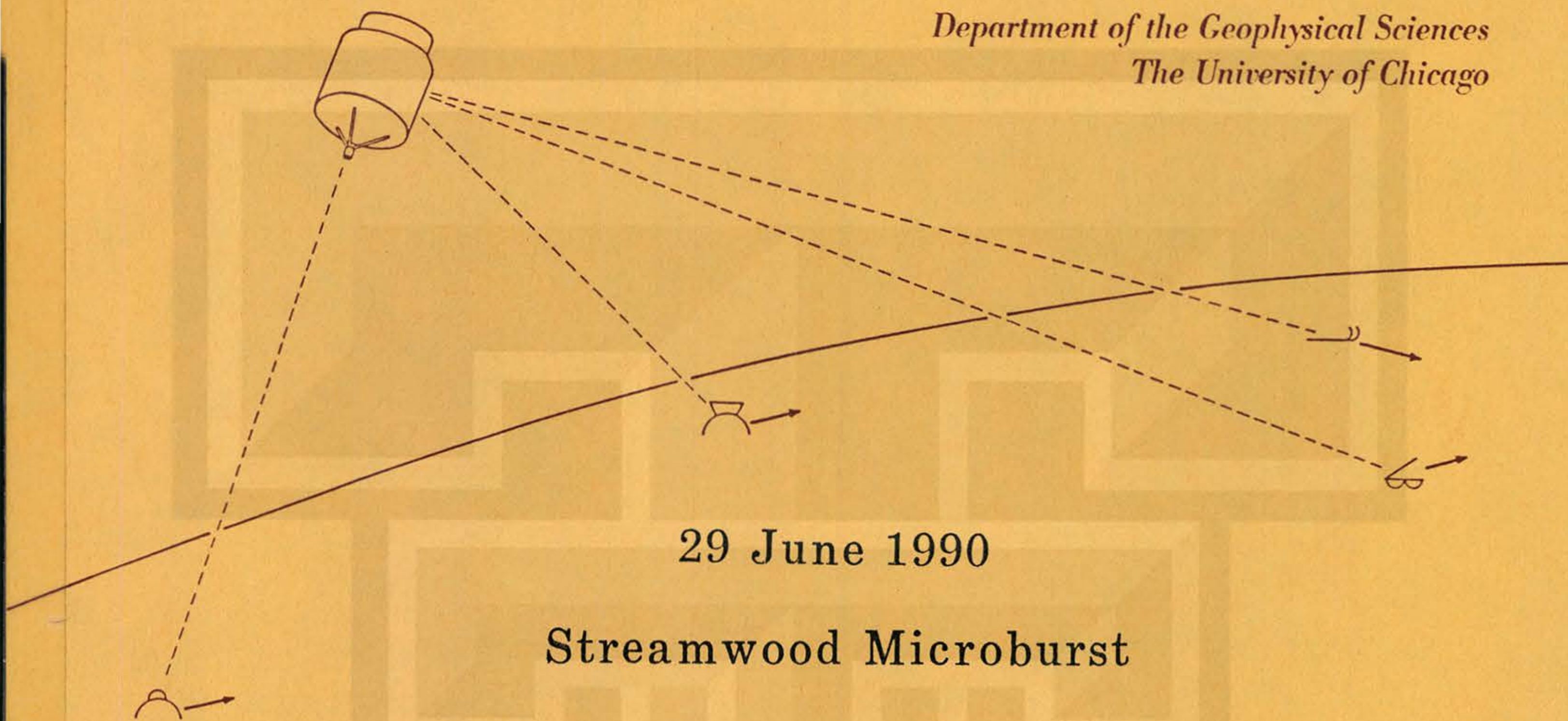
WIND RESEARCH LABORATORY

Department of the Geophysical Sciences
The University of Chicago



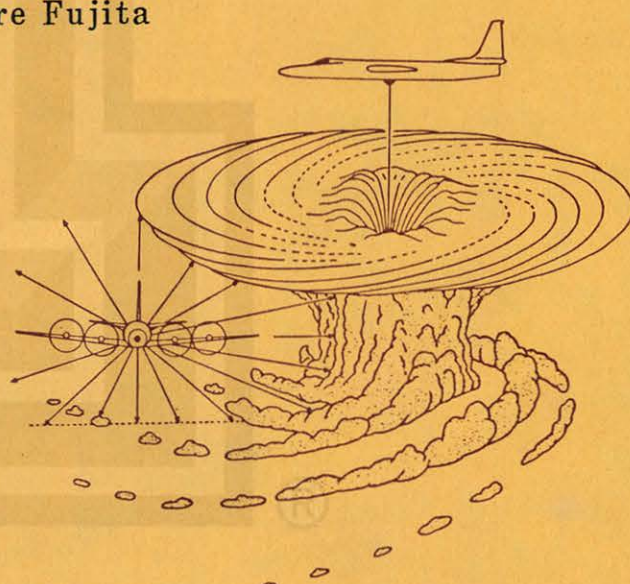
29 June 1990

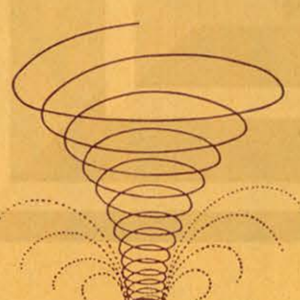
Streamwood Microburst

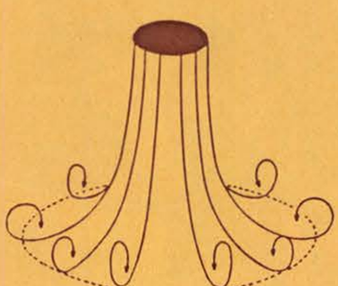
Final Report to NCAR

NSF/UCAR Grant S9129

by T. Theodore Fujita







WRL Report 236

December 1991

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Streamwood Microburst of

29 June 1990

by T. Theodore Fujita

This study revealed that there were two microbursts in Streamwood, Illinois in the early morning of 29 June. They are identified as No.1 over the industrial park and No.2 over a nearby forest. The former was rated as F2 with estimated 130 mph maximum windspeed and the latter, as F1 with estimated windspeed of 90 mph. The average horizontal dimensions were 400 m (1,300') and 250 m (800'), respectively (Fig. 1). They were rather small in size, but Microburst No.1 could endanger aircraft operations at critical altitude by reducing IAS down to less than 50 kts if it occurs at the wrong time at the wrong location.

1. Wind Effects at Industrial Park

At the south edge of the industrial park, southerly winds increased from approximately 70 mph (31 m/s) to 120 mph (58 m/s) within a distance of 30 m. While neglecting the diverging streamlines, the divergence value computed from the windspeed differential is as large as 0.9 per sec. This magnitude of divergence results in a 9-m/s downdraft at 10-m AGL height.

In order to substantiate the nature of the microburst winds, both direction and speed, five aerial photographs, A through F, used in producing the damage map (Fig. 2) were located on the detailed map of the industrial park. The overall photo A (Fig. 3) reveals the abrupt increase in the southerly winds at the south edge of the industrial park. Photos B and C show the southwest section of the industrial park damaged by the 100 to 120 mph winds from the south-southeast (Figs. 4 and 5).

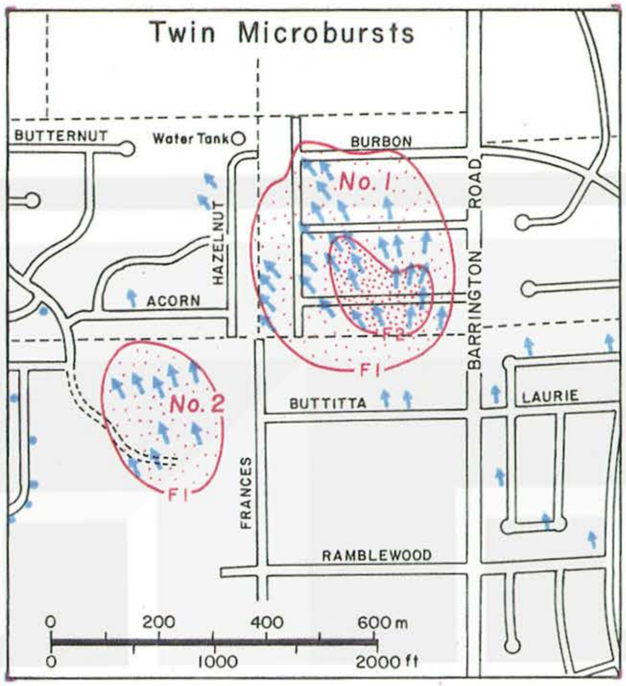


Fig. 1 Twin Microbursts No.1 and No.2 which descended in Streamwood over the industrial park and over a small forest, respectively.

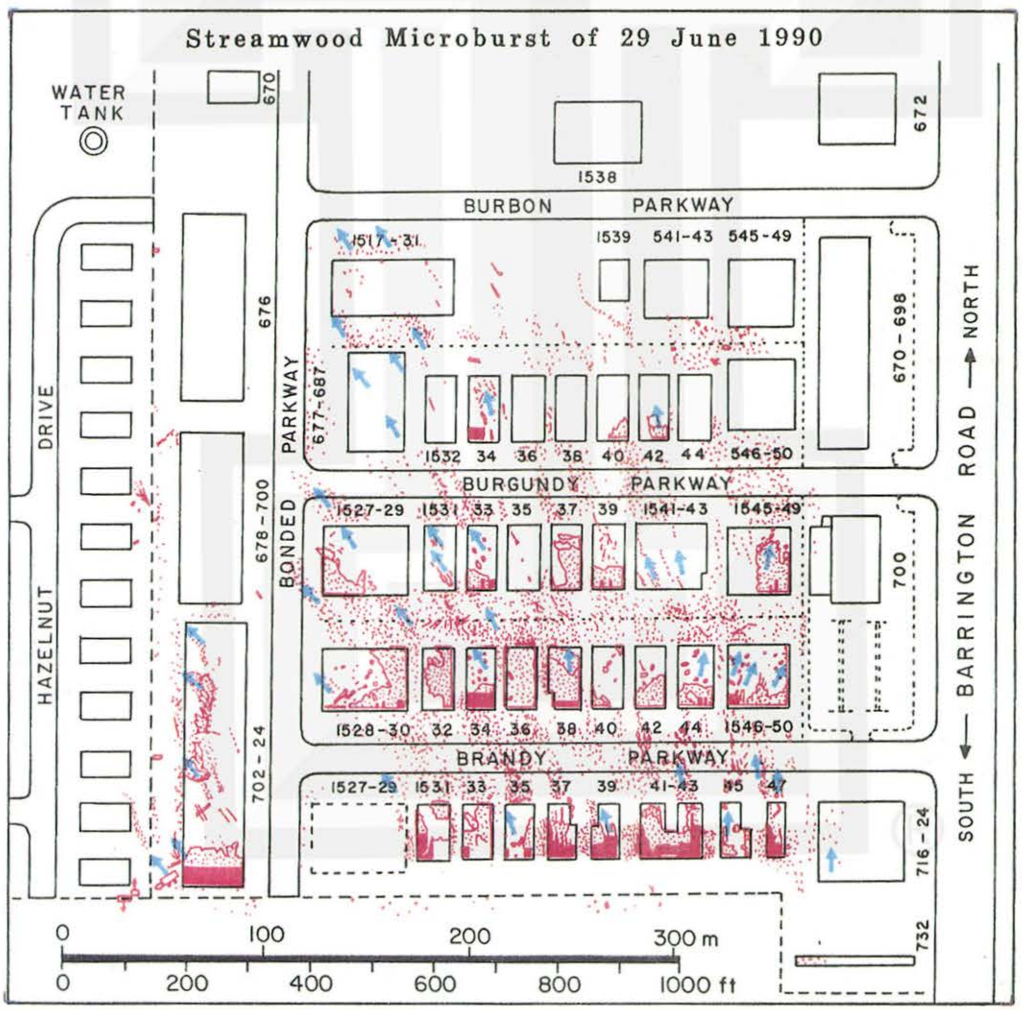


Fig. 2 Detailed damage map of the industrial park.

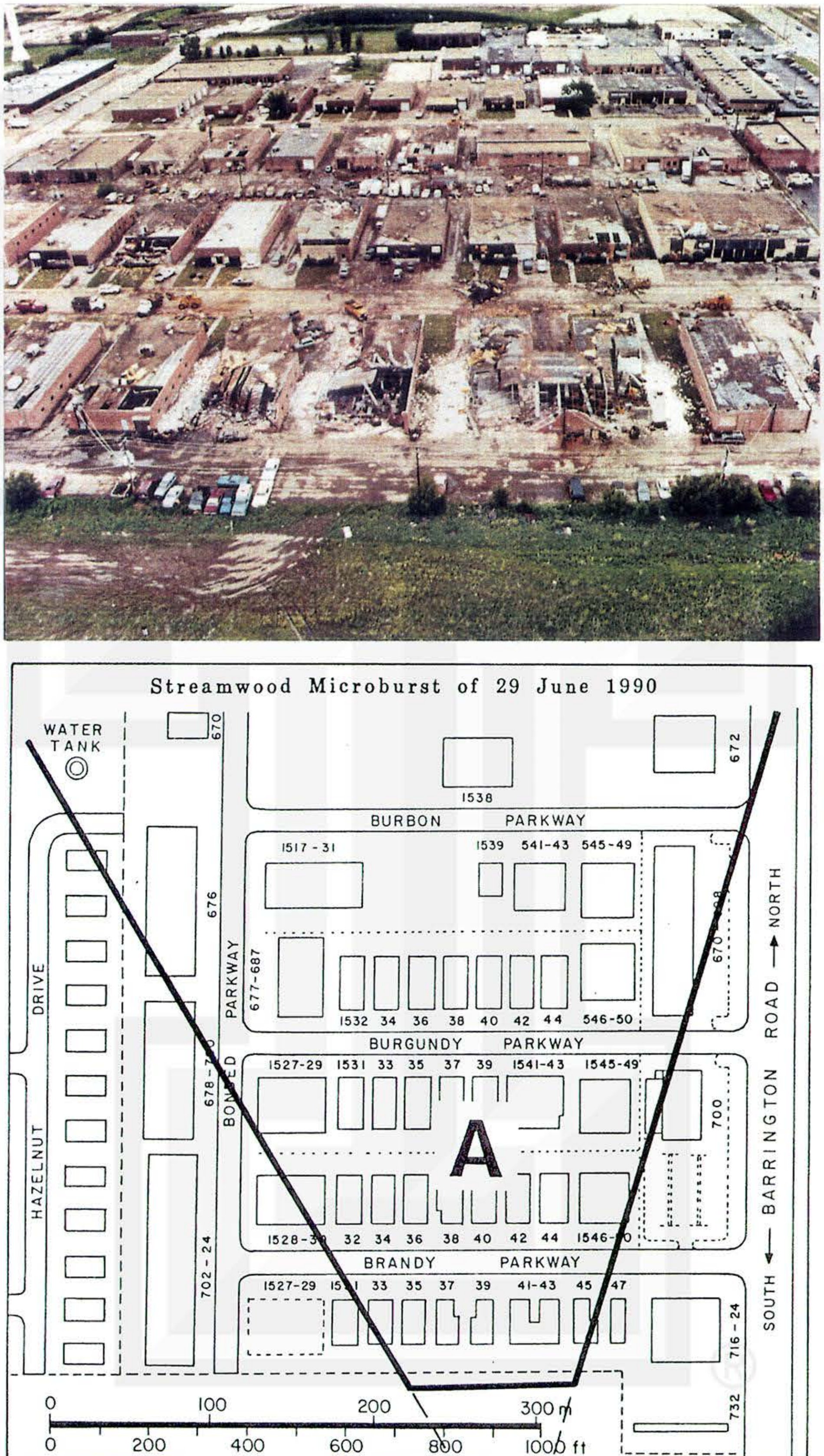
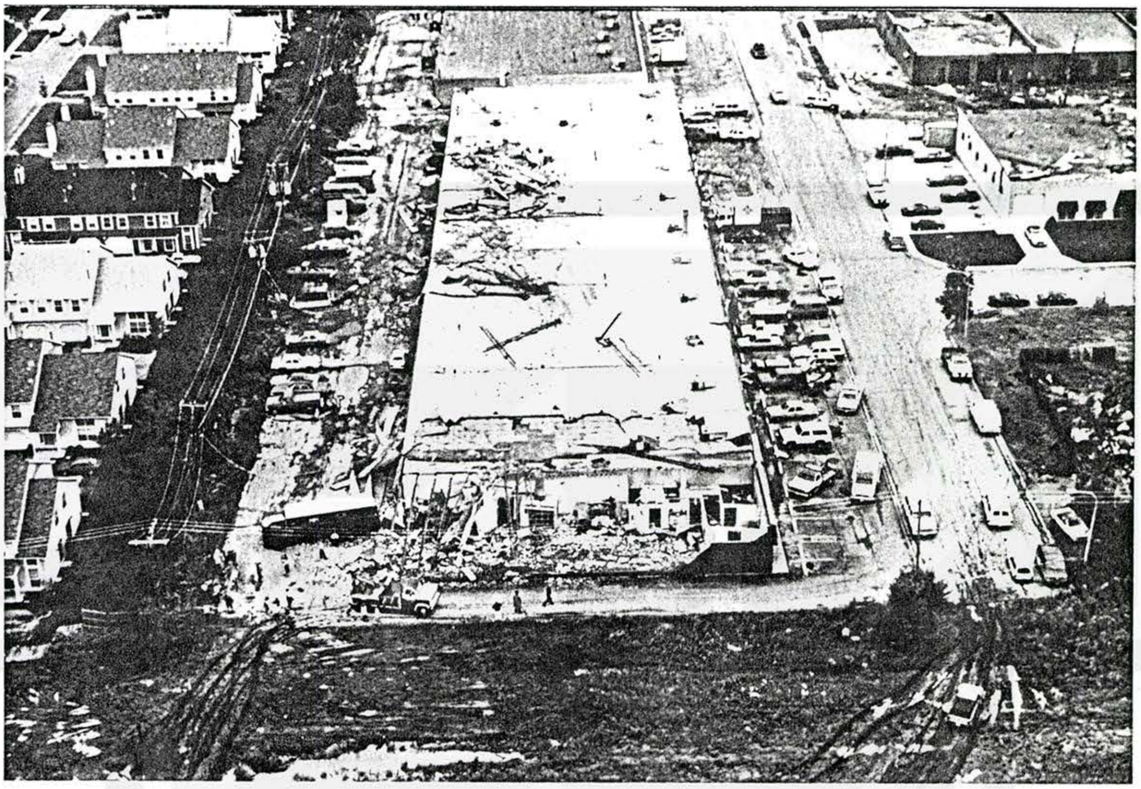


Fig. 3 Aerial photo A showing the sudden increase in the microburst winds along the south edge of the industrial park.



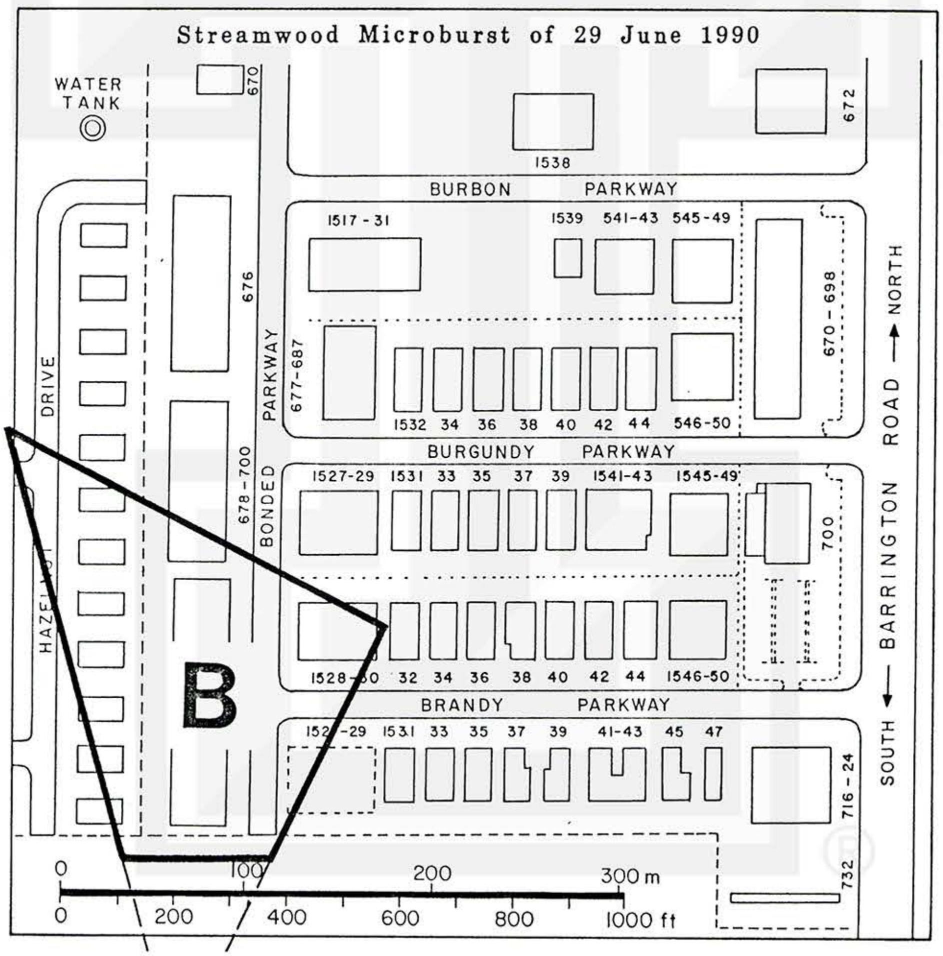


Fig. 4 Damage of a large commercial building at 702-724 Bonded Parkway. A truck was pushed over near the southwest corner of the building.

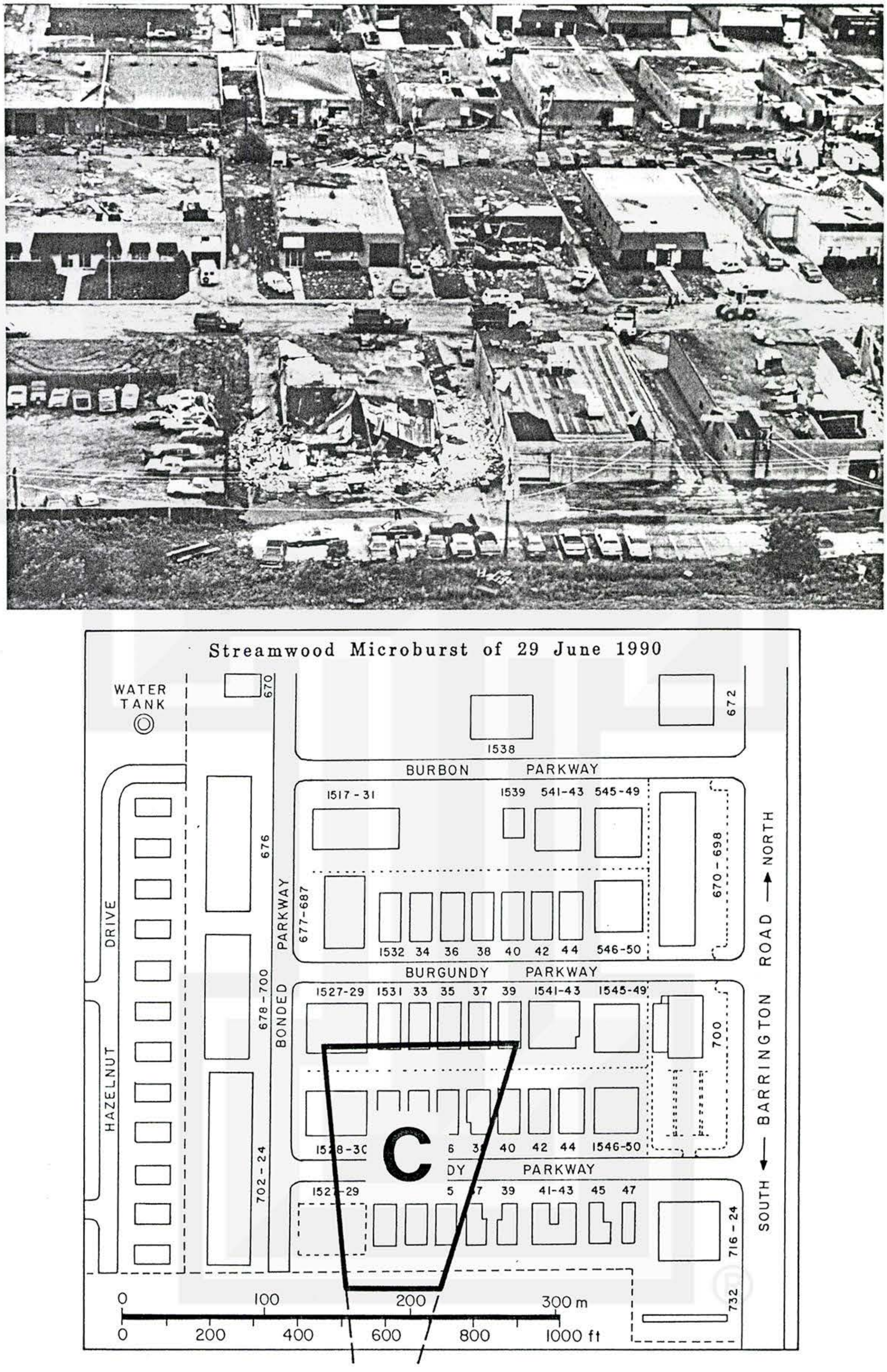
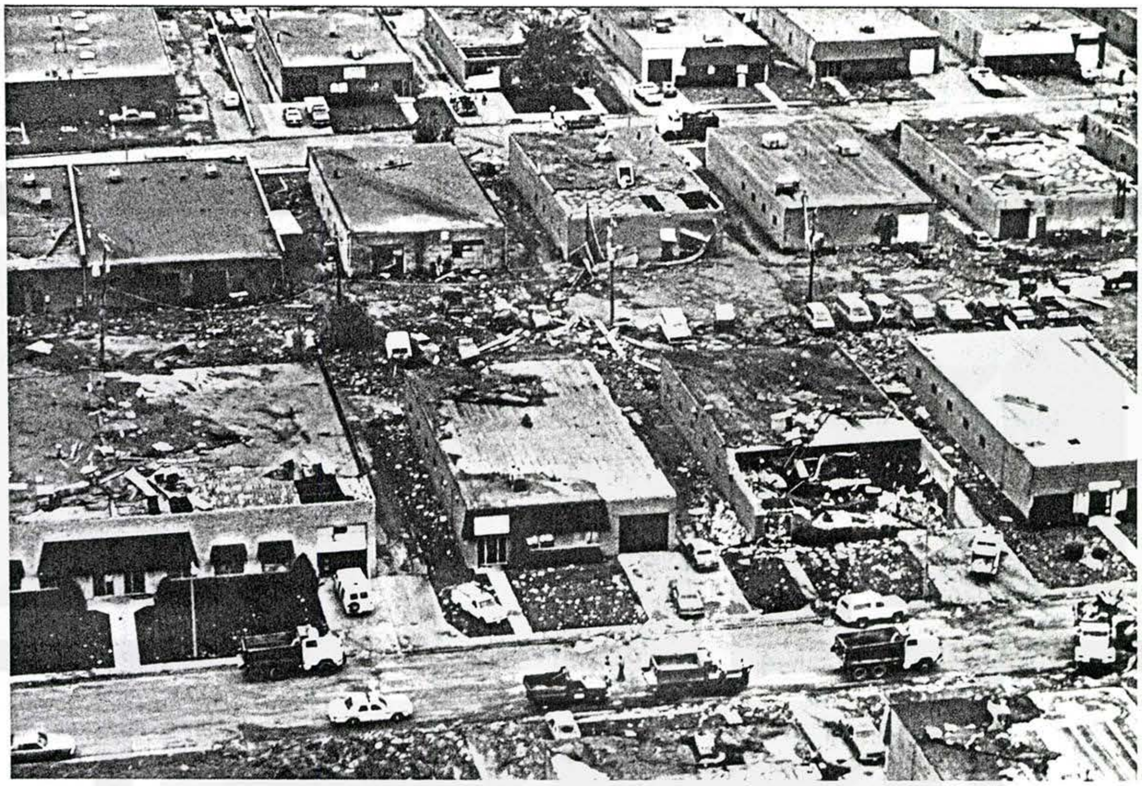


Fig. 5 Stores and shops at 1531 and 1534 Brandy Parkway damaged by estimated 120 mph winds.

Streaks of high winds on roofs, made visible by the thin deposits of wind-driven dirt, are seen on many structures. Photo D shows one of the best examples seen on the roof at 1531 Burgundy Parkway (Fig. 6). The worst damage is seen in photo E looking west (Fig. 7). The roof of a large square building at 1546-50 Brandy Parkway was peeled off by the near-horizontal winds from the south (Fig. 8). Winds are estimated at 100 to 110 mph.

Ground wiews of the damaged industrial park are very similar to those seen in the wake of F1 to F2 tornadoes. Initially, the local residents assumed that it was a tornado which caused the severe damage within a matter of one to two minutes. The building at 1537 Brandy Parkway was smashed at its south side where the microburst descended (Figs. 9 and 10). There were numerous automobiles inside the industrial park when the microburst hit. A 2X4 piece of lumber penetrated the front windshield (Fig. 11) and the car was stuffed with all types of debris blown inside by the microburst winds (Fig. 12). A light-weight trailer landed upside-down (Fig. 13) and numerous tin roofings piled up around a power pole in the parking alley between Brandy and Burgundy Parkways (Fig. 14). In tornadoes, automobile windows are often blown out in all directions due to the pressure reduction induced by the funnel and the dynamic pressure in high winds. In microbursts, however, winds will blow through an automobile after the initial breakage of the window(s) on the impinging side (Figs. 15 and 16).

Microburst No.2 which descended on a small forest was small in size and weak in winds, but it blew large twigs off trees (Fig. 17) and uprooted large trees (Fig. 18). There were a number of twig streets extending from the forest toward the north-northwest.



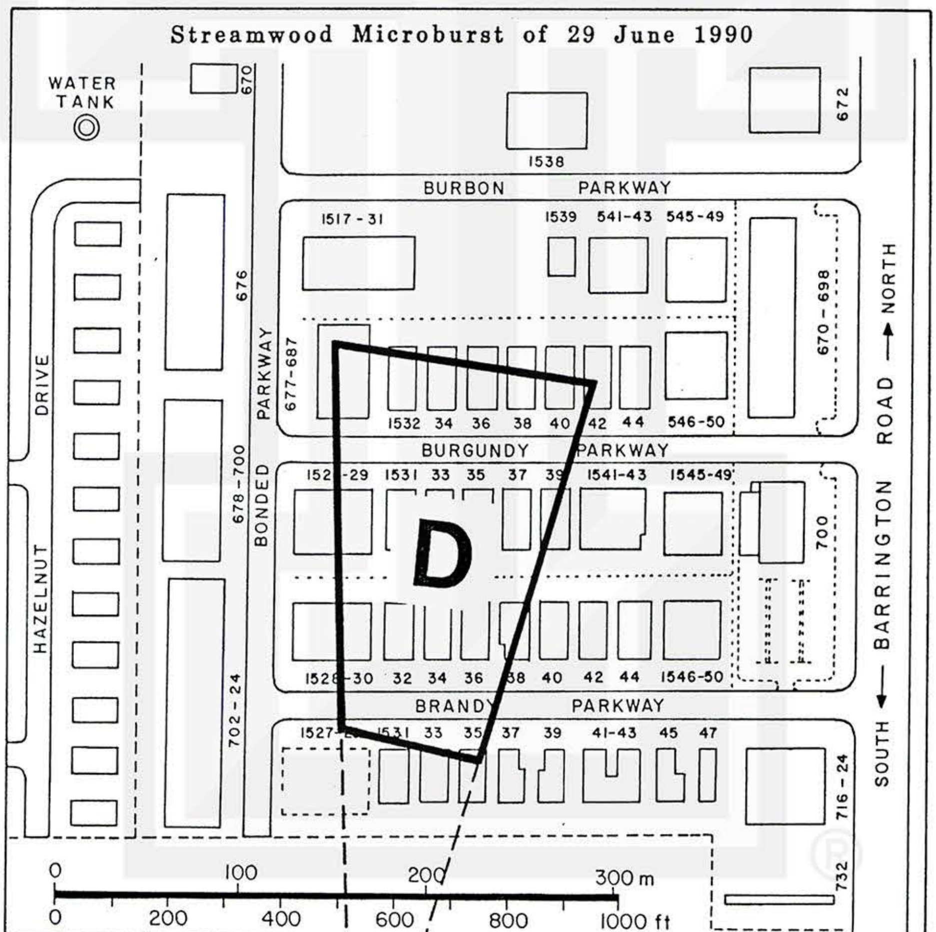


Fig. 6 Building at 1531 Burgundy Parkway showing a high-wind streak on the roof extending from the southeast to northwest corners.

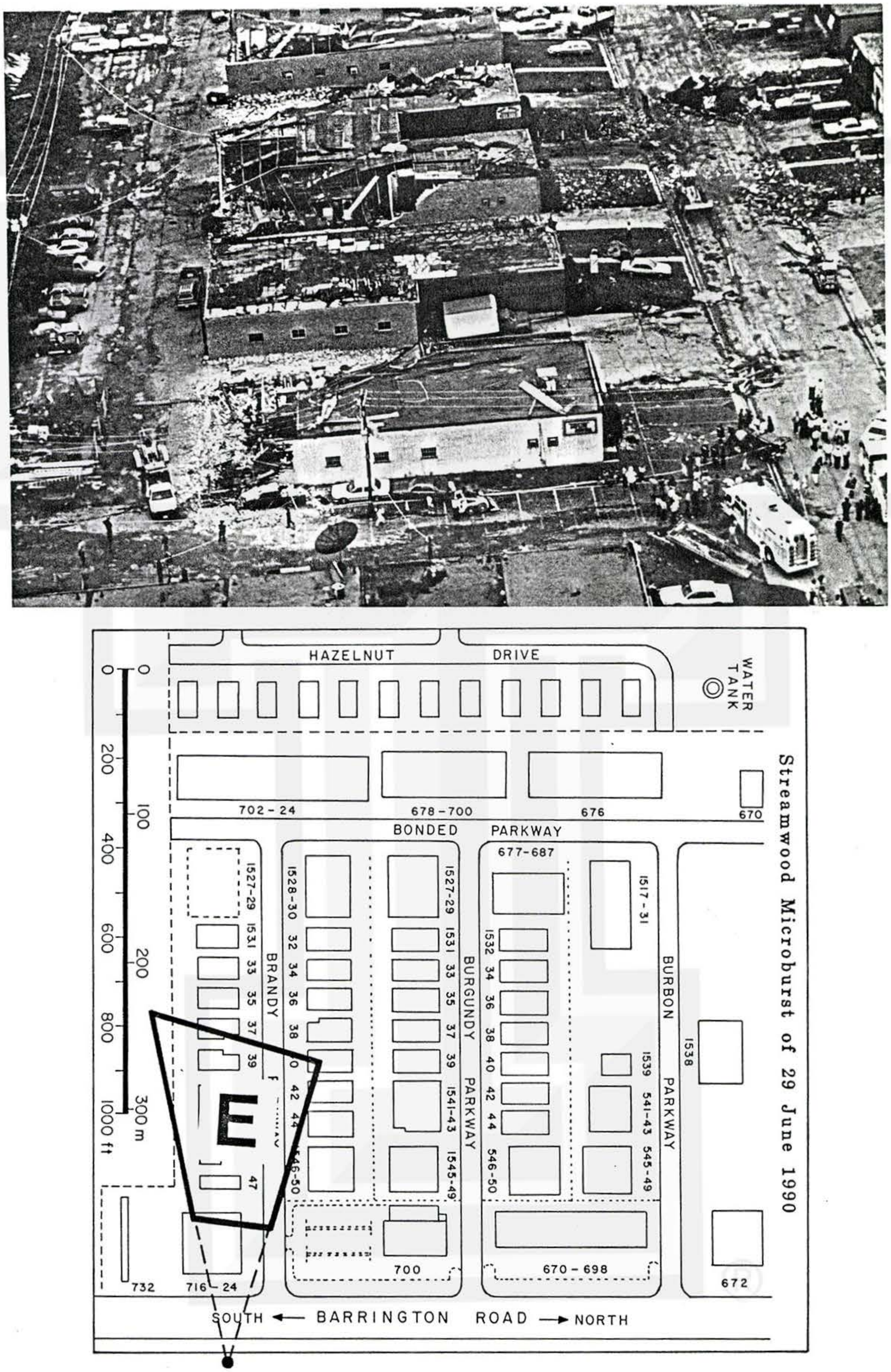


Fig. 7 The worst damage in the industrial park seen in the southeast section. The damage-causing winds are estimated at 130 mph from the south to south-southeast.

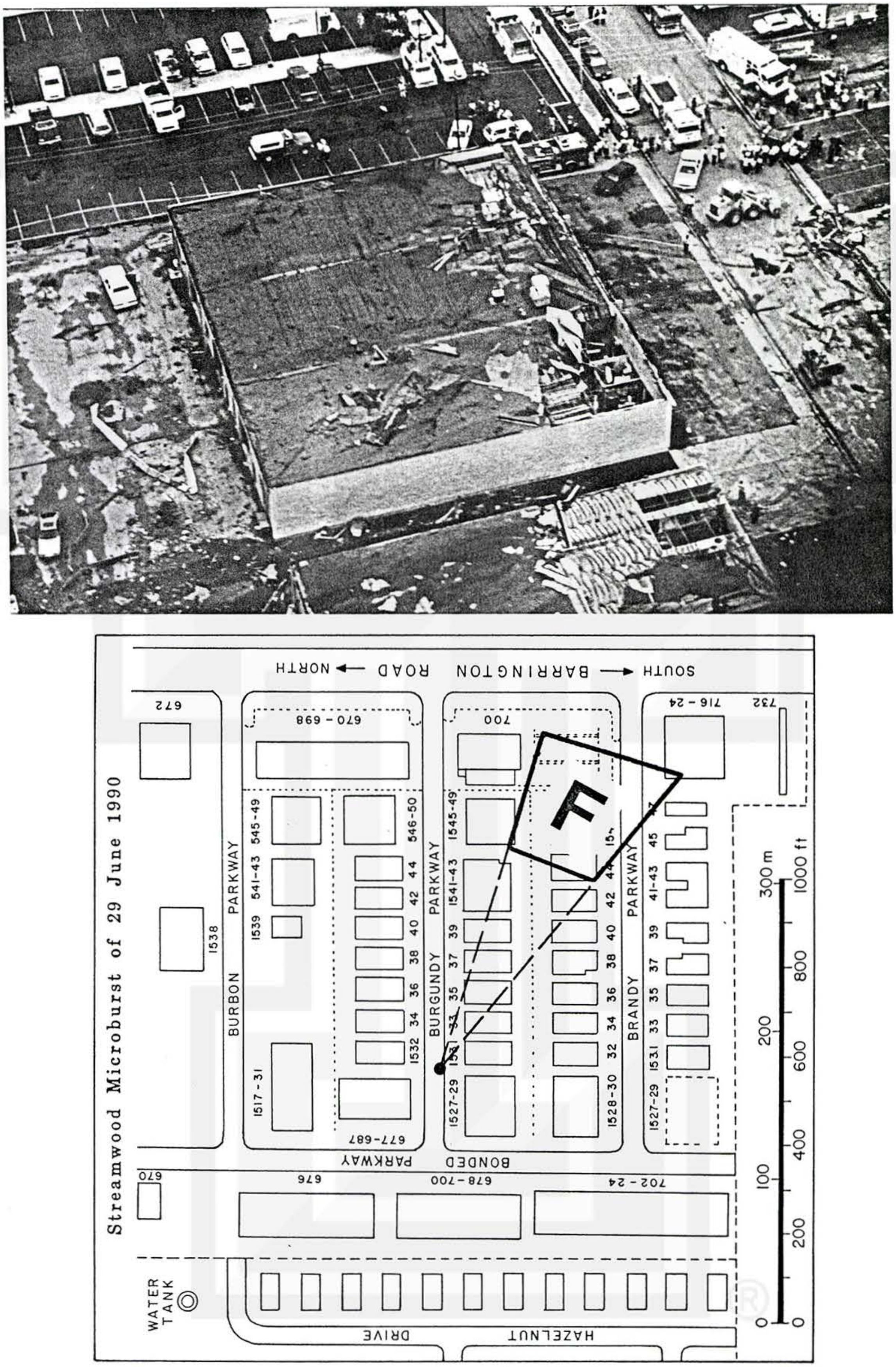


Fig. 8 The peeled-off roof of a large square building at 1546-50 Brandy Parkway.

Fig. 9 The south wall of the building at 1537 Brandy Parkway smashed by the microburst winds in the touchdown area.

Fig. 10 A close-up view of the building at 1537 Brandy Parkway.

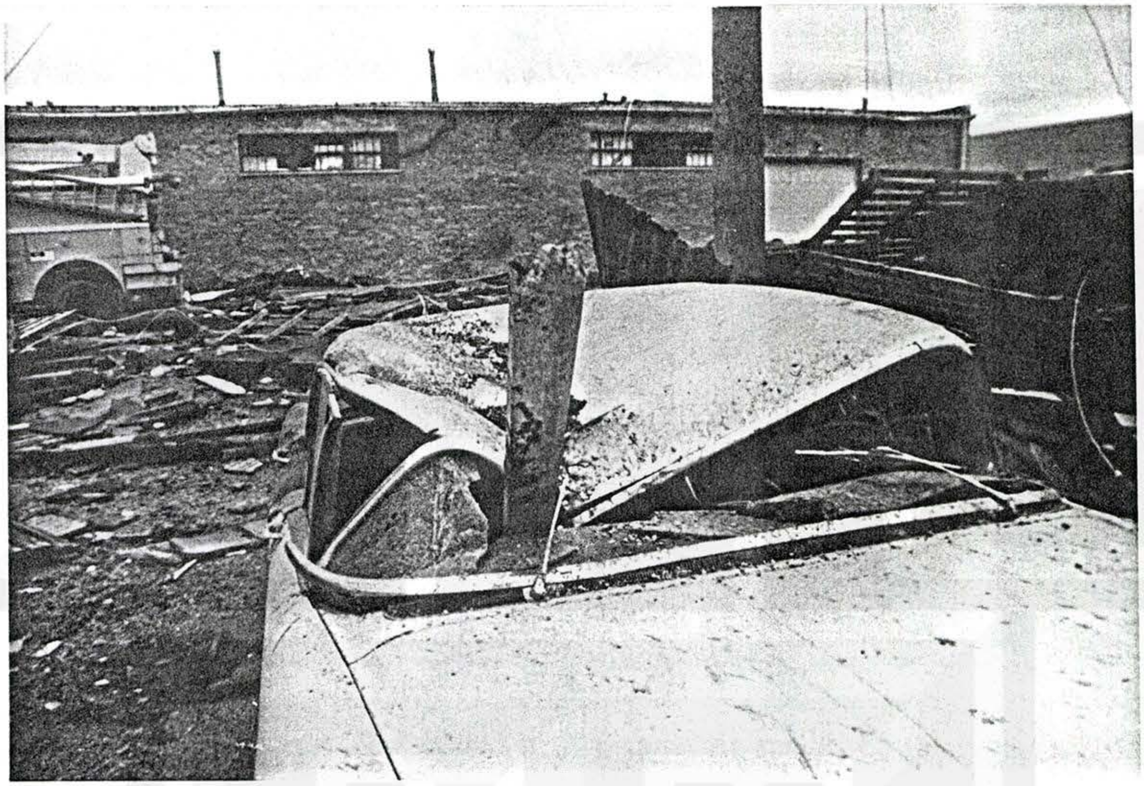


Fig. 11 An automobile with a 2X4 piece of lumber penetrating the front windshield.

Fig. 12 Debris blown into the above automobile.

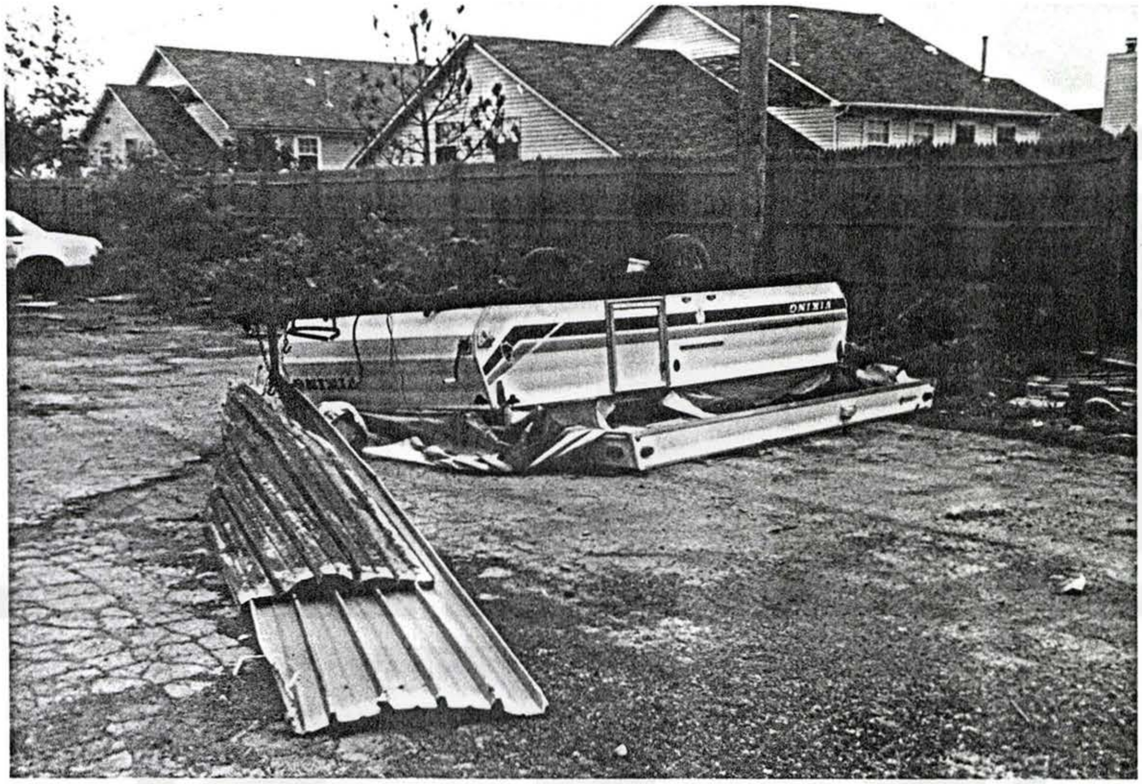


Fig. 13 A light-weight trailer overturned behind the store building at 702-724 Bonded Parkway.

Fig. 14 Parking area behind buildings at 1531-33 Burgundy Parkway and 1532-34 Brandy Parkway where numerous tin roofings piled up around a power pole.

Fig. 15 A truck which lost all windows on the upwind side. Photo taken from the direction of the impinging winds.

Fig. 16 The above truck seen from the opposite direction. All windows were blown out when the microburst winds blew through the truck.

Fig. 17 Large twigs scattered downwind from the east edge of a small forest where a small microburst descended.

Fig. 18 A large tree in the forest uprooted by Microburst No.2 winds.

2. No Microburst/Tornado Warning Issued

Because the unexpected storm occurred early in the morning, long after the passage of a squall line, no one suspected localized high winds, windshear and turbulence for which O'Hare airport was closed for about two hours. No warning was issued. Furthermore, it was not raining at the time of the microbursts. Eyewitnesses in the industrial park noticed an overcast layer of middle to high clouds when high winds lasting only up to two minutes occurred. The early morning thunderstorm had moved away toward the southeast long before the onset of the damaging winds.

The national radar summary (Fig. 19) also confirms the weather condition. In spite of the radar summary, pilot reports on localized severe winds began at about 1300 GMT (8 a.m. CDT). These reports consisted of severe downdrafts, waterspouts over Lake Michigan, severe turbulence, etc. Selected reports are listed below:

<u>1303 GMT Severe Downdrafts over Lake Michigan</u>

*ORD UUA/OV ORD 080040/TM 1303/FLDRGC/TP MD80/TB SVR DOWNDRAFT AND MDT TRBC/RM ALSO BY B727

<u>1319 GMT Waterspount over Lake Michigan</u>

*ORD UA /OV ORD 090055/TM 1319/FL100/TP SW4/RM NUMBERS WATERSPOUTS NORTH OF ORD 090R

<u>1325 GMT Aircraft Rolled 90° in Severe Turbulance</u>

*RFD UUA /OV ARR-RFD/TM 1325/FL050/TP BE20/TB SVR 025-050/RM COULD NOT CONTROL ACFT, ROLLED 90 DEGS

<u>1338 GMT Returned to DPA because of Turbulence</u>

*DPA UUA/OV DPA DURGC/TM 1338/FLUKN/TP C550/TB SVR/RM RETURN TO DPA BECAUSE OF TB

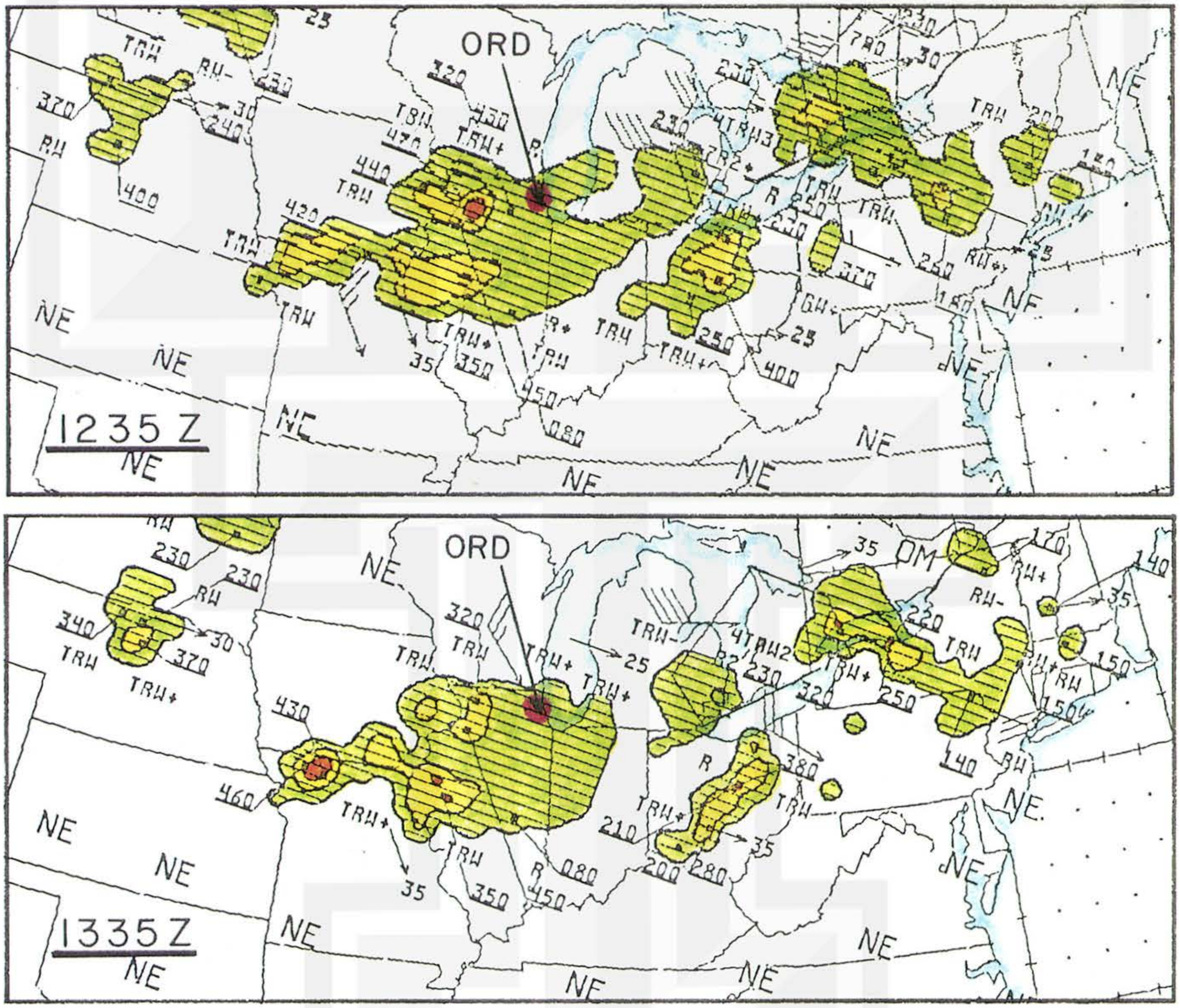


Fig. 19 National radar summary maps at 1235 and 1335 GMT, approximately 30 minutes before and after the microburst time at 1309 GMT.

3. Hourly Synoptic Maps

In order to reveal wind and pressure disturbances which gave rise to the formation of the microbursts and other windshear events in the morning of 29 June 1990, four hourly synoptic charts at 1200, 1300, 1400, and 1500 GMT were analyzed in detail (Figs. 20-23). It was obvious that the wake depression, which was identified and coined by Fujita (1955) was the parent pressure system in which all reported disturbances formed and developed. [When the wake depression was proposed in the mid 1950s, nobody paid attention to the low-pressure system, because there was no report of severe weather event associated with wake depressions. Most severe events occur near the leading edge of a squall line, rather than at its trailing edge where a wake depression forms and develops].

The sequence of four hourly maps clearly show the evolution of the squall-line system consisting of a mesoscale high pressure, mesohigh (MH) and a wake depression (WD). As expected, most thunderstorms occur on the front side of an MH and practically no thunderstorm is expected to occur on the rear side where a WD is located.

It should be noted that the squall-line system, in this case, could be traced for four hours without any difficulty, because the continuity of both MH and WD is very good. This result is encouraging for predicting the pressure systems for several hours.

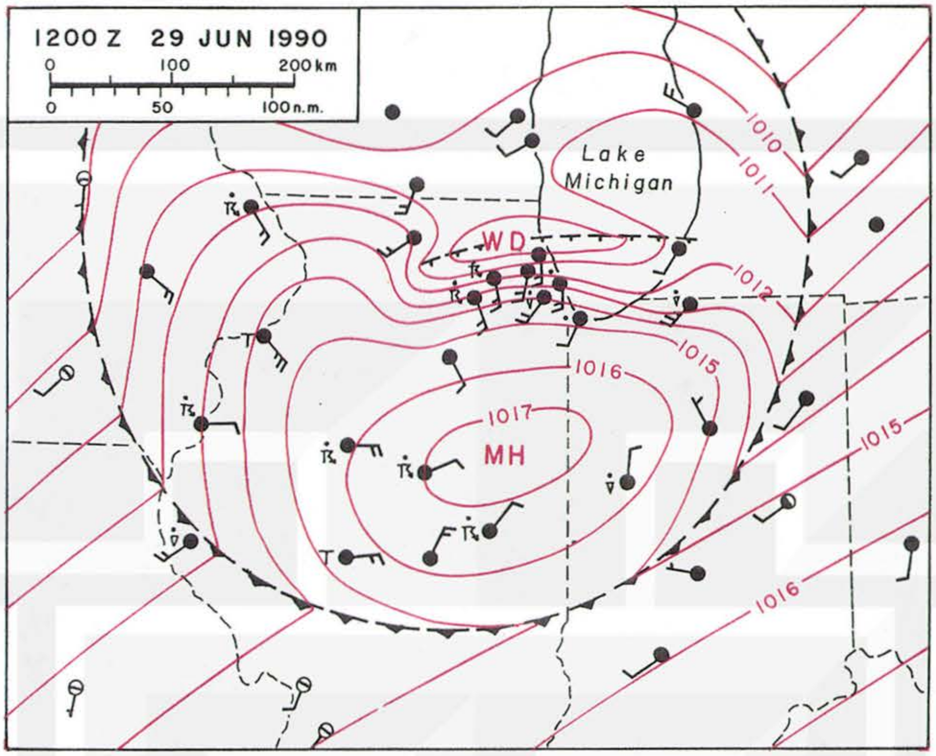


Fig. 20 The parent mesohigh (MH) of the Streamwood microbursts located over east-central Illinois at 1200 GMT. The wake depression (WD) was moving toward the O'Hare area.

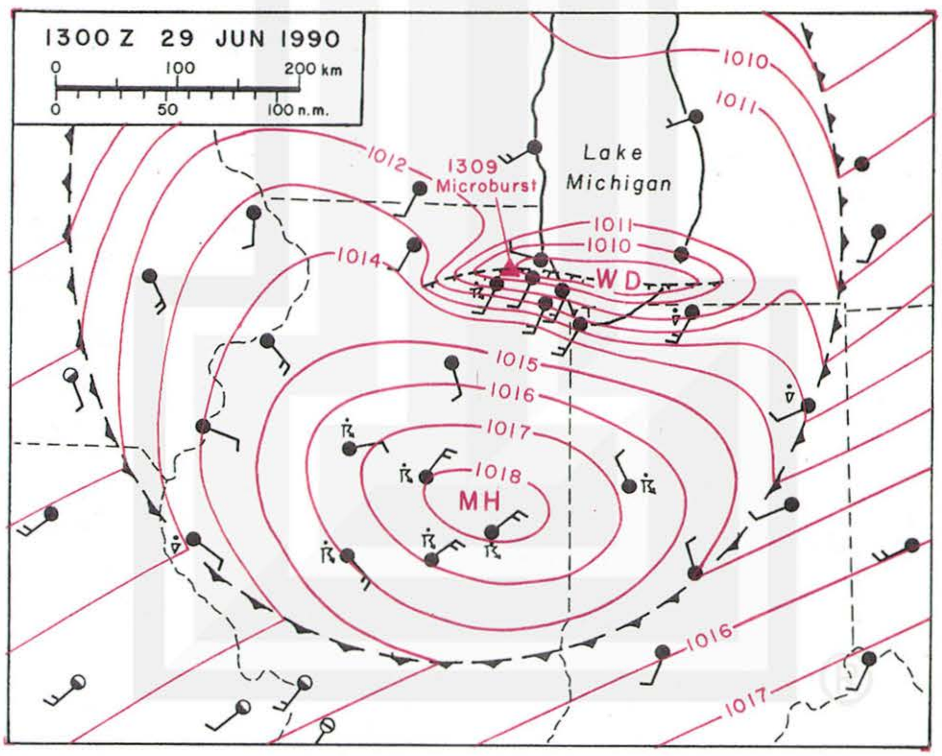


Fig. 21 The wake depression at 1300 GMT several minutes before the onset of the microbursts.

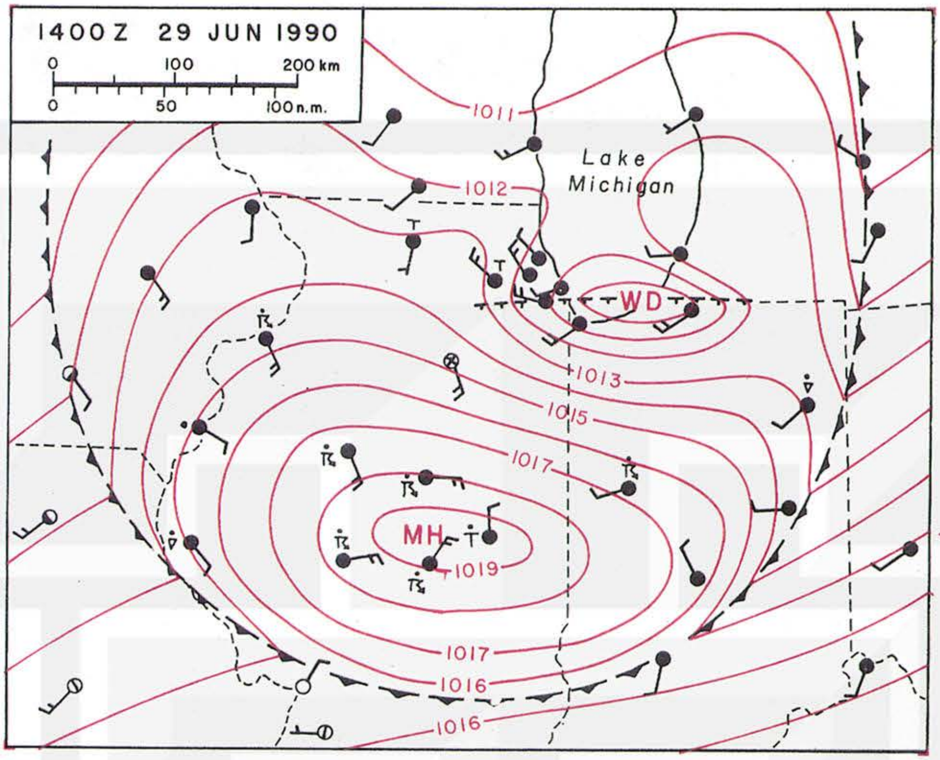


Fig. 22 Surface chart approximately one hour after the Streamwood microbursts.

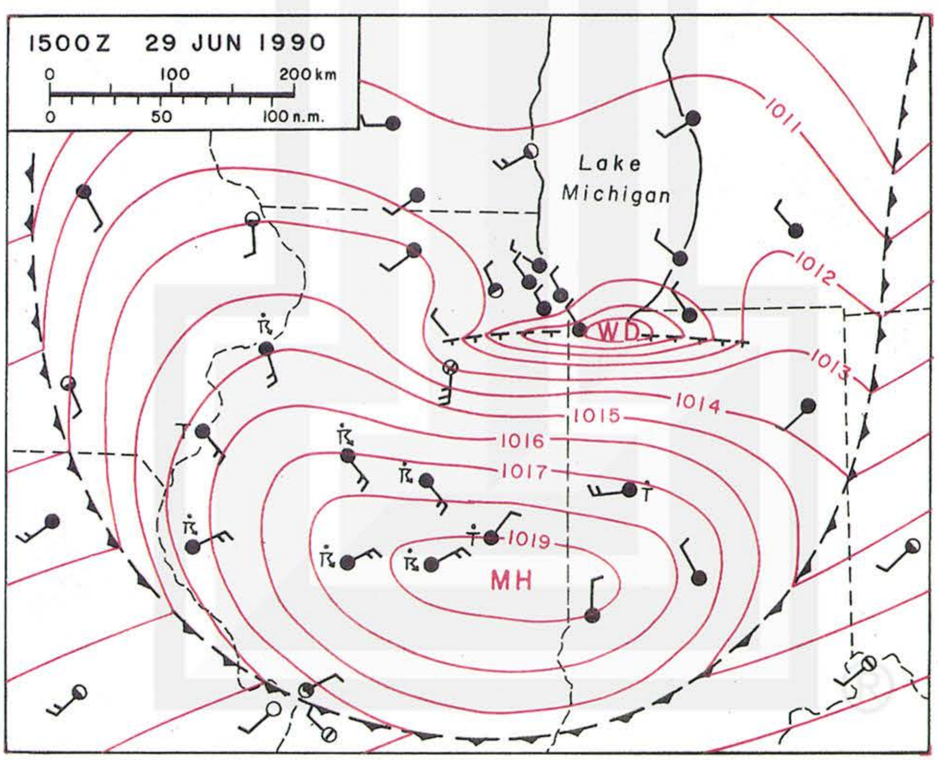


Fig. 23 The MH-WD complex at 1500 GMT, 2 hours after the microbursts.

4. Time Cross Sections

In an attempt to examine the time changes of various meteorological parameters, ten stations affected by the active stage of the wake depression under discussion were plotted on time-section charts (Figs. 24-33). These stations are MKE, ORD, NBU, DPA, MDW, MMO, CGX, RFD, and SBN, all located in the area of the windshear in pilot reports. These time sections show equally a significant MH followed by a deep WD which played a significant role in the formation of the early morning disturbances.

The wake depression at Milwaukee lasted for about one hour during which a 4-mb pressure drop and recovery took place (Fig. 24). At O'Hare airport, located 21 km (13 miles) east-southeast of Streamwood, the WD was characterized by two major pressure drops and two minor drops inside the second major drop. Because the O'Hare barograph was located too far from the microburst area, it is hard to relate these pressure variations with the microburst events. Nevertheless, the microburst time corresponds to that of the first minor pressure drop within the second major drop (Fig. 25). In view of the fact that a microburst is usually associated with a small pressure rise, rather than a dip, the Streamwood microburst could have been associated with a small dome of high pressure seen at the bottom of the second major pressure drop recorded at O'Hare. The time of the small pressure dome was 1315 GMT, 6 minutes later than the microburst time. This time difference could occur due to the distance between the locations of the barograph and microbursts.

Pressure variations at Milwaukee, O'Hare, and Marseilles (Fig. 34) reveal the progressive increase in the central pressure of MH and its duration. This is usual because the pressure dome of an MH is caused mainly by the accumulation of the cold air generated by successive thunderstorms located inside the region of an MH. As in other cases, the WD traveled at much slower speed than its parent MH. It should be noted that a small pressure dome was not recorded at Milwaukee where no microburst was reported.

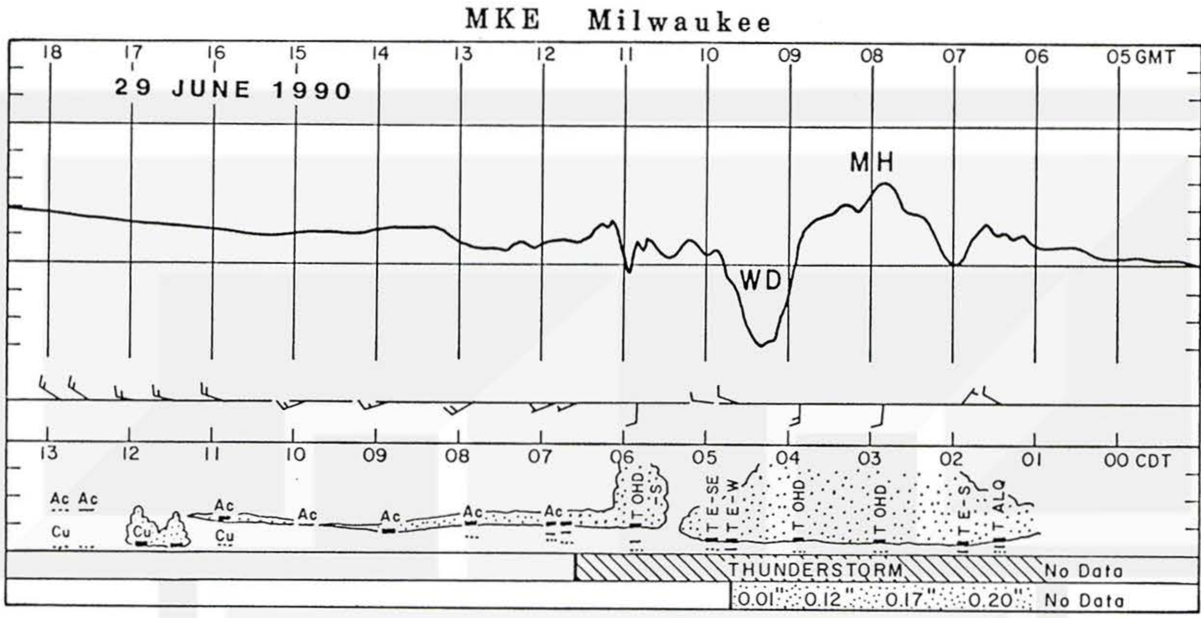


Fig. 24 The time cross section of the meteorological parameters from Milwaukee, Wisconsin.

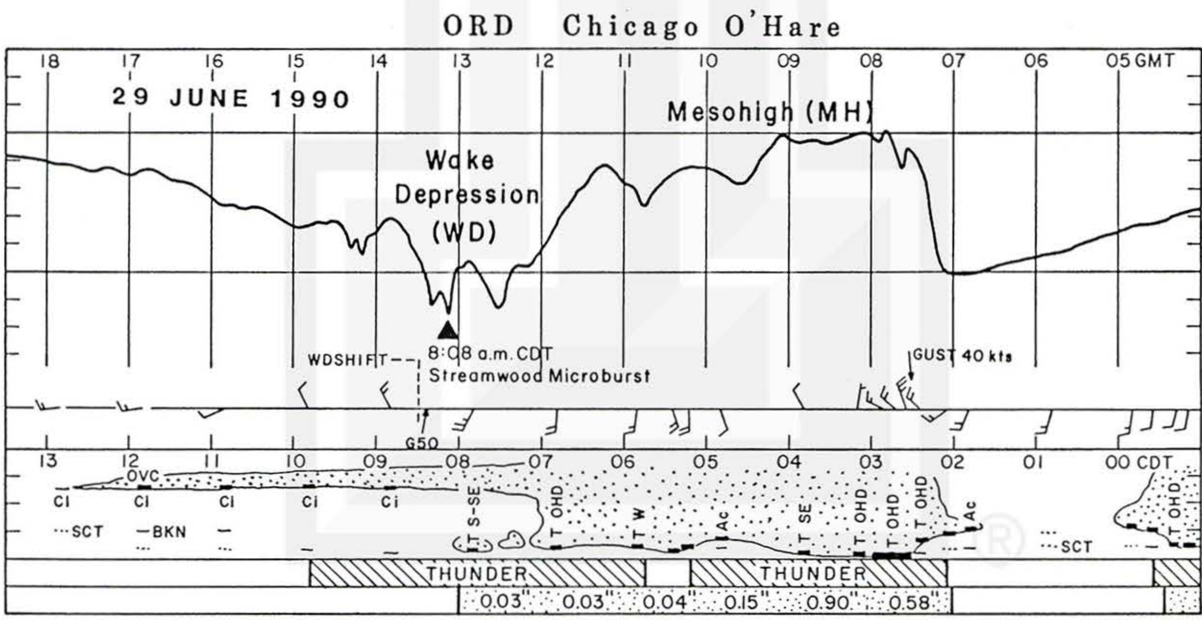


Fig. 25 Time cross section at Chicago O'Hare airport.

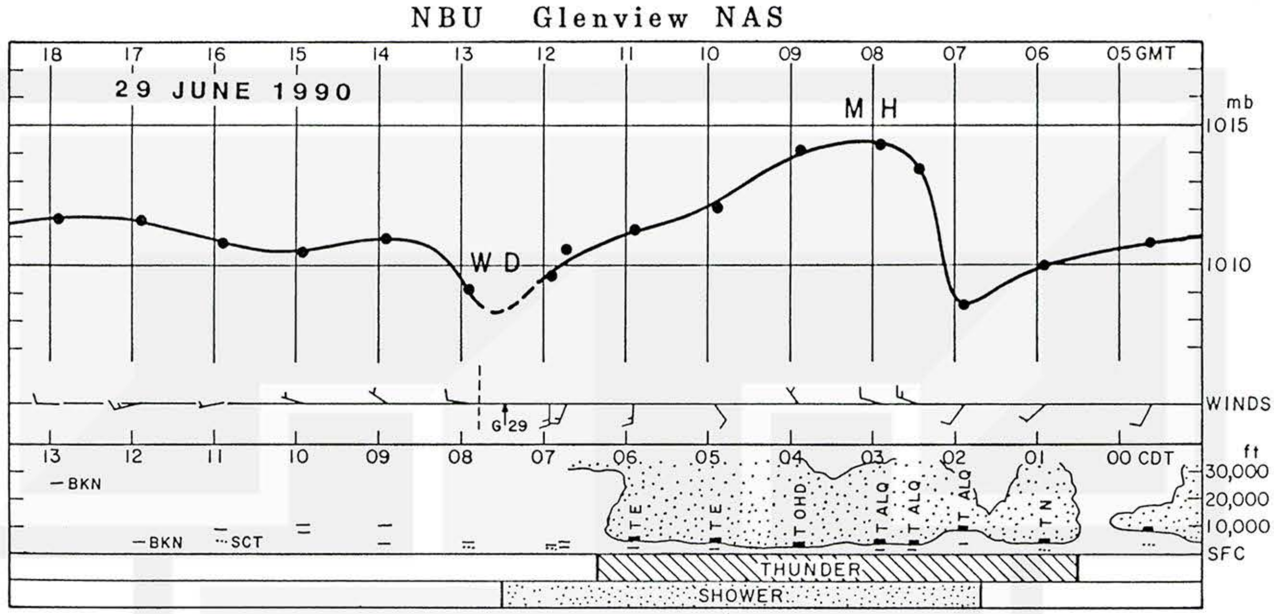


Fig. 26 Time cross section at Glenview Naval Air Station.

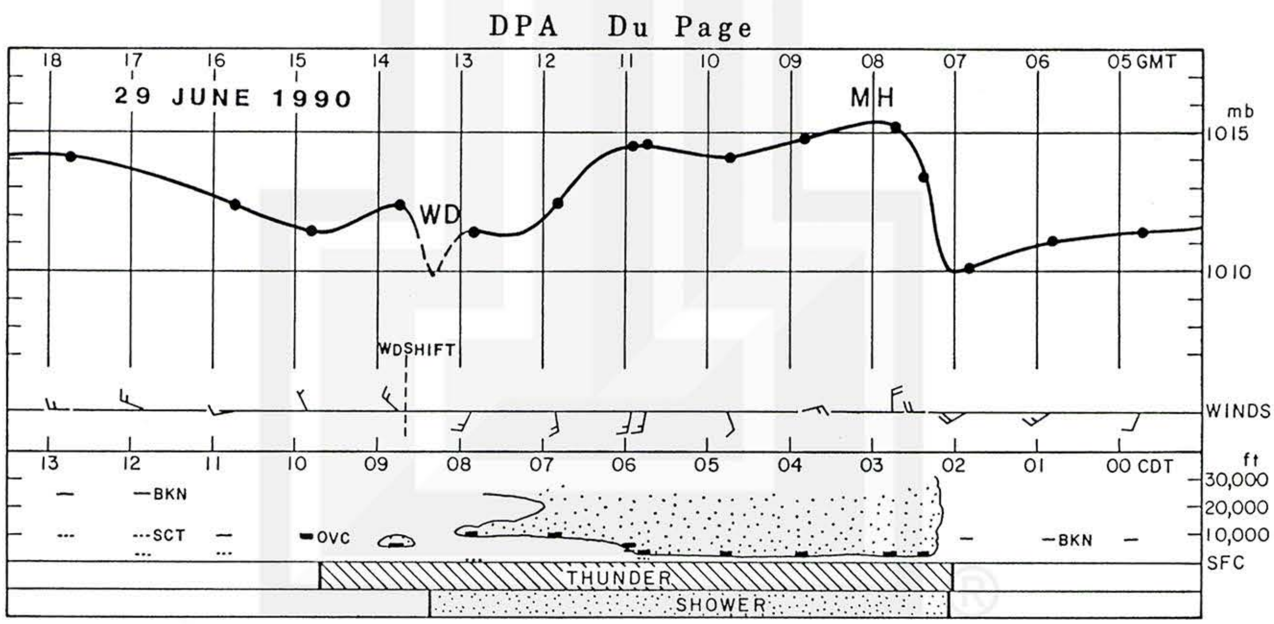


Fig. 27 Time cross section at Du Page County airport.

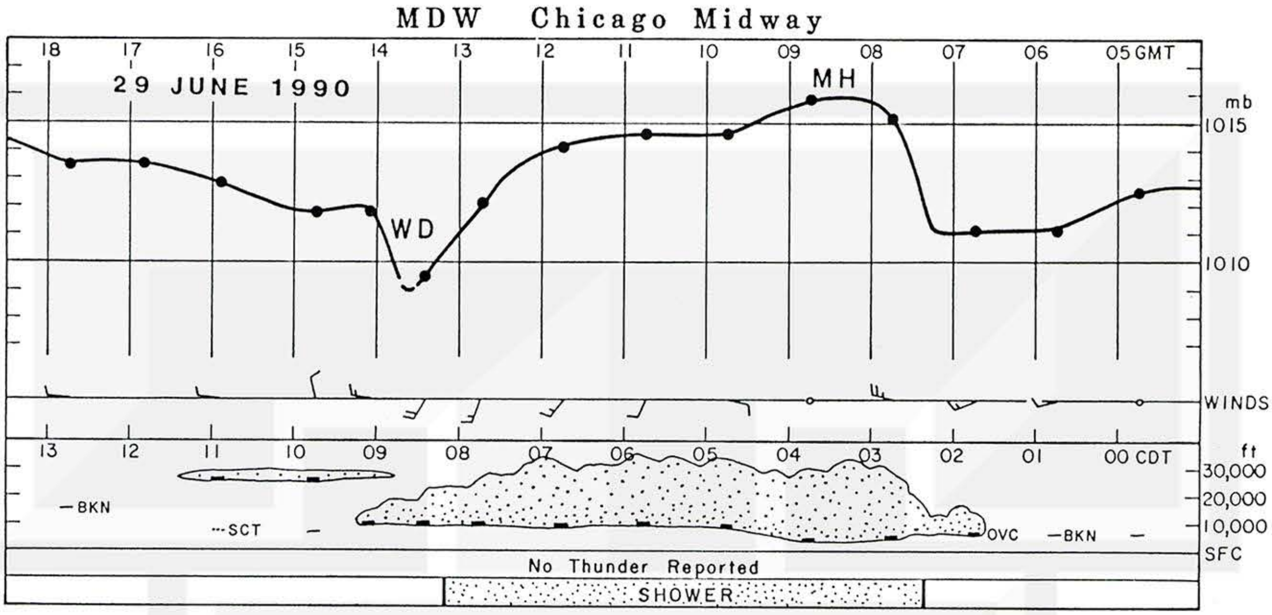


Fig. 28 Time cross section at Chicago Midway airport.

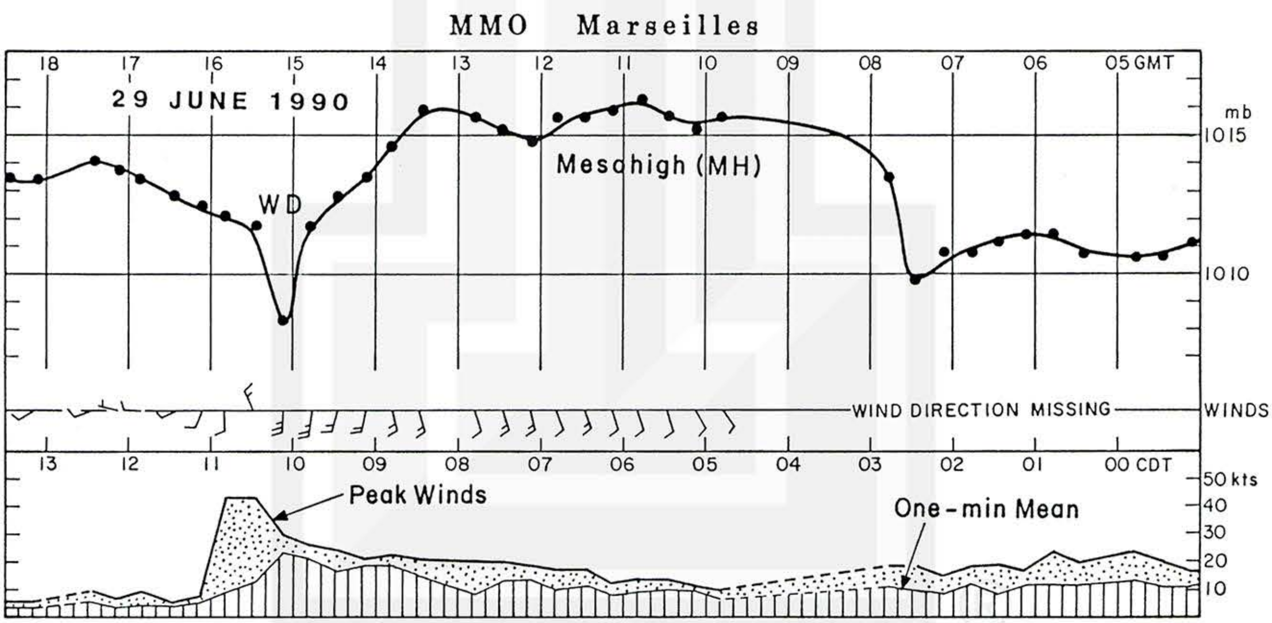


Fig. 29 Time cross section at Marseilles Radar station. It should be noted that peak winds are very high during the recovery period of the wake depression.

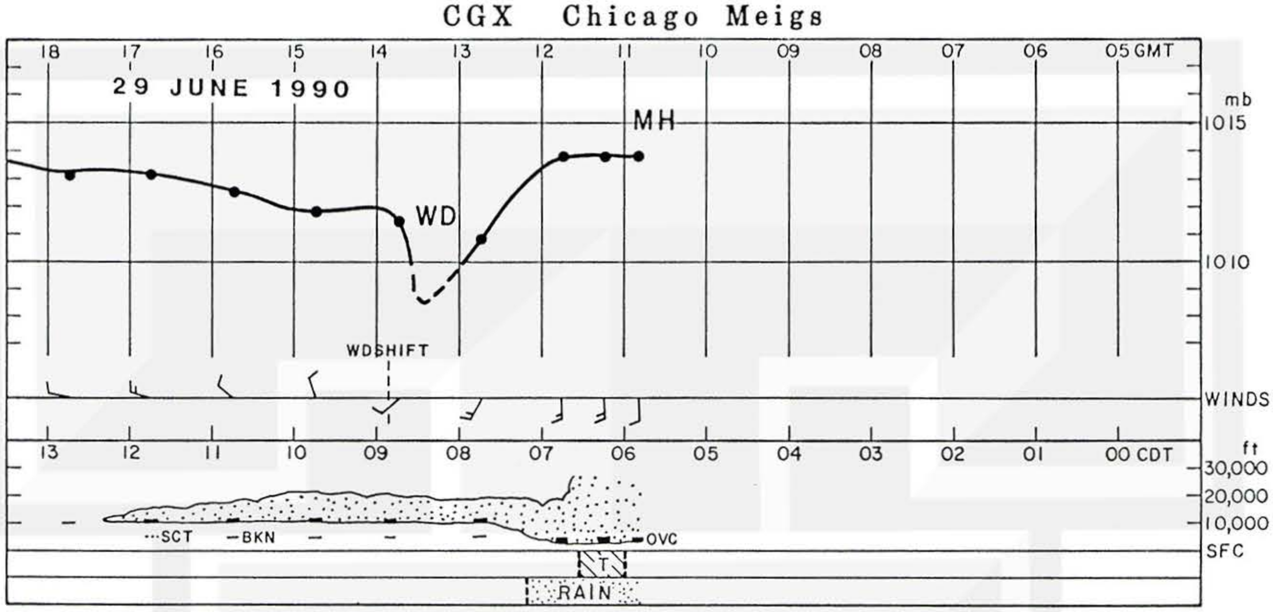


Fig. 30 Time cross section at Chicago Meigs, the lake-front airport.

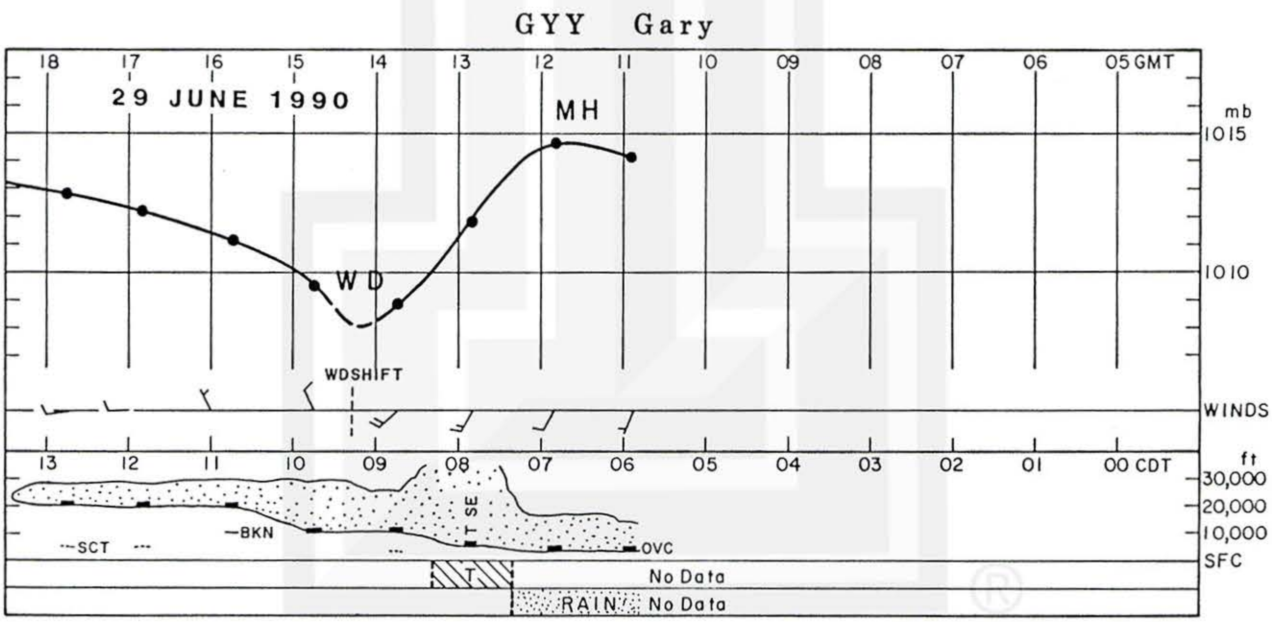


Fig. 31 Time cross section at Gary, Indiana airport.

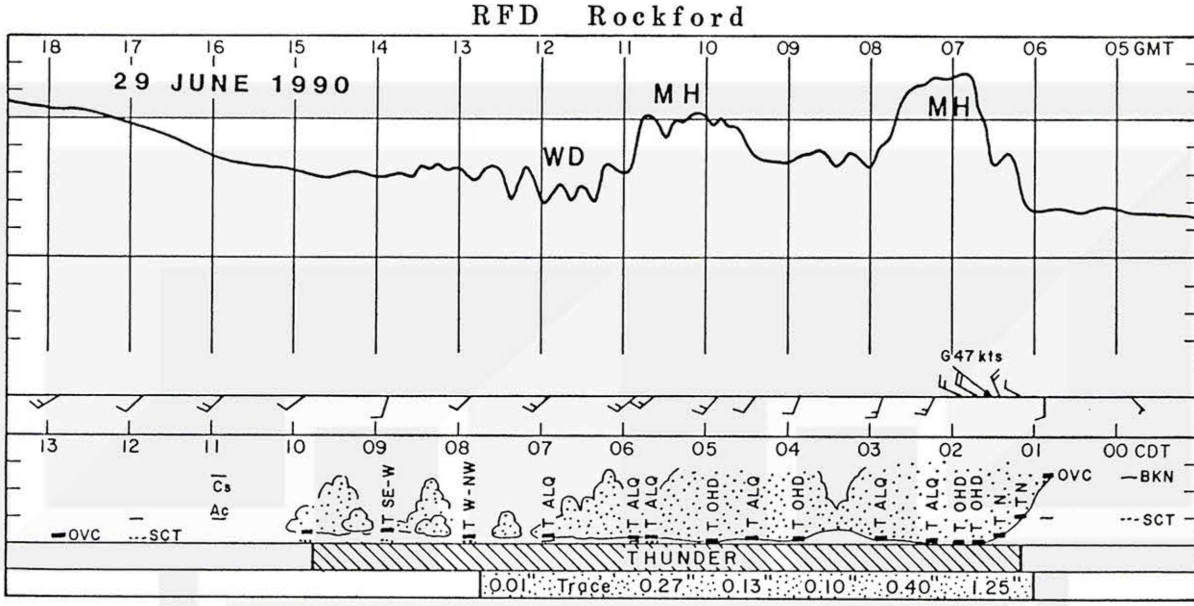


Fig. 32 Time cross section at Rockford airport.

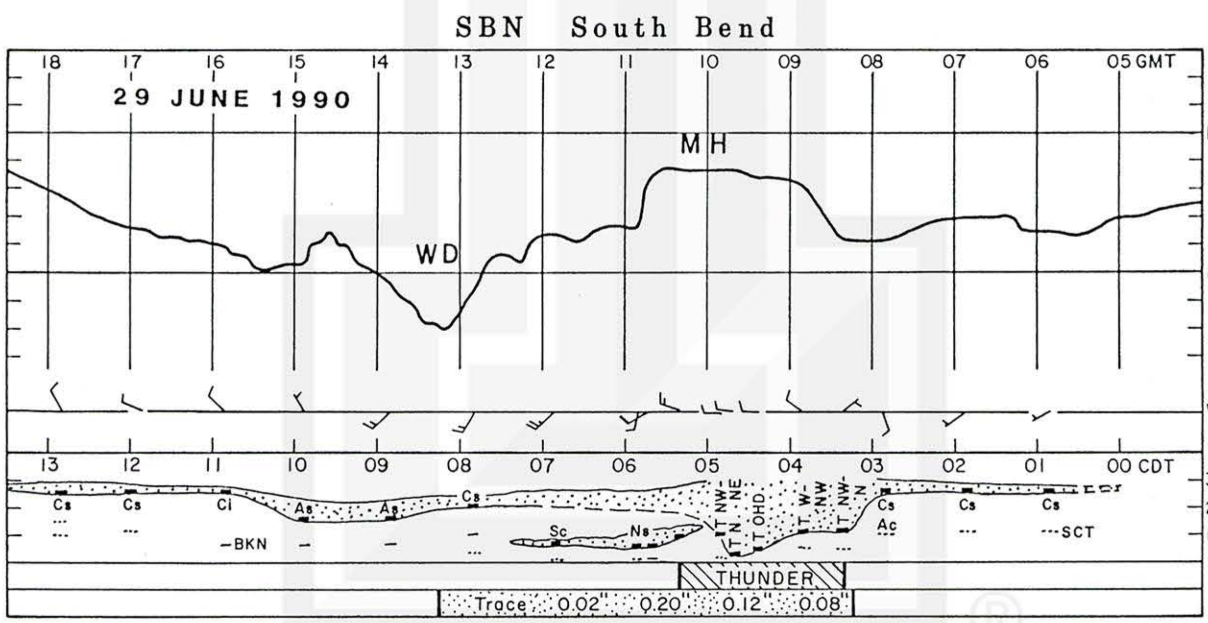


Fig. 33 Time cross section at South Bend, Indiana airport.

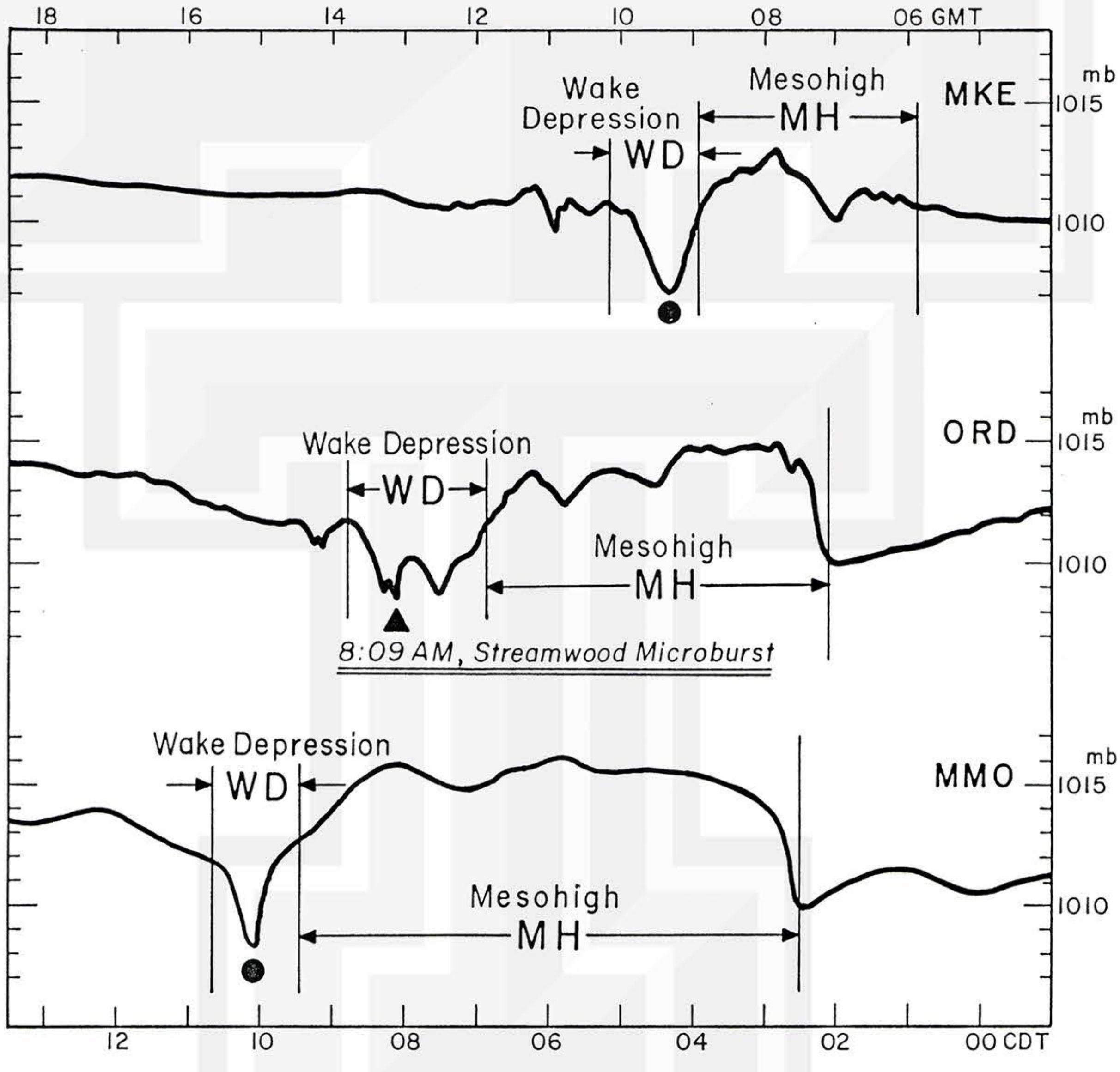


Fig. 34 Pressure variations at Milwaukee, Wisconsin, O'Hare airports, and Marseilles Radar station showing the propagation of the wake depression in which the Streamwood microbursts occurred. Because of the 21-km distance between Streamwood and O'Hare airport, it is hard to decide if the microbursts occurred at the time of the pressure dip or the small pressure dome.

5. Best Surface Map Generated by Mesoanalysis

A detailed mesoanalysis map was produced by applying the analysis technique developed by Fujita in the 1950s. Time cross sections from ORD, NBU, DPA, CGX, MDW, MMO, and GYY were utilized in converting time changes at these stations into the space changes on the mesoanalysis map. In spite of the sparse station density, a significant increase in the spatial data due to time-space conversions resulted in the pattern of wind and pressure at the microburst time.

The four-color surface map in Fig. 35 presents a distinct windshift line along the trough line of the wake depression. Seen to the north of the windshift line are weak northwesterly winds which moved down along with the progressive southward movement of the windshift line. The southerly winds on the south side of the windshift line were very strong, with the 50 kt peak wind reported at O'Hare at 1329 GMT, some 20 minutes after the microburst time. These high winds are the outflow from the thunderstorm complex inside the vast area of the mesohigh.

This mesoanalysis suggests that the strong southerly winds crossed the trough line of the wake depression, resulting in the up-gradient winds on the north side of the trough line. In other words, the southerly winds, by virtue of its large horizontal momentum, along with the cool temperature of the outflow air, kept pushing northward while undercutting the northwesterly wind blowing toward the trough line. The zone of the expected up-gradient winds in the mesoanalysis map is stippled. Unfortunately, no wind reports are available to determine the nature of the up-gradient flow. The Marseilles winds (Fig. 29) reveal, however, that the peak winds are significantly higher than the mean winds in the up-gradient zone, suggesting that it could be a zone of turbulent winds.

This evidence indicates that the microbursts occurred inside the narrow zone of the up-gradient winds to the north of the trough line of the advancing wake depression. Because the up-gradient winds are strong, the parent downdraft descending into the turbulent southerly could receive an additional momentum in deviating and accelerating the microburst winds northward. Needless to say, the Streamwood microburst was entirely different in mechanism from those studied during NIMROD (1978), JAWS (1982), and MIST (1986) in which Fujita was involved.

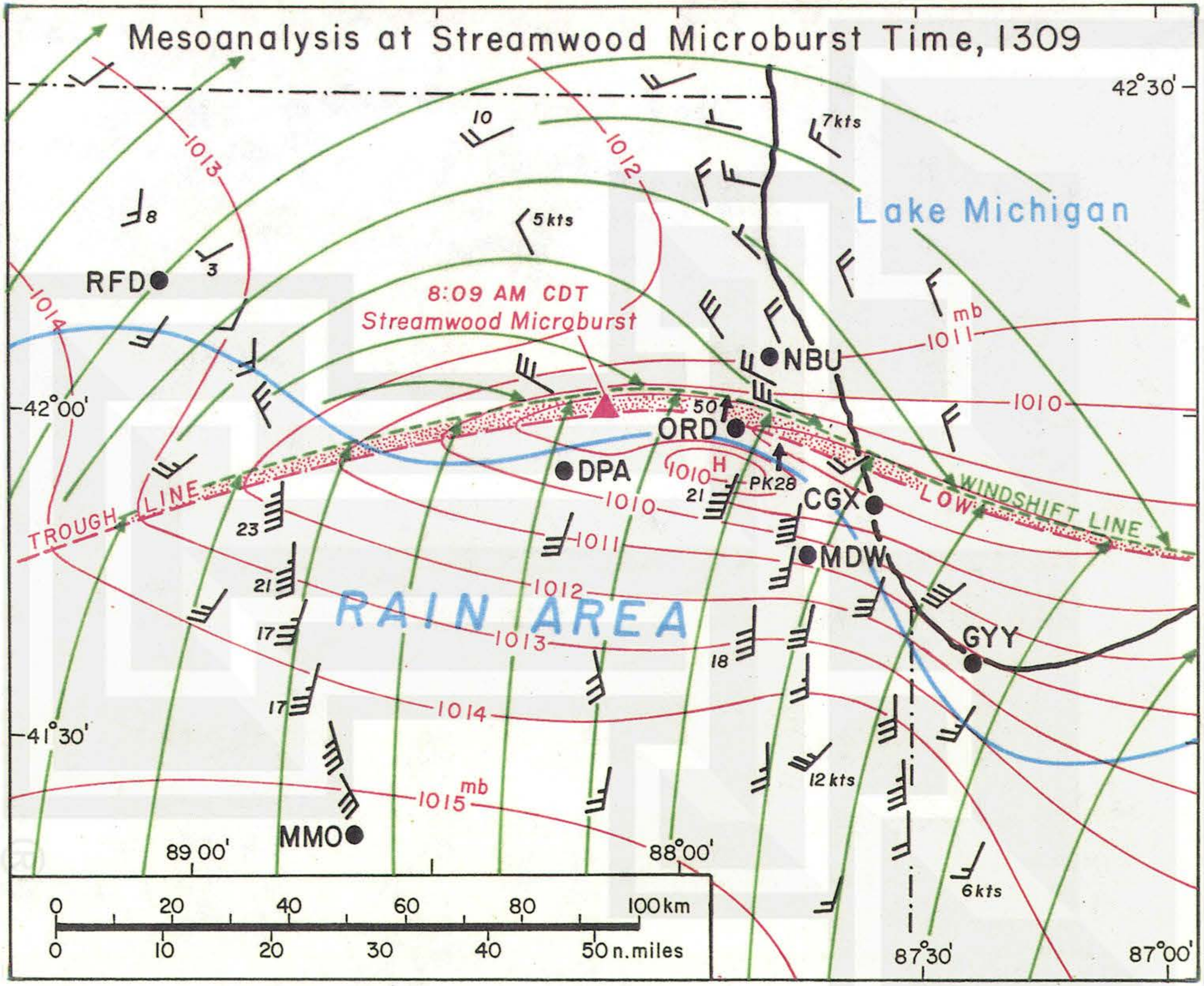


Fig. 35 A mesoanalysis surface map produced by converting time sections into spatial data. A narrow zone between the trough line of the wake depression and the windshift line is stippled in red. It is likely that the strong southerly winds pushed northward against the adverse pressure gradient.

Conclusions

It has been concluded that the wake depression which has long been assumed to be a harmless pressure disturbance is a mesoscale pressure system which could induce small but intense turbulence, windshear, microburst, and even waterspout over the lake. This study suggests the existence of significant up-gradient winds along the trough line of an advancing wake depression. So far, no mesoscale experiment on wake depression has been conducted.

It is recommended that a fact-finding experiment on the wake depression be conducted in the Midwest in conjunction with a future experiment on storms. The experiment will require dual Doppler radars, 20 PAM stations, upper-air soundings, and a wind profiler.

Acknowledgements

The author wishes to express his appreciation to Mr. Carl Knable, Manager of Meteorology, United Airlines, for collecting both meteorological and aviation data pertaining to this unusually small but intense microburst occurring at an unusual time, 8:08 a.m. Central Daylight Time.

Acknowledgements are due to Messrs. Dennis LaFrana and Larry Knoll of the Streamwood Police Department and Mr. William Johnson of the Emergency Services and Disaster Agency of Streamwood for making damage data and aerial photographs available to the author. Without their assistance, the nature of the microburst could not have been revealed.

The initial damage survey was made by Mr. Duane Stiegler of WRL in the afternoon of the microburst day. It was followed by a joint damage survey by Fujita and Stiegler on the day after the microburst, resulting in the identification of the storm as being a microburst rather than a tornado.

A preliminary study on this microburst began immediately after the storm as a volunteer effort of the staff members of WRL of the University of Chicago. The final research leading to the completion of this report was supported by the National Center for Atmospheric Research under NSF/UCAR Grant S9129.