SECTION IV

DISCUSSION AND EVALUATION
OF INITIAL DETECTION,
FORECAST TECHNIQUES EMPLOYED
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A. DETECTION TECHNIQUES

Extremely important to the JTWC in detecting tropical cyclones in the formative stages of development were the surface and upper air reports from the Trust Territory Islands and Guam. The importance of these reports can be readily understood since, during the 1959 Typhoon Season, 13 of a total of 17 typhoons were first detected in the area of the Trust Territory Islands. The Trust Territory Island reporting stations are shown on page 29. During the Typhoon Season very careful analyses were made of the area encompassing the Trust Territory Islands, both for the surface and upper air levels. These detailed analyses often gave the first indications of a tropical cyclone in the initial stages of development. Also, very valuable tools in first detecting tropical cyclone development were the Stidd Diagram and Time Cross-section of the Winds Aloft. A Stidd Diagram, an example of which is shown on page 30, is maintained continuously throughout the year, and includes all of the Trust Territory Islands transmitting surface reports. Time Cross-sections of the Winds Aloft, one of which is included on page 31, are also continuously maintained on all Trust Territory Island stations taking RAWIN or PIBAL observations. Weather Observations from the Vulture Lima reconnaissance track (shown on page 29), ship reports, and reports from scheduled and unscheduled aircraft also provided additional information from which the initial formation of tropical cyclones could first be detected. Normally, during the Typhoon Season, the Vulture Lima track was flown at least every other day.

As soon as indications pointed to the development of a tropical cyclone, a reconnaissance aircraft was dispatched to the suspect area to confirm or deny the existence of a closed circulation on the surface. During the 1959 Typhoon Season, there were very few instances in which tropical cyclone warnings were issued prior to a reconnaissance aircraft confirming the existence of a closed surface circulation. It can be stated, without equivocation, that the existence of 95 percent of 1959 typhoons, tropical storms and depressions could not initially have been confirmed without aircraft reconnaissance. This is due to the sparsity of reporting stations in the tropical cyclone spawning area to the southeast of Guam.

B. FORECAST TECHNIQUES

For ease of operation in preparing tropical cyclone warnings, a basic chart plus three acetate overlays were used by the Typhoon Duty Officers. All reconnaissance and radar fixes were plotted on the basic chart. Forecast positions were plotted on the bottom overlay, warning positions on the second overlay, and the top overlay was utilized as a work sheet.

Once the existence of a tropical cyclone was confirmed, a track, based on climatology and the forecast high level flow, was projected forward on the work sheet through the recurvature point (if applicable). This long range forecast track was used as a guide, and was continually modified based on reconnaissance and changes in the upper air pattern.

Normally, a reconnaissance fix on all typhoons was received approximately two hours before each warning was issued. Each fix was carefully evaluated by the Typhoon Duty Officer in terms of the type of fix, the reported accuracy of navigation, and the basis of navigation. Each fix was also evaluated in terms of previous fixes, the best track to date, and the high level flow. In preparing warnings, particular care was exercised not to be unduly influenced by short period fix to fix trends. Typhoons appear to have minor oscilations in movement, but it has been observed, in most instances, that the underlying or basic track is a straight line or smooth curve.

Warnings were based largely upon the information contained in completed Warning Forecast Worksheets, an example of which is included on page 32. Some of the more important features of the Warning Forecast Worksheet are:

1. Twenty-four hour forecast by Malone: Malone is an objective method of forecasting hurricane movement developed under the supervision of Doctor T. F. Malone of the Travelers Weather Research Center, Hartford, Connecticut. The method was adopted directly for forecasting typhoon movement in the Pacific. Since the method is based on the climatology of Atlantic hurricanes, it undoubtedly is not completely valid for forecasting typhoon movement. The JTWC computed typhoon movement using this method throughout the 1959 Typhoon Season, and found the forecasts to be 30 percent less accurate than the forecasts contained in the warnings prepared by the JTWC.

2. Speed of movement computations: The speeds between the last evaluated fix and the past five warning positions were computed. Likewise, the speeds between the last warning position and the pre-

vious four warning positions are computed. One advantage of this procedure is that acceleration and deceleration can be readily detected.

3. Upper air discussion: A somewhat detailed discussion of the high level flow, and its possible steering effects on the tropical cyclone, has proven very useful. The JTWC Typhoon Duty Officers are of the opinion that fully developed typhoons are usually (except during strong polar outbreaks) steered by the flow above the highest closed contour around the typhoon. Generally, the best steering flow has been found to be at the 200 or 150 millibar level. High level movement and intensity trends of the semi-permanent Pacific subtropical high were observed to be important indicies with regard to the recurvature of typhoons. Post-analysis of the 1959 Typhoon Season has indicated that splitting of the subtropical high or ridge by eastward moving major troughs, and advective temperature effects on the intensity of the high or ridge, were invariably the determining factors as to when and where a typhoon would recurve. However, the complete lack of upper air data in the area of most frequent recurvature (the rectangle formed by Guam, Iwo-Jima, Taiwan and Clark Air Base) often precluded an accurate analysis in this critical area. For this reason, it is believed that forecasting typhoon recurvature will continue to be one of the major forecasting problems facing the JTWC.

It is appropriate to mention that typhoon forecasts provided by Tokyo Weather Central proved very useful. These forecasts, prepared using the space-mean technique, were transmitted to the JTWC twice daily whenever a typhoon had reached approximately 20 degrees north. In event the forecast differed significantly from that prepared by the JTWC, coordination was effected by radiotelephone.

Forecast error data for the 1959 Typhoon Season has been compiled and is included on page 33. The following "ground rules" were used for verifying forecasts: Forecasts were verified only when the cyclone was of tropical storm or typhoon intensity, and no forecasts were verified when the actual position of the storm or typhoon was north of 35 degrees.

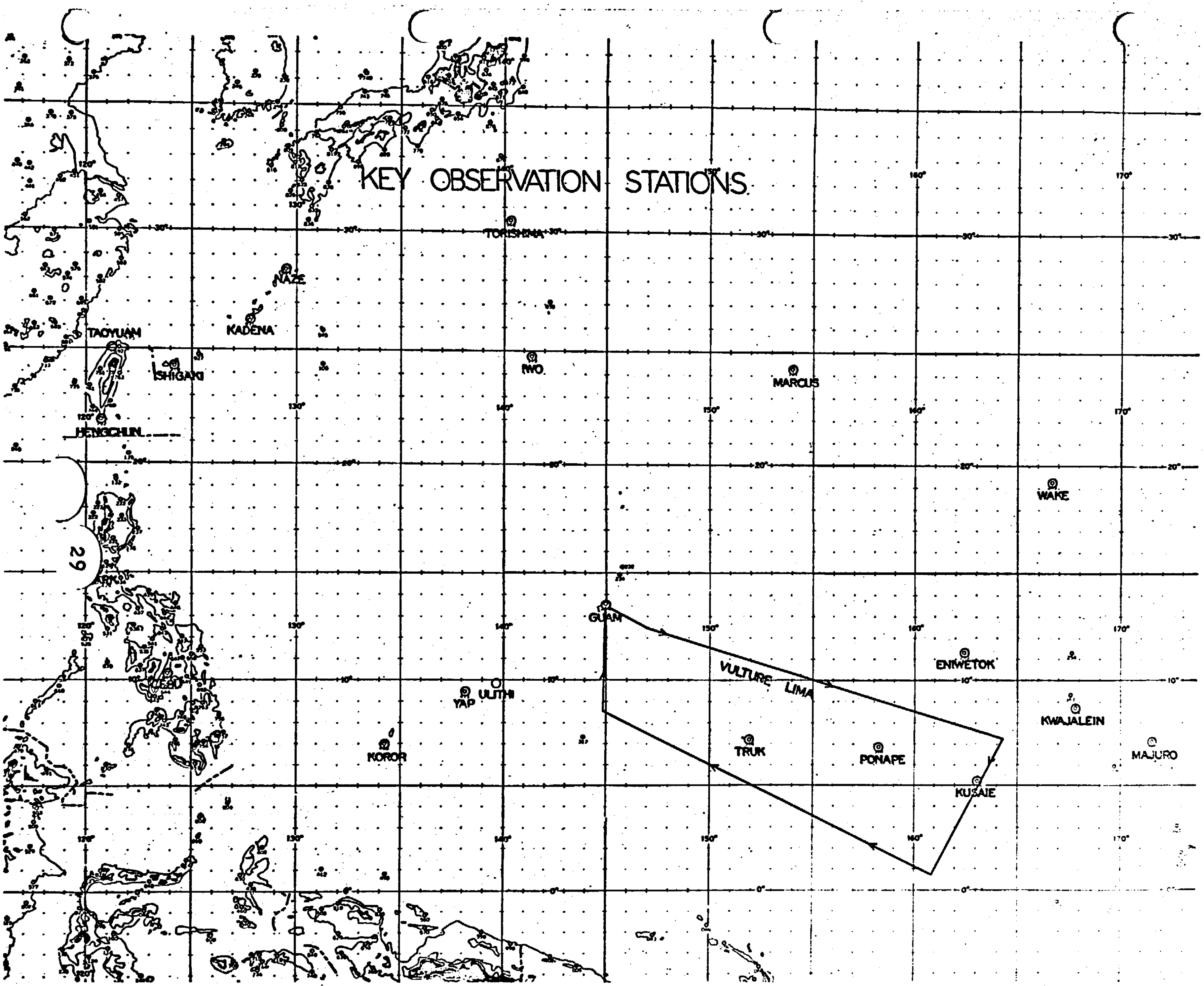
C. AIRCRAFT WEATHER RECONNAISSANCE

The tropical cyclone reconnaissance provided by the 54th Weather Reconnaissance Squadron during the 1959 Typhoon Season was outstanding. The cooperation of the commander, Lieutenant Colonel Dale D. Desper, and his entire organization was commendable. The spirit of cooperation which existed between the 54th Reconnaissance Squadron and the Fleet Weather Central/Joint Typhoon Warning Center is perhaps the major factor which contributed to the effectiveness of this joint organization during its first year of operation. Perusal of the chart on page 34 clearly shows that during the 1959 Typhoon Season the 54th Weather Reconnaissance Squadron efficiently discharged its assigned responsibility for typhoon reconnaissance in the Western Pacific. It should be noted that 98 percent of all fixes requested by the Joint Typhoon Warning Center were made.

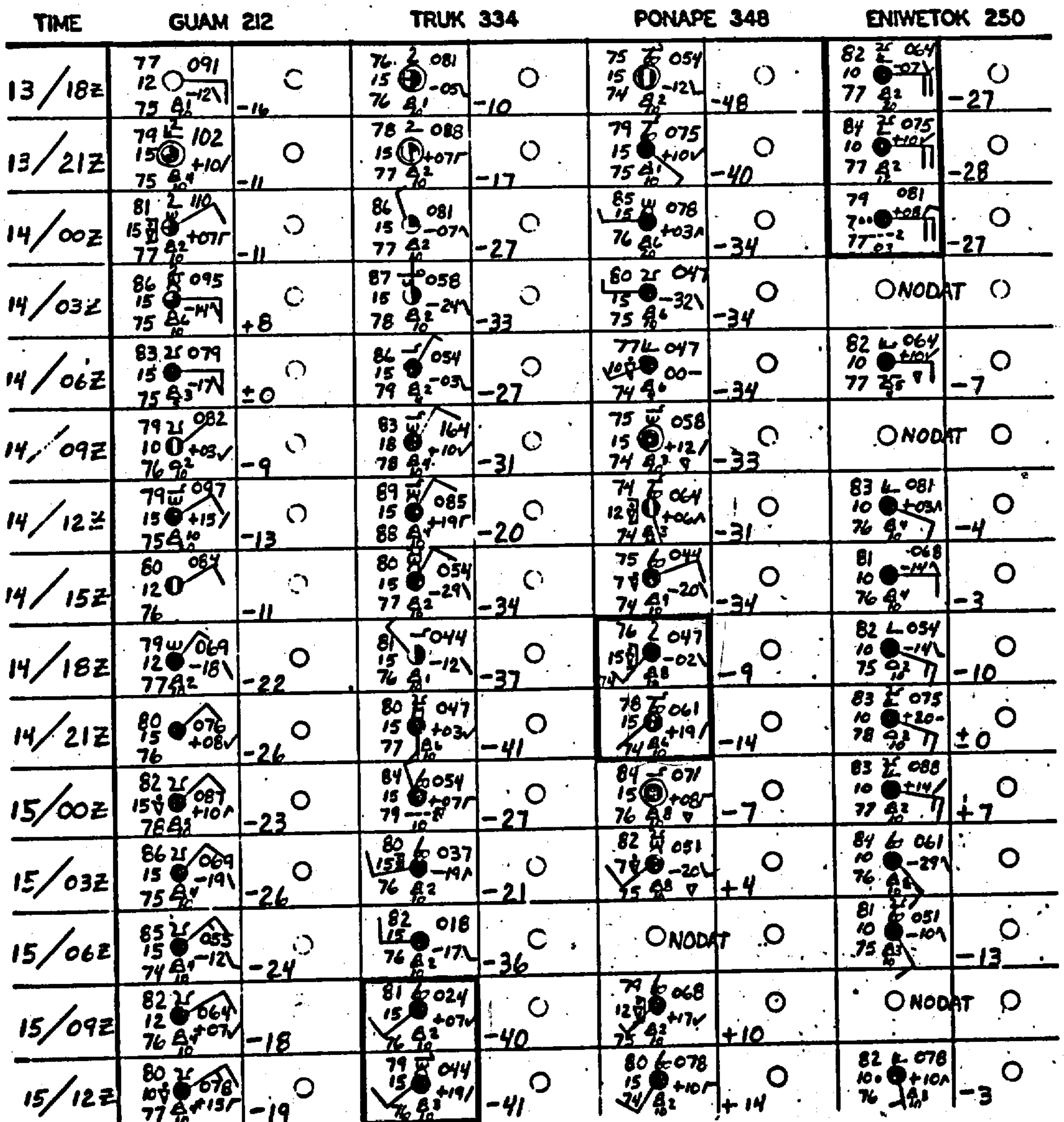
Additional units of the Air Force and Navy also provided the Joint Typhoon Warning Center with typhoon fixes which proved to be of invaluable assistance. The 56th Weather Reconnaissance Squadron made 21 fixes on diversions from fixed tracks; the 11th and 12th Tactical Reconnaissance Squadrons made 54 radar fixes; Navy BARPAC aircraft made 3 fixes on Typhoon PATSY; and an aircraft of Navy VW-3 Squadron made 3 fixes on Typhoon HARRIET.

The method used by the 54th Weather Reconnaissance Squadron wherein typhoons were penetrated at the 700 millibar level was found to be completely satisfactory. Occasional penetrations at the 500 millibar level were found to be less reliable for several reasons: (1) Difficulty was encountered in locating the eye. (2) Cloud cover often made it impossible to observe the surface, thus precluding a determination of the wind speed in the immediate vicinity of the typhoon center. (3) When observed, estimates of surface wind speeds tended to be less accurate than those made at the 700 millibar level.

There appears to be a high degree of correlation between the maximum wind speed reported by reconnaissance at the 700 millibar level in the vicinity of a fully developed typhoon and the maximum reported surface wind speed. In most cases, the maximum surface wind speed appears to be approximately 15 to 25 percent higher than the wind speed at the 700 millibar level. However, the foregoing statements are based on an incomplete investigation, and a more detailed study will be undertaken during the coming months. If a definite correlation can be established, a marked improvement should result in the accuracy of existing maximum wind speeds, as reported in issued typhoon warnings. It should be mentioned that the flight level wind measuring equipment, with which B-50 weather reconnaissance aircraft are now equipped, is extremely accurate. Winds measured with this equipment (APN/82, Doppler Navigation Equipment) are generally accurate to plus or minus one degree in direction, and plus or minus 5 knots in speed.

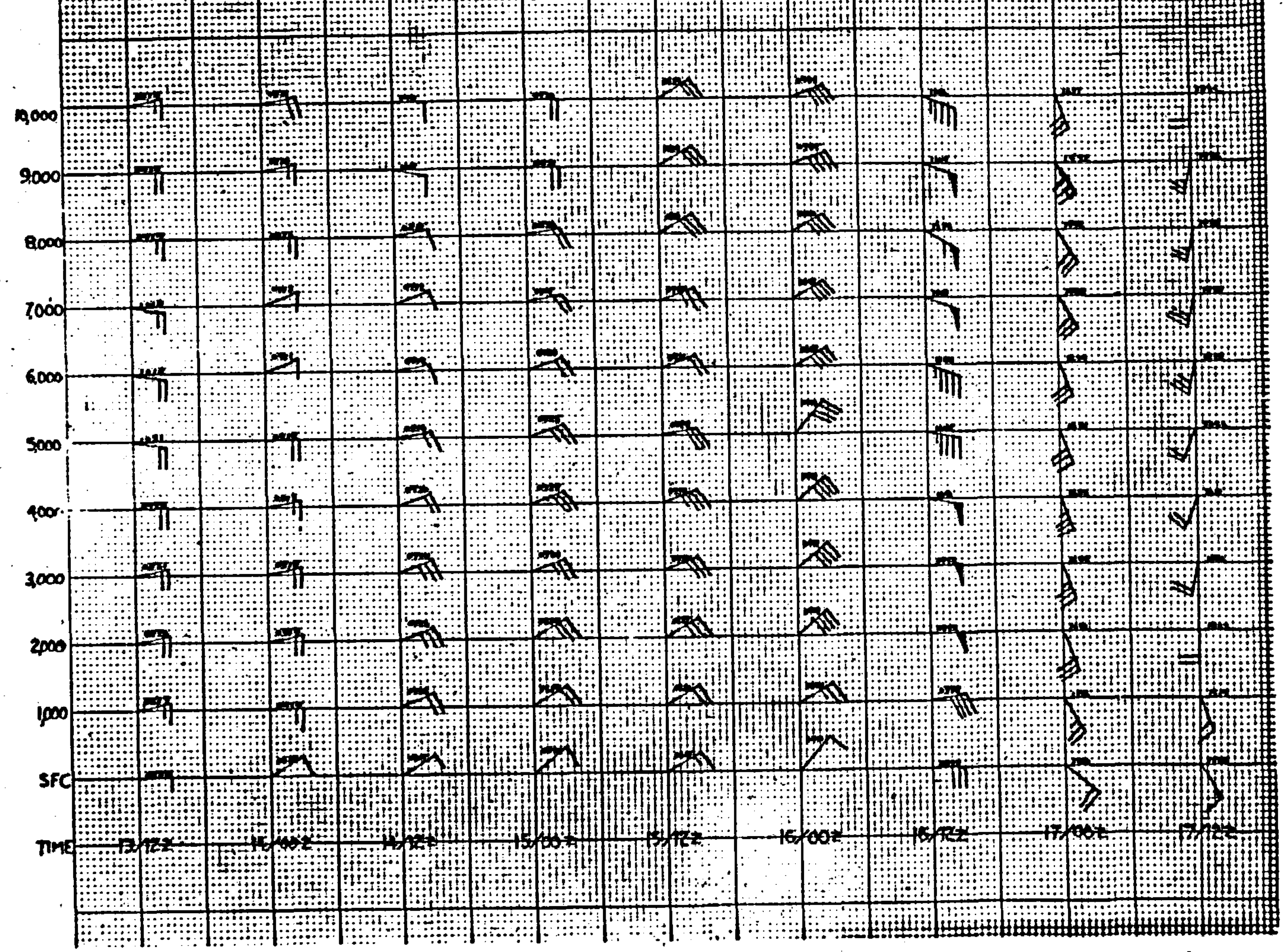

KEY OBSERVATION STATIONS
TORISHIMA
NAZE
KADENA
TAOYUAN
ISHIGAKI
HENGCHUN
IWO
MARCUS
WAKE
GUAM
VULTURE LIMA
ENIWETOK
YAP
ULITHI
KWAJALEIN
KOROR
TRUK
PONAPE
MAJURO
KUSAIE

STIDD DIAGRAM
(FIRST INDICATIONS OF DINAH)
OCTOBER 1959



TIME CROSS SECTION WINDS ALOFT

(GUAM – OCTOBER 1959 – TYPHOON DINAH)



WARNING FORECAST WORKSHEET

(TD) (TS) (TYPHOON): __________. WARNING #:___. SYN TIME: __________

TDO:________________________. MONTH AND YEAR: __________

1. TWENTY-FOUR HOUR FORECASTS: DIRECTION SPEED

MALONE: ________ ________

CLIMATOLOGY (statistics): ________ ________

CLIMATOLOGY (tracks): ________ ________

2. PAST MOVEMENT (SPEED): _____Z* _____Z* _____Z* _____Z* _____Z*
Latest Fix ______Z
To Past 5 Posits: _____ _____ _____ _____ _____
Latest Posit ______Z
To Past 4 Posits: _____ _____ _____ _____

3. BEST TRACK (PAST 24 HOURS): ______Deg.

4. UPPER AIR DISCUSSION: ____________________

(8 lines on actual form)

5. SURFACE DISCUSSION: ____________________

(3 lines on actual form)

6. INDICATIONS OF INTENSIFICATION OR WEAKENING: ____________________

7. FINAL ASSESSMENT: ____________________

(6 lines on actual form)

8. FORECAST MOVEMENT: **1ST 12HRS **12-24HRS **1ST 24HRS 24-48HRS

Deg/Kts: ________ ________ ________ ________

*-- Time of past posits in chronological order.
**-- Use as applicable.

TYPHOON FORECASTS ERRORS

TYPHOON	12 HR FORECASTS NO. OF CASES	12 HR FORECASTS MEAN ERROR (NM)	24 HR FORECASTS NO. OF CASES	24 HR FORECASTS MEAN ERROR (NM)	48 HR FORECASTS NO. OF CASES	48 HR FORECASTS MEAN ERROR (NM)
TILDA	34	43.9	32	94.6	NONE MADE	
BILLIE	16	64.1	15	106.4	13	247.9
ELLEN	24	74.7	23	158.8	19	290.8
GEORGIA	9	122.3	7	236.0	3	596.0
IRIS	11	47.5	9	123.8	5	309.4
JOAN	22	57.1	20	105.7	16	228.6
LOUISE	17	46.8	16	114.6	16	290.8
PATSY	16	113.4	14	205.6	4	360.8
SARAH	20	43.8	18	105.4	14	269.7
VERA	17	42.5	15	87.3	11	160.8
AMY	13	78.1	11	176.8	7	355.6
CHARLOTTE	34	48.0	32	98.6	28	310.3
DINAH	27	50.1	25	97.7	21	231.0
EMMA	27	69.1	25	149.4	21	335.7
FREDA	27	41.9	25	97.8	21	166.5
GILDA	30	35.1	29	74.9	25	178.2
HARRIET	35	46.5	33	100.9	29	272.7

AVERAGE ERROR - 12 HR FORECASTS (379 CASES) 55.6

AVERAGE ERROR - 24 HR FORECASTS (349 CASES) 115.5

AVERAGE ERROR - 48 HR FORECASTS (253 CASES) 262.1

54TH WEATHER RECONNAISSANCE SQUADRON TYPHOON DATA

TYPHOON	MISSIONS FLOWN	TOTAL OBS.	TOTAL DROPS	FIXES REQUESTED	FIXES MADE	PENET FIXES	OTHER FIXES*
TILDA	14	313	17	35	32	25	7
BILLIE	10	205	21	13	12	9	3
ELLEN	13	262	33	22	21	18	4
GEORGIA	5	88	11	7	7	5	2
IRIS	6	110	18	10	10	10	3
JOAN	9	170	27	17	17	15	5
LOUISE	10	149	22	18	17	13	5
PATSY	4	85	13	4	4	4	0
SARAH	11	200	28	20	20	15	8
VERA	10	159	29	18	17	13	4
AMY	12	218	32	15	15	11	5
CHARLOTTE	22	386	57	44	44	28	16
DINAH	19	228	31	30	30	19	11
EMMA	22	349	64	36	36	27	9
FREDA	12	215	30	23	23	17	6
GILDA	16	277	42	36	36	23	10
HARRIET	20	385	36	43	41	28	15
TOTAL	215	3799	511	391	382	280	113

*Radar or Triangulation Fixes