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Some Observations and Radar Pictures of the Blackwell and Udall Tornadoes of May 25, 1955

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ABSTRACT

Some accounts of meteorological conditions along the paths of these two severe tornadoes are described. Photographs of 3 centimeter radar of the Oklahoma A. & M. College sferics project show the development of a cyclonic protuberance out of the left rear quadrant of the radar echo similar to those previously observed in Illinois, Texas, and Massachusetts. Other similarities in the development of these tornadoes to the Massachusetts tornadoes of June 9, 1953, are pointed out. The average speed of radar echoes passing through the area of the tornadoes increases from 18 to 63 knots in a little more than one hour.

INTRODUCTION

THIS paper is more or less a by-product of a research project on tornado identification by sferics methods which is being conducted at Oklahoma A. & M. College with Weather Bureau participation and sponsored by the U. S. Signal Corps.

As we all know, the tornado is probably the most difficult of all the natural phenomena to study in detail. Because of the small size of the tornado as compared to other atmospheric disturbances, the occurrence of this type of storm near a meteorological observatory equipped to measure the important parameters is rare indeed. We were very fortunate here at Stillwater to be in an almost ideal position to obtain radar and sferics data on the two severe tornadoes that developed in north-central Oklahoma and passed into south-central Kansas on the night of May 25, 1955. For the sake of convenience we shall call the first of these two storms the Blackwell tornado and the second the Udall tornado, since these were the only towns in the respective paths. Radar evidence indicates that both of the tornadoes generated from the same thunderstorm complex, which was only one of a series of isolated echoes that developed and moved through the area during the afternoon and evening of the 25th. At the time of origin of the Blackwell tornado, the system that developed the tornado was not connected with a line of echoes as such, but was rather a detached echo moving in a general northerly direction.

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This paper presents observational data that were described by witnesses along the paths soon after the storm, plus a few observations made by ourselves in retracing the courses of these funnels. In addition, photographs showing the development of the now familiar tornado protuberance or hook on the radar echo are presented.

GENERAL METEOROLOGICAL CONDITIONS

During the daylight hours of May 25th, a front of maritime tropical air advanced northward across the state of Oklahoma ahead of a complex low pressure system and a mass of Pacific air moving eastward through Arizona. By 6:30 p.m., CST, the tropical air covered the entire state at the surface, and the lowest surface pressure had advanced to the extreme western tip of the Oklahoma Panhandle, with the Pacific front extending from this point, southward through the Panhandle and Big Bend National Park areas of Texas. Widely scattered thunderstorms occurred in the western two-thirds of Oklahoma throughout the day, ex-

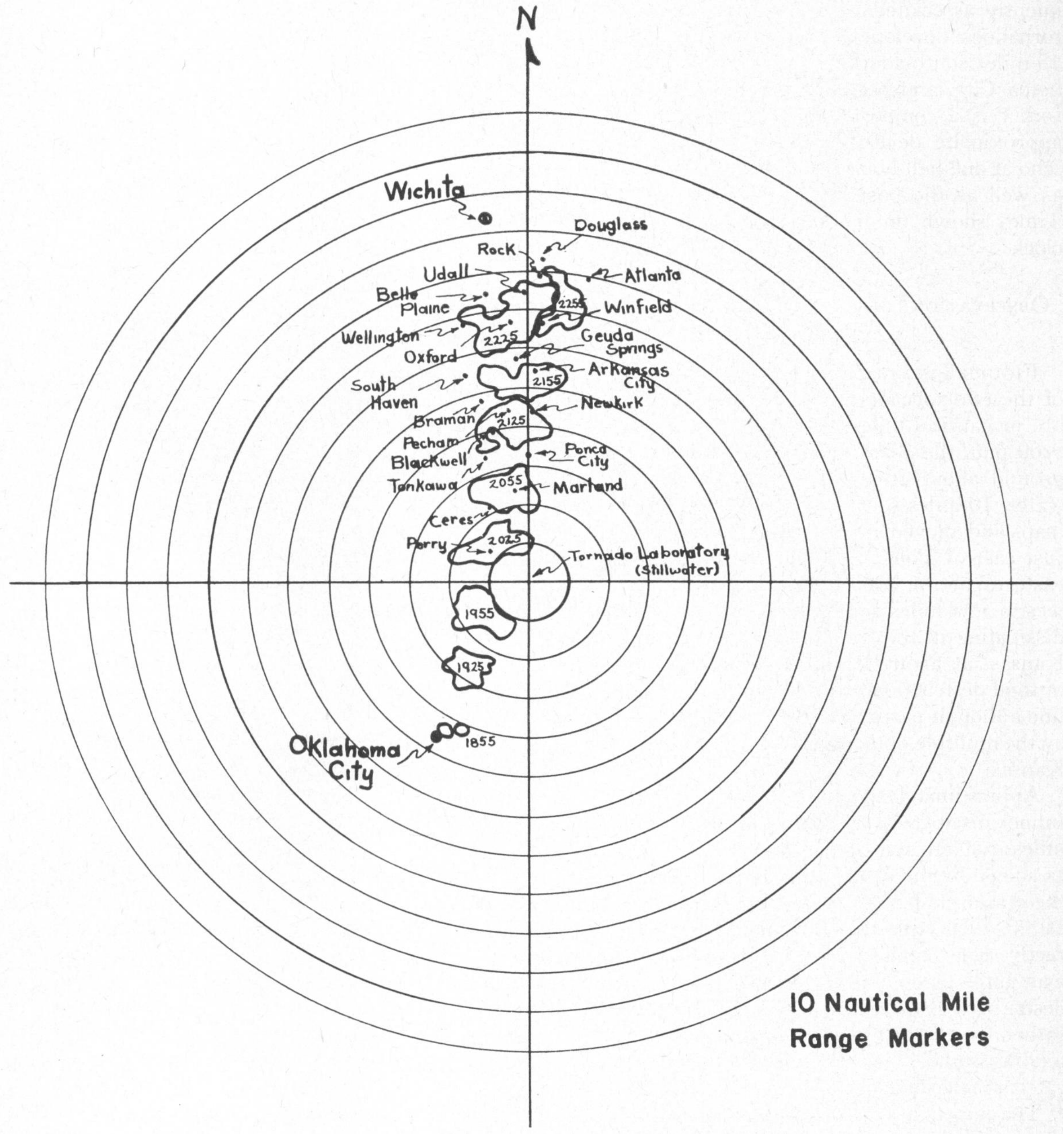

FIG. 1. Composite tracing of tornado radar echo.

cluding the panhandle, with damaging winds and hail being reported in several of these storms in the southwest part of the state as early as 5 a.m. Damaging winds also occurred in the Blackwell-Newkirk area of north-central Oklahoma about 11 o'clock in the morning. A little after 3 p.m., a tornado was reported on the ground in the Texas Panhandle, moving northeast into west-central Oklahoma, and funnels were also sighted about 6 p.m. in the same area and about 75 miles to the north.

At about 6:50 p.m., the echo that was subsequently associated with the Blackwell and Udall tornadoes developed on the station 3-cm radar, 45 miles south-southwest of Stillwater near Oklahoma City, and began to move northward. FIGURE 1 is a composite radar tracing showing the approximate development and movement of this echo at one-half hour intervals during its existence, as well as the positions of towns along its path. Times shown on the figure are from a 24-hour clock.

OBSERVATIONS OF THE BLACKWELL AND UDALL TORNADOES

FIGURE 2 is a map of the area showing the paths of the two tornadoes. All references to distance are in nautical miles unless otherwise stated. At 9:00 p.m. the Blackwell tornado first touched the ground about 26 miles north-northwest of Stillwater, 10 miles south of highway 60 shown on the map, and moved in a northerly direction passing just east of Tonkawa at about 9:17; through the eastern part of Blackwell at 9:30; curving northwest a few miles south of the Kansas border and dissipating in the area southeast of South Haven, Kansas, at about 10:00 p.m. The last evidence of total destruction in this tornado was at the state line although partial damage occurred as indicated by the multiple dots to the vicinity of South Haven, Kansas.

Approximately 20 minutes before the Blackwell funnel dissipated, the Udall tornado developed 5 miles east (to the right) at 9:40 p.m. and moved as shown by the dotted line, more or less following the Arkansas River around the town of Oxford at 10:20, then curving to the northeast, passing directly over Udall at 10:30. Beyond Udall there was little evidence of the narrow path of total destruction usually associated with a tornado, but rather a widening belt of partial destruction extending some 15 or 20 miles to the east, as indicated by the multiple dots on the map.

The duration of the Blackwell tornado was one hour, and its average speed was 34 knots, whereas

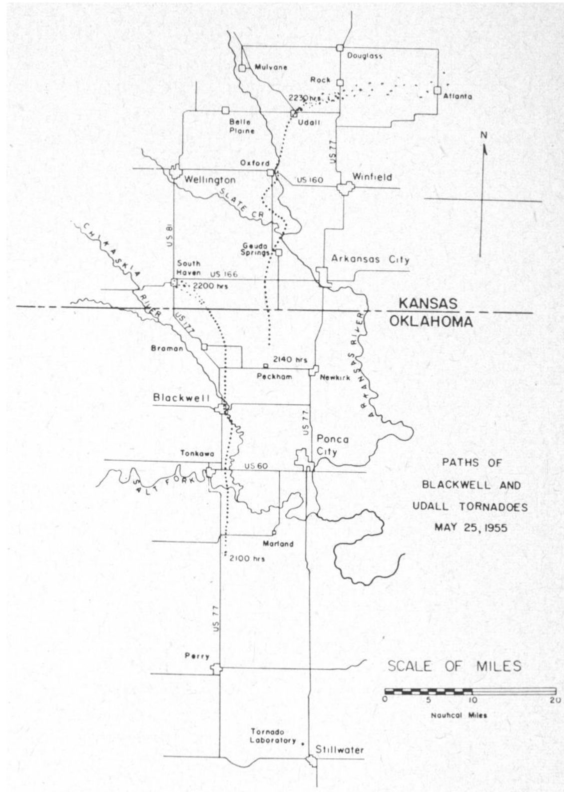

FIG. 2. Map of tornado area.

the duration of the Udall tornado was approximately 50 minutes with an average speed of 38 knots. The speed of movement of the Blackwell tornado changed little during its existence, whereas the speed of the Udall tornado increased somewhat as it progressed.

In surveying the tornadoes, we were able to criss-cross the paths of the storms by automobile at almost every mile and it is believed that the tracks indicated on the map are correct to the nearest ¼ mile. During the survey, an effort was made to gather from witnesses along the paths of these two storms, as much information as possible regarding meteorological conditions that accompanied the tornadoes. Witnesses were interviewed at many points along each path, however only a few of these interviews are described in detail. In general, witnesses reported that along the paths of the funnels, light rain, heavy lightning, and hail occurred immediately prior to the tornadoes. The heaviest hail apparently fell slightly to the left (west) of the paths, and at most places light rain continued to fall after the funnel had passed, but no hail. It is interesting to note that the hail belt occurred to the left of the tornado path, similar to the Illinois tornado of April 9, 1953 [1]. Several persons reported seeing the funnels against a background of lightning, but few heard any roar more than a minute or two before the funnels approached. The occurrence of large hail was more evident in the Blackwell storm, with the largest stones being reported in the vicinity of Tonkawa and Blackwell near the midpoint but to the left of the tornado path. Witnesses reported hail as large as baseballs, however, the largest stones that could be verified were about two and one-half inches in diameter.

A witness watched the Blackwell tornado form at 9:00 p.m. from a point three or four miles south of where it formed (FIGURE 2), and the first damage was to a farmstead on the road west out of Marland at 9:04 p.m. There was apparently some skipping from here to highway 60, although light damage was evident over all of this part of the path. The tornado struck the southeast edge of Blackwell very near 9:30 p.m., and in this area, which was about midway in the path of the storm, the damage gave evidence that the tornado was at the peak of its development.

FIGURE 3 is a photograph looking east across the path of total destruction in Blackwell. At this point, the total destruction was about 300 yards

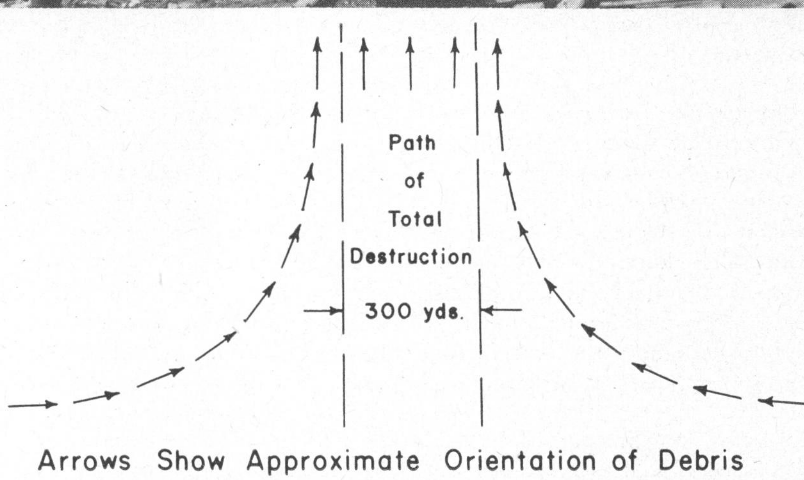

FIG. 3. Tornado damage in Blackwell and drawing of debris scatter pattern.

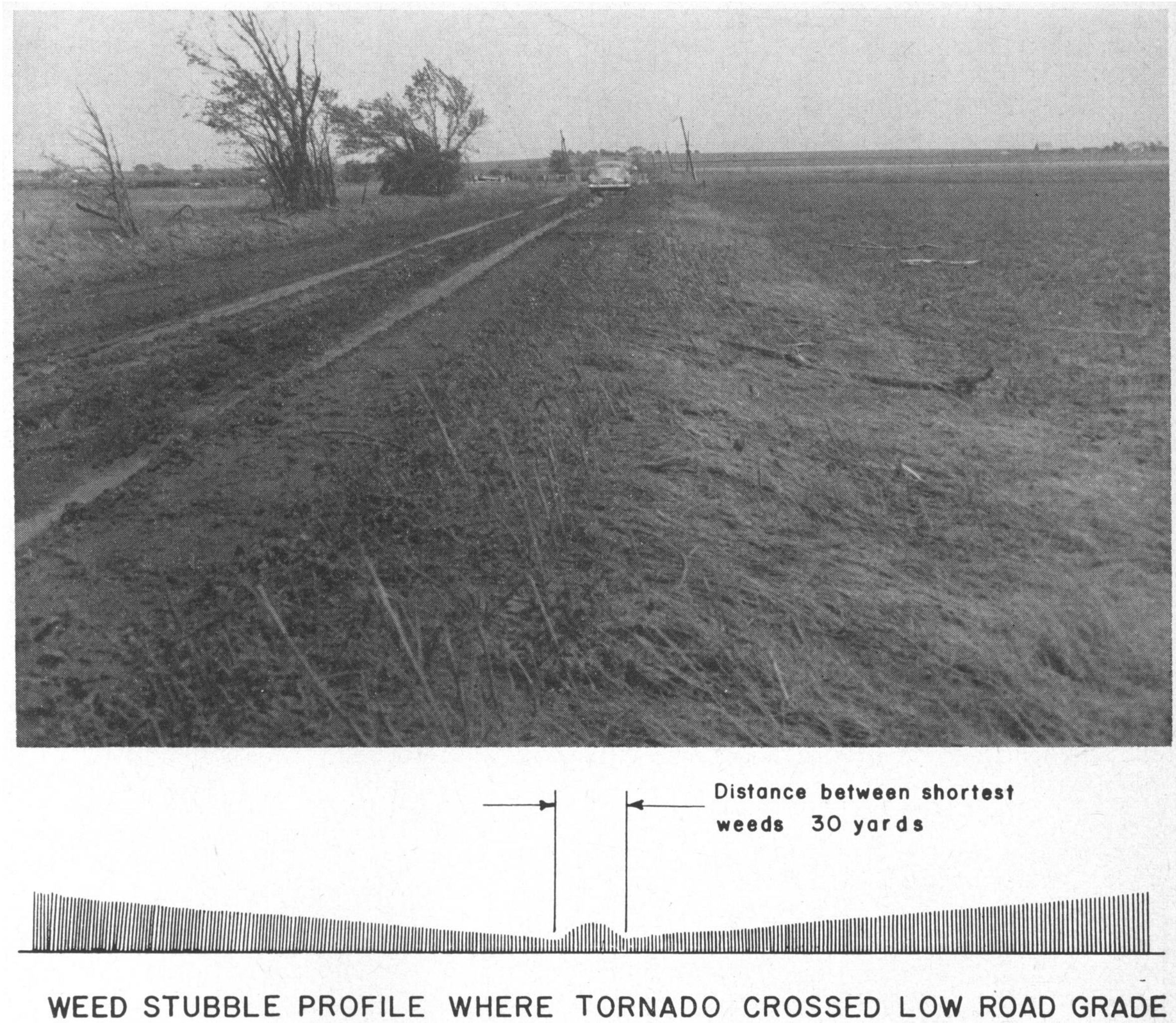

FIG. 4. Weed stubble profile.

wide with marginal damage extending roughly one-quarter mile on either side. Most broken television antennas, tree limbs, etc., out one-quarter mile from the center were lying normal to the path. As one approached the path of total destruction from either side, the angles subtended by the fallen objects and the line of the path decreased to a point some 200 yards from the center, where most remaining objects were lying parallel to the path with the tops pointing north toward the direction of movement. The debris scatter pattern as drawn below the photograph in FIGURE 3 suggested that at this point, the inflow was greater than the tangential flow except very near the vortex [2].

A mile or two north of Blackwell along a road shown in FIGURE 4, with a small grade running east-west, normal to the path of the funnel, there had been a two or three-foot growth of weeds. For about 100 yards on either side of where the center of the funnel passed over the grade, the weeds were stripped of their leaves, and as one approached the center of the path from the west toward the automobile in the photograph, the height of the weed stubble decreased gradually from about 10 inches, 100 yards out, to a minimum average of about 2 inches. From this point of minimum average height, the stubble increased for 15 yards to 5 inches and decreased again to about 2 inches in another 15 yards, then gradually increased. This stubble profile as drawn with the vertical scale exaggerated in FIGURE 4, suggested that the diameter of the strongest tangential winds was 30 yards at this point.

The story behind the photograph in FIGURE 5 of a devastated farmstead a few miles north of

Blackwell is, we think, worth mentioning. Litter from the several buildings was strewn for a mile back through the fields. A mother and eight children were in the house on the night of the 25th and a neighbor and his wife on hearing the severe weather warnings on television, decided to go after the family and bring them back to the comfort of their storm cellar. As they were all about to leave this house, the tornado struck. All eleven of them huddled together on the dining room floor, and when the storm was over they were all still on the floor in the foreground. Four of the children were injured but no one was killed. It is difficult to imagine how human beings can survive such forces.

The storm continued on north for a few miles then curved to the northwest, dissipating as indicated by the multiple dots, southeast of South Haven. The last evidence of the typical narrow tornado path was at the state line, but in South Haven itself there was a destructive wind from the northwest about 10 p.m. Television antennas, tree limbs, and a few trees were blown down, and plate glass windows blew out of a filling station as if by an internal explosion. Letters from Blackwell, Oklahoma were found a few miles northeast of this town.

At a point about four miles north and a little west of where the Udall tornado first touched the ground, very light rain with hail started falling about 15 minutes prior to the storm, and ended about the time that the witness saw the funnel pass one mile east of his house at 9:50 p.m. At Oxford, Kansas, hail reportedly shaped like broken icicles and about the size of a little finger, fell for a short time approximately five minutes before the funnel passage at 10:20 and it rained a little. After the storm passed, heavy rain fell. There was practically no damage in the town but houses were completely destroyed both to the south and to the north of the town. One mile southwest of Udall where a farmstead was completely destroyed, the owner stated that one of his cancelled checks had been found west of Florence, Kansas, 50 miles north of Udall. Where the tornado crossed a hedgerow running east-west near this farm, the broken trees were lying to the south on the west side of the path and to the north on the east side, indicating that the rotation of the vortex was cyclonic.

The little town of Udall was almost completely destroyed. The path of total destruction was nearly one-half mile wide at this point and the town was right in the center of this path. It was

FIG. 5. Remains of farmhouse north of Blackwell.

interesting to note however, that the last row of houses on the east side of town suffered only partial damage, suggesting that the violence of the whirl decreased rapidly at this point. Beyond Udall, where the storm curved rapidly to the east, there was little evidence of total destruction but rather a widening belt of partial destruction sometimes as wide as three or four miles with the dam-

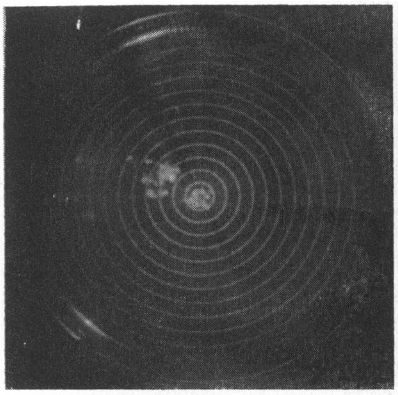

FIG. 6.
6:50 p.m. CST.

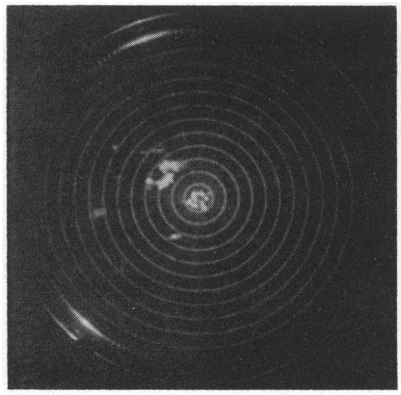

FIG. 7.
7:09 p.m. CST.

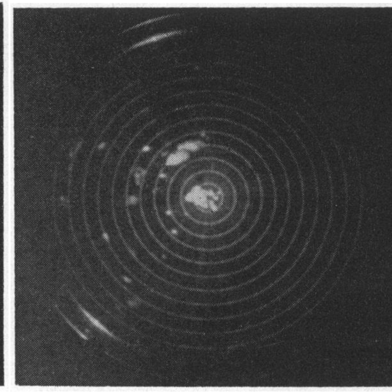

FIG. 8.
8:09 p.m. CST.

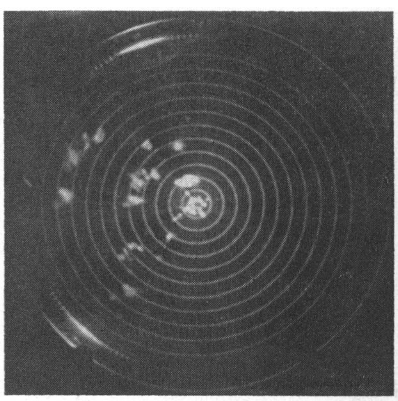

FIG. 9.
8.39 p.m. CST.

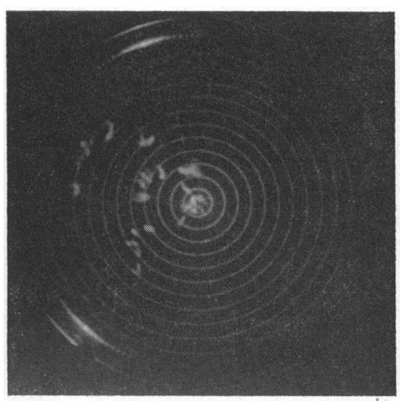

FIG. 10.
8:55 p.m. CST.

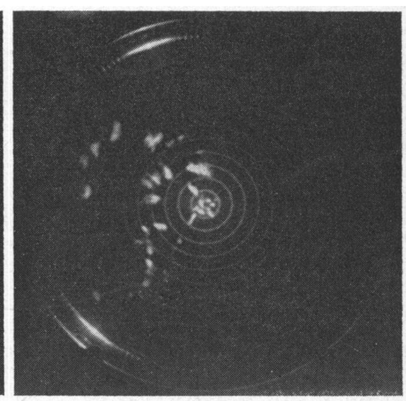

FIG. 11.
8:59 p.m. CST.

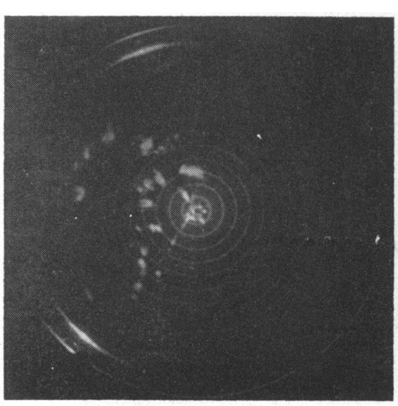

FIG. 12.
9:04 p.m. CST.

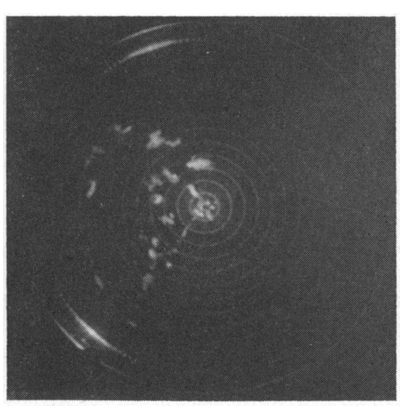

FIG. 13.
9:09 p.m. CST.

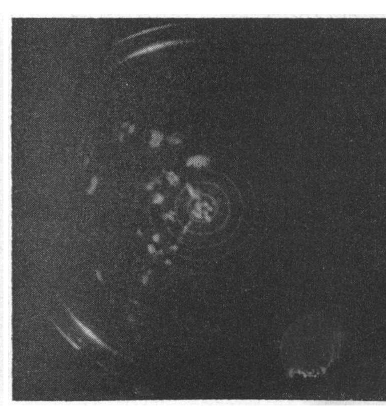

FIG. 14.
9:14 p.m. CST.

FIGURES 6–14. Sequence of PPI scope photographs of Blackwell-Udall storm echoes.

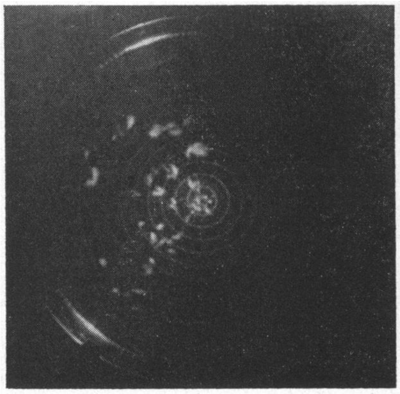

FIG. 15.
9:19 p.m. CST.

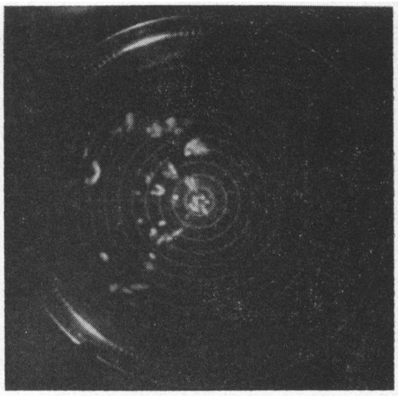

FIG. 16.
9:24 p.m. CST.

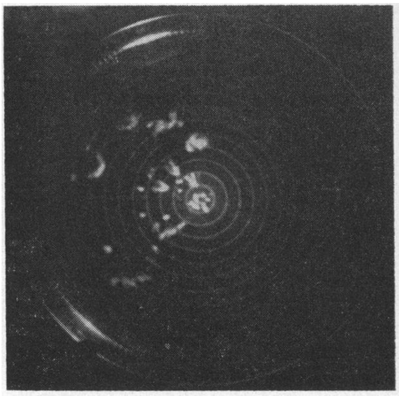

FIG. 17.
9:29 p.m. CST.

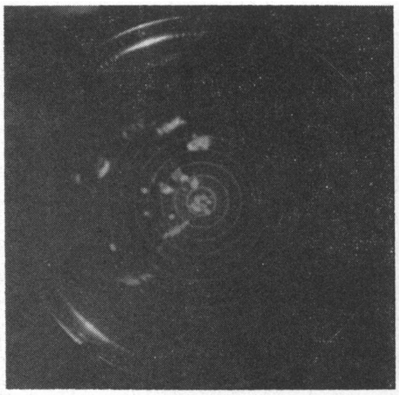

FIG. 18.
9:34 p.m. CST.

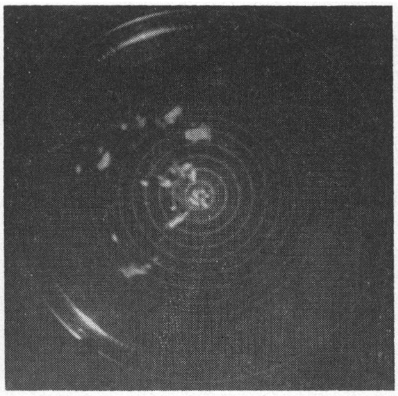

FIG. 19.
9:40 p.m. CST.

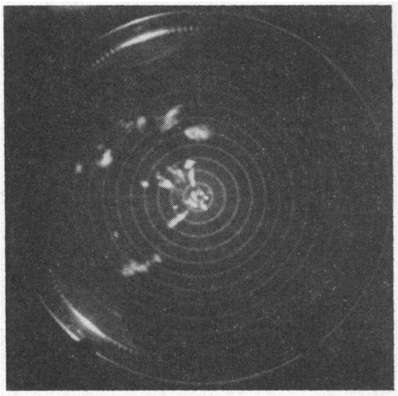

FIG. 20.
9:45 p.m. CST.

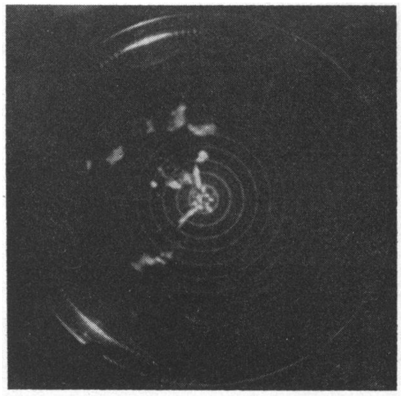

FIG. 21.
9:55 p.m. CST.

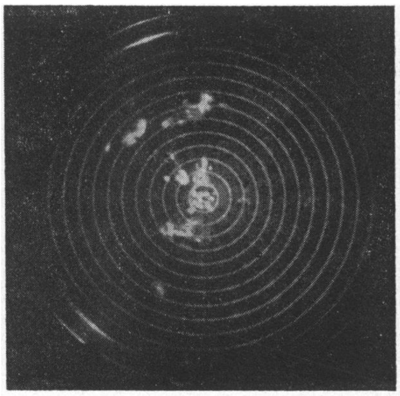

FIG. 22.
10:29 p.m. CST.

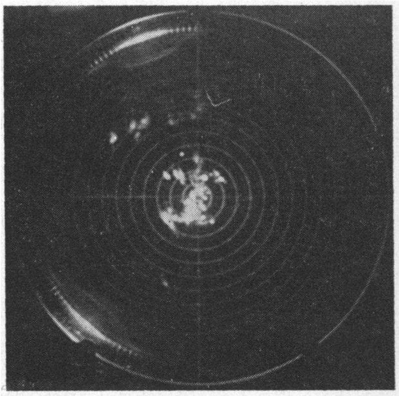

FIG. 23.
10:44 p.m. CST.

FIGURES 15–23. (Continuation of FIGURES 6–14).

age litter along this belt strewn toward the middle of the path of destruction. A witness at a point one mile northeast of Udall stated that the wind had been blowing from the southwest and suddenly shifted to a strong northeast. After a minute or so, the northeast wind eased off to a dead calm for about 30 seconds, during which time his ears popped, the attic cover blew off, some windows were blown out, and the house filled with dust coming up through the floor. After the calm, the wind blew destructively from the northwest. This sequence of events would fit a point slightly to the left of center of the path of a cyclonic vortex much larger than is usually associated with a tornado but comparable in size with the tornado cyclone described by Brooks [3].

RADAR

As stated earlier, the thunderstorm system that subsequently developed both the Blackwell and Udall tornadoes was first observed on the radar at 6:50 p.m. near Oklahoma City. FIGURE 6 shows the first radar film evidence of this echo at 206 degrees, 46 miles. On all of the radar photographs the range markers are 10 nautical miles. Azimuth indications on the photographs are in error by about 13 degrees, however the cross hairs indicate the true cardinal directions with north at the top. At the time of these exposures, the radar set was double pulsing which resulted in spurious images of most echoes more distant than about 50 miles. Therefore, all echoes occurring at the same azimuths but about 50 miles nearer the station than more distant echoes should be regarded with suspicion. The elevation of the antenna at the time of these photographs was zero degrees, making the half power point of the antenna beam fall approximately 4700 feet above the ground at 30 miles. The next 4 photographs, FIGURES 7–10, show the development and movement of this echo during the next two hours. At 8:55, FIGURE 10, the tornado echo which is centered about 25 miles north of Stillwater is beginning to become more sharply defined on the southwest side. The exposure at 8:59, FIGURE 11, was made one minute before the Blackwell tornado first reached the ground at a point about four miles south of the west edge of the echo boundary.

The exposures shown in FIGURES 12–16 were made at 5 minute intervals and show the development of the protuberance or hook on the left rear quadrant of the echo similar to those previously observed in Illinois [4] and Massachusetts [5] in 1953. It should be noted that the protuberance in this instance first begins to show about 15 minutes after the tornado reached the ground, as was apparently the case in the Worcester, Massachusetts tornado of June 9, 1953. In the Illinois tornado of April 9, 1953, the protuberance began to develop on the radar about 20 minutes prior to the time that the tornado first touched the ground [1]. The proximity of the tornado to the radar transmitter may account for the difference in time between the development of the radar echo protuberance and the tornado. The Illinois tornado developed only 10 miles from the radar site, whereas the Worcester tornado developed about 35 miles from the radar and the Blackwell tornado developed 26 miles for the radar.

FIGURES 17–20 show the completion of the cyclonic folding of the protuberance into the parent echo. The exposure in FIGURE 17 was made at the time that the tornado started through the outskirts of Blackwell at 347 degrees, 40 miles. The time of the photograph in FIGURE 19 is very near the time of development of the Udall tornado at 350 degrees, 45 miles from the radar site. In FIGURE 20, the hollow core in the echo which is no doubt associated with the tornadoes is still visible. At this time both the Blackwell and Udall tornadoes were on the ground, the Blackwell funnel very near the left edge of the hollow core and the Udall funnel near the right edge. In this photograph most of the echoes within a 40 mile radius are spurious and can be easily identified as such by their radial elongation. The echo centered at 345 degrees, 26 miles is real, however, and as it moves rapidly to the northeast it probably obscures all but the heaviest precipitation in the tornado echo on the next exposure, FIGURE 21.

The exposure in FIGURE 22 was made at about

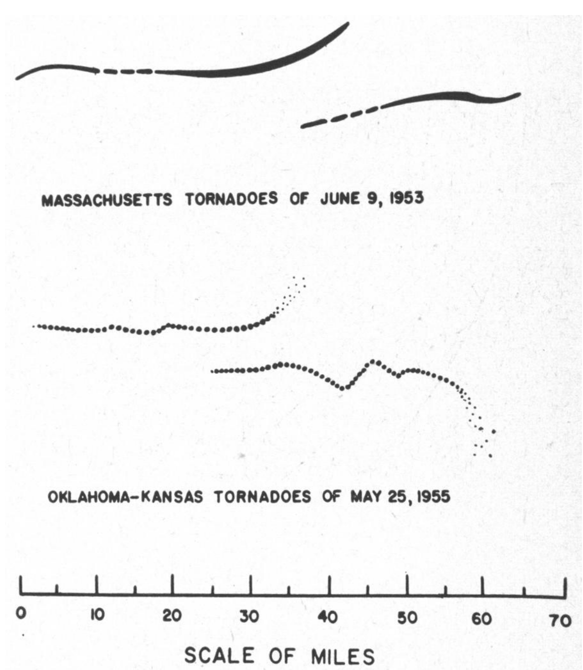

FIG. 24. Path comparison of Massachusetts and Oklahoma–Kansas tornadoes.

the time the tornado struck Udall, Kansas at 359 degrees, 75 miles. In FIGURE 23, 15 minutes later, the echo is almost dissipated.

OTHER OBSERVATIONS ON THE STORMS

There is a striking similarity in the development of these two tornadoes with the Massachusetts tornadoes of June 9, 1953, as reported by Penn, Pierce and McGuire [5]. First, the protuberance develops on the radar echo some 15 to 20 minutes after the formation of the first tornado, and secondly, another tornado develops a few miles to the right of the first at about the time that the first begins to curve to the left and some 15 to 20 minutes before the first one dissipates. FIGURE 24 shows a comparison of the paths of the Massa-

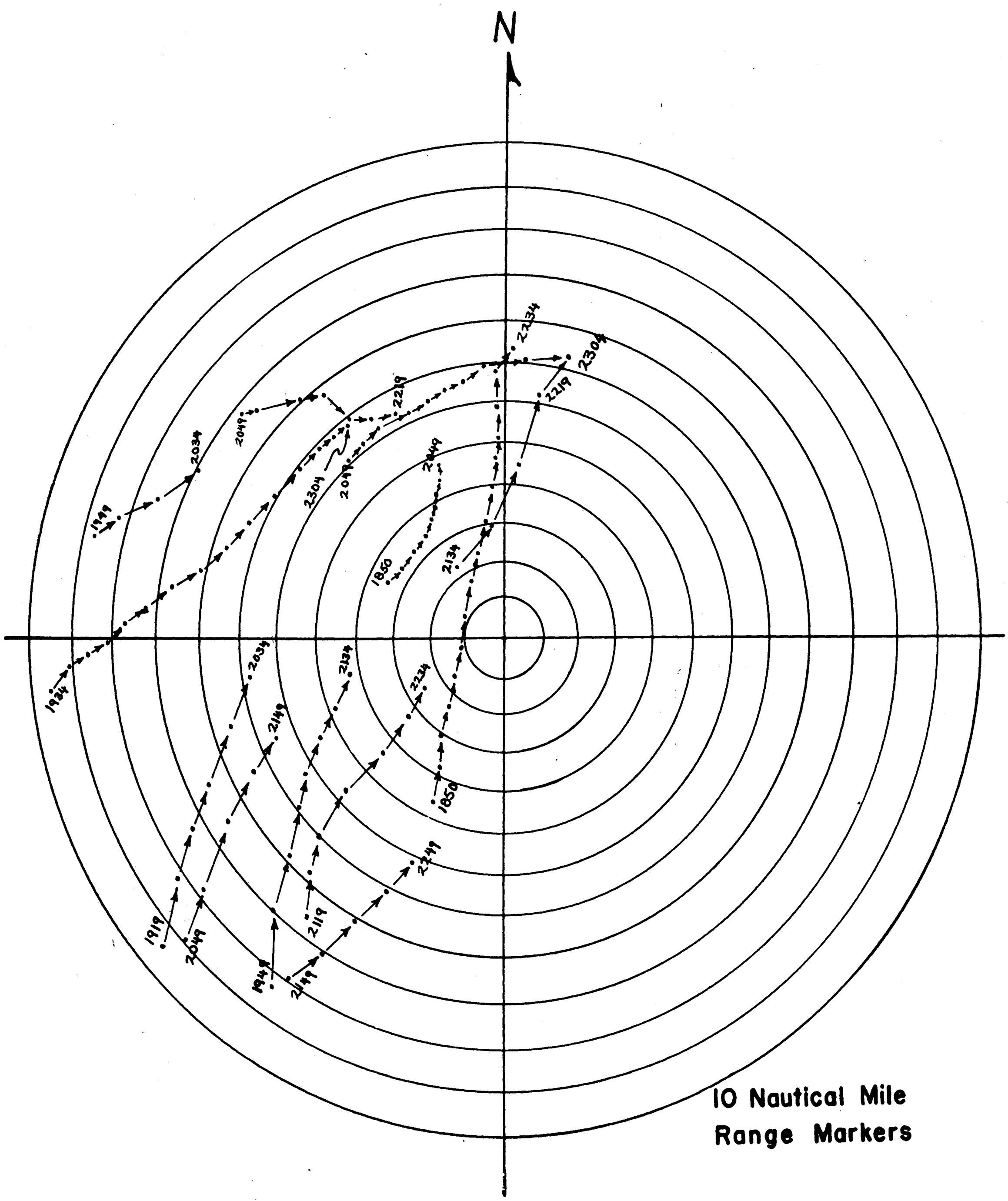

FIG. 25. Trajectories of major echoes during evening of tornadoes.

chusetts and Blackwell-Udall tornadoes on the same scale. The general direction of the Massachusetts storm was east-southeast and the Oklahoma storm north.

FIGURE 25 shows the approximate trajectories of most echoes observed during the evening of May 25th. Each dot represents the approximate center of a major echo or cluster of small echoes at 15 minute intervals, and the times shown at the beginnings and endings of the trajectories are approximate times of formation and dissipation on the radar display. During their existence, some echoes changed shape, split into pieces, or united with other small ones to form larger masses such that it was impossible to show these trajectories exactly as they occurred. It is interesting to note that, in general, the trajectories seem to converge in the area east of Udall.

It was also noted that the apparent speed of movement of certain echoes is much greater than the speed of others. The center of the echo that is first noticed at 6:50 p.m. (1850), at 294 degrees, has an apparent average speed of 18 knots; the tornado echo that developed at the same time at 204 degrees, 46 miles, moved at a speed of 33 knots; and the echo that was first observed at 9:34 p.m. (2134), 325 degrees, 23 miles, had a speed of about 63 knots. The apparent speed of echoes passing through the area of the tornadoes increased from 18 to 63 knots in a little more than one hour.

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Editorial Notice

All manuscripts for technical articles, Correspondence items, and Reviews sent to the Editor of the *Bulletin* in the future should be directed to his new address: William E. Hardy, P. O. Box 592, Gainesville, Ga.

As previously announced in the March 1956 issue of the *Bulletin,* page 128, several sections of the *Bulletin* are now prepared in the Office of the Executive Secretary and submitted to press for publication. With the most recent addition, About Our Members, the sections include: Minutes of the Council, About Our Corporation Members, News From Our Branches, Necrology, News and Notes, Announcements, Meetings of the AMS (the Calendar, announcement of deadlines, meeting programs), the Professional Directory and all other advertising.

Bulletin material for the categories mentioned above are edited and prepared by Ruth Anderson and Frances Ashley in the AMS headquarters office. Members are urged again to submit material for these sections of the magazine at any time to the AMS address at 3 Joy Street, Boston 8, Mass. All changes of address, inquiries, publication orders should be sent to this address of the Society. Often the address of Lancaster Press is used in error which delays action on the requests being made by members and subscribers.