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Report on the Post Analysis of Typhoons in the Western North Pacific - 1950

March'52 86pp diagrs, graphs, maps, charts

Typhoons
Weather - Forecasting
Meteorologic data - North Pacific

Meteorology (30)
Winds (5)

UNCLASSIFIED

AIR WEATHER SERVICE
TECHNICAL REPORT NO. 105-89

REPORT ON THE POST ANALYSIS OF TYPHOONS IN THE WESTERN NORTH PACIFIC —1950

COELUM AD PROELIUM ELIGE

MARCH 1952

HEADQUARTERS
AIR WEATHER SERVICE
ANDREWS AIR FORCE BASE
WASHINGTON 25, D. C.

AWS TECHNICAL REPORT)
NO. 105-89

HEADQUARTERS
AIR WEATHER SERVICE
ANDREWS AIR FORCE BASE
Washington 25, D. C.

April 1952

FOREWORD

1. General. Air Weather Service Technical Report No. 105-89, "Report on the Post Analysis of Typhoons in the Western North Pacific - 1950," is published for the information and guidance of all concerned.

2. Scope. This report describes the analysis and forecasting techniques employed by the Post Analysis Board, Guam, Marianas Islands, in reviewing typhoons of the 1950 season. The report, as published here, consists of large extracts from the "1950 Annual Report of the Typhoon Post Analysis Program of the North Pacific Typhoon Warning Service of the 2143rd Air Weather Wing."

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INTRODUCTION

Considerable data about tropical cyclones in the Western North Pacific has been collected by the Air Weather Service since 1945 and the advent of the Typhoon Post Analysis Program. This material has been published in previous AWS Technical Reports.[1,2,3] Similarly the administrative and operational aspects of the Typhoon Warning Network and the reconnaissance units have been described previously and need not be repeated here.

Relatively little mention is made in this report to steering as a means of forecasting the movement of typhoons. This subject has been treated at considerable length in reports on the 1948 and 1949 seasons. Charts are included on pages 2 through 7 of this report, however, to show how the storms of 1950 fit the patterns. Attention is also called to two interesting articles in the Bulletin of the American Meteorological Society. These articles on the movement of typhoons grew out of research on the 1950 storms.[4,5] Dr. Cressman's article discusses the typhoon "Doris" which developed as two cyclonic vortices, which gradually merged into one, in agreement with a principle of Fujiwhara. Capt. Horn's article discusses a theory of oscillating movements of a typhoon along a broad curving path, in agreement with computation of Yeh for Caribbean storms.

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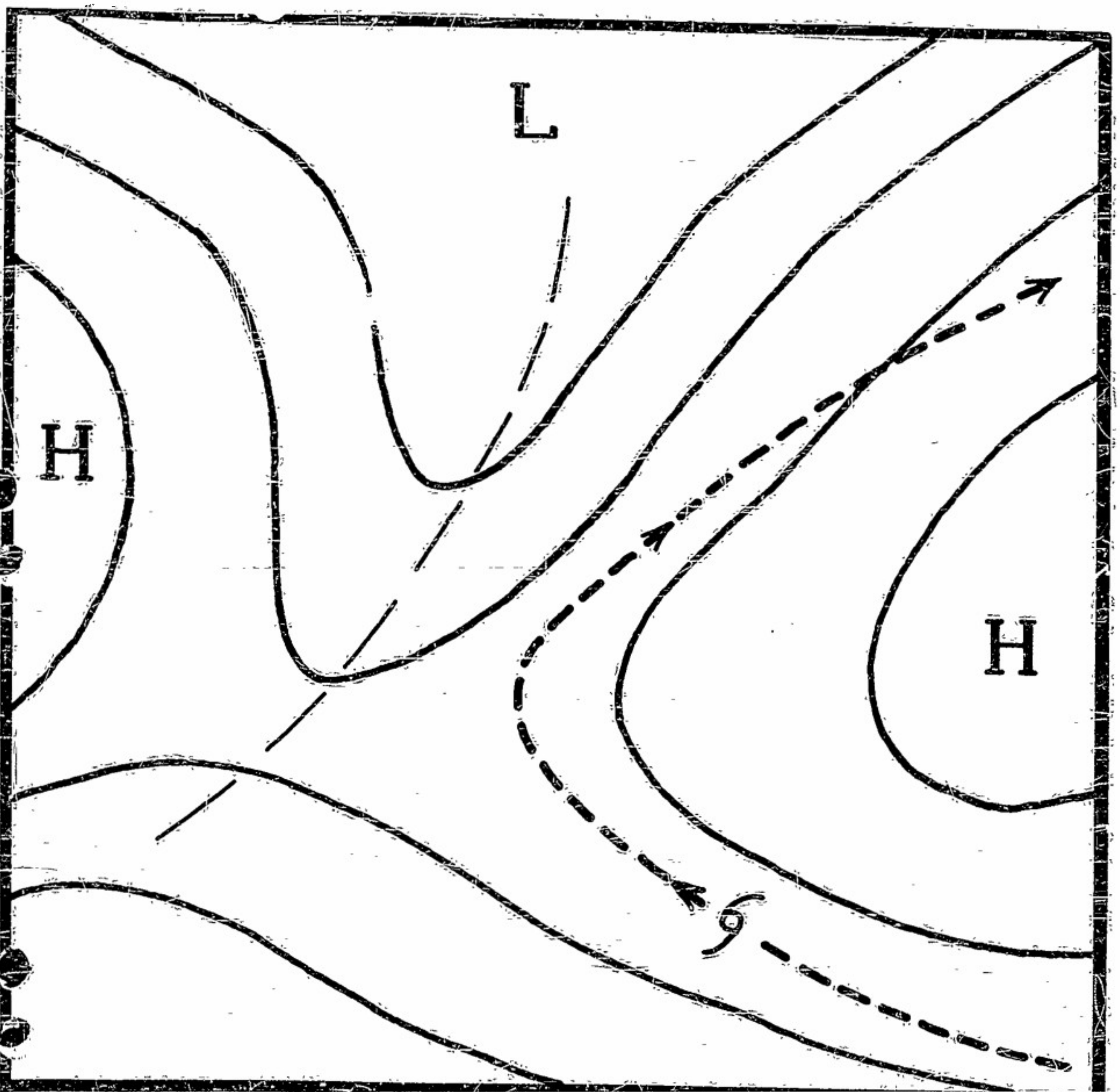
1. AWS TR 105-42, "Report on post analysis of typhoons in the Western North Pacific 1947," July 1949.
2. AWS TR 105-43, "Report on the Typhoon Post-Analysis Program (1948-1949) of the North Pacific Typhoon Warning Service," August 1951.
3. AWS TR 105-77, "Forecasting the typhoons of 1949 with special reference to the use of streamline analysis," August 1951.
4. Cressman, George P., "The development and motion of typhoon 'Doris'." Bull. Am. Met. Soc., Vol. 32, No. 9, Nov. 51, pp. 326-333.
5. Horn, John D., "On irregular movements of tropical cyclones in the Pacific," Bull. Am. Met. Soc., Vol. 32, No. 9, Nov. 51, pp. 344-345.



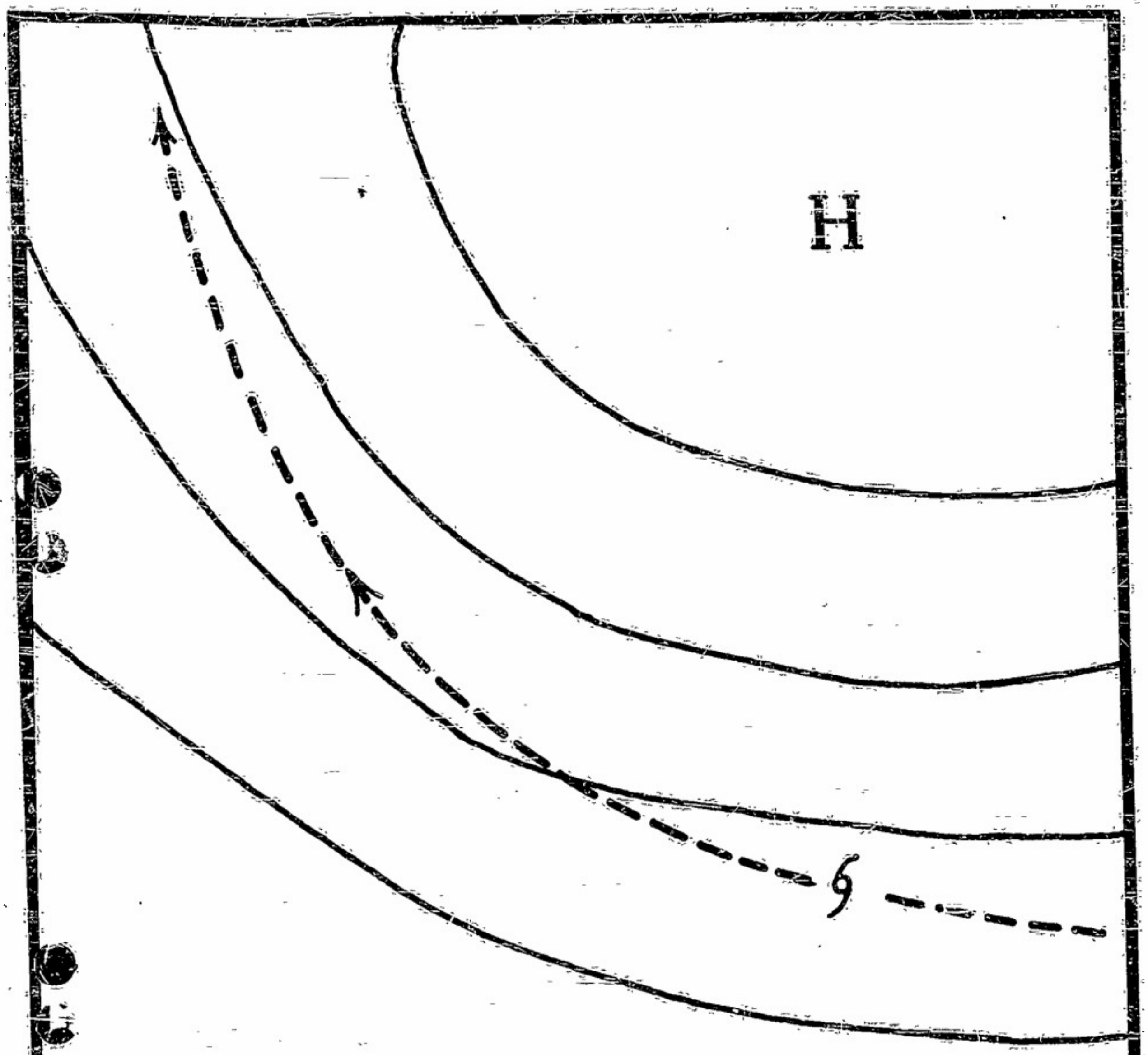
UPPER AIR STEERING

CASE I.

NORMAL RECURVATURE

EXAMPLES:

PATRICIA
ALLYN
CAMILLA



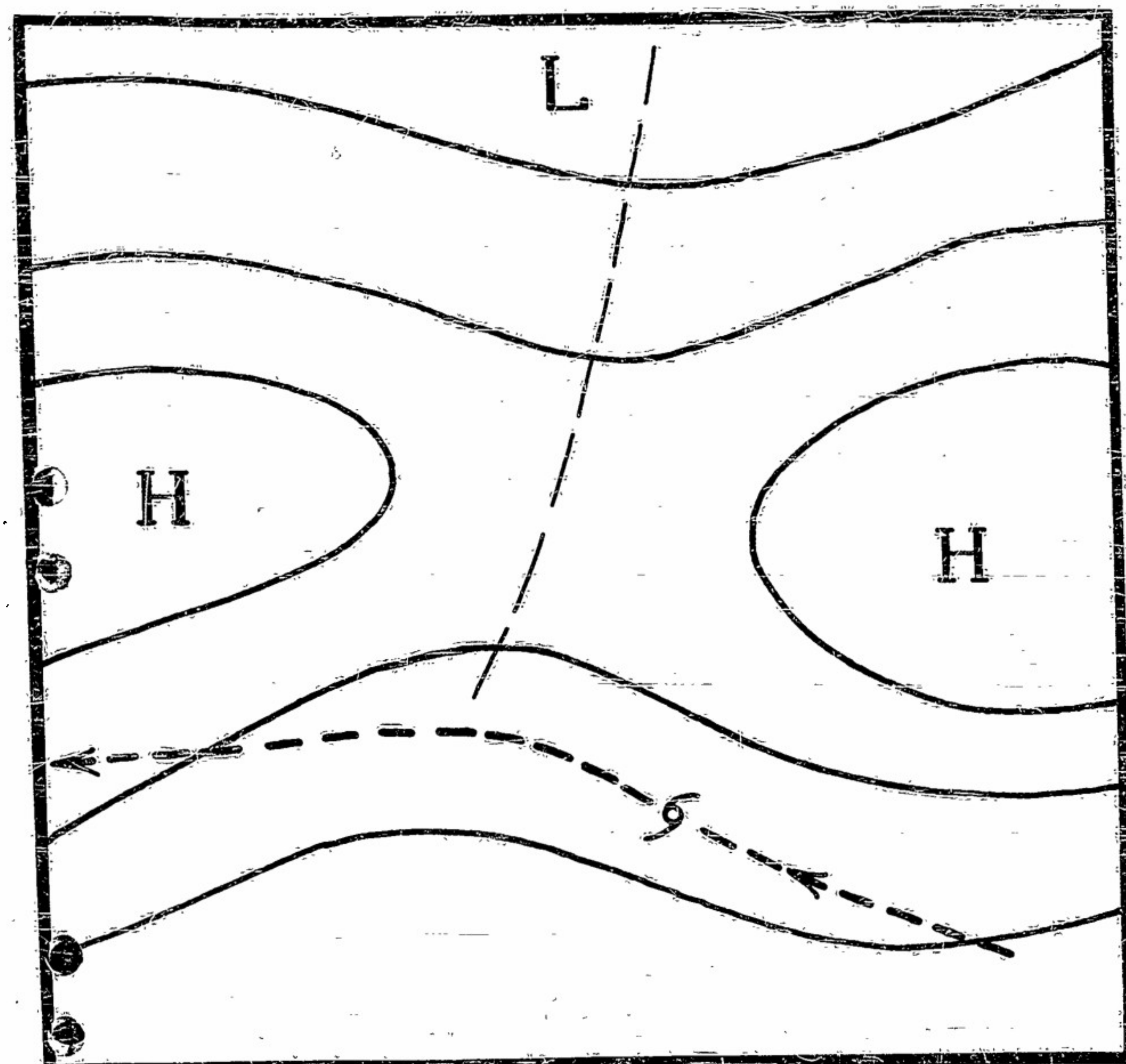
UPPER AIR STEERING

CASE II.

SLIGHT RECURVATURE

EXAMPLES:

FAYE
KITTY
RENA
ELAINE
OMELIA

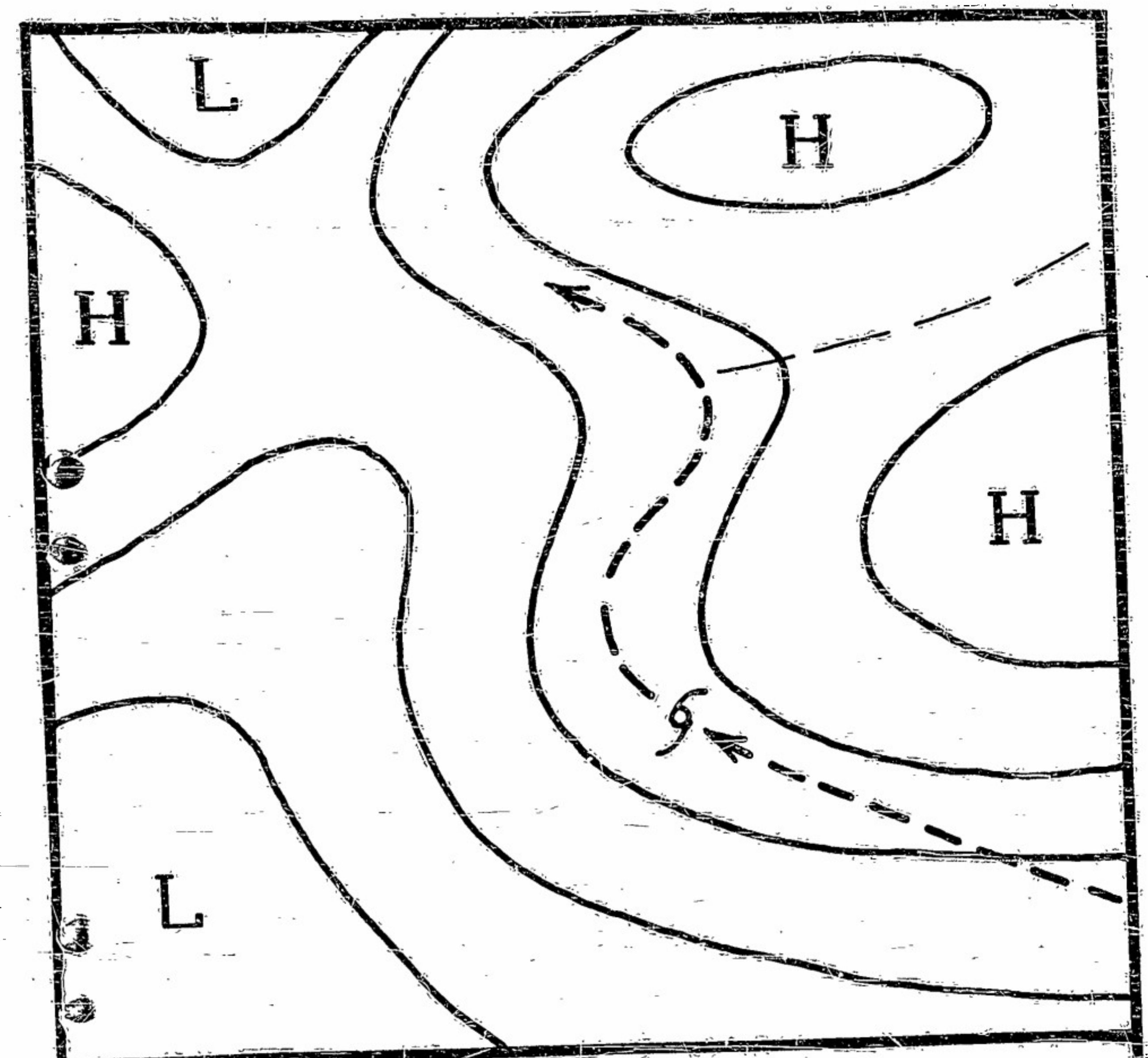


UPPER AIR STEERING

CASE III.

NON-RECURVATURE

EXAMPLES:
BETTY
NELLY



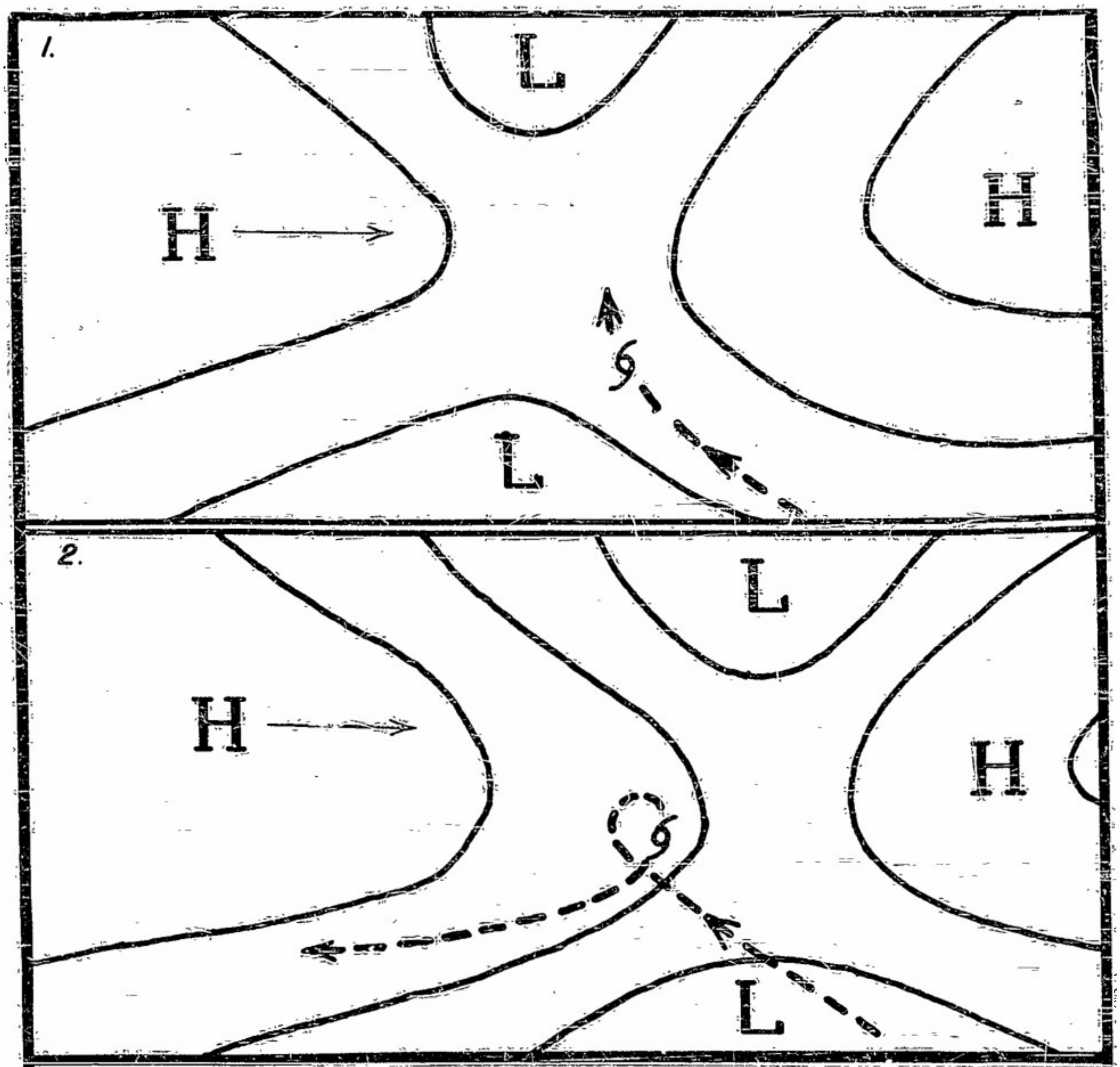
UPPER AIR STEERING

CASE IV.

INVERSE RECURVATURE

EXAMPLES:

GLORIA
JUDITH



UPPER AIR STEERING

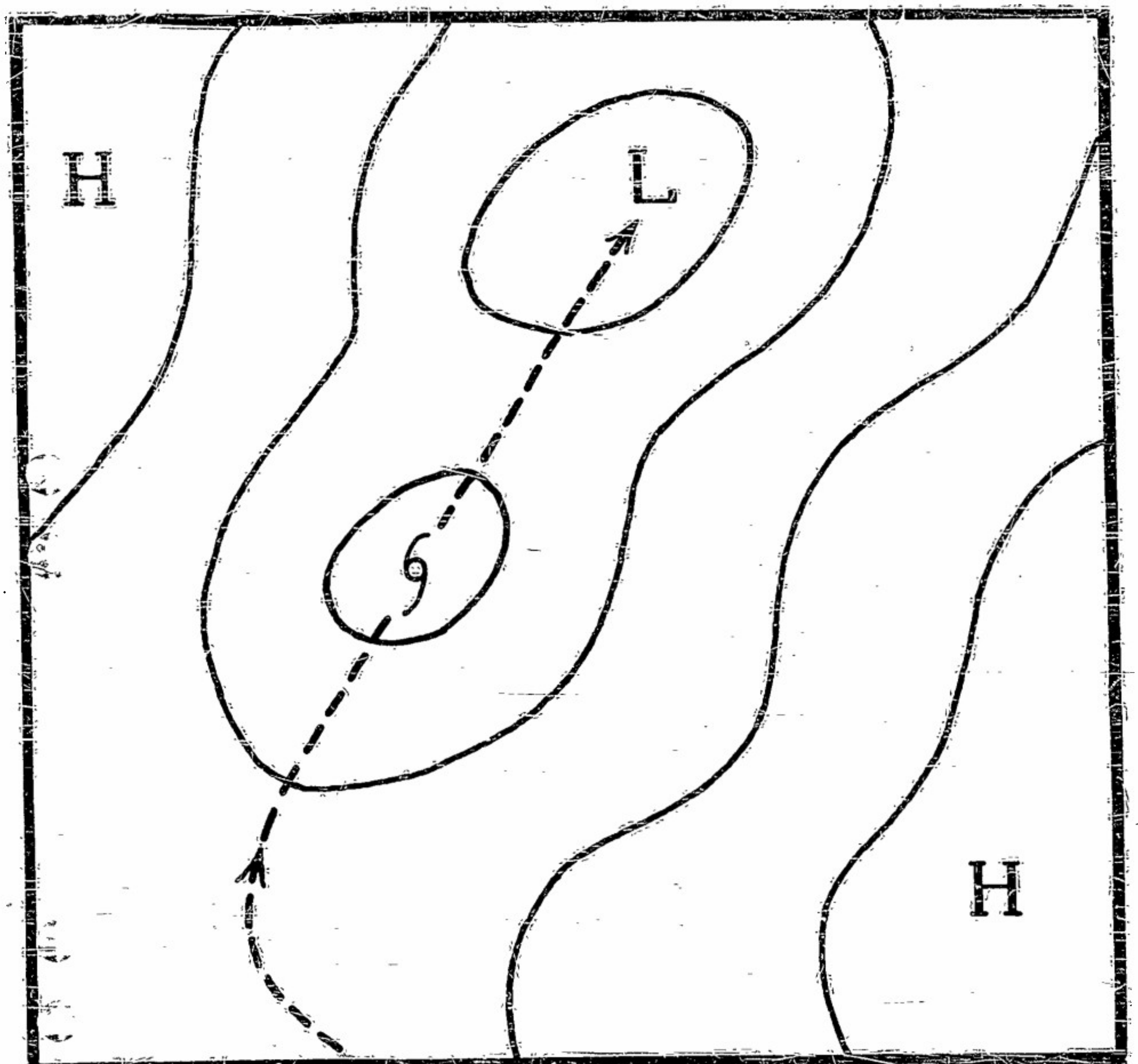
CASE V.

FAST MOVING TROUGH

(LOOP)

EXAMPLE:

CARMEN



UPPER AIR STEERING
CASE VI.
STORM FOLLOWING ANOTHER STORM

EXAMPLE:
LISE

MICROSEISMS[1]

Microseisms are more or less regular elastic surface waves which are recorded continuously by sensitive seismographs. These waves are caused partly as a result of meteorological phenomenon and partly due to traffic, industry, etc. The typhoon forecaster is mainly interested in microseisms which originate at or near the center of a typhoon. Fortunately this type of microseism is usually easily distinguished by the appearance from those from other sources.

As early as 1909 it was discovered that the ampitude of microseisms increased with the approach of a storm. Seismologists and meteorologists from different parts of the world made various attempts to use this information but it was not until 1944 that Capt. H. T. Orville, U. S. N., started the first routine use of microseisms in detecting and locating hurricanes in the Caribbean. In 1946 the project was extended to the Pacific. Both "Tripartite" and "Single" station were used. From the tripartite station both the amplitude of microseisms and bearing of the source is obtained. Three seismographs are placed in position at the corners of a triangle with sides not exceeding a few miles. By noting the difference in the time of arrival of a distinct wave at the three instruments the bearing can be computed.

There is little doubt that the amplitude of microseisms decrease exponentially with depth although this has not been determined by direct measurements. This decrease depends on the wave length and a constant depending on the structure below the observation point. Theoretically most of the energy is transmitted in a layer of thickness equal to the wave length. The speed of the waves is usually 2½ to 4 km/sec. and the period is equal to 3 to 7 seconds, so the wave length is 10 to 20 km. Therefore, for most microseismic waves a large percentage of the energy is transmitted in the upper 20 km of the earth's crust. It has been found that waves are propagated for great distances through geologically undisturbed areas. Microseisms from the coast of Norway are propagated to central Asia but decrease to the south as they cross the geologically younger areas of Central Europe and the still younger Alpide belt. If the discontinuities are deep (50 km or more) the microseisms may not be transmitted at all.

In the Caribbean area the amplitude of microseisms decreases rapidly from island to island. The maximum amplitude does not occur simultaneously

---

1. Much of the material in this section was obtained from an article "Microseisms and Weather Forecasting" by B. Gutenburg published in the Journal of Meteorology, Vol. 4, No. 1, February 1947. Gutenburg presents the history of the development of the use of microseisms in tracking and detecting low pressure areas up to that time, complete with a list of references.

at all stations at the time of maximum intensity of the storm but is more closely related to the proximity of the storm. In the Pacific the same condition exists as far as major faults are concerned although less is known of the geological structure and its effect on the transmission of microseisms. There are several trenches or "deeps" in the North Pacific area which are indicative of extensive faulting. The Ryukyus, Mindinao and Marianas Trenches are approximately 7 km, 10.5 km and 10 km in respectively. The depth of the faults would of course be in excess o depth of these trenches. There are good indications that these faults have an important effect on bearings and amplitudes recorded at the different microseism stations in the Pacific. Sufficient data have not been compiled to arrive at any definite conclusions; however, it has been observed that the amplitude of microseisms decreases rapidly at Guam as soon as a typhoon crosses to the northwest of the Ryukyus Trench even though the typhoon itself did not change in intensity. It has also been observed that the bearings become erratic as a typhoon moves beyond a deeply faulted area. An explanation of this is that the energy is transmitted for some distance along the fault line instead of directly through it.

Most authors are in agreement as to the types of waves which are set up. It is generally belived that microseisms are a combination of Rayleigh and Love or "shear" waves. In Rayleigh waves the particles move in elipses with the long axis vertical and the short axis in the direction of propagation of the wave. With Love waves the particles move parallel to the earth's surface and perpendicular to the direction of propagation. Experiments indicate that Rayleigh waves predominate. Japanese seismologists have measured the vertical components of microseismic waves, which indicate the presence of Rayleigh waves. In an experiment at Guamtanamo, Cuba, an instrument was oriented north-south and another east-west. It was found that with bearings from an east-west direction the east-west amplitude was greatest and for north-south bearings the north-south amplitude was greater. It is, therefore, important that all instruments in a tripartite station be oriented in the same direction so the same type of waves will be recorded on all instruments and to avoid confusion in interpreting the records. In the Pacific area the instruments are usually oriented north-south.

It is fairly well established that the energy of the microseisms originates from the energy of the storm and probably from the high waves in the area of strongest winds. The amplitude usually decreases rapidly when a typhoon is over shallow water and may die out entirely over land. In shallow water the height of waves is limited directly by the depth. Storms usually decrease over land but not as sharply as the microseisms. Gutenburg previously believed that surf breaking on the beach was the only source of microseisms. In a tropical storm this is not likely, since the area affected by surf with the presence of a typhoon is so small. Also microseisms have been recorded in the absence of surf.

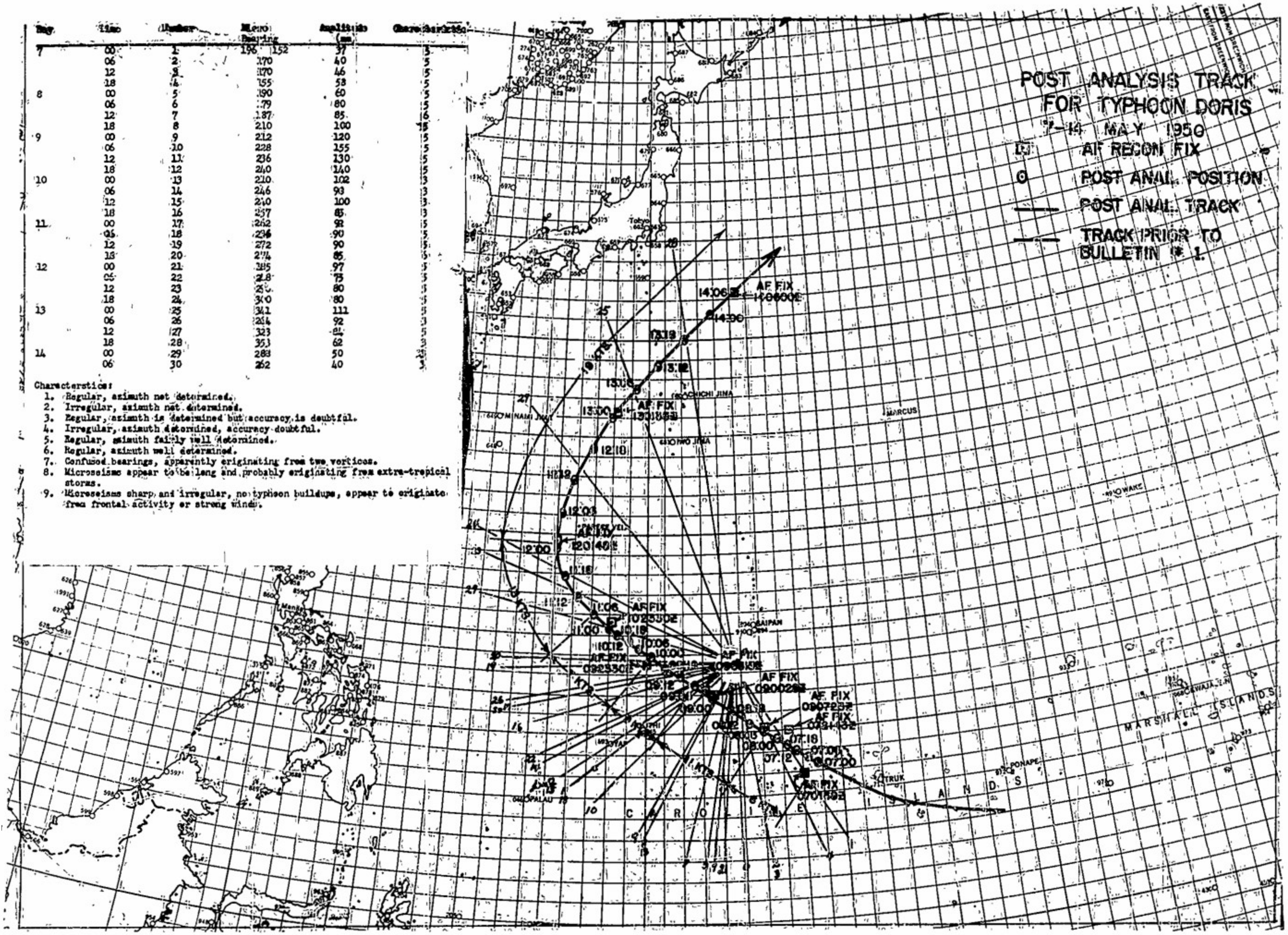
The problem of the mechanism by which energy is transferred from the surface of the water to the bottom is still unsolved. In hydrodynamical waves the amplitude decreases exponentially with depth such that at a depth of one half wave length the variation of pressure is insignificant. However, in the development of this theory, incompressibility of the fluid is assumed. It has been shown that in addition to hydrodynamic waves, compressioned or elastic waves with amplitude decreasing only slowly with depth are set up which may be the cause of microseisms. Future measurements at different depths are necessary to determine this.

A good network of stations is desirable in order to get cross-bearings. At the present time tripartite stations are in operation at Guam, Manila and Koror. A tripartite station is being constructed at Truk Island and is expected to be in operation early in the 1951 season. The station at Manila is being operated by the Philippine government and the other stations by the U. S. Navy. During the 1950 typhoon season only the Guam and Manila stations were in operation. Only on a few occasions when a storm was located north of a line between Guam and Manila was it possible to obtain cross bearings. Amplitude rises have been found to be much more reliable than the bearings. Care must be exercised in interpreting change in amplitude, since storm may cross over fault lines or over shallow water with no decrease of intensity while the amplitude of microseisms may decrease sharply. Bearings have been found to be somewhat less reliable. A point source for microseisms is assumed with waves radiating from this point in concentric circles. In computing the bearings it is assumed that the wave crests are straight. The error introduced by the slight curvature of the crests is negligible. However, discontinuities or faults in the earth's crest may affect the shape of a wave crests so as to introduce considerable error in the bearing obtained. Some error may be introduced by the method of computation of bearings, however, since a large number of bearings are computed and averaged, only systematic deviations should remain. Probably the most important source of error lies in the assumption that the microseisms waves emanate from a point source which coincides with the center of the typhoon. It seems probable that if the energy is derived from the high waves in the typhoon, it is likely that the source of microseisms would be the region of strongest winds and may not be confined to a small area. The apparently random variation in bearing angle of five to ten degrees or more, from one six-hourly observation to the next, which is frequently observed, may be a result of this fact.

At the present time M. H. Gilmore is reported to be working on a new approach to the subject which eliminates all but the last source of error discussed above. In short, the proposed method utilizes non-dimensional ratios of amplitude, and bearings are not required. Using the post-analysis positions and corresponding microseism amplitudes during past storms, charts of the ratio of the amplitudes at any two stations can be spotted on a base chart of the area for as many years of data as are available. Isolines of equal ratio can then be drawn. This process is to be repeated for all possible combinations of two stations. That is, with four reporting stations one could obtain six charts of amplitude ratio; for example, Guam-Koror, Guam-Truk, Guam-Manila, Koror-Truk, Koror-Manila and Truk-Manila. By plotting the observed ratio of amplitude at two stations during the time a typhoon is in progress on the appropriate ratio chart it is possible to get a line of position for the storm. By repeating this process for two other combinations of stations one can obtain from the intersection of these three lines of position, either a point or small triangle for the location of the storm. The intensity of the storm is not a factor, since it is the ratio of two amplitudes and not the actual values themselves, which is used. Since several years of data are necessary it will not be possible to utilize this method in the Pacific area at this time.

Microseism bearings obtained during Typhoon DORIS were probably the most accurate obtained on any storm during the 1950 season. Typhoon DORIS was the first storm of the season and passed a short distance to the southwest of Guam. A plot of the bearings from Guam may be found on page 13. The amplitude as recorded at both Guam and Manila is found on page 4. DORIS caused a maximum rise in amplitude at Guam for the season, primarily because of its proximity to Guam, but also because of its intensity. No bearings were obtained from Manila so it was impossible to get a "fix" from microseism data alone. Plots of bearings and amplitudes for KEZIA, LUCRETUA, MISSATHA, OSSIA, BILLIE and CLARA are reproduced on pages 15 to 22. These storms offer the best illustrations of the value of microseisms during the 1950 season. Close examination of the plot of bearings on the post-analysis tracks shows that there are several bearings which pass through or near the post-analysis position for the corresponding time; however, seldom if ever do the bearings from Manila and Guam intersect to give a position which is even close to the correct location. The main limitation which must be placed on the bearings obtained at present is in knowing when they are accurate. Only through post-analysis can this be determined. It can be seen from the plots of amplitude for the storms listed above that the sharp rise in amplitude coincides remarkably with the increase in intensity of the storm. In addition to those storms included in this discussion, most of the other storms during the 1950 season were accompanied with a rise in amplitude of microseisms recorded at Guam or Manila, or both, even though the bearings were often inaccurate or erratic, no significant increase was recorded at either Guam or Manila during ELSIE, IDA, JANE or PETIE. ELSIE developed to storm intensity near Okinawa which was apparently too far north to influence the recording stations. This was also true of JANE and PETIE. IDA formed at about 22.5 degrees north but the maximum winds were never in excess of 50 knots.

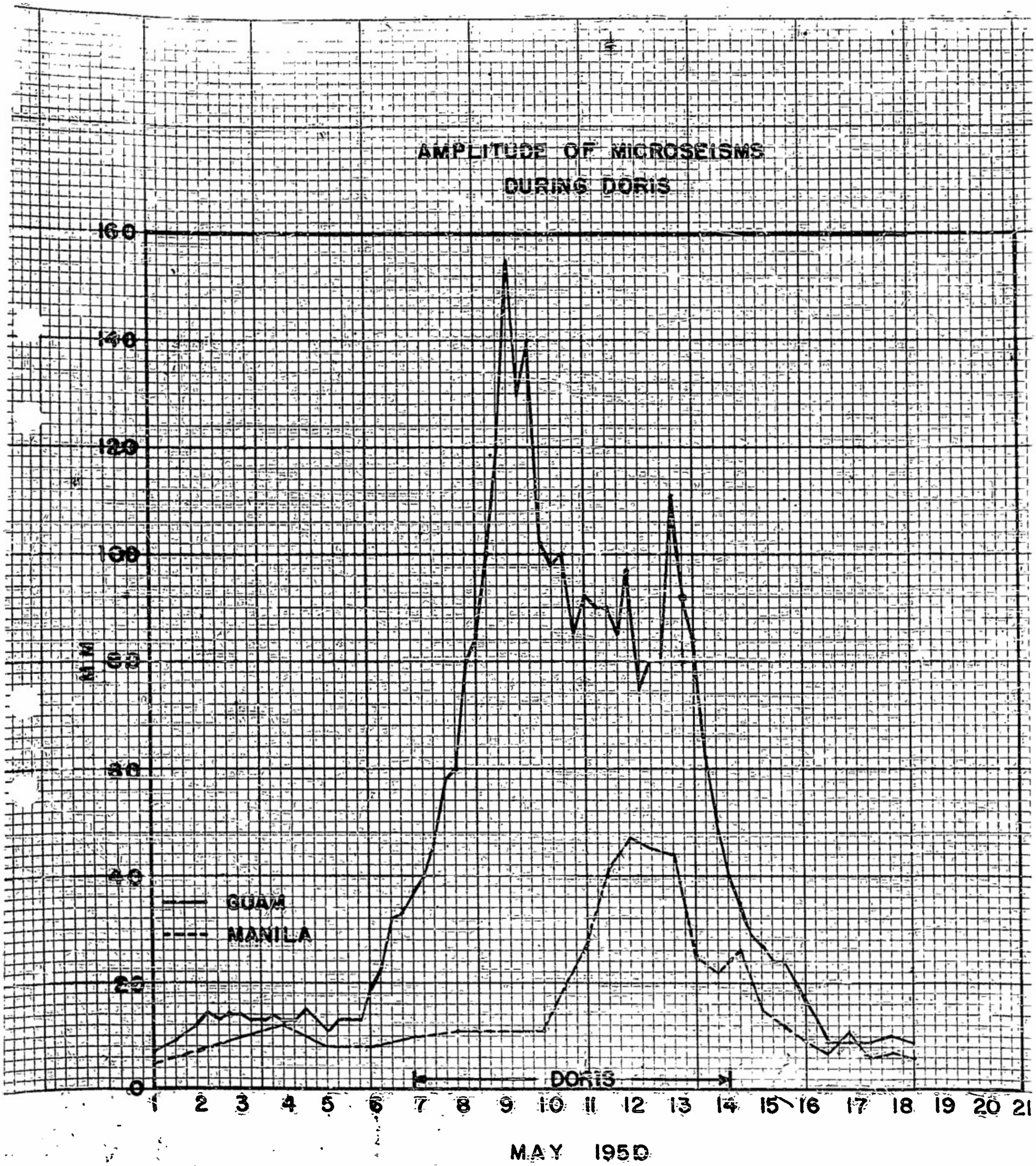
Since a sudden increase in amplitude to above normal has been found to be reliable in detecting the presence of a typhoon, it is desirable to maintain a running graph of the amplitude against time for all of the reporting stations. The bearings, although less reliable, can be of value if properly interpreted and if their limitations are realized. The closer network of reporting stations which will be operating during the 1951 season should aid materially in the initial detection of tr[illegible] cyclones and may offer the possibility of increased utilization of in[illegible] section of bearings in locating these storms.

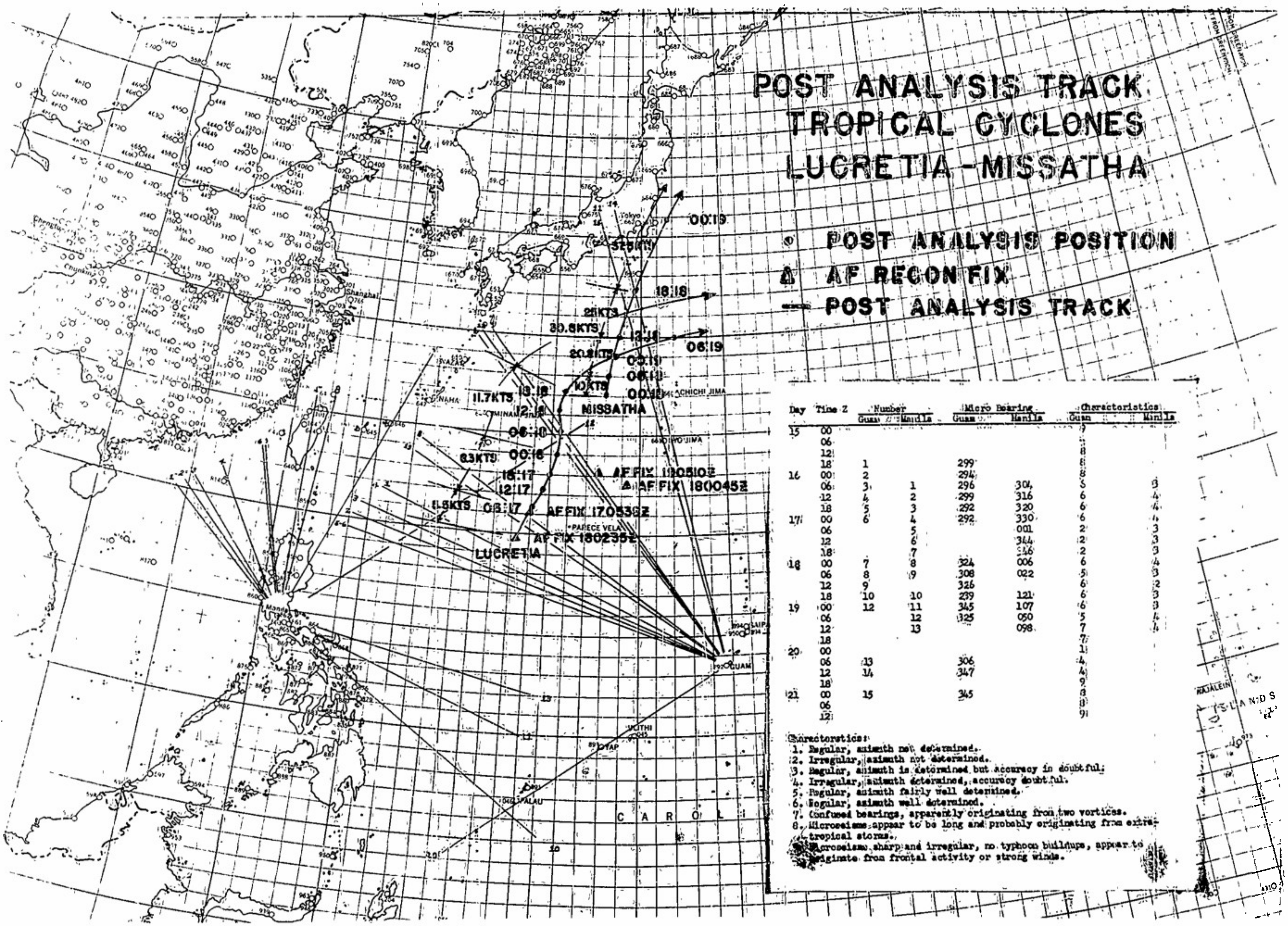


Day	Time	Number	Micro Bearing	Amplitude (mm)	Characteristic
7	00	1	196 152	37	5
	06	2	170	40	5
	12	3	170	46	5
	18	4	155	58	5
8	00	5	190	60	5
	06	6	179	80	5
	12	7	187	85	6
	18	8	210	100	5
9	00	9	212	120	5
	06	10	228	155	5
	12	11	236	130	5
	18	12	240	140	5
10	00	13	210	102	3
	06	14	246	93	3
	12	15	240	100	3
	18	16	257	85	3
11	00	17	262	92	5
	06	18	296	90	5
	12	19	272	90	5
	18	20	274	85	5
12	00	21	305	97	5
	06	22	318	75	5
	12	23	[illegible]	80	5
	18	24	340	80	5
13	00	25	341	111	5
	06	26	284	92	3
	12	27	323	81	5
	18	28	353	62	3
14	00	29	283	50	3
	06	30	262	40	3

Characterstics:

1. Regular, azimuth not determined.
2. Irregular, azimuth not determined.
3. Regular, azimuth is determined but accuracy is doubtful.
4. Irregular, azimuth determined, accuracy doubtful.
5. Regular, azimuth fairly well determined.
6. Regular, azimuth well determined.
7. Confused bearings, apparently originating from two vortices.
8. Microseisms appear to be long and probably originating from extra-tropical storms.
9. Microseisms sharp and irregular, no typhoon buildups, appear to originate from frontal activity or strong winds.


AMPLITUDE OF MICROSEISMS
DURING DORIS
160
140
120
100
80
60
40
20
0
M M
GUAM
MANILA
DORIS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
MAY 1950



Day	Time Z	Number Guam	Number Manila	Micro Bearing Guam	Micro Bearing Manila	Characteristics Guam	Characteristics Manila
15	00					7	
	06						
	12					8	
	18	1		299		8	
16	00	2		294		8	
	06	3	1	296	304	5	3
	12	4	2	299	316	6	4
	18	5	3	292	320	6	4
17	00	6	4	292	330	6	4
	06		5		001	2	3
	12		6		344	2	3
	18		7		346	2	3
18	00	7	8	324	006	6	4
	06	8	9	308	022	5	3
	12	9		326		6	2
	18	10	10	239	121	6	3
19	00	12	11	345	107	6	3
	06		12	325	050	5	4
	12		13		098	7	4
	18					7	
20	00					1	
	06	13		306		4	
	12	14		347		4	
	18					9	
21	00	15		345		8	
	06					8	
	12					9	

Charactorstics:

1. Regular, azimuth not determined.
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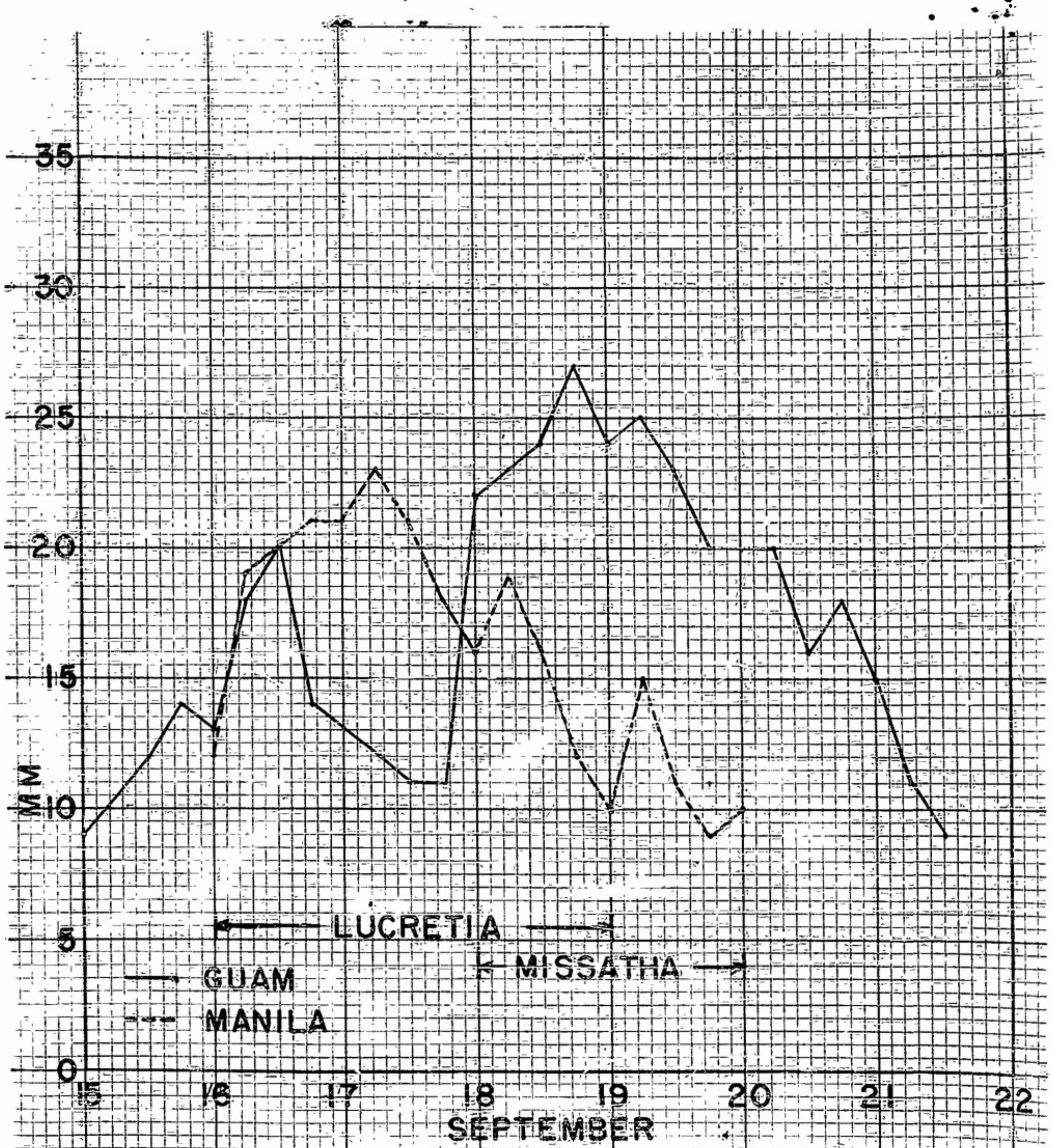
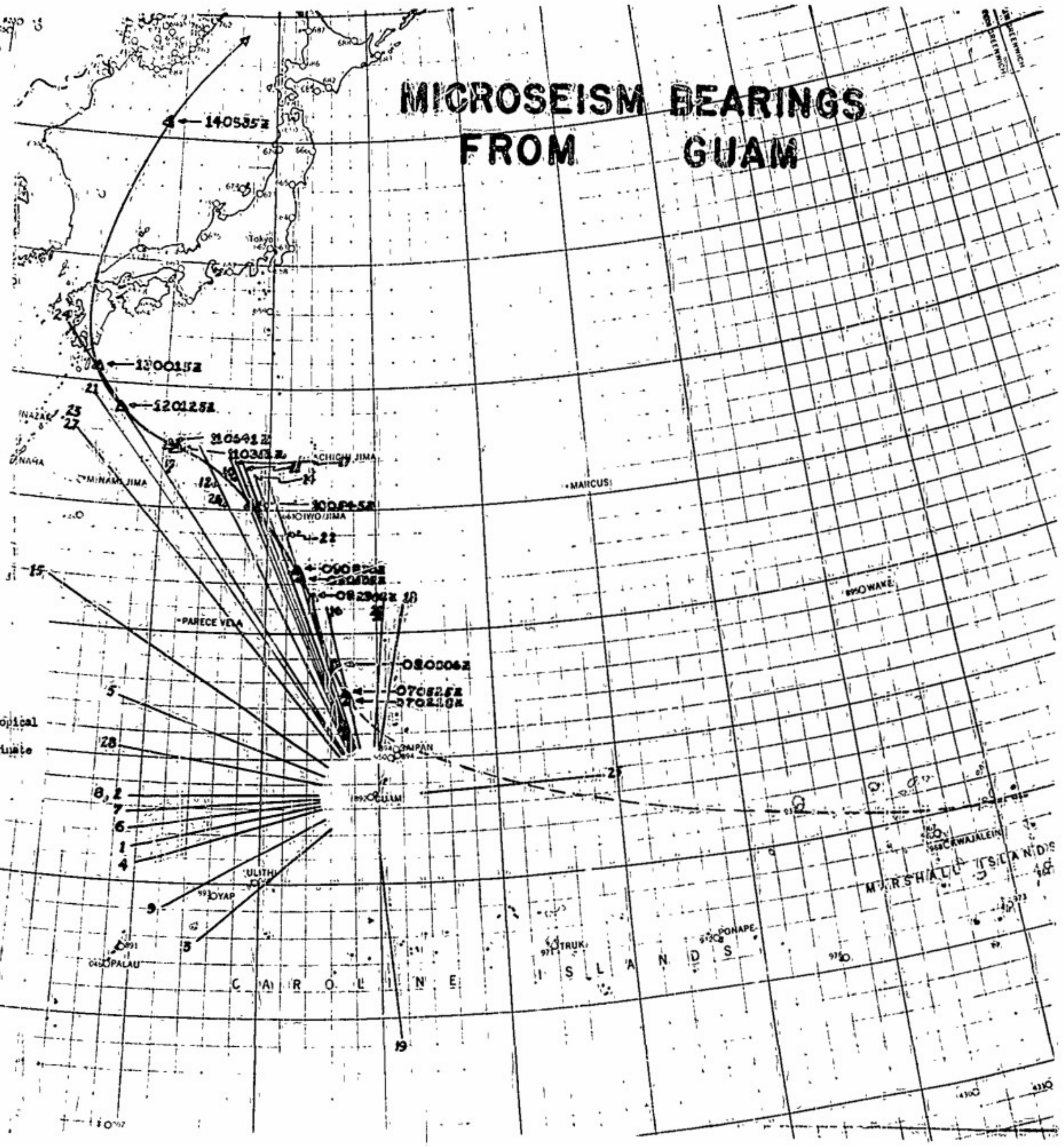


MICROSEISM AMPLITUDE AT GUAM AND MANILA
LUCRETIA AND MISSATHA



Number	Day	Time Z	Amp. (mm)	Micro bearing	Characteristics
1	5	00	12	260	9
		06	12	-	9
		12	09	-	9
		18	-	-	
2	6	00	16	272	4
3		06	21	232	4
4		12	23	256	4
5		18	30	293	6
6	7	00	40	264	4
7		06	47	268	4
8		12	38	272	4
9		18	36	244	4
10	8	00	47	337	6
11		06	47	339	6
12		12	50	334	6
13		18	50	328	6
14	9	00	43	340	6
15		06	38	305	4
16		12	35	347	6
17		18	38	338	6
18 19	10	00	24	010. 173	5
		06	23	-	7
20		12	25	004	5
		18	23	-	1
21	11	00	31	326	6
22		06	28	342	6
23		12	21	322	6
		18	25	-	7
24	12	00	21	328	5
25		06	18	086	4
26		12	16	334	4
27		18	15	322	4
28	13	00	13	283	5
		06	11	-	2
		12	09	-	2

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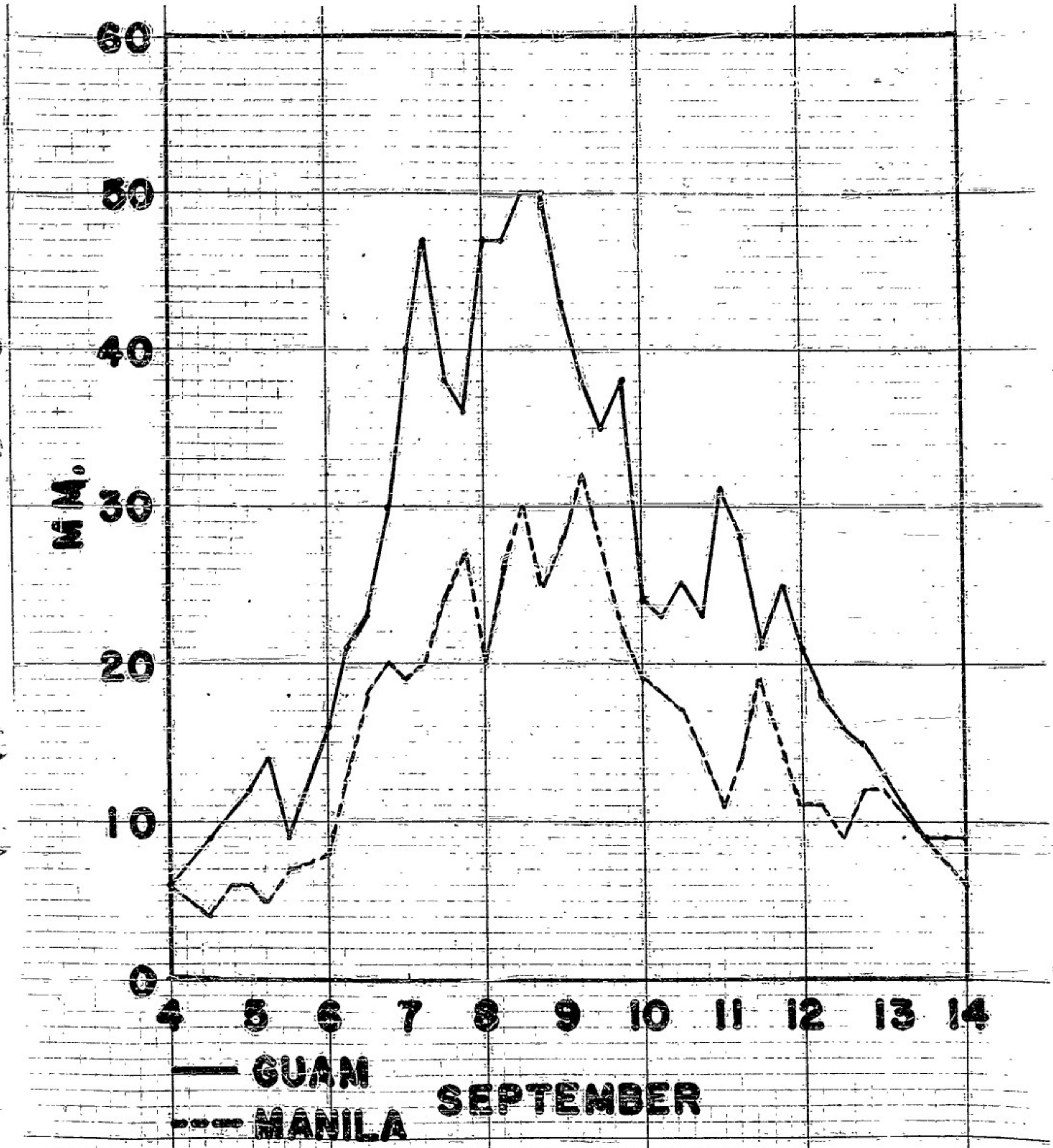
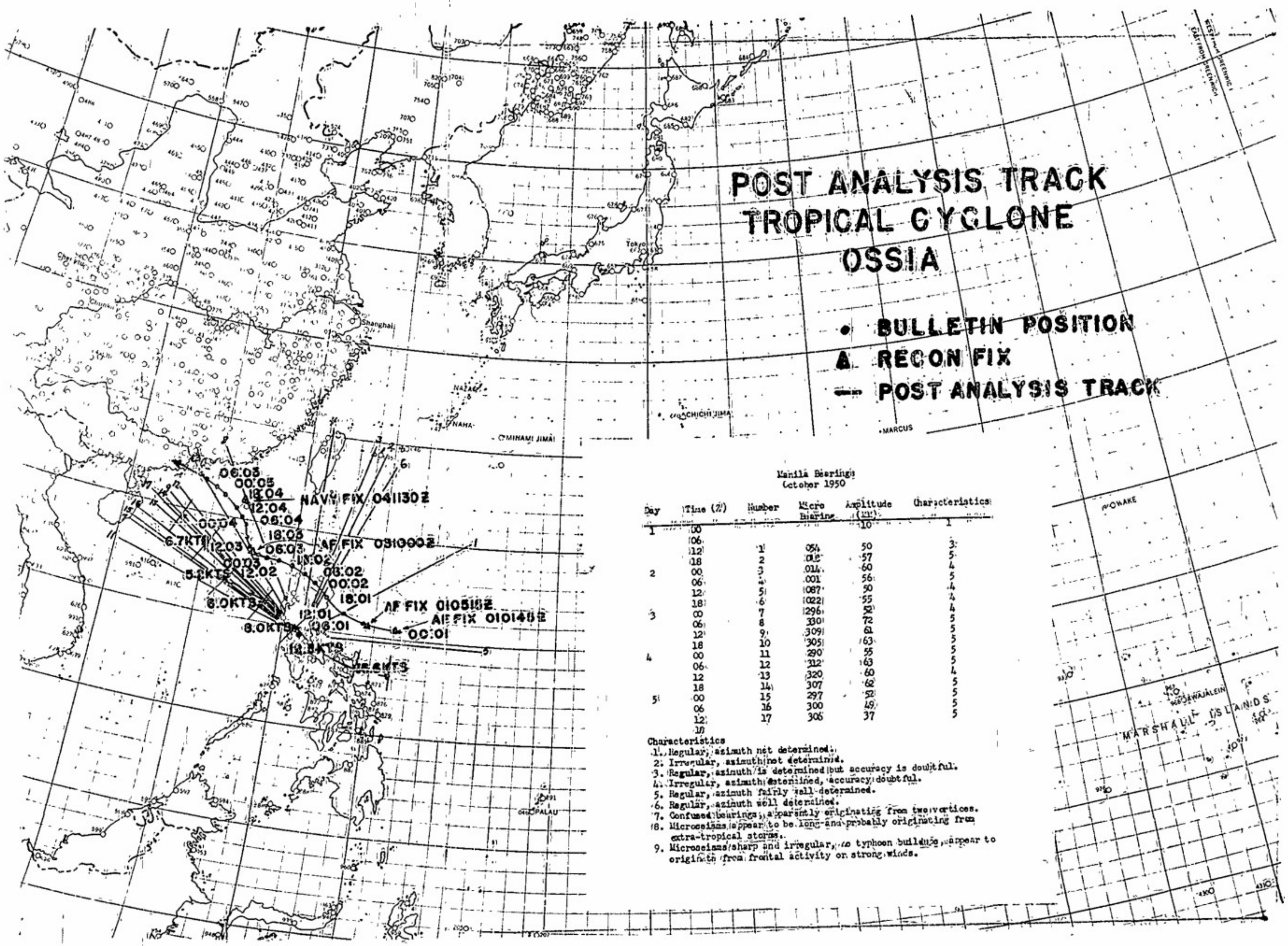


AMPLITUDE OF MICROSEISMS DURING KEZIA



Manila Bearings
October 1950

Day	Time (Z)	Number	Micro Bearing	Amplitude (μ)	Characteristics
				10	1
1	00				
	06				
	12	1	054	50	3
	18	2	[illegible]	57	5
2	00	3	014	60	4
	06	4	001	56	5
	12	5	087	50	4
	18	6	022	55	4
3	00	7	296	52	4
	06	8	330	72	5
	12	9	309	61	5
	18	10	305	63	5
4	00	11	290	55	5
	06	12	312	63	5
	12	13	320	60	4
	18	14	307	62	5
5	00	15	297	52	5
	06	16	300	49	5
	12	17	306	37	5
	18				

Characteristics
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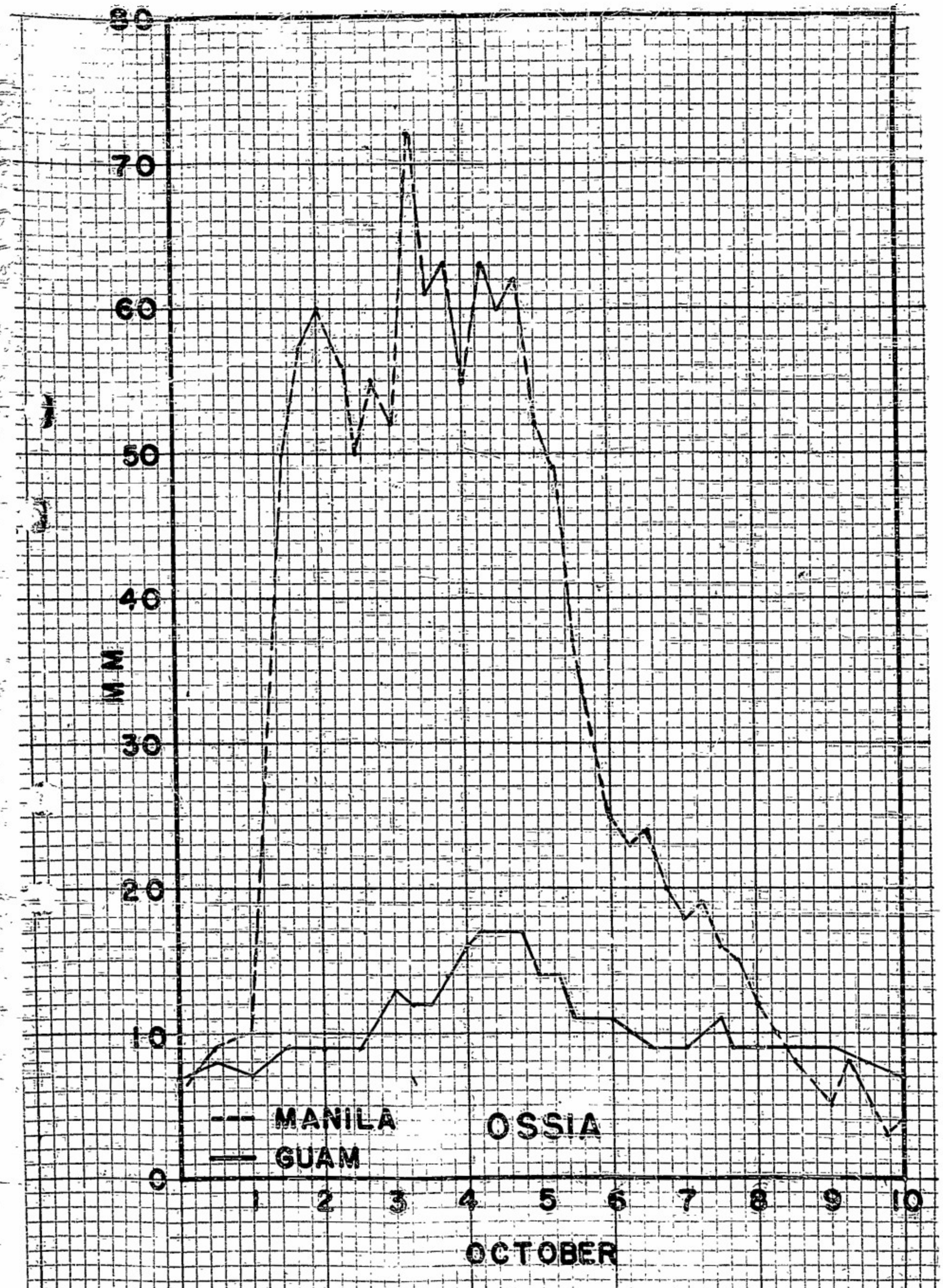
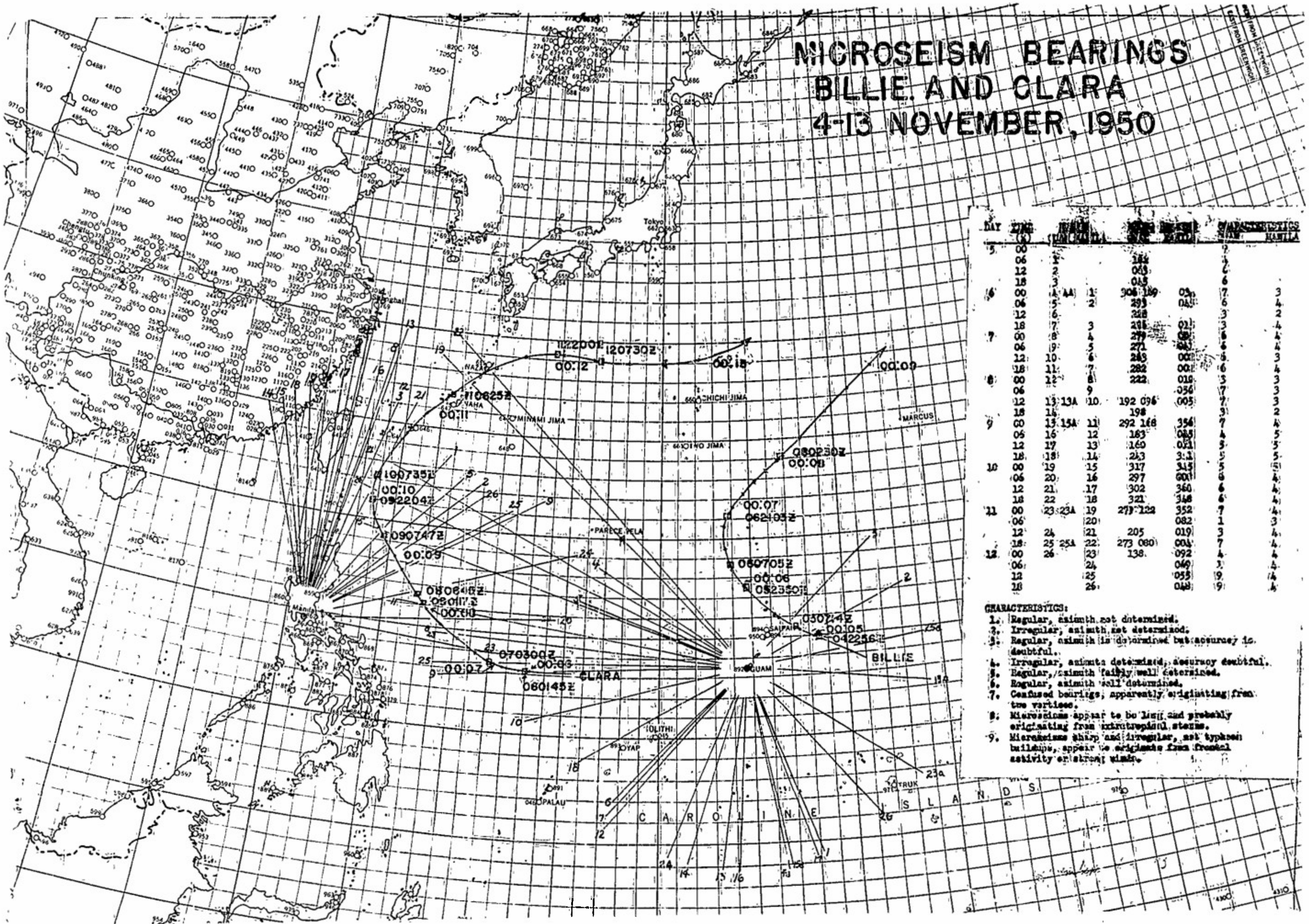
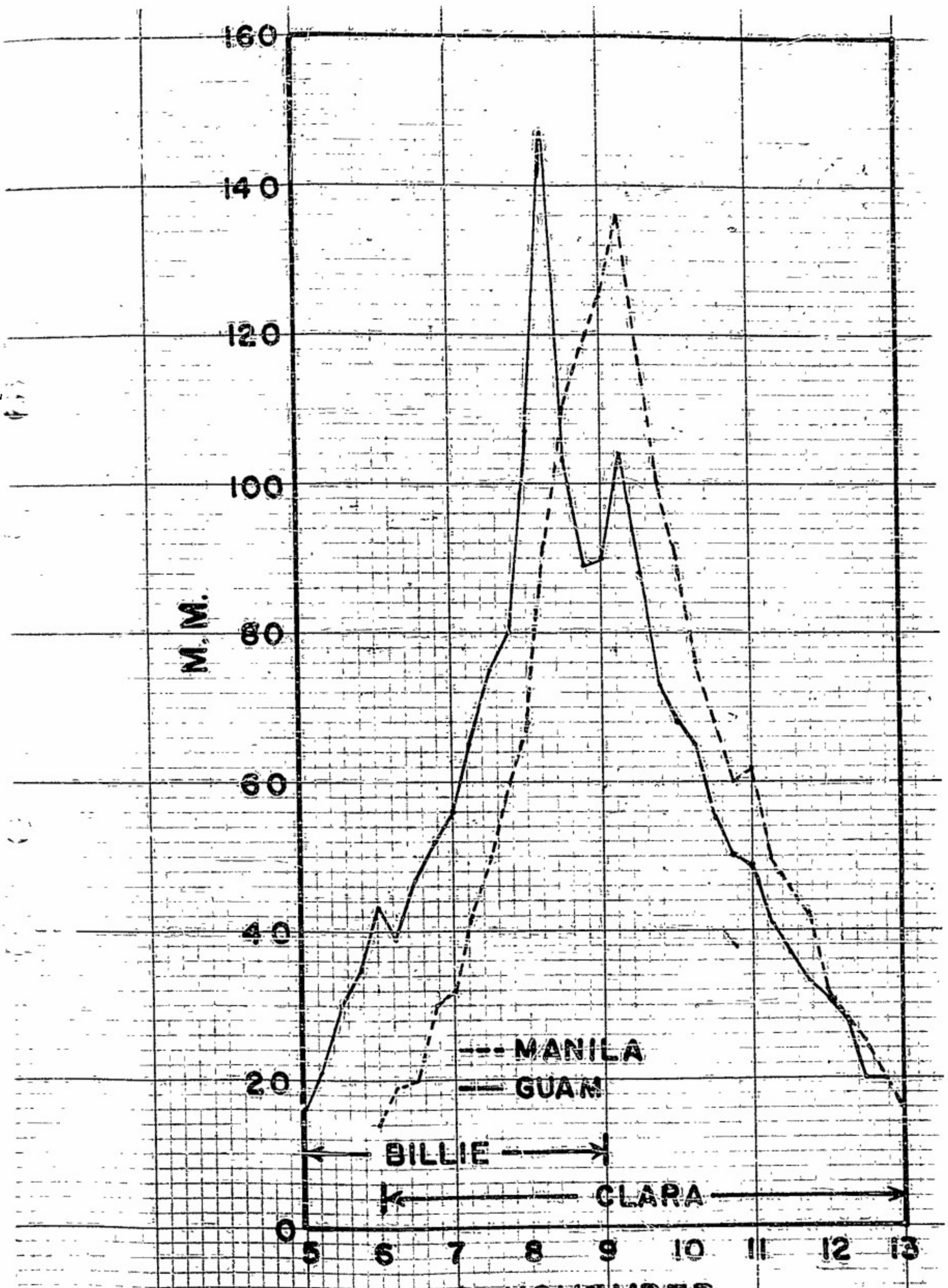


MICROSEISM AMPLITUDE AT GUAM AND MANILA



DAY	TIME (Z)	[illegible]	[illegible]	[illegible]	[illegible]	CHARACTERISTICS GUAM	MANILA
5	00					9	
	06	1		184		4	
	12	2		063		6	
	18	3		045		6	
6	00	4 4A	1	306 189	03[illegible]	7	3
	06	5	2	293	045	6	4
	12	6		228		3	2
	18	7	3	215	021	3	4
7	00	8	4	279	[illegible]	6	4
	06	9	5	271	[illegible]	6	4
	12	10	6	263	00[illegible]	6	3
	18	11	7	282	001	6	4
8	00	12	8	222	019	5	3
	06		9		056	7	3
	12	13 13A	10	192 096	005	7	3
	18	14		198		3	2
9	00	15 15A	11	292 168	356	7	4
	06	16	12	183	085	4	5
	12	17	13	160	021	5	5
	18	18	14	243	3[illegible]1	5	5
10	00	19	15	317	345	5	(5)
	06	20	16	297	001	6	4
	12	21	17	302	360	6	4
	18	22	18	321	348	6	4
11	00	23 23A	19	277 122	352	7	4
	06		20		082	1	3
	12	24	21	205	019	3	4
	18	25 25A	22	273 080	004	7	4
12	00	26	23	138	092	4	4
	06		24		049	3	4
	12		25		055	9	4
	18		26		048	9	4

CHARACTERISTICS:
1. Regular, azimuth not determined.
2. Irregular, azimuth not determined.
3. Regular, azimuth is determined but accuracy is doubtful.
4. Irregular, azimuth determined, accuracy doubtful.
5. Regular, azimuth fairly well determined.
6. Regular, azimuth well determined.
7. Confused bearings, apparently originating from two vortices.
8. Microseisms appear to be long and probably originating from extratropical storms.
9. Microseisms sharp and irregular, not typhoon buildups, appear to originate from frontal activity or strong winds.



MICROSEISM AMPLITUDE AT GUAM AND MANILA.

BILLIE AND CLARA

CLIMATOLOGY

From the vast quantities of data compiled, in the Pacific, during and since the World War II, has evolved a tool very useful to the typhoon forecaster--climatology. Of course, there is climatological information dating back much farther than this period, but efforts at compilation were hampered by poor communications, slow transportation etc., until this time. Upper-air data, especially, have become more available due to the above reasons and development of new instruments and procedures. The problem now seems not to be so much a shortage of data, as a shortage of studies of the data. Some studies have been compiled recently and made available to the typhoon forecaster, however much more could be done, with the data already compiled, if the man-hours were available. Some of these will be discussed later in this section.

There appears to be two diametrically opposed attitudes toward climatology among the typhoon forecasters today. One school regards it as useless and maintains that each tropical cyclone is an individual problem and that attempts to gain any information from actions of cyclones in the past are doomed to complete failure. On the other side of the question are those who believe that climatology is the sure-fire cure-all for the problems confronting the forecaster and that he need only to refer to history to come up with a perfect forecast. As in most controversial subjects, the proper attitude lies between the two outlined above. Climatology, when used <u>in conjunction</u> with other methods is an invaluable additional tool to the forecasters kit. A glance at the tracks of the 1949 and 1950 tropical cyclones on pages <u>60</u> and <u>62</u> of this report should indicate to the most ardent user of climatology that it is not the final answer, however its importance can not be denied. All forecasts should be modified initially with climatology, then with other factors, assuming that the basic forecast can be based upon extrapolation. This is especially important when the first forecast of movement is made and when the cyclone breaks away from some associated phenomenon, such as an easterly wave, and starts an independent movement.

The primary, current climatological study available, in quick reference form, to the forecaster is the set of mean tracks, speeds, and areas of intensification and dissipation, which was prepared by the Typhoon Post-Analysis Board of the Andersen Weather Central. Copies of these tracks with the track of the 1950 tropical cyclones superimposed on them are shown on pages <u>25</u> through <u>38</u>.

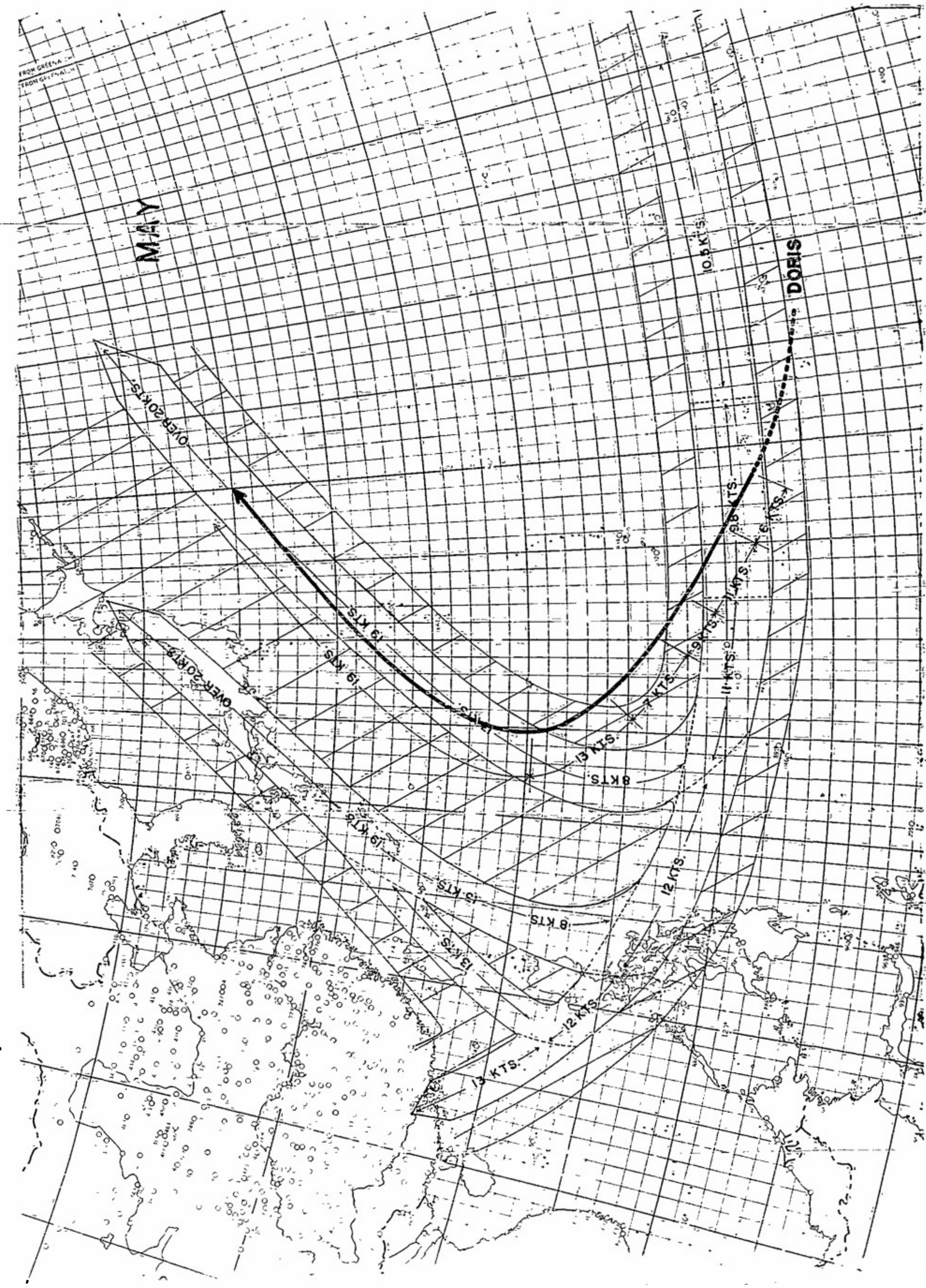
When a tropical cyclone is first located, the chart (from the mean tracks) for that particular period can be consulted for average speed and direction of movement, the probabilities for future movement and intensification, and percentages of deviation from the mean. These charts become more valuable as the forecaster gains some experience by noting the behavior of a few cyclones and comparing their behavior with that indicated by the charts; however it is believed that their value could be considerably increased if a series of surface and upper-air were prepared, corresponding to the postions of each of the storms from which the average tracks were made, then average surface and upper air charts prepared from this collection. That is, synoptic climatology would be more accurate than statistical climatology. The results would probably be more accurate if the charts and tracks of each cyclone could be consulted, but that method would be too cumbersome for use by the forecaster unless a quick-reference index could be made. The preparation of such a study as above would be a large project quite beyond the capabilities of a s organization.

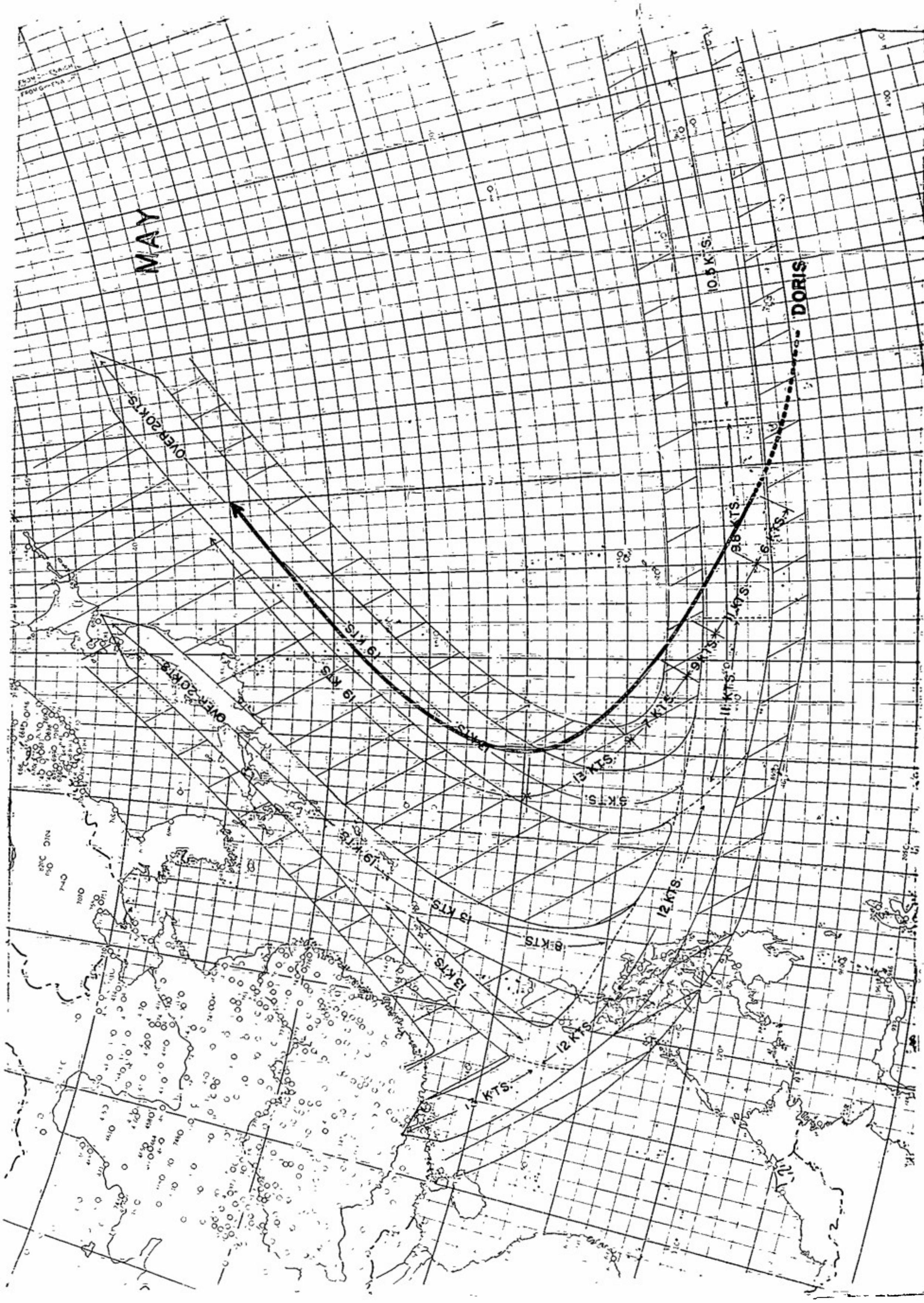
Another phase of climatology with which the typhoon forecaster must be familiar is the climatology of the area for which he is responsible. The initial indications of tropical cyclones are often significant falls in pressure, increase in wind velocity, and change of direction of winds, therefore the forecaster must know what the normal situation is for his area for all times. There are several good studies of this type available.

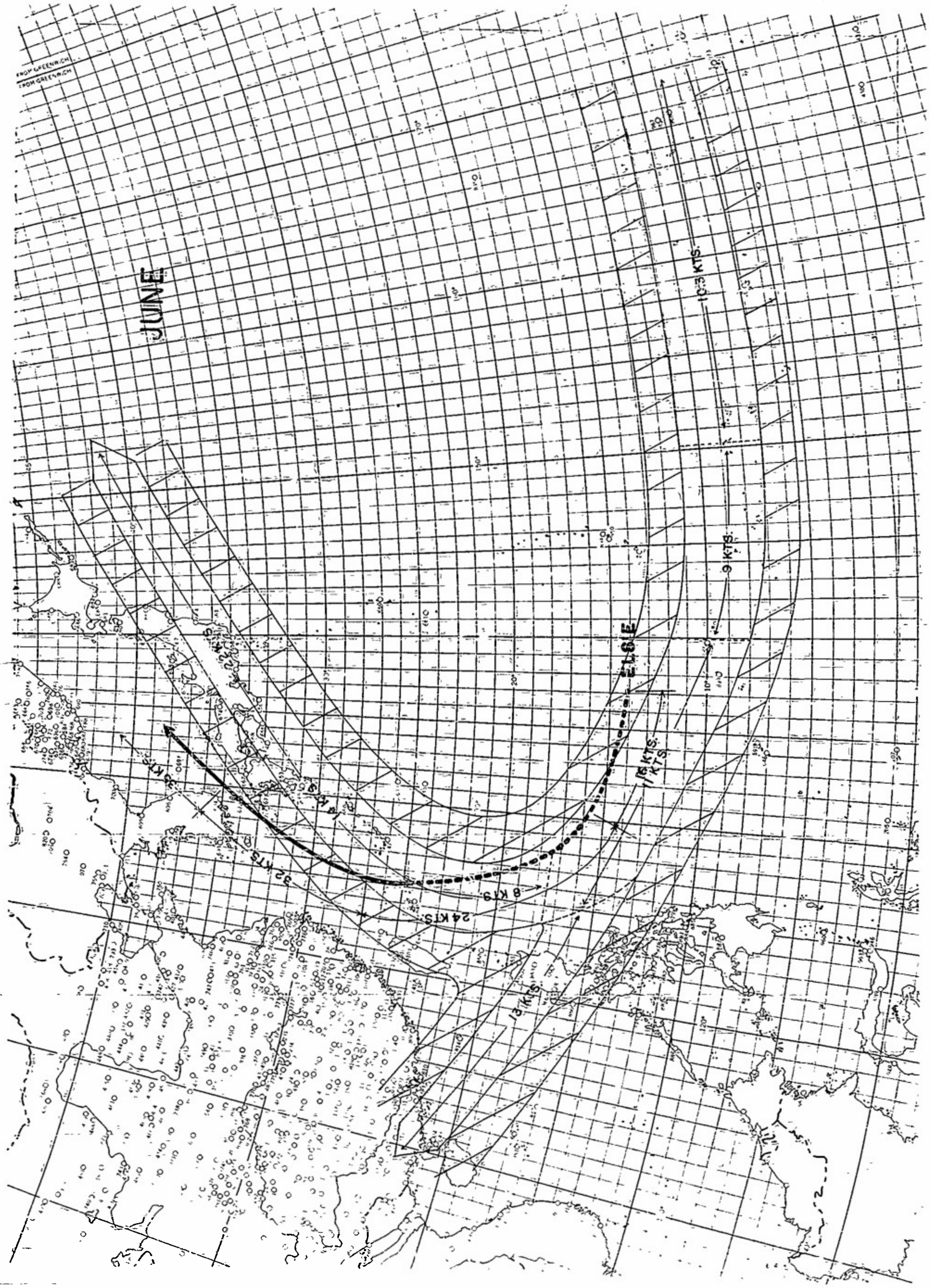
When using the mean track one must bear in mind that the speeds and directions will usually verify even though a cyclone occurs outside the extremes (hatched area) of the track. After one has determined whether the movement of the cyclone is being influenced by easterly or westerly flow the probable nature of the movement can be determined from the portion of the mean track in that type of flow. It is believed that a supplement to these tracks, showing the average maximum wind velocities, and average radii of maximum winds for significant areas, would be of value also, especially to the newcomer to the field of typhoon forecasting.

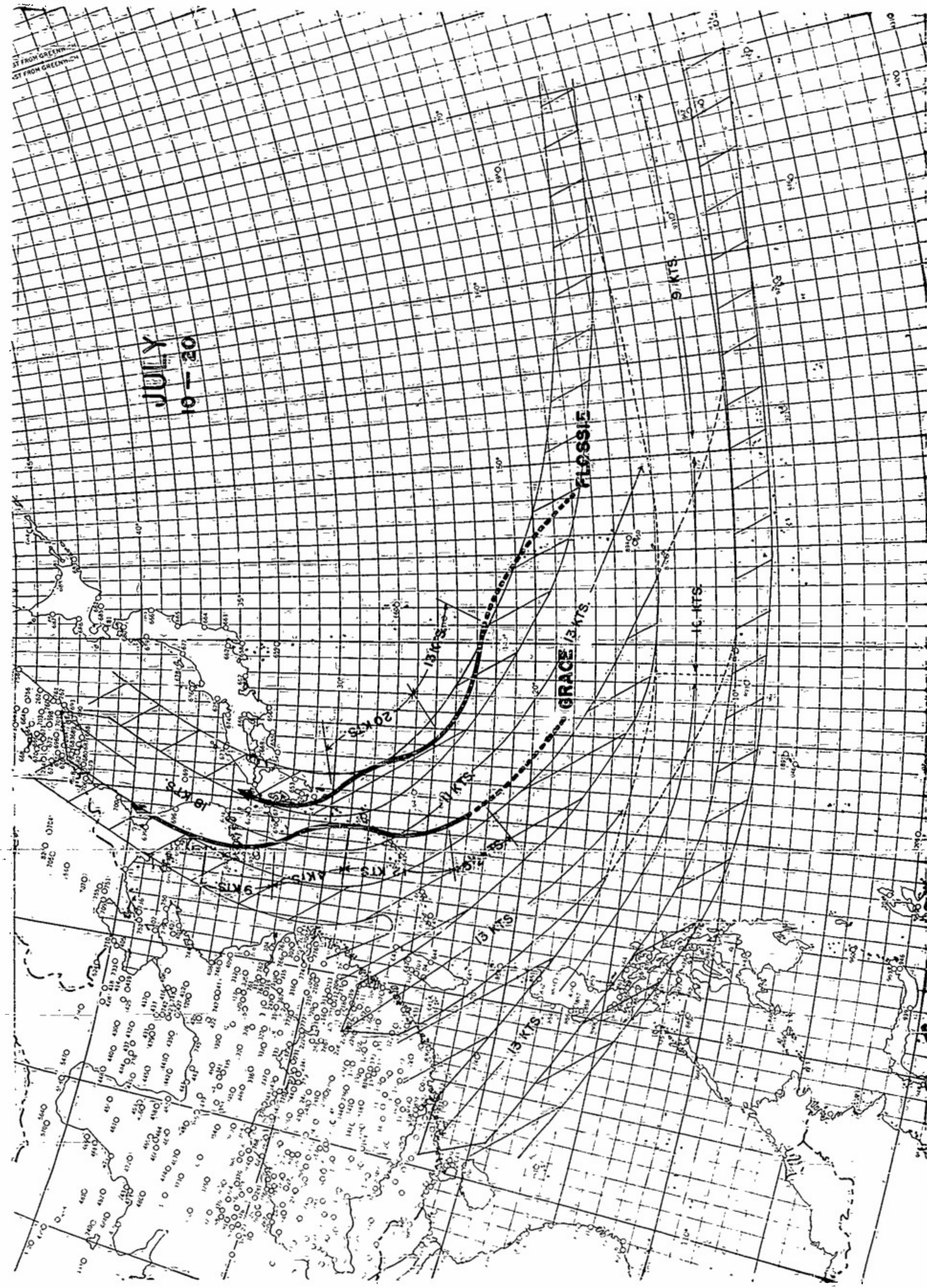
During the 1950 season there were 18 tropical cyclones of storm or typhoon intensity. Only one of these, Ida, moved contrary to the indications of climatology. Thus we can say that climatology was useful for 94.5% of the storms and typhoons. Occasionally the direction of movement varied from the mean by about 45 degrees, but in a majority of the cases the direction was within 20 degrees of that of the mean. It is noted that climatology gives the best results for latitude of formation and direction of movement and the poorest results for speed of movement and recurvature. The cyclones follow the mean tracks much more closely after recurvature than before, there climatology should be given greater weights when preparing a forecast for the area in which most of the passage is after recurvature, than in the areas of intensification and recurvatures. This means that in the latter areas, climatology should be modified more with consideration of the synoptic situation.

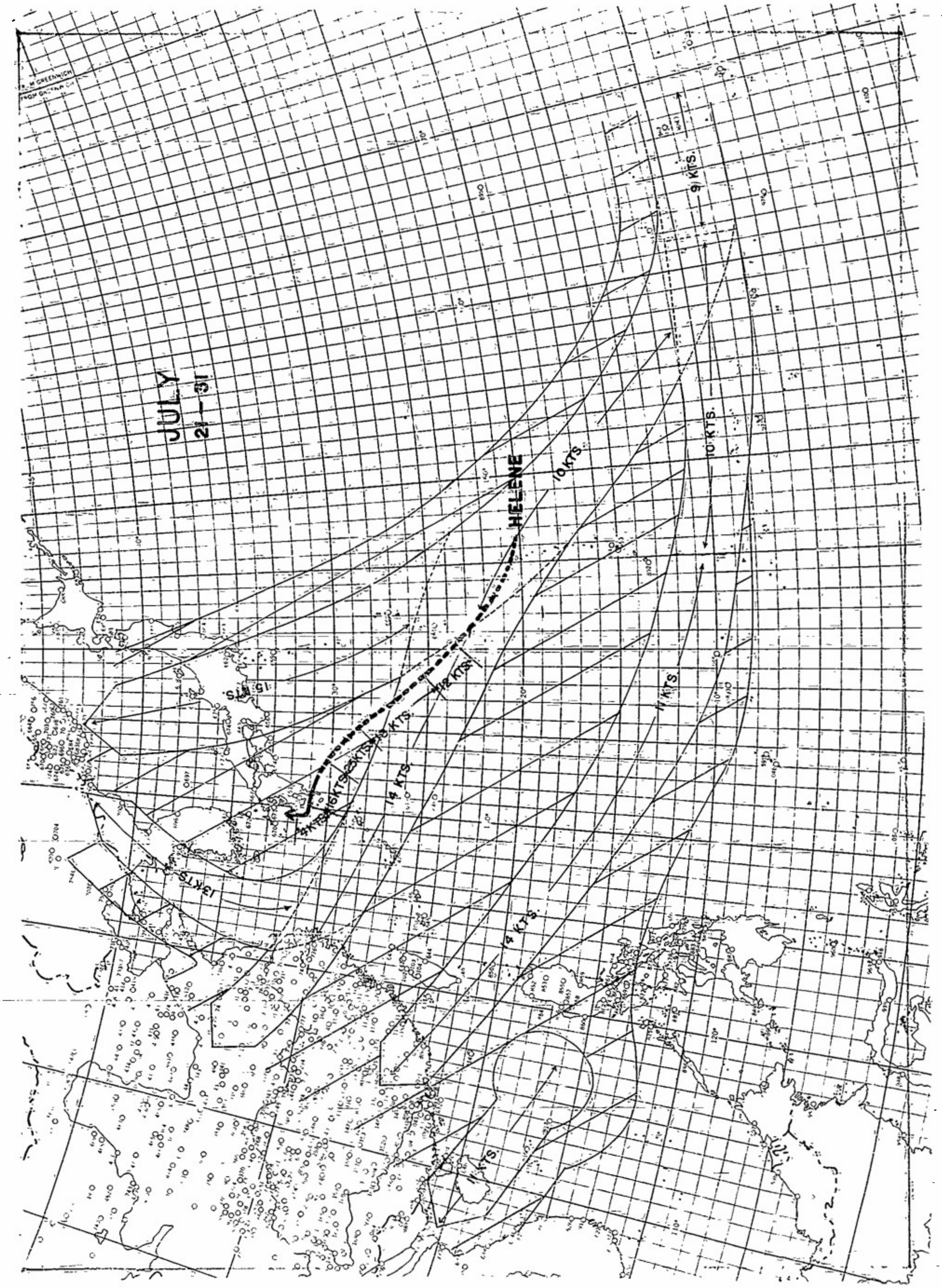
Climatological tracks are prepared from the tracks of numerous tropical cyclones whose peculiarities were determined from the various factors of the synoptic situation. In view of that fact, if there were adequate data available, and if each typhoon forecaster were an expert at evaluating the synoptic picture, there would be little use for the climatological study. In view of the few reporting stations in the Pacific, and since human errors are likely to be with us for some time, climatology will continue to be of value in tropical cyclone forecasting.

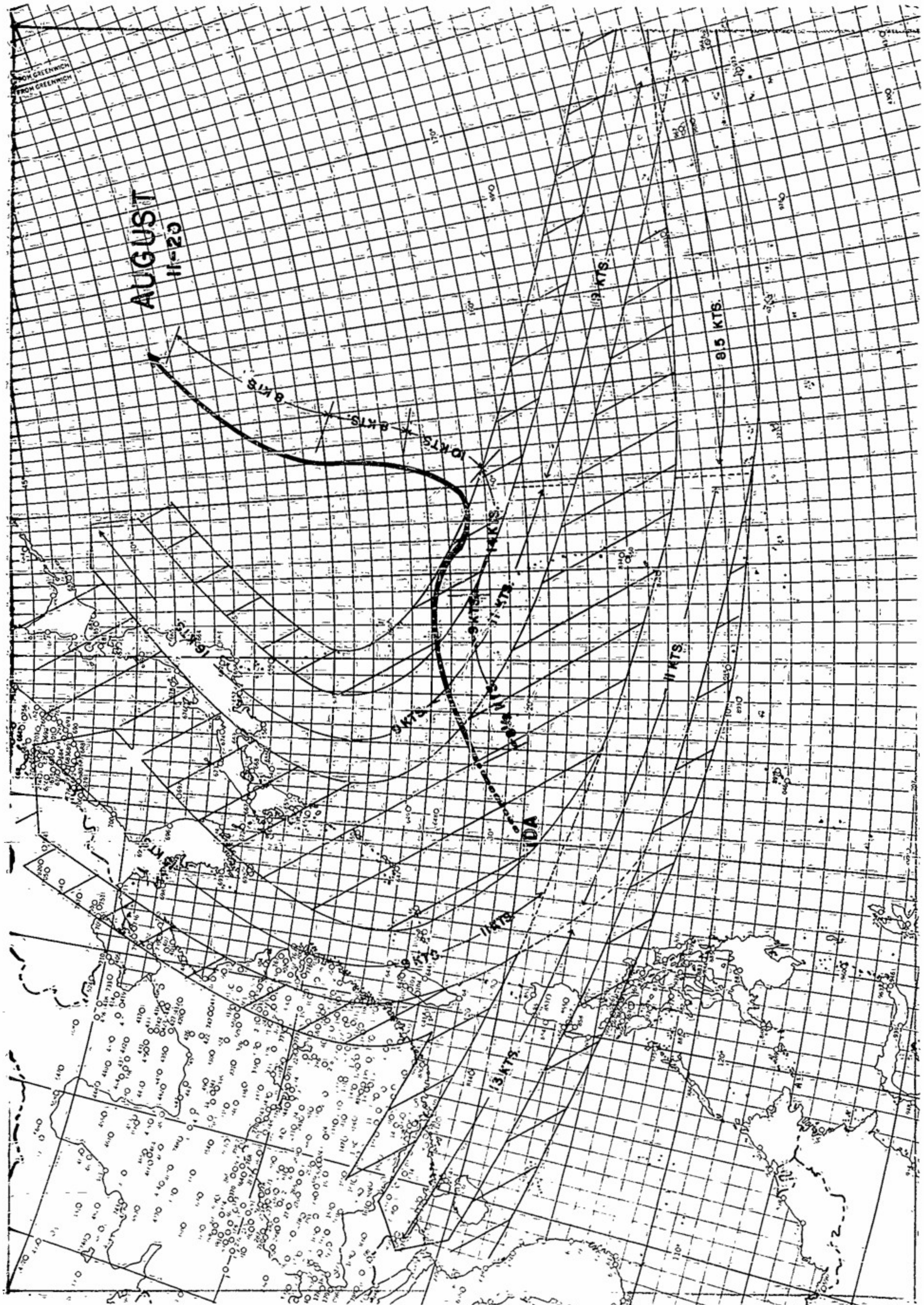

MAY
DORIS
OVER 20 KTS.
19 KTS.
13 KTS.
8 KTS.
12 KTS.
10.5 KTS.
9.8 KTS.
11 KTS.
9 KTS.
7 KTS.
6 KTS.

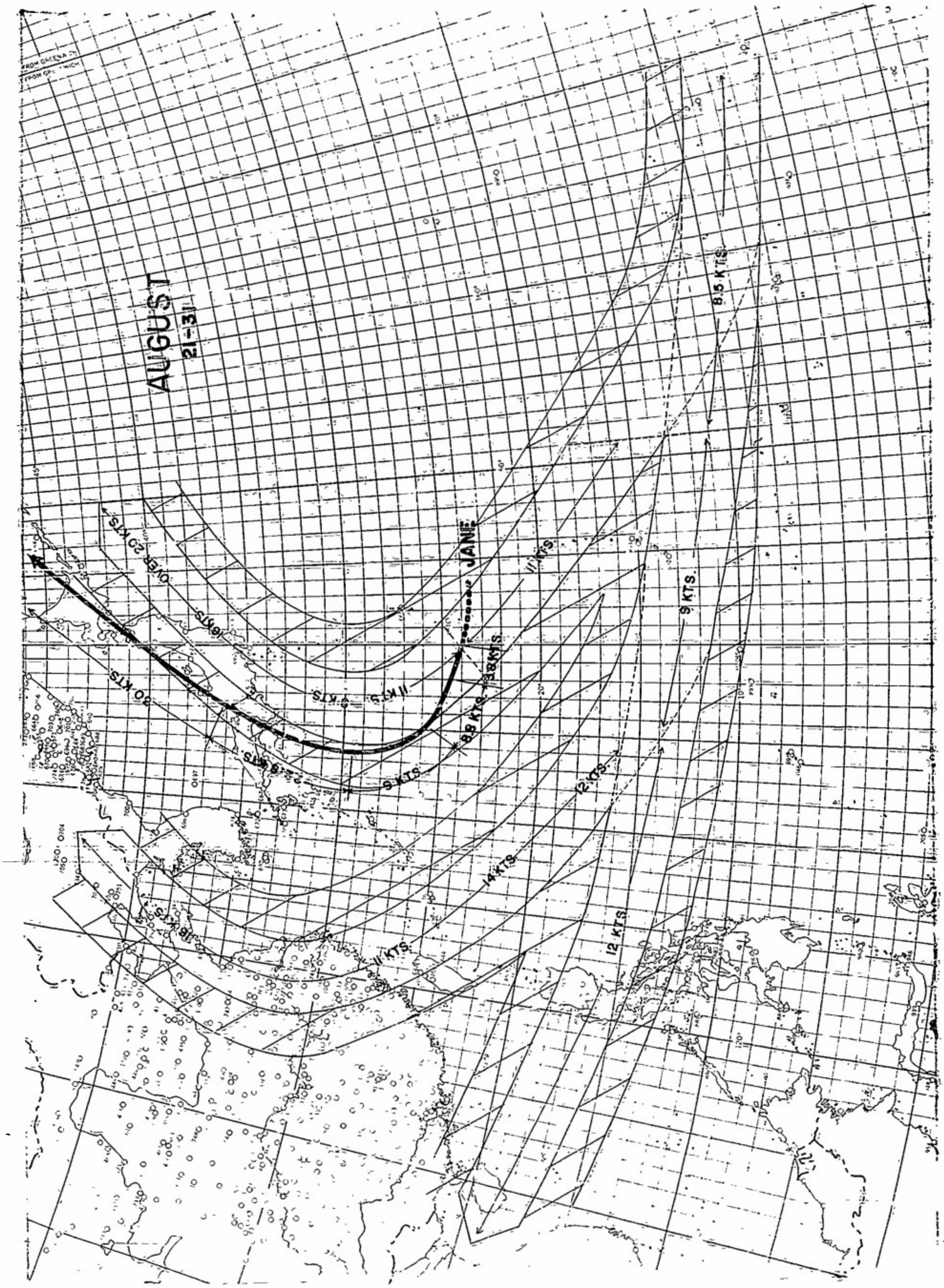

MAY
DORIS
10.5 KTS.
9.8 KTS.
6 KTS.
11 KTS.
9 KTS.
7 KTS.
12 KTS.
5 KTS.
19 KTS.
OVER 20 KTS.
13 KTS.
8 KTS.

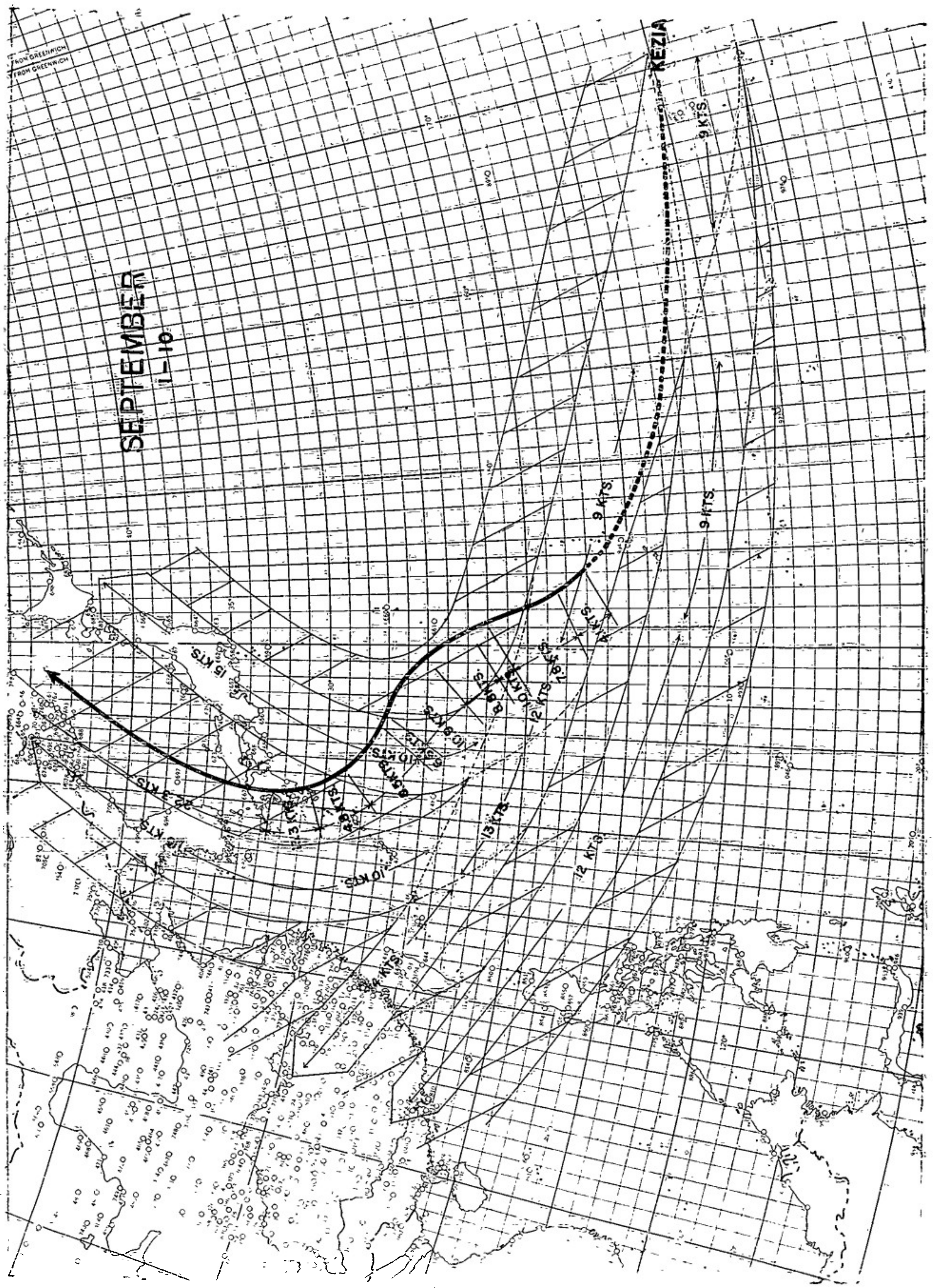

JUNE
ELBE
10.3 KTS.
9 KTS.
16 KTS.
13 KTS.
24 KTS.
32 KTS.
8 KTS
14 KTS.

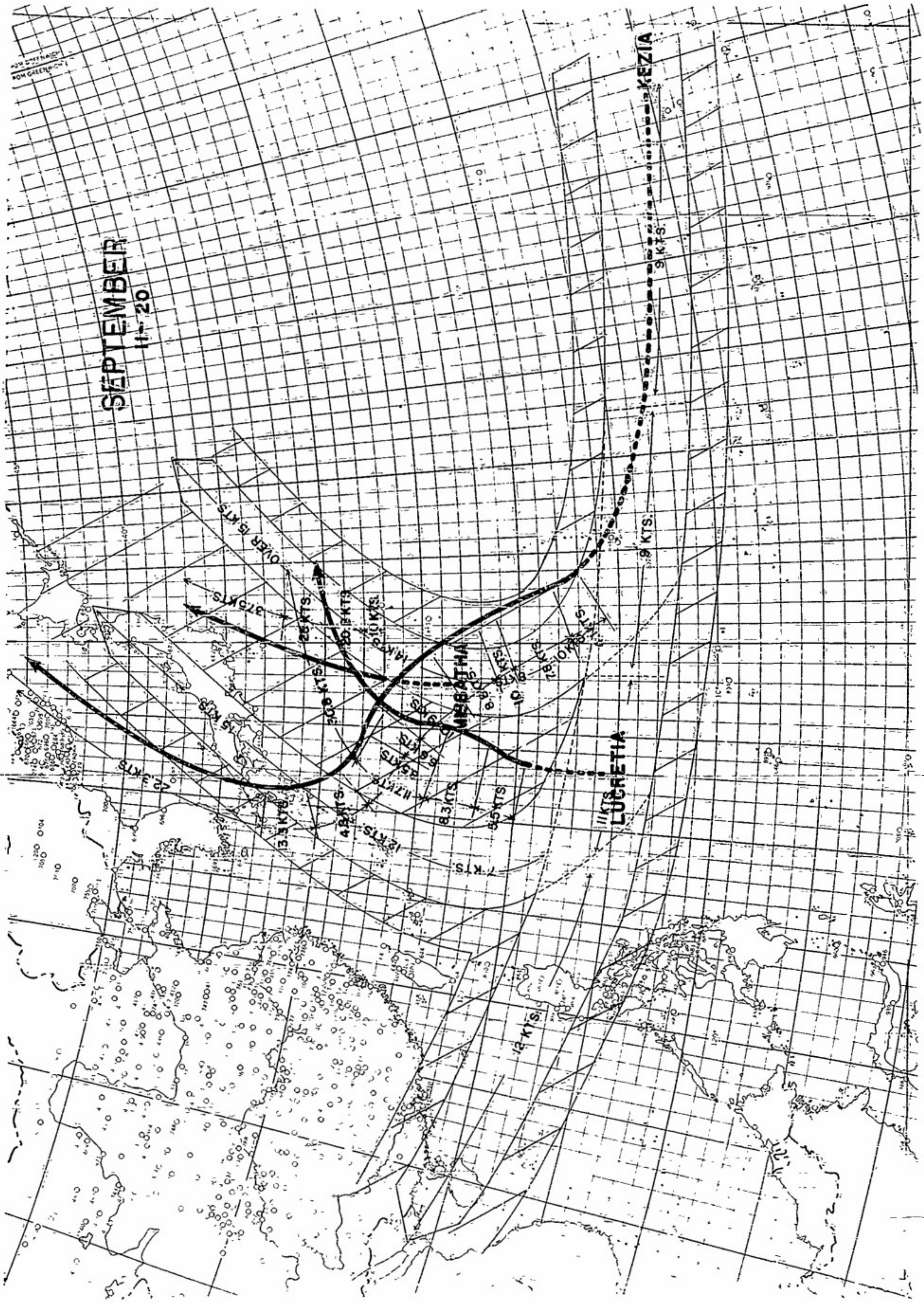

JULY
10 — 20
FLOSSIE
GRACE
13 KTS.
20 KTS
18 KTS
9 KTS.
16 KTS.
13 KTS

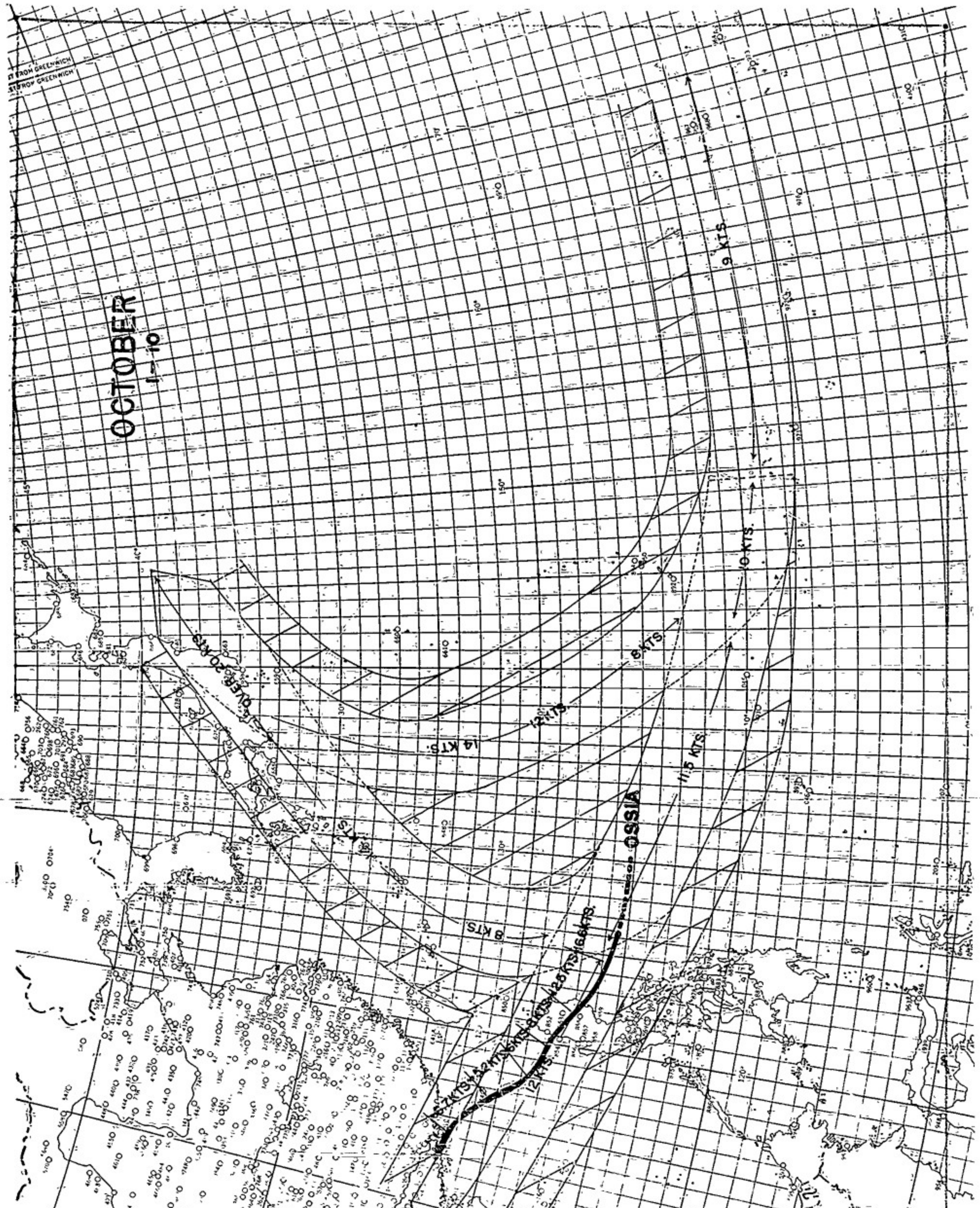

JULY
21 — 31
HELENE
9 KTS.
10 KTS.
10 KTS.
14 KTS.
11 KTS.
4 KTS.


AUGUST
11-20
8.5 KTS.
11 KTS.
13 KTS.
9 KTS.

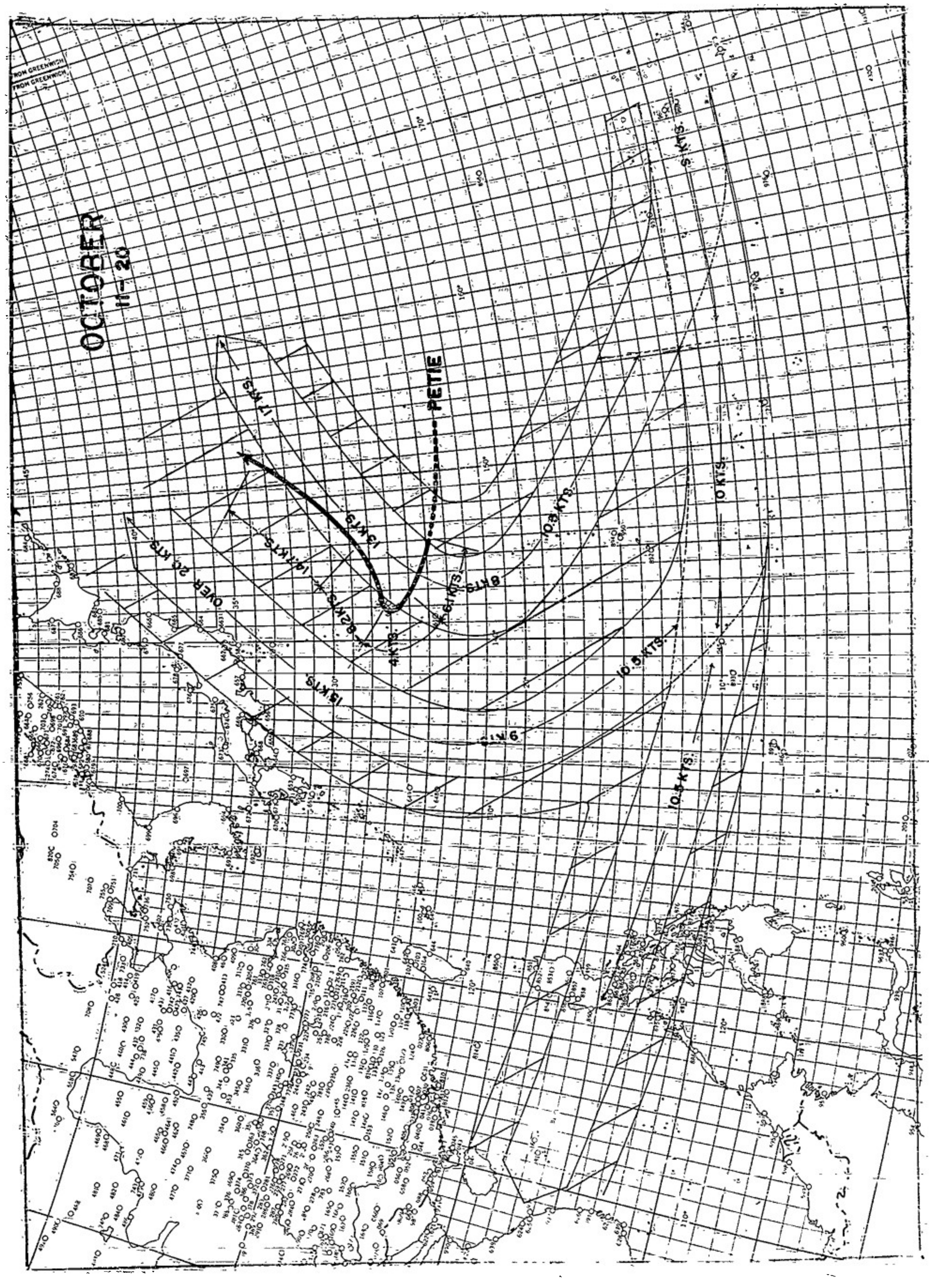

AUGUST
21-31
JANE
OVER 20 KTS.
16 KTS.
20 KTS.
11 KTS.
9 KTS.
8.5 KTS.
9 KTS.
12 KTS.
14 KTS.
11 KTS.
12 KTS.
9 KTS.
8.5 KTS.
18 KTS.

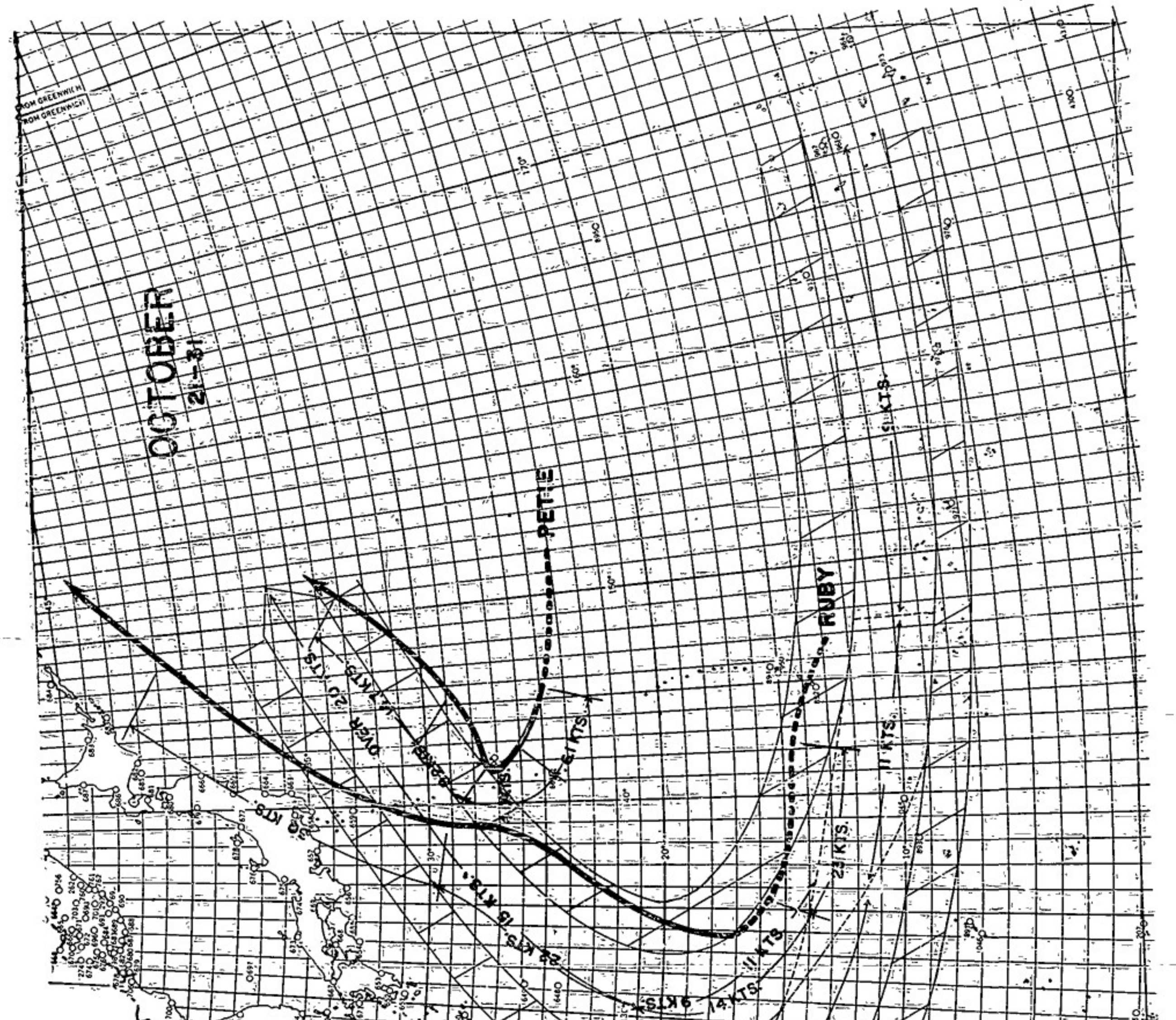

SEPTEMBER
1–10
KEZIA
9 KTS.
15 KTS.
13 KTS.
12 KTS.
10 KTS.

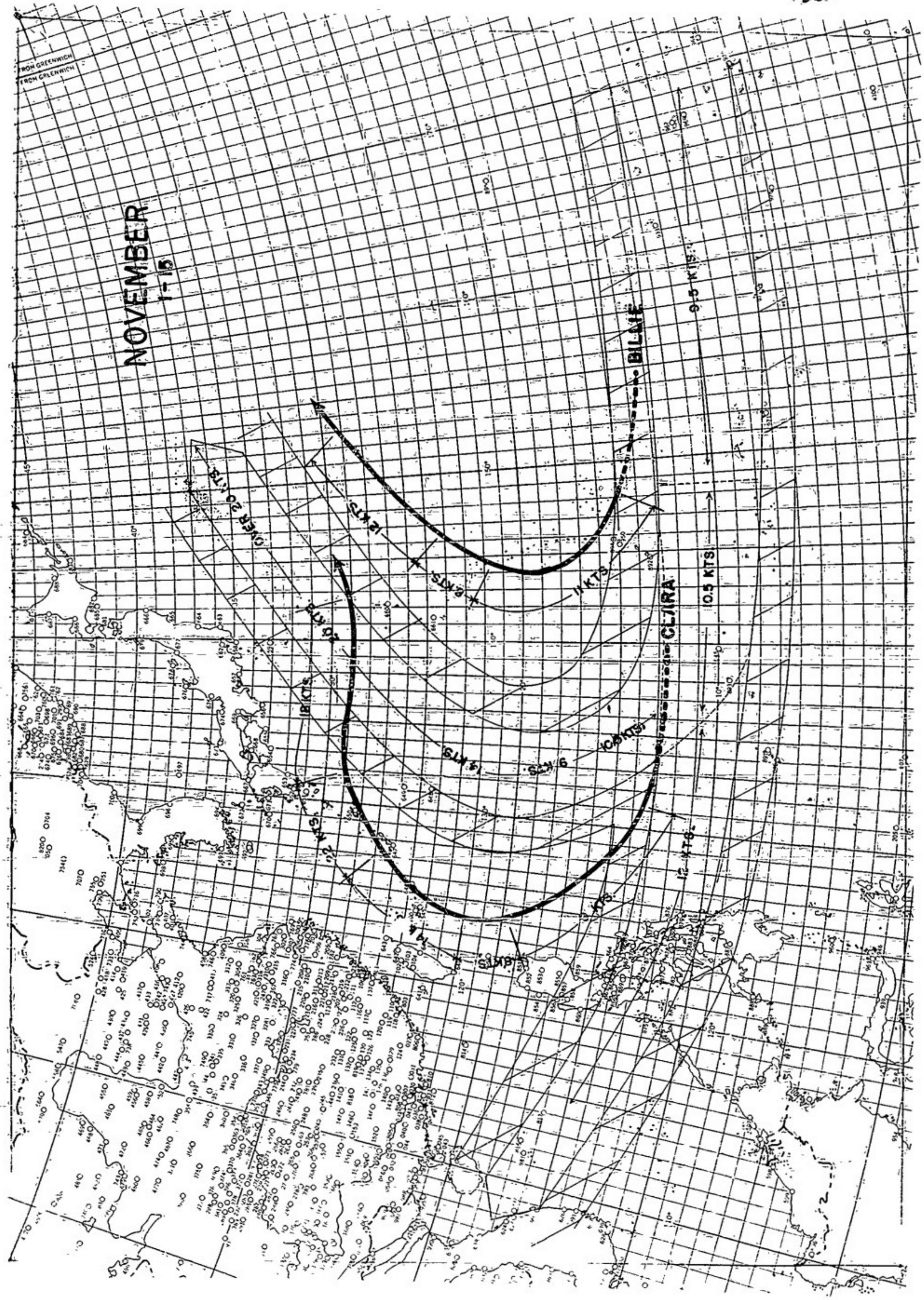

SEPTEMBER
11 - 20
KEZIA
HIAWATHA
LUCRETIA
OVER 15 KTS.
9 KTS.
12 KTS.
7 KTS.
11 KTS.
3.3 KTS.
8.3 KTS.
9.5 KTS.
28 KTS.
30.8 KTS.
37.5 KTS.

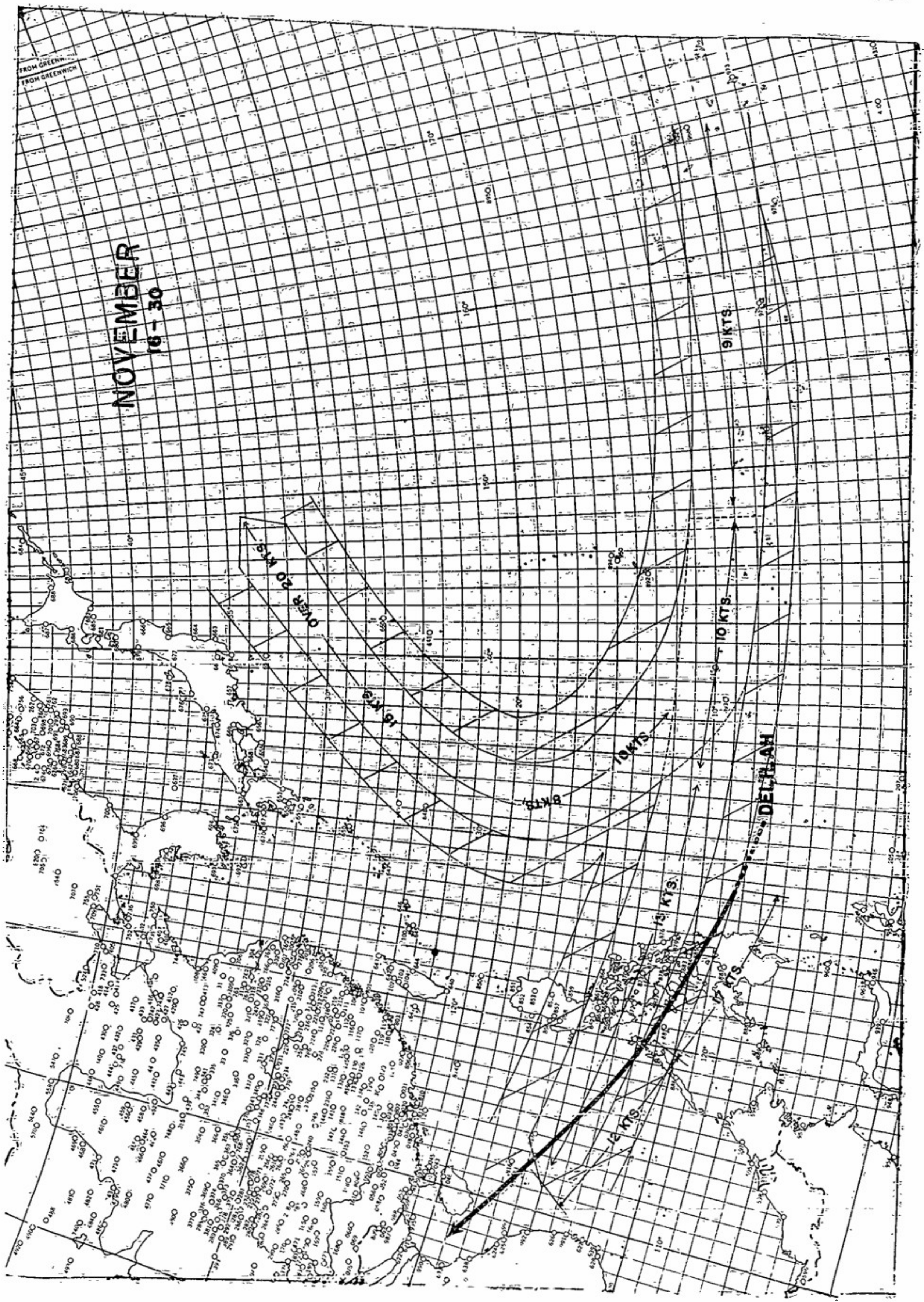


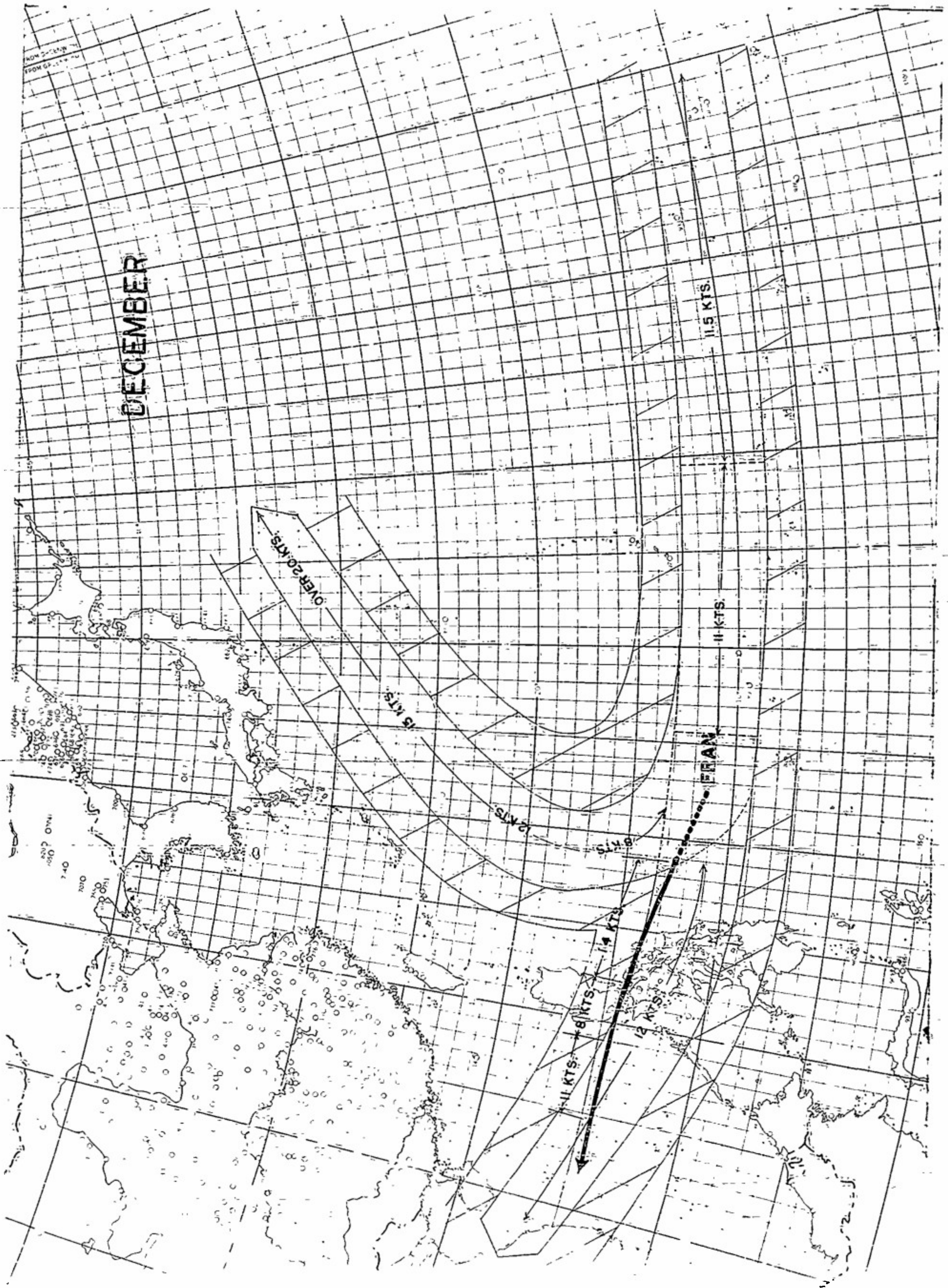
OCTOBER
1—10
OVER 20 KTS.
14 KTS.
12 KTS.
8 KTS.
9 KTS.
10 KTS.
11.5 KTS.
OSSIA
12 KTS.


OCTOBER
11 - 20
PETIE
17 KTS.
13 KTS.
14.7 KTS.
OVER 20 KTS.
82 KTS.
61 KTS.
8 KTS.
4 KTS.
10.8 KTS.
15 KTS.
9 KTS.
10.5 KTS.
10.5 KTS.
10 KTS.
5 KTS.


OCTOBER
21-31
PETIE
RUBY
23 KTS.
11 KTS.
13 KTS.
14 KTS.
9 KTS.


NOVEMBER
1 - 15
BILLIE
CLARA
OVER 20 KTS
12 KTS
11 KTS
14 KTS
9 KTS
18 KTS
10.5 KTS
9.5 KTS
FROM GREENWICH


NOVEMBER
16 - 30
OVER 20 KTS.
15 KTS.
10 KTS.
8 KTS.
9 KTS.
13 KTS.
12 KTS.


DECEMBER
OVER 20 KTS.
15 KTS.
12 KTS.
8 KTS.
11.5 KTS.
11 KTS.
FRAN
14 KTS.
8 KTS.
11 KTS.
12 KTS.

EXTRAPOLATION

Extrapolation as a forecasting technique has been both overrated and underrated. To many, this method, because of its simplicity, appears to be unscientific. However, when tropical cyclones move through areas of little or no data, as is often the case, extrapolation is one of the few tools available to the forecaster. It is imperative, therefore, that each typhoon forecaster be familiar with this technique, which is s[illegible] and easily applied. Forecasts based on this method should be modifi[illegible] by climatology and synoptic analysis and should not be made for periods longer than 24 hours. The shorter the forecast period the more accurate the results.

Based on the assumption that the movement and trends of tropical cyclones tend to persist with few rapid changes in either speed or direction of movement, best results are obtained on those storms which follow a smooth curved path. During periods of deceleration, acceleration, and recurvature, or, when the path becomes irregular, greatest errors occur. Some consideration can be given these phenomena but they are difficult to forecast with any degree of accuracy using extrapolation alone.

Accuracy of extrapolation forecasts, just as the accuracy of forecasts based upon other techniques, depend upon the reliability of the data used. In the vast regions of the North Pacific below 25° N, where reporting stations are scarce, positions of tropical cyclones are usually fixed by weather reconnaissance with the elapsed time between fixes varying from 6 hours to 24 hours. Reconnaissance fixes are considered to be quite accurate

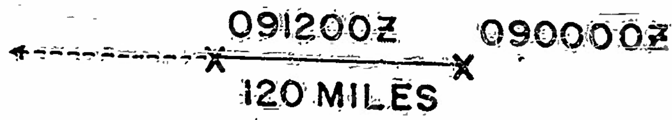
Two general methods are considered. The first simple linear extrapolation, and the second modified linear extrapolation. For simple linear a minimum of two accurate fixes is needed (see Fig. 2 page 41.) Direction of movement is obtained by projecting the line connecting these two positions in the indicated direction. Because of the scarcity of data, instantaneous speed of movement can seldom be obtained. Instead, average speed is obtained by dividing the distance between positions by the elapsed time between points. For simple linear extrapolation assuming no acceleration or deceleration the cyclone can be projected along the extrapolated path at the average rate as obtained by the above method. Small scale changes in speed are usually averaged out, and normally, only trends in average speed are noticeable. Accelerations and decelerations may be forecast by observing the rate of change of average speed between pairs of points and applying this to the forecast speed, i.e., if between one pair of points the average speed has been 4 knots, the next set of points 7 knots and the period covered 24 hours, then an acceleration of 3 knots per 24 hours should be applied and a forecast of 10 knots in 24 hours be made. In the same way maximum winds and areas of intense weather may be extrapolated. If for one position, maximum winds were 45 knots and 12 hours later 60 knots then an acceleration of 15 knots per 12 hours should be made.

Simple linear extrapolation using two positions is in most cases inadequate. A minimum of three points should be used and the more points used, the better the results obtained. In determining direction of movement using several positions the smooth curve which most closely satisfies all points should be projected and motion forecast along this path. (See figure 2 page 41). Quite often tropical cyclones in the early stages move in an oscillatory manner as suggested by Yeh. Using the above mentioned method averages out these oscillations. For speed of movement using several points, averages between pairs of points should be used to establish a trend, rather than an overall average along the path.

As mentioned before extrapolation forecasts must be modified. At the time of initial detection only one position is normally available. Hence, extrapolation in the usual sense is not practical. However, the initial position can be projected along the mean climatological track after due consideration of the synoptic analysis. After additional fixes are obtained, simple linear extrapolation using several points may be used for an initial forecast path. This should be adjusted after careful consideration of synoptic analysis and by use of climatological models. Many times the adjusted path will be quite different from that using extrapolation alone. A good example of this is the case of a fast moving trough to the north of a tropical cyclone. The cyclone will be deflected northward, (see case V Upper Air Steering page 42). Using extrapolation alone the storm would be projected northward. However, climatology indicates that the storm will become stationary, or loop, then move in a westward direction as the trough to the north continues its eastward movement no longer influencing the path of the cyclone. As a result the extrapolated path must be modified radically.

The value of extrapolation as a forecasting technique can be seen by examining the chart page 51 - 52, which gives a comparison of forecast and persistence errors. By comparing this chart with chart page 62, which shows the tracks of storms during 1950 season, it can be seen that best results are obtained on storms which show little irregularity.

FIG I

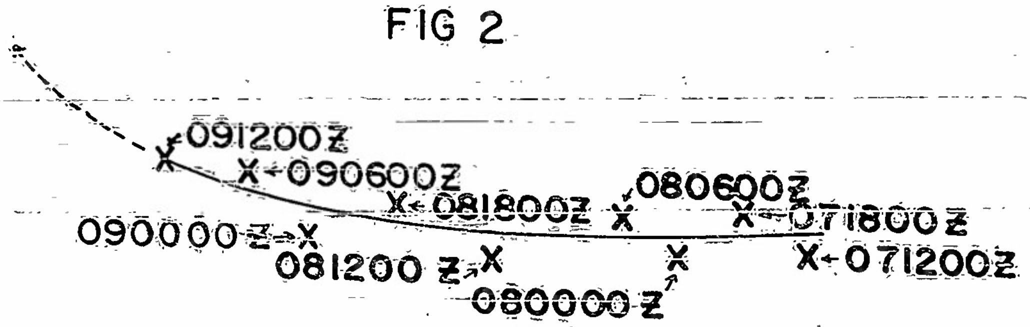


EXTRAPOLATED PATH

$$\frac{120 \text{ MILES}}{12 \text{ HOURS}} = 10 \text{ MILES PER HOUR AVERAGE SPEED}$$

SIMPLE LINEAR EXTRAPOLATION USING TWO FIXES

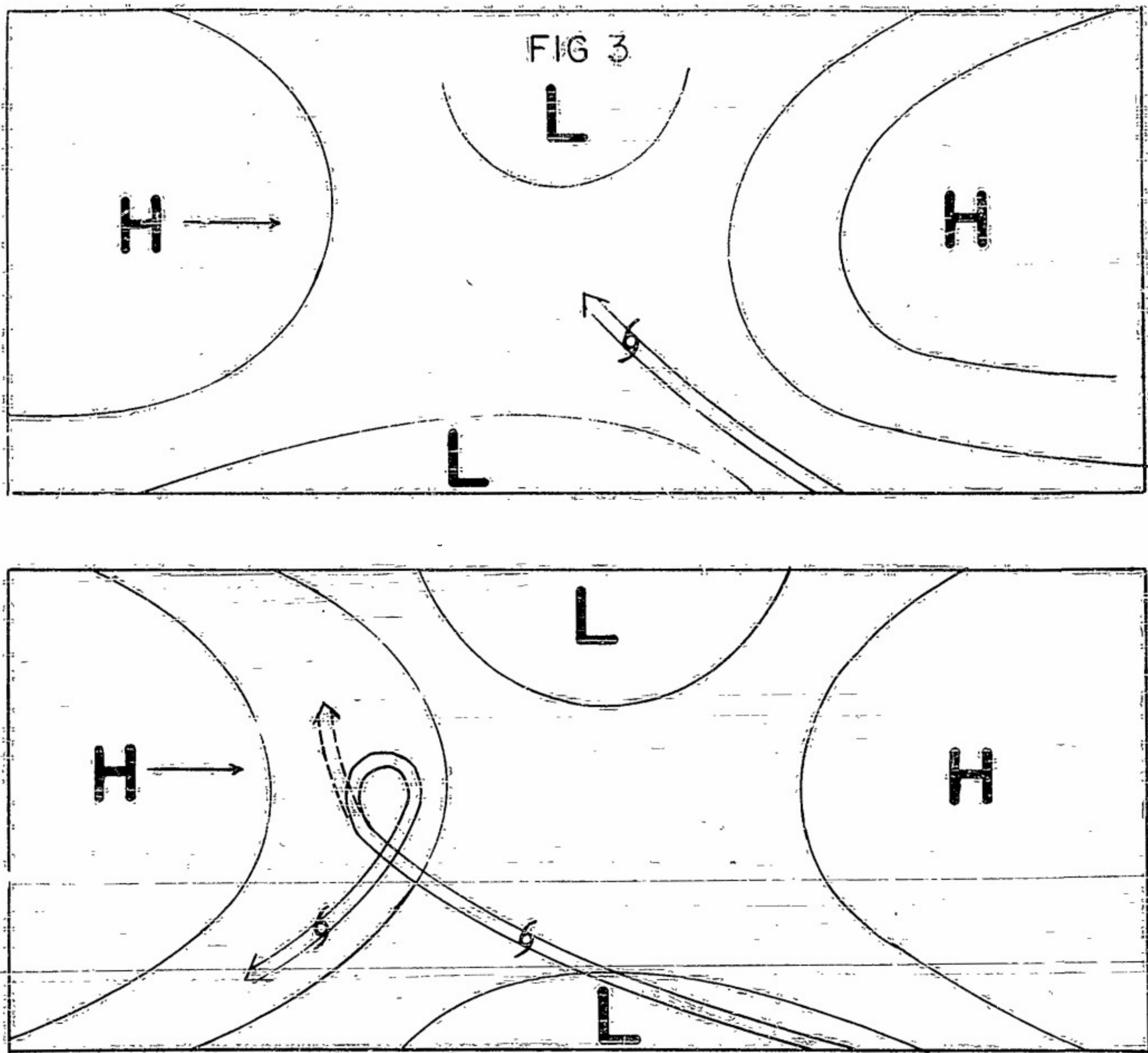
FIG 2



EXTRAPOLATED PATH

NOTE OSCILLATIONS DAMPENED OUT BY CHOOSING AVERAGE PATH. AVERAGE SPEED BETWEEN POINTS CAN BE OBTAINED AS IN FIG 1 SIMPLE LINEAR EXTRAPOLATION USING SEVERAL POINTS.

FIG 3



CASE V

UPPER AIR STEERING

SHOWING FAST MOVING TROUGH

⇐=== EXTRAPOLATED PATH

⟸ PATH INDICATED BY CLIMATOLOGY

ERROR ANALYSIS

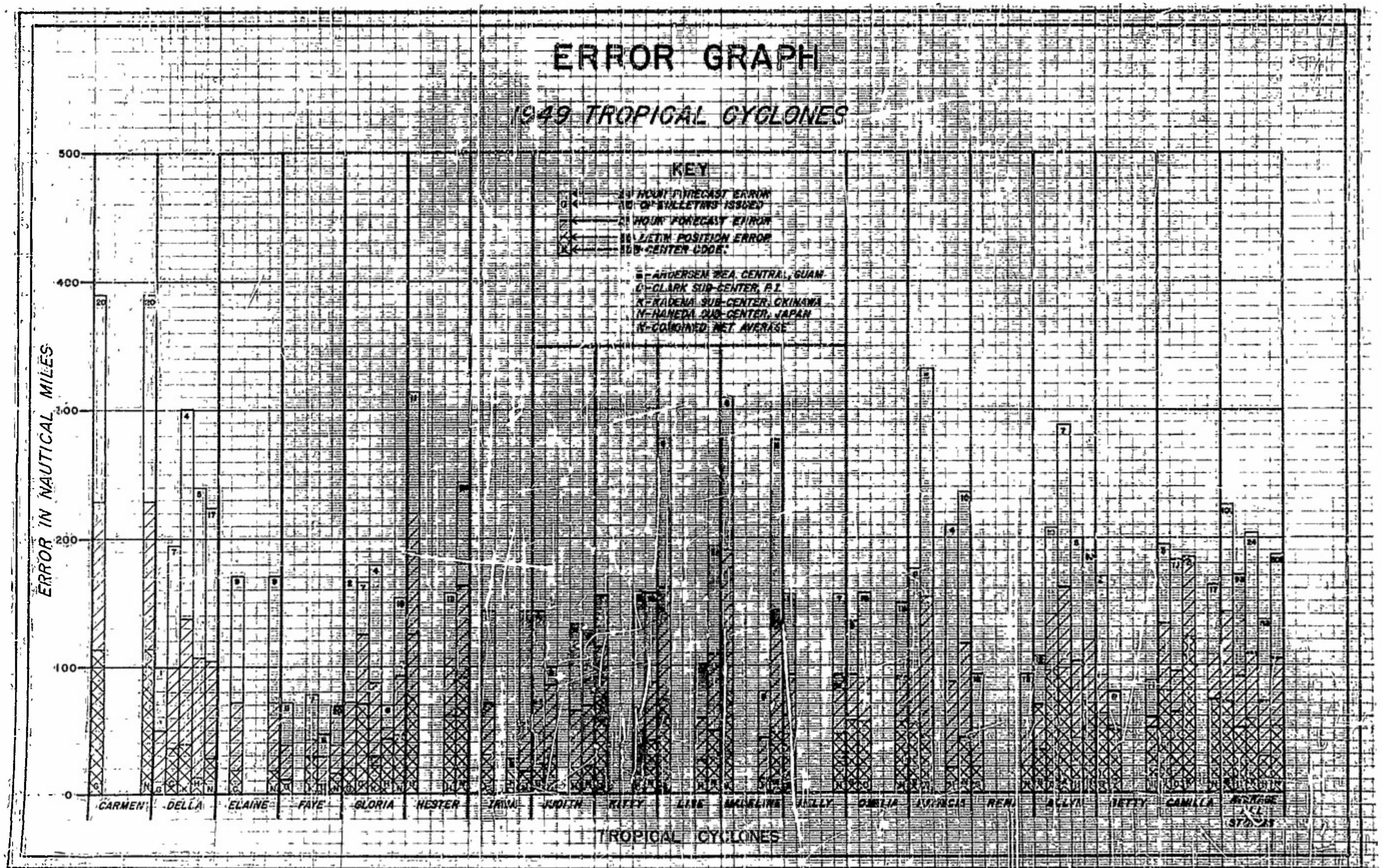
Of primary interest, to the agencies who depend upon the Typhoon Warning Network for warnings and forecasts pertaining to tropical cyclones is the analysis of forecast errors, both 12 hour and 24 hour, made by the Typhoon Warning Service. For this reason a series of charts showed errors and comparison of errors have been included in this report.

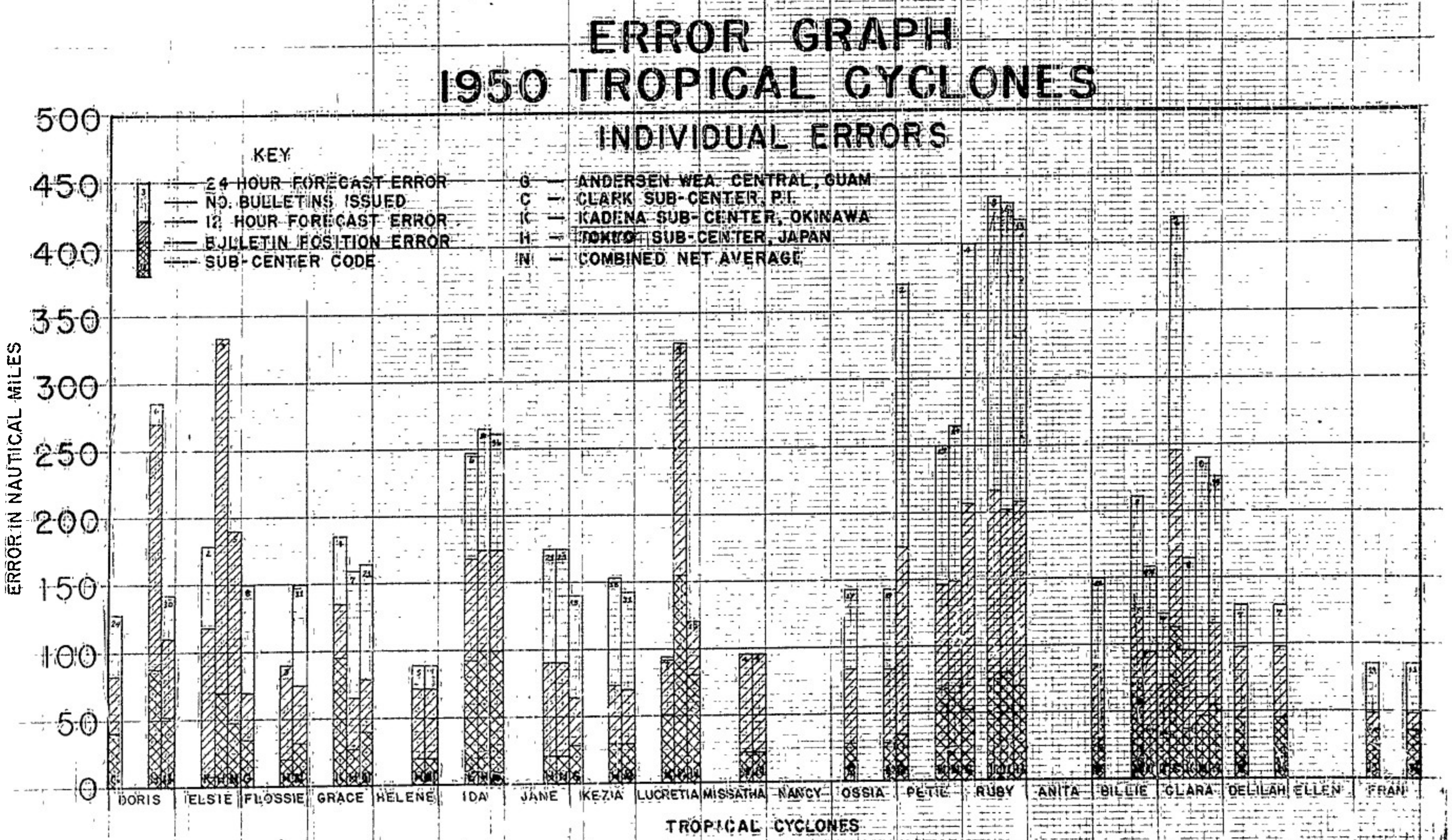
First on page 45 is shown the bulletin error, 12 hour forecast and 24 hour forecast errors for each storm. The average error for each sub-center and the combined Network is shown as indicated by the legend. The cumulative error for each sub-center and the combined Network is also shown on page 46.

During the past year many discussions have arisen upholding the merits of trapolation. To place more light on this subject, a set of charts shown on pages 47 thru 50, similar to those mentioned in the preceding paragraph, have been prepared showing the errors that would have been made by linear extrapolation (persistence) and modified linear extrapolation. A sincere effort was put forth to accomplish this project fairly and as it would have been done at the time the tropical cyclone was in existence, however, it is possible that the errors shown here are smaller than if the forecasts had been made at the time of the storm. All errors shown in this section, with the exception of 1949 errors, are plus or minus 21.2 nautical miles due to giving positions to the nearest half degree.

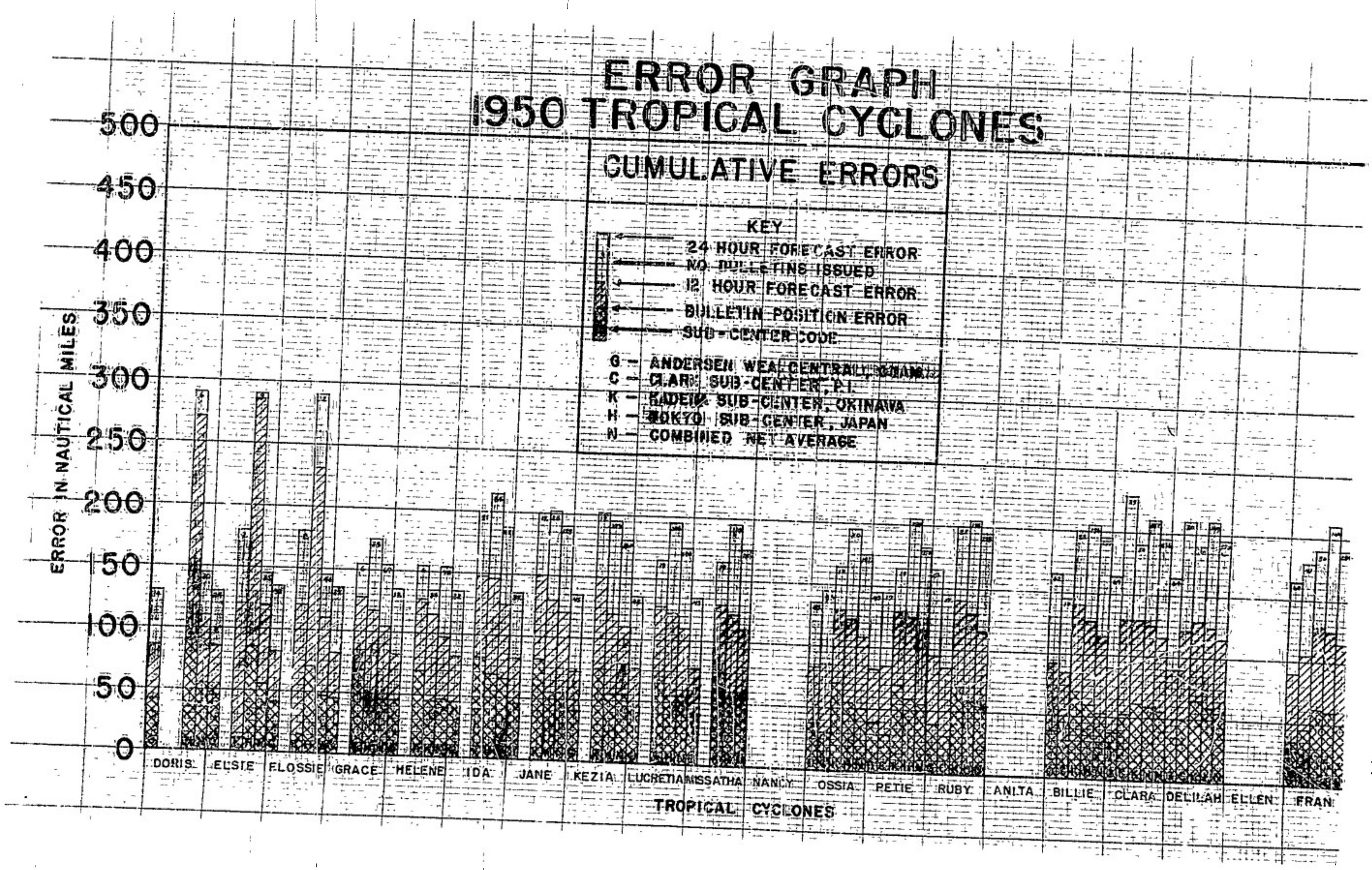
Another chart, page 51 - 52, was prepared showing the 12 and 24 hour forecast errors made during 1949 and 1950 and comparing these errors with both types of extrapolation for each sub-center and for the combined Network. It can be seen from this chart that the Andersen Center and the Tokyo Sub-Center exchanged places between 1949 and 1950, Andersen now having the smallest error in the Network. This change may be attributed to two main factors. The first and primary explanation of this change is that during 1950 many storms formed in pairs and in such cases there was an interaction bwteen the two storms causing considerable difficulty in forecasting the movement of the cyclones. The second factor is that of experience. In 1949 the experience level of the typhoon forecasters at Tokyo was well above that of the forecasters at Guam. This situation was reversed during the 1950 season. The results of the 1951 typhoon season should prove interesting.

Since the arithmetic mean or average is often misleading, graphs showing the distribution of errors made by each of the sub-centers, the Center and the Network as a whole for all storms during 1950 were computed and are presented on pages 54 thru 58 of this report.

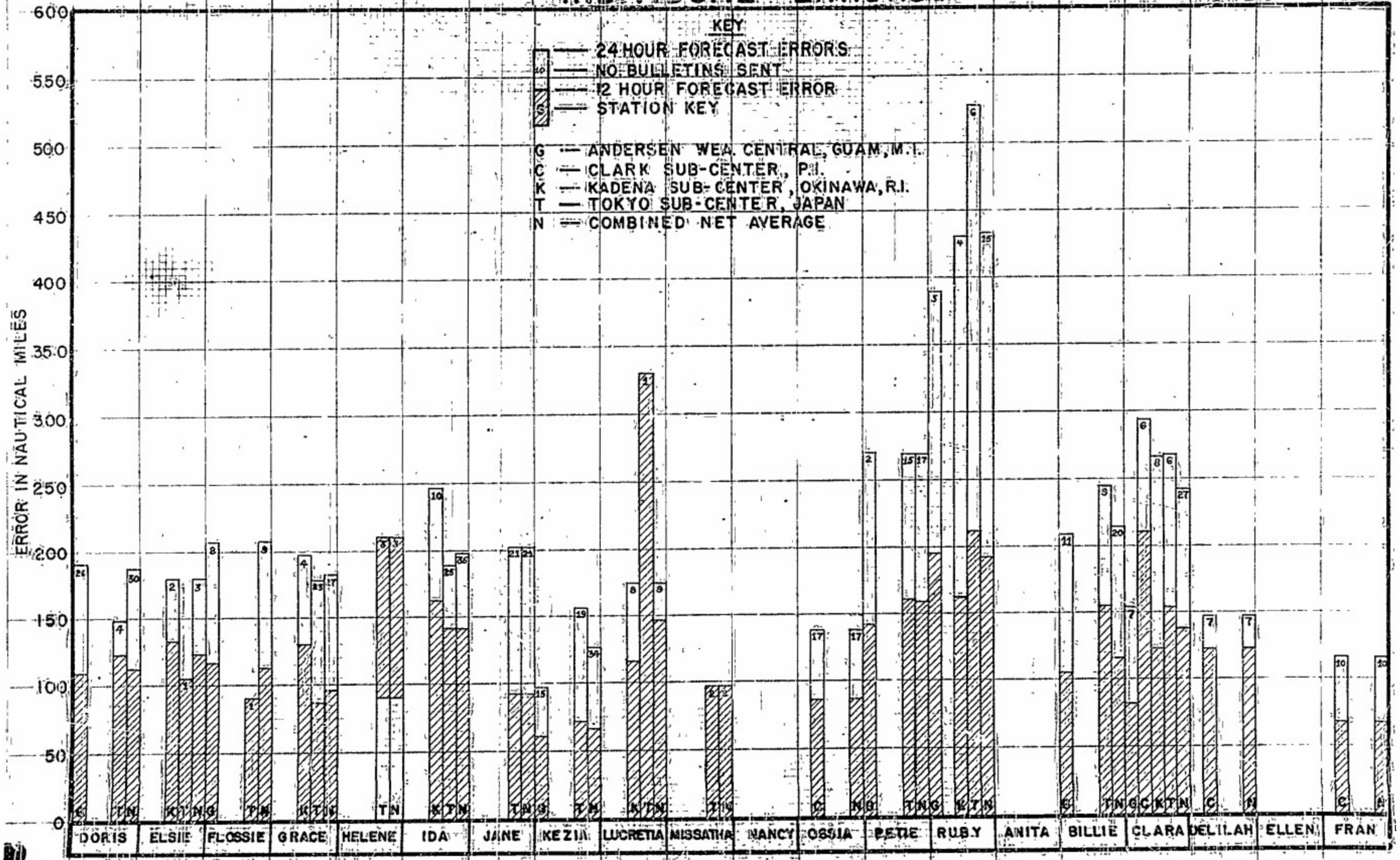

ERROR GRAPH
1949 TROPICAL CYCLONES
KEY
HOUR FORECAST ERROR
HOUR FORECAST ERROR
SUB-CENTER CODE:
C-CLARK SUB-CENTER, P.I.
K-KADENA SUB-CENTER, OKINAWA
N-COMBINED NET AVERAGE
ERROR IN NAUTICAL MILES
500
400
300
200
100
0
CARMEN
DELLA
ELAINE
FAYE
GLORIA
HESTER
JUDITH
KITTY
OPHELIA
BETTY
CAMILLA
TROPICAL CYCLONES



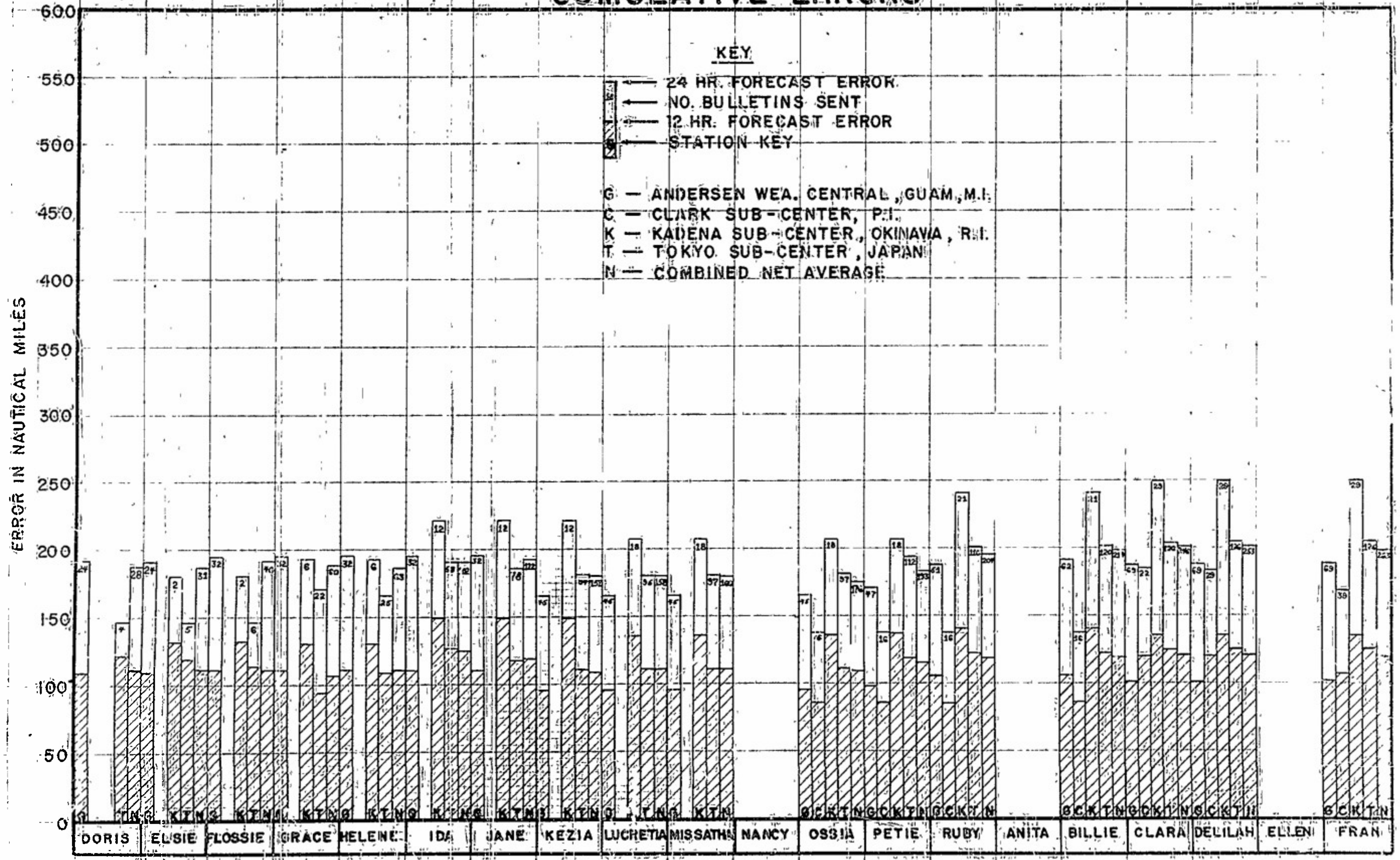
ERROR GRAPH
1950 TROPICAL CYCLONES
INDIVIDUAL ERRORS
KEY
24 HOUR FORECAST ERROR
NO. BULLETINS ISSUED
12 HOUR FORECAST ERROR
BULLETIN POSITION ERROR
SUB-CENTER CODE
G — ANDERSEN WEA. CENTRAL, GUAM
C — CLARK SUB-CENTER, P.I.
K — KADENA SUB-CENTER, OKINAWA
H — TOKYO SUB-CENTER, JAPAN
N — COMBINED NET AVERAGE
ERROR IN NAUTICAL MILES
500
450
400
350
300
250
200
150
100
50
0
DORIS
ELSIE
FLOSSIE
GRACE
HELENE
IDA
JANE
KEZIA
LUCRETIA
MISSATHA
NANCY
OSSIA
PETIE
RUBY
ANITA
BILLIE
CLARA
DELILAH
ELLEN
FRAN
TROPICAL CYCLONES

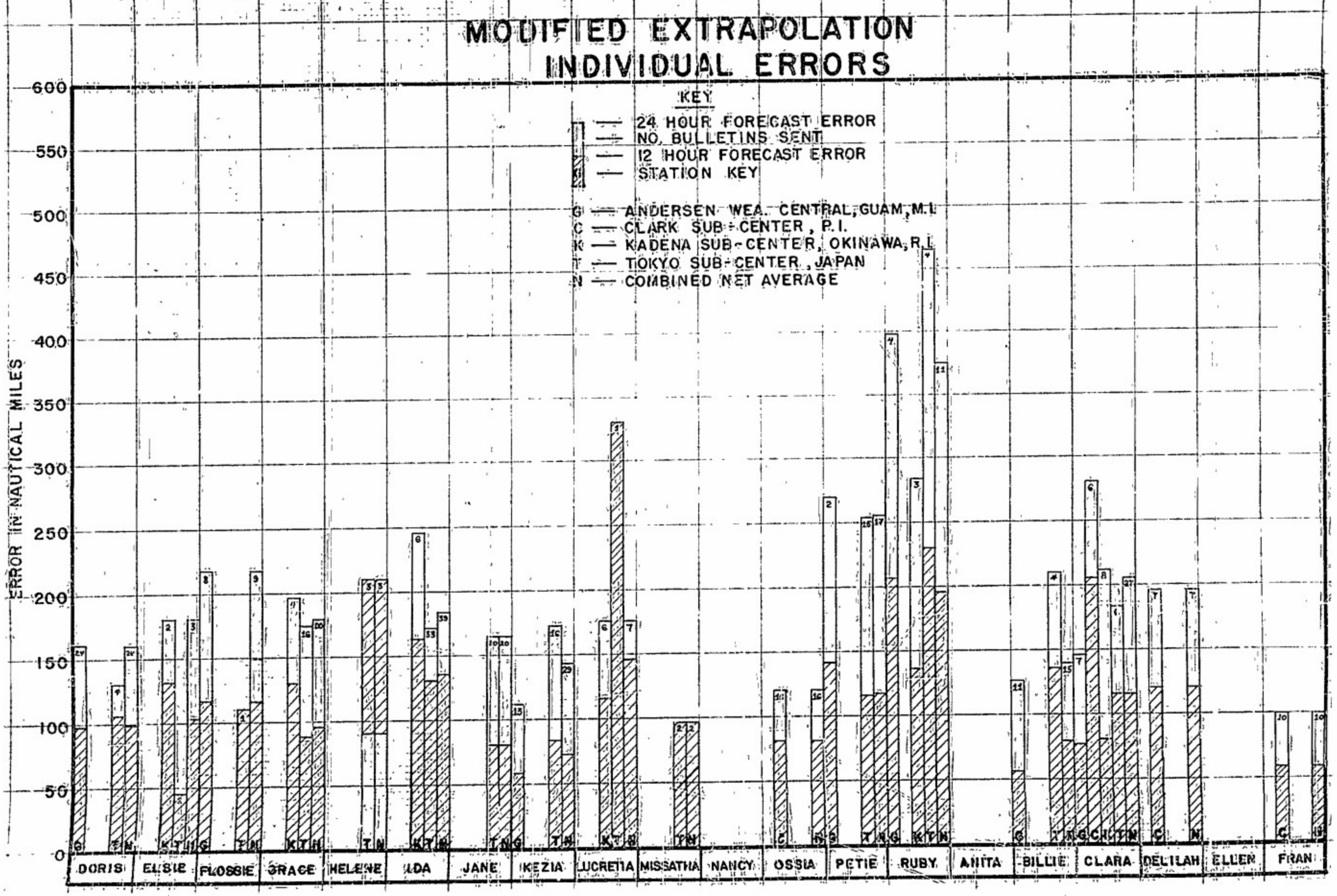

ERROR GRAPH
1950 TROPICAL CYCLONES
CUMULATIVE ERRORS
KEY
24 HOUR FORECAST ERROR
NO BULLETINS ISSUED
12 HOUR FORECAST ERROR
BULLETIN POSITION ERROR
SUB-CENTER CODE
G — ANDERSEN WEA CENTRAL
C — CLARK SUB-CENTER, P.I.
K — KADENA SUB-CENTER, OKINAWA
H — TOKYO SUB-CENTER, JAPAN
N — COMBINED NET AVERAGE
ERROR IN NAUTICAL MILES
500
450
400
350
300
250
200
150
100
50
0
DORIS
ELSIE
FLOSSIE
GRACE
HELENE
IDA
JANE
KEZIA
LUCRETIA
NISSATHA
NANCY
OSSIA
PETIE
RUBY
ANITA
BILLIE
CLARA
DELILAH
ELLEN
FRAN
TROPICAL CYCLONES

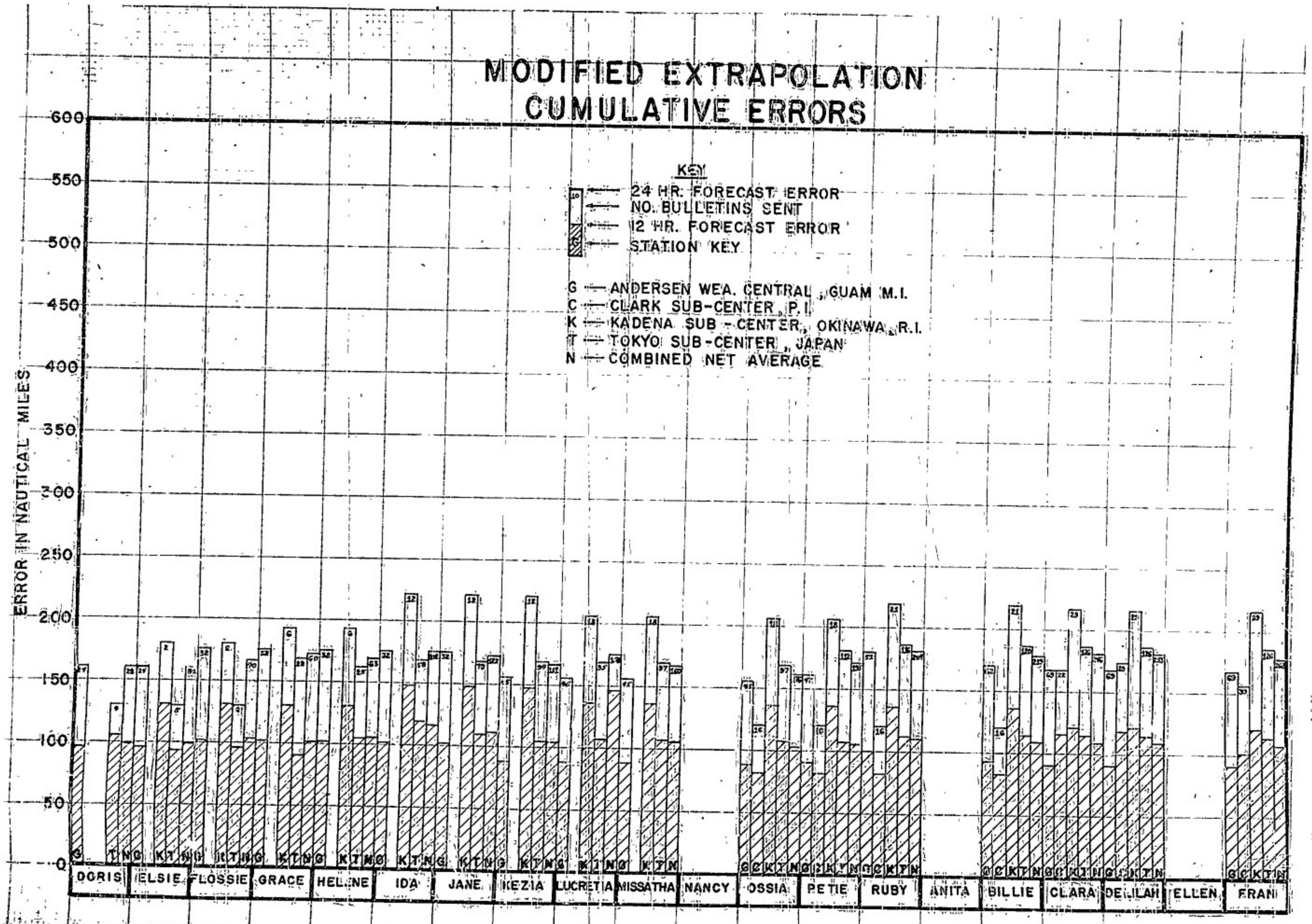
LINEAR EXTRAPOLATION INDIVIDUAL ERRORS



LINEAR EXTRAPOLATION CUMULATIVE ERRORS




MODIFIED EXTRAPOLATION
INDIVIDUAL ERRORS
KEY
24 HOUR FORECAST ERROR
NO. BULLETINS SENT
12 HOUR FORECAST ERROR
STATION KEY
G — ANDERSEN WEA. CENTRAL, GUAM, M.I.
C — CLARK SUB-CENTER, P.I.
K — KADENA SUB-CENTER, OKINAWA, R.I.
T — TOKYO SUB-CENTER, JAPAN
N — COMBINED NET AVERAGE
ERROR IN NAUTICAL MILES
0
50
100
150
200
250
300
350
400
450
500
550
600
DORIS
ELSIE
FLOSSIE
GRACE
HELENE
IDA
JANE
KEZIA
LUCRETIA
MISSATHA
NANCY
OSSIA
PETIE
RUBY
ANITA
BILLIE
CLARA
DELILAH
ELLEN
FRAN


MODIFIED EXTRAPOLATION
CUMULATIVE ERRORS
KEY
24 HR. FORECAST ERROR
NO. BULLETINS SENT
12 HR. FORECAST ERROR
STATION KEY
G — ANDERSEN WEA. CENTRAL, GUAM M.I.
C — CLARK SUB-CENTER, P.I.
K — KADENA SUB-CENTER, OKINAWA, R.I.
T — TOKYO SUB-CENTER, JAPAN
N — COMBINED NET AVERAGE
ERROR IN NAUTICAL MILES
0
50
100
150
200
250
300
350
400
450
500
550
600
DORIS
ELSIE
FLOSSIE
GRACE
HELENE
IDA
JANE
KEZIA
LUCRETIA
MISSATHA
NANCY
OSSIA
PETIE
RUBY
ANITA
BILLIE
CLARA
DELILAH
ELLEN
FRAN

COMPARISON
OF
FORECAST AND EXTRAPOLATION
12 HOUR

	12 Hour Fcst	12 Hour Lin Extrap	Diff	12 Hour Mod Extrap	Dif.
DORIS	117.5	111.3	- 6.2	98.9	- 18.6
ELSIE	191.7	123.3	- 68.4	103.3	- 88.4
FLOSSIE	77.0	113.3	+ 36.3	116.1	+ 39.9
GRACE	81.3	95.8	+ 14.5	96.8	+ 15.5
HELENE	73.3	210	+136.7	210	+136.7
IDA	175.3	135.3	- 30	135.2	- 40.1
JANE	92.3	92.3	0	80.6	- 11.7
KEZIA	70.7	66.8	- 3.9	72.2	+ 1.5
LUCRETIA	123.1	146.4	+ 23.3	146.4	+ 23.3
MISSATHA	97.5	97.5	0	97.5	0
NANCY	------				
OSSIA	84.7	85.6	+ 0.9	82.5	- 2.2
PETIE	151.2	158.5	+ 7.3	118.8	- 32.4
RUBY	209.1	192.7	- 16.4	195.9	- 13.2
ANITA	------				
~~BILLIE~~	~~95.0~~	~~116.0~~	~~+ 21.0~~	79.0	- 16.0
CLARA	115.4	138.9	+ 23.5	115.9	+ 0.5
DELILAH	98.3	122.9	+ 24.6	120.0	+ 21.7
ELLEN	------				
FRAN	48.5	68.0	+ 19.5	59.0	+ 10.5
AVE. ALL STORMS	113.3	119.2	+ 5.9	108.1	- 5.2

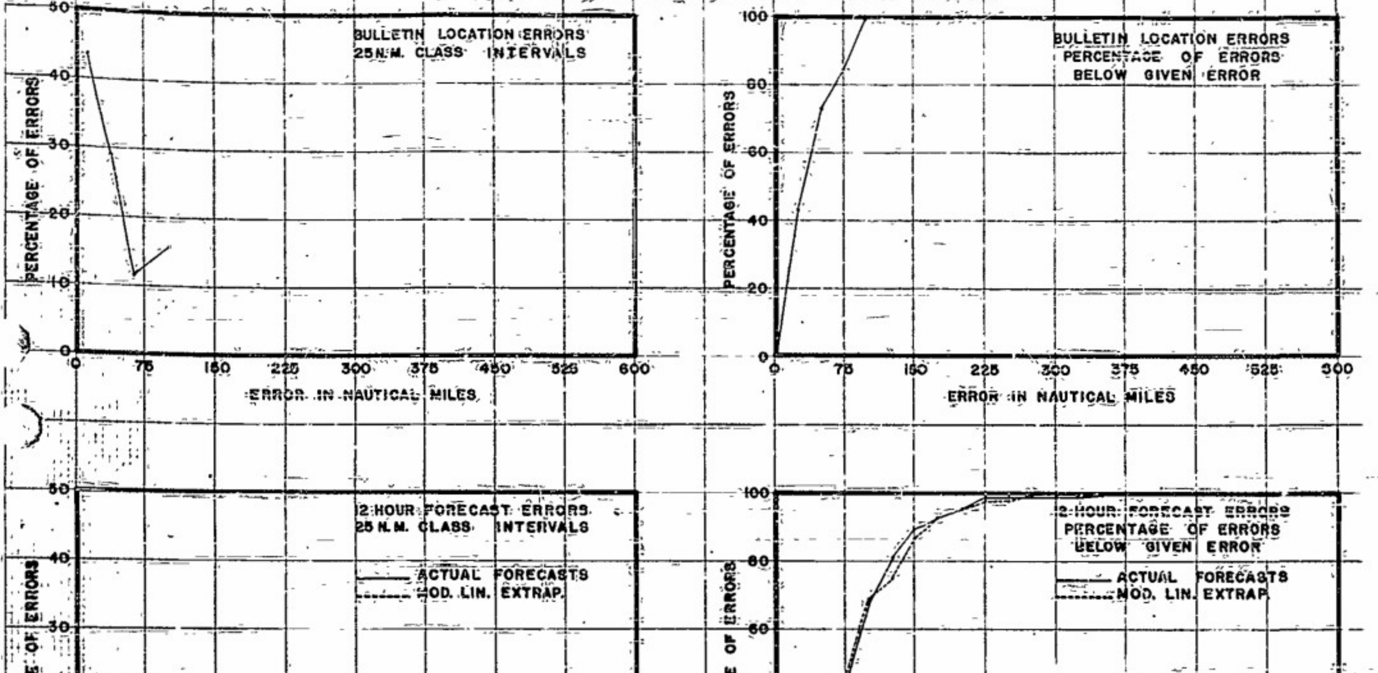
COMPARISON OF FORECAST AND EXTRAPOLATION 24 HOUR

	24 Hour Fcst	24 Hour Lin Extrap	Diff	24 Hour Mod Extrap	Diff
DORIS	145.8	187.3	+ 41.5	160.0	+ 14.2
ELSIE	180.0	180.0	0	180.0	0
FLOSSIE	150.9	207.9	+ 57.0	217.9	+ 67.0
GRACE	167.6	182.1	+ 14.5	178.7	+ 11.1
HELENE	90.0	90.0	0	90.0	0
IDA	263.7	197.9	- 65.8	183.7	- 80.0
JANE	176.9	202.7	+ 25.8	164.3	- 12.6
KEZIA	144.8	127.4	- 17.4	142.9	- 1.9
LUCRETIA	95.0	175.0	+ 80.0	175.0	+ 80.0
MISSATHA	-----	-----		-----	
NANCY	-----				
OSSIA	144.6	138.2	- 6.4	120.0	- 24.6
PETIE	265.7	269.7	+ 4.0	255.7	- 10.0
RUBY	419.4	433.3	+ 13.9	374.4	- 45.0
ANITA	-----				
BILLIE	159.6	197.6	+ 38.0	178.4	+ 18.8
CLARA	227.7	242.2	+ 14.5	205.4	- 22.3
DELILAH	130.0	146.7	+ 16.7	195.8	+ 65.8
ELLEN	-----				
FRAN	86.2	116.9	+ 30.7	100.0	+ 13.8
AVE. ALL STORMS	191.0	198.9	+ 7.9	178.9	- 12.1

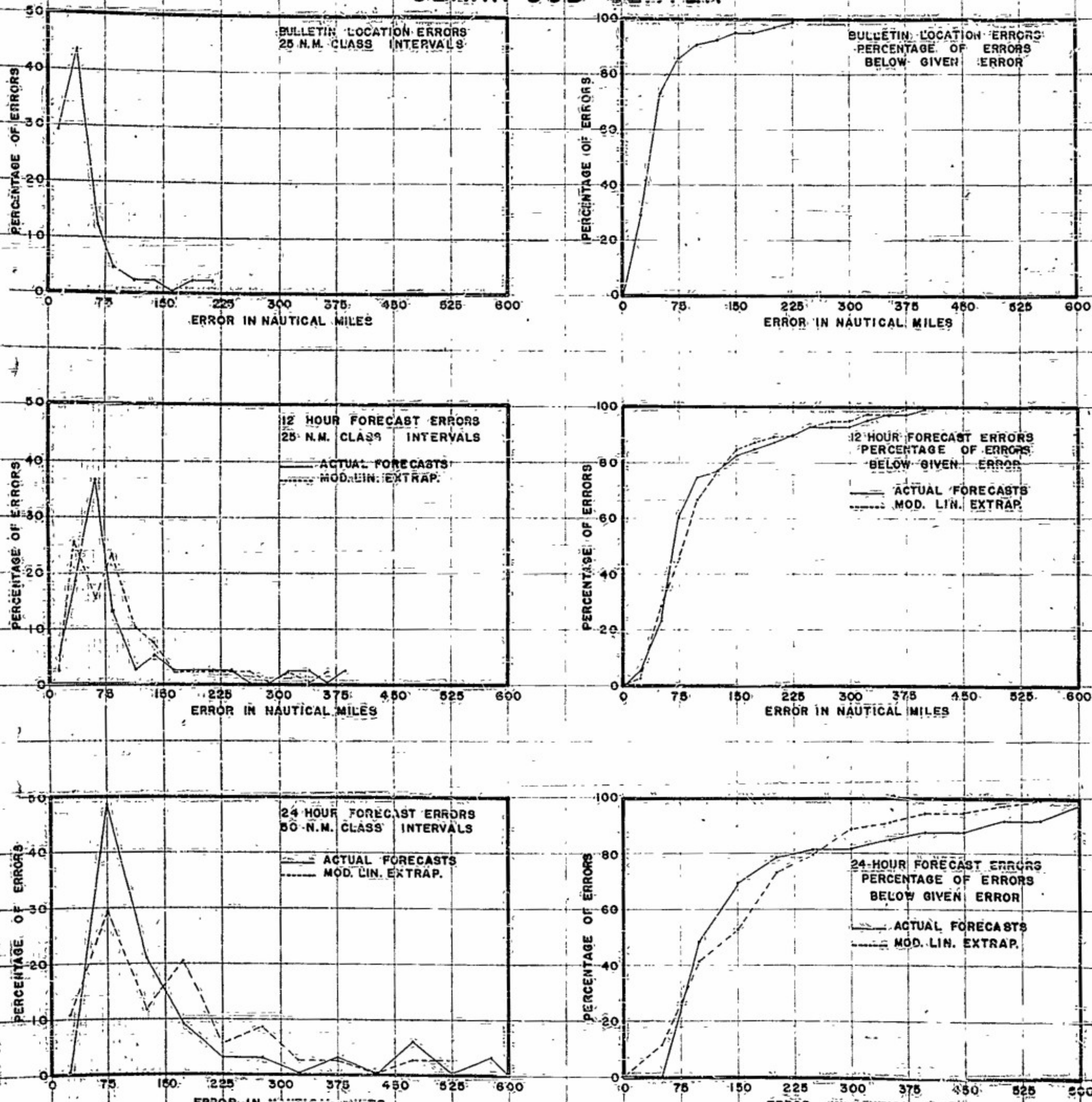
COMPARISON OF FORECAST AND EXTRAPOLTAION

	Ave. 12 Hr. Fcst Error 1949	Ave. 12 Hr. Fcst Error 1950	Ave. 12 Hr. Linear Extrap Error 1950	Ave. 12 Hr. Modified Extrap Error 1950	Ave. 24 Hr. Fcst Error 1949	Ave. 24 Hr. Fcst Error 1950	Ave. 24 Hr. Linear Extrap Error 1950	Ave. 24 Hr. Modified Extrap Error 1950
ANDERSEN	142	90	102	91	226	165	188	167
CLARK	92	105	107	102	171	180	168	157
KADENA	109	127	185	122	204	190	250	216
TOKYO	72	125	125	114	136	210	205	186
NET	105	115	120	108	187	190	198	178

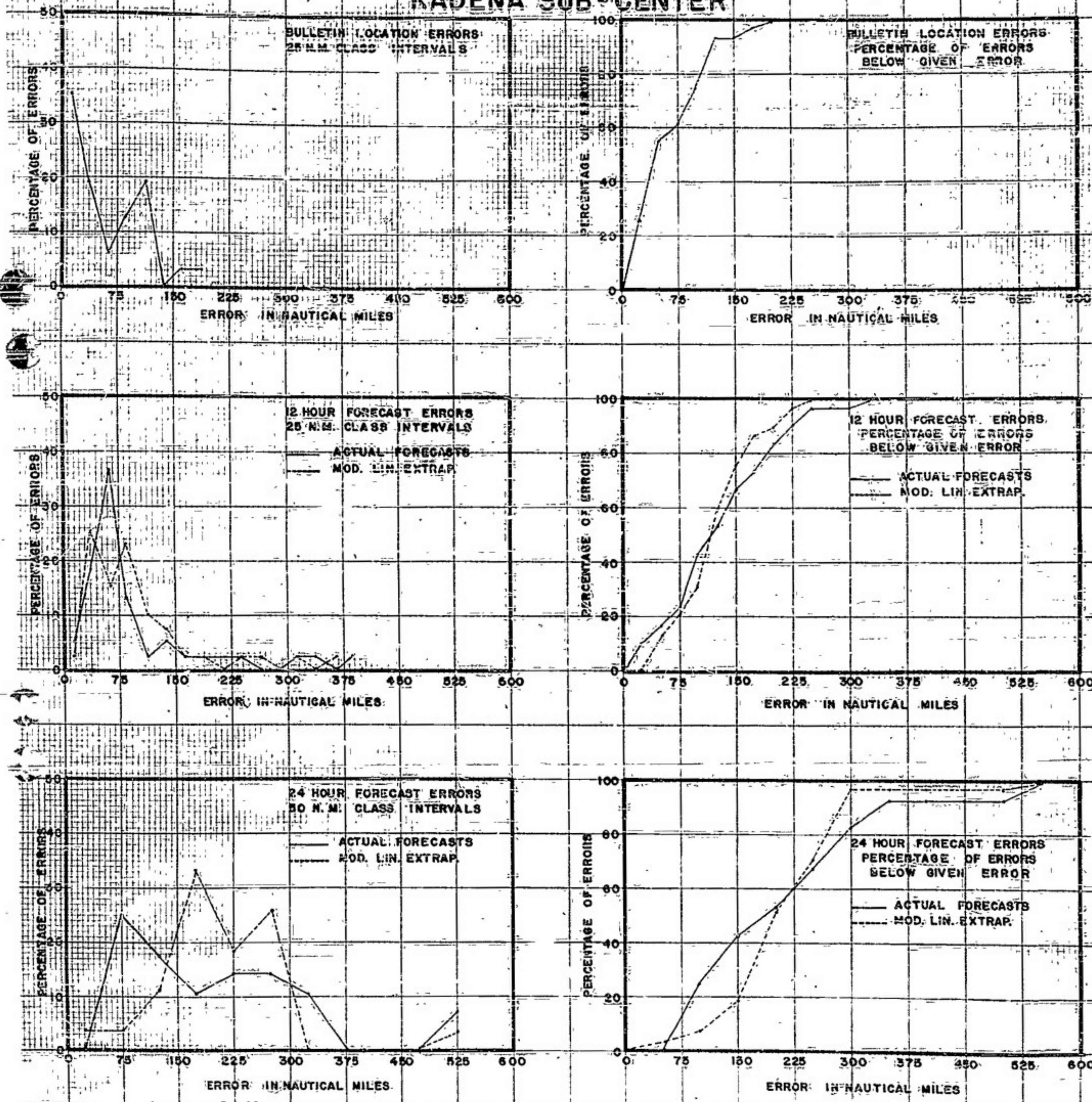
DISTRIBUTION GRAPHS
BULLETIN LOCATION AND FORECAST ERRORS
ANDERSEN WEATHER CENTRAL

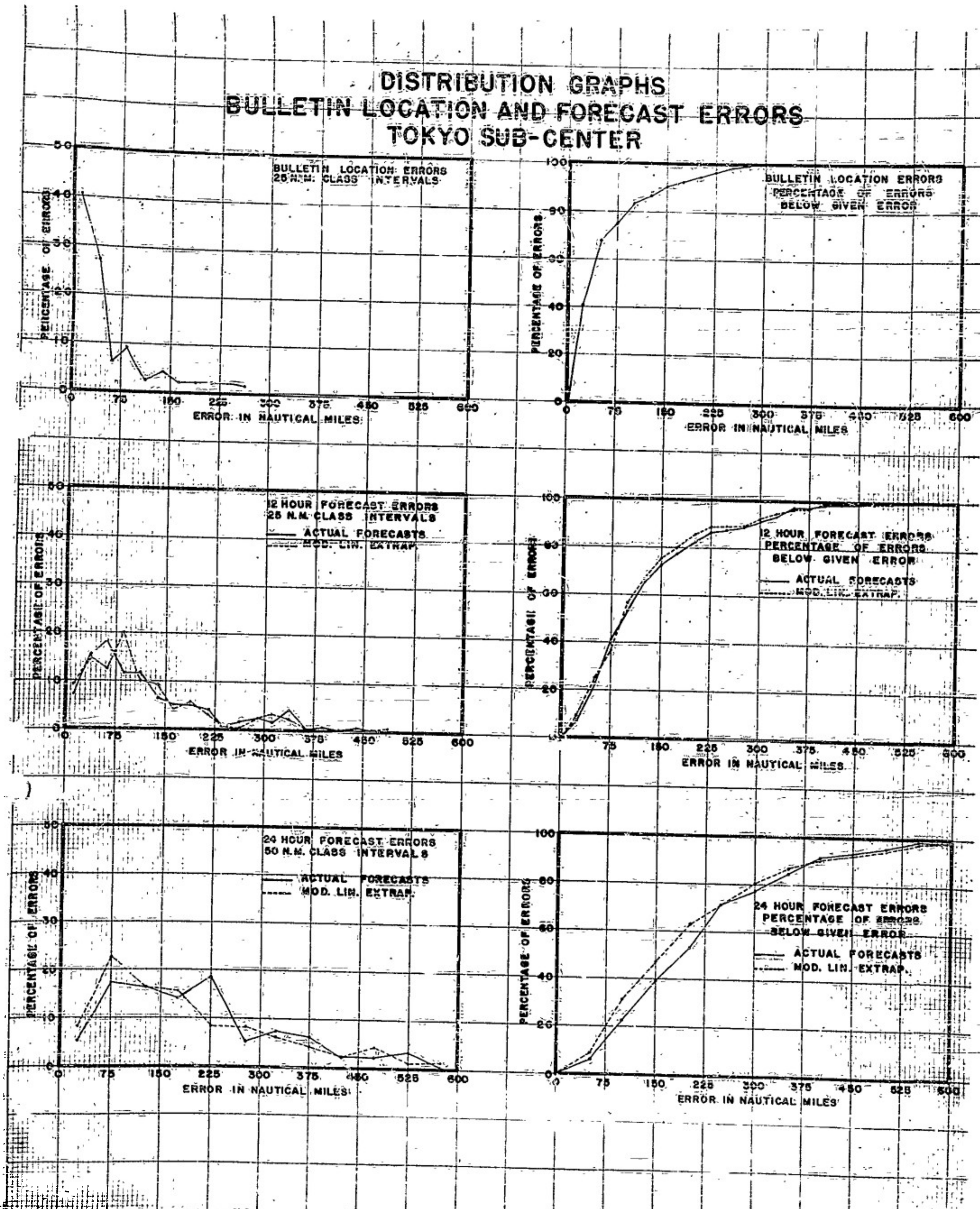


DISTRIBUTION GRAPHS
BULLETIN LOCATION AND FORECAST ERRORS
CLARK SUB-CENTER

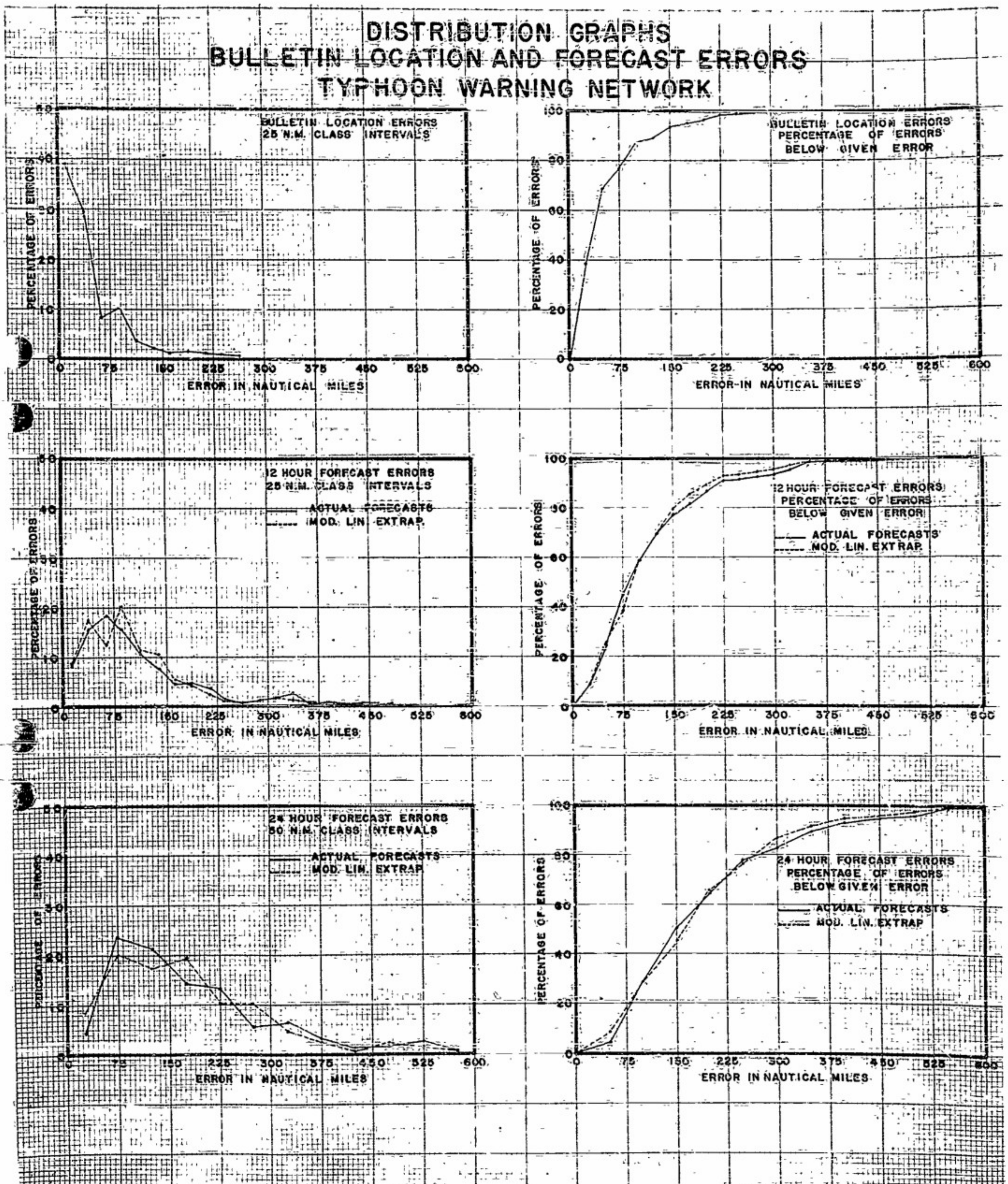


DISTRIBUTION GRAPHS
BULLETIN LOCATION AND FORECAST ERRORS
KADENA SUB-CENTER





DISTRIBUTION GRAPHS
BULLETIN LOCATION AND FORECAST ERRORS
TOKYO SUB-CENTER
BULLETIN LOCATION ERRORS 25 N.M. CLASS INTERVALS
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
BULLETIN LOCATION ERRORS PERCENTAGE OF ERRORS BELOW GIVEN ERROR
12 HOUR FORECAST ERRORS 25 N.M. CLASS INTERVALS
ACTUAL FORECASTS
MOD. LIN. EXTRAP.
12 HOUR FORECAST ERRORS PERCENTAGE OF ERRORS BELOW GIVEN ERROR
24 HOUR FORECAST ERRORS 50 N.M. CLASS INTERVALS
24 HOUR FORECAST ERRORS PERCENTAGE OF ERRORS BELOW GIVEN ERROR


DISTRIBUTION GRAPHS
BULLETIN LOCATION AND FORECAST ERRORS
TYPHOON WARNING NETWORK
BULLETIN LOCATION ERRORS
25 N.M. CLASS INTERVALS
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
BULLETIN LOCATION ERRORS
PERCENTAGE OF ERRORS
BELOW GIVEN ERROR
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
12 HOUR FORECAST ERRORS
25 N.M. CLASS INTERVALS
ACTUAL FORECASTS
MOD. LIN. EXTRAP.
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
12 HOUR FORECAST ERRORS
PERCENTAGE OF ERRORS
BELOW GIVEN ERROR
ACTUAL FORECASTS
MOD. LIN. EXTRAP.
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
24 HOUR FORECAST ERRORS
50 N.M. CLASS INTERVALS
ACTUAL FORECASTS
MOD. LIN. EXTRAP.
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES
24 HOUR FORECAST ERRORS
PERCENTAGE OF ERRORS
BELOW GIVEN ERROR
ACTUAL FORECASTS
MOD. LIN. EXTRAP.
PERCENTAGE OF ERRORS
ERROR IN NAUTICAL MILES

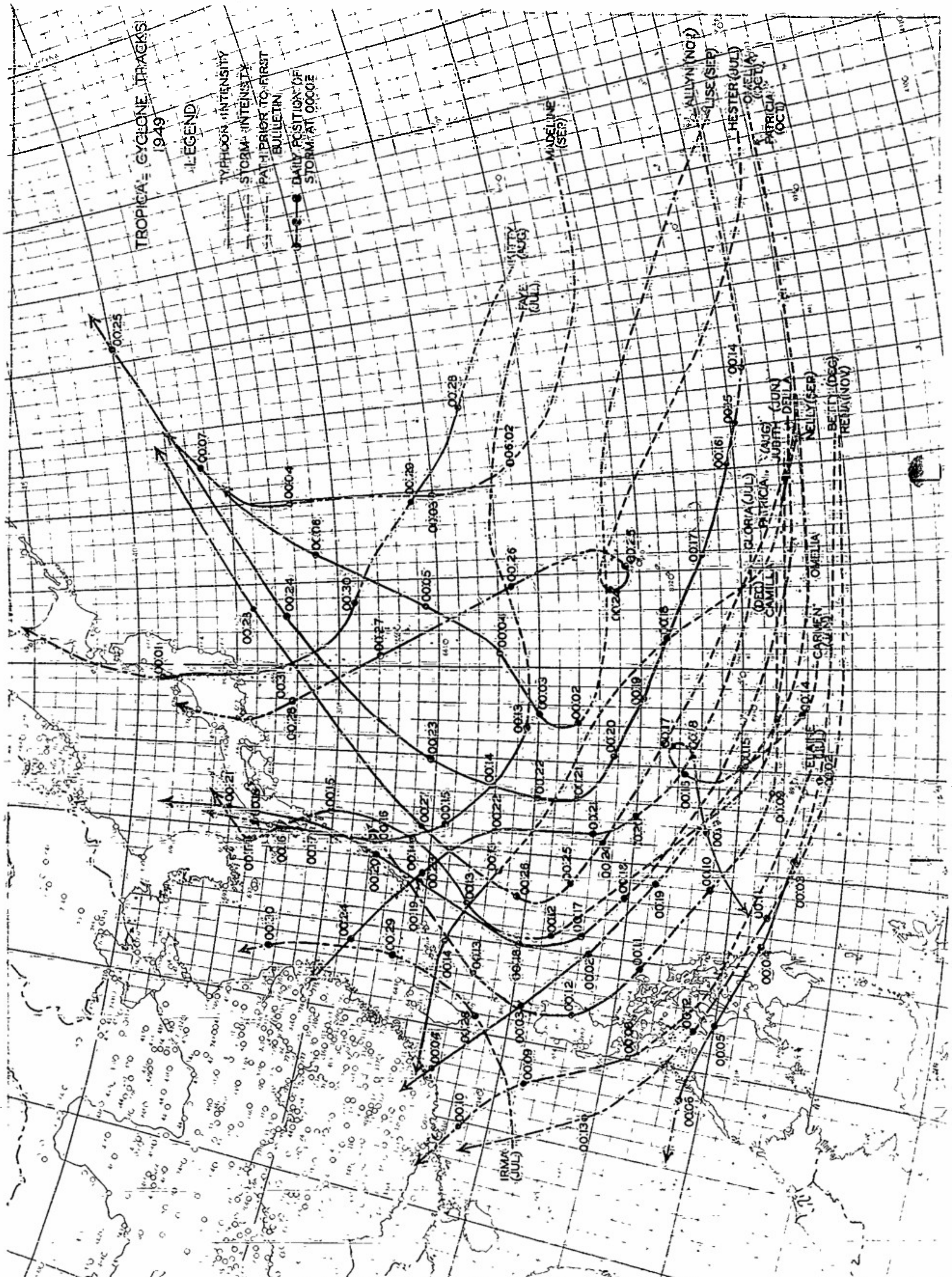
OBSERVED CHARACTERISTICS OF 1950 TROPICAL CYCLONES

It has been noted in other sections of this report that each tropical cyclone is an individual problem and that it is most difficult to determine the characteristics of a "normal" cyclone, however it is of interest to compare each season, or month as the case may be, with historical data. In some cases, trends can be determined which are of some value to the forecaster. One must keep the great variations in behavior in mind when attempting to use climatological data.

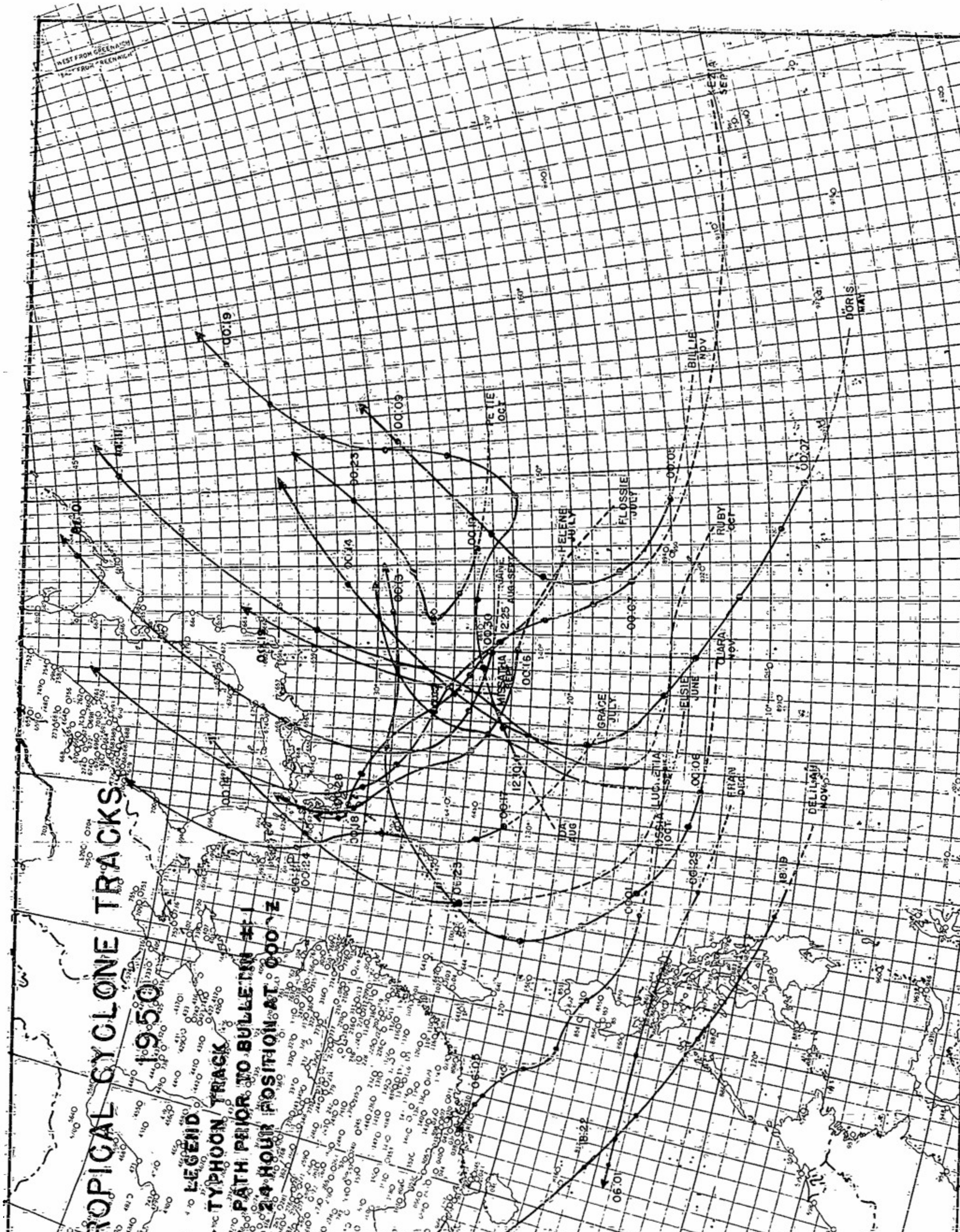
The graph on page 64 of this report shows the average number of tropical cyclones occurring in the North Pacific Ocean each month for the periods 1905 to 1936, 1945 to 1950, and for the 1950 season. It is noted that the number of cyclones for each month of the 1950 season agrees fairly well with the historical data as well as for the 1945-1950 period. That is, the month of the greatest and least activity are approximately the same. The differences which do exist are believed to be the result of using a smaller sample of data. All in all, the primary use of data of this nature is to establish a distribution curve, rather than to lead to conclusions concerning the activity for each month.

The seasonal distribution of cyclones during 1950 varied considerably from the mean (see chart on page 67). There were fewer cyclones for every month during 1950, with the exception of November. However, the 1950 seasonal distribution agreed quite closely with that of 1949, thus suggesting that since both are less than that of the longer period data, that there may be periods of years during which there are consistently greater than lesser numbers than the mean. In the number of cyclones 1950 was a relatively average year. There was one cyclone "Salome" which occurred east of 180° longitude and is not included in the data. The deviations of any year from the mean appears to depend upon whether or not cyclones occur in the "off" season of November to July, rather than fluctuations during the period of maximum occurrence.

The chart on page 66 gives a comparison of the speeds of movement of the 1950 cyclones as compared with historical data. With a few exceptions these were very similar. The 1950 average speeds of movement were not in agreement with the "average" track in that the average speed (for all storms) during recurvature was one mile per hour faster than the speed before recurvature. During the 1949 season the reverse was true, that is, the speed during recurvature was the smaller by one mile per hour. The 1950 cyclones deviated most from the average in their latitude of formation. A glance at the chart on page 67 will show that the index appeared to be shifted quite far northward for the entire season, and the time of northernmost formation shifted from August to June. May was the only month with the latitude of formation south of the average.


TROPICAL CYCLONE TRACKS
1949
LEGEND
TYPHOON INTENSITY
STORM INTENSITY
PATH PRIOR TO FIRST BULLETIN
DAILY POSITION OF STORM AT 0000Z
HESTER (JUL)
LISE (SEP)
MADELINE (SEP)
KITTY (AUG)
FAYE (JUL)
IRMA (JUL)
NELLY (SEP)
OMELIA
CARMEN
ELAINE

NAME OF TROPICAL CYCLONE	CARMEN	DELLA	ELAINE	FAYE	GLORIA	HESTER	IRMA	JUDITH	KITTY	LISE	MADELINE	NELLY	OPHELIA	PATRICIA	RENA	ALLYN	BETTY	CAMILLA
DATE OF INITIAL DETECTION (FIRST BULLETIN ISSUED)	15 JAN	17 JUN	01 JUL	13 JUL	20 JUL	23 JUL	28 JUL	12 AUG	28 AUG	2 SEP	2 SEP	13 SEP	1 OCT	23 OCT	11 NOV	14 NOV	3 DEC	9 DEC
NUMBER OF DAYS DURATION (BULLETINS ISSUED)	5	4	2		4		2	5	4	5	3	2	3	5	2	10	3	4
NUMBER OF DAYS DURATION AS A TYPHOON	3	4	0	4	4		0	3	3	5	1	1	2	2	0	9	1	2
REASON FOR FORMATION I. INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY SW MONSOON SURGE II INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY WESTERLY TROUGH III INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY A TROUGH IN THE EASTERLY LOW INDUCED BY WLY TROF IV INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY NORTH INDIAN WESTERLIES. V. FORMATION AND INTENSIFICATION OF LOW PRESSURE AREA AT BASE OF WLY TROF IN VICINITY OF ITC VI INTENSIFICATION OF SURFACE LOW BY LOW ALOFT SURFACING VII UNKNOWN VIII. MOVEMENT OF A VORTEX INTO A STAGNANT LOW PRESSURE AREA	V	I	VII	VI	II	II?	VIII	I?	II	VIII	VI	V	II	I?	I?	II	VII	VII
LOCATION OF DEVELOPMENT (FIRST BULLETIN)	10.9 N 134.4 E	15.3 N 128.0 E	13.8 N 120.8 E	20.7 N 136.8 E	15.1 N 132.7 E	16.3 N 143.9 E	20.8 N 120.7 E	18.5 N 125.8 E	23.5 N 154.5 E	18.0 N 137.0 E	20.5 N 151.5 E	21.8 N 127.7 E	13.1 N 131.2 E	17.0 N 131.5 E	08.3 N 127.8 E	09.3 N 153.9 E	07.4 N 131.5 E	09.0 N 134.0 E
MAXIMUM WINDS (KNOTS)	85	110	45	90	110/175	110	50	60	65	65	70	90	70	110	45/65	120	70	65
MAXIMUM WINDS BEFORE FIRST CURVATURE (KNOTS)	65	75	45	85	90	30	50	60	65	65	55	90	70	58	50	120	70	65
MAXIMUM WINDS DURING FIRST CURVATURE (KNOTS)	65	85	UNK	85	100	85	50	65	90	70	60	90	--	85	50	100	--	60
MAXIMUM WINDS AFTER FIRST CURVATURE (BEFORE SECOND CURVATURE, IF ANY) (KNOTS)	60	110	UNK	90	110	65	50	65	75	120	45	95	--	--	50	75		55
MAXIMUM WINDS DURING SECOND CURVATURE (KNOTS)	60	75	--	--	110	50	--	65	--	--	--	--	--	--	--	--	--	--
MAXIMUM WINDS AFTER SECOND CURVATURE (KNOTS)	85	70	--	--	110	120	--	45	--	--	--	--	--	--	--	--	--	--
POINT OF FIRST CURVATURE	11.0 N 154.3 E	17.5 N 125.5 E	10.0 N 117.7 E	24.0 N 131.5 E	16.0 N 132.0 E	16.9 N 145.0 E	25.0 N 123.0 E	20.0 N 125.0 E	31.1 N 141.1 E	18.5 N 136.5 E	22.3 N 150.2 E	23.5 N 125.5 E	--	19.5 N 127.5 E	13.9 N 117.5 E	18.2 N 131.8 E	--	18.0 N 121.5 E
POINT OF SECOND CURVATURE, IF ANY	13.2 N 136.1 E	30.0 N 130.0 E	--	--	22.0 N 131.0 E	35.0 N 136.5 E	--	30.0 N 131.0 E	--	--	--	--	--	--	--	--	--	--
DIRECTION OF FIRST CURVATURE EXAMPLE: W-NNW	NW-NE	NW-NNE	NNW-WNW	NW-N	NW-N	SE-E-N-SW	NE-N	NW-NE	NW-N	NW-NNE	NW-N	NW-W	--	NW-N-NE	NW-N	NW-N-NE	--	NW-NE
DIRECTION OF SECOND CURVATURE	SE-WSW	NNE-N	--	--	N-NW	NW-N-NE	--	NE-NNW	--	--	--	--	--	--	--	--	--	--
REASON FOR CURVATURE A: FIRST CURVATURE B: SECOND CURVATURE EXAMPLE. A I B IV I. RECURVED IN ADVANCE OF WLY TROF II. RECURVED INTO WESTERLY TROUGH III. RECURVED IN TROUGH CAUSED BY ANOTHER STORM IV. CURVED BECAUSE OF MISSING TROUGH V. CURVED BECAUSE OF BLOCKING HIGH. VI. CURVED BECAUSE OF CHINA LOW CIRCULATION VII. RECURVED BECAUSE OF A SPLIT HIGH CELL	A II B IV	A II B IV	IV	II	A I B V	V	VI	A II B VI	I	VII	VIII	V	--	III	I	I	--	I
QUADRANT OF STRONGEST WINDS (WHEN CONSTANT DURING EXISTENCE OF CYCLONE)	--	--	UNK	--	--	UNK	UNK	--	UNK	--	SW	SE	SE	--	SW	--	S	--
QUADRANT OF STRONGEST WINDS BEFORE FIRST CURVATURE	S	NE	UNK	E	N	UNK	--	NE	S	W-SW	SW	SE	SE	SW	SW	S	S	N
QUADRANT OF STRONGEST WINDS DURING CURVATURE	SE	UNK	UNK	NE	NW	SW	--	UNK	UNK	W-S	UNK	UNK	--	SE	--	SW	--	UNK
QUADRANT OF STRONGEST WINDS AFTER FIRST CURVATURE	SE	E	UNK	NE	NE	UNK	--	UNK	UNK	W	UNK	UNK	--	S	--	W	--	UNK
QUADRANT OF STRONGEST WINDS DURING SECOND CURVATURE	UNK	UNK	--	--	N	UNK	--	NE SE	--	--	--	--	--	--	--	--	--	--
QUADRANT OF STRONGEST WINDS AFTER SECOND CURVATURE	NW	UNK	--	--	N	UNK	--	UNK	--	--	--	--	--	--	--	--	--	--
SPEED OF MOVEMENT (OVERALL AVERAGE) (KNOTS)	7	14	11	8	10	12	15	10	15	7	15	12	12	15	15	13	11	13
SPEED BEFORE FIRST CURVATURE	10	9	13	9	7	UNK	13	10	10	10	15	10	12	8	15	8	11	11
SPEED DURING FIRST CURVATURE	7	8	10	19	8	7	14	14	13	5	13	10	--	8	15	7	--	10
SPEED AFTER FIRST CURVATURE	2	19	7	10	12	15	16	10	19	7	15	30	--	AVG. 30	15	26	--	24
SPEED DURING SECOND CURVATURE	3	34	--	--	9	15	--	9	--	--	--	--	--	--	--	--	--	--
SPEED AFTER SECOND CURVATURE	10	12	--	--	UNK	UNK	--	7	--	--	--	--	--	--	--	--	--	--
MINIMUM PRESSURE REPORTED	RECON 1001	KADENA 956.3	PRATAS 1002	NAZE 968.7	NAHA 946.8	SHIP 949	FORMOSA 992	RECON 987	RECON 980	SHIP 967.8	RECON 984	FORMOSA 984	RECON 991	RECON 840	SFC CHART 964	RECON 932	RECON 929	SFC CHART 992
MAXIMUM RADIUS OF FORCE SIX WINDS OR GREATER IN NAUTICAL MILES.	300	350	50	250	400	200	100	210	200	250	125	110	150	300	150	200	75	200
POINT OF DISSIPATION (LAST BULLETIN)	9.5 N 128.2 E	37.4 N 131.3 E	21.3 N 114.9 E	33.8 N 130.3 E	29.5 N 122.0 E	35.0 N 137.5 E	32.0 N 123.0 E	33.8 N 129.7 E	44.2 N 141.0 E	34.9 N 150.5 E	35.4 N 150.5 E	24.3 N 117.1 E	21.3 N 111.5 E	34.4 N 143.5 E	18.7 N 114.3 E	32.0 N 142.2 E	10.8 N 120.7 E	22.0 N 123.0 E
UNITED STATES INSTALLATIONS DAMAGED	NONE	OKINAWA KYUSHU	NONE	NONE	OKINAWA	NONE	NONE	KYUSHU	HONSHU	NONE	NONE	NONE	NONE	NONE	NONE	GUAM	NONE	NONE
MINIMUM 700 MB PRESSURE	9600	UNK	UNK	8250	9620	10050	UNK	9130	UNK	8900	UNK	UNK	9730	8600	UNK	RECON 6900	UNK	9400


TROPICAL CYCLONE TRACKS 1950
LEGEND
TYPHOON TRACK
PATH PRIOR TO BULLETIN #1
24-HOUR POSITION AT 0000 Z
WEST FROM GREENWICH
EAST FROM GREENWICH
DORIS MAY
BILLIE NOV
EZRA SEP
PETIE OCT
HELENE JULY
FLOSSIE JULY
RUBY OCT
JANE AUG-SEPT
GRACE JULY
ELSIE JUNE
CLARA NOV
FRAN DEC
DELILAH NOV
OSSIA OCT
IDA AUG

NAME OF TROPICAL CYCLONE

	DORIS	ELSIE	FLOSSIE	GRACE	HELENE	IDA	JANE	KEZIA	LUCRETIA	MISSATHA
DATE OF INITIAL DETECTION (FIRST BULLETIN ISSUED)	MAY 070000Z	JUNE 230600Z	JULY 151200Z	JULY 161200Z	JULY 270000Z	AUG. 101200Z	AUG-SEPT 300000Z	SEPT. 070000Z	SEPT. 170600Z	SEPT. 180600Z
NUMBER OF DAYS DURATION (BULLETINS ISSUED)	8	1	3	6	1	9	5½	9	3	1
NUMBER OF DAYS DURATION AS A TYPHOON	7 DAYS	18 HRS.	6 HRS.	2 DAYS	0	5 DAYS	2 DAYS	6 DAYS	6 HRS.	12 HRS.
REASON FOR FORMATION	II	VII	I & II	I & II	V	V	V	IV	I	I
LOCATION OF DEVELOPMENT (FIRST BULLETIN)	08.0 N 147.0 E	24.5 N 125.0 E	21.5 N 143.0 E	23.0 N 128.5 E	28.5 N 132.5 E	22.0 N 134.0 E	24.0 N 140.0 E	18.0 N 144.0 E	21.5 N 134.0 E	28.0 N 138.0 E
MAXIMUM WINDS (KNOTS)	130 K	75 K	65 K	70 K	50 K	80 K	100 K	100 K	75 K	65 K
MAXIMUM WINDS BEFORE FIRST CURVATURE (KNOTS)	135 K	-	65 K	50 K	38 K	60 K	80 K	100 K	50 K	65 K
MAXIMUM WINDS DURING FIRST CURVATURE (KNOTS)	100 K	-	45 K	70 K	30 K	60 K	100 K	90 K	75 K	65 K
MAXIMUM WINDS AFTER FIRST CURVATURE (BEFORE SECOND CURVATURE - IF ANY) (KNOTS)	100 K	-	30 K	70 K	50 K	80 K	90 K	90 K	75 K	65 K
MAXIMUM WINDS DURING SECOND CURVATURE (KNOTS)	-	-	45 K	40 K	40 K	75 K	-	90 K	75 K	-
MAXIMUM WINDS AFTER SECOND CURVATURE (KNOTS)	-	-	45 K	35 K	30 K	75 K	-	60 K	40 K	-
POINT OF FIRST CURVATURE	19.5 N 135.0 E	26.0 N 125.5 E	24.0 N 135.5 E	24.0 N 129.0 E	30.0 N 134.0 E	25.0 N 143.0 E	27.0 N 134.0 E	22.5 N 141.5 E	25.0 N 135.5 E	-
POINT OF SECOND CURVATURE, IF ANY	-	-	31.0 N 130.0 E	34.0 N 127.0 E	31.0 N 133.0 E	22.5 N 149.0 E	-	29.0 N 132.5 E	26.5 N 135.2 E	-
DIRECTION OF FIRST CURVATURE	WNW-NNE	NNW-NW	WNW-NNE	NNE-N	N - W	ENE-ESE	WNW-NNE	ENE-WNW	NE - N	-
DIRECTION OF SECOND CURVATURE	-	-	NW-NNE	NNE-N	W - N	ESE-NNE	-	WNW-NNE	NNE-ENE	-
REASON FOR CURVATURE	A I	A I	A IX B VIII	A IX B VIII	A IX B X	A IX B III	A I	A I B VIII	A IV B II	A I
QUADRANT OF STRONGEST WINDS (WHEN CONSTANT DURING EXISTENCE OF CYCLONE)	UNK	UNK	UNK	UNK	UNK	-	SE - E	-	UNK	NE
QUADRANT OF STRONGEST WINDS BEFORE FIRST CURVATURE	UNK	-	UNK	UNK	UNK	SW	-	SE	SE	-
QUADRANT OF STRONGEST WINDS DURING CURVATURE	UNK	UNK	UNK	UNK	UNK	SE	-	NE	UNK	-
QUADRANT OF STRONGEST WINDS AFTER FIRST CURVATURE	UNK	UNK	UNK	UNK	UNK	SW	-	NE	UNK	-
QUADRANT OF STRONGEST WINDS DURING SECOND CURVATURE	-	-	UNK	UNK	UNK	SW	-	S	UNK	-
QUADRANT OF STRONGEST WINDS AFTER SECOND CURVATURE	-	-	UNK	UNK	UNK	NW	-	UNK	UNK	-
SPEED OF MOVEMENT (OVERALL AVERAGE) (KNOTS)	12 K	31 K	25 K	7.8 K	8.3 K	9 K	13.9 K	9.25 K	11.8 K	22.8 K
SPEED BEFORE FIRST CURVATURE	13 K	-	13 K	5.5 K	16 K	8.5 K	9 K	10 K	8.3 K	-
SPEED DURING FIRST CURVATURE	16 K	23 K	13 K	5.5 K	17 K	9 K	9 K	8.75 K	11.7 K	10 K
SPEED AFTER FIRST CURVATURE	19 K	34 K	20 K	12 K	17 K	14 K	22.8 K	20.9 K	11.0 K	30 K
SPEED DURING SECOND CURVATURE	-	-	20 K	4 K	3.3 K	14 K	-	9 K	11.7 K	-
SPEED AFTER SECOND CURVATURE	-	-	UNK	9 K	3.3 K	10 K	-	21.3 K	30.8 K	-
MINIMUM PRESSURE REPORTED	UNK	UNK	UNK	984	UNK	960	946.2	945	995	999
MAXIMUM RADIUS OF 50 KNOT WINDS OR GREATER IN NAUTICAL MILES	200	180	75	78	120	120	140	200	300	70
POINT OF DISSIPATION (LAST BULLETIN)	32.5 N 145.5 E	35.5 N 131.0 E	30.5 N 129.5 E	36.0 N 127.5 E	31.5 N 129.5 E	37.5 N 159.0 E	43.5 N 142.5 E	41.5 N 136.0 E	27.5 N 139.0 E	36.0 N 141.5 E
UNITED STATES INSTALLATIONS DAMAGED	NONE	NONE	UNK	UNK	UNK	UNK	UNK	UNK	NONE	NONE
MINIMUM 700 MB HEIGHT	UNK	UNK	UNK	UNK	UNK	9290	8689	8670	-	-

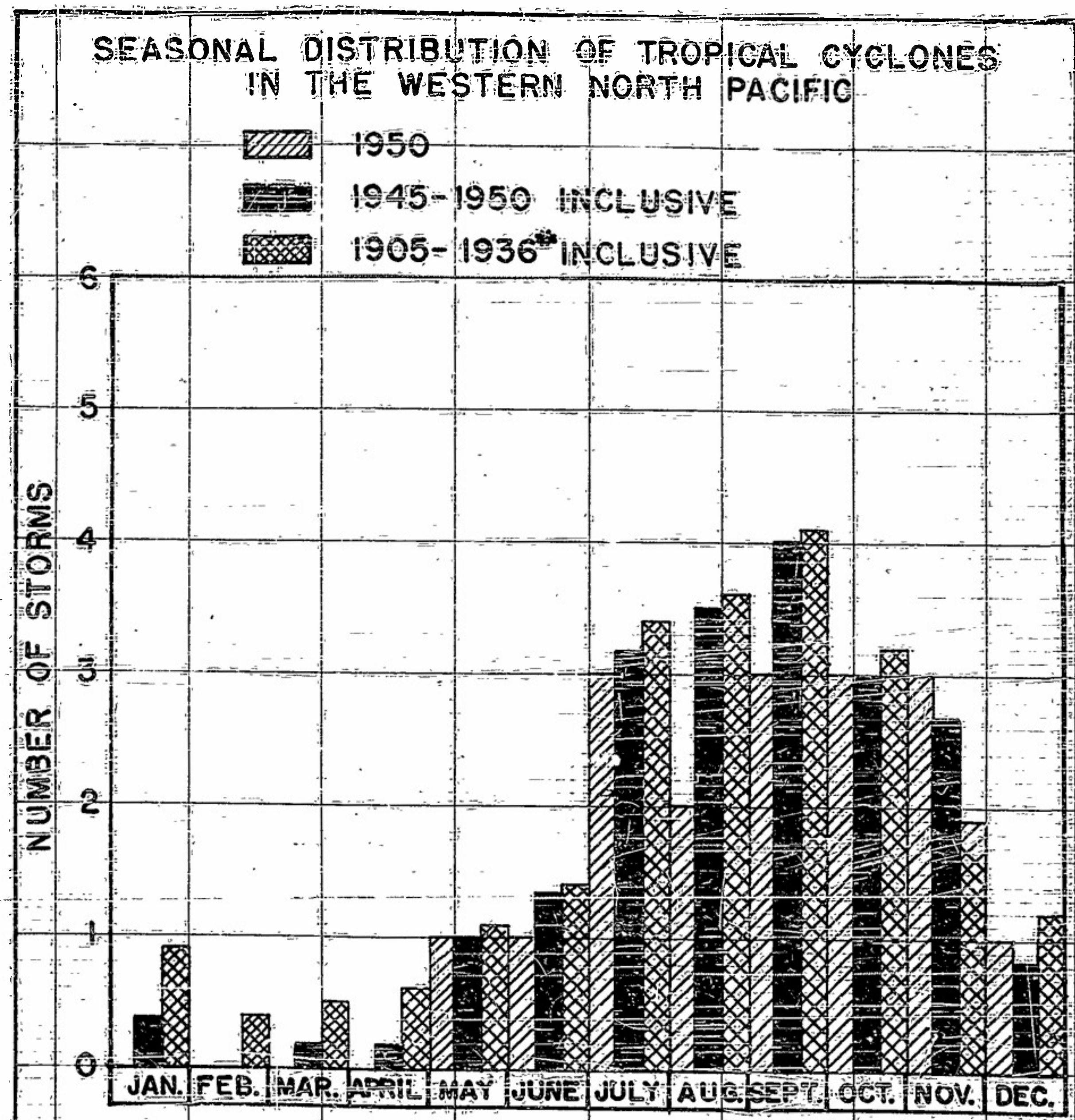
	OSSIA	PETIE	RUBY	BILLIE	CLARA	DELILAH	FRAN
DATE OF INITIAL DETECTION (FIRST BULLETIN ISSUED)	OCT. 300000Z	OCT. 190000Z	OCT. 290000Z	NOV. 050000Z	NOV. 060000Z	NOV. 201200Z	DEC.-JAN. 241200Z
NUMBER OF DAYS DURATION (BULLETINS ISSUED)	3½	5	3	3	7	1½	3
NUMBER OF DAYS DURATION AS A TYPHOON	3½ DAYS	3 DAYS 6 HRS.	2½ DAYS	2½ DAYS	7 DAYS	0	1 DAY
REASON FOR FORMATION	VII	IV	I	VIII	VIII	II	I & VIII
LOCATION OF DEVELOPMENT (FIRST BULLETIN)	15.5 N 125.5 E	25.0 N 145.5 E	17.5 N 133.5 E	15.0 N 148.5 E	15.0 N 135.0 E	13.0 N 123.5 E	13.0 N 124.0 E
MAXIMUM WINDS (KNOTS)	100 K	90 K	100 K	80 K	135 K	60 K	80 K
MAXIMUM WINDS BEFORE FIRST CURVATURE (KNOTS)	-	85 K	100 K	80 K	125 K	-	-
MAXIMUM WINDS DURING FIRST CURVATURE (KNOTS)	-	70 K	100 K	75 K	100 K	-	-
MAXIMUM WINDS AFTER FIRST CURVATURE (BEFORE SECOND CURVATURE - IF ANY) (KNOTS)	-	50 K	100 K	50 K	90 K	-	-
MAXIMUM WINDS DURING SECOND CURVATURE (KNOTS)	-	-	-	-	-	-	-
MAXIMUM WINDS AFTER SECOND CURVATURE (KNOTS)	-	-	-	-	-	-	-
POINT OF FIRST CURVATURE	-	27.5 N 142.0 E	18.0 N 133.8 E	20.0 N 143.5 E	21.0 N 123.9 E	-	-
POINT OF SECOND CURVATURE, IF ANY	-	-	-	-	-	-	-
DIRECTION OF FIRST CURVATURE	-	NNW-NE	WNW-NNE	NE-NE	NW-NE	-	-
DIRECTION OF SECOND CURVATURE	-	-	-	-	-	-	-
REASON FOR CURVATURE	-	A II	A II	A I	A VII B VIII	-	-
QUADRANT OF STRONGEST WINDS (WHEN CONSTANT DURING EXISTENCE OF CYCLONE)	SE	-	-	NE&SE	-	UNK	UNK
QUADRANT OF STRONGEST WINDS BEFORE FIRST CURVATURE	-	SE	N	-	S	-	-
QUADRANT OF STRONGEST WINDS DURING CURVATURE	-	SE	UNK	-	NW	-	-
QUADRANT OF STRONGEST WINDS AFTER FIRST CURVATURE	-	E	NE	-	NE	-	-
QUADRANT OF STRONGEST WINDS DURING SECOND CURVATURE	-	-	-	-	-	-	-
QUADRANT OF STRONGEST WINDS AFTER SECOND CURVATURE	-	-	-	-	-	-	-
SPEED OF MOVEMENT (OVERALL AVERAGE) (KNOTS)	7.9 K	8.4 K	23.3 K	11.3 K	13.4 K	15 K	16 K
SPEED BEFORE FIRST CURVATURE	-	6.1 K	23 K	11 K	9 K		-
SPEED DURING FIRST CURVATURE	-	4.0 K	14 K	11 K	8 K	-	-
SPEED AFTER FIRST CURVATURE	-	8.2 K	26 K	12.5 K	18 K	-	-
SPEED DURING SECOND CURVATURE	-	-	-	-	-	-	-
SPEED AFTER SECOND CURVATURE	-	-	-	-	-	-	-
MINIMUM PRESSURE REPORTED	971	994.0	917.5	981.6	898	UNK	998
MAXIMUM RADIUS OF 50 KNOT WINDS OR GREATER IN NAUTICAL MILES	150	90	270	60	300	50	70
POINT OF DISSIPATION (LAST BULLETIN)	20.5 N 117.0 E	33.5 N 152.5 E	41.0 N 147.0 E	24.5 N 147.5 E	30.0 N 144.0 E	15.5 N 116.5 E	14.5 N 115.5 E
UNITED STATES INSTALLATIONS DAMAGED	NONE	UNK	UNK	UNK	UNK	UNK	UNK
MINIMUM 700 MB HEIGHT	9290	9530	7610	9624	9635	UNK	UNK

REASON FOR FORMATION

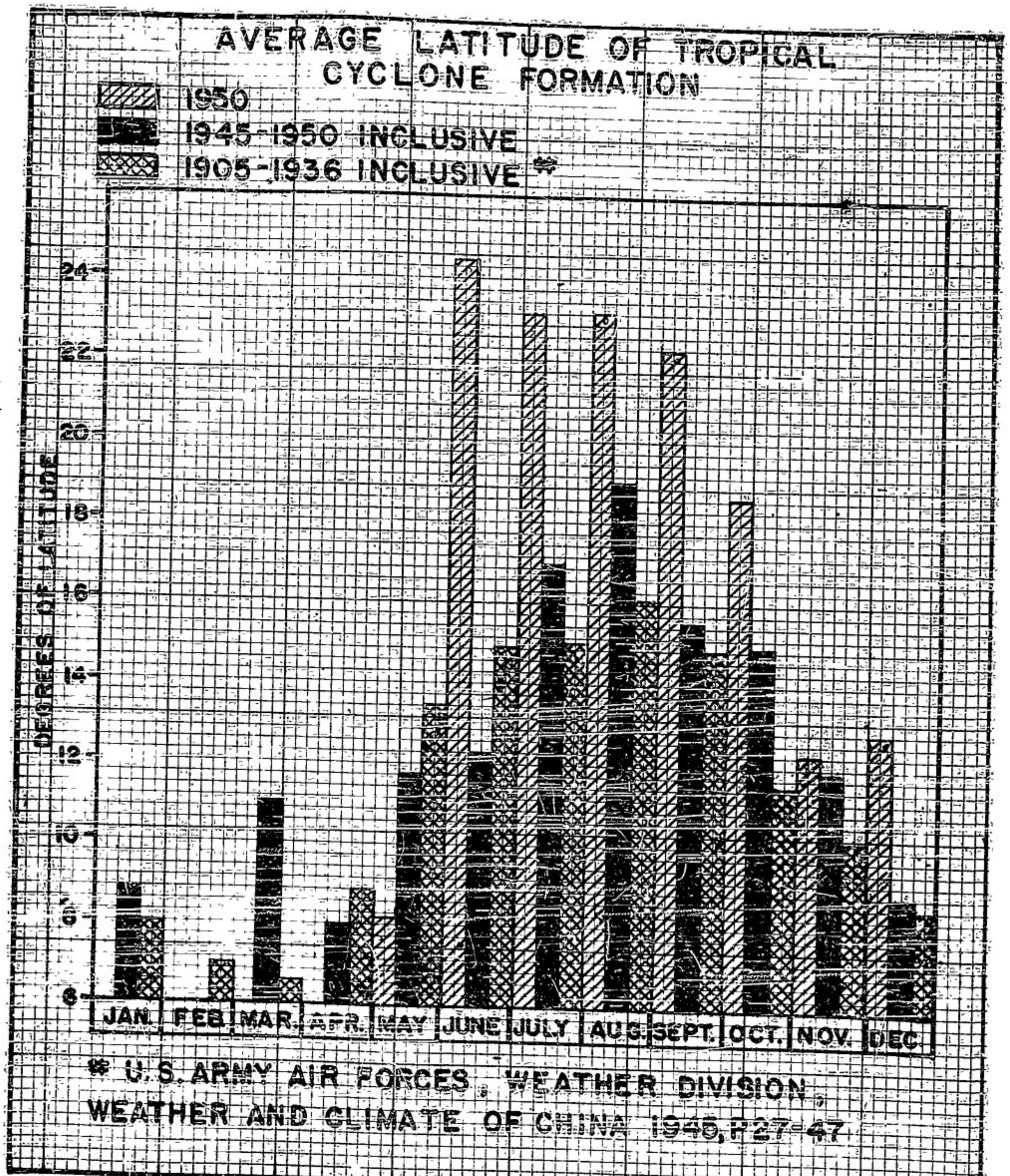
I. INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY SW MONSOON SURGE
II. INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY WESTERLY TROUGH
III. INTENSIFICATION OF EASTERLY WAVE ON ITC CAUSED BY NORTH INDIAN WESTERLIES
IV. FRACTURE OF EASTERLY WAVE AND WESTERLY TROUGH
V. INTENSIFICATION OF SURFACE LOW BY LOW ALOFT SUPERPOSED
VI. MOVEMENT OF A VORTEX INTO A STAGNANT LOW PRESSURE AREA
VII. UNKNOWN
VIII. DIVERGENCE ABOVE 300 MBS OVER SFC LOW

REASON FOR CURVATURE A. FIRST CURVATURE; B. SECOND CURVATURE (EXAMPLE: A. I; B. IV)

I. RECURVED IN ADVANCE OF EASTERLY TROF
II. RECURVED INTO WESTERLY TROUGH
III. RECURVED IN TROUGH CAUSED BY ANOTHER STORM
IV. CURVED BECAUSE OF MISSING TROUGH
V. CURVED BECAUSE OF BLOCKING HIGH
VI. CURVED BECAUSE OF CHINA LOW CIRCULATION
VII. RECURVED BECAUSE OF A SPLIT HIGH CELL
VIII. RECURVED INTO ANCHOR TROUGH
IX. CURVED BECAUSE OF INTERACTION OF TWO CYCLONES



*U.S. ARMY AIR FORCES, WEATHER DIVISION, WEATHER AND CLIMATE OF CHINA 1945, P 27-47



AVERAGE LATITUDE OF TROPICAL CYCLONE FORMATION
1950
1945-1950 INCLUSIVE
1905-1936 INCLUSIVE *
DEGREES OF LATITUDE
24
22
20
18
16
14
12
10
8
6
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
* U.S. ARMY AIR FORCES, WEATHER DIVISION,
WEATHER AND CLIMATE OF CHINA 1945, P27-47

RATES OF MOVEMENT

1950 COMPARED WITH 1949 AND HISTORICAL MEANS

LATITUDE	YEAR	BEFORE RECURVING		WHILE RECURVING		AFTER RECURVING	
		MEAN	ORDINARY LIMITS	MEAN	ORDINARY LIMITS	MEAN	ORDINARY LIMITS
5°-10°N	1905-1937	14	7-22	13	5-21	---	----
	1949	11	5-16	5	----	10	----
	1950	13	9-17	--	----	--	----
10°-15°N	1905-1937	13	9-17	13	5-21	--	----
	1949	13	9-17	16	16-17	--	----
	1950	13	6-23	--	----	--	----
15°-20°N	1905-1937	12	8-17	13	5-21	10	5-16
	1949	9	7-11	8	5-12	11	----
	1950	10	6-12	13	9-24	--	----
20°-25°N	1905-1937	12	8-17	13	5-21	15	9-22
	1949	13	10-15	11	8-12	19	14-29
	1950	10	6-13	14	6-24	15	10-22
25°-30°N	1905-1937	13	7-20	13	5-21	18	9-31
	1949	12	----	10	8-15	18	8-32
	1950	15	8-20	12	4-24	19	8-32
30°-35°N	1905-1937	17	9-26	13	5-21	22	12-33
	1949	--	----	9	4-15	23	11-36
	1950	5	4-6	11	4-20	23	8-32
35°-40°N	1905-1937	--	----	--	----	28	15-38
	1949	--	----	--	----	31	11-47
	1950	--	----	--	----	24	8-38

Average speeds for 1950 cyclones:

Before recurvature ---- 11 knots
During " " ---- 12 knots
After " " ---- 21 knots

MONTHLY DATA ON TROPICAL CYCLONES

IN SOUTHWEST PACIFIC

1950 COMPARED WITH 1949 AND HISTORICAL DATA[1]

MONTHS	JAN THRU APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
AVERAGE NO. PER YEAR	NO STORMS IN 1950	1.1	1.4	3.4	3.6	4.1	3.2	1.9	1.2	22.3
NUMBER IN 1949		0	1	6	2	4	2	2	2	20
NUMBER IN 1950		1	1	3	2	3	3	3	1	17
MEAN LAT. OF FORMATION		9	15	15	16	14.5	11.5	10	8.5	
MEAN LAT. IN 1949		—	15.5	17.5	21	20	15	9	8	
MEAN LAT. IN 1950		8	24.5	23.5	23	21	19	12	13	
MEAN LAT. OF RECURVATURE		18	22	29	30	25	15	19	17	
MEAN LAT. OF RECURV. IN 1949		—	17.5	20	25.5	21.5	19.5	16	18	
MEAN LAT. OF RECURV. IN 1950		20	26	33	26.5	26	22.5	20.5	—	

[1](1905-1937 Incl). From US Air Force, Weather Div., Weather and Climate of China

HISTORIES OF INDIVIDUAL STORMS OF 1950

DORIS
7-14 MAY

Typhoon Doris was first detected as a disturbance by its passage at Truk late on 5th of May. Based on this passage, reconnaissance was dispatched on 7 May and on 070149Z a 514th Recon aircraft fixed the center at 07.9 N and 148.0 E. From this point Doris moved in an undecided manner until her passage at Guam on 9 May, where considerable rain and winds with gusts to 65 knots were experienced. After her passage at Guam, Doris moved northwest for two days and on 11 May began normal recurvature in the vicinity of 135 degrees east longitude. From there, Doris moved northeast passing well to the northwest of Iwo Jima and slightly southeast of Torishima and then moved off towards the Aleutian Low. Typhoon Doris had the distinction of being the first typhoon since 1922 to affect Guam in the month of May. A total of 32 bulletins were issued by the network and no military installations received any damage as a result of Doris.

ELSIE
JUNE 23-24

Typhoon Elsie developed from E" 06053 which passed Guam 18 June 1950 at 1800Z; at the time of its passage there was no indication that it would develop into such a violent storm. After passing Guam, this wave was moved westward and reclassified as a vortex at 0000Z on June 21st. Very little can be said in regard to the intensification of Elsie. At this time Andersen Weather Central was making a concerted effort to insure that every piece of data was plotted and analyzed; further, extra charts were being analyzed. With all this activity Elsie still was not detected, which is further evidence of the extremely small size of this storm. The synoptic situation indicated a large low pressure area in the Philippine Sea; under this condition, considerable moist southerly flow was made available to the vortex. Another possibility as to the cause of intensification would be in accord with Dr. Petterson's theories. This being that when an easterly wave has a westerly movement of less than the easterly component of flow in which the wave is embedded, immediate intensification will occur. Limited data revealed Elsie was moving west-northwest at 16 knots between 0300Z on the 21st of June and 0300Z on the 22nd of June. During the period the easterly component of the flow in this area was 20.3 knots. From this figure it is understandable why Elsie moved so rapidly thru this area and still intensified. Bulletin One was issued on 230600Z by Kadena sub-center, placing the storm at 25.5° N - 125° E; the final bulletin was issued by Haneda sub-center on 250600Z placing Elsie at 35.5° N - 131° E. Thus ended the career of Elsie who was born lived and died in the 24 hours from Bulletin 1 to 5. She left behind a score of 14 dead, hundreds homeless and untold damages at the little island of Miyako Jima.

FLOSSIE-GRACE
JULY 15-21

The first indications of Tropical Cyclone Flossie was detected by an aircraft of the 514th Reconnaissance Squadron while flying scheduled Vulture Easy track on 15 July. Bulletin One was issued by Andersen Weather Central on 151500Z, with max winds of 60 knots. From the fix of 23.2° N 137.9° E. Flossie moved in a west-northwesterly direction until it started to recurve at 134° E. Recon on the 17th revealed very little evidence of a distrubance, so, Andersen Weather Central issued the final bulletin. Evidence of Flossie was found later and the storm was picked up again. From the 171800Z surface chart, it appeared that the storm would continue normal recurvature, but it developed inverse recurvature and moved northwest to the vicinity of 130° E, then approached the coast of Japan on 180000Z. The remnants of Flossie then moved out into the Sea of Japan and accelerated in a north-northeasterly direction as it became extratropical. The final bulletin was issued on 180930Z.

Tropical Cyclone Grace was first detected by the Andersen Weather Central as a depression in the vicinity of 22.5° N and 133.0° E on July 120300Z. Its location was determined from analysis of surface and upper air reports. Tropad One was issued by Clark Field Sub-Center and Tropad Two by the Kadena Sub-Center. The first reconnaissance fix placed the center at 22.5° N and 130.0° E at 0308Z on 17 July, with maximum winds of 45 knots. Bulletin One was issued by the Kadena Sub-Center with valid time of 162000Z. For a while, Okinawa was directly in the path of the apparent movement of the storm; however, the storm passed about 60 nautical miles to the east of Okinawa, and after the center passed the wind speed began to increase until a max of 40 knots with gusts to 50 knots were reached. At approximately 26° N 129.0° E, Grace became a full-fledged typhoon with winds of 70 knots. Transfer of forecast responsibility to the Tokyo Weather Central was accomplished for July 171500Z and they issued Bulletin Nine, valid time 171200Z. After leaving the vicinity of Okinawa, Grace passed over or near many of the small islands of the Ryukyus chain and during her normal recurving path appeared to be headed for Kyushu; however, a sub-tropical ridge over Japan probably kept Kyushu from feeling the full fury of Grace. Grace passed through Korea and moved along the western edge of the Sea of Japan as she became extratropical. The final bulletin was issued on July 212100 Z.

HELENE
JULY 27-28

Tropical Cyclone Helene was first detected as a tropical disturbance near 22.0 degrees north and 142.0 degrees east, late on the 24th July. From this position, the disturbance moved north-northwesterly with a speed of 10 knots gradually increasing to 20 knots. The first bulletin, issued by the Tokyo Weather Central, placed the center at 28.5 degrees north and 132.5 degrees east with maximum winds of 50 knots. This bulletin was referring to a disturbance originating near Okinawa, but upon post-analysis it has been concluded that the path of the two disturbances crossed in

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HELENE
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IDA
AUGUST 10-19

Typhoon Ida developed from one of a series of low pressure centers between 20.0 degrees north to 30.0 degrees north and 130.0 degrees east to 145.0 degrees east. The first three tropads were issued by the Andersen Weather Central and Bulletin One was issued by the Kadena Sub-Center on 1200Z 10 August with the center located at 22 degrees north and 134 degrees east. From this point the storm moved east-northeast and the final bulletin was issued at 0600Z, 12 August. The issuance of the final bulletin proved to be premature and the next bulletin was issued at 1200Z 12 August, at which time the storm was only twenty miles northwest of Iwo Jima. The storm then developed into typhoon intensity and moved southeast after swinging around Iwo Jima. At approximately 22.5 degrees north and 148.5 degrees east, Ida began to curve to the north-northeast and normal recurvature began at about 30.0 degrees north. The disturbance then moved to the northeast as it became extratropical and the final bulletin was issued at 0600Z 19 August.

JANE
AUGUST 30-SEPT. 04

Typhoon Jane was first detected as a tropical storm near 25 degrees north 138.5 degrees east on 1200Z 29 August. The first tropad was issued by Tokyo Weather Central on the basis of surface reports from Iwo Jima. The final tropad was issued 200000Z and Bulletin One followed. The first recon mission on 30 August showed no evidence of a closed circulation or surface winds in excess of 20 knots. However, the second mission on 31 August located the storm at 24.3 degrees north 138.0 degrees east with max winds of 55 knots. Vulture Easy was diverted on 1 September and fixed the center at 25.9 degrees north 135.4 degrees east with max surface winds of 80 knots. Jane was again fixed on 2 September at 28.4 degrees north 133.7 degrees east with winds in excess of 100 knots. From the point of the last fix, Jane moved northeastward across Honshu almost directly over Kobe and into the Sea of Japan, skirting the west coast of Honshu becoming extratropical as it tracked thru central Hokkaido. The final bulletin was issued on 040000Z. Considerable property damage was done in the Kobe-Osaka area as Jane moved over Honshu.

KEZIA
SEPTEMBER 07-14

Kezia had its origin from easterly wave 08061 which was detected by Hickam at 150 degrees west on 17 August 1950. The wave reached the vortex stage on 30 August in the vicinity of Eniwetok and remained weak prior to its passage at Truk late on 31 August. In analyzing the limited d[illegible] available in this area it is believed that two vortices were prese[illegible] the system passed Truk. The vortex that became Kezia passed to the nor[illegible] of Guam near 2100Z on 3 September. She remained nearly stationary until 07 September when it was fixed at 17.3 degrees north and 143.6 degrees east, with winds in excess of 100 knots. Bulletin One Kezia was issued on 070000Z by the Andersen Weather Central. From the point of the first fix Kezia began a slow north-northwest movement passing east of Parece Vela, curving northwesterly across Central Kyushu and then northeast into the Sea of Japan, where it became extratropical. Thirty-Six bulletins were issued and 10 recon missions flown.

LUCRETIA-MISSATHA-NANCY
SEPTEMBER 17-19

On 15 September, Clark Sub-Center issued a tropad on a tropical disturbance located in vicinity of 16.0 degrees north and 129.5 degrees east longitude. The Center assigned forecast responsibility to Clark Sub-Center and reconnaissance was dispatched on the 16th which located a weak circulation with max winds of 35 knots. On September 17th reconnaissance located a tropical storm at 21.3 degrees north 134.0 degrees east; forecast responsibility was transferred to Kadena Sub-Center, who issued Bulletin One on Lucretia at 0840Z on 17 September. Lucretia moved north-northeast to 27.0 degrees north 136 degrees east, then northeast at 25 knots into Tokyo's area of responsibility on 180045Z. On 18 September at 0000Z, Tokyo Sub-Center issued a tropad on the area 27 degrees north and 138 degrees east; on 180600Z, Bulletin One Tropical Storm Missatha was issued by Tokyo Sub-Center. Though Kadena was of the opinion that Lucretia and Missatha were the same storm, it was decided to continue issuing bulletins on Missatha. At this time Tokyo had responsibility for both storms. Missatha moved nearly north at an average speed near 30 knots from its point of detection about 250 nautical miles west of Chichi Jima on 0000Z, 18 September. Twenty-four hours later she passed 120 miles east of Tokyo and was declared extratropical at this time. On 0510Z 19 September, reconnaissance fixed the center of a small storm at 23 degrees 18 minutes north 137 degrees 50 minutes east. As this storm was not in the vicinity of Lucretia or Missatha, it was concluded that this was a new disturbance and was named Tropical Storm Nancy. Recon on 20 September failed to find any evidence of a disturbance. It was concluded that Nancy had dissipated.

OSSIA
OCTOBER 1-5

On 24 September at 0600Z, Andersen Weather Central detected a trough in the easterlies at 161 degrees east longitude. By 0000Z, 27 September the easterly wave had intensified to the vortex stage and was located at 09 degrees north 146 degrees east longitude. On 30 September the Andersen Weather Central issued a tropad locating a tropical disturbance at [illegible] degrees north latitude 131 degrees east longitude. Reconnaissance on 30th found maximum winds of 40 knots. Tropad responsibility was transferred to Clark Sub-Center on 311500Z. On October 1 at 0145Z reconnaissance fixed the center of a typhoon at 15.6 degrees north 126.1 degrees east, 240 nautical miles east southeast of Luzon; max winds were estimated to be 70 knots. Ossia moved in a west northwest direction and passed over the east central coast of Luzon, approximately 120 miles northeast of Clark Field, late on 01 October. On 021200Z, Ossia moved off the west coast of Luzon into the South China Sea. On 04 October Navy reconnaissance fixed the center of Ossia approximately 160 nautical miles southeast of Pratas Island, she started a gradual inverse recurvature toward the west-northwest. On 04 October, the flow of continental air from southeast China began to flow into Ossia. The storm began to fill rapidly and move westward as a tropical storm along the south edge of the China high cell into Indo China where it lost all of its characteristics as a tropical disturbance. The final bulletin was issued at 0300Z on 05 October.

PETIE
OCTOBER 19-23

Typhoon Petie was first detected as a small closed circulation on the surface chart at 1800Z, 18 October. The location of the circulation was not definite but it was estimated to be in the vicinity of 22 degrees north 147 degrees east. Andersen Weather Central issued a tropad on the disturbance and requested that Vulture Fox reconnaissance mission divert and investigate the area. Reconnaissance found a fully-developed typhoon located at 25 degrees 08 minutes north 145 degrees 22 minutes east at 0220Z, 19 October; max winds were estimated at 90 knots with central pressure 988 millibars. On 20 October reconnaissance located Petie at 26 degrees 19 minutes north 142 degrees 36 minutes east. Extrapolation between fixes indicated that Petie had moved northwest at 6 knots. Petie was passing to the north of Iwo Jima and was approaching Chichi Jima. This was an entirely unsuspected movement as Iwo Jima's hourly reports had given no indication of the approach of a tropical cyclone. Reconnaissance indicated that Petie was very small in lateral extent and it was expected that she would not exist for any lenght of time after it recurved into the westerly flow. On 21 October, Petie decelerated to a speed of 4 knots. Recurvature started at a point 40 miles south of Chichi Jima and recurved in a very short radius arc and started moving northeastward at 8.2 knots, passing over Chichi Jima at 0600Z, 21 October. After recurvature Petie accelerated rapidly and started a gradual dissipation; however, three more reconnaissance fixed were obtained prior to its becoming extratropical on 23 October.

RUBY-ANITA
OCTOBER 28-31

Easterly wave 10053, which was first detected in the vicinity of 149 degrees east, passed south of Guam as a vortex at approximately 1000Z on 26 October. Late on 27 October the intensity of the vortex had reached a point that made reconnaissance necessary. On 28 October reconnaissance fixed a depression at 14.5 degrees north 142.3 degrees east at 0114Z; winds were estimated at 40 knots. A second reconnaissance mission departed from Guam on 29 October and found a fully developed typhoon with maximum winds of 100 knots. This mission located Ruby at 17 degrees 46 minutes north 133 degrees 42 minutes east at 0409Z. Typhoon Ruby now began a movement to the northeast and began acceleration as it caught a trough extending down from Japan. Ruby was now moving in the direction of Iwo Jima. Reconnaissance fixed Ruby at 22.2 degrees north 135.7 degrees east at 0043Z, 30 October; a late afternoon fix was also obtained on this date. As Ruby continued a north-northeastward movement, Kadena Sub-Center issued a TROPAD on a tropical disturbance that was located in the vicinity of 27.5 degrees north 141.5 degrees east at 1500Z, 29 October. Max winds were estimated at 60 knots; Anita was very short lived, dissipating within 12 hours after the first bulletin. This storm was actually Ruby in a more northerly position than had been forecast. Typhoon Ruby moved past Tori Shima at approximately 2100Z 30 October; she continued a northeast movement and passed to the east of Honshu, approximately 150 miles east of the Tokyo area on 31 October. Ruby began to dissipate rapidly as it moved into extratropical latitudes and the final bulletin was issued on 1800Z, 31 October.

SALOME
AUGUST 18-26

The tropical storm Salome was one of the rare tropical storms which had its origin and storm track in the Western Pacific Ocean. Salome can be traced directly through the Easterly Wave Program. It's origin was that primarly of a wave formation and a zone of convergence associated with the intertropical front. The storm progressed from the stage of an Easterly Wave through the stage of a Vortex into a full fledged Tropical Storm. On 11 August inflight reports indicated the presence of an easterly wave near 6.0 degrees north and 143.0 degrees west. By 14 August Hilo's surface winds and winds aloft had shifted into the north-northwest and it had become evident that the wave had reached vortex stage. During 15 August, the storm continued a west-northwest movement at approximately 10 knots, without apparent intensification. On 17 August a reconnaissance plane located the center at 23.3 degrees north 160.5 degrees west or 175 miles northwest of Kauai; winds of 90 mph were encountered. During the 17th and 18th of August there was little movement of the storm and a recurvature to the north and northeast was anticipated. However, the storm continued a west to west-southwest movement. On 180000Z, Hickam Weather Central issued Bulletin One on Salome. Salome persisted in its general westward movement and its position was ascertained by synoptic data. Bulletins were issued until such time as it was deemed impractical to locate the center of the storm by means of synoptic data alone. By 0600Z, 26 August the storm had become no longer hazardous to any installation in the 2143d Weather Wing and bulletins were discontinued.

BILLIE AND CLARA
NOVEMBER 04-13

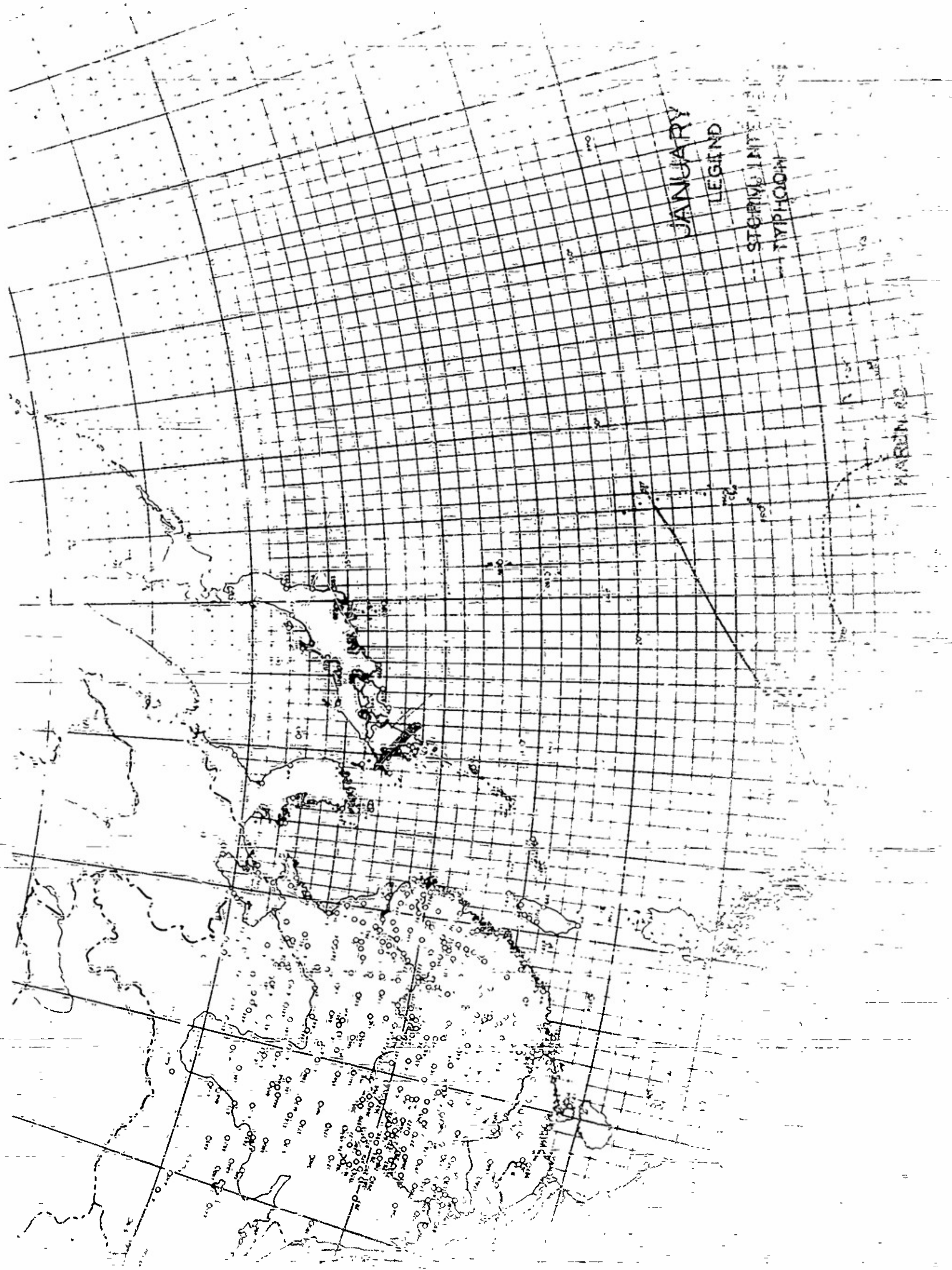
Early in November of 1950 the tranquillity of the Pacific was menaced by the development of two vortices in critical area for further intensification. These vortices developed into typhoon Billie and Clara. Billie was named on 04 November in the vicinity of 15 degrees north and 149 degrees east, which was east of Guam; however, this storm recurved at 20 degrees north and 144 degrees east, thus no land installations were endangered. Clara, was one of the most violent storms of the season; forming in the Philippine Sea midway between Guam and the Philippines. Clara moved northwest to 21 degrees north and 124 degrees east where she recurved and lashed Okinawa with steady winds in excess of 70 knots with occasional gusts to 100 knots. Clara then moved eastward, becoming extratropical on 13 November. A total of 15 reconnaissance fixes were obtained on the two storms; nine on Clara and 6 on Billie. Sixteen bulletins were issued on Billie with Andersen Weather Central and Tokyo Sub-Center sharing the forecast responsibility. Thirty-two bulletins were issued on Clara and all sub-centers participated in the forecast responsibility.

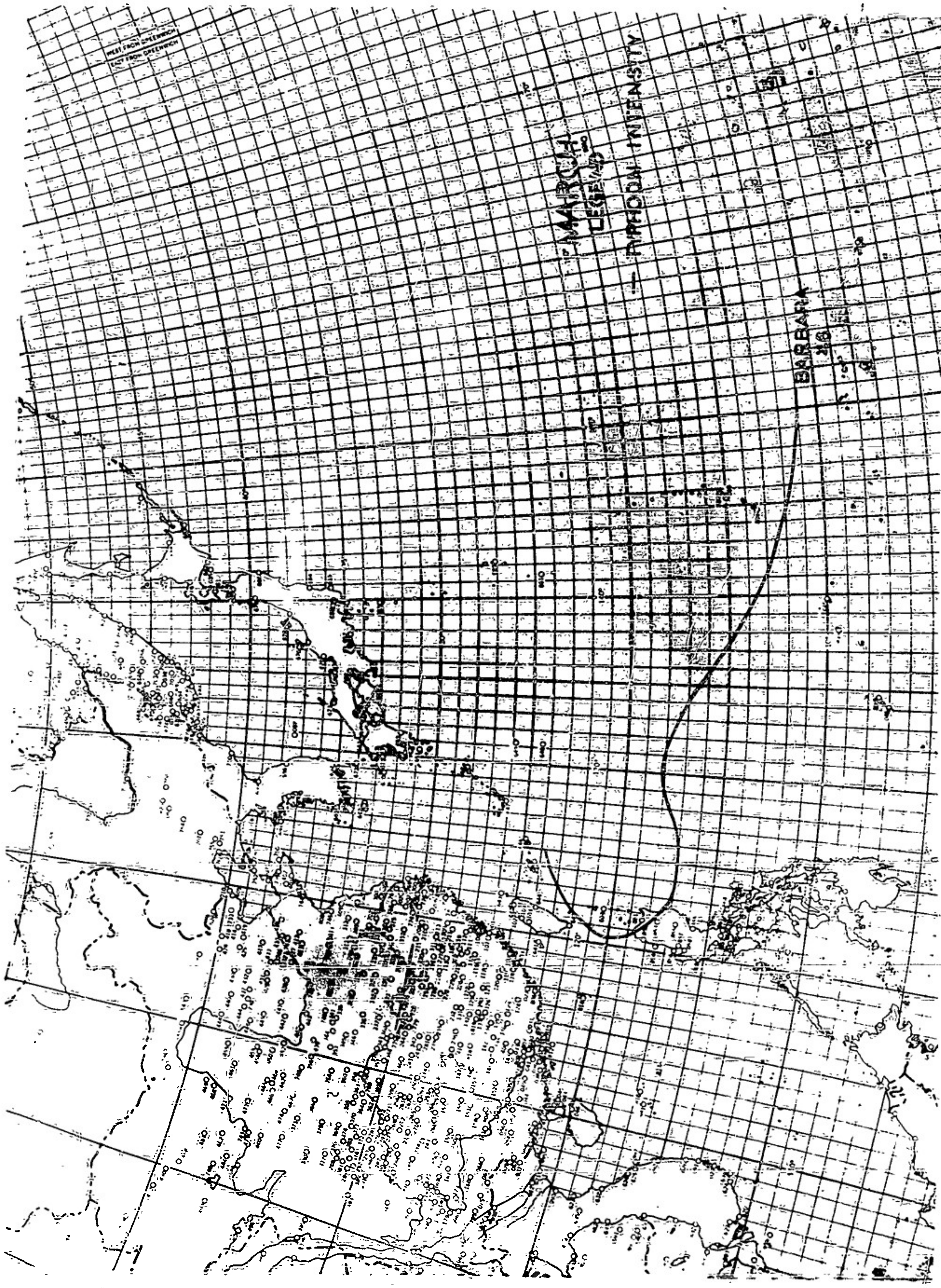
DELILAH
NOVEMBER 20-22

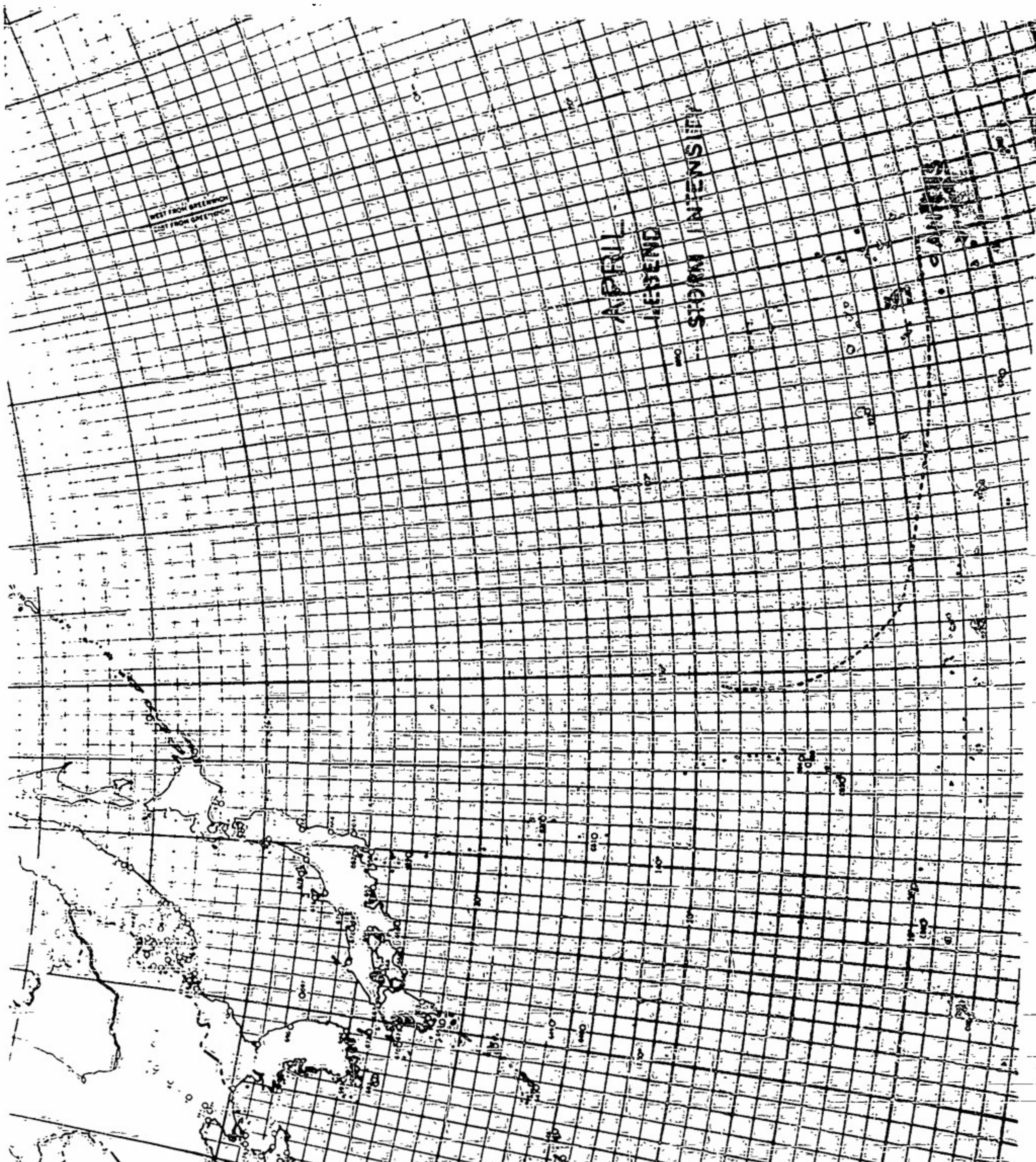
During the last half of November 1950, a tropical storm of moderate intensity, named Delilah, was detected as she entered the east coast of Mindanao. Delilah moved across the Philippine Islands on a west-northwesterly heading passing to the north of Palawan and continuing northwesterly across the South China Sea. Inasmuch as Delilah was moving over land stations it was determined that no reconnaissance would be necessary. Clark Sub-Center had forecast responsibility throughout the storm and issued seven bulletins. Max winds attained were 60 knots.

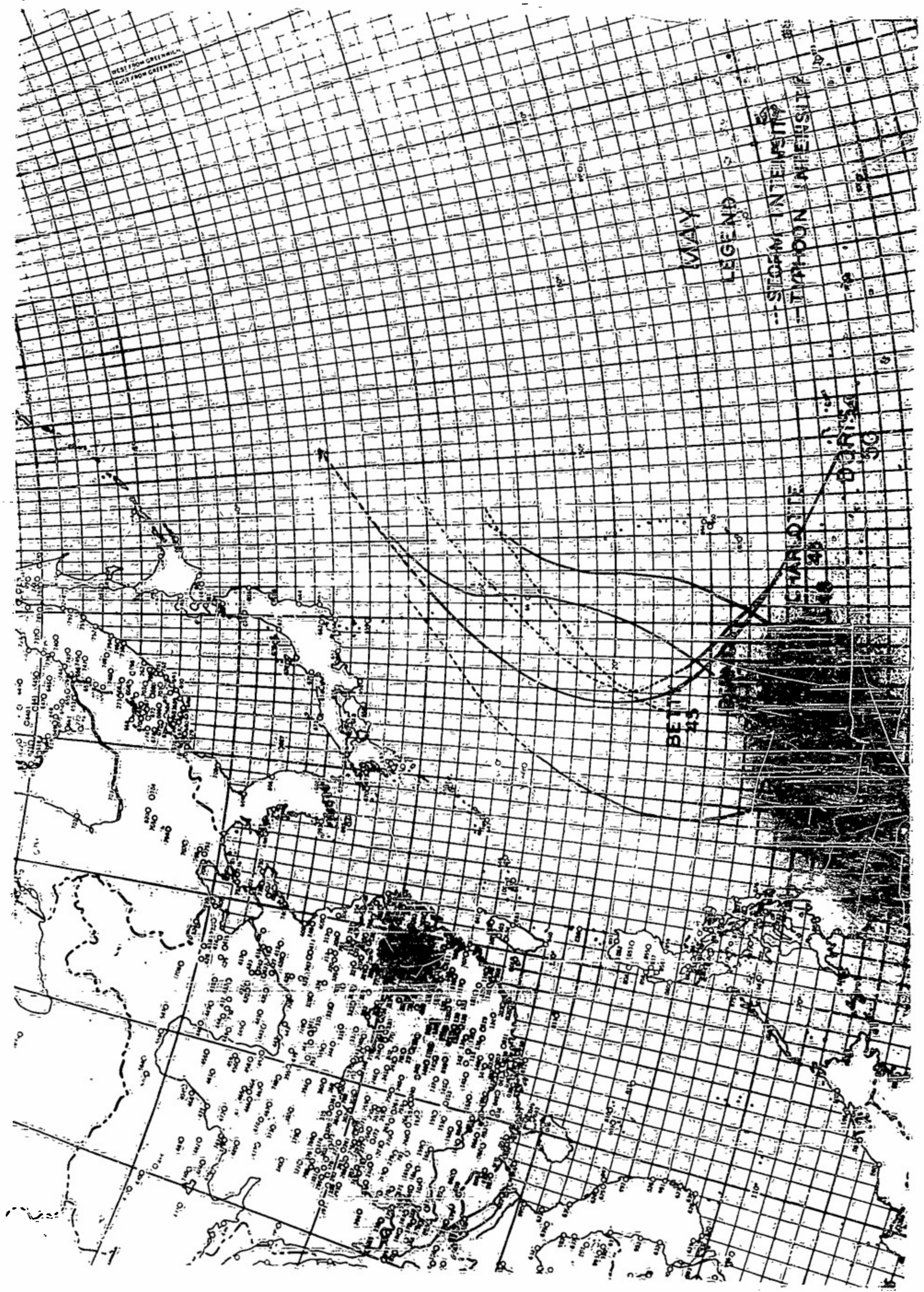
FRAN
DEC. 29 - JAN. 01

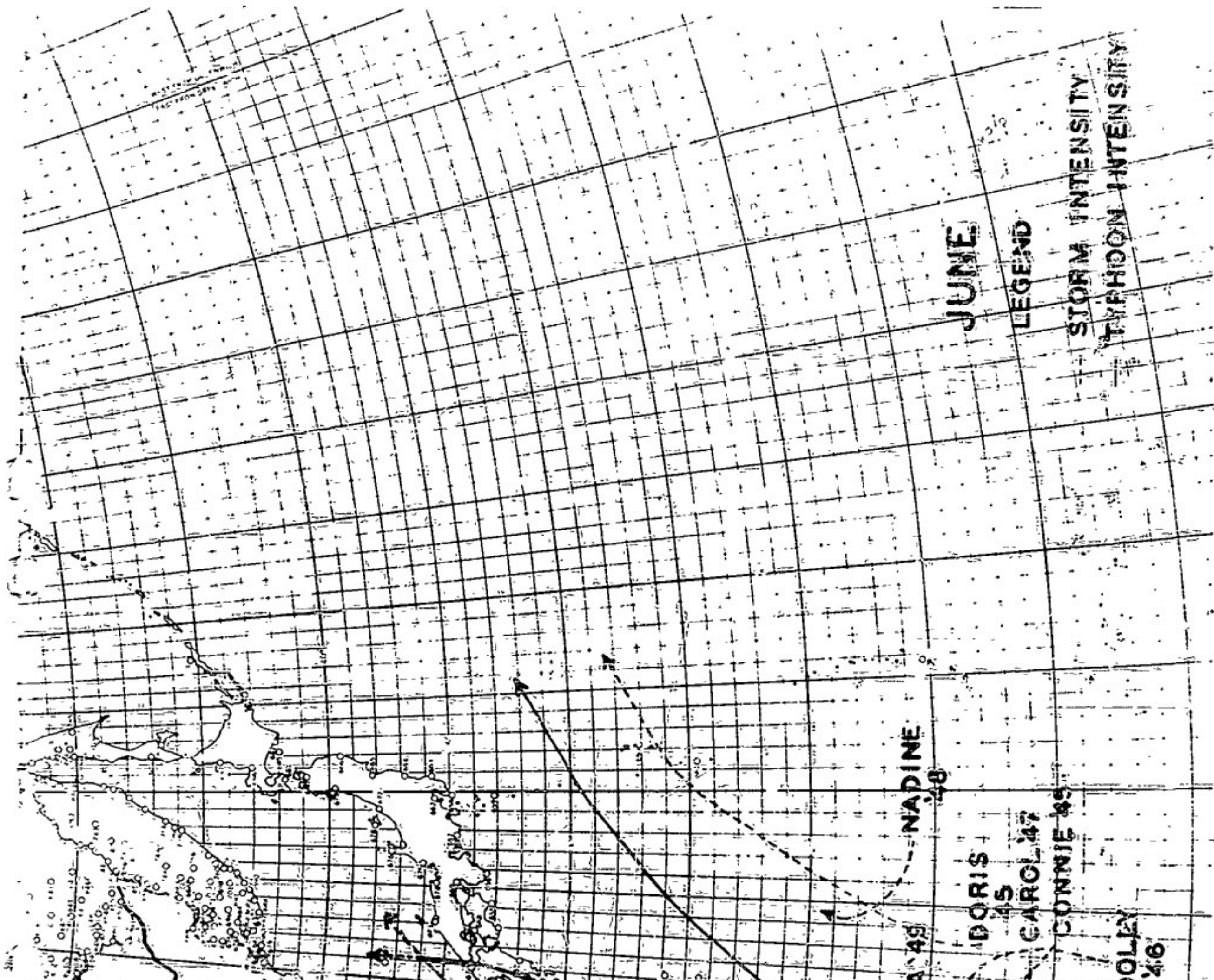
The easterly wave and subsequent vortex, which later became typhoon Fran was originally detected in the vicinity of 150 degrees east longitude early on 23 December. After passing Guam this system was kept under surveillance and on 27 December reconnaissance was dispatched to the suspected area. This mission failed to find any evidence of a storm. This area was then dropped from tropads to easterly wave bulletins. On 29 December Clark Sub-Center reinstated tropads on this area and later on the same day, issued Bulletin One on typhoon Fran; the center was located near 13 degrees north and 124 degrees east at 291200Z. From this point Fran moved in west-northwest direction until 30 December when she began a western movement, passing south of Manila late on the 30th. After passage over the Philippines, Fran continued a west movement and dissipated rapidly; the final bulletin was issued at 0600Z on 1 Jan. 1951.

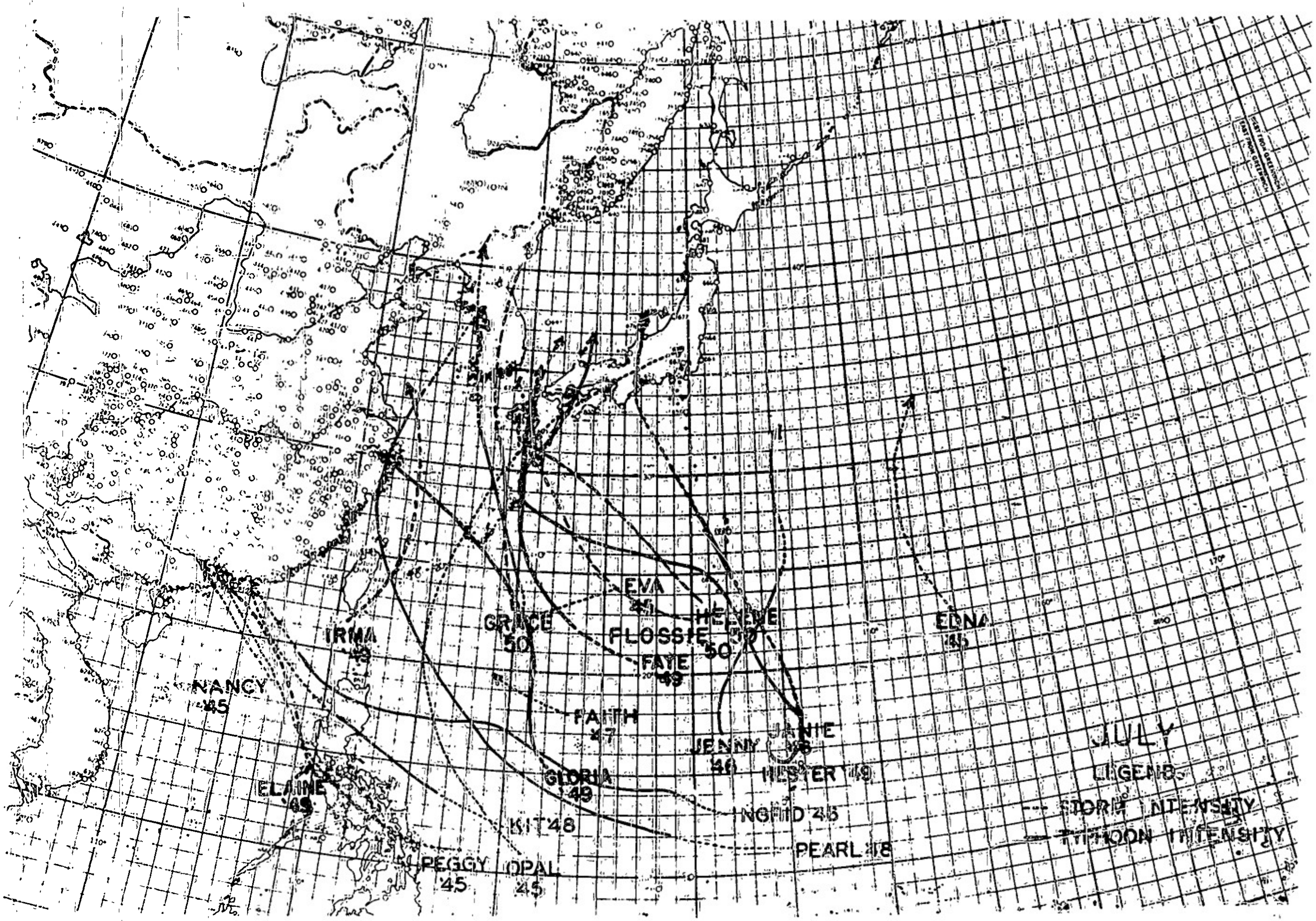

JANUARY
LEGEND
TYPHOON
KAREN

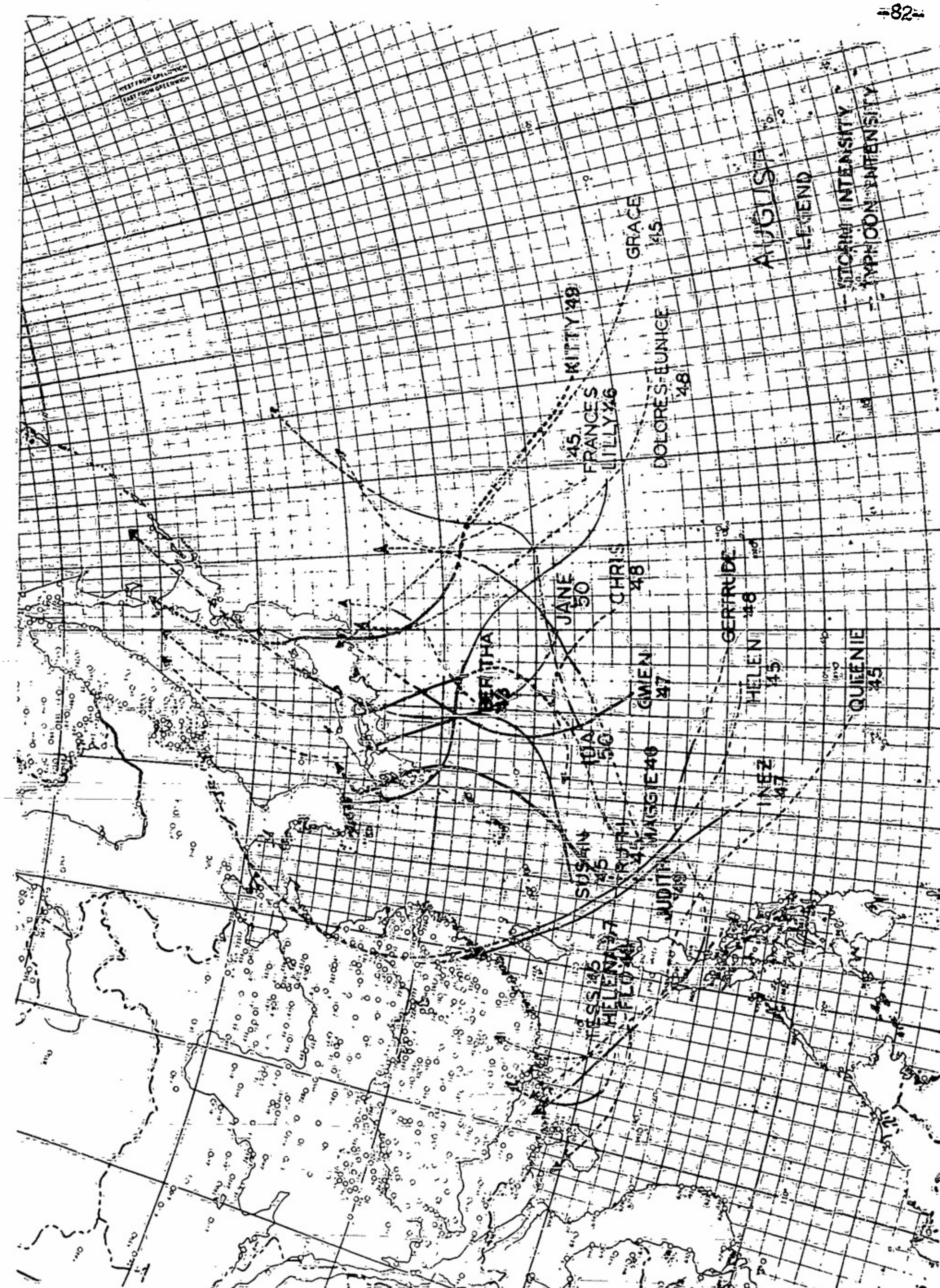

WEST FROM GREENWICH
EAST FROM GREENWICH
MARCH
LEGEND
— TYPHOON INTENSITY
BARBARA
28

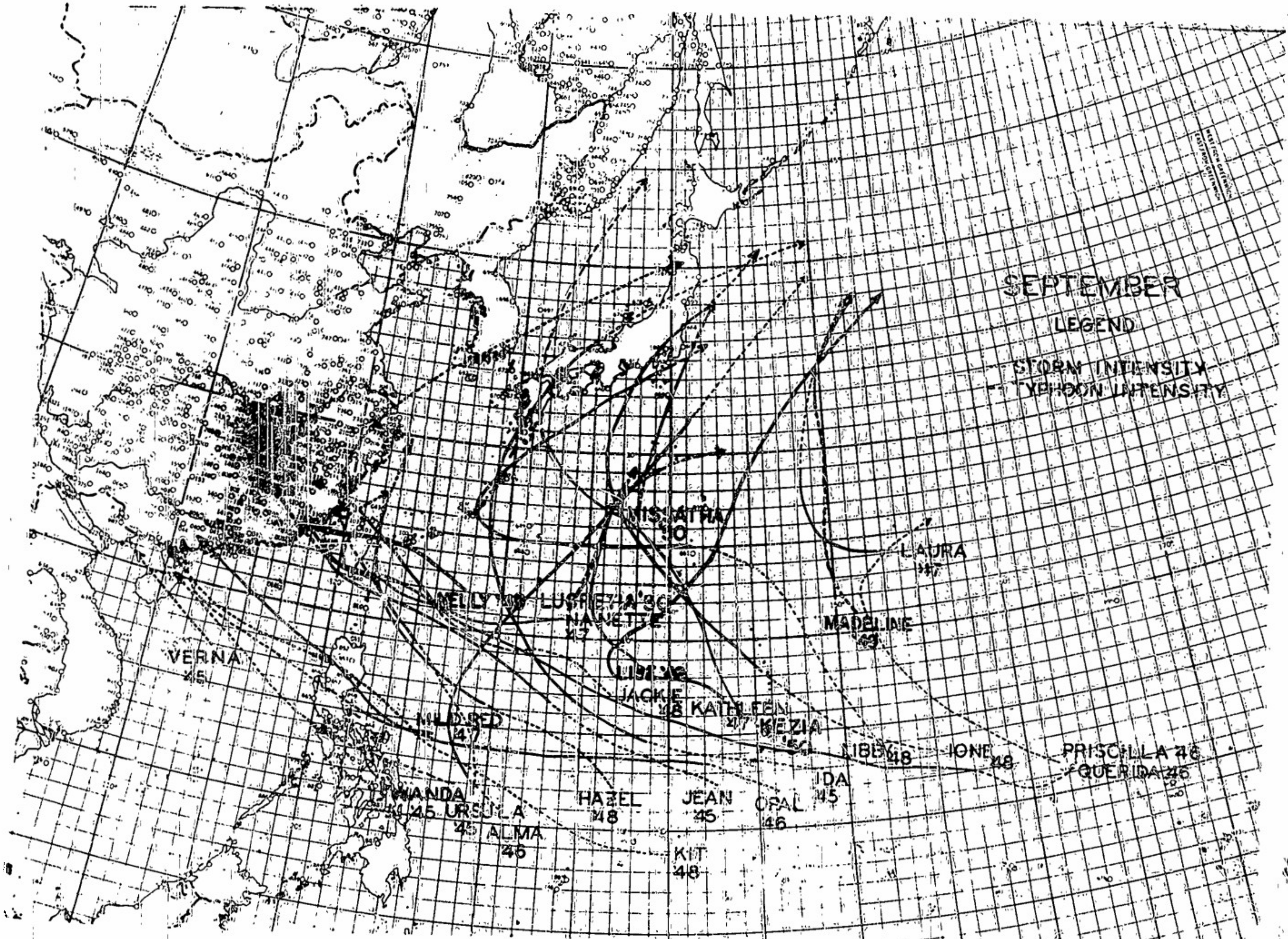

APRIL
LEGEND
STORM INTENSITY
WEST FROM GREENWICH
EAST FROM GREENWICH

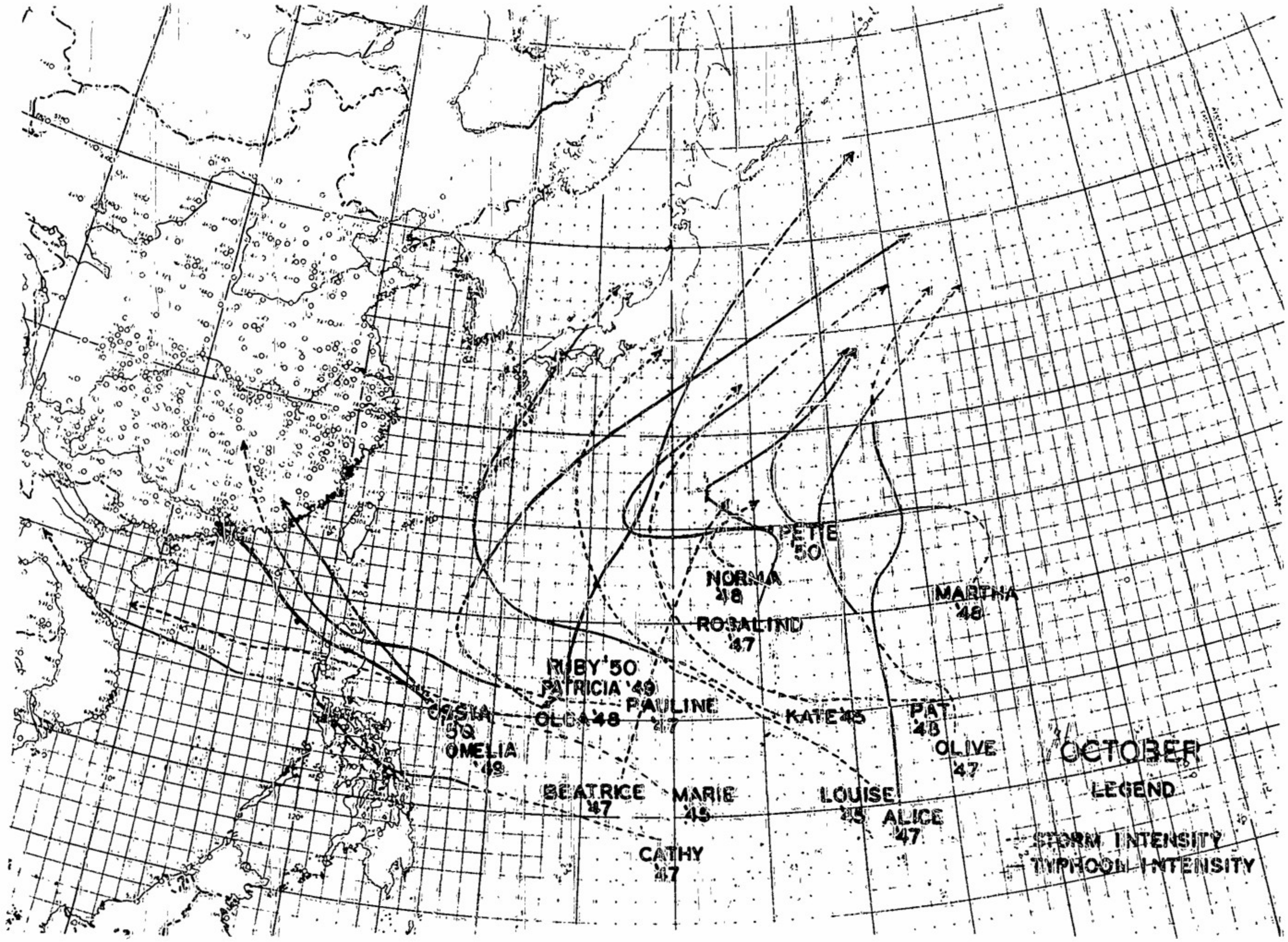

MAY
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
CHARLOTTE
DORIS
36


JUNE
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
NADINE '48
DORIS '45
CAROL '47
CONNIE '45
DOLLY '46
DELLA '49
DELLA
ELSIE '50
OPHELIA '48

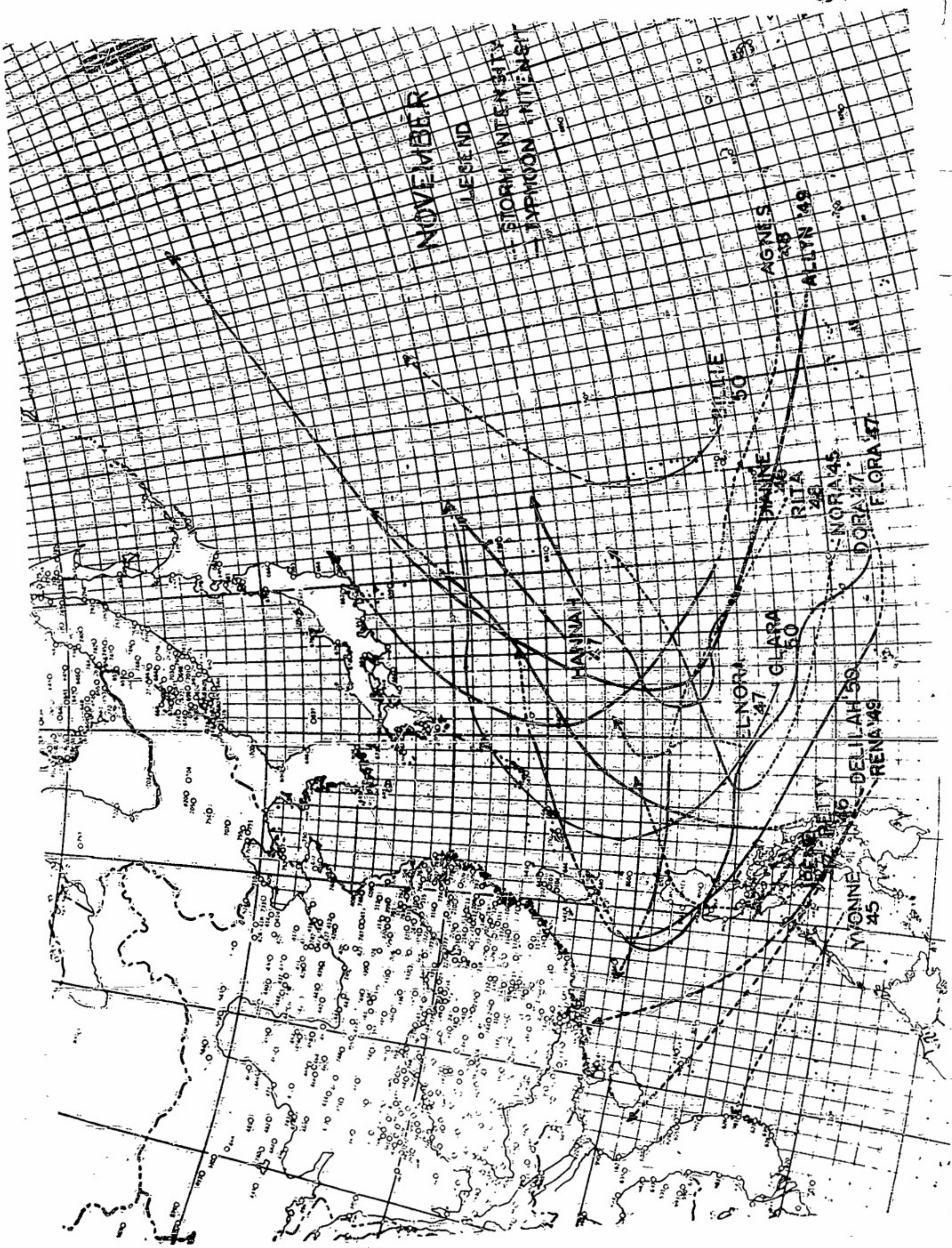

JULY
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
EAST FROM GREENWICH
EDNA
45
EVA
47
GRACE
50
FLOSSIE
FAYE
49
FAITH
47
JENNY
46
JANIE
HESTER 49
GLORIA
49
KIT 48
NANCY
45
PEGGY
45
OPAL
45

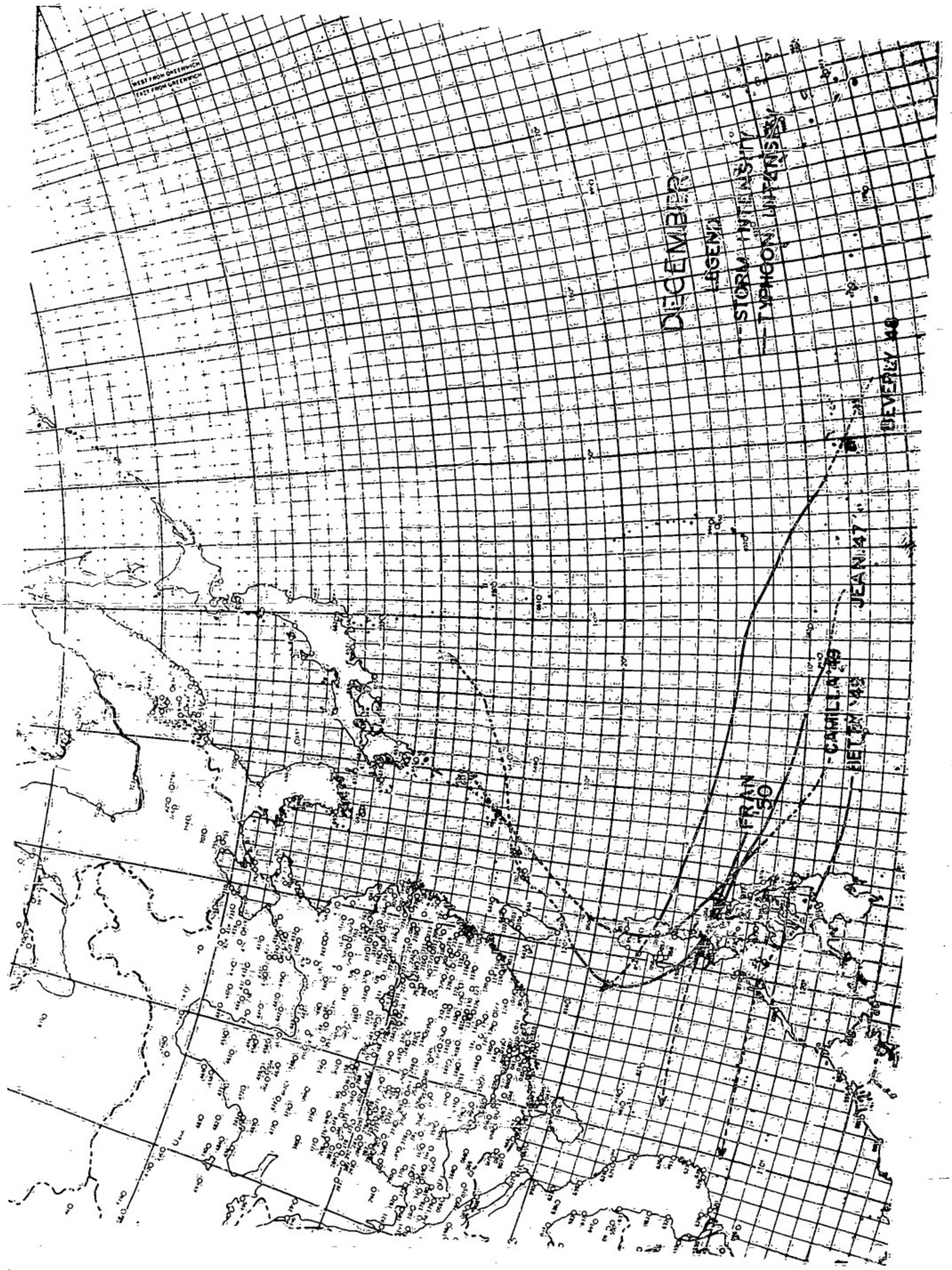

WEST FROM GREENWICH
EAST FROM GREENWICH
AUGUST
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
GRACE 45
KITTY 49
45 FRANCES
LILLY 46
DOLORES-EUNICE 48
JANE 50
CHRIS 48
GERTRUDE 48
BERTHA 48
GWEN 47
HELEN 45
QUEENIE 45
IDA 50
MAGGIE 48
INEZ 47
SUSAN 45
RUTH 47
JUDITH 49
TESS 45
HELENA 47
FLO 46


SEPTEMBER
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
LAURA
MADELINE
NANETTE
47
VERNA
45
MILDRED
47
JACKIE
KATHLEEN
KEZIA
LIBBY 48
IONE 48
PRISCILLA 46
QUERIDA 46
IDA
45
WANDA
45 URSULA
45 ALMA
46
HAZEL
48
JEAN
45
OPAL
46
KIT
48



RUBY '50
PATRICIA '49
OLGA '48
PAULINE '47
OSSIA '50
OMELIA '49
BEATRICE '47
MARIE '45
CATHY '47
PETE '50
NORMA '48
ROSALIND '47
KATE '45
PAT '48
OLIVE '47
MARTHA '48
LOUISE '45
ALICE '47
OCTOBER
LEGEND
STORM INTENSITY
TYPHOON INTENSITY


NOVEMBER
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
AGNES 48
ALLYN 49
50
DIANE 48
RITA 49
NORA 45
DORA 47
FLORA 47
HANNAH 47
CLARA 50
ELNORA 47
DELILAH 50
RENA 49
YVONNE 45


DECEMBER
LEGEND
STORM INTENSITY
TYPHOON INTENSITY
BEVERLY 48
JEAN 47
CAMILLA 49
HELEN 49
FRAN 50
WEST FROM GREENWICH
EAST FROM GREENWICH