REPORT UAG -50

WORLD DATA CENTER A
for
Solar-Terrestrial Physics

HIGH-LATITUDE SUPPLEMENT TO THE URSI HANDBOOK ON IONOGRAM INTERPRETATION AND REDUCTION

October 1975

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by

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INTRODUCTION

This Supplement to the Second Edition of the *URSI Handbook of Ionogram Interpretation and Reduction* [W. R. Piggott and K. Rawer, *Report UAG-23*, World Data Center A (WDC-A) for Solar-Terrestrial Physics, November 1972] is intended to provide samples of actual ionograms to illustrate the line drawings given in the Handbook, to provide reference ionograms and ionogram sequences so as to aid future discussion and to clarify particular difficulties. This collection should also be useful to scientists who need to use ionospheric data but are not expert in the field of ionogram interpretation. Many of the phenomena shown occur at most latitudes. Typical examples of ionograms from all parts of the world will be found in the *Atlas of Ionograms* [A. H. Shapley, *Report UAG-10*, WDC-A for Solar-Terrestrial Physics, May 1970]

As there are many types of ionosondes in use and the characteristics of the ionosonde can change the appearance of the ionogram considerably, it has been thought best to keep ionograms from a given station or a given organization together. Comparison between different ionograms from a given station show clearly local effects due to interference, antenna characteristics, instrumental faults, degree of differentiation in use, etc.

Some organizations have provided a text commenting on their contribution which is most easily used when kept close to the ionograms discussed. The input has therefore been presented in two incompatible ways, with organization or network collections, but otherwise in order of descending geomagnetic latitude, first for the Northern Hemisphere and then for the Southern. There are also several discussions on particular phenomena, illustrated by special collections of ionograms.

To use the Supplement most effectively the Ionospheric Network Advisory Group (INAG) advises you to look first at the ionograms which are most nearly similar to those at your station and then to read the comments made on any given parameter from other stations. The figures, mainly ionograms, are listed by topic and station on pages ii to viii.

Some of our contributors have prepared their ionograms without having full access to the Second Edition or to the notes and comments in the INAG Bulletin and many have translation difficulties. After much thought, your Chairman decided that it would probably help all groups if their original reduction was shown with Editor's comments where they appeared not to agree with the best analysis. This means that these groups, and those who went to much trouble to pick out particularly difficult ionograms, will appear to need more correction than the remainder. INAG must stress that the presence of many comments and corrections does not imply that the analysis at the station was below standard -- samples of ionograms at the WDCs show that standards vary considerably from year-to-year and even the best stations have off-periods when their analysis is less than adequate. In selecting ionograms from the large number sent preference has been given to cases where a better analysis is possible or where a particular error is very widespread.

Some contributors have not provided full analyses of their ionograms and the work needed to do this was prohibitive for the Editor. There are, however, enough examples of full analyses to act as a guide, incompleteness in the remainder should not be regarded as permission to omit the missing parameters. Similarly height and frequency scales have been provided for a sample of the ionograms from each station. In some cases these had to be worked out by the Editor -- please remember to send scales when submitting ionograms for publication in the INAG Bulletin or for discussion by the INAG Chairman -- when the frequency scale is unusual or not steady, the deduction of the scale is difficult and often also not unique.

Owing to shortage of time, the majority of the comments have been made by your Editor without the advantage of discussion with other members of INAG. This implies that some of his comments may well be controversial. It is hoped that any reader disagreeing with the interpretation will inform INAG so that the problem can be publicly discussed in the INAG Bulletin and at INAG meetings. Your Editor apologizes for this which is entirely his fault.

The USSR contribution contains both examples of normal practice and examples to show special phenomena which deserve special treatment in the International Magnetosphere Study (IMS). Some of the proposals have not been discussed by INAG and are controversial. Further discussion will occur in the INAG Bulletin.

The Editor has freely amended contributions which appear incomplete where this is likely to be useful to the reader. Common cases include Es-r becoming Es-r and Es-k; Es-a becoming Es-a and Es-f or Es-a and Es-c with some examples of the use of numbers to indicate the number of multiple traces present. Most of the stations do this but some do not.

An attempt has been made to collect examples and sequences of ionograms to show abnormal F-layer structures as seen by as many types of ionosonde as possible. The monitoring of the major high latitude ridges and troughs by means of an ionosonde is an important contribution to the IMS. It is now clear that several important magnetospheric phenomena can be readily recognized by their effects on ionograms. Movements of the auroral oval can be monitored in this manner and there is a growing literature collating such observations with aircraft, satellite and rocket observations. These work both ways, establishing that the phenomena are correctly identified and then using the ionosonde data to show where particular magnetospheric boundaries were on occasions when detailed studies are being made.

At this time of writing, different groups are still using different words to describe the same phenomenon, e.g. ionogram patterns associated with the increased ionization on the poleward side of the plasmapause have been called 'replacement layer' phenomena by some groups, 'trough' phenomena by others and it is clear that at least part of the phenomena called FLIZ by the USSR refers to this condition.

There is also some difference in the words appropriate for the scientist and for those active in ionogram reduction. The former describes a complex phenomenon physically, the latter identifies each perturbation separately by its appearance on the ionogram and seldom has the training to make a physical interpretation. Thus Es-s (slant Es) can be generated by any mechanism which makes the E or Es layer sufficiently irregular to reflect signals back to the ionosonde over a considerable range of distances. The trace is highly characteristic and can thus be readily recognized and classified by an operator. Intense instability over a range of heights can cause the signal reflected to be weakened by many orders of magnitude -- the Lacuna phenomenon -- the trace suddenly disappears. A similar disappearance of the trace can be due to layer tilt (Handbook p. 78, 107). A scientist will note that, when intense instability is present, Es-s and weakened or missing traces are normal. He will make allowance for absorption weakening or hiding the Es-s or for weak traces to be visible rather than complete Lacuna and often gives the code name Slant Es Condition (SEC) or Lacuna to the combined phenomenon. SEC is the name adopted by J. K. Olesen who first described the phenomenon. For an operator, Lacuna means a missing trace, Es-s the presence of a slant-Es trace on the ionogram and his responsibility ends when he had adequately described what he saw on the ionogram. The name particle E has been widely adopted for the abnormal thick layer formed in the E region. While this is usually clearly associated with the particle activity, the definition (Handbook p. 17, 1.15 (Particle E-night E) is independent of the cause of the layer and does not imply that all particle E layers must be due to particle activity -- it is purely a question of whether the value of foE is abnormally large. A scientist would probably prefer the term Enhanced E to Particle E but the latter has been widely adopted, is more easily understood by operators and is appropriate for most, if not all, examples.

At the INAG meeting at Lima it was agreed that, for better clarity, Es types should be tabulated in capital letter form. This change has not been introduced in this Supplement. For tabulation purposes, Es-f, ℓ, c, h, a, r, k, s should become ES-F, L, C, H, A, R, K, S respectively as is the practice for computer-constructed tables. There appears to be no reason to change the more attractive lower case form for use in text, Es-a, etc. As more computers become available with both upper and lower case letters, it is likely that the original conventions foF2, foEs, etc, Es-a, etc., will again become popular except for manual tabulation of Es types where capitals have great advantages.

INAG at Lima decided to adopt spread-F typing with entry in the descriptive letter columns of fxI, foF2, h'F and recommends that this be used universally. With this convention the type letter takes precedence over the descriptive letter when doubt is present.

At Lima, F-layer nomenclature at high latitudes was discussed. It is desirable to keep clear three different phenomena:

(a) Trough-ridge phenomena characteristically changing in position,

(b) Polar cap enhancements characteristically changing in time,

(c) Exceptionally low F2-layer seen in solar minimum years.

It seems that some confusion has arisen because (a) and (b) can sometimes be superimposed and have then been discussed as if they were alternative forms of one phenomenon; some proposed names further confuse these distinctions.

For example the Irregular Zone identified by Pike in 1971 often contains the ridge (replacement layer) widely seen at night near the auroral zone and the F layer associated with this ridge is usually lower and thinner than the F layer adjoining it. Group retardation at the high-frequency end of the trace is not seen until the layer is overhead.

In its simplest form, phenomenon (b) is seen as a sudden replacement of the normal F layer in summer by a lower, thinner and denser structure which disappears as quickly as it appears leaving the normal F-layer traces relatively unaltered. A typical summer day ionogram is suddenly changed, the F1 trace, if present, disappears, and the F2 trace is low with a rapid change in retardation near foF2 corresponding to a remarkably thin layer sometimes only twice as thick as normal E. Particularly at the start and end considerable scatter and tilt can be present. Unlike phenomena (a), (b) can seldom be seen moving relative to the station and then only for a short time from when it is overhead. The jumps in foF2 reported have been large, usually several MHz.

In solar minimum years, h'F in the polar region often decreases slowly with time finally reaching E heights, e.g. about 110 km. Satellite ionograms confirm (at least for the few tests made) that there is no higher F structure present. The value of foF2 also varies slowly in time, the thickness of the layer is much greater than for particle E and decreases slowly as h'F decreases. This phenomenon is seen only in years of low solar activity.

INAG at Lima suggested that the name "Low F2-layer" should be confined to this phenomenon (c).

The characteristic feature of (b) is the enhancement of foF2 -- it is sometimes spread, sometimes not. For these reasons INAG proposed at Lima that phenomenon (b) be called Enhanced F. As there was not adequate representation of all high latitude groups at Lima, discussion on the name, definition and limits to be made for phenomenon (a) are left for further discussion in the INAG Bulletin. In the contributions to this UAG Report trough structure appears to be popular, with FLIZ (F2 layer of the Irregular Zone) a possible contender. When contrasted, thin and thick F-layer traces represent reflections from the ridge and trough when the trough is absent. The normal F layer and the denser thinner layer found at the boundary (see USSR and Olesen contributions and many individual examples) give similar patterns. Similarly some Es decisions have had to be left for further discussion.

The opportunity has been taken to update and collect the Handbook corrections as published in the INAG Bulletins so that they are readily available in one place. These are attached as an Appendix to this Supplement and include all decisions made at Lima. Where considerable changes have been made to the Handbook, replacement pages have been typed out which can be pasted onto the old page or, for those who have made it into a loose leaf book, used to replace obsolete pages. Any further changes will be announced in the INAG Bulletin.

Japanese, Russian and Spanish translations of this Supplement are planned to complement the corresponding translations of the Handbook. There does not appear to be sufficient demand to justify a French translation at present as French high latitude stations can use the English version without difficulty. Note that many of the changes in the English version of the Handbook have already been incorporated into its translations which were prepared after the Handbook had been widely circulated and discussed. Please make comments as soon as possible so that any changes needed in this Supplement can also be published quickly and incorporated into the translated versions.

A work of this nature can only be completed by unselfish work by many people. INAG wishes to thank all those who have helped to identify the problems of the station operators in interpreting ionograms either in discussions at INAG Meetings, in training symposia reported to INAG, by contributions to the INAG Bulletin or by letters to the INAG Chairman and Members. There are many problems for which suitable ionograms were not submitted. INAG asks you to select ionograms illustrating your difficulties for comment and publication in the INAG Bulletin and, in particular, asks those organizing training symposia to report on difficulties or problems where clarification is needed, preferably with illustrative ionograms. INAG wishes to make ionogram analysis problems a permanent regular feature of the INAG Bulletin and will use some of the ionograms not included in this UAG Report to start this feature.

Particular thanks are needed to those who have directly contributed to this Supplement. Wherever possible they have been identified in the introduction to their contribution -- people often do not read Introductions and Acknowledgements! Special mention must be made to Mr. Richard Smith of the Appleton Laboratory, Slough, Bucks, England, who examined all ionograms and comments included in this Report, identified a number of problems on particular ionograms which would interest operators and even on occasion successfully challenged an editorial comment. The INAG Secretary and Vice Chairman had the unenviable responsibility of translating the Editor's handwritten manuscript and notes into the form reproduced and the finished product would not have been possible without the large amount of detailed editing carried out by Helen E. Coffey and Raymond O. Conkright. The typing was done by Alice E. McRae and J. May Starr working from the Editor's manuscript as sorted and amended. This work was carried out at the World Data Center A for Solar-Terrestrial Physics and the Editor wishes to thank Mr. A. H. Shapley, Director, National Geophysical and Solar-Terrestrial Data Center, EDS, NOAA, for making this possible. Many users have expressed their appreciation of the Handbook and Atlas previously published through the good will of Mr. A. H. Shapley and the WDC-A and your Editor, acting as Chairman of INAG, feels that the operators and users of the World Vertical Sounding Network would wish him to convey these thanks to all concerned.

The Editor wishes to thank the Director of the British Antarctic Survey, Dr. R. Laws, for an allocation of time to be devoted to INAG problems and for his understanding and support in the special and large effort needed to produce this booklet.

On behalf of the Network, INAG wishes to thank its Members and Consultants who have contributed to this volume:

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SECTION 1. USSR STATIONS

Vostok, Mirny, Heiss, Dixon and Tixie

Compiled by

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General

This contribution has been prepared using data from the high-latitude network of vertical incidence sounding stations organized by the Arctic and Antarctic Research Institute (AARI) under the leadership of Dr. V. M. Driatsky. Geographic and geomagnetic positions of the stations with the indication of the type of ionosonde used are shown in Table 1. All times on the ionograms are local time. In accordance with the recommendation to add a special High Latitude Suppplement to the *URSI Handbook on Ionogram Interpretation and Reduction* the examples for this contribution were chosen with the aim:

1. To show the practice of ionogram reduction and interpretation, and

2. To show various types of ionograms for different latitudinal areas.

Table 1

LIST OF THE USSR STATIONS

Station	Geographic Coordinates		Geomagnetic Coordinates		Invariant Latitude	Inclination or Dip	Time Zone	Ionosonde Type
	Lat.	E. Long.	Lat.	E. Long.				
Vostok	76°26'S	106°30'E	89°.2S	91°.4E	84°.3S	79°.5S	105 E	AIS
Mirny	66°33'S	93°01'E	77°.0S	146°.8E	76°.8S	76°.7S	90 E	AIS
Heiss	80°37'N	58°03'E	71°.0N	156°.0E	73°.8N	84°.3N	45 E	AIS
Dixon	73°30'N	80°24'E	63°.0N	161°.4E	67°.2N	83°.5N	105 E	AIS
Tixie	71°34'N	128°54'E	60°.4N	191°.0E	65°.2N	82°.6N	135 E	C-3

Figures 1.1-1.24 are matched examples of quiet and disturbed ionosphere. The division into quiet and disturbed ionosphere is somewhat arbitrary for the high-latitude ionosphere and is mostly based on the magnetic activity. The quiet conditions cover periods with three-hourly Kp index not larger than 1. The ionograms show day and nighttime ionosphere effects. Table 2 gives the list of numerical values of the standard parameters taken from the ionograms of Figures 1.1-1.24.

It is interesting to note the appearance of Es type a in the near-pole area on the magnetically quiet day (Figure 1.7), low critical frequencies of F2-layer in the daytime at Heiss Island Station (Figure 1.13) and at night at Dixon Island Station (Figure 1.23) on a magnetically quiet day corresponding to the station position in the main trough [Muldrew, 1965], and the increase in scatter and the change from the normal structure in the ionosphere in magnetically disturbed periods: a) anomalous increase of critical frequencies under the conditions of dark ionosphere (Figures 1.14, 1.20, 1.24) (replacement layer -- Ed.); b) decrease of critical frequencies in the light periods (Figures 1.2, 1.4, 1.6); c) appearance of Lacuna in the daytime auroral zone (Figure 1.16), and d) disturbances of normal stratification of the ionosphere (tilts: Figures 1.2, 1.4, 1.6, 1.12; range-spread traces: Figure 1.10). The Lacuna Figures 1.25, 1.26, 1.27 and 1.28 may be compared with Figures 1.1, 1.11 and 1.17. Some examples of partial Lacuna are shown. A Lacuna sequence is shown in Figure 1.29. (More commonly the spread would disappear when the phenomenon disappeared. -- Ed.)

Figures 1.30, 1.32 and 1.34 are the examples of classical Es type a traces that completely correspond to the definition given in the Handbook.

Figures 1.34-1.38 are the examples of Es type a which are similar to other types of Es: Es-f and Es-r. That is why their interpretation is doubtful. (See Editor's Notes below.)

Table 2

LIST OF STANDARD PARAMETERS AVAILABLE FROM IONOGRAM FIGURES 1-24

Name of station	Page No.	Fig. No.	fmin			F Region															E Region																
			fmin	qualif	descrip	foF2	type spread	qualif	descrip	h'F2	qualif	descrip	h'F	qualif	descrip	foF1	qualif	descrip	foE	qualif	descrip	h'E	qualif	descrip	fbEs	foEs	qualif	descrip	h'Es	qualif	descrip	type Es	fxI	qualif	descrip
Vostok	11	1.1	010			076	F		F	370			220			460			320		H	100			G			G			G		090		
Vostok	11	1.2	010				P		F	410	U	F	190		H	470		H	320			100			G			G			G		070		
Mirny	11	1.3	010			070	X			380			230		H	490		H	340	U	R	100			G			G			G		078		X
Mirny	11	1.4	010			056	P	U	F	460		F	210			430		F	320			100			G			G			G		078		
Heiss	11	1.5	010			060	X			390			210		H	480		H	320			100			G			G			G		068		X
Heiss	11	1.6	010			051	P	U	F	550			200		H	420		H	310			100			G			G			G		075		
Vostok	12	1.7	010			060	X			330			260			410					A			A	030	084	J	X	100			a	068		X
Vostok	12	1.8	010				P		N			N			N			N	280	E	A			A	G	080	J	X	120			ℓ,ℓ3	068		
Mirny	12	1.9	010			060	F		F				270	E	A						A			A	032	043	J	X	100			ℓ4	070		
Mirny	12	1.10	010				Q		F				240						120	E	A			A	G	092	J	X	110			a	060		
Heiss	12	1.11	010			060	M	U	F	350			240			400			250			100			G			G			G		072		
Heiss	12	1.12	010			046	P			460			210			390			210			105			G			G			G		065		
Heiss	13	1.13	010			024	F	U	F				250												E			E			E		036		
Heiss	13	1.14	010				M		F				240						220		K				021	028	J	X	135			r,k	096		
Dixon	13	1.15	010			052	X			440			220			400			330		R	110			G			G			G		070		X
Dixon	13	1.16	010			062	F		F	410					Y	390		Y			Y	110			G			G			G		075	O	B
Dixon	13	1.17	010			050	X						240		Z						E			E	E			E			E		058		X
Dixon	13	1.18	013			059	F		F				240						130	E	B				G			G			G		074		
Heiss	14	1.19	010			029	P	U	F				260	E	A										017	025	J	X	100			f3	052		
Heiss	14	1.20	010			050	P,F		F				250												019	040			100			f3	105		
Dixon	14	1.21	010			056	F		F	350	U	L	330					L	270	U	F	130			G			G			G		068	O	B
Dixon	14	1.22	010			046	M	U	F				300								F	110			G	044	J	X	120			c	062		
Dixon	14	1.23	010			019	F		F				330	E	E										E			E			E		036	O	B
Dixon	14	1.24	010			046	M	U	F				270												016	030			120			a	062		

Figures 1.31, 1.35, 1.36 and 1.38 are examples of Es similar to type r, but with increased scatter (Figures 1.31, 1.36, 1.38) or with a monotonic rise of the lower edge of the trace with the frequency increase (Figures 1.35, 1.36b).

Figures 1.36d and 1.37 are examples of Es-a similar to Es-f. This situation usually occurs with the increased absorption when scattered reflections typical of Es-a are absent.

Figure 1.48. Ionogram sequence is given illustrating assumed division of the sporadic ionization into particle E (Es-k) and Es-r depending on the rise at the lower frequency end of the F-layer trace. The classification is given in accordance with URSI Handbook recommendations (p. 69).

Figure 1.49. Figure 1.49h is defined as the regular E layer, since at this time critical frequencies of the E layer start to increase with the increase of the sun's altitude.

Figures 1.50-1.55 show different types of spread F traces according to the classification recommended by the URSI Handbook (section 12.34).

Editor's Notes: The following notes supplement those given by the authors and draw attention to some controversial points. Note that the reference quiet ionograms odd numbered Figures 1.1 to 1.23 can be used to match approximately to most of the other illustrative ionograms, Figure 1.25 onwards.

Clear z mode traces can be seen on Figures 1.1 and 1.2 (low frequency) and Figures 1.17 and 1.47 (high frequency end of F-trace).

Sporadic E gives much trouble. It is often overlooked that two types may be superimposed when a, k, r traces are present, e.g. a,f; c,k; r,k. When a or r types are superimposed on normal E or on particle E (Es-k), there is often a cusp at foE. This does not alter the ascription Es-a, Es-r. If however there is clear evidence of a normal type of Es (h,c,ℓ or f) superimposed on the a,r or k trace, its presence should be shown in the type table. Some examples: Figure 1.7 Es-a, f2; Figure 1.8 a, f3; Figure 1.9 f4; Figure 1.10 a; Figure 1.14 r,k with foE = 021UK; Figure 1.22 a,a (two distinct a structures); Figure 1.24 a; Figures 1.30, 1.32 and 1.33 show Es-a growing from a normal E trace (foE near 3.0 MHz).

Figure 1.32 has controversial features. The second order trace suggests this is an Es-c with Es-a superimposed but the intervals are not equal, showing tilt. I prefer Es-c with foEs about 083 and types c2,a. Figure 1.31 is a variant of Figure 4.29 (Handbook), center figure, f-min is low; there are no multiple traces so Es-a should be used. In Figure 1.33 Es-a characteristics dominate over r, thus a seems preferable. Figure 1.34 possibly Es-c present, but prefer just Es-a. Figure 1.35 is very difficult. There is a second order trace to about 6.0 MHz so this cannot be a pure Es-a. The first order trace is solid with weak scatter about it. I prefer Es type r,a (a for the blob near 4.0 MHz) with foEs from (ftEs) JA. Figure 1.36 shows multiple traces to above 6.0 MHz with weaker traces to 10 MHz. Prefer a,r2; r2 acceptable. Figure 1.37 trace tilted and shows some structure (Es type a). In the ionogram sequences retardation due to particle E can be seen so type k should be added. The presence of a z-mode trace in Figure 1.48b-e makes it fairly certain that the Es was really a particle E (Es-k) with the F-layer retardation missing because that layer was severely tilted. This is confirmed by lack of scatter near foEs. This sequence suggests INAG should alter rules so that when foEs = fbEs for an Es-r type trace, the trace is regarded as a particle E (Es-k) trace, even if retardation cannot be seen on the F trace.

Figure 1.48e shows enough retardation to justify Es-k according to existing rules. Note rapid changes of foF2 with time make it likely that the F layer is not horizontal. Figure 1.41 shows Es-k (particle E) confirmed by second order trace with little or no evidence of F-layer retardation.

f-plot conventions in Figures 1.57, 1.59, 1.61 and subsequent figures do not conform with rule 6.3g (p. 144 Handbook). This does not allow q-q to be used when a main trace is present, as in Figures 1.57, 1.61 or when it can confuse the representation of frequency spread, Figure 1.59. I do not see how this use could be accepted (see FLIZ below). Dots at fxI on sequence figures to identify fxI should be arrows (not at f-plot entry). There are also a number of cases where accurate values of foF2 are shown with a solid dot instead of an open circle and solid dots for satellite critical frequencies are not shown. The compilers wish to identify foF2 and fxI only, not to give a full f-plot interpretation in the Figure 1.64 illustrations.

Figure 1.65 d and e, the dashes below foF2 are not allowed as they confuse frequency spread interpretation. Presence of clear satellite traces should be shown by dots. (In practice if these appear only on one ionogram little is lost by omitting them but they often give a reasonable value for the critical frequency of an incipient replacement layer). Figure 1.65f,g,h is improper use of q-q according to rules, also Figure 1.68d,e. Note the proposal [INAG17, p. 6] to use P to denote polar spurs (Handbook type S) has been adopted in this contribution. This was confirmed at Lima.

FLIZ Phenomenon

Editor's Notes: It is not clear at present whether the FLIZ phenomenon described below is identical with the "replacement" layer (trough and ridge phenomenon) or includes other phenomena also, e.g. Figures 1.57, 1.59, 1.61, 1.63 could be examples from trough sequences and Figure 1.65 is similar in form to a conventional trough-ridge sequence (e.g. Figure 1.66) but at a much earlier time than is usual. The characteristics given could apply directly to trough-ridge phenomena, e.g. Figures 3.39c,d in Handbook. However, pending clarification in the INAG Bulletin, the word FLIZ is used to identify the phenomenon described below. The text and figures have been included as proposed by the authors so as to start informed discussion and to make clear exactly what type of ionograms are under discussion. The problem was discussed at Lima and it was felt that further discussion was needed in the INAG Bulletin to produce an agreed consensus of opinion. This opinion was strongly supported by INAG at Lima.

Operators should not be asked to identify physical phenomena but only to describe ionograms as seen. I feel that the proposed use of q to identify FLIZ conditions on f-plots will not be practical -- it blurs the distinction between frequency spread and range spread on f-plots. When frequency spread is present it must have priority. This was strongly supported by INAG at Lima. For scientific purposes the simultaneous presence of range spread can be identified on an F-type table (letter Q) or by descriptive letter Q with the h'F entry. The proposed usage does not conform with Handbook rule 6.3g, p. 144 which most operators find simple and convenient. Note for scientific purposes this type of condition can be readily recognized in tabular data by the difference foF2 and fxI by the jump in values of foF2 and by the proper use of h'F-Q. I believe that a proper description of the morphology could be obtained using existing rules if all stations obeyed them carefully, in particular by recording fxI and using the q convention on f-plots according to rule 6.3g. It is very important that such phenomena are identified for purposes of the International Magnetosphere Study (IMS).

Figures 1.56-1.65. At a number of high latitude stations F-region traces are observed which cannot be interpreted as oblique traces but at the same time differ from the usual ones which correspond to a relatively thick F2 layer. Preliminary studies of such traces revealed their following characteristics [Whatman, 1949; Hill *et al.*, 1959; Besprozvannaya *et al.*, 1967; Wakai, 1960]:

a. They often lack a well-defined group retardation at the high frequency end of the trace.

b. They appear sporadically (on one day for several hours, on others they would not occur at all).

c. The top frequencies can vary with the gain.

d. The traces may be either blanketing or transparent.

e. Critical frequencies, as a rule, are much higher than those usually observed reflected from the F region for corresponding normal conditions.

In order to better understand the origin and spatial/temporal distribution of these traces it is necessary to interpret them similarly at all the stations of the high-latitude network. Figures 1.56-1.65 show the examples of ionograms with two different reflecting structures and the transitions from one to another. In accordance with the terminology proposed by Pike [1971], the reflections from a "thin" F2 layer with a poorly-defined group retardation were identified as F2 layer of the Irregular Zone (FLIZ). The AARI practice is that when FLIZ traces result from an overhead phenomenon and the traces from the normal "thick" F2 layer are absent, the foF2 parameter is not scaled, only descriptive letter Q is used (Figures 1.57, 1.59, 1.61, 1.63); parameter fxI with the entry spread F classification Q is used. When the diffusion is large, f-plot shows the whole range of FLIZ traces.

Determination of Position of Plasma Trough Structures

Figures 1.66-1.69. The study of the morphology of the spatial distribution of ionization by satellite and ground-based data has shown that the synoptic F2-layer model can be expressed by a circumpolar zone of enhanced electronic density (plasma ring), bounded at the equator by a main "trough" and at the pole by a polar cavity [Thomas and Andrews model, 1969]. The equatorial boundary of the plasma ring crosses the night side depending on the magnetic activity at the corrected geomagnetic latitudes 65-69° and at the daytime side at 75-80° latitudes.

Figures 1.66 and 1.67 illustrate conditions in the nighttime ionosphere and Figures 1.68 and 1.69 in the daytime ionosphere.

Figure 1.66 shows the ionogram sequence from Dixon Station (invariant latitude = 67.2°N) on a magnetically quiet day (Kp does not exceed 0+). In this period the equatorial wall of the plasma ring passes northward of Dixon Station and the station is in the main trough with characteristic low critical frequencies of F2 layer ($\sim$ 2MHz). Traces at h = 340-350 km are interpreted as oblique traces from the northern polar boundary of the trough. In this case we can calculate the position of the equatorial boundary of the plasma ring which appears to be located at a distance of 2° from Dixon Island.

Figure 1.67 shows the ionogram sequence corresponding to the conditions of moderate magnetic activity (K values = 2+), with the equatorial boundary of the plasma ring crossing to the south of Dixon Island. The zone of enhanced electron density of F2 layer moves over the station. The observed values of critical F2-layer frequencies are two to three times larger than foF2 on a magnetically quiet day.

Figures 1.68 and 1.69 demonstrate conditions in the high-latitude daytime ionosphere. The comparison of the airborne ionospheric soundings with those obtained by Alouette Satellite allowed Dr. Pike [1971] to conclude that the daytime position of the plasma ring coincides with the FLIZ zone.

Figure 1.68 shows ionogram sequence from Vostok Station, Antarctica about local geomagnetic noon (1900 LT). It is interesting to note the disappearance of the normal summer structure (separate F1 and F2 layers) at 1945 and 2000 LT when the station is located in the FLIZ zone. The ionogram sequence in Figure 1.69 is interesting, since at about that period only oblique traces from FLIZ zone were observed (polar spurs).

Bearing in mind the fact that the height of F2 layer in the irregular zone at vertical incidence is 250 km (See Figure 1.68d), we can estimate that during the period in question the FLIZ zone was at a distance of about 3° from Vostok Station. It seems that the boundary of the plasma ring was determined in this case.

(A further discussion of these phenomena will be found on page 111 and in the Introduction.)

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DAYTIME IONOGRAMS

QUIET

VOSTOK 1970 22 JAN 1015 LT
(105° EMT)

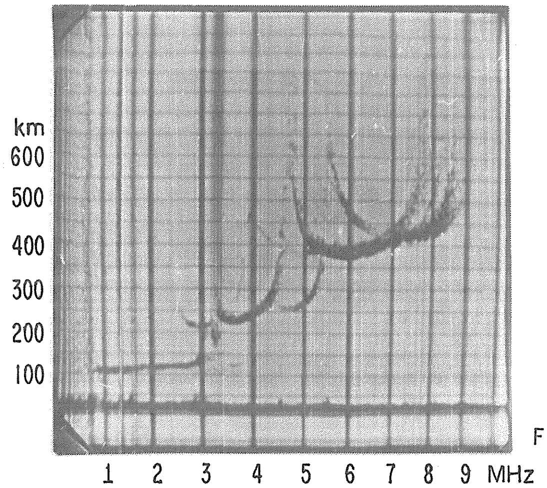


Fig. 1.1

DISTURBED

VOSTOK 1970 23 JAN 1405 LT

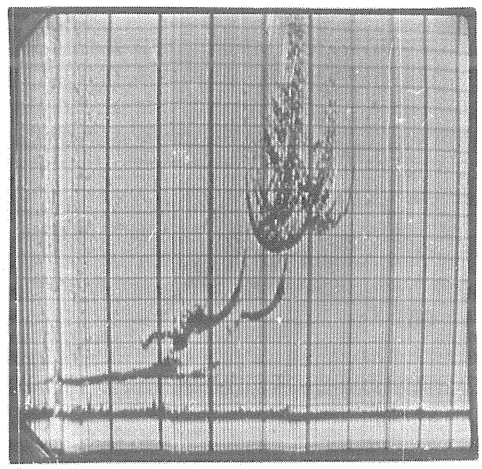


Fig. 1.2

MIRNY 1970 25 JAN 1300 LT
(90° EMT)

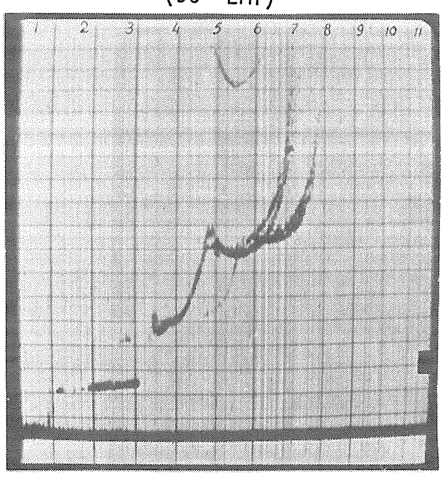


Fig. 1.3

MIRNY 1970 24 JAN 1500 LT

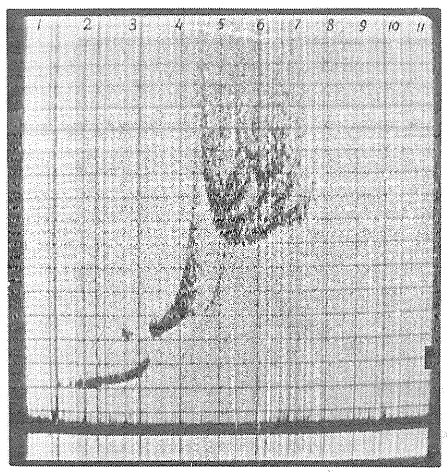


Fig. 1.4

HEISS 1970 7 JUL 1100 LT
(45° EMT)

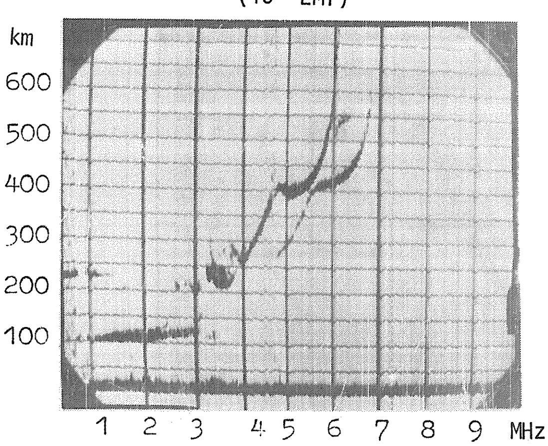


Fig. 1.5

HEISS 1970 27 JUL 1230 LT

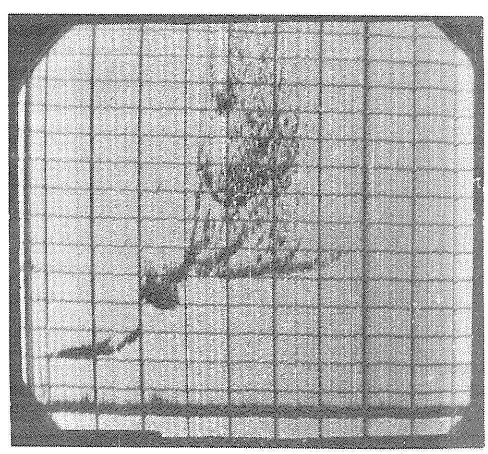


Fig. 1.6

NIGHTTIME IONOGRAMS

QUIET

DISTURBED

VOSTOK 1970 11 JAN 0400 LT
(105° EMT)

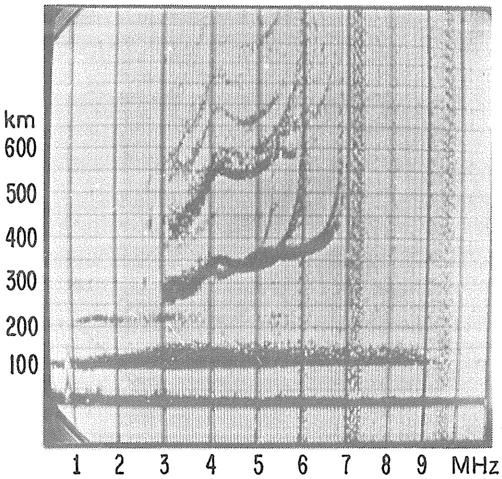


Fig. 1.7

VOSTOK 1970 13 JAN 0355 LT

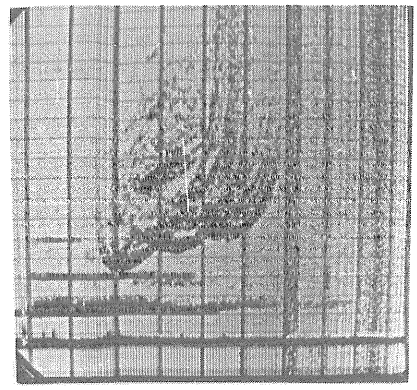


Fig. 1.8

MIRNY 1970 26 JAN 0045 LT
(90° EMT)

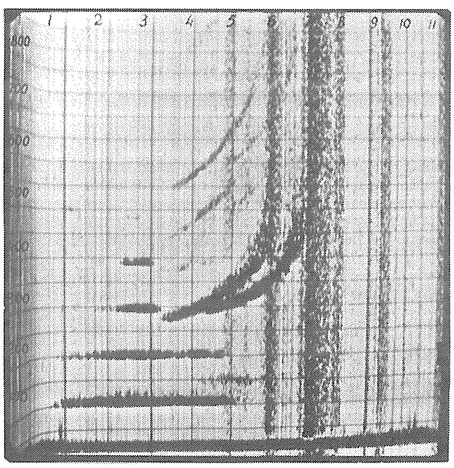


Fig. 1.9

MIRNY 1970 24 JAN 0055 LT

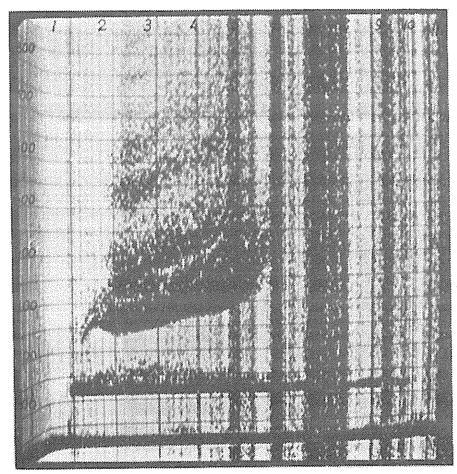


Fig. 1.10

HEISS 1970 7 JUL 0200 LT
(45° EMT)

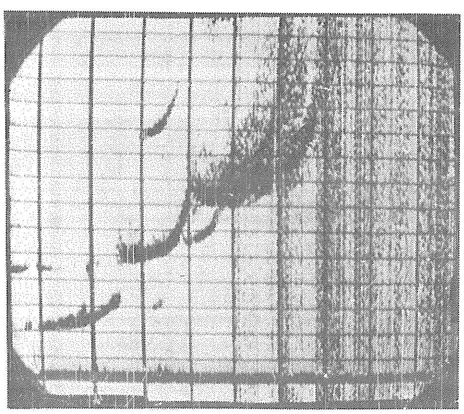


Fig. 1.11

HEISS 1970 27 JUL 0045 LT

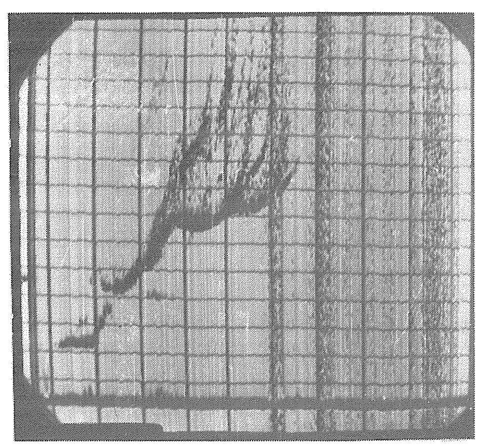


Fig. 1.12

DAYTIME IONOGRAMS

QUIET

HEISS 1970 4 JAN 1055 LT
(45° EMT)

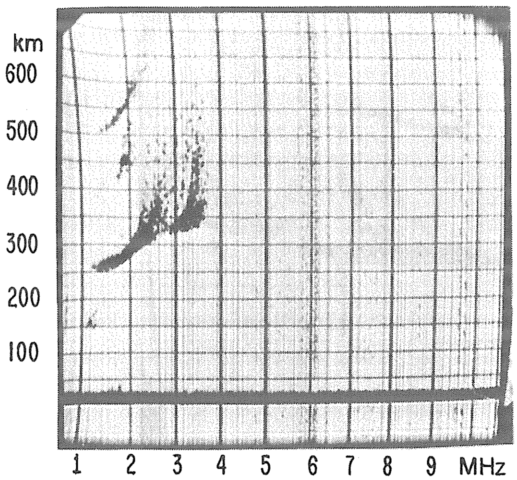


Fig. 1.13

DIXON 1970 7 JUL 1200 LT
(105° EMT)

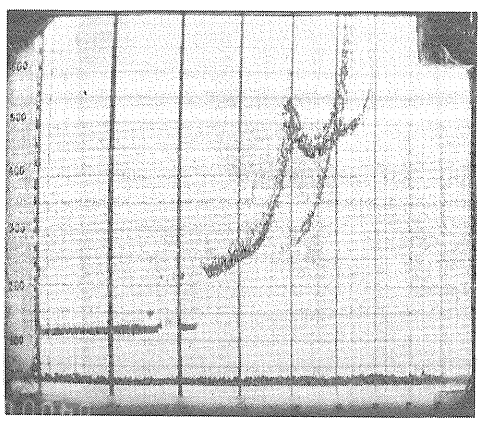


Fig. 1.15

DIXON 1969 3 JAN 1505 LT

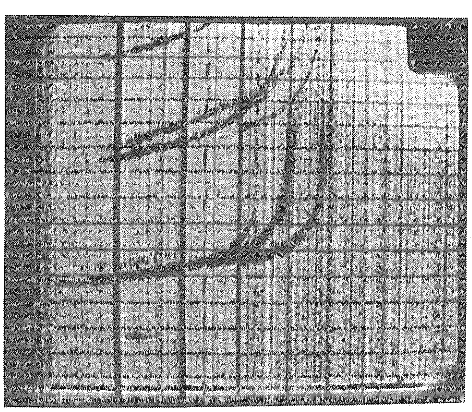


Fig. 1.17

DISTURBED

HEISS 1970 2 JAN 1215 LT

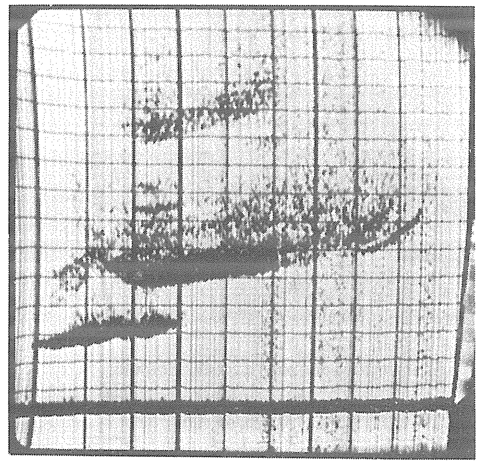


Fig. 1.14

DIXON 1970 29 JUL 1315 LT

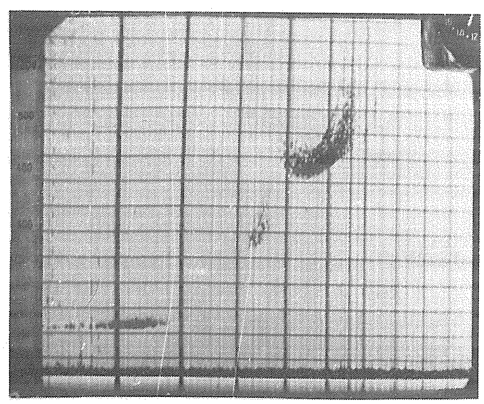


Fig. 1.16

DIXON 1970 2 JAN 1430 LT

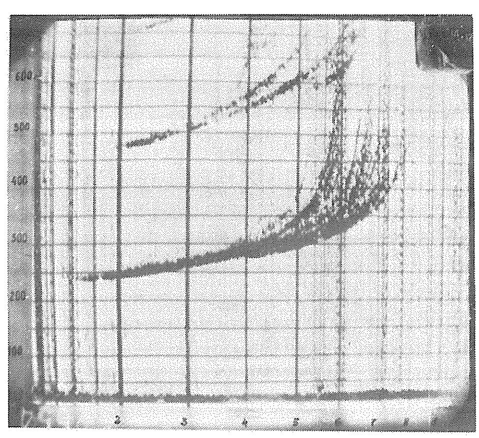


Fig. 1.18

NIGHTTIME IONOGRAMS

QUIET | DISTURBED

HEISS 1970 3 JAN 1950 LT
(45° EMT)

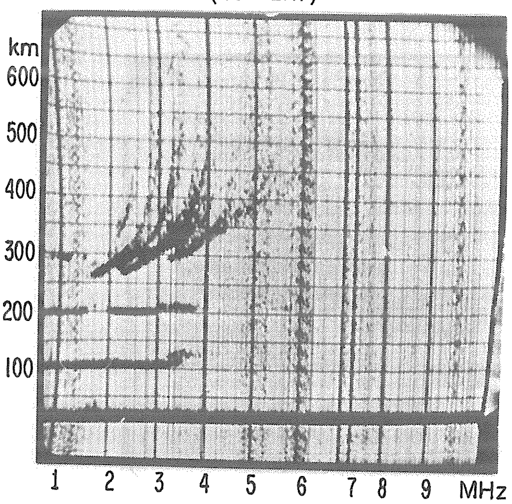


Fig. 1.19

HEISS 1970 1 JAN 2130 LT

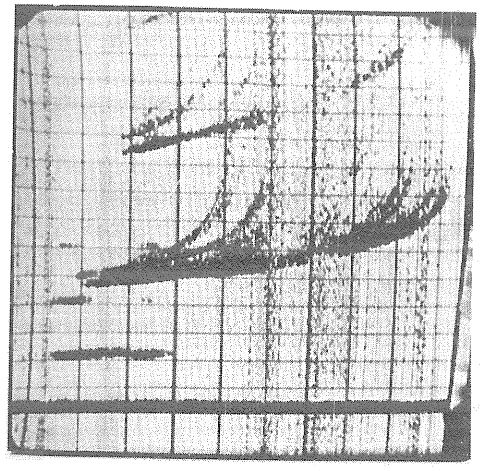


Fig. 1.20

DIXON 1970 7 JUL 0100 LT
(105° EMT)

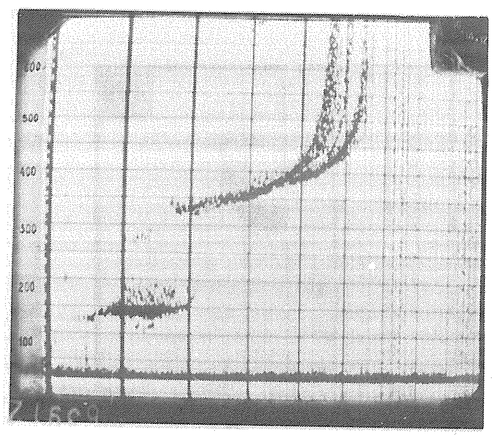


Fig. 1.21

DIXON 1970 13 JUL 0145 LT

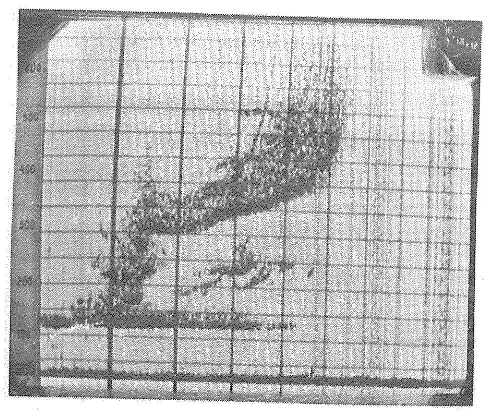


Fig. 1.22

DIXON 1969 3 JAN 0330 LT

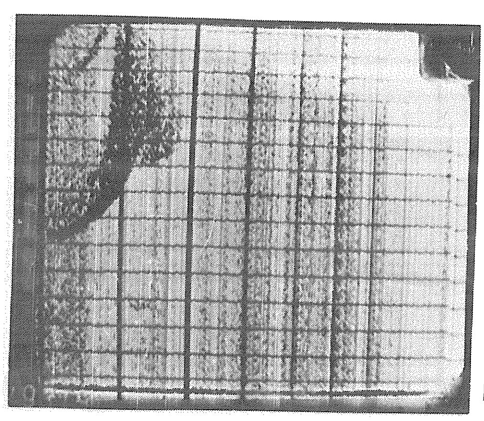


Fig. 1.23

DIXON 1969 8 JAN 0130 LT

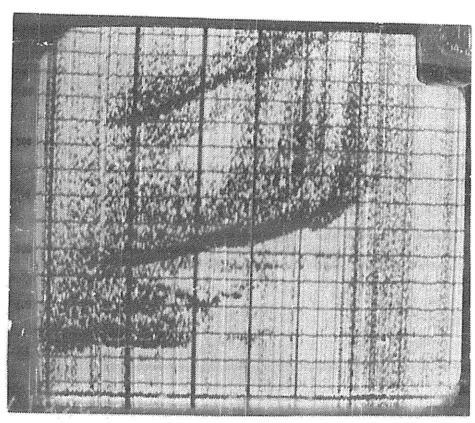


Fig. 1.24

LACUNA

MIRNY 1970 23 JAN 1105 LT
(90° EMT)

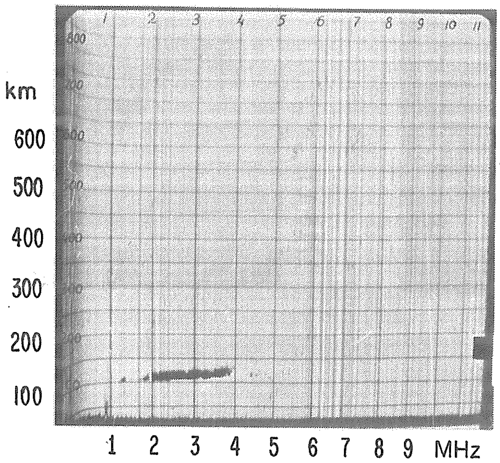


Fig. 1.25a

foE= Y foF1=Y foF2=Y

HEISS 1970 27 JUL 0530 LT
(45° EMT)

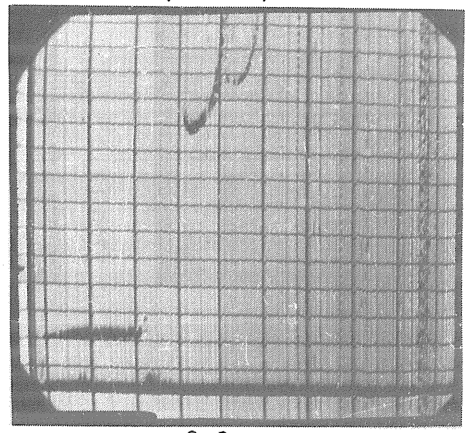


Fig. 1.26

fo fF2 foE=Y

MIRNY 1970 23 JAN 1115 LT

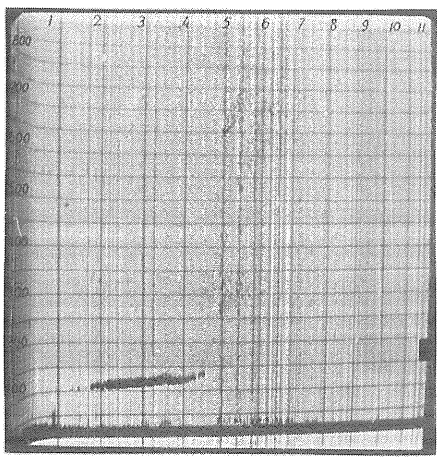


Fig. 1.25b

foE foF1 foF2=Y

HEISS 1970 29 JUL 0550 LT

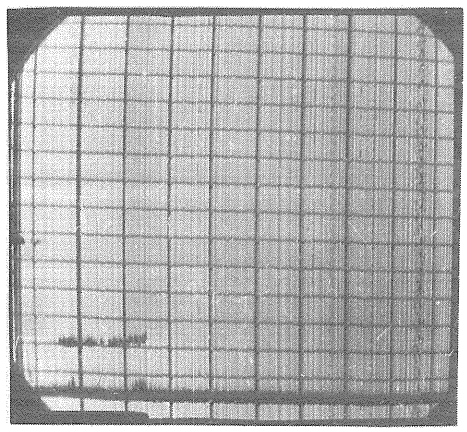


Fig. 1.27

foE=Y foF1=Y foF2=Y

MIRNY 1970 23 JAN 1130 LT

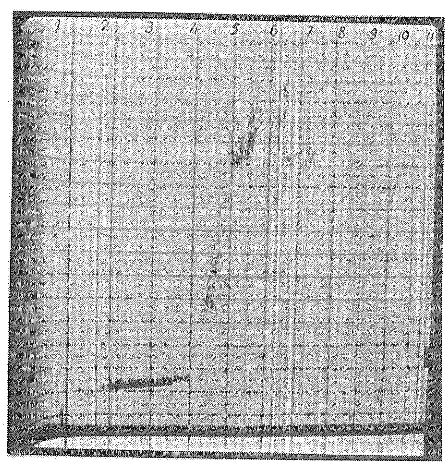


Fig. 1.25c

foE foF2
foF1

DIXON 1969 25 JAN 1655 LT
(105° EMT)

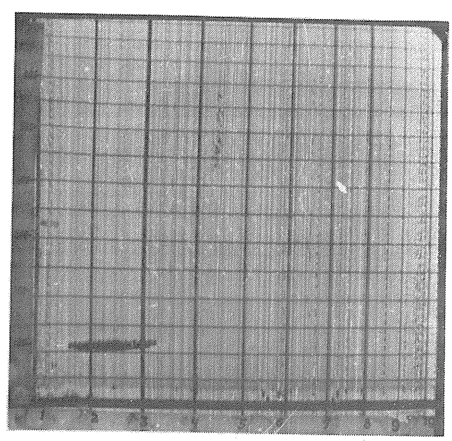


Fig. 1.28

foE=Y foF1=UY foF2= ..EG

DEVELOPMENT OF LACUNA

DIXON 1970 9 JUL 1530-1715 LT
(105° EMT)

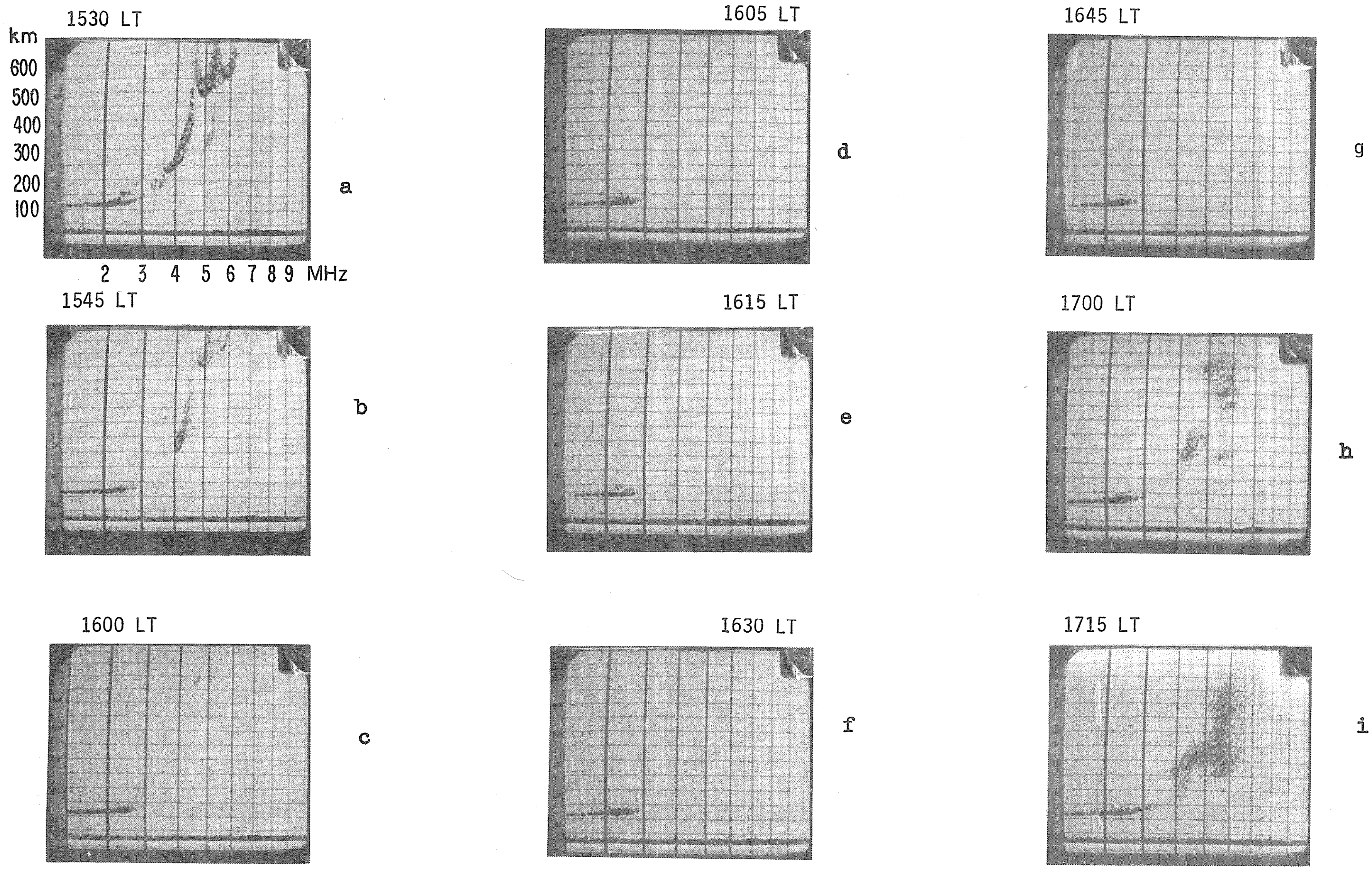


Fig. 1.29

DIXON 1969 7 JAN 2055 LT
(105° EMT)
a

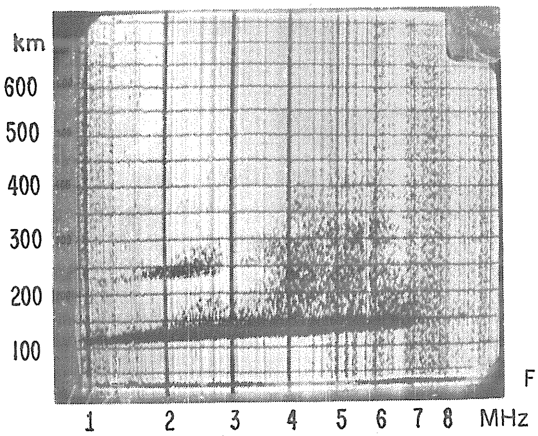


Fig. 1.30

DIXON 1970 10 JUL 0300 LT
a

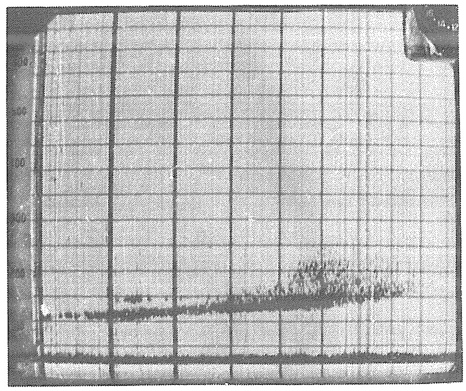


Fig. 1.31

DIXON 1970 2 JAN 2015 LT
c,a

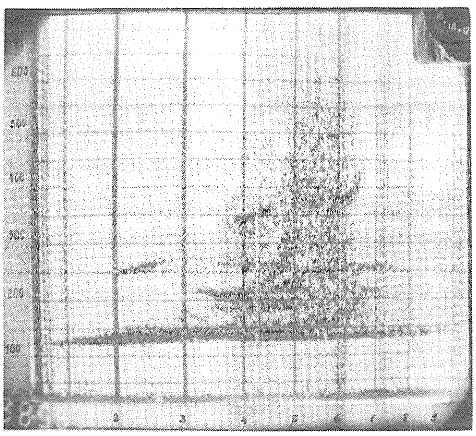


Fig. 1.32

DIXON 1970 29 JUL 1715 LT
a

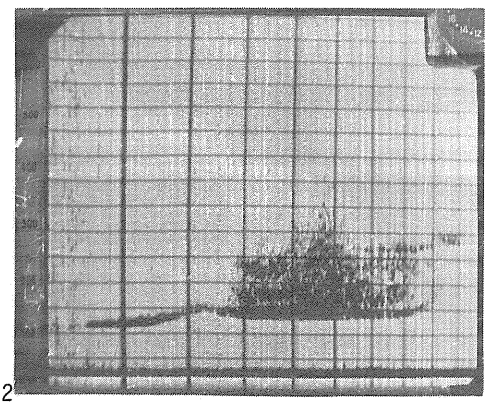


Fig. 1.33

HEISS 1970 27 JUL 1700 LT
(45° EMT)
a

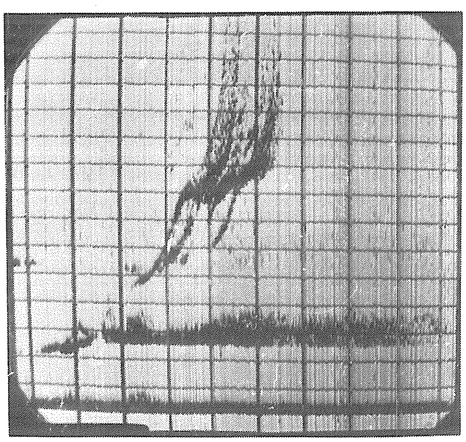


Fig. 1.34

HEISS 1970 29 JUL 1715 LT
r

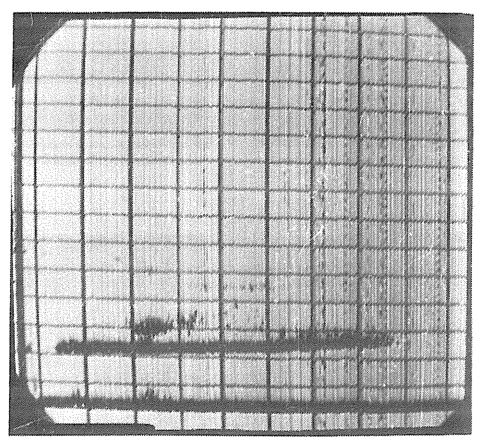


Fig. 1.35

SPORADIC E TYPE a and ASKAFILMS

TIXIE BAY 1958 10 NOV 1920 LT

(135° EMT)

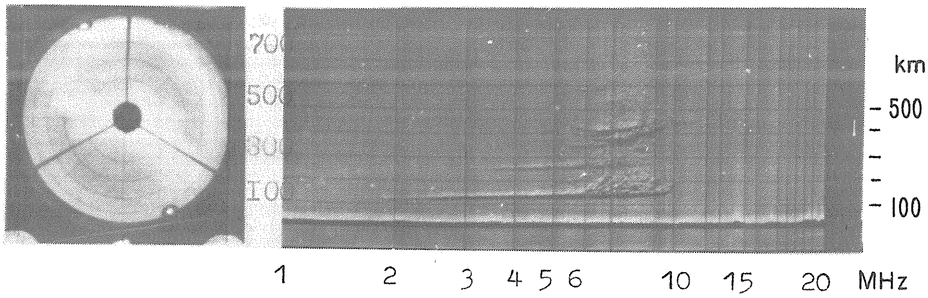


Fig. 1.36

TIXIE BAY 1958 19 NOV 0000-0230 LT

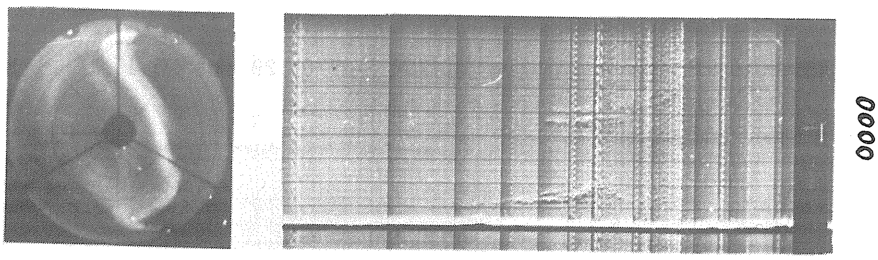


Fig. 1.36a

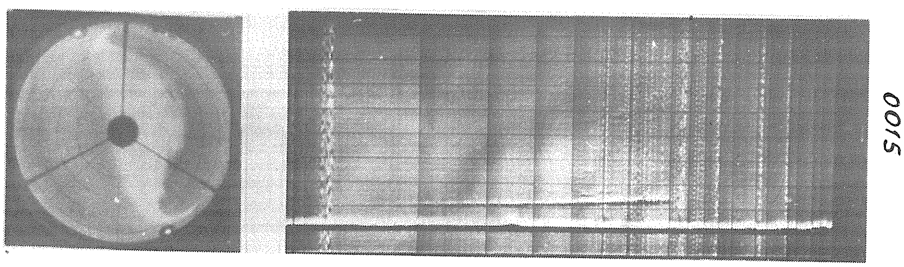


Fig. 1.36b

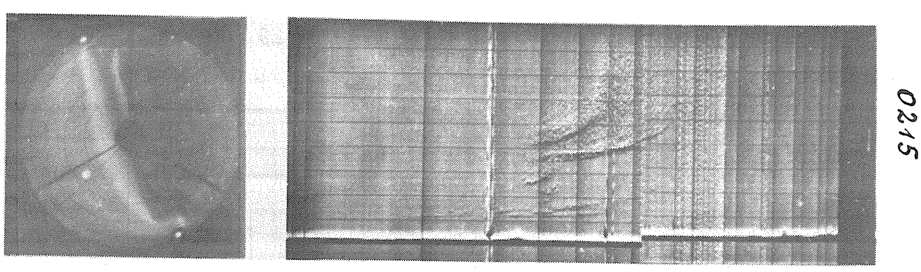


Fig. 1.36c

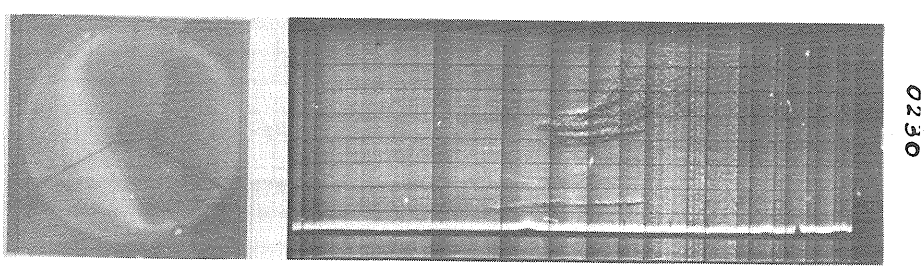


Fig. 1.36d

TIXIE BAY 1958 7 SEP 1155 LT

(135° EMT)

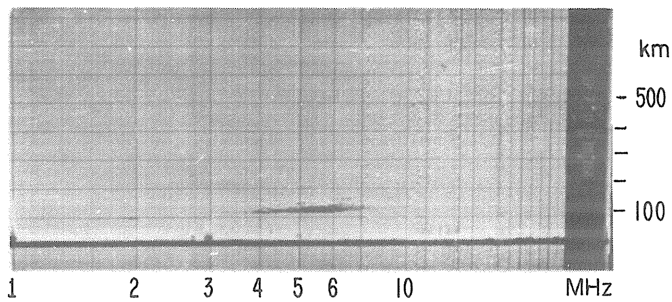


Fig. 1.37

Es under high absorption conditions (Es-a)

TIXIE BAY 1958 5 SEP 1200 LT

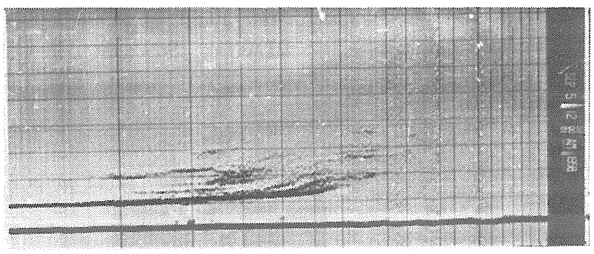


Fig. 1.38

Es-a

TIXIE BAY 1958 7 SEP 0845 LT

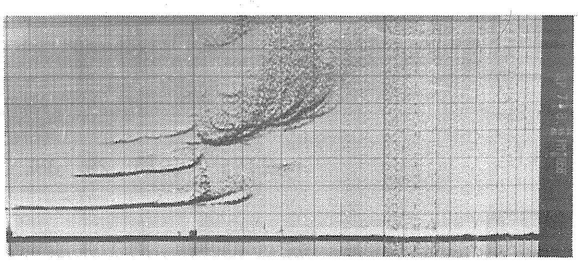


Fig. 1.39

Particle E (night E) (Es-k)

TIXIE BAY 1958 30 JUN 1600 LT

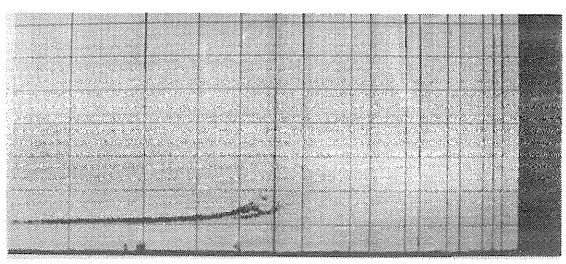
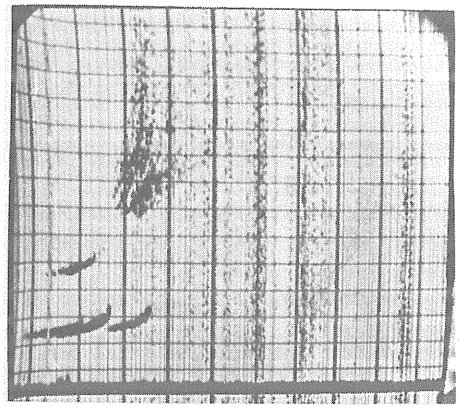


Fig. 1.40

Es-r

HEISS 1970 4 JAN 0545 LT
(45° EMT)



km
500
100

1 2 3 4 5 6 7 8 9 MHz

Fig. 1.41

Particle E (Es-k)

DIXON 1970 3 JAN 2005 LT
(105° EMT)

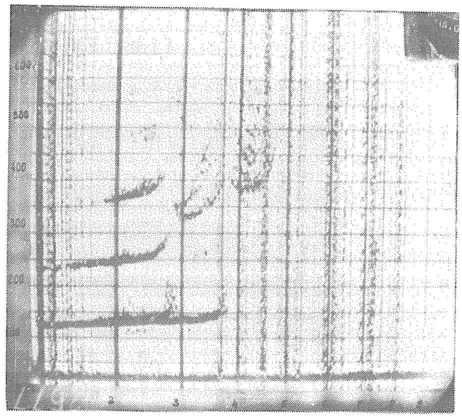


Fig. 1.42

Particle E (Es-k)

HEISS 1970 3 JAN 1245 LT

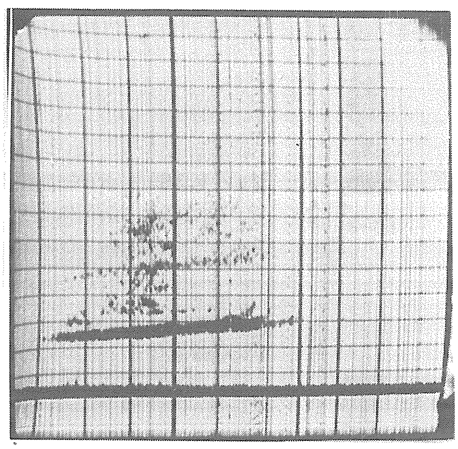


Fig. 1.43

Es-r

DIXON 1969 9 JAN 0345 LT

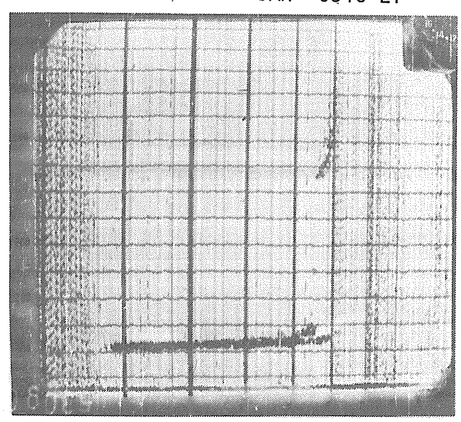


Fig. 1.44

Es-r

MIRNY 1970 4 JAN 1945 LT
(90° EMT)

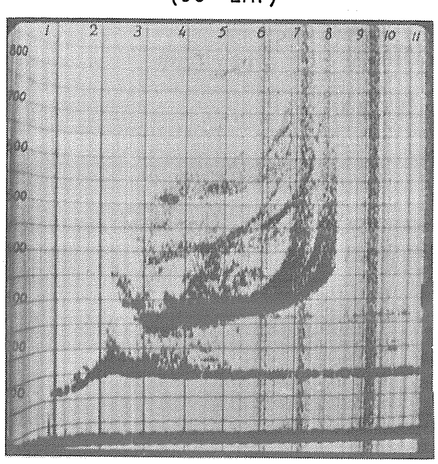


Fig. 1.45

Es-c

HEISS 1970 29 JUL 2045 LT

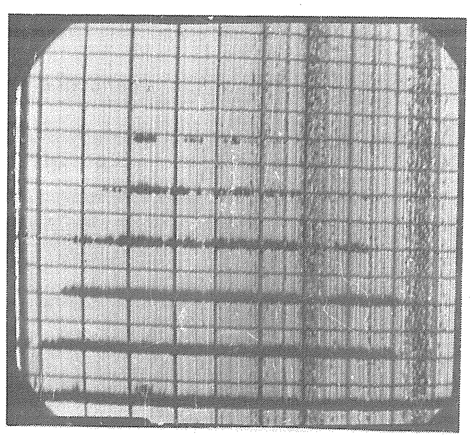


Fig. 1.46

Es-ℓ

IONOGRAM SEQUENCE. Es TYPES CHANGING IN TIME

DIXON 1970 2 JANUARY 1800-1930 LT

(105° EMT)

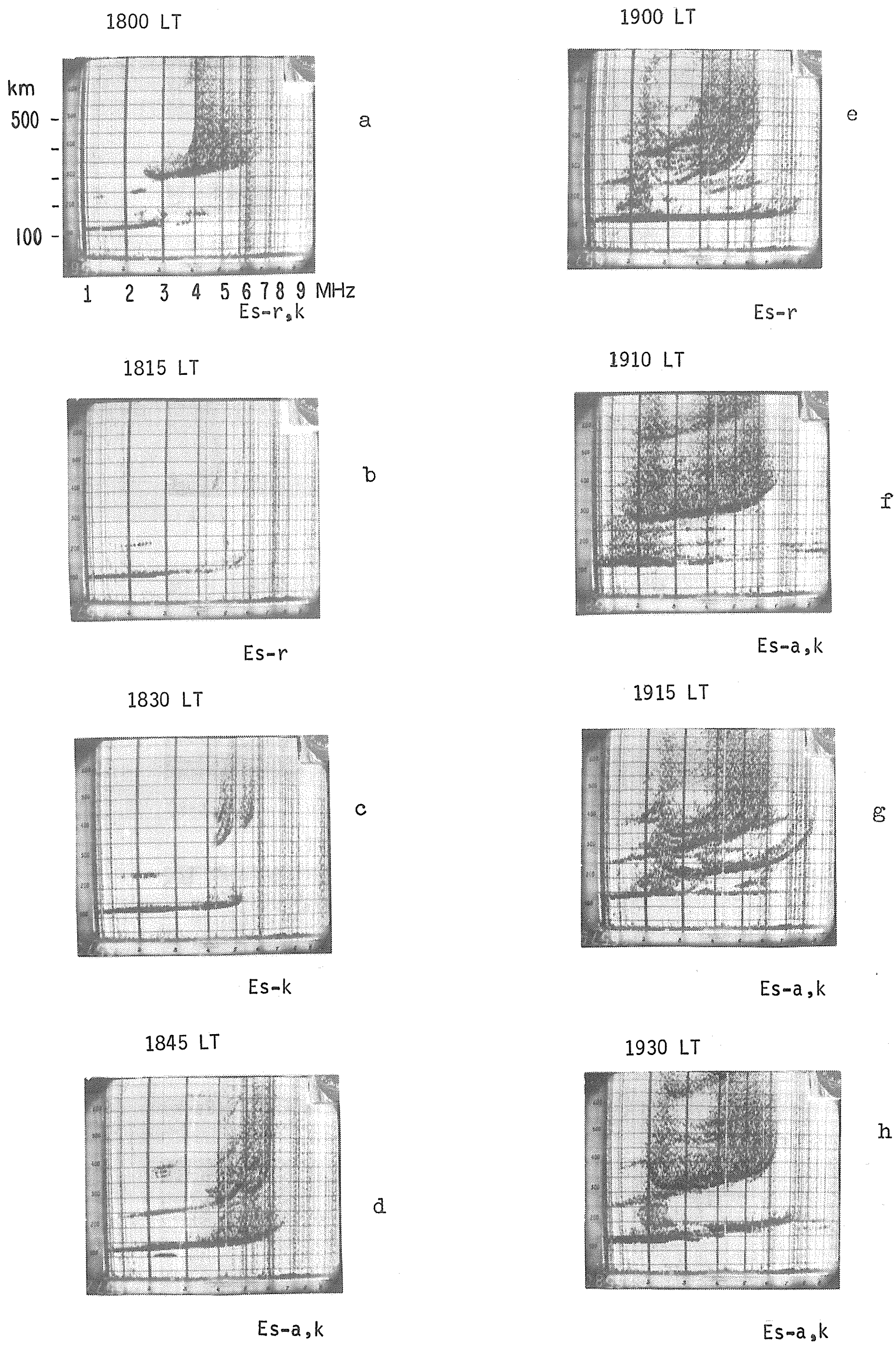


Fig. 1.47

IONOGRAM SEQUENCE. Es TYPES CHANGING IN TIME

DIXON 1970 1 JANUARY 0605-0755 LT

(105° EMT)

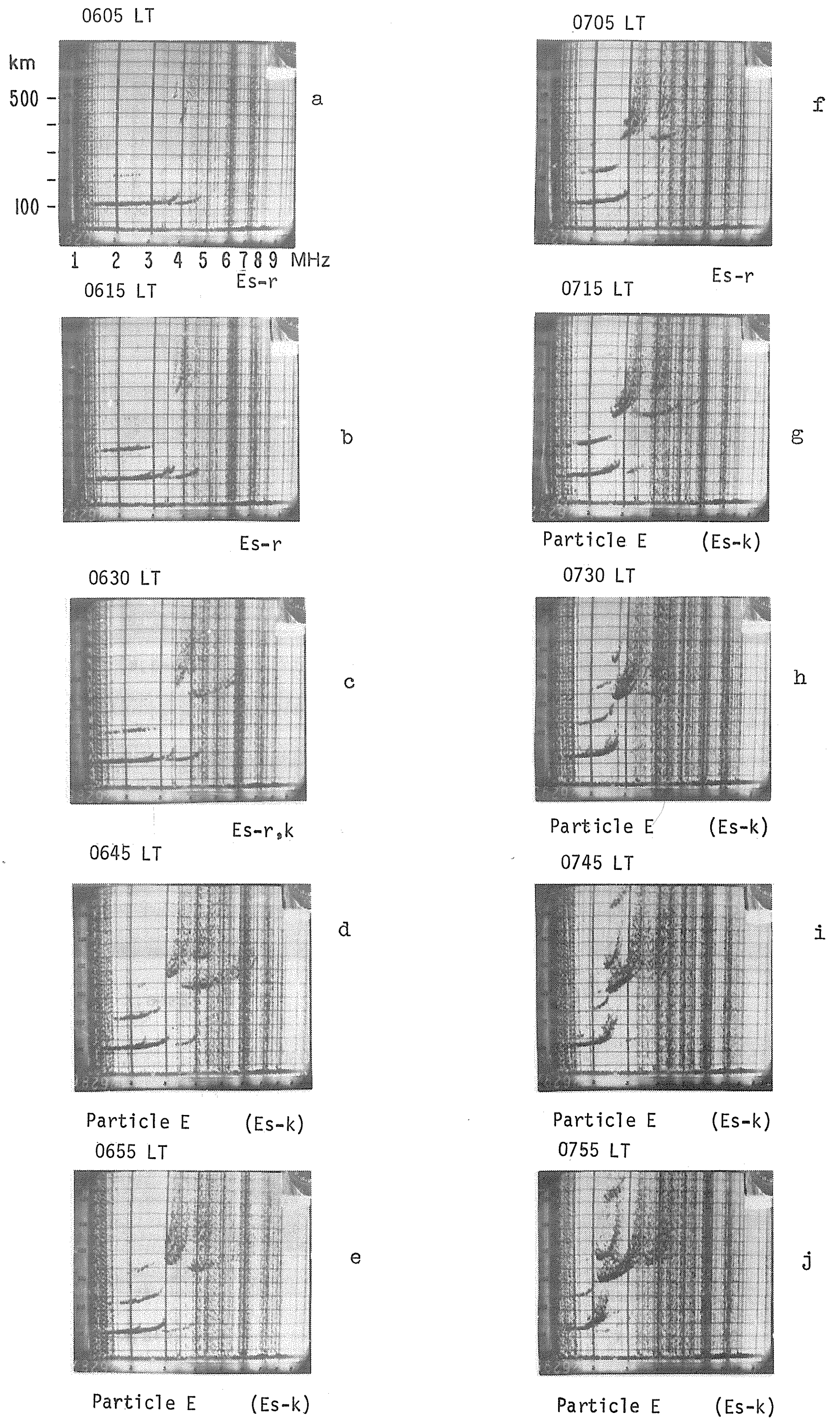


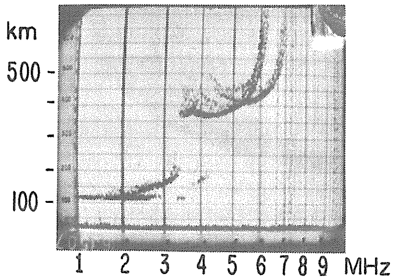
Fig. 1.48

IONOGRAM SEQUENCE WITH THE CHANGE OF PARTICLE E INTO E LAYER

DIXON 1970 5 JULY 0400-0530 LT

(105° EMT)

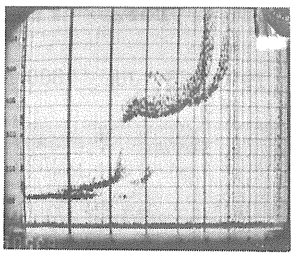
0400 LT



a

Particle E (Es-k)

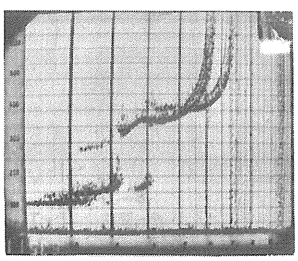
0405 LT



b

Particle E (Es-k)

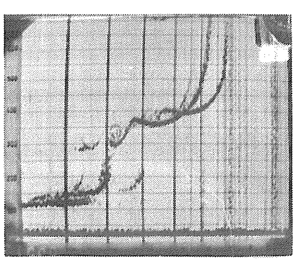
0415 LT



c

Particle E (Es-k)

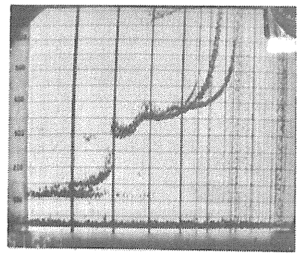
0430 LT



d

Particle E (Es-k)

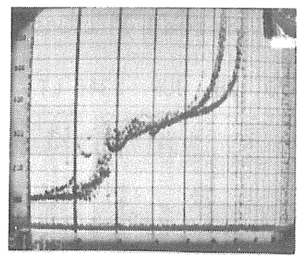
0445 LT



e

Particle E (Es-k)

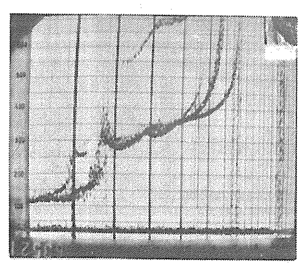
0500 LT



f

Particle E (Es-k)

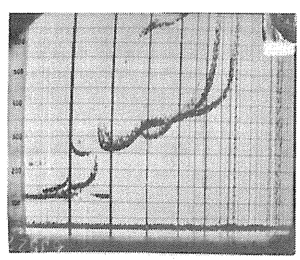
0515 LT



g

Particle E (Es-k)

0530 LT



h

Normal E Layer

Fig. 1.49

SPREAD F CLASSIFICATIONS

VOSTOK 1970 25 JUN 0915 LT
(105° EMT)

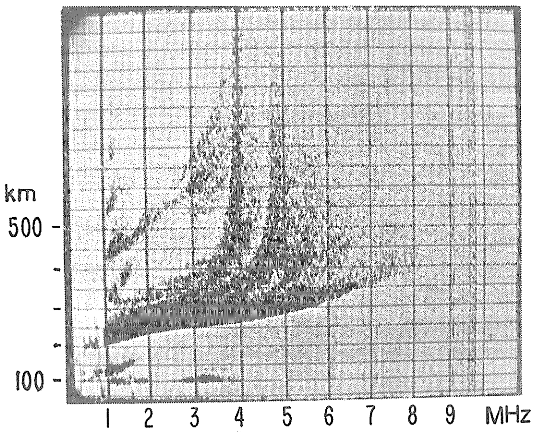


Fig. 1.50

foF2 fxI
Spread F classification P

MIRNY 1970 21 JUN 1215 LT
(90° EMT)

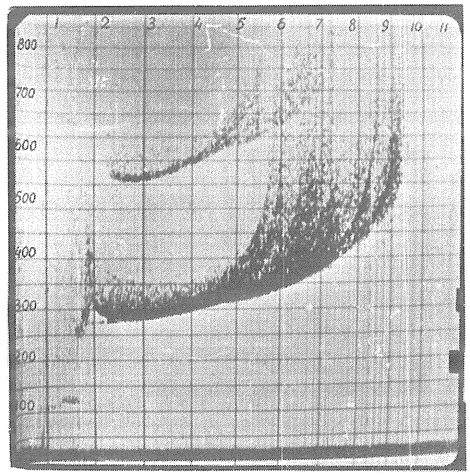


Fig. 1.53

foF2 fxI classification F

MIRNY 1970 28 JUN 2345 LT

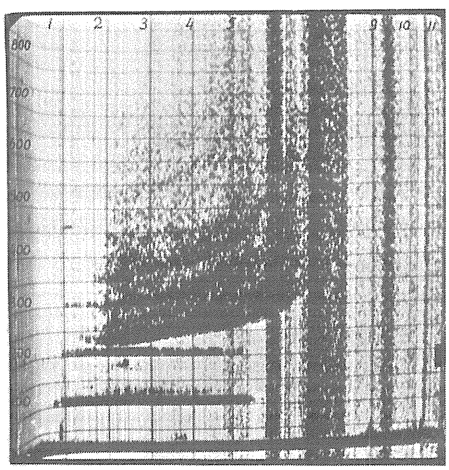


Fig. 1.51

q fxI q classification Q

HEISS 1970 28 JUL 1800 LT
(45° EMT)

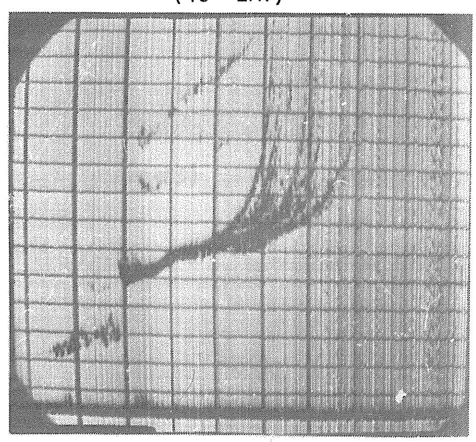


Fig. 1.54

foF2 fxI classification F

DIXON 1969 9 JAN 0445 LT
(105° EMT)

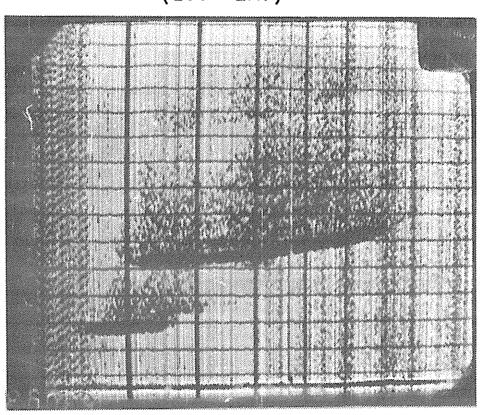


Fig. 1.52

q q
fxI classification Q

HEISS 1970 2 JAN 1845 LT

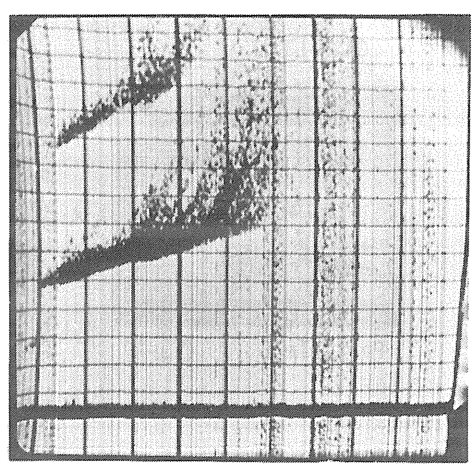


Fig. 1.55

foF2 fxI classification F

"THICK" F2 LAYER

"THIN" F2 LAYER (FLIZ)

VOSTOK 1970 28 JUN 0955 LT
(105° EMT)

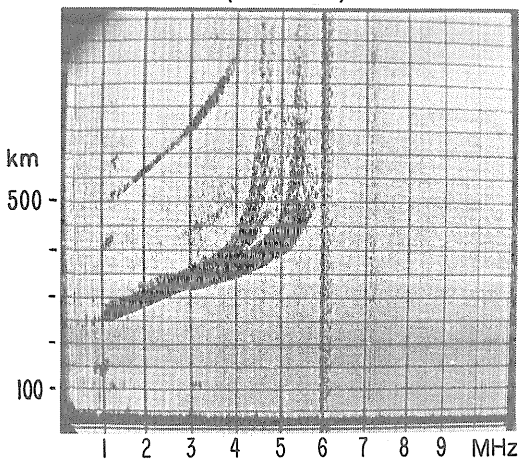


Fig. 1.56

o-x-
foF2

VOSTOK 1970 23 JUN 1400 LT

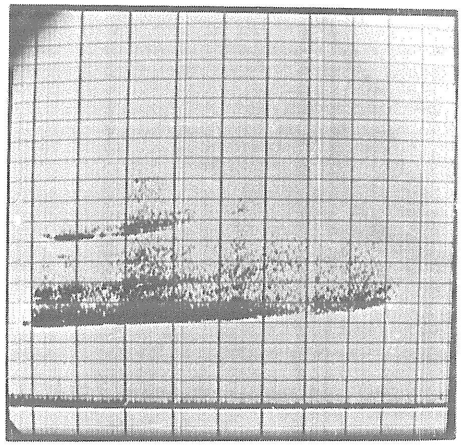


Fig. 1.57

q——q fxI

MIRNY 1970 24 JUN 1600 LT
(90° EMT)

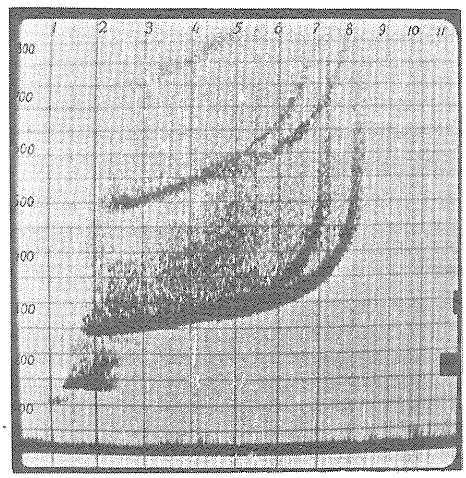


Fig. 1.58

o x
foF2

MIRNY 1970 29 JUN 1255 LT

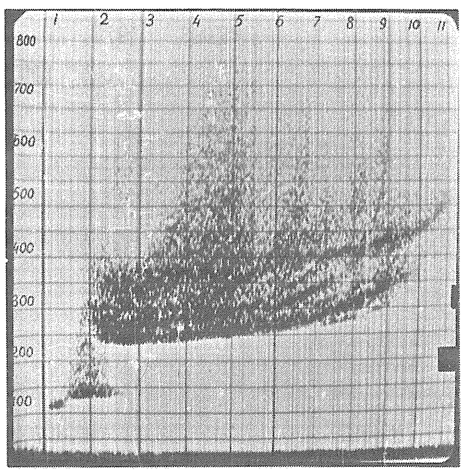


Fig. 1.59

q——q fxI

MIRNY 1970 1 JAN 2305 LT

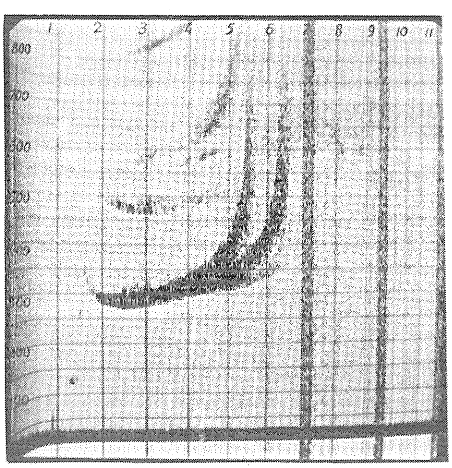


Fig. 1.60

o-x-
foF2

MIRNY 1970 2 JAN 0155 LT

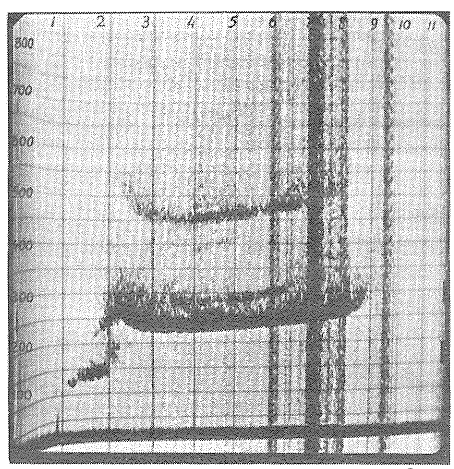


Fig. 1.61

q——q fxI

FLIZ PHENOMENON AT HIGH LATITUDES, WINTER

"THICK" F2 LAYER

HEISS 1970 16 JAN 1845 LT

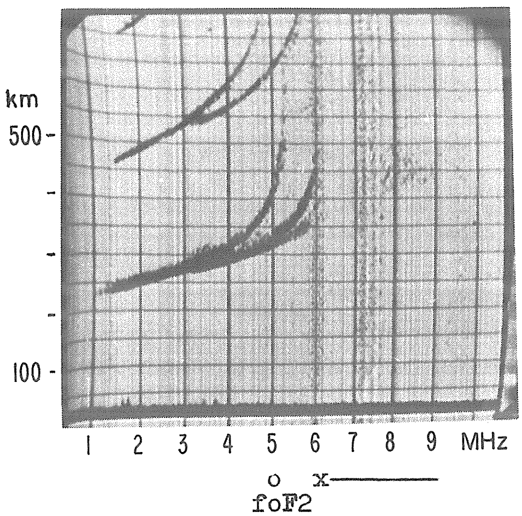


Fig. 1.62

"THIN" F2 LAYER

HEISS 1970 16 JAN 2230 LT

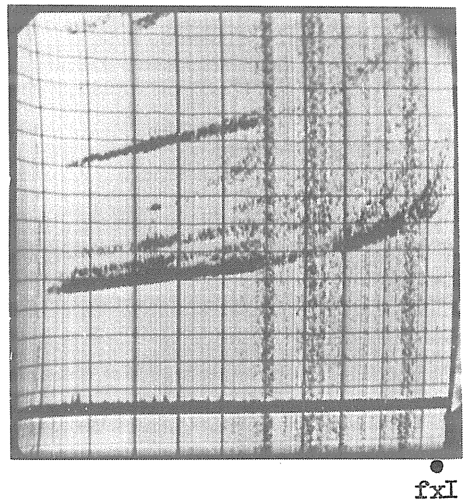


Fig. 1.63

IONOGRAM SEQUENCE SHOWING FLIZ PHENOMENON, WINTER

HEISS 1970 16 JANUARY 1915-2005 LT

(45° EMT)

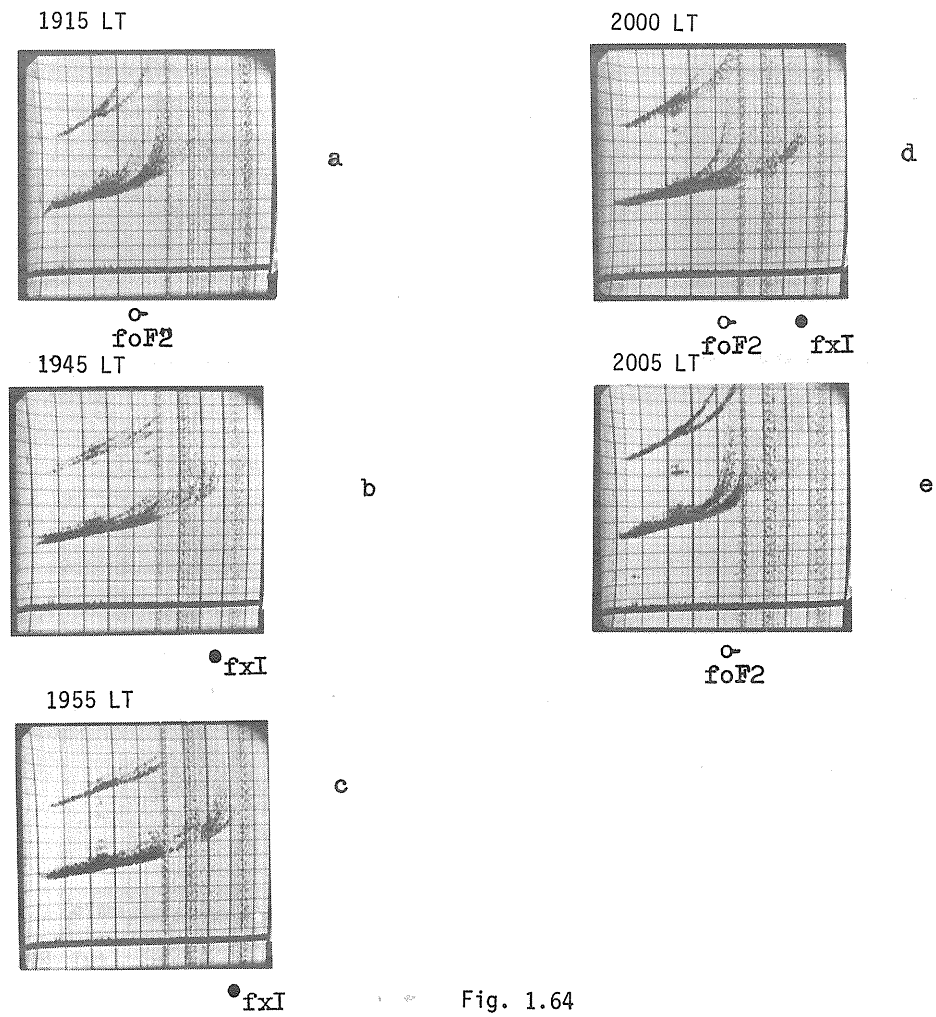


Fig. 1.64

IONOGRAM SEQUENCE SHOWING FLIZ PHENOMENON, WINTER

VOSTOK 1970 27 JUN 1905-2055 LT

(105° EMT)

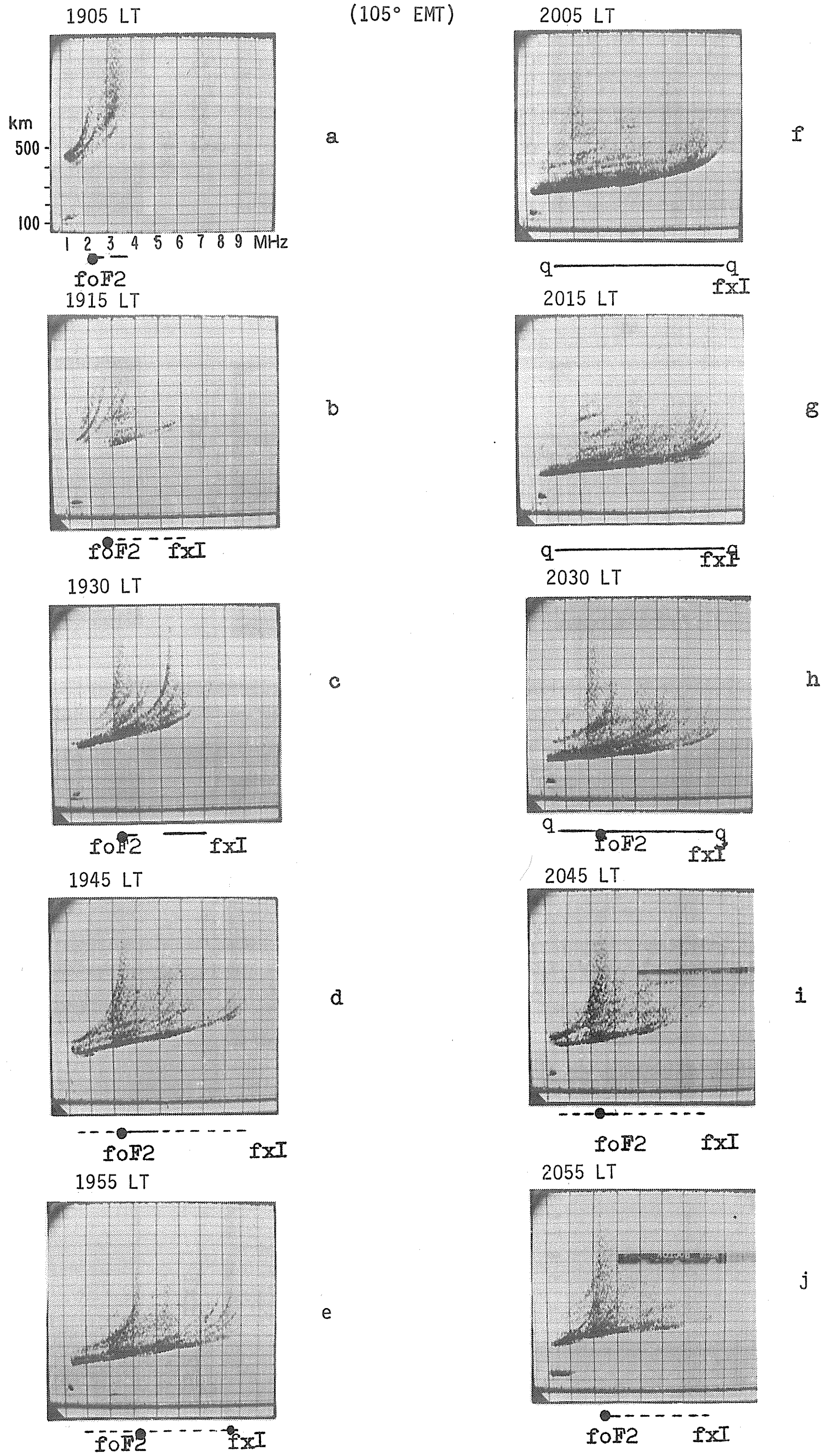


Fig. 1.65

IONOGRAM SEQUENCE IN THE NIGHT SECTOR OF THE AURORAL OVAL, MAGNETICALLY QUIET PERIOD, WINTER

DIXON 1969 4 JANUARY 0345-0645 LT
(105° EMT)

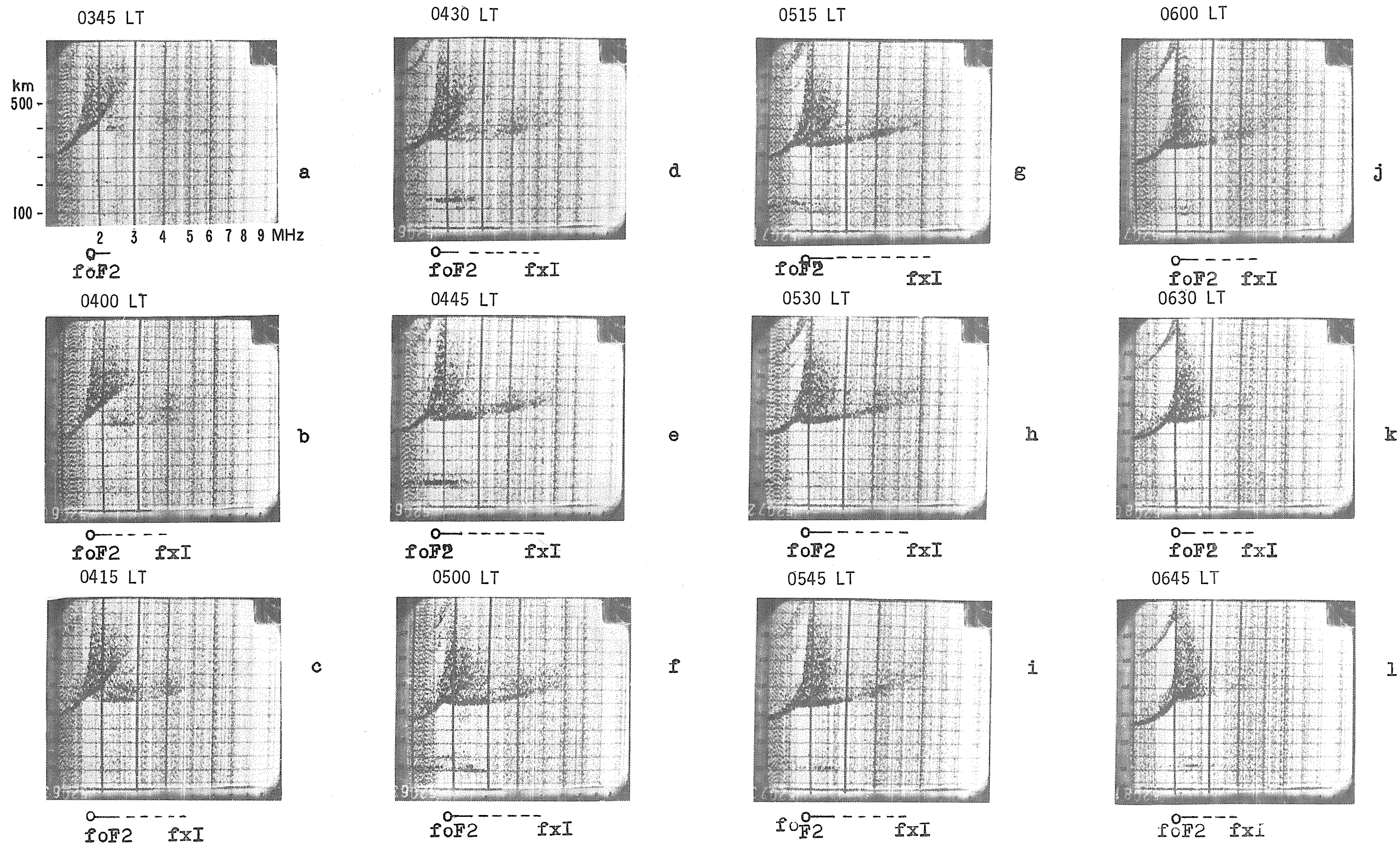


Fig. 1.66

IONOGRAM SEQUENCE IN THE NIGHT SECTOR OF THE AURORAL OVAL, MAGNETICALLY DISTURBED PERIOD, WINTER

DIXON 1969 24 JANUARY 0530-0930 LT
(105° EMT)

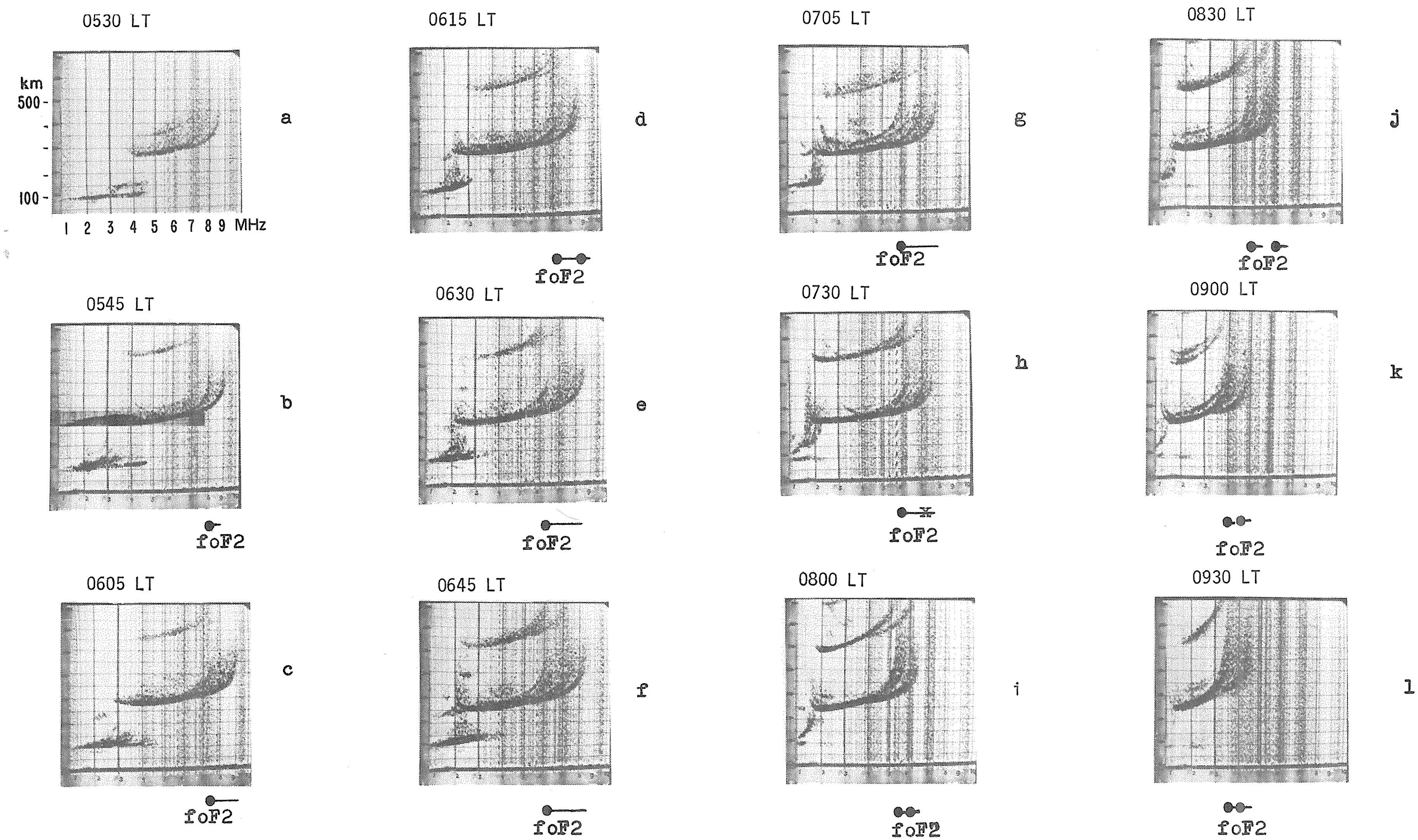


Fig. 1.67

IONOGRAM SEQUENCE IN DAY SECTOR OF AURORAL OVAL, MAGNETICALLY QUIET PERIOD, SUMMER

VOSTOK 1970 22 JANUARY 1905-2015 LT

(105° EMT)

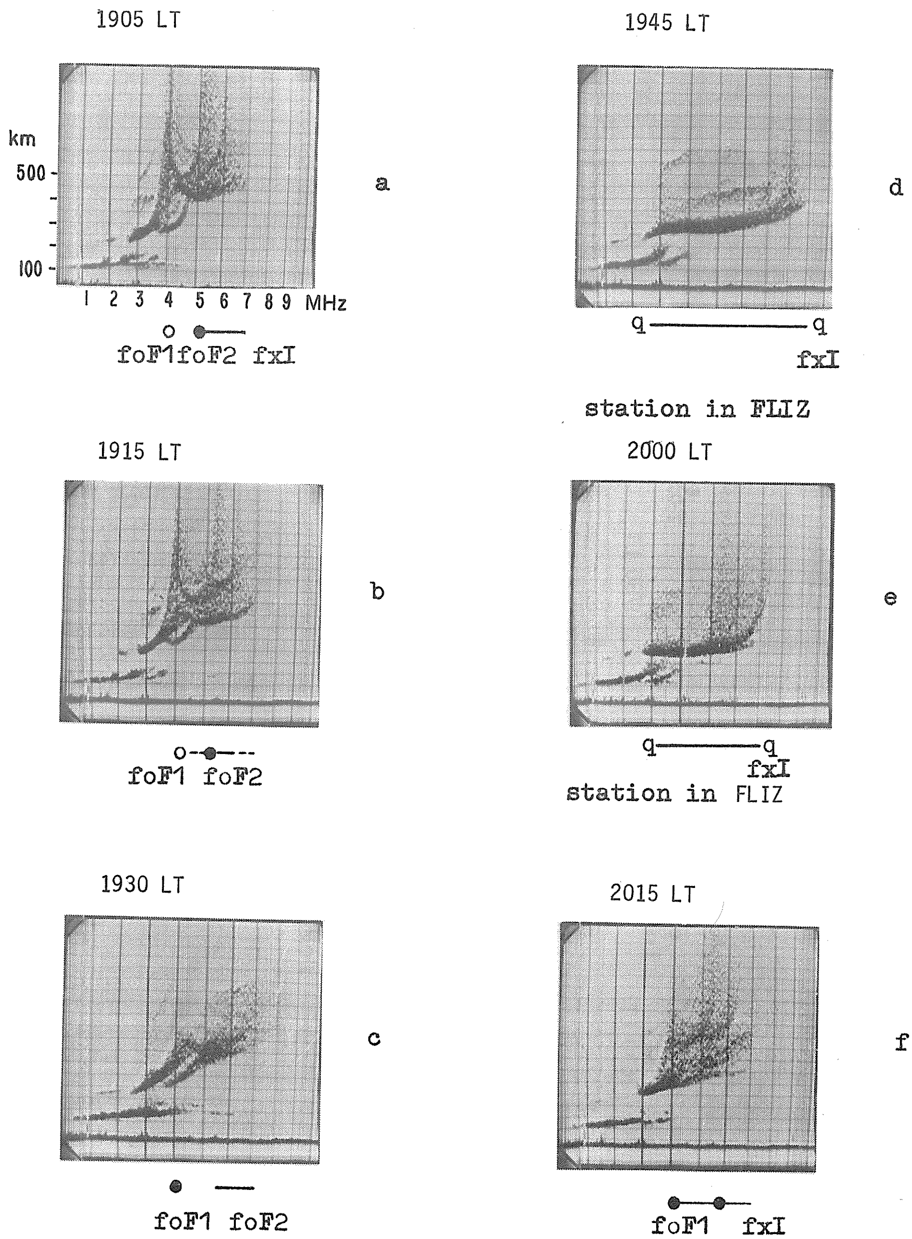


Fig. 1.68

IONOGRAM SEQUENCE IN DAY SECTOR OF AURORAL OVAL, MAGNETICALLY DISTURBED PERIOD, SUMMER

VOSTOK 1970 24 JANUARY 1745-1830 LT

(105° EMT)

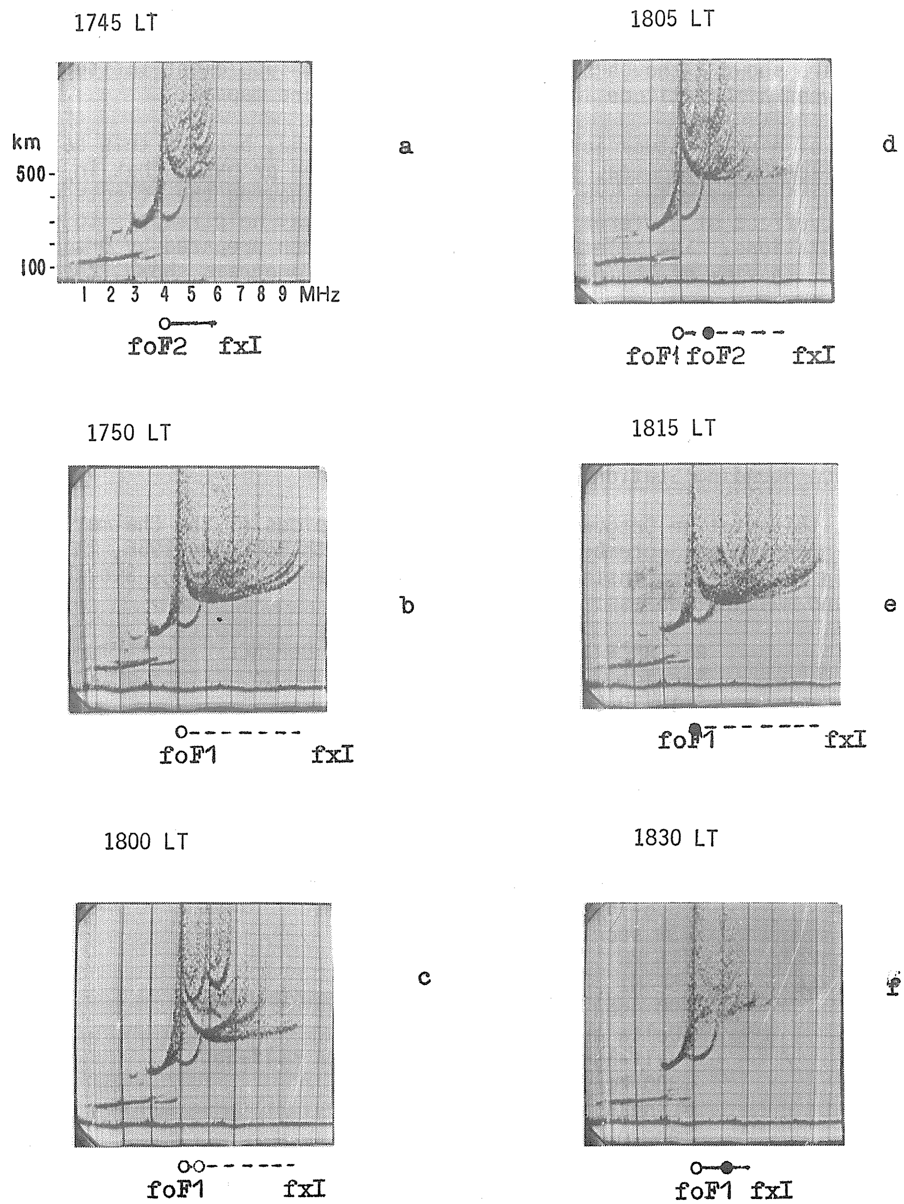


Fig. 1.69

SECTION 2. SCANDINAVIAN AND GREENLAND STATIONS

Part A. Scandinavian Stations

Kiruna, Sodankylä, Lycksele and Uppsala

Preface

This contribution gives examples of ionograms in the Scandinavian longitude sector. Some normal ionograms from Uppsala are shown although this is not within the "supplement latitudes". The station is, however, important when high latitude ionospheric phenomena are mapped.

The interpretation of high latitude ionograms is difficult and, because this selection consists mainly of difficult and special phenomena, it is possible and even probable that in some cases a wrong interpretation is given. Some examples are given for Sodankyla showing the effects of different types of recording (high gain, effect of differentiation, etc.) which may help readers to recognize similar phenomena at different stations. The selection and notes have been prepared by Dr. T. Turunen and shortened by the Editor. In view of the difficulty of the many ionograms shown, the Editor has added notes.

Data from Uppsala were provided by Dr. Ake Hedberg, from Lycksele by Mr. Oueklang, from Sodankyla by Dr. T. Turunen and from Kiruna by Rune Lindquist.

2A.1 KIRUNA

Vertical Incidence Sounding Station

Operation began at this station October 1948 under the auspices of the Chalmers University of Technology, Gothenburg, and ceased September 1955. Starting with February 1956, the station reopened and has been operated by the Research Institute of National Defence, Dept. 3, Stockholm, Sweden. Responsible authority and mailing address:

RESEARCH INSTITUTE OF NATIONAL DEFENCE
Section 346
S-10450 Stockholm 80, Sweden

Station Name:	Kiruna	
Geographic coordinates:	Lat. N 67.8°	E Long. 20.4°
Geomagnetic coordinates:	Lat. N 65.2°	E Long. 115.7°
Magnetic latitude:	65°	
Magnetic dip:	77°	
Time used:	15°E (UT + 1 hour)	
Frequency range:	0.6-15.0 MHz in 1 band	
Sweep time:	30 sec.	
Approximate peak power:	16 kW	
Pulse repetition rate:	50 Hz	
Pulse length:	50 μsec	
Aerial type:	Delta and special Rhombic	
Routine sounding:	Half-hourly, centered on each half-hour	
Height range:	800 km in 50 km intervals	
Height scale:	Linear	
Frequency scale:	Approximately logarithmic	

There is a frequency marker on the ionogram for each MHz of the range. Nominal frequency difference of x- and o-components: 0.7 MHz. Ionograms are recorded on 16 mm film.

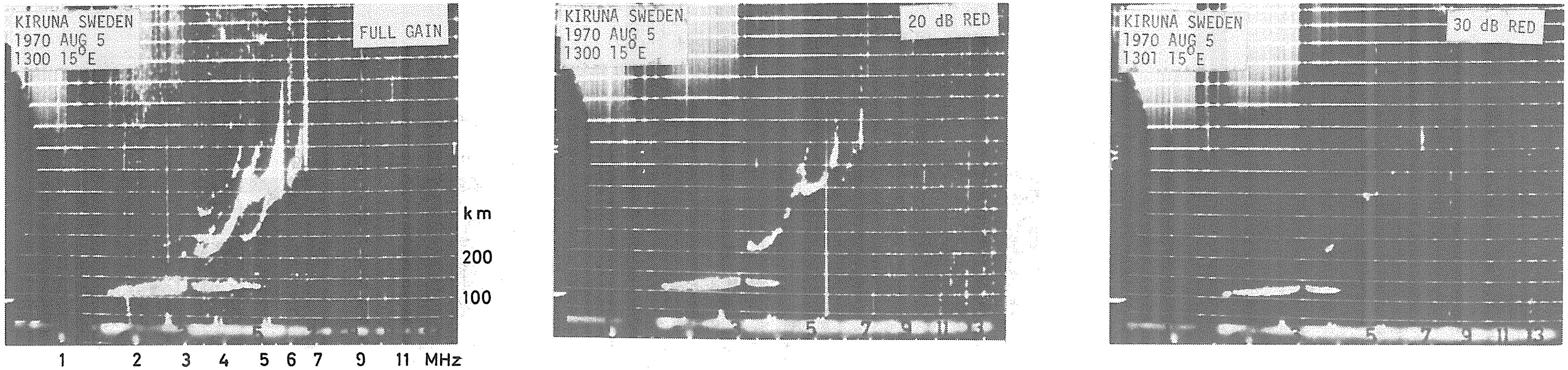
Most of the ionospheric data are published in FA-series booklets of U.S. Department of Commerce.

Terminology conforms with that recommended in the *URSI Handbook of Ionogram Interpretation and Reduction*, Second Edition, edited by W. R. Piggott and K. Rawer, *Report UAG-23*, World Data Center A for Solar-Terrestrial Physics, U. S. Department of Commerce, NOAA, November 1972.

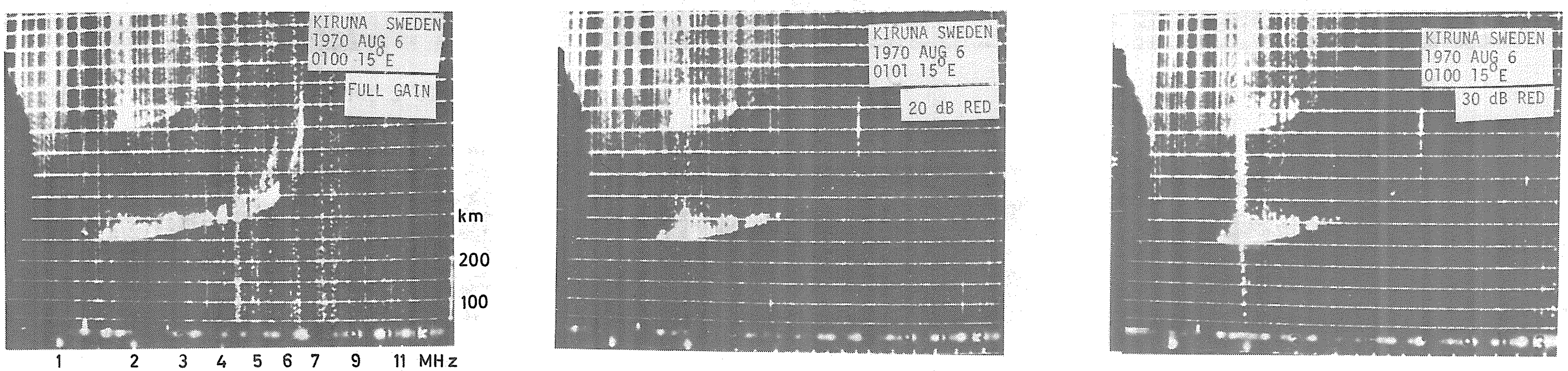
Editor's Notes: This station departs from normal practice in that the normal gain used is the highest available. The gain runs are therefore normal, minus 20 dB and minus 30 dB. The normal gain is often slightly too high for optimum analysis.

Comments on the ionograms have been added by the Editor.

Many additional ionograms have had to be left out due to lack of space, but will be used in discussions in the INAG Bulletin.



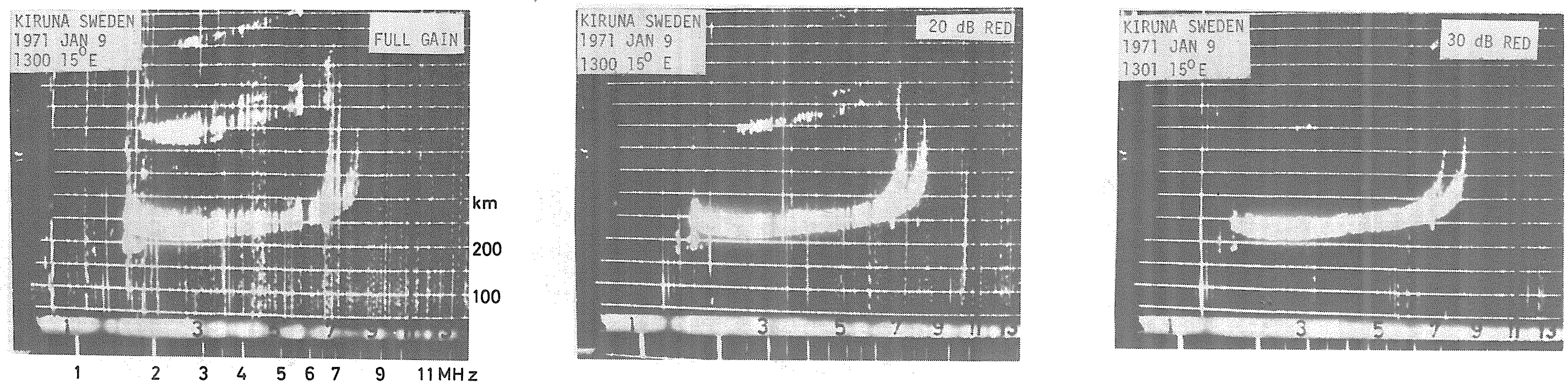
KIRUNA - Quiet Summer Day 1970 Aug. 5 1300-1301 LT (15°E)



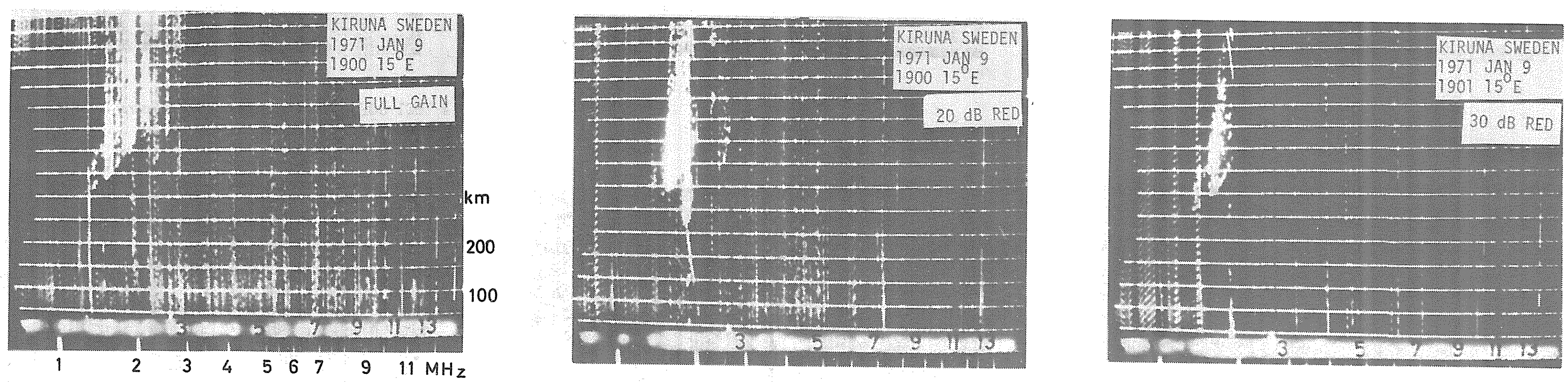
KIRUNA - Quiet Summer Night 1970 Aug. 6 0100-0101 LT (15°E)

Fig. 2.1 QUIET IONOGRAMS AT KIRUNA

Three gain runs for every hour.

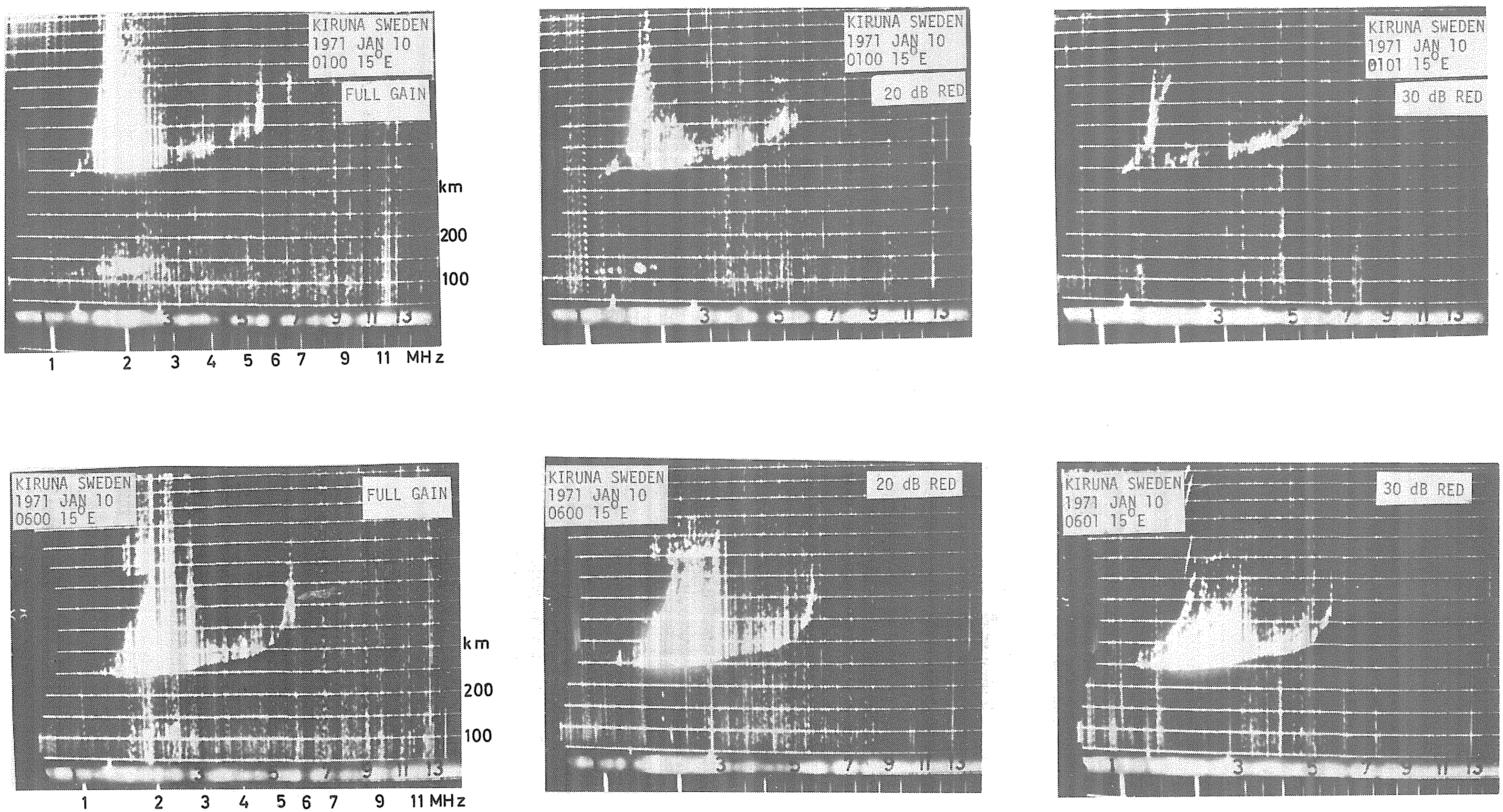


KIRUNA - Quiet Winter Day 1971 Jan. 9 1300-1301 LT (15°E)



KIRUNA - Quiet Winter Night 1971 Jan. 9 1900-1901 LT (15°E)

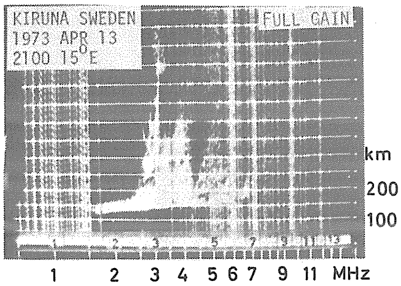
Fig. 2.2 QUIET IONOGRAMS AT KIRUNA

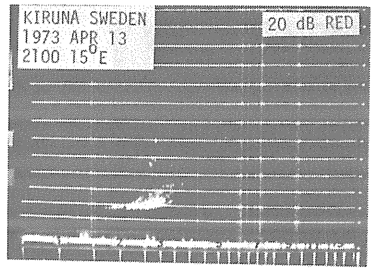


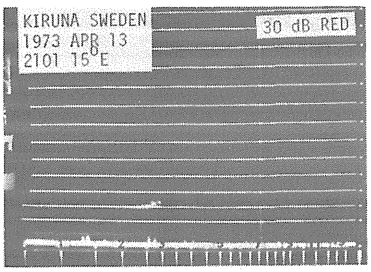
KIRUNA - Quiet Winter Night 1971 Jan. 10 0100-0101 LT (15°E)
0600-0601 LT (15°E)

Fig. 2.3 QUIET IONOGRAMS AT KIRUNA

Editor's Note: Quiet winter night - trough position constant. Kiruna 1971 Jan. 10, 0100 and 0600 LT. This is a good example of simultaneous traces from trough (small foF2) and from ridge structure (replacement layer - polar spur) when station is in trough. Note second order shows layer not horizontal. Large differences foF2 (about 020) and fxI (about 060) can be used to recognize days on which this occurs.

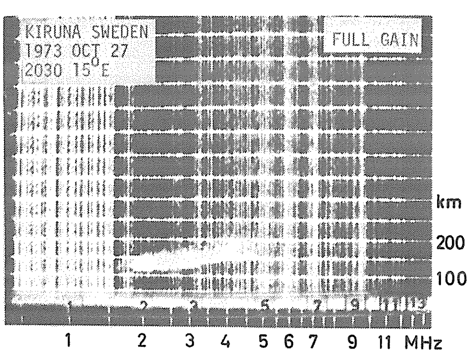


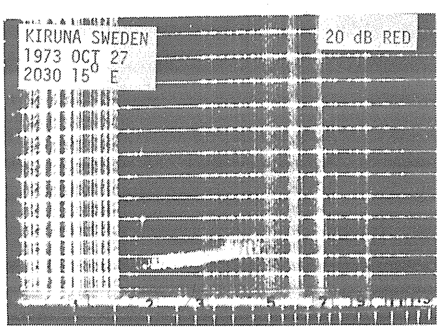


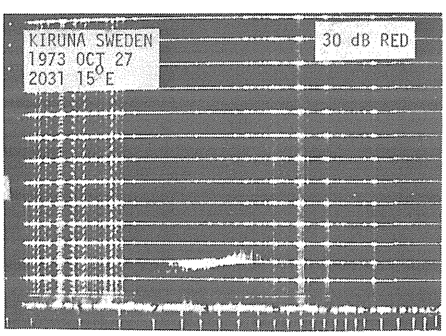


fmin ...	014	foF1 ...		h'Es ...	120
foEs ...	063JA	foF2 ...	A	h'E ...	
fbEs ...	063AA	fzF2 ...		h'E2 ...	
foE ...		fxI ...		h'F1 ...	A
foE2 ...		M(3000)F2	A	h'F2 ...	
Es type	a				

KIRUNA - Typical Auroral - Es 1973 Apr. 13 2100-2101 LT (15°E)



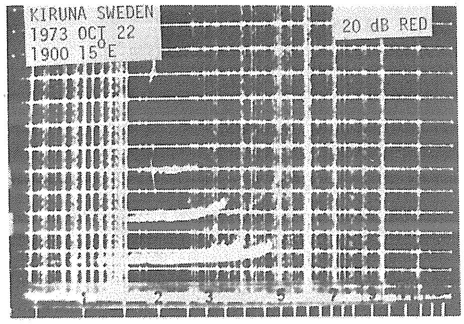


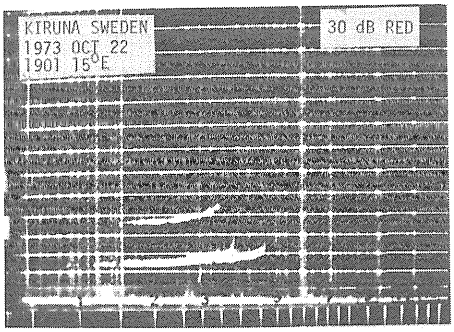


fmin ...	016	foF1 ...		h'Es ...	110
foEs ...	040JA	foF2 ...	A	h'E ...	
fbEs ...	040JA	fzF2 ...		h'E2 ...	
foE ...		fxI ...	A	h'F1 ...	A
foE2 ...		M(3000)F2	A	h'F2 ...	
Es type	a				

KIRUNA - Es Type a (Sloping Type) 1973 Oct. 27 2030-2031 LT (15°E)

Fig. 2.4 KIRUNA - Es Type a

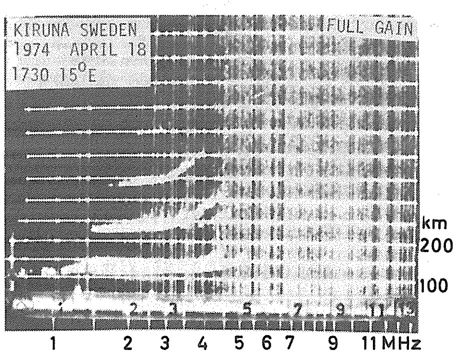


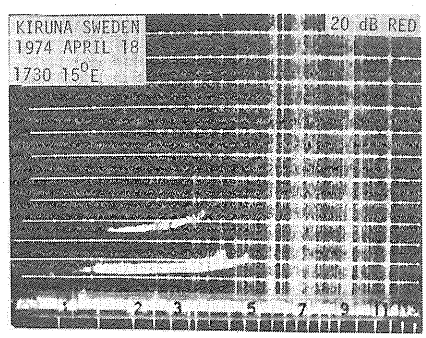


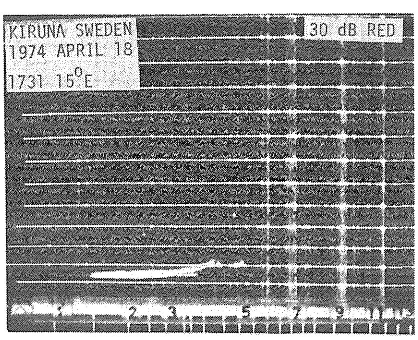
fmin ...	006	foF1 ...		h'Es ...	110
foEs ...	040-K	foF2 ...	G	h'E ...	
fbEs ...	035AA	fzF2 ...		h'E2 ...	
foE ...	400-K	fxI ...	G	h'F1 ...	G
foE2 ...		M(3000)F2	G	h'F2 ...	
Es type	k3				

KIRUNA - Particle E - Es-k 1973 Oct. 22 1900-1901 LT (15°E)

Editor's Note: The low gain shows foE clearly so this is Es-k. Layer is not horizontal so higher orders do not confirm either foE or h'E.



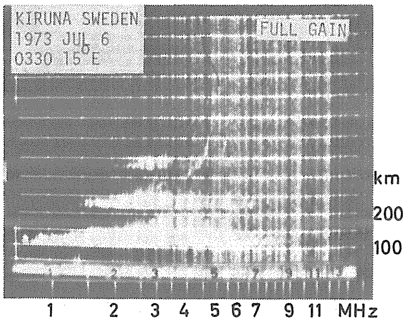


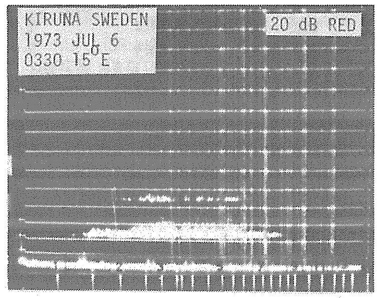


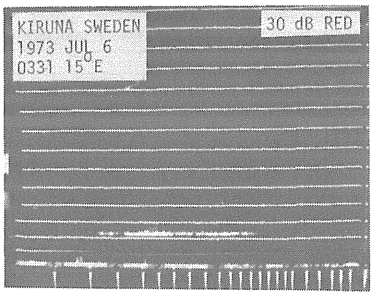
fmin ...	005EE	foF1 ...		h'Es ...	105
foEs ...	045-K	foF2 ...	G	h'E ...	105
fbEs ...	045-K	fzF2 ...		h'E2 ...	
foE ...	450-K	fxI ...	G	h'F1 ...	G
foE2 ...		M(3000)F2	G	h'F2 ...	
Es type	k3				

KIRUNA - Es Type k -- Particle E 1974 Apr. 18 1730-1731 LT (15°E)

Fig. 2.5 KIRUNA - Particle E (Es-k)



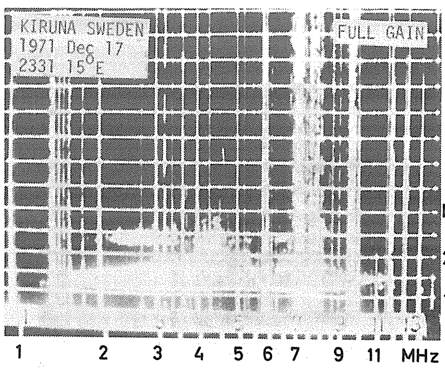


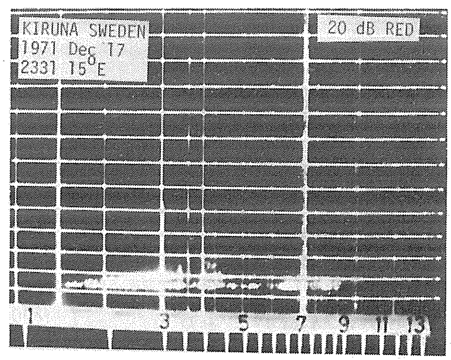


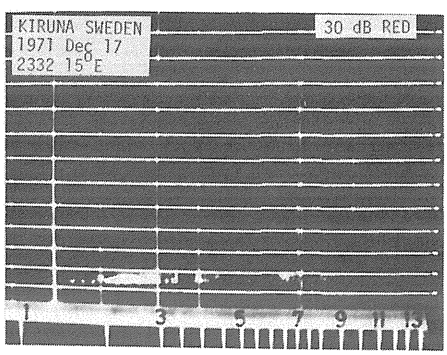
fmin ...	005EE	foF1 ...	A	h'Es ...	105 F
foEs ...	085JA	foF2 ...	048	h'E ...	A
fbEs ...	040	fzF2 ...		h'E2 ...	
foE ...	A	fxI ...	055 X	h'F1 ...	A
foE2 ...		M(3000)F2		h'F2 ...	A
Es type	f3 a1				

KIRUNA - Flat Es with Scatter Above It 1973 Jul. 6 0330-0331 LT (15°E)

Editor's Note: Main Es is f3. Question is whether scatter sufficient to justify "a" entry also. Borderline case but pattern sufficiently like "a" to make entry f3, a1. Should use h'Es = 105-F.





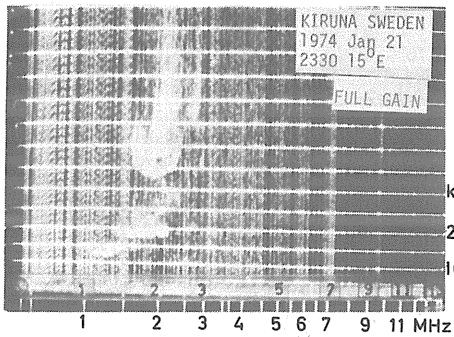


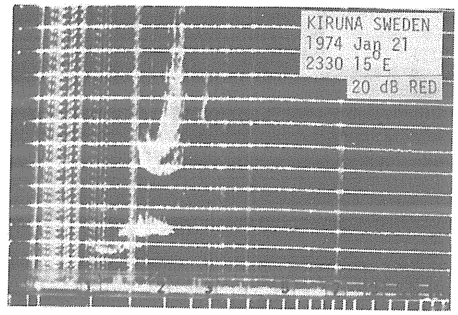
fmin ...	012	foF1 ...		h'Es ...	110
foEs ...	113JA	foF2 ...	A	h'E ...	
fbEs ...	080AA	fzF2 ...		h'E2 ...	
foE ...		fxI ...		h'F1 ...	A
foE2 ...		M(3000)F2	A	h'F2 ...	
Es type	a				

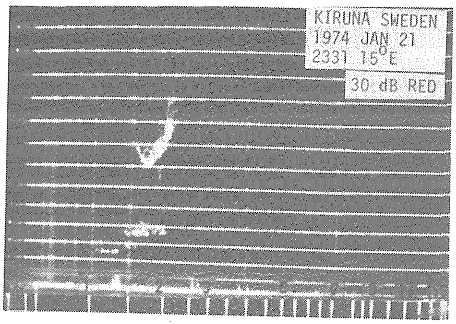
KIRUNA - Complex Es-a,f Pattern 1971 Dec. 17 2331-2332 LT (15°E)

Editor's Note: The F trace is blanketed which suggests not purely an Es-a. Second order present confirms this. Best interpretation probably a,f2. Second order suggests fbEs about 080AA.

Fig. 2.6 KIRUNA - Es Types a and f



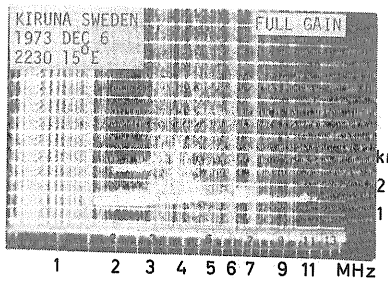


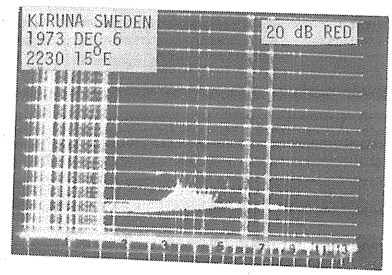


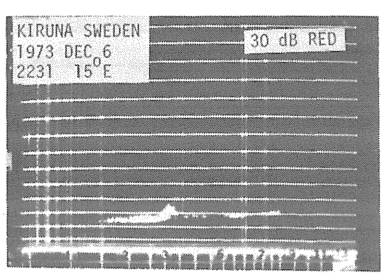
fmin ...	010ES	foF1 ...		h'Es ...	110 K
foEs ...	022	foF2 ...	021UF	h'E ...	110 K
fbEs ...	015 K	fzF2 ...		h'E2 ...	
foE ...	150 K	fxI ...	029	h'F1 ...	325 H
foE2 ...		M(3000)F2	F	h'F2 ...	
Es type	a k	fmI	019		

KIRUNA - Es Types k and a 1974 Jan. 21 2330-2331 LT (15°E)

Editor's Note: The Es-a structure is seen at oblique incidence (fbEs from F = foEs-K from E) but fbEs on "a" trace smaller. Gain change leaves main "a" still visible and confirms Es-k not r. Strict application of type rules is k,a as foEs measured on k trace, but this is clear from the Es entry so a,k as written preferable. Rule needs clarification at Lima. The foF2 trace is weak and no scatter seen on it. Hence strictly fxI = 029-X. o trace shows strong scatter so more useful alternative 0320B.





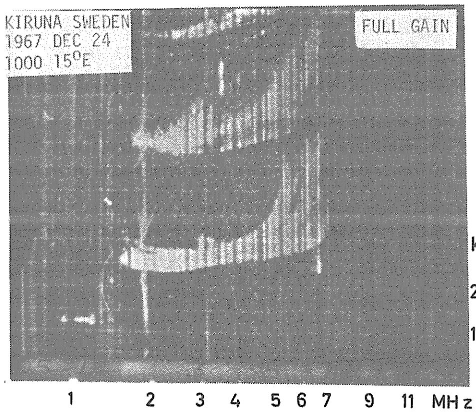


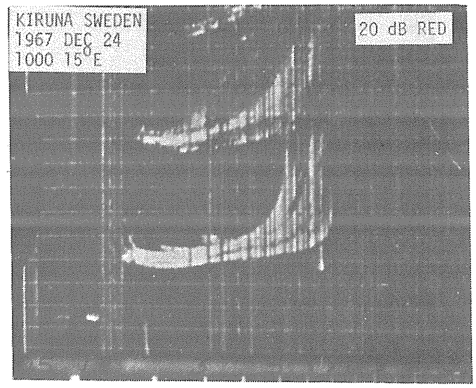
fmin ...	015	foF1 ...		h'Es ...	105
foEs ...	110JA	foF2 ...	G	h'E ...	
fbEs ...	033-K	fzF2 ...		h'E2 ...	
foE ...	330-K	fxI ...	G	h'F1 ...	G
foE2 ...		M(3000)F2		h'F2 ...	
Es type	a k2				

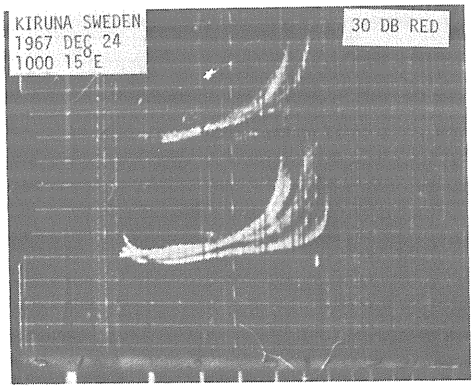
KIRUNA - Es Types k and a 1973 Dec. 6 2230-2231 LT (15°E)

Editor's Note: Es-a does not blanket as it is oblique. fbEs therefore given by particle E trace. Low gain record shows good echo to foE so not an r trace. Retardation at cusp very gain sensitive with r, not k. G is better than A when blanketing by particle E (Es-k).

Fig. 2.7 Kiruna - Es Type k and a



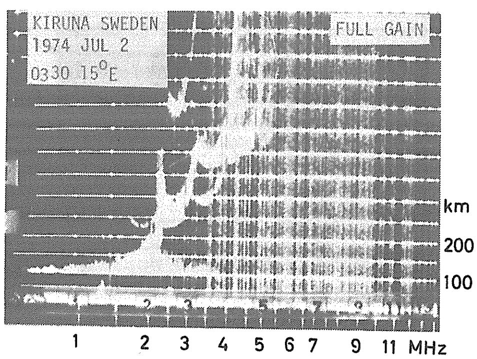


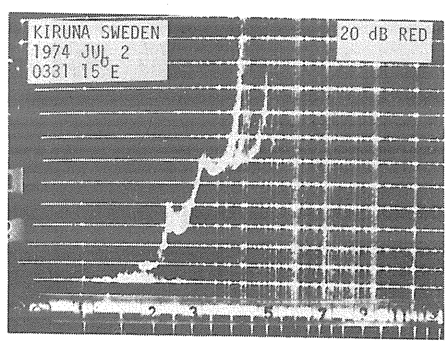


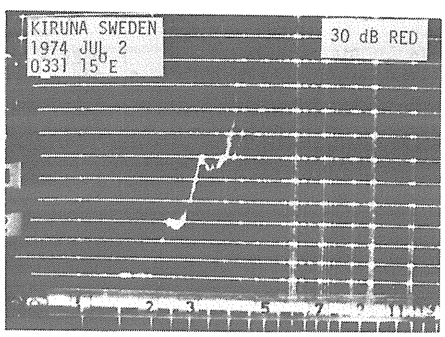
fmin ...	007	foF1 ...		h'Es ...	115 K
foEs ...	014UK	foF2 ...	052 F	h'E ...	115 K
fbEs ...	014UK	fzF2 ...		h'E2 ...	
foE ...	140UK	fxI ...	071	h'F1 ...	235 Q
foE2 ...		M(3000)F2	F	h'F2 ...	
Es type	k	fmI ...	052		

KIRUNA - Particle E (Es-k) - Range and Frequency Spread 1967 Dec. 24 1000 LT (15°E)

Editor's Note: foE must be less than 160 (150 if x trace extrapolated) and greater than 120. It is just allowed to use U, alternately the same information could be given by foEs = 120DK, fbEs = 160EK, or foE = 140UK.





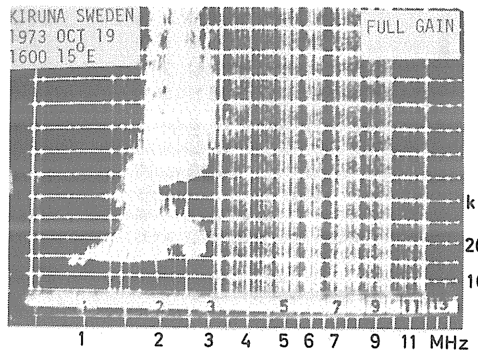


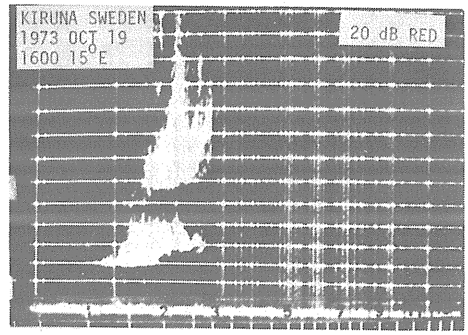
fmin ...	005EE	foF1 ...	330	h'Es ...	100
foEs ...	033JA	foF2 ...	041 F	h'E ...	100UA
fbEs ...	017	fzF2 ...		h'E2 ...	
foE ...	220 H	fxI ...	054	h'F1 ...	230
foE2 ...		M(3000)F2	F	h'F2 ...	370
Es type	ℓ	fmI ...	040		

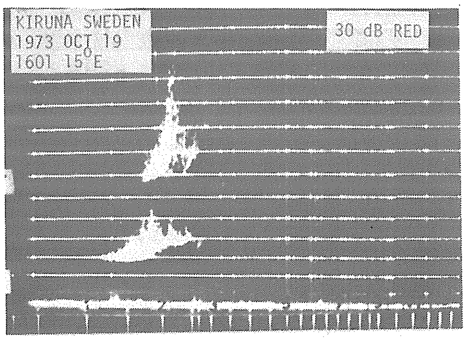
KIRUNA - Es - Type ℓ 1974 Jul. 2 0330-0331 LT (15°E)

Editor's Note: An unusually dense Es-ℓ trace.

Fig. 2.8 KIRUNA - Es Types k and ℓ



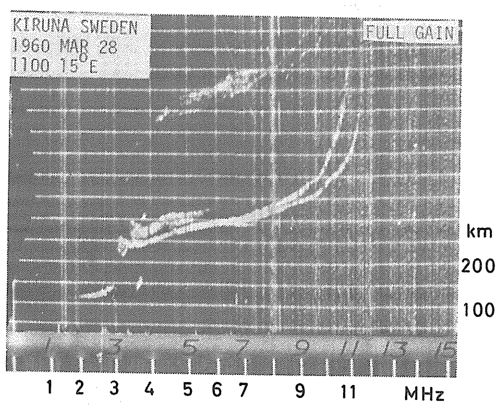


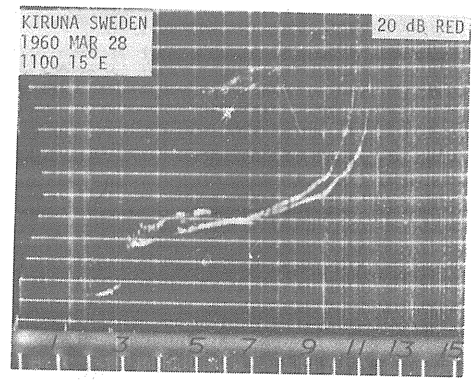


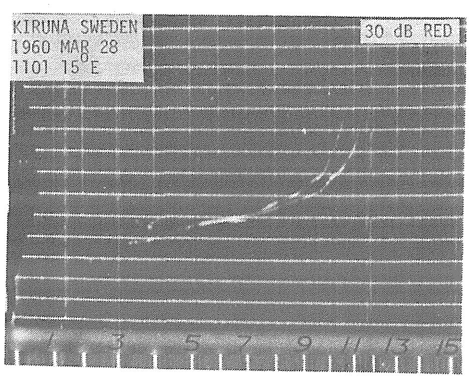
fmin ... 008	foF1 ...	h'Es ... 130
foEs ... 023JA	foF2 ... 021UF	h'E ... A
fbEs ... 015	fzF2 ...	h'E2 ...
foE ... A	fxI ... 031	h'F1 ... 325 A
foE2 ...	M(3000)F2 F	h'F2 ...
Es type a	fmI ... 017	

KIRUNA - Clarification of Interpretation by Gain Runs 1973 Oct. 19 1600-1601 LT (15°E)

Editor's Note: foF2 is sufficiently well defined on low and medium gain records to be given unqualified. Main Es pattern also confirmed as type Es-a. Another example of the help one has when making gain runs.



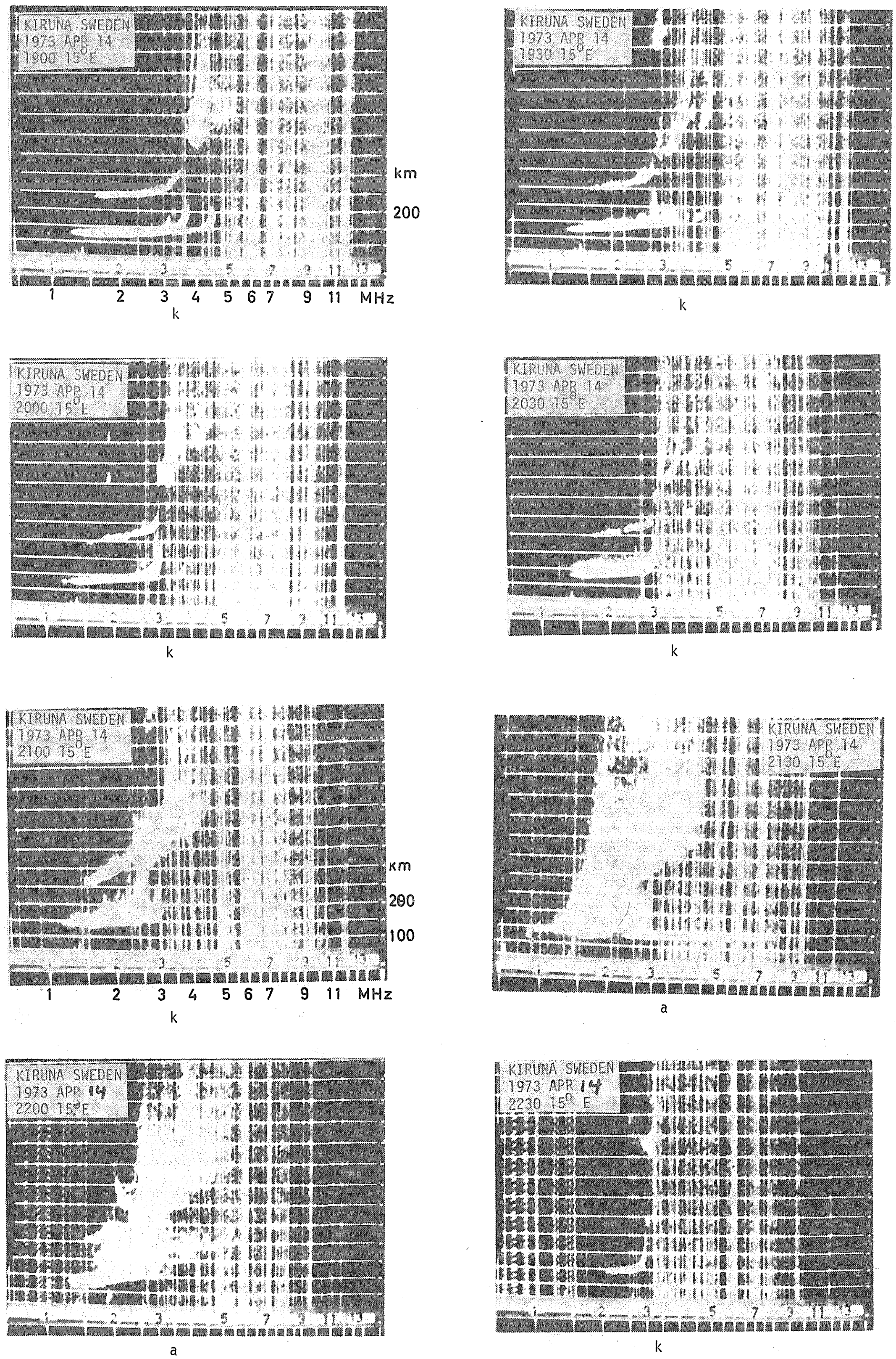




fmin ... 012--	foF1 ... L	h'Es ... G
foEs ... 030EG	foF2 ... 107	h'E ... 110--
fbEs ... 030EG	fzF2 ...	h'E2 ...
foE ... 300	fxI ... 113 X	h'F1 ... 235 H
foE2 ...	M(3000)F2	h'F2 ... L
Es type		

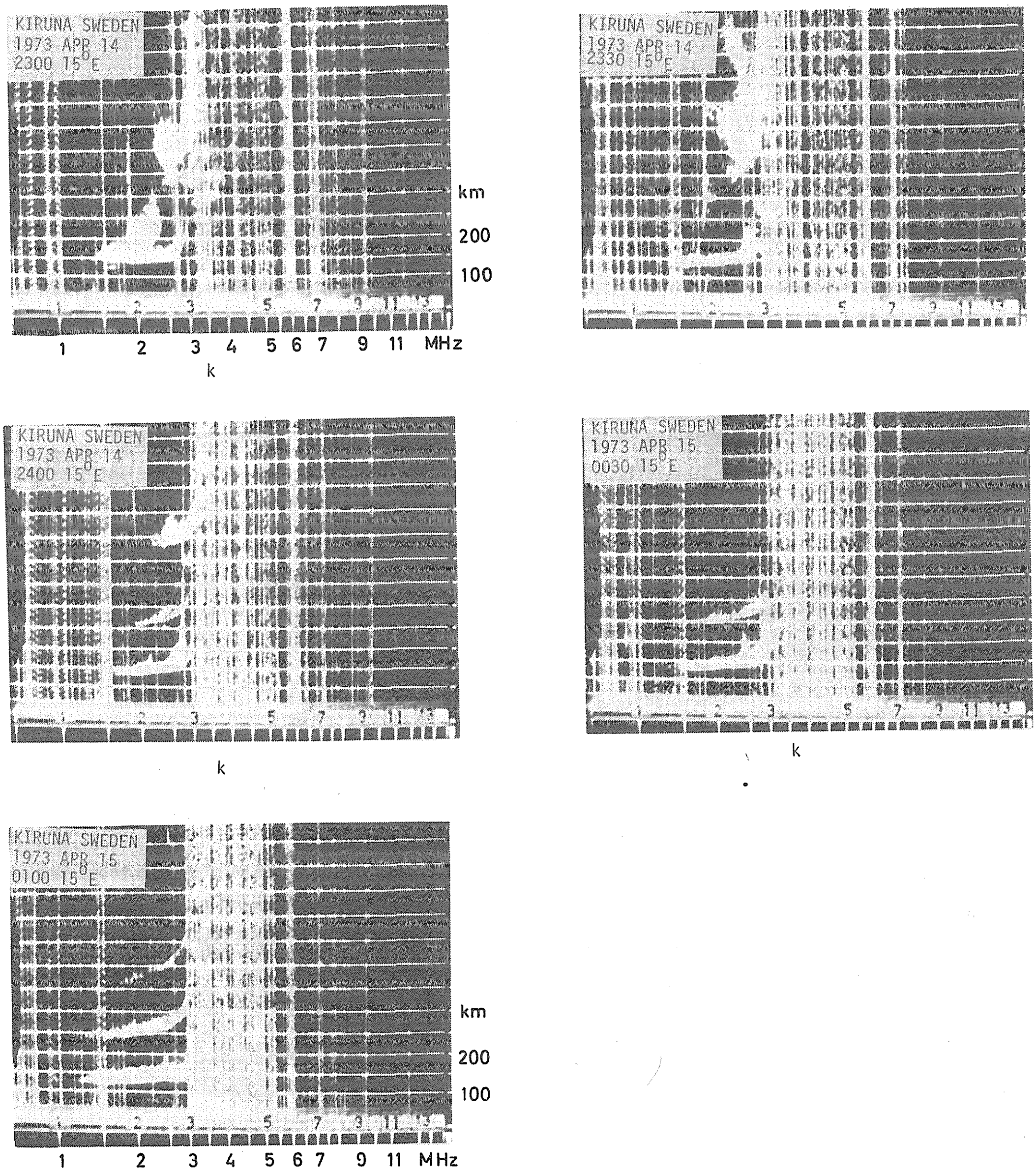
KIRUNA - Equinox Showing Traveling Disturbance Effects 1960 Mar. 28 1100-1101 LT (15°E)

Fig. 2.9 KIRUNA - Clarification of Interpretation by Gain Runs;
Equinox Showing Traveling Disturbance Effects



KIRUNA - Time Sequence in Disturbed Period 1973 Apr. 14-15 1900-0100 LT (15°E)

Fig. 2.10 (continued next sheet)



KIRUNA - Time Sequence in Disturbed Period 1973 Apr. 14-15 1900-0100 LT (15°E)

Editor's Note: Sequence on disturbed period showing particle E (Es-k) and auroral Es (Es-a). F layer shows rapid changes with much tilting. Note at 2330 LT F layer severely tilted so that overlap with Es trace is not significant. Retarded trace at 200 km, sequence and cleanness of Es trace suggests also Es-k with foE = 280UK (U to show doubt in interpretation).

Fig. 2.10

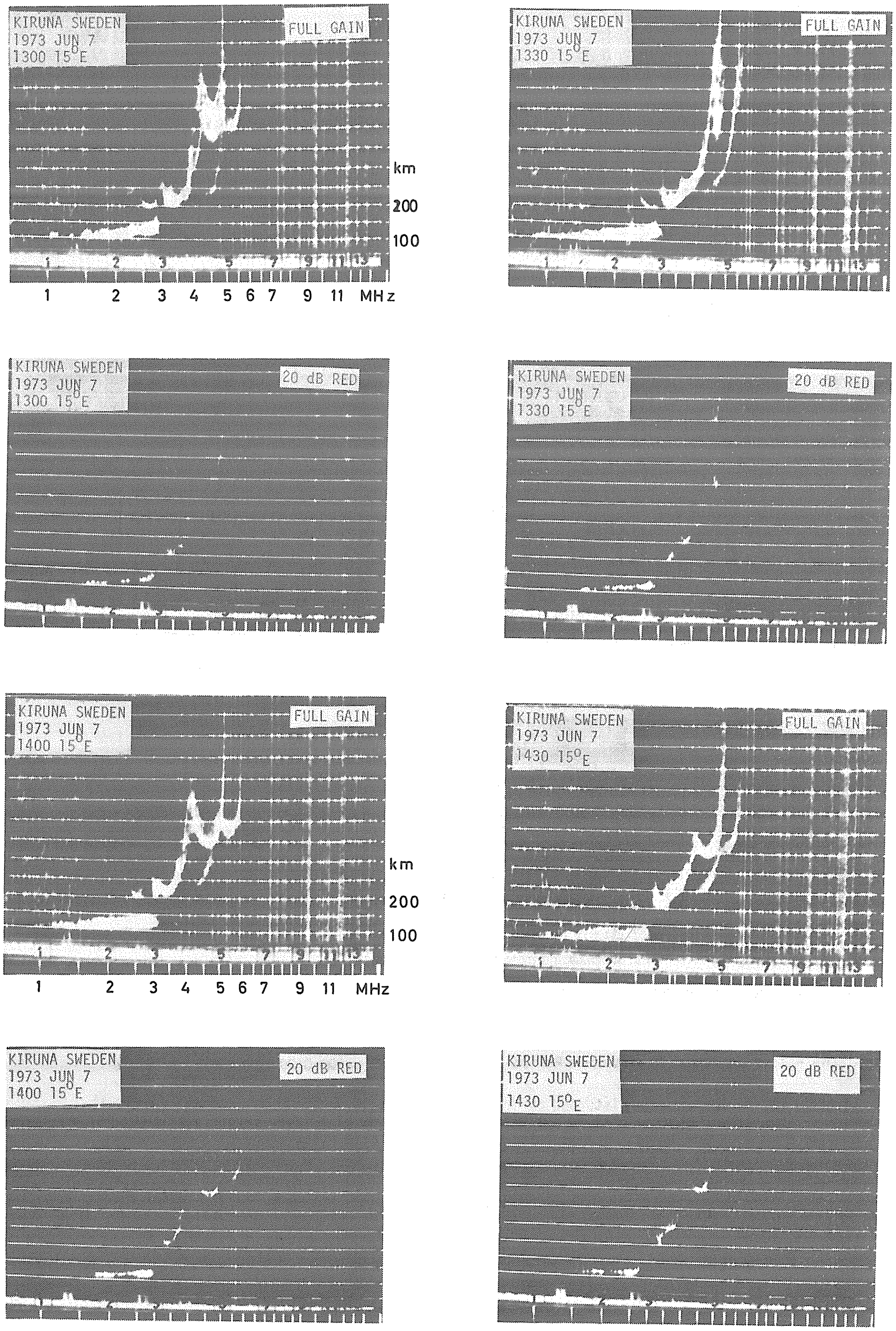


Fig. 2.11 (continued next sheet)

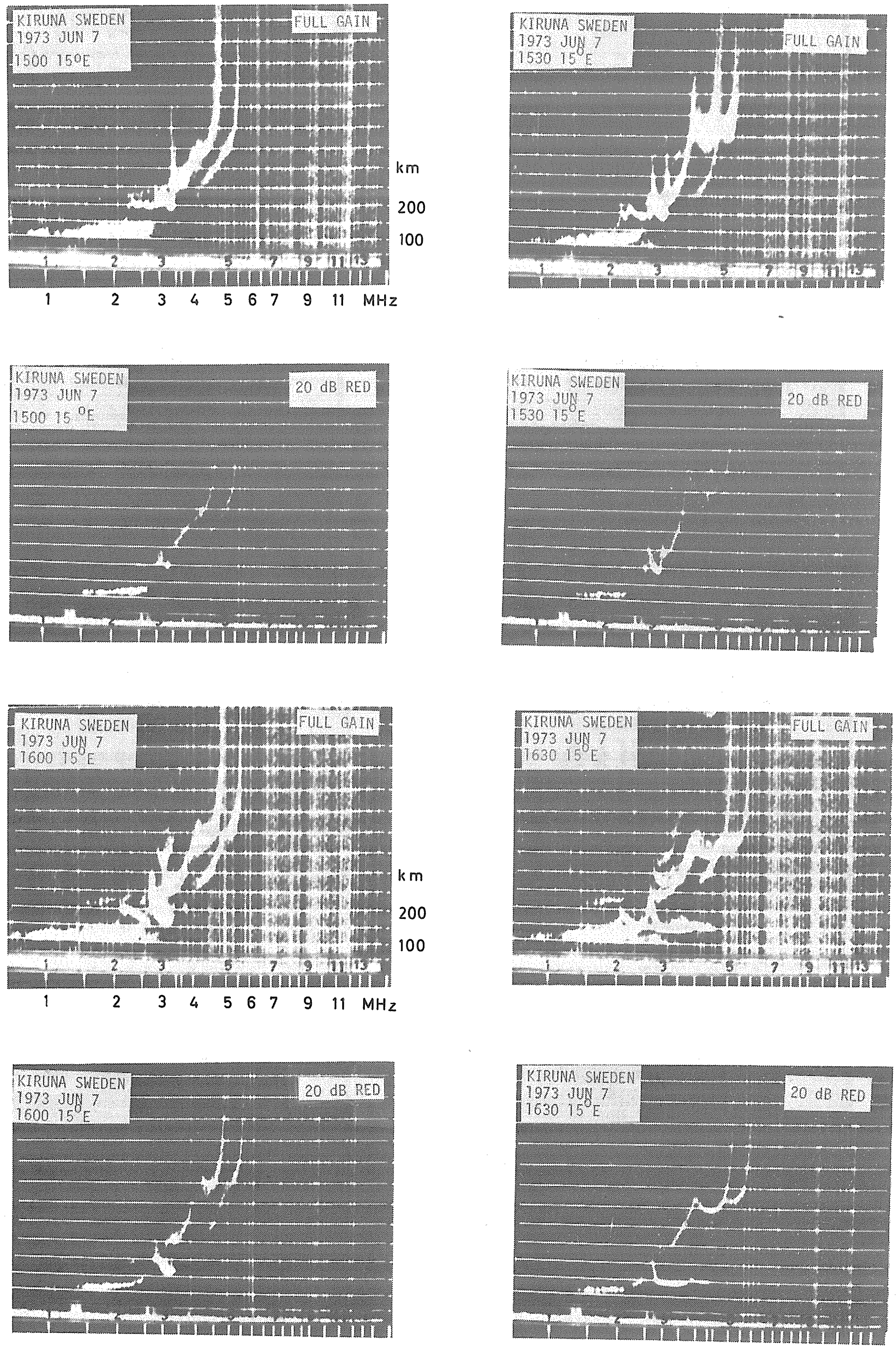


Fig. 2.11 (continued next sheet)

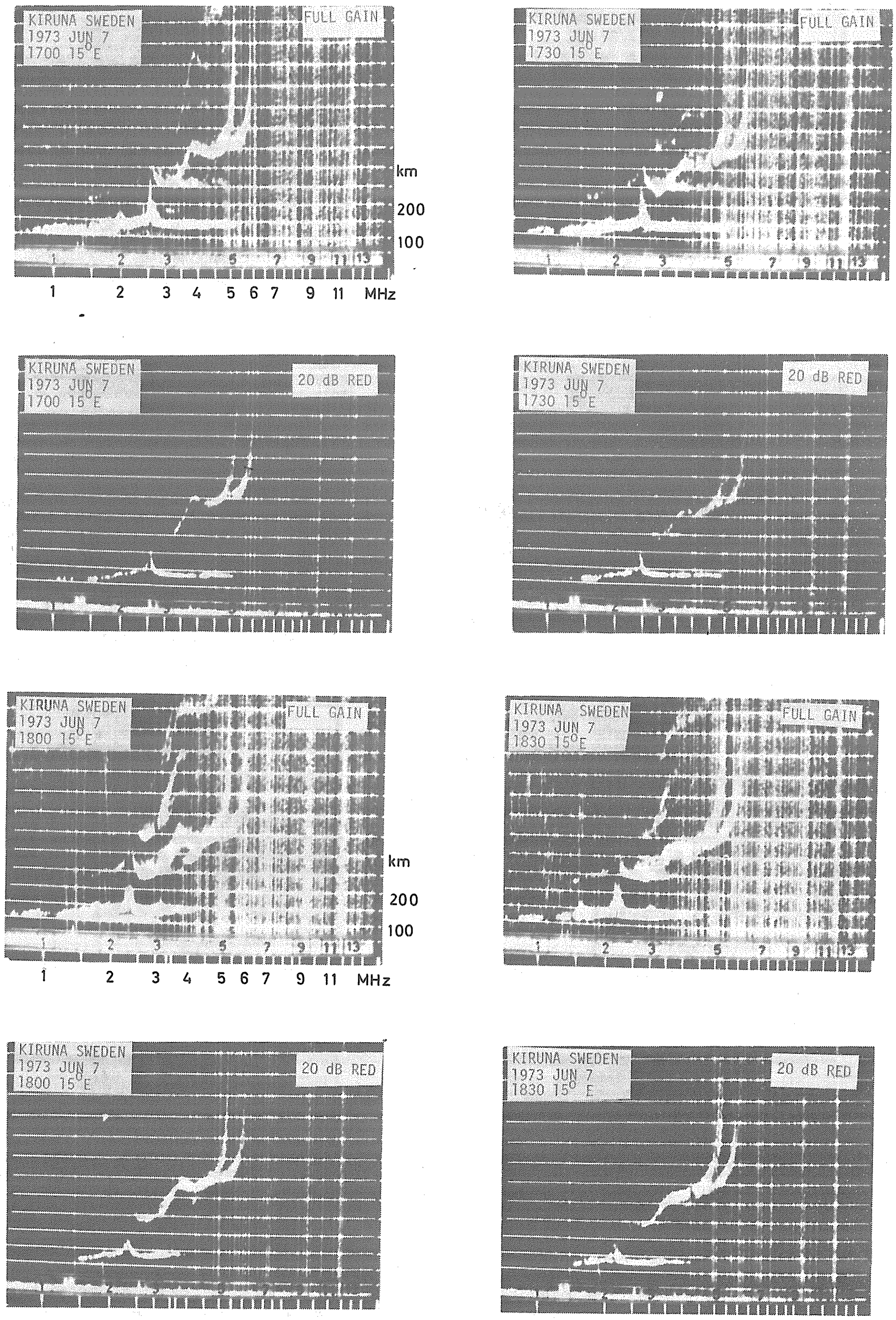


Fig. 2.11 (continued next sheet)

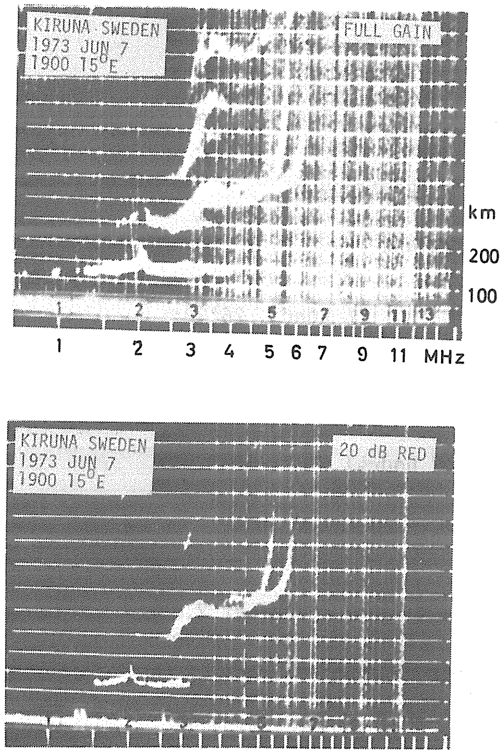


Fig. 2.11

KIRUNA - F2 and Es Changes on Summer Day 1973 Jun. 7 1300-1900 LT (15°E)

Editor's Note: Shows recordings made at half-hour intervals and with receiver operating at normal gain and attenuated 20 dB. Note a violent change in F1 layer between 1500 and 1530 LT.

2A.2 SODANKYLÄ

Ionospheric Vertical Sounding Station

This station has been in operation since August 1957. The Observer-in-charge is Dr. Tauno Turunen, and the station mailing address is:

GEOPHYSICAL OBSERVATORY
SF-99600
Sodankylä, Finland

Station name:	Sodankylä	
Geographic coordinates:	Lat. N 67°22'	E Long. 26°38'
Geomagnetic (dipole) coordinates:	Lat. N 63.8°	E Long. 120.0°
Geomagnetic coordinates: (corrected)	Lat. N 63.4°	E Long. 108.9°
Magnetic latitude:	63.59°	
Geomagnetic dip:	76.7°	
Time Used:	30°E (UT + 2 hours)	
Frequency range:	1.0 - 16.0 MHz, in 8 bands	
Sweep time:	8 min	
Peak power:	10 kW	
Pulse repetition rate:	50 Hz	
Pulse length:	100 μsec	
Aerial types:	3 rhombics, antenna change at 2.8 and 5.6 MHz TR-switch, height of mast 64 meters	
Routine sounding:	half-hourly, centered at 2.8 MHz passage (on RWD every 10 minutes) recording on 35 mm film	
Height range:	900 km	
Height scale:	linear, height markers every 50 km	
Frequency scale:	logarithmic, frequency markers every 0.5 MHz	

For terminology used, see *URSI Handbook of Ionogram Interpretation and Reduction*, Second Edition, edited by W. R. Piggott and K. Rawer, *Report UAG-23*, November 1972, World Data Center A for Solar-Terrestrial Physics, (U. S. Dept. of Commerce, Boulder, Colorado 80302, USA).

Sodankylä Ionograms with Gain Curve and Integration

Editor's Note: As Sodankylä ionograms will differ significantly from standard ones and include a gain curve, an explanation by Dr. T. Turunen is included. The technique described has considerable advantages at high latitude stations. The method of recording at several gains makes the traces look fuzzy in reproduction. A number of comparable ionograms taken with different ionosonde characteristics are also shown in Figures 2.12 through 2.16. Note in some cases the ionogram is recorded simultaneously on two different ionosondes, in others in close sequence on one.

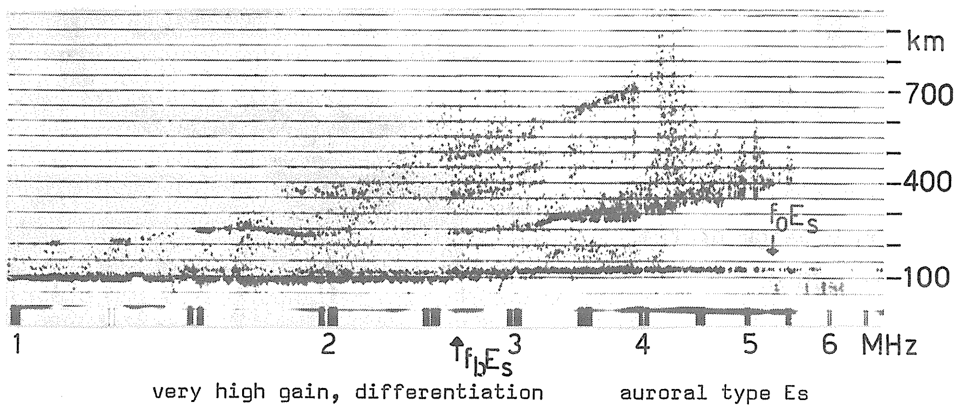
These ionograms are included not only for scaling examples, but also to show how my best possible ionograms look. The integration time constant is roughly equivalent to integration over 100 echoes. There are 100 channels and the channel width is 40 μsec. When the gain curve is not at constant level but shows more or less continuous shift downwards with increasing frequency, it means that the dynamic range of echoes at that frequency is 26 dB and the discriminators are showing the levels -6, -16, and -26 dB. (The density changes showing these have not reproduced clearly.) After the frequency at which the ionosonde starts to use fixed gain (gain curve remains at constant level), the amplitudes are measured relative to the echo amplitude at the frequency where the gain was locked at constant level. Usually this locking happens a little before foF2, but it can happen sometimes around any other critical frequency, or in the case of total blanketing, at the frequency where the real blanketing frequency is approximately. The criteria by which the gain is locked is that the echo amplitude decreases rapidly with increasing frequency by an amount which is greater than the range of normal fading. The gain which is used after locking is roughly the median gain which was used at some hundred kilohertz of frequency sweep just before the locking command. In this kind of system there are, of course, some approximations but the system works surprisingly well, is technically straightforward and fairly simple. The approximate component cost of the gain control unit is $20.00 (plus the mechanical parts, cables, connectors, etc.).

One can use the ionosonde to give a very good absorption measurement by using the gain curve. It is, however, more important that one really knows the dynamic range of the echoes and the amplitude at the frequency where the value for the gain sensitive parameters is given. This system could work with all conventional ionosondes except the types where the frequency sweep is very fast. I do not, however, claim that it is the best possibility, but in any case it works, and it is quite cheap and is physically correct. No technical failures occurred during the one year testing period.

Data from Sodankylä will be based on this gain control system beginning with the 1.4.74 (1 April 1974) data.

SODANKYLÄ 20.6.1973 20.40 LT

(a)



(b)

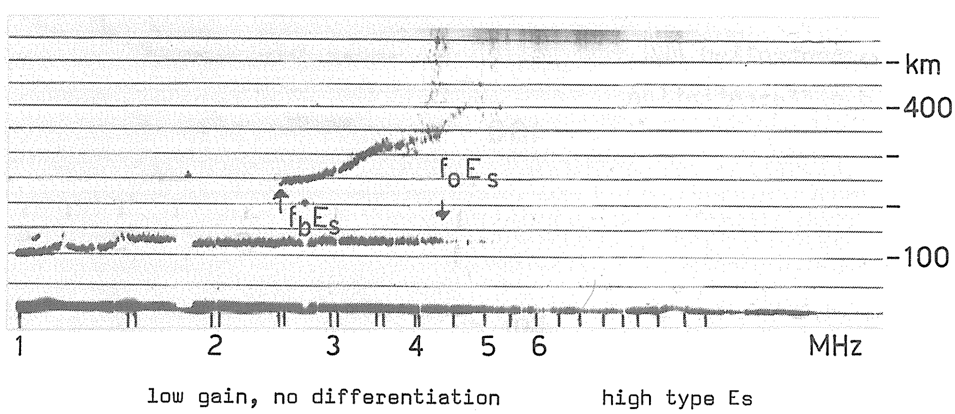


Fig. 2.12

SODANKYLÄ - Sporadic E Layer

20.6.1973 (20 June 1973) 2040 LT (30°E)

In the first ionogram (a) of 20.6.1973, 20.40 LT, an auroral type sporadic E (Es-a) is seen and the marks indicating foEs and fbEs values are also shown in the example.

The second ionogram (b) of 20.6.1973, 20.40 LT, has an Es which is not an auroral type Es, but a high type Es. The cusp between E layer and Es is not well-developed but it exists, and the virtual height of the Es is about 20 km higher than the virtual height of the E layer (which has small cusp activity at 1.2 MHz). The frequency parameters are quite straightforward to scale and the accuracy is better than 0.2 MHz. The virtual height is also easy to scale. The real difficulty is that these two ionograms are simultaneous and measured by using the same transmitted pulses. In ionogram (a) the gain is very high with rapid differentiation favoring steep gradients in the echoes while in ionogram (b) low fixed gain is used and only the strongest echoes are seen.

SODANKYLÄ

28.1.1974

10.46 LT

Echo amplitude controlled AGC
Integration
Dynamic range of the echoes 30 dB

10.53 LT

Noise controlled AGC
Rapid differentiation

11.00 LT

Noise controlled AGC
Slow differentiation

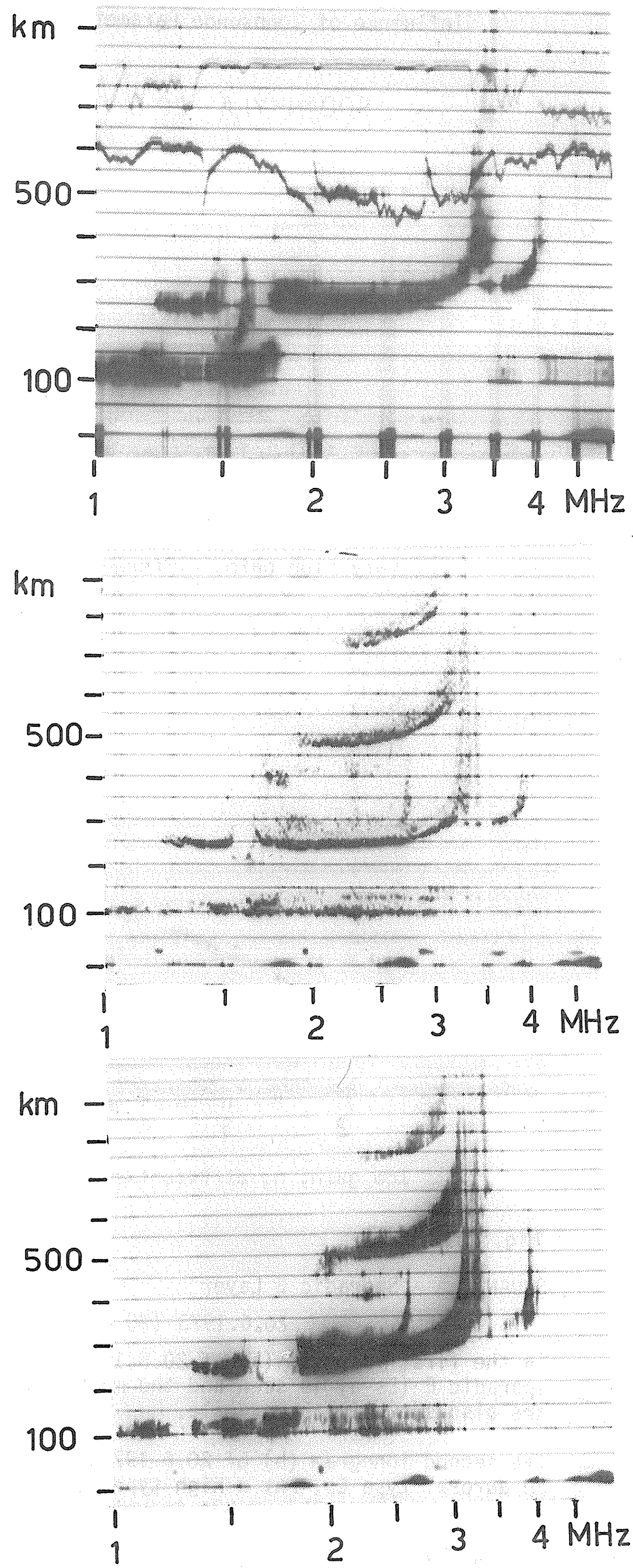


Fig. 2.13

SODANKYLÄ

28.1.1974

11.09 LT

High fixed gain
Rapid differentiation

11.16 LT

Low fixed gain
Slow differentiation

11.23 LT

Echo amplitude controlled
AGC
Slow differentiation

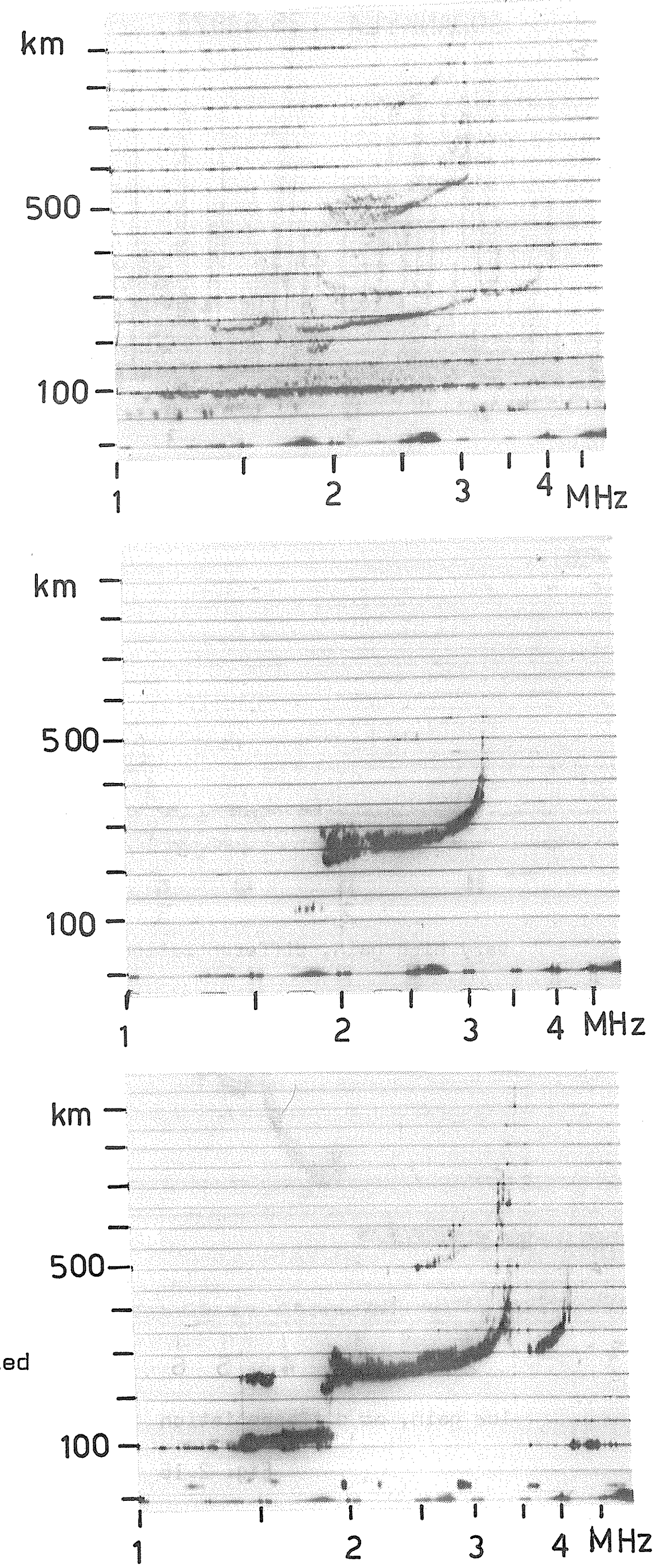
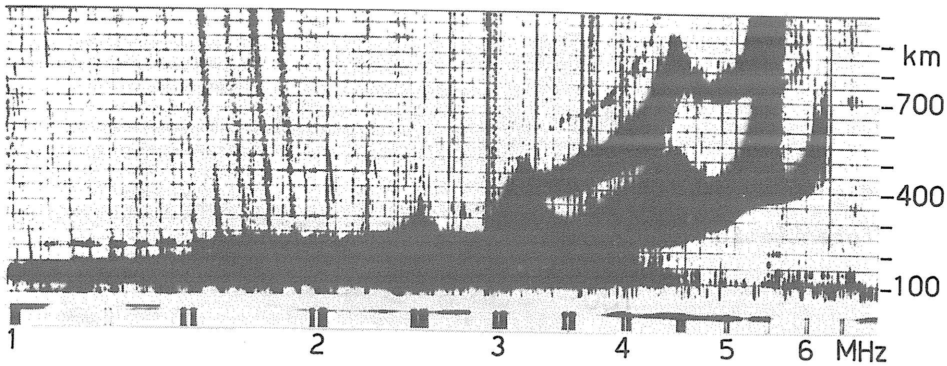
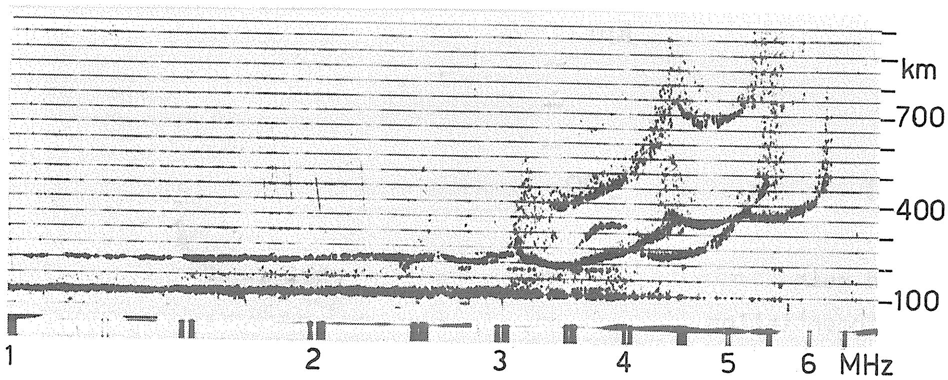


Fig. 2.14

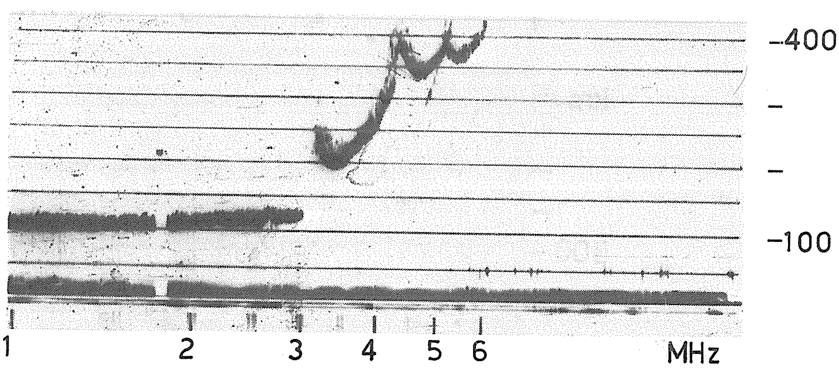
SODANKYLÄ 25.6.1973 13.40 LT



very high gain, no differentiation



very high gain, differentiation



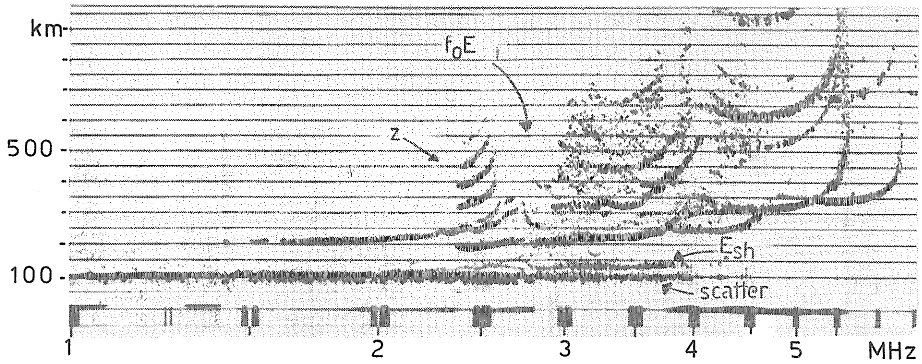
low gain, no differentiation

Fig. 2.15

SODANKYLÄ

6.7.1973

17.00 LT

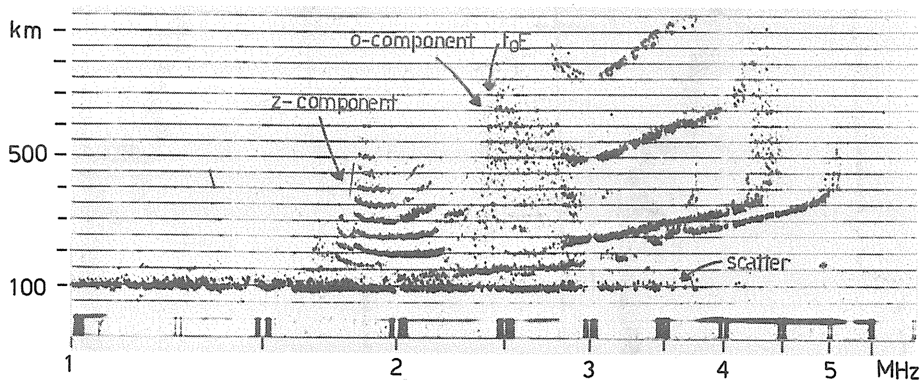


SODANKYLÄ

23.7.1973

18.30LT

very high gain



Simultaneous low gain ionogram, expanded height scale

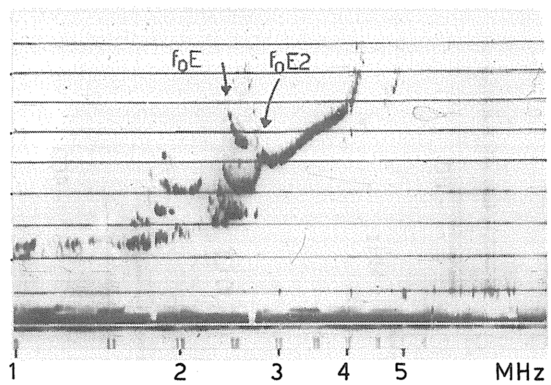


Fig. 2.16

SODANKYLÄ

6.7.1973 (6 July 1973)	1700 LT (30°E)
23.7.1973 (23 July 1973)	1830 LT (30°E)

Editor's Note: These ionograms illustrate a very common difficulty when the gain has been set too high -- the most common operating fault.

As I have already informed INAG, these echoes are seen by using extremely high gain about once per day in summer time.

The scatter above foE resembles Es-a. In my opinion, Es-a is often a similar but stronger scatter connected with the particle E. The layers at 100 km which look like Es-ℓ are not Es at all. They are really weak scatter or perhaps it is better to say gradient reflection, although one must remember that this "layer" seen on the film is only the lower boundary of scattered echoes. In 23.7.1973 the "foE scatter" is so strong that an inexperienced scaler could believe that blanketing Es is present because echoes disappear. It is however only an effect caused by saturation of the receiver. There is no Es-ℓ as can be seen from the low gain ionogram which is exactly simultaneous and made by using the same transmitted pulses.

The z-component groups are very nice phenomena. Sometimes there are more than ten multiples in the group. The phenomenon never causes scaling difficulties.

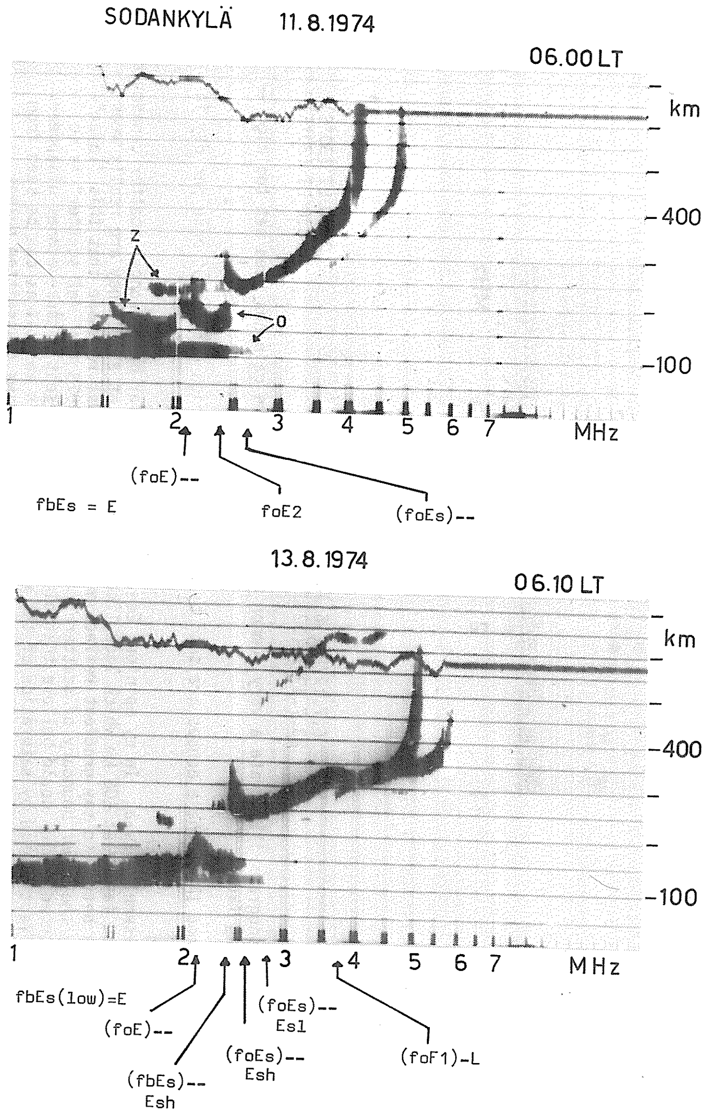


Fig. 2.17

SODANKYLÄ 11.8.1974 (11 Aug. 1974) 0600 LT (30°E)
13.8.1974 (13 Aug. 1974) 0610 LT (30°E)

Ionograms show Es-h, which in some cases is E2 or almost E2 layer. At Sodankylä the Es-h layers are usually developed from E2, although the so-called sequential Es is seldom clearly seen and the ℓ type is usually not reached (rarely during the morning time).

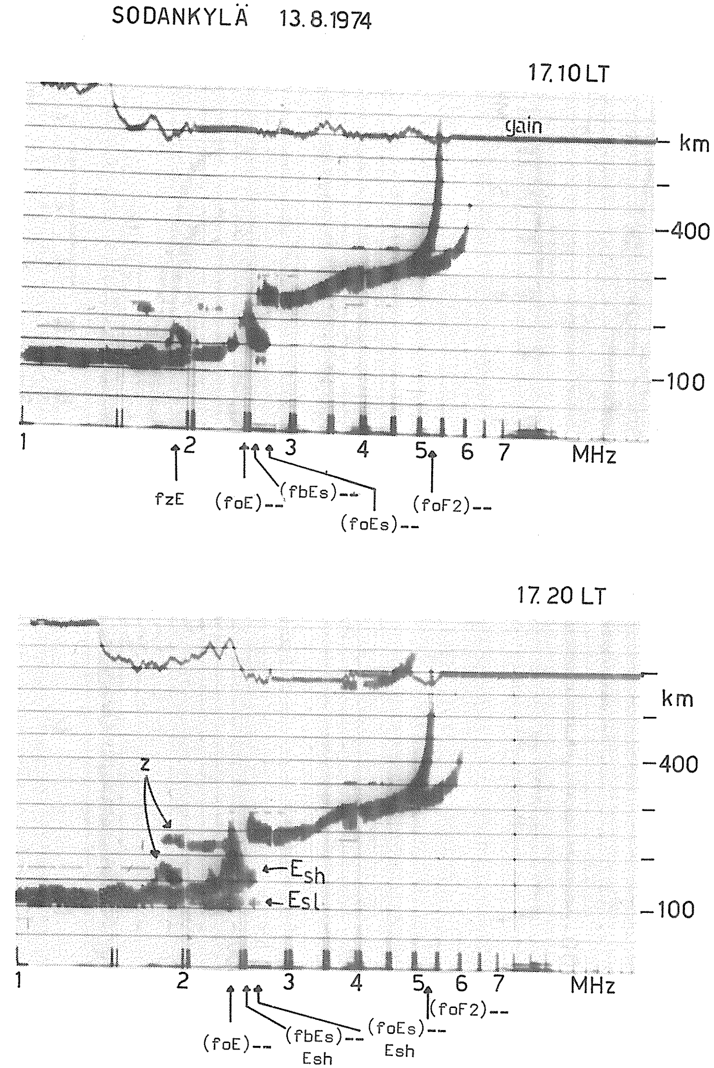


Fig. 2.18 13.8.1974 (13 Aug. 1974) 1710 LT (30°E)
1720 LT (30°E)

These ionograms show Es-ℓ which is very rare at normal gain. Es-ℓ reflections can usually be seen at higher gain (these are also present on Lycksele ionograms). These reflections are not now included in the Es type. Though this is against the basic rules, data from many stations show that this weak Es-ℓ is one of the basic reasons different station data vary so much.

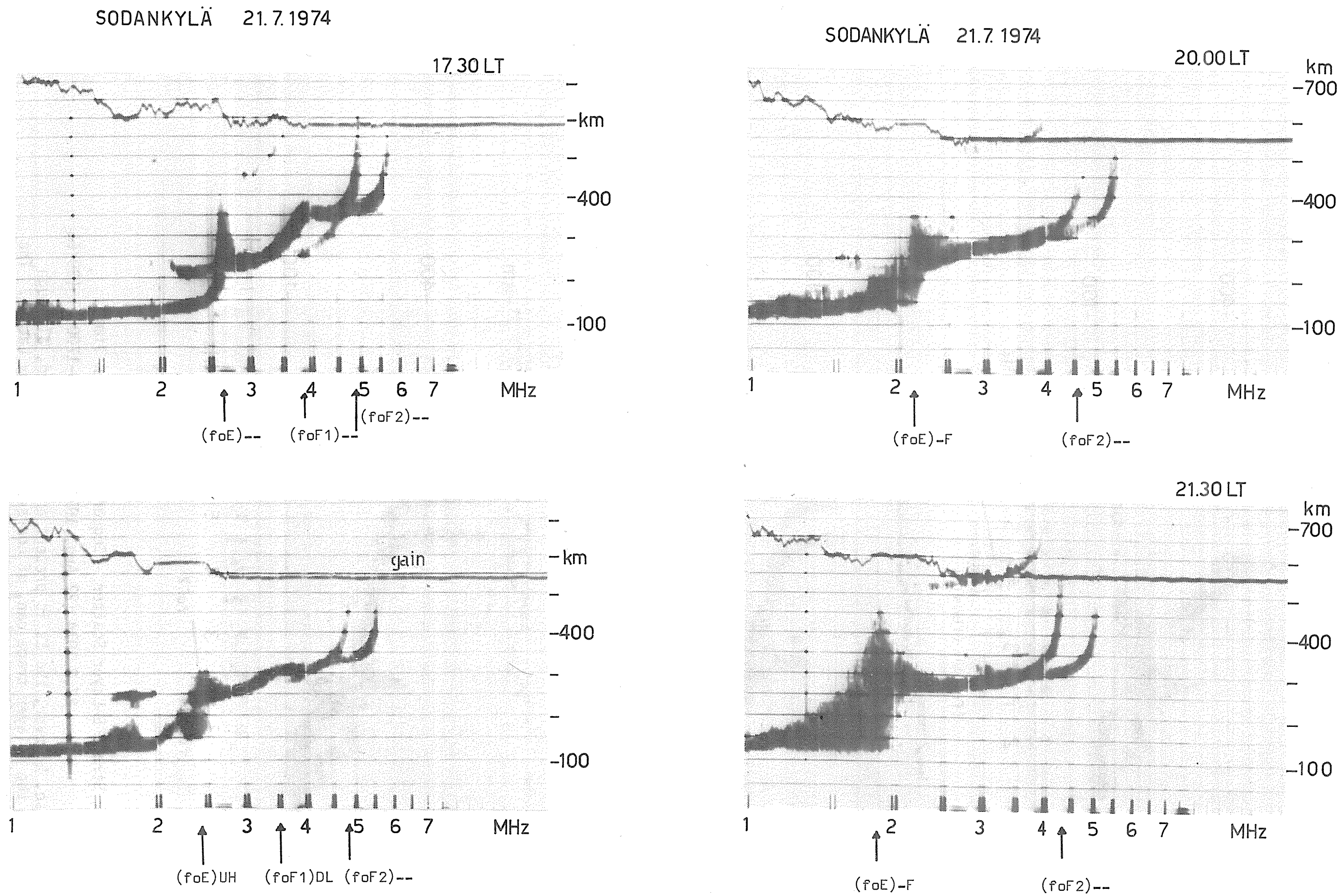


Fig. 2.19

SODANKYLÄ - Strong E-Layer Scatter

21.7.1974 (21 July 1974) 1730-2130 LT (30°E)

This sequence shows how one very usual type of E-layer scatter is formed around foE. foE-F in these cases describes the ionogram quite well. Discussions about the subject are needed. If E is present and one can see foE in the spread E, Es-a does not appear appropriate. However many stations would scale Es-a at least if high gain is used, and the scatter is the most pronounced feature in the ionogram.

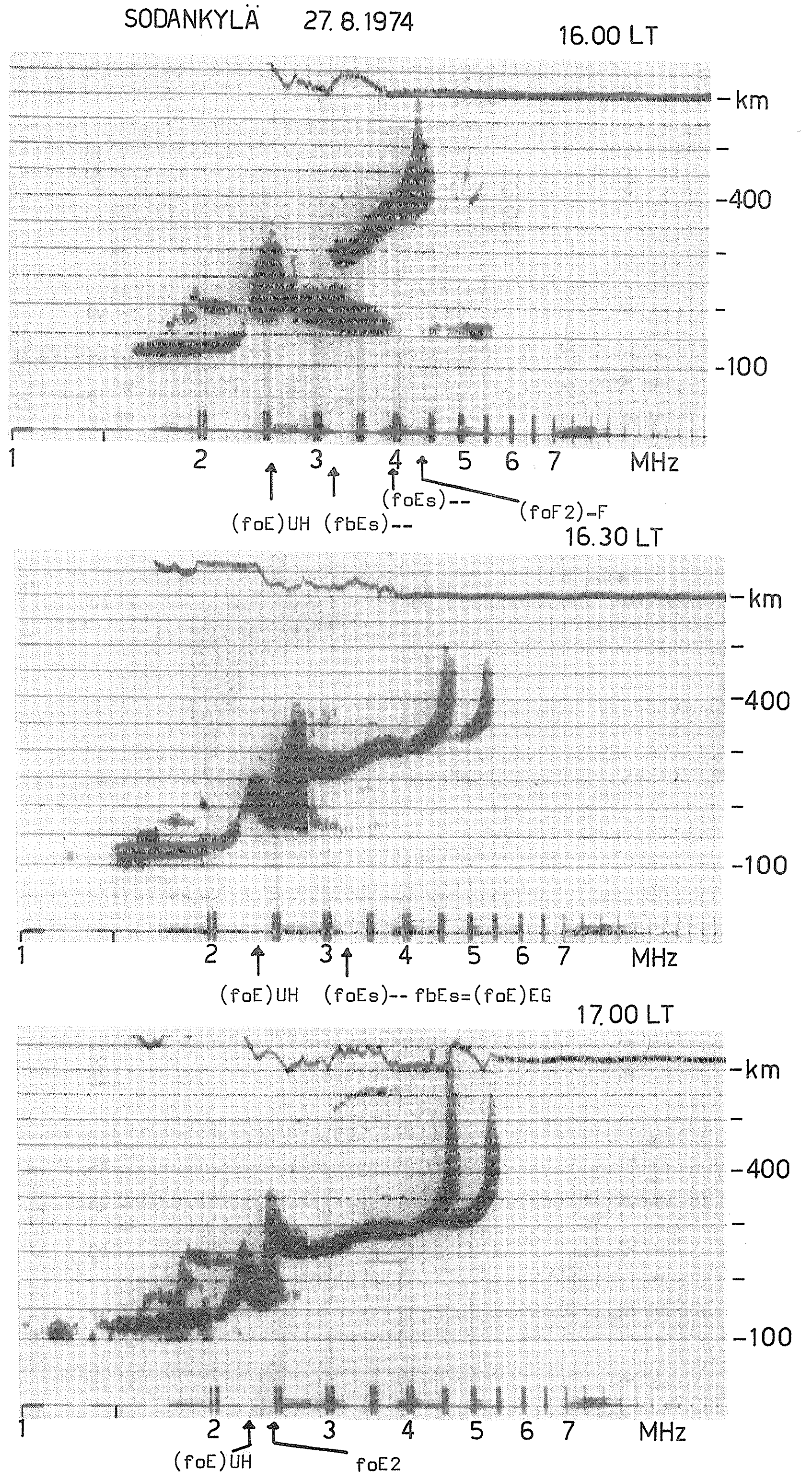


Fig. 2.20

SODANKYLÄ - Strong E-Layer Scatter - Sequence Reversed in Time
27.8.1974 (27 Aug. 1974) 1600-1700 LT (30°E)

In this case, however, the Es is present and is blanketed, although the gap in the F-layer trace can, of course, be caused by Lacuna. The Es type is not indicated in the Figure, but it is spread Es-h and the reader should scale it. Discussions should be held because such cases are not handled in the Handbook.

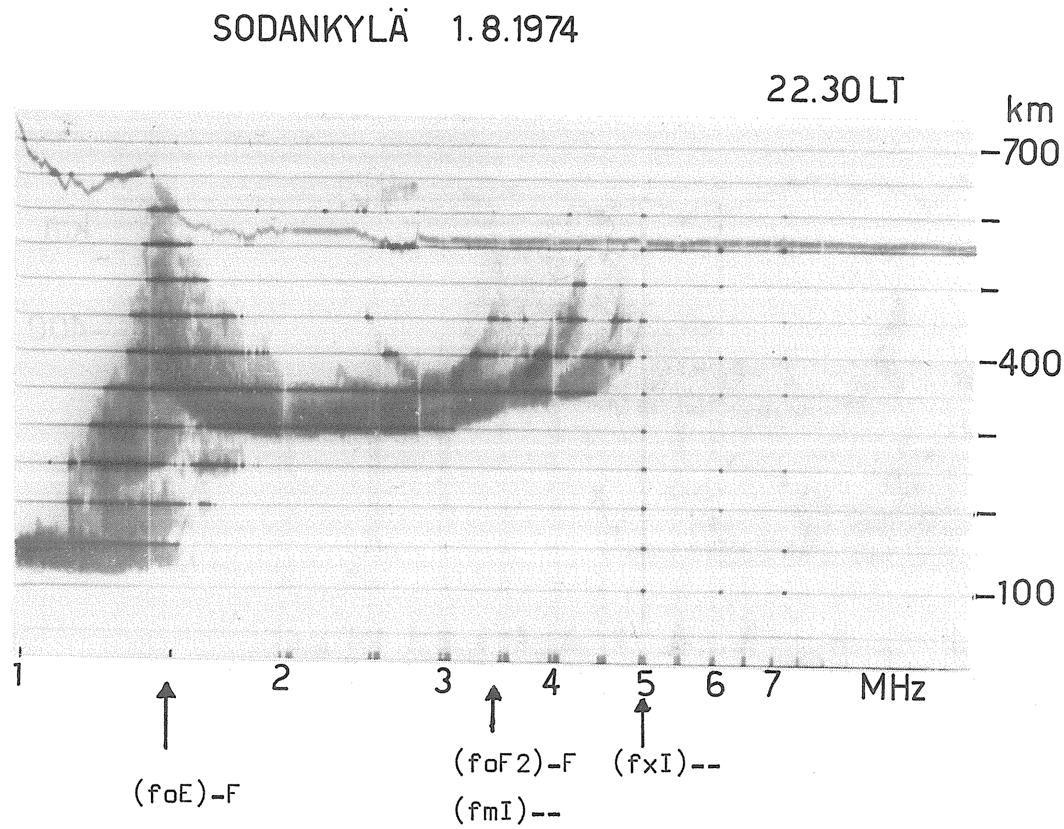


Fig. 2.21

SODANKYLÄ 1.8.1974 (1 Aug. 1974) 2230 LT (30°E)

Very nice spread E. Again foE-F is used, but is subject to change. (The gain is lower when gain curve is at lower "virtual height". Gain values are not indicated because the equipment is slightly different at different frequencies. Three antennas are used, thus one must have calibration for each antenna.)

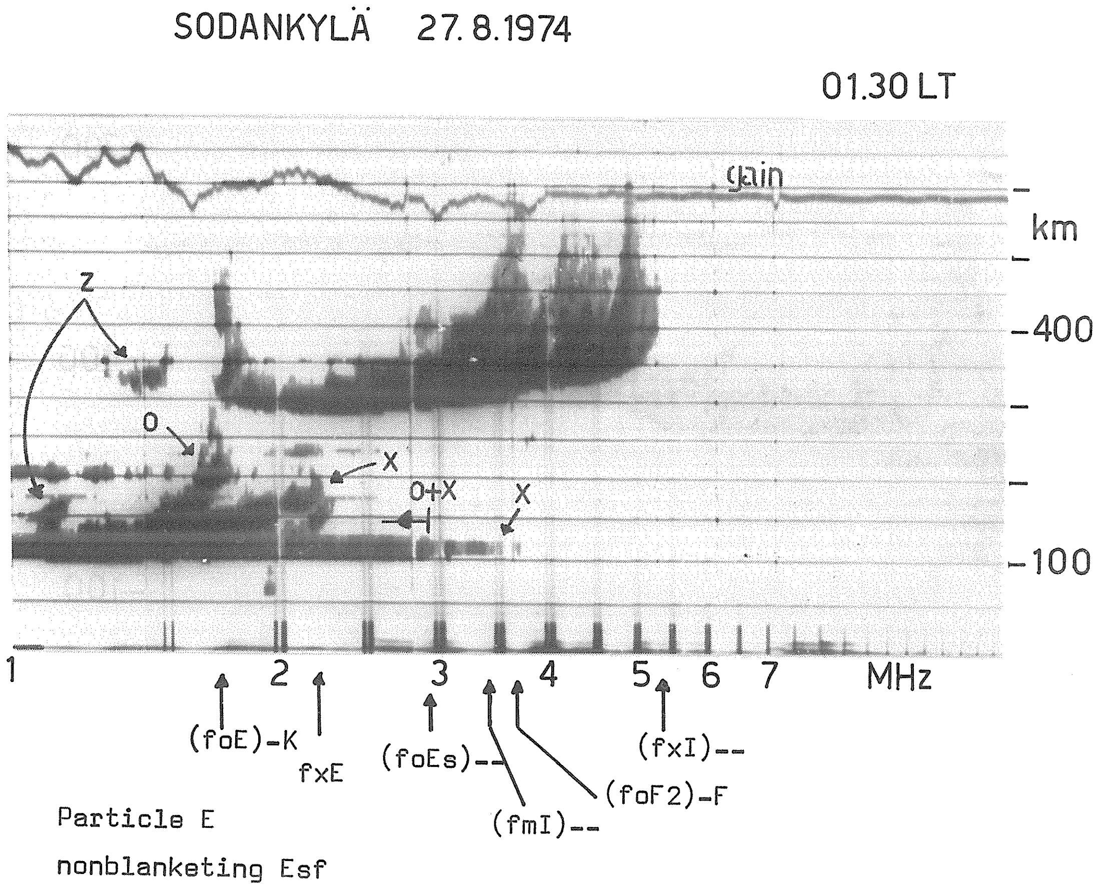


Fig. 2.22

SODANKYLÄ - Particle E with all Three Magneto-ionic Components
27.8.1974 (27 Aug. 1974) 0130 LT (30°E)

Es Type f

Spread F, which is quite a typical one and often seen at Sodankylä.

At higher gain this kind of ionogram often shows strong Es-a only, together with spread F traces. Unfortunately, simultaneous high gain ionograms are not available for that time.

Editor's Note: When particle E is present, a flat trace should be classified according to its height, in this case ℓ.

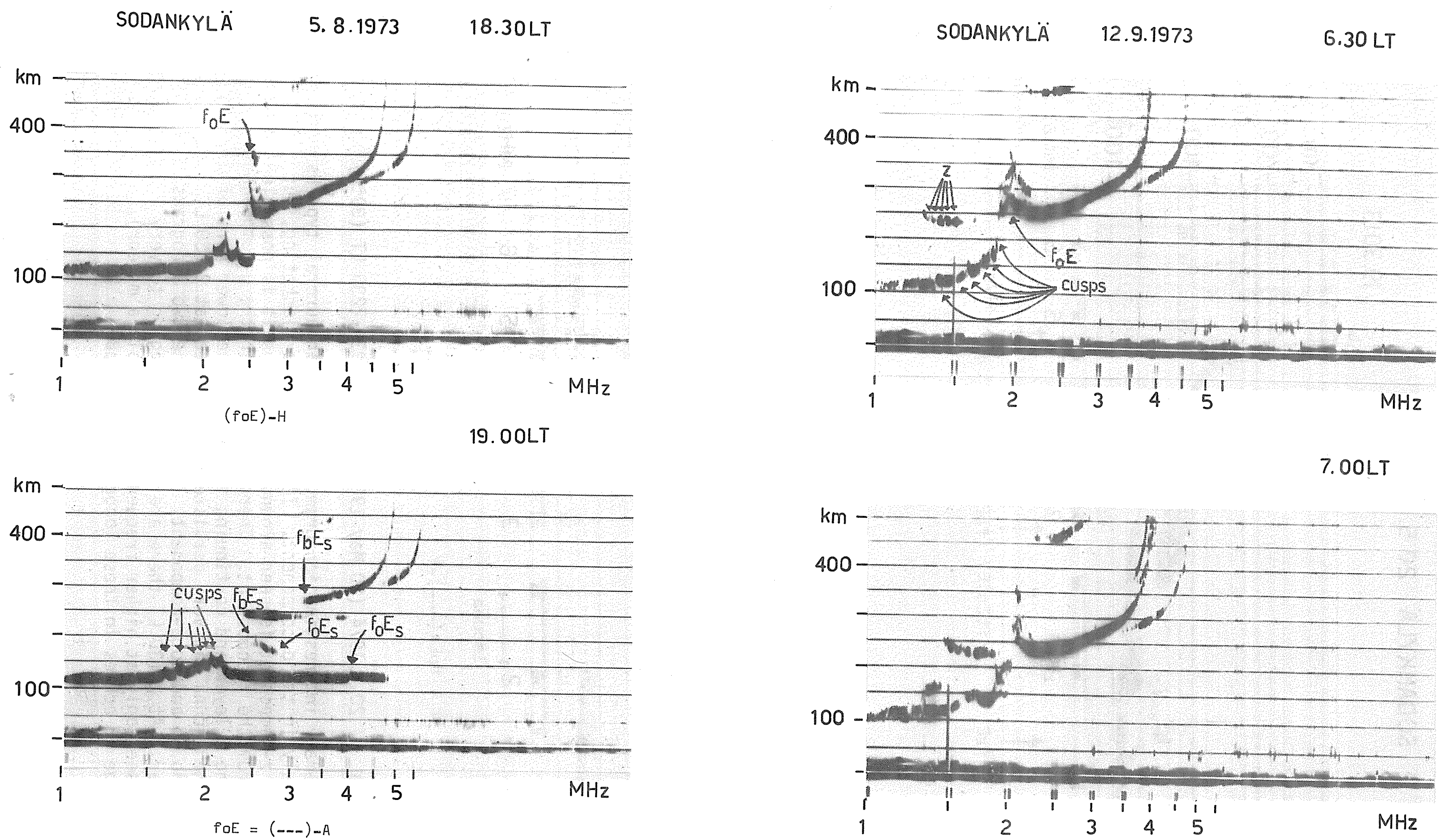


Fig. 2.23

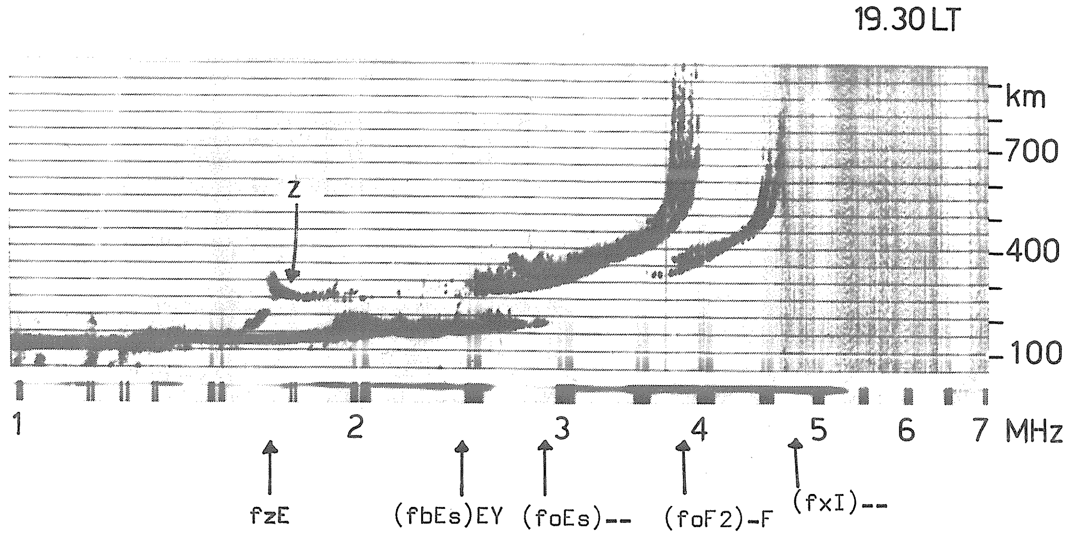
SODANKYLÄ - Examples of E-Layer Microstructure

5.8.1973 (5 Aug. 1973)	1830-1900 LT (30°E)
12.9.1973 (12 Sept. 1973)	0630-0700 LT (30°E)

The scaling is not indicated because there are no difficulties with one exception. At 19.00 LT 5.8.1973 the lower high type Es has two values of blanketing frequencies, one based on the F-layer echo and the other based on Es-h. The difference is about 1 MHz.

Editor's Note: The 2Es trace weakens at fbEs suggesting this is the true fbEs. The high Es is more likely to be slightly oblique as foE would be expected to be appreciably lower at this time. Would prefer upper fbEs. Accuracy rules indicate foE = 235UA.

SODANKYLÄ 20.5.1974



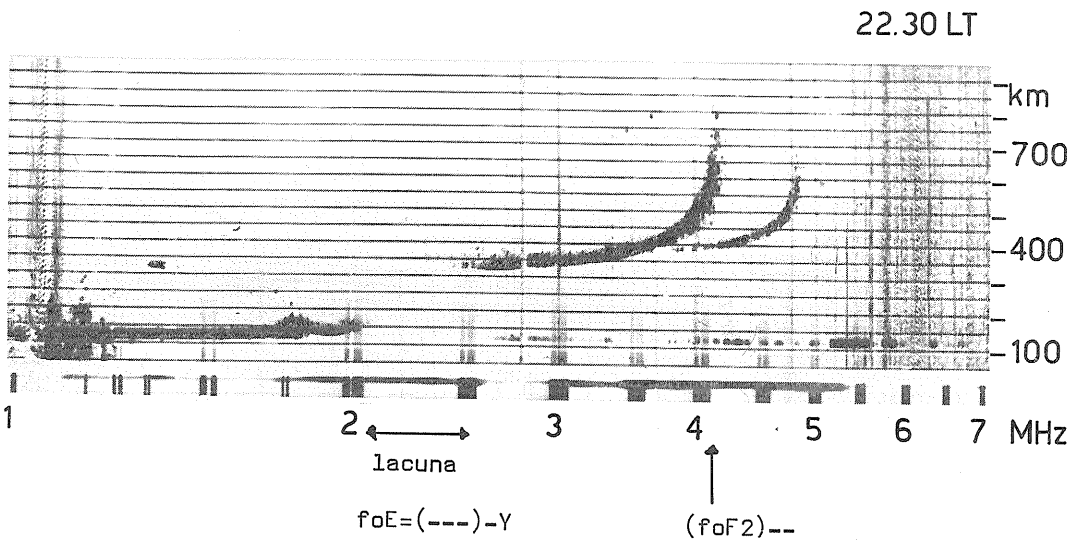
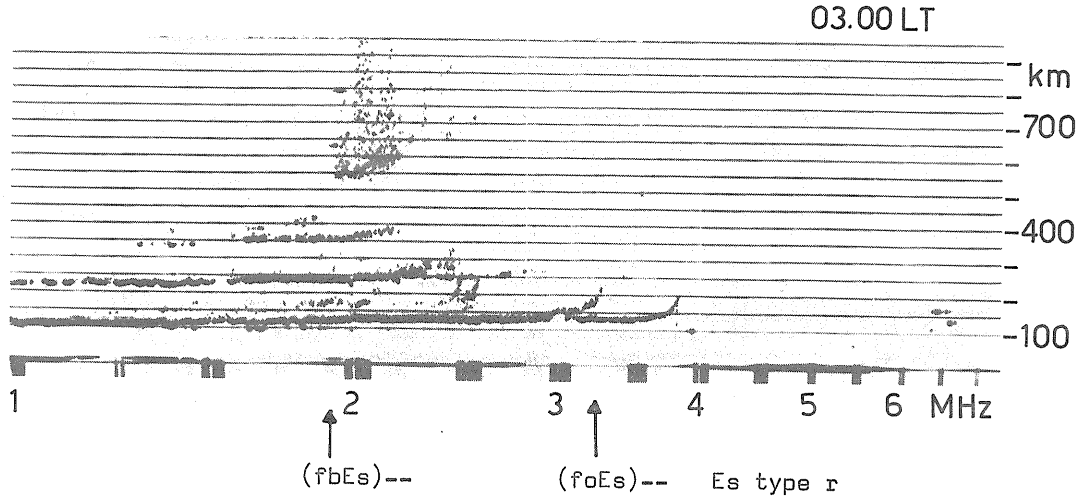


Fig. 2.24

SODANKYLÄ - Es-a 20.5.1974 (20 May 1974) 1930-2230 LT (30°E)

This is an extremely interesting ionogram. There is an auroral type Es which is seen only in the o-component. It seems to be blanketing, but it is not. The z-component is seen around fzE and thus it is possible to reduce foE from the z-component. There is Lacuna in the o-component starting from the E layer and continuing throughout the lower part of the F layer. The Lacuna was very persistent and is seen at 22.30 LT when there was no Es and no z-component. Otherwise the two ionograms are quite similar. At 22.30 LT there are traces belonging to very weak f type Es seen only at higher frequencies (possibly a meteor). The dynamic range of echoes in these ionograms is 26 dB.

SODANKYLÄ 3.4.1973



14.4.1973

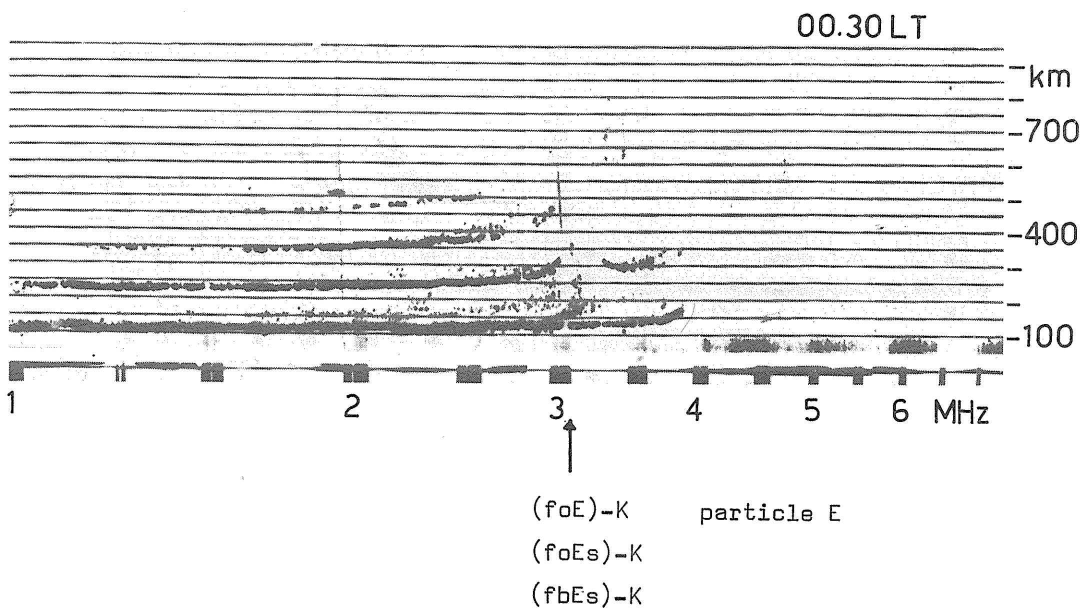


Fig. 2.25

SODANKYLÄ - Es-r, Particle E (Es-k) - (original ionosonde)

3.4.1973 (3 Apr. 1973)	0300 LT (30°E)
14.4 1973 (14 Apr. 1973)	0030 LT (30°E)

These are the best examples comparing particle E and Es-r; they are exceptionally nice and thus not very useful. Note the similarity between the shape of the two layers. Even the critical frequencies are almost the same.

If in the case of Es-r (3.4.1973) the gain had been much lower, the F-layer echo would perhaps disappear (or if the foF2 were a little lower). Even then, the layer must be scaled as Es-r because the multiples show that it is not an overhead layer.

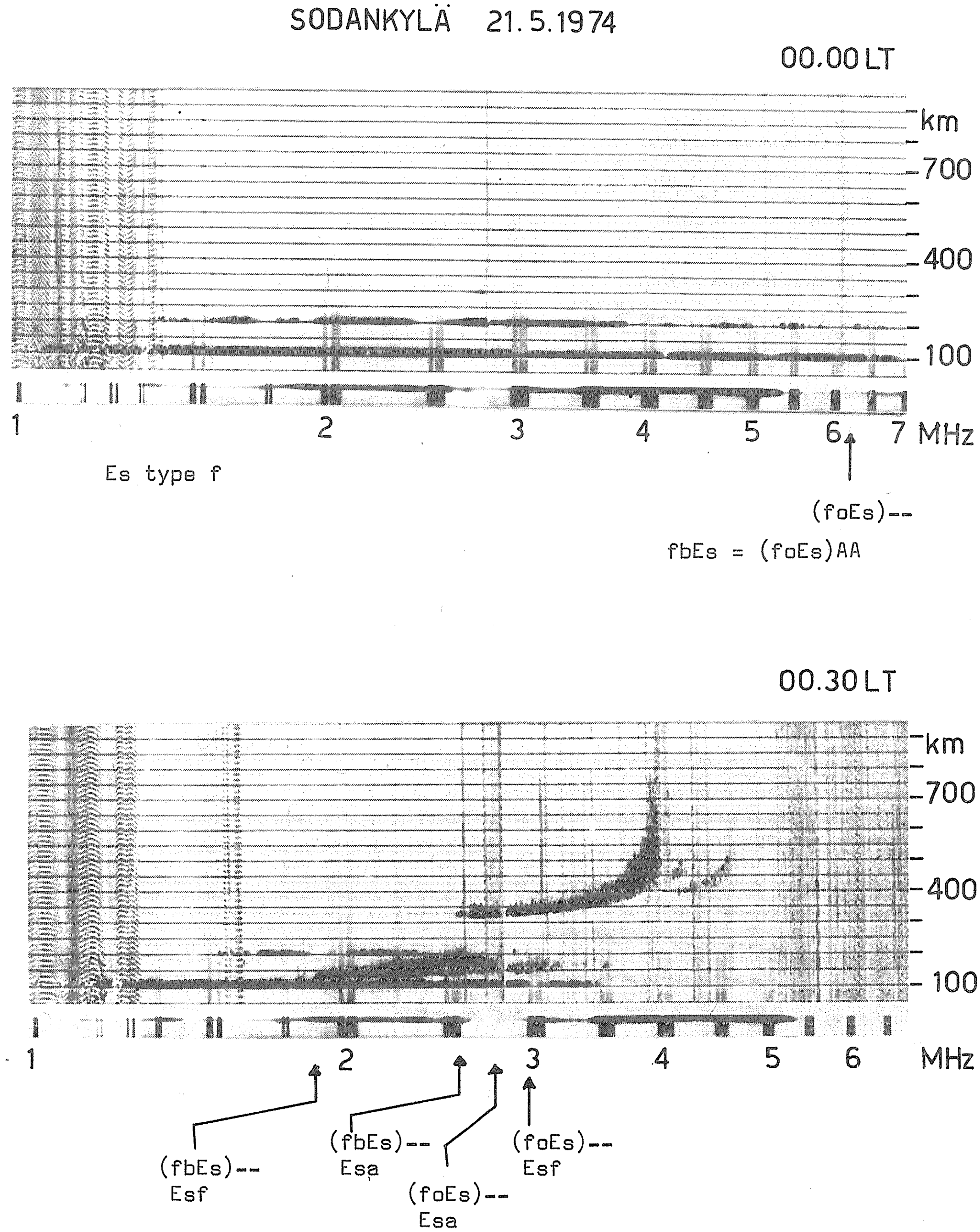


Fig. 2.26

SODANKYLÄ - Es-f, Es-f + Es-a - (original ionosonde)

21.5.1974 (21 May 1974) 0000-0030 LT (30°E)

Editor's Note: Do not agree with fbEs interpretation. Es-a does not blanket. Blanketing due only to Es-f as is confirmed by the second order trace ending just below fbEs value marked fbEs-a. Es-a arises from Es-f rather like an "s" trace, but both density of trace and its starting frequency indicate "a" not "s".

2A.3 LYCKSELE

Vertical Incidence Sounding Station

Operation began at this station January 1957. It has been operated by the Research Institute of National Defence, Dept. 3 until July 1, 1970. After that date the Kiruna Geophysical Institute is responsible for the operation of the station Lycksele. Data reduction, however, is still done by the Research Institute of National Defence. The station's mailing address is:

KIRUNA GEOPHYSICAL INSTITUTE
S981 00 Kiruna, Sweden

Station name:	Lycksele	
Geographic coordinates:	Lat. N 64.62°	E Long. 18.76°
Geomagnetic coordinates:	Lat. N 62.8°	E Long. 110.9°
Magnetic dip:	75°	
Meridian time:	15° E (UT + 1 hour)	

Ionosonde Data

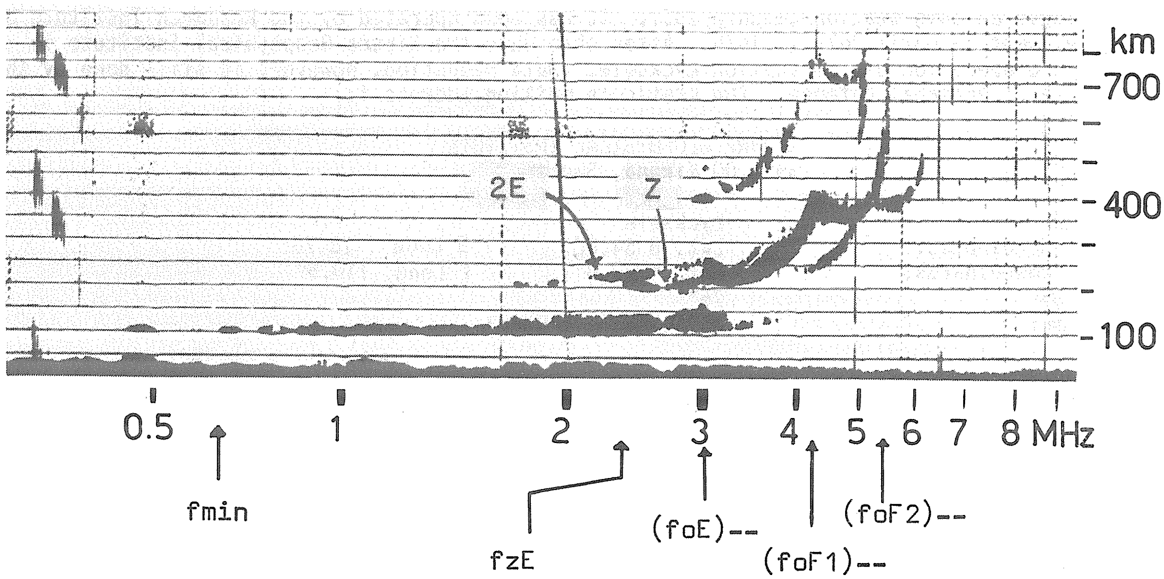
Frequency range:	0.33 - 20.0 MHz in four bands
Gain control:	Automatic
Sweep time:	3 minutes
Pulse Repetiton frequency:	50 Hz
Pulse length:	60 μsec
Height range:	900 km in 20 km intervals
Approx. power:	20 kW
Aerial types:	Delta and rhombic
Routine soundings:	Hourly, centered on each hour at 3 MHz passage
Nominal x-o difference:	0.7 MHz
Type of recordings:	Photosensitized 60 mm paper.

Most of the ionospheric data were published in the FA-series booklets of the U.S. Department of Commerce.

Terminology conforms with that recommended in the *URSI Handbook of Ionogram Interpretation and Reduction, Second Edition,* (Editors W. R. Piggott and K. Rawer), *Report UAG-23*, World Data Center A for Solar-Terrestrial Physics, U. S. Department of Commerce, NOAA, Boulder, Colorado 80302 USA.

LYCKSELE 12.5.1973

14.00 LT



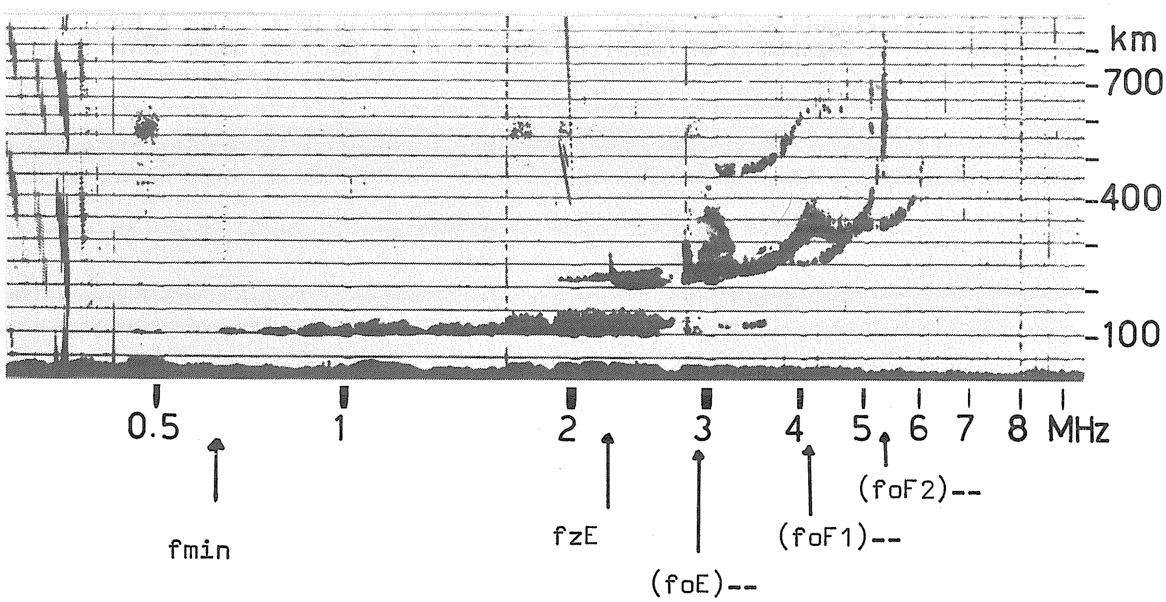


Fig. 2.27

LYCKSELE - Summer Day 12.5.1973 (12 May 1973) 1400-1500 LT (15°E)

Quiet time ionograms.

Editor's Note: When the z mode is clearly seen at low frequencies, fmin is in fact read from a z-mode trace. See Handbook. If this is rare, draw attention to fact by (fmin)-z.

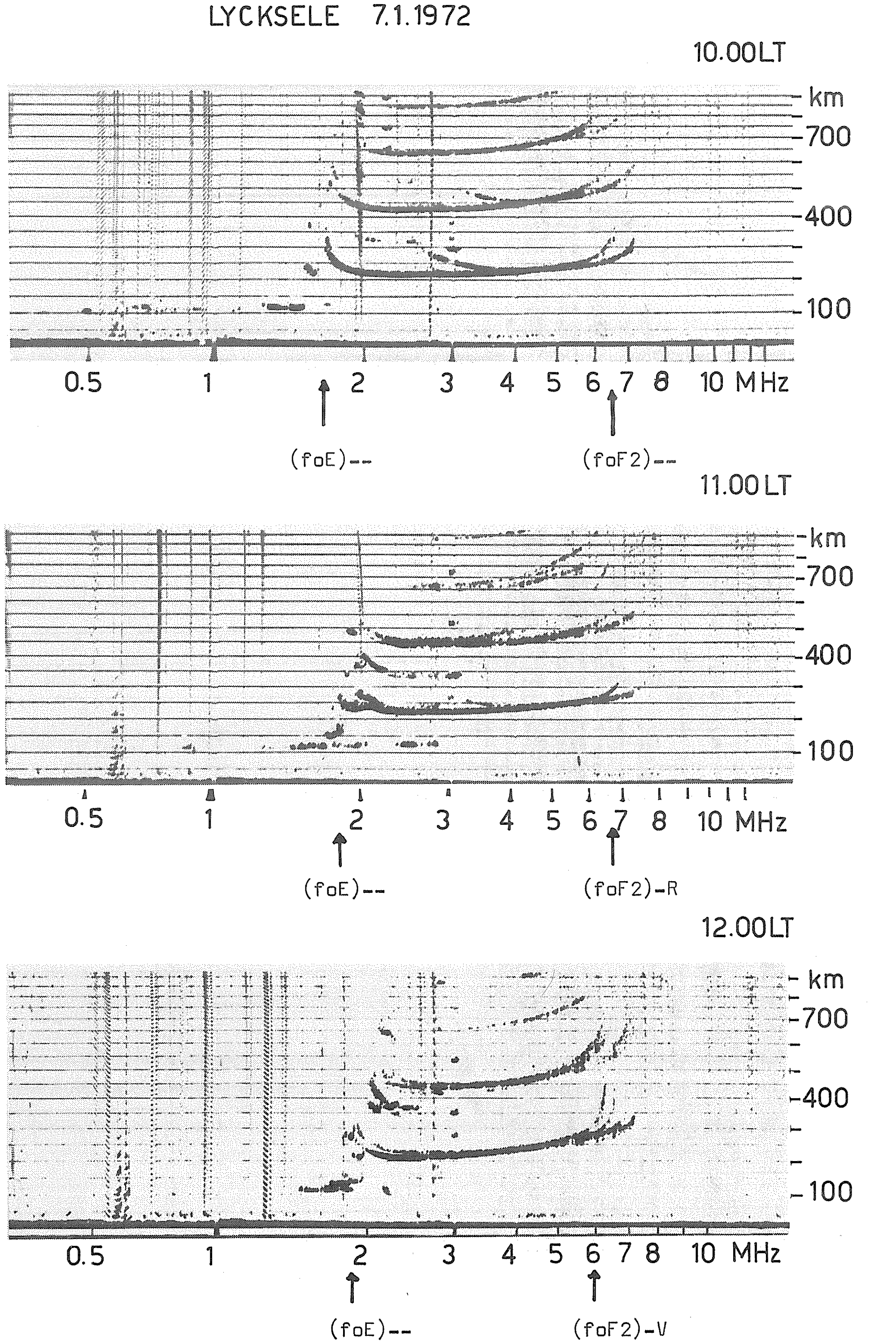


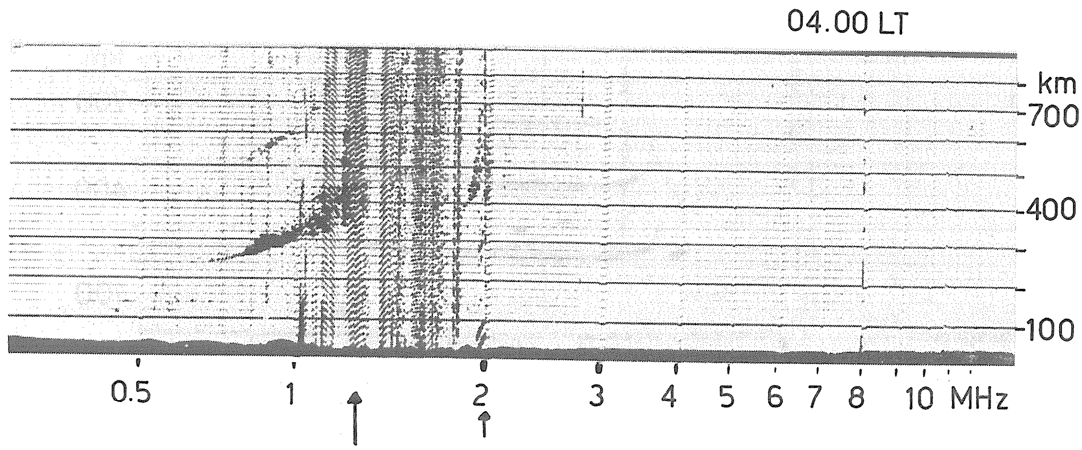
Fig. 2.28

LYCKSELE - Winter Day 7.1.1972 (7 Jan. 1972) 1000-1200 LT (15°E)

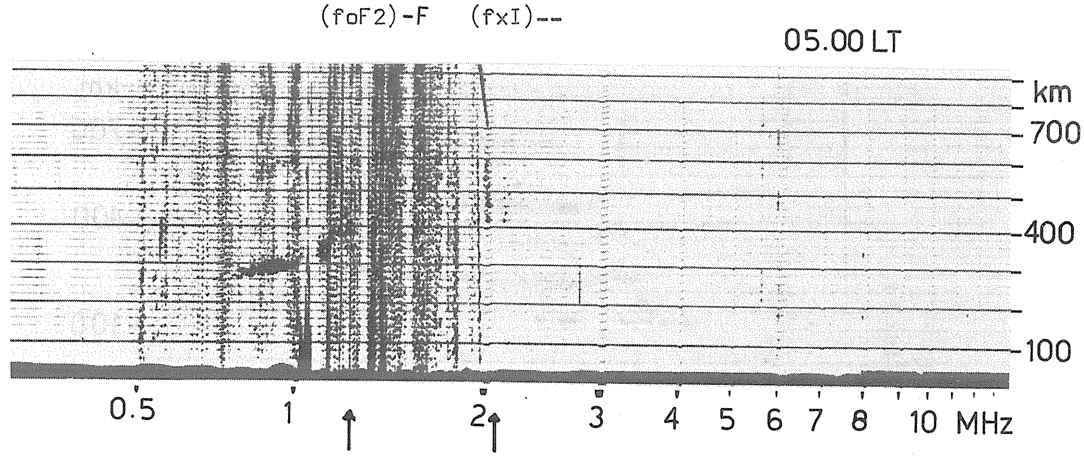
Quiet winter day with slightly disturbed foF2.

<u>Editor's Note:</u> Low type Es present at 1000-1100. Interpretation of foE at 1000 not typical trace at 200 km, probably an E2. foE better read from low frequency end of this trace (foE)-A. h'E = A unless adjacent days show E trace at 1100, 1200 not typical. foF2 should be read from higher frequency of V trace.

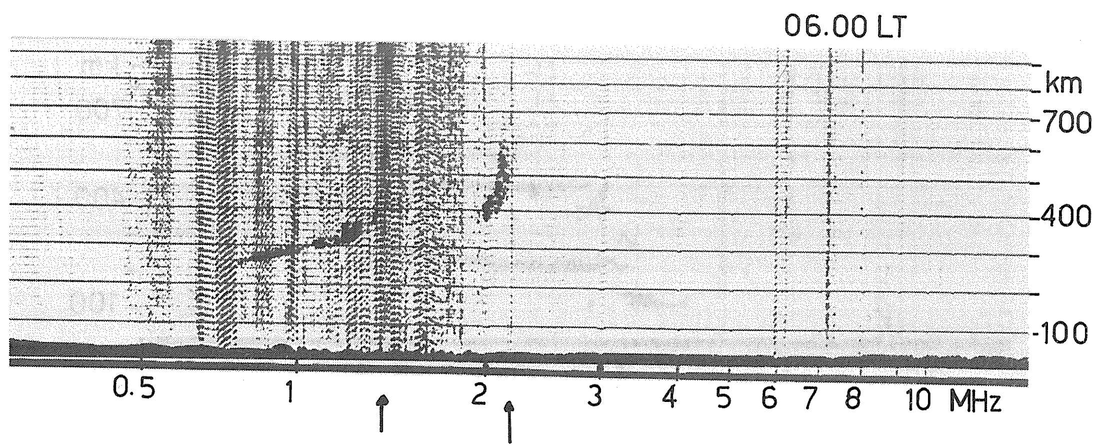
LYCKSELE 19.2.1974



(foF2)-F (fxI)--



(foF2)US (fxI)--



(foF2)US (fxI)--

Fig. 2.29

LYCKSELE - Winter Morning 19.2.1974 (19 Feb. 1974) 0400-0600 LT (15°E)

Quiet winter morning. High interference level.

Editor's Note: At 0600 foF2 should be deduced from the x trace (fxF2 - fB/2)JS. If this value agreed with the adopted foF2 as shown, (foF2)-S would be preferable.

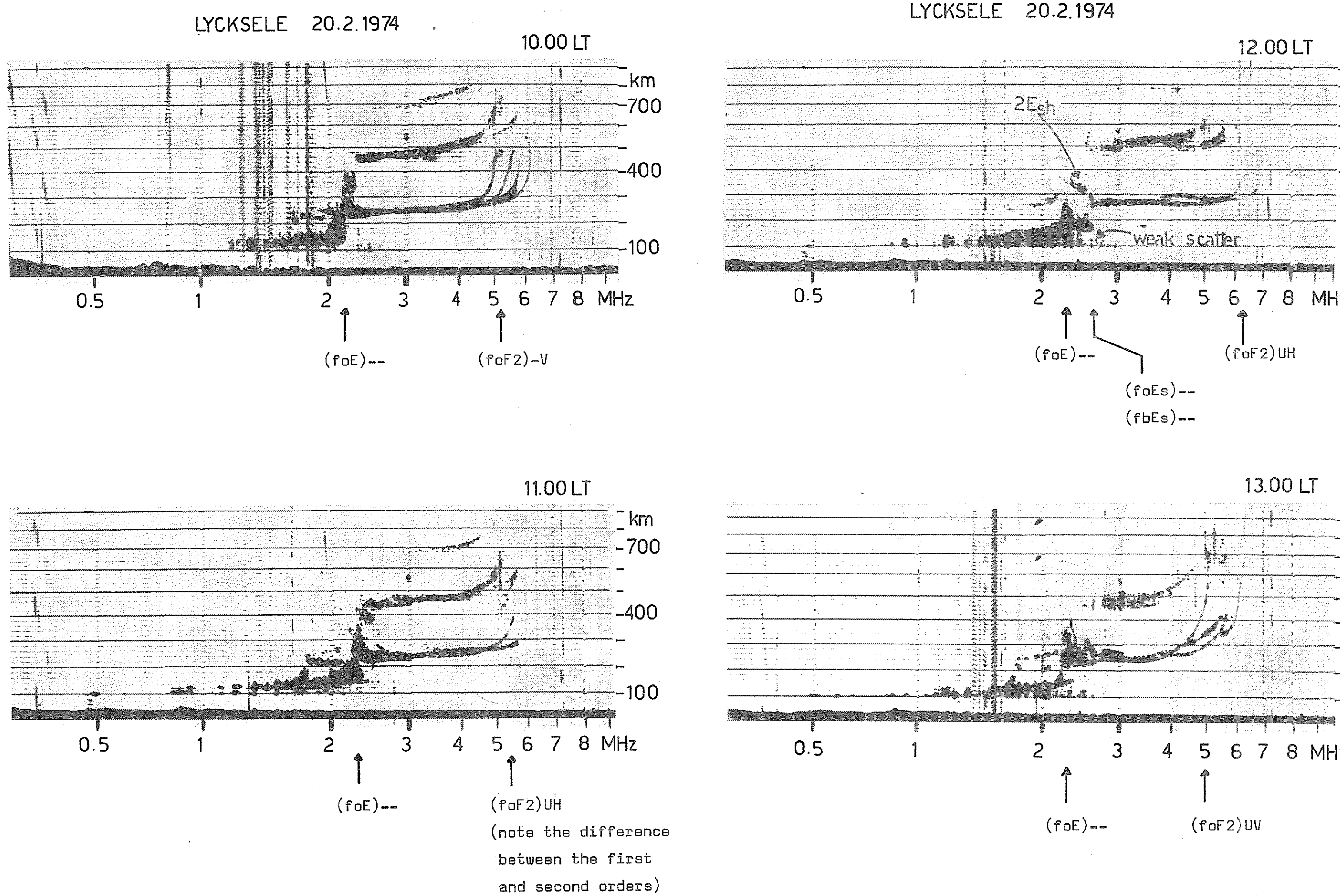


Fig. 2.30

LYCKSELE - Tilts and forking in the F layer.
20.2.1974 (20 Feb. 1974) 1000-1300 LT (15°E)

E-layer gradient reflection at 100 km ignored.

Editor's Note: When fork present, V, foF2 should be read from higher frequency trace. Note at 1100 and 1300 E doublet is z, o mode not o,x. This is very common at high latitudes.

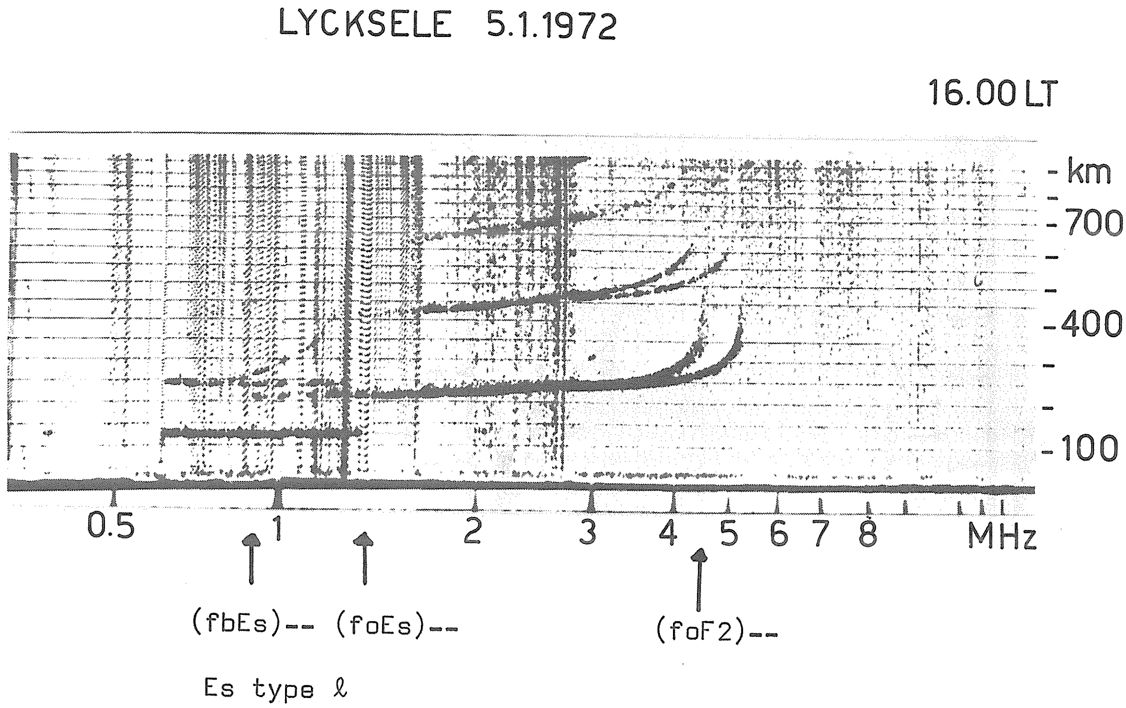


Fig. 2.31

LYCKSELE - Quiet time ionogram. The infinity echo may be seen.

5.1.1972 (5 Jan. 1972) 1600 LT (15°E)

Editor's Note: The gyro echo trace (infinity trace) is very rare but is more often present, as here, associated with an Es type f. At suitable times of year and of solar activity foF2 can be close to the gyrofrequency for many hours but is reflected normally, i.e. not a gyrotrace.

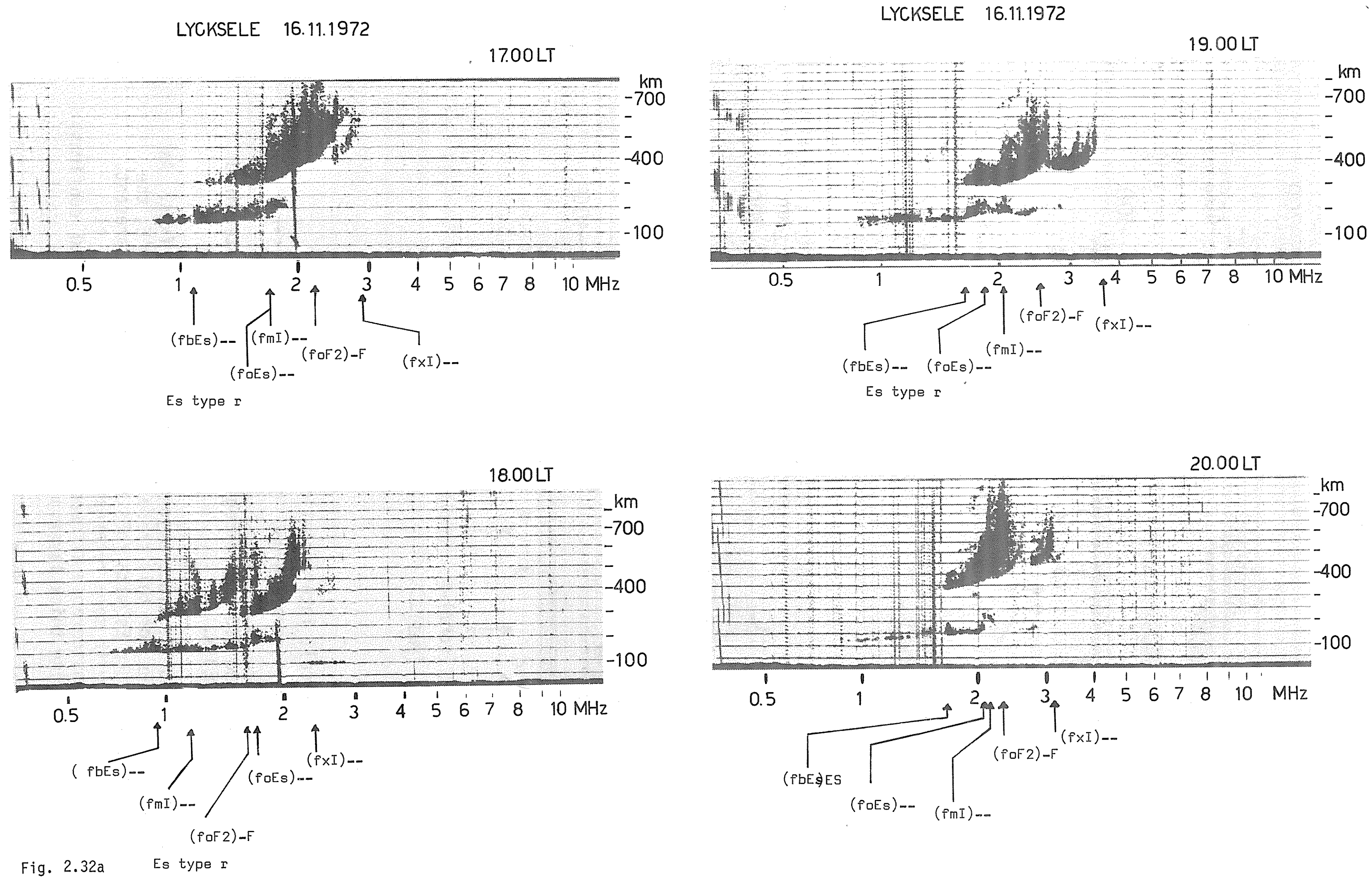


Fig. 2.32a

LYCKSELE - Spread F, Es-r. Scaling of fmI, fxI.

16.11.1972 (16 Nov. 1972) 1700-2000 LT (15°E)

Editor's Note: The interpretation of this sequence is difficult and is not consistent as given. 1700 LT: If foF2 and foEs are as shown (I agree), x trace is highly absorbed and is consistent with foF2. fxI = (foI + fB/2)OB = 0350B. 1800 LT: F traces suggest foEs = fbEs and ftEs = fxEs. Since h'Fx is close to h'F, particle is not present and foEs for type r likely to have decreased relative to values at 1700 and 1900 LT where h'Fx appreciably larger than h'F. This confirms interpretation.

1900, 2000 LT: Es-r turning into Es-k. The interference prevents retardation at foE-k to be seen on the F trace.

Normal practice would be to take fxI on normal gain ionogram from the weak trace seen at 1800 and 2000 LT particularly as similar traces can be seen on o-mode pattern.

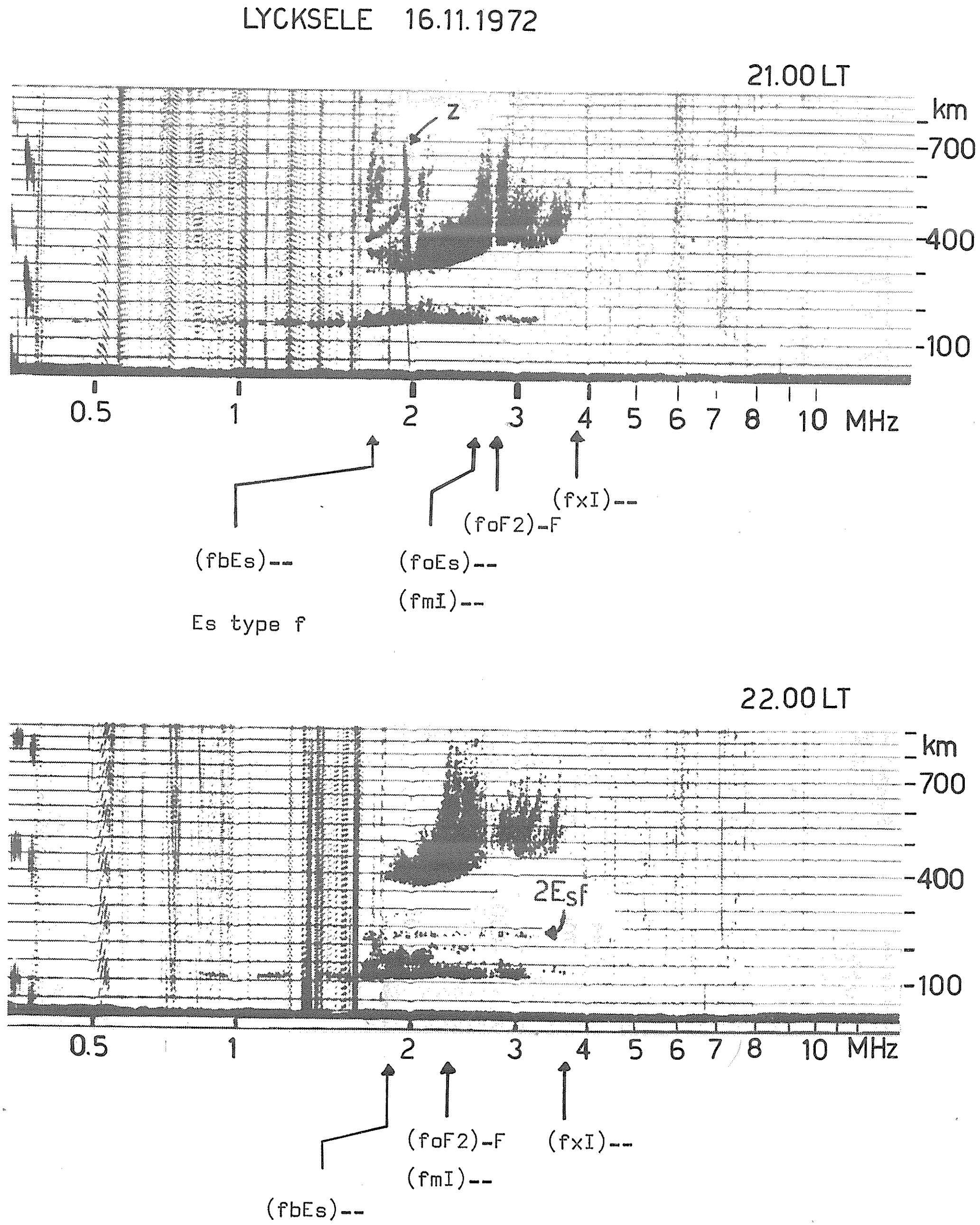


Fig. 2.32b

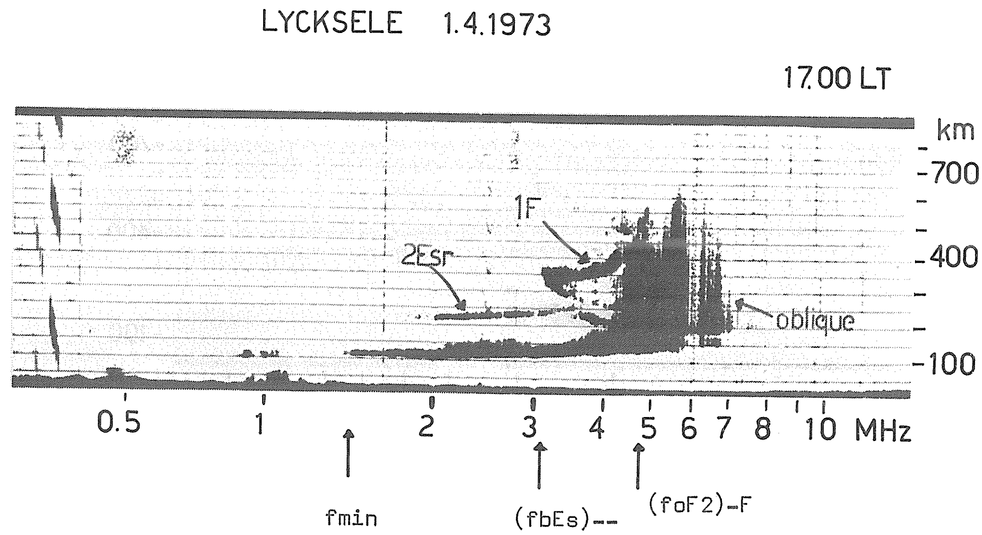
LYCKSELE - Spread F, Es diffficult interpretation, c, r, f.

16.11.1972 (16 Nov. 1972) 2100-2200 LT (15°E)

Editor's Note: At 2100 and 2200 LT, F-region trace shows fbEs determined by particle E, fBEs = (foE)-K.

At 2100 LT there is a clear Es trace beyond foE showing foEs and fxEs. As particle E present and h'Es for this trace is not greatly above h'E, the simplest interpretation cusp Es with foEs as shown. Types c1,k2 present. Ionogram also consistent with some retardation Es present. Types c1, r2,k acceptable. Note considerable difference between h'F and h'xF confirms interpretation. (Underlying thick layer.)

At 2200 LT the Es trace has moved down in height. The second order Es traces show pattern not auroral. The x and o F traces both indicate particle E probably present (compare with 2100 LT) but not certain. Interpretation as Es flat (f2) acceptable but original ionogram suggests best interpretation Es cusp (h'Es > h'E) type c2, with fbEs = (foE)UK, types c2,k.



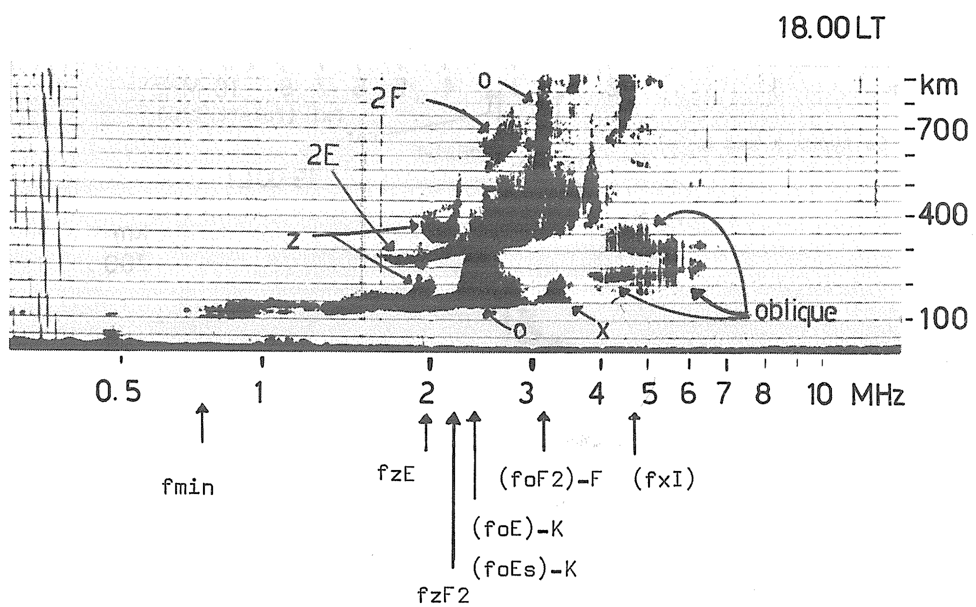


Fig. 2.33a

LYCKSELE - Particle E layer activity

1.4.1973 (1 Apr. 1973) 1700-1800 LT (15°E)

1700 LT: The multiple reflection from the Es layer shows presence of type r or type k. Because of the great scatter above foEs (r), one must add auroral type Es into Es type data.

Others: Quite clear particle E except at 1800 LT.

<u>Editor's Note</u>: The nose on the 1700 LT trace marked 1F shows that this must be oblique at the bottom end, hence fbEs cannot be deduced from this trace. The second order trace suggests fbEs = 039UK. The bottom edge of the trace above fbEs is more similar to "a" than to "r" and scatter hides possible r traces. Prefer Es type k2,a.

At 1800 the z mode confirms this is k3, slight a also present. Oblique auroral type could be indicated k3,a,a. (Two auroral Es structures.)

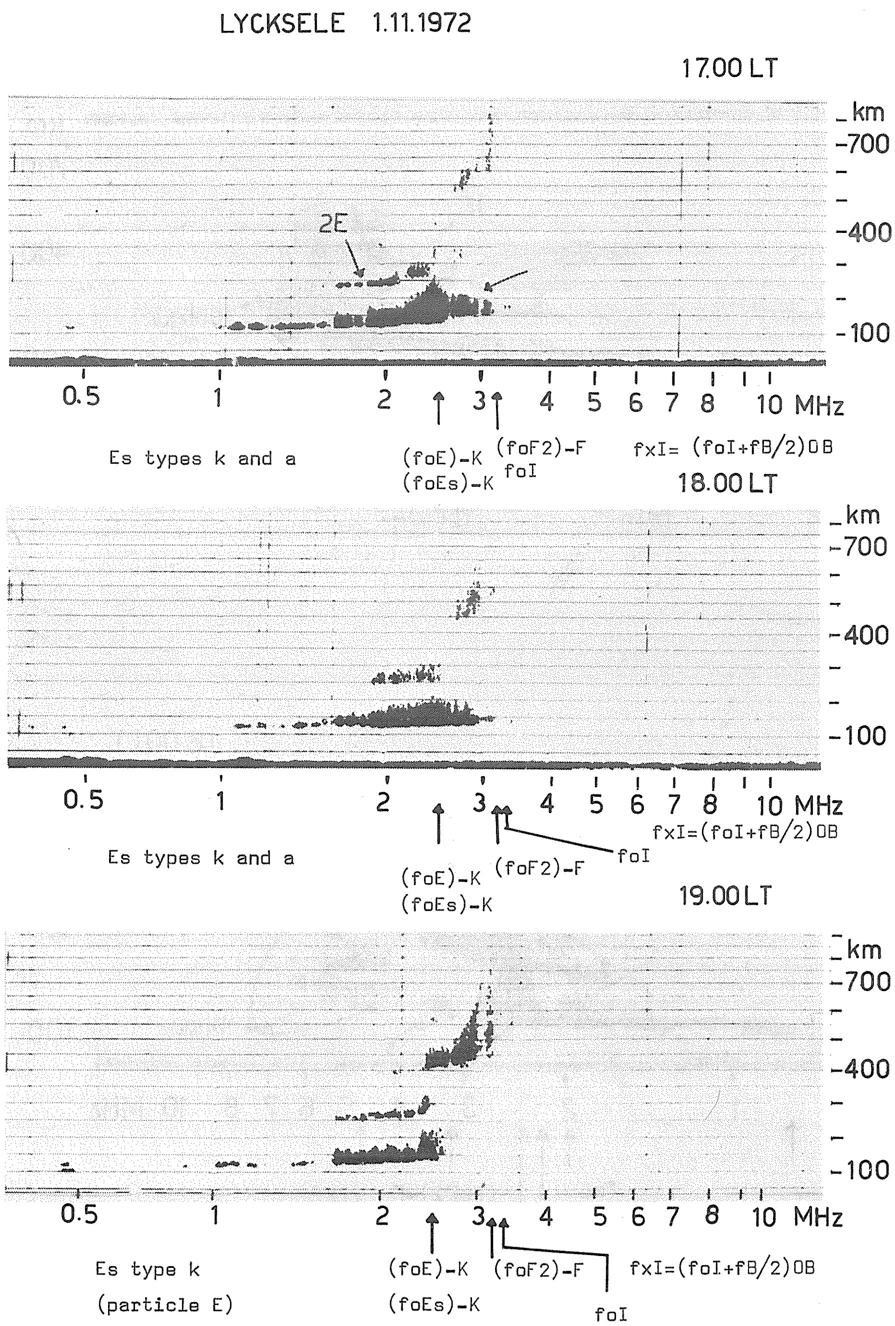


Fig. 2.33b

LYCKSELE - Es types k (particle E) and a

1.11.1972 (1 Nov. 1972) 1700-1900 LT (15°E)

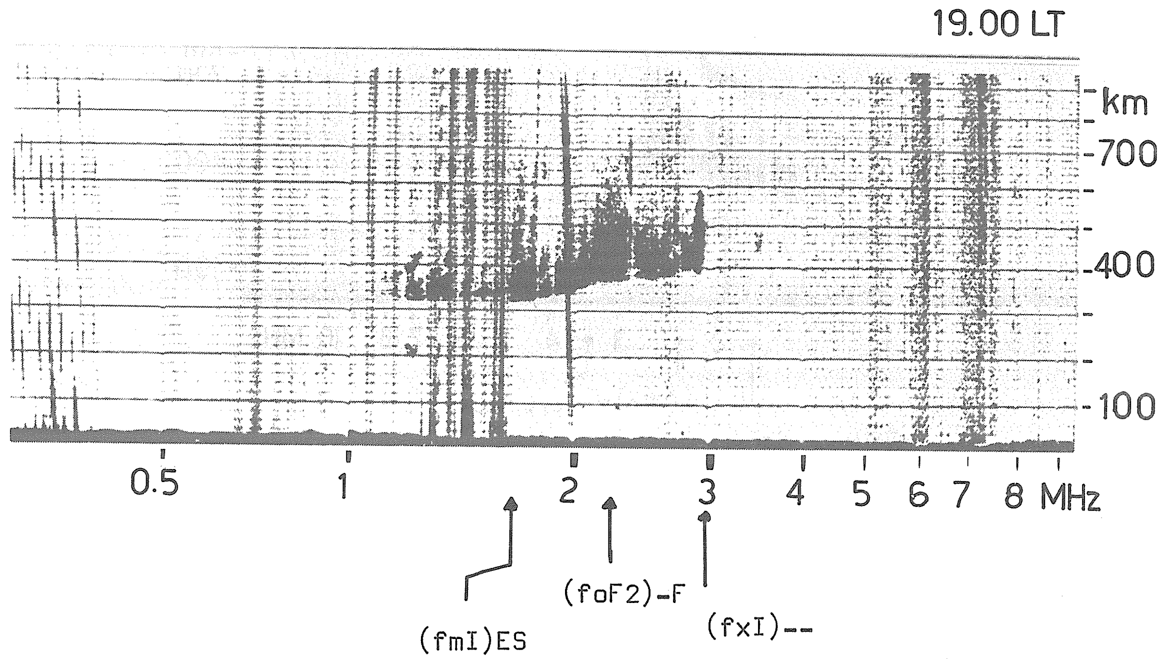
Editor's Note: The Es type k (or r when present) gives more useful information than the Es type a, therefore foEs has been measured from the Es-k trace. The presence of "a" is shown in the type.

At 1700, 1900 LT second order trace shows this is Es-k despite no evidence of retardation in F.

At 1800 LT more difficult as traces more scattered. However foEs for second order trace is close to fbEs. Second order shows main trace is r or k. Main reason for believing this is k with a superposed, is sequence similarity .

At 1900 LT Es-k. The blanketing frequency at 1700 LT and possibly 1800 LT appears to be greater than (foE)-k. However Es-a cannot blanket and F trace weak. (This is a tilt and weak echo condition so difficulty should be ignored).

LYCKSELE 28.2.1974



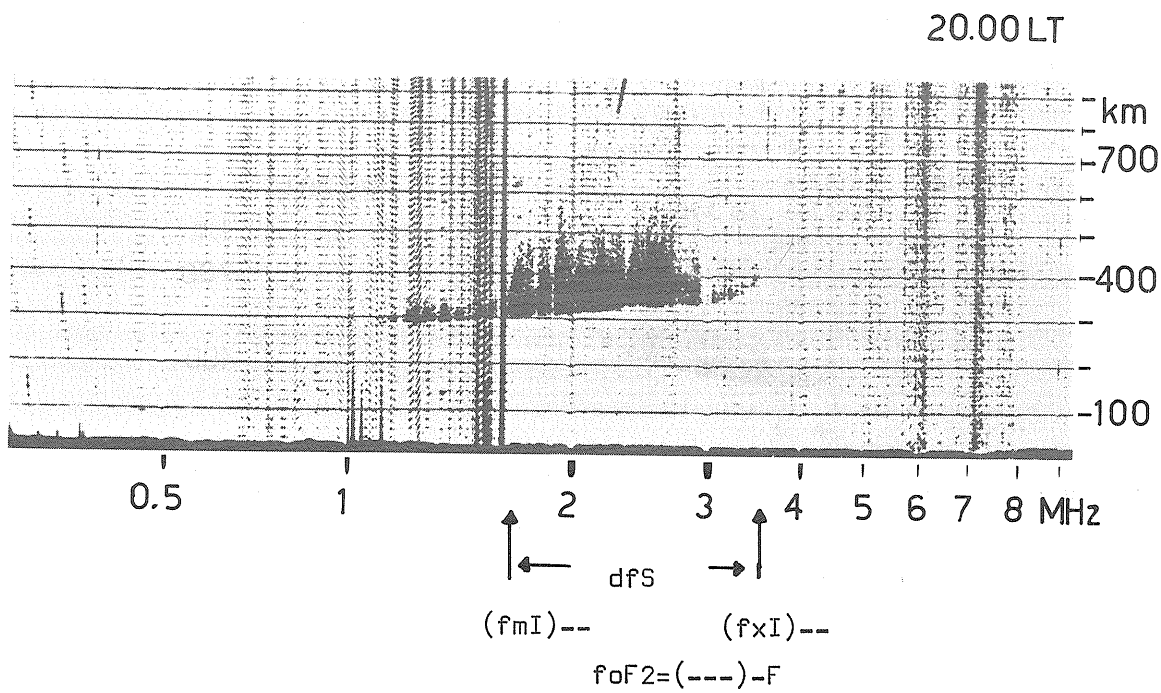


Fig. 2.34

LYCKSELE - Spread F 28.2.1974 (28 Feb. 1974) 1900-2000 LT (15°E)

<u>Editor's Note:</u> foF2 preferable UF at 1900 LT. foF2 replaced by F at 2000 LT.

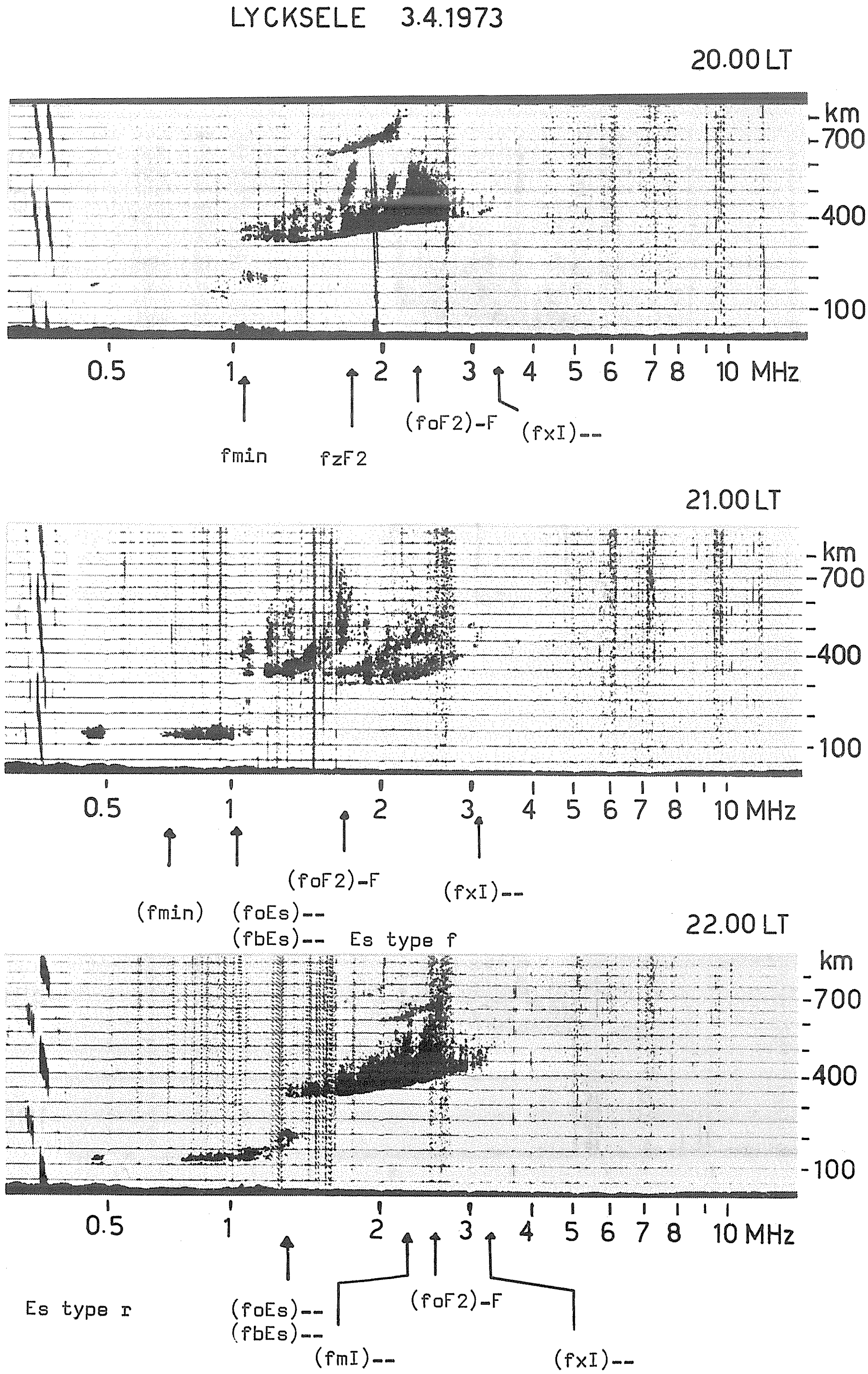


Fig. 2.35

LYCKSELE - Spread F, Es 3.4.1973 (3 Apr. 1973) 2000-2200 LT (15°E)

Editor's Note: One-quarter hourly recordings are needed in this type of situation. Inconsistent interpretation at 2000 and 2200 LT. Second order at 2000 LT confirms foF2 and fzF2. Therefore x-mode missing; fmin relatively high so fxI must be deduced from foI, fxI = (foI + fB/2)OB.

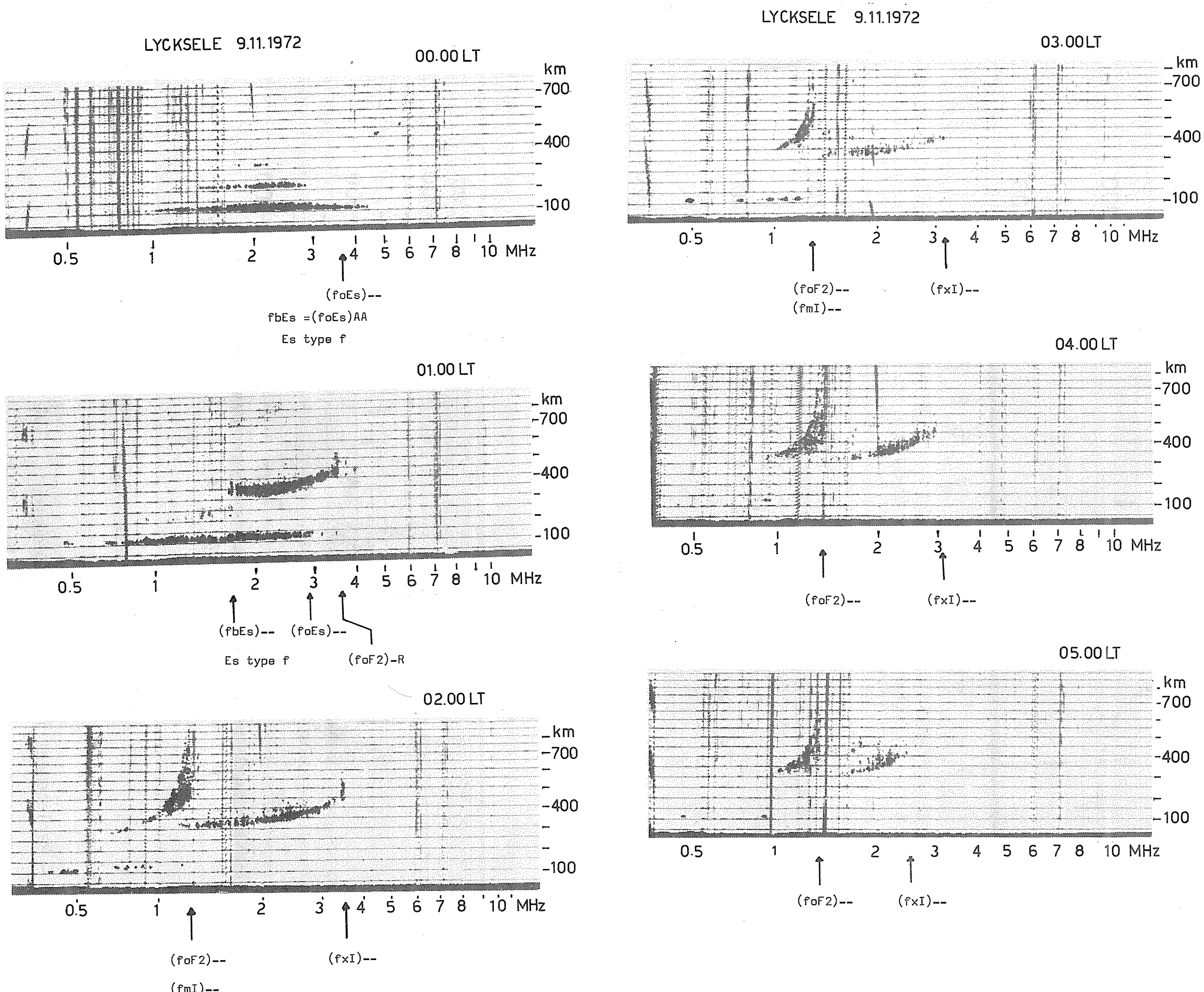


Fig. 2.36

LYCKSELE - Replacement Layer -- Trough Sequence

9.11.1972 (9 Nov. 1972) 0000-0500 LT (15°E)

0000 LT total blanketing caused by Es-f. 0200-0500 LT replacement layer. Replacement layer - trough condition, note very large difference between foF2 and fxI. Note fxI 0200 LT = foF2 0100 LT. At center of trough near 0300 LT.

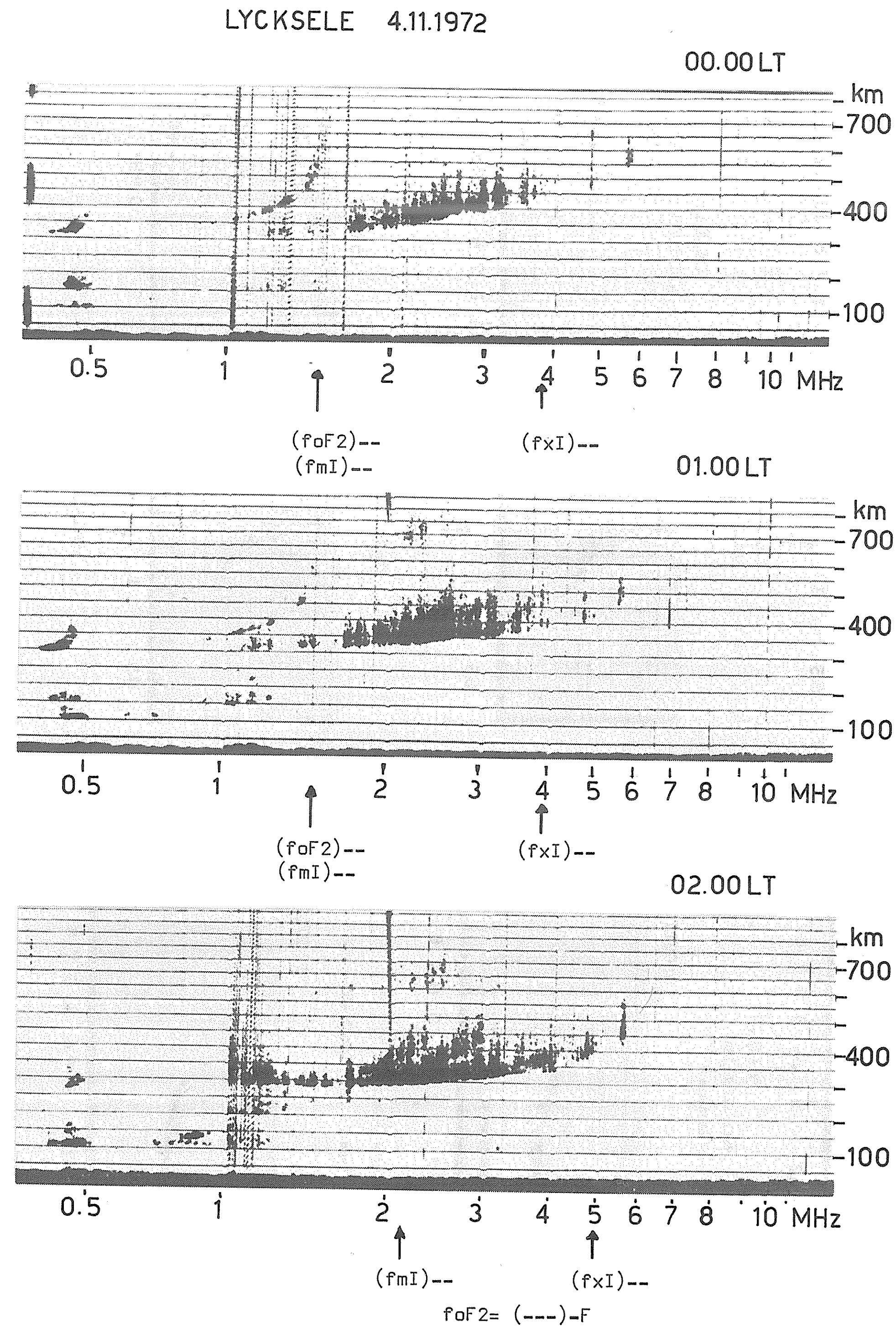


Fig. 2.37

LYCKSELE - Replacement layer -- Trough Sequence

4.11.1972 (4 Nov. 1972) 0000-0200 LT (15°E)

In this case the new layer is overhead by 0200 LT.

<u>Editor's Note</u>: As foF2 is near fB, the trough trace is an o-mode trace. Note scattered second order trace at 0200 LT shows that replacement trace is now nearly overhead and suggests foF2 near 030. Prefer foF2 = 030UF.

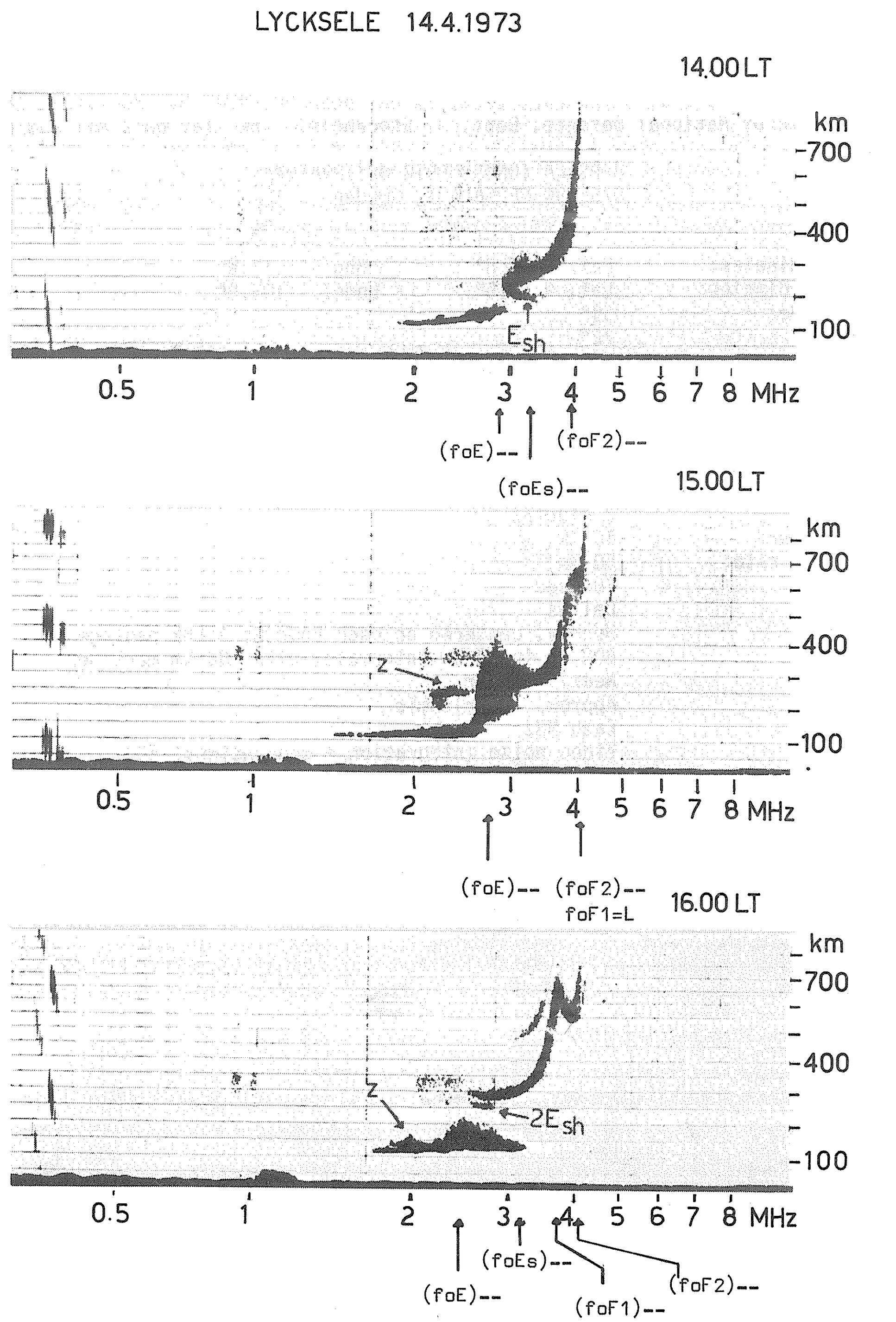


Fig. 2.38

LYCKSELE - "Spread Es-h" 14.4.1973 (14 Apr. 1973) 1400-1600 LT (15°E)

This is a quite common case. The whole ionosphere shows some kind of diffuse spread which is not so severe that numerical values for the ionospheric parameters could not be scaled. However, in these cases, it is sometimes difficult to determine the Es type. In this case the Es layer is of high type, moving steadily downwards. It is quite spread, but it is not an auroral type sporadic E. Sometimes in these kinds of ionograms the Es pattern is almost exactly like examples about Es-a given in the Handbook, although the development of the Es layer shows that mid-latitude type processes are the driving force. INAG should discuss this problem more thoroughly.

2A.4 UPPSALA

Vertical Incidence Sounding

Operation began at this station January 1952. It has been operated by and within the authority of the Research Institute of National Defence, Dept. 3, Stockholm. The station's mailing address is:

UPPSALA IONOSPHERIC OBSERVATORY
S755 90 UPPSALA 1, Sweden

Geographic coordinates:	Lat. N 59.8°	E Long. 17.6°		
Geomagnetic coordinates:	Lat. N 58.5°	E Long. 106.0°		
Magnetic latitude:	59°			
Magnetic Dip:	72°			
Time used:	15°E (UT + 1 hour)			
Ionosonde equipment type:	J4			
Frequency range:	0.33 - 20 MHz in 4 bands:			
	Band 1:	0.33 - 1.0 MHz	Band 3:	2.8 - 7.8 MHz
	Band 2:	1.0 - 2.8 MHz	Band 4:	7.8 - 20.0 MHz
Sweep time:	3 minutes			
Approx. peak power:	10 kW			
Pulse repetition rate:	50 Hz			
Pulse length:	70 μsec			
Aerial type:	Deltas			
Routine sounding:	Hourly, centered on each hour at 3 MHz passage			
Height range:	800 km in 20 km intervals, with 100 km markings			
Height scale:	Nearly linear			
Frequency scale:	Approx. logarithmic			
Frequency marker:	Each MHz			
Gain system:	Video noise integration + conventional AGC			

Nominal frequency difference of o and x components: 0.7 MHz. Routine ionograms are made on photosensitized paper 60 mm. 16 mm film records for PPI presentation with one picture each minute are made during special events. Most of the ionospheric data were published in FA-series booklets of U.S. Department of Commerce. Terminology conforms with that recommended in the "*URSI Handbook of Ionogram Interpretation and Reduction*", Second Edition, edited by W. R. Piggott and K. Rawer, *Report UAG-23*, World Data Center A for Solar-Terrestrial Physics, U. S. Department of Commerce, NOAA, November 1972.

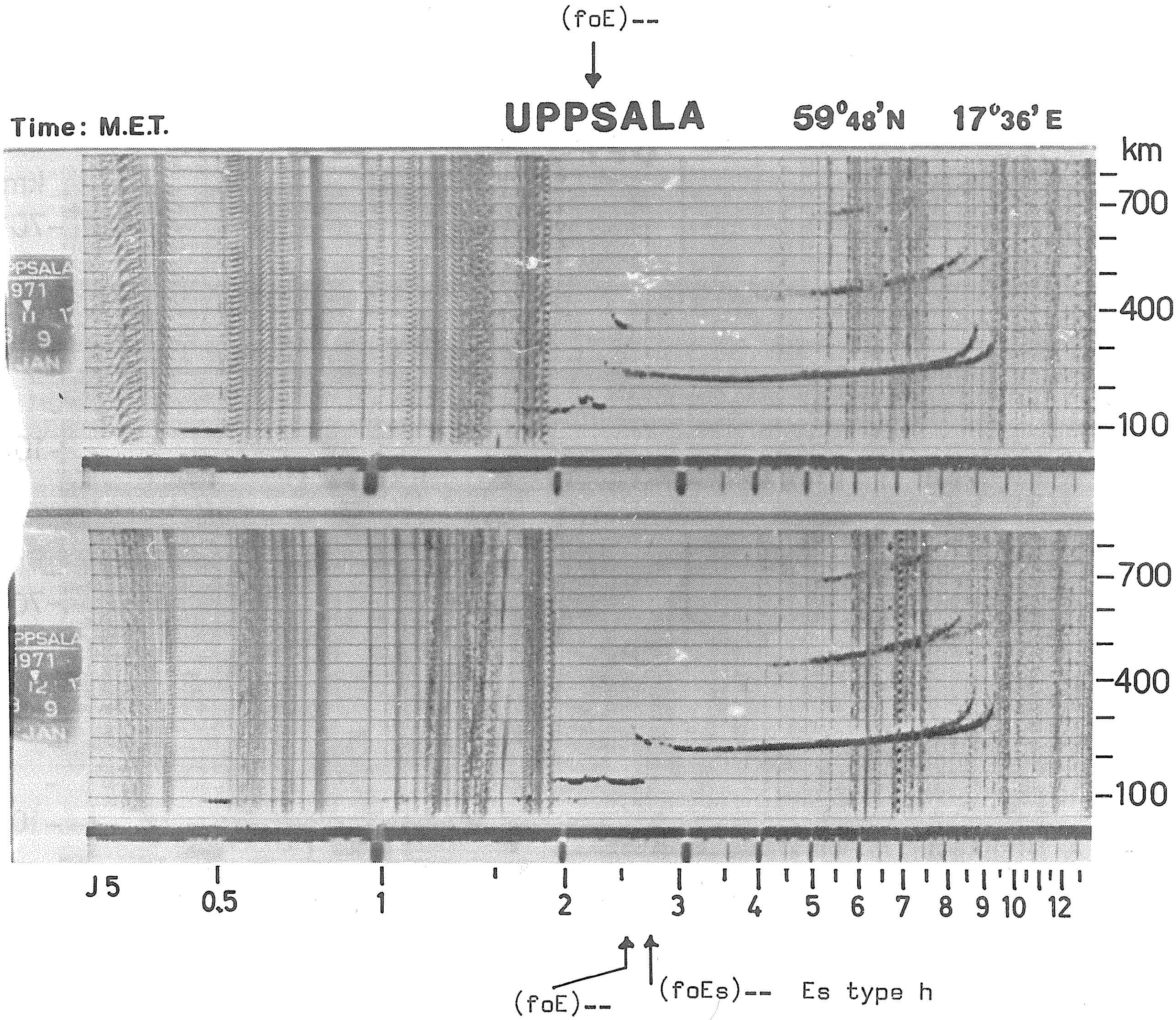


Fig. 2.39

UPPSALA - Winter Day 1971 January 9 1100 - 1200 LT (15°E)

Editor's Note: On a winter day at high latitudes, h'E can be very high. Values up to 200 km have been reported. For this station one would expect h'E about 130 km. The interpretation depends critically on whether the most probable value of foE is near 2.2 MHz (220 km) or near 1.8 MHz. It is worthwhile to run special sequences of more frequent records to check this and also to compare values at similar solar zenith angles at other stations. Interpretation as given is inconsistent. It could be:

	foE = 180US	Es type h	foE2 = 230 (1100 LT)
and	foE = 260 (1200 LT)	Es type h	
or			
	foE = 220-A	Es type c	(1100 LT)
and	foE = 230UA	Es type c	(1200 LT)

At both hours the trace at 100 km would then be a low Es. On the former interpretation it is h'E.

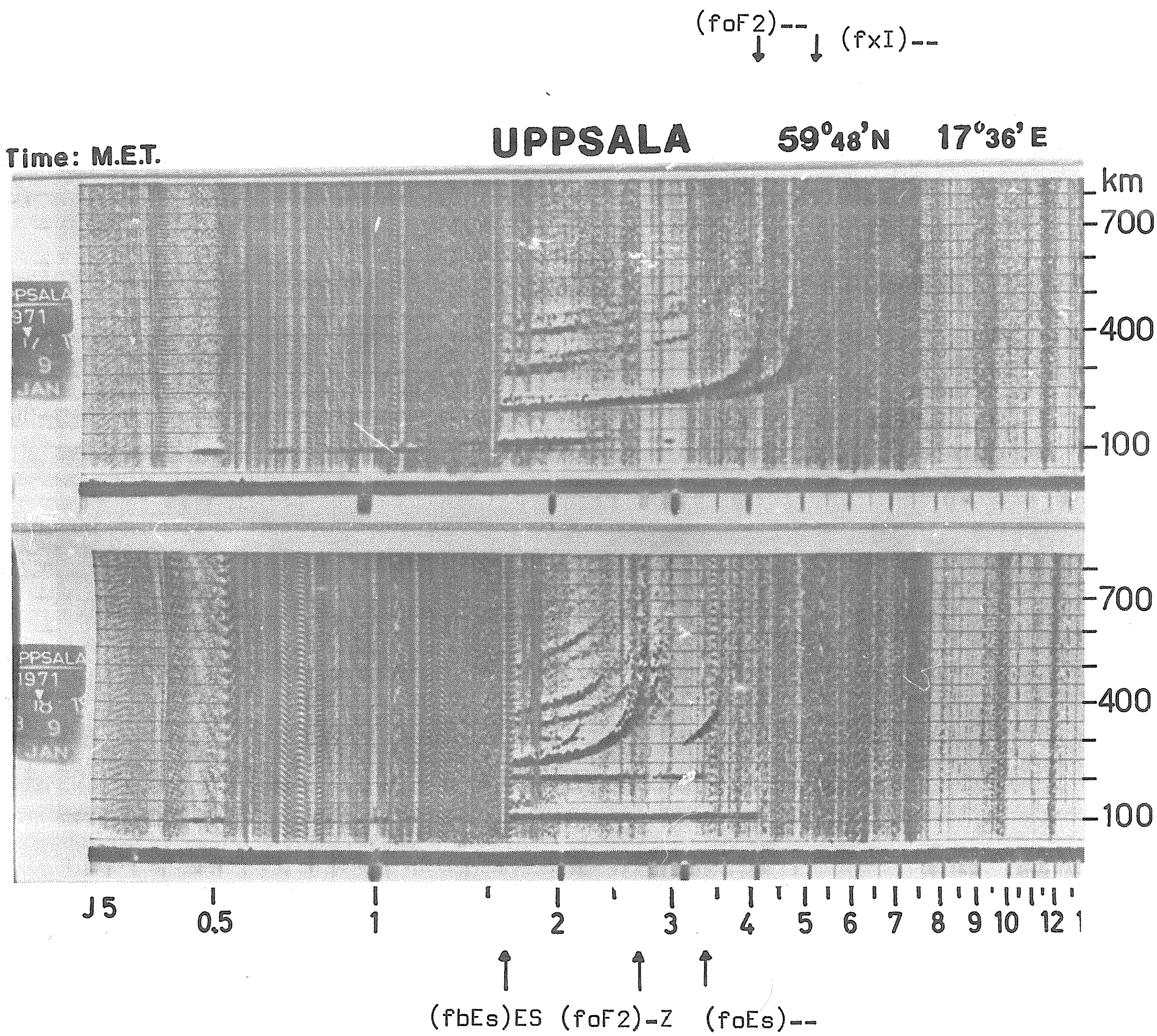


Fig. 2.40

UPPSALA - Winter Night 1971 January 9 1700-1800 LT (15°E)

Editor's Note:

1800 LT z mode present

o mode shows scatter
x mode - no scatter, but in interference band.

fxI = 035DS allowed, but fxI - (foI + fB/2) = 036OS is better.

Note presence of strong (E+F) and (2F-E) traces suggesting tilt condition may be approaching.

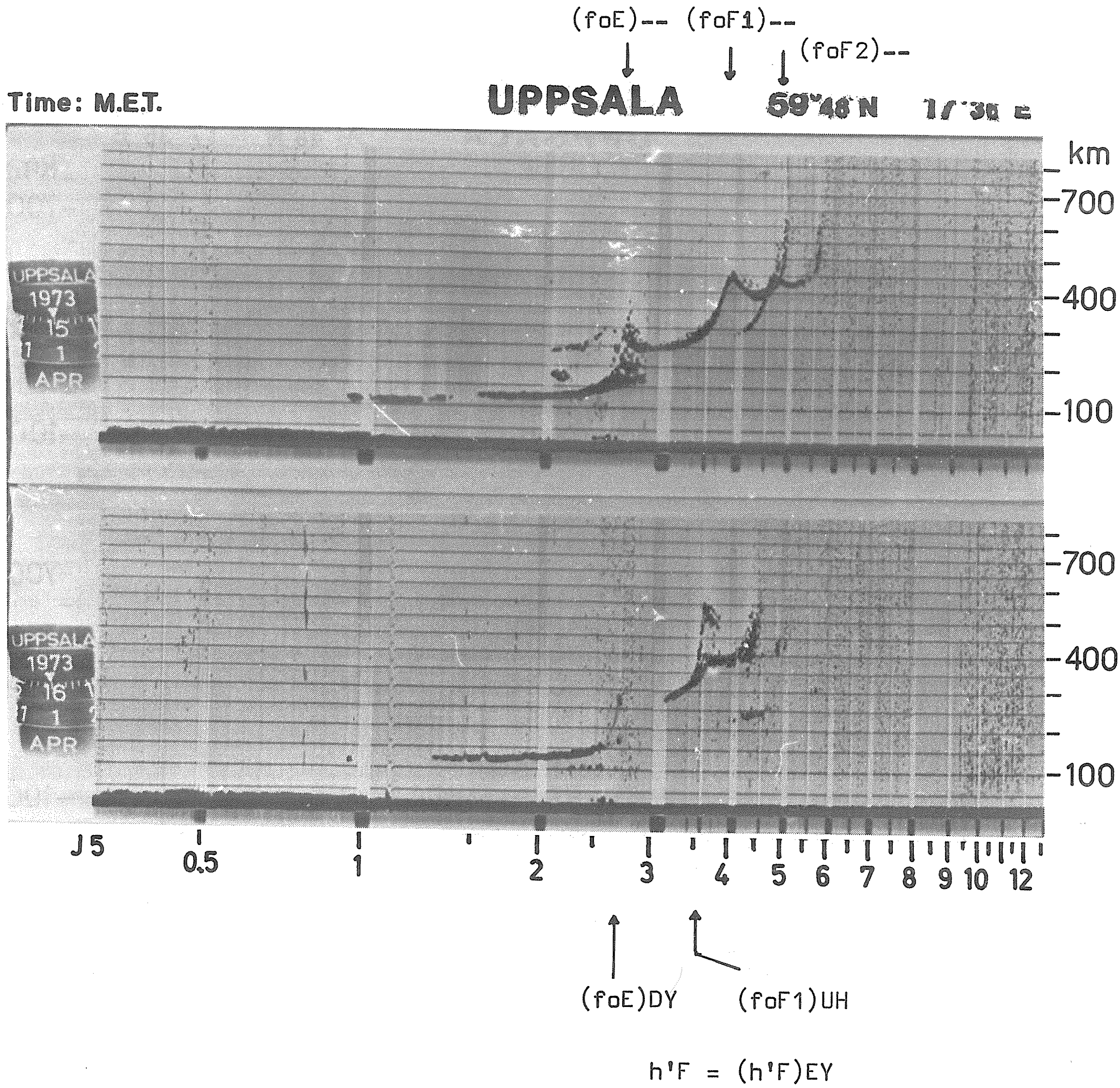
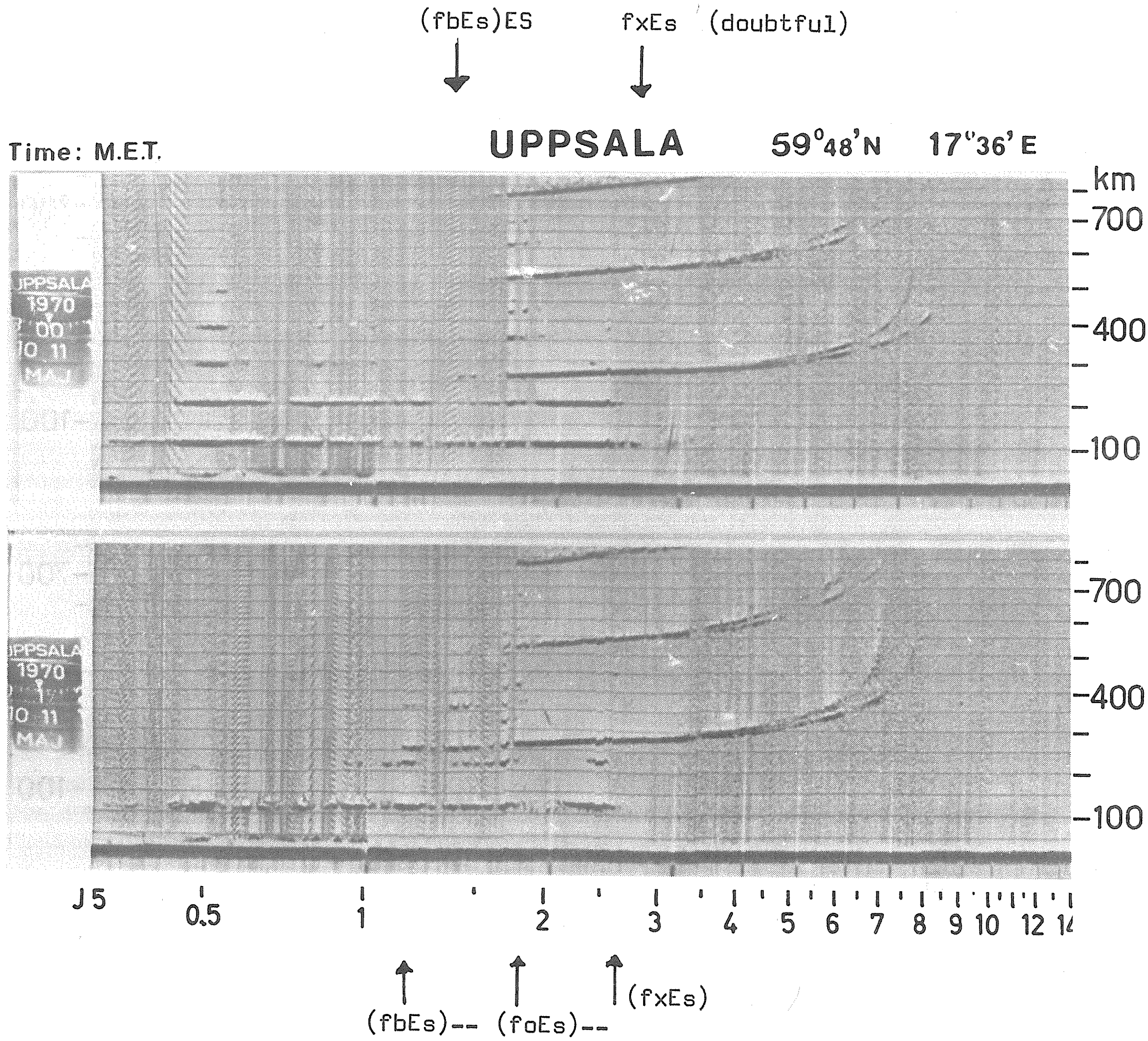


Fig. 2.41

UPPSALA - Development of Lacuna 1973 April 1 1500-1600 LT (15°E)

Editor's Note: Slant Es present

Probable value of foE could have been deduced from previous record or from another day at this time. Extrapolation within accuracy rules would have been found possible giving either 027UY or 027-Y. Do not use DX if UX is allowed or UX if -X is allowed by accuracy rules. (X means any descriptive letter in this case.)



Es type f

Fig. 2.42

UPPSALA - Flat Es 1970 May 11 0000-0100 LT (15°E)

Editor's Note:

Use of sequence to evaluate ftEs.

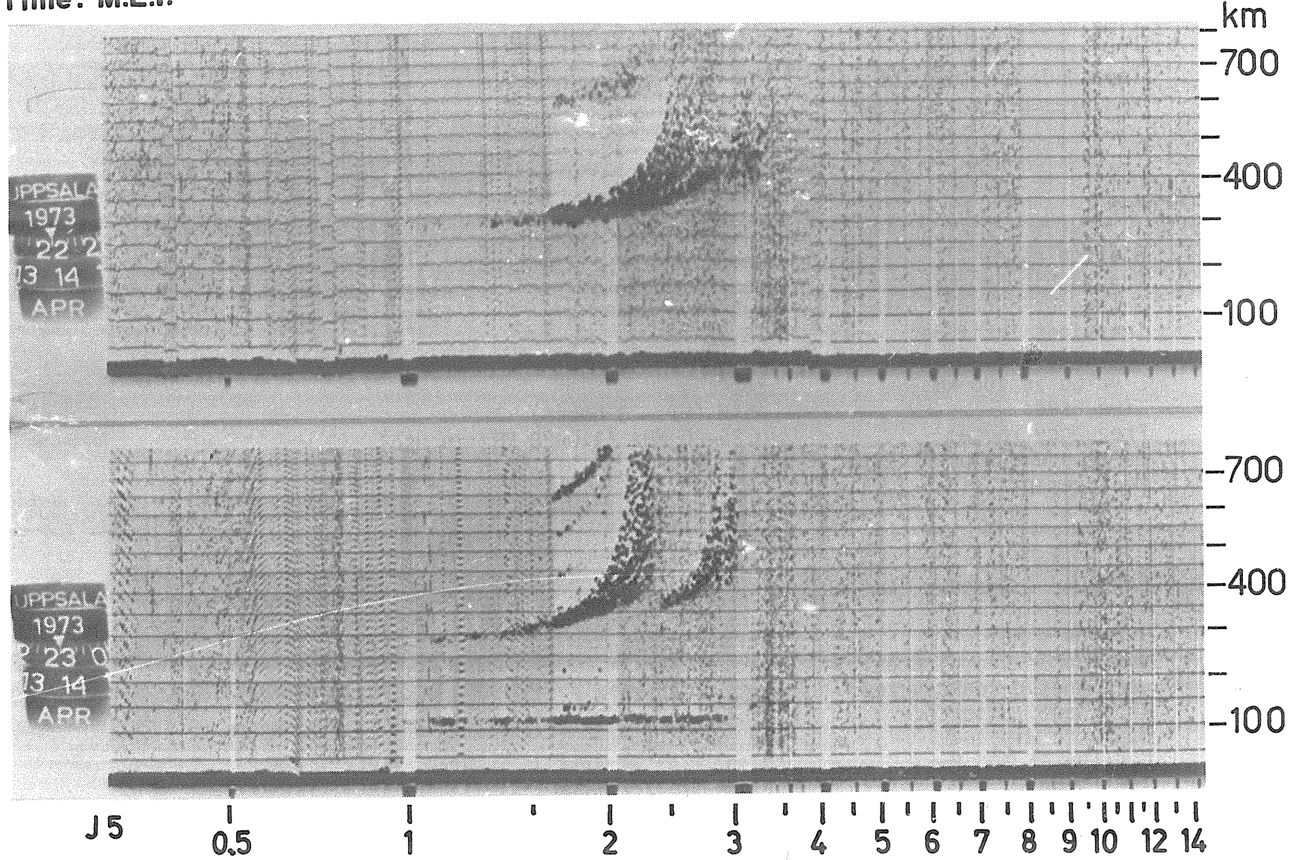
0100 LT o and x traces clear.

0000 LT more multiples present than at 0100; interference level similar, hence likely to be less absorption than at 0100. ftEs must be fxEs; deduce foEs using (fxEs-fB/2)JA. As this (020JA) checks within accuracy rules with apparent value foEs = 019, no qualifying letter needed. 019-A for 020-A best. 0.

(fmI)--
(foF2)-F

(fxI)-

Time: M.E.T. UPPSALA 59°48'N 17°36'E



(fmin)ES

(fbEs)ES

(foF2)-- (foEs)--

Es type f

Fig. 2.43

UPPSALA - Flat Es 1973 April 14 2200-2300 LT (15°E)

Editor's Note:

Strictly, as no dominant trace visible and x traces does not agree, (foF2)UF would be better; at 2300 (foF2)-F would be better.

Part B. GREENLAND STATIONS

2B.1 THULE (Qanaq)

Station name:	Thule (Qanaq)	
Geographic coordinates:	Lat. N 77.51°	E Long. 290.67°
Geomagnetic coordinates:	Lat. N 89.10°	E Long. 356.42°
Invariant latitude:	86.26°	
Magnetic dip:	85.89°	
L value at 100 km:	approx. 276	
Time used:	75°W (UT - 5 hours)	
Frequency range:	0.25 - 20 MHz	
Ionosonde equipment type:	C4 NBS ionosonde	
Measurements since 1968.		

2B.2 GODHAVN

Station name:	Godhavn	
Geographic coordinates:	Lat. N 69.25°	E Long. 306.49°
Geomagnetic coordinates:	Lat. N 80.05°	E Long. 33.20°
Invariant latitude:	76.95°	
Magnetic dip:	81.96°	
L value at 100 km:	20.41	
Time used:	45°W (UT - 3 hours)	
Frequency range:	0.25-20 MHz (1.0-20 MHz in use)	
Ionosonde equipment type:	J 5	
Measurements since 1951.		

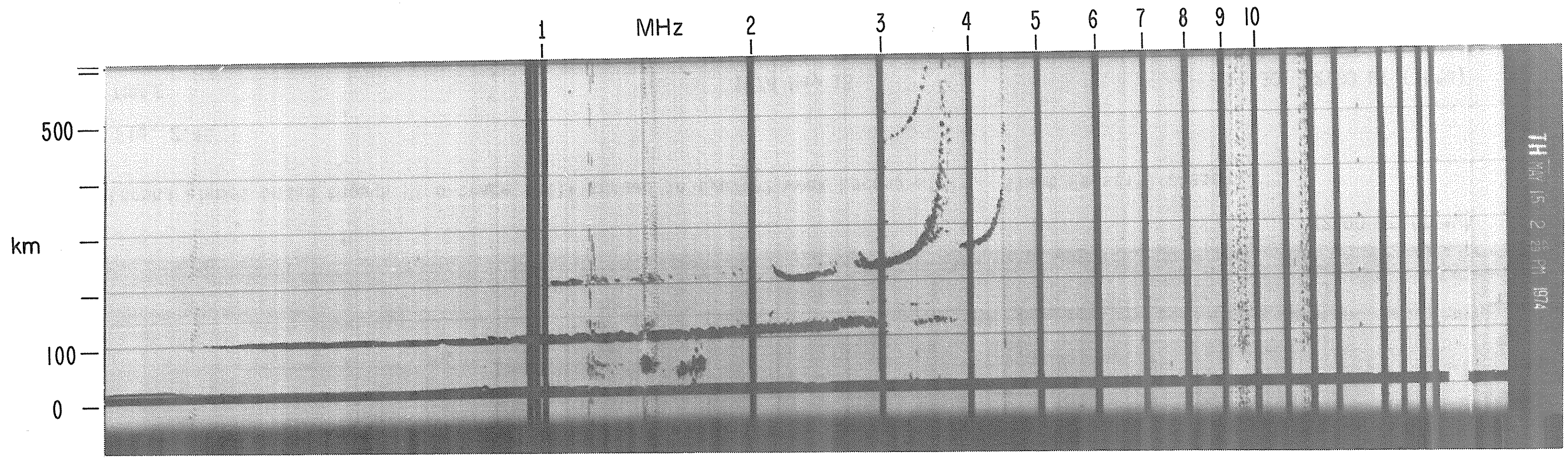
2B.3 NARSSARSSUAQ (ionogram code GR)

Station name:	Narssarssuaq	
Geographic coordinates:	Lat. N 61.17°	E Long. 314.59°
Geomagnetic coordinates:	Lat. N 71.35°	E Long 37.12°
Invariant latitude:	67.90°	
Magnetic dip:	77.34°	
L value at 100 km:	7.31	
Time used:	45°W (UT - 3 hours)	
Frequency range:	0.25-20 MHz	
Ionosonde equipment type:	Modified C3/C4 NBS ionosonde	
Measurements since 1950.		

Sponsored by:

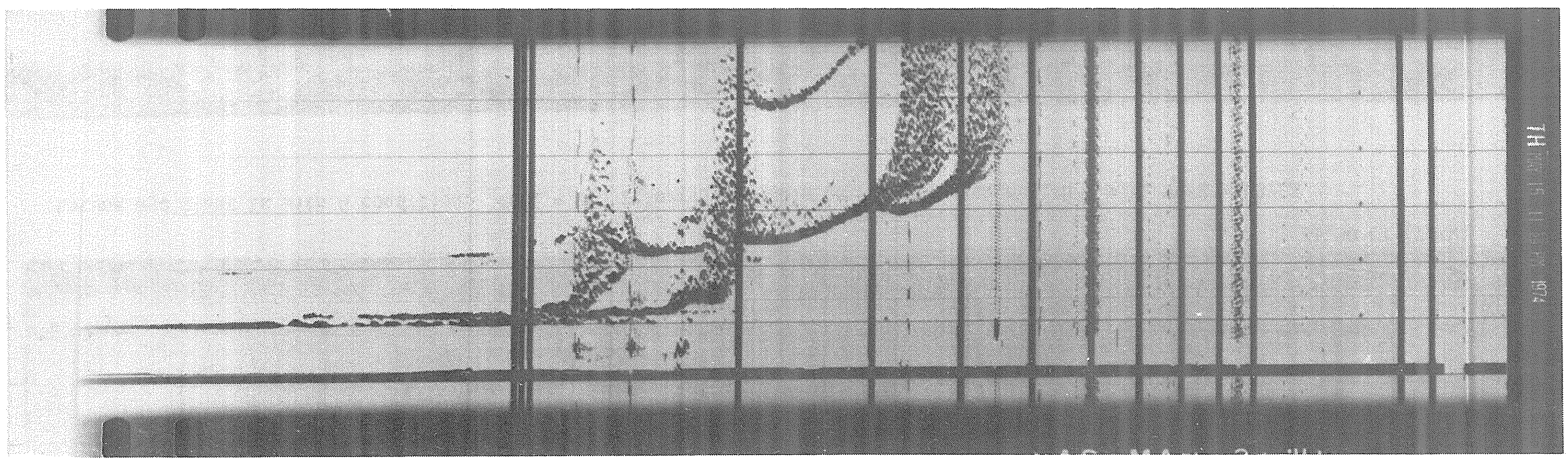
Ionospheric Laboratory
Technical University B348
DK 2800 Lyngby
Denmark

The data published have been provided by Mr. Palle Guldager, Greenland, who provided complete sequences for one or two disturbed days from each station. Notes and analysis have been provided by the Editor.



14.29 LT (75°W)

Summer Day. Very low cusp Es. foE = 270UA. foF1 = 380, foF2 = 038EG. Es type c (but ℓ would be acceptable).
Note: Presence of clear o and x traces shows that this is not a slant Es despite rise in h'Es towards foEs. z-trace of F present near foE, fzE.



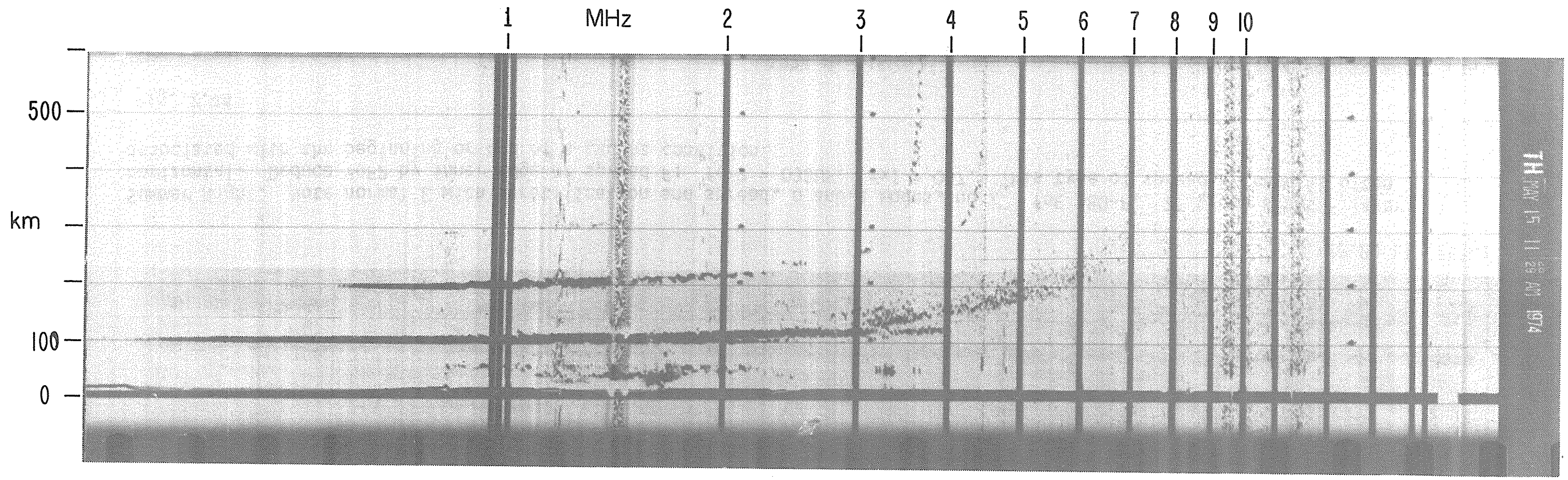
23.29 LT (75°W)

Summer Night. Note normal E with stratification and spread, o and z modes, no x. foE 180-F. 2F trace shows F layer horizontal. Deduce foF2 by inner edge of spread F: foF2 = 033UF. fxI = 047. This type of spread E trace is often associated with the beginning or end of a Lacuna condition.

Fig. 2.44

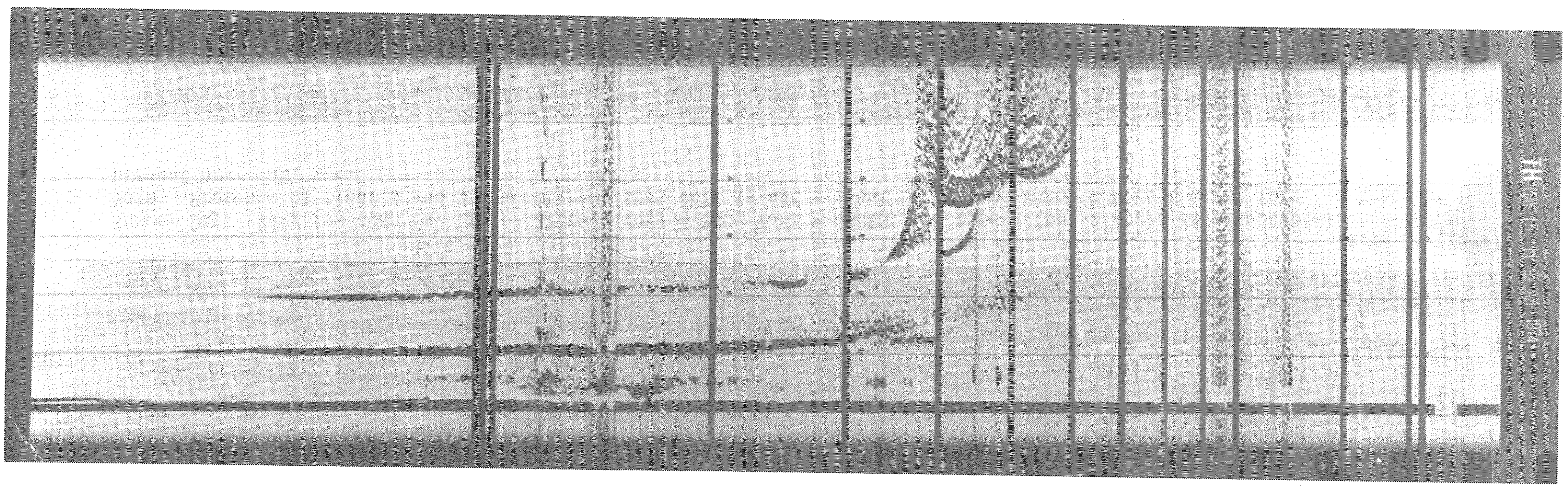
THULE 1974 May 15 14.29, 23.29 LT (75°W)

Summer Day and Summer Night (relatively undisturbed).



11.30 LT (75°W)

Lacuna and slant Es with G condition. foF1 = 370 (clearly readable on master), foE = Y, h'F = Y, foF2 = 037EG.



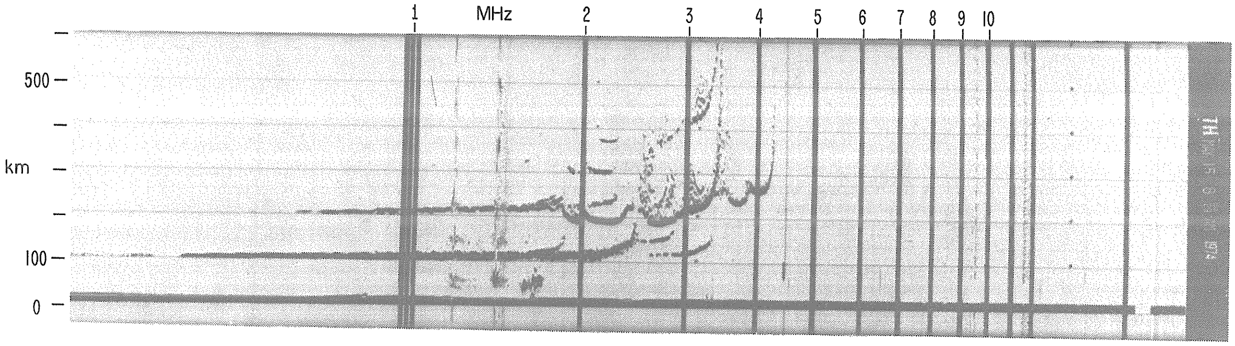
12.00 LT (75°W)

Lacuna almost ended though F1 o-trace still spread in typical weak Lacuna style. Slant Es still present.

Fig. 2.45

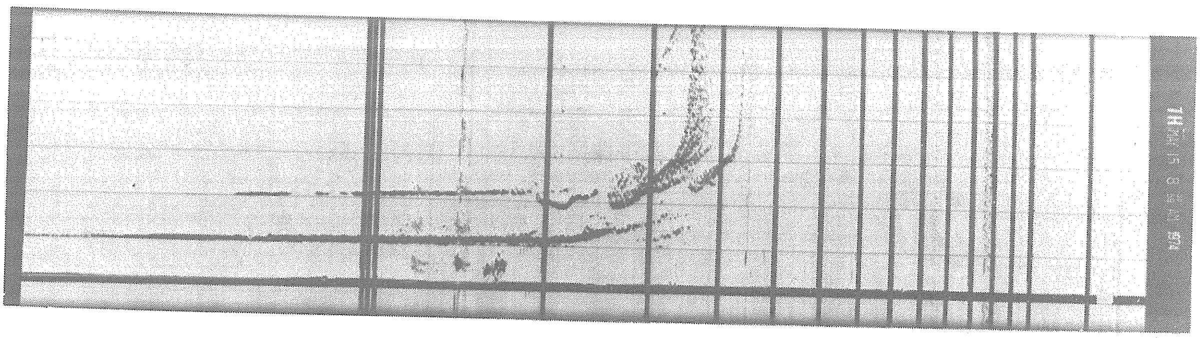
THULE 1974 May 15 11.30, 12.00 LT (75°W)

Weak Lacuna with slant Es and G condition.



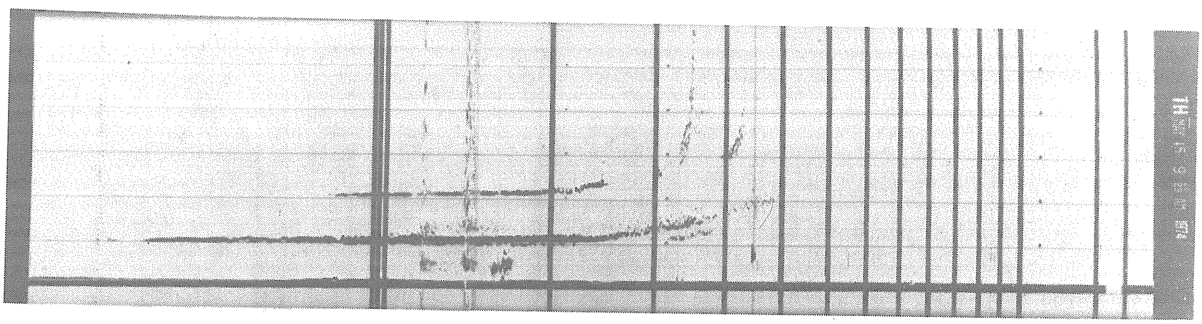
08.30 LT (75°W)

fxE, foE, fzE, F trace stratified, h'F = 180UH, foF1 = 350, foF2 = 035EG.



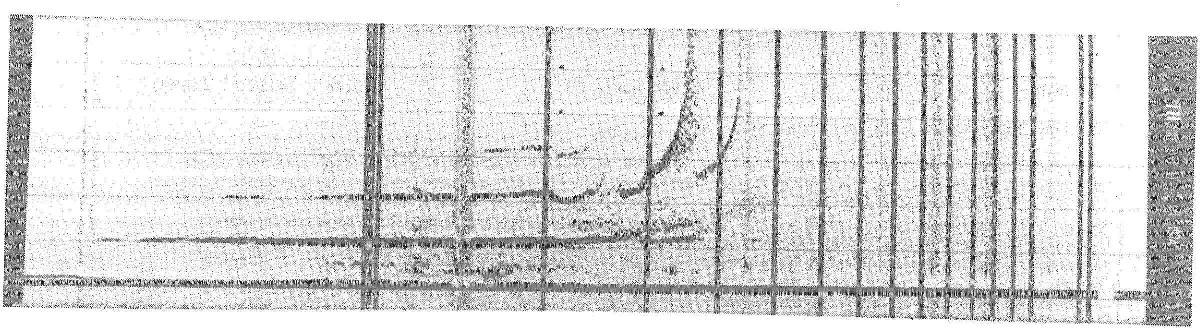
09.00 LT (75°W)

Slant Es seen and F1-layer trace weakens and becomes spread. Lacuna condition starting. foF1 = 360-F, foE = 260 (from F2 trace) or deduce foE = 260ZA. As both agree, no qualification needed - a good foE value. foF2 = 036EG. h'F = 190UH.



09.30 LT (75°W)

Slant Es arises near foE. foE = Y, h'F = Y, foF1 = 360-Y, foF2 = 036EG, h'F2 = G. Lacuna combined with G condition.



10.00 LT (75°W)

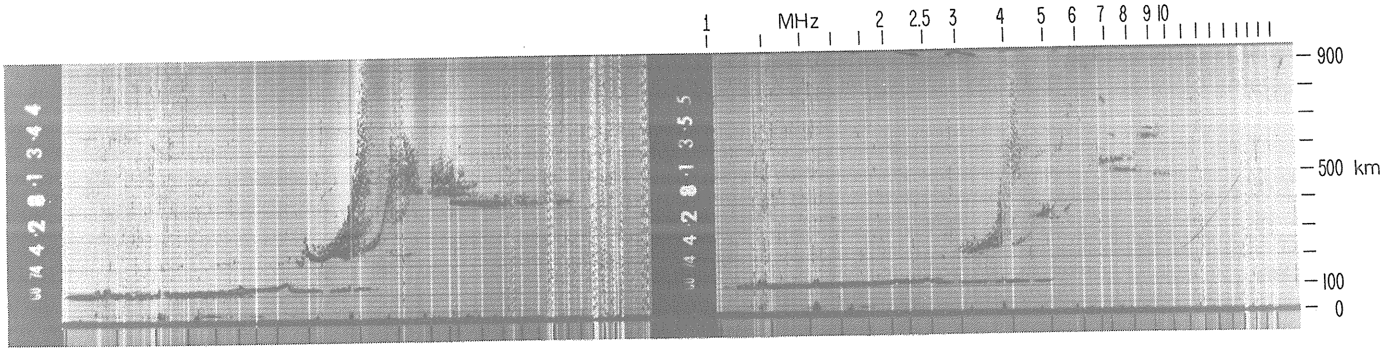
Lacuna declining. Slant Es still present. foE = 265UA, foF1 = 360-F (note fxF1 is clean), h'F = 215UH, foF2 = 036EG.

Fig. 2.46

THULE

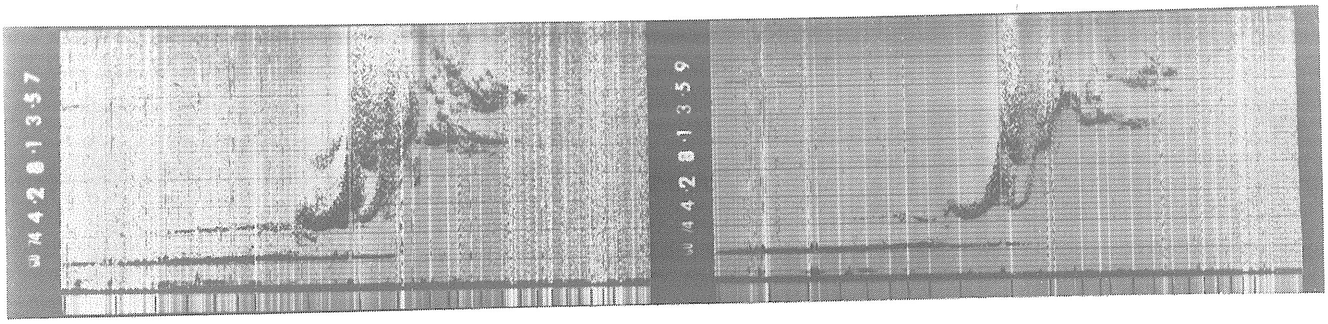
1974 May 15 08.30, 09.00, 0930, 10.00 LT (75°W)

Lacuna sequence. Weak Lacuna combined with G condition.



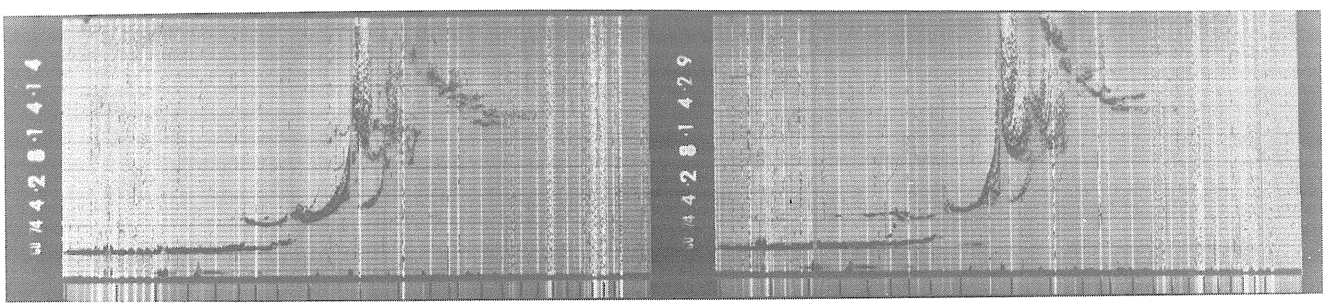
13.44 LT (45°W)

13.55 LT (45°W)



13.57 LT (45°W)

13.59 LT (45°W)



14.14 LT (45°W)

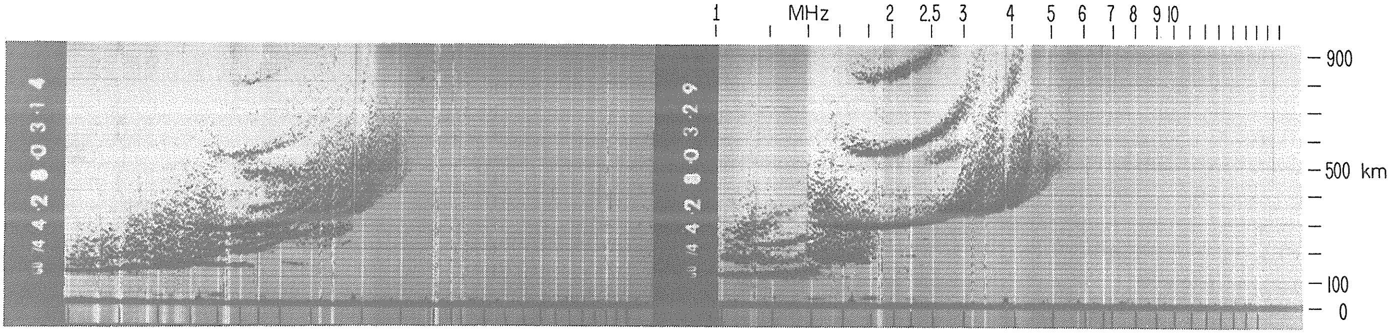
14.29 LT (45°W)

Fig. 2.47

GODHAVN 1974 April 28 13.44 - 14.29 LT (45°W)

Distinction between Es-a and polar spur.

A typical controversial sequence. Is this a polar spur with much tilt giving high and low angle structures or is it Es-a seen at oblique incidence with the aid of refraction in a particle E layer (Es-k). Needs check by aircraft evidence. It is not typical of either phenomenon but shows more polar spur characteristics than Es-a. Treat as polar spur with fxI qualified UA pending more evidence and discussion. The first ionograms show traces more like Es-a, latter polar spur; the presence of fairly clear traces suggests Es-a, the relatively slow change in trace and great height polar spur. See also contribution from Olesen, Section 12. This type of pattern is associated with approach of auroral oval to station.

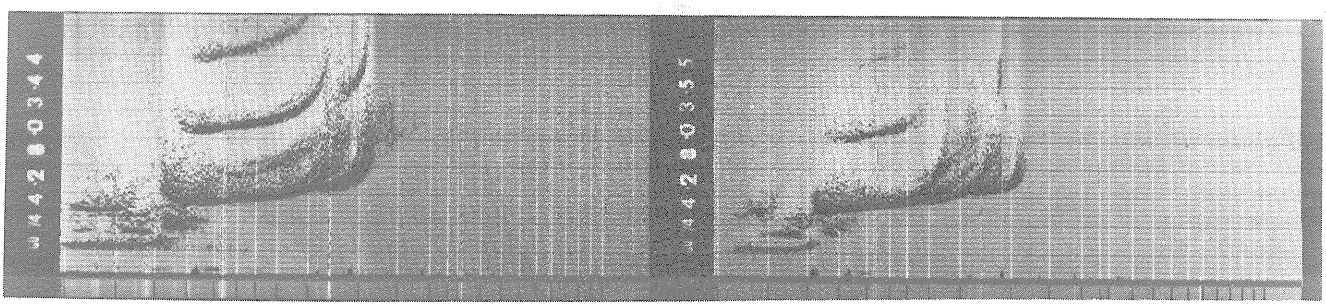


03.14 LT (45°W)

Auroral Es changing to particle E. Auroral Es confuses h'F but this can be identified from second order trace. This also shows that fxI is type P. Spread F classifications P, F.

03.29 LT (45°W)

Es-k3,a. Note x trace of Es-k missing as is usual at high magnetic latitudes. foF2 can be deduced from second order trace. Note Es-a is not blanketed by Es-k because it is oblique. foE = 140-K, foF2 = 032-F, fxI = 055-P.



03.44 LT (45°W)

Es-k,a. foE = 145-F. Range spread now present. Spread F classifications P, F, Q. foF2 = 035-F, fxF2 = 042, fxI = 055-P. Layer horizontal.

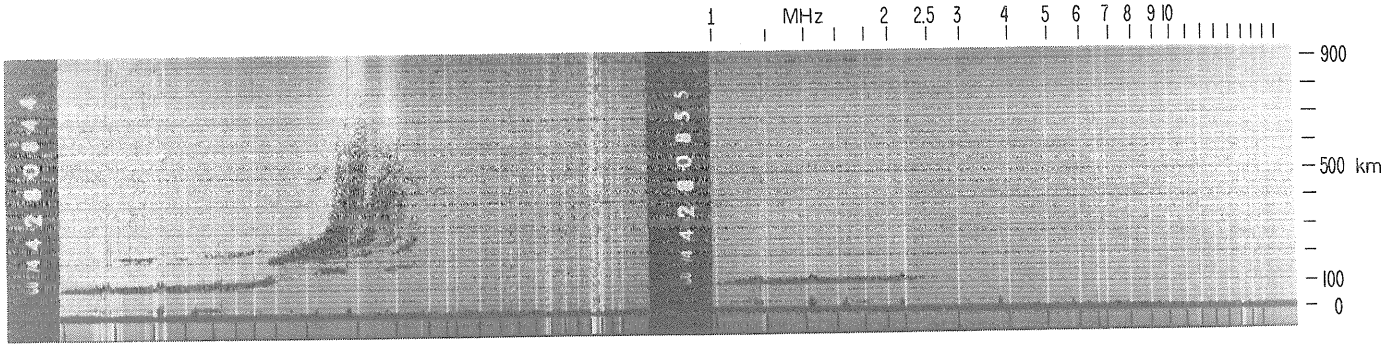
03.55 LT (45°W)

Es-k,a. h' shows layer tilted. Second order x trace suggests fxF2 = 038, foF2 = 031. Inner edge suggests foF2 = 028 and this shows some dominant ray. Accuracy rule c applies, making foF2 = 030UH.

Fig. 2.48

GODHAVN 1974 April 28 0314, 0329, 0344, 0355 LT (45°W)

Es-a, Es-k, Spread F classifications P, F, Q.

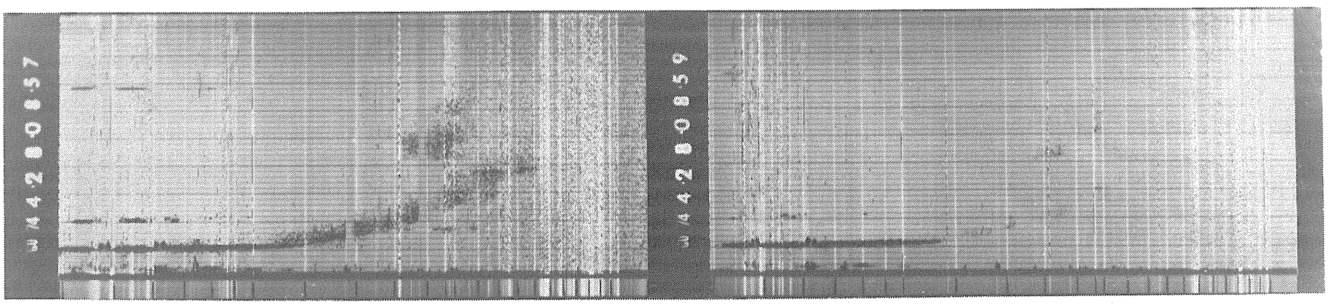


08.44 LT (45°)

foE = 240-Y. Note F trace does not show retardation but shape of E trace and second order trace show foE greater than 235. This look of retardation can cause confusion when particle E is present and F layer is slightly tilted as in this case.

08.55 LT (45°W)

Lacuna. foEs = 025DY, F parameters Y.

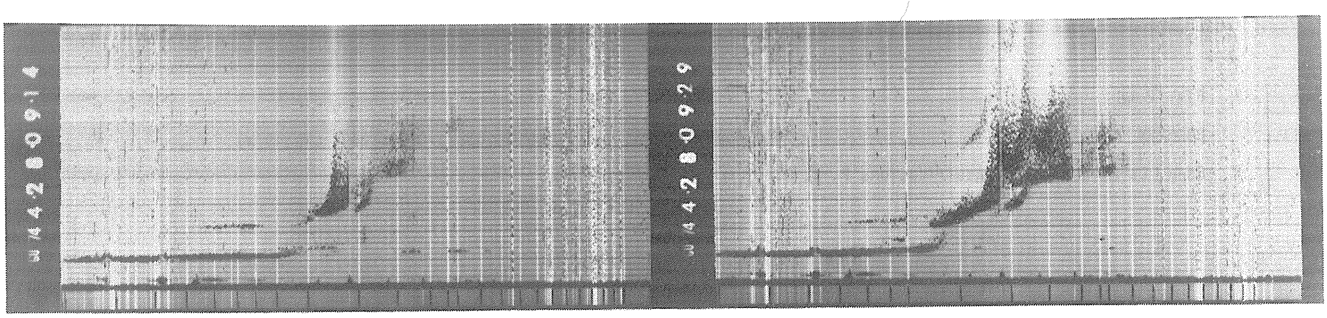


08.57 LT (45°W)

Slant Es rising from normal E. Note polar spur, fxI = 080 type P seen at oblique incidence. F-layer parameters Y.

08.59 LT (45°W)

Low gain.



09.14 LT (45°W)

Lacuna disappears. foE = 028DY, h'F = 260-Y

09.29 LT (45°W)

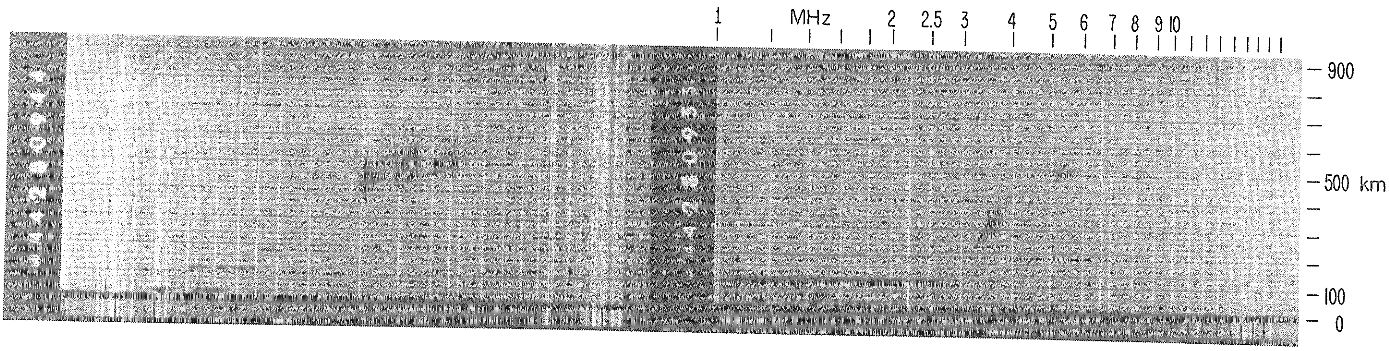
Spread F classifications P, F; foF1 = 380-F, foF2 = 044-F, h'F2 = 400UF.

Fig. 2.49

GODHAVN

1974 April 28 0844, 0855, 0857, 0859, 0914, 0929 LT (45°W)
0944, 0955, 0957, 0959 LT (45°W)

Lacuna sequence.

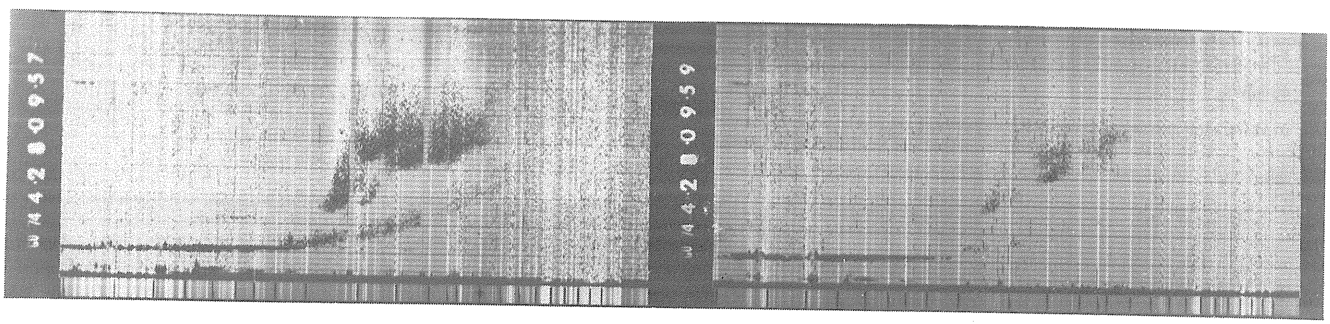


09.44 LT (45°W)

Lacuna. foE expected to be about 280. E trace ends 230. Replace foE by Y. fmin = 016 showing slight absorption often present with strong Lacuna. foF1 expected near 350. h'F = Y, foF1 = 350UY, foF2 = 045DY, fxI = 075, Spread F classification P.

09.55 LT (45°W)

foE = 028DY, foF1 = 380UY, h'F = 260EY, foF2 = 038EG, fxI = 058, Spread F classification P.



09.57-09.59 LT (45°W)

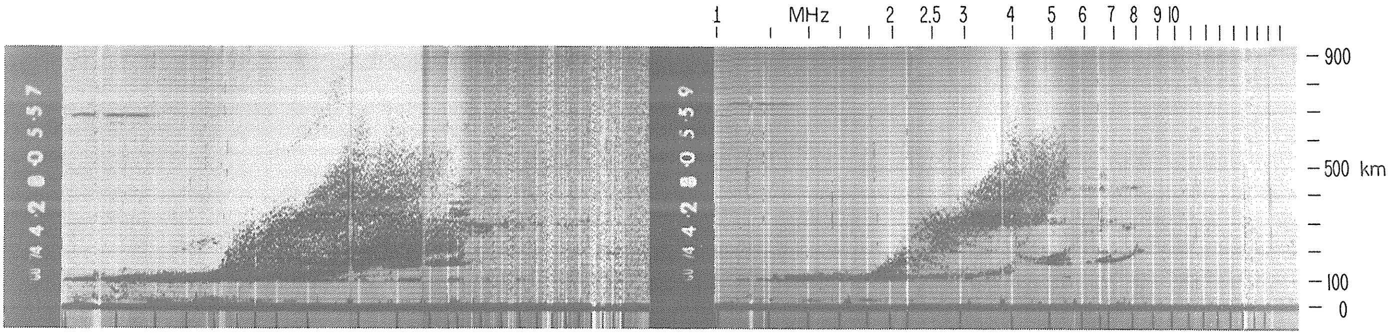
The high gain ionogram shows Es-s clearly. Note low gain ionogram shows Lacuna weakening of F2 trace with polar spur much less affected.

Fig. 2.49 (cont'd)

GODHAVN

1974 April 28

Lacuna.



05.57 LT (45°W)

Distinction between Es-a and spread F classification P. Weak second order trace shows foF2 = 039UF. Change in pattern shows fxI = 065. Spurs above this due to Es-a. On original weak second order trace shows Es-k with foE = 195UK (U due to spread). This is an Es-k pattern with some Es-a features due to large changes in foEs with position as confirmed by low gain ionogram. foEs = 040, fbEs = 019-K.

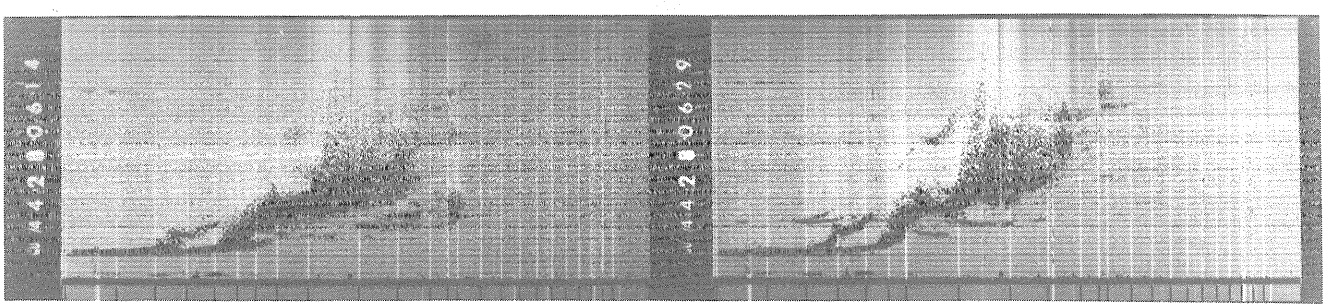
05.59 LT (45°W)

Low gain. Typical pattern when particle E-layer critical frequency changes rapidly with position. foE overhead near 200 (2 MHz), at slight obliquity near 400 (4 MHz) and about 100 km away near 800 (8 MHz). Note noses on traces show thick E layer present (high and low angle rays seen).

Fig. 2.50

GODHAVN 1974 April 28 05.57, 05.59 LT (45°W)

Distinction between Spread F Classification P and Es-a.



06.14 LT (45°W)

Normal E, foE = 195-F. h'F = 170 UH, foF1 = 025UF, foF2 = 035-F, fxI = 058UA, (confusion with Es-a), Es-a.

06.29 LT (45°W)

foE = 200. h'F = 200 UF, foF1 = 025-F, foF2 = 035-F, fxI = 059UA, Es-a.

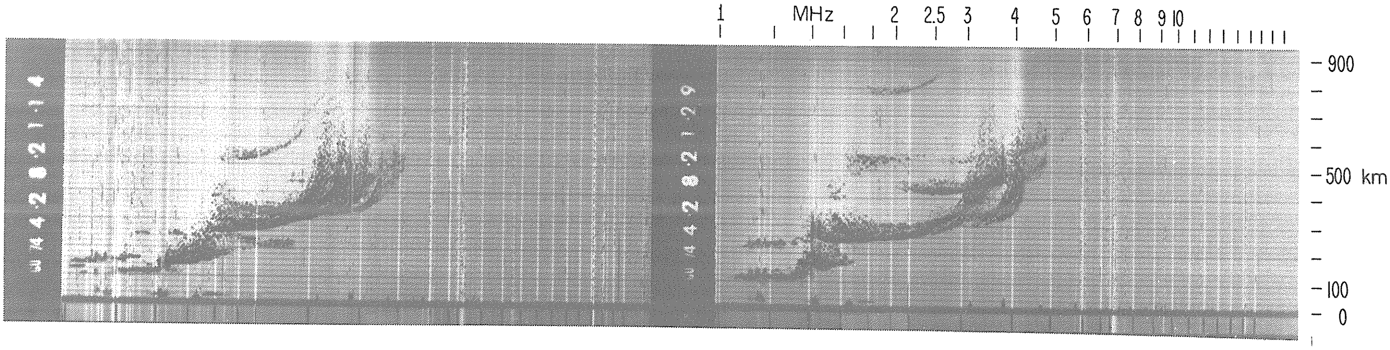
Fig. 2.51

GODHAVN 1974 April 28 06.14, 06.29 LT (45°W)

Very weak Lacuna (slant Es) phenomenon.

Note: This is an o-z pair not an o-x pair. Check foE with normal day for presence of particle E (Es-k) (None present here). h'F2 is always lower than h'F, usually by amount sufficient to prohibit using it but helps identify main F trace.

The normal E trace and h'F trace are spread at 06.14 LT, but there are no other Lacuna indications. Expert groups have identified this type of record as Y. foE = 195-Y, h'F = 170-Y, but for international use F is better.

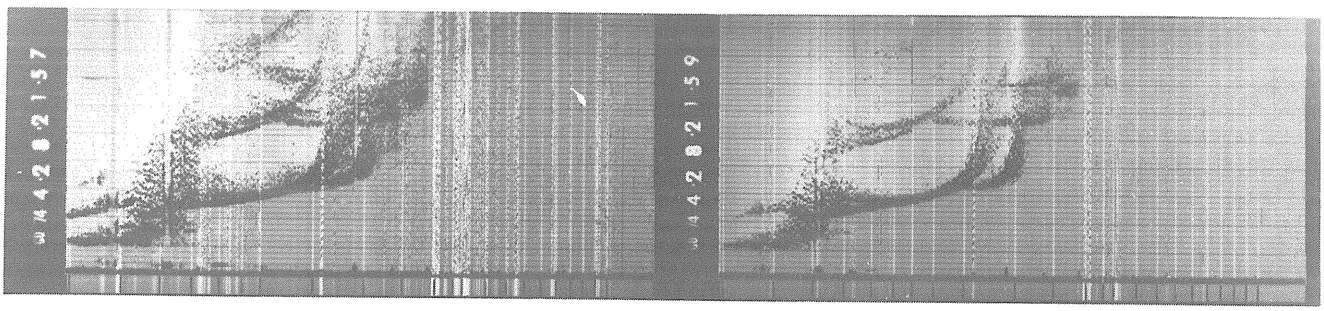


21.14 LT (45°W)

Range spread of field-aligned type (Fig. 2.16b in Handbook). foF2 decreases towards pole. foF2 = 037UF, h'F = 260UQ, fxI = 052, Spread F classification F.

21.29 LT (45°W)

Tilt has increased. foF2 = 036UF, h'F = 240-Q, fxI = 052, Spread F classification P.



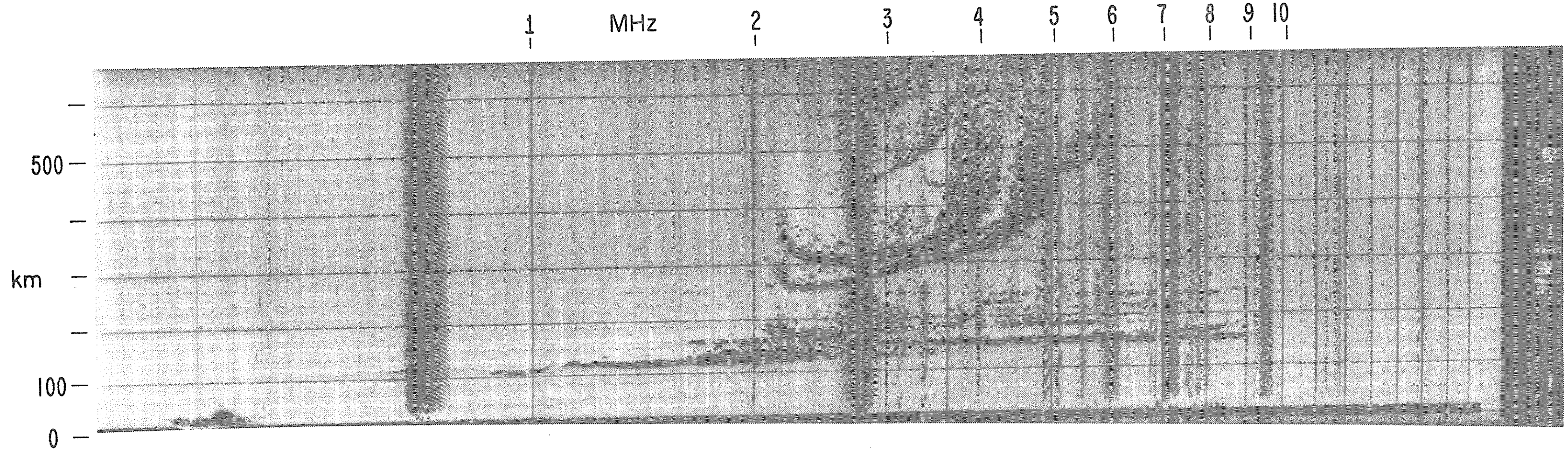
21.57, 21.59 LT (45°W)

The F layer is now effectively horizontal overhead. foF2 = 034, h'F = 195UH.

Fig. 2.52

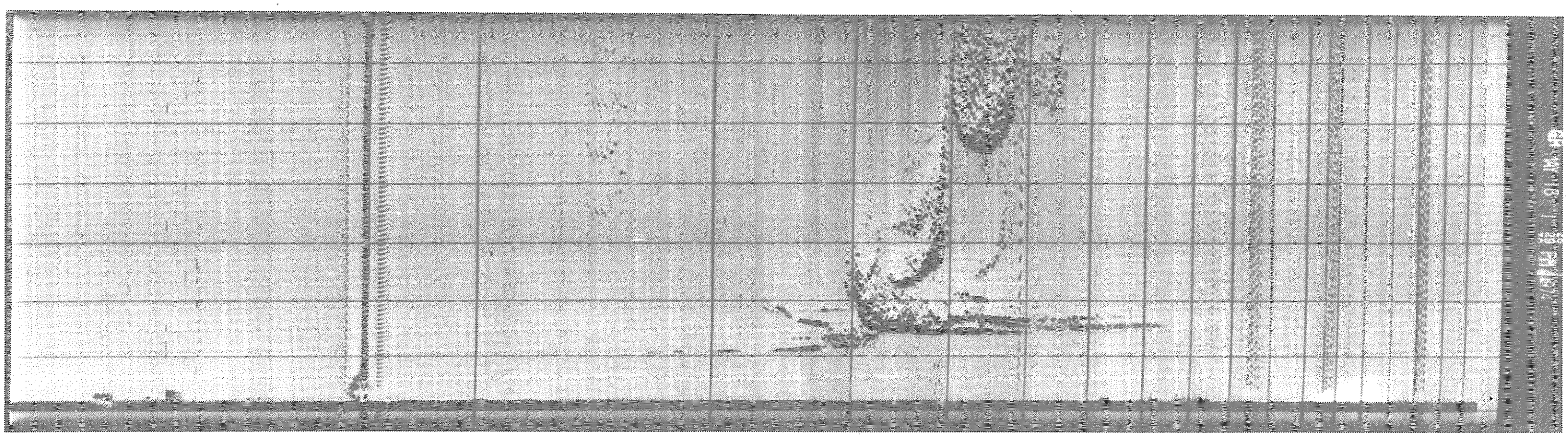
GODHAVN - Polar Spur 1974 April 28 21.14, 21.29, 21.57, 21.59 LT (45°W)

foF2 for the spur is probably not much larger than foF2 overhead but there is a severe tilt about 45° giving the spur traces. Note fxI does not change 21.14 - 21.29 LT but increases by 1 MHz near 2200 LT.



1974 May 15 19.14 LT (45°W)

Considerable tilt in F layer, h'F = 260UH, Ladder type Es-a rising from normal E (foE = 220).



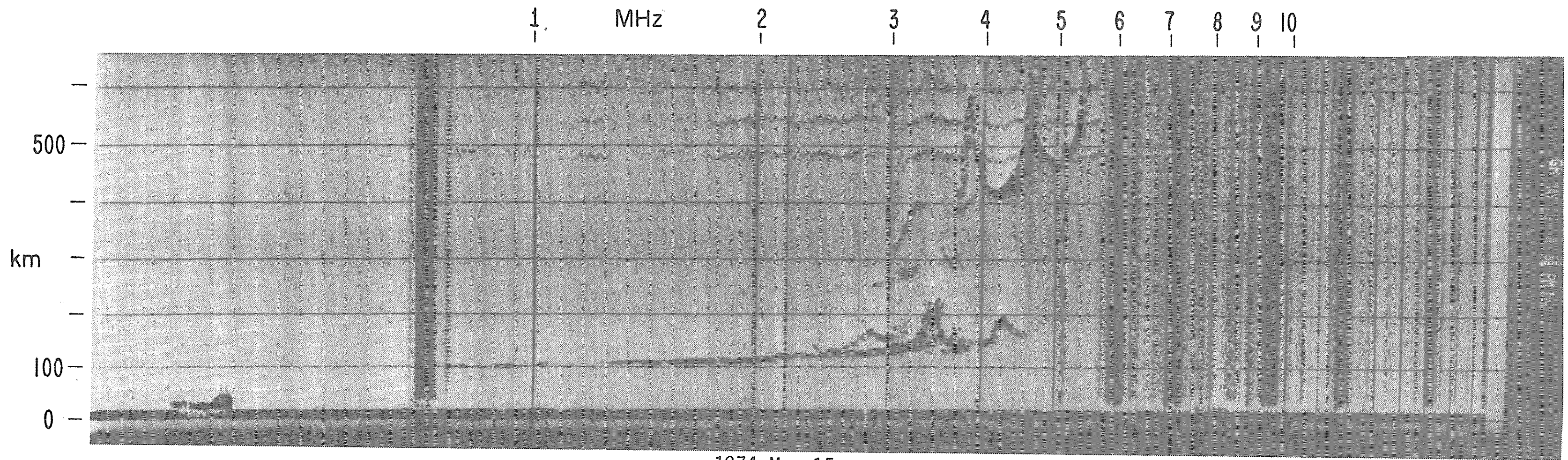
1974 May 16 13.29 LT (45°W)

Auroral Es superposed on normal E. foE = 290UA (note on quiet day would be 320). foF1 = 400, foF2 = 050UF. Auroral Es traces show retardation near foE, o-x traces show Es-h also present with foEs = 050.

Fig. 2.53

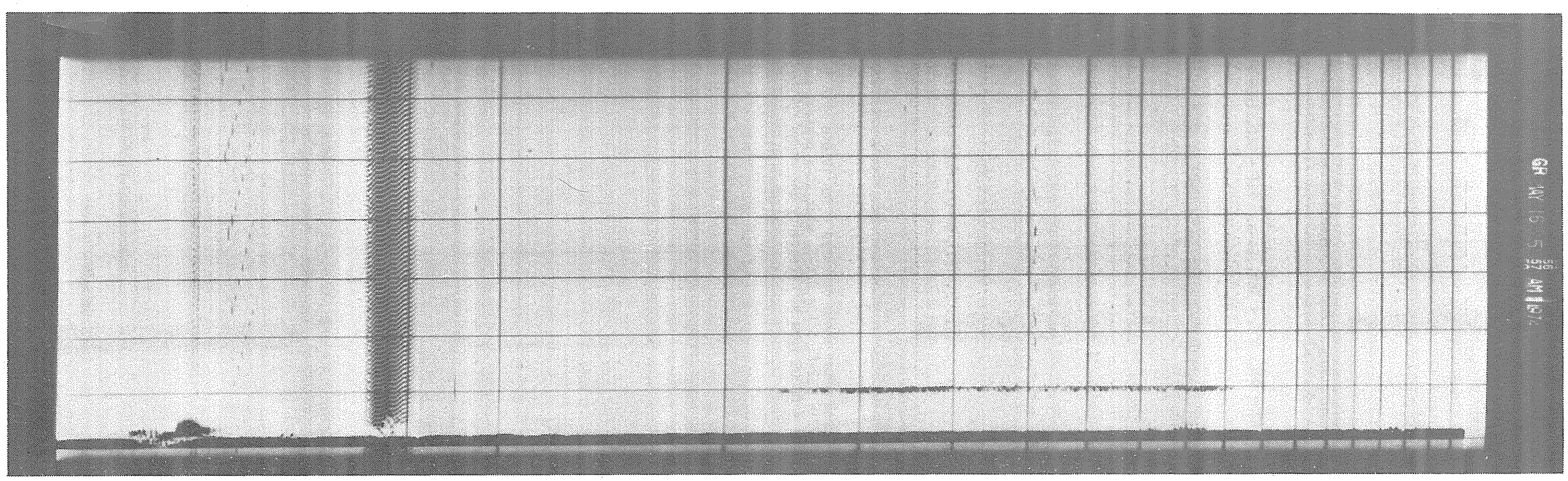
NARSSARSSUAQ - Es-a

1974 May 15 19.14 LT (45°W)
1974 May 16 13.29 LT (45°W)



1974 May 15 16.59 LT (45°W)

Es-h seen in z, o, x traces.



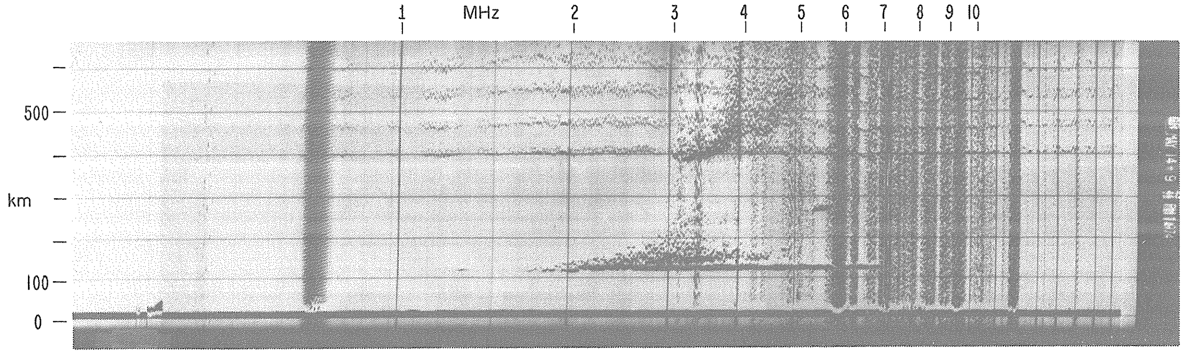
1974 May 16 05.57 LT (45°W)

Es-d during a blackout period. All parameters B.

Fig. 2.54

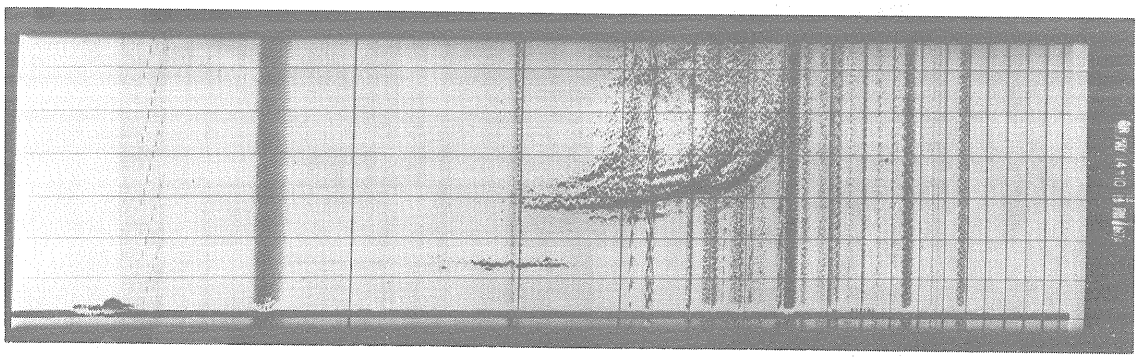
NARSSARSSUAQ - Es-h and d

1974 May 15 16.59 LT (45°W)
1974 May 16 05.57 LT (45°W)



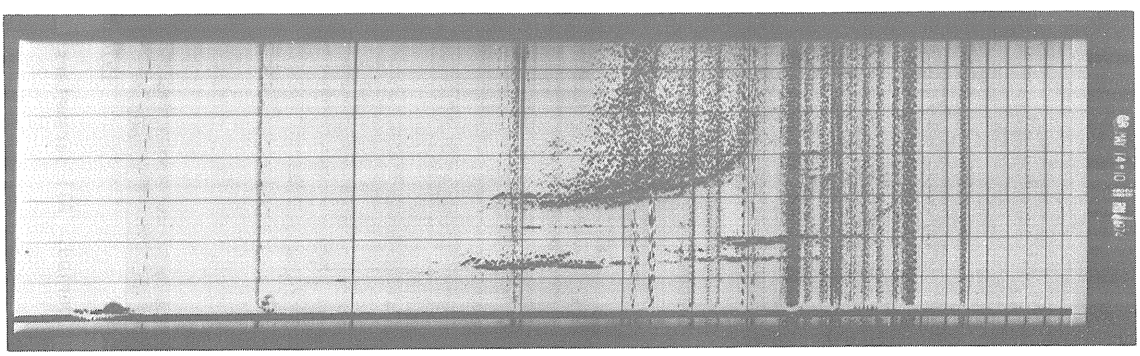
21.44 LT (45° W)

foF2 = 040, h'F = 385, Es-a. fxI = 052, type F. (Mixed type spread F).



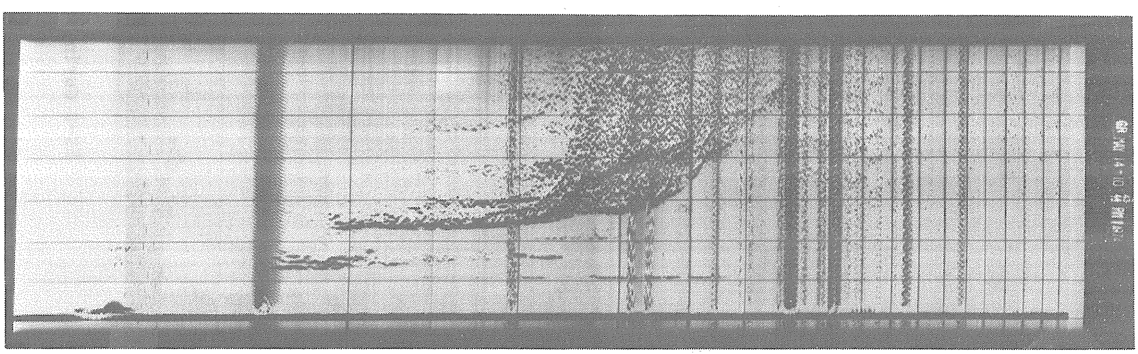
22.14 LT (45° W)

Second order shows overhead trace is one with foF2 = 050-F, h'F = 270-Q. Old layer has foF2 = 033-F, h'F = 320-F, weak Es-a present superposed on absorbed normal E, foE = 150EB, fxI = 060US type P. Frequency and range spread both present.



22.29 LT (45° W)

Neither trace overhead, fxI = 052. Type F small amount of range spread, nearest to a ruled type.

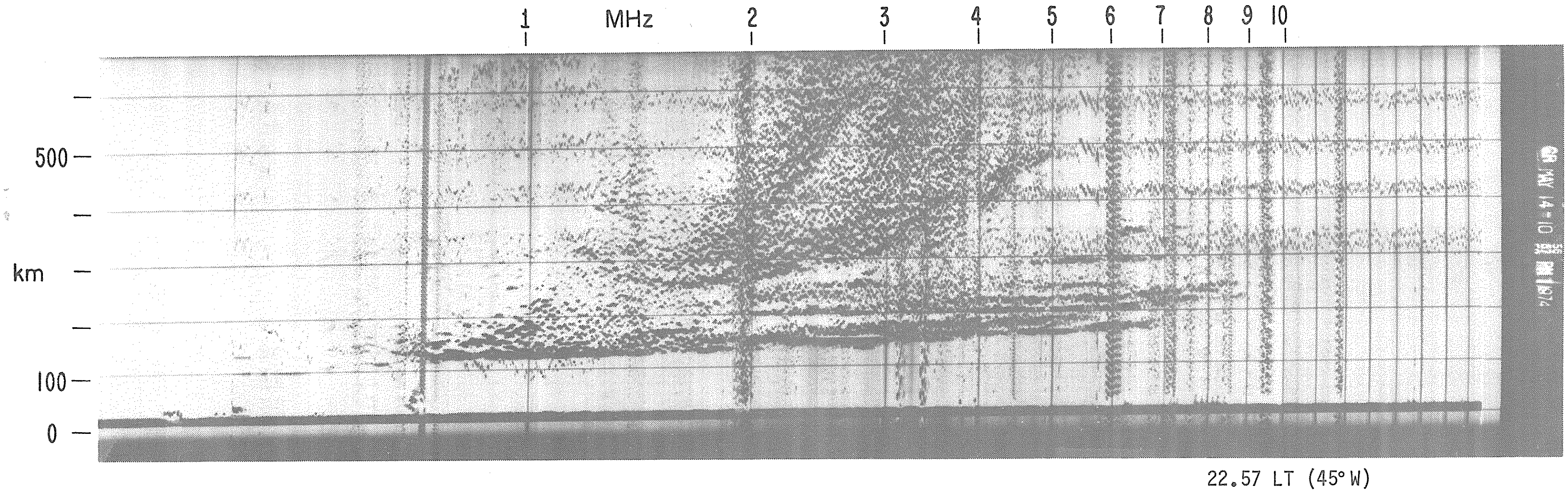


22.44 LT (45° W)

Second order trace shows denser layer. By 22.44 LT trace is now oblique. foF2 = 028UF, h'F = 220-F. Range spread with field-aligned type satellites present, fxI = 060US type P. Range and frequency spread also present.

Fig. 2.55

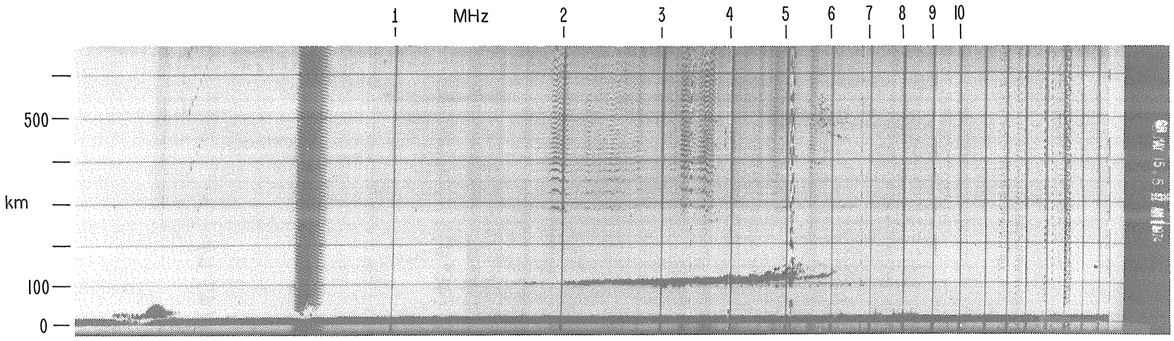
NARSSARSSUAQ - Two layer sequence 1974 May 14 21.44-22.44 LT (45° W)



A classical Es-a pattern. Es-k present with fbEs = 012UK, foE = 115UK.

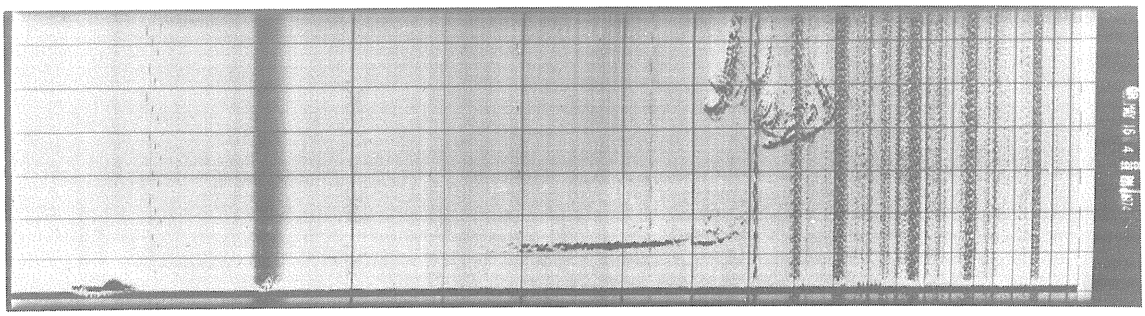
Fig. 2.56

NARSSARSSUAQ - Es Type a, k 1974 May 14 22.57 LT (45°W)



1974 May 15 05.57 LT (45°W)

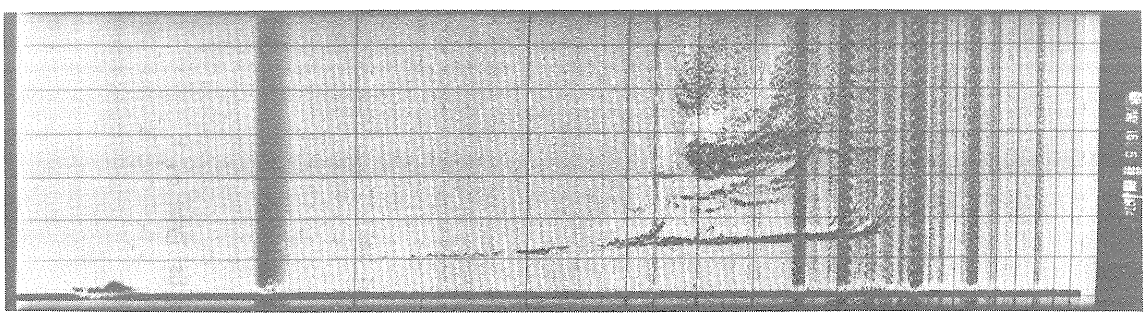
Particle E in fairly high absorption. fxE shows foE is Es-k not Es-r despite spread confirmed by very weak F traces which will not reproduce. foE = 630-K (foEs = fbEs = foE).



1974 May 16 16.29 LT (45° W)

Particle E (Es-k)

The F traces show layer is very tilted.
The Es o and x traces match and show good retardation. foE = 430-K.

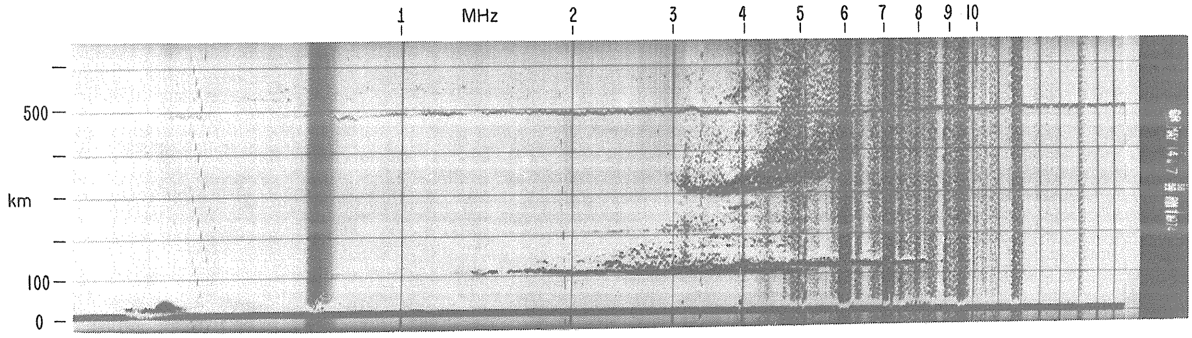


1974 May 16 17.29 LT (45° W)

Es-r with Es-k. Es-k traces clearly seen, with foE = 360-K, foEs = 074. Es-a also present. The particle E has doubled its critical frequency in probably less than 50 km.

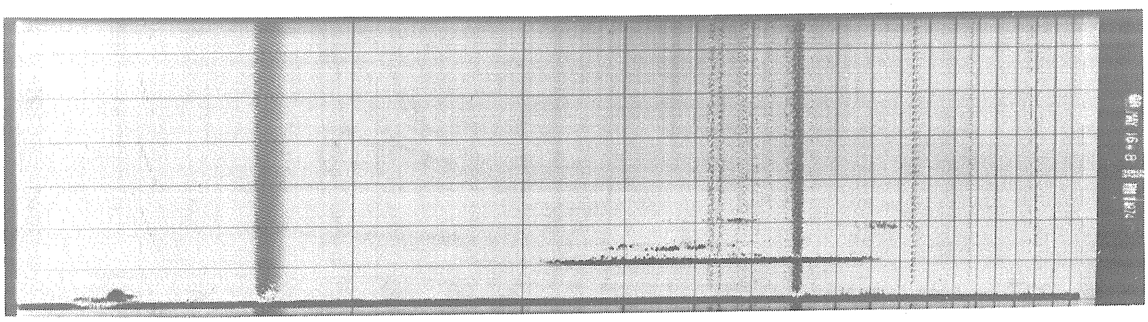
Fig. 2.57

NARSSARSSUAQ - Particle E (Es-k) 1974 May 15 05.57 LT (45°W)
1974 May 16 16.29-17.29 LT (45°W)



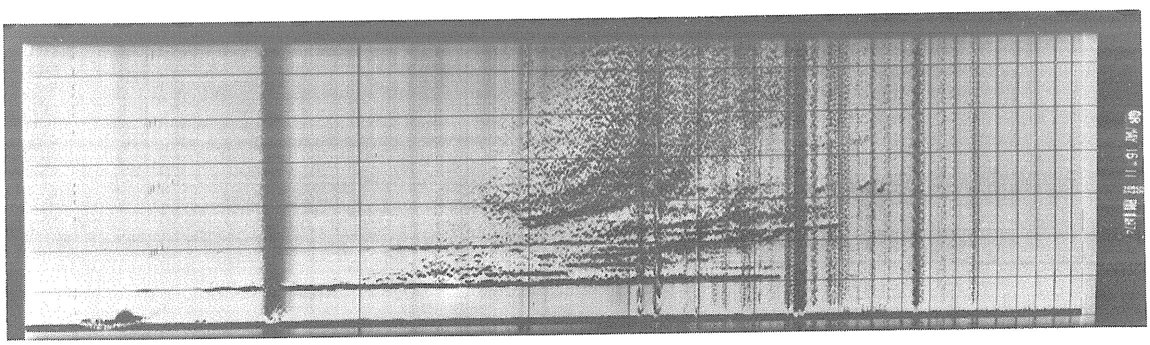
1974 May 14 19.59 LT (45°W)

Es-ℓ2 and Es-a. A flat Es below particle E so clearly a low Es. Note second order of Es-ℓ present to 037. Es-ℓ blankets Es-k (particle E). foE = 047JA, fbEs = 030UB. foE = 300UK, h'Es = 105. Second order F trace suggests no tilt. Can therefore use inner edge to give foF2, foF2 = 046UF.



1974 May 16 20.57 LT (45°W)

Es-f2, Es-a. The second order trace shows this is Es-f despite high absorption. Some Es-a also visible.

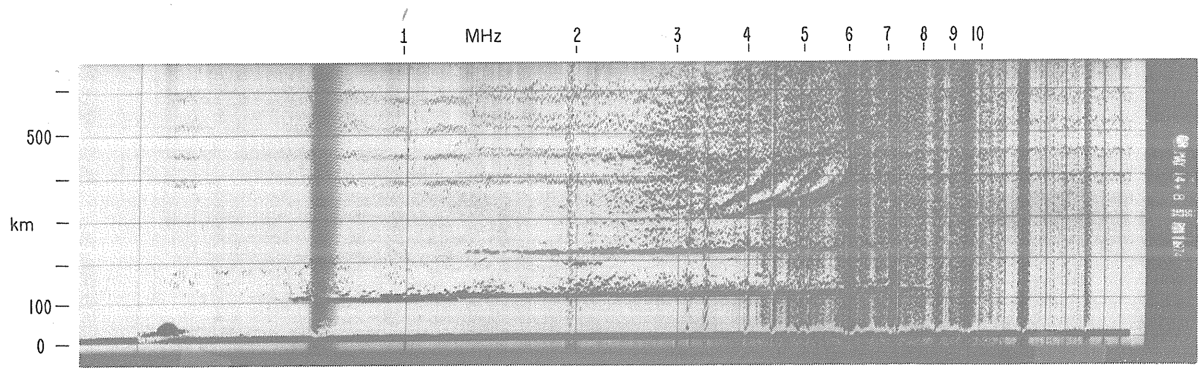


1974 May 16 23.57 LT (45°W)

Es-f and Es-a. Second order of Es-f shows Es-f present, foEs = 048JA. fbEs difficult owing to layer tilt and spread. Best fbEs = 020UQ. fbEs = 020UF acceptable. Es type f2,a.

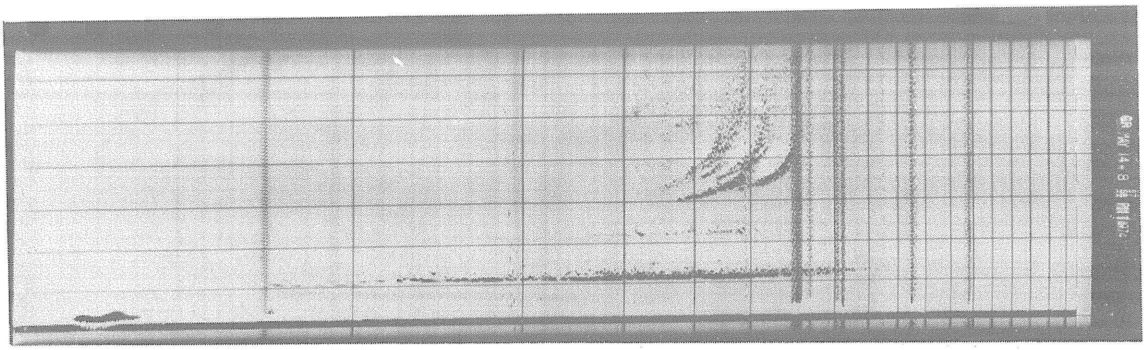
Fig. 2.58

NARSSARSSUAQ - Es Types f and ℓ with Es-a 1974 May 14 19.59 LT (45°W)
1974 May 16 20.57-23.57 LT (45°W)



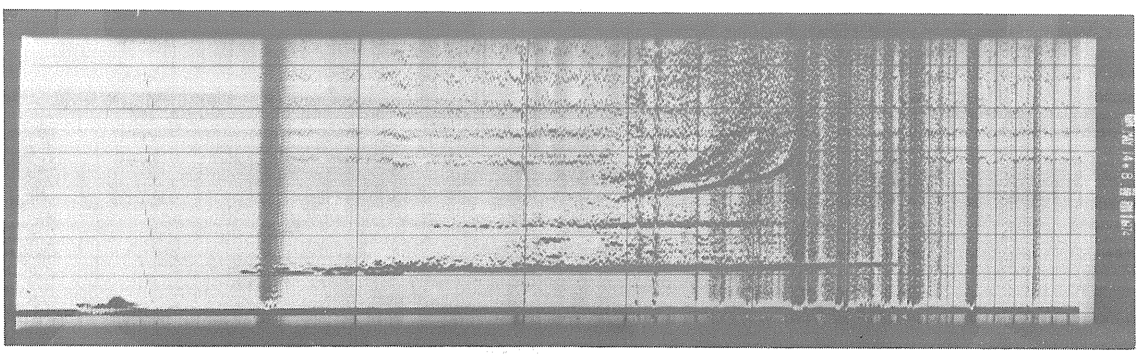
20.57 LT (45° W)

Es-c with some Es-a. Type c2,a. Both high and low gain ionograms show presence of second order and blanketing. Hence main trace not Es-a. foE should be present. h'Es = 110 km indicates cusp type.

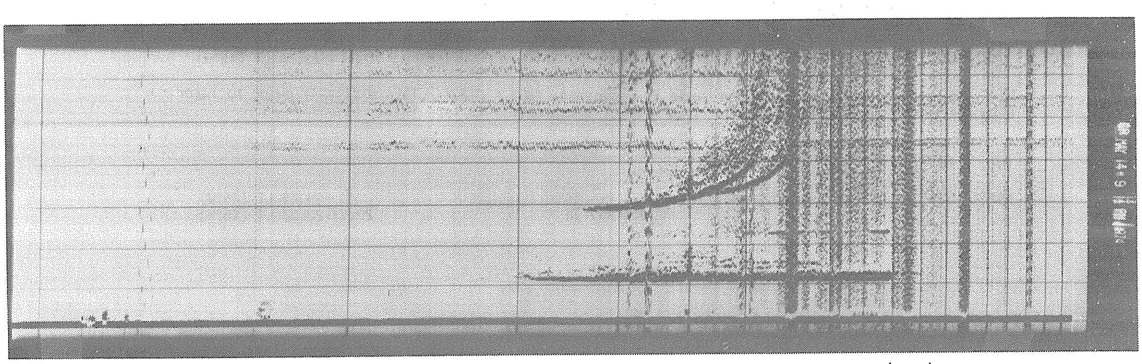


Low gain.

20.58 LT (45° W)



20.59 LT (45° W)

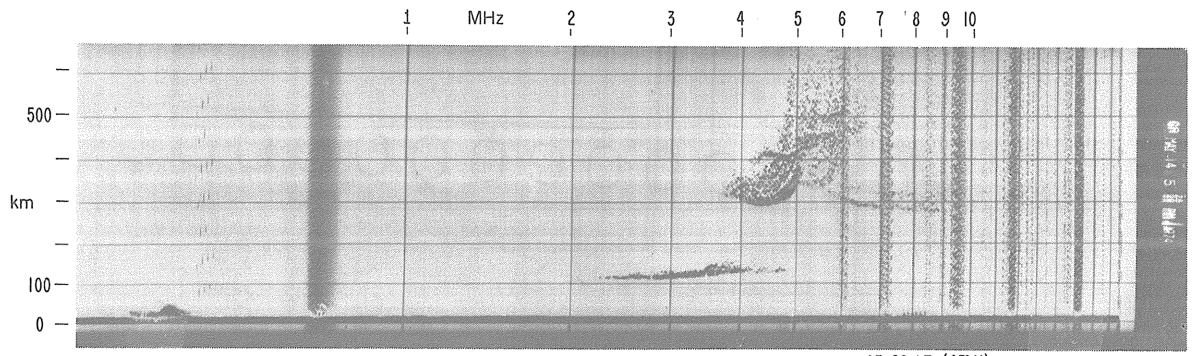


21.14 LT (45° W)

Es-a. The apparent second order is not consistent with fbEs. Hence most likely to be a second Es-a structure.

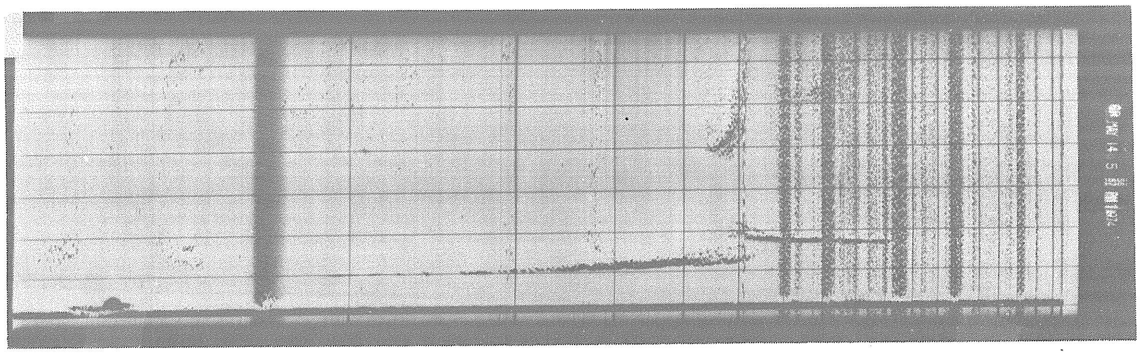
Fig. 2.59

NARSSARSSUAQ - Es Types c and a 1974 May 14 20.57-21.14 LT (45°W)



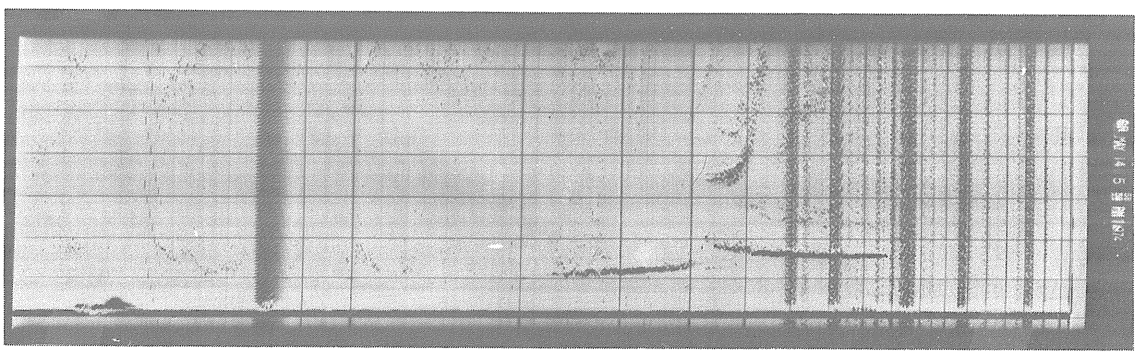
17.29 LT (45° W)

Es type r, foFl = 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)

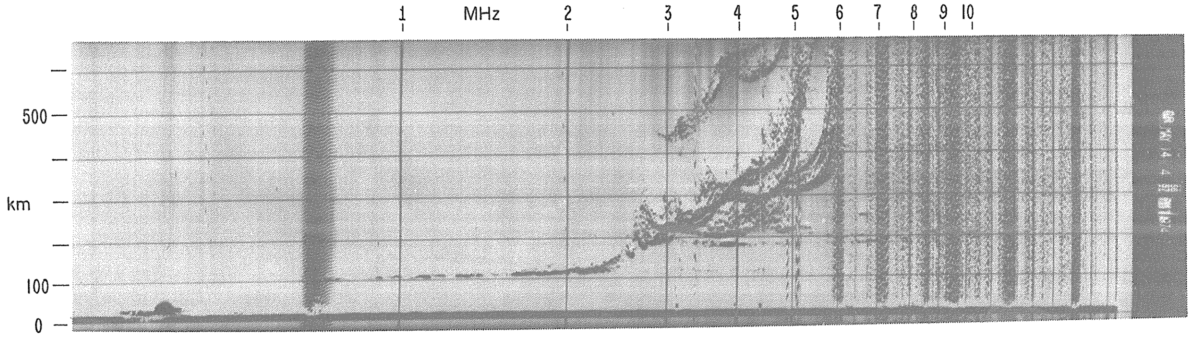
Sequence confirms analysis of 17.29 LT (45°W) as does retardation at low frequency end of Es-a trace and its general decrease in height with frequency.



17.59 LT (45° W)

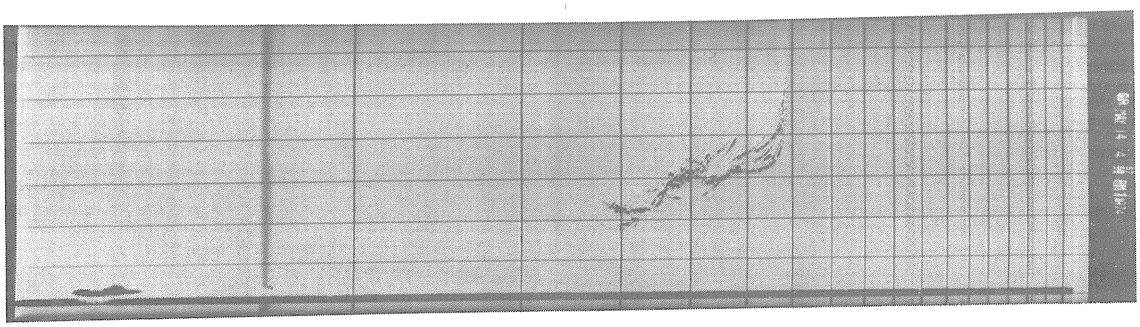
Fig. 2.60

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



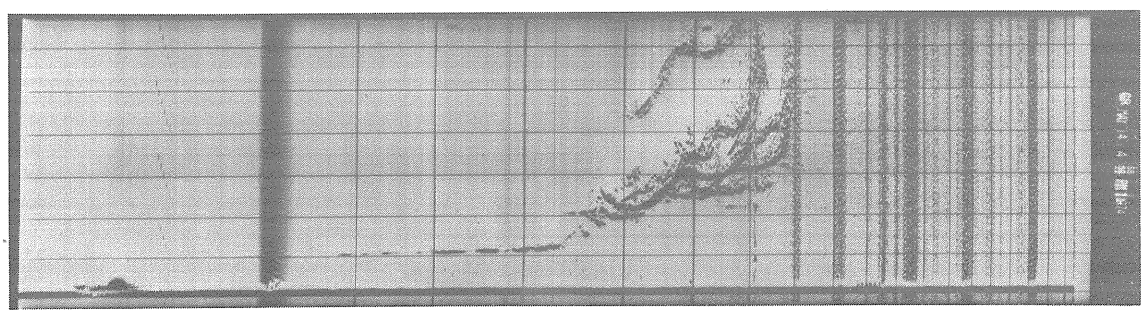
Es-a

16.57 LT (45°W)



Es-a

16.58 LT (45°W)



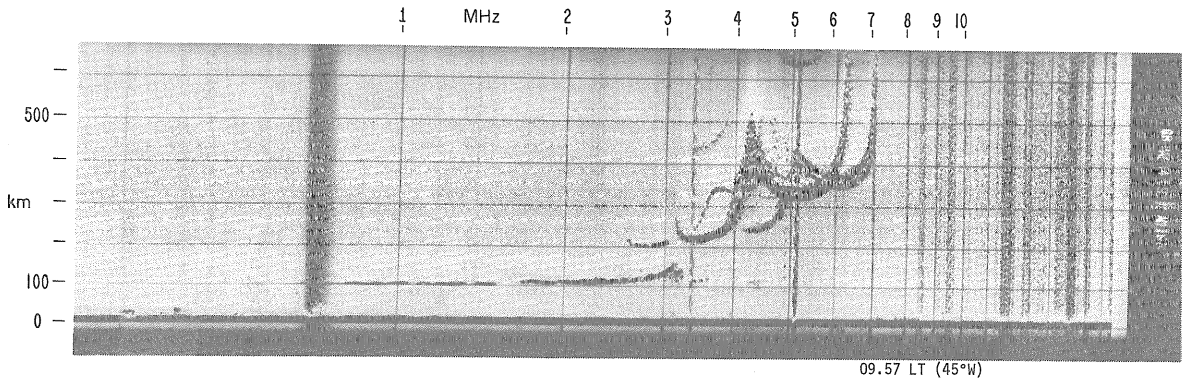
16.59 LT (45°W)

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

Fig. 2.61

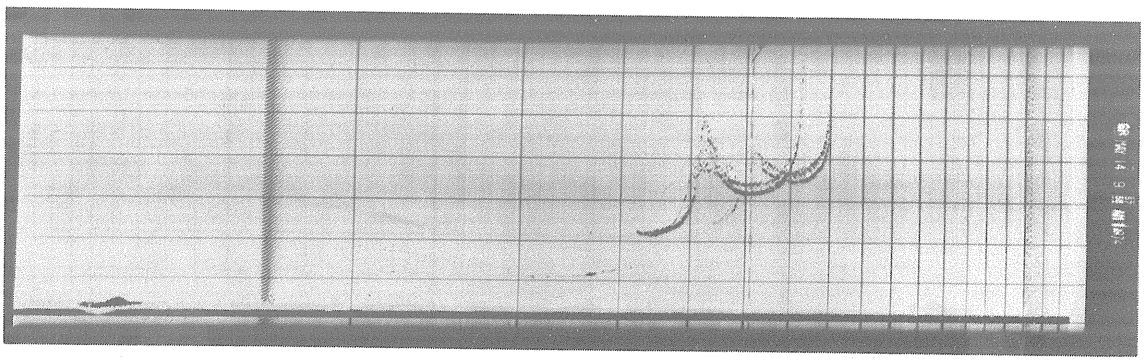
NARSSARSSUAQ - Auroral Es Superposed on F Pattern 1974 May 14 16.57-16.59 LT (45°W)

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.



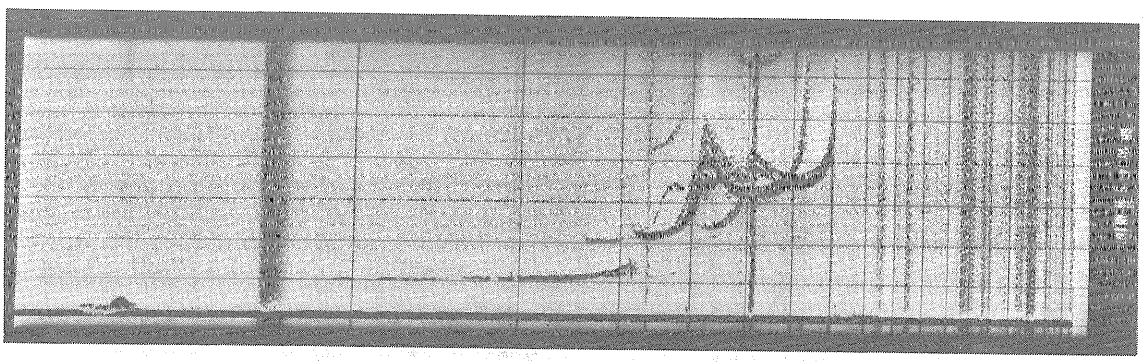
09.57 LT (45°W)

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.

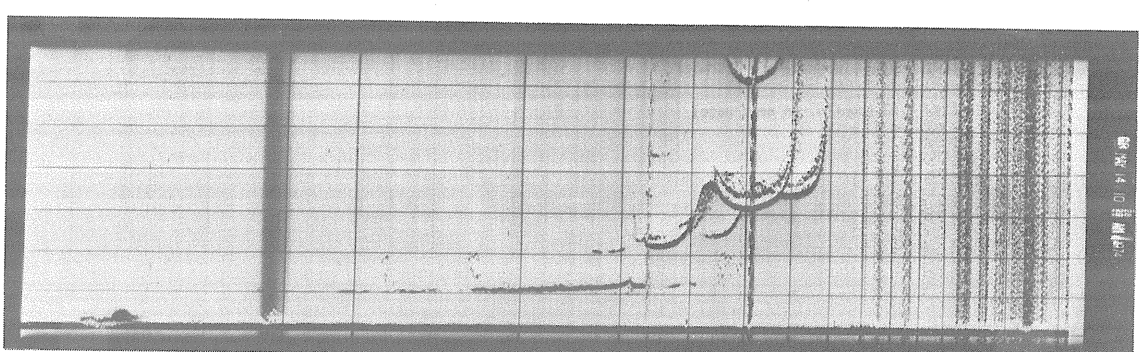


09.58 LT (45°W)

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



09.59 LT (45°W)



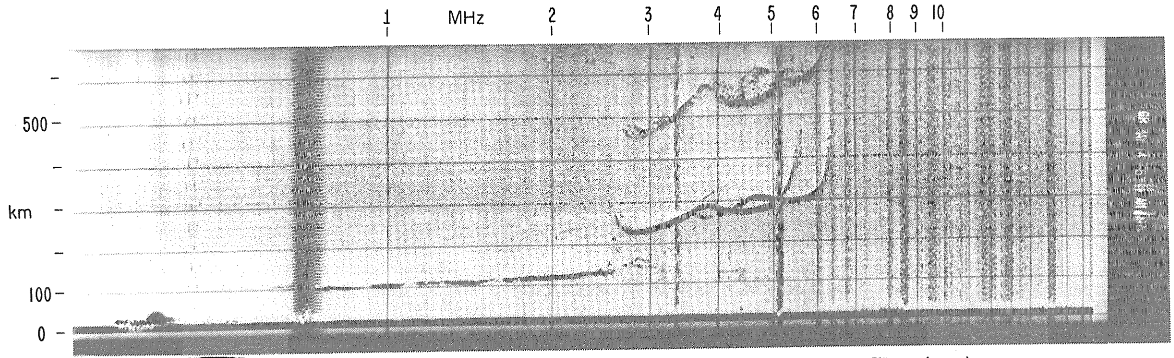
10.29 LT (45°W)

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

Fig. 2.62

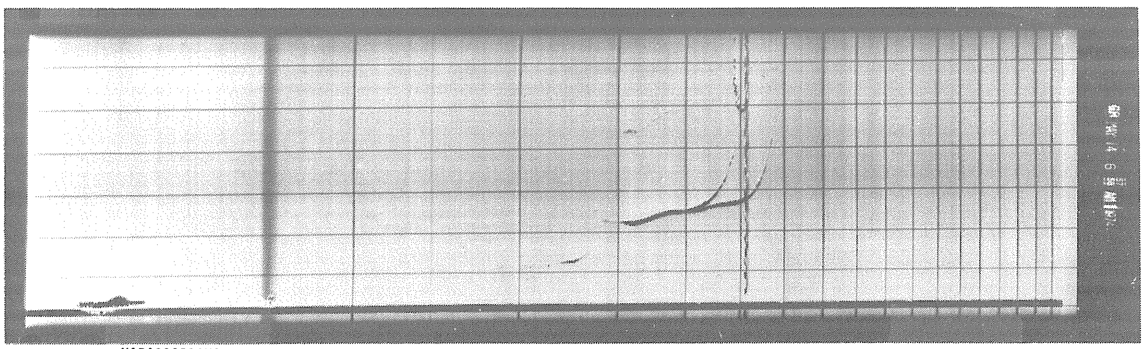
NARSSARSSUAQ - Range spread 1974 May 14 09.57, 09.58, 09.59, 10.29 LT (45°W)

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



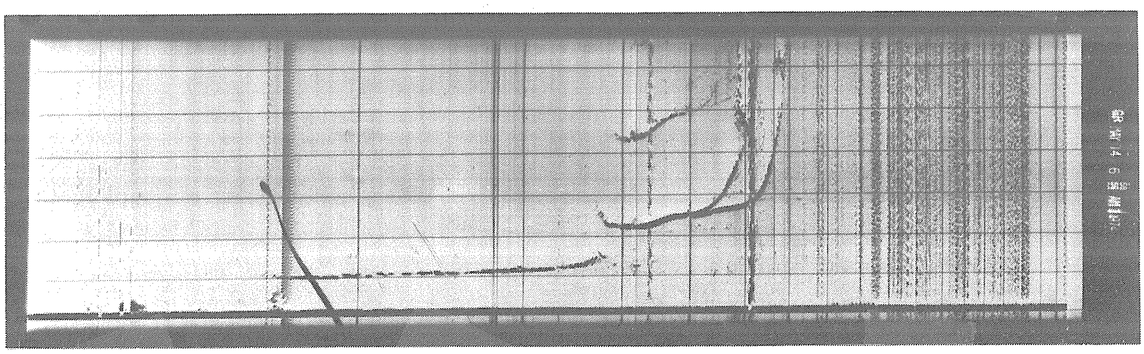
NARASSARSSUAQ 1974 May 14 06.30 LT (45°W)

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



NARASSARSSUAQ 1974 May 14 06.58 LT (45°W)

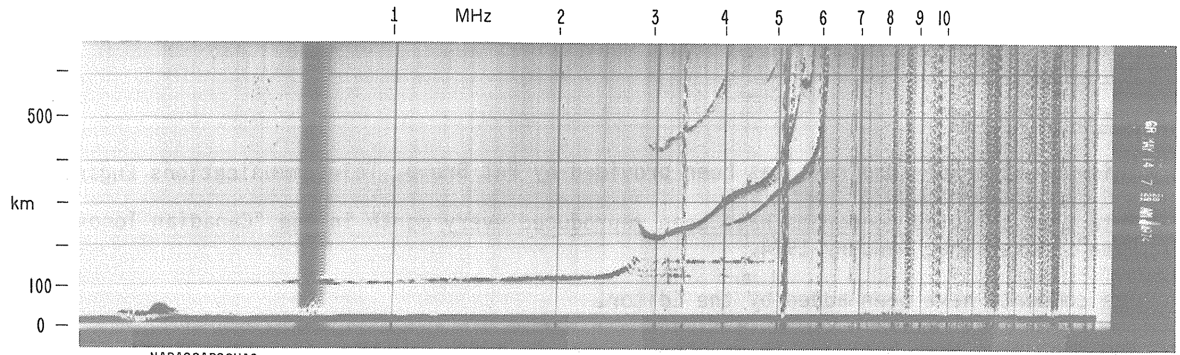
(Low gain) Typical change in F2 trace when large tilt present. foFl = 380UL. Forked F trace seen at oblique incidence above main trace suggests foF2 about 048, foF2 = 052EY. M(3000) and N(h) completely misleading as tangent point moved as well as error in foF2. M(3000) = Y.



NARASSARSSUAQ 1974 May 14 06.59 LT (45°W)

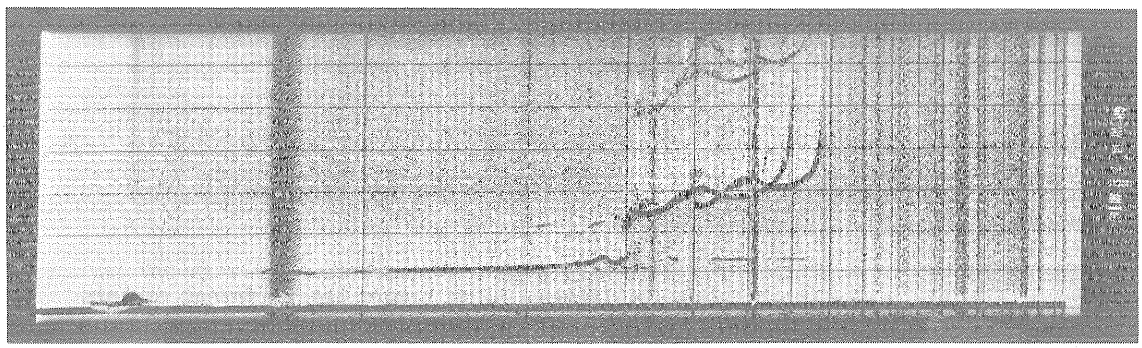
(Normal gain) Typical apart from oblique spur, foF2 = 053EY, M(3000) = Y. N(h) impossible above foFl. Note linearity of F2 trace.

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).

SECTION 3. CANADIAN STATIONS

CHURCHILL IONOGRAMS

Notes by Editor:

This selection of ionograms has been provided by Pat Brown, Telecommunications Engineering Lab.

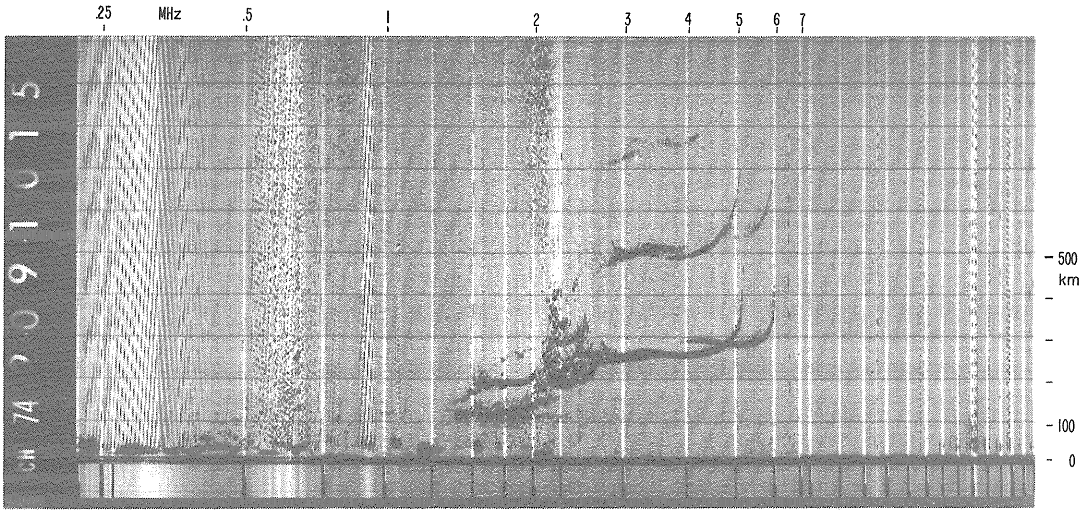
Note that selected ionograms have been reproduced every month in the "Canadian Ionospheric Data" books since January 1974.

The comments have been added by the Editor.

The ionograms have been picked to show typical Es types at Churchill and the use of sequences to help interpret trough phenomena (replacement layer, FLIZ). Lacuna is rare at Churchill and usually partial as shown. For enquiries contact:

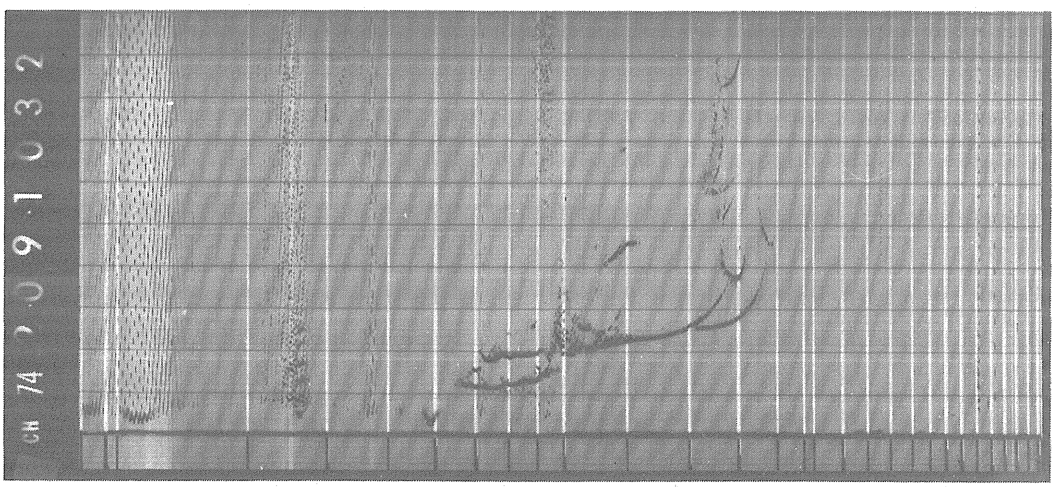
DIRECTOR
Telecommunications Engineering Laboratory
1241 Clyde Avenue
K2C 1Y3
Ottawa, Ontario
Canada

Station name:	Churchill
Geographic coordinates:	Lat. N 58.7° E Long. 265.8°
Geomagnetic coordinates:	Lat. N 68.0° E Long. 323.3°
Geomagnetic Dip:	83.9°
Time used:	90°W (UT - 6 hours)
Frequency range:	1-16 MHz, with 1 MHz markers (Note: 16 mm record has different markers -- Logarithmic Scale)
Sweep time:	16 sec.
Peak power:	10 kW
PRF:	30 per sec.
Pulse length:	50 microsecs.
Height range:	0-1000 km, with 100 km markers
Equipment:	LG17 Ionosonde
Original film ionogram:	24 mm x 52 mm, approximately.



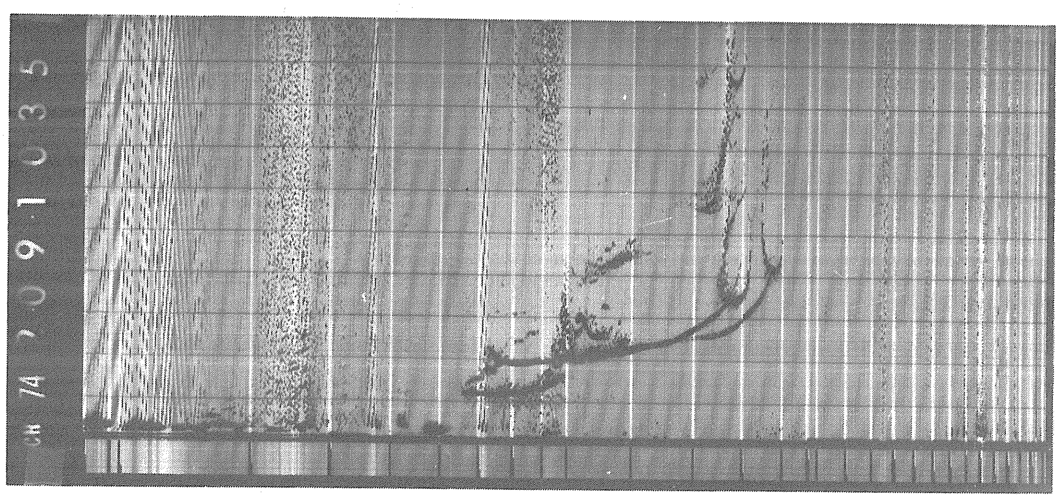
Editor's Note: Normal record.

1015 LT (90°W)



1032 LT (90°W)

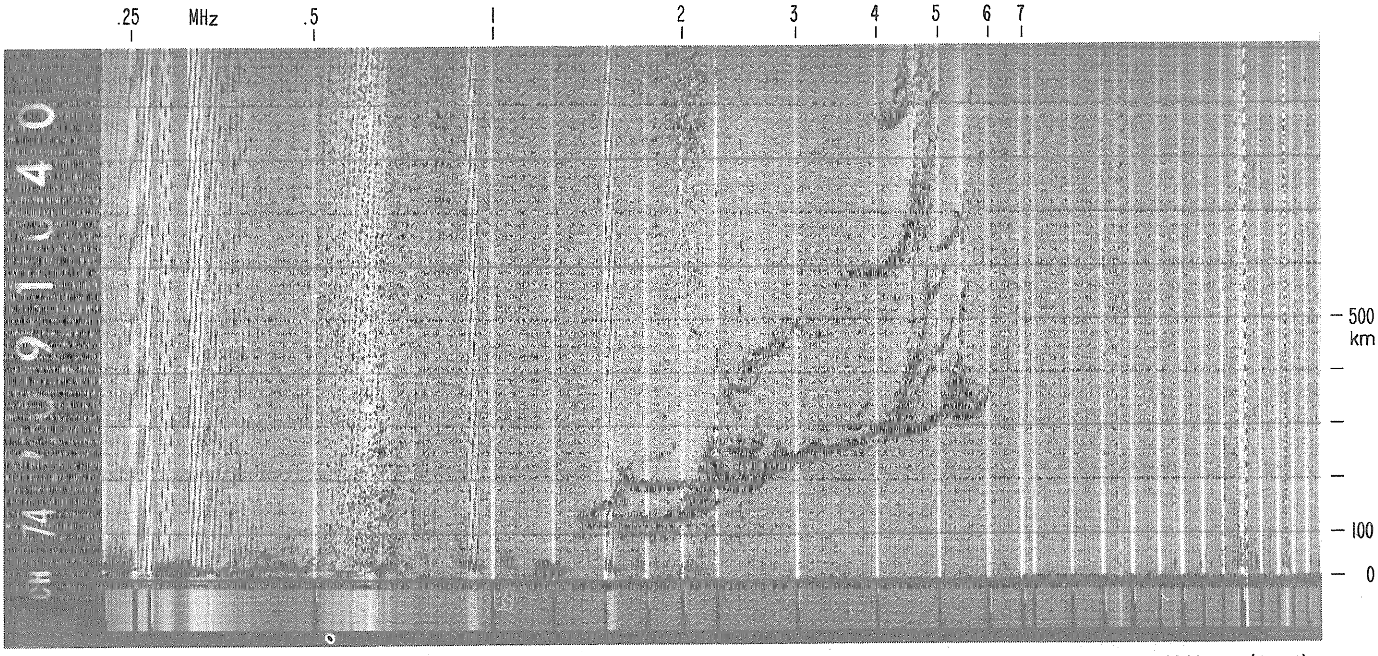
Distortion near hmF2. Note oblique spurs. foF2 has increased slightly on one side of station, decreased slightly on other, giving a change of about 300 kHz in a few km. The shape of the main trace changes as it is reflected obliquely.



1035 LT (90°W)

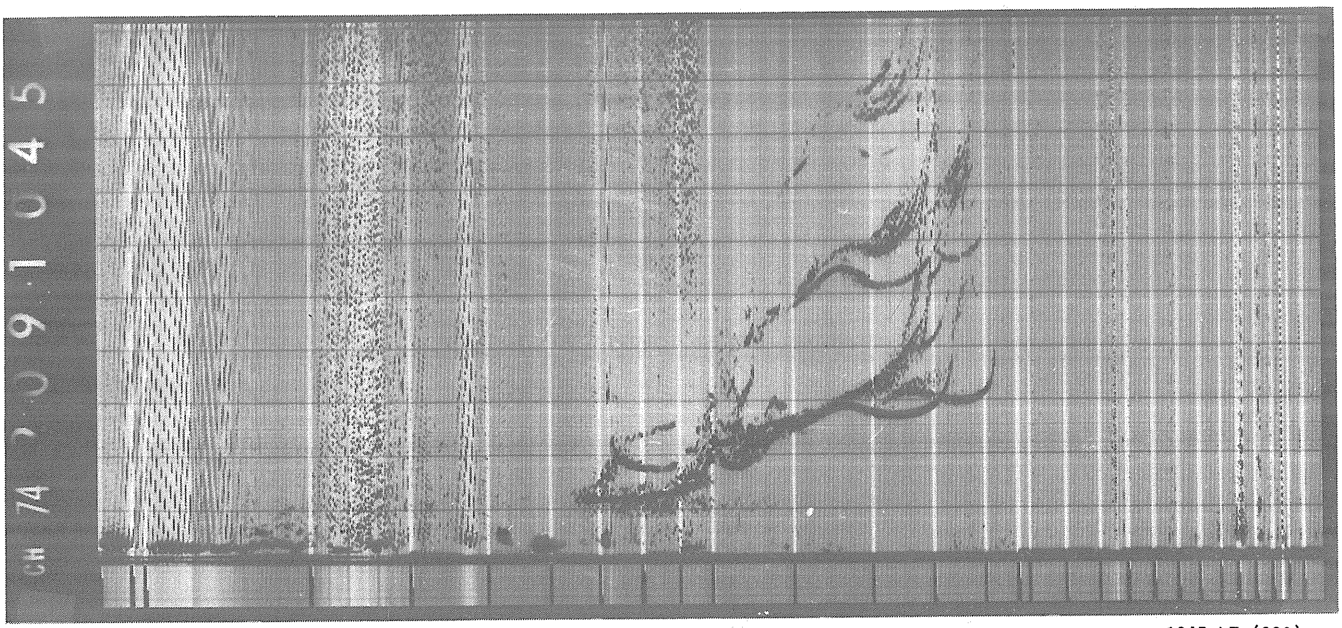
Spur moves down, main trace more distorted (hmF2 appears to rise, M(3000) to decrease) as it gets more oblique. Compare shape with 1015 LT.

Fig. 3.1 (cont'd. on next page)



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 <u>not</u> 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)

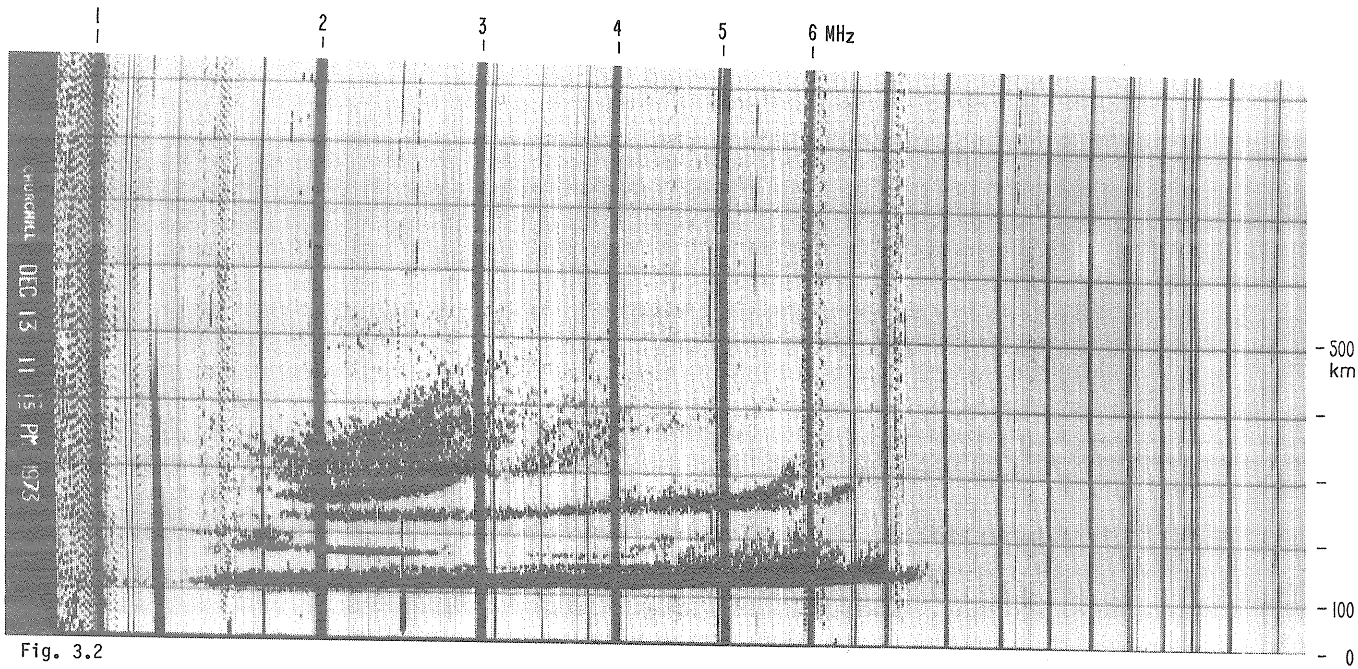


Fig. 3.2

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.

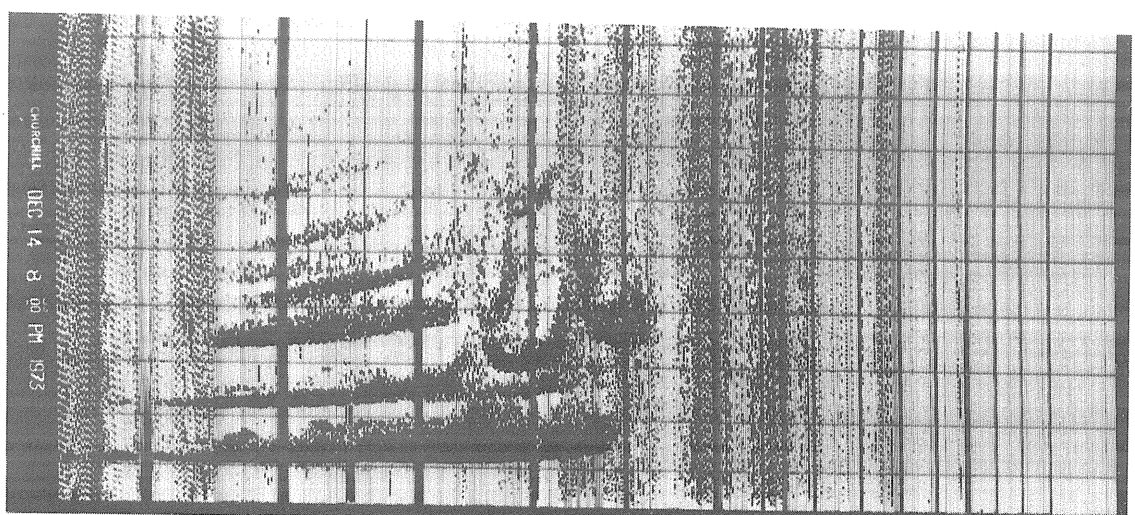


Fig. 3.3

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.

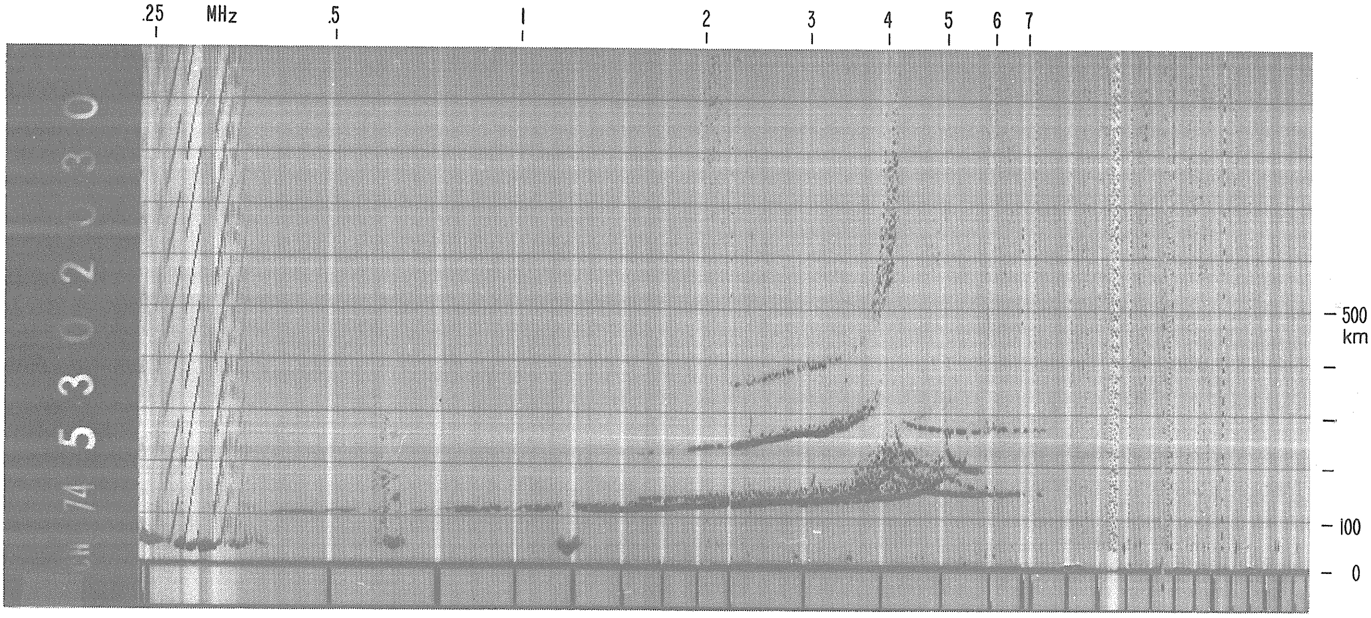


Fig. 3.4

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.

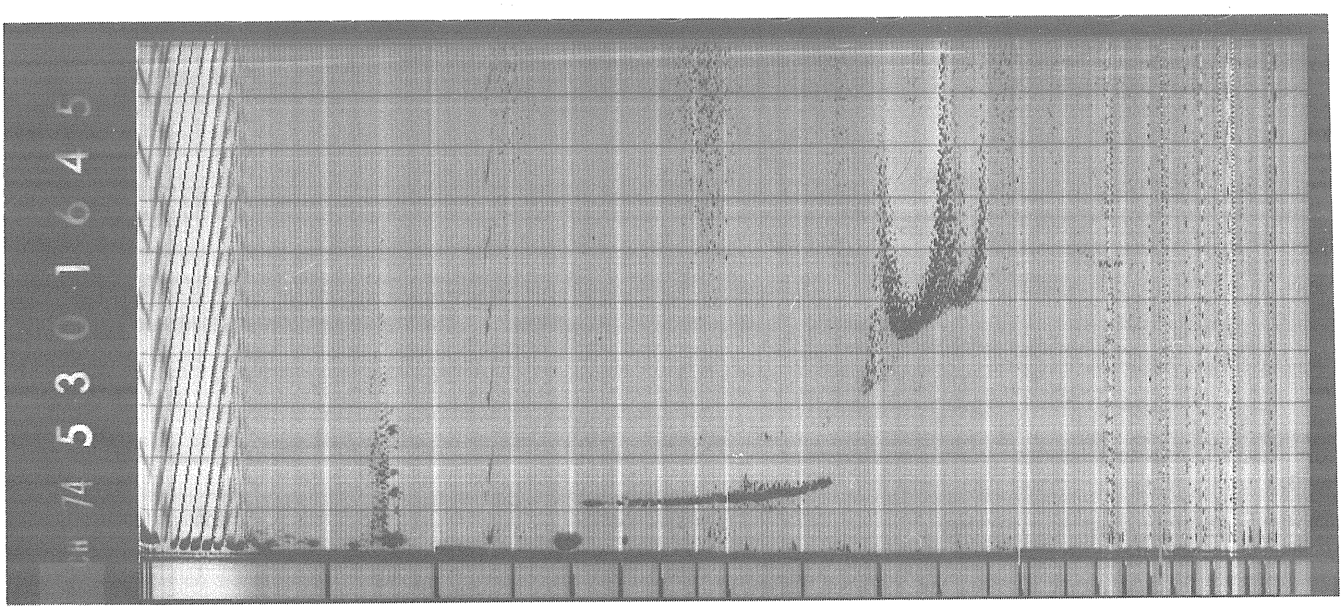
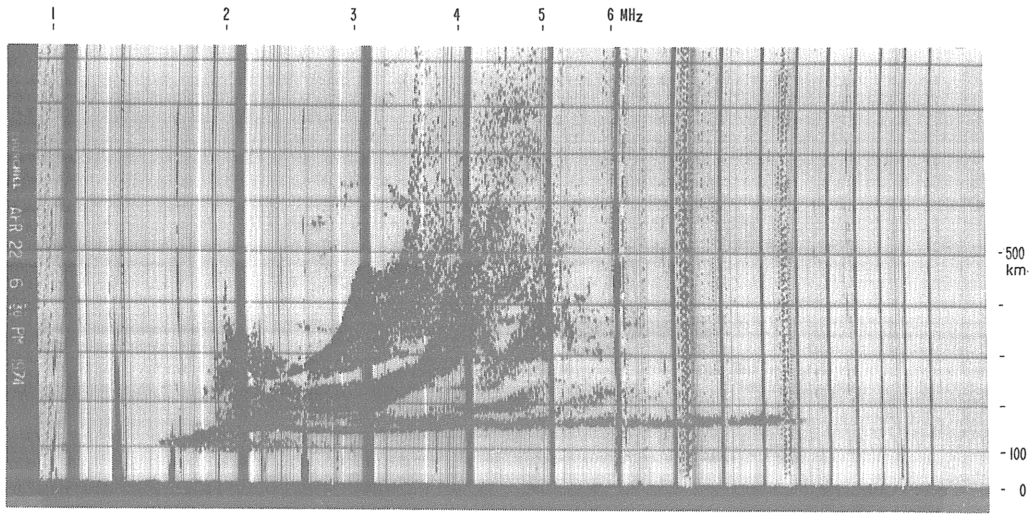


Fig. 3.5

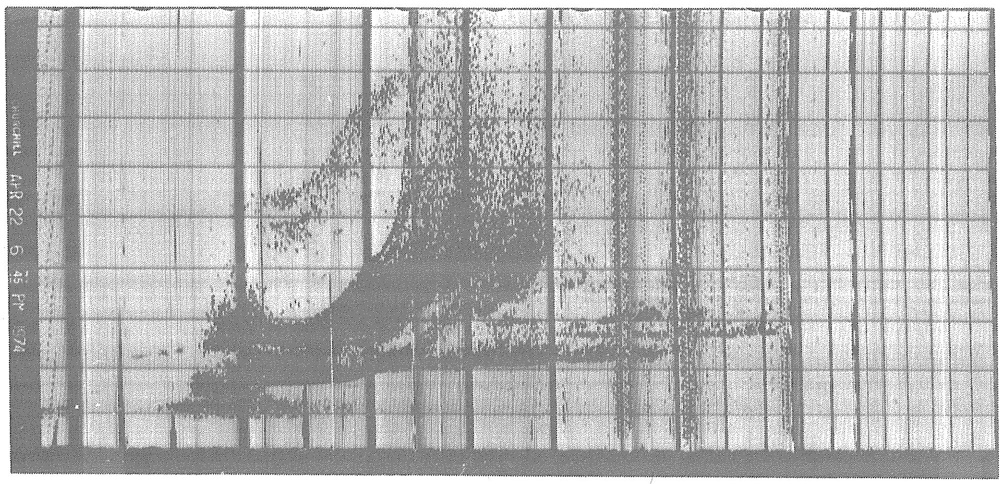
CHURCHILL - Lacuna 1974 May 30 1645 LT (90°W)

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



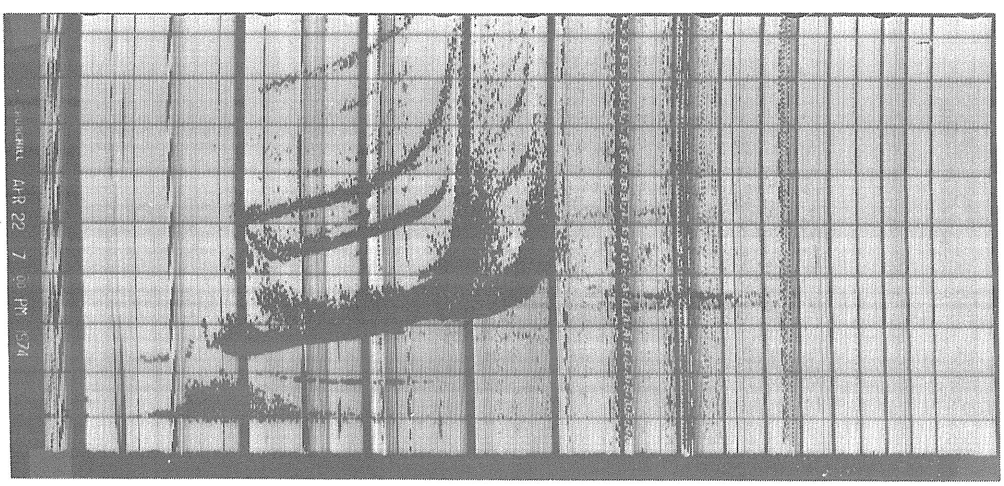
1974 April 22 1830 LT (90°W)

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.

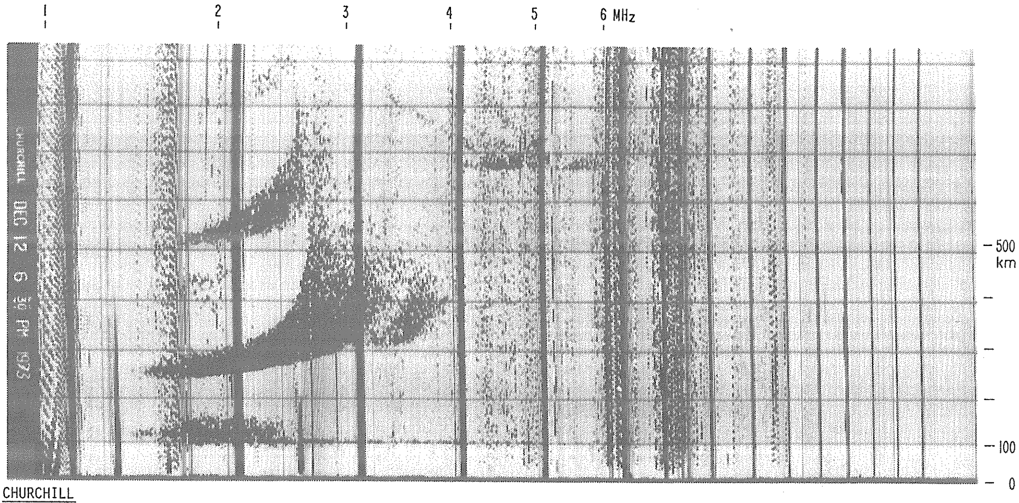


CHURCHILL 1974 April 22 1900 LT (90°W)

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

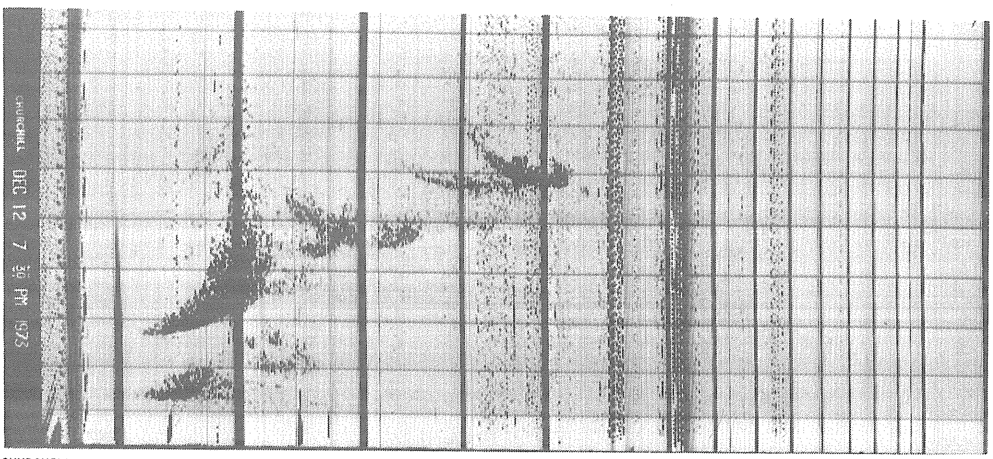


CHURCHILL

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

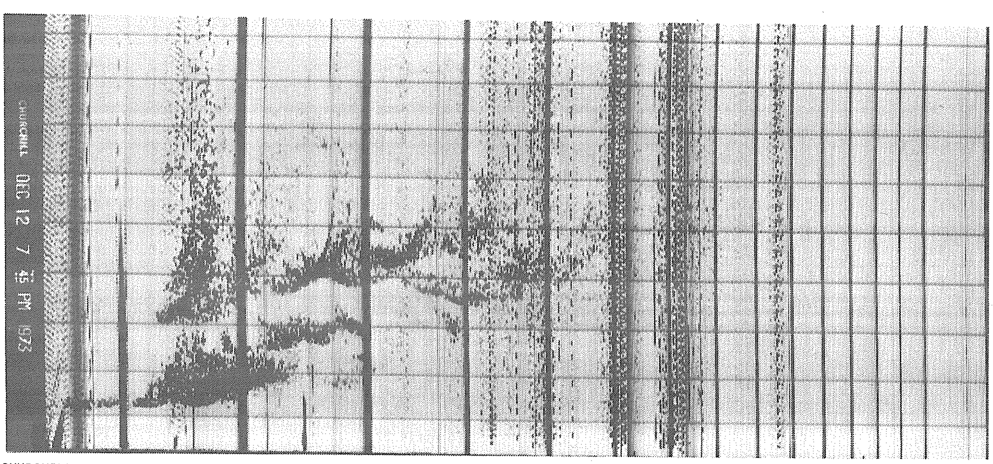
foF2 = 026-F trough layer. Third order height not consistent.
fxI = 060US h'I = 680 km
Weak auroral Es, foEs = 024.

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)

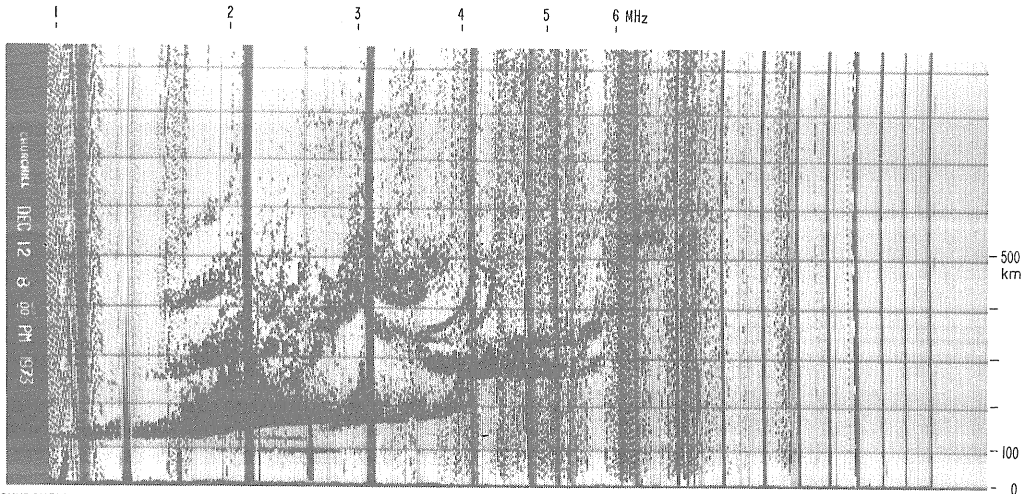
Editor's Note: foF2 = 020-F, (trough). fxI = 053. No frequency spread above 2.3 MHz so P trace represented by q-q 2.5 MHz to 5.3 MHz. Es type a. Two structures present so a,a better. "a" pattern beginning to show some r type structure. F classifications P, F.



CHURCHILL 1973 Dec. 12 1945 LT (90°W)

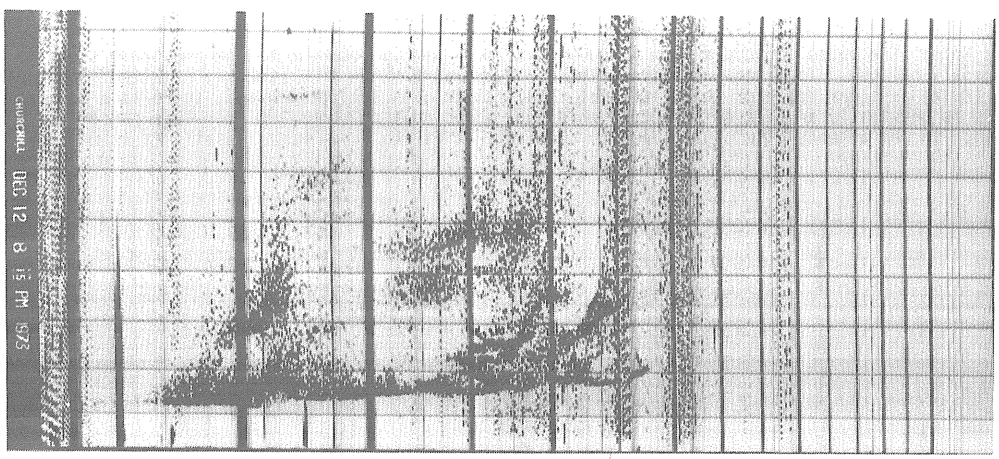
Editor's Note: foF2=017UF. Frequency spread to 023. fxI=060UA. It is not clear that the interpretation is correct. This could be an Es-a trace seen at oblique incidence with fxI really 044. Sequence shows that the latter interpretation is more likely, adopt fxI = 044UA. Es types a,a, suspicion that k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

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



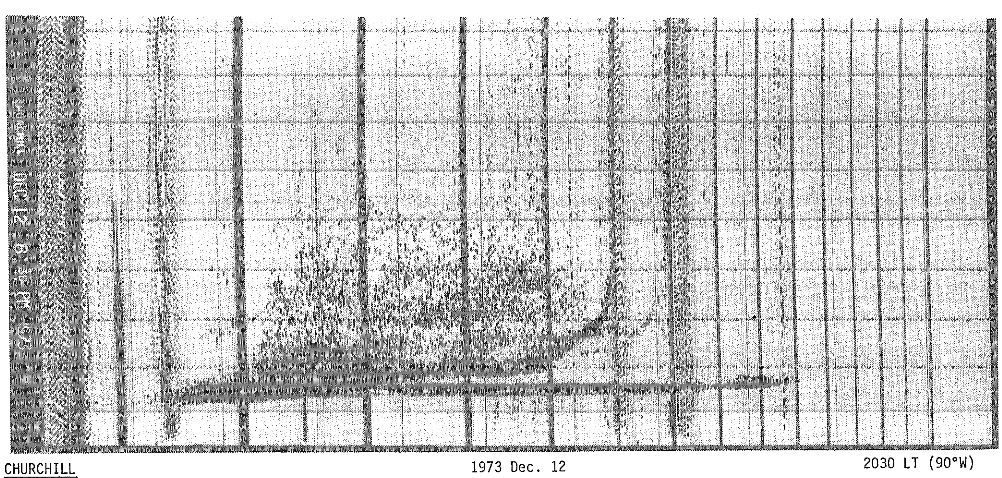
CHURCHILL 1973 Dec 12 2000 LT (90°W)

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)

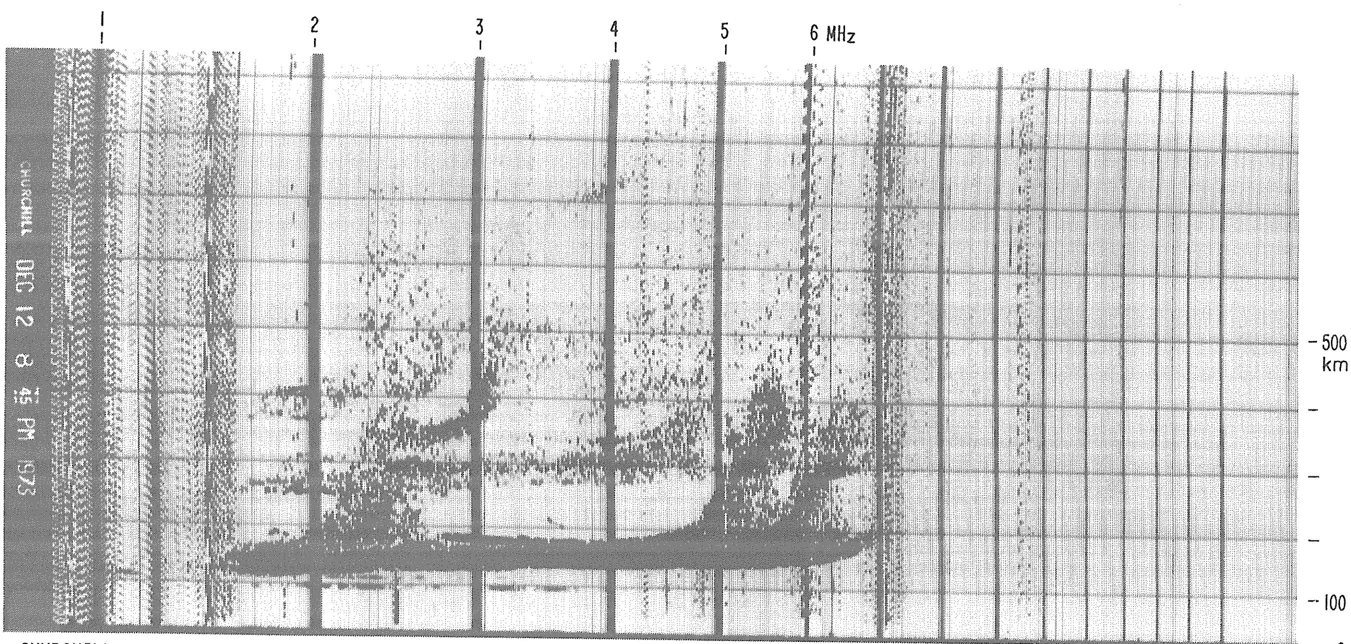
Editor's Note: Auroral Es of type associated with particle E when overhead. Second order suggests foE = 230UK (particle E present). Structure near 400 km possibly an F trace of P type giving fxI = 050UA. Type P. F parameters A.



CHURCHILL 1973 Dec. 12 2030 LT (90°W)

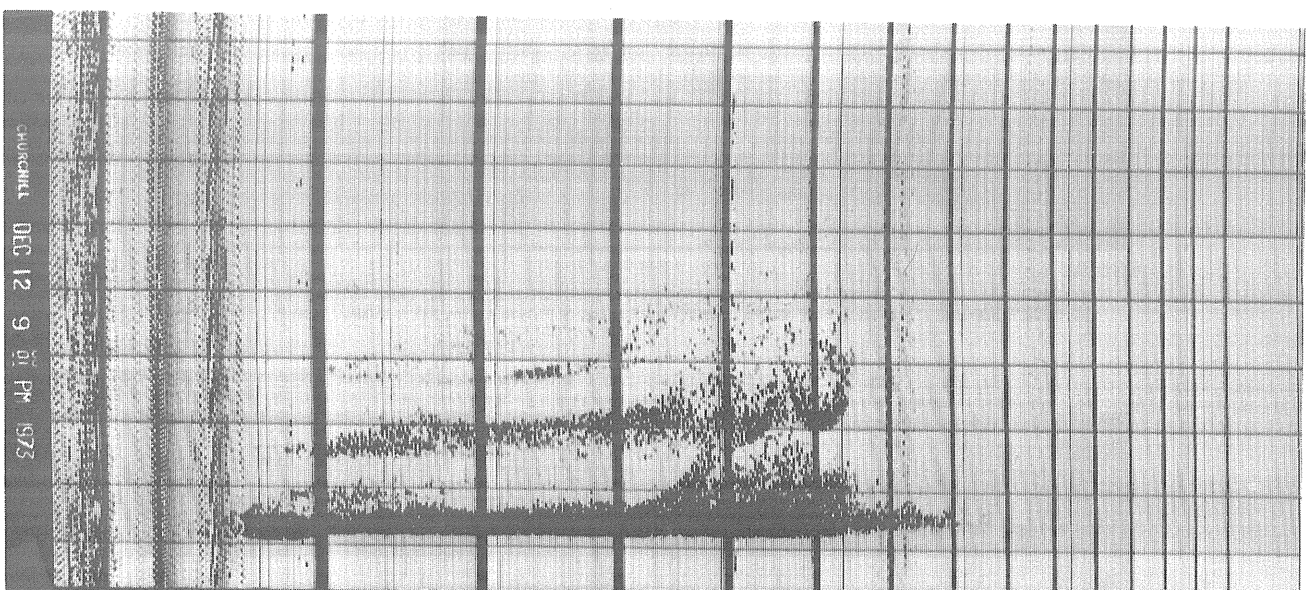
Editor's Note: Auroral Es. A weak second order k trace foE = 230UK is probably the only overhead trace. There is no sign of a second order of the strong c-like trace to about 8.0 MHz, so this is probably oblique. foEs for the densest structure seen from the station will be near 10 MHz if seen overhead.

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.



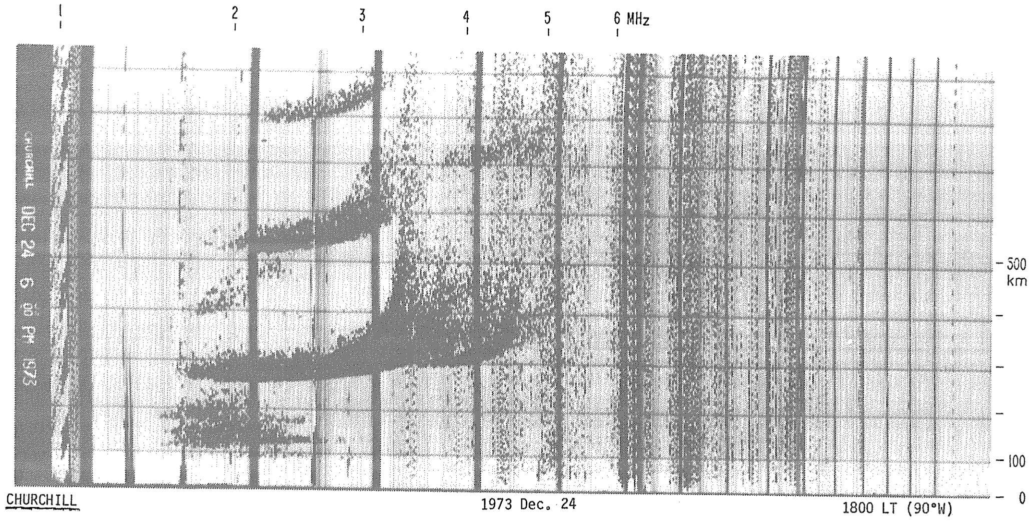
CHURCHILL 1973 Dec. 12 2100 LT (90°W)

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).

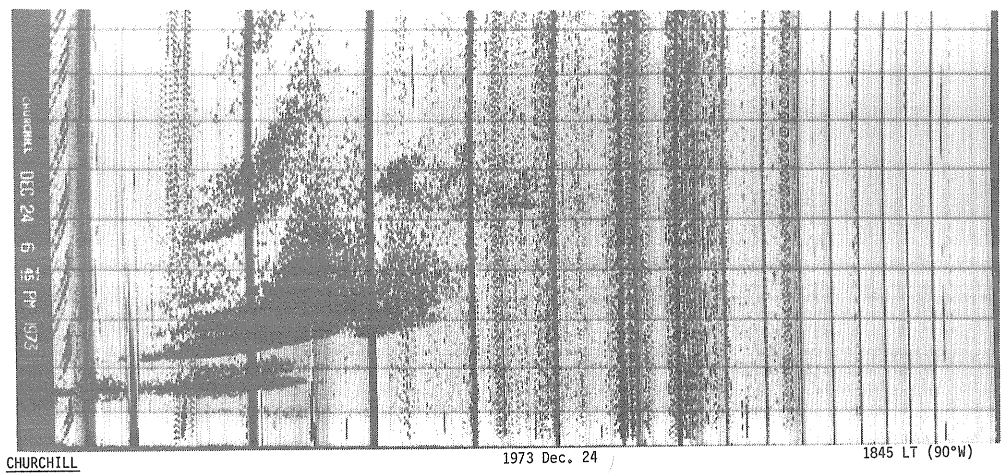
Fig. 3.7

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

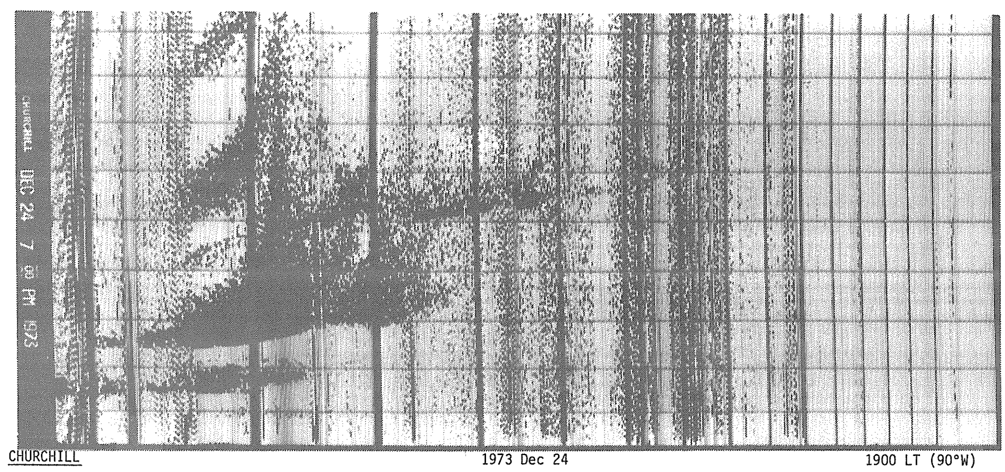
Editor's Note: This shows a fairly common case where the F structure is blanketed or confused by Es associated with the trough. A second sequence, December 24, 1973, 1800-2245 LT, shows a similar sequence with less Es. Comparing such sequences is the best way to get uniform interpretation.



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.

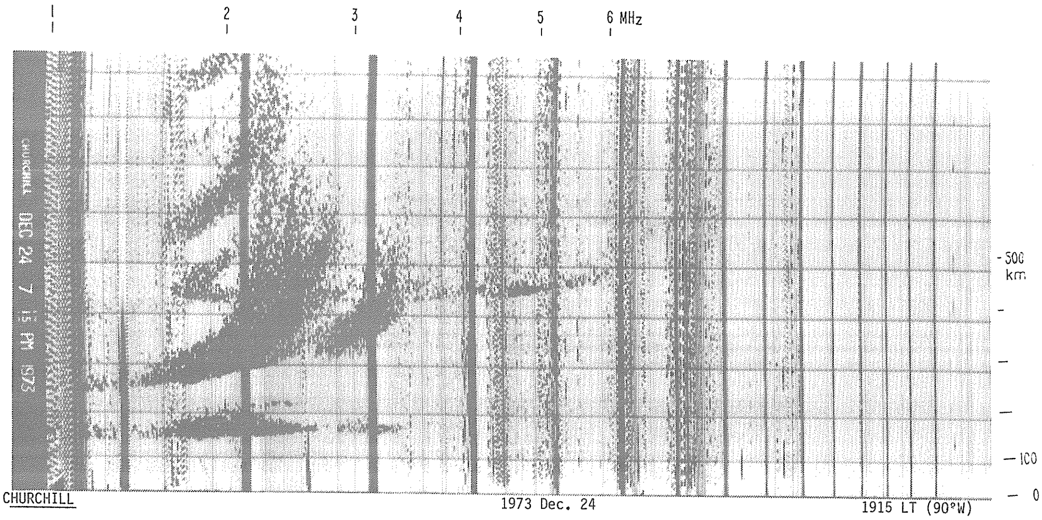


Editor's Note: Similar to 1973 December 12 at 1830 UT but trough is deeper. foF2 = 024UF; fxI = 045. F classifications P,F,(Q?). Frequency spread to 040 so P trace will be difficult to show on f-plot; best to show short dash ending at fxI. Es-a.



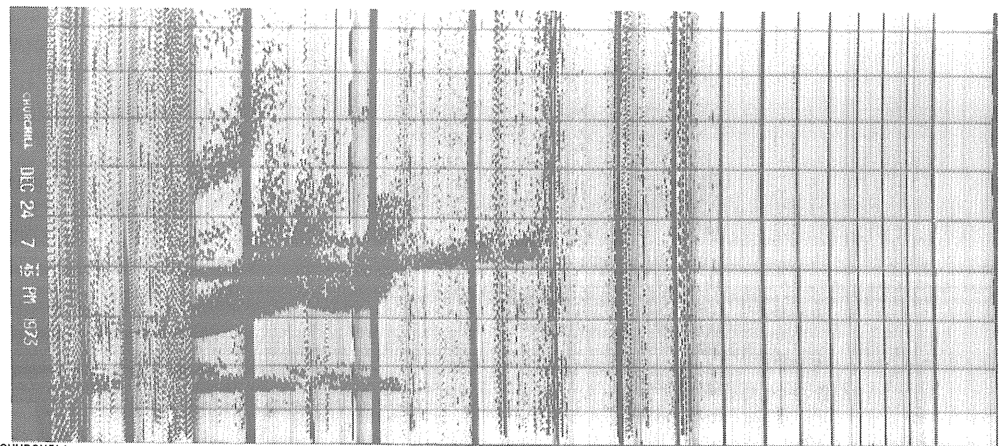
Editor's Note: foF2 = 022-F, frequency spread to 038. fxI = 070. P classification. P type curve can be denoted on f plot from about 040 to 070 by q-q. Note, not possible to show whole of P trace by q-q as overlaps frequency spread. This is not important as lower edge of trace terminates at minimum value 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)



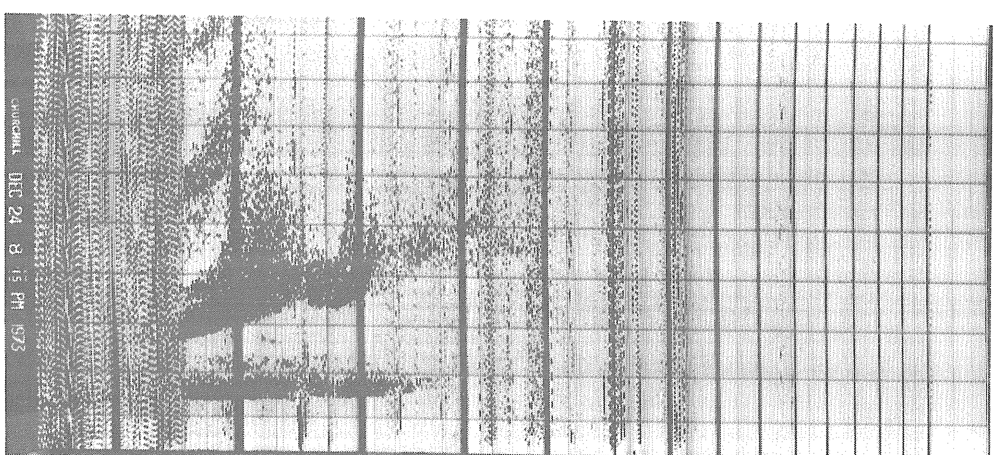
CHURCHILL 1973 Dec. 24 1915 LT (90°W)

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)

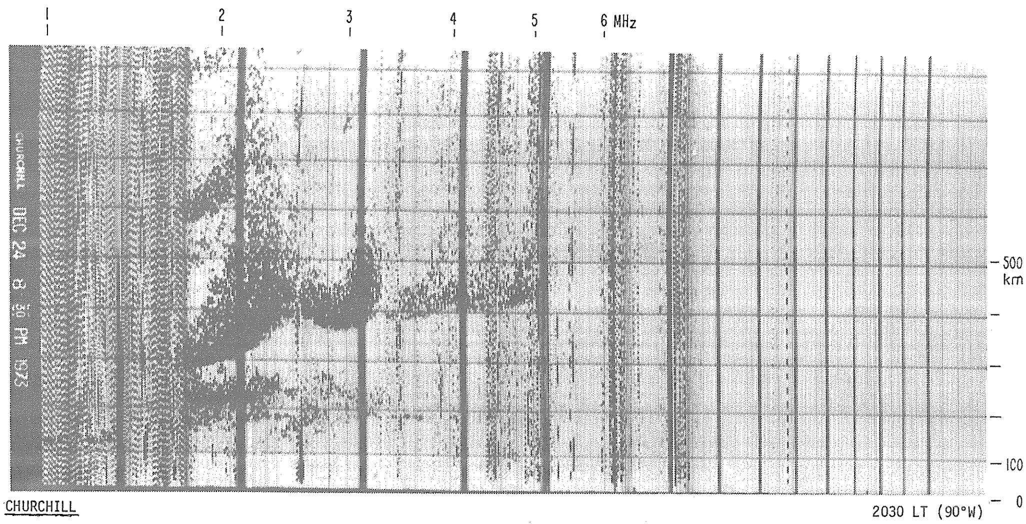
Editor's Note: Dominant o, x rays in thick layer traces do not agree with second order trace. h'F comparison shows the second order more nearly overhead. No unique interpretation possible. Put ● at 022, 024 and 031 on f-plot. Frequency spread ends 033. Denote P by q-q on f-plot between 035 and fxI. foF2 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).



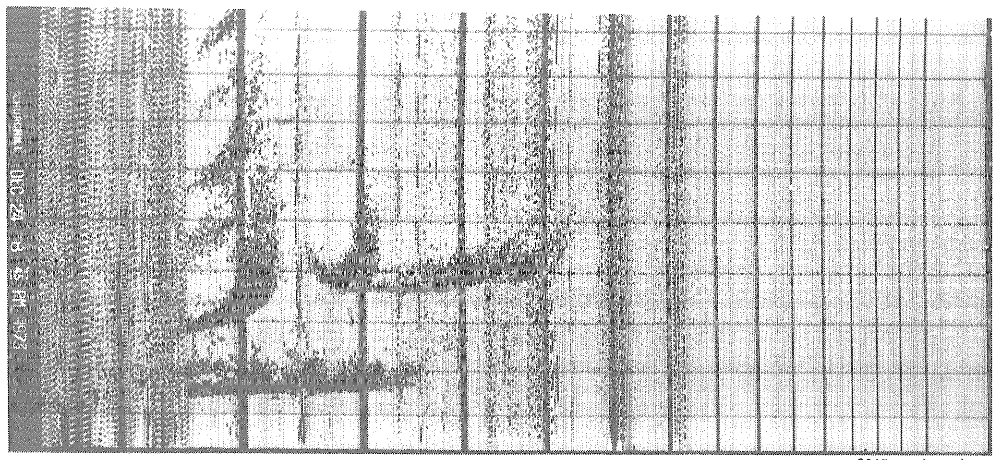
CHURCHILL 1973 Dec. 14 2015 LT (90°W)

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.)

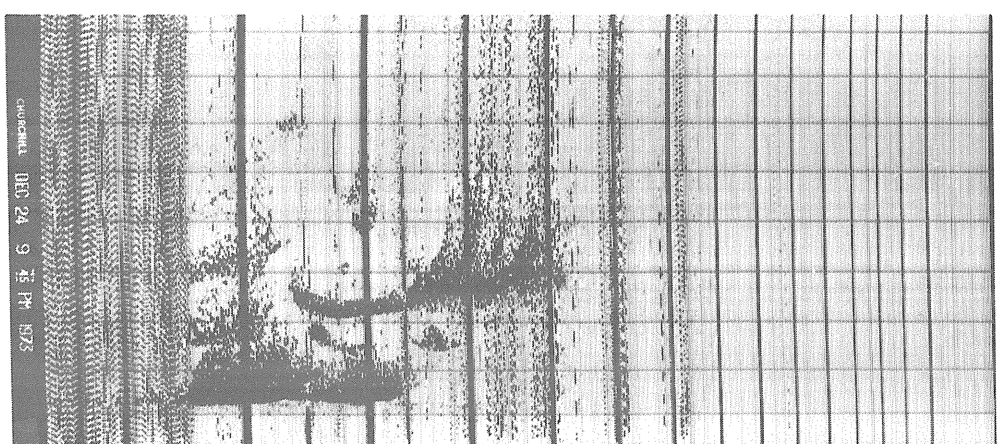


CHURCHILL 2030 LT (90°W)



CHURCHILL 1973 Dec. 24 2045 LT (90°W)

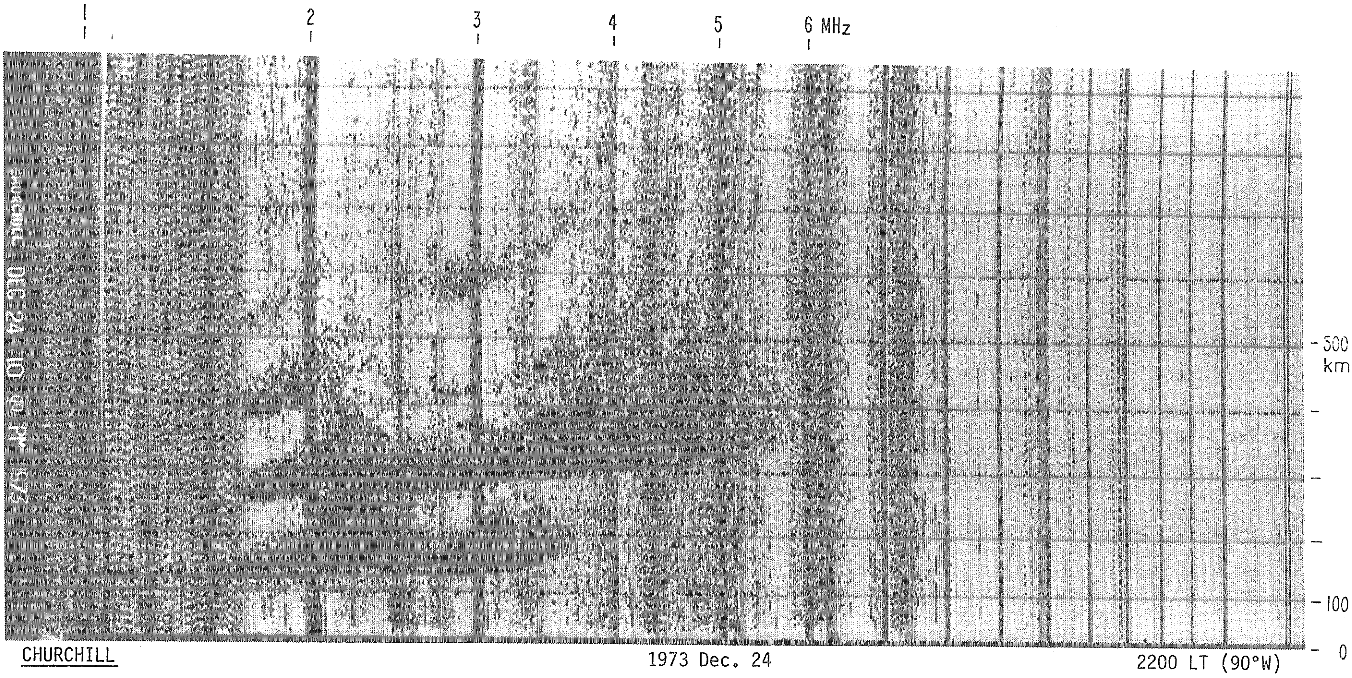
Editor's Note: This is a more common form for a P trace (replacement layer). Frequency spread ends at 032. Use q-q on f-plot between 035 and fxI. foF2 borderline, foF2 = 021-F (from second order) and foF2 = 022UF (center of spread). Prefer foF2 = 022-F on whole. Es-a with some Es-r characteristics. Note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



CHURCHILL 1973 Dec. 24 2145 LT (90°W)

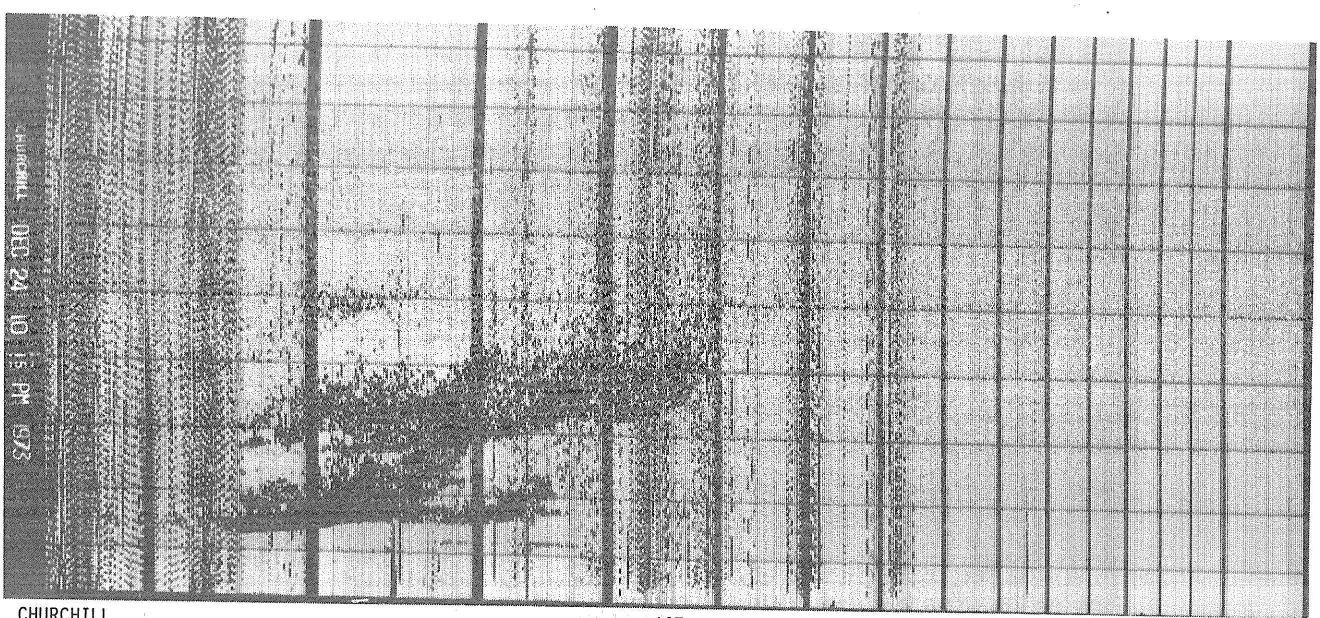
Editor's Note: Es more r than a. Note presence of Es-h on both o and x traces. Prefer Es-r but Es-a would not be wrong. foEs very close to foF2 so interpretation difficult. No second order for P trace so retardation at low frequency end probably due to foF2 as at 2045 LT. Presence of dominant traces 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)

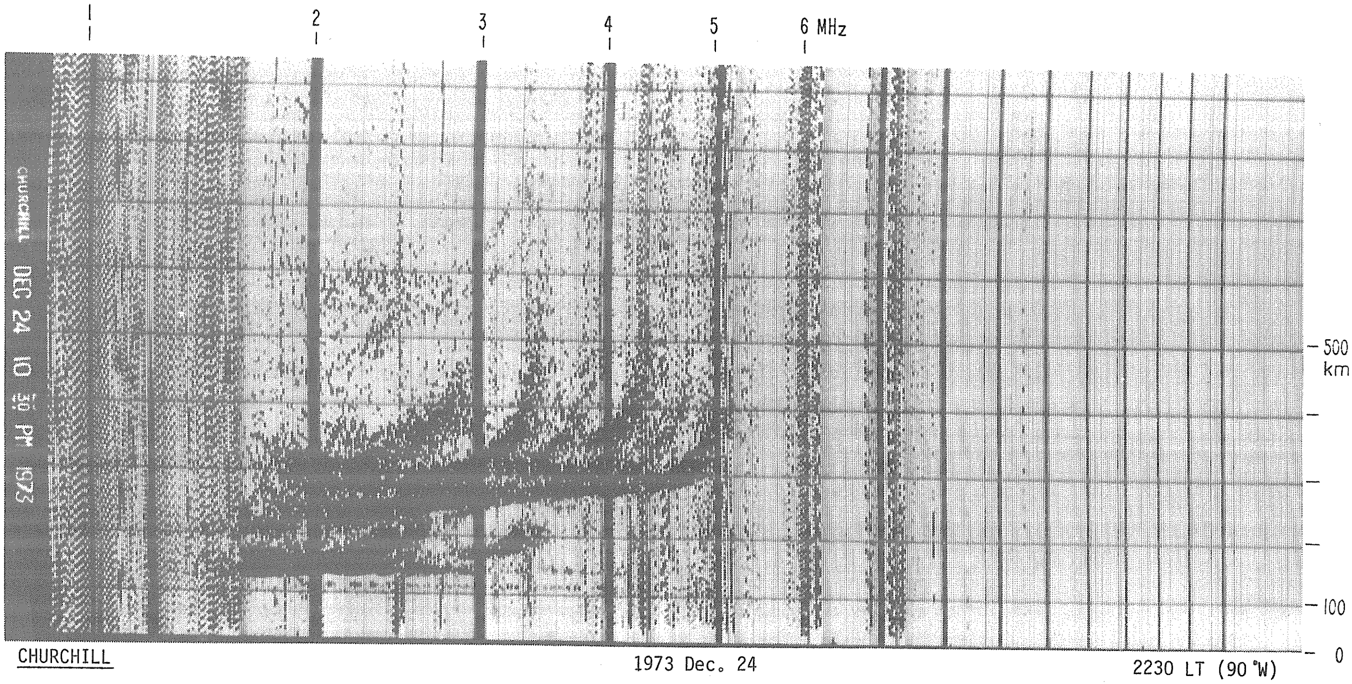
Editor's Note: P pattern shows some second order but dominant traces disappeared. Es shows o, x patterns so r type. From first and second orders h'F = 270EA (deduced near 2.8 MHz). Same Es as at 2145 LT.



CHURCHILL 1973 Dec. 24 2215 LT (90°W)

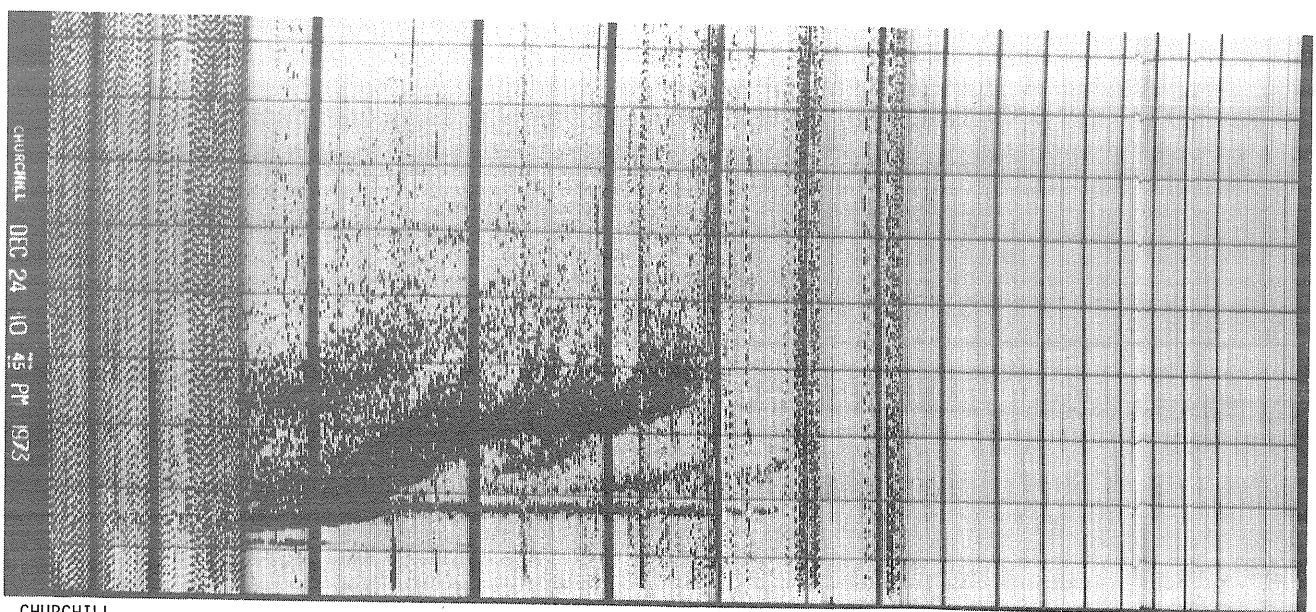
Editor's Note: The trace is similar to a FLIZ trace. fxI = 050, spread F classification P. Es-r. Probably not overhead, no dominant rays but some frequency spread clear. Much range spread.

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.

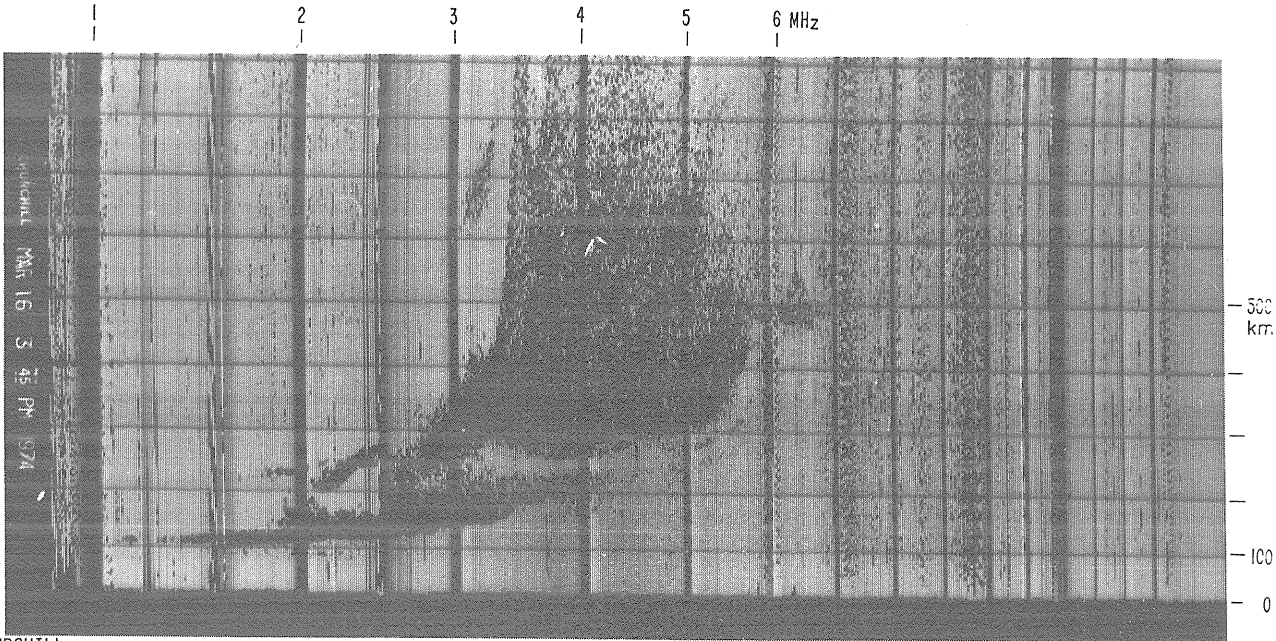


CHURCHILL 1973 Dec. 24 2245 LT (90°W)

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

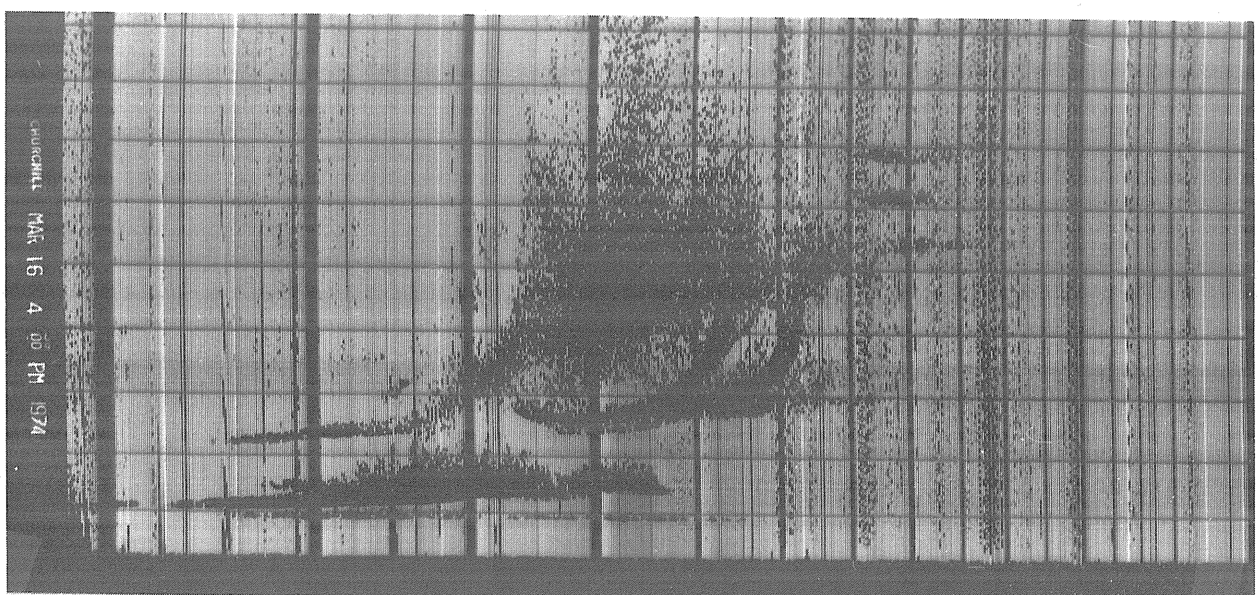
Fig. 3.8

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



CHURCHILL 1974 Mar. 16 1545 LT (90°W)

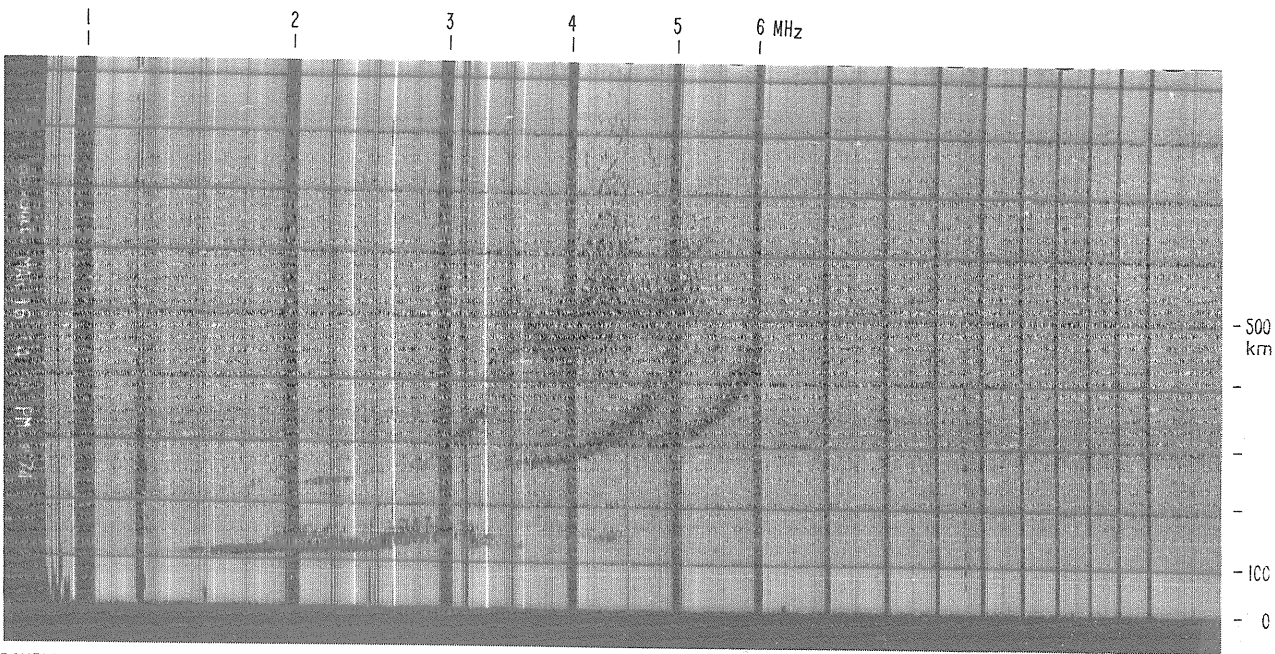
Editor's Note: Second order suggests little tilt. Inner edge can be used to deduce foF2. foF2 = 035UF. Expected value of foE about 024, of foF1 340 at this time of day. A low gain ionogram would probably allow h'F2 to be measured, an important parameter in this type of pattern sequence.



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 = 045UF̄, 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:

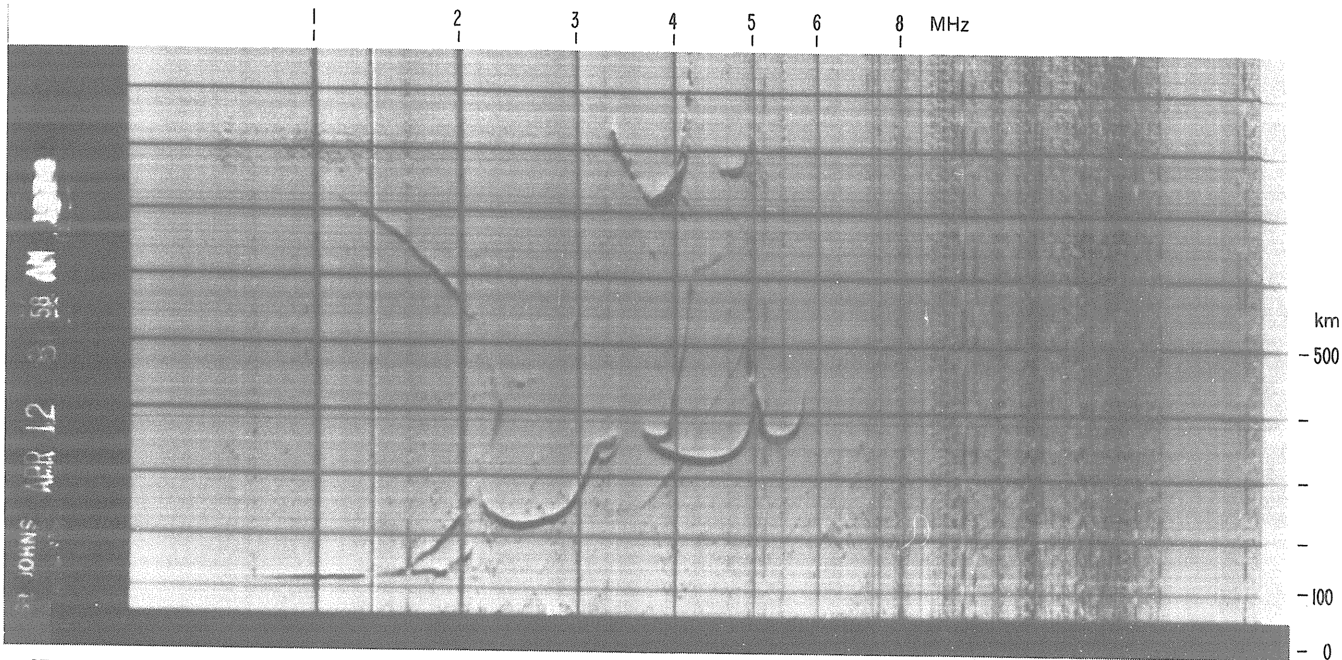
Selected ionograms have been reproduced in the "Canadian Ionospheric Data" books since January 1974.

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.

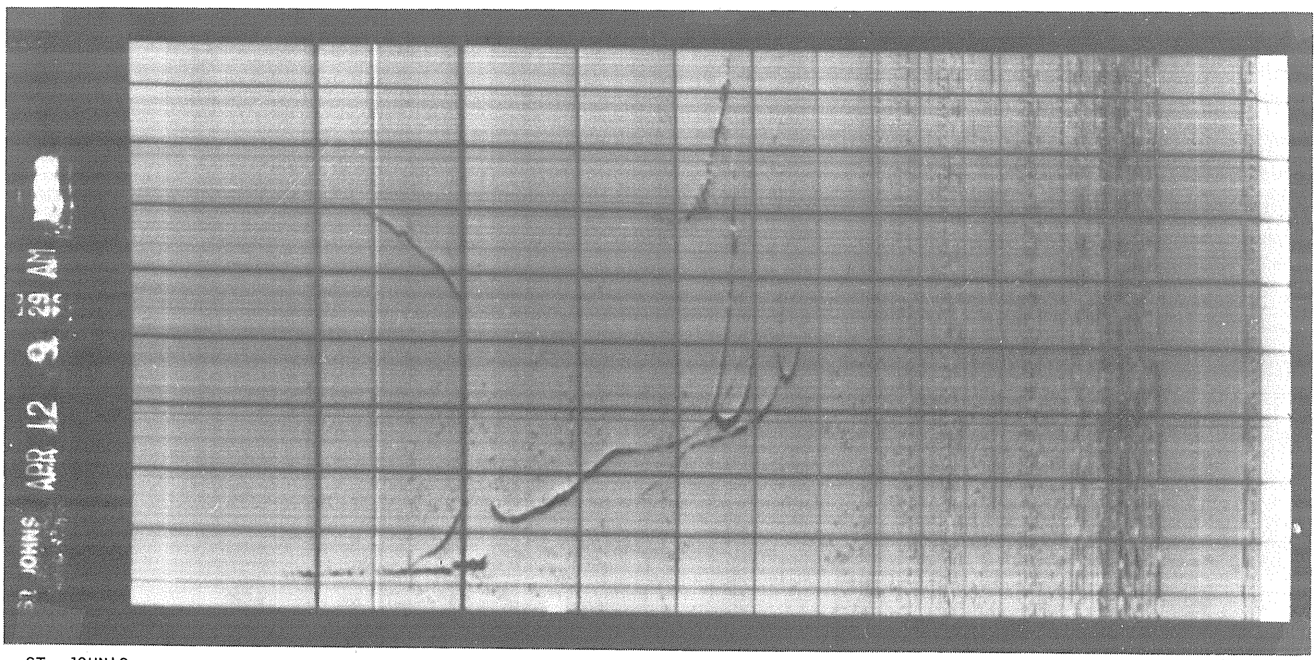
Enquiries: Director
Telecommunications Engineering Laboratory
1241 Clyde Avenue
K2C 1Y3
Ottawa, Ontario, Canada.

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. foF1 = 340UY, foF2 = 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.

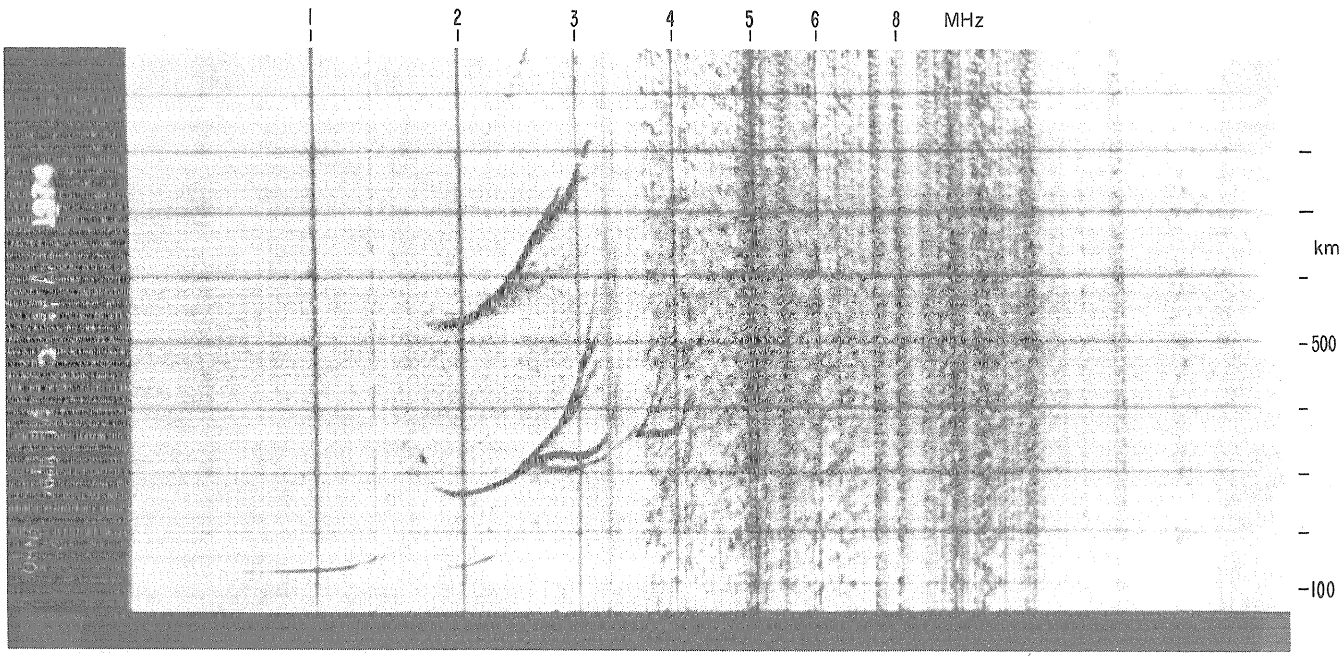


Fig. 3.11

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.

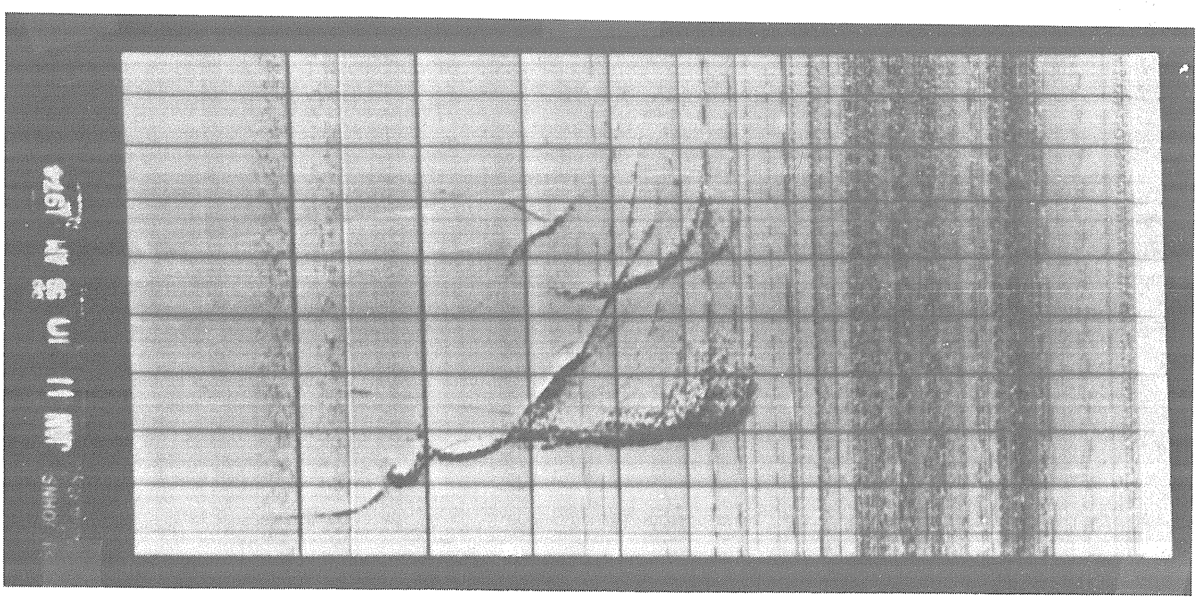


Fig. 3.12

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.

SECTION 4. U.S.A. STATIONS

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

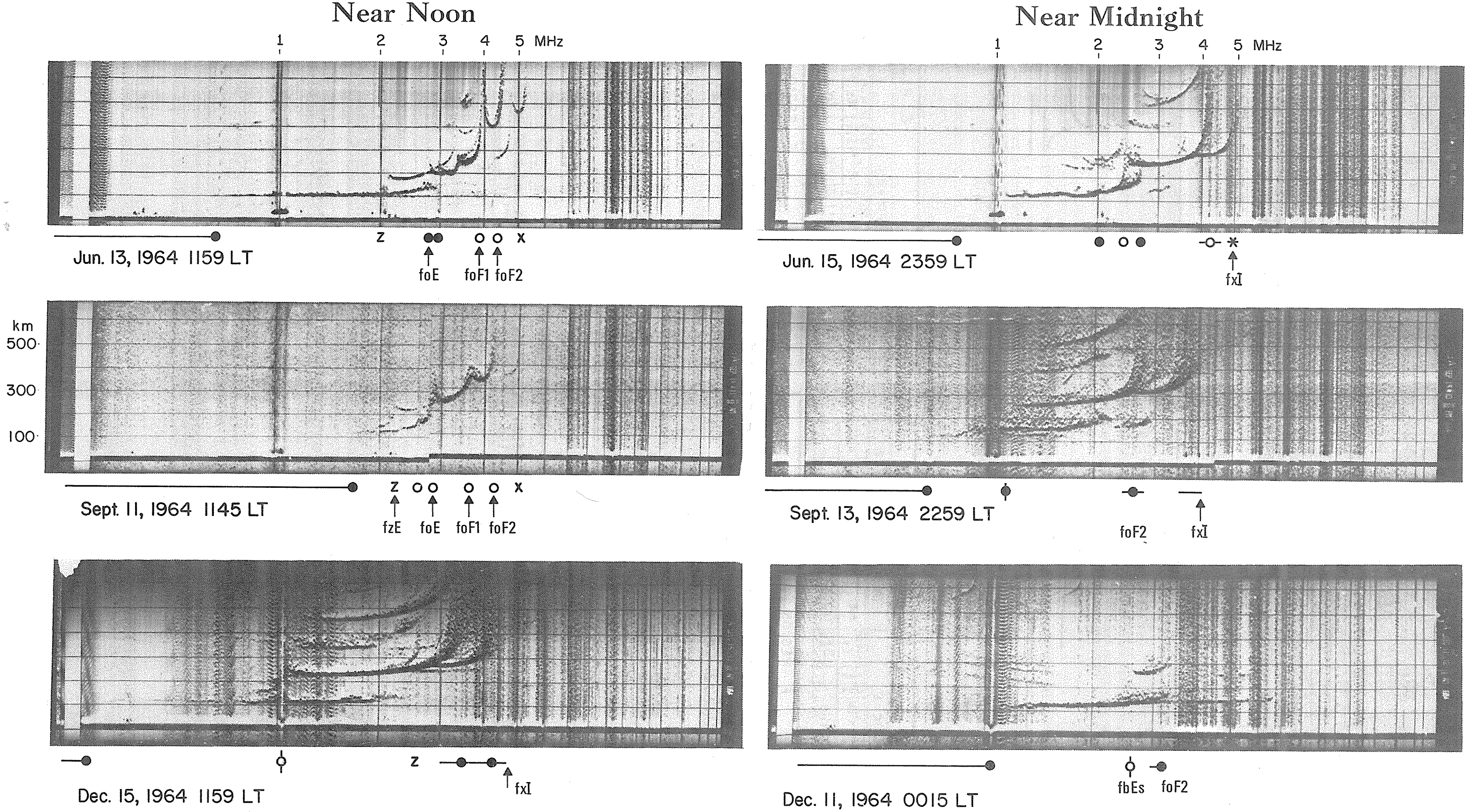
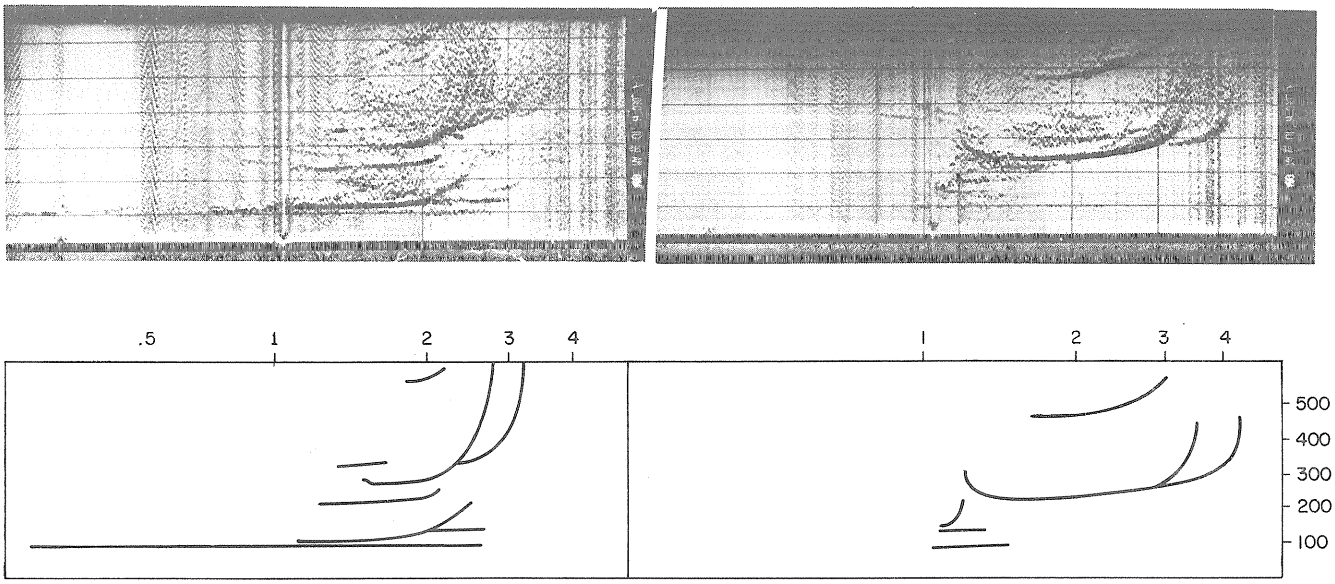


Fig. 4.1



Barrow: Dec. 6th 1964 1000 LT

Dec. 6th 1964 1059 LT

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			r3ℓs	160	E	A			A		

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						

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		

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.

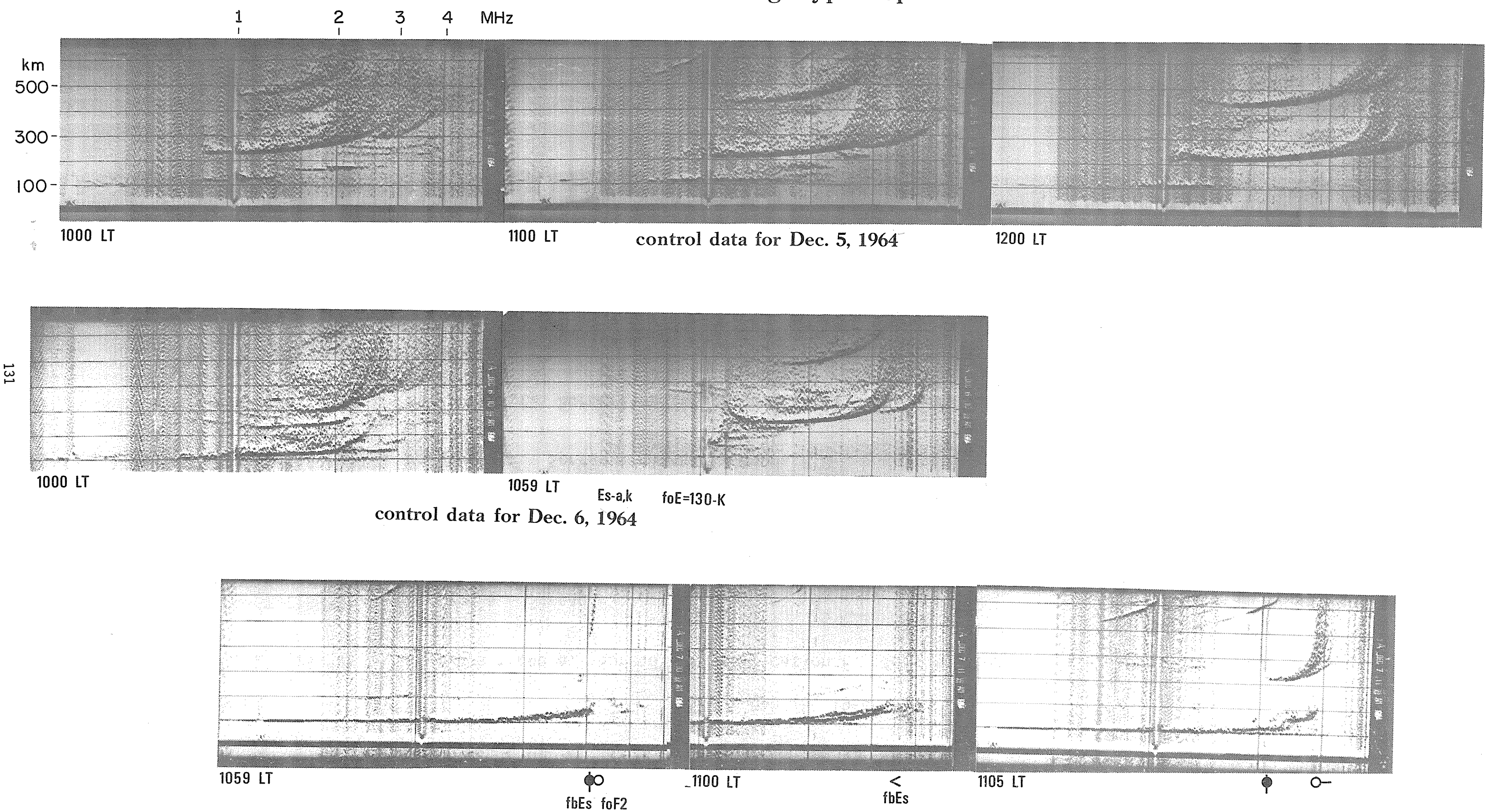
Dec. 7, 1964 — 1100 LT (150°W)

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



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.

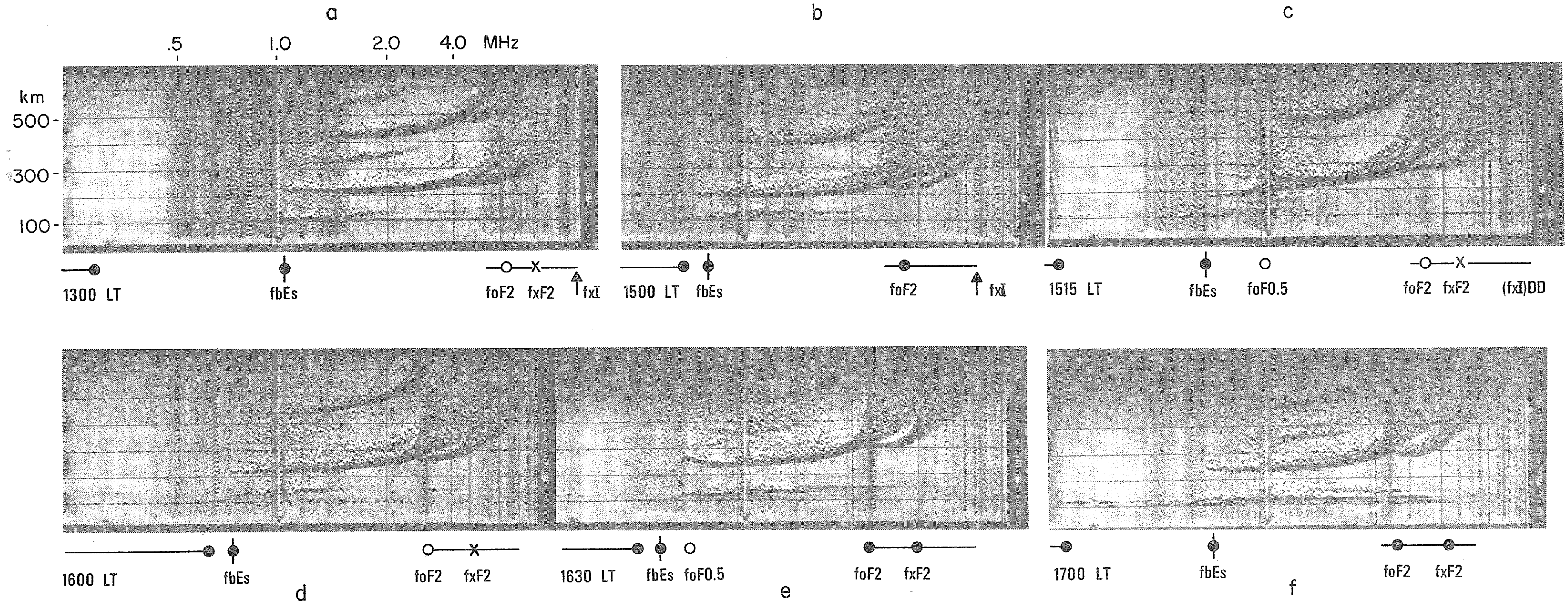
1515 LT (150°W) - Es type a. Some range spread. F trace continuous around foF0.5 = 010. Spread F classifications F, Q. h'F = 180UH.

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).

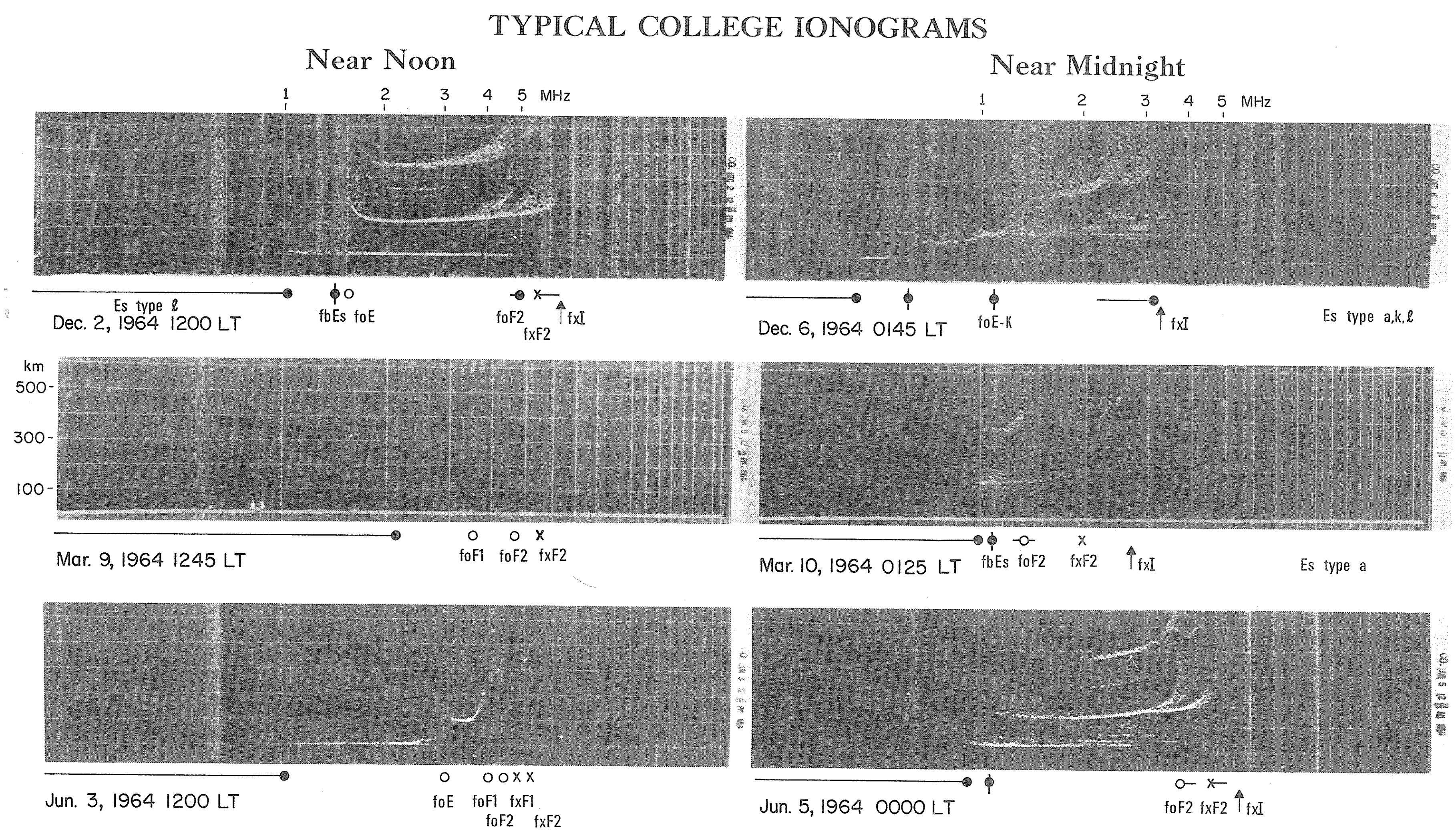

TYPICAL COLLEGE IONOGRAMS
Near Noon
Near Midnight
1
2
3
4
5 MHz
Es type ℓ
Dec. 2, 1964 1200 LT
fbEs foE
foF2
fxF2
fxI
Dec. 6, 1964 0145 LT
foE-K
fxI
Es type a,k,ℓ
km
500
300
100
Mar. 9, 1964 1245 LT
foF1 foF2 fxF2
Mar. 10, 1964 0125 LT
fbEs foF2
fxF2
fxI
Es type a
Jun. 3, 1964 1200 LT
foE
foF1 fxF1
foF2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

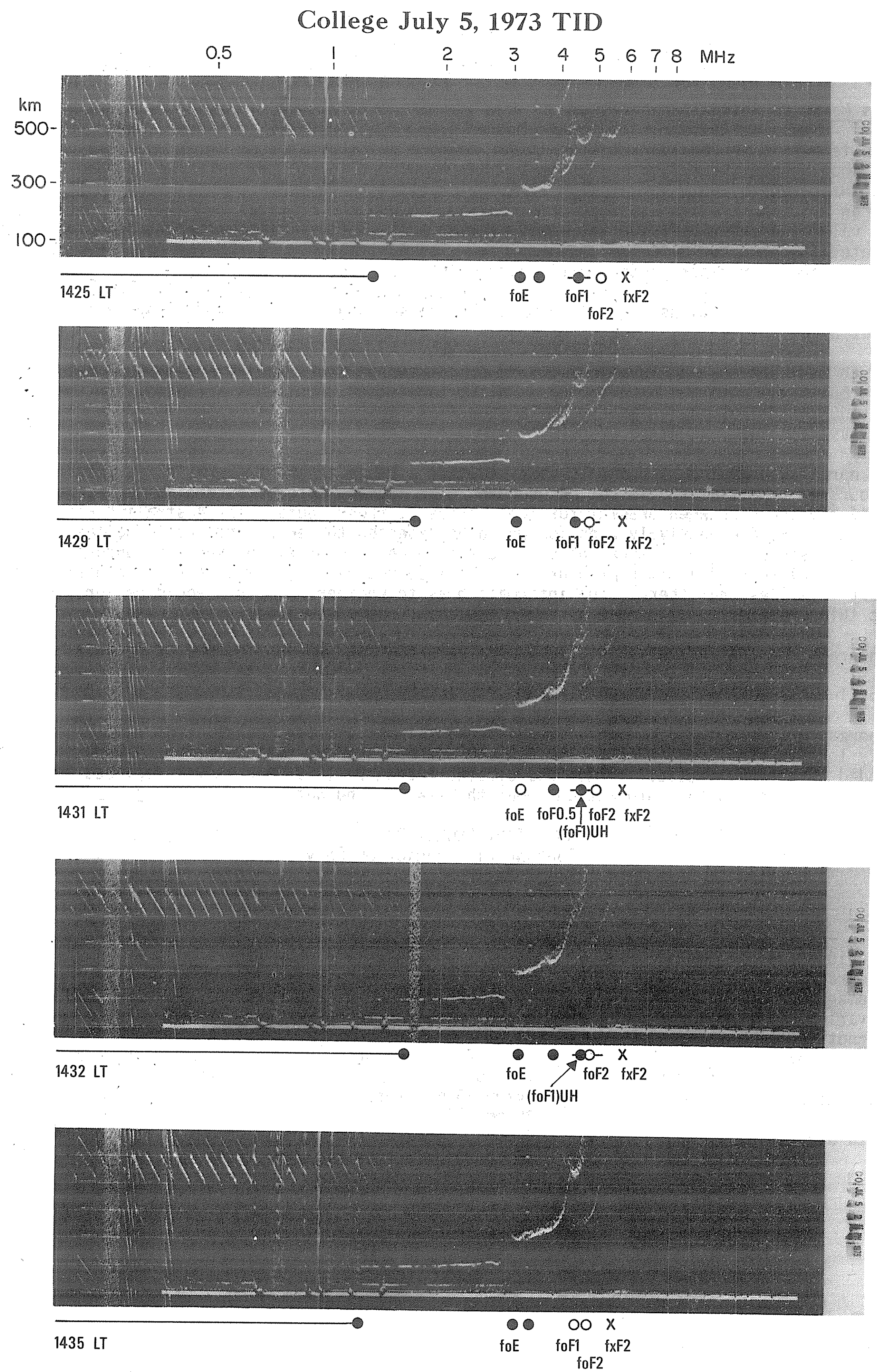
Fig. 4.5

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.



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.

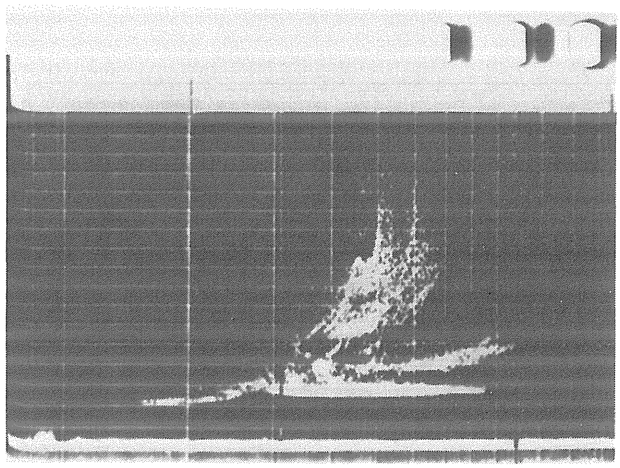
Vertical Incidence Soundings at Casey

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

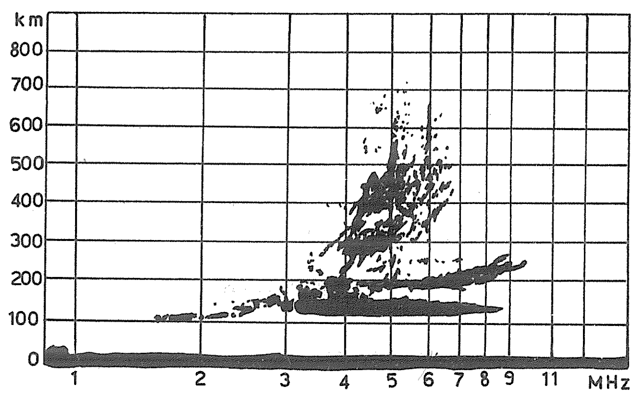


CASEY

5TH DECEMBER 1973

0801 U.T.
1601 L.T.

Fig. 5.1



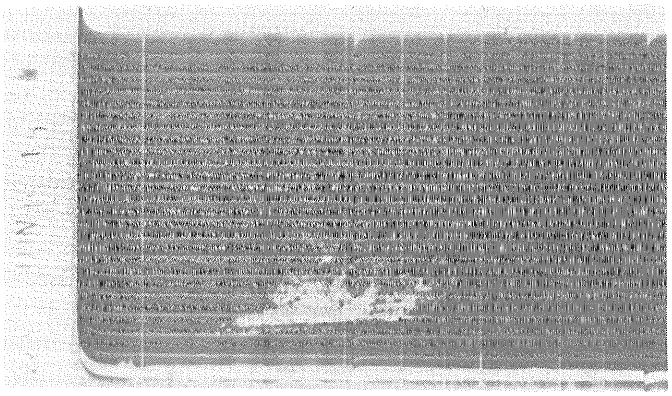
derived from fxEs

fmin	h'E	foE	h'Es	foEs ↓	fbEs	type Es
16	100	U320A	120	77JA	35	c, s
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	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.

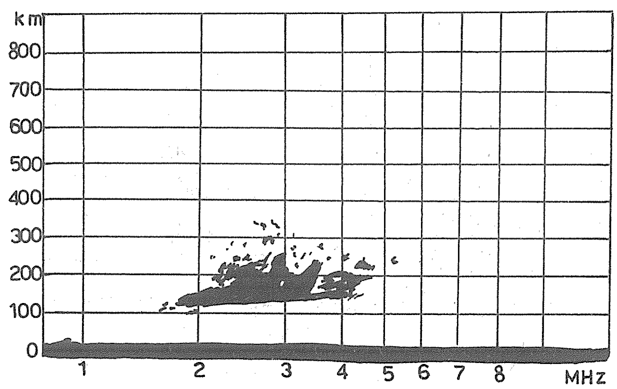
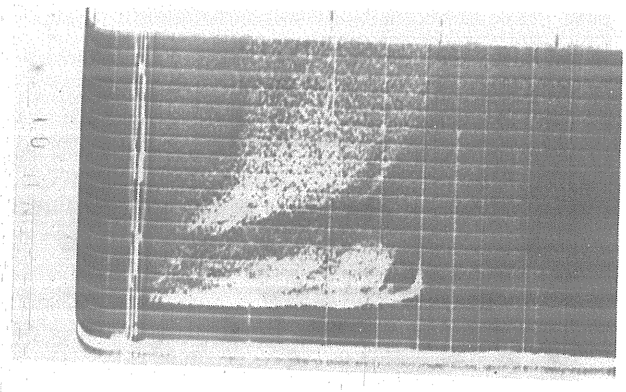


Fig. 5.2

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
15	B	E150B	E115B	35	A 35A	a
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	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

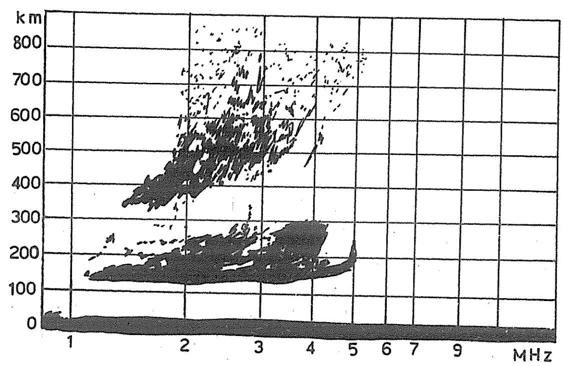


CASEY

19TH JUNE 1973

0101 U.T.
0901 L.T.

Fig. 5.3

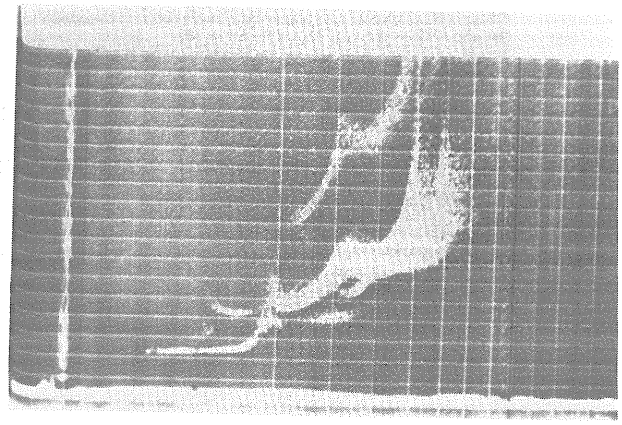


fmin	h'E	foE	h'Es	foEs	fbEs	type Es
11	B	E 110B	120	35	14	a, r
h'F	foF1	M 3000 F1	h'F2	foF2	M 3000 F2	fxI
E 320A				F		51

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

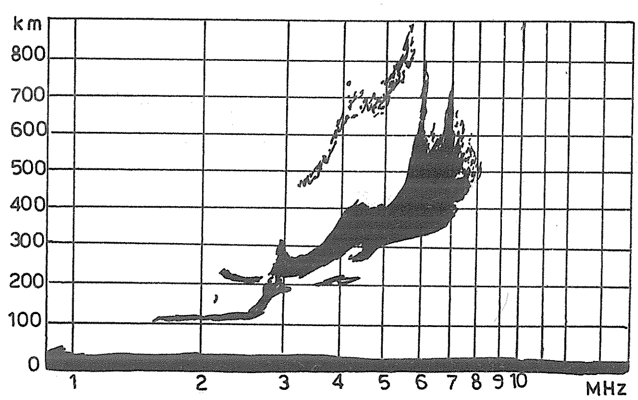


CASEY

1ST OCTOBER 1973

0401 U.T.
1201 L.T.

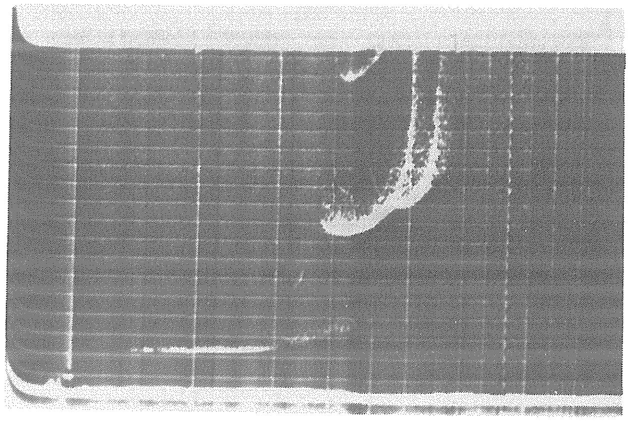
Fig. 5.4

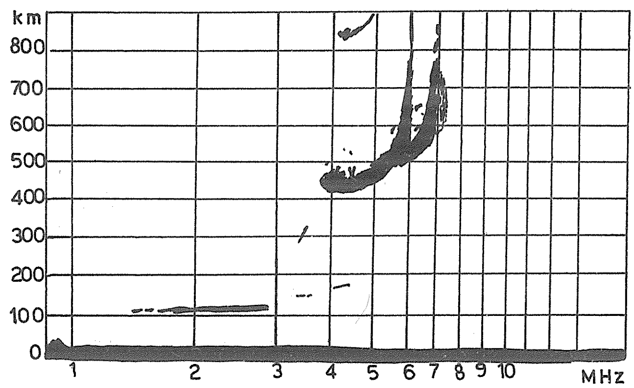


fmin	h'E	foE	h'Es	foEs	fbEs	type Es
16	110	295	E180G	31	E 30G	h
h'F	**foF1**	**M3000 F1**	**h'F2**	**foF2**	**M3000 F2**	**fxI**
215	43F		310	U 60F		81

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.

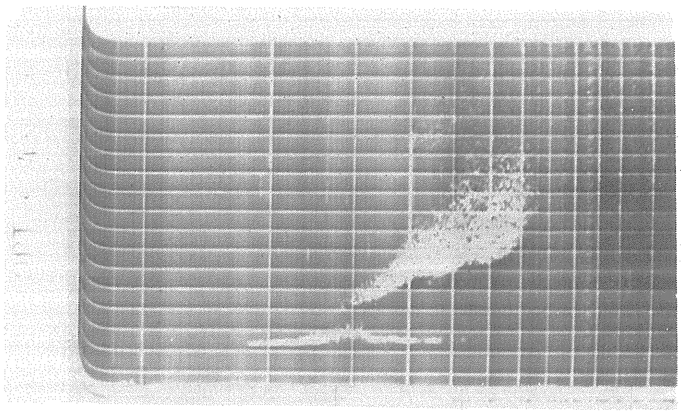
Fig. 5.5

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	110	320	G	G	G	s
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
E 275 Y	U 36Y		420	U 60 F		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

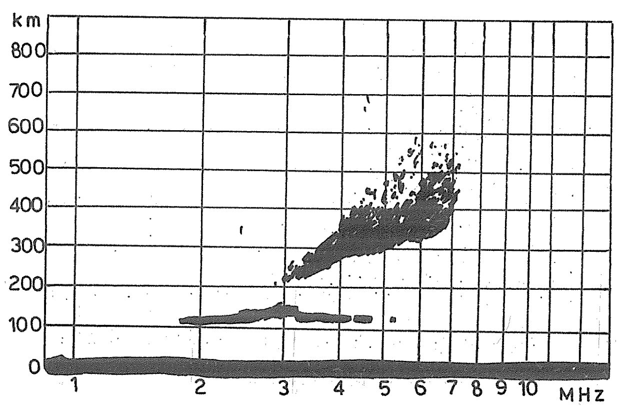


CASEY

5TH OCTOBER 1973

0645 U.T.
1445 L.T.

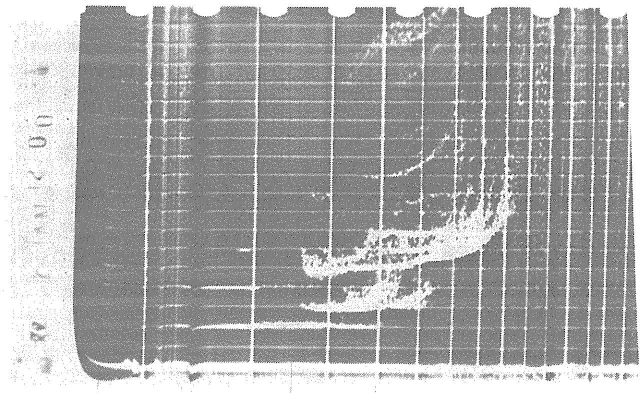
Fig. 5.6



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.

Es TYPE LOW AND RETARDATION



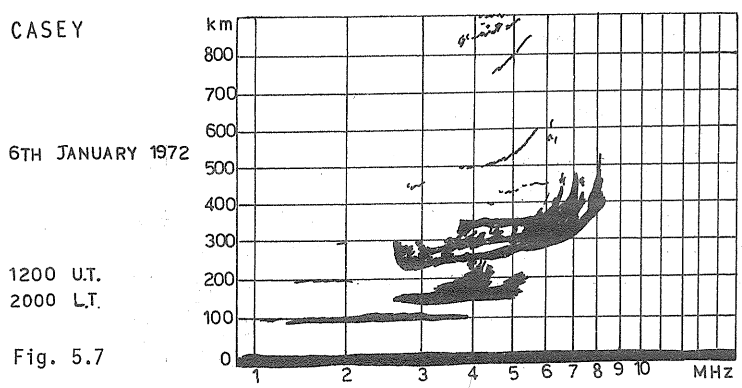


Fig. 5.7

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	A	U250A	95/135	33/45	25	l3/r
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
220	L			61F		84

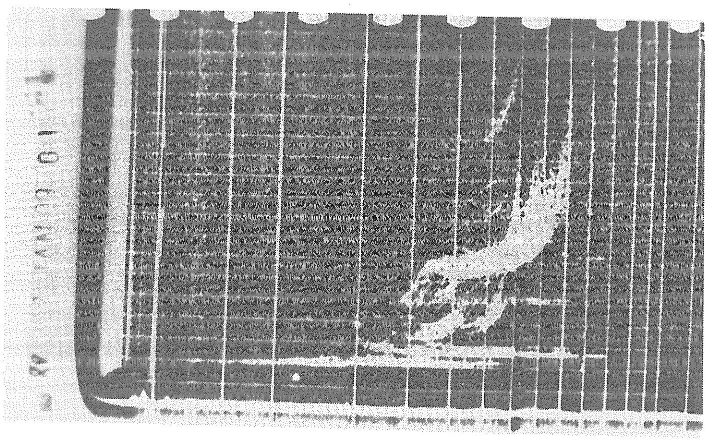
Observations: Two values of h'Es and foEs shown, although only one, that which is considered the most important, would normally be scaled. Obliques indicate presence of tilts, also (h3-3h1) is not equal to (h2-2h1); h3 = 850 km, h2 = 500 km, h1 = 250 km.

foF1 scaled as L. It appears that the trace with h'F at 220 km is the true overhead reflection, as a second reflection is observed with h'F at 500 km (at 4MHz). The primary trace shows little or no foF1 cusp. The cusp at 3.8 MHz is an oblique. Should foF1 be scaled as H (small tilt condition)?

foF2 was scaled as 62F because it appears to be a discrete trace matching with the second reflection.

Editor's Note: The r type Es is clearly at oblique incidence about 100 km away and can be rejected for tabulation under the oblique incidence trace rule. The first entries therefore represent the ionosphere most nearly overhead and would be adopted internationally.

Es TYPES LOW, HIGH, RETARDATION



CASEY

7TH JANUARY 1972

0901 U.T.
1701 L.T.

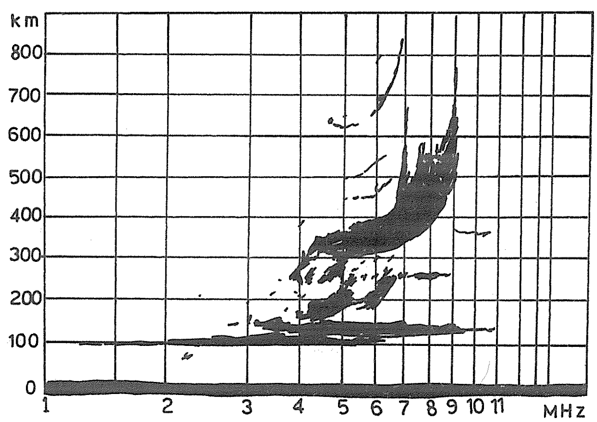
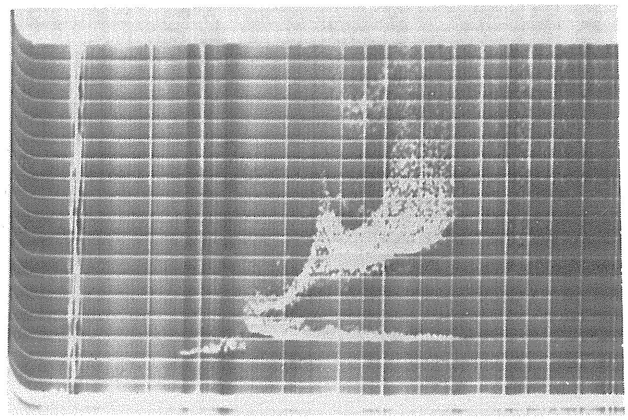


Fig. 5.8

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
13	A	A	100/125/160	61/102/55	38	l/h/r
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
A	U 43L		310	U 70F		90

Editor's Note: Similar to 6 January 1972. The high Es shows multiple traces which appear overhead. Best analysis is foEs = 102JA, h'Es = 125, type h2, ℓ,r. As second order confirms foF2 value, U not needed. M(3000) could be obtained by identifying main trace from height of second order but needs UF.

ES TYPE HIGH

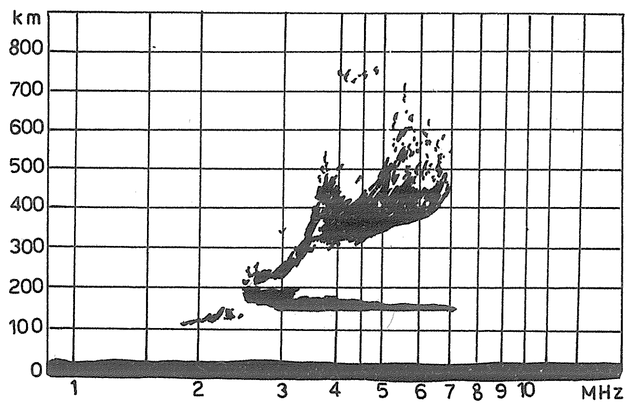


CASEY

5TH OCTOBER 1973

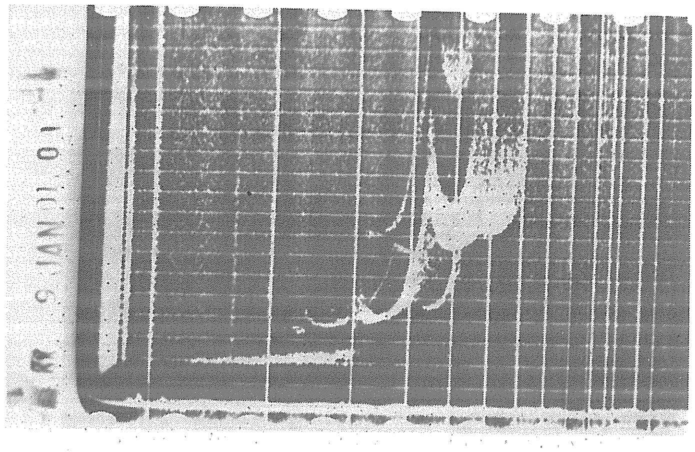
0815 U.T.
1615 L.T.

Fig. 5.9



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
18	110	245	150	64	E 25G	h
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
210	36		315F	U 52F		72

Z TRACES

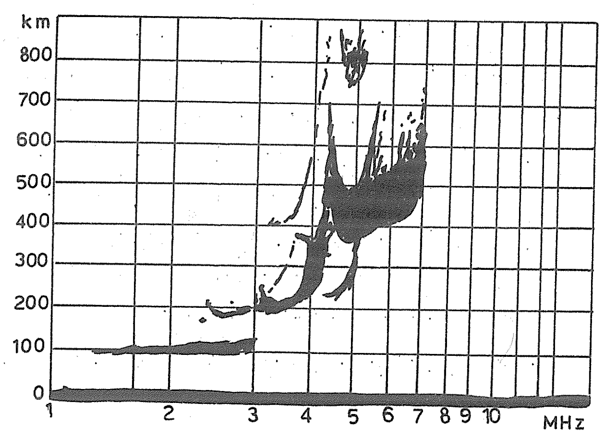


CASEY

9TH JANUARY 1972

0101 U.T.
0901 L.T.

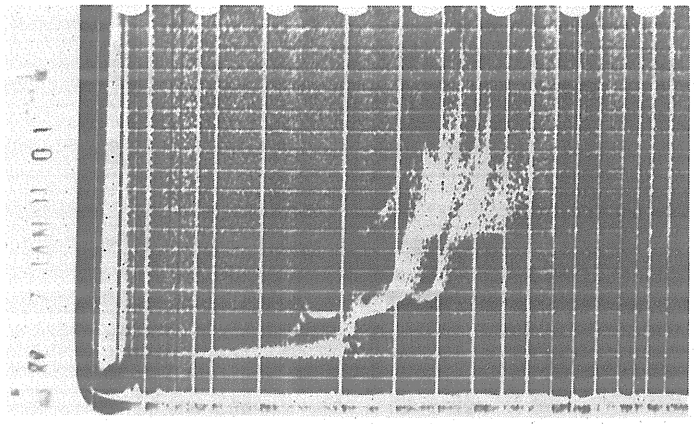
Fig. 5.10



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	95Z	310	G	E 31G	E 31G	
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
190	42		365	U 54F		70

Observations: A z component is visible, with fzE = 240-Z, fzF1 = 037. fzF2 is obscured by spread, and the foF2 frequency is determined using the inside edge of the F2 trace.

fzE

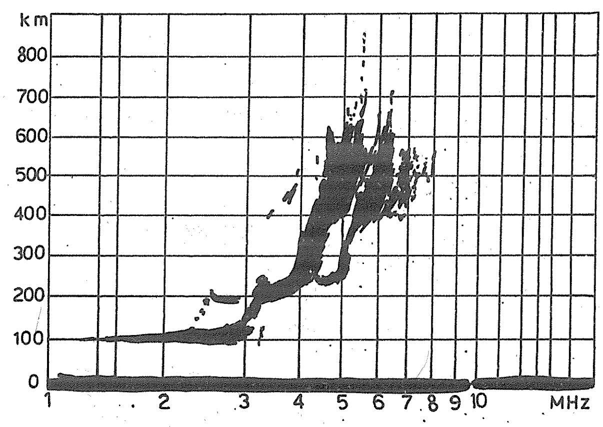


CASEY

7TH JANUARY 1972

0101 U.T.
0901 L.T.

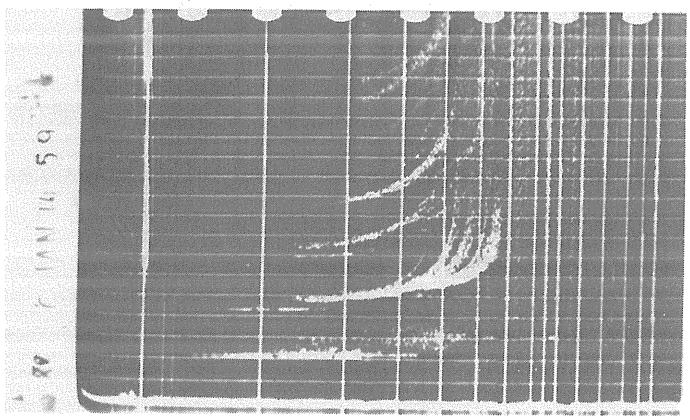
Fig. 5.11



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	95Z	320	G	E 32G	E 32G	
h'F	**foF1**	**M3000 F1**	**h'F2**	**foF2**	**M3000 F2**	**fxI**
190	U 46F		385	55F		80

Observations: fzE at 2.5 MHz. foF2 is measured from a discrete trace at 5.5 MHz.

Fz TRACE



CASEY

6TH JANUARY 1972

1459 U.T.
2259 L.T.

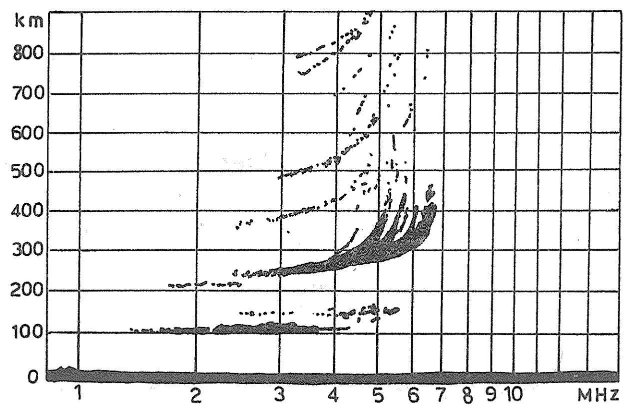
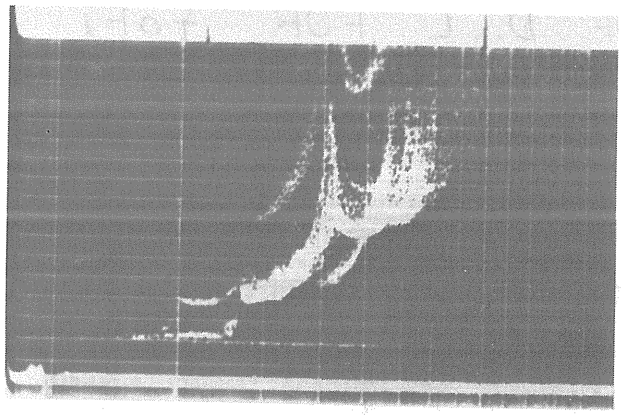


Fig. 5.12

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	A	A	100	36	24	ℓ
h'F	**foF1**	**M3000 F1**	**h'F2**	**foF2**	**M3000 F2**	**fxI**
235 Z				Z 53F		68

Observations: Notice the z component trace at 4.6 MHz, clean, no spread, no second reflection. The value of foF2 was derived from the z component, although the second reflection trace would also give a good value for foF2.

Editor's Note: Where several different criteria confirm, the numerical value lies within accuracy rules limit for unqualified data, no qualification is needed. Prefer 053 or 053F.

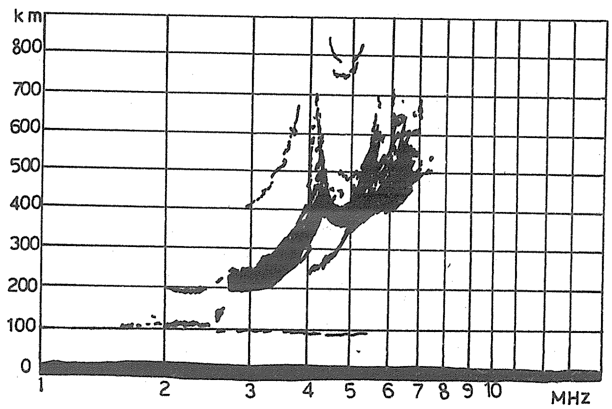


CASEY

3RD DECEMBER 1973

0401 U.T.
1201 L.T.

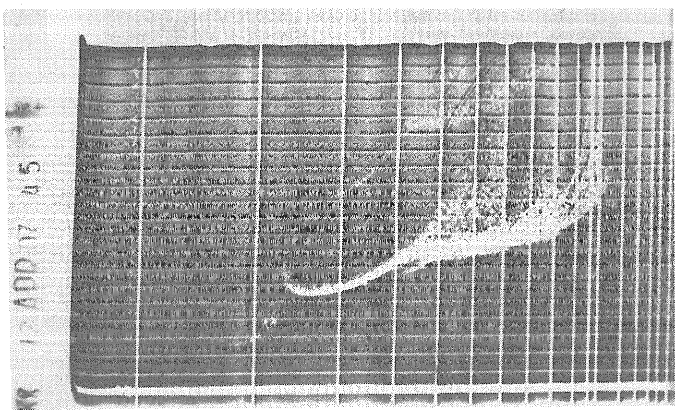
Fig. 5.13

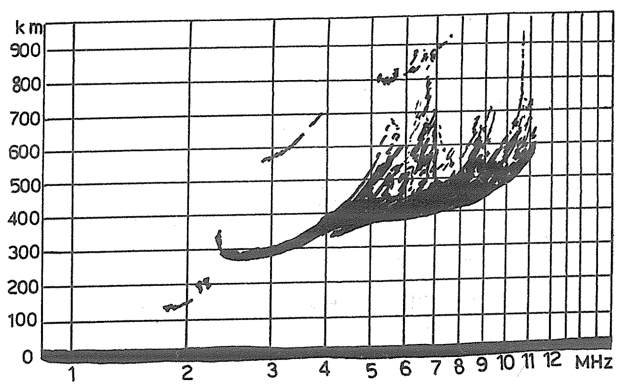


fmin	h'E	foE	h'Es	foEs	fbEs	typeEs
15	110Z	280	100	45	E 28G	ℓ
h'F	**foF1**	**M3000F1**	**h'F2**	**foF2**	**M3000F2**	**fxI**
190	41		360	U55F		76

<u>Observations</u>: fzE at 2.0 MHz. fxF1 just visible at 5.0 MHz. foF2 was identified from the second reflection trace.

USE OF D..L FOR foF1





CASEY

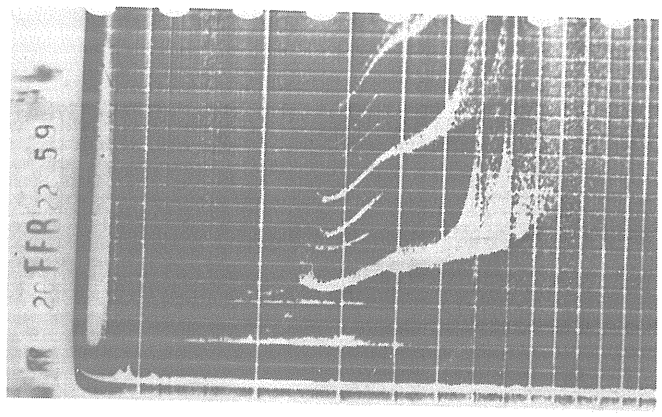
12 TH APRIL 1970

0745 U.T.
1545 L.T.

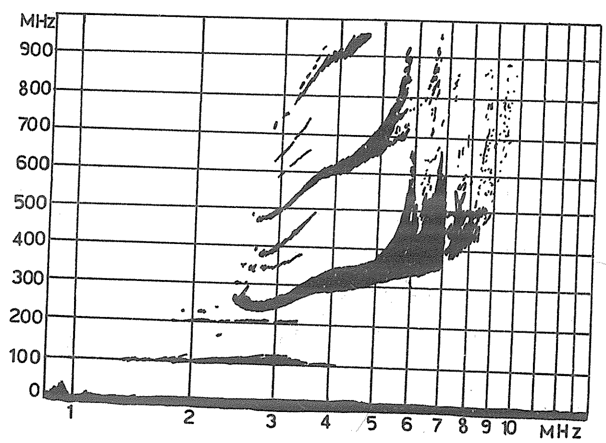
Fig. 5.14

fmin	h'E	foE	h'Es	foEs	fbEs	typeEs
18	120	220	G	E 22G	E 22G	
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
260	D 45 L		H	106 F		114

LARGE SCALE TILTS



CASEY



20 TH FEBRUARY 1972

2259 U.T.
21/ 0659 L.T.

Fig. 5.15

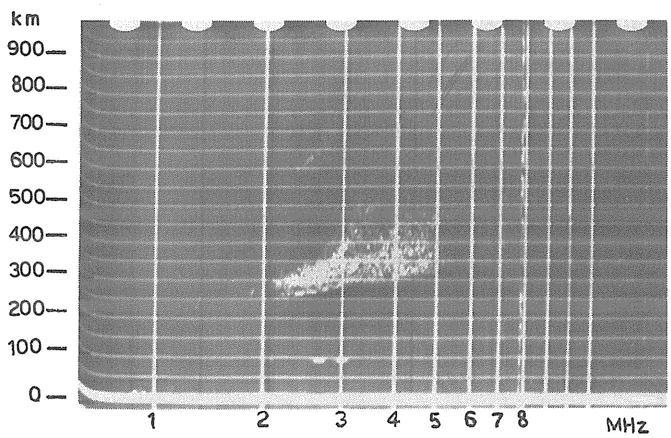
fmin	h'E	foE	h'Es	foEs	fbEs	typeEs
13	A	U220A	100	34	24	ℓ
h'F	**foF1**	**M3000F1**	**h'F2**	**foF2**	**M3000F2**	**fxI**
230	D42L		L	U60F		98

Observations: The height intervals of the multiple F2 echo traces are dissimilar, indicating large scale tilt. This would not be shown on our normal scaling sheets, as letter F would take preference. An inside edge measurement was used for foF2, as the second order value is inconsistent.

Editor's Note: The doubt in the possible value of foF2, as shown by second order and trace width, does not exceed accuracy rule limit, so qualifying letter U not necessary.

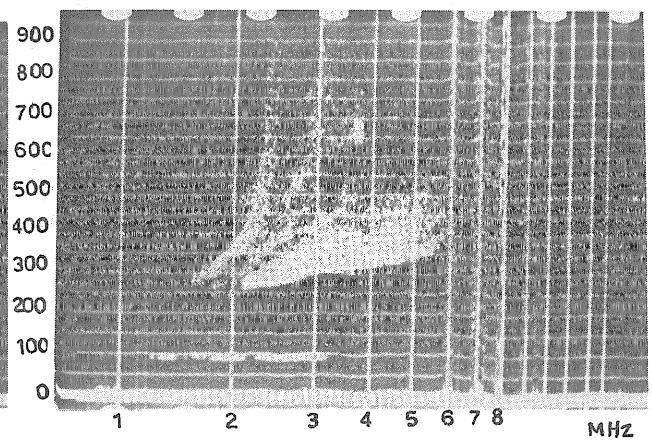
REPLACEMENT LAYER SEQUENCE

CASEY



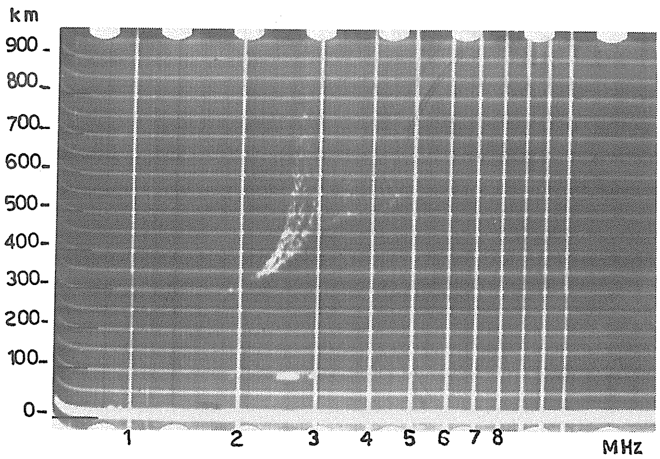
17TH MARCH 1971 1945 U.T. 18/0345 L.T.

CASEY



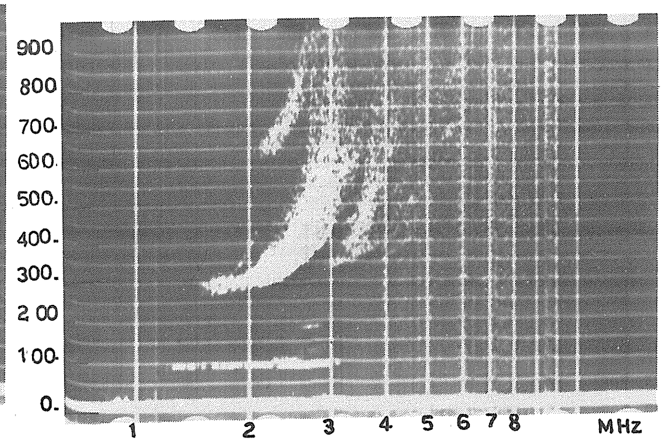
17TH MARCH 1971 1959 U.T.

CASEY



17TH MARCH 1971 2045 U.T.

CASEY



17TH MARCH 1971 2059 U.T.

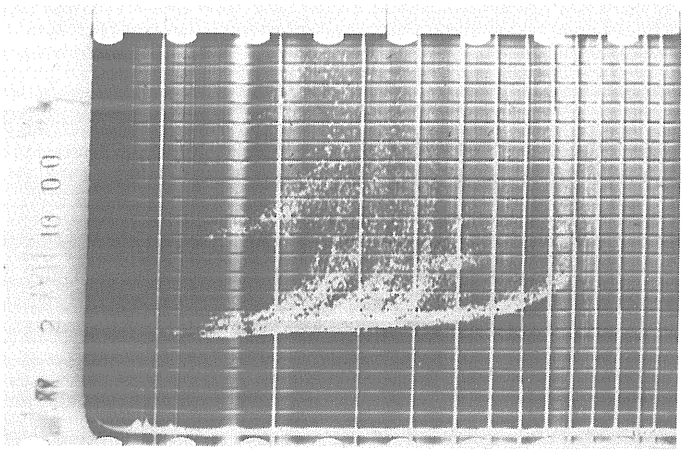
Fig. 5.16

17TH MARCH 1971 CASEY 1959 U.T.

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	B	E120B	90	21	15	f
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
E255A				U22F		60

Observations: In this sequence the F layer with h'F at 250 km at 1945 UT is gradually replaced by another F layer, visible on the 1959 UT ionogram (foF2 at 2.4 MHz). The high gain ionogram taken at 2059 UT shows the first F layer completely replaced.

POLAR SPUR



CASEY

2ND MAY 1972

1000 U.T.
1800 L.T.

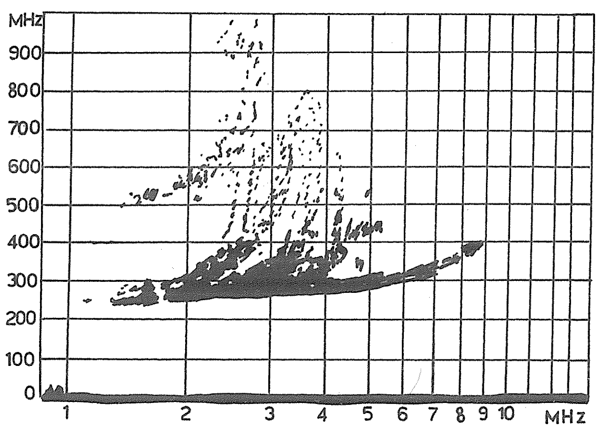
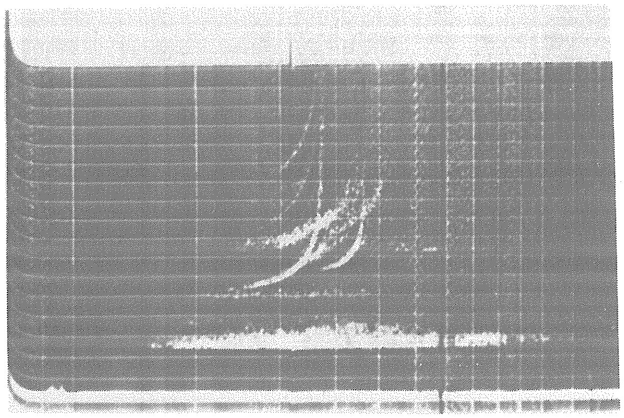


Fig. 5.17

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
13	B	E130B	B	E 13B	E 13 B	
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
230				27F		89

Observations: foF2 was measured using a discrete trace at 2.7 MHz, hence the unqualified value. fxI is measured as the highest observed frequency, i.e. the top frequency of the polar spur, 8.9 MHz.

SUMMER - NO SPREAD



CASEY

5TH DECEMBER 1973

1445 U.T.
2245 L.T.

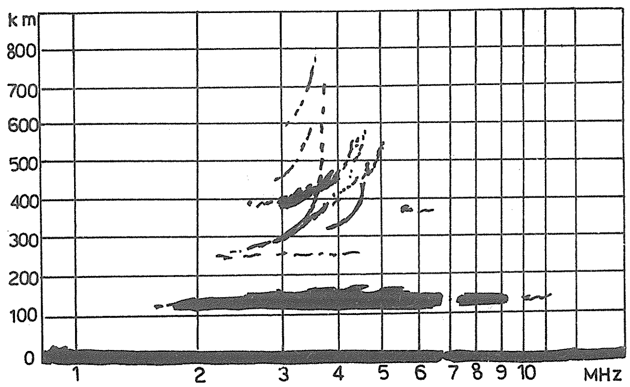
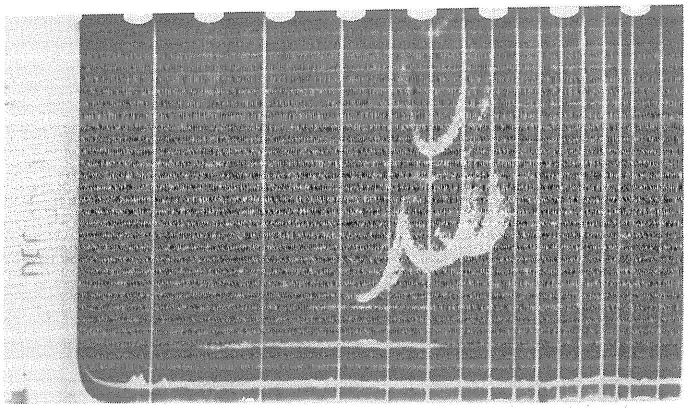
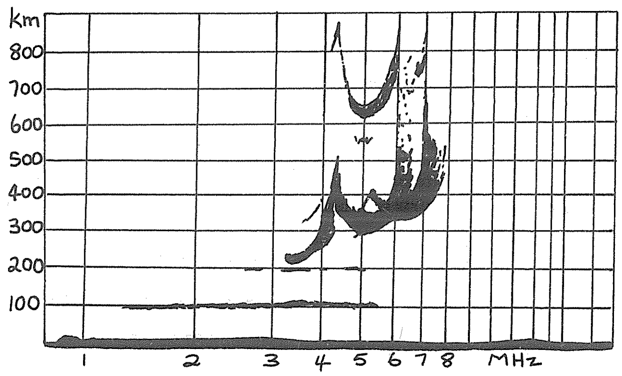


Fig. 5.18

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
15	B	E 150B	120	104	23	f
h'F	foF1	M 3000 F1	h'F2	foF2	M 3000 F2	fxI
E 260 A				37		46X

Editor's Note: The foE entry shows normal E is expected to be present; h'Es is consistent with Es type c at this time of day. The range spread is considerably greater than normally expected so there is a possibility of some Es type a also present. Non-vertical traces at F heights also suggest this. Preferred typing c2,a, or c2.





CASEY

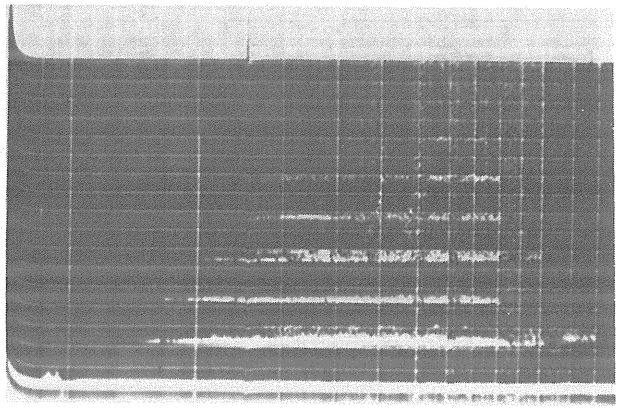
13TH DECEMBER 1972

0045 U.T.
0845 L.T.

Fig. 5.19

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	A	A	100	48	32	l_2
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
210	43		300	60F		79

REPLACEMENT LETTER "A"



CASEY

6TH DECEMBER 1973

1400 U.T.
2200 L.T.

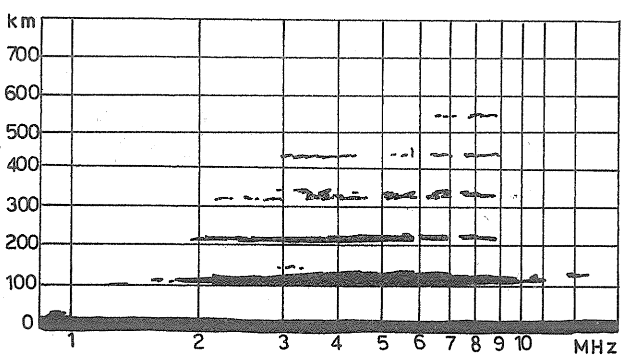
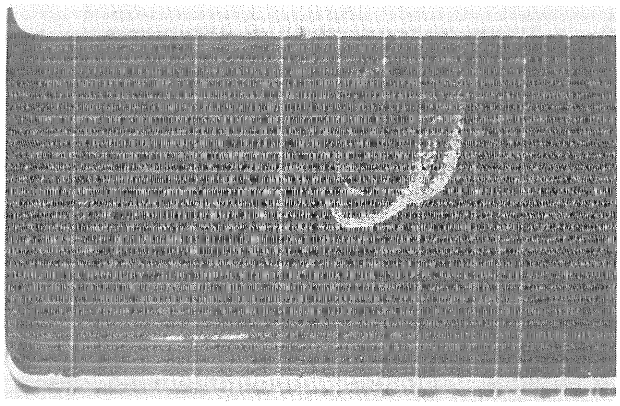


Fig. 5.20

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
15	B	E150B	100	J143A	A110A	f5
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
A	A		A	A	A	A

Observations: fbEs deduced from multiples (3rd order).

SMALL TILTS, USE OF DESCRIPTIVE LETTER H

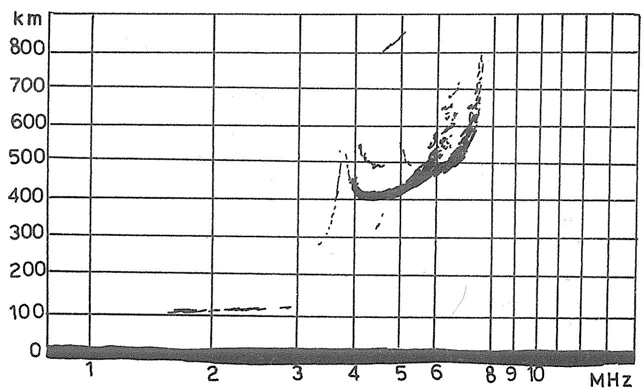


CASEY

2ND OCTOBER 1973

0615 U.T.
1415 L.T.

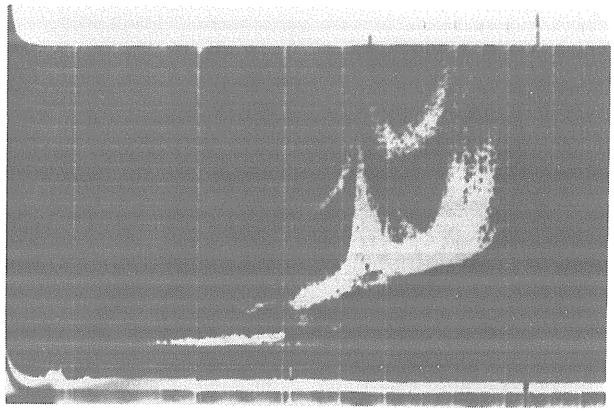
Fig. 5.21



fmin	h'E	foE	h'Es	foEs	fbEs	typeEs
16	110	U310Y	G	E 31G	E 31G	
h'F	**foF1**	**M3000F1**	**h'F2**	**foF2**	**M3000F2**	**fxI**
Y	U 38H		400	U 62F		75

Observations: Satellite trace near foF1 indicates small tilts. Note gap in region of foE, possibly due to Lacuna, as there is no retardation cusp at fmin F.

DAYTIME SUMMER IONOGRAM, WITH SPREAD

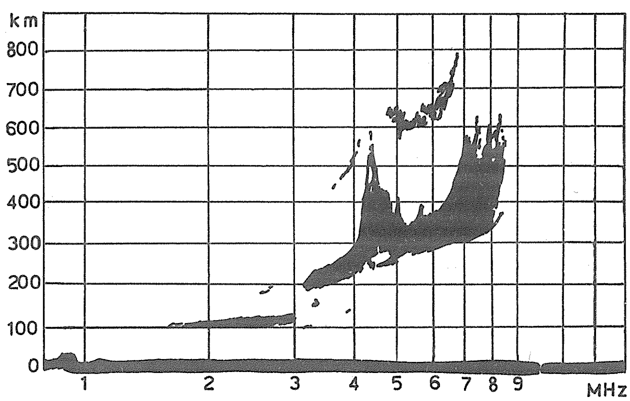


CASEY

3RD DECEMBER 1973

0901 U.T.
1701 L.T.

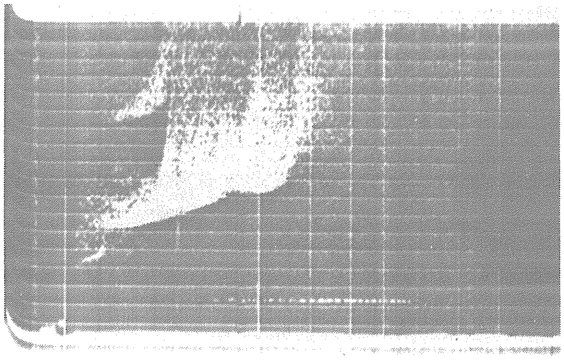
Fig. 5.22



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
16	100	305	G	E 31G	E 31G	
h'F	**foF1**	**M3000 F1**	**h'F2**	**foF2**	**M3000 F2**	**fxI**
180	43		270	U 70F		86

Observations: Good foF1 cusp. fxF1 is at 5.2 MHz.

WINTER SPREAD F

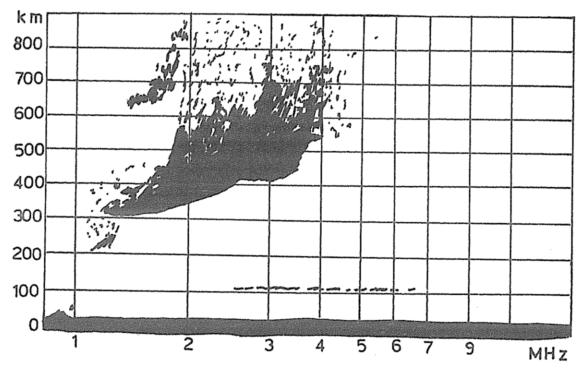


CASEY

19TH JUNE 1973

0201 U.T.
1001 L.T.

Fig. 5.23

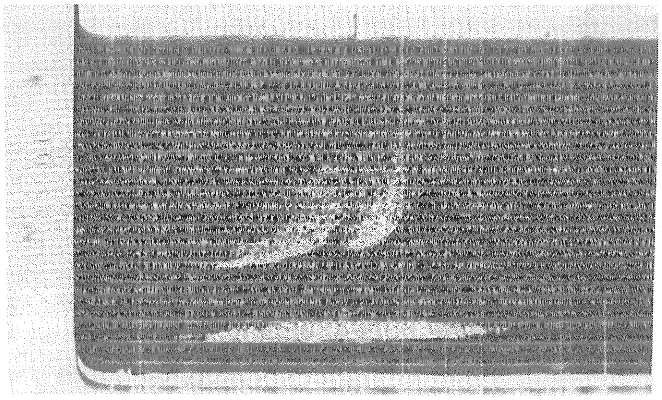


fmin	h'E	foE	h'Es	foEs	fbEs	type Es
11	B	U 125 K	115	60	E 13 G	k, f
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
310				U 19 F		45

Observations: Using second reflection, a good value may be obtained for foF2. Value of foE is uncertain due to layer tilt. This is believed to be a particle E layer, and "k" is used for Es type. However foEs, fbEs and h'Es are scaled for the flat type Es layer observed.

Editor's Note: Meteor Trace. This is a typical example of a large meteor giving an apparent Es flat trace. The regular deep fading is typical. h'Es, foEs, fbEs entries therefore incorrect, foE entry permissible. This is strictly either particle E seen obliquely or an Es type r trace. The virtual height is abnormally large so it could be rejected as an oblique trace. Optimum analysis probably type r,k, foEs = 125, fbEs = (foE)K = 110UK. foE entry 110UK. (K takes precedence over UB).

WINTER SPREAD F



CASEY

18TH JUNE 1973

1000 UT
1800 L.T.

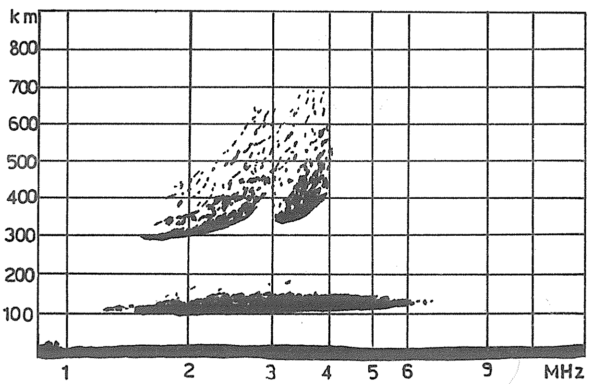
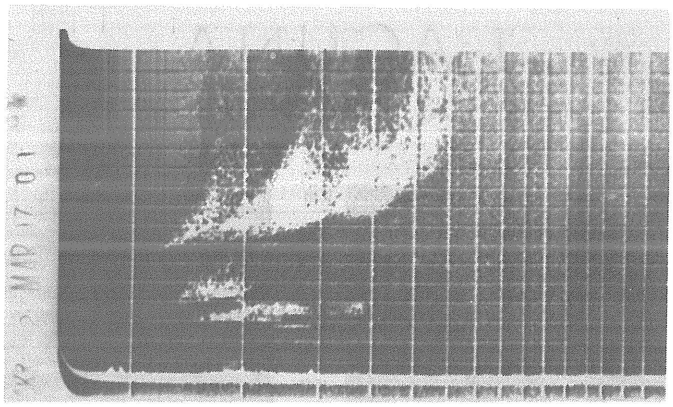


Fig. 5.24

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	B	E120B	100	62	15	f
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
285				F		40

Observations: Normal winter spread, with some range spreading present.

Editor's Note: The existence of foE above 1 MHz in winter is unlikely; probably no entry better. If foE is expected at this time, Es trace cannot be flat and type is deduced from h'Es relative to expected h'E. By convention flat is used when foE cannot be recorded.

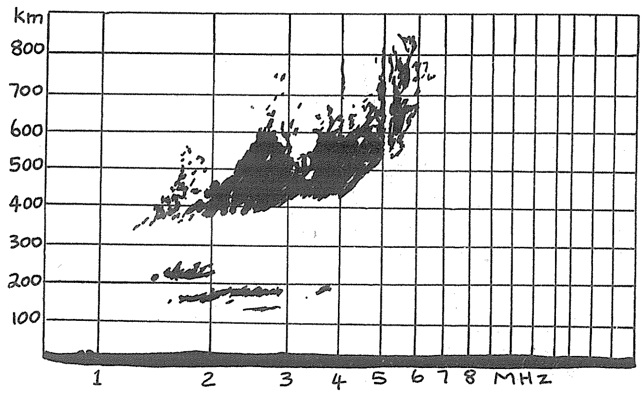


CASEY

20TH MARCH 1973

1701 UT
0101 L.T. (21 ST)

Fig. 5.25



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
13	B	E130B	150	29	E 13B	a
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
E330B				F		60

LACUNA

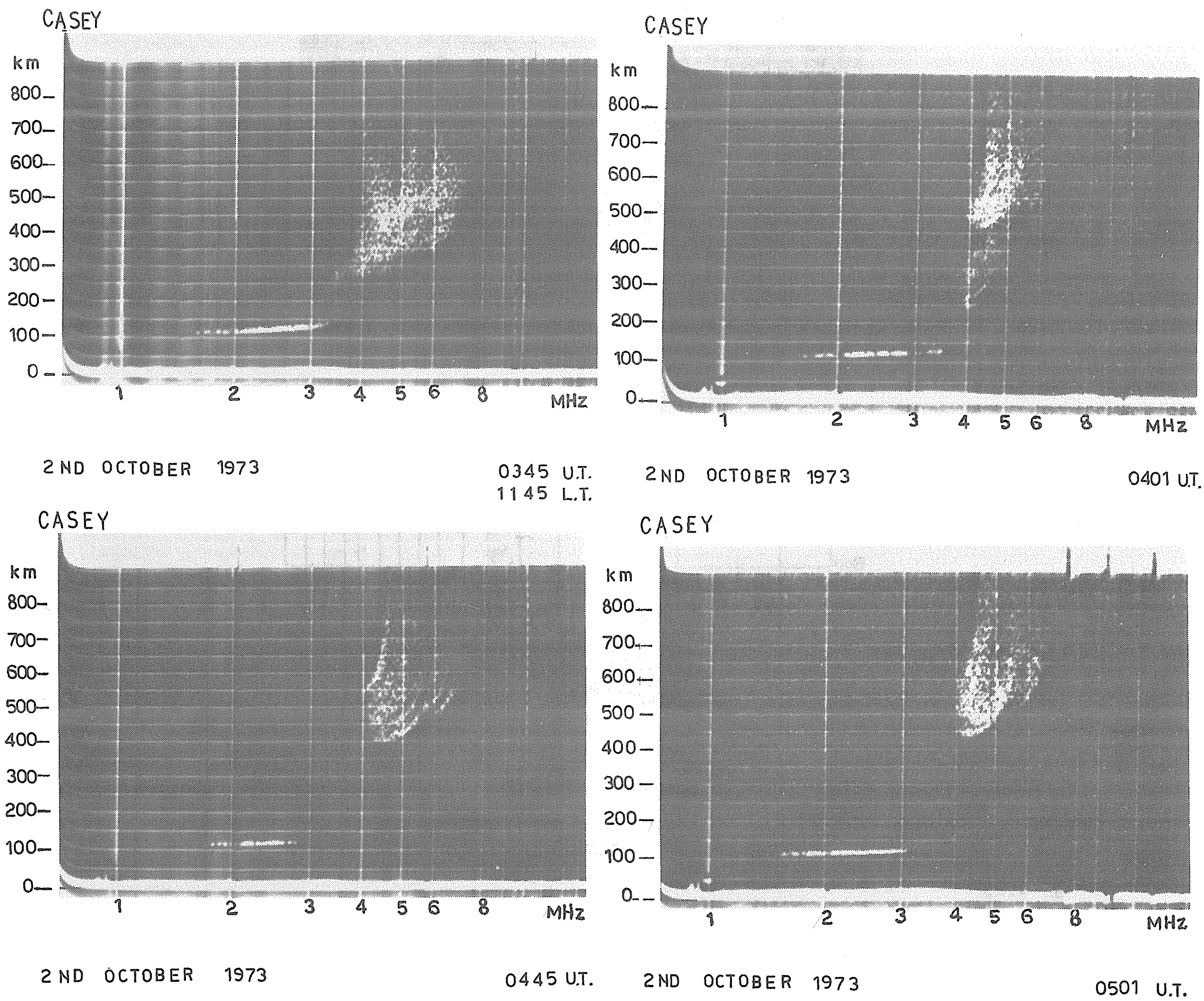


Fig. 5.26

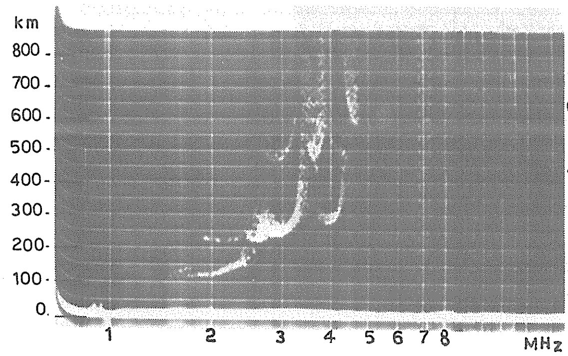
2ND OCTOBER 1973 CASEY 0445 U.T.

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
18	110	Y		E 18B	E 18B	
h'F	**foF1**	**M3000 F1**	**h'F2**	**foF2**	**M3000 F2**	**fxI**
Y	Y			U 46F		69

Observations: A typical case of Lacuna. In the ionogram at 0501 UT there is a faint trace of slant type Es extending from 3.1 MHz to almost 5.0 MHz. Lacuna is closely associated with slant type Es.

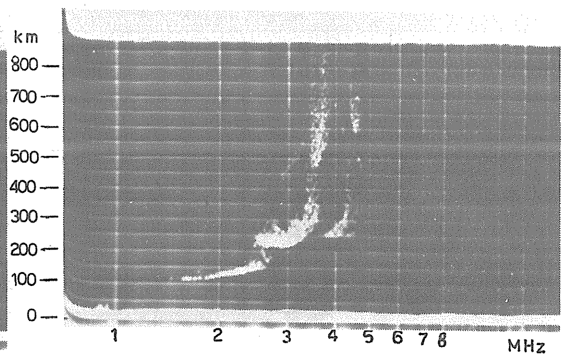
USE OF LETTER "G" FOR FoF2

CASEY



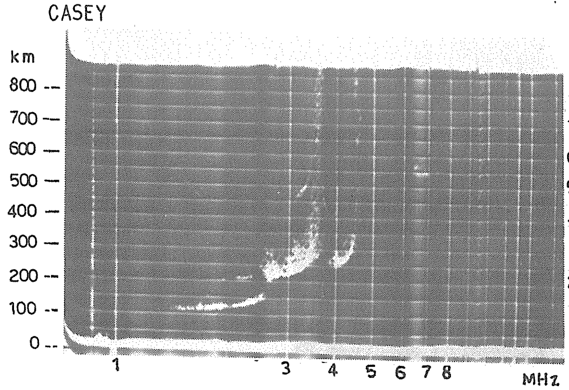
17TH OCTOBER 1973 0030 U.T. 0830 L.T.

CASEY



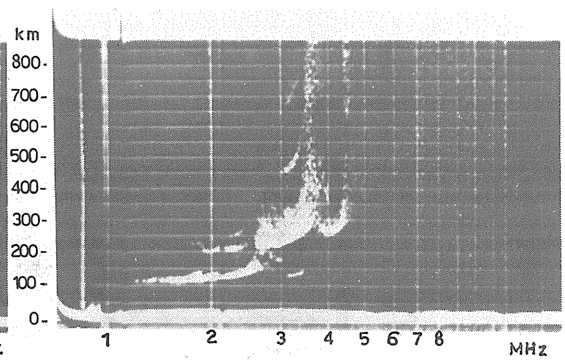
17TH OCTOBER 1973 0045 U.T.

CASEY



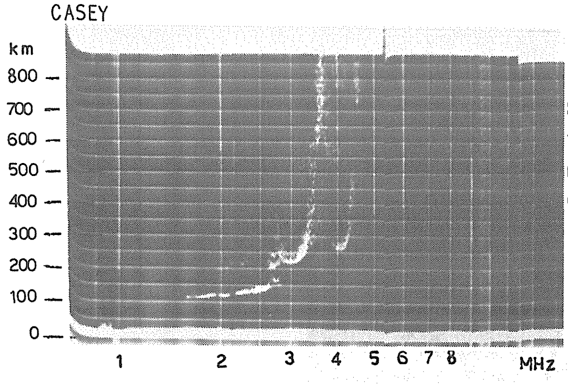
17 TH OCTOBER 1973 0100 U.T.

CASEY



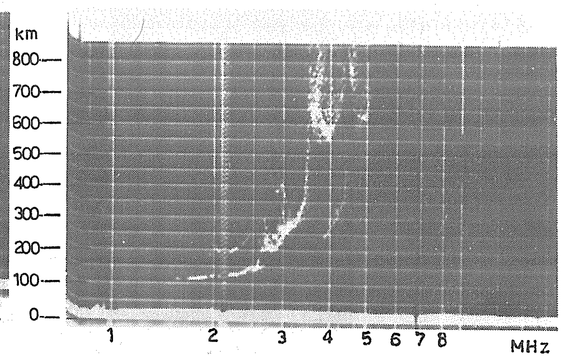
17 TH OCTOBER 1973 0101 U.T.

CASEY



17 TH OCTOBER 1973 0115 U.T.

CASEY



17 TH OCTOBER 1973 0130 U.T.

17TH OCTOBER 1973. CASEY 0100 U.T.

Fig. 5.27

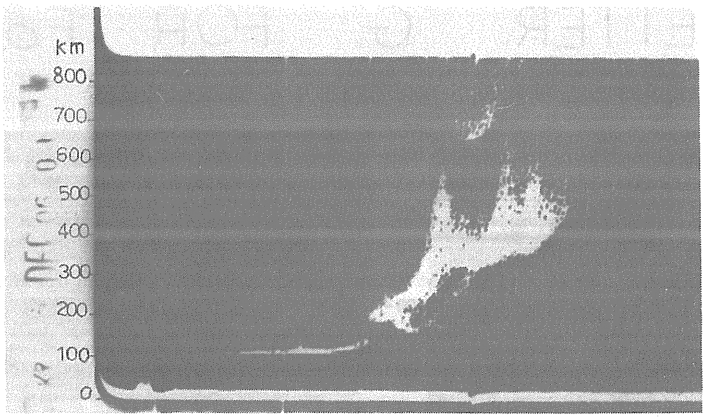
fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	110	260	G	E 26G	E 26G	
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
210	U 34F		G	E 34G	G	45X

USE OF LETTER "G" FOR foF2

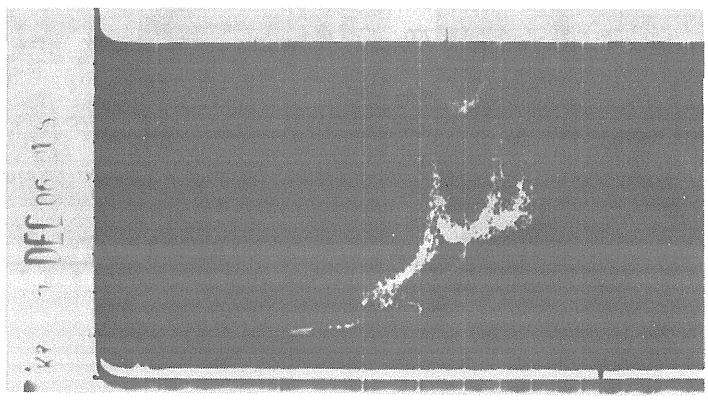
This sequence of ionograms shows the foF2 frequency decreasing to below the foF1 frequency. At 0030 UT foF1 = 3.4 MHz, foF2 = 3.8 MHz. By 0045 UT, foF2 has decreased in value to below foF1, only the spread component of foF2 showing. At 0115 UT, foF2 gradually reappears.

CASEY

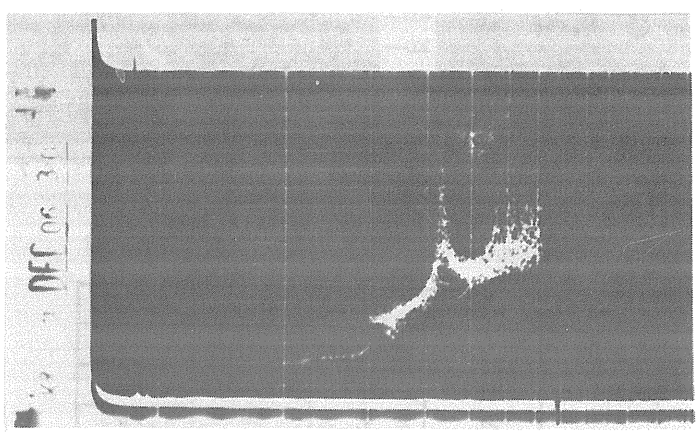
3RD DECEMBER 1973



0601 U.T.
1401 L.T.

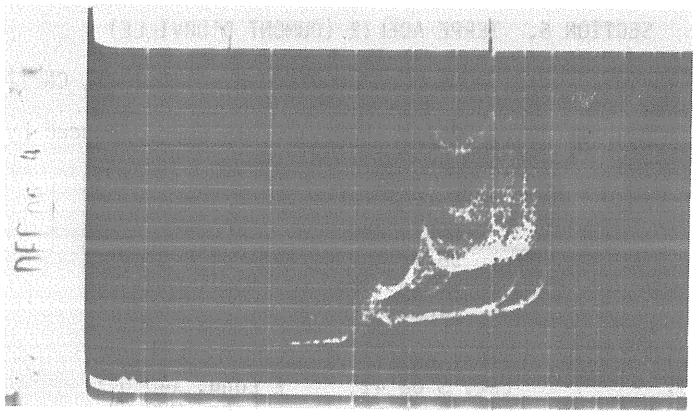


0615 U.T.
1415 L.T.



0630 U.T.
1430 L.T.

Fig. 5.28 (cont'd.)



CASEY

3RD DECEMBER 1973

0645 U.T.
14 45 L.T.

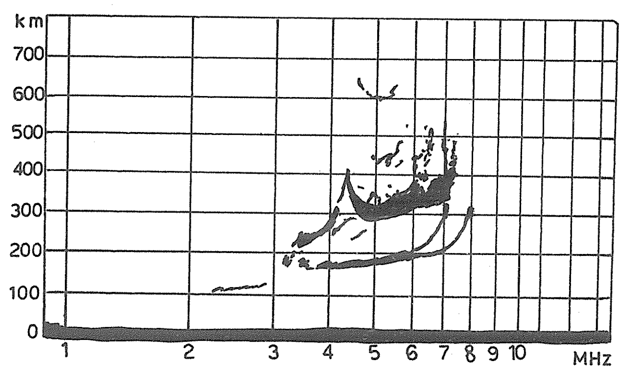


Fig. 5.28

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
22	110	335	?	?	?	?
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
220	42		290	U 61F		74

Observations: The unusual feature, at 175 km, with critical frequency at 7.0 MHz does not appear to be an Es layer. This feature appeared only on one frame, and the sequence on the previous page shows ionograms taken before 0645 UT. There appears to be a high type Es on all the ionograms.

Editor's Note: While very rare, this type of trace has been reported before as a short-lived phenomenon. More cases are needed to find out what is happening. Anyone seeing such a sequence is invited to inform INAG. Some research is needed --- there is no obvious solution at present. It could be a very severe local TID or a particle E seen at oblique incidence. It is more likely to be an F-layer anomaly than E, but if so probably involves electric forces not yet recognized.

SECTION 6. TERRE ADÉLIE (DUMONT D'URVILLE)

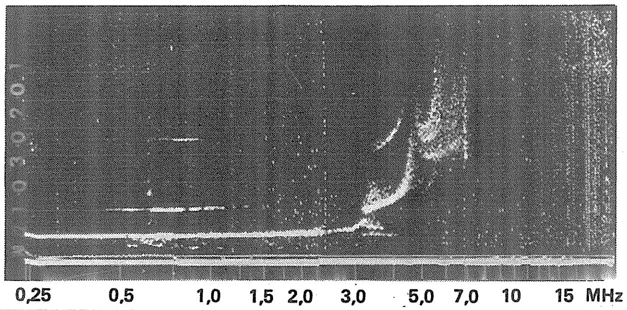
Terre Adélie ionograms and ionogram notes have been provided by G. Pillet, CNET/CRPE, Paris, France.

Editor's Note: A collection of Terre Adélie ionograms has been produced by G. Pillet and published as a booklet. Copies can be obtained from:

Mlle G. Pillet
CNET/CRPE
38-40 Rue du General LeClerc
92 131 Issy Les Moulineaux
Paris, France.

Station name:	Terre Adélie (Dumont d'Urville)	
Geographic coordinates:	Lat. S 66°41'	E Long. 140°01'
Geomagnetic coordinates:	Lat. S 75.5°	E Long. 230.9°
Invariant latitude:	80.52°	
Magnetic dip:	89.62°S	
Time used:	135°E (UT + 9 hours)	

DUMONT D'URVILLE
3.1.1972
02.01 UT
11.01 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E	100	315	135-G	037	032 EG	H
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
195 UH	047	xxx	440 UH	063-F	xxx -F	070

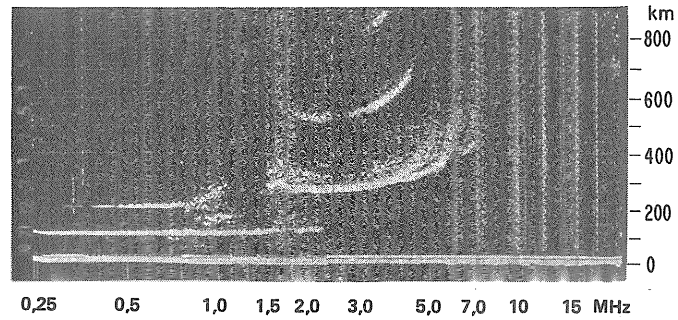
Fig. 6.1

TERRE ADÉLIE 3 January 1972 11.01 LT (135°E)

SUMMER DAY

fmin is low but varies regularly through the day. The E layer is very low and usually shows z traces. h'E can fall to 90 km. The z trace disappears when Lacuna or slant Es conditions are present. x traces from the E region are seldom seen. foE is easy to read except when Lacuna is present. Very little Es, mostly type c and h. h'F is abnormally low in summer, often near 180 km. The differences between the median values of fxI and fxF2 are as large as at night. Lacuna is a day time phenomenon at the station.

DUMONT D'URVILLE
31.12.1971
15.15 UT
00.15 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E	A	140 UH	100	017	008-G	L2
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
260-Q				050-F	xxx-F	72

Fig. 6.2

TERRE ADÉLIE 31 December 1971 00.15 LT (135°E)

SUMMER NIGHT

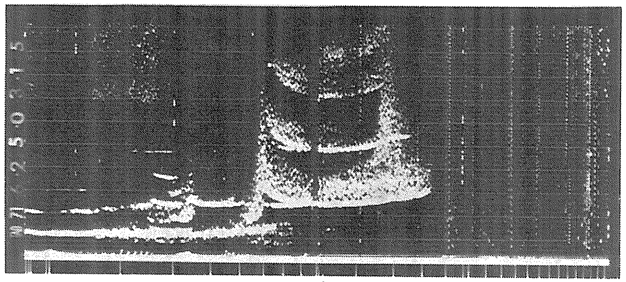
<u>Note</u>: E trace expected to be well above Es trace but probably not seen here. foE between 013 and 015. F layer tilted. Compare with Fig. 2.14-2.17 in Handbook.

Blanketing Es type ℓ predominates causing difficulties in measuring h'E. Numerous stratifications are present. fbEs exceeds foE on about 50% of occasions. foF1 is seldom seen between 21.00 and 03.00 LMT. foF2 is easy to read but there is usually some spread above fxF2.

DUMONT D'URVILLE

25.6.1971

03.15 UT
12.15 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E	100-H	150-H	120-Z	017	013 EG	C2S
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
235-Q				036 DF	F	053

Fig. 6.3

TERRE ADÉLIE 25 June 1971 12.15 LT (135°E)

WINTER DAY

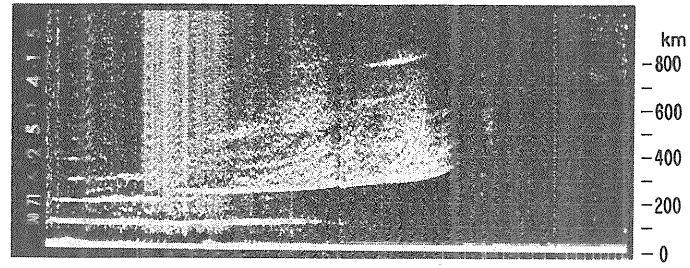
Note: z, o traces present in E; no x trace.

Very little absorption is observed in winter. h'E is usually near 100 km but the trace is often irregular, showing spurs, stratifications and spread as on the example shown. Es is seldom seen, when present usually type c or h. foF1 is seldom distinct and is transient. foF2 is seldom visible and the values found are not representative of average conditions. For example, a good median value of fxI of 10.2 MHz was found when median of 4 values of foF2 were only 064UF.

Editor's Note: The interpretation of this ionogram is not clear in the reproduction. In the original, it is more clear that the top end of the slant trace is hidden by the cusp Es trace so that foEs is 017. foEs is, of course, never measured from a slant trace. The cusp Es can be more clearly seen on the z mode which is always lower than the o-mode trace.

DUMONT D'URVILLE

25.6.1971
14.15 UT
23.15 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E			095	010	007	F4
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
235				033 JF	F	54

Fig. 6.4

TERRE ADÉLIE 25 June 1971 23.15 LT (135°E)

WINTER NIGHT

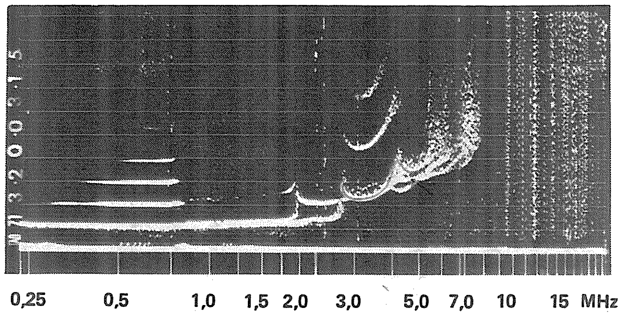
Absorption normally absent. Particle E (Night E) is often observed (50% of the time) but the values of foE are often blanketed. Particle E is found between midnight and sunrise. Es is always present. It is usually type f or, when particle E is present, type ℓ with h'Es close to 100 km. Auroral Es is frequently seen about 0400 LT (135°E). Much spread F is present but h'F is easily evaluated. fxI is the most important F-region parameter. The few foF2 values found represent abnormal conditions.

DUMONT D'URVILLE

20.III.1971

03.15 UT

12.15 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E	100	270	095	012 G	G	L5
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
220	041	xxx	340 UH	066 UH	xxx F	077

Fig. 6.5

TERRE ADÉLIE 20 March 1971 12.15 LT (135°E)

EQUINOX DAY

Note: fbEs is seen clearly on z trace. fbEsZ = 008 but is not visible on o trace. There is no INAG ruling. Descriptive letter G is needed as foEs and fbEs less than foE. Optimum is fbEs = (fbEsZ + fB/2)ZG = 015ZG.

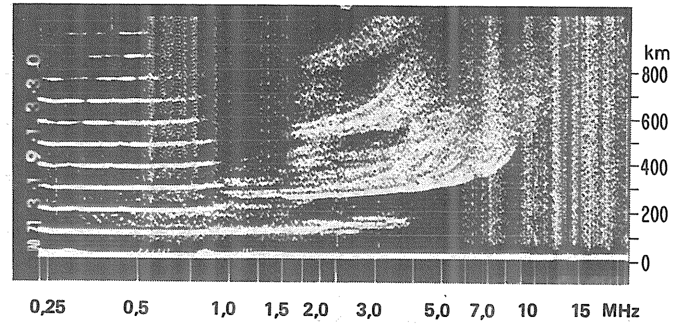
The absorption is usually maximum at the equinoxes. The example given with fmin = E is not representative. h'E varies smoothly during a day but its value from day-to-day can vary between 100 and 120 km. There are few problems in interpreting foE as Es is usually absent. Es when present is usually type h or c and is seldom blanketing. Good values of foF1 and M(3000)F1 can be observed between 0700 and 1600 LT (135°E). Spread F and tilted F layers are very common. About one-third of the values of foF2 are replaced by F and most of the remainder are uncertain (UF). The greatest values of foF2 are found between about 1200 and 1800 LT (135°E). fxI usually exceeds fxF2 by between 1 and 2 MHz. This is due to frequency spread.

DUMONT D'URVILLE

19.III.1971

13.30 UT

22.30 LT



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
E			095	021	010	F9
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxI**
280-Q				040-F	xxx-F	94

Fig. 6.6

TERRE ADÉLIE 19 March 1971 22.30 LT (135°E)

EQUINOX NIGHT

Note: Overhead trace is upper trace of multiple patterns which show downwards range spread. x trace is below o trace showing severe N/S tilt. (Fig. 2.12 in Handbook).

There is seldom enough absorption for fmin E. Very few examples of normal or particle E are observed mainly because of blanketing by Es. Es is always present and interferes with the interpretation of higher traces. Es traces are often diffuse and complicated, covering between 100 and 200 km. F traces are usually diffuse showing both range spread and frequency spread. Only a few values of foF2 are obtainable. Correspondingly few values of M(3000)F2 are available. fxI is therefore our main F2 parameter; the value of fxI exceeds fxF2 by at least 1 MHz.

SECTION 7. MAWSON STATION

AUSTRALIAN STATIONS

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 tables 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.

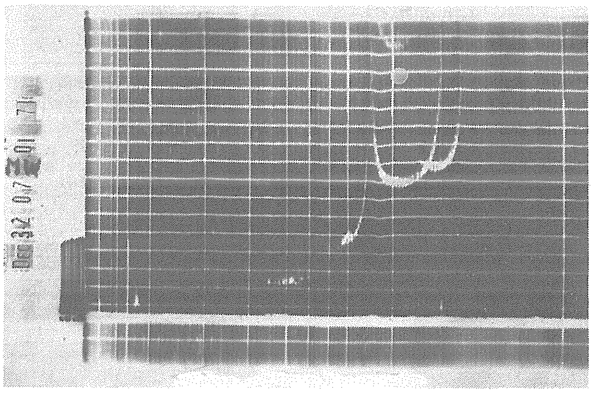
Vertical Incidence Soundings at Mawson

Operation of the IPS Type 3E ionosonde began at this station in February 1959. Vertical incidence data are published monthly in an Australian ionospheric data computer listing. Information about the station or the data is available from:

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

Station name:	Mawson	
Geographic coordinates:	Lat. S 67.60°	E Long. 62.90°
Geomagnetic coordinates:	Lat. S 73.17°	E Long. 103.54°
Invariant latitude:	70.28°	
Magnetic dip:	68.92°	
Time Used:	60°E (UT + 4 hours)	
Ionosonde equipment type:	IPS 3E	
Routine sounding:	Every 15 minutes	
Recording medium:	35 mm film	
Data available:	Tables, computer printouts normally available 14 months after observations	

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



MAWSON

SUMMER DAY

1ST JANUARY, 1972

0701 U.T.

1101 L.T.

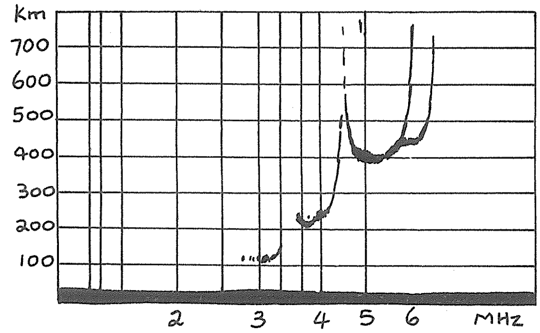
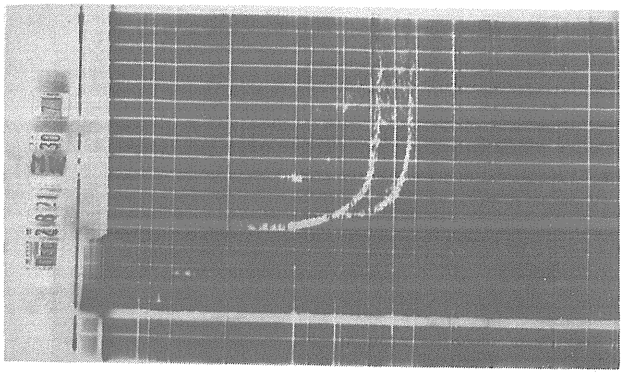
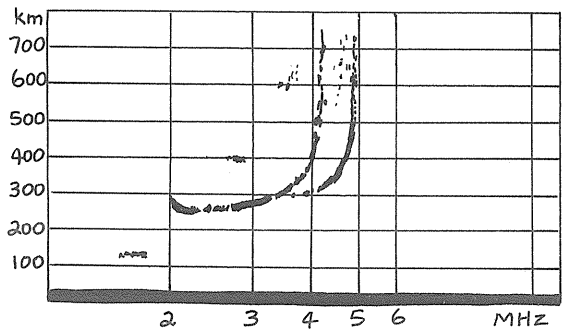


Fig. 7.1

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
27	110	350R	G	E 35G	E 35G	
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
200	45		380	62		69X





MAWSON

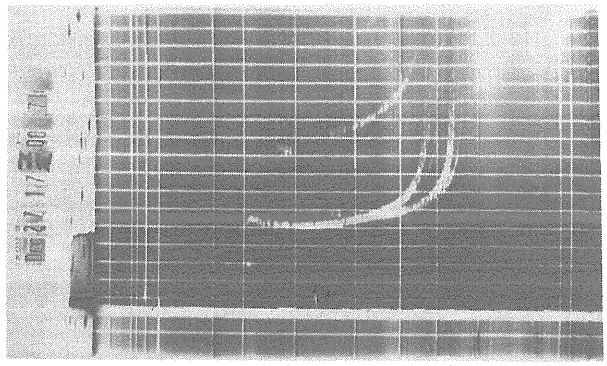
SUMMER NIGHT

28TH DECEMBER, 1971

2130 U.T.
0230 L.T. (29TH)

Fig. 7.2

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	A	U190R	120	E 18G	U 18R	f
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
250				42F		50



MAWSON

SUMMER NIGHT

27TH DECEMBER, 1971

1700 U.T.

2100 L.T.

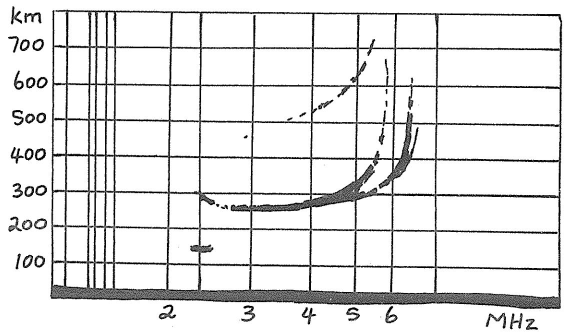
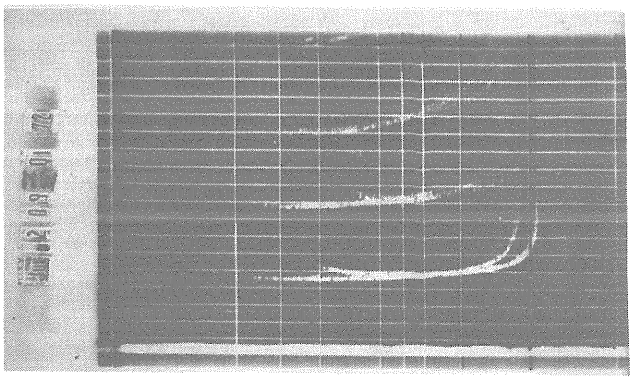


Fig. 7.3

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
22	B	U220B	135	23	E 22 B	f
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
250				57 F		69



MAWSON

WINTER DAY

2ND JULY, 1972

0901 U.T.

1301 L.T.

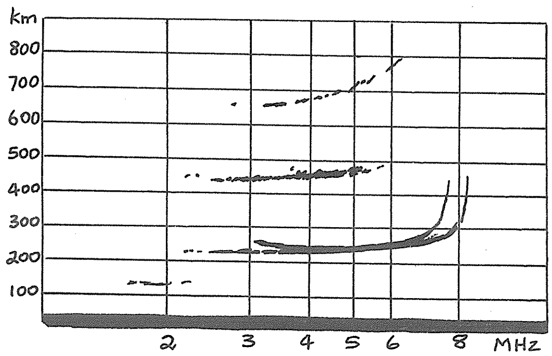
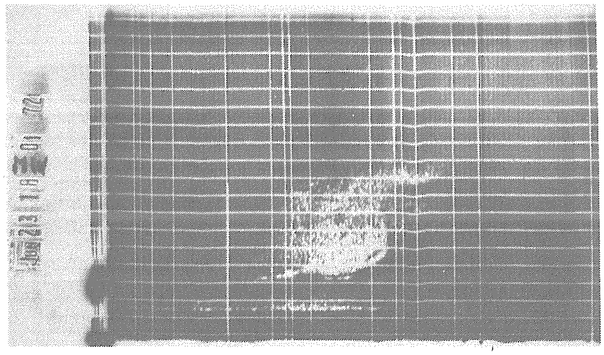


Fig. 7.4

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
16	A	E 220 A	130	22	22	f
h'F	foF1	M3000F1	h'F2	foF2	M3000F2	fxI
220				75		82 x

Editor's Note: foE is usually expected to be present so Es type can be deduced from h'Es-h'E. In this case optimum analysis would give Es type c or h depending on value of h'E usually found. If foE not usually seen, better to leave foE entry blank in which case f appropriate.



MAWSON

WINTER NIGHT

23RD JUNE, 1972

1801 U.T.

2201 L.T.

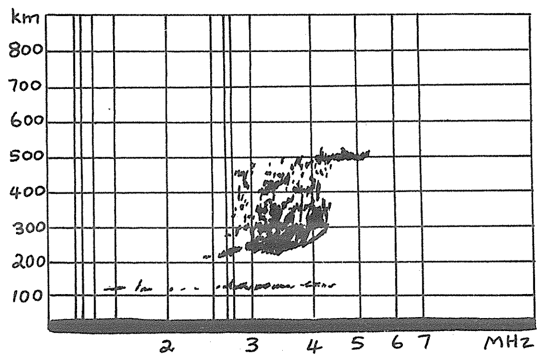
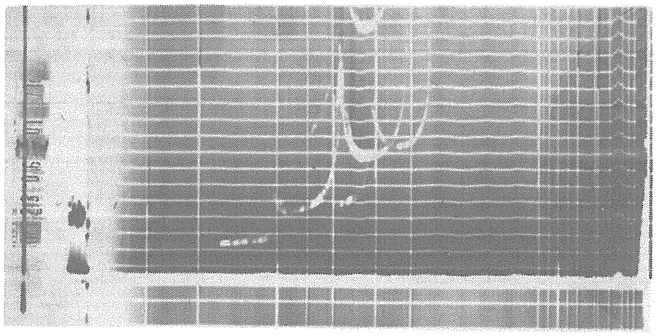


Fig. 7.5

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
12	A	A	120	37	23	f
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
210				F		55

Editor's Note: A very tilted layer, fxF2 is probably below 4.1 MHz, foF2 above 3.1 MHz suggesting foF2 between 3.1 and 3.5. Possible to interpret this as foF2 = 033UF as shape of lower edge strongly suggests o and x traces present. If sequence suggests doubt on whether x present, foF2 = F. Quick sequence, e.g., from gain runs, is essential to analyze this type of record which could be due to auroral Es seen at oblique incidence.



MAWSON

23RD OCTOBER, 1971

0601 U.T.
1001 L.T.

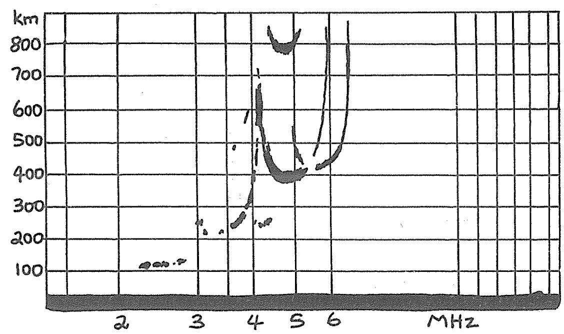
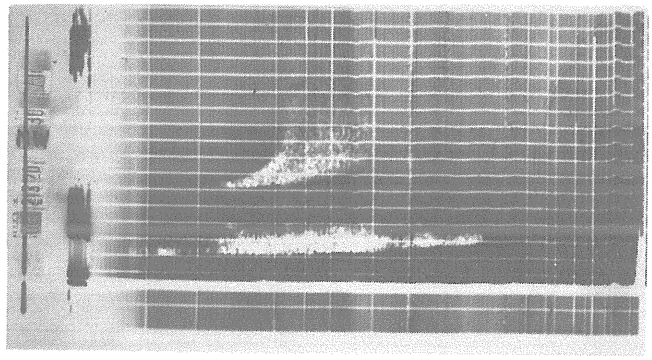


Fig. 7.6

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
22	110	295	G	E 29G	E 29G	
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
205	42		375	58		65X



MAWSON

23RD OCTOBER 1971

2030 U.T.
0030 L.T. (24TH)

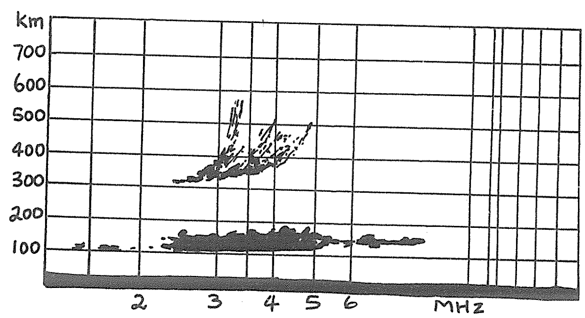


Fig. 7.7

fmin	h'E	foE	h'Es	foEs	fbEs	type Es
14	B	E 140 B	100	78	23	f
h'F	foF1	M3000 F1	h'F2	foF2	M3000 F2	fxI
300				U 32 F		50

Editor's Note: This Es trace is not horizontal and shows much broadening with ftEs for thick part of trace near fxF2. Most likely to be an auroral trace with slant rising from it. fmin low so ftEs probably x mode, prefer foEs = 046JA types a,s.

SECTION 8. BYRD STATION

Ionograms from United States operated ionosondes

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

BYRD -- Operations began July 1957. This station was operated by NBS, ESSA and NOAA and closed December 1970.

Station name:	Byrd	
Geographic coordinates:	Lat. S 80.00°	E Long. 240.0°
Geomagnetic coordinates:	Lat. S 79.50°	E Long. 336.21°
Invariant latitude:	67.82°	
Magnetic dip:	75.1°S	
Time used:	120°W (UT - 8 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:	700 km	
Height scale:	Linear	
Frequency scale:	Logarithmic	

Enquiries about this station should be addressed to:

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

Fig. 8.1

Editor's Notes on Es Sequence BYRD STATION, April 17-18, 1966.

April 17, 1966, 2300 LT (120°W). Es-r with second order trace showing retardation at low frequency end and low Es. Other weak Es traces present types a and r. Retardation indicates thick layer with foE near 150 which must be Es-k with foE = 150UK. h'E = A. (Expanded record suggests h'E = 120UA). Type r2, ℓ,k.

April 18, 1966, 0000 LT (120°W). Es-a. Es-h with retardation at low frequency end and shape of pattern indicate Es-k with foE = 160UK. foEs from high = 019 confirmed by x trace. fbEs = 017. Types h,k,a.

0015 LT (120°W). Retardation at fbEs and weak 2E trace show Es-k with foE = 130-K. Hence flat trace is Es-ℓ. General pattern Es-a. foEs from low trace 018, fbEs 010. Types ℓ,k,a, foF2 = 044.

0100 LT (120°W). No trace of particle E. Es-f and Es-a. F pattern breaks up into two with foF2 probably near 022 and 036, respectively. Apparently nearing trough condition. Lower o-x pair most nearly correct so foF2 = 022UF. (U mainly interpretation).

0130 LT (120°W). Es-f and two Es-a structures. Type ℓ,a,a. Two F structures. o and x traces suggest foF = 045 more nearly overhead. foF2 = 045UF.

0200 LT (120°W). Large increase in absorption. Es-a, Es-d, foF2 = 021UR. fxI deduced from o-trace scatter, fxI = 0520B.

0300 LT (120°W). Difficult. fmin as high as 020, Es-d still present, Es-r with foEs = 026 strong enough to screen foF2 near 022. Hence foF2 is ---A. (fxI more likely to be absent due to absorption judging by previous record.) Hence prefer fxI ---B.

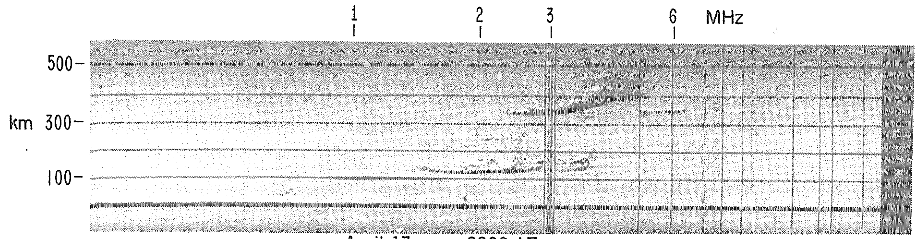
0400 LT (120°W). Expanded scale pattern clearly shows Es-k. Lack of scatter near foEs on main ionogram shows this also. Es-k (particle E) with foE = 380-K. This is a thick layer so F parameters best replaced by G. foEs = fbEs = 038-K.

0430 LT (120°W). Es-r with short length of Es-f near fmin. Es-a also. Types r,f,a.

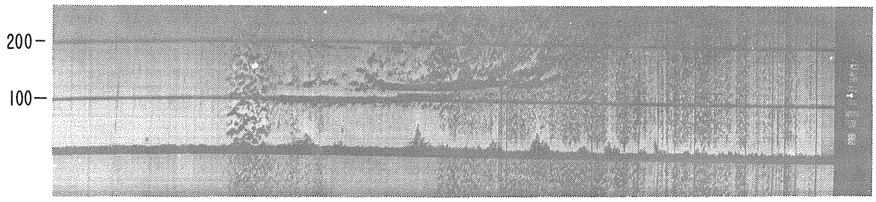
0445 LT (120°W). Es-r with short possible second order. However not blanketing so probably not a true second order trace. Retardation at low frequency end of F trace, hence Es-k also typical Es cusp. Types r,k2,c. foE = 135UK, fxI deduced from o-trace. Es-k confirmed by second order trace.

0500 LT (120°W). Es-r and Es-k. Second order Es-k gives foE-K slightly less than foEs but consistent with low frequency boundary of Es cusp. x trace suggests no Es-r. Hence foE value could be either 250 or 270. Adopt more certain 250UK with U for interpretation doubt. In practice these small differences have little scientific importance so 270-K would be acceptable.

BYRD STATION APRIL 1966 (120° WMT)

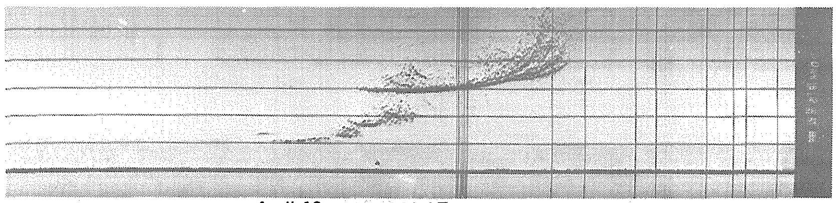


April 17 2300 LT



2301 LT

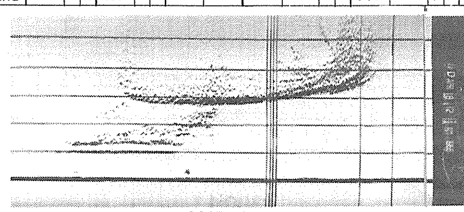
fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
009			023	027			120			r²ℓk	150	U	Ā	125	U	Ā							044		U	F	042	057			330					



April 18 0000 LT

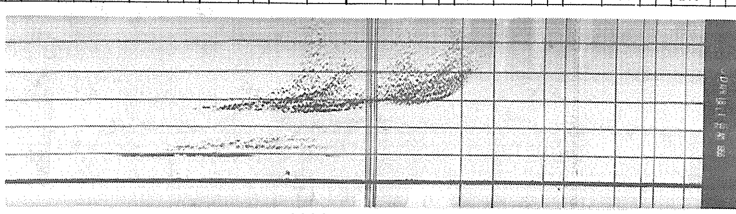
0001 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
010			018	021			160			hka			A	130									044		U	F	043	058			280					



0015 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
010			010	018			125			ℓka	130			230	E	A							044				044	054			270					



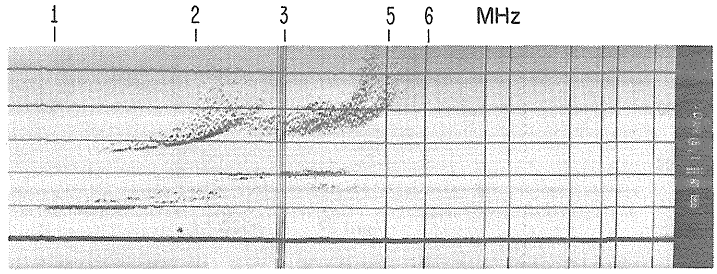
0100 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
008			010	017			096			ℓa			A			A							022		U	F	019	056			270					

Es Sequence

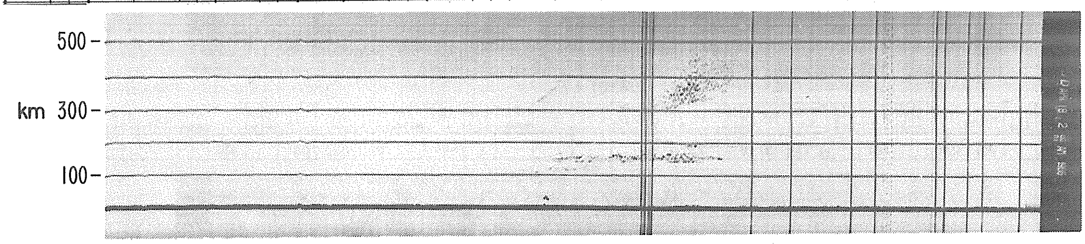
Fig. 8.1 (cont'd.)

BYRD STATION APRIL 1966 (120° WMT)

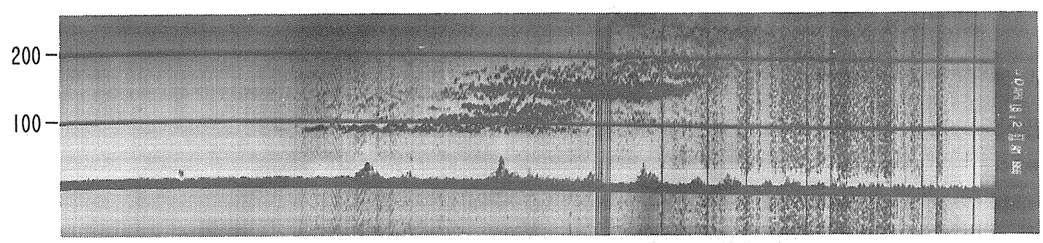


April 18 0130 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
009			012	016			097			ℓaa			A			A							045		U	F	019	054			320					

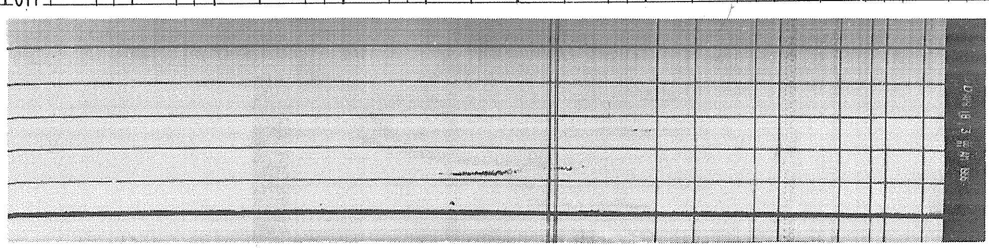


0200 LT

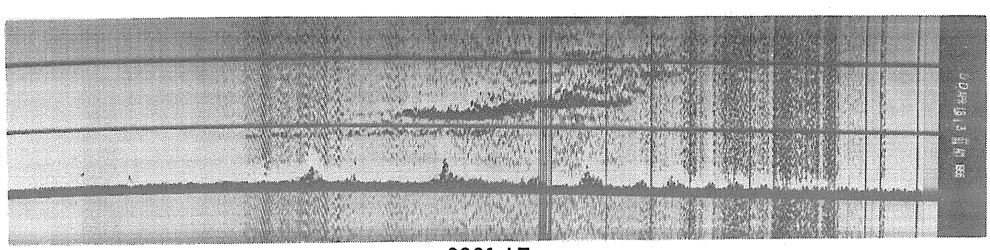


0201 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
017			EB 017	037	J	A	140			ad			B			B							021		U	R	021	052	0	B	320	E	B			



0300 LT

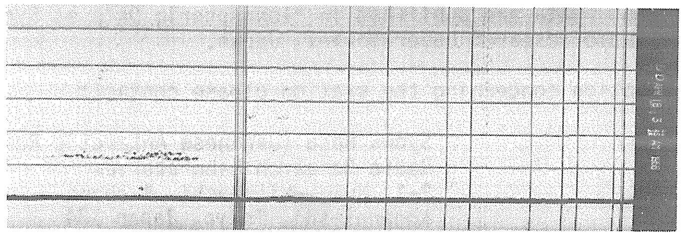


0301 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
018			EB 018	026			108						B			B										A				B			B			

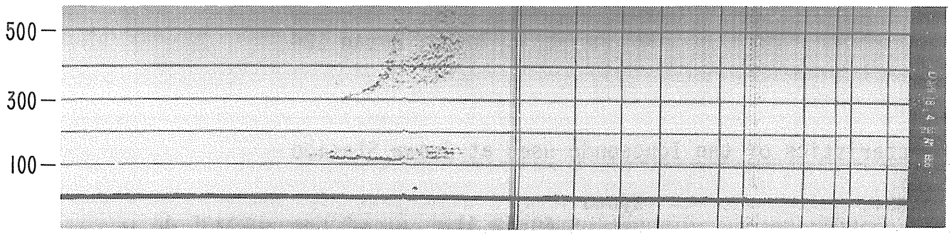
Es Sequence

Fig. 8.1 (cont'd.)

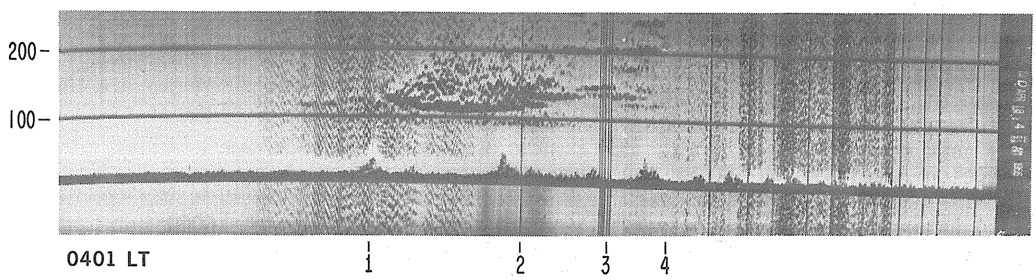


April 18 0345 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
014			016	019	J	A	115			ra													016								350	E	A			

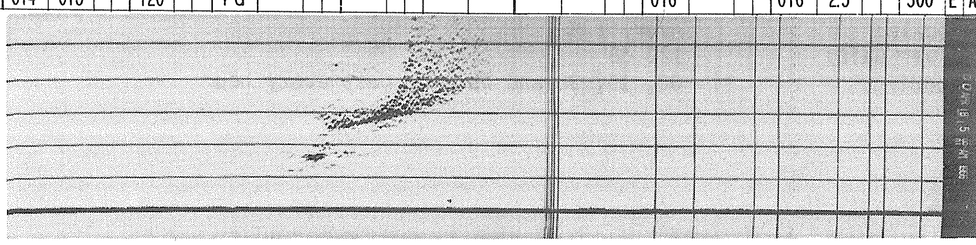


0400 LT

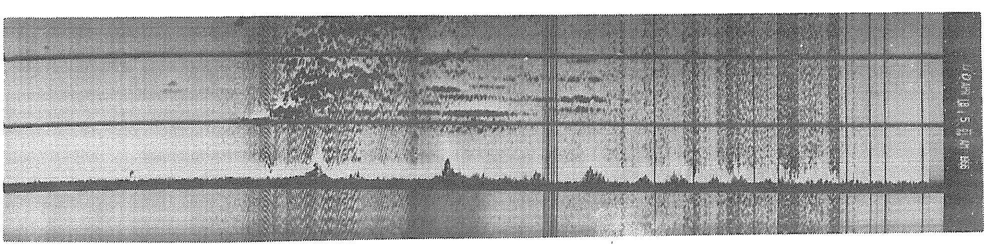


0401 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
012			014	015			120			ra													016				016	2.3			300	E	A			



0500 LT



0501 LT

fo	QUA	DES	fbEs	foEs	QUA	DES	h'Es	QUA	DES	TYPE OF Es	foE	QUA	DES	h'E	QUA	DES	foE2	h'E2	foF1	F1 M3000	QUA	DES	foF2	F2 M3000	QUA	DES	fmI	fxI	QUA	DES	h'F	QUA	DES	h'F2	QUA	DES
008			010	011						a													016			F	016	022			240	U	A			

Es Sequence

Fig. 8.1 (cont'd.)

SECTION 9. SYOWA BASE

Operation began at this station in February 1959. The station was closed between February 1961 and January 1966. Data are published in "Ionospheric Data at Syowa Station", a semiannual publication issued by the Radio Research Laboratories, Japan.

For information concerning the station please contact:

Syowa Base (Japanese Antarctic Research Expedition)
Radio Research Laboratories
2-1, Nukui-kitamachi 4-chome
Koganei-shi, Tokyo, Japan 184

Information concerning the station data is available from:

World Data Center C2 for Ionosphere
Radio Research Laboratories
2-1, Nukui-kitamachi 4-chome
Koganei-shi, Tokyo, Japan 184

Main Characteristics of the Ionosonde used at Syowa Station

Station name:	Syowa	
Geographic coordinates:	Lat. S 69°00.4'	E Long. 39°35.4'
Geomagnetic coordinates:	Lat. S 69.6°	E Long. 77.1°
Invariant latitude:	66.08°	
Magnetic dip:	65.26°S	
Time used:	45°E (UT + 3 hours)	
Ionosonde equipment type:	PIR-9	
Frequency Range:	500 kHz ∿ 15 MHz	
Duration of Sweep;	30 sec	
Approximate peak power:	10 kW	
Pulse repetition rate:	50 Hz (by power frequency)	
Pulse length:	100 μsec	
Transmitting Antenna	30 m height vertical delta terminated by 600Ω	
Receiving Antenna:	29 m height vertical delta terminated by 600Ω	
Power Supply:	100 Volt AC, 2.5 KVA	
Recording Method:	35 mm film running	
Height range:	900 km	
Height scale:	every 50 km	
Frequency scale:	every 1 MHz	
Total Receiver Gain:	120 dB	
Routine sounding:	00, 15, 30 and 45 min. past every hour	

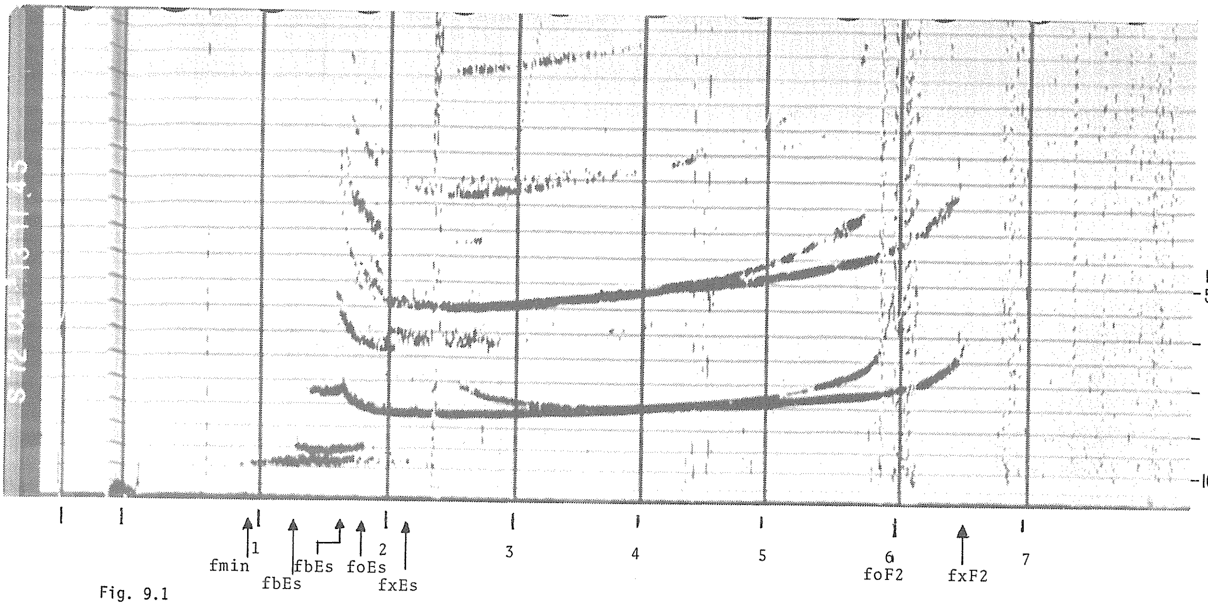


Fig. 9.1

1145 LT (45°E) Jul. 13, 1972 - SYOWA

fmin --- 009
foE --- A
foEs --- 018
fbEs --- 016E
foF2 --- 060

h'E --- A
h'Es --- 140
h'F --- 225
type of Es : h,ℓ

DAYTIME IONOGRAM IN WINTER - SYOWA STATION

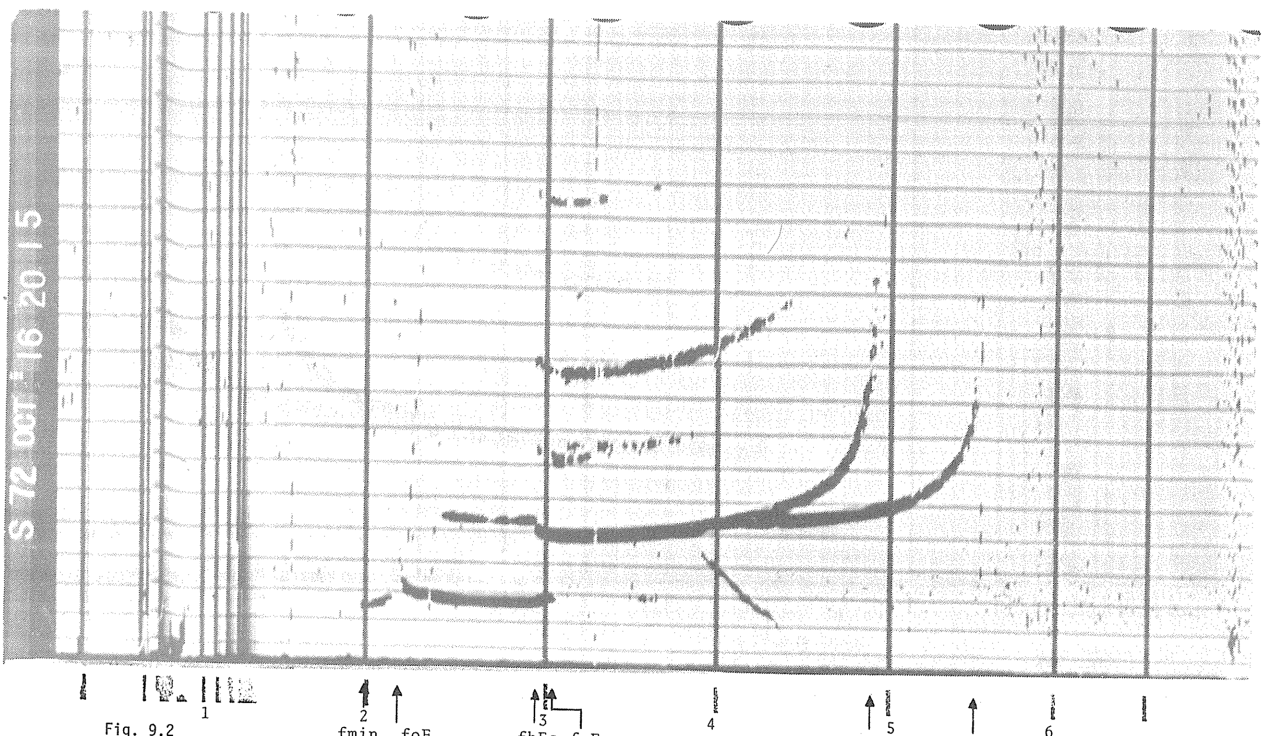


Fig. 9.2

2015, OCT. 16, 1972

fmin --- 020
foE --- 230
foEs --- 030
fbEs --- 029
foF2 --- 049

h'E --- 120EB
h'Es --- 130
h'F --- 240
type of Es : h

NIGHTTIME IONOGRAM IN WINTER - SYOWA STATION

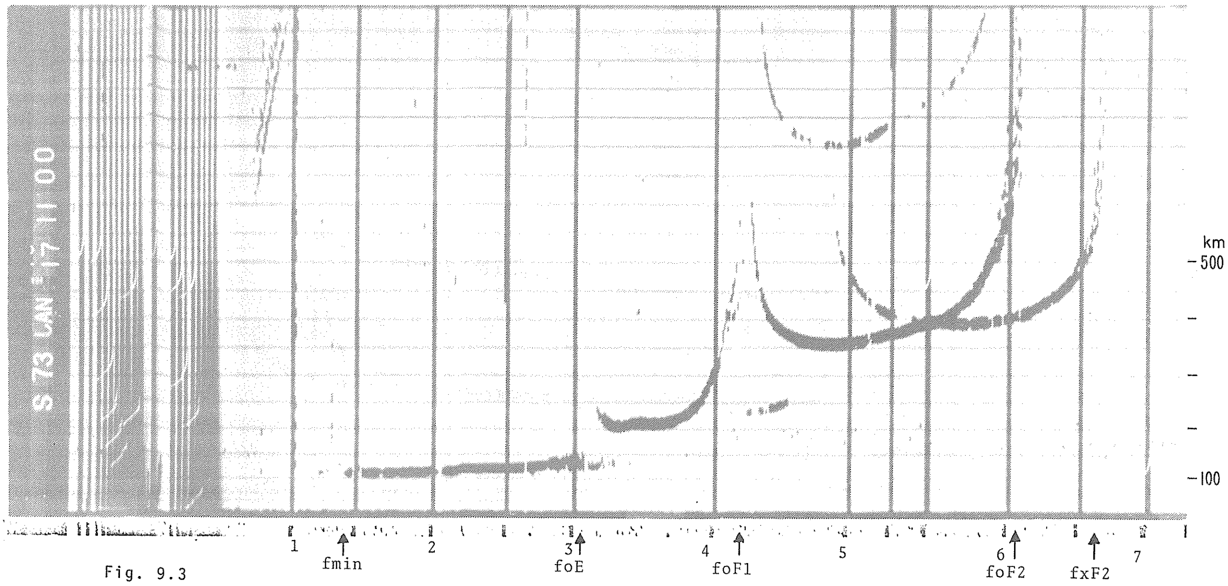


Fig. 9.3

1100, JAN. 17, 1973

fmin ---	014	h'E ---	100
foE ---	305	h'Es ---	G
foEs ---	G	h'F ---	200
fbEs ---	G	h'F2 ---	350
foF1 ---	430		
foF2 ---	061		

DAYTIME IONOGRAM IN SUMMER - SYOWA STATION

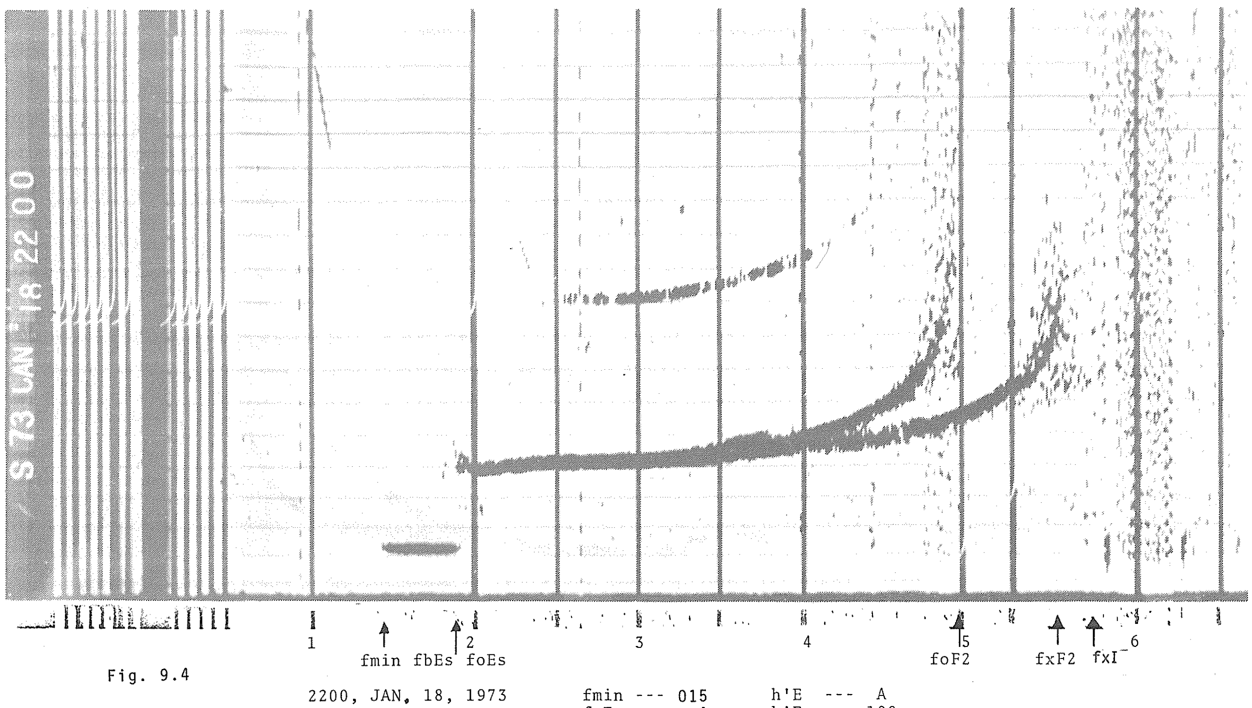


Fig. 9.4

2200, JAN. 18, 1973

fmin ---	015	h'E ---	A
foE ---	A	h'Es ---	100
foEs ---	019	h'F ---	240
fbEs ---	019	type of Es :	ℓ
foF2 ---	050-F		

NIGHTTIME IONOGRAM IN SUMMER - SYOWA STATION

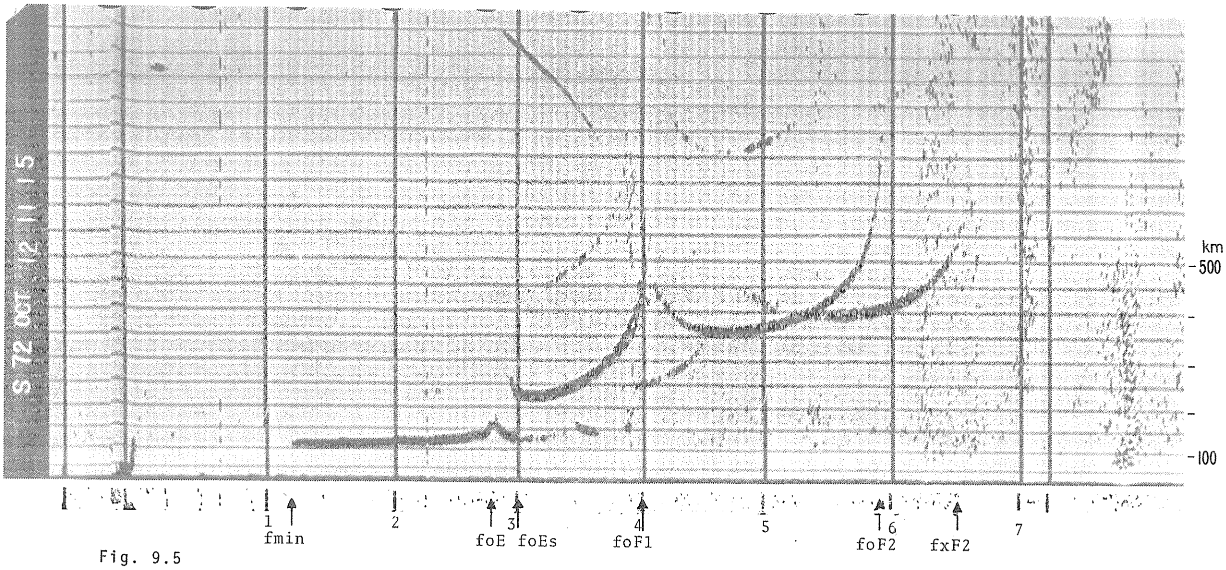


Fig. 9.5

1115, OCT. 12, 1972

fmin	013	h'E	100
foE	275	h'Es	125
foEs	030	h'F	215
fbEs	G	h'F2	350
foF1	400	type of Es : h	
foF2	059		

DAYTIME IONOGRAM IN SPRING - SYOWA STATION

Editor's Note: Concur with interpretation of Es type. This is very close to an Es cusp condition and on a less good ionogram would probably be called cusp. The layer is slightly tilted so for scientific purposes either h or c would have been acceptable. Note Es trace at top of cusp is a little higher than E trace, hence "h" type.

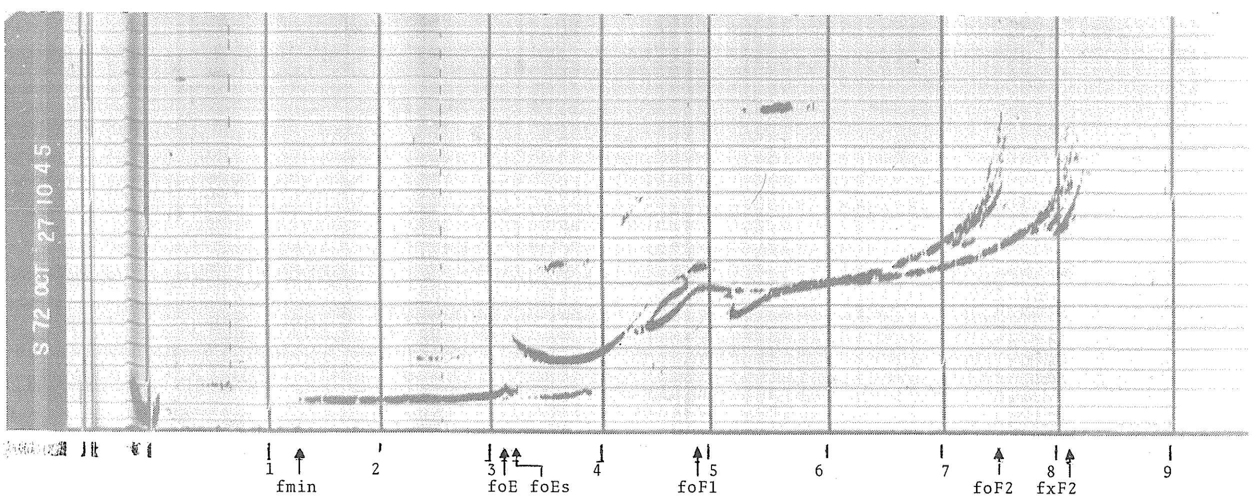


Fig. 9.6

1045, OCT. 27, 1972

fmin	013	h'E	100
foE	315	h'Es	125EG
foEs	032	h'F	205
fbEs	G	h'F2	380
foF1	490DL	type of Es : h	
foF2	075-F		

EXAMPLE OF REFLECTION FROM TILTED LAYER - SYOWA STATION

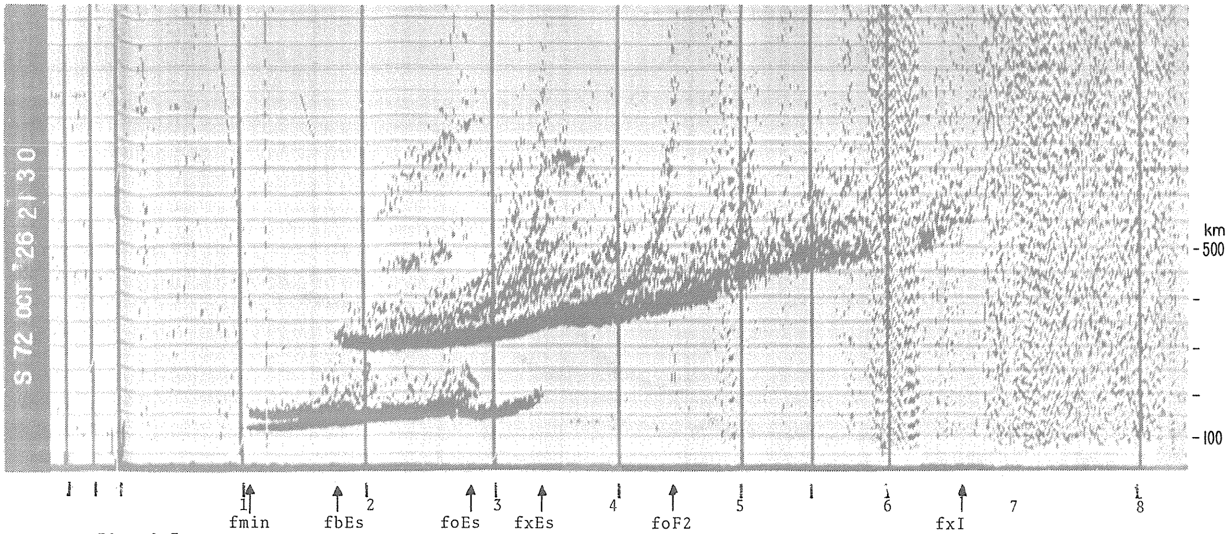


Fig. 9.7

2130, OCT. 26, 1972

fmin --- 011	h'E --- A	
foE --- A	h'Es --- 115	
foEs --- 027	h'F --- 295	
fbEs --- 017	type of Es : r	
foF2 --- 045-F		
fxI --- 066		

EXAMPLE OF FREQUENCY SPREAD - SYOWA STATION

Editor's Note: This is a border line case in which particle E is probably present at fbEs. Analysis as given is acceptable especially as Es trace is complex below fbEs. Difference in height h'Fx and h'F and retardation at fbEs taken together could give a doubtful particle E, fbEs = 017UK; foE = 170UK also acceptable.

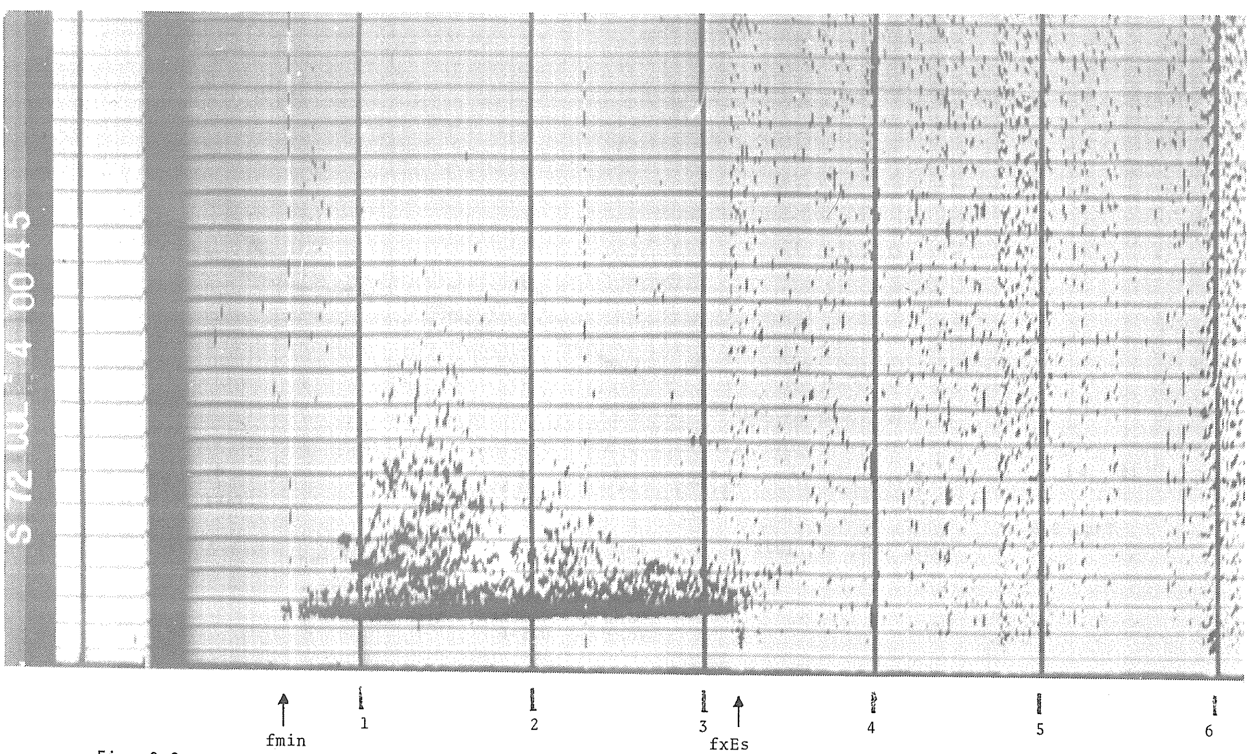


Fig. 9.8

0045, JUL. 4. 1972

fmin --- 006	foF2 --- A	Es type a
foEs --- 027JA	h'Es --- 120	
fbEs --- 027AA	h'F --- A	

EXAMPLE OF SPREAD Es - SYOWA STATION

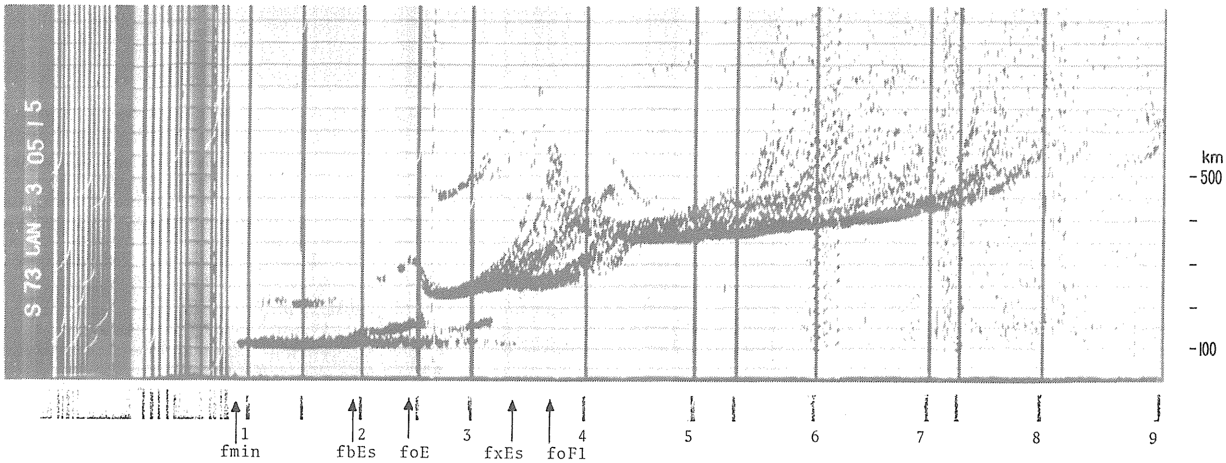


Fig. 9.9

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.

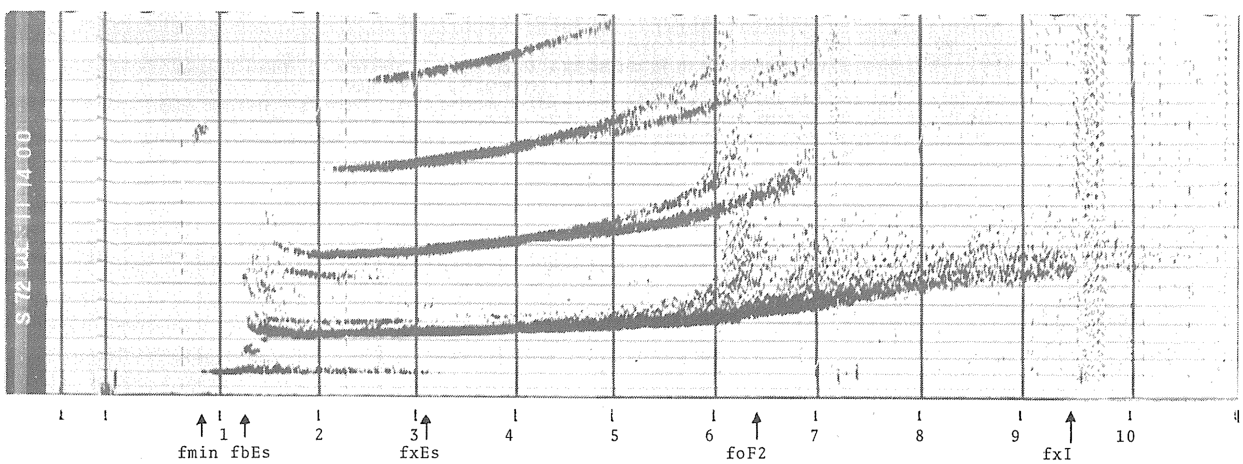


Fig. 9.10

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.

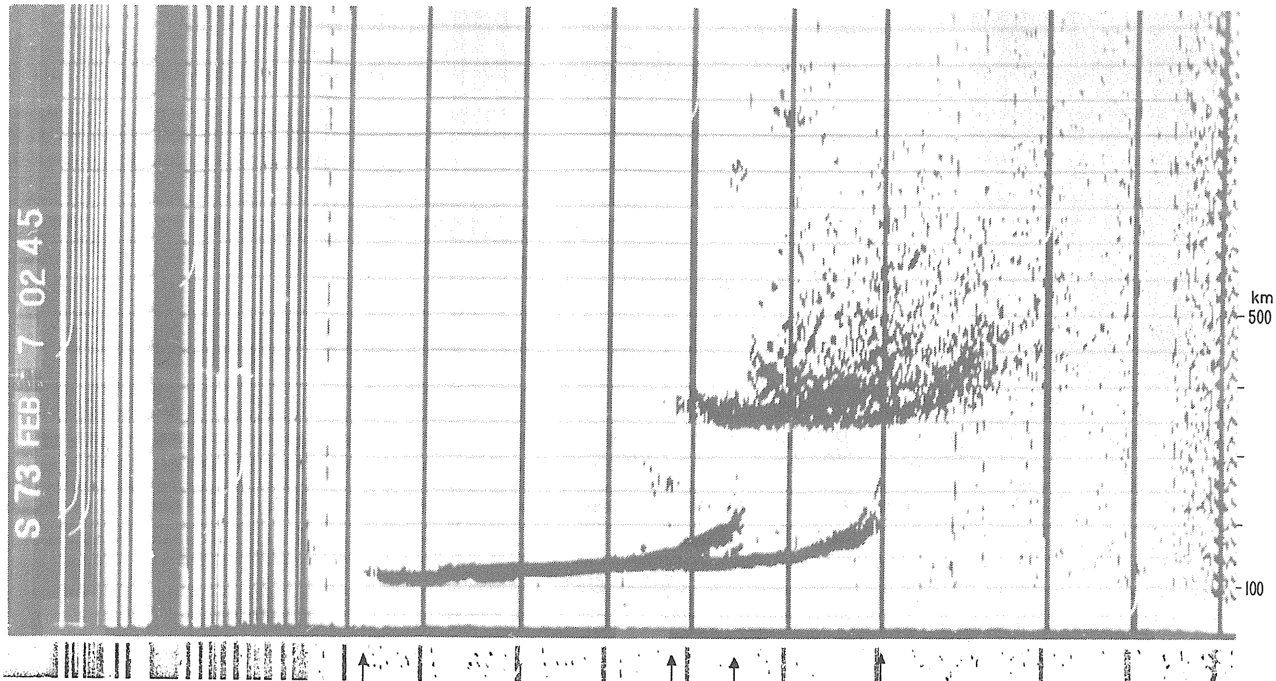


Fig. 9.11

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.

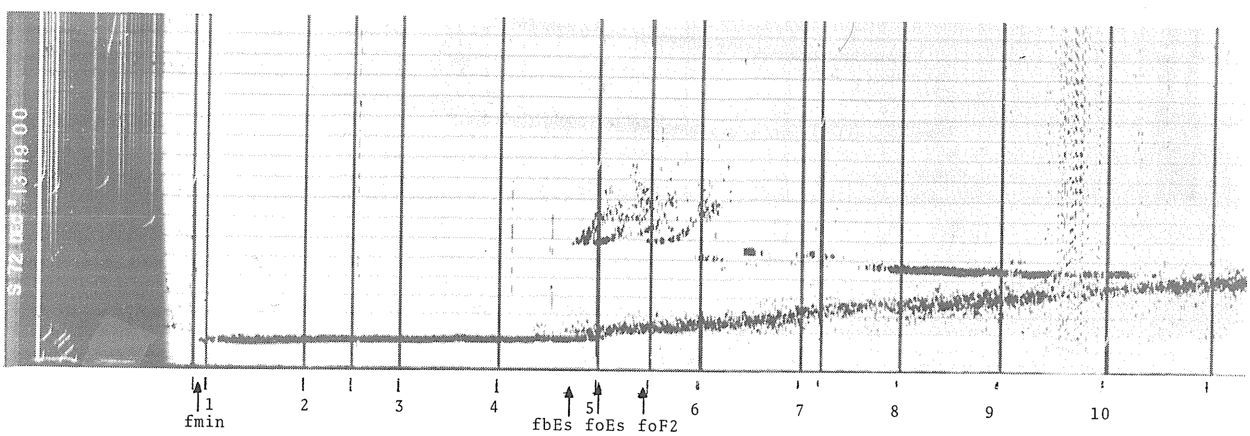


Fig. 9.12

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

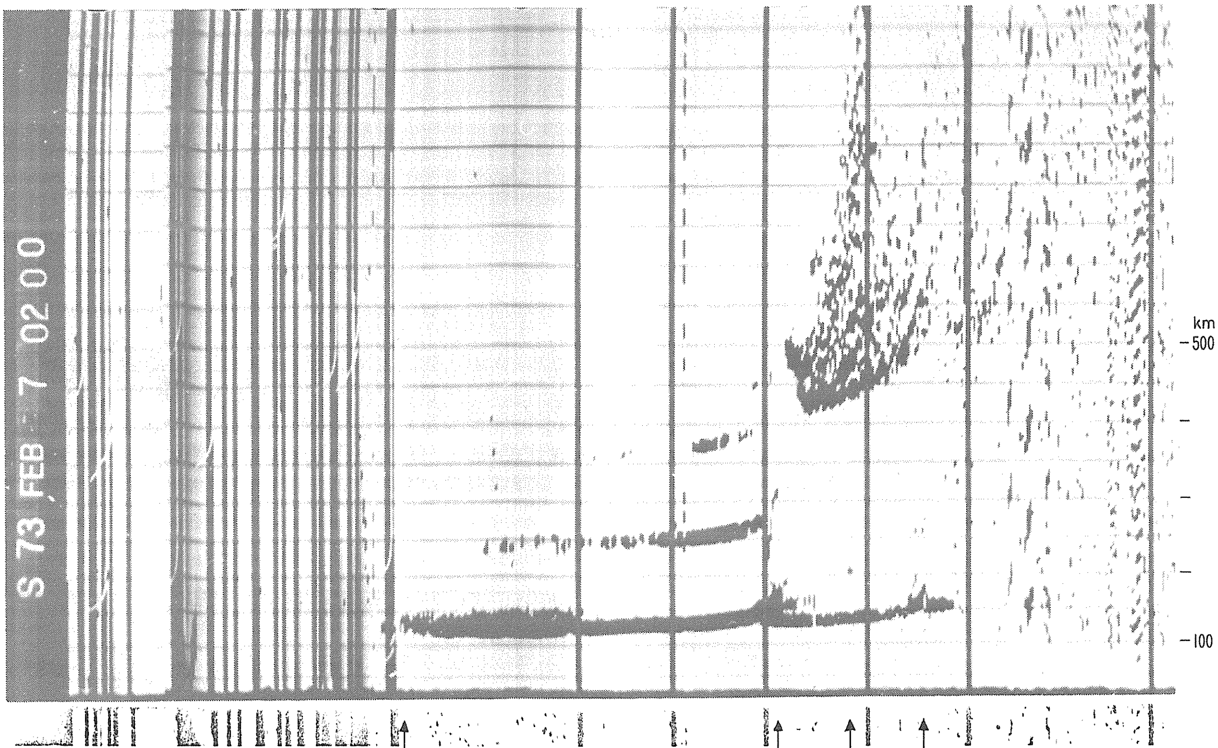


Fig. 9.13

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

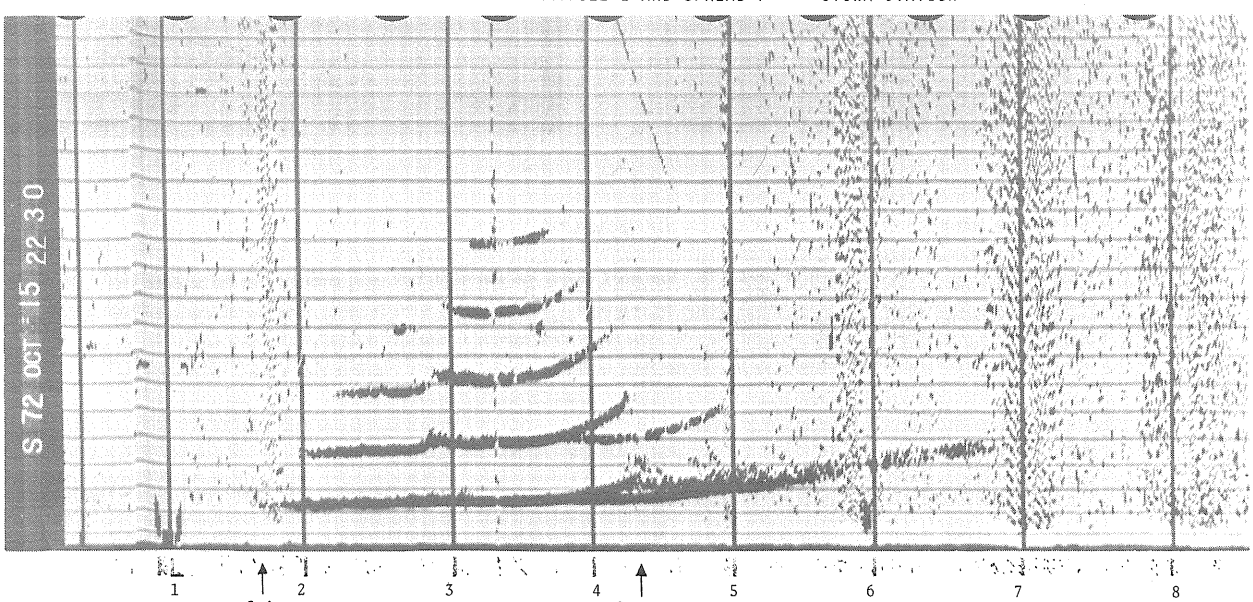


Fig. 9.14

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.

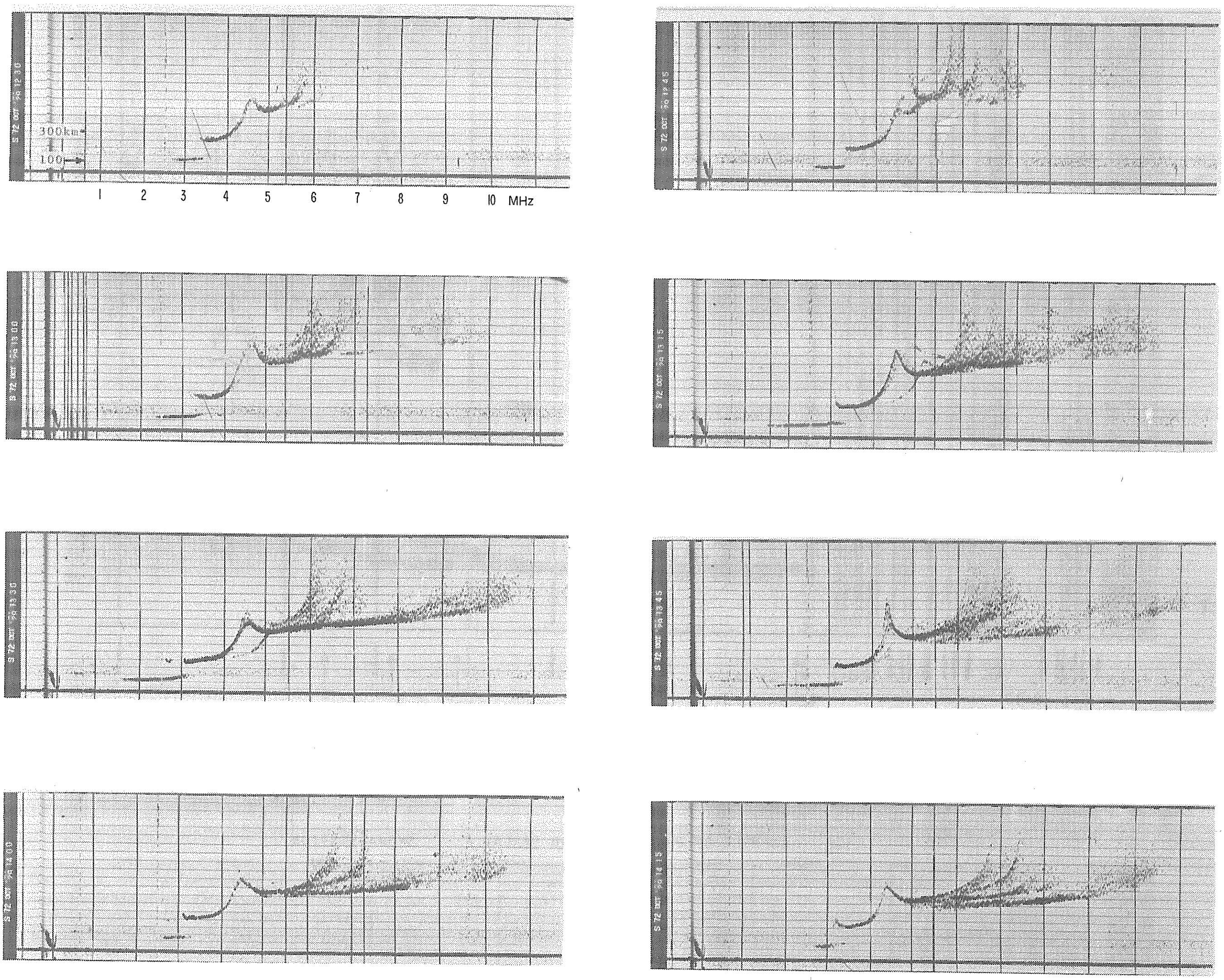


Fig. 9.15

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.

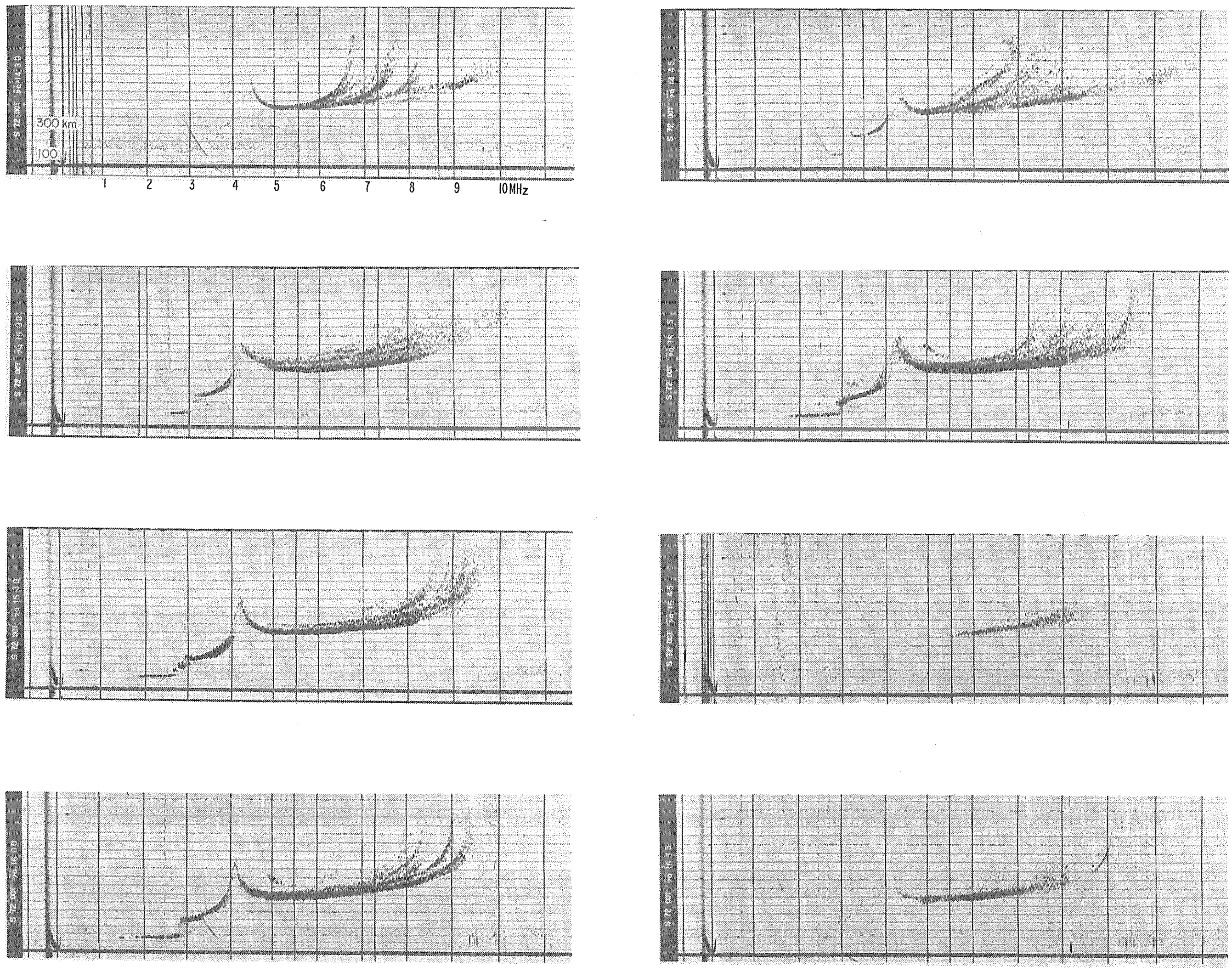


Fig. 9.15 (cont'd.)

SEQUENTIAL SPREAD F, SYOWA STATION 9 APRIL 1971

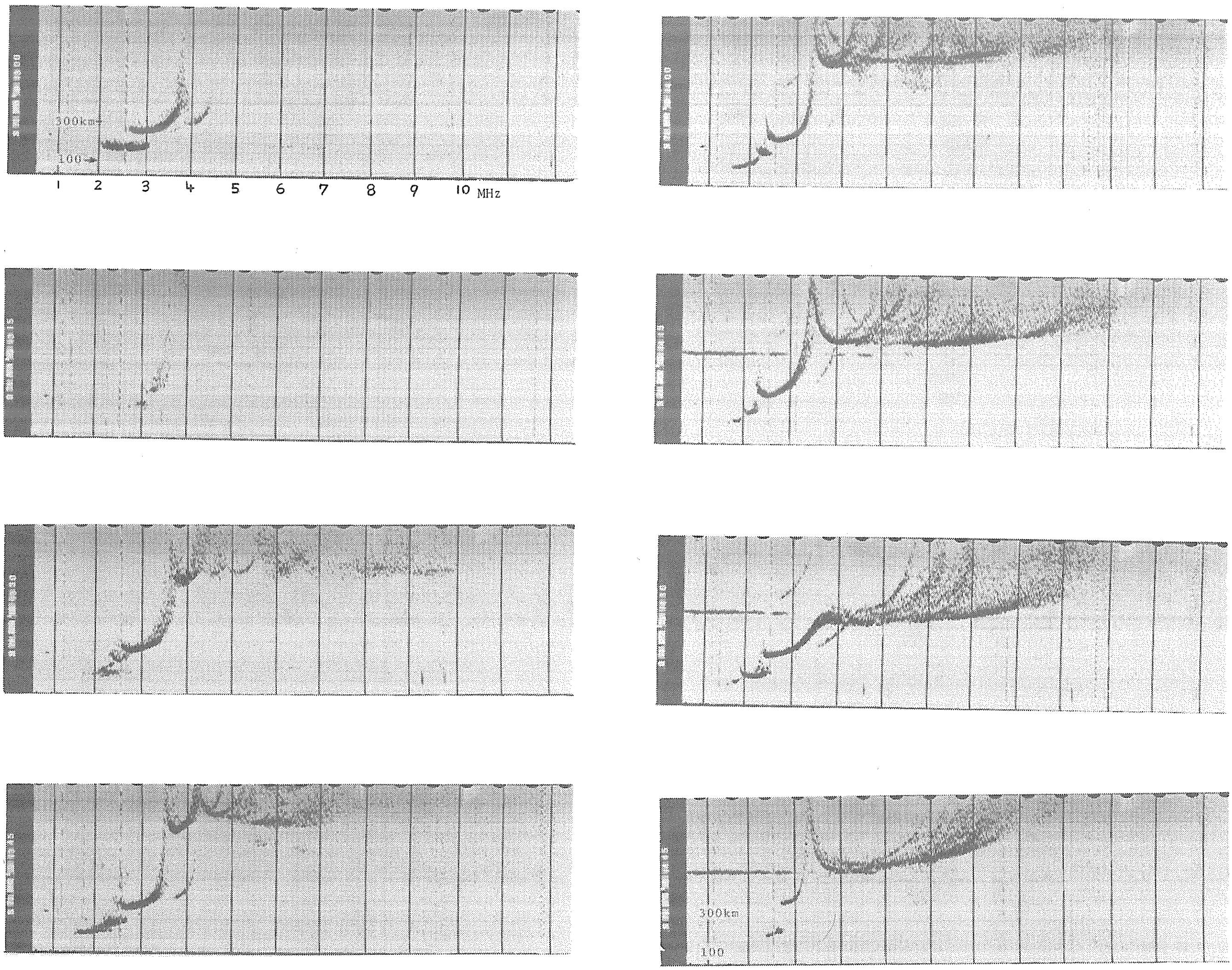


Fig. 9.16

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)	

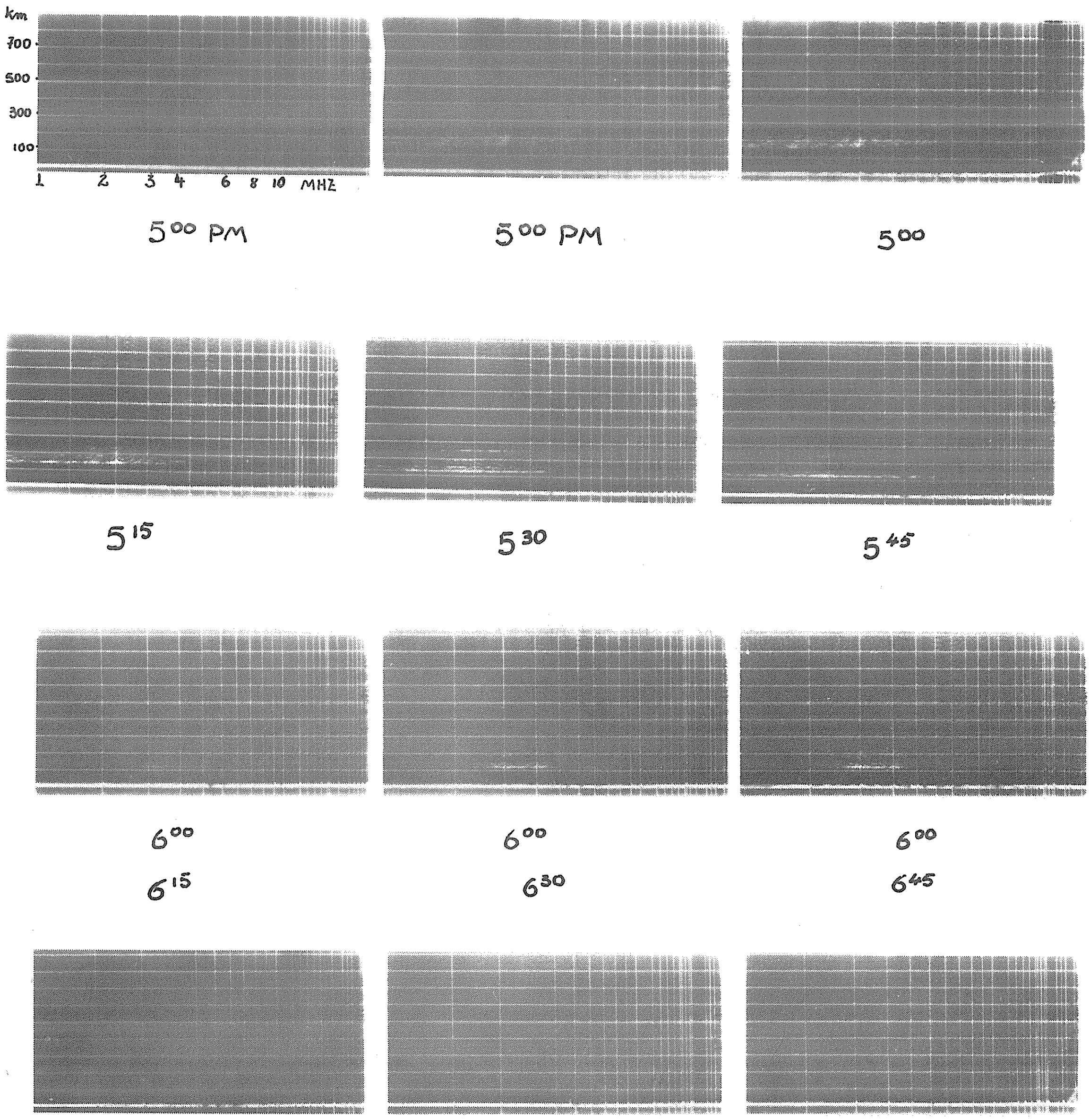


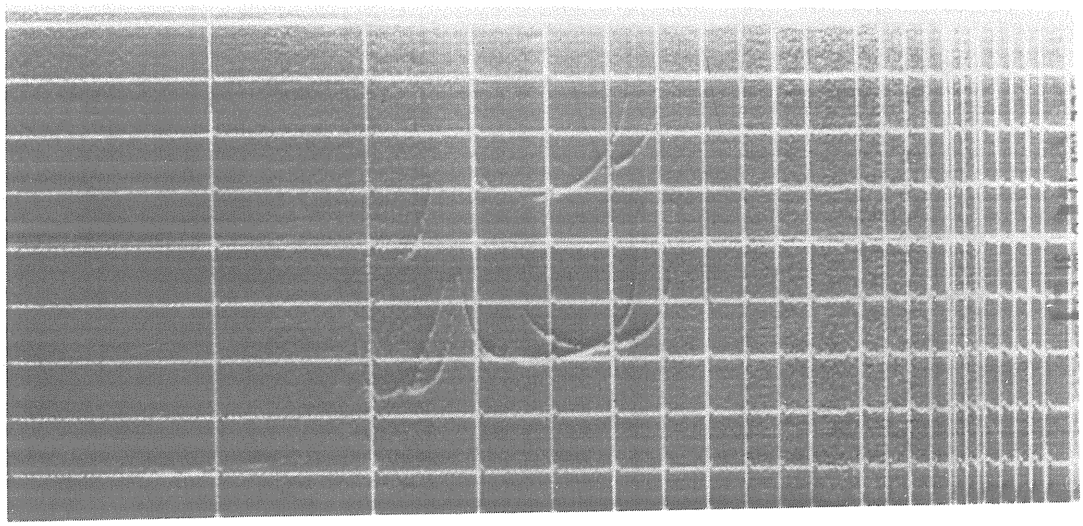
Fig. 10.1

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.

Editor's Note: Es-a in early morning. 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.

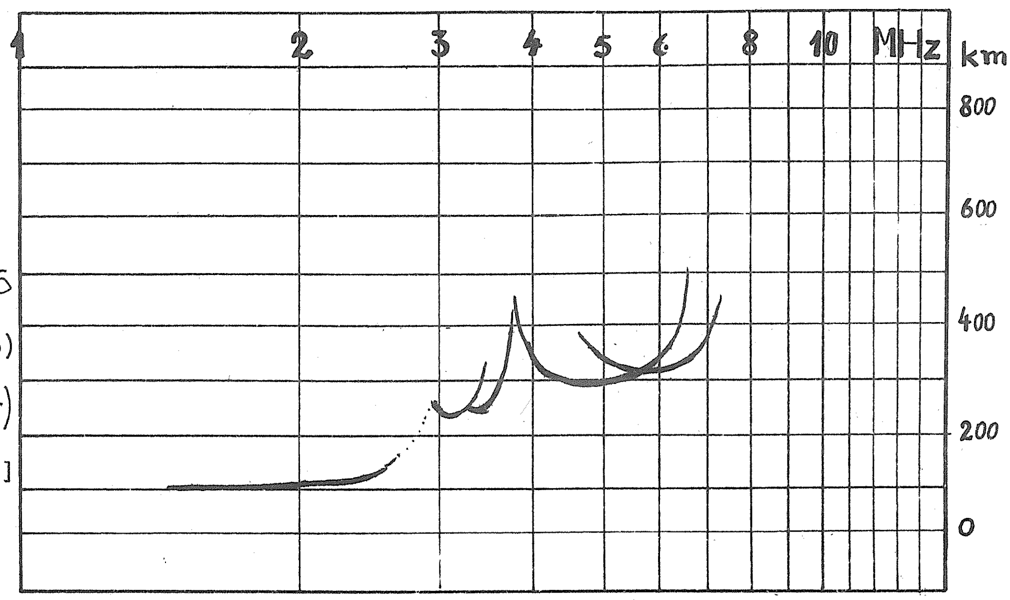


BASE
GENERAL
BELGRANO

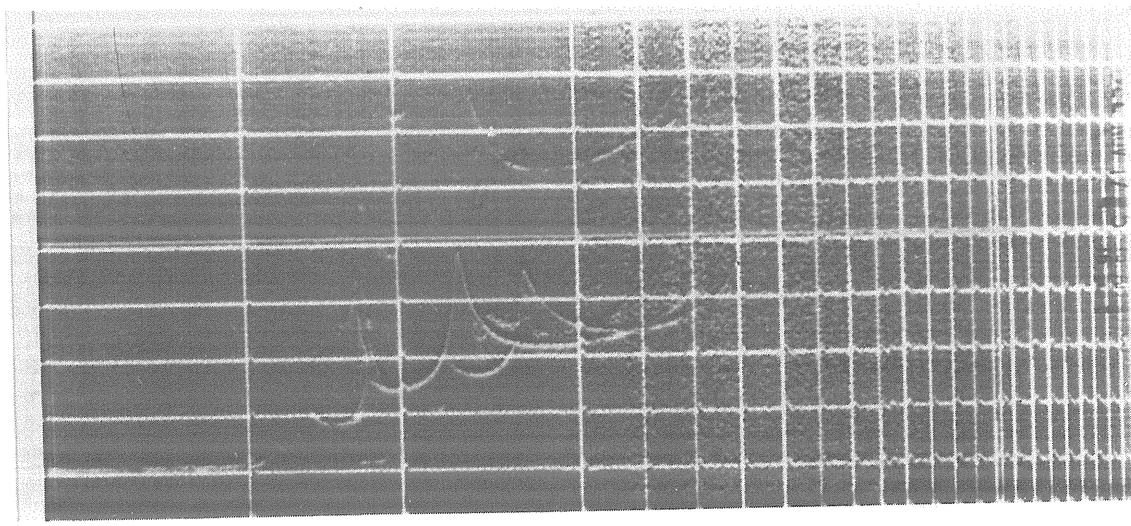
DATE: 17/11/1965
(17 Nov. 1965)

TIME: 8^{30} AM (L.T)
[0830 LT (60°W)]

Fig. 10.2



fmin	f_oF_2	M3000F_2	$h'F_2$	$h'F$	f_oF_1	M3000F_1
0,16	0,65	310	295	240	380-H	360-H
f_oE	$h'E$	f_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
270UR	100	G	G	G	—	0,72-X



BASE
GENERAL
BELGRANO

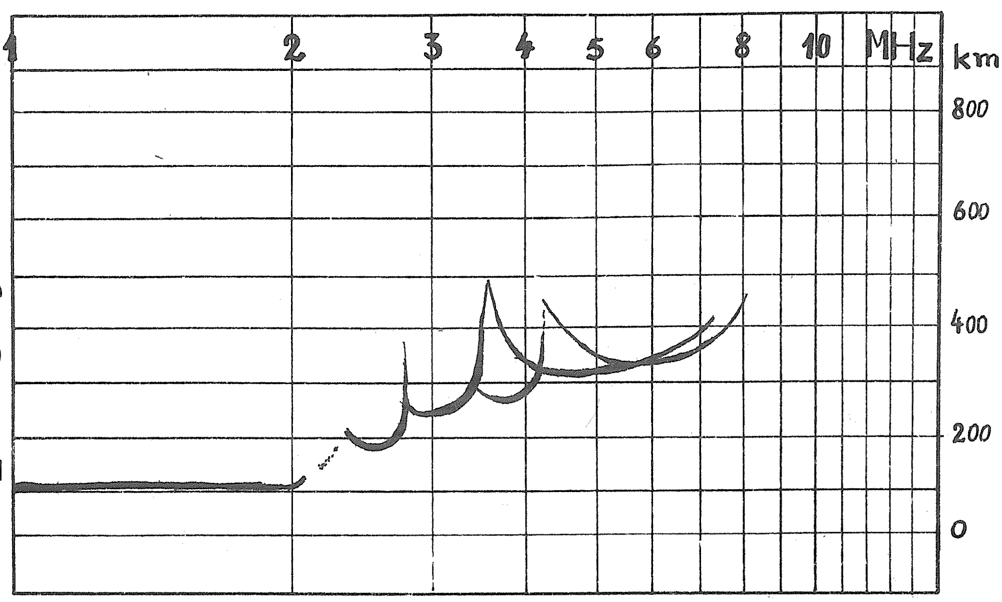
DATE: 17/11/1965

(17 Nov. 1965)

TIME: 5¹⁵ AM (L.T)

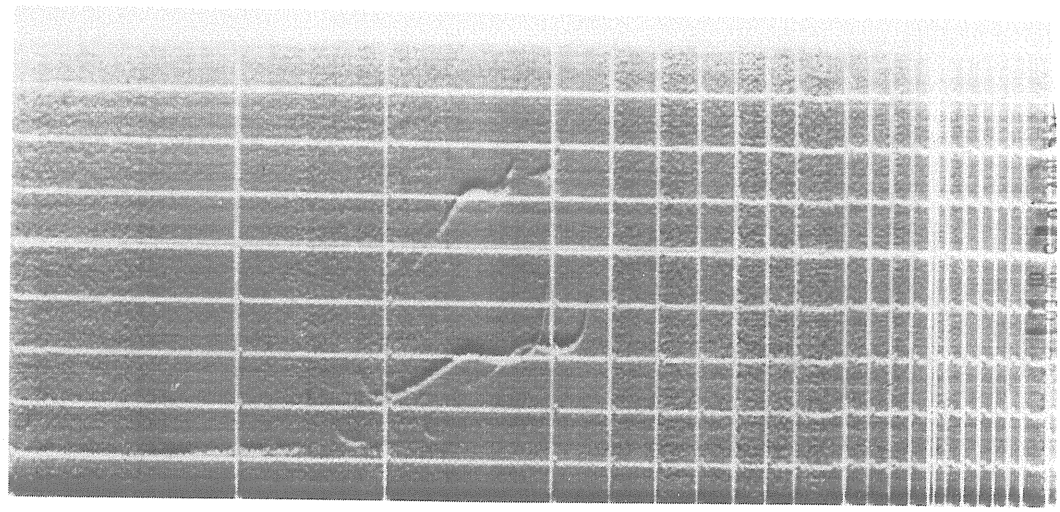
[0515 LT (60°W)]

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.

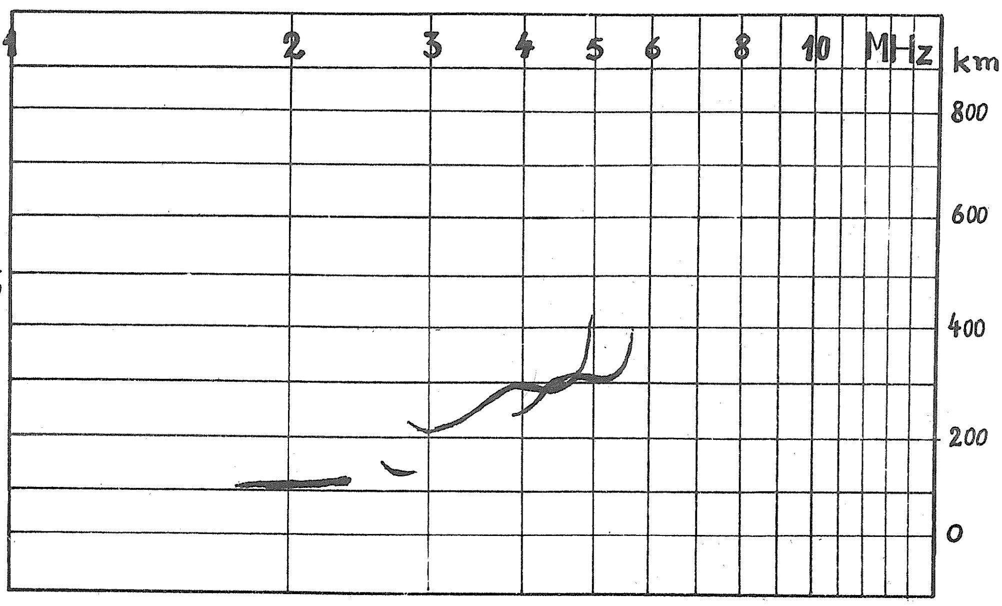


BASE
GENERAL
BELGRANO

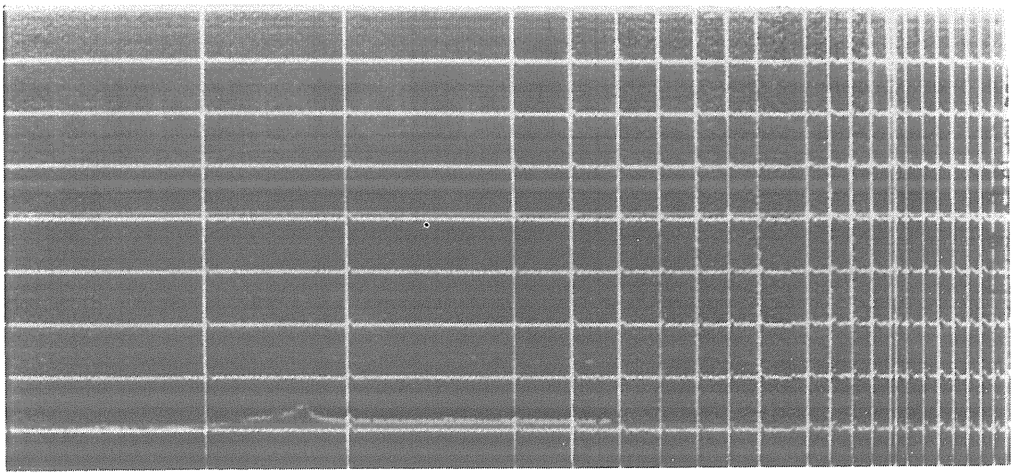
DATE: 16/11/1965
(16 Nov. 1965)

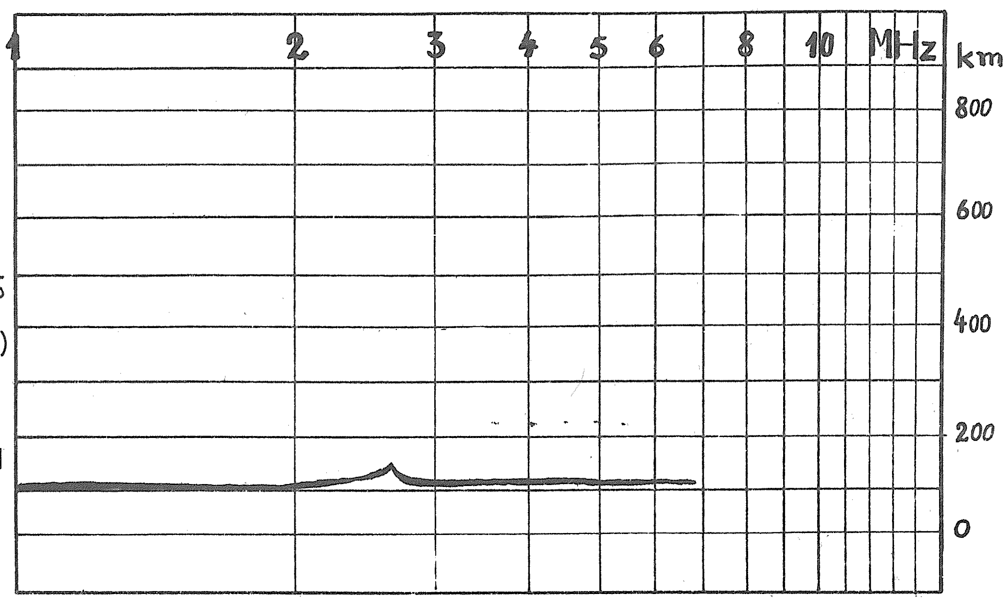
TIME: 3^00 PM (L.T)
[1500 LT (60°W)]

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_bE_s	f_oE_s	$h'E_s$	type E_s	f_xI
270	105	028	029	130	h1	0,56X





BASE
GENERAL
BELGRANO

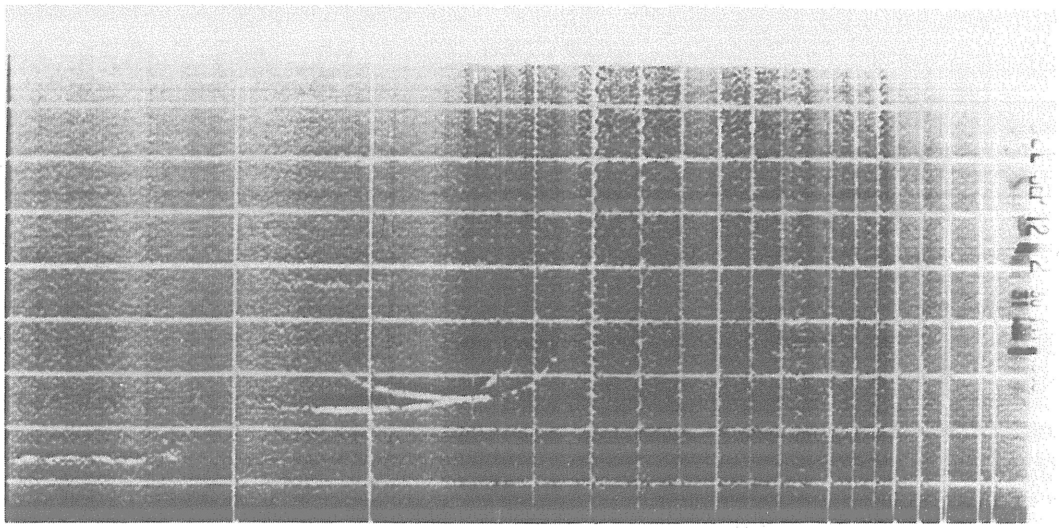
DATE: 15/11/1965
(15 Nov. 1965)

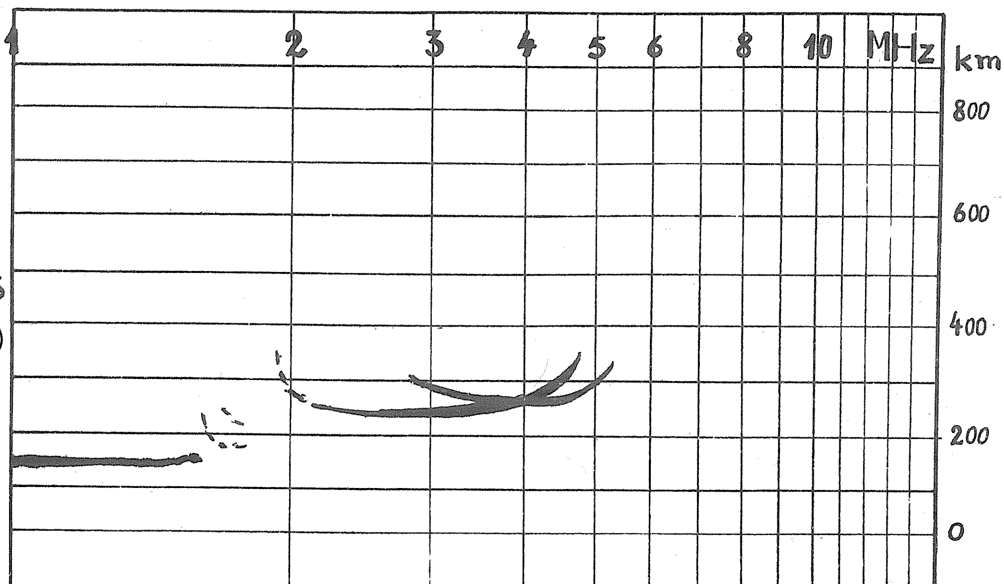
TIME: 8^45 AM (L.T)
[0845 LT (60°W)]

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

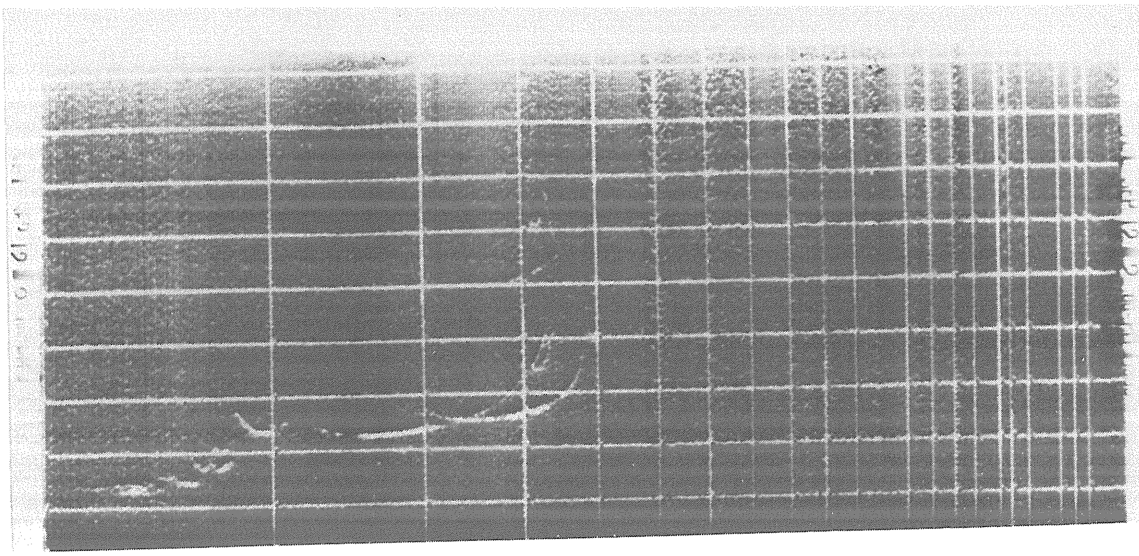
DATE: 12/9/1965
(12 Sept. 1965)

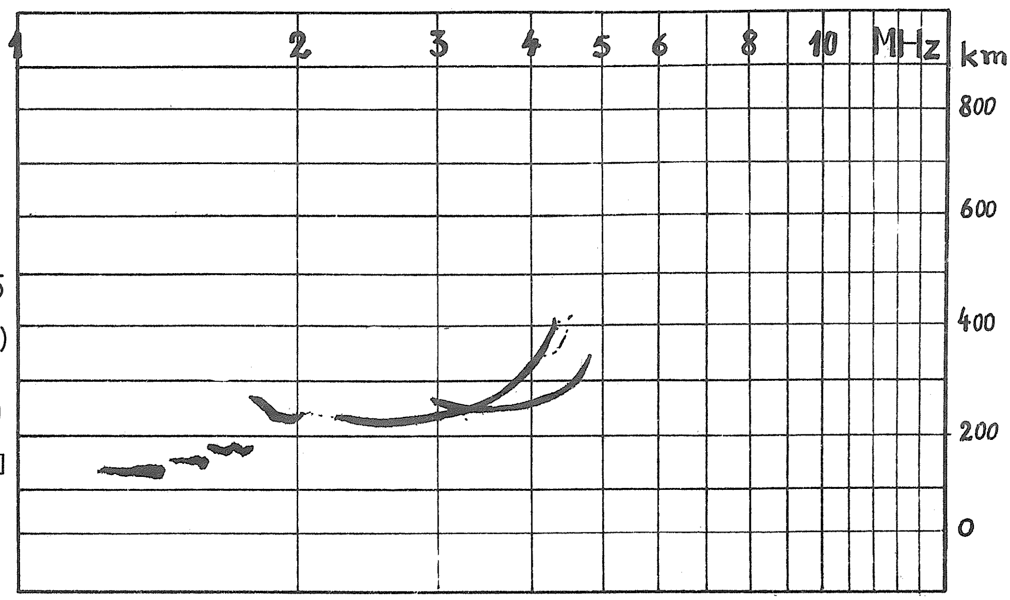
TIME: 2 30 PM (L.T)
[1430 LT (60°W)]

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

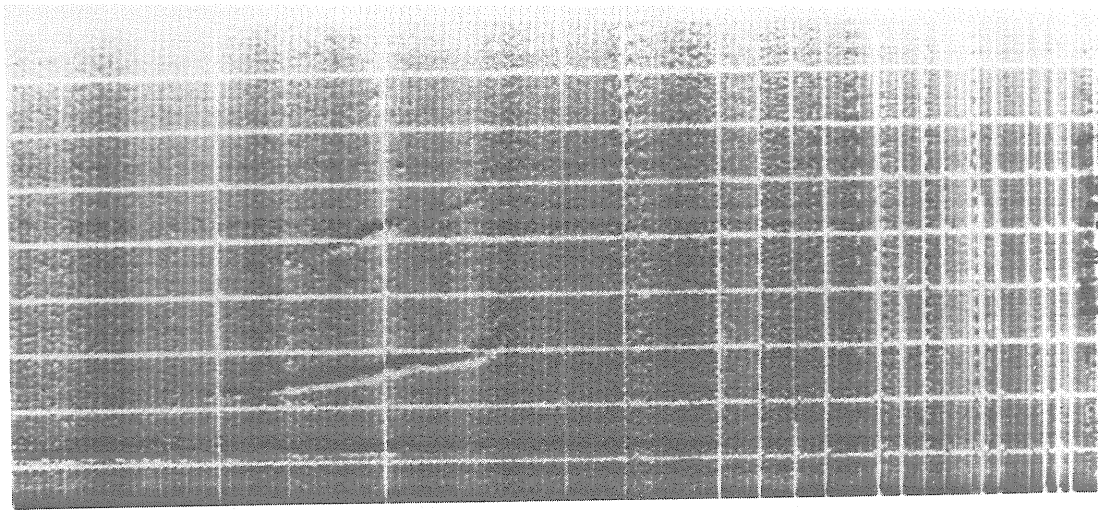
DATE: 12/9/1965
(12 Sept. 1965)

TIME: 2^00 PM (L.T.)
[1400 LT (60°W)]

Fig. 10.7

f_{min}	f_oF_2	$M3000F_2$	$h'F_2$	$h'F$	f_oF_1	$M3000F_1$
0,11	0,43-V	330-V	—	225-H	—	—
f_oE	$h'E$	f_bEs	f_oEs	$h'Es$	type Es	f_xI
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.

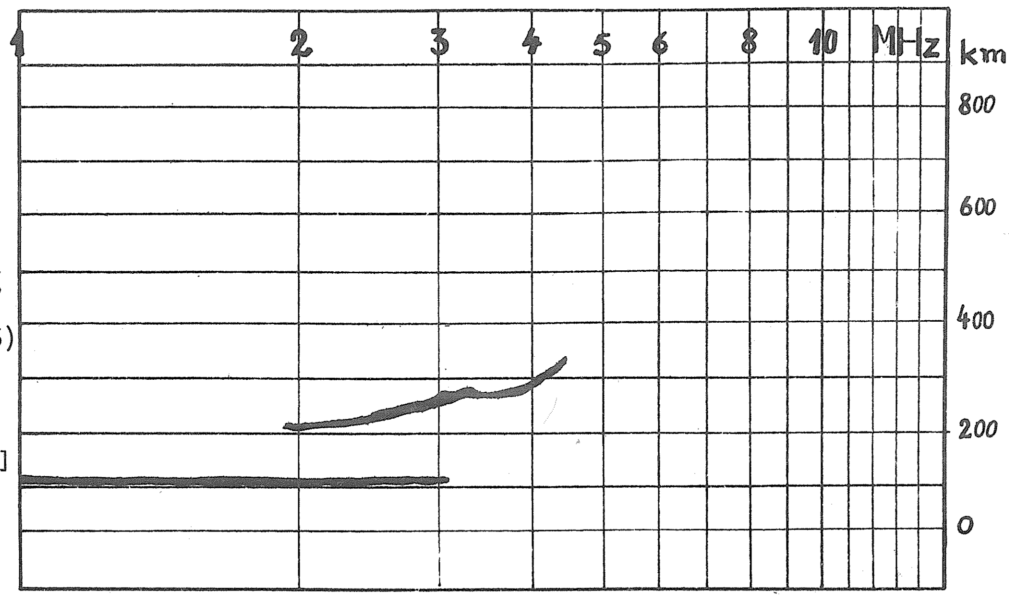


BASE
GENERAL
BELGRANO

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

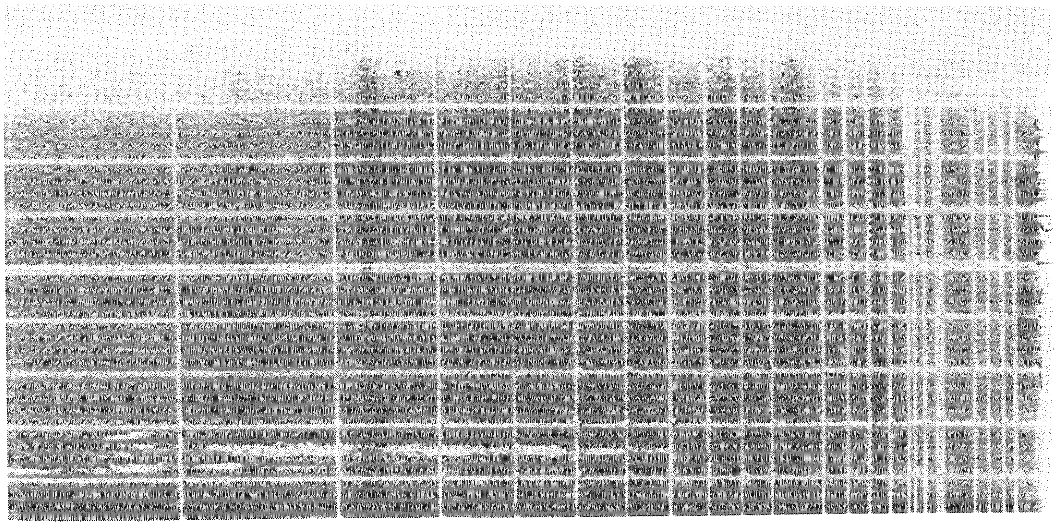
TIME: 9⁰⁰AM(L.T.)
[0900 LT (60°W)]

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	l 1	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.

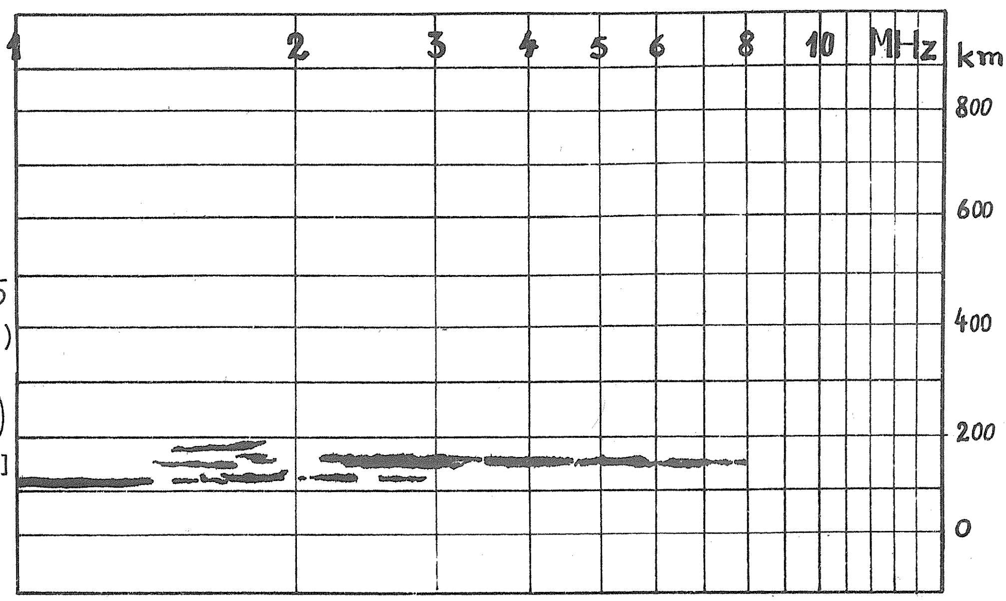


BASE
GENERAL
BELGRANO

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

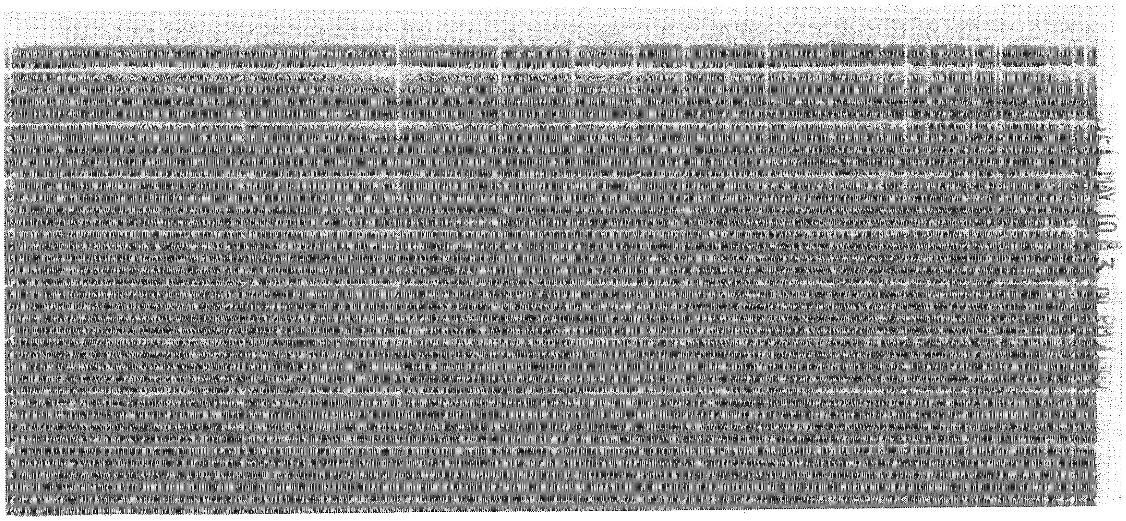
TIME: 1^{45} PM (L.T.)
[1345 LT (60°W)]

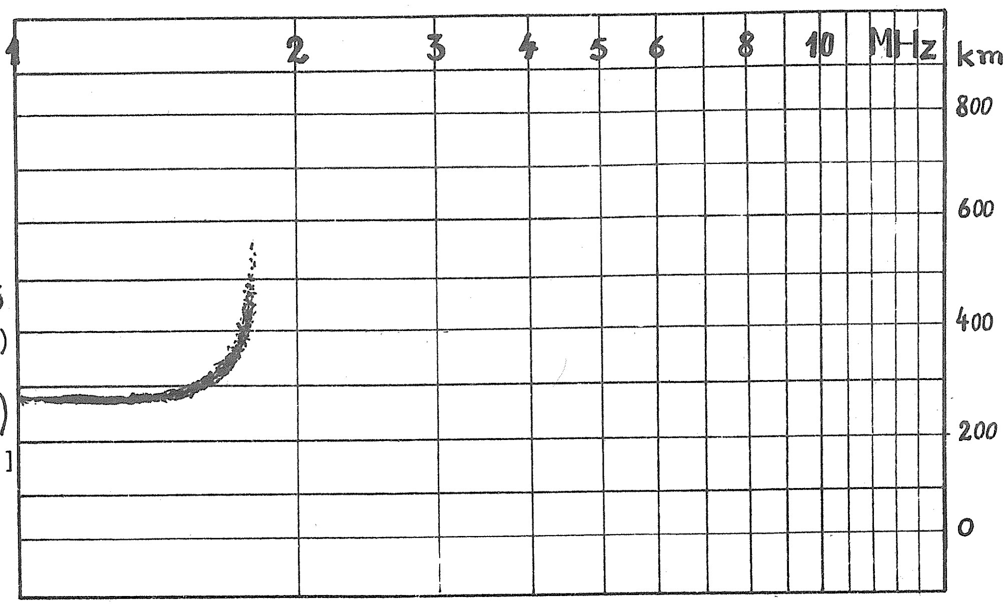
Fig. 10.9



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

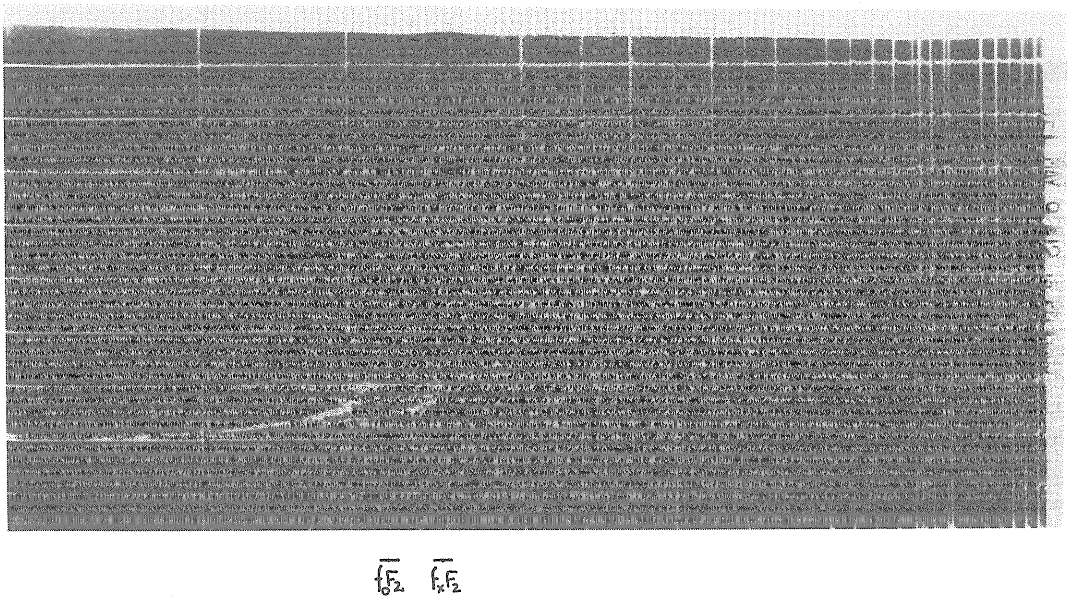
DATE: 10/5/1965
(10 May 1965)

TIME: 3⁰⁰ PM (L.T.)
[1500 LT (60°W)]

Fig. 10.10

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
E	017 UR	320	—	270	—	—
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
—	—	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.

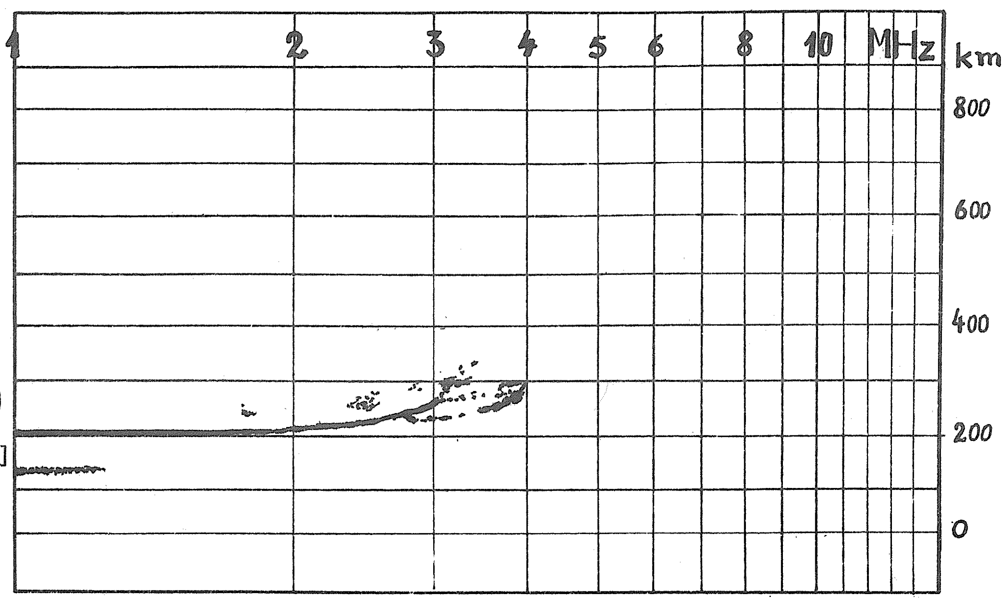


BASE
GENERAL
BELGRANO

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

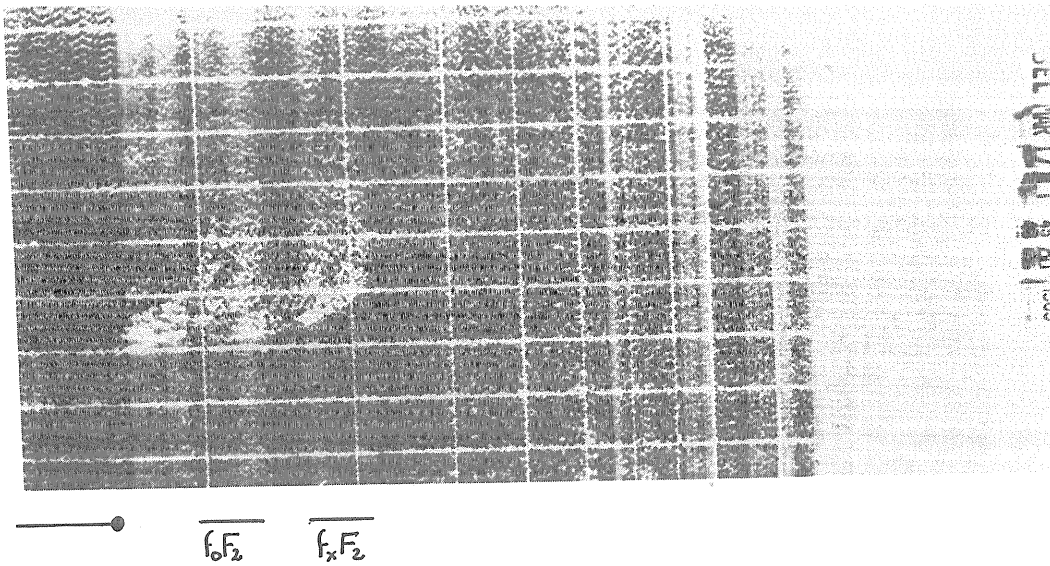
TIME: 12¹⁵ PM (L.T.)
[1215 LT (60°W)]

Fig. 10.11



f min	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.

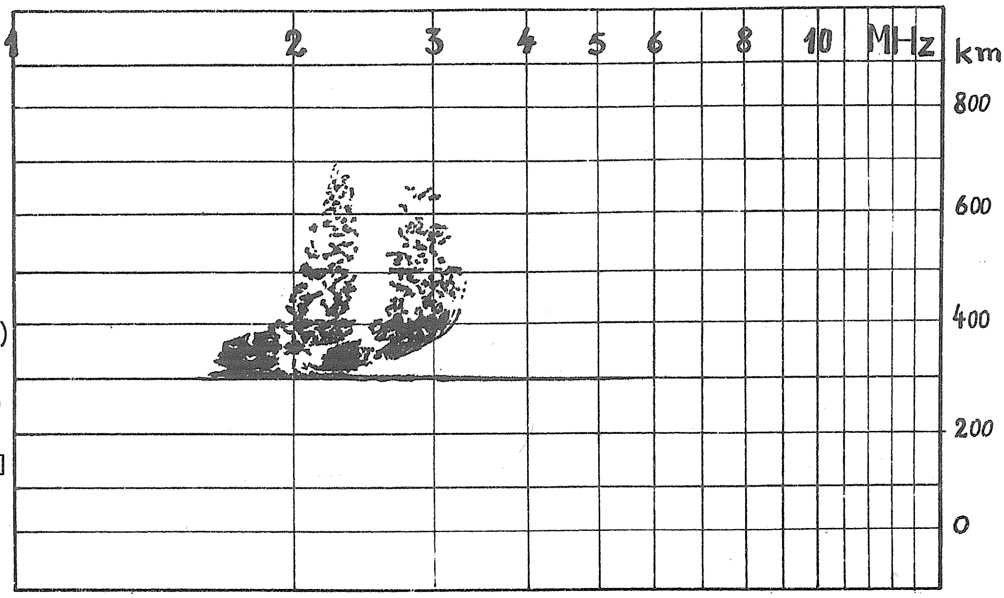


BASE
GENERAL
BELGRANO

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

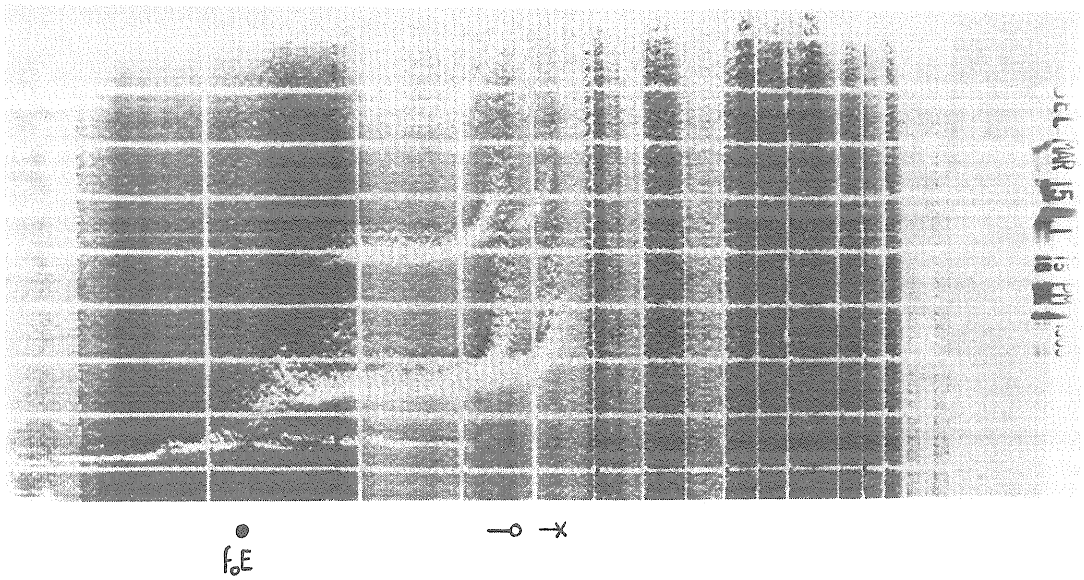
TIME: 1⁴⁵AM (L.T.)
[0145 LT (60°W)]

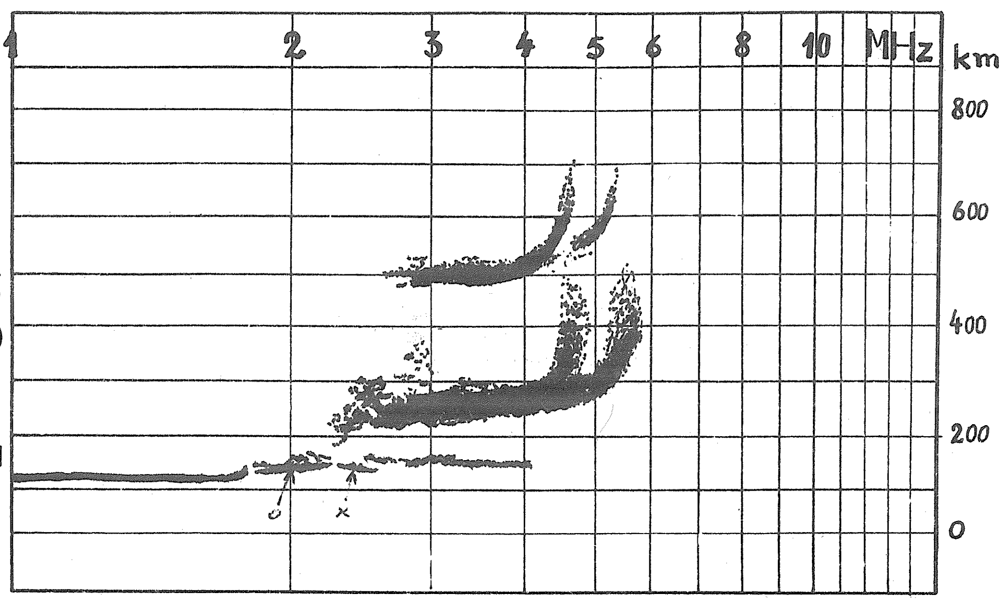
Fig. 10.12



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

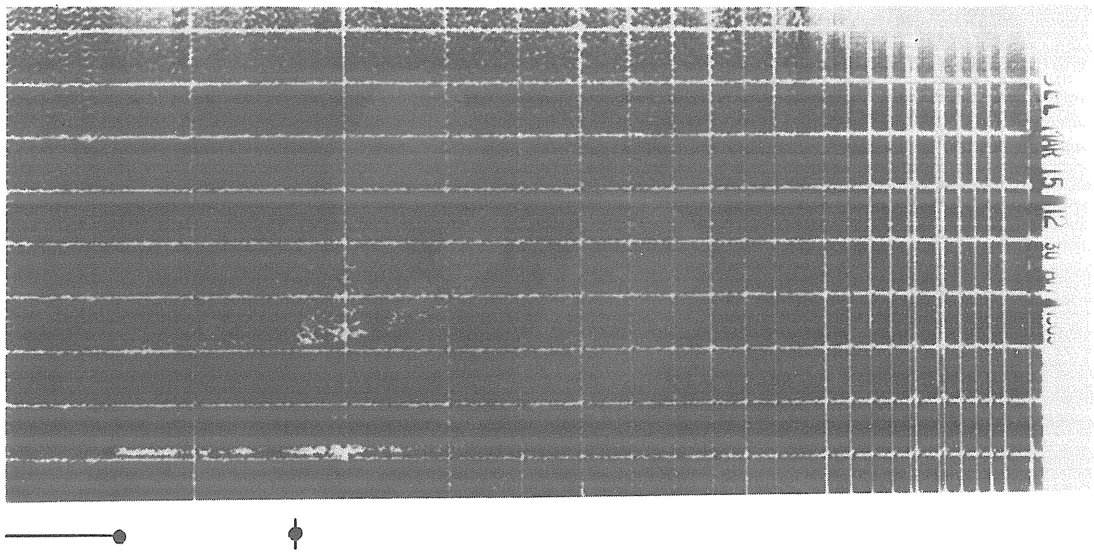
DATE: 15/3/1965
(15 March 1965)

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.

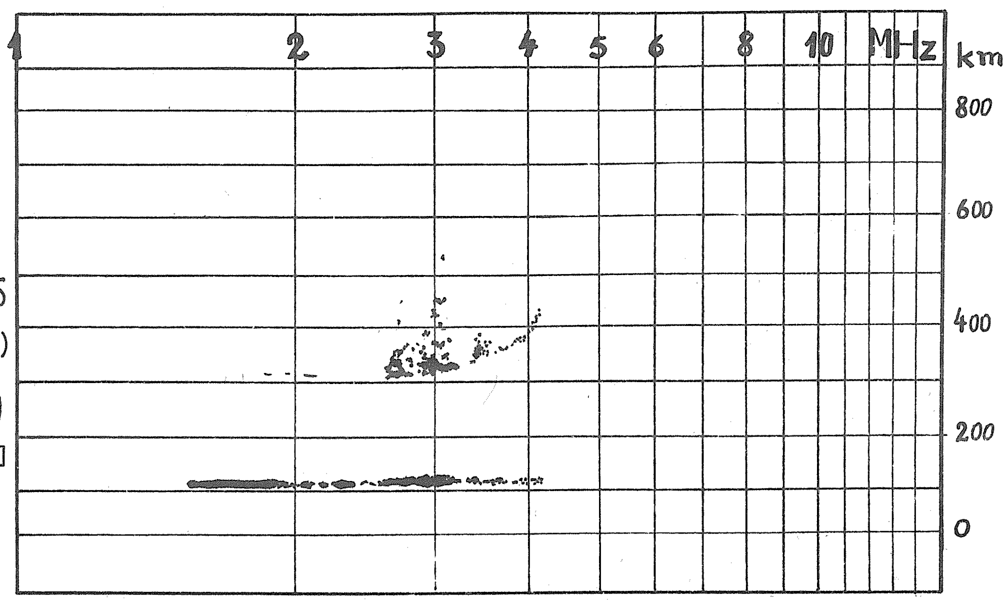


BASE
GENERAL
BELGRANO

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

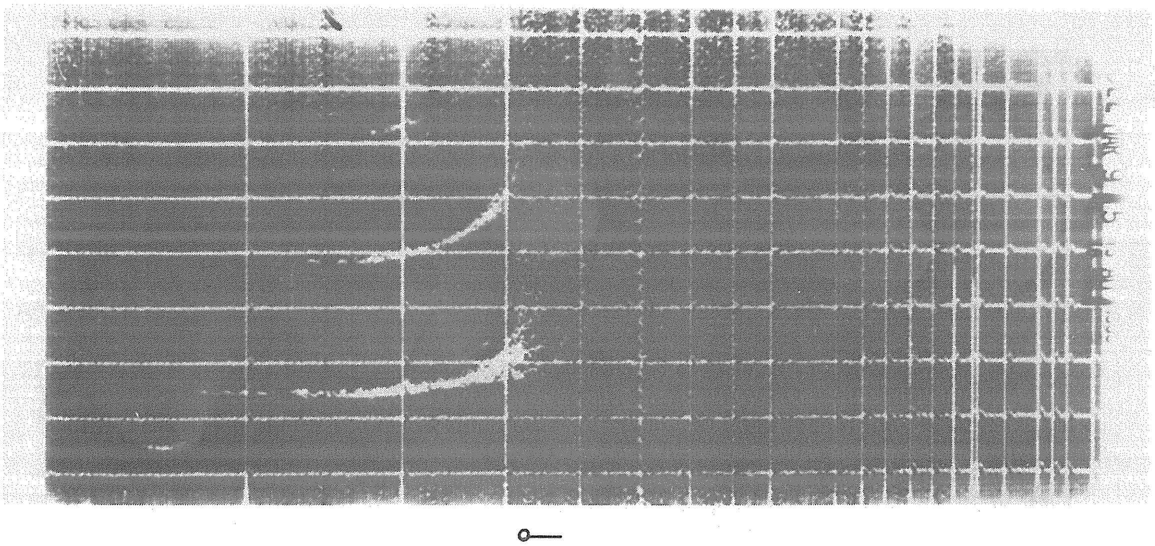
TIME: 0³⁰ AM (L.T.)
[0030 LT (60°W)]

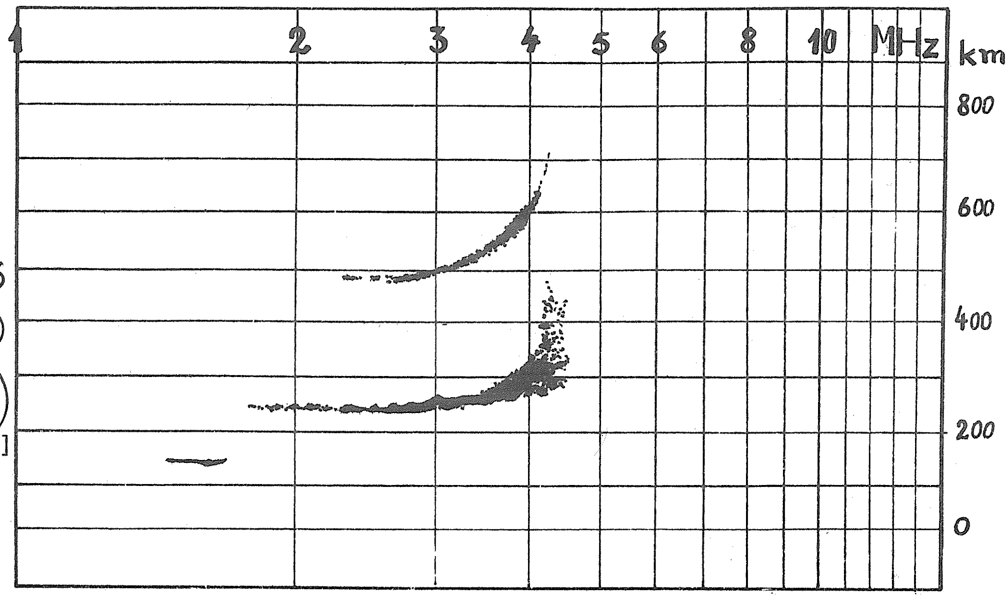
Fig. 10.14



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

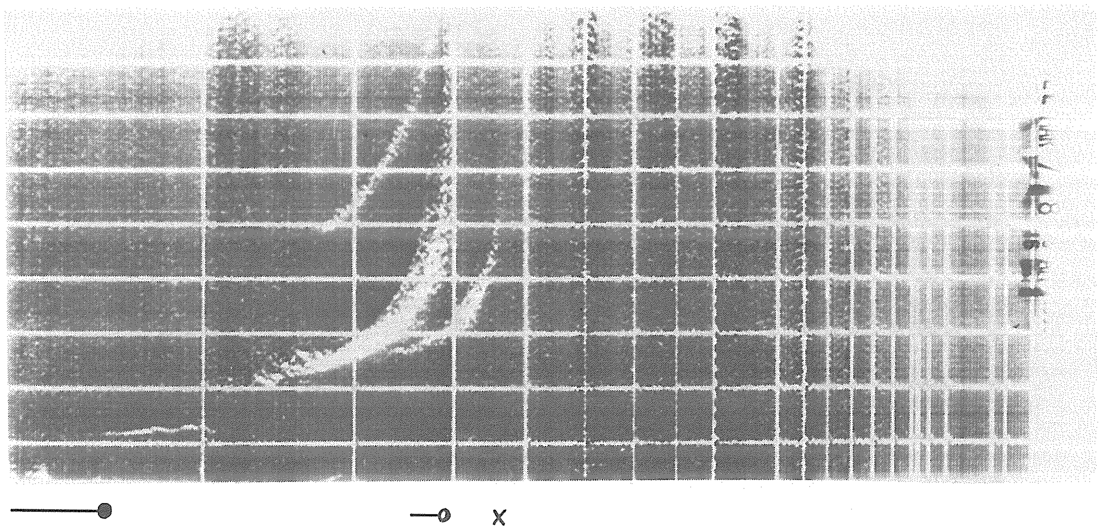
DATE: 9/3/1965
(9 March 1965)

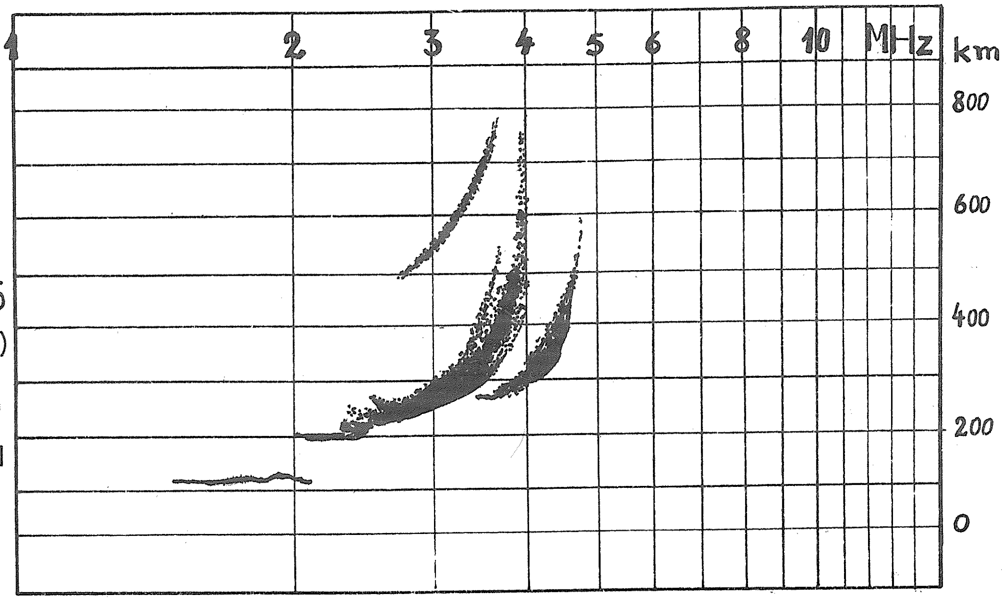
TIME: 5 15 AM (L.T.)
[0515 LT (60°W)]

Fig. 10.15

fmin	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

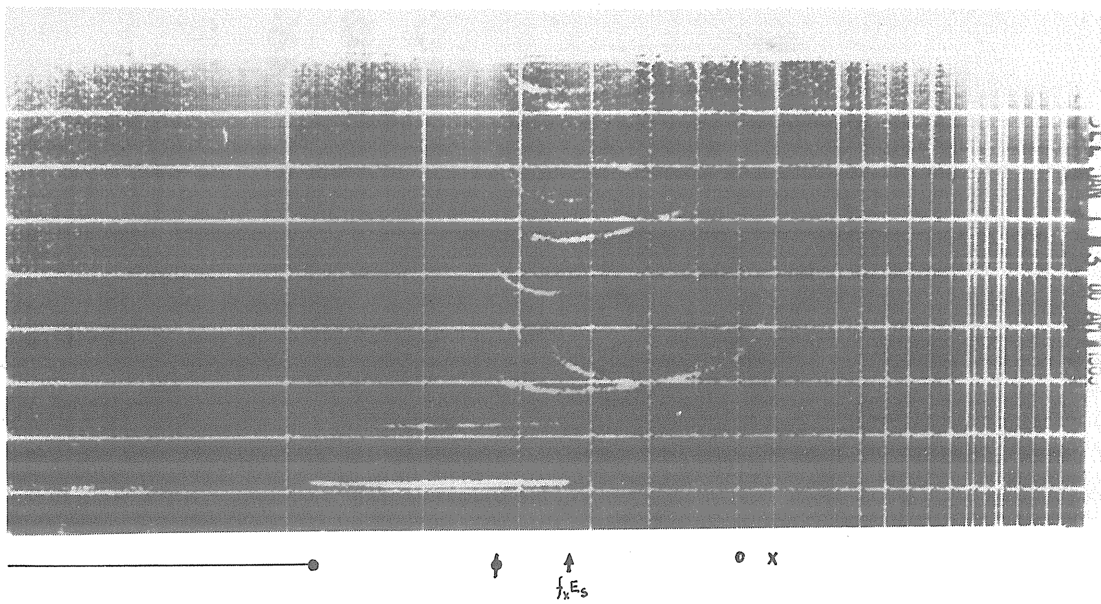
DATE: 7/3/1965
(7 March 1965)

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.

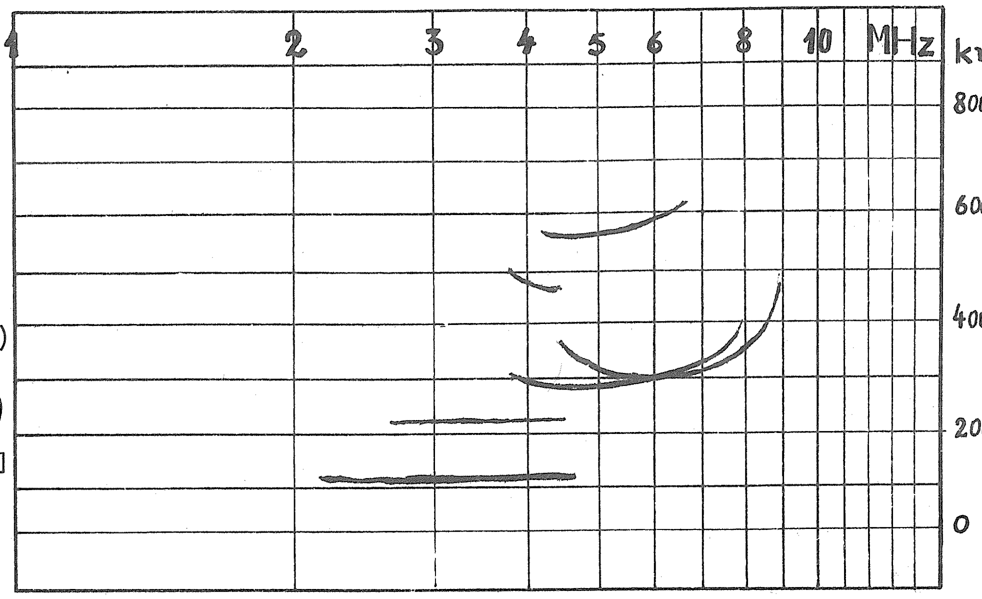


BASE
GENERAL
BELGRANO

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

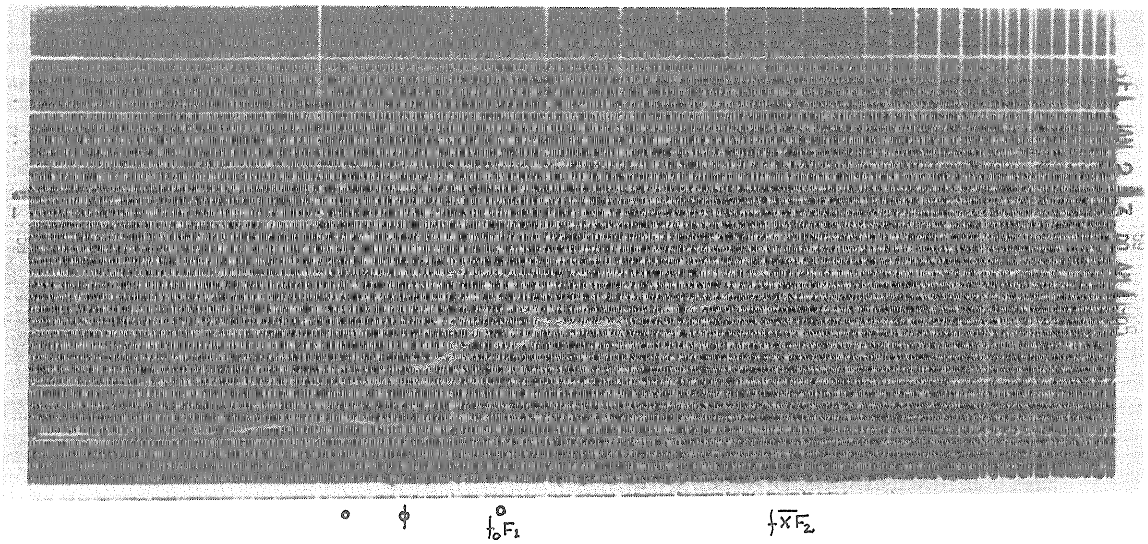
TIME: 3⁰⁰ AM (L.T.)
[0300 LT (60°W)]

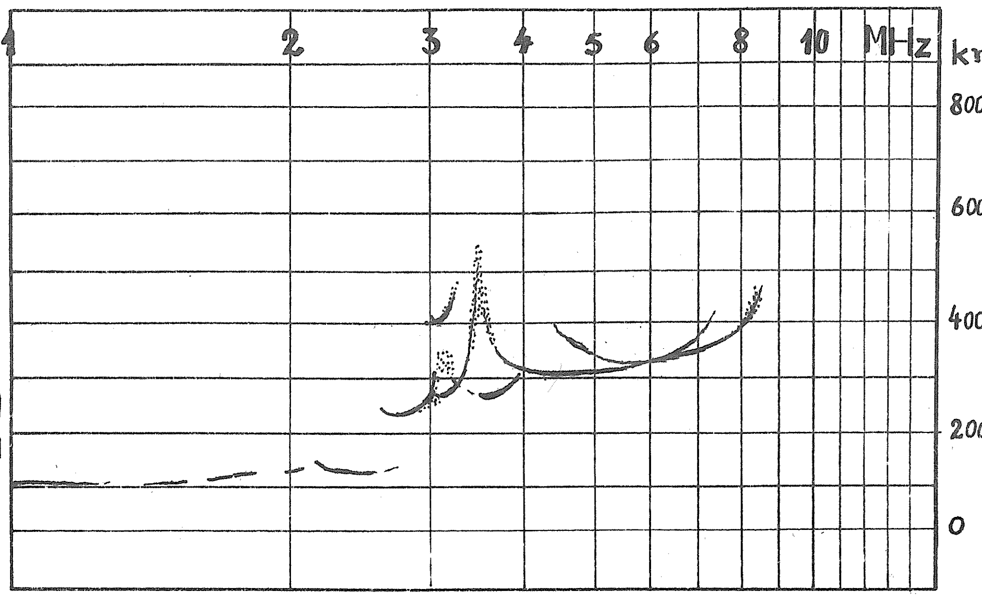
Fig. 10.17



fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
022-R	080		280	A	A	A
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**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.





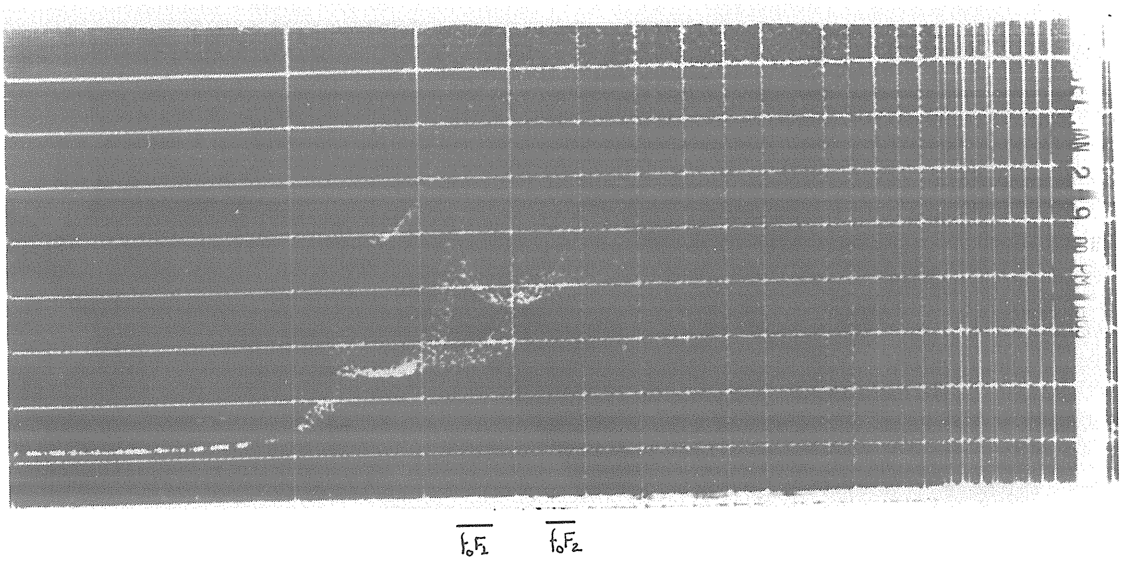
BASE
GENERAL
BELGRANO

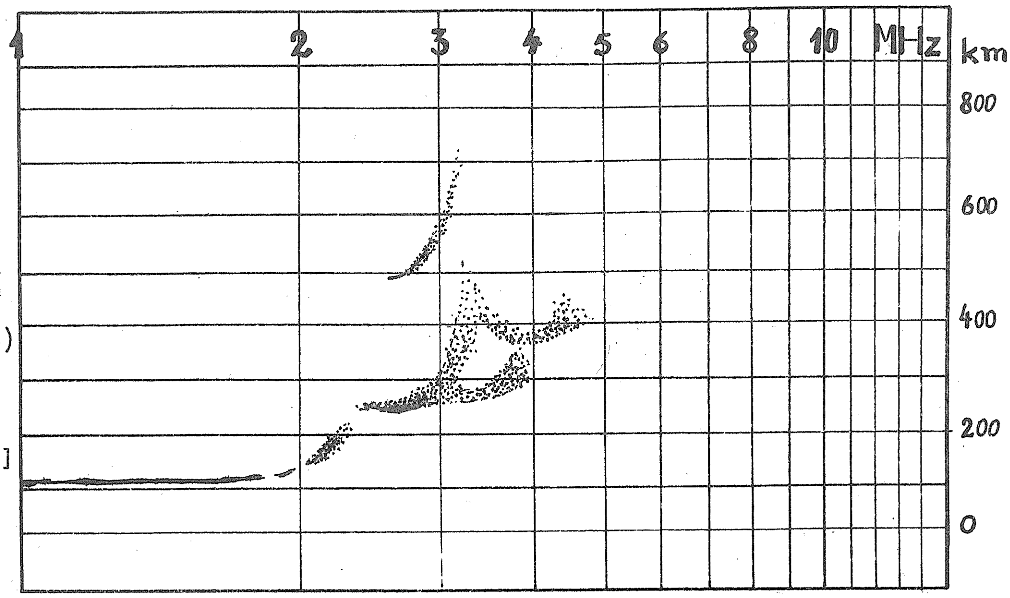
DATE: 2/I/1965
(2 Jan. 1965)

TIME: 3⁰⁰AM (L.T.)
[0300 LT (60°W)]

Fig. 10.18

fmin	f_oF_2	M3000F_2	h'F_2	h'F	f_oF_1	M3000F_1
E	076JR	290	300	230	350	350
f_oE	h'E	f_bE_s	f_oE_s	h'E_s	type E_s	fxI
250EA	109	0.25	0.27	125	h1	0.82





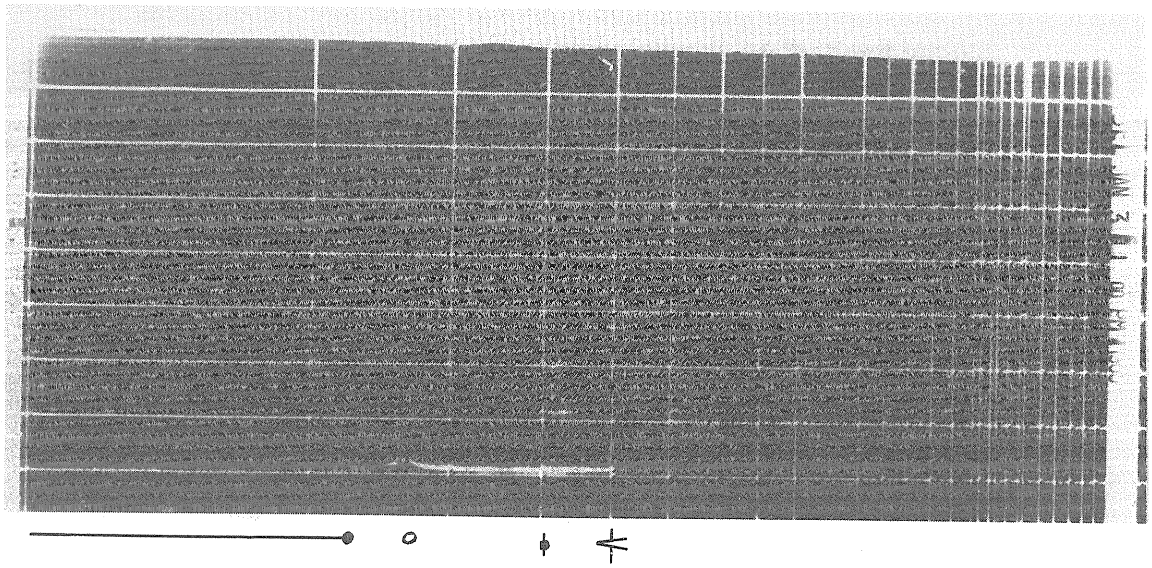
BASE
GENERAL
BELGRANO

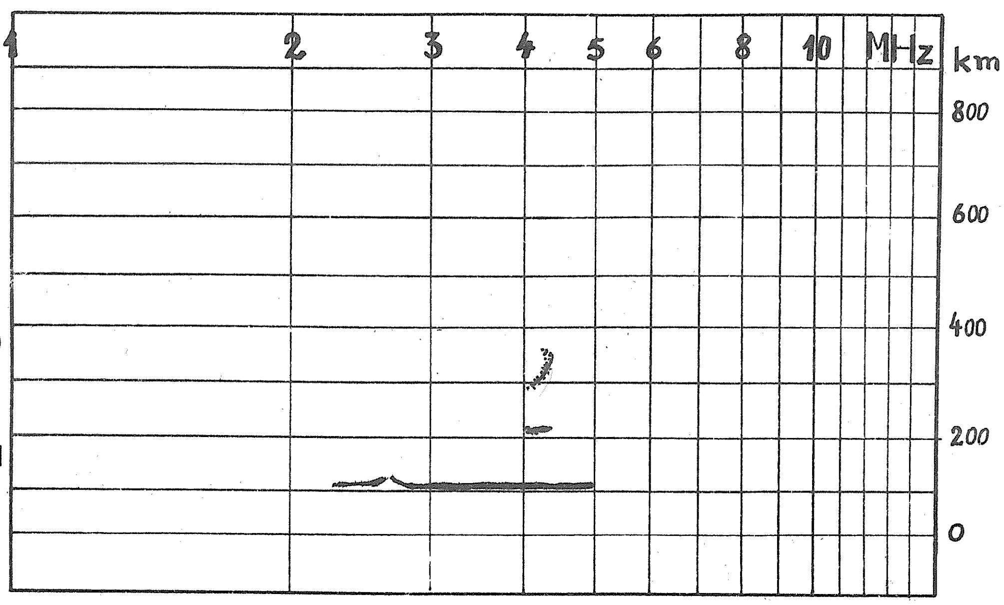
DATE: 2/I/1965
(2 Jan. 1965)

TIME: 9⁰⁰ PM (L.T.)
[2100 LT (60°W)]

Fig. 10.19

f_{min}	f_oF_2	M3000F2	h'F2	h'F	f_oF_1	M3000F1
E	0,48UF	F	370	245	330-F	350-F
f_oE	h'E	f_bE_s	f_oE_s	h'Es	type Es	fxI
210UF	121	G	G	G		0550R





BASE
GENERAL
BELGRANO

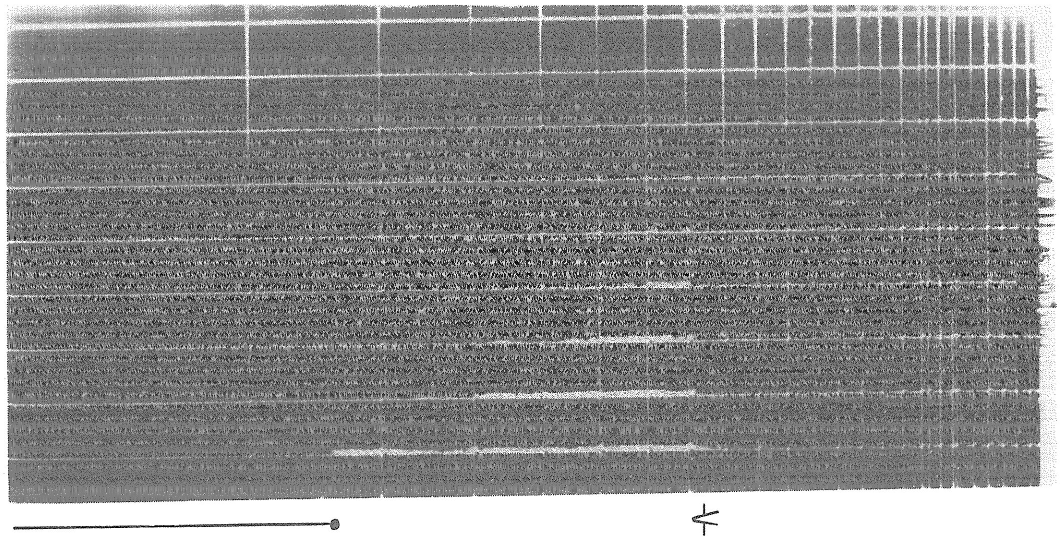
DATE: 3/I/1965
(3 Jan. 1965)

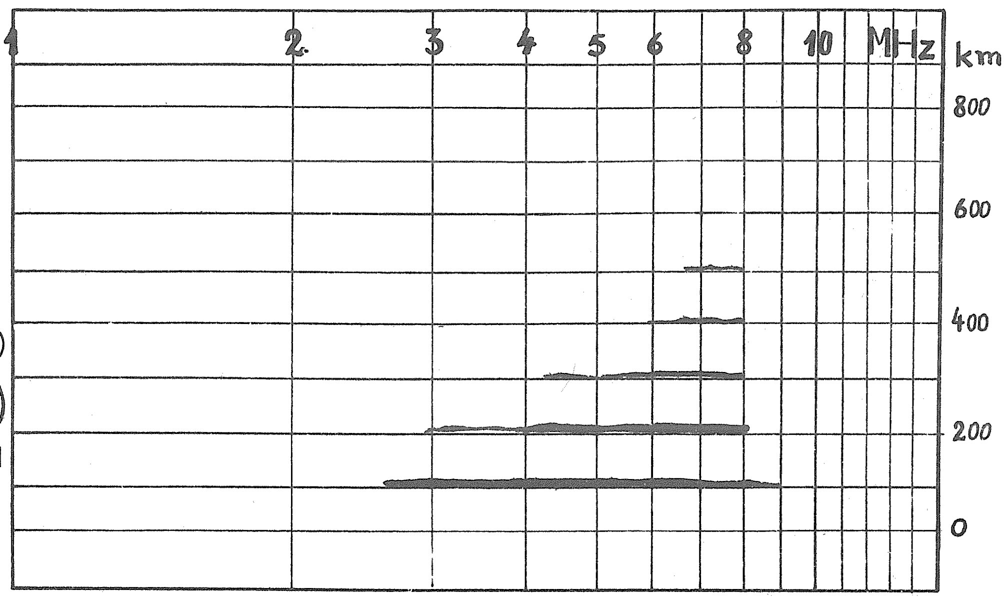
TIME: 1°° PM (L.T.)
[1300 LT (60°W)]

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

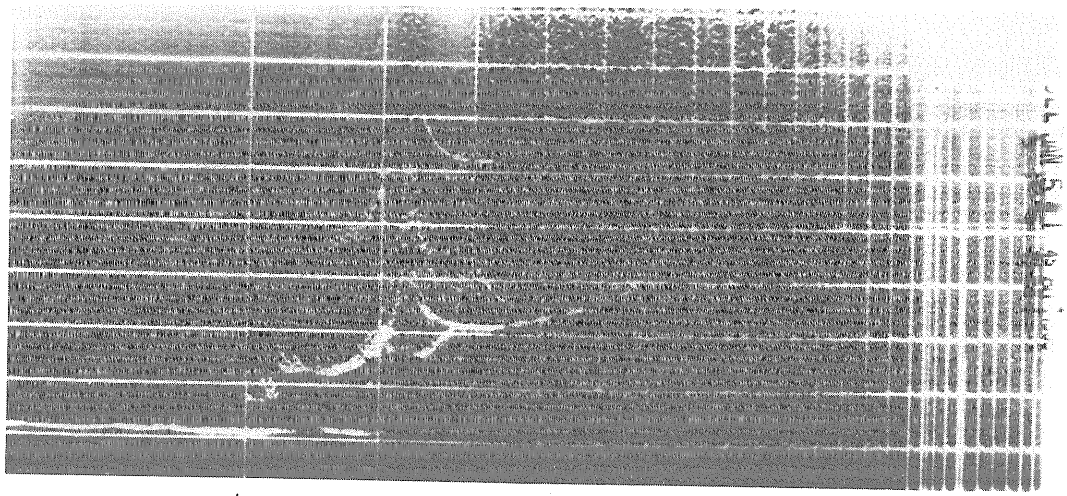
DATE: 4/I/1965
(4 Jan. 1965)

TIME: 11⁴⁵AM(LT.)
[1145 LT (60°W)]

Fig. 10.21

fmin	foF2	M3000F2	h'F2	h'F	foF1	M3000F1
0,26	A	A	A	A	A	A
foE	**h'E**	**fbEs**	**foEs**	**h'Es**	**type Es**	**fxI**
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.

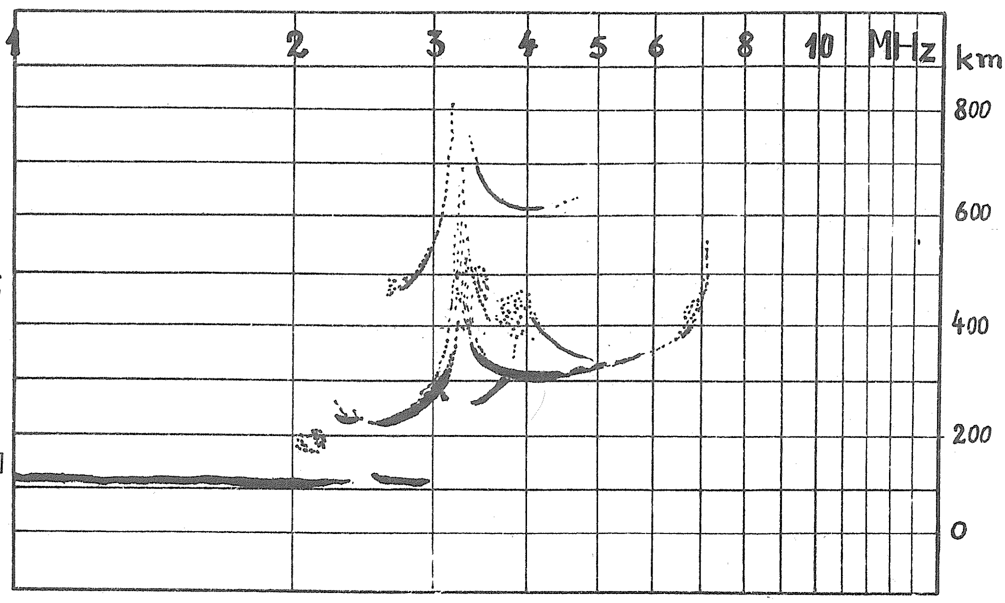


BASE
GENERAL
BELGRANO

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

TIME: 1⁴⁵AM(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.

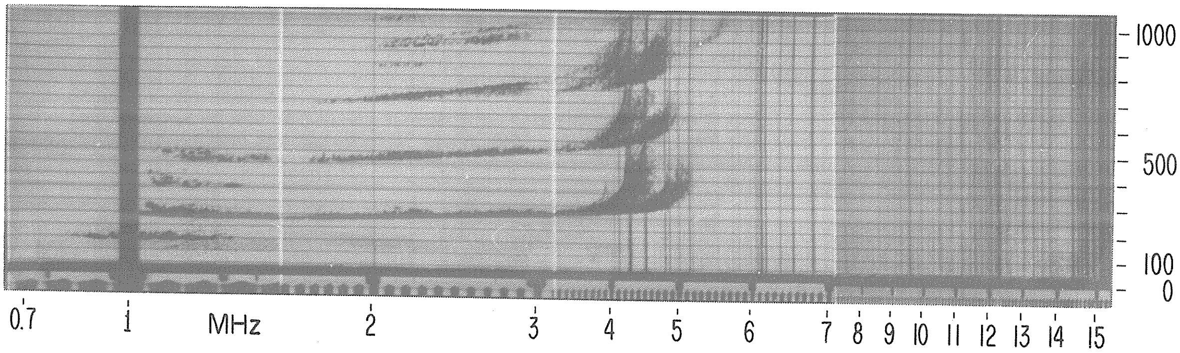


Fig. 11.1

HALLEY BAY

Winter day 1972 July 7 11.45 LT (30°W)

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.

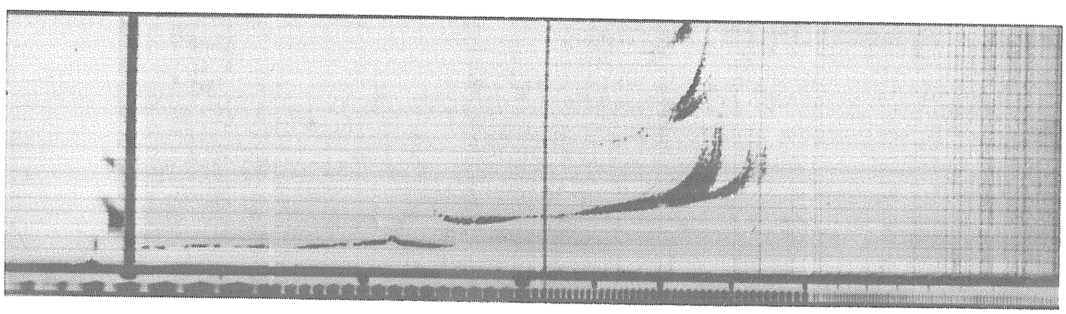


Fig. 11.2

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.

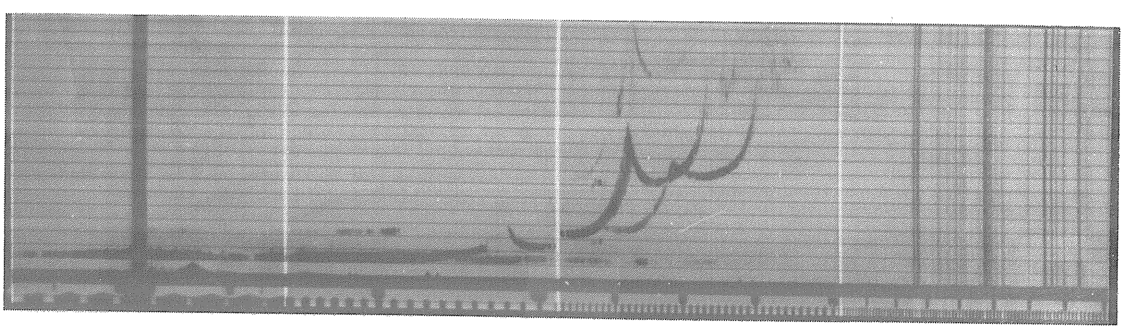


Fig. 11.3

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.

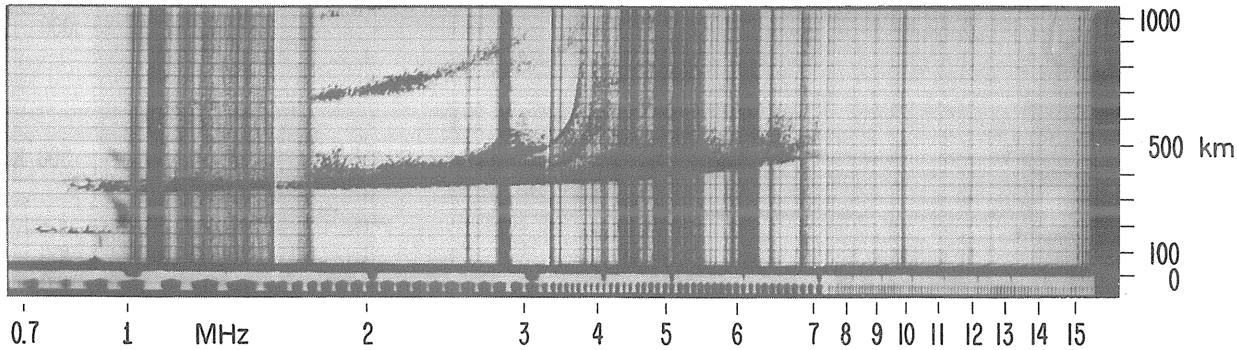


Fig. 11.4

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.

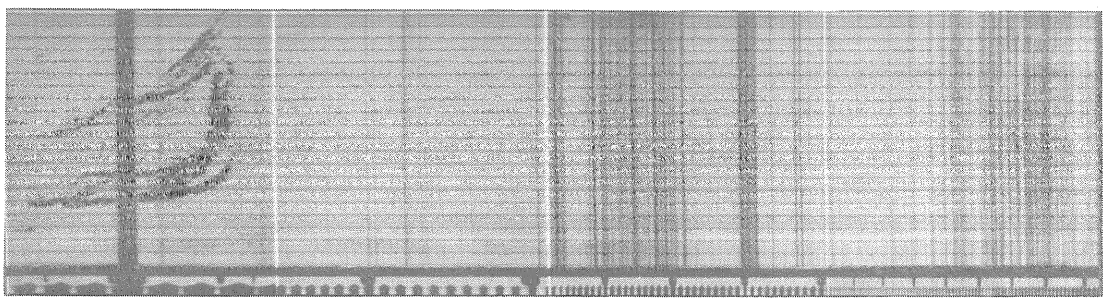


Fig. 11.5

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.

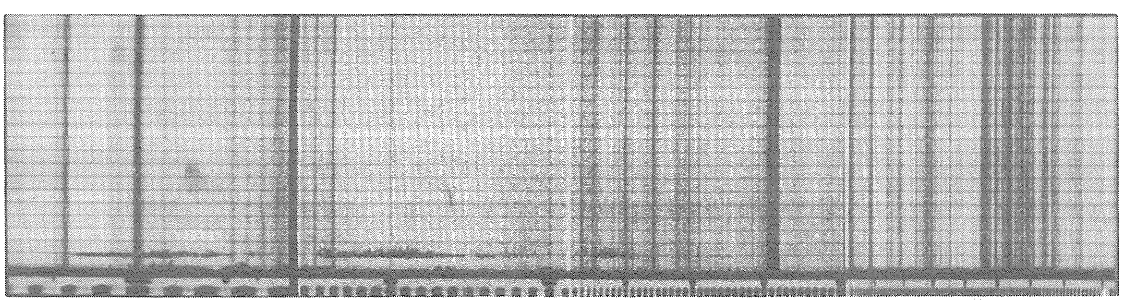
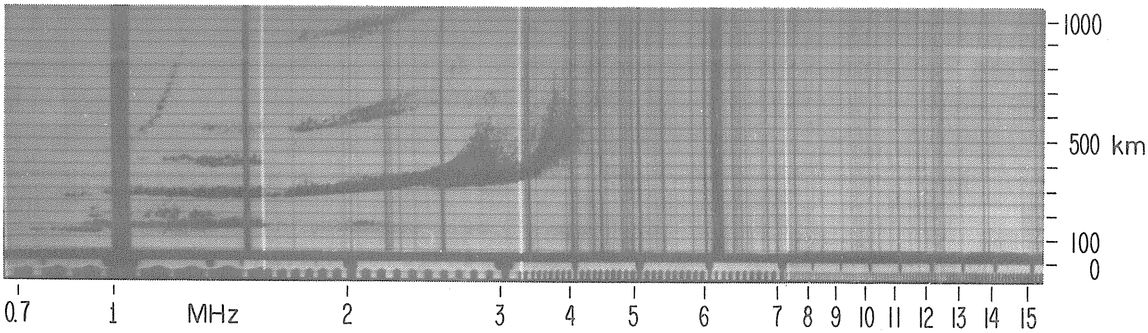


Fig. 11.6

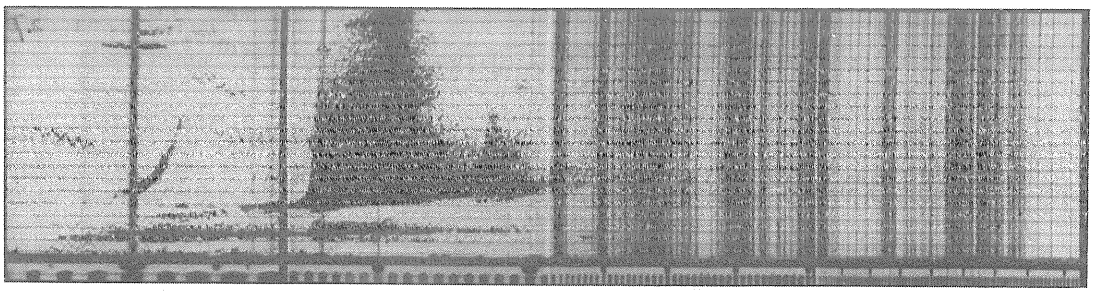
HALLEY BAY - Es-d 1973 July 28 21.30 LT (30°W)

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.

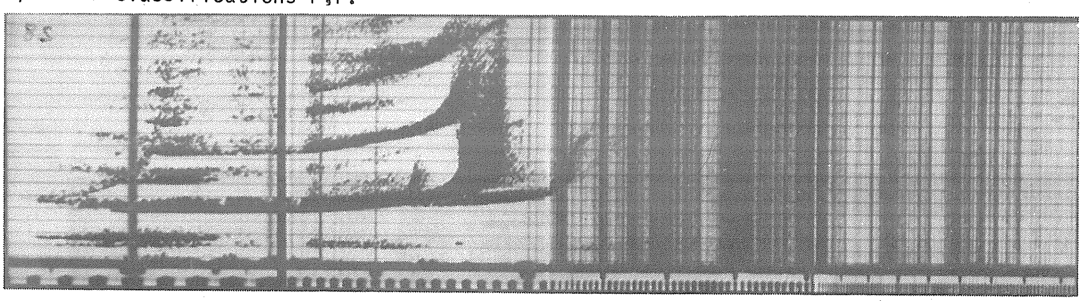


foF2 = 029-F Es-f 1973 July 7 10.15 LT (30°W)



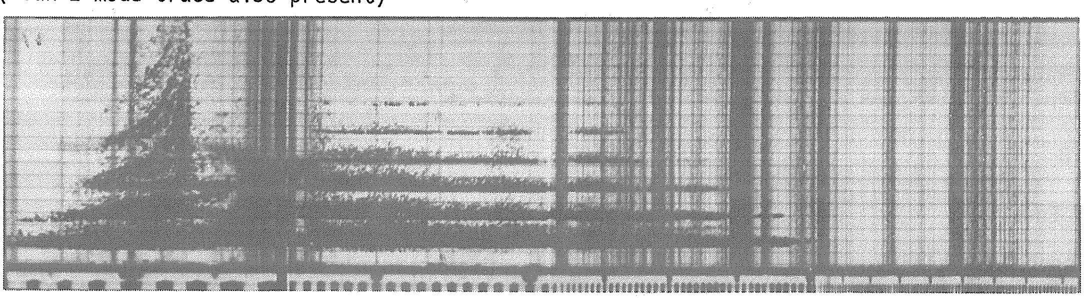
foF2 = 021-F Es-a 1973 July 23 14.45 LT (30°W)

(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

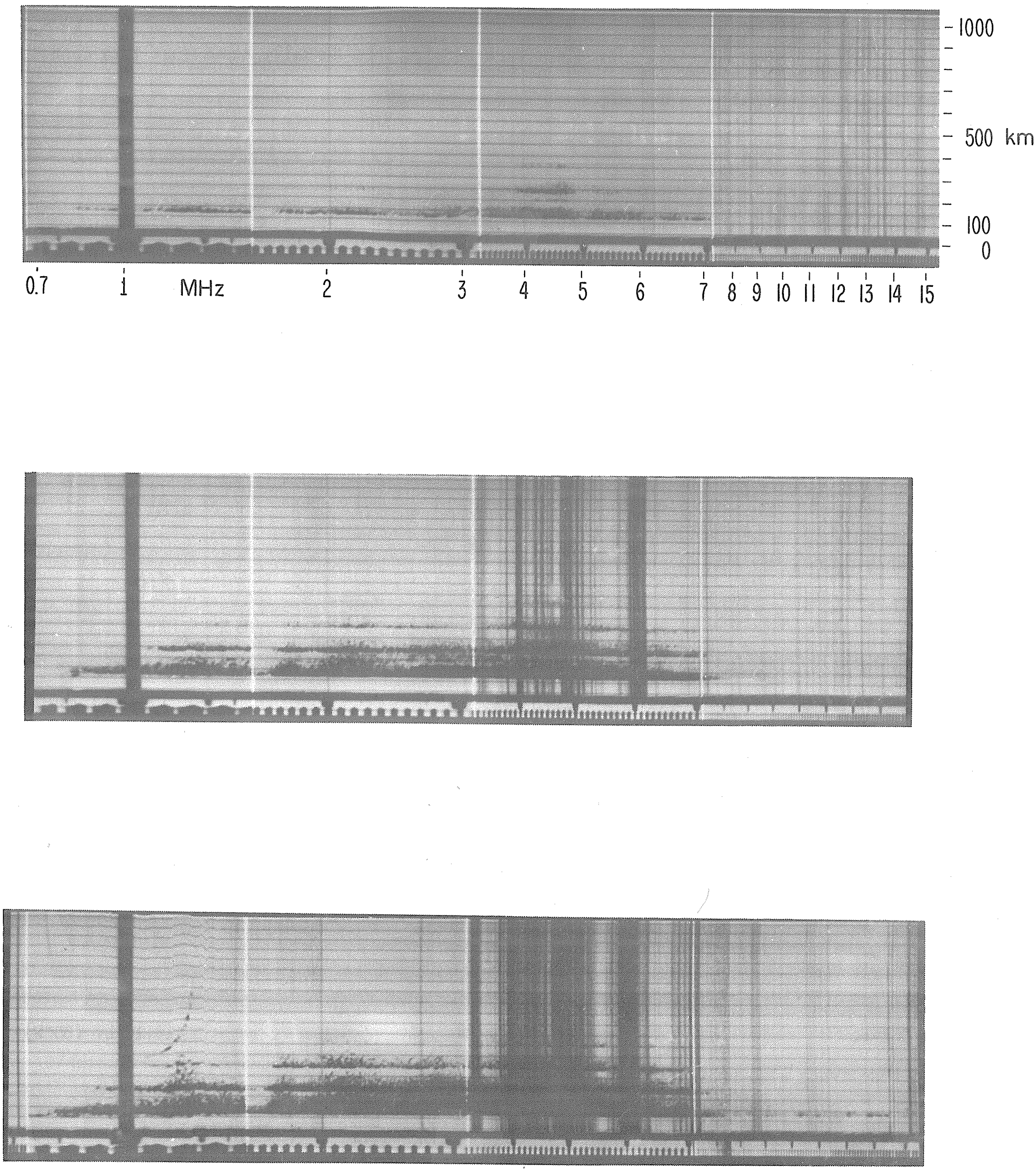


Fig. 11.8

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.

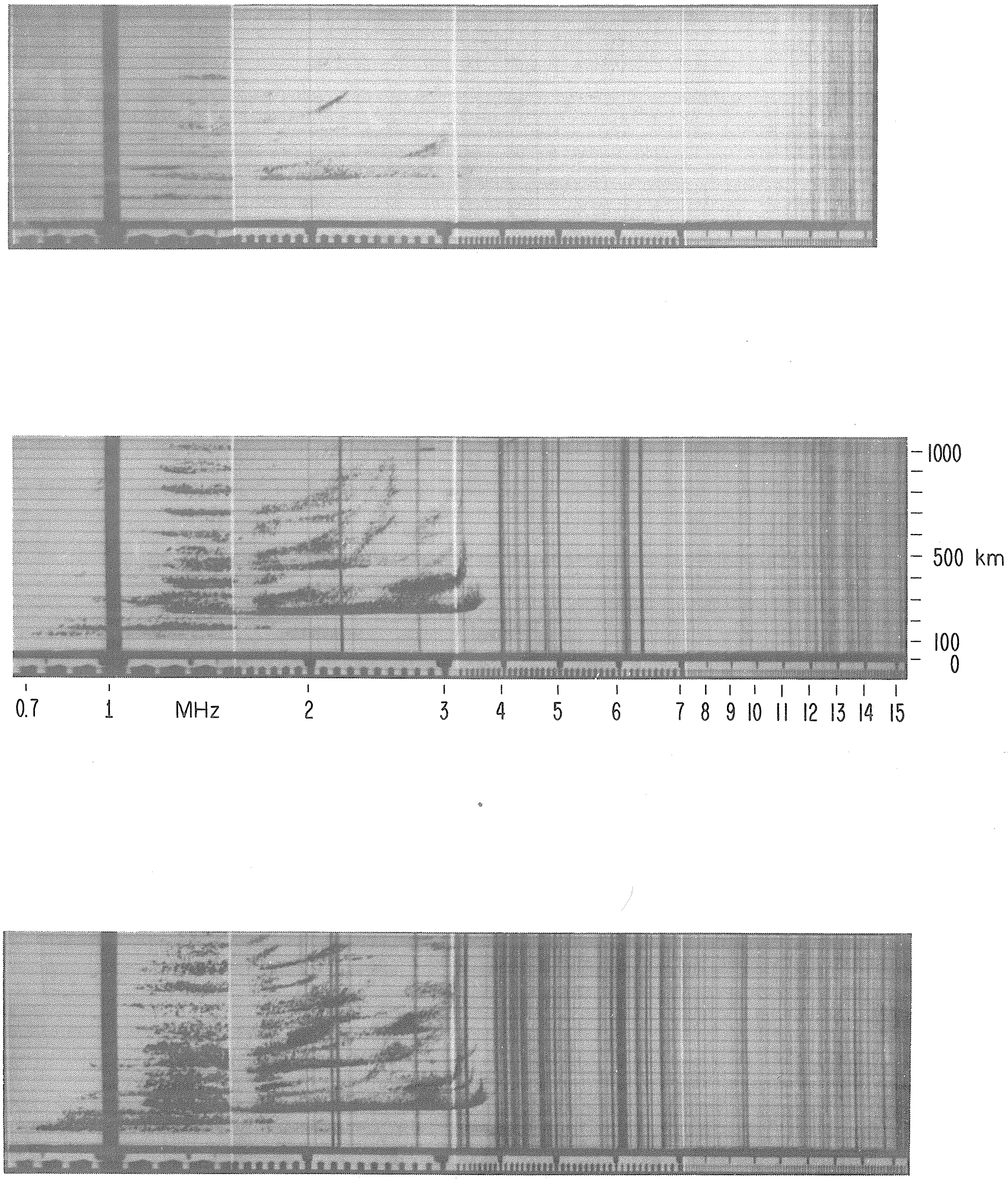


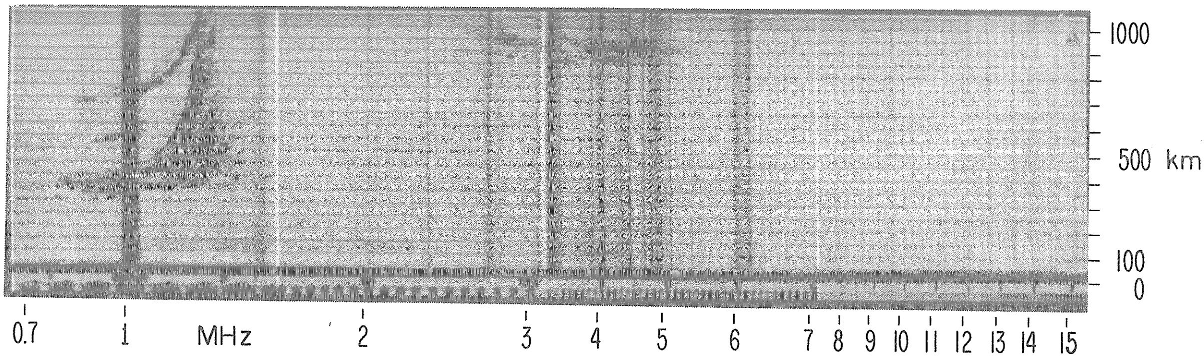
Fig. 11.9

Gain sequence

1972 July 3

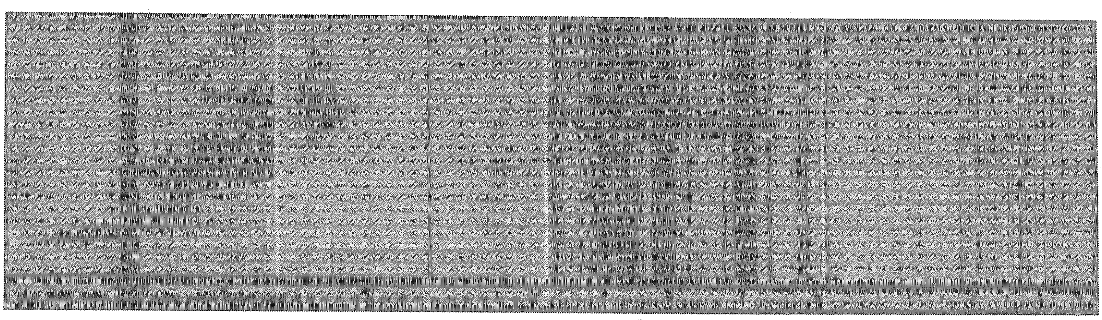
10.00 LT (30°W)

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.



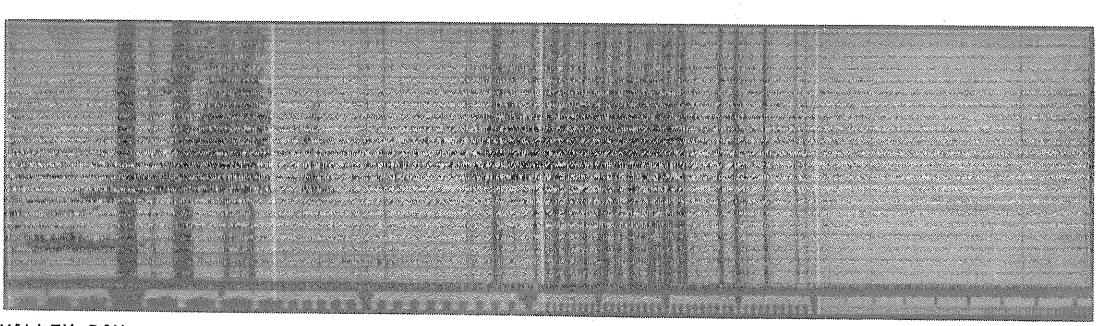
HALLEY BAY 1972 July 2 20.15 LT (30°W)

Trough (Replacement Layer) sequence Halley Bay. 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.

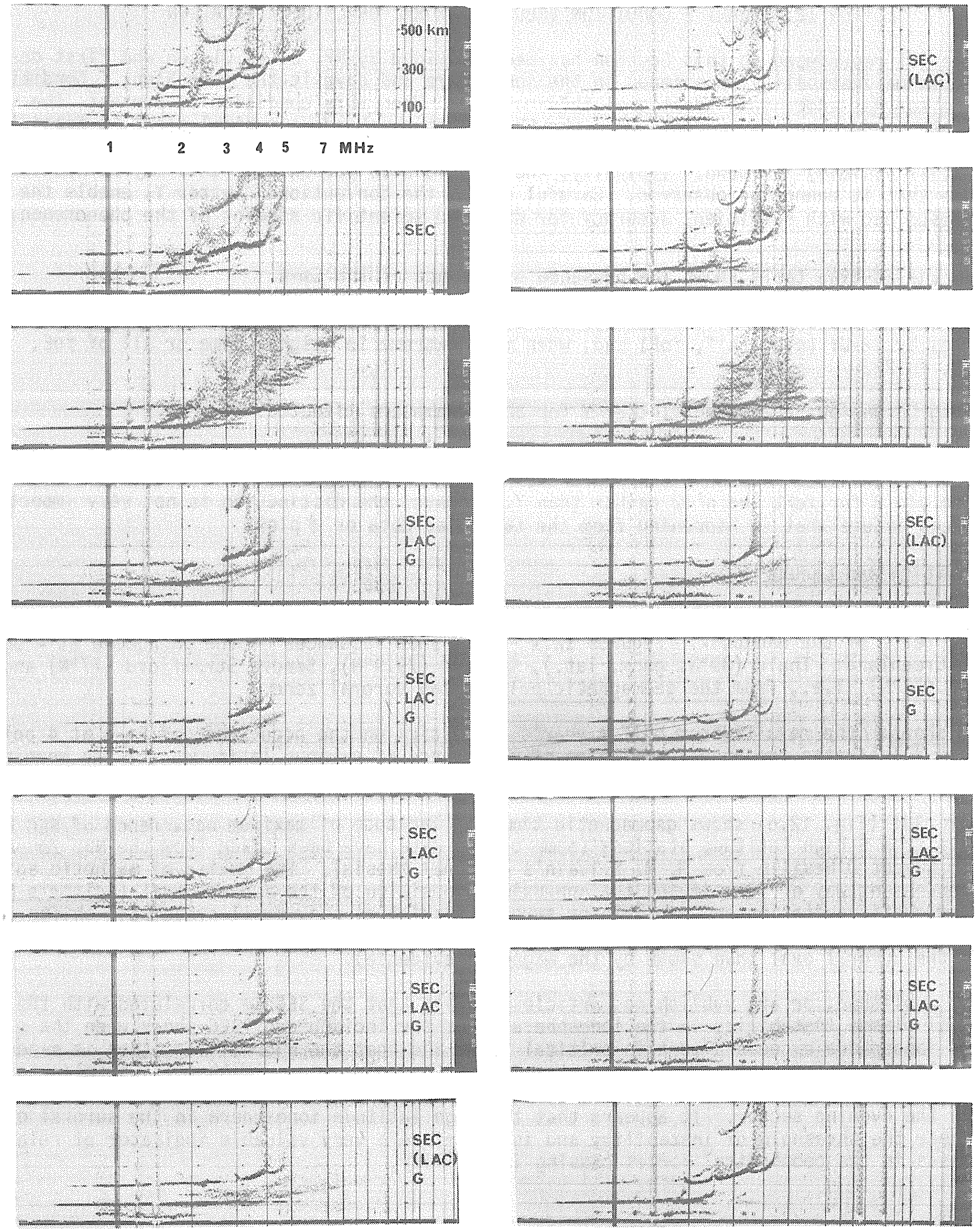
Slant E Condition and Lacuna

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.

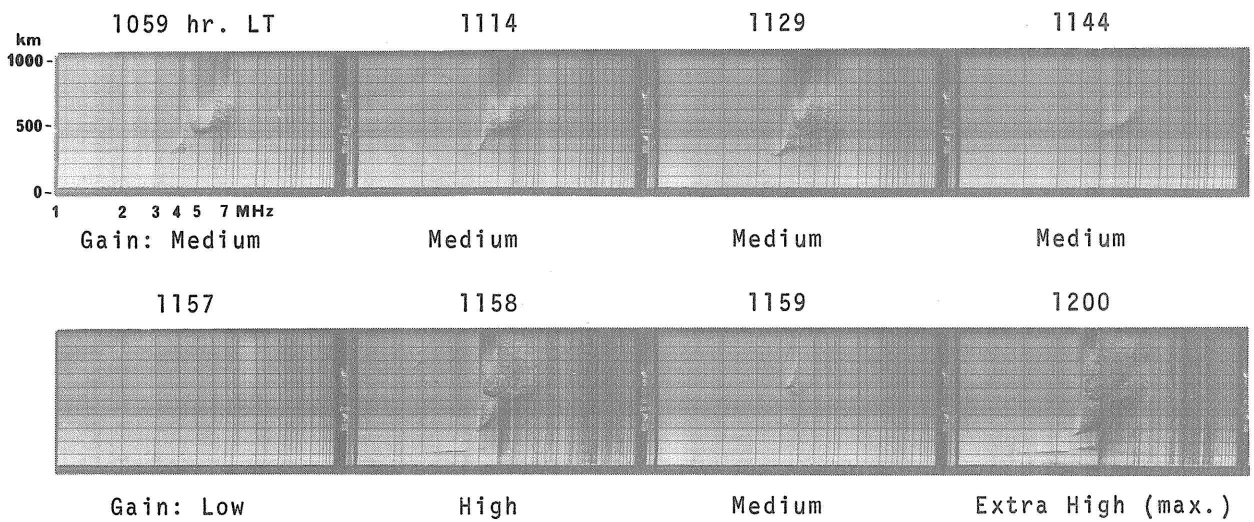


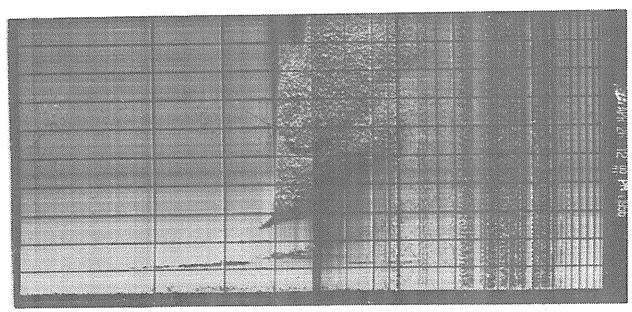
June 2, 1973 at 0559,0629,0659,0729, 0759,0829,0859,0929 LT (45° WMT)

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.



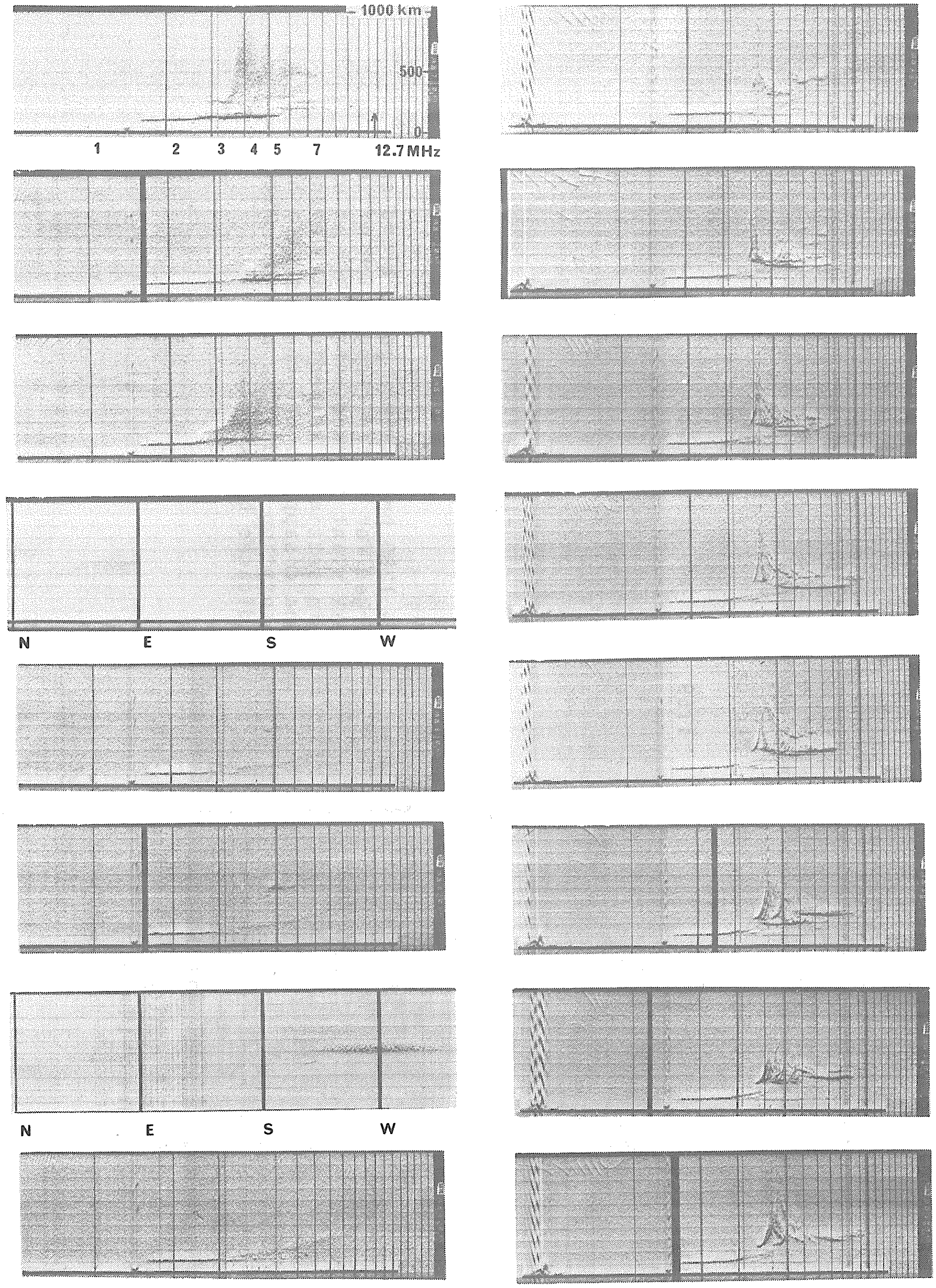


The 1200 hr. maximum gain record enlarged for better recognition of the weak slant E trace, invisible at other gain settings. At medium gain even Lacuna disappears and changes to a high absorption condition. Low gain record indicates black-out.

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.

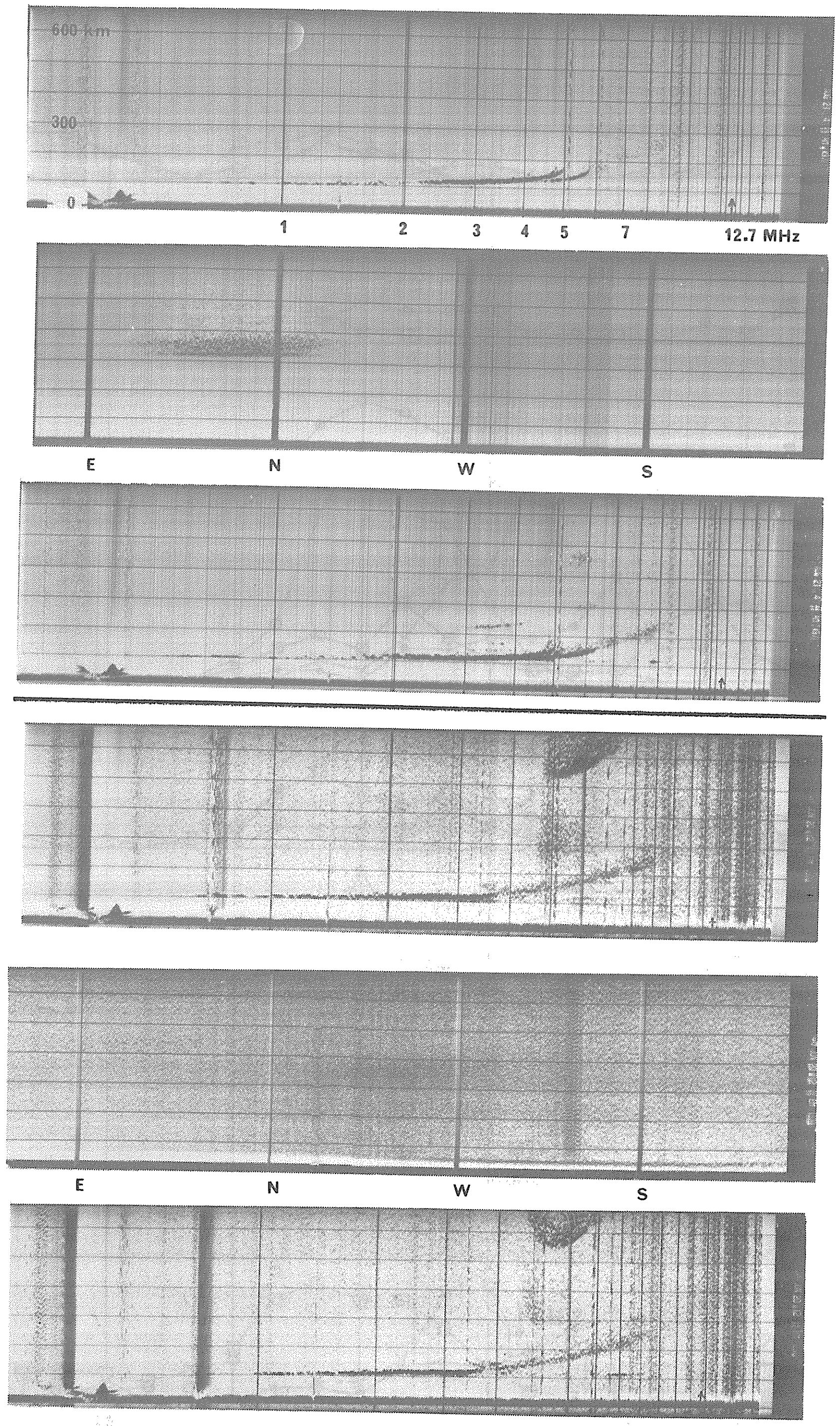


Fig. 12.4. Shows patterns from Narsarssuaq similar to Fig. 12.3. Note the backscatter is from the Northeast in the morning, Northwest in the evening.

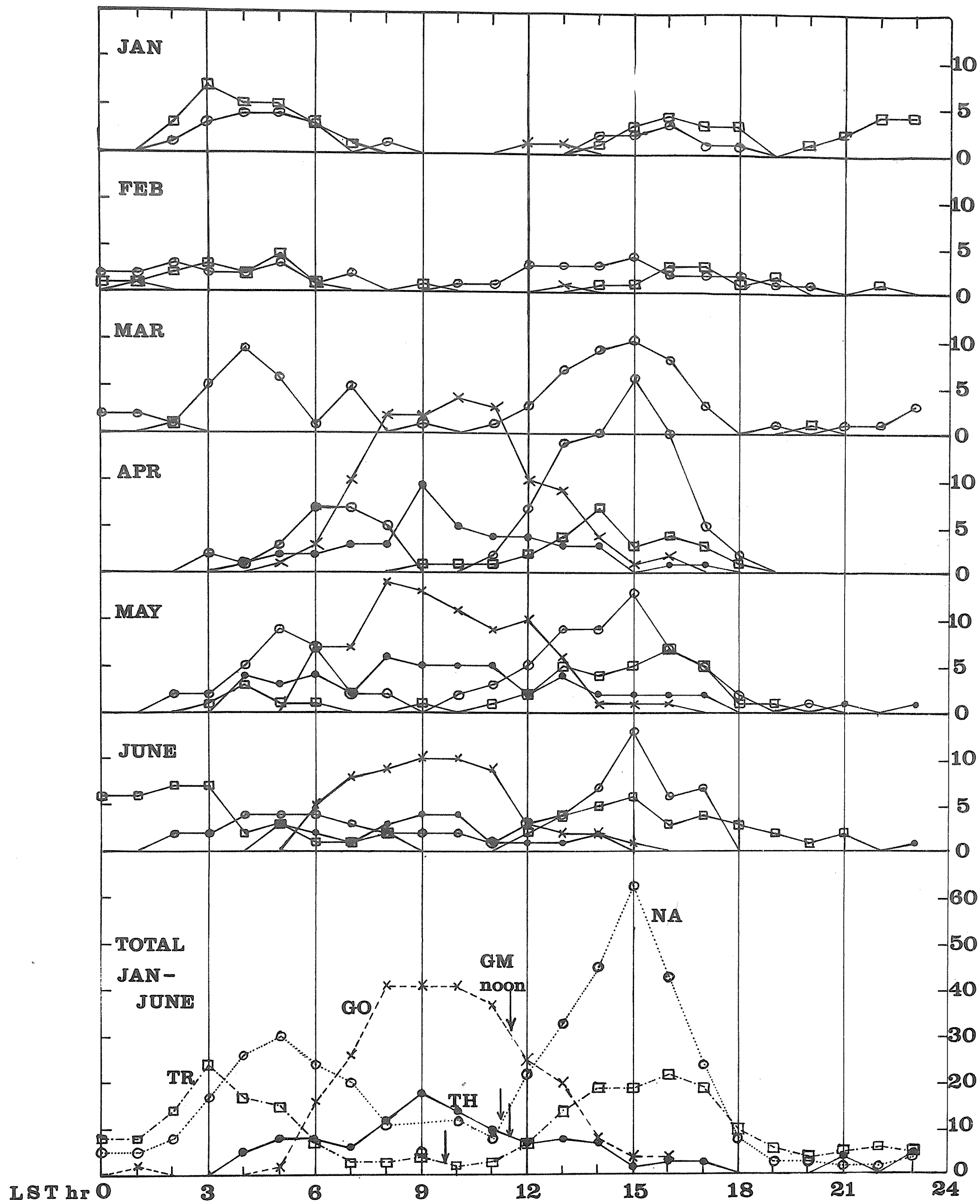
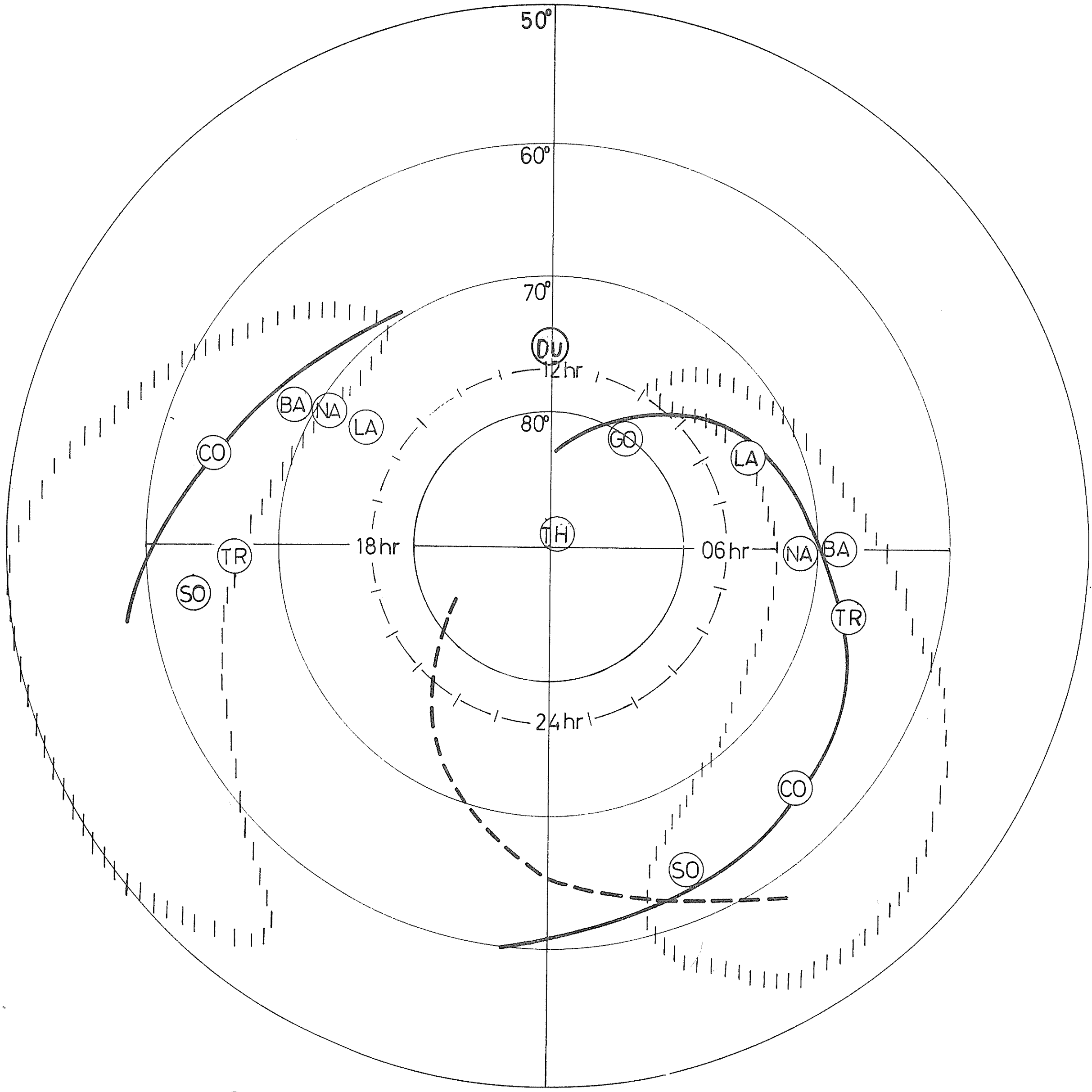


Fig. 12.5

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.

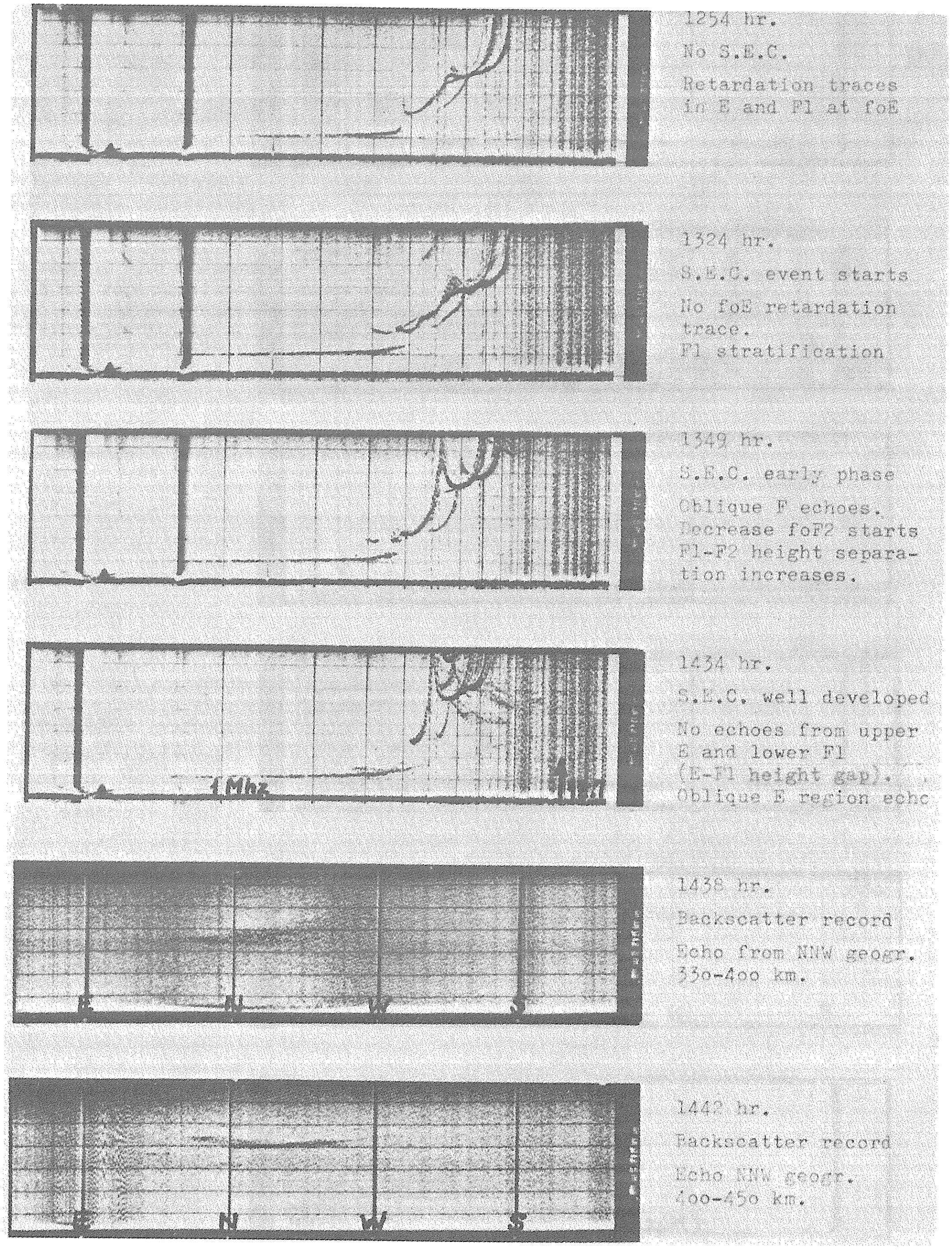
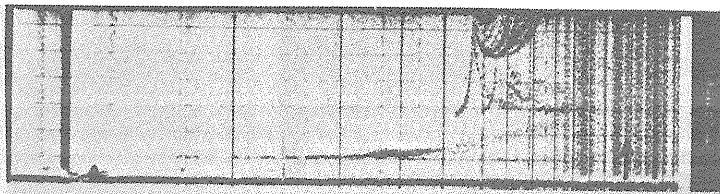


Fig. 2 a

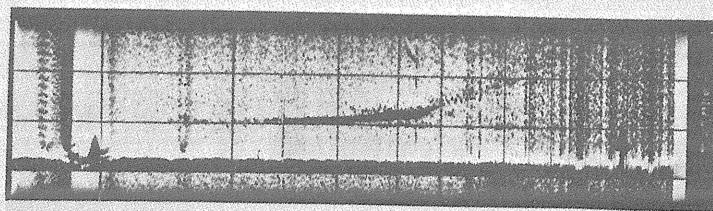
Typical daytime Slant E Condition (S.E.C.) at Narssarssuaq, June 17, 197o. (45°WMT). Ionograms are o.25 - 2o Mhz, o-65o km.
12,7 Mhz backscatter record have same distance range, azimuth is E,N,W,S geographical from left to right, antenna elevation 3o°.



1444 hr.

S.E.C. continues

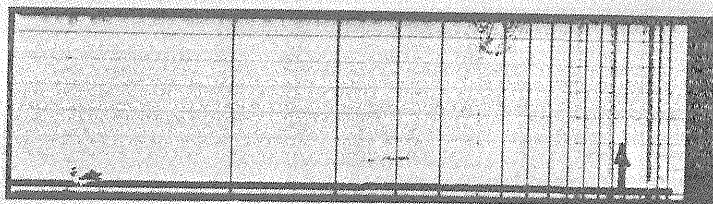
Oblique upper E region echoes.



1457 hr.

S.E.C. continues

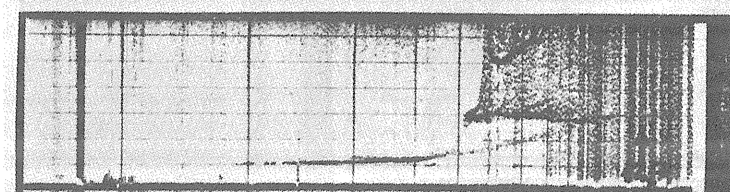
High gain-, expanded scale-record.
Note F1-z-echo.



1458 hr.

S.E.C. continues

Low gain record.
Notice: no slant trace but E-F height gap present.

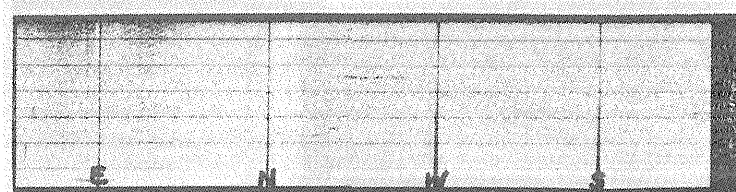


1534 hr.

S.E.C. continues

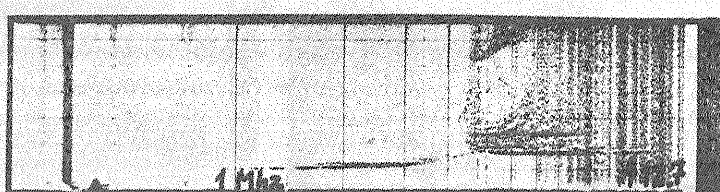
Constant range F-echoes increase.

foF2 decrease continues.



1542 hr.

Backscatter record
Echoes NW, NNW and SE, various distances



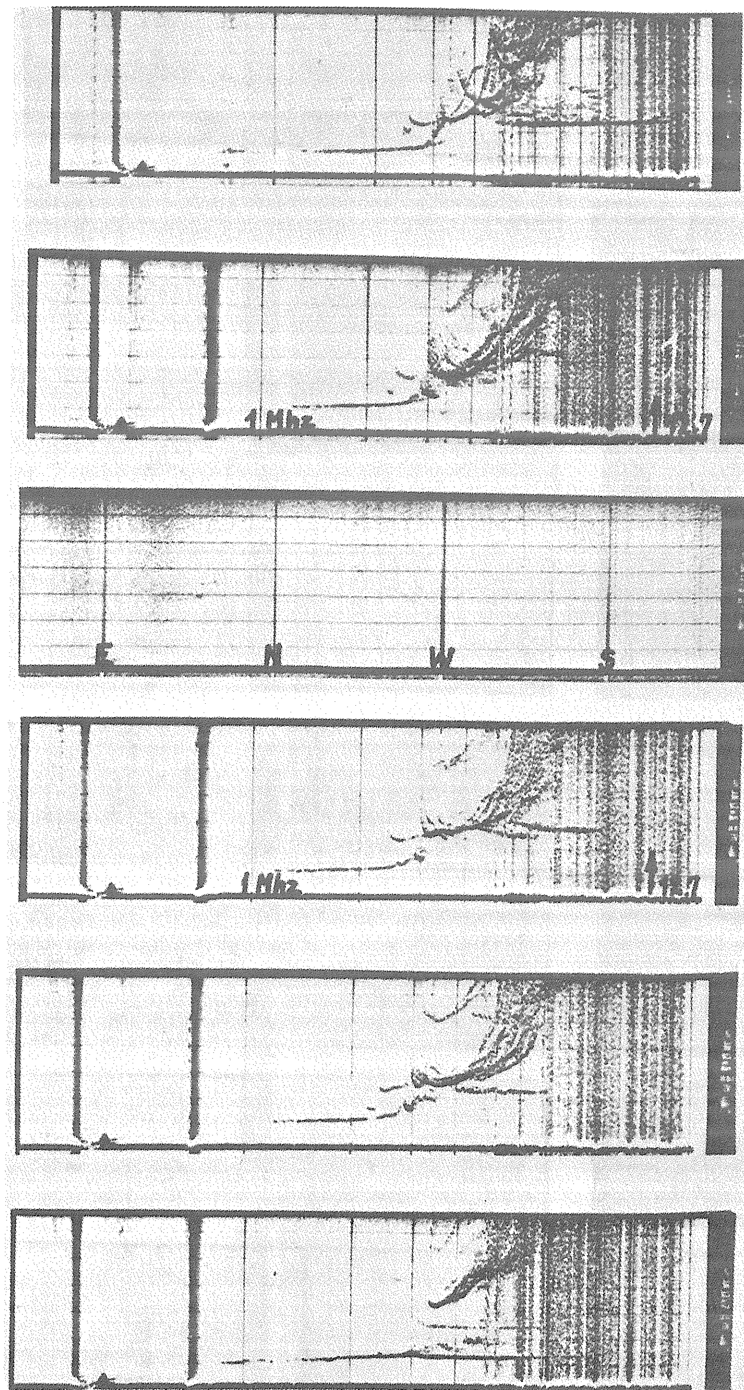
1544 hr.

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

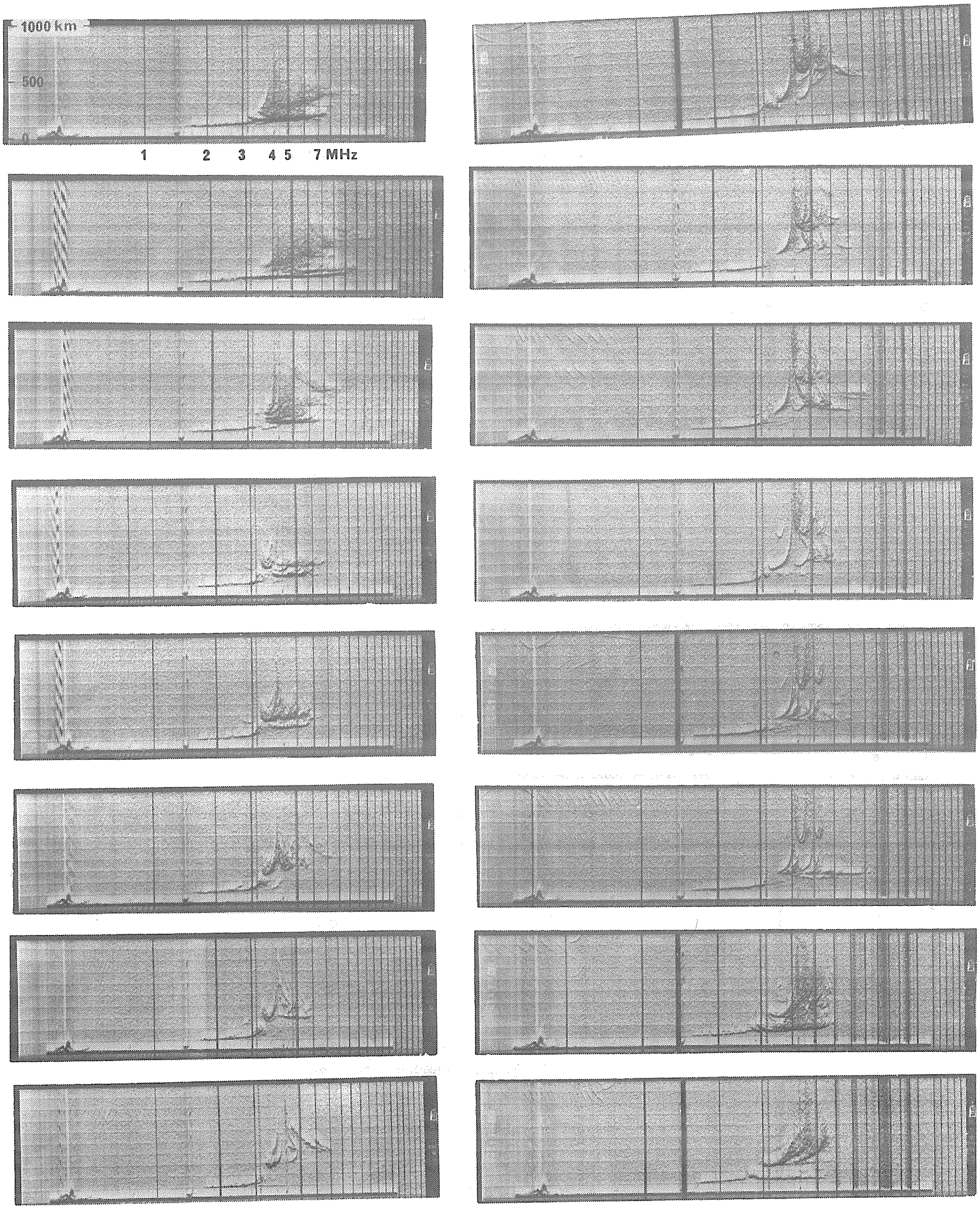
1749 hr.
S.E.C. over.
Constant range and other oblique after-effects.

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].

APPENDIX

CORRECTIONS AND ADDITIONS TO HANDBOOK (REPORT UAG-23)

The corrections are identified as follows:

(a) page number as given on bottom of page
(b) section number
(c) (i) paragraph number (in brackets) from top of page if section starts on an earlier page
    (ii) paragraph number (in brackets) in section if section starts on the page
(d) line in paragraph

Displayed equations are regarded as part of the preceding paragraph when counting. Otherwise, a blank line implies a new paragraph.

p iii Add:

"The current names and addresses of INAG members are published in the INAG Bulletin and other publications sponsored by INAG. The current list is attached to documents giving changes in the Handbook and its supplements."

p iii	Foreword	(5)3	Replace "4-chrome" by "4-chome"
p 5	0.4	(1)2	Replace "modity" by "modify"
p 7	1.02	(1)1	Insert after [A70D]: "(see foreword p i and piii)"
p 8	1.03	(1)3	Replace "frequency (Fig. 1.3)." by "frequency when above fB (Fig. 1.3)."
			Replace "In certain circumstances ... 1.05 below." by new text below:

"Since the conditions of reflection for the two components are different, each produces its own h'(f) pattern. These are similar but displaced in frequency, the extraordinary ray having the higher critical frequency above fB (Fig. 1.3). The magnetoelectronic theory shows that the reflection levels of the two modes (o and x) depend on the ratio of the exploring frequency f to the gyrofrequency fB. These are given below, where $X = fN^2/f^2$ and $Y = fB/f$

If $f < fB$ ordinary mode : $X = 1$ extraordinary mode : $X = 1 + Y$
If $f > fB$ ordinary mode : $X = 1$ extraordinary mode : $X = 1 - Y$

For any set of circumstances, there can only be two chracteristic modes but, because of coupling, there may be more than two characteristic traces.

For ionogram reduction it is more convenient to denote the traces according to the conditions of reflection:

Reflection at $X = 1$	o-trace
at $X = 1 - Y$	x-trace
at $X = 1 + Y$	z-trace (or third magnetoionic component)

Near the gyrofrequency the x-mode trace shows a special type of retardation (Fig. 1.4(a) and Fig. 1.5) which does not correspond to a critical frequency. As the x-mode is more strongly absorbed than the o-mode, the retardation near fB is only seen when absorption is small. This trace is called an x-trace. The patterns which would be expected as the ordinary wave critical frequency for changes from fo >> fB to fo $\doteqdot$ fB and fo < fB are shown schematically on Fig. 1.4."

p 9	1.04	(2)2	Replace "1T = 10^6Gs" by "1T = 10^4Gs"
		(5)3	Replace "$fx^2 - fxfB\ fo^2$"" by "$fx^2 - fxfB \doteqdot fo^2$"
		(5)5	Replace "fx - fo = fB/2 by "fx - fo $\doteqdot$ fB/2"

p 9 1.04 Delete the paragraph under Eq. (1.8): "When conditions allow reflection ... schematically in Fig. 1.4."

p 9 1.04 At the end of section add:

"The value of fB can be calculated from the local ground value of B using the inverse cube variation with height

$$B(h) = B_0 \left(\frac{r_0 + h}{r_0}\right)^{-3} \doteqdot B_0 \left(1 - \frac{3h}{r_0}\right)$$

where r_0 is the local radius of the earth.

If this is not available, use the dipole approximation p. 317 (e). By convention, h = 100 km is used for E layer. h = 300 km for F layer, h = 200 km when one value is used for both."

p 17 1.14 Insert at end of section:

"By convention entries of foE are omitted at hours when foE is usually below the lower limit of the ionosonde."

p 17 1.15 Replace existing paragraph by:

"1.15 <u>Particle E</u>: The ionogram shows the presence of a thick layer in the E region with a critical frequency significantly greater than that of normal E (1.14). In most cases particle E can be attributed to direct or indirect ionization by particle activity. Traditionally this trace was called night E as the critical frequency of the normal E was below the lowest recordable frequency at night. Fortunately, on almost all practical cases, the difference between the critical frequency of the particle E and of normal E is large -- much larger than the differences between foE and foE2 (1.16). Thus at night when foE for normal E is between 300 kHz and 500 kHz particle E usually gives foE2 above 1 MHz -- often up to about 5 MHz. Particle E is often preceded or followed by retardation type Es (Es-r) or auroral type Es (Es-a), in such cases foE usually varies rapidly with time. When particle E is present, as indicated by retardation of the traces from higher layers or by the character of the E trace (see section 3.2 letter K and section 4.24) it is identified in the tabulations by descriptive letter K (foE, foEs, fbEs, h'E, h'Es and Es type tables). Note retardation of a higher trace is enough to identify particle E (foE)-K if it obeys the definition given above. Particle E normally blankets normal E but is sometimes seen at heights up to about 170 km."

p 17 1.15 3 Insert:

"Night E always causes group retardation in any traces from higher layers, and such retardation near foE is sufficient to identify foE for night E."

p 17 1.15 8 Delete: "Normal E is not seen in these conditions."

p 17 1.15 8 Add: "(see section 4.24, p. 90).

p 19 1.19 (2)4 Replace " in all tables" by "in all other tables".

p 19 1.22 (1)4 Add after section 7.34:

"which seems to have fallen out of use and may be ignored."

p 20 1.26 (1)1 Insert: "<u>foI</u>:" before "foI is".

p 20 1.38 (1)1 Replace " fol.5" by "foF1.5"

p 21 1.50 (4)8 Replace "Fig. 1.14" by "Fig. 1.15"

p 27 2.0 (c)1 Replace "weak trace" by "weak traces"

October 1975

p 26			Add new section after section 1.8:

"1.9 Computer Output

Parameters reproduced in computer form are usually identified by the standard characteristic codes given in section 7.3 of the Handbook. These may be supplemented or replaced if desired by the corresponding parameters in computer printout form, e.g., FOF2 for foF2, FMIN for fmin, etc. All lower case symbols are replaced by capitals for computer reproduction and are regarded as equivalent to the international conventions. Other use of the capital letter forms is permitted on a voluntary basis.

The use of capitals rather than lower case symbols for Es types was adopted in 195 because in practice the lower case symbols are often difficult to read on worksheets. The original convention Es-a, Es-c etc. is preferred in texts. It is probable that, as more computers become available with lower case symbols, the parameters in computer form will also revert to the original form.

Originally lower case symbols were devised for Es types so as to avoid confusion with letter symbols which have quite different meanings. This is important to trainees but not important to fully trained operators who easily recognize the different context."

p 30	2.22	Fig. 2.1	Replace "Fig. 2.1" by " Fig. 2.1a. and Fig. 2.1b"
p 31	2.22	7	Replace "Fig. 2.1" by "Fig. 2.1a.".
p 31	2.22		After 7th line insert:

"2.23. Accuracy rules in total range of uncertainty forms: Operators who prefer to consider the total range of uncertainty may use the following rules which are equivalent to those given above.

(a) If the total range of uncertainty does not exceed 4% or 2Δ, whichever is greater, then the numerical value is unqualified.

(b) If the total range of uncertainty exceeds 4% or 2Δ, whichever is greater, but does not exceed 10% or 4Δ, whichever is greater, the value is considered doubtful and the qualifying letter U is used with the most probable value together with the descriptive letter which most nearly represents the reason for the uncertainty.

(c) If one boundary is certain and the other possible boundary lies within 10% or 3Δ, whichever is greater from it, the most probable value is taken as being midway between the observed limits, and the qualifying letter U is used with this value and the appropriate descriptive letter.

(d) When the total range of uncertainty exceeds that in paragraph (b) but is less than 20% or 5Δ, whichever is greater, of an observed boundary of possible positions of the principal echo trace, then this observed limit is tabulated with the qualifying letter D or E, whichever is applicable, and the appropriate descriptive letter.

(e) When the total range of uncertainty exceeds 20% or 5Δ, whichever is greater, a descriptive letter only is tabulated without a numerical value.

The application of these rules to F-region frequency parameters Δ = 0.1 MHz and E-region parameters with Δ = 0.05 MHz are shown graphically in Figs. 2.1 (a) and (b), respectively."

p 31			Insert after line 7 the heading: "2.24. Historical Note:"
p 31	2.3	letter F	Add: "Frequency spread present."
p 31	2.3	letter K	Replace "Night E" by "Particle E"
p 31	2.3	letter L	Add: "Mixed spread F present (see section 2.8.)"
p 32	2.3	after letter O	Insert:

"P - Man-made perturbations of the observed parameter; or spur type spread F present (see section 2.3)."

p 32	2.3	letter Y	Replace "Intermittent trace or trace missing due to defocusing." by Lacuna phenomena or severe F2-layer tilt present."

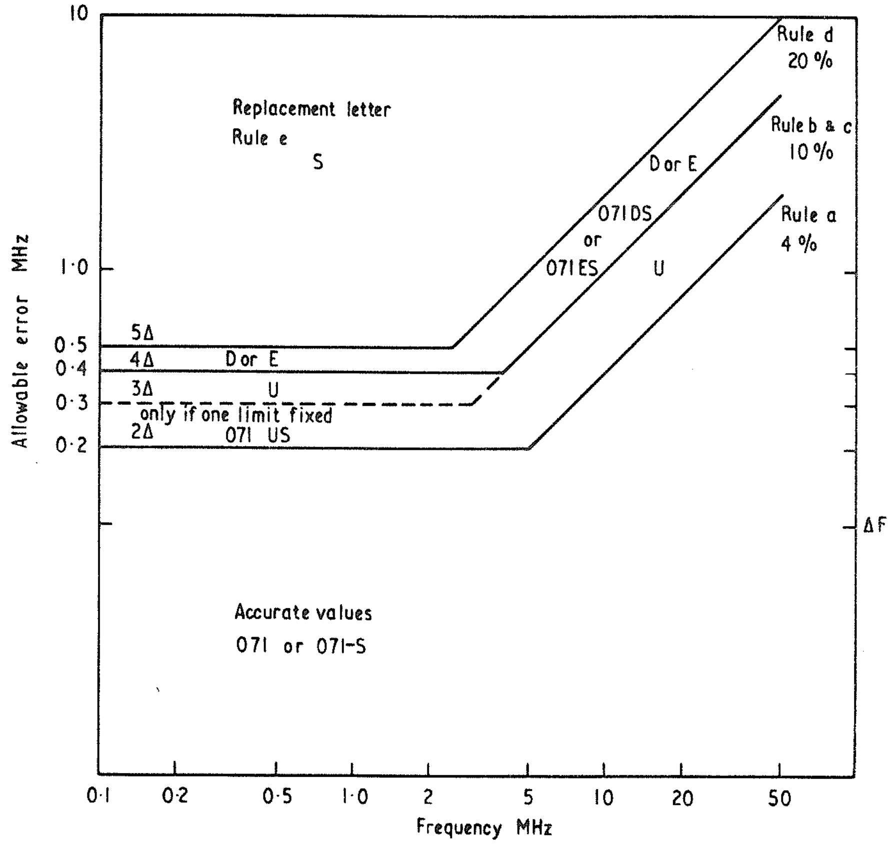


Fig. 2.1a Accuracy rules for F region frequencies Δ = 0.1 MHz in terms of total range of error.

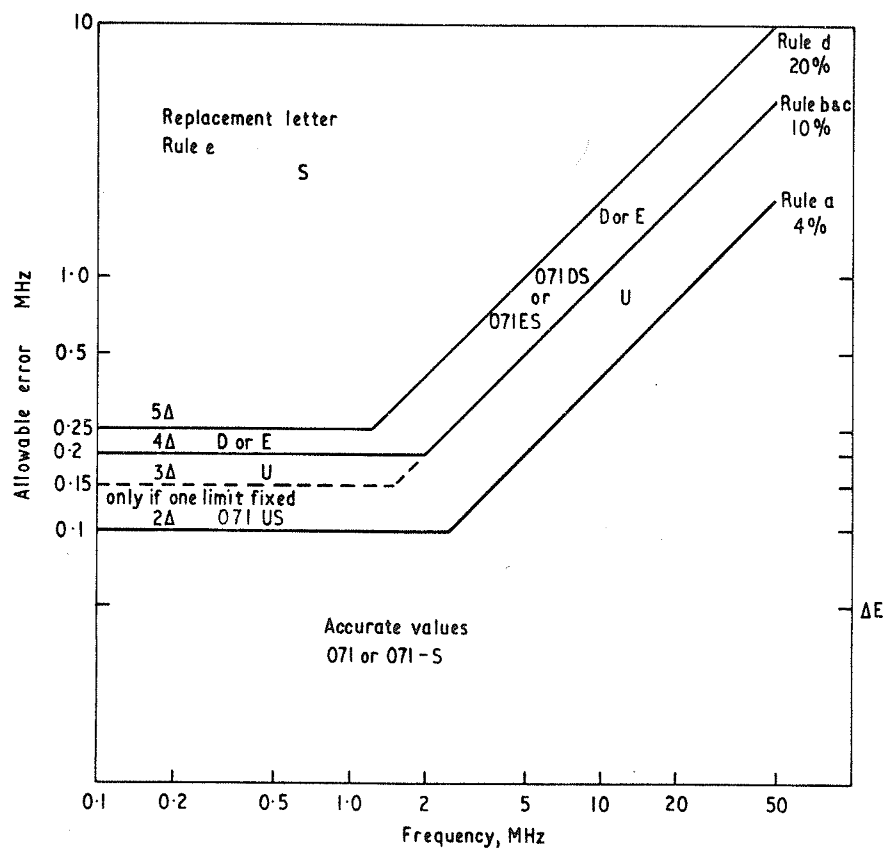


Fig. 2.1b Accuracy rules for E region frequencies Δ = 0.05 MHz in terms of total range of error.

p 32 2.3 end Add:

"The following descriptive letters are used to show spread F types and then take precedence over all other letters. (See section 3.2, p 72.)

F - Frequency spread present. foF2 and fxI tables only.
L - Mixed spread present. foF2 and fxI tables only.
P - Polar spurs fxI table only.
Q - Range spread present h'F, h'F2 rarely. foF2 tables only.

p 32 2.4 5 lines from bottom Insert:

"The extrapolation rule is that the range of uncertainty extends from the end of the observed trace to the deduced value of the critical frequency. This has the merits of simplicity and long use. However this rule restricts the number of numerical values allowed by the accuracy rules. The convention shown in Fig. 2.2b is also permitted. This can be stated: The ranges of uncertainty allowed by the accuracy rules are to be compared with the ranges between the least and largest value of critical frequency permitted by the extrapolation process."

p 32 Add: Figure 2.2b:

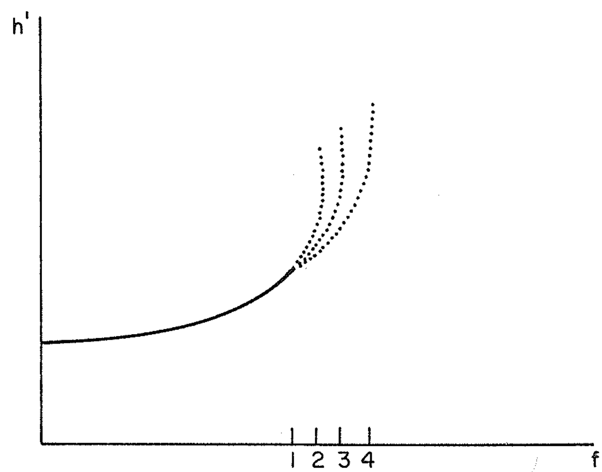


Fig. 2.2b Range of uncertainty when extrapolating to a critical frequency

The observed trace ends at frequency 1.
The most probable trace gives a critical frequency at frequency 3.
The least possible value of the critical frequency is 2.
The greatest possible value of the critical frequency is 4 when the frequency difference 2-3 or 3-4 is Δ.
The range of uncertainty to be used when applying the accuracy rules (section 2.2) is then $\pm\Delta$, or if total range rules are used, 2Δ.
Note that the range of uncertainty is usually less than the range of extrapolation given by the difference 1-3.

p 37	2.70	equation below Fig. 2.6	Replace " $h'(02) \neq h'(01)$" by "$h'(02) \neq 2h'(01)$"
p 42	2.72	(2)3	Delete: "more than"
p 43		Fig. 2.12	Delete: "Lacuna present on fxE2"
p 43		Fig. 2.12 caption, line 14	Insert: "badly"; -- "If x trace badly distorted ... ."

p 45 2.73 (1)end Add:

"The interpretation of some of these patterns by the use of aircraft is discussed, with examples in section 11.6 p 260-270. These patterns should correspond with those given in the Handbook Supplement on High Latitude Ionograms."

p 48 2.75 Replace text by the following:

"2.75. Lacuna phenomena. Under certain circumstances, traces reflected from a certain range of true height disappear although the remaining traces show that the absorption is either normal or only slightly increased. The name Lacuna (lacune in French) has been proposed for this phenomenon, Lacuna being the Latin word for "gap". The explanation of Lacuna is still controversial though it is generally agreed that the reflected signal is greatly weakened by scattering or defocussing processes occurring over a limited range of reflection heights. This is attributed to the effect of plasma instability mechanisms. When the equipment sensitivity is high or the phenomenon weak it is possible to see weak, diffuse reflections spread in frequency and height over parts of the range where normal reflections have disappeared.

Lacuna appears to be closely associated with activity along the auroral oval and is also found at the magnetic poles. It is proving to be a useful tool for studying activity in these zones. It is also closely associated with slant Es seen at high latitudes and has been discussed under the title Slant E Condition (SEC) (J. K. Olesen, AGARD CP97, 1972, pp. 27.1-27.19, NATO Paris, INAG 12, pp. 14-19). Many cases of the combined phenomena, Lacuna plus Es-s are shown in the High Latitude Supplement. This is the most common type of ionogram when SEC conditions are present.

The distinguishing feature of Lacuna is that the amplitude of signals reflected from a certain range of heights is abnormally small. In contrast absorption causes greater losses on the lower frequencies and on the x-mode relative to the o-mode traces. Similarly when Lacuna affects a trace near a critical frequency the signal suddenly disappears or reappears at normal strength, abnormal absorption would cause a gradual change with frequency. When absorption is low, slant Es is common during Lacuna. The F traces disappear suddenly when Lacuna occurs and reappears suddenly, with relatively little change in shape over the interval. In practice the Lacuna is most often seen on the F1 trace, Fig. 2.18, causing a gap between foE and foF1 (sometimes the E-trace retardation is also cut off giving a trace at normal height but looking like an Es trace). This is called F1 Lacuna. It can effect all F-layer traces -- total F-Lacuna. When the sensitivity is high, weak diffuse traces can be detected over part or all of the perturbed height range.

The presence of Lacuna phenomena is indicated by letter Y. Care must be taken to distinguish between Lacuna and the effects of increased absorption and of blanketing by Es. (See Figure 2.18)."

p 48 2.75 Fig. 2.18 Replace "Fig. 2.18" by "Fig. 2.18(a)" and add to caption:

"(e) At some stations the second order trace is not seen during Lacuna conditions."

p 48 2.76 Insert after page 48:

"Slant Es Condition (SEC): In practice Lacuna is most frequently associated with Slant Es, the two phenomena being due to intense plasma instability. This is believed to be associated with the two stream mechanism, and most probabl indicates occasions when the local electric field in the E and lower F region exceeds a critical limit. The phenomena is thus important for studying magnetospheric phenomena at high latitude. Figure 2.18(b) shows a fairly typical example of an ionogram with both Lacuna and Slant E present. Many examples of this phenomena are given in the High Latitude Supplement. Very often the Slant Es is visible before the Lacuna appears and it can also be seen after the Lacuna disappears. It appears that the Slant Es shows the presence of intense turbulence in the E region up to several hundred kilometers from the station whereas a Lacuna shows the presence of this intense turbulence overhead. As a Slant Es trace is a relatively weak trace it can readily be screened by absorption and its apparent frequency of occurrence depends on the sensitivity of the ionosonde."

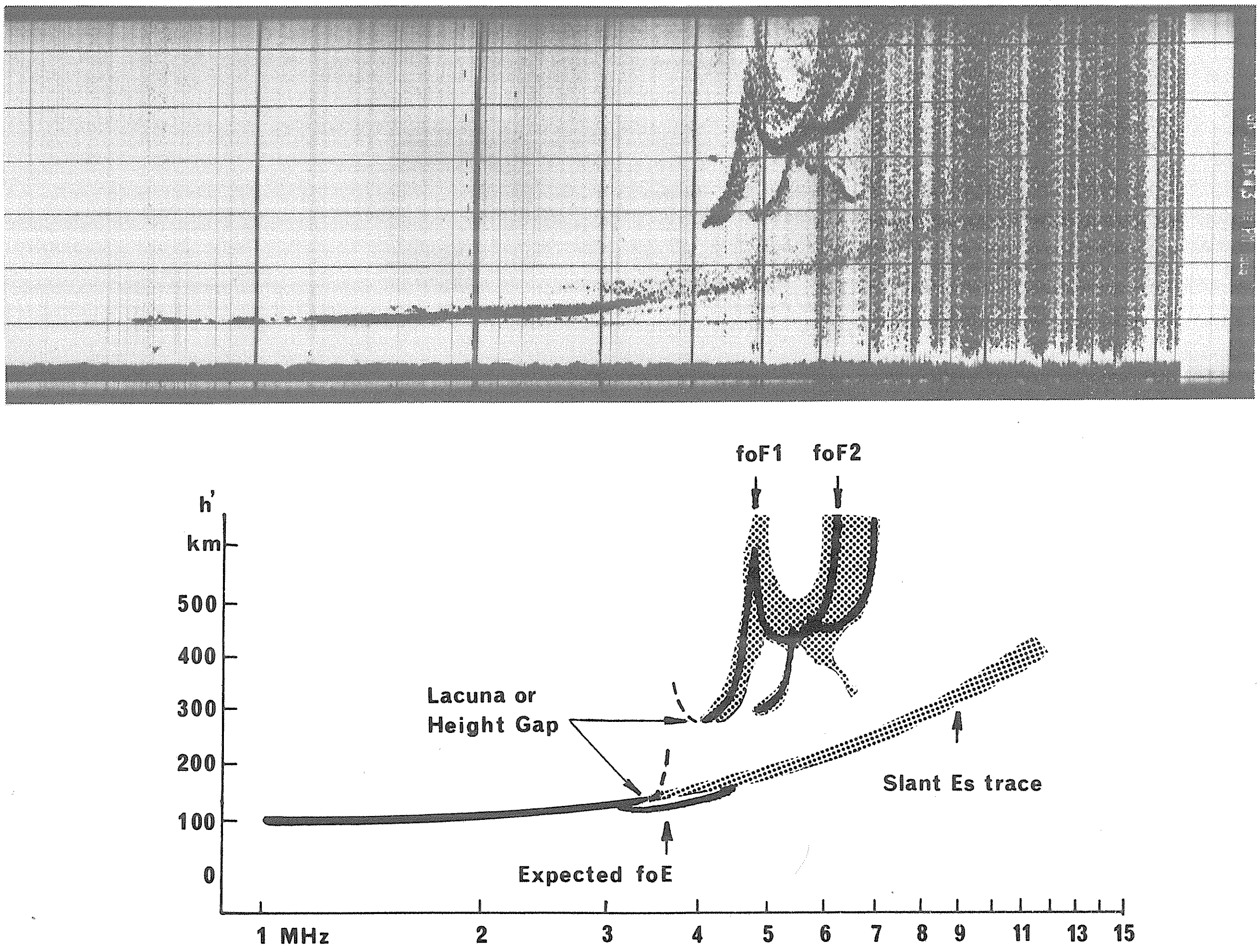


Fig. 2.18 b Typical day time ionogram with Slant Es phenomenon at an auroral zone station illustrating the main characteristics: Slant Es trace, Lacuna or Height Gap, F-spreadiness even in low part of F1-trace, and obliques. Narssarssuaq, June 15, 1969 at 1559 hr. LT.

After p 48 new section

2.8 Spread F types

2.80. Historical: After considerable discussion INAG decided at Lima 1975 to adopt a simplified form of spread F typing and to recommend it for general use. The original proposals in section 12.34 were used as a basis. Many examples of spread F typing are given in the High Latitude Supplement published in 1975 by World Data Center A (WDC-A) for Solar-Terrestrial Physics, NOAA, Boulder, Colorado, USA, (*Report UAG-50*).

While all agreed that the ideal solution would be to provide a spread F-type table similar to the Es-type table section 4.8, it was felt that this would cause too much work at stations for general use. INAG recommends that a separate spread F-type table be produced where possible, section 2.82.

In order to obtain widespread use and avoid additional work at the stations a compromise scheme was developed, see sections 2.83, 2.84.

2.81. Definition of spread F types:

(a) Frequency spread; letter symbol F.

The traces near the critical frequencies are broadened in frequency and may show additional traces similar to a normal critical frequency trace. This is the most common type of spread F. Figure 2.19. Other examples are shown in Figures 2.11, 2.17 trace z, 2.18, 3.8, 3.11, 3.12, 3.14, 3.28, 3.35, 3.39 a,b, 3.40 a,c,d; and for f-plot presentation 6.4, 6.5, 6.6, 6.7, 6.8. Frequency spread from a tilted F layer, Fig. 2.20 is also included in this classification. (See also 6.10e). Letter F should be used whenever the frequency range of the spread exceeds 0.3 MHz (accuracy rule for $\pm\Delta$, total range 2Δ for unqualified result.)

(b) Range spread; letter symbol Q.

The traces away from the critical frequency show broadening in range or the presence of satellite traces or both Figure 2.21. Other examples are show in Figures 2.14, 2.16, 2.17 trace 1, 3.13, 6.10. For uniformity Q is used when the range spread exceeds 30 km in virtual height. When broad pulses are used so that the normal trace is wider than this limit use Q when the additional broadening of the trace exceeds 15 km.

(c) Mixed spread; letter symbol L.

The traces are broadened in both range and frequency and do not show the presence of distinct F and Q types. Figure 2.22. This classification shows a physical phenomenon distinct from those given by F and Q and INAG wishes to encourage its use on a voluntary basis.

(d) Spur (historically polar spur, equatorial spur); letter symbol P.

This class includes all types of spread F not classifiable under F, Q or L. It indicates the presence of traces from an oblique reflecting region which usually reflects to a considerably higher frequency than the F layer nearest overhead. When as the structure moves in time it may move overhead in which case the classification changes to F or Q as appropriate. Figure 2.23. Other examples are shown in Figures 3.39 c, 6.10 c,d.

2.82. Rules for use with a spread F type table.

When a spread F type table is made the following rules should be used.

(a) First entry — Spread F type used to give fxI.

(b) Second entry — Spread F type present at expected value of foF2.

(c) Third entry — Range spread if present.

Note in most cases fxI is given by a frequency spread trace type F or by a range spread trace from near overhead, type Q, and only one entry is needed.

(d) When L is not used mixed type should be shown by entries of F, Q.

(e) Possible entries are:

Single entry	F; Q; L.
Double entry	F, Q; P, F; P, L.
Treble entry	P, F, Q; P, L, Q.

(f) X may be used to show the absence of spread F at times when it would normally be expected in the spread F type table.

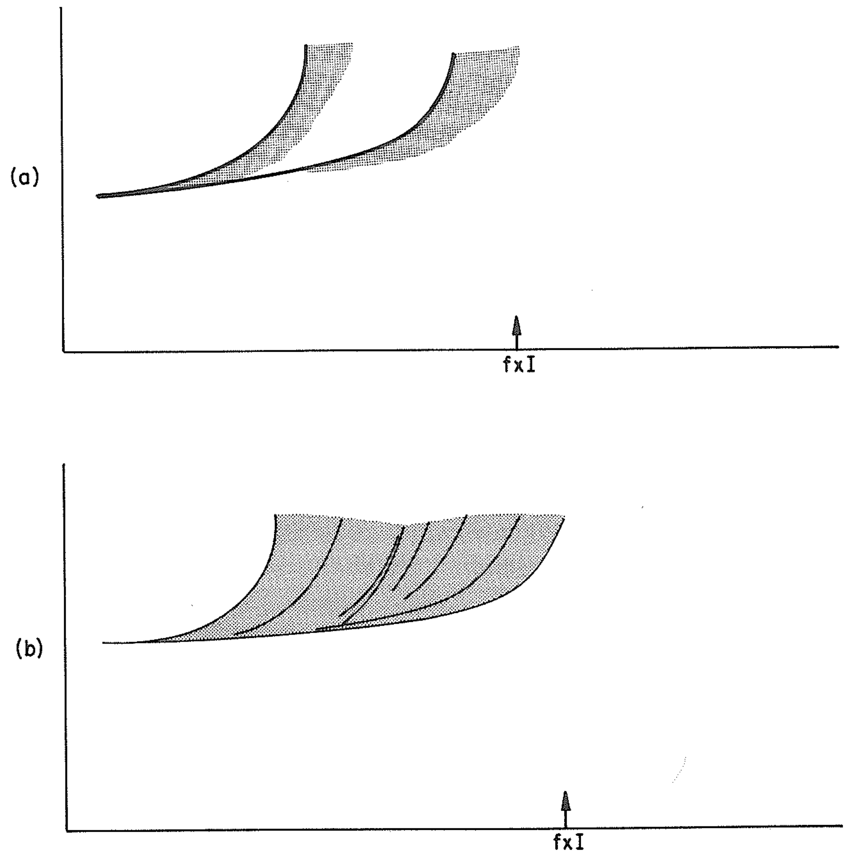


Fig. 2.19 Frequency spread. Type F

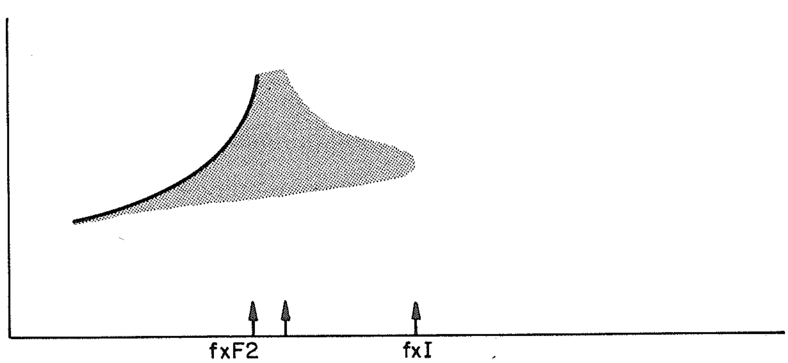


Fig. 2.20. Frequency spread. Type F

Note: In logic fxI should be read at the middle arrow but the standard fxI rule (read the highest frequency of spread visible) is easier and more useful.

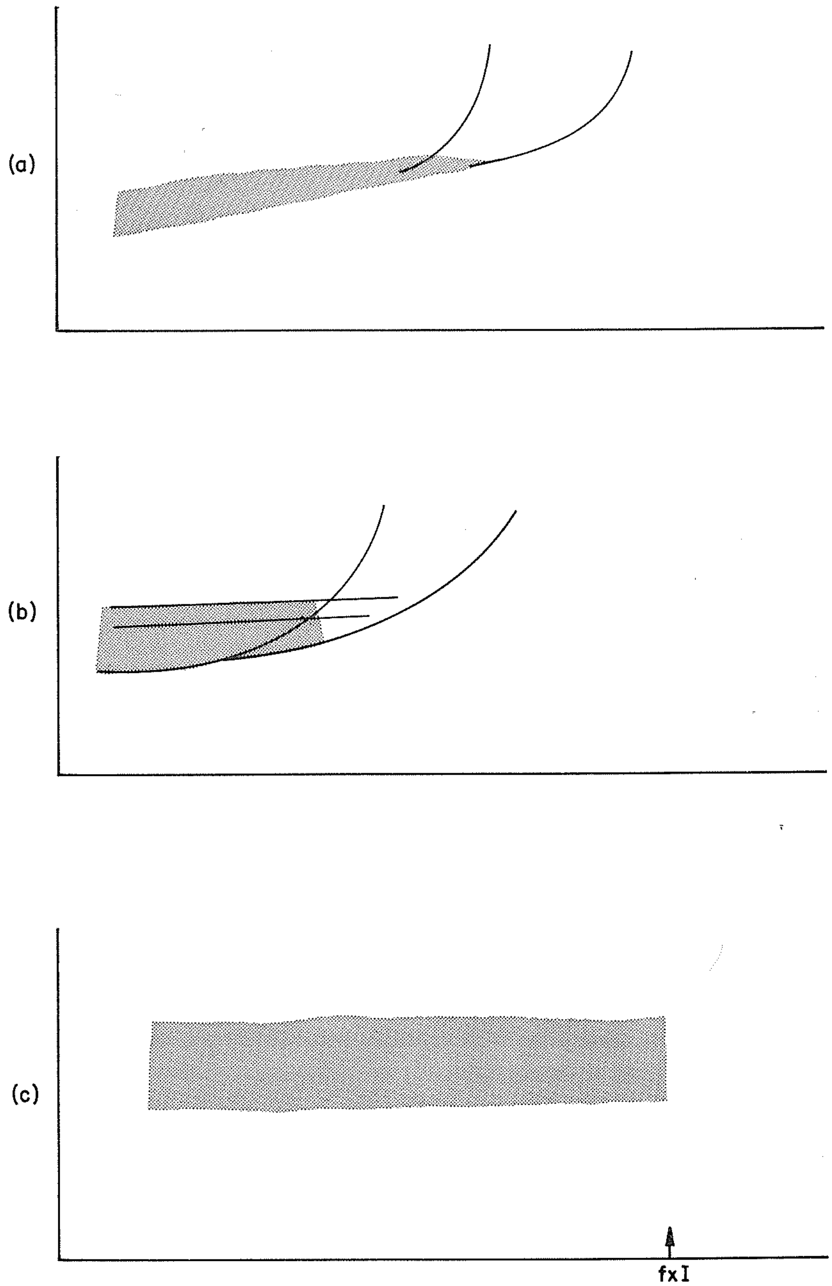


Fig. 2.21 Range spread. Type Q

(a) Shows an unresolved range spread Q in h'F table.
(b) Shows resolved range spread Q in h'f table.
(c) Shows fxI determined by a range spread pattern Q in h'f and fxI (or foF2 table).

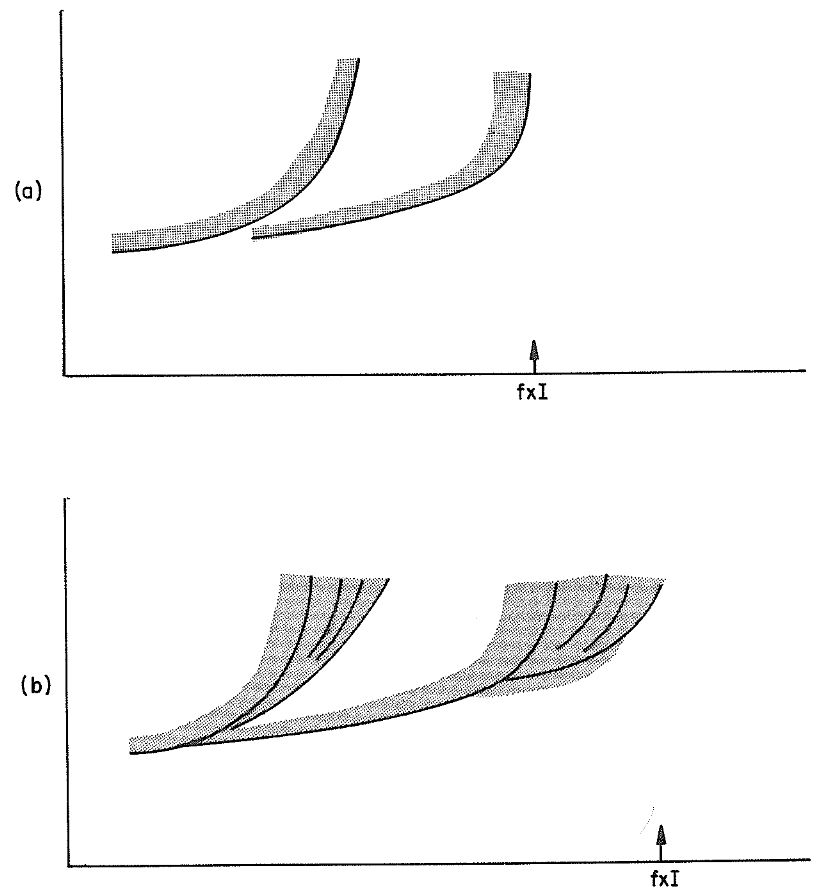


Fig. 2.22 Typical mixed. Type L

Note no structure in horizontal parts of trace. Usually no structure in frequency spread as in (a).

Structural frequency spread (b) superposed on pattern (a): Use F in fxI, L in h'F to give exact description. (Voluntary.)

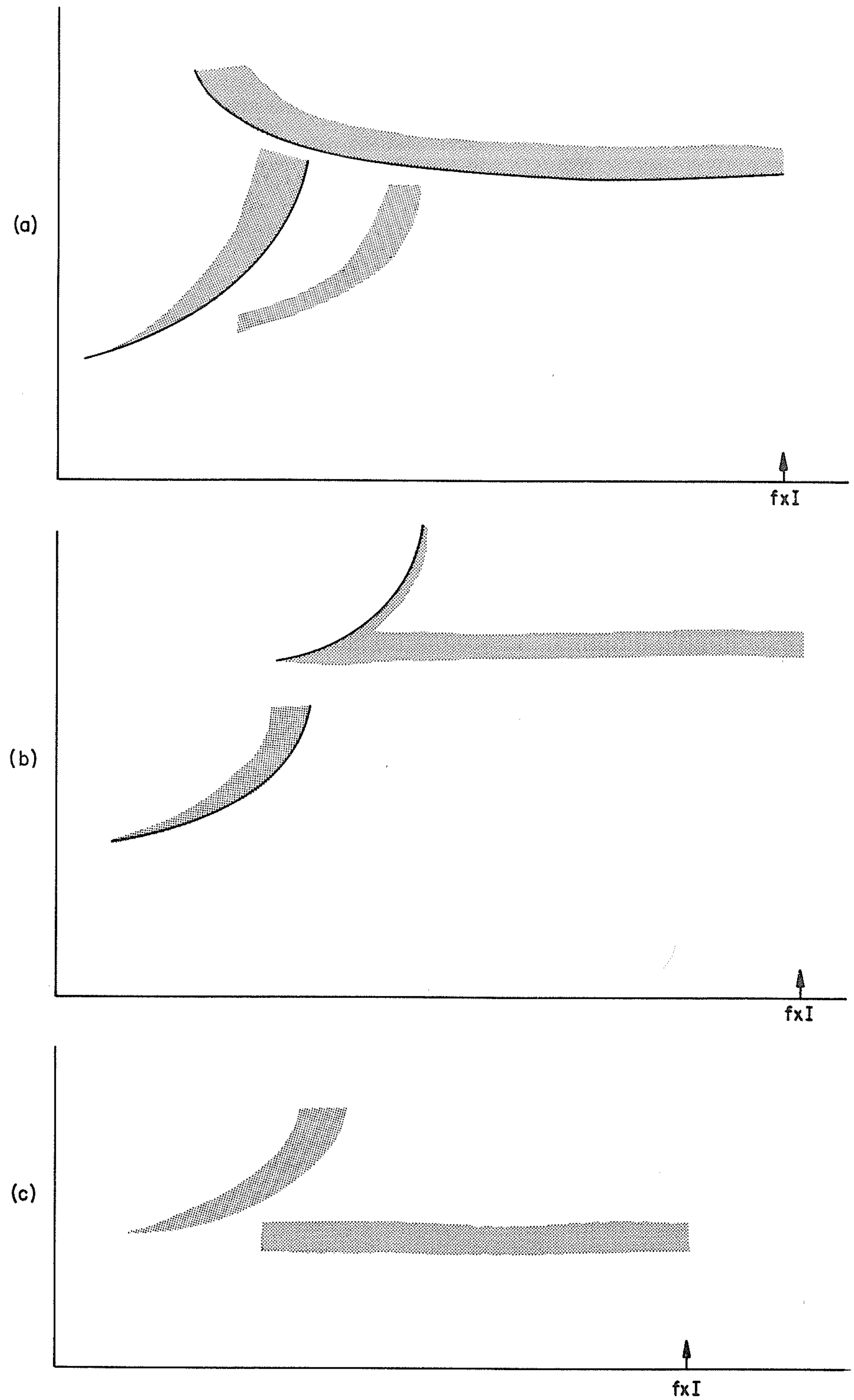


Fig. 2.23 Spur. Type P

Note the P traces may be alone or below the main traces and may start at lower or higher frequencies than shown.

2.83. Rules for typing spread F in standard parameter tables.

Where a separate spread F table is not used spread F types should be shown in the numerical tables using the following rules.

(a) Descriptive letters representing spread F types F, L, P, Q take priority over descriptive letters showing doubt in the tables to which they apply only. Do not use these letters in other tables, e.g. M(3000).

(b) The type of spread F used to evaluate fxI is shown in the fxI table. Absence of spread is shown by descriptive letter X (see fxI rules section 3.3).

(c) Frequency spread, F, is shown in the foF2 table. If fxI is also given by F and has been tabulated in the fxI table letter symbols denoting reason for doubt may be used in preference to F in the foF2 table.

(d) Range spread, Q, is shown in the h'F table.

(e) When frequency spread or spur are absent and fxI is determined by a range spread trace Q is used in the fxI table.

(f) Mixed spread, L, is shown in both h'F and foF2 tables unless structured traces Q or F are also present in which case these take priority in their appropriate tables.

(g) When L is not used mixed type traces are shown by F in the foF2 table, Q in the h'f table.

Typical Cases

Present	fxI	foF2	h'F
No spread	X	-	-
Spur, F	P	F	-
F Q	F	(F)	Q
L	L	(L)	L
P F Q	P	F	Q

( ) without priority.

2.84. Rules when fxI tables are not available.

(a) Descriptive letters representing spread F types take priority over descriptive letters showing doubt in the tables to which they only apply. Do not use these letters in other tables, e.g. M(3000).

(b) The type of spread F which would be used to evaluate fxI (see fxI rules section 3.3) is denoted by its descriptive letter symbol in the foF2 table (possible symbols F, P, Q or L).

(c) The presence of range spread is shown in the h'F table (possible symbols Q, L). Note in this case it is impossible to fully describe the ionogram and a priority system has to be used. In this fxI greater than fxF2 is more important than denoting frequency spread.

(d) Structured traces of types F or Q are always shown in preference to L when superposed.

2.85. Difficulties.

The main difficulty in practice is to distinguish between spur traces and Es-a traces seen at very oblique incidence. When a close sequence is available, e.g. three gain ionograms at the hour, it will be seen that the Es traces vary considerably in a space of a minute whereas spurs change more slowly. Spurs and high Es-a traces tend to occur together so possibly a unique solution is not essential. Spur patterns tend to recur on different nights at similar levels of magnetic activity showing similar patterns whenever Es-a is less regular.

Certain types of spur appear to identify the movement of the auroral oval over the station (see High Latitude Supplement, *Report UAG-50*)."

p 51	3.0	(1)4	Insert after first paragraph:

"The old WWSC convention, with qualifying letter before the number and descriptive letter after it, was dropped for general use as it was found to cause trouble when the data were punched for computer use. This convention is convenient for manual work and is allowed where the data also exist in computer form. When letter symbols are printed above the number the convention is that the qualifying letter, if any, is placed above the first figure of the number and the descriptive letter above the third figure."

p 51	3.0	(4)3	Replace "(fxEs)-x" by "(fxEs)-X"
p 51	3.1		Add after E -:

"Letter E implies a limit value which is less than the numerical value. These values must be moved to the bottom of the distribution when forming the second median.

Letter A also implies a less than limit value but this value is expected to be abnormally large and hence should not be moved to the bottom of the distribution when forming the second median. The connotation "less than" is thus ignored in forming the medians."

p 51	3.1	(5)4	Insert after "fbEs = foEs": "(see section 4.6, p 108)."
p 52	3.1		Insert under letter J and O, after equation:

"or when fo is near or below fB the appropriate value of fx-fo (section 103, p 9)."

p 52	3.1	letter J	Replace "fo = fx-1/2fB" by "fo = fx - fB/2"
p 52	3.1	letter Z	Delete: "and indirectly to M(3000)."
p 52	3.2	letter Z (2)5	Insert after "oblique": "except at the magnetic dip pole,"
p 53	3.2	letter A (6)3	Delete: "the value of foEs deduced from"
p 53	3.2		Delete paragraph (c).
p 53	3.2	letter A	Continue first paragraph with:

"When an Es trace is such that foEs cannot be distinguished and must be deduced from fxEs letter A is used. foEs = (fxEs - fB/2)JA.

Historically, this case was treated using letters JX but this is misleading and obsolete. A is not used when foEs cannot be evaluated directly because of interference (use JS) or instrumental trouble (use JC)."

p 54	3.2	letter A	Insert above Fig. 3.1:

"A special case occurs when particle E, Es-k, completely blankets the F trace. Logically this would imply the use of G but such use would cause difficulties with the F-layer medians. Also the distinction Es-r, Es-k is often difficult in this case. For simplicity particle E is regarded as an Es type for this purpose and the value of foF2 should be replaced by letter A. It is impossible to know whether foF2 was normal or not so the accuracy rules do not allow E to be used. Thus total blanketing by Es or particle E are treated alike, use replacement letter A."

p 54	3.2	Fig. 3.1 caption (iv)	Add: "(see section 2.4, p 32, Fig. 2.2)."
p 55	3.2	Fig. 3.2	Delete: paragraph (iv).
p 56	3.2	Fig. 3.5(ii)	Replace "fofl" by "foF1"
p 56	3.2	Fig. 3.5(iv)	Delete existing text and insert:

"(iv) If there is little doubt that ftEs is foEs, i.e. that the x mode is absorbed

foEs = (ftEs)-B

If doubt exists, for example if ftEs - fmin is large

foEs = (ftEs)MB

see section 4.3 for details.

In both cases fbEs = (ftEs)AA."

p 63	3.2	Fig. 3.13	Insert after foF2: "replaced by F(Q if spread typing is used)."

p 64 3.2 letter F At end insert:

"When F is used to denote spread F type frequency spread in foF2 or fxI tables it takes precedence over all other descriptive letters (see section 2.76, p 49).

Letter F must be used whenever the frequency spread is equal to or exceeds 0.3 MHz and should not be used when it is less than this value. This rule enables the presence of spread F to be compared at different stations."

p 67 3.2 Fig. 3.20 In last line replace "form, E." by "form, G."

p 69 3.2 letter K Change to:

"K - Presence of particle E layer."

p 69 3.2 letter K (1)6 Replace: "Night E is seen only on disturbed days." by:

"The primary indication that particle E is present is the presence of group retardation at the low frequency end of the trace from the higher layer. (Fig. 4.2, p 91.)

A possible physical definition of particle E is that it is a thick layer formed below the F layer directly or indirectly by the action of ionizing particles and having a critical frequency greater than that of the normal E layer. For scaling purposes the descriptive definition given in the Handbook is quite adequate."

p 69 3.2 letter K Replace "night" by "particle" wherever night appears.

p 69 3.2 letter K (1)7 Replace last line by:

"Letter K is inserted in the Es type table when particle E, Es-k, is present. Es-k takes precedence over all other Es traces present other than that giving foEs."

p 69 3.2 letter L (a) Replace "foF1" by "foF1"

p 71 3.2 letter L (b) Replace "M(3000)F1" by "M(3000)F1"

p 72 3.2 letter L At end of description add:

"Letter L is used to denote the presence of spread F type mixed and is used in spread F type, foF2 or fxI tables only (see section 2.3 p 32). The identification of spread F-L is voluntary but recommended by INAG as being valuable scientifically. When L is used in the foF2 or fxI tables for this purpose it takes precedence over all other descriptive letters."

p 73 3.2 Before letter Q Insert:

"P - Man-made perturbation of parameters - Presence of polar spur traces.

P is used to show that the ionosphere has been modified by man-made phenomena, e.g. heating experiment, injection of foreign substances.

Spread F types. P shows the presence of spur type spread F. When used for this purpose in fxI tables P takes precedence over all other descriptive letters."

p 73 3.2 letter Q (1)2 After 2.17 add: "and see section 2.3, p 32."
Replace "h'f." by "h'F."

letter Q (1)3 Delete: "A general broadening ... by letter F."

p 77 3.2 letter X Add to paragraph:

"Letter X is used in fxI tables to show that no spread was present, i.e. fxI = fxF2. When more than half of the values are described by X the median of fxI must be described by X."

p 78 3.2 letter Y (1)5 Replace "A, B, F, H and R" by "A, B, F, G and H."

p 78 3.2 letter Y Add after first paragraph:

"The accuracy rules are, as usual, followed, use replacement letter Y, DY, EY, UY or -Y as given by the rules. This holds for all cases where Y is used, both Lacuna and severe layer tilt cases."

p 78 3.2 letter Y (b)5 In (iii) replace "value of fmin" by "value of fm2"

p 78 3.2 letter Y (b)10 Replace "h'F1" by "h'F."

p 78 3.2 letter Y Insert before letter H rule:

"G. (a) When the ionograms before and after the Lacuna event show G conditions for the F2 layer, G should be used in preference to Y.

(b) When the ionogram sequence shows an F2 layer before and after the Lacuna event and this trace disappears in the event, F2 parameters are replaced by Y."

p 78 3.2 letter Y Insert after letter H rule:

"Note in most cases Lacuna is accompanied by Es-s and this is also often seen when the Lacuna is about to develop or is dying away. The presence of slant Es is a clear distinction between layer tilt and plasma instability causes of Lacuna phenomena.

When Lacuna is present with Es-s the two phenomena are treated independently for scaling (see section 4). Es-s can arise from a normal E trace, a particle E trace (Es-k), or from a blanketing Es trace (usually f, but h, c, ℓ also possible). For convenience the rules are summarized below:

(a) foEs is deduced from the top frequency of the Es pattern from which the slant Es rises, foE is deduced ignoring the slant trace.

(b) Slant Es cannot blanket.

(c) If the Es trace is of a blanketing type and there are good reasons to believe that blanketing is effective in screening the upper level, characteristics below the estimated value of fbEs should be replaced by A, or for Es-k by G.

(d) If the F1 trace is seen but the F2 trace is missing, the F2 parameters are treated as G cases (foF2 less than foF1). It is quite possible for a G condition to occur during or after a Lacuna event, see general rules use of G above.

(e) If parts of the F1 trace are missing, the missing F1 parameters are replaced by Y. (See accuracy rule note.)

(f) If both F1 and F2 traces are missing use G rules given above.

(g) If the E region trace is Es, the problem of whether Y should be used depends on whether foEs is likely to be influenced by the Lacuna phenomenon. For low, flat or auroral types of Es this is improbable. For particle E (night E) or retardation Es the appearance of the ionogram sequence will suggest when Y is needed, i.e., when the nose of the trace is missing. If there is no evidence suggesting that foEs is affected by the Lacuna, it would appear best not to use Y — we know Lacuna is present from the F-layer tables. However, this point should be discussed more fully in the Bulletin and at INAG meetings.

(h) Although slant Es frequently accompanies Lacuna and is usually present at some stage in a Lacuna sequence, its presence is not essential on a particular ionogram. If the F traces are missing, Y should be used for the missing parameters except where G above applies."

p 78 3.2 <u>Severe layer tilts present - para (a)2</u> Delete line 2. Insert:

"as in Fig. 4.22 use accuracy rules to give appropriate use of Y. When in doubt use replacement letter Y."

p 78 3.2 last paragraph (b)1 Replace "F layer" by "F2 layer"

p 80 3.2 Fig. 3.34 Replace "(foF2 + fB/2)OY" by "(foF2 + fB/2)EY."

p 80 3.2 Fig. 3.34 Replace "N-S or E-W" by "E-W or N-S."

p 81 3.2 letter Y Add new paragraph at end:

"Note the use of Y to identify severe layer tilts is restricted to tilts in the F2 layer for physical reasons. Tilts near F1 are better described by H. Only tilts giving the type of ionogram illustrated in Fig. 3.34 should be identified by Y. H is more appropriate in other cases."

p 81 3.2 letter Z(3) Add at end of third paragraph:

"When fz is near or below fB the appropriate value of fo-fz (p 9) must be used."

p 81 3.2 letter Z(4)2 Replace "transmissiion" by "transmission"

p 83 3.30 13 Add: "In this case replacement letter B should be used for fxI."

p 86 3.32 after (d) Insert:

"(e) When the spread F structure is not gain stable the value of fxI from the normal gain ionogram is recorded.

At some stations spread is found on the o trace but not on the z trace even when absorption is low. This is due to the fact that the two traces are reflected at different points separated by typically about 50 km in the magnetic meridian plane. A small movement of the station would, therefore, cause this situation to change. As fxI is intended primarily to show the existence of spread F near the station it is preferable to deduce the value from foI, fxI = (foI + fB/2)OF (F, if spread F typing is in use, otherwise X). This also makes the analysis simple -- always look at the o trace if the x trace is clean and deduce fxI from it. If in doubt between B and X prefer B."

p 87	3.34	(1)2	Change sentence to read: "A missing value of fxI in these cases can be ... ."
p 90	4.0	(2)1	Replace "station is" by "station are"
p 93	4.31	(1)2	Replace "magneto ionic" by "magneto electronic"
p 93	4.31	(3)4	Replace "ftEs $\geq$ fB" by "ftEs > fB"
p 102	4.42	(3)3	Replace "described by X" by "described by A"
p 103	4.42	letter G (f)	Delete: "or night"
p 104	4.51	Table 4.2	In column "preferable":
			Replace "000JX" by "000JA" Replace "067JX" by "067JA".
p 107	4.6	Fig. 4.22	Replace "fbEs = (foEs)UY" by:

"fbEs = Y unless accuracy rules allow an estimated value to be made. If in doubt use Y."

p 108 4.6 Delete paragraph (c) and insert:

"The rules for interpreting foEs and fbEs have been summarized (R. Smith, INAG 10, p 5-6) for training purposes and are reproduced in Figures 4.32 and 4.33. The diagrams omit the x-mode traces and should be used as a guide only. Detailed rules are given in the text above."

p 109	4.83	(1)5	Replace "night" by "particle"
p 109	4.83	(ℓ)2	Replace "night" by "particle"
p 110	4.83	(d)	Replace "A weak" by "A weak diffuse"

p 110 4.83 (k) After paragraph "k", add:

"Note: (i) Es-r and Es-a type traces can be present with normal E or particle E, Es-k. In these cases the retardation at the low frequency end is ignored in deciding the type.

(ii) It is common for Es-f, Es-h, Es-c to be superposed on Es-a, occasionally on Es-r also. In these cases f, h or c is given priority over a, r for the second entry."

p 117 4.83 Fig. 4.31 Replace existing Fig. as below:

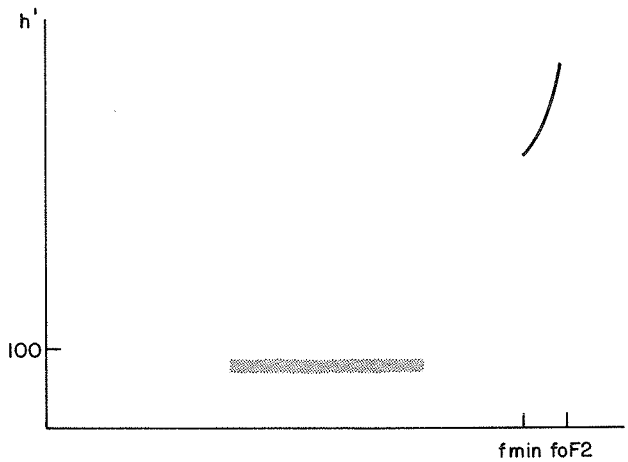


Fig. 4.31 Es type d. Partial reflection from absorbing layer.

A weak diffuse trace normally seen below 90 km and extending between 1 and 3 MHz, sometimes higher in frequency. All other traces show high absorption or are missing because of it (B condition).

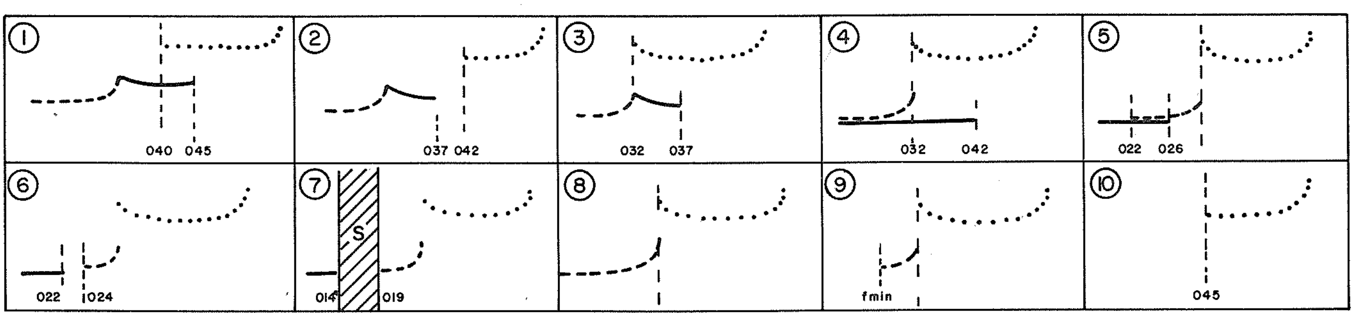
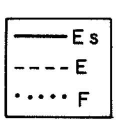


Fig. 4.32 Rules for interpreting foEs and fbEs in daytime

No.	foEs	fbEs
1	045	040
2	037	037UY
3	037	032EG
4	042	032EG
5	026-G	022-G
6	022-G	022-G
7	014DG	014DG
8	G	G
9	G	G
10	045EB	045EB

Note: (a) Diagrams show only the ordinary trace.
(b) For median determination, all values described by G or replaced by G or changed to (foE)EG.
(c) If gap exceeds limit for use of U, use replacement letter Y.



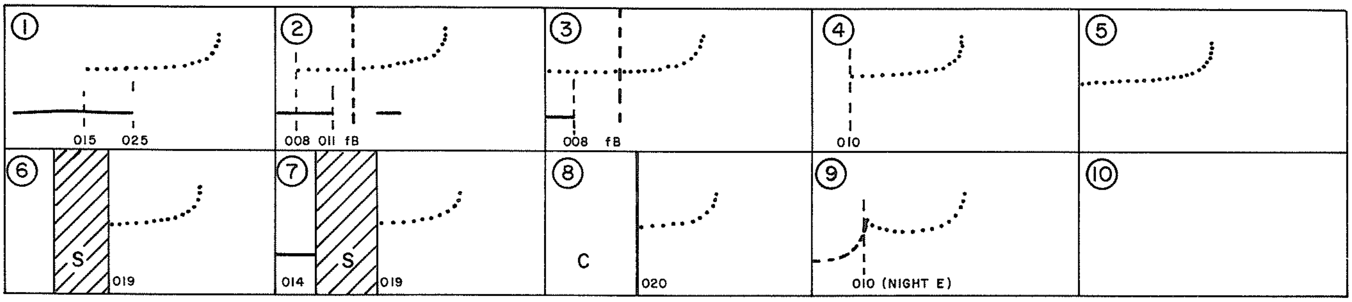


Fig. 4.33 Rules for interpreting foEs and fbEs at night

No.	foEs	fbEs
1	019JA	015
2	011	008
3	008	007EE
4	010EB	010EB
5	007EE	007EE
6	019ES	019ES
7	014DS	014DS
8	020EC	020EC
9	010EG	010EG
10	B	B

Note: (a) Diagrams show only the ordinary F trace.
(b) For particle E, foEs = fbEs = (foE)-K
No. 9 will be foEs = 010K, fbEs = 010-K.
(c) No. 10 correct provided sequence shows foF2 above 007.

fB = 12
Minimum frequency of ionization

———	Es
----	E
·······	F

p 131 5.63 (1)4 Replace "f1S, fxS, f2S" by "foS, fxS, fzS"

p 137 5.91 FHS Replace "MHz/sec" by "MHz"

p 143 6.3 (b) Add at end of second paragraph:

"fzE may be plotted to show when it occurs if it is seen only rarely. This should be done if there is likely to be local or regional study of the phenomenon."

p 143 6.3 1 Identify as "6.31".

p 143 6.3 (f)1 First sentence should read:

"When frequency spread is present from fmin upwards a small gap is made between the dot"

p 144 6.3 (g) Delete existing text.

p 144 6.3 after (i) Insert new subsection:

"6.32 <u>Representation of range spread and polar spur traces on f-plot.</u>

(a) Range spread and polar spur traces should be represented by a line with letter q at the upper and lower frequency ends of the line, Fig. 6.10. This line should <u>never</u> be allowed to confuse the representation of frequency spread 6.3(e) or fmin 6.31(f).

(b) When range spread and polar spur traces extend below the upper frequency of frequency spread traces, q is placed between the upper limit of frequency spread and the lower frequency end of the line representing the oblique trace, Fig. 6.10 (c), (d).

(c) When all traces are oblique that nearest overhead is treated as an F-layer trace, 6.31 (a), (b), (c), (d), (e), (f).

(d) The nose type of trace representing frequency spread F in a tilted F layer is treated as a frequency spread trace, Fig. 6.10 (e)."

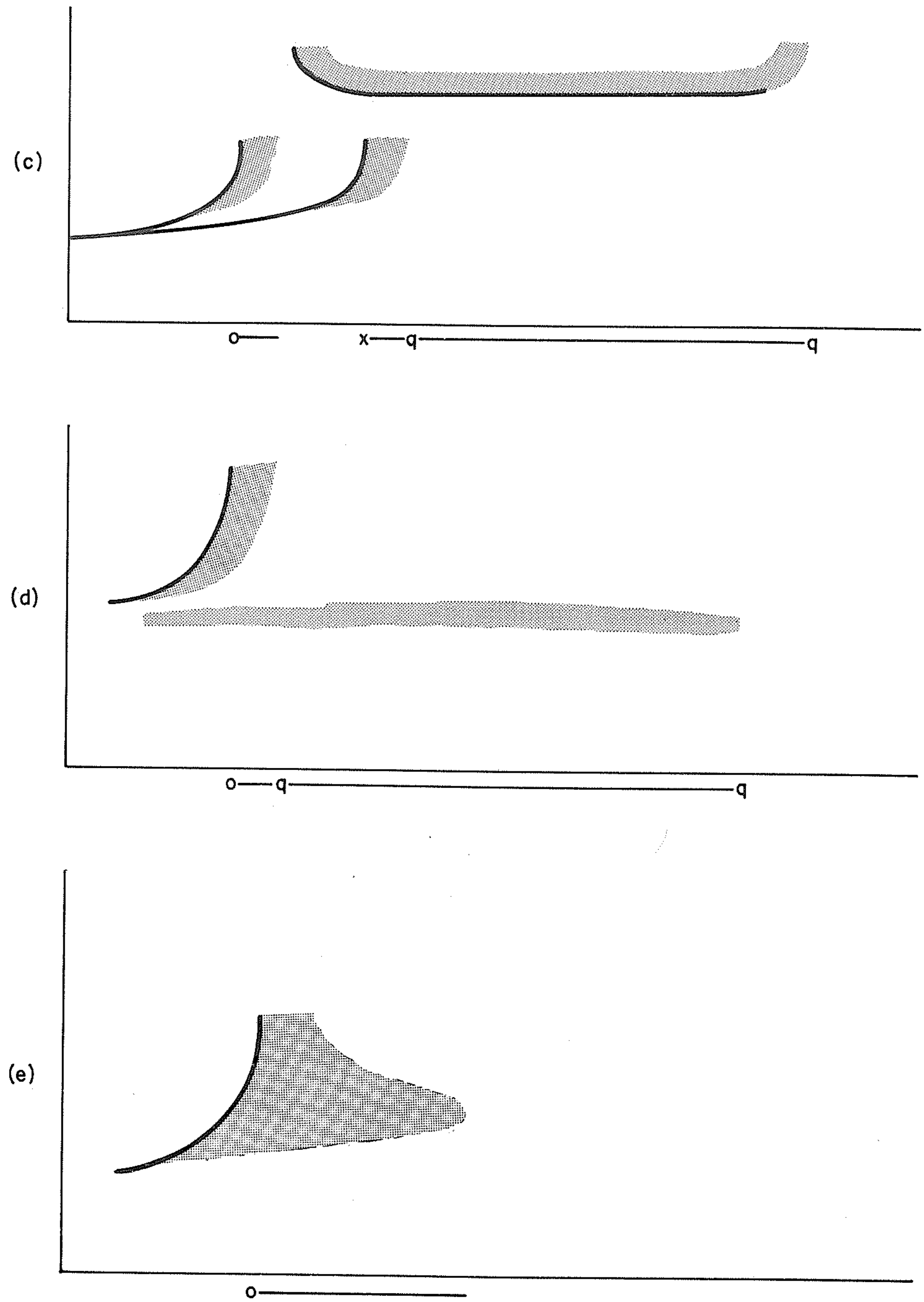


Fig. 6.10. f-plot convention when spread is present

(c)(d) Use of q, spread F type P
(e) Nose type trace treated as frequency spread type F

p 152	6.6	(1)2	Delete: "which are attributable to the same Es trace"
p 163	7.25	(1)3	Add: "See note in section 3.0, p 51."
p 178	8.2	foEs	Add in 072-X: "It is preferable to use the procedure shown in entry 066JA below."
p 178	8.2	foEs	Replace "066JX" by "066JA" Replace "JX" 066 by "JA" 066
p 178	8.2	h'F	Delete: "but the error is unknown."
p 180	8.33	(3)2	Replace "A, C" by "A (new rule) C"
p 180	8.33	(b) letter B1	Replace "median" by "highest value in the count."
p 180	8.33	(b) letter B (2)2	Delete: "logical"
p 180	8.33	(b) letter G foEs1	Delete: "equal to or"
p 180	8.33	(b) letter G M(3000)	Replace "count as equal to or less than median." by "count as less than smallest value in the count."
p 180	8.33		Insert at end of subsection 8.33:

"The rules equal to or greater than and equal to or less than a median are treated as greater than or less than the median, unless the median is itself a limit value, when they are taken as equal to this value."

p 182	8.36	(iii)(a)	Replace "D" by "A,D"
p 182	8.36	(vi)1	Replace "D" by "A or D"
p 182	8.36	(vii)	Replace "D" by "A or D"
p 182	8.36	(viii)	Replace "D" by "A or D"
p 183	8.36	(1)1	Replace "D" by "A,D"
p 183	8.4	(4)1	Replace "D" by "A,D"
p 183	8.4	(4)3	Replace "D" by "A,D"
p 183	8.4	(5)1	Replace "D" by "A or D"
p 183	8.4	Note (iii)1	Replace "D" by "A,D"
p 183	8.4	Note (iii)2	Replace "D" by "A,D"
p 183	8.4	Note (iii)3 3	Replace "D" by "A or D"
p 183	8.4	After (iv)	Add:

"(v) The quartiles are not as important as the medians and therefore second quartile values are not calculated. Similarly if the quartile lies between a qualified and unqualified value, it is more useful to know the value unqualified than qualified -- at the lower accuracy possible it is unlikely to be significantly changed."

p 184	8.5	After table	Add:

"Note (i): Strictly the cases D,D; E,E; E are indeterminate but it is often useful to give an idea of the scatter of the numerical values. The fact that the median is a limit value shows that U is used as a convention and has not its usual accuracy implications.

Note (ii): For fbEs the above rules apply when qualifying letter A replaces qualifying letter D, or A and D values are mixed. Use A as equivalent to D in this case."

p 187 9.0 (Last paragraph)5 Replace text starting with "However" by:

"In 1972 the status of the former Inter-Union Commission on Solar-Terrestrial Physics was changed into that of a Special Committee of ICSU (SCOSTEP) the principal responsibility of which is the organization of the International Magnetospheric Study in 1977-1978. This project requires the cooperation of the many national groups that are concerned with regular astronomical and geophysical observations. Within SCOSTEP, a steering committee for MONSEE (Monitoring of the Sun-Earth Environment) has been set up to coordinate, on an international scale, series of observations required for the IMS and other projects being organized by SCOSTEP."

p 188	9.0	(2)1	Replace "COMSTEP" by "SCOSTEP"
p 188	9.0	(Last paragraph)1	Replace "COMSTEP" by "SCOSTEP"
p 188	9.0	(Last paragraph)5	Replace "COMSTEP" by "SCOSTEP"
p 190	9.14	(1)1	Delete: "generally"
p 191	9.31	(2)4	Replace "RGD" by "RWD"
p 194	9.44	(i)2	Replace "h'F, h'Es" by "h'F, h'F2, h'Es"
p 200	10.11	Equation 10.4	Replace "$\frac{dr}{dh}$" by "$\frac{dN}{dh}$"
p 200	10.11	3 lines below equation 10.4	Replace "$\frac{dr}{dh}$" by "$\frac{dN}{dh}$"
p 201	10.12	(5)2	Replace "[Paul and Smith, 1968]" by "[Paul and Smith, 1968, Radio Science, 2, p 163-170]."
p 201	10.12	(5)6	Replace "[Becker, 1959]" by "[Becker, 1959, J. Atmos. Terr. Phys., 16, p 67-83]."
p 203	10.13	(last paragraph)2	Replace "μ" by "μ'"
p 203	10.14	(1)4	Replace "sample" by "simple"
p 204	10.14	(1)2	Replace "sample" by "simple"
p 207	Table 10.2		There are a number of errors, identified by block, i.e., value of ϕ line and column in line:

			Incorrect	Correct
10°	2	1	0.900	0.990
	3	1	0.950	0.980
	3	3	2.2708	2.2707
	5	2	1.2173	1.2175
	7	2	0.3827	0.3862
	7	4	0.3807	0.3867
30°	2	1	0.900	0.990
	4	4	1.5526	1.8526
40°	3	3	2.4552	2.4882
	6	4	0.8191	0.8199
50°	5	1	0.830	0.880
54°	9	3	0.0621	0.0721
60°	1	2	3.7005	3.7095

				Incorrect	Correct
	67°	3	5	3.2688	3.2668
		5	5	1.1551	1.5511
	70°	5	1	0.850	0.880
		5	3	1.3552	1.3882
		6	1	0.700	0.760
		6	4	0.9019	0.9010
		7	1	0.5880	0.580
		7	3	0.4228	0.4328
		10	3	0.126	0.0126
		11	1	0.0400	0.040
	80°	4	5	2.5852	2.5882
		8	3	0.4976	0.1976

p 216	10.30	Table 10.6 line 3	Replace "00" by "∞"
p 217	Fig. 10.6	Caption 3	Replace "h(0.45 foF2)" by "h(0.95 foF2)"
p 222	10.43	(last paragraph)1	Replace "f3/fc =" by "fc = "
p 224	10.45	last line	Replace "h'o = 0" by "h'o = 1"
p 224	10.45	last line	Replace "meximum" by "maximum"
p 253	11.33	(2)3	Replace "a SID" by "an SID"
p 258	Fig. 11.9	Caption	Add:

"The amplitude is shown by the blackness of the entries."

p 267	Fig. 11.17	Caption	Replace "of Fig. 12.16" by "of Fig. 11.16"
p 283	12.33	end	Add after last line of text: "and section 2.8"
p 282	12.34		Delete text of whole section and replace by:

"12.34. INAG's proposals have now been formally accepted in the form given in section 2.8. The original proposal will be found in Chapter 15, List of obsolete rules removed from Handbook."

p 308	14.21	(b)(1)2	Replace "GINZBURG" by "GINSBURG"
p 309	14.21	(b)(2)2	Replace "V. SUCHY" by "K. SUCHY"
p 311	14.21	(e)(6)1	Replace "Mcgraw-Hill" by "Mc Graw-Hill"
p 311	14.21	(e)(11)1	Replace "Comite Consultative" by "Comité Consultif"
p 321	14.82	8	Replace "Radio and Space Research Station Ditton Park, Slough SL3 9JX, England." by "S.R.C. Appleton Laboratory Ditton Park Slough Bucks SL3 9JX, England."
p 323	14.9	(7)2	Replace "K. Kondo" by "T. Takiguchi".

15. LIST OF OBSOLETE RULES REMOVED FROM HANDBOOK

For those using data from early years it is convenient to know when rules were changed and what rules were in use before the change. The earliest references are given in section 0.01 this Handbook.

The first widely used manual was the IGY Instruction Manual for the Ionosphere, Annals of the IGY, Vol. III, Part 1 which is still useful for the large number of ionograms published in it. The rules were revised and clarified for station use in the First Edition of this Handbook.

As a result of many discussions the rules were clarified, extended and changed at the meeting of INAG held at the XVII URSI General Assembly at Warsaw, August 1972. These changes were incorporated in the Second Edition of the Handbook as published in August 1972. Almost immediately, however, additional clarifications were found to be needed and new problems suggested new rules.

Starting with the changes adopted at Lima, August 1975, modified rules will show the date at which they were formally adopted and the obsolete rules will be transferred to this Chapter, again with the date of formal statement of obsolescence. Minor clarifications or additions which should have little effect on the data are not dated.

Corrections and amendments to the Handbook were published in INAG 16, December 1973.

(i) December 1973. X changed A.

Old rule. When an Es trace is such that foEs cannot be distinguished and must be deduced from fxEs, X is used, foEs = (fxEs - fB/2)JX.

p 53 section 3.2
p 102 section 4.42
p 178 section 8.2

(ii) December 1973. Use of descriptive letter A in (foF2)DA when total blanketing present.

Old rule. No longer allowed.

(c) When rules (a) (b) cannot be used, the best estimates of foF2 give fbEs, fbEs = (foF2)DA. This should be found from the sequence of foF2 values near the time involved or from corresponding values on other days.

p 53 section 3.2 letter A
p 108 section 4.6

(iii) December 1973. Median rules for B; G, Es; and G, M(3000).

(b) Values of parameters replaced by the following letters are treated as shown below:

B - For fmin, count as greater than the median.

Note: B is often used when fmin is greater than the normal value of the characteristic. In this case it does not contribute to the median. The logical form (fmin)EB adds little or no real information and involves proceeding to a second median. For foEs, fbEs the full form, (fmin)EB, should be used when (fmin) is numerical and determines these characteristics.

G - For foEs and fbEs, count as equal to or less than median foE. When foEs or fbEs are less than foE, which may occur when low type Es is the dominant Es type, the numerical values are described by G and treated as equal to or less than foE.

G - For M(3000) and MUF (3000), count as equal to or less than the median.

p 180 section 8.33, (b)

(iv) March 1974. Change of name, Night E to Particle E. p 17 section 1.15

(v) March 1974. Y - Intermittent trace or trace missing due to defocussing.

p 32 section 2.3

(vi) March 1974. Change of letter symbols for spread F classification.

12.34. <u>INAG proposals for spread F classification</u>: At the time of going to press, the general view of INAG members and consultants was that Penndorf's scheme should be greatly amplified. The proposal for initial study is to divide the phenomenon into four types:

(i) Frequency spread, proposed letter symbol F:
All cases where the spread shows frequency structure and not range structure (see section 2.70, 2.72) (Penndorf Fig. 12.1, α1, α2, α3, α4; β2, β3, β4).

(ii) Range spread, proposed letter symbol R:
All cases where the spread shows spread in range but not frequency structure (see section 2.74) (Penndorf Fig. 12.1, δ1, δ2, ε1).

(iii) Mixed spread, proposed letter symbol M:
Patterns which show a range spread at lower frequencies changing to frequency spread at higher frequencies, the lower edge of the range spread trace being continuous with the lower edge of the frequency spread trace. (e.g., Penndorf 12.1, β3, δ3, δ4). Cases where the limitation is not true are treated as superposed independent F and R traces and are tabulated F,R. Thus cases where a range spread trace is seen either above or below the trace giving the frequency spread are tabulated separately.

Note: One of the purposes of the classification is to show when an oblique structure becomes overhead by entry F,R being replaced by M. Also the sequences of F turning to R or R to F may represent different situations to F,R turning to M.

(iv) Spur (historically polar spur) proposed letter symbol S:
This includes the range of patterns found when the ionosphere is very tilted or a second reflecting structure is visible at oblique incidence. There are two main groups:

(a) Spurs or noses superposed on a normal F or M pattern (Penndorf type γ).

(b) A spread trace at a different apparent virtual height to the normal traces and with considerably different top frequency (Fig. 3.39 (c) and (d)). These have been called polar spurs as they often show group retardation near foF2 and are closely associated with the plasmapause trough in years of large solar activity. This type is usually present at the same time as type F or M; sometimes with F,R, so that it is possible to have entries:
single type present F; R; M; S.
two types present F,R; F,S; M,S; R,S; R,M.
three types present F,R,S; M,R,S.

It is suggested that, until more experience has been obtained, no attempt be made to make the tabulation more complex.

Note that if these proposals obtain general approval, the definitions and detailed rules are likely to be refined in the future and published in the INAG Bulletin.

p 282 section 12.34

(vii) August 1975. Range spread.

(g) There are some cases where the F trace is replaced by a range spread pattern which does not show frequency spread. This can be represented by a line extending over the range of frequencies showing spread provided that letter q is used at both ends of the line. Occasionally frequency spread can be detected at the upper frequency end of the range spread pattern. In this case the line is broken between the range spread section and the frequency spread section with q in the break. q is not used where a main trace is visible or when it may confuse the interpretation of frequency spread, Fig. 6.10 (a) (b).

p 144 section 6.3 (g)

(viii) August 1975. Definition of night E changed to that for particle E.

1.15 Night E: The ionogram pattern corresponding to night E is very similar to that for normal E. The difference is that the critical frequency is significantly larger than would be expected for normal E at the time involved and varies rapidly with time. Night E is often preceded or followed by retardation type Es or auroral type Es and is due to particle bombardment causing excess ionization in the E region. Thus at night when foE for normal E is between 300 kHz and 500 kHz, night E often shows values of foE between 1 MHz and 5 MHz. When night E is present, as shown by group retardation in the

E or higher traces, the critical frequency of this layer is included in the foE tabulation. Normal E is not seen in these conditions.

p 17 section 1.15

(ix) August 1975. Use of q on f-plots.

The old rule 6.3 (g) stated q is not used when a main trace is visible or when it may confuse the interpretation of frequency spread. This was a rule devised for equatorial stations where range spread develops from a normal pattern in order to enable a sharp distinction to be made. q can now be used more freely.

p 144 section 6.3 (g)

(x) August 1975. Use of G with night E.

The same conventions apply when foE is equal to or greater than foF2, foF2 = (foE)EG (usually a night E case). This is withdrawn in favor of A as this use of EG causes difficulties with foF2 medians.

p 64 section 3.2, G

(xi) August 1975. Spread F typing and limit rules for the use of descriptive letters F,Q will change the apparent incidence of spread F.

(See new section 2.8 after p 48)

(xii) August 1975. f plot.

Delete p 152, 6.6, line 2, "which are attributable to the same Es trace."

p 152 section 6.6

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