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THE TORNADOES OF MARCH 18, 1925 [1]

By ALFRED J. HENRY

The destructive tornado that swept eastward over parts of Missouri, Illinois, and Indiana, together with those of shorter path in Kentucky and Tennessee, on March 18, 1925, created a new record of destruction both of human life and property from these much-dreaded storms. Seven separate and distinct tornadoes were observed on the date mentioned, the most destructive of which was the one starting near Annapolis, Mo., which moved in an almost straight line to the Mississippi River, crossing that stream into Jackson County, Ill. It laid waste a number of towns and villages as it crossed Illinois, continuing its devastating course into Indiana and finally disappearing 3 miles southwest of Petersburg, Pike County, Ind.

Two Weather Bureau officials, William E. Barron, of the Cairo station, and Clarence J. Root, of the Springfield station, were at once directed to survey the path of the storm.

Grateful acknowledgment is here made for the matter I have drawn from the report of these two officials. Information as to the remaining tornadoes was drawn largely from the printed issues of "Climatological Data" for the States in which the storms occurred.

THE CYCLONIC STORM THAT GAVE RISE TO THE TORNADOES

The previous history of the cyclonic storm with which the tornadoes were associated is not illuminating; evidently the storm was an offshoot from a cyclone which occupied the northeast Pacific from March 13 to 18. This offshoot was first recognized on the p. m. chart of the 16th as a depression centered over western Montana. At that time and during the next 24 hours, this depression gave no evidence of anything out of the ordinary; on the morning of the 18th it was centered in northwestern Arkansas, as shown in Figure 1 (A). At this time, 7 a. m. 90th meridian time, the center of lowest pressure was shown by the isobars of 29.8 and 29.7 inches, respectively, both isobars being within a trough of low pressure that extended in a NE.-SW. direction.

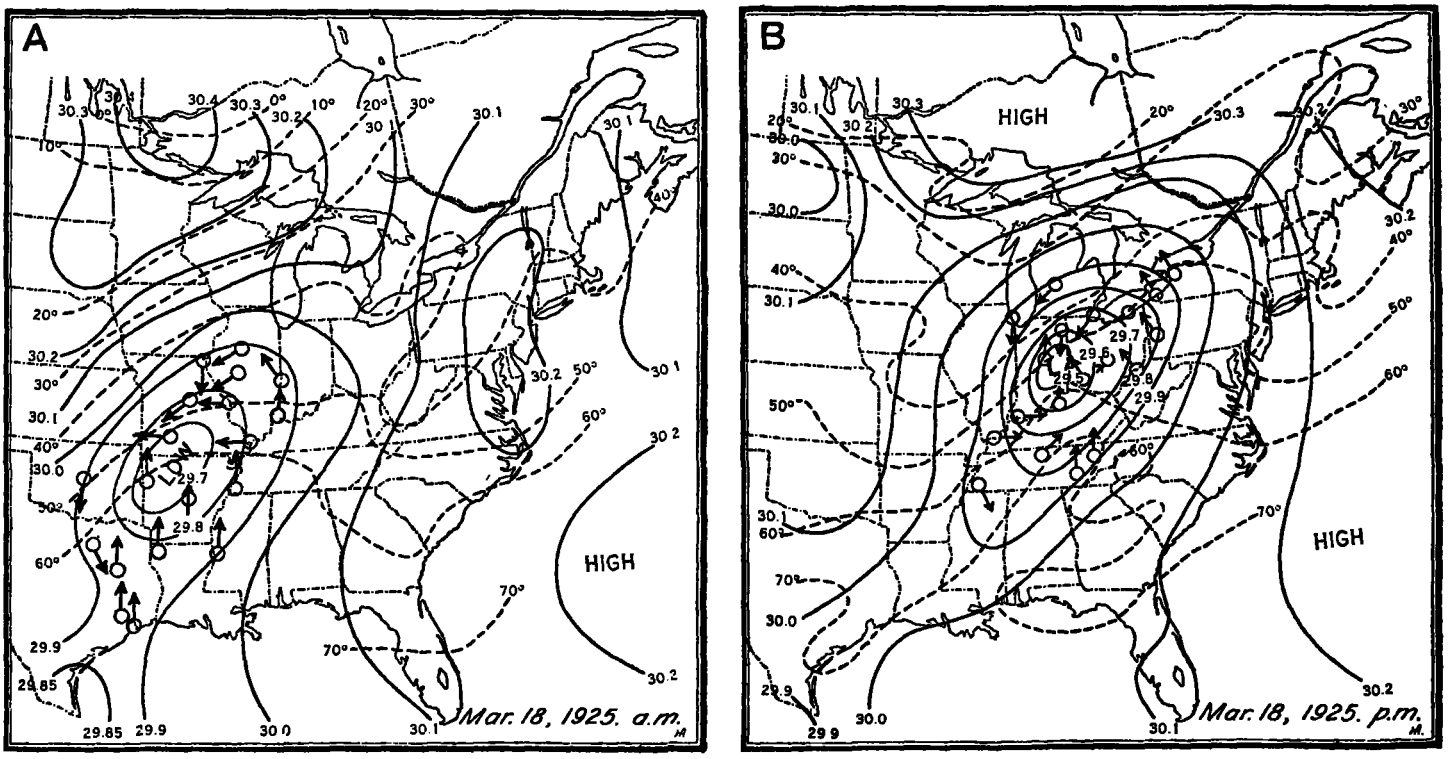


FIG. 1.—Weather maps for 8 a. m. and 8 p. m., March 18, 1925

Movement of the cyclone.—During the daylight hours of the 18th the center of lowest pressure was displaced northeastward a distance of about 500 miles to southeastern Indiana, as shown in Figure 1 (B), or at the rate of about 40 miles per hour.

For the purpose of better relating the progression of the center of lowest pressure with that of the formation and progression of the tornadoes, weather charts covering the lower Ohio Valley for the hours 1, 2, 3, and 4 p. m., central meridian time, were constructed. The charts for 1 and 4 p. m. have been reproduced in the lithograph charts in Figure 2 (A and B).

[1] Condensed from reports by the following field officials: J. H. Armington, William E. Barron, James L. Kendall, Roscoe Nunn, George Reeder, Clarence J. Root, and Geo. B. Wurtz, with discussion by the editor on the meteorological aspect of the phenomenon. Details of loss of life and damage to property were included in this REVIEW for March, 1925, and may also be found in the publication "Climatological Data" for Missouri, Illinois, Indiana, Kentucky, and Tennessee for the same month.—ED.

On the A chart the tracks of the tornadoes are shown by a heavy line. The times of beginning and ending of each tornado are also shown, and the times of beginning have been used as a basis of classification into (a), (b), (c) storms, etc.

As before intimated, the pressure formation was not characterized by circular isobars but consisted of a rather restricted region of low pressure within a trough of low pressure whose longer axis extended in a NE.-SW. direction. The apparently rapid movement of the central low pressure is well understood by forecasters since the southern center of low pressure in a trough often moves with great rapidity toward the opposite end of the trough and thus the center of the formation as a whole is sometimes carelessly considered as having a very rapid rate of translation.

The intermediate charts.—The charts for 1 to 4 p. m., 90th meridian time, show rather conclusively that not only did the center of low pressure move rapidly northeastward but also that in so doing the formation as a whole passed from that of a trough to that of oval-shaped isobars oriented in the same general direction as those of the earlier formation.

The 1 p. m. chart (fig. 2 (A)) shows the lowest pressure at Cairo with pressure almost as low at St. Louis and a being about 200 miles northeast of Cairo and registering a greater pressure fall, seems to indicate that the development of the storm was in some way conditioned upon the great temperature contrast on the northern border of the mass of warm southerly winds at the time flowing over southern Illinois and Indiana, which may have had more of a westerly component aloft than at the surface.

At 3 p. m. the center of low pressure had assumed the form of a long narrow oval stretching from Cairo with pressure of 29.56 inches to Terre Haute, Ind., with pressure 29.59 inches, and the whole disturbance had now largely passed from the "trough" form to that of an oval, the latter being oriented in a NE.–SW. direction.

The 4 p. m. chart is reproduced as (B) in Figure 2. Lowest pressure is now at Terre Haute, Ind., 29.55 inches.

THE BAROGRAPH TRACES

The barograph traces in the path of the cyclonic storm we have been considering show not only its progression from hour to hour, but also that a disturbed condition of the atmosphere, as indicated by short irregular fluctuations in the pressure, prevailed during the early morning hours of the 18th. None of the Weather Bureau barographs were close enough to the tornado's path to record

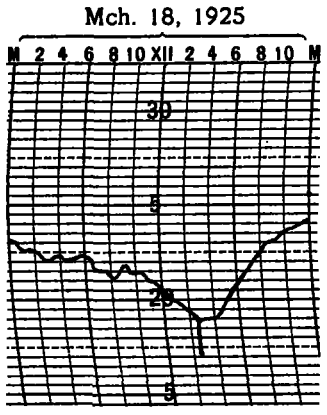


FIG. 3.—Barograph trace, Old Ben coal mine

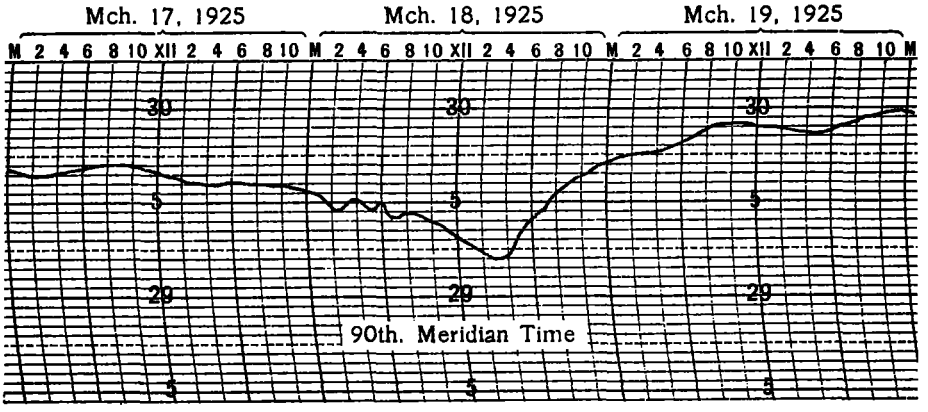


FIG. 4.—Barograph trace, Cairo

widening out of the isobaric lines toward the northeast, thus indicating a tendency toward movement in that direction.

The center of the cyclone at 1 p. m., 90th meridian time, was probably 100 miles or thereabouts west-southwest of Cairo, possibly in Ripley County, Mo., or 40 miles south of Reynolds County, where the tornado was first seen. If this assumption be correct and it be further assumed that the form of the inner isobar of the cyclone was that of a north-south oval, then it may be said that the tornado probably developed in the northern left front of the cyclone—the northwest quadrant. The left front is a more probable place of origin than the right front since the tornado moved with greater speed than the cyclone, and, as we shall see later, the paths of the two phenomena over Illinois and Indiana were nearly concurrent in point of time but not parallel in direction. The tornado moved in a direction 21° north of east while the center of the cyclone followed a slightly curved path over Missouri and Illinois, concave to the north. (See Path No. VIII, chart 2, March, 1925, REVIEW.)

At 2 p. m. pressure at Cairo had fallen to 29.60 inches and at Terre Haute, Ind., to 29.62 inches; whereas at Evansville, Ind., about 112 miles due northeast of Cairo, pressure had fallen to 29.65 inches only. Terre Haute the characteristic oscillation due to the passage of a tornado. Fortunately, however, we have come into possession of a baragroph trace made within less than a mile from the center of the tornado that swept through West Frankfort, Ill. This trace is reproduced in Figure 3, through the courtesy of Mr. J. E. Jones, of the Old Ben Coal Corporation of that city. The curve from the Cairo barograph, which was about 65 miles due south of West Frankfort, is also reproduced (Fig. 4) as typical of the curves from other instruments near the tornado path.

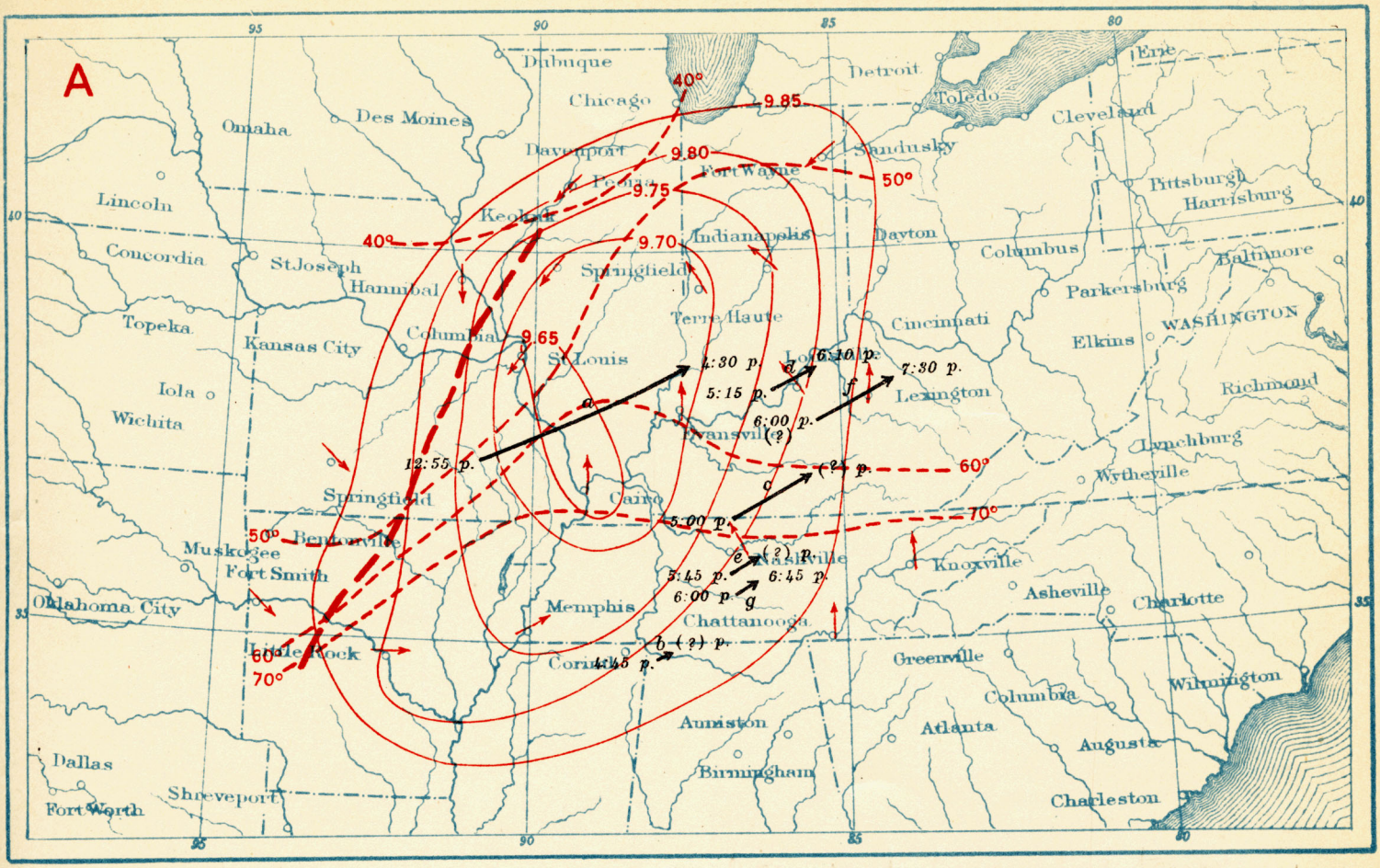
THE TORNADO PATHS WITH REFERENCE TO THE CENTER OF THE CYCLONE

Investigations of the last 40-odd years have shown that tornadic storms mostly occur in the southeast quadrant of a general cyclonic disturbance and at a distance that may range from 200 to 600 miles from the cyclone center.

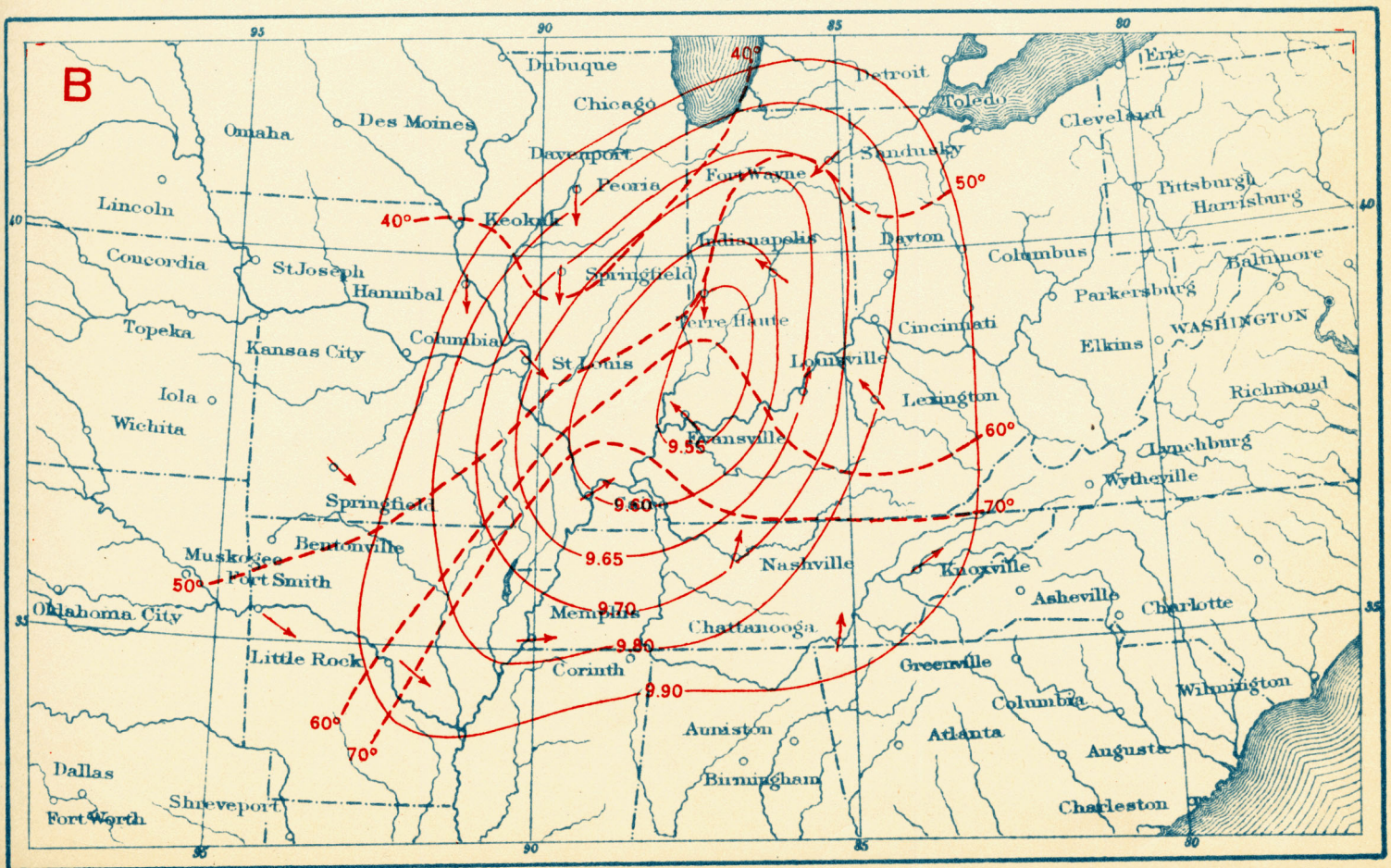
The editor does not recall having seen an authoritative record of the occurrence of a tornado in or very close to the center of a general cyclone up to the present case.

It has been suggested that the (a) tornado as depicted on Figure 2 (Chart A) had its origin in the left half and well toward the front of the cyclone shown on that chart.

A. J. H. **Fig. 2. Cyclone Center at 1 and 4 p. m., respectively, Central Time, March 18, 1925**



Letters are assigned in probable order of their starting.



(To face p. 142)

The movement of the tornado across southern Illinois is definitely fixed by the time at which the train despatchers' wires went out of commission. The evidence of the barograph traces for West Frankfort and Cairo (figs. 3 and 4), and also that of the time of the tornado's crossing into Indiana, and the Terre Haute barograph, go to show that the two phenomena—the tornado and the cyclonic storm—moved very nearly concurrently but not parallel, the tornado in the later portion of its path being on the south or the side on which warm southerly air prevailed. The remaining tornadoes developed later in the afternoon and much more distant from the cyclone center, and in this they conformed to the experience of many years' study of that phase of the phenomenon.

Mention may also be made of the fact that the form of the isobars on March 18 greatly resembled that on February 19, 1884, on which day 44 tornadoes were observed in the east Gulf States, the Carolinas, and Georgia. On March 18, as on the date above mentioned, the time of occurrence of the tornadoes was later and later in the day and farther and farther to the eastward as the afternoon hours were passed.

FREE AIR METEOROLOGICAL OBSERVATIONS AND DEVELOPMENT OF TORNADOES ON MARCH 18, 1925

Stations south of the cyclone center.—The records from two points are available, viz, Broken Arrow, Okla., and Groesbeck, Tex. The geographical coordinates of the four kite stations are given in the table below:

Station	W. longitude	N. latitude	Elevation
	° ′	° ′	*Feet*
Broken Arrow	95 49	36 02	764
Groesbeck	96 28	31 30	463
Drexel	96 16	41 20	1,299
Royal Center	86 29	40 53	738

March 17.—Southerly winds turning clockwise to W.-SW. at 3,587 m. (11,768 ft.) prevailed at Broken Arrow; at Groesbeck the clockwise turning was also in evidence, but after reaching W.-SW. the winds backed to SW. and increased in speed to 19.0 m. p. s. at 3,780 m. (12,401 ft.)—the top of the flight. The maximum wind speed at Broken Arrow was 14.7 m. p. s. at 1,000 m., and but 12.8 m. p. s. at the highest point reached.

The temperatures of the air column above both stations were alike in that the lapse rate up to the 2 km. level was small and at both stations there was a more or less pronounced inversion of temperature, at approximately 1,000 m. at Broken Arrow and 1,500 m. at Groesbeck. Up to these levels (3,000 to 4,000 ft.) the air strata were in stable equilibrium.

March 18.—As the center of the cyclonic storm passed to the eastward of the meridian of these stations the winds very naturally went to northerly and the temperature at Broken Arrow fell several degrees in all levels. Groesbeck, more distant from the center of the cyclone, also experienced northerly winds, but only small changes to lower temperature, so that instead of an inverted temperature layer in the air column there was a small lapse rate from the surface to 3,000 m. (9,842 ft.), also a condition of stable equilibrium.

Stations north of the cyclone center. Drexel, March 17.—On this date S.-SE. surface winds turned clockwise to SW. at 1,780 m. (5,840 ft.)—the top of the flight. The temperature at that level was 3.6° F. higher than at the surface and, as at the southern stations, there was a rather pronounced temperature inversion with its maximum at the 1 km. level.

On the following date the winds were NNW. at the surface, backing to NE. at the top of the flight, 2,765 m. (9,071 ft.), and there was a fall in temperature ranging from 5 to 15° F. in the several levels. All of these changes are in accord with what might be expected, owing to the changed geographic position of the cyclone center with respect to Drexel.

Royal Center, March 17.—This station was under the influence of the southeastern anticyclone; accordingly winds were SSW. at the surface, turning to SW. and WSW. at the highest level reached, 2,848 m. (9,344 ft.). On the 18th as the cyclone center approached from the SW., the NNE. surface winds became E. at the top of the flight, 1,815 m. (5,954 ft.). The lapse rate on the 17th was about half the adiabatic, and on the 18th, while it had increased somewhat, was yet not more than half of the adiabatic.

The chief facts brought out are therefore: (1) The existence of a rather strong southerly current in front of the cyclone on the 17th which apparently extended from the Gulf of Mexico to the Great Lakes, possibly to the Canadian border; (2) the current was warm in the lower levels and cold above 3 km., with a rather small lapse rate between the surface and that level, therefore stable; (3) indications drawn from the barograph curves point to an instability in the atmosphere in the early morning hours of the 18th and that this instability progressed from west to east concurrently with the advance of the cyclone center. Finally, the free-air records give no direct indication of the forces which institute and maintain the tornado vortex although the presence of a warm layer of air at the 1-km. level, if sufficiently warm, of which we have no knowledge, may have conspired with other conditions to pierce the cold upper ceiling by vertical convection and thus induce a vortex which later will reach the earth's surface. In this instance there is no warrant for assuming that such conditions obtained. It must also be reluctantly admitted that there is little hope that the actual conditions that initiate a tornado vortex will ever be experimentally observed.

GENERAL REMARKS

The (a) tornado.—Messrs. Barron and Root, by using an automobile, were able to cover the track of the (a) tornado in Illinois and Indiana in seven days. From its inception in Reynolds County, Mo., the tornado pursued a remarkably straight path through Iron, Madison, Bollinger, and Perry Counties, of that State, and across Illinois, passing through the counties of Jackson, Williamson, Franklin, Hamilton, and White. It continued its course with slight deviation through the counties of Posey and Gibson in Indiana, and terminated as a destructive tornado 3 miles southwest of Petersburg, Pike County, Ind.

The total length was 219 miles with an average width of less than 1 mile. Its speed in Missouri was 57 m. p. h.; Illinois, 59; and Indiana, 68.

In western Illinois very few observers reported the presence of a funnel-shaped cloud; farther east, however, some thought they saw such a cloud, especially those who were on the outside of the storm's path. These witnesses were not very definite as to what they saw but all agreed that two clouds came together. This appearance is perhaps the most common testimony of pesons observing tornadic storms. It has been repeatedly given since investigations on this type of storm were begun some 40-odd years ago.

There is no doubt but that clouds are seen rushing toward a common point, viz, the vortex of the tornado. As explained by Professor Davis many years ago, it is not the rushing together of two clouds that creates the tornadic whirl but rather this cloud motion is the visible result of the whirl already in existence.

Root suggests that the absence of a funnel-shaped pendant cloud may be due to the fact that the main cloud was so close to the earth that there was no room left for the formation of the usual funnel-shaped cloud. The writer pointed out many years ago [2] that the character of the pendant funnel-shaped cloud varies with geographic position and the average hygrometric state of the air.

Thunder was heard quite generally a few minutes in advance of the tornado; rain and hail fell at various places. Hail was moderately heavy at Gorham, West Frankfort, and Carmi, Ill., and east of Princeton irregular-shaped chunks of ice as large as goose eggs were reported.

The usual roaring sound as of several freight trains was heard.

Loss of life and property.—For convenience the statistics of loss of life and injury to persons and property loss published in the March REVIEW are here repeated, with slight revision based on later estimates, in Table 1.

TABLE 1.—*Deaths, injuries, and property losses in the seven tornadoes of March 18, 1925*

Tornado	Deaths	Persons injured	Property losses
a	742	2,771	$16,532,000
b	1	12	15,000
c	38	98	200,000
d	6	101	225,000
e	1	9	30,000
f	2	35	850,000
g	2	7	20,000
Totals	792	3,033	17,872,000

Root and Barron say with respect to further details of the (a) tornado:

From inquiries made among the country people it would seem that they had about five minutes' warning after first noting the cloud. Asked as to the length of time in which the destruction took place, opinions varied, but most persons thought about two minutes. If the whirl was round, the path of the storm 1 mile or less in width, and the velocity of translation about a mile a minute, then the tornado would pass a given point in one minute or less.

There was much sameness throughout, the degree of property damage simply depending on what was in the track. The tornado advanced across the country with undiminished intensity and none of the lifting and skipping commonly attributed to this type of disturbance.[3]

Topography seemed to have little effect on the action of the storm. All farm properties were damaged or destroyed, and in most cases there was complete demolition. Livestock were killed, fences blown down, automobiles and machinery damaged, grain and supplies scattered about, and in many cases entire orchards were uprooted. In some cases residences were carried from the foundations, with scarcely a board left in the immediate vicinity. The country was strewn with débris. Freight cars were turned over. The term "utter confusion" nicely illustrates conditions in the tornado zone. * * * The tornado did not cut a swath through the timber. In numerous places there was severe damage, many trees being broken off or uprooted. In other areas there was little destruction. Trees were down here and there in all parts of the storm's track.

It may be wondered why the number of casualties was so great. In the first place, the path was of great length and was wider than usual, thus embracing an unusually large area. * * * There are relatively few basements in this region and surprisingly few storm caves. Where could the people take refuge? Many did not realize the danger present, thinking it merely a severe thunderstorm. Some entered the houses to take shelter from the rain. Notwithstanding the great number killed or injured, there were many remarkable and almost unbelievable escapes.

The (b) tornado.—This was doubtless a true tornado, but of relatively little intensity, short path, and short duration. It originated in Colbert County, Ala., about 6 miles north of Russellville.

The (c), (e), and (g) tornadoes.—This grouping is made for convenience of description, since all of the storms occurred in west-central Tennessee. The (c) storm was first observed 8 miles north of Gallatin, Sumner County, Tenn., at about 5 p. m., when the cyclone center was in extreme western Indiana and about 200 miles distant. This tornado cut a swath of from 200 to 400 yards in width and 15 miles long through the northern part of Sumner County, continuing about 50 miles farther into Adair County, Ky. The intensity of the storm decreased somewhat in the latter part of its course.

The (e) storm began 45 minutes later than the (c) storm and 50 miles almost due south of it, moving in a northeasterly direction. Its path was from 100 to 400 yards wide and about 20 miles long and it was not so severe as the one immediately preceding.

The (g) storm had a path 100 to 200 yards wide and moved in a northeasterly direction, paralleling that of the (e) storm. It was not a storm of great intensity, and it would seem that in the group of three storms here considered their intensity diminished in proportion to their distance from the cyclone center.

The (d) and (f) tornadoes.—The (d) storm was first seen about 75 miles southeast of the point where the (a) tornado disappeared, and the (f) tornado was first observed about 75 miles due south of where the (d) tornado disappeared. The path of the former was 40 miles long and that of the latter about 60 miles.

The occurrence of these tornadoes, each one successively farther and farther to the south and closely related in point of time, suggests an analogy between the origin of secondary cyclones and tornadoes.

It is a matter of common knowledge that when a cyclonic system entering the continent from the Pacific can not progress eastward along the northern boundary by reason of the presence of untoward atmospheric conditions a secondary cyclone will almost always develop to the southward of the primary. Similarly, it is conceivable that the (a) tornado of this series gradually found itself in atmospheric surroundings which made its further endurance impossible; hence the whirl lost contact with the earth and soon disappeared. Farther south, where the atmospheric conditions evidently were more favorable, a second whirl developed, made contact with the earth, and it, too, disappeared after a course of 40 miles. In each case movement toward the northeast brought the whirl into regions of lower temperature and, possibly, less moisture content. This action was again repeated in the case of the (f) tornado, which originated in Marion County, Ky., and moved as before described.

The observations on the (d) tornado were especially worth while; they confirm the suggestion by Root, previously mentioned, with respect to the lower end of the pendant funnel cloud. Following is a brief account of this tornado, with excerpts from Kendall's report.

[2] Annual Report, Chief of Weather Review, 1895–96, p. xxiv.

[3] The occasional lifting of the funnel cloud and losing contact with the earth may be considered as an indication of the more or less imperfect development of the whirl.—ED.

The tornado originated in Harrison, County, Ind., moved thence east-northeast in a path about 40 miles long and of varying width. The effect of rising ground on the pendant funnel cloud is discussed as follows:

* * * The district traversed rises in a rolling plateau, with the highest part a rather abrupt escarpment on the eastern edge, along the Ohio River, where the elevation averages about 850 feet above sea level. With the increasing elevation the funnel of the tornado became more and more deeply truncated, which caused the path of practically total destruction to widen to about half a mile. At the edge of the plateau along the Ohio River, where the descent is very abrupt, being about 400 feet in as many yards, the funnel dipped down immediately and destroyed all buildings in its path, even at the foot of the bluff over which it had come. At this point the path narrowed to about 900 feet; it narrowed further in crossing the Ohio, but widened again to more than 1,000 feet as higher ground was reached about 2 miles to the eastward, after which it generally contracted until it was only 50 feet wide at Pewee Valley.

* * * At the time of its passage the center of the low-pressure area was near Indianapolis. Immediately after the passage of the tornado at Louisville the skies cleared, the air became calm, and the temperature rose about 8° * * *.

Mr. Kendall notes that this tornado passed through Harrison County near Elizabeth, within less than 2 miles of the path of the severe tornado of May 27, 1890, which, it may be remembered, struck Louisville, causing great loss of life and property.

The Louisville barograph shows frequent oscillations from about 7:30 a. m. to 4 p. m., or just before the passage of the tornado. The lowest point on the Louisville trace was reached at 6 p. m., which corresponds pretty closely with the time of the passage of the cyclone center about 115 miles to the north.

ABILITY OF MODERN STRUCTURES TO WITHSTAND TORNADOES

Much interest is evident in recent years in the ability of well-constructed buildings of brick, stone, concrete, or what not, to withstand the terrific force of the wind as exerted in tornadoes.

Photographs of the destruction in various parts of the tornado path seem to show that light frame structures, which abounded in the towns and villages of southern Illinois, were totally demolished, although in a few cases the framework of the buildings held together even when the building was swept from its foundation.

The damage to school buildings of brick construction was particularly noticeable; the roofs were ripped off and the upper stories badly wrecked.

A correspondent of Engineering News-Record, writing in the issue of March 26, mentions the fact that at Murphysboro, while a clean sweep was made of structures in the northwest part of the city, two reinforced concrete coal bins within 300 feet of the Mobile & Ohio Railroad shops, which latter were destroyed, were left standing undamaged in the midst of a mass of wreckage. Also near the railroad shops two steel wheat bins * * * are still intact, although one of them is leaning. The brick building of the Brown Shoe Co. in Murphysboro was damaged considerably. Immediately in the rear is a 160-foot reinforced-concrete smokestack. In spite of the great amount of destruction around this structure, it remains standing and shows no signs of damage whatever. A small two-story building of plain concrete was practically destroyed, its 8-inch walls being sheared off entirely at the top of the first floor.

Root and Barron, in a supplemental report on damage to buildings, say:

Frame dwellings.—Unless well built, largely totally demolished in main path of tornado. A house in Griffin, Ind., lying on its side was returned to its original position by workmen practically intact. It had diagonal sheathing, which added much strength. Of houses not destroyed, the roofs and porches were taken off and in some cases the second story.

Stucco residences.—An architect in Murphysboro invited our attention to the fact that stucco houses resisted the storm to best advantage, and we found from observation that they did stand up better than frame buildings. There were few stucco houses except in Murphysboro. (We saw none.)

Brick buildings—Schools.—For the most part in two-story brick schools the first floor walls remained practically intact; in the second story the interior walls largely remained standing, though the outer walls crumbled. The Mobile & Ohio shops at Murphysboro, brick buildings, were demolished by wind and afterwards burned. In general, brick store buildings in the direct path of the storm were destroyed. A new brick two-story mine office building at Orient No. 2 mine at West Frankfort was practically undamaged, but it was in the lee of the large steel mine tipple. To the best of our memory, brick buildings stood up where they had steel trussed roofs.

Steel construction.—Steel water and oil tanks belonging to the railroad at Gorham were unharmed. A similar steel water tank at West Frankfort mine was blown over. At the same mine (Orient No. 2) the steel conveyor was badly damaged, but the large modern steel tipple was not greatly harmed. The tipple at Caldwell mine (wood and steel) was demolished.

THE TORNADO OF APRIL 5, 1925, NEAR MIAMI, FLA.

By RICHARD W. GRAY

[Weather Bureau Office, Miami, Fla., April 15, 1925]

The destructive tornado which passed north of Miami during the early afternoon of Sunday, April 5, 1925, occurred in connection with a disturbance that had moved southeastward across the United States from the California coast and that was central over extreme northern Florida at the time of the tornado.

The tornado developed over the Everglades, apparently in the vicinity of Hialeah, which is about 4 miles northwest of the city limits of Miami and about 8 miles northwest of the Weather Bureau station. The funnel cloud was first observed by golf players on the municipal golf course at Hialeah at 1 p. m. or a few minutes earlier. Its development was also seen by many other persons whose attention had been attracted by the unusually threatening sky which attended a thunderstorm and hailstorm preceding the tornado. The opportunities for observing the storm were exceptionally favorable. The usual large Sunday crowd was out of doors, many hundred automobilists being near the tornado path. Moreover, on account of its slow progress, word of the tornado was widely spread and several thousand persons watched it until it disappeared.

Many observers stated that the development of the tornado immediately followed the uniting of two dense cloud masses. When first seen by the writer, at 1:15 p. m., the development was complete, and the funnel cloud appeared as a very slender cone extending in a straight line from the dense cloud mass above to the earth. With the exception of a slight bending and twisting of the lower part of the cone, there was no deviation at any time from the vertical position of the funnel cloud. This was undoubtedly due to the slow movement of the general cloud mass. The funnel cloud, however, frequently rose from the ground only to descend again within a few minutes. When its end touched the ground there invariably followed a phenomenon similar