U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

AD-A028 876

Reduction, Analysis and Interpretation of Photographic Data

GCA Corp.

May 1976

244133

ADA028876

REDUCTION, ANALYSIS AND INTERPRETATION OF PHOTOGRAPHIC DATA

by

John F. Bedinger

GCA CORPORATION
GCA/TECHNOLOGY DIVISION
Bedford, Massachusetts

FINAL REPORT

September 1975 through March 1976

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-76-0102	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) REDUCTION, ANALYSIS AND INTERPRETATION OF PHOTOGRAPHIC DATA		5. TYPE OF REPORT & PERIOD COVERED Final Report Sept. 1975 through March 1976
		6. PERFORMING ORG. REPORT NUMBER GCA-TR-76-1-A
7. AUTHOR(s) John F. Bedinger		8. CONTRACT OR GRANT NUMBER(s) F19628-76-C-0062
9. PERFORMING ORGANIZATION NAME AND ADDRESS GCA Corporation GCA/Technology Division Bedford, Massachusetts 01730		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 76351405
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory Hanscom AFB, Massachusetts 01731 Contract Monitor: W. K. Vickery/LKC		12. REPORT DATE May 1976
		13. NUMBER OF PAGES 53
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

During Project Aladdin, June 1974 at Wallops Island, measurements of thermospheric winds were obtained from observations of the motions of chemical vapors released from seven sounding rockets beginning in the evening twilight of 28 June and extending past noon on 30 June. The release materials were TMA during twilight and night and lithium during twilight and the day. The wind data obtained from those releases are contained in the report. Most of the data reported here were obtained photographically from on board the NASA Lear Jet flying

at 40,000 feet. Auxiliary information was supplied by a ground based tracking radar and an on board navigation system. Data from two of the releases were obtained from ground sites.

PREFACE

The data presented in this report resulted from a cooperative program in which AFGL supplied the rocket vehicles and the data reduction process and NASA supported the observations from the aircraft.

The author wishes to acknowledge the considerable aid in the data reduction which was patiently supplied by Ms. Linda Vincent and Dr. M.T. Mills of the Technology Division, GCA Corporation.

CONTENTS

ILLUSTRATIONS

Preceding page blank

ILLUSTRATIONS

TABLES

TABLES

REDUCTION, ANALYSIS AND INTERPRETATION OF PHOTOGRAPHIC DATA

1. INTRODUCTION

The purpose of this contract was the reduction of photographic recordings of chemical releases to obtain upper atmospheric wind profiles. The releases occurred in June 1974 at Wallops Island, Virginia during Project Alladin, a large atmospheric research program sponsored jointly by AFGL and NASA. Approximately 50 sounding rockets were launched during a 27 hour period, seven of which released chemicals. The chemical releases were photographed from conventional ground sites and also from on board the NASA Lear Jet at an altitude of 40,000 ft. NASA supplied the air craft in order to circumvent the serious problem of adverse weather conditions often associated with ground sites. In addition, the use of the aircraft allowed photography of the daytime lithium releases. The reduction of the photograph data obtained with the aircraft is the primary purpose of this contract. In addition, data from a single ground site was utilized to obtain winds for two of the releases, one of which was not covered by the aircraft.

An account of the observational procedures utilized on the aircraft is contained in the Final Report, Phase II, of NASA Contract No. NAS2-7998. The methods of photography and data reduction are discussed in the final reports on NASA Contracts NASW-2308 and NASW-2450. Briefly, the technique allows the use of a single aircraft to obtain the required photographs. Auxiliary data are obtained from an inertial navigation system (INS) aborad the aircraft, and from tracking radars on the ground. The data reduction technique used for the aircraft applies equally well to conventional ground-based data (that is, to photographic observations obtained simultaneously from two or more ground sites). Further, it applies to data in the form of a temporal sequence of observations from a single ground site. Finally, it applies to data obtained by distinct ground sites at different times. These features allow the method to be used under circumstances that did not permit complete coverage by conventional ground sites as occurred during this program. The wind data obtained from the releases and pertinent information concerning each release are presented in the following sections of this report.

2. OBSERVATIONS

The chemical releases during Project Alladin occurred during the night, at twilight, and during the day. These widely varying conditions required different equipment. Kodak 2475 film in 70 mm rolls were used to record all observations from the aircraft. Standard, wide-angle lenses were used for the twilight releases, and narrow-band interference filters were added for the daytime trails. Auxiliary data from the INS onboard the aircraft were recorded in two ways: (1) on video tape from accurate digital readouts; and, (2) on an analog magnetic tape recorder. The recorded information includes the attitude angles of the aircraft (heading (H), roll (R), pitch (P)), the time, as well as pulses indicating the initiation of photographic exposure. In some instances, the recorded information is incomplete. A summary of the pertinent information for each chemical release is given in Table 1.

The aircraft did not photograph release number three at 0158 on 30 June in order that the aircraft operation could be moved from Wallops Island to Langley Field from whence the aircraft could operate under less favorable weather conditions.

Photographs of releases 2, 4, and 6 are shown in Figures 1, 2, and 3, as examples of a twilight, night and daytime release. The photographic exposures used for the various releases are given in Table 2. The aircraft location for the data utilized in the reduction contained in this report was obtained from a tracking radar and is tabulated in Tables 3 through 8.

Table 1. Project Aladdin Chemical Releases

Release Number	Vehicle Number	Launch		Attitude Angles		Comments
		Time (EDT)	Date	Digital	Analog	
1	A07.105-7	2110	6/28/74	HRP	HRP	Pre-Alladin. A/C data complete.
2	A09.301-1	2106	6/29/74	RP	HRP	A/C data complete.
3	A09.207-4	0158	6/30/74	-	-	No A/C coverage.
4	A09.301-4	0330	6/30/74	RP	HRP	A/C data complete.
5	A10.301-6	0435	6/30/74	RP	HRP	Poor chemical release. Very little data.
6	A09.105-9	0855	6/30/74	RP	HRP	A/C data good. INS problem.
7	A09.301-7	1320	6/30/74	R	HR	A/C data OK. INS problem.

Figure 1. Release No. 2, Downtrail Release of TMA During Evening Twilight

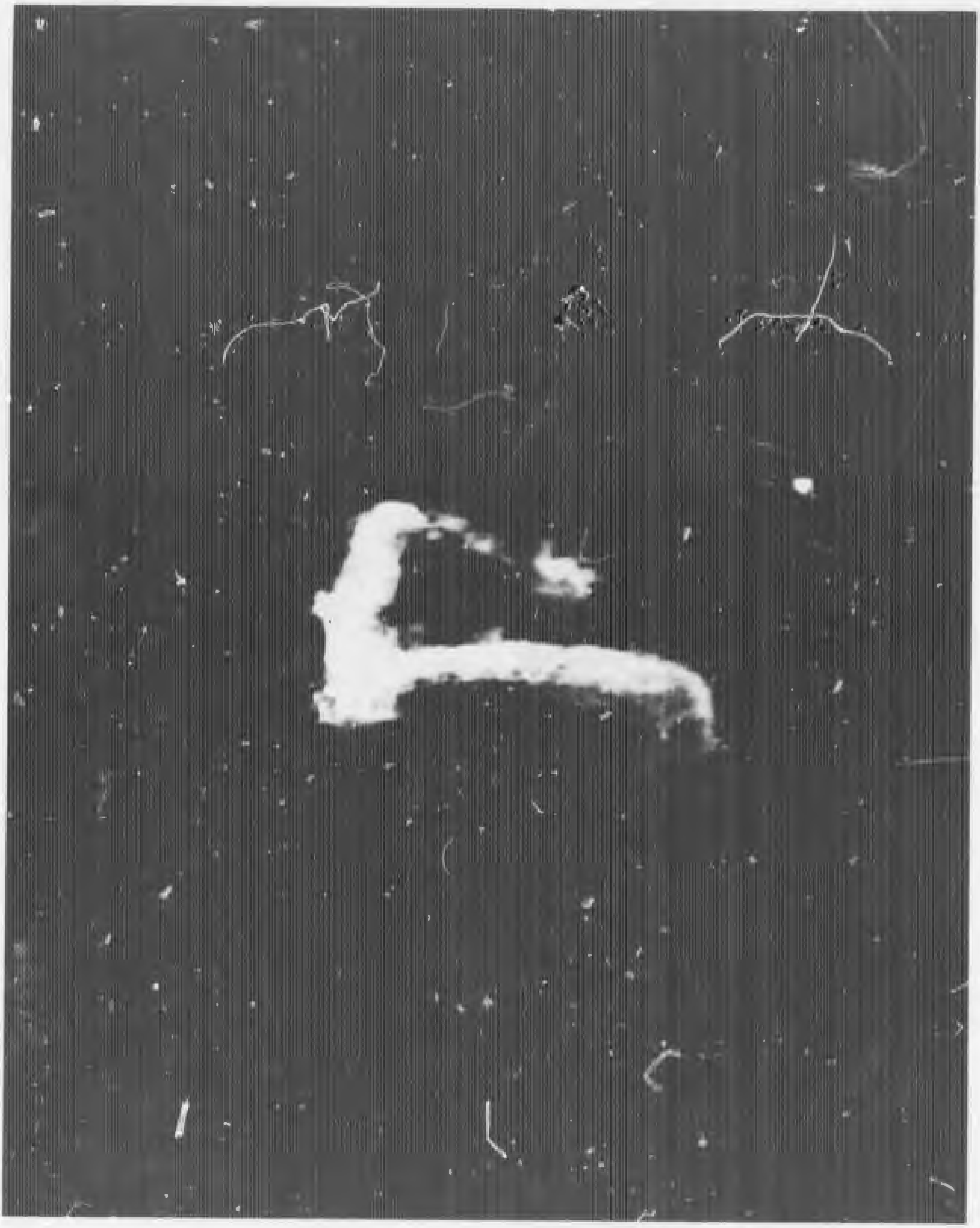

Figure 2. Release No. 4, Downtrail Release of TMA During the Night

Figure 3. Release No. 6, Uptrail Release of Lithium During the Day

Table 2. Photographic Exposures for Chemical Releases During Project Aladdin

Rocket No.			Camera #1		Camera #2		Camera #3		Camera #4	
AFCRL	NASA	Time	Stop	Exp.	Stop	Exp.	Stop	Exp.	Stop	Exp.
A0-7-105.7	D2-7285	6/28/74 2110 EDT	2.8	1/2 sec.	2.8	1 sec.	1.5	5 sec.	2.8	1 sec.
A09-301.1	D2-7290	6/29/74 2106 EDT	2.8	1/2 sec.	2.8	1 sec.	1.5	5 sec.	2.8	1 sec.
A09-301.4*	D2-7294	6/30/74 0330 EDT	1.5	5 sec.	1.5	5 sec.	1.5	1/2; 1 sec.	2.8	5 sec.
A10-301.6	D2-7291	6/30/74 0435 EDT	2.8	1/2 sec.	2.8	1 sec.	2.8	5 sec.	2.8	1 sec.
A09-105.[illegible]+	D2-7296	0855 EDT	4	1/10 sec.	4	1/10 sec.	5.6	1/10 sec.	4	1/10 sec.
A09-301.7+	D2-7297	1320 EDT	4	1/10 sec.	4	1/10 sec.	5.6	1/10 sec.	4	1/10 sec.

*Camera 1 & 2 utilized stabilized mirror system.

+All cameras were equipped with narrow band filters.

Table 3. Lear Jet Data— NASA No. D2-7285.
AFGL No. A0-7-105.7, Launch 2110 EDT, 6/28/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	21	15	02.1	35.4165	75.0365
5	21	15	26.0	35.4453	75.0871
10	21	15	56.0	35.4788	75.1527
15	21	16	26.0	35.5086	75.2172
20	21	16	56.1	35.5388	75.2818
25	21	17	26.1	35.5710	75.3452
30	21	17	56.1	35.6037	75.4093
35	21	18	26.1	35.6067	75.4720
40	21	18	56.1	35.6674	75.5323
45	21	19	26.2	35.6992	75.5993
50	21	19	56.2	35.7306	75.6648
55	21	20	26.2	35.7628	75.7308
60	21	20	56.3	35.7959	75.7979
65	21	21	26.3	35.8295	75.8647
70	21	21	56.3	35.8650	75.9302
75	21	22	26.4	35.9053	75.9938
80	21	22	56.4	35.9523	76.0549
85	21	23	26.4	36.0038	76.1092
90	21	23	56.4	36.0568	76.1583
95	21	24	26.4	36.1032	76.2184
100	21	24	56.4	36.1513	76.2752

Table 4. Lear Jet Data— NASA No. D2-7290, AFGL No. A09-301.1, Launch 2106 EDT, 6/29/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	21	08	56	35.4722	74.7993
5	21	09	20	35.4713	74.8495
10	21	09	50	35.4761	74.9132
15	21	10	20	35.4854	74.9780
20	21	10	50	35.4956	75.0414
25	21	11	20	35.5051	75.1071
30	21	11	50	35.5179	75.1722
35	21	12	20	35.5294	75.2386
40	21	12	50	35.5431	75.3035
45	21	13	20	35.5606	75.3674
50	21	13	50	35.5852	75.4305
55	21	14	20	35.6146	75.4919
60	21	14	50	35.6446	75.5484
65	21	15	20.1	35.6769	75.6088
70	21	15	50.1	35.7135	75.6666
75	21	16	20.2	35.7534	75.7198
80	21	16	50.2	35.7915	75.7739
85	21	17	20.2	35.8323	75.8294
90	21	17	50.2	35.8719	75.8837
95	21	18	20.2	35.9067	75.9415
100	21	18	50.2	35.9375	76.0004
105	21	19	20.3	35.9667	76.0642
110	21	19	50.2	35.9931	76.1258

Table 5. Lear Jet Data—NASA No. D2-7294, AFGL No. A09-301.4, Launch 0330 EDT, 6/30/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	03	33	00.2	35.4168	74.6964
5	03	33	23	35.4145	74.7402
10	03	33	53	35.4266	74.8019
15	03	34	23	35.4611	74.8550
20	03	34	53	35.5027	74.9028
25	03	35	23	35.5449	74.9506
30	03	35	53	35.5885	74.9981
35	03	36	23	35.6304	75.0403
40	03	36	53	35.6879	75.0775
45	03	37	23	35.7408	75.1139
50	03	37	53	35.7932	75.1506
55	03	38	23	35.8454	75.1876
60	03	38	53.1	35.8998	75.2223
65	03	39	23.1	35.9540	75.2533
70	03	39	53.1	36.0123	75.2762
75	03	40	23.1	36.0739	75.2897
80	03	40	53.1	36.1368	75.2976
85	03	41	23.1	36.2001	75.3017
90	03	41	53.1	36.2641	75.3003
95	03	42	23.1	36.3283	75.2960

Table 6. Lear Jet Data— NASA No. D2-7295, AFGL No. A10-301.6, Launch 0435 EDT, 6/30/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	04	39	20	35.5543	75.0822
5	04	39	44	35.5728	75.1194
10	04	40	14	35.5962	75.1660
15	04	40	44	35.6247	75.2125
20	04	41	14		
25	04	41	44	no data	
30	04	42	14		
35	04	42	44	35.7671	75.3340
40	04	43	14	35.8127	75.3522
45	04	43	44	35.8586	75.3725
50	04	44	14	35.9053	75.3924
55	04	44	44	35.9542	75.4081
60	04	45	14	36.0056	75.4195
65	04	45	44	36.0574	75.4313
70	04	46	14	36.1081	75.4483
75	04	46	44	36.1528	75.4787
80	04	47	14	36.2034	75.4969
85	04	47	44	36.2554	75.5137
90	04	48	14	36.3092	75.5274
95	04	48	44	36.3642	75.5382

Table 7. Lear Jet Data— NASA No. D2-7296, AFGL No. A09-105.9, Launch 0855 EDT, 6/30/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	08	56	01.4	38.9386	74.5527
5	08	56	25.4	38.9242	74.4940
10	08	56	55.4	38.9047	74.4199
15	08	57	25.4	38.8831	74.3477
20	08	57	55.4	38.8603	74.2755
25	08	58	25.4	38.8351	74.2045
30	08	58	55.4	38.8056	74.1363
35	08	59	25.4	38.7722	74.0715
40	08	59	55.4	38.7380	74.0018
45	09	00	25.4	38.7046	73.9426
50	09	00	55.5	38.6683	73.8804
55	09	01	25.6	38.6294	73.8221
60	09	01	55.7	38.5855	73.7681
65	09	02	25.7	38.5396	73.7185
70	09	02	55.7	38.4940	73.6693
75	09	03	25.8	38.4467	73.6213
80	09	03	55.8	38.3979	73.5762
85	09	04	25.9	38.3484	73.5313
90	09	04	55.9	38.2989	73.4883
95	09	05	25.9	38.2481	73.4474
100	09	05	56.0	38.1955	73.4082

Table 8. Lear Jet Data— NASA No. D2-7297, AFGL No. A09-301.7, Launch 1320 EDT, 6/30/74

Frame No.	Time EDT Hr.	Min.	Sec.	Lat. Deg.	Long. Deg.
1	13	21	00	35.7944	75.6664
5	13	21	24.4	35.8037	75.7229
10	13	21	54.5	35.8208	75.7921
15	13	22	24.5	35.8431	75.8582
20	13	22	54.8	35.8688	75.9237
25	13	23	25	35.8974	75.9870
30	13	23	55.2	35.9316	76.0471
35	13	24	25.5	35.9714	76.1036
40	13	24	55.8	36.0127	76.1574
45	13	25	26	36.0585	76.2093
50	13	25	56	36.1044	76.2593
55	13	26	26.2	36.1519	76.3080
60	13	26	56.2	36.1992	76.3560
65	13	27	26.3	36.2478	76.4009
70	13	27	56.5	36.2987	76.4446
75	13	28	26.4	36.3528	76.4824
80	13	28	56.5	36.4052	76.5229
85	13	29	26.6	36.4562	76.5654
90	13	29	56.6	36.5071	76.6085
95	13	30	26.6	36.5588	76.6496
100	13	30	56.7	36.6127	76.6880

3. WIND DATA

The wind data are tabulated in Tables 9 through 15 and presented graphically in hodograph form and as height profiles of zonal and meridional components in Figures 4 through 24. All heights are in kilometers and wind speeds in meters per second. The direction is that of mass transport as is generally used in the thermosphere but is opposite to the standard meteorological designation at lower altitudes. The direction is designated positive to the east and north.

The precision of the measurements is generally 3 to 5 m/sec below 120 km and 5 to 10 m/sec above that altitude except for certain regions which are discussed separately in the following paragraphs.

Most of the errors in the reported wind speed are due to height uncertainty which is especially important in high shear regions. In such cases the end points of the shear are usually most accurately specified. Relative values are generally more accurate than those at absolute heights.

A. RELEASE NO. 1, ROCKET NO. A07.105-7 (2110 EDT, 6/28/74)

The first chemical release was a down trail of sodium and lithium vapor released during the evening twilight. The trail was photographed well from the aircraft and all auxiliary information was recorded. This trail data was utilized to provide the calibration (by means of fiduical marks) for the daytime trails. The early cessation of the vapor release prevented the obtaining of data below 110 km.

B. RELEASE NO. 2, ROCKET NO. A09.301-4 (2106 EDT, 6/29/74)

This evening twilight down trail release consisted of a puff of barium vapor, followed by a series of puffs of TMA and finally by a TMA trail. The continuous wind profile in the upper altitude range was obtained from later time photographs when the puffs had expanded to become effectively a trail. Although the aircraft heading was recorded in the less accurate analog form only, the presence of star images in all of the photographs provided good calibration and accurate wind data.

Table 9. Winds From Flight No. 1, 2110 EDT, 6/28/74

Ht, km	E, m/s	N, m/s
110	-47	-5
112	-43	0
114	-41	2
11[illegible]	-38	4
118	-34	6
120	-29	8
122	-24	10
124	-18	11
126	-14	11.5
128	-14	9
130	-14.5	6
132	-17	2
134	-25	-3
136	-30	-6
138	-35	-8
140	-40	-10
144	-47	-14
148	-54	-18
152	-62	-22
156	-68	-24
160	-73	-26
164	-75	-28
168	-75	-30
172	-73	-33
176	-72	-36

Table 10. Winds From Flight No. 2, 2106 EDT, 6/29/74

Ht, km	E, m/s	N, m/s	Ht, km	E, m/s	N, m/s
90	74	40	142	-32	-32
92	76	35	144	-35	-34
94	80	29	146	-39	-36
96	84	15	148	-43	-37
98	90	4	150	-47	-38
100	94	-4	152	-51	-39
102	99	-6	154	-55	-40
104	102	-5	156	-59	-41
106	102	10	158	-62	-40
107	98	20	160	-64	-40
108	80	29	162	-66	-39
109	40	37	164	-67	-38
110	0	39	166	-66	-37
111	-50	38	168	-66	-35
112	-90	34	170	-64	-34
113	-95	30	172	-62	-33
114	-96	27	174	-58	-31
115	-94	23	176	-55	-29
116	-90	19	178	-52	-27
118	-75	11	180	-50	-25
120	-64	5	182	-46	-23
122	-57	-1			
124	-50	-6			
126	-44	-10			
128	-39	-17			
130	-35	-19			
132	-32	-22			
134	-30	-24			
136	-29	-26			
138	-29	-28			
140	-30	-30			

Table 11. Winds From Flight No. 3, 0158 EDT, 6/30/74

Ht, km	E, m/s	N, m/s	Ht, km	E, m/s	N, m/s
90	+2	17	117	10	-41
91	-2	14	118	8	-46
92	-7	9	119	5	-50
93	-15	0	120	4	-52
94	-90	-12	122	3	-51
95	-122	-21	124	2	-45
96	-128	-26	126	3	-33
97	-127	-27	128	4	-30
98	-125	-26	130	7	-28
99	-120	-23	132	12	-26
100	-114	-19	134	15	-26
101	-103	-13	135	15	-25
102	-77	-5	136	14	-24
103	-50	7	138	6	-23
104	-10	30	140	-1	-24
105	13	70	142	-9	-24
106	30	74	144	-15	-26
107	40	72			
108	47	66			
109	51	59			
110	55	45			
111	55	28			
112	51	12			
113	43	-2			
114	30	-15			
115	18	-26			
116	12	-34			

Table 12. Winds From Flight No. 4, 0330 EDT, 6/30/74

Ht, km	E, m/s	N, m/s
85	-4	8
86	4	3
87	11	-4
88	20	-20
89	30	-28
90	33	-32
91	32	-30
92	20	20
92.5	0	54
93	-30	56
94	-39	54
95	-40	50
96	-43	40
97	-44	31
98	-45	26
99	-46	23
100	-44	20
101	-38	13
102	-25	5
102.5	-10	-0
103	9	-2
103.5	40	-4
104	48	-7
105	55	-10
106	60	-14
107	66	-16
108	68	-19
109	66	-22
110	60	-24
111	50	-26

Table 12 (continued). Winds From Flight No. 4, 0330 EDT, 6/30/74

Ht, km	E, m/s	N, m/s
112	38	-32
113	30	-39
114	22	-60
115	22	-65
116	23	-69
117	24	-71
118	28	-73
119	32	-74
120	38	-75
121	44	-76
122	49	-76
123	54	-77
124	60	-78
125	64	-79

Table 13. Winds From Flight No. 5, 0435 EDT, 6/30/74

Ht, km	E, m/s	N, m/s
150	-135	-95
160	-130	-106
170	-125	-116
180	-117	-128
190	-108	-138
200	-100	-145

Table 14. Winds From Flight No. 6, 0855 EDT, 6/30/74

Ht, km	E, m/s	N, m/s	Ht, km	E, m/s	N, m/s
95	10	-5	120	-123	-22
96	11	-8	121	-132	-11
97	12	-11	122	-137	-7
98	13	-15	123	-140	-6
99	14	-20	124	-139	-16
100	16	-27	125	-137	-23
101	18	-35	126	-135	-27
102	22	-44	127	-132	-28
102.5	25	-60	128	-127	-26
103	30	-78	129	-122	-18
104	50	-92	130	-112	-9
104.5	64	-95	131	-90	-5
105	68	-97	132	-74	-3
106	74	-102	133	-65	-1
107	77	-105	134	-61	0
108	76	-107	135	-58	0
109	72	-110	137	-55	-2
110	64	-110	140	-53	-3
111	50	-108			
112	22	-104			
113	-13	-98			
114	-42	-94			
115	-65	-82			
116	-81	-67			
117	-93	-57			
118	-102	-46			
119	-113	-34			

Table 15. Winds From Flight No. 7, 1320 EDT, 6/30/74

Ht, km	E, m/s	N, m/s	Ht, km	E, m/s	N, m/s
90	60	25	117	88	132
91	63	23	118	93	131
92	64	20	119	96	130
93	66	18	120	97	129
94	67	15	121	97	126
95	67	13	122	96	123
96	67	11	123	94	119
97	64	8	124	91	115
98	58	7	125	88	112
99	40	5	126	83	108
100	18	4	127	78	104
101	8	2	128	72	98
102	0	2	129	68	90
103	-5	1	130	62	84
104	-9	1	131	55	77
105	-12	0	132	49	71
106	-13	1	133	43	65
107	-14	10	134	39	59
108	-13	25	135	35	54
109	-12	60	136	32	49
110	-7	85	137	30	45
111	0	105	138	29	42
112	8	118	139	28	39
113	15	124	140	27	37
114	30	128	145	25	30
115	55	131	150	24	27
116	76	132	155	26	28

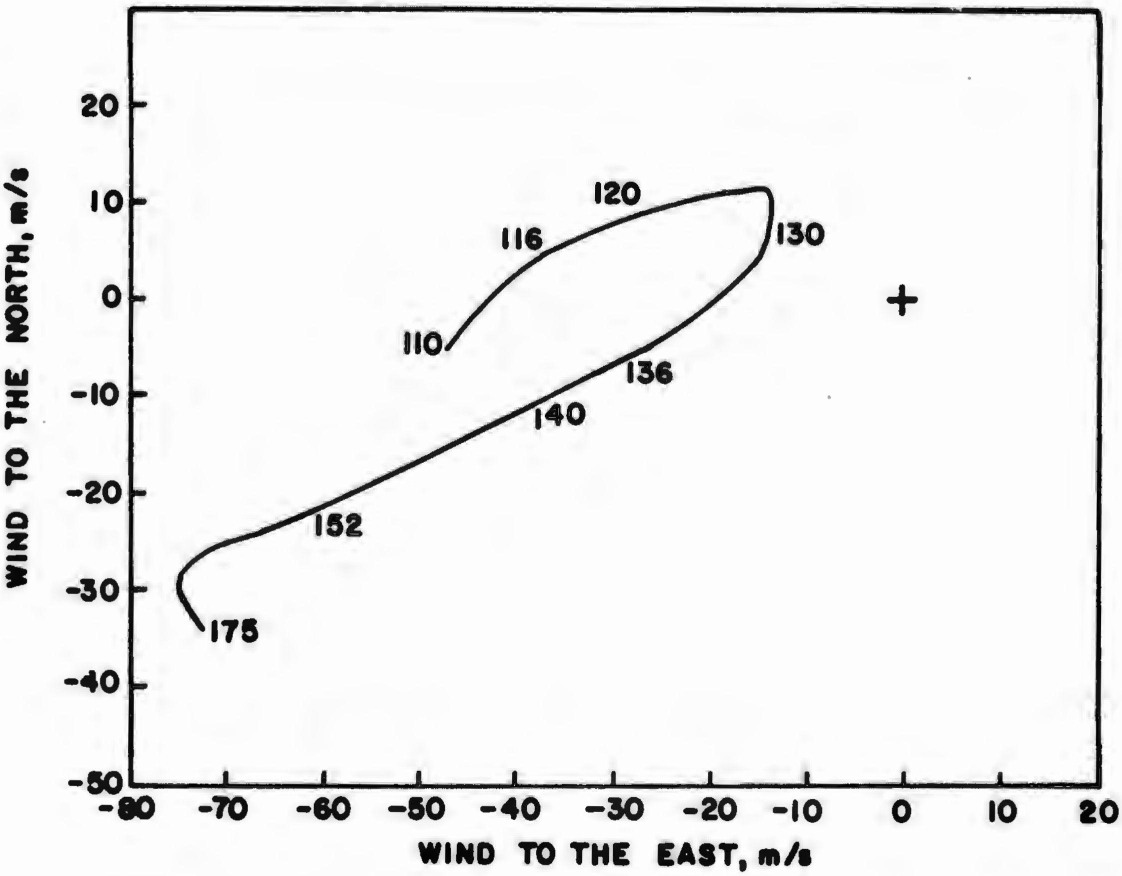

Figure 4. Hodograph of Winds from Flight No. 1, 2110 EDT, 6/28/74.

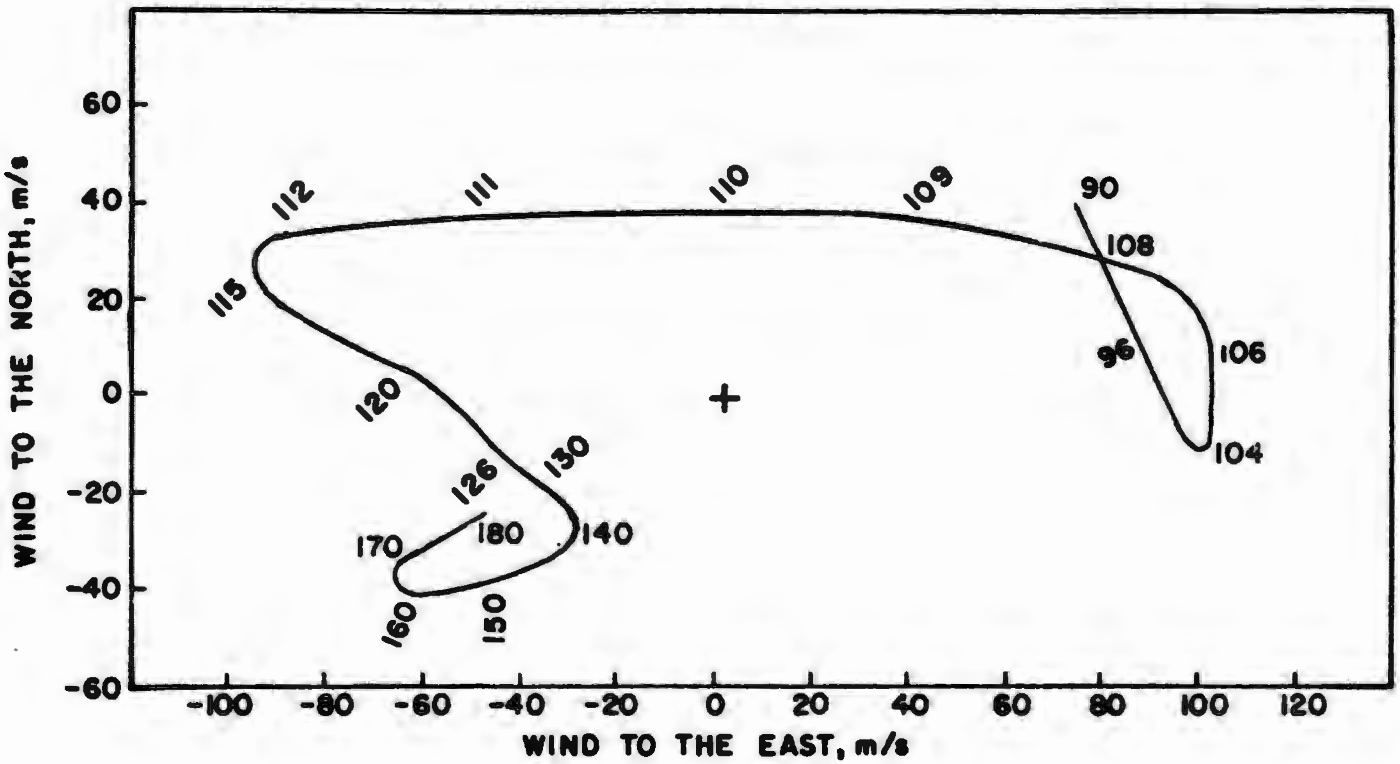

Figure 5. Hodograph of Winds from Flight No. 2, 2106 EDT, 6/29/74.

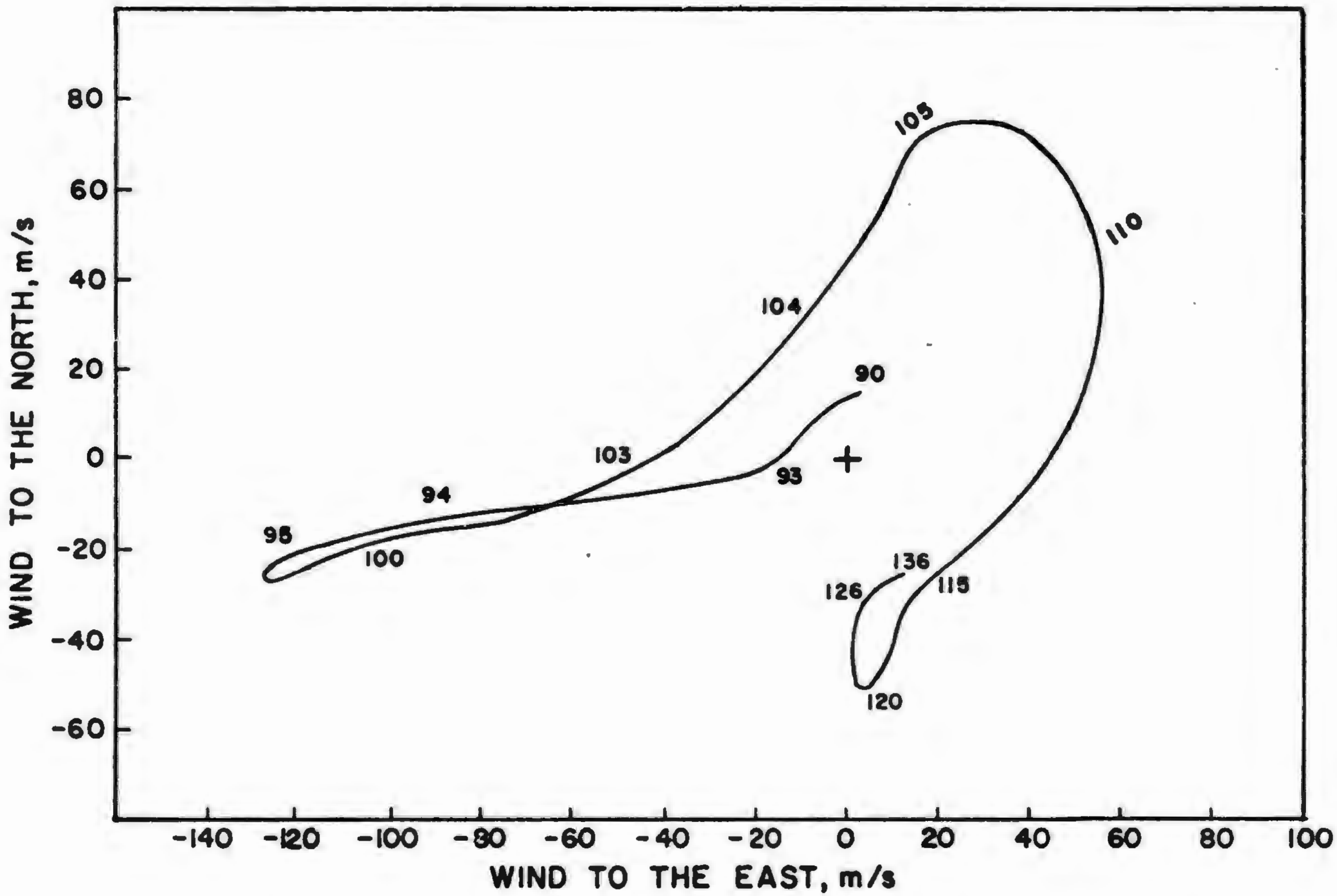

Figure 6. Hodograph of Winds from Flight No. 3, 0158 EDT, 6/30/74.

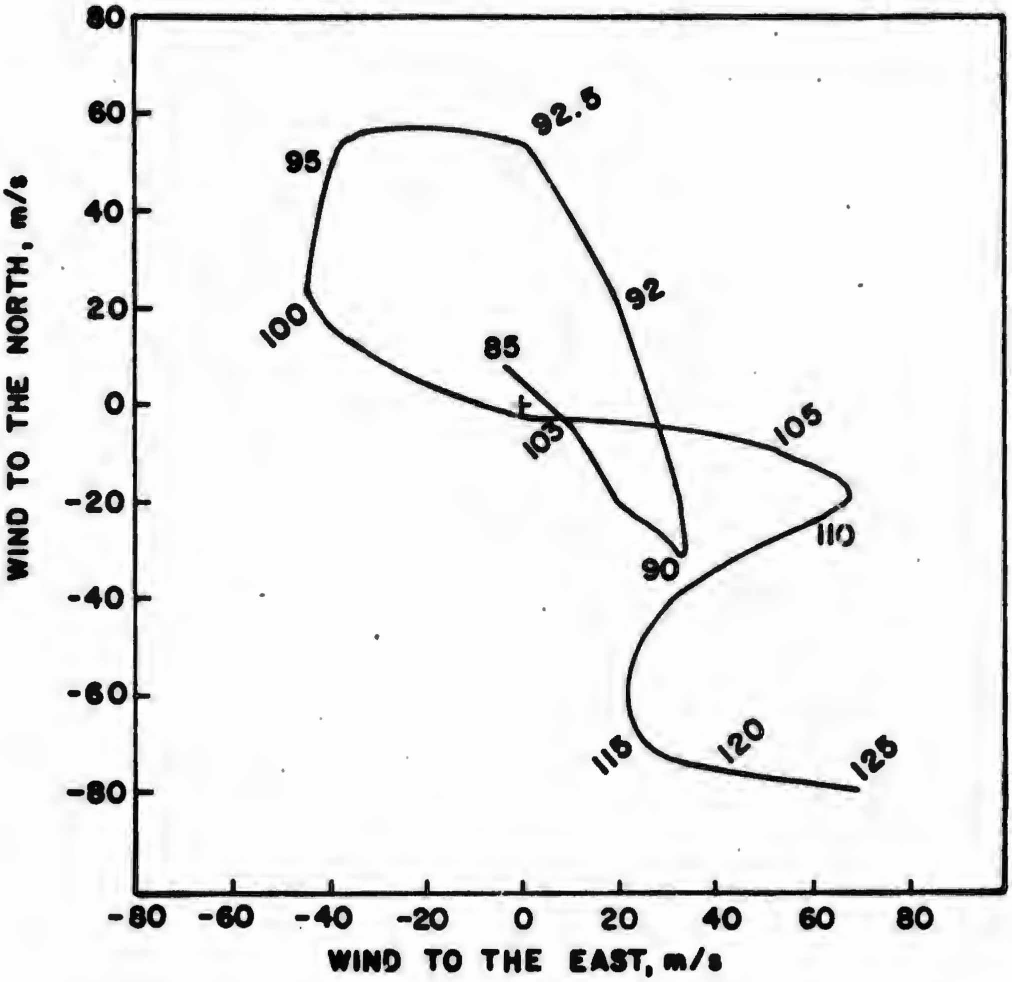

Figure 7. Hodograph of Winds from Flight No. 4, 0330 EDT, 6/30/74.

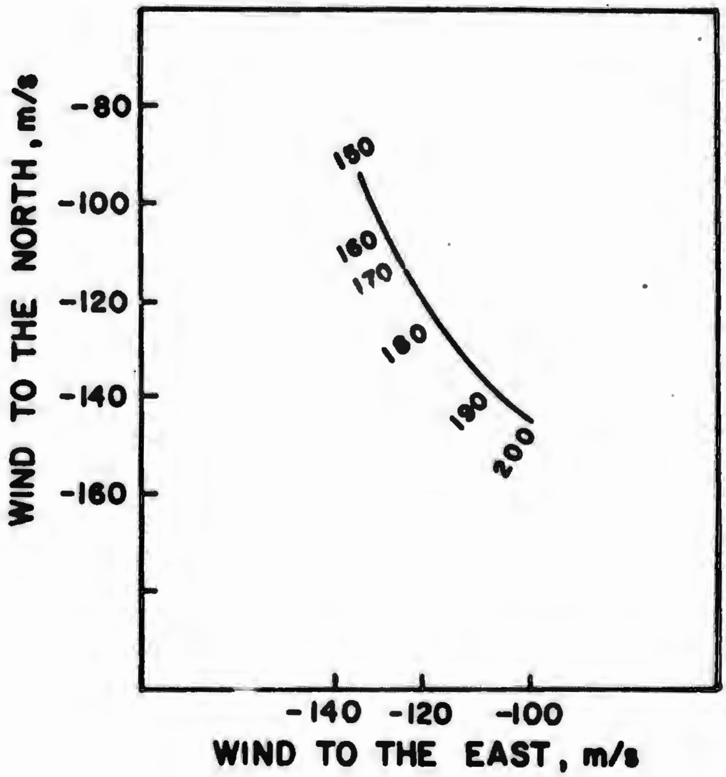

Figure 8. Hodograph of Winds from Flight No. 5, 0435 EDT, 6/30/74.

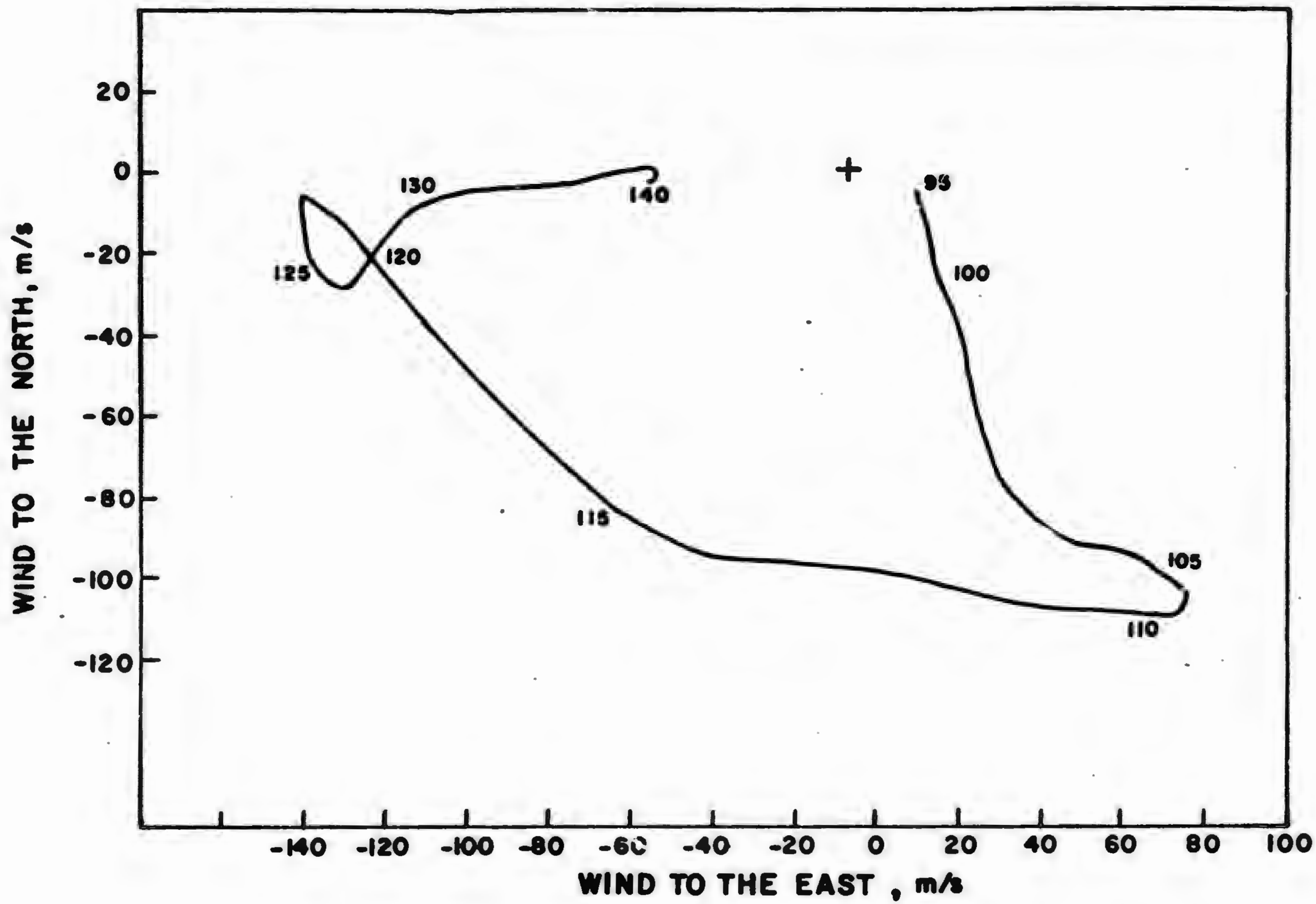

Figure 9. Hodograph of Winds from Flight No. 6, 0855 EDT, 6/30/74.

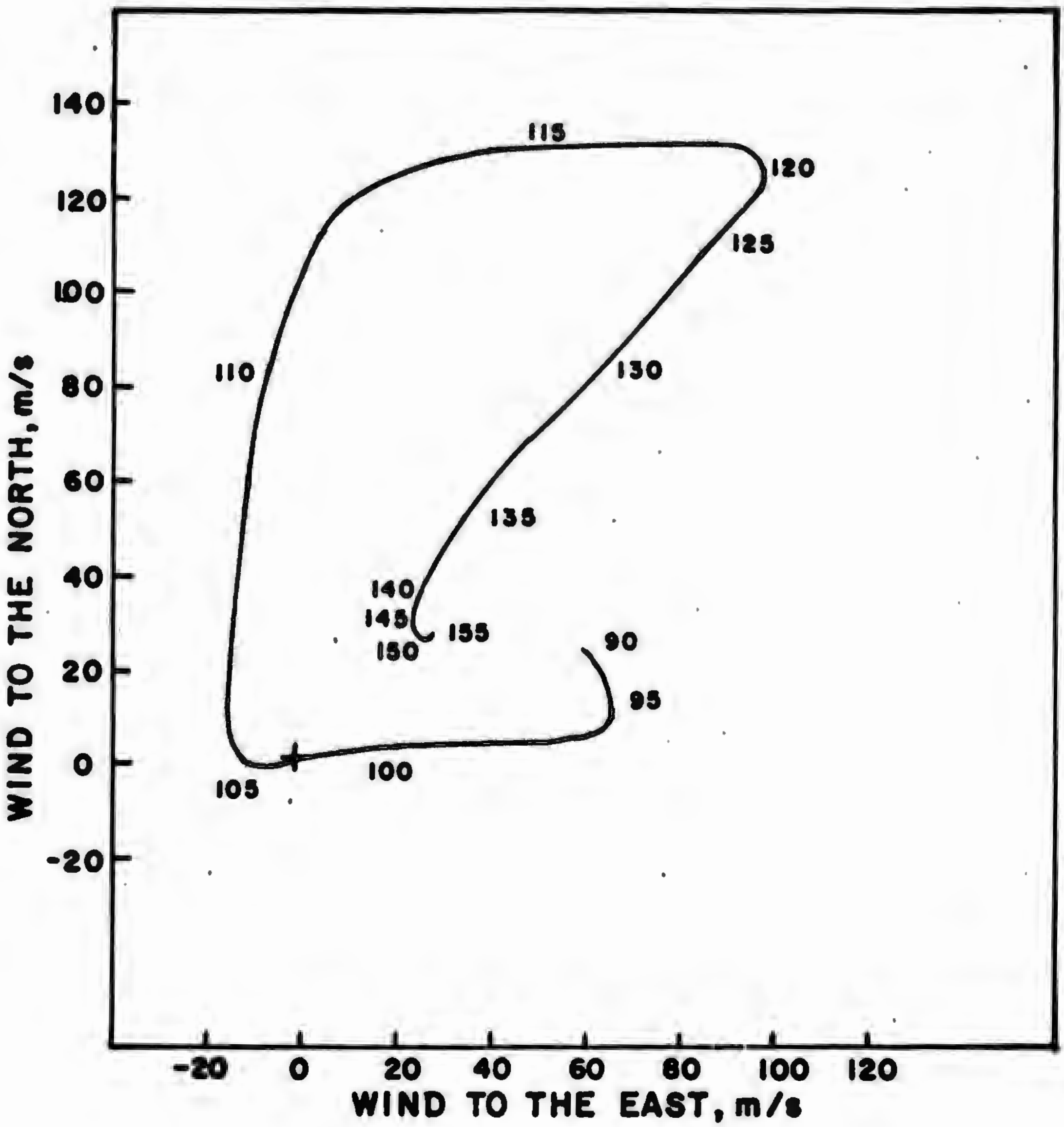

Figure 10. Hodograph of Winds from Flight No. 7, 1320 EDT, 6/30/74.

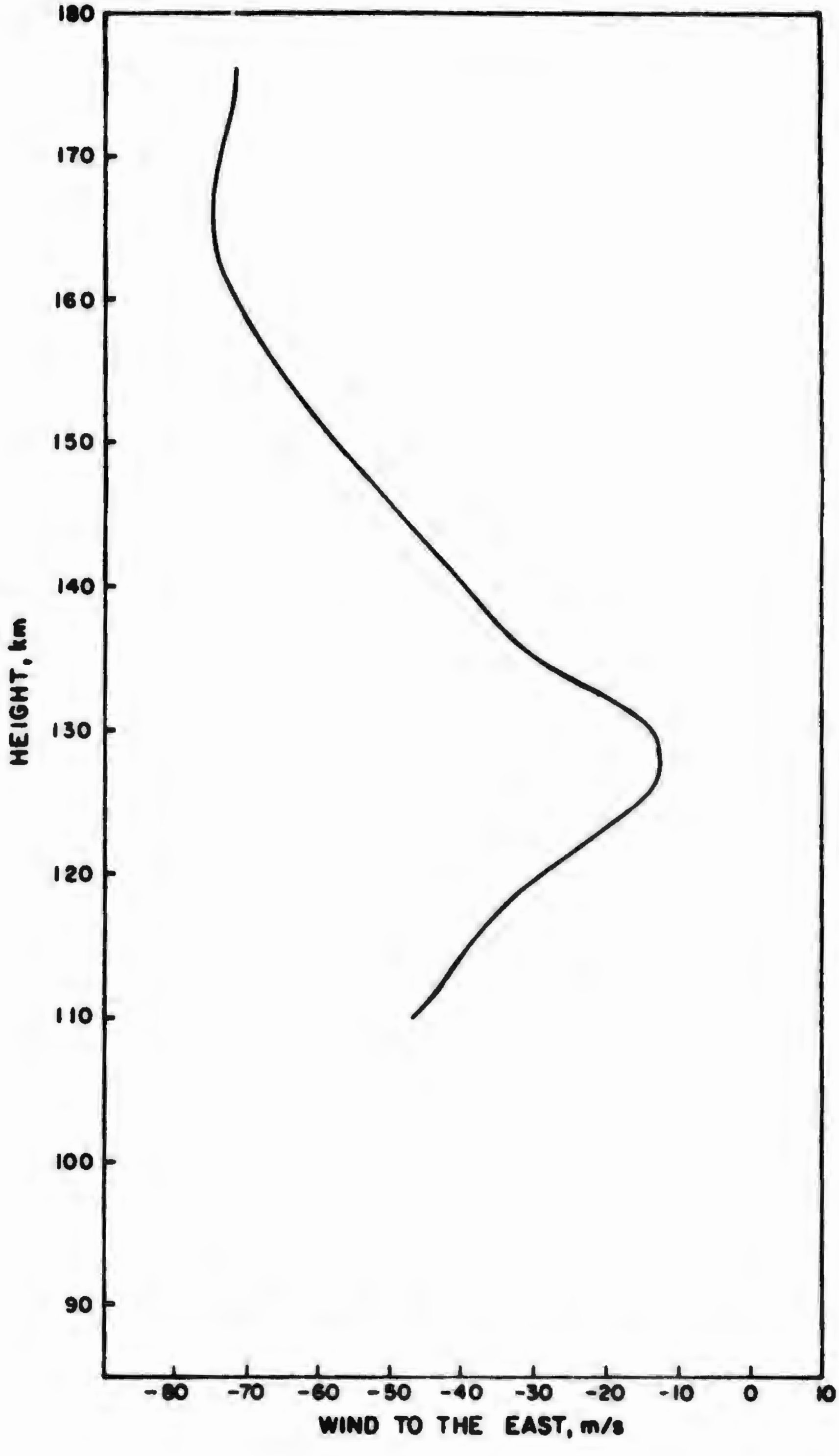

Figure 11. Height Profile of Eastward Winds From Flight No. 1

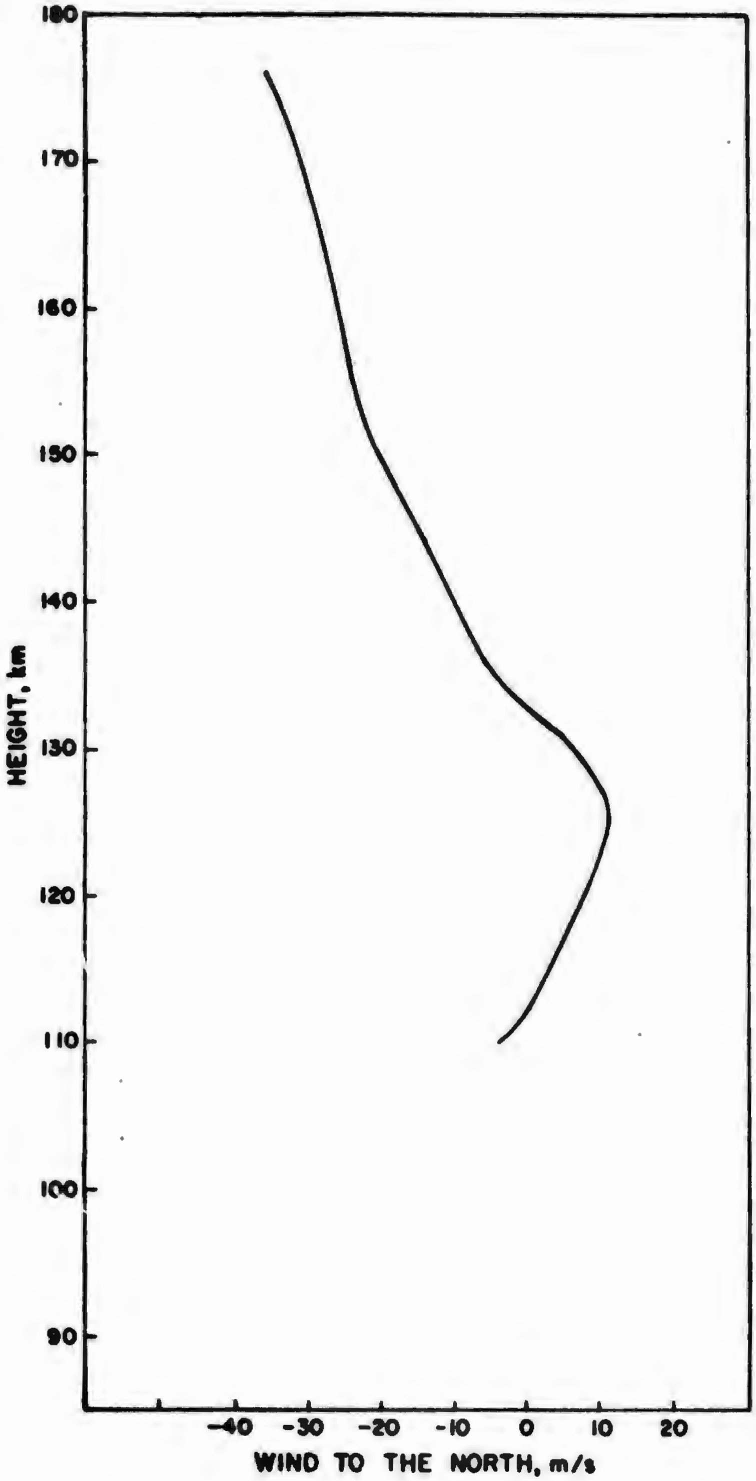

Figure 12. Height Profile of Northward Winds From Flight No. 1

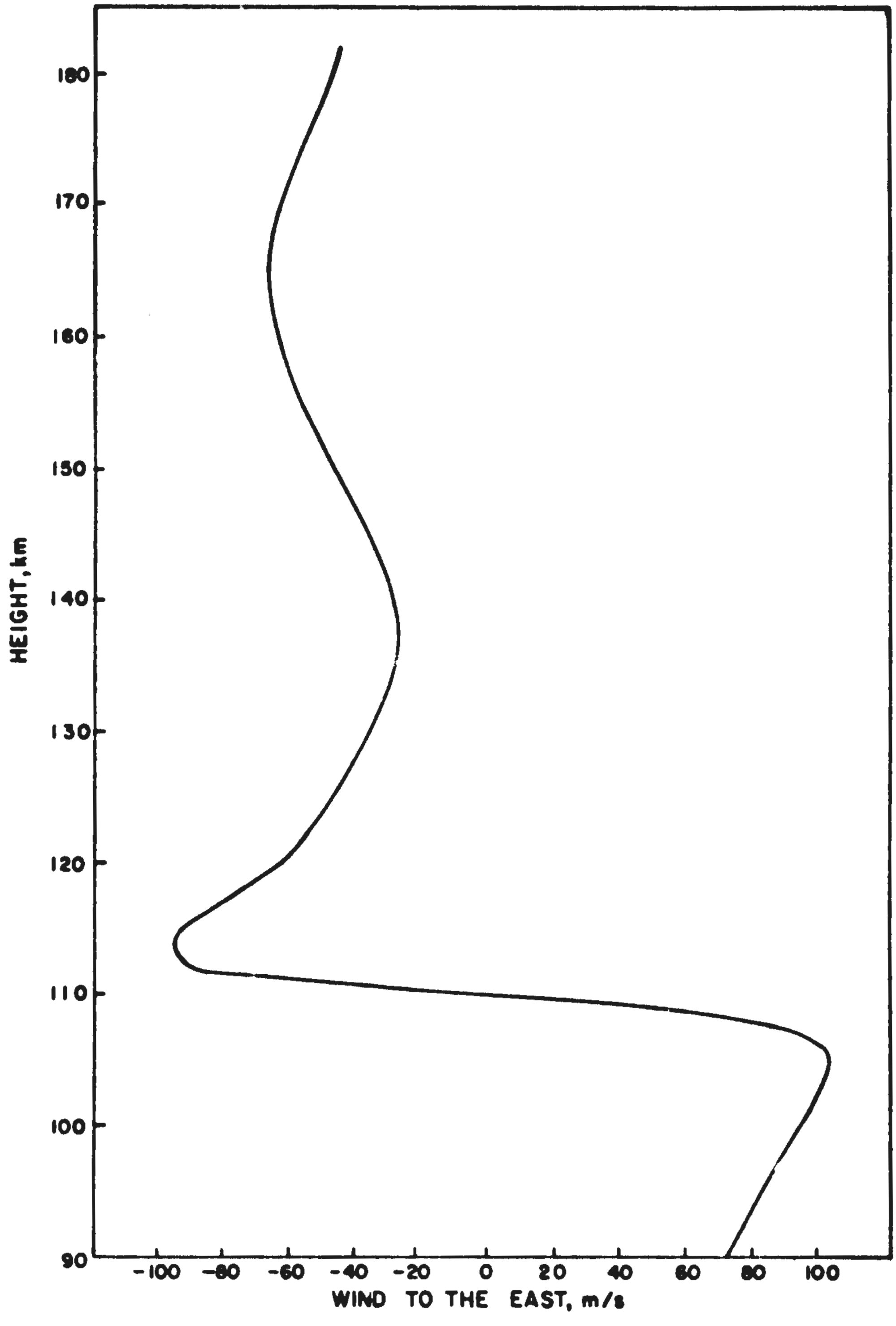

Figure 13. Height Profile of Eastward Winds From Flight No. 2

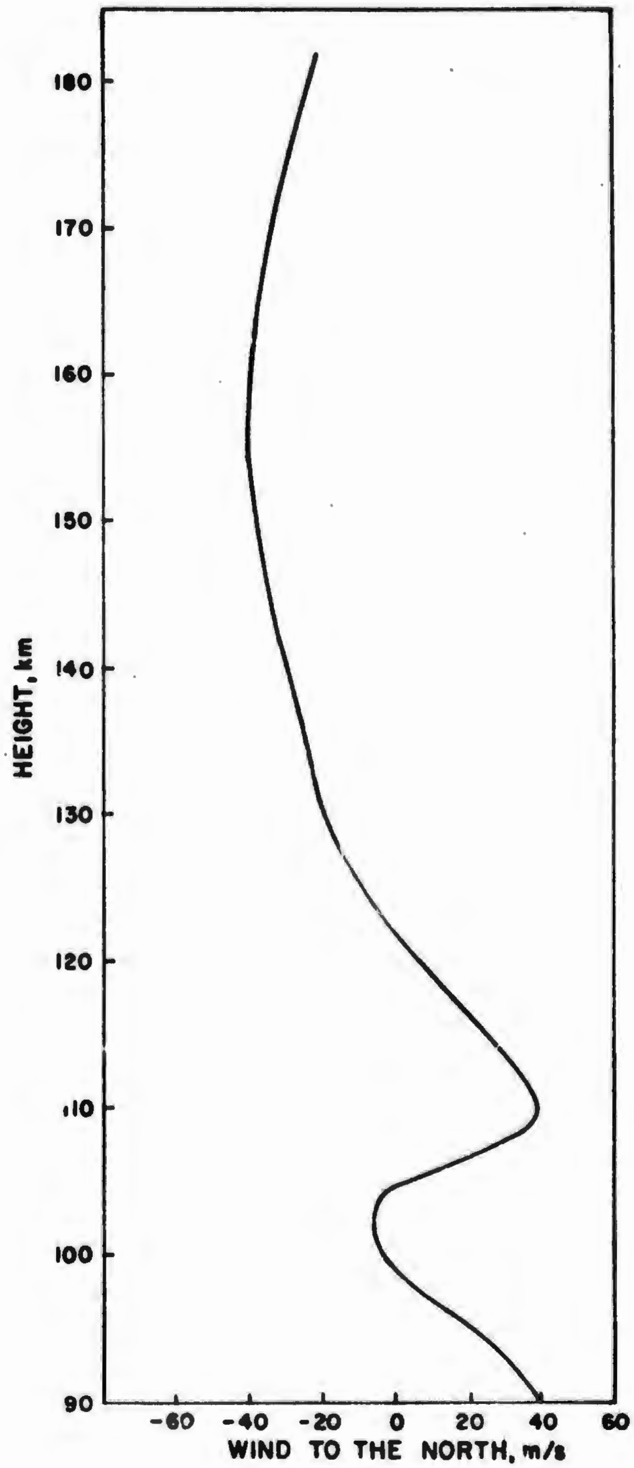

Figure 14. Height Profile of Northward Winds From Flight No. 2

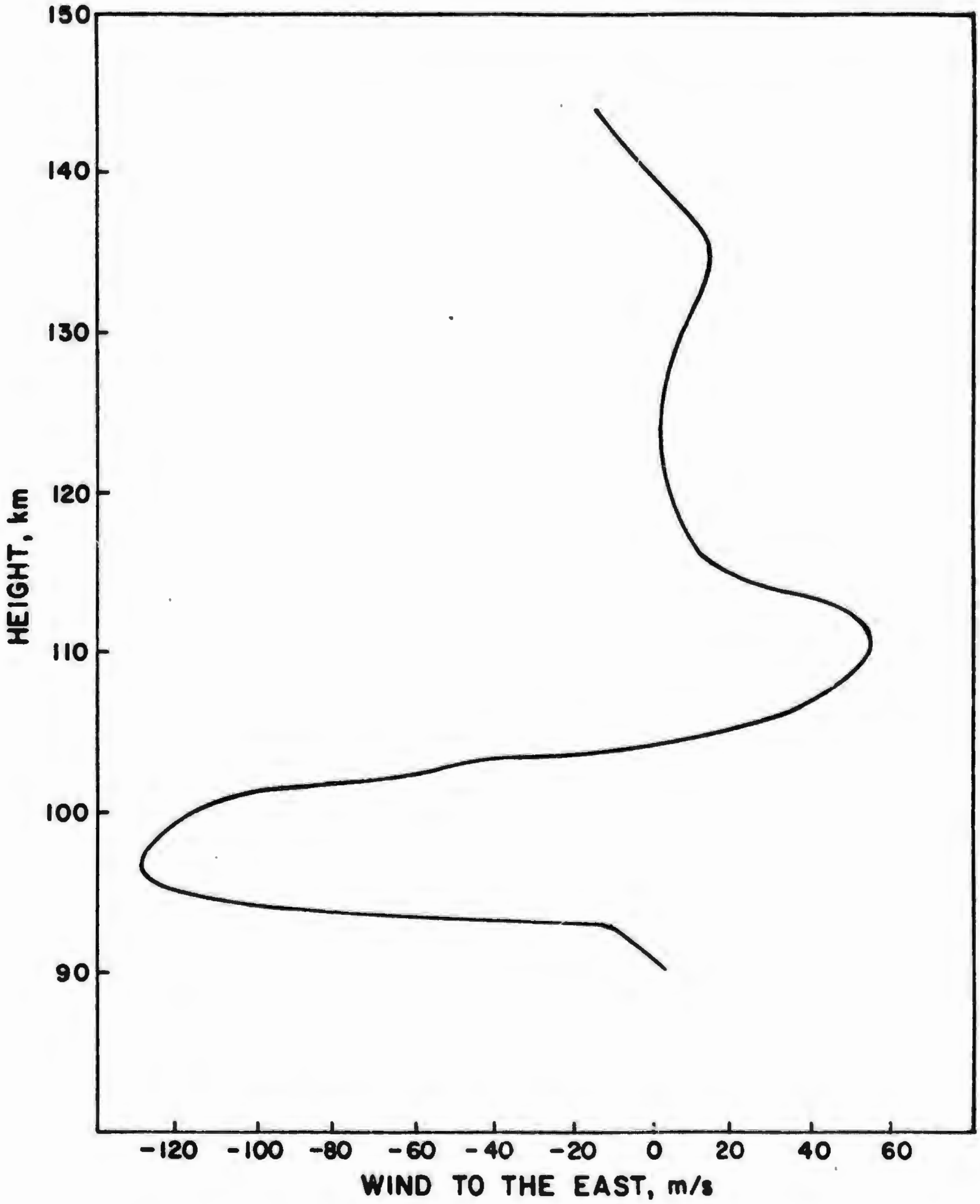

Figure 15. Height Profile of Eastward Winds From Flight No. 3

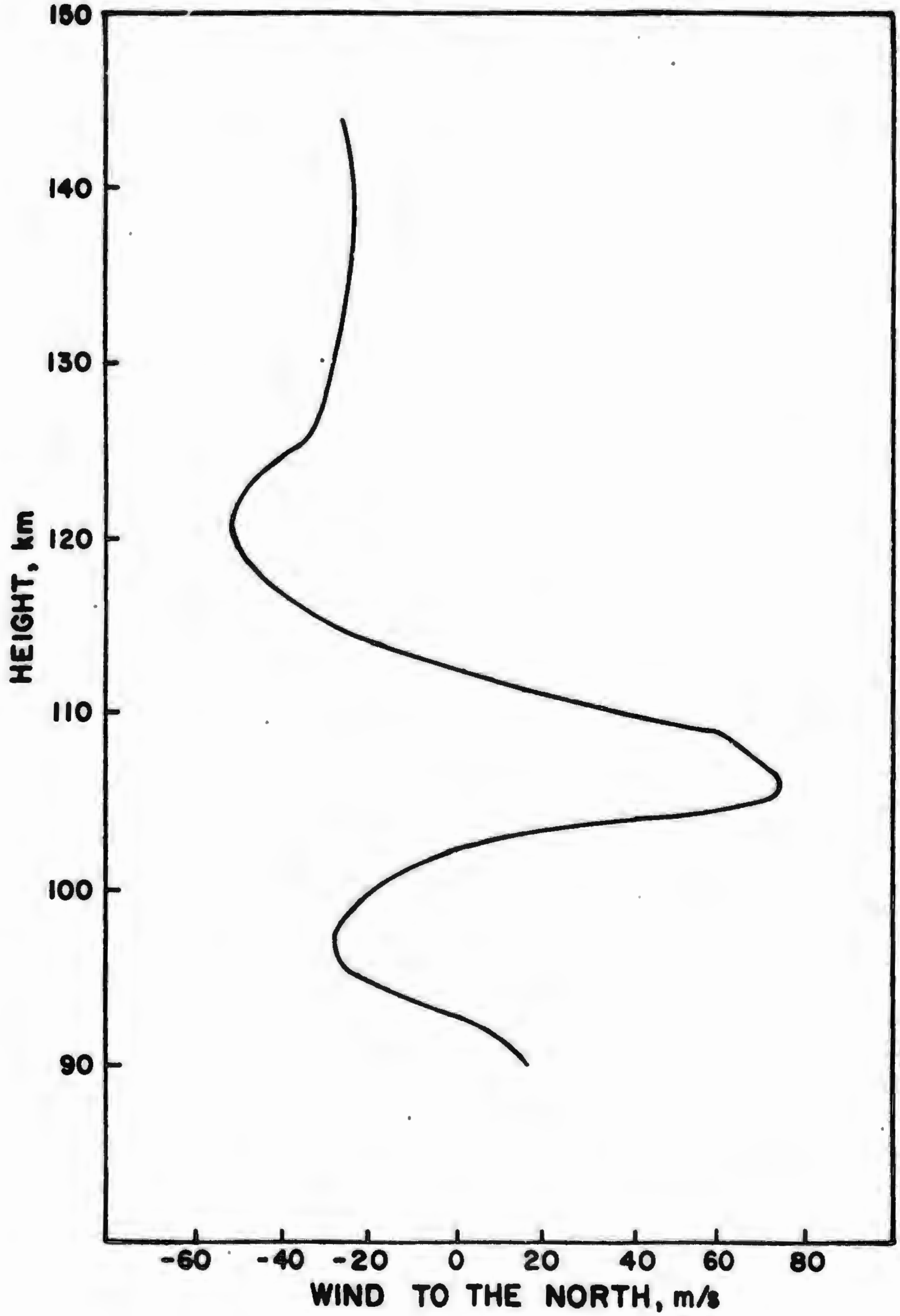

Figure 16. Height Profile of Northward Winds From Flight No. 3

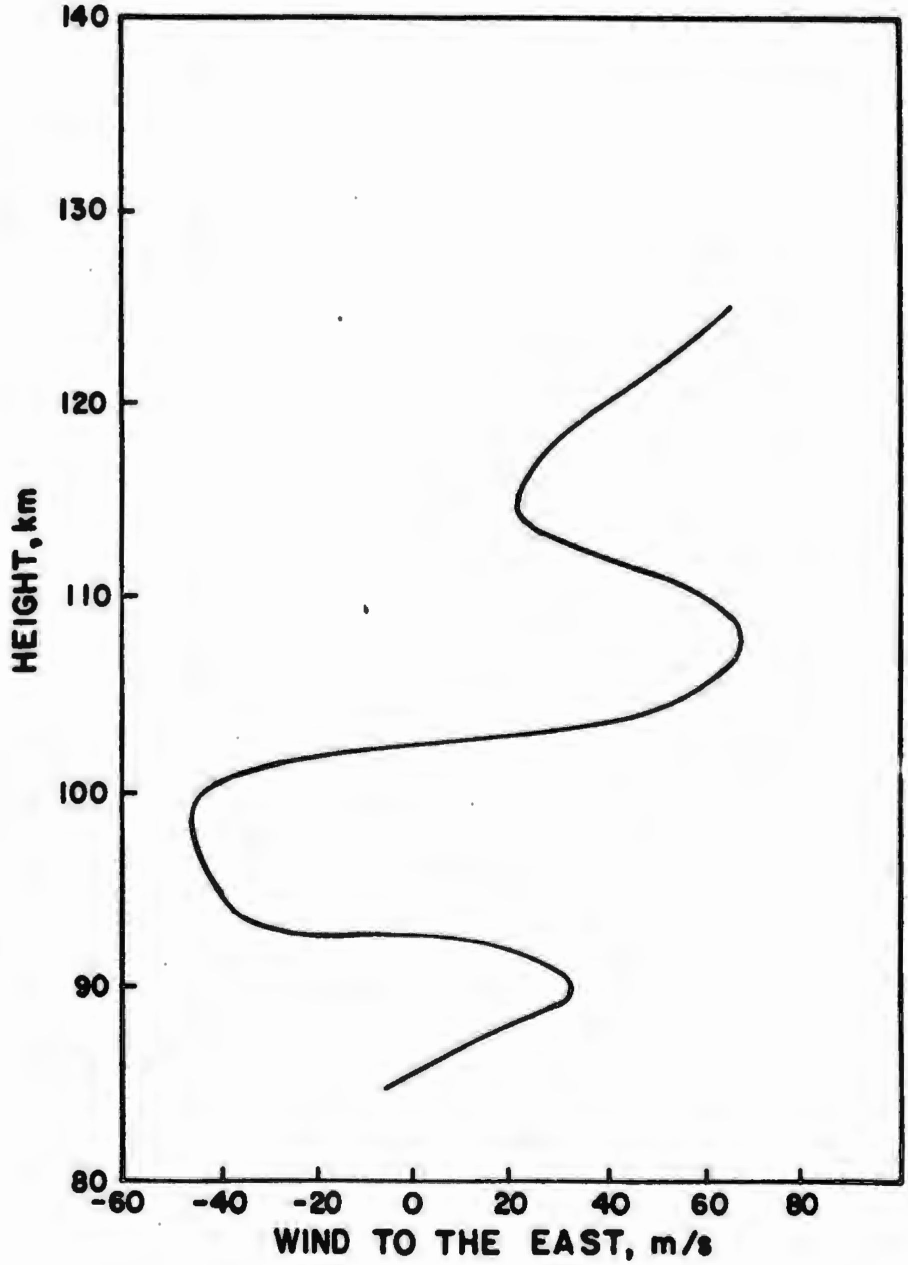

Figure 17. Height Profile of Eastward Winds From Flight No. 4

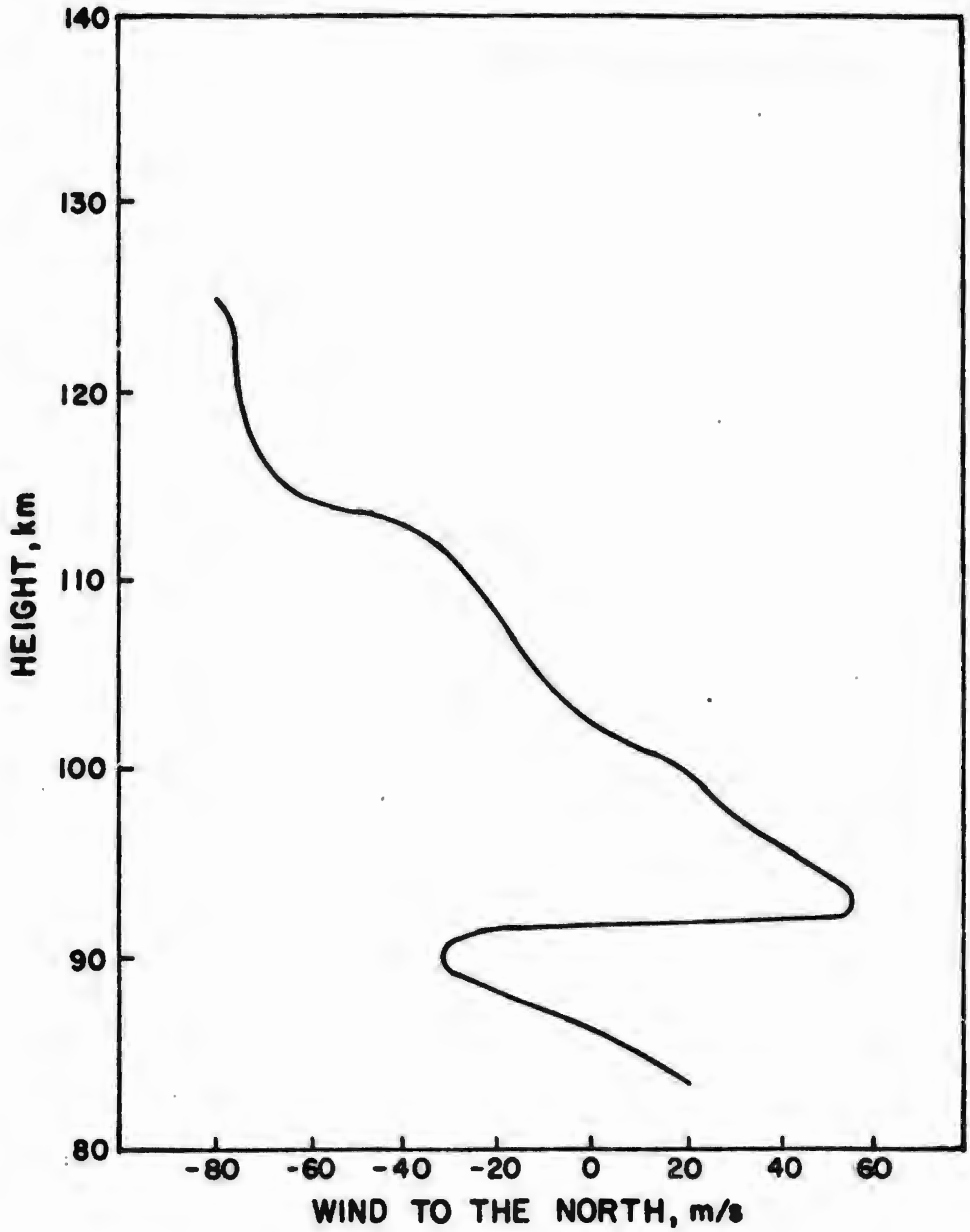

Figure 18. Height Profile of Northward Winds From Flight No. 4

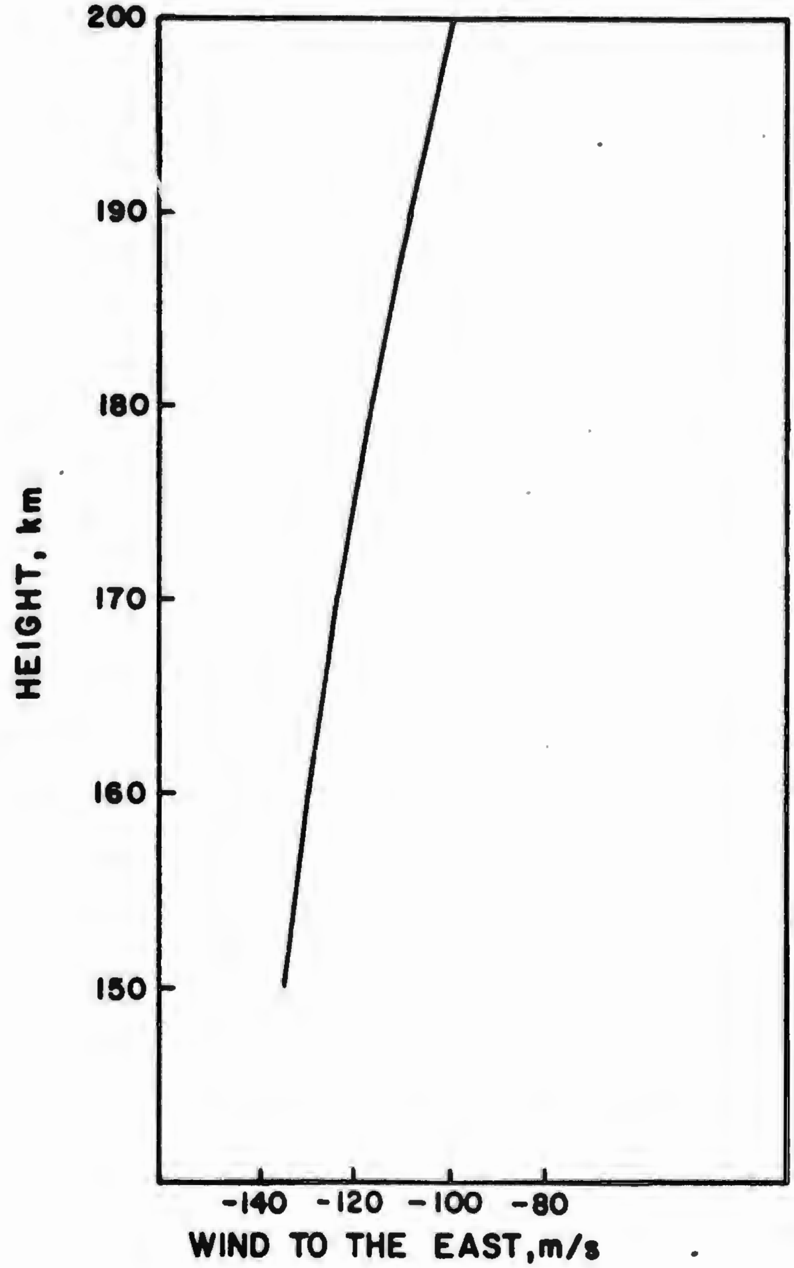

Figure 19. Height Profile of Eastward Winds From Flight No. 5

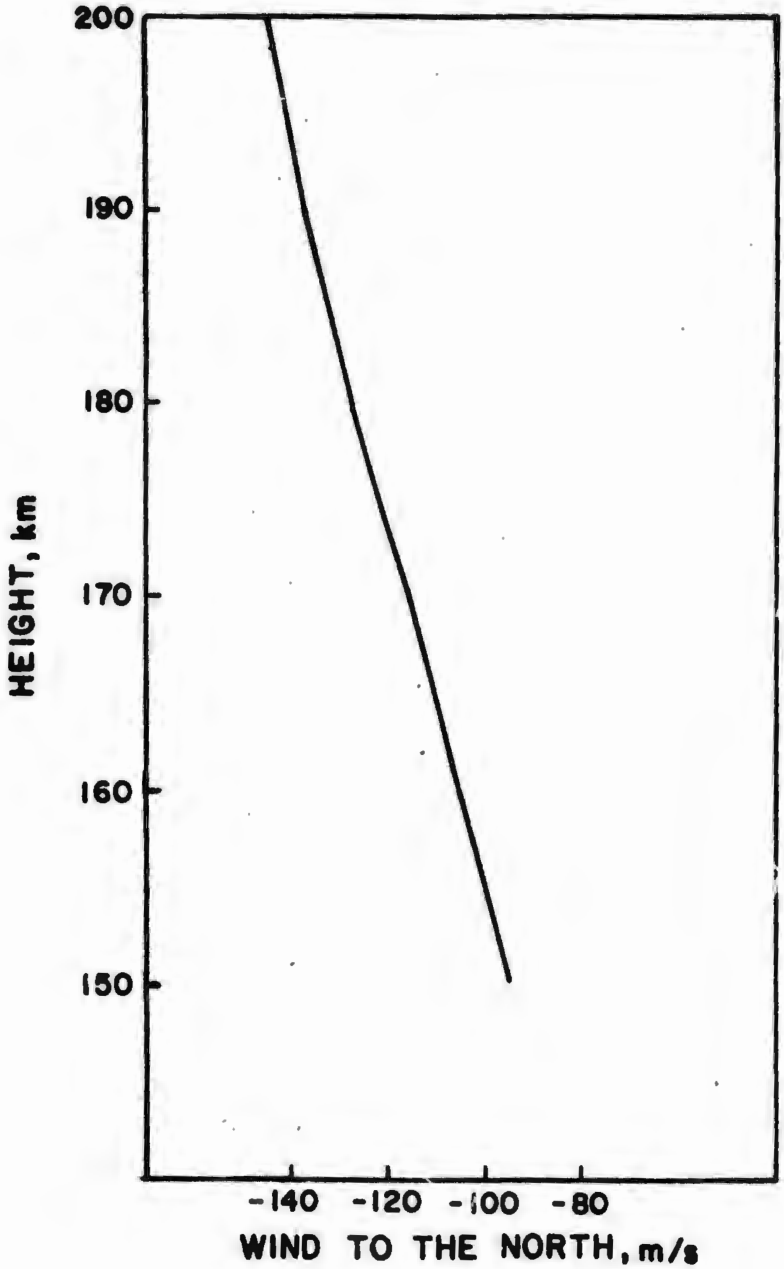

Figure 20. Height Profile of Northward Winds From Flight No. 5

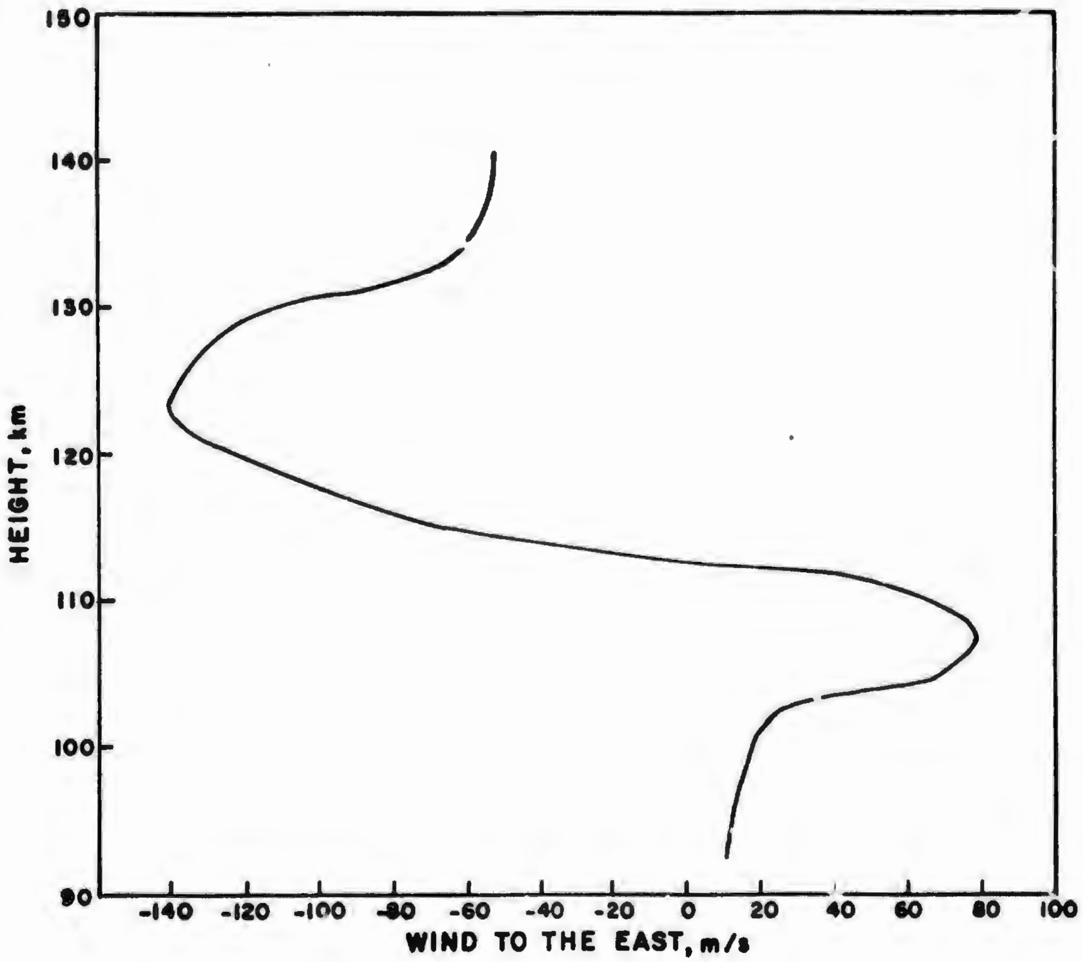

Figure 21. Height Profile of Eastward Winds From Flight No. 6

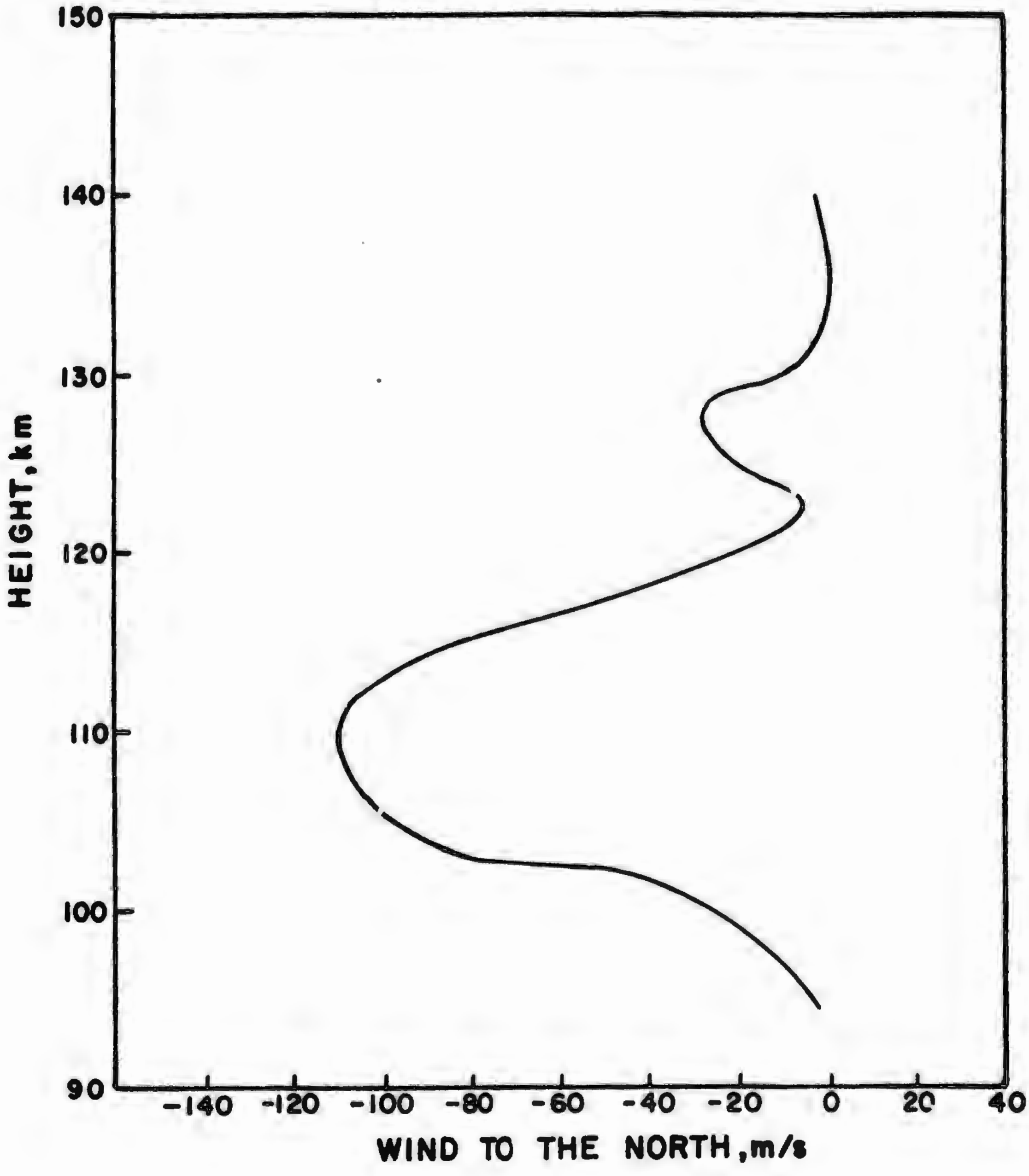

Figure 22. Height Profile of Northward Winds From Flight No. 6

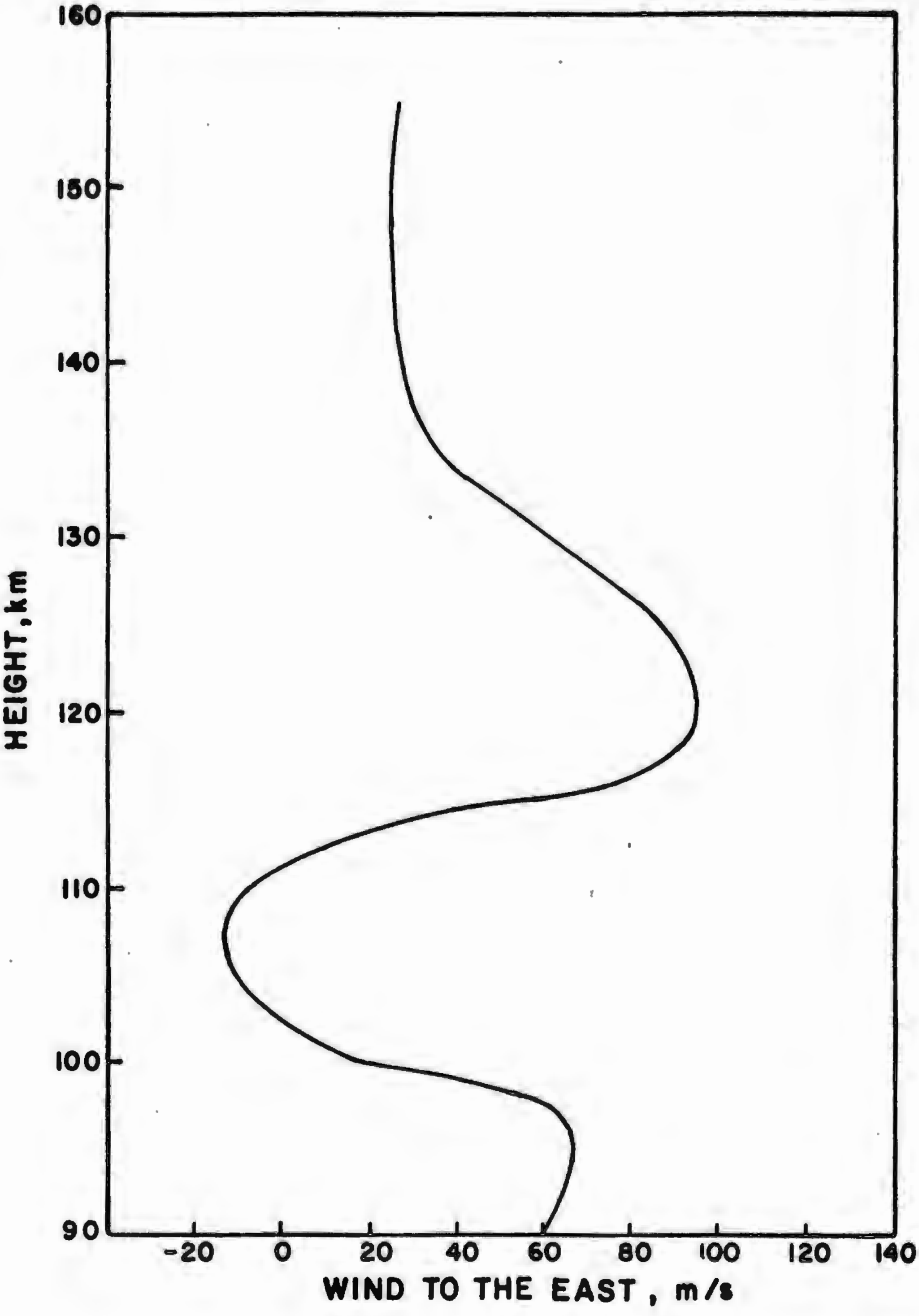

Figure 23. Height Profile of Eastward Winds From Flight No. 7

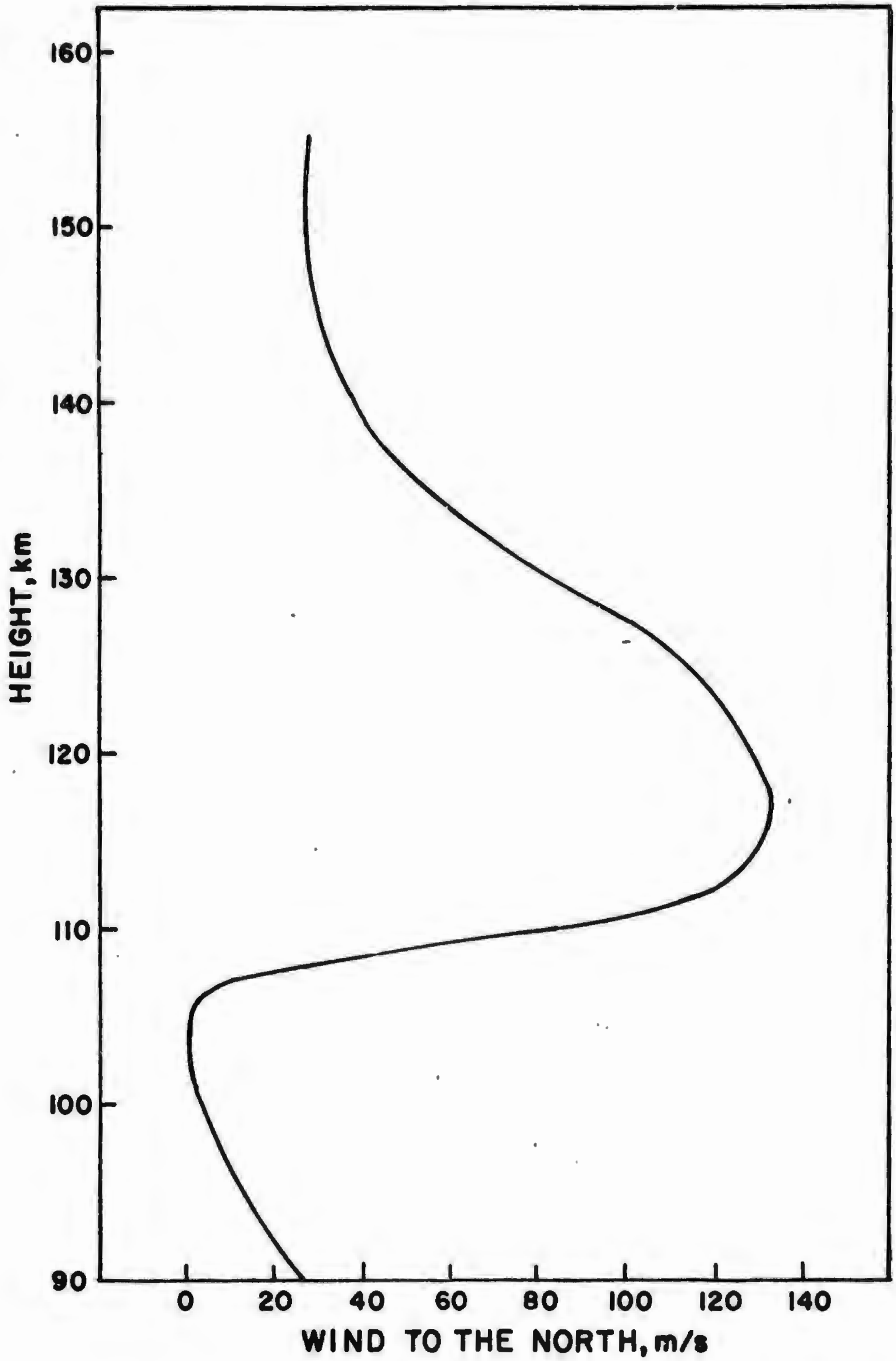

Figure 24. Height Profile of Northward Winds From Flight No. 7

C. RELEASE NO. 3, ROCKET NO. A09.207-4 (0158 EDT, 6/30/74)

This down trail of TMA was not photographed from the aircraft. The wind data were obtained from a series of photographs from a single ground site which were supplied by Dr. R. Roper of the Georgia Institute of Technology. The site location was given as latitude 36.722° N and longitude 75.933° W. This location is about due west of the release point and did not provide an ideal perspective for determination of the large east-west wind shear. Thus, the uncertainty in the wind speed at the farthest west point of the shear around 95 km is of the order of 10 m/sec.

D. RELEASE NO. 4, ROCKET NO. A09.301-4 (0330 EDT, 6/30/74)

This down trail release of TMA was observed well from the aircraft and the appearance of stars in all frames allowed the determination of accurate wind data. Although the wind speed was relatively small throughout the observed altitude range, there are some regions of high shear in which a small height error could produce a large uncertainty in wind speed. In general the end points of the shears are determined more accurately than intermediate points.

E. RELEASE NO. 5, ROCKET NO. A10.301-6 (0435 EDT, 6/30/74)

An imperfect release prevented the formation of this intended down trail of TMA. Photographs from the aircraft contained only a large upper release puff and a lower reentry region. However, a series of photographs supplied by Dr. Roper, taken near the launch area (latitude 37.841° N, longitude 75.485° W) recorded a dim trail descending from the upper release which allowed determination of winds between 150 to 200 km. The intermediate trail was recorded for about 3 minutes only and the lack of discernible features on the trail decreases the precision of the reduction process and uncertainty in wind speed of 20 m/sec may be appropriate for this trail data.

F. RELEASE NO. 6, ROCKET NO. A09.105-9 (0855 EDT, 6/30/74)

This up trail daytime release of lithium vapor was photographed extremely well from the aircraft. However, the reduction of data from daytime releases which have no star images require cross-calibration (by means of fiducial marks) with previous photographs containing stars and in addition the aircraft attitude must be known accurately. Unfortunately the accurate digital values of aircraft headings were not recorded and the less precise analog values were utilized. An initial uncertainty due to base line shift in the analog record was corrected by careful comparison with early time photographs in which the position of the rocket could be determined. Detailed heading adjustments for each location used were laboriously determined by an iterative trial and error process based on selfconsistency criteria and certain other relative information available from the photographs. Continuous wind data were obtained over the height range, 95 to 140, but due to the lack of precision of the heading measurement, a larger than desired uncertainty is present in the location of the zero east-west wind speed. The trail photographs, for which the time, focal length of the lens and slant range to the trail are known, verify that the east-west displacement of the trail is due to a total east-west wind of over 200 m/sec. However, the imperfection in the heading adjustment for the individual photographs cause an uncertainty of 10 to 15 m/s in some regions of shear and at extreme wind speeds.

G. RELEASE NO. 7, ROCKET NO. A09.301-7 (1320 EDT, 6/30/74)

The final release in the series was an up trail of lithium vapor around local noon. The data reduction from this release encountered the same difficulties as the previous daytime release and in addition the pitch angle of the aircraft was not recorded and the release was photographed for a short period of time. However, several early time photographs which included the rocket vehicle were used as in the reduction of the previous trail and winds were obtained over the height range 90 to 155 km. However, the uncertainty in some regions, especially the greatest northerly wind speeds, may be 15 to 20 m/s.

4. CONCLUSIONS

The results obtained during Project Aladdin dramatically demonstrated the usefulness of the aircraft method of observation of chemical releases. The difficulties associated with the recording of the auxiliary data were generally overcome during the analysis. Those difficulties were primarily due to the very short time which was available for the initial installation of the assorted equipment in the Lear Jet. Since the initial observations a much more reliable and straightforward method of recording these data has been developed and successfully utilized.

Finally, the results of the reduction of these data to determine winds indicate that continual analysis is important for several reasons. The data from this series are unique in that this is the first time that such a series has contained daytime observations. The inclusion of the daytime measurements may indicate a different order of importance of the various tidal modes when compared to previous series which contained only nighttime observations. The development of a complete temporal representation of the dynamics throughout the period is important for other reasons as well; i.e., comparison with A. E. observations at various times and with ground based sounders which integrate over varying time intervals.

Additional analysis is important also in combination with other measurements. For instance, L. G. Smith (University of Illinois) reported the observations of the most dense sporadic $\mathcal{E}$ layers that he has ever observed at night. The peak electron densities in the layers were comparable to the very dense layers which have been observed during the day but are not completely described. The analyses of previous simultaneous measurement of ionization and winds at mid-latitude have shown that the redistribution of ionization by horizontal winds can explain the development, motion, and shape of the observed ionized layers. In addition, a simple model which assumed that the layer development is diffusion limited, allowed the determination of an effective recombination coefficient which may be compared with known rates for atmospheric species. Analysis of this type would be especially instructive when applied to the very dense ionized layers which were observed during Aladdin.