On the Constancy of the Frequency of some Temperature and Air Pressure Waves.

by

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This paper deals with the widely studied atmospheric wave problem by examining the frequency of rhythms in the annual course of air temperature and pressure in Helsinki.

The material covers the observations on air temperature and pressure during the 30 year period 1922—51. The meteorological elements used were the average values for five days, i.e. the pentads. The relative extremes were determined from the annual curves for air temperature and pressure thus smoothed. Tables I and II give the appearance of the relative maxima [↑] and minima [↓]. The meteorological year was taken as the period from the beginning of October to the end of September.

Examination of the frequency of relative extremes during different years and their distribution between winter and summer shows that the variations in frequency, especially during the winter, are fairly slight. With the aid of Table 1, which gives the average frequencies [f] of the relative extremes for temperature and pressure, and their deviations [σ], we can see that the frequency of the extremes is almost constant, especially for winter temperature. The table shows that an average of 19 rhythms appear in the annual temperature course in Helsinki, about 11 of them during October—April and about 8 during May—September. In the annual course of air pressure we find additional 2 rhythms, i.e. a total of approx. 21. According to these tables the mean duration of a tempera-

ture rhythm is roughly 19 days, that of a pressure rhythm 17 days. J. BJERKNES has computed the time of a complete polar circulation as 22 days and L. WEICKMANN has proved that a polar pressure wave covers 24 days.

Table 1.

Average frequencies [f] and standard deviations [σ] of the relative maxima and minima for air temperature and pressure in Helsinki. Years 1922—51.

Months	Temperature				Pressure			
	Rel. max.		Rel. min.		Rel. max.		Rel. min.	
	f	σ	f	σ	f	σ	f	σ
Oct.—Apr.	11.1	1.0	11.4	1.1	12.0	1.4	12.1	1.2
May—Sept.	8.0	1.3	7.6	1.3	8.9	1.2	8.7	1.2
Oct.—Sept.	19.1	1.6	19.1	1.6	20.9	1.6	20.8	1.5

The above result based on the observations in Helsinki represents general conditions for a larger region. The yearly number of temperature rhythms determined by the same method for Gothenburg is also 19, and for Lapland, Karesuando, 20 (Years 1922—43).

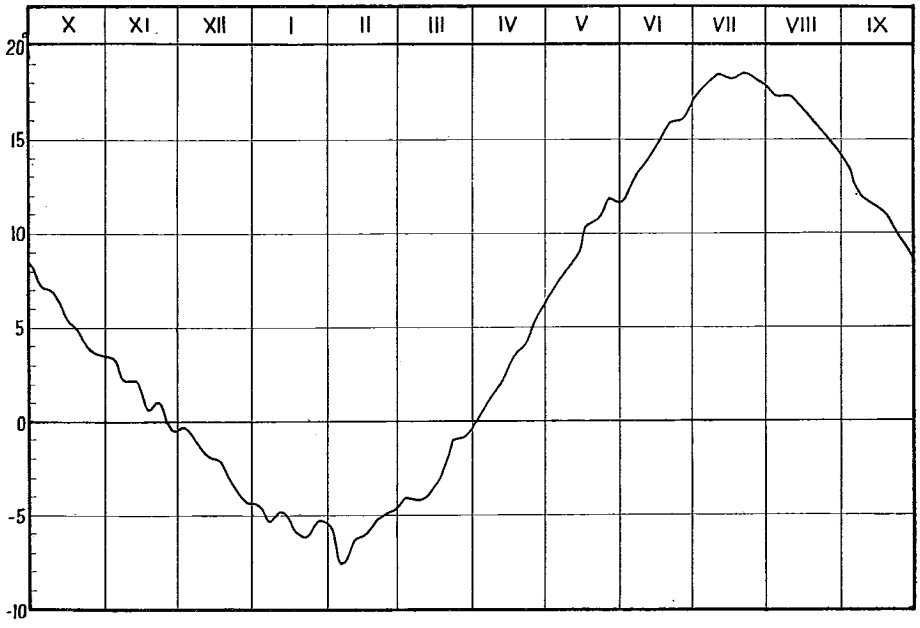

Figure 1. The annual air temperature course at Helsinki calculated from pentad means. Years 1922—51.

According to Tables I and II the duration of the rhythms varies considerably and no uniformity att all can be noted in their recurrence. From the shortest possible lenght arrived at by the levelling method, namely 10 days, the duration of the temperature rhythms may grow to 55 days.

The curve for the average annual course of air temperature, drawn on the basis of mean pentad values and thus considerably smoothed, shows distinct rhythms, especially during winter (Fig. 1). These singularities appear still more distinctly in Figure 3, which gives the average distrib-

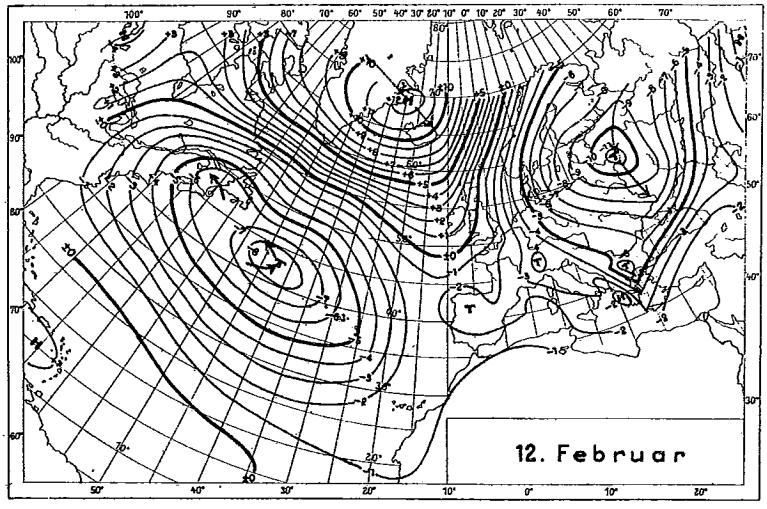

Figure 2. Distribution of average pressure variations on 12 February after W. Lay Years 1890—1909.

ution of relative extremes of temperature and pressure between different pentads (Tables I and II). The existence of these singularities may be proved by studying the average annual course of general weather conditions. According to W. LAY's maps of the average distribution of air pressure, the major part of the singularities found may be explained synoptically. Without going into this question in greater detalis here it may, however, be mentioned that for instance the breaking-in of cold air during the second pentad in February, which on an average causes the lowest winter temperature, depends on a singular pressure decrease in Russia whilst the high pressure increases simultaneously in Greenland (Fig. 2). The temperature decrease generally noted in the middle of March is probably the consequence of heat out-radiation by night during this time in connexion with

anti-cyclonal weather. The variations in air pressure during this period are slight and the fourth pentad in March seems to form a point of symmetry, as can be seen on the curves for pressure variations (Fig. 3).

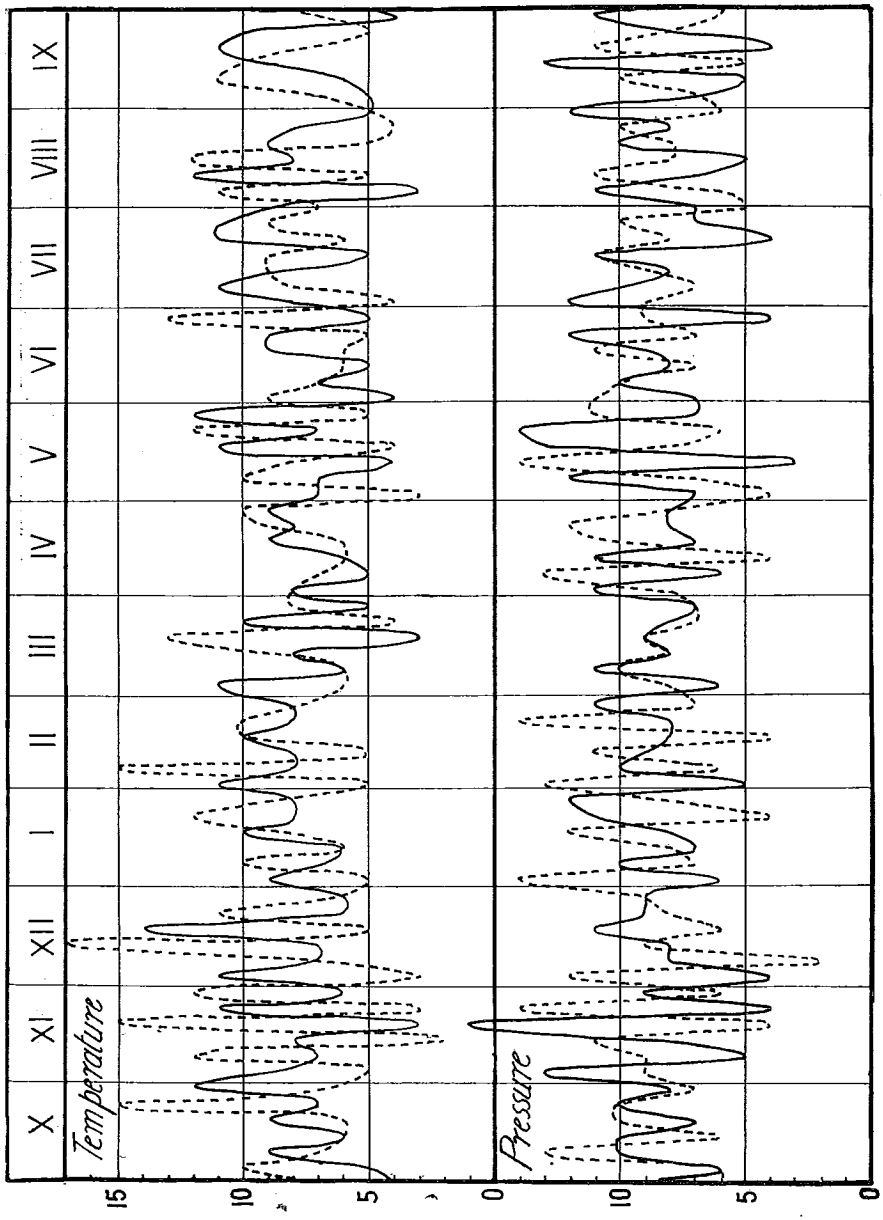

Figure 3. Frequency distribution of relative extremes for temperature and pressure in Helsinki calculated from pentad means. Years 1922—51. Full line: relative maximum, broken line relative minimum.

The constancy of the frequency of temperature rhythms especially in winter also appears from Figure 4, which gives the deviations of mean pentad values for the 10 coldest and 10 mildest winters from the 30 year average under consideration. The grouping in cold and mild winters was based on the mean temperature for the period December-March. The figure has been extended to cover the time from August to May. In the group of cold winters we have during October-April an average of 12 relative minima, in the group of mild winters 10. The same figure shows, moreover, the dissimilarity in the general temperature course in cold winters on the one hand and mild winters on the other. Cold winters are

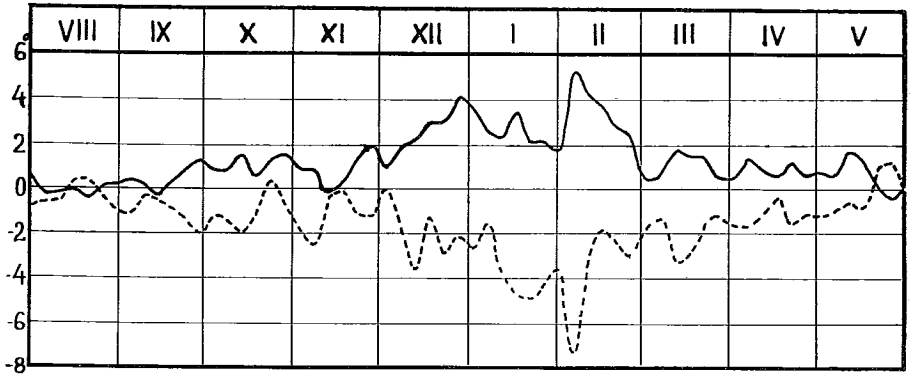

Figure 4. The average deviation of temperature from the normal during »mild» and »cold» winters in Helsinki. Full line mild winter, broken line cold winter.

preceded from the end of August by a temperature lower than normal, and October is quite cold. In November, on the contrary, when cyclonal activity is lively, the difference between cold and mild winters is slight. Later on the dissimilarity increases once more, reaches its maximum in February and decreases again considerably in March. Generally March is the coldest month in so-called mild winters. It is at the end of May that the difference between cold and mild winters first disappears.

The dissimilarity between cold and mild winters can also be seen from the following brief table, which shows the monthly distribution of the frequency of relative minima for air temperature during the 10 cold and 10 mild winters examined above.

	A	S	O	N	D	J	F	M	A	M
Cold winters	14	17	17	17	14	19	17	10	16	13
Mild winters	19	15	16	18	16	13	19	18	14	14

Table I. The distribution of

Year	Oct.						Nov.						Dec.						Jan.						Feb			
	5	10	15	20	25	30	4	9	14	19	24	29	4	9	14	19	24	29	3	8	13	18	23	28	2	7	12	1
1921/22	↓		↑	↓	↑		↓	↑	↓	↑	↓		↑	↓	↑		↓	↑				↓		↑	↓		↑	
1922/23	↓	↑		↓				↑	↓	↑	↓		↑	↓	↑	↓			↑			↓	↑		↓	↑		
1923/24			↓	↑	↓		↑	↓	↑			↓			↑		↓				↑		↓		↑	↓		
1924/25	↑			↓	↑			↓			↑		↓	↑	↓	↑	↓	↑		↓		↑		↓			↑	
1925/26			↓		↑			↓	↑			↓		↑	↓				↑	↓			↑	↓	↑	↓		
1926/27	↓	↑			↓			↑				↓		↑		↓	↑	↓		↑	↓	↑	↓	↑		↓	↑	
1927/28			↓	↑	↓	↑			↓			↑			↓	↑	↓			↑	↓			↑	↓	↑		
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1929/30	↓	↑		↓	↑		↓	↑		↓	↑	↓		↑			↓			↑						↓		
1930/31	↓			↑		↓	↑			↓			↑		↓	↑				↓	↑		↓	↑		↓		
1931/32		↑			↓		↑						↓	↑	↓		↑	↓				↑	↓	↑		↓		
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1938/39	↑				↓	↑		↓	↑	↓	↑						↓		↑	↓			↑	↓		↑	↓	
1939/40	↓		↑	↓	↑		↓	↑			↓	↑		↓	↑		↓	↑	↓		↑	↓		↑		↓		
1940/41		↑			↓	↑		↓			↑	↓	↑		↓	↑			↓	↑			↓		↑	↓	↑	
1941/42			↓	↑		↓	↑		↓			↑			↓	↑		↓	↑		↓	↑	↓				↑	
1942/43				↓		↑		↓	↑			↓			↑	↓	↑			↓		↑	↓		↑	↓	↑	
1943/44		↓		↑	↓	↑		↓	↑	↓	↑			↓			↑		↓	↑	↓		↑					
1944/45		↓	↑			↓	↑			↓			↑			↓		↑						↓			↑	
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1950/51	↓	↑			↓	↑		↓	↑	↓	↑	↓	↑	↓	↑			↓	↑	↓		↑	↓			↑		
Σ ↑	5	9	6	9	7	12	9	7	8	3	11	6	11	7	7	14	6	6	9	7	6	10	8	8	11	8	8	
Σ ↓	10	7	6	6	15	7	5	12	2	15	3	12	3	7	17	5	11	7	5	10	6	8	12	9	5	15	5	

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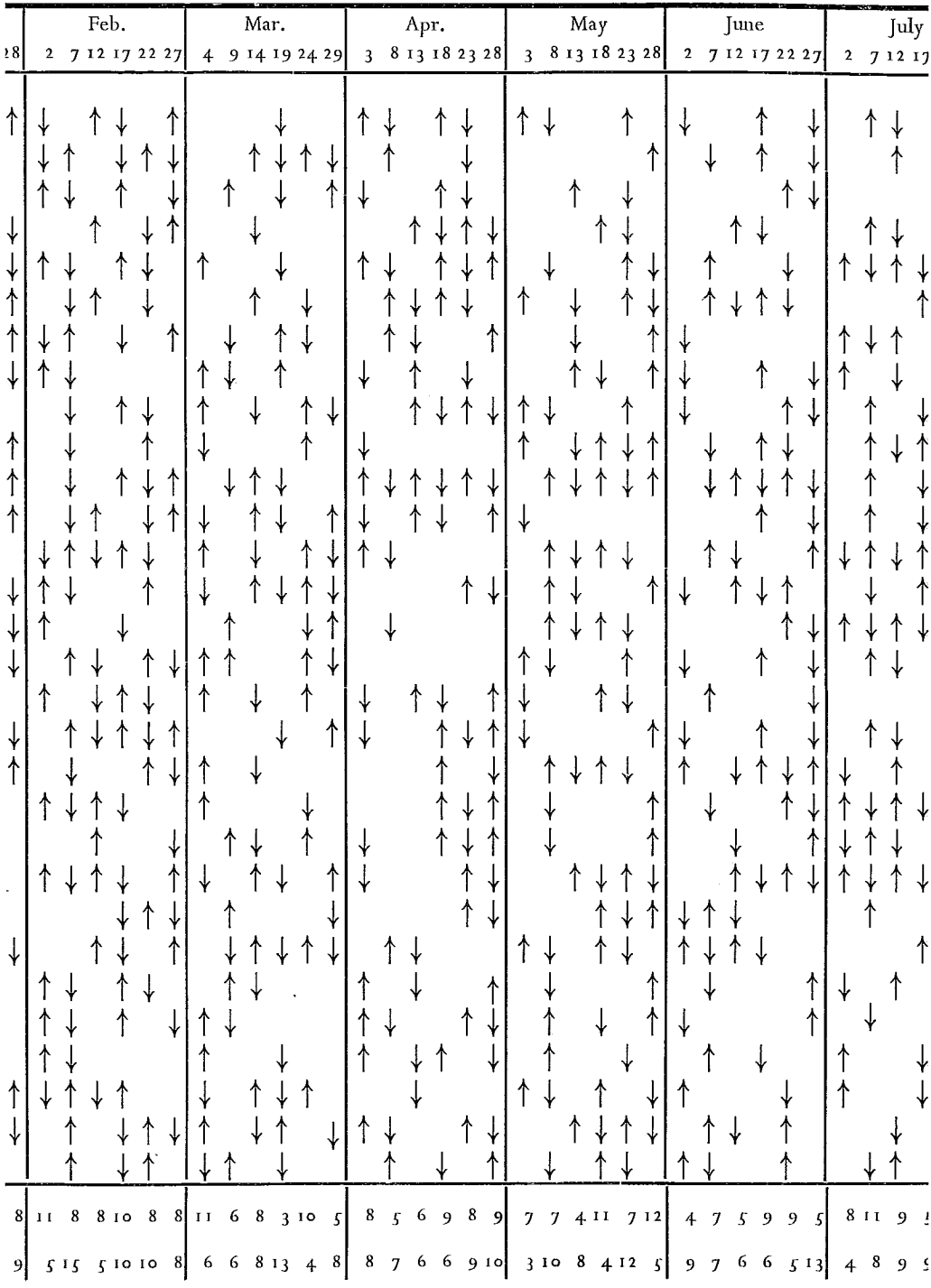

:cording to pentad means in Helsinki.

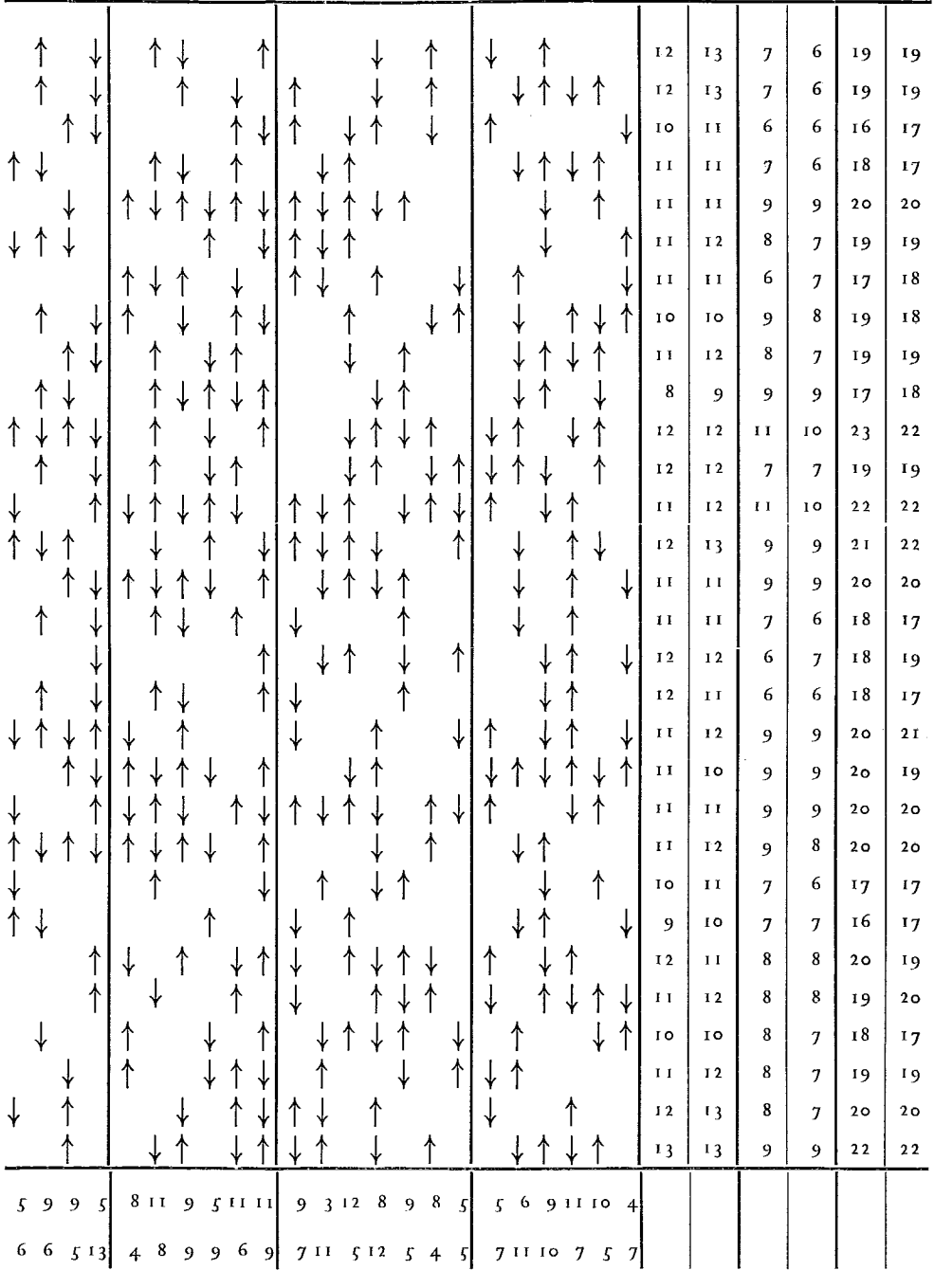

Table II. The distribution

Year	Oct.						Nov.						Dec.						Jan.						Feb		
	5	10	15	20	25	30	4	9	14	19	24	29	4	9	14	19	24	29	3	8	13	18	23	28	2	7	12
1921/22		↑		↓	↑		↓			↑			↓		↑	↓	↑		↓				↑		↓	↑	
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1923/24	↑	↓		↑	↓	↑	↓	↑	↓					↑		↓				↑		↓	↑		↓		↑
1924/25			↑	↓	↑		↓		↑		↓			↑		↓	↑		↓				↑		↓		
1925/26	↓	↑	↓			↑		↓	↑		↓			↑				↓			↑		↓			↑	
1926/27		↓			↑	↓	↑			↓		↑			↓		↑	↓				↑		↓			↑
1927/28	↓	↑		↓	↑	↓	↑	↓		↑		↓	↑		↓	↑	↓	↑			↓	↑		↓	↑		↓
1928/29	↑	↓	↑			↓	↑		↓	↑	↓		↑	↓		↑		↓		↑	↓			↑	↓			
1929/30		↓		↑	↓		↑		↓		↑	↓	↑		↓		↑		↓			↑		↓		↑	↓
1930/31		↓		↑			↓	↑	↓	↑	↓				↑		↓	↑	↓	↑		↓	↑	↓	↑		↓
1931/32	↓		↑	↓						↑	↓	↑			↓	↑		↓	↑	↓			↑		↓	↑	
1932/33		↑			↓				↑		↓	↑	↓		↑	↓	↑	↓	↑	↓	↑	↓	↑		↓	↑	↓
1933/34	↓			↑				↓		↑	↓	↑			↓	↑	↓	↑		↓	↑	↓	↑	↓	↑	↓	↑
1934/35			↓		↑	↓	↑	↓		↑		↓		↑	↓			↑	↓	↑	↓	↑	↓	↑	↓	↑	
1935/36		↓	↑	↓	↑	↓	↑	↓		↑			↓		↑		↓	↑	↓	↑	↓	↑	↓	↑	↓	↑	↓
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1940/41	↑	↓	↑		↓	↑	↓	↑	↓	↑	↓	↑	↓			↑		↓	↑		↓			↑			↓
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1942/43		↓		↑	↓			↑		↓	↑	↓					↑		↓		↑	↓	↑				↓
1943/44	↓		↑		↓		↑		↓	↑	↓				↑	↓	↑			↓		↑	↓	↑	↓		
1944/45			↑	↓	↑		↓		↑		↓	↑	↓			↑			↓		↑	↓		↑	↓	↑	↓
1945/46		↓		↑	↓		↑	↓	↑			↓	↑		↓		↑	↓	↑	↓			↑		↓		↑
1946/47	↑		↓		↑	↓	↑		↓	↑	↓	↑	↓		↑		↓		↑			↓		↑		↓	↑
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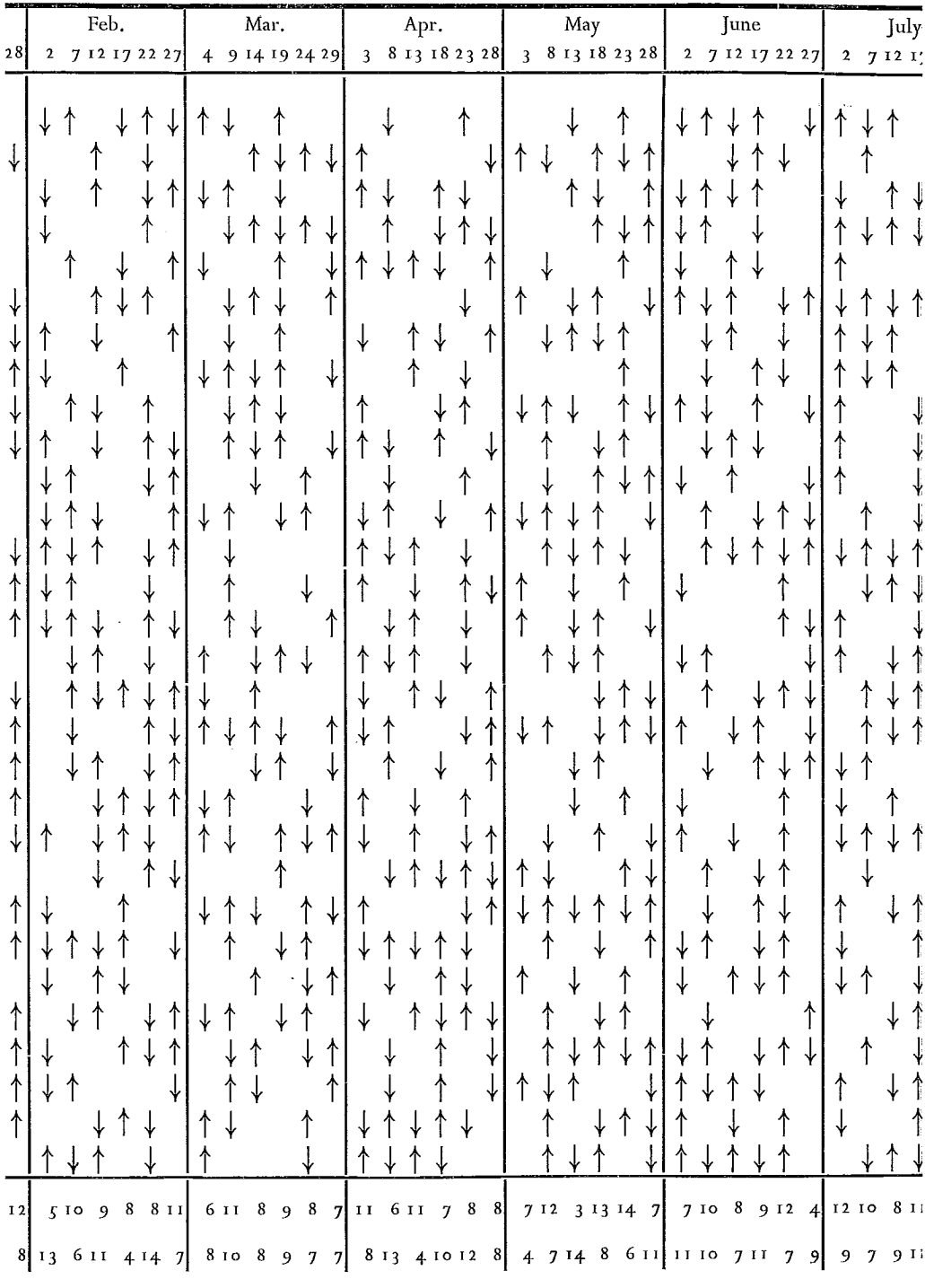
1950/51	↑	↓	↑	↓		↑			↓	↑			↓	↑	↓	↑						↓			↑	↓	↑
Σ ↑	7	10	10	7	10	8	13	5	8	16	4	9	4	8	8	11	9	9	6	10	7	8	11	12	5	10	9
Σ ↓	8	13	6	10	10	7	9	9	11	4	14	6	12	2	9	6	8	9	14	7	8	12	4	8	13	6	11

Distribution of relative maxima and minima of the air pressure, according to pentad



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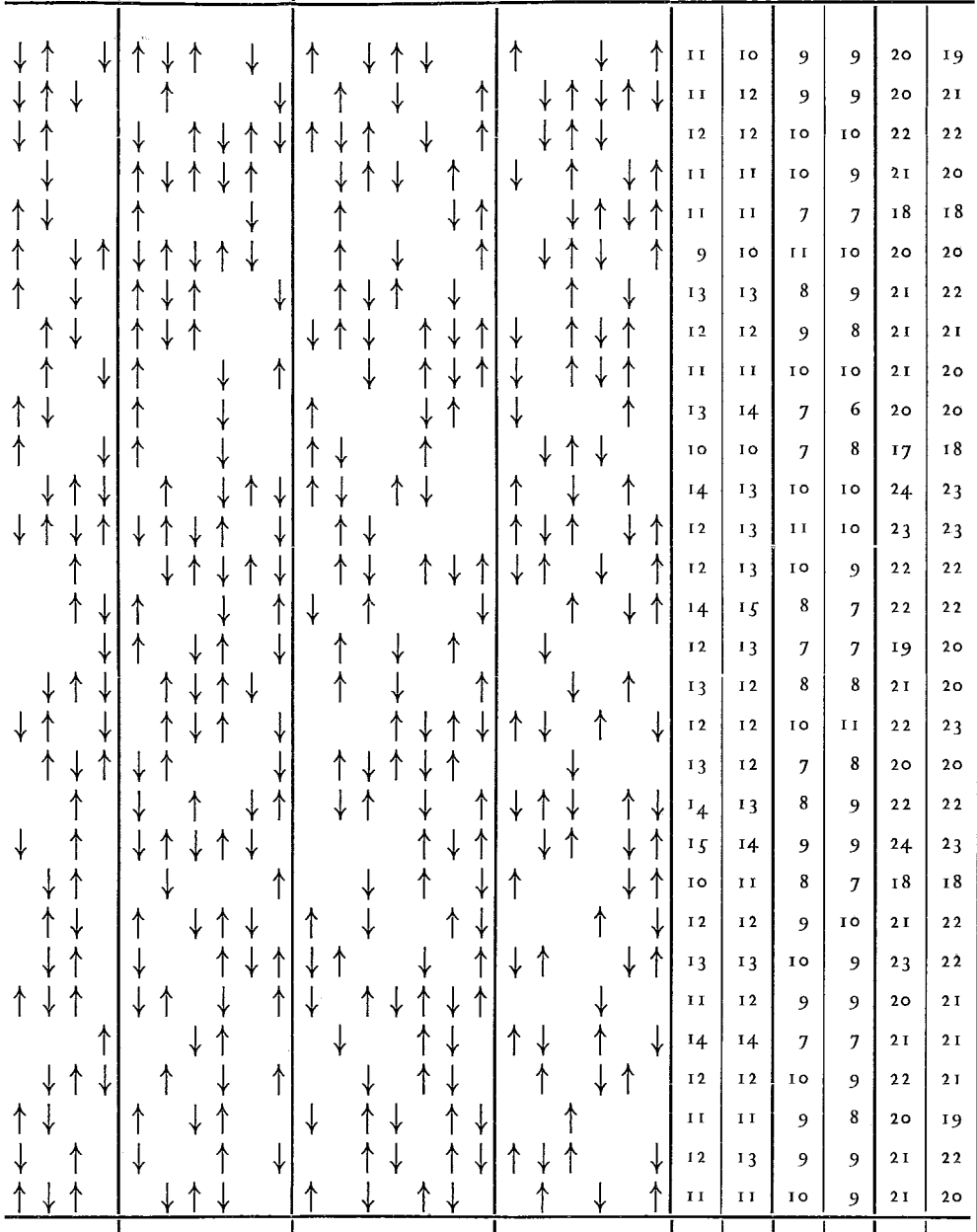

The frequency figures show for the two groups a phase difference of about one month. A mild winter begins later than a cold winter and its middle part is therefore shorter than that of a cold winter.

The above mentioned constancy of the frequency of the temperature rhythms could be utilised to some degree im working out a long-term forecast for a winter. By following the frequency of the rhythms from a given time, for instance from the beginning of October, we may in the course of the winter determine how many rhythms remain for a definite time, for instance, until the end of April.

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