60. *Note on the Eye of the Storm.*

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It is a well known fact that in the innermost part of a well developed tropical cyclone there exists a region in which light and variable wind or often absolute calm prevails. In this region the rain which falls in torrents in the surrounding region ceases here to fall, and the clouds occasionally break up, so that the sun, or the moon and stars, become visible on the blue sky. The central calm area is commonly called "the Eye of the Storm." Usually the central calm area of the tropical storm is described as the region of high temperature and excessive dryness, basing on a single example of the Manila typhoon of October 20, 1882. As an explanation of the high temperature and low humidity of air in the central calm area is assumed the existence of a descending current of air within the area caused by a vigorous circulatory motion of winds around it. In Japan we have a dense net of the meteorological stations and have ample opportunity in observing the passage of the eye of the storm over the stations. We have many instrumental records of the meteorological elements taken during the passage of the storm centre. From examination of these records we have ascertained that there are many cases of the eye of the typhoon, having the high temperature and also high humidity. Hence it seem to us that the excessive heat and dryness of air are not essential characteristics of the eye of the storm. We give below a couple of the remarkable instances of the eye of the storm observed in our net of stations in recent years:—

The eye of the typhoon observed at Tomie in the Goto island off the northwest coast of Kyusyu on September 26, 1931.—The typhoon was noticed near Jap island on the 17th of September, 1931. Moving westwards the cyclonic centre approached to Luzon on the 19th. Inclining northwards the typhoon visited the island. After traversing Formosa on the 23rd the typhoon travelled over the Eastern sea, causing a violent storm of wind and rain along the track. On the morning of the 26th the centre crossed the island of Goto. The eye of the storm passed over Tomie in the island about 7h 30m on the same morning. According to the observations made at the Tomie meteorological station the gales of 21.5 m.p.s. was observed at 3h 50m on the 26th. At

4h a.m. the barometer fell to 745.1 mm. The wind shifted towards SSE. At the zenith some stars were visible for a few seconds. Lower clouds are coming from SSE. At 6 a.m. the barometer fell to 743.4 mm. The wind began to increase in force and the velocity of 16.5 m.p.s. was observed at 6h 30m. At 7 a.m. the barometer fell to 742.4 mm. At 7h 30m the wind suddenly ceased and calm set in. This shows the central calm area of the typhoon is passing over Tomie. At 8h 00m the light wind from WSW was prevailing. The amount of clouds was 8 and the sky, though not perfectly blue, was visible through the breaks of clouds. A few streaks of fibrous cirri were seen drifting high in the sky. At 8h 7m the sky become brighter. A swarm of dragon flies was seen, but they were flying about pretty high so that we could not catch them with bare hands. Drizzling rain showers were experienced. The sun shone forth for the interval from 8h 20m to 8h 58m, and left a distinct trace in the Jordan sunshine recorder. This state of calm continued about 35 minutes. At 8h 30m the strong winds from NNW set in, and the storm of wind and rain was increasing.

Tomie.

 $\phi = 32^{\circ} 37' N.$ $\lambda = 128^{\circ} 46' E.$

H = 26.7 m.

September 26, 1931.

Time h m	Atm. Press.	Air Temp.	Rel. Hum.	Wind Vel.	Wind Dir.	Weather
5 00 a.m.	744.1 mm.	24.0 c.	94%	10.9 m.p.s.	SE	Rain.
6 00	743.4	24.8	96	7.1	S	Rain.
7 00	742.4	24.5	97	8.0	SSE	Rain.
8 00	742.0	25.5	93	2.2	WSW	Rain.
8 10	741.9	25.2	90	5.7	NNW	Rain, on & Off.
8 20	741.8	25.1	86	7.2	NNW	Rain, on & Off.
8 30	741.7	25.0	85	8.2	NNW	Rain, on & Off.
8 40	741.8	25.1	84	7.2	NNW	Rain, on & Off.
8 50	742.3	25.0	82	9.3	NNW	Rain, on & Off.

The eye of the typhoon observed at Tyôsi on November 15, 1932 is noteworthy one, since a complete instrumental record of the chief elements of weather is taken at Tyôsi where the passage of the central calm of the typhoon is also observed by the Meteorological Observatory there. This remarkable typhoon was first noticed near Jap island on the 7th. Moving towards WNW and inclining gradually northwards the typhoon centre passed along the northeast coast of Luzon where it recurved towards northeast on the evening of the 12th. On the early morning of the 15th the typhoon passed near Tyôsi on

the Pacific coast of Bôso peninsula. At this locality the barometer began to fall rapidly on the morning of the 14th and very rapidly from 11 p.m. A terrible storm of wind and rain prevailed. From 8h p.m. the wind began to veer towards the southeast. At about 2h 10m a.m. the wind suddenly fell, showing the passage of the eye of the typhoon over the locality under consideration. The calm prevailed about 6 minutes. At 2h 40m a.m. the barometer fell to 714.3 mm., the lowest reading that ever observed at Tyôsi. After the end of an ominous calm of about six minutes the gale from the northwest suddenly began to blow and rain squall of terrible intensity set in. During the passage of the central calm the warm and moist air from the southeast was felt. About 1 a.m. the sky which was very dark and threatening became faintly lighted. About 2 a.m. the western sky became especially lighter, and the trees at a distance of about 50 metres were distinctly visible. A misty moon was also visible, but no stars and patches of the blue sky were not seen at all. The heavy rain which continued from 2 a.m. stopped at 2h 21m a.m. and no drop of rain fell till 2h 35m a.m. After the laps of 14 minutes the rain set in and continued till 6 a.m. of the same morning. We give below an extract of the record of observations taken at the Tyôsi Observatory:—

Tyôsi.

 $\varphi = 35\ 44' \text{ N.}$ $\lambda = 140\ 51' \text{ E.}$ $H = 18 \text{ m.}$

November 15, 1932.

Time $\begin{smallmatrix} \text{h} \\ \text{m} \end{smallmatrix}$	Atm. Press.	Air Temp.	Rel. Hum.	Wind Vel.	Wind Dir.	Weather
1 00 a.m.	721.2 mm.	16.9 c.	85%	23.9 m.p.s.	ESE	Rain.
2 00	715.0	18.1	97	12.2	ESE	"
2 10	714.7	18.6	97	7.6	SE	"
2 20	714.5	18.6	96	8.2	SE	Cloudy.
2 30	714.4	18.6	96	5.1	SE	Rain.
2 40	714.3	18.5	96	1.3	SE	"
2 50	714.8	16.8	98	11.1	SW	"
3 00	715.3	16.5	96	14.1	NW	"
4 00	722.1	10.8	93	27.6	WNW	"

In the case of an ideal fluid there may occur a potential motion in which the stream lines are circular and encircle an area where the fluid rests in absolute calm. We consider here a case of such motions. Let u and v be the velocity components, φ be the velocity potential and ψ be the current function.

Customarily we put $z = x + iy$, then any function of z may be written as

$$w = f(z) = \varphi + i\psi.$$

As a solution of the equation of continuity we consider a case in which we may put

$$w = \log z \quad \text{or} \quad z = e^w = e^{\varphi + i\psi} = x + iy.$$

The equation of stream lines is

$$\varphi = \text{const} \quad \text{or} \quad x^2 + y^2 = e^{2\varphi} = \text{const},$$

which shows they are concentric circles.

The velocity potential and velocity components are

$$\varphi = \log r, \quad u = \frac{x}{r^2}, \quad V = \frac{y}{r^2}.$$

Since the velocity becomes infinitely large at the centre of the revolving fluid we will exclude a central area having a radius of R from our consideration, and will imagine a cylindrical wall around the area, which disturbs the motion in no way. In the central area the fluid may be absolutely at rest while it may make a tangential motion of enormous velocity, the cylindrical wall being the surface of discontinuity.

In the earth's atmosphere there can not occur such a discontinuous motion as in the case of an ideal fluid. Nevertheless we may consider an analogous state of motion occurring within the area of a tropical storm, especially near the centre, since there occurs a calm area at the centre of the storm and the winds circulate almost tangentially around the calm area. Such being the case for the eye of the storm the air filling the central core of the storm may be of any properties as regard to temperature and humidity. Originally the air in the central area may have the high temperature and low humidity, or it may be of excessive high temperature and humidity as seen from the instances given above. We have no necessity in assuming a descending current of air in the central area as were done by Davis, Ballou and others.