AD-A179 133 PREDICTION OF TYPHOON-INDUCED PEAK WINDS AT FOUR PACIFIC STATIONS(U) WEATHER WING (1ST) HICKAM AFB HI J E PETTETT 15 SEP 80 1WW-TN-80-1 1/1

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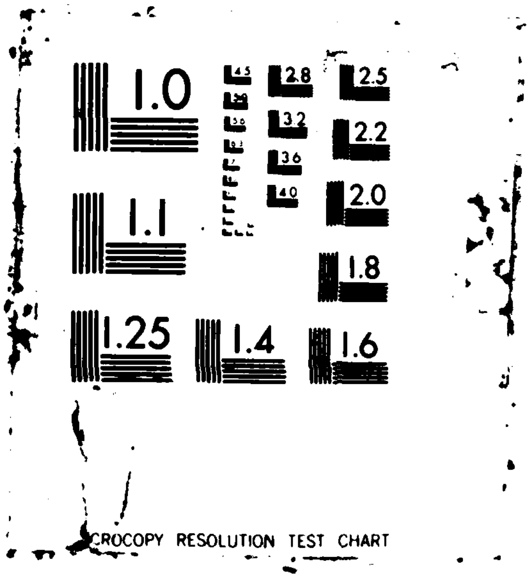
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1WW/TN-80/001

PREDICTION OF TYPHOON-INDUCED PEAK WINDS AT FOUR PACIFIC STATIONS

Capt James E. Pettett

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15 September 1980

United States Air Force
Air Weather Service (MAC)
Headquarters 1st Weather Wing
Hickam AFB, Hawaii 96853

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Wind Gusts	Okinawa	Andersen AFB
	Philippines	Yokota AB
	Japan	Clark AB

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This note contains nomograms and instructions for estimating peak wind gusts at the station when a typhoon is within 360 nm. The method of preparing the nomograms is discussed in detail. Terrain influences are also discussed.

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PREFACE

It was brought to the attention of 1WW/DON that there were inconsistencies in Special Reports 121, 122, 123, 124, and 126, nomograms for predicting typhoon-induced peak wind gusts at certain Pacific stations. Nine more years of data, collected by improved methods of satellite and aircraft reconnaissance, plus more sophisticated methods of presenting the data, warranted an update of this information. Four of the station analyses (omitting SR 124) are here combined into a single technical note that includes an explanation of the construction of the nomograms and directions for their use.

ACKNOWLEDGMENTS

I wish to thank Colonel Atkinson for his professional guidance and personal inspiration throughout this project. I am also grateful to Major Cochran for his talents in technical writing.

James E. Pettett

JAMES E. PETTETT, Capt, USAF
Chief, Climatology
Aerospace Sciences Branch

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APPENDIX

1. INTRODUCTION

In April 1967, Atkinson and Penland produced 1 WW Technical Study 12 on Typhoon Weather Models for Kadena AB, Okinawa to address the forecasting problems of predicting typhoon winds. As a consequence of this study, 1 WW Special Reports 121, 122, 123, 124, and 126 were produced to help forecasters predict maximum winds caused by typhoons at their stations. These reports were based on data from an 18-year time period from 1953 through 1970. They used 16 compass-point azimuthal nomograms centered on the station (e.g. see Appendix). On the nomograms were isolines showing the percentage of a typhoon's maximum sustained winds that the forecast point (at the center of the nomogram) would be likely to receive from a typhoon within the 360 nautical miles radius of the nomograms. In this effort to improve the nomograms, the author, with the assistance of one of the original authors (Atkinson), has eliminated some inconsistencies in the past statistics, added new data from 1971 through 1979, and incorporated a more sophisticated smoothing technique. The resulting nomograms are now mutually consistent and more suitable as forecast aids. Stations considered include: Andersen AFB, Guam; Clark AB, Philippines; Kadena AB, Okinawa; and Yokota AB, Japan. The methods used to construct the new nomograms and how to use them follow.

2. METHOD USED TO CONSTRUCT THE TYPHOON NOMOGRAMS

Typhoon data for the affected stations was extracted from the Joint Typhoon Warning Center's (JTWC) Annual Typhoon Report and plotted, as in the previous studies, on a 16 compass-point (true versus magnetic) azimuthal nomogram centered on the station. The 16 resulting sectors were lettered sequentially A to P beginning clockwise from 000°. The nomogram was further divided into six concentric rings defining range intervals of 60 nautical miles (NM) from the center out to 360 NM. These annular regions were numbered 1 through 6 from the outside inward. This divided the 16 sectors into 96 identifiable sections. For instance, Section D3 is bounded by 067.5° and 090° radials at a range of 180 to 240 NM from the station. Only the portion of each storm's track that equalled or exceeded typhoon strength was extracted from the JTWC best track summaries and plotted on the station nomogram. In keeping with the practice observed in the prior studies, the storm tracks were divided into 30 NM segments. Each 30 NM segment within a given section thus represents one occurrence in the statistics. In the summary Tables 1 through 4, the number of occurrences is listed as the third number in each section; i.e., as ZZ in the format XX-YY-ZZ. When segments traversed section boundaries the occurrence was credited to that section wherein most of the 30 NM track segment had occurred. Inside the innermost two rings (numbers 5 and 6) where the 30 NM segment distance is large compared to overall section dimensions, subjective modifications occasionally credited an occurrence to each of two, and sometimes three, sections, from only one parent track segment. To weight storms in proportion to the amount of area of each section that the storm influenced, the original authors selected this "track segment" methodology rather than another which weighted, for instance, the amount of time a storm affected a given section. The present updating of the climatology elected to continue this practice.

With the segmented best tracks plotted on the nomograms for each station, the applicable WBANs (AWS Form 10) were then searched. For the time interval associated with each segment the highest observed wind gust (sustained winds were used if no gusts were reported) was extracted. This wind was then divided by the corresponding sustained center wind speed reported in the JTWC's best track for each storm. This speed, representing the typhoon's average strength in each segment, was derived by averaging the

JTWC center speed bulletin values (linearly-interpolated if necessary) at the time of entry and exit from each 30 NM segment.

The observed peak gusts divided by the JTWC center speed yielded a percentage. The 1971 through 1979 data was combined with the 1953 through 1970 data to yield the revised statistics presented in Tables 1 through 4 in the Appendix.

From this "one segment-one percentage technique" an average percentage for each section for all storms was calculated and plotted on the nomogram for each station. The percentages were further searched for maxima and a second nomogram was plotted containing the maximum peak gust per section. As in the prior studies, in sections where the maximum percentage equalled or exceeded 100% of the typhoon's center speed, 99% was entered on the working percentage nomogram. In order to transform the climatology into a forecast tool, a simple isoline analysis of the working percentage values was made, using the arithmetically averaged and geographically smoothed values.

The working percents were averaged azimuthally by assigning to each of the 96 sections a new value obtained by averaging its initial value with that of the section on either side of it within the same number ring. The values were not radially averaged because of the much stronger radial gradients of the data. This gradient also necessitated careful attention to the sections in the innermost two rings, 5 and 6. Here, each section's percentage value was positioned for later analysis <u>not</u> at a point halfway (or 30 NM) outward from the inner ring boundary, and halfway between the boundary azimuths, but at a point, always farther away from the station, analogous to the "center of gravity" of the section. The isolines shown on the final nomograms represent standard synoptic analyses of the smoothed, plotted data. Final minor smoothing of anomalous curvature in the isolines was unavoidably subjective. These smoothing techniques were applied identically to the percentages forecasting mean peak gusts (Figures 1, 3, 5, 7) and to those for maximum peak gusts (Figures 2, 4, 6, 8).

3. HOW TO USE THE TYPHOON NOMOGRAMS

The typhoon may be positioned on the nomogram by either latitude/longitude coordinates or by its distance and direction from the station. For example, using Figure 1, if a typhoon's current or forecast position is 150 NM from the station on a 100° radial, the storm would be in section E4 of the nomogram. Interpolation between the 40 and 30 percent isolines in that section yields a percent of 36. If the typhoon's maximum sustained surface winds are expected to be 90 knots, multiplication (90 times .36) yields predicted peak wind gusts of 32 knots at the station.

The maximum peak gust nomograms (Figures 2, 4, 6, and 8) are used similarly. Although storm size and radial distribution of winds in each individual storm will be critical parameters, gust speeds derived from these smoothed nomograms will provide the forecaster with an estimate of the absolute maximum gust to be expected.

Forecasters should remember that the values derived from the nomograms are, in fact, wind <u>gusts</u>. An approximation to the local <u>sustained</u> wind speeds can be derived by dividing the peak gusts by an appropriate gust factor. A typical gust factor for stations which do not have pronounced local terrain features is 1.5; however, individual stations will probably have local studies covering average gust factors for strong wind situations. All stations with terrain influences should definitely conduct local forecast studies to determine appropriate gust factors. These factors are likely to vary with wind direction so that it may be appropriate to have a direction-dependent catalog of gust factors available.

4. COMMENTS AND SUGGESTIONS FOR FURTHER RESEARCH

It is well known that typhoons exhibit strongest winds in their right front quadrants when viewed along the direction of motion. Geographically stratified nomograms such as these should therefore exhibit a pattern reflecting this asymmetry, as well as the effect of the prevailing direction of motion near the terminal. Thus for Andersen and Clark, where storms usually move past on a westward track, the nomograms should indicate maximum vulnerability for storms passing to the south of the station. Similar reasoning will suggest somewhat different patterns for Kadena, where mean storm movement is from the southeast, and Yokota, where mean movement is from the south or southwest. The nomograms suggest, however, that these considerations can be overridden by terrain influences.

Andersen and Kadena have the lowest surrounding terrain. Judging from the area enclosed by the 30 percent isoline, Kadena achieves the dubious distinction of being the most vulnerable of the stations to typhoon winds. However, the compact nest of isolines around Clark AB indicates a storm needs to approach much closer to overcome the effects of the surrounding mountains and produce like results there.

Yokota's nomogram provides a dramatic illustration of the effect of the mountains to the north and west of the field. The pattern of isolines is strongly skewed to the WNW, indicating that storms in this area (which produce winds from the south or southwest at Yokota) induce much stronger gusts than storms equidistant in another direction. One might have expected a minor "ridge line" in the isolines extending toward the southwest because of the open terrain northeast of the field. Its absence may mean that as storms move through the region toward the northeast, northeast winds around the storm are weakened by dynamic subtraction.

This study assumes that the past foretells the future and therefore the composite of past typhoon effects will provide useful forecasts of peak wind gusts induced by future storms. The nomograms are believed to provide such useful forecasts. It is recognized that in many sections the climatological sample was small and perhaps not statistically reliable. No tests of the statistical significance or accuracy of forecast results using these nomograms have been made. Better methods of producing terminal forecasts of typhoon wind gusts might include various methods of stratifying the climatology, i.e., by the storm's direction of movement, by storm size, symmetry, or both. When used in conjunction with JTWC forecast tracks, we feel that these nomograms are the best tools currently available for forecasts of typhoon induced wirds. Users are, however, encouraged to consider the limitations mentioned above and to communicate all suggestions and comments to First Weather Wing, Aerospace Sciences Branch.

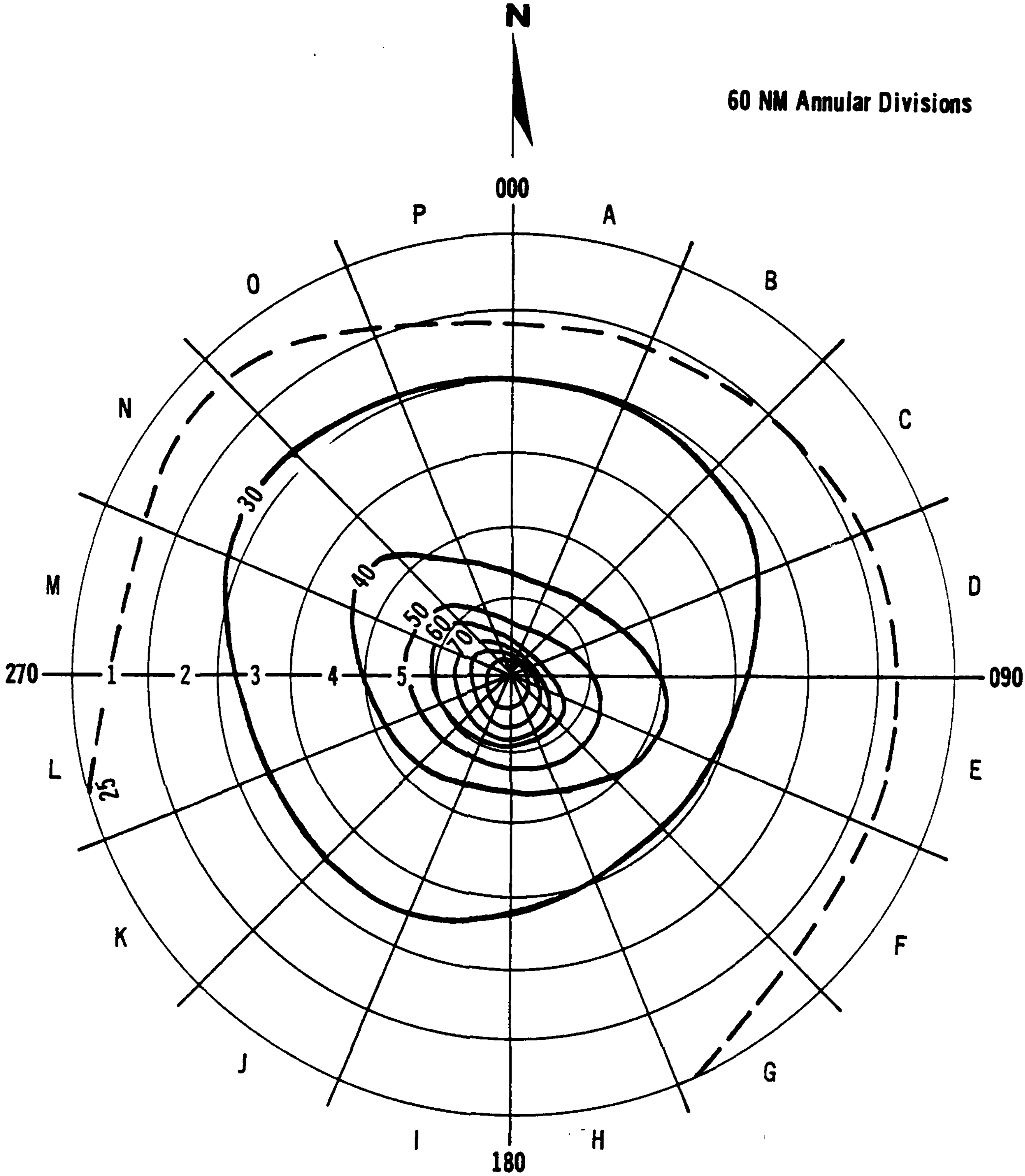

FIGURE 1

MEAN PEAK GUST AT ANDERSEN AFB

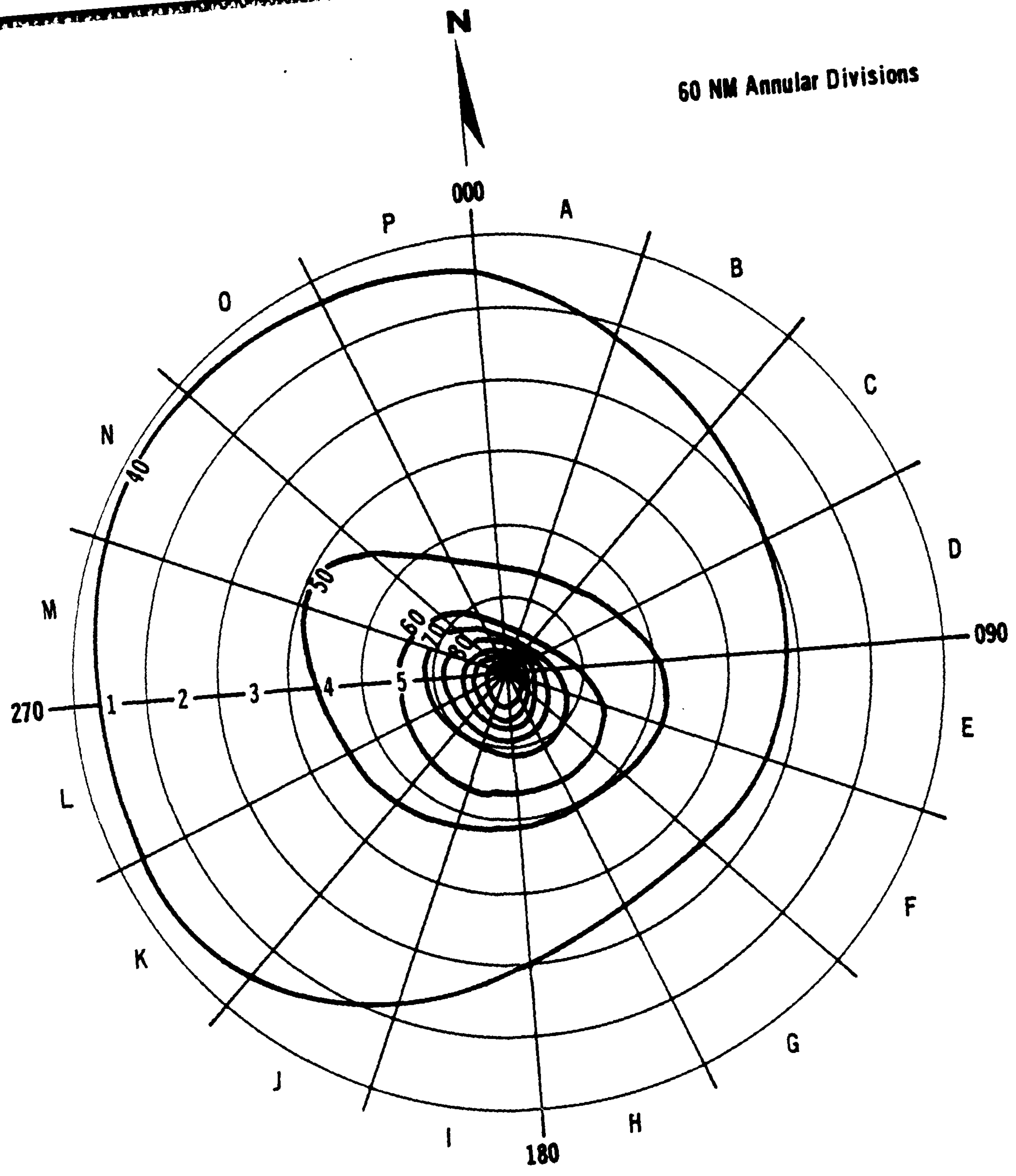

FIGURE 2

MAXIMUM PEAK GUST AT ANDERSEN AFB

MEAN AND MAXIMUM RATIOS AND NUMBER OF RATIOS AT ANDERSEN AFB

	OUTER RING					INNER RING
	1	2	3	4	5	6
A	21-40-27	26-46-21	33-50-20	28-38-7	37-45-2	38-38-1
B	20-40-15	22-33-13	41-71-15	31-50-8	37-43-3	X
C	19-30-5	X	28-35-5	22-28-3	38-43-4	47-47-1
D	29-39-3	35-37-3	28-30-3	32-45-6	40-43-3	X
E	20-33-8	27-35-8	31-42-9	34-43-6	51-57-2	64-76-3
F	23-39-12	23-39-14	24-41-11	38-46-7	43-53-6	49-65-3
G	24-27-3	22-25-5	23-40-9	28-47-10	41-50-6	70-70-1
H	33-37-7	36-48-8	32-34-3	29-35-5	39-55-10	92-92-1
I	40-45-2	X	30-40-12	X	39-73-8	71-92-2
J	35-45-3	36-48-7	30-39-12	27-35-4	36-52-12	73-92-2
K	33-49-9	29-40-16	29-49-12	30-57-11	46-60-6	63-83-2
L	21-28-8	21-33-13	31-52-10	31-46-11	45-51-3	48-83-3
M	27-50-28	24-51-21	31-51-19	35-42-8	43-50-8	87-91-2
N	25-46-19	36-63-16	37-62-17	44-63-10	50-60-5	64-79-4
O	29-51-17	27-66-10	34-53-9	X	39-45-2	X
P	20-40-27	22-46-22	35-65-13	26-35-2	42-42-1	38-57-3

TABLE 1

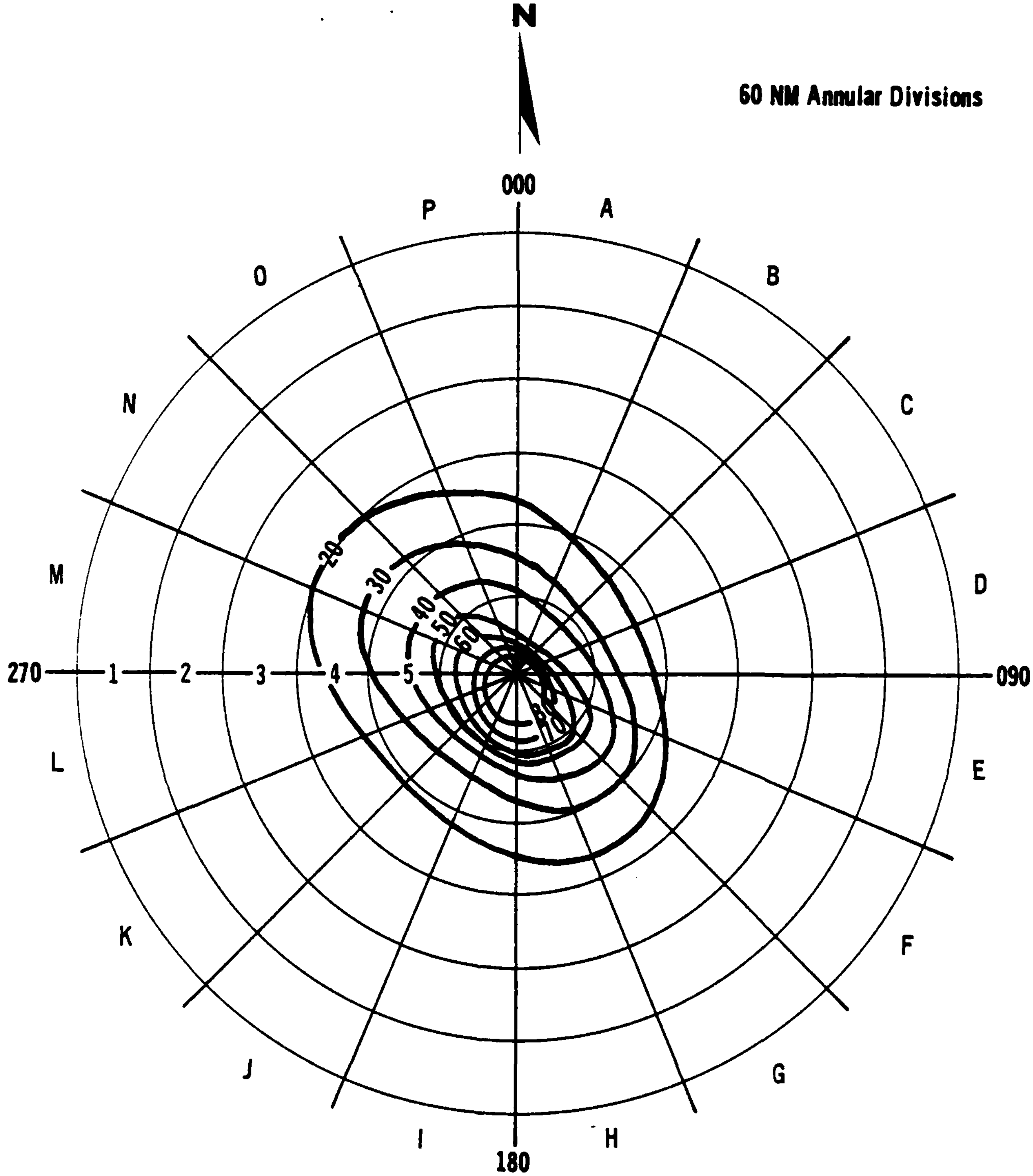

FIGURE 3

MEAN PEAK GUST AT CLARK AB

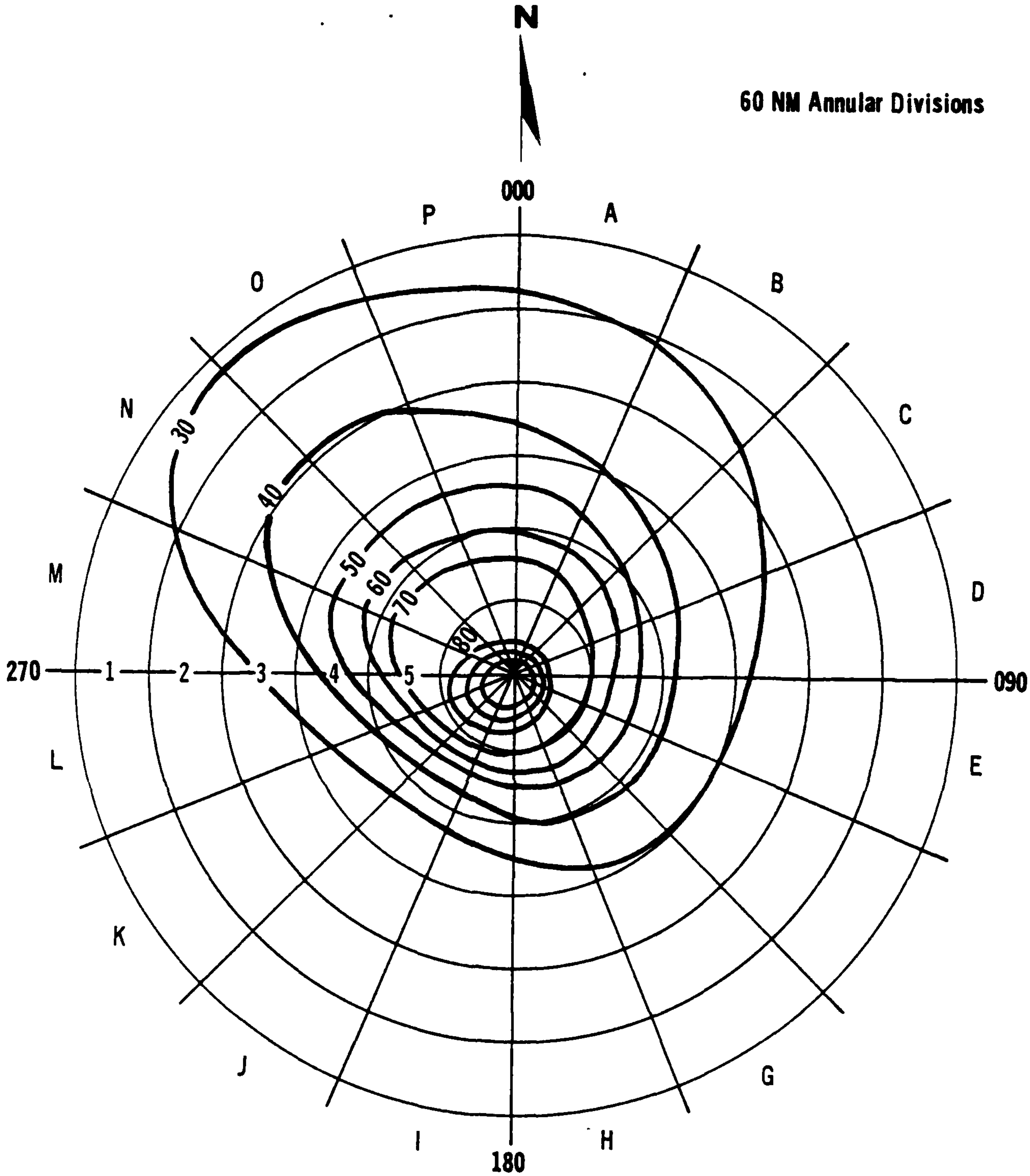

FIGURE 4

MAXIMUM PEAK GUST AT CLARK AB

MEAN AND MAXIMUM RATIOS AND NUMBER OF RATIOS AT CLARK AB

	OUTER RING					INNER RING
	1	2	3	4	5	6
A	8-23-46	12-70-52	22-44-27	23-60-32	35-80-9	26-26-1
B	7-17-53	6-18-35	11-34-46	14-56-32	25-77-8	37-54-6
C	8-47-63	6-18-57	6-24-49	5-13-16	18-74-16	35-48-3
D	7-23-60	6-17-46	10-40-33	10-43-29	16-43-22	60-99-4
E	9-36-47	7-25-44	9-21-36	12-27-21	34-48-6	38-60-4
F	10-40-28	11-17-23	14-32-14	22-39-8	33-48-3	72-72-1
G	13-22-11	14-27-10	17-32-19	24-34-17	62-72-2	73-79-3
H	10-12-5	14-27-6	9-11-2	22-31-12	21-37-6	74-76-2
I	13-27-13	13-27-4	13-17-4	21-31-6	25-43-4	91-91-1
J	6-10-10	11-30-9	11-18-7	13-14-4	16-37-5	89-91-2
K	9-20-12	7- 9-6	6- 7-4	14-24-5	21-43-6	54-91-4
L	11-32-18	12-28-12	8-17-7	18-28-5	41-62-6	63-91-5
M	13-38-24	12-41-15	14-25-9	25-50-11	35-90-9	57-88-4
N	16-32-35	15-38-32	15-42-18	31-77-15	38-64-4	65-65-1
O	13-28-48	22-38-38	19-46-38	19-38-16	44-76-9	60-60-1
P	11-33-57	12-35-38	13-27-29	20-38-23	28-54-7	27-27-2

TABLE 2

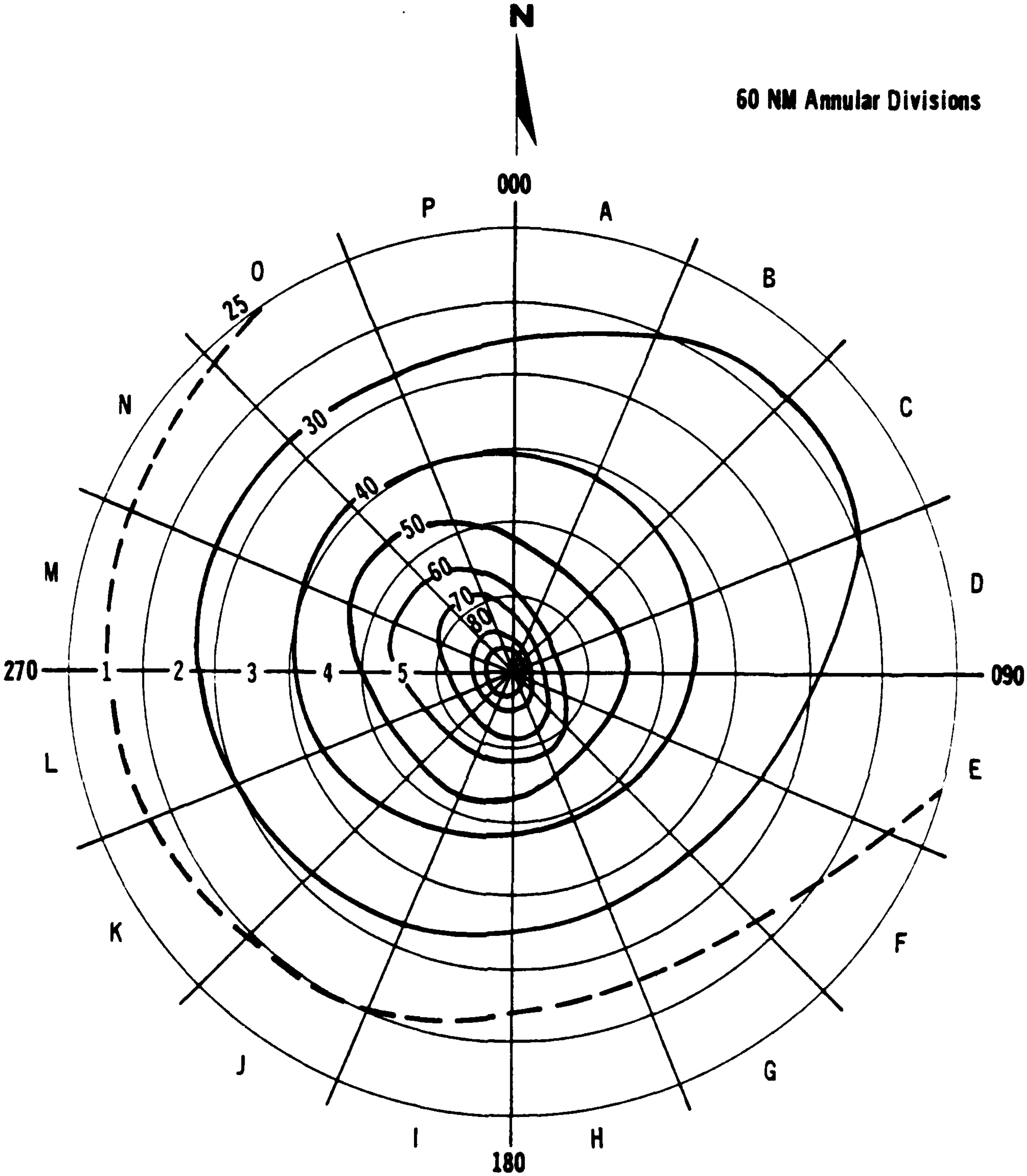

FIGURE 5

MEAN PEAK GUST AT KADENA AB

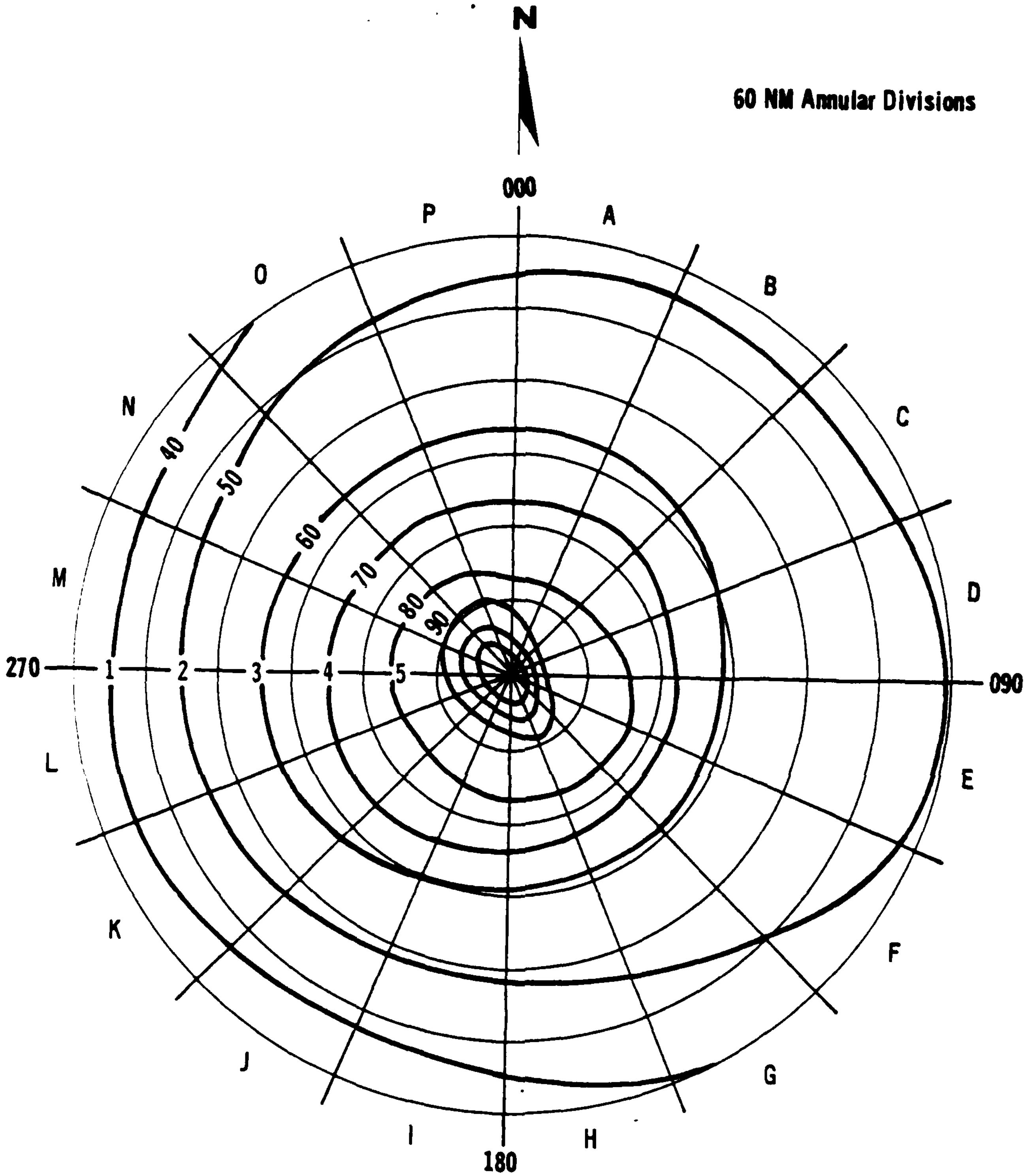

FIGURE 6

MAXIMUM PEAK GUST AT KADENA AB

MEAN AND MAXIMUM RATIOS AND NUMBER OF RATIOS AT KADENA AB

OUTER RING | INNER RING

	1	2	3	4	5	6
A	23-54-8	30-56-14	30-69-15	41-81-22	45-64-8	80-99-6
B	32-54-16	34-52-22	34-49-15	40-52-18	52-80-13	49-78-3
C	25-44-12	31-49-15	38-63-22	44-84-20	48-73-16	68-68-1
D	29-50-34	34-67-30	38-61-22	40-66-22	51-88-14	45-53-3
E	32-67-22	24-49-30	25-40-33	36-60-19	55-96-15	38-45-3
F	20-50-24	21-47-30	30-46-17	32-61-19	43-68-11	75-99-3
G	24-49-37	24-49-30	25-41-30	34-68-29	44-81-10	72-90-3
H	23-34-26	28-57-23	36-63-34	34-69-20	55-79-10	73-99-7
I	24-41-23	24-43-24	28-44-27	38-69-29	55-77-17	79-79-1
J	22-33-46	30-43-22	28-41-39	36-62-21	51-69-10	63-72-2
K	24-33-24	25-42-32	36-70-24	43-99-26	47-75-11	73-98-8
L	29-57-29	27-64-22	30-47-13	42-68-18	57-99-11	60-99-8
M	20-29-7	30-46-13	34-54-19	44-60-15	58-63-6	63-99-8
N	27-41-10	30-40-12	34-66-12	48-83-15	70-99-6	67-99-5
O	31-51-17	28-43-11	35-55-8	49-64-6	55-75-9	72-99-6
P	29-50-8	28-50-15	37-59-17	49-66-17	59-92-10	90-99-2

TABLE 3

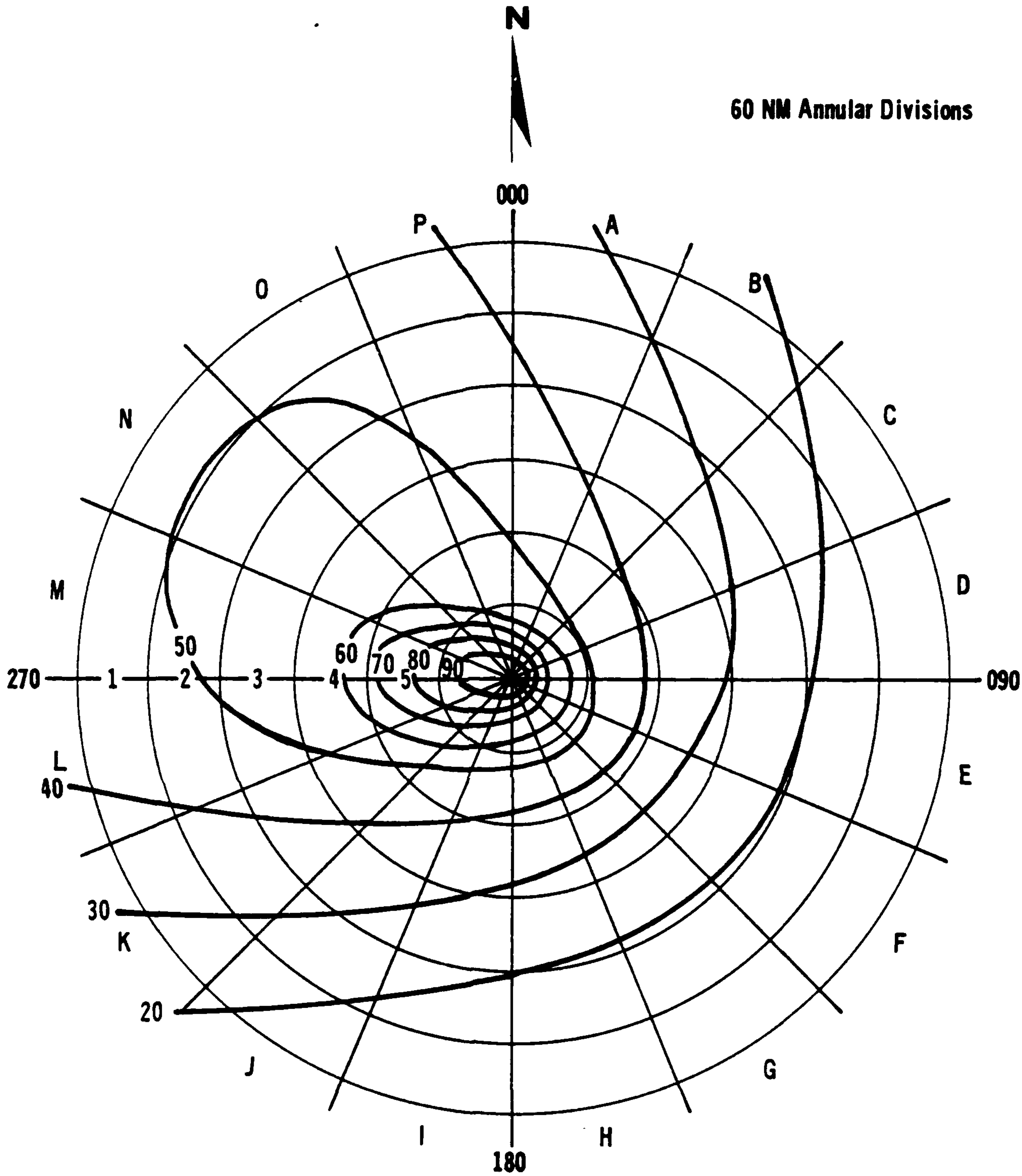

FIGURE 7

MEAN PEAK GUST AT YOKOTA AB

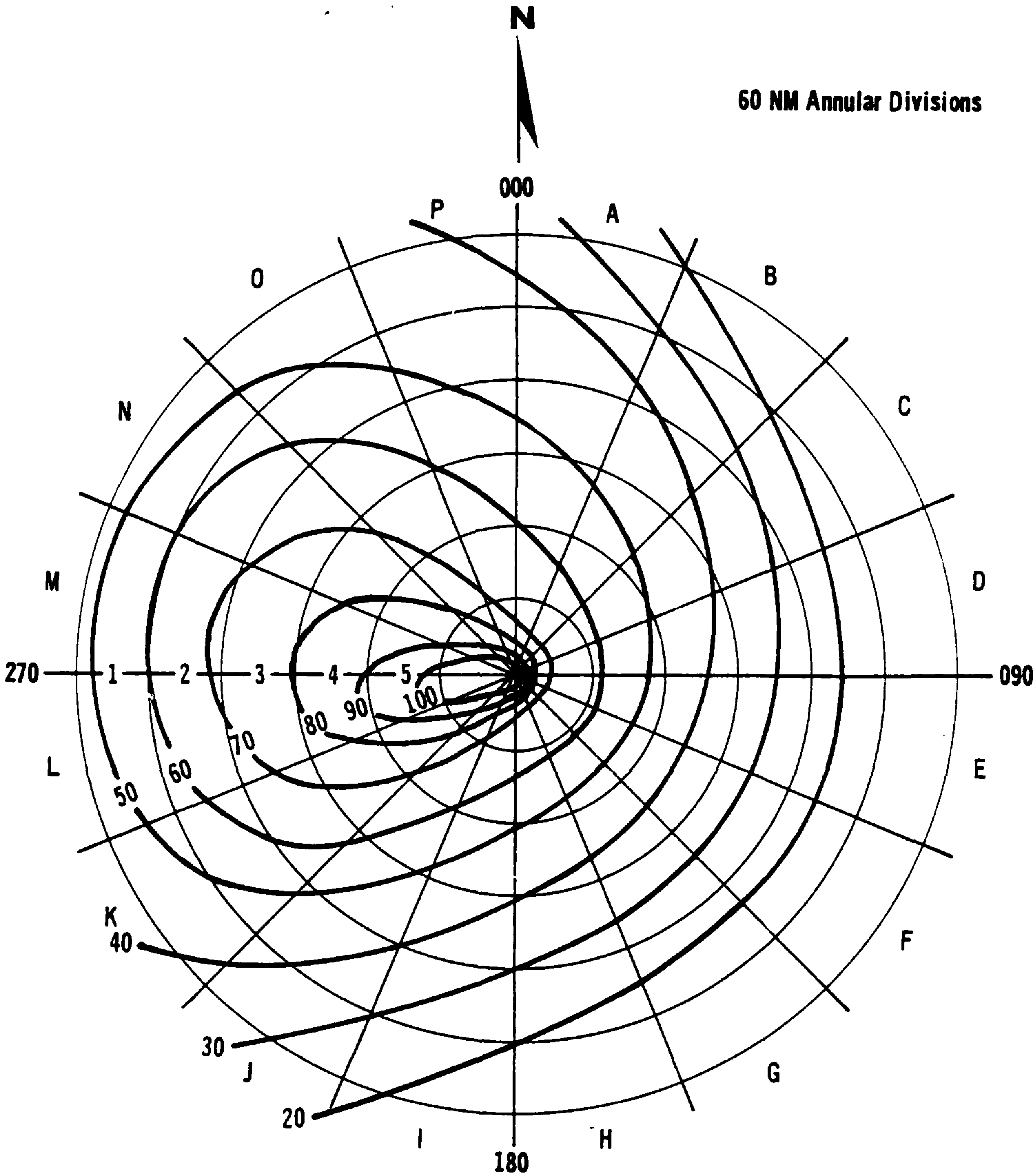

FIGURE 8

MAXIMUM PEAK GUST AT YOKOTA AB

MEAN AND MAXIMUM RATIOS AND NUMBER OF RATIOS AT YOKOTA AB

	OUTER RING					INNER RING
	1	2	3	4	5	6
A	X	32-32-1	36-49-5	37-49-4	32-32-1	69-69-1
B	X	X	35-35-1	X	X	49-49-1
C	X	X	X	X	X	47-47-1
D	X	17-17-1	X	X	45-50-3	49-56-2
E	16-16-1	18-18-1	29-35-2	31-37-2	36-44-6	63-72-2
F	X	17-21-7	27-37-5	25-35-4	45-69-5	54-54-1
G	6-7-5	10-13-7	25-33-6	28-43-11	41-45-4	62-75-2
H	9-11-2	17-30-5	20-24-6	33-48-8	37-45-6	X
I	10-17-17	13-20-3	17-31-10	20-35-8	30-33-2	33-33-1
J	13-20-4	21-36-6	26-37-3	26-40-3	35-80-5	96-96-1
K	36-61-6	36-72-10	47-67-10	51-83-4	56-88-6	46-75-5
L	48-48-1	52-75-7	55-75-6	58-83-9	82-99-6	99-99-1
M	X	49-64-10	X	53-88-7	81-99-3	54-54-1
N	X	66-73-4	47-66-6	63-86-9	58-58-1	99-99-3
O	X	54-56-2	52-58-6	53-77-8	37-43-3	80-80-1
P	X	42-52-3	48-56-4	52-74-8	42-42-1	X

TABLE 4

END

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DTIC