TYPHOON FORMATION WITHIN THE ZONE OF THE INTERTROPICAL CONVERGENCE

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ABSTRACT

A case study of the early development of typhoon Marie (October 1966) revealed that this storm formed and intensified within the zone of the ITC. Satellite photographs, including infrared read-out during the night-time hours were obtained over the area of formation successively every 12 hr. with only one missing observation. 700- and 200-mb. streamline analyses are presented in relationship to these observations which include reconnaissance data obtained by the author as a pilot on flights into the storm. The development of Marie suggests a sequence of events which may be applicable to the development of other storms, particularly those occurring in early spring or the fall of the year. Four separate stages of development are shown covering the period prior to generation of vortical centers to that time when near typhoon intensity was attained.

1. INTRODUCTION

Tropical cyclones in the Western Pacific have been considered to have originated primarily in one of three ways: 1) as the result of the generation and intensification of an embedded vortex within an easterly wave; 2) as the result of the generation and intensification of a vortex associated with the zone of the intertropical convergence (ITC) or equatorial trough; and, finally, 3) as the result of the intensification and impression through lower levels of an initial upper-level cyclonic circulation. Well-documented case studies of these different methods of origin are very sparse in current literature due primarily to the lack of conventional data in and surrounding the areas of origin. The availability of satellite data during the past 7 yr. has opened a new avenue, however, for promising investigations concerning these phenomena. The TIROS program shed much light on aspects of tropical cyclone development [1] but consecutive daily views during the complete period of formation were rarely, if ever, obtained. The advent of daily meteorological satellite pictures received during this past year over the Western Pacific has significantly changed this bleak, data-void picture. For the first time it is possible to present descriptive studies of the development process without the gaps encountered in the TIROS program. A well-documented collection of such studies is required before adequate models of typhoon generation can be formulated.

This paper contains an unprecedented series of photographs over the area of formation of typhoon Marie (October 1966). Not only were daylight pictures obtained every 24 hr. but interim night-time infrared data were also obtained with only one missing observation.[1] In addition, reconnaissance information was obtained by the author on flights into the storm during the latter portion of the formative period.

The results of this study indicate that Marie formed and developed *in situ* within the zone of the ITC. A schematic depiction of the sequence of events observed in this study is presented in summation of the complete case which follows.

2. THE PICTURES AND ANALYSES

For purposes of this study the 700-mb. level was selected to show representative features of low level conditions. Waves and vortices in the Tropics in early stages of development are frequently better defined at this level and supporting reconnaissance information was obtained at this level. Upper-level conditions are shown on selected 200-mb. analyses. Actual work charts, continuity charts, space and time sections which supported the study were examined at all levels and influenced the locations of features on the 700- and 200-mb. analyses.

Figure 1 shows the 700-mb. streamline analysis for Oct. 24, 1966, at 0000 GMT. Notable in this analysis is the asymptote of convergence between 170°E. and 160°W., which separates northeasterly trade winds of the Northern Hemisphere from southeasterly trades of the Southern Hemisphere. But this is the definition of what has been called the Intertropical Convergence Zone. When this zone is active and actual mass convergence is taking place one might anticipate the development of a considerable amount of convective cloudiness within its confines. ESSA 2 pictures received at 24/0046 GMT reveal little significant cloudiness, however, along the convergence asymptote in the area of interest west of 180°.

An examination of Nimbus infrared data received on October 24 at 1219 GMT also indicated that the entire zone from 170°E. to 170°W. and from 5°S. to 10°N. was generally cloud free. Twelve hours later ESSA 2 and Nimbus pictures were received over the area at

[1] All pictures presented in this study are of the operational product received at Fleet Weather Facility, Agana, Guam. Although the pictures are not all of uniformly high quality, details important for the study are readily apparent. Analyses presented are adapted from the operational product also prepared at Fleet Weather Facility.

24/2148 GMT and 25/0011 GMT respectively. At this time a considerable amount of cloudiness was generated in the area between Ponape and Majuro. The main outline of the essentially overcast cloudiness observed has been traced onto the 700-mb. analysis for 25/0000 GMT shown in figure 2. This figure indicates that a transformation of the simple asymptote of convergence had taken place coincidently with the development of a considerable amount of cloudiness. A streamline trough is shown passing through the area of Kwajalein. ESSA 2 pictures obtained in the same area on 25/2036 GMT, 24 hr. later, are shown in figure 3. Note that the major characteristic of this cloudiness is its alignment in a band approximately 300 mi. wide stretching from east to west over a distance of at least 1,800 mi. This is perhaps an almost classic picture of what has been termed ITC cloudiness. The 700-mb. analysis (fig. 4) valid less than 4 hr. after the ESSA 2 pictures were taken revealed that the wind field about the ITC was completely transformed at this time from a field showing a simple asymptote of convergence into a field dominated by a streamline trough. It is difficult to explain the formation of this trough. However, one may speculate that its formation was aided by a lowering of pressure within the zone due to the release of latent heat attending the increased cumulonimbus production shown in the satellite photographs. Upper-level conditions may also have been an equally important factor. At 200 mb. a ridge line was located directly over the convective cloudiness. Such a feature favors upper-level divergence necessary for the maintenance of low pressure at the surface. If this line of reasoning were correct the configuration shown in figure 4 could be interpreted to represent an active ITC which had been transformed from an earlier, less developed state. Note that, as in the classic model of an easterly wave, cloudiness is generally restricted to locations east and in this case south of the trough axis.[2] This cloudiness distribution is anticipated for a wave pattern embedded in easterly flow where the winds are moving through the wave pattern at a speed greater than the movement of the wave axis. This reasoning holds equally well for a trough in the easterlies oriented more nearly east-west or east-northeast–west-southwest.

Figure 5 shows a Nimbus night-time infrared view of the area. A continuation of the banded cloudiness noted earlier is still evident confined broadly between latitudes 5°–10° N. The cloud element near the western end of the band between 5°N.–10°N. and 160°E.–165°E. is of special interest. In an earlier study prepared by the author [1] the formative stages of tropical cyclones were separated into four progressive stages of development—A through D (fig. 6). The first indication of a closed circulation appeared in Stage B. At this time a comma-like cloud form was generated with the head of the comma near the center of circulation and the tail of the comma broadened in a sweep to the south. Note that the cloud in figure 5 is a virtual duplicate of the lower extremity of the cloud area depicted in the model formation of Stage B. Thus a closed center is suggested by this picture at approximately 7.5°N., 160°E. Such an interpretation normally would not have been applied in the author's previous study since ITC bands were omitted from the sample considered.

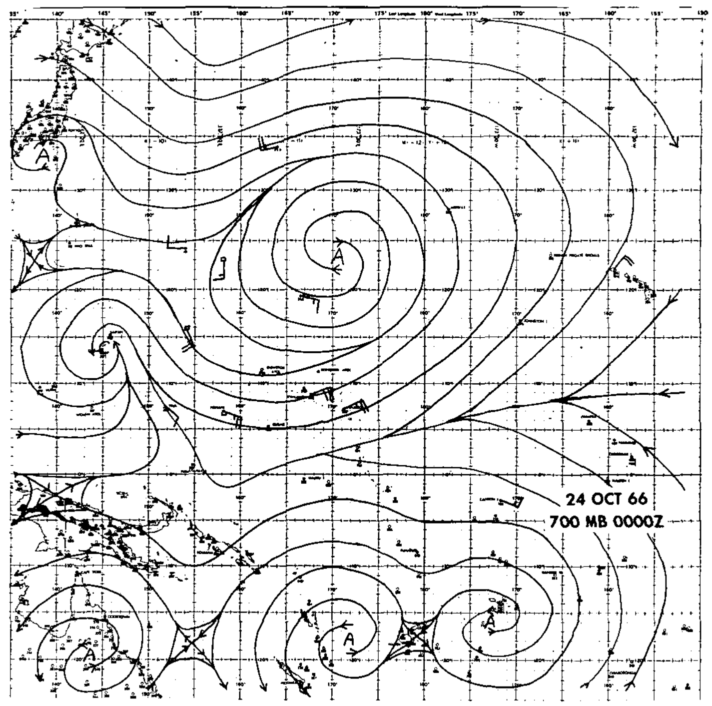

FIGURE 1.—700-mb. streamline analysis for Oct. 24, 1966, at 0000 GMT.

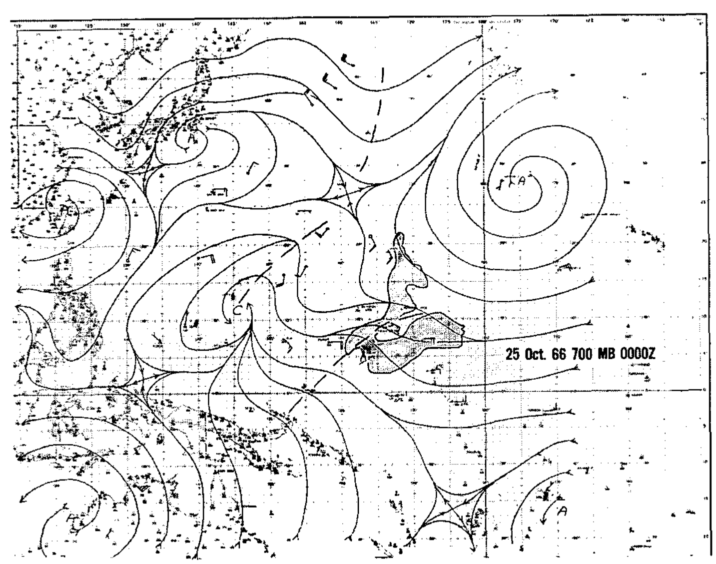

FIGURE 2.—700-mb. streamline analysis for Oct. 25, 1966, at 0000 GMT. Cloud patterns observed by ESSA 2 and Nimbus, at 24/2148 GMT and 25/0011 GMT respectively, are superimposed on this analysis.

[2] Cloudiness west of the trough axis near Ponape may have been an indication of the intensification of the trough in that area or alternately of cloudiness at some higher level swept westward beyond the lower level trough axis.

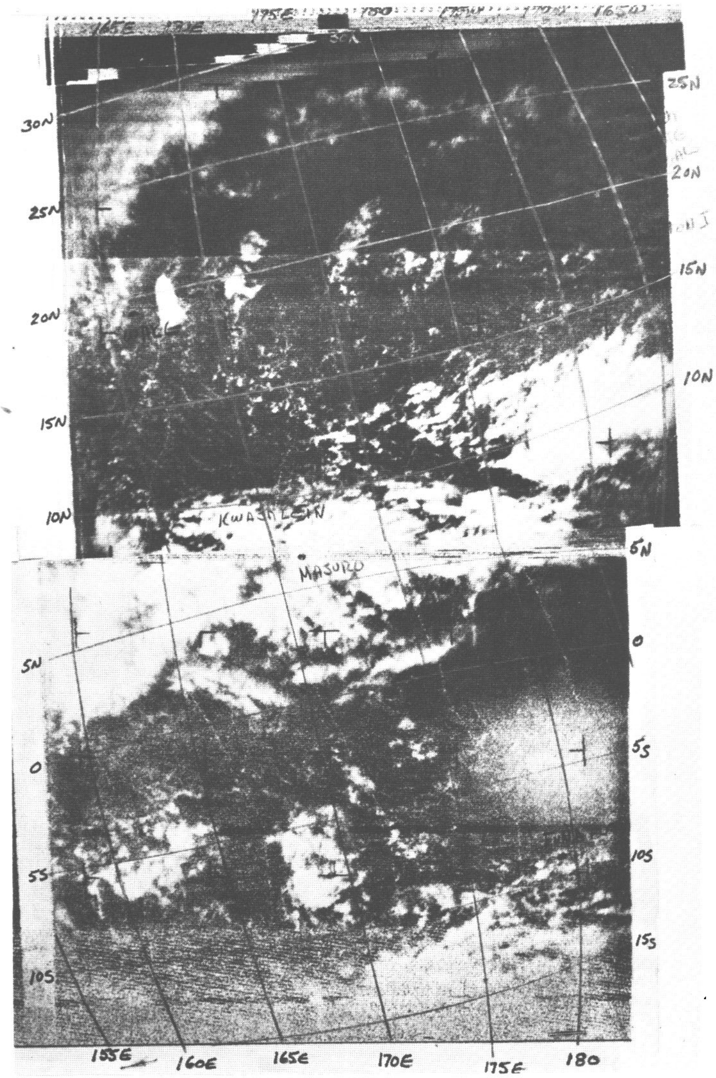

FIGURE 3.—ESSA 2 pictures of the ITC on Oct. 25, 1966, at 2036 GMT.

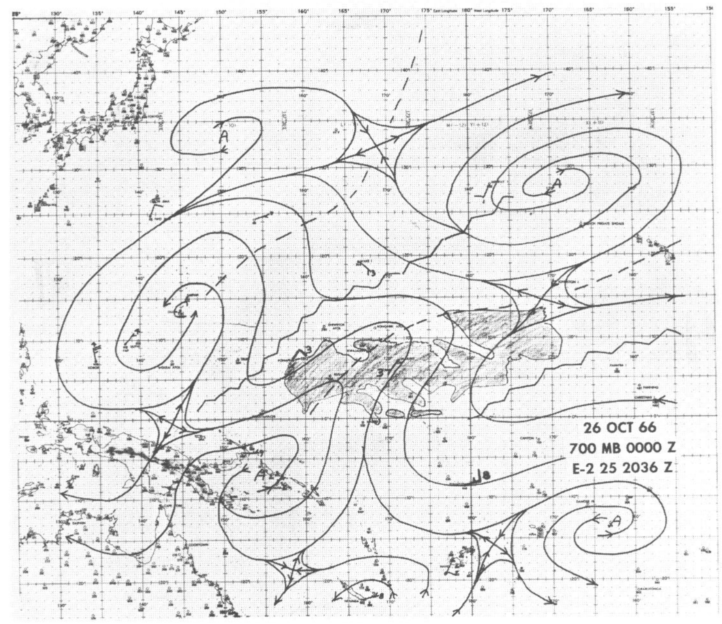

FIGURE 4.—700-mb. streamline analysis for Oct. 26, 1966, at 0000 GMT. Cloud patterns revealed in figure 3 are superimposed on this analysis.

However, there is no reason to assume that vortices generated within the ITC would not display similar pattern transformations if the wind flow within the pattern were not too dissimilar from that of the typical easterly wave. The 700-mb. analysis for October 26, at 1200 GMT (fig. 7), reveals that generally southeasterly flow prevailed through the area of cloudiness of the ITC similar to an easterly wave configuration. The trough had moved only slightly northward during the 12 hr. since the preceding analysis. Note that the closed circulation suggested by the satellite IR photographs near 7.5°N., 160°E., is substantiated in the analysis.[3] Although winds over Ponape at the 700-mb. level and higher were easterly, all lower level winds were westerly and at the surface southwesterly indicating the presence of a low pressure center to the north. Eniwetok's winds at the same time were continuously easterly from the surface through the 500-mb. level. This combined evidence is sufficient to suggest a vortex between the two stations below 700 mb. In fact this same vortex was maintained with good evidence and continuity on succeeding charts and was destined to develop into tropical depression #34(T.D.#34).

In figure 8 ESSA 2 TV pictures for the next day are shown. A continuation of heavy, banded, convective activity is evident along the ITC. The picture is not clear enough to locate accurately any specific centers of circulation within this cloudiness zone. To the north a polar front is clearly depicted. Surface winds behind the front, west of 180°, were northeasterly with some ships reporting wind speeds of 30 kt. General northeasterly flow also prevailed in the more open area between the two systems. The movement of the frontal system southward and the ITC band northward during the period to be described gradually resulted in an increased pressure gradient between the two systems. Wind speeds over Wake Island (near 19.5°N., 166.5°E.), for example, reflected the increased pressure gradient as shown by the 2,000-ft. winds in table 1. The progressively increasing wind speeds cover the period up to the final observations on October 30 when Marie first attained tropical storm intensity of 35 kt. At this time the center of the storm was still over 240 n.mi. from Wake. The author flew initial reconnaissance into the area of Marie during the period October 29 at 0145 GMT until October 29 at 0445 GMT. At this time maximum surface winds within approximately 100 n.mi.

[3] The 8,000-ft. wind rather than the 700-mb. wind is drawn over Ponape to illustrate more nearly the geographical position of the vortex. The 700-mb. wind was east-northeasterly at less than 3 kt.

FIGURE 5.—Nimbus infrared read-out of data over the ITC on Oct. 26, 1966, at 1250 GMT.

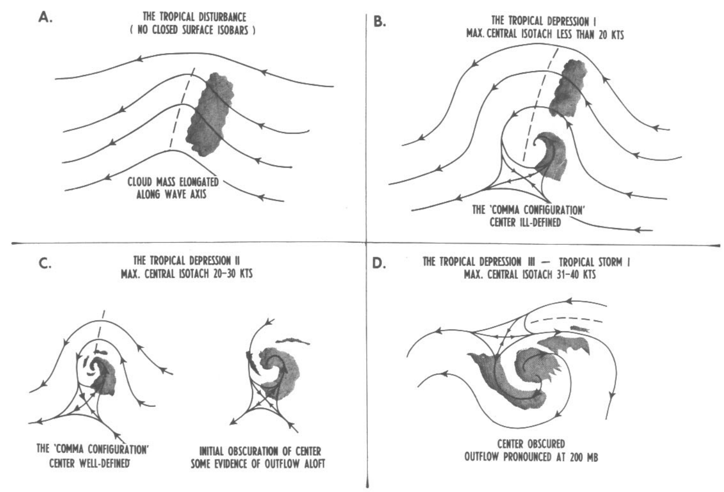

FIGURE 6.—Schematic model of the formative stages of tropical cyclone development based on satellite photographs [1].

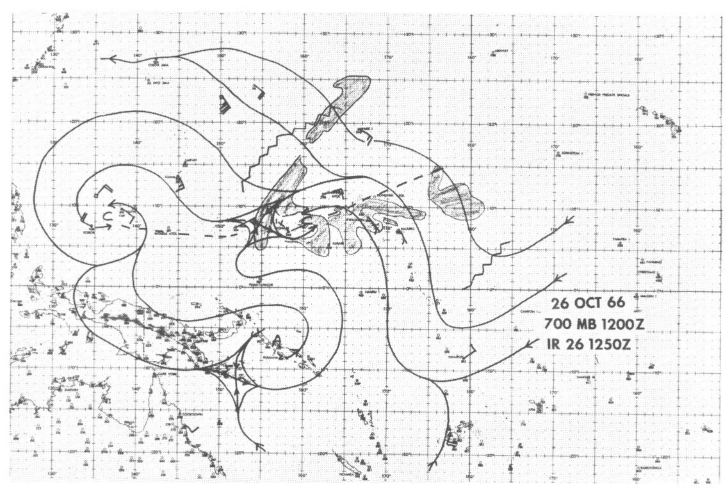

FIGURE 7.—700-mb. streamline analysis for Oct. 26, 1966, at 1200 GMT. Cloud patterns revealed in figure 5 are superimposed on this analysis.

TABLE 1.—*Wind directions and speeds at 2,000 ft. over Wake Island, Oct. 27–30, 1966*

Oct.	0000 GMT	1200 GMT
27	080/10 kt.	090/15 kt.
28	090/20 kt.	060/25 kt.
29	070/30 kt.	070/30 kt.
30	070/45 kt.	130/35 kt.

of the storm center (near 13.8°N., 168.8°E.), were only approximately 5 to 10 kt. Wake's surface winds at the same time were 20 to 25 kt. and stronger at higher levels. Thus considerable cyclonic vorticity existed due to the speed shear between the storm center and the area to the north. It is this factor which is believed to have been an important element leading to the rapid intensification of Marie at that time. With respect to this argument it is of interest to note that over the years numerous storms have been known to intensify only after having come into close proximity to a frontal band extending into tropical latitudes. A similar development, for example, was noted

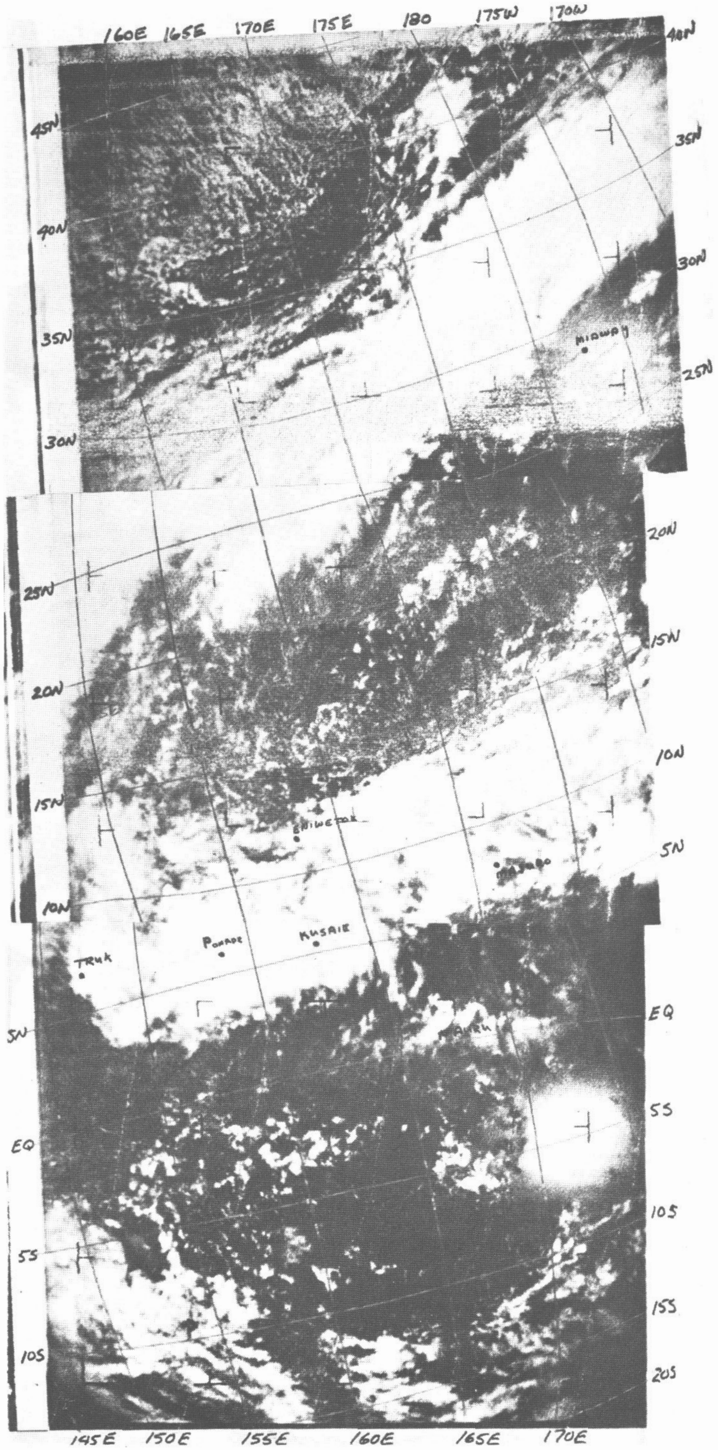

FIGURE 8.—ESSA 2 pictures of the ITC on Oct. 26, 1966, at 2106 GMT.

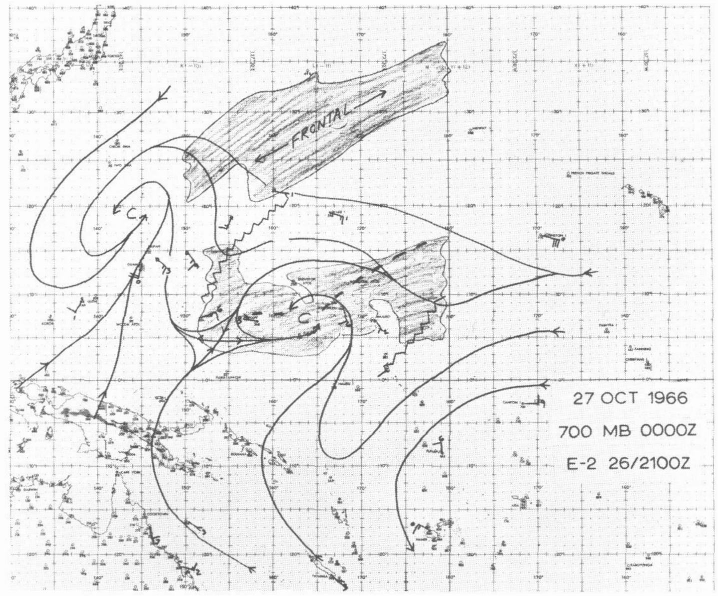

FIGURE 9.—700-mb. streamline analysis for Oct. 27, 1966, at 0000 GMT. Cloud patterns revealed in figure 8 are superimposed on this analysis.

and described by the author [2] in the case of typhoon Jean, 1962. (See description and schematic of Marie's development—Stage III—figure 26.)

Figure 9 shows the 700-mb. analysis coinciding most clearly with the preceding view. The continued presence of the streamline trough in the area of the ITC is quite evident. Ponape's 700-mb. wind in this analysis now has also shifted to the west. Cloudiness, it will be noted, now extended north of the trough axis. Much of this cloudiness may have been from higher clouds swept northward by the developing upper-level anticyclone. (See figure 13.)

Nimbus IR pictures were not received over the area for October 27. However, ESSA 2 pictures for that day (fig. 10) revealed a vortex SW of Eniwetok which prompted the first request for investigation by reconnaissance aircraft. The pictures show well-defined banding and convective activity implying a center of circulation near 10°N., 160°E. The depression has the comma configuration typical of Stage B and, in fact, can only be the further development of the Stage B configuration noted 36 hr. earlier in the Nimbus IR picture (fig. 5). To the northeast of the depression area continued cloudiness of the ITC is evident as is the polar front near 25°N.

The 700-mb. analysis coinciding most closely with these pictures (fig. 11) reveals an intensification of the ITC trough with a new vortical development near 12°N., 170°E. The polar trough at the 700-mb. level is evident just north of Marcus Island (Station 131, near 14.2°N., 154°E.). Note that the leading edge of the frontal system as shown in figure 10 extends south of 25°N. into the area covered by a ridge at the 700-mb. level. As is common in tropical latitudes, fronts are very shallow and located at upper levels far north of the surface position. Fleet Weather Facility's surface analysis indicated a shear line remnant of the front extending along 22°N.—a little over °2 north of Wake Island.

Remarkable pictures obtained 12 hr. later through the Nimbus IR system (fig. 12) show a repeat view of the Stage B comma configuration noted 12 hr. earlier (fig. 10). The retention of all essential features over a 12-hr. period is quite notable. The only significant change in appearance of the depression is what appears to be a reduction in the

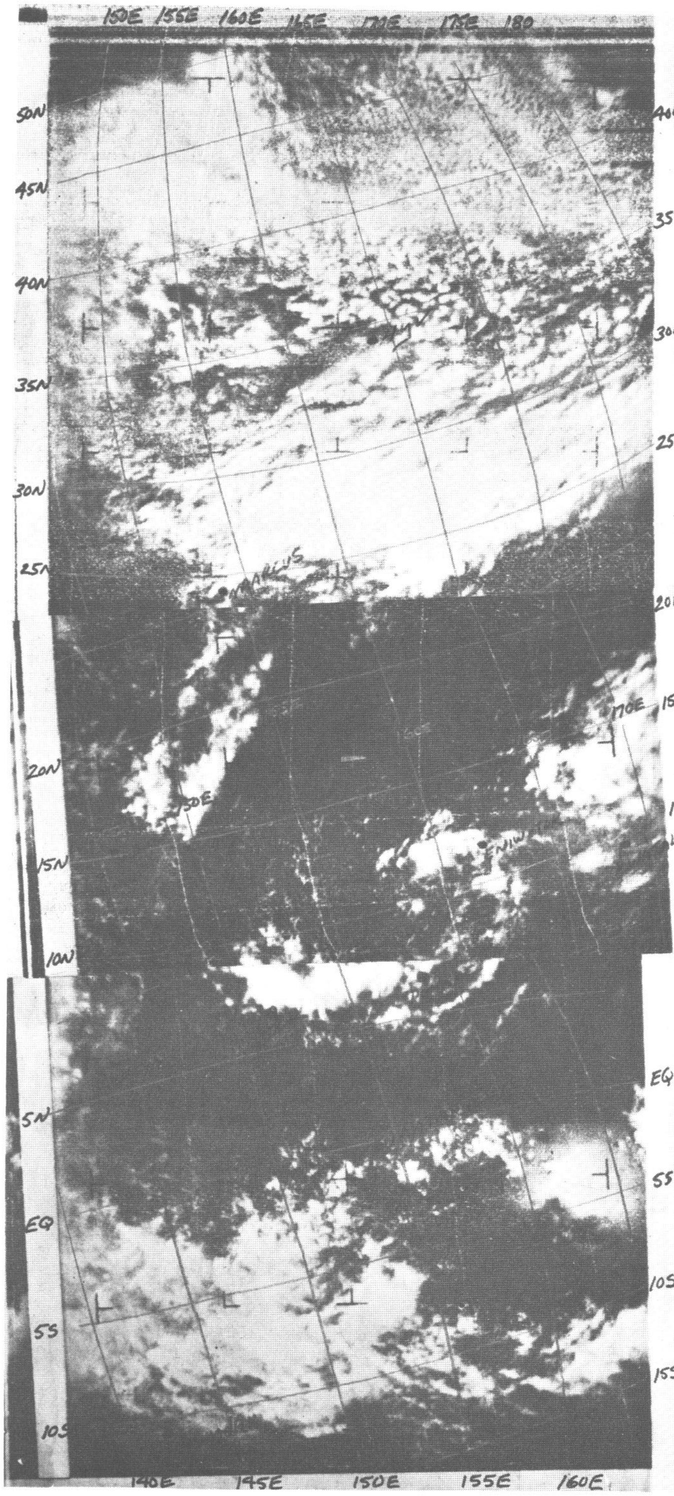

FIGURE 10.—ESSA 2 pictures of the ITC on Oct. 27, 1966, at 2142 GMT.

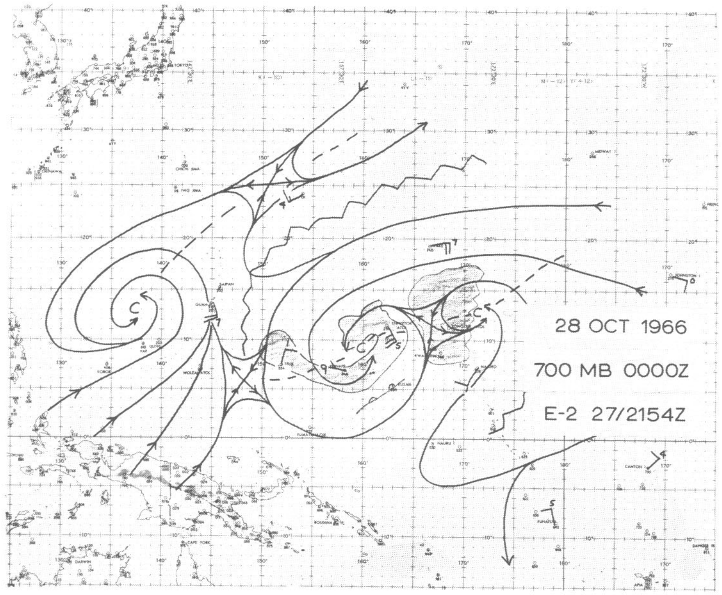

FIGURE 11.—700-mb. streamline analysis on Oct. 28, 1966, at 0000 GMT. Cloud patterns revealed in figure 10 are superimposed on this analysis.

amount of convective cloudiness in the band along 5°N. The frontal band to the north is visible with the leading edge intersecting points near 25°N., 175°E.; 22°N., 170°E.; and 20°N., 165°E. To the south of the front between 10° to 15°N. along 170°E. the secondary vortex on the ITC is apparent. Gray elongated cloudiness leading northward from the western side of the disturbed area is interpreted to be cirrus cloudiness swept northward by southwesterly upper-level winds. Such winds are normally encountered in advance of a tropical disturbance [1]. This suggestion was verified by the 200-mb. analysis (fig. 13) derived through observations taken 1½ hr. prior to the IR photos. Note that an upper-level col appears superimposed over the Stage B disturbance near 10°N., 160°E. Such upper-level super-position is extremely unfavorable for development. On the other hand the anticyclone over the disturbed area near 12°N., 168°E., is the ideal pattern for development [3]. Attention at this time was diverted to the latter disturbance and reconnaissance was rerouted for an investigation of this area. Figure 14 shows the 700-mb. streamline analysis coincident with the preceding data. This analysis shows that both disturbances were embedded in the same trough—the ITC trough which had been slowly progressing northwestward.

Figure 15 shows the ESSA 2 view of the eastern-most disturbed area obtained 12 hr. later. Banding is quite evident along the northern edge of the disturbance, in particular in the area of Wake and from 17° to 20°N. along 170°E. The polar front and the disturbance are connected by a common band of clouds stretching northeastward from the disturbed area. This band may have been the leading edge of the frontal shear-line which was now degenerating in lower latitudes. As previously shown Wake's winds at this time had increased to almost 30 kt. This was the beginning of the period of Marie's most rapid intensification. As the author flew into the storm a few hours later gigantic patterns of the dense cirrus were observed spiralling out from the storm center. The 200-mb. analysis (fig. 16) shows the dominating influence of the anticyclone aloft over Marie. The 200-mb. shear-line in advance of the cloudy area is still very evident and shows

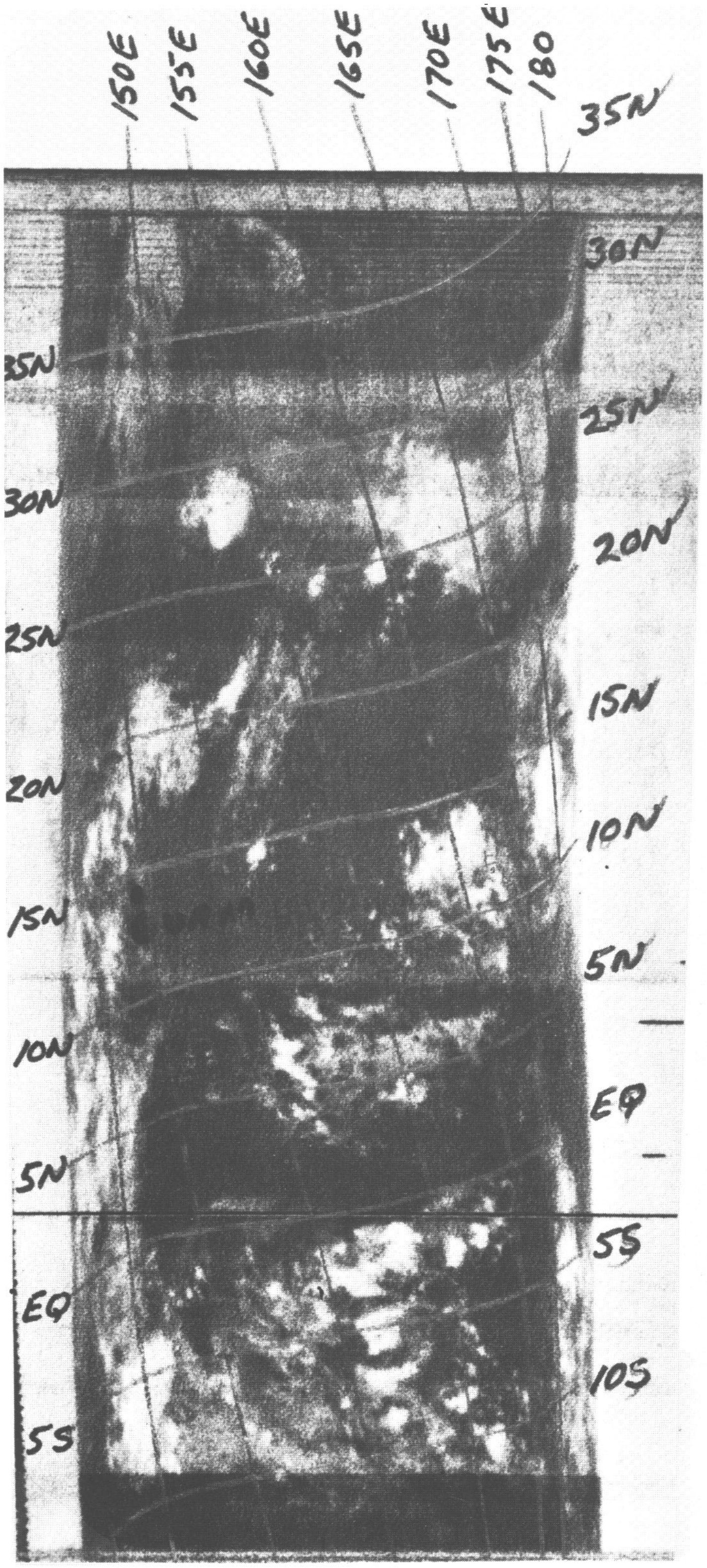

FIGURE 12.—Nimbus infrared read-out of data over the ITC on Oct. 28, 1966, at 1328 GMT.

significant westerly progression over the preceding 24-hr. period. The 700-mb. analysis (fig. 17) shows good continuity from the preceding analysis. The expanding effects of the circulation around the vortex south-southeast of Wake are evident.

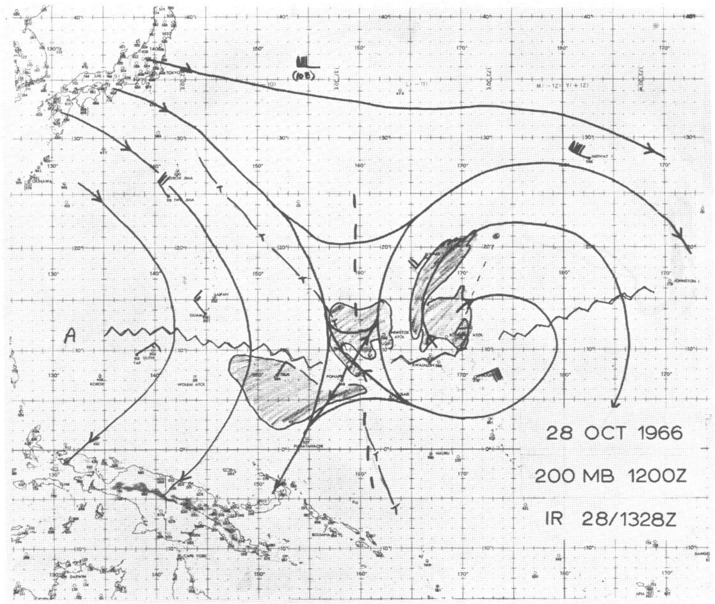

FIGURE 13.—200-mb. streamline analysis for Oct. 28, 1966, at 1200 GMT. Cloudiness patterns revealed in figure 12 are superimposed on this analysis.

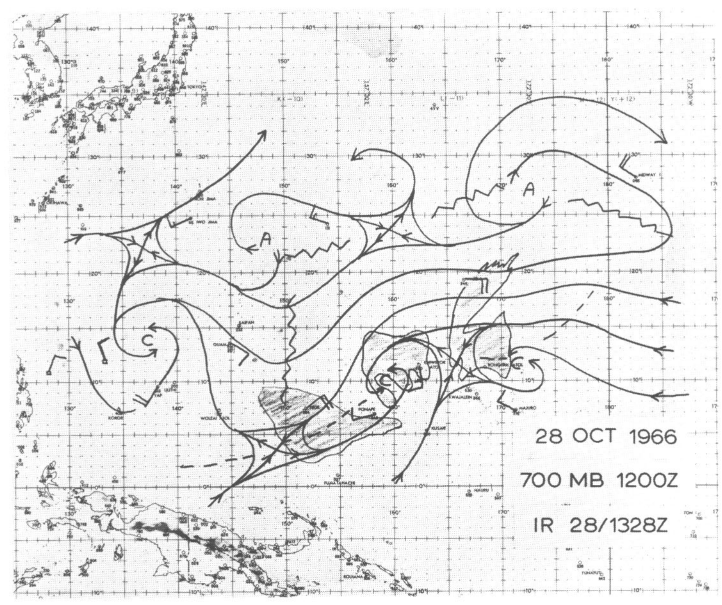

FIGURE 14.—700-mb. streamline analysis for Oct. 28, 1966, at 1200 GMT. Cloudiness patterns revealed in figure 12 are superimposed on this analysis.

Nimbus IR pictures obtained 12 hr. later (fig. 18) show all indications of a rapidly intensifying depression which would be categorized Stage C or C+.[4] An anticylone aloft over the disturbance is suggested through cirrus striations

[4] Independent corroboration of this stage description was received from the Satellite Center at Suitland, Md., which sent a Satellite Bulletin on the basis of TIROS photos received at 29/0220 GMT designating a Stage C depression centered near 15°N., 168.5°E.

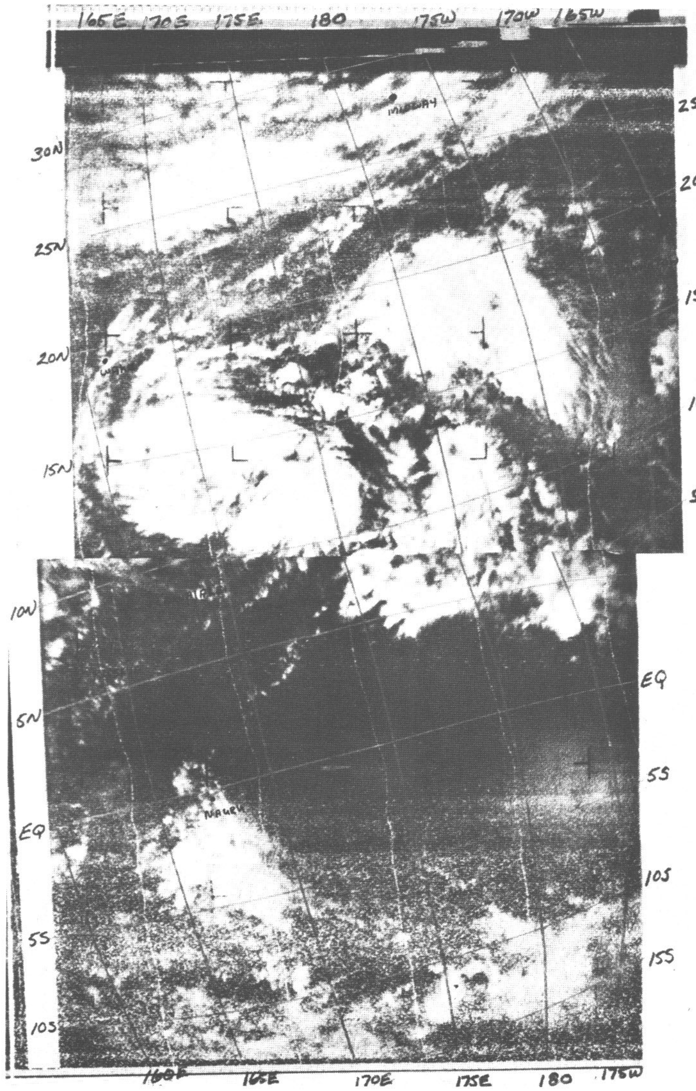

FIGURE 15.—ESSA 2 pictures of the ITC on Oct. 28, 1966, at 2029 GMT.

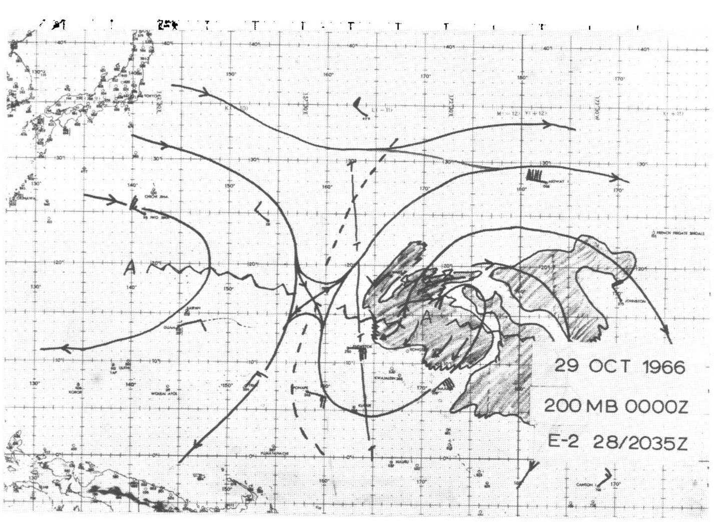

FIGURE 16.—200-mb. streamline analysis for Oct. 29, 1966, at 0000 GMT. Cloudiness patterns revealed in figure 15 are superimposed on this analysis.

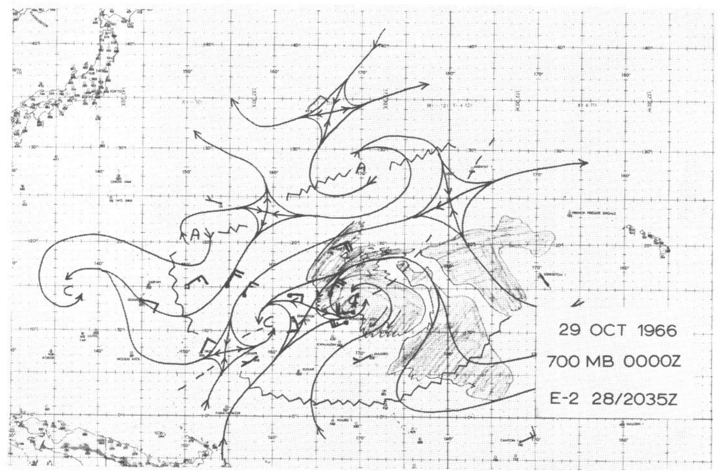

FIGURE 17.—700-mb. streamline analysis for Oct. 29, 1966, at 0000 GMT. Cloudiness patterns revealed in figure 15 are superimposed on this analysis.

visible in this photograph. The center of circulation appears in this figure to be on the very edge of the overcast shield near 14.5°N., 168°E. Little evidence can be gleaned from this photo concerning the presence or whereabouts of the disturbance formerly noted on the western end of the ITC trough in figures 5, 10, and 12.

The 200-mb. analysis (fig. 19) coinciding with these pictures reveals the dominant presence of the upper anticyclone over the depression. Continued westward advancement of the shear-line or trough in the normal manner in advance of the disturbance is also evident [1].

Figure 20 shows the 700-mb. analysis for the preceding pictures and also indicates the expanding effect of the eastern-most depression and the diminishing influences of what was to be called T.D. 34. Note at this point how difficult it would have been to to have tracked these two disturbances as separate easterly waves. However, as in this analysis, the development of the two depressions within the slowly moving trough area was very reasonable and consistent from one analysis to the next.

The final two views to be shown of Marie represent the culmination of the formative process. Figure 21 shows Marie shortly before attaining tropical storm intensity. The center in this picture appears definitely embedded within the overcast cloudiness. Frontal effects of the trailing edge of the shear-line are obscured in cloudiness to the east. Figure 22 shows the corresponding 700-mb. analysis which still delineates Marie retained within the original streamline trough of the ITC. Figure 23, the final view of Marie with maximum winds of 50 kt., is of special interest. Cloudiness of the ITC apparently reformed at lower levels and can be seen stretching over a distance of 1,200 mi. southeastward from the storm area. The remnants of the polar front stretching eastward from Wake are also clearly defined. The 700-mb. analysis at this time

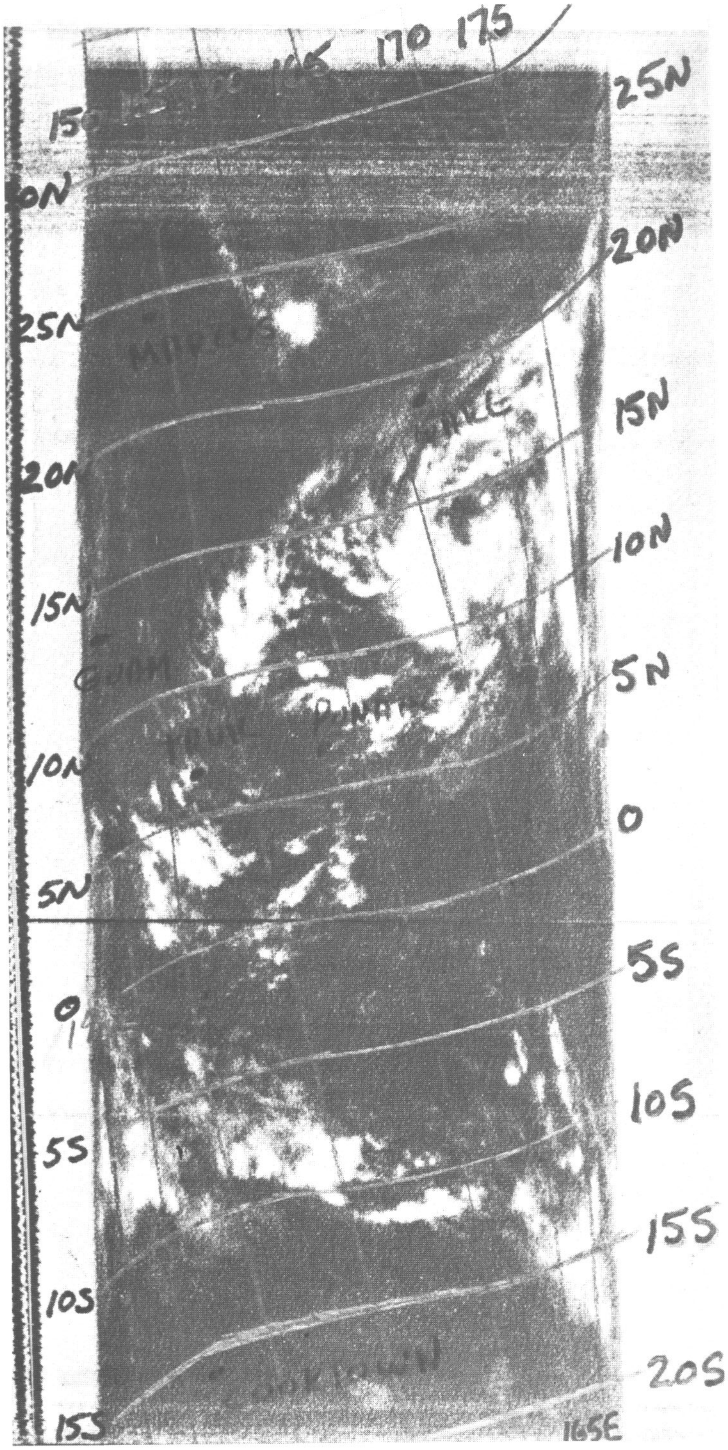

FIGURE 18.—Nimbus infrared read-out of data over the ITC on Oct. 29, 1966, at 1256 GMT.

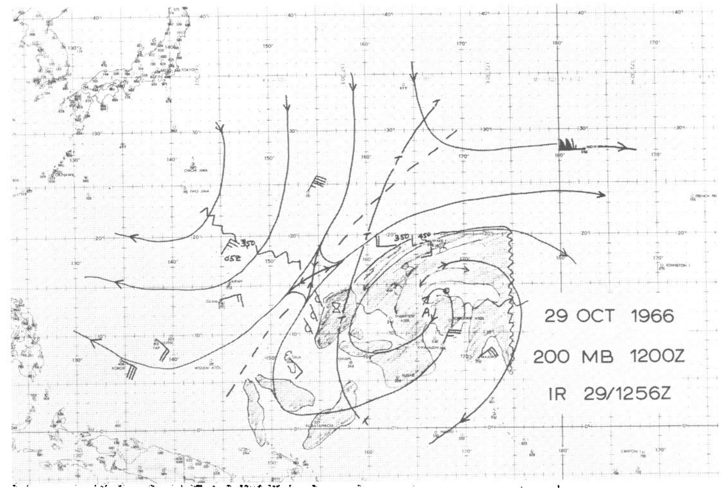

FIGURE 19.—200-mb. streamline analysis for Oct. 29, 1966, at 1200 GMT. Cloudiness patterns revealed in figure 18 are superimposed on this analysis.

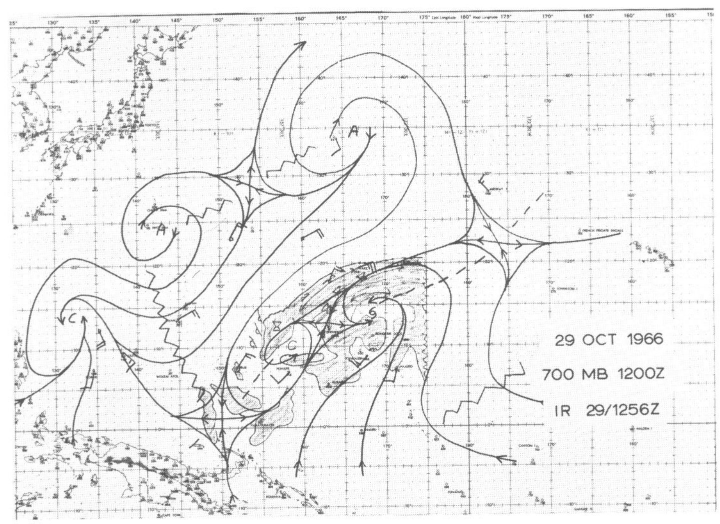

FIGURE 20.—700-mb. streamline analysis for Oct. 29, 1966, at 1200 GMT. Cloudiness patterns revealed in figure 18 are superimposed on this analysis.

(fig. 24) verifies the reformation of the ITC southeast of the storm area. This analysis is essentially similar to the initial analysis with which the entire series began. However, the pattern is displaced farther to the east. (See fig. 1.) The main anticyclone, as in the initial analysis, has low pressure to the southwest and an asymptote of convergence to the south and southeast. This suggests that a full cycle had been completed at this point resulting in the creation of a new ITC. Here northeasterly trades of the Northern Hemisphere converged with southeasterly trades of the Southern Hemisphere setting the stage for renewed development in the wake of the original storm. This particular analysis shows cloudiness north of the asymptote of convergence east of the storm area rather than to the south as in the more typical configuration. Note, however, that an adjustment of the asymptote northward to resolve this apparent inconsistency could be accomplished without violating the available data.

3. SUMMARY

1) Typhoon Marie developed *in situ* within the zone of the ITC. No reasonable past history retrograding to a typical easterly wave pattern is conceivable for this storm. On the contrary an easterly wave advocate would

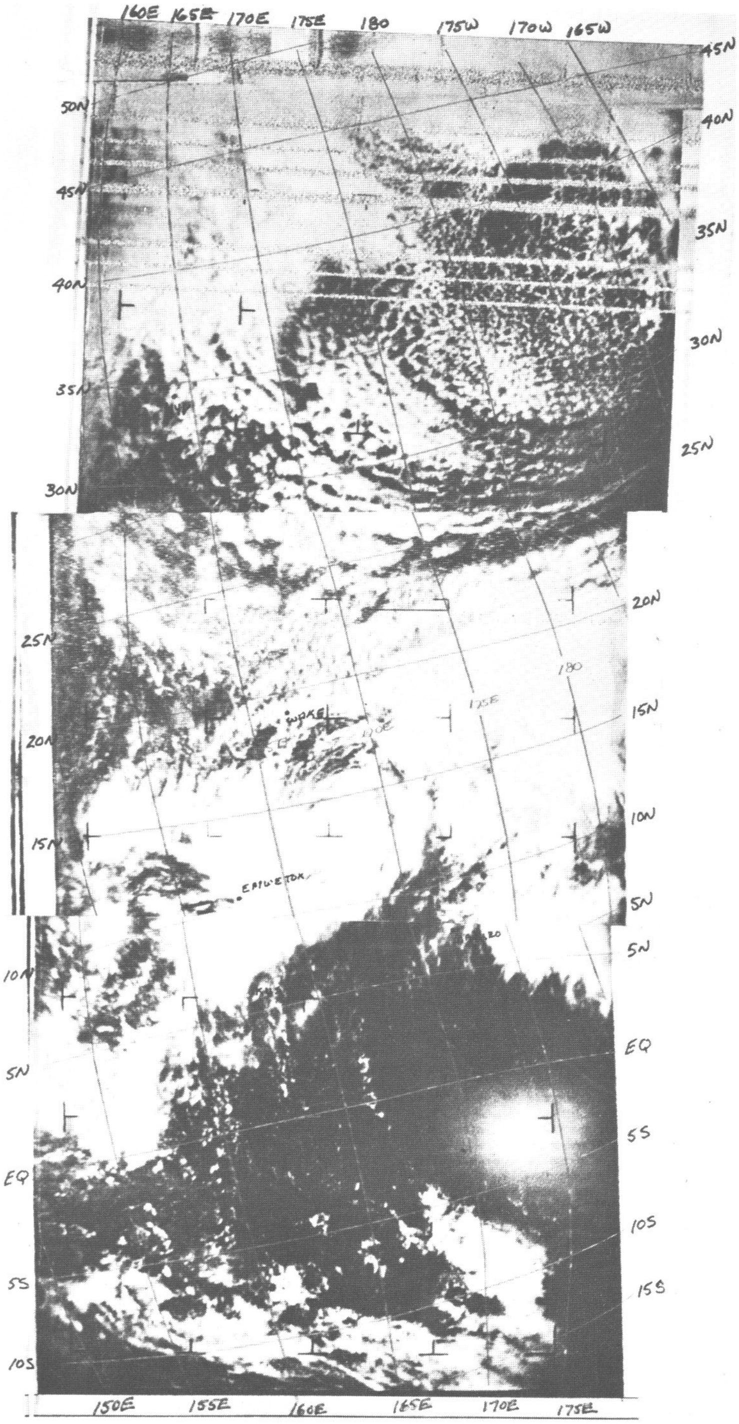

FIGURE 21.—ESSA 2 pictures of tropical storm Marie on Oct. 29, 1966, at 2059 GMT.

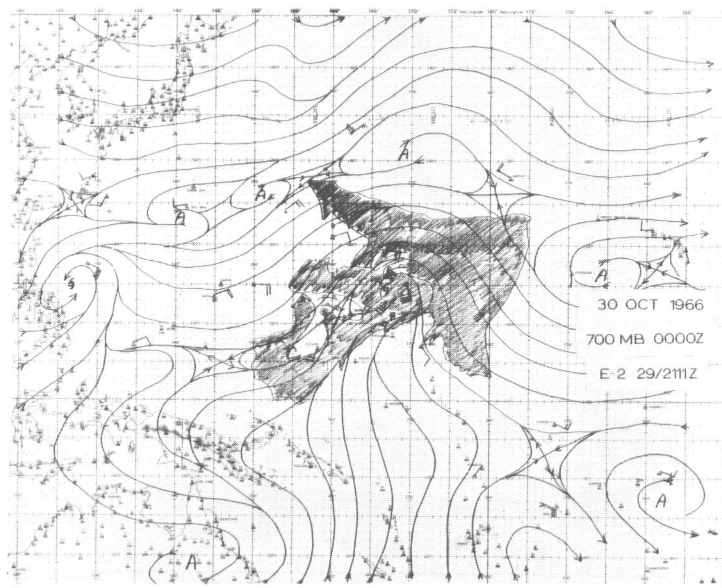

FIGURE 22.—700-mb. streamline analysis for Oct. 30, 1966, at 0000 GMT. Cloudiness patterns revealed in figure 21 are superimposed on this analysis.

have been continually frustrated if he would have tried to have tracked the movement of either Marie or of the vortex which was destined to develop into T.D. 34 as easterly waves. Their speeds of translation, for example, were far too slow. Figure 25 summarizes the mean 700-mb. flow pattern during the period of formation of typhoon Marie. This figure also shows the 12-hr. locations of trough, ridge lines, and vortices during the period October 26–29. The figure reveals that the two vortical centers developed and drifted slowly northwestward during this period within a general trough area oriented approximately perpendicular to the direction of movement of the storm centers. The trough area extended east-northeastward over a distance of almost 2,500 n.mi.

2) A schematic model depicting the sequence of events noted in the development of Marie is shown in figure 26. It is possible that other storms may originate in a similar manner. Polar frontal penetration into tropical latitudes was observed in the development of Marie (and typhoon Jean, 1962). Since polar fronts penetrate tropical latitudes more frequently in the early spring and in the fall of the year, it is probable that this pattern of development is most characteristic of those periods. The model shows the 700-mb. pattern and differentiates four separate stages of development.

Stage I. In Stage I, outflowing air from anticyclones of the Northern and Southern Hemispheres converges near the Equator along an asymptote conventionally referred to as the Intertropical Convergence Zone (ITC). Scattered areas of cloudiness form primarily on the southern side of the convergence asymptote.

Stage II. In Stage II, an elongated streamline trough forms between the Northern and Southern Hemispheric anticyclones. Reasons for the formation of this trough in such an exaggerated condition were not demonstrated in this paper. A plausible hypothesis, however, was suggested. Formation of intensified trough conditions may partially be attributed to the reduction of pressure through the release of latent heat of condensation which occurred as a result of forced convection necessitated by the Stage I configuration. A favorable upper level

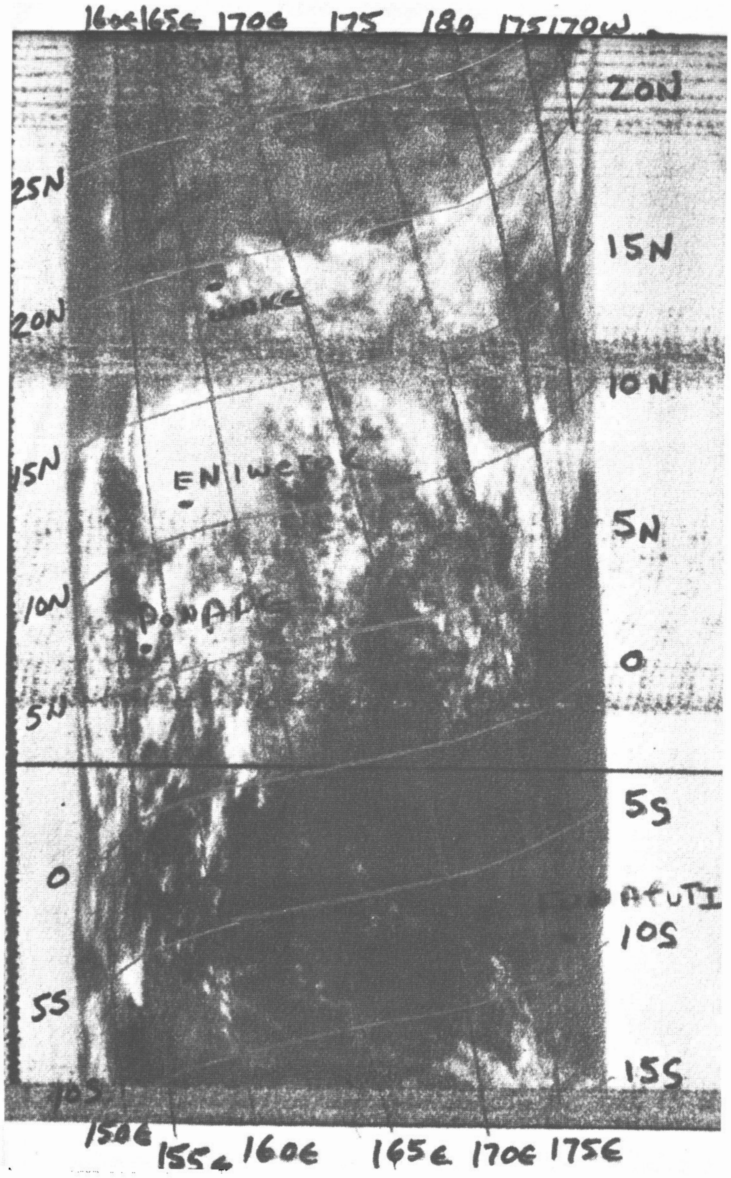

FIGURE 23.—Nimbus infrared read-out of data over tropical storm Marie on Oct. 30, 1966, at 1224 GMT.

divergent pattern is also necessary to account for the prospering convection noted at this time. Cloudiness as in Stage I and in the typical easterly wave pattern remained dominantly south and east of the trough axis. The trough area contained embedded closed circulations. Wind speeds around the circulation centers at the surface were very light. Higher wind speeds were found at greater distances from the storm centers.

Stage III. In Stage III, the vortices generated within the trough area of maximum relative vorticity further developed. The trough moves northwestward into close proximity to a polar front. The increased pressure gradient between the two systems results in higher wind speeds (and hence cyclonic vorticity) north of the storm center. Rapid intensification follows as tropical storm speeds are attained.

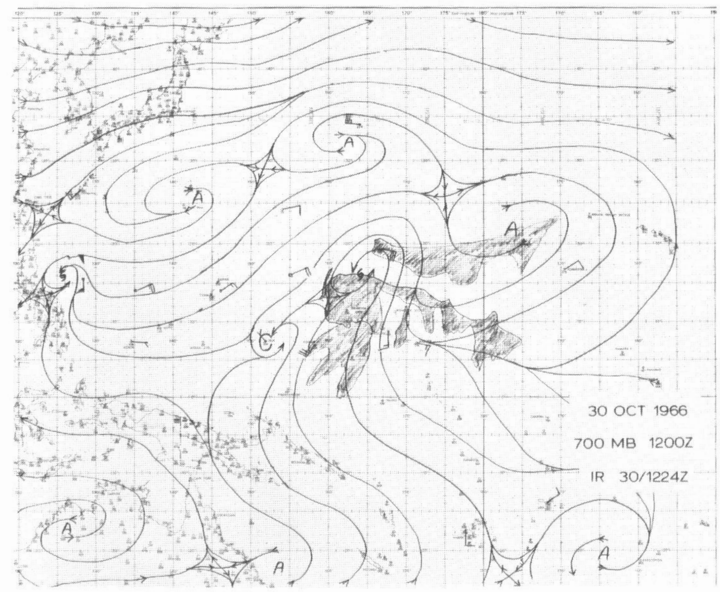

FIGURE 24.—700-mb. streamline analysis for Oct. 30, 1966, at 1200 GMT. Cloudiness patterns revealed in figure 23 are superimposed on this analysis.

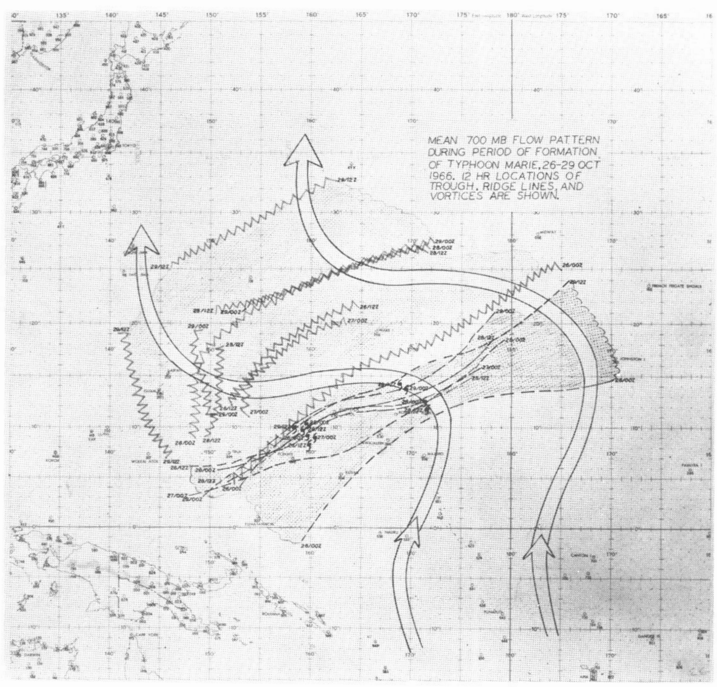

FIGURE 25.—A schematic of the mean 700-mb. flow pattern over the ITC during the period of formation of Marie from Oct. 26–29, 1966. 12-hr. locations of trough (dashed lines), ridge lines (crooked lines), and vortices during this period are also shown.

Stage IV. As the storm reaches typhoon intensity it continues its generally northwesterly movement around the Northern Hemispheric anticyclone; the frontal pattern moves off to the east; and the ITC reforms at lower latitudes. With the reestablishment of the ITC in the

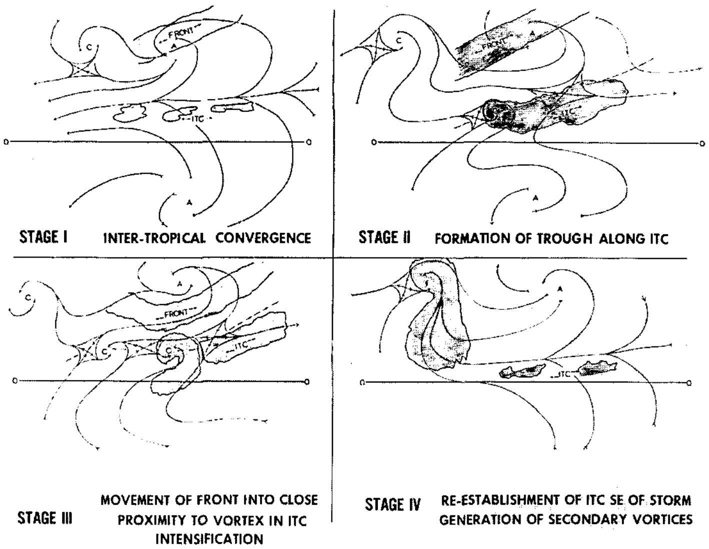

FIGURE 26.—Schematic depiction of the main sequence of events noted in the development of typhoon Marie, 1966.

wake of the original storm the cycle of formation is completed. The stage is now set for the establishment of a new ITC streamline trough and the generation of secondary vortices in a manner similar to the development of the original storm.

4. CONCLUSIONS

The history of the development of typhoon Marie within the ITC suggested a sequence of events which may be applicable to the development of certain other storms. The suggested model is in no manner confirmed at this time. Its main purpose will be to serve as a useful hypothesis for testing and evaluation during the coming storm seasons. One of the interesting results of this study was that satellite patterns of formative storms within the ITC were in some instances similar in appearance to the Stage A through D patterns noted in earlier easterly wave investigations. Such similarities undoubtedly account for the many confused analyses and mistaken inferences which have led to opposing interpretations of the same phenomena. These errors of interpretation in turn may lead to significantly different forecasts. For example, Marie moved very slowly northwestward in its initial phases as a vortex within a slow moving trough. Had Marie moved as a typical vortex embedded within an easterly wave its rate of movement would have been much greater. In this case the apparent key to a better forecast would have been to immediately recognize the "nature of the beast." Fortunately advanced meteorological satellite observations on a daily basis make this a rather easy task. Despite the fact that discreet disturbances within the ITC are often similar in appearances to the stages of development of the typical easterly wave, the over-all pattern is quite different. Wave-like disturbances have a notable absence of peripheral cloudiness in their immediate vicinity whereas ITC cloudiness is connective and elongated over long distances more or less parallel to the Equator. Surveillance satellites such as the ATS (Applications Technology Satellite) hovering great distances above the earth provide integrated pictures over large areas so that it should be an easy matter to differentiate between the separate types of development. Recognition of the main characteristics of these developments will be a major step toward improved analyses and forecasts of the future.

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