SYNOPTIC PATTERNS ASSOCIATED WITH HAIL OCCURRENCE IN NORTHEASTERN COLORADO

by

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National Science Foundation Research Participation
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Appendix A-1 missing

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SYNOPTIC PATTERNS ASSOCIATED WITH HAIL OCCURRENCE IN NORTHEASTERN COLORADO

- Abstract -

Hail on the high plains of Northeastern Colorado is associated with four major types of synoptic patterns. The first and most prevalent is the cP outbreak. The second most common is a frontal effect associated with a lee-side low. The third pattern is that of a strong mT flow into a surface low caused by intense surface heating in eastern Colorado and western Nebraska. The fourth pattern is associated with a frontal effect without a lee-side low. Each of these types exhibit certain characteristics which can be used to help identify the types. These characteristics can generally be defined by the location and motion of the Polar and Tropic high pressure cells, the location and motion of frontal activity, the existence of a lee-side low, the relative strength of the cT low, and the existence of a high pressure cell over the Rocky Mountains.

OBJECTIVES

This is a preliminary study of the types of synoptic patterns associated with hail occurrence in northeastern Colorado. As a part of an evaluation study of a hail suppression project, answers were sought for the following specific questions:

1. Are there synoptic types associated with hail occurrence in northeastern Colorado?
2. What are some of the characteristics of these synoptic types?

PROCEDURE

Primary data for this study were the dates of hail occurrence in northeastern Colorado and measures of the severity of the hail storms. Most of this information came from the Great Western Sugar Company offices at Ovid, Sterling, and Fort Morgan, Colorado. A cross-check from 1949-1958 was obtained from the Severe Weather Files of the State Climatological office, Denver, Colorado.

A "Hail Day" was defined as a day that hail fell on beets in areas near Ovid, Sterling, or Fort Morgan. The type of damage, light, medium, and heavy, (recorded in Appendix A) represents an opinion on the severity of damage to beets by the field men of the Great Western Sugar Company. Amount of damage was recorded as number of acres, but, in order to give a common denominator, the amount of damage for each damage class was also tabulated in percent of total acres planted for that year. Records were available from Great Western Sugar Company from 1929-1958. Records for May and June for 1959 were obtained from the Hail Suppression Evaluation Program carried on by Colorado State University.

Synoptic data for this project were obtained from the following sources:

1. U. S. Daily Weather Map, Dept. of Commerce, 1959.
2. U. S. Surface Charts, Micro-film, 1942 - 1945; 1949 - 1958.
3. U. S. Surface Charts, Script Maps, USWB, Denver, Colo., 1946 - 1948.
4. U. S. Historical Series, Surface Charts, 1933 - 1939.

Each "Hail Day" was examined from these charts in the following manner:

1. Principal synoptic features (highs, lows, fronts) were sketched for 105 cases. For each of these cases the synoptic features were sketched from the 0130 EST surface map for the day before, the day during, and the day after the "Hail Day."
2. Maps having similar characteristics were classified into different synoptic types

An outline (See Results) was developed to identify each synoptic type. This outline was used to type 223 other "Hail Days." Tabulations were then prepared to show the characteristics of these types.

RESULTS

SYNOPTIC TYPES -

The first and most prevalent type that occurs in the cP outbreak, which hereafter will be given the letter designator of U-1. This is identified primarily by a closed high pressure cell moving from the north or northwest. Even though the cell moves over the Great Lakes, this pattern may produce hail if it exerts an influence as far west as the Eastern Slope of the Rocky Mountains. Hail occurs 24-36 hours after frontal passage. During this time interval, the anti-cyclonic circulation brings back warm, moist air from the Gulf of Mexico. For this U-1 pattern to produce hail, the closed high pressure cell must continue to move. Micro-analysis may show a shallow trough moving across

Wyoming. The existence of mT air may be verified by the orientation and position of the 60 degree F dew point iso-line.

The second non-frontal type is created by intense inland heating in the vicinity of southwestern Nebraska, and is hereafter given the designation of U-2. This pattern forms a shallow low to the lee of the Rocky Mountains and a small high pressure cell over the Rocky Mountains. Cyclonic flow around the low cell will turn mT air into the vicinity of a cap of subsiding air from the high pressure cell. The Bermuda High should be far enough inland to produce a flow of mT air into northeastern Colorado to help create this condition.

The most prevalent frontal type hereinafter designated T-2 is that associated with a lee-side low, either southeast or northeast of Sterling, Colorado. The lee-side low has the property of frequently delaying the hail occurrence 24 hours or more after the formation of the lee-side low. This type many times has a squall line associated with it and the cT low in southwestern United States is usually below 1006 mb. A slight variation of this pattern is a front north of Sterling joined with the cT low. Complex lows frequently form on the front and move eastward as unstable waves. This situation will many times precede a long spell of hot clear weather with very few thunderstorms and/or hailstorms.

The second frontal type, hereafter given the designated T-1, is associated with either the end of a frontal system or a frontal system without a lee-side low. The front moves in very rapidly from the northwest and will be accompanied by a rapidly moving mP high pressure cell breaking off from the Pacific high. Many times the south end of the front will slow down over the mountains with cooler air behind pushing past the surface front giving a squall line moving rapidly to the east-southeast. A good indication of this pattern is south-southeast winds over northeastern Colorado at 10-15 knots and lowering pressure in northeastern Colorado.

A very unusual variation of either frontal type (hereafter designated T-3) occurs in late August or September. This pattern is associated with a Hurricane off the southeastern coast of the United States. During this situation mT air is brought to the eastern slope of the Rocky Mountains on a trajectory from the Atlantic Ocean.

Schematic diagrams illustrating each of these types are given on pages 6-9.

Outlines defining the four synoptic types are given on pages 10 and 11.

Appendix B gives two examples of each of the synoptic types.

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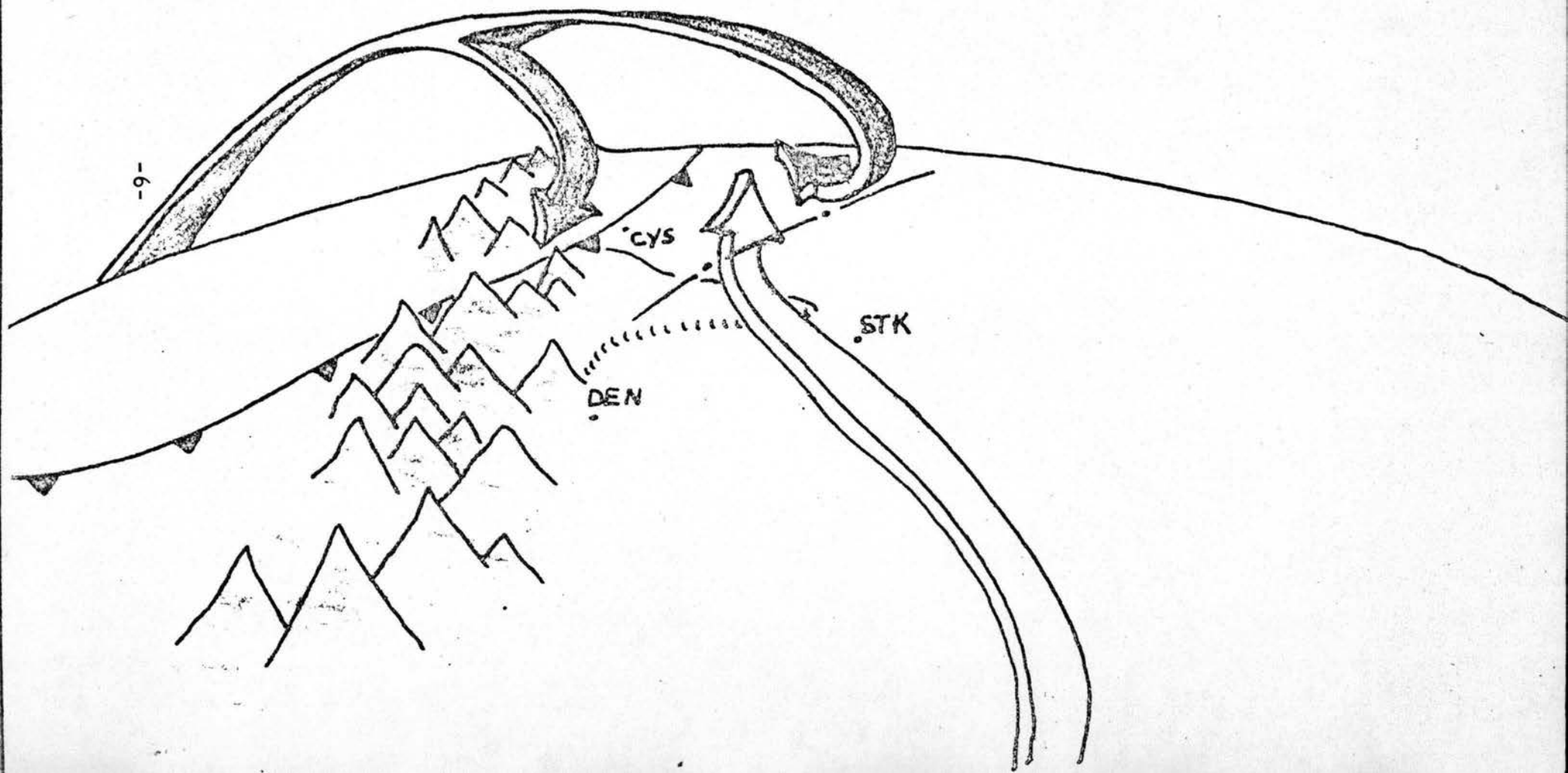
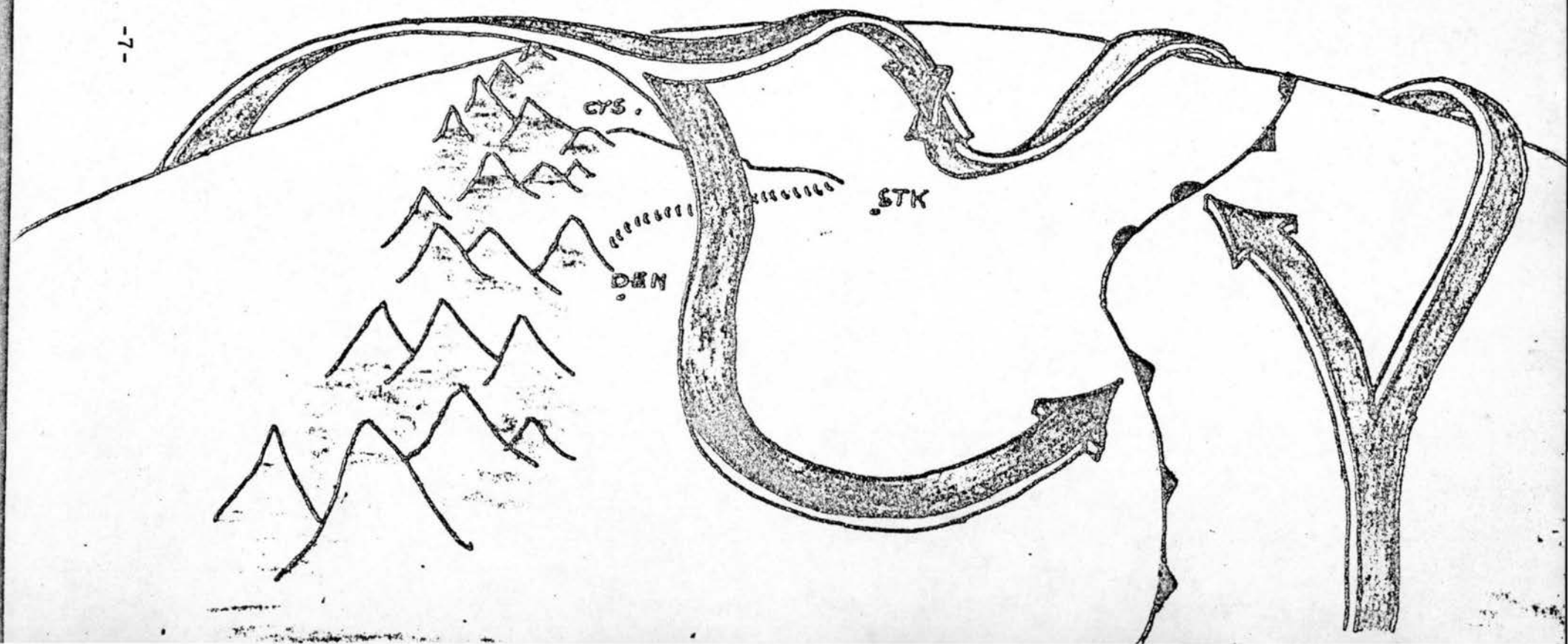
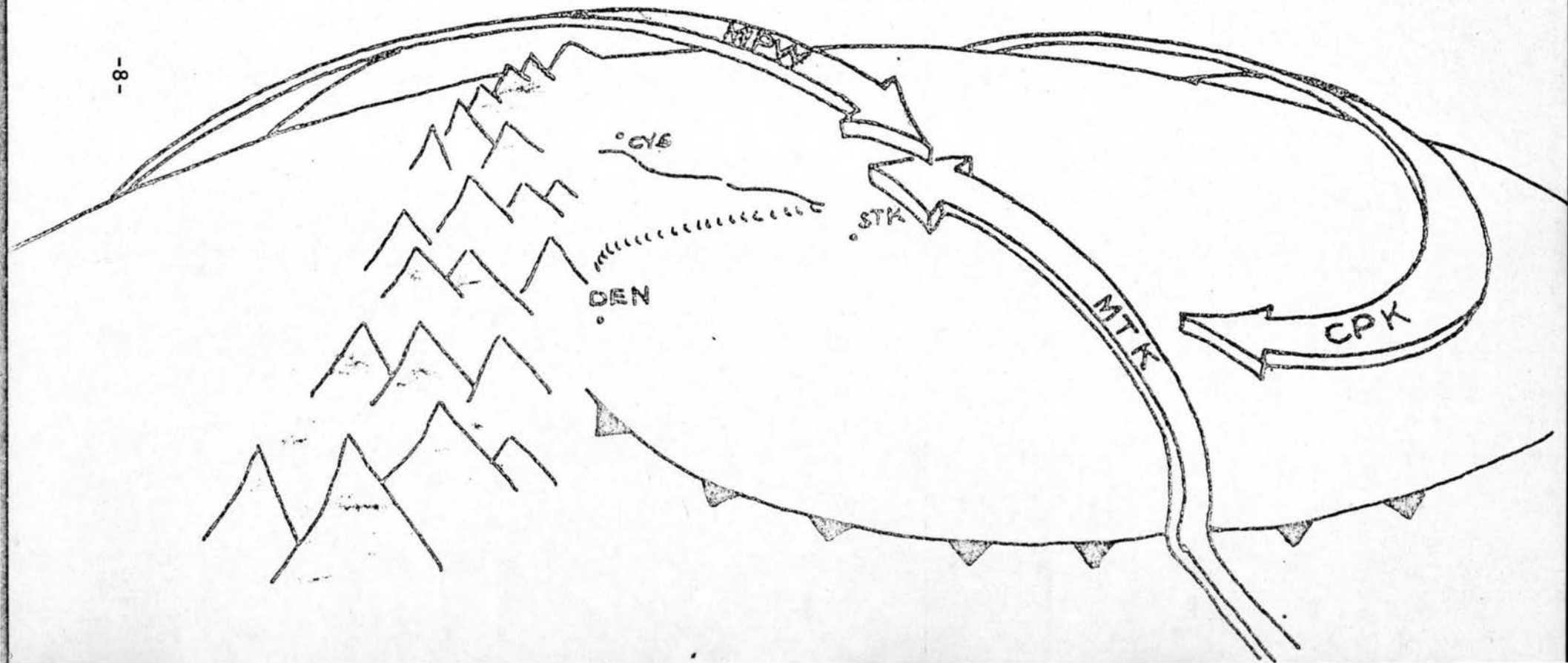


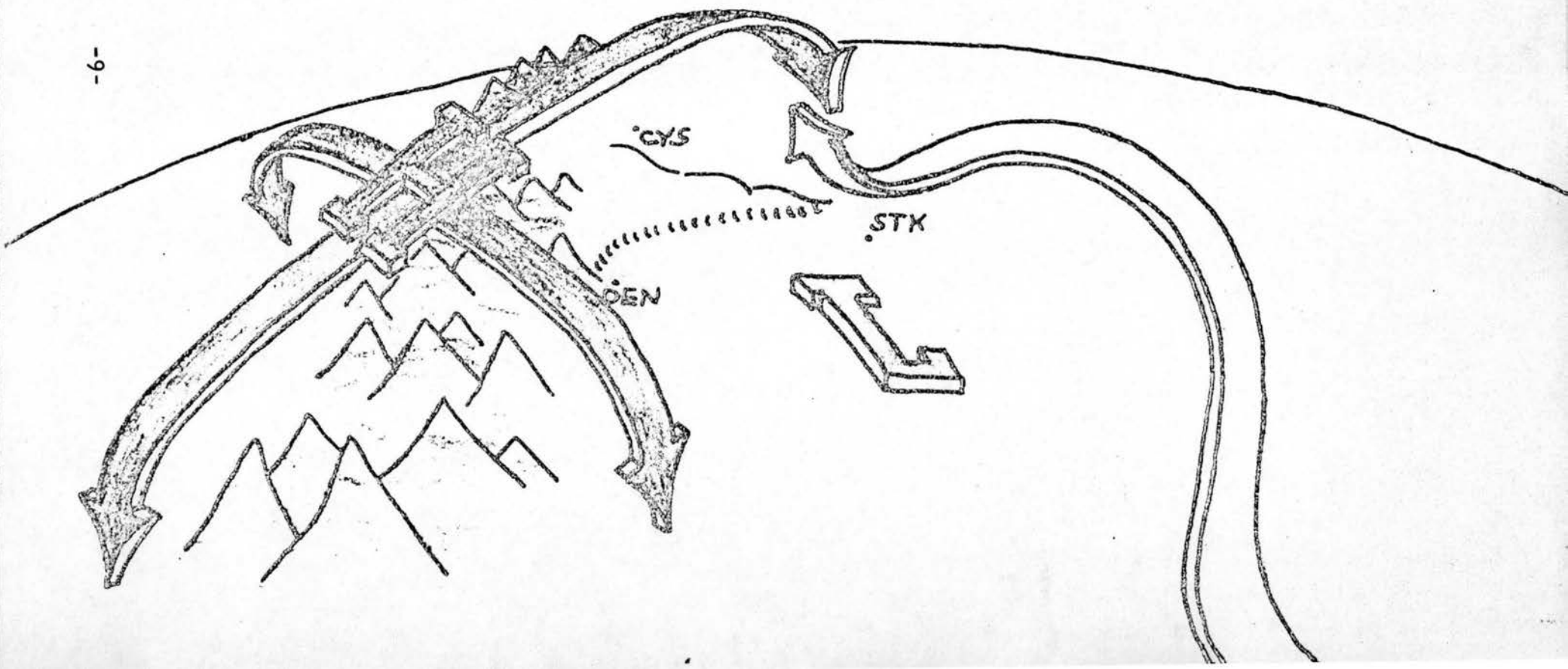
T-2 MP FRONT - LEE LOW



U-1 CP OUTBREAK

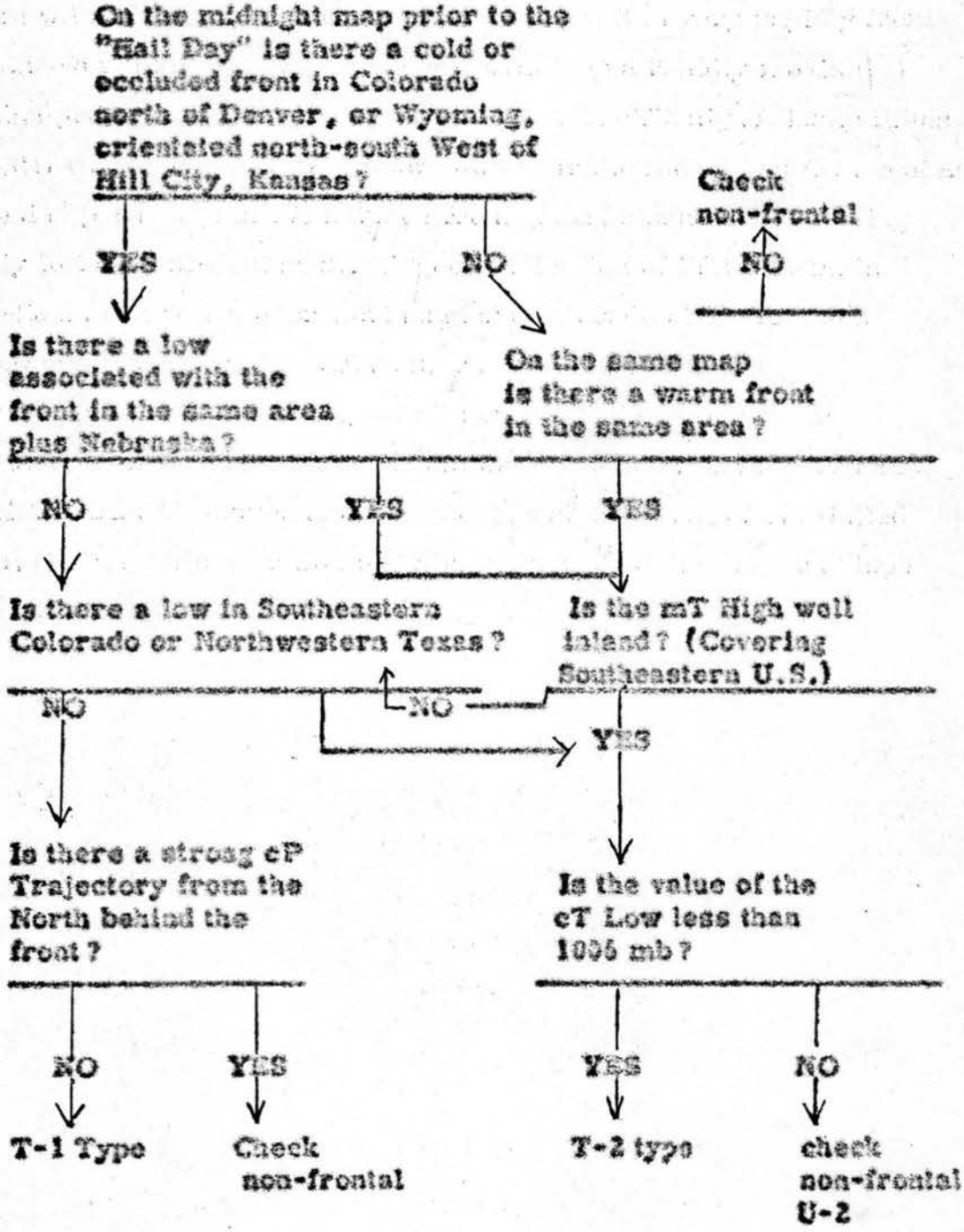


U-2 MOUNTAIN CAP-LEE LOW



REFERENCE OUTLINE TO CHECK SYNOPTIC TYPE

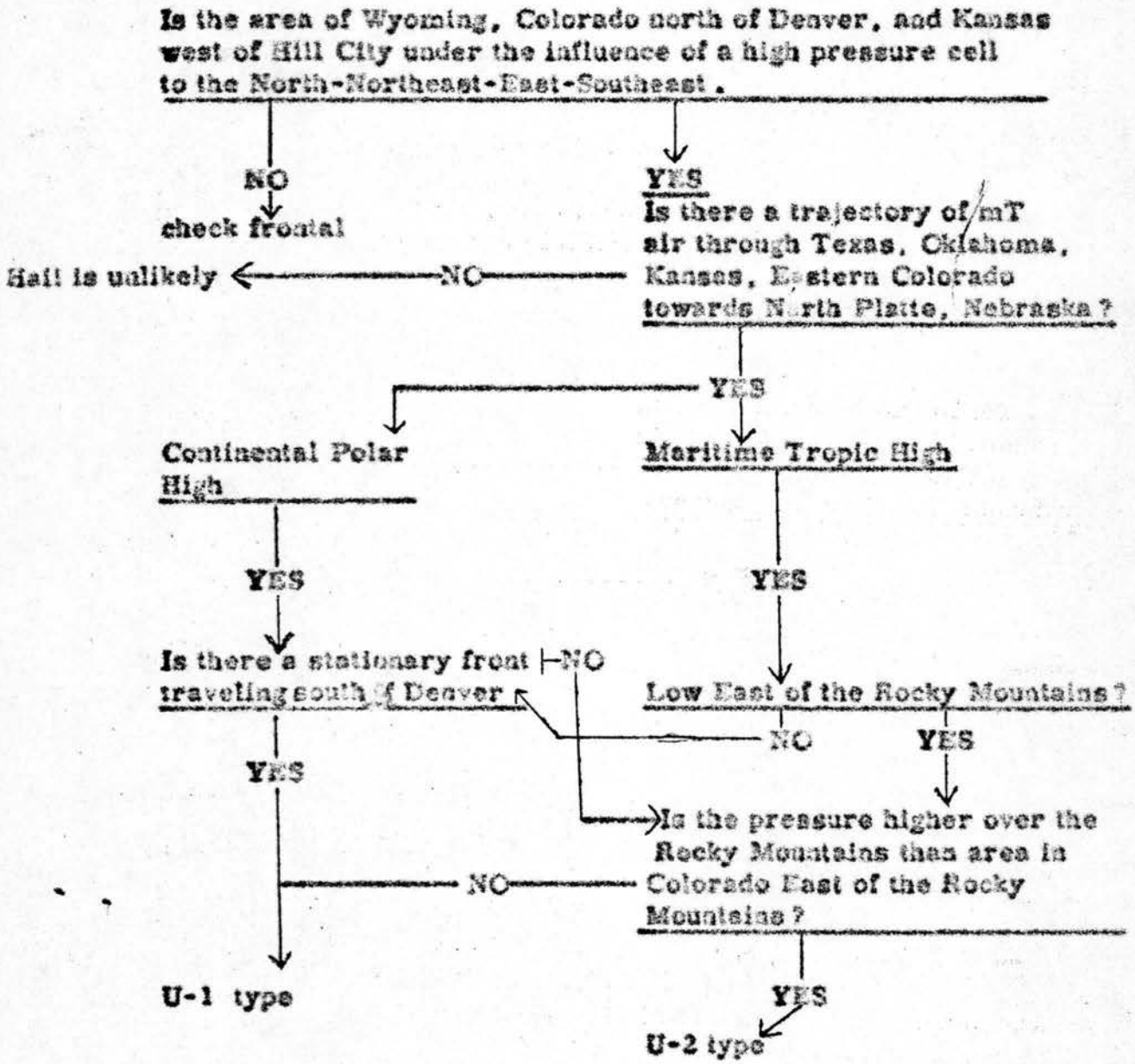
Part 1 - FRONTAL



FRONTAL TYPE TAKES PRECEDENCE OVER NON-FRONTAL

REFERENCE OUTLINE TO CHECK SYNOPTIC TYPE

Part 2 - NON-FRONTAL



CHARACTERISTICS OF SYNOPTIC TYPES -

Each "Hail Day" and its associated synoptic type is listed in Appendix C. The T-3 type occurred only six times in 16 years. No further tabulations were made of this type.

The seasonal distribution of synoptic type was determined by summarizing the occurrences of each type for the months of May, June, July, August, and September. Figure 1 shows the seasonal distribution of synoptic types. A tabulation appears in Appendix D.

A summary of hail damage by synoptic types for the years 1937 to 1958 is given in Table 1.

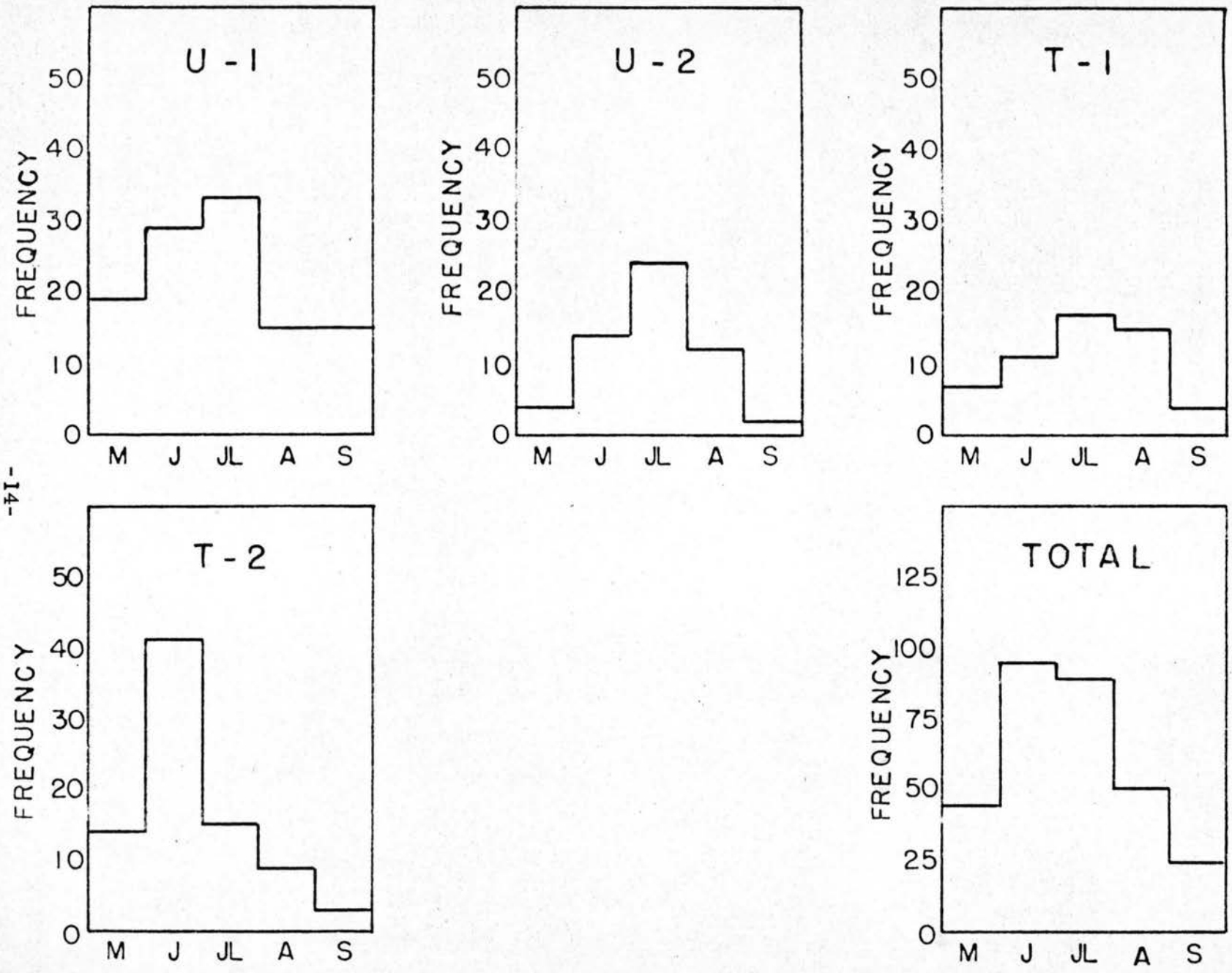
A graph of Hail Damage by Synoptic type appears in Figure 2.

A tabulation appears in Appendix E.

TABLE 1.

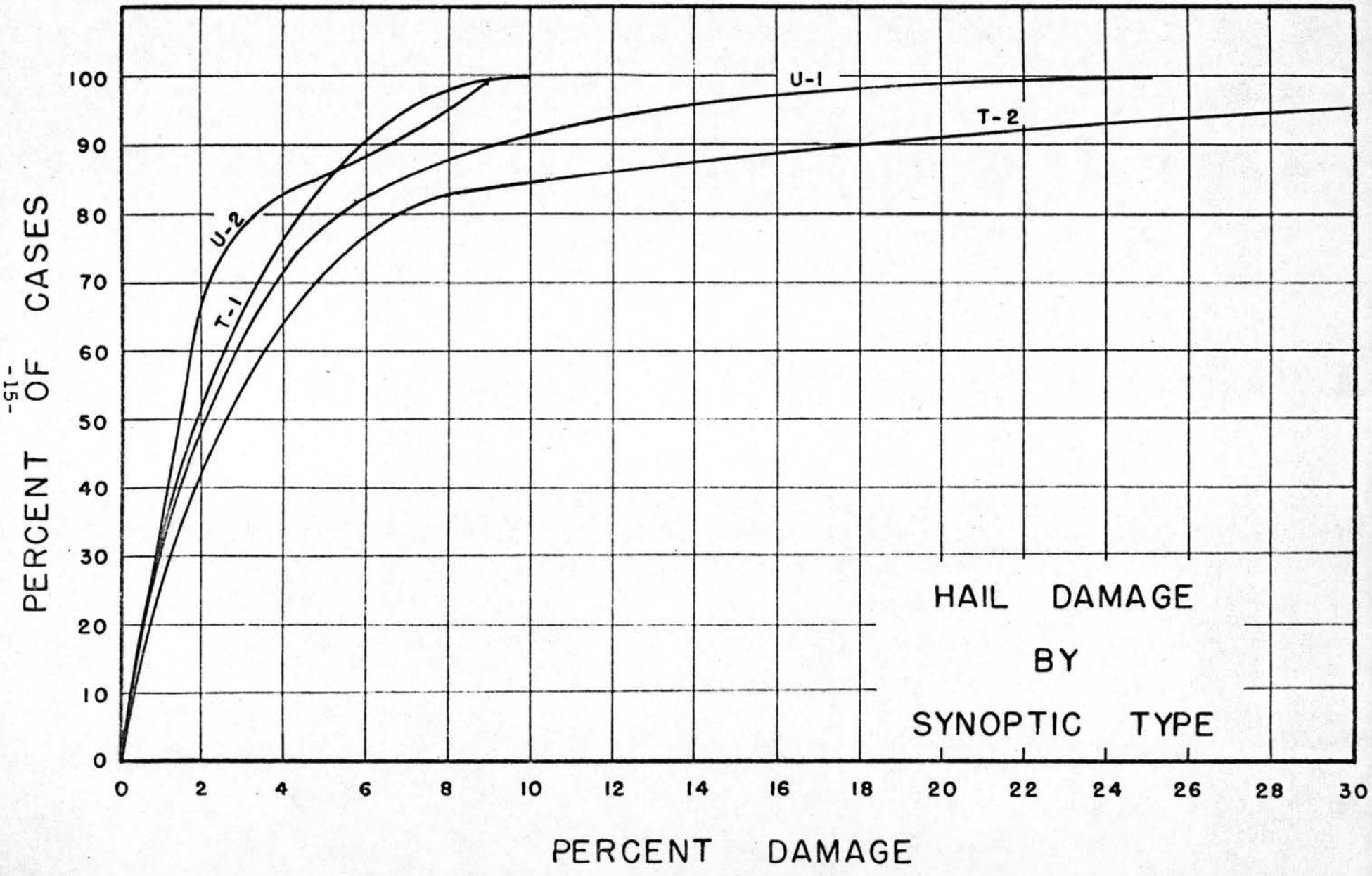
Hail Damage to Sugar Beets by Synoptic Types
For the Period 1957 to 1968.
(Source of data on hail damage: Great Western Sugar Company)

	U-1	U-2	T-1	T-2
Total damage to beets in percent of total acres planted	286 percent	196 percent	101 percent	249 percent
Number of cases	81	49	41	52
Mean damage per hail case	3.53 percent	2.18 percent	2.46 percent	4.80 percent



SEASONAL DISTRIBUTION OF STORM TYPES

FIGURE 1


PERCENT OF CASES
0
10
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40
50
60
70
80
90
100
0
2
4
6
8
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12
14
16
18
20
22
24
26
28
30
PERCENT DAMAGE
U-1
T-2
U-2
T-1
HAIL DAMAGE
BY
SYNOPTIC TYPE

FIGURE 2

CONCLUSIONS

1. Four types of synoptic situations can be identified in association with "Hail Days" in Northeastern Colorado.
2. These types can be determined from surface data alone.
3. The U-1 type has its greatest frequency of occurrence in May, June, and July.
4. The U-2 type has its greatest frequency of occurrence in July.
5. The T-1 type has its greatest frequency of occurrence in July and August.
6. The T-2 type has its greatest frequency of occurrence in June. This frequency is high in comparison with other summer months.
7. June and July have the greatest frequency of occurrence for all synoptic types.
8. More non-frontal cases than frontal cases were noted for the period 1937 to 1958. During this period the 130 non-frontal and 93 frontal cases were observed in connection with "Hail Days."
9. U-1 type occurred more frequently than any other type. During the same period 81 U-1 cases were observed, with 52 cases of T-2 type being second.
10. Frontal types have a tendency to produce more damage than non-frontal. (4 percent/case vs 3 percent/case)
11. The T-2 type produces more damage on the average than any other synoptic type.
    (4.80 percent average vs 3.53 percent average for the next highest number)
12. Approximately one out of ten cases of the T-2 synoptic type inflict damage to beets in excess of 20 percent with an upper limit of 31 percent.

13. Approximately one out of ten cases of the U-1 synoptic type inflict damage to beets in excess of 10 percent with an upper limit of 25 percent.

14. Approximately one out of two cases of the T-1 synoptic type inflict less than 2 percent damage.

DISCUSSION

Further refinement to five types could have been made of the four synoptic types described in this study. The T-2 (frontal with lee-side low) category could have been subdivided into two types: one for the frontal system east of Sterling orientated Northeast-Southwest with a lee-side low, and the other with a East-West orientation north of Sterling with a lee-side low. This distinction was not made in this study because of suitable parameters could not be found to make such a distinction. The T-1 category appears to be of a cyclic nature, having greatest concentration in the late 40's. Recent years indicated have fewer T-1 types.

The frequency pattern over the summer months agreed closely with what could be expected from physical reasoning. The U-1 type or cP outbreak, appears in the early summer months and declines in the late summer months when the maritime highs move northward. The U-2 type has its greatest frequency in July and early August since it is dependent on the inland surface heating of mid-summer.

The T-1 type has its greatest frequency in late summer since by then storm tracks have moved north and the usual frontal passage would be the southern tip of these systems. Another factor favoring a maximum frequency of the T-1 type in July and August is the position of the Pacific High which is further North in late summer. The cause for the high frequency of the T-2 type in June is not completely understood. The fact that the greatest frequency of all hail occurrences falls in June and July agrees with most studies of hail occurrences in this region.

In 1959 very few hail days occurred in August. This may be related to the cyclic nature of the T-1 type noted previously.

The topography of the area under study is close to the Eastern Slope of the Rocky Mountains and produces an up-slope condition from

from Easterly winds. The fact that this up-slope condition can be brought about by any component of wind from north-northeast through southeast, helps to explain the predominance of the U-1 type.

The stronger cyclonic circulation associated with the T-2 type is probably the explanation for the greater damage associated with this type.

The n curves shown in Figure 2 show that most of the damage cases are small, with a small number of cases of high hail damage. This appears to be a characteristic of hail storms in the region studied.

This study considered only the dates of hail occurrence, not all cases. Time did not permit a study of whether these types can exist without hail. Hence, additional work is needed before results of this study can be applied to the problem of forecasting hail.

Since only surface data was used in this study, a further refinement of these types probably could be obtained with additional data from upper-air charts and radiosonde observations.

APPENDIX A

APPENDIX A-1 Tabulation of Cases of Light, Medium and Heavy Hail Damage to Beets from

OVID,
FORT MORGAN,
AND
STERLING
Districts of Great Western Sugar Company, 1958 - 1937.

APPENDIX A-2 Tabulation of Total Acres of Beets Planted for

OVID,
FORT MORGAN,
AND
STERLING
Districts of Great Western Sugar Company.

APPENDIX A-1

Tabulation of Cases of Light, Medium and Heavy Hail Damage to Beets from

OVID,

FORT MORGAN,

AND

STERLING

Districts of Great western Sugar Company

1937 - 1958

APPENDIX A-2

Tabulation of Total Acres of

Beets Planted for

OVID,

FORT MORGAN,

AND

STERLING

Districts of Great Western Sugar Company.

RECORD OF TOTAL PLANTED ACRES

1929 - 1958

OVID DISTRICT

Year	Planted Acreage	Year	Planted Acreage
1929	15361	1944	12265
1930	11299	1945	13980
1931	10891	1946	15712
1932	8520	1947	16652
1933	14146	1948	9244
1934	11532	1949	7439
1935	9379	1950	10182
1936	12471	1951	9677
1937	14129	1952	8879
1938	16959	1953	9076
1939	15560	1954	11364
1940	17586	1955	7951
1941	14017	1956	8715
1942	19514	1957	9564
1943	14271	1958	10059

RECORD OF TOTAL PLANTED ACRES

1929 - 1959

FORT MORGAN DISTRICT

Year	Planted Acreage	Year	Planted Acreage
1929	18734	1944	10935
1930	17023	1945	13939
1931	15177	1946	16693
1932	13537	1947	18768
1933	13595	1948	11776
1934	14061	1949	13035
1935	8298	1950	15412
1936	13337	1951	14345
1937	12907	1952	14483
1938	9481	1953	15471
1939	11398	1954	18615
1940	12928	1955	13475
1941	10182	1956	14479
1942	17468	1957	15230
1943	9578	1959	16646

RECORD OF TOTAL PLANTED ACRES

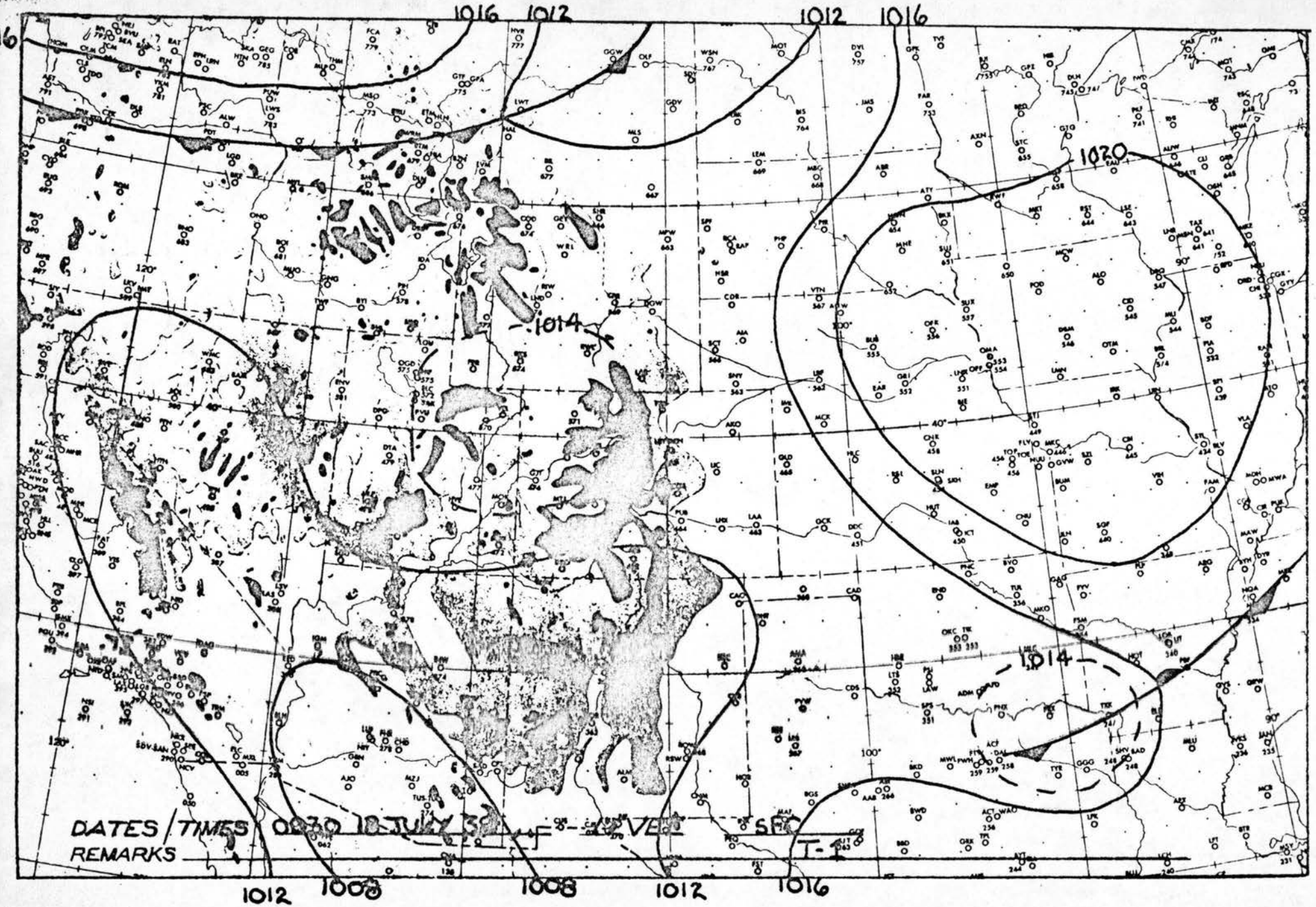
1928 - 1957

STERLING DISTRICT

Year	Planted Acreage	Year	Planted Acreage
1928	15450	1943	9263
1929	11934	1944	7900
1930	16869	1945	9933
1931	15265	1946	9402
1932	10461	1947	11175
1933	15711	1948	6836
1934	14381	1949	7248
1935	10695	1950	9388
1936	13874	1951	7689
1937	13353	1952	6163
1938	12090	1953	8136
1939	12686	1954	5857
1940	11992	1955	6670
1941	10709	1956	8267
1942	13806	1957	8176

APPENDIX B.

Examples of Synoptic Types Associated With Hail Occurrences in Northeastern Colorado.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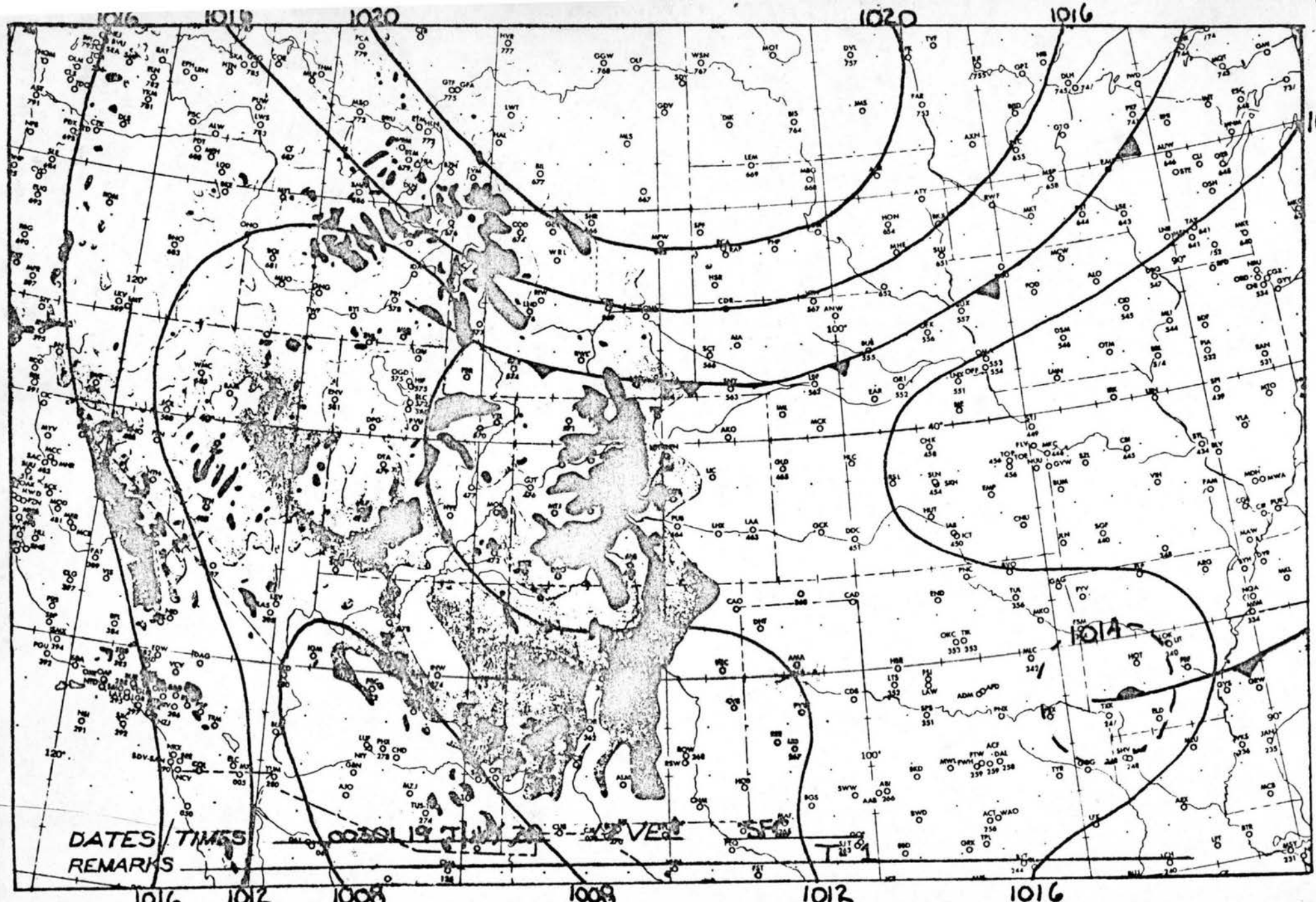
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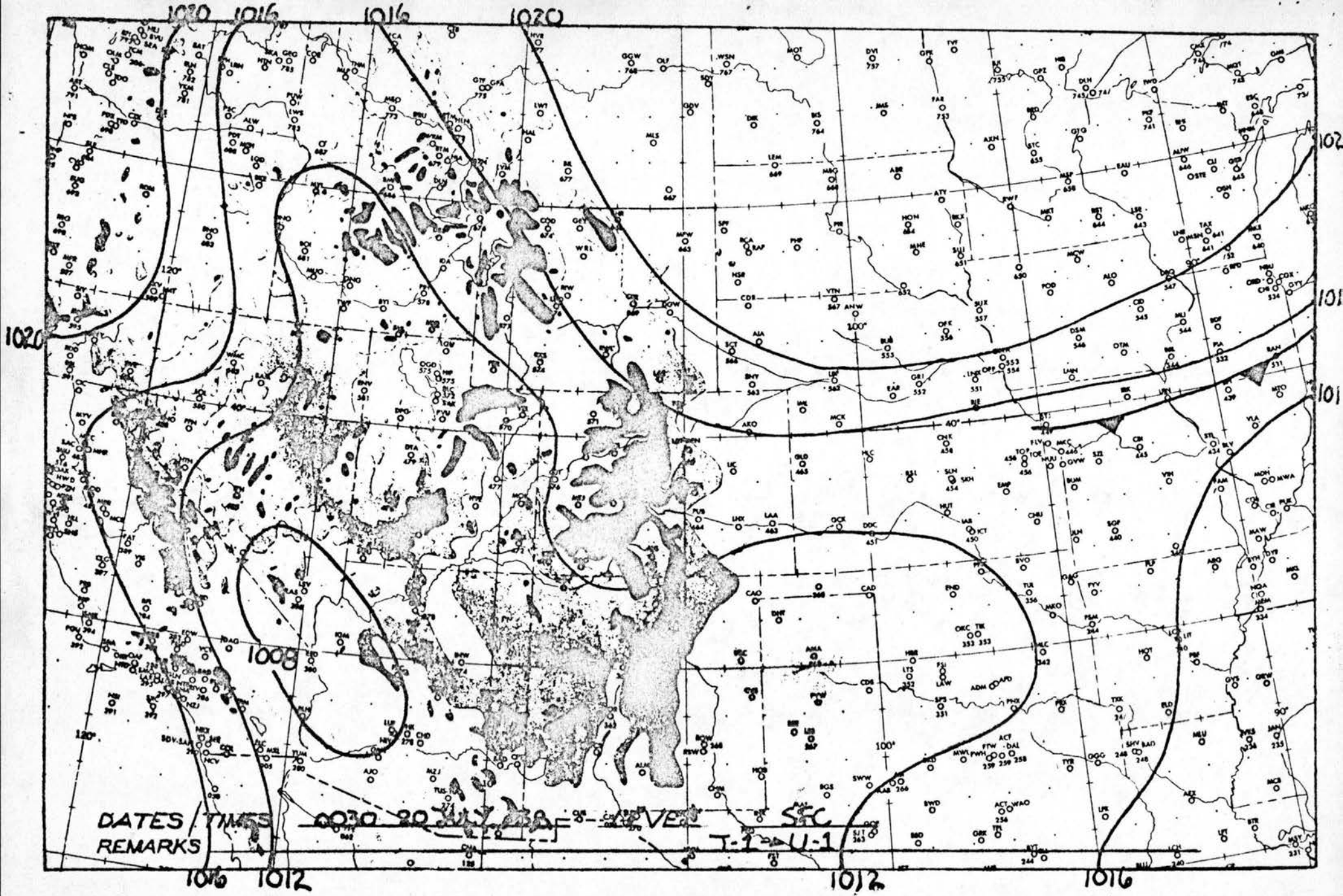
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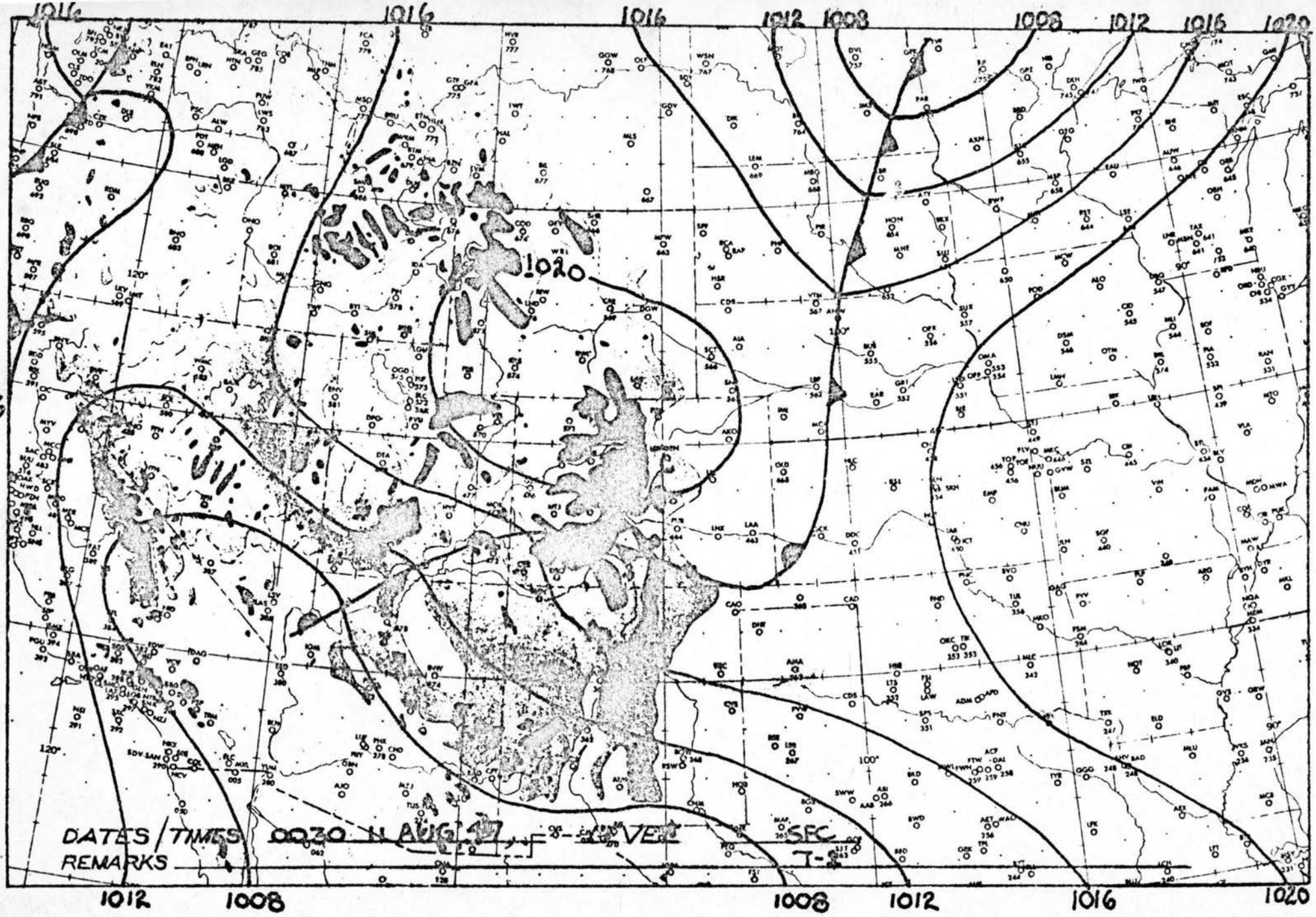
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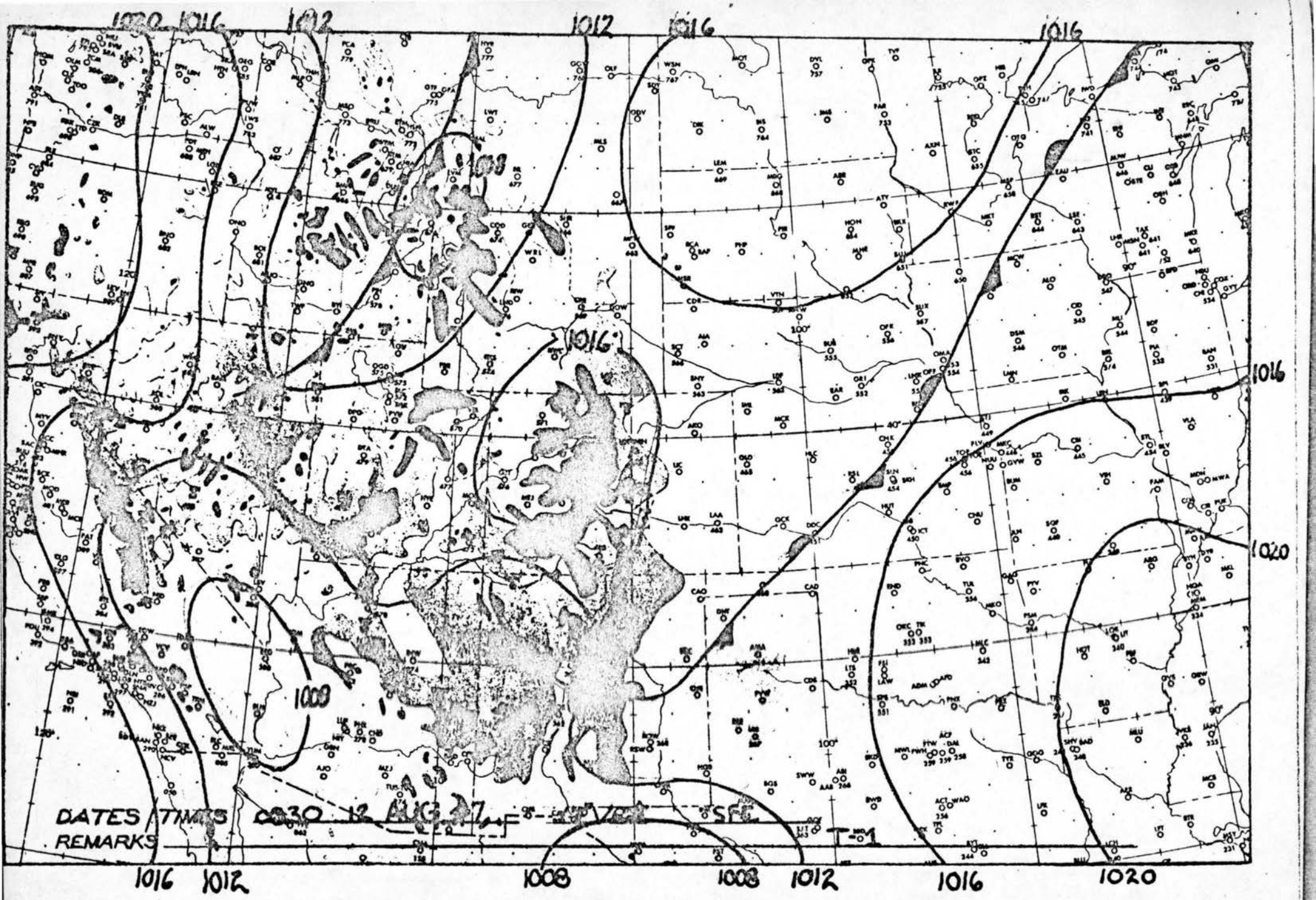
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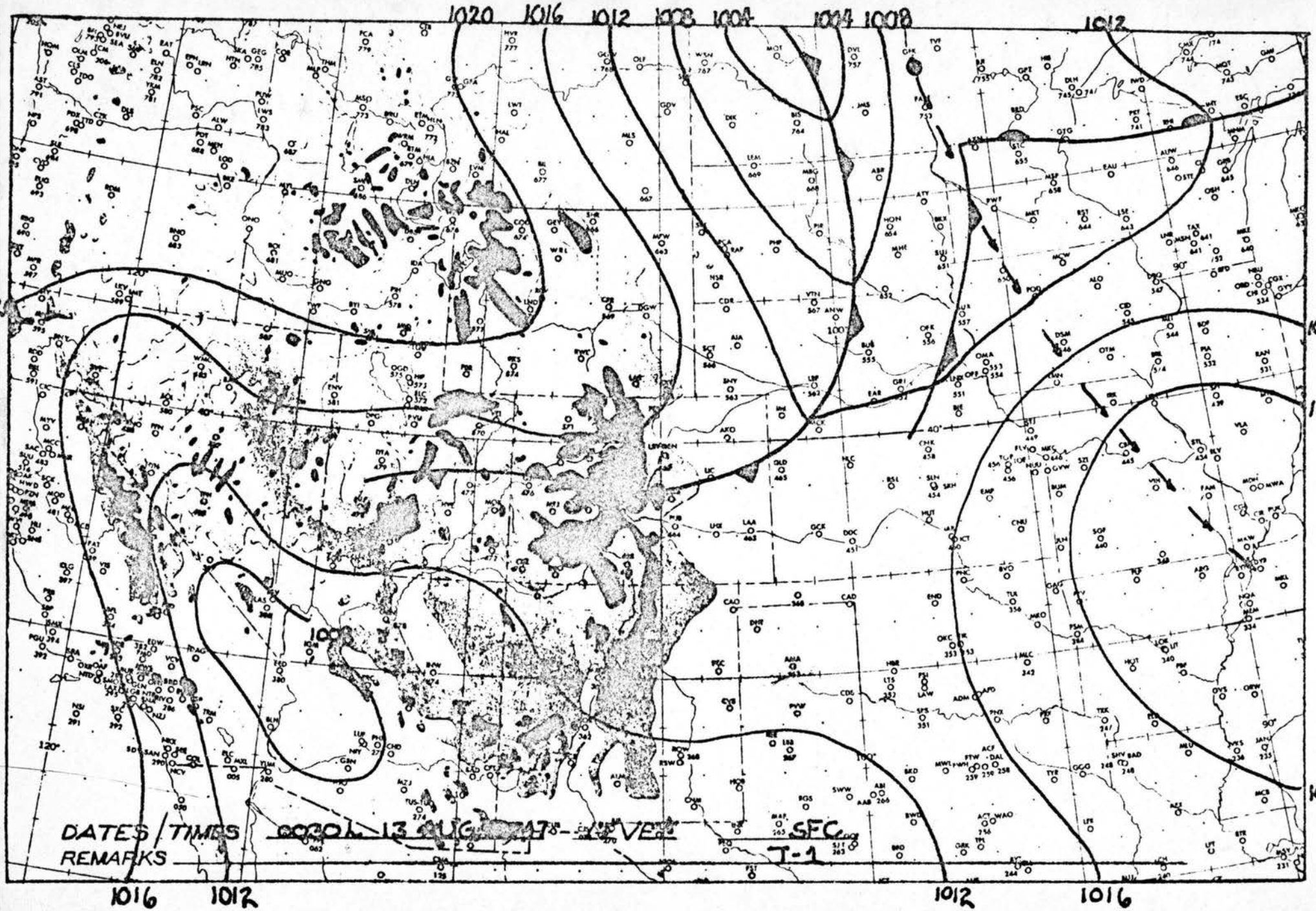
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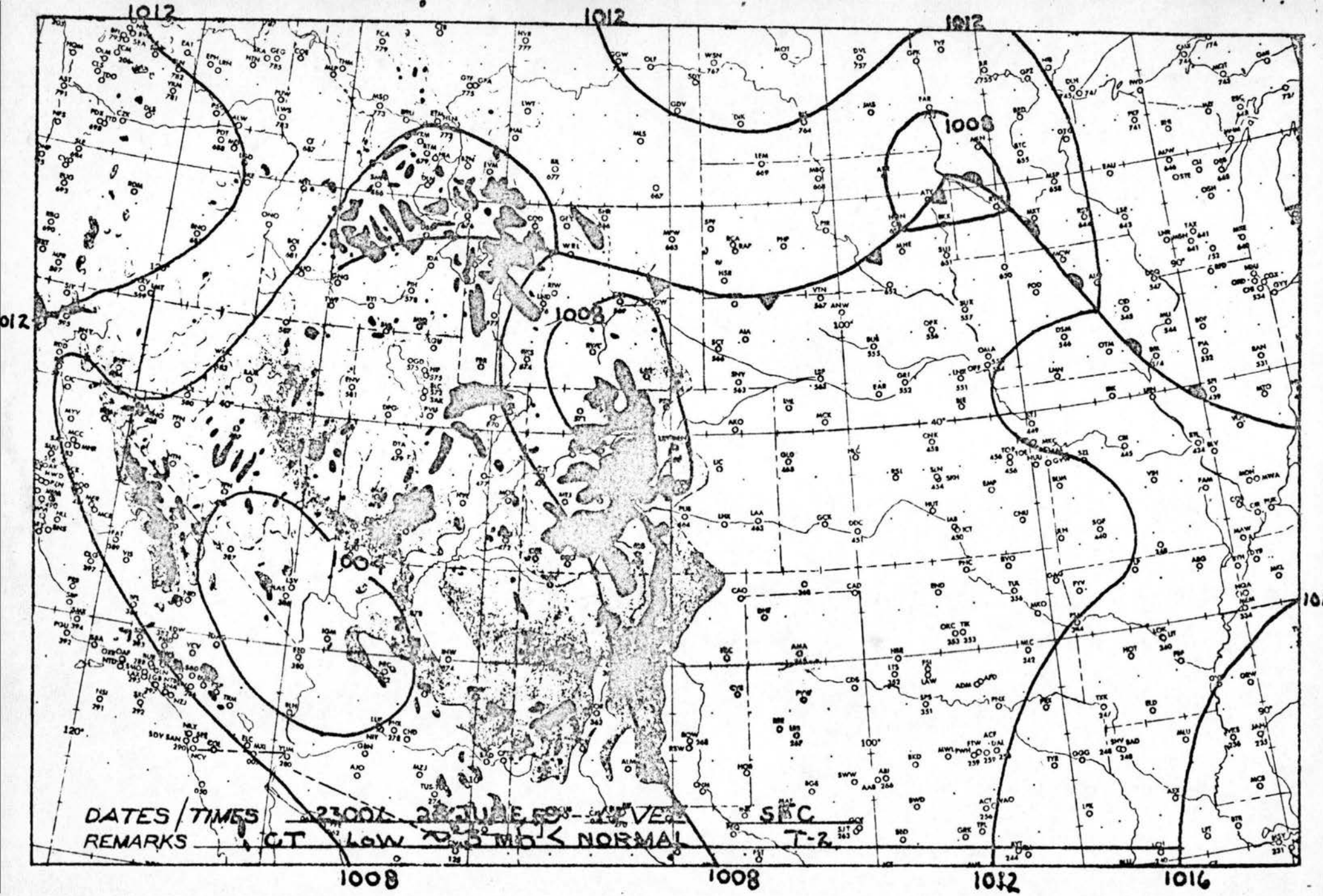
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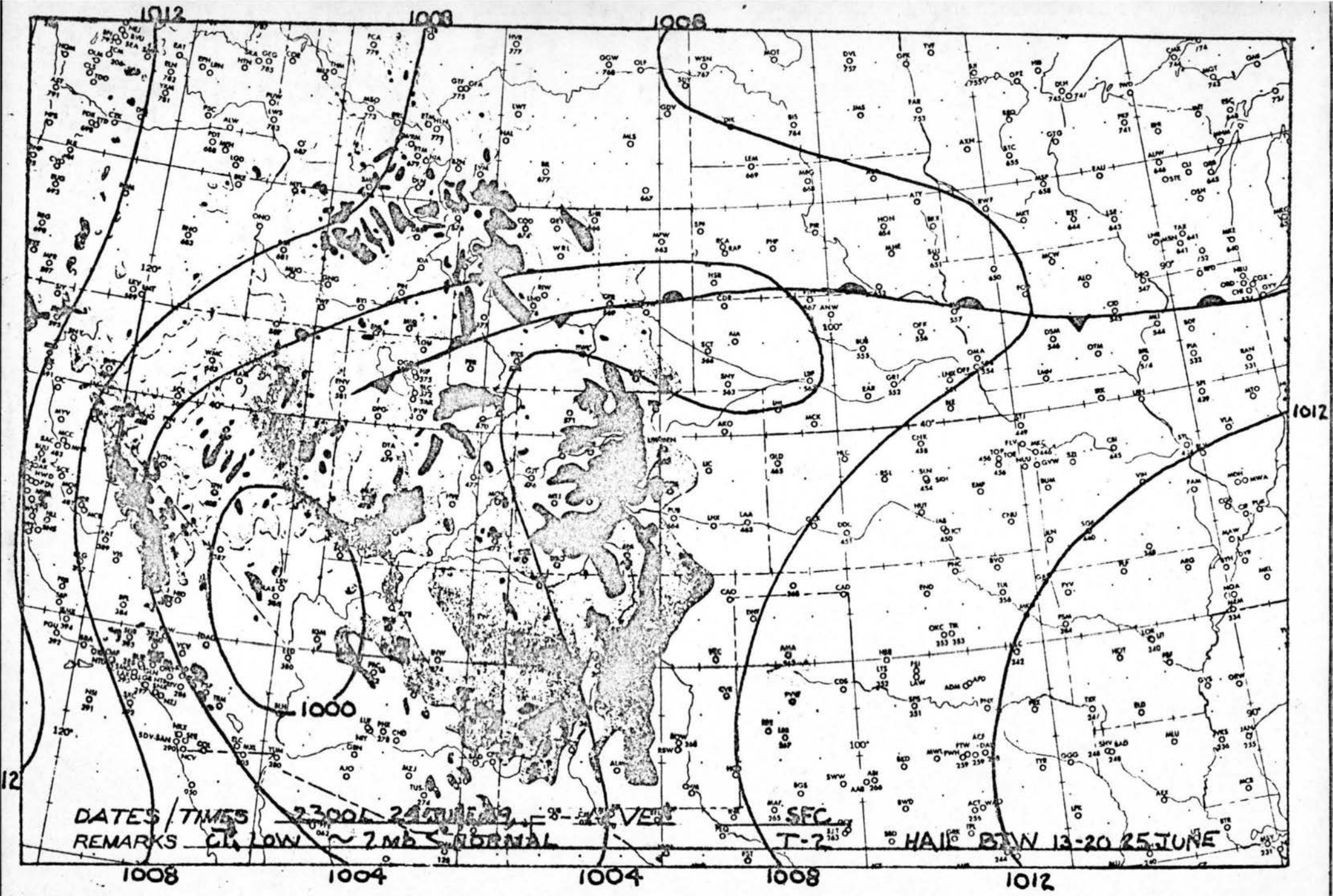
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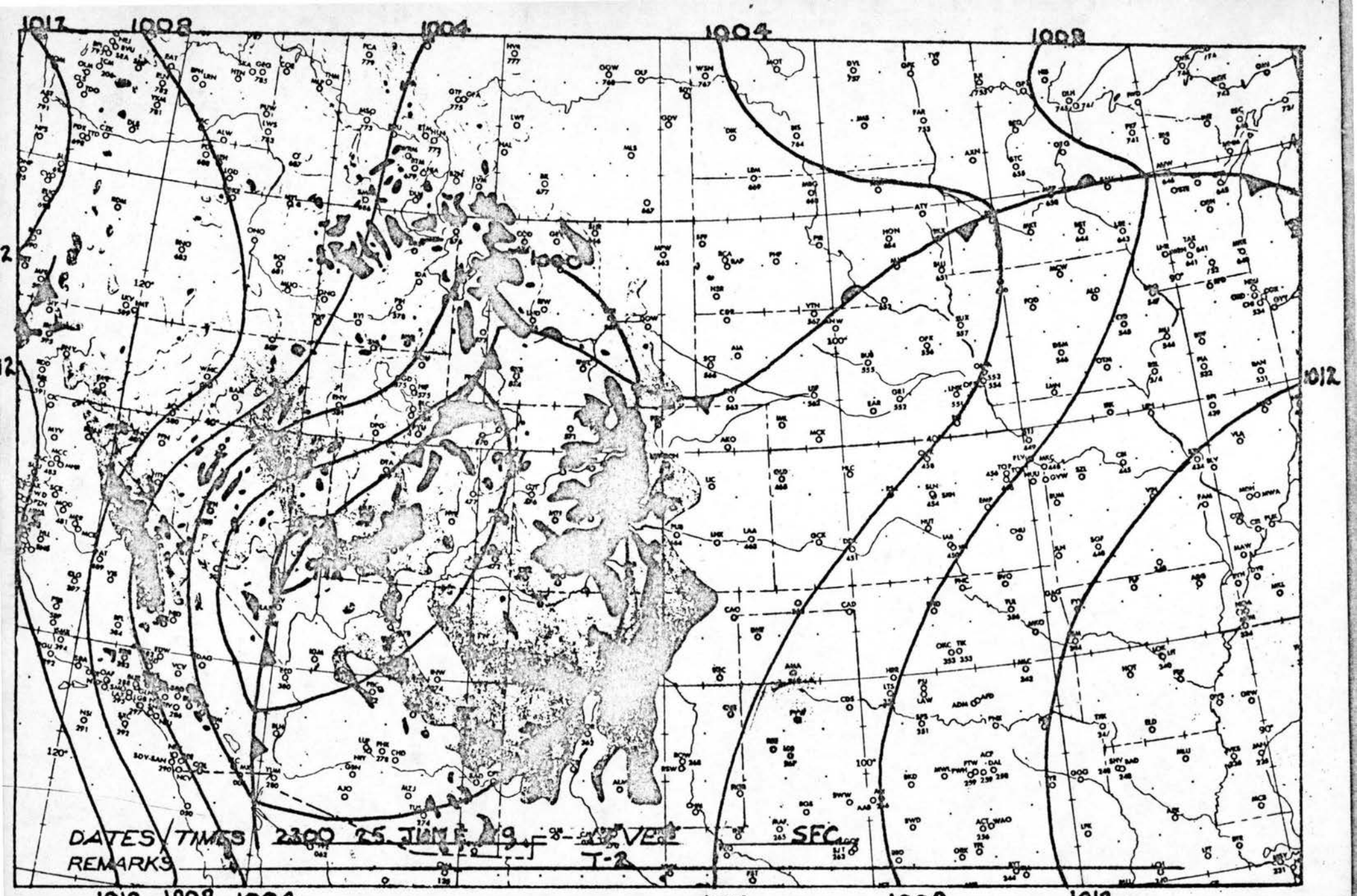
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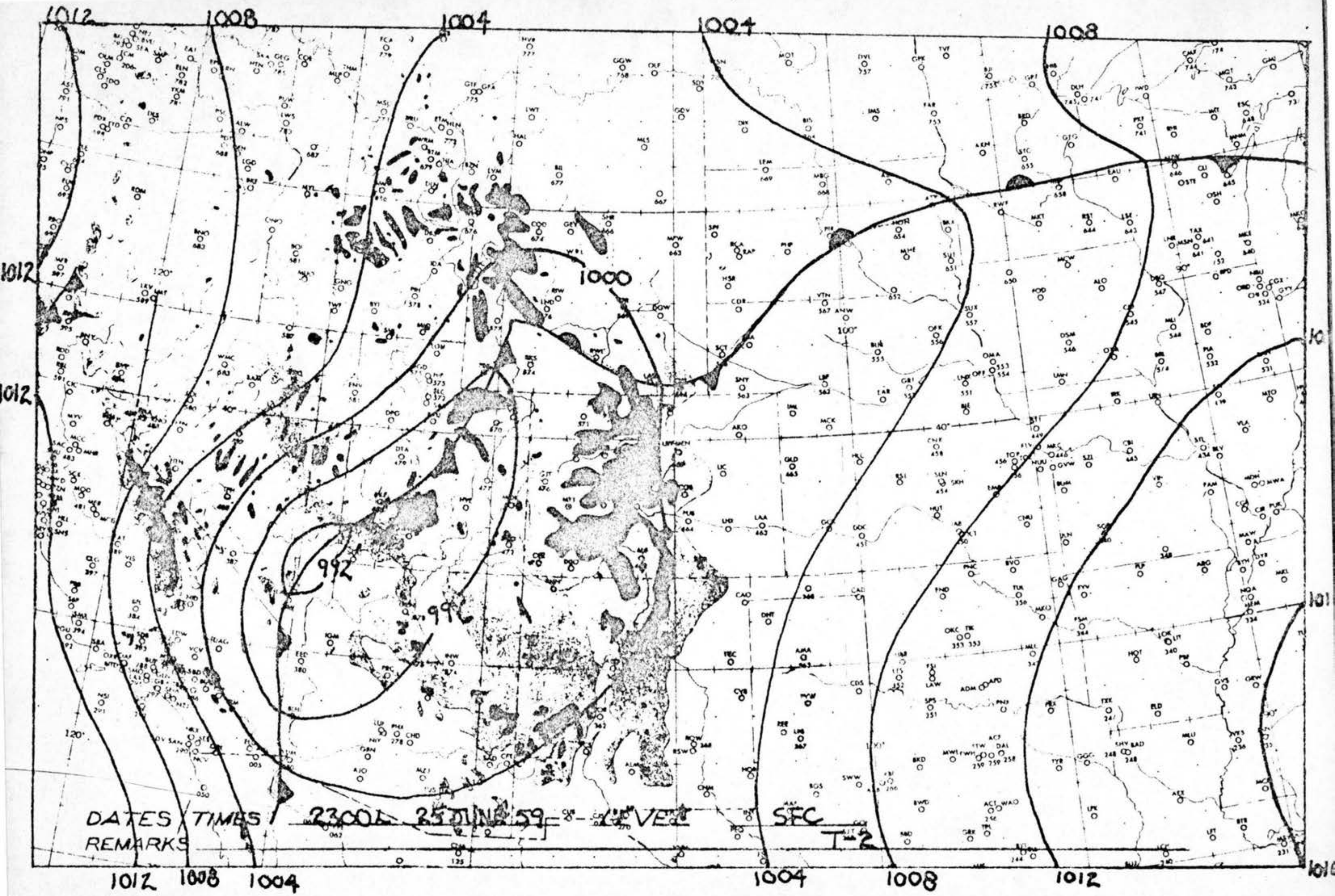
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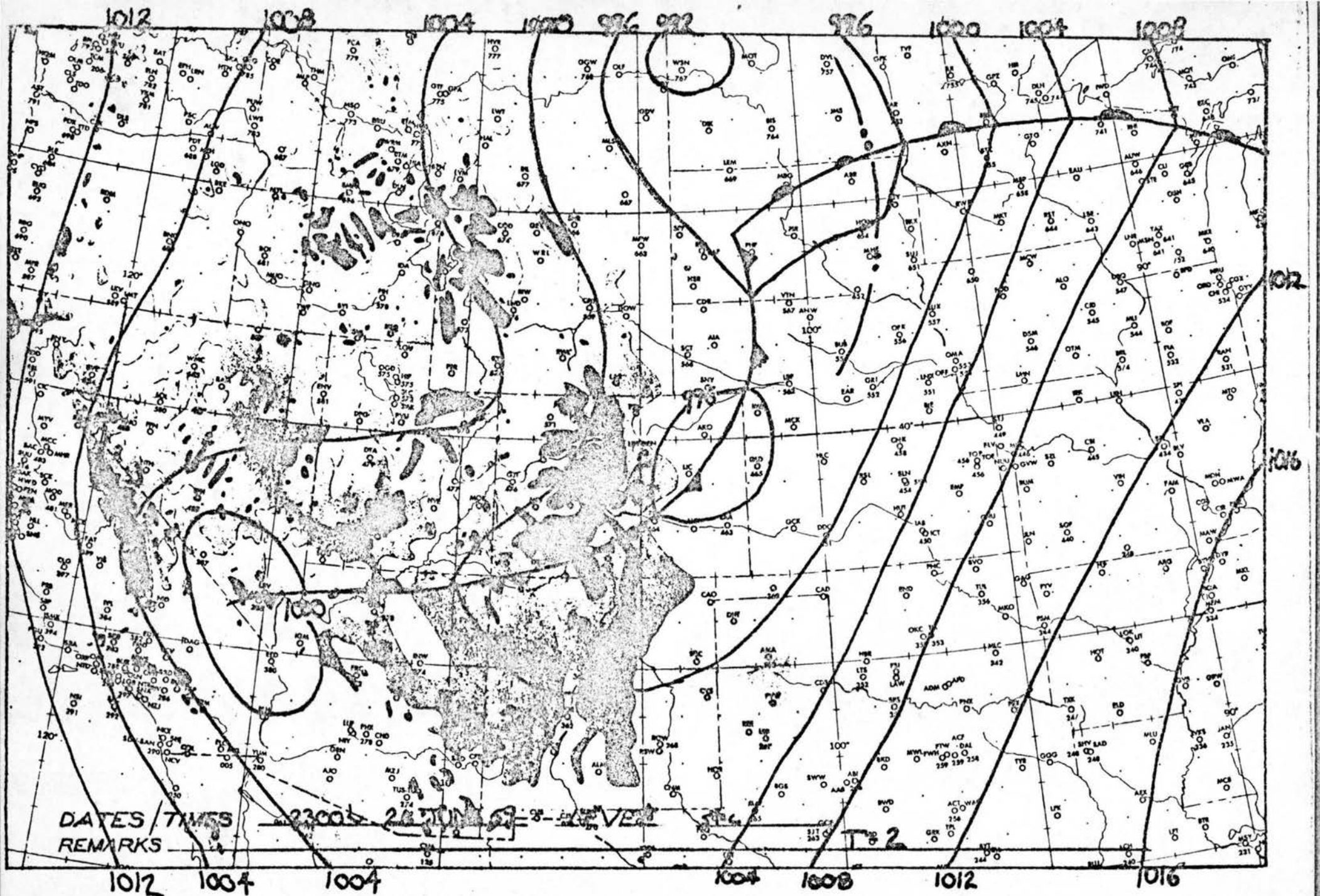
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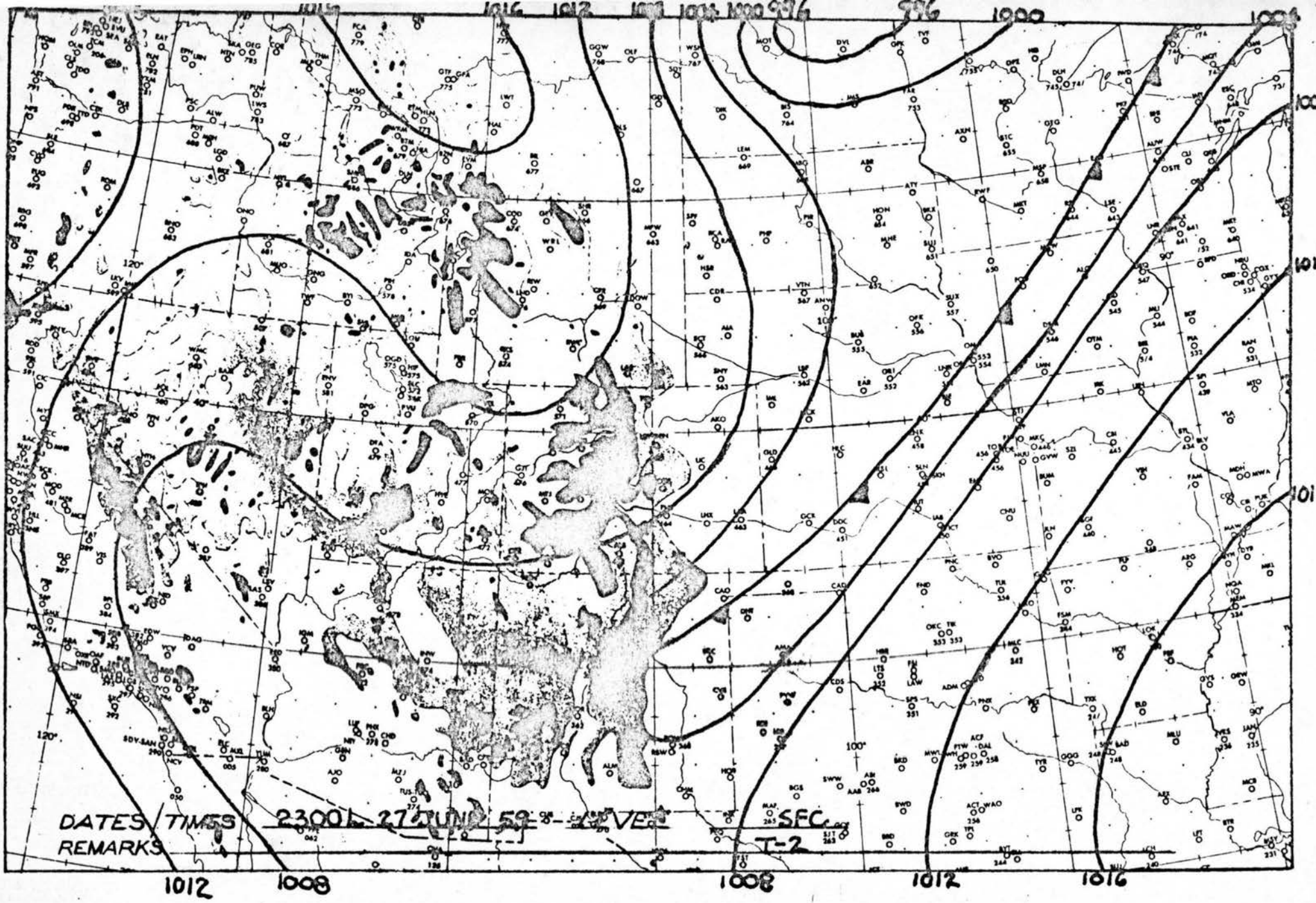
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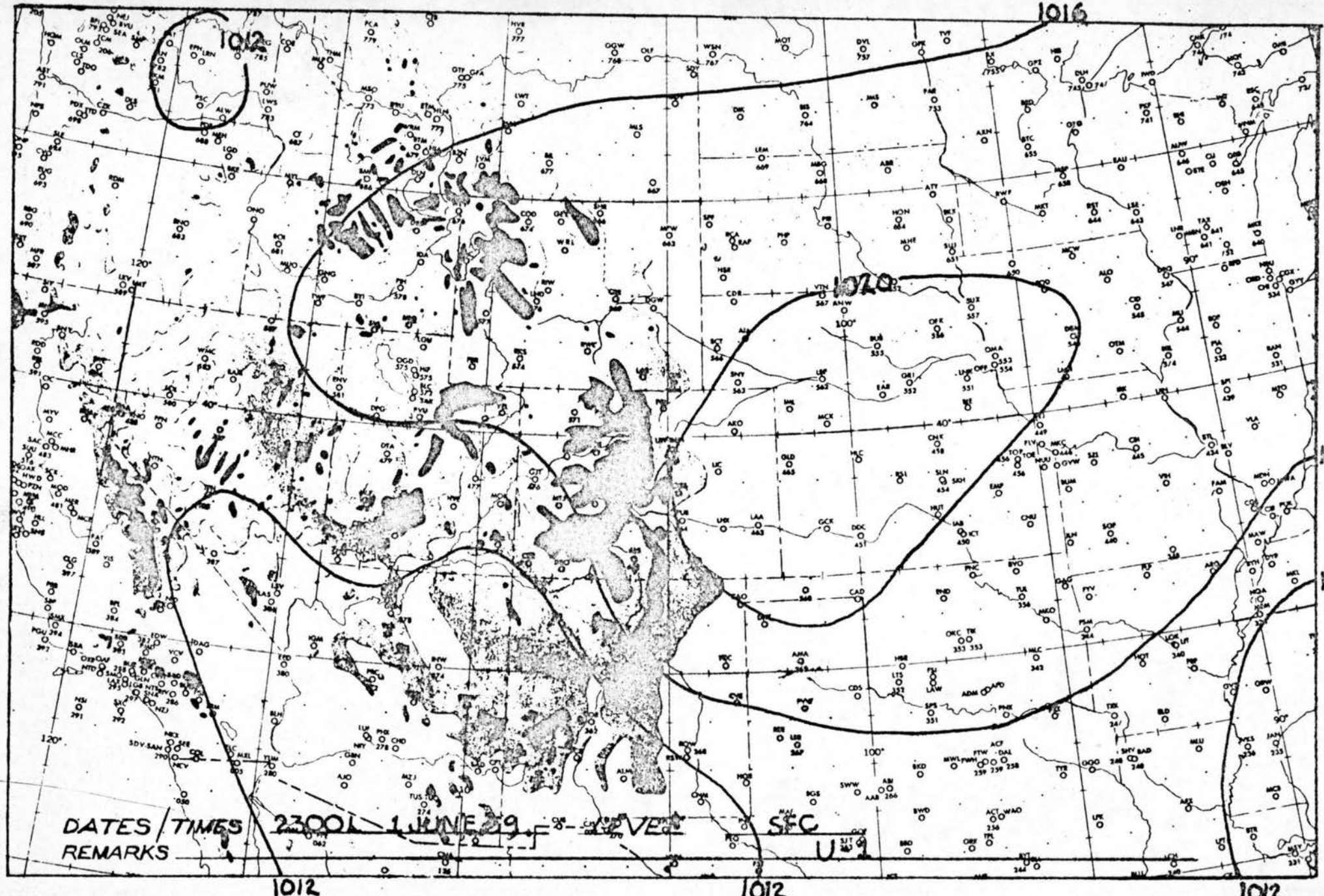
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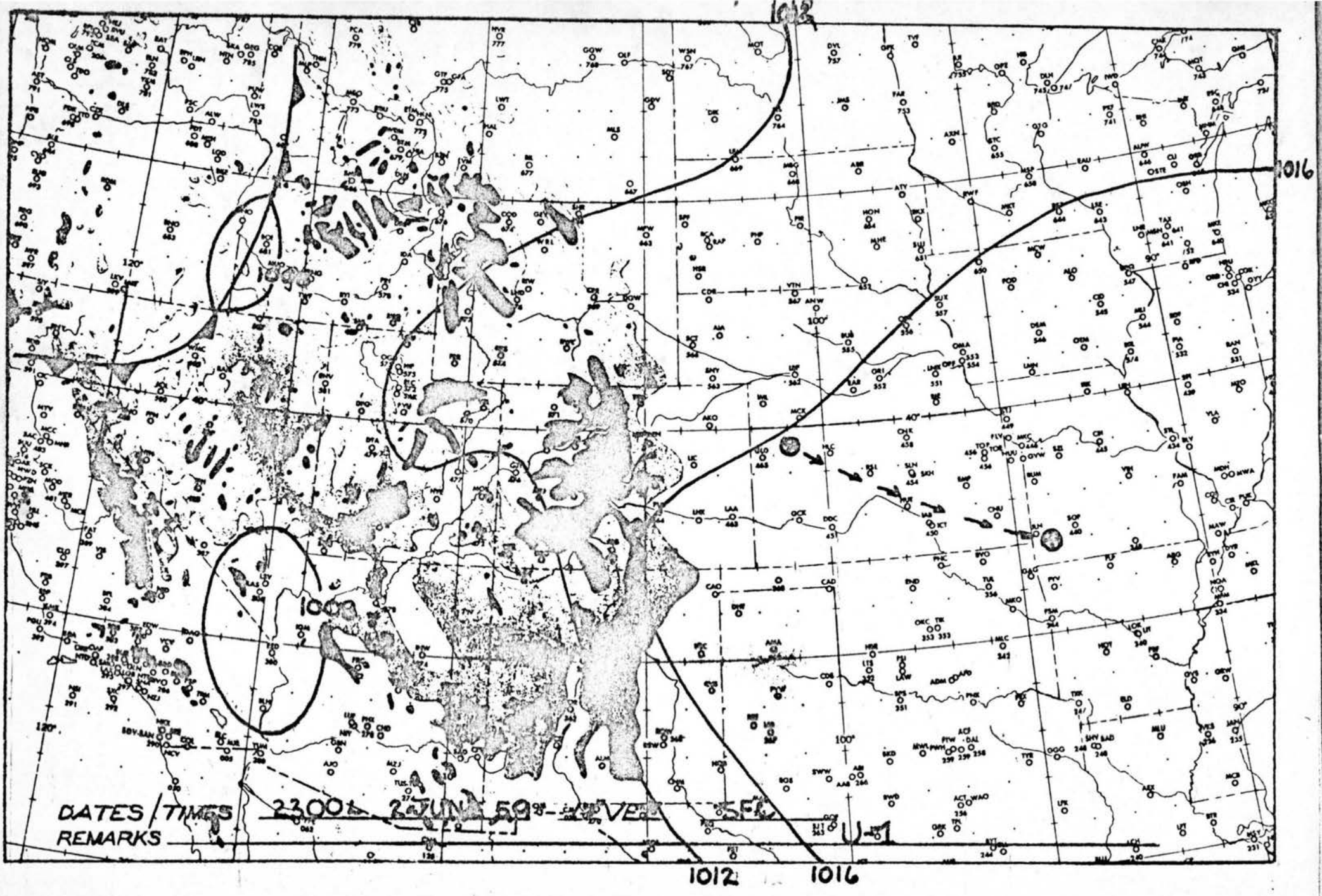
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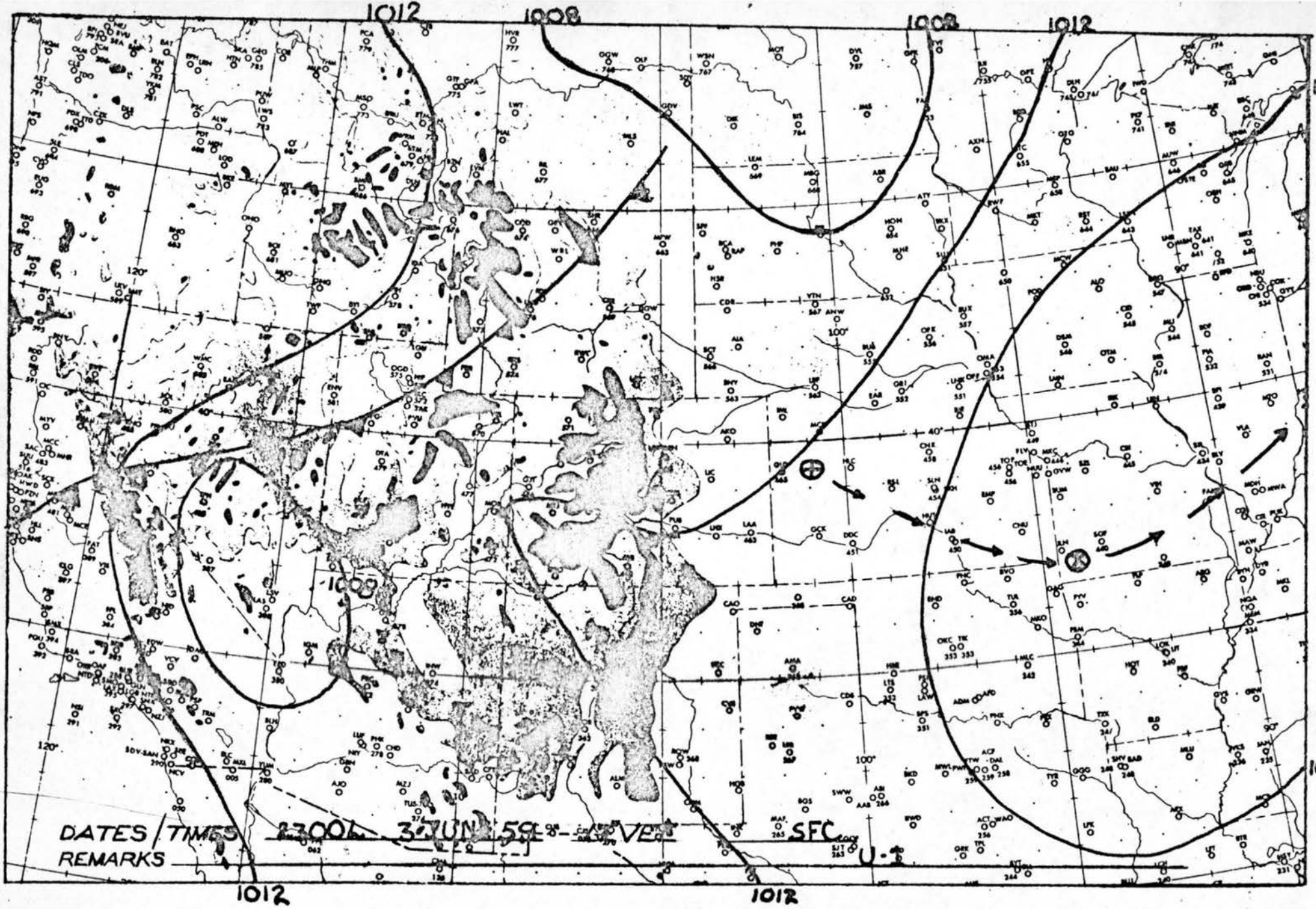
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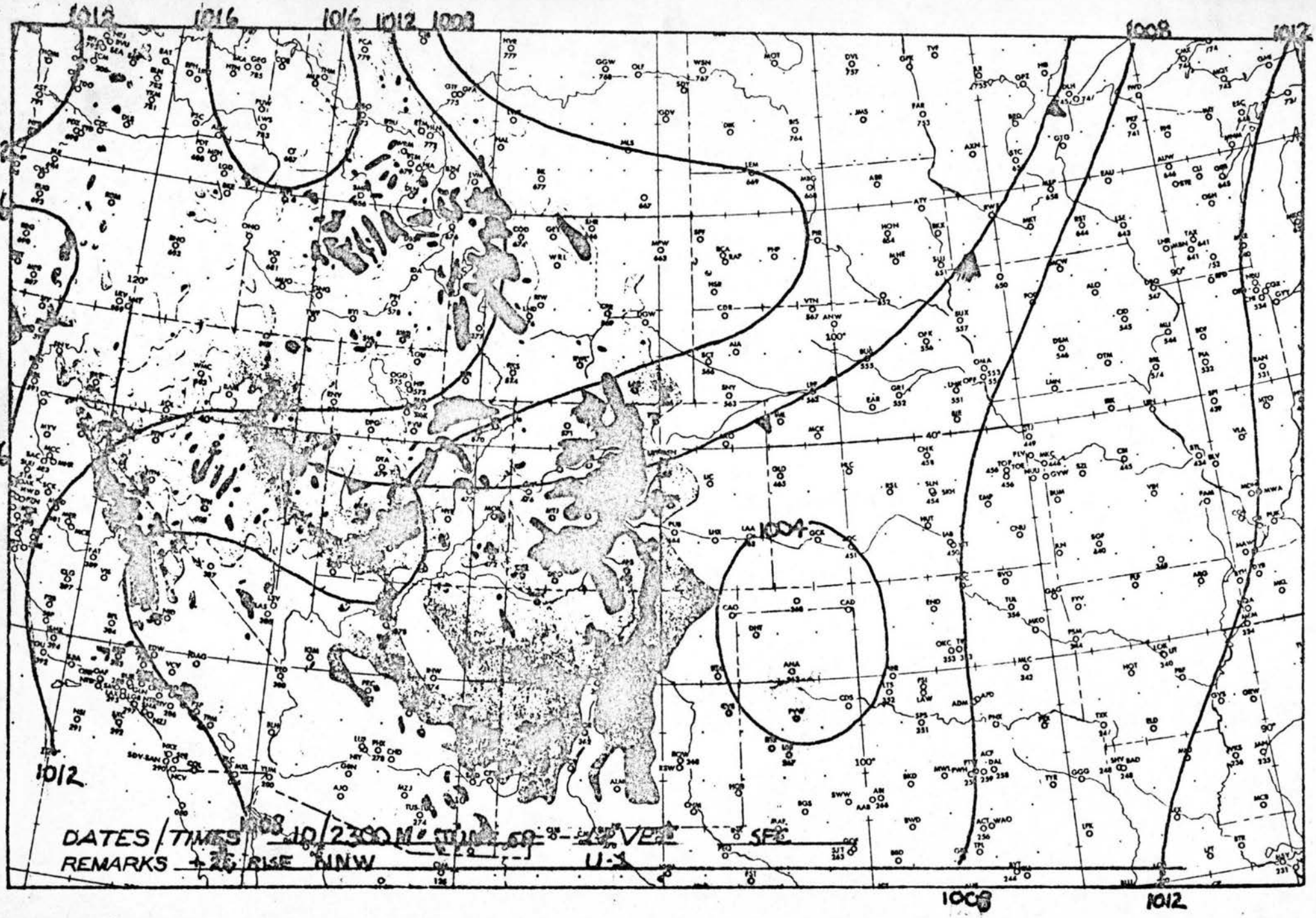
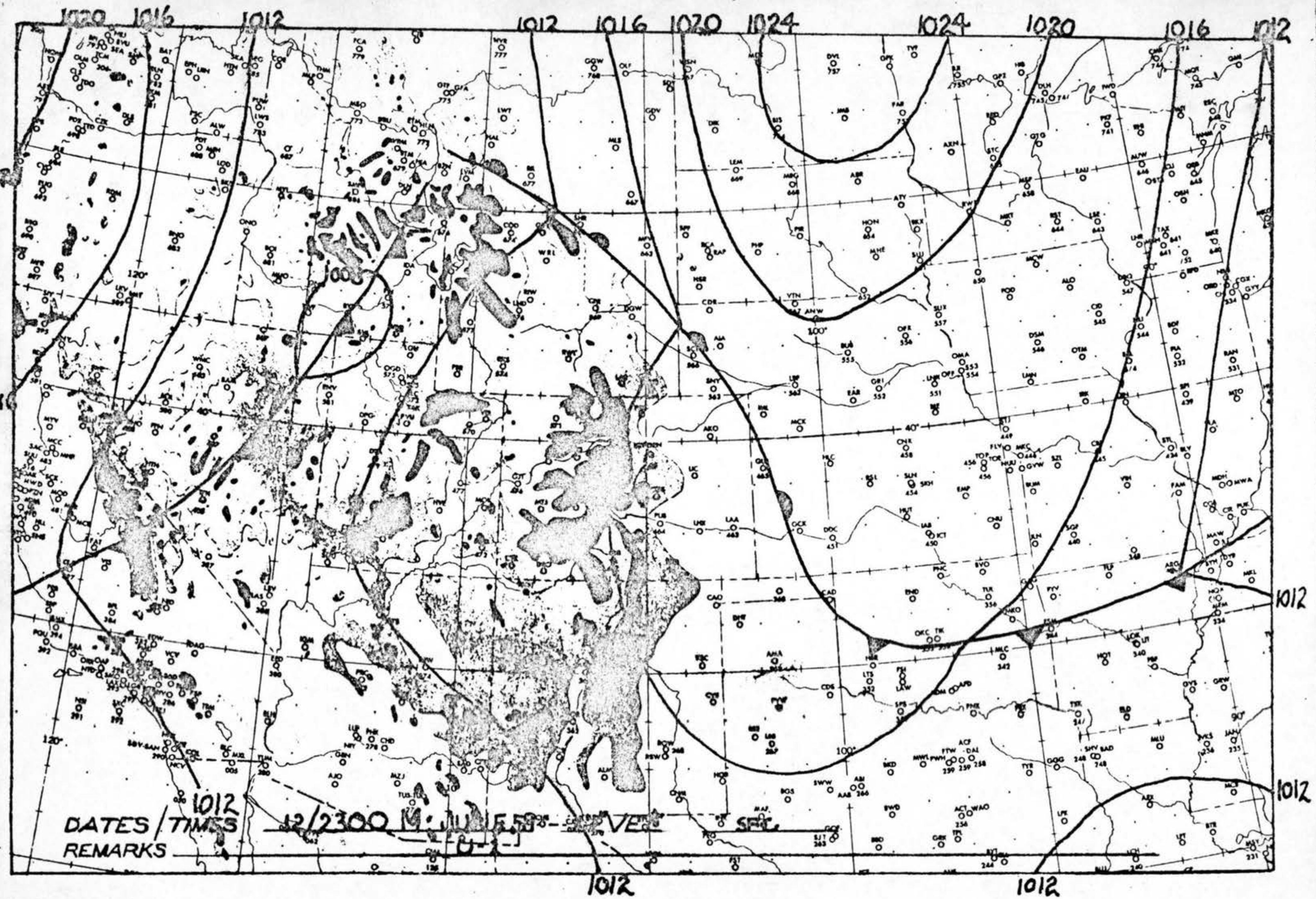

1012
1016
1016 1012 1008
1008
1012
1004
100°
120°
40°
1012
DATES / TIMES 08 10/2300 M
REMARKS +25 RISE NNW
U-1
1008
1012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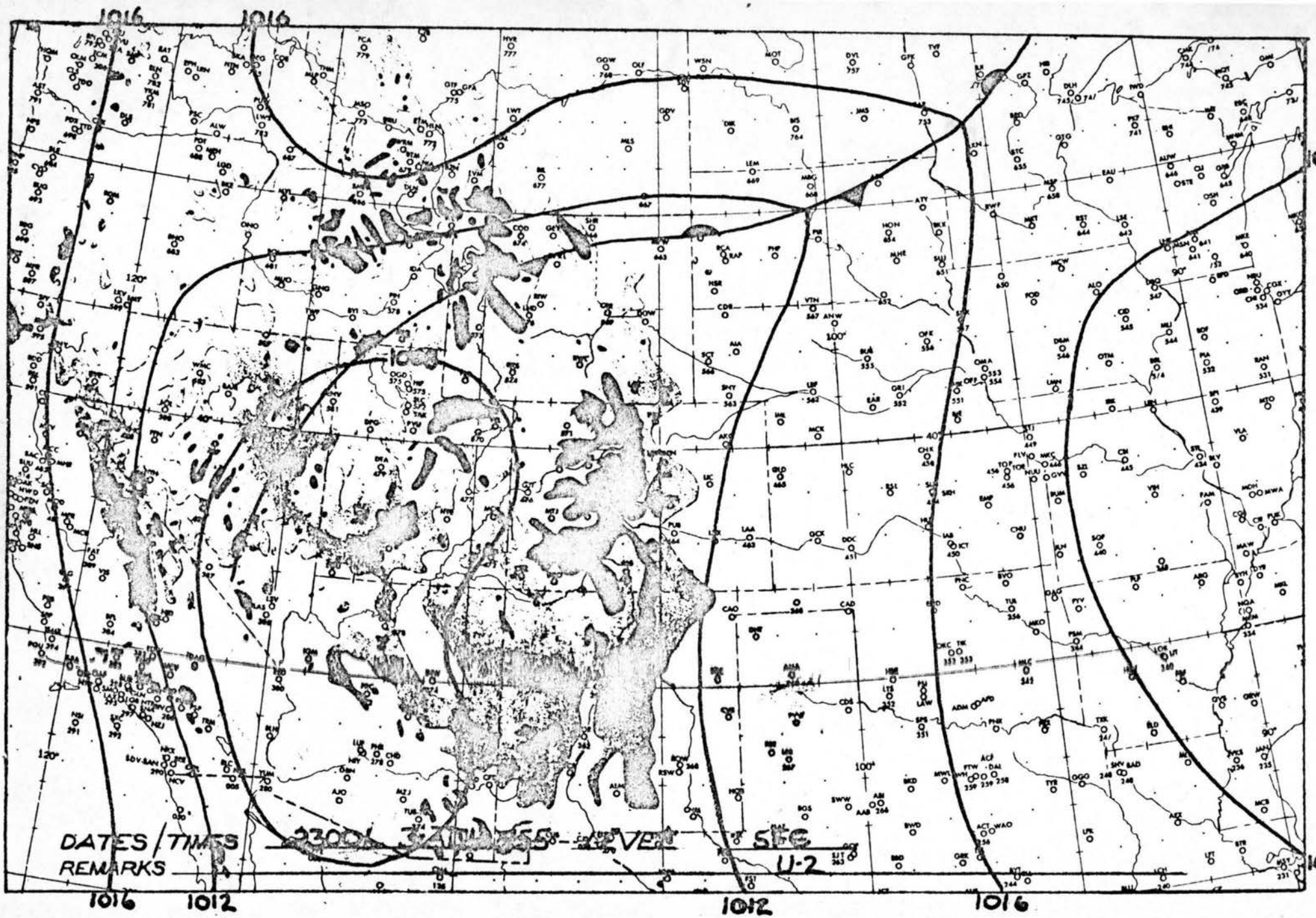
1016
1012
1012
1016
1020
1024
1024
1020
1016
1012
1008
1012
1012
1012
1012
1012
DATES / TIMES
REMARKS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1016
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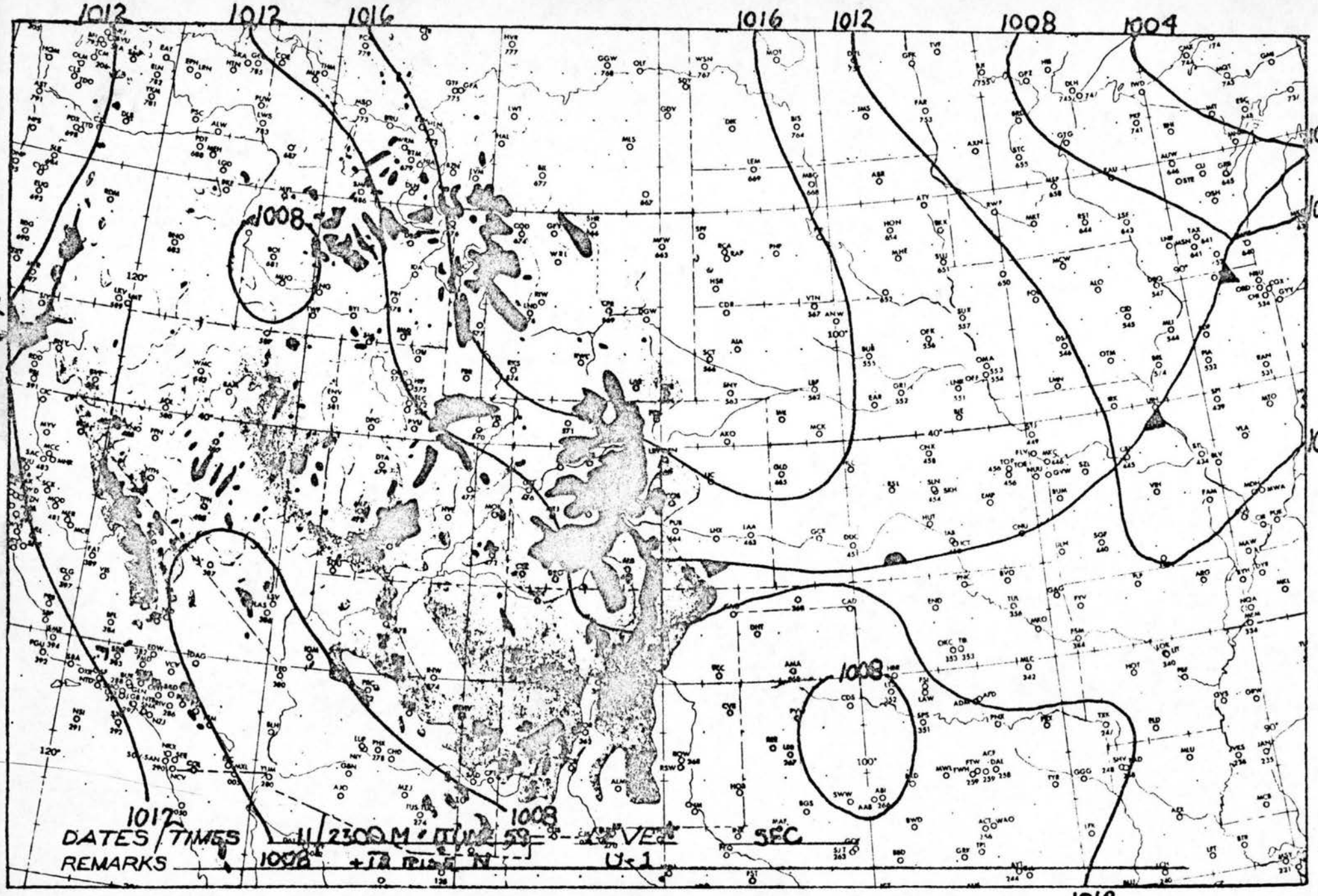
1012
1012
1016
1020
DATES/TIMES
REMARKS
U-2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1012
1016
1016
1012
1008
1004
1004
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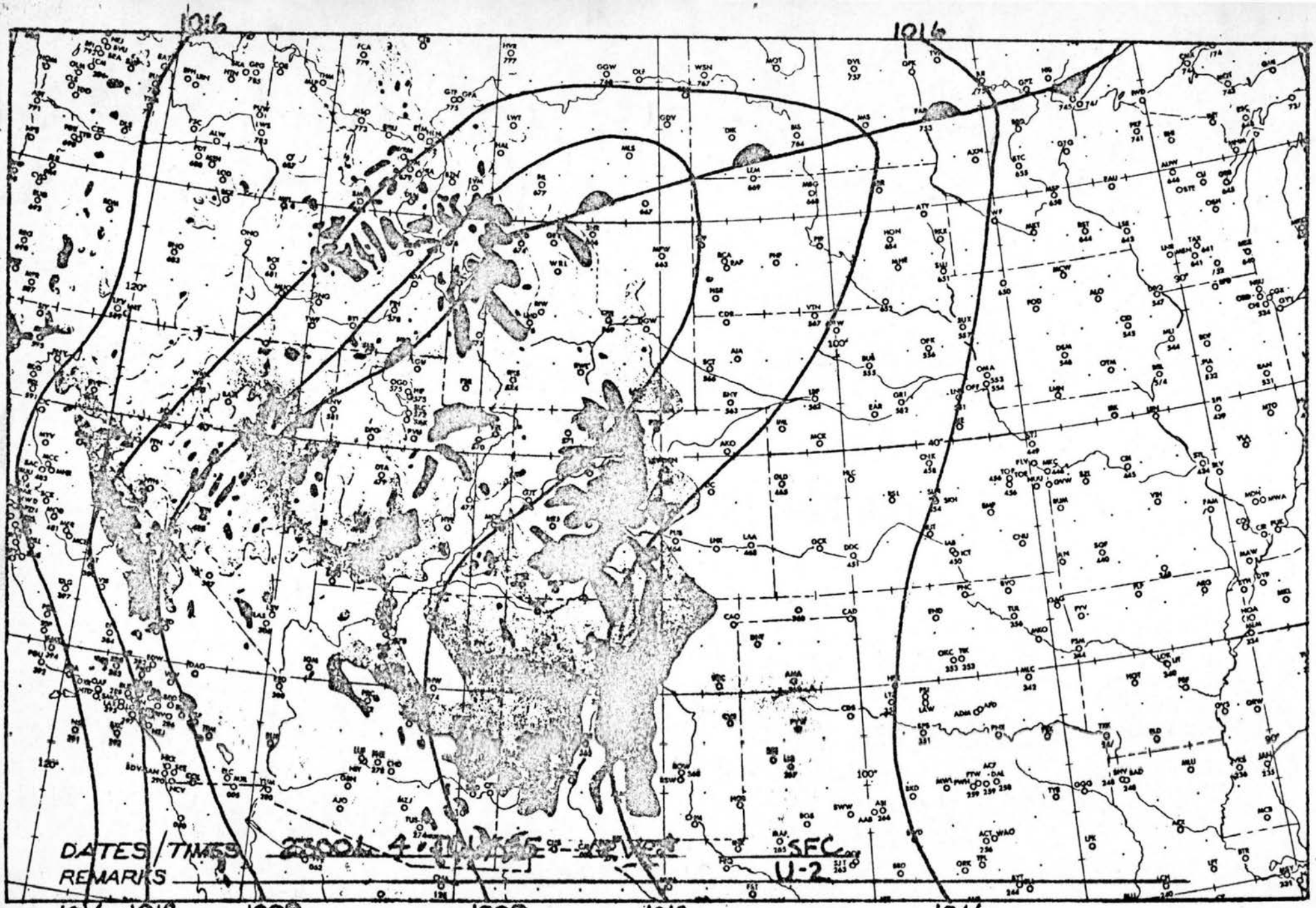
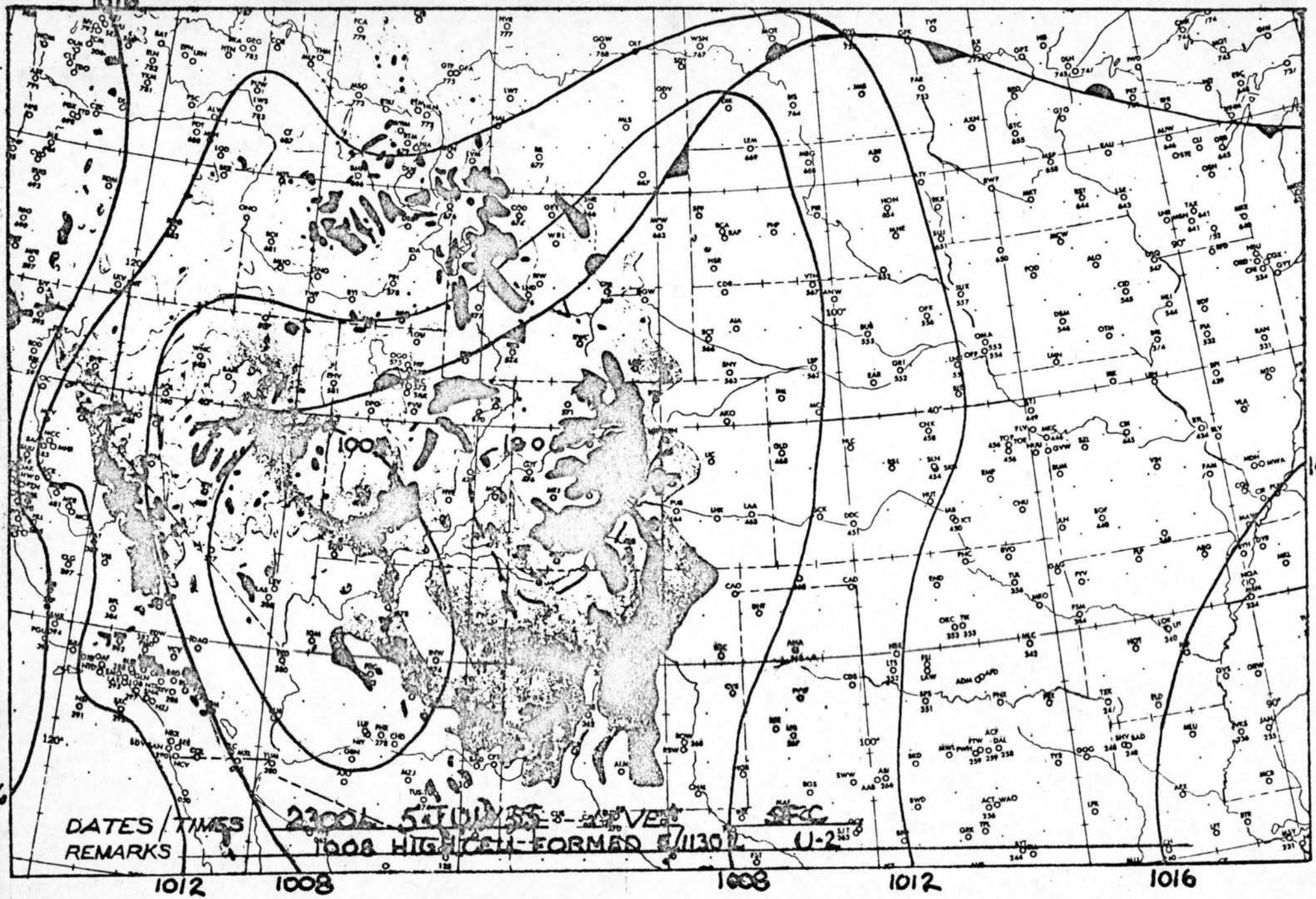
1012
1008
1008
1012
DATES/TIMES
REMARKS


1016
1016
DATES/TIMES 2500L 4 JUNE SEC
REMARKS U-2
1016 1012 1008 1008 1012 1016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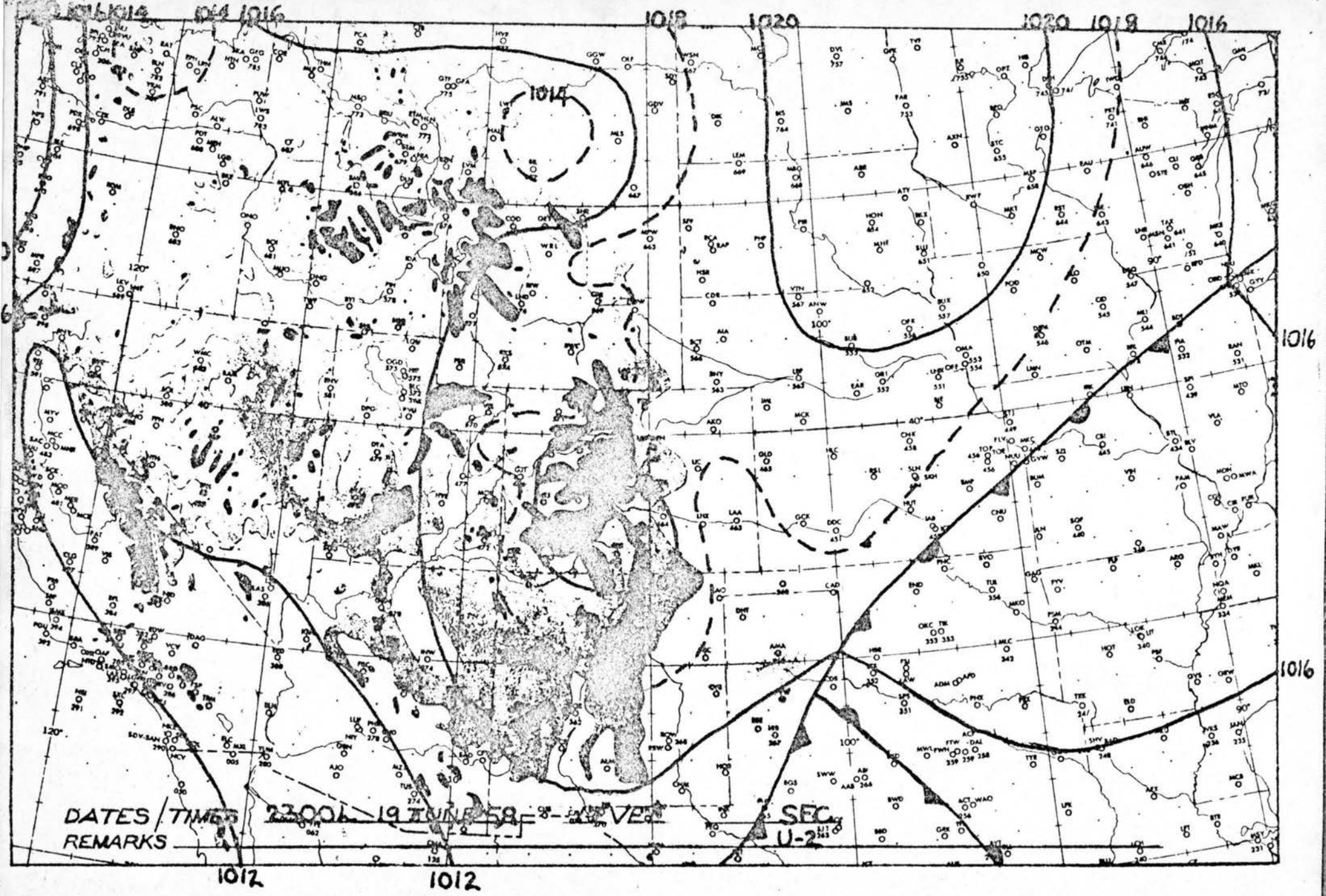
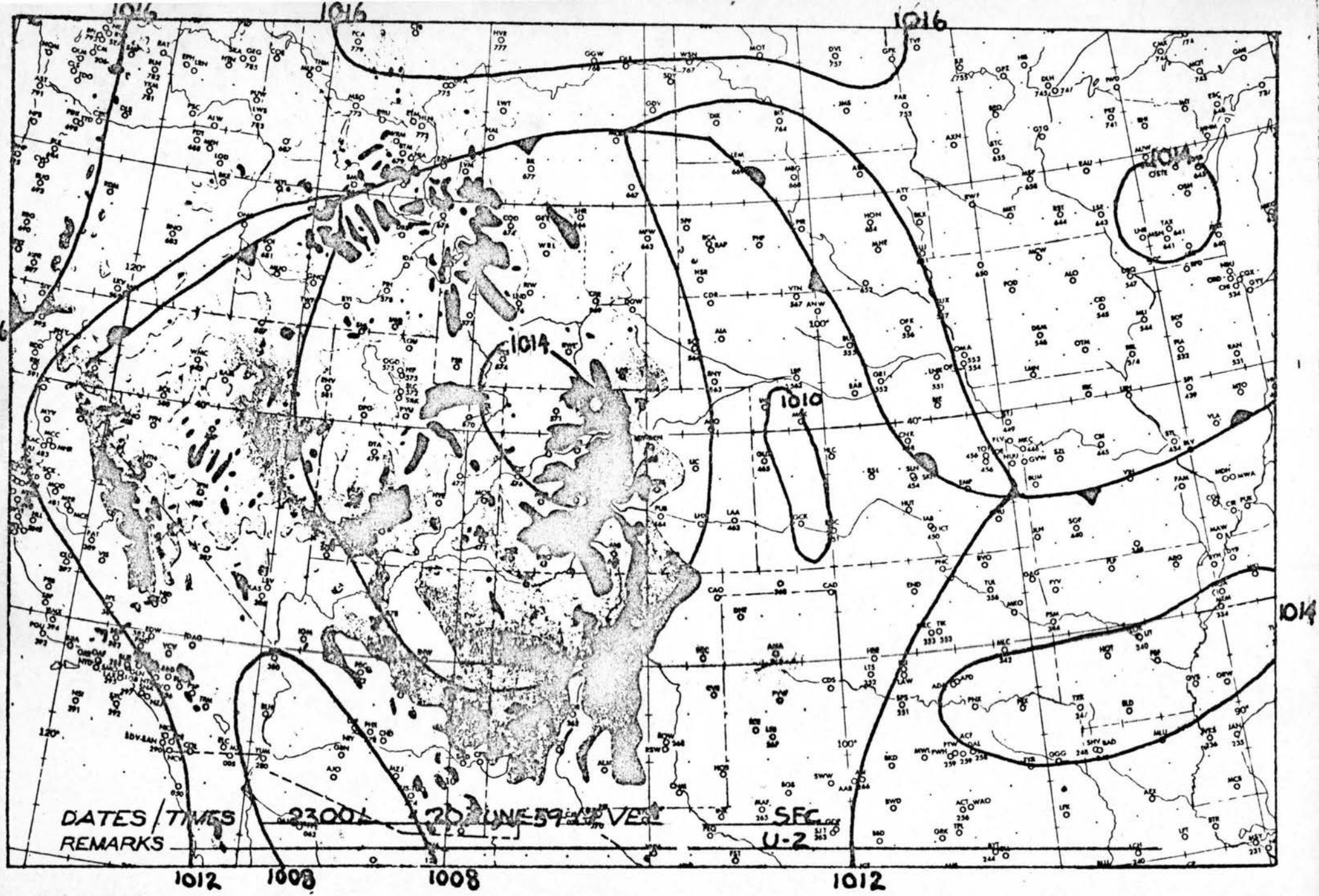
1016
1012
1008
1008
1012
1016
DATES / TIMES
REMARKS
1008 HIGH CEIL - FORMED 1130
U-2


1014
1016
1018
1020
1020 1018 1016
1016
1016
1012
1012
DATES / TIMES 23001 19 JUN 58 8-12 VE SEC
REMARKS U-2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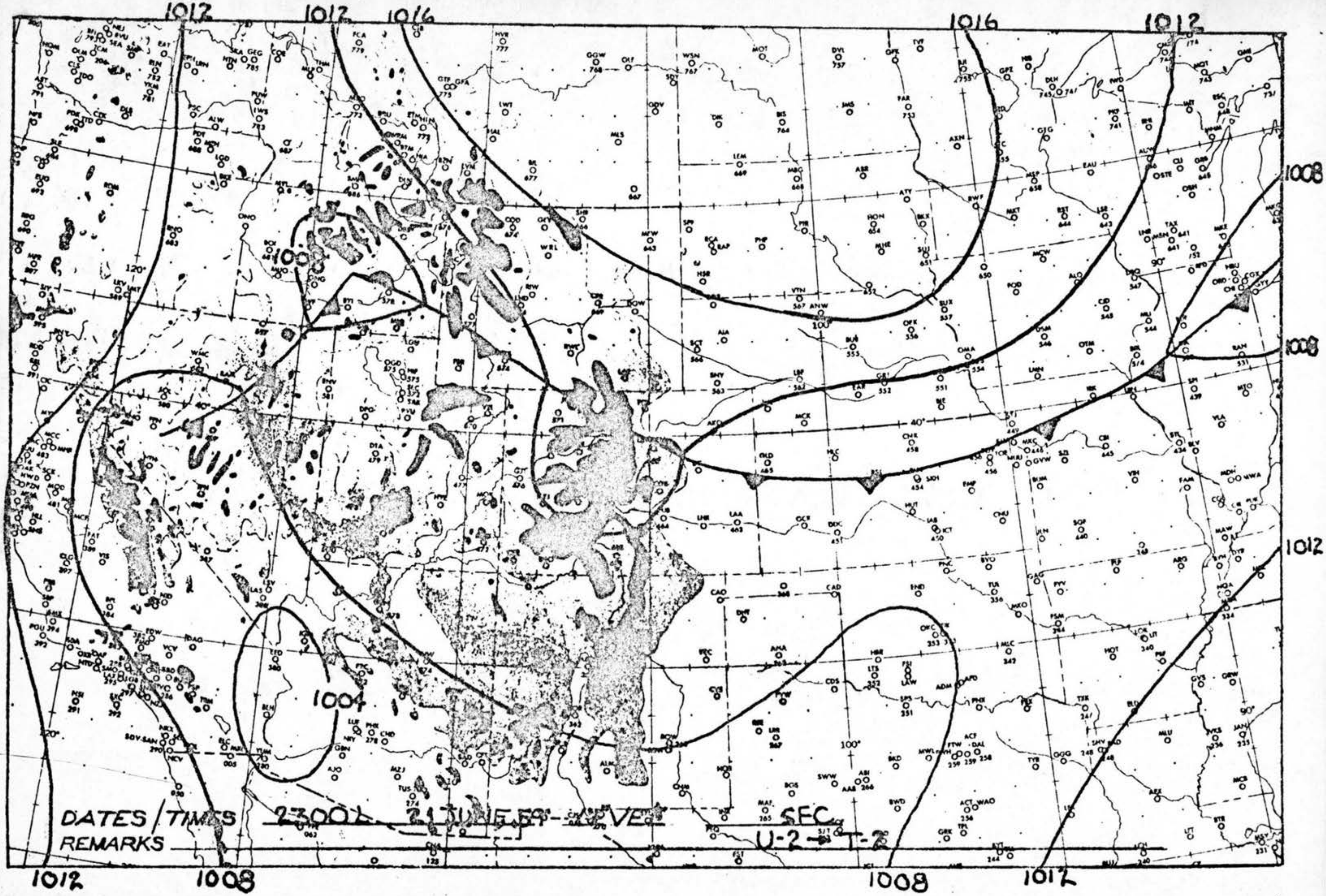
1016
1016
1014
1014
1010
1014
1012
1008
1008
1012
DATES/TIMES
REMARKS
SFC
U-2


DATES / TIMES 2300Z 21 JUNE 59 - ... SFC
REMARKS U-2 → T-2
1012
1016
1008
1004

APPENDIX C

CLASSIFICATION

of

HAIL DAYS

BY

SYNOPTIC

TYPE

DATE 1959	U-1	U-2	T-1	T-2	T-3	
16 MAY	X					
17				X		
18				X		
19				X		
20				X		
25			X			
26			X			
27				X		
30				X		
1 JUNE	X					
3	X					
12	X					
14	X					
16			X			
17				X		
18			X			
21		X				
22	X					
24				X		
25				X		
26				X		
27				X		
12 JULY	X					
13	X					
14	X					
15		X				
20	X					
21						
22						
TOTAL	10	2	4	11	0	

DATE 1958	U-1	U-2	T-1	T-2	T-3	
7 MAY		X				
13				X		
15			X			
20	X					
21				X		
26	X					
28	X					
1 JUNE				X		
3	X					
9	X					
11	X					
12	X					
13	X					
16	X					
17				X		
18				X		
19	X					
24				X		
1 JULY			X			
2			X			
4				X		
6	X					
8						
9			X			
10		X				
18	X					
19				X		
20		X				
21	X					
22	X					
25			X			
27			X			
31	X					
6 AUG.			X			
15		Mesg.				
16						
27		X				
4 SEPT.	X					
12	X					
18			X			
TOTAL	17	4	8	8	0	

DATE 1957	U-1	U-2	T-1	T-2	T-3	
7 JUNE	X					
15				X		
16				X		
26				X		
30				X		
13 JULY			X			
14	X					
18				X		
26		X				
29			X			
3 AUG.			X			
17				X		
22			X			
23	X					
27	X					
30 SEPT.	X					
TOTAL	5	1	4	6	0	

DATE 1956						
28 APR.						Mssg.
5 JUNE		X				
6				X		
16				X		
17				X		
18				X		
25				X		
26			X			
28	X					
1 JULY				X		
2				X		
5	X					
9	X					
17	X					
10 AUG				X		
13				X		
TOTAL	4	1	1	10	0	

DATE

1955	U-1	U-2	T-1	T-2	T-3	
11 APRIL	NDA					
12	NDA					
16 MAY				X		
17				X		
14 JUNE				X		
27				X		
5 JULY		X				
8				X		
9				X		
12				X		
26		X				
4 AUG.		X				
10					X	
18 SEPT.					X	
19					X	
TOTAL	0	3	0	8	3	

DATE

1954						
15 MAY	X					
16	X					
22	X					
26	X					
29	X					
31	X					
6 JUNE				X		
12				X		
14				X		
19				X		
2 JULY	X					
3	X					
17			X			
21	X					
27			X			
9 AUG.				X		
16		X				
7 SEPT.	X					
8	X					
14	X					
16	X					
TOTAL	13	1	2	5	0	

DATE 1953	U-1	U-2	T-1	T-2	T-3	
1 JUNE	X					
5				X		
19		X				
20		X				
21		X				
30				X		
2 JULY				X		
10	X					
15		X				
19		X				
26		X				
1 AUG.		X				
4		X				
15	X					
16	X					
17	X					
18			X			
19	X					
TOTAL	6	8	1	3	0	

DATE 1952						
9 MAY	X					
16	X					
20		X				
25			X			
29	X					
31	X					
20 JUNE	X					
21		X				
25				X		
26	X					
27	X					
28	X					
13 JULY				X		
18			X			
23 AUG.			X			
24			X			
TOTAL	8	2	4	2	0	

DATE

1951	U-1	U-2	T-1	T-2	T-3	
20 MAY	X					
1 JUNE				X		
5		X				
7		X				
8			X			
9	X					
10	X					
13				X		
17	X					
21	X					
22						
25				X		
26				X		
28	X					
29	X					
1 JULY	X					
4	X					
10	X					
15		X				
16				X		
21			X			
27				X		
2 AUG.				X		
10	X					
12	X					
14		X				
17		X				
24		X				
1 SEPT.	X					
2	X					
4	X					
5			X			
TOTAL	15	6	3	7	0	

DATE 1950	U-1	U-2	T-1	T-2	T-3	
16 MAY				X		
27	X					
15 JUNE				X		
16	X					
17	X					
19	X					
3 JULY	X					
4	X					
10	X					
18				X		
20			X			
21	X					
23			X			
24	X					
26	X					
27	X					
28		X				
29		X				
30						
5 AUG.	X					
6	X					
8						
19			X			
25	X					
27				X		
29					X	
9 SEPT.					X	
14	X					
17	X					
19	X					
TOTAL	17	2	3	4	2	

DATE

1949	U-1	U-2	T-1	T-2	T-3	
12 MAY				X		
19				X		
23	X					
29		X				
6 JUNE				X		
16				X		
17			X			
19		X				
23			X			
25		X				
28				X		
16 JULY	X					
31	X					
12 AUG.		X				
15			X			
19			X			
27	X					
29					X	
6 SEPT.	X					
TOTAL	5	4	4	5	1	

DATE

1948						
3 MAY			X			
17				X		
26	X					
3 JUNE			X			
13	X					
14	X					
15		X				
3 JULY			X			
11		X				
13		X				
14				X		
15		X				
17		X				
1 AUG.		X				
TOTAL	3	6	3	2	0	

DATE

1947	U-1	U-2	T-1	T-2	T-3	
28 APRIL	NDA					
26 MAY				X		
4 JUNE				X		
5				X		
9				X		
17				X		
21				X		
23		X				
25		X				
27			X			
28				X		
29				X		
30	X					
13		X				
14		X				
16			X			
21	X					
22	X					
23		X				
12 AUG.			X			
9 SEPT.				X		
TOTAL	3	5	3	9	0	

DATE

1946						
30 APRIL	?					
8 MAY			X			
29			X			
17 JUNE			X			
23			X			
2 JULY		X				
3		X				
5		X				
3 AUG.		X				
31	X					
8 SEPT.				X		
12		X				
13		X				
TOTAL	1	6	4	1		

DATE

1939	U-1	U-2	T-1	T-2	T-3	
19 MAY			X			
1 JUNE				X		
12	X					
13	X					
15				X		
20				X		
22 ?	X					
24			X			
25						
28		X				
30		X				
1 JULY			X			
4						
2 AUG						
6						
18						
19						
TOTALS	3	2	3	3	0	

DATE

1938	U-1	U-2	T-1	T-2	T-3	
3 MAY				X		
4				X		
5		X				
17				X		
19				X		
24	X					
25	X					
30				X		
5 JUNE						
8						
10						
16						
19						
20						
23						
24						
2 JULY		X				
3		X				
10		X				
13	X					
19			X			
21	X					
24						
28	X					
18 AUG.			X			
28 AUG.		X				
31			X			
7 SEPT.			X			
14	X					
TOTALS	6	5	4	5	0	

DATE

1937	U-1	U-2	T-1	T-2	T-3
10 MAY			X		
25 NDA					
8 JUNE				X	
12			X		
17			X		
2 JULY	X				
17	X				
18	X				
1 AUG.			X		
3	X				
12	X				
16			X		
25			X		
3 SEPT.			X		
TOTALS	5	0	7	1	0

APPENDIX D

SEASONAL DISTRIBUTION OF SYNOPTIC TYPES 1937 - 1958

	U-1					U-2					T-1					T-2					T-3	
YEAR	M	J	J	A	S	M	J	J	A	S	M	J	J	A	S	M	J	J	A	S	A	S
1959																						
1958	3	7	5		2	1		2	1		1		5	1	1	2	4	2				
1957		1	1	2	1			1					2	2			4	2	3			
1956		1	3				1					1					5	2	3			
1955								2	1							2	2	3		1	1	2
1954	6		3		4				1				2				4		1			
1953		1	1	4			3	3	2					1			2	1				
1952	4	4				1	1				1		1	2			1	1				
1951	1	6	3	2	3		2	1	3			1	1		1		4	2	1			
1950	1	3	7	3	3			2					2	1		1	1	1	1		1	1
1949	1		2	1	1	1	2		1			2		2		2	3				1	
1948	1	2					1	4	1		1	1	1			1		1				
1947		1	2				2	3				1	1	1		1	7			1		
1946				1				3	1	2	2	2								1		
1939		3					2				1	1	1				3					
1938	2		3		1	1		3	1				1	2	1	5						
1937			3	2							1	2		3	1		1					
TOTAL	19	29	33	15	15	4	14	24	12	2	7	11	17	15	4	14	41	15	9	3	3	3
/ Yr	1.2	1.8	2.0	.9	.9	.3	.9	1.5	.8	.2	.5	.8	1.1	.9	.3	.8	2.5	.9	.5	.1	.2	.

Monthly Totals : May - 44 ; June - 95 ; July - 89 ; Aug. - 51 ; Sept. - 24 .

APPENDIX E.

SUMMARY OF STORM DAMAGE BY SYNOPTIC TYPES.

Values are percent of total acres of beets planted in the Ovid, Sterling, and Fort Morgan Districts of Great Western Sugar Company that received light (L), medium (M), and heavy (H) damage from hail. The last column gives total (T) damage in all categories of damage.

DATE	L	M	H	T
1958				
2 JL	2.68	0.86	4.01	7.75
18 S		0.35		0.35
1956				
26 J	1.69		2.27	3.96
1954				
17 JL	0.76	0.33		1.09
27 JL	0.58	1.65	0.63	2.86
1953				
18 A	1.35			1.35
1952				
26 M	1.17	0.50	0.72	2.39
18 JL	2.00	0.85	0.22	3.07
23 A	1.96	0.35	0.63	2.94
24 A		1.40	0.30	1.70
1951				
8 J	3.15			3.15
21 JL	0.43	1.46	1.75	3.64
5 S		0.08	0.73	0.81
1950				
23 JL	0.27			0.27
19 A	0.07		0.37	0.44
1949				
23 J	0.69			0.69
19 A	2.42	1.84	0.85	5.11
1948				
2 M	0.70			0.70
3 J	4.00	1.44	0.90	6.34
8 JL	1.06			1.06
1947				
27 J	2.33			2.33
16 JL	3.01	0.97	0.32	4.30
12 A		0.32	0.39	0.71

T - 1 Continued

DATE	L	M	H	T
1946				
8 M	0.26	0.17	0.96	1.39
29 M	1.66	1.11	1.18	3.95
17 J	0.46			0.46
23 J	0.36			0.36
1939				
19 M		0.08	0.64	0.72
24 J	3.15	1.50	0.95	5.60
1 JL	3.94	0.57		4.51
1938				
19 JL	2.39	0.85	2.03	5.27
18 A		0.39		0.39
31 A	0.13	0.37		0.50
7 S	1.93	3.10	5.01	10.04
1937				
10 M		4.13		4.13
12 J			0.85	0.85
17 J			3.24	3.24
1 A	0.31	0.05	0.17	0.53
16 A	0.98	0.35		1.33
25 A	0.31			0.31
3 S	0.42			0.42
TOTAL	46.82	25.07	29.12	101.01

$\bar{X} = 2.46$
$N = 41$

DATE	L	M	H	T
1958				
13 M	0.40	6.00	3.00	9.40
21 M			0.30	0.30
17 J	0.37			0.37
18 J	0.97	0.98	1.30	3.25
4 JL	0.67		0.54	1.21
19 JL	2.88	1.40	2.30	6.58
1957				
15 J		0.94	1.30	2.24
26 J	1.13		1.97	3.10
17 A	0.25	0.45	0.39	1.09
1956				
18 J	5.46	12.97	13.39	31.82
10 A	5.30	3.07	4.21	12.58
13 A		3.40		3.40
1955				
17 M	14.38	6.64	8.63	29.65
9 JL	0.83			0.83
12 JL			0.14	0.14
1954				
6 J	14.87		7.10	21.97
9 A	5.10	4.39	1.89	11.38
1953				
5 J	0.02		0.53	0.55
30 J		1.17	0.15	1.32
2 JL	0.15	5.97	0.81	6.93
1952				
25 J	0.32		1.19	1.51
13 JL	0.97	4.19	4.97	10.13
1951				
1 J			0.66	0.66
13 J	1.16		0.73	1.89
25 J	2.39			2.39
26 J	1.20		0.90	2.10
27 JL	0.32		0.13	0.45
2 A	1.03	0.71	0.86	2.60

T - 2 Continued

DATE	L	M	H	T
1950				
16 M		5.78		5.78
15 J	1.05	1.40	0.69	3.14
18 JL	0.29		0.52	0.81
27 A			0.06	0.06
1949				
12 M	0.58			0.58
19 M	3.28	0.67	0.17	4.12
6 J			0.82	0.82
28 J	1.17	0.92	1.23	3.32
1948				
17 M	0.21	0.27	0.71	1.19
14 JL	5.18	5.28	3.27	13.73
1947				
26 M	0.62	0.38		1.00
4 J	0.19	0.45	0.09	0.73
5 S	0.77	0.46	0.24	1.47
9 J	0.72	3.58	1.75	6.05
17 J	1.34	1.30	0.79	3.43
21 J	0.16	0.87		1.03
29 J	1.16	4.66	4.64	10.46
9 S	0.26	0.42		0.68
1946				
8 S	3.43	1.48	0.44	5.35
1939				
1 J	1.53	0.65	0.03	2.21
15 J	3.83	1.09	0.59	5.51
20 J	0.23	0.75		0.98
1938				
4 M	1.47		0.57	2.04
19 M	1.39	1.37	2.71	5.47
TOTAL	89.03	84.06	76.71	249.80

$\bar{X}$ = 4.80
N = 52

DATE	L	M	H	T
1958				
20 M			0.2	0.2
26 M	0.7	0.6	0.6	1.9
3 J	0.29	0.3		0.59
9 J	0.62			0.62
16 J	0.24	0.41	3.24	3.89
19 J	4.26	2.77	1.39	8.42
21 JL	0.57	0.39	9.11	10.07
22 JL	0.11	0.54		0.65
31 JL	0.09		0.37	0.46
4 S	0.96			0.96
12 S		0.16	0.69	0.85
1957				
7 J	4.91	2.60	1.64	9.15
14 JL		1.29		1.29
23 A	1.44	0.30	3.23	4.97
30 S			0.65	0.65
1956				
5 JL	1.08	1.95		3.03
9 JL	0.22		0.42	0.64
1954				
16 M		1.67	1.55	3.22
3 JL		0.23	0.51	0.74
21 JL	1.02			1.02
7 S		0.60	0.73	1.33
14 S	0.63	1.06	2.75	4.44
1953				
1 J	16.83	0.27		17.10
17 A	0.35	0.33	0.49	1.17
1952				
9 M	3.06			3.06
16 M	0.20	0.11	1.45	1.76
28 M		0.75		0.75
20 J			2.34	2.34
27 J	6.12	4.72	12.04	22.88
28 J	0.89	0.61	1.17	2.67
1951				
9 J	2.26	5.06	5.24	12.56
10 J	0.48	0.29	0.12	0.89
17 J	1.91	0.17		2.08
21 J	1.33	1.26	2.91	5.50
28 J	3.72	2.35	3.37	9.44

Continued to next page

U - 1 Continued:

DATE	L	M	H	T
29 J		0.33	0.46	0.79
1 JL	3.64	2.40	3.04	9.08
4 JL	3.15	2.84	1.43	7.42
10 JL	4.90	0.52	0.38	5.80
10 A	1.64	1.33	3.99	6.96
12 A	0.61			0.61
1 S	1.37	1.41	1.67	4.45
2 S	6.61	3.79	4.43	14.83
4 S		0.04	0.19	0.23
1950				
27 M	3.22	0.86	1.09	5.17
16 J	0.70			0.70
19 J	1.21	0.45	1.75	3.41
10 JL	5.31	1.07	4.52	10.90
21 JL	4.81		0.10	4.91
24 JL	0.05			0.05
26 JL			2.87	2.87
27 JL	0.44	0.67	0.13	1.24
5 A	9.98		0.06	10.04
6 A	3.47			3.47
25 A	0.33	0.34		0.67
14 S	0.21		0.86	1.07
17 S	0.80	0.17	0.59	1.56
19 S	0.66	0.45	0.77	1.88
1949				
23 M	0.54	0.49	1.18	2.21
31 JL	0.82	1.64	0.83	3.29
27 A	0.36	0.54	0.27	1.17
5 S		0.66		0.66
1948				
13 J	1.94			1.94
14 J	4.51	0.94	0.38	5.83
1947				
30 J	2.59	1.13		3.72
21 JL	0.73	1.85	1.15	3.73
22 JL	0.34	0.77	1.46	2.57

U - 1 Continued:

DATE	L	M	H	T
1946				
31 A			0.63	0.63
1939				
12 J	1.51	0.58	0.17	2.26
13 J		3.13		3.13
22 J	0.68	0.30	1.68	2.66
1938				
24 M	0.86	1.55		2.41
25 M	1.06	0.49	0.47	2.02
21 JL	0.19	0.39	0.14	0.72
28 JL			0.29	0.29
14 S	0.11	0.40	0.30	0.81
1937				
2 JL	0.45	0.70	0.74	1.89
17 JL	0.40	0.52		0.92
18 JL		0.67		0.67
3 A	0.03	0.10	0.20	0.33
12 A	1.12	0.36	1.43	2.91
TOTAL	125.64	64.73	95.86	286.23

$\bar{X} = 3.53$
$N = 81$

DATE	L	M	H	T
1958				
10 JL	0.23			0.23
27 A	0.82			0.82
1956				
3 A	0.64	1.97		2.61
1955				
5 JL	1.14	3.45	3.84	8.43
26 JL	0.21	0.75	0.99	1.95
20 S	1.53			1.53
1954				
16 A	2.94	2.47	3.11	8.52
1953				
19 J		0.40	1.95	2.35
20 J	0.40	0.67		1.07
21 J	0.21	0.61		0.82
18 JL	0.84		0.15	0.99
19 JL	0.23	1.81	3.69	5.73
26 JL	0.19	0.15	0.25	0.59
1 A			0.80	0.80
4 A	1.53		0.95	2.48
1952				
21 J	0.97		0.18	1.15
1951				
5 J	0.32			0.32
7 J		0.38		0.38
15 JL	0.56			0.56
14 A	0.42	0.79	4.39	5.60
17 A	0.16	0.06		0.22
24 A	0.58			0.58
1950				
29 JL	1.10	0.03		1.13

U - 2 Continued

DATE	L	M	H	T
1949				
29 M	0.55	0.71	1.66	2.92
19 J		1.27	0.89	2.16
26 J	2.18			2.18
12 A	1.08			1.08
1948				
15 J	1.05	1.93	3.14	6.12
13 JL	1.78	0.79	0.89	3.46
15 JL	0.85	1.84	2.15	4.84
17 JL	0.40	0.64	0.90	1.94
1 A	2.69	1.46	0.63	4.78
1947				
23 J			0.21	0.21
25 J	0.26			0.26
13 JL	0.22	0.36	0.15	0.73
14 JL			0.19	0.19
23 JL	0.96	0.39		1.35
1946				
2 JL	0.52	0.62	0.23	1.37
3 JL	1.15			1.15
5 JL	0.12			0.12
3 A	0.17	0.32	0.44	0.93
12 S	0.13	0.84	0.84	1.81
13 S	0.13	0.17	0.97	1.27
1939				
28 J	0.65	1.27		1.92
30 J	1.17	1.14	2.91	5.22
1938				
2 JL	2.48	3.48	2.25	8.21
3 JL			1.36	1.36
10 JL	1.23			1.23
28 A		1.32		1.32
TOTAL	34.79	32.09	40.11	106.99

$\bar{X} = 2.18$
$N = 49$