CORRELATION OF ATMOSPHERICS WITH WEATHER PHENOMENA

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1. Introduction

The idea of locating storm areas by means of the associated atmospherics has prevailed more than ten years in Europe [1] as well as in Japan [3][4]; in fact, R. Bureau [1] in Paris made early an extensive study on the theme for long time by using rotating type direction-finders. In order to critisize, from a point of the present circumstances, the practical value on their applicability to weather analysis and forecast, we made the directional observation of atmospherics at two stations, distant 56 km from each other, simultaneously with "Instantaneous Type Direction Finders", and determined the origin of atmospherics by triangulation. Their results were compared with the weather maps and associated meteorological information; the intimate correlations with thunderstorms, cumulo-nimbus and the similar discharge phenomena in the atmosphere were ascertained.

The observation was made in the autumn of 1943 at Iwatsuki Receiving Station, Ministry of Communications, and Kakioka Magnetic Observatory, Central Meteorological Observatory, both of which are situated in the Kanto-Plains.

2. Method of Observation

Atmospherics direction finding involves determining the arrival direction of electromagnetic pulses associated with certain types of active meteorological phenomena. The variation of these pulses is of short duration and wide variety. They have no definite call sign; they have a very short duration, rarely exceeding 3 ms [5][6]; their energy is distributed over very wide range of frequencies, of which they have maximum energy at 7.5 kc/s [5][6]; they often arrive from several directions almost simultaneously; the antenna system for them should not exhibit a blind angle azimuth in any direction at any instance. Consequently, the device to be required should be an instantaneous type direction-finder [2]. Rotating frame type [1], used ten years ago by some European authors and by us, are impractical for the present requirement, except for that from very long distance.

The instantaneous type direction-finder consists of the two frame antennae oriented mutually perpendicular, two amplifiers connected separately to each frame antenna, and an indicating cathode-ray oscillograph.

Two frame antennae of direction finder are placed at right angle to each other so that the mutual inductive effect may be avoided. The plane of each frame antenna

is oriented vertically, the one in the north-south direction, the other in the east-west direction; the north-south direction was determined by observing the polestar, and consequently the east-west direction was set by measuring the perpendicular direction to the north-south one. Each of the frame at Iwatsuki consists of 4 turn loops, measured 21 m in horizontal length and 7 m in vertical; the one at Kakioka consists of 5 turn loops, measured 20 m in horizontal length and 8 m in vertical, the underside wires of loops at both stations being set 4 m above ground. Stays of the antenna poles were insulated at every 4 m length to avoid the energy loss and directional disturbances due to interfering effect of induction. These two stations are in the middle of the Kanto-Plains, being free from disturbances due to electric railways, power transmission lines, communication lines, iron frame works, factories, woods and forests, and hills and mountains, etc. These favourable conditions make them ideal sites for direction finding of atmospherics. Double supper-heterodyne receivers, with the first and second intermediate frequencies of 400 kc/s and 60 kc/s respectively, were employed; they could be tunable in every frequency between 10 and 20 kc/s (Fig. 1). Although this type of receiver is convenient to attain to sufficient gain and good selectivity, it is rather difficult to adjust circuits to obtain strictly the same gain and phase angle, for every frequency of passing band, at each stage of both receiving sets. This adjustment is indispensable to keep the pattern on the oscilloscope in a straight line, for in general it is an ellipse whose dimensions are related to the phase difference in accordance with known principles.

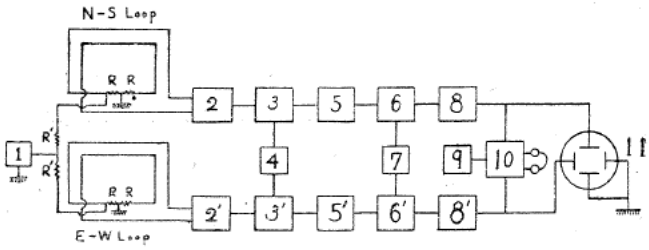

Fig. 1. Block diagram of a direction-finder for atmospherics.
R : Coupling resistance of 1 ohm.
R' : Buffer resistance of 1,000 ohms.
1 : Test oscillator.
2, 2′: High frequency amplifier tuned to 20 kc/s.
3, 3′: First converter.
4 : First local oscillator of 380 kc/s.
5, 5′: First intermediate frequecy amplifier for 400 kc/s.
6, 6′: Second converter.
7 : Second local oscillator of 340 kc/s.
8, 8′: Second intermediate frequency amplifier for 60 kc/s.
9 : Third local oscillator of 61 kc/s.
10 : Third converter for aural reception.
11 : Braun tube oscilloscope.

The frequency conversion receiving system has advantages of high and controllable selectivity as well as high gain with stability, which makes up satisfactorily disadvantages for elabolate adjustment required. At present the advanced technique of radio engineering and highly developed amplifier tubes allow us to use straight amplifiers with sufficient gain for receiving atmospherics at a far distance, and therefore we adopted the latter principle for the recently constructed receiver with circuit Q adjusts. This procedure helps us to obtain exactly the same characteristics for both receivers over wide range of frequencies in the psssing bands, and so we can expect

a straight line pattern on the oscilloscope independent of frequencies and amplitudes.

For exact balancing of the two limbs, the output of the test oscillator was injected to the two accurately matched resistors, each of 1 ohm, inserted at the centre of each loop with their junction points earthed, in order to maintain symmetry to earth (Fig. 1). Consequently, if equal voltages are injected into each frame, with the amplifiers exactly adjusted for similarity of gain and phase, the result is the simulation of a signal incident at 45° to the meridian, this being the signal which exites both frames equally. The image on the oscilloscope should be a line inclined midway between the two axes of deflection.

To record patterns on the oscilloscope, we reconstructed a long time recording camera for ordinary electromagnetic oscillograph, and employed it with a lens of aperture ratio $f = 2.0$ at Kakioka, while at Iwatsuki we employed a variable speed photo-recorder of Rokuo Co. with a lens of aperture ratio $f = 0.85$. The film used was a supersensitive panchromatic one, Sakura USS, and their peripheral speed on the drum was 2 cm/s at Kakioka and 4 cm/s at Iwatsuki. As a time mark, we employed a converged beam of lamp imposed on the oscilloscope which was modulated by a standard clock output at every second in Iwatsuki, while in Kakioka we employed a 2 elements oscilloscope, one of which was used to impose a time mark similar to the one in Iwatsuki.

As a standard clock, we used a Liefler's pendulum clock at Kakioka and a crystal clock at Iwatsuki, both of which were calibrated by a radio time signal and found to be satisfactory. Gain of receiving sets at both stations were adjusted exactly to equal value for convenience of triangulation.

3. Results and Discussions

The film recorded was enlarged by a magnifying glass and we took reading of direction, approximated within 5°. The origin of atmospherics was determined for every observation at both stations by triangulation, and was compared with the aeronautical weather reports as well as the thunderstorm reports. We found a fairly well coincidence between the origin of atmospherics and the position of thunderstorms and cumulo-nimbus. Some examples will be found in the following with tables and diagrams.

(*1*) *September 15, 1943.* The origin of atmospherics are indicated by dots in Fig. 2, where the informations from aeronautical weather reports are indicated, and the direction in addition to the time of occurrence of thunderstorm are written from thunderstorm reports. On Sept. 15, at first the thunderstorms were stagnant over south-eastern suburbs of Niigata-city as well as over zonal district including Fukushima-city, the Lake Inawashiro and Shirakawa-city. It is very likely that these thunderstorm groups moved afterwards in the eastern direction as a whole. Both of these groups of thunderstorms are coincident with those origins of atmospherics.

Another group of thunderstorms over near Utsunomiya-city was found in the

morning by atmospherics to be in coincidence with the reports of weather service. However, it is not clear whether the former one has any correlation with the latter. According to the aeronautical weather reports the atmospherics near Tomizaki and Oshima were due to cumulonimbus there.

General meteorological situation at 12.00 JST. on Sept. 15, 1943 is shown in Fig. 3. A discontinuous line traverses Honshu-Island from Onahama to Wajima and extends further to the Chugoku District. Thunderstorms near Niigata-city and Fukushima-city occurred on this discontinuous line. In the San-in and Kyushu District, in the north side of this discontinuous line, we observed the thunderstorms which could not be caught by the direction-finder due to the masking effect of near-by atmospherics.

(*2*) *September 19, 1943.* According to a small base line, we could not find often a point of intersection for a distant origin. In such cases the arrows in the diagram show the direction of arrival of atmospherics. On Sept. 19 we found no thunderstorms on the weather map of the Kanto District. According to the atmospherics in Fig. 4, it seems that they move from the north of Iwatsuki Station to the east by way of the west. On

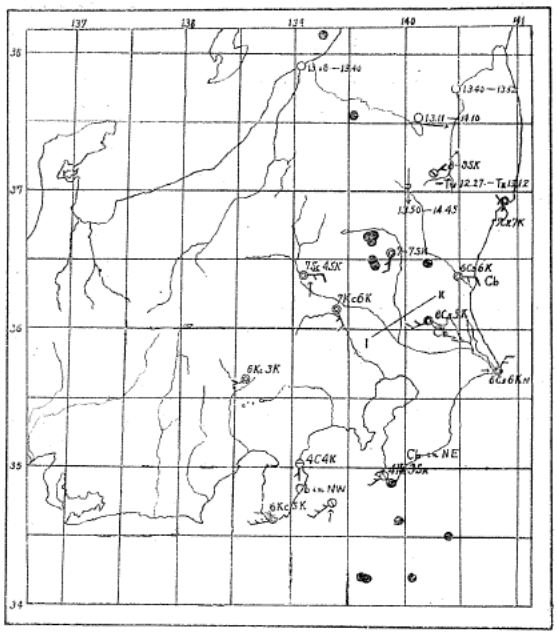

Fig. 2. Diagram indicating the origin of atmospherics on September 15, 1943. Dots show the origins determined by triangulation, *K*: Kakioka, *I*: Iwatsuki.

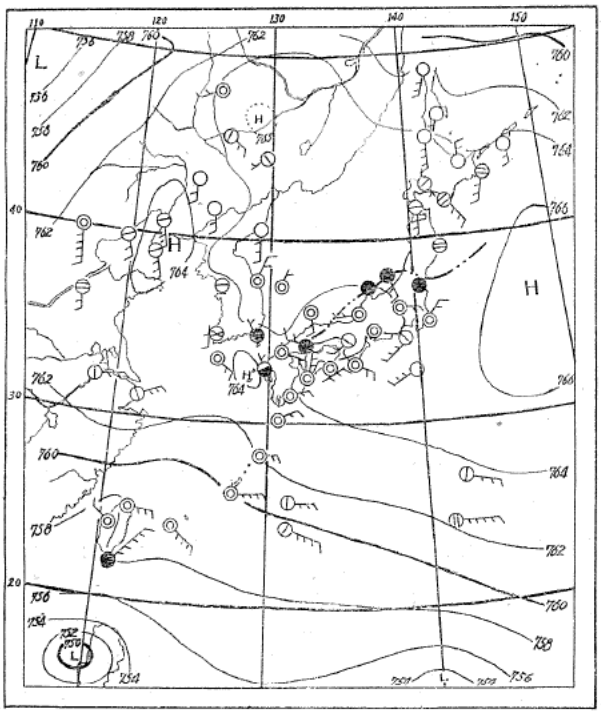

Fig. 3. Weather map on September 15, 1943. (12.00 JST.)

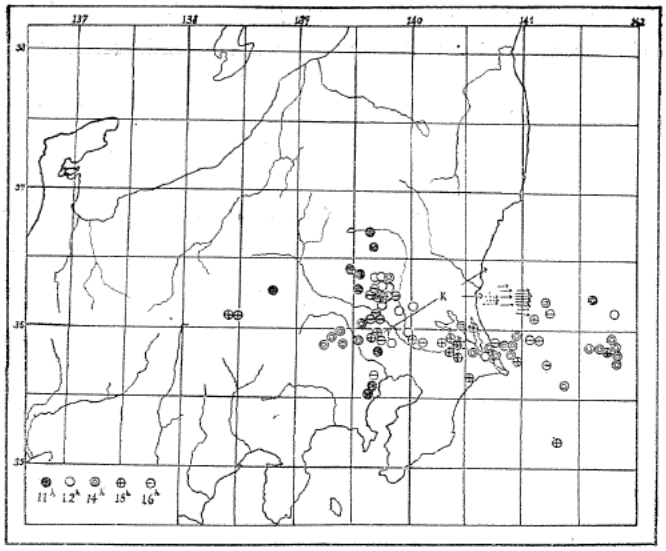

Fig. 4. Diagram indicating the origin of atmospherics on September 19, 1943. Displacement of atmospherics with times is indicated by the notations employed in the diagram.
K: Kakioka, *I*: Iwatsuki.

that day, thunderstorm reports failed, nor had we any report or message informing movements of thunderstorms. Generally speaking, we can divide their origins in two groups, the one is near the lower part of the River Tone, and the other is the district from the north of Iwatsuki to Utsunomiya. According to the aeronautical weather reports, the former seems due to the cumulo-nimbus near Tsuchiura; while the latter seems partly due to the heavy showers in that district, accompanied by the approaching typhoon, and partly due to the cumulo-nimbus assumed to develop on the slope of the border mountain-ranges of the Kanto District. Of course, we could not really observe the cumulo-nimbus on the slope masked by nimbo-stratus under them. However, the weather map of Sept. 19, 1943 in Fig. 5 shows that a strong south wind blew in the Kanto District, influenced by the typhoon approaching near Naha, and cumulo-nim-

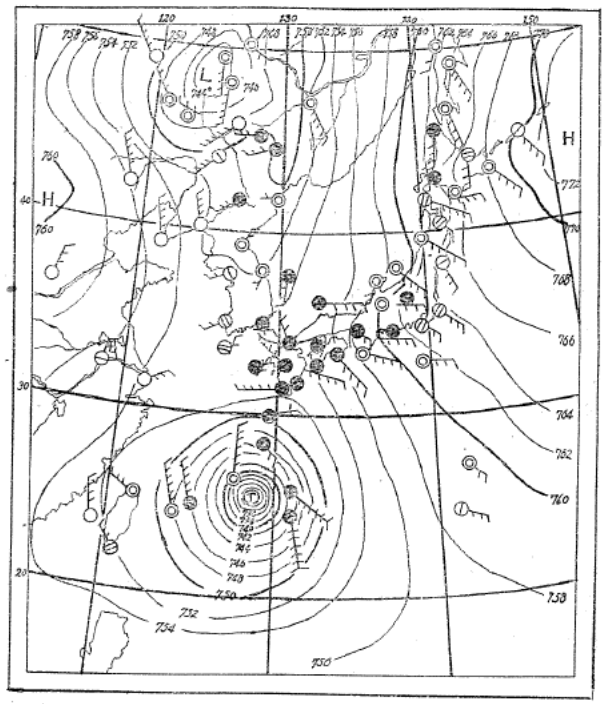

Fig. 5. Weather map on September 19, 1943. (12.00 JST.)

bus is to be grown on the slope of the border mountain-ranges due to the powerful ascending air current excited by the strong south wind, mentioned above, in the Kanto District.

In short, those sources of atmospherics, which are not explained explicitly for the failure of thundrstorm reports, can also be made clear by the reasonable theoretical consideration.

(3) *September 20, 1943.* According to the weather map at noon on Sept. 20, 1943

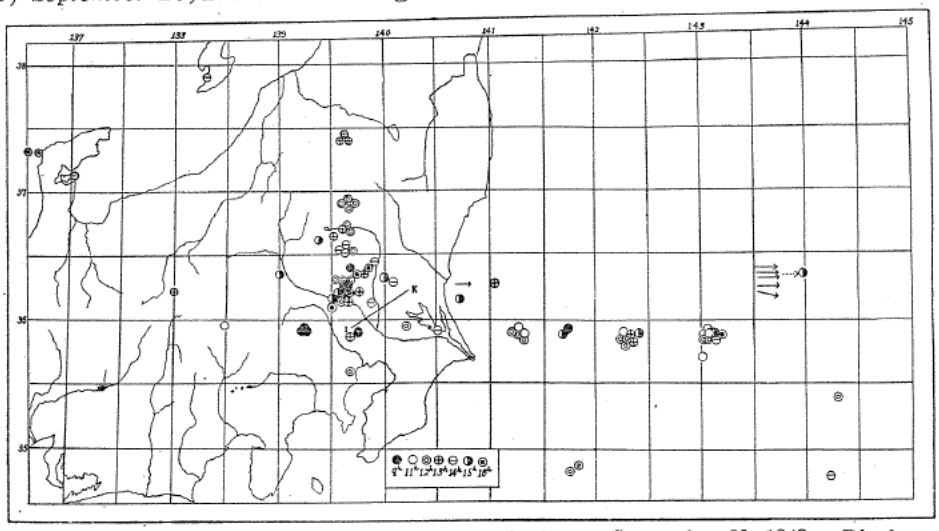

Fig. 6. Diagram indicating the origin of atmospherics on September 20, 1943. Displacement of atmospherics with times is indicated by the notations employed in the diagram. *K*: Kakioka, *I*: Iwatsuki.

in Fig. 6, a typhoon was approaching the Ashizuri Point of the Shikoku District. A cumulonimbus was observed near Choshi. In the neighbourhood of Kumagai in the northern district of Iwatsuki strato-cumuli were observed and the weather was cloudy or rainy. In this case also a strong south wind blew in the Kanto District (Fig. 7.) and a powerful ascending air flow along the mountain sides was very likely to exist. We can therefore reasonably assume the existence of cumulonimbus above the strato-cumulus. Atmospherics observed in the rainy area of northern dis-

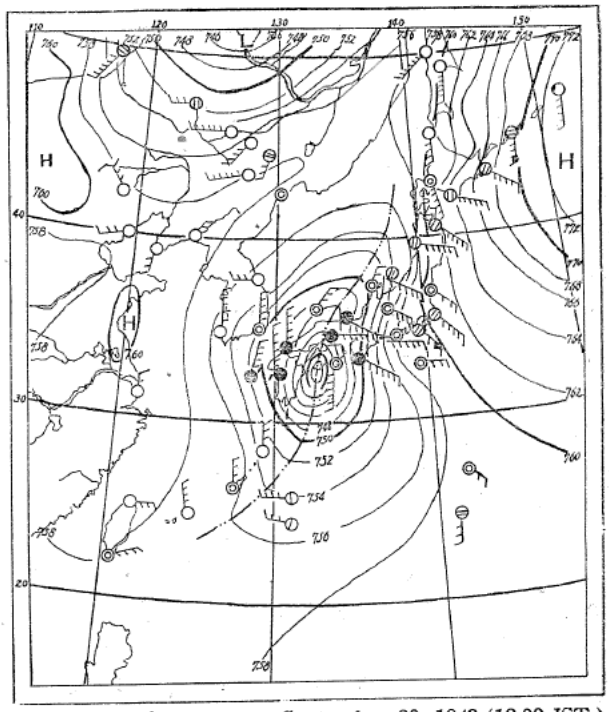

Fig. 7. Weather map on September 20, 1943.(12.00 JST.)

trict of Iwatsuki and Choshi District can be attributed to the cumulo-nimbus grown in the way as above mentioned.

(*4*) *Conclusion*

In conclusion we may add a few words as remarks. Although direction-finders used in those days were not satisfactory, we could find a fairly intimate correlation of atmospherics with active weather phenomena; sometimes atmospherics suggests those phenomena which were not observed for insufficient distribution of the weather observatories, some of them were found to be correct, informed afterwards by watchmen in electric power plants and substations, and some were not ascertained for lack of informations. Consequently we may conclude that if we have direction-finders of higher accuracy and reasonable gain, we can have not only reliable informations of active weather phenomena at a long distance, but also we can study the detailed construction or mechanism of them when they approach. Recently we could manage to construct a fairly satisfactory direction-finder which affords a very narrow beam less than 0.3° for 10 kc/s. Results observed with it will be reported in later publications.

4. Acknowledgement

This work has been done under the direction of the Lightning Research Committee in Japan whose president is Dr. S. Fujiwara. The author wishes to acknowledge his indebtness to Dr. M. Shibuzawa and Dr. T. Otani for their kind support and useful suggestions, and to Messrs. Fujita, Amano, Kondo and Inagaki for their heartful assistances.

References

1) M. R. Bureau, *Les foyers d'atmosphériques*, 1936.

2) R. A. Watson Watt, *The Application of the Cathode Ray Oscillograph in Radio Research*, 1933.

3) A. Kimpara, "Correlation of Atmospherics with Weather Phenomena," Rep. Radio Res. Com. Japan, April, 1931.

4) A. Kimpara, *The Atmospherics and the Method of Eliminating Their Disturbances* (Kyoritsu Co.), p 37, 1937.

5) A. Kimpara, "On the Wave Form of Atmospherics," J. Inst. Elec. Eng. Japan, **63**, 451, 1943.

6) A. Kimpara, "On the Wave Form of Atmospherics," Memoirs Fac. Eng. Nagoya Univ., **1**, 1, 1949.

Table I. Directional Distribution of Atmospherics

September 15, 1943
(13.00 to 13.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 01 5	0°	0 01 2	0°
12 6	340	12 1	355
17 5	10	17 9	0
20 9	300	21 0	0
44 7	5	44 6	0
54 1	355	54 0	340
58 8	0	58 4	0
59 6	0	59 2	45
1 00 4	315	1 00 9	0
17 2	5	17 3	0
38 0	10	38 3	0
39 6	0	39 6	355
43 0	315	43 0	0
44 8	350	44 9	0
50 7	5	51 0	0
51 9	300	52 7	0
54 8	0	54 6	0
55 7	0	55 6	0
2 12 6	0	2 12 9	0
16 9	5	16 9	350
21 4	10	21 5	350
22 5	340	22 2	350
31 7	5	31 6	350
32 2	315	32 5	0
41 8	355	41 8	0
49 2	355	49 2	0
53 7	0	53 8	0

September 19, 1943.
(11.00 to 11.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 08 9	60°	0 08 2	355°
15 2	60	15 1	0
24 8	310	24 8	0
24 9	310	25 1	0
25 0	310	25 6	0
32 0	90	32 1	0
45 4	100	45 2	340
48 3	110	48 5	340
49 0	110	49 0	345
50 5	90	50 6	90
53 6	50	53 7	50
1 24 7	50	1 24 1	0
30 5	90	30 6	95
31 3	90	31 3	80
54 2	90	54 1	5
2 10 1	45	2 10 4	0
10 2	95	10 5	115
11 0	80	11 1	30
11 5	70	11 5	45
15 1	320	15 0	0

September 19, 1943.
(12.00 to 12.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 16 5	50°	0 17 2	10°
20 1	90	20 6	90
35 0	85	35 7	0
1 24 7	90	1 25 1	65
28 8	30	28 7	80
29 1	95	28 8	85
36 0	290	36 2	0
38 7	95	38 2	5
44 1	80	46 1	0
50 9	90	51 0	10
56 2	70	57 1	0
2 15 0	90	2 13 2	330
16 1	90	16 7	90
16 9	45	16 8	95
28 8	100	26 7	10
38 7	90	39 2	95
44 2	90	45 2	355

September 19, 1943.
(14.00 to 14.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 05 8	300°	0 05 4	90°
06 6	300	06 4	95
07 4	70	07 3	90
07 9	70	08 0	130
09 8	85	09 7	85
22 5	310	22 9	90
28 6	320	28 7	85
28 9	300	28 9	95
38 8	100	38 8	90
44 0	100	44 2	90
45 8	60	45 6	85
49 3	120	49 5	90
57 2	100	57 4	90
1 06 8	65	1 06 1	90
07 2	90	07 4	80
11 8	70	11 9	100
12 0	315	12 2	80
15 7	95	15 7	90
19 5	310	19 7	90
47 9	70	47 8	100
51 5	70	51 5	95
59 1	90	59 3	95
2 02 2	120	2 02 3	120
22 9	120	23 4	100
25 0	100	25 4	90
25 3	85	25 5	90
28 9	90	28 4	110
39 0	30	39 9	80
49 9	110	49 4	85
50 1	110	50 0	355

September 19, 1943.
(15.00 to 15.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 04 9	30°	0 05 5	90°
07 2	95	07 3	90
07 9	330	07 7	0
09 0	90	09 1	90
10 7	330	10 2	0
11 2	290	11 9	95
14 1	90	14 3	90
17 6	90	17 8	80
18 5	290	18 6	95
21 0	280	20 9	0
26 3	310	26 3	90
28 0	90	28 0	85
28 6	30	28 6	90
33 8	310	34 2	90
38 9	320	38 1	100
40 1	20	39 6	90
42 3	90	42 6	95
42 9	20	43 0	90
46 2	340	46 0	0
48 8	90	48 6	0
49 2	100	49 1	90
50 2	10	50 1	290
50 8	70	50 6	0
51 9	330	52 9	90
57 6	70	57 5	90
59 0	310	58 4	90
1 03 6	80	1 03 3	90
03 9	90	03 8	90
09 4	320	09 3	95
10 3	95	10 6	90
11 8	350	11 9	90
13 0	90	13 3	95
14 1	10	14 5	0
16 5	330	16 6	90
21 7	350	21 2	90
24 0	340	24 0	110
26 5	320	26 2	0
27 1	50	27 2	95
27 4	50	27 3	90
32 5	100	32 3	90
33 1	330	33 0	100
37 3	10	36 3	90
38 2	120	38 2	95
39 2	340	39 0	95
39 4	120	39 4	85
41 4	330	41 6	0
42 6	85	42 7	95
44 4	350	44 7	0
47 5	320	47 7	300
49 4	25	49 7	90
50 6	85	50 3	95
54 6	10	54 3	0
56 1	100	56 4	80
58 5	340	58 0	90
58 8	340	58 6	90
2 04 3	90	2 04 7	90

September 19, 1943.
(16.00 to 16.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 03 8	20°	0 03 5	90°
08 5	70	08 0	0
12 8	70	12 1	0
13 1	85	13 6	70
20 1	290	19 8	90
27 3	60	26 7	85
41 3	90	41 2	95
54 2	90	54 1	95
1 06 1	290	1 06 9	95
24 8	45	24 8	90
47 2	70	46 8	95
48 0	320	48 8	0
51 9	95	52 0	95
53 1	90	52 9	0
54 8	90	54 8	90
55 0	90	54 9	90
56 6	300	57 4	90
2 00 4	90	2 00 8	95
03 0	90	03 1	90
05 0	70	05 2	0
18 9	90	18 3	95
24 0	300	23 8	90
25 8	90	25 6	10
26 3	90	26 4	90
35 0	90	35 1	90
40 2	95	40 2	85
41 7	95	41 9	90
42 4	30	42 5	0
43 2	300	43 9	345
46 0	300	46 2	95
50 9	90	50 2	0
51 6	300	52 3	90
52 2	95	52 5	0
56 5	290	56 5	90

September 20, 1943.
(09.00 to 09.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 13 1	70°	0 12 8	90°
41 2	40	40 6	95
44 6	90	44 8	95
1 28 7	340	1 27 3	172
2 15 2	275	2 14 6	0
20 0	290	19 6	0
26 8	90	26 9	0
44 0	275	42 3	0
57 2	280	56 8	90

September 20, 1943.
(11.00 to 11.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 12 4	110°	0 11 5	90°
22 5	120	23 3	0
1 10 5	80	1 10 2	90
24 4	95	24 8	90
25 1	100	25 5	90
25 2	110	25 9	90
44 8	100	45 2	105
55 8	95	55 7	90
56 7	70	56 3	90
2 02 5	100	2 02 3	90
13 7	100	11 8	0
15 0	110	15 5	90
55 4	95	54 5	90
58 7	70	57 9	90

September 20, 1943.
(12.00 to 12.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 02 5	90°	0 02 4	90°
06 2	100	06 0	90
12 3	130	11 6	0
14 0	0	14 5	90
15 7	90	16 1	90
16 5	30	16 5	0
17 2	320	17 3	0
18 1	100	18 0	115
20 1	100	20 1	90
23 3	95	23 0	90
42 1	110	41 4	90
45 8	85	45 7	0
54 0	320	54 9	125
1 03 6	330	1 03 6	0
05 1	95	05 1	90
05 4	95	05 8	0
07 5	330	07 3	0
11 7	110	11 6	90
15 6	100	15 6	90
25 5	110	25 2	90
26 0	90	25 8	90
26 4	100	26 1	90
29 7	320	29 5	0
56 0	330	56 4	0
2 02 0	330	2 02 0	0
06 0	90	06 3	90
19 9	110	19 9	90
25 5	100	25 5	95
35 5	100	34 8	0
37 7	100	37 1	101
41 6	350	41 6	0

September 20, 1943.
(13.00 to 13.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 01 3	80°	0 02 1	90°
16 5	90	16 0	75
19 0	340	19 3	0
23 1	340	22 9	0
27 7	340	27 5	0
35 6	320	34 3	0
37 9	90	37 5	100
46 9	320	45 2	100
1 04 6	50	1 03 9	0
07 1	100	06 6	90
14 1	310	15 2	0
19 0	320	18 5	0
35 5	90	35 4	0
2 16 0	310	2 15 8	170
23 2	95	22 8	90
28 5	310	28 0	0
34 0	300	34 2	0
37 9	100	37 4	90
41 4	90	40 7	0

September 20, 1943.
(14.03 to 14.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 02 0	330°	0 02 1	150°
19 9	310	19 3	115
20 3	310	21 1	15
24 8	95	23 8	90
1 10 5	110	1 10 7	115
29 7	340	28 7	110
49 3	290	49 7	115
52 3	70	51 6	40
2 08 6	310	2 07 7	120
23 3	310	23 4	35
46 8	95	45 7	90
55 5	320	56 3	90

September 20, 1943,
(15.00 to 15.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 00 6	310°	0 00 7	140°
02 0	280	01 6	90
07 1	280	06 1	75
17 3	300	17 5	30
25 3	90	26 1	90
30 0	285	30 1	90
1 00 3	95	1 00 8	130
38 2	90	37 6	0
42 0	275	41 2	0
51 5	95	50 4	90
54 6	85	55 0	160
2 27 9	290	2 27 4	10
39 7	300	39 5	160

September 20, 1943.
(16.00 to 16.03 JST.)

Kakioka		Iwatsuki	
Time	Direction	Time	Direction
m s		m s	
0 06 1	95°	0 05 5	90°
10 0	300	09 3	20
53 2	310	52 5	125
55 0	290	54 3	115
1 58 0	290	1 57 8	160
2 13 3	280	2 12 5	120
20 8	85	21 8	155