INSTITUTO GEOFISICO DEL PERU

RADIO OBSERVATORIO DE JICAMARCA

REPORT ON
COORDINATED SATELLITE AND
INCOHERENT SCATTER OBSERVATIONS

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RADIO OBSERVATORIO DE JICAMARCA

OCTOBER 1975

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ABSTRACT

This document reports measurements taken at the Jicamarca Radar Observatory at Lima, Peru during the Cooperative Sounding Rocket Program. The following types of data were acquired: 1) Electron Density and Temperature 2) Vertical Plasma Drift 3) Electrojet Relative Echo Power Density 4) Electrojet Doppler Shift and Condition 5) 150 km Echoing Region.

INTRODUCTION

This document reports work carried out at the Jicamarca Radar Observatory of the Instituto Geofísico del Perú (11.95° S, 76.87°W, 2° Dip) during the Cooperative Sounding Rocket Program at Punta Lobos, Chilca, Perú.

As described in the proposal of June 1974, submitted to the National Aeronautics and Space Administration, the general objectives of the coordinated measurements are as follows:

1. Ionospheric studies under quiet and disturbed conditions. The specific objectives are:

   a) Comparison of electron temperature measurements by rocket-borne probes and the incoherent scatter technique used at the Jicamarca Radar Observatory.

   b) Observation of the fine structure in the electron density profile to examine the role of vertical transport in layering metallic ions.

   c) Examination of the role of energetic electrons as a nighttime source of ionization.

2. Measurement of precipitated particle flux. The major objectives are:

   a) Investigation of the possible influence of soft energetic electron interaction with the thermosphere on the mesosphere via a bremsstrahlung radiation energy transfer process.

   b) Study of the diurnal behavior of ozone in the equatorial region.

   c) Determination of the distribution and energy spectrum of the soft energetic particle belt at the magnetic Equator.

d) Validation of current theories about particle distributions at thermospheric altitudes.

3. Determination of Equatorial Electric and Magnetic Fields. The specific objectives are:

a) Three-axis-vector determination of electric fields.

b) Total magnetic field measurements.

c) Electron density determination.

To this effect we have performed radar measurements of electron concentration and temperature, vertical drift, electrojet echo power spectra, doppler shift and condition, and the 150 km echoing region as described under their own headlines and listed in Tables I, II, IV and V.

ELECTRON CONCENTRATION AND TEMPERATURE

We have obtained nine contour plots of electron concentration, N_e, and six contour plots of electron temperature, T_e, as functions of height at the dates and times listed in Table I.

The measuring technique employed has been in use in Jicamarca for a long time now and is thorougly described by Farley [1969a, b].

The results are presented in 15 figures shown in Appendix A. All electron concentration and temperature measurements were taken at the request of Dr. S. Schutz, Assistant Project Scientist of the University of Illinois, and Dr. R. Goldberg, NASA Project Scientist, in attention to their rocket shots.

VERTICAL DRIFT

We have performed ten continued measurements of vertical plasma drifts as functions of height at the dates and times listed in Table I.

The measuring technique was developed at the Jicamarca Radar Observatory and is fully described by Woodman and Hagfors [1969].

The vertical drift is taken as the average value of drifts between 300 and 400 km, except during the presence of coherent echoes from F-region irregularities that completely mask the incoherently scattered signal and the average is then taken from 400 to 500 km. The dotted segments in the figures indicate the presence of such echoes (equatorial -- spread-F). The 3-hour K_p index for Huancayo is indicated in every graph.

The results are presented in 17 figures shown in Appendix B. After the first set of six graphs a composite picture is presented. There is also another composite graph for the second set of four figures. In addition, five drift profiles are presented in order to give an idea of the actual height variation in our measurements. It is interesting to observe that the last two profiles were obtained so as to encompass the last two rocket flights of the Cooperative -- Rocket Program. The first set of measurements was taken at the request of Dr. R. Goldberg, NASA Project Scientist, while the second one was requested by Dr. N. C. Maynard, NASA Project Scientist, and Dr. J. F. Bedinger, G.C.A. Project Scientist, in attention to their rocket launchings in coordination with AEC satellite passes and Lear jet measurements.

ELECTROJET RELATIVE ECHO POWER DENSITY

We have obtained 35 composite plots of electrojet relative echo power density as functions of frequency deviation at the dates and times listed in Table II.

The measuring technique employed has been amply described by Balsley [1967].

The results are presented in 35 figures shown in Appendix C. All these measurements were taken at the request of Dr. N. C. Maynard, NASA Project Scientist, and Dr. J. F. Bedinger, G.C.A. Project Scientist,in attention to their rocket launchings in coordination with AEC satellite passes and Lear jet measurements.

It should be noted that the vertical scale for every graph is not the same due to normalization with respect to a wrong maximum at zero frequency caused by a faulty dc bias in the analog-to-digital converter. Excepting one, allways shown in dotted lines, the dc spikes have been omitted in those graphs as can be seen in Fig. 36, for example.

The actual identification of each composite is given in Table III.

ELECTROJET DOPPLER SHIFT AND CONDITION

We have obtained five electrojet doppler shifts and condition plots as functions of time for the periods listed in Table IV.

The measuring technique is the same as the one for the electrojet relative echo power density as given by Balsley [1964] but the presentation is new.

The results are presented in five figures shown in Appendix D. By doppler shift we simply mean the frequency deviation that corresponds to the maximum of the power density plot and by condition we signify the relative power of type I and type II irregularities. Dr. R. Woodman suggested the radio a_I/a_{II} as a quantitative measure of electrojet condition. Here a_I is the relative echo power for type I irregularities while a_{II} corresponds to type II irregularities as measured at a frequency half that of a_I. Furthermore, the following convention is adopted:

Range	Condition	Symbol
$0 \leq a_I / a_{II} < 1$	Type II	⟐
$1 \leq a_I / a_{II} < 2$	Marginal	◬
$2 \leq a_I / a_{II} < 3$	Developed	⊡
$3 \leq a_I / a_{II}$	Saturated	✳

The heavy line corresponds to the curve a_I/a_{II} while the symbols represent <u>both</u> the electrojet doppler shift and its condition. These measurements were taken at the request of Dr. N. C. Maynard, NASA Project Scientist, and Dr. J. F. Bedinger, G.C.A. Project Scientist.

150 KM ECHOING REGION

We have obtained 10 photographs to detect the presence of the 150 km echoing region as described by Balsley [1964] at the times listed in Table V.

These experiments were carried out at the request of Dr. N. C. Maynard, NASA Project Scientist, and are presented in Appendix E.

ACKNOWLEDGEMENT

The author wishes to thank the Jicamarca Radar Observatory Staff for their technical assistance.

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FARLEY, D. T., Incoherent scatter power measurements; a comparison of various techniques, Radio Sci., 4, 139-142, 1969a.

FARLEY, D. T., Incoherent scatter correlation function measurements, Radio Sci., 4, 935-953, 1969b.

WOODMAN, R. F. and T. HAGFORS, Methods for the measurement of vertical ionospheric motions near the magnetic equator by incoherent scattering, J. Geophys. Res., 74, 1205-1212, 1969.

TABLE I

ELECTRON CONCENTRATION AND TEMPERATURE AND VERTICAL DRIFTS MEASUREMENTS

PARAMETERS	DATE	INTERVAL (LT)
N_e	May 19-20, 1975	11:40-19:50
N_e	May 20-21, 1975	13:50-23:40
N_e	May 21-22, 1975	14:50-21:40
N_e	May 22-23, 1975	15:10-16:05; 19:30-23:50
N_e	May 23-24, 1975	10:10-10:30; 16:10; 18:50-23:50
N_e	May 24 , 1975	08:50-15:10
N_e	May 27 , 1975	12:50-15:35
N_e	May 28 , 1975	09:50-19:20
N_e	May 29 , 1975	14:30-14:55; 21:10-22:50
T_e	May 19 , 1975	11:40-19:50
T_e	May 20 , 1975	13:50-14:10; 15:50-21:00
T_e	May 21 , 1975	16:00-20:10
T_e	May 24 , 1975	10:00-15:10
T_e	May 27 , 1975	12:30-14:20
T_e	May 28 , 1975	09:50-17:40
V_z	May 19-20, 1975	16:00-22:20
V_z	May 20-21, 1975	14:20-23:55
V_z	May 21-22, 1975	15:30-15:40; 17:40-23:50
V_z	May 22-23, 1975	20:10-00:00
V_z	May 23-24, 1975	14:30-01:30; 03:50; 06:10-08:00
V_z	May 24-25, 1975	08:00-15:55
V_z	June 02-03, 1975	12:20-15:30
V_z	June 05-06, 1975	09:30-16:00
V_z	June 06-07, 1975	09:10-13:20
V_z	June 07-08, 1975	09:10-13:10

TABLE II

RELATIVE ECHO POWER DENSITY MEASUREMENTS

DATE	INTERVAL (LT)
JUNE 02, 1975	10:30-11:22
JUNE 02, 1975	13:10-14:32
JUNE 02, 1975	14:50-15:47
JUNE 03, 1975	08:27-08:50
JUNE 03, 1975	09:00-09:10
JUNE 03, 1975	09:12-09:45
JUNE 03, 1975	09:50-10:20
JUNE 03, 1975	10:22-10:50
JUNE 03, 1975	10:52-11:20
JUNE 03, 1975	11:22-11:50
JUNE 03, 1975	12:22-12:50
JUNE 03, 1975	12:52-13:22
JUNE 03, 1975	13:25-13:52
JUNE 03, 1975	13:55-14:27
JUNE 05, 1975	08:47-09:20
JUNE 05, 1975	09:22-09:32
JUNE 05, 1975	09:52-11:27
JUNE 05, 1975	11:42-11:57
JUNE 05, 1975	12:10-12:20
JUNE 05, 1975	12:40-13:07
JUNE 05, 1975	13:10-13:47
JUNE 05, 1975	14:02-14:07
JUNE 06, 1975	08:52-09:45
JUNE 06, 1975	09:47-11:12
JUNE 06, 1975	11:15-11:47

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JUNE 06, 1975	12:52-13:57
JUNE 06, 1975	08:45-09:47
JUNE 07, 1975	10:02-10:55
JUNE 07, 1975	10:57,11:50
JUNE 07, 1975	12:12-13:02
JUNE 07, 1975	13:05-13:27

TABLE III

RELATIVE ECHO POWER DENSITY

60° EAST- WEST SPECTRUM

JUNE 02, 1975

COMPOSITE N°1	COMPOSITE N°2	COMPOSITE N°3
10:30	13:10	14:50
10:32	14:02	14:52
10:35	14:07	14:55
10:37	14:12	14:57
10:42	14:17	15:00
10:47	14:20	15:22
10:20	14:22	15:25
10:57	14:25	15:27
11:02	14:30	15:40
11:17	14:32	15:42
11:22		15:45
		15:47

JUNE 03, 1975

COMPOSITE N°1	COMPOSITE N°2	COMPOSITE N°3
08:27	09:00	09:12
08:30	09:05	09:15
08:32	09:07	09:17
08:37	09:10	09:20
08:40		09:22
08:42		09:25
08:45		09:30
08:47		09:37
08:50		09:40
		09:42
		09:45

..//

JUNE 03, 1975

COMPOSITE N°4	COMPOSITE N°5	COMPOSITE N°6
09:50	10:22	10:52
09:52	10:25	10:55
09:55	10:27	10:57
09:57	10:30	11:00
10:02	10:32	11:02
10:05	10:35	11:05
10:07	10:37	11:07
10:10	10:40	11:10
10:12	10:42	11:12
10:15	10:45	11:15
10:17	10:47	11:17
10:20	10:50	11:20

COMPOSITE N°7	COMPOSITE N°8	COMPOSITE N°9
11:22	11:52	12:22
11:25	11:55	12:25
11:27	11:57	12:27
11:30	12:00	12:30
11:32	12:02	12:32
11:35	12:05	12:35
11:37	12:07	12:37
11:40	12:10	12:40
11:42	12:12	12:42
11:45	12:15	12:45
11:47	12:17	12:47
11:50	12:20	12:50

//..

..//

JUNE 03, 1975

COMPOSITE N°10	COMPOSITE N°11	COMPOSITE N°12
12:52	13:25	13:55
12:55	13:27	13:57
12:57	13:30	14:00
13:00	13:32	14:02
13:02	13:35	14:05
13:07	13:37	14:07
13:10	13:40	14:10
13:12	13:42	14:12
13:15	13:45	14:15
13:17	13:47	14:17
13:20	13:50	14:20
13:22	13:52	14:22
		14:25
		14:27

JUNE 05, 1975

COMPOSITE N°10	COMPOSITE N°2	COMPOSITE N°3
08:47	09:22	09:52
08:50	09:25	09:55
08:52	09:27	10:10
08:55	09:30	10:12
09:00	09:32	10:25
09:02		10:27
09:07		11:02
09:10		11:05
09:12		11:07
09:17		11:22
09:20		11:25
		11:27

//..

..//

JUNE 05, 1975

COMPOSITE N°4	COMPOSITE N°5	COMPOSITE N°6
11:42	12:10	12:40
11:45	12:12	12:42
11:47	12:15	12:45
11:50	12:17	12:47
11:52	12:20	13:02
11:55		13:05
11:57		13:07

COMPOSITE N°7	COMPOSITE N°8
13:10	14:02
13:12	14:05
13:35	14:07
13:37	
13:40	
13:42	
13:45	
13:47	

JUNE 06, 1975

COMPOSITE N°1	COMPOSITE N°2	COMPOSITE N°3
08:52	09:47	11:15
08:55	10:07	11:17
08:57	10:10	11:22
09:00	10:45	11:25
09:02	10:50	11:27
09:05	10:52	11:30
09:07	10:57	11:32
09:22	11:00	11:35
09:25	11:05	11:37
09:27	11:07	11:40
09:42	11:10	11:42
09:45	11:12	11:47

..//

JUNE 06, 1975

COMPOSITE N°4	COMPOSITE N°5
11:52	12:52
11:55	12:57
11:57	13:02
12:00	13:40
12:02	13:42
12:05	13:45
12:07	13:47
12:22	13:52
12:25	13:55
12:27	13:57
12:47	

JUNE 07, 1975

COMPOSITE N°1	COMPOSITE N°2	COMPOSITE N°3
08:45	10:02	10:57
08:47	10:05	11:20
09:02	10:07	
09:05	10:10	COMPOSITE N°4
09:07	10:15	
09:20	10:17	11:22
09:22	10:30	11:25
09:25	10:32	
09:27	10:35	COMPOSITE N°5
09:42	10:37	11:27
09:45	10:50	11:50
09:47	10:52	
	10:55	

///.

..//

JUNE 07, 1975

COMPOSITE N°6	COMPOSITE N°7
12:12	13:05
12:15	13:07
12:17	13:10
12:20	13:20
12:22	13:22
12:35	13:25
12:37	13:27
12:40	
12:42	
12:45	
12:47	
13:02	

TABLE IV

ELECTROJET DOPPLER SHIFT AND CONDITION

DATE	INTERVAL (LT)
JUNE 02, 1975	10:37-11:17; 12:07; 13:10; 14:02-14:32; 14:50-15:00; 15:22-15:27; 15:40-15:47
JUNE 03, 1975	08:27-14:27
JUNE 05, 1975	08:47-09:32; 09:52-10:27; 11:02-11:07; 11:22-11:27; 11:42-12:20; 12:40-13:12; 13:35-13:47; 14:02-14:07
JUNE 06, 1975	08:52-09:07; 09:22-09:27; 09:42-09:47; 10:00; 10:07; 10:45-12:07; 10:22-10:27; 10:47; 13-02; 13:40-13:57
JUNE 07, 1975	10:45-10:47; 09:02-09:07; 09:20-09:27; 09:42-09:47; 10:02-10:17; 10:30-10:57; 11:20-11:27; 11:50; 12:12-13:27

TABLE V

150 KM ECHOING REGION

JUNE 07, 1975

LOCAL TIME

10:00
11:04
11:12
11:13
11:36
11:56
12:00
12:03
11:06
12:27

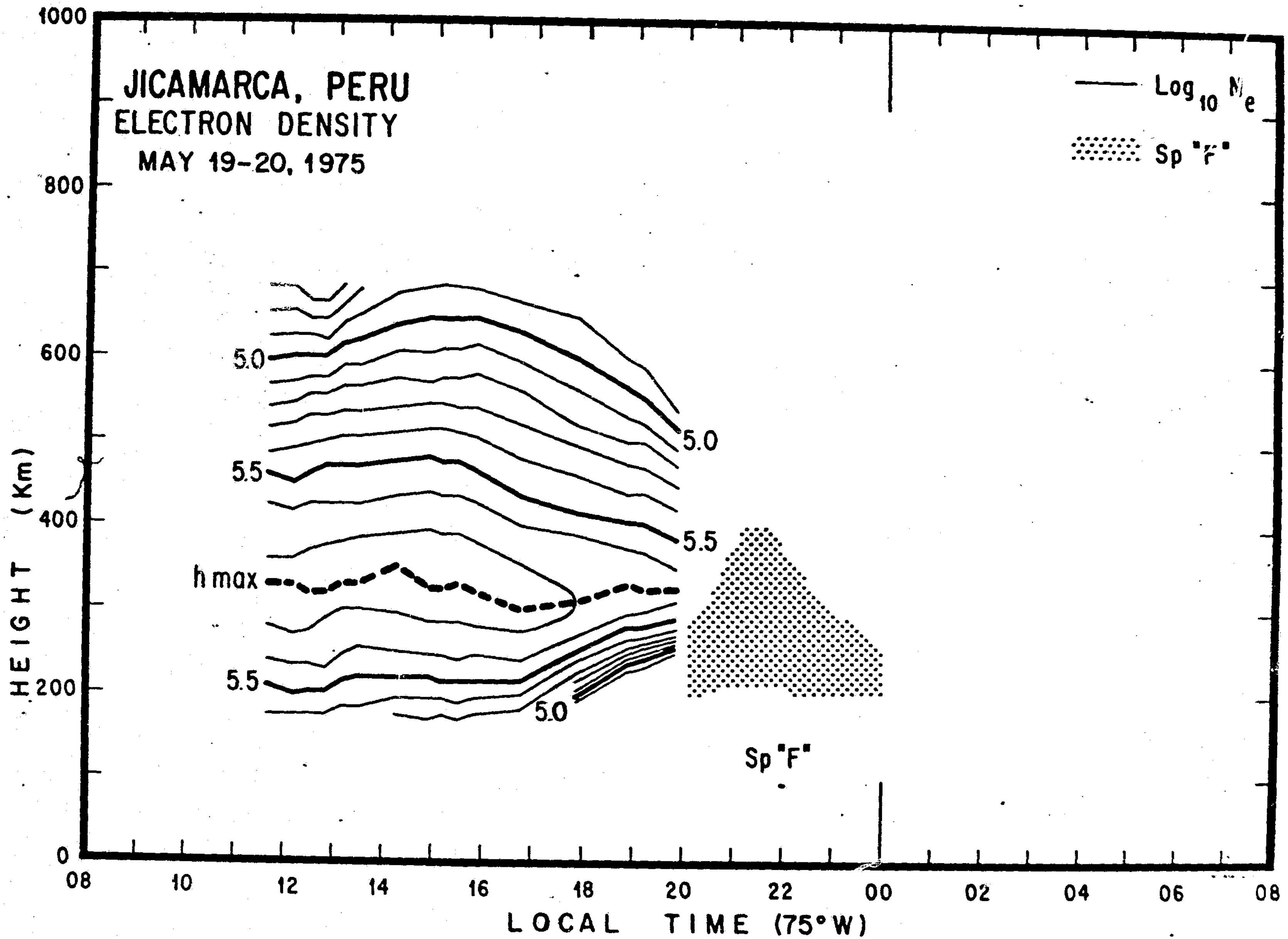
APPENDIX A

ELECTRON CONCENTRATION AND TEMPERATURE

FIGURE CAPTIONS

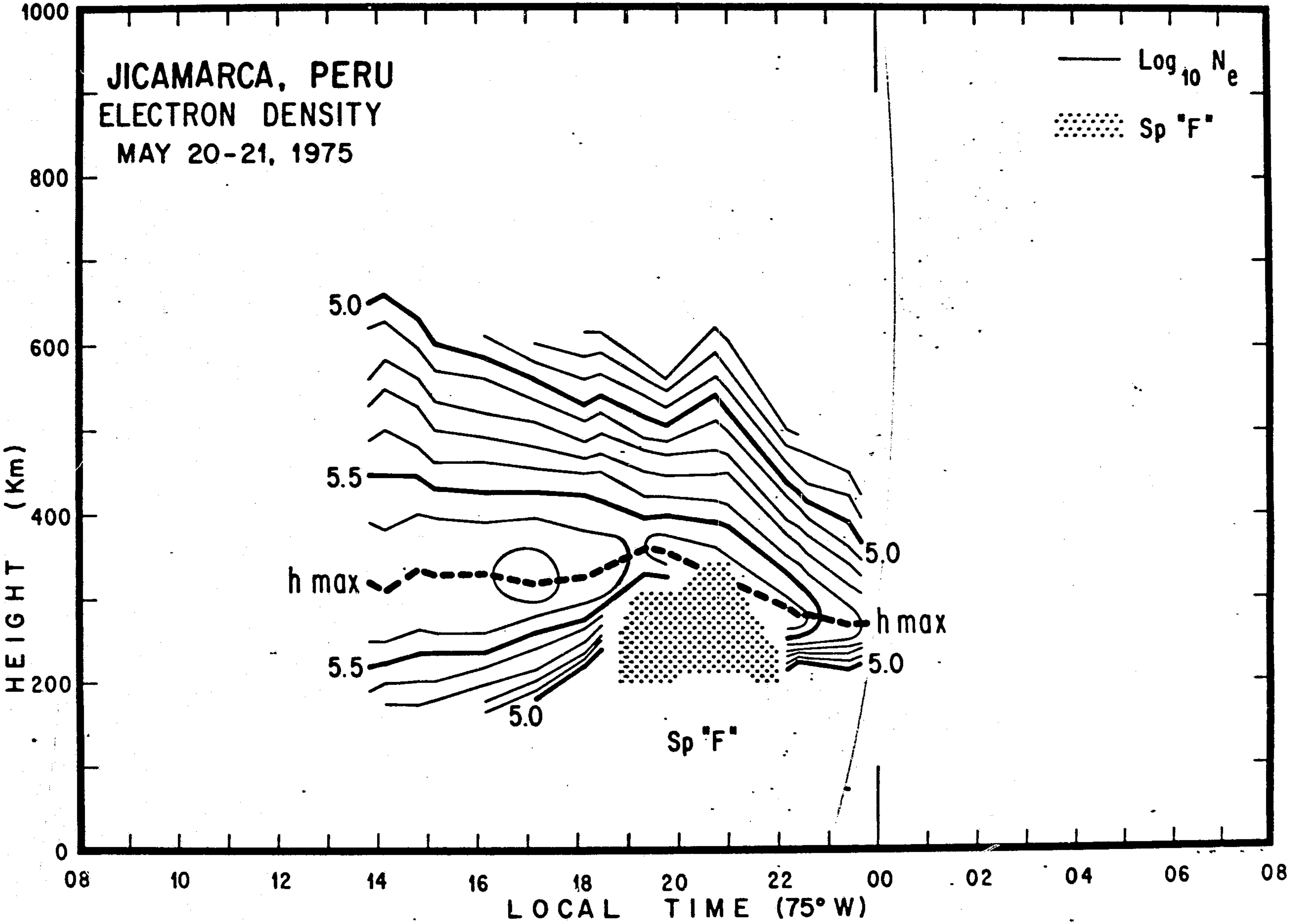
Fig. 1 to 9 Electron Density contour as function of height at local times indicated in the figure.

Fig. 10 to 15 Same as above but the electron temperature contour is shown.



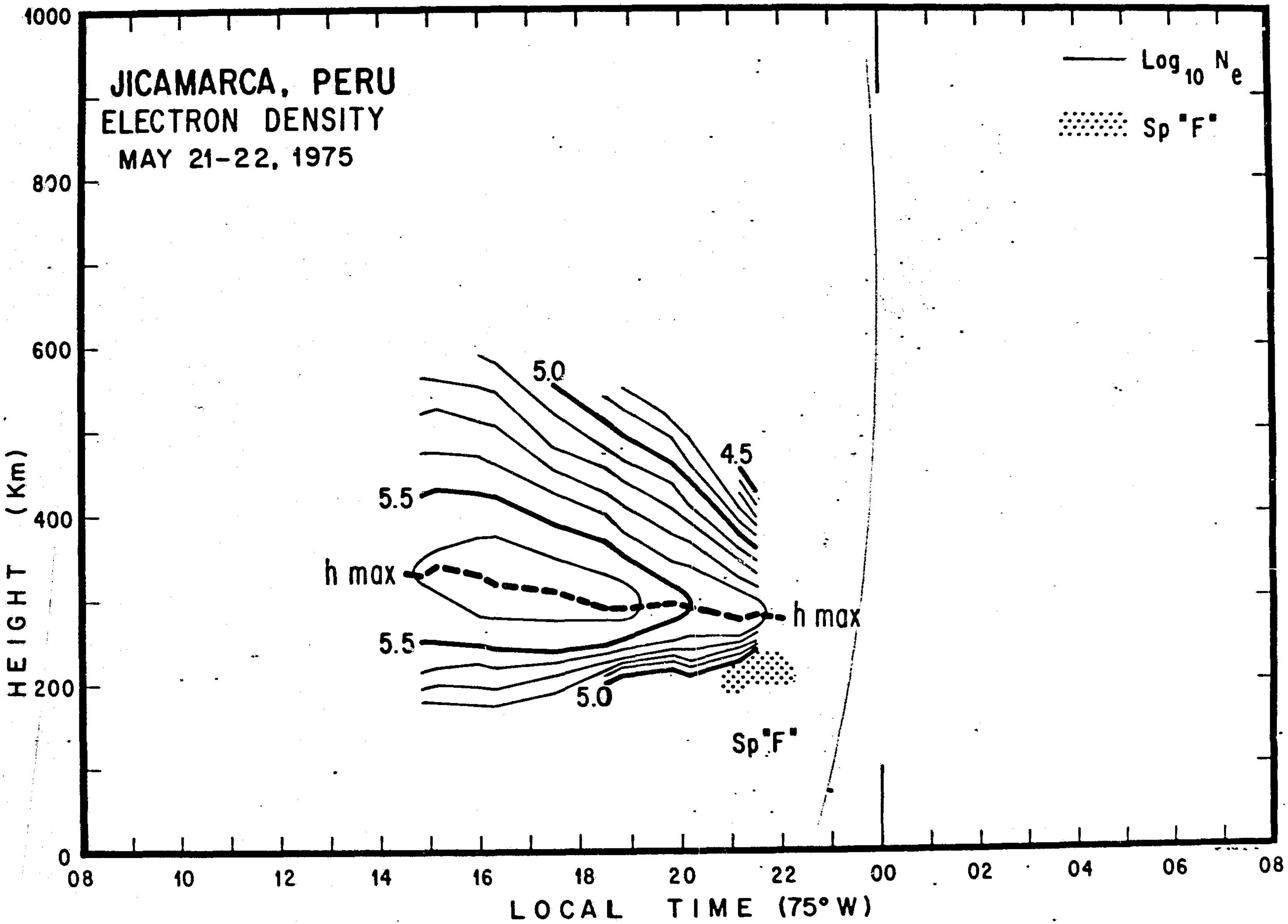
JICAMARCA, PERU
ELECTRON DENSITY
MAY 19-20, 1975
Log10 Ne
Sp "F"
HEIGHT (Km)
1000
800
600
400
200
0
5.0
5.5
h max
5.5
5.0
5.0
5.5
Sp "F"
08
10
12
14
16
18
20
22
00
02
04
06
08
LOCAL TIME (75° W)

Fig. 1



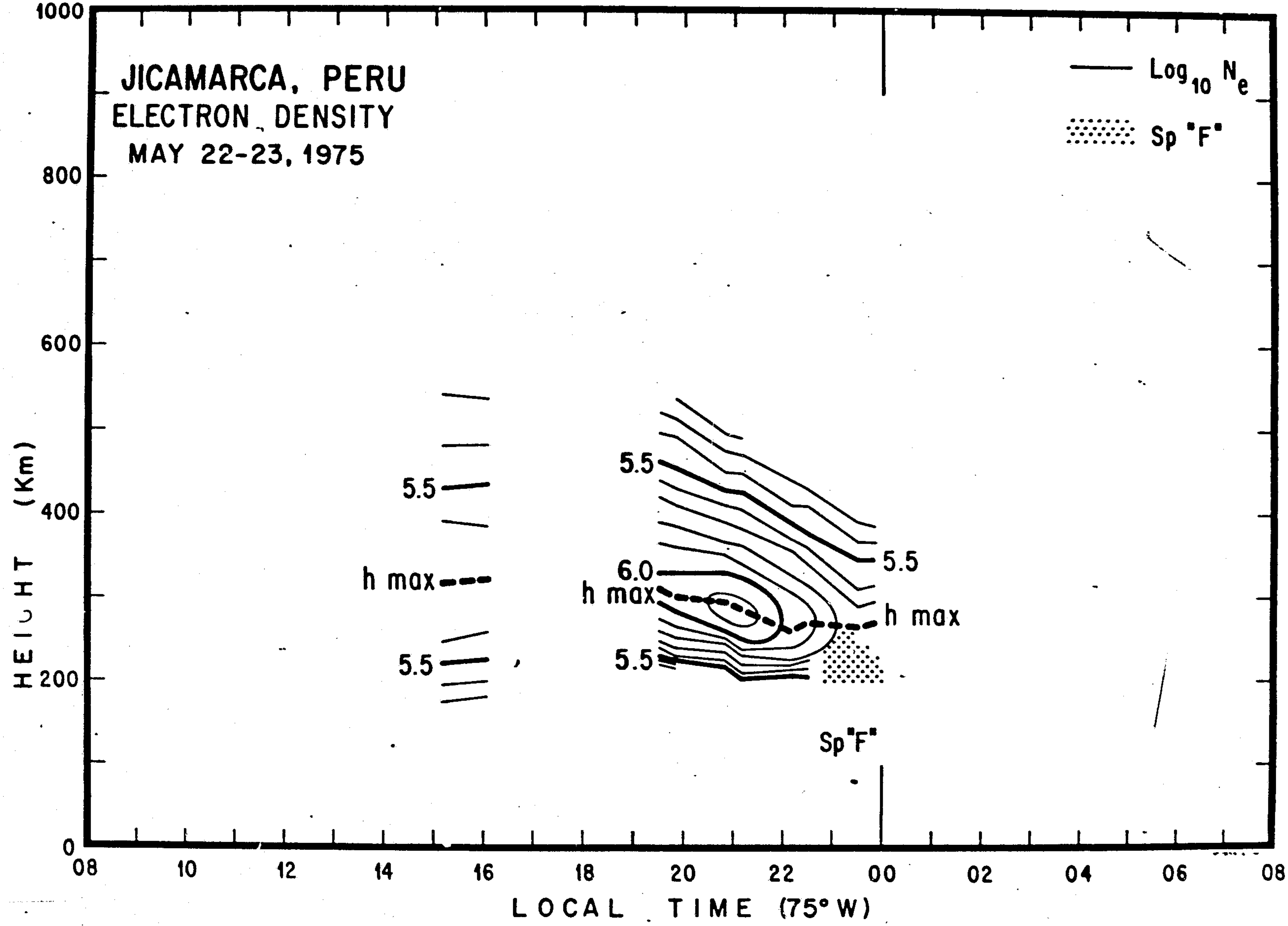
JICAMARCA, PERU
ELECTRON DENSITY
MAY 20-21, 1975
Log$_{10}$ N$_e$
Sp "F"
5.0
5.5
h max
5.5
5.0
5.0
h max
5.0
Sp "F"
HEIGHT (Km)
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
00
02
04
06
08
LOCAL TIME (75° W)

Fig. 2



JICAMARCA, PERU
ELECTRON DENSITY
MAY 21-22, 1975
Log10 Ne
Sp "F"
5.0
4.5
5.5
h max
h max
5.5
5.0
Sp "F"
HEIGHT (Km)
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
00
02
04
06
08
LOCAL TIME (75° W)

Fig.3



JICAMARCA, PERU
ELECTRON DENSITY
MAY 22-23, 1975
Log10 Ne
Sp "F"
5.5
h max
6.0
Sp"F"
HEIGHT (Km)
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
00
02
04
06
08
LOCAL TIME (75° W)

Fig. 4

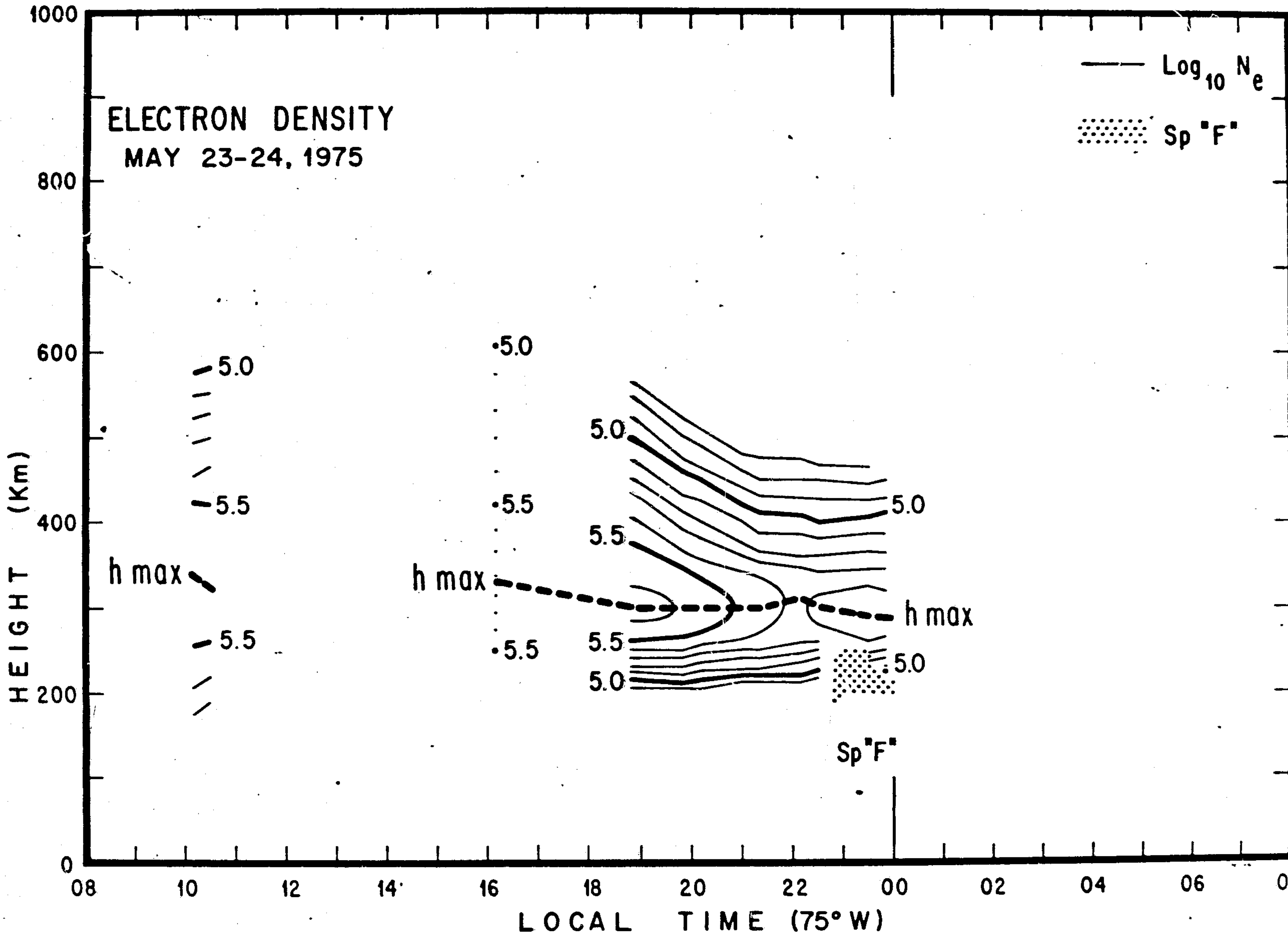

ELECTRON DENSITY
MAY 23-24, 1975
Log10 Ne
Sp "F"
HEIGHT (Km)
LOCAL TIME (75° W)
h max
5.0
5.5
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
00
02
04
06
08

Fig. 5

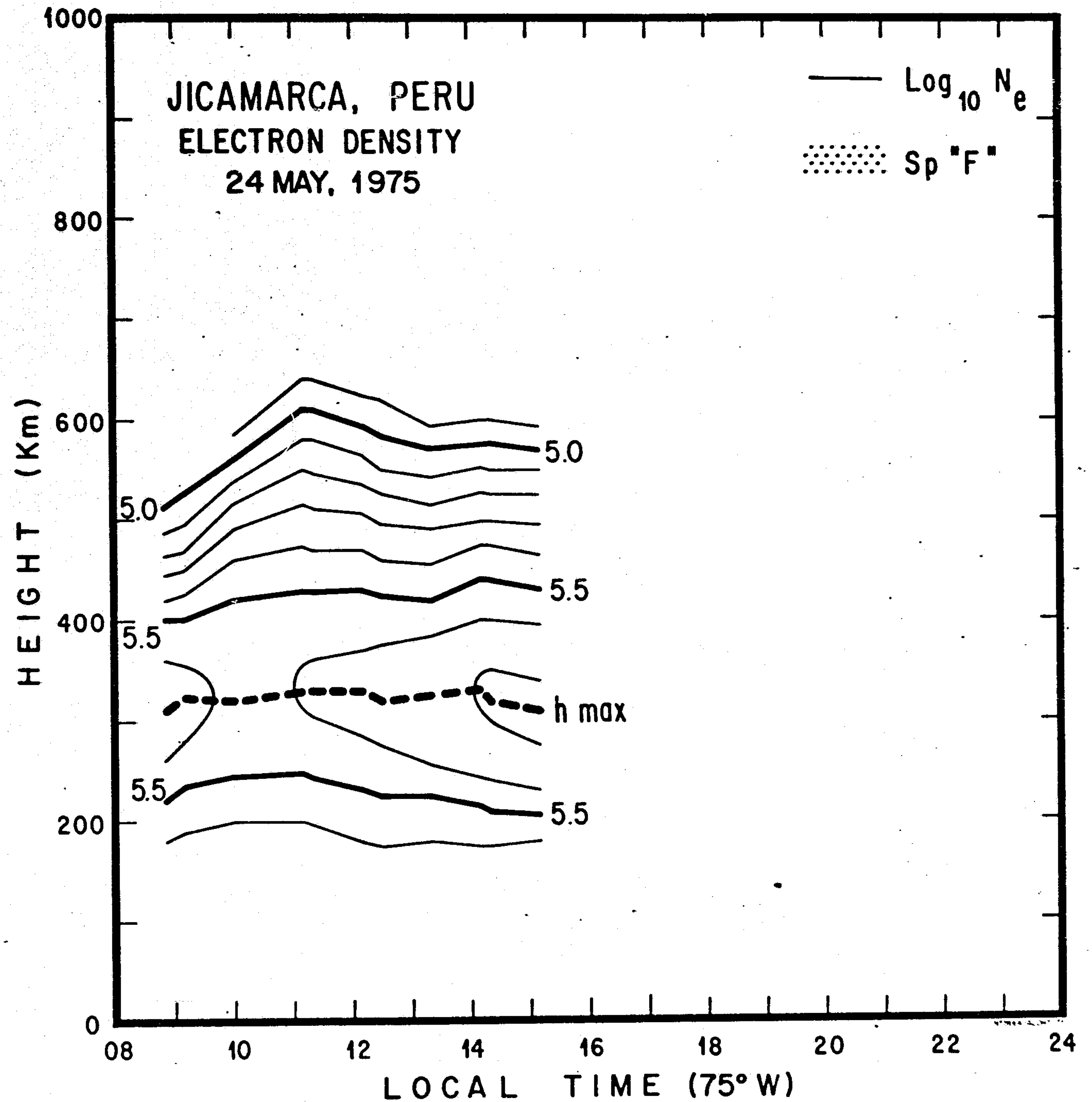

JICAMARCA, PERU
ELECTRON DENSITY
24 MAY, 1975
Log 10 Ne
Sp "F"
HEIGHT (Km)
LOCAL TIME (75° W)
5.0
5.5
h max
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
24

Fig. 6

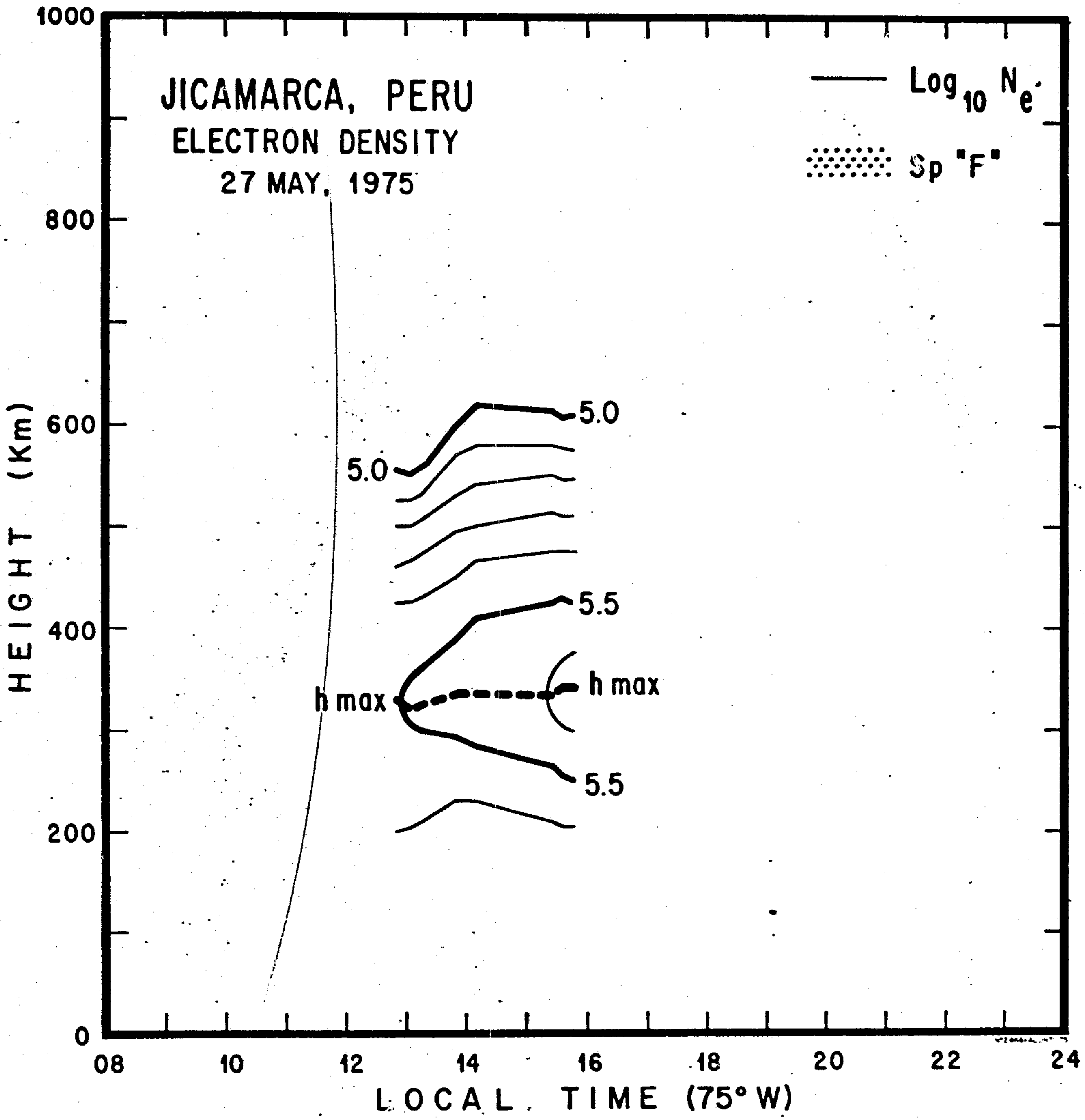

JICAMARCA, PERU
ELECTRON DENSITY
27 MAY, 1975
Log10 Ne
Sp "F"
5.0
5.0
5.5
5.5
h max
h max
HEIGHT (Km)
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
24
LOCAL TIME (75° W)

Fig. 7

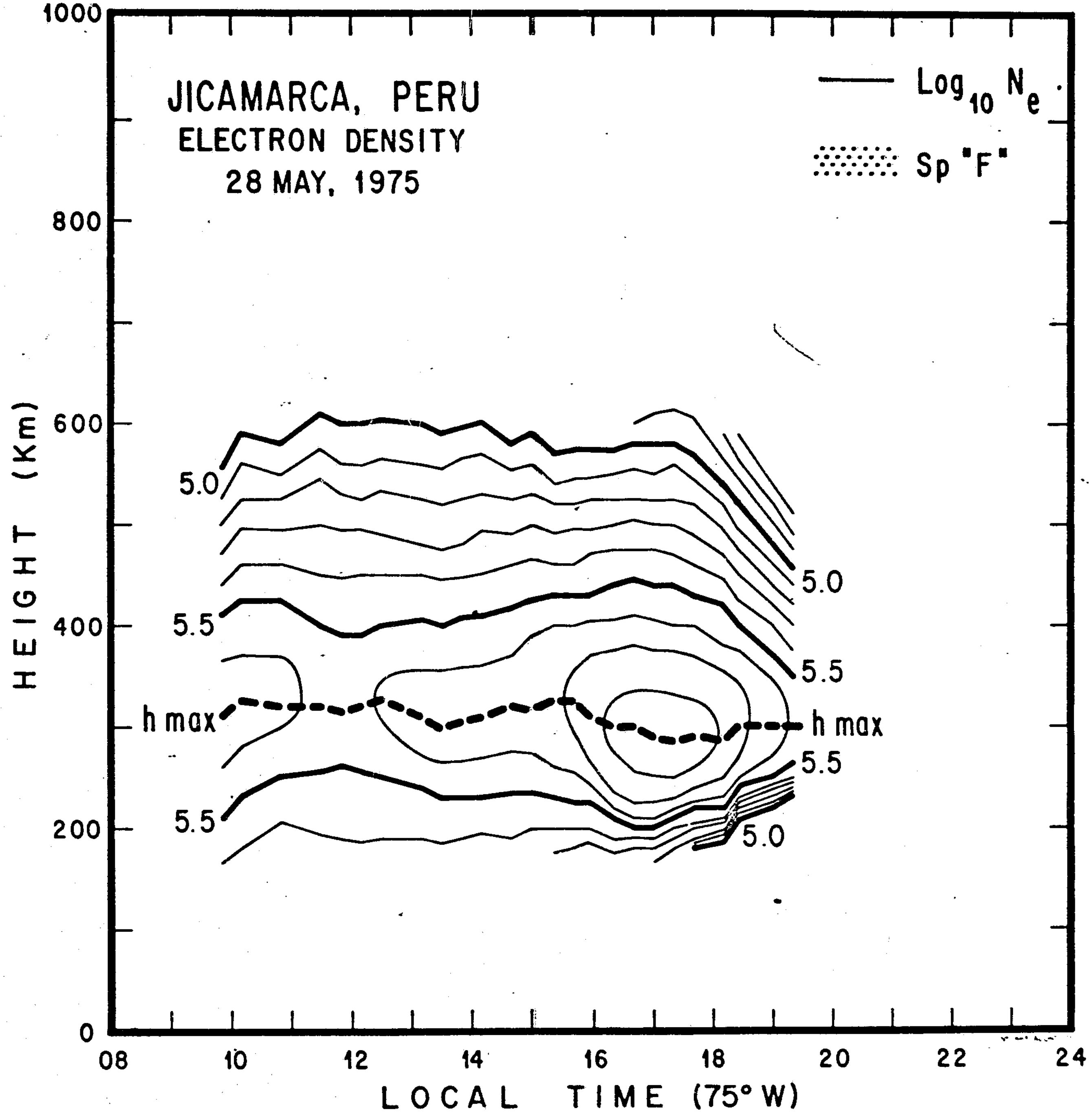

JICAMARCA, PERU
ELECTRON DENSITY
28 MAY, 1975
Log10 Ne
Sp "F"
HEIGHT (Km)
1000
800
600
400
200
0
5.0
5.5
h max
5.5
5.0
5.5
h max
5.5
5.0
08
10
12
14
16
18
20
22
24
LOCAL TIME (75° W)

Fig. 8

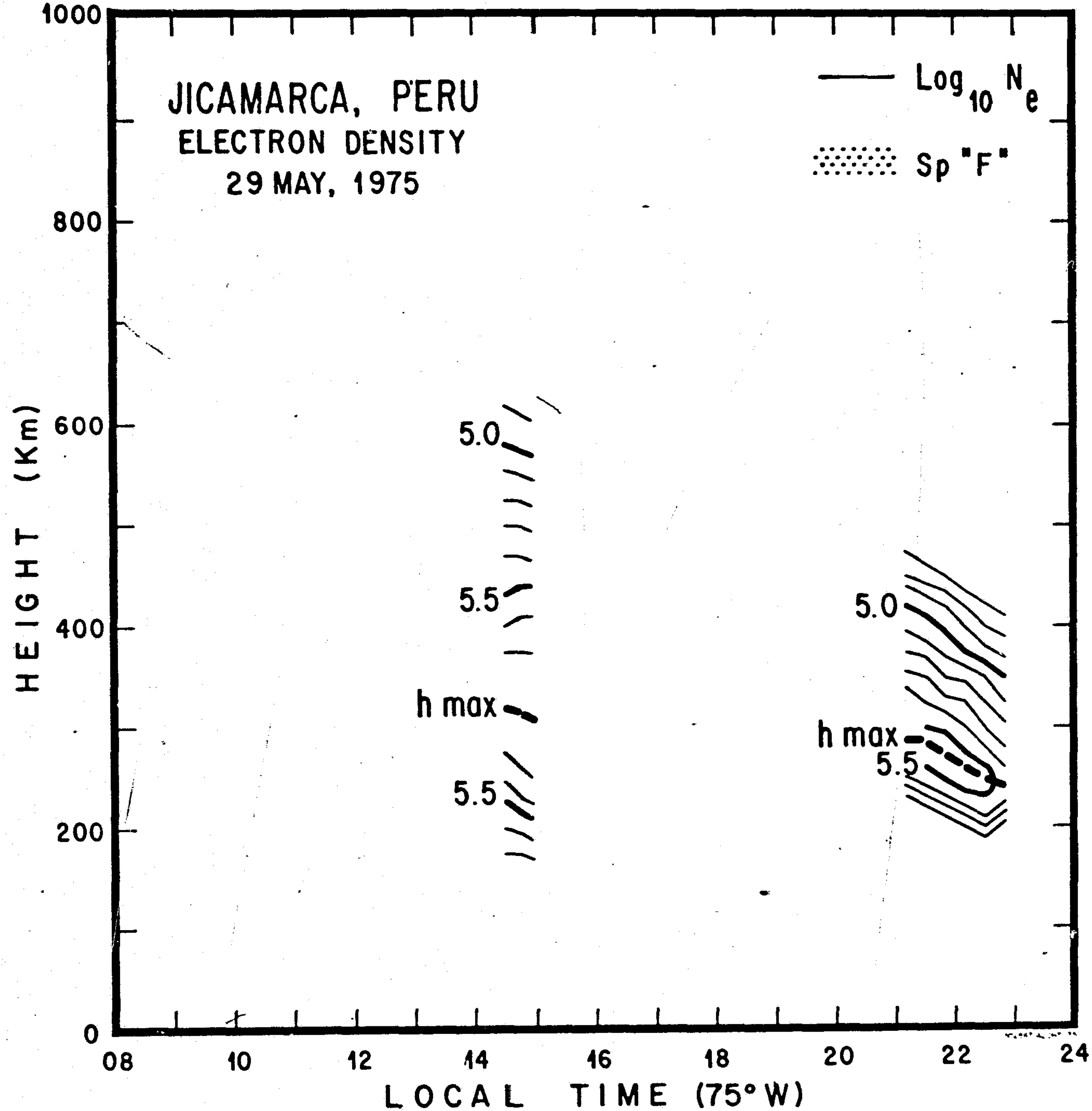
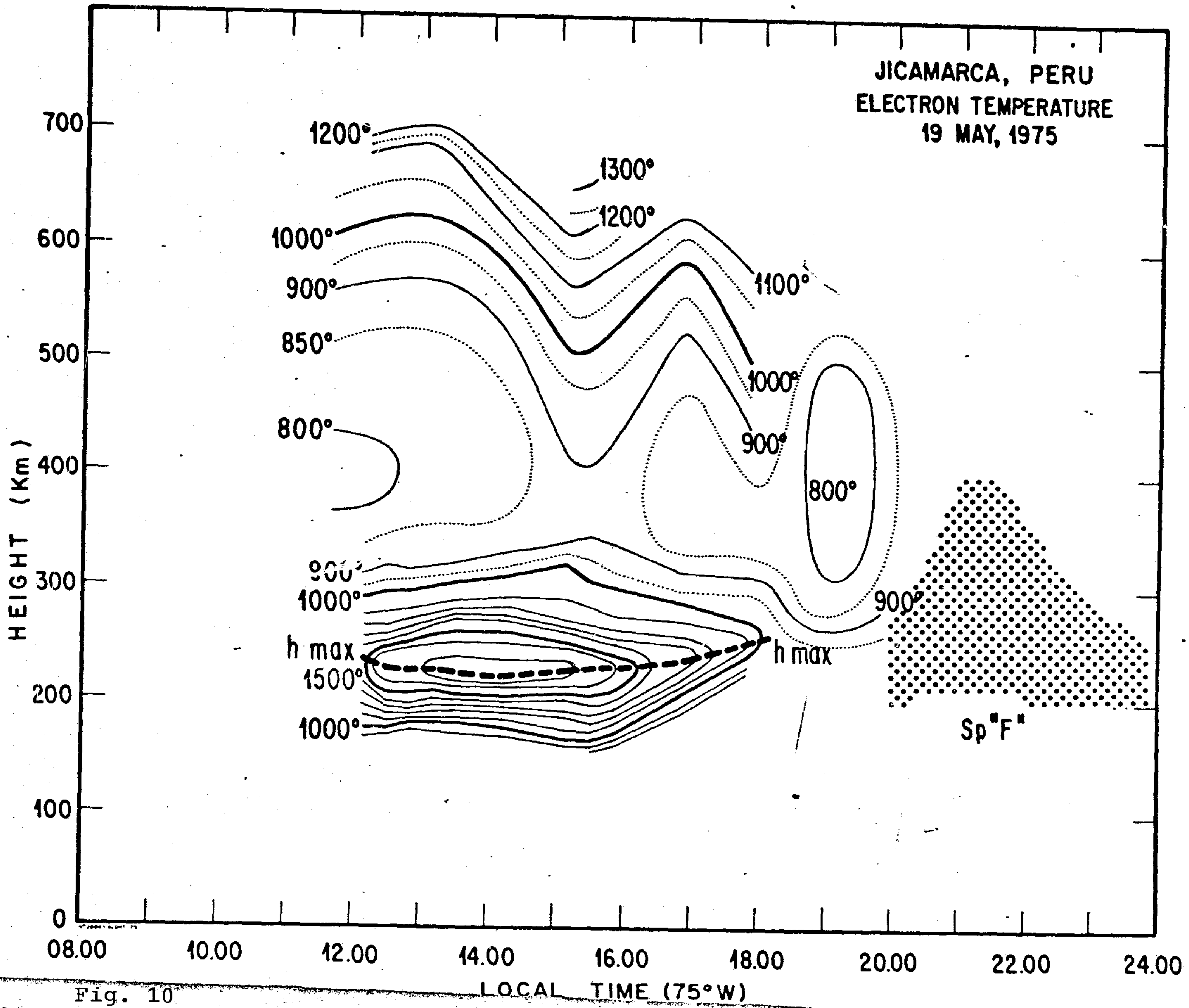

JICAMARCA, PERU
ELECTRON DENSITY
29 MAY, 1975
Log 10 Ne
Sp "F"
HEIGHT (Km)
LOCAL TIME (75° W)
1000
800
600
400
200
0
08
10
12
14
16
18
20
22
24
5.0
5.5
h max
5.5
5.0
h max
5.5

Fig. 9



JICAMARCA, PERU
ELECTRON TEMPERATURE
19 MAY, 1975
1200°
1300°
1200°
1000°
1100°
900°
1000°
850°
900°
800°
800°
900°
1000°
h max
h max
1500°
1000°
900°
Sp"F"
HEIGHT (Km)
700
600
500
400
300
200
100
0
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
LOCAL TIME (75° W)

Fig. 10

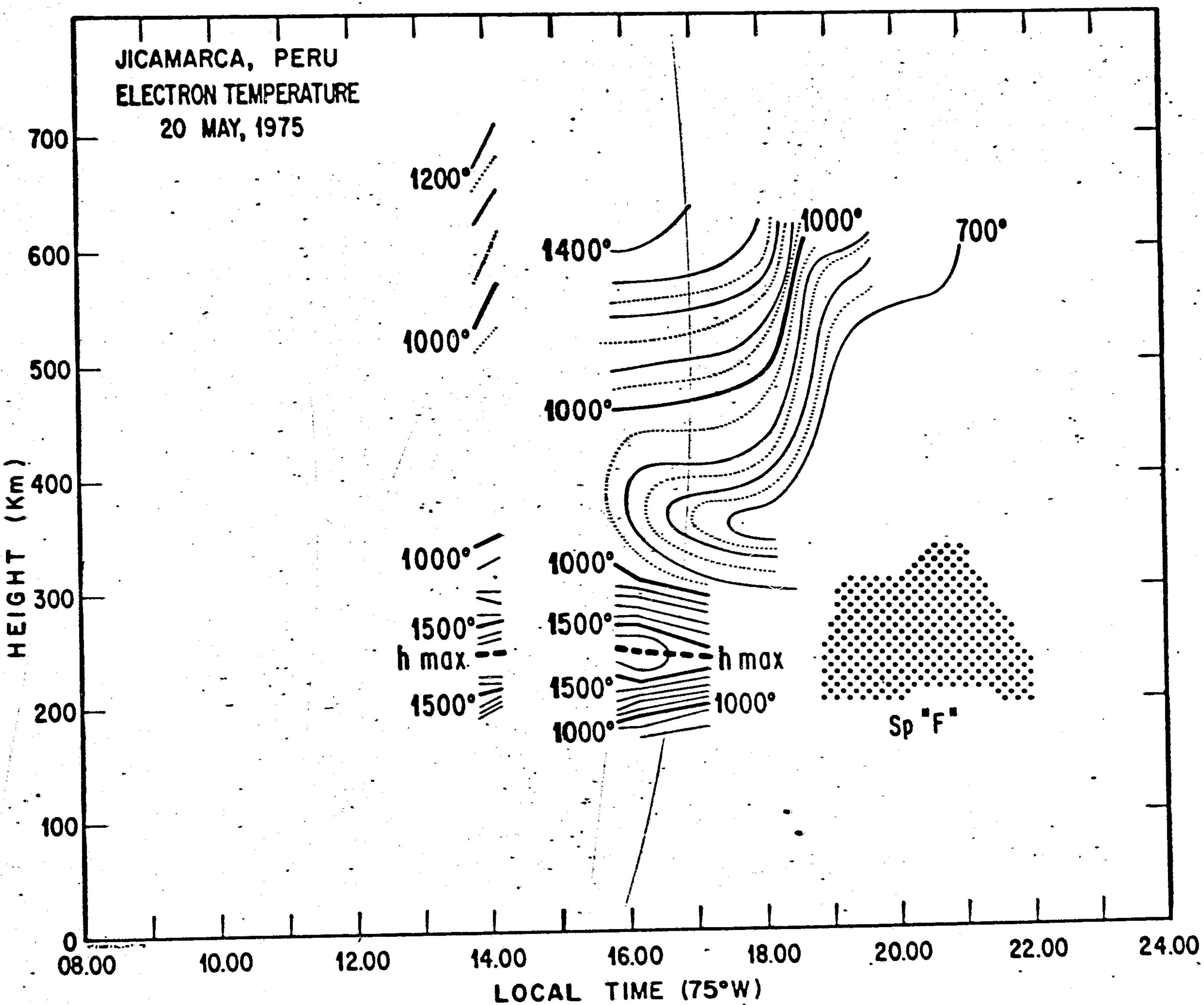

JICAMARCA, PERU
ELECTRON TEMPERATURE
20 MAY, 1975
1200°
1000°
1400°
1000°
700°
1000°
1000°
1000°
1500°
1500°
h max
h max
1500°
1500°
1000°
1000°
Sp "F"
HEIGHT (Km)
0
100
200
300
400
500
600
700
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
LOCAL TIME (75°W)

Fig. 11

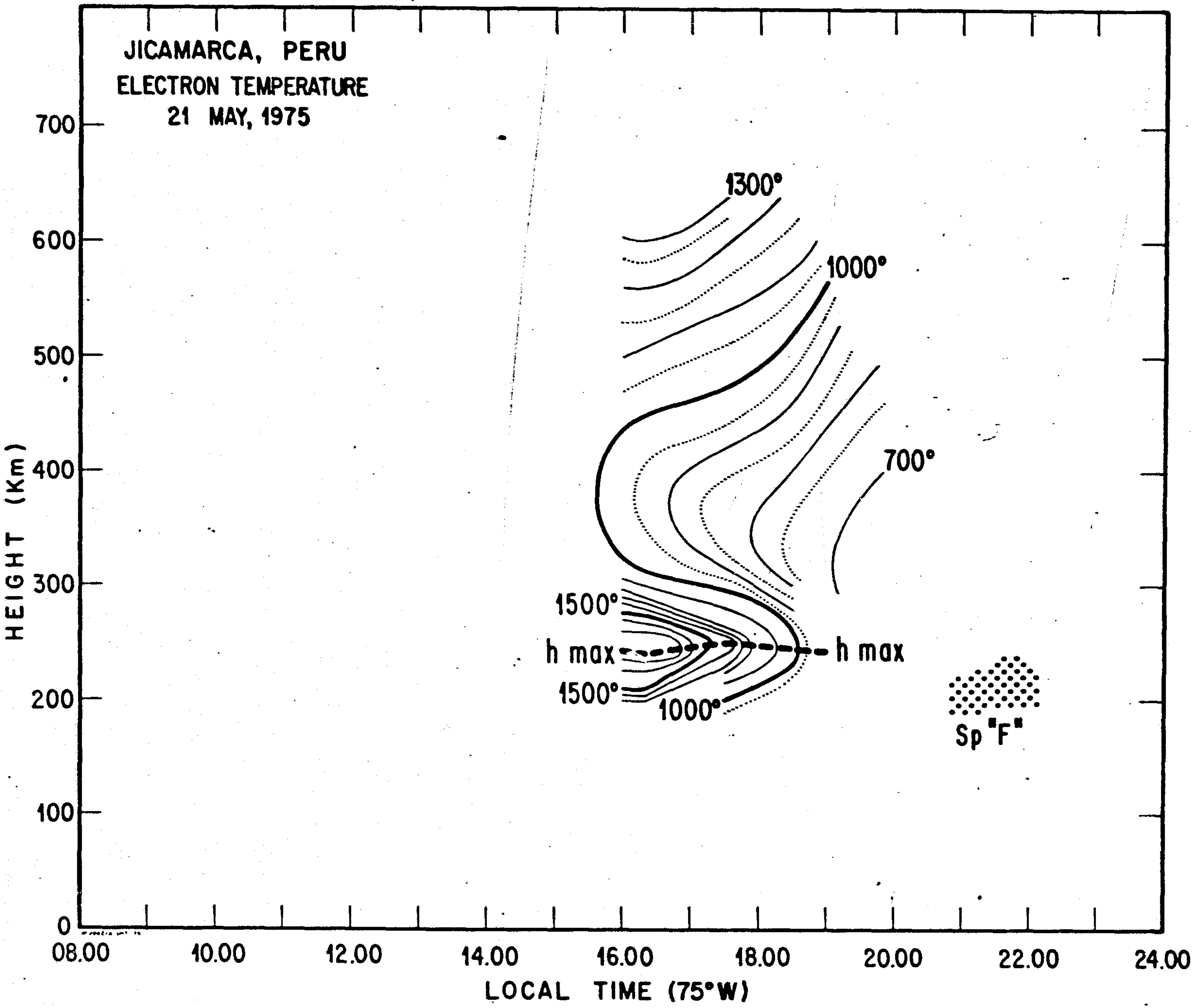

JICAMARCA, PERU
ELECTRON TEMPERATURE
21 MAY, 1975
1300°
1000°
700°
1500°
h max
h max
1500°
1000°
Sp "F"
HEIGHT (Km)
700
600
500
400
300
200
100
0
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
LOCAL TIME (75°W)

Fig. 12

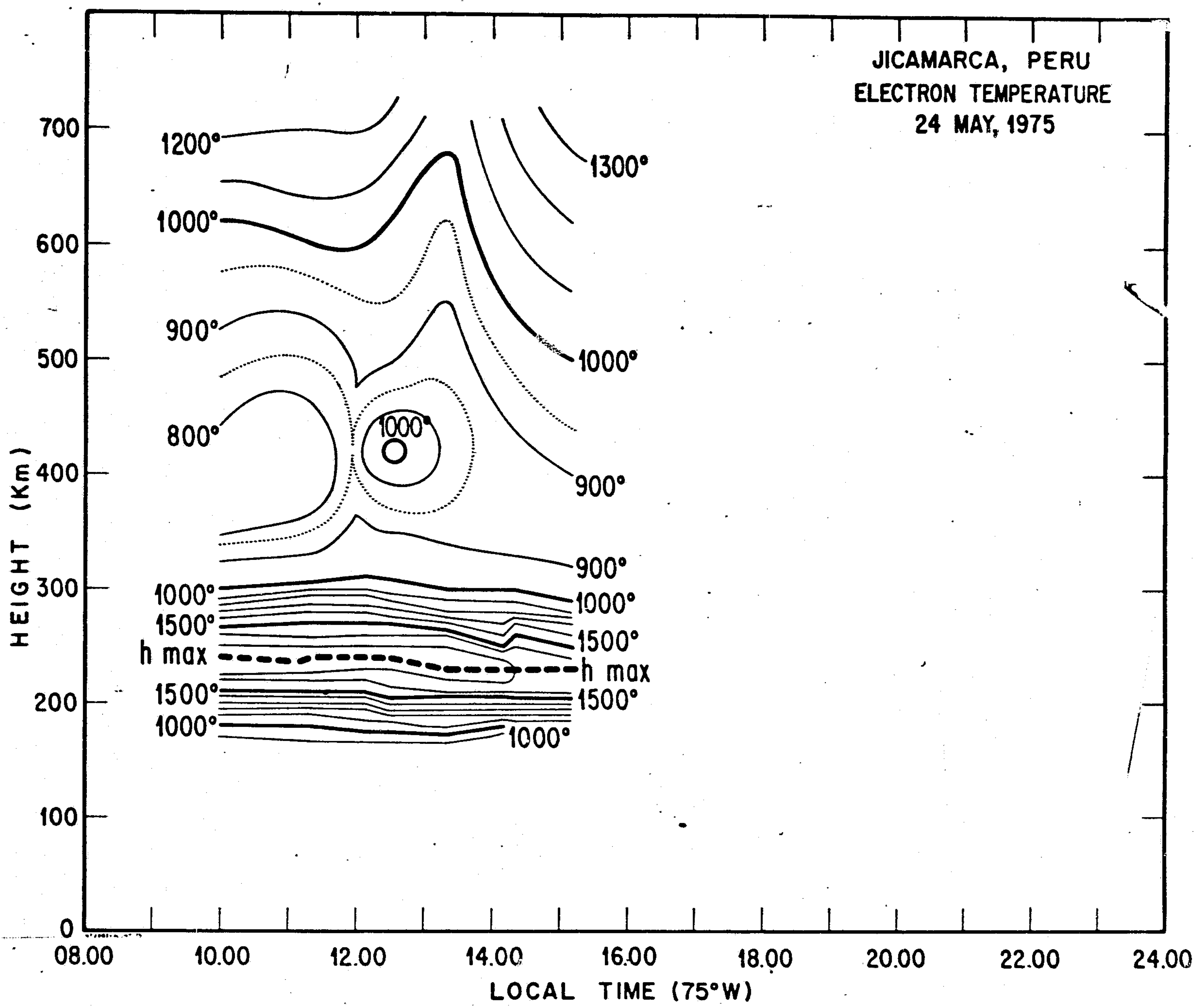
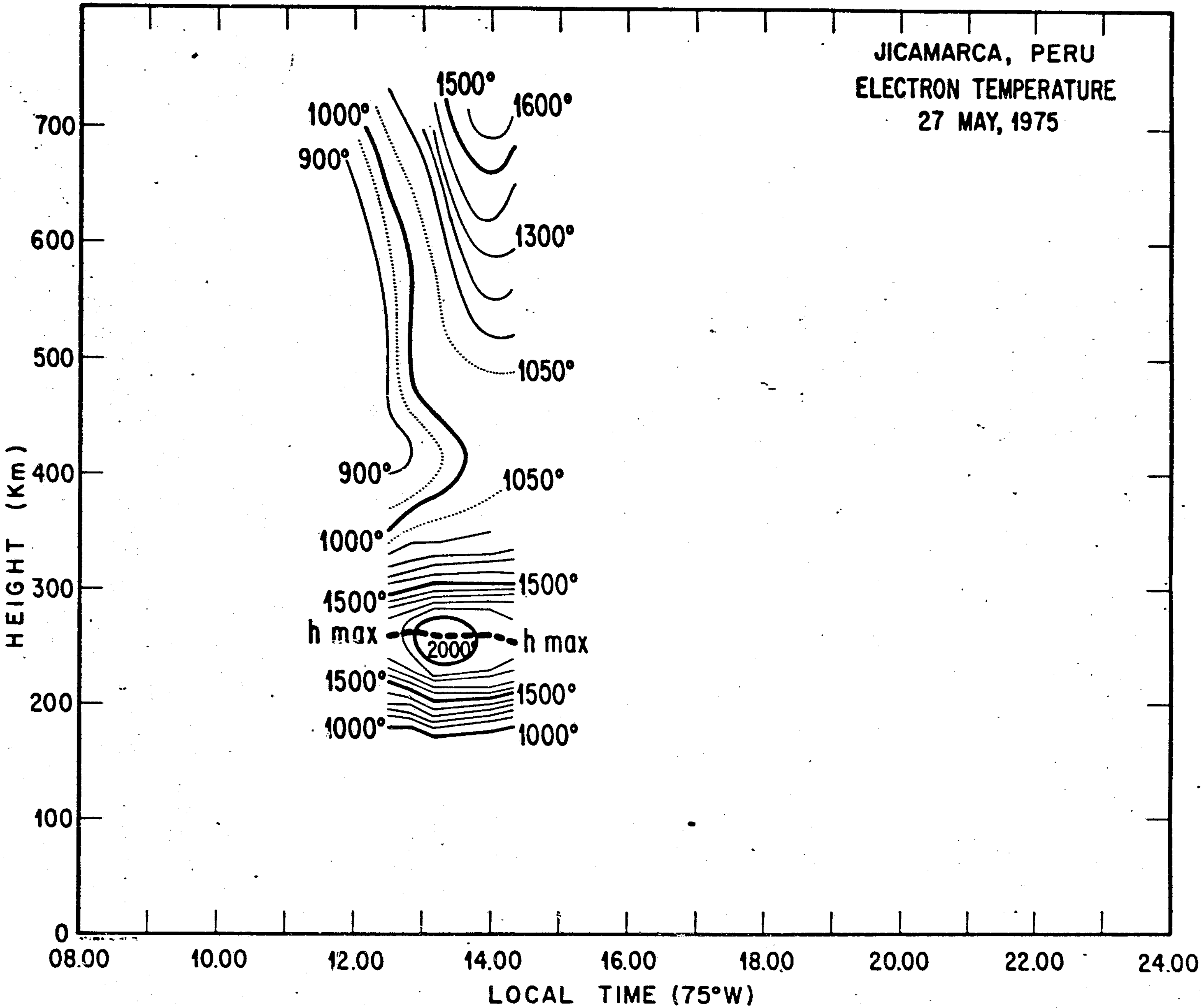

JICAMARCA, PERU
ELECTRON TEMPERATURE
24 MAY, 1975
HEIGHT (Km)
LOCAL TIME (75°W)
0
100
200
300
400
500
600
700
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
1200°
1300°
1000°
900°
1000°
800°
1000°
900°
900°
1000°
1000°
1500°
1500°
h max
h max
1500°
1500°
1000°
1000°

Fig. 13



JICAMARCA, PERU
ELECTRON TEMPERATURE
27 MAY, 1975
HEIGHT (Km)
LOCAL TIME (75°W)
700
600
500
400
300
200
100
0
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
1000°
900°
1500°
1600°
1300°
1050°
900°
1050°
1000°
1500°
1500°
h max
h max
2000
1500°
1500°
1000°
1000°

Fig. 14

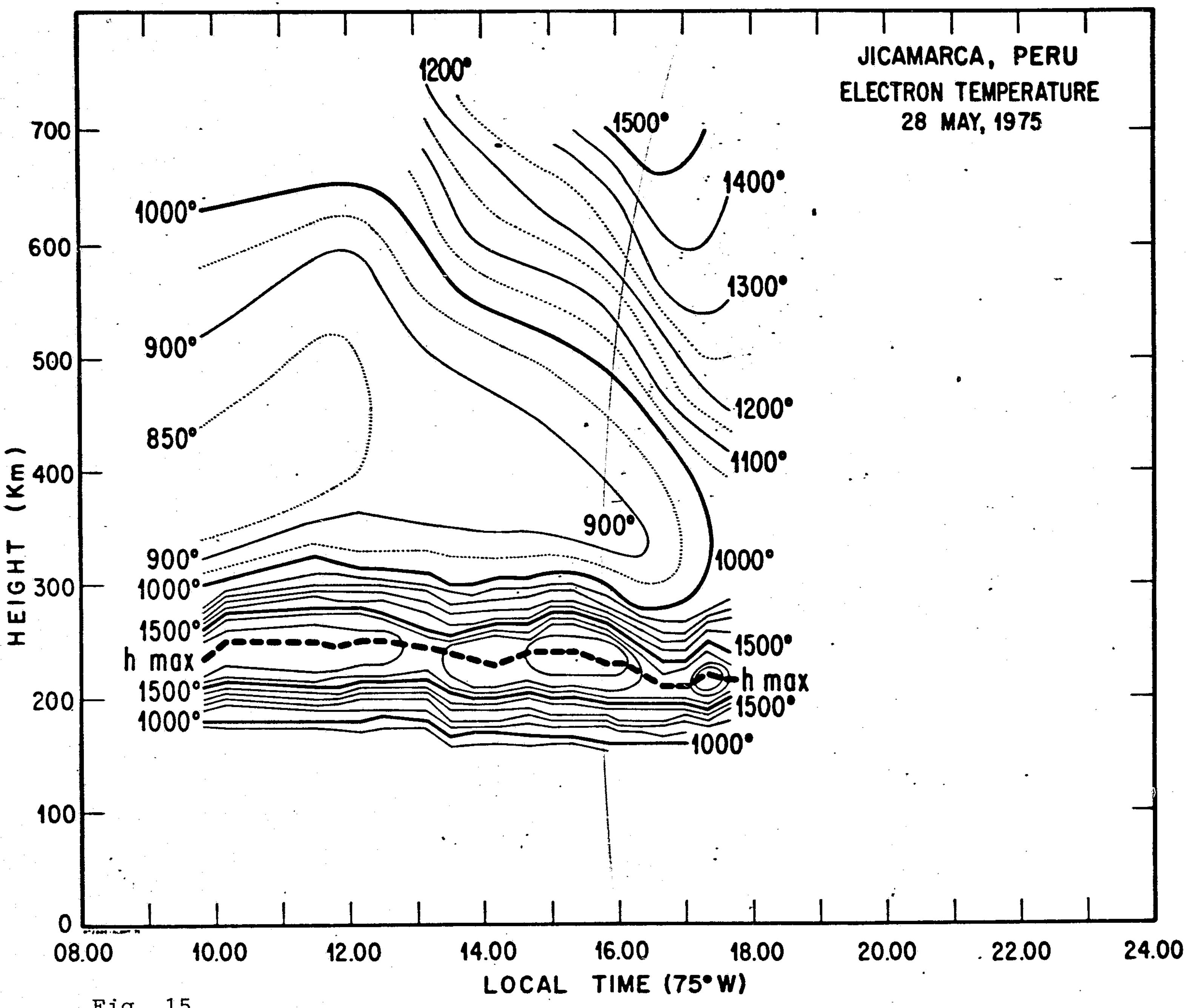

JICAMARCA, PERU
ELECTRON TEMPERATURE
28 MAY, 1975
1200°
1500°
1400°
1300°
1000°
900°
850°
1200°
1100°
900°
1000°
900°
1000°
1500°
h max
1500°
1000°
1500°
h max
1500°
1000°
HEIGHT (Km)
0
100
200
300
400
500
600
700
08.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
LOCAL TIME (75° W)

Fig. 15

APPENDIX B

VERTICAL DRIFT

FIGURE CAPTIONS

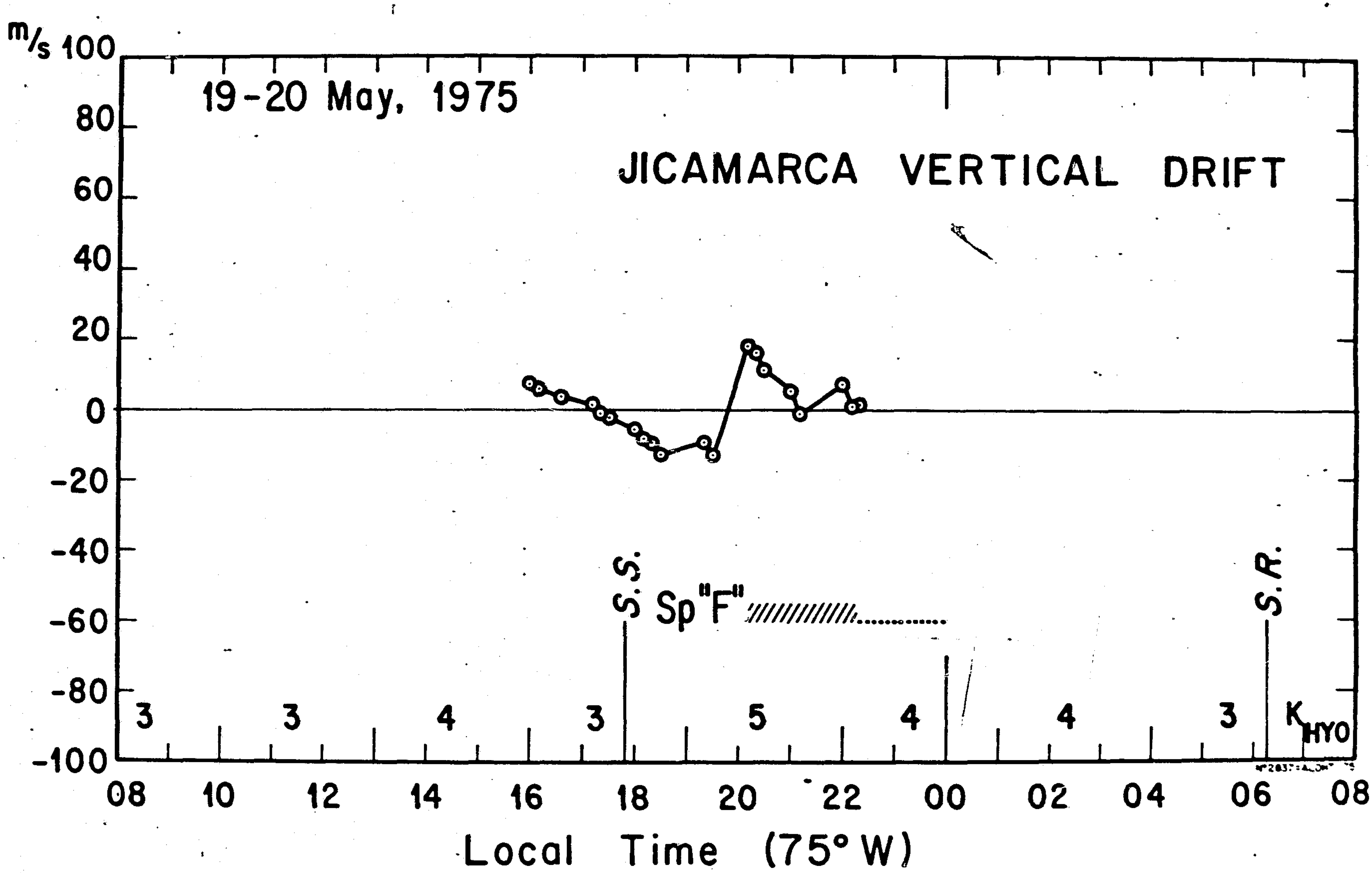
Fig. 16 to 21 Vertical drift velocities and Spread-F activity for the local times (75°W) and dates indicated.

Fig. 22 Composite of Figs. 16 to 21.

Fig. 23 to 26 Vertical drift velocities and Spread-F activity for the local times (75°W) and dates indicated.

Fig. 27 Composite of Figs. 23 to 26.

Fig. 28 to 32 Typical drift profiles for the times (75° W) and dates indicated as functions of height.



m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
19-20 May, 1975
JICAMARCA VERTICAL DRIFT
S.S.
Sp"F"
S.R.
3
3
4
3
5
4
4
3
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 16

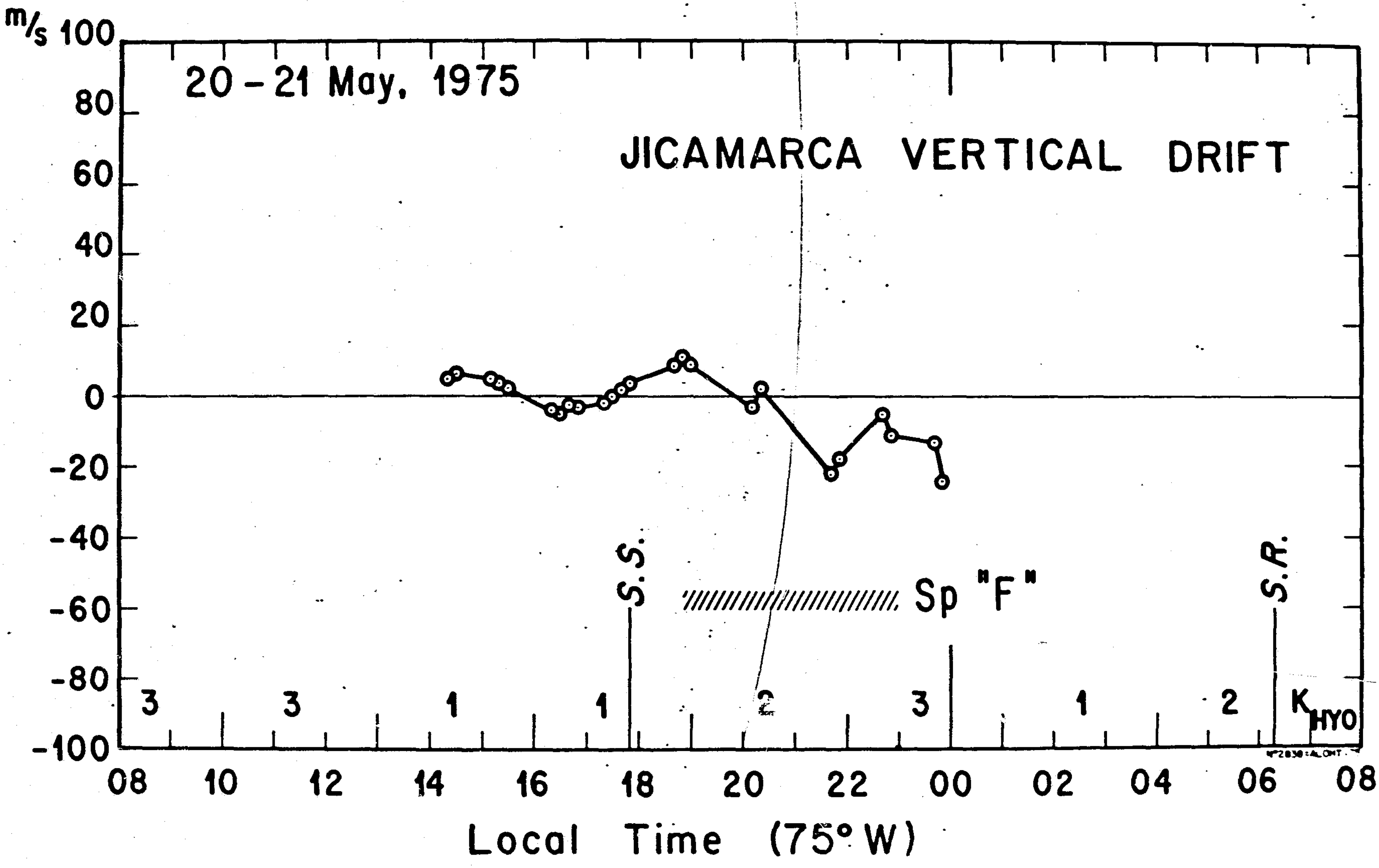

20 - 21 May, 1975
JICAMARCA VERTICAL DRIFT
m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
S.S.
Sp "F"
S.R.
3
3
1
1
2
3
1
2
K_{HYO}
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 17

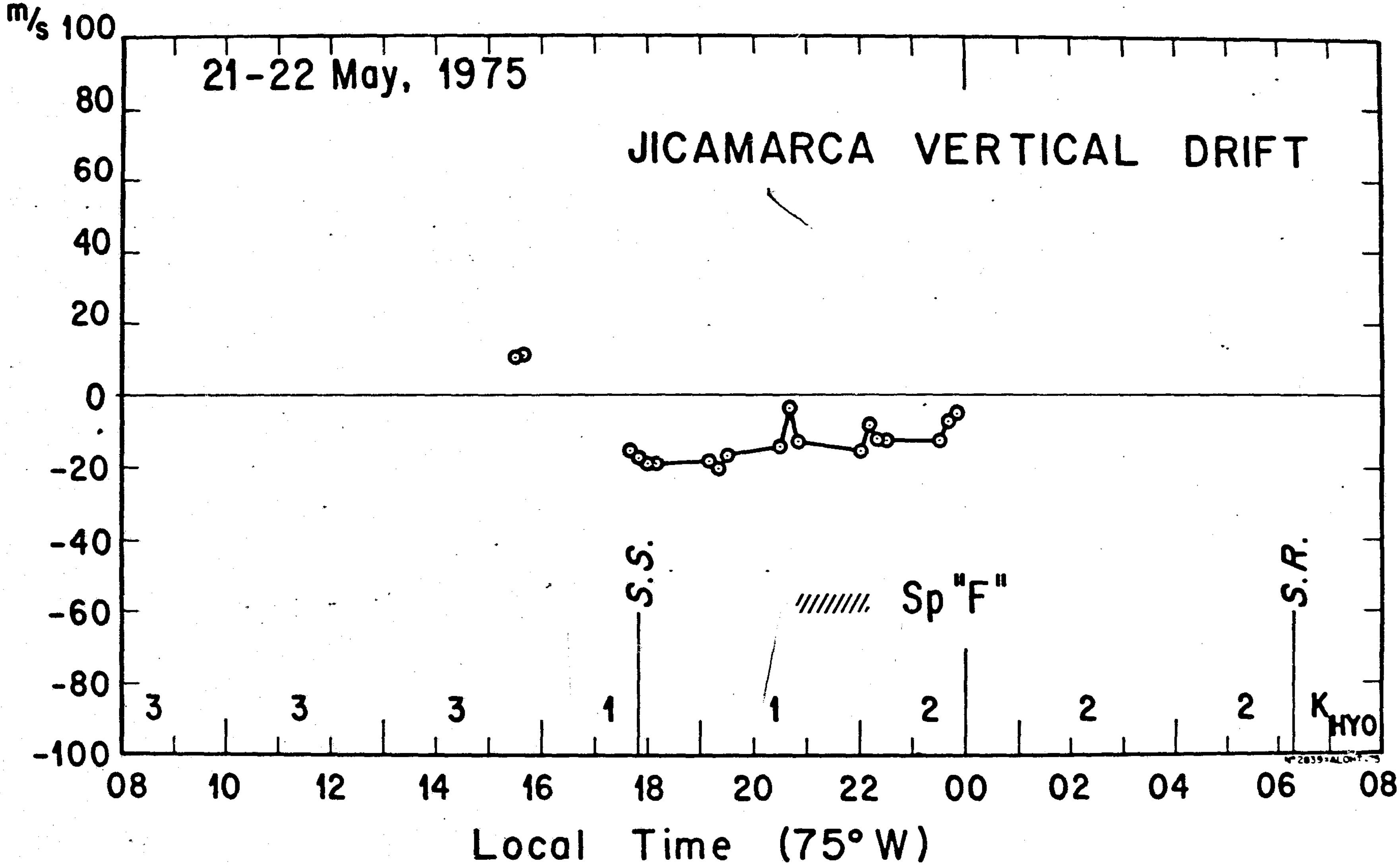
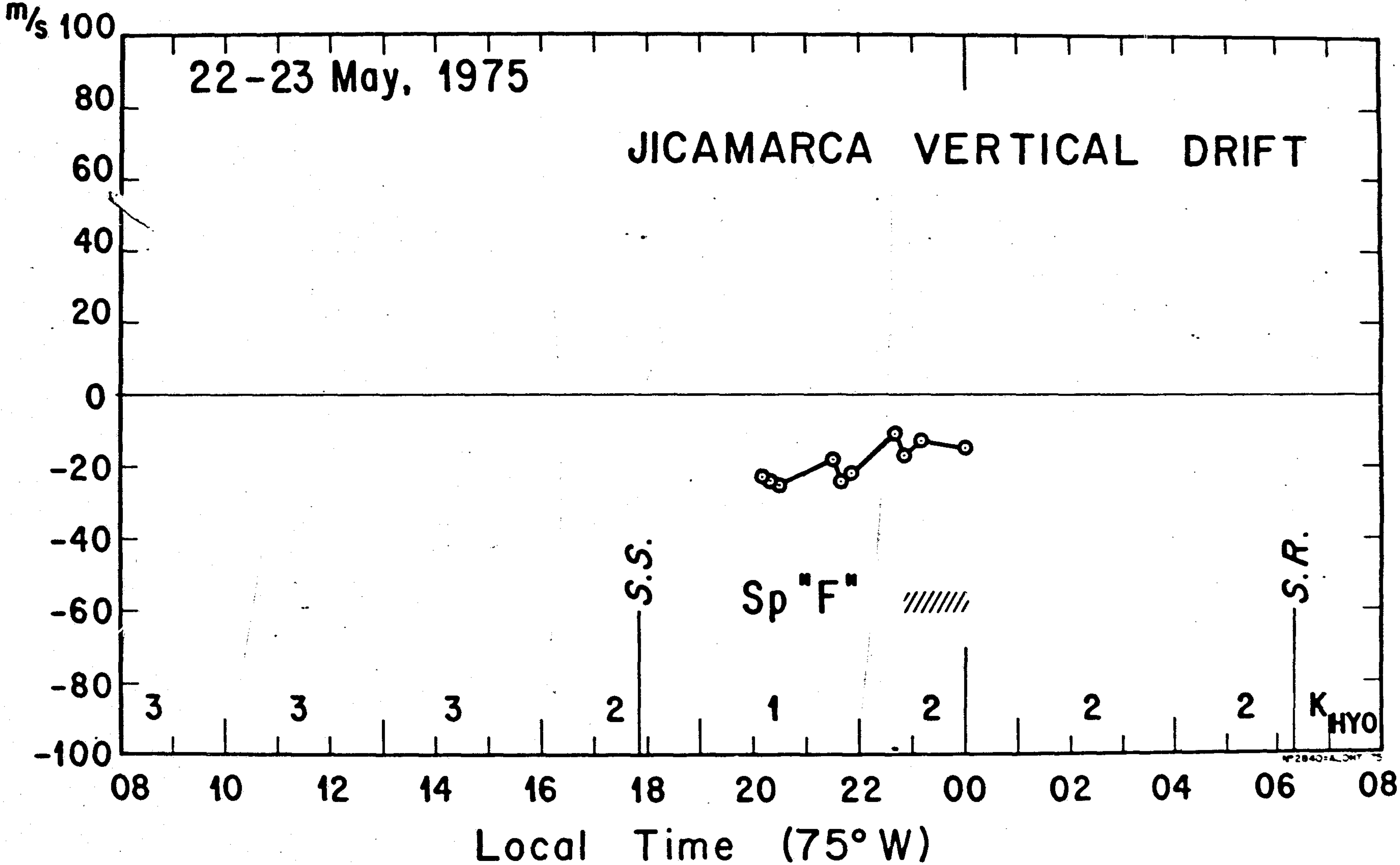

m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
21-22 May, 1975
JICAMARCA VERTICAL DRIFT
S.S.
Sp "F"
S.R.
3
3
3
1
1
2
2
2
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 18



m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
22-23 May, 1975
JICAMARCA VERTICAL DRIFT
S.S.
Sp "F"
S.R.
3
3
3
2
1
2
2
2
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 19

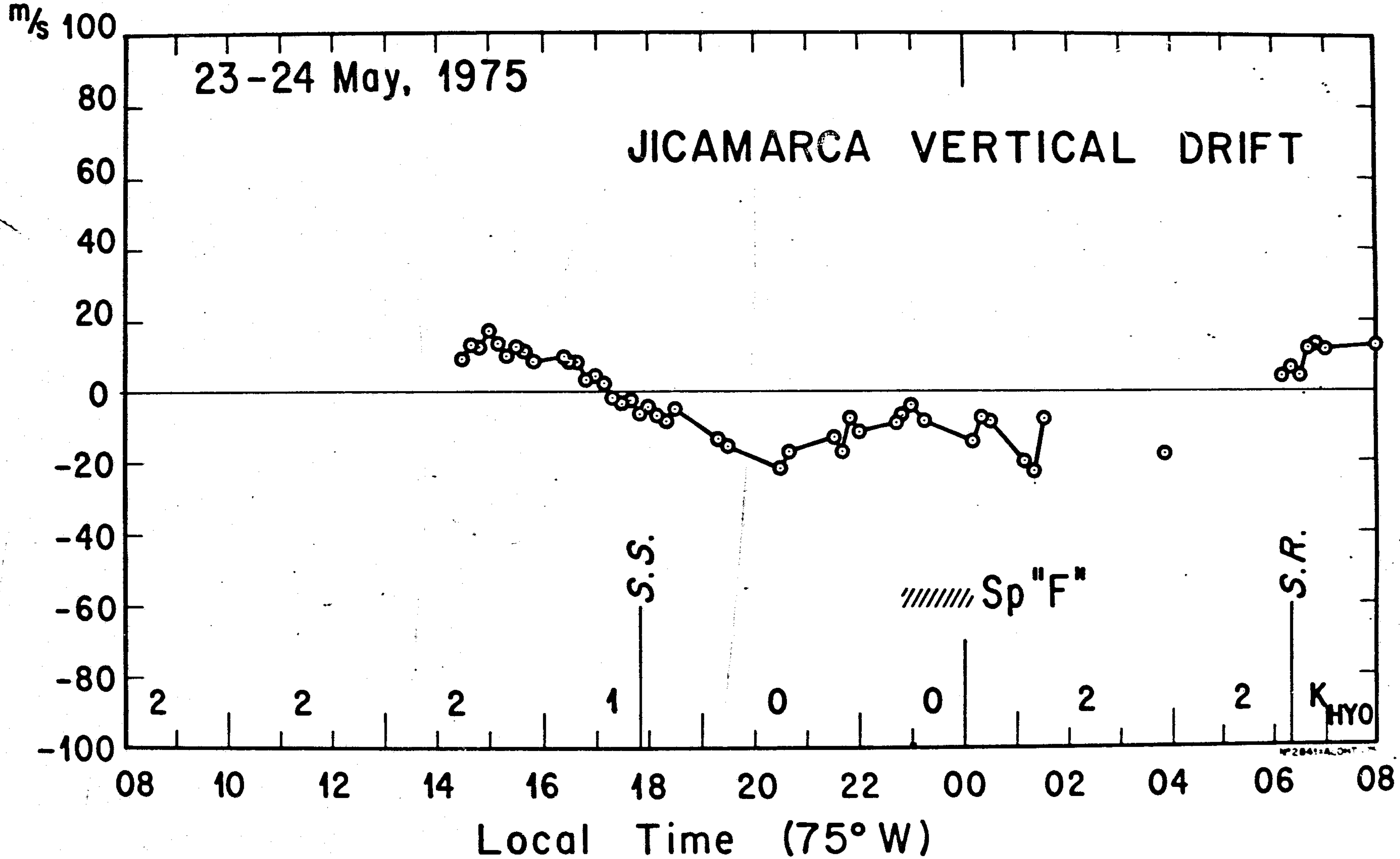
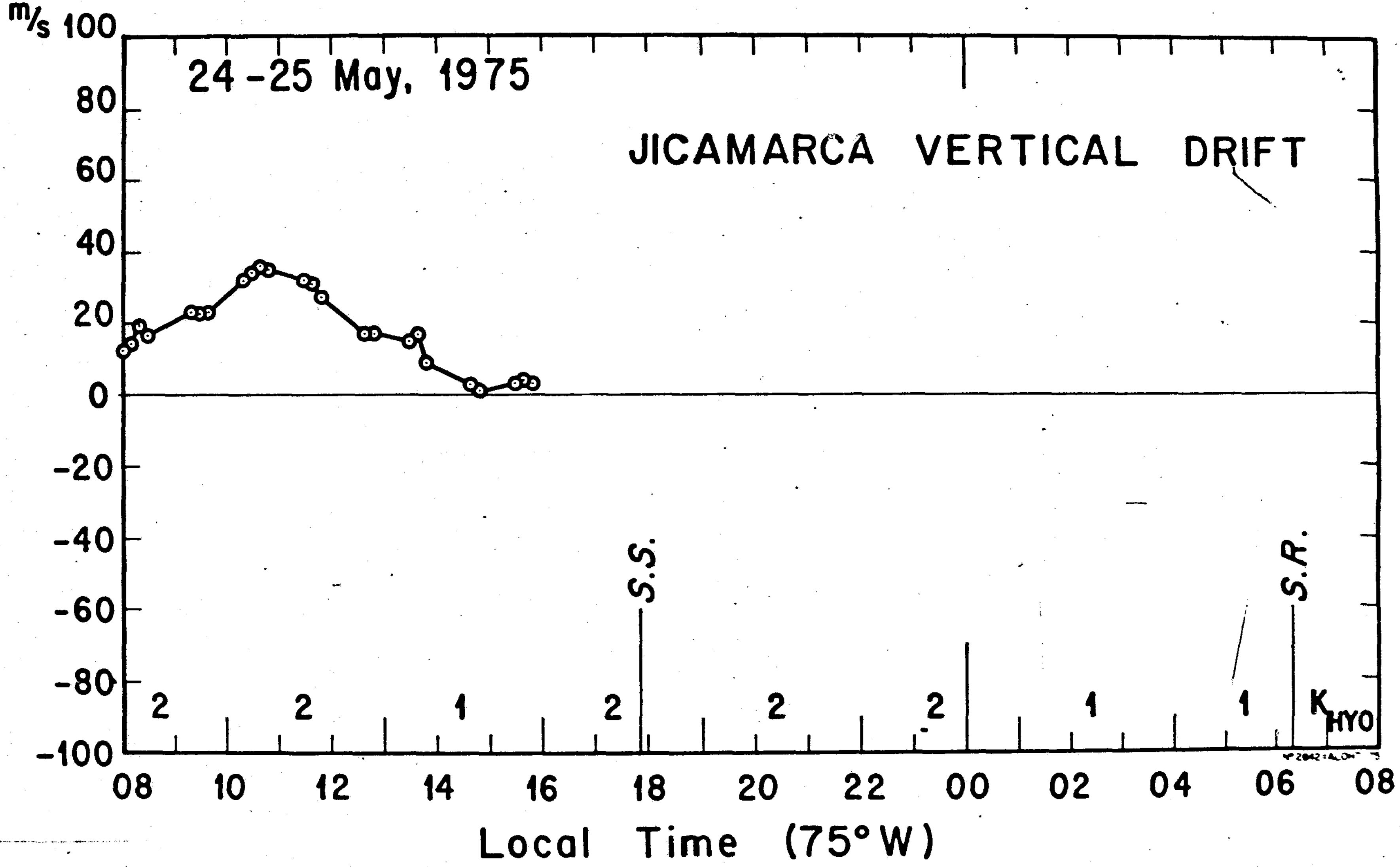

23-24 May, 1975
JICAMARCA VERTICAL DRIFT
m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
S.S.
S.R.
Sp"F"
2
2
2
1
0
0
2
2
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 20



24-25 May, 1975
JICAMARCA VERTICAL DRIFT
m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
S.S.
S.R.
2 2 1 2 2 2 1 1
K HYO
08 10 12 14 16 18 20 22 00 02 04 06 08
Local Time (75° W)

Fig. 21

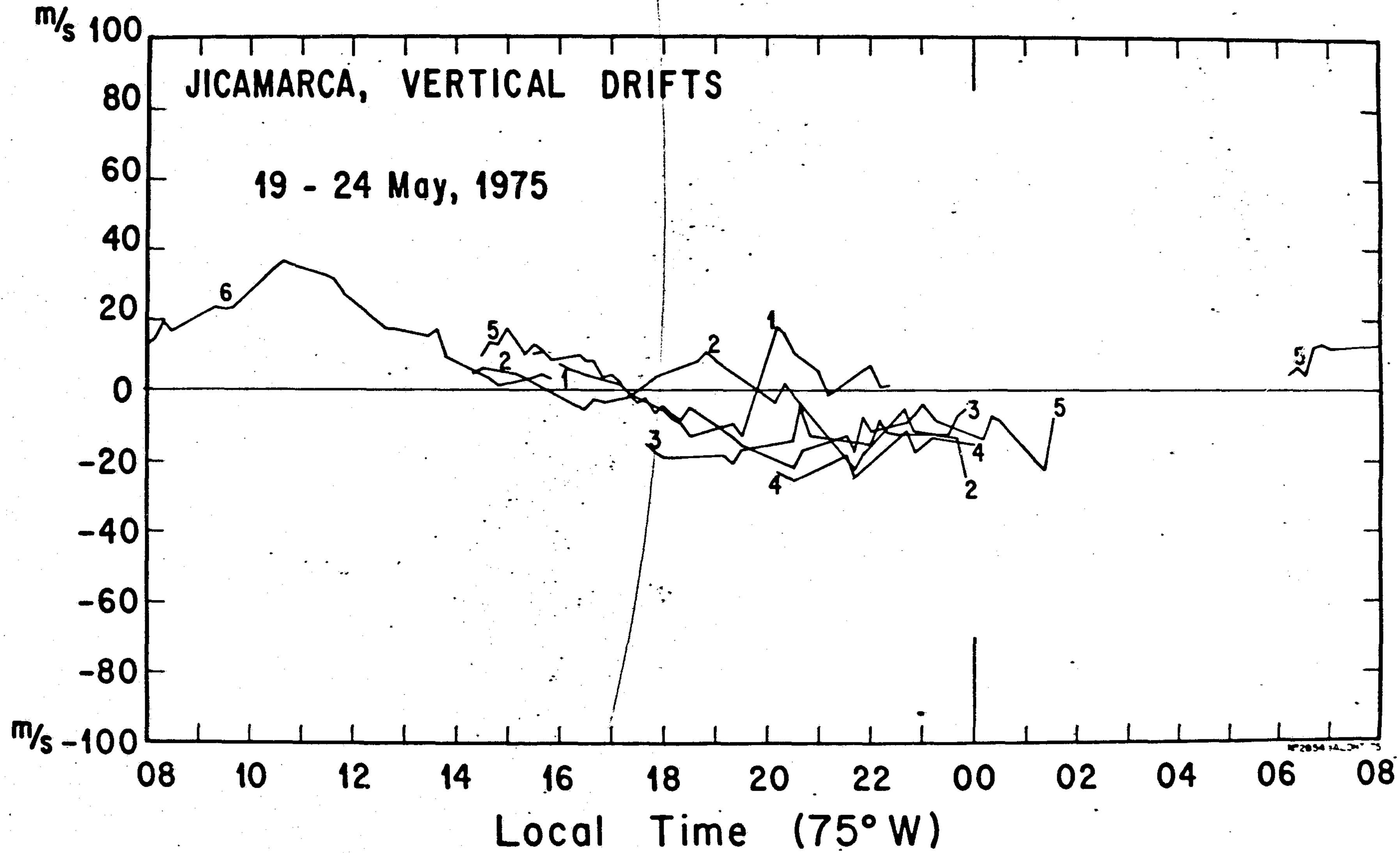
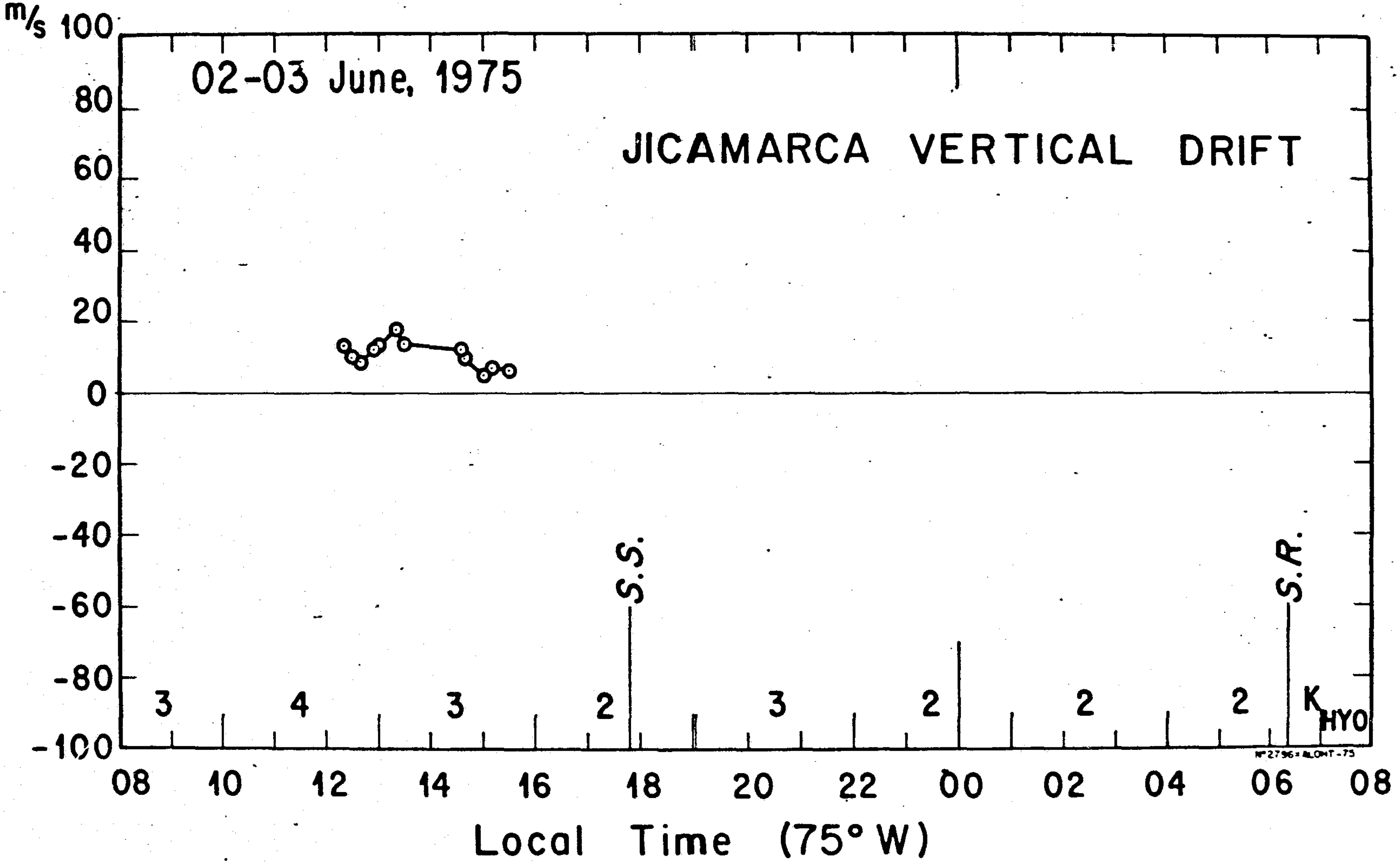

JICAMARCA, VERTICAL DRIFTS
19 - 24 May, 1975
m/s 100
80
60
40
20
0
-20
-40
-60
-80
m/s -100
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 22



m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
02-03 June, 1975
JICAMARCA VERTICAL DRIFT
S.S.
S.R.
3
4
3
2
3
2
2
2
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 23

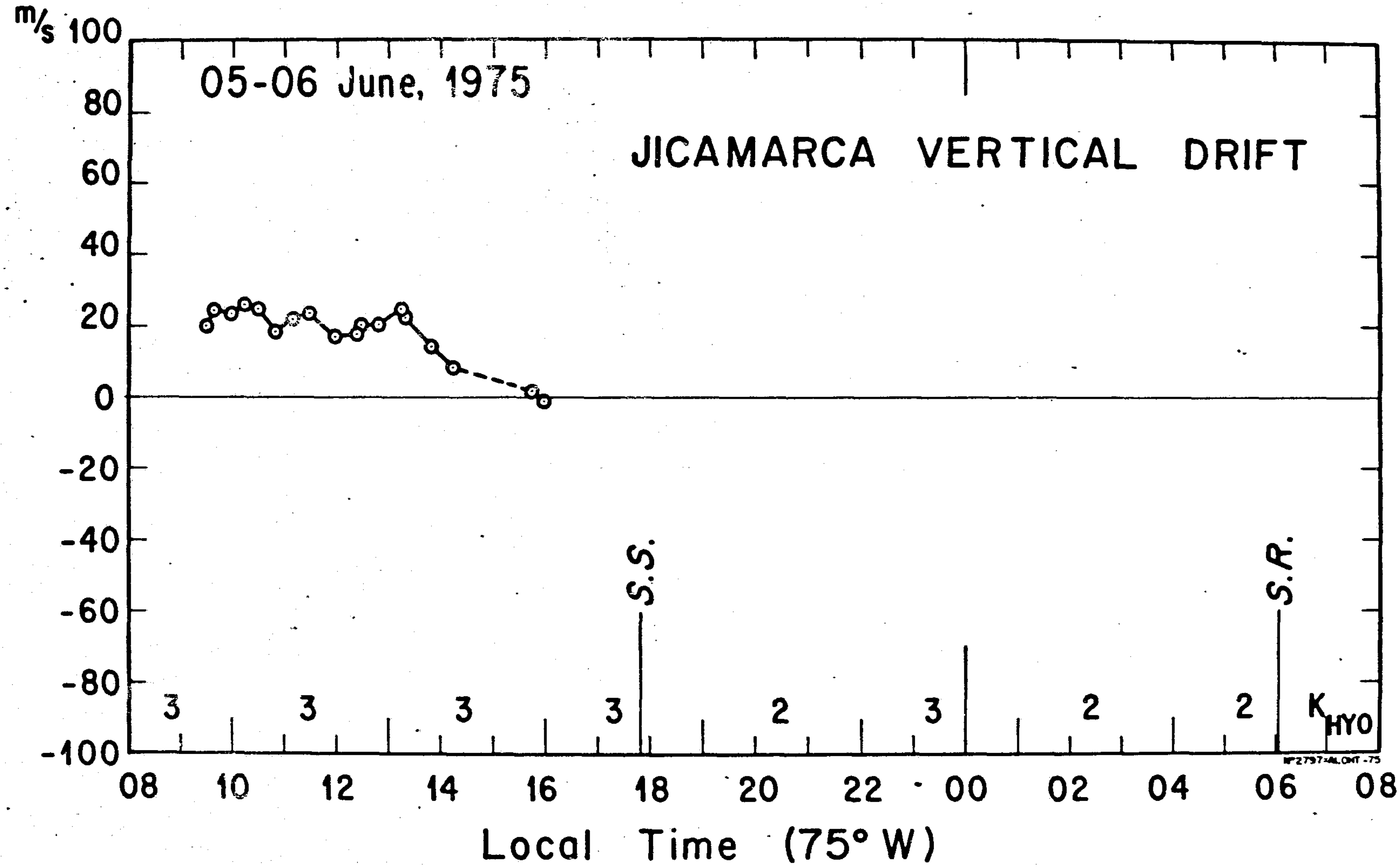

05-06 June, 1975
JICAMARCA VERTICAL DRIFT
m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
S.S.
S.R.
3
3
3
3
2
3
2
2
K HYO
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 24

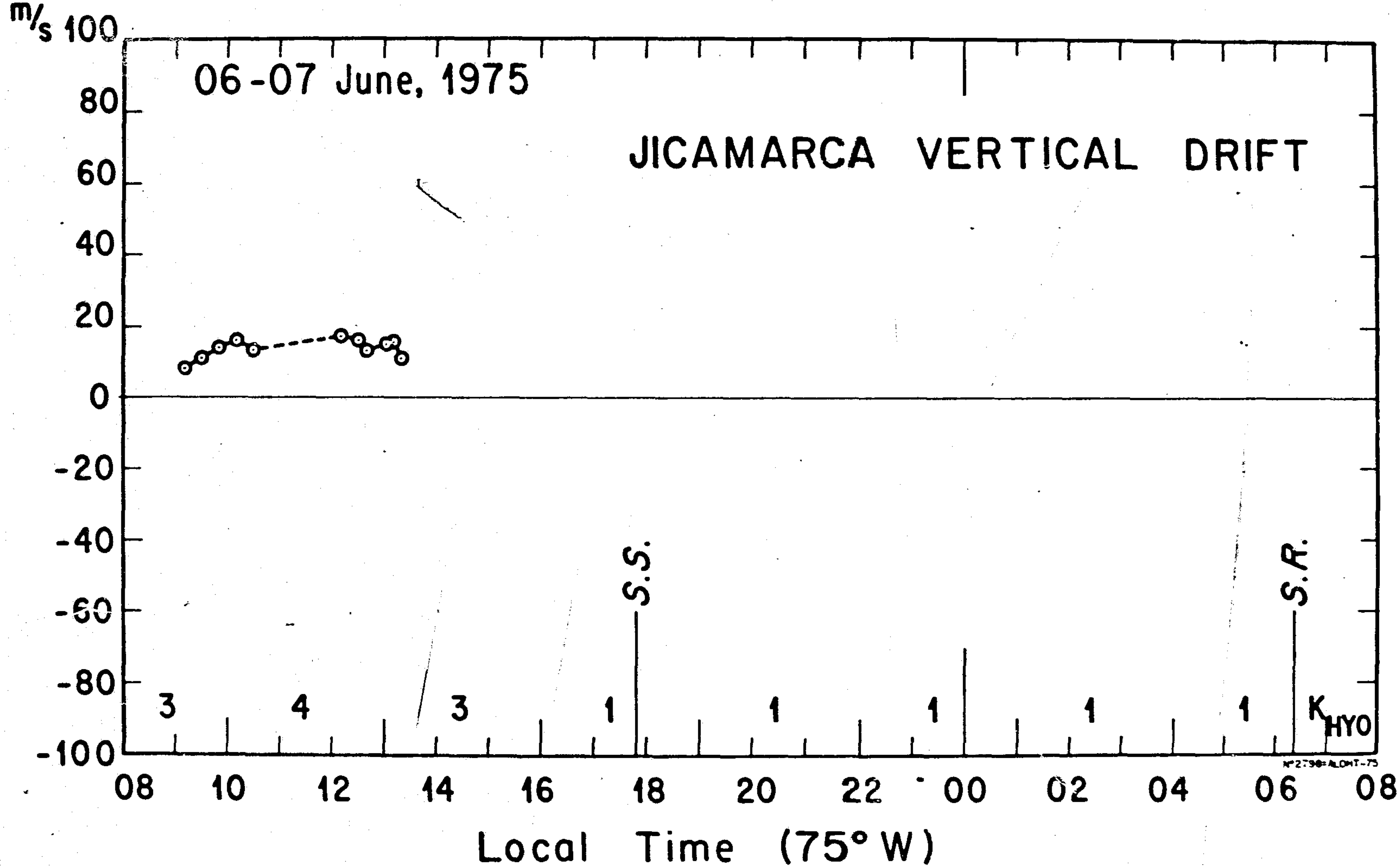
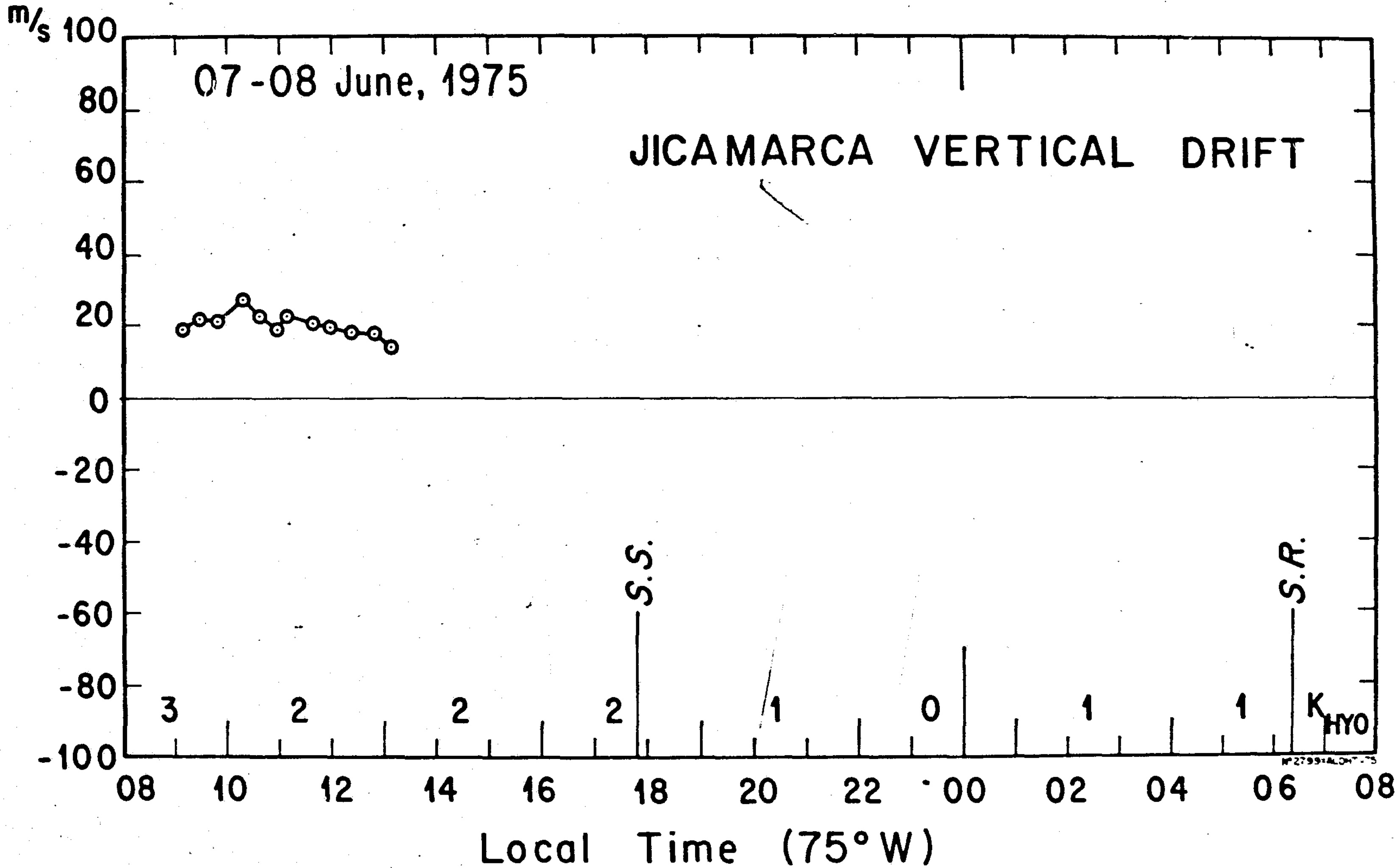

m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
06-07 June, 1975
JICAMARCA VERTICAL DRIFT
S.S.
S.R.
3
4
3
1
1
1
1
1
K_{HYO}
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 25



m/s
100
80
60
40
20
0
-20
-40
-60
-80
-100
07-08 June, 1975
JICAMARCA VERTICAL DRIFT
S.S.
S.R.
3
2
2
2
1
0
1
1
K_{HYO}
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 26

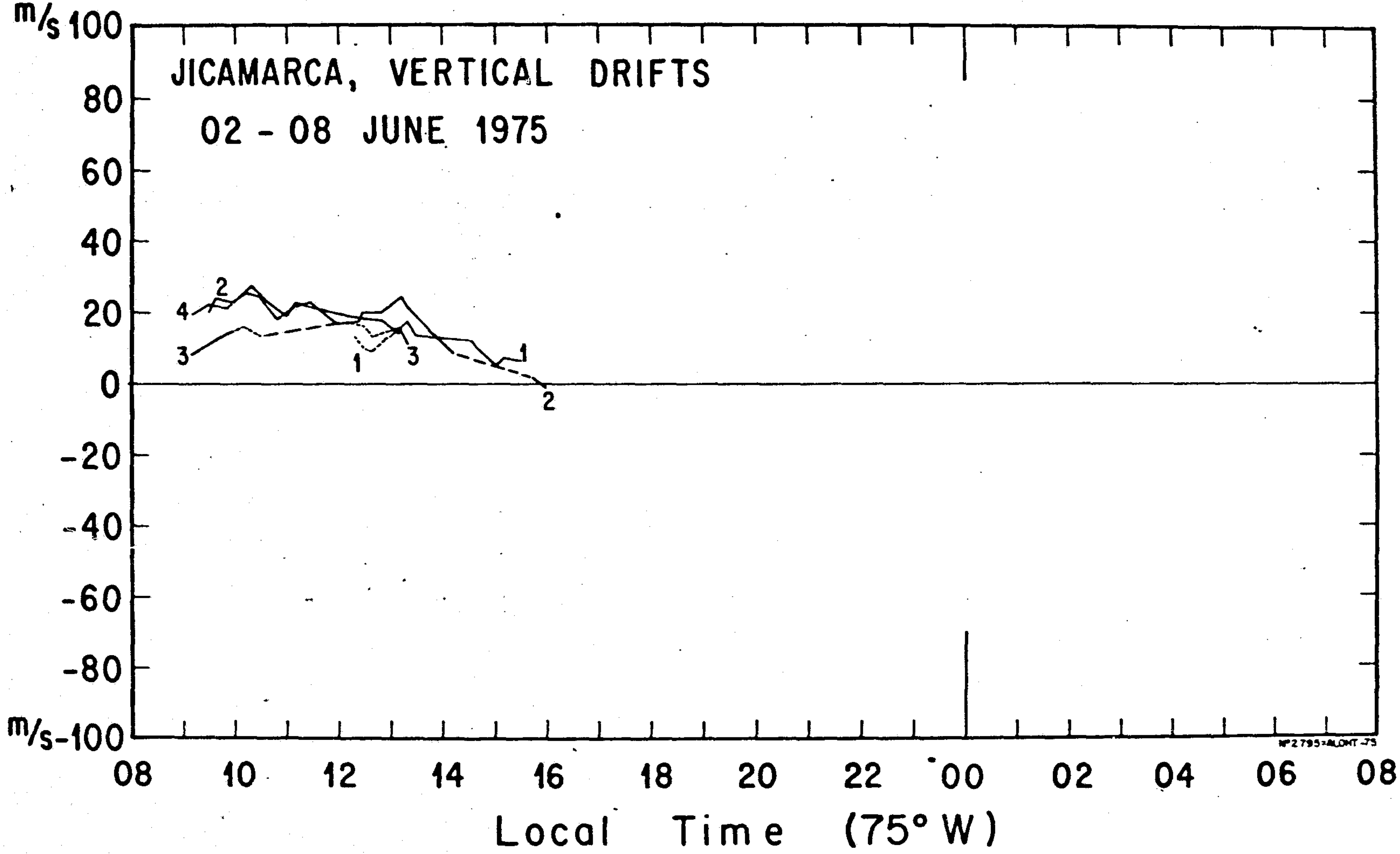

JICAMARCA, VERTICAL DRIFTS
02 - 08 JUNE 1975
m/s 100
80
60
40
20
0
-20
-40
-60
-80
m/s -100
4
2
3
1
3
1
2
08
10
12
14
16
18
20
22
00
02
04
06
08
Local Time (75° W)

Fig. 27

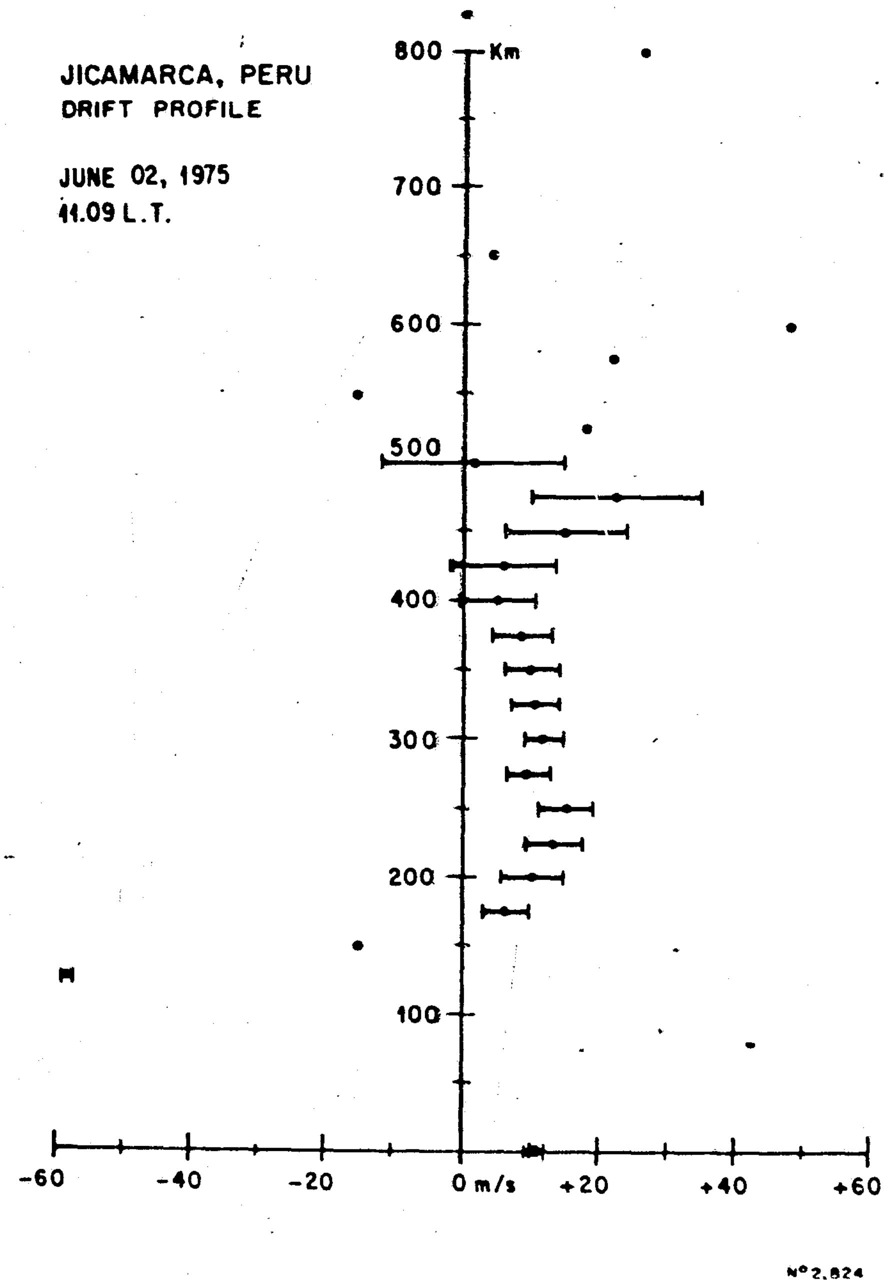

JICAMARCA, PERU
DRIFT PROFILE
JUNE 02, 1975
11.09 L.T.
800
Km
700
600
500
400
300
200
100
-60
-40
-20
0 m/s
+20
+40
+60
N° 2.824

Fig. 28

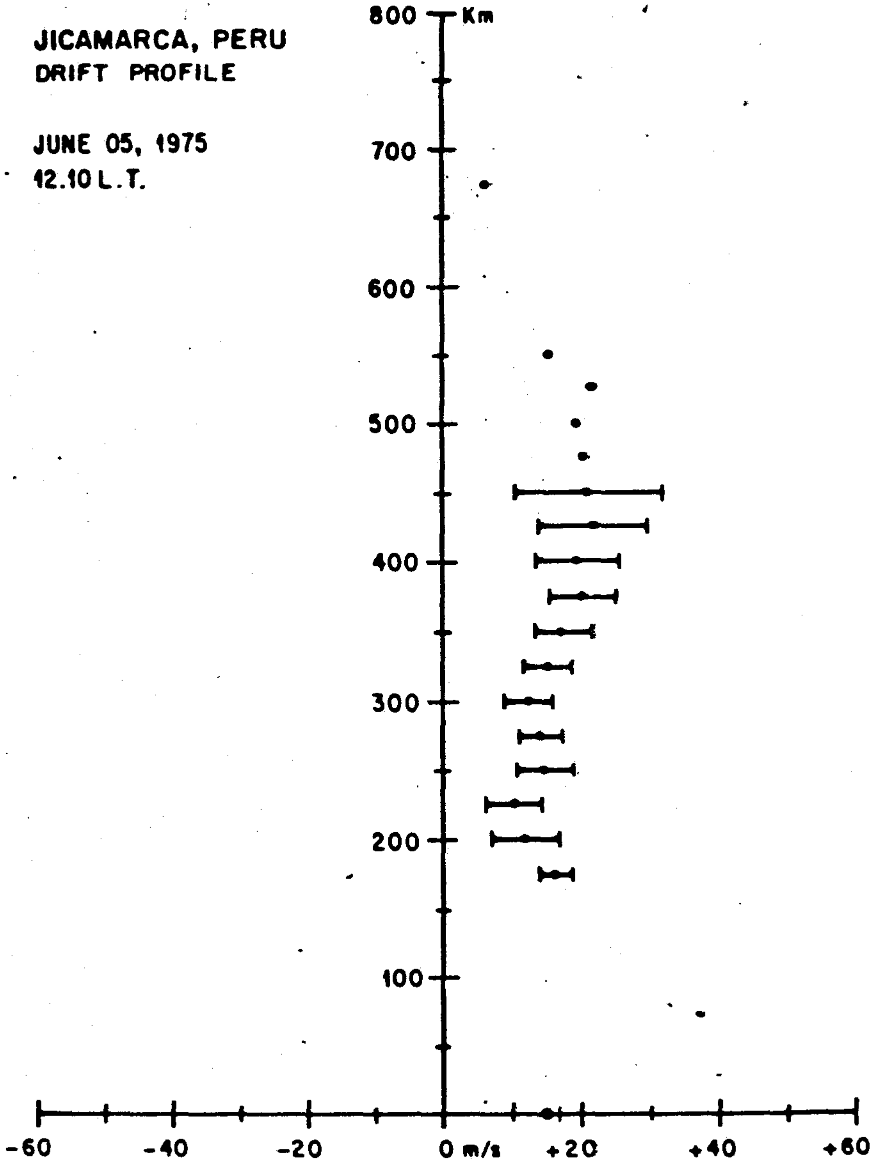

JICAMARCA, PERU
DRIFT PROFILE
JUNE 05, 1975
12.10 L.T.
800
Km
700
600
500
400
300
200
100
-60
-40
-20
0 m/s
+20
+40
+60

Fig. 29

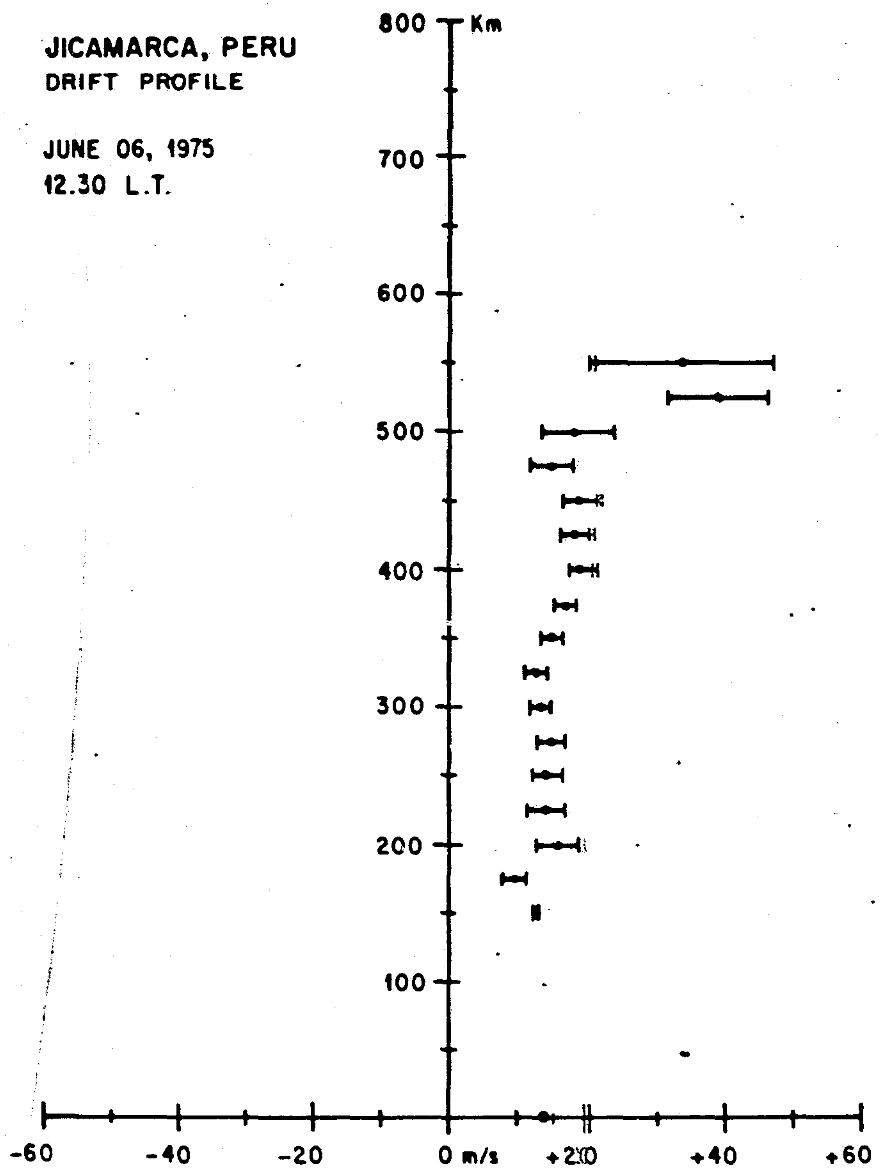

JICAMARCA, PERU
DRIFT PROFILE
JUNE 06, 1975
12.30 L.T.
800
Km
700
600
500
400
300
200
100
-60
-40
-20
0 m/s
+20
+40
+60

Fig. 30

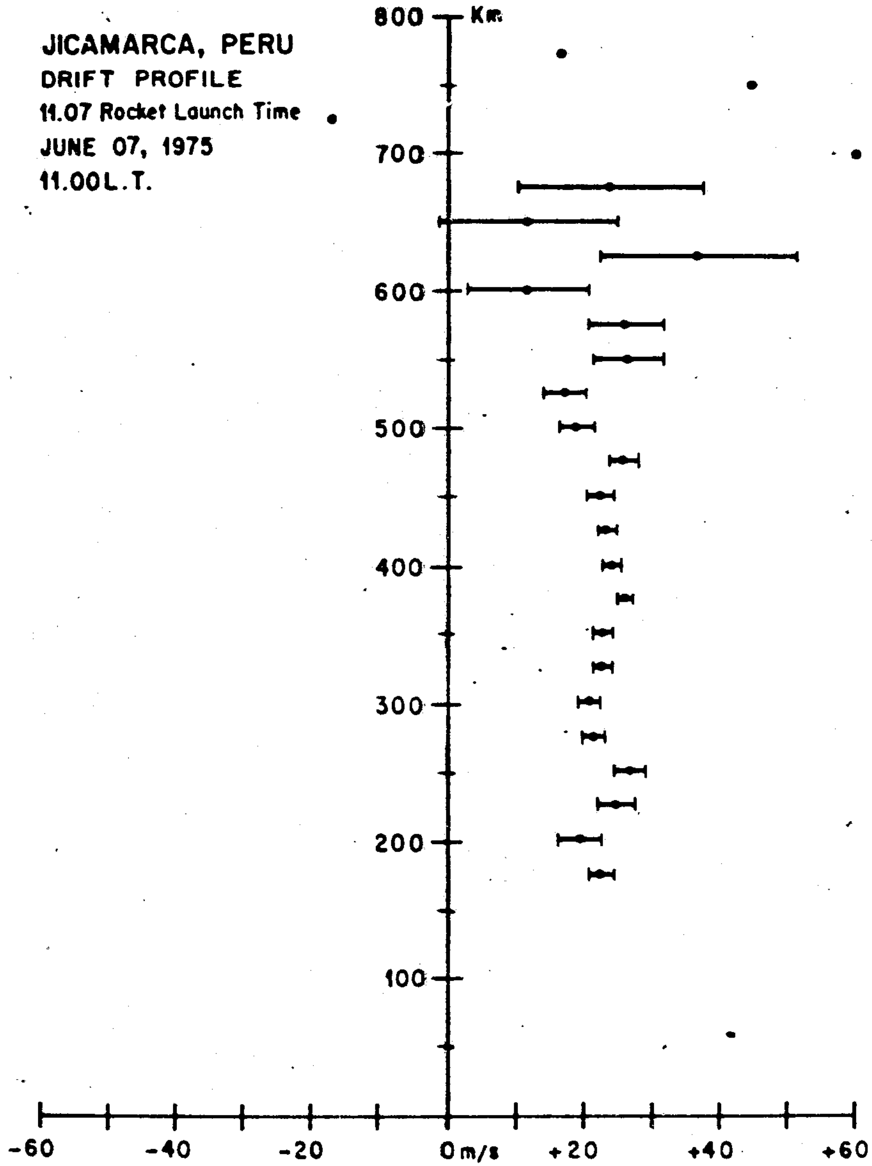

JICAMARCA, PERU
DRIFT PROFILE
11.07 Rocket Launch Time
JUNE 07, 1975
11.00L.T.
800
Km
700
600
500
400
300
200
100
-60
-40
-20
0 m/s
+20
+40
+60

Fig. 31

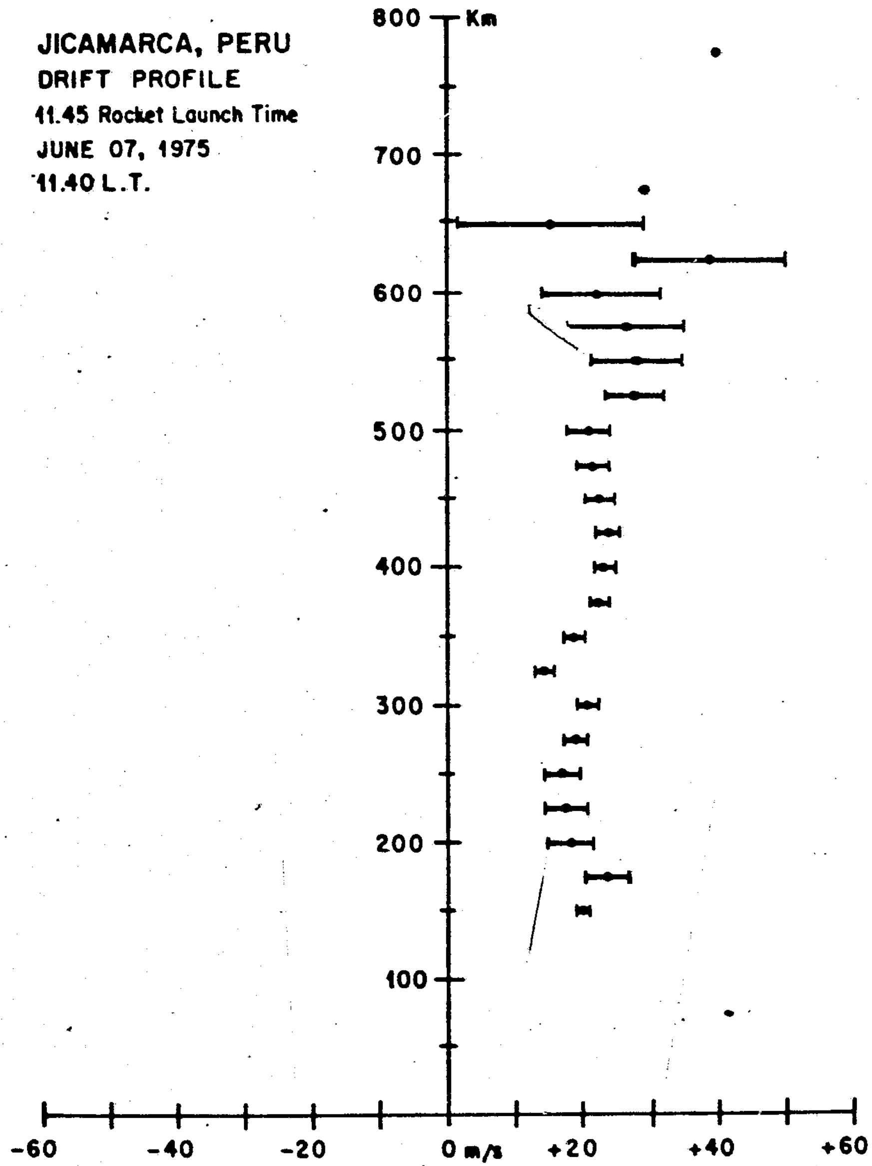

JICAMARCA, PERU
DRIFT PROFILE
11.45 Rocket Launch Time
JUNE 07, 1975
11.40 L.T.
800
Km
700
600
500
400
300
200
100
-60
-40
-20
0 m/s
+20
+40
+60

Fig. 32

APPENDIX C

ELECTROJET RELATIVE ECHO POWER DENSITY

FIGURE CAPTIONS

Fig. 33 to 67 Composite of relative echo power density versus frequency deviation for the times (75°W) and dates indicated.

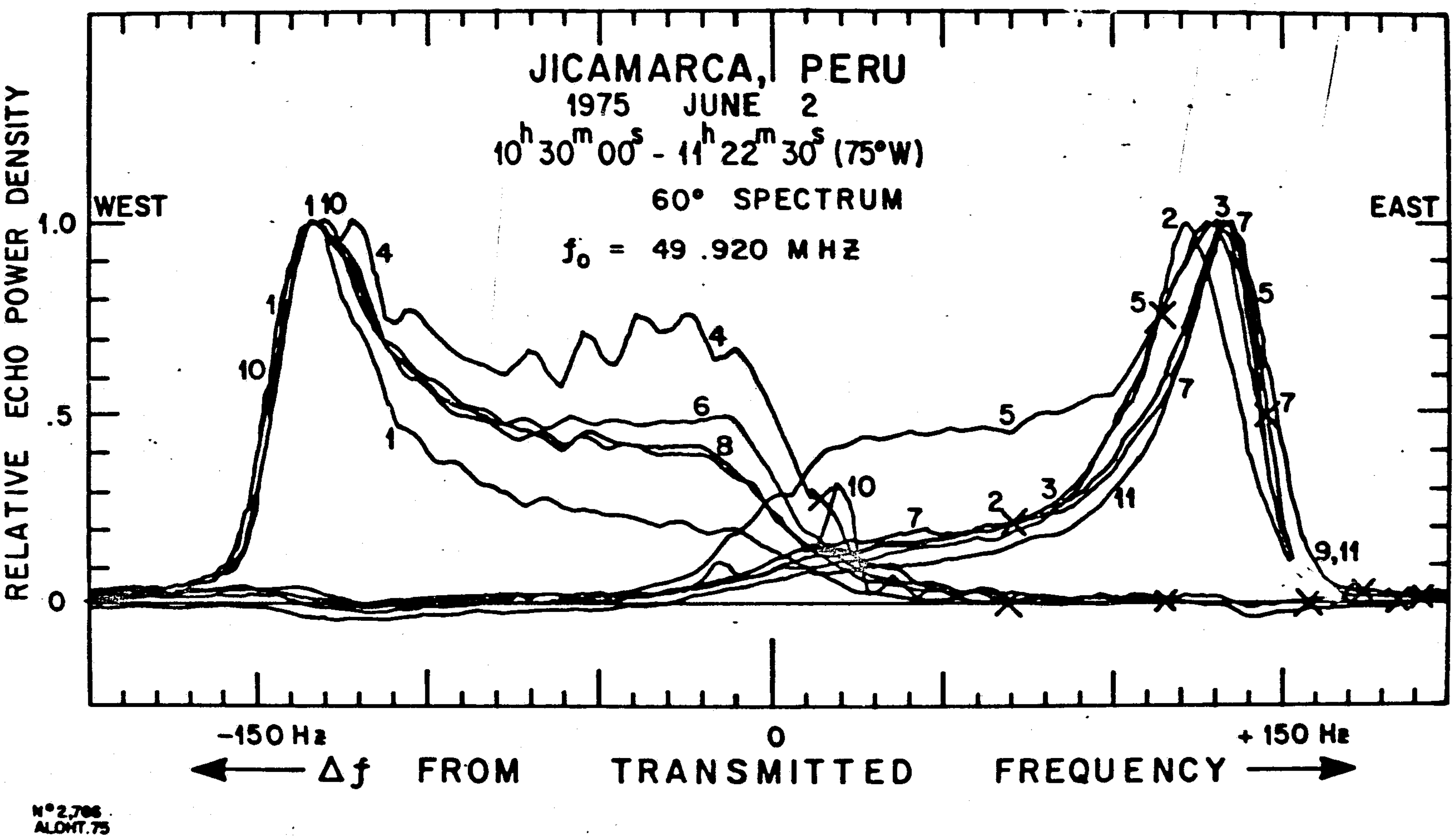
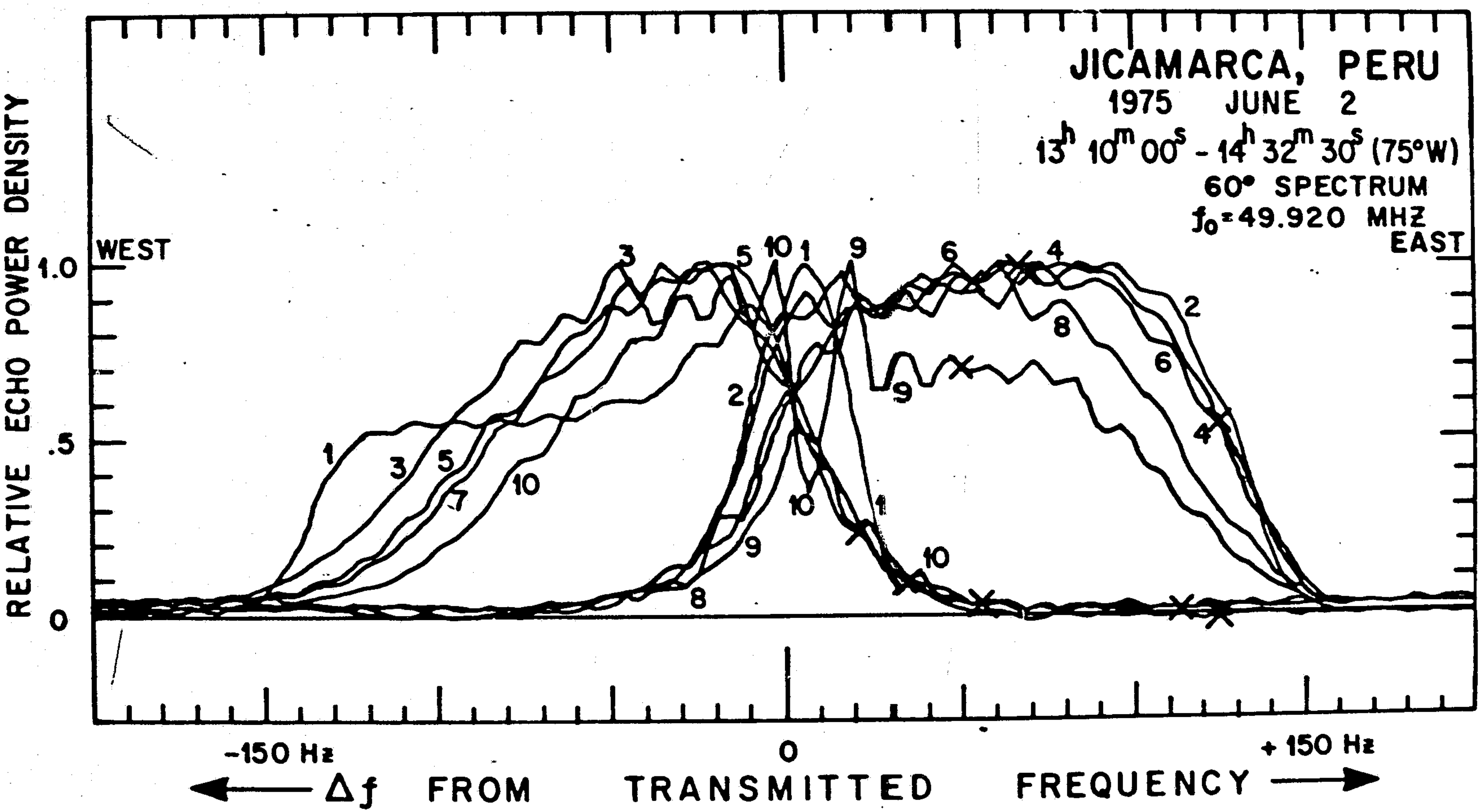

JICAMARCA, PERU
1975 JUNE 2
10h30m00s - 11h22m30s (75°W)
60° SPECTRUM
f_o = 49.920 MHZ
WEST
EAST
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
9,11
N°2,786
ALOHT.75

Fig. 33



N°2,767
ALOHT.75

Fig. 34

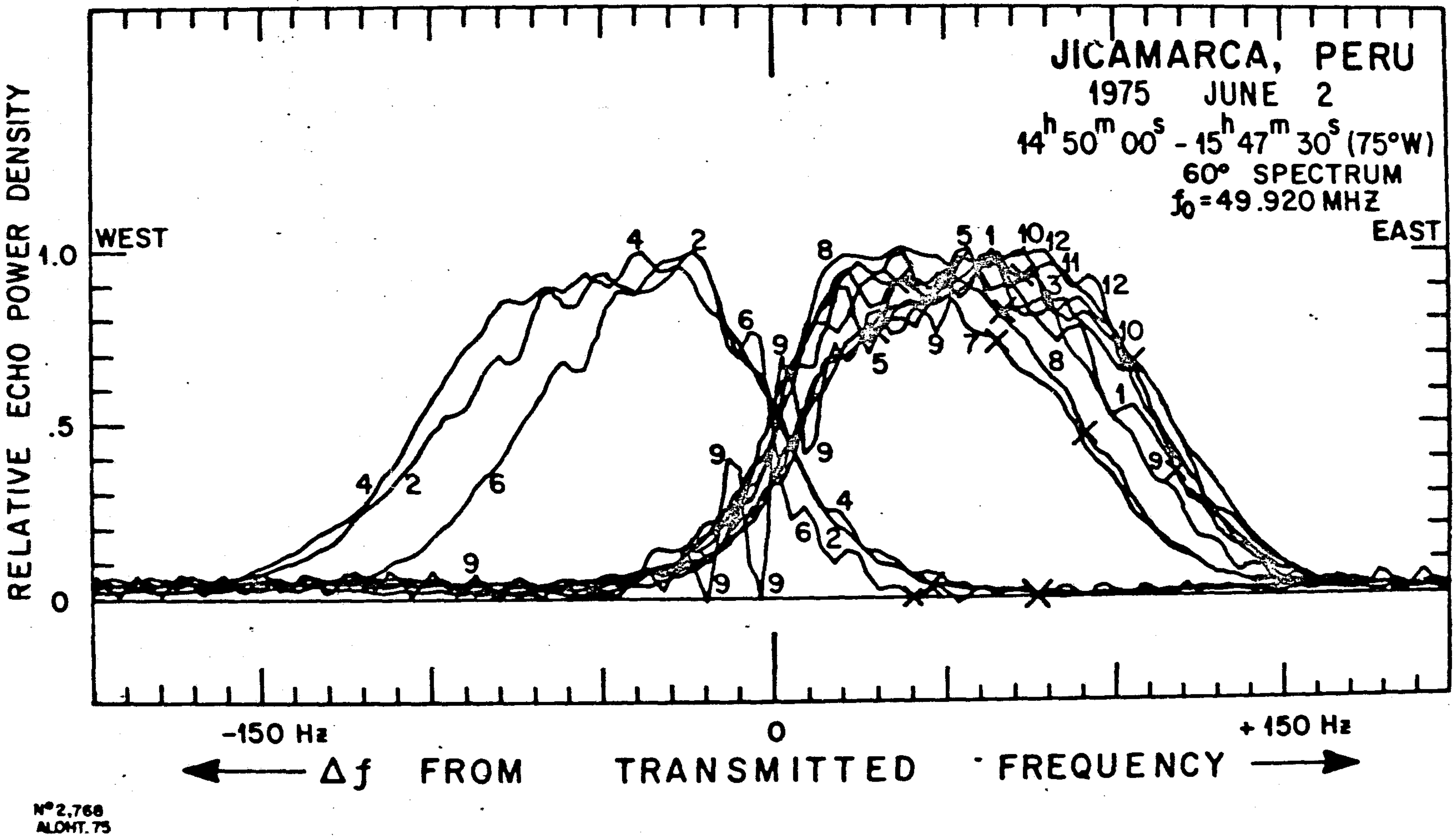

JICAMARCA, PERU
1975 JUNE 2
$14^h 50^m 00^s - 15^h 47^m 30^s$ (75°W)
60° SPECTRUM
f_0=49.920 MHZ
WEST
EAST
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2,768
ALOHT.75

Fig. 35

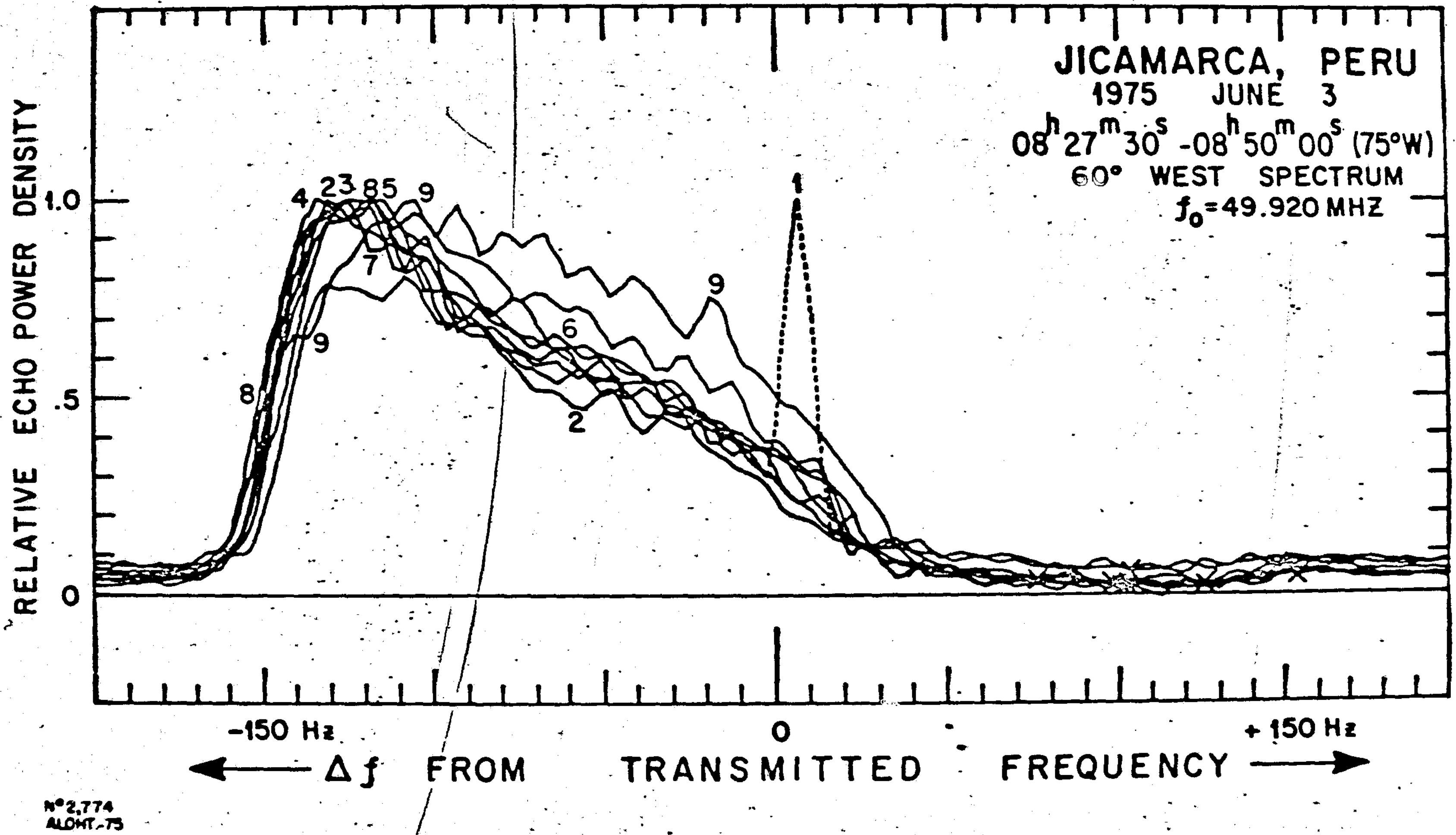

JICAMARCA, PERU
1975 JUNE 3
08h27m30s -08h50m00s (75°W)
60° WEST SPECTRUM
fo=49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,774
ALOHT-75

Fig. 36

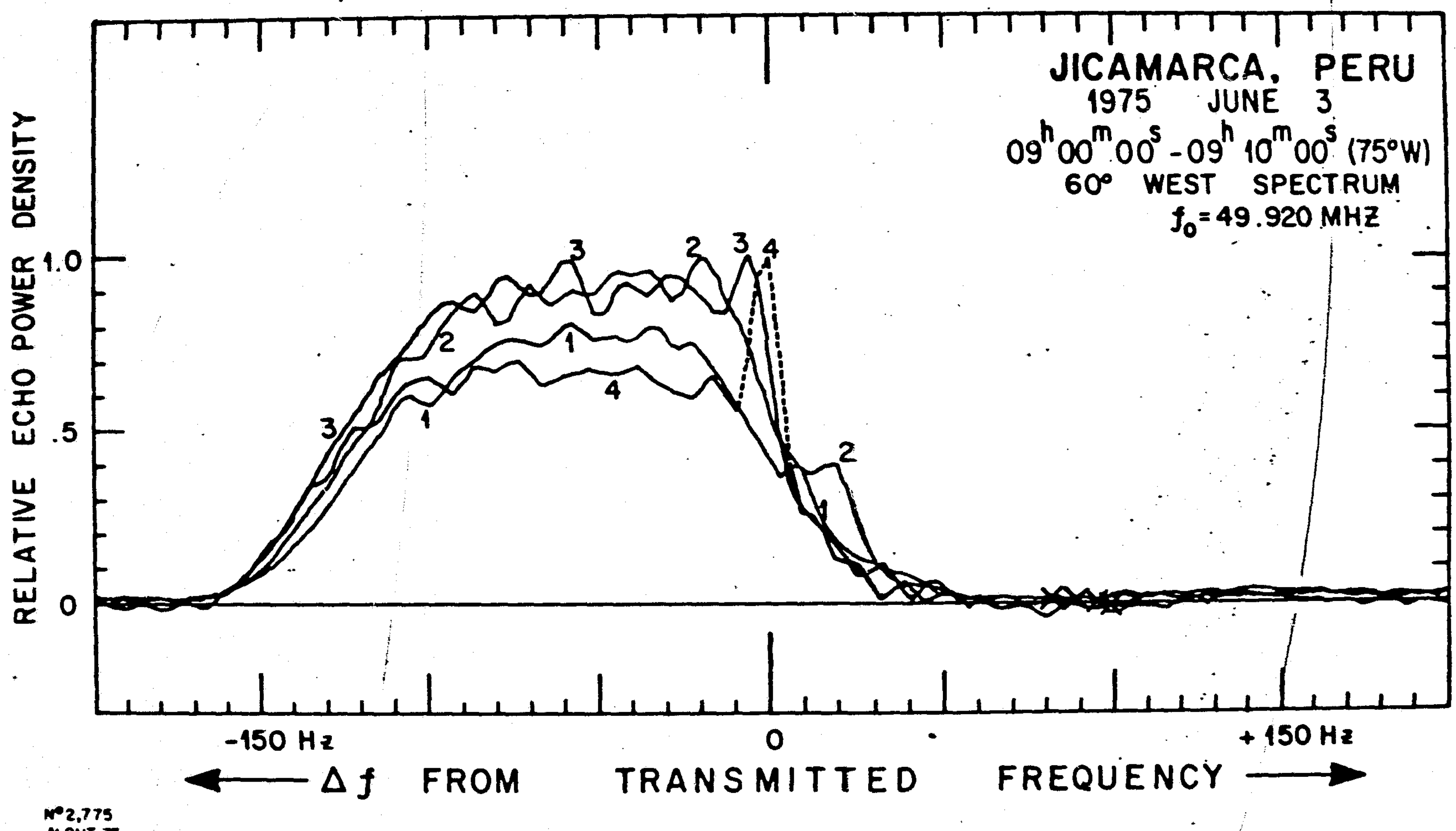
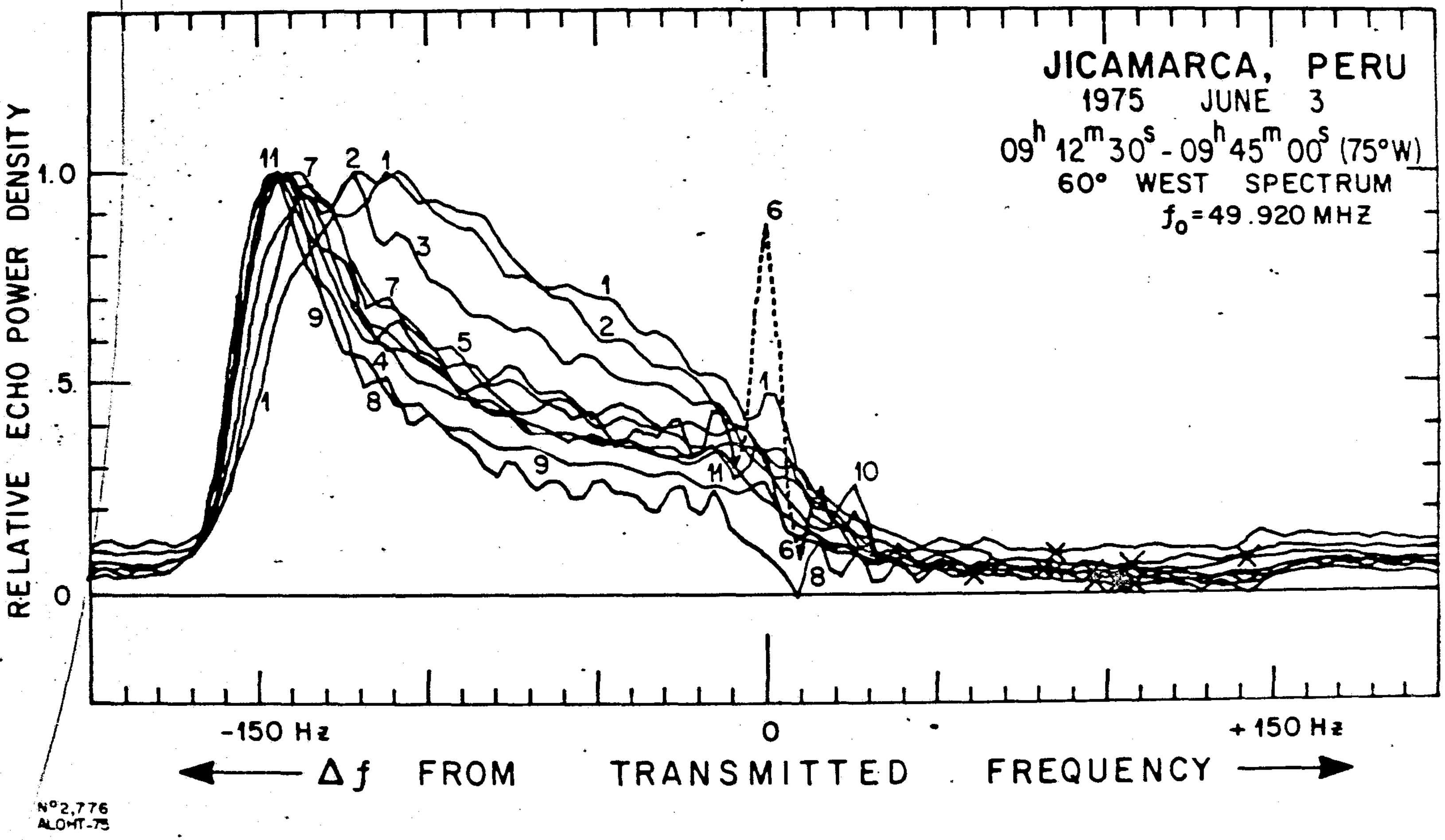
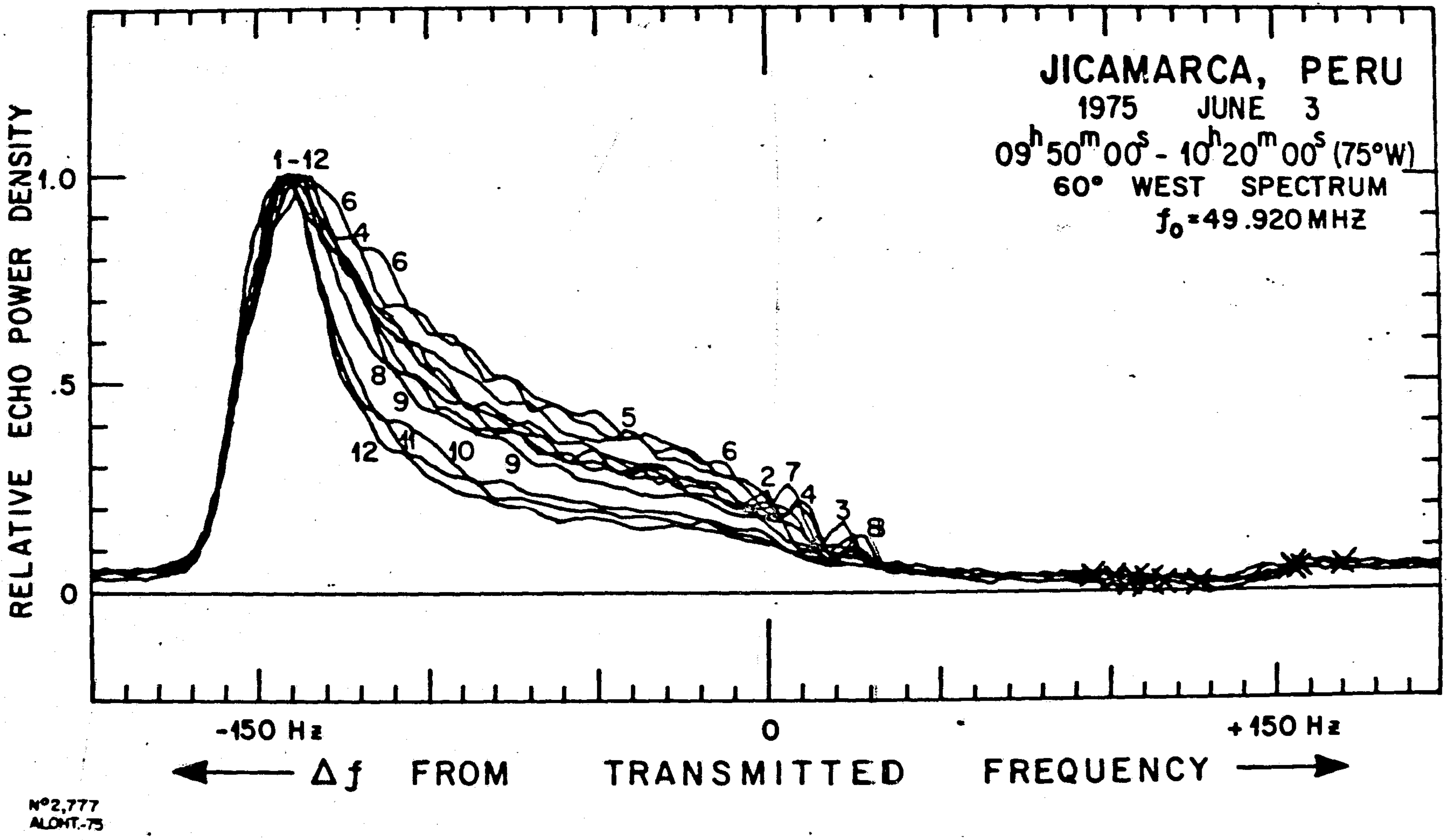

JICAMARCA, PERU
1975 JUNE 3
09h 00m 00s - 09h 10m 00s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
1
2
3
4
N° 2,775
ALOHT-75

Fig. 37



JICAMARCA, PERU
1975 JUNE 3
09h 12m 30s - 09h 45m 00s (75°W)
60° WEST SPECTRUM
fo=49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,776
ALOHT-75

Fig. 38



JICAMARCA, PERU
1975 JUNE 3
09h50m00s - 10h20m00s (75°W)
60° WEST SPECTRUM
fo=49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1-12
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,777
ALDHT.-75

Fig. 39

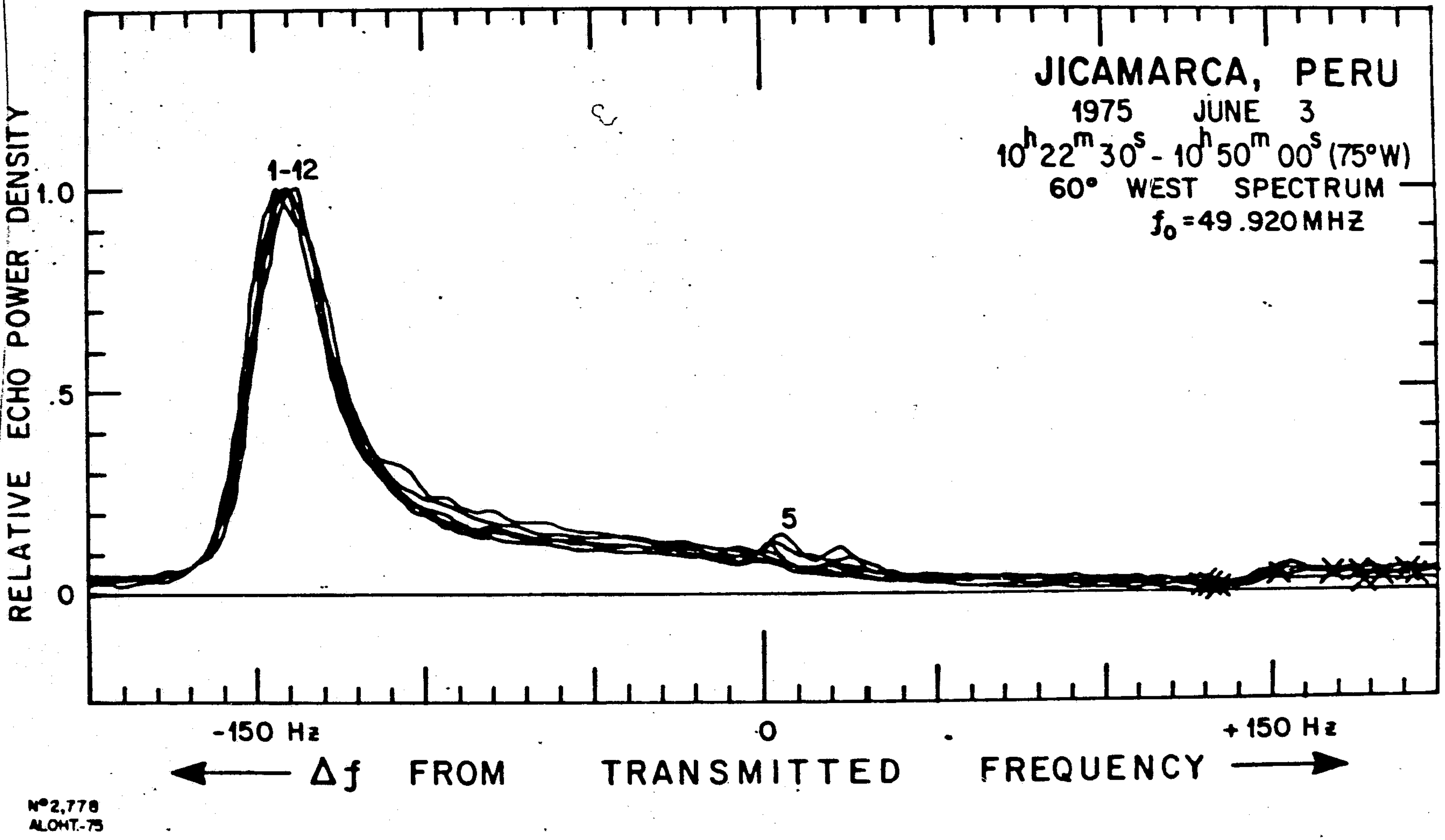

JICAMARCA, PERU
1975 JUNE 3
10h22m30s - 10h50m00s (75°W)
60° WEST SPECTRUM
f0=49.920 MHZ
1-12
5
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,778
ALOHT.-75

Fig. 40

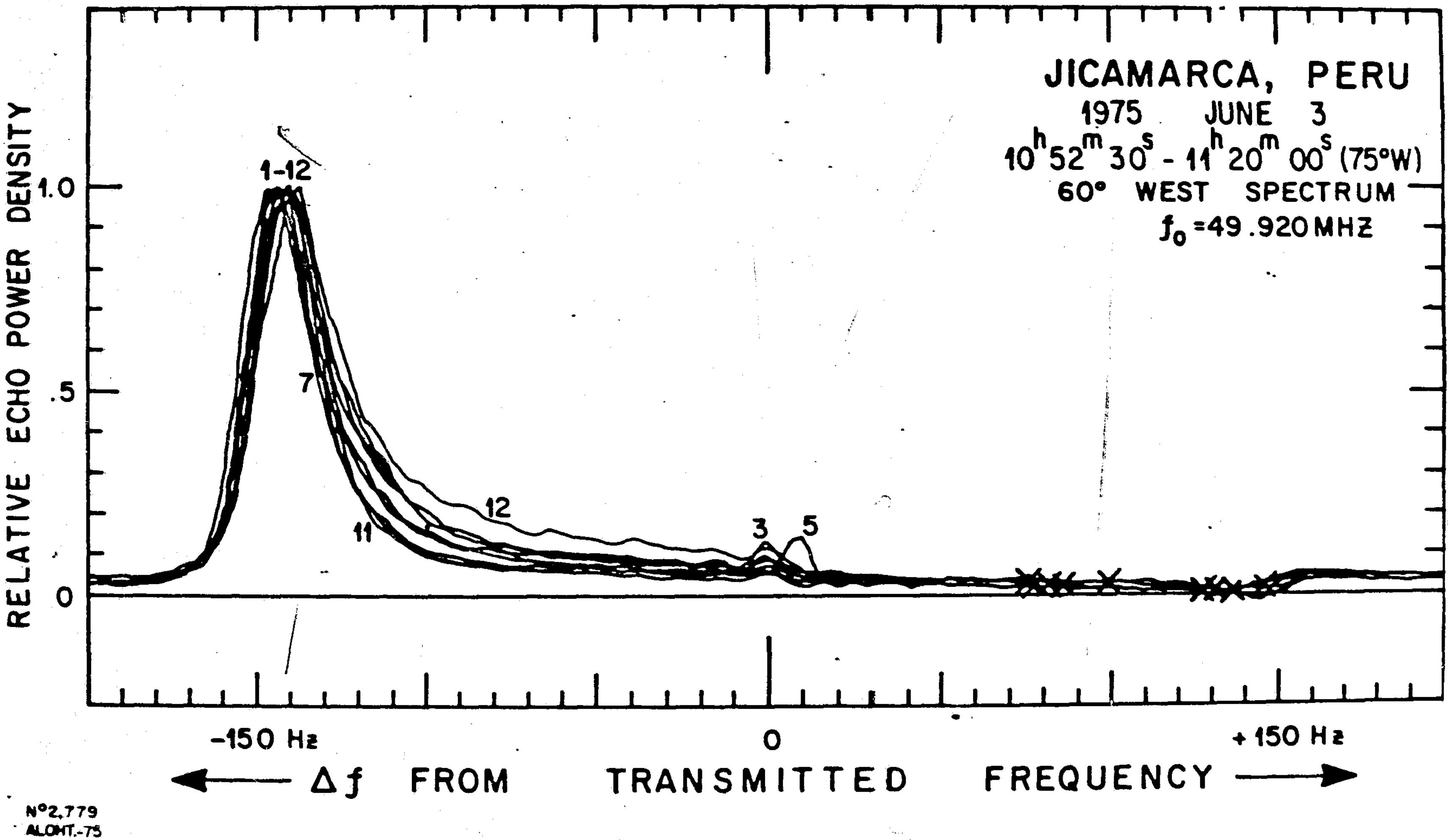
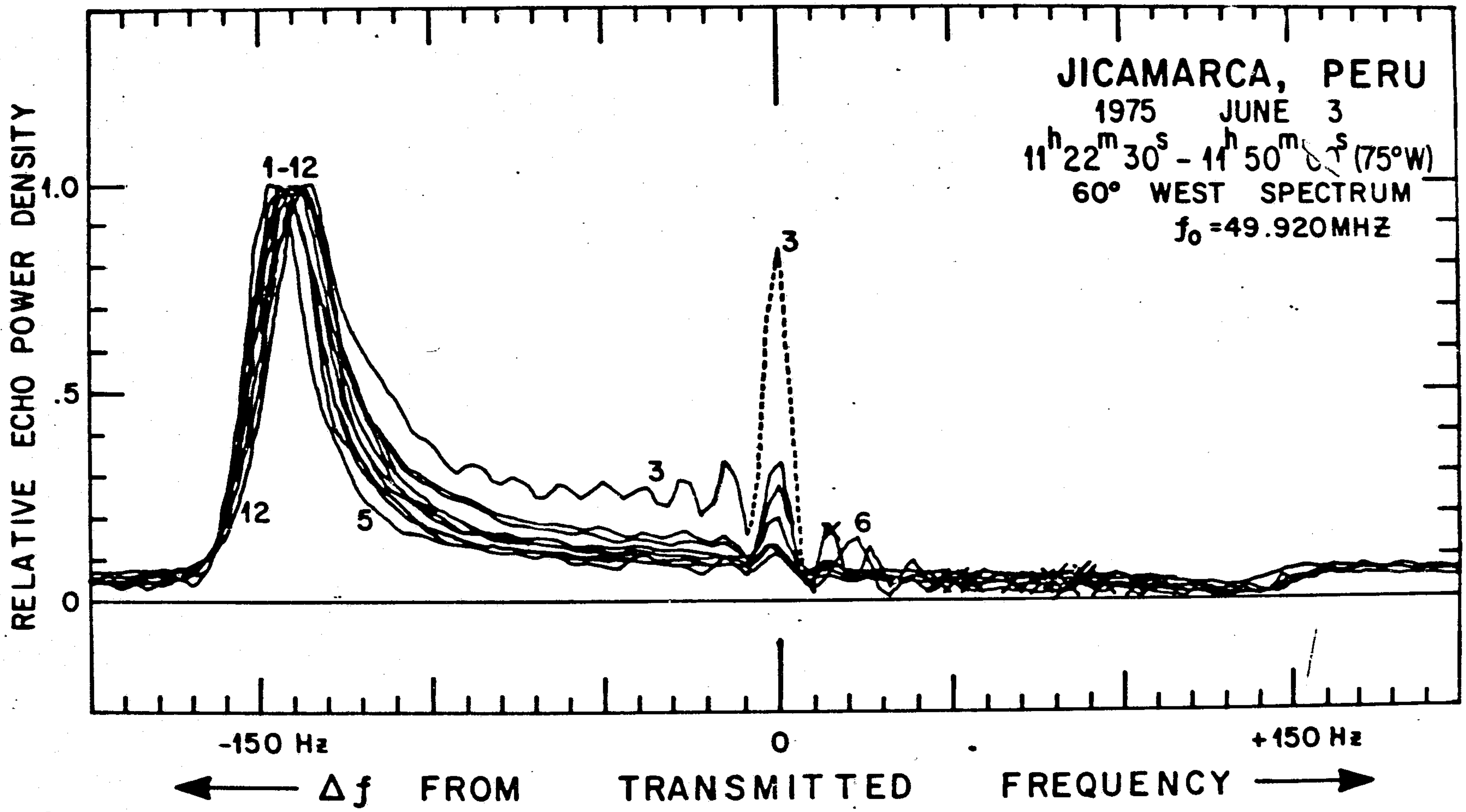
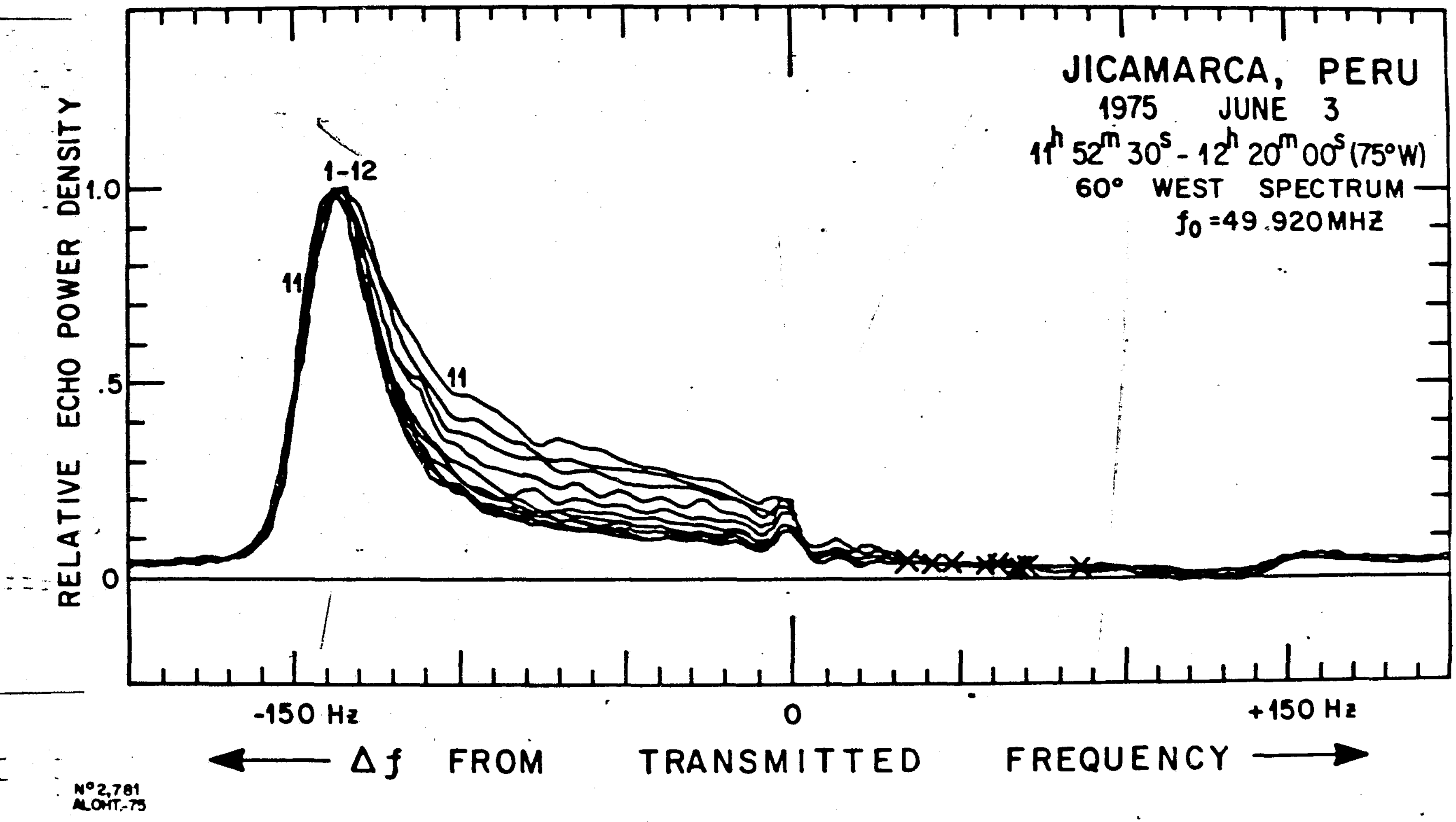

JICAMARCA, PERU
1975 JUNE 3
$10^h 52^m 30^s$ - $11^h 20^m 00^s$ (75°W)
60° WEST SPECTRUM
f_0=49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1-12
7
11
12
3
5
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,779
ALOHT.-75

Fig. 41



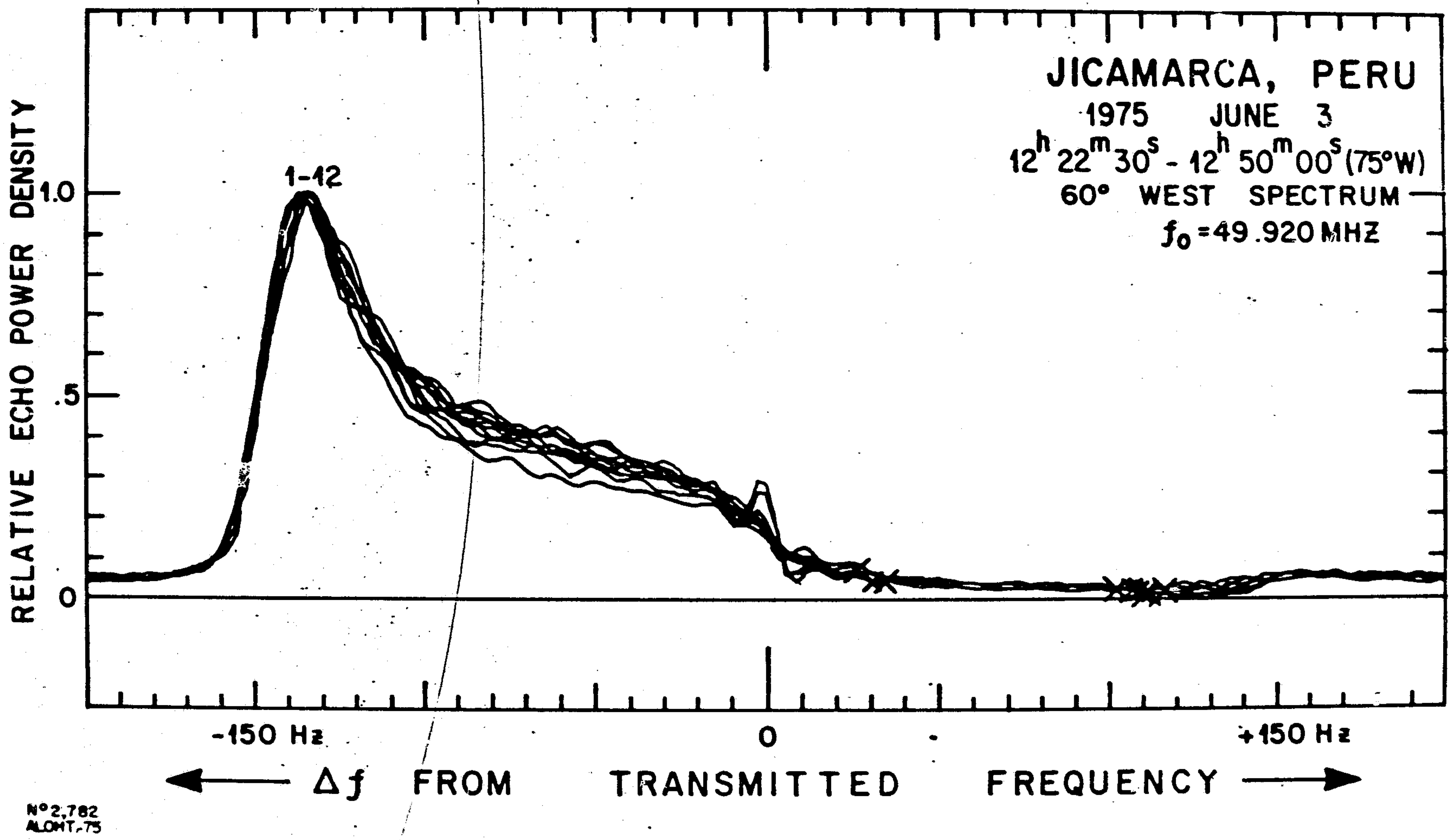
N°2,780
ALOHT.-75

Fig. 42



JICAMARCA, PERU
1975 JUNE 3
11h 52m 30s - 12h 20m 00s (75°W)
60° WEST SPECTRUM
f_0 =49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1-12
11
11
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,781
ALOHT.-75

Fig. 43



JICAMARCA, PERU
1975 JUNE 3
12h 22m 30s - 12h 50m 00s (75°W)
60° WEST SPECTRUM
f0 =49.920 MHZ
1-12
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,782
ALOHT.-75

Fig. 44

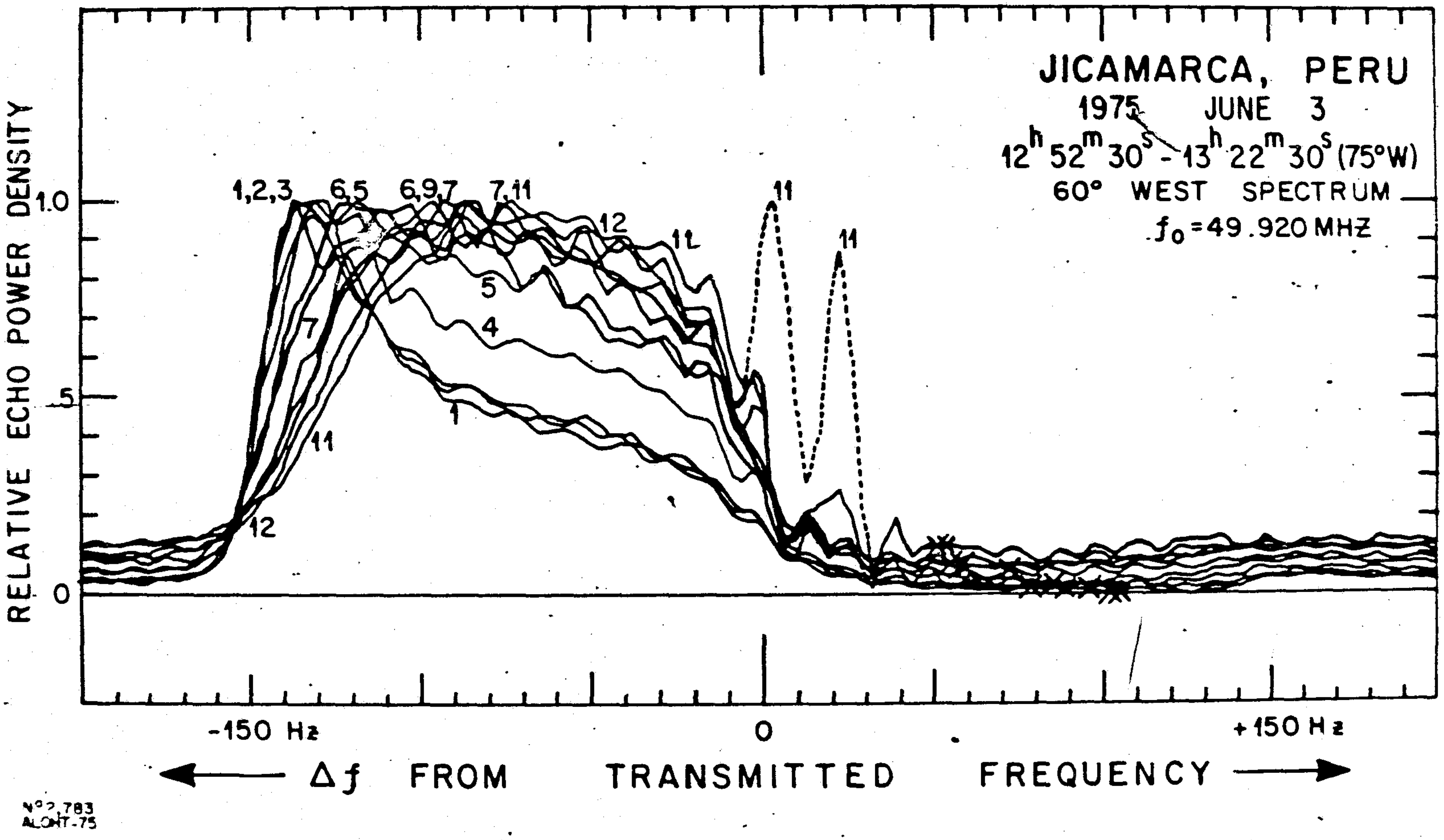

JICAMARCA, PERU
1975 JUNE 3
12h 52m 30s - 13h 22m 30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1,2,3
6,5
6,9,7
7,11
12
11
5
4
7
1
11
12
11
11
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,783
ALGHT-75

Fig. 45

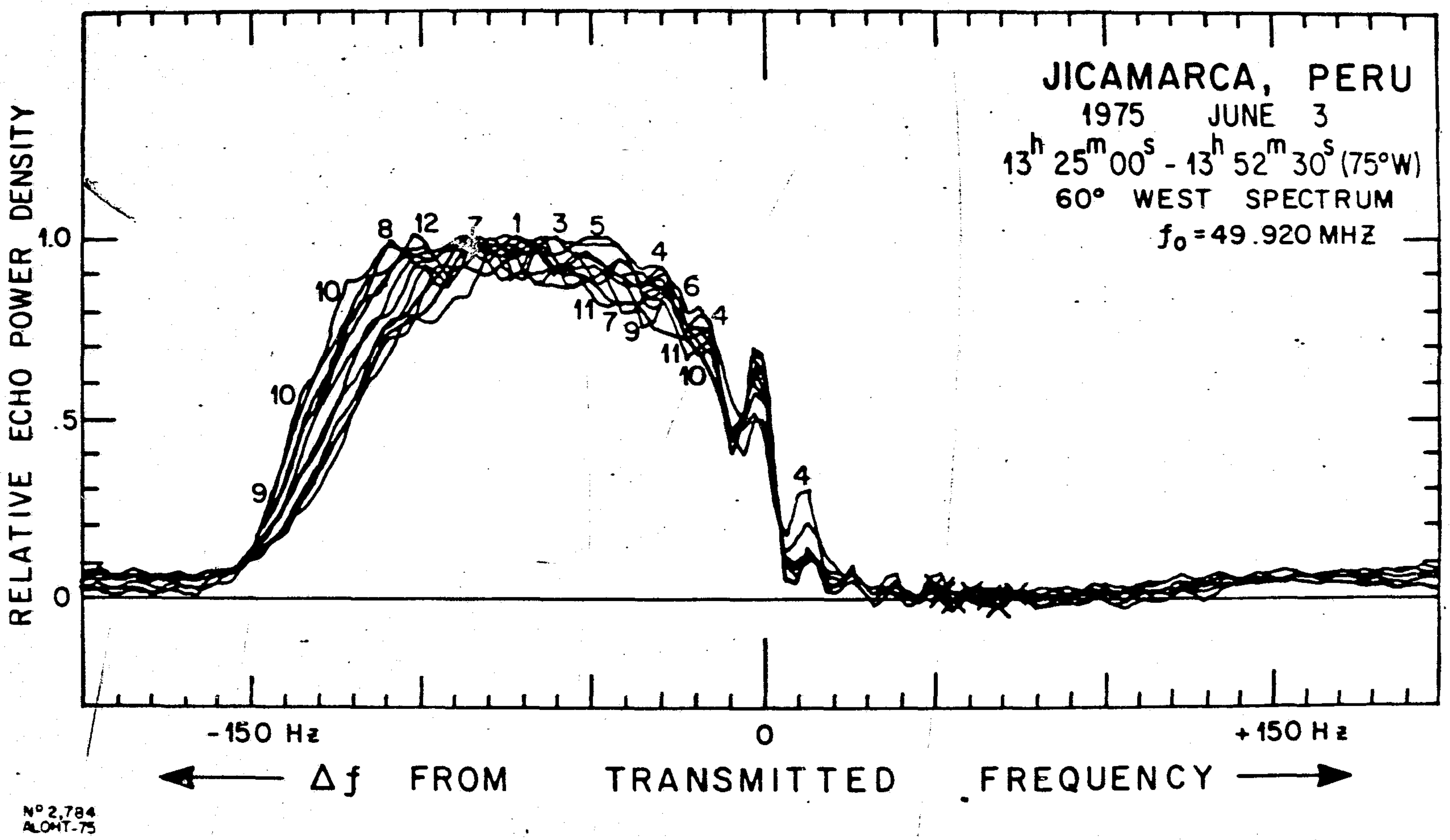

JICAMARCA, PERU
1975 JUNE 3
13h 25m 00s - 13h 52m 30s (75°W)
60° WEST SPECTRUM
f0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2,784
ALOHT-75

Fig. 46

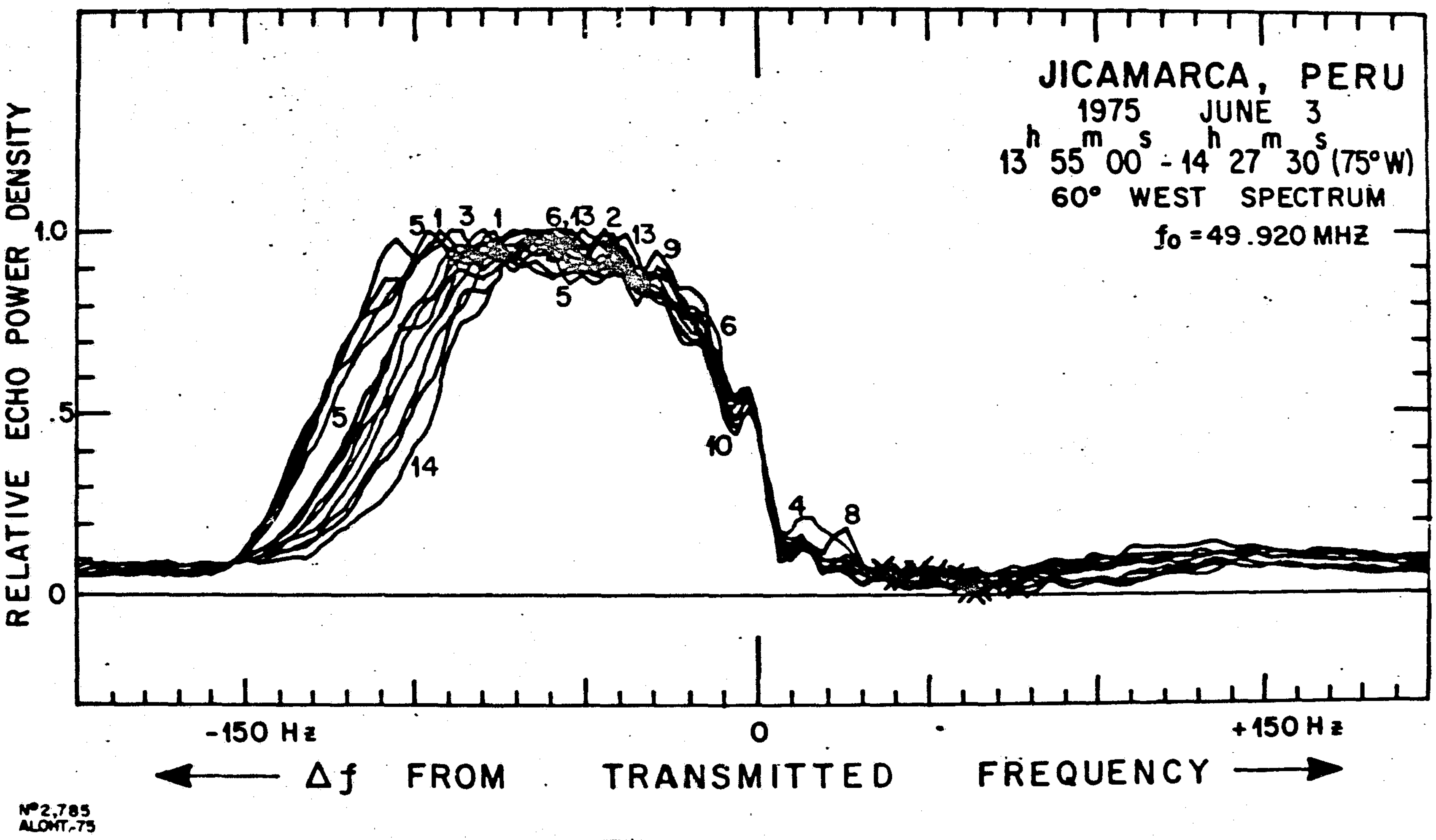
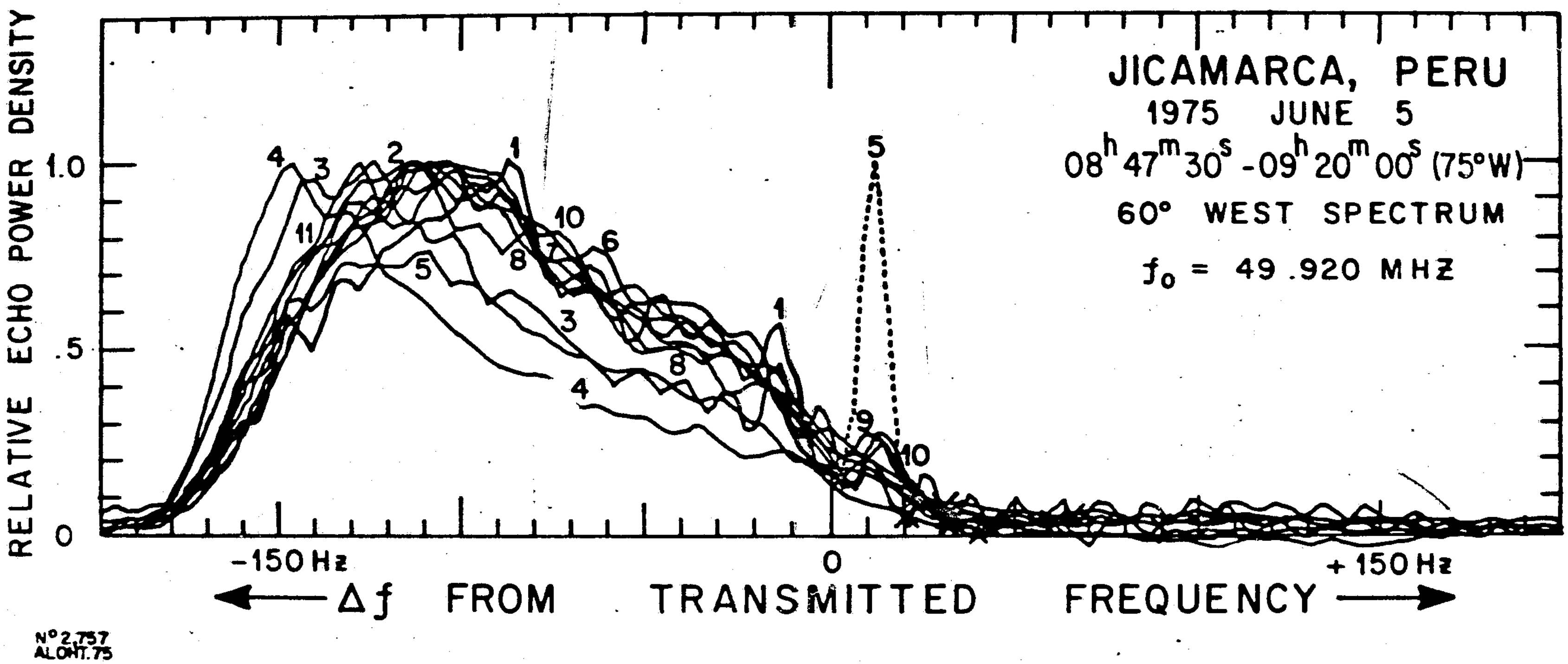

JICAMARCA, PERU
1975 JUNE 3
13h 55m 00s - 14h 27m 30s (75°W)
60° WEST SPECTRUM
fo = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,785
ALOHT,-75

Fig. 47



JICAMARCA, PERU
1975 JUNE 5
08h 47m 30s - 09h 20m 00s (75°W)
60° WEST SPECTRUM
f_o = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2,757
ALONT. 75

Fig. 48

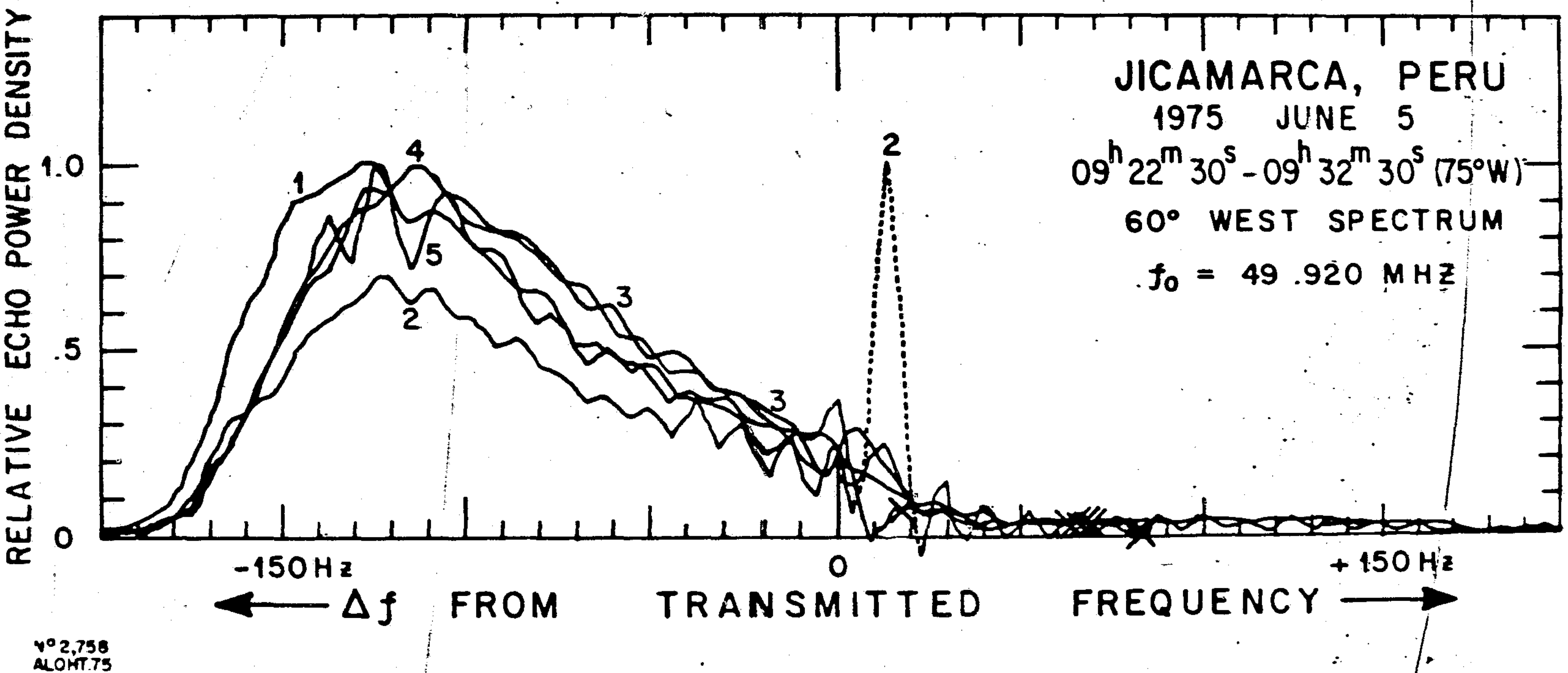

JICAMARCA, PERU
1975 JUNE 5
09h 22m 30s - 09h 32m 30s (75°W)
60° WEST SPECTRUM
fo = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150Hz
0
+150Hz
Δf FROM TRANSMITTED FREQUENCY
1
2
3
4
5
4°2,758
ALOHT.75

Fig. 49

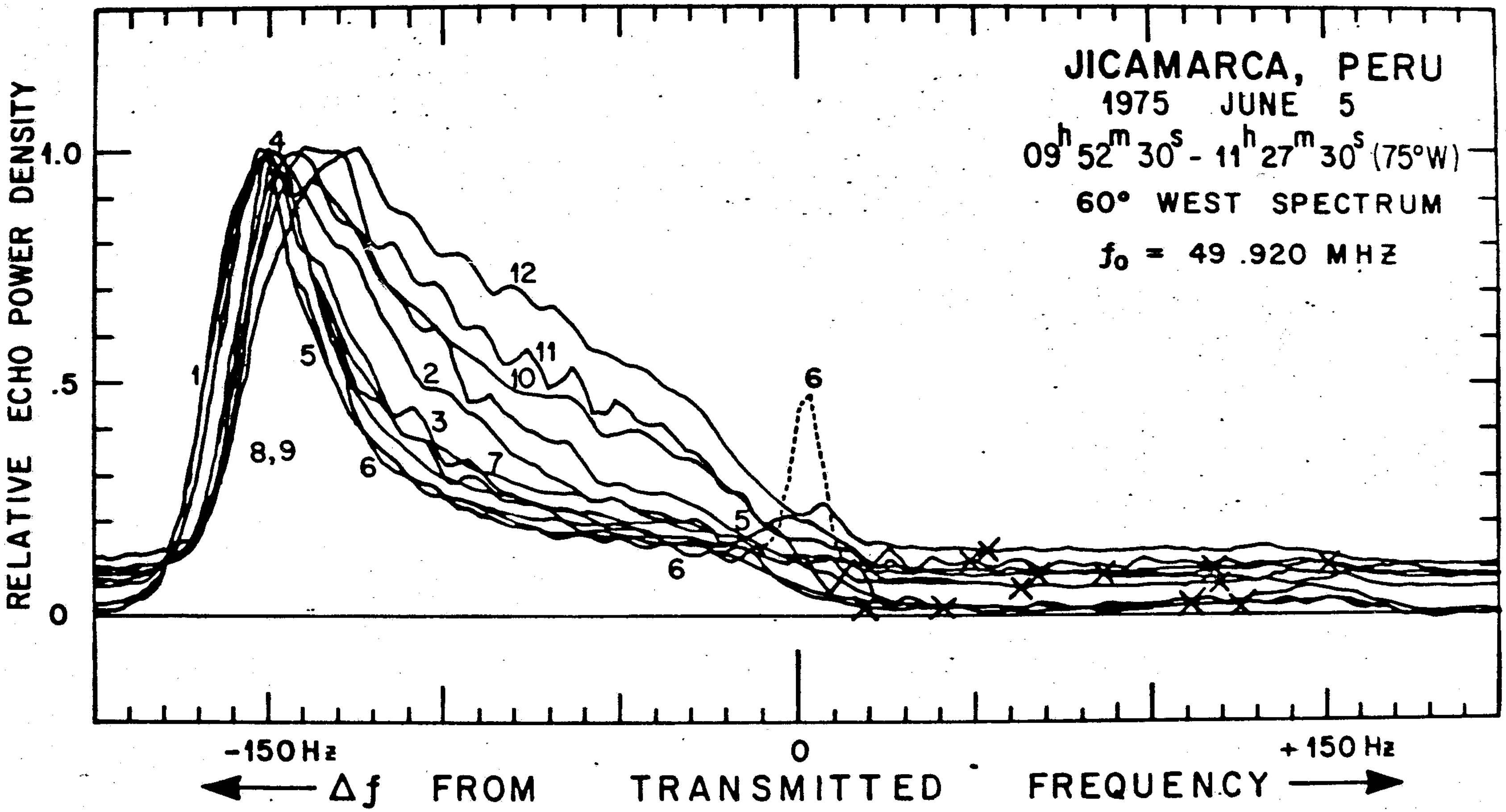

JICAMARCA, PERU
1975 JUNE 5
09h52m30s - 11h27m30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1
2
3
4
5
6
7
8,9
10
11
12
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY

Fig. 50

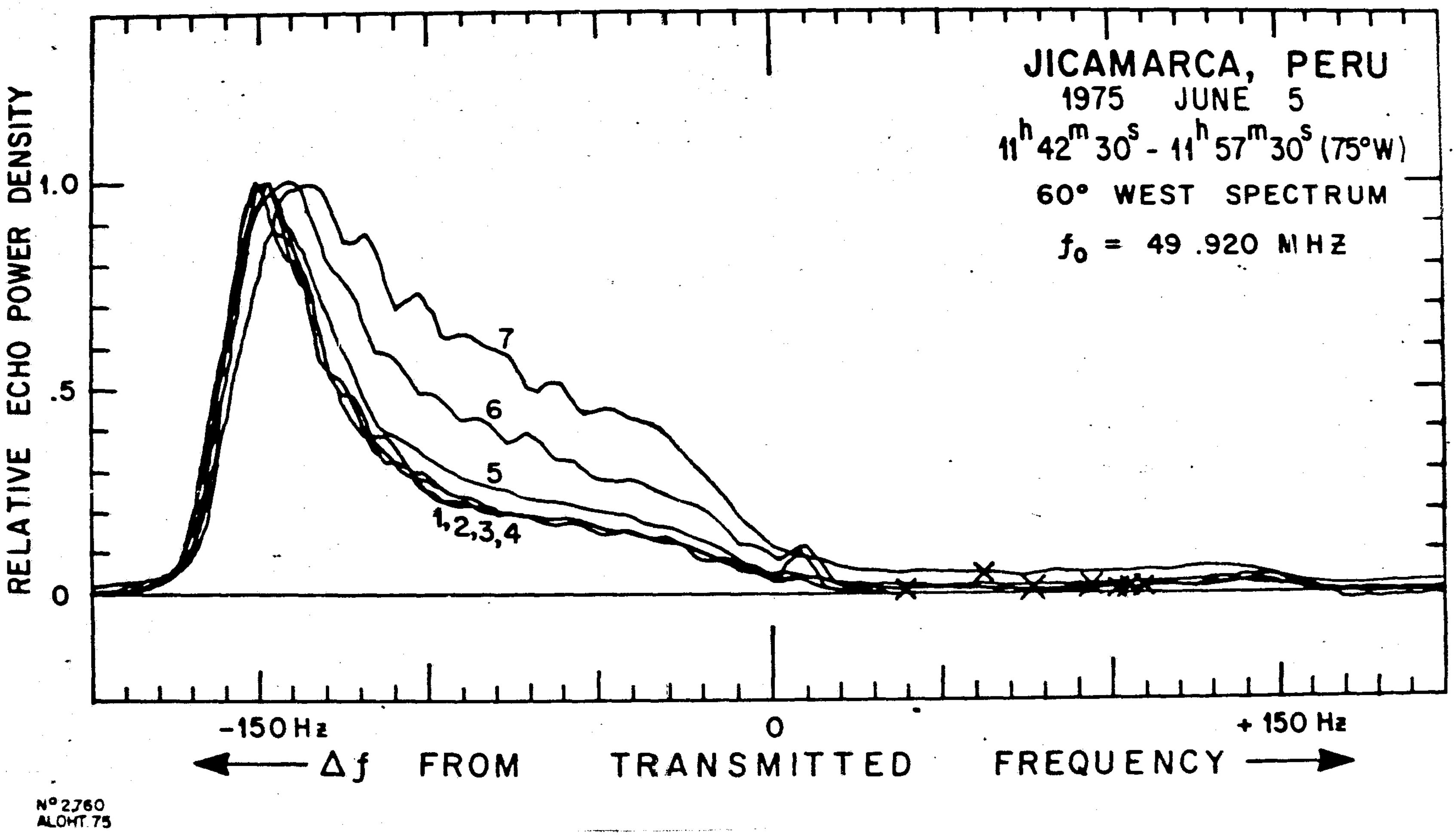
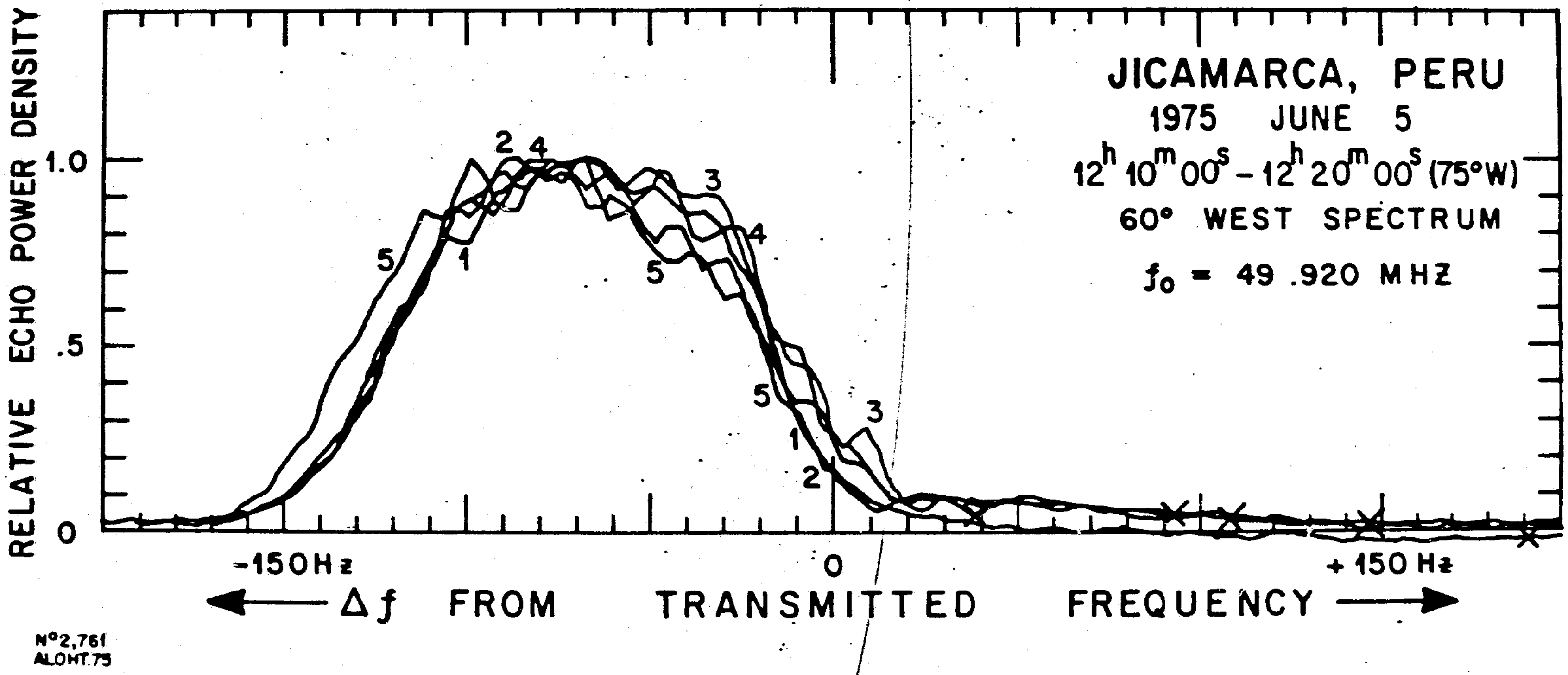

JICAMARCA, PERU
1975 JUNE 5
11h 42m 30s - 11h 57m 30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
7
6
5
1,2,3,4
-150 Hz
0
+ 150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2760
ALOHT 75

Fig. 51



JICAMARCA, PERU
1975 JUNE 5
12h 10m 00s - 12h 20m 00s (75°W)
60° WEST SPECTRUM
fo = 49 .920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,761
ALOHT.75

Fig. 52

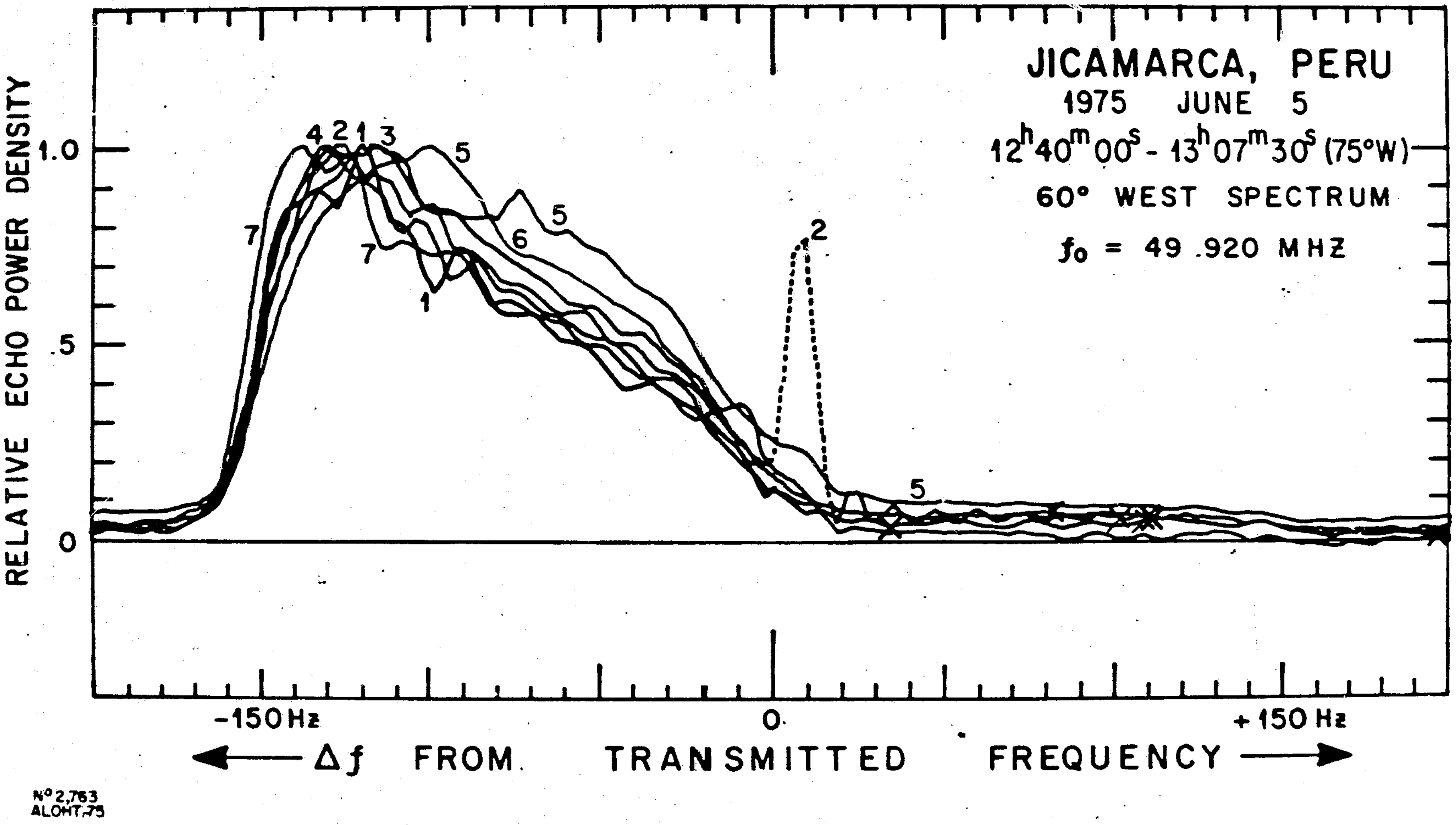
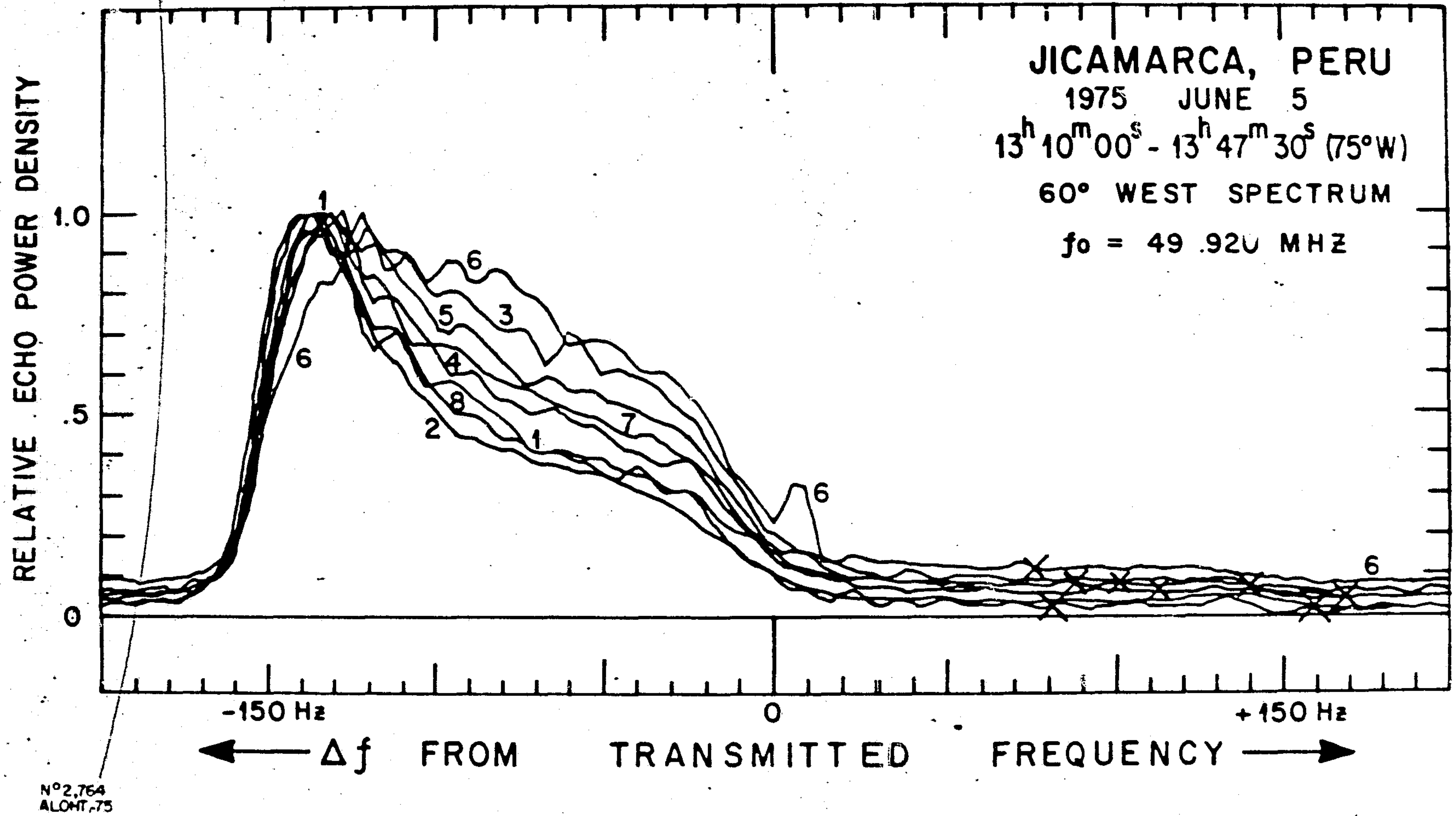

JICAMARCA, PERU
1975 JUNE 5
12h40m00s - 13h07m30s (75°W)
60° WEST SPECTRUM
fo = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
Nº 2,763
ALOHT-75

Fig. 53



JICAMARCA, PERU
1975 JUNE 5
13h 10m 00s - 13h 47m 30s (75°W)
60° WEST SPECTRUM
fo = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,764
ALOHT-75

Fig. 54

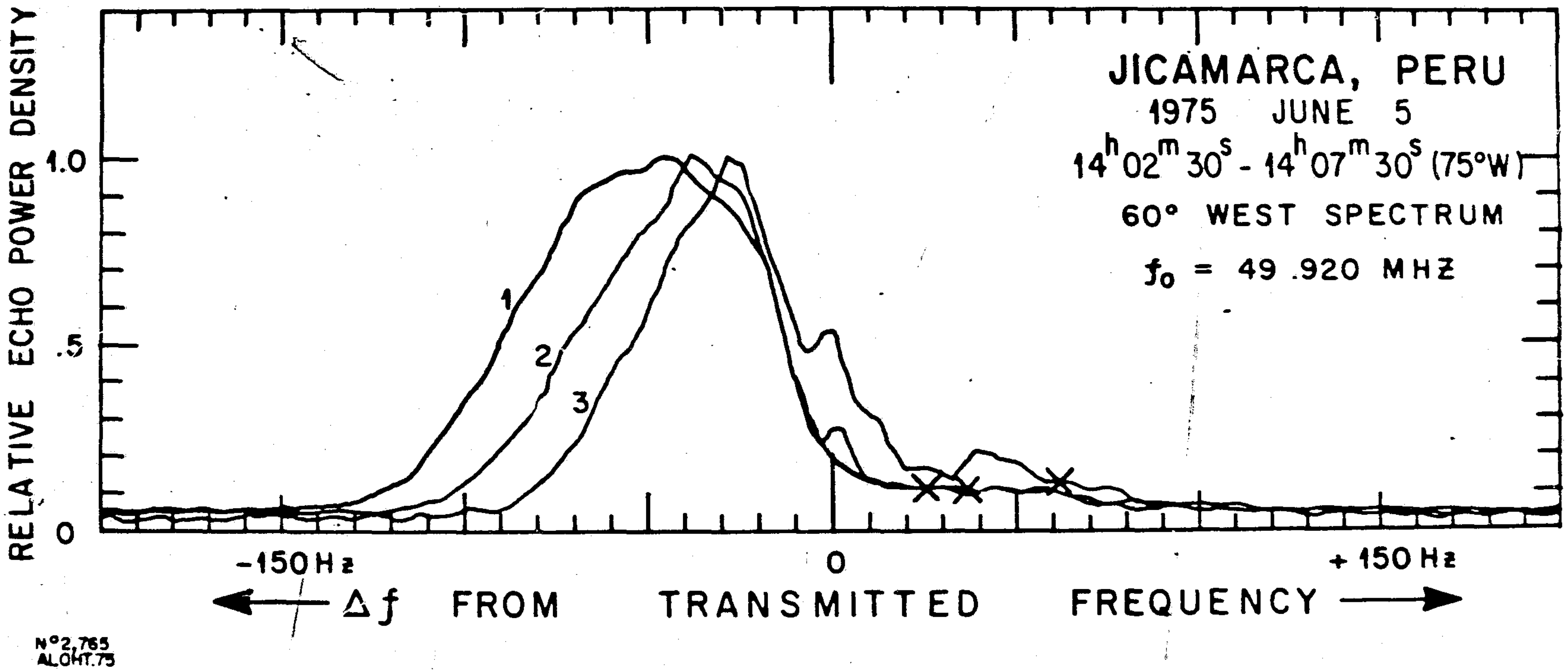
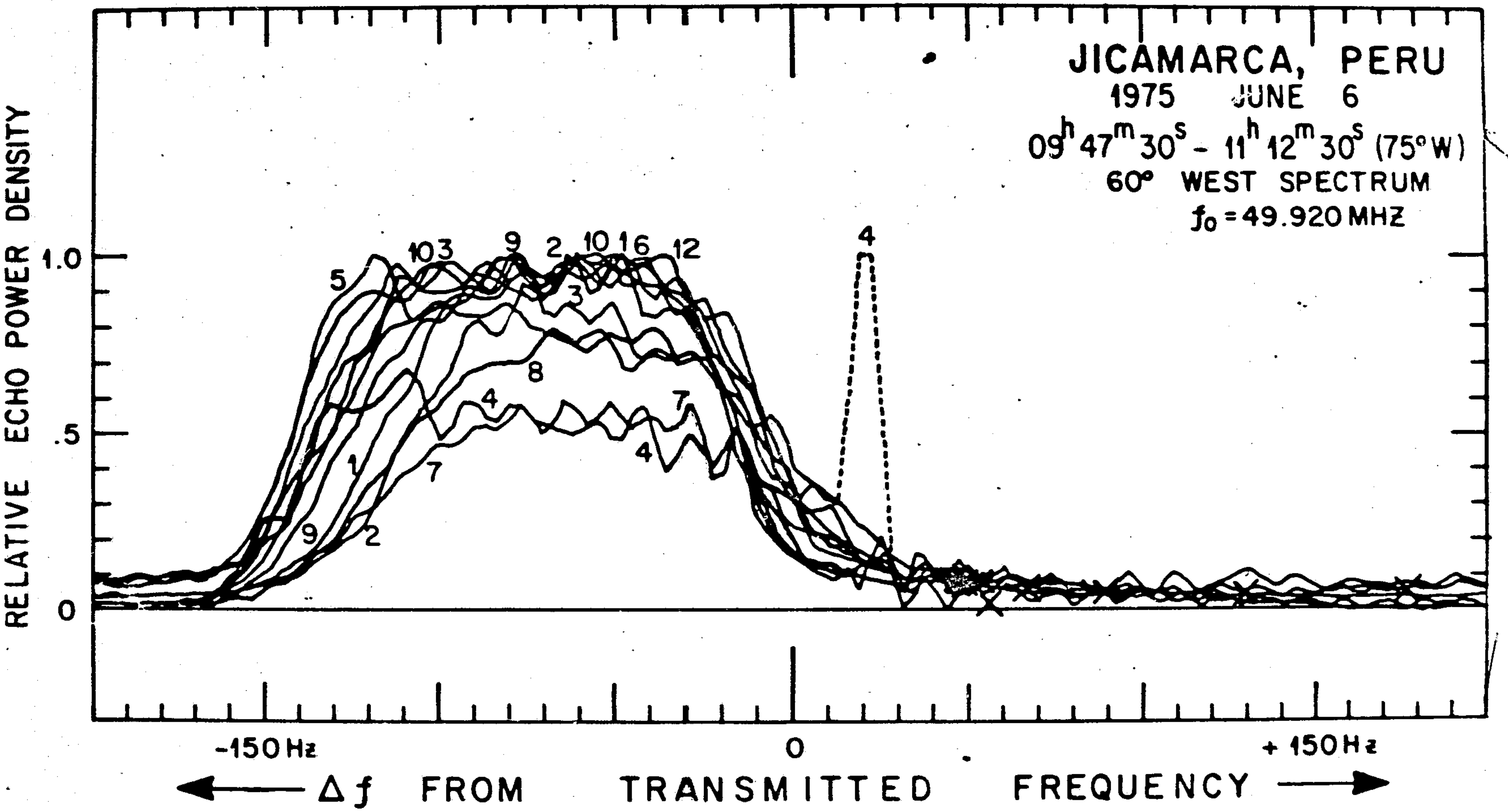

JICAMARCA, PERU
1975 JUNE 5
14h02m30s - 14h07m30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1
2
3
-150 Hz
0
+150 Hz
← Δf FROM TRANSMITTED FREQUENCY →
N°2,765
ALOHT.75

Fig. 55



N° 2,770
ALOHT-75

Fig. 56

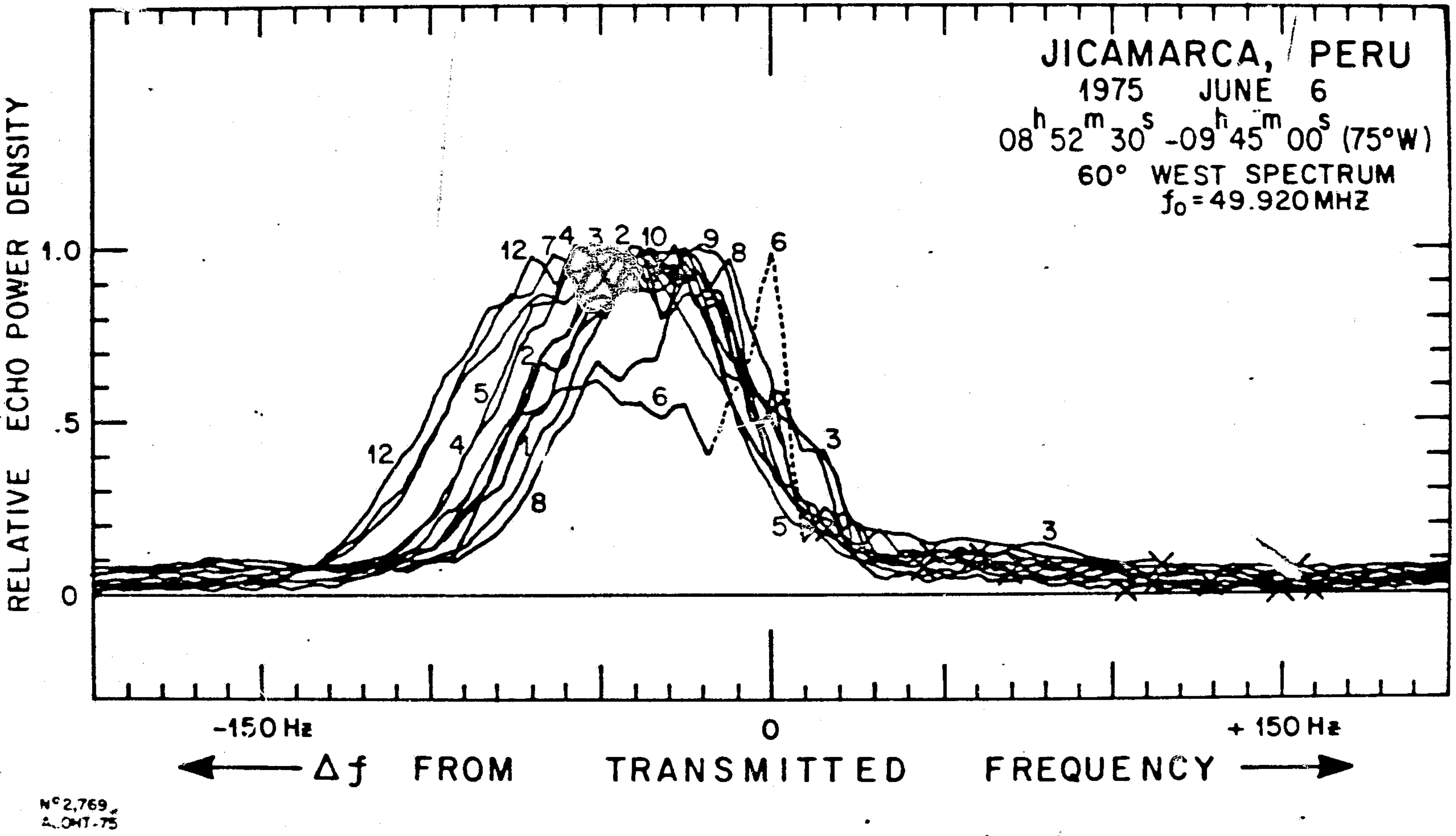
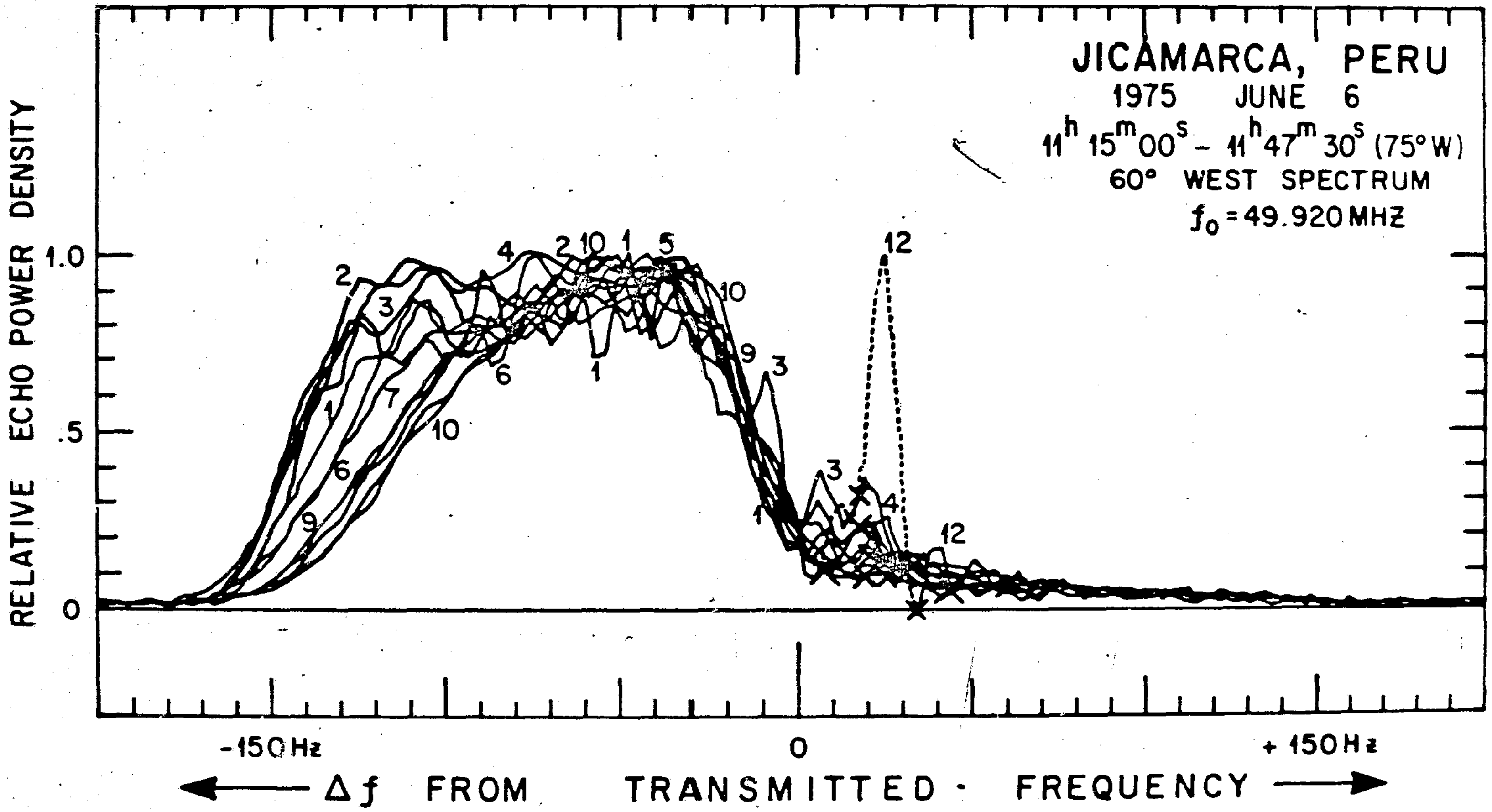
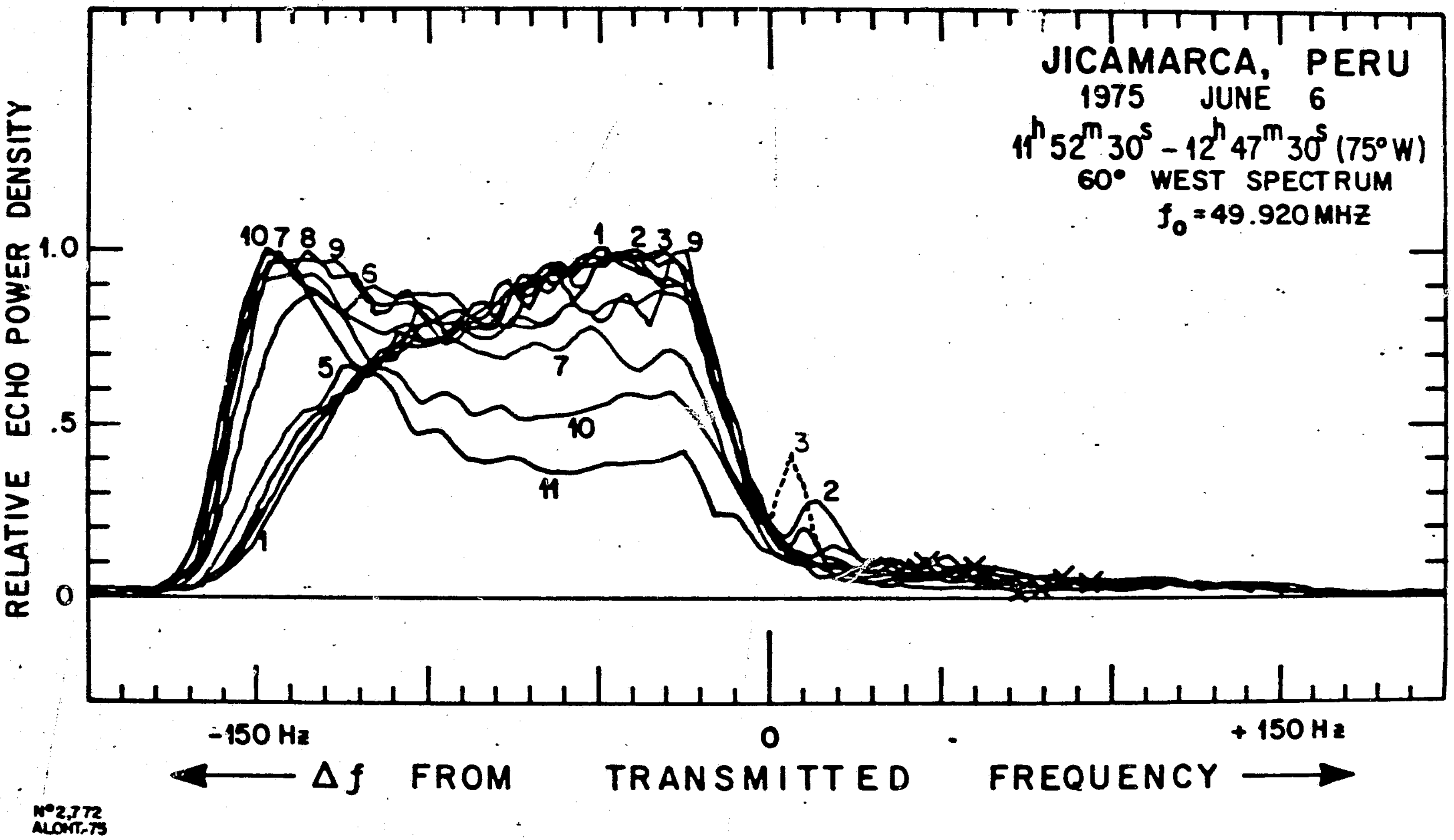

JICAMARCA, PERU
1975 JUNE 6
08h52m30s -09h45m00s (75°W)
60° WEST SPECTRUM
f_0=49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
12
7
4
3
2
10
9
8
6
5
1
-150 Hz
0
+ 150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2,769
A.OHT-75

Fig. 57



N° 2,771
ALOHT-75

Fig. 58



JICAMARCA, PERU
1975 JUNE 6
11h 52m 30s - 12h 47m 30s (75° W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
10 7 8 9
6
5
1 2 3 9
7
10
11
3
2
1
-150 Hz
0
+ 150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,772
ALONT.-75

Fig. 59

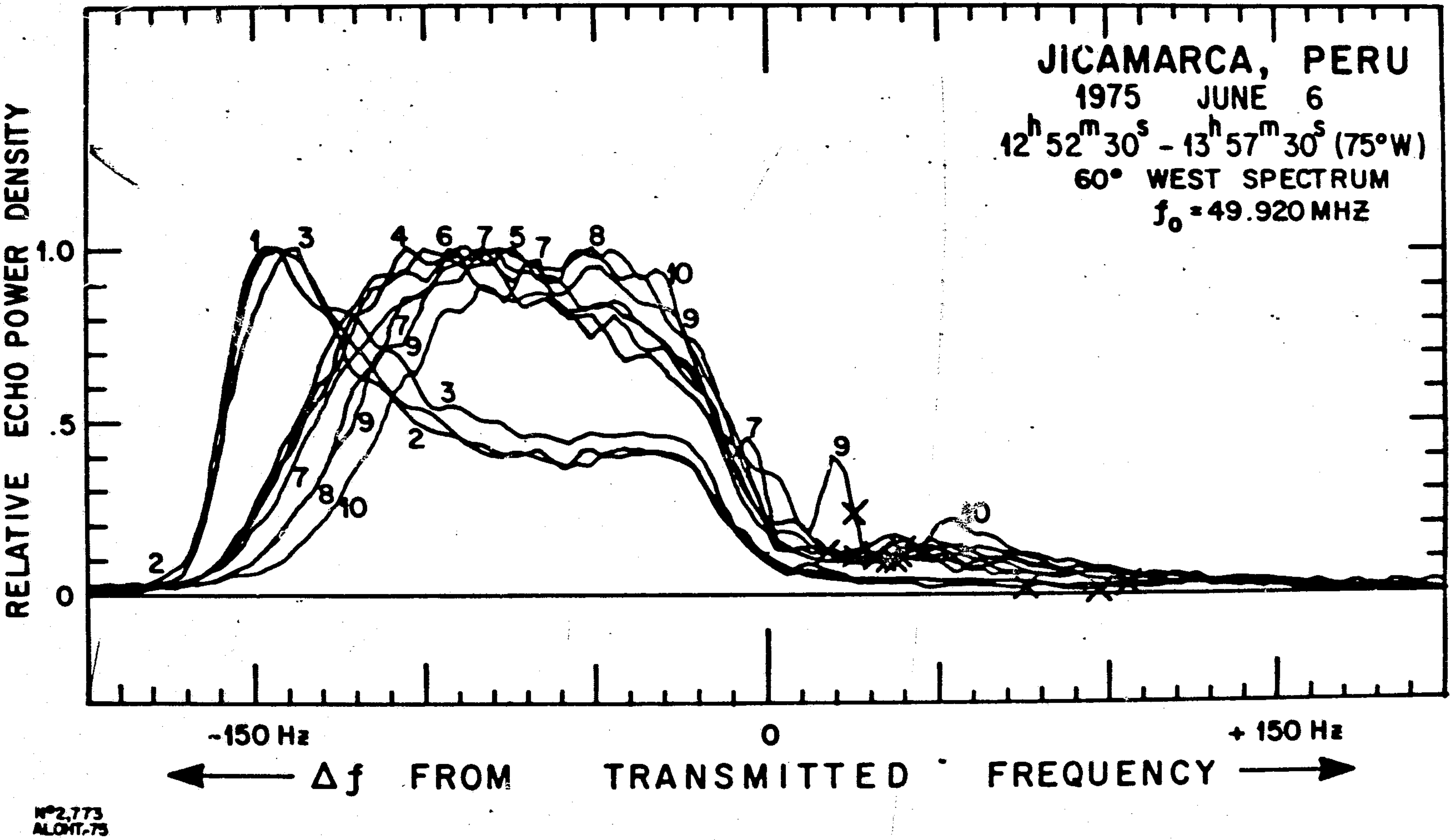
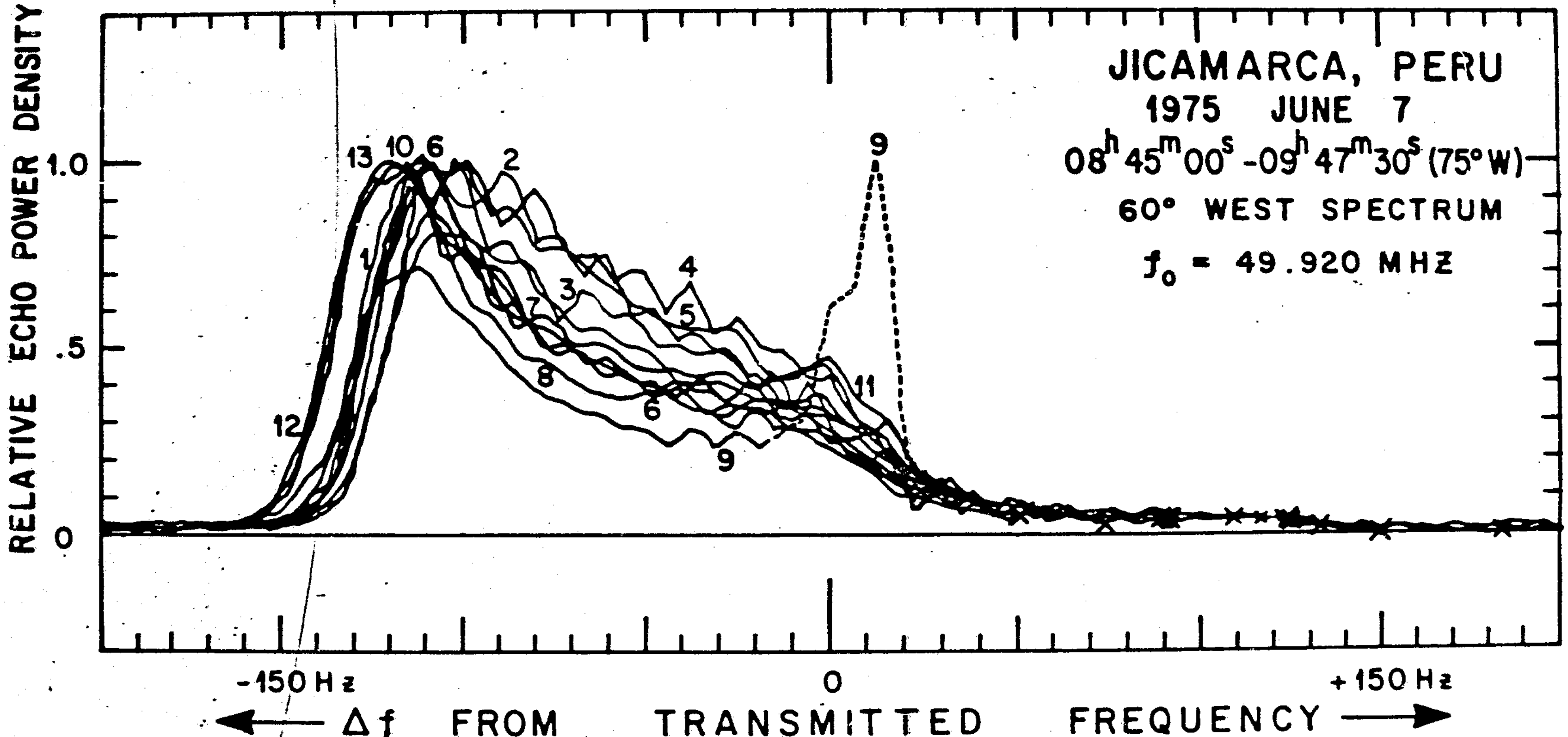
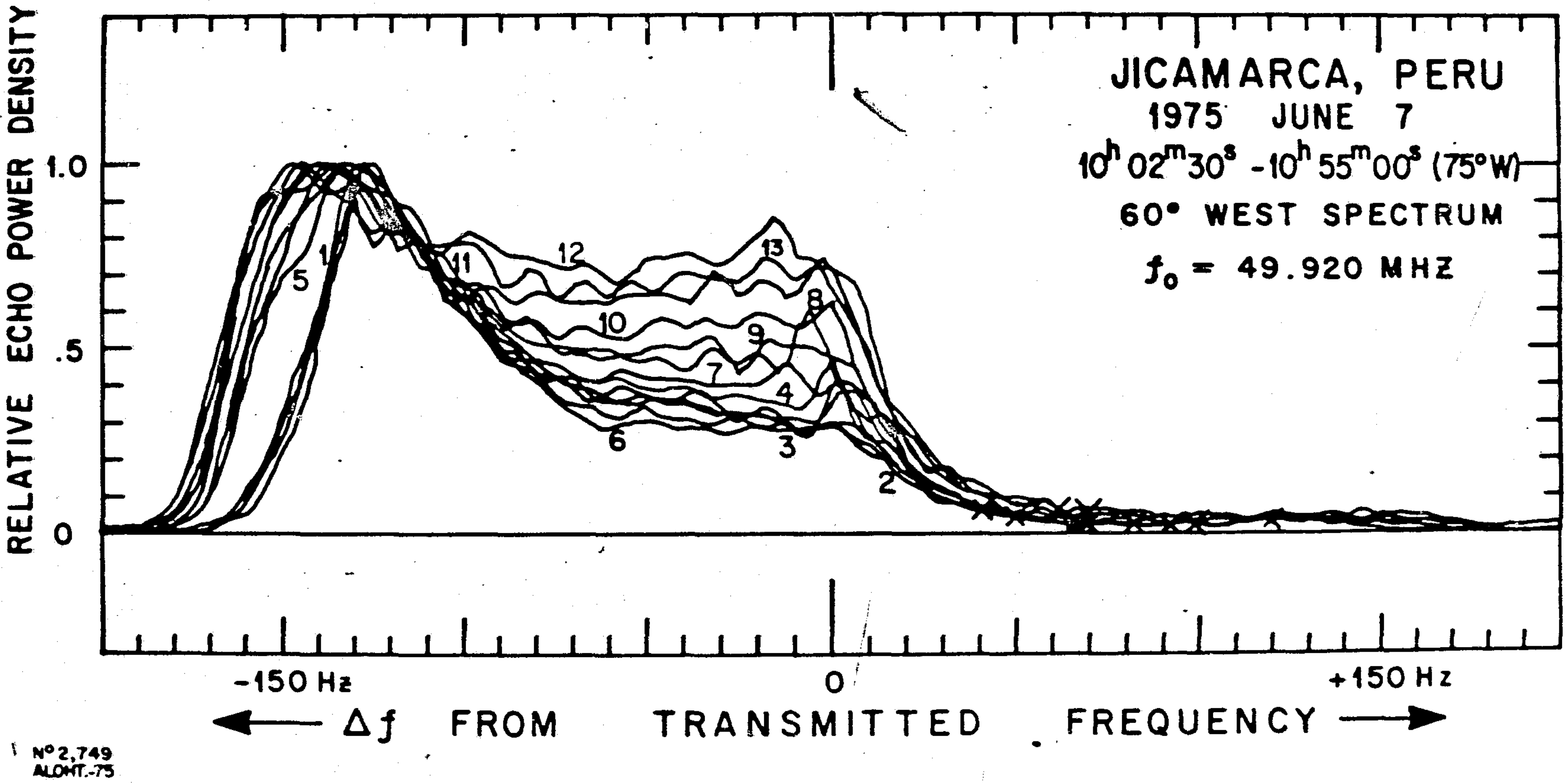

JICAMARCA, PERU
1975 JUNE 6
12h 52m 30s - 13h 57m 30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+ 150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,773
ALCHT.-75

Fig. 60



N°2,748
ALOHT-75

Fig. 61



JICAMARCA, PERU
1975 JUNE 7
10h 02m 30s - 10h 55m 00s (75°W)
60° WEST SPECTRUM
fo = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
1
2
3
4
5
6
7
8
9
10
11
12
13
N° 2,749
ALOHT.-75

Fig. 62

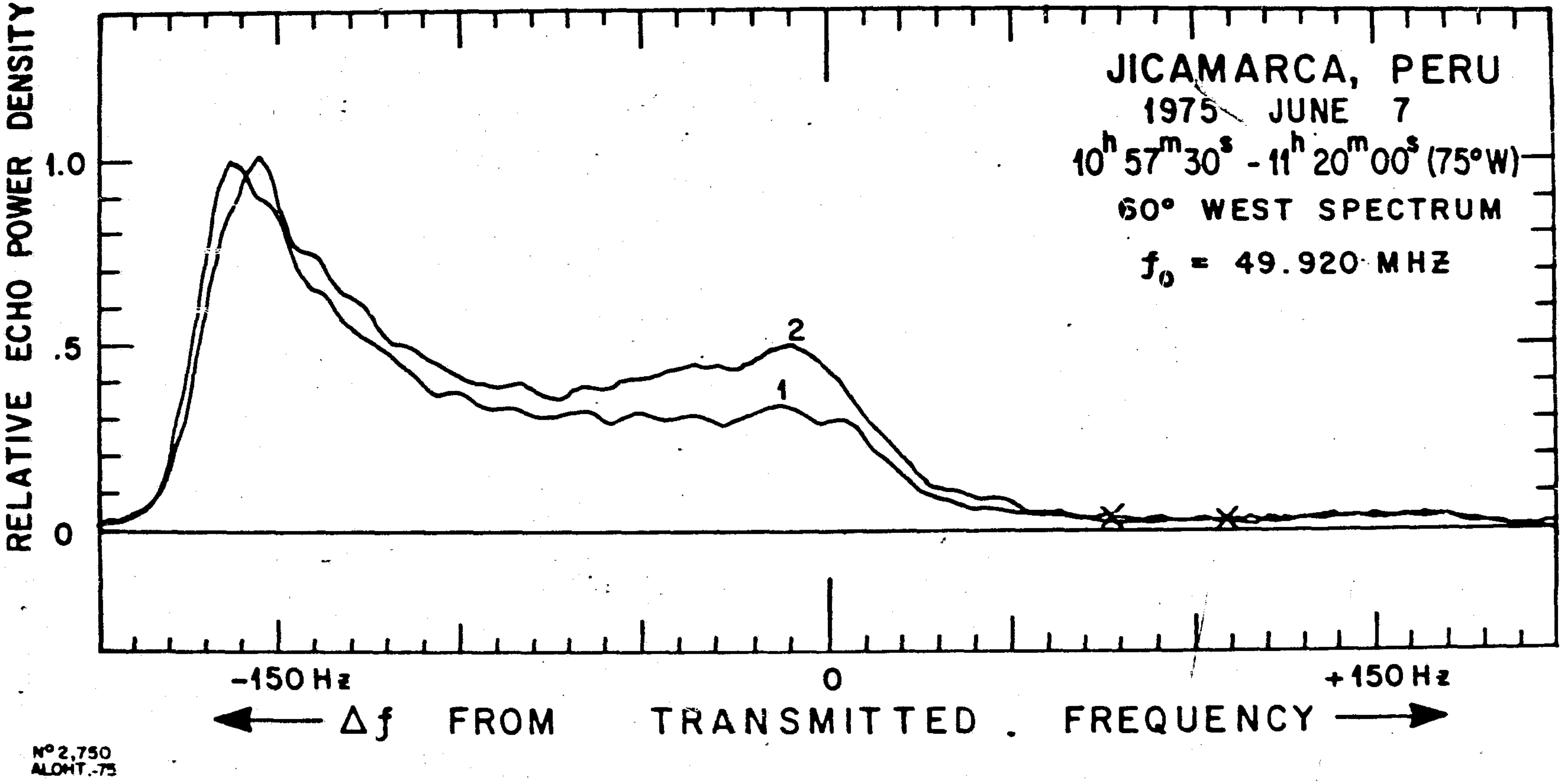

JICAMARCA, PERU
1975 JUNE 7
10h 57m 30s - 11h 20m 00s (75°W)
60° WEST SPECTRUM
f0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1
2
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N° 2,750
ALOHT.-75

Fig. 63

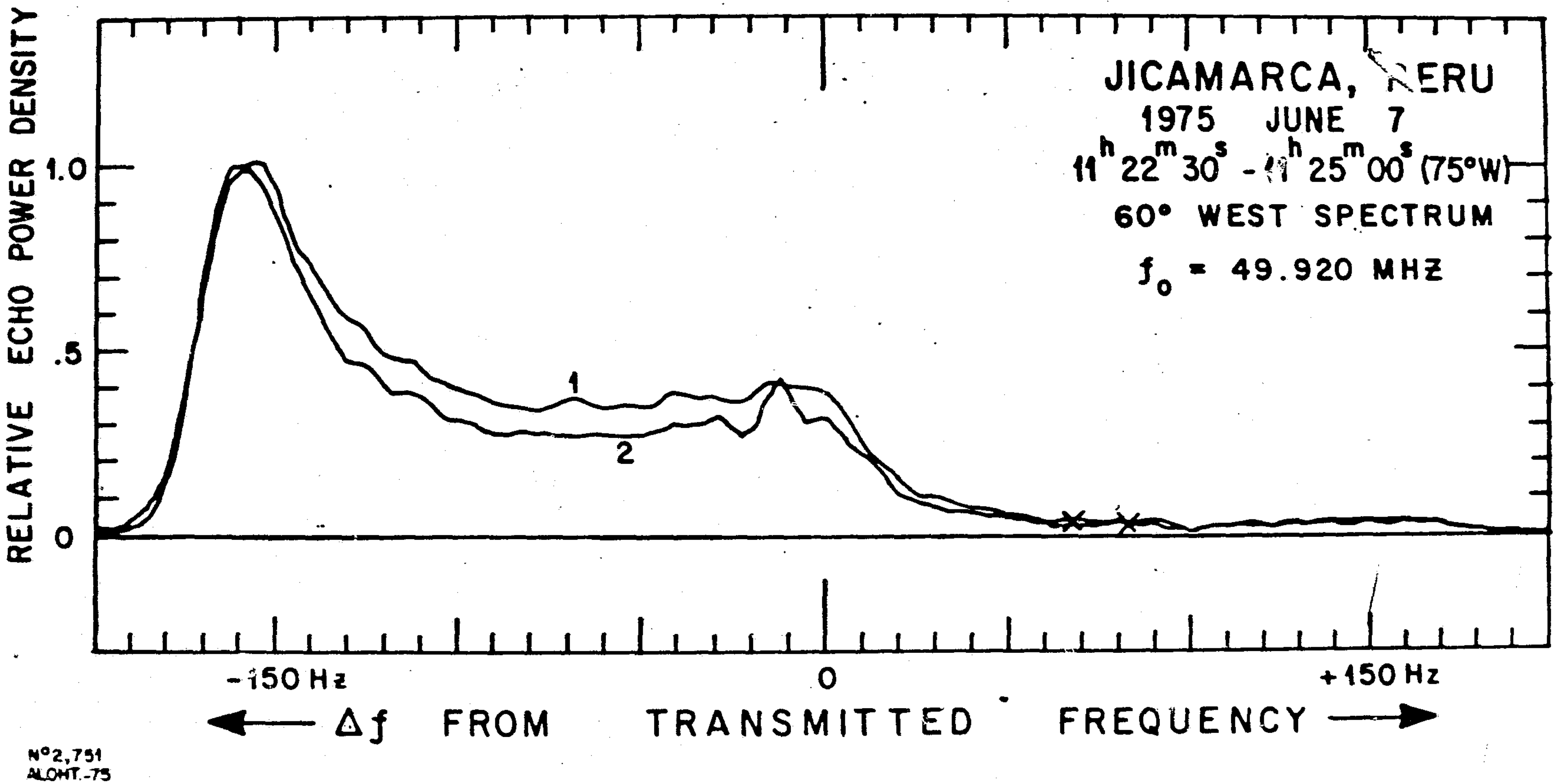
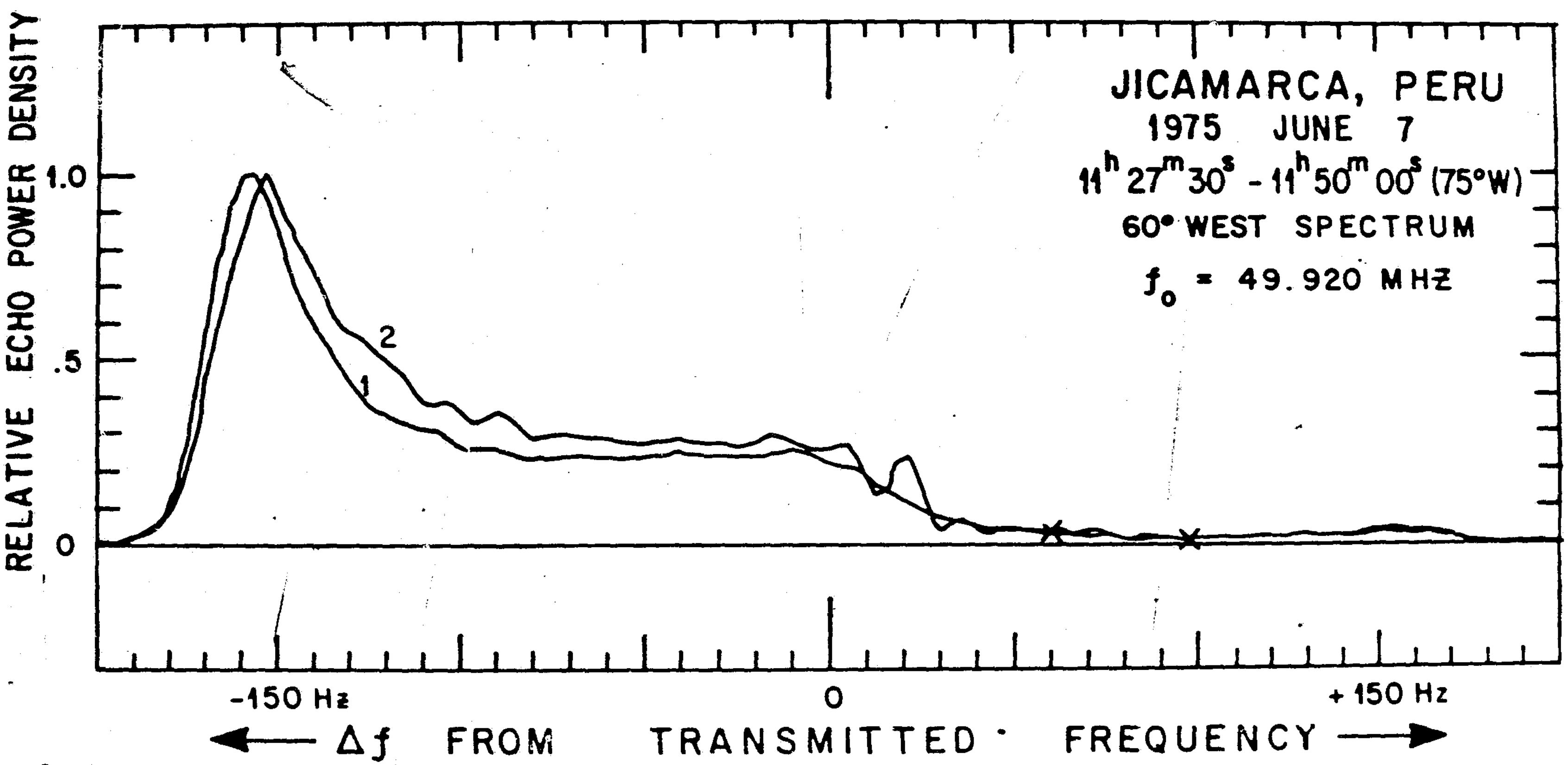

JICAMARCA, PERU
1975 JUNE 7
11h22m30s - 11h25m00s (75°W)
60° WEST SPECTRUM
f_o = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1
2
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,751
ALOHT.-75

Fig. 64



N°2,752
ALOHT.-75

Fig. 65

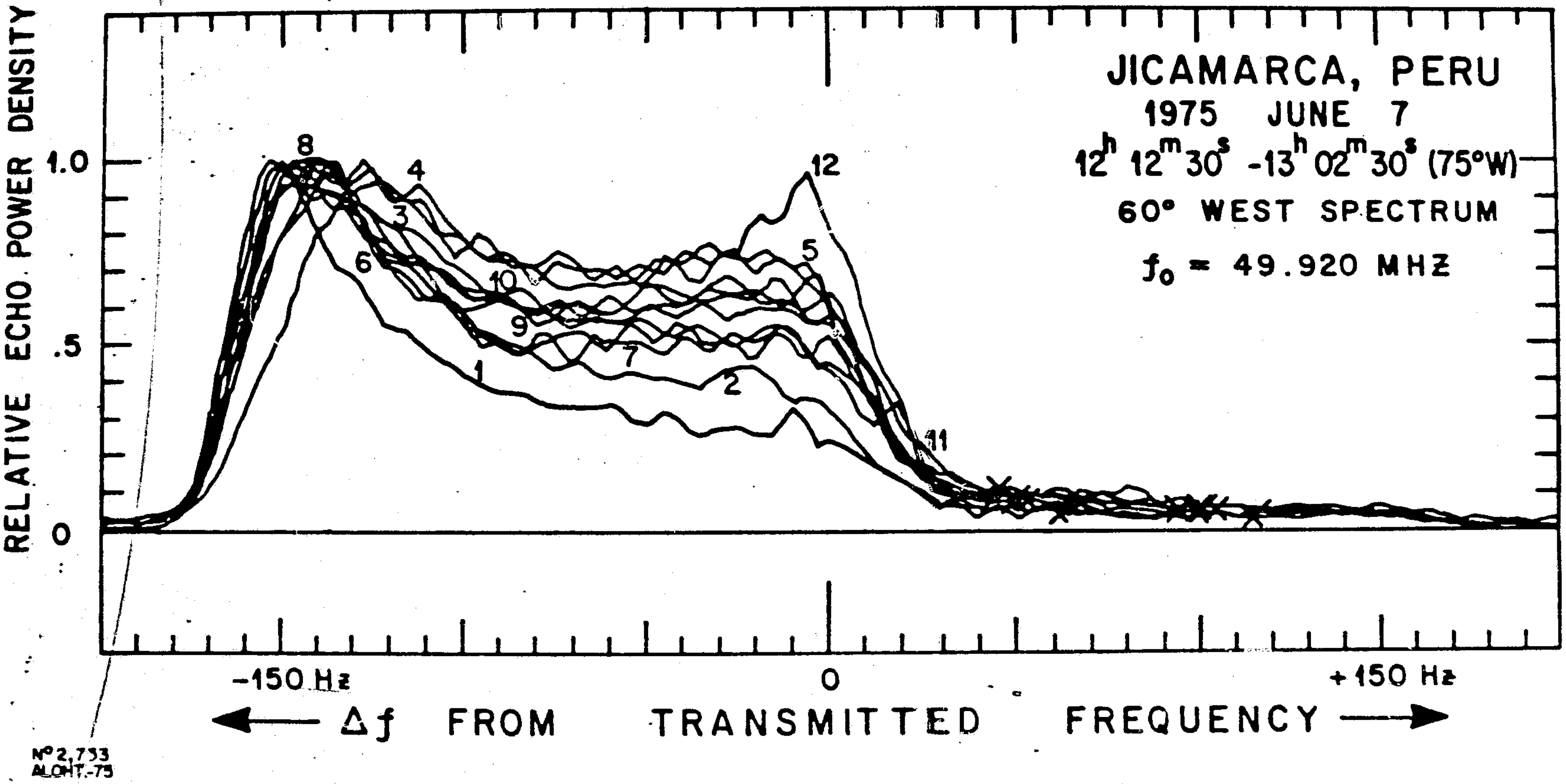

JICAMARCA, PERU
1975 JUNE 7
12h 12m 30s -13h 02m 30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
1
2
3
4
5
6
7
8
9
10
11
12
-150 Hz
0
+150 Hz
Δf FROM TRANSMITTED FREQUENCY
N°2,733
ALOHT.-75

Fig. 66

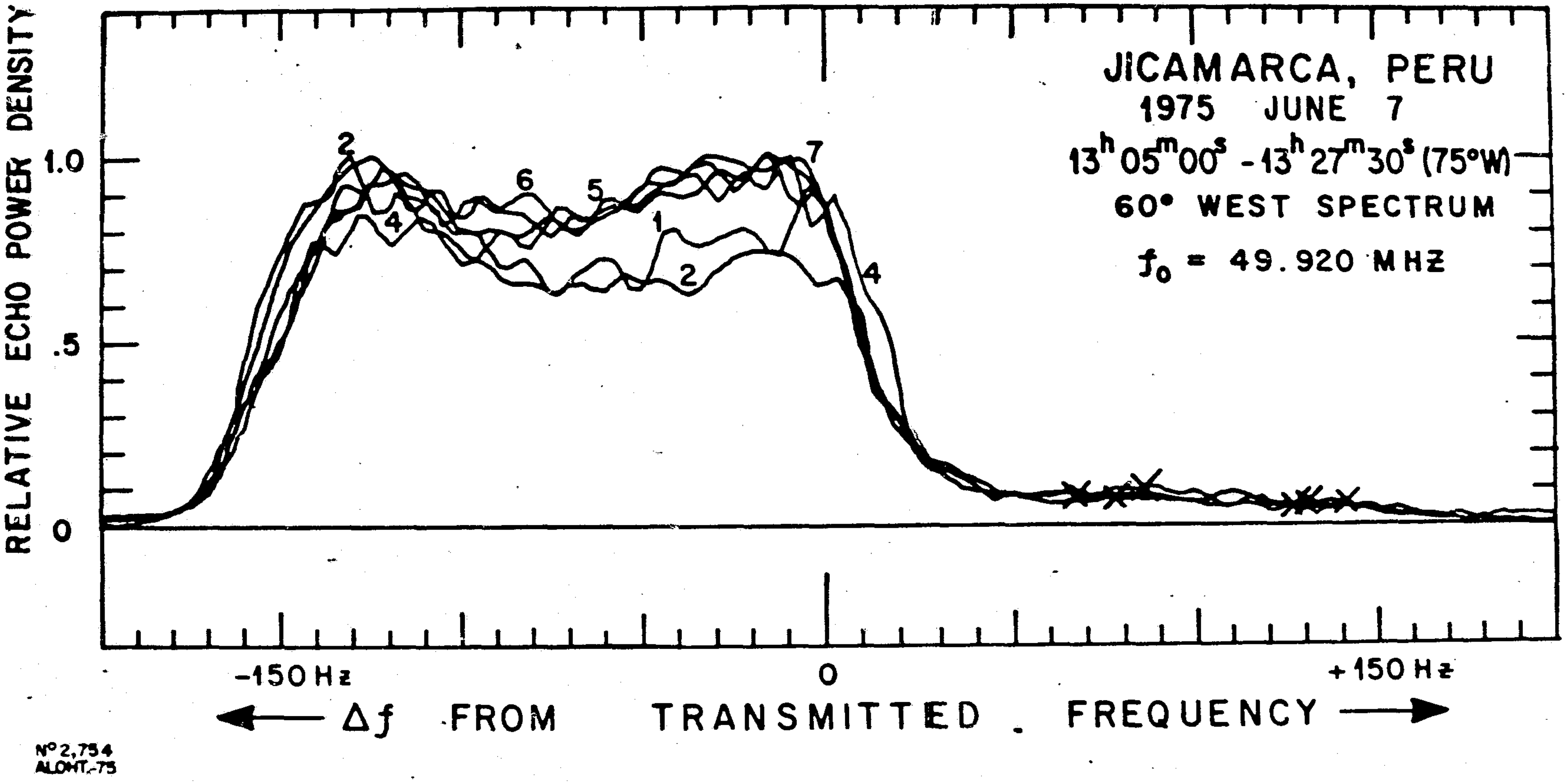

JICAMARCA, PERU
1975 JUNE 7
13h 05m 00s - 13h 27m 30s (75°W)
60° WEST SPECTRUM
f_0 = 49.920 MHZ
RELATIVE ECHO POWER DENSITY
1.0
.5
0
-150 Hz
0
+150 Hz
← Δf FROM TRANSMITTED FREQUENCY →
N° 2,754
ALOHT.-75

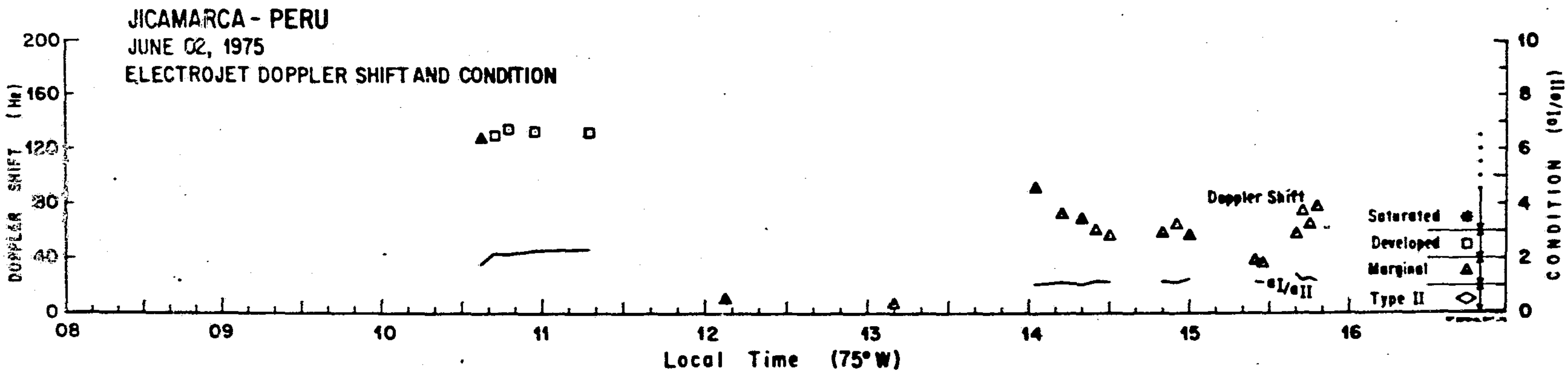
Fig. 67

APPENDIX D

ELECTROJET DOPPLER SHIFT AND CONDITION

FIGURE CAPTIONS

Fig. 68 to 72 Electron temperature and condition as function of local time (75°W) for the dates indicated in the figures.



JICAMARCA - PERU
JUNE 02, 1975
ELECTROJET DOPPLER SHIFT AND CONDITION
DOPPLER SHIFT (Hz)
CONDITION (eI/eII)
Doppler Shift
Saturated
Developed
Marginal
Type II
Local Time (75° W)

Fig. 68

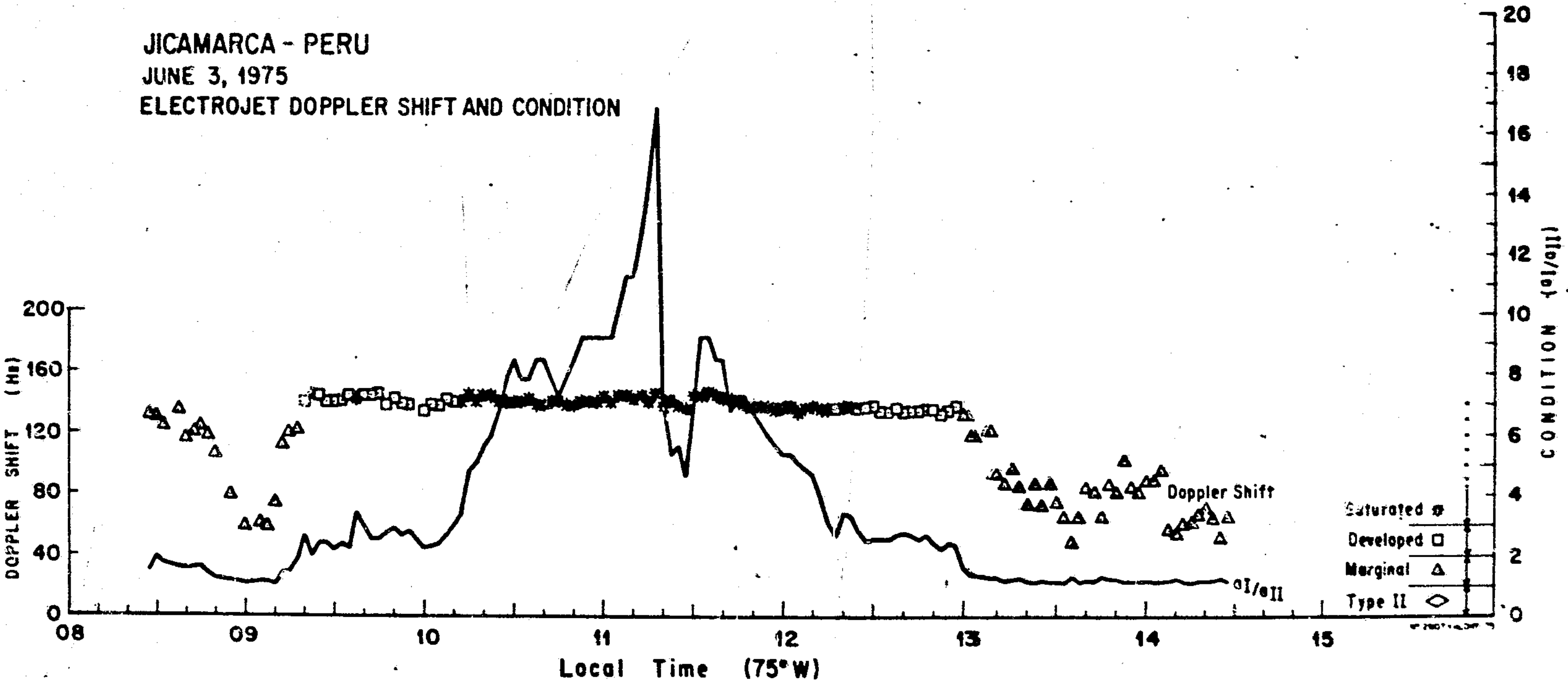
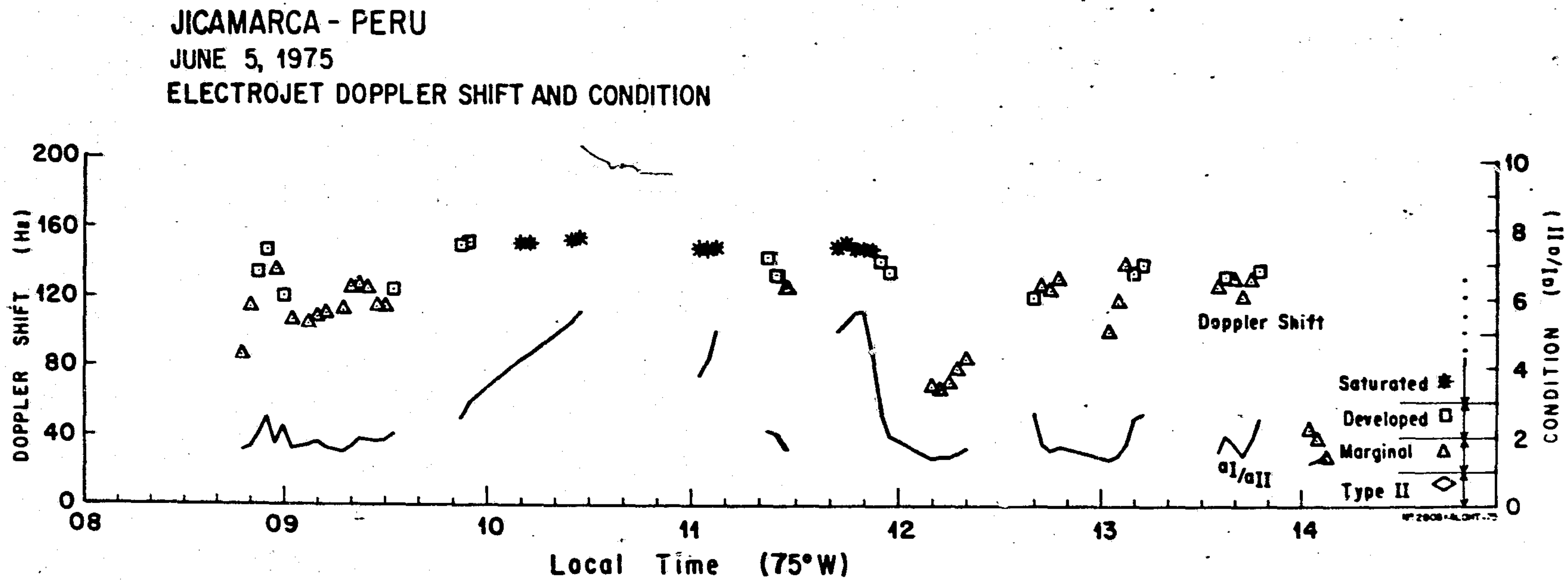

JICAMARCA - PERU
JUNE 3, 1975
ELECTROJET DOPPLER SHIFT AND CONDITION
DOPPLER SHIFT (Hz)
CONDITION (σI/σII)
Local Time (75° W)
Doppler Shift
σI/σII
Saturated
Developed
Marginal
Type II

Fig. 69



JICAMARCA - PERU
JUNE 5, 1975
ELECTROJET DOPPLER SHIFT AND CONDITION
DOPPLER SHIFT (Hz)
CONDITION ($^{a}I/_{a}II$)
Doppler Shift
$^{a}I/_{a}II$
Saturated
Developed
Marginal
Type II
Local Time (75°W)

Fig. 70

JICAMARCA - PERU
JUNE 6, 1975
ELECTROJET DOPPLER SHIFT AND CONDITION

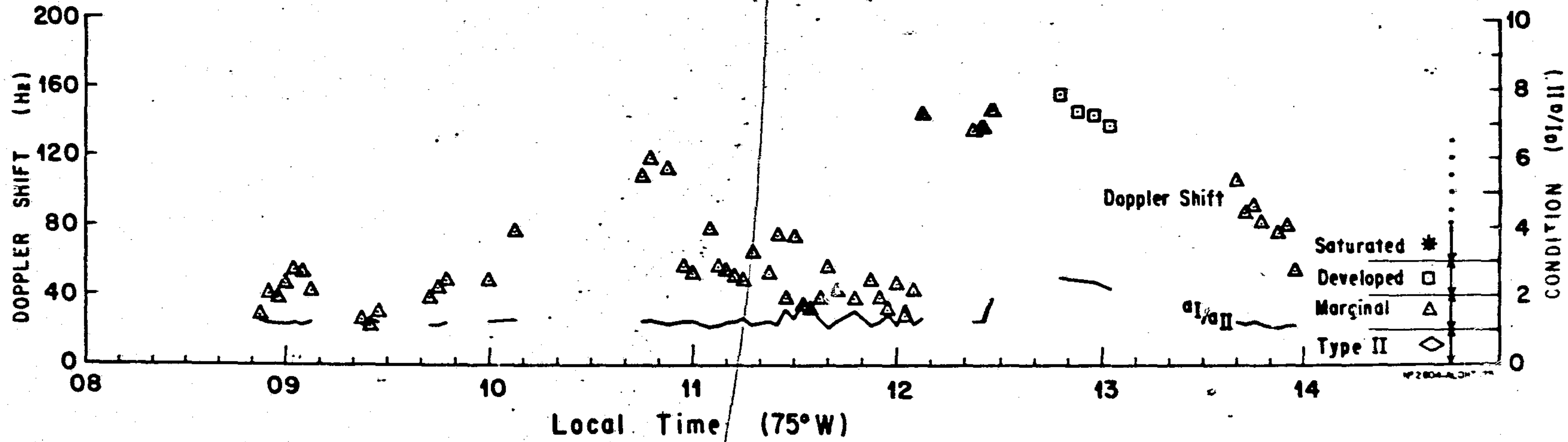


Fig. 71

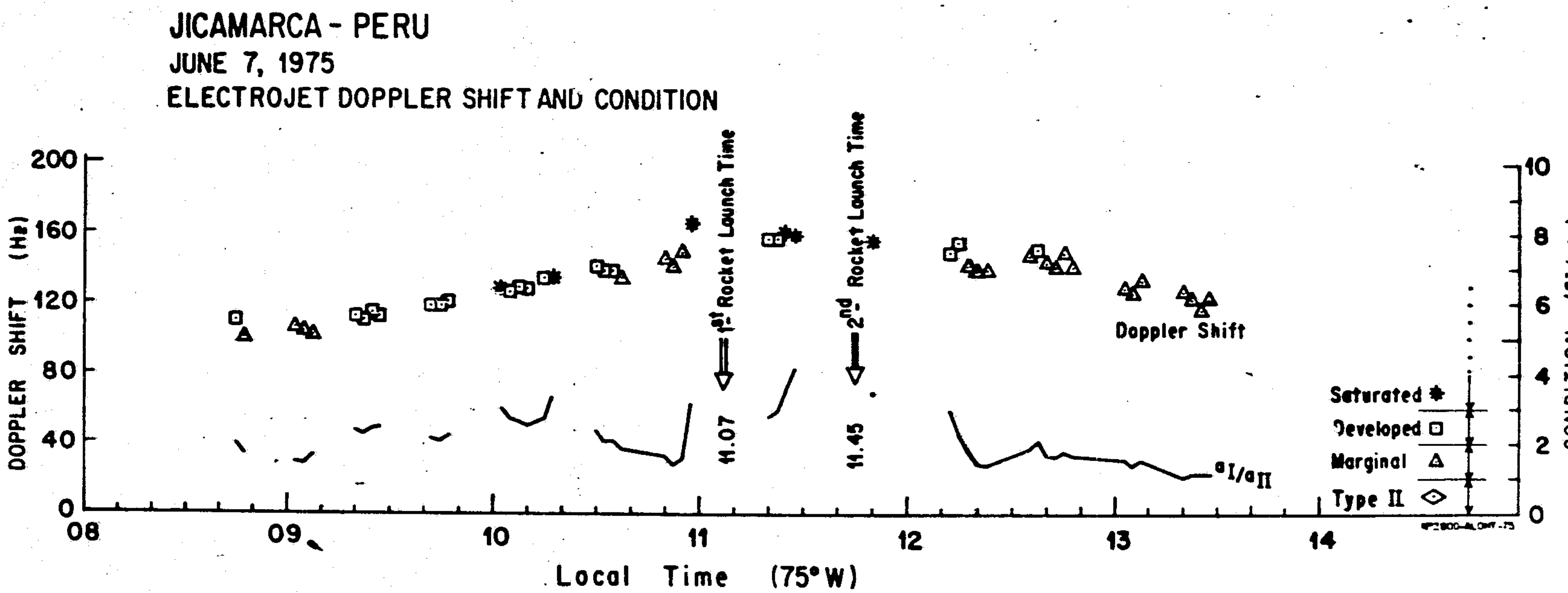

JICAMARCA - PERU
JUNE 7, 1975
ELECTROJET DOPPLER SHIFT AND CONDITION
DOPPLER SHIFT (Hz)
CONDITION (a_I/a_{II})
Local Time (75° W)
1st Rocket Launch Time
11.07
2nd Rocket Launch Time
11.45
Doppler Shift
a_I/a_{II}
Saturated
Developed
Marginal
Type II

Fig. 72

APPENDIX E

150 KM ECHOING REGION

FIGURE CAPTIONS

Fig. 73 to 82 **Photographic records of the 150 km Echoing Region on June 7 1975 at the local times (75°W) indicated in each photograph.** The first pulse corresponds to 155 km and the interpulse distance is 25 km.

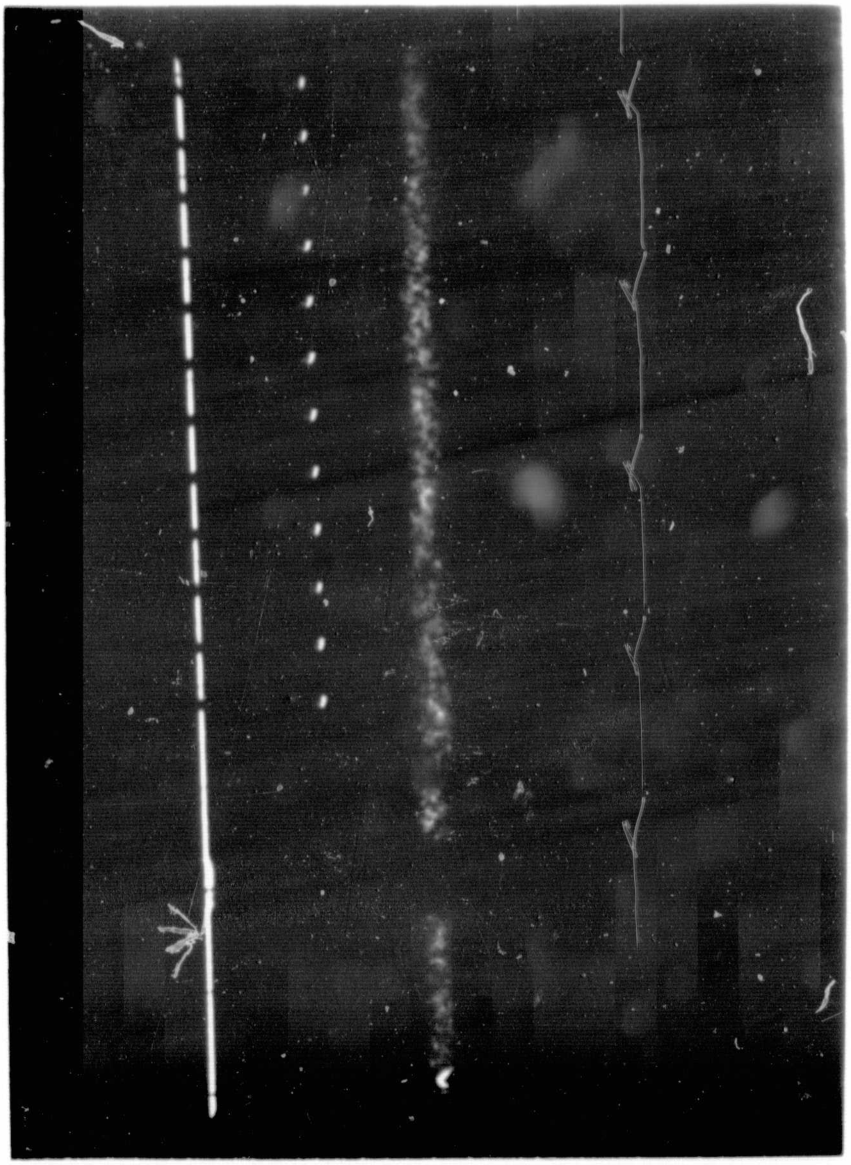


Fig. 73

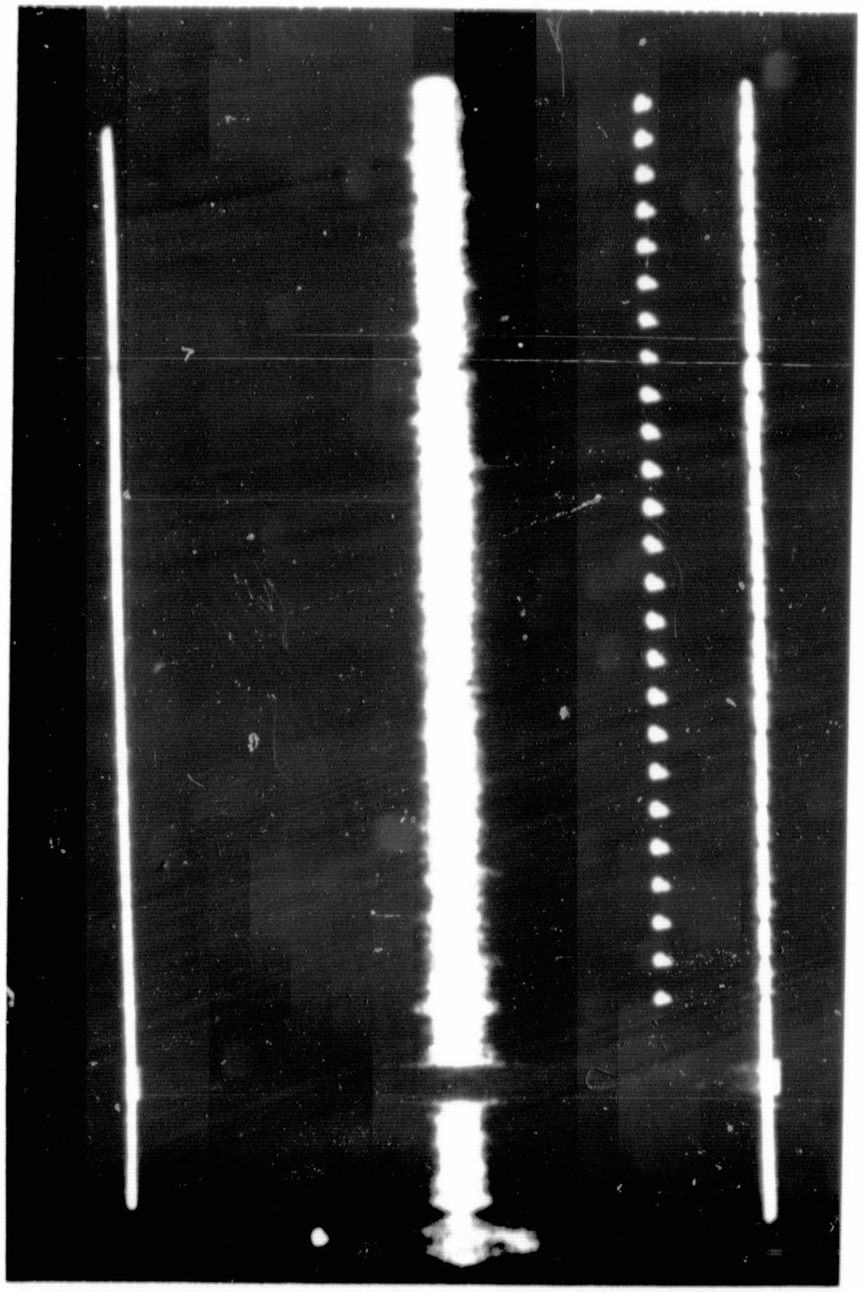


Fig. 74

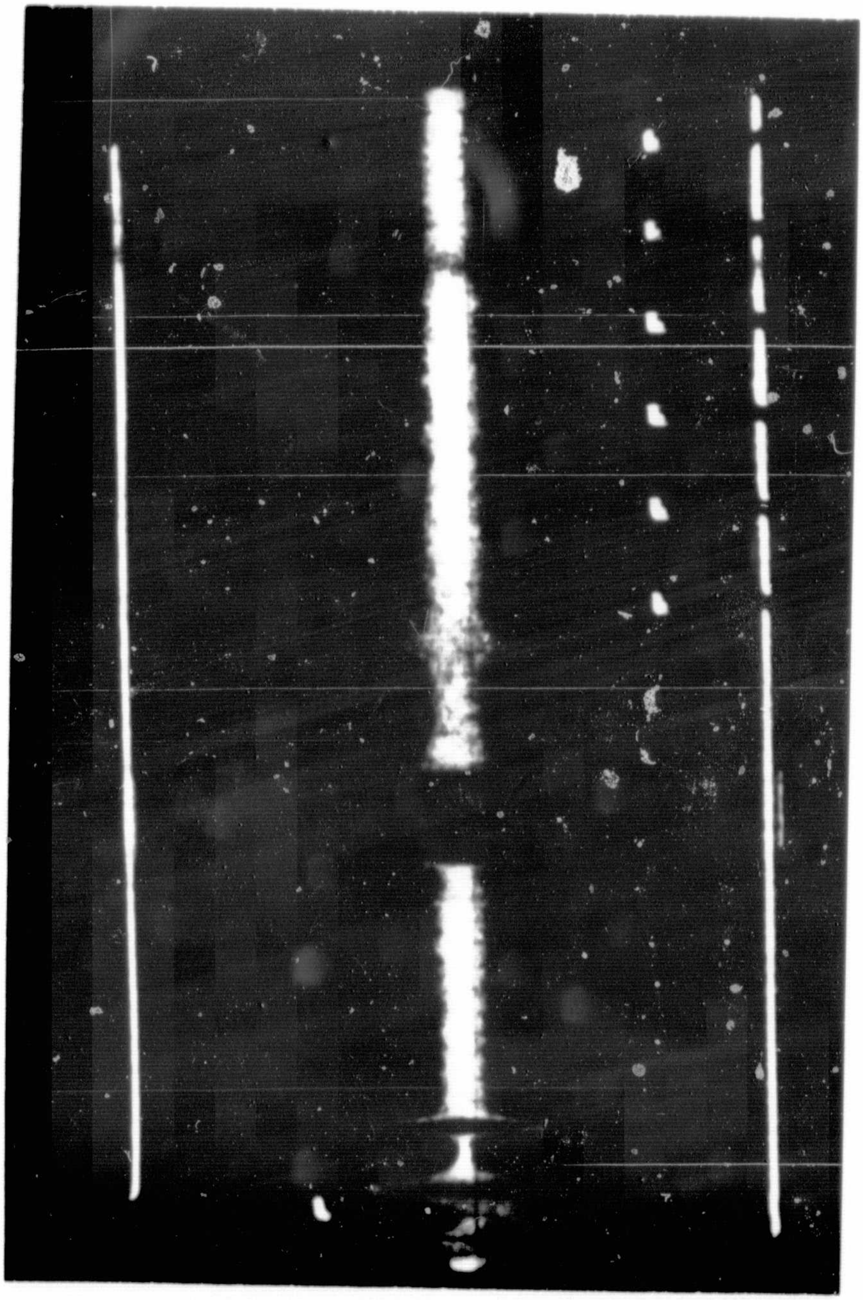


Fig. 75

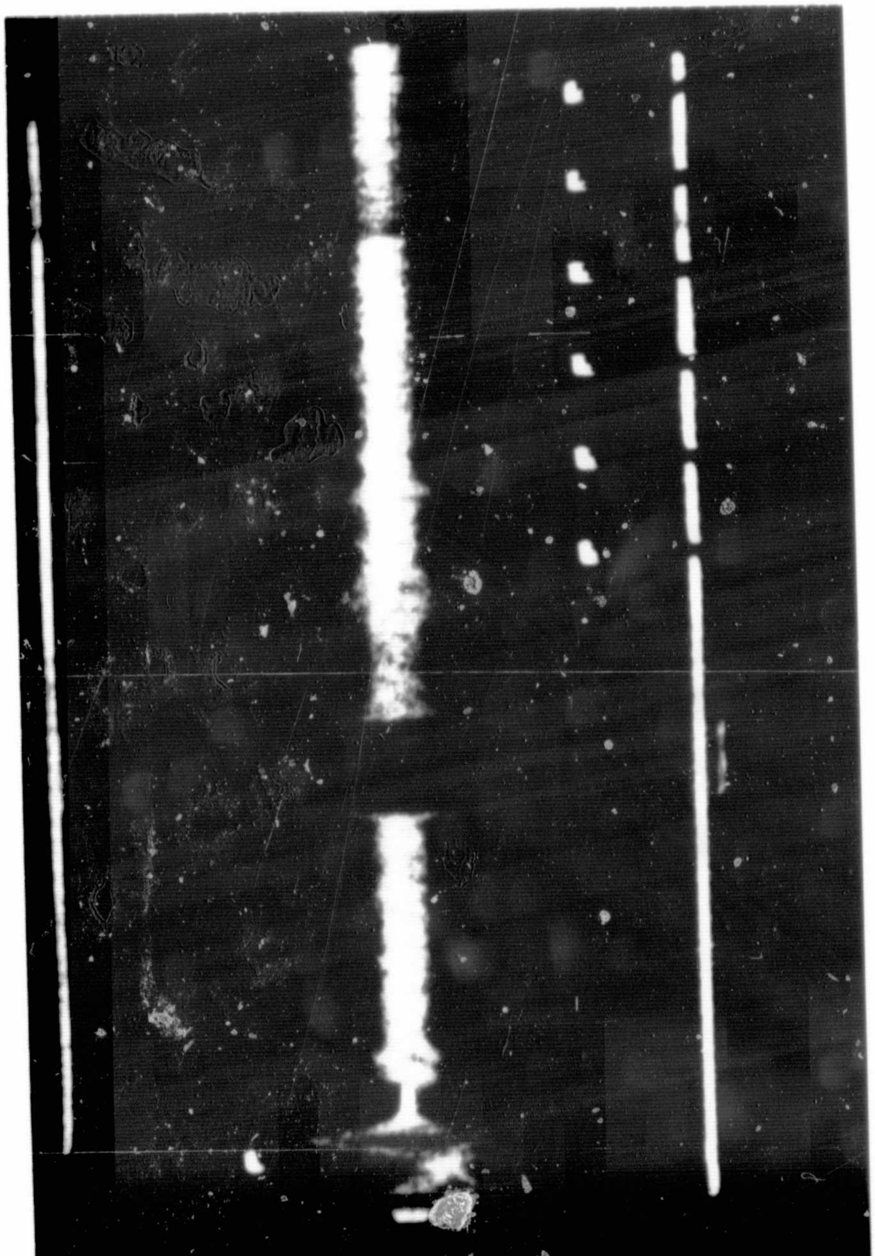


Fig. 76

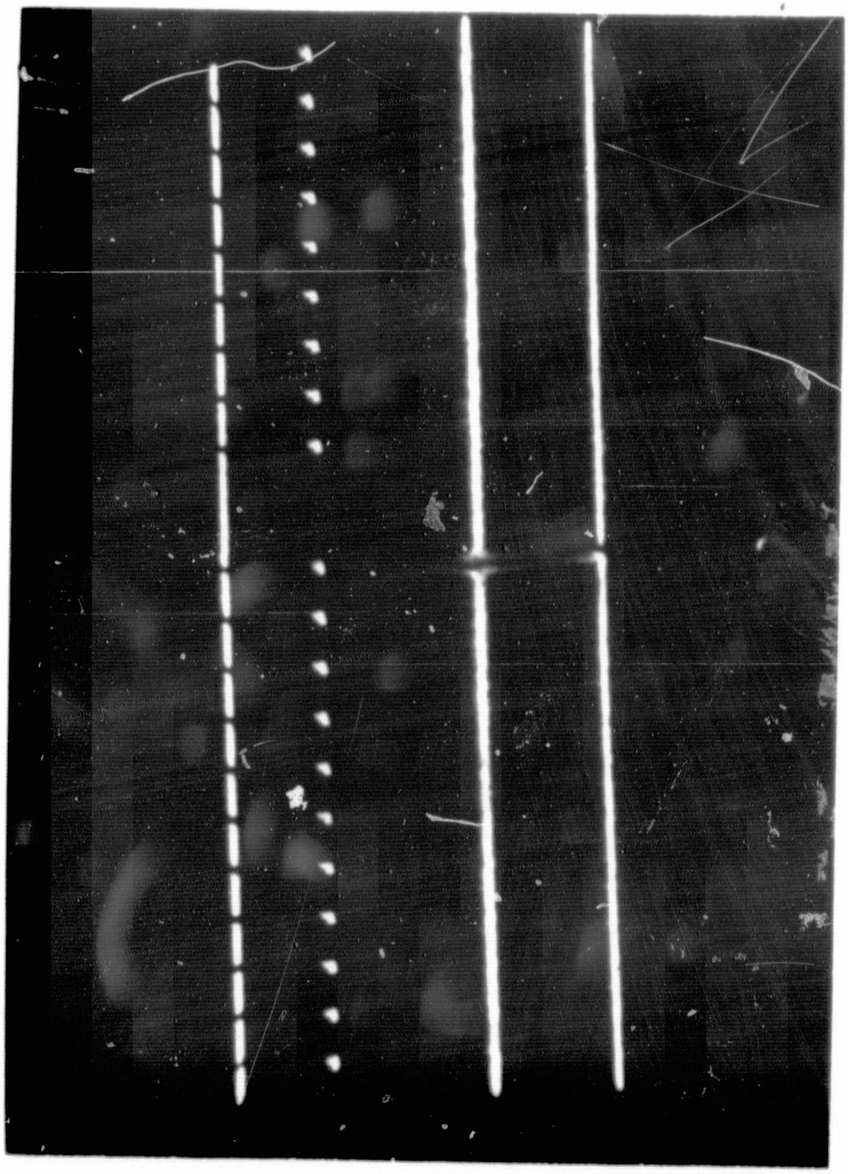


Fig. 77

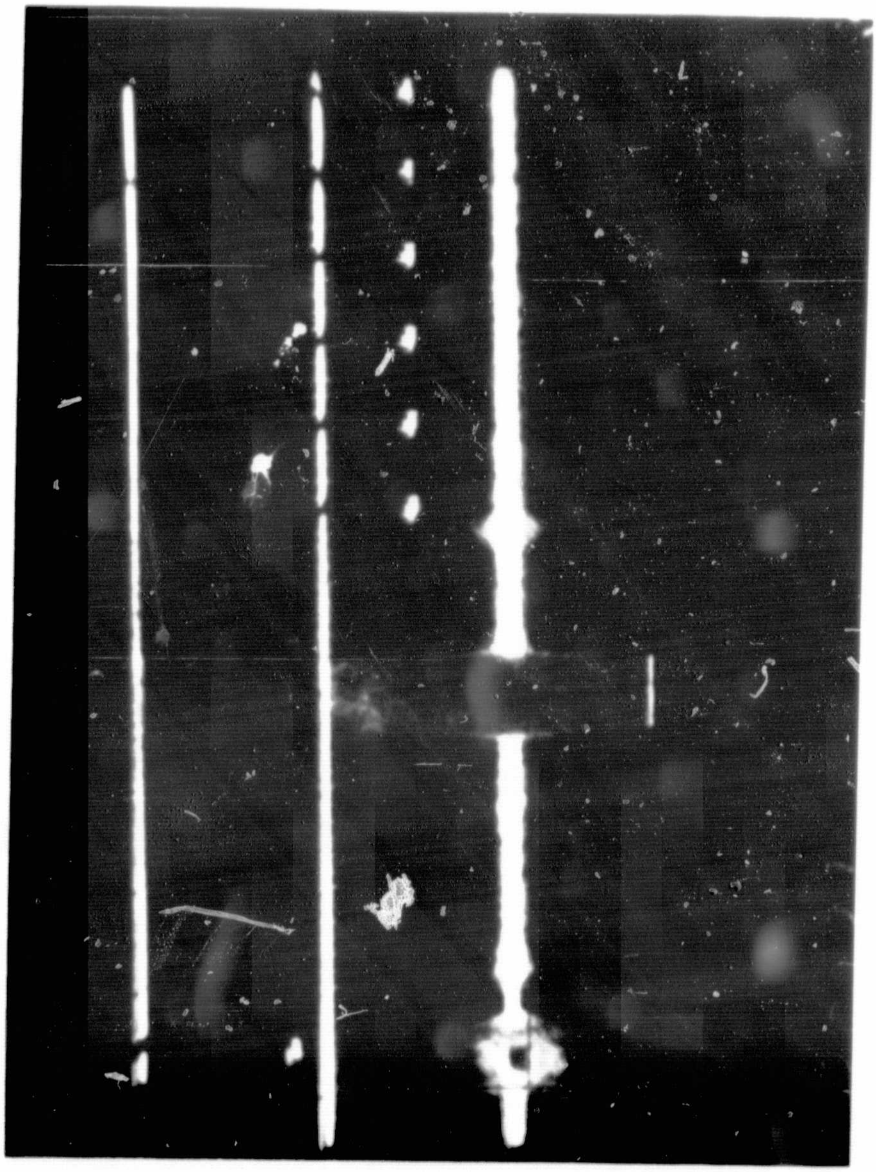


Fig. 78

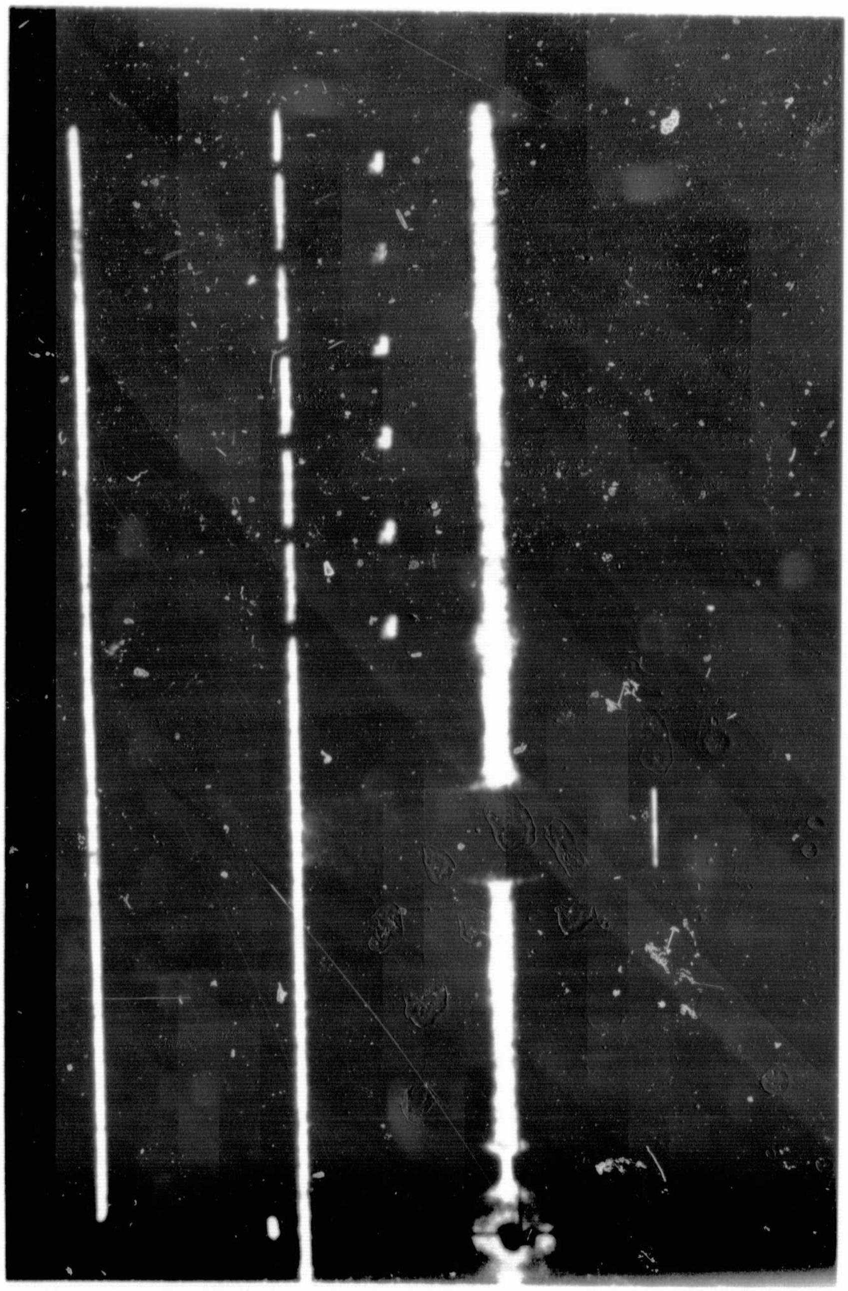


Fig. 79

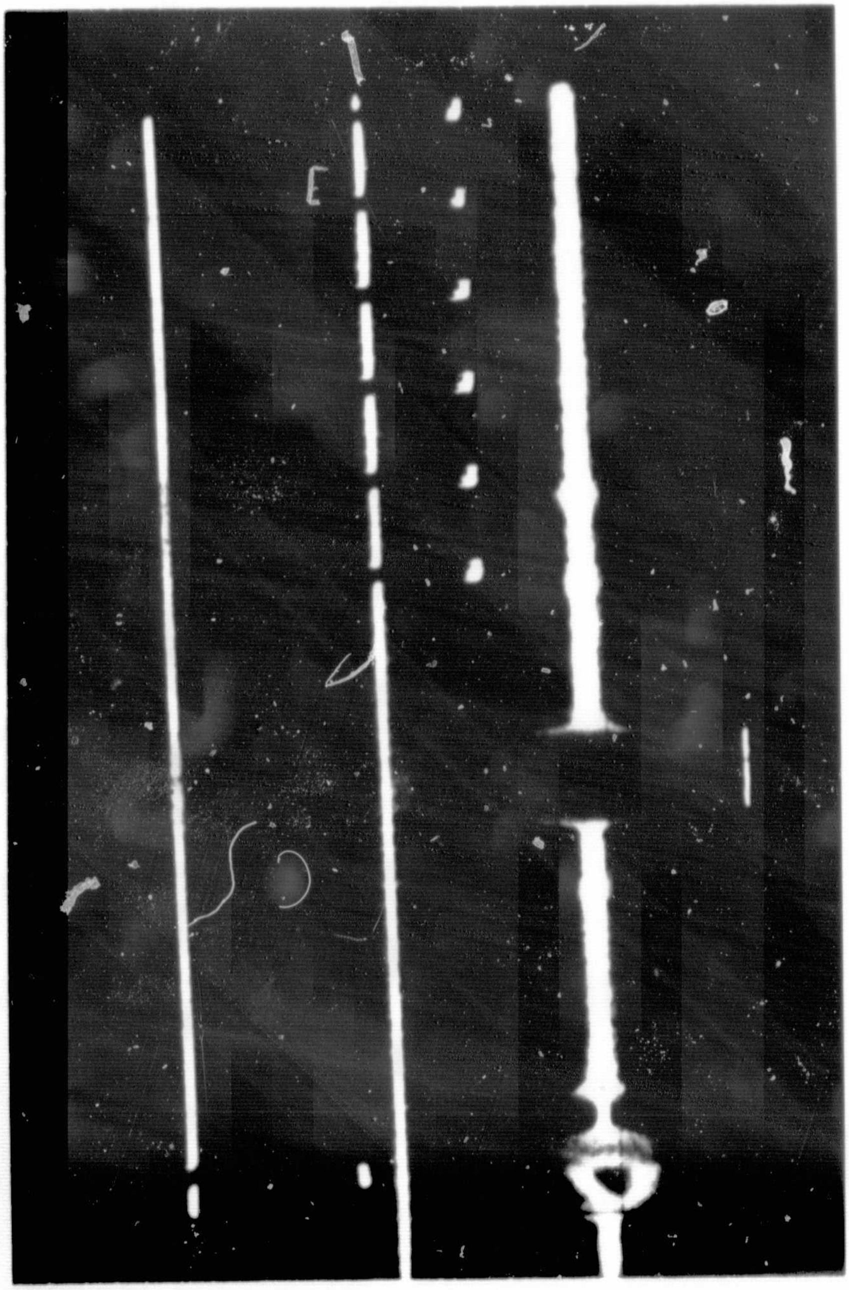


Fig. 80

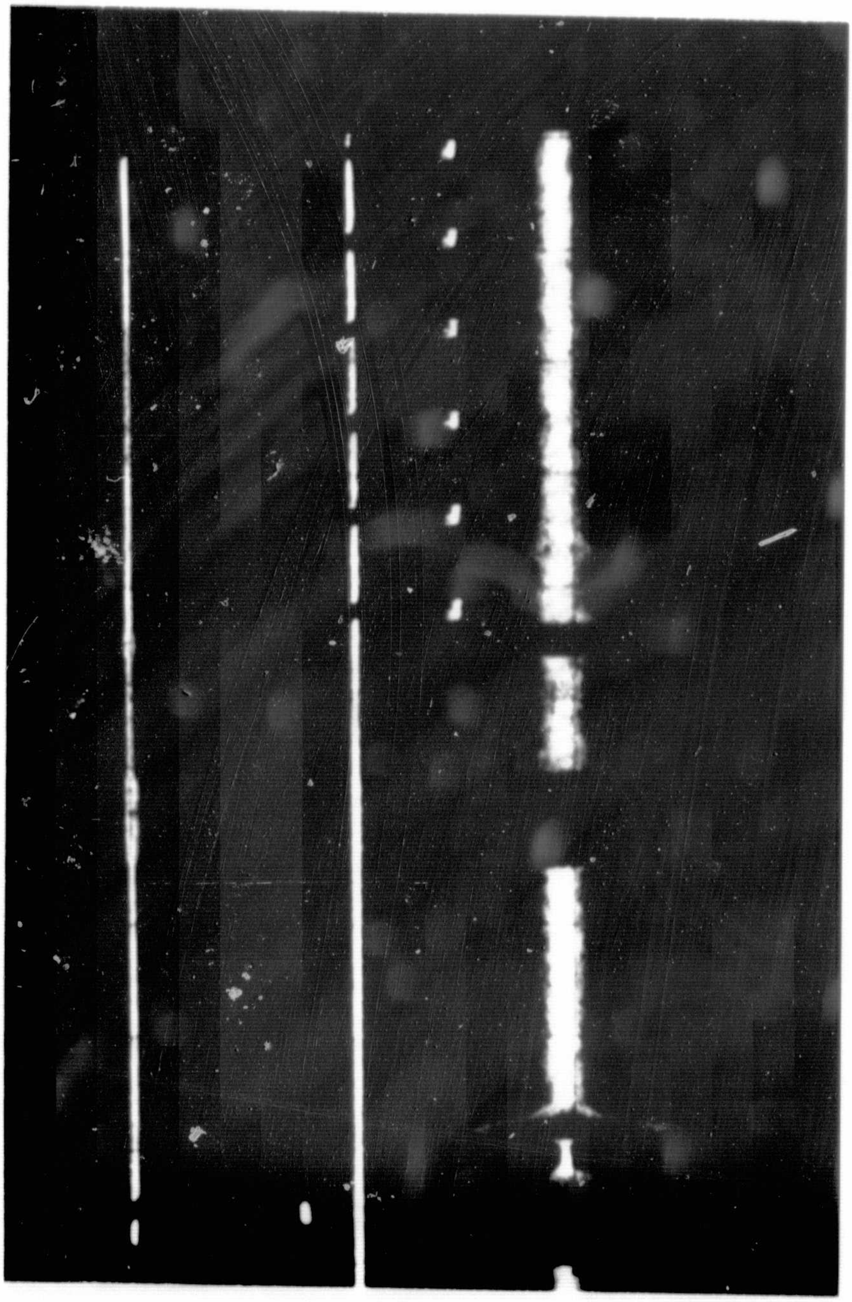


Fig. 81

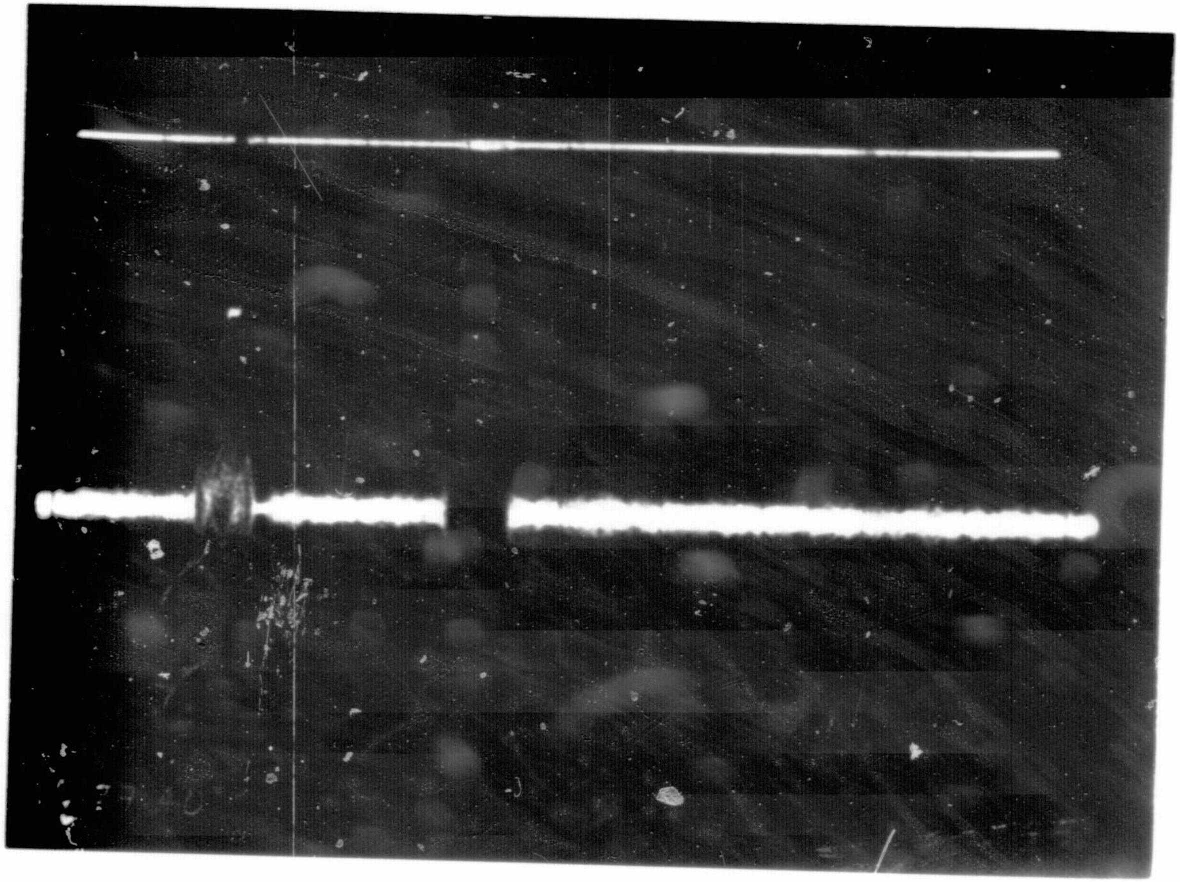


Fig. 82