IONOSONDE NETWORK ADVISORY GROUP (INAG)*

IONOSPHERIC STATION INFORMATION BULLETIN NO. 48**

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

** Prepared by R Haggard, Hermann Ohlthaver Institute for Aeronomy, Department of Physics and Electronics, Rhodes University, Grahamstown, 6140, South Africa.
Issued on behalf of INAG by World Data Center A for Solar Terrestrial Physics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80303, USA. This 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.

1. From the Chairman

by J A Gledhill

One of the exciting developments at the SCOSTEP International Symposium in Toulouse was the approval given by SCOSTEP to the proposed World Ionosphere Thermosphere Study (WITS). This comprehensive programme includes all aspects of ionospheric and thermospheric research, including satellites, rockets and ground-based and theoretical work. The ionosonde network will play a leading role in the monitoring of ionospheric behaviour during the study, which is planned to begin on I July 1987. I offered INAG's enthusiastic cooperation at the WITS meeting. All stations are encouraged to contribute data, through the World Data Centres and by direct correspondence.

A development that emerged just before the meeting was the unwelcome news that the New Zealand DSIR had decided to close all its ionosonde stations at the end of September 1986. While one appreciates that, in these days of financial stringency, it is essential to economize wherever possible, one wonders whether the full impact, both nationally and internationally, of such a step has been fully appreciated. At its Toulouse meeting, INAG resolved to send a telex pointing out some of the implications, and this has now been done, as is elaborated upon elsewhere in this Bulletin (page 8). All members who feel the loss of the New Zealand data are encouraged to write to: The Director, DSIR Geophysical Observatory, P 0 Box 2111, Christchurch, New Zealand, in support of the continuation of the New Zealand network. We understand that the decision could be reversed if there is enough support.

A different kind of problem was brought to our attention by Or Alberto Foppiano, who operates an ionosonde at King George Island, 62,2°S, 58,9°W. He has recently found that there is a similar ionosonde in operation at the Chinese base, "Great Wall", a few kilometres away. While this offers a unique opportunity to compare the results from two ionosondes very close to each other, one wonders if a little previous publicity of plans might not have avoided the duplication. INAG is always ready to advise the ionospheric community of proposed developments and to coordinate international opinion on such proposals. I once again draw the attention of the authorities to the desirability of putting forward plans for ionospheric work (or its discontinuation) in good time for the community to be advised of them and to react, thus giving the authorities concerned a more realistic basis for a final decision.

2. Julian Days

by H Rishbeth, Southampton University, UK

Occasionally I have seen tables of data in which "day numbers" (such as 112 for 22 April) are called "Julian Days". That is nonsense.

According to an astronomical textbook in my possession (J C Duncan, Astronomy, Harper, New York, 1946), Julian days are numbered in a cycle of 7980 years which began on BC 4713 January 1. The name was given in AD 1582 by its inventor, Joseph Scaliger, in honour of his father, and has nothing to do with the "Julian Calendar" attributed to Julius Caesar. In European longitudes, the JD number does not change during the night, which is convenient for many astronomical observations. JD numbers are independent of the vagaries of our calendar, and are therefore useful for long sequences of observations, such as records of variable star behaviour.

The JD numbers are now quite large; for example, JD 2446431 started at 12 UT on 1985 December 31. To produce more convenient numbers, a "modified Julian Day" has been defined as:

$$MJD = JD - 2400000.5$$

Thus MJD 0 began at 00 UT on 1858 November 17 (which happens to be about five years after the start of Carrington's Solar Rotation No. 1 on 1853 November 9) and MJD 46431 began at 00 UT on 1986 January 1. Routine ionospheric sounding at Slough began on MJD 26352. The principal users of MJD in the solar terrestrial physics community seem to be the "satellite orbit" people.

We should find a different name for the sequence of numbers that starts afresh each year. "Day number" seems simplest and best. And - while we are at it - can we agree on whether to start at 0 or 1? I am told both systems are used! My suggestion would be to run from 001 to 365 in normal years, 000 to 365 in leap years. Then at least the numbers are the same for most of the year, 060 (March 1) to 365 (December 31)! Anyone want to argue?

3. An Ionosphere Model for an IBM personal computer

The Penn State Mark III Ionospheric Model, which covers the E and F regions of the ionosphere is now available.

The Fortran program, written by Simon C-Ming Lee, can be run on an IBM XT personal computer. It uses the MSIS-83 thermospheric model, solar flux and absorption data from Hinteregger, Torr's updated values of the ten predominating reactions and the NTIA model for peak electron density. It runs interactively and asks for UT, latitude, longitude, solar 10.7 cm flux for the previous day, month, year and day number, Kp index, average 10.7 cm flux for the previous 3 months and Ap index.

It can handle 24 times at a single location or one time at up to eight locations, includes the mid latitude trough as a default instruction and will output either the output listing or the binary file for further use by other programs. 107 K of memory is needed to store the source program and 144 K for the executable machine code. It compiles in 40 minutes and takes 96 seconds to link, using Professional Fortran. Execution time for 24 hourly profiles for 44 altitudes is less than 5 minutes using a 8087 coprocessor.

For more details see Scientific Report PSU CSS, S, I 482 available from the Director (John S Nisbet) Of the Communications and Space Sciences Laboratory, Electrical Engineering Dept., The Pennsylvania State University, University Park, Pennsylvania 16802, USA .

4. Mode dependent arrival angle data

by A W V Poole, Rhodes University, S A

General

In the last INAG Bulletin our research into the development of an advanced chirp ionosonde was discussed. That article was illustrated with some digital data, reproduced here in Figure 1, representing a typical daytime ionogram at the mid latitude station of Grahamstown. Space did not allow a detailed discussion of the data then, so this short note can be viewed as a continuation article to fulfil that purpose.

Arrival angle anomalies

One feature of the data set which has drawn some enquiry can be seen in the North-South arrival angle data shown in Fig. 1(c). It will be noted that, especially in the region near 5.4 MHz, the arrival angles of the two polarisation modes appear to diverge, the O-ray apparently being reflected from about 100 further north than the X-ray. Under normal circumstances, one would expect the shape of the X mode arrival angle variation to be a rough replica of the O-mode, but shifted towards the higher frequency end by half the gyro-frequency in the fashion that is familiar in the group range plots. This phenomenon is, however, a feature of all our digital ionograms taken around this time, which strongly indicates some non-ionospheric origin. The explanation for the phenomenon is given here because it is interesting and may serve as a caution to others who are planning sites for digital ionosondes.

In common with other advanced ionosonde practice, the North-South arrival angle is measured by comparing the phases of the echo energy as measured on two spatially separated antennas lying in the plane of the meridian at the same height. In our case, these antennas were two simple electrically short dipoles. The arrival angle, which is defined as the angle that the downcoming ray makes with the vertical plane perpendicular to the line joining the antennas, is given by

$$\theta = \sin [(\phi_S - \phi_N) c/2\pi fD] \qquad (1)$$

where ϕ_S and ϕ_N are the phases measured on the South and North antennas respectively,
c is the speed of light, f the average sounding frequency and D the antenna separation.

Both the North and South dipoles were aligned with their elements in the plane of the meridian, so that normally their phases would refer only to the North South components of the elliptically polarised echo energy. Because of space limitations the large transmitting delta antenna was physically close to the South receive antenna. This delta was aligned roughly East-West, and positioned in such a way that energy absorbed from the East-West component of the field could be re-radiated and so "pull" the phase of the Southern antenna towards the East-West component. Since the East-West component will either lead or lag the North-South component according to the polarisation mode of the energy, the phases of signals on the Southern antenna will experience a mode dependent error, and will accordingly give mode-dependent deviations in the arrival angle as evaluated through equation (1). Further credibility is given to this diagnosis by noting that the peak deviation at 5.4 MHz implies some sort of resonance behaviour. A half wavelength at 5.4 MHz is 28 m which is almost exactly the length of the horizontal, East-West oriented element of the transmitting dipole.

Conclusions

We have learnt two lessons from this experience. Firstly, mode-dependent deviations in arrival angle data are diagnostic of unwanted coupling of energy from one orientation into sampled energy at right angles. Secondly, such coupling can be readily caused by large metallic structures near the elements of the receiving array, and such proximity should be avoided. It is worth noting that the measurement of polarisation ellipse orientations by means of advanced ionosondes will also be particularly sensitive to such coupling of energy.

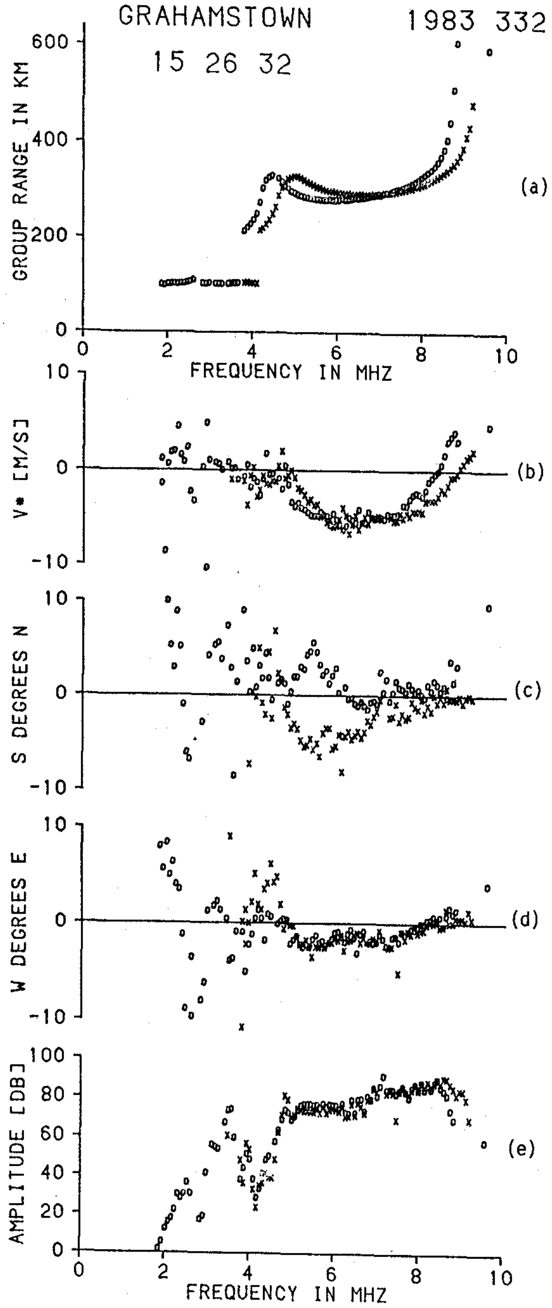


Fig. I A computer generated digital ionogram showing (a) group range, (b) Doppler velocity, (c) north-south arrival angle, (d) east-west arrival angle and (e) echo amplitude, against frequency.

5. The Structure of Slant Es

by A S Rodger and M Pinnock
British Antarctic Survey, UK.

With the advent of ionosondes capable of determining the angle of arrival of the received signals, hence the location of echoing regions of the ionosphere, some of the questions that are frequently raised in ionogram interpretation can be addressed. Examples of problems that could be studies include:-

1. Does Es-a really blanket ?
2. Should the inner edge of a trace showing spread-F be used to give foF2 ?
3. Is Es-r just Es-k seen at oblique incidence as has been proposed on numerous occasions ?
4. When a forked F-region trace occurs which spur should be used to scale foF2 ?

It is hoped to address each of these questions in a short series of articles for the INAG Bulletin by using examples of ionograms recorded by the Advanced Ionospheric Sounder, AIS, deployed at Halley, Antarctica. In this note, the spatial structure of slant Es will be discussed.

The AIS uses the coherent reflections of pulsed radiowaves in the frequency range 0.1 - 30 MHz in a similar manner to a conventional ionosonde. However, it provides a vector description for all the ionospheric echoes together with the time of flight of the pulse. From this information, the AIS can locate the echoing region in range, azimuth and elevation, a feature which will be used extensively here. To do this, the AIS uses a WERPOL array of receiving dipole antennas illustrated schematically in Fig. 1 and two receivers which are connected alternately to the north/south and east/west pairs under computer control. From the measured phase difference between the signals received at the two antennas in each pair, the location of the echoing region in the relevant plane can be determined as illustrated in Fig. 2. Comparison of the mean phase in the N/S direction with that in the E/W gives the polarisation of the received signal. A more sophisticated receiver array has now been deployed at Halley which has several significant advantages over that described above but the principles involved are the same. The new array is described by Jarvis and Dudeney (Radio Science, 21, 151-158, 1986).

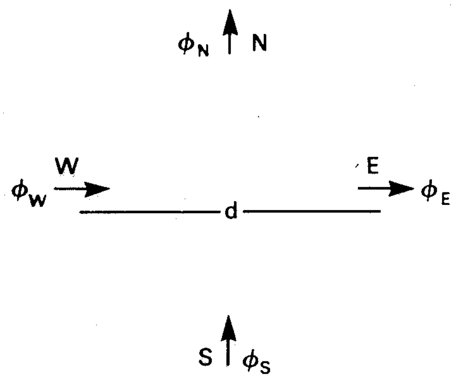


Fig. 1 Plan of the WERPOL receiving array of four dipoles aligned in the cardinal directions as shown. The phase, Φ, is measured at each antenna and d is the distance between the antennas

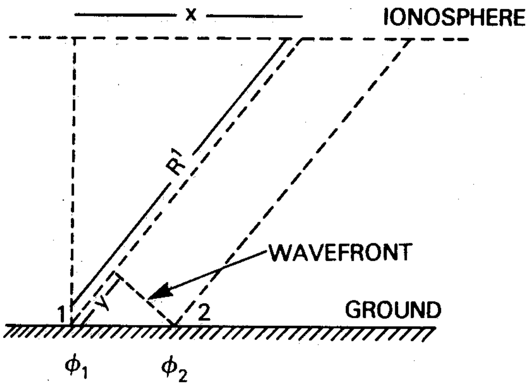


Fig. 2 Computation of the "skymap" position is determined by measuring the phase difference of the signals at antennas 1 and 2. $y = (\Phi_1-\Phi_2)\lambda/2\pi$, where λ is the wavelength of the sounding wave and $x = y R'/d$

Only when geomagnetic activity is very high will Halley, which is normally a sub-auroral observatory, record ionograms characteristic of the day-side auroral oval. Slant Es is one of these characteristics, at least during summer months. On 26 September 1982 the oval moved over Halley. On this occasion, the ionogram sequence shows many similarities to the event reported by M Pinnock (INAG Bulletin 38, 10-13). In particular, the ionograms show the ionospheric signature of the polar cleft (INAG Bulletin 42, 23-25) about magnetic noon, followed by a period of about 1 hour in which slant Es was observed. A typical ionogram from the sequence is illustrated in Fig. 3. This shows a normal E-layer between 2.0 and 4.0 MHz, with a slant Es layer rising steadily in virtual height from approximately 120 km at 4.0 MHz to about 245 km at 8.5 MHz. Between 5.0 and 5.4 MHz, there is present a weak F-region trace, rather characteristic in appearance to the many examples of lacuna that have been reported previously (See UAG - 23A, 53-57).

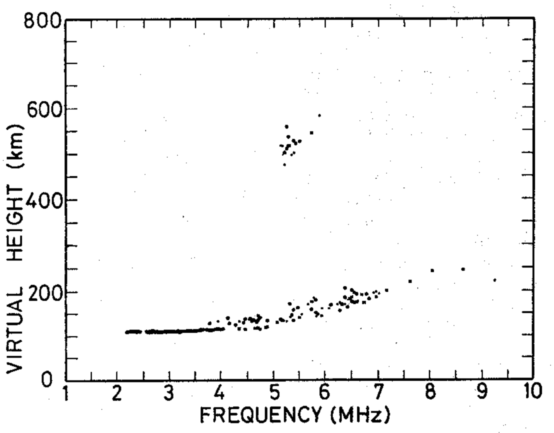


Fig. 3 Ionogram recorded at 1545 LT on 26 September 1982, showing normal E and F region traces together with a slant Es layer.

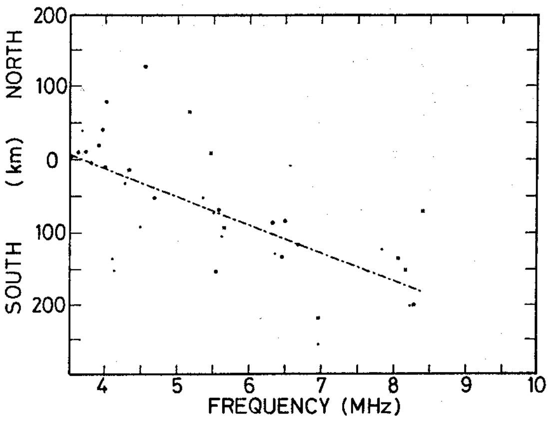


Fig. 4 North-south deviations of the echoes from the slant Es layer recorded at 1515 LT on 26 September 1982 at Halley. The broken line is the linear regression of the north-south deviation upon frequency.

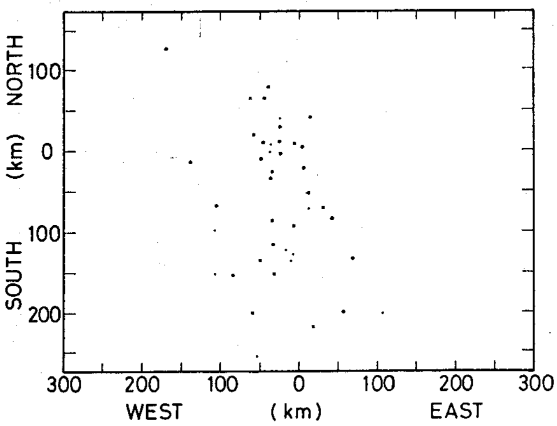


Fig. 5 Skymap location for the slant Es layer shown in Fig. 4.

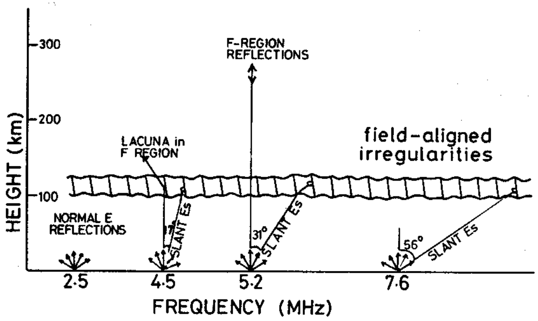


Fig. 6 Schematic diagram illustrating a proposed model for slant Es (after Olesen et al., 1986). See text for a more complete description

The geographic north-south deviations of the echoes forming a slant Es layer are shown in Fig. 4 as a function of frequency. This shows that the echoing regions are progressively further south (poleward) with increasing frequency. A linear regression of y upon x (north-south deviation upon frequency) has also been shown. The correlation coefficient of this link, determined using the 45 points, is 0.73 showing that it is statistically significant at better than 0.001% level. The equation of the line is:-

North-south deviation (km) = (-38±5)f(MHz) + (140±30)

The skymap (east-west, north-south deviations) locations of the Es-s layer, shown in Fig. 5, confirm that the echoing region is appreciably more spread in the meridional plane than in the zonal plane.

Olesen and others (Radio Science, 21, 127-1409 1986) have recently reviewed the properties of slant Es and lacuna using data obtained by a variety of techniques. They conclude that Es-s echoes result from the backscatter of the sounding radio waves from small scale ($\approx 10^1$s m) irregularities of electron concentration in the E-region. The irregularities are formed by plasma instability processes driven mainly by strong electric fields. The AIS data confirm their suggested backscatter mechanism as shown schematically in Fig. 6. For frequencies, f. less than the normal E-region plasma frequency, fo, the radio waves are returned from overhead. However, radio waves with f>fo can only be returned to the transmitting site if they are first refracted at oblique incidence in the normal E-layer to bring the rays perpendicular to the field-aligned irregularities. Since the refraction introduced decreases as f increases, the geometry of Fig. 6 indicates that the angle of take off and arrival (from the horizontal) must decrease with increasing f to fulfil this condition. Examples of the angles-of-arrival of the received signals are also shown in Fig. 6 for the 1545 LT ionogram shown in Fig. 3. The maximum horizontal range for an irregularity layer at 110 km and with a dip angle of 65° is 235 km which gives a maximum virtual height of 260 km. These maxima both increase as the tangent of the geomagnetic dip angle.

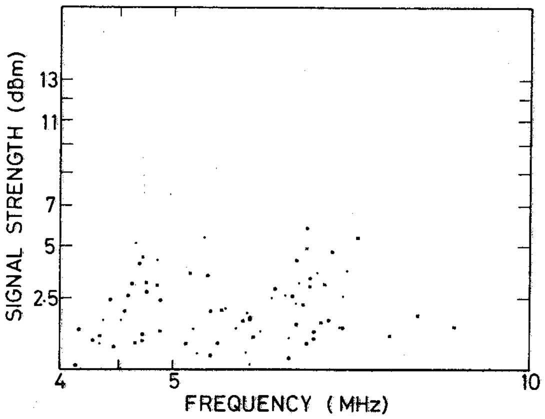


Fig. 7a Echo strength for the slant Es layer shown in Fig. 3.

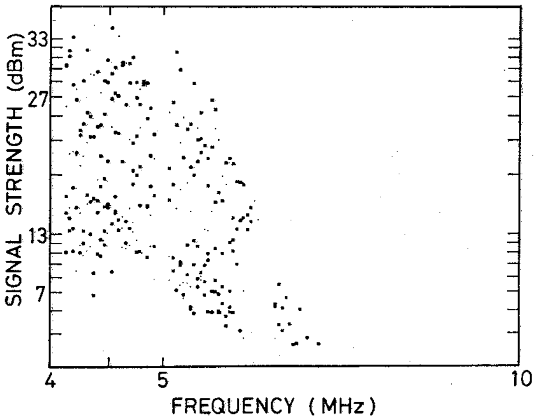


Fig. 7b Same as Fig. 7a, but for an auroral Es layer recorded at 1615 LT on 26 September 1982. Note that the vertical scales of Figures 7a and 7b and very different.

As Es-s echoes appear to be the result of backscatter from irregularities, whose sale size is ≈½ the wavelength of the sounding radio wave, then their amplitudes should be considerably less than those from large structures (eg Budden, 1985, The propagation of radio waves, Cambridge University Press, UK). Fig. 7a shows the signal strength as a function of frequency for the slant Es layer shown in Fig. 3 whilst Fig. 7b shows a similar type of plot for an auroral Es layer (Es-a) seen 30 minutes later than the E-layer. Comparison of these figures shows that the signal strengths are 10-20 dB greater for many of the echoes from the Es-a layer than those of the Es-s layer. The parameter, fmin, has not changed significantly between the two ionograms, thus the differences are not due to D-region absorption. However, we note that the Es-a layer has some echoes comparable in signal strength to those of the Es-s layer suggesting that small scale irregularities are also present.

The AIS observations can also shed light on the cause of lacuna. The slant Es event began at 1445 LT. For the first 45min., there was a partial lacuna of the F1 layer, giving a gap between the high frequency end of the normal E trace and fminF of ≈1 MHz. Towards the end of the event near-total lacuna (Fig. 3) occurs. In the 75min. that the event lasted, the F-region echoing location moved from being close to overhead to being 250km north (equatorward) of Halley, indicating that very significant tilts of the contours of equal ionisation must have been present. Under these conditions, some defocusing of the sounding radio waves could occur. Also, since the F-region echoes have propagated through the D-region at oblique incidence, their path lengths and hence attenuations are increased compared with echoes from vertical incidence. These factors combine to provide an explanation of the missing F-region traces. They are consistent with the ideas of Silvain and others (Planetary and Space Science, 26, 785-799, 1978), who did not have the benefit of direction of arrival information.

The INAG rules for scaling Es-s recommend that Es-s is not used to determine any Es parameter and that its presence is only indicated in the Es types column. The evidence provided by the AIS and discussed in this note, confirms that the Es-s layer is largely oblique. Thus its omission from the standard scaling tables is consistent with the INAG rule that oblique traces are neglected.

6. Report of the INAG Meeting, Toulouse, France

An INAG meeting was held on 8 July 1986 during the 26th COSPAR Plenary Meeting in Toulouse, France. The meeting was attended by 19 people representing 10 countries.

Participants:

T Kelly	Australia
R Thompson	Australia
P Triska	Czechoslovakia
A Ranta	Finland
H Ranta	Finland

R Hanbaba	France
H Sizun	France
P Vila	France
V Kakane	Ghana
T Ondoh	Japan
J Oyinloye	Nigeria
J Gledhill (Chairman)	South Africa
R Haggard (Secretary)	South Africa
G Heymann	South Africa
H Rishbeth	United Kingdom
A Rodger	United Kingdom
J Allen	United States of America
B Reinisch	United States of America
E Szuszczewicz	United States of America

The Chairman welcomed all present and apologized for the unfortunate clash of the INAG and IRI meetings, which meant that some participants had to leave early to present papers in the IRI session. The minutes of the Prague INAG meeting having been circulated, were taken as read, with no matters arising from them.

1. Chairman's Report

The Chairman reported that he had been corresponding with several organisations and people in an effort to solve the obsolete equipmental and spares problems at present being experienced by the Huancayo Ionosphere Observatory, Peru.

He further reported on the unfortunate situation on King George Island where two ionosondes had been installed 3 km apart, one by Chile and the other by China. He added, that if nations would inform INAG of proposed installations it may avoid a recurrence of the present situation. In reply to a question from the floor re mutual interference of the 2 closely sited ionosondes he confirmed that interference traces are observed on the Chilean records.

The Chairman noted that since the last INAG meeting, INAG Bulletins 46 and 47 had been circulated and that INAG Bulletin 48 should be in the mail during the month of August.

2. Use of UT in reporting ionospheric data

Our Publication Secretary, Ray Conkright, had requested INAG to stress the importance of using UT when reporting ionospheric data to World Data Centres, a view our Chairman fully endorsed after his experience when working with data for the SCAR Cooperative Data Study period where he found some stations using UT and others local time.

Alan Rodger expressed the view that there would be no overwhelming advantages in adopting the proposed resolution except much confusion and felt that f plots in UT would not be easy to follow and would look very strange indeed, especially if the station was far away from the Greenwich meridian. Further, he felt we would have to redefine the day and month in terms of UT and added that geophysicists and aeronomers tended to prefer UT whilst the radio propagation people preferred LT which is more realistic for their purposes.

The Radio Research Laboratory of Tokyo, Japan tabled a memorandum stating that it used LT and that for the analysis of ionospheric data, local time has more advantages over UT and hence Japan would continue to use LT with a clear statement of the relationships between LT and UT at the station concerned.

Bodo Reinisch informed INAG that they had unilaterally made a decision about 2 years ago that all their new sounders would use UT and commented that it was up to the user what time he wished to use when plotting data. Further, he pleaded for the community to make a firm decision as to what time to use, since only chaos would develop if different stations used different time bases - especially if individual stations changed time bases.

Richard Thompson informed INAG that the Australian Ionospheric Prediction Service stations are all using UT as from 1st July and that the records reflect the fact that the time display is different from previous months. He further emphasized the fact that all data should be useful and easy to understand, hence their decision to use only UT. Terry Kelly suggested that perhaps both times, viz UT and LT, could be displayed on ionograms.

Joe Allen confirmed that Ray Conkright's suggestion is now policy of the WDC-A in that networking is a very important factor and when studying progressive phenomena the many different time systems are eliminated if we only use UT instead of LT.

Henry Rishbeth emphasised the fact that since machines and computers are getting more sophisticated we should make the machines work for the researchers and hence the chosen time is of little relevance except that if a change is made it must remain thus to alleviate any confusion, but stressed the need for a uniform time system to be used by the whole community, although he felt that INAG should not pressurize the community to work in a set time.

It was decided that people should prepare documents for the URSI INAG meeting in Tel Aviv in August 1987 for a final decision. The general impression obtained was that the majority favoured the use of UT.

3. IRI Recommendations

The meeting felt that the desired accuracy (INAG 47 p.2) could not be obtained from normal ionosondes and INAG decided merely to draw people's attention to the request without encouraging stations to meet the desired accuracy since this could drastically increase the time required to scale a particular ionogram.

4. Oblique incidence ionograms

Several people felt that this topic should be fully investigated since oblique incidence ionograms offer a promising field of research which does not need new ionosonde installations although the interpretation of oblique ionograms is difficult. The meeting was informed that the Japanese had developed oblique incidence ionosondes in the interim (see page 12). Bodo Reinisch stressed the importance of oblique incidence ionogram input for the use of modeling and forecasting for communications purposes. Terry Kelly informed INAG that Kel Aerospace were also developing an ionosonde which would extend to 32 MHz and expressed the hope that they would produce an oblique incidence facility within the next few years. Alan Rodger pointed out that oblique incidence data were not only important from a communications point of view but that WITS would require oblique incidence data as well for its global study of the ionsophere.

5. Ionosondes for the 1990's

Henry Rishbeth reported that 11 groups had submitted completed questionnaires, as appeared in INAG Bulletin 46, covering 29 ionosondes - which is approximately a quarter of worldwide ionosondes; many others had submitted details to MONSEE in reply to an earlier questionnaire. A heartening aspect of his report was that most stations would continue to operate regularly, certainly for a number of years to come. The most common recording medium is still photographic film, whilst some also use magnetic tape. Most people expressed an interest in phase information and some in real height whilst a lesser number expressed interest in oblique incidence work. One of the disturbing features of the questionnaire was the fact that a lot of stations do not contribute data to the World Data Centres since this is beyond their financial means; hence there are a lot more data available than there appear to be. Henry Rishbeth strongly recommended that INAG should have a complete catalogue of stations that are operating and should make this available to the World Data Centres and the INAG community.

6. Station News

Bodo Reinisch reported that currently there were 8 Digisonde 256 stations with autoscaling operating at the following locations: Goose Bay, Argentina, Fort Monmouth, Thule, Slough, Dourbes, Beijing and La Trobe - Melbourne, whilst three more will become operational during 1986, viz. Bermuda, Wallops Island and Pakistan. During 1987/8 a further 18 Digisonde 256's will be installed, of which 16 will be for the US Air Weather Service with tentative locations distributed in Korea, Guam, Hawaii, Alaska, Continental US, Azores, England, Italy, Turkey and Australia. Two ionosondes will be deployed in China (CRIRP) with one being installed on Hainan Island. Hence, by the end of 1988 there will be 30 fully automatic Digisonde stations operational.

New Zealand Network

INAG received a letter from Phil Wilkinson informing us of the unfortunate decision by the New Zealand Authorities to close down all ionosonde stations as of October 1, 1986. A telex message from David Cole to the Antarctic Division in New Zealand was read to the meeting and after some discussion it was decided to send the following resolution to the New Zealand Authorities.

> "At the meeting of the Ionosonde Network Advisory Group (INAG) held on July 12, 1986 in Toulouse, France, the following resolution was unanimously adopted.
>
> The INAG meeting at Toulouse heard with dismay of the decision to discontinue ionosonde operation at New Zealand stations as of October 1, 1986. In particular INAG received no warning of the proposal to close these stations, which would have enabled it to consult its members on the effects of the decision. INAG has always encouraged the organisations operating ionosonde networks to inform it in good time of any proposals that may affect the availability of data for international scientific and communications purposes. It is hoped that it is still possible to modify the decision that appears to have been taken. In the light of information and support from users of New Zealand data, INAG supports strongly the sentiments expressed by David Cole, of the Australian Ionospheric Prediction Service and INAG also points out:-
>
> (i) that the World-wide Ionosphere-Thermosphere Study (WITS) project approved by SCOSTEP at its Toulouse meeting requires the largest possible number of participating ionospheric stations; the loss of the New Zealand stations would seriously impair the effectiveness of this world programme,
>
> (ii) data from Scott Base are currently being used in an International Coordinated Study of the Antarctic Upper Atmosphere and will be required in future studies of a similar kind,
>
> (iii) data from New Zealand stations form an essential part of the input to concurrent project SUNDIAL.
>
> INAG earnestly requests the authorities responsible not to close the stations concerned until a survey can be made of the consequences in many fields. If it should not be possible to keep all stations going then INAG pleads for the retention of at least Scott base and Christchurch, which is an International IF2 station."

Huancayo

The attention of INAG was once more drawn to the plight of the Huancayo Observatory. It was noted that although the rest of the world uses its data, the Peruvians themselves do not use ionospheric data. Members of INAG, and others, are asked to send copies of publications using data from Huancayo to Dr R Woodman, Inst. Geofisico Del, Peru, Apartado 3747, Lima, Peru in the hope of influencing a decision to help the station.

Sanae

Since the last INAG Bulletin it has been decided to keep Sanae going and to try to establish an additional Observatory on Gough Island. This would involve the cessation of ionosonde operation at Grahamstown if another ionosonde does not become available.

Nigerian Stations

Two IPS 42 ionosondes are installed at Ilorin and lbadan. Unfortunately the lack of funding has curtailed the operation of these ionosondes until such time that money is available for spares and film.

Japan

Recently an ionospheric sounder was developed in Japan for approximately US $ 10 000 which can be used as a vertical incidence as well as an oblique incidence sounder (see page 12).

China

It was reported that the Chinese network will soon contribute to the World Data Centres and are also interested in joining INAG.

7. Real Time Acquisition and Exchange of Data

Terry Kelly expressed concern about the problems that could arise when attempting real time acquisition and exchange of data between stations in separate countries. He had hoped that INAG would arrange a workshop to discuss fully the macro- and micro problems involved and possible foreseeable problems. Thereafter INAG could issue some guidelines for the future.

He further stressed the fact that there is zero cooperation between ionosonde manufacturers on a local as well as world-wide level and expressed the opinion that it would be nice if the different ionosondes that are being manufactured could communicate with each other.

Bodo Reinisch commented that it was impossible to tie up different ionosondes since it is difficult enough to tie up similar ionosondes, for example, the Digisonde 256 ionosondes are compatible but the Digisonde 256 and 128 ionosondes are incompatible.

The networking of data and data archiving is a good idea but again conceptionally very difficult. Joe Allen mentioned that an analogous situation exists between incoherent scatter radars. They tried for several years to reach consensus on a common radar data format, but have only managed to find a common format for some of the parameters.

Ed Szuszczewicz spoke briefly about the SUNDIAL Campaign in relation to real time data acquisition. During the SUNDIAL Campaign 70 stations were involved in a wonderful spirit of cooperation concerning data format and data archiving as agreed upon prior to the campaign. In fact several people even changed their style of reporting data. Real time data acquisition was not found to be necessary except perhaps during rocket launches and he added that perhaps only HF communicators needed real time data.

8. General

Terry Kelly distributed copies of the Kel Aerospace Time Series Graph, TIDPLOT, stating that the use of these could become a useful research tool for people operating even very simple ionosondes and that the separation between ordinary and extra-ordinary ray is very easily achieved (see page 11).

Joe Allen showed the Boulder ionograms for the beginning of February during the eighth largest magnetic storm since 1952, commenting that it completely disrupted HF communications and satellite communications.

The planning edition of the International Geophysical Calendar for 1987 was brought to the attention of those present for comment and suggestions, which could be communicated directly to Joe Allen.

The Chairman also informed the meeting that the WITS programme was looking for proposals for regional studies or special interest projects and that WITS would ultimately be absorbed into STEP.

The meeting urged the Chairman to try and arrange an INAG meeting during the IUGG XIX General Assembly in Vancouver before the INAG meeting scheduled to be held in Tel Aviv during the URSI General Assembly.

There being no other business, the Chairman thanked all those present and declared the meeting closed at 1645. (UT + 2h)!

7. The Terrestrial Consequences of the Solar Flare of 1956 February 23

by H Rishbeth, Southampton University, UK

The major solar flares of 1986 February 4 - 7 and the ensuing solar-terrestrial disturbances and geomagnetic storms reminded me of a remarkable event thirty years earlier which, too, began with a large end-of cycle flare in a relatively low heliographic latitude. At 0334 UT on 1956 February 23, a major solar flare was observed at the Kodaikanal Solar Observatory in India (1). Throughout the sunlit hemisphere the flare caused a major sudden ionospheric disturbance (SID), besides other solar flare-associated phenomena and a massive cosmic ray increase. It was, however, the ionospheric effect in the nighttime hemisphere which aroused the greatest interest in the ionospheric physics community, and eventually led to the discovery of "polar cap absorption" or PCA (2). Possible F2-layer effects were reported at Okinawa and Singapore (3, 4) though the detection of such short lived phenomena on intermittent ionograms - even quarter-hourly ones - has always been problematical. The subsequent magnetic storm (SSC 0307 on 1956 February 25) attained Kp 8+.

A recent literature search was carried out for me by Miss Cathy Costain of the Library, Rutherford Appleton Laboratory. This search, based principally on the date of the event, yielded 42 references published in the open literature between 1956 and 1960. About thirty of these dealt with cosmic rays, ten with ionospheric phenomena, and several with other aspects (some papers deal with more than one subject). There was a suggestion (later disproved) that the event affected the earth's rotation (5, 6).

My own memory of the event is vivid. At the time I was working at the Fleurs Observatory of the Radiophysics Laboratory, Sydney. We had just finished the routine midday re-pointing and calibration of the Mills Cross radio telescope, which was surveying galactic and extragalactic emission at 85.5 MHz. The telescope went on the air at 0330 UT. Suddenly the pen-recorder shot off scale. On the assumption that the receiver was misbehaving, recording was stopped and the record thrown away (it was later retrieved from the waste paper basket). The Sydney solar observers were unlucky that day: all the Radiophysics Laboratory's solar radio telescopes were down for maintenance and, because of the typical "summer monsoon" weather, the Sun was not sighted that day or for several days previously. The only Sydney instrument that recorded the radio emission associated with the flare was the 19.6 MHz Jupiter interferometer, which had latterly been built to monitor the newly discovered Jovian decametric emission.

I am planning to write a short Research Note of historical nature, mainly about what the 1956 February 23 flare taught us about the ionosphere. Does anyone else have anything to contribute, either personal memories of the event or opinions on what we learnt from it?

References

1. See for example Indian J. Meteorol. Geophys. 8, 7 (1957).

2. D K Bailey, JGR 62, 431 (1957).

3. A H Shapley and R W Knecht, Trans. IRE AP-5, 326 (1957).

4. C M Minnis and G H Bazzard, Nature 181, 690 (1958).

5. A Danjon, "July 1959 Events Symposium", p. 5, Helsinki (1960).

6. C J A Penny, "July 1959 Events Symposium", p. 7, Helsinki (1960).

8. IAGA Resolution and Recommendation

At the Fifth Scientific Assembly of IAGA, which took place in Prague, Czechoslovakia, from 5 to 17 August 1985, nine Resolutions were adopted by the assembly. Resolution 6 is reproduced here as being of general interest to the INAG community.

"IAGA, noting the importance of Antarctica as a unique area in which to observe a great variety of geophysical phenomena, which are essential for the understanding of the physics of atmospheric and near Earth space processes, and recognizing its particular suitability for international scientific cooperation, recommends that funding agencies continue to support existing experiments in Antarctica and implement new installations of equipment for studying the ionosphere, thermosphere, mesosphere, stratosphere and solid earth in these regions by means of ground based instruments, rockets and low altitude orbiting spacecraft.

The following material was reviewed in 1985 by spokesmen of IAGA, WMO and URSI as suitable for coordinated geophysical programmes in 1986.

Ionospheric Phenomena

Special attention is continuing on particular events which cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is possible to analyse the detailed data only for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the vertical incidence (VI) sounding programme, the summary recommendations are: (a) all stations should make soundings at least every quarter hour. Stations which normally record at every quarter should, if possible, record more frequently on RWDs, particularly at high latitudes; (b) all stations are encouraged to make f-plots on RWDs; f-plots should be made for high latitude stations, and for so-called "representative 11 stations at lower latitudes for all days (i.e. including RWDs and WGIs). (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate- and low latitude stations); (c) copies of hourly ionograms with appropriate scales for QWDs are to be sent to WDCs; (d) stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under Airglow and Aurora Phenomena.

For the incoherent scatter observation programme, every effort should be made to obtain measurements at least on the Incoherent Scatter Coordinated Observation Days, and intensive series should be attempted whenever possible in WGIs or the Airglow and Aurora Periods. The need for collateral VI observations with not more than quarter-hourly spacing at least during all observation periods is stressed. Or V Wickwar (SRI International, 333 Ravenswood Ave., Menlo Park, CA 94025, USA), URSI Working Group G/H.1, is coordinating special programmes.

For the ionospheric drift or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including RWDs.

> For travelling ionosphere disturbances propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected PRWD and RWD.
>
> For the ionospheric absorption programme half-hourly observations are made at least on all RWDs and half hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally low absorption (approximately October - March, Northern Hemisphere; April - September, Southern Hemisphere).
>
> For back-scatter and forward-scatter programmes, observations should be made and analysed on all RWDs at least.
>
> For synoptic observations of mesospheric (D-region) electron densities, several groups have agreed on using the RGD for the hours around noon.
>
> For ELF noise measurement involving the Earth ionosphere cavity resonances any special effort should be concentrated during the WGIs.
>
> It is recommended that more intensive observations in all programmes be considered on days of unusual meteor activity.
>
> ### Airglow and Aurora Phenomena
>
> Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanisms of inter alia, low latitude aurora, the coordinated use for all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately one week duration centred on the New Moon are proposed for high resolution of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter."

9. IPS Technical Reports

INAG has recently received two IPS Radio and Space Services Technical Reports which are of interest to the INAG community. Each report consists of 33 pages, so we shall only reproduce the abstracts.

IPS TR-86-02: A Review of Daily Ionospheric Indices:
Current Status and Recent Innovations, by P J Wilkinson.

Monthly ionospheric indices, based on monthly empirical F2 region models, have been used for some time to support HF service planning. Using the monthly framework, two daily ionospheric indices have now been developed which will allow global monthly models to be used on a daily basis.

One index, the daily ionospheric index, gives an estimate of the solar activity effects in the F2 region and is similar to the monthly ionospheric index. When averaged over a month, the daily ionospheric index will tend to the monthly index value - the T index.

The second index, called the disturbance index, is new. It gives a subjective estimate of how reliable a particular daily ionospheric index is when applied to the monthly predictions.

These two indices will make it possible to identify those 70% of the days in the year when the daily index is applicable, allowing it to be used globally with confidence.

IPS TR-86-03: Improved Empirical World Maps of FoF2.
1. The Method, by M W Fox and L F McNamara.

The IPS global maps of foF2, which form the basis of HF communications predictions, are being updated. All existing monthly median data (more than 45 000 station-months) are included in this process. This report describes the analysis of data from the various sources and the numerical techniques adopted for the derivation of new world maps.

Anyone interested in any of the above reports can obtain copies from IPS Radio and Space Services, P 0 Box 702, Darlinghurst, NSW 2010, Australia.

10. TIDPLOT

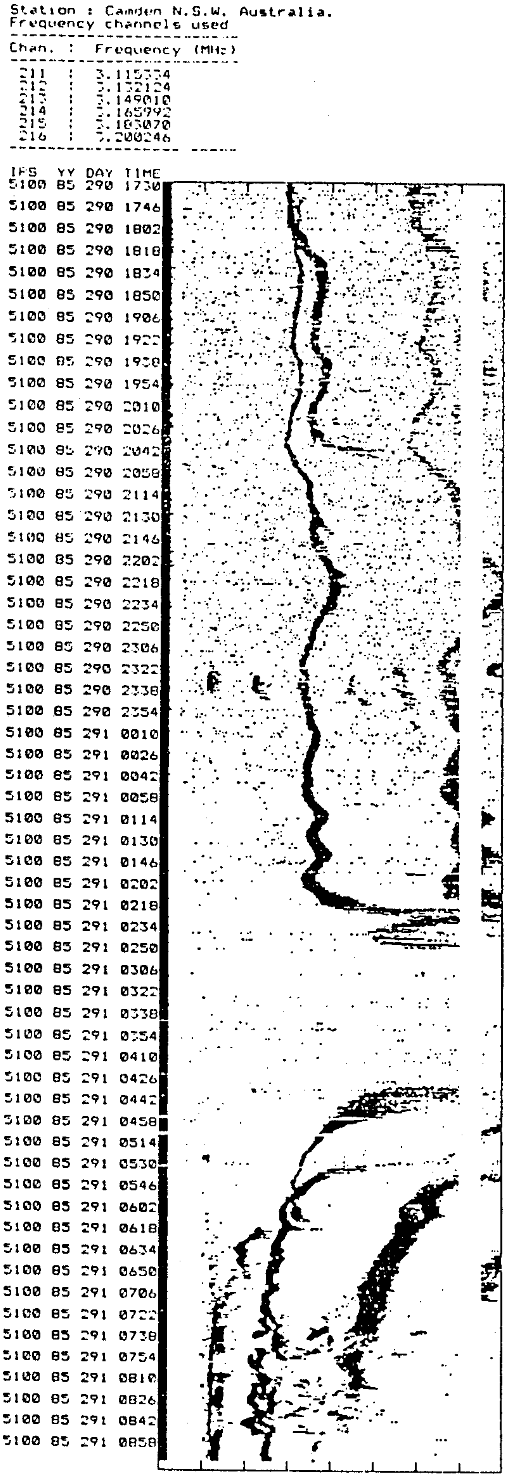
System Operation

A series of up to 1000 ionograms are taken on an IPS-42/DBD-43 digital ionosonde system. The ionograms may be as often as one every 40 seconds and they represent a 12s scan of all 576 frequencies. The magnetic tape in the DBD-43 is then re-played, using a special data-transfer routine that communicates with a microcomputer of the IBM PC-XT type. The IBM PC-XT simultaneously runs a program called 'TIDPLOT' which accepts the data from the DBD-43 generated ASCII data file on a standard IBM-format disk and prints the accompanying graph on an Epson FX-105 printer.

The frequencies selected may be a single frequency or a range of frequencies. In this example, the frequency range specified was 3.1 to 3.2 MHz. The IPS-42 channel numbers actually used are shown in the adjacent table. The height range is identical to that of the IPS-42, i.e. 0 to 800 km intervals. The time displayed is of the form YY DDD HHMM where YY is the year, DDD is the day, HH is the hour and MM is the minute. The time information is printed once for each sixteen ionograms and corresponds to the time that the eighth sounding of the series took place.

The blank area above the 700 km graticule is due to the IPS-42 blanking the display in order to insert the identification block.

More information may be obtained from Kel Aerospace, 12 Brennan Close, Asquith, NSW 2078, Australia.



```
Station : Camden N.S.W. Australia.
Frequency channels used
-------------------------------
Chan. :  Frequency (MHz)
-------------------------------
 211  :   3.115334
 212  :   3.132124
 213  :   3.149010
 214  :   3.165992
 215  :   3.183070
 216  :   3.200246
-------------------------- ------

IPS  YY DAY TIME
5100 85 290 1730
5100 85 290 1746
5100 85 290 1802
5100 85 290 1818
5100 85 290 1834
5100 85 290 1850
5100 85 290 1906
5100 85 290 1922
5100 85 290 1938
5100 85 290 1954
5100 85 290 2010
5100 85 290 2026
5100 85 290 2042
5100 85 290 2058
5100 85 290 2114
5100 85 290 2130
5100 85 290 2146
5100 85 290 2202
5100 85 290 2218
5100 85 290 2234
5100 85 290 2250
5100 85 290 2306
5100 85 290 2322
5100 85 290 2338
5100 85 290 2354
5100 85 291 0010
5100 85 291 0026
5100 85 291 0042
5100 85 291 0058
5100 85 291 0114
5100 85 291 0130
5100 85 291 0146
5100 85 291 0202
5100 85 291 0218
5100 85 291 0234
5100 85 291 0250
5100 85 291 0306
5100 85 291 0322
5100 85 291 0338
5100 85 291 0354
5100 85 291 0410
5100 85 291 0426
5100 85 291 0442
5100 85 291 0458
5100 85 291 0514
5100 85 291 0530
5100 85 291 0546
5100 85 291 0602
5100 85 291 0618
5100 85 291 0634
5100 85 291 0650
5100 85 291 0706
5100 85 291 0722
5100 85 291 0738
5100 85 291 0754
5100 85 291 0810
5100 85 291 0826
5100 85 291 0842
5100 85 291 0858
```

11. Ionospheric Sounding in Japan

The Japanese have recently developed an ionospheric sounder which can be used not only for vertical incidence but also for oblique incidence. The ionospheric network in Japan using the newly developed sounders consists of five identically specified sounders with the starting times staggered according to a prearranged schedule. Consequently, swept frequency reception can be made between the stations as well as other common users whose receivers can be synchronized with the network's emission frequencies, thereby facilitating the immediate information of the usable frequency range for HF communications.

In order to provide the necessary frequencies and timing signals for the oblique incidence sounder, a rubidium frequency standard is employed and its output signals are fed to a frequency synthesizer and a signal controller, thereafter the swept-frequency, the synchronizing signal and other signals are supplied to the regular vertical incidence sounder instead of using its conventional variable frequency oscillator. The pulsed swept-frequency from 1 to 25 MHz produced by the frequency converter in the regular vertical sounder are emitted by a delta-shaped antenna. Accordingly, the time and frequencies in the sounder are kept and controlled with an accuracy of the rubidium frequency standard.

For the convenience of common users a small, lightweight portable receiver has been developed in Japan as well, so that the common users can receive the oblique incidence swept-frequency signals from the main network. From an economic viewpoint, these receivers employ the usual quartz oscillator and simplified frequency synthesizer.

The specifications of the newly developed vertical/oblique incidence ionosondes are as follows:

Transmitting frequency	1 - 25 MHz
Frequency changing rate	20 kHz/step (20 ms)
Pulse repetition frequency	50 Hz
Transmitting pulse width	80 μs
Transmitting power	10 kW peak
Starting time of operation	Within 1 ms according to the schedule
Transmitting antenna	Delta-shaped antenna - 45 m high

Figures 1 and 2 show examples of oblique incidence ionograms obtained by using (a) the regular sounder receiver with a delta-shaped antenna and (b) the small, lightweight portable receiver with simple wire antenna on the path Yamagawa-Kokubunji (960 km).

Further information can be obtained from the Radio Research Laboratory, Koganei-shi, Tokyo 184, Japan.

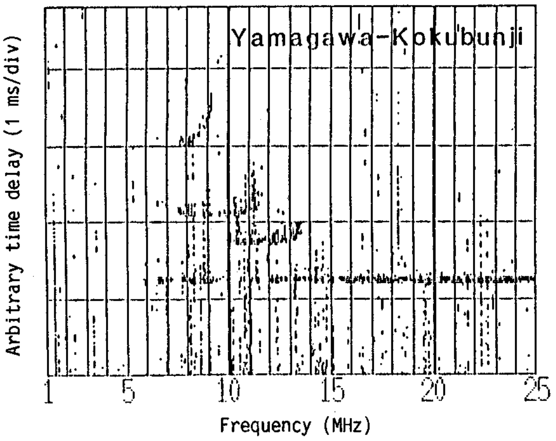


Fig. 1 An example of oblique ionogram obtained by using regular sounder receiver with delta-shaped antenna.

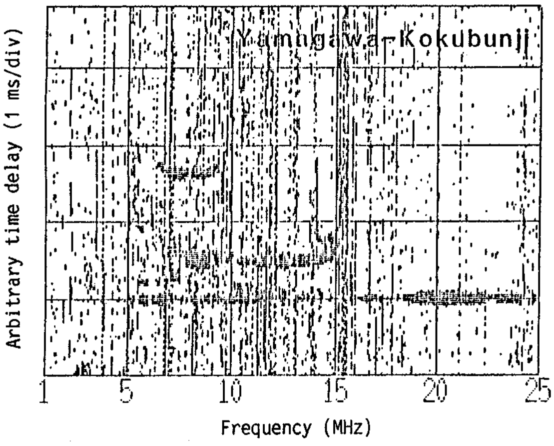


Fig. 2 An example of oblique ionogram obtained by using portable receiver with simple wire antenna.

12. The Digisonde 256 system and Ionospheric Research

Advances in microprocessor technology have revolutionized the high-frequency radio field in both communication and ionospheric research. The University of Lowell Center for Atmospheric Research (ULCAR) has developed the Digisonde 256, a pulsed-HF sounding system which serves the ionospheric research community as well as the HF communications engineer. More than fifteen years of development, sponsored by U.S. and foreign government agencies, resulted in a robust and reliable digital HF sounder. Today, Digisonde 256 systems are operating in the U.S.A., Canada, England, Australia, Europe, Greenland, China and Pakistan. The U.S. Air Weather Service is currently setting up a world-wide Digisonde network of 20 sounders. The first few stations are already in operation feeding the auto-scaled ionogram data, including the electron density profile, into the Automated Weather Network. The systems run fully automatically and can be reprogrammed and tested from remote terminals. The Air Force Geophysics Laboratory operates several Digisondes, one on board a KC-135 airplane for polar cap and auroral research. The U.S. Army Electronics Command runs a Digisonde 256 at Fort Monmouth, New Jersey.

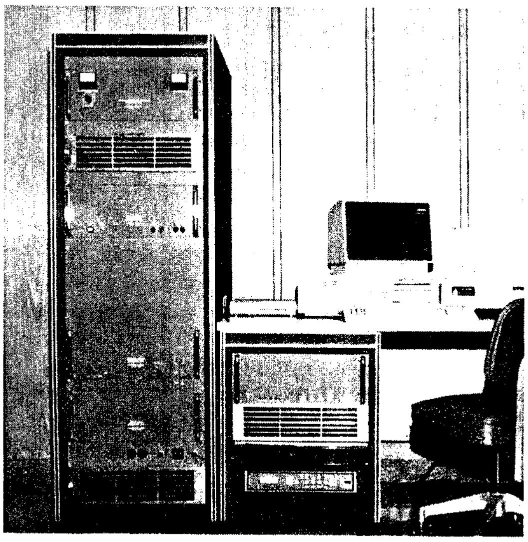
THE DIGISONDE Z56 SYSTEM AND IONOSPHERIC RESEARCH

System Configuration

The Digisonde 256 is housed in one standard 19" wide rack and an equipment desk. The design is rugged and modular. The system is complete with an array of seven receiving antennas, antenna switch, wideband 10 kW pulse transmitter, antenna transformer, transmit antenna, cabling, recording peripherals, the ARTIST for automatic data processing and data communication, and a remote terminal. The system requires 2kW line-power and operates on 110 or 220 VAC, 50 or 60 Hz. An uninterruptable power supply protects against brief interruptions of the line-power.

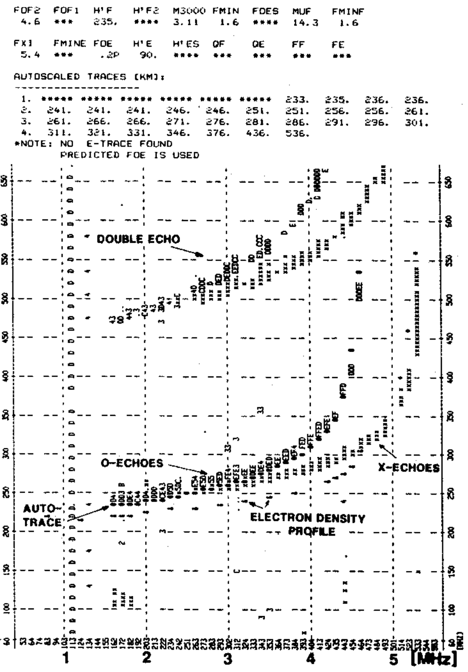
System Concept

The Digisonde 256 can operate as a vertical incidence ionosonde, in a bistatic mode for real time channel evaluation, as a backscatter sounder, or as a multiantenna ionospheric drift measurement system. High-frequency (0.5 to 30 MHz) pulses are transmitted with pulse repetition rates of 50, 100 or 200 Hz. In the ionogram mode the receiver output signal (intermediate frequency of 225 kHz) is digitized (12 bits) at 128 or 256 selectable range increments (2.5 km, 5 km and 10 km, or combination thereof). Phase coherent spectrum integration of the quadrature digital samples gives high signal to-noise ratios, and the measured Doppler spectra resolve the ionospheric motions. In the ionogram mode, the antenna beam formed with the receiving antenna array changes its pointing direction from pulse ' to pulse, sampling the incidence angles of the ionospheric returns. Use of polarized receiving antennas allows identification of ordinary and extraordinary polarization of the echoes, which is mandatory for the automatic scaling of the ionograms. In the Doppler-Drift mode the full (complex) spectrum of each individual antenna signal is calculated. Spectrum cross-correlation reveals the ionospheric reflection points (structure) and the corresponding Doppler frequencies give the velocity of the moving ionization.



DIGISONDE 256 SOUNDING SYSTEM WITH ARTIST

The transmitter on the left produces 10 kw peak power, an advantage for ionospheric research and oblique propagation studies.



```
FOF2  FOF1  H'F   H'F2  M3000 FMIN  FOES  MUF   FMINF
 4.6  ***   235.  ****  3.11   1.6  ****  14.3   1.6

FX1   FMINE FOE   H'E   H'ES  QF    QE    FF    FE
 5.4  ***    .2P   90.  ****  ***   ***   ***   ***

AUTOSCALED TRACES [KM]:
-------------------
 1. ***** ***** ***** ***** ***** *****  233.  235.  236.  236.
 2.  241.  241.  241.  246.  246.  251.  251.  256.  256.  261.
 3.  261.  266.  266.  271.  276.  281.  286.  291.  296.  301.
 4.  311.  321.  331.  346.  376.  436.  536.
*NOTE: NO  E-TRACE FOUND
       PREDICTED FOE IS USED
```

NIGHT TIME IONOGRAM

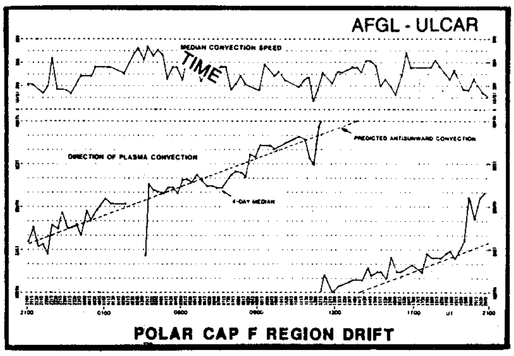
AUTO-SCALED TRACES AND ELECTRON DENSITY PROFILES ARE SUPERIMPOSED ON THE IONOGRAM. SCALED PARAMETERS ARE LISTED ON TOP.

System Integration

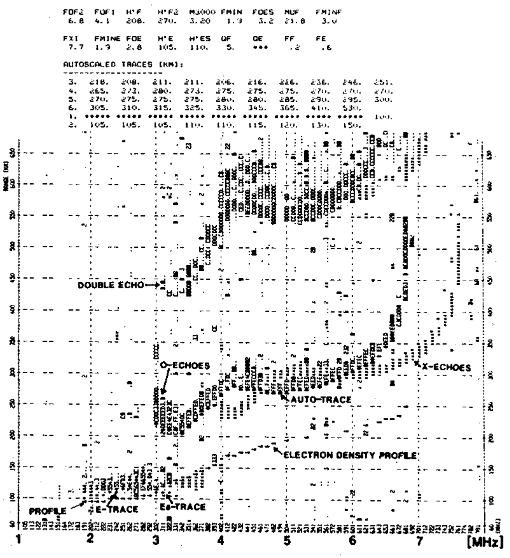
The Digisonde 256 is the result of 15 years of continuously improving design, based on the latest available electronic components. The digital and analog circuit boards were optimally designed for efficiency and reliability. Several microprocessors in the system control the input and output functions, the operational sequencing, parameter selection and the low-speed data processing. The front-end data processing and the high-speed spectrum integration (discrete Fourier transform) is handled by hardware. The purely computational processes (ionogram scaling and true height calculation), as well as data display, archiving and telecommunication, are performed in the Digisonde's ARTIST, which is based on an IBM PC/AT.

Adaptive Sounding

Sounding operation is completely software controlled, and the operational parameters and the sounding sequence can be selected according to user requirements. The best sounding frequencies (lowest interference level) around the assigned frequency steps in an ionogram. Are automatically selected. The receiver gain is digitally controlled for each sounding frequency and the transmitter output power can be automatically reduced to the lowest level which still gives a specified minimum signal-to-noise level.



THE DIRECTION OF THE F REGION PLASMA DRIFT IN THE POLARCAP VARIES ALMOST LINEARLY WITH TIME, ROTATING 360° IN 24 HOURS. THE VELOCITIES VARY FROM 150 to 750 m/s.



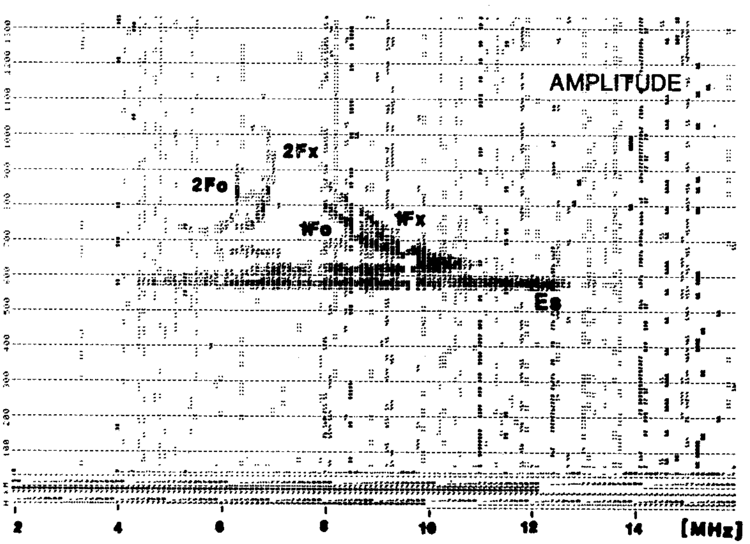
```
FOF2  FOF1  H'F   H'F2  M3000 FMIN  FOES  MUF   FMINF
 6.8  4.1   208.  270.  3.20   1.9   3.2  21.8   3.0

FXI   FMINE FOE   H'E   H'ES  QF    QE    FF    FE
 7.7  1.9   2.8   105.  110.   5.   ***    .2    .6

AUTOSCALED TRACES (KM):
-------------------
 3.  218.  208.  211.  211.  206.  216.  226.  236.  246.  251.
 4.  265.  273.  280.  273.  275.  275.  275.  270.  270.  270.
 5.  270.  275.  275.  275.  280.  280.  285.  290.  295.  300.
 6.  305.  310.  315.  325.  330.  345.  365.  410.  530.
 1. ***** ***** ***** ***** ***** ***** ***** ***** *****  100.
 2.  105.  105.  105.  110.  110.  115.  120.  130.  150.
```

DAY IONOGRAM

AUTO-SCALED TRACES AND ELECTRON DENSITY PROFILES ARE SUPERIMPOSED ON THE IONOGRAM. SCALED PARAMETERS ARE LISTED ON TOP.

Pulsed Radar Versus Chirp Radar

For oblique HF sounding chirp radars have proven to be a valuable tool to select or verify usable communication frequencies. They are not recommended for ionospheric research, however, for the following reasons. First, the frequency spectrum of the received signal is needed for determination of the echo ranges and hence can give no information on the motion of the reflectors. Second, a chirp radar is ill-suited to vertical sounding, because of saturation of the receiver input by the transmitted signal. Third, no automatic scaling techniques exist for the chirp sounders, while the autoscaling of Digisonde ionograms has proved very successful. Fourth, the information content of the available chirp sounders is small: range versus frequency with some limited amplitude information. The Digisonde, on the other hand, provides the full information on the received signals: range (with better than 1 km resolution using the phases), amplitude, phase, incidence angle, polarization and Doppler frequency. Finally, in a hostile environment the Digisonde can use a random frequency sequence for the ionograms to avoid jamming (or listening); the chirp sounder must maintain its monotonic frequency sweep and thus is very vulnerable.



OBLIQUE IONOGRAM

OPTICALLY WEIGHTED FONT INDICATES SIGNAL STRENGTH.

THE DIGISONDE 256 AS A FREQUENCY MANAGEMENT SYSTEM

The System Concept

The Digisonde is unequalled in accuracy and flexibility in measuring the characteristics of HF skywave communications channels. It also provides the "big picture" by monitoring the entire HF spectrum rather than just a few selected frequencies. Even if the operator is only authorized the use of a small set of frequencies the survey of the entire spectrum allows the Digisonde to analyze trends. This trend analysis allows the operator to detect significant changes in the channel characteristics or to recognize better performance on a different frequency without the need for time consuming manual frequency checks. Since the Digisonde system works in parallel with existing communications equipment, operational procedures need not be altered or interrupted to accommodate the channel monitoring. Furthermore, the system provides an independent verification of channel connectivity which has proven to be a great help in distinguishing between equipment malfunctions and degraded ionospheric conditions.

The pulse sounder is capable of measuring channel characteristics which are totally ignored by most other channel management systems. The measurement of time delay spread is of critical importance in providing acceptable voice fidelity and in maintaining low error rate data communications. The pulse sounder also measures Doppler shift and Doppler spread characteristics. Even "average" Doppler conditions have been shown to seriously degrade multitone DPSK data modems.

Flexibility is the key attribute of the Digisonde system. It can be used as a point-to point oblique incidence channel monitor over a variety of path lengths, and to automatically select optimum operating frequencies. It can also be operated in a vertical incidence mode to select frequencies for short range channels or to provide high quality ionospheric measurement data to update propagation prediction models. It can sound an entire star network simultaneously from a central node location, and can even broad cast low data rate messages during its routine sounder operations. Because the high level functions of the Digisonde system are controlled by a super-microcomputer it can easily be tailored to specific user applications. The time delay resolution can be decreased and the pulse integration time and duration of the sounder scan increased, to provide a cleaner measurement or to allow low power operation. The pulse repetition frequency can be increased to accommodate high Doppler platforms such as aircraft. Operation in networks is also straightforward by simply staggering the timing of various Digisoinde transmitters. The complement of assigned frequencies from which to select operating frequencies can easily be modified as assignments change. Also the super-microcomputer provides world-wide telecommunications which allows transfer of ionospheric data to a central location or patching of the low data rate messages into a data network (e.g. LAN's, DDN, ARPANET, etc.).

Global and Theater Networking

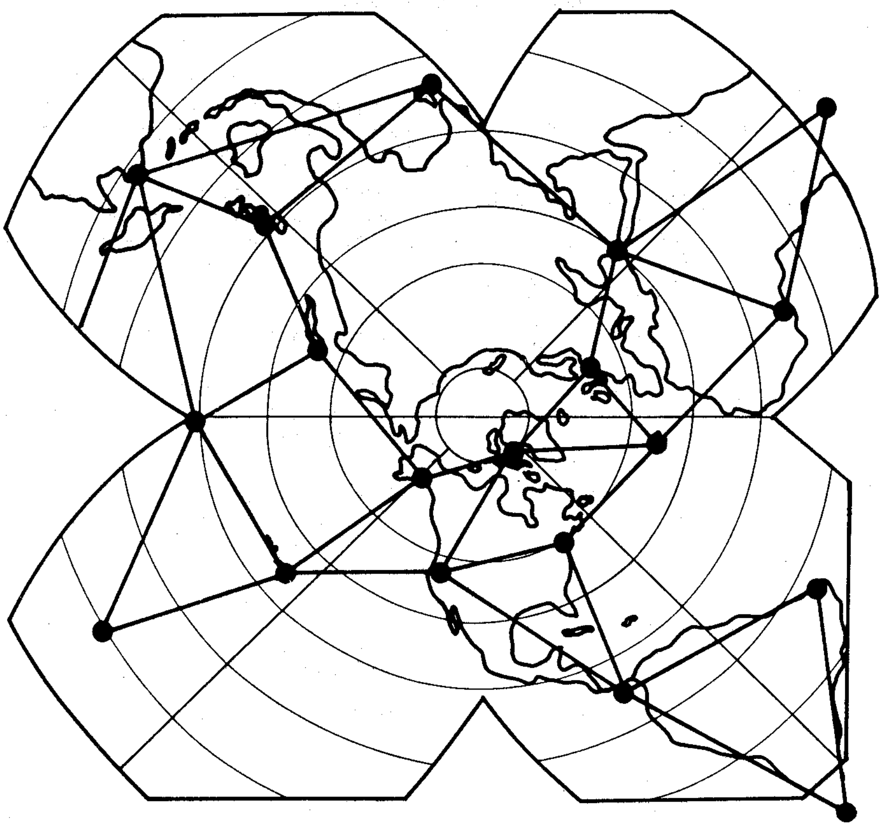
Over areas of strategic interest anywhere on the globe it is possible to establish a network of digital ionospheric sounders that can provide frequency management information to meet both long and short range communications requirements. Strategically located nodes can be established that provide both local frequency management permitting any one or more nearby nodes to communicate with any mobile HF user, and long range frequency information that makes it possible to communicate over a network of paths to insure a high probability of successful transmission.

One example of this capability is illustrated in what we call the GLOBAL HF NET Here, using approximately twenty nodes, all within one hop propagation of each other we can provide multiple node coverage over 75 percent of the globe, excluding the south polar region.

This networking capability with automatic ionogram scaling and noise monitoring provides the information necessary to establish and maintain intranode and internode communications. Typically any node must maintain linkage with some three or four other nodes, and this can be done on a time sharing basis that permits rapid update of channel conditions without affecting ongoing communication traffic.

Vertical sounding in conjunction with the oblique modes provides the information required for effective short path frequency management.

GLOBAL HF NET

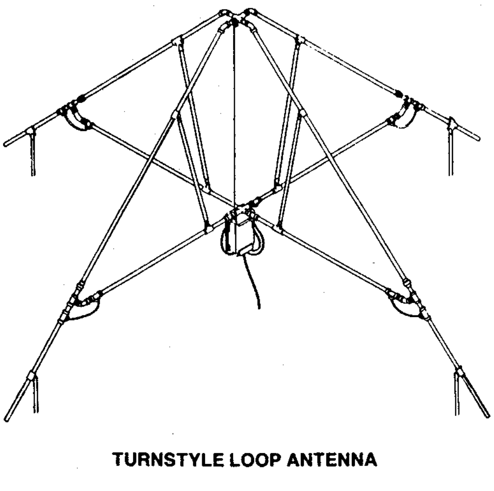


WORLDWIDE NETWORK OF SOUNDERS PROVIDE FREQUENCY MANAGEMENT

Oblique Antenna System

These frequency management concepts require that links be established between nodal points that lie in different directions from any given base node. In order to accomplish reliable linkage with relatively low transmitter power, the transmit antenna provides approximately 6 dB gain in the required directions and at frequencies from 2 to 30 MHz. Low frequency capability is essential for the short range paths.

For reception, a two dimensional array of seven circularly polarized loop antennas is used with directive steering in the direction of the specific transmitting node. Electronic switching is provided to permit the receiving array to be automatically directed to a new node whenever necessary.



TURNSTYLE LOOP ANTENNA

SPECIFICATIONS

GENERAL:

Frequency Range: 0.5 - 30 MHz

Sweep Duration: Programmable, 20 sec to several minutes

Frequency Step Size: 5, 10, 25, 50, 100, 200 kHz linear. 20, 40, 80 steps per octave logarithmic. 50, 100, 200 kHz pseudo-random linear.

Frequency Search: Prior to transmission, the Digisonde listens at the nominal frequency, + 10 kHz and + 20 kHz and uses the one with the lowest interference level.

Restricted Frequencies: The user can restrict transmission on any frequency or band of frequencies.

Pulse Repetition Rate: 50, 100, or 200 Hz.

Pulse Width: 66 or 133 μsec.

Phase Coding: Interpulse and intrapulse pseudo-random phase coding to minimize effects of coherent interference.

Dynamic Range: 64 dB, plus digital AGC in 6 dB steps.

Frequency Source: Rapid switching frequency synthesizer derived from crystal with 10^{-9} stability

Automatic Operation: User-friendly interface allows operator to design schedules which repeat every hour. During the hour, starting times of up to 12 each of three different ionograms can be specified.

At specific times during the day diurnal changes in both schedule and sounding programs may be made automatically. The same facility allows similar changes to be made for a more intense World Day Schedule.

Modes of Operation:

Multiparameter ionograms (A, B and C modes). Operational parameters for nine different type ionograms can be stored in EEPROMs for automatic access. The system can run vertical incidence and oblique incidence (bistatic) ionograms.

Fixed-frequency sounding (F mode). Fixed-frequency soundings (either one or four frequencies simultaneously) can be run in between ionograms.

Doppler-Drift observations (G mode). For detailed studies of ionospheric structures (tilts) and motions, the system operates in the drift mode.

Input Power: 100 - 130 VAC or 200 - 260 VAC, 50 or 60 Hz. Uninterruptable Power Supply (UPS) bridges operation over short power outages and allows automatic orderly shutdown during longer power outages.

U.S. Government Nomenclature: AN/FMQ-12, Digital Ionospheric Sounding System (6660-01-148-4205).

TRANSMITTER:

Output Impedance: 50 Ohms.

Output Power: 10 kW during pulse, nominal.

Max. VSWR: Any mismatch permitted.

SIGNAL PROCESSING:

Digitization: 12 bit linear, quadrature sampling of IF signal (225 kHz).

Amplitude Resolution: 1/4 dB.

Phase Resolution: 1.4°

Height Resolution: 2.5, 5.0 and 10.0 km

Range Bins: 128 and 256. Selectable range start.

Doppler Resolution: Discrete Fourier Transform has resolution of 1/T, where T is the observation time. T is selectable from 0.25 to 82 seconds.

Doppler Bins: Variable, 2 to 256.

ARTIST:

The ARTIST (Automatic Real-Time Ionogram Scaling with True Height) is a computer which processes all ionogram data and handles all data communication tasks.

Software: The ARTIST has both floppy and hard disks. The scaling and true height programs are written in Fortran. Data communication programs are written in 8086 assembly language.

Data Communication: Three serial RS-232 ports provide communication to modems on dial-up or dedicated phone lines.

Port 1 1200 baud asynchronous/2400 baud synchronous specialized polling formats only. RTS/CTS control for half duplex or multidrop circuits.

Port 2 300, 1200, 1200/75, 2400 baud asynchronous; 1200, 2400 baud synchronous. Full remote terminal operation. RTS/CTS control.

Port 3 300, 1200, 2400 baud asynchronous. Full remote terminal operation RTS/CTS control.

Video Display: Several different modes of operation optimize display of processor control information, alphanumeric text or ionograms on a low **r**eflection amber screen.

Printing: Standard dot matrix impact printer uses inexpensive 9-1/2 x 11 " z-fold computer output paper.

Tape Recording: Self-loading 9-track 1600 BPI tape recorder records digital ionograms, scaled ionogram parameters, and drift data.

Ionogram Scaling: Auto-scaling of E, Es, F1 and F2 traces gives h' (f) in 100 kHz steps. Echo amplitudes, Doppler shifts and spread are saved. The standard URSI parameters (critical frequencies, heights and M(3000) factor) are determined. All information is available within about 30 seconds after completion of the sounding.

True Height: The electron density profiles are calculated from the auto-scaled h' (f) traces using the POLAN conversion program.

REMOTE TERMINAL:

The remote terminal presents all of the video and printed displays available at the main site in real time. In addition to the real time displays, the user may poll the display for the previous ionogram or for the ionospheric parameters of the last 24 hours. Full control of ionosonde processor function including ARTIST is also provided.

Input Power: 115 VAC or 230 VAC, 50 or 60 Hz, 130 Watts.

Data Communication: RS-232 for connection to either a dedicated or dial-up modem. 300 (not recommended), 1200, 1200/75, 2400 baud asynchronous, 1200, 2400 baud synchronous. Supports RTS/CTS controls for half duplex or multidrop circuits.

Depending on telephone circuit flexibility, one remote terminal may access multiple Digisondes or conversely many remote terminals may access one Digisonde.

Video Display: Several different modes of operation optimize display of processor control information, alphanumeric text or ionograms on a low reflection amber screen.

Printing: Standard dot matrix impact printer uses inexpensive 9-1/2 x 11" z-fold computer output paper.

For further information, contact:

UNIVERSITY OF LOWELL
CENTER FOR ATMOSPHERIC RESEARCH
450 AIKEN STREET
LOWELL, MA 01854
USA
TELEPHONE (617) 458-2504
TWX 710 343-6461

CONTACT: PROF. BODO W. REINISCH