

side of the track, however, these conditions were reversed, the twisting action seeming to have been from left to right, and all fallen trunks were lying pronouncedly diagonally inward toward the center. The wreckage in the woods lots visited was almost impassable.

A half mile from this first woods lot the storm cut through another, where the same effects were observed. It was in this second woods, however, that in several instances small, tough branches were observed twisted around the upstanding stumps from left to right; that is, from west around through north to east. These branches were in some instances 2 or more inches thick, furnishing unmistakable evidence of the tornadic action.

Beyond this point the path of the storm for some distance was across open fields, though one orchard was observed to be nearly ruined. Farther on, it was reported, several more barns were demolished. The last report of the storm was about midway between Morrice and Bancroft, Mich.

At no point observed did the width of the path of destruction exceed approximately 100 yards, often being as narrow as 75 yards. The time of occurrence could not be determined within about 15 minutes, all who observed the storm stating that it came "between 5:30 and 6" in the afternoon, the sum of opinions being about 5:40 to 5:45 p. m.

Fortunately, no lives were lost, nor was any one seriously hurt, and very little live stock, the observer hearing

of one cow, two sheep, and one hog definitely lost, and a report not yet confirmed that several more sheep were lost on one farm.

No traces of the storm beyond 4 miles northeast of Morrice could be obtained, and the storm probably did not strike the ground again.—*B. B. Whittier, Lansing.*

Oakland County.—There is little definite information reported concerning the Oakland County tornado. The cities of Fenton and Flint reported serious damage from wind storms. The path as marked on the map (fig. 4) is that reported by the observer at Lansing. Four deaths were reported at Fenton.

IN CENTRAL ILLINOIS.

Logan County.—A tornado occurred in Logan County between 5 and 5:30 p. m. It had its origin near the Sangamon County line, west of Cornland, moved north by 30° east to a point near Broadwell, thence due north, passing just west of Lincoln, and dissipating a few miles north of that city. (See fig. 4.) Its path was about 20 miles long. It seemed to rise when it reached the west boundary of Lincoln and at other places in its path, leaving some places unharmed. Several farm residences were damaged, and there was considerable loss or damage to trees, electric wires and poles, and to barns and other farm buildings. Several head of cattle were killed. The property loss is estimated at \$15,000. Four persons were reported injured.—*Clarence J. Root, Springfield, Ill.*

DISCUSSION OF TORNADO CONDITIONS.

The weather conditions which produced 11 tornadoes in the States bordering on Lake Michigan, and at least two in Alabama and Georgia, are well worthy of study.

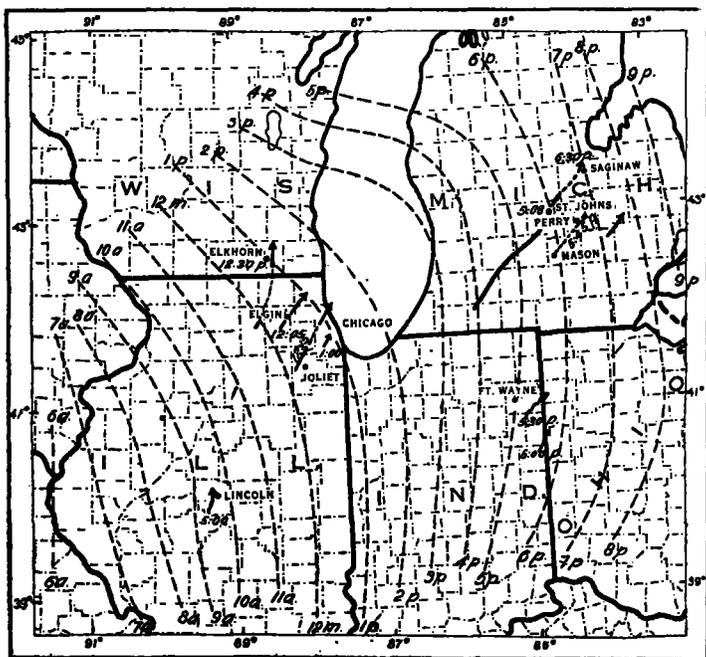


FIG. 4.—Tornadoes in the vicinity of Lake Michigan, March 28, 1920, and the hourly advance of the squall line. (A third tornado was reported in Indiana but its location not mentioned.)

With respect to lower Michigan in which three of the tornadoes appeared, Mr. B. B. Whittier, of the U. S. Weather Bureau at Lansing, made an interesting study of the time of passage of the squall line and lines of first thunder and beginning of rainfall, in connection with

the occurrence of tornadoes. In order to investigate the entire region in which the northern group of tornadoes occurred, his plan has been extended to cover the territory between Iowa and Ohio. Figure 4 shows the area in which the tornadoes occurred with their various paths and with hourly positions of the squall line as it progressed from west to east. These data have been obtained from the original instrumental records of the stations concerned. At many stations, especially those in the southern part of the region, the time of squall-line passage is difficult to determine from the records.

Appearing at 6 a. m. in eastern Iowa, a line of wind convergence advanced on a slightly curved front in a general east-northeasterly direction, reaching the vicinity of Chicago at about 12:30 o'clock. As the squall on this line crossed the Lake, the lesser friction of the water surface enabled the line to advance with increased speed thus creating a forward bulge in this part of the line. (See fig. 4.) In Indiana, this wind front was not so well marked. The last appearance of the squall within the region of the map was at 9:30 p. m. at Port Huron, Mich. Figure 5 shows the wind directions and speeds at various stations as the squall progressed across the region.

The line of first thunder as shown by Mr. Whittier occupied five hours in crossing Michigan, appearing on the east shore of Lake Michigan at 3 p. m. and leaving the State at about 8 p. m. First rain followed thunder half hour later across the State, but the rains were not so general.

A clearer idea of the weather on the day in question in the tornado region can be obtained from a study of the actual weather at a few places. Springfield, Ill., and Grand Rapids, Mich., afford good examples: At Springfield the day began with an overcast sky, with rain during the early morning hours, and a little hail which fell for about two minutes about 4 a. m. But

there was a rapid clearing so that by 7 a. m. the sky was clear. The wind was from the south-southeast at 8 a. m., became south by 8:30 and continued so until about 10, when there was an abrupt change to southwest. While the velocity in the early morning hours was higher than usual, there was a decided increase from 25 to 37 miles per hour in the wind about a half hour before the wind shift. Immediately after the wind shift, the speed of the wind reached 40 miles per hour. This wind did not drop below 30 miles per hour all day, and reached a maximum for the day of 41 miles per

in the March REVIEW (48:172), there was a belt of extremely low humidity extending from eastern Missouri northward over central Illinois, which was probably caused by the descent of rain-dried air, foehn-like, from high altitudes immediately in the rear of the line of wind convergence which gave rise to the tornadoes.

At Grand Rapids, on the contrary, the wind speed during the day was not very high, being for the greater part below 20 miles per hour between 12 and 2 p. m. Until about 4 p. m., the wind was south-southeast, but at that time it became variable between southwest, south-southwest, and south, and about 6.15 more steady southwest. Between 4 and 4.30 p. m., there was a shower, in which 0.37 inch of rain fell. The morning observation showed a total sky cover of cirro-stratus moving from

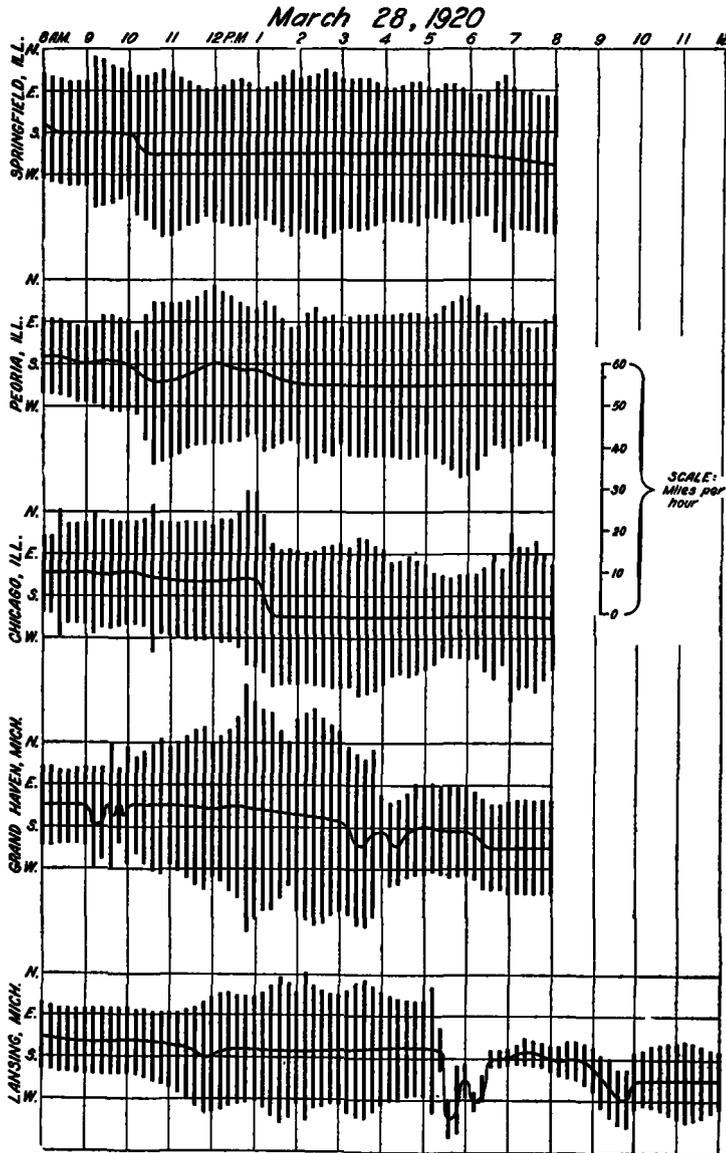


FIG. 5.—Wind velocity and direction at various stations, March 28, 1920.

hour at 6:30 p. m. About 5 p. m., the wind, which had been steady southwest since morning, began a slow change toward west. The nearest tornado occurred at Lincoln, Ill., about 30 miles northeast of Springfield, at 5:30 p. m. An interesting and striking feature of the squall-line passage was the presence in its rear of a region of extremely low relative humidity. The reading taken at noon at Springfield was 16 per cent, the lowest ever recorded at that station. The morning and evening observations gave relative humidities of 76 and 48 per cent, respectively. As pointed out by Mr. P. C. Day

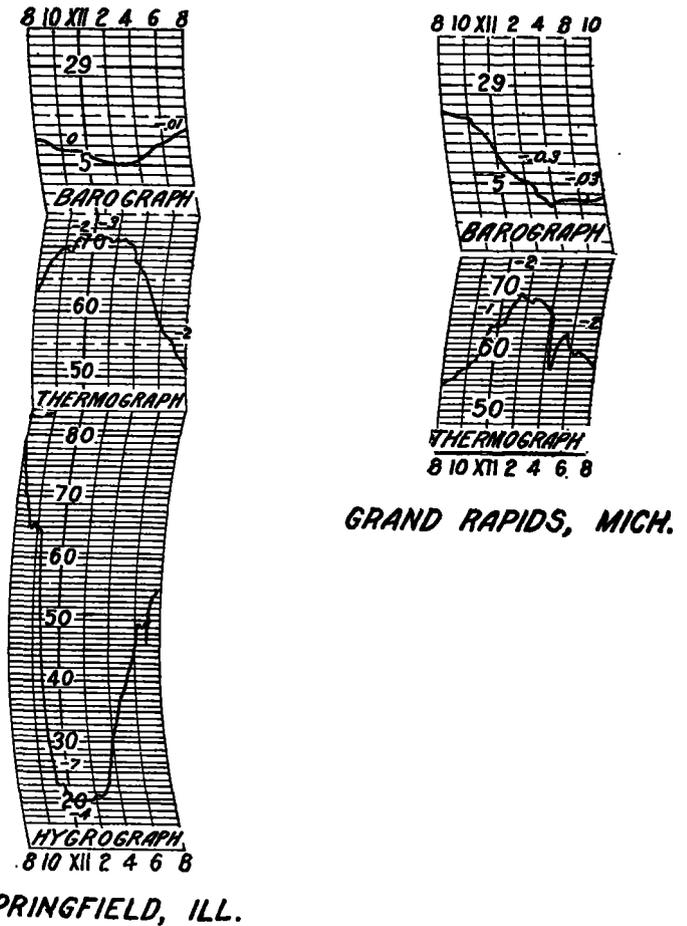


FIG. 6.—Traces of recording instruments at Springfield, Ill., and Grand Rapids, Mich., March 28, 1920.

the west. By noon, there had appeared a layer of strato-cumulus which covered eight-tenths of the sky. These clouds moved from the southeast. At the time of evening observation, after the tornadoes had occurred in that region, the sky was perfectly clear, a condition suggestive of descending air similar to that noted in Illinois. The humidity did not show a marked change such as was noted at Springfield, although one can not make this statement without reservation since the Grand Rapids station does not maintain a hygrograph which would afford a continuous record. At 7 a. m., noon, and 7 p. m., observations of relative humidity gave 56, 58, and 61 per cent, respectively. The temperature rose steadily all morning, reaching a maximum of 69° at 1.30. About

the time of the shower, however, (and this may be said to mark the passage of the squall line,) there was a very sudden drop from 65° to 56° and a somewhat slower rise to 63° by 5.15, followed by an irregular drop to 56° at 8 p. m.

Figure 6, giving the copies of the original records from Springfield and Grand Rapids, shows the progress of meteorological phenomena during the day. It appears from the examination of many records, even from those much closer to the paths of the tornadoes than these,

that there is very little disturbance to the diurnal march of the elements upon the passage of these very violent disturbances up to within a very short distance from the whirl. This simply emphasizes the extremely local character of the tornado, and is borne out by the seemingly capricious conduct of the whirling cloud as it passes along. As is seen from the figure there was little or no barometric disturbance at the time of tornado passage, although severe tornadoes passed only a few miles from the station.—*C. LeRoy Meisinger.*

A KITE FLIGHT IN THE CENTER OF A DEEP AREA OF LOW PRESSURE.

By VINCENT E. JAKL, Meteorologist.

[Weather Bureau Aerological Station, Drexel, Nebr., May 24, 1920.]

Kite flights are not ordinarily possible near the centers of intense lows on account of the kites being unable to withstand the attendant stormy weather or winds of gale to hurricane force. On March 28, 1920, Drexel was evidently in or near the very center of a well-defined low of the circular or oval type. Light winds in this region of the low made a flight possible, but also limited the flight to a comparatively low altitude. Notwithstanding the low height attained by the kites on that day, the rather unusual circumstance of the flight invites a discussion of the free-air conditions that prevailed, especially in view of the fact that tornadoes occurred on the same day over middle eastern and southern States. The deductions arrived at, suggesting an explanation of tornado conditions, are principally from the results of this flight and a comparison of them with the conditions shown by the flights of the previous and following days. Related conditions on other dates or at other stations are also discussed or referred to.

The weather map for 7 a. m., 90th meridian time, on March 28, 1920, shows a deep area of low pressure over the Missouri Valley, the innermost isobar, 29 inches (sea-level), encircling Omaha, Nebr., as an approximate center. Drexel, Nebr., being only 18 miles west-northwest of Omaha, can be given equal prominence as the center of the low-pressure trough. In point of fact, the pressure at this hour of observation, reduced to sea level by the usual method of computation, was 28.94 inches at Drexel, or 0.04 inch lower than at Omaha.

A kite flight, begun almost simultaneously with the general 7 a. m. surface observations represented on the weather map of this date, was finished two hours later. The surface pressure reached its lowest level about the time the flight was begun, and remained practically stationary till about an hour after the flight was ended. The upper-air observations recorded during the flight can therefore be properly referred to the position of Drexel in the low indicated on the 7 a. m. weather map.

Light haze prevailed during the flight and until 11 a. m., or throughout the time the pressure remained low and stationary. Following the abrupt rise in pressure that began at 11 a. m., the haze gave place to stratocumulus clouds that quickly overcast the sky, and brought a fall of light rain, turning to snow. The surface wind, that had been light southerly during the flight, became a northwest gale shortly after the rise in pressure set in.

The significant facts that it is intended to bring out are the veering diminishing winds aloft during the progress of the flight, the apparent progressive veering of the winds from the highest altitude down to the ground, and the progressive fall in temperature at certain altitudes from the 27th to the end of the flight on the 28th.

The generally light diminishing winds encountered during the flight are undoubtedly a feature of the central area of a low, and can probably be explained as due to the gradual readjustment of the air masses to an almost opposite direction of movement. Some interesting conclusions, however, may be inferred from the apparent circumstance of the progressive veering of the wind downward toward the ground and the fall in temperature that attended and preceded the veering in direction. If the inference that the fall in temperature attending and preceding the veering in direction is carried farther, and an earlier fall in temperature in the higher altitudes assumed, some of the observed characteristics of the front of lows might be more easily explained.

A question that suggests itself from the records of the 27th and 28th is: Was the rapidly rising temperature in the strong southerly winds noted at and near the ground on the 27th, coincident with falling temperature at higher altitudes; and if so, was a similar but more pronounced condition a day later over sections farther to the east responsible for the tornadoes that were reported from middle eastern and southern States?

The first part of this question can be answered in the affirmative if the evidence is sufficient that the fall in temperature (with presumably no change in surface-wind direction, but with a change of 2 or 3 points at 1,500 meters) noted in the lower strata on the 28th began in the higher strata on the 27th. While it will be noted from Table 1 that much lower temperatures were recorded at all altitudes on the 28th as compared with corresponding altitudes on the 27th, there seems no reason to doubt, from the circumstance of pressure distribution, that the wind at these altitudes was blowing continuously from a southerly or southwesterly direction from the morning of the 27th to the morning of the 28th.

Owing to the strength of the winds aloft on the 27th, the flight on that day did not reach an altitude high enough nor cover a period of time long enough to show any marked changes in temperatures in the higher strata. A more complete kite flight was made on the same day at Royal Center, Ind., a record of which is given in Table 2. This record shows a small but distinct fall in temperature and increase in the lapse rate in the higher levels. However, more definite evidence of a simultaneous fall in temperature aloft and rising or sustained high temperature near the ground in the front quadrants of a low may be deduced from the records of some diurnal series of flights. Reference is made to the records of the diurnal series of October 16-17 and November 8-9, 1917 (1), both of which are good illustrations of progressive temperatures aloft preceding thunderstorm conditions. While these records apply to the autumn