maximum of but 60° F. This evidently represents the type of thermogram which must be obtained during the transition to an "occlusion," when the warm sector is on the point of disappearing from the surface. The sharp maximum in the Baltimore thermogram is entirely absent from the Washington record obtained less than 40 miles away, but on the other side of the track, while the other portions of the curve are very similar at both places.

The longest duration of the "warm sector" is to be found on the two stations Block Island (4 a. m.–2 p. m.) and Nantucket (4 a. m.–6 p. m.). Although situated not more than 80 miles apart, these two stations have rather different thermograms during the time the warm sector passes. This may, however, be accounted for when considering the local conditions at both stations. Whereas the station at Block Island is situated on a very small island, Nantucket lies on a larger one, and—what is in this case of special importance—on the northwestern side of the island.

As we have already mentioned, the warm sector current from the southeast contained a shallow fog layer produced by the cooling in contact with the cold coastal waters. This fog must dissolve again when arriving over land, especially if the higher cloud layers break up so as to expose the fog layer to direct insolation. This is the phenomenon which we may observe on Block Island and Nantucket. At the latter place, where the air has passed over land surface before reaching the station, the fog vanishes shortly after sunrise, and the temperature rises, under the influence of insolation, to 68° F. At the former, the fog does not dissolve until some two or three hours after sunrise, and the structure of the curve—rapid small temperature fluctuations—is a sign of alternate heating by the sun and cooling as new fog patches drift over. It is not until the last half of the warm sector that the fog disappears perfectly, unveiling the almost cloudless sky, which was characteristic of the tropical current on the first maps considered. (Figs. 1 and 2.)

The cold front leaves a very marked trace on the thermograms (Block Island 2 p. m. and Nantucket 6.30 p. m.). The arriving cold wedge has apparently a rather gentle slope as it is not until some time after the cold front passage at the ground that the warm air has been lifted sufficiently to give precipitation. Once started, however, the rain lasts rather long.

Boston, Hartford, New Haven, and New York provide good examples of thermograms with the passage of a "warm sector," the maximum temperatures reaching (partly assisted by the diurnal effects) 70° F., 68° F., 67° F., and 65° F., respectively. Portland represents the same type with, however, a markedly depreciated warm sector temperature on account of the fog. Harrisburg represents the type of thermogram to be expected at the place where the warm sector air has just been lifted away from the ground, and Pittsburgh (on the western side of the track) shows the presence of rather uniformly cold air during the whole cyclone passage.

The complete mechanism of the depression in all layers, the rules for its growth, propagation, etc., can of course not be analyzed without an additional aerological diagnosis. In the absence of adequate information of this kind we must confine our attention to the conclusions as to the mechanism of our retrograde depression which may be drawn merely from surface observations. The results, which may seem partly hypothetical, receive, however, additional support from their concordance with those of numerous other cases.

The movement of the depression, although surprising when considered in relation to average tracks, appears quite normal when it is seen in relation to its thermal structure. The motion of the center is, at each moment, approximately parallel to the instantaneous direction of the warm current. It is this current which decides the displacement of the extremity of the warm tongue where the lowest pressure is located. The warm current in the present case is originally from almost due south, but later acquires a component from the east, at the time when the depression curves toward the northwest. (See track, fig. 5.)

The depression continues its northwestward propagation also after the warm air has been lifted off the ground, probably governed by the southeast current of a still existing "upper warm sector." This view is also confirmed by the fact that the upper clouds in front of the depression were moving from southeast. From the moment when the warm air nearest the center is lifted away from the ground the depression begins to fill up, being from now deprived of the supply of potential energy—in the form of temperature contrasts—for the maintenance of its kinetic energy. Farther east, where the "warm sector" still exists, potential energy is still available and gives rise to the formation of a secondary depression. The first sign of it is to be seen on Figure 3b in the region of New York, at the extremity of the warm tongue. The formation is more accentuated the next day over northern Massachusetts and reaches finally the stage of an independent center between Montreal and Quebec on the morning of the 25th. This center from now on becomes the main one, and the dying "mother cyclone" over Lake Ontario behaves as a secondary, while they both move off the map toward Labrador.

VARIATION IN SOLAR RADIATION INTENSITIES MEASURED AT THE SURFACE OF THE EARTH

551.52

By HERBERT H. KIMBALL

[Weather Bureau, Washington, Dec. 1924]

This paper brings up to date a communication on the same subject published in 1918.[1] For the years previous to 1901 no additional data are available. Revised data have been obtained for Warsaw, Poland, for the years 1901 to 1918, inclusive. Data have been added from Kew Observatory, England, for the years 1908 to 1921, inclusive, and from Helwan Observatory, Egypt, for the years 1914 to 1923, inclusive. The data for Washington, D. C., Madison, Wis., and Lincoln, Nebr., have been revised and brought down to the end of 1923. That for Santa Fe, N. Mex., ended with March, 1922.

In Table 1 there are given for each station the month and year of the beginning and ending of the record, and reference to a footnote giving the character of the data that have been made use of in this paper. In the previous paper it was noted that some of the records were fragmentary in character. There has been improvement in this respect in the records of later years.

The monthly normals of the solar radiation intensities for Kew Observatory and also for stations in the United

[1] Kimball, Herbert H., Volcanic eruptions and solar radiation intensities. Mo. Weather Rev., August, 1918, 46: 355–356.

States have been obtained by dividing the sum of all the radiation intensities measured in the respective months by the number of measurements. The normal monthly maxima of radiation have also been obtained in this way. All other monthly normals are averages of the monthly means for the respective months.

TABLE 2.—*Duration and character of solar radiation intensity records*

Year	Station													
	Montpellier, France	Pavlovsk, Russia	Lausanne, Switzerland	Warsaw, Poland	Washington, D. C.	Simla, India	Paris, France	Mount Weather, Va.	Kew Observatory, England	Madison, Wis.	Santa Fe, N. Mex.	Helwan Observatory, Egypt	Lincoln, Nebr.	Total number of stations
1882	Dec.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1883	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1884	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1885	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1886	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1887	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1888	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1889	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1890	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1891	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1
1892	x	Sept.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
1893	x	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
1894	x	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
1895	x	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
1896	x	+	Jan.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1897	x	+	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1898	x	+	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1899	x	+	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1900	Dec.	+	x	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1901	-----	+	x	Jan.	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1902	-----	+	x	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1903	-----	+	x	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1904	-----	+	Aug.	+	-----	-----	-----	-----	-----	-----	-----	-----	-----	3
1905	-----	+	-----	+	June.	-----	-----	-----	-----	-----	-----	-----	-----	3
1906	-----	+	-----	+	o	Oct.	-----	-----	-----	-----	-----	-----	-----	4
1907	-----	+	-----	+	o	x	Jan.	Sept.	-----	-----	-----	-----	-----	6
1908	-----	+	-----	+	o	x	+	o	Jan.	-----	-----	-----	-----	7
1909	-----	+	-----	+	o	x	+	o	♯	-----	-----	-----	-----	7
1910	-----	+	-----	+	o	x	+	o	♯	July	-----	-----	-----	8
1911	-----	+	-----	+	Aug.	x	+	o	♯	o	-----	-----	-----	8
1912	-----	+	-----	+	-----	x	+	o	♯	o	Oct.	-----	-----	8
1913	-----	Apr.	-----	+	-----	x	Dec.	o	♯	o	o	-----	-----	8
1914	-----	-----	-----	+	Oct.	x	-----	Sept.	♯	o	o	Feb.	-----	8
1915	-----	-----	-----	+	o	Dec.	-----	-----	♯	o	o	*	July.	8
1916	-----	-----	-----	+	o	-----	-----	-----	♯	o	o	*	o	7
1917	-----	-----	-----	+	o	-----	-----	-----	♯	o	o	*	o	7
1918	-----	-----	-----	Dec.	o	-----	-----	-----	♯	o	o	*	o	7
1919	-----	-----	-----	-----	o	-----	-----	-----	♯	o	o	*	o	6
1920	-----	-----	-----	-----	o	-----	-----	-----	♯	o	o	*	o	6
1921	-----	-----	-----	-----	o	-----	-----	-----	Dce.	o	o	*	o	6
1922	-----	-----	-----	-----	o	-----	-----	-----	-----	o	Mar.	*	o	5
1923	-----	-----	-----	-----	o	-----	-----	-----	-----	o	-----	*	o	4

x Monthly mean of noon solar radiation intensity.
+ Monthly maximum of solar radiation intensity.
o Monthly mean of solar radiation intensity with the sun at zenith distance 60°.
* Monthly mean of solar radiation intensity with the sun at zenith distance 54°.
♯ Average of monthly maximum and monthly mean of noon solar radiation intensity.

The monthly means or the monthly maxima of radiation for the different stations have been expressed as a percentage of their respective normals. Then for each month an average of these percentages has been computed, and smoothed by the formula $\frac{a+2b+c}{4}$, where b is the average percentage for the month in question, and a and c are the average percentages for the preceding and following months, respectively. The smoothed percentages have been plotted in Figure 1.

In the previous paper attention was invited to the fact that in the record for the earlier years, when data were available for only one or two stations, the plotted monthly values are somewhat scattered. As the number of stations increases, the difference between successive monthly values becomes markedly less, and it is possible to draw a free-hand curve that represents the variations in the smoothed monthly values fairly well. This has also been done for the earlier years but with less satisfactory results. It is thought that the available data do not justify a closer graphical representation than is given by this free-hand curve.

The main features of this curve—namely, the three great depressions following volcanic eruptions, Kratatoa in 1883, Pelée, Santa Maria and Colima, in 1902, and Katmai in 1912—are practically the same as shown in the previous paper. This is also true of the two minor depressions in 1888–9, and 1907–8. The curve has been modified to coincide more closely with the low values for December, 1890, to March, 1891, inclusive, and the depression shown in 1917–18 has disappeared, as was anticipated it might do when data from additional and more widely scattered stations were received.

From July, 1914, to the end of 1923 the plotted monthly values show little variation, the extremes being 97 and 105. During the same period the annual mean values vary between 100 and 101. Since the beginning of systematic pyrheliometric measurements in December, 1882, the only period comparable with the above in the uniformity of the radiation intensities is from September, 1892, to October, 1902, inclusive, or the 10 years preceding the volcanic eruptions of 1902.

There is a slight depression in the plotted monthly values between October, 1920, and March, 1921, or about at the beginning of the depression in Abbot's[3] published values of the solar constant. The depression does not persist as does the depression in Abbot's values, however.

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[3] Abbot, C. G., and colleagues. Values of the solar constant, 1920–1922. Mo. WEATHER REV., February, 1923, 5; 71–81.

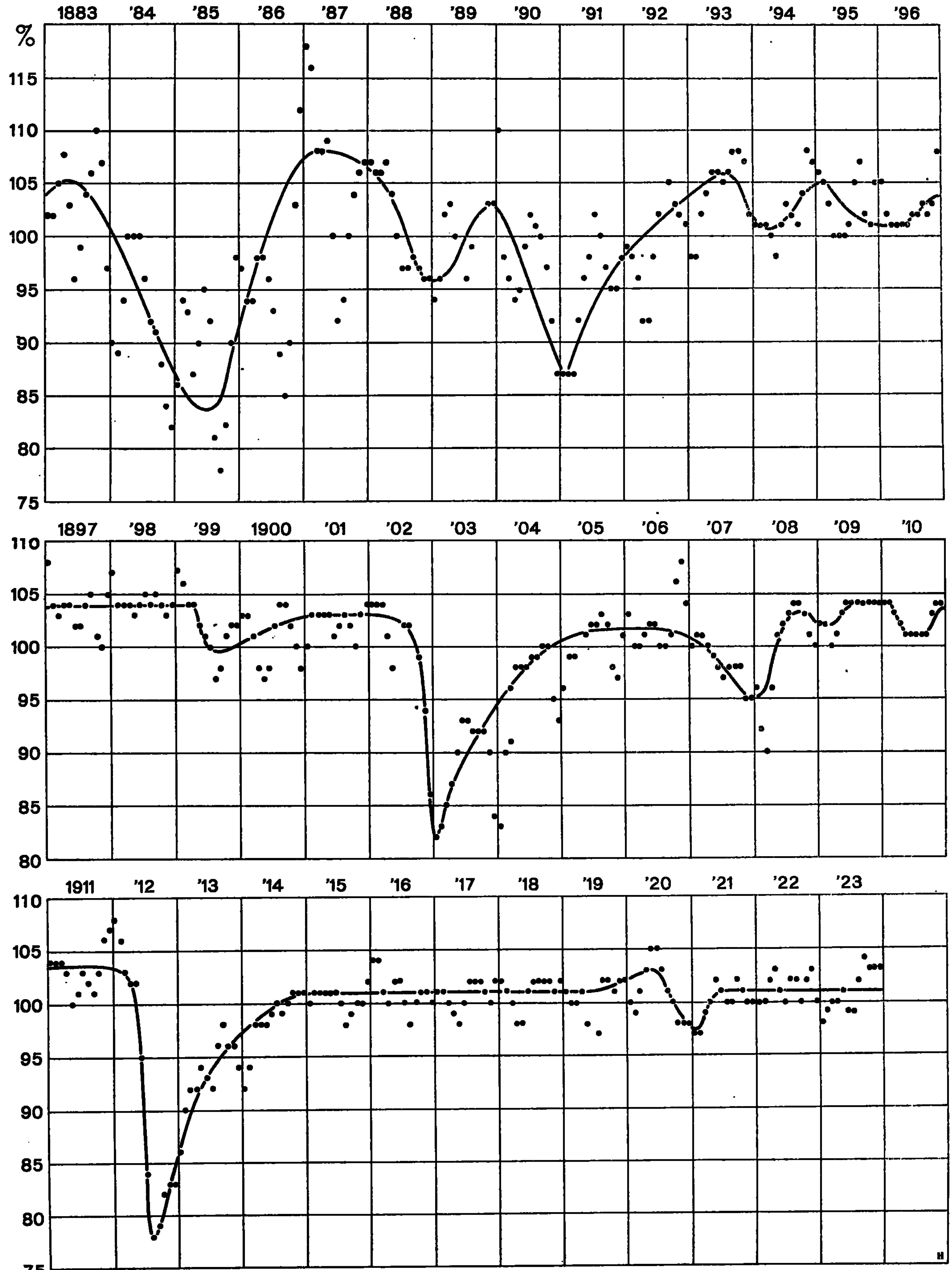

FIG. 1.—Monthly averages of Solar radiation at earth's surface, expressed as percentages of the monthly normals.