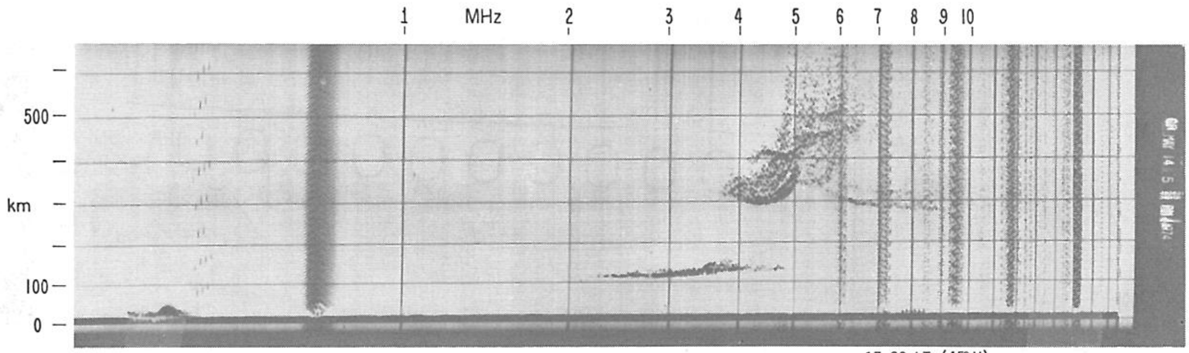
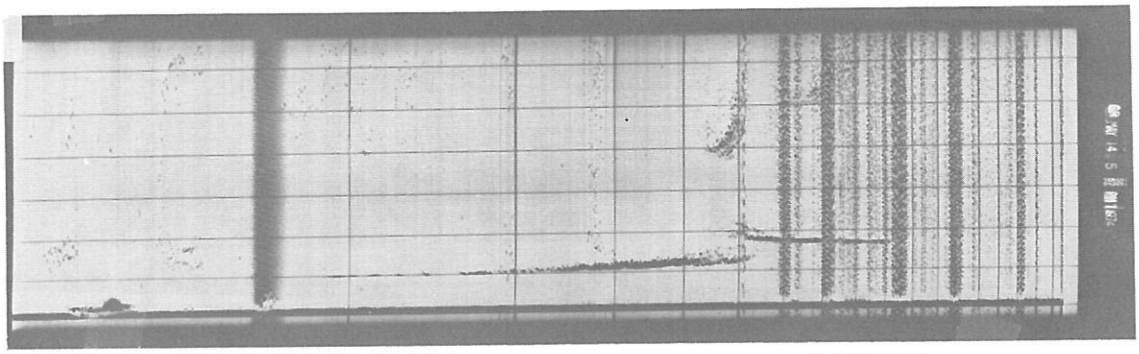


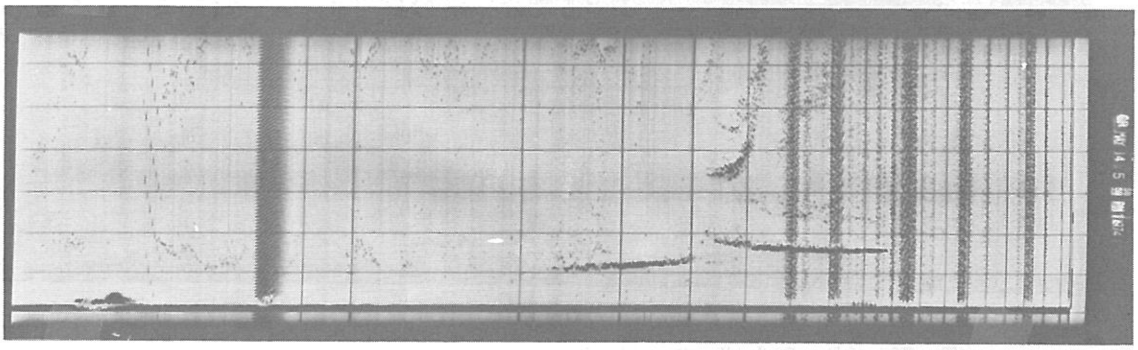
17.29 LT (45° W)

Es type r, foF1 = 380EA. Es-a at oblique incidence (h' about 280). fbEs = 038. This is a difficult distinction from Lacuna (F1). Note F trace near fbEs gradually weakens, E trace typical of Es-r and not of an E cutoff by Lacuna, foEs much larger than expected value of normal foE (around 3 MHz).



17.57 LT (45° W)

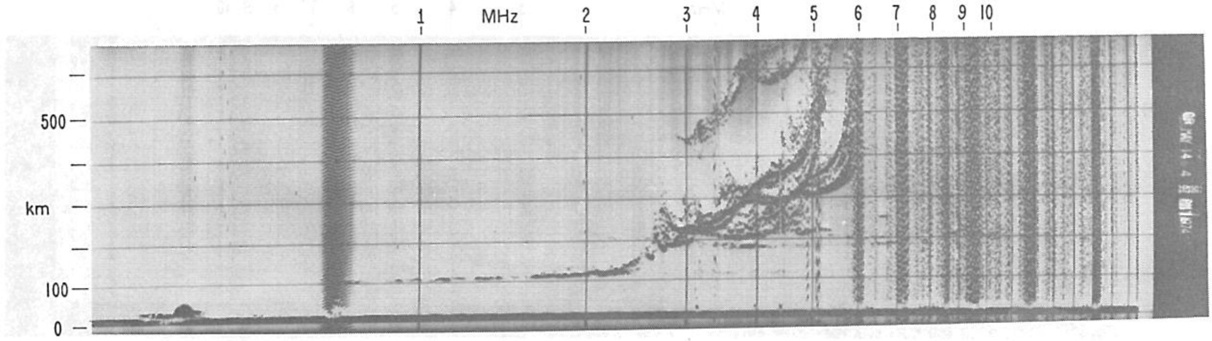
Sequence confirms analysis of 17.29 LT (45°W) as does retardation at low frequency end of Es-a trace and its general decrease in height with frequency.



17.59 LT (45° W)

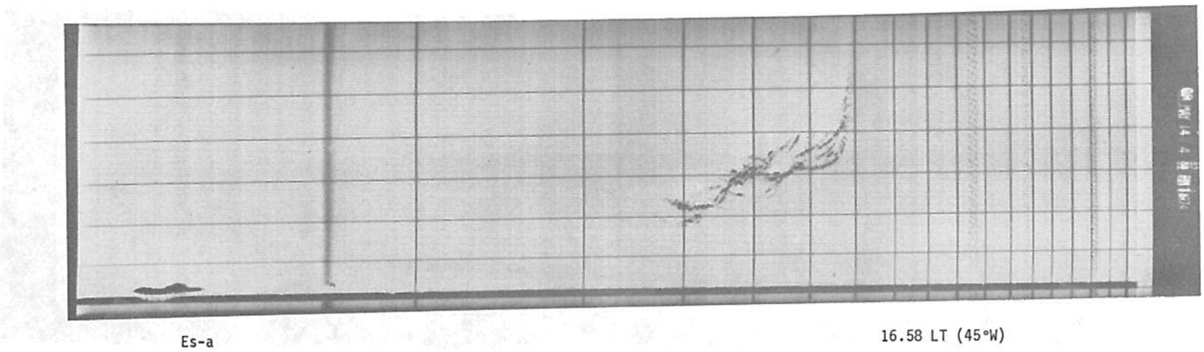
Fig. 2.60

NARSSARSSUAQ - Auroral Es Distinction from Polar Spur   1974 May 14   17.29-17.59 LT (45°W)



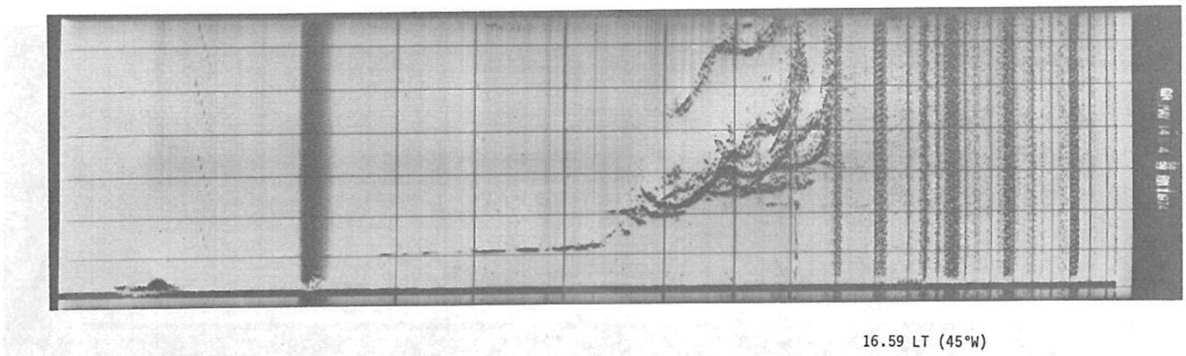
Es-a

16.57 LT (45°W)



Es-a

16.58 LT (45°W)



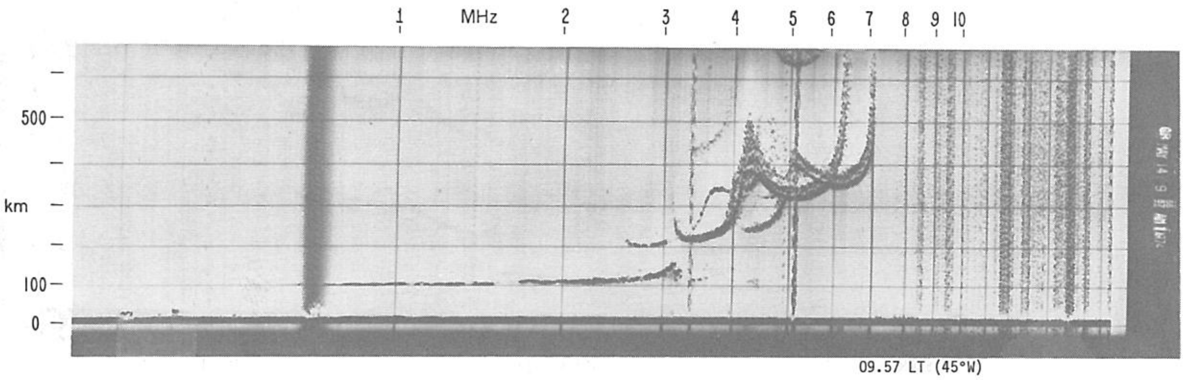
16.59 LT (45°W)

foF2 = 052UH, foF1 = 380-H, h'F = 215, h'F2 = 285-H. Spread F types F, Q.

Fig. 2.61

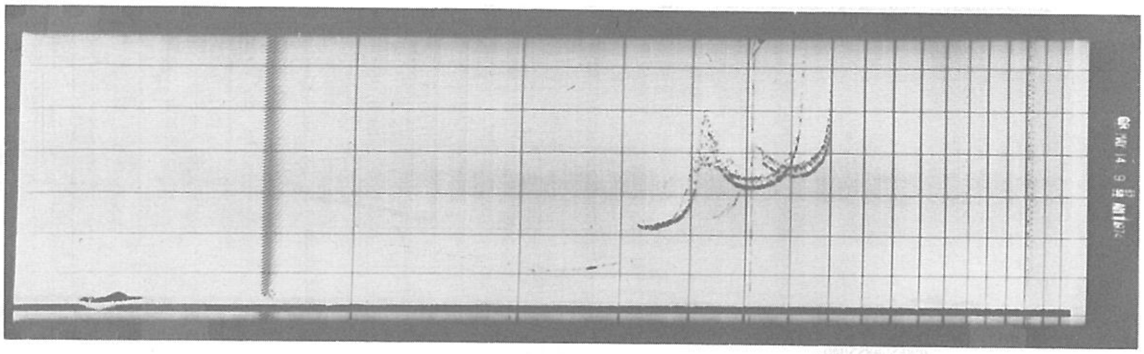
NARSSARSSUAQ - Auroral Es Superposed on F Pattern 1974 May 14 16.57-16.59 LT (45°W)

The F layer is tilted (compare first and second order traces) with lower trace most nearly overhead and not varying rapidly in time. Es 'a' traces seen at oblique incidence change considerably in each minute. Tilted F trace varying with time at intermediate rate.



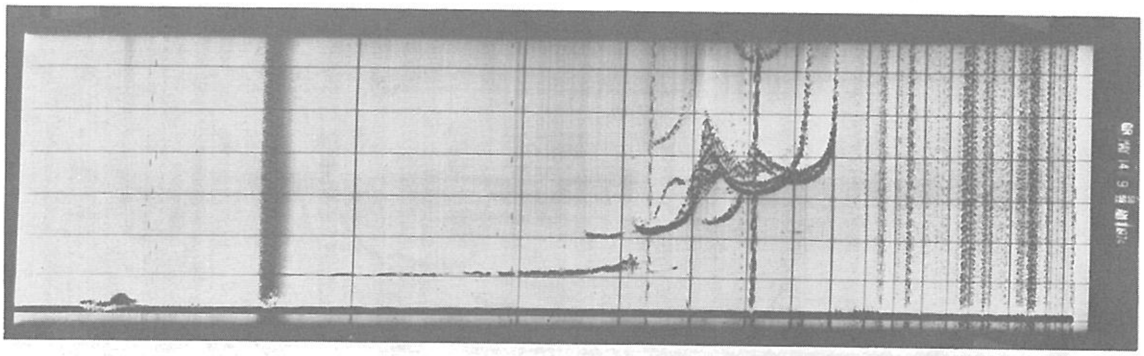
09.57 LT (45°W)

Second order trace shows h'F2 lower trace is overhead, h'F = 315-Q or 315-F (Q suggests satellite traces or tilt, F spread). If spread F typing in use, use type Q.

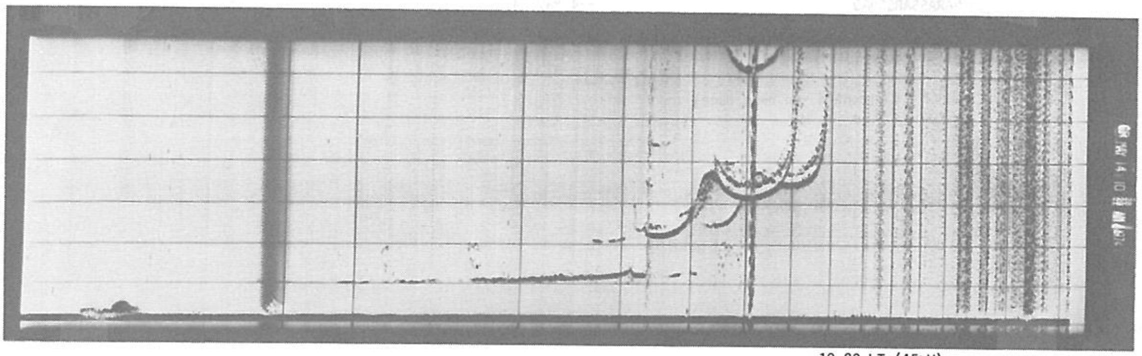


09.58 LT (45°W)

(Low gain) Satellite traces clear as is coincidence at foF2.



09.59 LT (45°W)



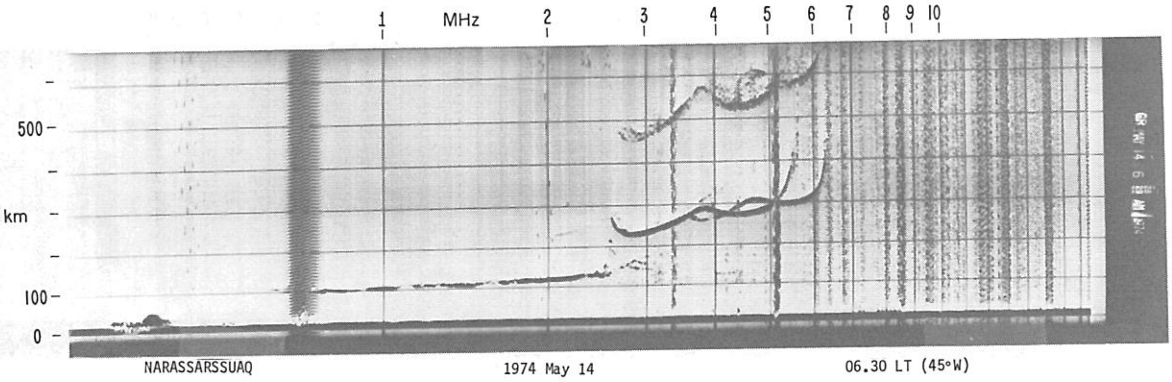
10.29 LT (45°W)

Second order trace shows h'F2 <u>not</u> overhead, h'F2 = 310UQ or 310UF.

Fig. 2.62

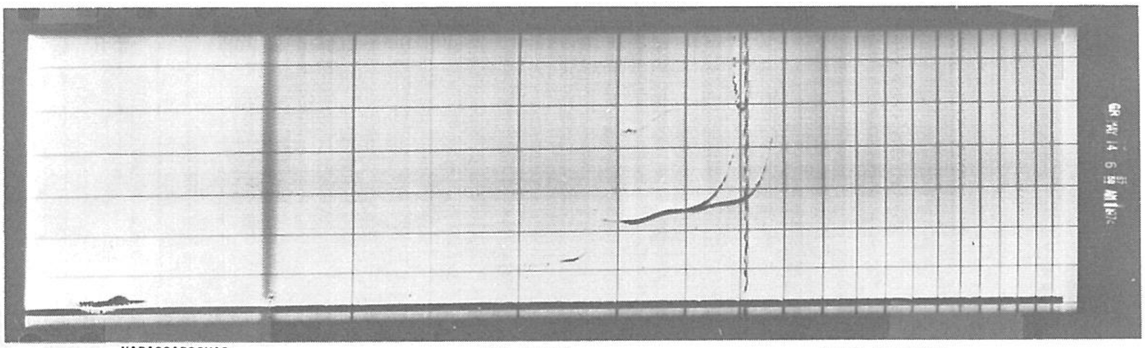
NARSSARSSUAQ - Range spread 1974 May 14 09.57, 09.58, 09.59, 10.29 LT (45°W)

F2-layer satellite traces due to tilt perpendicular to magnetic meridian. Height of layer changing but foF2 not changed.



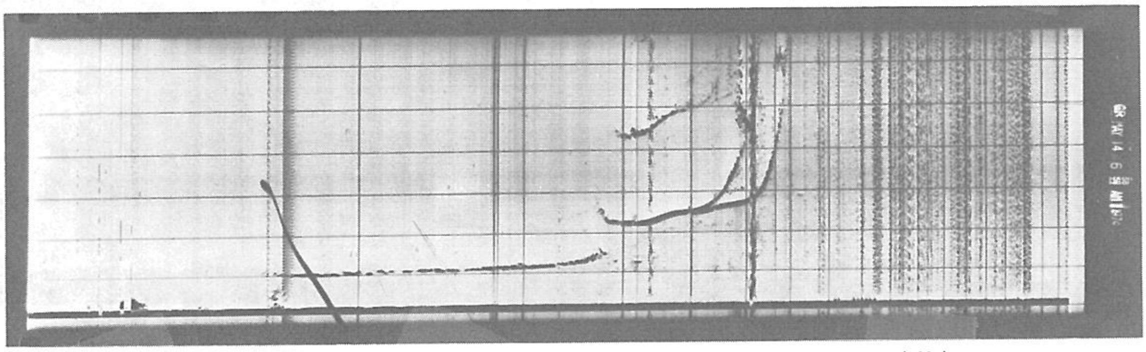
NARASSARSSUAQ 1974 May 14 06.30 LT (45°W)

Normal conditions, foF1 = 380, foF2 = 053, h'F2 = 270, M(3000)F2 good.



NARASSARSSUAQ 1974 May 14 06.58 LT (45°W)

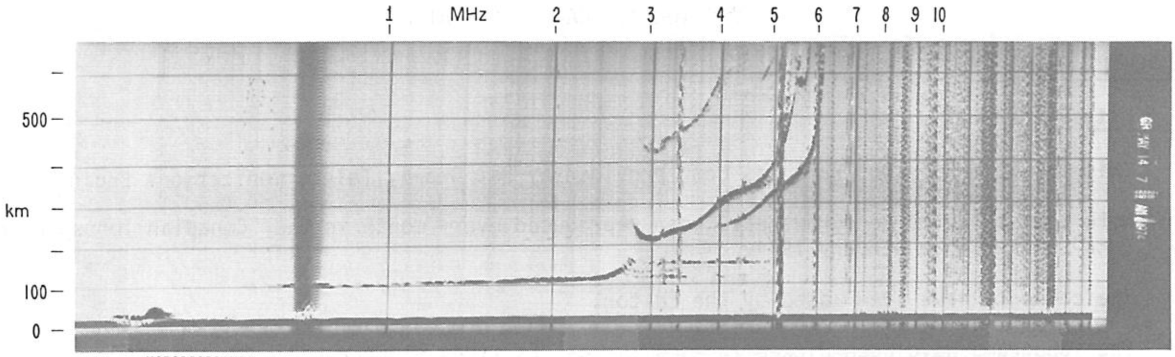
(Low gain) Typical change in F2 trace when large tilt present. foF1 = 380UL. Forked F trace seen at oblique incidence above main trace suggests foF2 about 048, foF2 = 052EY. M(3000) and N(h) completely misleading as tangent point moved as well as error in foF2. M(3000) = Y.



NARASSARSSUAQ 1974 May 14 06.59 LT (45°W)

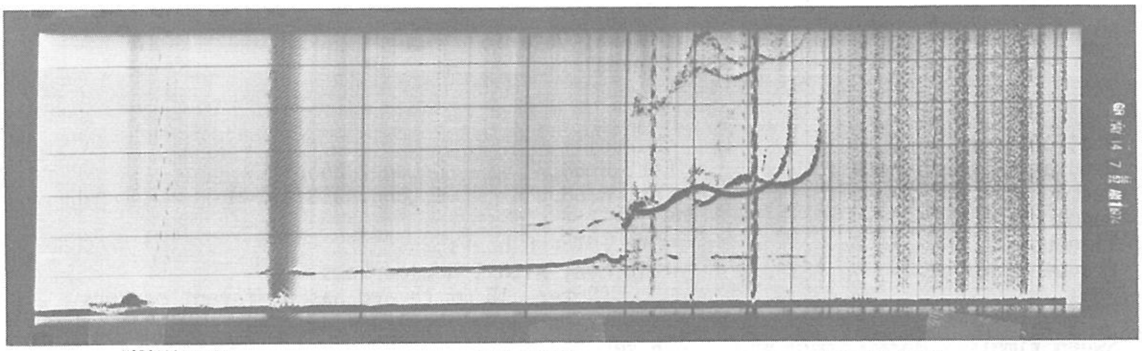
(Normal gain) Typical apart from oblique spur, foF2 = 053EY, M(3000) = Y. N(h) impossible above foF1. Note linearity of F2 trace.

Fig. 2.63 (cont'd. on next page)



NARASSARSSUAQ 1974 May 14 07.30 LT (45°W)

foF2 = 054UV. Here x trace shows no spur and confirms foF2 not given by spur. Hence measure foF2 from main trace. Note F2 trace now convex at all frequencies as is normal. If 1000 km had been available, it would have been possible to check if this trace is now overhead. Fine structure near fork (not clear on reproduction shows it is not vertically overhead. Fork shows low frequency nose as at 06.58 LT.



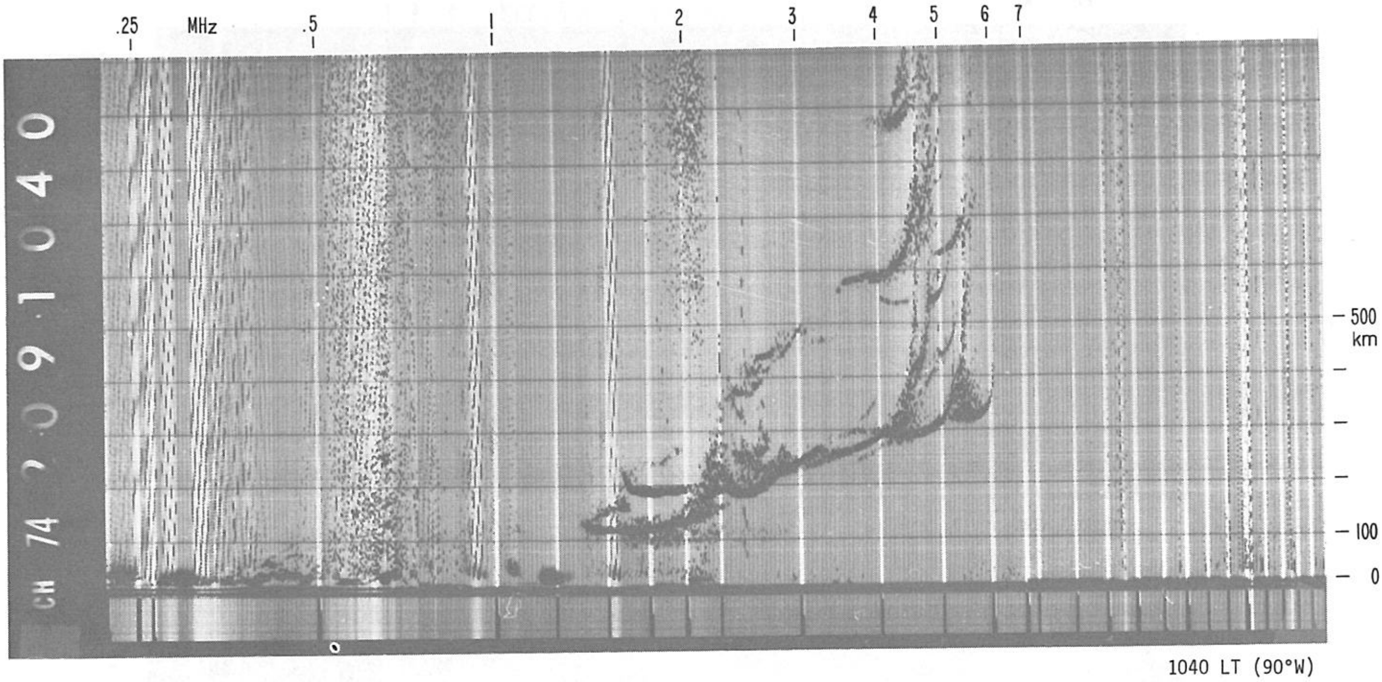
NARASSARSSUAQ 1974 May 14 07.57 LT (45°W)

Layer again horizontal. foF2 = 060, foF1 = 410.

Fig. 2.63

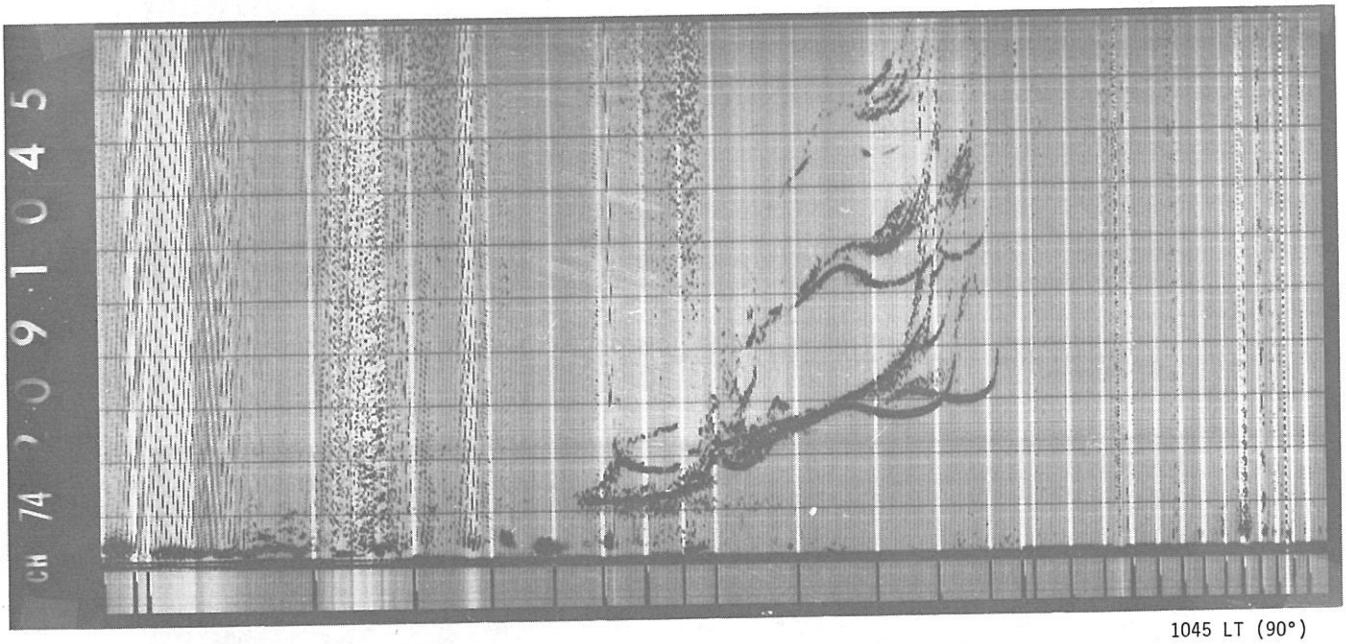
NARASSARSSUAQ - F-layer tilt sequence. 1974 May 14 06.30, 06.58, 06.59, 07.30, 07.57 LT (45°W)

Use of Y for large tilts near foF2. (Note, can be distinguished from Y = Lacuna as F1 and E not influenced). 06.30, 07.00 LT (45°W).



1040 LT (90°W)

The perturbation has moved down the F trace, foF2 is decreasing. Spur goes to foF2 at 1015 LT.



1045 LT (90°)

The highest frequency pair are at same critical frequencies as at 1015 LT. Note how apparent height of hmF2 on continuous trace has risen. This is not a height change but oblique reflection. The true height is given by the spur (very nearly).

This shows the reason for reading foF2 from the upper fork of a V trace in a dramatic way.

Fig. 3.1

CHURCHILL - Travelling Disturbance Sequence

- Sequence Showing TID Distortion of Ionogram

1974 Feb. 9

1015-1045 LT (90°W)

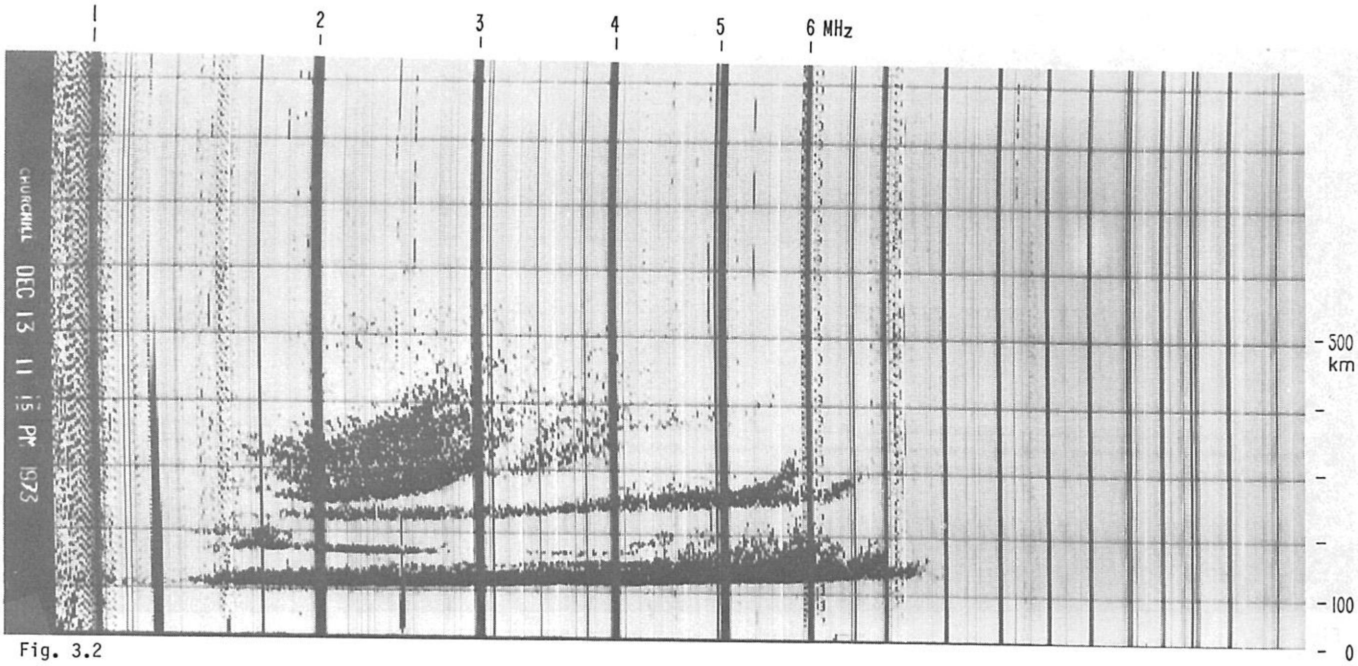


Fig. 3.2

CHURCHILL - Es Types r, k   1973 Dec. 13   2315 LT (90°W)

Editor's Note: This is a difficult ionogram. Es first order trace is an Es-r but second order trace shows particle E with rather lower critical frequency confirmed, even lower by third order. F traces are present at low frequencies. Probably neither Es nor F traces were overhead. Best analysis Es-r3, foEs = 070, fbEs = 017ES. Physically the tilts are likely to be greater than 60° so the particle E is only a few km from the station.

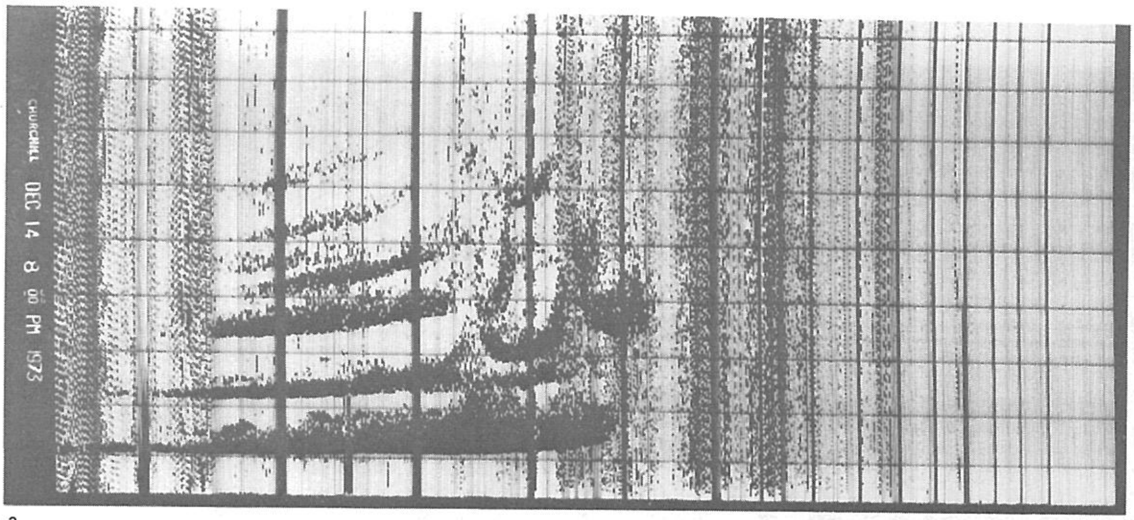


Fig. 3.3

CHURCHILL - Particle E (Es-k) - Daytime   1973 Dec. 14   2000 LT (90°W)

Editor's Note: Normal foE at noon 023. foE = 035-K. x trace suggests Es-r also present with fxEs = 048. Hence foEs = 040JA, fbEs = 035-K, foE = 350-K. Es-r, k2.

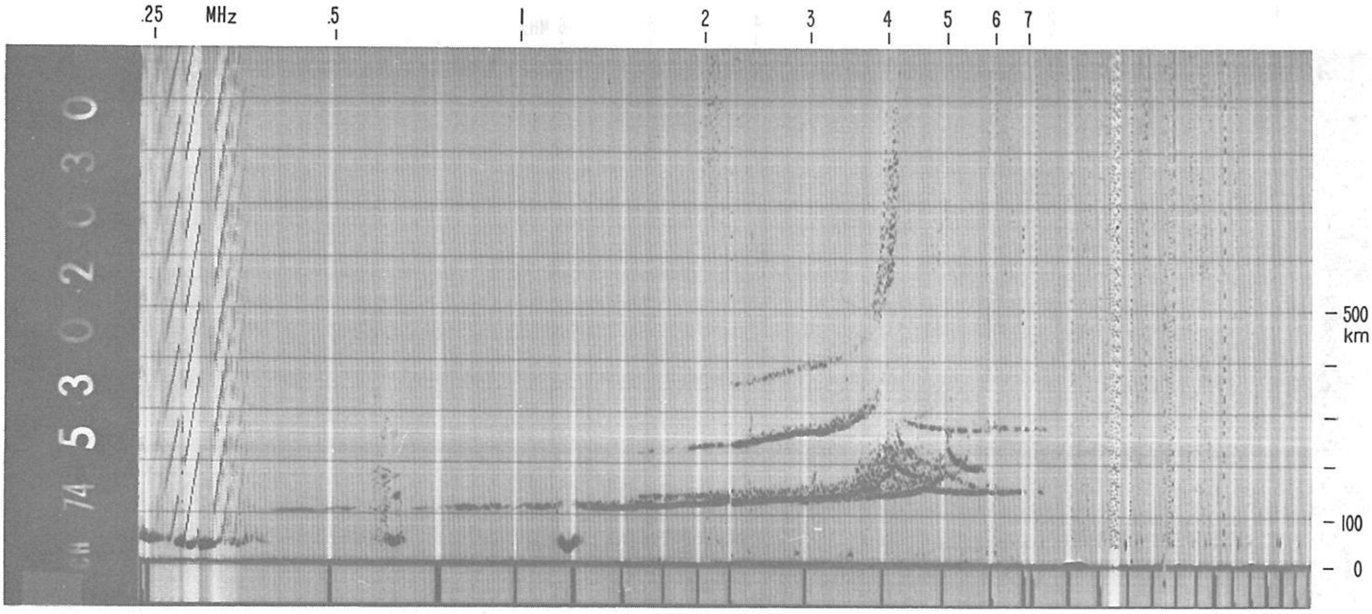


Fig. 3.4

CHURCHILL - Es Types c, r, k 1974 May 30 2030 LT (90°W)

Editor's Note: This is a case where an Es-r is turning into an Es-k. There is much tilt so interpretation doubtful. Cusps are visible at 4.0 MHz and Es x trace strong although F-layer x trace not visible. Multiple orders show slightly decreasing critical frequency with fbEs less than foEs. According to rules this is an r trace but (foE)-K within accuracy rule limits of foEs for r trace, and evidence as whole shows layer probably a slightly non-horizontal particle E with F layer tilted. Prefer foE = 400UK. Sequence needed to see whether ftEs due to auroral Es or is really a cusp Es, second order trace suggests Es-a but a cusp Es is also visible. foF2 = 040-F. fxI = (fσI+fB/2)OB.

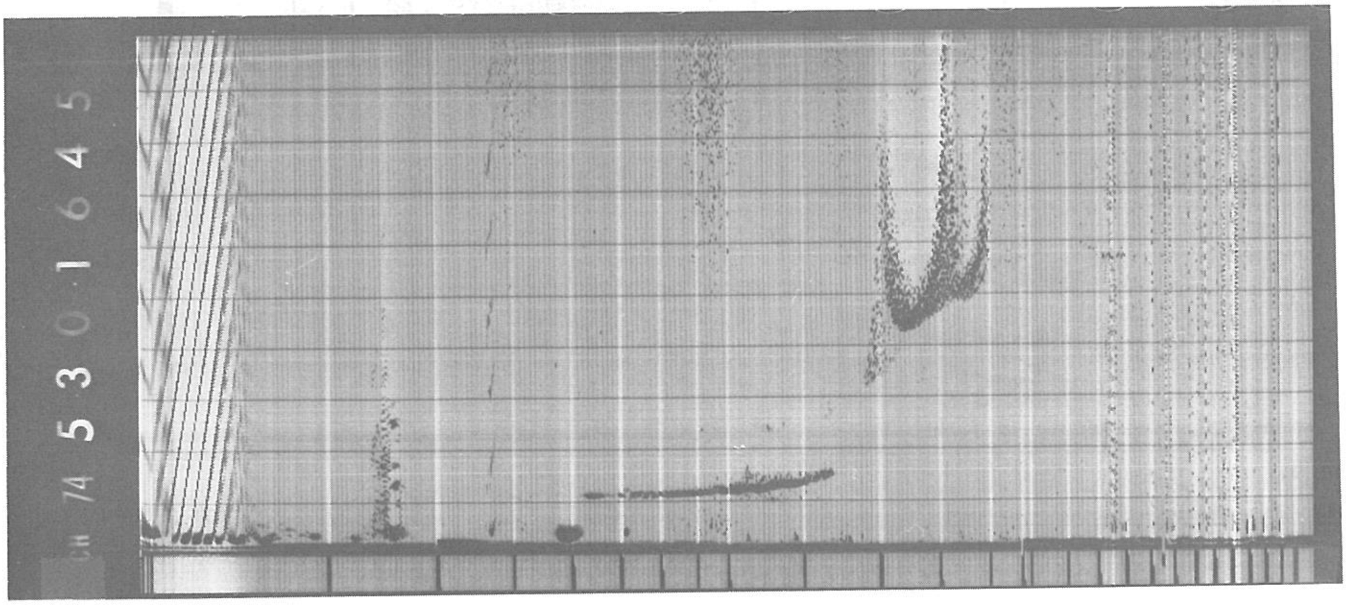
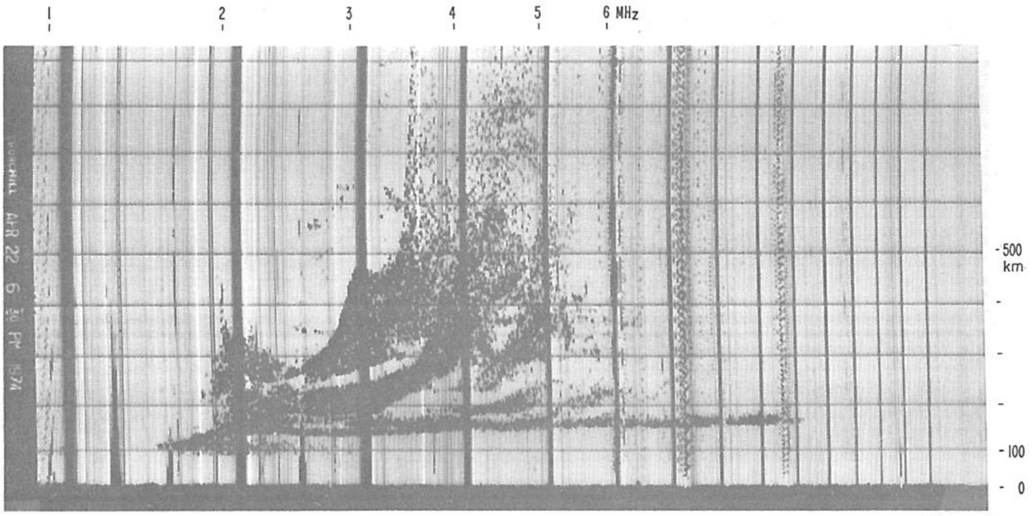


Fig. 3.5

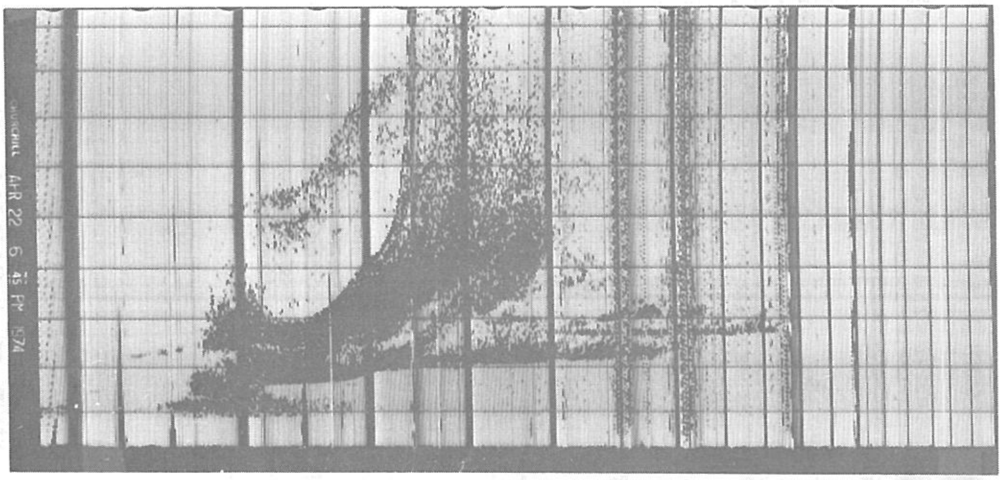
CHURCHILL - Lacuna 1974 May 30 1645 LT (90°W)

Editor's Note: F1 Lacuna. Note sharp cut-off of E trace. Weak F1 scatter just visible.



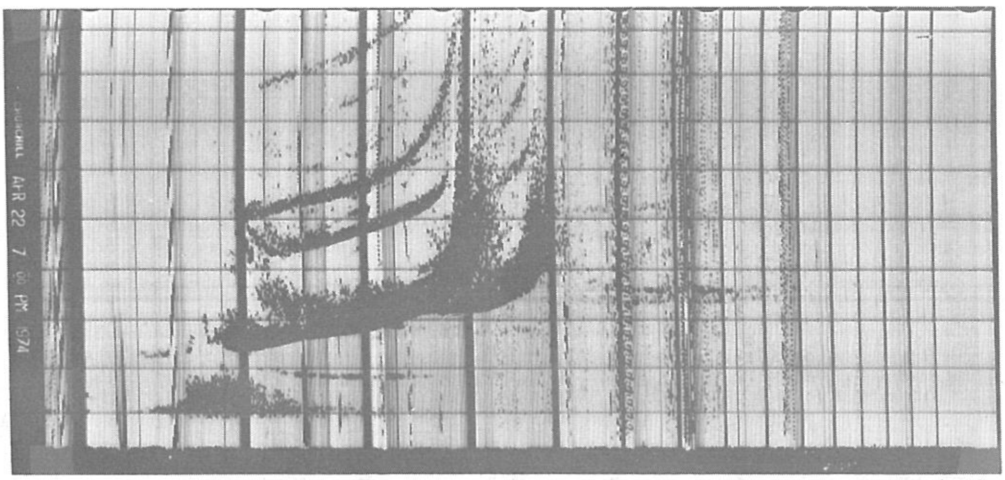
1974 April 22 1830 LT (90°W)

Editor's Note: Note presence of F1-type trace on upper F structure but not on lower. (See USSR FLIZ pattern.)



CHURCHILL 1974 April 22 1845 LT (90°W)

Editor's Note: Second order shows severe tilt of layer. Lower F pattern has moved down.

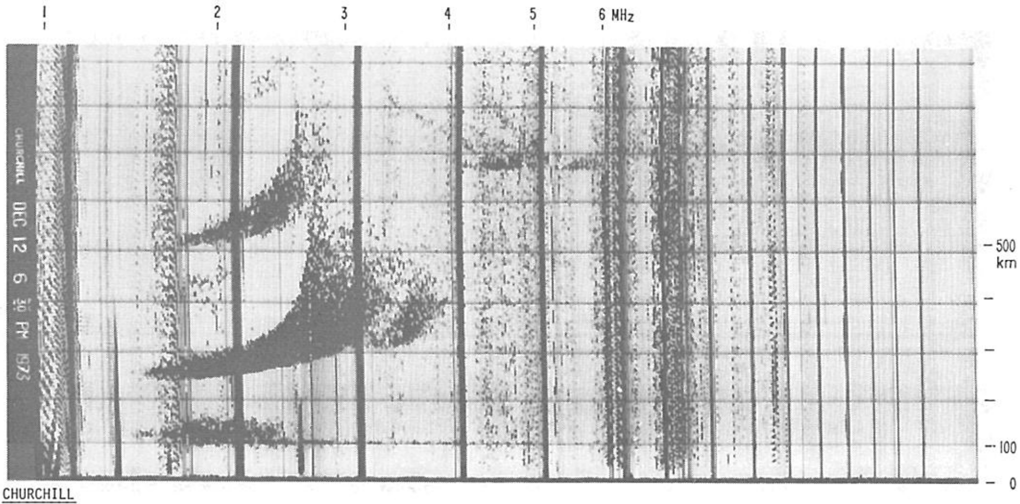


CHURCHILL 1974 April 22 1900 LT (90°W)

Editor's Note: Layer effectively horizontal. Critical frequency corresponds to lower pattern at 1830 LT. Auroral Es and M (2F-E) traces suggest dense Es structure not far away.

Fig. 3.6

CHURCHILL - Replacement Layer (Trough) Sequence

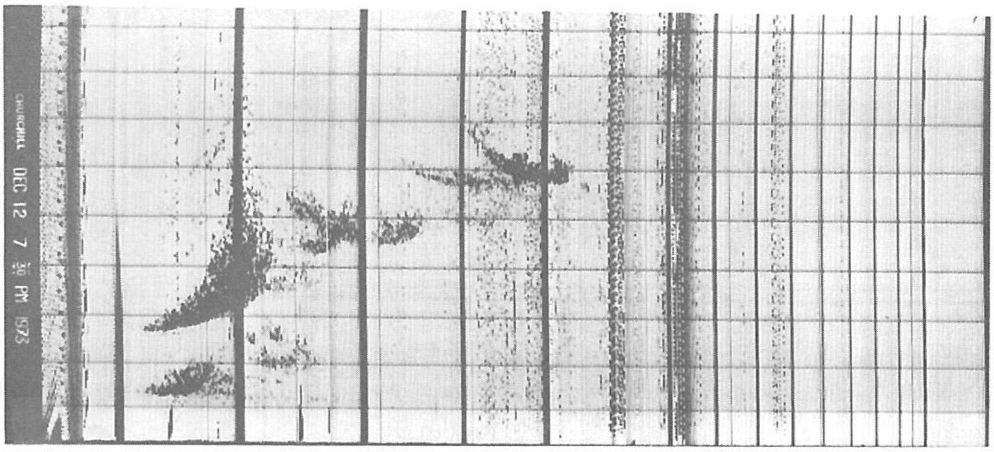


CHURCHILL

Editor's Note: Replacement Layer (Trough-Ridge) Sequence 1830 LT (90°W)

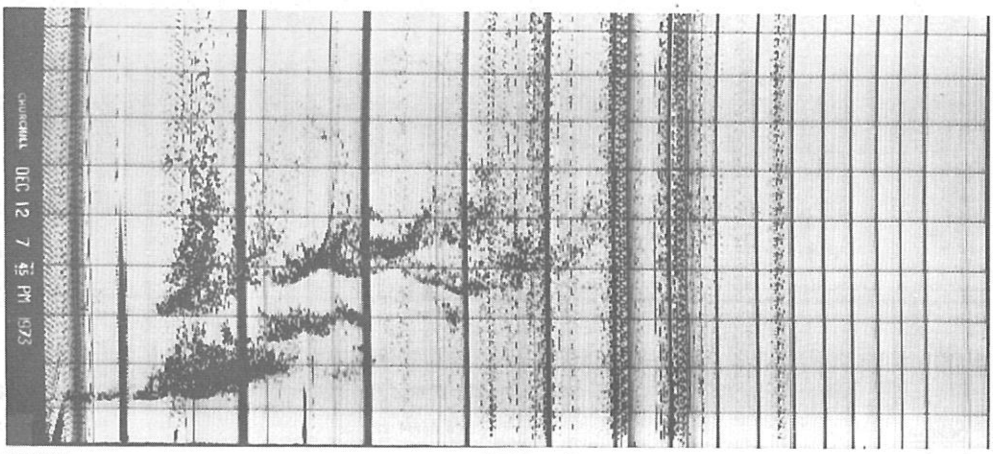
foF2 = 026-F trough layer. Third order height not consistent.
fxI = 060US h'I = 680 km
Weak auroral Es, foEs = 024.

There is no frequency spread above 4.0 MHz so P trace (replacement structure) can be represented by q - q on f plot 4 MHz to 6 MNz. Spread F classifications P, F (INAG 17, p. 6).



CHURCHILL 1973, Dec. 12 1930 LT (90°W)

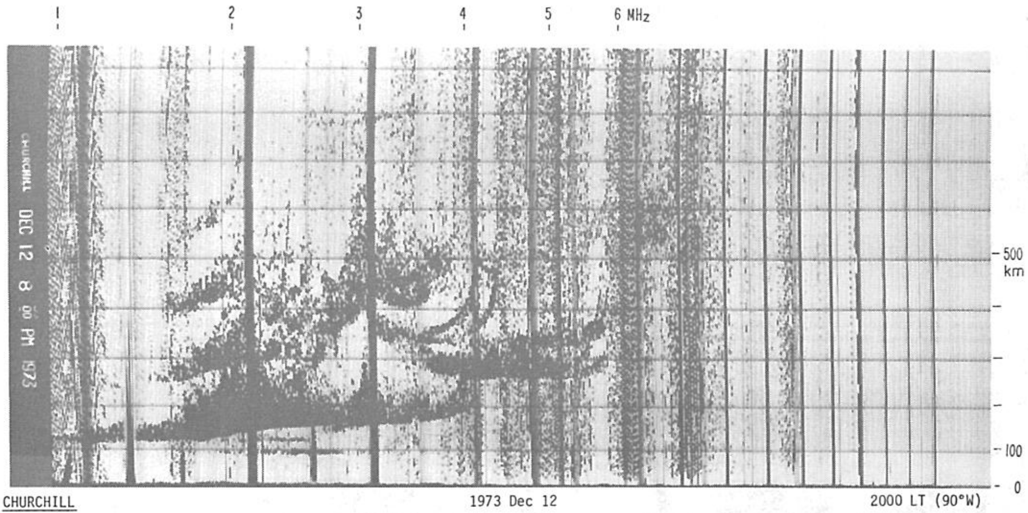
Editor's Note: foF2 = 020-F, (trough). fxI = 053. No frequency spread above 2.3 MHz so P trace represented by q-q 2.5 MHz to 5.3 MHz. Es type a. Two structures present so a,a better. "a" pattern beginning to show some r type structure. F classifications P, F.



CHURCHILL 1973 Dec. 12 1945 LT (90°W)

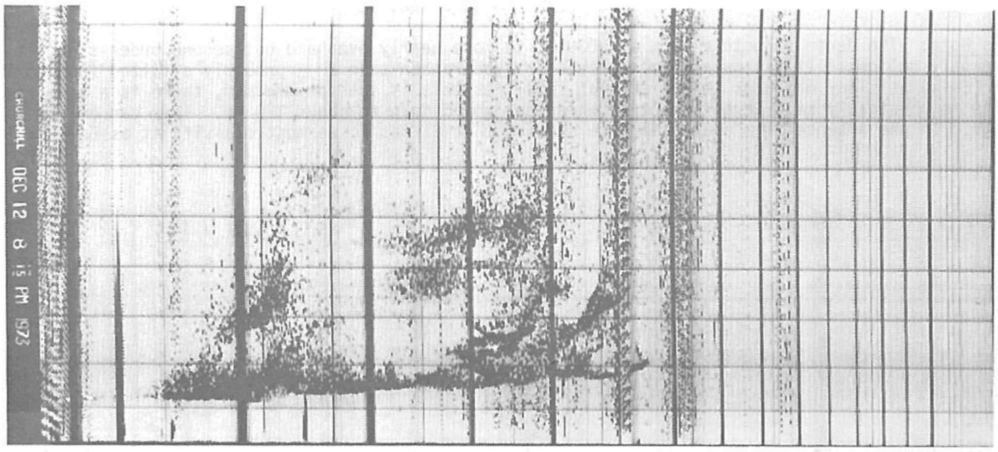
Editor's Note: foF2=017UF. Frequency spread to 023. fxI=060UA. It is not clear that the interpretation is correct. This could be an Es-a trace seen at oblique incidence with fxI really 044. Sequence shows that the latter interpretation is more likely, adopt fxI = 044UA. Es types a,a, suspicion that k present with foE = 150-K but not enough evidence. F classifications P, F.

Fig. 3.7 (cont'd. on next page)



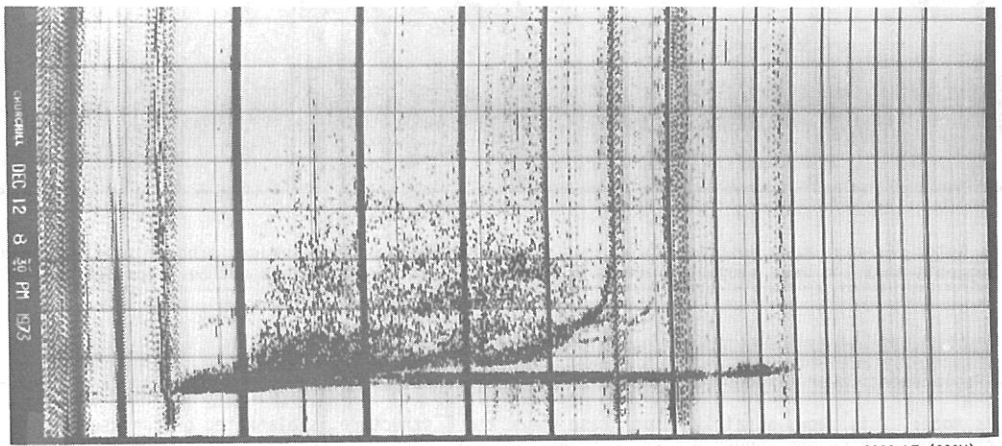
CHURCHILL 1973 Dec 12 2000 LT (90°W)

Editor's Note: Multiples show Es-k with foE = 200UK. (Not typical so doubtful.) The main Es trace shows both a and r type structure but clearly oblique. "a" preferred. F structure hidden by Es-a. fxI possibly (by sequence) 038UA.



CHURCHILL 1973 Dec. 12 2015 LT (90° W)

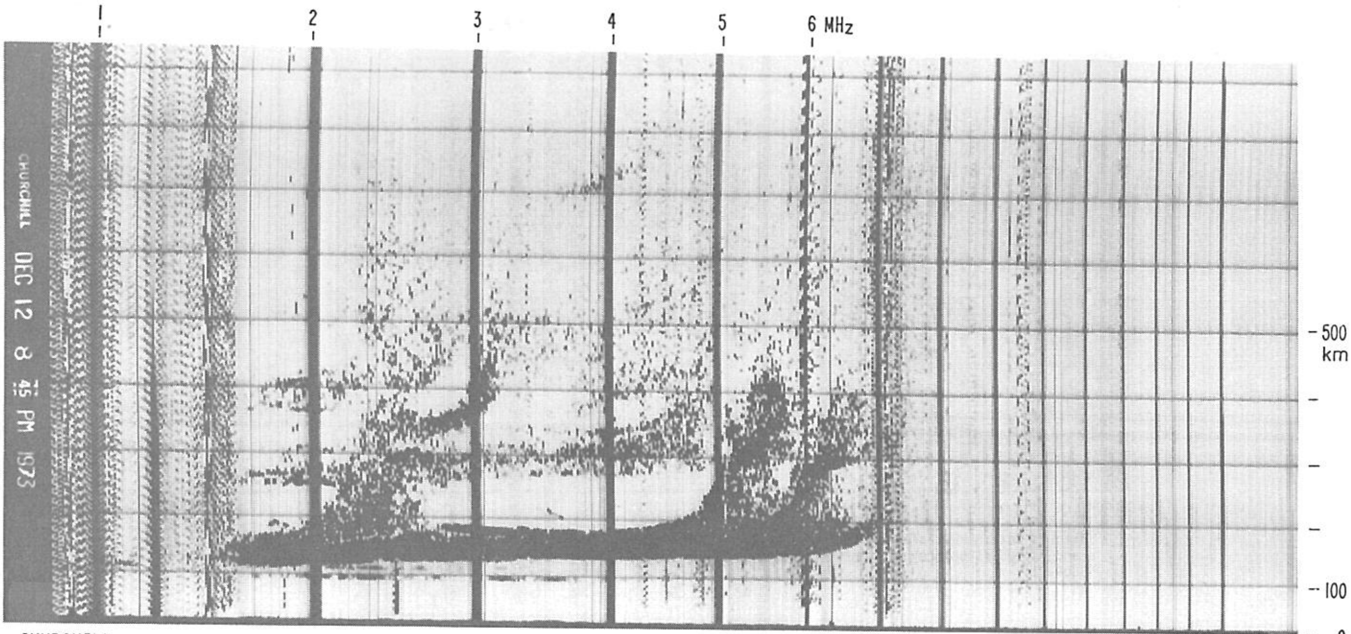
Editor's Note: Auroral Es of type associated with particle E when overhead. Second order suggests foE = 230UK (particle E present). Structure near 400 km possibly an F trace of P type giving fxI = 050UA. Type P. F parameters A.



CHURCHILL 1973 Dec. 12 2030 LT (90°W)

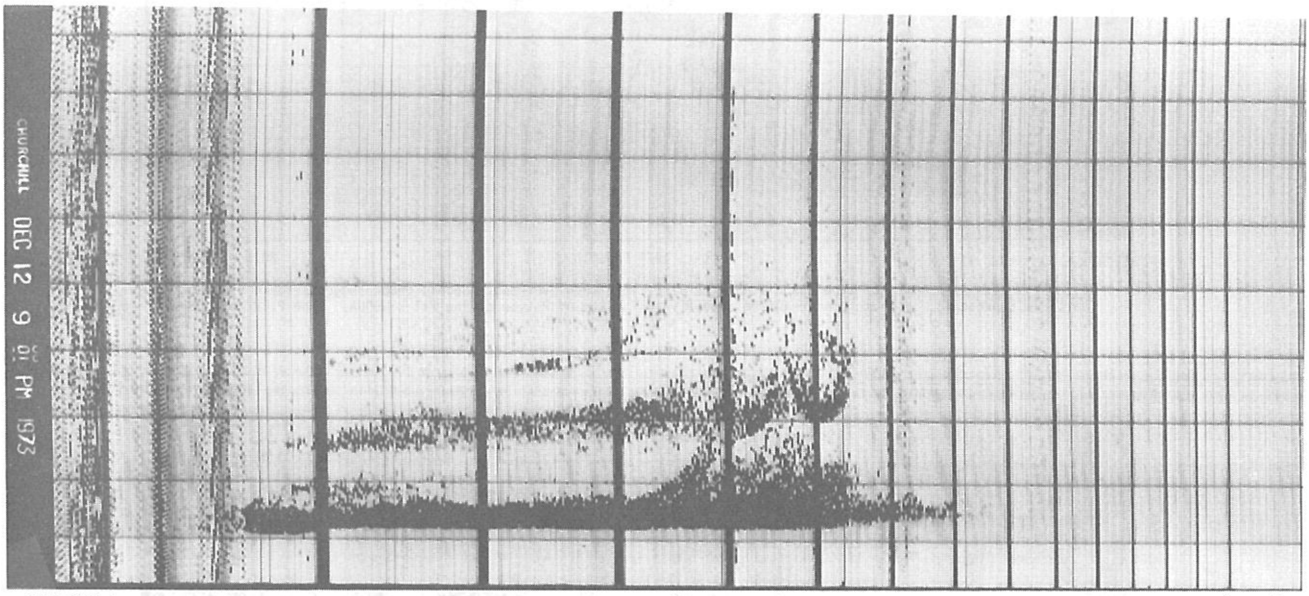
Editor's Note: Auroral Es. A weak second order k trace foE = 230UK is probably the only overhead trace. There is no sign of a second order of the strong c-like trace to about 8.0 MHz, so this is probably oblique. foEs for the densest structure seen from the station will be near 10 MHz if seen overhead.

Fig. 3.7 (cont'd.)



CHURCHILL 1973 Dec. 12 2045 LT (90°W)

Editor's Note: The dense structure seen at 2030 LT is more nearly overhead but second order shows it is still significantly oblique. It is now predominantly an r type rather than a -- probably a tilted (non-horizontal) particle E layer (Es-k) as clear dominant traces seen at foEs. As this is sunspot minimum, there is a significant chance that this is physically an F-layer structure which has moved down to about 120 km. This can only be proved by topside soundings. In the absence of a clear sequence showing that it was F, we must classify it as Es-r or Es-k.



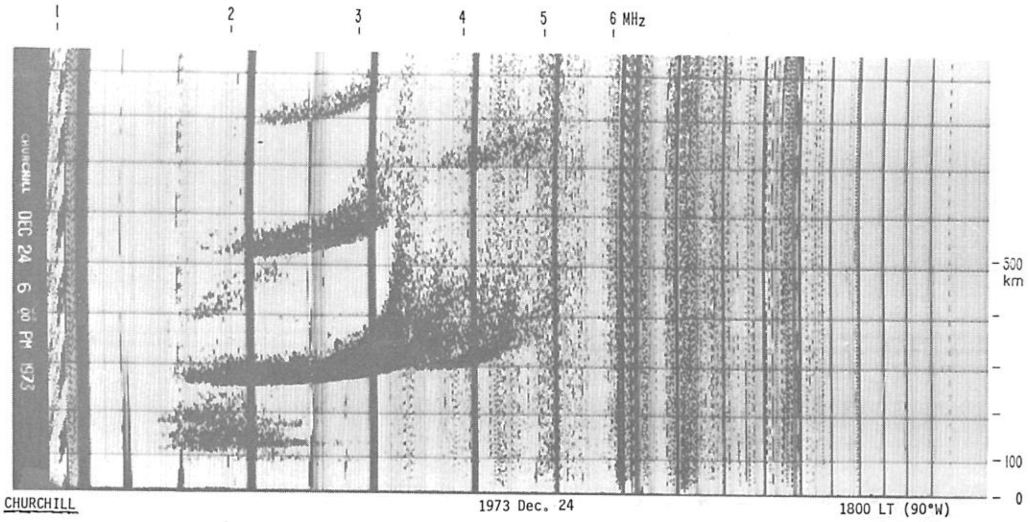
CHURCHILL 1973 Dec. 12 2100 LT (90°W)

Editor's Note: Es-r is more descriptive of this trace than Es-a as three orders present (not overhead). The second order suggests that the weak sloping trace is a weak Es-s trace but this need not be recorded (too doubtful).

Fig. 3.7

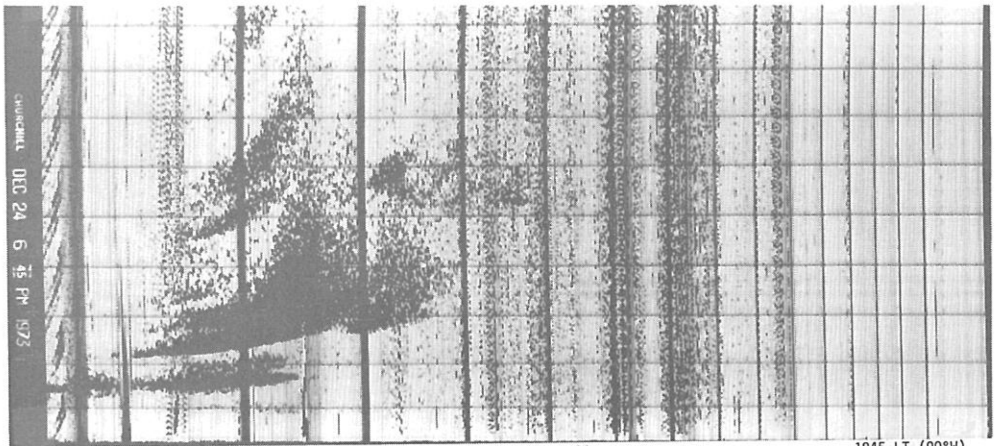
CHURCHILL - Replacement Layer (Trough) Sequence 1973 Dec. 12 1830-2100 LT (90°W)

Editor's Note: This shows a fairly common case where the F structure is blanketed or confused by Es associated with the trough. A second sequence, December 24, 1973, 1800-2245 LT, shows a similar sequence with less Es. Comparing such sequences is the best way to get uniform interpretation.



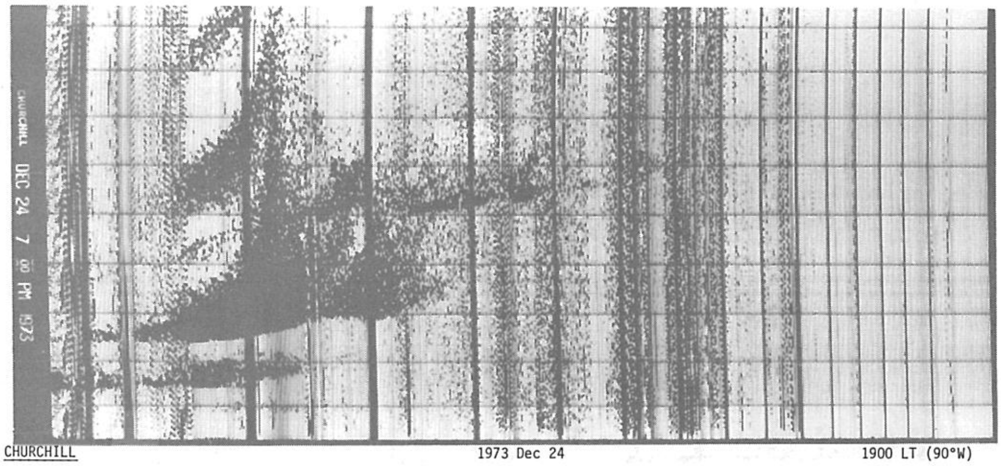
CHURCHILL 1973 Dec. 24 1800 LT (90°W)

Editor's Note: foF2 = 032-F. Weak traces from replacement layer visible at 700 km determine fxI = 050. Spread F classifications P,F. Es type a. If F classifications put in numerical table as descriptive letters (INAG 17, p. 6) foF2 = 032-F, fxI = 050-P. Note third order trace not consistent with first two showing layer starting to tilt.



CHURCHILL 1973 Dec. 24 1845 LT (90°W)

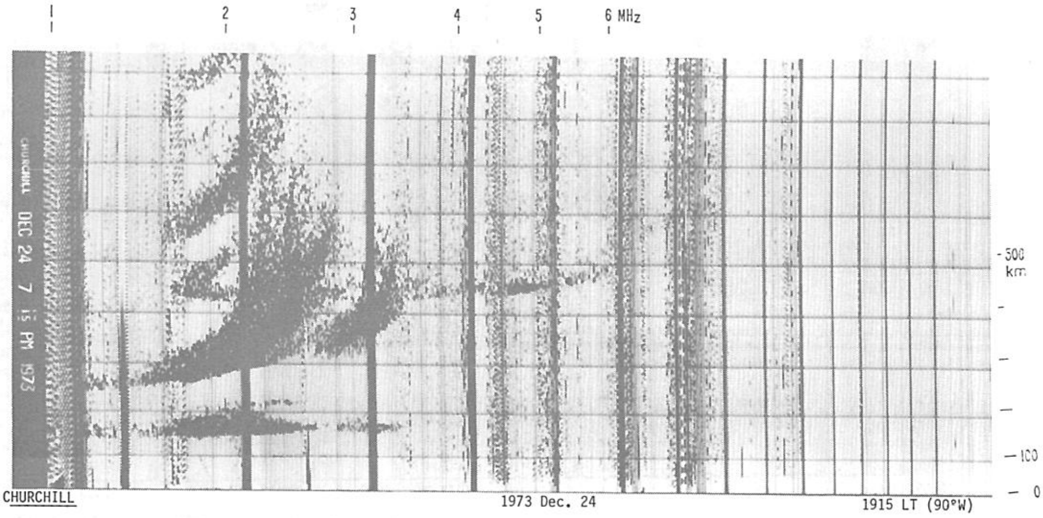
Editor's Note: Similar to 1973 December 12 at 1830 UT but trough is deeper. foF2 = 024UF; fxI = 045. F classifications P,F,(Q?). Frequency spread to 040 so P trace will be difficult to show on f-plot; best to show short dash ending at fxI. Es-a.



CHURCHILL 1973 Dec 24 1900 LT (90°W)

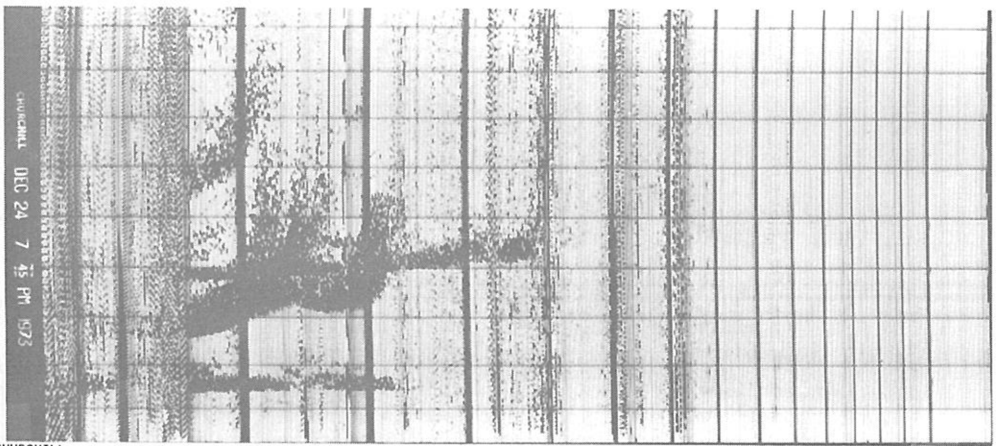
Editor's Note: foF2 = 022-F, frequency spread to 038. fxI = 070. P classification. P type curve can be denoted on f plot from about 040 to 070 by q-q. Note, not possible to show whole of P trace by q-q as overlaps frequency spread. This is not important as lower edge of trace terminates at minimum value of foF2 in trough. When large tilts are present this can show an inverted MUF nose at a lower frequency but the high angle trace of this still goes to the minimum value of foF2. When the P trace crossed the foF2 trace, this means that the station is not seeing the lowest foF2 in the trough -- the converse is not true.

Fig. 3.8 (cont'd. on next page)



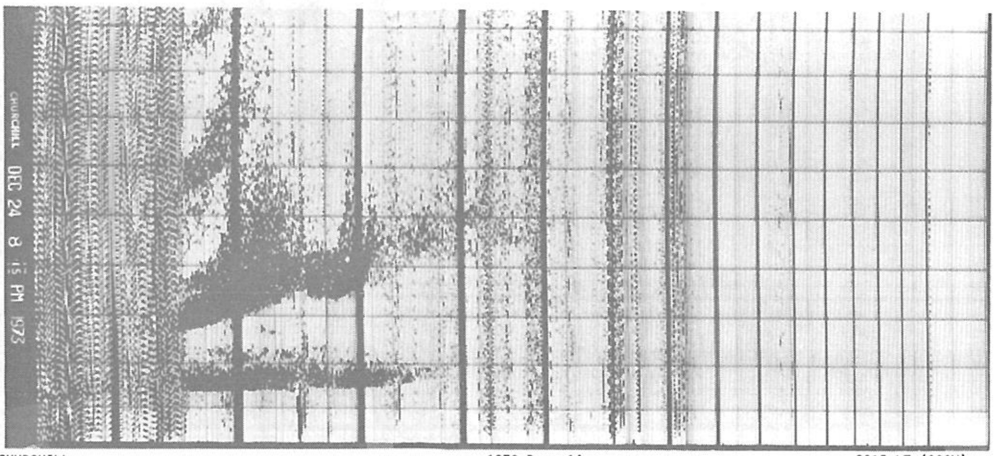
CHURCHILL 1973 Dec. 24 1915 LT (90°W)

Editor's Note: foF2 = 022-F, fxI = 060-S, F types P,F. Note inverted MUF nose at low frequency end of P trace is at lower frequency than foF2. This indicates that station is not at place where foF2 is least, for this trough. High angle trace joins onto foF2. High Es-a.



CHURCHILL 1973 Dec. 24 1945 LT (90°W)

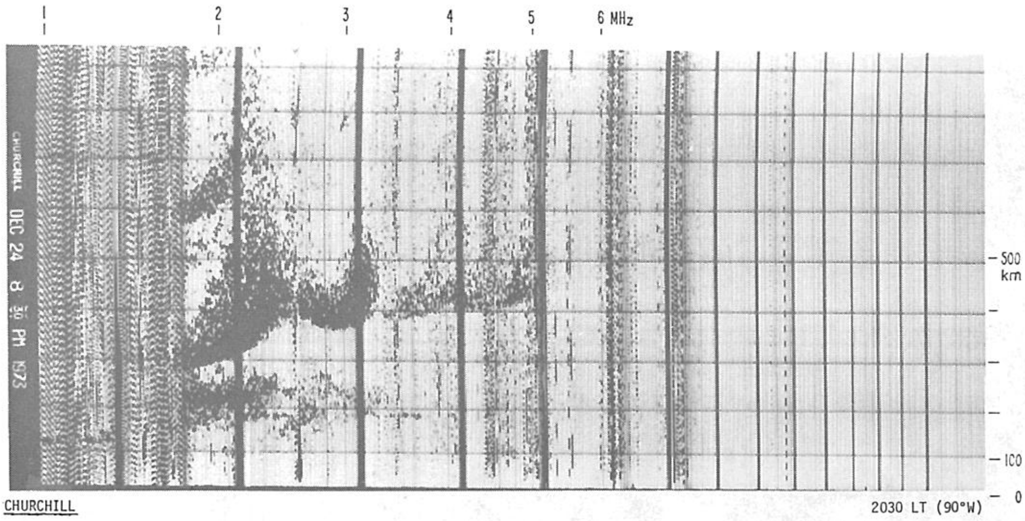
Editor's Note: Dominant o, x rays in thick layer traces do not agree with second order trace. h'F comparison shows the second order more nearly overhead. No unique interpretation possible. Put ● at 022, 024 and 031 on f-plot. Frequency spread ends 033. Denote P by q-q on f-plot between 035 and fxI. foF2 must lie between 022 and strong trace 024, so to get best numerical value use 023UF. Es shows second order and is doubtful a or f. Prefer Es-f2. fbEs = 017-S. foEs = 024. Note in this type of situation foEs is often nearly equal to upper end of frequency spread o pattern, fxEs similar to corresponding x pattern (● also visible at 1915 LT).



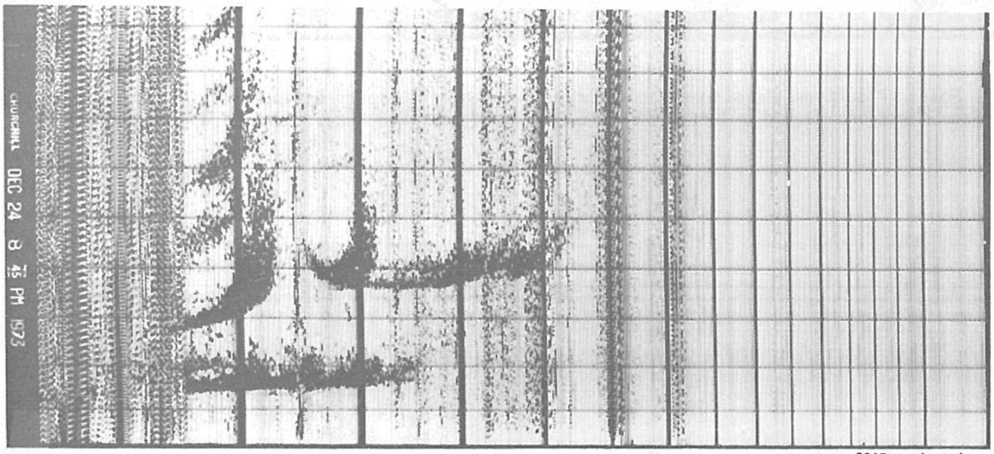
CHURCHILL 1973 Dec. 14 2015 LT (90°W)

Editor's Note: foF2 = 020-F. fxI = 035. Classifications P,F. Apparent Q pattern is bottom end of P trace.

Fig. 3.8 (cont'd.)

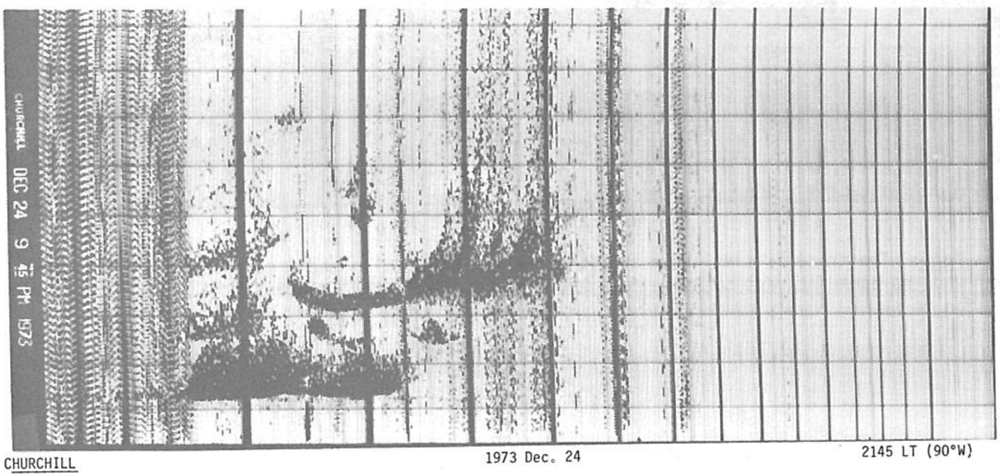


CHURCHILL 2030 LT (90°W)



CHURCHILL 1973 Dec. 24 2045 LT (90°W)

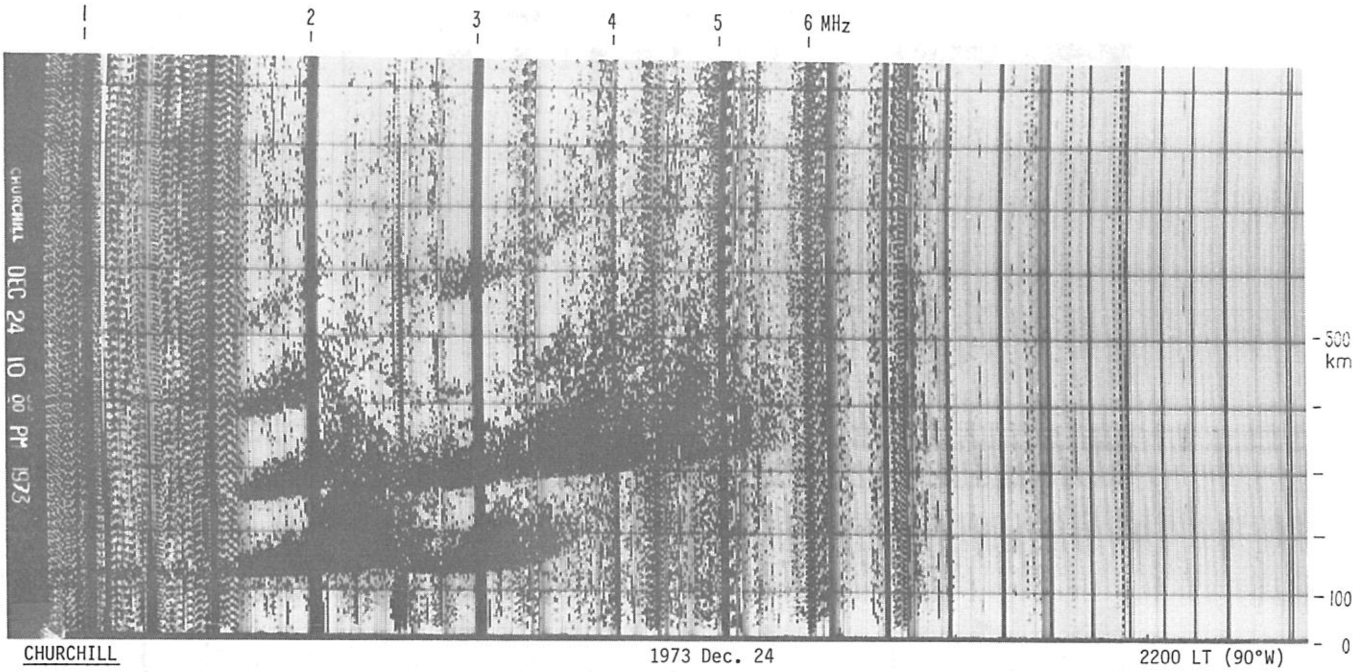
Editor's Note: This is a more common form for a P trace (replacement layer). Frequency spread ends at 032. Use q-q on f-plot between 035 and fxI. foF2 borderline, foF2 = 021-F (from second order) and foF2 = 022UF (center of spread). Prefer foF2 = 022-F on whole. Es-a with some Es-r characteristics. Note traces widen in step with F traces (not instrumental). fxI = 053. F types P, F.



CHURCHILL 1973 Dec. 24 2145 LT (90°W)

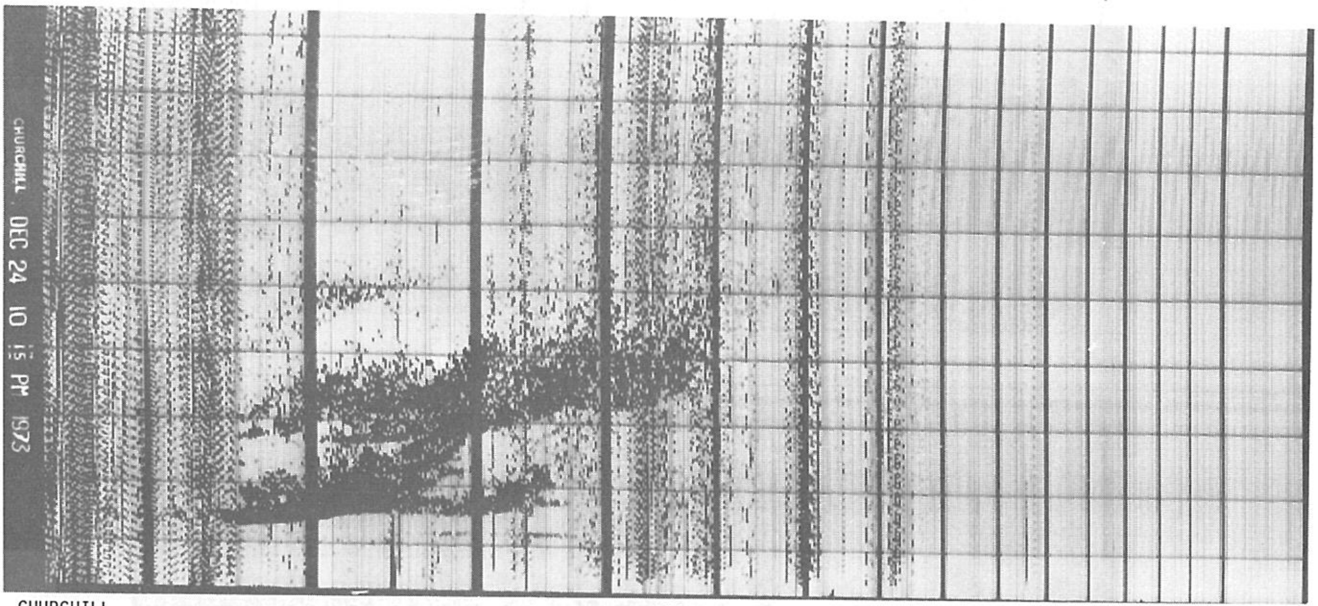
Editor's Note: Es more r than a. Note presence of Es-h on both o and x traces. Prefer Es-r but Es-a would not be wrong. foEs very close to foF2 so interpretation difficult. No second order for P trace so retardation at low frequency end probably due to foF2 as at 2045 LT. Presence of dominant traces at 041, 048 consistent with the trace overhead and Es-k, foE = 023UK present to account for retardation. A gain run would clarify this. As the Es traces are very diffuse and thus not typical of Es-k prefer F-layer interpretation: foF2 = 023EA, fxI = 052. h'F (interpretation difficult) = 260UA. P + mixed classification spread F. fxI = 058-S, fbEs = 017ES. (This doubtful ionogram also consistent with foE = 220UK.) Range spread present 028 to 042.

Fig. 3.8 (cont'd.)



CHURCHILL 1973 Dec. 24 2200 LT (90°W)

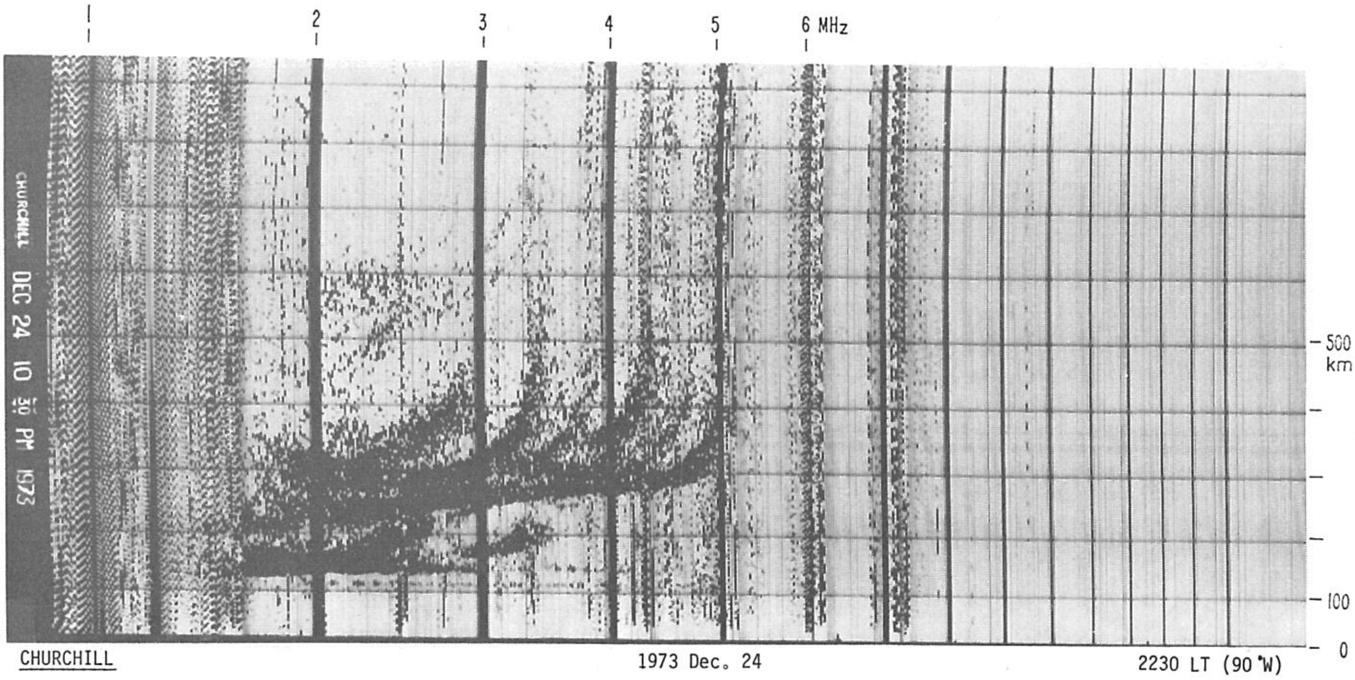
Editor's Note: P pattern shows some second order but dominant traces disappeared. Es shows o, x patterns so r type. From first and second orders h'F = 270EA (deduced near 2.8 MHz). Same Es as at 2145 LT.



CHURCHILL 1973 Dec. 24 2215 LT (90°W)

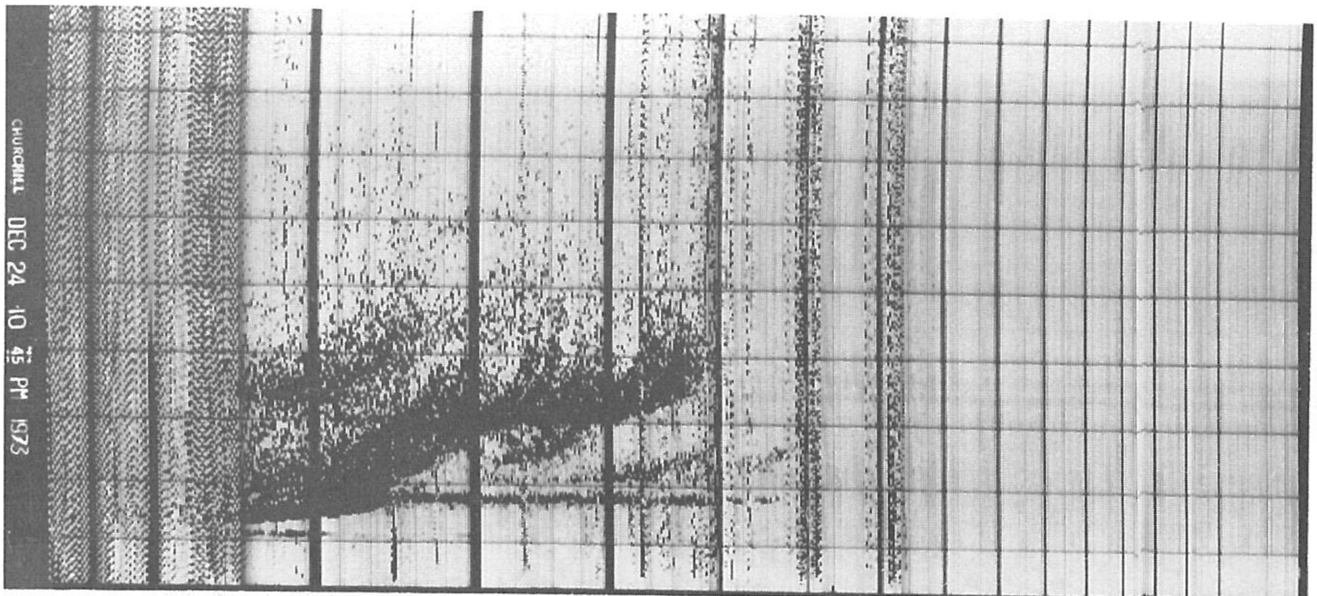
Editor's Note: The trace is similar to a FLIZ trace. fxI = 050, spread F classification P. Es-r. Probably not overhead, no dominant rays but some frequency spread clear. Much range spread.

Fig. 3.8 (cont'd.)



CHURCHILL 1973 Dec. 24 2230 LT (90°W)

Editor's Note: When a mainly range spread trace as at 2215 LT changes to one with clear dominant traces, place solid dots at these traces on f-plot.

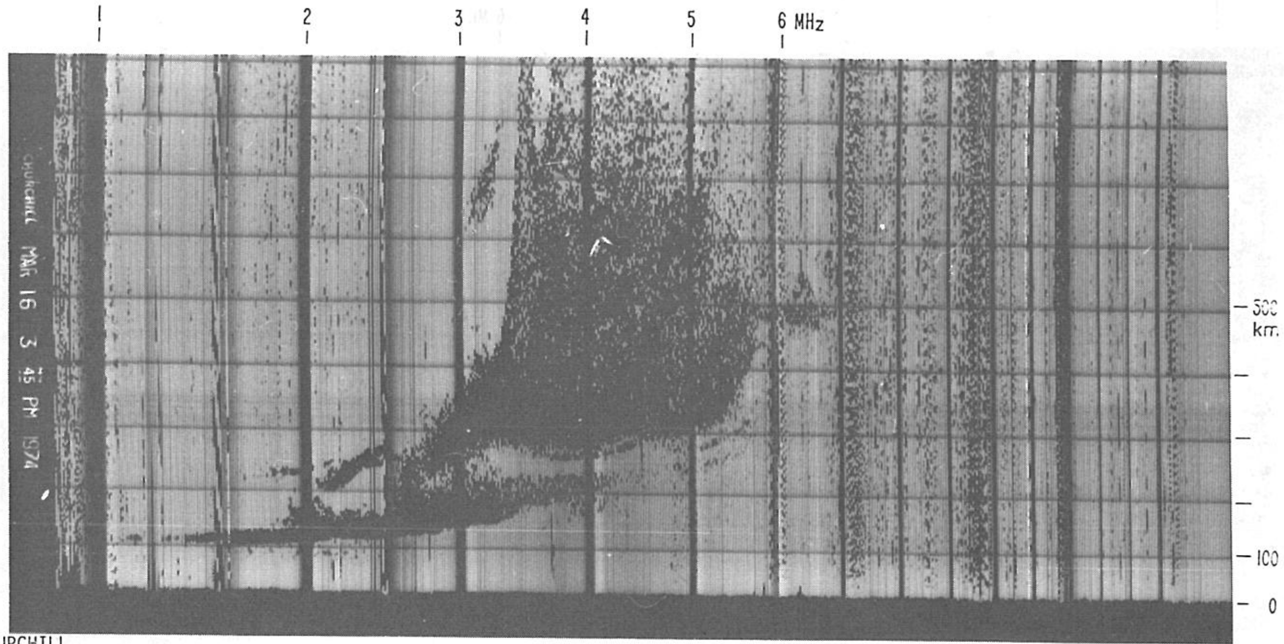


CHURCHILL 1973 Dec. 24 2245 LT (90°W)

Editor's Note: Superimposed Es-a and F patterns.

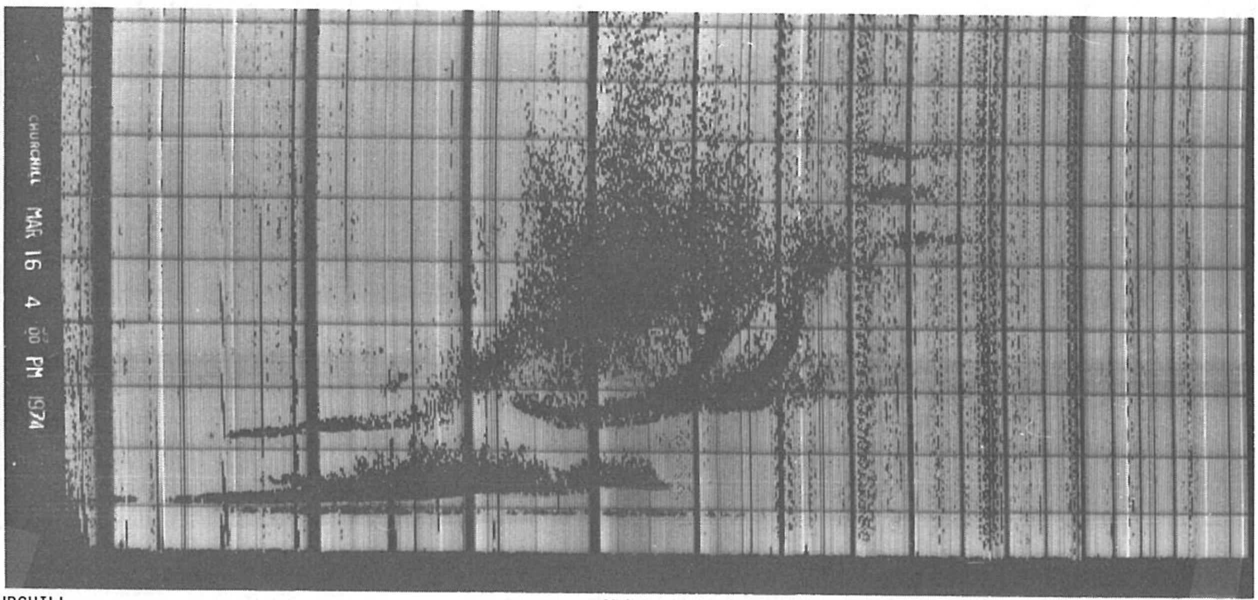
Fig. 3.8

CHURCHILL - Replacement Layer (Trough) Sequence - 1973 December 24 1800-2245 LT (90°W)



CHURCHILL 1974 Mar. 16 1545 LT (90°W)

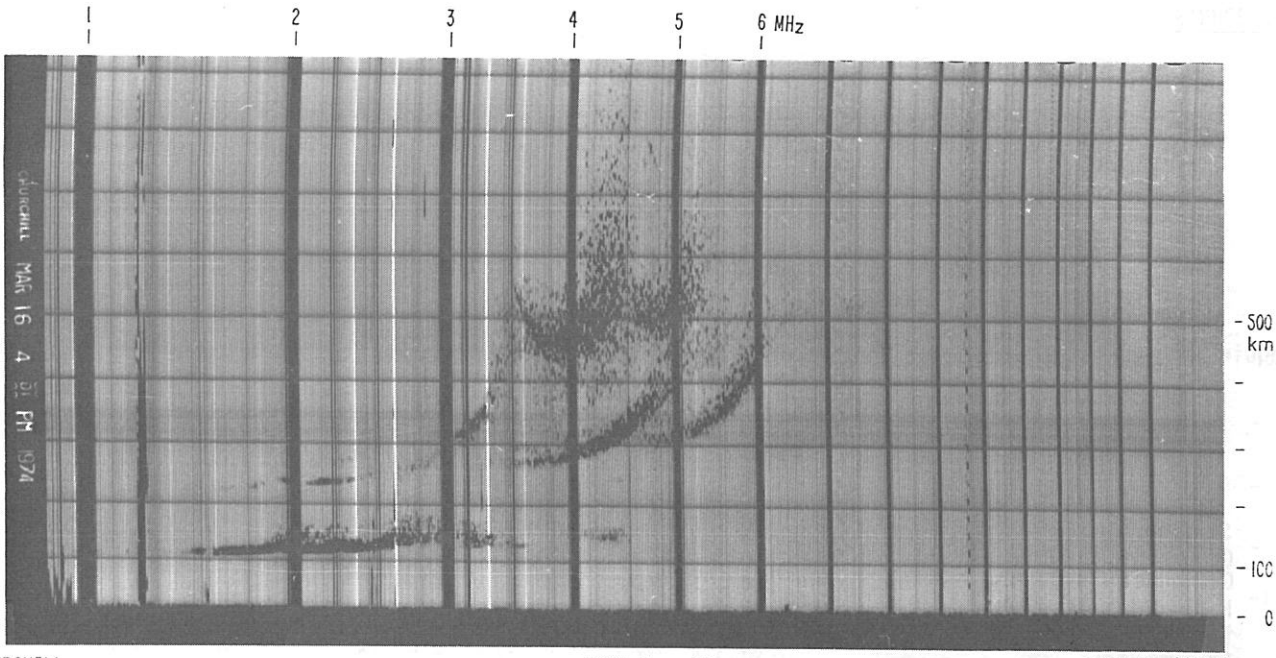
Editor's Note: Second order suggests little tilt. Inner edge can be used to deduce foF2. foF2 = 035UF. Expected value of foE about 024, of foF1 340 at this time of day. A low gain ionogram would probably allow h'F2 to be measured, an important parameter in this type of pattern sequence.



CHURCHILL 1974 Mar. 16 1600 LT (90°W)

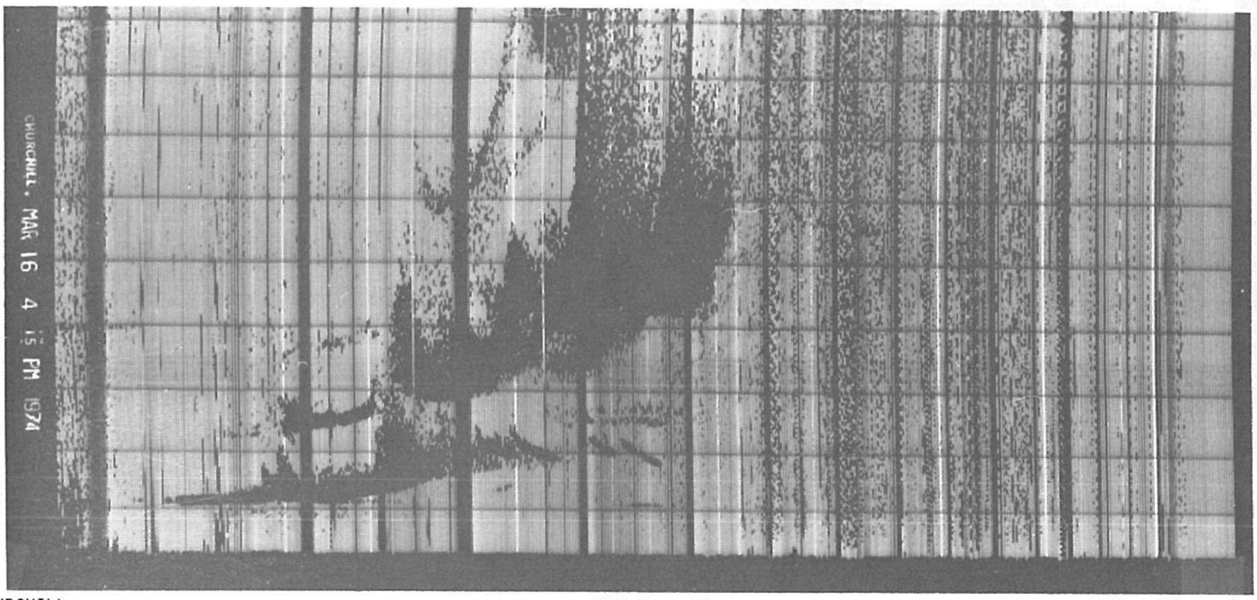
Editor's Note: Second layer comes in under old layer. Distinct o, x traces only slightly broadened with near correct separation. This most likely to be nearest overhead. foF2 = 053-F, fxI = 070, h'F = 250. Old layer shown on f-plot by frequency spread 035 to 060. o, x entries for lower trace will show that different patterns probably are present, solid dot at inner edge would show this more clearly. Ridge very nearly overhead.

Fig. 3.9 (cont'd. on next page)



CHURCHILL 1974 Mar. 16 1601 LT (90°W)

Editor's Note: Low Gain Ionogram. o, x traces present on both patterns. Upper shows foF1 of normal shape so is most likely to be overhead. Note upper ends of lower pattern no longer turn vertical but end oblique. This continuous trace oblique. foF2 = 045UF, fxI = 061, F classifications P, F. Note on f-plot it is only possible to show critical frequencies and frequency spread unambiguously with present rules. The layer shape has changed since 1600 LT. For tabulation this shows what is happening more clearly and should be used.



CHURCHILL 1974 Mar. 16 1615 LT (90°W)

Editor's Note: Second order shows F layer tilted. foF1 = 340 foF2 = 041-F. Es non-standard type a.

Fig. 3.9

CHURCHILL - Replacement Layer (Trough) Sequence 1974 Mar. 16 1545-1615 LT (90°W)

ST. JOHN'S

Notes by Editor:

Selected ionograms have been reproduced in the "Canadian Ionospheric Data" books since January 1974.

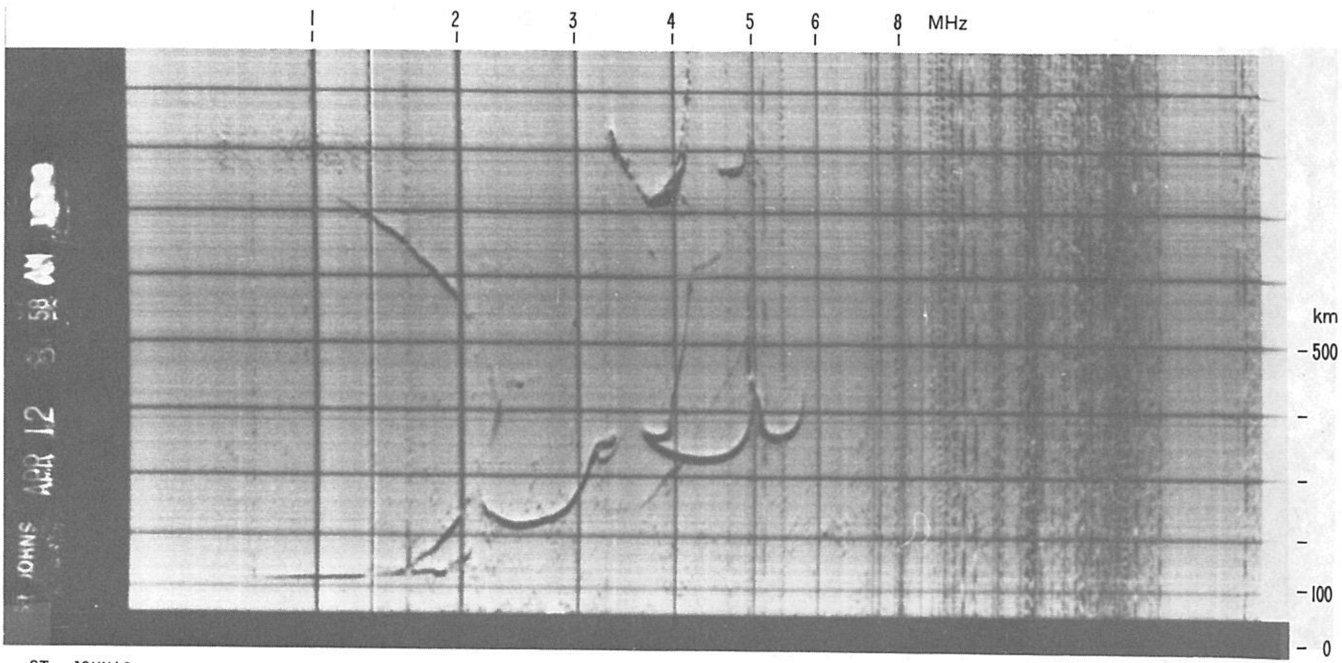
The following ionograms were provided by Pat Brown, Telecommunications Engineering Laboratory, Canada.

These ionograms are examples of tilts associated with travelling disturbance type phenomena. They show some of the curious patterns produced when the height or critical frequency changes rapidly with position in an otherwise normal layer.

Enquiries:

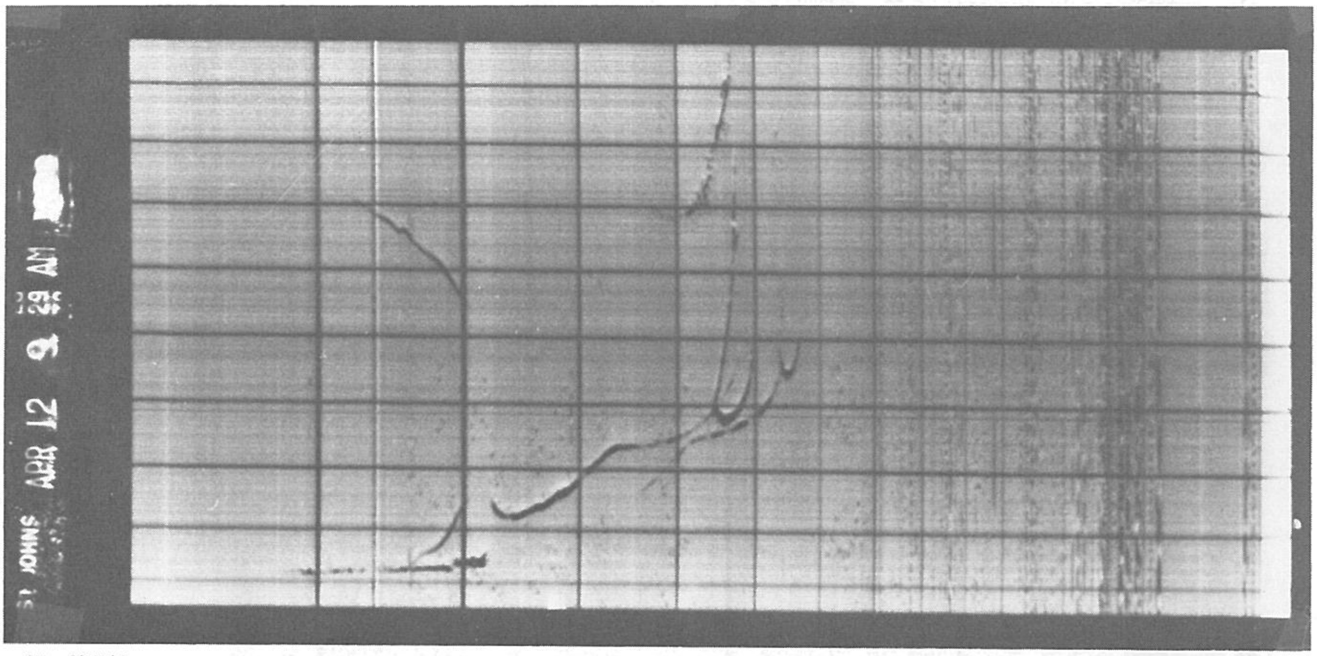
Director
Telecommunications Engineering Laboratory
1241 Clyde Avenue
K2C 1Y3
Ottawa, Ontario, Canada.

Station Name:	St. John's	
Geographic coordinates:	Lat. N 47.6°	Long. E 307.3°
Geomagnetic coordinates:	Lat. N 58.4°	Long. E 21.82°
Magnetic Dip:	72.3°	
Time Used:	60.0°W (UT - 4 hours)	
Equipment:	SI-1	
Frequency Range:	1.0-16 MHz	
Height Range:	0-1000 km	
Duration of Sweep:	20 sec.	
PRF:	30 per sec.	
Pulse Length:	50 μsec.	
Peak Power:	2.5 kw	



ST. JOHN'S 1974 Apr. 12 0858 LT (60°W)

Severe tilt. foFl = 340UY, fcF2 = 042UY, h'F2 = 710UY, h'F = 210, foF2 for oblique trace is 050.



ST. JOHN'S 1974 Apr. 12 0930 LT (60°W)

Editor's Note: Effects of Layer Tilt. Strong north-south tilt near foF2. foF2 = 050-V. Note strong focusing of high angle ray of spur. This is same phenomenon as seen on high Es and F retardation near foE but with larger tilts than are usual.

Fig. 3.10

ST. JOHN'S 1974 Apr. 12 0858 and 0930 LT (60°W)

Editor's Note: Curved trace running from 700 km at 2.2 MHz to 400 km at 3.2 MHz and back to 2.7 MHz at 125 km is an interference spike probably due to a faulty fluorescent lamp.

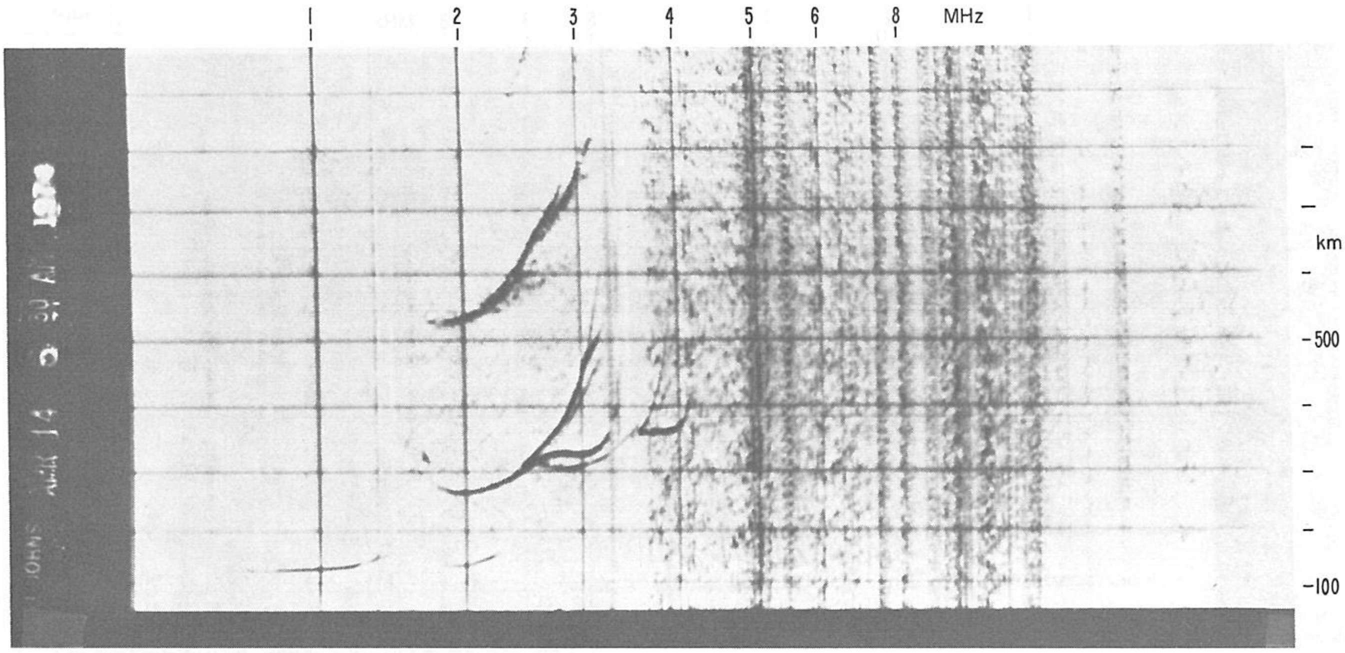


Fig. 3.11

ST. JOHN'S 1974 April 14 0630 LT (60°W)

Editor's Note: Letter Y Severe Tilt. The main trace is typical of the type of patterns deserving foF2 = 032EY if spur had been absent. Note difference in shape of first and second order traces at 032, 500 and 800 km. Bottom part of trace below 035 definitely from a horizontal layer. o - x separation on spur checks, other part of pattern also probably nearly overhead. foF2 = 033UV best. Spur shows some type of trace as main trace, i.e. does not go vertical, but error likely to be within U limits.

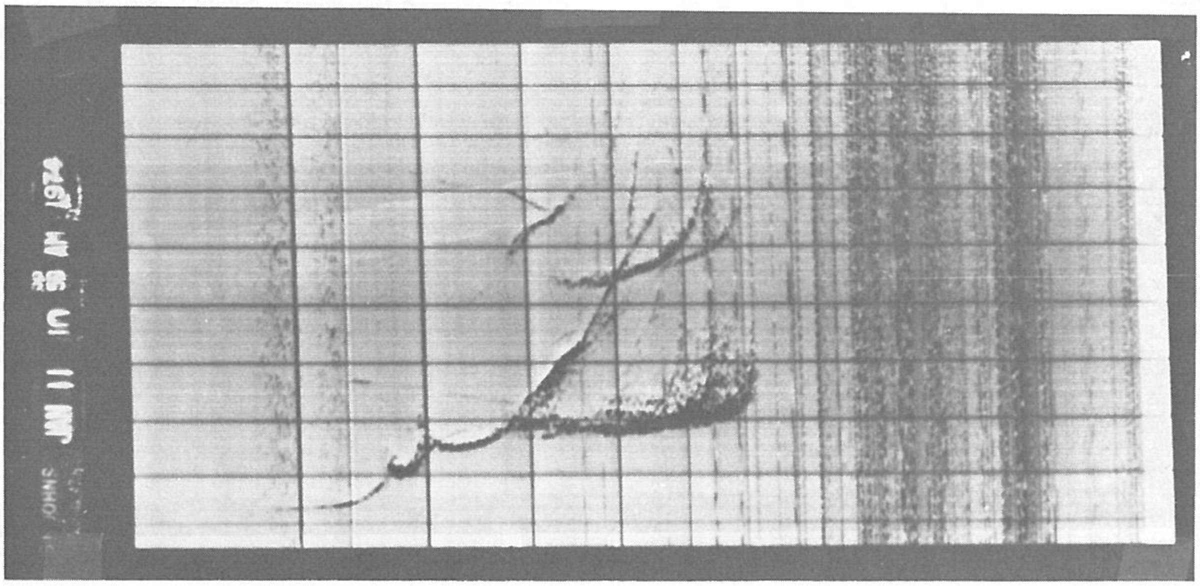


Fig. 3.12

ST. JOHN'S 1974 Jan. 11 1059 LT (60°W)

Editor's Note: foF1 varying rapidly with position. Sloping linear F1 trace is oblique as shown by second order. Shape typical of tilt effect at foF2. (Fig. 3.34 in Handbook). foF1 probably varies by about 1 MHz over a few tens of km, e.g., from 280 to 380.

Ionograms from United States operated ionosondes

The ionograms reproduced for the following stations have been selected and provided by Raymond O. Conkright and Lucile Hayden of World Data Center A, Boulder, Colorado.

Barrow -- Operations began at this station in December 1949. It was operated by NBS and ESSA and closed November 1965.

Station name:	Barrow	
Geographic coordinates:	Lat. N 71.30°	E Long. 203.20°
Geomagnetic coordinates:	Lat. N 68.63°	E Long. 241.52°
Invariant latitude:	69.43°	
Magnetic dip:	80.3°N	
Time used:	150°W (UT - 10 hours)	
Ionosonde equipment type:	C 3/4	
Frequency range:	0.25-20.0 MHz (from Nov. 1963)	
Sweep time:	30 sec.	
Approximate peak power:	20 kW	
Pulse repetition rate:	60 Hz	
Pulse length:	50 μsec	
Aerial type:	Vertical Delta	
Routine sounding:	Quarter-hourly, plus hourly gain runs	
Height range:	700 km	
Height scale:	Linear	
Frequency scale:	Logarithmic	

College -- Operations began at this station in July 1941. Until the end of July 1946 the station was operated by the Carnegie Institution of Washington (Department of Terrestrial Magnetism). From August 1946 the station has been an associated laboratory of the NBS, ESSA and NOAA.

Station name:	College	
Geographic coordinates:	Lat. N 64.90°	E Long. 212.20°
Geomagnetic coordinates:	Lat. N 64.76°	E Long. 256.98°
Invariant latitude:	64.66°	
Magnetic dip:	77.1°N	
Time used:	150°W (UT - 10 hours)	
Ionosonde equipment type:	C 3/4	
Frequency range:	0.25-20.0 MHz	
Sweep time:	30 sec.	
Approximate peak power:	20 kW	
Pulse repetition rate:	60 Hz	
Pulse length:	50 μsec	
Aerial type:	Vertical Delta	
Routine sounding:	Quarter-hourly	
Height range:	600 km	
Height scale:	Linear	
Frequency scale:	Logarithmic	

Enquiries about Barrow and College should be addressed to:

Raymond O. Conkright
World Data Center A for
Solar-Terrestrial Physics
Boulder, Colorado U.S.A. 80302

Fig. 4.1

Editor's Note: BARROW. Note unusual shape of normal E trace in summer. This is typical of a station with no valley between E and F. In those circumstances forking of the E trace is common, as is shown in both noon and midnight June records. Second order and z mode traces can be used to identify main trace and hence foE. The equinox day curve is more difficult, but as the thick E-layer curve is very subject to small cusps, physically the cusp at 2.8 MHz is not likely to be foE.

Notes: Typical BARROW ionograms.

Summer Day	June 13, 1964	1159 LT (150°W)

Note unusual shape of E trace. This suggests E tilted. This type of E often breaks up into a series of minor cusps. TID causes z-mode trace to be different from o mode and does not show z trace from foF0.5 at 034. This is therefore likely to be transient.

Summer Night	June 15, 1964	2359 LT (150°W)

foE would be expected to be below 2 MHz. Es type k (particle E) present with foE = 245-K. Note z traces present. Normal E can also be seen at foE = 021-A. Note presence of second order k trace confirming foE value and showing retardation at 021.

Equinox Day	Sept. 11, 1964	1145 LT (150°W)

Equinox Night	Sept. 13, 1964	2259 LT (150°W)

Es-a or Es-r present. Similar shapes and correct o-x interval indicate best interpretation Es-r. foEs = 022. Some a also present so type as r,a.

Winter Day	Dec. 15, 1964	1159 LT (150°W)

Retardation at fbEs, therefore E present. h'Es shows Es type is low. z trace visible near fzF2. h'E expected to be near 140 km so weak trace with h'E = 150EA likely to be normal E.

Winter Night	Dec. 11, 1964	0015 LT (150°W)

F layer usually blanketed by Es. foF2 expected to be near 025. Nontypical Es could be a or r. Blanketing of F suggests main trace is r. Trace at h'F = 260 possibly F but shows remarkably little thickness. If it is F, fbEs = (foE)-K particle E with foE = 270UK. foEs for this trace is 032, the same as foF2. The weak trace to about 065 is most likely to be an Es-a (note turn up at end) or Es-r seen at oblique incidence.

TYPICAL BARROW IONOGRAMS

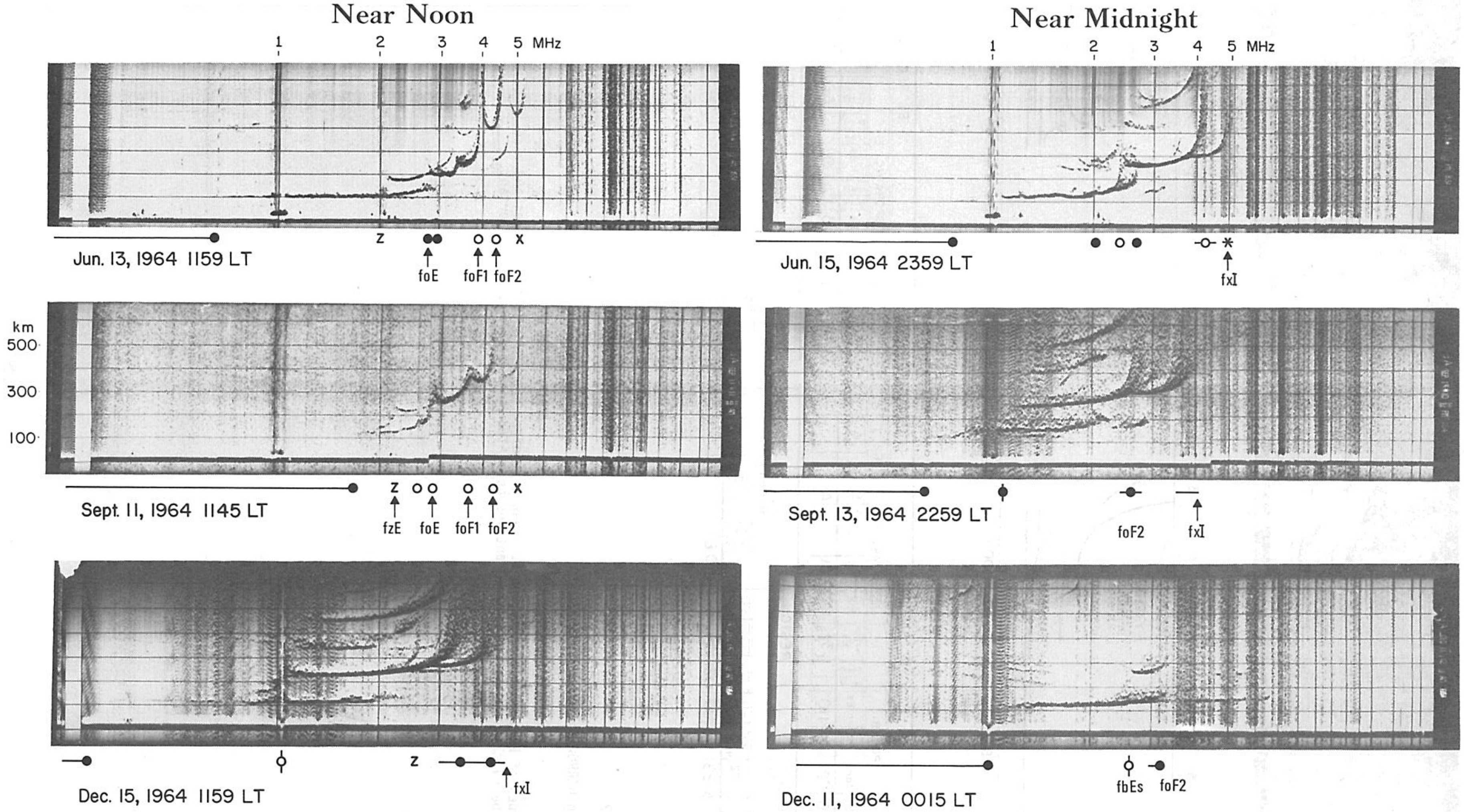
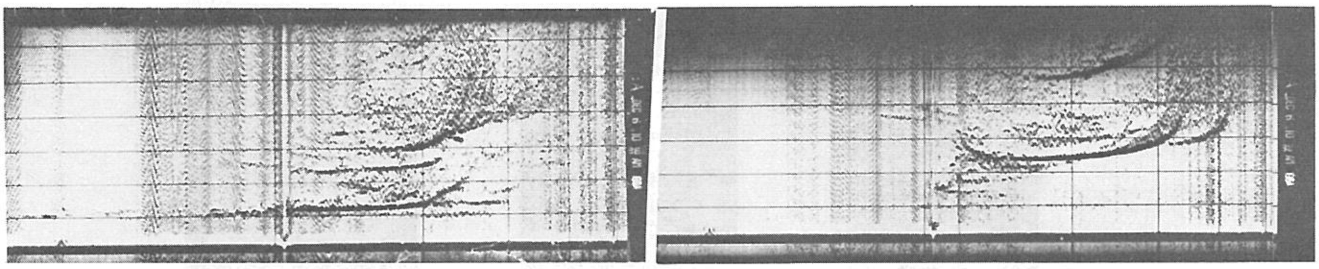
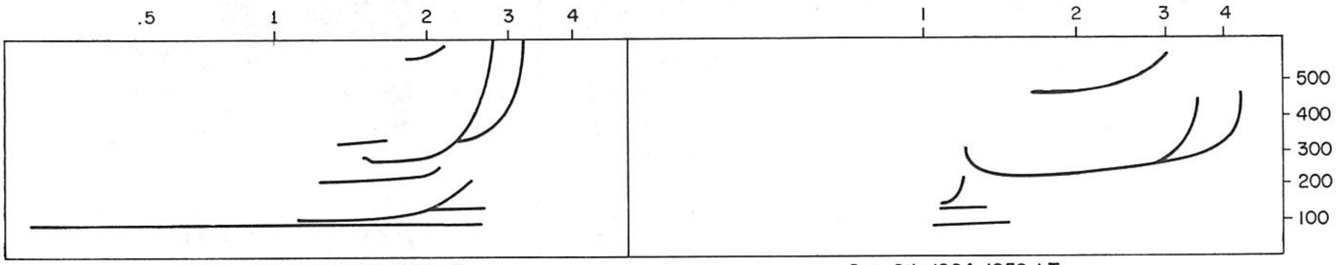


Fig. 4.1





Barrow: Dec. 6th 1964 1000 LT

Dec. 6th 1964 1059 LT

Barrow, Dec. 6th 1964, 1000 LT: E region

f-min			Sporadic E								Normal E						E2	
fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	Type of Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2
03			016	021			110			$r^3\ell s$	160	E	A			A		

Barrow, Dec. 6th 1964, 1000 LT: F region

												Heights								
foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES	hpF2	QUA	DES
				028		U	F	021	040			280	E	N						

Dec. 6th 1964, 1059 LT: E region

f-min			Sporadic E								Normal E						E2	
fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	Type of Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2
10			011	013	J	A	098			ℓa	130			155	E	A		

Dec. 6th 1964, 1059 LT: F region

												Heights								
foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES	hpF2	QUA	DES
				035				031	043			230								

Fig. 4.2

Notes on BARROW

Dec. 6, 1964 1000 LT (150°W)

Four types of Es are present r3,ℓ,s,a. Weak a is often associated with r traces and vice versa so type entry should be r3,ℓ1,s (in full). Only 3 entries permitted by rules, pick most important.

Fig. 4.3

Notes on BARROW - 5 - 7th Dec. 1964

Dec. 5, 1964 1000 LT (150°W)

Es type a,a. Spread F classification F (in presence of strong Es-a apparent Q traces may be Es-a or E+F as here).

Dec. 5, 1964 1100 LT (150°W)

Es type a (or a,a). Spread F classification F.

Dec. 5, 1964 1200 LT (150°W)

Es type f. Ionogram not clear enough to show if Es-k present. Retardation at different frequencies on first and second order trace suggest Es-k with foE = 100UK. Spread F classification F.

Dec. 6, 1964 1000 LT (150°W)

Es type r3 with 's' from foEs and a superposed. Second order F trace not overhead. foF2 = 026-F. Spread F classification P (polar spur), F. Similarity between F and E traces makes decision on whether Q present difficult -- could well be Es-a or Es-r multiples.

Dec. 6, 1964 1059 LT (150°W)

Es types a,k. foE = 100-K. Frequency and range spread classifications F,Q.

Dec. 7, 1964 1059 LT (150°W)

Gain low. Es types r2, fbEs = 030. foEs = 032.

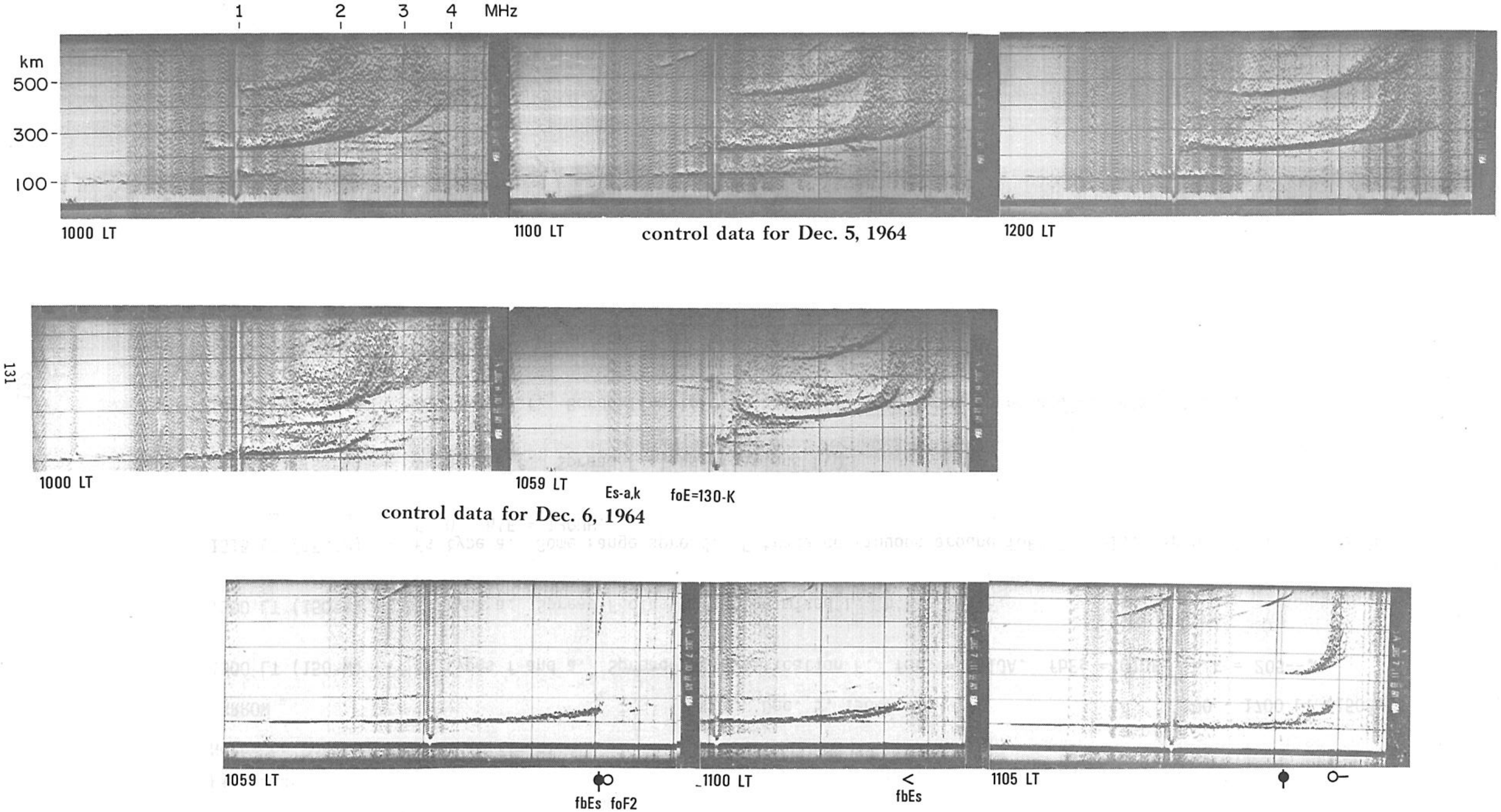
Dec. 7, 1964 1100 LT (150°W)

Nonstandard r trace. Second order shows lower trace overhead and not an Es-a. fbEs given by limit less than, <.

Dec. 7, 1964 1105 LT (150°W)

No x mode F trace visible at foEs so this is a complex Es-r, r pattern. Note higher r has foEs $\cong$ foF2, a common situation.

Barrow Blanketing Type r Sporadic



control data for Dec. 5, 1964

control data for Dec. 6, 1964

Total blanketing Es-r on Dec. 7, 1964

Fig. 4.3

Fig. 4.4

Notes on Dec. 5, 1964 stratification

BARROW — Dec. 5, 1964 — 1300 - 1700 LT (150°W)

1300 LT (150°W) - Es types f and a. Spread F classification F. foEs = 051JA. fbEs = 010Es, h'F = 205--.

1500 LT (150°W) - Es type a. Spread F classification mixed L. h'F = 195-F.

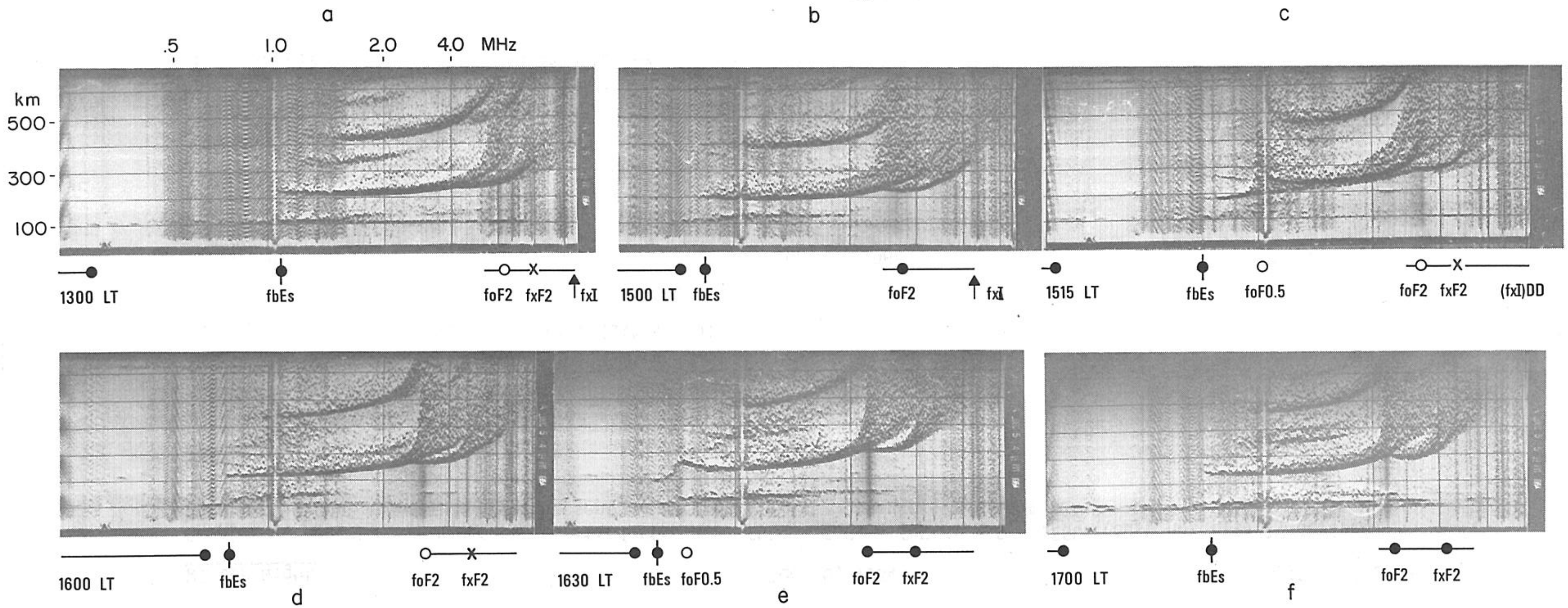
1515 LT (150°W) - Es type a. Some range spread. F trace continuous around foF0.5 = 010. Spread F classifications F, Q. h'F = 180UH.

1600 LT (150°W) - Es type a,f. Spread F classifications F,Q.

1630 LT (150°W) - Es types a,f. Borderline foF0.5, but still continuous so no doubt. h'F = 195UH.

1700 LT (150°W) - Es type a. Mixed spread F. h'F = 230-F.

Barrow Dec. 5, 1964



Stratification between E and F layers
(See page 18, UAG-23) (Es-a also present)

Fig. 4.4

Fig. 4.5

Notes on typical COLLEGE ionograms

<u>Winter Day</u> Dec. 2, 1964 1200 LT (150°W)

Low Es partially blanketing normal E. foEs = 040JA. h'E = ----A.

<u>Winter Night</u> Dec. 6, 1964 0145 LT (150°W)

Complex auroral Es. F trace shows retardation near fbEs. fbEs = foE-K, foE = 120UK (cusp not clearly defined). h'Fx - h'Fo confirms thick layer present. Es types a,k,ℓ. ℓ blankets at about 007US.

<u>Equinox Day</u> Mar. 9, 1964 1245 LT (150°W)

Gain too low and pulse too narrow for good recording.

<u>Equinox Night</u> Mar. 10, 1964 0125 LT (150°W)

Es type a. foF2 = 014-F. Polar spur just visible.

<u>Summer Day</u> Jun. 3, 1964 1200 LT (150° W)

<u>Summer Night</u> Jun. 5, 1964 0000 LT (150°W)

Retardation at fmin. fmin = 008-R. Es types a and c. foEs for c trace 022, fbEs = 012. h'E = B, (fully (fmin) EB). fxI given by weak polar spur trace, fxI = 055-P. Spread F classifications P,F. Descriptive P, F or Q can be used to show type of spread F in standard tables (INAG17, p. 6).

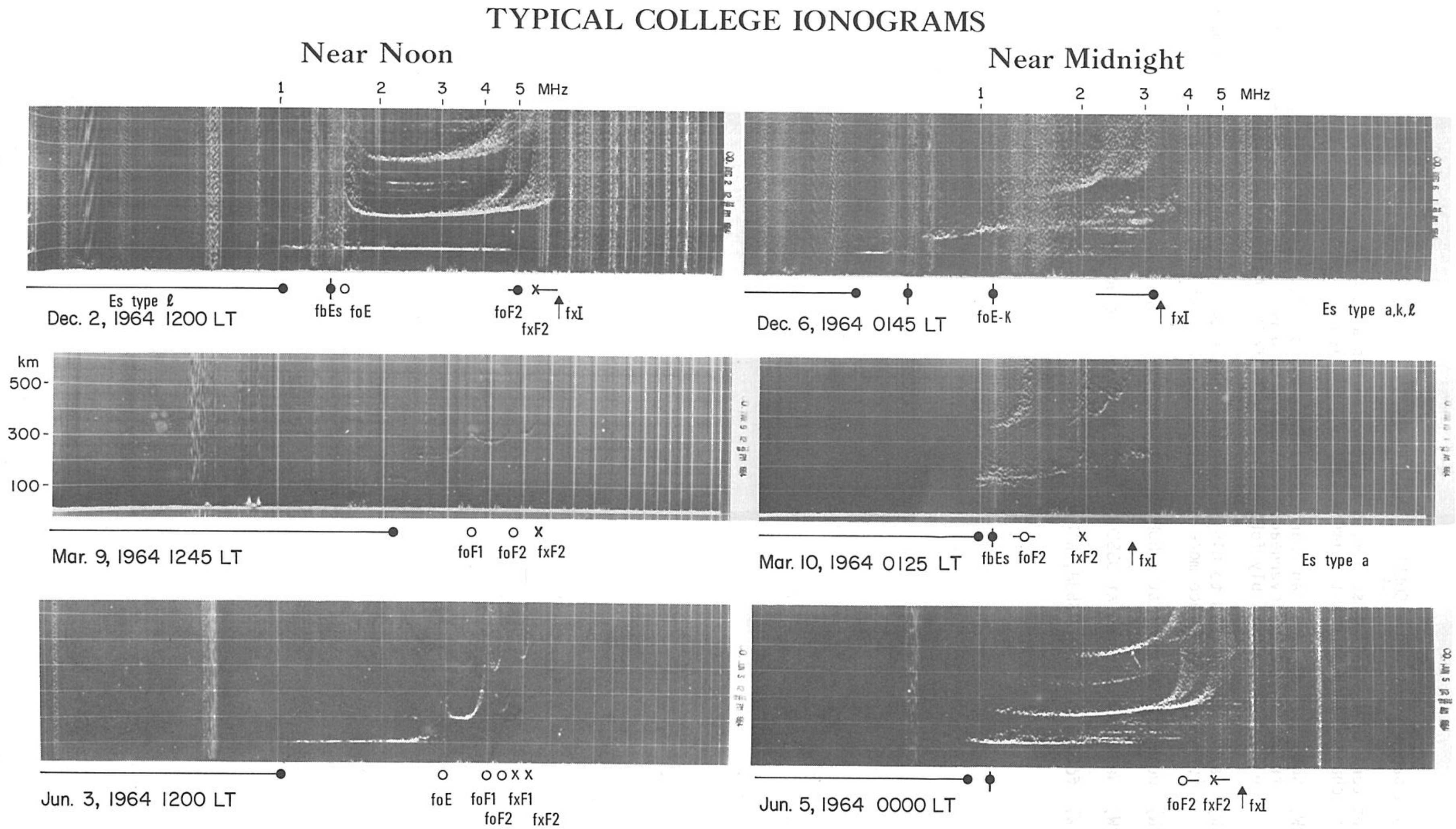

TYPICAL COLLEGE IONOGRAMS
Near Noon
Near Midnight
1 2 3 4 5 MHz
Es type ℓ
Dec. 2, 1964 1200 LT
fbEs foE
foF2
fxF2
fxI
Dec. 6, 1964 0145 LT
foE-K
fxI
Es type a,k,ℓ
km
500
300
100
Mar. 9, 1964 1245 LT
foF1 foF2 fxF2
Mar. 10, 1964 0125 LT
fbEs foF2
fxF2
fxI
Es type a
Jun. 3, 1964 1200 LT
foE foF1 fxF1
foF2 fxF2
Jun. 5, 1964 0000 LT
foF2 fxF2 fxI

Fig. 4.5

Fig. 4.6

Travelling Disturbance Sequences - COLLEGE, July 5, 1973

This type of pattern is most often seen with a TID which has a long wavelength and amplitude. The relatively slow change of pattern with time shows long wavelength.

1425 LT (150°W) Note tilt at foF1 can change foF1 from 042 to 046. Second order shows lower F1 trace most nearly overhead. Subsidiary cusp near 039. Whole pattern distorted. h'F = 200UH. Possibly foF1 = 046EH best, foF1 = 044UH allowable.

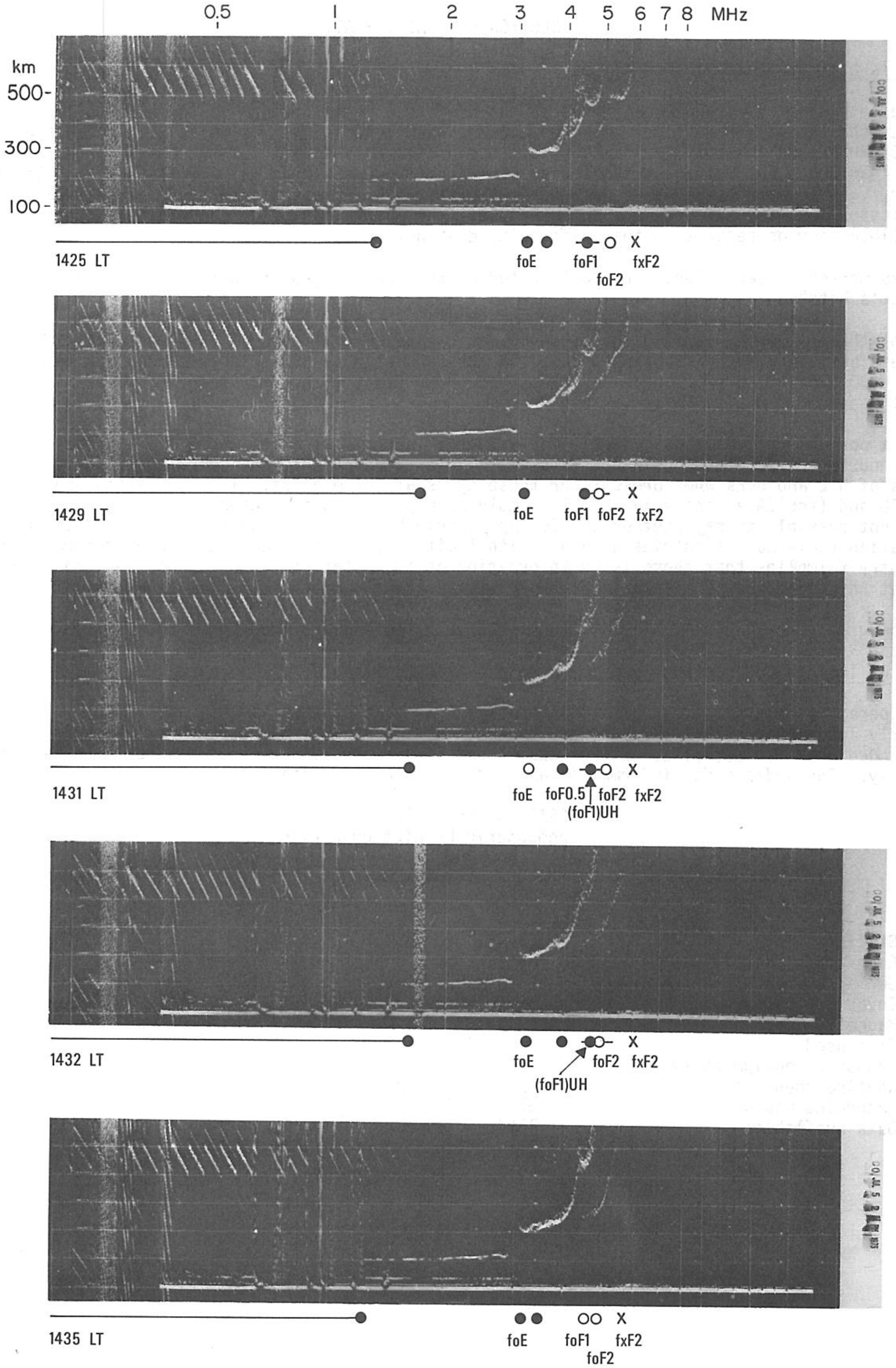
1429 LT (150°W) Range of foF1 (043 to 045) decreased, foF1 = 044UH standard practice. x mode suggests upper trace more nearly overhead near 250 km.

1431 LT (150°W) Weak foF0.5 forms at 038UH in a tilted layer structure.

1432 LT (150°W) Weak foF0.5 forms at 038UH in a tilted layer structure.

1435 LT (150°W) foF0.5 falls to 035UH, h'F = 200UH.

College July 5, 1973 TID



Travelling wave distortion of F traces

Fig. 4.6

ANTARCTIC STATIONS

SECTION 5. CASEY STATION

Editor's Notes on Australian Analyses:

Please note entries on analyses tables do not conform to international usage where all numerical entries should have three figures. Thus 1.6 MHz when read in 0.1 MHz units would read 016, if read in 0.05 MHz(E) units 160. Normal high latitude practice is to use 0.1 MHz units for all parameters other than foE. Australian stations also continue to use the original WWSC layout: qualifying letter, value, descriptive value in manual tabulations. This is discouraged for general use as it complicates punching the data for computer use. The Australian group can provide data in computer compatible form on request so this difficulty does not arise.

Entries marked "Observations" are contributed by the scaling group; Editor's comments are marked "Editor's Note".

Most of these ionograms should have shown numerical values of M(3000)F1 and M(3000)F2 if reduction was complete but these have not been included in the tabulation. Comments are added for some ionograms where M(3000) is likely to be measurable although at first glance it is not, as many high latitude groups do not measure M(3000) as often as possible.

It is a normal convention to put only foE values in a table at hours where foE is observable. For these hours Es type flat should not be used, h, c or ℓ being entered according to the observed values of h'E and h'Es when present for these types at these hours. The Australian group use (foE)EB and (foE)EA extensively when foE would be expected to be present but is not seen. It is then often not possible to say whether the Es type should be h, c or ℓ, so type f is used instead. Thus Australian table have f entries at hours with limited foE values, a departure from normal practice. The entry f implies that there is no information as to whether h, c or ℓ would be more appropriate so that this practice is allowable by the rules.

The ionograms for the Australian stations were selected and provided by Mr. G. D. Cole.

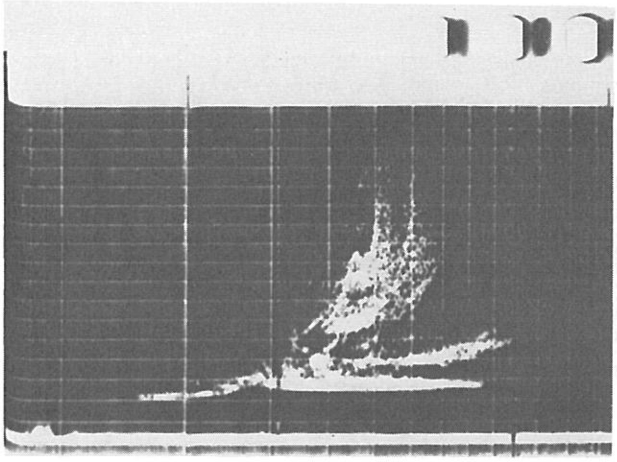
Vertical Incidence Soundings at Casey

Operation of the IPS Type 3D ionosonde began at this station in July 1967. This station was formerly located at Wilkes (S66.25 E110.51) and was operated by the U.S.A. until January 1959 when it was handed over to Australia. Wilkes was closed in January 1969 when it was replaced by the new station at Casey. The address for information about the station and data is:

ASSISTANT SECRETARY
Ionospheric Prediction Service
P. O. Box 702
Darlinghurst, N.S.W. Australia 2010

Station name:	Casey	
Geographic coordinates:	Lat. S 66.28°	E Long. 110.53°
Geomagnetic coordinates:	Lat. S 77.75°	E Long. 180.00°
Invariant latitude:	80.92°	
Magnetic dip:	82.13°	
Time used:	120°E (UT + 8 hours)	
Ionosonde equipment type:	IPS 3D	
Routine sounding:	Every 15 minutes	
Recording medium:	35 mm film	
Data available:	Tables, computer printout, normally available 14 months after observation date.	

Es TYPES SLANT AND CUSP



CASEY

5TH DECEMBER 1973

0801 U.T.
1601 L.T.

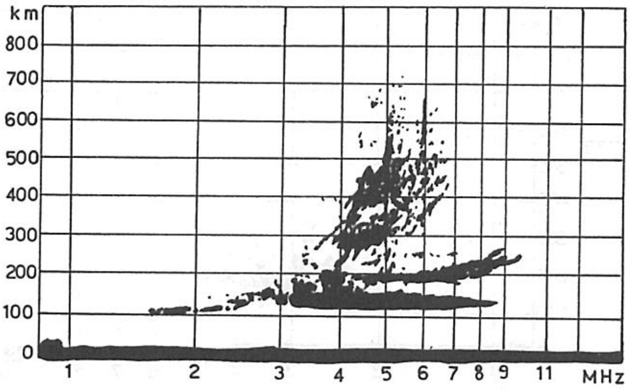


Fig. 5.1

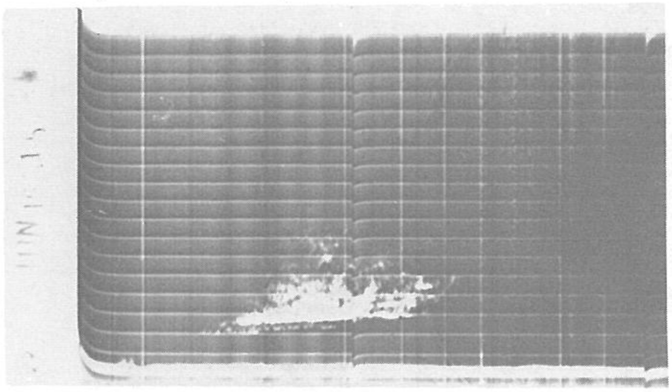
derived from f_xEs

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
16	100	U320A	120	77JA	35	C,S
h'F	**foF1**	**M3000F1**	**h'F2**	**foF2**	**M3000F2**	**fxI**
E260A	U 46F			U 50F		69

Observations: foF2 scaled from inside edge. Cusp at 4.5 MHz does not appear to be an foF1 cusp. Slant Es is shown, but Es type s traces must not be used to determine foEs, fbEs and h'Es.

Editor's Note: This is not a typical c, s pattern. The upper Es trace shows definite slant characteristics but the pattern as a whole is more typical of an Es type a condition. The lower trace is most nearly overhead giving foEs 077JA. The auroral Es would have a higher critical frequency within a distance of 200 km. Preferred analysis Es type a.

Es TYPE AURORAL



CASEY

18TH JUNE 1973

1615 U.T.

19/ 0015 L.T.

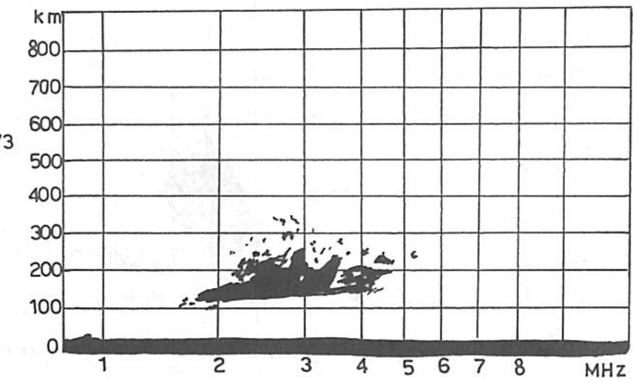
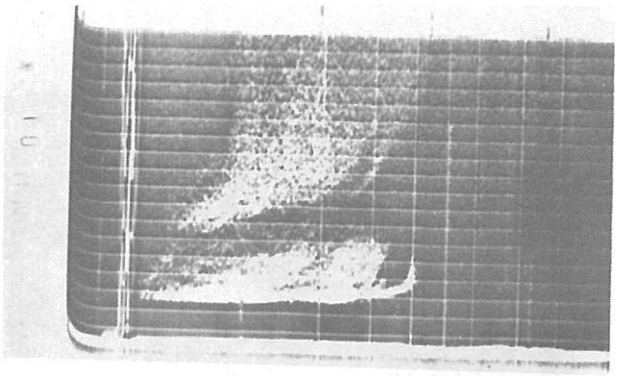


Fig. 5.2

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
15	B	E150B	E115B	35	A 35A	a
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
A	–			A	A	A

Editor's Note: Again not typical. Auroral Es seldom shows the quasi-retardation type of trace and does not blanket. Preferred analysis would be Es type r, but "a" acceptable.

Es TYPE AURORAL

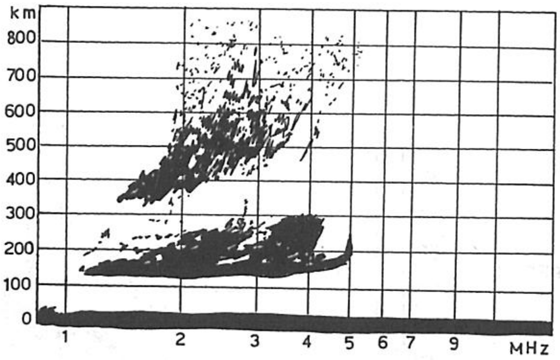


CASEY

19TH JUNE 1973

0101 U.T.
0901 L.T.

Fig. 5.3

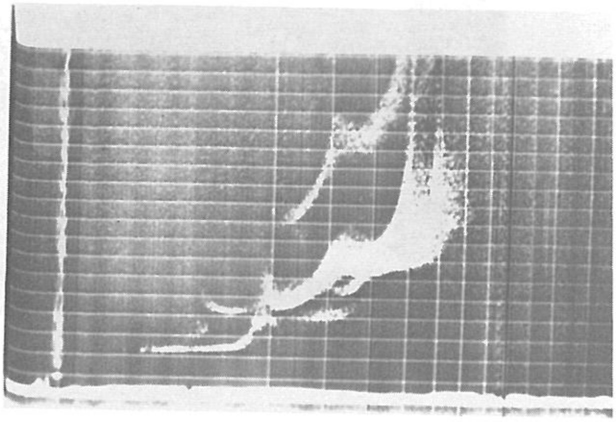


fmin	h'E	foE	h'Es	foEs	fbEs	type Es
11	B	E 110B	120	35	14	a, r
h'F	foF1	M 3000 F1	h'F2	foF2	M 3000 F2	fxI
E 320A				F		51

Observations: In this type of ionogram it is difficult to decide the value of fxI and foEs. foEs derived from fxEs. The spur at 5.0 MHz is believed to be the x component of Es type r.

Editor's Note: The traces show characteristics of both "a" and "r" types. The lack of blanketing of the F trace suggests an "a" pattern, the clear o and x retardation at 4.2 and 5.0 MHz are particle E rather than retardation (Es-r). If so, it is seen at oblique incidence as it does not blanket the F trace and is higher than the main Es trace. Physically, I think that both E and F layers are severely tilted so that normal reduction rules cannot be applied strictly. The condition fxEs = fxI often occurs during particle activity and is thus often a guide. In this case the pattern was probably changing very rapidly in time (within seconds) so that there is a large margin allowable in interpretation. The two simplest possibilities are to adopt fxEs = 5.0 MHz, foEs = 043JA, Es types r, a or fxEs = 4.3 MHz, foEs = 036JA, Es type a.

Es TYPE HIGH

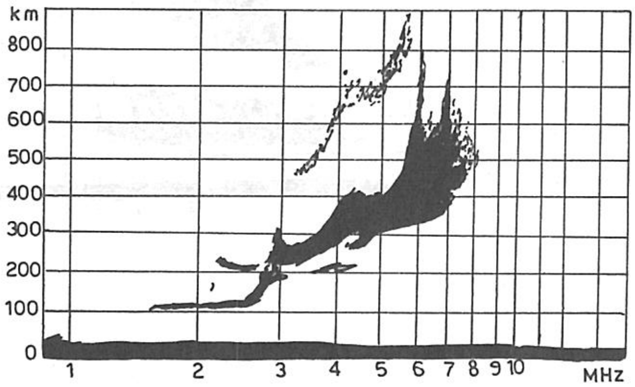


CASEY

1ST OCTOBER 1973

0401 U.T.
1201 L.T.

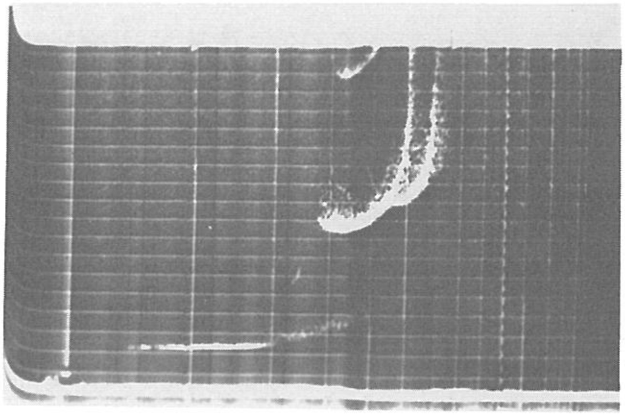
Fig. 5.4



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
16	110	295	E180G	31	E 30G	h
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
215	43F		310	U 60F		81

Observations: fzE = 210. foF2 was measured using the inside edge, as the second reflection trace was outside the height limit of the ionosonde.

Es TYPE SLANT



CASEY

2ND OCTOBER 1973

0601 U.T.
1401 L.T.

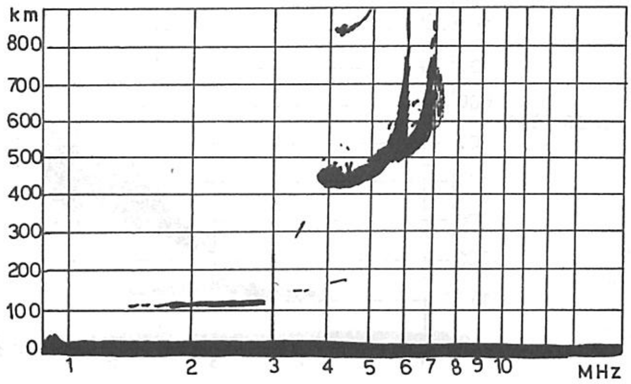


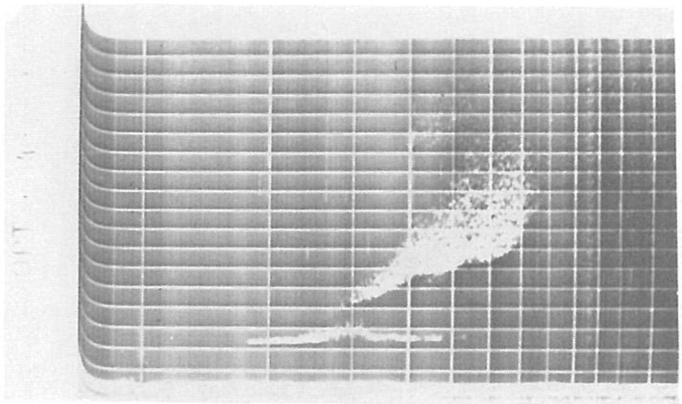
Fig. 5.5

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	110	320	G	G	G	s
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
E 275 Y	U 36Y		420	U 60F		74

Observations: Es type s must not be used to determine foEs, fbEs or h'Es, hence the replacement letter "G". foF1 scaled is 036UY, but 036UR may be acceptable.

Editor's Note: Typical Es type s with Lacuna h'F replaced by Y as not enough of trace present to obey accuracy rules. foF1 = 036UR not acceptable. This is clear Y case.

Es TYPE CUSP

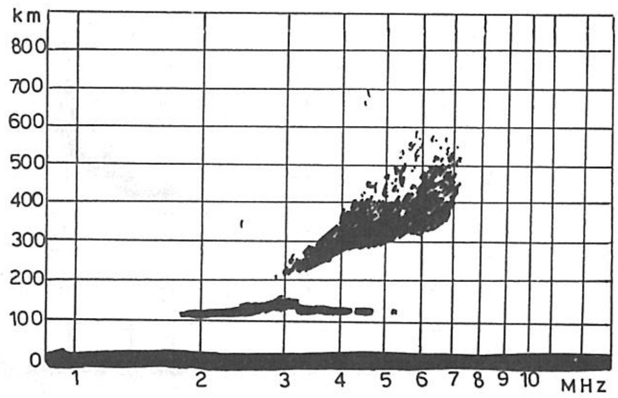


CASEY

5TH OCTOBER 1973

0645 U.T.
1445 L.T.

Fig. 5.6



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
18	110	310	120	46	E 31G	c
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
210	F		285	F		73

Observations: Cusp type Es, almost symmetrical with the E layer, starting at or below foE. First Es trace at 5.3 MHz, thus identifying foEs as 4.6 MHz.