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A CORRELATION BETWEEN ATMOSPHERIC ELECTRICAL ACTIVITY AND THE JET STREAM

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ABSTRACT

A radioactive collector and a sensitive recording microammeter have been used for several years to indicate variation in the potential gradient of the atmosphere at the General Electric Research Laboratory in Schenectady. Recently it has been found that there is a good correlation between the magnitude of the current measured on fair-weather days and the presence of the jet stream over the Schenectady area. On fair-weather days from October 1952 through February 1953, when the radioactive collector current exceeded +0.05 microampere for a few hours or more a jet stream was indicated over Schenectady at the 500-, 300-, or 200-millibar levels on 42 out of 50, or 80 per cent, of the days. This relation suggests to the author that a jet stream may carry a higher positive charge sufficient to increase the normally positive fair-weather field under the region of the jet stream. This higher positive charge may be acquired by the jet stream as it passes over thunderstorms or other stormy areas previous to its arrival over a region of fair weather.

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A CORRELATION BETWEEN ATMOSPHERIC ELECTRICAL ACTIVITY AND THE JET STREAM

Raymond E. Falconer

For the past five years we have been making nearly continuous records of a number of meteorological variables at our weather station located at the General Electric Research Laboratory in Schenectady, New York. Most of the recording instruments were put into operation as part of the laboratory research studies conducted under Project Cirrus. Some of this type of study is now being carried on under a contract with the Office of Naval Research.

The instruments in use include some of the common ones found at most weather stations and, in addition, a number of new instruments that were developed during the course of the project.

Except for the occasional inoperation of equipment due to repairs, etc., we have continuous records of temperature, relative humidity, precipitation (heated tipping bucket), pressure, wind direction, wind velocity, solar radiation (Eppley pyrheliometer), reflected light from the northern sky, outgoing nighttime radiation (Gier and Dunkle flat plate radiometer), absolute moisture content of the atmosphere, variation in the electrical potential gradient (obtained by use of a radioactive point collector), concentration of condensation nuclei, and a count of the salt particles in the air. Many of these instruments have been recording since 1948, while others have been in operation for shorter periods of time. Most of the instruments use General Electric photoelectric recorders with chart speeds of two inches per hour.

Figure 1 shows the exposure site for most of the instruments, while Fig. 2 shows the installation of recorders in the weather office. Figure 3 shows simultaneous variations of several meteorological elements at times of different weather situations. The record charts for each 24-hour period are mounted, with times coinciding, in a manila folder, so that simultaneous activity on any or all of the instruments can be readily detected. A folder for each day since October 1948 is on file in our weather office.

Several months ago it became evident that such a large file of data should have some means for quickly determining the days on which particularly interesting weather phenomena occurred. This has been accomplished in part by adopting a color code using colored tabs

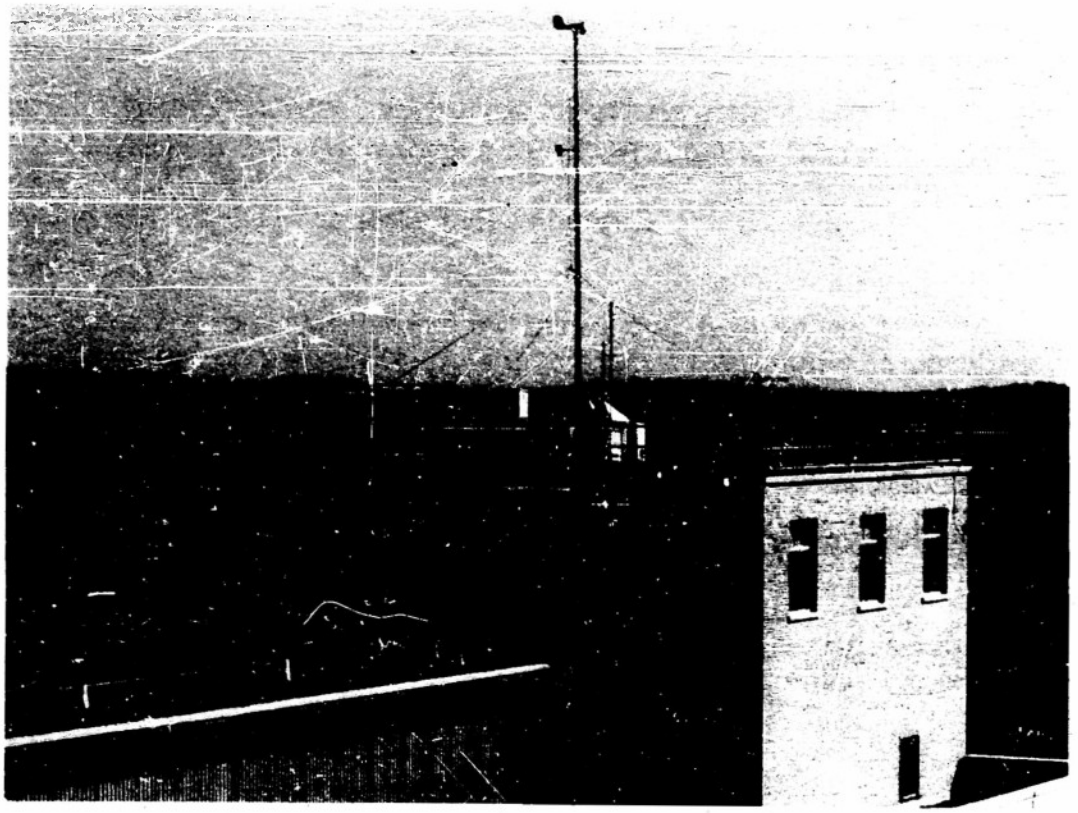

Fig. 1

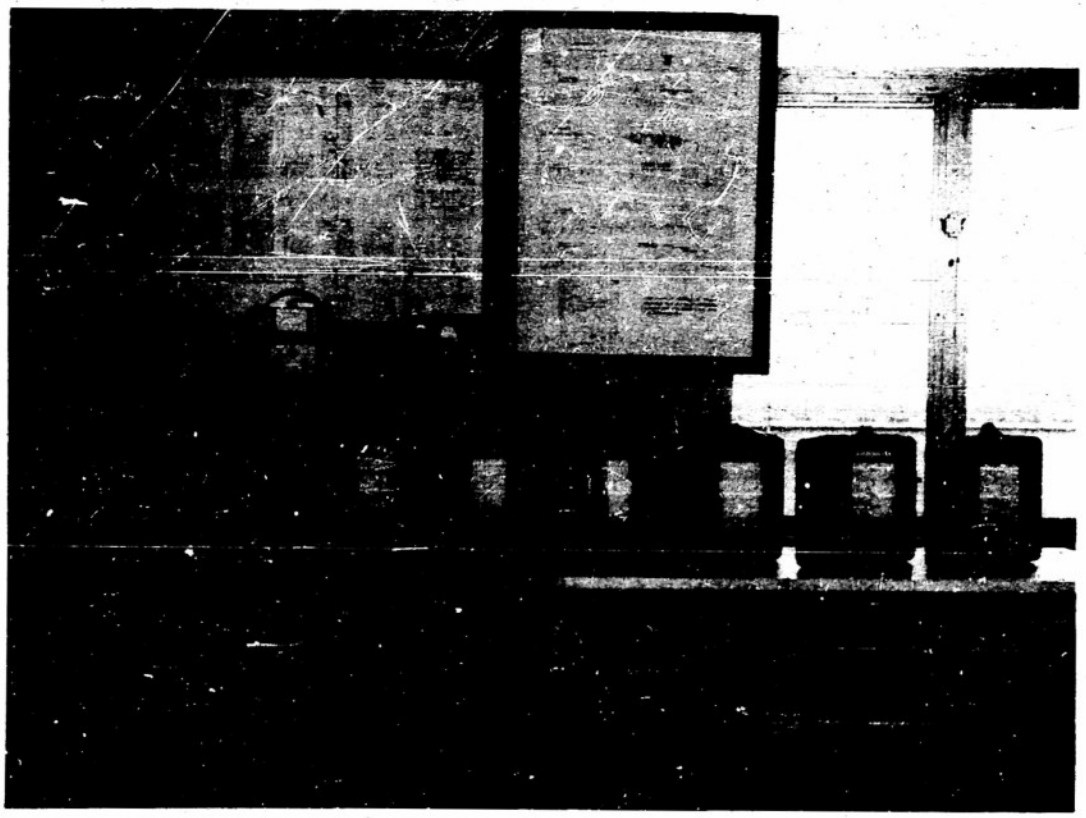

Fig. 2

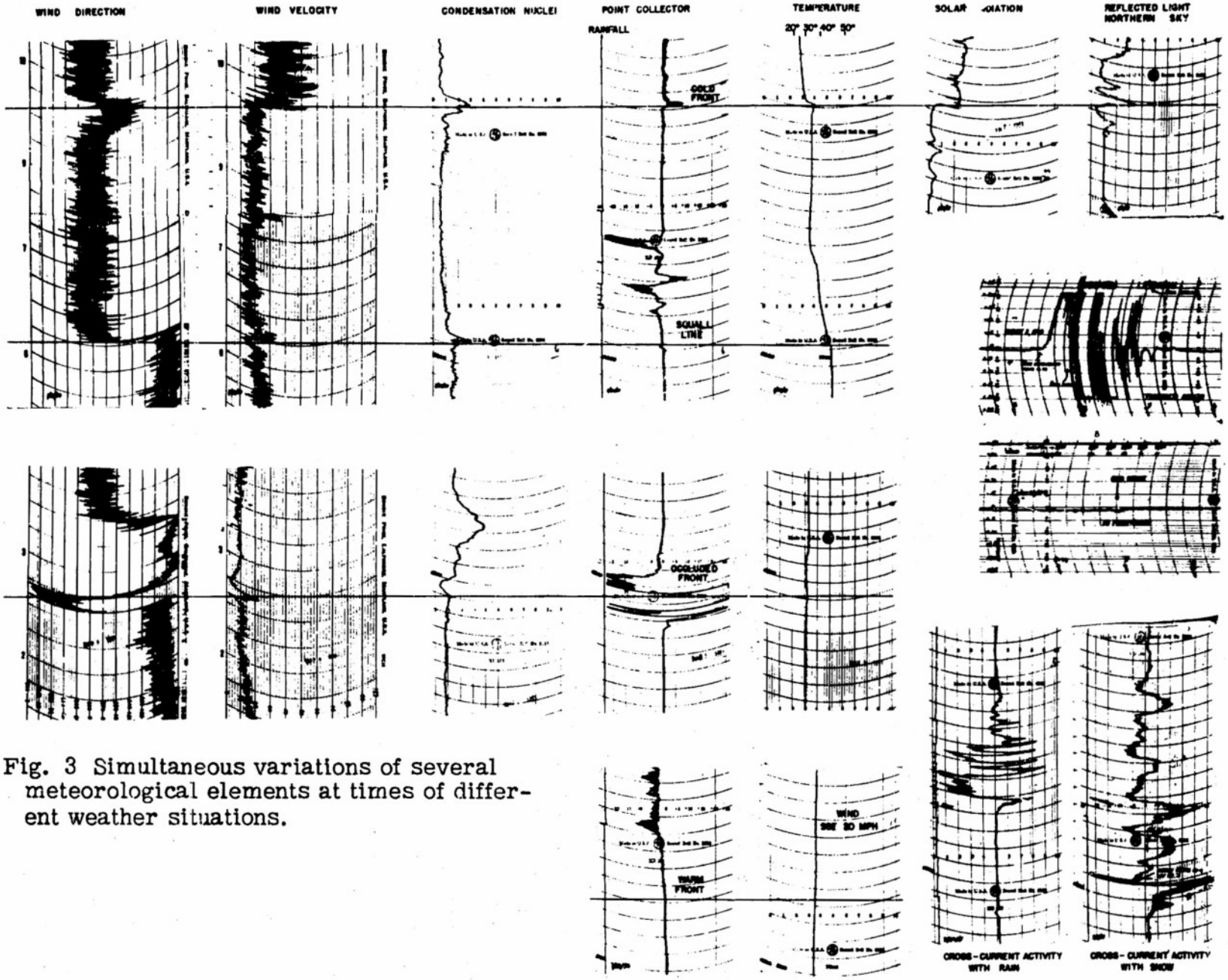

Fig. 3 Simultaneous variations of several meteorological elements at times of different weather situations.

attached to the exposed edge of each folder, as shown in Fig. 4. The position of the tab along the folder indicates the weather element of interest, while the color of the tab indicates the intensity, type, or other description. Clouds, fronts, precipitation, etc., are indicated in this way.

Last summer I assisted Vincent Schaefer in his study of cloud types related to the jet stream. I supplied him with jet stream locations as obtained from the WBAN 500- and 400-millibar facsimile charts received in our weather office each weekday by radio facsimile.

With the jet stream on my mind and while in the process of typing the daily weather folders, it occurred to me that it might be of interest to see what relation, if any, existed between certain increased positive currents in fair weather frequently noted on the radioactive point collector record and the presence of the jet stream over the area. A preliminary check indicated that higher positive current readings occurred in fair weather on days when the jet stream was near.

Before the results of more detailed comparisons are presented, it might be well to briefly describe the collector and some previous results. The mechanical arrangement of the point and insulator has been described previously in Project Cirrus Occasional Report No. 18,(1) but is shown here in Fig. 5. The brass point was sent to the United States Radium Corporation, where a length of radium-impregnated gold foil 2.5 millimeters wide by 0.005 inch thick was wrapped spirally along the 1/16-inch-diameter brass rod and made fast to it. The gold foil contains about 250 micrograms of radioactive material. The radium used in the foil is radium sulphate, having a half life of approximately 23 years. A point thus treated was obtained in 1948 and has been exposed daily since that time. Recently, 4-1/2 years later, two new points were ordered to be treated in the same way as the original one. After 4-1/2 years, little difference was noted in the characteristics of the old versus the new points. Figure 6 shows the variation in current in the radioactive collector circuit when various d-c voltages are applied to a metal cylinder 2.2 centimeters in diameter which is concentric with the collector.

Figure 7 shows an actual radioactive point and insulator assembly. This unit is mounted on a pipe 15 feet long, the point being connected to one side of a sensitive recording microammeter, located in the weather room, through a length of shielded R.G./8U cable. The other side of the recorder is grounded as is the shield around the cable.

(1) Falconer, R.E., "Some Correlations Between Variations in the Atmospheric Potential Gradient at Schenectady and Certain Meteorological Phenomena," Project Cirrus Occasional Report No. 18, G-E Research Lab. Rept. No. RL-287 (December 1949).

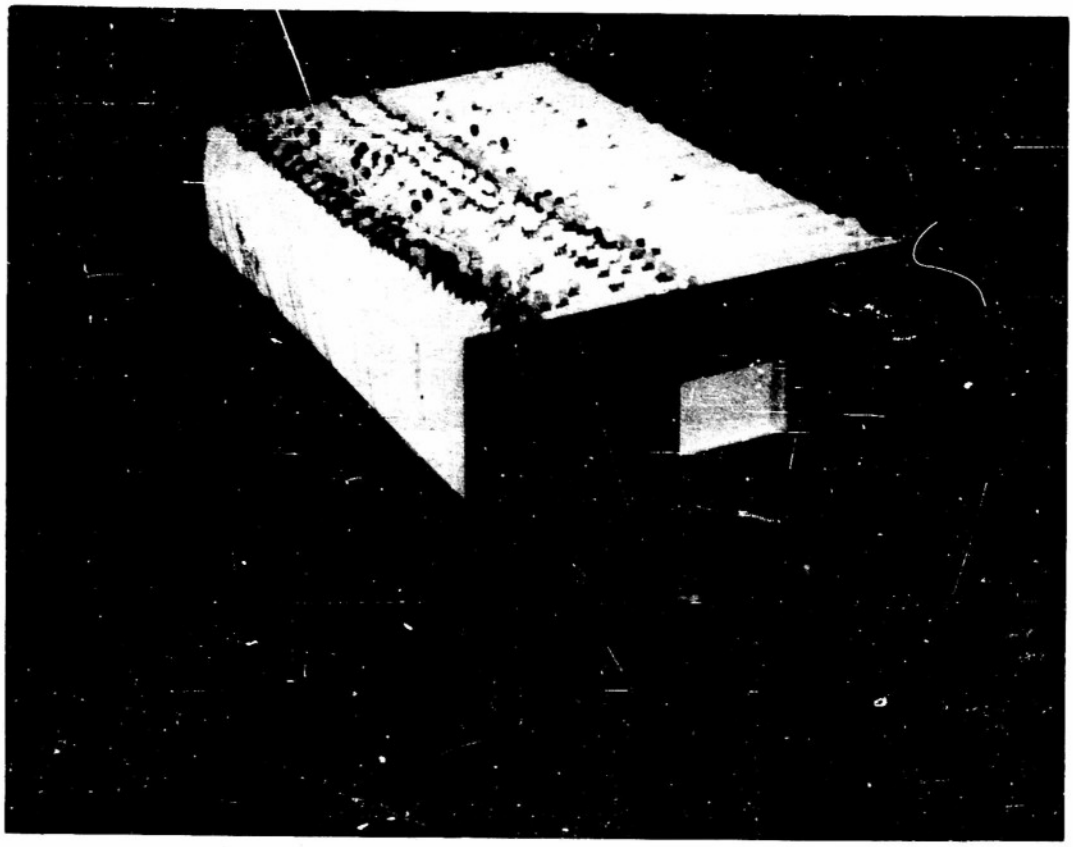

Fig. 4

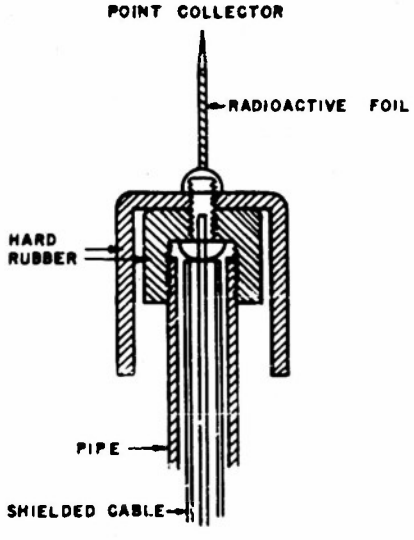

Fig. 5 Radioactive collector insulated mounting.

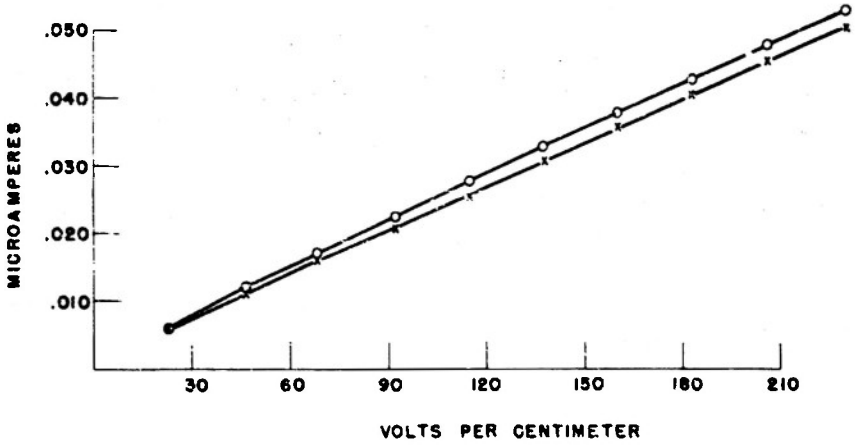
.050
.040
.030
.020
.010
MICROAMPERES
30
60
90
120
150
180
210
VOLTS PER CENTIMETER

Fig. 6

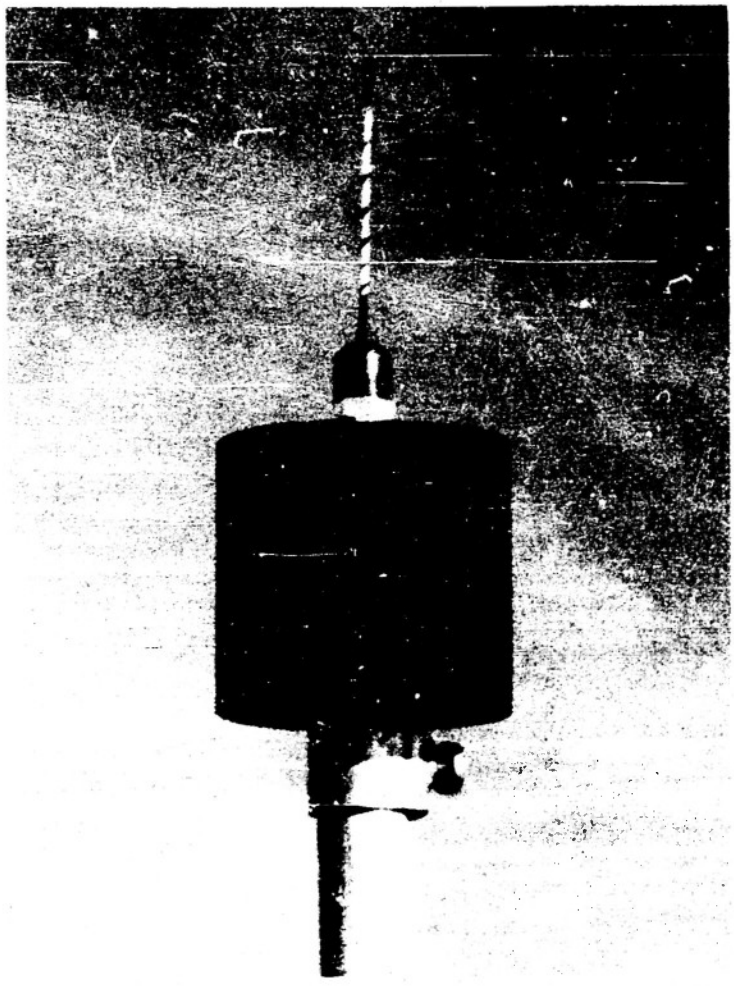

Fig. 7

From 1948 to the fall of 1951, the recorder in use had a sensitivity of 5.0 microamperes full scale. In the fall of 1951 an electrometer was added between the point and the recorder in order to increase the sensitivity of the system. Full scale on the recorder then equalled about 0.6 microampere. While it had been suspected that there was more structure to fair-weather currents than we had been recording, the greater sensitivity obtained with the electrometer verified this suspicion.

Through the winter of 1951-1952 it was noted that on some days, particularly clear, good-visibility days, the radioactive point record often showed higher positive current readings than on some other non-stormy days. Notes made on the daily records indicated some wonderment over this, and an attempt was made to correlate the higher positive readings with the appearance of cirrus clouds or ice crystals in the air.

It was thought at that time that possibly the Simpson-Scrase ice friction theory[2] of separation of charge might be responsible for these high positive current readings. We began to suspect that there were perhaps considerable numbers of ice crystals in the high atmosphere on days when the sky was apparently quite clear. This observation found some support when we later read a report on cirrus clouds by Fletcher and Sartor which appeared in Weatherwise for February 1952.[3] They report the following:

> "...1. Cirrus is more frequently encountered and more extensive than would be supposed from surface observations. With a surface report of one- or two-tenths cirrus coverage it is by no means uncommon for a pilot to report that he has been flying in or above an overcast cirrus layer. 2. Cirrus clouds are thicker than might be guessed from surface observations; thicknesses are frequently greater than 6000 feet and occasionally exceed 10,000 feet. ...4. In the upper troposphere there frequently exist haze layers which are not evident from the ground observations and which do not appear to be in the nature of ordinary cirrus. ..."

In addition to the ice friction theory, the possibility had been considered that, in the formation of high-level ice crystals or cirrus clouds, a separation of charge due to the change in state of water from vapor to ice might take place which would be of the right sign and magnitude to fit our observations.

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(2) Chalmers, J.A., Atmospheric Electricity, Oxford University Press (1949), pp. 159-160.

(3) Fletcher, R.D., and Sartor, D., "Cirrus," Weatherwise, 5, 8 (1952).

At about the time it was discovered that there appeared to be some relation between the high fair-weather currents and the presence of the jet stream, a new electrometer was put into service in the radioactive collector circuit. The new electrometer provided full-scale sensitivity on the G-E photoelectric recorder of 0.55 microampere.

After a study of some of the records obtained by using this arrangement, it was determined that when the fair-weather current exceeded +0.05 microampere for a period of one or two hours or more, the jet stream was usually near. During cloudy conditions, it was determined that in most cases a positive current reading of +0.04 microampere or more would signify the presence of the jet stream. It should be mentioned that ordinarily when nonprecipitating clouds form or pass over the observation point in a deck, there is a noticeable decrease in the positive fair-weather current, although it does not usually go to zero or negative unless there is light precipitation. On the other hand, when the clouds dissipate or otherwise move well beyond the observation site, the current will then go more positive. These critical values may only be true for our location at Schenectady, and further detailed study might change them slightly.

In January of this year, preliminary data were analyzed which showed a good correlation between the days when the fair-weather current was believed to indicate the presence of the jet and the actual location of the jet within 150 to 200 miles, as indicated on our 1500Z 500-millibar maps received each weekday by radio facsimile. Weekend and holiday maps and the 0300Z maps were not available on this circuit, but even so there seemed to be a pretty definite indication that the jet stream, or at least high-level, high-velocity winds, might be detected by the increased positive fair-weather current.

Through the kindness of Harry Wexler of the Washington Office of the U.S. Weather Bureau and Ernest Christie of the New York office, the 200-, 300-, and 500-millibar maps from September 1952 through February 1953 were obtained to aid in making a more detailed comparison between electrical activity as observed at Schenectady and the presence of the jet stream over the area. For the purposes of this paper, only the period from October 1 on, after the new electrometer had been installed, has been used.

From each of the maps, the distance of the nearest jet-stream axis from Albany within a radius of 250 miles was determined. The indicated wind velocity over Albany was also noted. The daily charts of the radioactive point collector were then examined, although most

of them had already been typed with the color-tab system before the maps arrived. Days when there were few or no clouds, and with radioactive collector current readings of 0.05 microampere for an hour or more, were taken as indications that the jet stream was present. Some cloudy days when precipitation was not falling at the time were used if the positive current reading was 0.04 microampere or more.

Figure 8 shows a typical trace of the increase in positive current reading when the jet stream is near. In this case, the jet had not been plotted over our area for several days and was not expected to be near this day according to prognostic maps. However, shortly after 8 a.m. it was noted that the radioactive point recorder pen was climbing to current values usually associated with the presence of the jet. The current reading went down to a slight negative value after an hour or so as a very light sprinkle occurred, but this was followed by a definite increase in current reading to a value above the minimum of 0.05 microampere required for identification of the jet. The reading remained high for 3-1/2 hours. During this time there was a small break in an otherwise overcast sky, which was visible just to the west. There were some lenticular clouds visible near the break. It will be noted that during this period winds were fairly constant but diminishing in velocity toward the latter part of the period. We were pleased to note on the 1500Z 850-millibar map received by radio facsimile at 3:30 p.m. that afternoon that a jet was plotted exactly over the Albany area, as shown in Fig. 9.

Another good example of high positive currents associated with jet-stream activity is shown in Fig. 10. As can be seen, the current readings were high all through the night. Winds were generally light, averaging 10 mph, on the evening of January 15 and increasing to an average of 15 mph, all from the SE, during the early morning of January 16. A strong jet stream moved in from the west late on January 15, and its axis was plotted directly over Albany by the following morning with velocities of 140, 120, and 100 knots indicated over Albany at the 200-, 300-, and 500-millibar levels, respectively, as shown in Figs. 11 and 12.

On January 25 (see Fig. 13), we have one of the few cases where the point was high, indicating high-velocity winds aloft, but the jet axis was not plotted within 250 miles at any level. It was, however, plotted off the east coast and roughly parallel to it on the 1500Z 200-millibar chart as shown in Fig. 14. Winds were high, 140 knots, along the axis with the 80-knot isotach plotted right over Albany. Surface winds were rather strong on this day.

In th. llowing tables are shown the results of comparisons between the days when the presence of the jet stream over the Albany-Schenectady area was indicated on the high-level charts and the probable presence of the jet as indicated by the increase in fair-weather current as determined from the radioactive collector record.

Table I shows the dates by months on which the jet-stream axis was plotted within 150 miles or less of the Albany-Schenectady area. It will be noted that a jet axis can be found within 150 miles of this area a large percentage of the time. During October 1952 it was within this radius at one or more of the three levels every day.

Similar tables were made for the times when the jet axis was within 100 miles and 50 miles of Schenectady, as shown in Table II. On the average it appears that, during winter months at least, the jet may be found within 50 miles of Albany 50 per cent of the time, within 100 miles 69 per cent of the time, and within 150 miles 83 per cent of the time, at some level between about 20,000 and 40,000 feet.

Table III shows the actual dates on which the radioactive collector current was believed to indicate the presence of high-velocity jet-stream winds aloft. There were 14 days during the 5-month period on which the jet stream was within 150 miles of Albany which were classified as stormy days and were not used in these comparisons. It should be kept in mind, however, that on these days atmospheric electrical activity is considerable and may be of both signs and large magnitude.

Table IV shows the dates on which the radioactive collector current was believed to indicate the presence of the jet stream when the jet was actually plotted within 150 miles of the Albany-Schenectady area.

In Table V, a summary of the results of the comparisons by months is shown, and Table VI gives a similar summary for the five-month period. From Table VI it will be noted that the jet-stream axis was plotted within 50 miles of the Albany-Schenectady area on 69 days and that the presence of the jet was detected correctly by the radioactive collector current reading on 61 of those days, or 89 per cent of the time. However, on five days during that period, it was felt the fair-weather current was not high enough to properly indicate the presence of the jet. Also, the point was thought to indicate the jet on 38 other days when the jet axis was not plotted within 50 miles.

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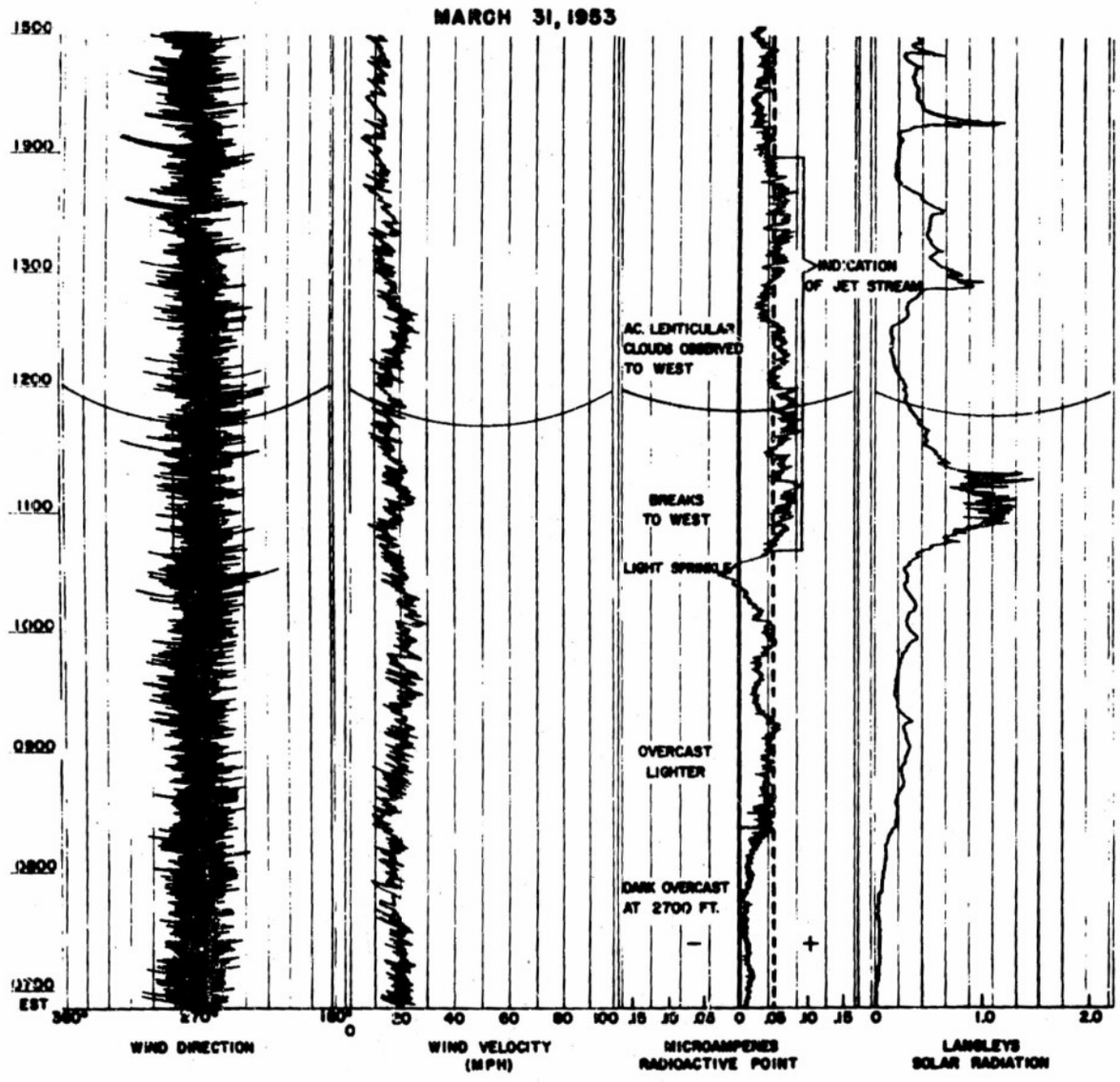
MARCH 31, 1953
1500
1900
1300
1200
1100
1000
0900
0800
0700
EST
AC. LENTICULAR CLOUDS OBSERVED TO WEST
INDICATION OF JET STREAM
BREAKS TO WEST
LIGHT SPRINKLE
OVERCAST LIGHTER
DARK OVERCAST AT 2700 FT.
360°
270°
180°
0
WIND DIRECTION
20
40
60
80
100
WIND VELOCITY (MPH)
.15
.10
.05
0
.05
.10
.15
MICROAMPERES RADIOACTIVE POINT
0
1.0
2.0
LANGLEYS SOLAR RADIATION

Fig. 8

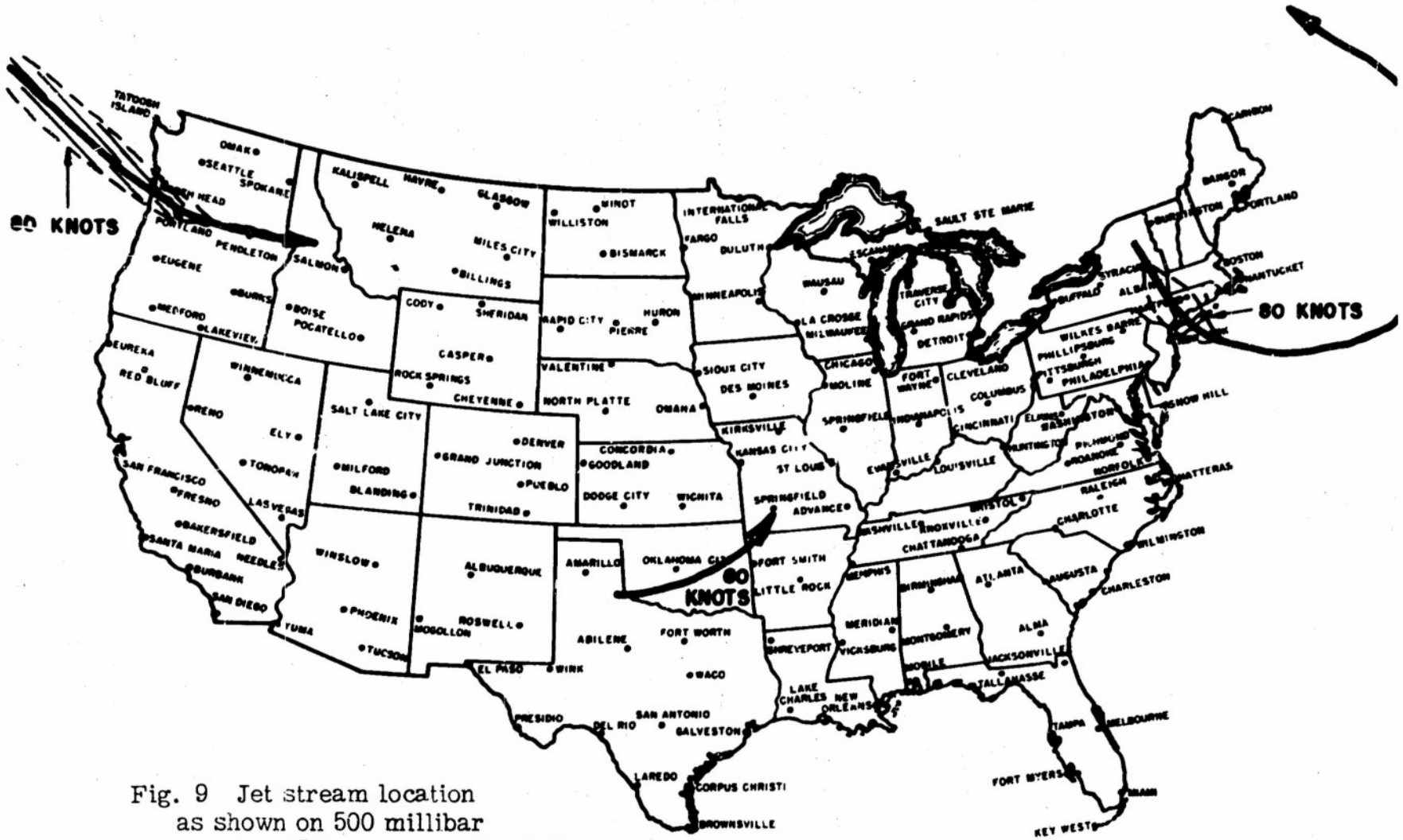

Fig. 9 Jet stream location as shown on 500 millibar map for 1500 Z March 31, 1953.

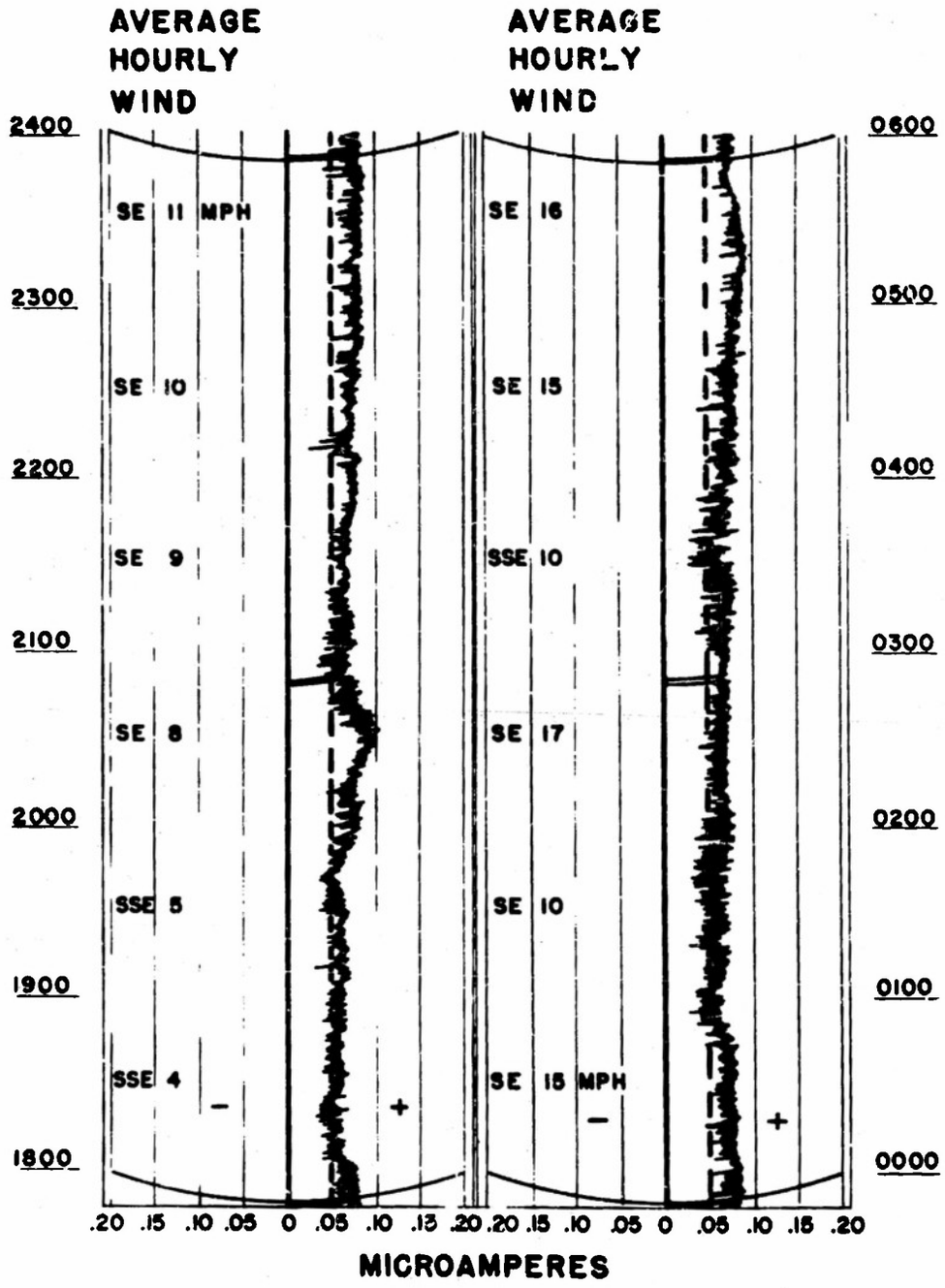

Fig. 10 Radioactive point record from 1800 January 15 to 0600 on January 16, 1953.

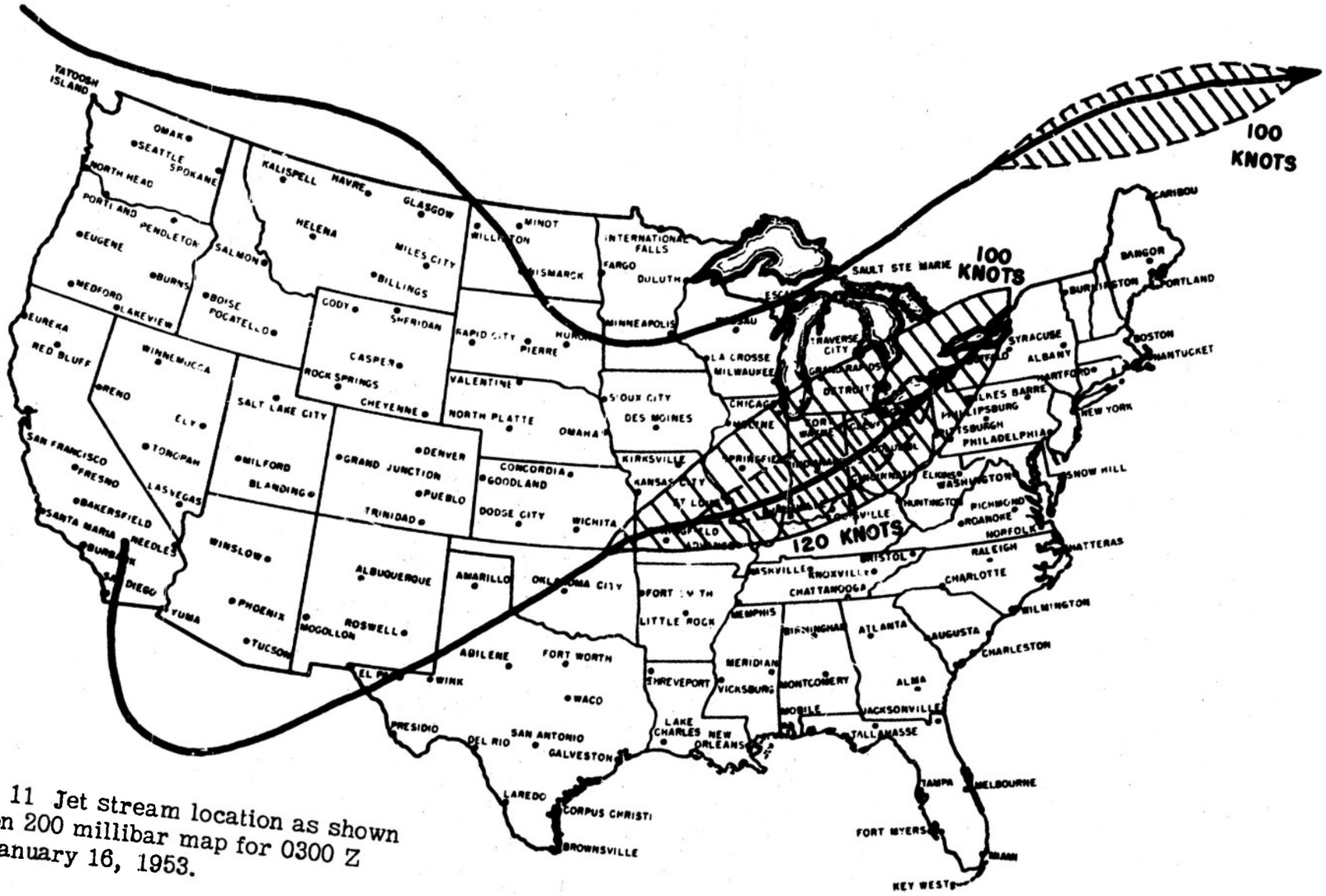

Fig. 11 Jet stream location as shown on 200 millibar map for 0300 Z January 16, 1953.

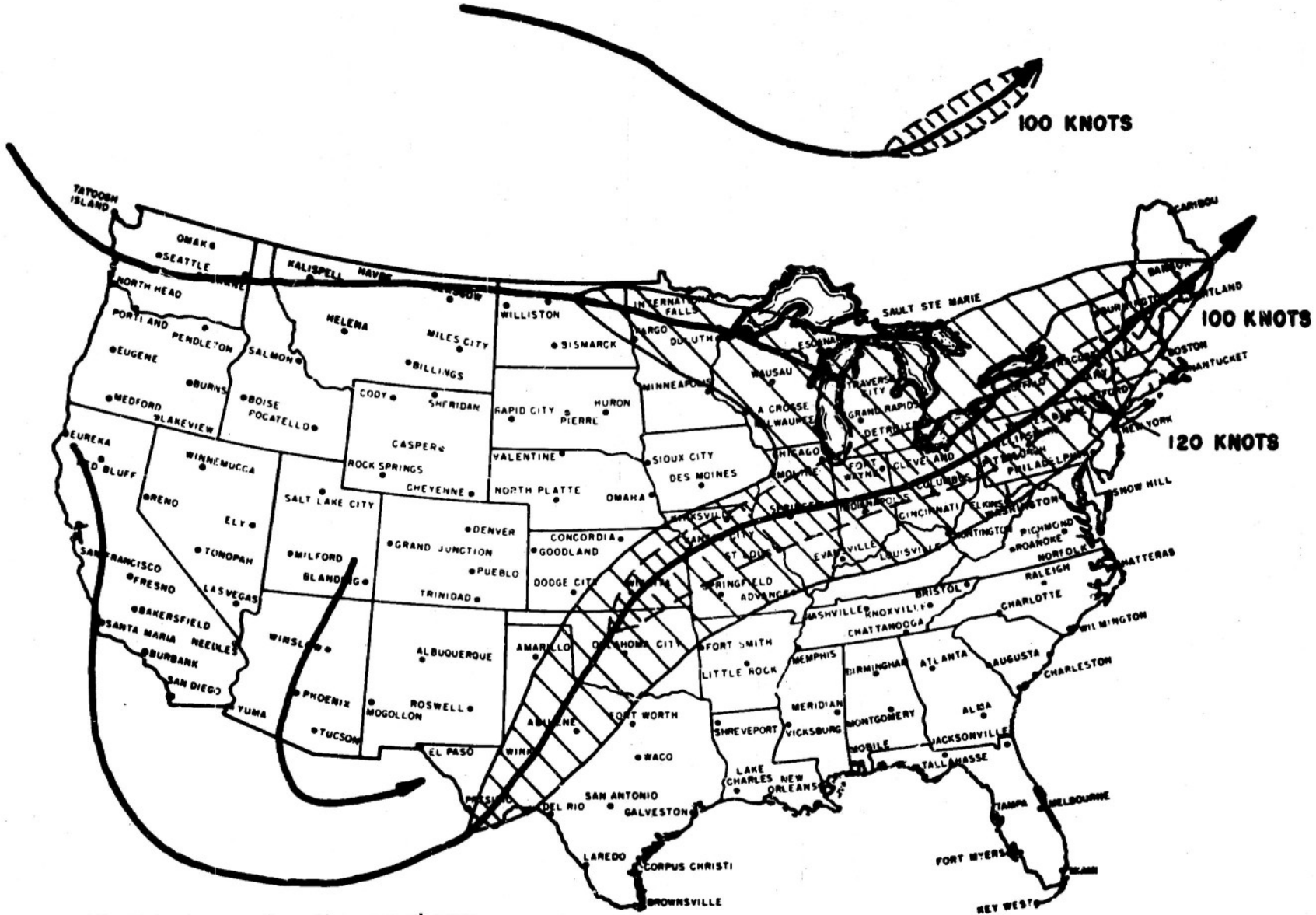

Fig. 12 Jet stream location as shown on 200 millibar map for 1500 Z January 16, 1953.

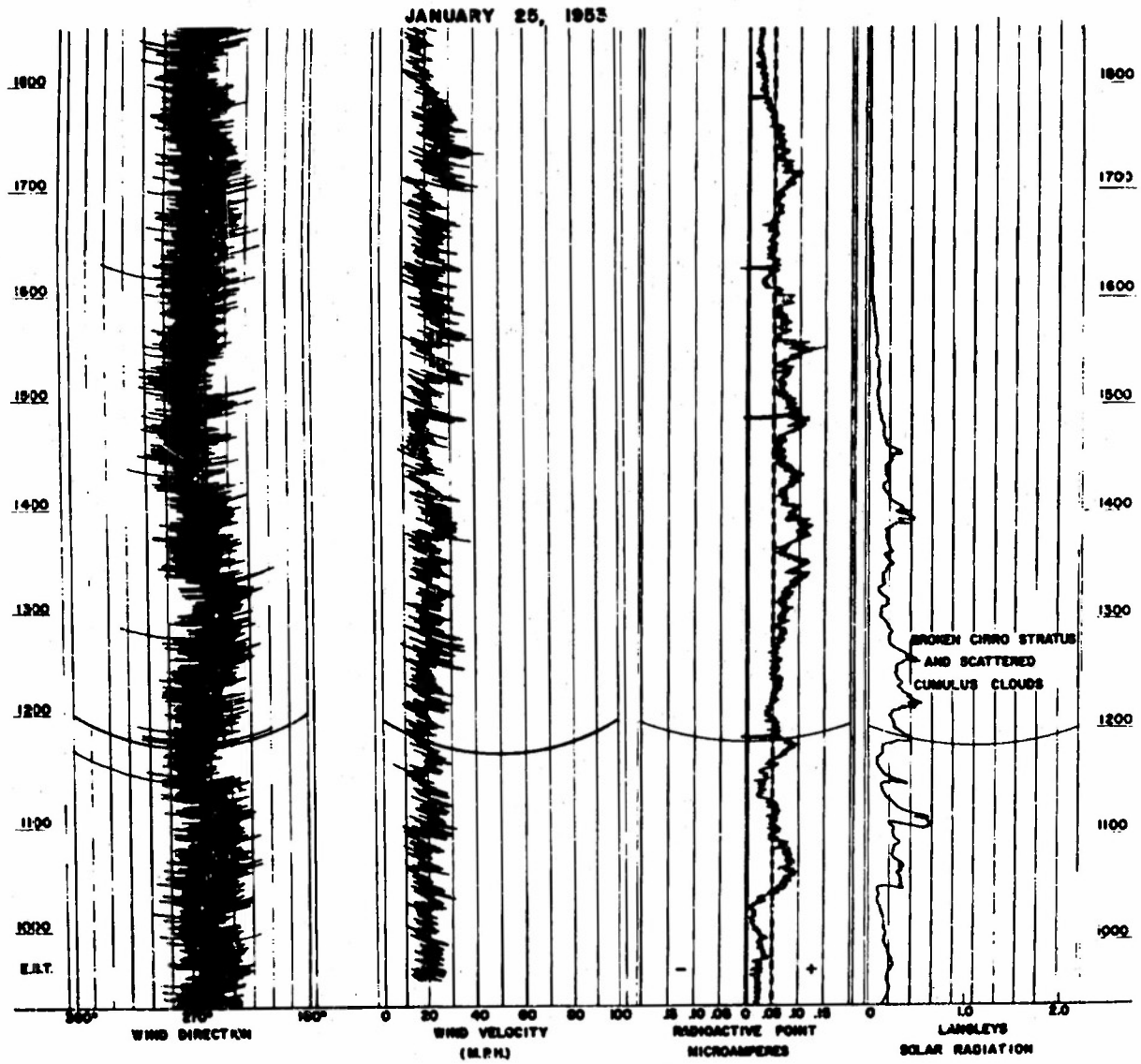
JANUARY 25, 1953
1800
1700
1600
1500
1400
1300
1200
1100
1000
E.S.T.
BROKEN CIRRO STRATUS
AND SCATTERED
CUMULUS CLOUDS
WIND DIRECTION
WIND VELOCITY
(M.P.H.)
RADIOACTIVE POINT
MICROAMPERES
LANGLEYS
SOLAR RADIATION

Fig. 13

Fig. 14 Jet stream location as shown on 200 millibar map for 1500 Z January 25, 1953.

TABLE I

Dates on Which the Jet-stream Axis Was Plotted within 150 Miles or Less of Albany, N. Y., on the 200-, 300-, or 500-millibar Map

Sept. 1952	Oct. 1952	Nov. 1952	Dec. 1952	Jan. 1953	Feb.* 1953
1	1	3	1	1	1
2	2	4	3	2	2
3	3	5	4	3	3
4	4	8	5	6	4
5	5	9	6	7	5
7	6	10	7	8	6
8	7	11	9	9	7
9	8	12	10	10	8
10	9	13	11	13	9
11	10	14	15	14	10
12	11	16	16	15	11
13	12	17	17	16	12
15	13	18	18	17	13
16	14	19	19	18	14
17	15	20	20	19	15
18	16	21	21	21	16
19	17	22	23	22	19
20	18	23	24	23	21
21	19	24	25	24	22
22	20	26	26	26	23
23	21	27	27	27	24
24	22	28	28	28	
26	23	29	(29)?	29	
27	24	30	30	31	
29	25		31		
	26				
	27				
	28				
	29				
	30				
	31				
Total Days 25	31	24	25	24	21
Per Cent of Days 83	100	80	81	77	75

*One week of 200-mb charts missing.

/ = Stormy days not used in other data.

TABLE II

Percentage of Days per Month on Which the Jet-stream Axis Was Plotted within 50, 100, or 150 Miles of Albany, N.Y., on the 200-, 300-, or 500-millibar Map

	Sept. 1952	Oct. 1952	Nov. 1952	Dec. 1952	Jan. 1953	Feb. 1953*	Average for 6 Months
Within 50 Miles	43	65	50	42	52	50	50
Within 100 Miles	63	84	73	55	71	64	69
Within 150 Miles	83	100	80	81	77	75	83

* On six days the 200-mb maps were unavailable.

TABLE III

Dates on Which the Radioactive Point Collector Current Was Believed to Indicate the Presence of the Jet Stream

Oct. 1952	Nov. 1952	Dec. 1952	Jan. 1953	Feb. 1953
1	3*	1	1	1
4	(4)?	3	2	2
5*	5	4	4	3
8	8	5*	5	5
10	10	7	(6)?	6
12	11	8	7	8
13	12	12	8*	9
14*	13	15	11*	10
15	14	16*	12	11
(16)?	16	17	13	(13)?
17	17*	18	14	14
18*	18	19	15	16
19	19	20	16	17
20	21	25	17	(20)?
21	24	26	18*	21
22	25	27	19*	(22)?
23	26	28	(21)?*	23
24	27	29	22	24
25	28	(31)?	23	25
30			24*	28
31	(29) †		25	
	(30) †		26	
			27	
			29	
			30	
			31	
Total Number of Days 20	18	18	24	17
Questionable Days 1	1	1	2	3

* Light precipitation occurred but not at time of "jet" indication.
† Instrument out of order.

TABLE IV

Dates on Which the Radioactive Collector Current Was Believed to Indicate the Presence of the Jet Stream when the Jet Axis Was Plotted Within 150 Miles of Albany, N.Y.

Oct. 1952	Nov. 1952	Dec. 1952	Jan. 1953	Feb. 1953
1	3*	1	1	1
4	(4)?	3	2	2
5*	5	4	(6)?	3
8	8	5*	7	5
10	10	7	8*	6
12	11	9		
13	12	15		8
14*	13	16*	13	10
15	14	17	14	11
(16)?	16	18	15	(13)?
17	17*	19	16	14
18*	18	20	17	16.
19	19	25	18*	21
20	21	26	(19)?*	(22)?
21	24	27	(21)?*	23
22	26	28	22	24
23	27	(29)?	23	
24	28	30	24*	
25		(31)?	26	
30			27	
31			29	
			31	
22	18	18	20	15

						Total for 5 Months
Questionable days not used.....	1	1	2	3	2	
Total days on which the point correctly indicated presence of jet..	21	17	16	17	13	84
Total days on which jet was plotted within 150 miles.....	29	22	23	20	18	112
Percentage of "jet" days correctly indicated by point.....	73	77	70	85	72	75

TABLE V

Frequency Table by Months Showing Relation between Radioactive Point Indications of the Jet and the Presence of the Jet Axis when It Was Plotted within 50, 100, or 150 Miles of Albany, N.Y., on the 200-, 300-, or 500-millibar Map

	Oct. 1952			Nov. 1952			Dec. 1952			Jan. 1953			Feb. 1953		
	Within			Within			Within			Within			Within		
Number of days	50	100	150	50	100	150	50	100	150	50	100	150	50	100	150
Jet plotted on maps	19	24	29	13	20	22	11	15	23	14	19	20	12	16	18
Number of these days that point indicated jet	16	17	21	11	16	17	10	11	16	14	17	17	10	12	13
(in per cent)	84	71	73	85	80	82	91	73	70	100	89	85	84	75	72
Jet plotted but no point activity	3	6	8	2	3	2	0	4	6	0	0	0	0	4	2
Point activity but no jet plotted	4	2	0	7	2	1	8	7	2	11	7	6	8	6	4

TABLE VI

Frequency Table for Total 5-month Period--
October 1952 through February 1953--
Showing Relation between Radioactive Collector Indications of the Jet
and the Presence of the Jet Axis
when It Was Plotted within 50, 100, or 150 Miles of Albany, N. Y.,
on the 200-, 300-, or 500-millibar map

	Average for 5 Months		
Number of days	Within 50 miles	Within 100 miles	Within 150 miles
Jet plotted on maps	69	94	112
Number of these days that point indicated jet	61 (89%)	73 (78%)	84 (75%)
Jet plotted but no point activity	5	17	18
Point activity but no jet plotted	38	24	13

When we consider the cases in which the jet axis was within 150 miles, it is found that the radioactive collector current correctly indicated the presence of the jet on 84 out of the 112 days, or 75 per cent of the time. The radioactive collector current trace failed to indicate the presence of the jet on 18 days and incorrectly indicated the presence of the jet on 13 other days. It might be mentioned that there were 9 days not used in the above comparisons when the positive current readings were probably high enough to indicate the jet, but when it still was questionable. Also, if we consider all the days when the jet was within 250 miles of Albany at any of the three levels we have used, it is found that the radioactive collector failed to indicate the presence of the jet on three days (January 4,5, and 25).

Data in the previous tables were based on the distance from Albany to the nearest jet-stream axis. Since the band of high-velocity winds is certainly wider than the indicated axis line on the maps, it probably would have been better to use the distance to the first isotach line enclosing the jet axis. This should make the previous correlation somewhat better.

As a check on this, all the days on which the radioactive collector showed the highest fair-weather currents (well above 0.05 microampere for 6 to 12 hours or more) were picked out; there were 50 such days in the five-month period. Upper-air charts for these days were then examined, and the distances from Albany to the region of highest winds along the jet-stream axis were noted. Table VII shows the results of these comparisons. On 42 out of the 50, or on 80 per cent of the days, Albany was within the band of highest winds along the jet axis. On 46 out of the 50 days, winds were 80 knots or more over Albany, and on 28 days they were 100 knots or more. On two successive days in November 1951, current readings were exceptionally high during the night and morning, and at the same time there was a dense fog. There was, however, a 60- to 80-knot jet indicated right over Albany on both occasions.

It is realized that the exact position of the jet-stream axis as drawn on the upper-air charts is of doubtful accuracy on many occasions, since reliable data in a fine enough network to detect a narrow band of high-velocity winds are not available to the map plotters at present. It is felt that on several occasions when the jet was not plotted over the area, although the electrical activity indicated that it should be, the maps were in error--owing to lack of sufficient information. On several of these days of high electrical activity with no jet indicated on the maps, typical jet-stream clouds, as described[4] by Schaefer in Stockholm and

(4) Schaefer, Vincent J., "Clouds of the Jet Stream," Tellus, 5, 27-31 (1953).

TABLE VII

Dates on Which Radioactive Collector Currents Were Highest for 6 to 12 Hours or More and the Number of These Days on Which the Jet-stream Winds over Albany Were of Certain Indicated Velocities at the Level of Highest Winds

	Oct. 1952	Nov. 1952	Dec. 1952	Jan. 1953	Feb. 1953	Total for 5 Months
	8	3	4	4	1	
	10	5	7	5	7	
	14	8	8	7	8	
	15	10	16	12	9	
	16	12	17	14	10	
	17	16	18	15	16	
	24	17	19	16	17	
	25	19	26	17	18	
		27	27	25	25	
		28	28	26		
			29	27		
				31		
Total Days	8	10	11	12	9	50
Days with Indicated Winds of						
60 knots	0	1	2	1	0	4
80 knots	2	2	5	6	0	15
90 knots	0	2	0	1	0	3
100 knots	2	3	4	2	3	14
120 knots	2	2	0	0	5	9
130 knots	0	0	0	0	1	1
140 knots	2	0	0	2	0	4

On 42, or 80 per cent, of all days with highest electrical activity, the band of jet-stream winds was right over the Albany-Schenectady area. On 46 days the winds were 80 knots or greater; on 28 days they were 100 knots or greater; and on 14 days they were 120 knots or greater.

at the New York American Meteorological Society meeting last January, were observed. On such occasions, we often find from nephoscope readings of the cirrus clouds that higher velocities exist at the cloud level than are indicated on the isotach charts. On many of these occasions, we believe that we may be detecting the presence of a so-called "jet streak."

The apparently good correlation between fair-weather electrical activity and the jet stream discussed above is, of course, based on observations made at Schenectady and may be different at other locations. The limiting current values for determining jet activity are likely to be somewhat different at other locations, depending upon such things as the height of the collector above ground and its proximity to other objects or structures. However, field tests with a portable radioactive point and an ultrasensitive d-c microammeter show that the current indicated by a point held 15 to 20 feet above the ground runs about 0.01 to 0.02 microampere less than that obtained at the same time from a similar point collector located on our laboratory roof 90 feet or so above the ground.

Why is there an apparent relation between atmospheric electrical activity and the jet stream?

First of all, we should consider the possibility that, because a jet stream is over the Schenectady area at some level a large part of the time, there would automatically be a good correlation if there were also a large number of jet days indicated by the radioactive collector.

In using radium as the radioactive material, we may be experiencing difficulties with β- and γ-rays as discussed by Chalmers in his book on atmospheric electricity.(5) Although there is a fairly direct effect of local wind variations on the current readings when velocities are below 8 or 10 miles per hour, at higher velocities the currents may or may not show a direct relation to the surface wind. It can only be said that for the purposes for which we have been using this type of collector the over-all results seem quite consistent, and it is believed that the major changes in the electrical field are indicated quite clearly.

There is one other consideration that may be confusing our observations: on a large number of days when the fair-weather currents were high, the relative humidity was low. This condition, of course, usually exists in fair weather anyway, but it is also true that conductivity

(5) Chalmers, J.A., Atmospheric Electricity, Oxford University Press (1949), pp. 53-54.

of the air is usually greater on clear days with low moisture content of the air. However, it is not quite clear why a jet stream should always be near on days of low relative humidity.

If the radioactive collector is indicating variations of the fair-weather field--as presumably it is--then on clear dry days when conductivity is greater the field should be lower. This is the opposite effect from what we observe and lends further support to the belief that there is an increase in the positive fair-weather field underneath the region of jet-stream winds aloft.

In spite of the previous considerations, which could account for some of the higher fair-weather fields, it is the feeling of the author that these electrical effects are definitely associated with the jet stream for the following reasons. It is noted that a jet in traveling over the earth will pass over regions of stormy weather, as well as fair weather. In fact, a jet stream is usually found in the vicinity of heavy thunderstorms or other stormy areas, including tornadoes.

If we accept C.T.R. Wilson's theory(6) that the electrical activity associated with thunderstorms produces a separation of charge such that the earth regains a negative charge while the high atmosphere receives an equivalent amount of positive charge, it may be that some of this positive charge could be picked up by a passing narrow band of high-velocity wind and this charge could be carried out with the jet winds to a fair-weather area and there increase the positive field already existing. A timely article as far as this paper is concerned appears in the April 1953 issue of the Scientific American. On pages 34 and 35 there appears a drawing which illustrates Wilson's theory of how the earth's charge is maintained. If the streams of positive current flow out of the thunderstorm areas were labeled "jet stream," it would serve as an excellent illustration for this paper. Even if there are no thunderstorms, a considerable positive charge is likely to develop in the upper portion of an otherwise heavy storm area which would be subject to the same transfer of charge from the stormy area to a fair-weather area by means of the jet stream.

Some evidence in support of this is recalled from previous observations using a nonradioactive point collector when it was noted by Schaefer(7) and Falconer(1) that small positive pips often occurred

(6) Wilson, C.T.R., Compendium of Meteorology (1951), p. 113.
(7) Schaefer, Vincent J., "Properties of Particles of Snow and the Electrical Effects They Produce in Storms," Trans. Am. Geophys. Union, 28, 587 (1947).

on the record chart from 6 to 12 hours or so preceding the arrival of precipitation. We now observe with the radioactive collector that fair weather currents are generally high preceding the arrival of major precipitation. This is particularly true when a jet stream moves in from the south or southwest. When a jet moves down from the northwest or north, it is more apt to maintain fair cool weather over the area.

The possibility should not be overlooked that the Simpson-Scrase ice-friction theory[2] might contribute additional charge of the right sign to further increase the fair-weather field. This would have some definite possibility if we consider the fact that cirrus or ice-crystal haze is much more common in the high atmosphere than can be detected from the ground,[3] as discussed earlier. Certainly there is enough wind shear, turbulence, etc., associated with the jet stream to create considerable friction among any existing ice crystals.

On February 21 and 22, 1953, the jet stream was indicated within 50 miles of Schenectady at all levels and with winds from 100 to 160 knots from the southwest. The electrical activity even with clear skies was too low to safely say that the jet was indicated by this means. However, unless there were some undetectable difficulties with the amplifier, one possible reason may have been the severe duststorms in the Southwest that occurred on February 16 and 19. Duststorms are known to produce negative fields and, therefore, if large quantities of highly electrified dust get into the high atmosphere, it may tend to neutralize an otherwise large positive field.

Now, if the jet-stream winds really do carry higher positive charges acquired because the jet stream has previously passed over a stormy area, it may be that this additional charge contributes to the triggering off of some thunderstorms and tornadoes, since the jet stream is usually associated with these phenomena.

In conclusion, then, it seems to the author that there may be an electrical effect associated with the jet stream which can be readily detected by as simple a device as a radioactive collector and a suitable sensitive current indicator or recorder.

However, before definite conclusions are drawn, observations at other locations around the country should be made to determine more definitely whether the electrical effects observed at Schenectady apply generally. It is suggested that a network of such instruments might be useful for continuously checking on the location of jet streams. Such information might be useful in detecting the possibilities of tornadoes, thunderstorms, turbulence, and general precipitation, since all appear to be related to the effects of the jet stream.

The author has now found that a General Electric photoelectric recorder having a sensitivity of 0.266 microampere shunted to read 0.50 microampere full scale is about the right sensitivity to use. Such a recorder was recently installed; it eliminates the need for an electrometer, which tends to drift and cause misleading results unless a frequent zero check is maintained.

The radioactive collector and recorder combination would probably cost in the neighborhood of $800 or $900. Although the recorder would be most desirable, cost might prohibit its general use. There is, however, an ultrasensitive d-c microammeter on the market which with the radioactive collector might cost $150 to $200. Readings on the meter every hour or so would give some idea of the magnitude of the fair-weather current, and any general increases due to the jet stream could be readily detected.

It is not presumed that the results presented here prove conclusively that a relation exists between atmospheric electrical activity and the jet stream. However, in view of the present-day interest in the jet stream and the ways of detecting it, it was thought that our findings at Schenectady should be made known as soon as possible, with the hope that similar observations might be made in other parts of the country. If the relation is real, then such observations made regularly at many points should be of great value to forecasters and others concerned with high-velocity winds in the high atmosphere.

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