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THE SEVERE STORM OF APRIL 3, 1974, AT WINDSOR, ONTARIO

by

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ABSTRACT

On the evening of April 3rd, 1974, at 8.00 p.m. EST, a funnel cloud passed over the city of Windsor touching down at several locations. This paper describes the synoptic, dynamic, and thermodynamic factors associated with the funnel cloud. The author visited the site several days after the storm's occurrence and damage is demonstrated with photographs and by a review of eyewitness reports.

LA VIOLENTE TEMPÊTE DU 3 AVRIL 1974 À WINDSOR (ONTARIO)

par

E.H. Roete

RESUMÉ

Dans la soirée du 3 avril 1974, à 20h HNE, un nuage en entonnoir est passé au-dessus de Windsor touchant terre en plusieurs endroits. Dans le présent article, l'auteur décrit les facteurs synoptiques, dynamiques et thermodynamiques associés aux nuages en entonnoir. L'auteur s'est rendu sur les lieux quelques jours aprés la tempête. Il présente des photographies et un compte rendu de rapports de témoins oculaires pour illustrer les dégâts.

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E.H. Roete

(Manuscript received July 9, 1975)

1. Introduction

On April 3rd, 1974, the worst single outbreak of tornadoes occurred from the Gulf states northward to southwestern Ontario. 127 confirmed tornadoes were reported across the U.S. creating a swath of destruction from Windsor southward through Ohio, Kentucky, Tennessee and Alabama. At 0100 GMT, April 4th, a funnel cloud spawned by a large thunderstorm cell, touched down at several Windsor locations taking the lives of eight persons at the Windsor Curling Club.

This paper will examine the pertinent synoptic, dynamic, and thermodynamic factors associated with the April 3rd tornadoes. Radar plots will be presented as well as a plot of the apparent path of the funnel cloud. Damage sites scattered throughout Windsor were visited by the author several days after the occurrence and several interesting pictures will be included.

2. Synoptic Description

The first indication of a developing severe weather situation occurred on the night of April 2nd. A low had moved from Montana southward into Kansas between 1200 GMT and 0000 GMT, April 2nd. The PE progs showed a deepening low moving from Kansas northeastward towards the lower Great Lakes. The 700 mb 12-hour vertical displacement chart indicated vertical lift in excess of 100 mb over the affected area by 0000 GMT, April 4th. A severe weather analysis was performed during the morning hours of April 3rd and, on the basis of this, a general severe weather warning was issued by the Toronto Weather Office at 10:30 a.m., April 3rd. The first confirmation of possible severe weather development came in the mid-afternoon with a report from the Chicago area of wind gusts to 70 mph and $1\frac{1}{4}$ inch hail. Numerous reports of funnel cloud sightings and tornadic activity were received during the late afternoon.

3. Synoptic and Dynamic Features

(a) The Surface Charts

Figure 1 shows the 1200 GMT surface features. A 980 mb low was centred over Kansas with the arctic warm front just moving through Windsor. Figures 2 and 3 show the 1800 and 0000 GMT surface features, respectively. By 1800 GMT, the maritime warm front was located over Windsor with the main low pressure centre moving northeastward at a moderate rate of speed (approximately 30 knots). A meso-low pressure centre developed over western Illinois by 1800 GMT and moved northeastward to northern Indiana by 0000 GMT. Significant pressure falls, in the order of 1 to 2 mb per hour, were occurring ahead of the meso-low. Several hours after the development of the meso-low, a squall line took shape approximately 100 miles east of the meso-low and associated cold front. The air ahead of the polar cold front was warm and moist with dew points in the 15 to 18 degrees Celsius range and was being carried northward by strong southerly winds. The squall line moved through the eastern half of lower Michigan during the evening, triggering tornadoes along the meso-system.

(b) The 850 mb and 700 mb Charts

Figure 4 shows the 850 and 700 mb charts for 0000 GMT, April 4th. The primary features of concern at the 850 mb level are the temperature and moisture distribution and the wind field. The moist tongue at 850 mb is long and narrow and well defined. A strong low level jet is present, implying strong mechanics for the release of instability. The most important feature on the 700 mb chart is the dry line, which lies almost directly over the 850 mb moist tongue.

(c) The 500 mb and 300 mb Charts

Warm moist and unstable air covered most of the U.S. south of the Great Lakes and east of the Mississippi, as a strong 500 mb vorticity pattern moved northeastward towards the lower Great Lakes. Figure 5 shows the 500 mb and 300 mb charts for 0000 GMT, April 4th. The most notable feature at the 500 mb level was diffluence in the flow from the Ohio Valley northeastward across Michigan. This diffluent flow was located directly over convergence in the lower levels giving maximum vertical motion.

Positive vorticity advection at 500 mb plays a major role in many severe weather situations but apparently had very little influence on the storm which struck Windsor. The CMC 0000 GMT vorticity analysis was not available due to a computer outage but the 12-hour baroclinic prog valid 0000 GMT showed a vorticity centre moving northeastward to Lake Michigan with the p.v.a. through western Lower Michigan. This p.v.a. likely had a strong influence on the redevelopment of thunderstorms along the actual cold front but was not a significant feature in the development of the squall line.

The 300 mb chart shows an anticyclonically curved jet. Figure 10 shows the intersection of the 300 mb jet with the cyclonically curved 850 mb jet. The boundaries of predicted tornado area are composed of a line from the point of intersection southwestward, bisecting the angle between the two jets. Severe weather usually breaks out first in the south and moves northward along the line bisector.

(d) Radar Reports

Figures 8 and 9 represent the last radar plot before the Windsor storm, and the track of the funnel cloud, respectively. The funnel associated with the Windsor storm crossed the international border twice around 8:00 p.m. EST. It was aloft most of the time and its classification of "tornado" must be considered marginal. However, inspection of the damage and eyewitness reports leave little doubt that a funnel cloud passed over Windsor from southwest to northeast, skirting the Windsor airport. The southwest to northeast track becomes quite evident when damage locations are plotted on a Windsor city map (Figure 9). The extent of damage indicates that the funnel cloud definitely touched down twice, the first touchdown occurring at the Devonshire Mall and the second at the Windsor Curling Club at 8:10 p.m. EST. Good time checks are not available for calculating the speed of the funnel cloud, but Detroit radar plots indicate that the parent thunderstorm, which spawned the funnel, was moving at approximately 35 knots (Figure 8). The thunderstorm cell, with a maximum top of 45 thousand feet, was located just southwest of Windsor at 2330 GMT. It was part of a squall line which extended southward through central Ohio. Subsidence behind the squall line is evident in the lack of radar echoes with some redevelopment ahead of the cold front.

(e) Composite of Severe Weather Potential Factors

Figure 10 is a composite chart of severe weather potential factors for 0000 GMT, April 4th. Central pressure of the

parent low was 984 mb. Galway (9) showed that most tornadoes occur with pressures of the parent low less than 1005 mb, preferably less than 1000 mb. Two-thirds of the tornadoes occur 160-320 km southeast of the parent low centre, mostly within the warm sector (Fluto (7)).

The 700 mb dry-line is an exceptionally favourable line for activity to develop in a rapid manner. The motion of the dry-line over the moist tongue in the lower levels is often associated with the squall line development. The steeper the gradient from dry to moist the more violent the activity. Figure 8 shows the relation of the 700 mb dry-line to the 850 mb moist tongue.

The significance of the intersection of the 300 mb jet with the 850 mb jet has been discussed in section (c) of this report.

4. Thermodynamic Features

(a) Stability Indices

In Figure 7 the 1200 GMT and 0000 GMT stability indices (K-factors and Total Totals) are reproduced. The K-factor is the best indicator for probability of occurrence of convective activity (Lawrynuik (4)), while Total Totals indicate the severity of the convective activity. It appears that a peak in the stability indices was reached at Flint and at Dayton shortly after 1800 GMT, with values decreasing after that time.

(b) Upper Air Soundings

Figure 6 shows the 0000 GMT Dayton sounding. Dayton was chosen as the most representative sounding, being approximately the same distance east of the squall line as Windsor, at the time of the storm (0000 GMT). Typical characteristics found with average tornado ascents, while present to some degree, fell short of that associated with tornado development.

The absence of a moist lower layer capped by a dry inversion is most notable. The atmosphere displayed real latent instability in the layer below 800 mb, while potential instability was present between the 850 and 500 mb levels. Upward vertical movement of the air column created by the squall line likely converted much of the potential instability into real latent instability. It is theorized that a steepening of the lapse rate occurred through evaporative cooling, producing a condition approaching absolute instability. This process often results in the spectacularly rapid growth of giant cumulonimbi, followed closely by the development of large hail and tornadic storms (Miller (6)).

The wet-bulb zero height (WBZ) has been statistically related to the severity of any storms that occur. Miller (6) found that 68% of tornadoes occurred with WBZ between 1500 m and 2700 m above ground. On the Dayton sounding (Figure 6) the WBZ is located at approximately 3000 m.

5. Damage and Eyewitness Reports

The major damage from the Windsor storm occurred at the Devonshire Mall and at the Windsor Curling Club. Severe damage was done to a department store under construction. Structural steel I-beams, anchor bolted to a concrete foundation were twisted and bent by the storm's fury. On the construction site, a 30-ton crane, with legs extended was moved six feet by the storm. The evening watchman on duty at the construction site was a fortunate man. He was inside a trailer located just a few hundred feet from the store, when he began to experience breathing difficulty. The tremendous pressure difference caused by the proximity of the funnel cloud created a vacuum in the trailer. In spite of torrential rain, he opened the windows, likely saving his life. A house trailer within 50 yards of the construction site was overturned and a car reportedly had its windows shattered with the glass having been pushed inside the car.

6. Concluding Remarks

Having examined pertinent synoptic dynamic and thermodynamic features associated with the Windsor storm, it becomes evident that while the thermodynamic support appeared to be lacking, the vital synoptic and dynamic features were extremely favourable for the development of tornadic storms. In regard to the apparent lack of thermodynamic evidence, one must keep in mind that circulation generally associated with severe storms is such that meteorological parameters may change dramatically in time periods of less than twelve hours. The synoptic and dynamic conditions I have analyzed have been recognized as favourable for severe storm development by various investigators (Lawrynuik (4), Miller (6), Fluto (7)). The main ingredients necessary for the development of severe thunderstorms were found to be present. The air was conditionally unstable with the presence of a mechanism to release this instability and strong injection of low level moisture to sustain the activity, once it had developed.

7. Acknowledgements

I wish to thank Mr. P. Pender of the Toronto Weather Office for his assistance with the compilation of data pertaining to the Windsor

storm. Thanks also to Mr. A. R. Waymann (ACCI) for his excellent photographs of the storm damage.

APPROVED,

J.R.H. Noble,
Assistant Deputy Minister,
Atmospheric Environment Service.

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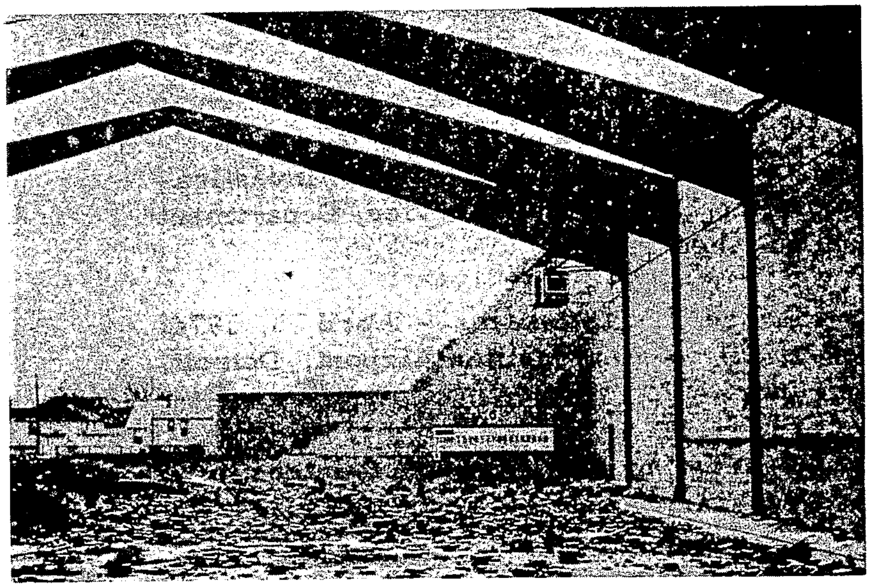
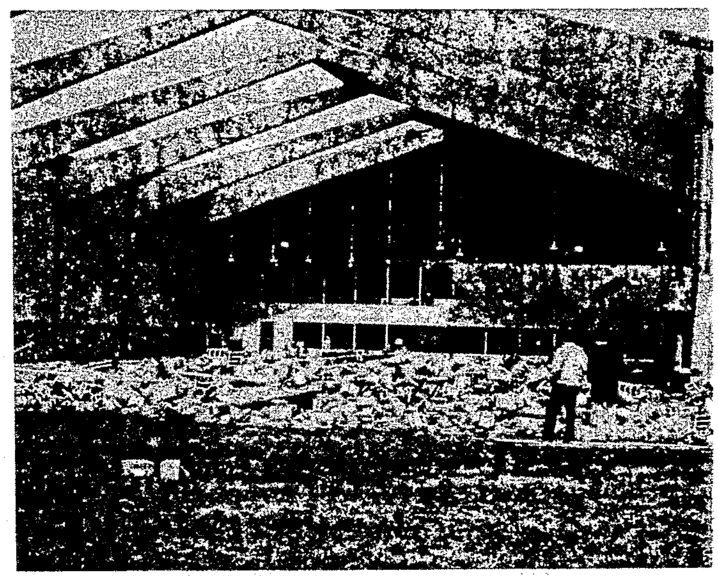


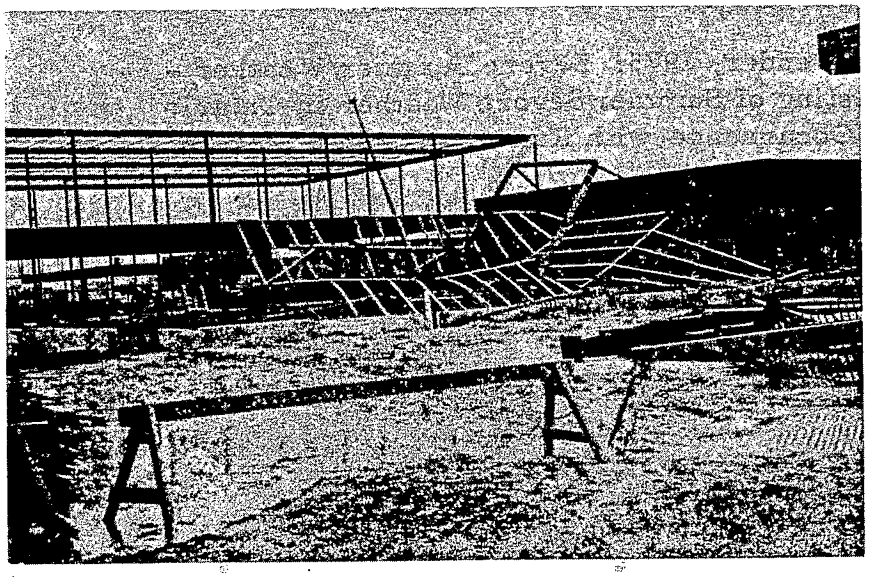
PICTURE

WINDSOR CURLIN
(AS SEEN FROM
OF BUILDIN

PICTURE 2

WINDSOR CURLING CLUB





PICTURE

DEVONSHIRE
CONSTRUCTIO

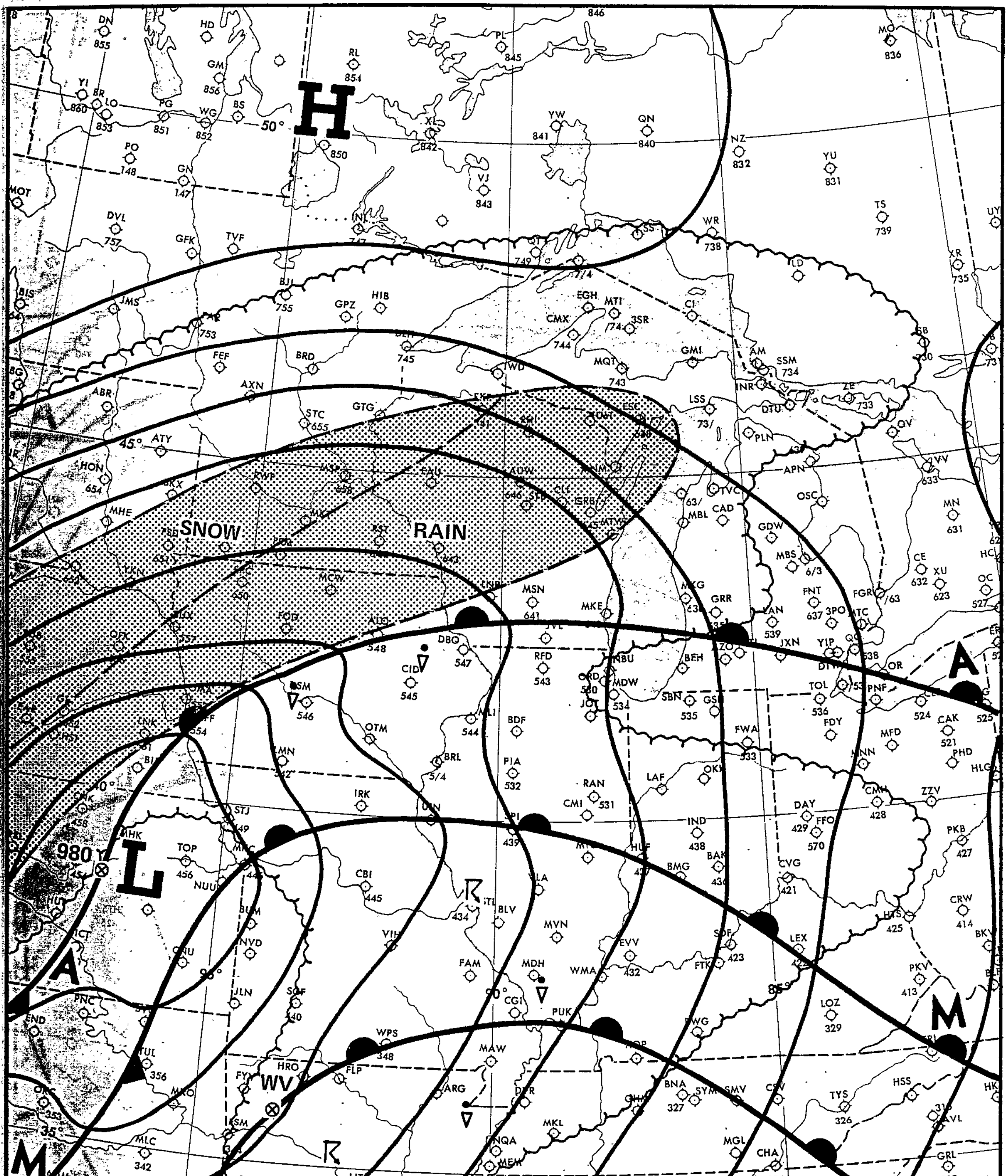


Figure 1
12Z Surface Chart April 3, 1974

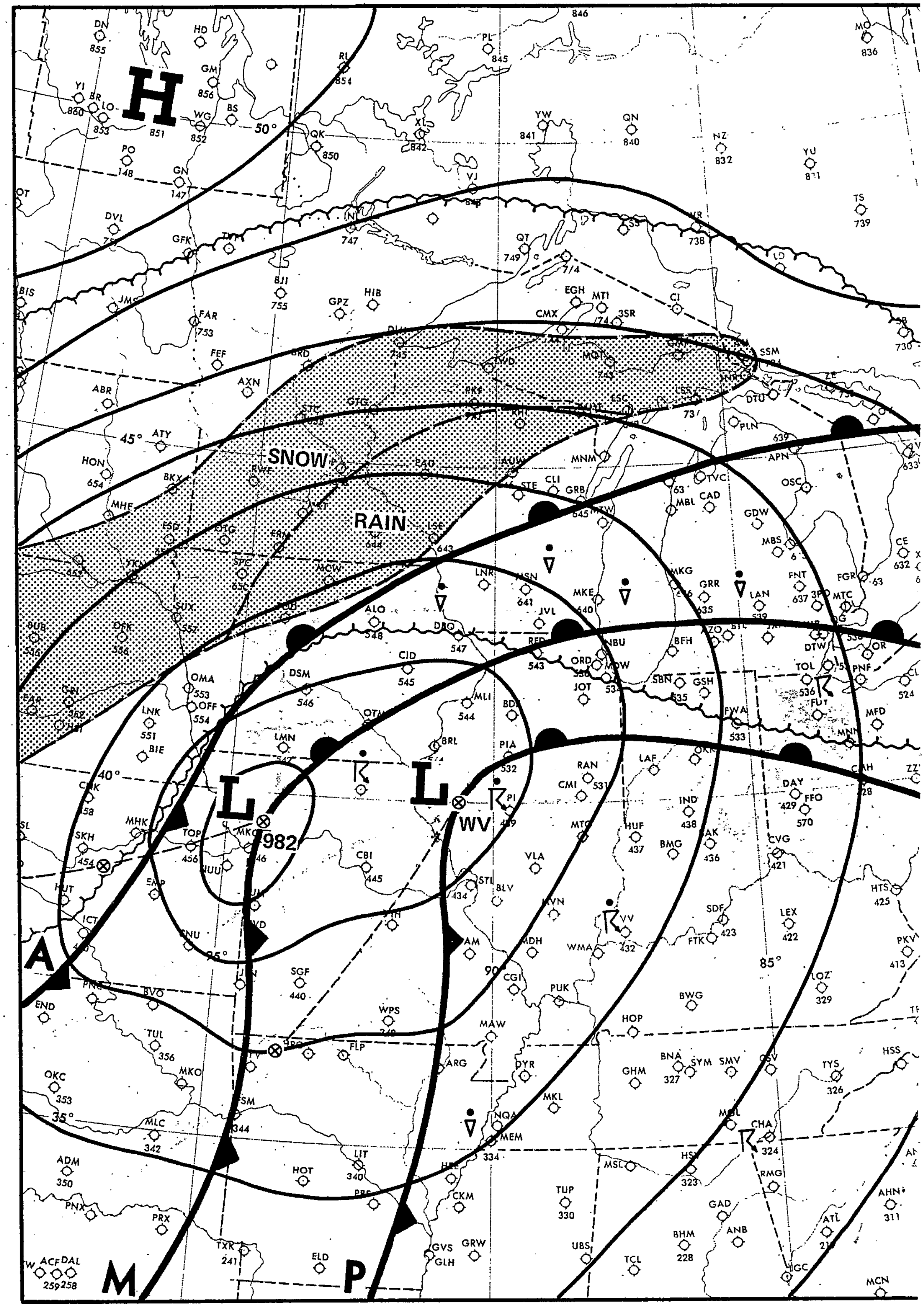


Figure 2
18Z Surface Chart April 3, 1974

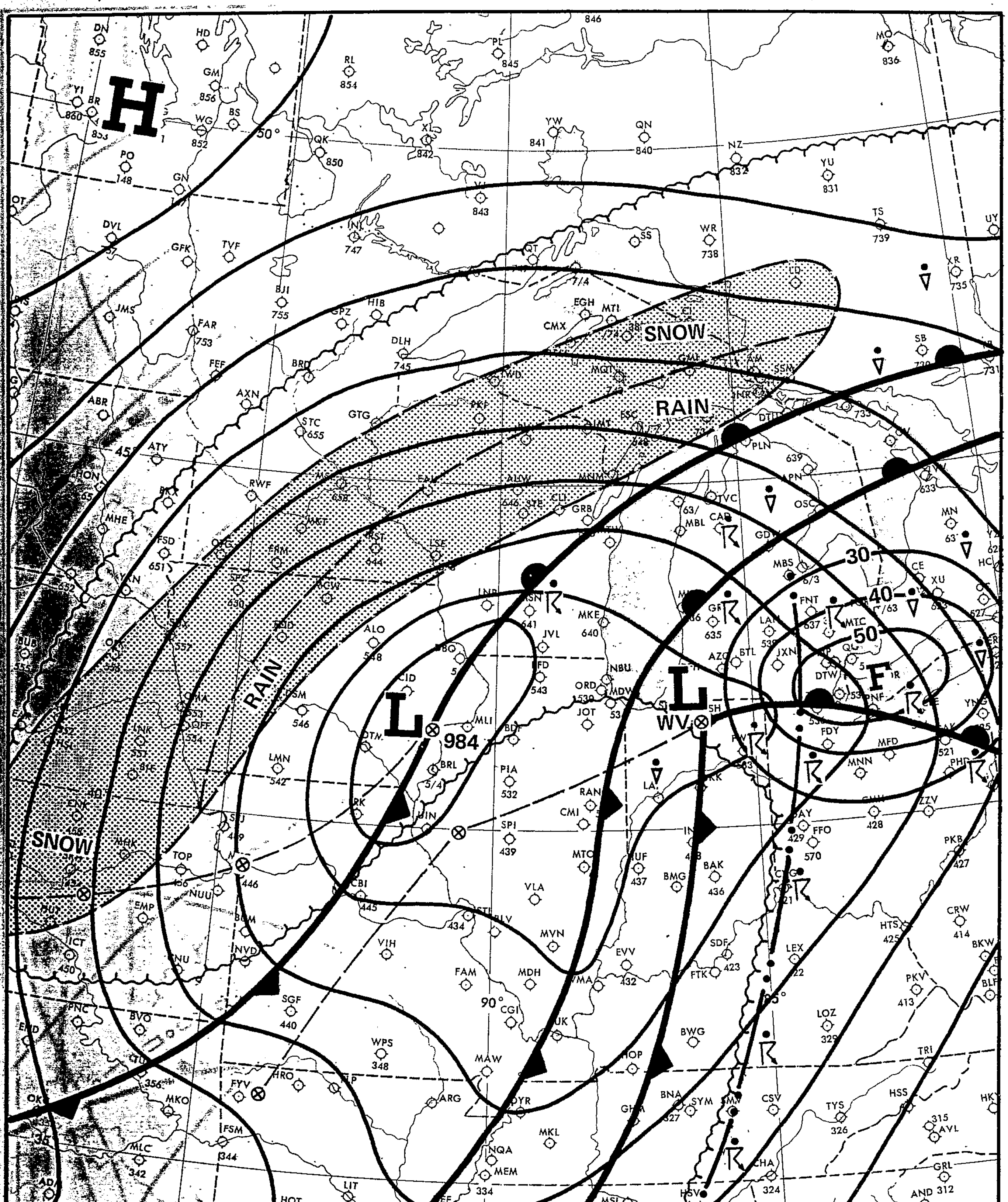


Figure 3
00Z Surface Chart April 4, 1974

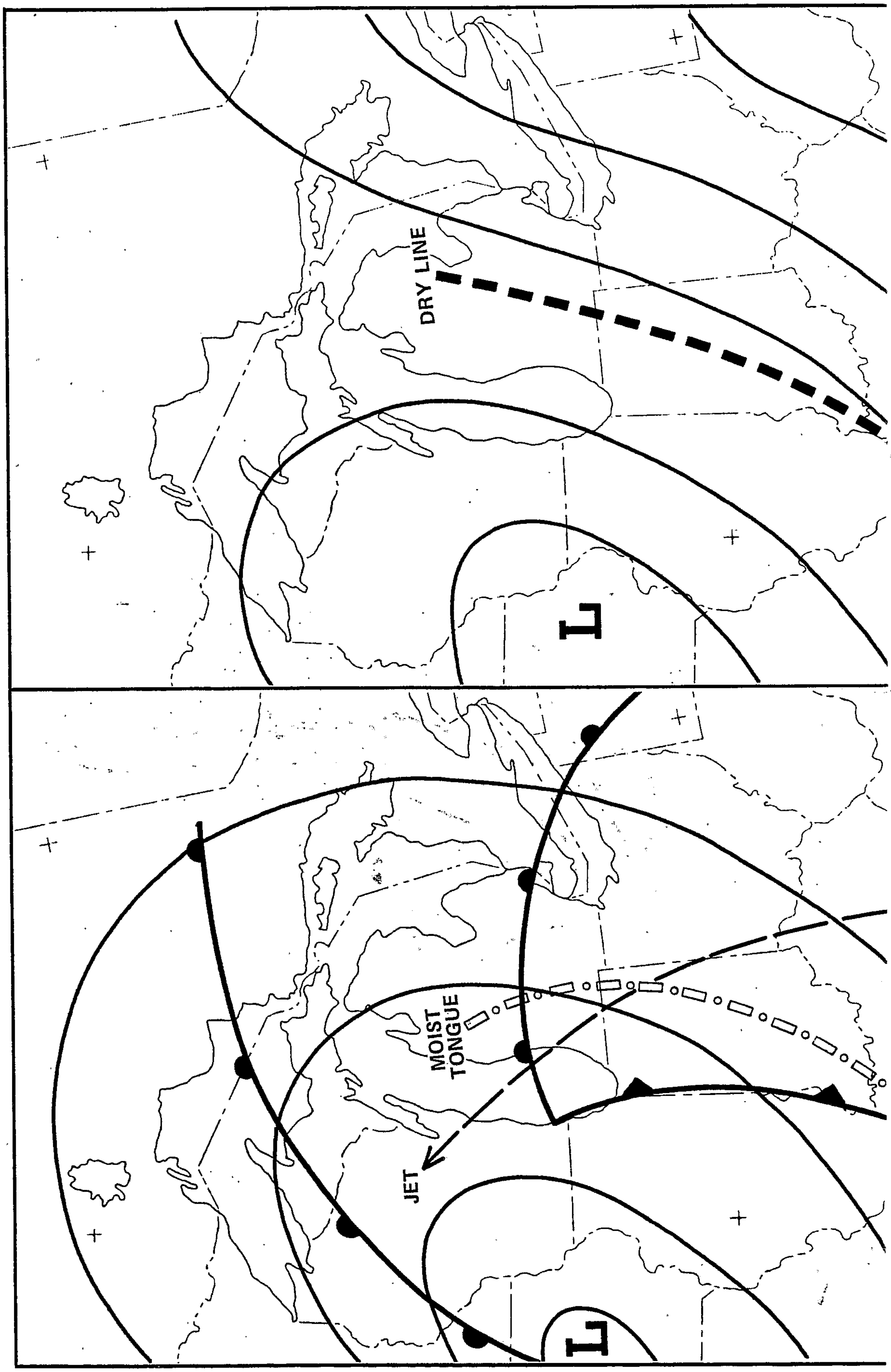


Figure 4: Left Side: 850 mb analysis at 0000Z April 4, 197-
Right Side: 700 mb analysis at 0000Z April 4, 197-

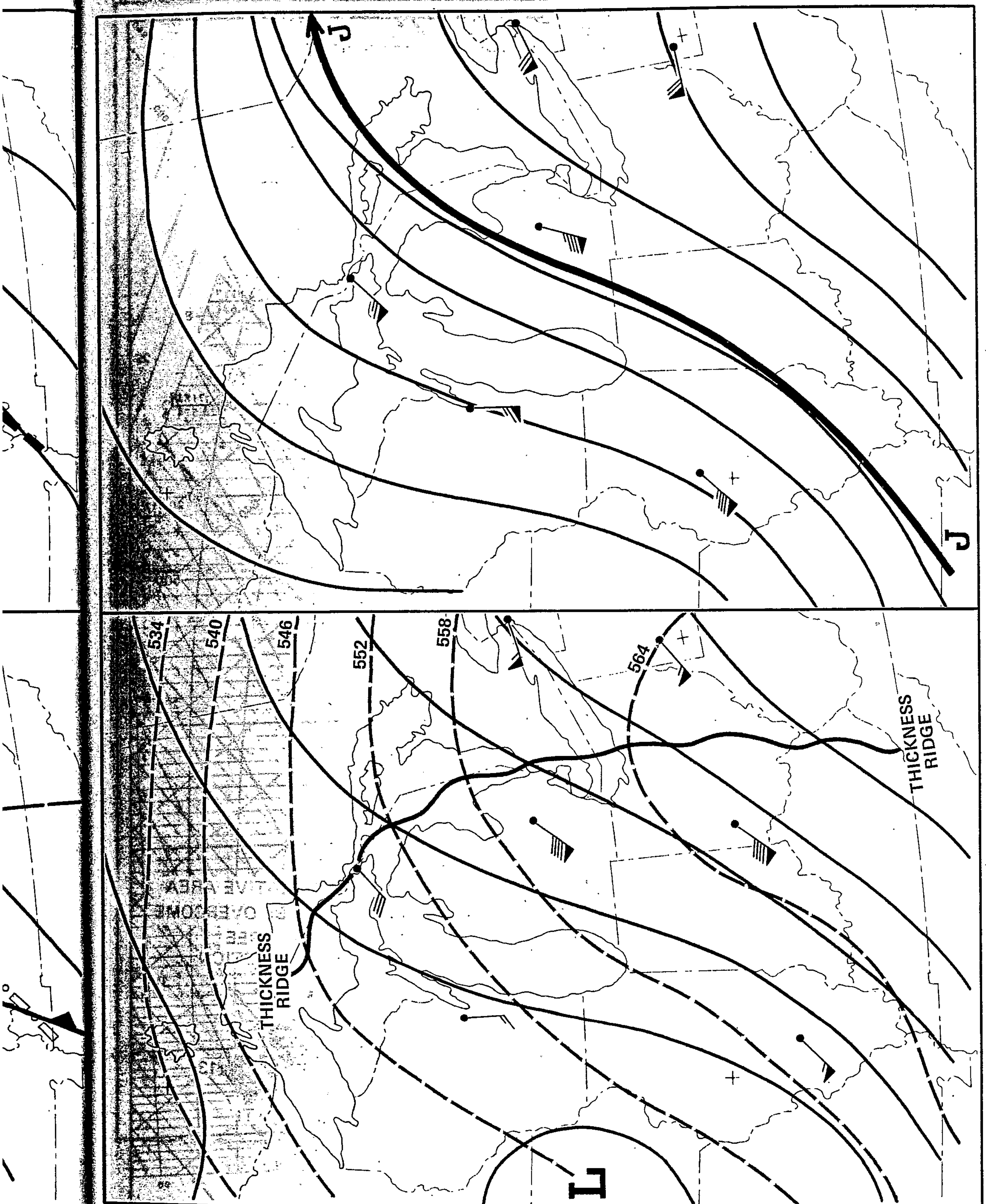


Figure 5: Left Side: 500 mb analysis at 0000Z April 4, 1974
Right Side: 300 mb analysis at 0000Z April 4, 1974

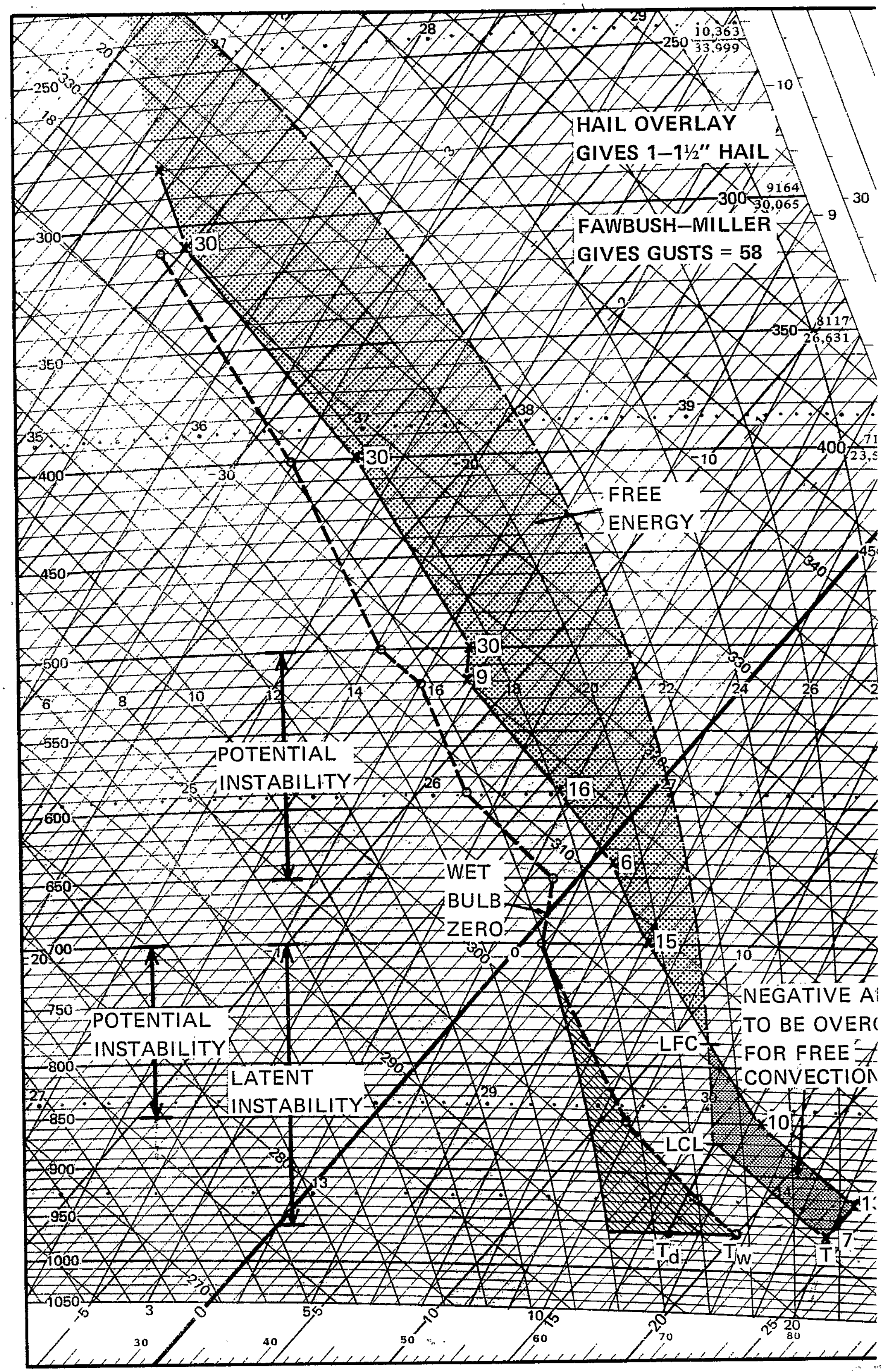


Figure 6
Dayton Sounding 0000Z April 4, 1974

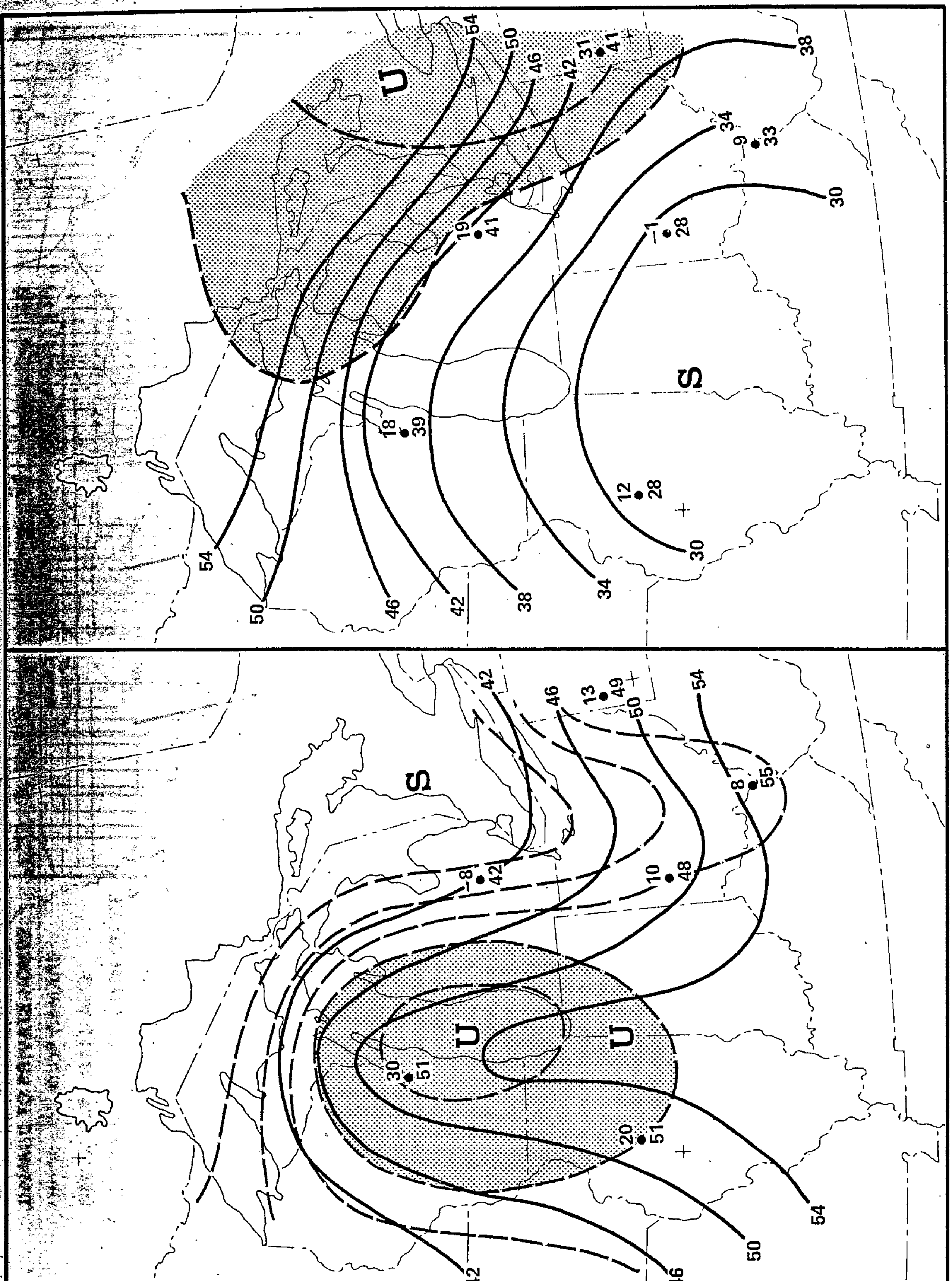


Figure 7: Stability Indices: Left Side for 1200Z April 3, 1974
Right Side for 0000Z April 4, 1974

Legend: ---------- K Factors
__________ Total Totals

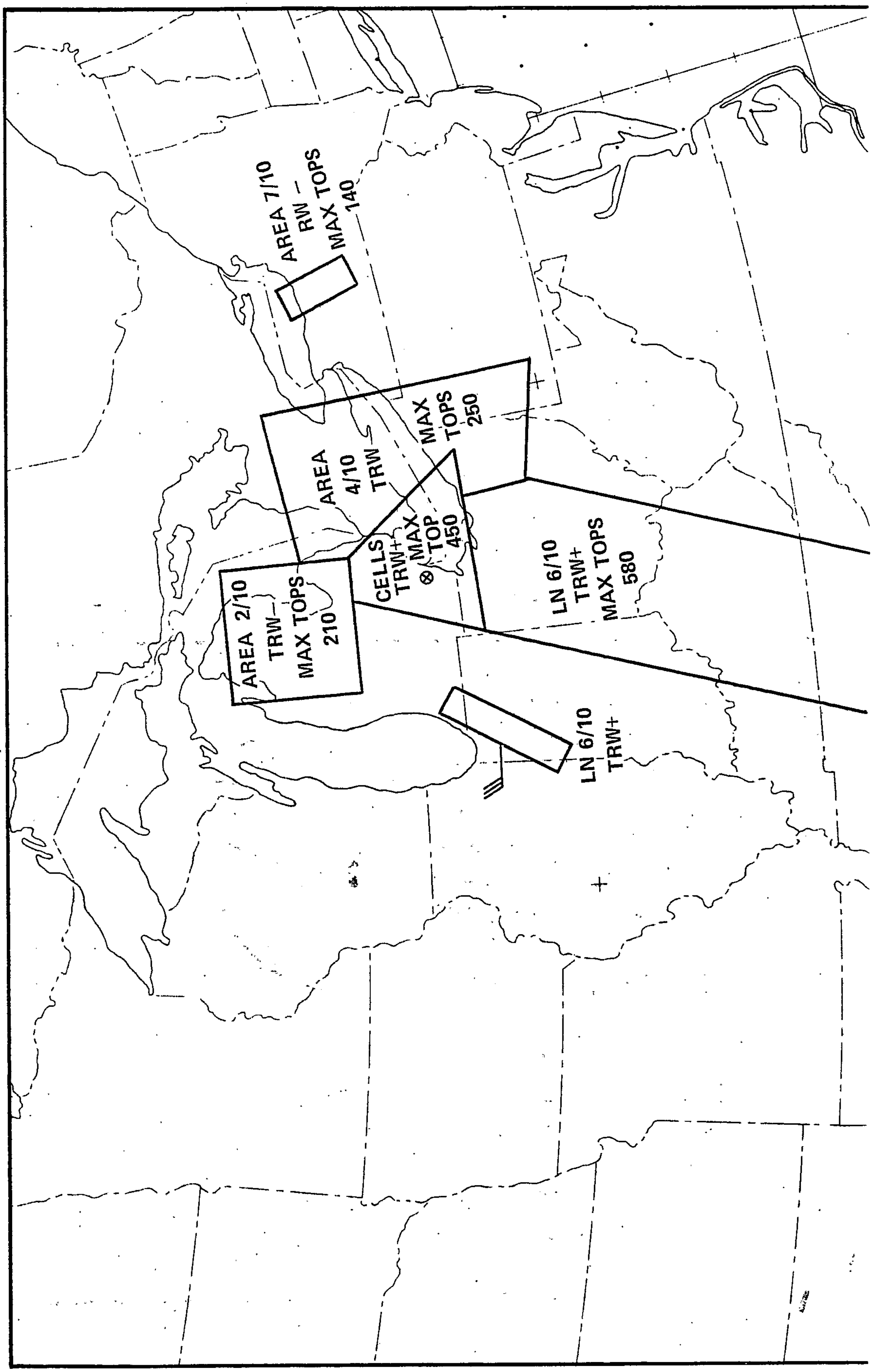


Figure 8
Composite Radar Plot at 2330Z April 3, 1974

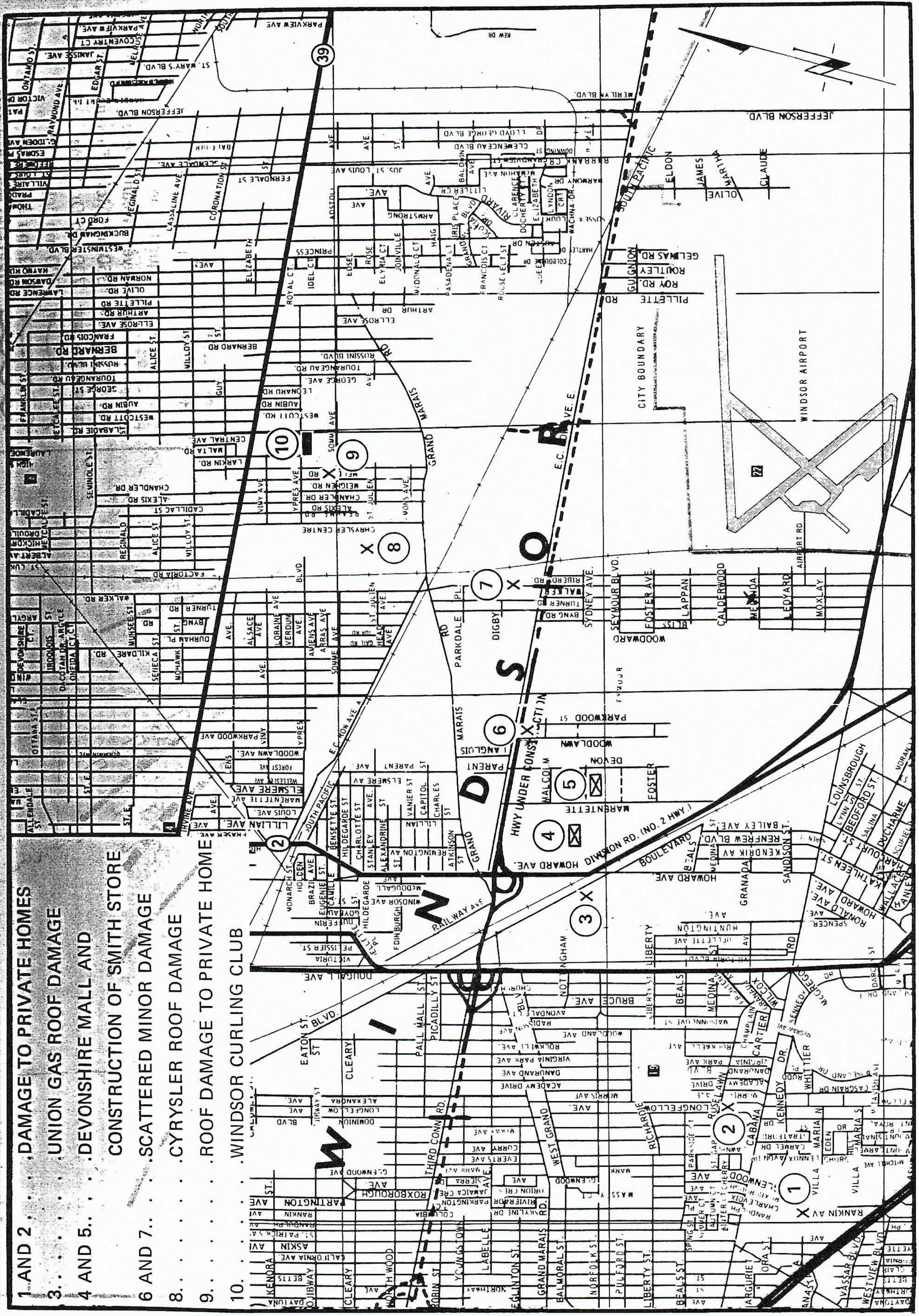


Figure 9
Track of Funnel Cloud

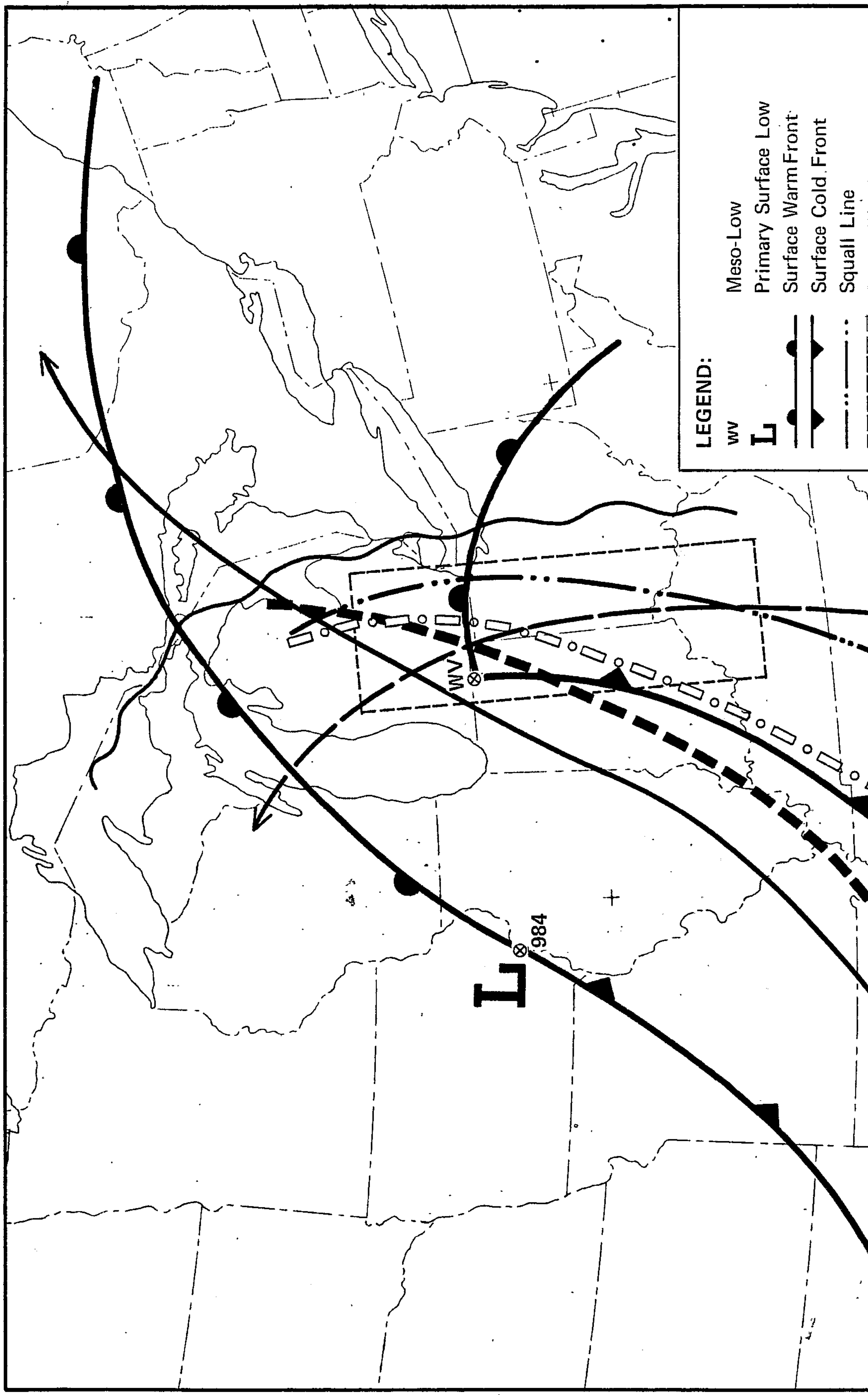
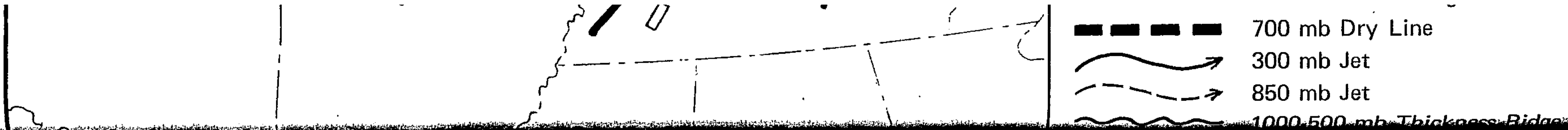


Figure 10
Composite of Severe Weather Potential Factors at 0000Z April



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