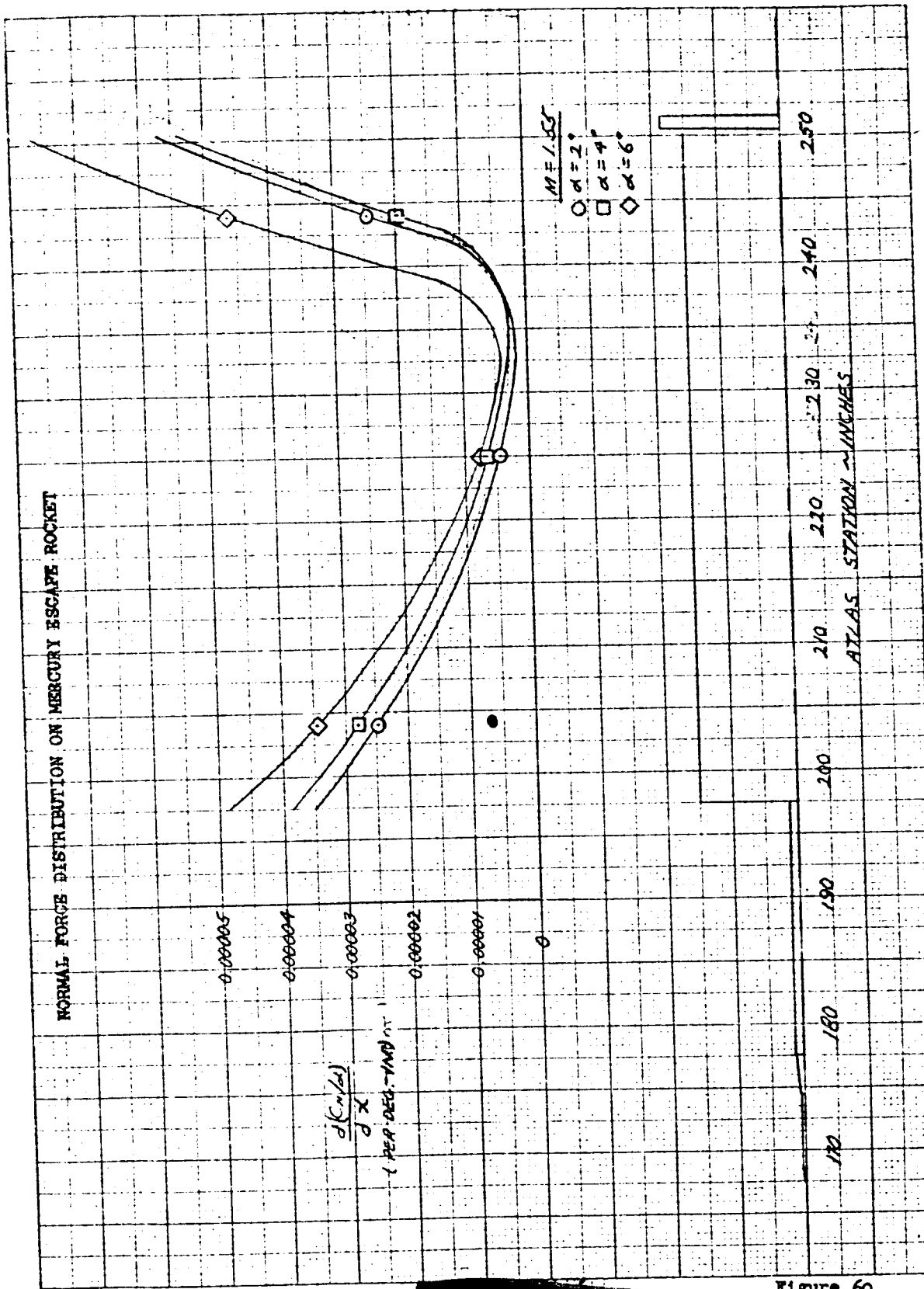


Figure 60

CONFIDENTIAL