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I. COMMENTARY

The Editor of Storm Track attended the 12th Conference on Severe Local Storms in San Antonio this month. It was great to meet old friends again and make some new ones. As with previous conferences, one had to read and listen with a practiced eye and ear to "separate the wheat from the chaff." Some papers presented new findings, others gave documentation to verify prior models, and several substantially re-invented the wheel by reporting long known storm characteristics as if discovered for the first time. And of course, there were films -- awesome slides and movies -- of twisting vortex columns, stretching and grinding -irresistibly- beneath seething black cumulus oceans, inverted at flood tide . . . a world transformed! The Editor also showed some new slides, including several of a storm near Garden City (reported in more detail later in this issue), which generated some follow-up interest, by conference attendees and ST subscribers. The dominant memory from this Conference, however (like the last one attended in Omaha), is the easy camaraderie and friendship among chasers and the genuine interest in each other's storm experiences. The science is still young enough that unique storm encounters continue to confound and perplex. The recounting of "war stories" still commands a respectful silence by those trying to puzzle through what is really going on in that which is -at, once- the most common place and the most strange.

II. ROSTER
III. LETTERS TO THE EDITOR
IV. BULLETIN BOARD/COMMERCIAL MARKET -$- FOR PICTURES
V. CAMERA TIPS VI. TRAVEL TIPS FUNNEL FUNNIES

VIII. FEATURE #1

HISTORY OF THUNDERSTORM FORECASTING
Part II: The Instruments

By John F. Weaver

The age of weather lore and climatology did not come to a sudden, resounding halt with the invention of the first weather instrument. Indeed, local climatology continues to play a major role in modern forecasting. When all the maps are analyzed, all the data are synthesized, and all the numerical products studied, the successful local forecaster inputs what is known about the local climatology. But as most of us are aware, climatology is not nearly enough to supply the specific and detailed forecast required by today's complex society. The maps, analyses and computer products form the mainstay of the forecast, and basic to all of these is measurement.

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The ability to record the four basic parameters of synoptic meteorology (pressure, temperature, humidity and winds) have only been with us a few hundred years. This is not to say that measurements weren't made before then. Wind 'measurements' were made from antiquity in terms of compass points and subjective statements of strength. Many early proverbs in weather lore referred to wind direction. Rainfall measurements were taken in many countries even before the time of Christ. However, the development of instruments capable of moving meteorology into the scientific era awaited the general advances which came with the Renaissance.

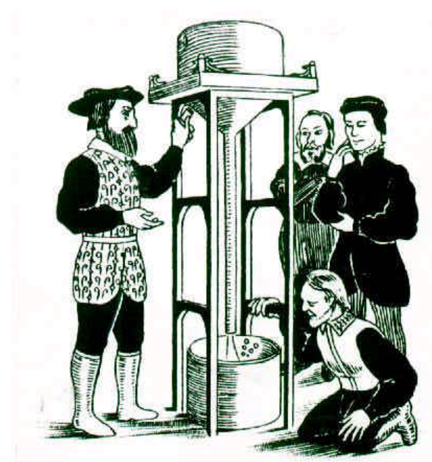
The first parameter to be studied was humidity. It seems strange to this author (as it has to many meteorological historians) that this should be the case. Aristotle, by establishing air as a singular element, had successfully 'misled' science over the centuries. His teaching went so far as to assume that evaporating water somehow turned into 'air,' then back to water, during the hydrological cycle. This idea was generally accepted until the 'atomic' theory of matter suggested by Rene Descartes) made its appearance in the early 1600's. It was then that water vapor began to be treated as a separate entity. Yet, the instrument to measure humidity was invented almost two hundred years earlier. In fact, two men working independently appear to have discovered the hygroscopic principle at very nearly the same time. In a book published in 1450 AD, the German mathematician Cardinal Nicolas de Cusa described how he had found that the weight of a ball of wool increased with increasing dampness in the air. A book published two years later by philosopher, writer, architect and scientist Leone Alberti, noted the fact that a dry sponge increases in weight on moist days.

He suggested that a sponge on a scale balance could be used to keep track of humidity changes. Some fifty years later, Leonardo da Vinci made two very detailed drawings of hygrometers based on Albertis concept and (somehow), until very recently, ended up with credit for the invention in most texts.

In passing, it should be noted that other means of measuring humidity were devised at later dates. In 1655, Ferdinand II, Grand Duke of Tuscany, while experimenting with condensed moisture on the outside of a drinking glass, discovered the principle later used for the condensation hygrometer. In 1681, Francesco Eschinardi noted the fact that a wetted thermometer cools. This principle led eventually to the psychrometer, or 'wet-bulb' thermometer. Space limitations prevent a detailed discussion of these instruments, and their complex development. The interested reader is urged to consult any good encyclopedia for the particulars.

As with most basic inventions, history has clouded the events leading to the invention of the thermometer. As best this author can reconstruct these events, they are as follows. In 1575 AD, a book was translated concerning the experience of Philo of Byzantium (roughly 300 BC) and Hero of Alexandria. One of Philo's experiments discussed the fact that water can be forced from a nearly closed vessel by applying heat. In the 1590's, Galileo Galilei became interested in this principle. He contained a fluid in a slander glass tube which stood in a goblet of the same fluid. He found that heat would cause the liquid to rise in the tube in proportion to the amount of heat added. His device was actually a 'thermoscope,' and not a thermometer in the strictest sense, since it had no scale (Santorio Santorre, a physician, is credited with first, scaling the thermometer in 1612). Furthermore, although his general hypothesis was correct, the actual device failed to be precise, since it was exposed to atmospheric pressure variations as well as those due to heat,. Evangelista Torricelli deduced this fact in the late 1640's. Torricelli's sponsor, the Duke of Tuscany, then constructed the first instrument in which the fluid was sealed in a glass tube, and which had a fixed scale (1654). All of these events were important to the development of the thermometer -- the decision as to who 'invented' it is left to the reader.

Mention should also be given the man whose name is most often associated with the thermometer, G. D. Fahrenheit, (1686-1736). His contribution involved the calibration of the thermometer to the freezing/boiling points of water. Furthermore, he came up with the idea of using liquid mercury as his fluid, which gave the thermometer a range encompassing the full scale of atmospheric temperatures.



The development of the barometer was triggered in a most peculiar fashion. In 1630, an Italian miner (Giovanni Baliani) wrote a letter to Galileo to inquire why a 21 meter tall siphon wouldn't work. Galileo answered the man by stating that the effect was likely due to the extreme weight of the water breaking away from what was probably a vacuum in the top part of the siphon. This led Galileo to the idea that vacuums might be studied using siphons, and this he suggested to a group of scientists working in Rome -- many of which had been his pupils. One of these (Gasparo Berti) performed the following experiment. A long, hollow pipe standing vertical in a bucket of water, had a small metal cask attached to its upper end. Petcocks were installed both at the lower end of the pipe and in the top of the cask. Next, the cask and pipe were filled with water. The top petcock was closed, then the bottom one opened. Much of the water left the cask, but some remained suspended; AND when the valve on the cask was opened, air rushed in with a loud noise.
Another member of the group became fascinated with the concept. In the early 1640's, Torricelli continued the experiments and decided he might be able to use the principle to measure 'the weight of the air overhead.' With a young pupil, Vincenzio Vivianni, Torricelli went on to study many variations of Berti's work. Though Torricelli never built a truly successful barometer, and never scaled the barometers he did build, he is given full credit for the invention -since he was the first to visualize using the apparatus to measure the pressure of the atmosphere. He even went so far as to suggest that barometers be used to track and record changes in pressure over long periods of time. The person that finally had need of an accurate and scaled barometer (and built it!) was Blaise Pascal, who -in 1648- suggested to fellow researcher Florin Perier, that two calibrated instruments might be used to find the variation or atmospheric pressure with height. One was taken to the top of a high mountain (the Puy-de-Dome) while the other remained below as a control. This was the first 'sounding' of the atmosphere.

To end the discussion on barometers, I should add a few words about the aneroid barometer. In 1663, Pascal suggested a sort of sealed, cylindrical accordion-like contraption which could be used as an alternative method for measuring pressure. But he never built it. The most probable reason that neither man actually constructed their instrument was that the design was beyond the ability of the craftsmen of the day. For the next one hundred-fifty years, ideas were suggested and tried, but it remained for Lucien Vidie to construct a working aneroid in 1843. Most probably, this was simply a case of an idea patiently awaiting the technology to carry it out.

As with instrumentation, quantitative wind measuring devices arrived about the time of the Renaissance. The first known suggestion for an instrument to measure the wind was put forth in a little known book on mathematics by Leone Alberti in about 1450. The device employed a wind vane for direction and had a small piece of wood that deflected along a scale when the wind blew. As in the case of the hygrometer, Leonardo da Vinci presented a very detailed drawing of the device in the Codex Atlanticus and was subsequently credited with its invention. However, it is likely that da Vinci was not purposely trying to claim historical credit, since in another work he makes reference to Alberti's anemometer. The mistake seems to have been made by historians, fascinated by all the various devices in the Codex, but not generally aware of his other works. As to the actual building of the device, history is again unclear. It would seem that an anemometer must have been built and used during the 1500's, considering the fascination of the time for instrumentation. Nevertheless, the first record of a working anemometer concerns that constructed by Robert Hooke in 1664. His instrument was similar enough in design and operation to Alberti's that, even though Hooke made no mention of the earlier device, it is assumed the idea for his anemometer came from Alberti or da Vinci.

Thus, by the late 1600's, the instruments necessary to define the atmosphere had been assembled. It was now incumbent on the 'weatherman' to put them to use.

VII. FEATURE #2

Pulsing Microbursts Along the Southwest Flank of a Severe Thunderstorm

By David Hoadley

On May 30, 1978, an isolated severe thunderstorm developed ahead of a dry line, northeast of Garden City, Kansas. It moved slowly east and southeast, dropping 1-3" hail for over an hour (one reported to 9" near Spearville), 1-2" rains, several small tornadoes and many small microbursts radiating southwesterly from the storm's base. The last feature was of special interest. to the ST Editor, who is unaware of any other accounts in the literature on downbursts or microbursts extending primarily in a southwesterly direction. Fujita's Manual of Downburst Identification for Project Nimrod and other recent papers show many examples of easterly radiating downbursts. The Garden City storm is the first one in my experience to show predominantly westerly and southwesterly microbursts. Also, and equally interesting, was the repeated recovery and regeneration of these events within a comparatively small area, as if the storm was going through some kind of cycle of limited venting.

At 1200 CDT, a 1003.5 mb low was located in southeastern Colorado with a preceding dry line between Trinidad 33 deg F, La Junta 42 deg F, and Dodge City 62 deg F (Fig. 1). A thermal ridge extended from southeastern Colorado through western Kansas, and a moist ridge from central Oklahoma through central Kansas turning westerly through southwestern Nebraska and northeastern Colorado.

An isolated pocket of TCU and small CBs were noted by 2:45 CDT within 25-50 miles north to northeast of Garden City. The NWS issued a tornado watch from 4:00-10:00 PM CDT for southwestern Kansas to northeastern Nebraska. The Garden City storm developed in the extreme southwest corner of the watch. By 4:00 PM CDT, except for small, turbulent but weak CBs about 50 miles northeast of the city, the only significant cell was one small, isolated CB base building slowly 20 miles north-northeast, with an enormous anvil vis-à-vis the base diameter (Fig. 2). The first severe weather was a microburst at 4:53 PM CDT (Shown as "M-1" in Fig. 3.

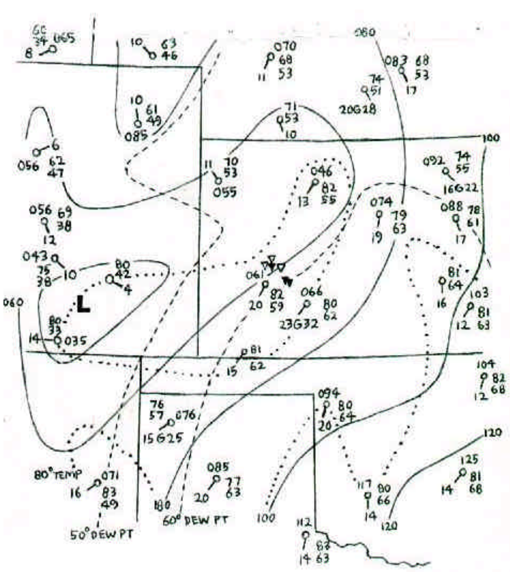


Figure 1

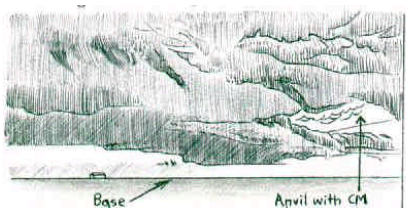


Figure 2. Looking SW from 15.9 mi N of Site A on highway. Illustration from slide.

No visible rain was seen and the first hail (pea size) wasn't encountered until 5:04 PM CDT (Hereafter all times are given as PM CDT) at the location of F-18. Subsequently, a proliferation of microbursts, rotating wall clouds and small short-lived funnels and tornadoes sprinkled themselves across the plains northeast, of Garden City. Fig. 3 plots these in numbered sequential order by nature of occurrence (M = microburst, RC=rotating cloud base, RD=rotating dust on ground, RW=rotating wall cloud, F=funnel and T = tornado). The double-line on the highway/farm road indicates the chase route. A few numbered spots are designated on this chase route, which locate photographic sites at the time of and corresponding to each numbered severe weather event in Fig. 3. Additionally, a time scale is given below this Figure, to time-spot each sighting.

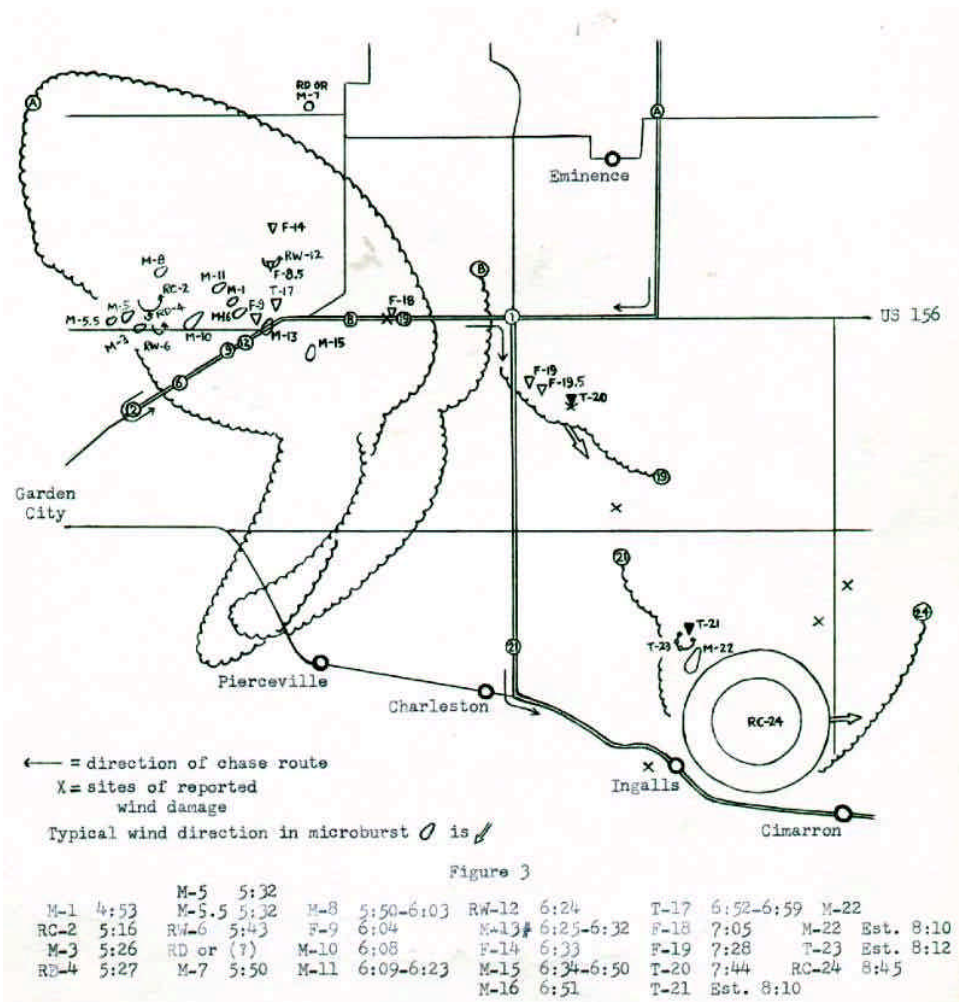


Figure 3. #Filming site for F-14, M-15, M-16 and T-17.

An approximate outline of the cell base is shown by lines extending from circlet "A, B, 19, 21" and "24," which are coincident. with the approximate base location within visual range at the time of the severe event, numbered for that time (e.g. RC-24 = cloud base outline 24, F-19 = 19, etc.). One prominent CM area was noted southeast of the storm and was photographed from site F-18 at 5:01.

Fifty one slides were taken of the storm, and most had specific odometer/time notations separately recorded. Of course, all distance estimates from road-side to observed events in Fig. 3 are approximate, based on the photographer's many years of experience (This suggests the need for a future ST article on how accurately we estimate cloud base distance; a key ability for training spotters, who should have a passing knowledge of whether the tornado is 5 miles away or 1 mile away!! -Probably should be Phase II of Spotter training by NWS, after learning what to look for).

Fig. 4 shows a characteristic microburst from this storm, as it moves southwesterly from the CB base. After the dust, reaches its highest altitude, it dissipated and gradually was swept back into the storm's base on returning inflow. Two specific encounters

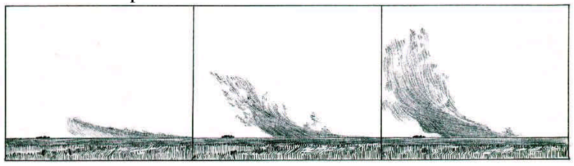


Figure 4. Illustration from slide.

further characterize these events. Microburst M-13 developed about 500 feet northeast of the photographer and moved ominously toward him. It appeared to be like some of the other larger ones in the area but developed far enough away to allow time to enter the car and turn it into the approaching wind(5-7 seconds). He emerged, just after the peak gust, with difficulty, and estimated wind speed at 60-70 MPH in warm outflow. This flow changed after a minute or so into inflow. Apparently, the photographer was sited and sighting along an outflow/inflow boundary, where at least 20-30 similar microbursts occurred (too many to photograph economically). There appeared to be no clear pattern, except for a late developing trend to begin occurring further southeast as the cell base began intensifying and drifting in that direction.

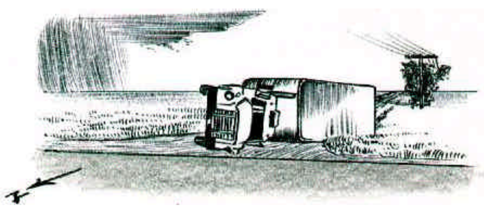


Figure 5. Illustration from slide.

If the previous wind estimate was correct, then the initial touchdown 500 feet northeast probably involved higher winds -perhaps 80-90 MPH, This high side estimate tends to be supported by the second detailed event, the overturning of a semi-trailer truck (Fig. 5) at location F-18 (6:40 CDT). The estimated truck location prior to overturning (unfortunately no record was taken from the tense and excitable witnesses) was perpendicular to US 156, facing north on a farm road. Assuming an empty trailer and a 45 deg wind angle (characteristic of most microbursts this day), an 80-90 MPH wind might, have been sufficient to turn this rig. What do you think?
The photographer was reasonably certain that no tornado had done this work, since he was continuously alert to and observing all parts of the storm, and the trucks distance from him of 3.4 miles at the time of overturning was not obscured by rain. In summary, 20-30 microbursts occurred over a two hour period from 4:53 to at least 6:51, while the storm was in its organizing stage and either stationary or drifting slowly east-southeast. From about 7:44 to 8:10, at least one more was observed, associated with a brief tornado north of Ingalls (Fig. 6). There may have been more microbursts throughout this second stage of the storm (since about 7:00), when it began to move more rapidly to the southeast and raining; heavily, but the viewing angle to the east provided poor contrast for observation.

In its final, and apparently most wind-destructive stage north of Cimarron, a dramatic onion ring shaped cloud base was observed. Blowing dust obscured all visibility from the lower, inner ring to the ground (Fig. 7). In fact, visibility within this core area was likely to have been near zero, with only a reddish opaque tint through windshields or windows. The photographer took two wide angle pictures of the rings but dispaired of encompassing all of this formation, even in a dozen pictures (he was located under the outermost ring).

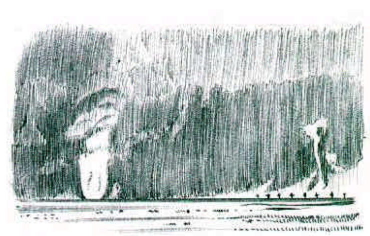


*Figure 6. *T-21 and M-22. Illustration from slide.*

The diameter of the largest ring appeared comparatively small vis-à-vis the overall storm and may have been less than five miles in diameter. Noteworthy during its maximum organization, about 8:45, was that all rings were -apparently- perfectly circular. The photographer was unable to see any irregularity in this formation in any of the rings for several minutes, as if they had been drawn by an architect's protractor. Figure 7 attempts to capture this occasion, partly based on slides taken at the time. Figures 8 and 9 show two tornadoes observed, respectively, at T-17 and T-23 in Fig. 3.

Figure 10 illustrates one interesting, additional insight of the photographer, which may not be original to others but was new to him. Tornado damage was reported from this small vortex, near the dust on the ground. It may be that downburst triggering of small events like this are the real producers of damage and not the weak vortex that, results. There- fore, even though visible funnels are present (and may be reported by police or trained spotters), they may not be the actual instruments of destruction.

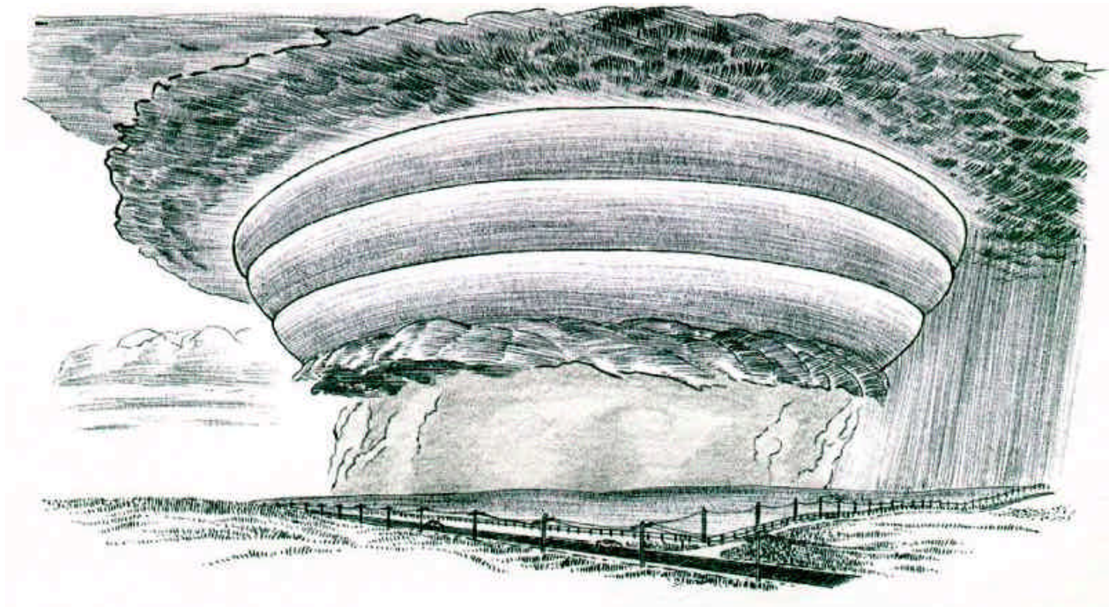
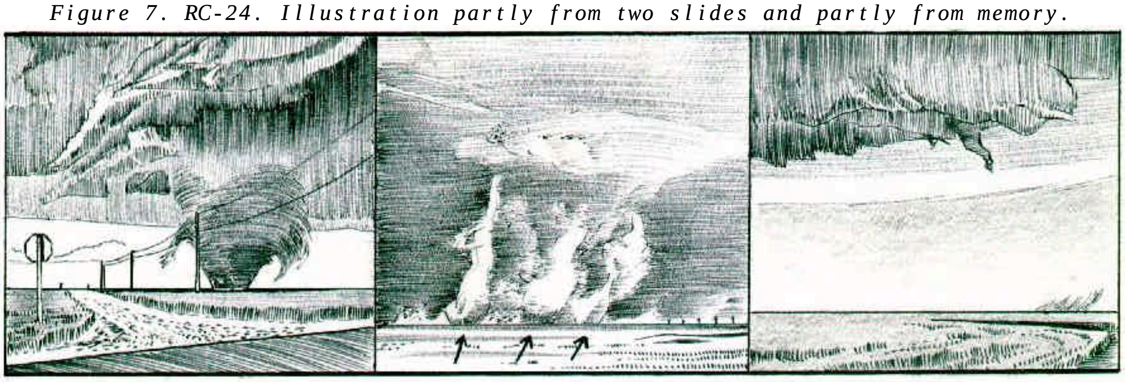


Figure 7. RC-24. Illustration partly from two slides and partly from memory.



Figures 8 (T-17), 9 (T-23), and 10 (T-20). Illustration from slide.

In summary, a small complex but destructive storm developed northeast of Garden City, Kansas. It developed slowly, ahead of a dryline, and produced numerous microbursts (some damaging) which outflowed southwesterly from the storm's base. At least two tornadoes, three tornadic suction vortices and several funnels were photographed, all short lived and none exceeding 15 seconds. Over a million dollars damage was done in sparsely settled farmland (farm buildings, drainage pipes, crops). In its final stage, a striking onion ring cloud base capped a swirling dust wall that prevented observation, even with clear back lighting from a setting sun. The author briefly considered entering this maelstrom to record what was going on inside, but reconsidered (and survived to write this account). Was Fig. 7 the actual structural outline of a highly organized meso-low? What explains a pulsing microburst (or is it something else), which doesn't vent a substantial mass of the cell at one time but, repeats itself again and again? I'd be interested in your comments.

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Next issue will Feature Part III of John Weaver's continuing series on the History of Thunderstorm Forecasting: The Air. Also planned is an unusual hail story from Jan Curtis, a capsule analysis on why chasers chase, photography hints, an illustrated "test page" on estimating distances from tornadoes, and for Funnel "Funnies; The Sophisticated Chaser.

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PS - If you haven't already noted, Volume 4 incorrectly has two Number 5's. The November issue should read "No. 6."