Exploring Eye of Typhoon "Marge," 1951

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ABSTRACT

In August 1951 an unusual airplane reconnaissance of a mature typhoon succeeded in collecting extensive data from the eye and adjacent rain area of the storm. The eye, which was clear except for a low stratocumulus undercast, was circular, 40 miles in diameter, and had a central pressure at the surface of 26.43 inches (895 mb) with a sizable pressure gradient from the center to edge of the eye. Walls of nimbostratus surrounding the eye rose like a huge coliseum to a height of 35,000 feet. Two eye soundings from the surface to 17,000 feet were made, the first at midday, the second in late afternoon. These revealed exceptionally warm temperatures, more than 16°C at 17,000 feet, with lapse rates essentially isothermal from the surface to 10,000 feet. Marked cooling occurred between these two soundings in the layer 7,000–10,000 feet. Horizontally, temperature varied little at 800 feet; at 9,000 feet, however, the eye center was nearly 8 C° warmer, and at 18,000 feet 18 C° warmer than the adjacent rain area. At 9,000 feet, significant temperature gradients were confined primarily to the eye, while at 18,000 feet they were concentrated in the rain area.

1. INTRODUCTION

AIRPLANE flights into the eyes of typhoons or hurricanes have been common occurrences in recent years. In fact, planes of the Air Force or Navy usually penetrate the eye of most tropical cyclones twice a day as long as the storm remains a threat to coastal areas. These flights are made primarily to obtain critical information on the storm position and intensity for use of the forecaster in issuing warnings. Because of the hazard and the complexity of such flights, it is rare that an opportunity is afforded to explore fully the core of these severe storms to obtain more particular information on structure and physical characteristics.

Through the courtesy and cooperation of the Air Force's 2143d Air Weather Wing, the writer was privileged to make an unusual exploration of typhoon "Marge" in the West Pacific on August 15, 1951. This reconnaissance was not planned primarily as a research flight, its main objectives being to obtain two position "fixes" from the center of the typhoon 8 hours apart. This and other operational requirements of the flight therefore limited the extent of the exploration and the amount of particular data which could be recorded. Nevertheless, more than 3 hours were spent in the eye of this typhoon on the day of its peak intensity, exploring and recording various characteristics at elevations ranging from 600 to 20,000 feet. The information gained, while incomplete in many details, comprises an unusual documentation of interest and importance to studies of typhoon structure.

2. DESCRIPTION OF FLIGHT

We took off from Guam shortly after dawn in an RB-29 of the 54th Strategic Weather Reconnaissance Sq. The plane climbed slowly to altitude near 11,000 feet beneath a dull overcast of cirrostratus and altostratus clouds. Even at this distance, some 700 (statute) miles from the storm center, the overcast apparently was a part of the great shield of high clouds associated with "Marge." The sea surface here also bore evidence of the energies harnessed by the typhoon. Brisk southwest winds, probably 25 to 30 miles per hour, caused choppy seas upon which were distinctly superimposed long swells oriented northeast-southwest. These unquestionably were the remnants of great waves generated near the typhoon center.

There was an ominous absence of isolated or random convective cloudiness. With the exception of several well-organized lines of towering cumulus encountered periodically, there were only patches of small stratocumulus and stratus clouds beneath the plane. With the development of early-warning radars during World War II, it was discovered that convective-type clouds in large tropical cyclones such as "Marge" tend to be concentrated in a series of squall lines, each of which spirals cyclonically about the eye of the storm almost parallel to the streamlines of surface wind. These lines, usually separated by a

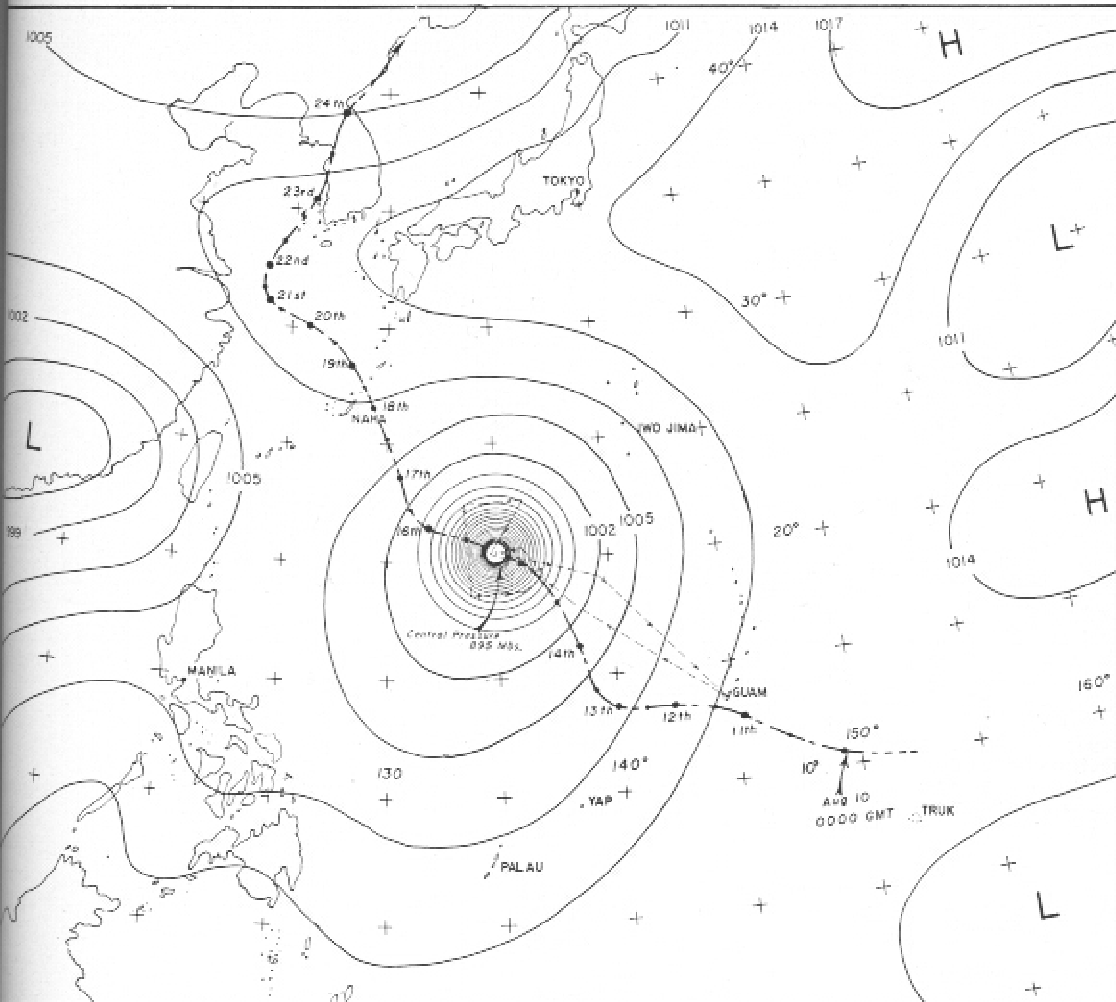

Fig. 1. Surface map showing Typhoon "Marge" at 0600 GMT, August 15, 1951. The heavy broken line is e path of the typhoon showing 12-hour positions. The light dash line is the track of the plane during its re-naissance of "Marge."

udiness minimum, have been described by aynard [4] and their significance discussed by exler [11] and others. Six such squall lines, sible both to radar and the naked eye, were ob-erved extending for scores of miles to either side the flight track. (See Figures 5 and 6.)

Proceeding toward the storm center, the base the altostratus shield lowered steadily until finally engulfed the plane approximately 150 iles from the eye. From that point on, only oc-sional glimpses could be had of the sea surface. avigation toward the eye thereafter depended on proper interpretation of the squall-line pat-rns visible through radar, and of pressure (or D"-value) variations.

Surface winds which had varied little the first 00 miles out of Guam increased rapidly from a point about 300 miles east-southeast of the eye. Two hundred miles from the center, winds had reached full typhoon force (74 miles per hour), and at 150 miles from the center were judged to be more than 100 miles per hour.

A word about methods of estimating sea surface winds from a plane is of interest at this point. Both direction and speed of surface winds are usually estimated in terms of the extent and appearance of surf or whitecaps. With a large amount of surf present it is not difficult to determine wind direction. Whitecaps which form as a wave occludes are quickly outrun by the wave and overtaken by the trough which follows. Viewed from aloft the relative motion of the surf, with respect to its parent wave, is directly opposite to the wind direction. In Figure 11, arrow S shows the apparent movement of the surf as viewed aloft, while arrow W, representing the wind direction, points to the parent wave crest. Wind speed is judged in terms of amount of surf present, and general appearance of the sea. Here, there is a relatively large margin for error in the higher range of velocities. To begin with, very few pictures have been made of seas under the influence of 100-mph winds. Moreover, these seas look different under varying conditions of

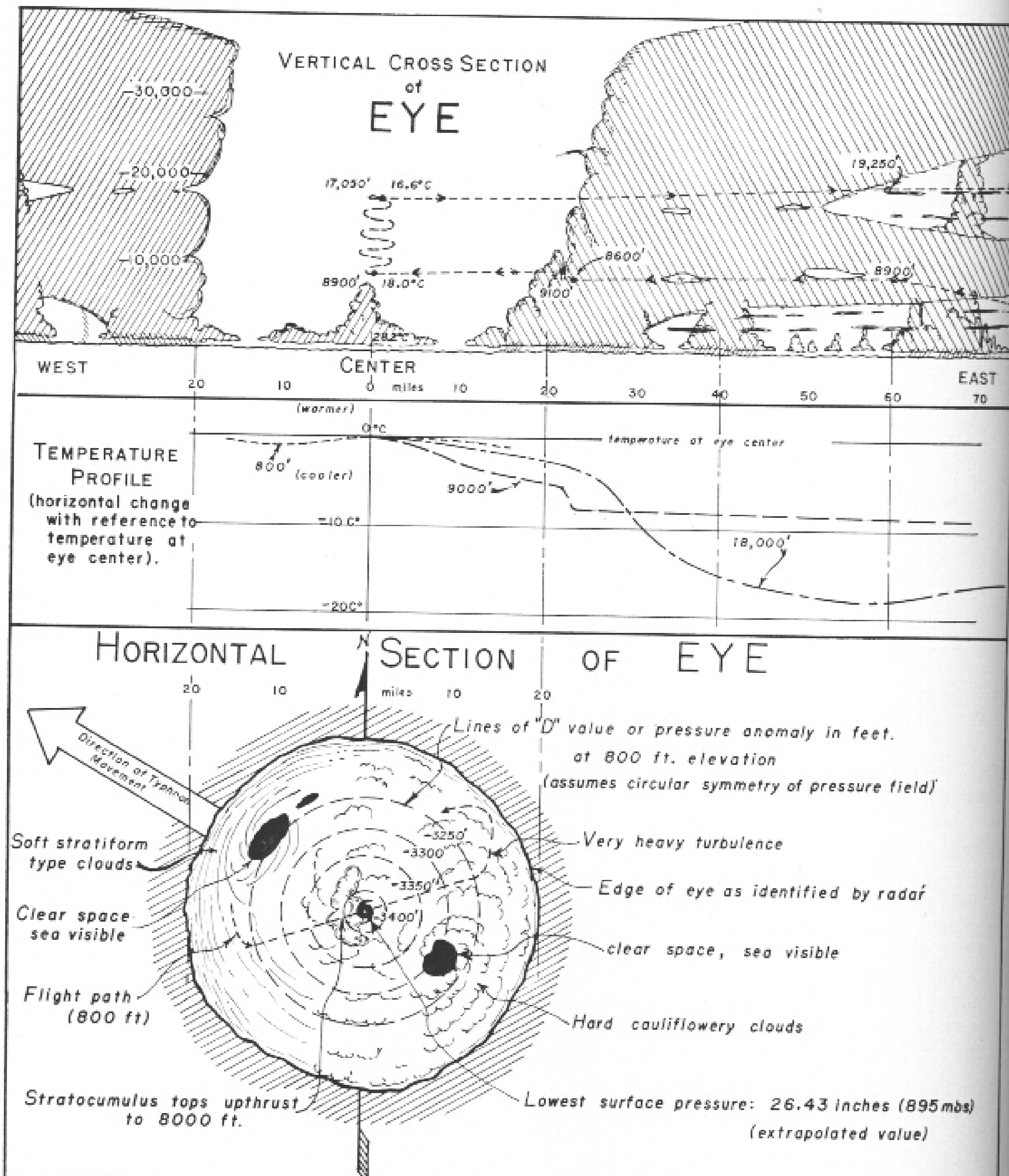

FIG. 2. Horizontal and vertical sections of the eye of typhoon "Marge" showing distributions of cloudiness and of temperature in the eye and the vortex area immediately adjacent to the eye.

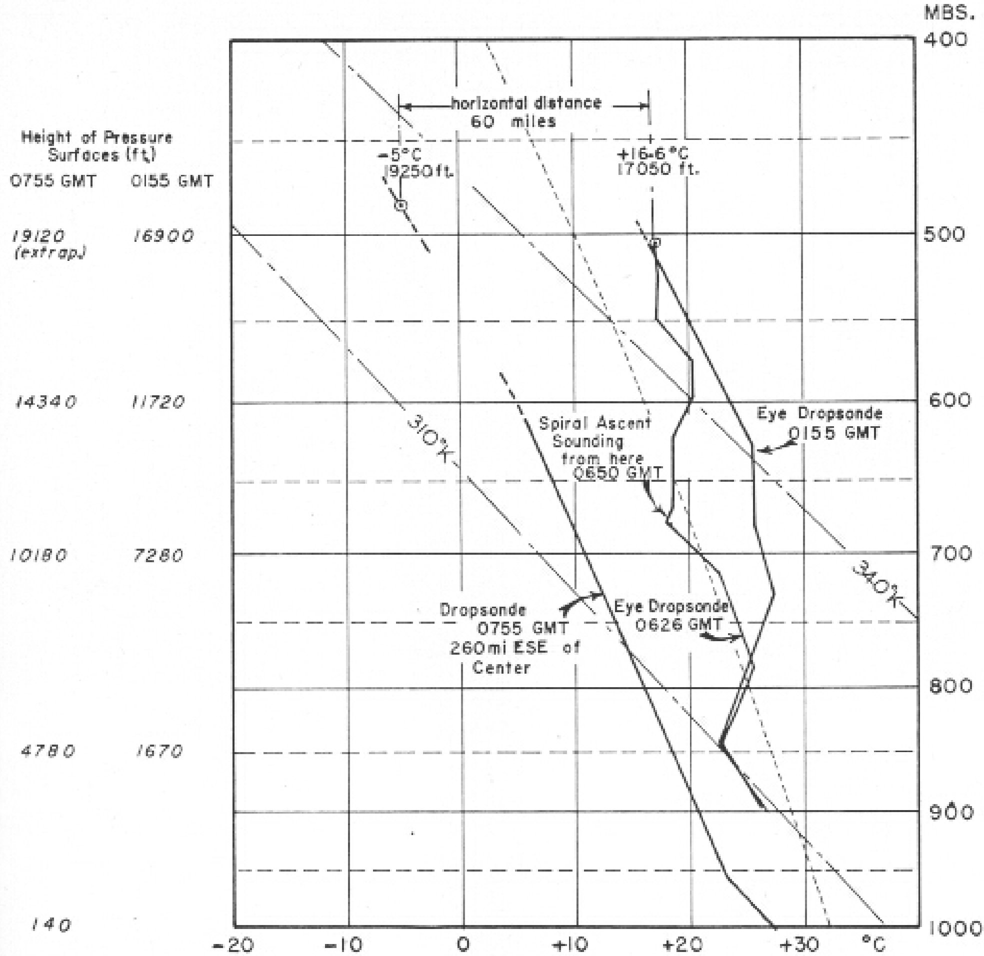

Fig. 3. Soundings taken in the eye and in the outer vortex of typhoon "Marge" on August 15, 1951. The thin irregular broken lines are dry adiabats; thin dashed line is a moist adiabat.

light. In general, however, the relative degree of greenish streakiness of the sea surface which develops as whitecaps are blown away by the winds, is the principal criterion for estimating surface winds of 50 mph or more.

At flight elevation, winds measured by double-drift observation increased less rapidly and failed to keep pace with the apparent increase of surface winds. One hundred fifty miles from the center, flight-level winds were computed (by double drift) to be 86 miles per hour. The flight during this increase in winds was a relatively smooth one. The only significant turbulence occurred while flying through the spiral lines of convective clouds. Even here (at 11,000 feet) only light turbulence was felt.

Continuing on instruments, radar soon detected the edge of the rainless typhoon eye directly ahead. A series of heavy rainbursts followed and then several bumps of moderate turbulence as the plane broke through the walls of the eye into clear air.*

Here was one of Nature's most spectacular displays. "Marge's" eye was a vast coliseum of clouds, 40 miles in diameter, whose walls rose like galleries in a great opera house to a height of approximately 35,000 feet where the upper rim of the clouds was smoothly rounded off against a background of deep blue sky. The sea surface was obscured by a stratocumulus undercast except for two circular openings on the east and west sides of the eye respectively. Clouds in the undercast layer were grouped in bands which spiraled cyclonically about each of these openings, or clear spots, both of which were approximately five miles wide. This horizontal alignment of clouds suggested the possibility that two separate

* This sequence is similar to that reported by Wood and Wexler [12] in an Atlantic hurricane September 1944.

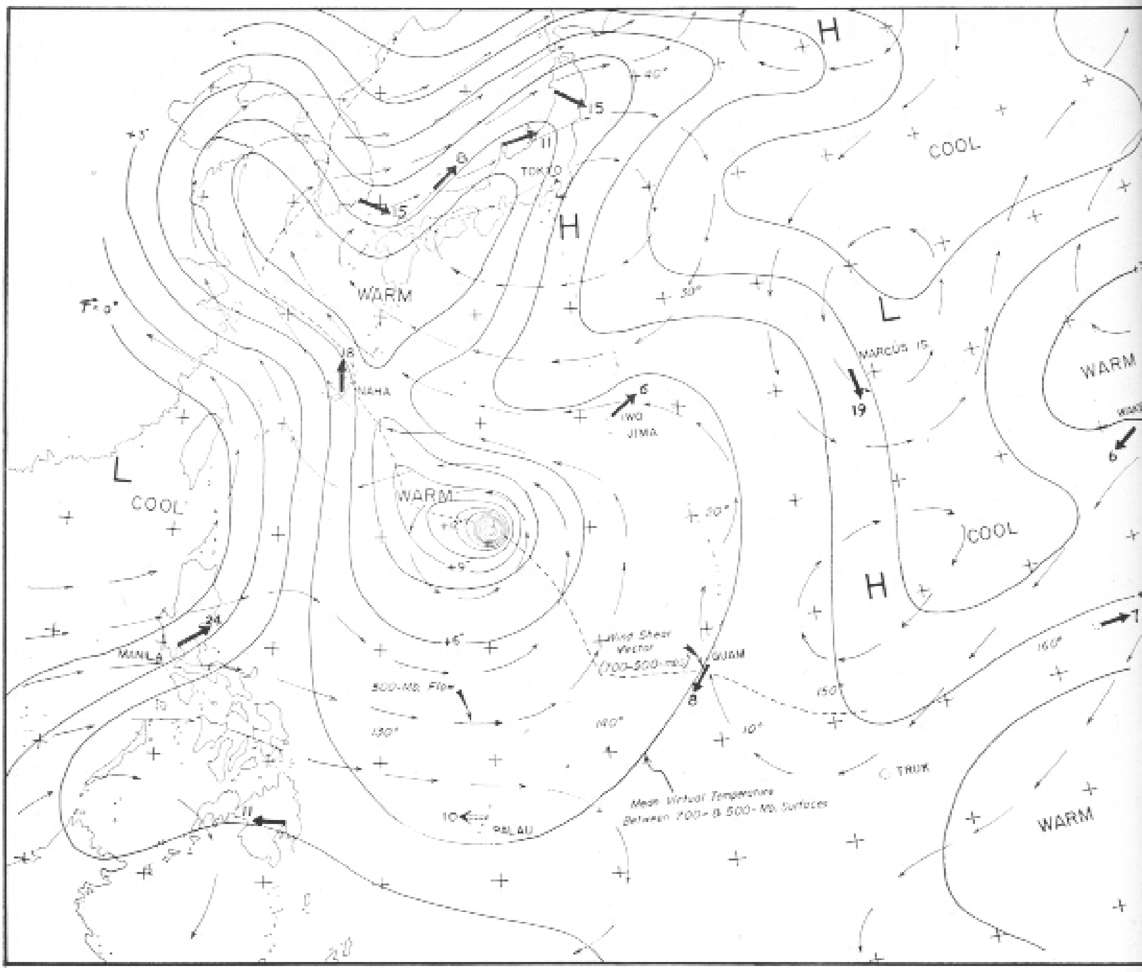

FIG. 4. Mean virtual-temperature fields for the typhoon area and its environment at 0300 GCT, August 15, 19
Isotherms are computed from thicknesses between the 700- and 500-mb surfaces and include sounding and ot
temperature data obtained by airplane reconnaissance of the typhoon vortex. Thin arrows represent flow at
mb. Heavy arrows are wind-shear vectors between the 700- and 500-mb levels.

small eddy circulations were present within the eye envelope.

In the geometric center of the eye the strato-cumulus overcast bulged upward in a domelike fashion to a height of 8,000 feet. Light turbulence in the tops of this dome was comparable to that in ordinary ocean cumulus.

The walls of the eye on the west side were steep, either vertical or overhanging, and had a soft stratiform appearance. On the east side, however, clouds were more a cumuliform type with a hard cauliflowery appearance. In this sector the walls of the eye rose with a gradual concave slope to the upper rim. The overall appearance indicated that the axis of symmetry (in the vertical plane) was tilted to the east or northeast.

The reflection of a late forenoon sun on th
clouds was remarkably intense. A standard W
ton light meter was thrown completely off-sc
on high range by the glare. Many pictures tak
at 1/300th second f.20 and with a Wraten A r
filter were over-exposed (using Super XX film

From the weather observer's position in t
nose of the plane, where a view almost vertica
downward can be had, the sea surface could
seen occasionally through breaks in clouds.
the plane skirted close to the north wall of the e
at an elevation of 8,000 feet, fleeting glimpses
the seas below revealed an amazing state
turmoil. Waves were scarcely distinguishal
here and the ocean was almost completely o
scured by the mad rush of greenish streaked wh

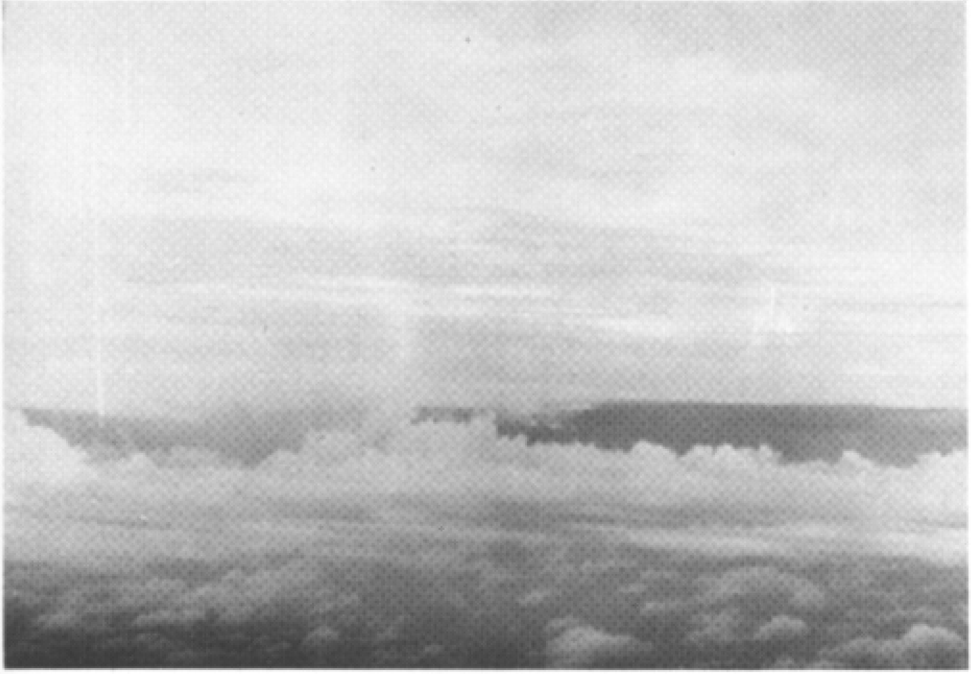

Fig. 5. A line of convective clouds, the first of six encountered between Guam and the typhoon center. These lines spiral cyclonically toward the eye of the storm, approximately parallel to the surface wind-flow. Most of the squalliness and heavy rains of the typhoon vortex are concentrated about these lines of convection. Broken altostratus clouds above airplane level are surmounted by an overcast of cirrostratus.

Fig. 6. The second line of convective cloudiness. Here, there is greater vertical development and the towers penetrate the altostratus overcast. Lines successively closer to the storm consisted of much larger towering cumulus whose towers neither diminished in size nor showed signs of spreading laterally as they penetrated the overcast.

FIG. 7. Panorama of eye from 17,000-ft elevation at a point just west of the eye-center looking southwest. Time 1100 LST. Temperature 16°C. Walls of the eye rise vertically to a height of approximately 35,000 feet. The cloud rim of the eye is 40 miles in diameter. Sky overhead is cloudless.

froth. Most of the crew were veterans of many typhoon reconnaissances; however, none had ever seen a sea condition, either inside or outside a typhoon eye which compared with that glimpsed from this vantage point.

A descent was made in the eye to as low as 600 feet in order to measure and observe more accurately conditions near the surface. Most of this low level flight, at an average (actual) elevation of 800 feet, was through stratocumulus clouds, and it was necessary to depend upon radar to direct the plane on a course diametrically across the eye. (*Note:* The APQ-13 radar ordinarily is capable of detecting and locating the position of only those clouds which contain rain droplets. The periphery of the eye, as revealed by radar, is essentially the envelope of the inner edge of nimbostratus or rain clouds which surround the eye.) The intent had been to measure pressure and temperature variations across the eye, turning back 5 miles before reaching the far edge in order to avoid the strong wind-shear near the edge. As the plane approached the turning point almost 6 miles from the edge of nimbostratus, most severe turbulence was suddenly encountered. Violent winds or vertical currents had extended well into the rainless sector of the eye. In the following four minutes the plane's flight analyzer recorded more than 5 *G*'s of turbulence on two occasions! This experience was sufficient to convince the crew that further exploration of the eye at low levels was impracticable.

In the brief period of that low-level flight very interesting information was obtained nevertheless (see FIGURE 2). There was a pressure gradient of important magnitude across the eye itself. The center of low pressure was in the geometric center of the eye (as identified by radar). Lowest sea-level pressure was computed to be 26.43 inches or about 895 mb. The temperature averaging 28°C varied less than 1 C° across the eye diameter. The particular diameter flown did not traverse or approach close enough to the two clear areas to determine with assurance whether these were localized eddy circulations or not.

A spiral ascent was next made in the eye to the 17,000-ft level, where a dropsonde was released (see FIGURE 3). This sounding indicated that the atmosphere from the surface to about 630 mb, while stratified, was essentially isothermal. Even at 500 mb the temperature was still more than 16°C! These spectacularly warm temperatures and the humidities with which they were associated deserve particular attention and will be discussed later. Suffice to say here, to the knowledge of this writer, such temperatures in the free atmosphere at the 500-mb level have never been observed previously under any circumstances.

Returning to operational requirements of the flight, the plane descended and left the eye to fly a n path about the vortex from a flight level of 00 feet (see track, Figure 1). The boxing aneuver consisted of measuring the velocities ar the surface in each quadrant of the storm order to determine storm intensity. Seas along is track were swept by winds estimated to range om 75 mph on the southwest side to more than 0 mph on the east and north sides of the vortex. typical example of sea conditions under the ess of such winds is shown in Figure 11. This cture was taken from a position about 60 miles st of the storm center (surface winds probably 5 to 85 mph).

In the east quadrant, the plane again climbed to 00 feet and headed for the eye to obtain the cond "fix" of the day. Temperatures at plane vel, measured frequently during this approach the eye, rose less than a degree until the plane reached the edge of the eye, than *rose very rapidly three centigrade degrees as the plane penetrated the eye.* Temperature continued to rise rapidly as the plane approached the center, reaching a peak value nearly 8 C° warmer than the area immediately adjacent to the eye. A second set of eye soundings was made at this time which revealed that temperatures in the layer 600–700 mb had cooled markedly—as much as 7 C°—in the five hours since the first sounding had been made, although still just as warm at the 500-mb level.

With fuel growing short, the plane upon completing the second ascent in the eye departed for home at an elevation of 17,000 feet. As the walls of the eye were reached, moderate turbulence was felt, somewhat greater and more continuous than had been felt when entering the eye through the same quadrant at 9,000 to 10,000 feet. At the

Fig. 8. View of eye from a point near the center of eye looking northwest. Note sea surface visible at wer left. Also note the conical shaped cloud at center which resembles a tornado vortex in a horizontal posi- on. Elevation of plane 16,000 feet. Temperature 18°C. Time 1050 LST.

FIG. 9. Southeast side of the eye as viewed from 15,000 feet, approximately 10 miles from the upper rim of the e
Note the clouds here have a harder appearance and the walls of the eye slope gradually upward to the east.

same time, it was noted that temperature began to fall more rapidly as the plane entered the wall of clouds surrounding the eye. It was not long before ice began forming on the cockpit windshield and other parts of the plane as the thermometer leveled off at − 5°C. *In a lapse of several minutes and a distance of 60 miles the temperature had dropped a total of 21.6 C°!* In this distance, however, turbulence had carried the plane up to 19,250 feet.* The drop in temperature due to change in elevation could theoretically have been as much as 7 C°. However, a sounding made a short while later indicated that the lapse rate of temperature in that area would have allowed little more than 3½ C° drop as a result of the 2,200-ft change in elevation of the plane. Therefore, a reasonable adjusted value of this important hor-zontal temperature gradient is probably abo *18 C° in 60 miles.*

* This change in altitude due to updrafts, while larger than that encountered at 9,000 feet, is approximately the same as that reported by Wood and Wexler [12] flying at 3,000 feet.

3. SIGNIFICANT FINDINGS

To summarize, the flight had recorded the f lowing significant information about the typho vortex:

1. A central surface pressure of 26.43 inch (895 mb). Insofar as this writer knows, *only* t other tropical cyclones of record have had low central pressures. Surface pressures compute from the dropsondes were slightly higher, b there was no assurance that these instrumen reached the surface at the exact center of the e

2. The pressure gradient from the edge of t eye to the center was more than 8 mb (in a di tance of 20 miles). This is sufficient to susta a 45-mph gradient wind, at a radius of 10 mil m center (and 10 miles from the edge of the e).

3. Violent winds or vertical currents near the rface had invaded the rainless circle of the eye tending more than 5 miles closer to the center. ese may have been associated with tornadic tion from a vortex similar to that in Figure 8.

4. Horizontal temperature variations in the rm were observed as follows:

a. Near the surface, little change in temperature across the SW–NE diameter of the eye.
b. At 9,000 feet:
   (1) little change in east quadrant approaching the eye;
   (2) rapid rises from edge of eye to center, nearly 8 C° in approximately 20 miles.
c. At 18,000 feet, phenomenally large temperature falls leaving the eye, approximately *18 C° in 60 miles.*

5. Pronounced cooling occurred near the 700-b level between the first and second set of eye undings, the first sounding having been made th the sun nearly overhead, the second in the e afternoon with the sun at a low angle.

These features not only attest the storm's greatss, but are of curious interest in connection with e structure of tropical cyclones in general.

4. The Eye Soundings

Consider the warmth of the eye soundings, escially in midtroposphere layers. The temperare was more than 16°C at an elevation of 17,000 feet. It is well known that the core of tropical cyclones is a region of stable lapse rates and unusually warm air. Such extreme conditions as encountered in "Marge" are unprecedented, however. By comparison with eye soundings made at Tampa, Florida during the hurricanes of October 1946 [8], and October 1944 [9], it is evident that in "Marge's" eye, temperatures at 10,000–15,000 feet averaged 10 C° warmer than the 1944 hurricane, and 14 C° warmer than the 1946 hurricane. Obviously the air in the core of this great storm had experienced exceptional modifications either through adiabatic compression, or absorption of radiation.

If this warmth were the result of descending motions in the eye, the ambient airmass would have had to be brought down from an initial injection height of approximately 47,000 feet to reach the 17,000-ft level with a temperature of 16°C. Moreover, if saturated at the injection level, the air would have reached 17,000 feet with a *relative humidity of less than two-tenths of one percent*—provided moisture were not entrained during the descent. If there were extensive descending motion originating at such heights, the inference might be drawn that the air in the eye was of stratospheric origin, the tropopause having been swept downward to the surface by the descending currents. An examination of primary tropopause heights during the approach and passage of other tropical cyclones [10] has indicated, however, that the tropopause falls during the early approach of the storm reaching a minimum about the time the first squalls begin, then rises rapidly to a maximum near or over the center. In both eye soundings at Tampa, the radiosonde failed to reach the primary tropopause after rising to 100 mb in the 1944 storm and 150 mb in the 1946 storm. One sounding at Tokyo, released within a few miles of the eye during the passage of typhoon "Kitty" [1] in 1949, extended to 19 km without reaching the stratosphere. A secondary type of tropopause as suggested by Palmén (1948) may form in connection with descending motions in the eye and extend to the surface; however, the air which fills the eye undoubtedly has its main source in the upper troposphere, probably being injected through some such circulation process as suggested by Riehl [6].

The possibility that the exceptional warmth of "Marge's" eye was at least partly due to nonadiabatic changes merits examination. The contribution of solar radiation in warming the clear air of the eye suggests itself in view of the cooling which occurred in the 600–700 mb layer during

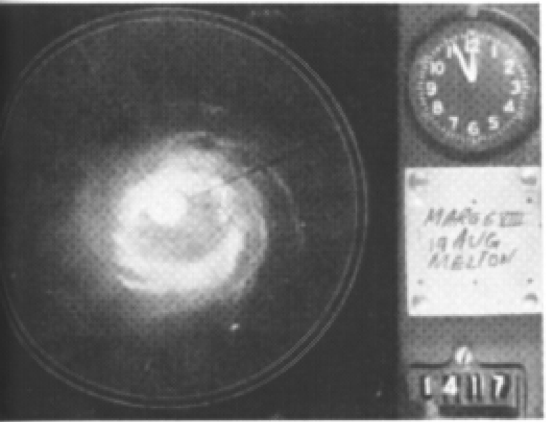

Fig. 10. Radar view of the eye of typhoon "Marge." he bright lines are a reflection of radar waves upon in droplets. The eye itself being relatively free of in is identified by a minimum return of radar energy th the spiral bands of convective cloudiness winding out the eye like a spiral nebula.

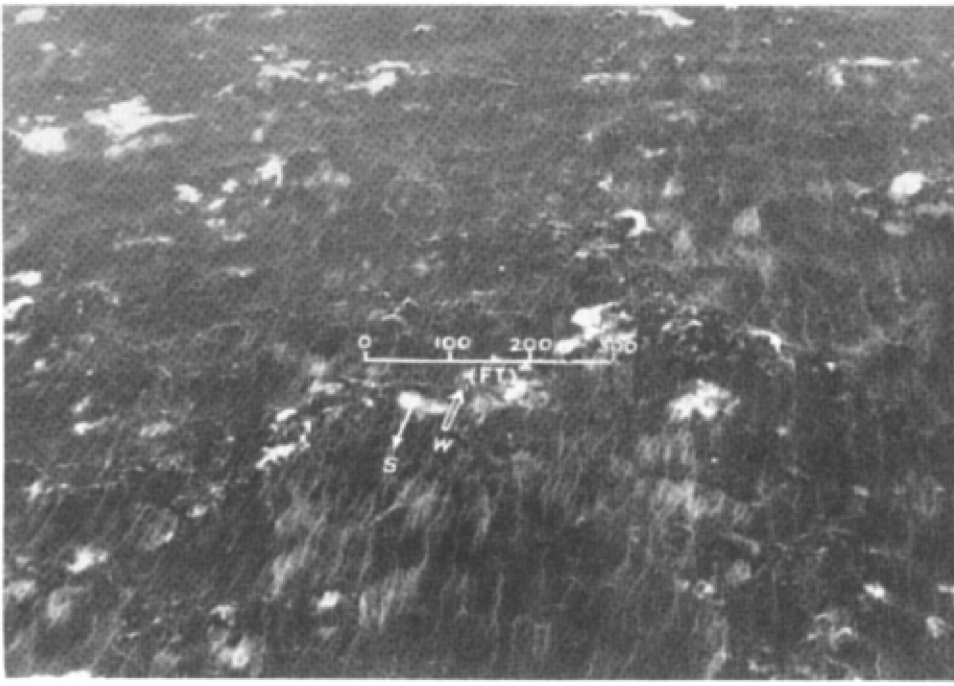

FIG. 11. The sea surface as viewed from 1,700 feet looking downward at a 60-degree angle (from the horizontal). This picture was made from a point approximately 60 miles west of the typhoon center, which was under the influence of surface winds estimated to be 75 to 85 miles per hour.

the five hours between the two eye soundings in typhoon "Marge." The first sounding was made with the sun overhead, the second in late afternoon with the sun approaching the horizon, and the lower portion of the eye shaded. However, assuming ideal stratification of moisture with the clear air from 600–700 mb saturated with water vapor, the maximum cooling of that layer due to long-wave radiation outward to space in the five-hour interval between the two soundings could scarcely have exceeded 2 C°—far less than observed. Moreover, as pointed out earlier, the presence of large amounts of water vapor in this part of the eye is unlikely if subsidence played any part at all in warming the air of the eye.

Unfortunately, the distribution of water vapor in the column of air which filled the eye was not well established by this reconnaissance, because of conflicting data. The ascent sounding, using the ML-313 psychrometer, indicated quite high humidities above 8,000 feet, while the hair hygrometer of the dropsonde recorded humidities which dropped off from near saturation in the lower clouded part of the eye to less than 30% in the clear air above. TABLE 1 compares the humidities of the ascent soundings at 0120 and 0650 GMT with those of the dropsonde at 0155 and 062 GMT.

Finally this curious cooling might have resulte from adiabatic expansion. If for some reason th

TABLE 1. COMPARATIVE DATA FOR EYE SOUNDINGS IN TYPHOON "MARGE," AUGUST 15, 1951

Elevation (Gdm ft.)	Midday			Late afternoon		
	Tmp. (°C)	Relative humidity (%)		Tmp. (°C)	Relative humidity (%)	
		Dropsonde	ML-313		Dropsonde	ML-3
Surface	26.2	92	(98)	26.8	100	
2,000	22.9	96	M	23.3	100	
4,000	25.0	79	M	25.2	80	
6,000	27.2	47	M	23.7	75	
8,000	25.8	39	98	19.0	65	
10,000	25.2	32	98	18.2*		87
12,000	23.2	28	100	18.6*		78
14,000	20.3	28	100	20.4*		100
16,000	17.4	28	100	17.4*		100
17,000	16.6	M	100	16.6*		100

* ML-313 temperatures (ascent sounding); all othe are dropsonde (bimetal element) temperatures.

[?]y middle layers of the eye, between 7,000 and [?]000 feet, were lifted as much as 2,000 feet, adiabatic expansion could account in full for the cooling observed.

Whatever the true explanation of this example of cooling a cursory examination of eye soundings made in previous typhoons reconnoitered from Guam indicates that this is not an isolated case of large diurnal temperature changes in the eye of typhoons.

5. Horizontal Temperature Gradients

The warmth of "Marge's" eye was no less spectacular than the horizontal temperature gradient around the midtroposphere core of this storm. While large temperature gradients have been observed previously in the upper troposphere near the eye of tropical cyclones (Arakawa [1]), a drop of 18 C° in a horizontal distance of 60 miles is unprecedented, and rarely encountered aloft under any circumstances even in strong Arctic fronts.

It is interesting to note that the greatest change in temperature at 18,000 feet occurred in the rain area just outside the eye, while at 9,000 feet very little change was observed in the rain area, most of the increase occurred after the eye had been penetrated.

Figure 4 shows the horizontal distributions of temperature in typhoon "Marge" and its environment at the time of the reconnaissance. Here the isopleths of mean virtual temperatures, computed from thicknesses, 700–500 mb, define the characteristic warm-tongue pattern [8] whose distention in advance of the storm foreshadowed its general direction of movement.

6. Convective Turbulence

In view of the concentration of isotherms in the rain area at 18,000 feet, it is not surprising that turbulent drafts at this level were somewhat heavier and more sustained than those adjacent to the eye at 9,000 feet. This coupled with the fact that the plane, leaving the eye at 17,000 feet, was carried upward 2,200 feet by turbulence tends to support the hypothesis of Deppermann [2] that the eye is surrounded by an intense ring of vertical currents, which extend well into the middle troposphere. Since the traverse of this zone or ring of intense convection at 9,000 feet required only a few seconds, the plane did not encounter sustained drafts of note, only a pronounced bump or two, and was carried upward by vertical currents probably no more than 500 feet.* Based upon observations of turbulence this zone of convection would appear to be quite narrow probably less than 1 km near the surface, expanding gradually to a width of probably 10 or 12 km at 18,000 feet.

Wexler and Wood [12], in a research reconnaissance of a severe Atlantic hurricane in 1944, reported encountering a similar narrow band of updrafts near the edge of the eye, which carried the plane upward some 2,000 feet from the initial flight level of 3,000 feet. On that flight the area approaching the eye, however, was described as one of persistent downdrafts, and the eye itself as comprising generally turbulent air with persistent updraft. While it is possible the flight by Wood and Wexler never completely broke through into the characteristic air of the eye, it should be pointed out that the flight into typhoon "Marge" described here encountered no recognizable persistence of downdrafts in any quarter, and that the air in the unclouded section of the eye was generally quite smooth, notwithstanding the one example of severe low-level eye turbulence described previously.

7. Height of the Typhoon Circulation

In view of the very low central pressure at the surface and the exceptional warmth of the eye in typhoon "Marge," it is interesting to consider how high the storm circulation may have extended. Theoretical computations by Haurwitz [3] and observations from other mature storms [7] [8] [10] have shown that the cyclonic circulation of the storm in many instances may bore upward through most of the tropospheric column, if not into the stratosphere. In warm-core storms the pressure gradient which drives the cyclonic circulation diminishes with height since pressure decreases with height at a slower rate in warm air than in cool. Therefore, within the storm circulation the pressure difference between the storm center and a point, say 250 miles from the center, becomes smaller with height. At the elevation where this difference is reduced to zero, most of the forces tending to circulate the air about the vortex disappear. Theoretically, this should be the top of the storm above which circulations should gradually become anticyclonic if temperature differences between the core and outer vortex are of the same sign as in the lower layers of the

* During the few seconds in which the plane traversed the updraft zone at 9,000 feet, the pressure altimeter rose 1,100 feet. However, changes in the radio-altimeter indicated that some 600 feet of this change must have been due to the pressure gradient in the area.

storm. In FIGURE 3 a comparison of the difference in contour heights in the eye with those of the outer vortex shows that the pressure gradient (approximately 100 mb in 250 miles at the surface) has decreased by less than 30% in the lower 17,000 feet. In estimating the decay above this level it is convenient to refer to the Tampa hurricane soundings of October 1944. The sounding made when the storm was approximately 250 miles south of Tampa closely approximates the temperature and lapse rate of the dropsonde made 260 miles east of center in typhoon "Marge." If it is assumed (1) that upper troposphere lapse rates at a point 250 miles from center were the same in both storms, and (2) that the eye of the typhoon remained 18 C° warmer than the outer vortex, then the "top of the storm" would be reached at approximately 49,000 feet. On the other hand, if, as was true in both Tampa hurricanes, the lapse rate in the eye became steeper in the upper troposphere, so that eye temperatures approached the temperature of outer vortex air, the storm circulation would extend much higher. If, as indicated at Tampa in 1946, the eye became colder than its surroundings at some point below the top of the storm, a re-intensification of cyclonic circulation higher aloft could be expected. Assuming eye temperatures at 100 mb were the same as the outer vortex, then contour heights in the eye at that level would be approximately 200 feet lower than in the outer vortex 250 miles away.

8. RESEARCH RECONNAISSANCE PROJECT AT GUAM

The typhoon-research reconnaissance project at Guam should eventually provide extensive additional information from which a much clearer picture of tropical cyclone structure may be gained. Reconnaissance is planned for typhoons in several stages of development. Each research mission will plan to release some two-dozen dropsondes from high elevations into all strategic quarters of the storm. Careful measurements of temperature and pressure profiles will be made at significant levels in the eye and in all quadrants of the storm. In addition measurements will be made of wind components circulating about the core of the storm in the middle and upper troposphere.

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ANNOUNCEMENT

Call for Papers
119th National Meeting, St. Louis

The 119th national meeting of the American Meteorological Society in conjunction with the annual meeting of the American Association for the Advancement of Science will be held in St. Louis, Missouri, December 30-31, 1952. A symposium on Tornadoes and Tornado Forecasting is scheduled for the afternoon session, December 30, in Room B, Kiel Auditorium. An additional session on meteorology is planned for the morning of December 31, if sufficient papers are received. Anyone desiring to present a paper at the St. Louis meeting, December 31 session, should send title and abstract to Prof. Edward M. Brooks, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo.