CHAPTER I

OPERATIONAL PROCEDURES

A. GENERAL

Operational procedures involve the use of analysis and forecast aids, in the preparation sequence prior to issuing the warning. Within the Fleet Weather Central/ Joint Typhoon Warning Center (FWC/JTWC), the basic analysis is the responsibility of the Fleet Weather Central (FWC). Micro-analysis, forecast aid evaluation and the warnings as described below are the functions of the Joint Typhoon Warning Center (JTWC).

B. ANALYSIS - FWC/JTWC

1. Types of contour and/or streamline charts with standard times:

a. Surface, 0000Z, 0600Z, 1200Z and 1800Z.
b. Gradient level (2000 to 3000 ft above ground) 0000Z and 1200Z.
c. 850mb, 0000Z and 1200Z.
d. 700mb, 0000Z and 1200Z.
e. 500mb, 0000Z and 1200Z.
f. 300mb, 0000Z and 1200Z.
g. 200mb, 0000Z and 1200Z.

2. Cross Sections:

a. Checkerboards or Stidd Diagram.
b. Time Cross Sections analyzed for θe.
c. Space Cross Sections.

3. Micro-Analysis:

a. Sectional charts, hourly and 3-hourly as required.
b. Reconnaissance reports.

4. Easterly Wave Continuity Graph.

C. FORECAST AIDS

These are listed in alphabetical order and priority of importance is not indicated.

1. Climatology

Upon detection of a tropical cyclone and in preparation for issuance of the initial warning, a track based on climatology is developed. This track is prepared for a time interval of 4 or 5 days at the speed indicated by climatology. The following climatological publications are utilized when constructing the original forecast track for each cyclone:

a. Climatological Aid to Forecasting Typhoon Movement (1st Weather Wing)

b. Western Pacific Typhoon Tracks 1950-1959 (FWC/JTWC)

c. Far East Climatic Atlas (1st Weather Wing - February 1963)

d. Tropical Cyclones in the Western Pacific and China Sea Area (Royal Observatory, Hong Kong). This comprehensive publication covers 78 years of typhoon tracks.

Next, the track is modified in accordance with the existing and forecast upper air pattern, after which the initial warning is prepared and issued. The forecast track is extended and modified with time, as reconnaissance fixes are received and the synoptic upper air pattern changes.

2. Computer Products

During the 1963 Typhoon Season the following computer products were received and used extensively by JTWC:

a. From FNWF Monterey

(1) Steering Computations, or forecast positions, for 6, 12, 18, 24, 36, 48 and 72 hours for TD's, TS's and Typhoons (as requested by JTWC). These computations are prepared at 0000Z, 0600Z, 1200Z and 1800Z daily.

(2) 700mb, 500mb, 300mb and 200mb height and wind analysis

(3) 700mb, 500mb, 300mb and 200mb 24-hour prog

(4) 700mb, 500mb, 300mb and 200mb 36-hour prog

(5) 48-hour 500mb height and wind prog

(6) 72-hour 500mb height and wind prog.
(7) 500mb Long Wave Analysis and 48-hour prog.

All of the Monterey products are based on a Barotropic model. Items (2) and (7) are received twice daily for the synoptic times 0000Z and 1200Z.

b. From NMC Suitland

(1) 12-hour 500mb height, wind and vorticity prog.
(2) 24-hour 500mb height, wind and vorticity prog.
(3) 36-hour 500mb height, wind and vorticity prog.
(4) 48-hour 500mb height and wind prog.
(5) 72-hour 500mb height and wind prog.
(6) NWP Barotropic prog positions for typhoons for 12, 24, 36, 48, 60 and 72 hours.

All NMC items are received twice daily for the synoptic times 0000Z and 1200Z. All items are based on a Barotropic Model with the exception of items (4) and (5) which are based on a Baroclinic Model.

c. JTWC utilized computer steering computations, computer prognostic constant pressure charts and synoptic analyses as the main tools for forecasting typhoon movement during the 1963 season. (See Chapter II for an explanation and evaluation of techniques).

3. Coordination

Routine coordination with other U. S. agencies is obtained prior to issuance of a warning. When a circulation for which warnings are being issued is north of 25N, Fuchu Air Force Weather Central transmits coordination forecasts twice daily to JTWC. Coordination with other Air Force and Navy activities is on an "as required" basis, depending upon the location of a particular tropical cyclone.

4. Statistical Methods

The Miller-Moore and the Arakawa methods were used by JTWC early in the 1963 season, but as computer products became more numerous, these statistical methods were eliminated because of limited time and personnel.

5. Surveillance Systems

See Chapter II for evaluations of aerial reconnaissance, land radar and satellites.

6. Seay Graph

A hydrostatic graph was computed to check the eye data pressure reports from reconnaissance aircraft penetration. It was found that quite often the transmitted sea level pressure (SLP) was in error in excess of 10mb.

The graph for finding maximum surface winds was based on seven years of reconnaissance data. The data, 1956 through 1962, was used to modify the equation of Captain Limon E. Fortner, Jr. (1956), Typhoon Sara, Bulletin of the American Meteorological Society, Vol. 39, pp. 633-639.

The equation, $V_{max} = (19 - \frac{\theta}{5}) \sqrt{372 - \frac{H7\,(ft)}{28}}$

was obtained from a best fit basis.

Where: V_{max} = maximum surface winds
θ = latitude of cyclone
H7 = minimum 700mb height

The equation, $V_{max} = -100 + \sqrt{500V_7}$

Where: V_{max} = maximum surface wind within the cyclone
V_7 = maximum 700mb wind at penetration

for converting maximum 700mb wind at penetration to maximum surface winds within the cyclone was derived from the seven years of data. The equation is not defined when the 700mb wind is less than 20 kts.

A straight line correlation between the 700mb height and the SLP does not always exist. The temperature at the 700mb level can vary with the same 700mb height and this varies the SLP. To correlate the maximum surface wind with the minimum SLP, the temperature at the 700mb level (Tropical Storm 14°C, Typhoon 17°C, Super Typhoon 22°C) must be used for accuracy.

7. Work Chart

This is an operational and recording tool used in preparing tropical cyclone warnings. The basic chart is one of the Pacific Air Ways Plotting Chart series, plus 3 acetate overlays. All aircraft and land radar fixes are plotted on the basic chart. Twenty-four hour forecast positions are plotted on the bottom overlay, warning positions are plotted on the second overlay and the top overlay is utilized as a worksheet. Green, red and black china marking pencils are used on the three acetates for instantaneous visual reference.

8. Decay Graph

The decay of typhoon winds over land for Japan, Korea and Taiwan was developed from four years of data (1959-1962) based on best tracks prepared by JTWC. The following equation was used to fit the best track data to a family of curves:

$$V = C_1 \sum_{n=1}^{\infty} \left[Vn \left(e^{-C_2 Vn \bar{Z}} + e^{-C_3 t} + e^{-C_4 \frac{\sin \varphi}{r}} \frac{\overline{\partial P}}{\partial t} \right) \right]$$

Where:

V = Maximum wind speed in meters/second at any given time period

$\bar{Z}$ = Mean altitude of land mass above sea-level in meters

t = Time in seconds using a time period for each calculation of three hours and t=0 when wall cloud strikes land

φ = Latitude of land strike

r = Radius of curvature of storm in meters measured from storm center to last closed isobar.

$\overline{\frac{\partial P}{\partial t}}$ = Mean central pressure change with time such that at $t=0$, $\frac{\partial P}{\partial t} = 0$. $C_1 = .33$, $C_2 = C_3 = 10^{-5}$, $C_4 = 5X10^8$

D. WARNINGS

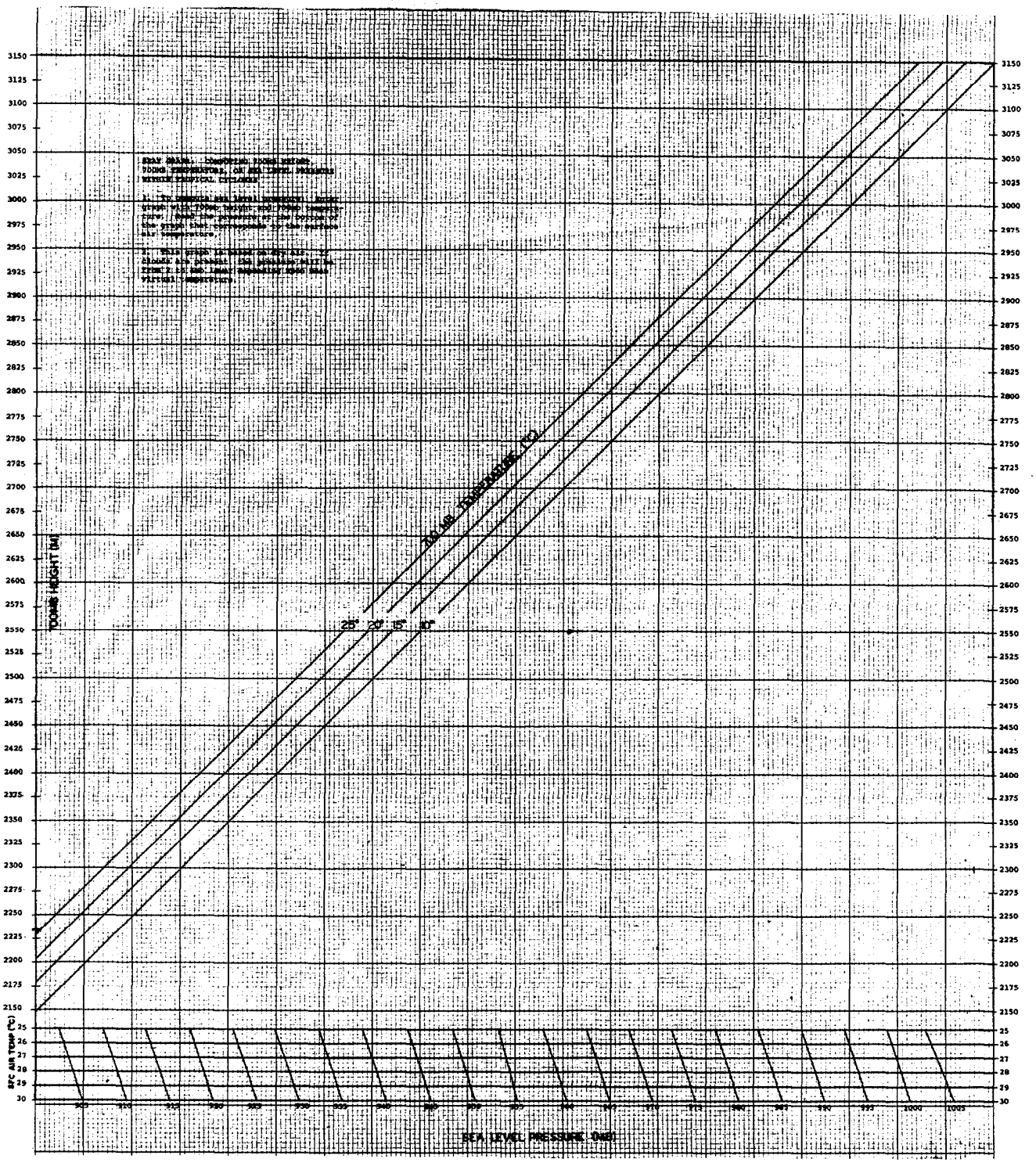
Warnings are filed and transmitted every six hours at synoptic times of 0000Z, 0600Z, 1200Z, and 1800Z. In accordance with CINCPAC INST 3140.1E, the message contains the present warning position of the tropical cyclone which is valid for the scheduled transmission time. This connotes that the 24 and 48 hour warning forecast positions are actually 30 and 54 hour forecasts from the last synoptic time.

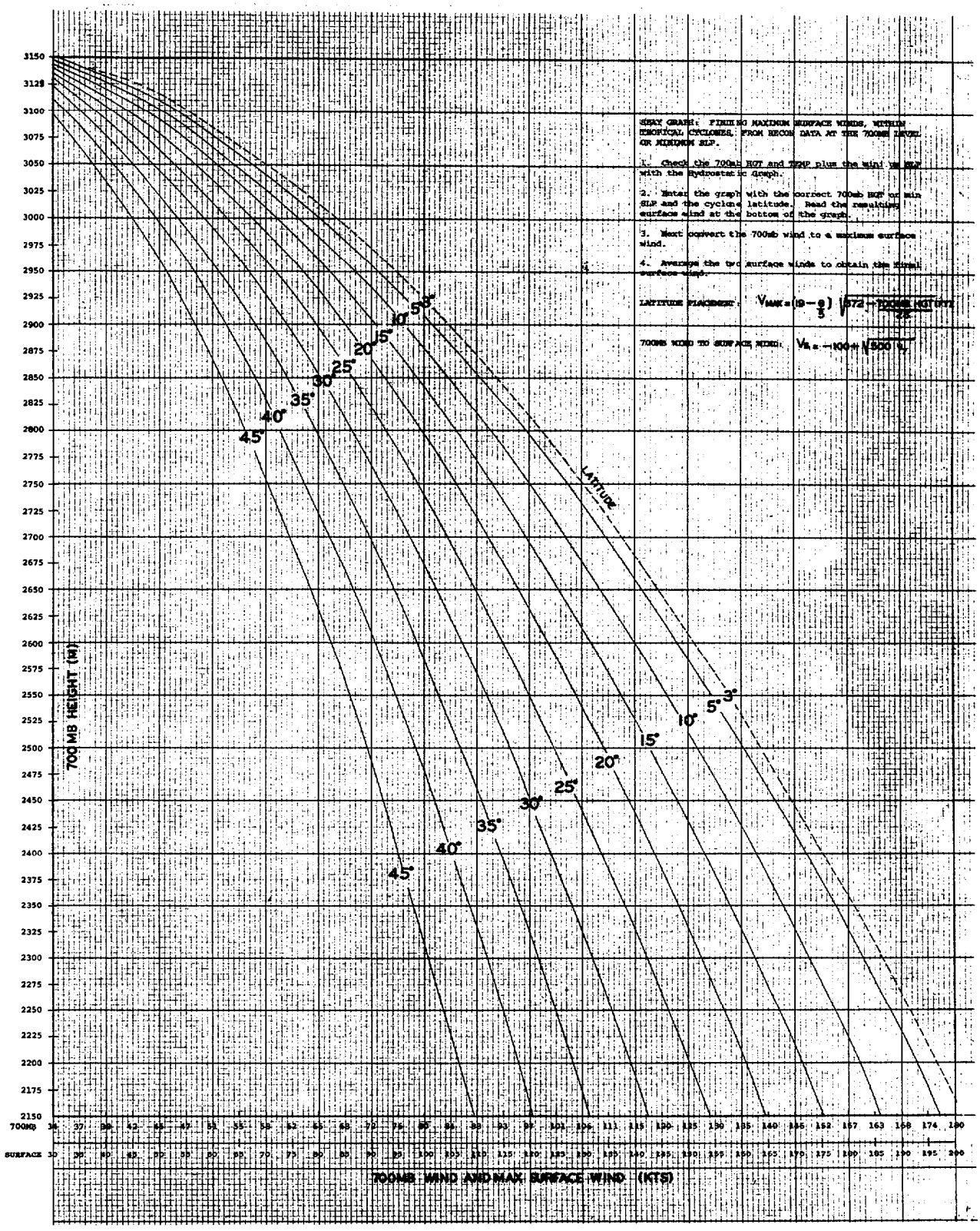
The warning position of a tropical cyclone is actually a short range forecast from the last "best" position. The last "best" position is usually about 2 hours old based on land radar, 2 to 3 hours old based on reconnaissance fixes, 3 to 6 hours old based on surface synoptic reports or 6 to 12 hours old based on upper-air synoptic reports. It is for this reason that the 0600Z warning, for example, may not agree with the position of the tropical cyclone as indicated by the 0600Z analysis. Amendments are issued when this difference is significant.

The numbers of tropical warnings run consecutively regardless of whether the cyclone is upgraded or downgraded from tropical depression, tropical storm or typhoon. If warnings are discontinued and the circulation regenerates, the new series of warnings are numbered consecutively from the number of the last warning of the previous series. As required, amendments and corrections are issued, and these are numbered the same as the warning which they amend or correct.

The 1963 Verification Summary is contained in Chapter III.

All 24, 48 and 72-hour forecasts made when a tropical cyclone is of tropical storm or typhoon intensity are verified against the "best" tracks at all latitudes through the last warning issued.


TOWER HEIGHT (M)
25°
20°
15°
10°
SEA LEVEL PRESSURE (MB)
8PC AIR TEMP (°C)


USAY GRAPH: FINDING MAXIMUM SURFACE WINDS, WITHIN TROPICAL CYCLONES, FROM RECON DATA AT THE 700MB LEVEL OR MINIMUM SLP.
1. Check the 700mb HGT and TEMP plus the wind or SLP with the Hydrostatic Graph.
2. Enter the graph with the correct 700mb HGT or min SLP and the cyclone latitude. Read the resulting surface wind at the bottom of the graph.
3. Next convert the 700mb wind to a maximum surface wind.
4. Average the two surface winds to obtain the final surface wind.
LATITUDE PLACEMENT:
700MB WIND TO SURFACE WIND:
700 MB HEIGHT (M)
LATITUDE
3°
5°
10°
15°
20°
25°
30°
35°
40°
45°
700MB
SURFACE
700MB WIND AND MAX SURFACE WIND (KTS)

$$V = C_1 \left[\sum_{n=1}^{\infty} Vn \left(e^{-C_2 Vn \bar{Z}} + e^{-C_3 t} + e^{-C_4 \frac{\sin \varphi}{r} \frac{\partial \bar{P}}{\partial t}} \right) \right]$$

Where:

V = Maximum wind speed in meters/second at any given time period

$\bar{Z}$ = Mean altitude of land mass above sea-level in meters

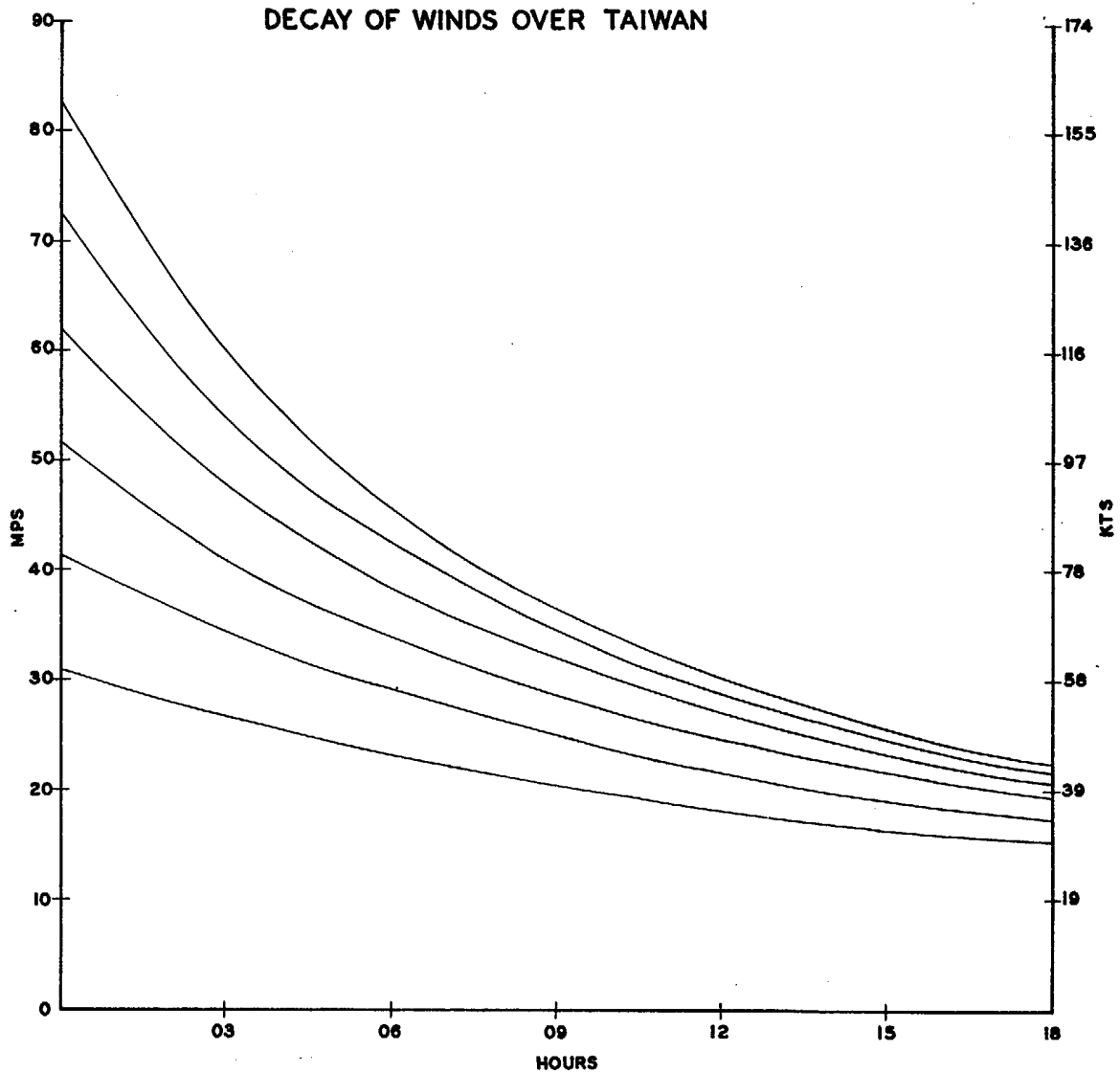
t = Time in seconds using a time period for each calculation of three hours and t=0 when wall cloud strikes land

φ = Latitude of land strike

r = Radius of curvature of storm in meters measured from storm center to last closed isobar

$\frac{\partial \bar{P}}{\partial t}$ = Mean central pressure change with time such that at t=0, $\frac{\partial P}{\partial t} = 0$. $C_1 = .33$,

$C_2 = C_3 = 10^{-5}$, $C_4 = 5 \times 10^8$



$$V = C_1 \left[\sum_{n=1}^{\infty} Vn \left(e^{-C_2 Vn \bar{Z}} + e^{-C_3 t} + e^{-C_4 \frac{\sin \varphi}{r} \frac{\overline{\partial P}}{\partial t}} \right) \right]$$

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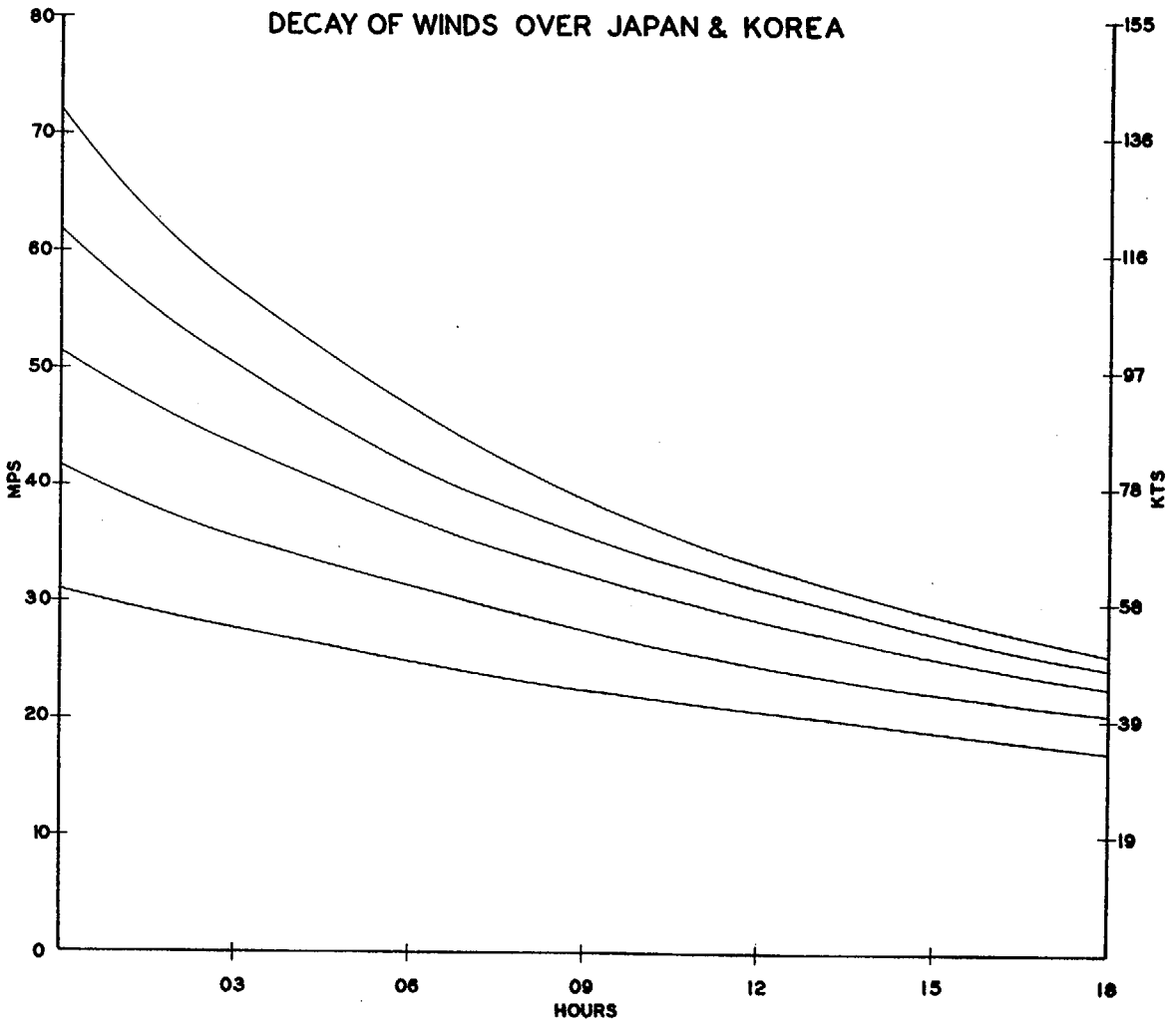
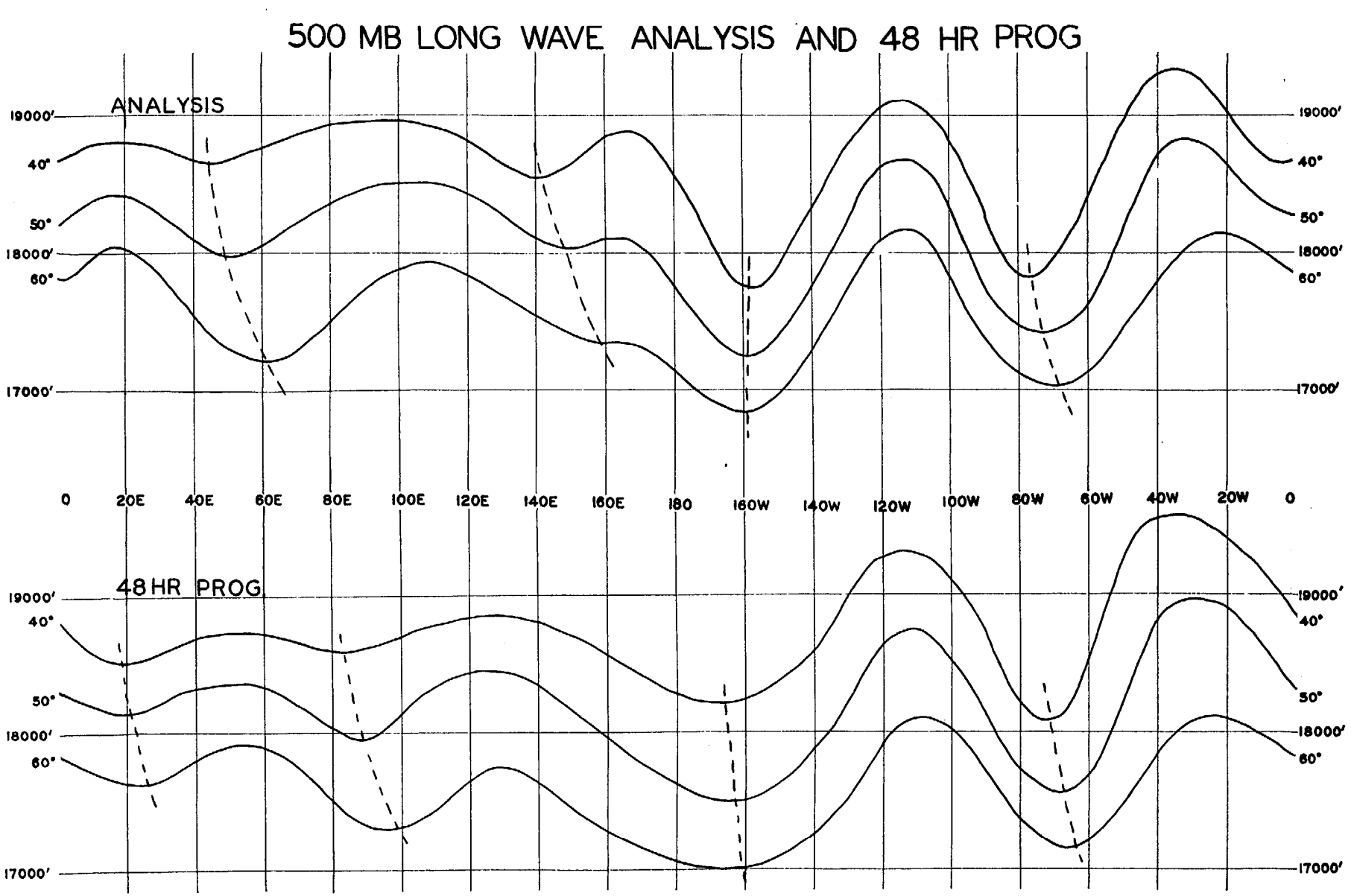
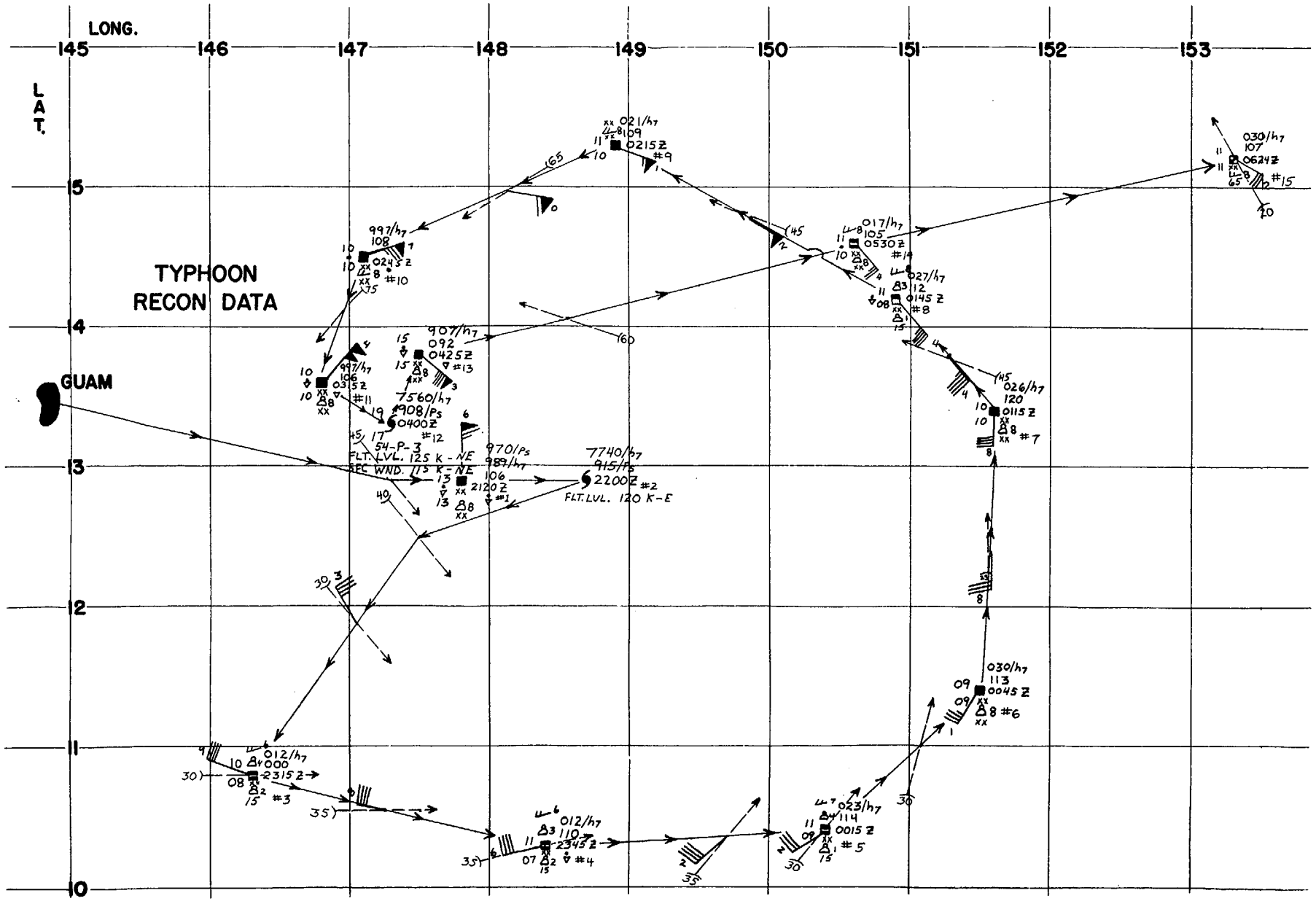
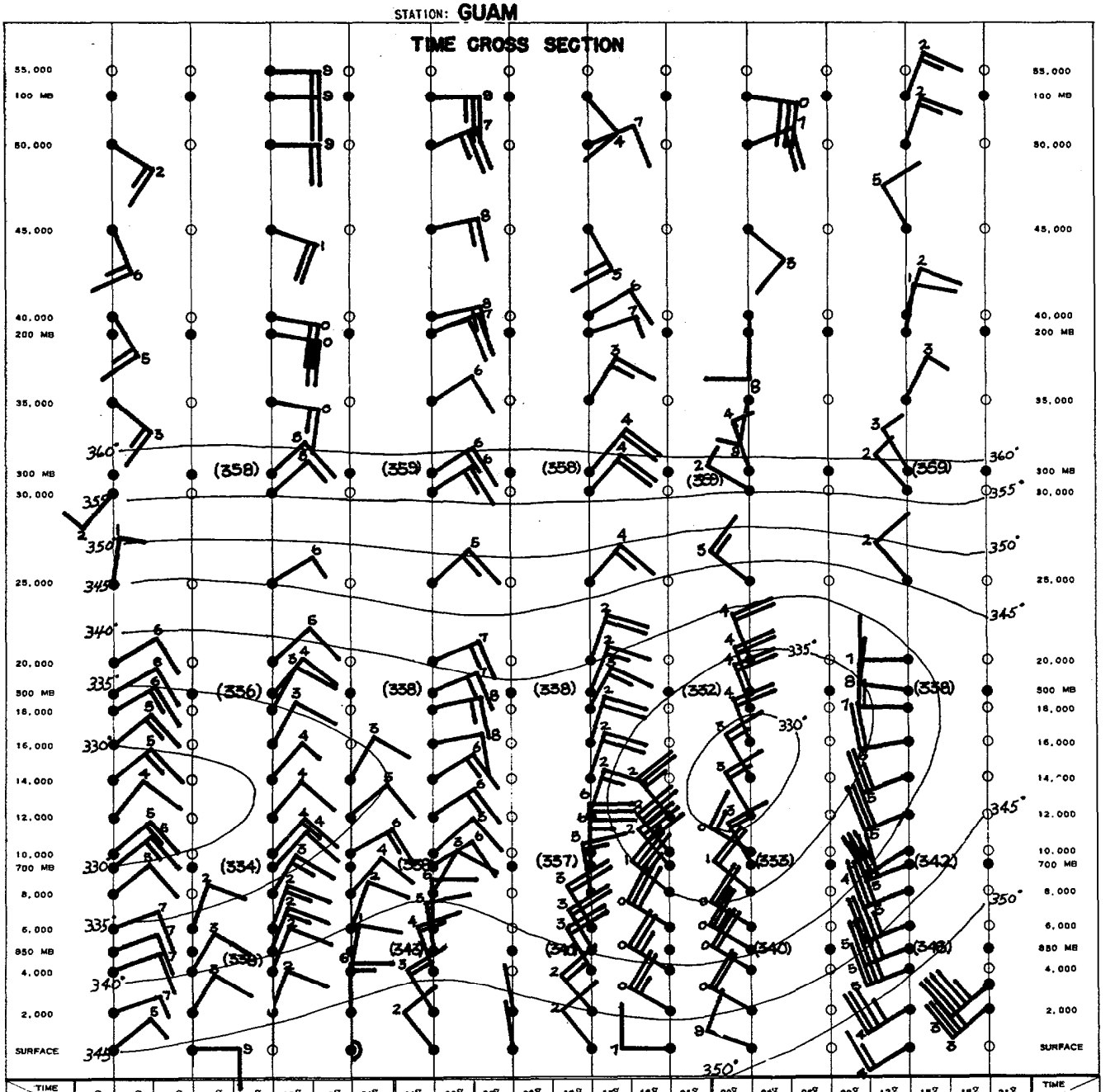



500 MB LONG WAVE ANALYSIS AND 48 HR PROG
ANALYSIS
19000'
40°
50°
18000'
60°
17000'
0
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
0
48 HR PROG
19000'
40°
50°
18000'
60°
17000'

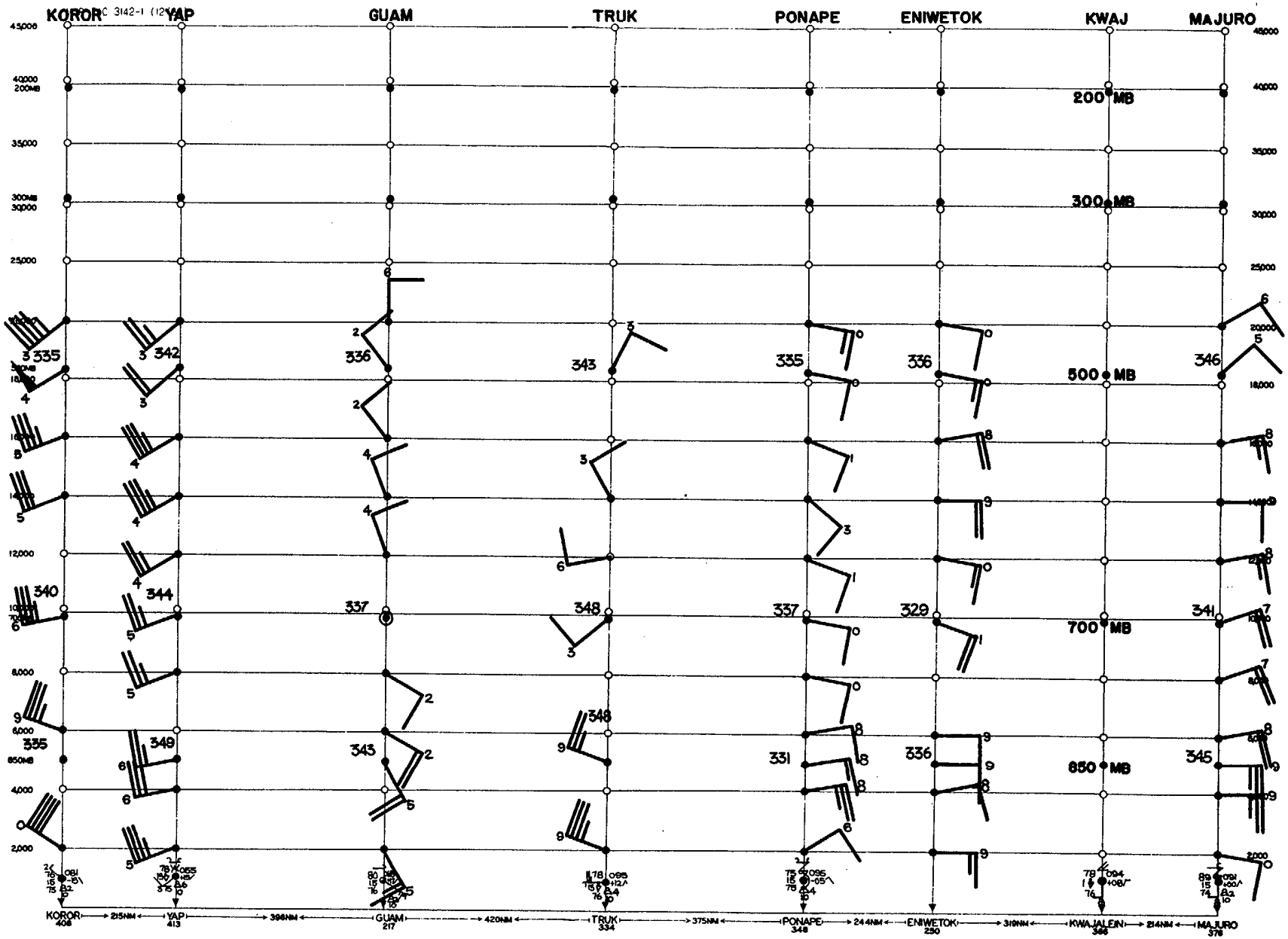

LONG.
145
146
147
148
149
150
151
152
153
LAT.
15
14
13
12
11
10
TYPHOON
RECON DATA
GUAM
021/h7
0215Z #9
997/h7
0243Z #10
907/h7
092
0425Z #13
997/h7
0315Z #11
7560/h7
1908/Ps
0400Z #12
54-P-3
FLT. LVL. 125 K - NE
SFC WND. 115 K - NE
970/Ps
989/h7
2120Z #1
7740/h7
915/Ps
2200Z #2
FLT. LVL. 120 K-E
017/h7
0530Z #14
027/h7
0145Z #8
026/h7
120
0115Z #7
030/h7
107
0624Z #15
030/h7
113
0045Z #6
023/h7
114
0015Z #5
012/h7
2345Z #4
012/h7
2315Z #3

STATION: **GUAM**

TIME CROSS SECTION



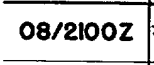
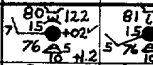
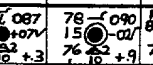
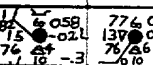
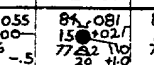
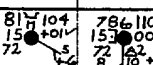
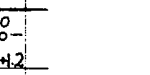
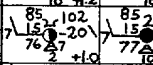
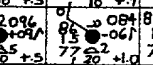
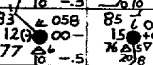
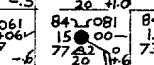
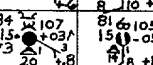
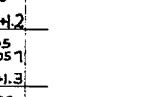
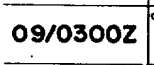
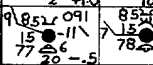
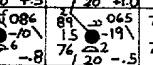
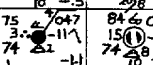
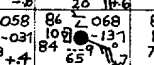
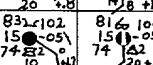
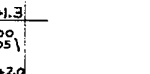
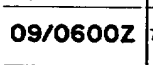
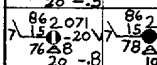
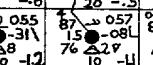
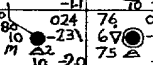
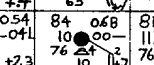
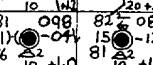
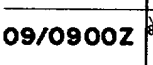
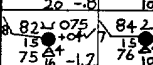
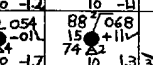
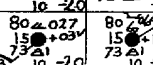
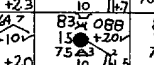
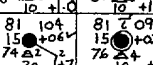
TIME / SFC DATA	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	TIME / SFC DATA
Ch																									Ch
Cm																									Cm
CL																									CL
N																									N
W																									W
ww																									ww
PPP	1010.5	1010.1	1008.9	1008.4	1010.4	1009.8	1008.0	1009.0	1008.3	1007.7	1006.0	1006.5	1007.0	1005.7	1004.4	1004.8	1005.8	1004.3	1003.7	1004.7	1006.9	1005.7	1004.9	1006.2	PPP
app	+03/	-02\	-08\	+05/	+10/	-07\	-19\	+12/	-02\	-12\	-17\	+05/	+05/	-1.9\	-1.4\	+05/	+07/	-1.2\	-07\	+10/	+1.2/	-02\	-08\	+1.4/	app
RR															.61		.24				.41				RR
24 HR Δ P	-0.2	-0.2	-0.5	-0.6	-0.6	-0.2	-1.9	MISG	-1.6	-2.8	-2.9	-2.9	-3.4	-4.3	-3.6	-4.2	—	-2.4	-2.3	—	-1.1	±0.0	+0.5	+0.4	24 HR Δ P
Δ p̄																									Δ p̄



SPACE CROSS SECTION (KOROR-MAJURO)

SCALE: 1" = 110NM
FWC/JTWC DEC 1960

STIDD DIAGRAM

TIME Z / DATE	KORORO	YAP	GUAM	TRUK	PONAPE	ENI-WETOK	KWAJ.	MAJURO
08/2100Z								
09/0000Z								
09/0300Z								
09/0600Z								
09/0900Z								
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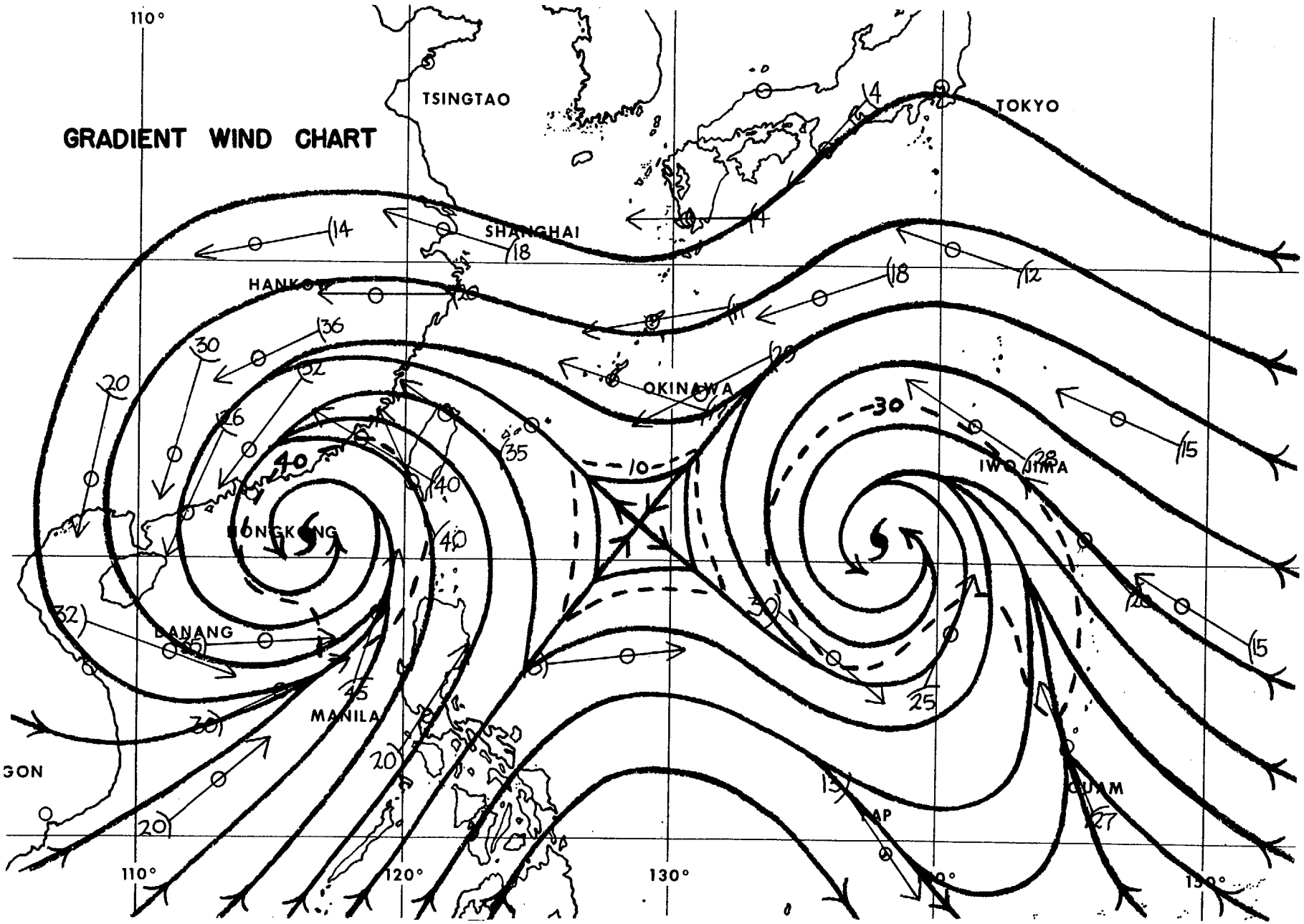
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