A Study of the Minor Fluctuation of the Atmospheric Pressure (III)

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(Received May 5, 1935)

Part II. Analysis of the Microbarograms (Continued)

Section III

Rapid Rise of the Barometric Pressure

1. Introduction

The phenomenon, "Crochets d'orage", i. e. the peculiar shape of the barometric trace associated with a summer shower or a winter squall, is very familiar to meteorologists. Numberless inquiries and researches have been made on this subject, and, in connection, also, with the recently advanced "Polar front theory," various reports and fairly detailed, have appeared from many places in the world.

It is not the wish of the present writer to look into these. He will give, in what follows, only the results of his own investigations in the matter, as part of this microbarographical study, by citing examples of the rapid rise of the atmospheric pressure in times of a shower or a squall.

2. Typical Examples

Ex. 1. An example of "Local Shower." 16 h, 23rd Apr., 1921.

Reproduction of the microbarograms: Fig. 54. (Three simultaneous records) $\Delta p \doteqdot 2$ mm. Hg. $\Delta T \doteqdot -6$°C
Weather Chart: Fig. 55. Remarks: This is a typical of a local shower. It must be noticed here that, in addition to the main shower occurring at about 16h, a minor shower was experienced at about 11 h. 45 min. and 13 h. 45 min.. This fact seems to suggest the mechanism of generation of this kind of local shower.

Ex. 2. An example of "Winter Squall." 17 h. 8th. Nov., 1922.

Reproduction of the microbarogram: Fig. 56. $\Delta p \doteqdot 2.5$ mm. Hg. $\Delta T \doteqdot -4$°C Weather Chart: Fig. 57.

Remarks: This is an example of the rapid pressure rise which accompanies the passage of a squall line belonging to the extratropical cyclone which often attacks our locality in winter. The rise occurred

(Microbarograms; $\frac{1}{2}$ of original size)

23rd. April. 1920.

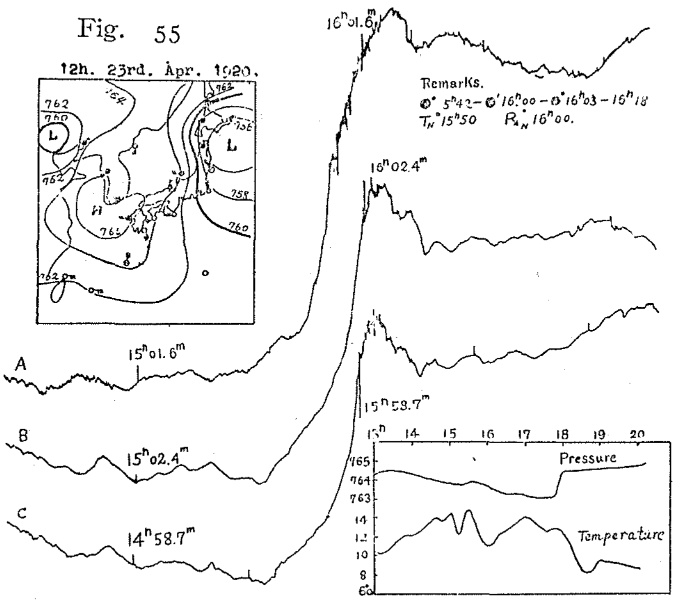


Fig. 54. Microbarograms at Kyoto.

Fig. 56. Microbarogram at Kyoto. ($\frac{1}{2}$ of original size)

8th. Nov. 1922.

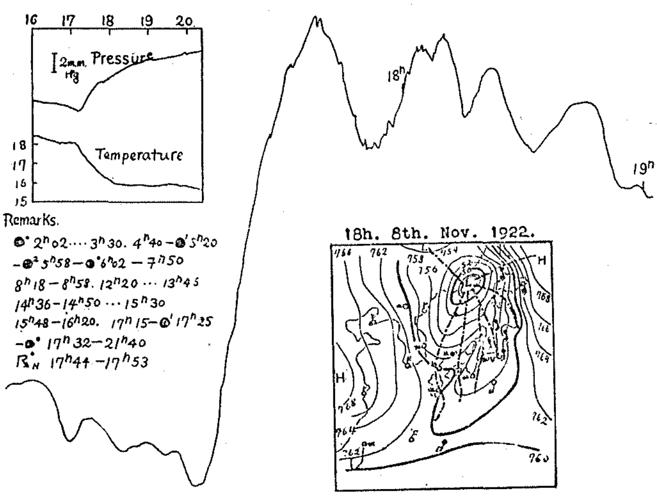


Fig. 57

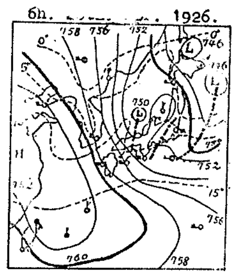
when a warm south-easterly current suddenly gave way to a cold north-westerly current.

Ex. 3. An example of two different kinds of minor squalls. 6 h. 30 min., and 10 h. 45 min. 26th Apr., 1926.

Reproduction of the microbarogram: Fig. 58. Weather Chart: Fig. 59.

(Microbarogram : ½ of original size)

Fig. 59



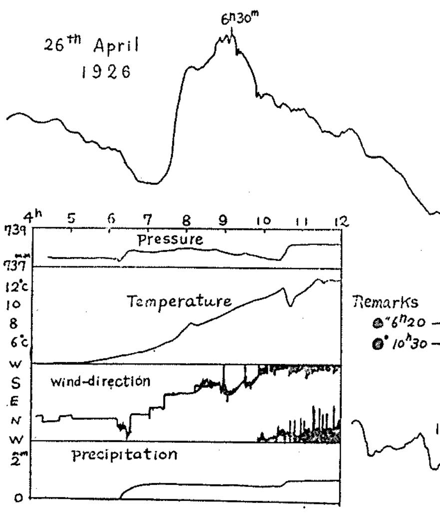
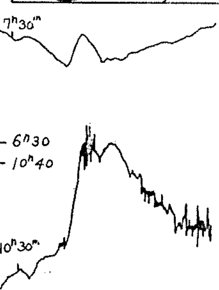



Fig. 58. Microbarogram at Kyoto.

Remarks: In Fig. 58 the minor squall which passed at 6 h. 30 min. was accompanied by slight rain of 0.3 mm. depth and a rapid rise of pressure of 0.7 mm. Hg., the air temperature showing no change.

But, later, at about 10 h. 45 min., another minor squall is shown to have passed; and, this time, a rapid rise of pressure of 0.7 mm. Hg., a sudden temperature fall of about 2°C., wind change from south to north, with suddenly increasing velocity, and rainfall of 0.2 mm. depth, were observed. These two minor squalls are presumably of the same structure, but the former did not present all the characteristics of normally recorded when a squall is passing. This can be accounted for by supposing that the first squall occurred in the upper strata of the atmosphere, thus partly eluding the observer on the ground. We shall hereafter call squalls of this type " Upper Squalls ", and ordinary squalls, like that which came after in this example, " Surface Squalls ", in order to distinguish between the two kinds.

Ex. 4. An example of an " Upper Squall" 1 h., 25th May, 1929.

Reproduction of the microbarogram: Fig. 60. Weather Chart: Fig. 61.

(Microbarogram : ½ of original size)

Fig. 60. Microbarogram at Kyoto. Fig. 61

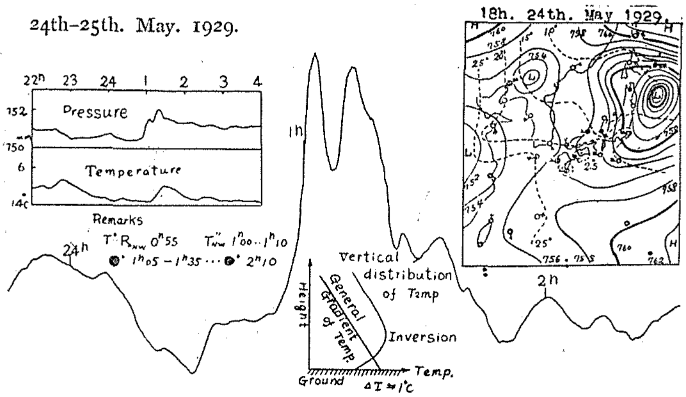


Fig. 62

Remarks: In this example, a quick rise of pressure of about 2 mm. Hg. is observed together with a thunder shower. The air temperature does not fall, but rises. This phenomenon can be explained fairly well by assuming that the squall passed over the thin surface air cooled by radiation at night in the Kyoto Basin. The air temperature rose, as in Fig. 62, when the surface layer was destroyed and the temperature distribution was restored to normal.

Among those which the writer calls " Upper Squalls " are included squalls, which, like this example, are only modified by the existence of a surface layer. Among them are also included, for convenience' sake, structural squalls, which have been made known and discussed by Bjerkness and his colleagues.

3. Detailed Examinations of Winter Squalls

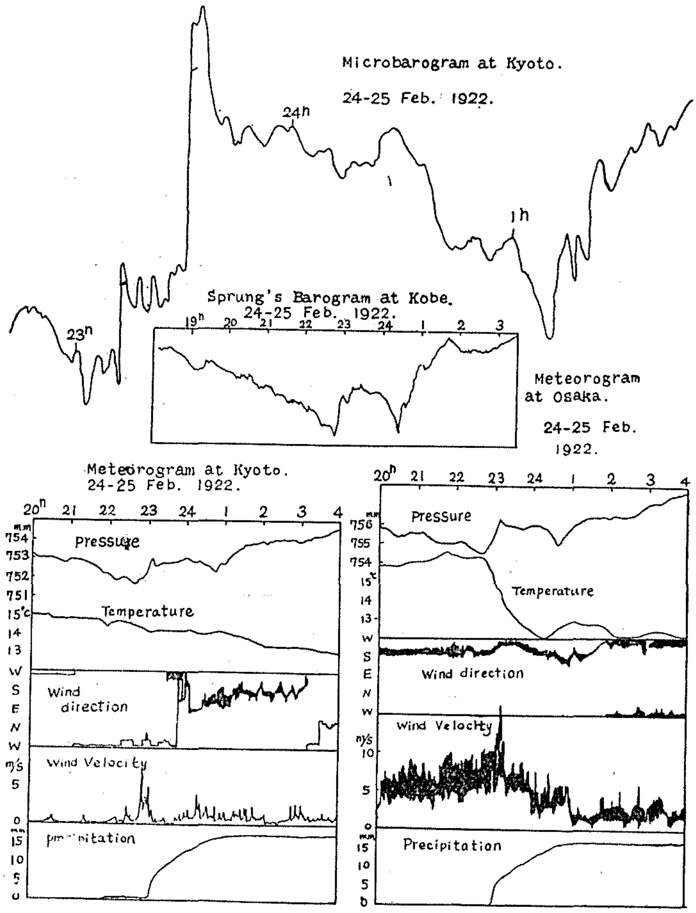
Ex. 5. A squall at 23 h, 24th., Feb., 1922.

Reproduction of the microbarogram and meteorograms at Kyoto, Kobe, and Osaka: Fig. 63.

Reproduction of the barograms and the thermograms at various stations: Fig. 64. Remarks on the squall: Table 8. Weather Chart at 18 h. 24th: Fig. 65. Weather Chart at 22 h. 24th and isochronous chart showing the advance of the squall: Fig. 66.

Fig. 63

(Microbarogram ; ½ of orininal size)



From Figs. 63, 64, 65, 66 and Table 8, it is clear that the squall travelled ESE. at a speed of about 60 Km/hour (17 m/s). Moreover, it is possible to conjecture from these records the probable structure of the squall as shown in Fig. 67. As this figure explains itself, no further comments are necessary. The only remaining question is the minor barometric trough appearing behind this squall. The barometric troughs appear with most squalls and are larger or smaller as the case may be. The writer first attributed this trough to the effect of a revolving fluid which occurs behind the head of the squall. But, in spite of most careful investigation, he could not find any trace of a revolving fluid passing with the squall. The key must be sought

Table 8

Stations.	Squall on 24^{th} Feb., 1922: Passage time.	Prss. Change ΔP	Temp. Change ΔT	V-shaped depression behind the squall: Passage time	Depth.	Meteorological Remarks.
Tadotu	21^{h}	1.8mm.	−5.5°C	23^{h}	0.6mm.	●°18h34—●'19h05—●°20h02—●'20h51—●²21h04—●°22h30—22h55
Okayama	$21^{h}\,10^{m}$	1.8	Steady	$22^{h}\,25^{m}$	0.6	●°17h03—17h45, ●°18h35—●'20h50—●²21h10●'21h13—●°22h50—23h15. T'NW 21h07—☈'E 21h34—
Murotozaki	$22^{h}\,10^{m}$	1.8	−3.0	$0^{h}\,20^{m}$	1.0	—<°SW—☈°SW22h20—, ●°22h30—, ☈°SSW22h50→☈°SE23h05—23h50, —●°—1h20
Tokusima	22^{h}		−3.0			●°21h43—●'22h07—●°23h20—23h57
Kôbe	$22^{h}\,50^{m}$	1.3		$0^{h}\,25^{m}$	1.2	●°21h56—●'22h22—●°22h35—●²22h49—0h40☈'N23h15—23h43 ⚡23h
Miyazu	22^{h}	2.0	gradual continuous fall			●°7h30—2h35 (next day), 8h10—8h55
Wakayama	23^{h}	1.5	−4.0	$0^{h}\,50^{m}$	1.0	●°21h25—●²23h30—●°23h50—0h50
Ôsaka	$13^{h}\,10^{m}$	1.8	−4.0	$0^{h}\,50^{m}$	1.2	●°16h18—●'23h02—●²23h08—●'23h25—●°0h28—, ☈'23h15—23h47
Yagi	$23^{h}\,45^{m}$	1.5	−2.0	$1^{h}\,17^{m}$	0.4	
Kyoto	$23^{h}\,30^{m}$	1.0	invisible fall	$1^{h}\,10^{m}$		●°16h55—17h15, ●°18h32‥21h45 ●°21h54—●'22h33—●°22h34—●'22h48—●°22h55—●'23h03—●²23h06—●'23h12—●²23h21—●'23h23—●²23h29—●°23h35—●'23h47—●°1h05—1h20…1h53—2h52 (25th). T°SW23h36—☈°23h37, ☈°23h43. T°S23h48—23h52.
Hikone	$23^{h}\,55^{m}$	1.8	−4.5	$1^{h}\,30^{m}$	1.5	
Tu	$0^{h}\,20^{m}$	1.2	−4.0	2^{h} or earlier		●4h50—8h10, 18h40—5h00 (next day) 8h35—8h53
Gihu	1^{h} or earlier	1.5	−3.5			●°6h58—7h15, 8h25—10h50, ●°22h54—●'23h00—●°2h04—2h37
Fukui	$23^{h}\,10^{m}$	2.0 not sudden	−3.5 not sudden			●°22h03—●'22h40—●²23h15—●'24h00—1h15

Fig. 64

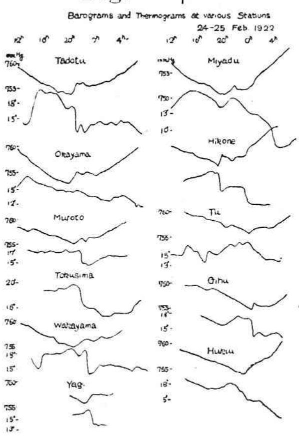


Fig. 66a
Weather Chart.

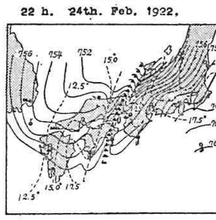
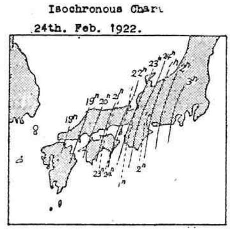


Fig. 66b



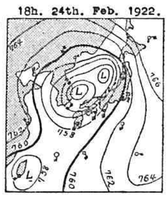


Fig. 65

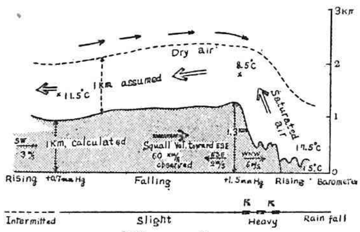


Fig. 67

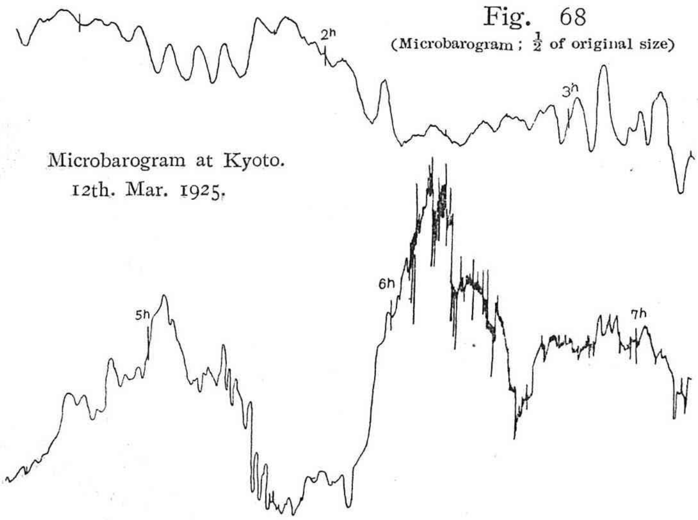
elsewhere. The writer belives that the reason for this pressure-fall can be explained on the assumption that the squall head is covered by a warm current about 1 Km. deep, as shown in Fig. 67. He also believes that the wave-like pressure-disturbance observed after the passage of a squall is due to internal waves occurring on the boundary surface between cold and warm air.

Ex. 6. A squall at 6 h., 12th., Mar., 1925. Reproduction of the microbarogram, and the meteorolograms: Fig. 68 and Fig. 69.

Weather Chart at 6 h, 12th: Fig. 70. Remarks on the squall: Table 9. In this example are found the following four characteristic lines: (i) Line of sudden intrusion of warm current. (ii) Line of "Upper Front." (iii) Line of "Main Squall." (iv) Line of "Secondary Squall."

Remarkable phenomena to be noticed in this example are that, when the squall passes, the air temperature rises at Osaka, and a sudden rise of above 10°C is observed at the Yagi Observatory. This temperature rise is to be attributed to the passage of the so-called "Disguised Front", as is shown clearly in Fig. 71. About five hours before the first appearance of the squall i. e., approximately between 1 h. and 2 h. on that day, barometric waves with a period of about 8 min. are observed. This phenomenon had already been discovered by W. Schmidt, who says that, as these barometric waves occur from

Fig. 68
(Microbarogram ; $\frac{1}{2}$ of original size)



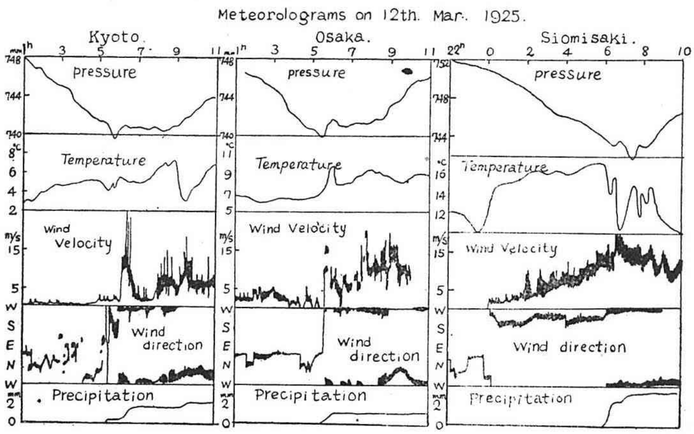


Fig. 69

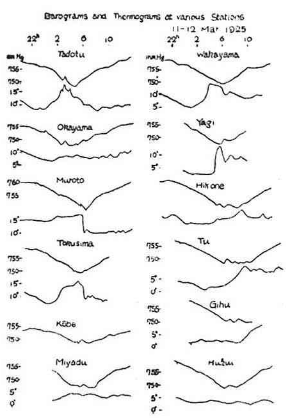


Fig. 70

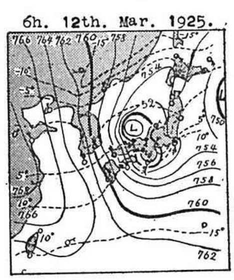


Table 9. (a) Penetration of warm Air. 12th Mar. 1925.

Stations	Time of passage	Change of temp. ΔT	Remarks.
Murotozaki	Before 22^h00^m 11th	4.0°C	NNE→SW
Sionomisaki	23^h50^m 11th	4.0°C	NNE→SW
Tadotu	2^h00^m or little later	6.0°C	
Tokusima	2^h00^m or little later	5.0°C	N→W
Wakayama	3^h30^m	5.5°C	
Yagi	4^h42^m	13.3°C	

Table 9. (b) Upper Squall. 12th. Mar. 1925.

Stations	Time of passage	Change of press. ΔP (in mm. Hg.)	Remarks
Okayama	3^h25^m	1.3	NE→NNW
Kôbe	4^h20^m		
Miyazu	4^h30^m not certain	0.5	
Ôsaka	5^h20^m		NE
Kyôto	5^h00^m		NW, Thunder SW. $4^h40^m - 4^h57^m$
Hikone	5^h00^m or little later	1.0	
Gihu	6^h00^m or little later	1.0	Hail shower Thunder $5^h40^m - 6^h50^m$
Hukui	6^h00^m	0.5	Rain moderate

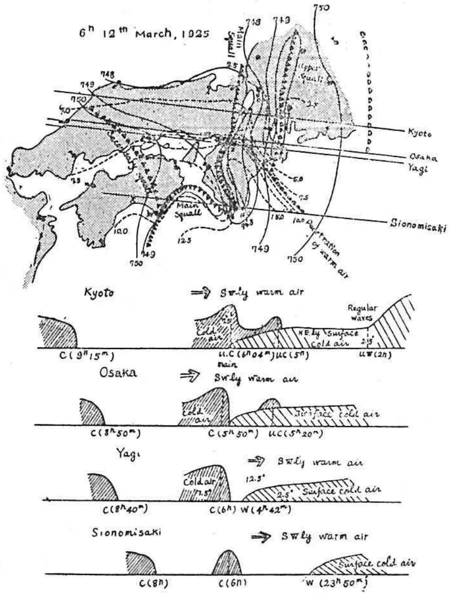
Table 9. (c) Main Squall. 12th. Mar. 1925.

Stations	Time of passage	Change of press. ΔP (in mm. Hg)	Change of temp. ΔT (in °C)	Remarks
Sionomisaki	6^h00^m	1.2	−5.5	SW→W, Rain $6^h00^m - 6^h20^m$, 2.5mm
Tadotu	4^h20^m	1.5	−4.0	Rain & thunder
Tokusima	5^h40^m	1.8	−5.0	SW→W, 10m/sec.
Wakayama	6^h00^m or little before		−3.0	
Yagi	6^h00^m	2.2	−4.3	
Okayama	4^h40^m	0.8		N→WSW, 10m/sec. Rain moderate
Kôbe	5^h35^m	2.1		Rain
Miyazu	5^h40^m	1.0		
Ôsaka	5^h50^m	1.8	−1.0	SW→WNW, 15m/sec. Rain
Hikone	6^h30^m	1.2		
Kyôto	6^h04^m	1.5	not fall	S→W Rain moderate
Tu	6^h40^m	1.9		
Gihu	7^h20^m	2.0		Rain slight

Table. 9. (d) Secondary Squall. 12th Mar. 1925.

Stations	Time of passage	Change of press. ΔP	Change of temp. ΔT	Remarks
Okayama	7^h20^m	1.8mm.	decrease	W→NW, 10m/sec
Kôbe	8^h45^m	2.0mm.		
Miyazu	8^h00^m	−2.0mm.	−2.0°C	
Ôsaka	8^h50^m	not remarkable	not remarkable	WSW→NW, 15m/sec
Kyôto	9^h15^m		−4.0°C	W→NW Rain slight
Hikone	9^h30^m	2.3mm. not sudden	−3.5°C	
Tu	9^h40^m	Steady	Steady	Rain feeble
Hukui	8^h50^m	Rising	Decreasing	Rain, snow, hail

Fig. 71



10 to 11 hours before a squall, it is possible to forecast a squall from them. But it seems to the present writer more natural to regard the waves as appearing near the warm front.*

Ex. 7. Example of regular barometric waves before a squall, 27th May, 1921. Fig. 72 shows that the squall passes Kyoto at 14 h. 30m., while the regular waves of pressure are recorded at about 11 h., i. e., about 3 hours before the passage of the squall. Fig. 73 is the weather chart of the day.

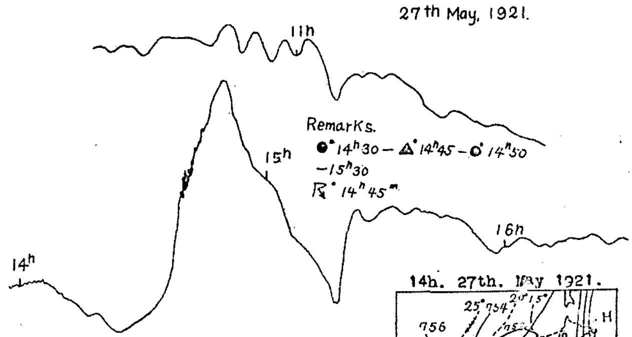
4. Statistical Study

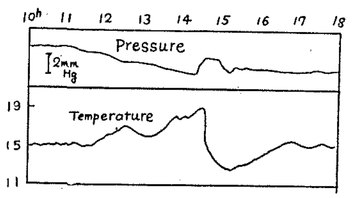
The results of the statistical studies of noteworthy disturbance of this kind during the 11 years covering 1919—1929 are shown in Table 10.

* Met. Zs. **29** (1912) 406–412.

Fig. 72. Microbarogram at Kyoto.

(Microbarogram ; ½ of original size)





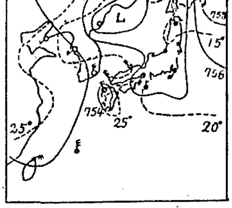


Fig. 73

Table. 10 Number of Occurrence of this Type.

Yearly Variation	No. of Occ.	Seasonal Variation	No. of Occ.	Daily Variation	No. of Occ.
1919	7	Jan.	2	0h–2h	2
1920	3	Feb.	9	2– 4	1
1921	18	Mar.	15	4– 6	4
1922	12	Apr.	10	6– 8	2
1923	8	May.	6	8–10	3
1924	8	Jun.	5	10–12	4
1925	3	Jul.	15	12–14	12
1926	9	Aug.	7	14–16	29
1927	10	Sept.	11	16–18	24
1928	8	Oct.	5	18–20	7
1929	8	Nov.	6	20–22	3
		Dec.	3	22–24	3
Total.	94		94		94

Barometer Rise (mm. Hg.)	No. of Occurrences	Temperature Fall. °C	No. of Occurrences
0.5–1.0	37	1.0	26
1.0–1.5	33	1.0–3.0	18
1.5–2.0	11	3.0–5.0	16
2.0–2.5	3	5.0–10.0	24
2.5–3.0	3	10<	1
uncertain	7	uncertain	9
Total.	94	Total.	94

Section IV

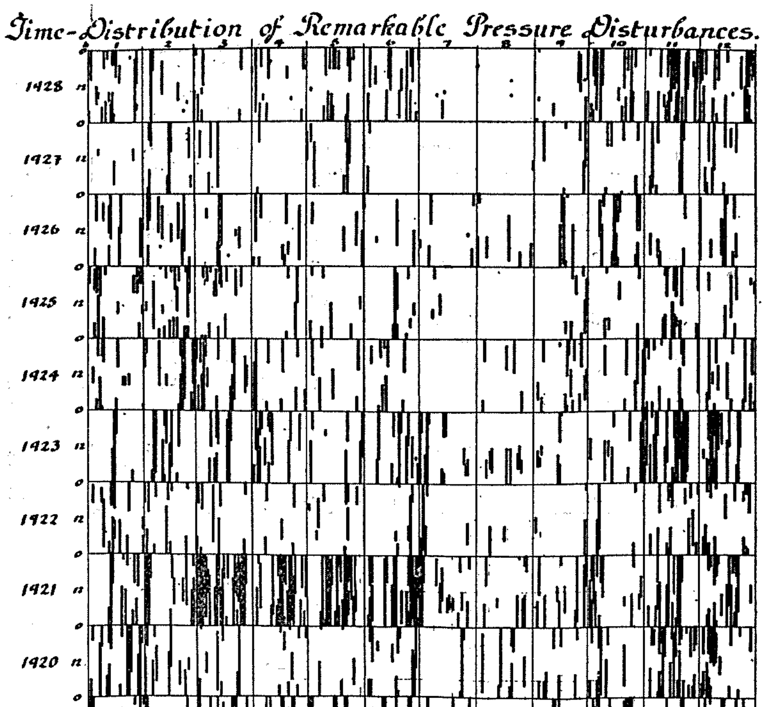
On the Disturbance-Type of the Microbarograms

1. Introduction

In the preceding three sections of Part II, abnormal types have been classified and discussed. These types, however, are recorded more frequently in association than in isolation. Therefore, when barometric waves, microbarographic depressions, etc. are recorded continuously in our microbarograms, they will, hereafter, be taken up, not analytically, but synthetically, and these records will be called "Disturbance-Type of the Microbarograms." Thus the microbarograms can be divided into two types —— Normal Type and Disturbance Type, the latter including all the abnormal types.

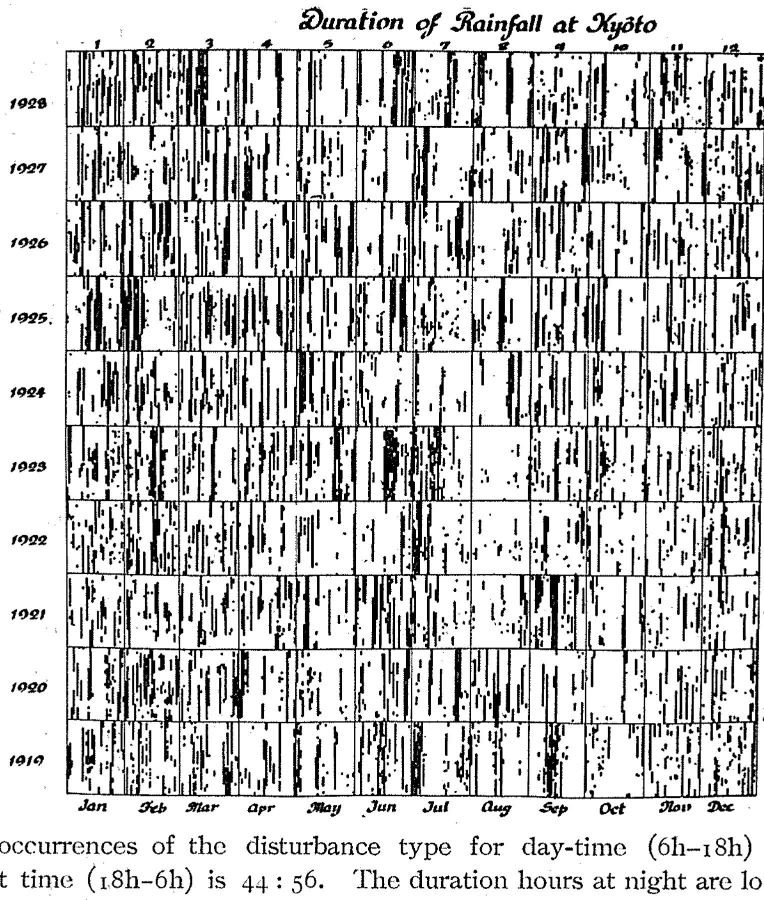
2. A Statistical Study of the Disturbance-Type of the Microbarograms

Fig. 74



The time of the appearance of this type during the ten years covering 1919–1928 is shown in black line in Fig. 74. A coordinate system is adopted in this figure, with months (Jan.—Dec.) and hours (oh–23h) as abscissa and ordinate respectively, the years arranged vertically in their order. This figure forms the foundation of our statistical study. The ratio between the sum of the duration hours of

Fig. 75



the occurrences of the disturbance type for day-time (6h–18h) and night time (18h-6h) is 44 : 56. The duration hours at night are longer in their total-sum. The statistics of the duration hours of this type are shown in Table 11, where D indicates the total hours of its occurrence within a particular year or month, and F, the number of its occurrences. Accordingly, "D/F" represents the mean duration hours of a single occurrence, and D/T, the ratio of the total hours of occurrences to the entire hours of a particular year or month. From this table, the total hours of occurrences are found by calculation to be 12.8% of the total hours under investigation, and the average number of hours of a single occurrence proves to be 14.1 hours. D/T, which shows the seasonal variation, reaches maximum (21.0%) in November and minimum (4.0%) in August. On the whole, D/T is greater in the cold season, the period Oct.–Mar. having 58% and the period Apr.–Sept., 42%. That November and March have the greatest number of occurrences is due to the fact that in these months the alternation of the monsoon occurs; and *Baiu*, the rainy season of Japan, increases the number in June. Moreover, the occurrence of this type varies each year in frequency and time; D/T being maximum (25.7%) in 1921, minimum (5.9%) in 1927; the difference amounting to 20%, although these statistics cover only ten years. In order to investigate the relation between the occurrence of this type and rainfall, the duration-time of rainfall of Fig. 74 is substituted for that of the occurrence of Disturbance-Type. Thus we have Fig. 75. Here, this type is shown to appear most frequently in bad weather, but it is impossible to count

Table 11

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	D/F	D/T
1928	D	124	62	38	69	98	134	8	2	47	164	246	180	1172		
	F	13	7	4	8	9	11	3	2	6	9	14	12	98	12.1	13.4
1927	D	14	82	53	10	76	14	2	5	61	26	96	80	519		
	F	3	10	6	2	6	2	2	3	5	3	3	8	53	9.8	5.9
1926	D	90	105	61	71	43	29	31	38	62	109	32	102	773		
	F	6	9	6	6	4	3	4	5	4	7	4	6	64	12.1	8.8
1925	D	88	119	79	32	32	36	10	3	48	31	104	55	637		
	F	9	14	11	4	6	7	3	3	6	5	10	8	86	7.4	7.3
1924	D	65	157	143	87	51	62	2	37	90	81	92	124	991		
	F	9	10	8	5	4	5	2	4	10	4	8	9	78	12.7	11.3
1923	D	47	128	113	144	72	138	115	61	39	104	267	200	1428		
	F	2	5	4	10	4	6	7	8	5	6	7	7	71	20.1	16.3
1922	D	134	69	79	32	52	40	50	15	19	46	128	82	746		
	F	12	9	9	4	8	5	4	2	4	3	9	10	79	9.5	8.5
1921	D	106	123	423	275	280	277	139	62	118	125	165	157	2250		
	F	6	6	12	10	8	9	12	5	7	9	7	11	102	22.0	25.7
1920	D	208	108	83	40	32	105	32	85	57	89	236	128	1203		
	F	9	9	6	7	5	9	3	6	8	5	14	12	93	13.0	13.7
1919	D	107	47	169	159	158	189	122	7	71	219	144	114	1506		
	F	7	4	10	7	4	11	9	1	3	6	4	6	72	20.9	17.2
Total	D	983	1000	1241	919	894	1024	511	315	612	994	1510	1222	11225		
	F	76	83	76	63	58	68	49	39	58	57	80	89	796		
D/F		12.6	12.1	16.4	14.6	15.4	15.1	10.4	8.1	10.5	17.4	18.9	13.7		14.1	
D/T%		132	14.2	16.7	12.6	12.0	14.2	6.9	4.2	8.5	13.4	21.0	16.4			12.8

it among the prognostic phenomena of rainfall. We next consider the relation between this type and the distribution of pressure. The distributions of pressure at the time of the occurrence of this type are roughly classified into ten groups in

Fig. 76

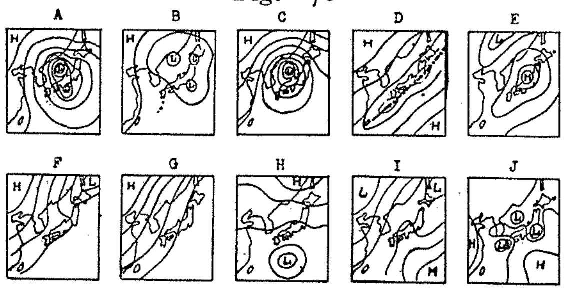


Fig. 76. The numbers of occurrences of disturbance types belonging to each of these ten are shown in Table 12. Table 13 shows the

Table 12

Month / Type	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
A	18	20	18	9	12	17	5	0	8	12	19	22	160
B	7	6	3	13	13	17	14	8	9	4	8	11	113
C	14	11	16	6	4	9	6	12	11	4	11	10	114
D	6	13	16	20	11	5	0	1	6	14	13	12	117
E	9	11	8	13	14	15	1	7	17	18	14	11	138
F	10	14	7	0	3	1	0	1	3	2	13	17	71
G	10	7	6	1	0	0	0	0	0	1	3	9	37
H	1	2	1	1	0	0	5	4	6	2	1	0	23
I	0	0	0	0	0	3	12	1	0	0	0	0	16
J	1	0	1	0	0	1	4	4	1	0	0	0	12

Table 13

"A"	— Groups of cyclones	20.0
"B"	— Groups of minor cyclones	14.1
"C"	— Single cyclone	14.2
"D"	— Col-shaped isobar	14.6
"E"	— Migratory anticyclone	17.2
"F"	— Border of westerly type	8.9
"G"	— Westerly type	4.6
"H"	— Border of northerly type	2.9
"I"	— Border of southerly type	2.0
"J"	— Border of southerly type with several secondary cyclone	1.5

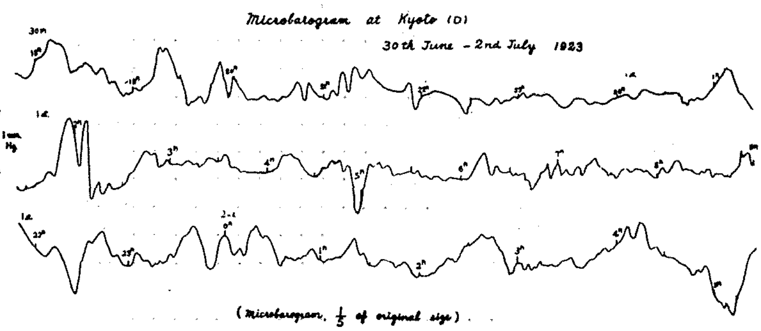
sums of the numbers in percentage. "A", "B" and "C", which are cyclonic, contain 48.3% of the whole number of occurrences.

"D" occurs during periods of monsoon alternation, and is observed frequently in spring and fall. "F" and "G" are seen in winter, and "H", "I" and "J" in summer. Here a doubt arises whether the converse of the result of the above statistical study is true i. e.—whether the pressure distributions described above are necessarily accompanied by disturbance-type of the microbarograms. The doubt is not endorsed by the facts. The statistics of the 3 years from 1926 to 1928 show that 42% of the cases of D group pressure distributions and a considerable percentage of the cases of the A, B, and C groups are accompanied by the disturbance-type of microbarogram. It may, therefore, be regarded as certain that, in cyclonic areas, minor fluctuations of pressure often recorded. A considerable percentage is also assigned to the cases of E group, which often gives rise to temperature inversions and is well-conditioned for the occurrence of atmospheric waves. It is almost the same with J group. The other groups have small percentage numbers. At any rate, the distribution of pressure alone cannot sufficiently account for these disturbance-types. The above result, of the statistical investigation of the relation between the pressure distribution and the microbarographic disturbances approximately agrees, in essentials, with the reports of several meteorologists on the same subject.*

3. Typical Examples

Ex. 1. 30th June–2nd July, 1923. Reproduction of the microbarogram and the meteorolograms: Fig. 77. Weather Charts: Fig. 78. On the weather chart showing the pressure disturbance in fluctuation, the

Fig. 77 a



* Cave: "The Structure of the atmosphere in clear weather." P 78. Met. Mag., Feb. (1922) 1.; Clayton, Harvard Ann. XI appendix.

Fig. 77 b

Meteorograms. 30th Jun.—2nd Jul. 1923.

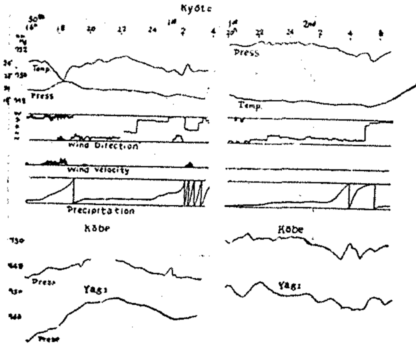
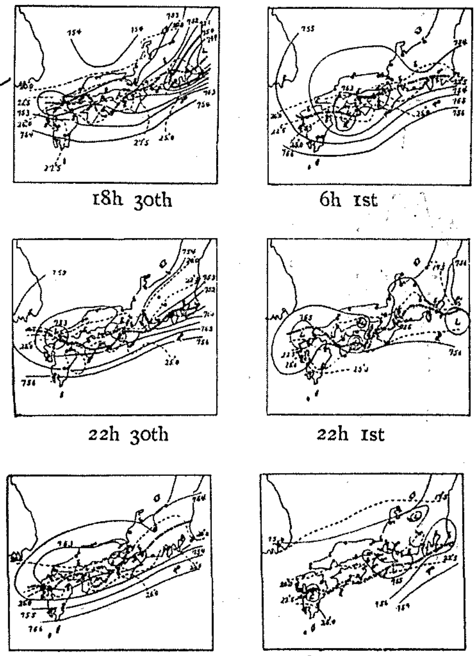


Fig. 78

Weather chart 30th Jun.—2nd Jul. 1923.



west part of Japan is covered by a depression zone, and small secondary cyclones are found in many places. On the southern coast, warm southerly winds are blowing with considerable velocity. It is inferred from these facts that there is a warm current over a cold current. As is often stated, such a condition of atmospheric strata as this is favourable for the occurrence of barometric waves. While the fluctuation continues, the sky is clouded and a heavy rain falls now and then. During the rainfall, striking pressure disturbances are often, but not always, recorded. This example belongs to group D.

Ex. 2. 22nd–23rd Feb., 1924. Reproduction of the microbarogram and the meteorograms: Fig. 79. Weather Chart: Fig. 80. This is one of the cases of group F. The border of a continental anticyclone passes near the southern coast of Japan proper. A newly-formed cyclone is seen near Chôshi.

According to J. Bjerkness, the juxtaposition of cold and warm currents is necessary for the formation of a cyclone. It is a necessary condition also for the occurrence of a pressure disturbance. So, where there is a striking pressure disturbance, as in this example, a newly-formed cyclone is often found.

Ex. 3. 5th Oct., 1928. Reproduction of the microbarograms: Fig. 81. Weather Chart: Fig. 82. This disturbance of pressure belongs

Fig. 79

(Microbarogram ; $\frac{1}{3}$ of original size)

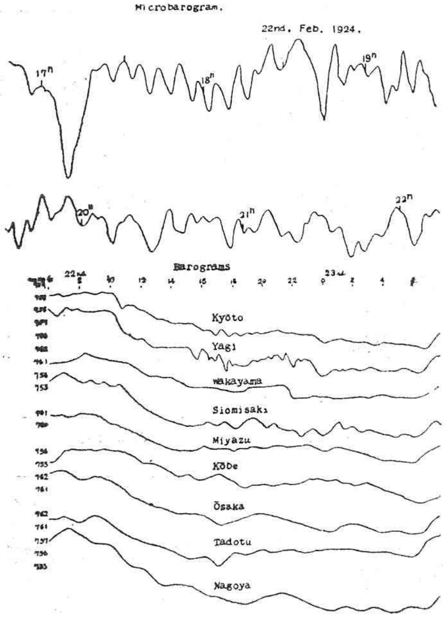


Fig. 80

18h. 22nd. Feb. 1924.

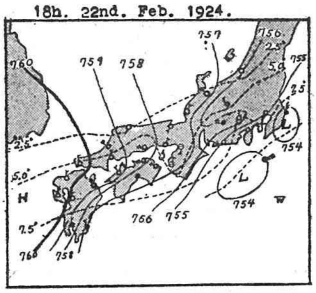


Fig. 82

18h. 5th. Oct. 1928.

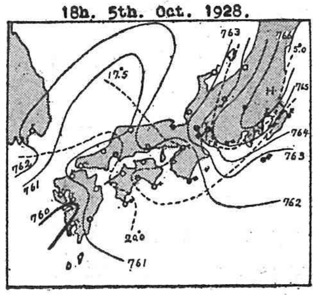
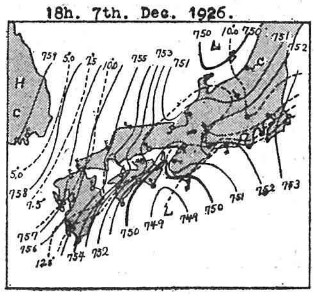


Fig. 84

18h. 7th. Dec. 1926.



to group E. On the weather chart, a remarkable fluctuation of pressure is recorded in the tail of the eastward migratory anticyclone. This example is one of the most characteristic of disturbance-types, the amplitude of barometric waves being as large as about 0.5 mm. Hg., and the duration considerably long. The weather is cloudy, with a cold north-easterly wind blowing. But, on Mt. Ibuki, southerly wind and a dense fog are observed. These facts point to the existence of a rather powerful discontinuous surface. This fluctuation is recorded also by the microbarograph at Takayama, Gihu Prefecture. But nothing is recorded at Beppu in Kyûshû.

Ex. 4. 7th Dec., 1926. Reproduction of the microbarogram: Fig. 83. Weather Chart: Fig. 84. This is one of the cases of group D, and shows the fluctuation of pressure near a trough line of V-shaped depression. The discontinuous line is very distinctly traced on the weather chart, but it becomes an *Upper Front* in such

Fig. 81

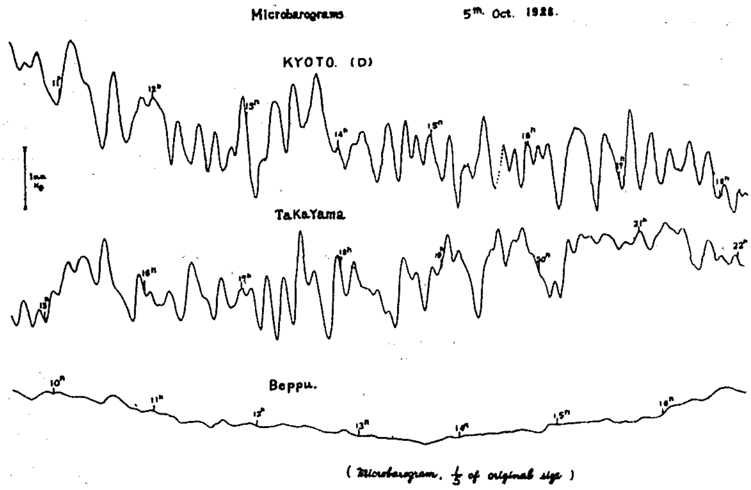
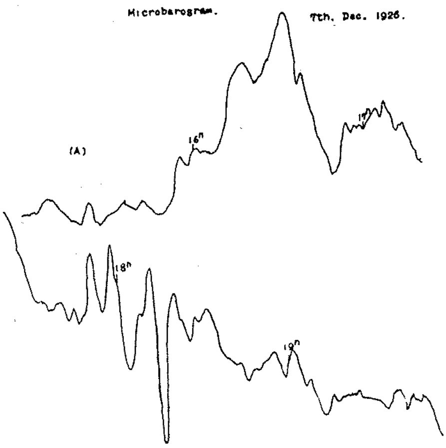


Fig. 83

(Microbarogram ; 1/3 of original size)



inland places as Kyôto. The *Upper Front* passes Kyôto at about 16h and the barometric trough at about 18h. As this example shows, the neighbourhood of the trough line of the V-shaped depression is a region of striking pressure disturbance.

Section V

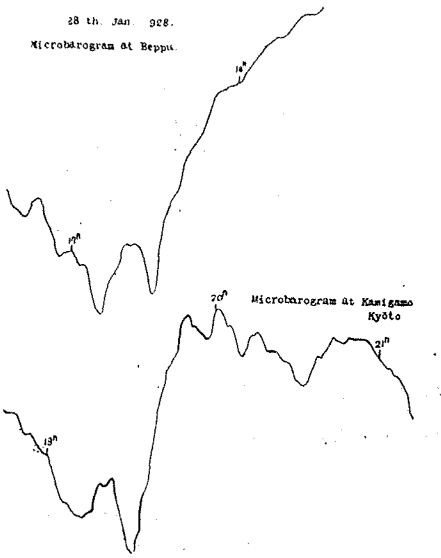
Some Interesting Miscellaneous Examples of the Microbarograms

1. On Two Examples of Fast Moving Disturbances of Atmospheric Pressure (Velocity, ca. 60. m.p.s.)

Shortly after 19h on the 28th Jan., 1928, and also shortly after 9h on the 5th Feb. in the same year, the microbarograph recorded remarkable pressure disturbances at Kyôto. (Cf. Fig. 85, and Fig. 87).

Fig. 85

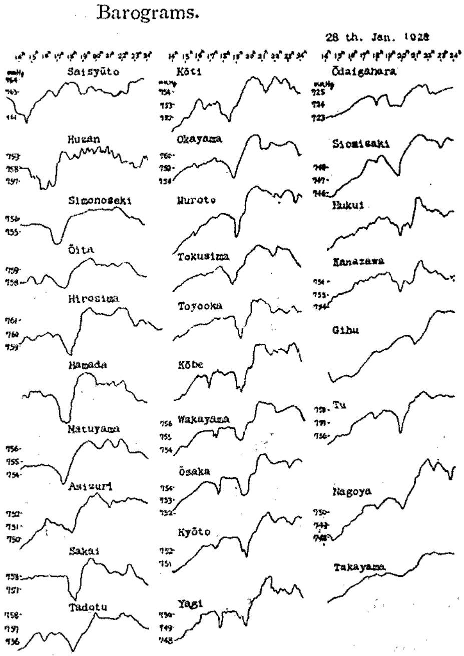
(Microbarogram : $\frac{1}{3}$ of original size)



The records of these disturbances, taken at various other stations, have been collected and put in due order in Fig. 86, and Fig. 88. These traces of baromometric pressure are roughly of the same form, though there are slight differences. To ascertain the state of propagation, an isochronous chart is drawn by linking together the phase times of the minor barometric trough in the front of the sudden rise of barometric pressure. The time records of the self-recording barographs must be correct approximately, but absolute accuracy cannot be expected, so that the curves of the front on the isochronous chart, have been obtained by smoothing down a little what resulted originally from actual records. At any rate, the velocity thus found is, on the 28th Jan., 66m/s from W to E, and, on the 5th Feb., 63m/s from WNW to ESE. Both of these velocities, which are almost equal, moved 2° of longitude in an hour, their direction being roughly from W to E. The pressure disturbance at the time can also be seen from the distribution of pressure on the weather chart. The peak and valley of the pressure disturbance

Fig. 86

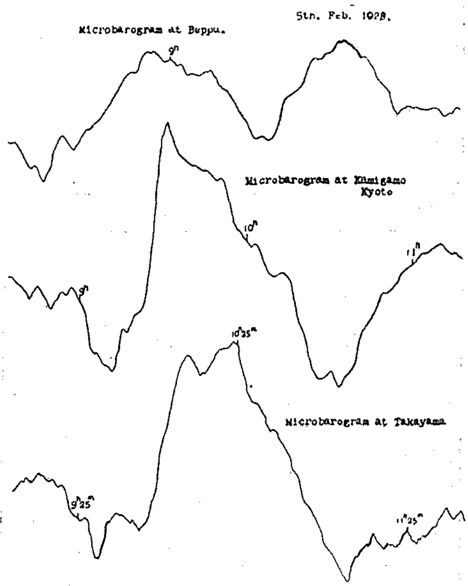
Barograms.



are situated as high and low pressures at points with a proportional distance between them. The problem gets clearer, when, as in Fig. 89, this disturbance and the general field of pressure are considered apart.

Fig. 87

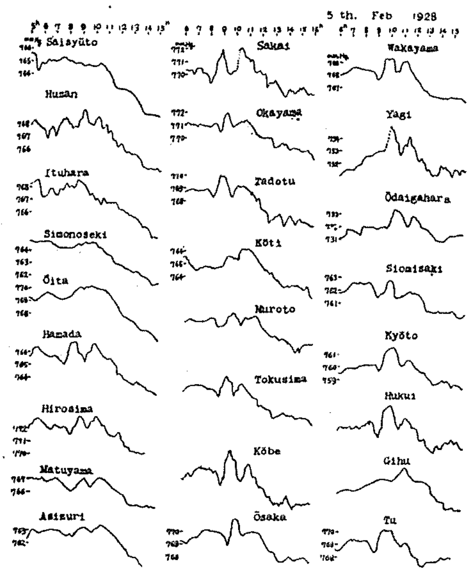
(Microbarogram ; $\frac{1}{3}$ of original size)



As the time of this disturbance, no striking fluctuations of meteorological elements are apparently observed; quite contrary to expectation, there is no change of wind-record. In the case of a rapidly propagating disturbance as in this example, however, it

Fig. 88

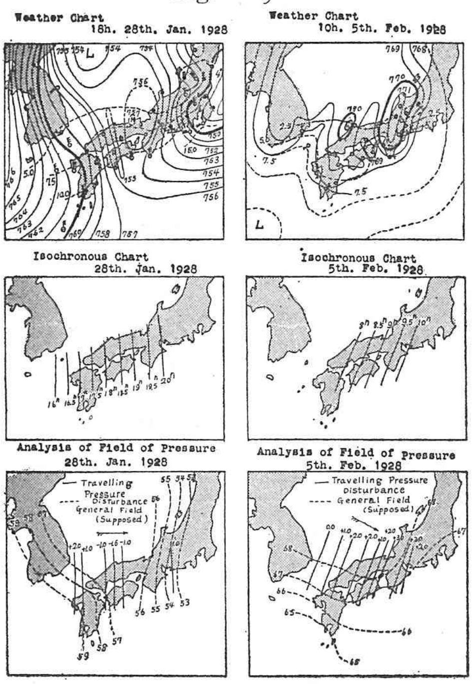
Barograms.



need not be deemed necessary that, the horizontal gradient of pressure $\frac{\partial p}{\partial x}$ should be great, even when the time rate of pressure change $\frac{\partial p}{\partial t}$ is large. Besides, if the influence of the friction near the surface of the earth is taken into consideration, the apparent scarcity of wind change is not surprising, though it must be accepted that the wind change is a little too scarce.

Now, the questions set before us are the cause of such a pressure disturbance and its velocity of propagation. It is impossible to guess the cause only from observations on the surface of the earth. The question of

Fig. 89



velocity seems to be equally difficult. The velocity of a cyclone or a squall is generally under 30m/s, and very rarely, if ever, reaches 60m/s. The present writer has never received a report of a pressure disturbance with a velocity of 60m/s. His attempt to solve this problem by applying some of the existing theories concerning the velocity of propagation of pressure disturbances has been fruitless. If, for example, in $V(\mathrm{m/s})=9.6\sqrt{P(\mathrm{mm.\ Hg.})}$, $\Delta P=4$mm. Hg. we get 20 m/s, which differs greatly from 60 m/s. Again, in Bjerkness' formula, $C=1.69\sqrt{(\theta'-\theta)(100-P)}$, $\theta-\theta'$ is the value of the temperature spring on the discontinuous surface, and P is the value of the pressure there. This equation is to be regarded as a special case of the present writer's internal wave theory propounded in Part I. Of course, this equation applies when both strata are at rest, and a convective term must be added when they are in motion. Its value is not definite, and is 10 m/s at most. Thus in the above equation, if we take C=50m/s, we shall get a temperature gap of about 20°C for a height of the discontinuous layer of about 5 Km.; about 15°C for 7 Km.; and about 10°C for 10 Km. according to the table in his paper. If the height of the discontinuous layer is about 7 Km. with a temperature gap of 15°C., the overturn of the cold and warm air with the depth of 400 m. produces the pressure change of 2 mm. Hg. This is easier to explain. It is very doubtful, however, whether such a structure is really possible in so high a layer.

The following bold inference may here be propounded. In the first instance, the disturbance occurs at 19.5 h on the 28th Jan., and, in the second, at 9.1 h on the 5th Feb., the interval being 181.6 hours. The former travels a distance covering about 2° longitude in an hour, approximately along the latitude circle. Therefore, if it goes round the earth at this speed, we have $2^\circ \times 181.6 = 363.2^\circ$ which is very near to 360°. This may be a mere coincidence, but too remarkable a coincidence to be lightly dismissed. From the physical point of view alone, it is a great strain on the imagination to think of an internal wave making its appearance after having travelled round the earth in more than a week. Whether this is fact or fiction could be quickly decided, if barograms were collected from all over the world and examined, though some difficulty may be experienced in such a procedure. The writer, therefore, cordially requests meteorologists who have chanced to read this paper to examine their barograms for any helpful information on this point and send their records of corresponding waves, if any such be found to exist.

2. Recurring Minor Squalls in the Basin of Kyôto

In late autumn and early winter, after the passage of a continental cyclone, when a north-westerly gale blows in the Kyôto Basin, several minor squalls are, not infrequently, experienced in succession. On such an occasion, a short rain or snow is immediately followed by a blue sky, which instantly gives way again to rain or snow. When this quick alternation has been repeated several times, the observer is apt to be bewildered. Such a phenomenon is called by the native inhabitants "*Kyôshigure*." Of course, there may be many more causes of "*Kyôshigure*" but that above mentioned is, without doubt, one of the causes. W. N. Shaw has also given his opinion on this kind of quickly recurring squalls.* Typical examples may be given to begin with.

Ex. Pressure disturbance of the 20th Feb., 1928. Fig. 90 shows minor squalls experienced at intervals of about one hour. From the meteorograms in Fig. 91, the following characteristics are obtained :—

Temp :	min. →	increase →	max. →	decrease →	min. →	……
Humidity :	max. →	decrease →	min. →	increase →	max. →	……
Weather :	………	fair …………………		rain ………………		fair…
Wind Vel. :	max. →	decrease →	min. →	increase →	max. →	……
Pressure :	max. →	decrease →	min. →	increase →	max. →	……

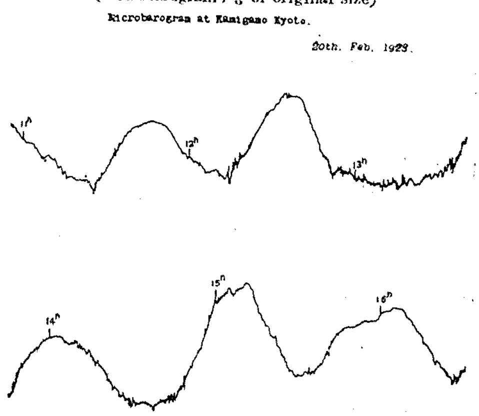
These characteristics are the same as those found when ordinary squalls are passing. The meteorograms recorded at various places in the Kyôto Basin and the vertical distribution of potential temperature is shown in Fig. 91. Concerning the mechanism of this phenomenon, the following consideration seems reasonable to present writer.

* Manual of Meteorology. Vol. III. P. 27.

Although the pressure change is wave-like, it cannot be ascrided to the atmospheric waves. It is much more reasonable to regard it as a phase of convection. There is a surface current in the lower layer in the basin, when the cold north-westerly wind blows in the upper layer, the boundary between them being supposed to be 100–150m. high. The surface layer gets warmed by solar radiation during daytime, and rises in temperature along with the rise of the ground temperature. Even when the surface layer below has got warmed and is in a unstable state, it remains unbroken, up to a certain limit. Once that limit is reached, an overturn of the strata occurs. Then the upper cold

Fig. 90

(Microbarogram ; $\frac{1}{3}$ of original size)



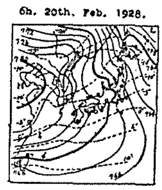


Fig. 92

Fig. 91

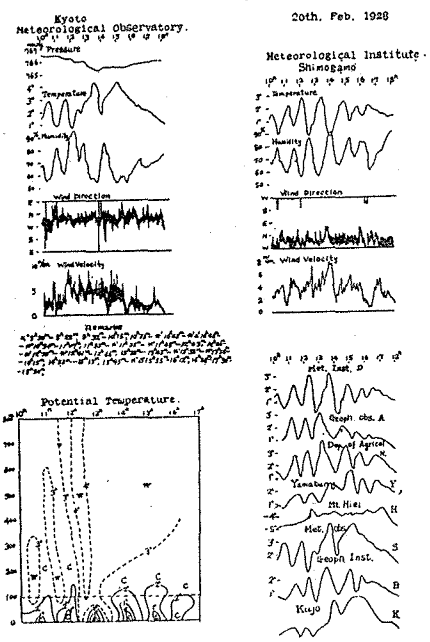
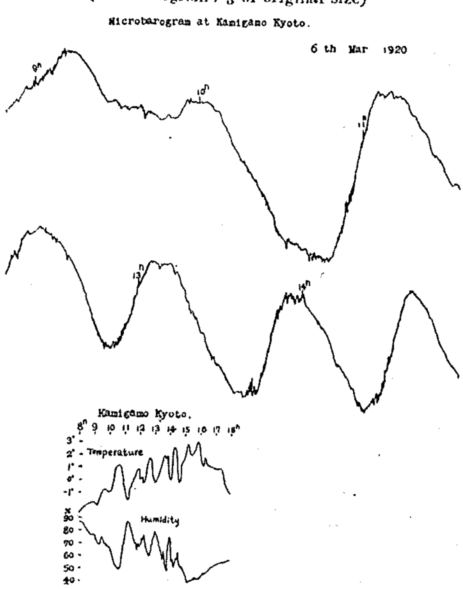


Fig. 93

(Microbarogram ; $\frac{1}{3}$ of original size)



current descends to the surface of the earth; and the warm lower air rises. This is accompanied by an increase of wind velocity and pressure, a sudden fall of air temperature, and rain or snow. After the sudden commotion, everything returns to the former state of quiscence, and, once more, the surface layer begins to get warmed from below, the commencement of the repetition of this phenomenon. While the surface layer is getting warmed, the weather is fine, and a blue sky appears from time to time. The writer believes that, in this way, the records can be explained. What is noteworthy in this example is, that, though the periodic change of air temperature distinctly appears in the Kyôto Basin, it is not recorded on Mt. Hiei.

Another remarkable example occurring on the 6th Mar., 1920 is shown in Fig. 93. Similar phenomena, though not so striking as this, have been observed from time to time. Those recorded in 1928 are listed in Table 14.

Table 14

1928

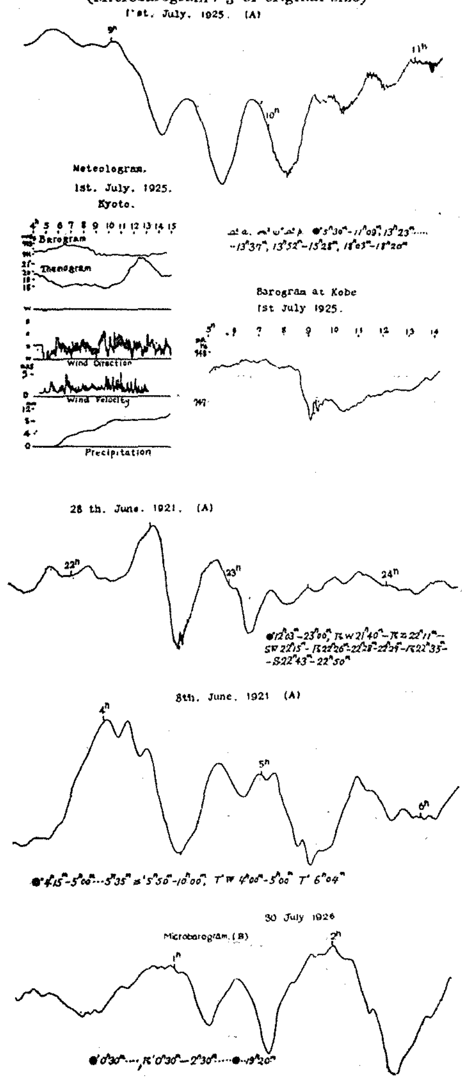
Month	Day	Duration	No.	Remark-able Period	Weather	Wind Direction	Weather Type
Jan.	7	12^h-18^h	5	60^{min}	S	NW	NW-ly
,,	20	10–16	5	30	S	N	NW-ly
* Feb.	1	8–16	8	60	S	N-NW	NW-ly
* ,,	7	10–16	6	60	R	W-N	NW-ly
,,	18	12–14	4	30	S	W-NW	NW-ly
,,	20	10–16	6	30	S	W-NW	NW-ly
Mar.	11	10–16	7	60	S	W-NW	NW-ly
,,	13	10–16	6	70		NW-N	NW-ly
,,	14	12–16	4	60		NW-NNW	NW-ly
Apr.	7	8–16	6	70	R	NE-N	Anticyclone
,,	23	10–15	5	40	R	W-NW	NW-ly
* Oct.	31	8–16	8	50	R	N-NE	NW-ly
Nov.	3	10–16	3	120	R	W-N	NW-ly
* ,,	10	8–14	8	40	R	N	NW-ly
* ,,	12	10–14	6	40	R	NW-NNE	NW-ly
,,	17	10–17	5	70	R	NNE-NW	NW-ly
,,	30	10–14	4	50	R	N-NW	NW-ly
* Dec.	10	9–14	6	40	R	N	NW-ly
,,	25	10–14	5	40	R	N	NW-ly
,,	29	10–14	3	120	R	N	NW-ly

S: Snow. R: Rain. * denotes a regular type.

3. Examples of Wave-like Pressure Changes with Longer Periods

In the first section of this Part, wave-like pressure changes with periods not longer than 20 min. are principally treated. Barometric oscillations much longer than these of course exist. Our instrument, however, being used for a different object, requires adjustment for waves with such long periods.* At any rate, it sometimes records striking pressure disturbances of great amplitude. These records may, on the whole, be regarded as true to the facts, and a few examples will be given below.

Fig. 94a, b, c, d
(Microbarogram; $\frac{1}{3}$ of original size)



Ex. 1. *9–11 h, 1st July, 1925.* (*Fig. 94a*) This accompanied a cyclonic trough. A very remarkable barometric oscillation with a period of about 25 min..

Ex. 2. *22–24 h, 28th June, 1921.* (*Fig. 94b.*) *Ex. 3.* *4–6 h, 8th June, 1921.* (*Fig. 94c.*) Both are pressure disturbances which occurred during night thunderstorms. They left on record a changing oscillation, with a period of about 25 min. in Ex. 2, and about 50 min. in Ex. 3.

Ex. 4. *1–3h, 30th June, 1926.* (*Fig. 94d.*) This is, again, an instance of a pressure disturbance during a night thunderstorm. Its period and am-

* To be discussed in the last part.

plitude increase with the lapse of time. This increase has already been touched upon in the discussion of local showers.

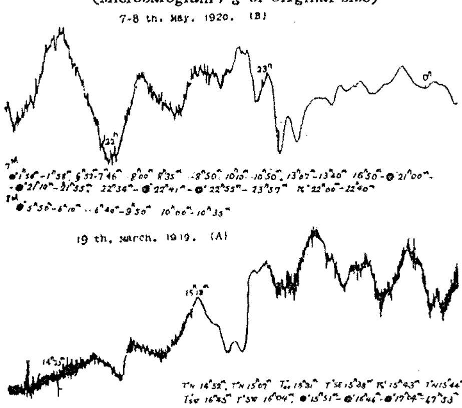
All four of the above examples must have occurred in an upper layer, and all must have been pressure disturbances near an "Upper Front." The last example in particular must have been due to an overturn of the strata. Its mechanism is not yet clear to the writer, but, when fully investigated, it will be a great help to meteorologists who attempt to solve the structure of these disturbances.

4. Examples of Remarkable Pressure Disturbances Accompanied by a Sudden Change of Wind Vector

Ex. 1. 23 h 7th May, 1920. In Fig. 95 (a) the wind is fairly strong till about 22.5 h.. (Small rapid fluctuations on the record of the micro-barograph indicate that there was a fairly strong wind.) Shortly after 22h, there is a sudden drop of wind, and the pressure disturbance occurs as shown in the figure, and accompanied by a thunderstorm. Along the boundary of two currents, striking pressure disturbances are often recorded, as this example shows.

Fig. 95 a, b

(Microbarogram ; $\frac{1}{3}$ of oirginal size)



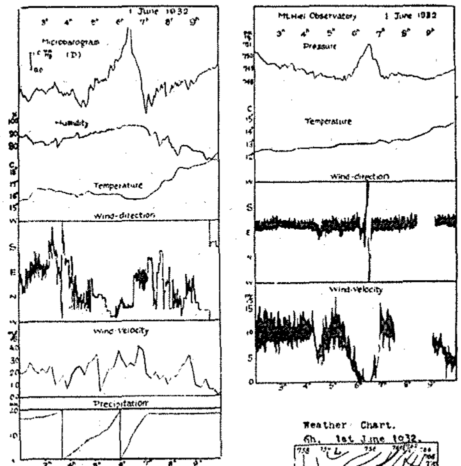
Ex. 2. 15 $\frac{1}{2}$h, 19th March, 1919. In Fig. 95 (b) the speed of the wind suddenly decreases after 15h, a pressure disturbance occurring at the same time. This indicates that the centre of a secondary cyclone passed Kyôto, and that, in its centre, there was a small calm area, like the eye of a typhoon, with associated pressure disturbances. Thunder was heard at about 15h, but rain did not begin to fall till about 16 h.

Ex. 3. 6 h, 1st June, 1932. Fig. 96 (a) is a record taken at Kyôto. In this figure, at about 6$\frac{1}{2}$ h, the pressure rises about 3 mm. Hg. The wind presents no noteworthy feature at Kyôto; but on Mt. Hiei, a striking change in the character of the wind is observed, together with a pressure disturbance. (Fig. 96 b.) To be precise, while the pressure is maximum, the wind is neary calm, but it blows before and after this disturbance at a speed of about 10 m/s. This remarkable change in the speed of the wind is observed likewise on Mt. Ibuki.

From these facts, is inferred that the sudden pressure rise is in some way related to the sudden change in the wind speed. This is one of the questions the present writer is trying to solve.

Fig. 96

(a) (b)



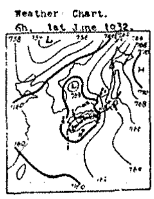


Fig. 97.