WILKINSON

IONOSONDE NETWORK ADVISORY GROUP (INAG)*

IONOSPHERIC STATION INFORMATION BULLETIN NO. 50**

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* Under the auspices of Commission G, Working Group G.1 of the International Union of Radio Science (URSI).

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INAG 50 August 1987

1. From the Chairman

by J A Gledhill

There will be two INAG meetings in August this year, the normal Business Meeting during the URSI General Assembly in Tel Aviv and one which has been arranged by request of several persons who will not be present in Tel Aviv but will be at the IAGA General Assembly in Vancouver. This meeting will take place in the evening of Monday, 17 August, in room Chem 126. An agenda which will serve for both meetings appears below.

2. Agenda for INAG Meetings, Vancouver and Tel Aviv

1. Welcome by the Chairman.
2. Report by the Chairman on INAG activities in the period since the last URSI General Assembly.
3. Discussion of INAG Bulletins - are they worth while? Do users want any changes? If so, what?
4. Should UT or LST be standard for ionograms, or can stations use whichever they wish, provided that the relationship of LST to UT is clear? (cf. Rodger, Piggott, Smith, Rishbeth and Hapgood, INAG 49). See also article 5 this issue.
5. Participation of ionosonde network in WITS programme.
6. Discussion of proposal by T. Kelly and C. G. McCue of the importance of real-time ionograms from remote sites.
7. At the URSI General Assembly in Tel Aviv it will also be necessary to elect the officers of INAG. The present holders are:

Chairman	J A Gledhill
Executive Secretary	R Haggard
Circulation Secretary	R O Conkright

The meeting may also review the list of members and reporters. The members are:

A S Besprozvannya (USSR)
D G Cole (Australia)
R O Conkright (USA)
A Giraldez (Argentina)
J A Gledhill (South Africa)
R Haggard (South Africa)
R D Hunsucker (USA)
J K Olesen (Denmark)
P R Pardo (Brazil)
G Pillet (France)
B W Reinisch (USA)
A S Rodger (UK)
A K Saha (India)
T Turunen (Finland)
N Wakai (Japan)
P J Wilkinson (Australia)

Honorary Members are:

W R Piggott (UK)
A H Shapley (USA)

The Reporters are:

(1) Ionogram interpretation and scaling values.
R Haggard and W R Piggott

(2) Handbooks and training aids.
P J Wilkinson

(3) New station co-ordinator.
J A Gledhill

(4) Co-ordinator for developing countries.
R Hanbaba

(5) Interchange of ionograms and data, emphasising digital methods.
R O Conkright

(6) Automatic ionogram analysis methods.
B Reinisch

(7) Technical development for ionosondes.
K Bibl

(8) N(h) profiling problems.
A Paul

(9) International Reference Ionosphere input and co-ordination.
L Bossy

(10) Low latitude problems.
S Radicella

(11) High latitude problems.
A S Rodger

(12) Developments for the acquisition of ionosondes and their reduction to meaningful echo parameters.
J W Wright

(13) Algorithms for extracting aeronomic parameters from ionosonde data.
J R Dudeney

3. On the Source Mechanisms for SEC (Slant Es and Lacuna)

by J K Olesen, Division of Geophysics, Danish Meteorological Institute, Denmark

Comments on the article "The Structure of Slant Es" by Rodger and Pinnock, INAG 48, Aug. 1986, pp 4-6.

I have read with great interest the above contribution on the AIS measuremnts of various characteristics of the slant Es and lacuna phenomenon, that we have studied for quite some years under the common designation "Slant E Condition - SEC". Our interest also comes from the fact, that we have recently - in July 1986 - made similar measurements with the Digisonde at Thule, Greenland, and these recordings are presently being analysed.

Our most recent publication on the subject (Olesen, Stauning, Tsunoda, Radio Science, 21, 1986) was referenced in the article and it is naturally gratifying that the AIS results support the model we believe in as far as the slant Es trace mechanism is concerned. I take it that the results are meant to show only the gross features, and that some data errors or uncertainties must be anticipated. For the skymap locations, for example, a simple check of the uttermost two locations shows that at least these (170 km W, 120 km N and 55 km W, 260 km S) do not belong to the slant Es trace in the ionogram (would be 4,5 MHz, h' = 235 km and 7 MHz, h' = 288 km).

As to the lacuna, however, we are rather surprised at the authors' suggestions concerning the source mechanism, which they ascribe to large scale defocusing effects due to electron density tilts. We do not believe in that source, due to the fact, that a true lacuna always starts around the "centre of the E-region", which we feel is in better harmony with our source mechanism described below.

That F-region echoes seen at frequencies just above the lacuna do not come from zenith, but from oblique locations, does not prove defocusing to be the source for lacuna, it may simply be due to the fact, that the lacuna E-region damping overhead, does not allow zenithal F-region echoes, but only obliques for the first F-region echoes above the lacuna frequencies.

Our surprise comes from the fact that our recent measurements and calculations were so convincing, that they finally should have solved the question on the lacuna source mechanism: upper E-region absorption above the station, due to abnormally high electron temperatures.

As may be seen from our publication mentioned above that we used several types of instruments to reveal the conditions during which a SEC event at Sondre Stromfjord, Greenland, in a situation without particle precipitation: incoherent scatter radar, ionosonde, HF backscatter set-up, riometer, magnetometer with which we recorded lacuna, slant Es, E-field, profiles of electron density and of electron and ion temperatures, absorption, equivalent currents. By these data we established an almost exact correspondence between the abnormal E-region electron temperature and the riometer E-region absorption which then transferred to lacuna frequency ranges amounted to 34 - 70 dB damping at these frequencies, i.e. more than sufficient to create the observed lacuna.

We feel that these results - we have several similar cases - justify our conclusion that: Lacuna is the result of upper E-region abnormal radio wave damping due to excessive electron heating in the presence of high E-fields, strong currents and plasma instabilities whose field-aligned irregularities are scatter reflectors for the slant Es echoes.

4. The structure of Es layers and atmospheric gravity waves at mid latitudes

by P Bencze,
Geodetic and Geophysical Research Institute, Hungary

It has been been established in the last years that at mid-latitudes sporadic E layers are produced by wind shear (Axford and Cunnold, 1966). Further investigations have shown that the wind shear can be the result of internal gravity waves propagating upwards (Whitehead, 1971). Vertical sounding of the ionosphere repeated frequently enough contributed to the knowledge of the short period variations of the Es parameters (Bossy, 1972; Piggott, 1984). The study of the Es layers by means of radars enabled the revelation of the fine structure of these layers (Miller and Smith, 1978). On the basis of these investigations further conclusions can be drawn concerning the formation of Es layers.

Analysing the results of vertical soundings of the ionosphere carried out frequently enough (e.g. making 5 minute measurements) a phenomenon called Es active has been revealed (Piggott, 1984). This phenomenon is characterized by a sudden increase and commencement of the fluctuations of foEs occurring after an inactive period (Fig. 1).

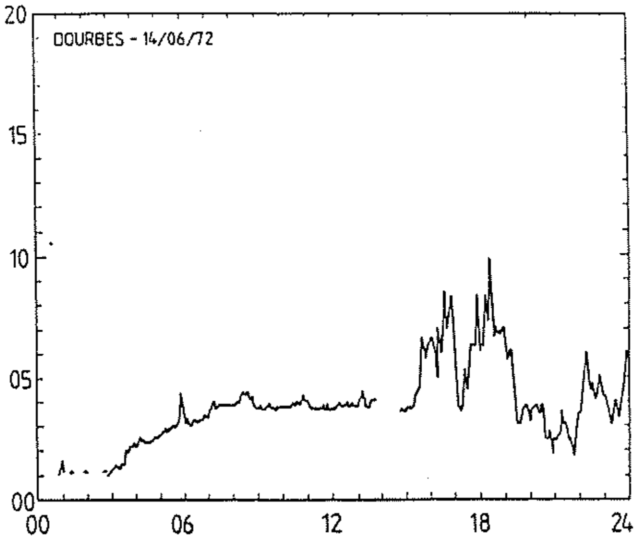

Fig. 1 Rapid variations in foEs showing the beginning of Es active on the basis of 5 minute samples (Piggott, 1984)

Es active is similar to the bursts of turbulence observed by ROster and Klostermeyer (1985) by VHF radar in the mesosphere (Fig. 2). They explained the bursts of turbulence by strong wind shears due to long period internal gravity waves (eg semi- or terdiurnal tides). According to their interpretation Kelvin-Helmholtz instability is produced by the wind shear, which in turn forms a superadiabatic lapse rate, resulting in static instabilities. The turbulence bursts are due to the static instabilities. As it is known, Kelvin-Helmholtz instabilities are formed at the interface of two layers moving with different velocity, that is, where wind shear occurs.
Gravity waves can lead to the formation of Kelvin-Helmholtz instability either by transversing a jet stream, a zone of strong wind, where the energy of the wave is absorbed and thus, increasing the velocity of the flow instability is produced, or the gravity generates directly unstable oscillations in the high velocity flow (Beer, 1975). Static (convective)

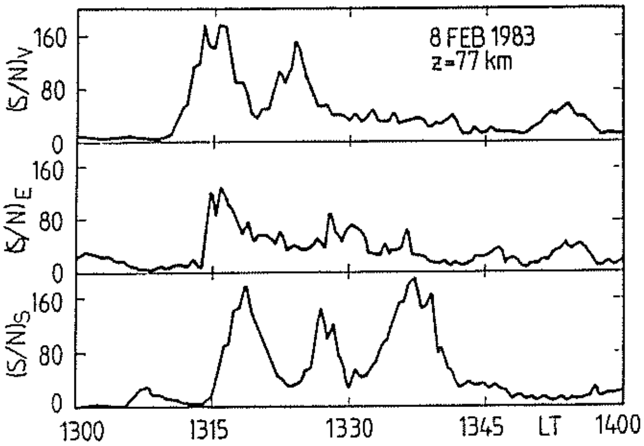

Fig. 2 Fluctuations of the signal-to-noise ratios measured in the vertical $(S/N)_V$, in the eastward $(S/N)_E$ and southward $(S/N)_S$ antenna beam directions showing strong turbulence bursts (Rüster and Klostermeyer, 1985)

instability can occur in regions, where the decrease of the density within an air parcel removed vertically from its equilibrium position is greater, than the rate of the density decrease in its environment; that is the lapse rate is superadiabatic. Thus, the Es active might be attributed to turbulence bursts.

Another factor, which suggests the relation of the structure of sporadic E layers to the saturation of internal gravity waves, are the observations carried out by incoherent scatter radars (Miller and Smith, 1978). The measurements show not only the presence of more layers of increased electron density one above the other, which indicates the formation of sporadic E layers at the nodes, where the direction of motion associated with the gravity wave changes from east-west to west-east, of a gravity wave having a downward phase speed. The layers themselves show a fine structure. This is formed as a result of the saturation of gravity waves. In consequence of the negligible damping, the kinetic energy is nearly constant, and decreasing in density, the amplitude of the internal gravity waves propagating upwards in the atmosphere increases with increasing height. Thus, an amplitude is reached at which the motion becomes unstable and the wave is saturated. This condition occurs at heights above about 90 km (Justus and Woodrum, 1973). Above this height, breaking level, the amplitude of the gravity waves does not increase any more.

At this point a cascade of the original wave into motions of smaller scale and turbulence is produced (Weinstock, 1982, 1985). These wavelike features, which resemble billows, braids and cat's eyes, maybe the result of dynamic instability due to the vertical shear of the horizontal wind. The former features are reflected also by the fine structure of sporadic E layers as incoherent scatter radar observations show (Miller and Smith, 1978), see Fig. 3. For the proof of the correctness of this interpretation the results of model calculations can also be cited (Balsley et al., 1983). However, it is to be noted that more gravity waves can simultaneously be present.

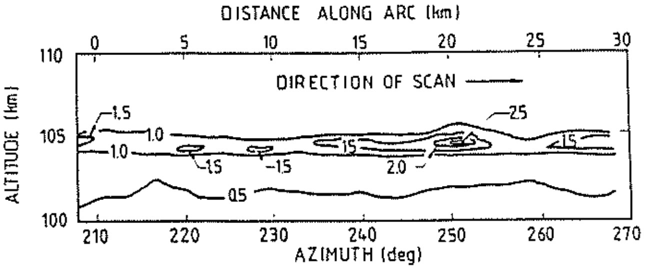

Fig. 3 Fine structure of the instantaneous distribution of electron density observed by incoherent scatter radar in a mid-latitude sporadic E layer (Miller and Smith, 1978)

Considering the above mentioned conditions it can be established that the structure of sporadic E layers seems to depend on the magnitude of the vertical shear of the horizontal wind. If the wind-shear is smaller than a critical value which is expressed by the corresponding value of the gradient Richardson number, the structure of the sporadic E layer is simply indicated in the vertical plane by straight horizontal lines of equal electron density. However, with increasing wind-shear wavelike features, billows, braids and cat's eyes appear in the central line of the layer, where the wind shear is largest.

The difference between the critical or top frequency and the blanketing frequency of a sporadic E layer, that is the partial transparency of the Es layers, can be attributed to the fine structure of the layers. Where this difference is greater, the structure is more developed, and more complex, and hence more patchiness is shown by the layer.

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5. UT - An Operational Necessity!

by P J Wilkinson, IPS, Australia

The original recommendation to record ionosonde outputs in local meridian time, LMT, no matter how attractive physically, was not good operational advice. Since an opportunity now exists to correct this, INAG should take it.

Why is LMT inappropriate operationally?

LMT is calculated using the expression:

$$\text{LMT} = \text{UT} + \text{integer}\ [(\text{longitude east})/15.0] \quad (1)$$

where

UT = universal time

and the appropriate meridian is;

$$= \text{integer}\ [(\text{longitude east})/15.0] * 15.$$

If LMT was always calculated this way, then it would be equivalent to UT and the only question left to discuss would be the relative merits of UT or a time derived from UT, and arguments such as those presented in INAG 49 could be used in support of LMT for operational data recording.

Unfortunately expression 1, above, is not always used to calculate LMT. Instead a different relationship is used having the form;

$$\text{LMT} = \text{LCT} + x \qquad (2)$$

where

LCT = local civil time

and

x = a constant.

Here the constant, x, may be +1 hour, maybe -1 hour or 30 minutes; dependent on location and local conventions. The operator who checks the time on the ionogram against his wristwatch time is using expression 2. Of course, an experienced operator will know what x is at all times. In fact, the experienced operator will use expression 1 first to know x. But very few networks will have all their stations operated by experienced operators at all times. As long as LMT is used as the basic recording time, then somewhere, sometime, there is the posibility that ionograms will be recorded with an incorrect x.

For instance, the Australian network spans five different time zones in winter and with daylight saving in summer this can increase to eight time zones. There is, in our network, the distinct possibility that an error will occur as more and more often IPS is going to be required to use less experienced operators.

We have had problems with LMT data recording and do not feel such problems are rare.

- On one occasion a month of Sydney data was lost because an ionosonde was inadvertently set on summer time at an unknown date during the month.
- When IPS introduced UT to all its stations in 1986 we discovered that Darwin had been operating on LMT derived from LCT with an incorrect value for x. This early Darwin data is all incorrect by 30 minutes.
- When operating two temporary stations under contract, IPS found it easier to use LCT and then scale the ionograms for the appropriate time later.

The problems all arose because time, in general, is difficult for untrained people to understand. We are all familiar with the many misinterpretations associated with daylight saving. During the Australian summertime the number of civil time zones is uncertain from year to year because daylight saving is a political decision.

However, there is only one UT and it can always be known with certainty. As a scientist, I would rather an unambiguous time to be used for my data recording. I now feel more confident that timing errors will be avoided with all our stations operating on UT. I will feel even more confident when all ionosonde station networks adopt UT.

While UT is unambiguous, LMT is open to misinterpretation. That is why LMT is inappropriate operationally and why INAG should strongly advocate using UT as a data recording time if no local reason exists for not doing so. That will be good operational advice to station networks.

I would like to take up two further points on timing raised in INAG 49.

First, it was suggested that long data studies would be inhibited, if not prevented, by a change in timing from LT to UT. This possibility was linked to the long time delays (of order five years) experienced in having new concepts accepted throughout the network. As a substantial proportion of the network has already changed over to UT (Ray Conkright's table reproduced in the following article) this is probably less of a problem. Even so, there should be no jumps in the time series across the time change if the data is handled correctly. However, if LMT has been incorrect for some, or many years, then jumps at the changeover will warn the researcher of possible data problems. I would have thought that this would be an advantage to the study, rather than a disadvantage.

Second, as far as I am aware, radio communicators almost never use LMT. Rather, they use UT. As more ionosonde data is used to suport HF in real time, so it will become more common for ionosondes to be operated in UT, not LMT.

However, I have to agree with many of the sentiments expressed in INAG 49. I much prefer to see ionospheric data plotted in LMT coordinates. F-plots undoubtedly look peculiar plotted in UT. In Australia we are well aware of the inconveniences. However, they can easily be overcome by computer processing. Scalers, also, find it harder to recognise features in UT without first carrying out a LMT conversion. However, we feel very strongly that these are quite minor aggravations compared to the significant data losses that can occur if LMT is confused with LCT, as does happen.

IPS, in making its decision to change to UT, did much soul searching along lines similar to those suggested in INAG 49, but it was decided that UT provided a much better time standard. This decision was agreed to by both scientists and station operators. Having made this decision, we considered it foolish not to implement it immediately.

I reiterate, UT is sound operational policy, LMT is not. I hope INAG will vigorously pursue a UT timing policy.

6. Stations Operating on Universal Time

by R Conkright

Number	Station Name	Date	N Latitude	E Longitude	Ionosonde Type
01	Argentia	01 July 1986	47.29	306.03	Digisonde 256
02	Boulder	01 Aug 1986	40.00	254.70	C-2/4
03	Brisbane	01 July 1986	-27.53	152.92	IPS 3E/IPS 4B
04	Camden	01 July 1986	-34.05	150.67	IPS 4B/IPS 4C
05	Canberra	01 July 1986	-35.32	149.00	IPS 4B
06	Cape Zevgari	Jan 1964	34.60	32.90	Chirp Ionosonde
07	Churchhill	01 Jan 1987	58.80	265.80	IPS 42
08	College	01 Aug 1986	64.90	212.20	C-3/4
09	Dakar	May 1949	14.70	342.60	IPS 4B
10	Darwin	01 July 1986	-12.45	130.95	IPS 4B
11	Davis	01 July 1986	-68.58	77.96	IPS 4B
12	De Bilt	Nov 1949	52.10	5.20	Panoramic
13	Dourbes	June 1987	50.10	4.60	Lowell
14	Fort Monmouth	Fall 1984	40.40	285.90	Digisonde 256
15	Garchy	Oct 1959	47.30	3.10	Magnetic AB
16	Goose Bay	01 Jan 1987	54.30	299.67	Digisonde 128 PS
17	Hobart	01 July 1986	-42.92	147.32	IPS 4B
18	Ibadan		7.40	3.90	IPS 42
19	Lannion	Jan 1971	48.45	356.73	C4
20	Macquarie Island	01 July 1986	-54.50	159.00	IPS 4B
21	Maui	01 Aug 1986	20.80	203.50	C-3/4
22	Mawson	Feb 1958	-67.60	62.90	IPS 4B
23	Mundaring	01 July 1986	-31.98	116.22	IPS 4B
24	Norfolk Island	01 July 1986	-29.03	167.97	IPS 4B

25	Ottawa	01 Jan 1987	45.40	284.10	IPS 42
26	Ouagadougou	May 1966	12.37	358.47	IPS 42
27	Patric AFB		28.20	279.40	Digisonde 128
28	Poitiers	July 1948	46.57	0.35	IPS 42
29	Port Arguello	01 Aug 1986	35.60	239.40	Granger
30	Qanaq (Thule)	20 Nov 1986	77.50	291.30	Digisonde 256
31	Resolute Bay	01 Jan 1987	74.70	265.10	IPS 42
32	Salisbury	01 July 1086	-34.70	138.60	IPS 48
33	Sanae Base	June 1962	-70.30	357.60	Chirp Ionosonde
34	Slough	Jan 1930	51.50	359.43	Digisonde 256
35	Saint Peter-Ording		54.18	8.37	Chirp Ionosonde
36	South Pole		-90.00	0.00	IPS 42
37	South Uist	Nov 1967	57.37	352.67	Magnetic AB
38	Tortosa	Sept 1957	40.80	0.30	Magnetic AB
39	Townsville	01 July 1986	-19.63	146.85	IPS 4B
40	Wallops Island	01 Aug 1986	37.90	284.50	IPS 42
41	Vanimo	01 July 1986	- 2.70	141.30	IPS 4B

7. A Combination of Optical and Radio Observations in the Interpretation of an Unusual Ionogram

by J A Gledhill
Hermann Ohlthaver Institute for Aeronomy
Rhodes University, South Africa

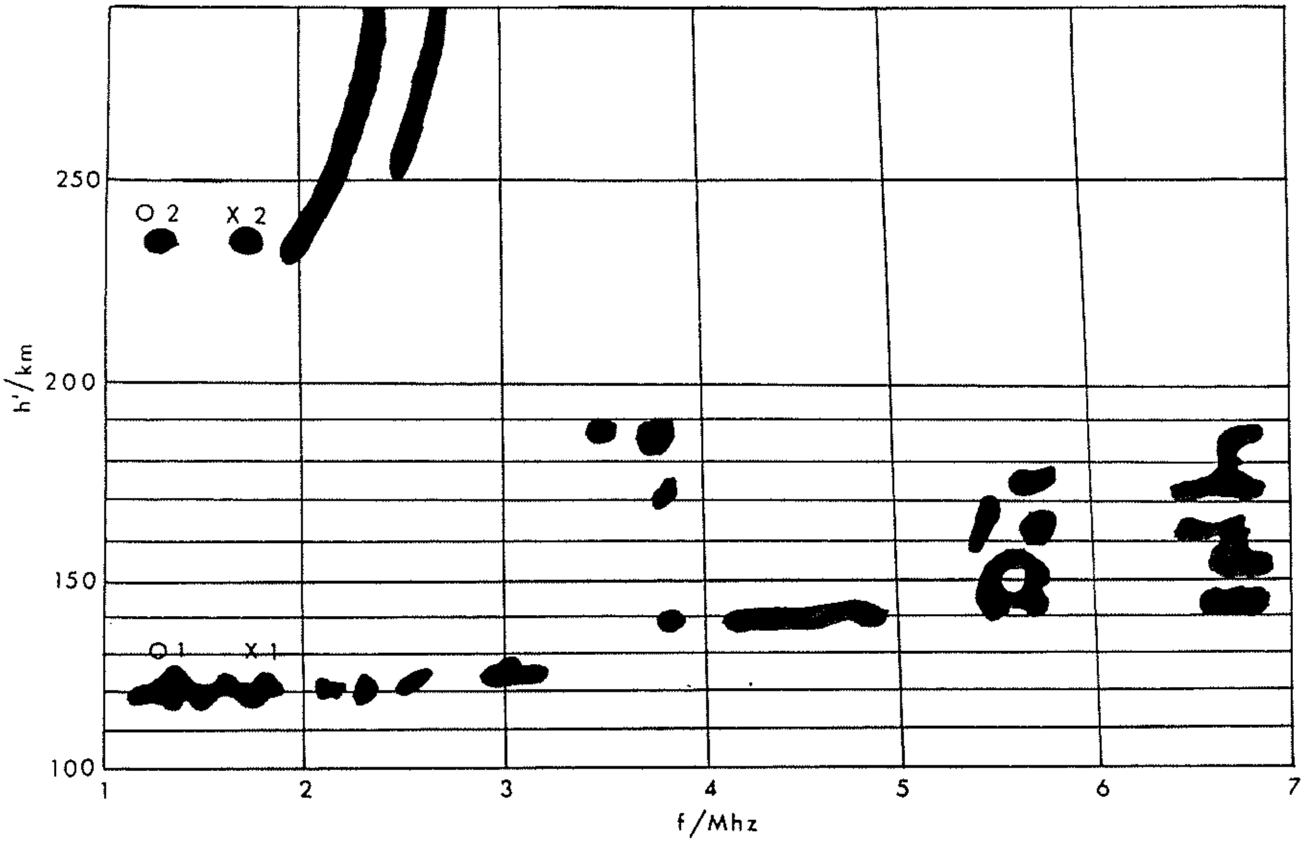
During the Project ISAAC (International South Atlantic Anomaly Campaign) cruise of the research ship S A Agulhas in July 1983 a great deal of evidence of the effects of electron precipitation into the ionospheric E-region was found. The results of the project are at present in course of preparation for publication in the international literature. The cruise lasted for 23 nights and on 12 of these typical auroral-type sporadic-E traces were recorded on ionograms, though the latitude was never south of 42°S and reached 30°S at its most northerly point. Thus the course of the ship was far equatorward of the southern auroral zone, where a-type Es is usually observed. Magnetic activity was low to moderate during the periods when the a-type Es traces were observed.

The figure shows the main traces on an ionogram of this type recorded at 2217 UT on 13 July 1983, at about 42°S, 39°W. There is some small evidence of the "layered" structure often found in auroral-type traces. Such reflections are normally thought to come from field-aligned ionization situated far from overhead (eg. Dudeney and Rodger, 1985).

In the case discussed here, a tilting-filter airglow photometer was recording the N_2^+ radiation at 391.4 nm from a 5° angle of the sky overhead. The upper state of the 391.4 nm emission requires more than 18eV of energy for excitation, and so is characteristic of charged particle precipitation, there being practically no photons with this energy at night. The photometer registered an intensity of about 15 rayleighs at the time the ionogram was recorded.

If it were assumed that the traces on the ionogram form a "patchy" E layer reflection and all come from overhead, the critical frequency foEs would be about 6-7 MHz; this would correspond to a minimum electron density of the order of 6×10^5 cm^{-3}. Using the method described by Gledhill (1984) we may estimate that this would require an energy flux, carried by the precipitating electrons, of about 17 erg $cm^{-2}s^{-1}$ and this would produce an intensity of about 5 kR of 391.4 nm radiation. This interpretation is clearly incompatible with the observed 15 R.

If, however, we estimate the precipitating electron flux that would produce 15 R of 391.4 emission and calculate the foEs that would correspond to this, we find a value of about 1.3 MHz. The prominent point marked O1 on the ionogram lies at 1.40 MHz and the point labelled X1 is at 1.84 MHz. The difference, 0.44 MHz, compares well with the value calculated from the electron gyrofrequency at the ship's position, 0.41 MHz. These could possibly be near the ordinary and extraordinary critical frequencies. This interpretation is strengthened by the presence of the two spots labelled O2 and X2. These lie at 1.34 and 1.78 MHz respectively, again separated by 0.44 MHz. They both lie at a virtual height of 230 km. The corresponding points on the first order trace should then lie at about 115 km if these are in fact the second-order vertical incidence reflections. The



virtual heights at the same frequencies on the supposed first-order trace do lie, in fact, at 116 km, though this is not easy to see, even on the original ionogram.

With so short an indication of the vertical-incidence Es trace we cannot deduce the precipitating electron spectrum that would produce the Es ionization. We can, however, assume a monoenergetic (i.e. average) energy which would produce the peak somewhat above 115 km and so estimate the intensity of 391.4 nm radiation that would accompany it. We find that a flux of 2.4 x 10^{10} electrons cm^{-2} s^{-1}, of energy 5.6 keV, would give a maximum of ionization at 118 km, with foEs 1.4 MHz and would produce about 11 R of 391.4 nm radiation. Even taking account of the approximations involved in the last step, this is much more satisfactory agreement with the observed values. We are led to believe that O1 and X1 are indeed near to foEs and fxEs, while the other reflections observed at higher frequencies and greater ranges are oblique reflections, probably from field aligned ionization patches.

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Gledhill J A, (1984). S. Afr. J. Phys., Vol. 7, No. 1, pp 33-38.

8. Separation of Ordinary and Extraordinary Magnetoionic Components using a Wideband 90° Phase-shift Network

by M Loveridge, IPS, Australia

A wideband (1.15 MHz) 90° phase-shift network was designed, constructed and tested at IPS radio and Space Services. When used with a crossed delta antenna and a 4B or IPS-42 ionosonde, it distinguishes between ordinary (O) and extraordinary (X) components of the received echoes. This can be valuable when scaling ionograms, especially those where complicated ordinary and extraordinary traces are superimposed.

The filter consists of two all-pass phase-shift networks connected so that a constant phase-shift of 90° is obtained over the band of interest. It was designed by following a method of synthesis, yielding component values for a fourth order phase-shift network; see Figure 1.

The filter inputs are matched to two delta antennae by means of 16:1 transmission line transformers. In order to minimise phase errors, construction of the delta antennae was kept as symmetrical as possible.

The network outputs are combined using a hybrid transformer. This summation then makes the antenna/filter system selective to clockwise or anti-clockwise circular wave polarisation (ordinary or extraordinary).

The printed circuit board, containing the filter components, was mounted inside a commerically manufactured cast metal box which was be placed on the mast near the feedpoint to the antenna.

Testing of the filter was undertaken both at Camden, NSW, and at Mawson, Antarctica with reasonable success. Some typical ionograms are displayed in Figure 2.

In the presence of frequency spread or disturbed conditions, the degree of supression of the unwanted magnetoionic component is reduced. However, in using the O-X separator several improvements have been observed in the recorded ionogram traces.

- o Trace intensity for the selected component is enhanced, sometimes revealing indistinct parts of the trace.
- o The signal-to-noise ratio is improved, making previously unobserved traces visible; fmin, for example, is usually reduced.
- o Regions of the ionogram where ordinary and extraordinary traces overlap are easier to interpret.

An IPS TR series has recently been published on this subject (IPS-TR-86-04). For further details please contact Dr P J Wilkinson, IPS, Darlinghurst, NSW 2010, Australia.

FIG. 1

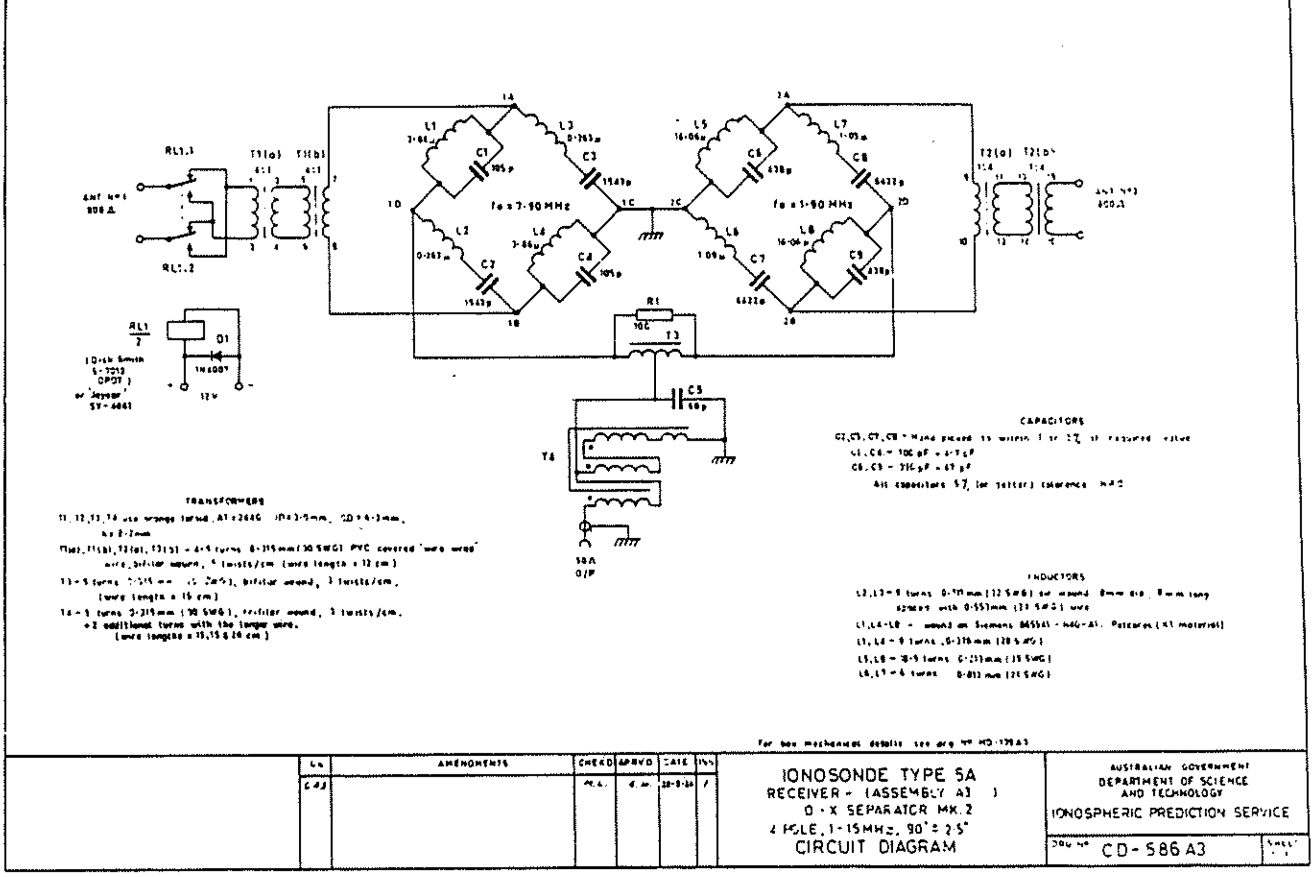
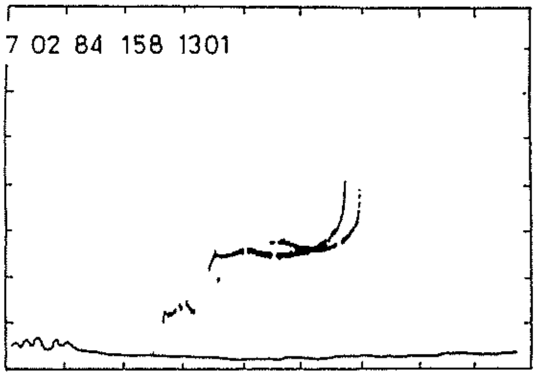


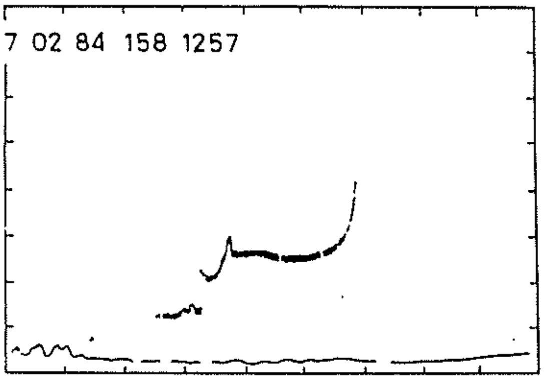
FIG. 2

CAMDEN, N.S.W., DAY 158, 1984



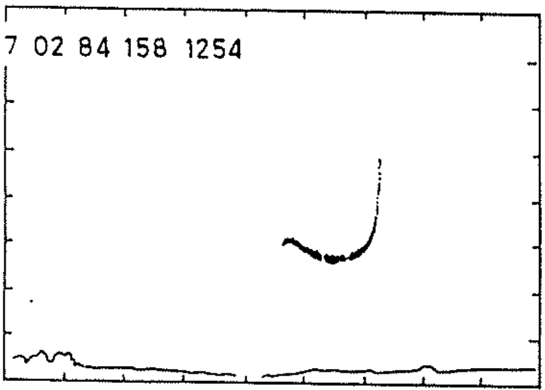
`O´ & `X´ COMPONENTS

Approximately equal intensity.



`O´ COMPONENT

Note enhancement of trace, particularly in E-region.



`X´ COMPONENT

Note trace enhancement.

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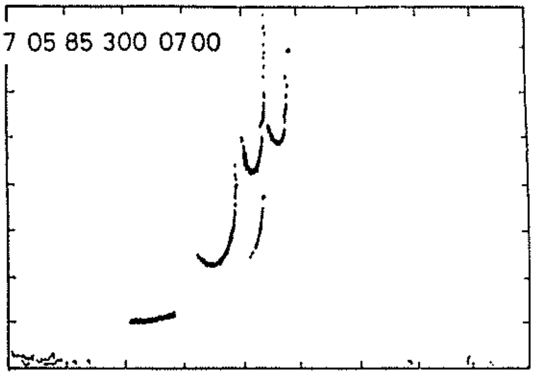
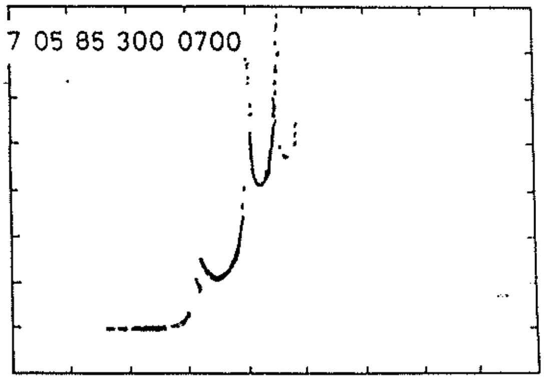


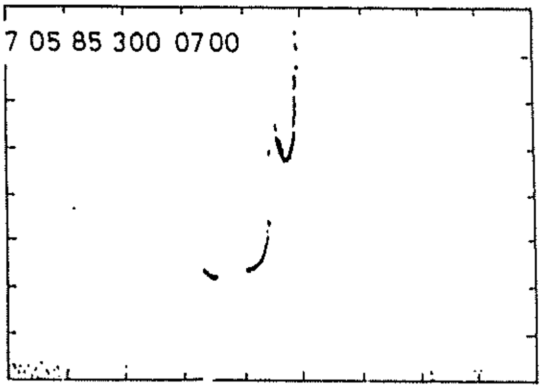
`O´ & `X´ COMPONENTS

foE, foF1 and foF2 critical frequencies evident.



`O´ COMPONENT

Note trace enhancement, particularly around E-region - extension of f min. and, clearer foEs evident.



`X´ COMPONENT

Trace enhancement.