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On the Distributions of Dusts from Chimneys in the Neighbourhood of a Factory

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Introduction

In order to obtain fundamental data concerning iron-dust troubles caused by dispersal of a large scale steel factory, measurements of distributions of iron-dusts in the site of a factory and its neighbourhood were required. So we have carried out a series of measurements as the members of the Dust Trouble Investigation Committee in August 1962. Though as we could not have a sufficient time for preparation, there still remain many subjects to be investigated further, the observed results are reported in this paper as preliminary ones.

Scheme of observations

The number of working chimneys is three and their height is 55 m above the ground. The size of the iron-dusts is abont 2μ or less in diameter. The claims hitherto have occurred within about 2 km, so observation posts were set at leeward distances (x) 0.5, 1 and 2 km. In order to obtain data of the atmospheric diffusion reasonably, angular distance of the posts should be 10° ca. and the angular width of the observation area should be about 60° ca., and the number of samplers for vertical concentration profiles should be more than five at each post. Therefore, we determined the positions of the posts as shown in Fig. 1. The total number of the posts is 27 and the total number of the samplers is 135. It is not easy to choose the samplers adequate to be used such a number in the filed.

We used flag samplers which had been adopted for the observations of the concentrations of rag weed pollen in the University of Michigan.[1] A pin is wrapped by double coated cellophane tape to be formed like a flag (Fig. 2), and the pin is inserted into a short brass tube and the tube is inlayed into a slender wooden bar. Five bars are fixed to a bamboo pole at the heights of 0.5, 1, 2, 3 and 5 m above the ground. The bamboo pole was set at each post.

As meteorological observations, temperatures at the heights of 10, 28, 46 and 69 m above the ground were measured in every 30 minutes. Simple wind speed-and direction recorders (Fig. 3) were set at the posts which are marked by ● in Fig. 1.

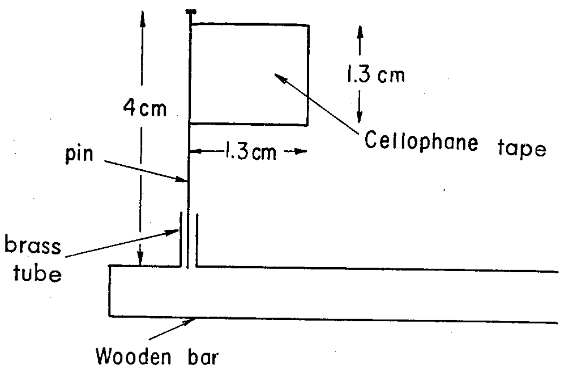

Fig. 2.

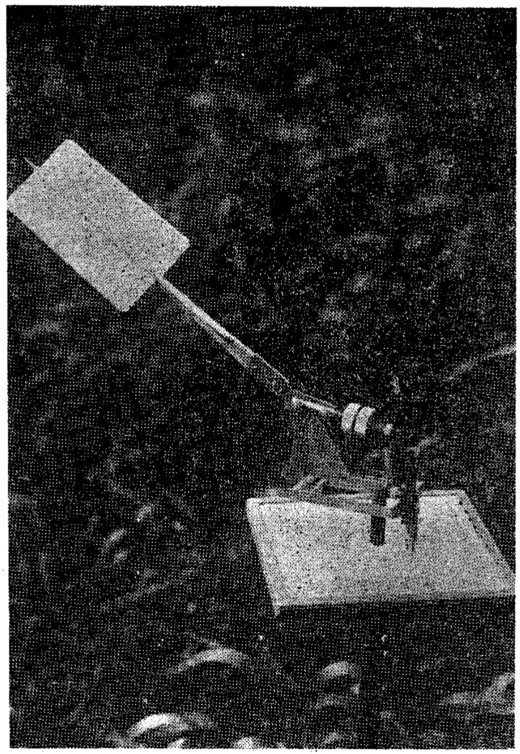

Fig. 3.

Determination of concentration

In order to separate the quantity of iron-dusts from that of earth-dusts collected on the cellophane tape, the amounts of iron-dusts were intended at first to be measured by the intensity of reflected light. However, as the iron-dusts were collected in a narrow band, about 0.5 mm in width (Fig. 4), it takes much more time to be able to measure the reflected light in such a tiny portion, and on the other hand, the results showed that the effect of earth-dusts was not so remarkable. So we measured the intensity of incident light (I_0) and that of transmitted light through the dusty portion (I) by using *CdS* and determined the quantity D

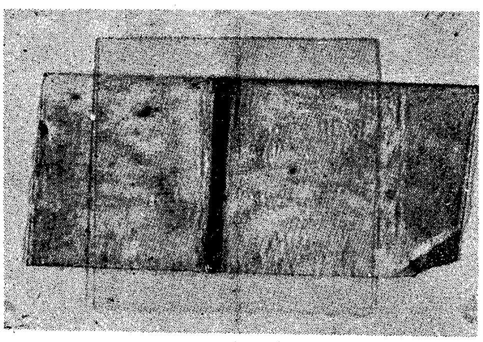

Fig. 4. (4×)

$$D = \log_{10} \frac{I_0}{I} \qquad (1).$$

When a cylinder whose diameter d, length l is exposed in the wind whose velocity is u (m/sec) and the dust concentration is C (mg/m^3) during the time t (hour), the dust amount in the air volume swept over the cylinder is

$$Cdult \quad (2).$$

We put further

$$C_1 = Ct \quad (3).$$

The total dust amount collected on the sylinder surface q (mg/cm^2) is expressed by

$$q = 2l\int_0^b q_1 d\sigma \quad (4),$$

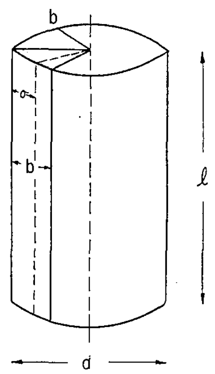

Fig. 5.

where q_1 is the surface density on the portion where the peripheral lenth is σ from the stagnation point and the length l. (Fig. 5).

If the impingement efficiency is $\alpha(u)$, which should be a function of u,

$$\alpha C_1 dlu = q = 2l\int_0^b q_1 d\sigma \quad (5).$$

If we assume that

$$\alpha = \alpha_1 u^n \quad (6),$$

we get

$$\alpha_1 C_1 dlu^{n+1} = q \quad (7).$$

As the dusts collected on a narrow band region whose bredth is $2b$,

$$q \doteqdot 2q_1 bl \quad (8).$$

Therefore, we get

$$\alpha_1 C_1 dlu^{n+1} = 2q_1 bl \quad (9).$$

On the other hand, we made aquous suspensoids of dusts with the same concentration (C' : mg/cm^3) but various heights (h : cm), and we set a cover glass on the bottom of each suspensoid and then left the dusts sediment on it. The surface density q' of the dusts on the cover glass is

$$q' = C'h \quad (10).$$

We measured the value of D for each q', and we get

$$q' = C'h = k_1 D \quad (11),$$

and

$$h = \frac{k_1}{C'} D = \gamma D \quad (12).$$

The observed result is shown in Fig. 6, and we get

$$\gamma = 65.6 \quad (13).$$

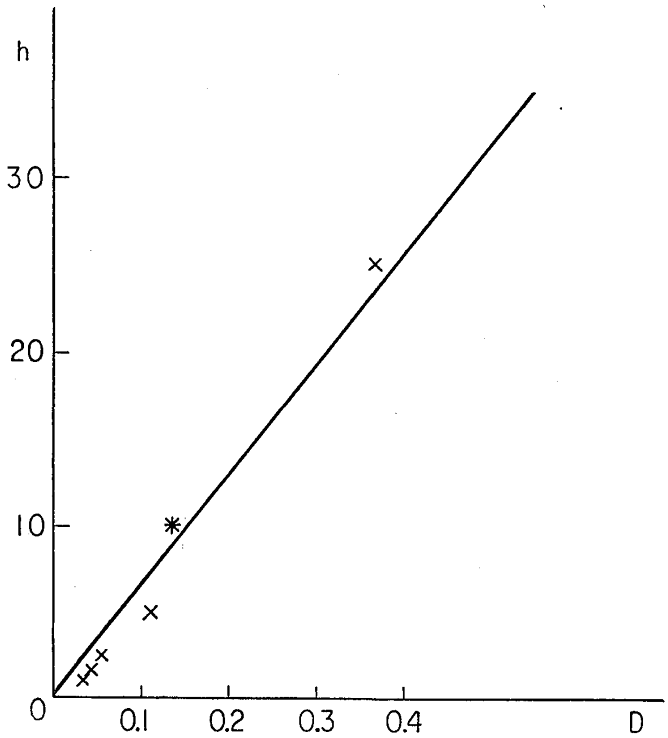

Fig. 6.

C' is determined by chemical analysis using *o*-phenanthroline and the result was

$$C'=0.00656 \text{ mg/cm}^3,$$

so we get

$$k_1=C'\gamma=0.430 \text{ mg/cm}^2 \quad (14).$$

From eqs. (7), (8) and (11), and putting $q'=q_1$, we get

$$\alpha_1 C_1 d u^{n+1}=2q_1 b=2bk_1 D \quad (15),$$

and

$$\frac{D}{C_1}=\frac{\alpha_1 d}{2k_1 b}u^{n+1} \quad (16).$$

We are now going to determine the exact form of α by wind tunnel experiment, but it takes much more time to obtain the results. On the other hand, if the relation between D, C_1, n and u can be found, the value of C_1 is able to be calculated from the value of D and u, without knowing the function $\alpha(u)$.

At a certain place, close to a flag sampler, a small Cottrel sampler was set and the dust concentrations were determined by weighing the collected dusts.[1] The results are shown in Table 1.

If we plot D/C_1 against u on a log-log paper, we obtain the marks $\triangle$ in Fig. 7. The resulted line shows that

(1) These experiments were carried by Dr. E. Shoji, Kawasaki Steel Industry.

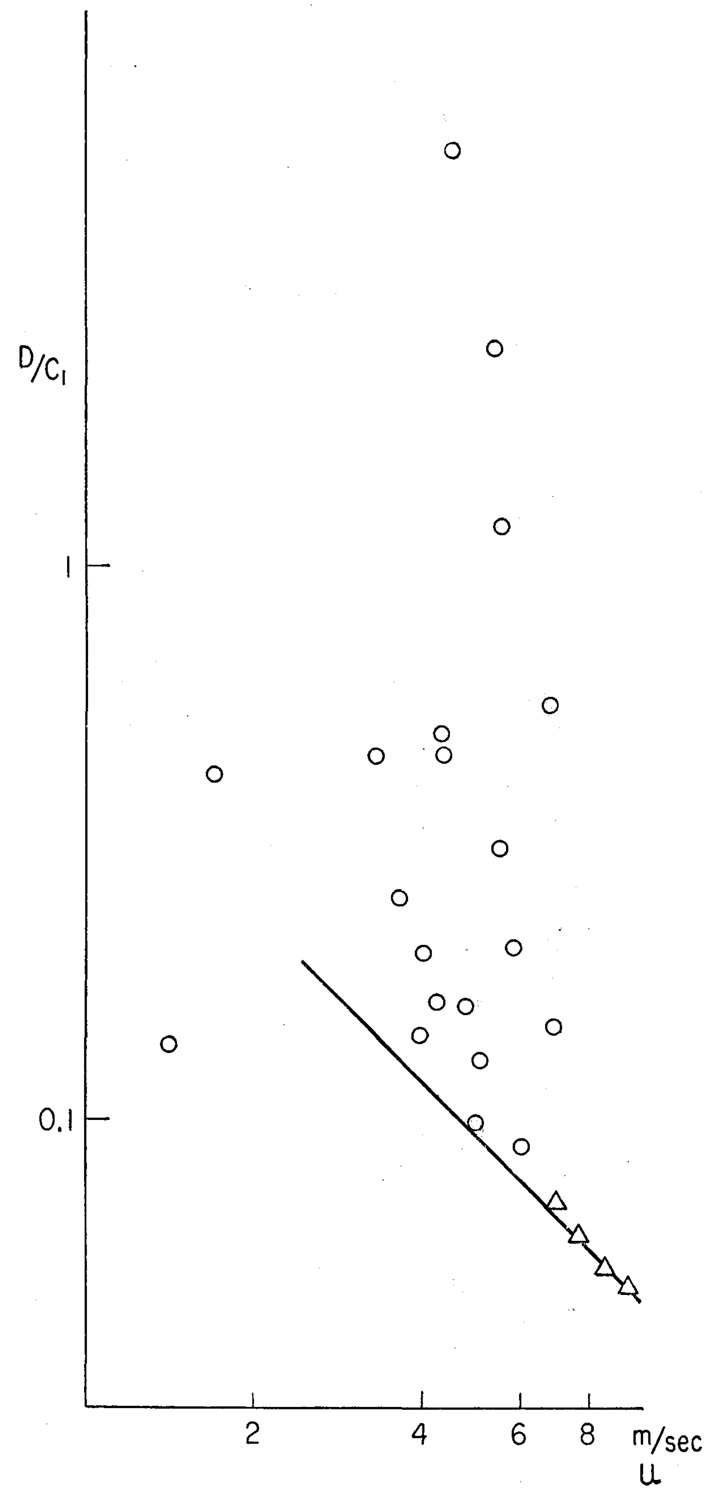

Fig. 7.

Table 1. Results of Cottrel Samplers.

		Aspirated volume $(m)^3$	Fe_2O_3	Concentration of Fe_2O_3 (mg/m^3)	u (m/sec)	C_1 $(mg.h/m^3)$	D	C_1/u
July 31	1345-1445	6	6.3	1.05	8.4	1.05	0.065	0.125
	1450-1550	6	14.5	2.42	9.3	2.4	0.130	0.258
Aug. 1	1000-1130	9	20.3	2.26	6.9	3.45	0.268	0.499
	1135-1305	9	16.0	1.71	7.6	2.7	0.167	0.355

$$u^{n+1}=u^{-1} \qquad \therefore n=-2 \tag{17}$$

From eq. (16),

$$C_1/u=\frac{2k_1}{\alpha_1}\frac{b}{d}D \tag{18}$$

If we plot C_1/u against D, we get the marks ▲ in Fig. 8. Though the number of the marks is few, they arrange themselves fairly well on a straight line;

$$C_1/u=\lambda D=1.88\,D \quad \left(\frac{\text{mg}}{\text{m}^3}\frac{\text{sec}}{\text{m}}h\right) \tag{19}$$

so we use this line as a calibration line.

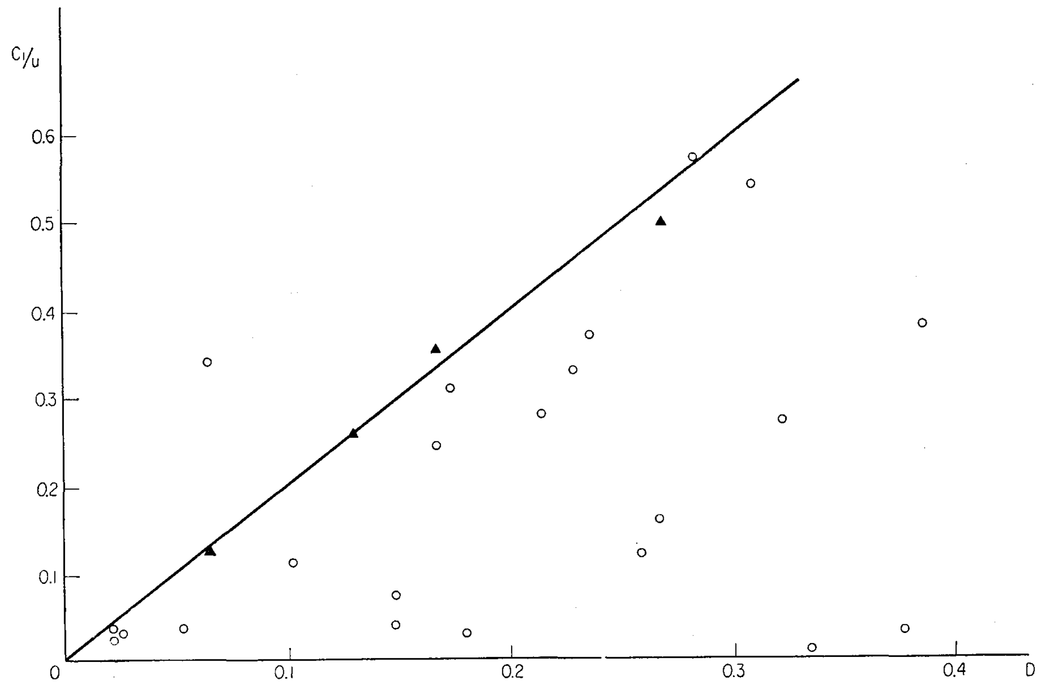

Fig. 8.

At another place, two filter samplers were set at the heights of 2 and 5 m and five flag samplers and five small Robinson type cup-anemometers were set at the same heights of 0.5, 1, 2, 3 and 5 m above the ground. The amounts of iron-dusts collected by the filters were determined by chemical analysis and calculated the mean concentrations C during the sampling time t.[(2)] The results are shown in

Table 2. Results of Filter Samplers.

Date	Height (m)	Sampling duration (min)	Aspirated volume (l)	C_1	D
Aug. 16 1546	5 2	30 30	247.5 240	0.037 0.022	0.022 0.022
Aug. 23 1325	5 2	30 30	247.5 240	0.03 0.01	0.377 0.377
Aug. 23 1416	5 2	30 30	247.5 240	0.37 0.33	0.236 0.229
Aug. 23 1500	5 2	30 30	247.5 240	0.28 0.31	0.214 0.173
Aug. 23 1540	5 2	30 30	247.5 240	0.34 0.24	0.065 0.167
Aug. 23 1619	5 2	30 30	247.5 240	0.03 0.04	0.026 0.055
Aug. 23 1659	5 2	30 30	247.5 240	0.07 0.11	0.148 0.102
Aug. 24 0942	5 2	30 30	247.5 240	0.16 0.12	0.267 0.259
Aug. 24 1021	5 2	30 30	247.5 240	0.54 0.57	0.309 0.283
Aug. 24 1101	5 2	30 30	247.5 240	0.38 0.27	0.385 0.322
Aug. 24 1142	5 2	30 30	247.5 240	0.04 0.03	0.148 0.180

Table 2. The plot of D/C_1 versus u is shown by the marks ○ in Fig. 7, and they scatter considerably and any relations cannot be recognized. The plot of C_1/u versus D is shown by the marks ○ in Fig. 8. The marks scatter as well as the marks in Fig. 7. We could not adopt these results for the determination of the concentrations.

The marks ○ in Fig. 8 show smaller values of C_1/u than the marks △ and this fact clearly indicate that the capturing efficiency decreases when the filter does not always face directly to the wind.

Using the data of exposed time (sampling time) t and the wind speed u, concentrations C were calculated.

(2) These experiments were carried by Mr. S. Nemoto and Dr. K. Naito, Meteorclogical Research Institute.

Table 3 (1). Wind Direction and Speed (m/sec).

Post	July 31 1400–1630	Aug. 23 1330–1530	Aug. 23 1530–1700	Aug. 24 1000–1130	Aug. 24 1130–1330
A 1	SE 1.5	SSE 2.5	SE 3.0	ES 2.0	SE 2.5
3	WN 1.0		SE 1.0	NW 1.0	NW 1.0
4	WNW 1.5	NNW 3.0	SW 2.0	SW ?	WNW 3.0
5	WNW 2.0		E 2.0	WNW 2.5	WSW 2.0
7	SW 1.5	SSW 3.5	SSW 4.0	SW ?	SSW ?
B 1	SW 1.5	SSE 2.0	SSE 2.0	WSW 2.0	SW 1.5
3	SW ?	SW 2.5	SW 2.5	SW 3.0	SW 1.5
4	SW 0.5	WN 2.5	NNE 2.5	NW 3.0	SSW 3.0
5	SW 2.5	S 2.5	SSW 2.5	SW 2.5	WSW 2.5
7	SW 2.0	SW 3.0	SSW 3.5	SW 2.5	WSW 3.0
C 1	ENE 1.0	SW 2.5		W 1.5	
3	SW 0.5	SW 3.0		SW 2.5	
5	NNW 1.0	NNW 3.5		NW 2.0	
7	SW 1.5	SW 3.0		SW 2.0	
9	W 2.0	SSW 2.0		SW 2.0	
11	W 1.5	SSW 1.5		SW 1.0	
12	WSW 1.5	SW 2.5		SW 2.5	

Table 3 (2). Temperature Profile.

Height (m)	July 31				
	1444	1500	1530	1600	1640
69	27.4	27.2	27.0	27.7	28.1
46	27.7	27.4	27.5	27.9	28.3
28	27.7	27.5	27.7	28.1	28.5
10	29.4	29.2	29.4	29.5	29.7

Height (m)	Aug. 23							
	1330	1400	1430	1500	1530	1600	1630	1700
69	29.0	29.5	29.6	29.4	29.5	29.2	29.2	29.0
46	29.5	29.7	30.0	29.5	29.6	29.5	29.5	29.2
28	——	——	30.0	29.8	30.0	29.6	29.6	29.5
10	28.8	29.2	31.4	30.8	31.3	30.5	30.7	30.6

Height (m)	Aug. 24									
	0940	1010	1040	1110	1140	1210	1310	1340	1510	1540
69	28.2	28.0	28.1	28.1	28.4	28.8	29.6	29.9	29.9	29.5
46	28.7	28.4	28.5	28.5	28.8	29.4	30.0	30.4	30.4	29.9
28	28.7	28.4	28.7	28.5	28.9	29.7	30.4	30.8	30.8	30.3
10	30.2	29.9	30.2	29.9	30.7	31.2	31.8	32.6	32.5	32.0

Concentration measurements

We measured the concentration distributions in three times, when the plume passed over the observation area. The fundamental data of the observations are shown in Table 3.

The vertical concentration profiles in each post are given in Table 4 and Fig. 9.

From the curves given in Fig. 9, we determined the reasonable values of the concentrations at the height of 2 m, and obtained the horizontal concentration distributions. (Fig. 10, 11 and 12).(3)

Table 4-1.

Date	Sampling time	u (m/s)	Post	Sampling duration (min.)	Concentration (mg/m³) 0.5 m	1.0	2.0	3.0	5.0	C_2 cor.
					×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²
July 31	1400	1.5	A 1	68	12.6	38.8	48.8	56.0	52.9	50.0
	|		2	112	8.03	8.03	18.1	21.6	——	13.9
	1700		3	108	22.5	18.7	18.7	——	40.5	23.9
			4	102	47.7	35.3	28.4	28.4	——	30.4
			5	102	57.3	75.4	73.5	82.2	——	77.6
			6	103	56.7	60.4	67.3	100	75.2	72.5
			7	98	53.1	53.2	70.0	74.7	——	71.0
		1.6	B 1	116	25.6	30.7	24.8	——	34.8	30.6
			2	102	34.8	34.8	70.4	37.6	——	39.2
			3	99	14.1	15.9	——	——	——	22.5
			4	98	0	1.05	——	12.0	16.1	9.72
			5	100	30.7	35.6	33.3	35.6	33.3	32.2
			6	97	——	——	——	54.0	72.2	41.5
			7	99	12.0	21.8	25.8	41.2	——	32.2
		1.3	C 1	82	0	0	0	0	0	0
			2	84	0	0	0	0	0	0
			3	90	0	0	0	0	0	0
			4	95	0	0	0	0	0	0
			5	97	0	0	0	0	0	0
			6	103	0	0	0	0	0	0
			7	109	0	6.60	7.27	10.5	11.7	7.10
			8	116	——	——	7.78	7.78	6.25	7.44
			9	113	1.69	11.2	11.2	11.2	7.61	11.2
			10	111	1.69	3.88	6.57	16.9	8.80	5.07
			11	132	14.5	14.2	8.59	2.70	2.70	6.94
			12	139	13.2	13.7	12.7	15.2	18.5	11.0
			13	131	8.93	20.5	10.9	11.8	20.2	11.5

(3) In these Figs. the posts marked by ● indicate that their observed values are not so reliable, because the samplers at those posts were considered to the strongly influenced by the bodies in their neighbourhood.

Table 4-2.

Date	Sampling time	u (m/s)	Post	Sampling duration (min.)	Concentration (mg/m³)					C_2 cor.
					0.5 m	1.0	2.0	3.0	5.0	
					×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²
Aug. 23	1330	3.0	A 1	100	——	109	140	154	160	133
	|		2	87	54.0	49.5	——	——	——	31.5
	1530		3	87	72.0	81.0	107	98.1	91.8	104
			4	87	28.8	89.1	105	112	105	104
			5	86	0	42.3	56.7	54.9	67.5	59.4
			6	85	50.4	65.7	85.5	80.1	90.9	85.5
			7	85	90.9	99.0	85.5	67.5	73.8	90.0
		2.5	B 1	106	——	32.5	57.5	41.8	54.3	50.0
			2	91	53.2	59.3	64.3	64.3	36.9	62.5
			3	86	33.7	65.6	68.2	106	219	80.0
			4	86	33.1	40.7	58.7	81.8	108	66.9
			5	85	50.6	50.6	59.3	66.8	71.2	61.3
			6	86	0	7.50	40.0	35.6	45.6	33.1
			7	88	20.0	40.7	46.2	42.5	54.4	45.0
	1530	2.4	A 1	103	52.5	66.3	144	122	126	116
	|		2	91	38.1	28.8	25.4	53.0	75.0	34.6
	1730		3	92	67.5	76.7	84.2	86.5	84.2	80.7
			4	91	40.9	57.1	73.2	80.7	80.7	70.3
			5	90	4.0	8.07	32.3	28.8	38.0	28.8
			6	89	63.5	79.1	61.1	56.5	51.9	30.0
			7	89	42.1	63.5	76.7	40.4	63.5	30.0
		2.6	B 1	89	——	29.1	92.6	89.3	79.2	82.5
			2	92	50.7	89.4	65.0	115	122	94.8
			3	87	60.9	54.2	60.9	79.2	89.3	70.4
			4	87	8.80	11.5	43.3	60.9	55.5	33.2
			5	88	45.3	48.1	54.8	48.8	54.8	56.2
			6	104	0	0	50.7	35.8	47.3	31.1
			7	108	50.7	37.8	55.8	69.6	55.8	55.4
		2.6	C 1	186	31.1	36.7	31.8	34.5	36.5	33.8
			2	182	48.7	47.3	46.7	37.2	37.2	40.6
			3	175	67.6	73.1	81.2	83.9	89.3	81.2
			4	170	18.3	——	32.5	43.9	69.7	29.1
			5	168	0	0	0	8.80	13.5	8.12
			6	162	——	17.6	13.5	12.2	15.6	13.5
			7	157	38.5	39.9	59.5	65.7	79.2	56.2
			8	156	——	30.4	——	58.8	69.0	49.4
			9	146	10.8	33.8	39.9	39.9	51.4	40.6
			10	146	45.3	25.7	——	18.3	9.47	20.3
			11	142	8.80	31.1	12.2	18.9	35.8	13.5
			12	140	43.9	43.9	47.3	39.9	58.2	38.5
			13	143	18.3	18.3	23.0	20.3	23.0	16.9

Table 4-3.

Date	Sampling time	u (m/s)	Post	Sampling duration (min.)	Concentration (mg/m³) 0.5 m	1.0	2.0	3.0	5.0	C_2 cor.
					×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²	×10⁻²
Aug. 24	0940	2.8	A 1	94	36.1	38.4	57.2	55.7	46.3	54.9
	|		2	95	24.3	33.7	59.6	90.2	120	60.4
	1200		3	93	51.5	94.2	77.6	91.6	143	91.0
			4	95	58.5	98.0	64.3	87.0	71.3	74.5
			5	95	109	101	107	117	120	108
			6	98	80.3	94.9	101	98.0	114	95.6
			7	97	70.2	93.3	93.3	111	114	91.7
		2.6	B 1	92	0	56.8	39.9	38.6	29.1	47.3
			2	94	59.5	47.3	41.3	44.7	26.4	46.0
			3	97	34.5	28.4	31.1	39.9	64.9	33.1
			4	98	16.2	35.8	47.3	71.0	81.2	50.0
			5	98	78.5	96.0	90.6	85.2	108	85.9
			6	98	27.7	44.6	73.0	73.0	64.9	62.2
			7	95	31.8	52.8	49.3	50.7	50.7	52.1
		2.1	A 1	119	19.4	35.7	35.7	45.4	56.9	41.0
			2	115	42.3	26.9	28.7	78.0	103	51.1
			3	115	36.6	53.3	42.3	51.6	78.0	52.9
			4	113	61.7	40.2	45.0	52.9	56.4	49.4
			5	113	15.4	40.2	34.8	43.2	44.9	53.8
			6	110	44.6	42.8	54.2	28.7	71.0	52.5
			7	109	39.3	58.2	53.8	49.8	60.3	52.9
		2.5	B 1	120	20.0	40.0	41.8	30.0	38.7	37.5
			2	117	27.5	45.0	40.0	38.7	43.2	43.2
			3	110	33.8	32.5	32.5	51.2	98.1	41.8
			4	108	15.0	28.7	60.0	75.0	96.9	53.7
			5	107	35.0	40.0	54.3	52.2	60.6	51.8
			6	104	23.1	19.9	32.5	31.2	46.8	31.8
			7	108	——	——	——	——	——	——
	0940	1.9	C 1	222	3.61	5.05	——	——	5.05	5.78
	|		2	219	16.6	9.02	16.6	11.9	13.0	14.4
	|		3	219	32.1	34.3	32.1	32.1	30.7	31.0
	1430		4	214	0	14.4	19.7	25.3	19.1	12.3
			5	212	6.85	7.56	5.77	11.5	9.75	7.93
			6	206	3.25	3.25	9.02	9.02	9.36	5.77
			7	207	15.5	22.4	30.3	35.4	37.2	22.7
			8	208	5.31	20.6	36.1	47.2	45.8	19.7
			9	208	9.40	20.6	22.0	21.3	22.0	20.2
			10	206	11.2	9.02	13.0	14.4	20.2	13.7
			11	208	16.2	21.3	14.8	16.2	19.8	18.0
			12	203	41.1	41.1	33.9	34.6	33.2	36.5
			13	205	15.2	11.9	12.6	9.02	11.2	18.0

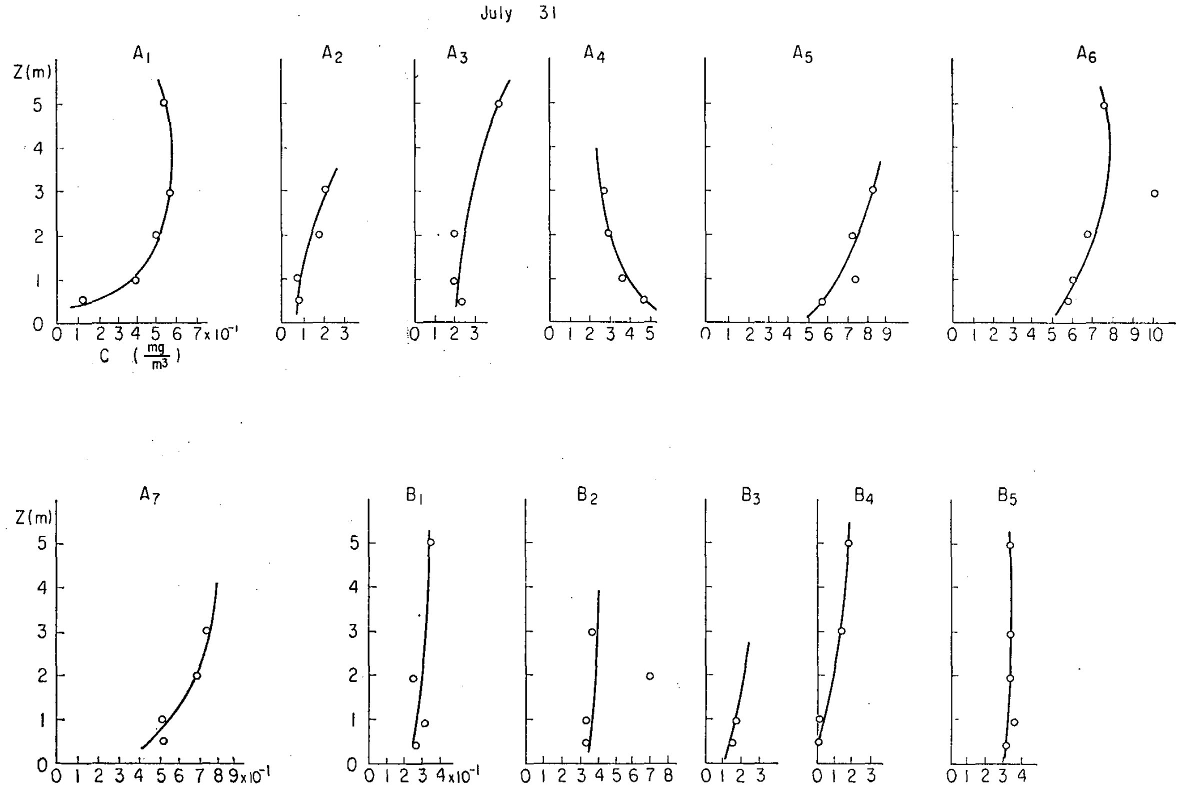
July 31
A1
A2
A3
A4
A5
A6
A7
B1
B2
B3
B4
B5
Z(m)
C (mg/m³)
x10⁻¹

Fig. 9-1

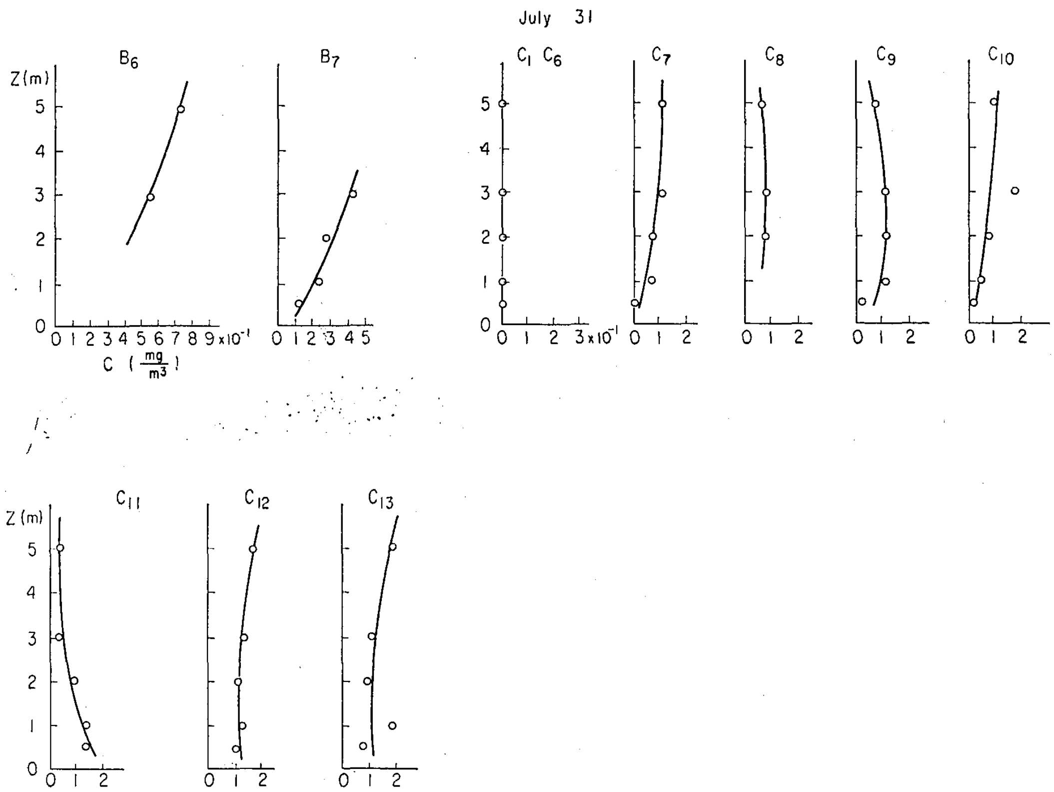
July 31
B6
B7
C1 C6
C7
C8
C9
C10
C11
C12
C13
Z(m)
C (mg/m³)
x10⁻¹

Fig. 9-2.

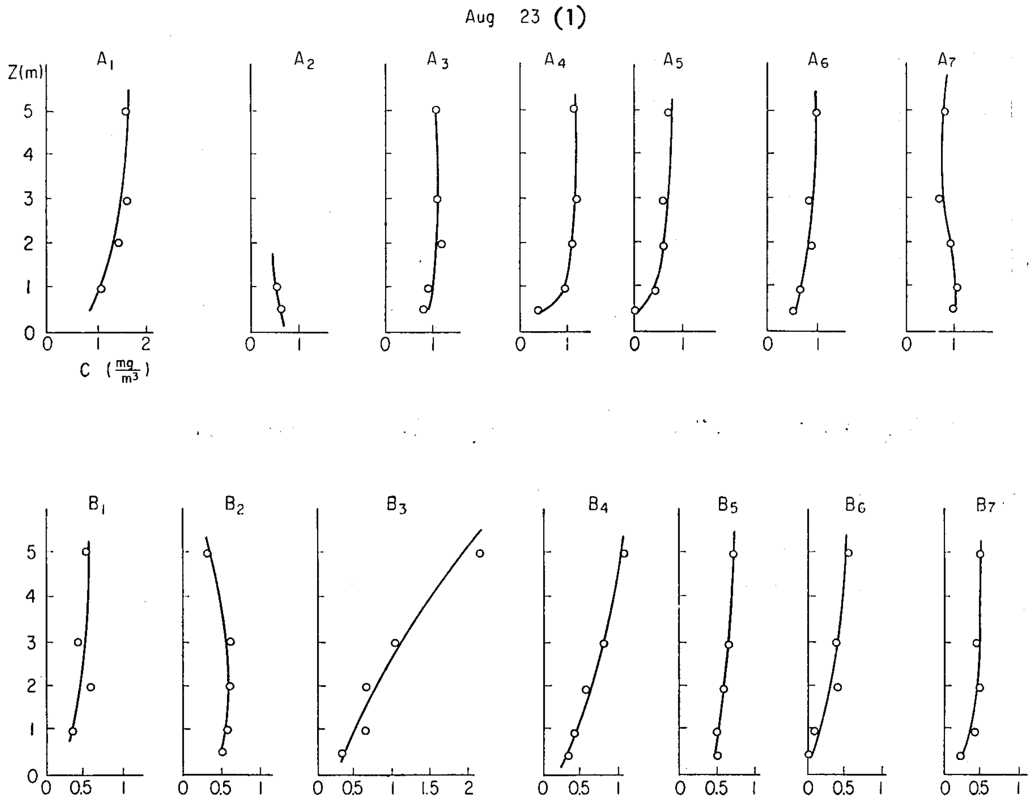
Aug 23 (1)
A1
A2
A3
A4
A5
A6
A7
Z(m)
C (mg/m³)
B1
B2
B3
B4
B5
B6
B7

Fig. 9-3.

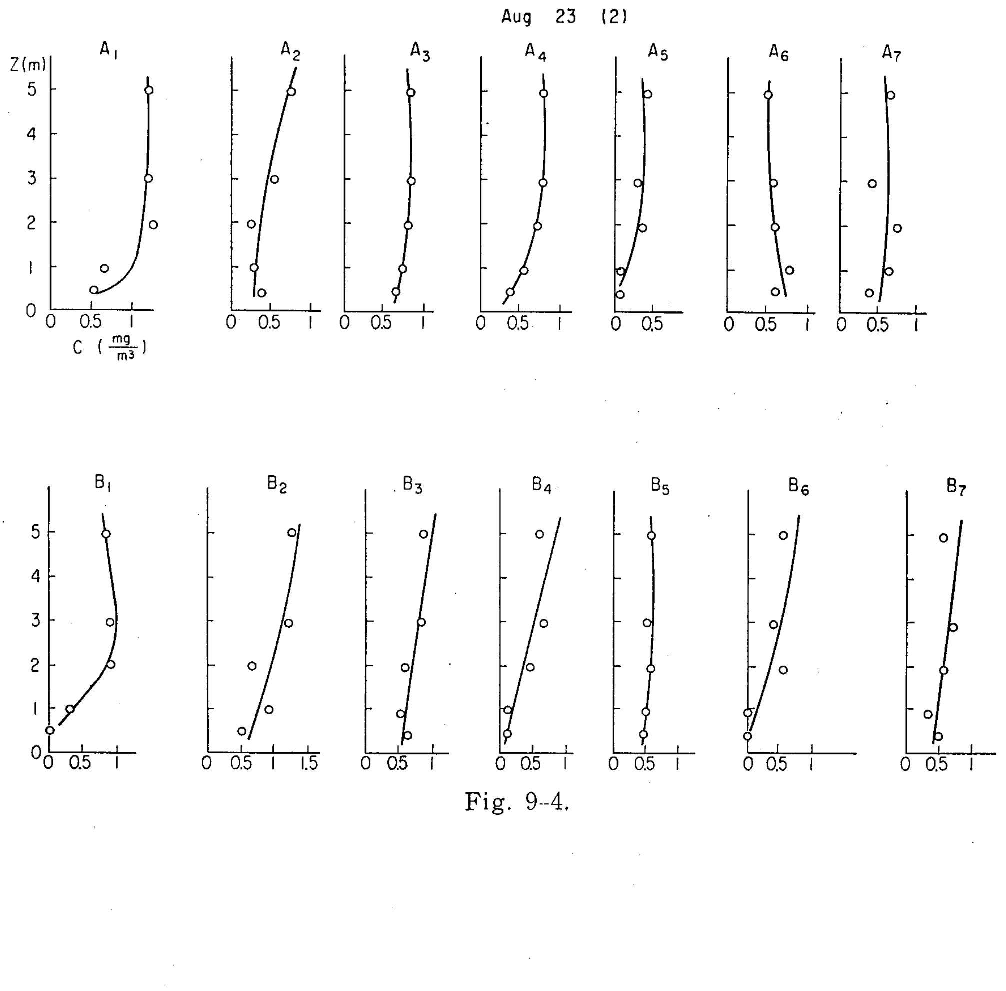
Aug 23 (2)
A1
A2
A3
A4
A5
A6
A7
Z(m)
C (mg/m³)
B1
B2
B3
B4
B5
B6
B7

Fig. 9-4.

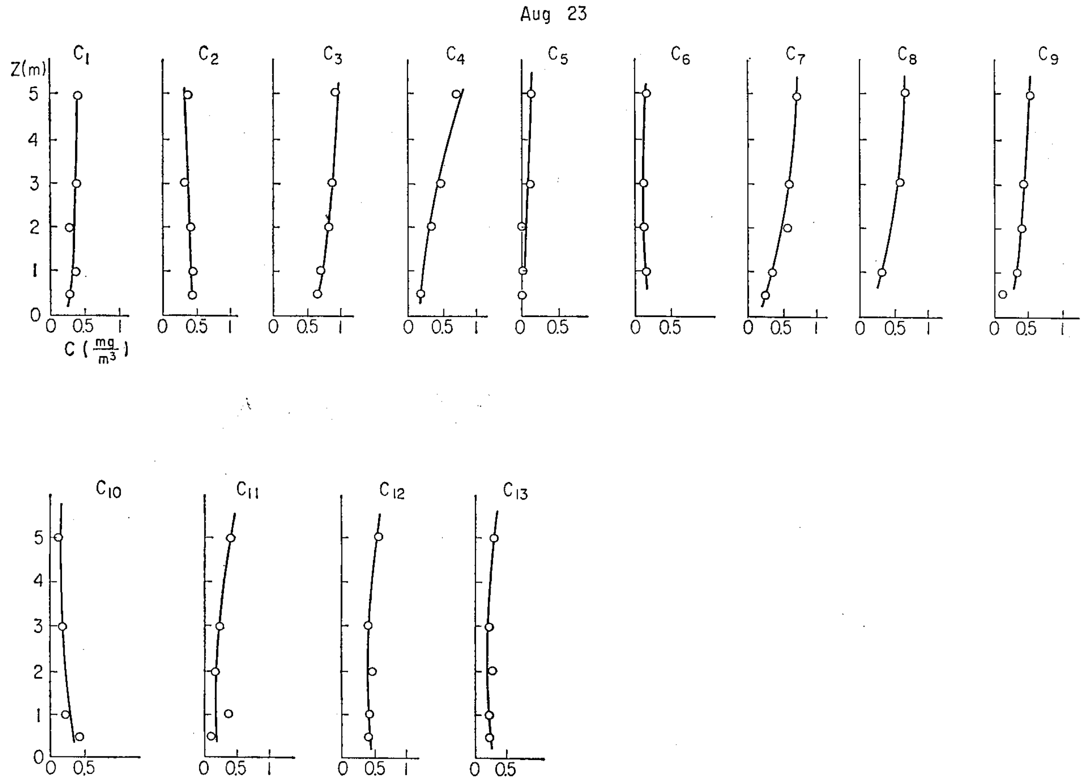
Aug 23
C_1 C_2 C_3 C_4 C_5 C_6 C_7 C_8 C_9
C_{10} C_{11} C_{12} C_{13}
Z(m)
C ($\frac{mg}{m^3}$)

Fig. 9-5.

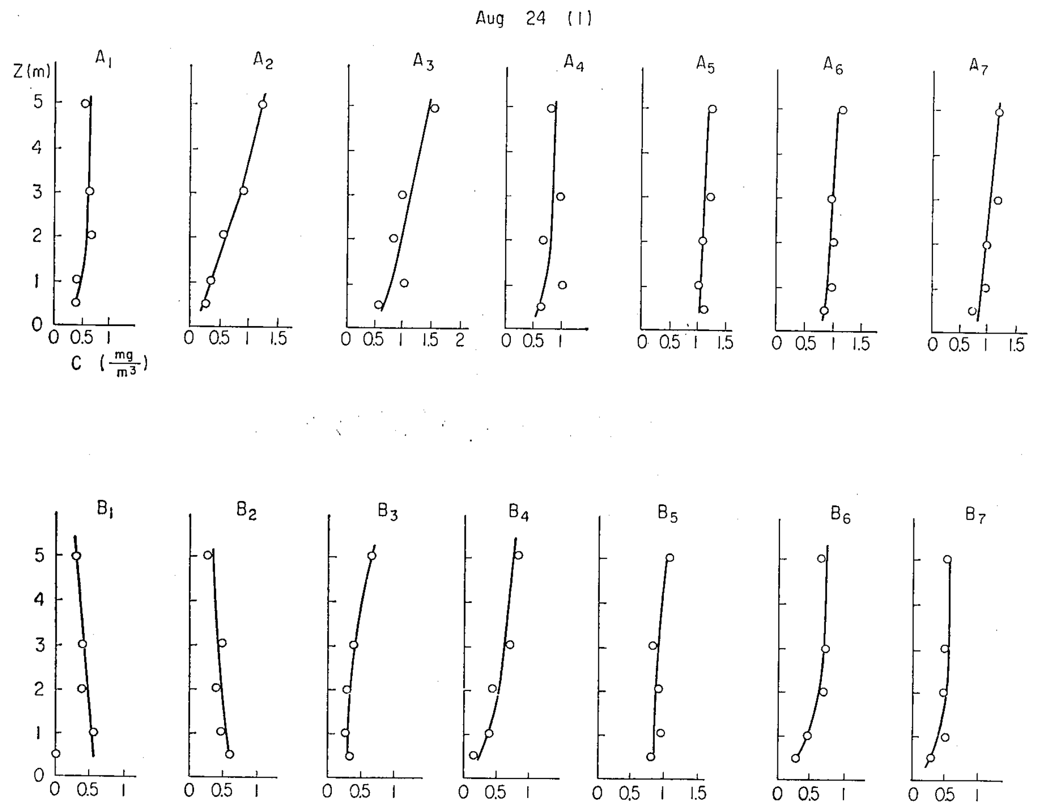
Aug 24 (I)
A_1 A_2 A_3 A_4 A_5 A_6 A_7
B_1 B_2 B_3 B_4 B_5 B_6 B_7
Z(m)
C ($\frac{mg}{m^3}$)

Fig. 9-6.

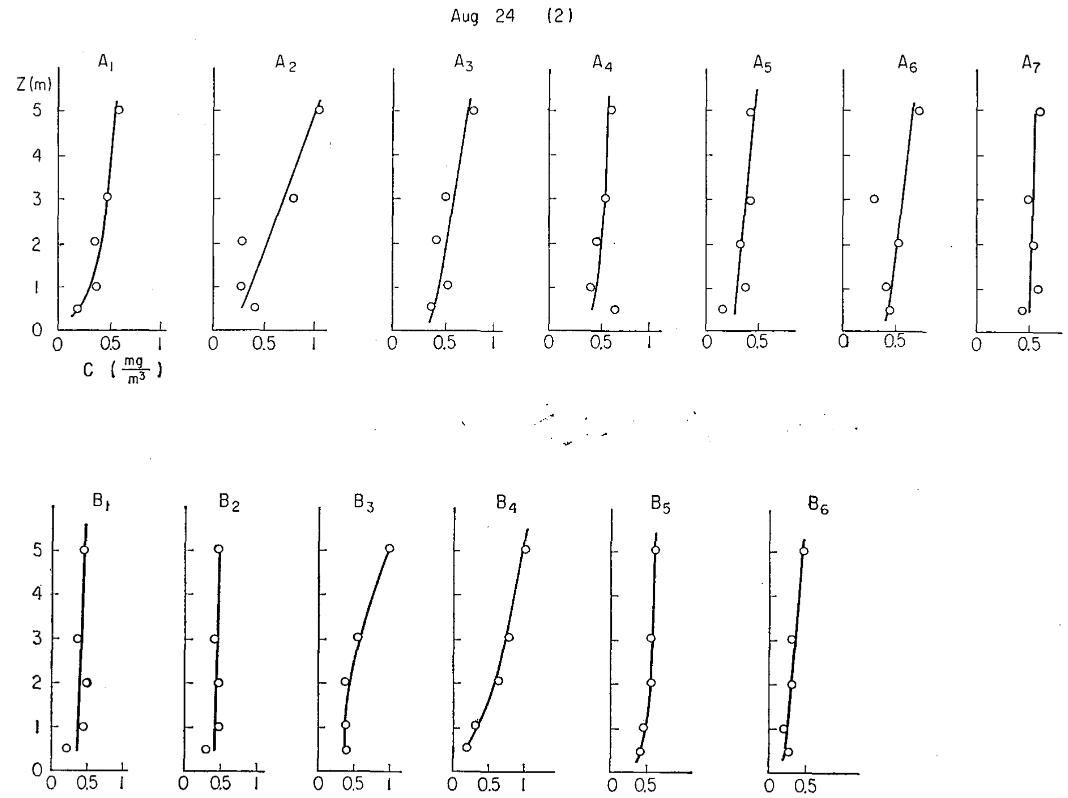
Aug 24 (2)
A1 A2 A3 A4 A5 A6 A7
B1 B2 B3 B4 B5 B6
Z (m)
C (mg/m³)

Fig. 9-7.

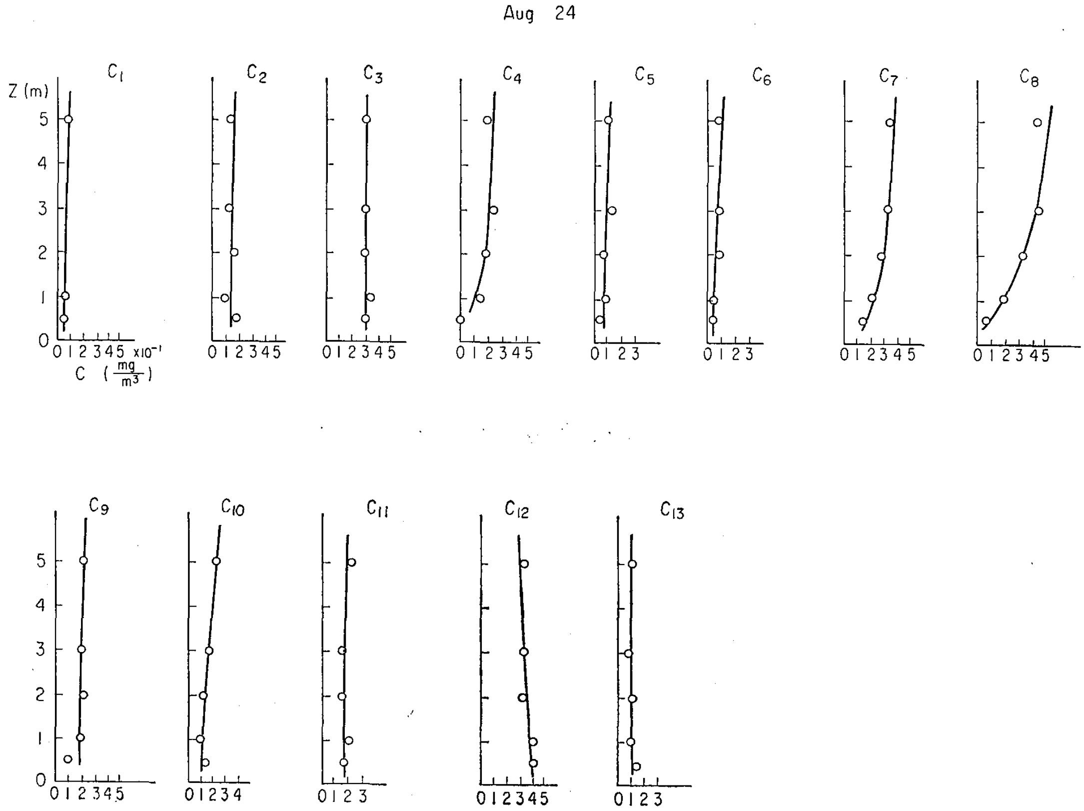
Aug 24
C1 C2 C3 C4 C5 C6 C7 C8
C9 C10 C11 C12 C13
Z (m)
x10⁻¹
C (mg/m³)

Fig. 9-8.

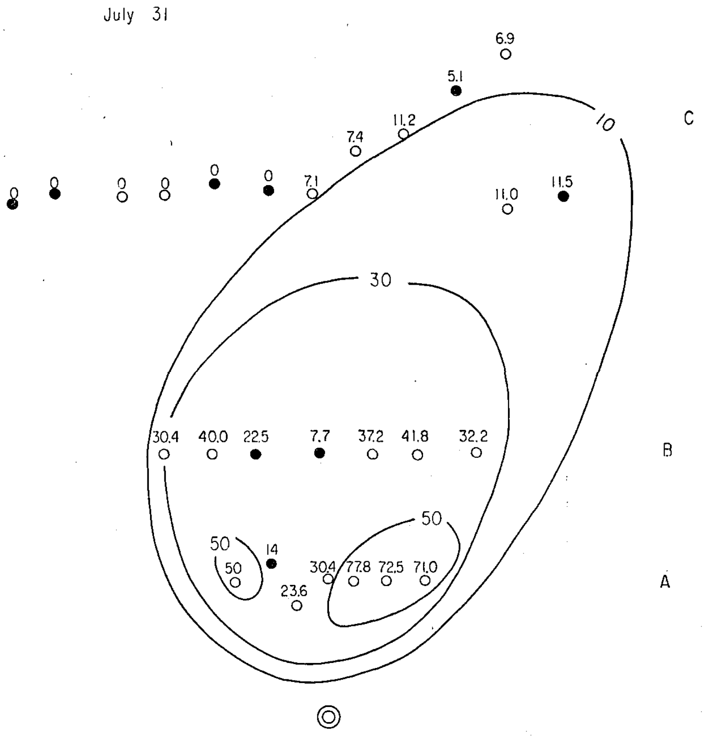
July 31
6.9
5.1
11.2
7.4
10
C
0
0
0
0
0
0
7.1
11.0
11.5
30
30.4
40.0
22.5
7.7
37.2
41.8
32.2
B
50
50
14
50
30.4
77.8
72.5
71.0
23.6
A

Fig. 10.

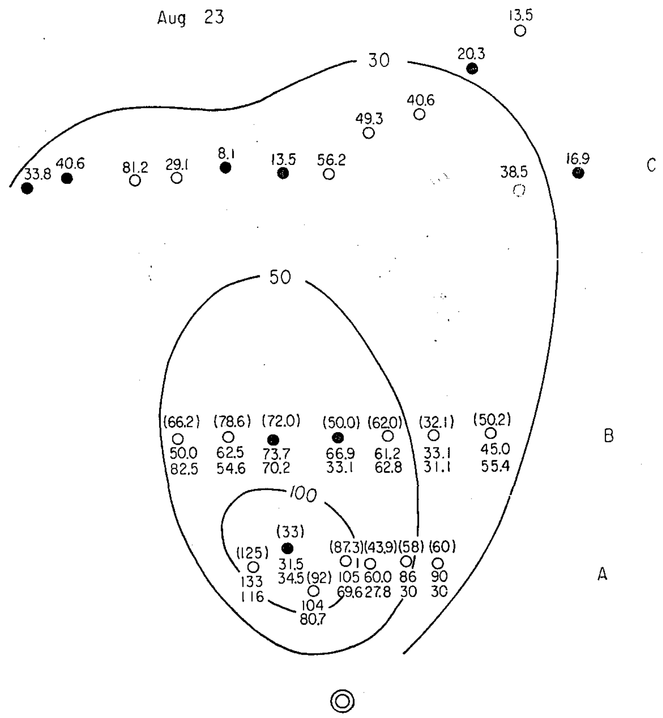
Aug 23
13.5
30
20.3
40.6
49.3
33.8
40.6
81.2
29.1
8.1
13.5
56.2
38.5
16.9
C
50
(66.2)
(78.6)
(72.0)
(50.0)
(62.0)
(32.1)
(50.2)
50.0
62.5
73.7
66.9
61.2
33.1
45.0
82.5
54.6
70.2
33.1
62.8
31.1
55.4
B
100
(33)
(125)
(87.3)(43.9)(58)
(60)
31.5
133
34.5
(92)
105
60.0
86
90
116
104
69.6
27.8
30
30
80.7
A

Fig. 11.

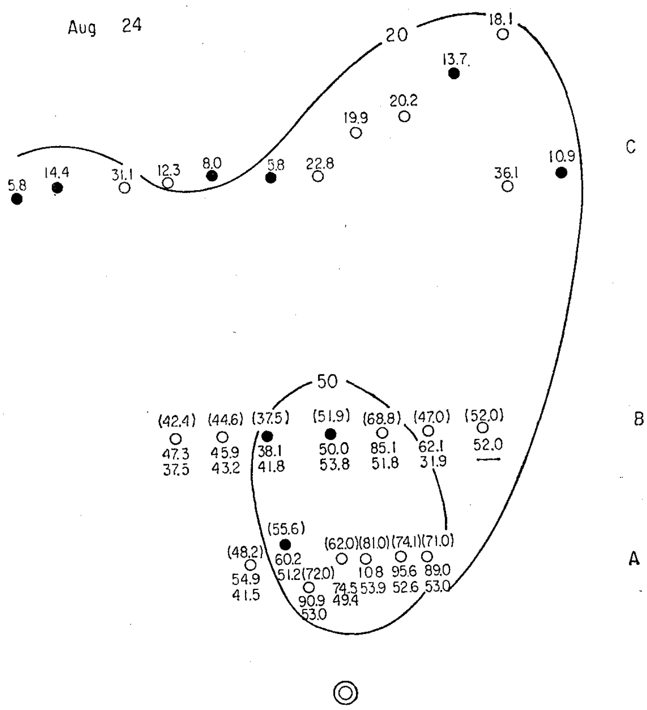

Fig. 12.

Comparison with the theoretical calculations

The curves of maximum concentration at each leeward distance versus x are shown as marks ○ in Fig. 13.

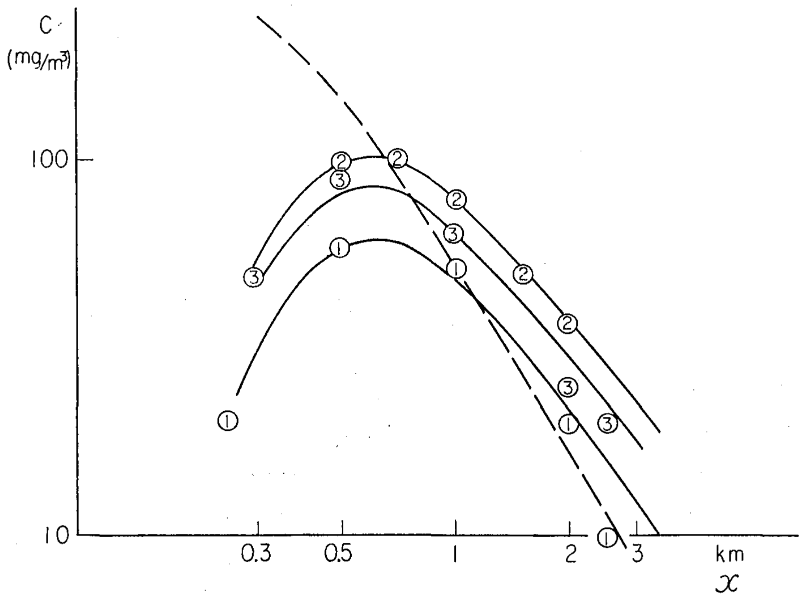

Fig. 13.

The corresponding formula deduced by the author[2),3)] for the present case is

$$C = \frac{Q}{uL}\frac{1}{B}e^{-\frac{h+z}{B}}J_0\left(i\frac{2\sqrt{hz}}{B}\right) \tag{20}$$

$$L^2 = q_A(\varphi_A x + e^{-\varphi_A x} - 1) \tag{21}$$

$$B = q_B(\varphi_B x + e^{-\varphi_B x} - 1) \tag{22},$$

where Q is the emitting rate of the iron-dusts (mg/sec), h is the chimney's height (m), z is the height of the post (m), φ_A, φ_B, q_A and q_B are diffusion parameters and u is the wind speed at the height of the chimneys. Eq. (20) can be written as follows:

$$\frac{C}{Q/u} = \frac{1}{L}\frac{1}{B}e^{-\frac{h+z}{B}}J_0\left(i\frac{2\sqrt{hz}}{B}\right) \tag{23}.$$

We calculated the concentration for $z=2$ m, and for the meteorological condition $\zeta \doteqdot -0.2$ which corresponds to slightly unstable condition and for which

$$\varphi_A = 6.6\times10^{-4},\ \varphi_B = 1.9\times10^{-2},\ \sqrt{q_A} = 2.0\times10^3,\ q_B = 1.8.^{4)}$$

There are tall buildings in the neighbourhood of the chimneys and they cause downwash of the plume. So the effective height of the chimneys is not 55 m, but it must be more lower. We assumed that the effective height is 40 m. The calculated results of C are plotted on a log-log paper against x and we obtain the curves in Fig. 13. We can see that the curves fit fairly well to the observed results and thus resulted values of Q/u, wind speed u and the calculated values of Q are given in Table 5.

Table 5. Q/u and Q.

Run No.	I (July 31)	II (Aug. 23)	III (Aug. 24)
Q/u	4.1×10^4	6.7×10^4	5.6×10^4
$u^{(4)}$ (m/sec)	7.9	9.5	6.9
Q (mg/sec)	3.26×10^5	6.43×10^5	3.88×10^5

The actual emmission rate Q was not given so definitely, but it is said that it is $0.31\sim1.25\times10^4$ mg/sec. The discrepancy between the calculated values and the supposed values is considerably large.

The result of calculation of Sutton's formula with $n=0.25$, $c_y=c_z=0.4$ is shown by the broken line in Fig. 13. The curve does not show the observed results, but the value of Q is the same order of those in Table 5 and shows the similar discrepancy as in the results

(4) The wind speeds at the height of 55 m were not able to be observed, so we are obliged to use the data at the height of 15 m.

already mentioned.

Capturing efficiency

The value of C_1 should be calculated from the data of D with the knowledge of $\alpha(u)$. In the present observations, we have the immediate relation between C_1 and D, so we can estimate the function $\alpha(u)$.

From eqs. (18) and (19),

$$\lambda = \frac{2k_1}{\alpha_1}\frac{b}{d} \qquad \therefore \alpha_1 = \frac{2k_1}{\lambda_1}\frac{b}{d} \tag{24}$$

We can calculate α_1 with following data:

$b = 2.25 \times 10^{-2}$ (cm)
$k_1 = 4.30 \times 10^{-1}$ (mg/cm^2)
$\lambda = 1.88$ (mg. sec. h/m^4) $= 6.77 \times 10^{-5}$ (mg. sec^2/cm^4)
$d = 2.05 \times 10^{-2}$ (cm).

We obtain

$$\alpha_1 = \frac{4.5\times10^{-2}\times4.30\times10^{-1}}{6.77\times10^{-5}\times2.05\times10^{-2}} = 1.39\times10^4 \text{ (cm/scc)}^2 .$$

$$\alpha = \alpha_1 u^{-2} = 1.39\times10^4\times u^{-2} \tag{25}$$

If we assume that $u = 3.0\times10^2$ cm/sec,

$$\alpha = \frac{1.39\times10^4}{9\times10^4} = 0.15 .$$

Theoretical treatments of the capturing efficiency hitherto have been based on the assumption that the particles depart from its original path when the stream line happens to have large curvature near the cylinder. The deduced result is that the capturing (impingement) efficiency increases with the wind speed.[5] This is quite different conclusion from that in the present case in which α varies as u^{-2}. If a particle moves with the air stream velocity u, and the air stream suddenly stops, the particle in the stream decreases its velocity as $u = u_0 \exp(-t/T)$. If the radius of a particle is 2μ, its density is 5.6, T becomes 4.6×10^{-5} sec. This means that the departure from the original path is very small and the particle moves closely along the stream line. This fact does not clearly coincide with the assumption of the usual theories.

Detailed consideration of the capturing efficiency in the present case will be reported in another paper.

Conclusion

We have obtained the preliminary data of the dust-distributions in a region near a large factory. The flag samplers seemed quite suitable to use a considerable number in such as these experiments, owing to their simplicity and low price.

The mechanism of the capture and the value of the capturing efficiency are the subjects to be investigated further and are now going to be investigated.

Literature

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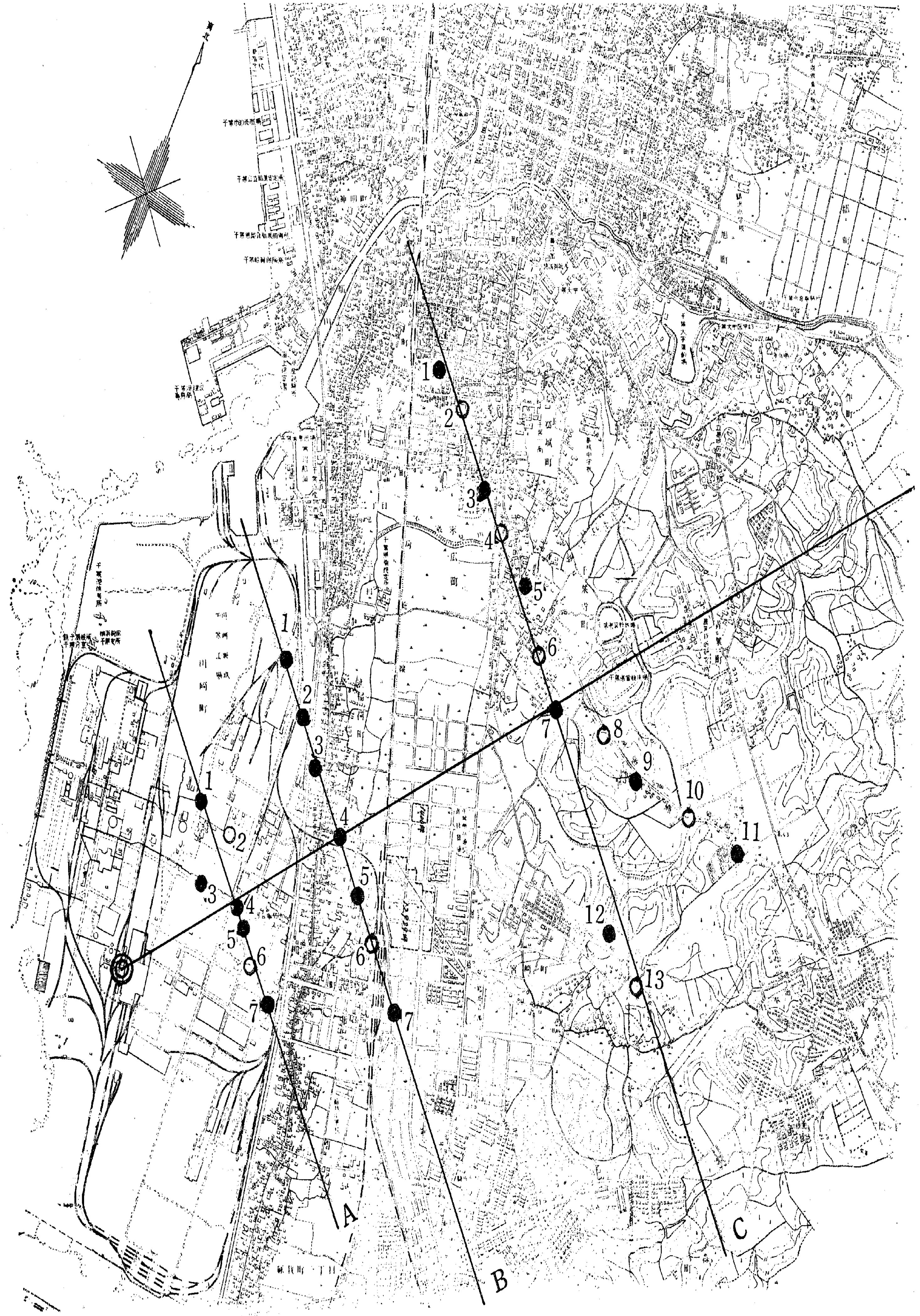

Fig. 1.