IONOSPHERIC NETWORK ADVISORY GROUP (INAG)*

Ionosphere Station Information Bulletin No. 22**

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

** Issued on behalf of INAG by World Data Center A for Solar-Terrestrial Physics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80302, U.S.A. The bulletin is distributed to stations by the same channels (but in the reverse direction) as their data ultimately flow to WDC-A. Others wishing to be on the distribution list should notify WDC-A.

† Information for Sections XVII to XX and continuation of Section XIV received January 29 after rest of manuscript to printer.

I. Introduction

by

W. R. Piggott, Chairman

It is with much pleasure that INAG can announce the publication of the High Latitude Supplement to the URSI Handbook of Ionogram Interpretation and Reduction, as Report UAG-50, October, 1975. Copies of this have been widely distributed by WDC-A and additional copies can be bought at the price of $4.00 U.S. currency. WDC-A have made an exceptional effort in producing this report in such a short time from a most difficult handwritten manuscript. *A number of problems are indicated in the introduction and INAG wishes to receive your comments on these and on any corrections or points on which you disagree with the interpretations, as soon as possible.* It is very important to obtain world wide agreement on the interpretation of ionogram patterns associated with magnetospheric phenomena so as to maximize the value of Vertical Incidence Sounding during the IMS. Only a few months are available for such discussions. *Please read and criticize the Supplement quickly.* Similar remarks apply to the corrections and modifications made at Lima and published in INAG-21 - if you have reservations about these or wish for more discussion or clarification, write now.

The INAG Meeting at Geneva will be held before the next issue of the INAG Bulletin. If you have items for the Agenda, please send them to the Chairman for this meeting, Dr. G. C. McCue, I.P.S.D., Commonwealth Bureau of Meteorology, Department of Science, 162-166 Goulburn Street, Darlinghurst, P.O. Box 702, N.S.W. 2010, Australia.* As announced in INAG—21, page 2 and page 11, the main meeting will be held on Thursday, February 12, 1976 in Room T-5 in the ITU Tower Building in Geneva, and there will be a joint meeting with CCIR Interim Working Groups 6/1 and 6/3 on February 13. Some INAG members and consultants expect to be available on February 11 for informal discussions in the same room. This Bulletin contains a short summary of the Ionogram Interpretation Meeting held at Uppsala on 28-30th of October, in which many problems of interest to the Vertical Incidence Network were considered.

At the request of several groups a pro forma invoice is attached to the back of this issue to facilitate subscriptions to the INAG Bulletin. (See INAG-21, pages 12-13). These subscriptions of $10.00 cover one copy of all issues of the INAG Bulletin during the 3 year period up to the next General Assembly of URSI. For convenience of potential subscribers, the appropriate abstract from INAG-21 is reproduced below.

> "It was decided to <u>invite</u> users to subscribe to the Bulletin for the nominal sum of $10.00 for the next three years per copy in which time INAG intends to produce 9 to 12 issues. Organizations are further invited to subscribe not only for the copies going to their own stations but for additional copies to be sent to stations which are unable to pay. Organizations which already give indirect support will, of course, not be expected to subscribe. Those stations which have practical problems about subscribing will be continued on the distribution list, in effect being covered by the oversubscribers, or the grant from URSI. Distribution to people whose work will benefit is more important than token payments."

A new ionogram discussion column to be known as “Uncle Roy’s Column” will begin with INAG-23 instead of this issue.
The object of this column will be to provide for the Vertical Incidence Network the equivalent of a readers problem page in popular magazines, and it is hoped that your Chairman will be able to play the part of “Uncle Roy” in answering your questions for a considerable period. You are invited therefore to contribute to the Chairman ionograms on which you would like comments. This is your column, if you do not send ionograms, they cannot be published.

A few copies of the questionnaire attached to INAG-21 have been returned to the Chairman or Secretary. More information is urgently needed since several administrations will shortly be considering the size of their effort in the post-IMS period.

On behalf of INAG your Chairman wishes you a very happy Christmas and a prosperous and effective New Year. This will be the first of a period of two or three years where we may hope to see a considerable expansion in the use of Vertical Incidence Network data.

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* The INAG Secretary apologizes that because of mail problems, W. R. Piggott's complete manuscript sent December 10, 1975 has not as of January 26, 1976, reached Boulder, Colorado. Therefore, this edition of the INAG Bulletin will be somewhat abridged. Also, it is obviously too late for suggestions for Geneva Agenda items to reach Mr. McCue.

II. The Application of Ionospheric Soundings to IMS Problems

The following note was prepared for the Committee for Co-ordination of Observations Association with GEOS (CCOG) but should be of interest to other ionospheric workers. It is intended to draw attention both to established methods of using Vertical Incidence ionospheric data and to potential uses, especially where there is controversy about the reality or morphology of a magnetospheric phenomenon.

Ionospheric Soundings Associated with GEOS

By W. R. Piggott (Ionospheric Consultant to CCOG)

The application of ionosonde data to IMS problems has not been adequately studied and the possibilities are not understood by many potential users. The purpose of this note is to discuss briefly the types of information which can be made available readily and in particular draw attention to certain applications which are often overlooked. The major limitation in the use of such data is due to the absorption which can be generated by the more penetrating particle activity which prevents the signatures of the phenomena to be seen on the ionograms. When riometer data are also present, the type of absorption phenomena can often be recognized by its variation in time. It appears probable that in these cases the presence of the absorption itself can be used to give limits to the position of a boundary.

Both aircraft and ground observations have shown characteristic changes in the ionogram pattern at the auroral oval, at least under average conditions. The usefulness of this criteria during severe magnetic storms is not as yet known.

The electron density structures in the ionosphere are very sensitive to coupling between the plasmas of the magnetosphere and ionosphere, to the presence of winds and electric fields, to the composition of the neutral atmosphere, and to the incidence of high speed particles or hot plasmas. There is much interest amongst ionospheric scientists to study these phenomena during the IMS so special efforts are being made to get uniform nomenclature and procedures for studying them. Groups primarily interested in solar effects on weather and climate are also becoming interested in the phenomena found in the ionosphere at high latitudes. The 22-year cycle in meteorological parameters found at low geographic latitudes strongly suggests that changes in the solar wind are responsible. All the apparent solar cycle relations with weather and climate involve major scientific problems for which IMS studies should be critical (ref: Solar-Terrestrial Physics and Meteorology - A working document, SCOSTEP, July 1975, compiled by A. H. Shapley, H. W. Kroehl and J. H. Allen, 142 pages, Acad. Sci., Washington, D. C., U.S.A.).

At high latitudes the ionosonde sees the maximum electron density for the E and F layers present within a considerable area, as well as sounding that nearly overhead. It could detect the ionization structures associated with the auroral oval with plasma instabilities in the ionosphere, with hot solar plasma, and local particle precipitation as well as showing the indirect effects of the coupling between the magnetosphere and ionosphere. These can be studied at two levels: -

(a) Morphological

(b) Detailed studies of particular phenomena.

The most important applications of (a) for CCOG purposes are to establish whether and when particular phenomena occur, and thus to monitor important magnetospheric parameters. For this application it is only necessary to know when and for how long, particular types of ionogram are present at one or more stations. The main interest in (b) in the past has been to find out the maximum electron density and the height at which it is produced due to particle activity, as seen by rocket or satellite observations.

Monitoring the Auroral Oval

The auroral oval is asymmetric about the geomagnetic pole, typically reaching some 10° lower latitude near geomagnetic midnight than near geomagnetic noon and more than doubling in width as it moves to the lower latitudes. Its exact position varies considerably with changes in solar wind and hence with solar and magnetic activity. As the earth rotates, stations at suitable geographic latitudes are carried across the auroral oval, and can detect its presence by characteristic changes in the patterns shown by the ionograms when it passes overhead. Such changes vary with season and day or night conditions, but are believed to be present at all times at which the oval crosses the station. In some cases of course high absorption may prevent them being detected.

There is strong indirect evidence that there is always enough activity in the auroral oval to give readily detectable changes on ionograms. Whether typical oblique traces could be identified and their range measured, the position of the oval can be detected even when several hundred kilometers from the station. Normally the equatorial edge shows the most characteristic traces and their position in latitude can be estimated to better than one degree when the geometry is favorable. Stations on the polar side of the auroral zone are especially valuable for monitoring the position of the auroral oval for most days. The immediate action needed is to complete agreement between different groups operating high latitude stations on the exact criteria to be used and to arrange for interchange of the critical times. Data from the local longitude zone is likely to be most readily available but data from other longitudes can supplement this when local blackout intervenes or when conditions are complicated. Since most particle activity is centered near magnetic midnight, observations at times well displaced from magnetic midnight are more valuable for evaluating the position of the oval accurately than those taken near magnetic midnight.

Monitoring the Direction of Inter-Planetary Magnetic Field

There is evidence that the Slant Es Condition (SEC) is due to plasma instabilities generated by abnormally great dawn-to-dusk magnetospheric electric fields. The phenomenon is common inside the auroral oval but is believed to occur most frequently under the auroral oval and at the magnetic pole. Near the pole it shows peaks in occurrence in the early morning or late evening, depending on the sense of the interplanetary magnetic field and this offers the possibility of using this phenomenon to monitor this field from the earth's surface. The possibility of using the phenomena as an index of the intensity of the total dawn-to-dusk electric field does not appear to have been studied.

Incidence of Hot Solar Plasma

Hot solar plasma incident from the polar clefts can cause easily recognized changes in the F2 layer, particularly in the summer months. In general the normal F1 and F2 pattern is replaced by traces from a low F2 layer with abnormally high critical frequency. The changes from normal to abnormal pattern, or vice versa, occur very quickly in marked contrast to the changes associated with changes in the position of the auroral oval. These patterns have often been detected in the polar cap and on a few occasions on the equatorial side of the auroral oval. They are often superimposed on typical auroral oval phenomena suggesting that the plasmapause appears to act as a partial barrier. It is not as yet known whether they can be uniquely identified in the presence of normal auroral oval phenomena using ground based observations alone. The relatively high temperature of the plasma identifies the phenomena in rocket and satellite observations. Further tests are needed as the phenomena seen could be caused by other processes.

Particle Precipitation

(a) D region

Particles penetrating to the D region (low about 95 km.) are readily detected by ionosondes when the precipitation is overhead. The technique is extremely sensitive and saturation (total blackout) occurs readily. The time variations of the excess absorption are usually more readily studied using the riometer though ionosonde measurements are always desirable to study weaker events and to show that absorption seen by the riometer is due to F-region phenomena. This is especially important when severe spread F is present since the F region can then give absorptions of one or two dB at 30 MHz. When PCA phenomena are present the ionosonde is more sensitive to solar electrons than to solar protons whereas the reverse is true for the riometer. This can be used to give warning of PCA events since the electrons normally arrive earlier than the protons.

(b) E region - Thick layer

Traces due to thick layers in the E region (Particle E, - Night E) are readily recognized and their critical frequencies are usually well defined. Two main classes of Particle E are found. The best known is associated with auroral activity and moves more or less in step with changes in the auroral oval. It is usually found some five degrees in latitude displaced towards the equator from the maximum of the visible aurora. The highest electron densities and critical frequencies appear near the lowest latitude effected by the phenomena. In general, as with most particle effects in the ionosphere, the height and maximum density are inversely related, most auroral associated layers appear to be formed below 130 km. The second Particle E phenomena occurs mainly at greater heights, between 150 and 200 km. It shows short time variations similar to those expected from local particle precipitations but is found at times and in places when auroral activity is not evident. It is common at much lower latitudes than the auroral associated Particle E phenomenon.

(c) E region - Es layer

Provided that the F layer is not too tilted, blanketing of Es gives a direct measure of the effects of particles overhead, (fbEs), but the majority of Es traces associated with geomagnetic storm conditions (other than those with foEs close to fbEs), are seen at oblique incidence. The traces can show the maximum density of the Es layer at distances up to several hundred kilometers. The ionospheric rules are at present under review. It is not clear whether the Es phenomena above the station should be stressed or the most intense Es phenomena near it. Guidance from potential users is required.

(d) Plasmapause trough

When the F layer is not illuminated by the sun (winter night conditions) a highly characteristic variation of electron density with position is found near the edge of the plasmasphere. The critical frequency of the F layer decreases significantly and its height increases by 100 km. or more to form a trough in the electron density, with width along the magnetic meridian of 100-300 km. A dense, field aligned structure is usually found on the polar side of this trough which is readily detected by the ionosonde. Typical particle produced Es traces are usually present near the edges of the trough. The position of the polar ridge can be followed with an accuracy to a fraction of a degree in latitude from suitably placed stations, though over Scandinavia the interpretation can be complex as simultaneous relations are usually present from several azimuths. Relations between the boundaries of the different auroral phenomena appear to be controversial. Possibly because they appear to be close together during major storm conditions but separate in quiet conditions, i.e., when detected at high latitudes.

Ce) Detection of winds and fields

Both winds and electric fields in the ionosphere can move the ionization, particularly in the F region. Winds cause movement along the magnetic fields, electric fields, at right angles to it. Such effects extend well beyond the zones where particle precipitation is taking place and can thus be detected by suitably placed stations, even when stations near the auroral oval are totally blacked out. It is probable that such phenomena are best studied using one or more fixed frequency pulse transmissions since such changes can occur very rapidly. However these must be interpreted with the aid of standard ionograms taken preferably not less frequently than at quarter-hourly intervals. Little work of this type has been done since the earliest days of the ionosphere but it appears to be timely to reconsider the value of this type of investigation.

As mentioned above, the normal dawn-to-dusk electric field in the magnetosphere is close to the critical value at which plasma instability can be generated in the upper part of the E and lower part of the F regions. In summer months local increases in field above the critical value show up on the ionograms as Slant Es and Lacuna patterns.

III. Ionogram Interpretation Meeting, 28-30th October, 1975, at Uppsala Ionospheric Observatory, Uppsala, Sweden

An ionogram scaling meeting, organized by Dr. A. Hedberg (Uppsala), was held at Uppsala Ionospheric Observatory, Uppsala, Sweden on 28th - 30th October, 1975. The primary objective of this meeting was to discuss ionogram scaling problems common to the Scandinavian and Greenland groups of stations with special reference to preparations for providing V.I. data during the IMS. This follows the meeting at Sodankyla, Finland, May 14-16, 1973, reported in INAG-15, pp. 13-14. On this occasion, however, the meeting was attended by two scientists from Denmark and two from India. The Chairman of INAG took part in both meetings. In all 22 participants were present from nine institutes in six countries. This was more than in the earlier meeting.

In general, each topic was introduced by a paper giving examples from ionograms and these were then discussed by those present. The Chairman of INAG then gave the INAG view on the points raised which was usually adopted. Several new points were raised which are discussed elsewhere in this Bulletin. These are identified by subject with "U.I.I.M." added.

The main topics and opening speakers were as follows:

Sporadic E classification	V. N. Jensen (Denmark, DM1)
Slant sporadic E, Es types	J. K. Olesen (Denmark, DM1)
Scaling of E-layer height	T. Turunen (Finland, GOS)
E and Es scaling problems - foEs, fbEs, foE	A. Hedburg (Sweden, UIO)
Identification of Polar Cap - Auroral Oval - Polar Cap phenomena	3. K. Olesen (Denmark DM1)
Cusp phenomena	*3.* K. Olesen (Denmark DM1)
F-layer scaling problems - fxI, fmI, spread F	A. Hedburg (Sweden, UTO)
Effects of the technical properties of the ionosonde on ionospheric data	T. Turunen (Finland GOS)
The new KLT-Rosen Ionosonde 15-14	H. Lame (Finland KLT) and F. Rose (Sweden GRE)
Report on URSI/INAG meeting at Lima, August 1975	W. R. Piggott (U.K., Chairman of INAG, B.A.S.)
The High Latitude Supplement	W. R. Piggott (U.K., Editor for INAG, B.A.S.)

A large number of particular ionogram problems were also discussed.

A full report on the meeting is being prepared by Dr. A. Hedberg and will become available in 1976. This will be circulated to all present, the members of INAG and others who apply to Dr. A. Hedberg, Uppsala Ionospheric Observatory, S-755 90 Uppsala 1, Sweden. Mr. W. R. Piggott wishes to acknowledge a travel grant made by the Royal Society of London and a subsistence grant from the Research Institute of the Swedish National Defence which made possible his attendance at this meeting.

IV. f-plot representation of foF2 when foF2 falls below fmin

The question has been raised of the correct representation of foF2 when foF2 falls below fmin and fmin is above the lowest limit of the ionosonde, e.g., when fmin is determined by interference. This case is not considered specifically in the Handbook. The corresponding case when fmin is at the lower limit of recording, (fmin)EE, is treated on page 60 of the Handbook, Fig. 3.10a.

The alternatives are:

(a) To treat foF2 as in the Handbook example. In this case foF2 = (fmin)ES and the f-plot entry is a V at the normal position of fmin (see Fig. 3.10a), no entry for foF2.

(b) To treat the ionogram as an example of total blackout, vertical lines across the f-plot.

The critical question is whether it is more likely that foF2 fell below the mean value of fmin shown by the previous sequence or whether the absorption really increased. In nearly all cases it is obvious from the f-plot from this and previous days that fmin is determined by interference and the absorption is small. This is identical with the Handbook case except that the stable, non-absorbed value of fmin is greater than the lowest frequency of the recorder and is treated accordingly foF2 = (fmin)ES with V on f-plot. If the absorption is changing significantly with time this is shown on the ionogram by a weakening of interference bands and by changes in fmin which are greater than those usually found. In this case there is no information about the value of foF2, use replacement letter B and the f-plot convention for total blackout given above.

Some stations operate the ionosonde at night, at least at some seasons, so that interference near the lowest recorded frequency does not show. In this case, fmin is above the lowest recorded frequency even when no absorption is present. Clearly (fmin)EB is not right and this leaves only letter C and S - the ionosonde has been operated so that fmin reads high - C or the gain has been adjusted to minimize the effects of interference - S. Since C is usually used to indicate a malfunction of the ionosonde, which is not present, S is the more appropriate letter. In fact, fmin is high because the gain has been decreased to avoid interference. Again since there is usually little or no absorption at night the minimum value of fmin is usually constant or near constant at night and increases in absorption are easily detected by increases in fmin from the limit value. Use foF2 = (fmin). S and a V at the normal value of fmin unless there is positive evidence that the absorption has increased.

In short, if there is positive evidence that absorption has increased, use B; if not, use the normal value of (fmin)ES both in tables and on the f-plot.

V. fbEs for Es type t when gradient reflection is present

U.I.I.M.

At the Scandinavian stations, a low type of Es is often present which appears to be due to a steep gradient on the lower edge of the E layer. This can be readily recognized as it gives a weak diffuse trace which does not blanket the E trace and has a low frequency limit (fmin λ) greater than fmin for the E trace. It was pointed out by Dr. Hedberg that the analysis of such cases could be assisted when fbEs is not given by an Es trace with larger value of foEs, by using the convention:
fbEs = (fmin λ)EG. This is consistent with the normal rules but the numerical difference (fmin λ) minus (fmin) enables the computer to pick out examples of gradient reflection. G must be used as fbEs is less than foE. After full discussion it was agreed that this was permissible as a local rule. Uppsala Ionospheric Observatory, therefore, formally give notice that they will be using this local rule in future analyses and that users should note that the (fmin λ) value is then not identical with the tabulated value of fmin.

There is only a restricted interest in this phenomenon so the technique is not recommended for general use. Other groups making studies of it may, however, wish to adopt the same local convention which is very convenient.

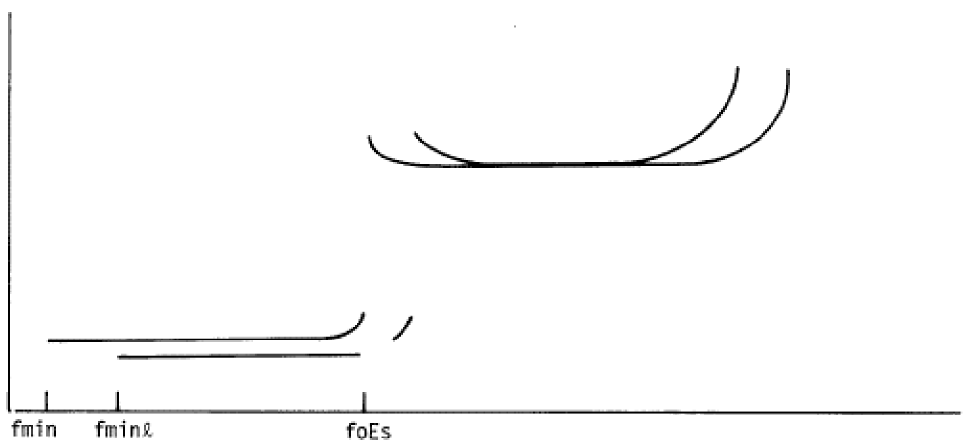
The observation (fmin λ) greater than fmin often causes operators doubt about what is occurring. It is usually due to gradient reflection, meteor traces or the presence of wind influence at Es heights.

VI. fbEs determined by foE or particle E

(U.I.I.M.)

For the rather common case of an Es trace with foEs greater than foE but no blanketing, the question has been raised whether it is logical to use fbEs = (foE)EG. It is suggested that fbEs = (foE)-G would be more logical since the value of foE is known to high accuracy. fbEs = (foE)EG would then be kept for cases where the apparent value of foE is itself a doubtful value. Accuracy rules would then determine the use of - U or E. In the case of blanketing by particle Es, type k, K takes priority over G so that the corresponding conventions are fbEs = (foE)EK and fbEs = (foE)-K, respectively. The rules for use of K adopt the second convention unless the value of (foE)-K is doubtful and a limit value.

This is a case where the development of the subject has generated a non-compatible treatment of two similar cases. It is a good rule not to change the conventions unless either it is really necessary to produce useful information or there is a widespread demand to clarify and simplify them. The existing convention has been in use for many years and is well understood. *Do you want it changed?* If so, please write to INAG or raise the point at the Geneva meeting. Without the pressure of an URSI General Assembly meeting of INAG, where decisions have to be finalized, there is plenty of time to allow a wide consensus of opinion to be sampled. Unless you let us know, INAG has no means of sounding this opinion adequately. *Please act.*



Convention for identifying gradient reflection

fbEs = (fmin λ) EG

Es type λ .

VII. The Interpretation and Use of fxI

Mr. A, S. Rodger and Dr. J. Dudeney (British Antarctic Survey) have drawn the Chairman's attention to some possible misunderstandings in the interpretation and use of fxI.

Relations between fxI and foI

The original purpose of fxI was to provide a convenient measure of the effects of F region spread on oblique propagation. At night this can greatly minimize the maximum usable frequency available for oblique incidence propagation. The results of the widespread production of fxI values in recent years have shown that there are also considerable scientific advantages in measuring this parameter, especially at very high and very low magnetic latitudes. This bonus has been greater than originally anticipated.

While fxI is the most convenient parameter for the operator to measure, it cannot be used directly for the practical purposes of calculating the effective MUF. For this application it is first necessary to deduce foI (= fxI — fB/2), then to multiply by the factor corresponding to the desired distance and then if the x mode is required, to add the difference, fx(MUF) - fo(MUF). For practical purposes this difference is usually about fB/2 (in theory it can range down to zero in extreme cases). Thus we are really trying to measure fxI in a manner which allows consistent values of foI to be deduced from it. There is an exact parallel with the use of fxEs instead of foEs which is fully described in the Handbook. In nearly all cases it does not matter whether foI or fxI is selected for measurement, provided the data are consistent but it is easier for the operator to measure fxI. Difficulties arise when fxI and foI are inconsistent, in the sense fxI ≠ (foI + fB/2).

These conditions fall into two classes:

(i) conditions when the differential absorption between the x and o modes makes fxI less than (foI + fB/2). These occur when the absorption is large or when fxI approaches fB.

(ii) conditions when the mode of reflection is more efficient for the o—mode than for the x-mode or when the amount of spread present is ranging rapidly in the magnetic meridian so that the spread present near the o- and x-mode reflection points is significantly different. In practice, in almost all cases, both of these phenomena result in foI being greater than (fxI - fB/2) i.e. fxI less than (foI + fB/2) as in the absorption case. The most common situation is that field aligned irregularities are present and the condition of reflection for the o-mode sets this wave at right angles to the irregularity. This gives a large reflection. The x mode, in contrast sets itself end on to the irregularity which therefore is a smaller target and gives a much weaker signal.

Thus in both cases, (i) and (ii), when fxI differs from (foI + fB/2) the value deduced from foI is physically more reliable than that from fxI. When the amount of scatter varies rapidly with position an oblique signal will be reflected in a non-symmetrical or non great circle path so as to take advantage of the largest MUF available. Again the same rule applies.

This greatly helps the operator who, in effect, has to make the same correction for all cases where fxI is not equal to (foI + fB/2) and thus does not have to worry about the exact cause of the difficulty. Many operators have accepted this position without question but some have had difficulty, feeling that they should be asked to record what they actually see rather than a deduced value when fxI ≠(foI + fB/2). I hope that this clarification will make the situation clear to all.

The figure, provided by Rodger and Dudeney, shows four representative patterns, Ca), Cb), Cc), Cd). In the first two foI and fxI are both measurable in the third only fxI can be measured and in the fourth the mode giving the top frequency cannot be specified without using a polarimeter or having information on the type of reflecting structure present and its variation with position. For this case, by convention, we assume that the top frequency is fxI unless we have evidence to the contrary. In practice fxI is usually so large that the difference fxI - foI is not of practical import--errors due to changes in scattering efficiency with frequency and to the gain of the ionosonde will be greater than this difference.

The values of fxI for the cases shown in the Figure, with fB/2 = 0.6 MHz are:

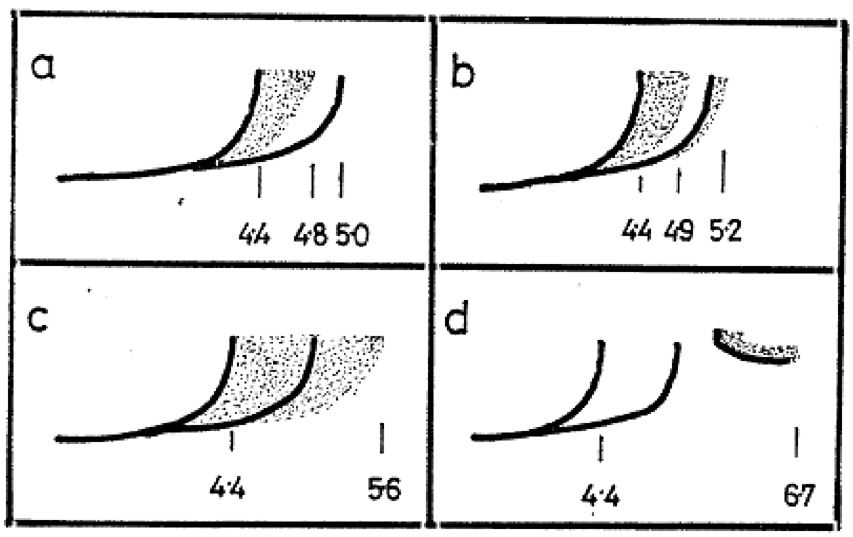
	Standard	If typing in fxI table
(a)	0540B	0540F
(b)	0550B	0550F
(c)	056	056-F
(d)	067	067-P

It is of interest that the same type of argument shows that, for practical applications, the highest frequency of a fork or the limit frequency for a highly tilted layer trace (Figure 2.8 page 40 Handbook) are the most important measurements.

<u>fxI when foF2 is less than foF1</u>

This case is not treated specifically in the Handbook. Confusion has arisen because it is not clear whether fxI should be treated in the same way as foF2.

For foF2 equal to or less than foF1, foF2 is reduced as (foF1)EG and by analogy it might be felt that fxI should be (fxF1)EG. However, the correct argument is based on the prime purpose of fxI as a communications parameter referring to the F region as a whole. We draw no distinction between a normal F trace and a polar spur so should not distinguish between F1 and F2. Thus for a clean F1 trace with foF2 = (foF2)EG, fxI = (fxF1)-X. When the F1 trace is spread, as often occurs at high latitudes, the fxI value is deduced from the top frequency of the F1 spread. High absorption cases, in which fxI ≠ (foI + fB/2), are treated exactly as if F2 spread was present. The fact that fxI is deduced from an F1 trace is clearly shown by the foF2 entry, when this information is needed, but is usually of no importance.



VIII.- <u>Range Spread - Q</u>

INAG 21, page 16, section 2.81 (b). In the discussion at Lima on range spread and the use of Q to denote range spread, it was found desirable to give a minimum spread relative to the normal trace width at which range spread would be regarded as being present.

At Lima opinion was somewhat split on the magnitude of the desirable limit, some people feeling that range spread should extend over twice the normal trace width before Q was used and others that this limit was too great. The consensus view was that Q should be used when the range spread exceeds 30 km, with narrow pulses, or exceeds 15 km beyond the width of a trace showing no range spread with wide pulses. This problem has not been discussed at length in the INAG Bulletin or at other INAG Meetings so that it is not clear that the most appropriate limit has been adopted.

INAG requests opinions on whether the rule given on page 16 of INAG 21 and page 255 of the Supplement is adequate or whether some other limit would be more appropriate. Since range spread is most important in equatorial and high latitudes, the views of groups in these zones will be especially valuable. Some tests made since the Lima meeting suggest that the adopted increase in trace width is too small.

The consensus view at Lima was that a fixed range spread limit was desirable so as to show whether range spread occurred over the world even if this meant that all entries at some stations might be Q. It is desirable to make a test of the number of Q entries as a function of position for a group of high latitude stations so as to see what limit gives the maximum information.

IX. fbEs Presentation of f—plots

Special attention is drawn to this note on fbEs presentation on f-plots. The recommendation made at Lima appears unsound and proposals for correcting it are made.

The original Handbook instructions for plotting fbEs, Section 6.6, page 152 states that fbEs should be plotted as a filled circle with a horizontal line through it. Alternatively, when consecutive values of fbEs are present which are attributable to the same Es trace they are linked by straight lines. The limit symbol V is used when fbEs is deduced using the rules for total blanketing, section 4.6.(a)(b) page 108.

This rule has been criticized at several INAG Meetings, and in discussions, on the grounds that the operator is not qualified to know when the consecutive values of fbEs are attributable to the same Es trace and when not.

When sequential Es is active at a station fbEs increases as the Es trace falls in height. At the end of the sequence the Es layer disappears but in general another sequence starts or has started at a greater height. Thus workers interested in sequential Es frequently disagree with the f-plot patterns produced by stations. In practice most stations link values of fbEs which form an unbroken time sequence linking high and cusp values of fbEs. When blanketing low Es Is also present most groups link consecutive values of fbEs for this trace also but would not link a high or cusp value with a low value when the former disappears. In the case of the densest forms of Es the trace can become type λ but differs from the other type λ traces in that foEs and fbEs are both very high--often totally blanketing. Such a trace is usually physically a direct development of the preceding and following high and cusp types and would therefore be linked with them on the f-plot.

This problem was discussed at Lima where the consensus was overwhelmingly in favor of changing the rule on page 152 by deleting "which are attributable to the same Es trace" and this change was accordingly made in the appendix to the Handbook Supplement, page 281.

Tests with the amended rule show that in practice it can introduce as many difficulties as it removes; thus if a low Es is blanketing, and high or cusp Es which have been blanketing disappear, the new rule would imply joining fbEs for the high or cusp types of the fbEs for the low type. This is clearly undesirable. Thus this amendment should be deleted.

The intention of the rule is to clarify the development of Es blanketing on the f-plot as shown by the actual samples taken. The operator has no knowledge of what is happening between samples and cannot be expected to take into account the behavior of sequential Es. Thus points joined by lines under the old rule do not necessarily imply that the physical sequence was exactly as shown by the f-plot. It is, of course, undesirable to link Es traces which are clearly of different origin, e.g., to link fbEs due to high and cusp traces with fbEs due to particle E traces.

X. Correction to INAG-21, page 23

Unfortunately, the Figure given on page 23 is incorrect. The correct Figure for Fig. 2.2b is given on page 249 of the Supplement and is reproduced below. The Figure shown on page 23 of INAG-21 was Figure 4.31 "Es Type d Partial reflection from the absorbing layer" with the comment "The 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)." The Figure on page 11 of this Bulletin replaces the existing Figure 4.31 in section 4.83 page 117 of the Handbook.

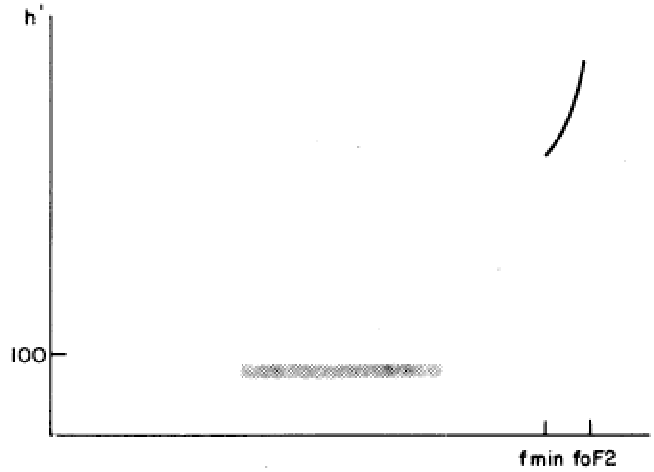


Fig. 4.31 Es type d. Partial reflection from absorbing layer.

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).

XI. Monitoring Digital Ionosondes -- A Correction
by
A. H. Shapley

At the INAG and URSI meetings in Lima, there was discussion of various plans for new ionosondes, including the monitoring digital ionosondes being developed by NOAA in the USA (INAG-21, p. 14). This development is proceeding along the lines given in a summary report which was described and distributed at the Lima meetings. One sentence in that report has been called into question. It was "No domestic commercial ionosondes are presently designed to meet the needs for monitoring or those of contemporary research and none are state-of-the-art in utilizing the great advances which have been made in digital signal processing and data analysis and display."

It has been pointed out that this statement is not accurate and in any case it was a very broad generalization which cannot be verified. The meaning of words "needs" and "state-of-the-art" depend on

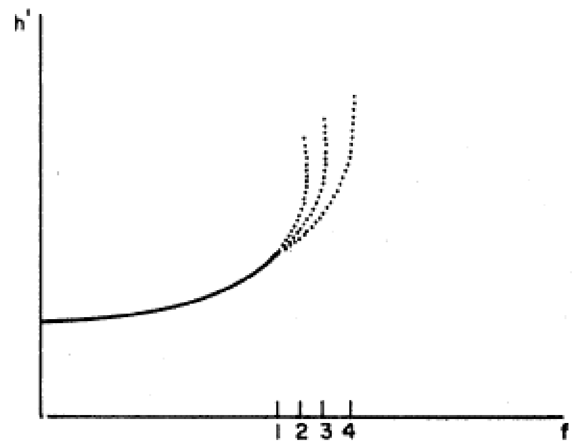


Fig. 2.2b Range of uncertainty when extra-polating to a critical frequency.

individual opinion and experience and this should have been made clear. To the extent that it is practical and consistent with the basic philosophy expressed in the report, the NOAA engineers plan to take account of the many advanced developments in ionosonde technique made in organizations in the USA and elsewhere. What should have been said was that not all of the NOAA criteria are met by any present domestic commercial ionosondes. We regret that an overbroad generalization was included in the report.

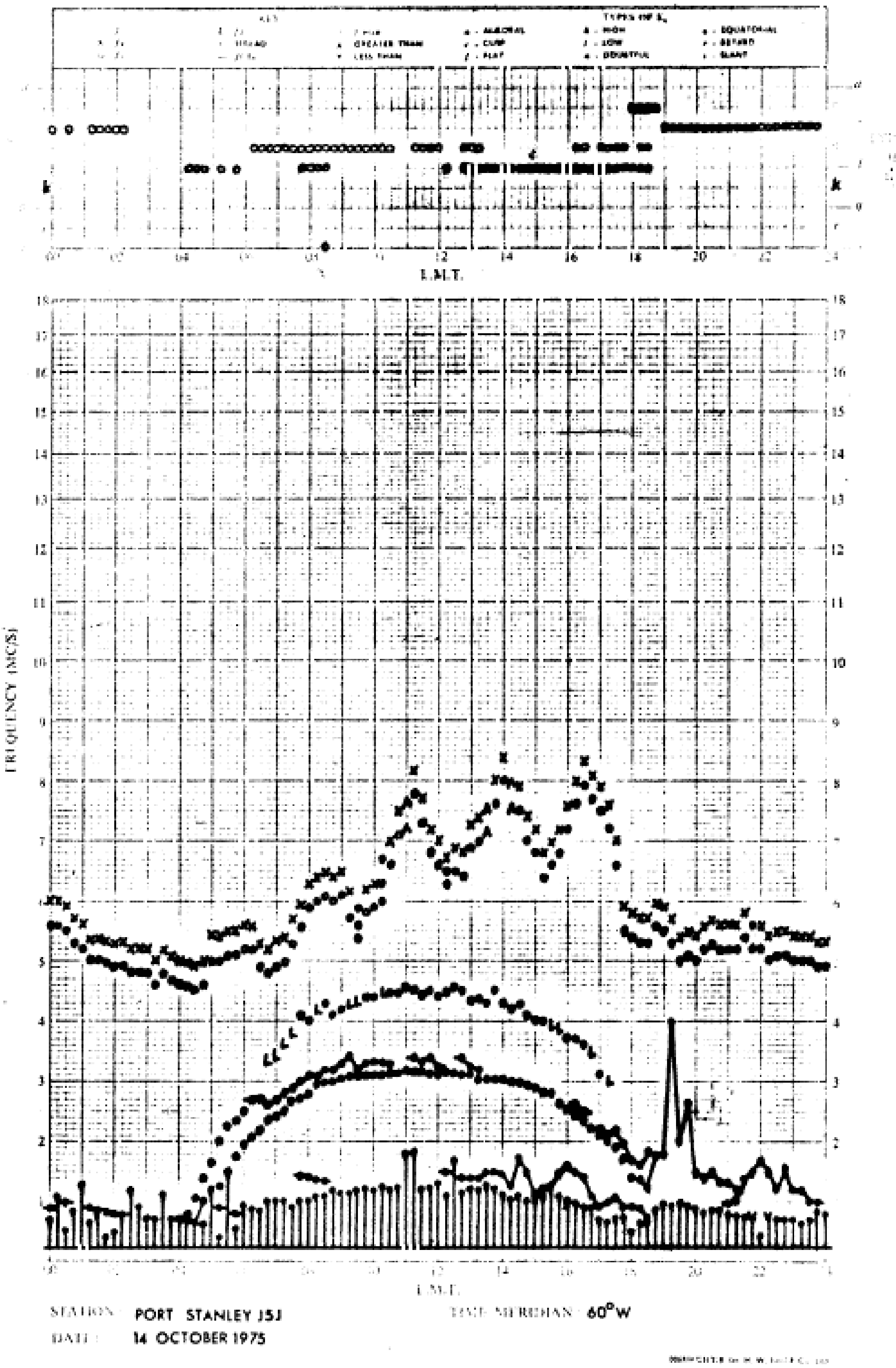
XII. Oscillations in the F—layer and Travelling Ionospheric Disturbances

There appears to be a growing interest in the effect of gravity waves on the ionosphere. Such waves can be generated both by active meteorological systems near the surface and by particle activity near the auroral zone. The former may play a significant role in transferring energy between the troposphere and the ionosphere. The majority of gravity wave phenomena at most latitudes last for between 20 and 40 minutes and can only be effectively studied using either continuous observations at constant frequencies or frequent ionosonde observations, e.g., every 5 or every 2 minutes. The attached f-plot shows the effect of a train of very large and long period disturbances observed at Port Stanley, (Lat. 51°42'S, Long. $57^0$52'W). Large perturbations of this type appear to be more common in the southern hemisphere than in the north, possibly because of the large expanse of ocean in the former hemisphere. The f-plot is slightly atypical in that perturbations of foF1 are not as clear as are usually seen and the sequential Es which usually accompanies such phenomena is not evident.

The perturbations of F1 values between 0530 and 0700 are probably associated with the F-region perturbation 0500 to 0630.

IONOSPHERIC DATA

f - PLOT



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XIII. Particle E Controversy

This is a contribution from A. S. Besprozvannaya:

"Your summarized case 'for and against' is very helpful and can serve a very good foundation for further discussions. It is my opinion that the proposals of the Arctic and Antarctic Research Institute at the Leningrad seminar were not completely understood at the time of the seminar, the situation has not changed since. The main idea (the rational core, as we call it) of our proposals was somehow missed, and as a result the discussion went in a somewhat wrong direction.

Perhaps we should better start from the very beginning: Here in tie Arctic and Antarctic Research Institute we have studied the current practice of the ionogramme reduction. This practice appeared to be quite diverse. We found that locally the operators record the night E and Esr differently than it is recommended in the Handbook (INAG Bull.-5, p.6-7). We understand that this is due not only to the uncertainty in the definition, given in the Handbook, but mostly to the physical origin of the phenomenon, which makes the distinguishing between the two traces difficult, they both are of corpuscular origin and their differences are more likely to be related to the geometry (dynamics of the auroral zone), than to the energy and sign of the charged particles. This can be determined by a special analysis which cannot be entrusted to the operators. That is why we tried to find a method which would give the scientists all necessary information and at the same time would be simple for an operator. Such a method was developed and proposed at the Leningrad seminar. Its essentials are as follows:

1. All traces of the sporadic ionization in the E layer which have group retardation should be classified as Es of r type, and when the complete blanketing occurs up to the critical frequency (Esr) it should be shown in the f-plot as empty circles. This would clearly show sporadic ionization centered overhead.

2. All cases of retardation on the low frequency end of the traces from the above layer due to signal delay in the sporadic thick layer In E region should be shown in the parameter fbEs on f-plot by an empty circle Instead of the usual thick circle (fbEs).

In this way any scientist using f-plot or two monthly tables (fbEs and types) can readily separate the classical night E without disturbing the temporal sequence of the event development.

We have indicated already the advantages of this method. It was tested at the soviet high latitudinal stations and the results were good. The observational data obtained at stations appeared to be quite compatible and useful for a scientific analysis. Thus the point of arguments is not the type of the table where we want to put night E, but the principally new approach to the reduction of the reflection from the sporadic ionization of the corpuscular nature which gives traces with group retardation."

XIV. Status of KLT-Rosen ionosonde LS-14

A brief note on the proposals for this ionosonde was given in INAG-20, p. 8-9. A full description was given at the U.I.I.M, The ionosonde Is based on the earlier Finnish development, INAG-7, p. 16. It is planned to give both conventional and a simple digitalized output at moderate cost, possibly about $40K, with special care given to make It reliable and servicing easy. It Is planned that the prototype will be deployed at Nurmlyarvi and the next built at Sodankyla. At present most units of the ionosonde have been thoroughly tested with the exception of the transmitter which Is still under development. Preliminary information is available from:

K.L.T., Linnankata 1, 5 F00160, Helsinki 16, Finland,
or Gosta Rosen Elektronik A/B
Karl sboclanagen 25,
Box 200034 5 161120,
Bronuna 20, Sweden.

XV. Notes from Stations Genoa-Monte Capellino: Torino.

Professor Bossolasco reports that a digisonde 128 supplied from the Lowell Institute for the station at Genoa will be moved within the next few months to Torino and operated under the auspices of the Instituto Elettrotecnico Nazionale 'Galileo Ferraris", Corso Massimo d'Azeglio 42, Torino. The old Genoa ionosonde built at Freiburg (Breisach) which has been operated at Genoa for the last twelve years will also be moved to Torino. Operation of the ionosonde will be directed by Professor
G. Rumi of the Instituto Elettrotecnico Nazionale and in collaboration with Professor G. E. Perona of the Politecnico di Torino. Professor Bossolasco, who is widely known for his ionospheric studies and in particular for the earliest correlations between winter anomaly of absorption and stratospheric phenomena, has recently retired from the University of Genoa and is now living in Torino. He will continue the editorship of the Rivista Italiana di Geofisica e Scienze Affini.

Canadian Stations

Of interest to network station operators might be the system which has evolved in Canada over the past five years. The Telecommunications Engineering Branch of the Department of Communications is responsible for the operation and maintenance of the Canadian ionospheric program. This operation is comprised of five field stations and a centralized data reduction center located in Ottawa. This Ottawa center also expedites processing of film and distribution of data.

Field Stations are located at St. John's, Newfoundland; Ottawa, Ontario; Kenora, Ontario; Churchill, Manitoba; and Resolute Bay in the northwest territories. During the past year the operation and maintenance of field stations have been decentralized and placed under the local administration of regional offices, the exception being Ottawa which continues to be the direct responsibility of the headquarters unit. All stations except St. John's have now been equipped with the Swedish Magnetic AB 1005W sounder. Storage scopes have also been installed for the accurate reading of values required hourly by users in the United States. This sounder is now also on hand at St. John's awaiting erection of antenna systems prior to installation.

Unprocessed ionograms are dispatched weekly by the field stations to the Ottawa Data Reduction Center where they are developed for scaling and reproduction purposes. All film is initially analyzed for quality control and stations are promptly advised if operator errors or equipment malfunctions are detected. On completion of scaling the film is edited and spliced into single rolls containing each individual station's ionograms for one month. These rolls are then duplicated with the originals being stored at the National Archives of Canada and the copies at World Data Center A at Boulder. In addition, at the end of the calendar year all f-plots are microfilmed for storage locally and at Boulder.

The actual scaling is accomplished by four scalers utilizing Canadian made instronics "Gradicon" graphic to digital converters, Ionograms are projected onto a table-top grid comprised of 10,000 increments in the X axis and 5,000 in the V axis. The scaler manipulates a cursor imbedded with a sensing coil to pinpoint the 12 required parameters. A servo system follows the movement of the cursor, generating positional information. An accessory keyboard allows the scaler to enter additional identifying, descriptive and qualifying information. The recording accessory records the output data in digital form on either 7 or 9 track magnetic tapes for computer processing.

Output of the daily tapes are concatenated onto a single 2400-ft back-up tape and it is the output of this tape that is fed into an IBM 360 computer. Output from this program is both in hard copy for perusal for maintaining quality control and into magnetic disk for storage. On completion of a month's data a second program is run which generates preliminary monthly summaries of hourly and median values. Operator and machine errors are rescaled at this stage and a final computer run made for publication purposes. A third program is now initiated resulting in the production of f-plots by a mechanical plotter. Also at this time card output of monthly summary values are generated for dispatch to World Data Center A.

Computer printouts of hourly and median values and f—plots are edited and then dispatched to printers for publication and on receipt the data books are mailed out to 73 user agencies both domestic and abroad, In addition, preliminary summary copies of hourly and median values are dispatched on a priority basis to agencies requesting this service. Under normal conditions regular data books are mailed out within 4 months of data being recorded at the field stations and the preliminary reports within 20 days. Recently these target dates have not been met due to staffing shortages. However, this shortcoming is now being overcome and a return to normality is expected in the near future.

XVI. Reports from World Data Centers

World Data Centre C1 for Ionosphere, Appleton Laboratory, Ditton Park, Slough SL3 9JX, England
Contributed by R. Smith

Requests from outside sources for ionospheric data during the period June 1974 to September 1975 inclusive are as follows:

Vertical incidence tables	5062	station parameter months
Vertical incidence data on punched cards	504	station parameter months
Al absorption tables	744	station parameter months
A2 absorption tables	45	station parameter months
Ionograms	87250	
Catalogues and reports	29	
Ionospheric predictions	29	months.

The very high total of ionograms is due mainly to requests from Dr. Becker, Lindau Harz, for two complete years of quarter-hourly ionograms from Argentine Islands.

World Data Center B2, Moscow, USSR.
Contributed by A.N-Sukhodolskaya

"Since the start of my work at WDC B2 in May 1970 the INAG Bulletins received by our Center (beginning from No. 4, July 1970) were being sent to the network of the Soviet ionospheric stations. INAG Bulletins No. 4-12 were not translated into Russian. I cannot say anything of the earlier three numbers.

We started translation from INAG Bulletin No. 13 as It was the first one that appeared after 'URSI Handbook...' (Second Edition, November 1972) and all the controversial questions of the Handbook, discussions as well as the amendments were published in the subsequent numbers of the Bulletin.

We have in our disposal 30 copies of Russian version of each INAG Bulletin; they are being sent to the network of the Soviet ionospheric stations, members of INAG Ors. N.V. Mednikova and A.S. Besprozvannaya and some persons concerned. We intend to look through the Bulletins No. 4-12 and if some portions appear to be still of importance we shall try to translate them into Russian too.

Please find enclosed the INAG Bulletins No. 15 and 16 translated Into Russian."

PRO FORMA INVOICE

SUBSCRIPTION, INAG BULLETIN, THREE YEARS beginning September 1975 (INAG No. 21) through August 1978, Issued three to four times each year under the auspices of the Ionospheric Network Advisory Group. Price includes postage.

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World Data Center A for Solar-Terrestrial Physics
NOAA
Boulder, Colorado 80302, USA

New Addresses

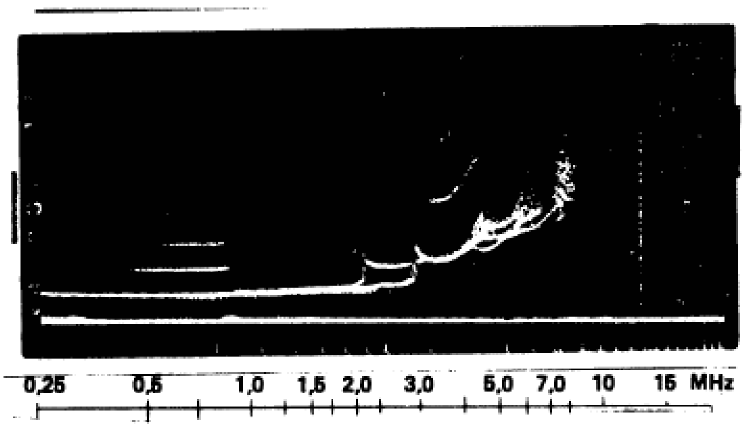
Dr. Victor I. Mesterman
Quintana 4271
1636 Olivos
Buenos Aires
Argentina

W. R. Piggott — Effective April 1, 1976
Chairman of INAG
British Antarctic Survey
Madingley Road
Cambridge CB3 OFT
England

XVII. Uncle Roy's Column

It is the custom for popular magazines and papers to have a column for readers' problems. INAG intends to follow this precedent. You are invited, therefore, to contribute to the Chairman ionograms on which you would like to comment. This is your column, if you do not send ionograms, they cannot be published, The ionogram shown below comes from Dumont d'Urville and shows an extreme case of low blanketing Es with foEs less than foE. This pattern is full of traps for the unwary operator. A close examination shows that the 2 E critical frequencies are in fact foE and fzE. fxE is missing. There is a dense Sporadic E below the normal E with fbEs equal to 0.8 MHz and hE is hidden by a lower z-mode trace. Both range and frequency spread are present, spread F types Q and F and fxI is determined by frequency spread - F.

E patterns which look superficially like this are very common at lower latitudes, where the higher frequency part of the trace is then a x-mode reflection. Thus an unskilled operator could easily misinterpret this ionogram when using temperate latitude experience.



fmin	h'E	foE	h'Es	foEs	fbEs	type Es
002 ES	115 EZ	270	095	008-G	008-G	1 4
h'F	**foF1**	**M3 000 F1**	**h'F2**	**foF2**	**M3 000 F2**	**fxl**
220	041-F		340-H	066 UF	F	077-F

XVIII. <u>Abnormally thin F-layer structure</u>

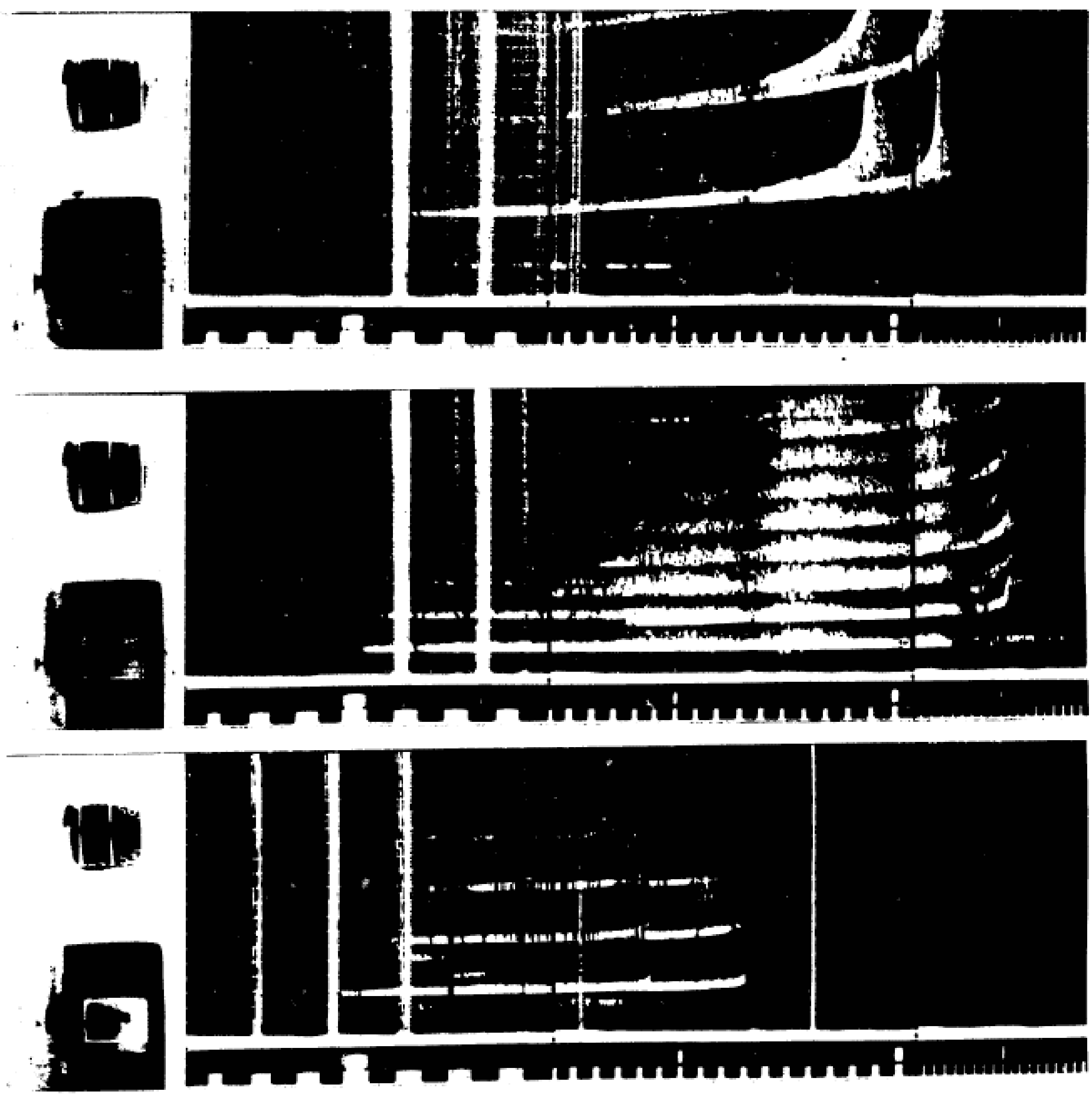
Large changes in the height and thickness of the F layer are well-known at high latitudes and a number of paired examples have been shown in the new Handbook Supplement. In this note, we show an extreme change in F-region shape and height seen at Port Stanley (51°42' S, 57°511' W, Magnetic Latitude 46°), September 3rd, 1962. This was in the middle of a period of medium magnetic disturbance with Kp reaching 5, Ap about 30 to 35. The first record at 0200 shows a normal, slightly disturbed F-region trace with critical frequency foF2 = 2.9 MHz, h’f = 315 (the ionogram runs from 0.6 MHz to 15 MHz with 0.1 MHz frequency marks); at 0400 the critical frequency has risen to about 3.8 MHz, h’f has fallen to 200 and there is much Es present, foEs 3.5 MHz, fbEs 1.7 MHz. An hour later, at 0500, h’f has fallen to 175 km, foF2 to 1.85 MHz and the retardation of the F trace is less than that normally seen for a normal E trace. Such phenomena appear to be very rare in temperate latitudes and it would be very interesting to hear whether similar changes have been observed at other stations. At the equinoxes it is normal for foF2 at Port Stanley to show a minimum about an hour before sunrise, i.e., in the case around 0500. In this sense a low thin layer showed a similar time variation to a normal layer at this time of day.

XIX. The International Geomagnetic Reference Field (IGRF)

The Grenoble Assembly of IAGA resolved that IGRF 1965 be replaced by IGRF 1975 and that IGRF 1975 be used until at least 1980.0. The new model consists of IGRF 1965 brought up to epoch 1975.0 for its main field coefficients plus new coefficients for secular change. The model is of internal coefficients up to and including the 8th order and degree. An explanatory note together with tables of the numerical values of the new coefficients will be submitted for publication in several geophysical journals of wide distribution.

XX. Location and Date of the 1976 Meeting of COSPAR

In 1974 the invitation from the U.S. National Academy of Sciences to hold the XIXth Plenary Meeting of COSPAR in 1976 was accepted by the Plenary. During the COSPAR meeting in Varna members of the Plenary were informed that the U.S. Academy proposed Philadelphia as the location and stated that the only possible



dates were the 6-19 June 1976.

Most unfortunately these dates coincide with the dates of the International Symposium on Solar-Terrestrial Physics (Boulder, Colorado, 7-18 June 1976) which is co-sponsored by COSPAR.

Continuation of XIV - KLT-Rosen Ionosonde IS-14

General Description

IS-14 is a vertical pulse sounder for 0.5-16 MHz frequency range to be used in measuring ionospheric backscatter properties. It has versatile programming possibilities and is well suited for both scientific and routine measurements. The measured ionogram is displayed by CRT display and registered on 35 mm film. Optional magnetic tape output in digital form is also available. IS-14 features automatic operation and low power requirements. The high reliability of IS-14 is due to its straightforward construction, digital frequency synthesizer, electronically tuned receiver and high quality components.

The output stage of transmitter is equipped with tubes having high pulse output capacity. The low level stages are fully solid state. The output impedance of transmitter is 600 ohm, balanced. The pulse output power is 5 kW nominal.

The receiver is a double superheterodyne, tuned electronically with Varicap diodes. Tuning takes place before every sounding pulse. A signal from the synthesizer with the same frequency as that of the transmittable pulse is utilized for tuning. The receiver gain is controlled by means of AGC system. The amplitude of the strongest echo will be constant in normal conditions of fading. The input section of the receiver is well protected against lightning and other overvoltages..

The RF signals required by the receiver and transmitter are generated by a digital synthesizer. All signals generated are phase-locked to a stable reference frequency. For high stability the reference frequency is generated by a quartz crystal oscillator and digital dividers. The output frequency of the synthesizer is determined by the sounding frequency from the control unit. The frequency sweep is logarithmic.

10 sounding pulses are transmitted at each sounding frequency. The integrator adds up the echoes corresponding to each height by means of 256 channels, one for each height interval. The average amplitude of the 10 echoes is displayed by a memory scope and a registration scope for photographing. The frequency and height markers, the time and station code are also displayed on both screens. Digital output is optional

The control section starts the sounding automatically according to the selected program. Two thumb wheel groups are available for selecting the corresponding start and stop frequencies. Sounding with discrete frequency can also be performed. The control section features a 24 hour digital clock with day, month and year indication. To eliminate clock errors during power failures the clock is battery powered. The sounding frequency is indicated with LED display to 1 kHz resolution.

IS—14 SPECIFICATIONS

FREQUENCY RANGE	0.5...16 MHz
PULSE POWER	5 kW
PULSE WIDTH	60 μs
PULSE FREQUENCY	50 Hz (30 Hz optional) line synchr.
FREQUENCIES PER OCTAVE	200 nominal
PULSES PER SPOT FREQUENCY	10
HEIGHT RANGE	70...1000 km
HEIGHT MARKERS	every 100 km
FREQUENCY MARKERS	every 1 MHz
SWEEP RATE	logarithmic, 40 s per octave
INTEGRATOR	digital, 256 channels (128x20 μs + 128x40 μs), linear or logarithmic
RECORDING	Panoramic display with time indication and station code 35 mm film
DIGITAL OUTPUT (OPTIONAL)	Frequency, height and digital echo amplitude in parallel form (TTL Levels)
POWER REQUIREMENT	approx. 600 VA, 220V AC, 50 Hz (60 Hz optional)
WEIGHT	approx. 200 kg
AMBIENT TEMPERATURE	0...40°C
RELATIVE HUMIDITY	20...90 %

USCOMM - ERL