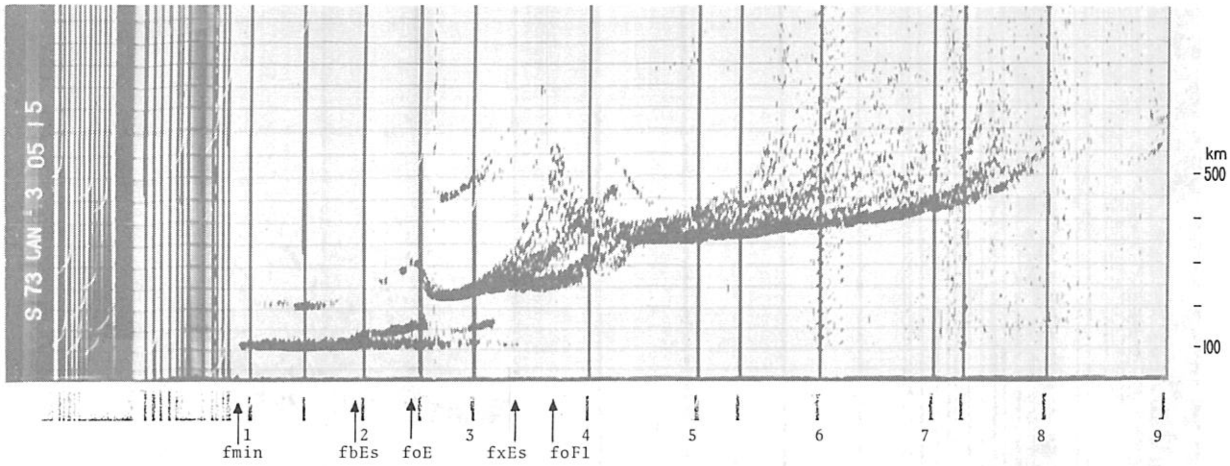


Fig. 9.9

0515, JAN, 3, 1973

fmin ---	009	h'Es ---	100
foE ---	250	h'E ---	130EA
foF1 ---	370-F	h'F ---	220
foF2 ---	F	h'F2 ---	350
foEs ---	028JA	type of Es :	ℓ2
fbEs ---	019		

EXAMPLE OF FREQUENCY SPREAD - SYOWA STATION

Editor's Note: The complexity of the trace near foF1, the range of satellite traces and lack of confirmation from second order trace would be better shown by foF1 = 370UH. U is needed as the interpretation of which cusp is foF1 is uncertain. H suggests the highly tilted condition near foF1 better than F. Thus H is preferable, but F acceptable. Also prefer foEs = 028, fbEs = 019-G.

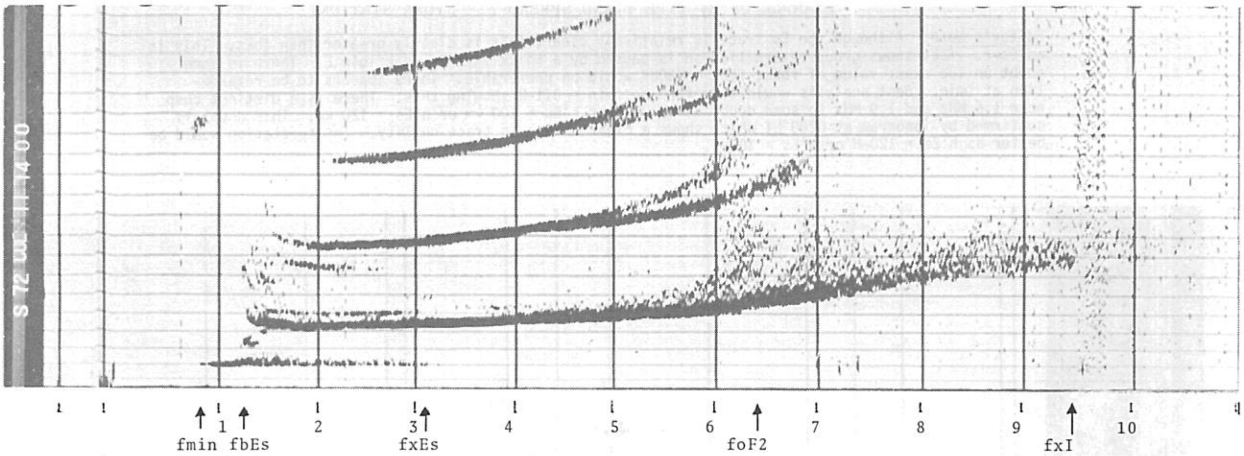


Fig. 9.10

1400, JUL, 11, 1972

fmin ---	008	h'E ---	A
foE ---	A	h'Es ---	100
foEs ---	025JA	h'F ---	200
fbEs ---	013	type of Es :	ℓ
foF2 ---	F		
fxI ---	095		

EXAMPLE OF FREQUENCY SPREAD - SYOWA STATION

Editor's Note: The M (2F-E) trace shows severe lateral deviation. Hence satellite trace above F trace probably 2E or (F+E) trace at oblique incidence. This is not F stratification calling for h'F = 200-Q. Also prefer fbEs = 013, foF2 = 063UF (from second order), fxI = 102.

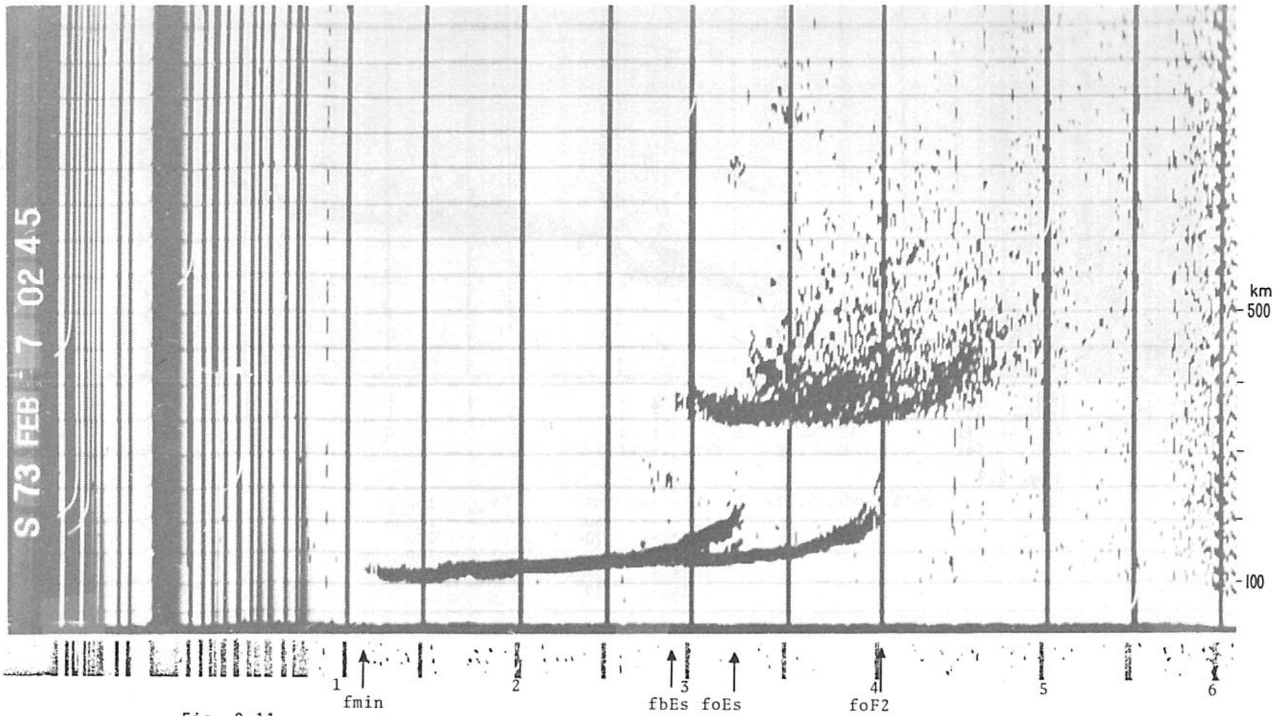


Fig. 9.11

0245, FEB. 7, 1973

fmin ---	011	h'Es ---	100
foEs ---	033	h'F ---	345
fbEs ---	030-K	type of Es :	r,k
foF2 ---	F	foE ---	300UK

EXAMPLE OF Es TYPE r AND SPREAD F - SYOWA STATION

Editor's Note: Although the Es trace is relatively clear, foEs is clearly greater than fbEs. This is an Es-r. fbEs shows group retardation so is caused by a thick layer -- particle E. There is some doubt on the exact value of fbEs, fbEs = 030UK would be preferable. There appears to be retardation at fmin. Best analysis would therefore be fmin = 011-R showing this. There is a distinct cusp near 1.6 MHz and 1.9 MHz so some doubt as to whether h'Es = 100 km or h'Es = 120 km. This doubt is confirmed by ionogram at 0200 LT which shows a clear change in trace quality. Interpretation would be better as h'Es = 120-H or h'Es = 100UH.

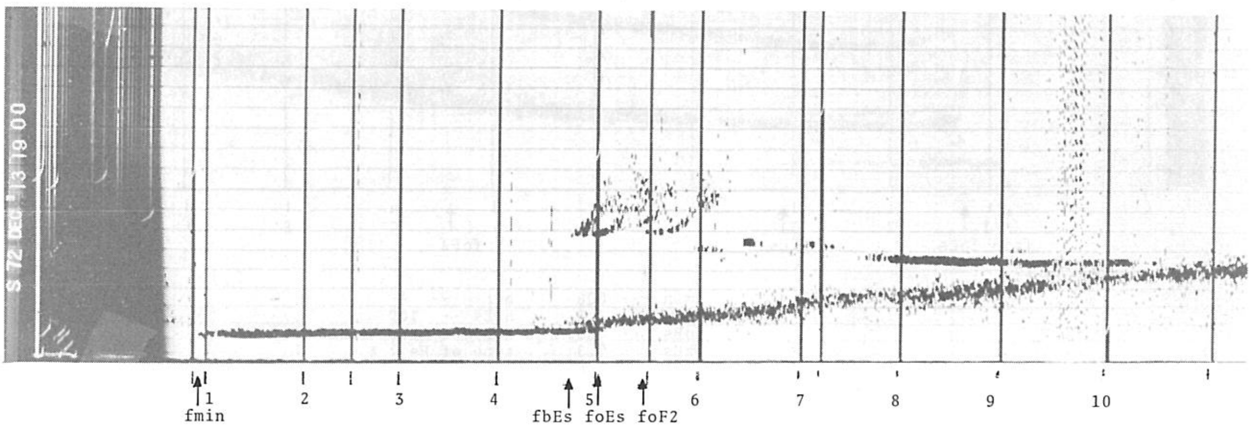


Fig. 9.12

1900, DEC. 13, 1972

fmin ---	009	h'E ---	A
foE ---	A	h'Es ---	100
foEs ---	050	h'F ---	A
fbEs ---	047	type of Es :	ℓ,s
foF2 ---	F		

EXAMPLE OF Es TYPE s - SYOWA STATION

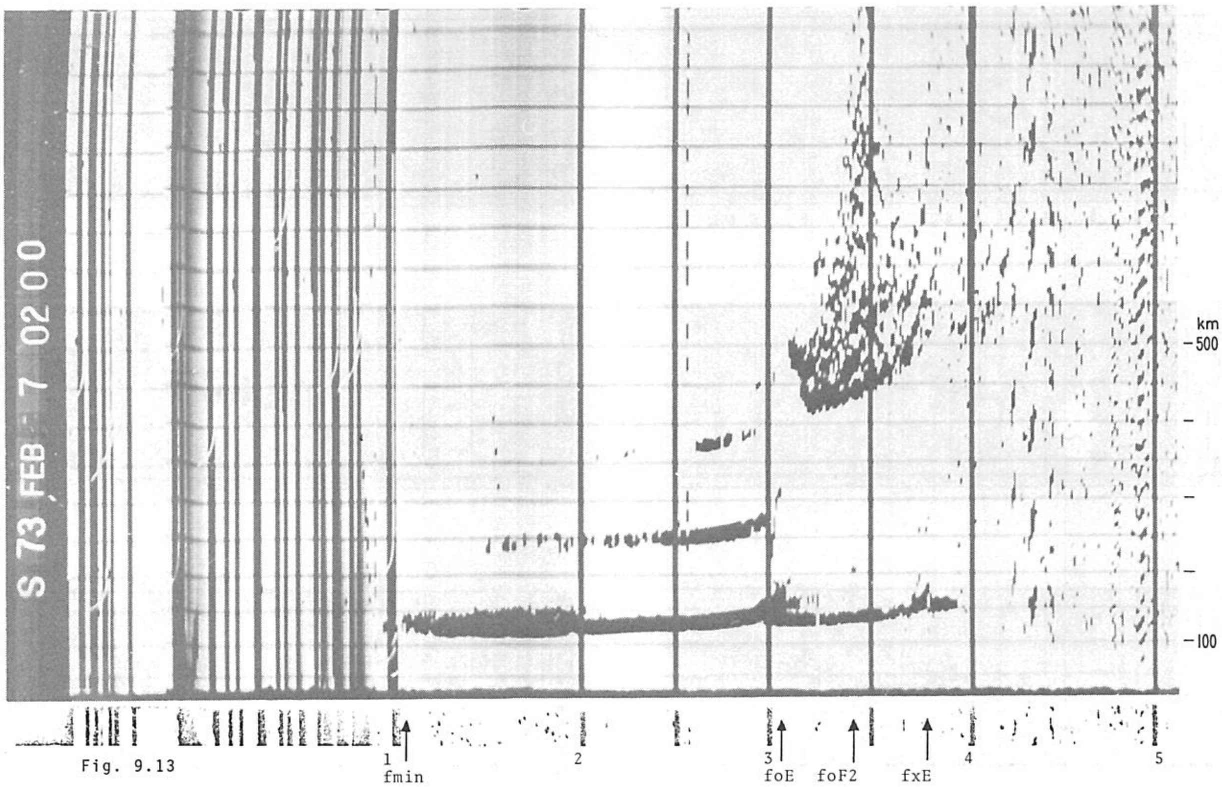


Fig. 9.13

0200, FEB. 7, 1973

fmin --- 011
foE --- 310-K
foF2 --- F

h'E --- 115UH
h'F --- 420

foEs = 033-K, fbEs = G
Es types c,k3
fbEs = 033-K
h'Es = 115UK
h'E = 115UK

EXAMPLE OF PARTICLE E AND SPREAD F - SYOWA STATION

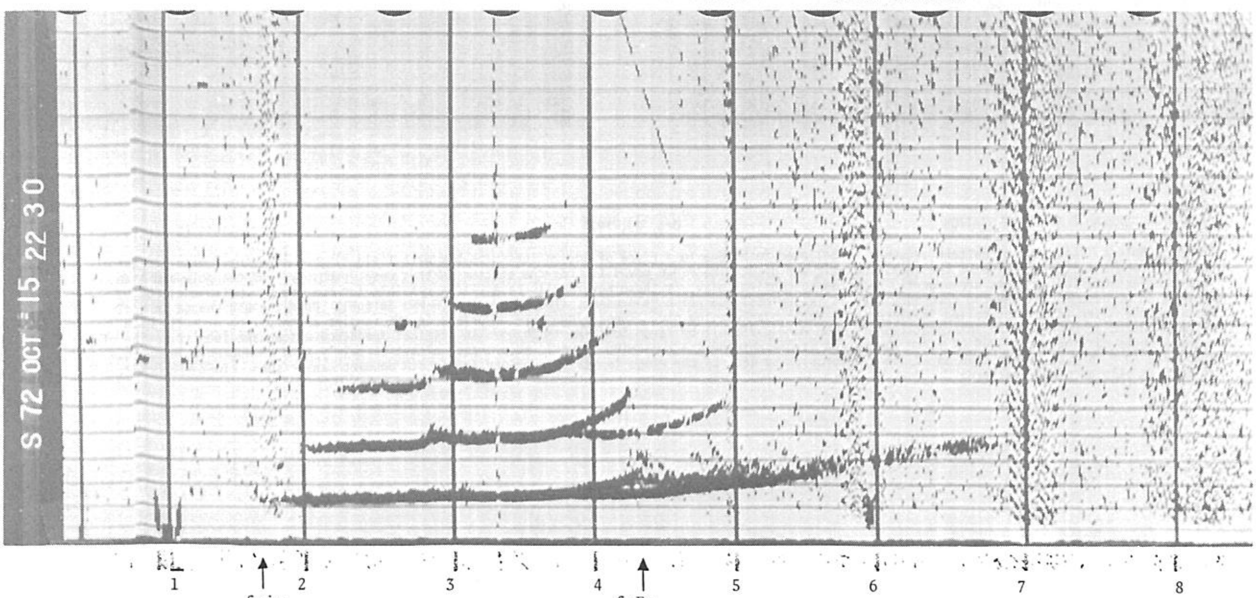


Fig. 9.14

2230 OCT. 15, 1972

foE --- 440-K
h'E --- 120-H
foEs --- 044-K
h'Es --- 105
type of Es : k5, k,s

EXAMPLE OF PARTICLE E AND Es TYPE s - SYOWA STATION

Editor's Note: The multiple order traces with group retardation to foEs show that this is a particle E layer. Normal E would be less than 2.0 MHz so that the stratification showing in the multiple traces at 2.9 MHz is also particle E. Best interpretation foE = foEs = fbEs, therefore foE = 440-K, foEs and fbEs = 044-K, F parameters A.

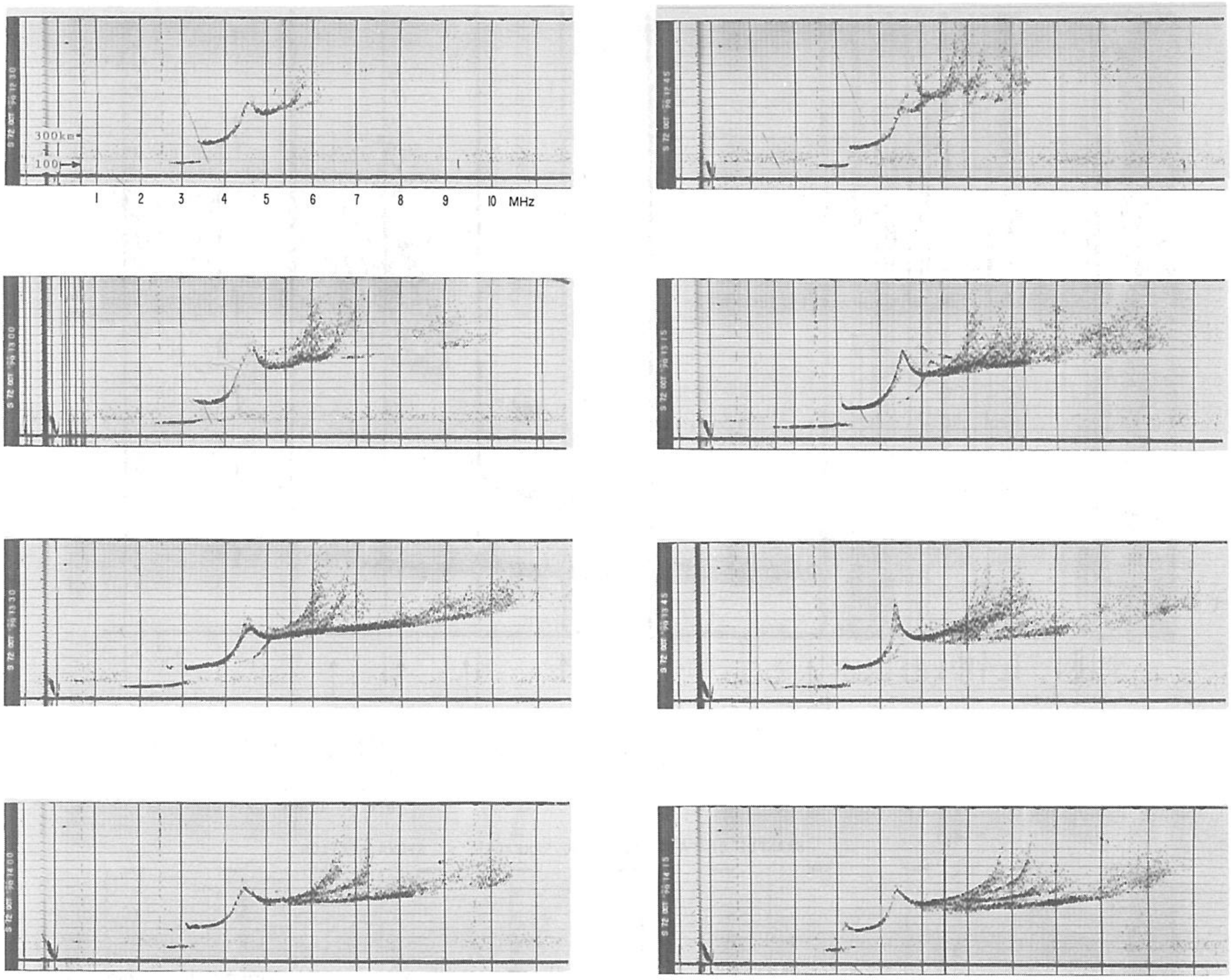


Fig. 9.15

SEQUENTIAL SPREAD F AT SYOWA STATION   Oct. 29, 1972   1230-1615 LT (45°E)

Editor's Note : This type of pattern sequence is believed to be due to a ridge of ionization (probably with field-aligned structure) with its axis making an angle tilted relative to the local magnetic meridian. The ridge moves towards the station in this case, probably from the poleward side though direction-finding tests are urgently required to confirm this. In these severe tilt cases it is possible for one mode to be absent, but by convention we assume that the top frequency seen is fxI unless absorption is present. The cusp near 4.5 MHz is foF1. Note the big change in foF2 when the new layer (sometimes called "replacement layer") blankets the old. These ridges are important in IMS studies as they link directly with magnetospheric phenomena. The interpretation is made more difficult by large South-North changes in critical frequency which make identification of o and x modes difficult. At 1345 LT large absorption is present and the remaining trace is an o trace, almost certainly seen at appreciable oblique incidence (h'F is much higher than on adjacent records). By 1600 LT the ridge is nearly overhead and an o,x doublet can be seen. foF2 = 8.0 MHz. 1615 LT is also an o-mode pattern.

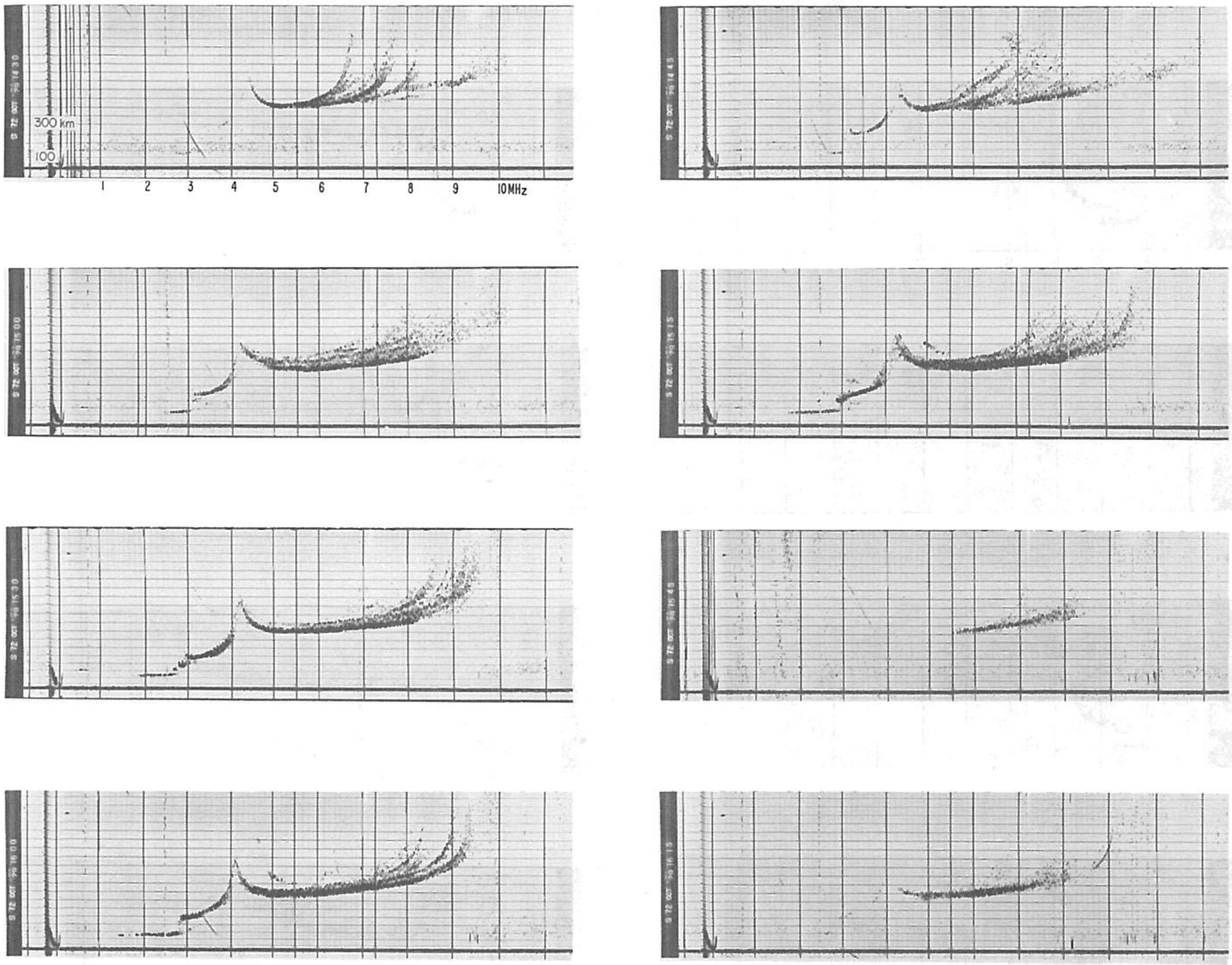


Fig. 9.15 (cont'd.)

SEQUENTIAL SPREAD F, SYOWA STATION 9 APRIL 1971

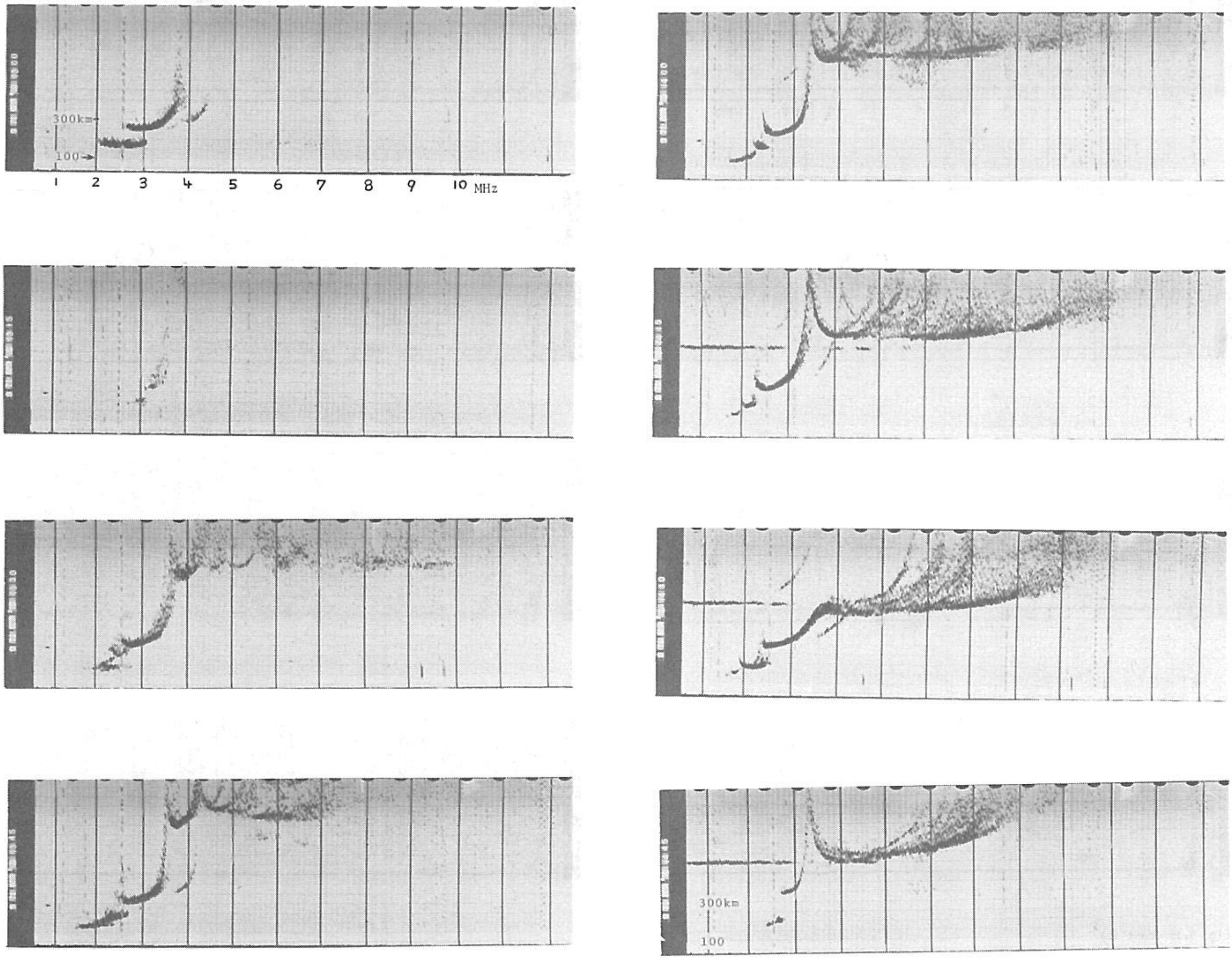


Fig. 9.16

SEQUENTIAL SPREAD F AT SYOWA STATION — April 9, 1971 — 1300-1445 LT (45°E)

Editor's Note. foF1 is expected to be near 3.4 MHz at this time. The pattern starts with G condition, significant absorption, the Es is most probably an r type seen at oblique incidence but could be an unusually dense high type. E parameters are B. Again the structure in the F trace is most probably due to simultaneous oblique reflections at different azimuths. The 1330 and 1345 LT ionogram suggests foF2 near 4.2 MHz UF. This type of pattern is often called Polar Spur. The F layer is severely tilted with foF2 varying rapidly with position. Again this type of structure is closely associated with magnetospheric phenomena and deserves more detailed analysis. The critical frequency of the most nearly overhead trace, as shown by o-x separation, increases from 038EG at 1300 LT, 042-F at 1400 LT to 062-F at 1430 LT. The layer at 1445 LT is too tilted to show an overhead trace, foF2-F. The z-mode trace suggests foF2 = 065ZF but this trace is clearly due to a tilted layer and is not confirmed by the remaining traces. F is probably slightly preferable to 065ZF in this case.

SECTION 10. BASE GENERAL BELGRANO

Belgrano Station 1965 Data

At the time of reduction, this station was in trouble in interpreting foE and has used a non-standard analysis with (foE)ER applied to the highest E-layer critical frequency possible. This is not consistent with the international ruling which is that foE must be deduced from the lowest thick E structure present. Weak cusps are ignored in this rule and the correct foE can be identified by looking at cases of Es type c. This is usually formed near the maximum of the normal E layer. The value adopted in the tabulations is usually foE2. At most stations this difficulty is found at sunrise and sunset when subsidiary cusps often develop so as to be indistinguishable from main cusps. LT at General Belgrano is 60° WMT (UT - 4 hours). Ionograms selected and analyzed by Dr. Giraldez.

For information concerning current station data please contact:

Dr. Horacio A. Cazeneuve
Instituto Antártico Argentino
Cerrito 1248
Buenos Aires, Argentina

Station name:	Base General Belgrano	
Geographic coordinates:	Lat. S77.90°	E Long. 321.40°
Geomagnetic coordinates:	Lat. S67.29°	E Long. 16.18°
Invariant latitude:	62.18°	
Magnetic dip:	65.74S	
Time used:	60°W (UT - 4 hours)	

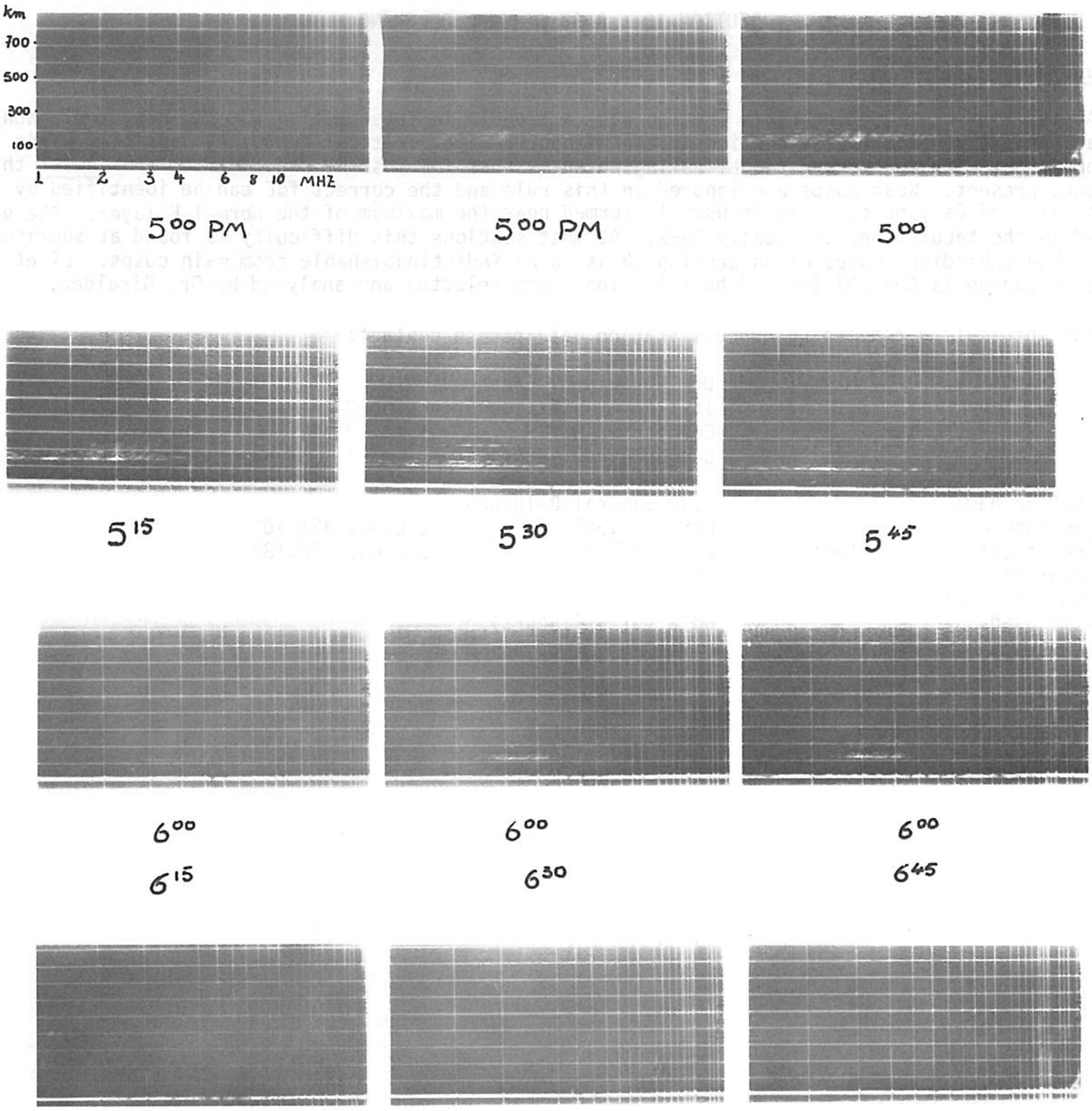


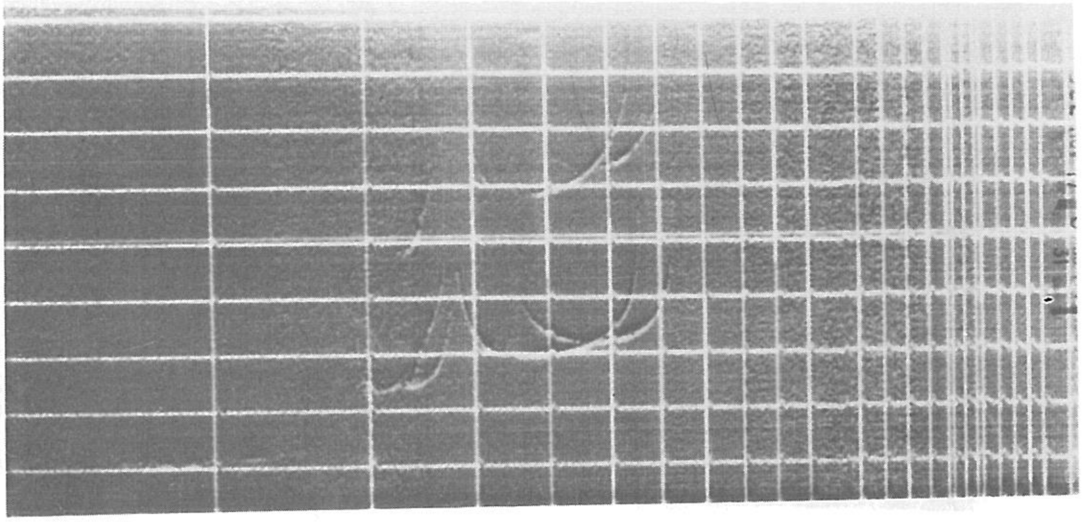
Fig. 10.1

Base General Belgrano 13 July 1965 5:00-6:45 PM (LT) (60°W)

Rapid Evolution of Structure Followed by High Absorption.

A fast descent of the structure is observed together with rapid changes in internal structure. The three ionograms of 05.00 and 06.00 PM(LT) are low gain, normal gain and high gain from left to right, respectively.

<u>Editor's Note:</u> <u>Es-a in early morning</u>. This is a sample of Es type a seen first at oblique incidence with h'Es about 160 and absorption increasing rapidly. The structure moves overhead till blackout occurs. This type of event is fairly common in the early morning in magnetic time getting later as the magnetic latitude increases.



BASE
GENERAL
BELGRANO

DATE: 17/11/1965
(17 Nov. 1965)

TIME: 8³⁰ AM (L.T)
[0830 LT (60°W)]

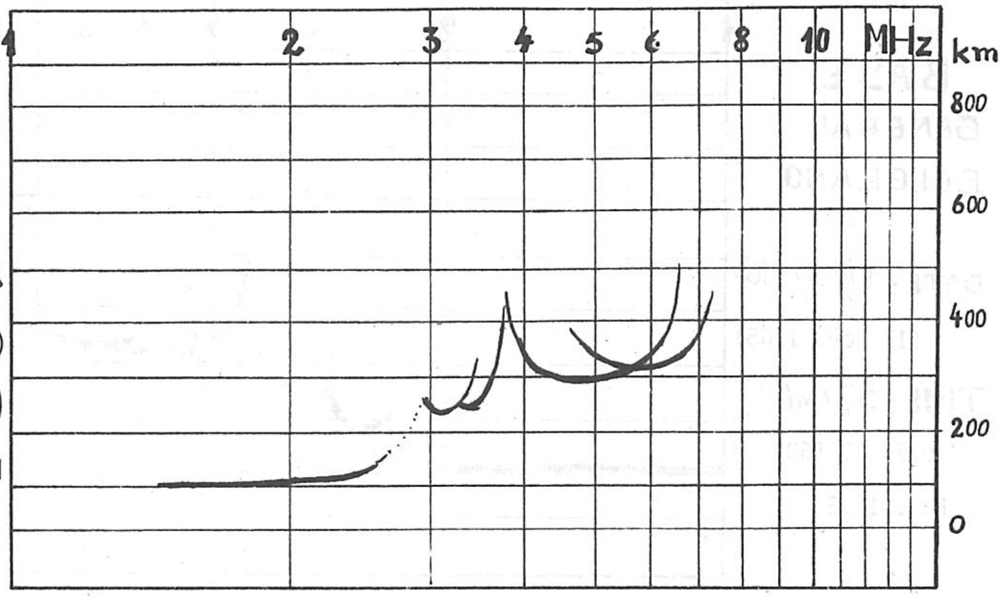
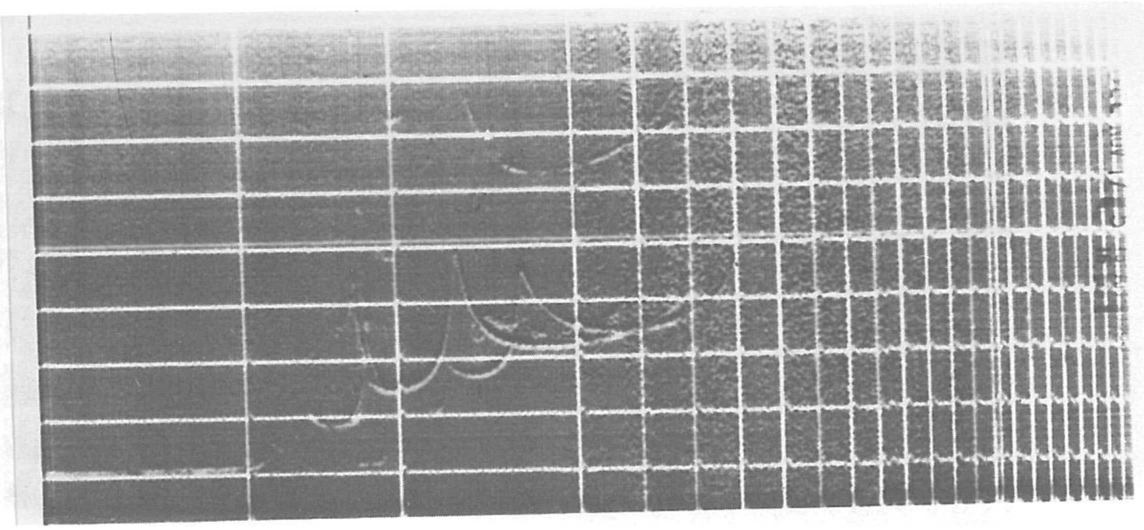
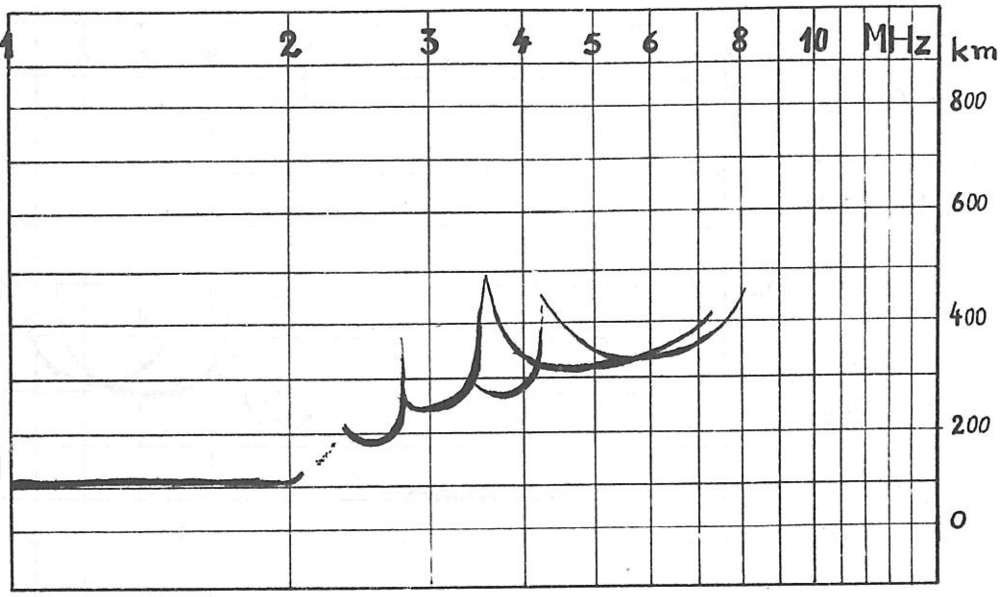


Fig. 10.2

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,16	0,65	310	295	240	380-H	360-H
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
270UR	100	G	G	G	—	0,72-X





BASE
GENERAL
BELGRANO

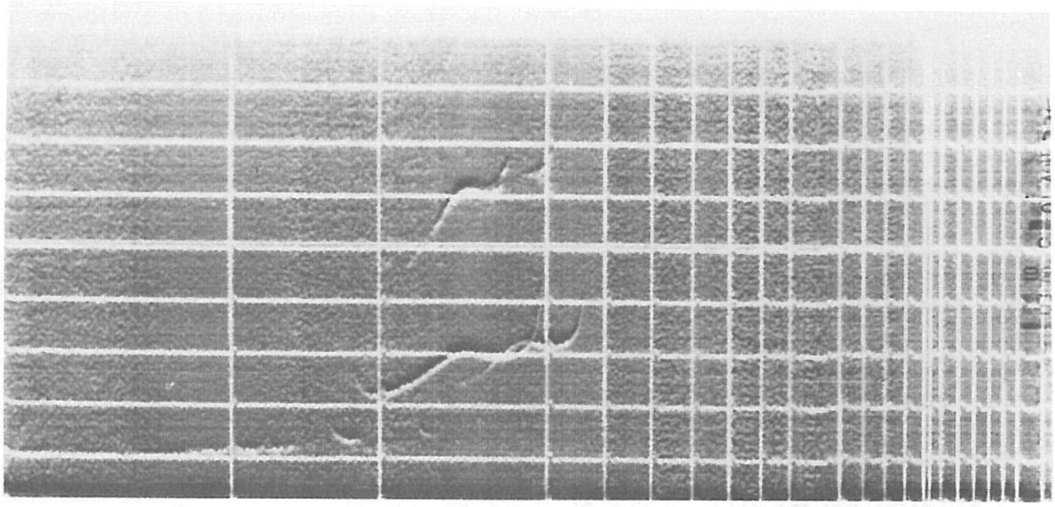
DATE: 17/11/1965
(17 Nov. 1965)

TIME: 5¹⁵ AM (L.T)
[0515 LT (60°W)]

Fig. 10.3

fmin	foF2	M3000F2	h'F	h'F2	foF1	M3000F1
E	074JS	280	240	315	360	360
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
230-R	100	G	G	G	—	0,81x

Editor's Note: Distinction Between E2 and F0.5. In this case the E2 trace has h'E2 = 190 km but is clearly E2 not F0.5 as E2 trace shows more retardation at foE2 than F trace. Ionogram also affected by tilt near foE2 as would be expected in a borderline case. According to strict rules foE = 230-R. There is a subsidiary thick layer trace, just detectable on master between 230 and 250. If this was absent, foE would have been 240UR.

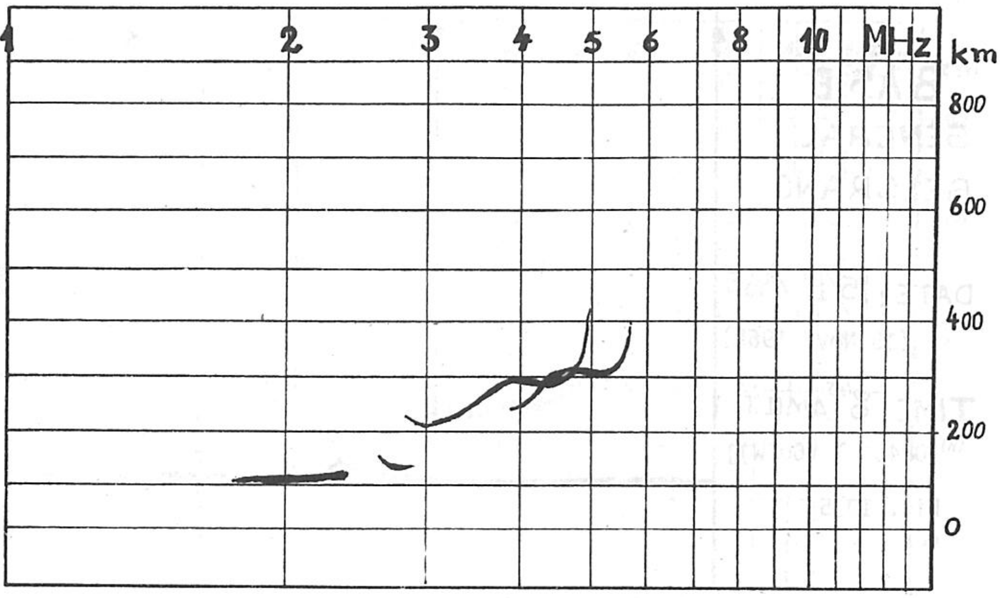


BASE
GENERAL
BELGRANO

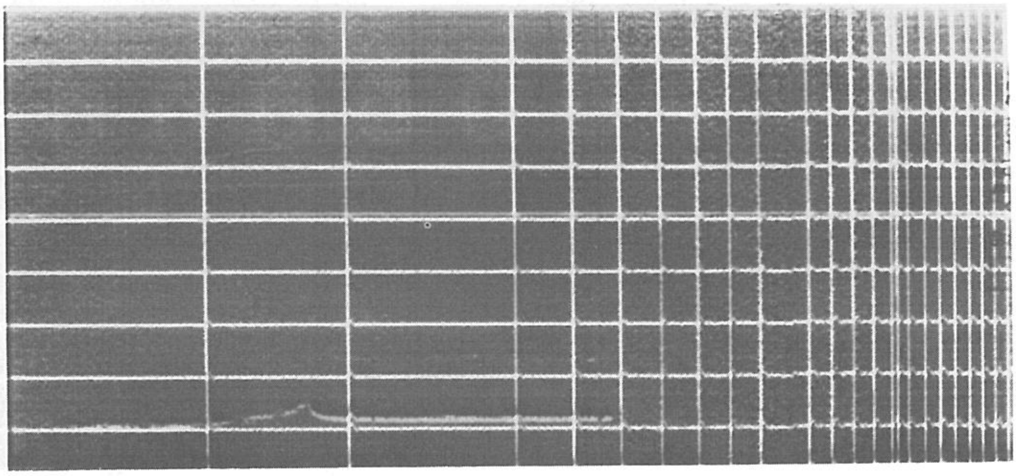
DATE: 16/11/1965
(16 Nov. 1965)

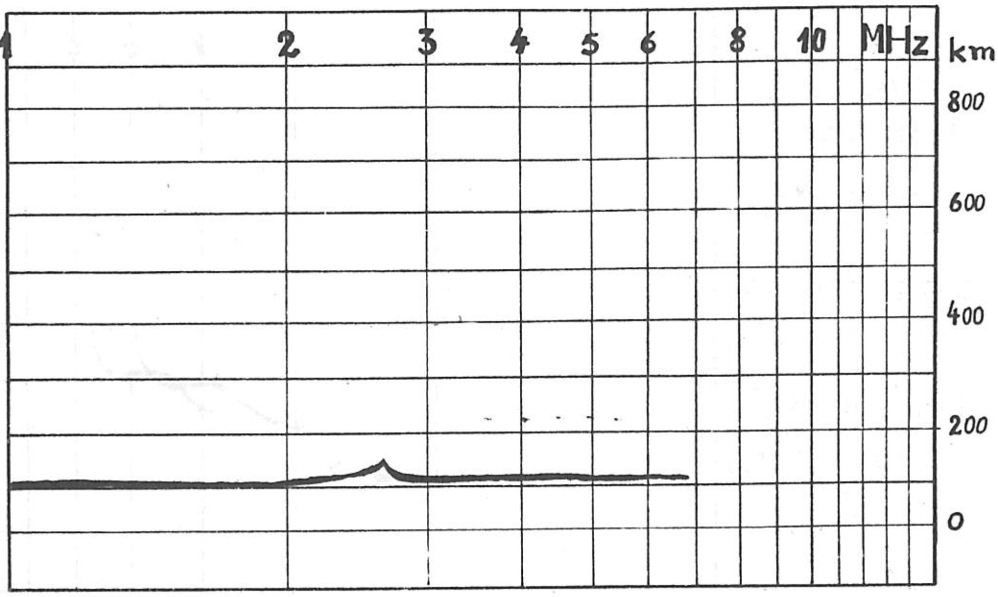
TIME: 3^{00} PM (L.T)
[1500 LT (60°W)]

Fig. 10.4



f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
0,18	0,50	330	295	215	390UL	350
f_oE	$h'E$	f_bEs	f_oEs	$h'Es$	type Es	fxI
270	105	028	029	130	h1	0,56X





BASE
GENERAL
BELGRANO

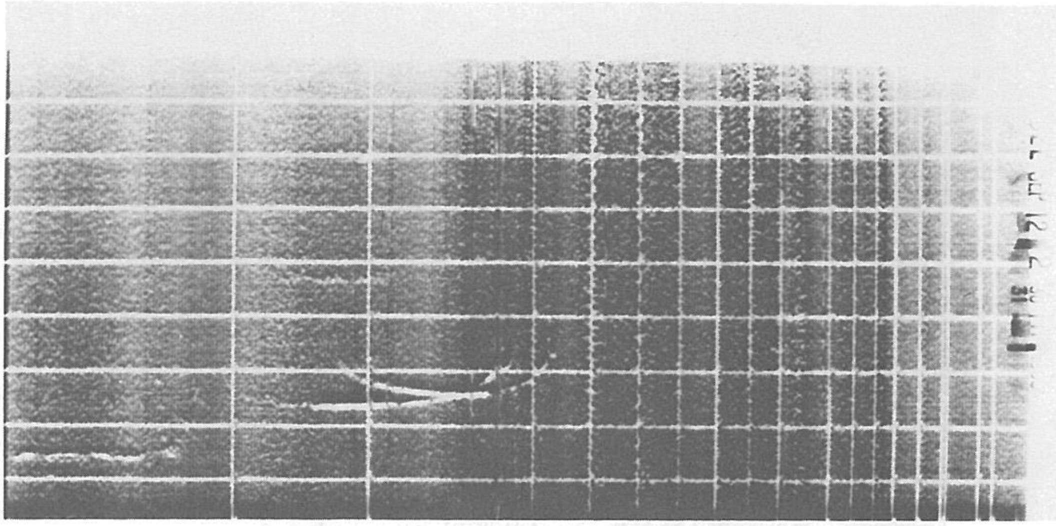
DATE: 15/11/1965
(15 Nov. 1965)

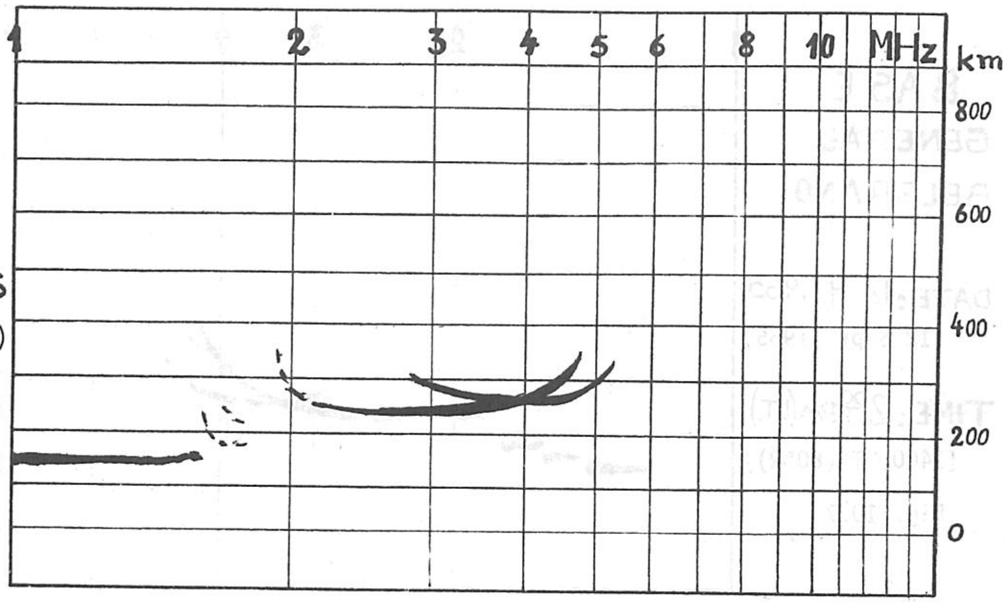
TIME: 8^{45} AM (L.T)
[0845 LT (60°W)]

Fig. 10.5

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	A	A	A	A	A	A
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
270-A	101	065AA	065-M	109	c2	A

Editor's Note: [15 Nov. 1965, 0845 LT (60°W)] Use of Letter A. A difficult ionogram. Low value of fmin is not consistent with absence of Es multiples or F trace. Probably a z trace at fmin. Cusp is adequate to give an unqualified value of foE. foE should be 270-A, not A. Very weak second order trace to 065 and ftEs at 068 suggest absorption present. Value foEs = 065-M is justified in this case. The main difficulty of using M is to deduce best value of fbEs. With foEs = 065-M and a second trace to about 065, fbEs = 065AA. This is almost certainly correct physically. In all these cases fbEs = (foEs)AA and F-layer entries are A.





BASE
GENERAL
BELGRANO

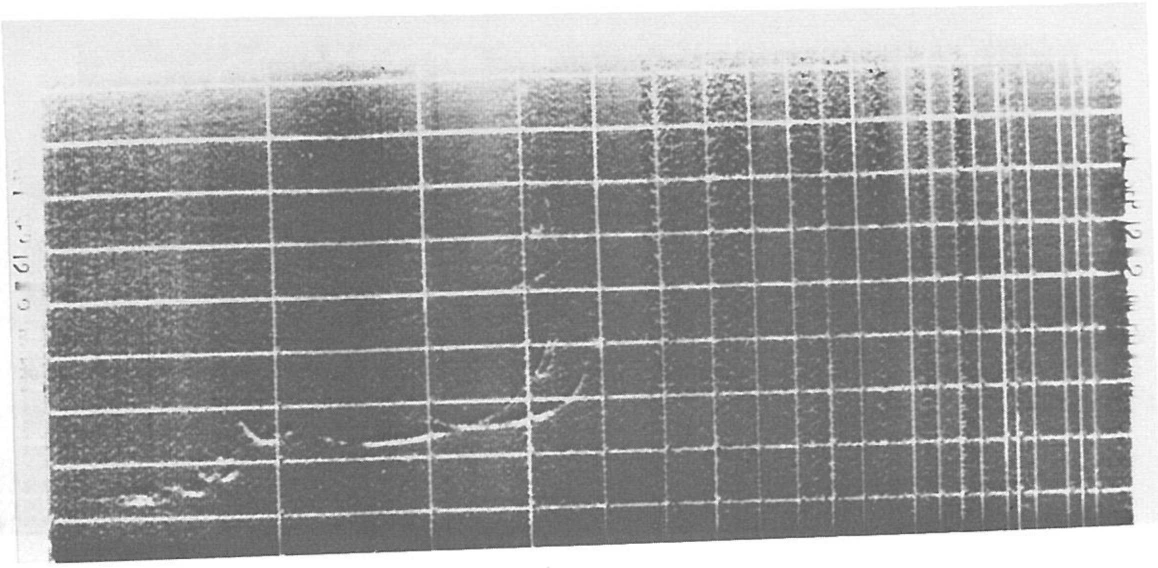
DATE: 12/9/1965
(12 Sept. 1965)

TIME: 2^{30}PM(L.T)
[1430 LT (60°W)]

Fig. 10.6

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	0,48	340		230	–	–
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
170UR	141	G	G	G	–	0,54-X

Editor's Note: [12 Sept. 1965, 1430 LT (60°W)] Close examination of ionogram shows F trace to 190 and slight trace of high Es or E2 with retardation from 170. Best value foE = 170UR. This is not a Lacuna record; see "--" on analysis (added by editor).



BASE GENERAL BELGRANO

DATE: 12/9/1965
(12 Sept. 1965)

TIME: 2^{00} PM (L.T.)
[1400 LT (60°W)]

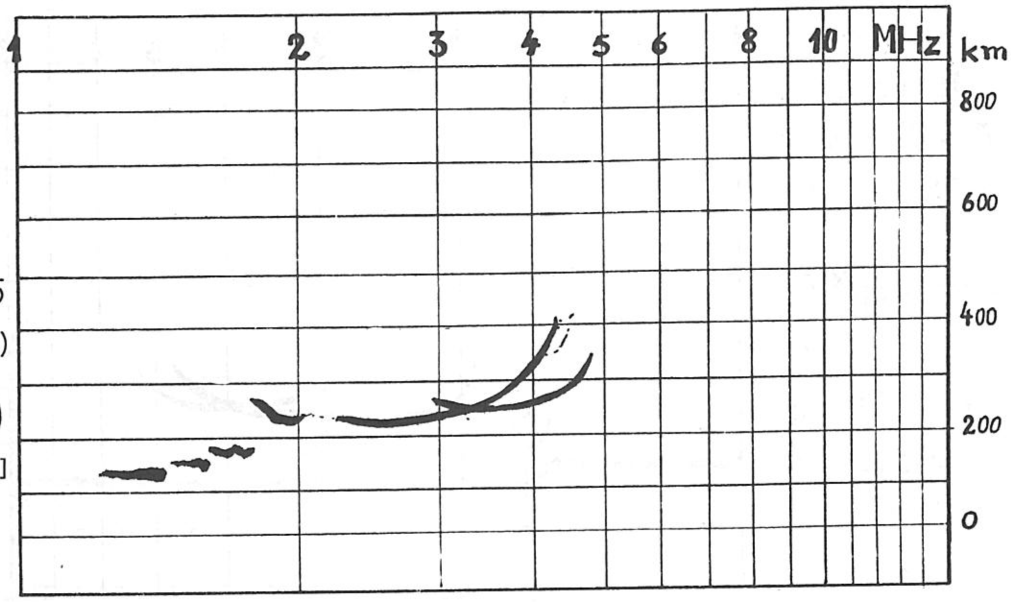
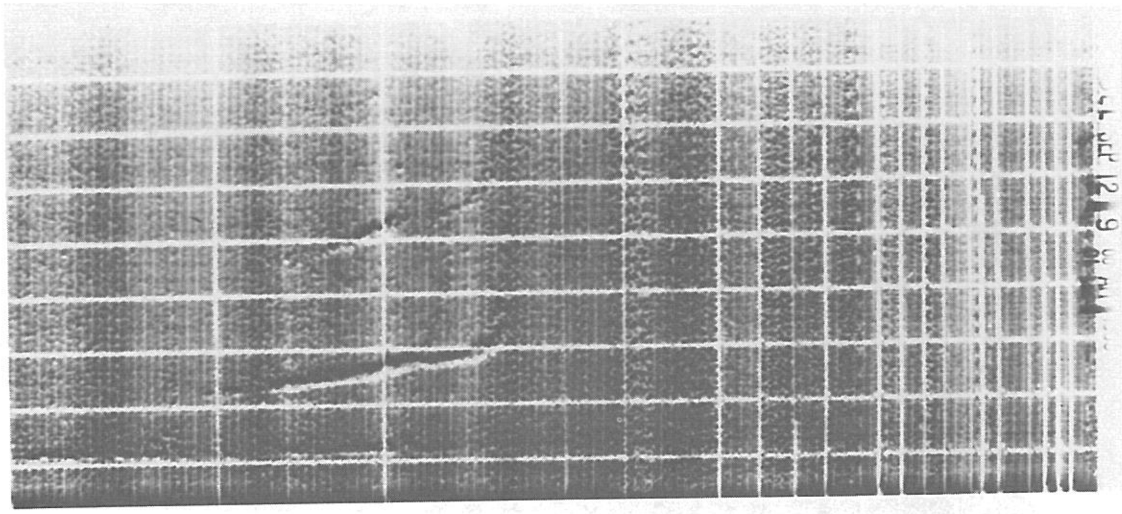


Fig. 10.7

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,11	0,43-V	330-V	–	225-H	–	–
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
160UH	125	G	G	G	–	050-X

Editor's Note: [12 Sept. 1965, 1400 LT (60°W)] The strong trace at low frequency end of F trace is superficially like a z trace but does not fit the frequency separation law and h'F is too high. Hence small cusp near 022 is an fo (F0.5), h'F is described by H. This is a difficult stratified E trace with the lowest cusp frequency at 150, highest at 170. The best value of foE would be 160UH.

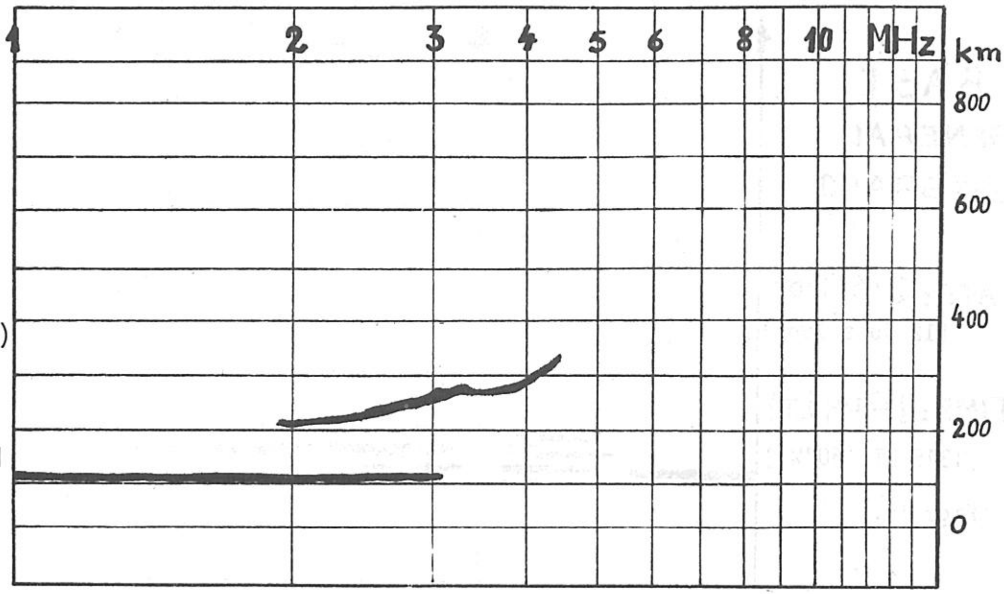


BASE
GENERAL
BELGRANO

DATE: 12/9/1965
(12 Sept. 1965)

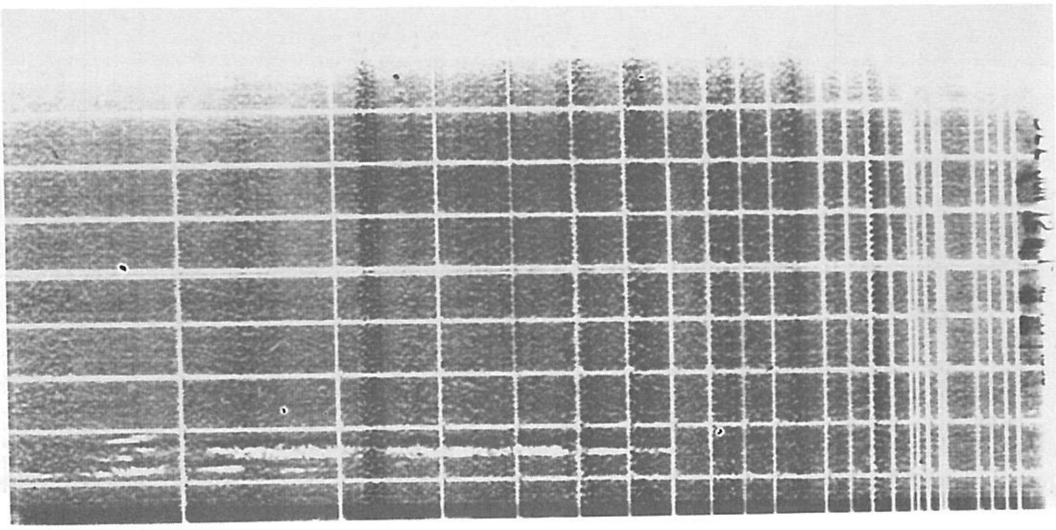
TIME: 9⁰⁰AM(L.T.)
[0900 LT (60°W)]

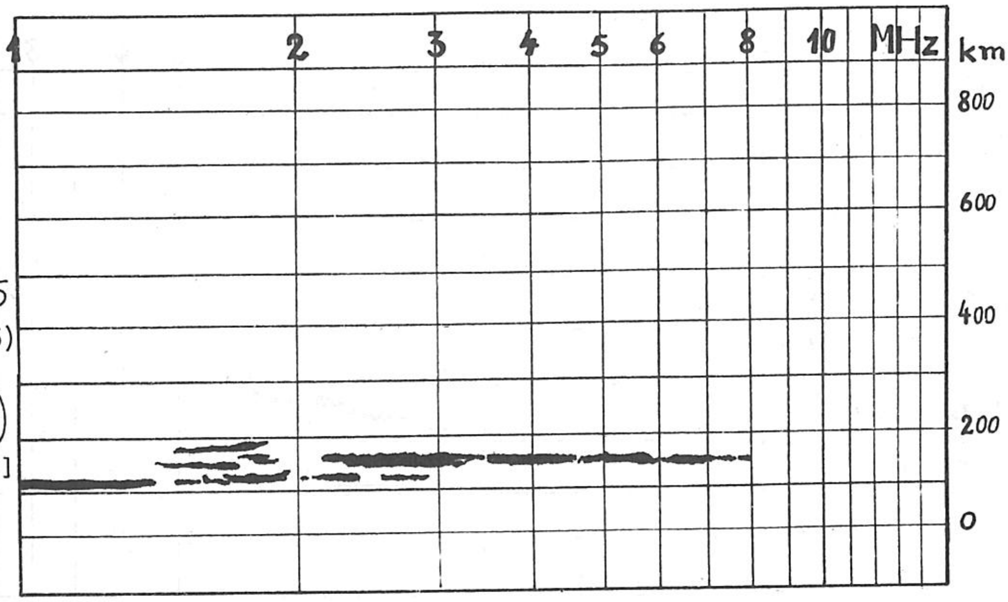
Fig. 10.8



fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	038JR	335UR		225		
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
A	A	0,19	024JA	111	ℓ1	0,45DR

Editor's Note: [12 Sept. 1965, 0900 LT (60°W)] The Es trace ends where the F-layer x trace starts so ftEs is fxEs, foEs is (fxEs - fB/2)JA = 025JA.





BASE
GENERAL
BELGRANO

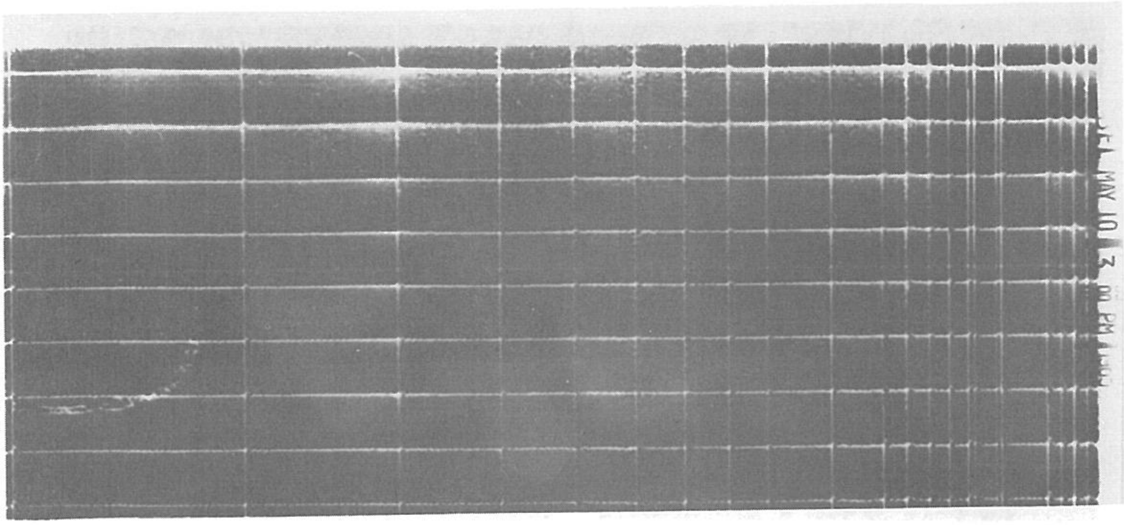
DATE: 12/6/1965
(12 June 1965)

TIME: 1^{45} PM (L.T.)
[1345 LT (60°W)]

Fig. 10.9

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	A	A	—	A	—	—
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
—	—	073AA	073JA	149	a1f1	A

Editor's Note: [12 June 1965, 1345 LT (60°W)] Distinction Between a and f. fmin is low - 010EE or E so little absorption present. ftEs should be interpreted as an x-value. foEs is (fxEs-fB/2)JA = 073JA. I concur that with auroral Es strictly speaking we do not know if top frequency is o or x but it is better to keep uniform rules for all Es rather than make auroral Es a special case. The doubt occurs because Es-a is always oblique so that it is in theory possible for one mode to be missing.

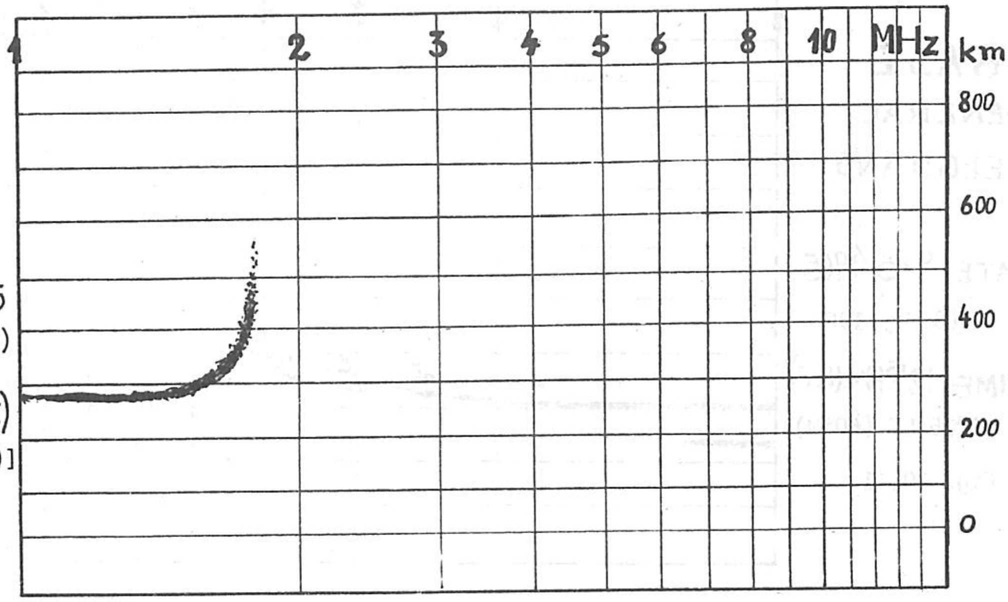


BASE
GENERAL
BELGRANO

DATE: 10/5/1965
(10 May 1965)

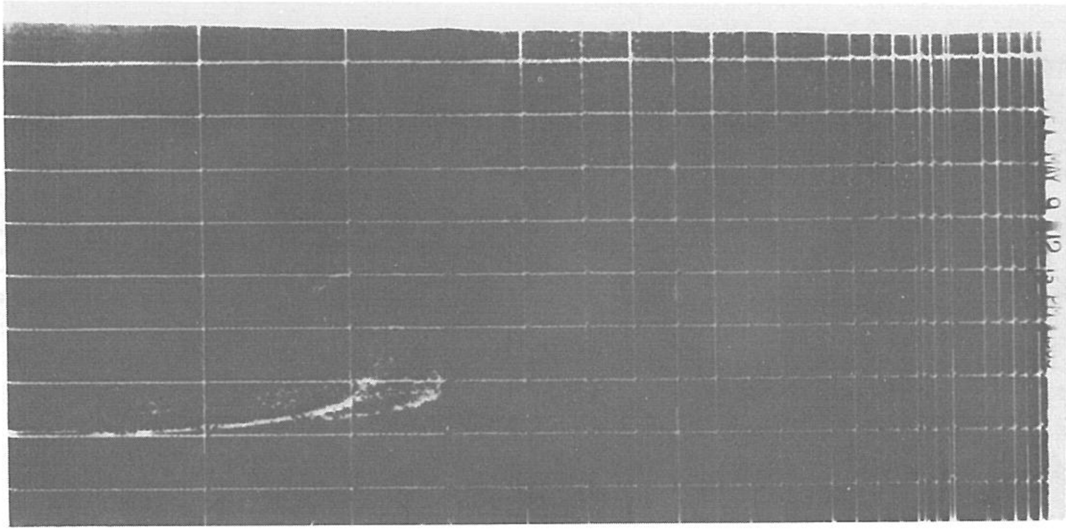
TIME: 3⁰⁰ PM (L.T.)
[1500 LT (60°W)]

Fig. 10.10

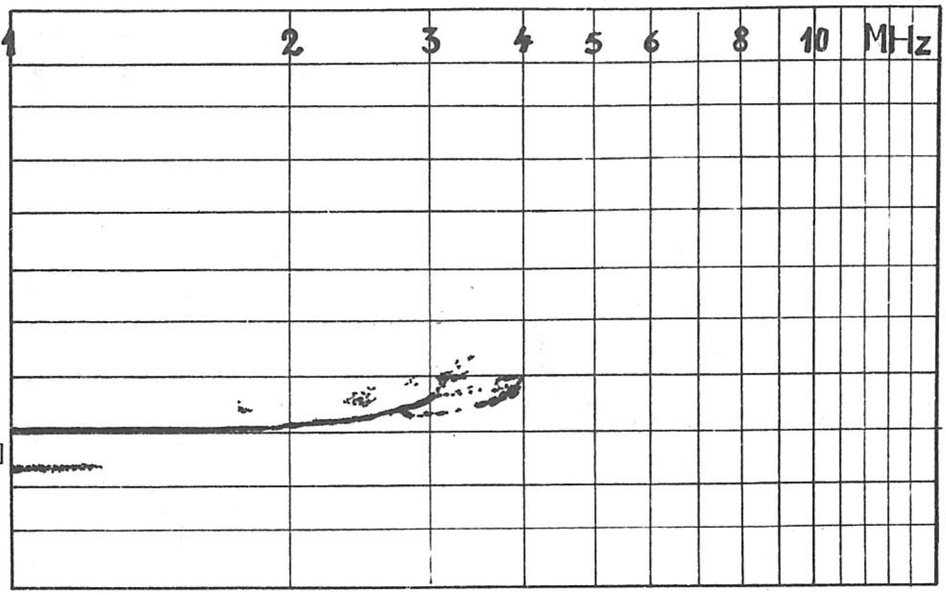


f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
E	017 UR	320	—	270	—	—
f_oE	$h'E$	f_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
—	—	E	E	E	—	0240B

Editor's Note: [10 May 1965, 1500 LT (60°W)] Misuse of U. This trace shows good retardation and cannot be extrapolated by more than 100 kHz in frequency. The trace width is less than 200 kHz. Hence foF2 does not need qualification or description and is accurate value, 017--, not 017UR. With foF2 near fB no x-mode trace is expected and fxI deduced from foI. fxI preferably 0240B.



$\overline{f_oF_2}$ $\overline{f_xF_2}$



BASE
GENERAL
BELGRANO

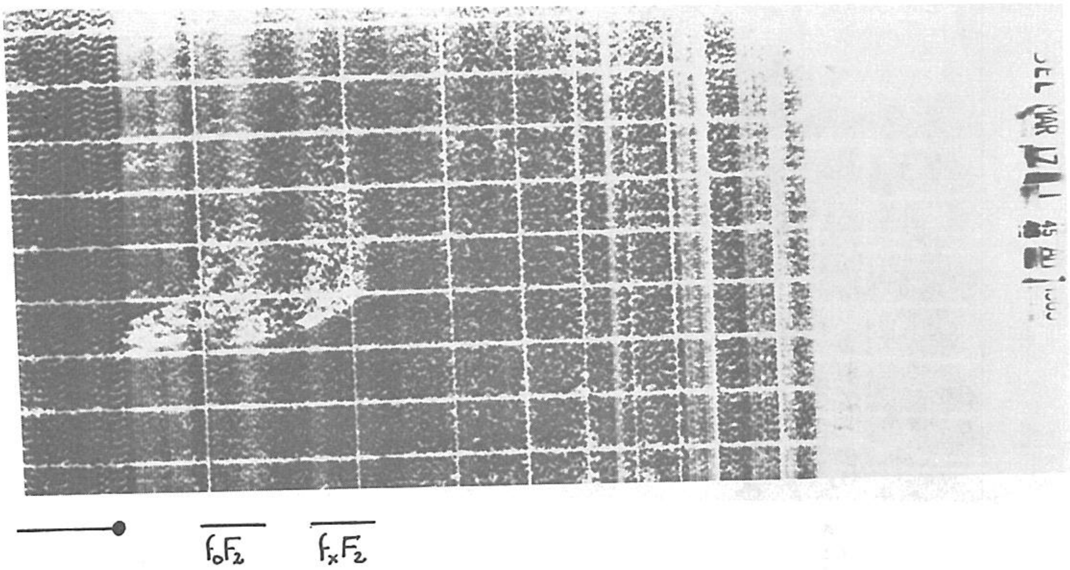
DATE: 9/5/1965
(9 May 1965)

TIME: 12.15 PM (L.T.)
[1215 LT (60°W)]

Fig. 10.11

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	034UR		–	200-Q	–	–
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
–	–	010EE	013	139	f1	040

Editor's Note: [9 May 1965, 1215 LT (60°W)] When the F2 trace is low, as here, the cusp is also relatively small. This trace could have been extrapolated to give foF2 = 034UR. The scatter is not sufficient to cause doubt - it is the weakness of the main trace. Range spread is present and could be shown using h'F = 200-Q. At high latitudes it is important to make foF2 a numerical value whenever the rules allow. As foEs is near fB, foEs = 013.

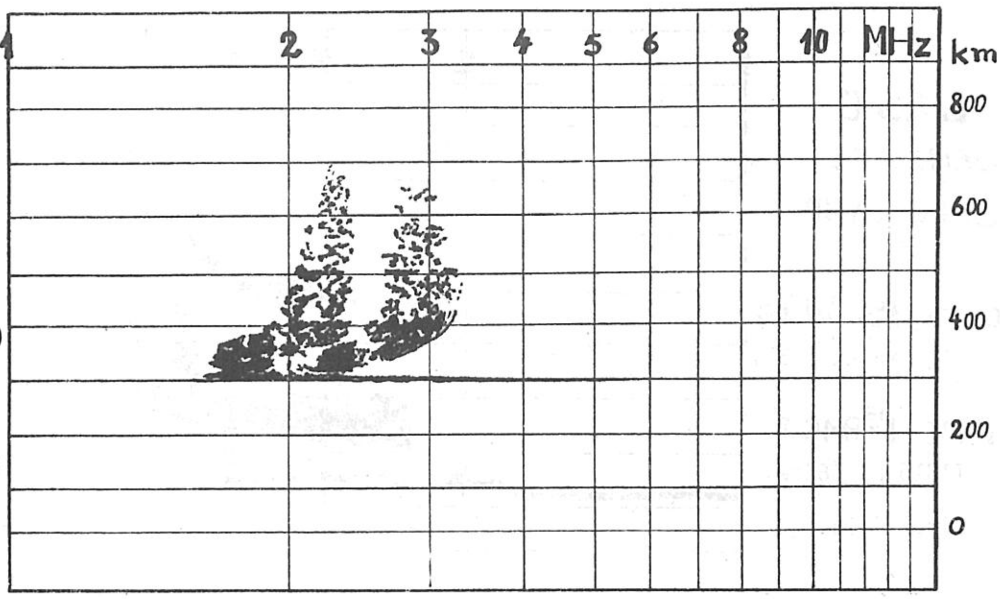


BASE
GENERAL
BELGRANO

DATE: 17/3/1965
(17 March 1965)

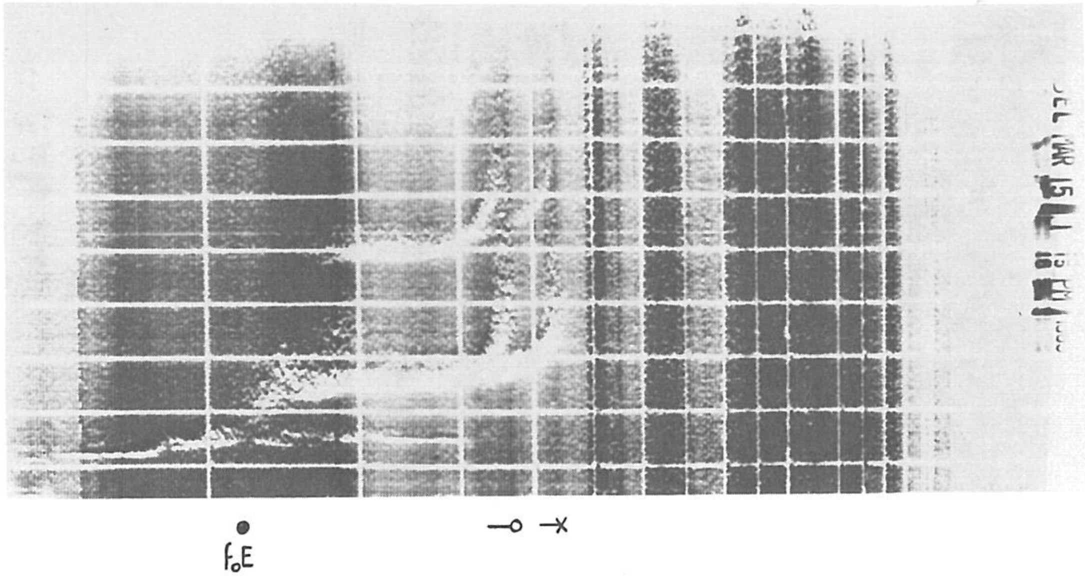
TIME: 1^{45} AM (L.T.)
[0145 LT (60°W)]

Fig. 10.12



f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
0,16	023-F	F	–	310	–	–
f_oE	$h'E$	f_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
–	–	016EB	016EB	B		032

Editor's Note: [17 March 1965, 0145 LT (60°W)] foF2 must be greater than 022 and less than 025. This is confirmed by x-mode trace which suggests nearer 022 than 025 (using fxF2 - fB/2). Hence, best value of foF2 is 023-F not F. 023UF is permissible. The second order trace shows that the layer is tilted.

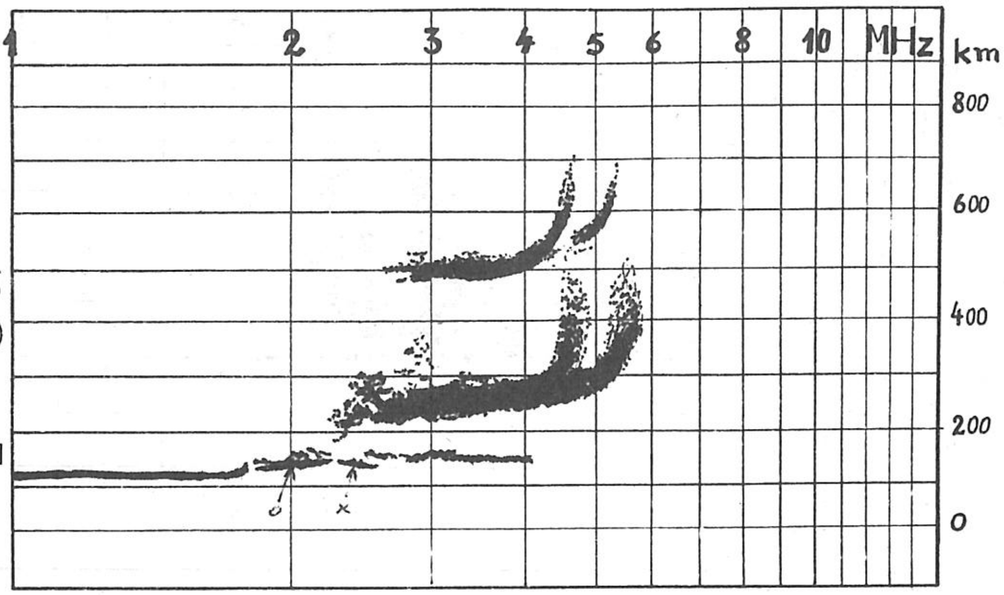


BASE
GENERAL
BELGRANO

DATE: 15/3/1965
(15 March 1965)

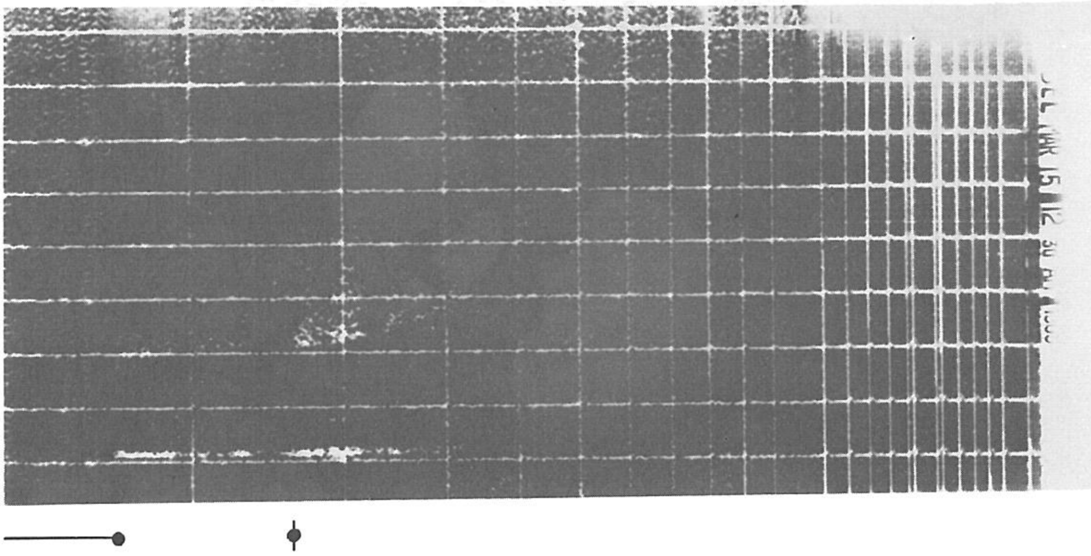
TIME: 1¹⁵PM (L.T)
[1315 LT (60°W)]

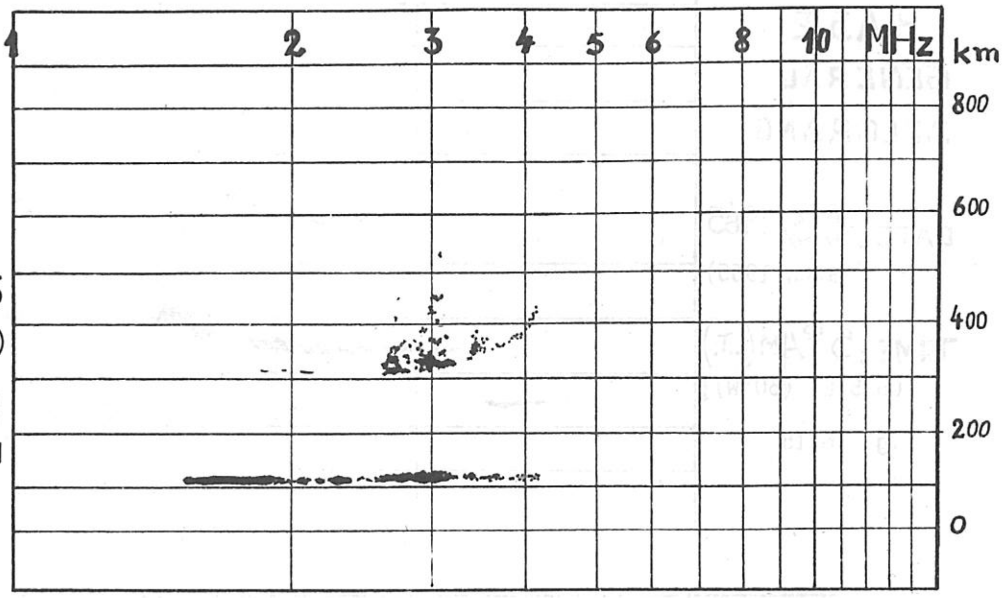
Fig. 10.13



fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	047-F	350-F	245	230-Q	L	L
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
170	121	025UF	033JA	151	h1c1	059

Editor's Note: [15 March 1965, 1315 LT (60°W)] Some range spread is present which could be indicated by h'F = 230-Q. The URSI rules state that foE is given by the lowest thick layer stratification in the E layer. In the absence of other information, e.g., from sequence, this should be 170. On an f-plot a doubtful E critical frequency is shown by a filled circle. The x trace of the weak cusp Es confirms foE probably near 170. There is no doubt that ftEs is an x-mode trace as it reaches to x trace on second order as well as first order F. foEs should be 033JA not 040-M.





BASE
GENERAL
BELGRANO

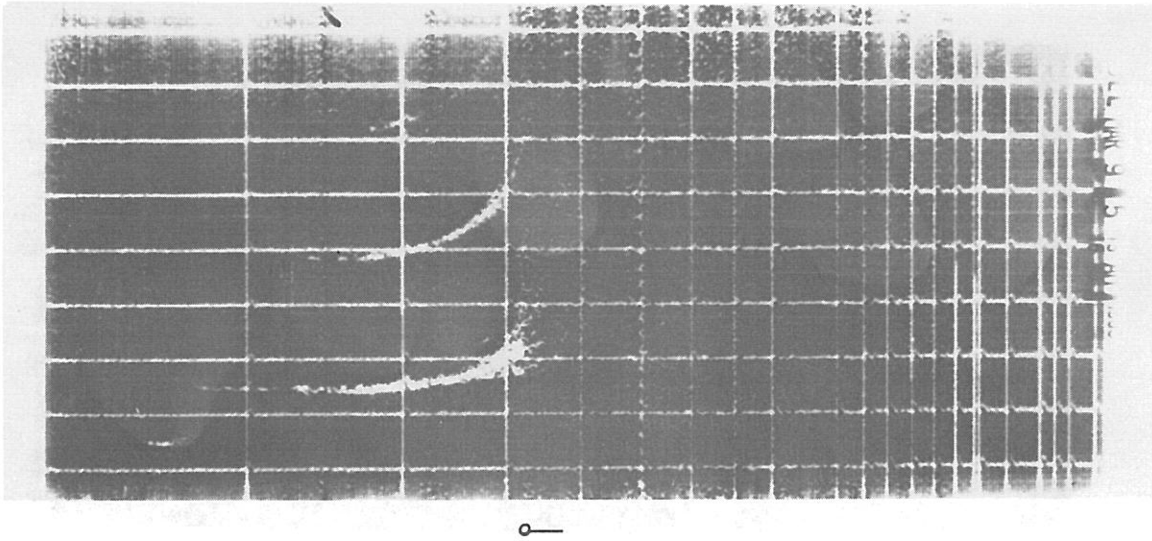
DATE: 15/3/1965
(15 March 1965)

TIME: 0³⁰AM(L.T.)
[0030 LT (60°W)]

Fig. 10.14

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,16	032UF	F	-	310	-	-
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
-	-	016EB	035JA	105	f1	042

Editor's Note: [15 March 1965, 0030 LT (60°W)] Weak trace probably not visible on reproduction shows h'F = 310. Similarly weak trace gives doubtful value of foF2 = 032UF. This is reasonably consistent with value at fxF2 - certainly within U limits. Top frequency of Es trace overlaps F-layer x trace so ftEs = fxEs. foEs = (fxEs - fB/2)JA = 035JA. fbEs value possible but I believe weak F trace present to fmin making fbEs (fmin)EB.

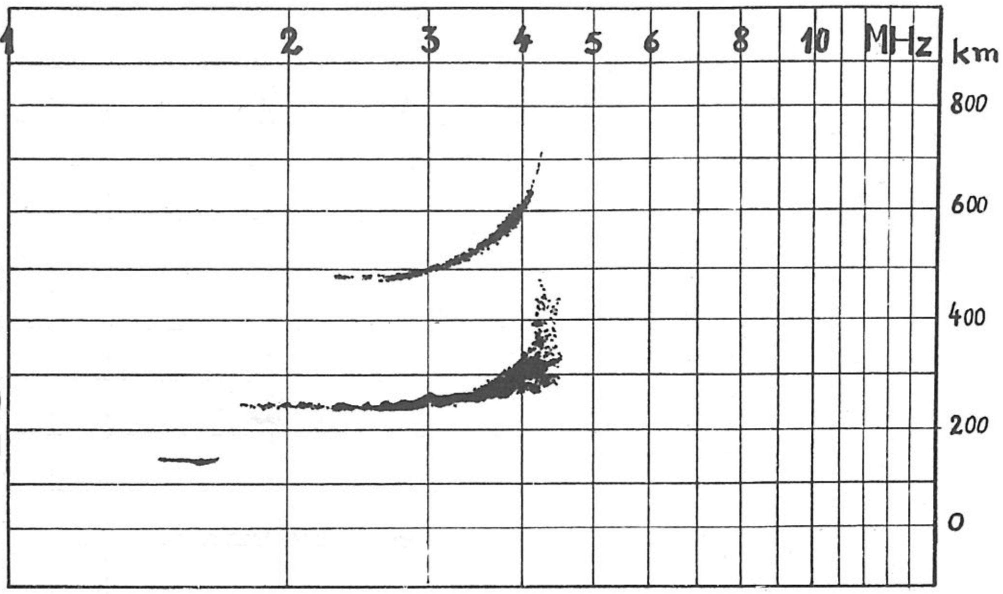


BASE
GENERAL
BELGRANO

DATE: 9/3/1965
(9 March 1965)

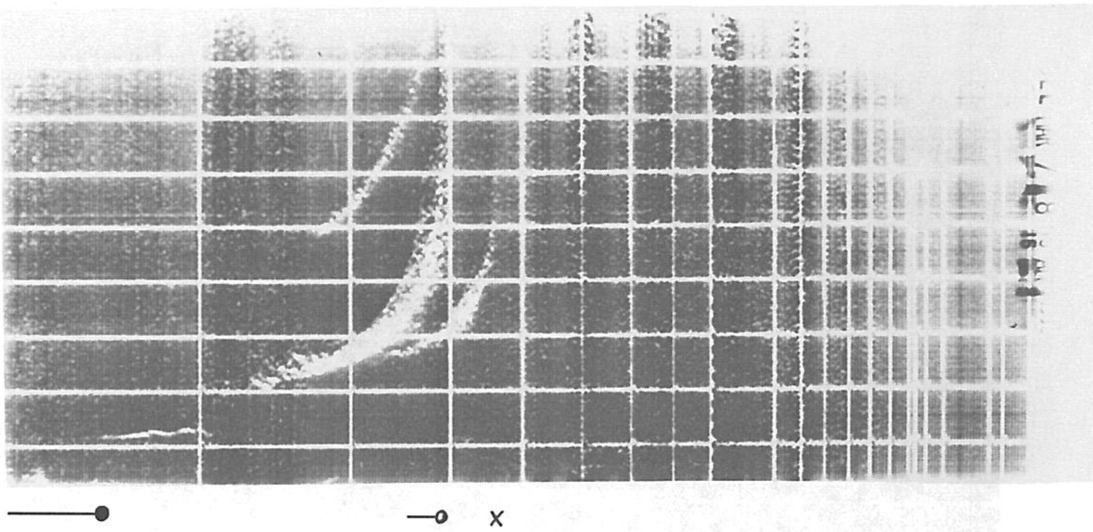
TIME: 5[15] AM (L.T.)
[0515 LT (60°W)]

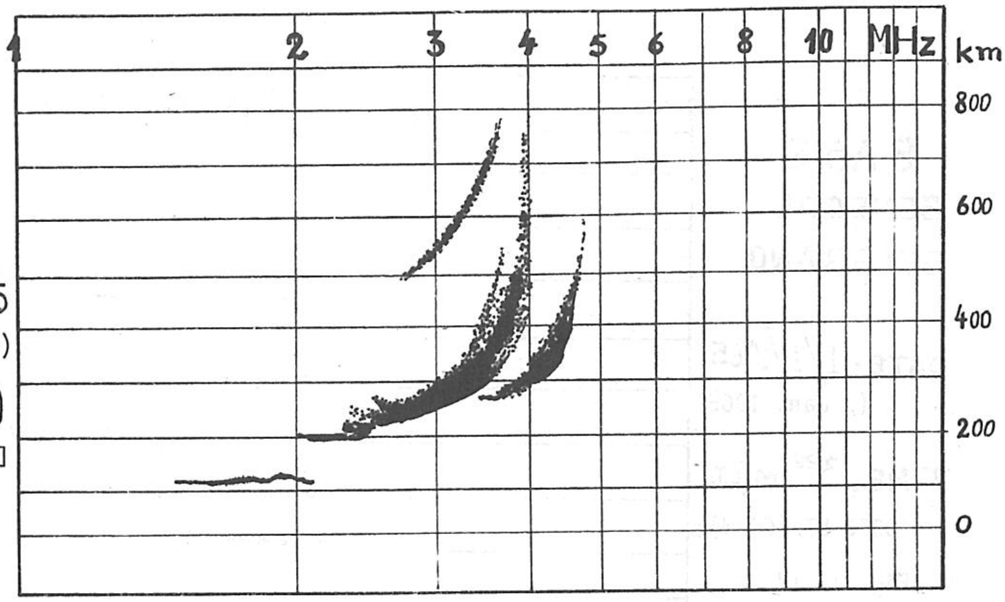
Fig. 10.15



f min	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,15	043DR	R		240		
foE	h'E	fbEs	foEs	h'Es	type Es	fxI
180	B	G	G	G		0520B

Editor's Note: [9 March 1965, 0515 LT (60°W)] This is a typical case of the scaler demanding too high a level of certainty and thus losing useful data. The second and third order traces show that tilt is not significant. The second order main trace gives foF2 between 043 and the extrapolated value of 045. foF2 is therefore 044-F not 043DR. The M(3000) fit should be attempted, deducing the main trace from half the height of the second order trace. M(3000) described by F. If range of factor is greater than ±010, U must be used. M(3000)UF is preferable even if range less than ±010 as structure of trace is abnormal, suggesting localized small-scale perturbation and x trace is missing.





BASE
GENERAL
BELGRANO

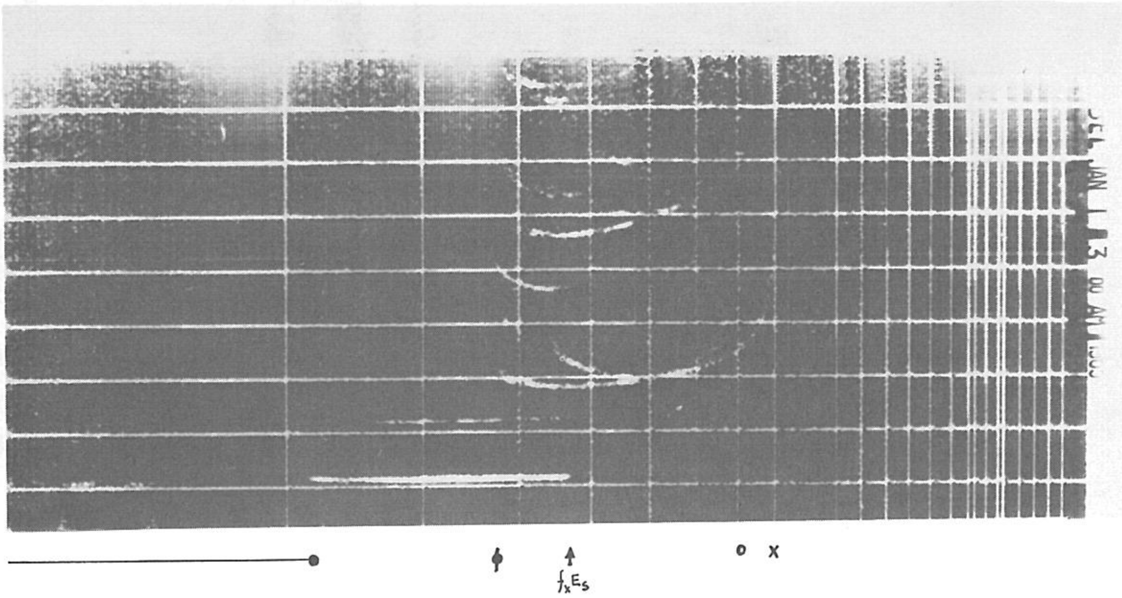
DATE: 7/3/1965
(7 March 1965)

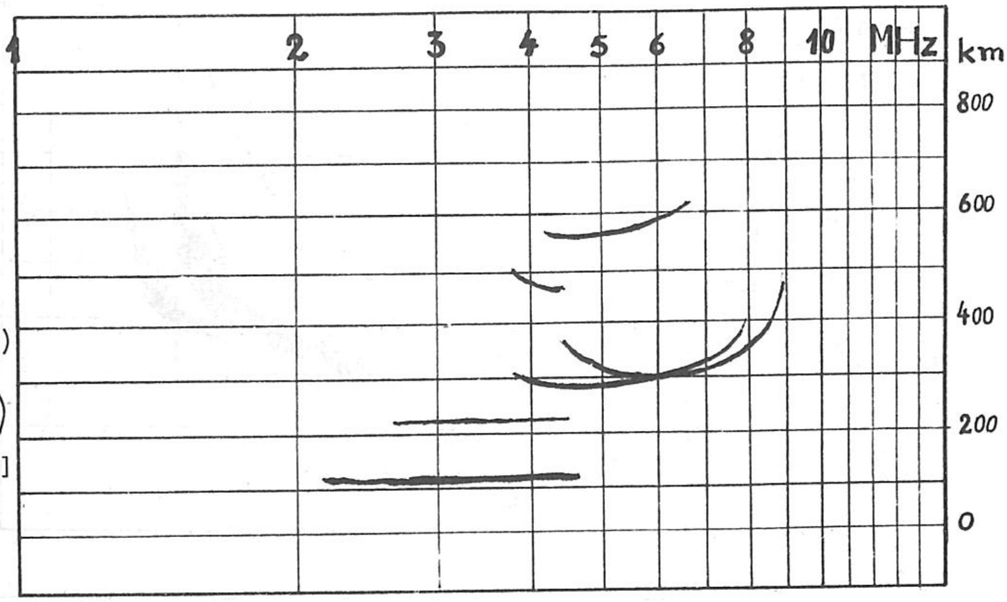
TIME: 8 15 AM (L.T.)
[0815 LT (60°W)]

Fig. 10.16

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,15	0,39-F	290-F		210		
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
220UR	119	G	G	G		046-X

Editor's Note: [7 March 1965, 0815 LT (60°W)] Use of X on fxI. The first order trace shows frequency spread mainly below foF2 but with some on the high frequency side of the main trace. The x trace is clearly more absorbed than the o-trace, e.g., second order is completely missing. In such cases X is misleading although allowed by accuracy rules. Best value fxI = (foF2 + fB/2)OB = 0460B. Looking closely at trace, fxI = 0470B would also be acceptable. This is an unusual case. Frequency spread most often extends above foF2, in which case fxI = (foI + fB/2)OB. The E trace is very difficult. The lowest certain F-layer retardation is at 240 and foE appears to be above 200 (the small ledges below this can be ignored). Best value foE = 220UR showing possible range of 040-- an exact description of ionogram.





BASE GENERAL BELGRANO

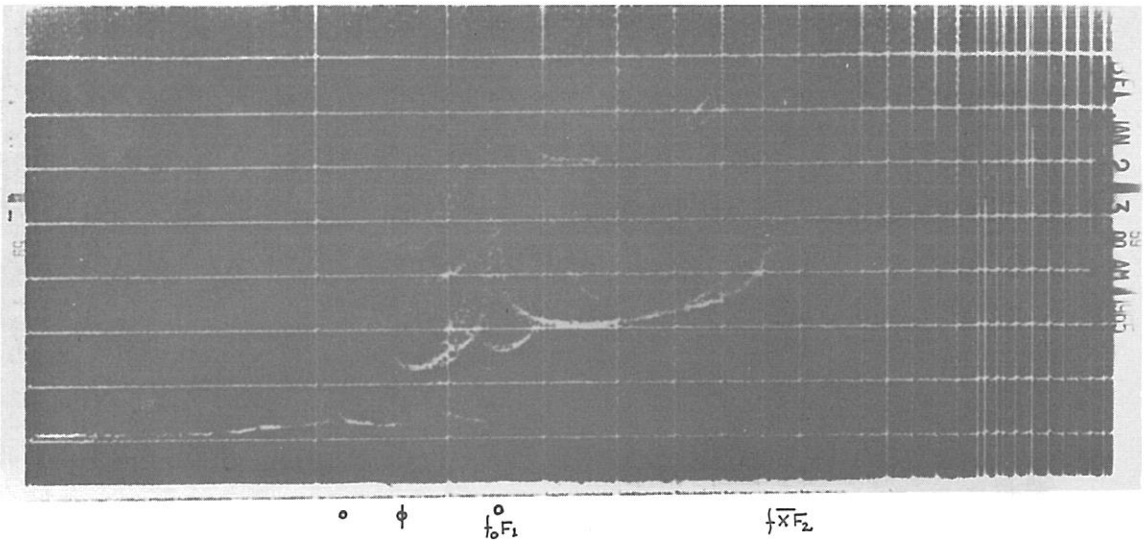
DATE: 1/I/1965
(1 Jan. 1965)

TIME: 3⁰⁰ AM (L.T.)
[0300 LT (60°W)]

Fig. 10.17

fmin	f_oF_2	M3000F_2	$h'F_2$	h'F	f_oF_1	M3000F_1
022-R	080		280	A	A	A
f_oE	h'E	f_bE_s	f_oE_s	$h'E_s$	type E_s	fxI
220EB	B	038	040JA	105	C-2	090-X

Editor's Note: [1 Jan. 1965, 0300 LT (60°W)] The next record on 2 Jan. 1965, 0300 LT (60°W), shows that fmin is close to foE. fmin should be described by R. fmin = 022-R (2.2 MHz) and E parameters are B. There is just sufficient retardation at fmin to make foE = 200UB permissible. This is a case where foE = 220EB is better than B. The 020 value was obtained by extrapolation from fmin.

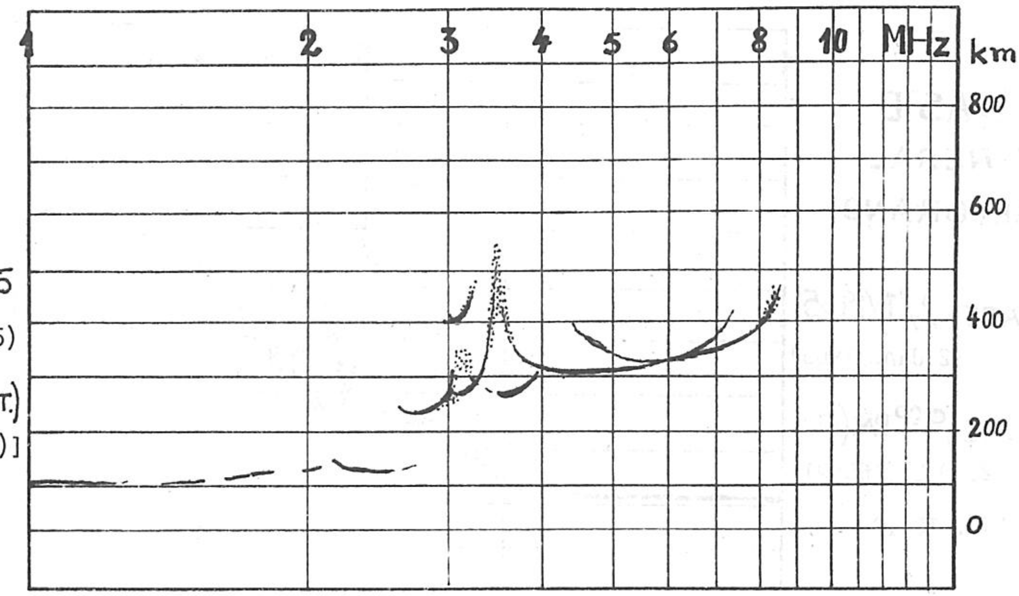


BASE GENERAL BELGRANO

DATE: 2/I/1965
(2 Jan. 1965)

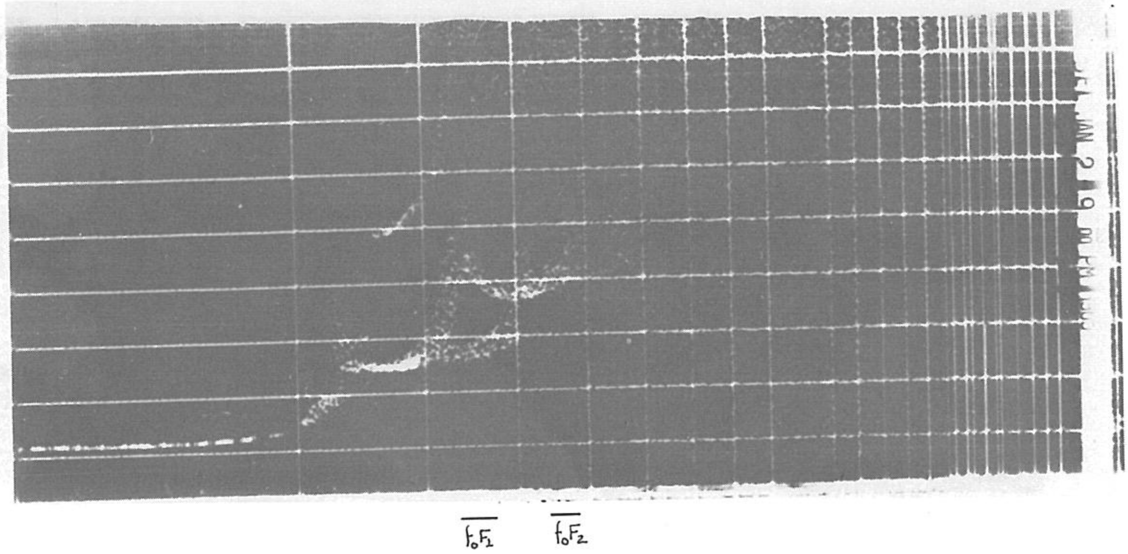
TIME: 3^00 AM (L.T.)
[0300 LT (60°W)]

Fig. 10.18



fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	076JR	290	300	230	350	350

foE	h'E	fbEs	foEs	h'Es	type Es	fxI
250EA	109	0,25	027	125	h1	0,82

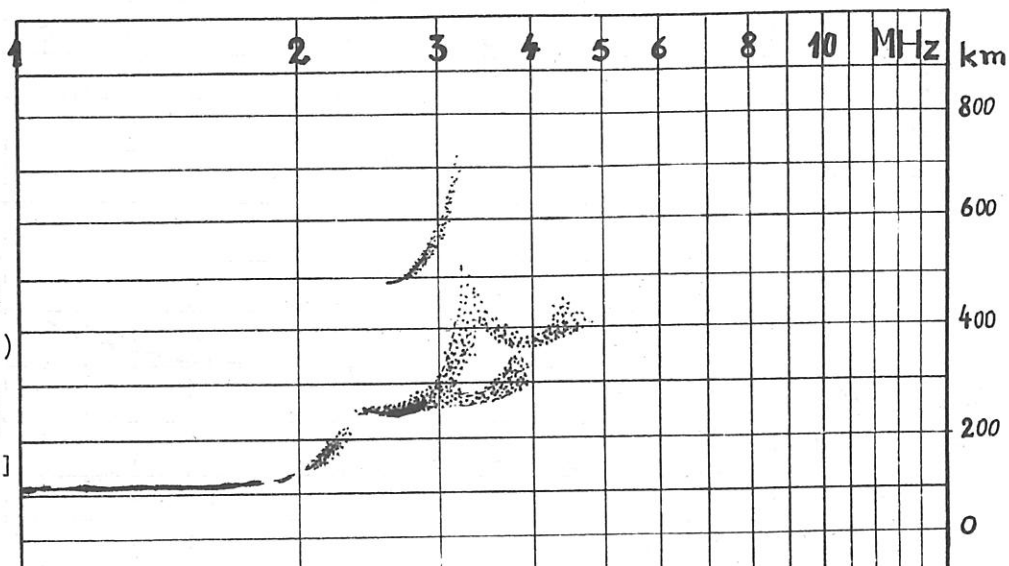


BASE GENERAL BELGRANO

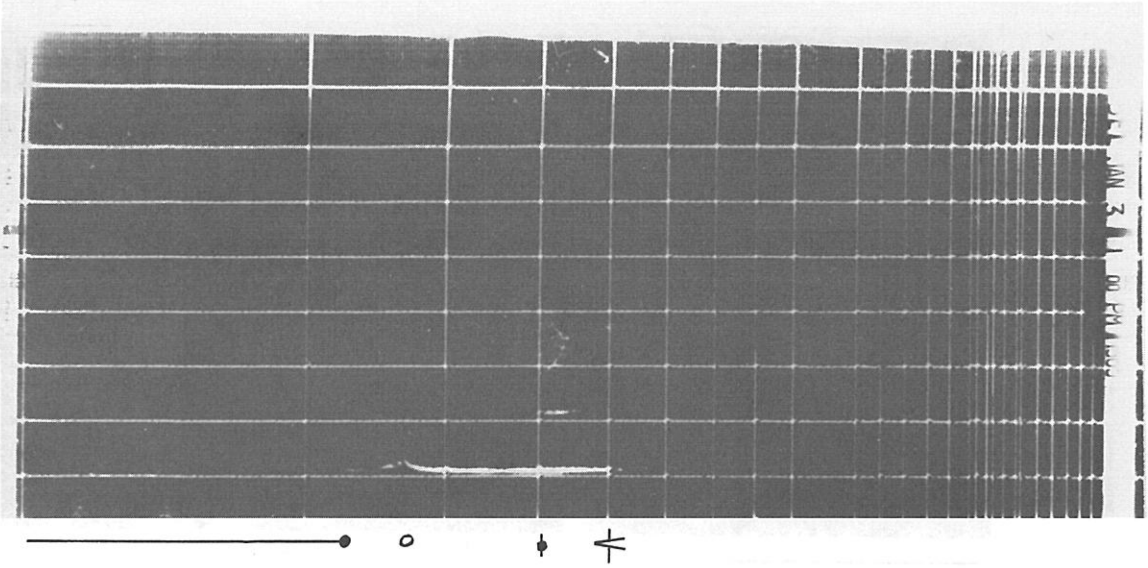
DATE: 2/I/1965
(2 Jan. 1965)

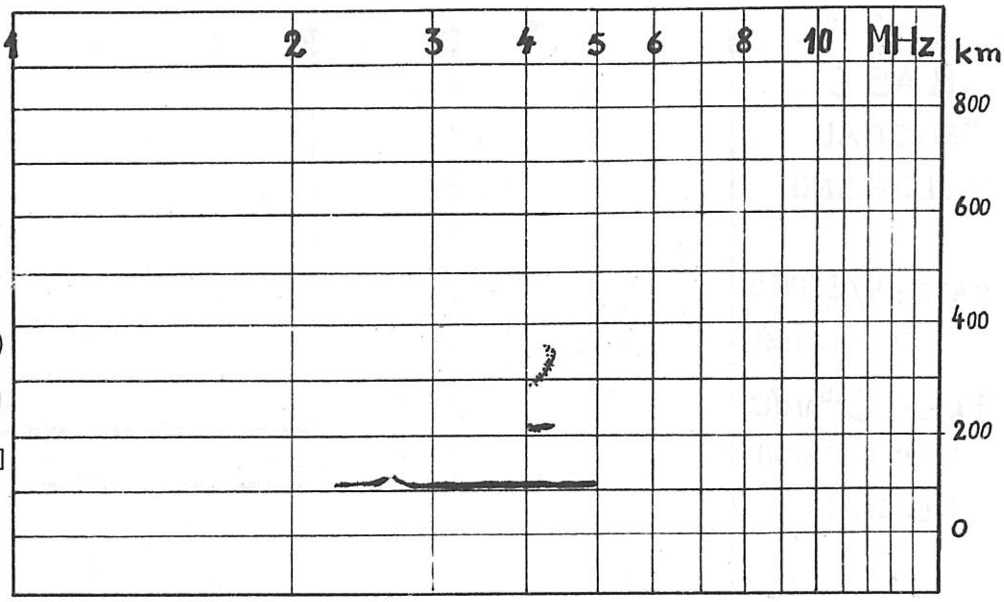
TIME: 9^00 PM (L.T.)
[2100 LT (60°W)]

Fig. 10.19



f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
E	048UF	F	370	245	330-F	350-F
f_oE	$h'E$	f_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
210UF	121	G	G	G		0550R





BASE
GENERAL
BELGRANO

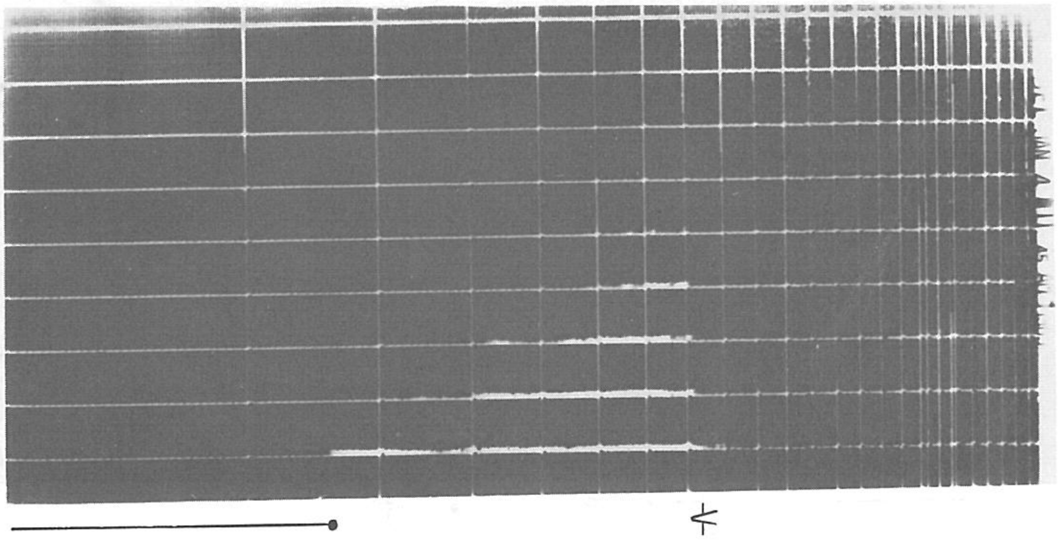
DATE: 3/I/1965
(3 Jan. 1965)

TIME: 1^{00} PM (L.T.)
[1300 LT (60°W)]

Fig. 10.20

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,22	A	A	A	A	A	A
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
270	109EB	0,40	043JA	105	C2	043

Editor's Note: [3 Jan. 1965, 1300 LT (60°W)] This is a typical cusp Es ionogram with foE = 270. h'Es less than h'E implies some doubt of the value of h'E, 109UB or 109EB would be logically preferable. Recording foEs on f-plot is permitted but not general practice.

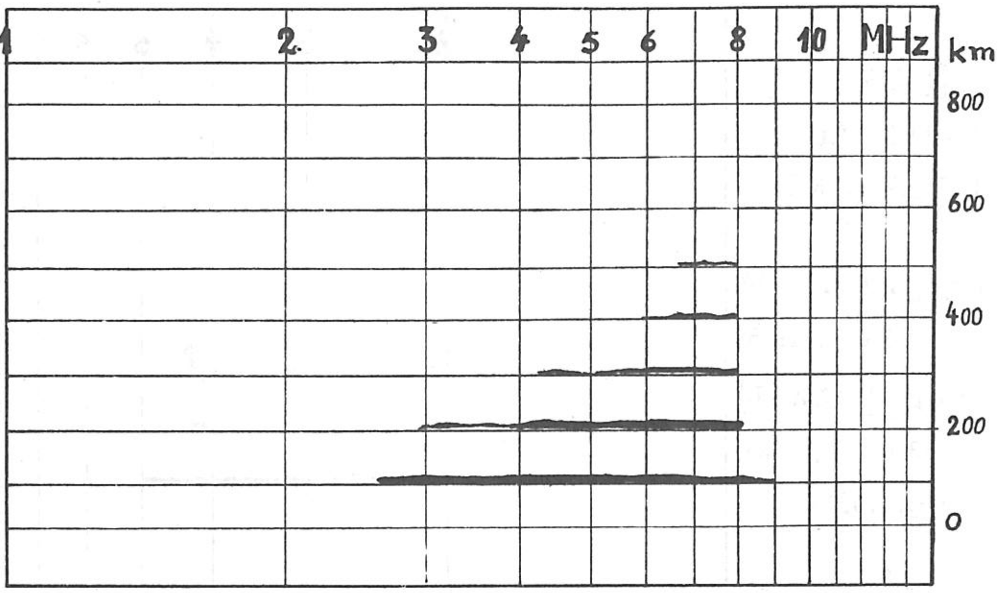


BASE
GENERAL
BELGRANO

DATE: 4/I/1965
(4 Jan. 1965)

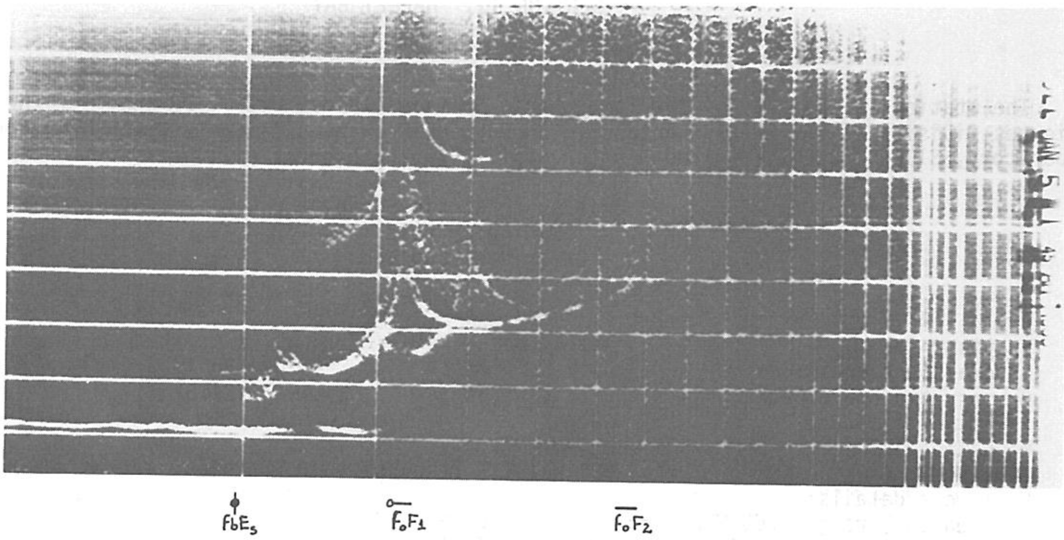
TIME: 11^45 AM (LT.)
[1145 LT (60°W)]

Fig. 10.21



f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
0,26	A	A	A	A	A	A
f_oE	$h'E$	f_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
A	A	080AA	084JA	101	l-5	A

Editor's Note: [4 Jan. 1965, 1145 LT (60°W)] fbEs can be deduced from the multiple orders and should be evaluated fbEs = 080AA. The ionogram has more than enough evidence to give foEs directly. With fmin = 026 and ftEs ≤090, ftEs must be at x trace. A change in trace thickness can be seen at (ftEs-fB/2) confirming this deduction. foEs = 084-A - the doubt in foEs is not sufficient to demand U.

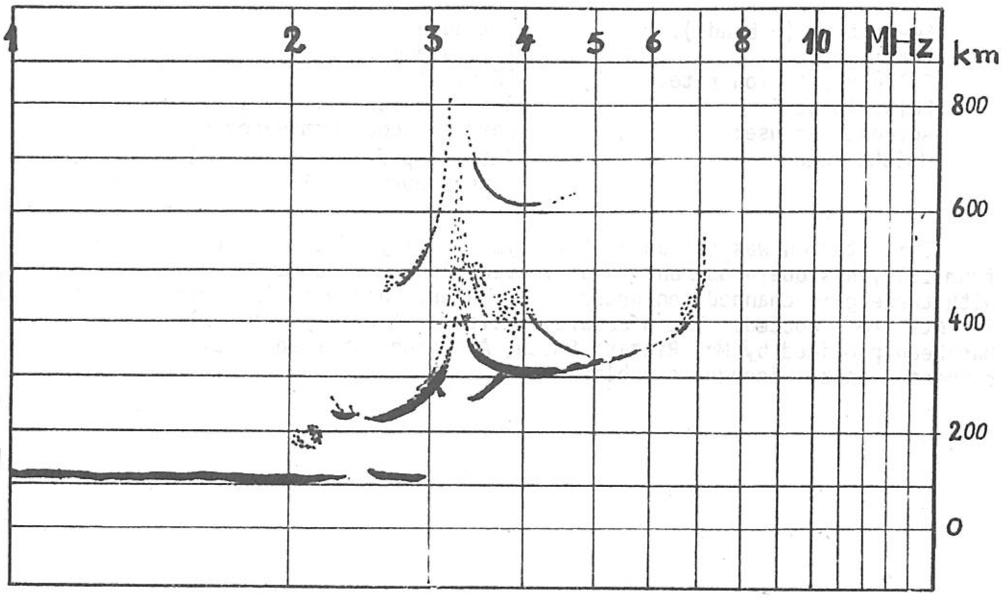


BASE
GENERAL
BELGRANO

DATE: 5/I/1965
(5 Jan. 1965)

TIME: 1[45] AM (L.T)
[0145 LT (60°W)]

Fig. 10.22



fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	0,70 UR	R	305	220	330-H	340-H
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
200EA	109	0,20	024	105	C1	0760R

Editor's Note: [5 Jan. 1965, 0145 LT (60°W)] Tilted layer. The presence of several traces near foF1 and difference in shape of foF1 and fxF1 cusps make(foF1)-H better than (foF1)-F.

The foE interpretation demands knowledge of probable foE and h'E values as this is a late night ionogram in summer. The value given is just acceptable but foE = 200EA would be better.

SECTION 11. HALLEY BAY

The station is operated by the Ionospheric Section (leader Dr. J. Dudeney) of the Atmospheric Sciences Division at the British Antarctic Survey, NERC. The data are published by the SRC, Appleton Laboratory, Slough, Bucks, England. After April 1976 the address will be:

British Antarctic Survey
Madingley Road
Cambridge, England

Station name:	Halley Bay	
Geographic coordinates:	Lat. S 75°31'	E Long. 333°18'
Geomagnetic coordinates:	Lat. S 65.8°	E Long 24.3°
Invariant latitude	60.88°	
Magnetic dip:	65°	
Time used:	30° W (UT - 2 hours)	

Equipment details:

Frequency range 0.65 MHz - 25 MHz in five bands

Band 1	0.65 - 1.4 MHz	0-1 minutes after start
Band 2	1.4 - 3.1 MHz	1-2 minutes after start
Band 3	3.1 - 6.9 MHz	2-3 minutes after start
Band 4	6.9 - 15.4 MHz	3-4 minutes after start
Band 5	15.4 - 25 MHz	4-5 minutes after start

Sweep time (5 bands):	5 minutes
Peak power:	1 kW approx.
Pulse repetition rate:	50 p.p.s.
Pulse length:	80 μs to 330 μs, normally 200 μs
Antennas in use:	Large folded terminated dipoles
Height range:	1000 km plus 300 km at half hour sounding when normal E layer is visible.

This station was set up by the Royal Society of London at the beginning of the IGY and, apart from 1959, has operated continuously ever since. Ionograms are produced at quarter hourly intervals with three gain changed ionograms at the hour. Analysis is strictly according to INAG rules, f plots are produced. The data are available at yearly intervals. This selection of ionograms has been provided by Mr. Richard Smith, Appleton Laboratory, Slough, Bucks, England, who has also commented on all ionograms published.

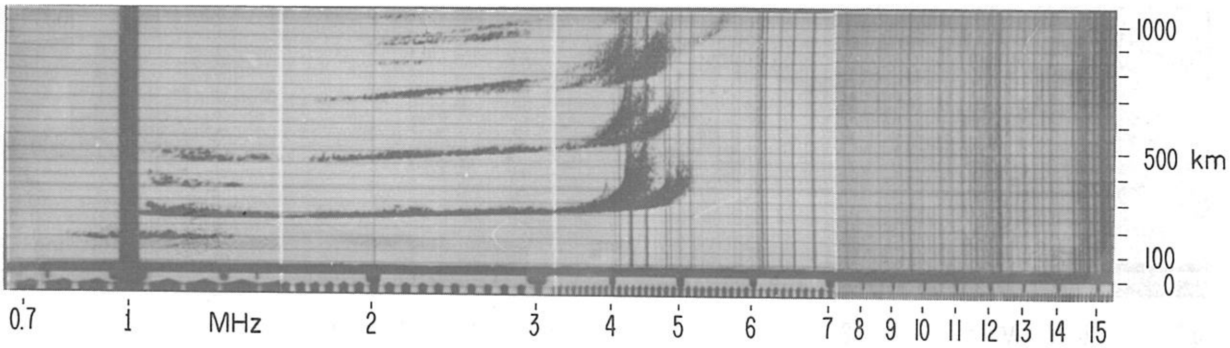


Fig. 11.1

HALLEY BAY

1972 July 7

11.45 LT (30°W)

Winter day

fmin = 008
foEs = 012   h'Es = 145
foF2 = 045-V

Note multiples show presence of TID near hmF2 with foF2 varying between 040 and 050. TID moving in magnetic meridian. The E+F trace shows that the flat Es is seen at oblique incidence - its vertical height is near 100 km.

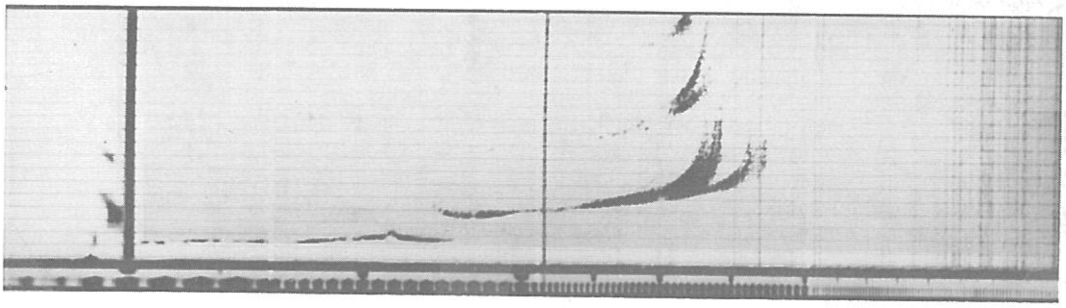


Fig. 11.2

Equinox day

1972 Sept. 26

08.45 LT (30°W)

Cusp Es blanketing on E2 layer. foEs = 026. fbEs = 024. foF1 = L. Second order and x trace both show foF2 = 056-F is overhead condition. foE = 220-A.

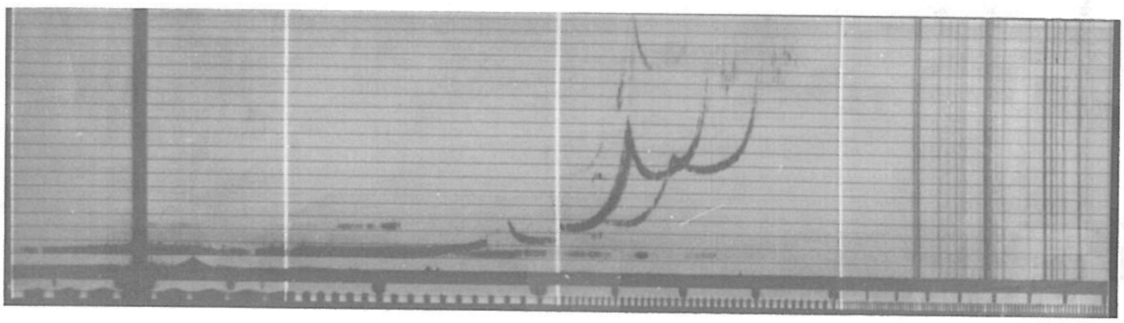


Fig. 11.3

Summer day

1972 Jan. 4

08.15 LT (30°W)

foF2 = 054. Faint forks with foF2 = 057 clearly oblique, foEs = fbEs = 031, Es-h, Es-ℓ.

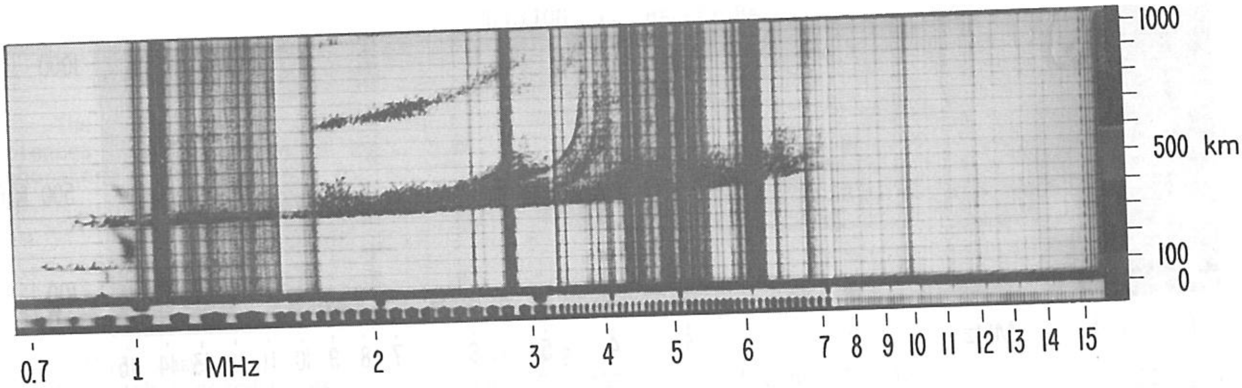


Fig. 11.4

POLAR SPUR - HALLEY BAY 1972 Sept. 26 03.15 LT (30°W)

The second order trace suggests foF2 = 031UR. The x-traces give foF2 = 031JR and 029JR, the former being more nearly overhead. (weak second trace which has not reproduced). Note x traces can be used to give shape of extrapolation to foF2 with certainty as allowed by accuracy rules. Best value foF2 = 031-F, fxI = 069.

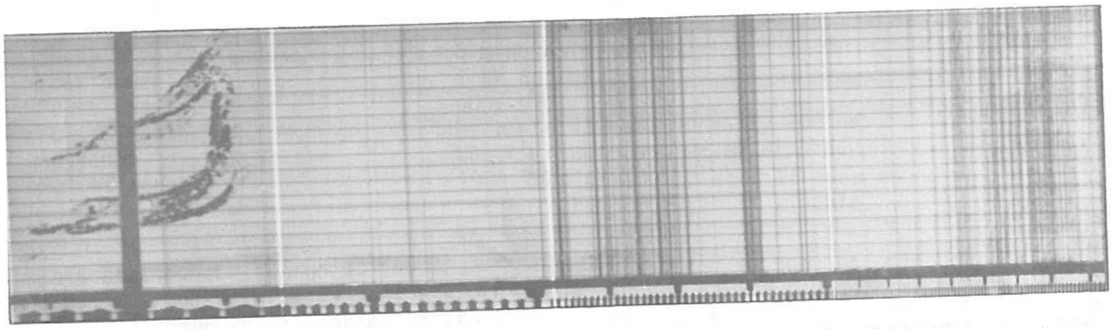


Fig. 11.5

HALLEY BAY 1972 July 6 20.15 LT (30°W)

Range spread due to layer tilt. There are considerable changes in h' with position but little change in foF2. Probably due to TID, not to field-aligned irregularities. This is confirmed by second order traces.

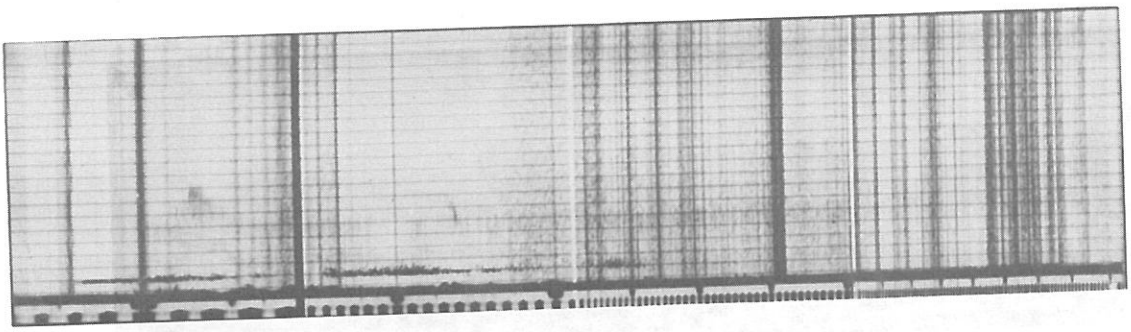
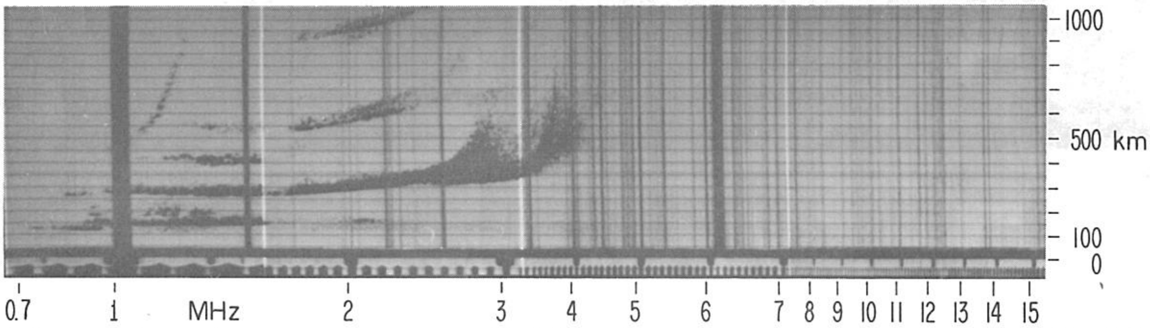


Fig. 11.6

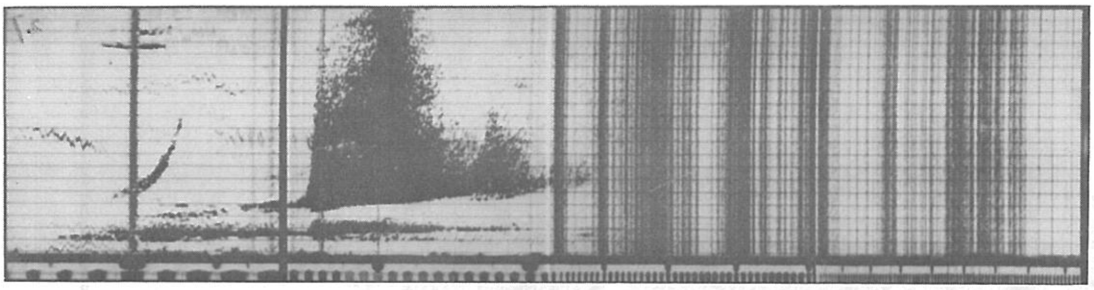
HALLEY BAY - Es-d 1973 July 28 21.30 LT (30°W)

All parameters B. Very high absorption.

Gyro (infinity mode) traces. These are rare and sequence normally shows that they cannot be a trough region foF2 trace.

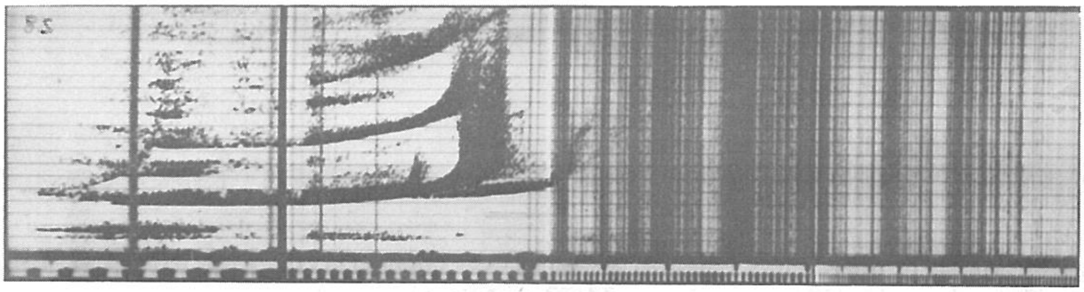


foF2 = 029-F Es-f 1973 July 7 10.15 LT (30°W)



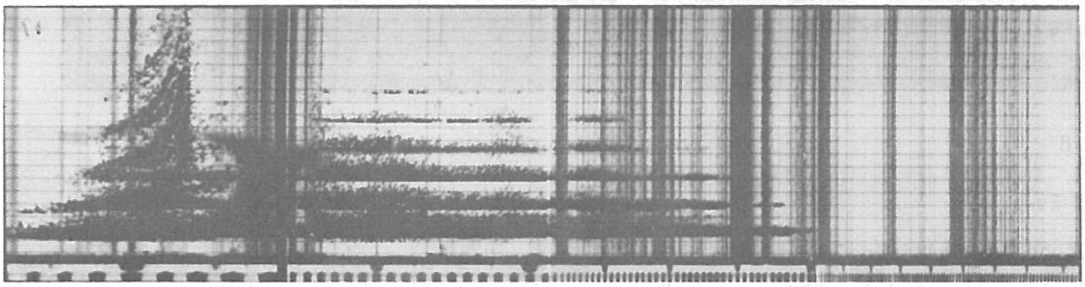
foF2 = 021-F Es-a 1973 July 23 14.45 LT (30°W)

(Note cutoff in spread 014 to 015 due to incorrect adjustment of ionosonde - C). fxI = 038 Spread F classifications P,F.



foF2 = 027-F. 1973 July 28 16.15 LT (30°W)

(weak z-mode trace also present)



1973 July 22 18.15 LT (30°W)

Multiple gyro traces from Es-f (extremely rare). Es-a also present. foEs = 063JA, fbEs = 060AA.

Note this is an unusual case with multiples showing spread.

Fig. 11.7

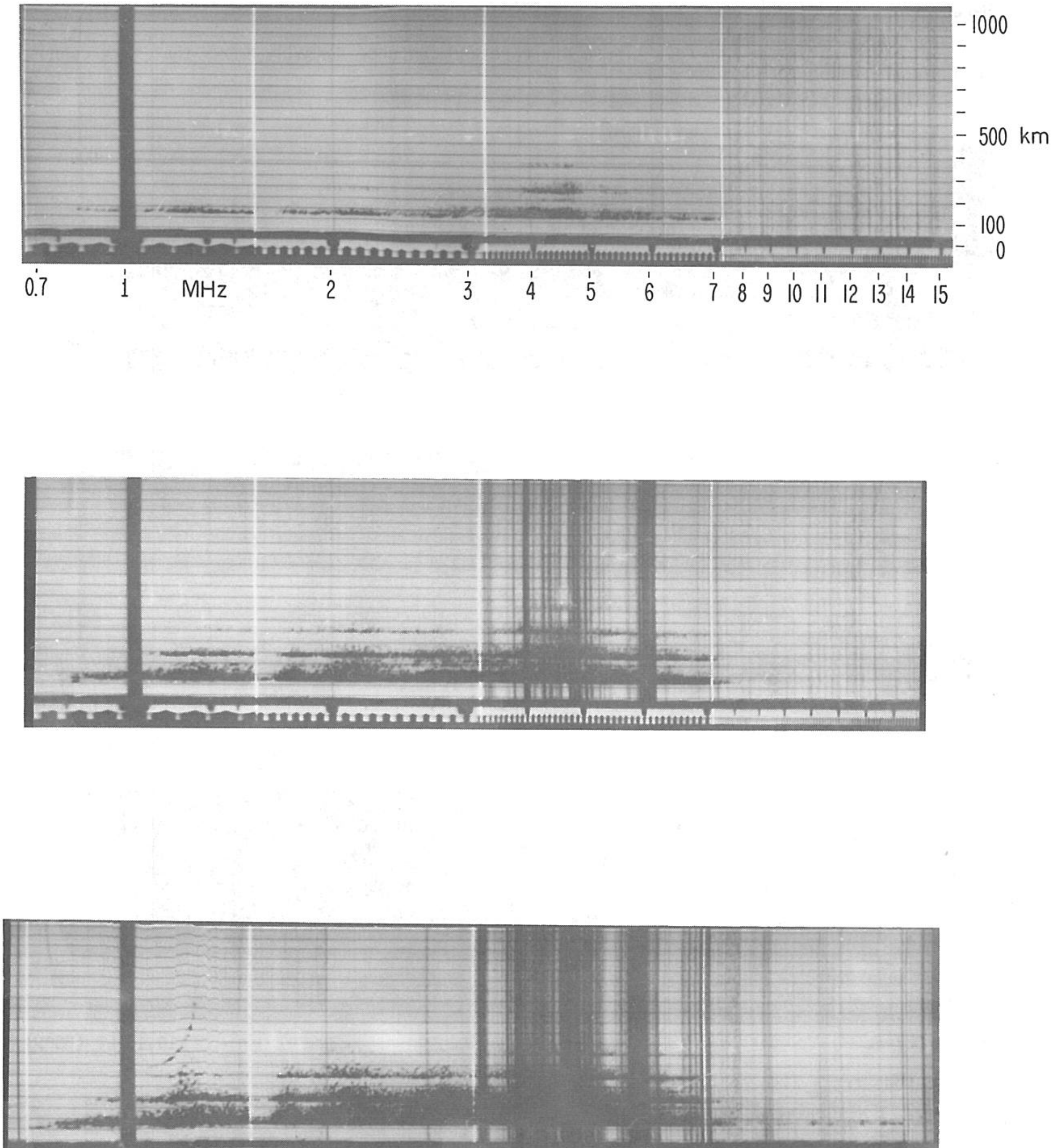


Fig. 11.8

Es-f and Es-a 1972 July 3 17.00 LT (30°W)

Presence of multiples shows main trace is Es-f. High gain also shows gyro trace. This is not foF2 as multiples give fbEs = 070AA and show fbEs is really close to this value. Scatter at 012 in Es trace due to same phenomenon. Es type f3, a.

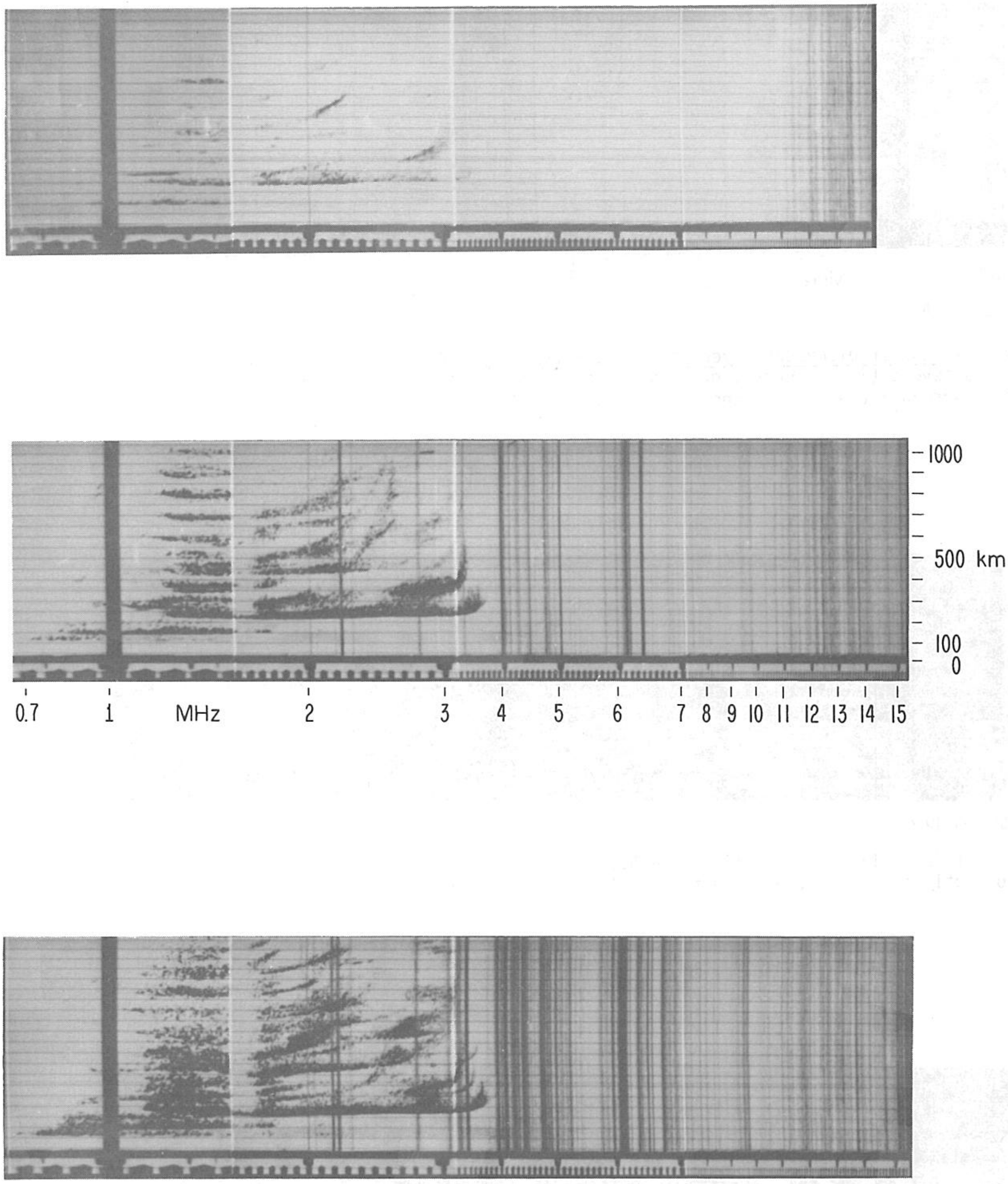
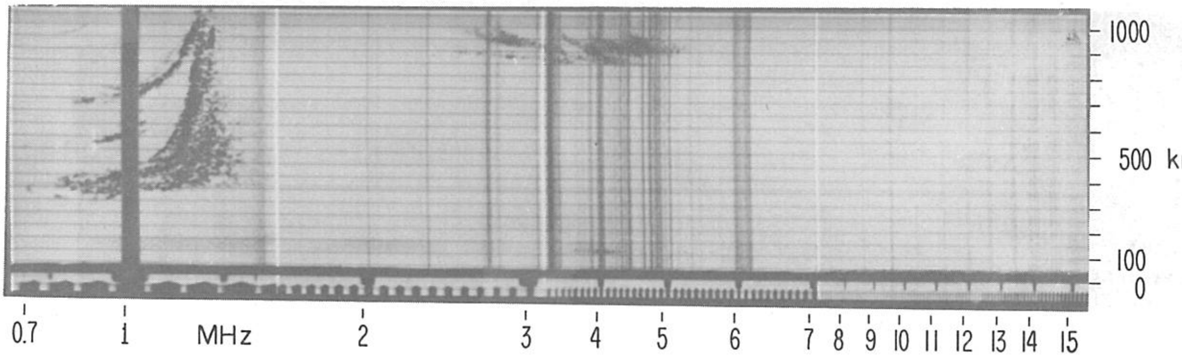


Fig. 11.9

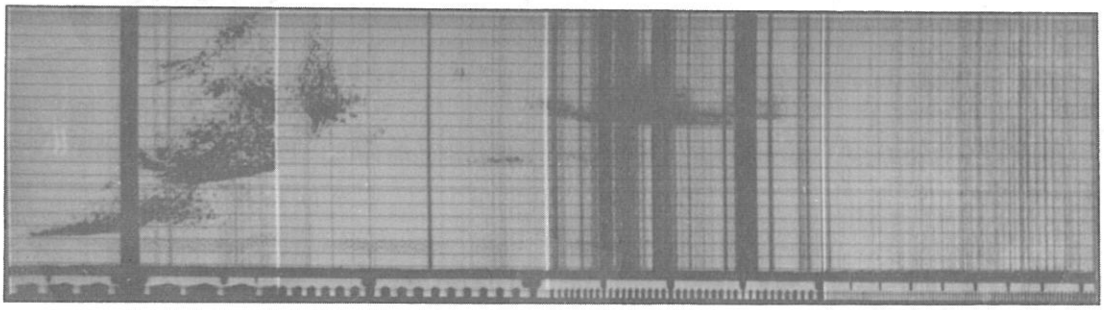
Gain sequence 1972 July 3 10.00 LT (30°W)

Considerable tilt in meridian (N-S) but foF2 only changing between 026 and 029. Upper value most nearly overhead, best interpretation foF2 = 029UY (Y denoting severe tilt). 029UH equally acceptable. Low gain shows Es-f present with fbEs = 011.



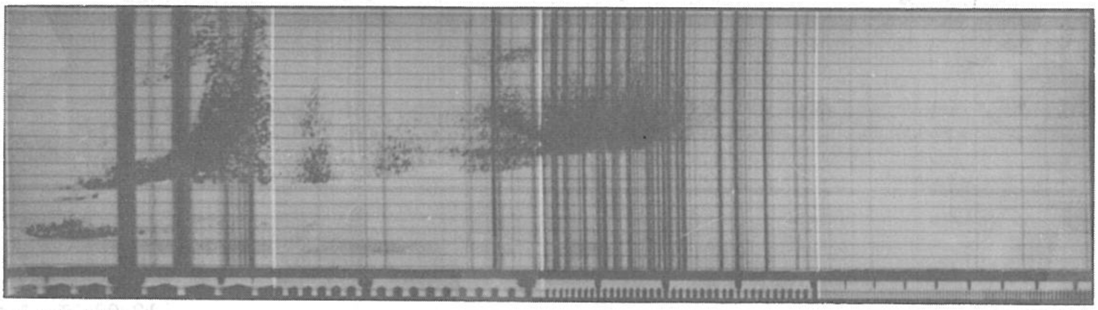
HALLEY BAY 1972 July 2 20.15 LT (30°W)

<u>Trough (Replacement Layer) sequence Halley Bay.</u> foF2 = 012-F. Note second order trace shows severe tilt. Inner edge shape distorted by this M(3000) can be measured -Y. fxI = 050, spread F classifications P, F, Q, h'I = 850, h'F = 325UQ.



HALLEY BAY 1972 July 2 21.15 LT (30°W)

foF2 = 013UF fxI = 064 h'I = 600. (gap in trace at beginning of band 2 instrumental - not correctly set up). Es-r with foEs = 011-A; fbEs = 010-K; types r, k, a. h'F = 365UQ.



HALLEY BAY 1972 July 3 03.45 LT (30°W)

foF2 = 013, h'F = 300, h'I = 325, Es-r, k, foEs = 010, fbEs = 008UK, foE = 085UK.

Fig. 11.10

SECTION 12. SLANT E CONDITION (SEC); AURORAL OVAL IDENTIFICATION

The material reproduced in this Section has been provided by Mr. J. K. Olesen who first described the plasma instability phenomenon in the ionosphere and gave it the name Slant E Condition (SEC) (The Editor has added some additional information). When this condition is present, the ionograms show Lacuna and slant Es traces. When the SEC is not overhead, a typical slant Es trace (Es-s) reveals its presence near the station. When overhead, Lacuna (or partial Lacuna where weak diffuse traces are still visible) is found. Typically, the Es-s is also present but this may be weakened by absorption so that it cannot be observed. Careful use of the conventions, letter Y, enable the ionogram to be described with sufficient accuracy for detailed scientific studies of the phenomenon:

s in the Es-type table shows the presence or absence of the Es-s.

Weak Lacuna where weak diffuse traces are still present is indicated in the parameter tables by ---UY (e.g., h'F, foF1 and, when more extreme in height, some or all of foE, h'F2, foF2).

Strong Lacuna by replacement letter Y for the parameters affected.

Note: Partial Lacuna is more common than full Lacuna (all F parameters replaced by Y). Hence, if the SEC starts and ends in conditions where the F layer cannot be seen (G condition), it is preferable to use G for foF2 and h'F2 rather than Y. However the distinction is not very important as the user can deduce what is happening from the tabulated data or f plot.

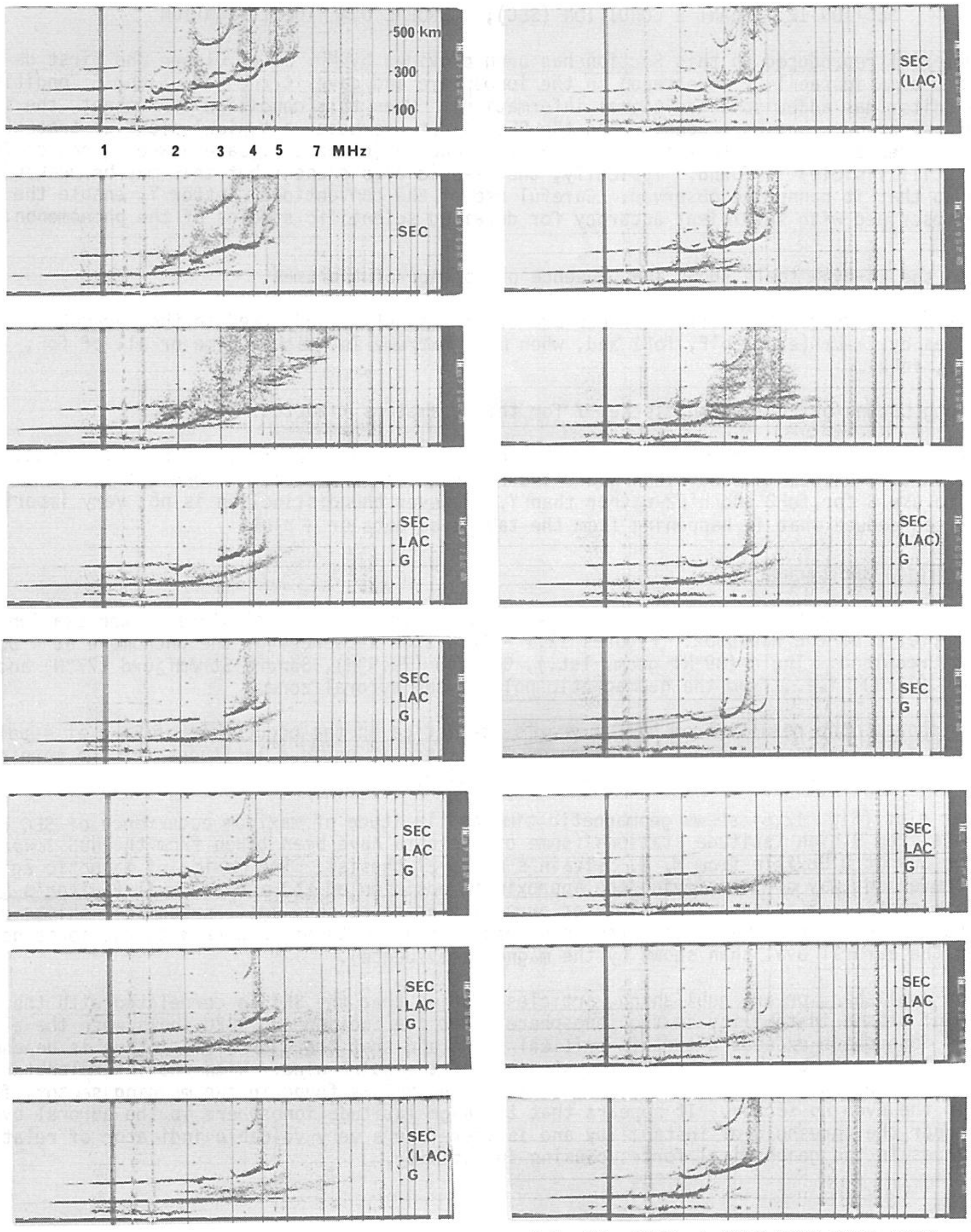
Slant E Condition and Lacuna

I hope that this material will help clarify the SEC phenomena. Particulars of the stations are given in Chapter 2 of the Handbook. Figures 12.1 - 12.4 show sequences of the phenomena at 4 polar stations in Greenland: Thule (89°N. geom. lat.), Godhavn (79.9°N), Søndre Strømfjord (77°N) and Narssarssuaq (71°N), i.e., from the geomagnetic pole to the auroral zone.

Figure 12.5 shows: the results from half a year's statistics on the occurrence of Es-s at 4 polar stations. It illustrates the annual variation of occurrence at various latitudes for the morning, noon and afternoon cases of SEC (and the diurnal variation).

A polar plot (Fig. 12.6) shows geomagnetic time and latitude of maximum occurrence of SEC based on statistics from 9 high latitude stations (some of the data have been taken from the NBS *Ionospheric Data* and for Dumont D'Urville from M. M. Sylvain's doctoral thesis). The maxima of magnetic agitation is a convenient way of identifying the approximate position of the auroral oval (Editor's Note: In general, magnetic agitation and particle or auroral statistics show small systematic shifts relative to each other. The shift shown in the afternoon sector agrees with other work with the ionospheric data nearer the auroral oval than shown by the magnetic evidence).

We have published, or are publishing, articles showing that the SEC is correlated with the two-stream type of plasma instability in the ionosphere, that the incidence of SEC shows when the electric field in the ionosphere exceeds a certain critical value and that the diurnal variation is dependent on the interplanetary magnetic field and the strength of the solar wind. With the interplanetary magnetic field in one direction [Olesen, *et al.*, 1975] the SEC is found in the morning sector, for the other in the evening sector. It appears that the high latitude ionosphere in the auroral oval is usually near the threshold of instability and is therefore a very valuable indicator of relatively small increases in the geophysical forces causing instability.

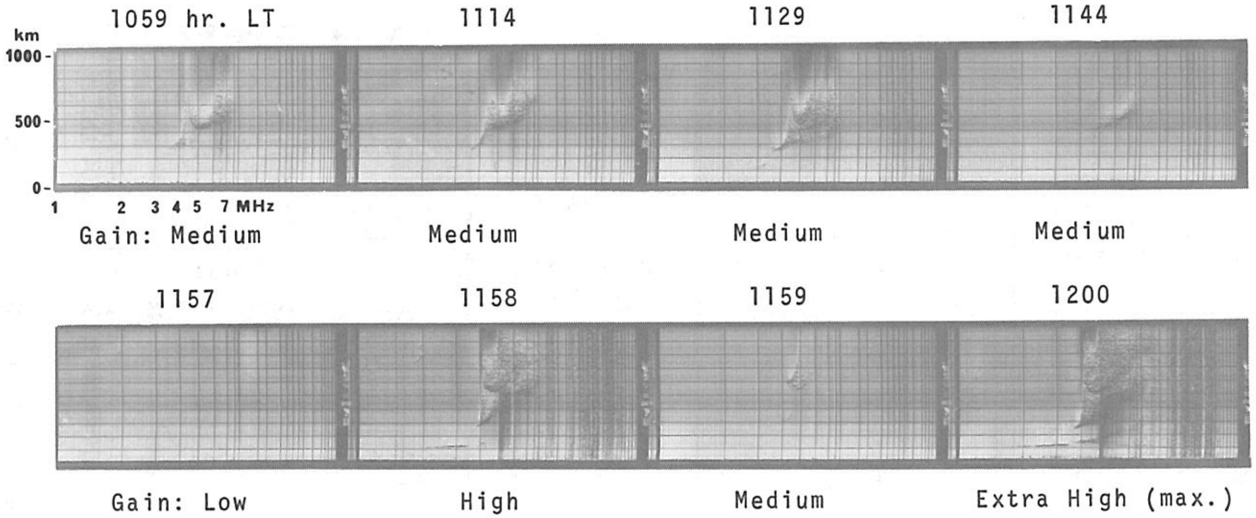


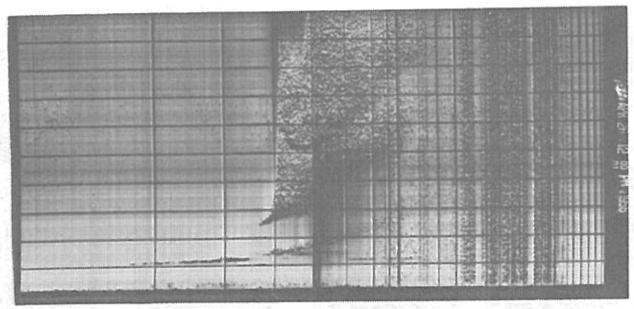
June 2, 1973 at 0559,0629,0659,0729, 0759,0829,0859,0929 LT (45° WMT)

July 15, 1973 at 0859,0929,0959,1029, 1329,1359,1429,1859 LT (45° WMT)

THULE (QANAQ)

Fig. 12.1. The ionograms show time sequences with Es-s (SEC), G and Lacuna (LAC) conditions present. These are coded in order on the ionograms if present. Thule June 2, 1973 sequence shows a narrow height range F1 Lacuna with a G condition. Thule July 15, 1973 sequence shows an F1 Lacuna with G condition in the F2 layer.



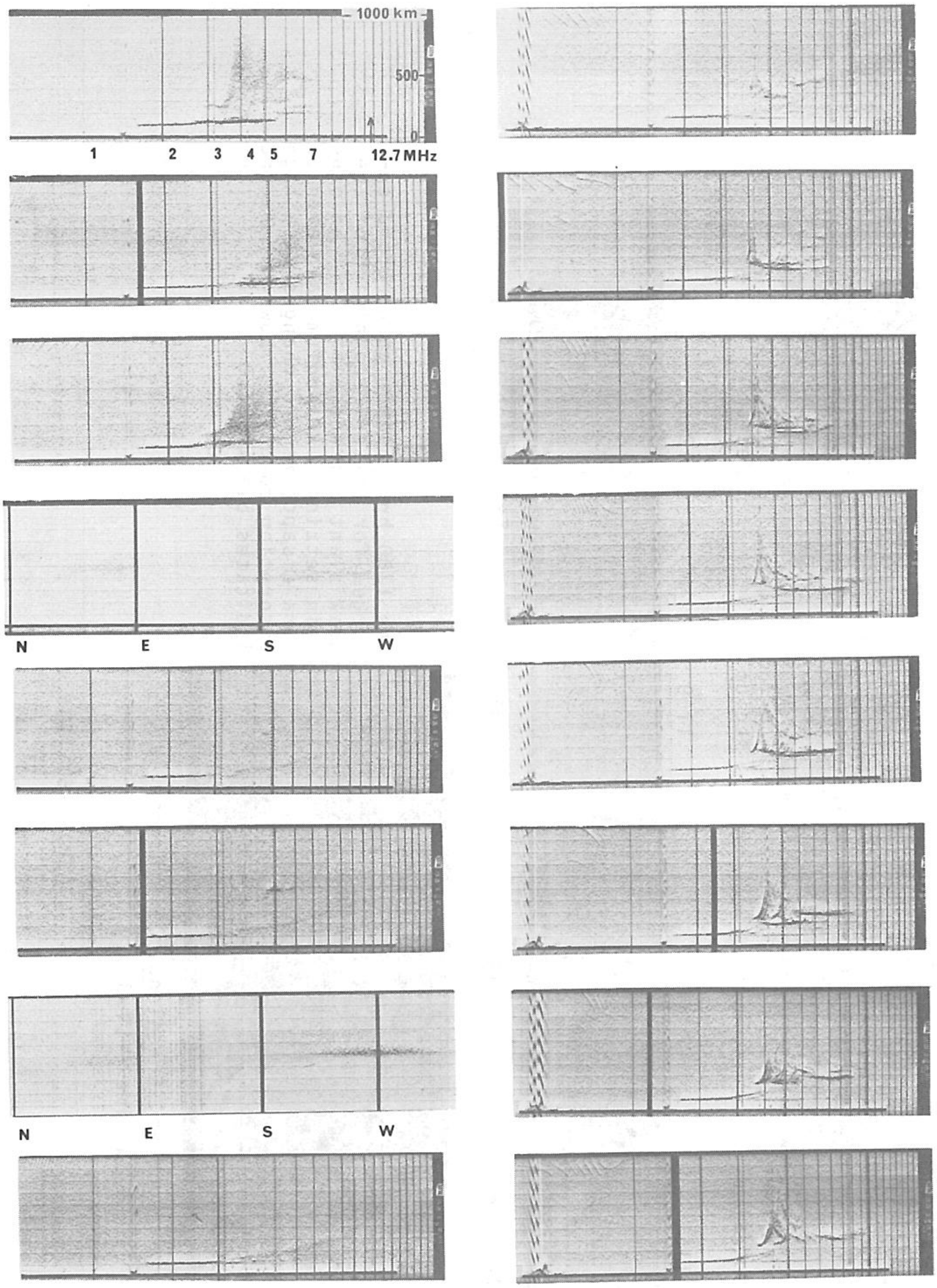


The 1200 hr. maximum gain record enlarged for better recognition of the weak slant E trace, invisible at other gain settings. At medium gain even Lacuna disappears and changes to a high absorption condition. Low gain record indicates black-out.

Godhavn, Greenland, 79.9°N.geom.lat.
(geom.time = LT+35m.)

April 26, 1956.

Fig. 12.2 Shows the effect of gain setting on Lacuna and Es-s traces during an SEC event.



A. June 26, 1974 at 0714,0719,0759, 0802 (bsc), 0814,0819,0832 (bsc),0833 LMT (geom.time = LMT+49m.)

B. June 29, 1974 at 1449,1453,1455, 1456,1458,1502,1503,1504 LMT.

Fig. 12.3. Shows morning (A) and evening (B) type ionograms at Søndre Strømfjord with an azimuth scan (bsc) at 12.7 MHz using a backscatter radar to detect the direction of strong backscattering irregularities. These are believed to show the passage of the auroral oval over the station. The backscatter is from the East in the morning period.

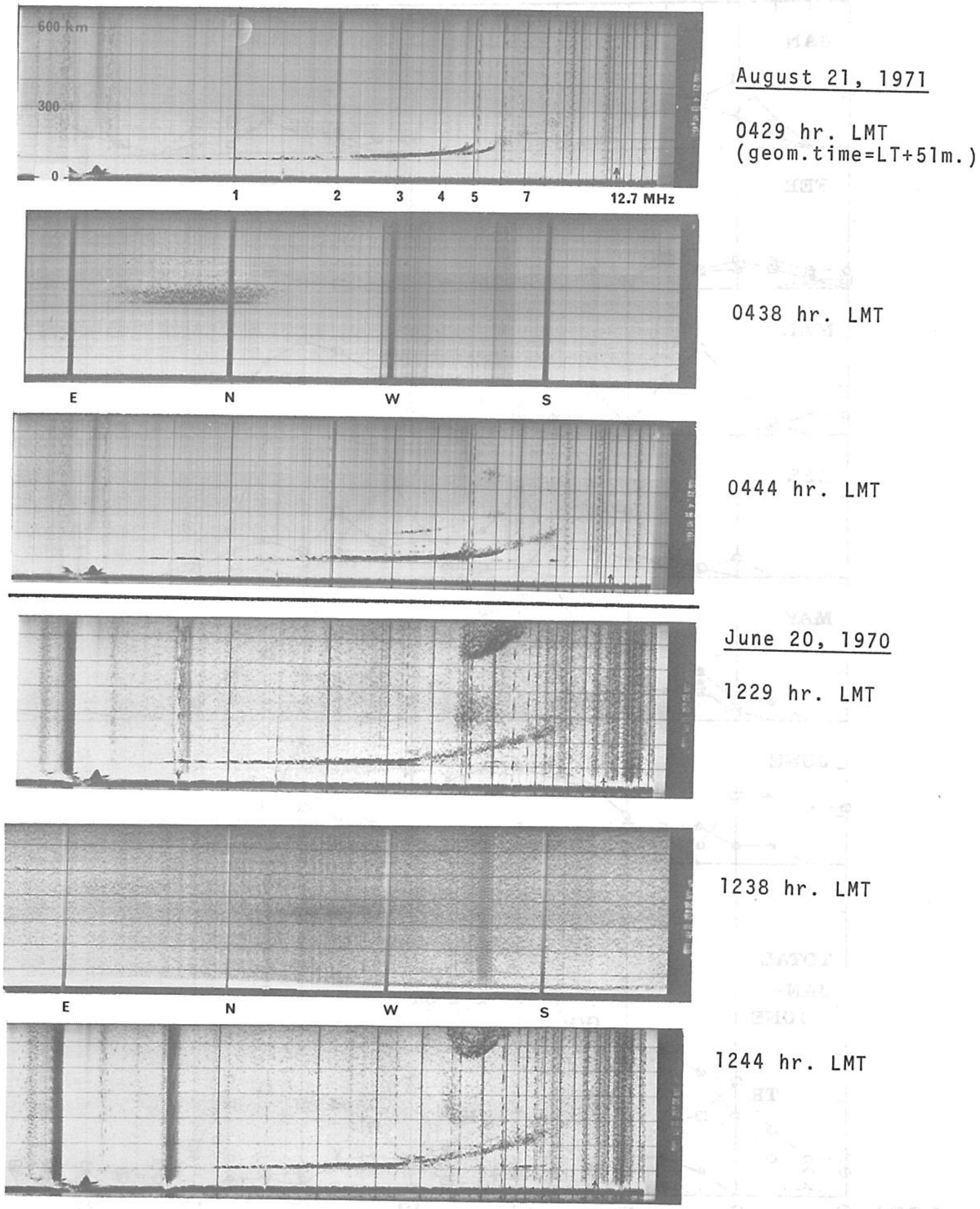


Fig. 12.4. Shows patterns from Narsarssuaq similar to Fig. 12.3. Note the backscatter is from the Northeast in the morning, Northwest in the evening.

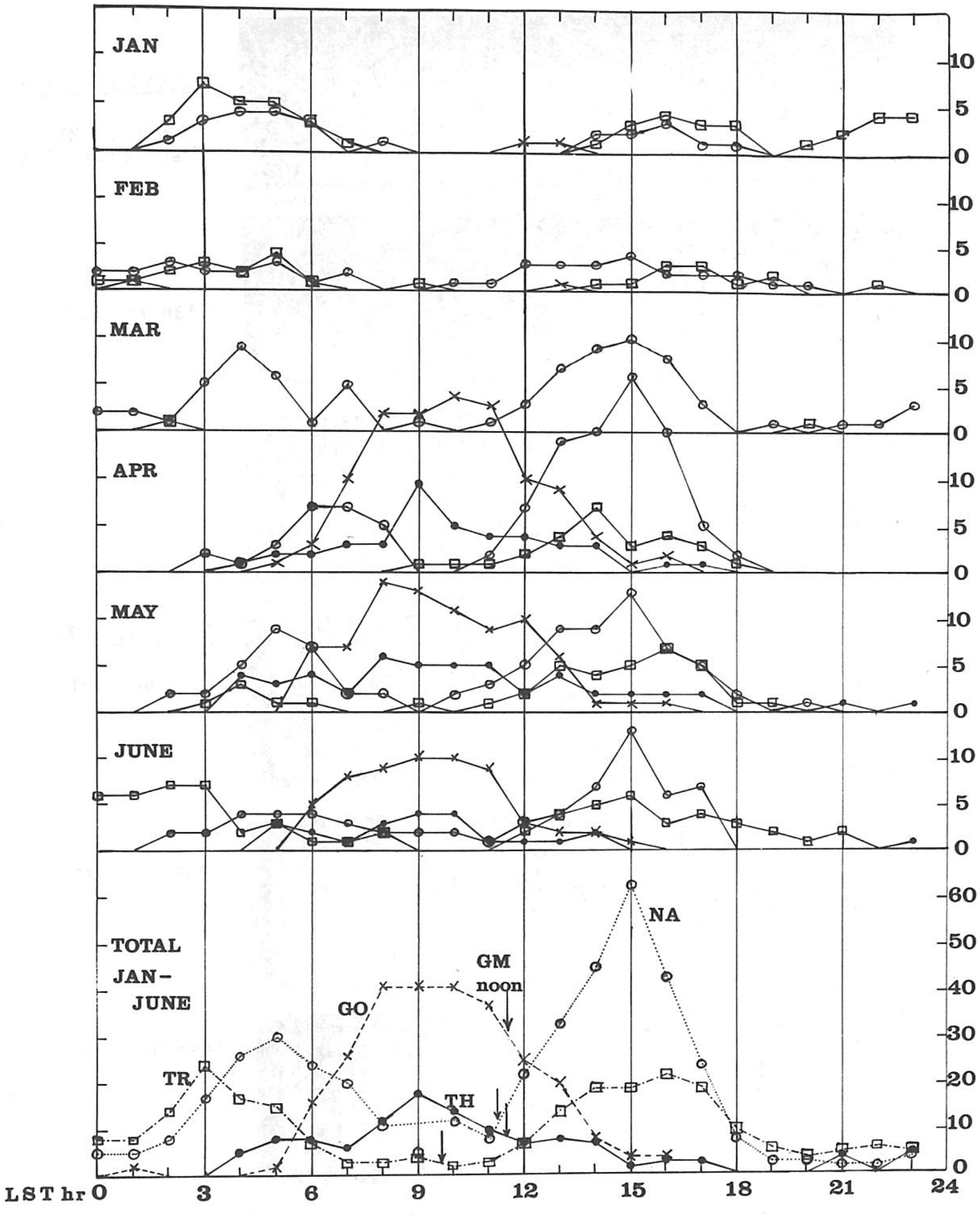
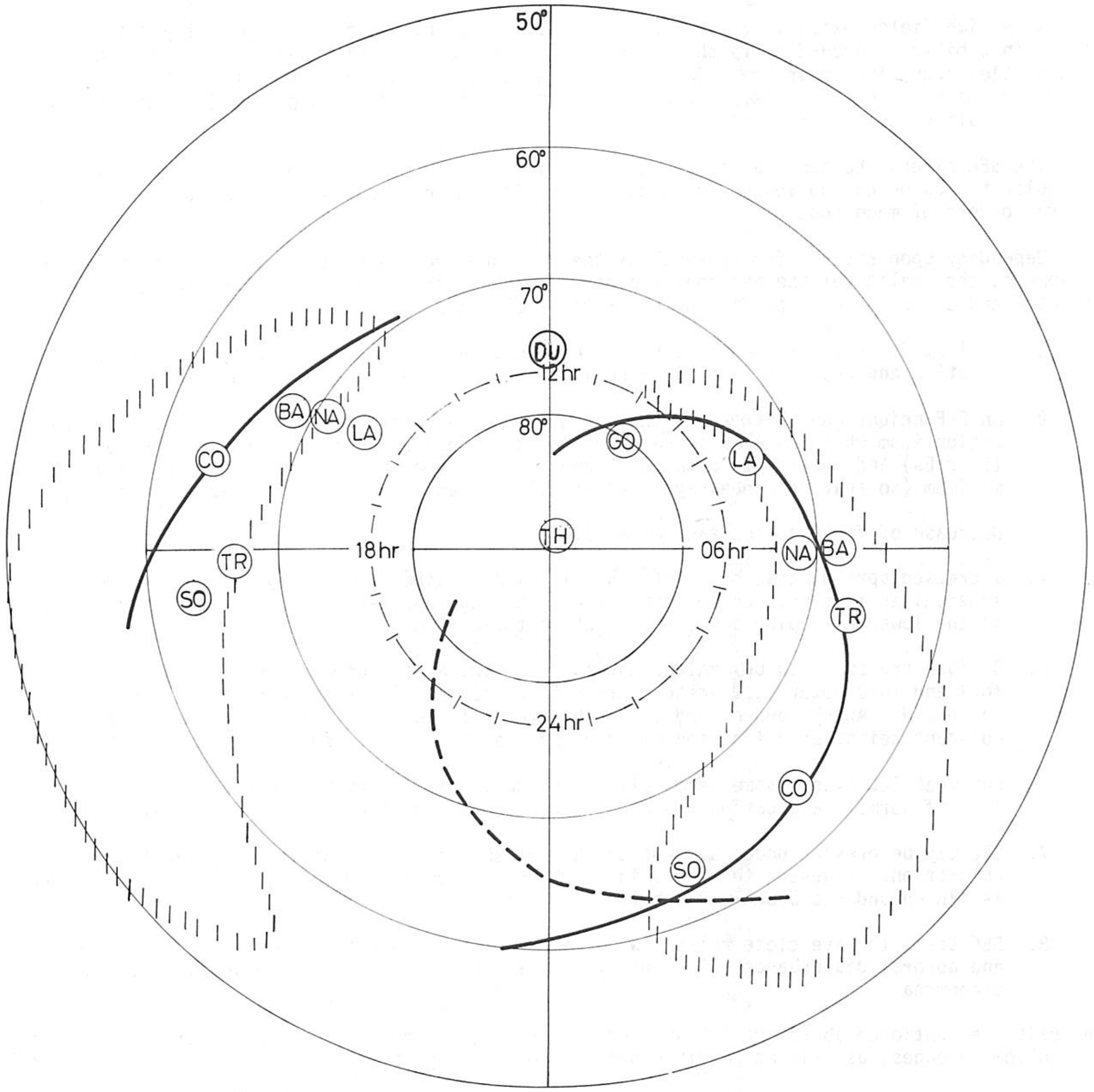


Fig. 12.5

SLANT E CONDITION. Number of occurrences each full hour Jan.- Jun. 1958 at

THULE : symbol ● ; LST = 75° WMT
GODHAVN : symbol × ; LST = 45° WMT
NARSSARSSUAQ: symbol o ; LST = 45° WMT
TROMSÖ : symbol □ ; LST = 15° EMT



○ = Daily maximum occurrence of SEC at stations indicated

//// = 55 Mhz backscatter at Bluff, N. Zealand 52°S geom. (Unwin 1966) at moderate magnetic disturbance in summer

⁄ = Summer maxima of magnetic agitation according to Feltstein 1963

⁄ = Winter maxima of magnetic agitation according to Feltstein 1963 (Unwin's corresponding winter backscatter area not shown here)

Stations: BA = BARROW; CO = COLLEGE; DU = DUMONT D'URVILLE; GO = GODHAVN; LA = LITTLE AMERICA; NA = NARSSARSSUAQ; SO = SODANKYLÄ; TH = THULE; TR = TROMSØ.

Fig. 12.6. Geomagnetic dipole time and latitude coordinates.

Slant E Condition - SEC - Phenomenon (Reprinted from INAG-12, pp. 14-19, with updating by Editor).

When high fields exist in the polar E regions an instability arises apparently due to the two-stream instability. According to the relevant theories ion-acoustic waves and field-aligned irregularities occur from near the "middle" of the E region and upwards through the F regions. In polar regions the occurrence is correlated with that of magnetic disturbance, i.e., maximum in the summer and along the auroral oval.

The SEC alters the ionogram appearance in several ways. The ionosonde waves reflected in the irregularity region can no longer be specularly reflected and their signal amplitude decreases several orders of magnitude.

Depending upon several factors such as the size and the age of the event, the sensitivity of the equipment, the quality of the antenna, the degree of absorption, etc., the ionogram appearance will be affected and one or more of the following criteria may be seen:

1. A slant Es trace from oblique E-region echoes generated by a suitable combination of refraction and backscattering in normals to the field-aligned irregularities.

2. An E-F height gap (Lacuna) in the ionogram, corresponding to the defocussing instability region from which no echoes are seen from somewhere close to the upturn of E-region traces (E or Es) and upwards through the F region, sometimes all the way up to the F2 ionization maximum (so that no echoes are seen at all, except those from the lower E regions).

3. Decrease of foF2 and increase of h'F2.

4. Increased spreadiness, often of a special fine-grained diffuse type, in the same height interval as mentioned under item 2 above (through upper-E, F1, F2); especially spreadiness in the lower F1 region above the "gap" is typical for SEC.

5. Oblique traces which before and during the event appear on the high frequency side of the foF1 and foF2 upturns, descending from there towards lower heights as the frequency is increased. At the end of and after the event, the oblique traces tend to appear with constant height as a function of frequency, a height that usually decreases with time.

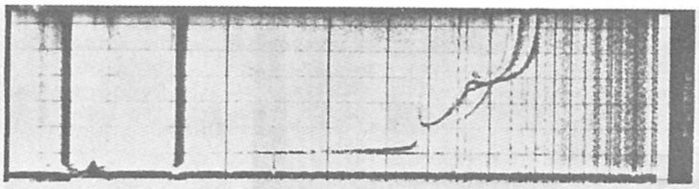
6. For weak SEC events some of or all of the above characteristics might be missing, but a lack of normal retardations in the upper E and lower F1 regions might reveal a weak SEC.

7. SEC may be present under various degrees of absorption and often during no noticeable absorption. However, there are indications that very frequently, maybe usually, a SEC is hidden under a black-out condition.

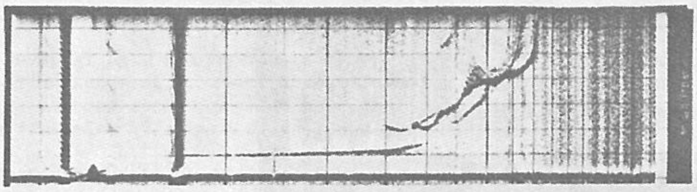
8. SEC seems to have close relations to several other geophysical phenomena, e.g., magnetic and auroral disturbances, ELF and VLF emissions, scintillation, fading and scatter phenomena.

The criteria mentioned above are illustrated in Fig. 2a, b, and c in Olesen [1971], as shown on the following pages, as well as possible propagation principles.

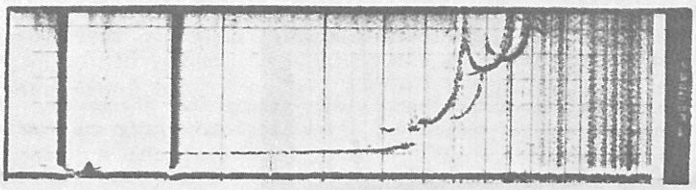
Editor's Note: This description appears to contain two phenomena, the SEC which is mainly found in the auroral oval and the characteristic changes in the ionosphere as the auroral oval approaches the station. Criteria three and five above may well prove to be auroral oval phenomena on which the SEC is superposed when the instability limit is reached.



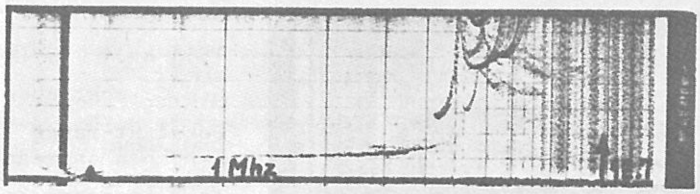
1254 hr.
No S.E.C.
Retardation traces in E and F1 at foE



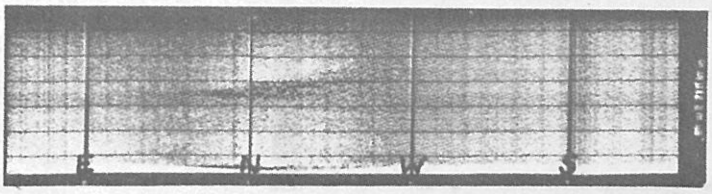
1324 hr.
S.E.C. event starts
No foE retardation trace.
F1 stratification



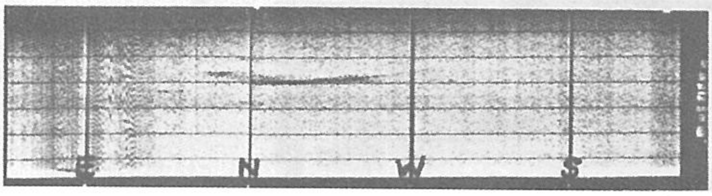
1349 hr.
S.E.C. early phase
Oblique F echoes.
Decrease foF2 starts
F1-F2 height separation increases.



1434 hr.
S.E.C. well developed
No echoes from upper E and lower F1
(E-F1 height gap).
Oblique E region echo



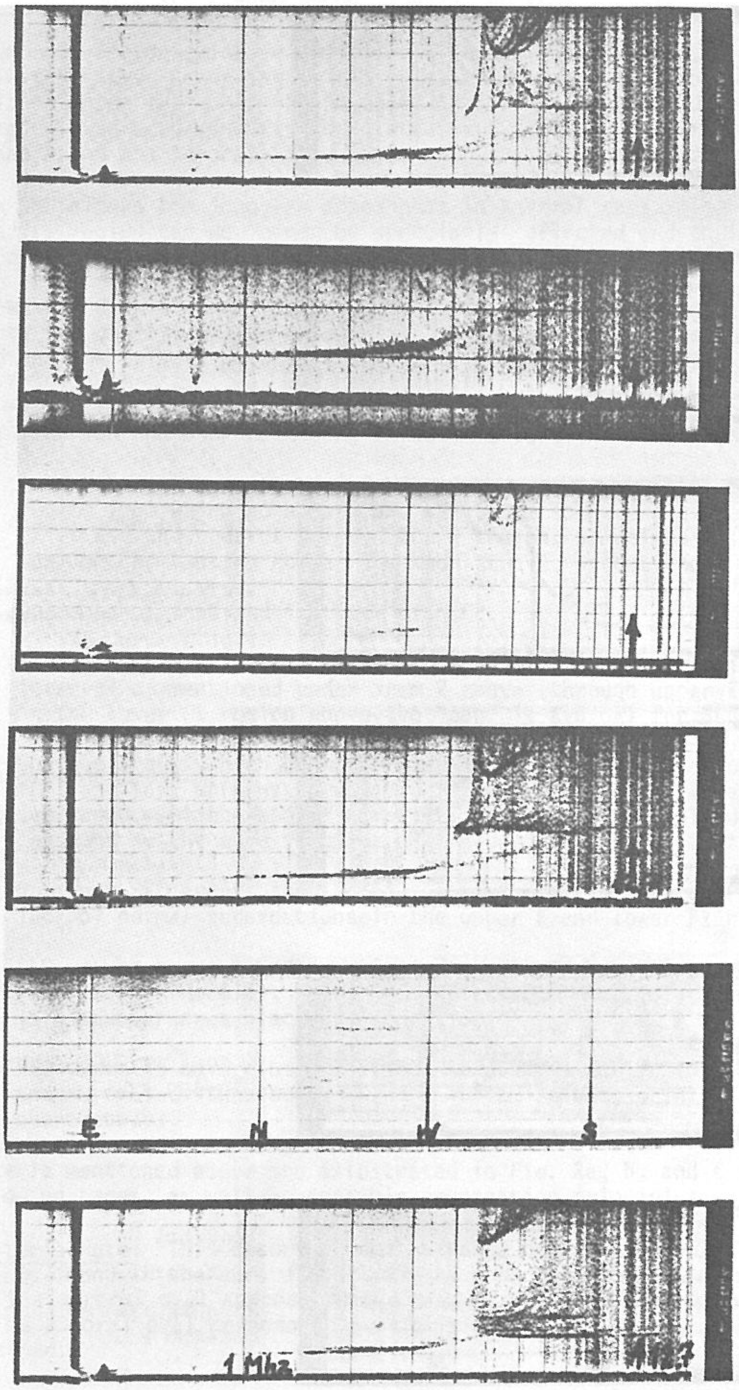
1438 hr.
Backscatter record
Echo from NNW geogr.
33o-4oo km.



1442 hr.
Backscatter record
Echo NNW geogr.
4oo-45o km.

Fig. 2 a

Typical daytime Slant E Condition (S.E.C.) at Narssarssuaq, June 17, 197o. (45°WMT). Ionograms are o.25 - 2o Mhz, o-65o km.
12,7 Mhz backscatter record have same distance range, azimuth is E,N,W,S geographical from left to right, antenna elevation 3o°.



1444 hr.
S.E.C. continues
Oblique upper E region echoes.

1457 hr.
S.E.C. continues
High gain-, expanded scale-record.
Note F1-z-echo.

1458 hr.
S.E.C. continues
Low gain record.
Notice: no slant trace but E-F height gap present.

1534 hr.
S.E.C. continues
Constant range F-echoes increase.
foF2 decrease continues.

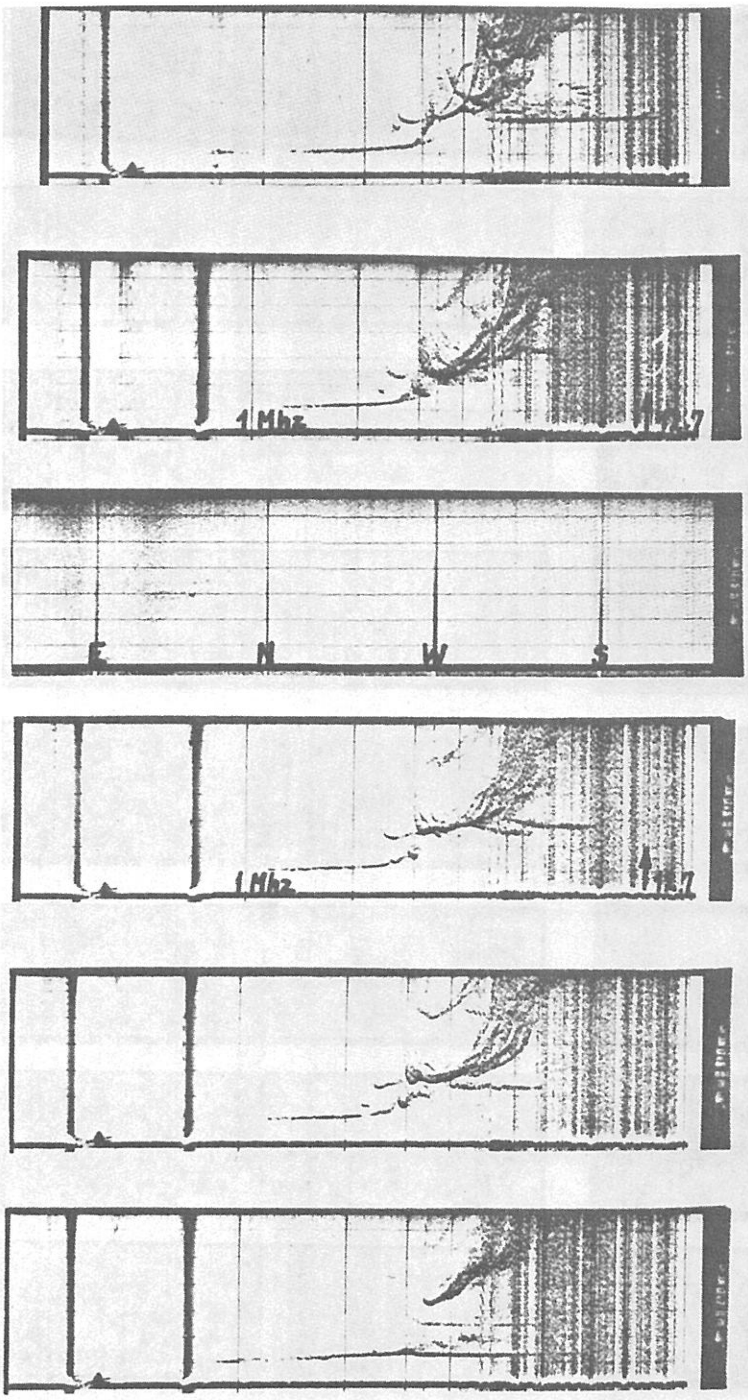
1542 hr.
Backscatter record
Echoes NW, NNW and SE, various distances

1544 hr.
Low constant range echoes.
E-F1 height gap increase.

Fig. 2 b

Typical daytime Slant E Condition (S.E.C.) at Narssarssuaq, June 17, 197o, continued.

Text see Fig. 2 a



1659 hr.

S.E.C. ends. Last record with distinct slant trace. Notice clear F1 trace.

1734 hr.

S.E.C. over at Narssarssuaq - constant range and other oblique after-effects present. Possibly start new disturbance.

1742 hr.

S.E.C. over.

Backscatter record. Echoes NE, 28o-35o km.

1744 hr.

S.E.C. over.

Constant range and other oblique after-effects

1749 hr.

S.E.C. over.

Constant range and other oblique after-effects.

1924 hr.

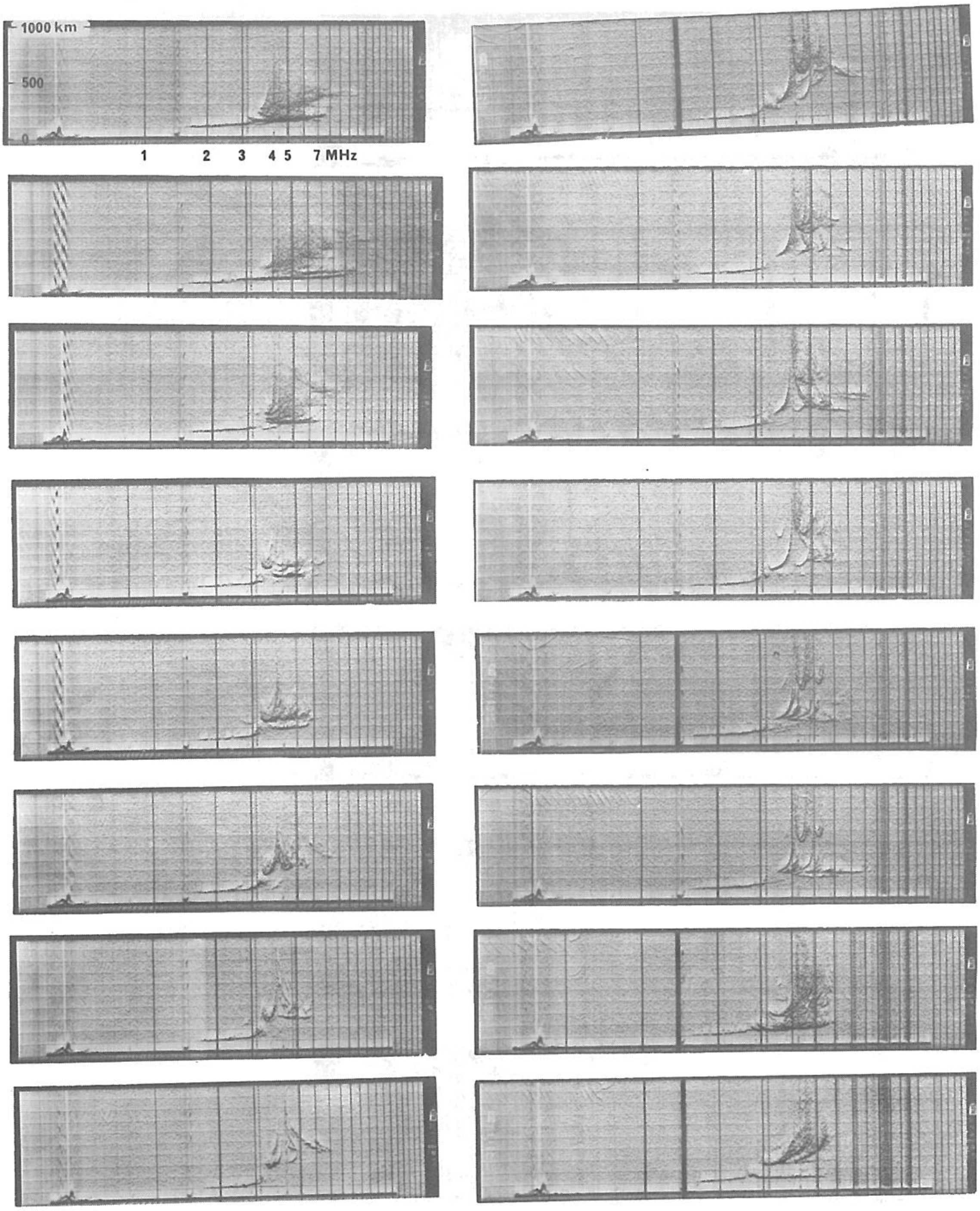
S.E.C. over.

New disturbances start

Fig. 2 c

Typical daytime Slant E Condition (S.E.C.) at Narssarssuaq, June 17, 197o, continued.

Text see Fig. 2 a



A. Morning passage from northern to southern side of auroral oval at 0727,0729,0734,0739,0741,0744,0749, 0756 LMT, July 1, 1974.

B. Afternoon passage from southern to northern side of auroral oval at 1445,1455,1505,1510,1545,1546,1745, 1800 LMT, July 2, 1974.

Søndre Strømfjord

Fig. 12.7.

Auroral Oval (incl. Polar Cusp-Cleft) Identification on Ionograms

As I have reported on previously and as illustrated in my note on SEC in INAG-12, reproduced above, certain trace configurations on ionograms have for many years been utilized by us to forecast an afternoon SEC event at Narssarssuaq (oblique F-region echoes above foF1-foF2 with decreasing range towards higher frequencies) while other configurations have been called "after-effects" of SEC (constant range echoes at low F and E region heights and spread F). During a rocket campaign in July 1974 at Søndre Strømfjord Greenland (77°N geom.) this feature came out still clearer: in the afternoon the same sequence appeared as at Narssarssuaq (1. high frequency "descending" traces, 2. SEC, 3. low height constant range traces and spread F), while in the morning hours the sequence occurred in opposite order. (Fig. 12.7). The frequent occurrence of these patterns lead us to the conclusion that what we saw was the station passing the auroral oval - and especially at the high latitude station in question - the passing of the Polar Cusp or Cleft part of it. In fact, we used these ionosonde recordings as a launch criterion for a rocket that was intended to cross the Cusp, and the results show that we succeeded. Although I have some ideas, I do not know for sure which propagation mechanisms produce the special oblique echoes. However, their regular occurrence makes me trust that they are connected to the oval in some way. The second of our two rockets, by the way, was devoted to the study of SEC. The promising results will be published later.

Editor's Note: There is evidence that polar cusp phenomena can occur both near the magnetic pole and occasionally even outside the auroral oval, possibly because the position depends on magnetospheric circulation. Probably more work is needed before we can firmly identify this whenever it occurs (see introduction).

REFERENCES

OLESEN, J. K. 1971 On the polar Slant E Condition, its identification, morphology and relationship to other electrojet phenomena. Presented at NATO-AGARD-EWPP-meeting, Lindau, Sept. 1971, published in *AGARD-CP 97*, pp. 27.1-27.19, January 1972.

OLESEN, J. K., F. PRIMDAHL, F. SPANGSLEV and N. D'ANGELO 1975 On the Farley Instability in the Polar Cap E Region, *J. Geophys. Res.*, *80*, 696.

ADDITIONAL REFERENCES

OLESEN, J. K. 1957 Slant Es Ionospheric disturbance at Godhavn and its correlation with magnetic activity. *Internal Ionosphere Laboratory Report R 1A - July 1, 1957.*

OLESEN, J. K. and J. RYBNER 1958 same title - with Appendix: Note on the occurrence of Slant Es at Narssarssuaq, published in *AGARDograph 34*: Sporadic E Ionization, Ed. B. Landmark, printed by NATO, Paris 1958.

also, 31 references given in Olesen *et al.* [1971].