T H E

B O I S E   T O R N A D O

O F   1 9 8 4

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INTRODUCTION

Tornadoes in Idaho are rare, based on a SELS log [1]. For example, during the period 1955-1967, only 31 tornadoes were logged in Idaho, compared to a national average of 893 for the 48 conterminous states. In Idaho the greatest tornado frequency during that 12-year period was June, when 13 (or 42%) of the tornadoes occurred. The latest reported tornado during that period was in September; the earliest was in March.

The Boise tornado of October 26, 1984, was the first and only tornado ever reported in Idaho during the month of October. It was also unusual in that it happened during the morning (9:20 am MDT), only about an hour after sunrise (8:12 am MDT).

The tornado was reported to the Boise Weather Service Forecast Office by an off-duty meteorologist a few minutes after it touched down near the intersection of Five Mile and Overland Roads in West Boise. Although no photographs of the actual tornado were taken, descriptions and damage patterns were adequate to ascertain that this was the real thing.

THE TORNADO AND ASSOCIATED WEATHER

According to the eyewitness meteorologist near the scene, there was no funnel. However, there was visible circulation of debris (signs, two-by-fours, etc.) mainly above the rooftops. Trees on one side of the road were bent over, while on the opposite side, the trees did not move. It was "too big for a dust devil".

PATH AND MOVEMENT

The point of touchdown (or first damage) was on Creek Drive, just off Overland Road (see accompanying maps). The tornado proceeded toward the east-southeast, crossing the shopping centers at the intersection of Five Mile and Overland Roads. Where the tornado left the ground and returned to the cloud or dissipated is unknown. The apparent path length was less than a quarter-mile.

DAMAGE

Refer to the accompanying photographs. Near the point of touchdown, a mail box was blown over (photo 1). About a block farther along the path, the rear window of a parked station wagon was blown into the car (photos 2 and 3 show the car). A piece of cardboard had been placed over the blown-in window; pieces of broken glass can be seen inside the car (photo 4).

In a field directly across the street from the parked station wagon, a number of political campaign signs were blown over or totaled. Apparently the tornado did not hit this corner directly, as none of the signs were carried out of the field. Photo 5 was taken from the corner of the auto parts store looking southwest. Two of the blown-down signs can be seen behind the telephone pole immediately to the right of the Killeen sign. They were blown over toward the northwest. Another sign, barely visible on the ground to the left of the white box, was blown toward the northeast; as it the Killeen sign, which can be seen leaning toward the right (photo 6), just to the left of the white box in the far left of the picture.

A damaged cigarette sign is visible near the center of photo 6.

The street sign held by the meteorologist in photo 7 was retrieved from inside the auto parts store. The sign was originally in front of the "Super C" Store. The glass door of the auto parts store was sucked open, and the sign was blown in through the open doorway.

Photo 8, looking in the direction the tornado traveled, shows the corner of the Red Steer restaurant. Ceiling tiles inside the Red Steer were sucked into the attic. Also note the bent light pole and mangled cigarette sign to the left.

The light pole and sign are shown again in photo 9. The sign probably hit the pole near the top, knocking off the light.

Also of interest in this picture is the "for lease" sign across the street (lower left of photo 9). That sign appears to have been untouched.

The Mann Theatres sign (photo 10) was partially demolished.

DAMAGE

Damage was inferred from eyewitness reports and photographs taken at the scene. Near the point of touchdown, a mailbox was blown over. About a block farther along the path, the rear window of a parked station wagon was blown into the car.

In a field directly across the street from the parked station wagon, several political campaign signs were blown over or totaled. Apparently, the tornado did not hit this corner directly, as none of the signs were carried out of the field. Two of the signs were blown over toward the northwest. Other signs were blown over toward the northeast.

A street sign was retrieved from inside the auto parts store. The sign was originally in front of the "Super C" store. The glass door of the auto parts store was sucked open, and the sign was blown in through the open doorway.

Ceiling tiles inside the Red Steer Restaurant were sucked into the attic. A bent light pole and a mangled cigarette sign were found nearby. The sign probably hit the pole near the top, knocking off the light. A theater sign nearby was partically demolished.

A sign almost directly across the street appeared untouched.

WINDS

Other than the tornado wind itself, there were areas of strong straight line winds, as well as areas of little or no wind. For example, about two miles east of the tornado on Brookover Street (see map), an off-duty meteorologist reported strong winds but no damage. About three miles farther east, another off-duty meteorologist observed brief heavy rain and nearly calm winds at the time of the tornado.

PRECIPITATION

Precipitation was not particularly heavy. In the southwest valley area, amounts ranged from nothing at Lucky Peak Dam, Emmett 2E, Mountain Home and Weiser 2SE; to .35 inch at Payette and .37 inch at Glenns Ferry. The Boise Weather Service (6 miles east of the tornado) recorded .15 inch; Boise 7N measured .16 inch. At the Weather Service, most of the rain fell with a moderate thundershower which began 14 minutes after the tornado was reported on the ground.

LIGHTNING

Occasional lightning (cloud to cloud and cloud to ground) was observed with the tornado.

PRESSURE

The pressure fell continuously from 2:50am MDT until the time of the gust front passage at the Weather Service (23 minutes after the tornado was reported 6 miles west). After the gust front passed, the pressure rose rapidly, about 2 mb in one hour. The barograph chart was not retrieved; however, no pressure jump was reported on the observation form.

SOUND

Residents at the site, some of whom had previously experienced a tornado, reported a roaring sound, typical of this type of storm.

DATA ANALYSIS PROCEDURES

SOURCES

In addition to regional analyses and plotted data from AFOS, data were obtained from the Boise surface observations (Form MF1-10A), Climatological Data for Idaho and Boise soundings.

TECHNIQUES

Time cross sections were constructed using information extracted from five Boise soundings, from 12Z on the 25th through 12Z on the 27th of October 1984. Although information from only three of those soundings was plotted, the other two (12Z on the 25th and 12Z on the 27th) were needed to estimate time rates of change of temperature.

Data for analyses of wind speed, potential temperature and dewpoint depression came directly from the soundings. Data for analyses of horizontal temperature advection and mean vertical motion were derived as follows.

The approximation for horizontal temperature advection was used in the following finite difference form:

$$-\vec{V}\cdot\nabla T \doteq V^2 \frac{\Delta\alpha}{\Delta z}\frac{fT}{g} \qquad (1)$$

where

$\vec{V}$	=	*wind vector at a given height*
∇	=	*vector gradient operator along a constant height surface*
T	=	*temperature at a given height*
$-\vec{V}\cdot\nabla T$	=	*advection of temperature on a constant height surface*
V	=	*wind speed at a given height*
α	=	*wind direction*
z	=	*given height*
f	=	*Coriolis parameter (1.006×10^{-4} sec^{-1})*
g	=	*acceleration of gravity (9.81 m sec^{-2})*

The approximation (1) can be derived from the thermal wind equation with the assumption of geostrophic flow, and the assumption that the actual temperature at constant height approximates the virtual temperature at constant pressure [2,3].

The input and output of approximation (1) are listed in Table 1.

The change in wind direction with height was estimated by taking the difference between the directions one minute before and one minute after the minute nearest the pressure level in question. This difference was divided by the corresponding height difference and converted to radians.

Wind data and temperature for each pressure level were interpolated, when necessary, from the soundings.

The approximation for mean vertical motion was used in the following finite difference form:

$$w \doteq -\frac{\Delta T/\Delta t + \vec{V}\cdot\nabla T}{\Gamma - \gamma} \qquad (2)$$

where

w	=	*mean vertical motion*
$\Delta T/\Delta t$	=	*local change of temperature with respect to time*
$-\vec{V}\cdot\nabla T$	=	*horizontal temperature advection*
Γ	=	*dry adiabatic lapse rate (9.767 °C km $^{-1}$)*
γ	=	*existing lapse rate*

Approximation (2) can be derived from the first law of thermodynamics:

$$Q = c_p\frac{dT}{dt} - \frac{1}{\rho}\frac{dp}{dt} \qquad (3)$$

where

Q	=	*rate of heating per unit mass*
c_p	=	*specific heat at constant pressure*
$\frac{dT}{dt}$	=	*differential change of temperature with respect to time following the air motion*
ρ	=	*density*

$\frac{dp}{dt}$ = *differential change of pressure with respect to time following the air motion (also known as vertical wind term in isobaric coordinates)*

From (3) it can be easily shown that:

$$\frac{\partial T}{\partial t} = \frac{Q}{c_p} - (\Gamma - \gamma)\omega - \vec{V}\cdot\nabla T + \frac{1}{\rho c_p}\left(\frac{\partial p}{\partial t} + \vec{V}\cdot\nabla p\right) \quad (4)$$

where

$\frac{\partial T}{\partial t}$ = *local change of temperature with respect to time*

$\frac{Q}{c_p}$ = *diabatic heating or cooling*

$-(\Gamma - \gamma)\omega$ = *vertical motion term*

$-\vec{V}\cdot\nabla T$ = *horizontal temperature advection*

$\frac{1}{\rho c_p}\left(\frac{\partial p}{\partial t} + \vec{V}\cdot\nabla p\right)$ = *ageostrophic flow term*

Diabatic heating or cooling due to radiation budget, mixing, condensation, evaporation and eddy transport of heat were not incorporated into (2). As Williams [2] indicated, these factors would have the greatest effect at "low levels", and would usually be negligible at about 800 mb and above. Data on diabatic effects were not available for the present study.

The final term of equation (4) was also dropped in approximation (2). This term would be small in cases of pure geostrophic flow. Ageostorphic flow would be important only in the friction layer and also near the cold front, the thunderstorm which spawned the tornado and the tornado itself. Unfortunately, these data were not available.

Estimates of $\Delta T/\Delta t$ *for (2) were obtained by a graphical (handdrawn) spline method, based on three temperatures at three times (12 hours apart) for each level (refer to worksheets). It was felt that spline fitting based on circular, sinusoidal, cubic or fractal equations would not have improved the estimates significantly for the purpose of this study (refer to worksheets 1, 2 and 3).*

Linear methods were used only for estimating vertical rates of change of variables because data with respect to height (pressure) were relatively close together.

It was felt that (2) would give results accurate enough to be useful, at least qualitatively, i.e., to determine where and when rising and sinking motions were occurring and their relative magnitudes.

The input and output of approximation (2) are listed in Table 1.

SYNOPTIC SETTING

UPPER TROPOSPHERE

At 300 mb (Figure 1) a large trough was moving in over the Pacific Northwest. At 12Z October 26, southern Idaho was squarely beneath the right existing quadrant of the jet (Figure 2). In accordance with theory, there was in fact subsidence just beneath this level, at a maximum rate of -11.9 cm sec^{-1} (Table 1) down to just about 500 mb (Figure 3).

MID TROPOSPHERE

At 500 mb (Figure 9) PVA was just beginning over the Boise area. The resulting rising motion reached an apparent maximum of 21.1 cm sec^{-1} at 500 mb (Table 1). Rising motion was in fact occurring through a deep layer (Figure 3).

The temperature advection patterns at the leading edge of the trough show weak cold advection at 500 mb and little or no advection at 700 mb and 850 mb on the AFOS analyses (Figures 10, 11 and 12). The time cross section (Figure 4) shows warm advection at 12Z, and at the time of the tornado, from just above 500 mb to about 650 mb, as well as most of the region below 700 mb. Since this information comes from a local sounding, it is probably more accurate than the course AFOS analyses.

Temperatures in the trough were quite cold for the time of year at all levels. The 500 mb temperature was colder than -30°C over Vancouver Island (Figure 10). The 700 mb temperature was colder than -10°C (Figure 11); and the 850 mb temperature was below freezing over a large area (Figure 12). The coldness of the air was reflected by a thickness of less than 5280 m under the trough, and a thickness gradient of more than 240 m between northwest Washington and the Boise area. In other words, it was a strong cold front.

There was a possible cold front(s) aloft which preceeded the surface front. The satellite photo at 1100Z shows a lineation of clouds from the northern California border into the enhanced clouds over southwest Idaho. This band has been indicated by the dashed cold front on Figure 13. The temperature advection cross section analysis (Figure 4) shows weak cold advection at 700 mb prior to the time of the tornado.

BOUNDARY LAYER

On the surface at 12Z, Boise was in the "warm sector", i.e., the cold front was still northwest of the station (Figure 13). Surface observations (refer to copy of MF1-10A) showed temperatures in the upper 40s, which is not really "warm" compared to conditions which "normally" preceed tornadoes in the Midwest and South.

The dewpoint was relatively high (near 40) at the time nearest the tornado (the observation taken at 8:50 am MST); the relative humidity was 74 percent. Just prior to the frontal passage, conditions were somewhat warmer and drier, with temperatures in the low 50s and humidities in the upper 40s, with dewpoints in the low 30s.

The wind ahead of the front was out of the southeast, fairly strong for the Boise area, reaching 18 kt just prior to frontal passage.

The combination of low-level moisture and southeast wind evidently resulted in moisture convergence in the Treasure Valley area of southwest Idaho. An enhanced area of clouds can be seen on the accompanying satellite photos, mainly just to the south and east of Boise. As the moist easterly air current crossed the Owyhee Mountains, there was a band of drying and clearing on the lee (southwest) side of the range, showing most clearly on the 1230Z, 1330Z and 1430Z photos.

The valley narrows from the east toward Boise. This terrain effect probably aided greatly in the low-level moisture convergence.

The surface to 500 mb relative humidity analysis (Figure 16) shows Boise in a col of over 60% relative humidity, located between moisture centers over southwest Oregon and northern Montana, and dry centers over northern Colorado and British Columbia. Computing the surface-to-500 mb humidity directly from the 12Z sounding gave 46%.

Figure 15 shows the AFOS analysis of the surface front position just prior to the tornado. Clouds on the satellite photo show that this position is fairly accurate.

VERTICAL PROFILES

The plotted sounding (Figure 8) does not fit any of the four severe weather airmass types given by Miller [4]. There is a shallow inversion near the surface, with moderately moist air.

Saturated (or near saturated) air extends from 700 mb to 600 mb. This is capped by a dry relatively stable layer. These features also show up in the cross sections (Figure 5 and 6).

The convective condensation level was found to be 695 mb, corresponding to the base of the saturated layer. The lifted condensation level was slightly lower, at 760 mb. The convective temperature (which was never reached) would have been 65°F. There was no level of free convection, hence no positive area (as defined by Petterssen [5]). The sounding is absolutely stable, but convectively unstable due to the dry cap atop the moist middle layer. Above 700 mb the sounding is not unlike the tornado sounding developed by Fawbush and Miller [6].

The wind speed profile (Figure 7) shows winds steadily increasing with height from 800 mb upward at the time of the tornado. Following the tornado, the vertical speed shear markedly decreased between 800 and 600 mb. Wind directional shears can be inferred from Figure 4 or Table 1 (due to approximation 1).

The tropopause at 12Z on the 26th was 42,500 ft msl.

RADAR AND SATELLITE

Lacking local warning radar of any kind at WSFO Boise, fax radar summary charts were used (Figures 18, 19 and 20); also refer to Figure 17.

The 1400Z 2HF satellite photo shows a probable cold top (anvil) just to the west northwest of Boise. This was probably the cell that spawned the tornado. It appears to be very near the cold front. The fax radar summary for 1435Z (Figure 19) shows no more than precipitation. On the visual at 1600Z, the top of the tornado cell is elevated only slightly above the surrounding clouds. Also of interest on this shot is the apparently huge cell just west of the Bitterroot Range, directly over the Selway-Bitterroot Wilderness Area. The fax radar (1535Z) shows nothing.

RESULTS

It is quite clear that this was not a "cold air funnel" but rather a "warm season" or "tornado alley" type of storm. Results taken from three different studies of cold air funnels [7,8,9] are summarized in Table 2. Those features which the cold air funnels had in common with the Boise tornado are marked with asterisks. The conclusion is that the Boise tornado had little in common with the cold air types.

The low-level inversion, above which potential instability was being dynamically created during the night, was advantageous to the coming storm. As Williams [2], Palmén and Newton [10], and others have observed, a surface-based inversion can guard against the premature release of instability by preventing overturning induced by (for example) surface heating.

Now consider the upper-level stable layer (445-610 mb). This was evidently induced by upper-level convergence in the right exiting quadrant of the wind maximum.

The fact that the dry tongue (Figure 6) extended at least 100 mb lower than the sinking motion (Figure 3) could be explained by the possibility that part of the dry air had been advected in, rather than having been created entirely by local subsidence. According to the 24-hour time cross section (Figure 3), the sinking motion occurred over Boise entirely above the 500 mb level until after the tornado.

Between the two stable layers, stability gradually decreased until about the time of the tornado (Figure 5). It seems that the tornado occurred within the time period when instability between 750 mb and 550 mb was decreasing most rapidly, i.e., when $\partial\Delta\theta/\partial t$ *was maximum (* $\Delta\theta$ *is the difference in potential temperature between the 750 mb and 550 mb levels). Also* $\Delta\theta$ *had reached a minimum at the time of the tornado.*

The culprits causing destabilization were (1) the increasing mass convergence and (2) the intruding cold tongue coming in at 600 mb.

Not only was the layer unstable with respect to potential temperature, it was also potentially unstable with respect to moisture profile (Figure 8).

So there was instability resulting from dynamics above 800 mb combined with low-level moisture convergence aided by terrain funneling. This setup required only lifting to release its instability.

This lifting was evidently accomplished by more than one mechanism. There was lifting at the surface by the surface cold front (approximately corresponding to the lowest blue area of Figure 3). There was also a possible cold front aloft (as mentioned earlier) at 700 mb. Above this there was PVA, which reached a maximum just after 12Z just below 500 mb (Figure 3).

The situation was like that described by Petterssen [5] as conducive to severe weather. "...an area of positive vorticity advection (in advance of a cold upper trough) will approach the low-level frontal system and spread over the area of warm advection in advance of the front."

As a note of interest, the cold front evidently became a "katafront", a term referenced by Palmèn and Newton [10] (and originated by Bergeron in 1937) and defined to be a cold front above which the relative motion is downslope, "where the wind component normal to the front (except at the lowest levels) is greater than the rate of advance of the cold front." Several of the satellite photos and especially those at 1700Z and 1830Z show the band of clearing which must have been caused by downward motion ahead of the front. This reflects the strength of the upper level dynamics involved in the storm. It also shows that the rising motion which released the instability eventually became sinking motion.

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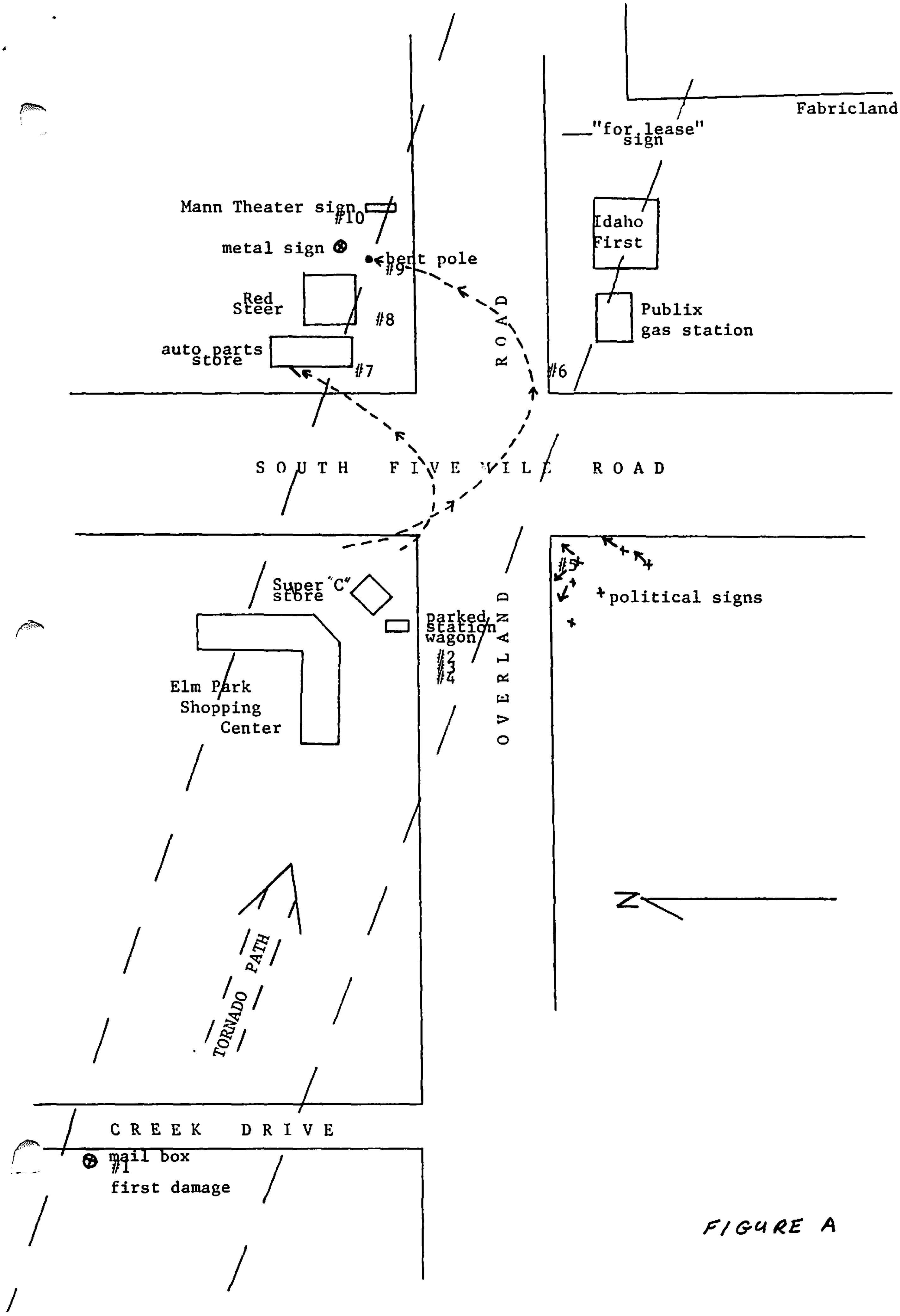
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Mann Theater sign
#10
metal sign
bent pole
#9
Idaho First
Red Steer
#8
Publix gas station
auto parts store
#7
ROAD
#6
SOUTH FIVE MILE ROAD
Super "C" store
#5
political signs
parked station wagon
#2
#3
#4
OVERLAND
Elm Park Shopping Center
TORNADO PATH
N
CREEK DRIVE
mail box
#1
first damage

FIGURE A

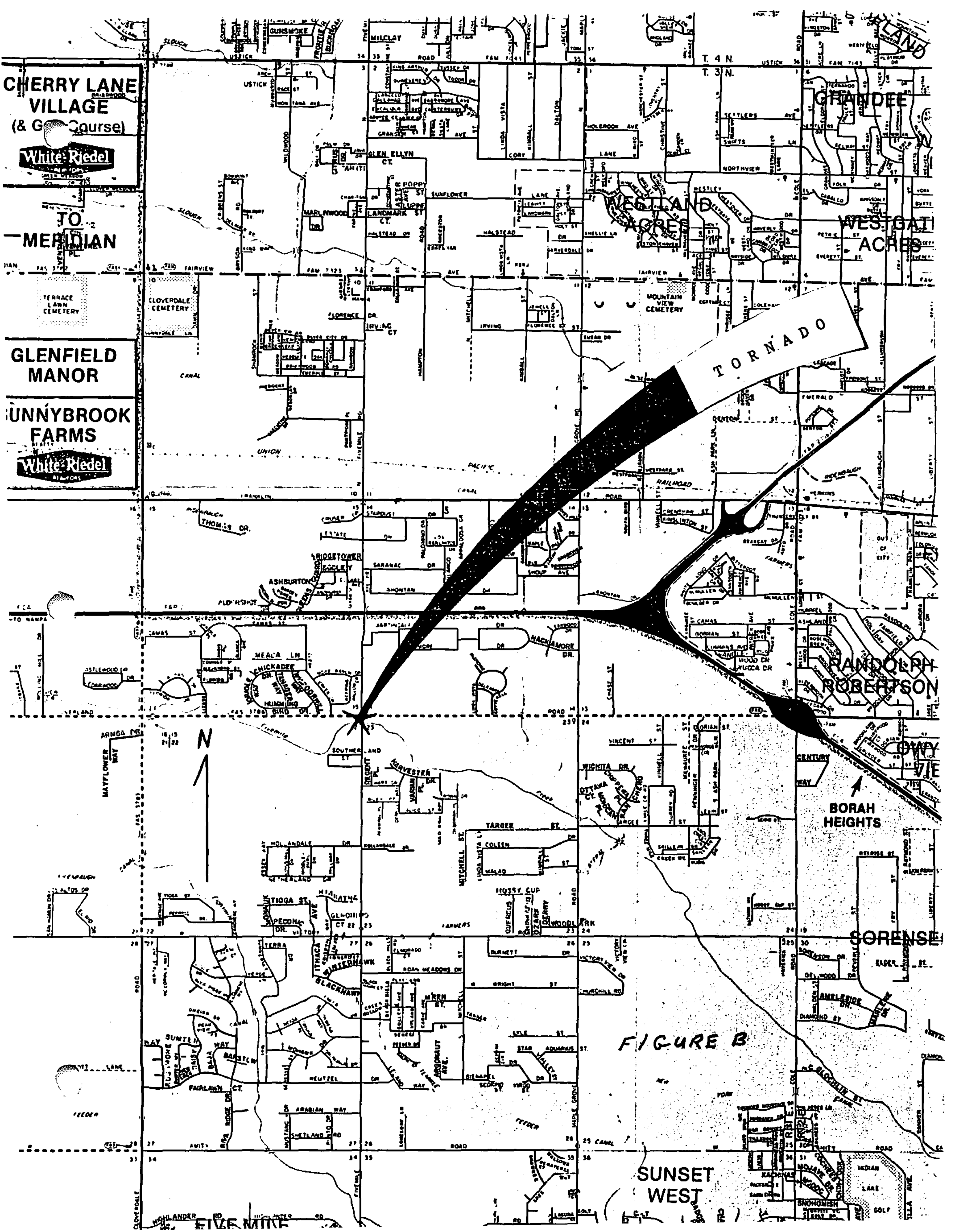

CHERRY LANE VILLAGE
White-Riedel
TO MERIDIAN
TERRACE LAWN CEMETERY
CLOVERDALE CEMETERY
GLENFIELD MANOR
FARMS
White-Riedel
GRANDEE
WESTLAND ACRES
MOUNTAIN VIEW CEMETERY
FAIRVIEW
USTICK
T. 4 N.
T. 3 N.
TORNADO
N
BORAH HEIGHTS
SUNSET WEST
FIGURE B

TABLE 1

BOISE SOUNDING DATA

1	2	3	4	5	6	7	8	9	10
00Z	10/26/84								
400	-24.1	12.6	7.2	2.6	-.17	-.14	3.31	22.7	-2.90E-5
450	-18.3	20.1	6.4	3.4	-.10	1.11	9.89	21.1	2.66E-4
500	-14.5	30.0	1.2	8.6	-.12	.21	1.07	19.0	5.92E-5
550	-11.1	1.2	8.3	1.5	-.28	.83	20.6	20.1	2.12E-4
600	-6.1	.9	6.8	3.0	-.33	-.74	-3.80	17.5	-2.47E-4
650	-1.8	.5	5.9	3.9	-.23	.33	3.99	15.4	1.38E-4
700	1.0	.5	3.8	6.0	-.12	.86	4.54	13.9	4.43E-4
750	1.6	4.1	5.6	4.2	.12	.53	2.71	9.8	5.44E-4
800	6.1	8.9	8.1	1.7	.18	.49	5.07	5.7	1.50E-3
850	9.9	14.1	8.1	1.7	.25	.06	-3.10	6.2	1.41E-4
12Z	10/26/84								
400	-25.9	6.6	6.5	3.3	-.44	.00	3.74	42.7	0
450	-20.0	2.9	6.6	3.2	-.40	-1.76	-11.9	39.6	-1.20E-4
500	-14.7	30.0	6.0	3.8	-.34	2.52	21.1	31.4	2.68E-4
550	-13.2	2.1	6.2	3.6	-.47	.13	4.67	29.9	2.87E-5
600	-11.9	30.0	1.2	8.6	-.54	1.96	8.10	22.7	3.98E-4
650	-6.3	.8	7.4	2.4	-.55	.14	8.09	16.5	5.14E-5
700	-2.3	1.0	7.6	2.2	-.52	-.66	-1.79	16.0	-2.57E-4
750	1.8	3.6	7.7	2.1	-.29	.34	8.45	16.5	1.22E-4
800	5.9	6.3	7.7	2.1	-.28	.85	15.2	10.8	7.09E-4
850	9.9	8.9	7.1	2.7	-.19	.64	8.64	5.1	2.31E-3
00Z	10/27/84								
400	-37.8	12.5	5.6	4.2	-.45	-1.75	-8.66	29.3	-2.34E-4
450	-31.9	21.3	7.5	2.3	-.53	0	6.49	32.9	0
500	-25.9	30.0	6.0	3.8	-.76	-1.87	-8.18	32.9	-1.89E-4
550	-24.1	7.6	4.1	5.7	-.51	-1.61	-5.39	20.6	-4.12E-4
600	-19.4	6.5	7.3	2.5	-.41	-.88	-5.29	17.5	-3.08E-4
650	-15.2	4.5	8.0	1.8	-.40	-.27	2.04	16.0	-1.11E-4
700	-11.3	.7	7.9	1.9	-.38	-.25	1.93	15.4	-1.10E-4
750	-6.5	2.1	9.1	.7	-.46	-.41	2.07	13.9	-2.15E-4
800	-1.7	7.1	9.5	.3	-.44	.15	60.7	15.4	6.35E-5
850	3.1	10.8	9.9	-.1	-.45	.45	-192.	13.9	2.29E-4

1. PRESSURE LEVEL (MB)
2. TEMPERATURE (DEG C) T
3. DEWPOINT DEPRESSION (DEG C)
4. PREVAILING LAPSE RATE (DEG/KM) $= \gamma$
5. DRY ADIABATIC LAPSE RATE MINUS PREVAILING LAPSE RATE $= \Gamma - \gamma$
6. LOCAL CHANGE OF TEMPERATURE WITH RESPECT TO TIME (DEG/HR) $= \Delta T / \Delta t$
7. TEMPERATURE ADVECTION (DEG/HR) $= -\vec{V} \cdot \nabla T$
8. VERTICAL VELOCITY (CM/SEC) = W
9. HORIZONTAL WIND SPEED (M/SEC) $= \vec{V}$
10. LOCAL CHANGE OF WIND DIRECTION WITH RESPECT TO HEIGHT (RAD/M) $= \Delta \alpha / \Delta Z$

(E INDICATES EXPONENT OF 10)

TABLE 2

OBSERVATIONS: COLD AIR FUNNELS

*1. USUALLY OCCUR EARLY SPRING/LATE FALL
2. FALL FUNNELS USUALLY FORMED MIDDAY/AFTERNOON
3. FAMILY OUTBREAKS NOT UNCOMMON
4. CB-S VICINITY THROUGHOUT THE DAY
5. NO ROARING NOISE (90% CASES)
6. NO TOUCHDOWN OR DAMAGE
7. HAIL COMMON
8. PROBABLE MARITIME INFLUENCES:
FRICTIONALLY INDUCED WIND SHEARS NEAR COAST
WATER PROVIDING HEAT AND MOISTURE
9. TROPOPAUSE HEIGHT AVERAGED 35 THOUSAND FEET MSL..GREATER THAN 10 THOUSAND FEET ABOVE RADAR TOPS
10. AIRMASS COLDER THAN GROUND AND SUPERADIABATIC
11. SURGE OF COLD DRY AIR ALOFT TO AMPLIFY LOW LEVEL INSTABILITY
12. NO INVERSIONS OR STABLE LAYERS
*13. UNSTABLE MOISTURE PROFILE (MOIST BELOW/DRY ABOVE)
*14. DRY LAYER HAD NOT YET DESCENDED TO 700 MB
*15. AIRMASS MOIST AT 12Z..DRYING BY 00Z
16. DEEP MOIST LAYER TO 500 MB WITH AVERAGE RH 86%
17. WIND SPEEDS LESS THAN 20 KT ALL LEVELS (FALL CASES)
18. EVIDENCE OF WEAK LOW LEVEL JET (SUMMER CASES ONLY)
*19. IN SOME CASES..STRONGLY INCREASING WINDS WITH HEIGHT
*20. STABLE LAYER ABOVE 600 MB
21. SHOWALTER INDEX RANGE 1-11
22. K INDEX RANGE 2-25 (ALL FALL CASES WERE LESS THAN 16)
23. MEAN LIFTED INDEX -3
24. BEHIND COLD FRONT
25. COLD FRONT PASSED 18-42 HOURS PRIOR TO FUNNELS
*26. SURFACE TEMPERATURE RANGE 10-20 DEG C
27. RAPID BUILDUP OF CONVECTION FOLLOWING FROPA/TOPS LESS THAN 18 THOUSAND FEET MSL
28. SURFACE LOW JUST EAST OF FUNNELS (80% CASES)
29. STRONG PVA FOLLOWED BY STRONG COLD ADVECTION
30. STRONG COLD ADVECTION 850-400 MB COMBINED WITH INFLUX OF MOISTURE SFC-850 MB ACCOMPANYING UPPER TROUGH (POST FRONTAL)
*31. FROPA PRECEEDED BY RAIN/ABUNDANT LOW LEVEL MOISTURE FOLLOWED BY STRONG COLD ADVECTION ALOFT
32. 500 MB TROUGH LINE DIRECTION OVERHEAD OR EAST OF FUNNELS (70% CASES)
*33. 500 MB TROUGH LINE WEST OF FUNNELS (30%) OF CASES
34. FUNNELS GENERALLY NEAR WESTERN EDGE OF CLOUD SHIELD OF UPPER LOW
35. WIND MAX CORE OVERHEAD

*features which the cold air funnels and the Boise tornado had in common

BOILSRBOI
WOUS00 KBOI 261900

STORM REPORT
NATIONAL WEATHER SERVICE BOISE ID
1230 PM MDT FRI OCT 26 1984

TIME	EVENT
930 AM	TORNADO REPORTED ON THE GROUND APPROX 6 MILES WSW OF THE AIRPORT MOVING EAST SOUTHEAST... REPORT MADE BY WEATHER SERVICE METEOROLOGIST
938 AM	TORNADO WARNING ISSUED FOR ADA COUNTY VALID UNTIL 1030 AM MDT
1020 AM	TORNADO WARNING CANCELLED
10 AM -11AM....	VISUAL INSPECTION OF THE PROBABLE TORNADO SITE SHOWED A TORNADO LIKELY TOUCHED DOWN FOR A BRIEF PERIOD OF TIME WITH A PATH LENGTH OF APPROX ONE QUARTER MILE. MINOR DAMAGE TO TREES...SIGNS...CARS.

$$

MF1-10A (5-83)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

SURFACE WEATHER OBSERVATIONS

STATION: WSFO, BOISE, IDAHO

DATE: 26 OCT 1984

TO CONVERT LST TO GMT ADD 7 hrs. SUBTRACT ___ hrs.

TYPE (1)	TIME (LST) (2)	SKY AND CEILING (Hundreds of Feet) (3)	VISIBILITY (Miles) SURFACE (4)	TOWER (4a)	WEATHER AND OBSTRUCTIONS TO VISION (5)	SEA LEVEL PRESS. (Mbs.) (6)	TEMP (°F) (7)	DEW PT. (°F) (8)	WIND DIRECTION (00-36) (9)	SPEED (Kts.) (10)	CHARACTER (11)	ALTIMETER SETTING (Ins.) (12)	REMARKS AND SUPPLEMENTAL CODED DATA (13)	OBSERVER'S INITIALS (18)
SA	0053	M 55 BKN 70 OVC	15			085	55	22	16	03		978	13 295	RSL
SA	0150	12 SCT 30 SCT M 55 OVC	7		R-	074	53	37	18	03		975	RB25/GR00 152/	RSL
SA	0250	30 SCT M 65 OVC	15		R-	063	51	36	11	06		974	R VRY LGT	RSL
SA	0350	M65 (BKN) 90 OVC	15			040	51	34	12	11		970	RE15	LH
SA	0450	M65 (BKN) 90 OVC	15			036	51	34	11	12		967	73400 157/ 51	LH
													RADAT 84085	/
		72681 11874 81112	10166		20011	39047			40036				57036 69901	LH
		70262 85571 333	10536		20106	90521								/
SA	0550	M65 BKN 85 OVC	15			030	51	33	12	10		964	BINOVC	LH
SA	0650	M65 (BKN) 85 OVC	20			021	52	31	13	15		961		LH
SA	0750	E60 (BKN) 85 (BKN) 120 OVC	20			011	51	32	13	18		958	CB OCNL LTGCCCG	LH
													NW) RWU W-N	/
													BINOVC LWR CLDS	/
													NW/ 725 1970	/
SP	0834	35 SCT M60 (BKN) 85 OVC	15		T				15	17		960	T B33 NW) MOVG E	LH
													OCNL LTGCCCG	/
													RWU SW-N	/
SP	0846	35 SCT M60 OVC	8		TRW				30	22G30		964	T B33 NW-NE	LH
													MOVG E OCNL	/
													LTGCCCG WSHFT	/
													43 FROPA PRESRR	/
RS	0850	35 SCT E60 OVC	~~2~~	2	TRW	030	48	40	31	20		966	T B33 NW-NE MOVG	LH
													E OCNL LTGCCCG	/
													WSHFT 43 FROPA	/
													PRESRR FEW LWR	/
													CLDS RB30	/
SP	0916	15 SCT E35 (BKN) 60 OVC	4		RW-				33	10		966	T E18 MOVD E	LH
													VSBY LWR E/OFF	/
													DUTY WEA SVC	/
													PERSONNEL TORNADO	/
													6W BOI SHORT	/
													DURATION) MOVG E	/
													1535 (COR: 1520)	/
SP	0941	15 SCT M38 (BKN) 60 OVC	10		RW-				36	10		967	F AND LOW ST AT	LH
													2 HND SE-SW)	/
													BINOVC NW)	/
SA	0950	15 SCT M38 (BKN) 60 OVC	10		RW-	043	46	41	34	08		967	F AND LOW ST	LH
													AT 2 HND SE-SW)	/
													BINOVC NW)	/
SA	1050	15 SCT M38 OVC	10		RW-	052	46	40	30	08		970	FEW LWR ST BINOVC	LH
													NW) /13614 1500	/
													46	/
		72681 11466 83008	10078		20044	39057			40052				51036 60041	LH
		78098 87500 333	10128		20078	70036			90531(0)					/
SA	1150	38 SCT M 55 BKN 110 OVC	20			057	47	38	33	10		971	RE30 FEW LWR ST	MR
/													RWU E-SW BINOVC W	/
SA	1250	40 SCT E 55 BKN 200 BKN	30			054	49	35	32	13		971	RWU SE-S	MR
SA	1350	55 SCT M 75 BKN	30			060	49	30	31	15		972	RB14E29 RWU SW ALQDS	MR
/													20701 1270	/

A synoptic observation using WMO code FM12-VII, as described in FMH-2, is entered on line following dated Basic observation.

FM12-VII: IIIII $i_R i_x h VV$ Nddff $1 s_n TTT$ $2 s_n T_d T_d T_d$ $3 P_o P_o P_o P_o$ 4PPPP 5appp $6 RRR t_R$ $7 ww W_1 W_2$ $8 N_h C_L C_M C_H$ plus regional and national data groups.

SUPERSEDES MF 1-10A (1-83) WHICH MAY BE USED.

U.S.GPO:1983-0-664-000/0010

TABLE 3

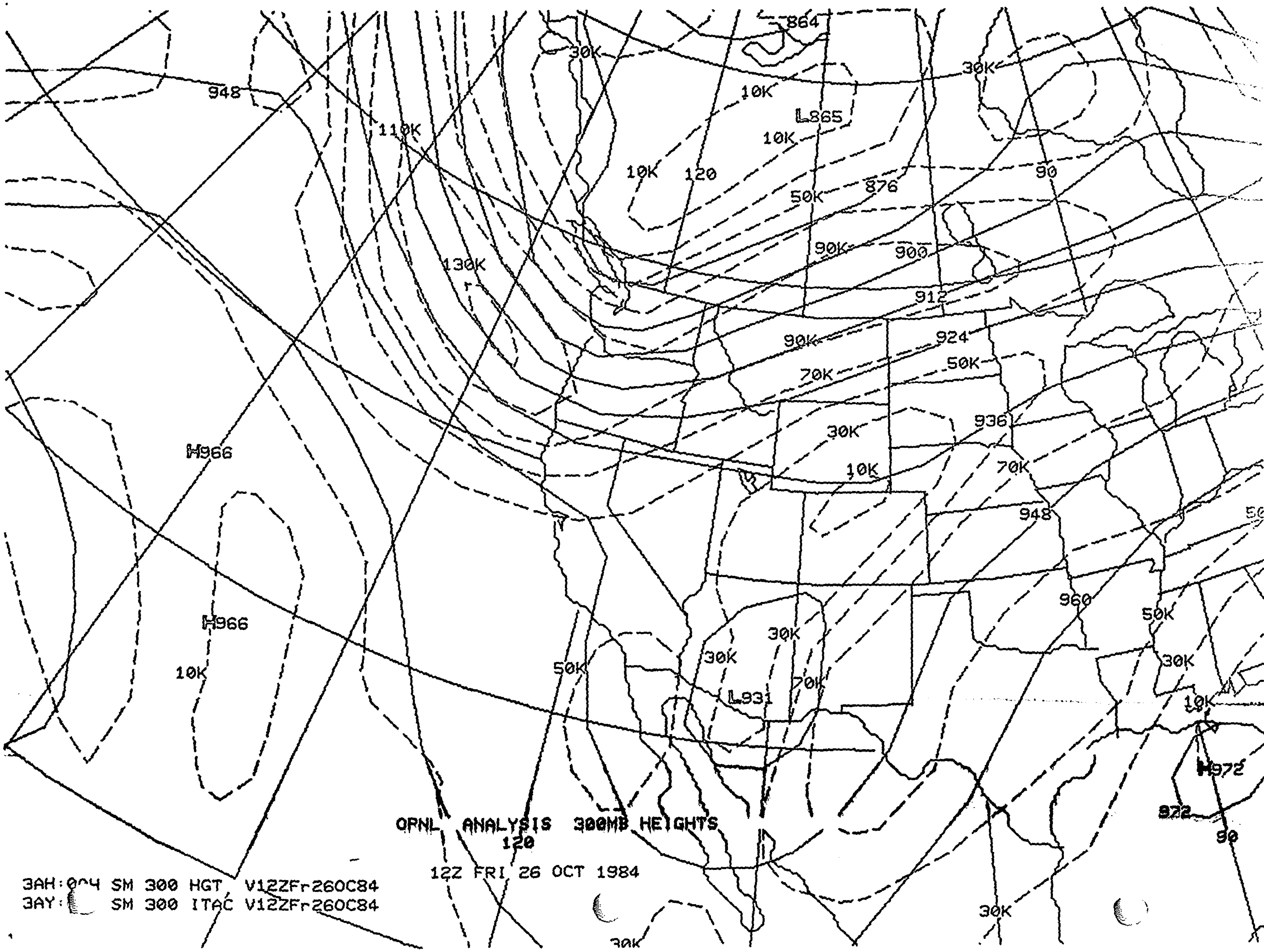

ORNL ANALYSIS 300MB HEIGHTS
120
12Z FRI 26 OCT 1984
3AH:004 SM 300 HGT V12ZFr260C84
3AY: SM 300 ITAC V12ZFr260C84
864
30K
948
10K
L865
110K
10K
10K
120
876
90
50K
90K
900
130K
912
924
90K
50K
70K
936
H966
30K
10K
70K
948
960
H966
30K
50K
30K
10K
50K
70K
30K
L931
10K
H972
972
90
30K

FIGURE 1

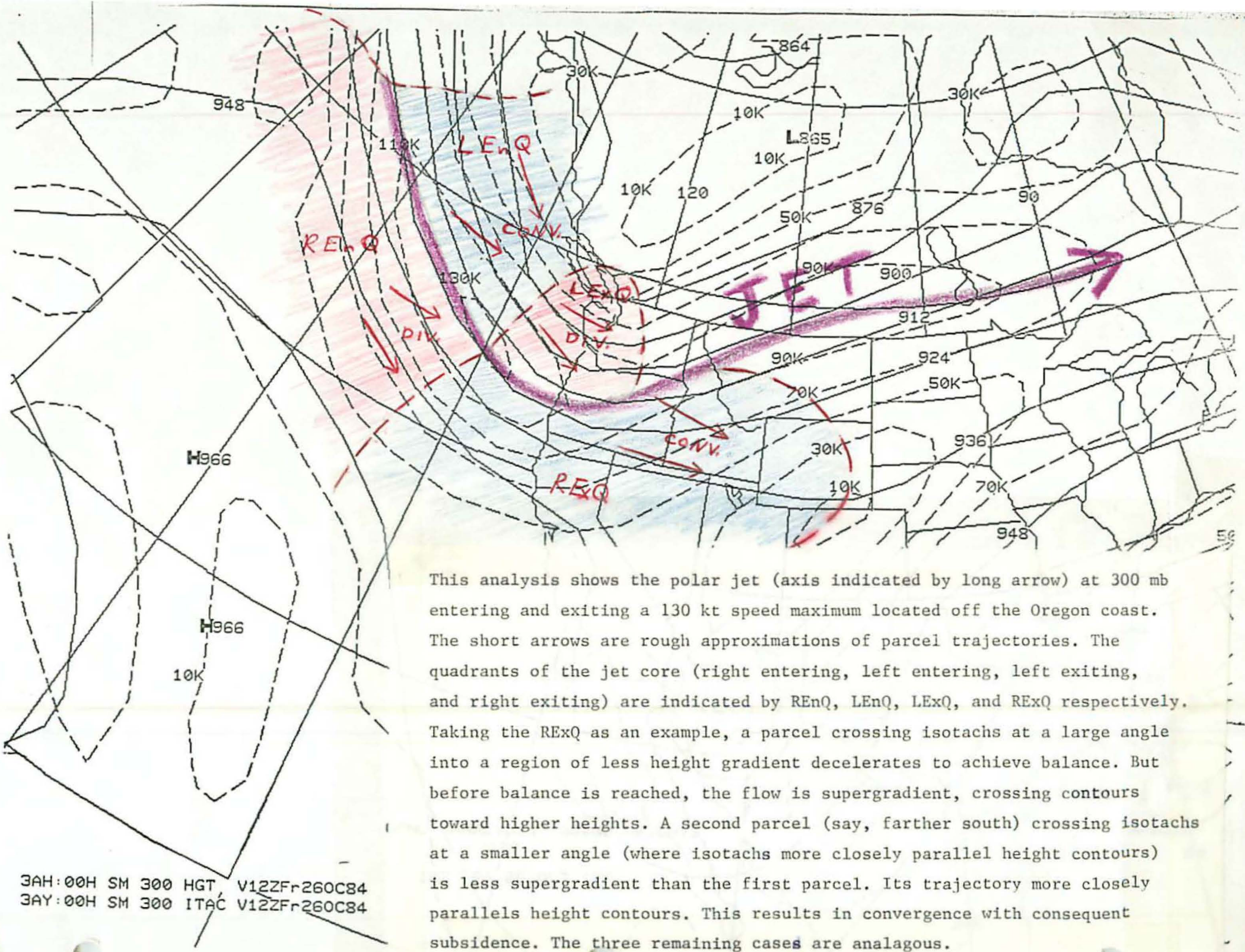


FIGURE 2

This analysis shows the polar jet (axis indicated by long arrow) at 300 mb entering and exiting a 130 kt speed maximum located off the Oregon coast. The short arrows are rough approximations of parcel trajectories. The quadrants of the jet core (right entering, left entering, left exiting, and right exiting) are indicated by REnQ, LEnQ, LExQ, and RExQ respectively. Taking the RExQ as an example, a parcel crossing isotachs at a large angle into a region of less height gradient decelerates to achieve balance. But before balance is reached, the flow is supergradient, crossing contours toward higher heights. A second parcel (say, farther south) crossing isotachs at a smaller angle (where isotachs more closely parallel height contours) is less supergradient than the first parcel. Its trajectory more closely parallels height contours. This results in convergence with consequent subsidence. The three remaining cases are analagous.

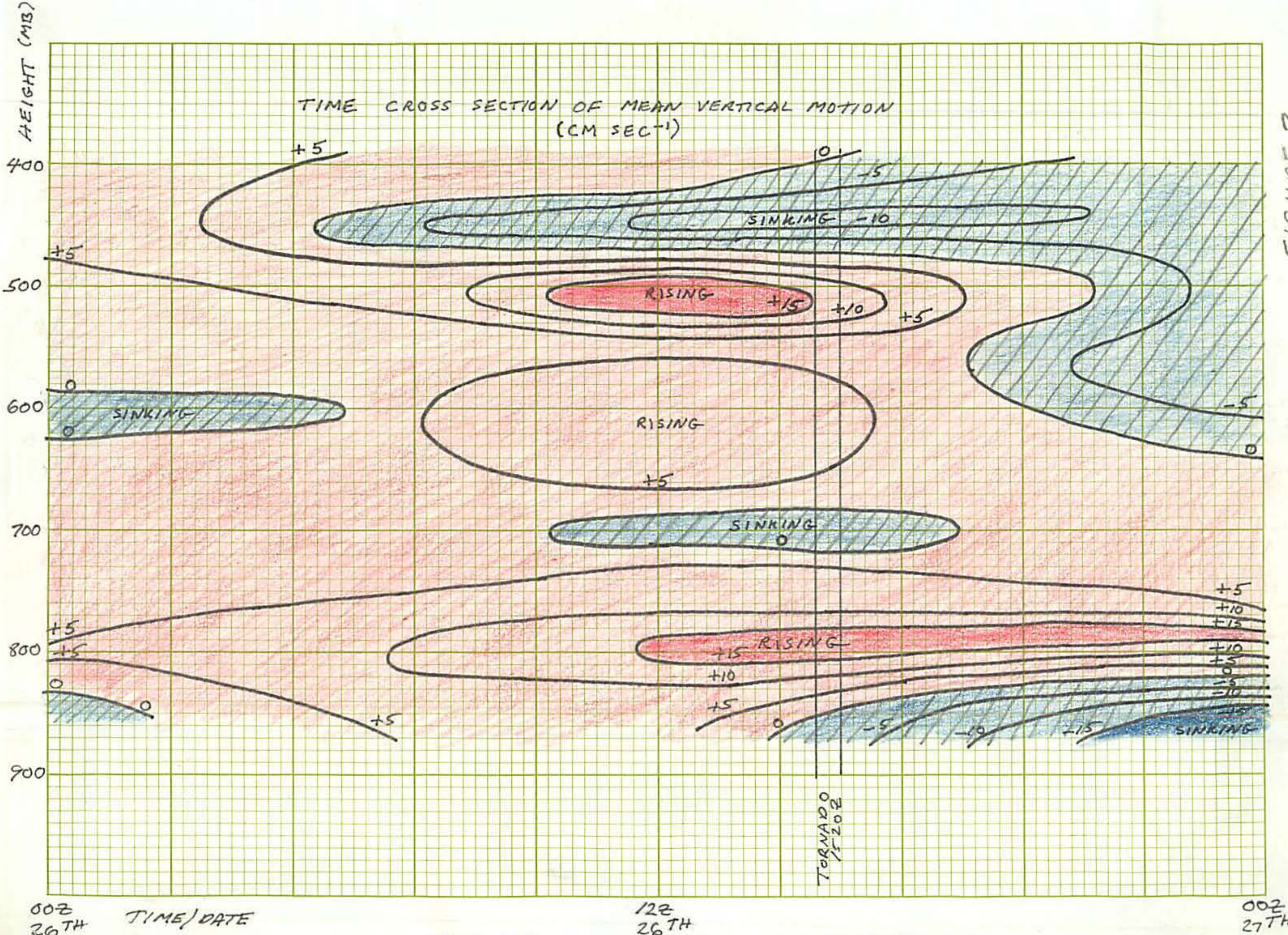

TIME CROSS SECTION OF MEAN VERTICAL MOTION
(CM SEC^{-1})
HEIGHT (MB)
400
500
600
700
800
900
+5
0
-5
-10
SINKING
RISING
+15
+10
+5
SINKING
0
RISING
+5
SINKING
0
+5
+10
+15
RISING
+15
+10
+5
0
-5
-10
-15
SINKING
TORNADO
1520Z
00Z
26TH
TIME/DATE
12Z
26TH
00Z
27TH

FIGURE 3

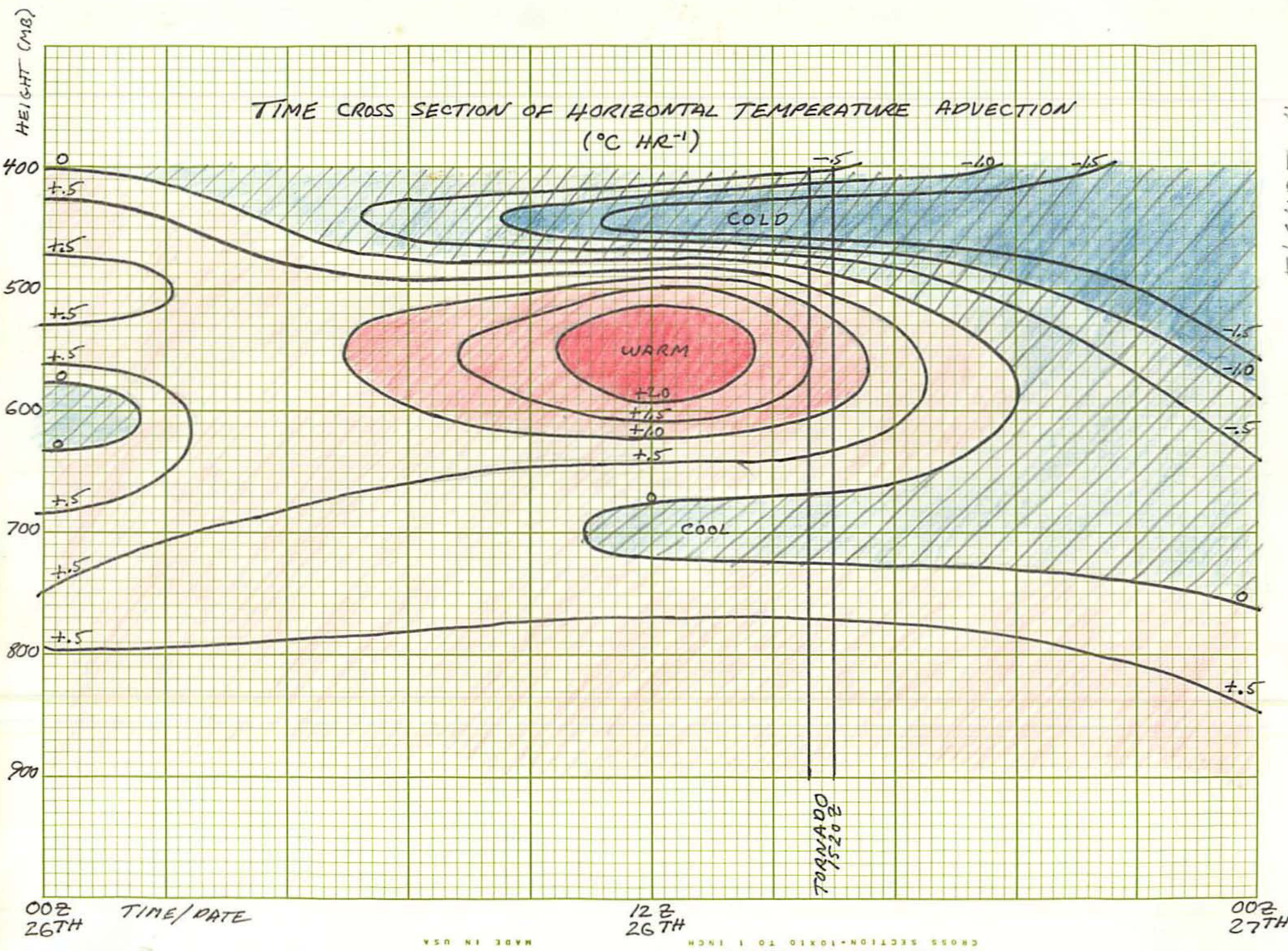

TIME CROSS SECTION OF HORIZONTAL TEMPERATURE ADVECTION
(°C HR⁻¹)
HEIGHT (MB)
400
500
600
700
800
900
COLD
WARM
COOL
+2.0
+1.5
+1.0
+.5
0
-.5
-1.0
-1.5
TORNADO 1520Z
00Z 26TH
TIME/DATE
12Z 26TH
00Z 27TH

FIGURE 4

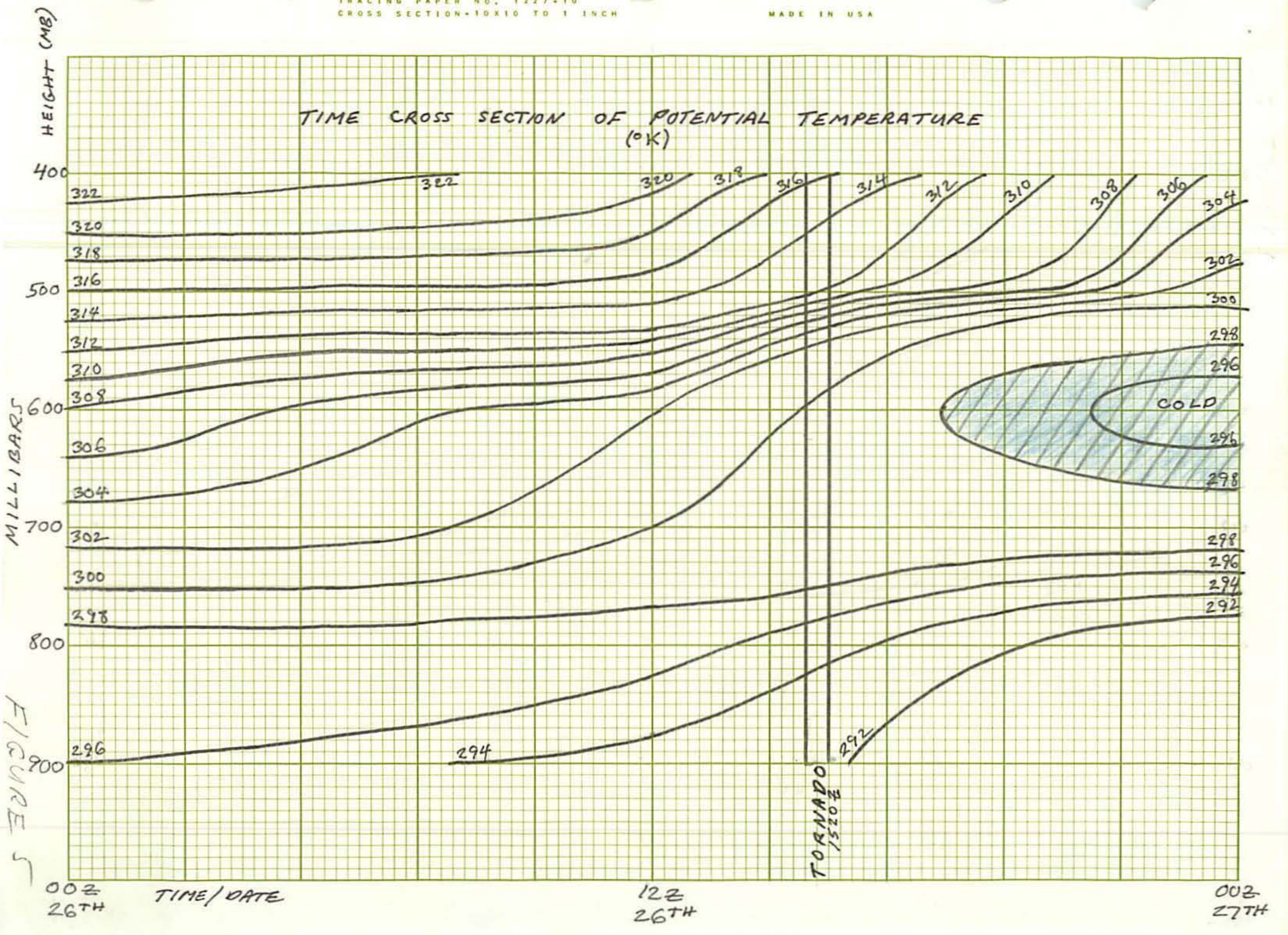

TIME CROSS SECTION OF POTENTIAL TEMPERATURE
(°K)
HEIGHT (MB)
MILLIBARS
400
500
600
700
800
900
322
320
318
316
314
312
310
308
306
304
302
300
298
296
294
292
COLD
TORNADO
1520Z
00Z
26TH
TIME/DATE
12Z
26TH
00Z
27TH

FIGURE 5

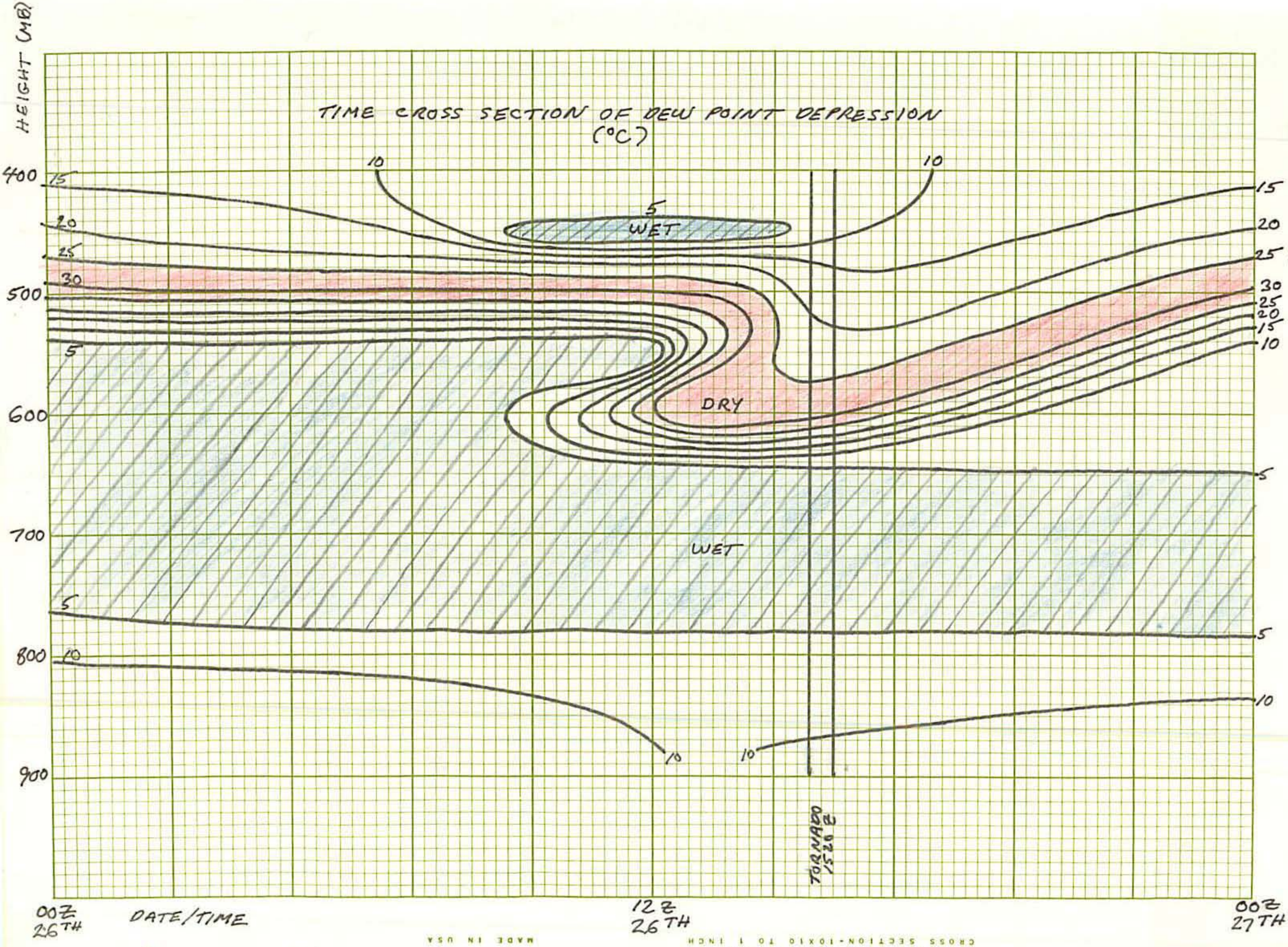

TIME CROSS SECTION OF DEW POINT DEPRESSION
(°C)
HEIGHT (MB)
400
500
600
700
800
900
WET
DRY
WET
TORNADO
1520 Z
DATE/TIME
00Z
26TH
12 Z
26 TH
00Z
27TH
15
20
25
30
10
5

FIGURE 6

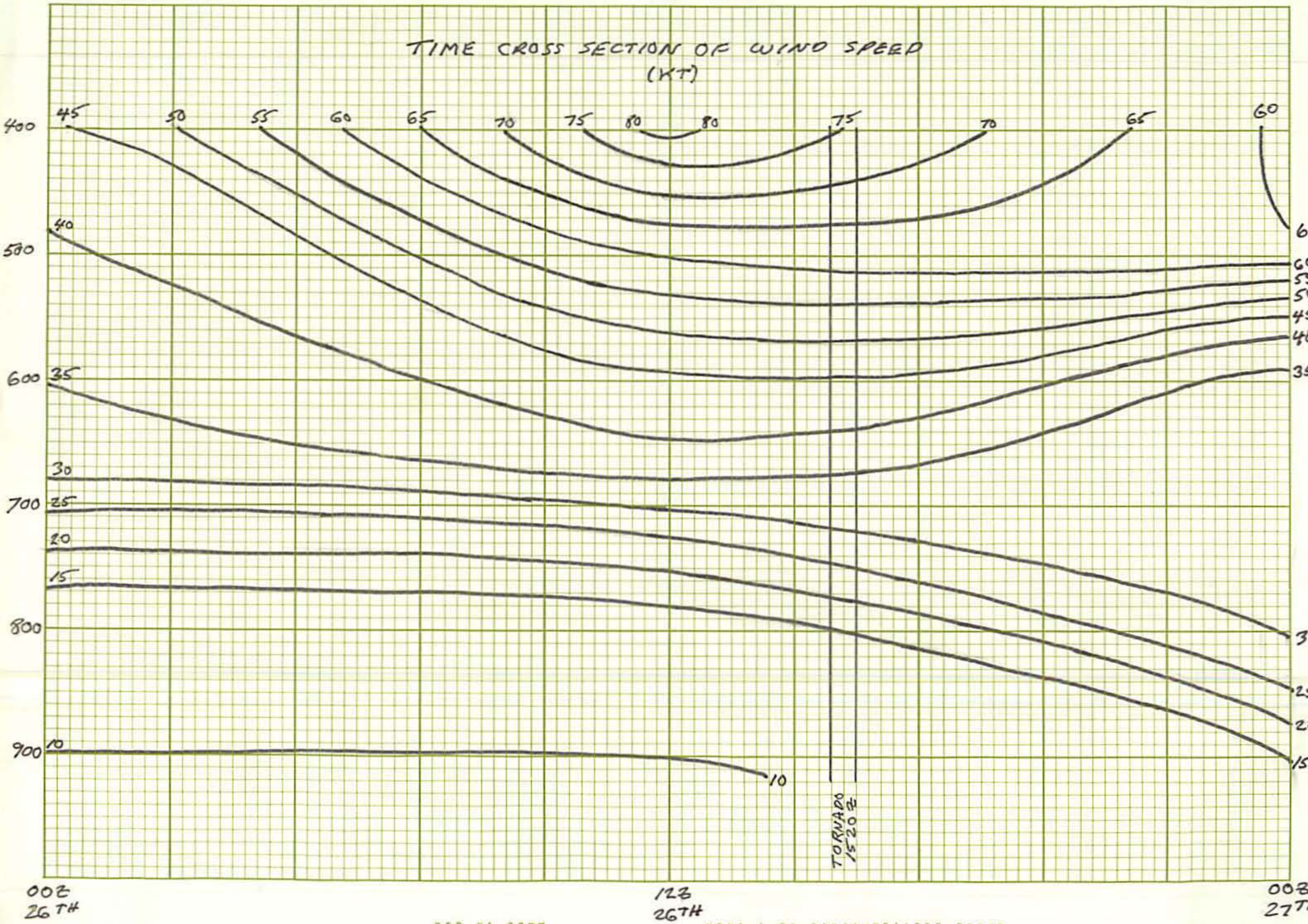
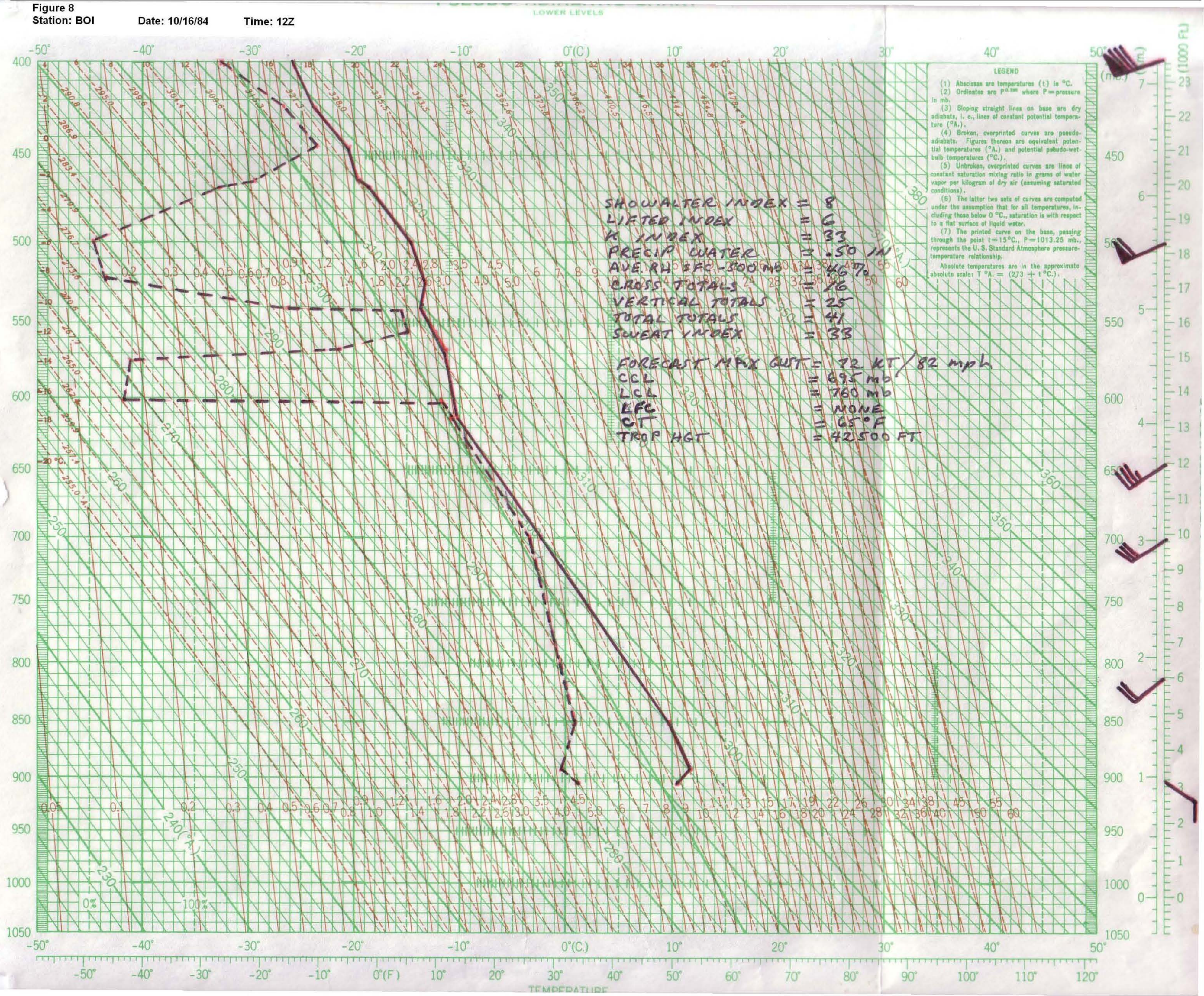

TIME CROSS SECTION OF WIND SPEED
(KT)
400
500
600
700
800
900
45
50
55
60
65
70
75
80
80
75
70
65
60
40
35
30
25
20
15
10
60
60
55
50
45
40
35
30
25
20
15
10
TORNADO
1520Z
00Z
26TH
12Z
26TH
00Z
27TH

FIGURE 7

Figure 8
Station: BOI Date: 10/16/84 Time: 12Z



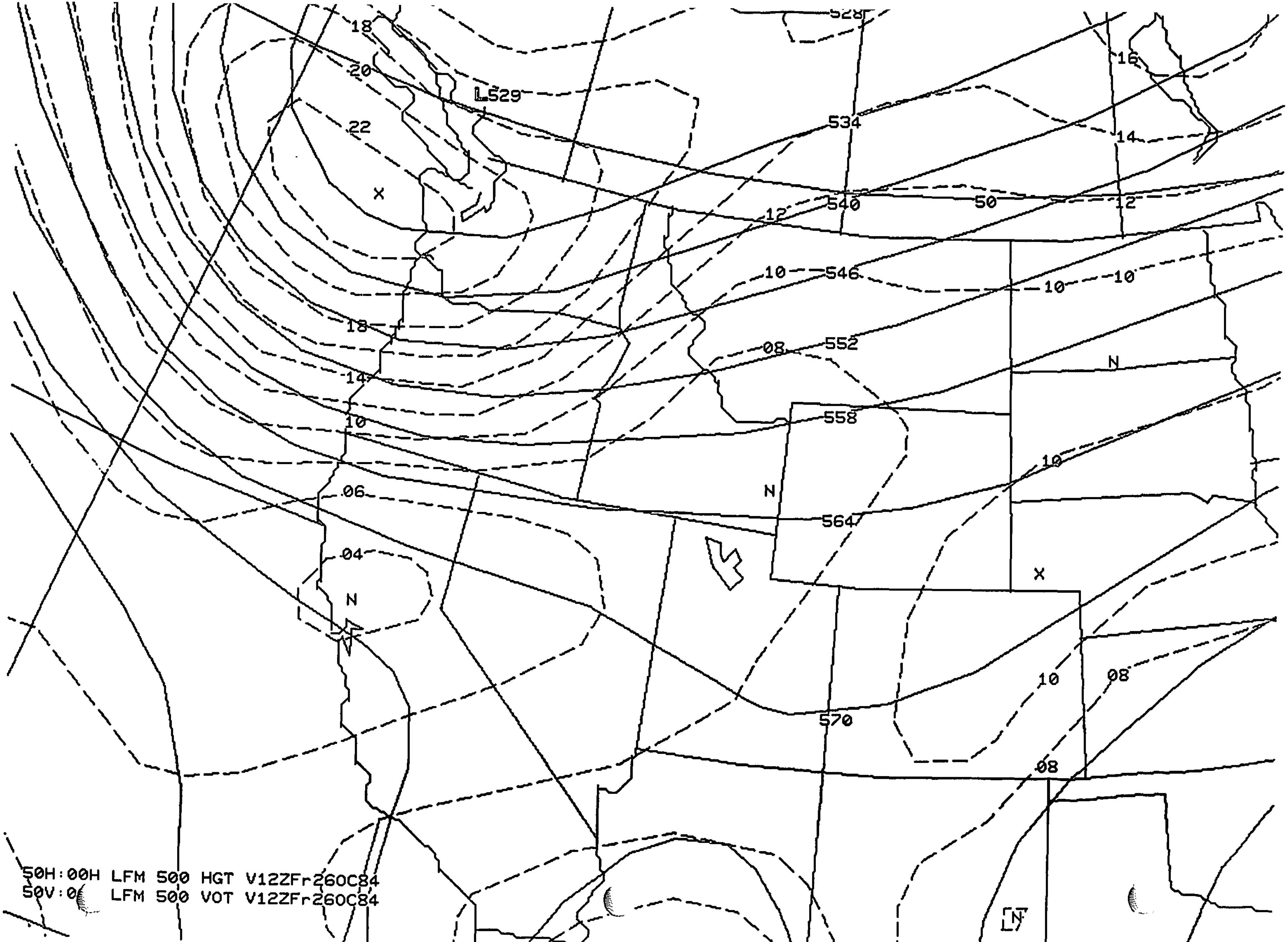

50H:00H LFM 500 HGT V12ZFr260C84
50V:00 LFM 500 VOT V12ZFr260C84
L529
528
534
540
546
552
558
564
570
50
18
20
22
18
14
10
06
04
16
14
12
12
10
10
10
08
10
10
08
08
N
N
N
N
X
X

FIGURE 9

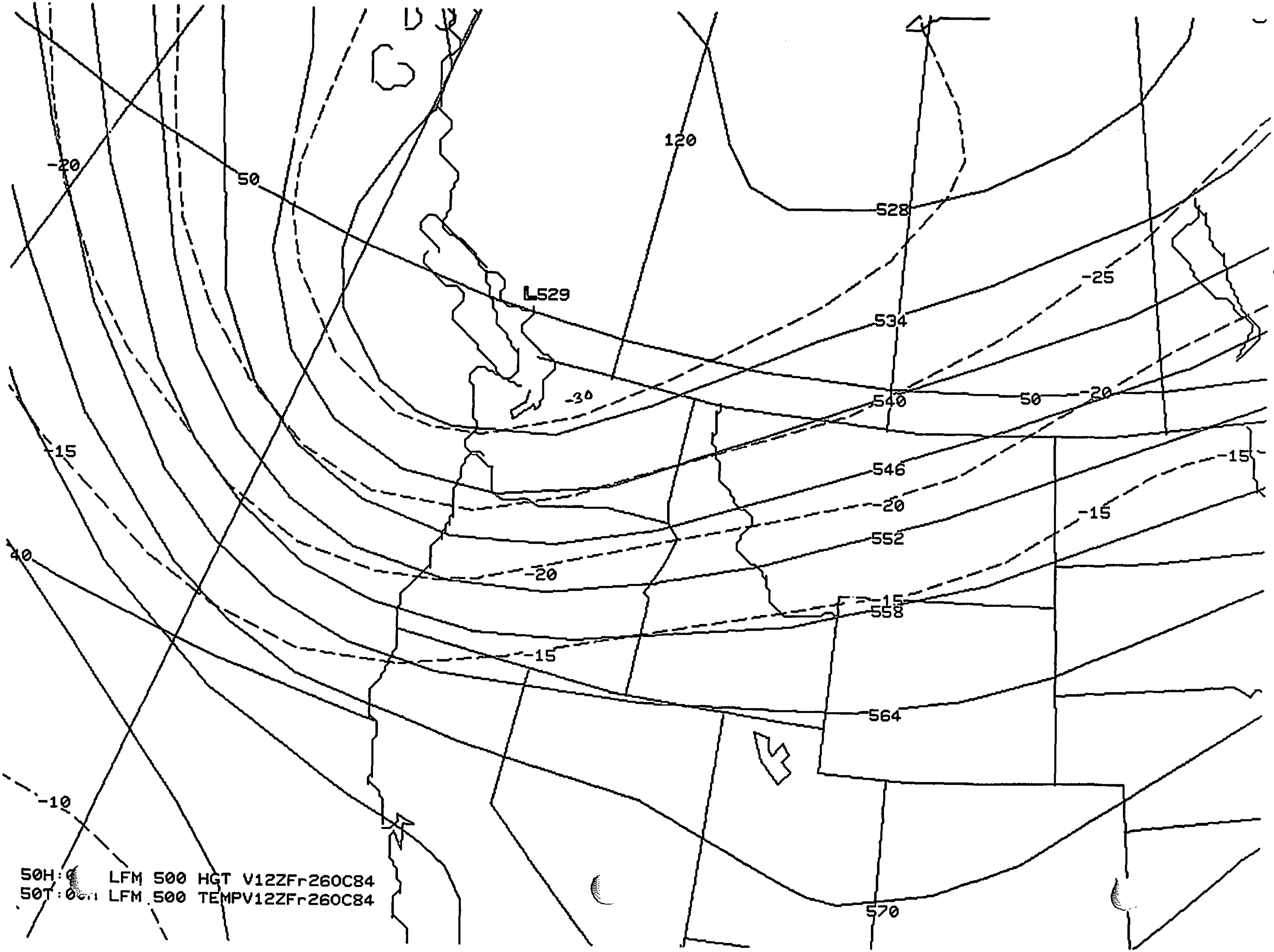

120
-20
50
528
L529
534
-25
-30
540
50
-20
-15
546
-20
-15
552
40
-20
-15
558
-15
564
-10
570
50H:0 LFM 500 HGT V12ZFr260C84
50T:0 LFM 500 TEMPV12ZFr260C84

FIGURE 10

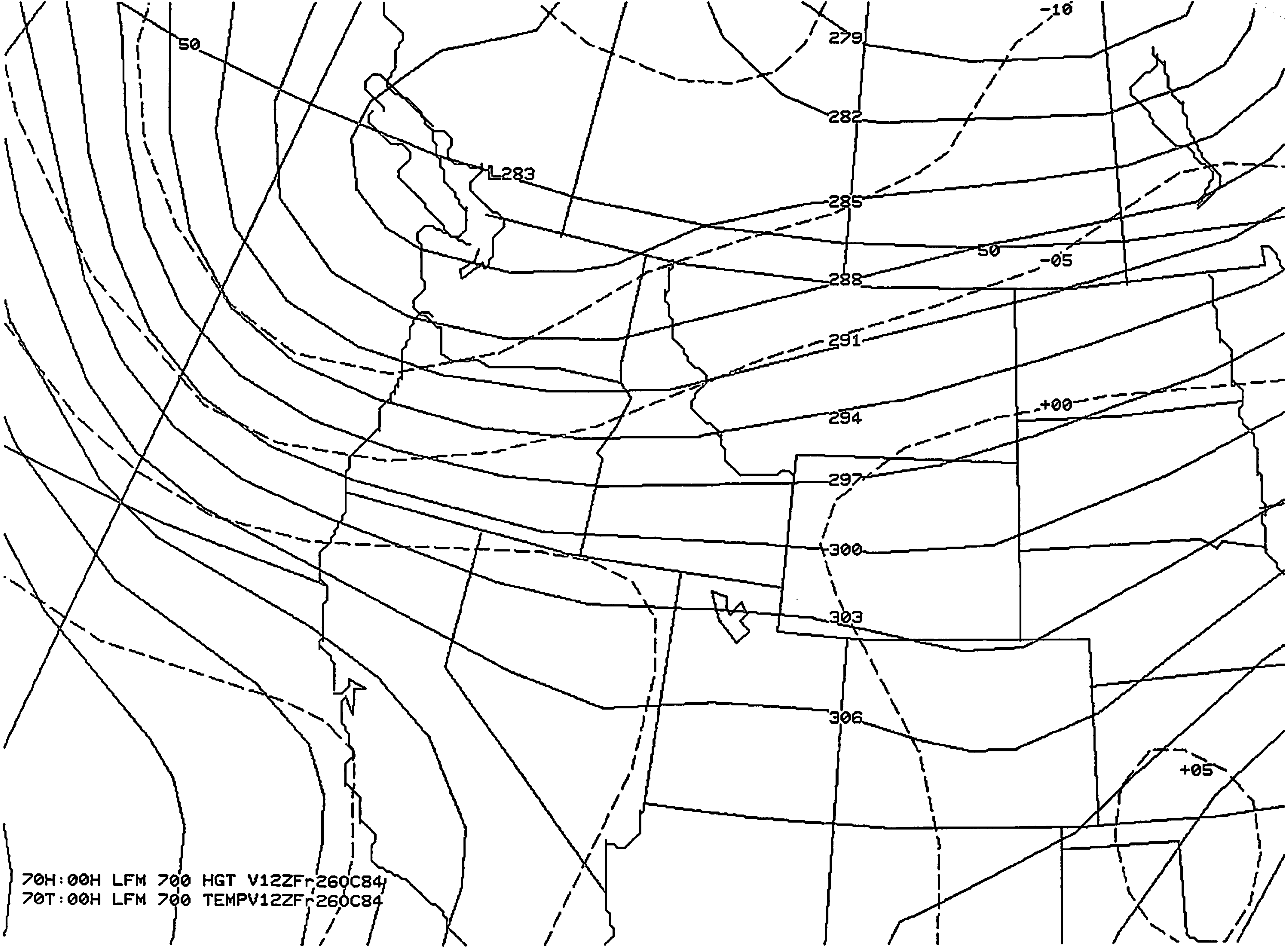

50
279
282
L283
285
50
-05
288
291
+00
294
297
300
303
306
+05
-10
70H:00H LFM 700 HGT V12ZFr260C84
70T:00H LFM 700 TEMPV12ZFr260C84

FIGURE 11

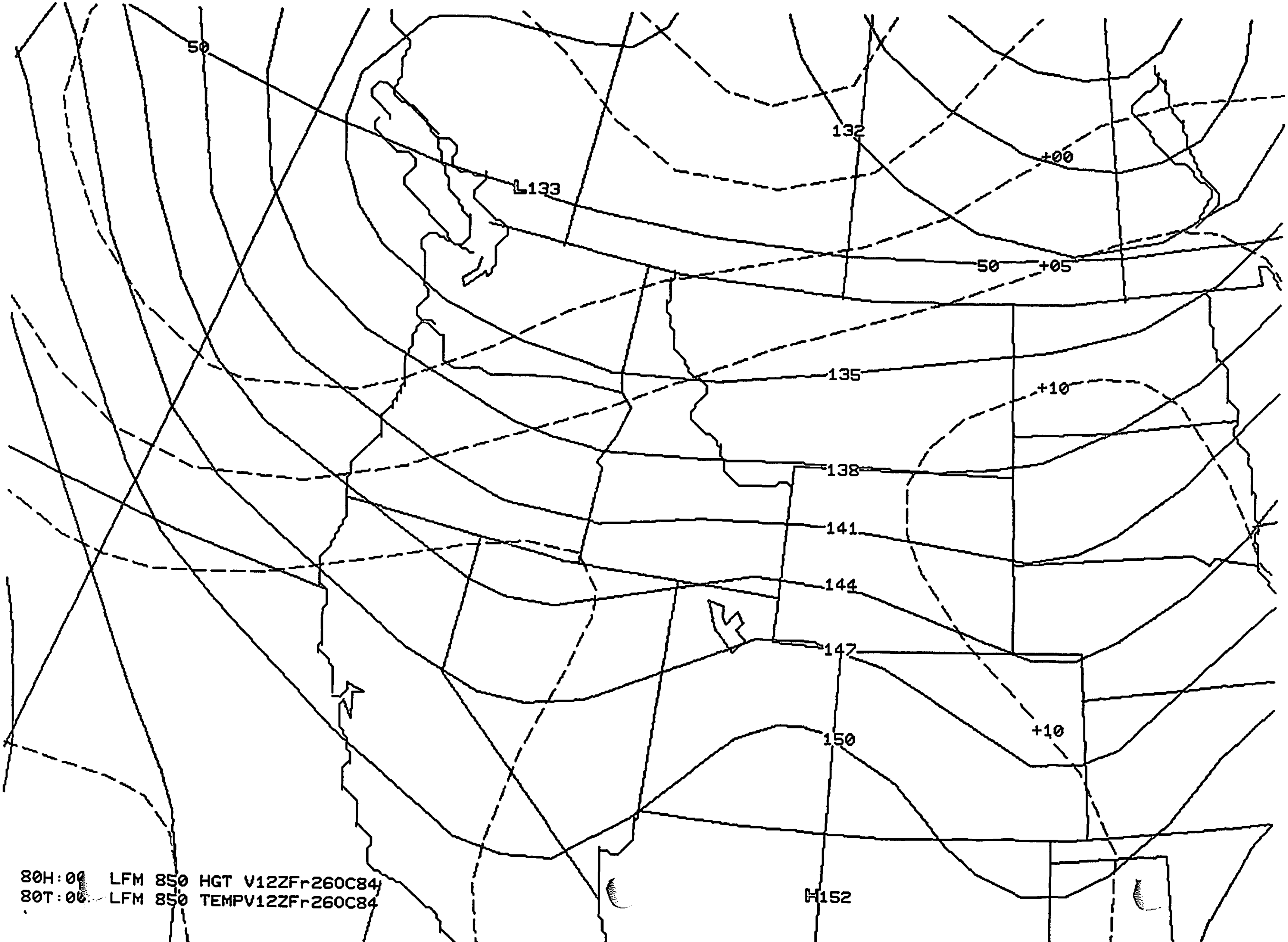

50
132
+00
L133
50
+05
135
+10
138
141
144
147
+10
150
H152
80H:00 LFM 850 HGT V12ZFr260C84
80T:00 LFM 850 TEMPV12ZFr260C84

FIGURE 12

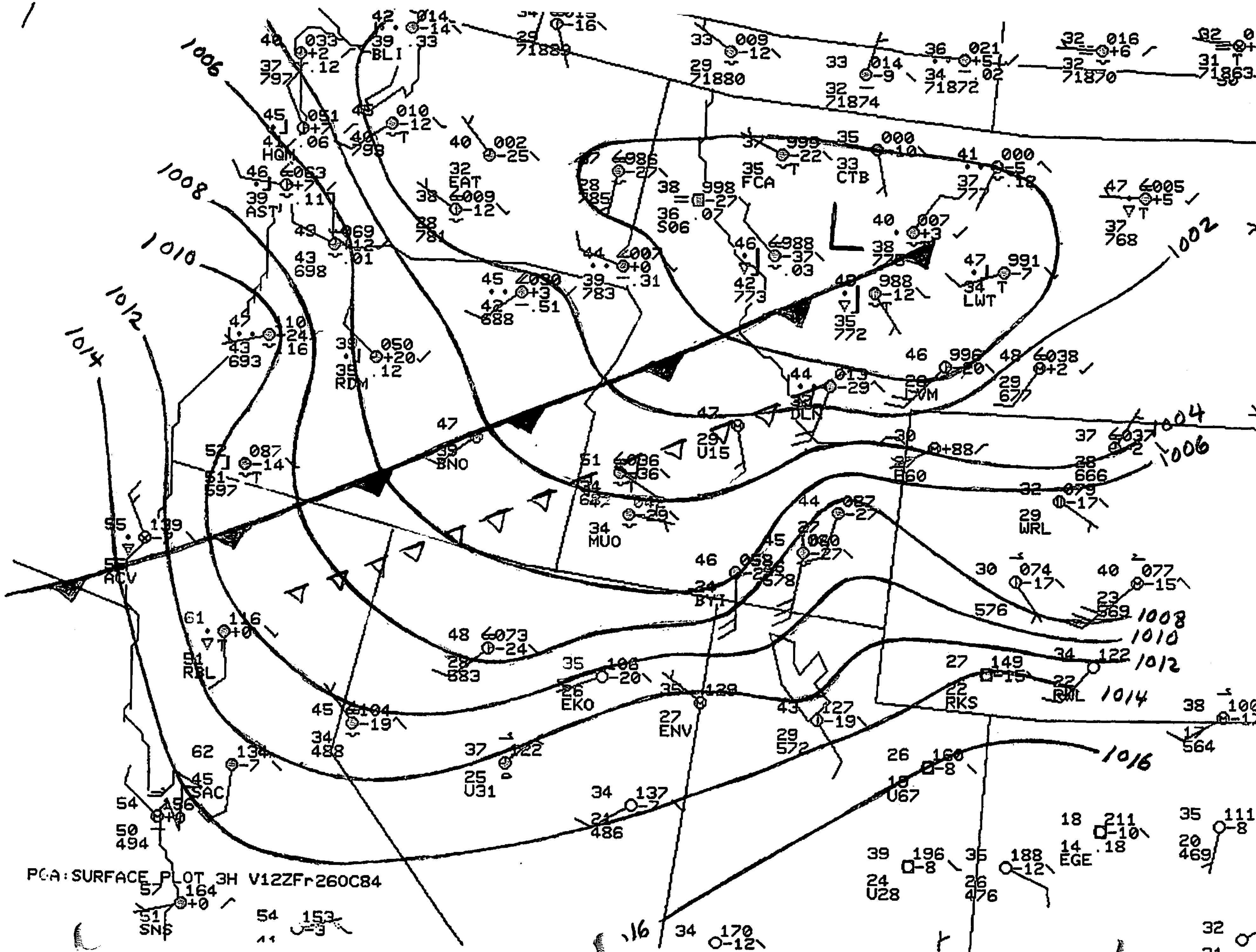

PCA:SURFACE PLOT 3H V12ZFr260C84
1002
1004
1006
1008
1010
1012
1014
1016
BLI
HQM
AST
EAT
RDM
FCA
CTB
S06
LWT
LVM
DLN
U15
BNO
MUO
B60
WRL
ACV
RBL
BYI
EKO
ENV
RKS
RWL
SAC
U31
U67
EGE
U28
SNS

FIGURE 13

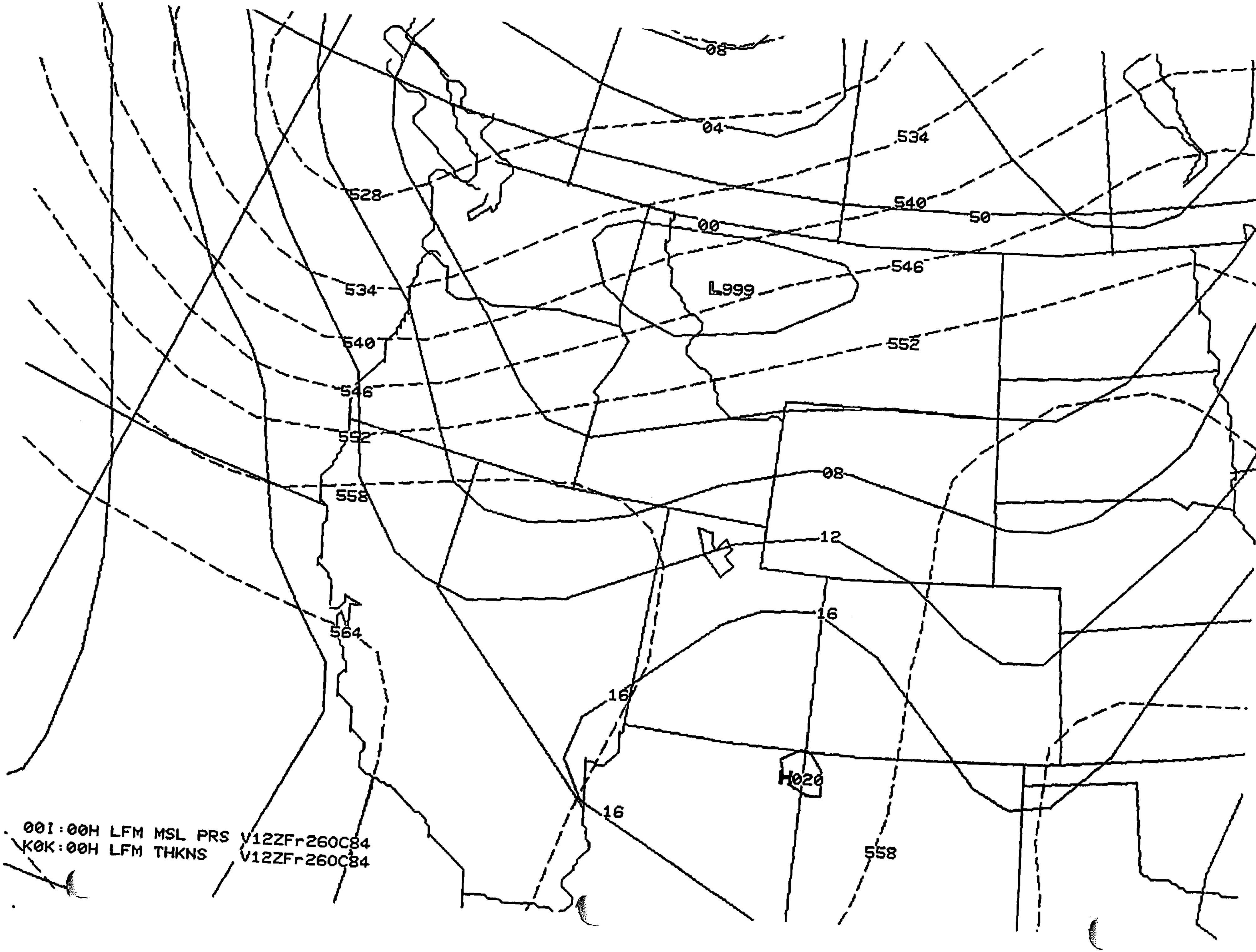

08
04
534
528
540
00
50
534
546
L999
540
552
546
552
558
08
12
564
16
16
H020
16
558
00I:00H LFM MSL PRS V12ZFr260C84
K0K:00H LFM THKNS V12ZFr260C84

FIGURE 14

FIGURE 15

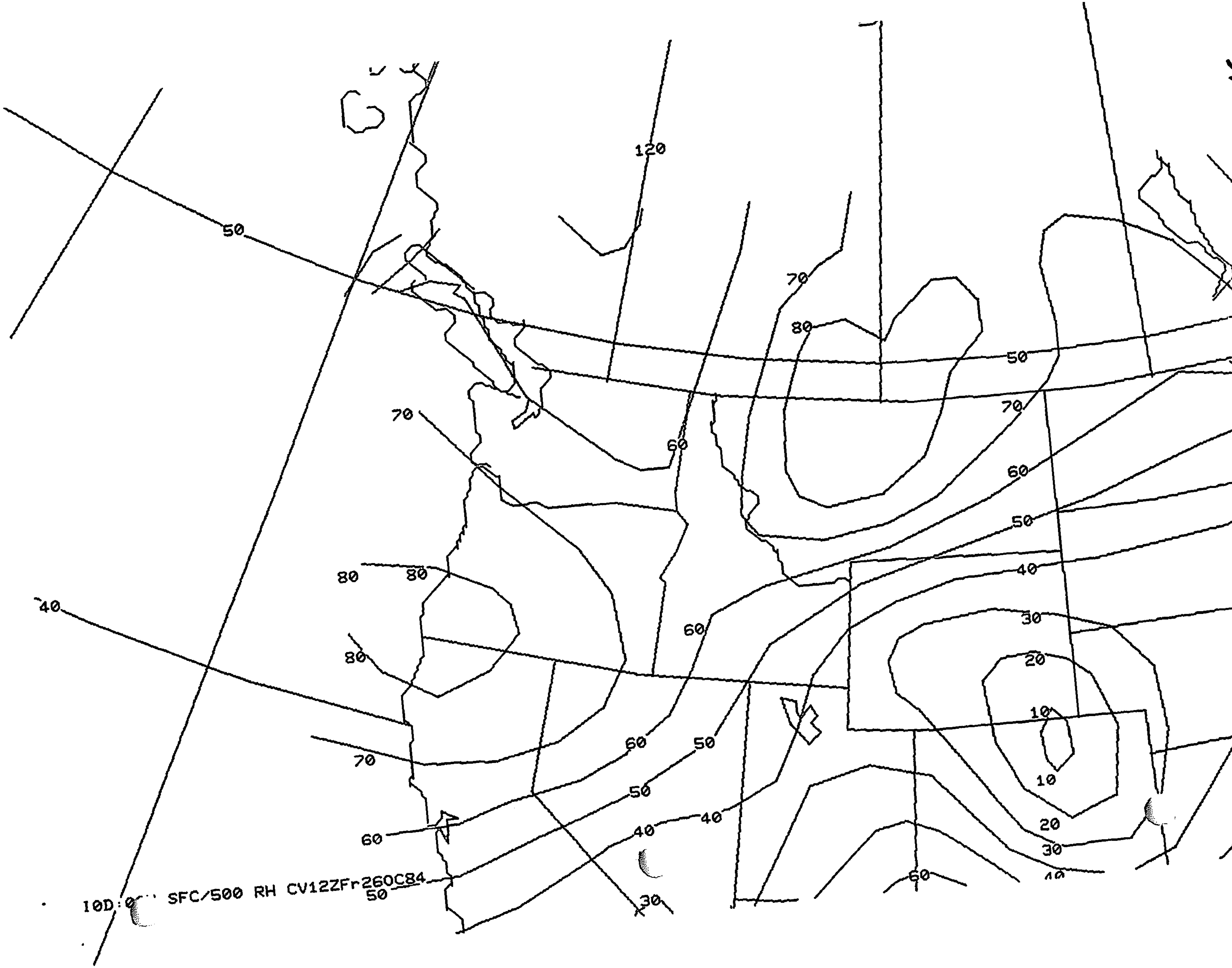

120
50
70
80
50
70
60
70
60
50
40
30
20
10
10
20
30
80
80
80
40
60
70
60
50
60
50
40
40
60
50
30
SFC/500 RH CV12ZFr26OC84

FIGURE 16

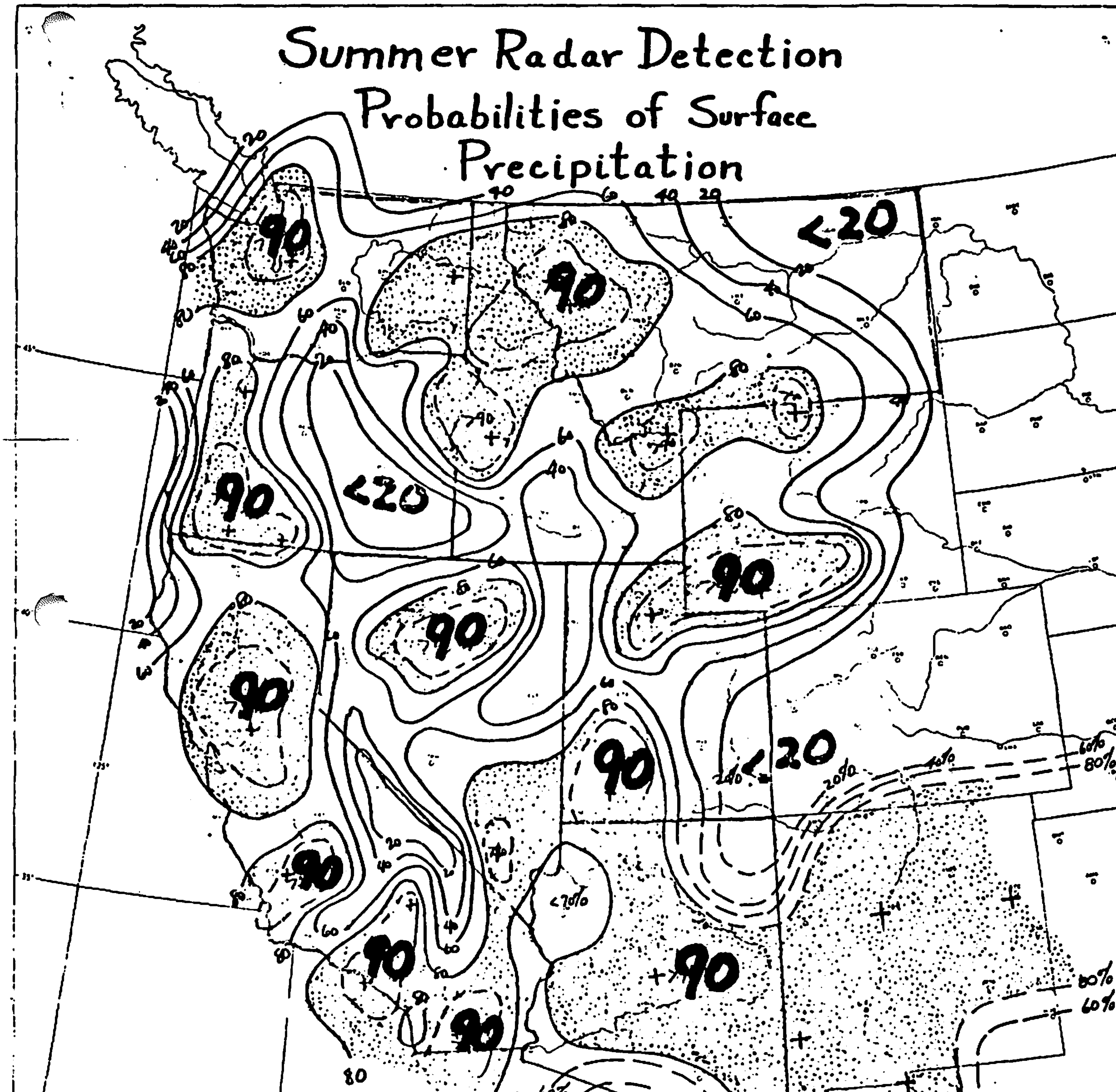
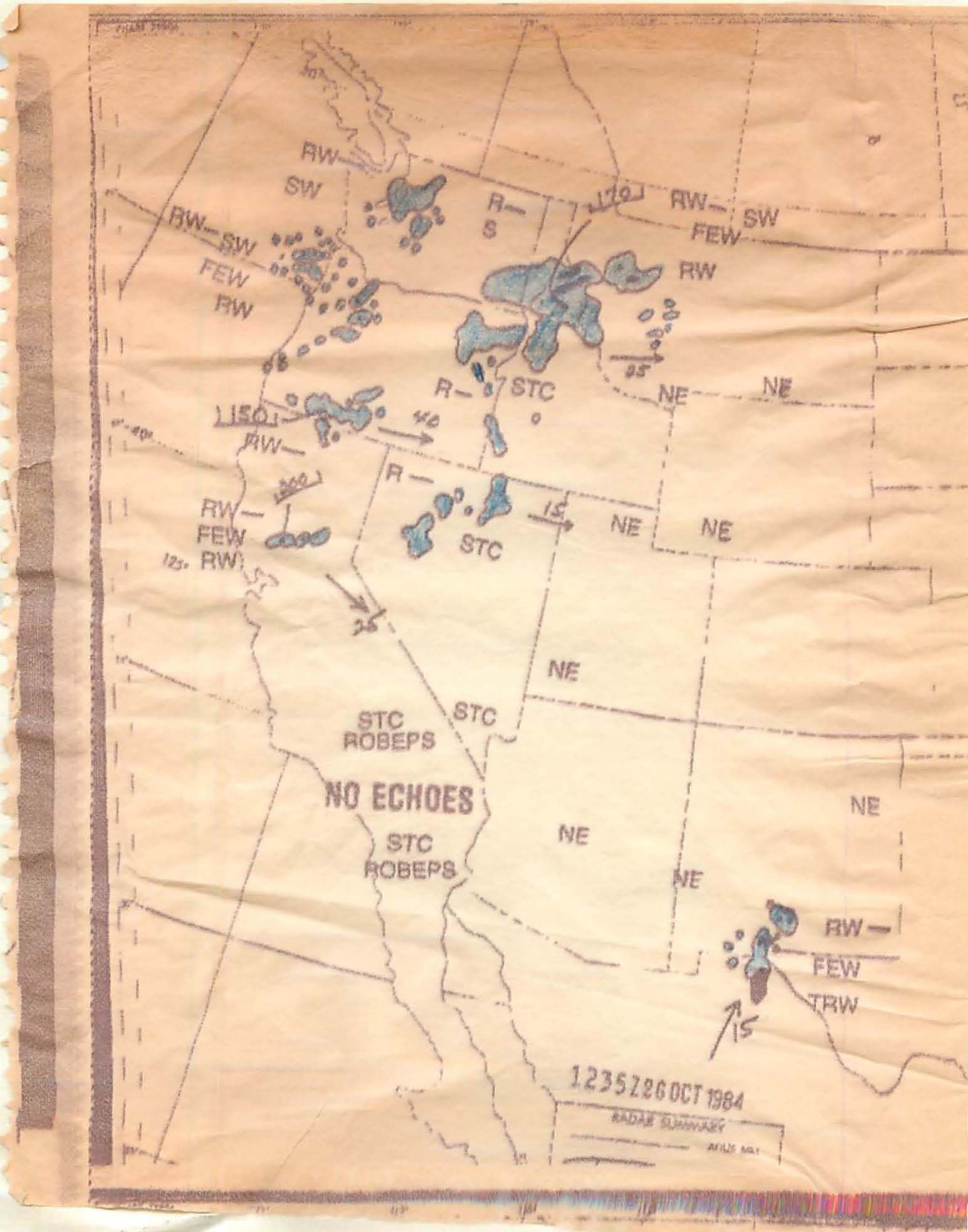


FIGURE 17. PROBABILITY OF SUMMER PRECIPITATION BEING DETECTED BY WSR-57 AND ARTC RADAR IN THE WESTERN REGION.

FIGURE 17

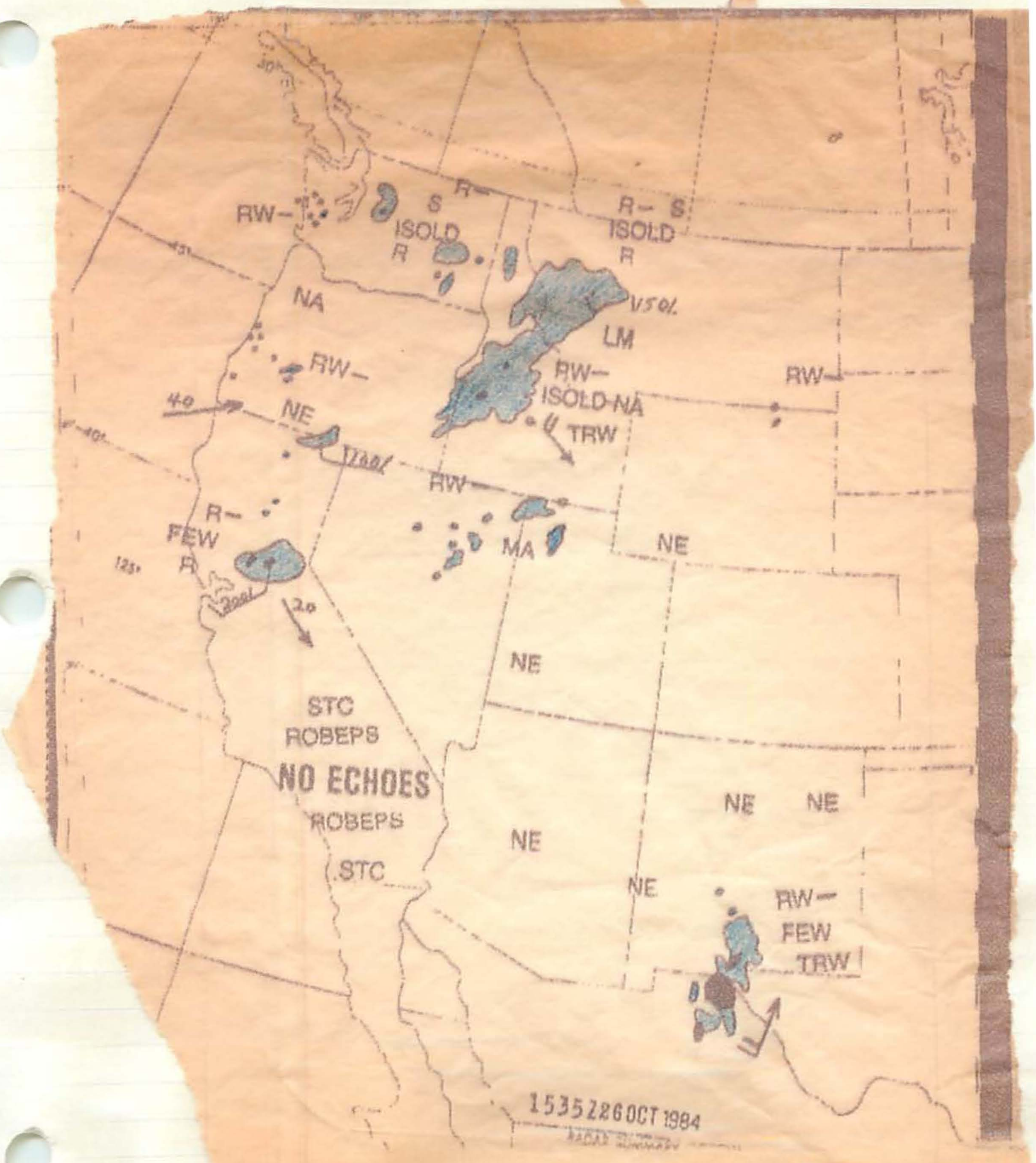


RW—
SW
RW—SW
FEW
RW
R—
S
170
RW—
SW
FEW
RW
R—
STC
NE
NE
150
RW—
40
R—
RW—
FEW
RW
15
NE
NE
STC
NE
STC
STC
ROBEPS
NO ECHOES
STC
ROBEPS
NE
NE
NE
RW—
FEW
TRW
15
1235Z 26 OCT 1984
RADAR SUMMARY

FIGURE 18

RW — SW
R — S
ISOLD
R
RW — SW
FEW
RW
NE
LM
R —
S
RW —
40
R —
SCTD
R
180
R —
S
RW —
NE
NE
STC
ROBEPS
NO ECHOES
ROBEPS
STC
NE
NE
NE
NE
RW —
FEW
TRW
1435Z 26 OCT 1984
RADAR SUMMARY

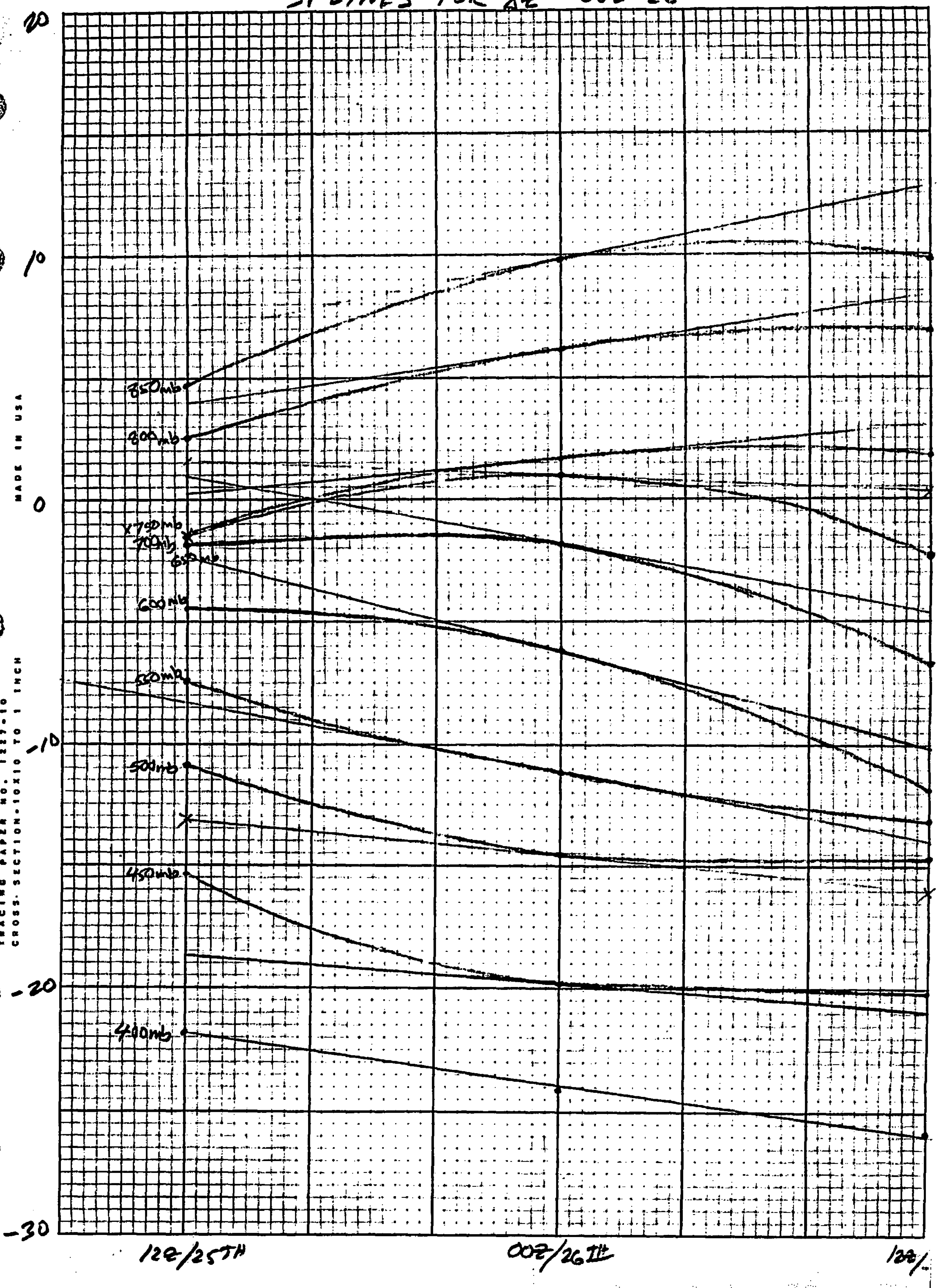
FIGURE 19



RW-
S
R-
ISOLD
R
R- S
ISOLD
R
NA
V50%
LM
RW-
RW-
ISOLD-NA
TRW
RW-
40
NE
170%
RW-
R-
FEW
R
MA
NE
200%
20
NE
STC
ROBEPS
NO ECHOES
ROBEPS
STC
NE
NE
NE
NE
RW-
FEW
TRW
1535Z26OCT 1984
RADAR SUMMARY

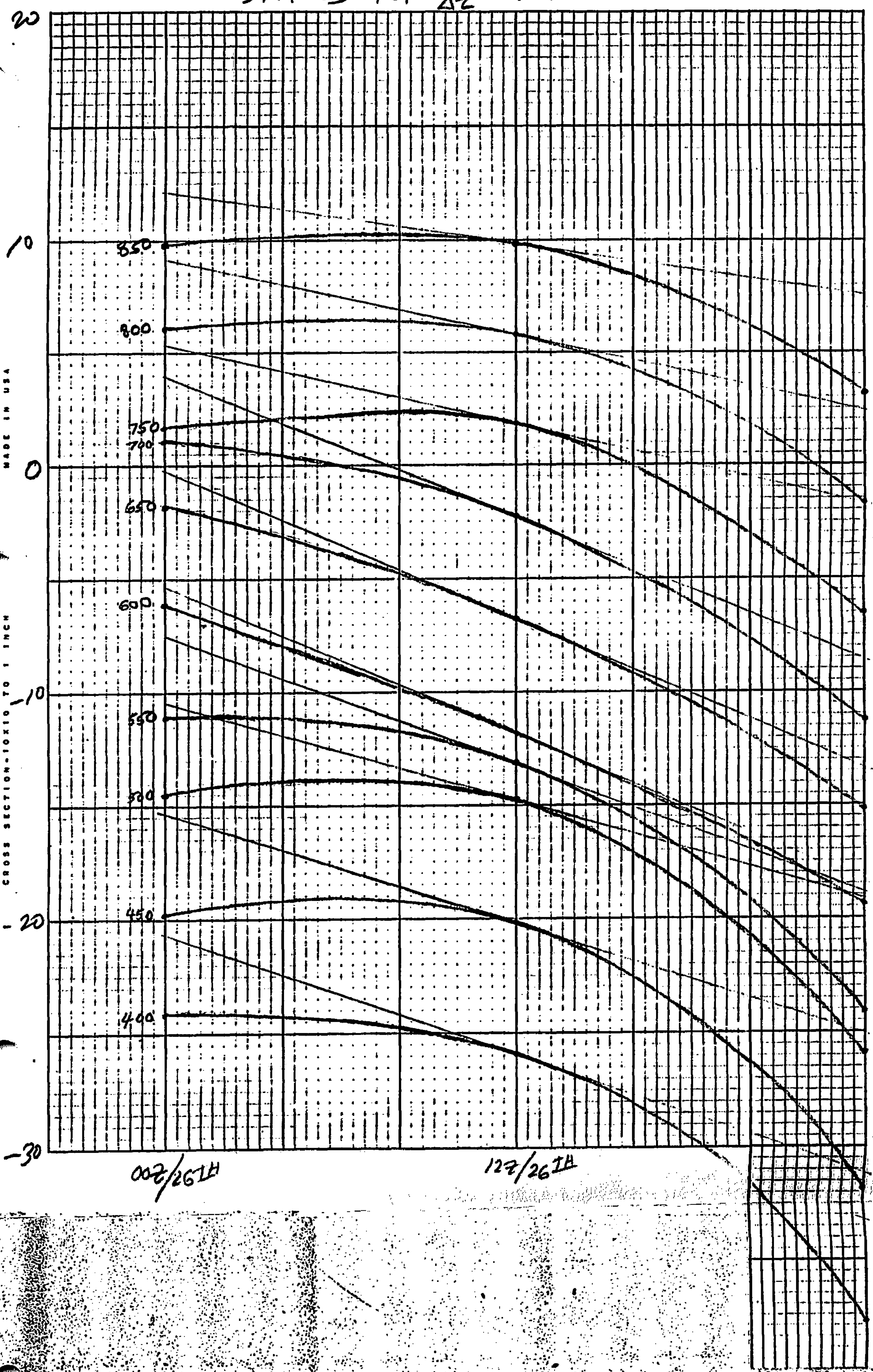
Figure

SPLINES FOR $\frac{\Delta T}{\Delta t}$ 00Z 26TH



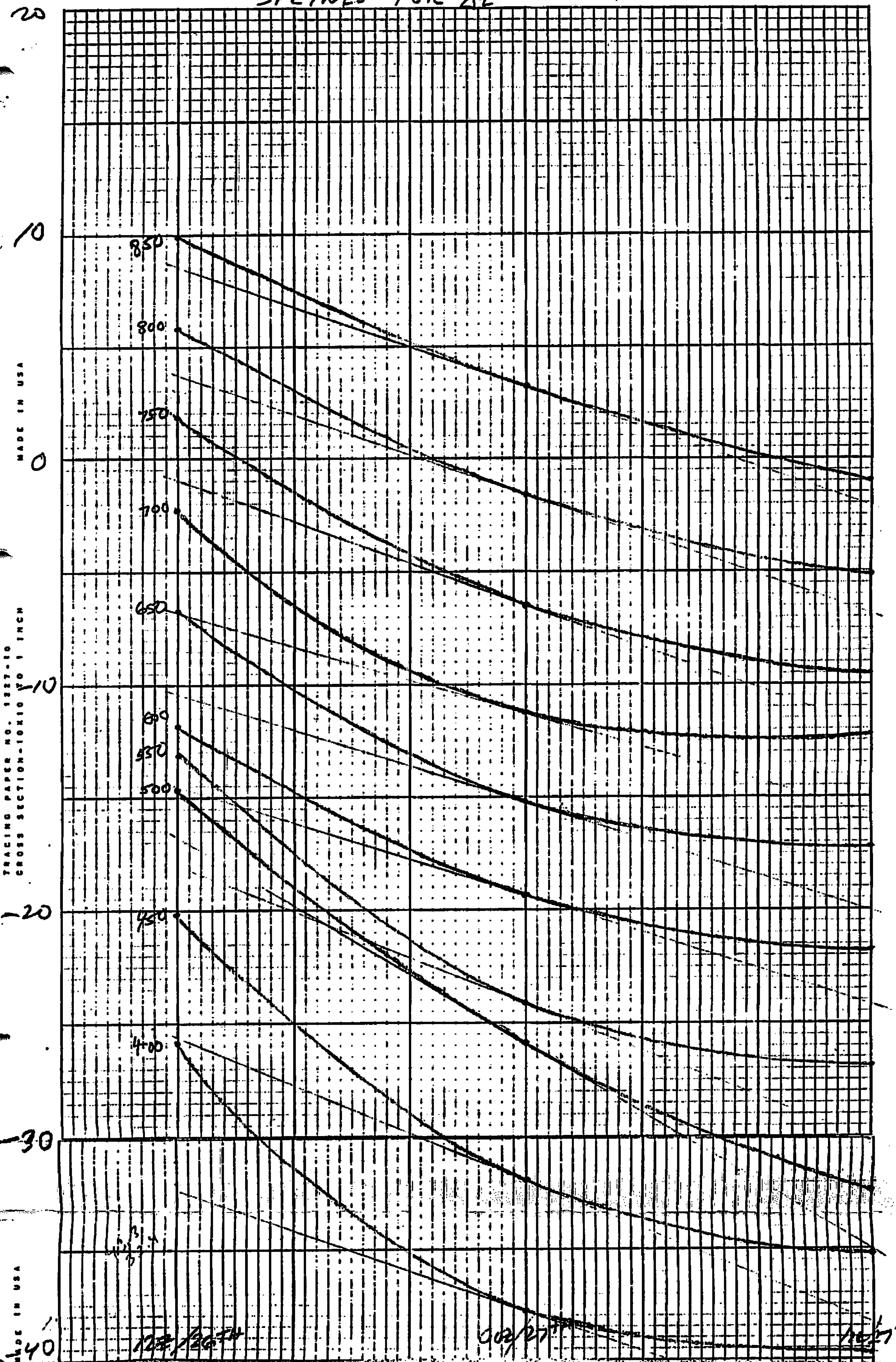
WORKSHEET 1

SPLINES FOR $\frac{\Delta T}{\Delta Z}$ 12Z 26TH

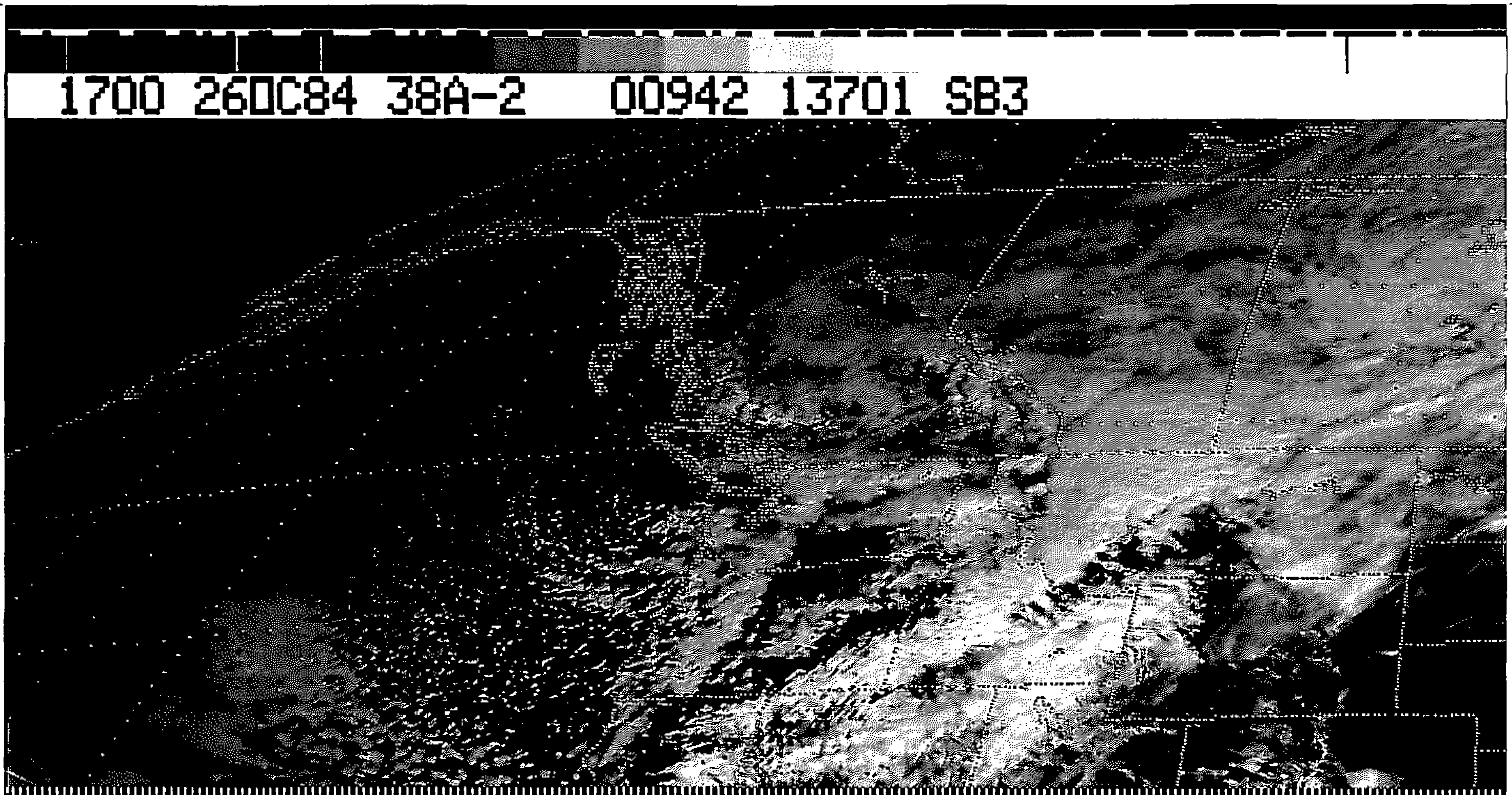


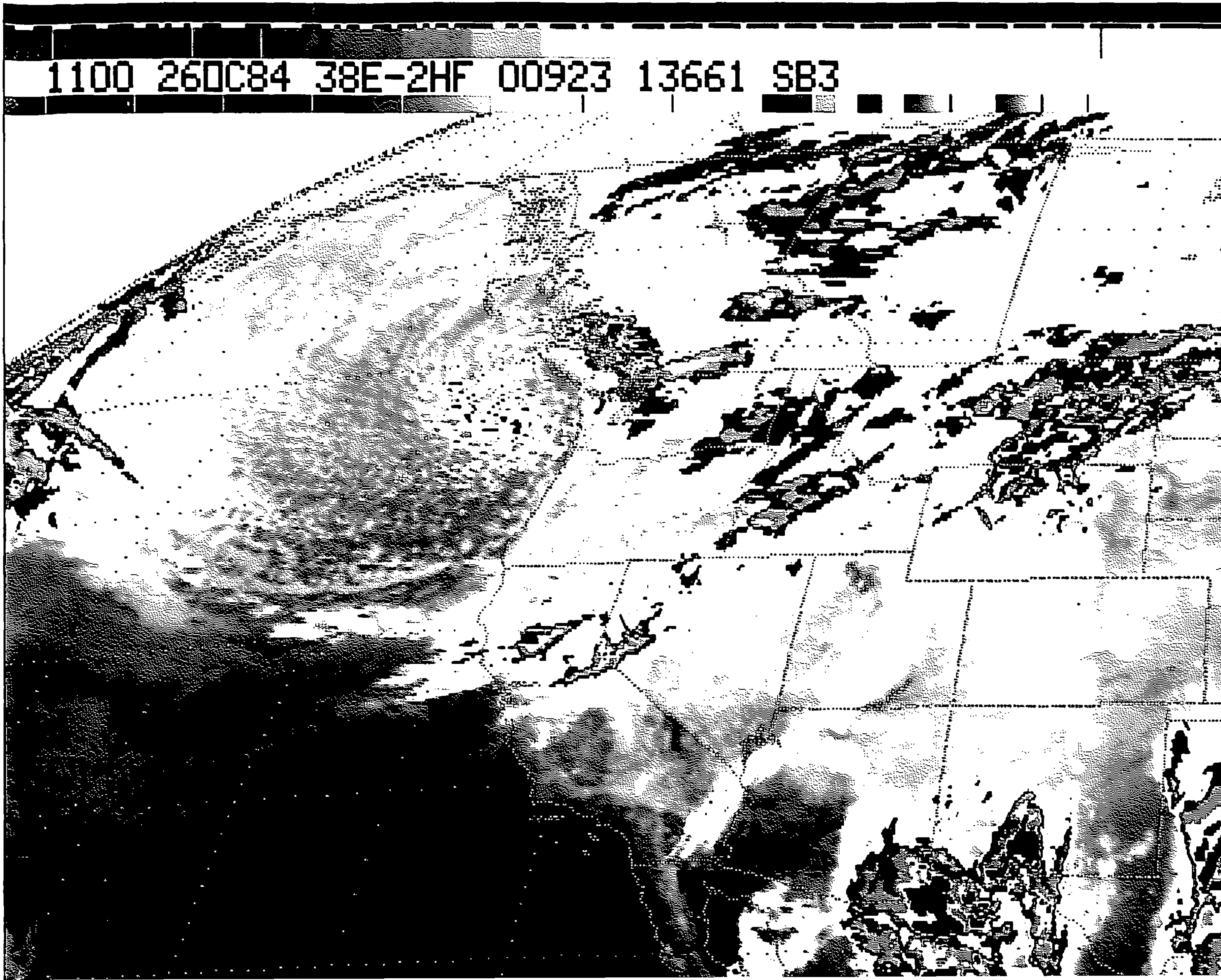
WORKSHEET 2

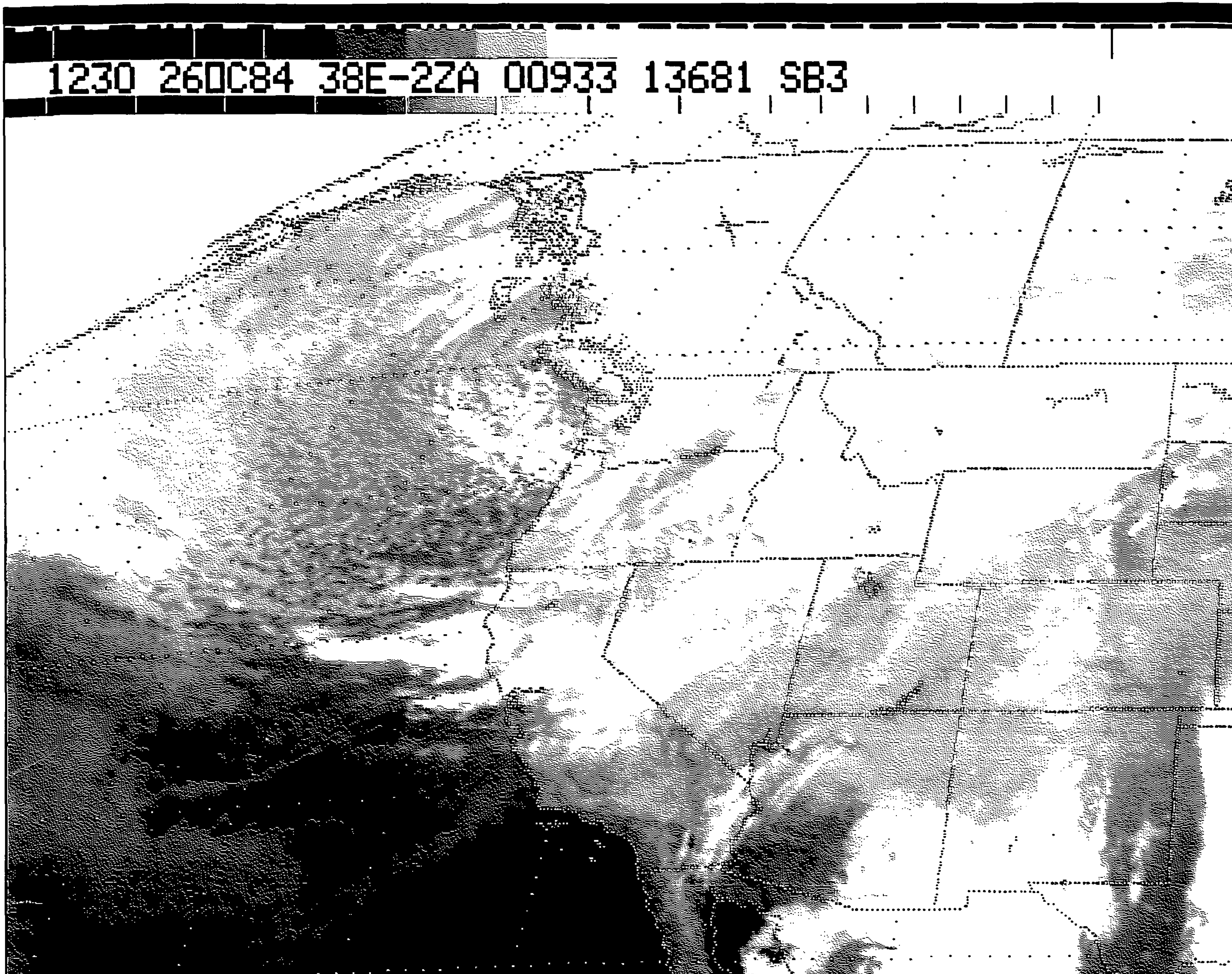
SPLINES FOR $\frac{\Delta T}{\Delta E}$ 002 27TH

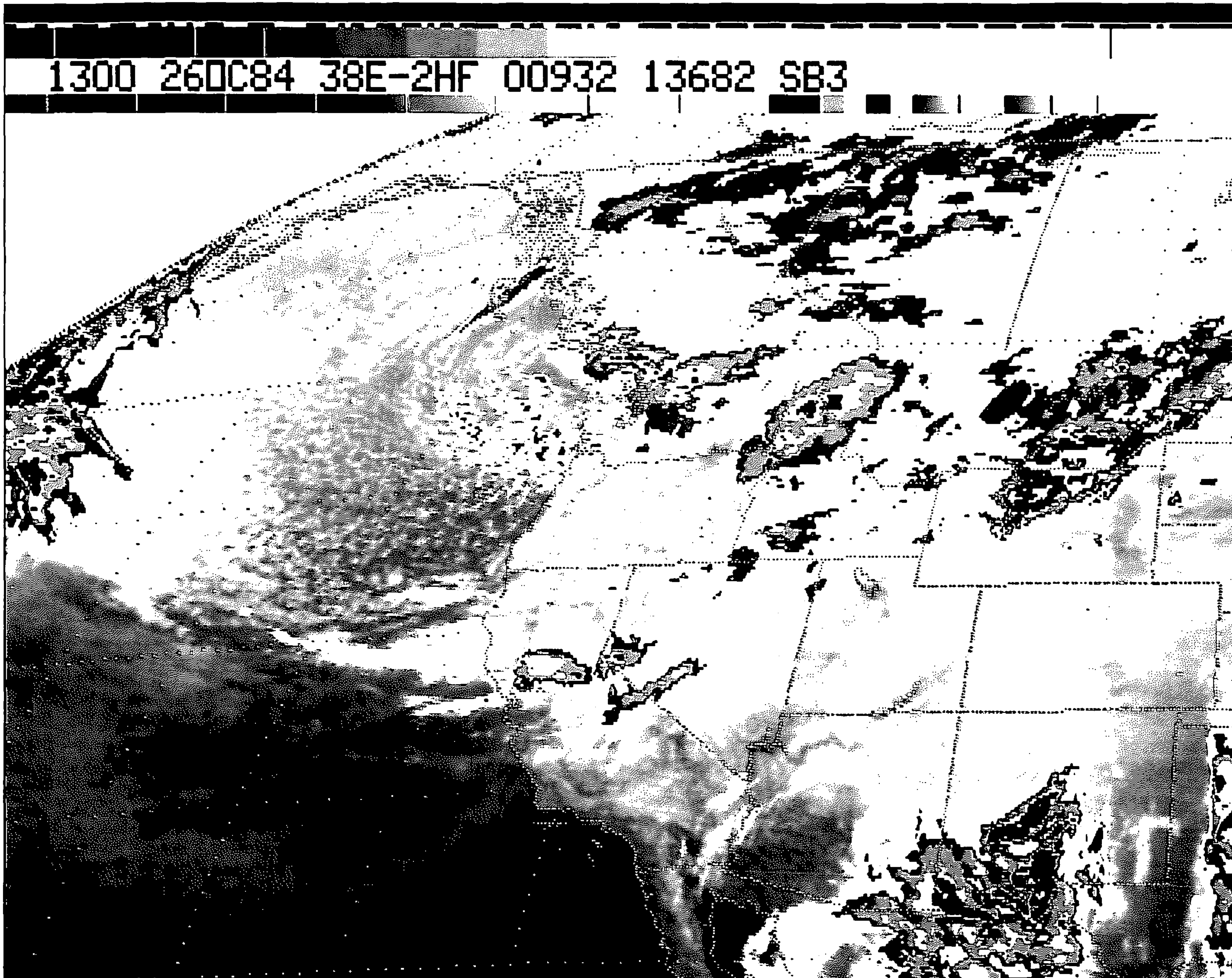


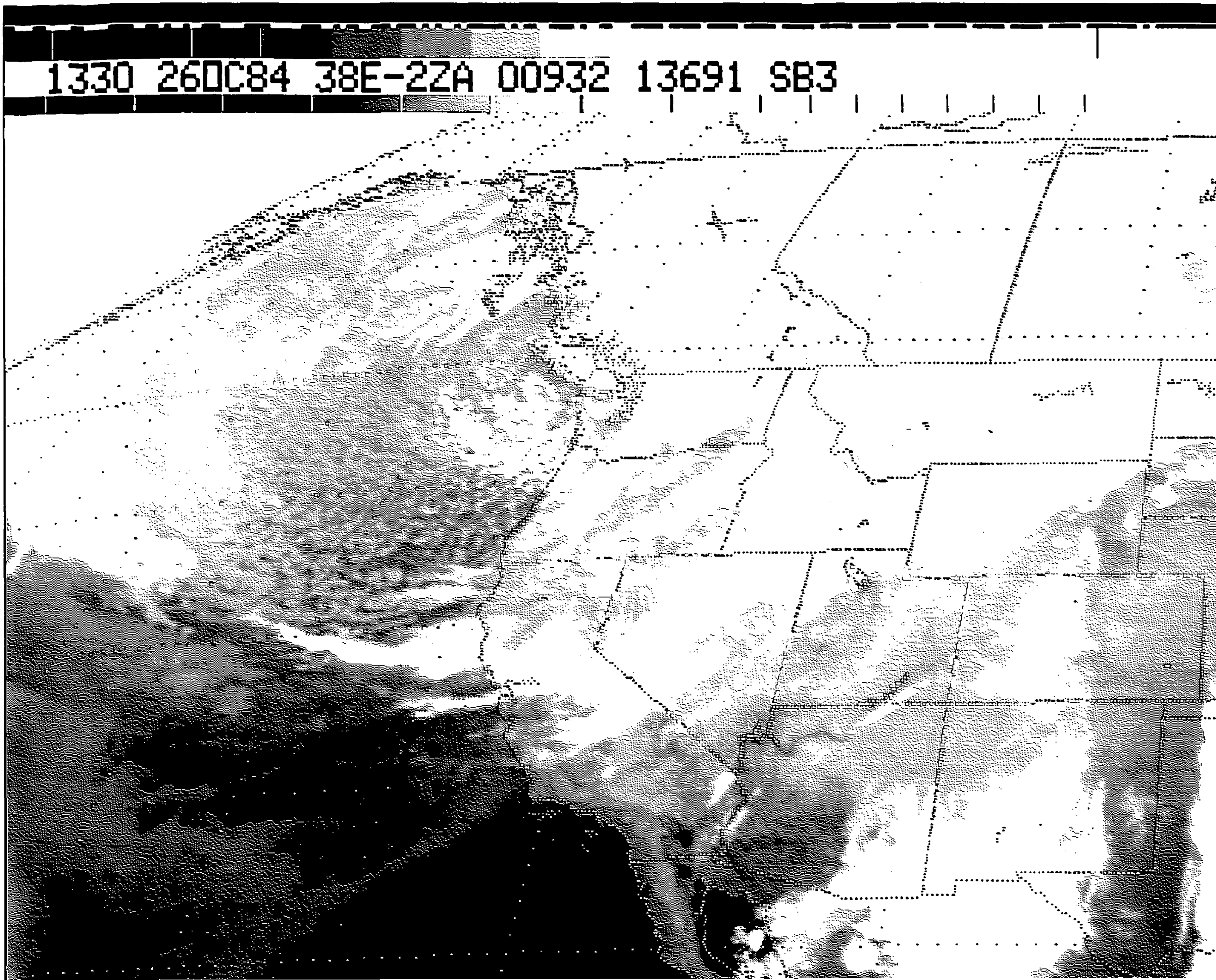
WORKSHEET 3

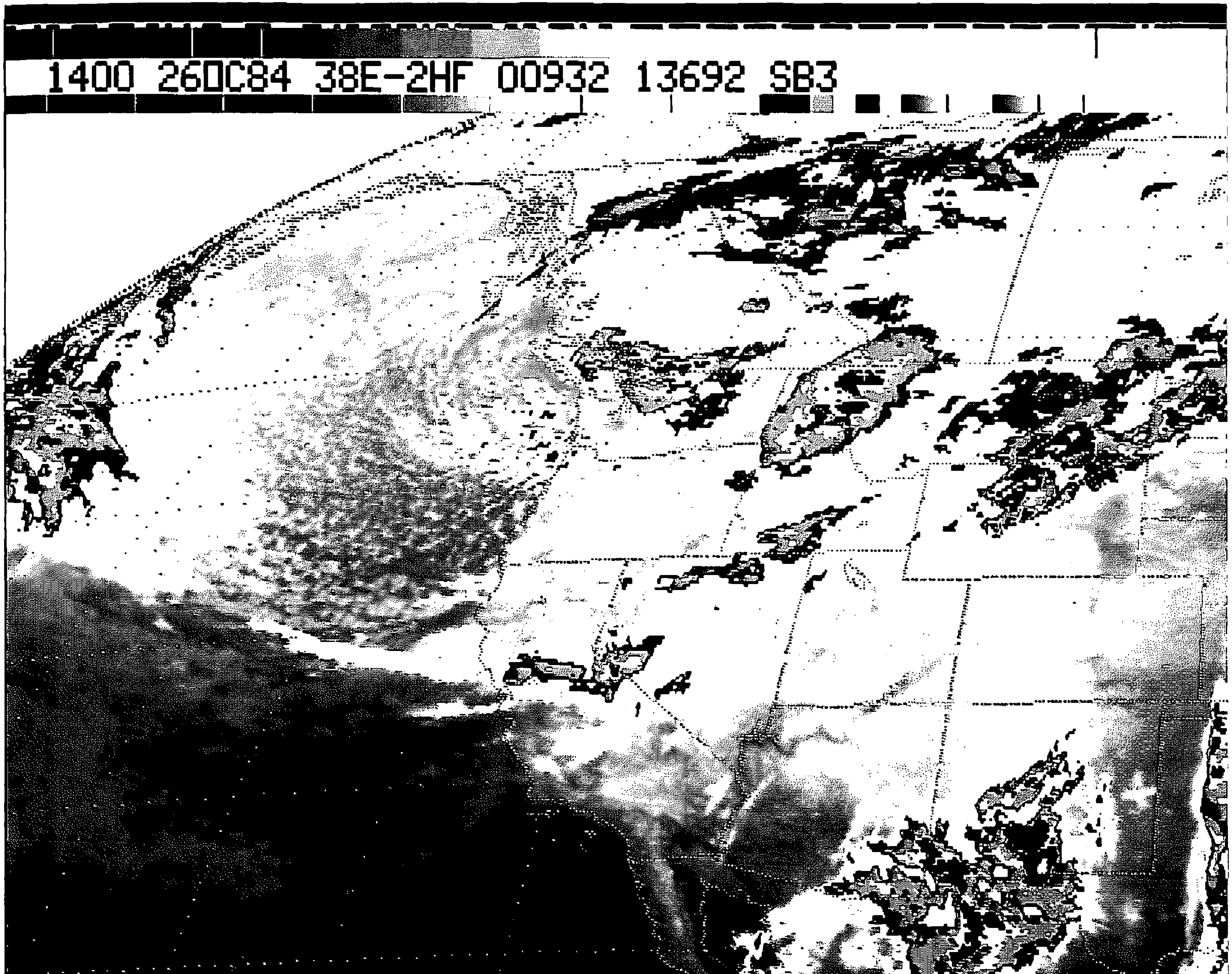

1700 26DEC84 38A-2 00942 13701 SB3

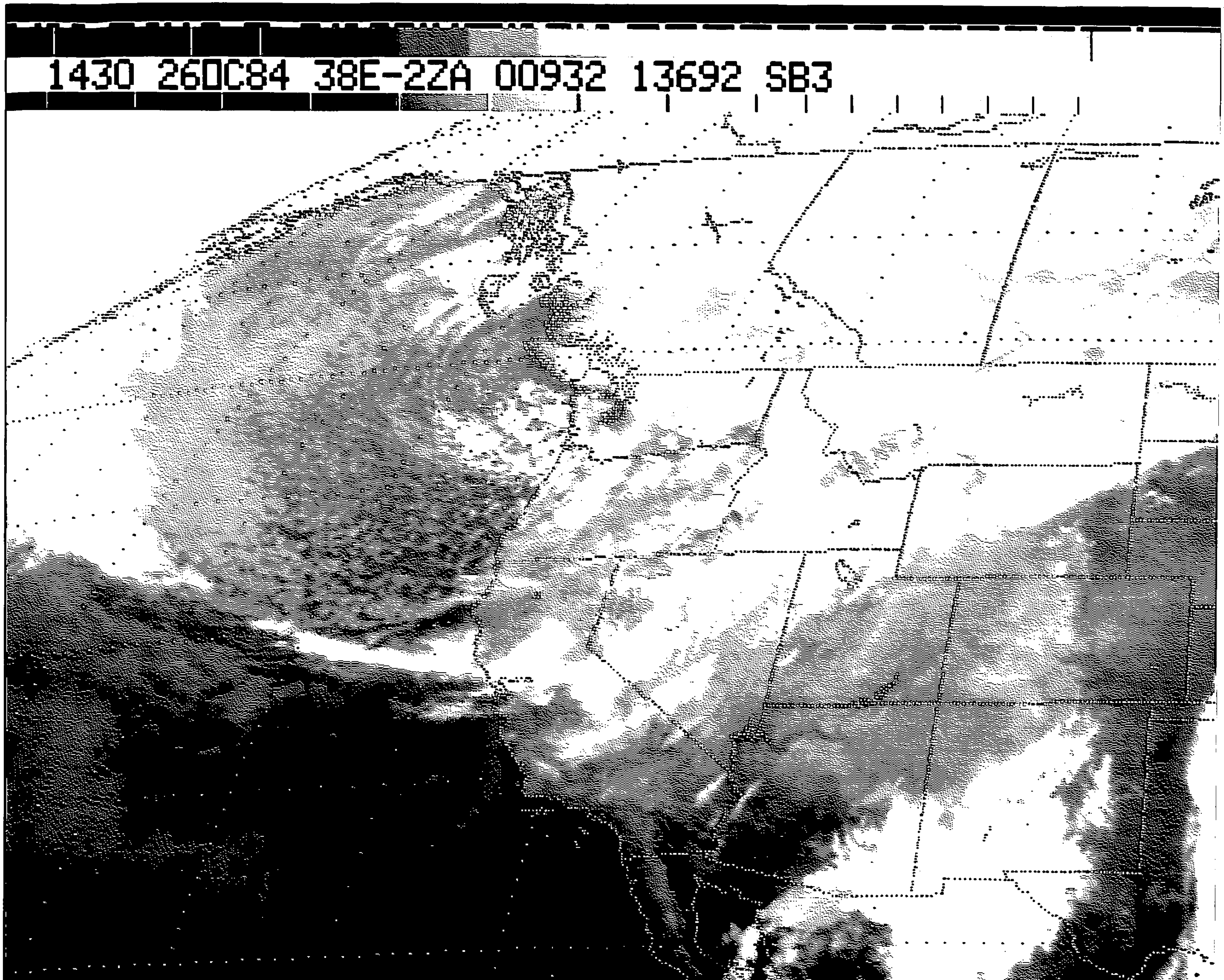

1100 26DC84 38E-2HF 00923 13661 SB3

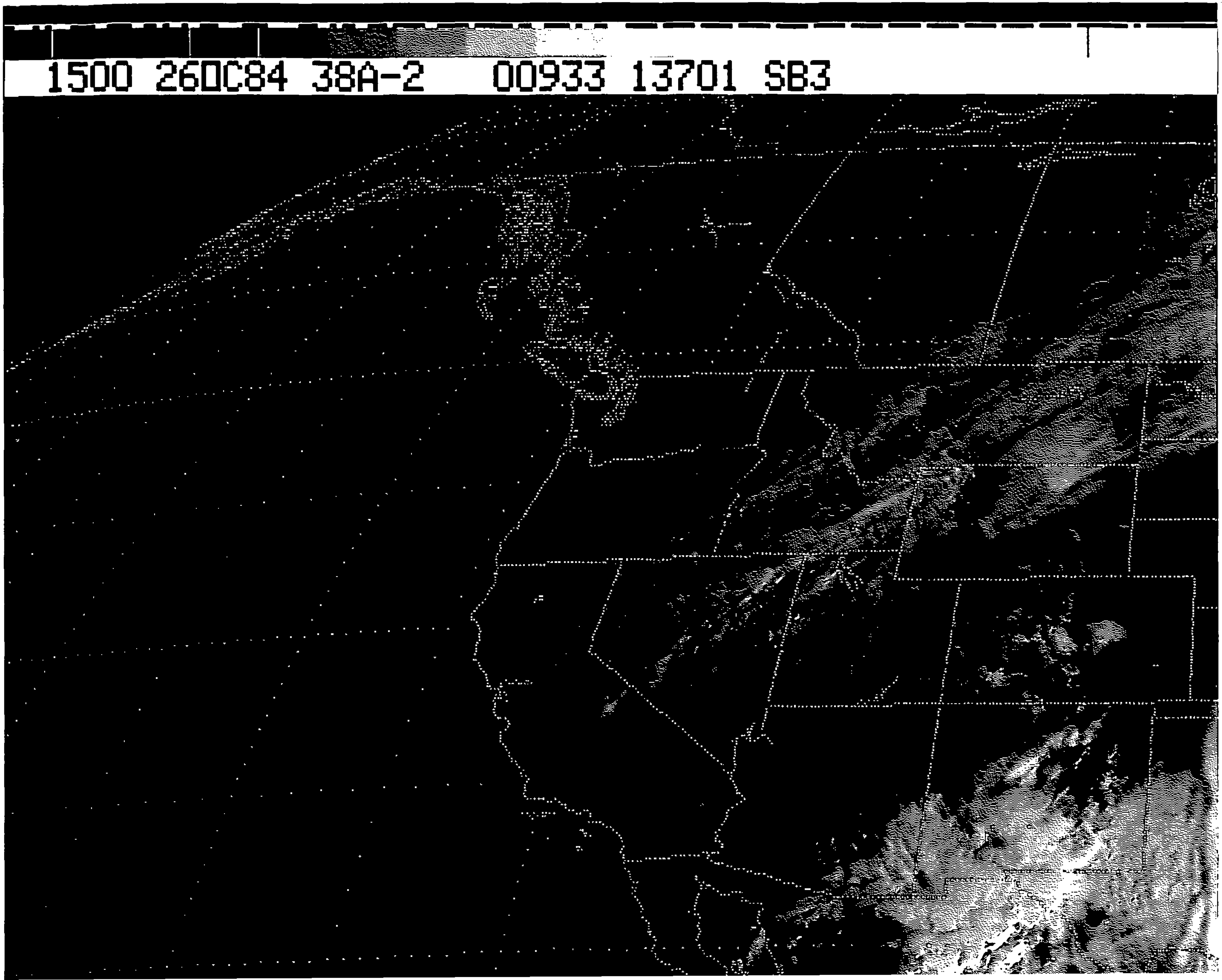

1230 26DC84 38E-2ZA 00933 13681 SB3

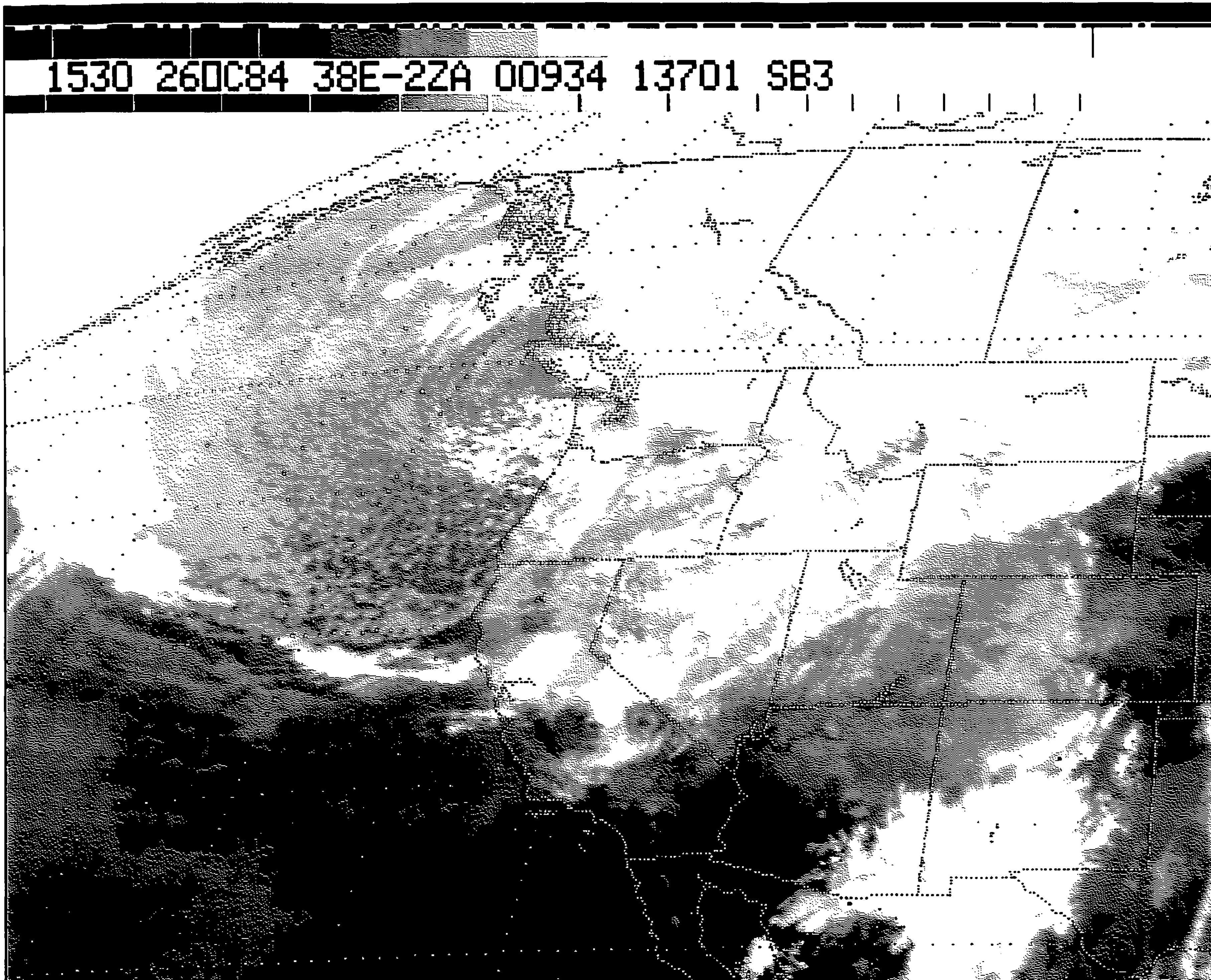

1300 26DC84 38E-2HF 00932 13682 SB3


1330 26DC84 38E-2ZA 00932 13691 SB3


1400 26DC84 38E-2HF 00932 13692 SB3


1430 26DC84 38E-2ZA 00932 13692 SB3


1500 26DC84 38A-2 00933 13701 SB3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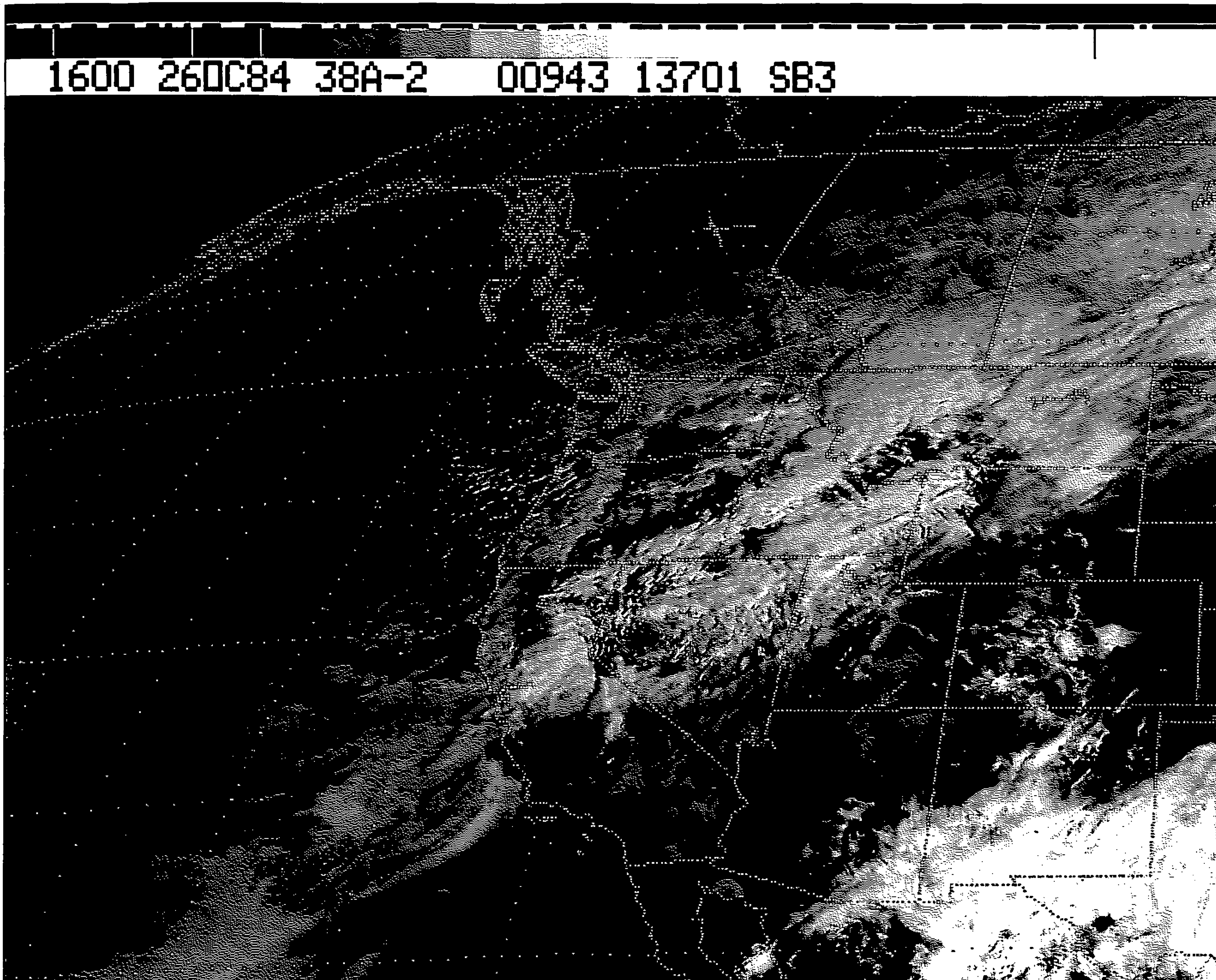
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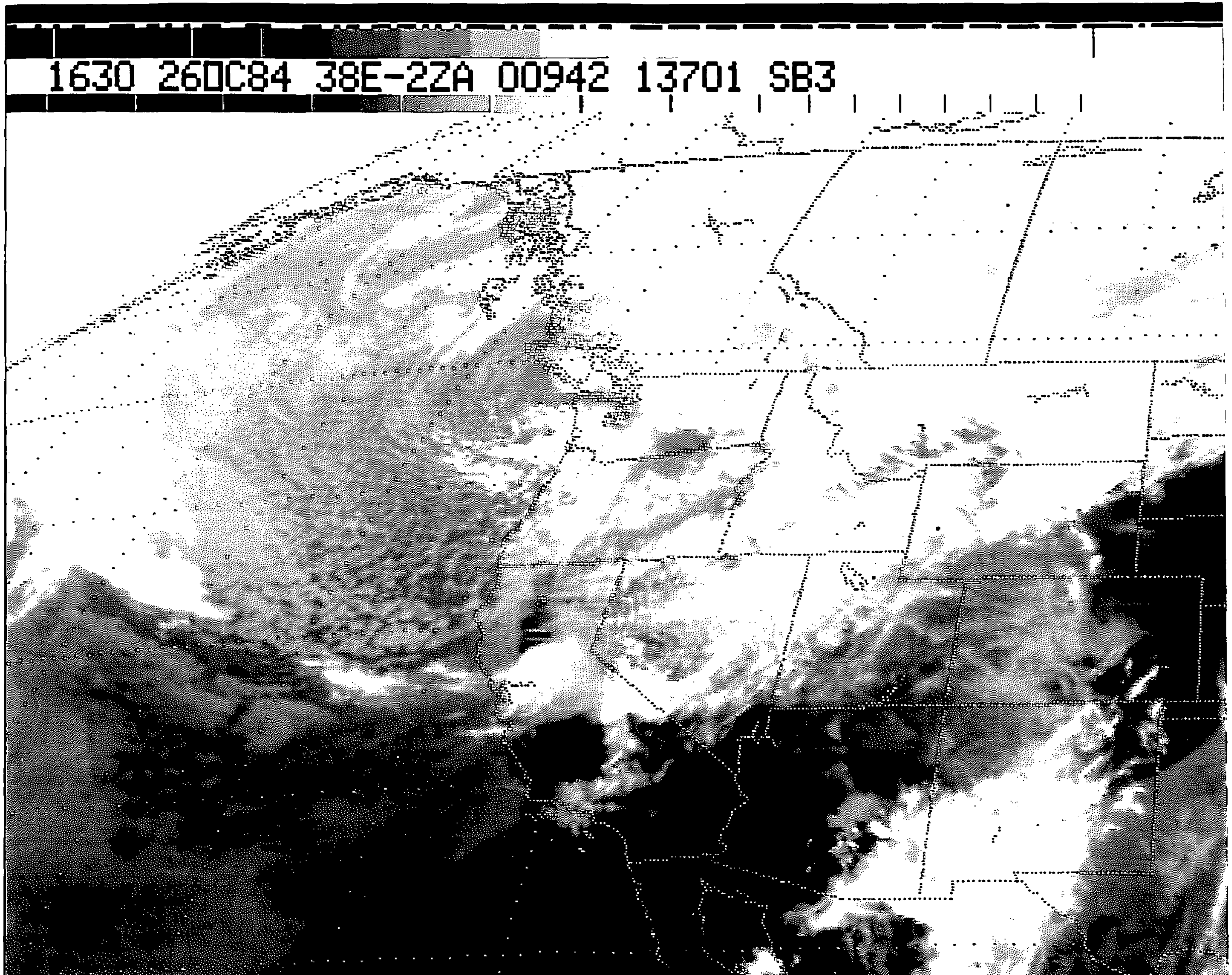
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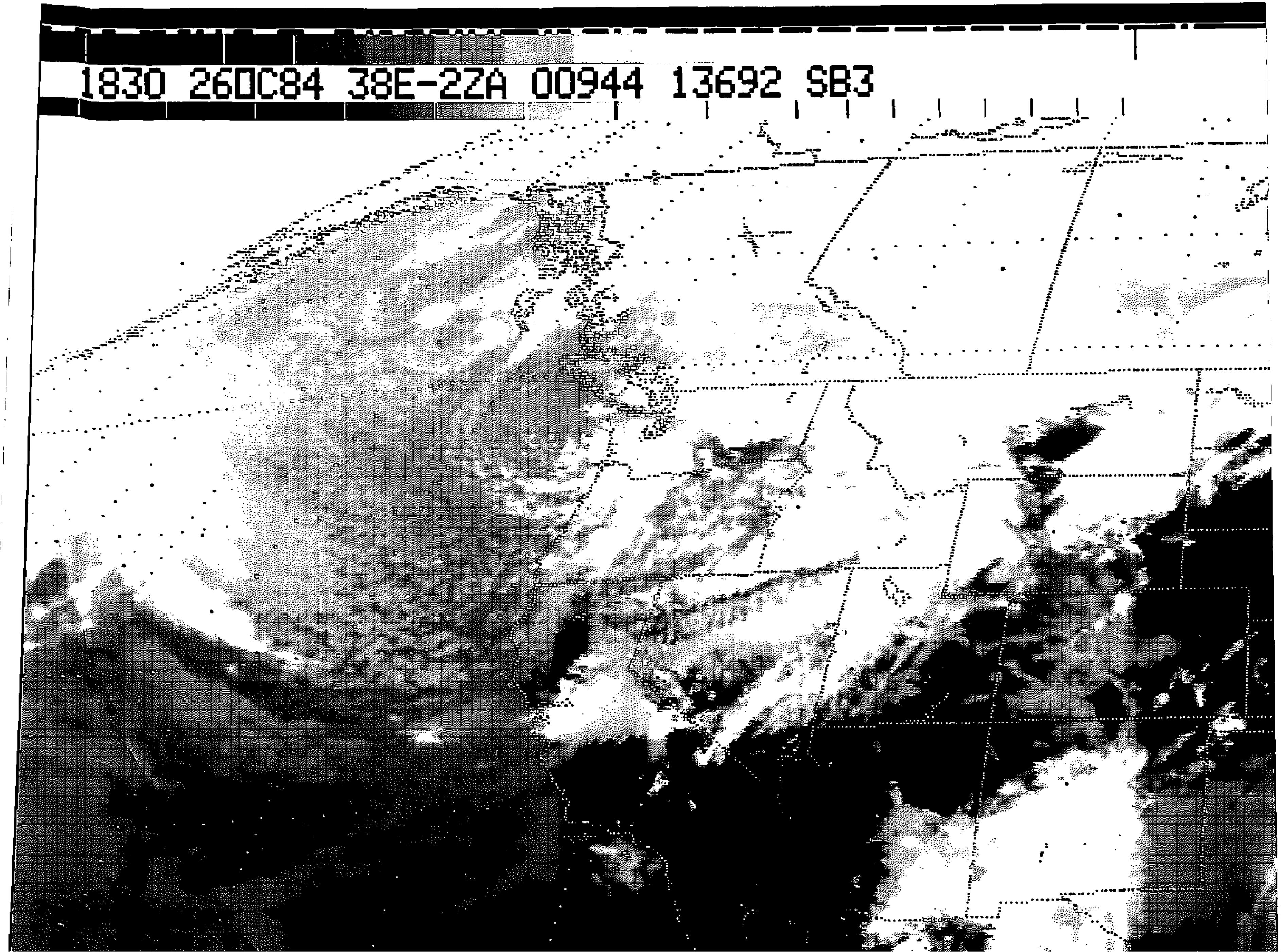
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