smaller than those of the ordinary bow; the other question was that how a drop of water can lie upon ice without wetting it and losing its shape altogether. In the light of the modern science these two questions seem to be clearly answered, as shown in the text of the present paper, taking the following facts into consideration: First, the water drops are very small ones, and, second, they float in the thin stratum of air in contact with the ice surface but [they do] not lie on the surface. According to the diffraction theory of the rainbow, the angular aperture of the bow becomes small when the droplets producing the bow are very small. In many cases they are invisibly small. That the droplets are floating in air, but not lying on the surface of ice or water, can easily be seen from the fact that the bow appears on the water surface as well as on the ice surface, and also that it occurs always on calm and bright mornings in the cold season. The following fact also supports the idea: On the morning of March 17 we observed a horizontal bow in the moat of our observatory. At about 9:20 a. m. we saw wind that came over the water surface from the west. The bow became faint when the head of ripples arrived at the bow, and gradually it vanished away as the wind became stronger.

From early times people in Suwa have been well acquainted with the phenomenon. They call the phenomenon "Ohikari" which means literally a holy shine, and take it to be a foretoken of the coming change of the weather. Indeed, many times when we observed a horizontal rainbow in the moat of this observatory we experienced rain or storm one or two days after. The reason of this, in my opinion, must be as follows: On the Pacific side of Japan the weather in winter is generally clear and the northwesterly monsoon prevails every day. On the appearing of a cyclone in the west the monsoon is disturbed by the easterly or southeasterly winds flowing into the cyclonic center. Hence there then prevails a calm. Considering the atmospheric pressure, this calm corresponds to the high pressure over Japan, which is followed by a cyclone. Such a calm is always favorable for the formation of a horizontal rainbow. Thus the calm, as well as the horizontal rainbow, are in many cases the foretokens of the coming cyclone.

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OBSERVATIONS OF HORIZONTAL RAINBOWS.[1]

By KATSUJI NAKAMURA.

[Dated Central Meteorological Observatory, Tokyo.]

The author of the present note had favorable opportunities of observing the horizontal rainbow in the moat near the entrance of Central Meteorological Observatory, which is situated in the compound of the old castle of Tokyo. The following lines contain short descriptions of the phenomena and of the weather conditions that then prevailed:

1. Horizontal rainbow on January 30, 1914.—On the morning of January 30, 1914, a greater part of the surface of the moat was covered with a thin coating of ice. The sky was cloudless, and the air was so calm that we scarcely felt even the quivering of the leaves of trees and grasses. We observed the rainbow from 9:30 a. m. until 10:40 a. m. before the ice began to melt.

When we stood at A (a point on the bridge) in figure 1, turning our back to the sun, we saw the rainbow on the left and downward as at DH, but its colors were not distinct. Then as we moved from A toward B, C, . . . the far side of the rainbow appeared to shift from D toward R and E, . . . and its colors gradually became vivid.

As seen from F, a point higher than A, B, M, C, etc., we also saw the rainbow toward KF, but its colors were not so distinct as when seen from the other places, A, B, etc. At G, one of the highest places, we saw that the bow was lying toward LG, its color becoming fainter. But when standing at O, a point having an equal height with G, we could not see the bow.

From what we have stated above we see that G is one of the limits of visibility of the rainbow on this morning.

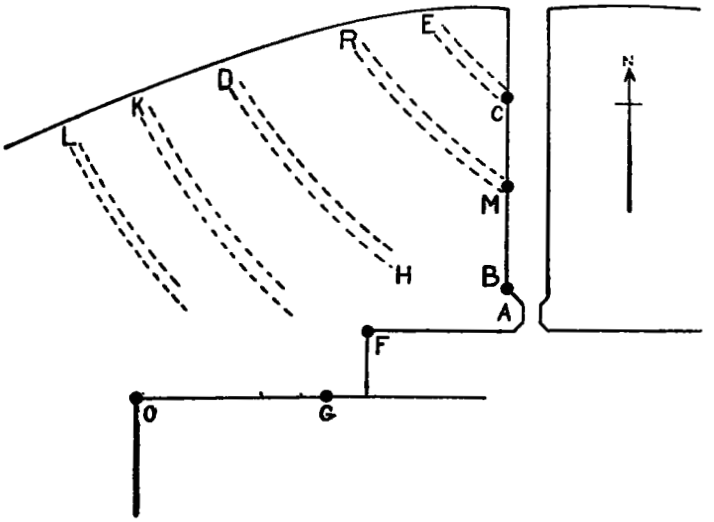

FIG. 1.—Plan of moat of Central Meteorological Observatory, Tokyo.

On the ice surface the rainbow was more clearly visible than on the water.

We give here the widths of the rainbow that Dr. S. Fujiwhara observed with a sextant:

9:50 a. m.:	°	′	10:25 a. m.:	°	′
Red	41	35	Red	42	36
Violet	38	54	Violet	39	53
Width	2	41	Width	2	43

Of course these values are rough approximations.

2. The rainbow observed on February 17, 1914.—On this morning upper clouds thinly covered the sun and the sky and it was so calm that it grew rather hazy all around and there was no ice in the moat.

We observed the rainbow, on this morning also, at the same places, A, B, M, C, etc., in figure 1. Its color as seen from B was more vivid than when seen from A, and clearer as seen from M than from B. When seen from C it was not so clear as when seen from M, that is to say, from M the bow was clearer than from other points and the color became thin by standing away from the place M. Besides this, even on the same zone MR, the color of the bow at R was very clear and became gradually faint toward M.

We give here the results of Dr. Fujiwhara's measurements:

9:44 a. m.:	°	′
Red	41	52
Violet	40	02
Width	1	50

[1] *Reprinted from* Jour. met'l soc., Japan, Tokyo. 33rd year. June, 1914, pp. 25-28.

At 10:30 a. m. the sun's altitude was about 34° 30′. The results of the meteorological observations made on these mornings in Tokyo are as follows:

Atmospheric condition on January 30 and February 17, 1914.

January 30, 1914.

Elements.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.
Pressure (mm.)	756.8	756.9	756.9	756.9	756.8	757.2	757.7	757.9	758.0	758.0	757.6	756.6
Air temperature (° C.)	−1.6	−1.8	−1.3	−1.8	−2.4	−2.5	−2.5	0.2	2.9	5.9	7.4	9.0
Relative humidity (per cent)	90	90	85	85	87	80	82	70	65	53	51	44
Vapor pressure (mm.)	3.7	3.6	3.5	3.4	3.3	3.0	3.1	3.3	3.6	3.7	3.9	3.8
Wind direction	SSE.	SSE.	W.	W.	W.	W.	W.	W.	W.	W.	NNW.	NE.
Wind velocity (m/s)	1.1	1.3	2.4	2.0	1.5	1.5	1.3	1.6	1.5	1.5	2.4	2.2

February 17, 1914.

Elements.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.
Pressure (mm.)	766.4	766.4	766.2	766.2	766.7	766.5	766.6	766.7	766.7	766.4	766.1	765.5
Air temperature (° C.)	2.4	2.6	2.8	2.1	0.6	−0.4	−0.2	3.0	5.2	7.9	11.6	11.2
Relative humidity (per cent)	98	98	96	98	96	95	95	94	79	67	60	60
Vapor pressure (mm.)	5.3	5.4	5.4	5.2	4.6	4.2	4.3	5.3	5.2	5.3	6.1	6.2
Wind direction	NE.	NE.	N.	N.	N.	N.	N.	N.	N.	N.	NNW.	NNW.
Wind velocity (m/s)	1.5	1.5	1.1	1.3	1.3	1.3	1.3	0.8	1.5	0.8	1.8	2.8

In the above tables the air pressure is not reduced to sea level, but only to freezing point.

3. *Horizontal rainbow on March 17, 1914.*—On this morning the sky was so clear that we observed not a single speck of clouds and the air was comparatively calm. At the surface of the same moat we observed a horizontal rainbow from 8:30 a. m. until 9:20 a. m. But on account of ripples on the surface of the moat we could observe no more after 9:20 a. m.

In the narrower part of the moat, which was nearer to [it ?] the north side of the bow was very distinctly visible. We could not measure the width of the bow with much accuracy, but the value estimated was about 3°.

In conclusion, the author wishes to express his hearty thanks to Dr. T. Okada for his kind guidance.

THE HALOS OF NOVEMBER 1 AND 2, 1913.

By Dr. LOUIS BESSON.

[Dated: Observatoire de Montsouris, Paris, April 21, 1914. Translated by C. Fitzhugh Talman, Professor of Meteorology.]

Some remarkable optical phenomena of the class of halos and parhelia were seen in the eastern half of the United States on November 1 and 2, 1913. On the 1st, there was observed at many places the halo of 22° radius, in some cases brilliant and accompanied by the parhelia pertaining to it, but the phenomenon appears to have attained abnormal complexity only in a rather limited region, comprising southwestern Missouri and extreme northeastern Arkansas. At Springfield, Mo., according to Mr. J. S. Hazen, Local Forecaster, "this unusual and remarkable phenomenon excited a great deal of interest and comment among all classes and the office had more than a hundred calls during the day concerning the phenomenon."

The following day, optical phenomena no less remarkable, and of a very similar aspect, were again observed, but this time at a great distance to the eastward, in the states of Virginia, West Virginia, and Maryland. In a letter to the editor of the Scientific American, Dr. E. C. L. Miller, of the University College of Medicine at Richmond, Va., says that the phenomenon was very complex and striking at that place. It was doubtless equally so, he adds, "in a considerable area, for several inquiries were received by the railway companies from their station agents out on their lines as to the cause of the phenomena." From inquiries made by Prof. J. Warren Smith at Columbus, it appears that in Ohio several persons observed brilliant and persistent halos on the 1st and 2d, as well as parhelia and other less common appearances, but that the phenomenon was less generally observed and probably less well developed in that region.

METEOROLOGICAL CONDITIONS ACCOMPANYING THE PHENOMENA.

Brilliant halos often precede or accompany atmospheric disturbances. Those of November 1 and 2, however, were produced under typically anticyclonic conditions, and were not followed by bad weather. A center of high pressure was over Iowa on October 31, over Indiana, November 1, and over West Virginia, November 2. Not much information is at hand in regard to the movement of the ice clouds in which the optical phenomena were produced. At Springfield, at 10:30 a. m. of the 1st, the clouds were of the cirro-stratus type, and were moving from the northwest. At 11:30 their appearance was that of alto-stratus, moving from the west, and about 3 p. m. they became stratus, from the same direction. This progressive descent of the clouds leads Mr. Hazen to say that "the downward movement of the ice particles, from which the halo resulted, was evidently large," and that "it is probably true that ice particles, which may result in halos, have a greater or less downward movement, and it is suggested that the more complex forms of halo may be due to large ice particles and consequently greater downward movement or velocity." This opinion is entirely in accord with that which I expressed in 1909 in my thesis "Sur la théorie des halos,"[1] in consequence of a large number of similar observations.

HALOS OF NOVEMBER 1.

Mr. J. S. Hazen, Local Forecaster, Weather Bureau, has furnished a detailed description and a drawing of the phenomenon observed at Springfield, Mo. This drawing, reproduced in figure 1, is a combination of three different sketches made during the rather long duration of the halo; it does not, therefore, relate to a definite time and elevation of the sun. The part of the phenomenon which attracted most attention was a wide ring, *A*, half a degree

[1] Annales de l'observatoire de Montsouris, 1909, 10: 161.