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International Scientific Radio Union

U. R. S. I.

CONTENTS

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COMMISSIONS

Commission I

On Radio Measurements and Standards

ACTIVITIES OF THE POLISH NATIONAL COMMITTEE IN THE FIELD OF COMMISSION I

by A. JELLONEK,
Official Member of the Commission

In the field of radio measurements and standards the following topics are considered in Poland :

1. — SECONDARY STANDARDS OF HIGH FREQUENCY VOLTAGE AND CURRENT

The interest in the field of high frequency standards is actually concentrated on the measurement of voltage and current, and on the construction of accurate high frequency resistances, potentiometers and micropotentiometers.

The main topics considered are included in the following papers :

1.1. S. DEMBICKA-JELLONKOWA, Z. GODZINSKI, J. KOSENDIAK. — Electrical Conductance of the Metal Films. *Zeszyty Naukowe Politechniki Wroclawskiej*, nº 3, 1955, pp. 67-77.

1.2. Z. GODZINSKI, S. DEMBICKA-JELLONKOWA. — The Structure, Technology and Properties of thin Films Deposited Thermically in Vacuum. *Ibid.*, nº 3, 1955, pp. 3-45.

1.3. A. JELLONEK. — Secondary Standards of High Frequency Voltages and their Application for Calibration of Voltmeters and Attenuators. Report to the symposium organised by the Polish Academy of Science (in the press).

2. — Dielectric Materials Used in High Frequency Fields

The factors affecting the accuracy of dielectric constants measurements were studied. The following topics are considered :

2.1. R. Calikowski. — Mineral Materials for the Construction of Modern Electrical Instruments. *Przeglad Elektrotechniczny*, 31, 1955, pp. 666-668.

2.2. A. Jellonek, L. Badian. — The effect of boundary field on the measurement of characteristics of insulating materials. *Prace PIT*, nº 10, 1955, pp. 9-21.

2.3. A. Jellonek. — Dielectric Losses Standards as Applied to A. C. Bridges Control. *Zeszyty Naukowe Politechniki Wroclawskiej*, nº 7, 1955, pp. 135-150.

2.4. W. Kavka. — Voltage Recovery High Frequency Ceramic Dielectrics. *Ibid.*, nº 5, 1955, pp. 79-100.

2.5. Z. Sicinski. — The Dielectric Properties of the paper-oil insulating system. *Rozprawy Elektrotechniczne*, ii, 1, 1956, pp. 3-20.

3. — Miscellaneous

3.1. H. Helbing. — Spectrum Measurements in Wireless Telegraphy. *Prace Instytutu Lacznosci*, nº 1, 1955, pp. 23-45.

3.2. J. Groszkowski. — Frequency Stability of L C Oscillators with Large Grid and Anode Capacities. *Bull. de l'Académie Polonaise des Sciences*, 3, 1955, pp. 149-155.

3.3. J. Kurylowicz. — A compensated Difference Method for Measuring Resistance. *Archiwum Elektrotechniki*, 2, 1953, pp. 191-204.

3.4. T. Tomankiewicz. — Measurement of the Field of the Ground Wave over an Anisotropic Ground. Report to the symposium organised by the Polish Academy of Science (in the press).

3.5. M. Warmus. — Approximate Computation in Technical Measurements and Corresponding Errors. *Przeglad Elektrotechniczny*, 31, 1955, pp. 749-753.

3.6. S. Borowski, S. Jasinski, S. Manczarski. — Doppler Effect in Ionospheric Propagation. *Archiwum Elektrotechniki*, nº 2, 1956, pp. 343-353. — The paper deals with the errors resulting from the Doppler effect when carrying out measurements using distant standard-frequency transmissions.

Commission V

On Radio-Astronomy

ELECTION OF A SECRETARY

We have to inform our readers that Dr. M. Nicolet resigned as secretary of the Commission due to the work he has to meet as Secretary General of C.S.A.G.I. To replace him the Official Members of the Commission have been consulted and they have appointed as Secretary Mr. Coutrez of the Observatoire Royal de Belgique.

Commission VI

On Radio Waves and Circuits

SYMPOSIUM ON ELECTROMAGNETIC WAVE THEORY

The proceedings of the Symposium on Electromagnetic Wave Theory held at Ann Arbor, Michigan, U.S.A., June 20-25, 1955, under the joint sponsorship of the University of Michigan and Commission VI of U.R.S.I., have been published in the *IRE Transactions on Antennas and Propagation*, Vol. AP-4, nº 3, July, 1956.

We want to give the Introduction written by Keeve M. Siegel, chairman of the organizing committee, and the table of contents of this work which contains nearly 400 pages and a great number of figures and diagrams.

Introduction

From June 20 through June 25, 1955, an International Symposium on Electromagnetic Wave Theory was held at Ann Arbor, Michigan. It was sponsored by Commission VI of U.R.S.I. and the Chrysler Corporation, Convair, Ford Motor Company, General Motors Corporation, Republic Aviation Corporation, Republic Steel Corporation Sylvania Electric Products, Inc., United States Air Force, United States Army, United States Navy, Westinghouse Corporation and the University of Michigan.

The purpose of this symposium was exclusively educational. The aim of the University of Michigan Organizing Committee was to assemble the leading scientists in the field of electromagnetic wave theory, in order to provide the opportunity for them to receive and present the latest developments. It was our belief that the discussions and stimuli furnished by such meeting could shorten by many years the time required for major scientific advances in boundary value problems of diffraction and scattering theory, forward and multiple scattering antenna theory and microwave optics, and propagation in doubly refracting media.

This volume contains the invited papers and abstracts of the contributed papers that were presented at the symposium. In addition, the panel discussions which followed each of the sessions have been summarized by the panel chairmen and are included in the text of the proceedings which follows.

I am taking this opportunity to thank the Professional Group on Antennas and Propagation of the Institute of Radio Engineers for publishing the proceedings of this symposium. I would also like to express my gratitude to the large number of scientists without whose help and encouragement this Symposium would not have been possible. It is my sincere hope that the members of the Professional Group will find these proceedings as simulating and interesting as I have.

TABLE OF CONTENTS

2.4. A method for the asymptotic solution of diffraction problems, R. TIMMAN.

2.5. The modeling of physical systems, R. K. RITT.

2.6. On the diffraction field near a plane-screen corner, W. BRAUNBEK.

2.7. Electromagnetic radiations pattern and sources, Claus MULLER.

2.8. A refinement of the WKB method and its application to the electromagnetic wave theory, Isao ISMAI.

2.9. Approximate method for scattering problems, C. E. SCHENSTED.

2.10 Electromagnetic research at the Institute of Mathematical Sciences of New York University, Morris KLINE.

2.11. Asymptotic developments and scattering theory in terms of a vector combining the electric and magnetic fields, H. BREMMER.

2.12. The theoretical and numerical determination of the radar cross section of a prolate spheroid, K. M. SIEGEL, F. V. SCHULTZ, B. H. GERE and F. B. SLEATOR.

2.13. Solution of problems in electromagnetic wave theory on a high speed digital calculating machine, E. K. RITTER.

2.14. Edge current in diffraction theory, P. C. CLEMMOW.

2.15. On discontinuous electromagnetic waves and the occurrence of a surface wave, Balth VAN DER POL.

2.16. The excitation of a perfectly conducting half-plane by a dipole field, A. E. HEINS.

2.17. A critique of the variational method in scattering problems, D. S. JONES.

2.18. The mathematician grapples with linear problems associated with the radiation condition, C. L. DOLPH.

2.19. Diffraction by a convex cylinder, J. B. KELLER.

3. *Forward and multiple scattering.*

3.1. Near field corrections to line-of-sight propagation, A. D. WHEELON.

3.2. On the scattering of waves by an infinite grating, V. TWERSKY.

3.2. Measurement and analysis of instantaneous radio-height-gain curves at 8.6 Millimeters over rough surfaces, A. W. STRAITON and C. W. TOLBERT.

3.4. Measurement of the phase signals received over transmission path with electrical lengths varying as a result of atmospheric turbulence, J. W. HERBSTREIT and M. C. THOMPSON.

3.5. Condition of analogy between the propagation of electromagnetic waves and the trajectories of particles of same spin with application to rectifying magnetrons, J. ORTUSI.

3.6. Scattering at oblique incidence from ionospheric irregularities (Abstract), D. K. BAILEY.

3.7. Forward and back-scattering from certain rough surfaces, W. S. AMENT.

3.8. Cerenkov and ondulator radiation, H. Motz.

3.9. Nonreflecting absorbers for microwave radiation, Hans Severin.

4. *Antenna theory and microwave optics.*

4.1. Theory of the corner driven square loop antenna, Ronold King.

4.2. The radiation pattern and induced current in a circular antenna with a circular slit, J. Meixner.

4.3. Aberration in circularly symmetric microwave lenses, M. P. Bachinsky and G. Bekefi.

4.5. Application of periodic function approximation to antenna pattern synthesis and circuit theory, J. C. Simon.

4.6. A theoretical analysis of the multi-element endfire array with particular reference to the Yagi-Uda antenna, Yasuto Mushiake.

4.7. Resolution, pattern effects and other problems of Radio Telescope antennas, J. D. Kraus.

4.8. Radiation from ring quasi-arrays, H. L. Knudsen.

4.9. Directivity, super-gain, and information, G. Toraldo di Francia.

4.10. Exact treatment of antenna current wave reflection at the end of a tube-shaped cylindrical antenna, E. Hallen.

5. *Propagation in doubly refracting media.*

5.1. Propagation in circular waveguides filled with gyromagnetic material, L. R. Walker and H. Suhl.

5.2. The low-frequency problem in the design of microwave gyrators and associated elements, C. L. Hogan.

5.3. Some topics in the microwave application of gyrotropic media, A. A. van Trier.

5.4. The seismic pulse, an example of wave propagation in a doubly refracting medium, C. L. Pekeris.

5.5. On the electromagnetic characterization of ferromagnetic media : Permeability tensors and spin wave equations, G. T. Rado.

5.6. Plasma oscillations, D. Gabor.

5.7. Theory of ferrites in rectangular waveguide, K. J. Button and Benjamin Lax.

6. *Summary of the pannel discussions.*

6.1. Panel discussion on boundary value problems of diffraction and scattering theory (I), G. Sinclair.

6.2. Panel discussion on boundary value problems of diffraction and scattering and scatterind theory (II), S. Silver.

6.3. Panel discussion on forward and multiple scattering, J. Wiesner.

6.4. Panel discussion on antenna theory and microwave optics, R. C. Spencer.

6.5. Combined panel discussion on propagation, in doubly-refracting media and future directions for research in electromagnetic wave in theory modern physics, Benjamin LAX.

Appendix : Abstracts of the contributed papers.

A.1. *Contributed papers : Scattering diffraction and general mathematical papers.*

1. Diffraction by an infinite grating of cylinders in the resonance case, N. S. KARP and J. J. RADLOW.
2. Diffraction of electromagnetic waves caused by apertures in absorbing plane screens, H. E. J. NEUGEBAUER.
3. Microwave tandem slit diffraction, L. R. ALLDREDGE.
4. Convergent representations for the radiation fields from slots in large circular cylinders, L. L. BAILIN and R. J. SPELLMIRE.
5. Electrodynamics of continua, P. C. ROSENBLOOM.
6. An analysis of edge behavior in vector diffraction theory, S. N. KARP.
7. Experimental measurement of diffraction of light at a half-plane, F. S. HARRIS, Jr. and GLEN J. MORRIS.
8. An expansion theorem for electromagnetic fields, C. H. WILCOX.
9. The hyperbolicity of Maxwell's equations, W. JAMES.
10. Diffraction of 3.2 cm electromagnetic waves by dielectric cylinders and semi cylinders, A. B. McLAY and M. K. SUBBARO.
11. Tensor scattering matrix for the electromagnetic field, D. S. SAXON.
12. A simplification of electromagnetic scattering problems involving a sphere, N. A. LOGAN.
13. Diffraction by a semi-infinite cone, L. B. FELSEN.
14. Some variational formulas for the changes in electromagnetic scattering cross section and dyadic Green's functions due to boundary perturbations, Carson FLAMMER.
15. Electromagnetic scattering by spheroids as power series in the ratio diameter/wave length, A. F. STEVENSON.
16. Variational corrections to geometric optics in scattering by a conducting cylinder, R. D. KODIS.
17. On the correction to the total geometric optical scattering cross sections of a circular cylinder and of a sphere, S. I. RUBINOW.

A.2. *Contributed papers-multiple scattering, scattering from rough surfaces and transmission reflection problems.*

1. Optical and Radio twilight and modes, T. J. CARROLL and R. M. RING.
2. Transmission characteristics of parallel wire grids with variable tilt angle, O. J. SNOW.
3. Light scattering of colloidal spheres, W. HELLER.
4. Solution of the Helmholtz equation with radom boundary values, Jack KOTIK.

5. Forward scattering of nonabsorbing MIE particles, Rudolf PENNDORF.
6. Total MIE scattering coefficients for real refractive indices, Rudolf PENNDORF.
7. A method for the calculation of the distribution of energy reflected from a periodic surface, W. C. MEECHAM.
8. Multiple scattering by randomly distributed obstacles-methods of solution, C. CHU and S. W. CHURCHILL.
9. Atmospheric attenuation of solar millimeter wave radiation, H. H. THEISSING and P. J. CAPLAN.
10. Approximate calculations for light scattering when the refractive index is near unity, A. F. STEVENSON.

A.3. *Contributed Papers-Waveguides, propagation, and slow waves and surface waves.*

1. Waveguide impulse response, G. I. COHN.
2. On the eigenvalue problem of slow-wave propagation in cylindrical structures, F. E. BORGNIS.
3. Propagation of transient fields from dipole near the ground, H. PORITSKY.
4. Theory of the multipath propagation of frequency modulated electromagnetic waves, J. P. VINTI.
5. Mode conversions in multimode waveguides, Wesley AYRES and E. T. JAYNES.
6. Propagation in ferrite-filled transversely magnetized waveguides, P. H. VARTANIAN and E. T. JAYNES.
7. An extension of Maxwell's solution of the wave equation for concentric strata to include tilted and wavy strata, P. B. TAYLOR.
8. Some variational principles for resonators and waveguides, A. D. BERK.
9. Contribution to a general transmission and matching theory for waveguides, F. J. TISCHER.
10. The application of higher cavity resonance modes to the measurement of free electron densities and diffusion coefficients, K. S. W. CHAMPION.

A.4. *Contributed papers-Ferrites, Plasma oscillations and anisotropic media.*

1. Filed displacement isolators at 55 kMc, E. H. TURNER.
2. Use of perturbation theory for cavities and waveguides containing ferrites, G. S. HELLER and Benjamin LAX.
3. Propagation and magnetoplasma effects in semiconductors, Benjamin LAX and L. M. ROTH.
4. Interaction between plasma oscillations and electromagnetic waves-*i*. Coupling conditions, R. M. GALLET.
5. Influence of the irregularities of land on the propagation of radio waves. Especially at great distances beyond the horizon, J. VOGE.

6. Microwave single-sideband modulator using ferrites, J. C. CACHERIS and H. A. DROPKIN.
7. An electric dipole above an infinite anisotropic slab, Bernard FRIEDMAN.
8. Non linearity of microwave ferrite media, N. G. SAKIOTIS, H. N. CHAIT and M. L. KALES.

A.5. *Contributed papers-Antennas and microwaves optics.*

1. Phase centers of microwave antennas, David CARTER.
2. A method of analysing coupled antennas of unequal sizes,
3. Diffraction of surface waves by a semi-infinite dielectric slab, C. M. ANGULO.
4. Radiation conductance of slots in plane and curved conducting surfaces, J. R. WAIT and J. Y. WONG.
5. Further investigations of aberrations in microwave lenses, M. P. BACHYNSKI and G. BEKEFI.
6. Radiation by a disk and conical structures, A. LEITNER and C. P. WELLS.
7. The Fresnel field of a finite line current distribution, R. B. BARRAR and C. H. WILCOX.
8. Variable index lenses producing conical wavefronts, K. S. KELLEHER.

Copy can be purchased from the Institute of Radio Engineers, 1, East 79 Street, New York 21, N. Y. at the price of $ 8.50 per copy.

IONOSPHERIC STATIONS

Gazetteer of Ionospheric Stations

The Gazetteer of Ionospheric Stations, in course of preparation, will include information on stations mentioned in the following lists.

We kindly request readers to inform us of any existing or planned station non mentioned.

Ionospheric Vertical Sounding Stations

Adak
Adare
Ahmedabad
Akita
Alert
Alma-Ata
Anchorage
Artic Ice Floe « B »
Ashkabad
Athènes

Baguio
Baker Lake
Bangui
Barrow
Belgrano
Bizerte
Bogota
Bombay
Brisbane
Budapest
Buenos Aires
Bunia
Byrd Land

Calcutta-Haringhata
Campbell Is.
Canberra
Canton
Capetown
Casablanca
Chiclayo
Chimbote
Chita
Chung Ching
Churchill
Clyde
College
Conception

Dakar
de Bilt
Deception
Delhi
Djibouti
Dourbes
Drifting Station « A »

Elisabethville
Eureka

Fort Belvoir
Fort Chimo
Fort Monmouth
Fort Norman
Fort Randolph
Freiburg
Frobisher Bay

Gao
Genova
Godhavn
Godley Head
Graz

Hobart
Hollandia
Huancayo

Ibadan
Inverness
Irkutsch

Johannesburg

Kerguelen
Kiruna
Kjeller-Oslo
Knox Coast
Kodaikanal
Kokubunji
Kyoto

La Paz
La Quiaca
Leidsendam
Leningrad
Léopoldville
Lindau
Little America
Longyearbyen
Luleå
Lwiro
Lycksele

Macquarie Is.
Madras
Manchuli
Marion Is.
Maui
Mawson
Meanook
Moscow
Mould Bay
Murmansk

Nairobi
Narsarssuak
Nha-Trang
Nurmijärvi

Okinawa
Ottawa

Panama
Paramaribo
Peking
Petropavlosk
Pointe Geologie
Poitiers
Pole Station
Port Lockroyd
Port Moresby
Port Stanley
Providenie Bay
Pruhonice
Puerto Rico
Punte Arenas

Quetta
Quito

Rabat
Ramey
Rarotonga
Resolute Bay
Reykjavik
Roma (St Alesio)
Rostov

St John's
Sao Paulo
Schwarzenburg
Scott Base
Simferopol
Singapore
Slough
Sodankylä
Stanford
Sverdlovsk
Swansea ?

Tahiti
Talara
Tamanrasset
Tananarive
Thule
Tikaya Bay
Tiruchirapalli
Tixie Bay
Tomsk
Tortosa
Townsville
Trelew
Trivandrum
Tromsoe
Tsumeb
Tucuman

Uppsala
U.S.S.R. Antarctic 1

Vahsel Bay
Victoria

Wakkanai
Watheroo
Weddel Sea
Wellington
West Florida ?
White Sands
Winnipeg
Wuchang

Yakutsk
Yamagawa
Yap
Yellowknife
Yuhzno

Zose

List of Absorption Measurement Stations

A1 = local transmitter
A2 = extra-terrestrial sources

Ahmedabad
Aklavit (?)
Alert (?)
Alma-Ata
Anchorage (A2)
Ashkhabad
Baker Lake
Bangui
Barrow (A2)
Barter Is.
Boulder
Bunia

Calcutta-Haringhata (A1)
Champfleury (A1)
Churchill
College

Dakar (A1)
de Bilt
Delhi (A1) (A2)
Djibouti (A1)

Edinburgh (?)
Elisabethville

Fort Yukon

Genova (A2)
Godhavn (A2)
Göteborg (?)

Hanover

Ibadan
Irkutsk
Ithaca

Johannesburg (A1)

Kerguelen (A1)
Knob Lake
Kokubunji (A1)
Kootwijk (A2)

Leopoldville (A1)
Lindau
Lwiro

Madras (A2)
Meanook

Naknek
Nederhorst den Berg

Ottawa (A1) (A2)

Paris-Domont (A1)
Port Stanley (A1)
Průhonice
Pullman
Resolute Bay

St. Michel l'Observatoire (A2)
St. Paul Is. (?)
Salta (?)
Shetland Is. (?)
Singapore (A1)
Slough (A1)
Sitka
Skwentna
Stanford
Swansea

Tamanrasset
Tananarive (A1)
Tsumeb

Unalaska
University Park

Vashel Bay

Whitehorse (?)
Winnipeg (A1)

List of Stations carrying out drift observations

Adelaide
Ahmedabad

Bangui
Brisbane

Calcutta-Haringhata
Cambridge
Champfleury

Churchill
Colorado Springs (?)
de Bilt
Delhi

Knob Lake (?)
Kokubunji
Kootwijk

Mawson
Mayaguez
Moscow

Ottawa

Paris Domont

Průhonice
Pullman

Swansea (?)

Tamanrasset

List of Stations carrying out forward scatter experiments

Angmassalik (?)
Antofagasta
Arequipa

Baker Lake
Banff (?)
Buenos Aires

Churchill
Clorinda
Guayaquil

Houston (?)
Huancayo

Kootwijk

Le Pas

Macquarie Is.

Pointe Géologie

Sao Paulo (?)
Saskatoon

Tatara
Thule
Trujillo

Yellowknife

Radio Communications

Some ionospheric stations are provided with an Amateur Radio Station ; the use of such facilities could be of great use to establish direct communication-links between stations carrying out coordinated observation and measurement. We are intended to publish in the *Information Bulletin* a list of such amateur radio stations and we kindly request ionospheric stations operating such radio station to provide us with the following information :

Name of the station,
Geographical location,
Call sign,
Working frequencies,
Power,
Hours of operation.

ATMOSPHERICS STATIONS

Gazetteer of Atmospherics Stations

1st LIST OF STATIONS CARRYING OUT OBSERVATION AND MEASUREMENT ON TERRESTRIAL RADIO DISTURBANCES (I)

In order not do delay the publication of the list of stations carrying out observation and measurement on radio disturbances (radio atmospherics, whistlers, etc.) announced in *Information Bulletin*, n° 98, we shall issue provisional lists giving the data as we receive them from the stations.

We would be grateful to the stations and to those interested in this field to keep us informed of any change brought to the information published, and also to provide us with the information required on any other station, mentioned or not, in *Information Bulletin*, n° 98, pp. 22-24.

It should be recalled that geomagnetic coordinates with the indication (1956) are those plotted by the C.S.A.G.I. on the basis of a dipole with North Pole at 78°30′, 69° W, coordinates adopted by the International Association of Magnetism and Aeronomy.

For each station we are giving the following informations :

1. Geographical coordinates.
2. Geomagnetic coordinates (N, + ; S, — ; lat. E).
3. Characteristics measured.
4. Type of apparatus.
5. Frequencies and bandwidths.
6. Other stations of the network (where applicable).
7. Operating schedule.
8. Publication of results.
9. Responsible authority and mailing address.
10. Date of report.

We are giving in the following list information on :

Accra	Brest	Delhi
Aden	Brisbane	Dourbes
Angmagssalik	Camborne	Dunedin
Bagneux	Colombo	Dunstable
Bangui	Cyprus	Durban

Accra

1. N 05°34′ W 00°14′.

2. + 09.6° 70.8°.

3. Field-strength of slow-speed Morse signal giving 95 % intelligibility through the noise.

4. (*a*) Thomas equipment : vertical aerial (6 m), preamplifier with 2-20 Mc/s filter, superhet. receiver, signal generator, keying unit.

(*b*) L. F. equipment : vertical aerial (12 m), superhet. receiver (15-500 kc/s), electronically keyed signal generator.

On both equipments, aural indication of level using headphones ; manual operation.

5. Equipment (*a*) : 2.5, 5, 10, 15, 20 Mc/s ; bandwidth 6 kc/s ; (*b*) : 18, 30, 135, 220 400 kc/s ; bandwidth 300 c/s.

6. —

7. Equipments (*a*) and (*b*) : 5 frequencies at the hour ; 0700-2100, each hour.

8. June 1945-Nov. 1951 : D.S.I.R. Special Report n° 26 (Radio Research Board).

Nov. 1951 onwards : Data available but unpublished.

9. D.S.I.R., Radio Research Station, Slough, Bucks, Great Britain.

10. March 1956.

Aden

1. N 12°46′ E 44°58′.

2. + 08.0° 116.0°

3. Field-strenght of slow-speed Morse signal giving 95 % intelligibility through the noise.

4. Thomas equipment : vertical aerial (6 m), no preampli., superhet. receiver, signal generator, keying unit.

Aural indication of level using headphones ; manual operation.

5. 2.5, 5, 10, 15, 20 Mc/s. Bandwidth 6 kc/s.

6. —

7. 1945-Dec. 1954 : 5 frequencies, every hour at the hour.

8. Dec. 1945-Nov. 1951 : 2.5, 5, 10, Mc/s : D.S.I.R. Special Report n° 26 (Radio Research Board).

Nov. 1951-Dec. 1954 : Data available but unpublished.

9. D.S.I.R., Radio Research Station, Slough, Bucks, Great-Britain.

10. March 1956.

Angmagssalik

1. N 65°36′ W 37°34′.

2. + 74.3° 52.8°.

3. Low frequencies atmospheric noise.

4. Low frequency noise measuring set on loan from D.S.I.R., Slough, England.

5. 15-500 kc/s.

6. —

7. At intervals of one or two hours.

8. Through D.S.I.R., Radio Research Stations, Slough, U.K.

9. Danish National Committee of U.R.S.I., c/o Professor J. Rybner, Royal Technical University, Oster Voldgate 10 G, Copenhagen K, Denmark.

10. September, 1956.

Bagneux

1. N 48°48′ E 02°19′.

2. + 51.3° (1956) 84.8° (1956).

3. Study of atmosph. propagation : recording of mean level (Maxwell/m), mean and quadratic fieldstrength (μ V/m), periodicity of atmosph. succession, study of S.I.D., localisation of atmosph. centres.

4. Recording-receivers, photo-recorders, narrow-beam direction-finder, cathode-ray direction finder.

5. 5.3, 12.5, 27, 60, 200 kc/s, 5 Mc/s.

6. Brest, Trappes, Rabat, Tunis.

7. Continuous recordings 0000-2400.

8. SFAZU messages to Météorologie Nationale.
PERTU messages (Ursigrammes).

9. Laboratoire National de Radioélectricité, Département R.N., 196, rue de Paris, Bagneux (Seine), France.

10. August, 20, 1956.

Bangui

1. N 04°36′ E 18°35′

2. + 05.0° (1956) 88.6° (1956).

3. Recording of mean field-strength of atmospherics (μ V/m), Localisation of atmospherics centres.

4. Recording-receivers. Narrow-beam direction-finder.

5. 27 kc/s — bandwidth 1000 c/s.
5 Mc/s.

6. Rabat, Tunis.

7. Continuous recording 0000-0024.

8. Results communicated to L.N.R. (Bagneux).

9. Laboratoire National de Radioélectricité, Département R.N., 196, rue de Paris, Bagneux (Seine), France.

10. August, 20, 1956.

Brest

1. N 48°27′ W 04°25′.

2. + 52.2° (1956) 77.8° (1956).

3. Localisations of atmospherics centres.

4. Narrow-beam direction-finder.

5. 27 kc/s.

6. Rabat, Bagneux, Trappes, Tunis.

7. Continuous recording from 0000-0024.

8. Recordings sent to L.N.R. (Bagneux).

9. Laboratoire National de Radioélectricité, Département R.N., 196, rue de Paris, Bagneux (Seine), France.

10. August, 20, 1956.

BRISBANE

1. S 27°32′ E 152°55′.

2. −36° 227°.

3. Whistling atmospherics.

4. Audio amplifier and magnetic tape recorder.

5. 400 c/s-15 kc/s.

6. Hobart, Macquarie Is.

7. 35-37 minutes past each hour.

8. —

9. Prof. H. C. WEBSTER, Professor of Physics, University of Queensland, St Lucia, Brisbane, Queensland, Australia.

10. August, 1956.

CAMBORNE

1. N 50°13′ W 05°.19½′.

2. + 54.1° (1956) 77.8° (1956).

3. Direction of arrival of atmospherics.

4. Two channel cathode-ray direction-finder, RRO type, Mark III.

5. 10 kc/s — bandwidth 300° c/s.

6. Leuchars, Irvinestown, Hemsby, Dunstable (plotting centre).

7. 10-00 minutes at the following times :
April-Sept. 0430, 0600 and hourly to 2100 U.T.
Oct.-March hourly 0600-2100 U.T.

8. Circulated to Meteorological Organizations through Dunstable.

9. The Director, Meteorological Office M.O. 12, Dunstable, Bedfordshire, Great Britain.

10. March, 1956.

COLOMBO

1. N 07°13′ E 79°52′.

2. —2.6° 148.9°.

3. Field-strength of slow-speed Morse signal giving 95 % intelligibility through the noise.

4. (*a*) Thomas equipment : vertical aerial (6 m), preampli. with 2-20 Mc/s filter, superhet. receiver, signal generator, keying unit.

(*b*) L.F. equipment : vertical aerial (12 m), superhet. receiver (15-500 kc/s), electronically keyed signal generator.

On both equipments, aural indication of level using headphones ; manual operation.

5. Equipment (*a*) : 2.5, 5, 10, 15, 20 Mc/s, bandwidth 6 kc/s.

Equipment (*b*) : 18, 30, 135, 220, 400 kc/s, bandwidth 300 c/s.

6. —

7. Every hour at the hour at the 5 frequencies on both equipments.

8. Equipment (*a*) : 1945-Nov. 1951 : D.S.I.R. Special Report n° 26 (Radio Research Board). Later results on (*a*) and recent results on (*b*) from Jan. 1956 : data available, unpublished.

9. D.S.I.R., Radio Research Station, Slough, Bucks., Great-Britain.

10. March, 1956.

CYPRUS

1. N 35°10′ E 79°52′.

2. + 32.0° 110.4°.

3. Field strength of slow-speed Morse signal giving 95 % intelligibility through the noise.

4. (*a*) Thomas equipment : vertical aerial (6 m), preampli. with 2-20 Mc/s filter, superhet. receiver, signal generator, keying unit.

(*b*) L-F equipment : vertical aerial (12 m), superhet. receiver (15-500 kc/s), electronically keyed signal generator.

On both equipments, aural indication of level using headphones ; manual operation.

5. Equipment (*a*) : 2.5, 5, 10, 15, 20 Mc/s ; bandwidth 6 kc/s.

Equipment (*b*) : 18, 30, 135, 220, 400 kc/s ; bandwidth 300 c/s.

6. 1947-1951 : Equipment located at Malta.

7. Equipment (*a*) : The 5 frequencies every hour at the hour : 1947 to date.

Equipment (*b*) : Above programme proposed.

8. 1947-1951 equipment (*a*) : D.S.R.I. Special Report n° 26 (R.R.B.).

1951 to date equipment (*a*) : Data available but unpublished.

Equipment (*b*) : Data not yet available.

9. D.S.I.R., Radio Research Station, Slough, Bucks., Great-Britain.

10. March, 1956.

Delhi

1. N 28°38′ E 77°11′.

2. +18.8° 149.2°.

3. Field-strength of slow-speed Morse signal giving 95 % intelligibility through the noise.

4. Thomas equipment : vertical aerial (6 m), preampli. with 2-20 Mc/s filter, superhet. receiver, signal generator, keying unit. Aural indication of level using headphones, manual operation.

5. 2.5, 5, 10, 15, 20 Mc/s ; bandwidth 6 kc/s.

6. —

7. Aug. 1945-Aug. 1947 : 4 frequencies (2.5, 5, 10, 15 Mc/s), hourly, at the hour.

March 1951-June 1951 ; Oct. 1951-May 1952 ; May 1953-Febr. 1956 : 5 frequencies hourly at the hour.

8. March-Nov. 1951 : 2.5 and 5 Mc/s : D.S.I.R., Special Report n° 26 (R.R.B.).

Nov. 1951 to date : data available, but unpublished.

9. D.S.I.R. Radio Research Station, Slough, Bucks., Great Britain.

10. March, 1956.

Dourbes

1. N 50°06′ E 04°35′

2. +51.7° (1956) 88.7° (1956).

3. Automatic recording of atmospherics.

4. Narrow-beam direction-finder (Lugeon-Nobile).

5. 27 kc/s ; bandwidth 2 kc/s.

6. —

7. 00, 06, 12, 18 G.M.T.

8. —

9. Institut Royal Météorologique de Belgique, 3, Avenue Circulaire, Uccle, Belgium.

10. August, 1956.

DUNEDIN

1. S 45°53′ E 170°35′.

2. −51.0° 250.1°.

3. Whistlers and dawn chorus, occurrence and dispersion.

4. Large loop aerial, audio-frequency amplifier and tape recorder.

5. 1-7 kc/s.

6. Wellington, Unalaska.

7. 4 minutes every 3 hours, commencing at 0235 UT (2 days per week).

8. Available on request.

9. The Secretary, New Zealand I.G.Y. Committee D.S.I.R. P. O. Box 8018, Wellington, New Zealand.

10. April, 1956.

DUNSTABLE

1. N 51°53′ W 00°33′.

2. +52.7° 83.7°.

3. Direction of arrival of atmospherics. Plotting centre for cathode-ray direction-finding network.

4. Twin channel cathode-ray direction finder, type RRO, Mark III.

5. 18 kc/s — bandwidth 300 c/s.

6. Leuchars, Camborne, Hemsby, Irvinestown —10 to 00 minutes :

7. April to Sept., 0430, 0600 and hourly to 2100 U.T. Oct. to March, 0600 hourly to 2100 U.T.

8. Position of storm centres up to 1500 km radius from network disiminated via International Met. Channels.

9. The Director, Meteorological Office M 012, Dunstable, Bedfordsh., England.

10. March, 1956.

DURBAN

1. S 29°51′ E 31°03′.

2. —31.3° (1956) 93.3° (1956).

3. Wave forms.

4. Oscillographic and magnetic tape recording.

5. Up to 50 kc/s.

6. Bernard Price Institute, Univ. of Witwatersrand, Johannesburg.

7. During summer months.

8. Quarterly Journal of Royal Meteorological Society.

9. Professor of Physics, University of Natal, Durban, Union of South Africa.

10. August, 1956.

C. C. I. R.

C.C.I.R.-U.R.S.I. Joint Study Group

SUMMARY RECORD OF THE FIRST MEETING

23 August 1956, at 9.30 a. m.

Chairman : Dr. R. L. Smith-Rose

Present : Representatives of the United States of America, France, Italy, Netherlands, P. R. of Poland, Federal German Republic, F. P. R. of Yugoslavia, Roumanian P. R., United Kingdom, Sweden, Czechoslovakia, and U.S.S.R.

International organizations represented : C.C.I.R., I.B.O.

Agenda :

1. Report by the Chairman on the work of U.R.S.I. of interest to the C.C.I.R.
2. Questions of interest both to the C.C.I.R. and U.R.S.I.
3. Other business.

The Chairman described the organization and the activities of the U.R.S.I. as well as the relations existing between that and other similar international organizations. The problems entrusted to Commissions I, II, III and IV of U.R.S.I. were of great importance to the C.C.I.R. and were being dealt with in greater detail.

In reply to a question from Mr. P. Beckmann regarding the deadline for the submission of documents for the General Assembly of U.R.S.I. to be held at Boulder, Dr. Smith-Rose stated that, as far as he knew, it was customary to submit documents 6 months before the opening of the General Assembly which in that instance was to be held on 22 August 1957.

At the Chairman's suggestion, it was *agreed* that a delegation consisting of one representative from each national delegation be appointed to represent the C.C.I.R. at the General Assembly of U.R.S.I. The members chosen were :

H. E. Dinger. — United States of America.
B. van der Pol. — C.C.I.R.
B. Decaux. — France.
M. Boella. -- Italy.
S. Namba. — Japan.
T. R. Clarkson. — New Zealand.
F. L. Stumpers. — Netherlands.
P. Szulkin. — Poland.
A. Heilmann. — Federal German Republic.
D. Bajic. — F.P.R. of Yougoslavia.
R. L. Smith-Rose. — United Kingdom.
S. Gejer. — Sweden.
E. Metzler. — Switzerland.
J. Stransky. — Czechoslovakia.
V. I. Siforov. — U.S.S.R.

The participants then proposed that the list of questions of common interest (Doc. ADM/48) be extended. In particular, Prof. Boella drew attention to the contribution by U.R.S.I. to Question nº 68, and Mr. Decaux to the contributions to Recommendation nº 118 and Study Programme nº 44.

Mr. van der Mark, on behalf of the Director of the C.C.I.R. who was not present at the meeting, suggested that whenever a matter of interest to U.R.S.I. was dealt with by the C.C.I.R. the relevant C.C.I.R. documents should bear a note to that effect.

Mr. Clarkson proposed that, in the interests of brevity, the C.C.I.R. should refer to U.R.S.I. all problems of a scientific nature. A discussion followed, in the course of which Dr. Smith-Rose, Prof. Szulkin, Prof. Siforov, Mr. Decaux, and Mr. van der Mark stressed that in so delicate and difficult a matter no simple satisfactory solution seemed possible.

It was *agreed* that the best procedure would be to leave the matter to the C.C.I.R. Organization Committee.

It was understood that, if necessary, a further meeting, for which no date was fixed, of the C.C.I.R.-U.R.S.I. Joint Group would be called.

Rapporteur :
K. Bochenek.

Chairman :
R. L. Smith-Rose.

I. G. Y

U.R.S.I.-A.G.I. Committee

BRUSSELS MEETING, AUGUST 29-31 1956

1. The following members, consultants and observers were present :

Members : Sir Edward Appleton (*Chairman*) ;
Dr. L. V. Berkner ;
Father Lejay ;
Dr. D. Lepechinsky ;
Dr. M. Nicolet ;
Mr. J. A. Ratcliffe ;
Mr. A. H. Shapley ;
Col. E. Herbays ;
Dr. W. J. G. Beynon (*Secretary*).

Consultants : Dr. Y. Aono ;
Dr. P. Herrinck ;
Dr. M. G. Morgan ;
Mr. W. R. Piggott ;
Dr. K. Rawer.

Observers : Dr. W. G. Baker ;
Dr. W. Becker ;
Mr. J. Bertrand ;
Mr. L. Bossy ;
Dr. P. Bourgeois ;
Dr. R. Coutrez ;
Sir Archibald Day (C.S.A.G.I. Coordinator) ;
Mr. P. Doyen ;
Mr. R. W. Knecht ;
Dr. P. Mange ;
Mr. R. W. E. McNicol ;
Mr. Lu Pao-wei ;
Mr. R. C. Peavey ;
Dr. R. Rivault ;
Dr. Chu Kang-Kun ;
Mr. Chen Chun-Tsi.

Mr. G. M. Brown and Mr. A. J. Lyon also attended as consultants at the invitation of the Chairman.

2. The report and resolutions of the 1955 meeting of the Committee were considered and the following points noted :

(*a*) *Proposed Station at Bogota, Colombia.* — Plans for this station are now in hand in accordance with the Resolution of the last meeting.

(*b*) *Ionospheric Station at Marion Island.* — This recommendation is still under consideration by the South African National Committee.

(*c*) *Ionospheric Station in Java.* — It appears unlikely that this station will be established.

(*d*) *Ionospheric Stations in the Chinese Peoples' Republic.* — Six vertical incidence ionospheric sounding stations will be operating in China.

(*e*) *Atmospheric Noise Measurements.* — A number of equatorial stations are likely to be in operation.

(*f*) *Calculation of Solar Zenith Angles.* — The Secretary of the Committee has circulated all ionospheric observatories inviting co-operation in this work and reported very satisfactory progress in the compilation of a complete set of tabulations.

(*g*) *Drift Intercomparison Experiments.* — Dr. K. Rawer reported the results of an intercomparison between drift measurements made on 14-16 December 1955, at three European stations. This intercomparison had been recommended at the last meeting of the Committee. Observations had been made by the spaced receiver fading method at Cambridge, Kootwijk and Neuf Brisach on E and F layer drifts. The results were rather limited but some points of interest emerged. There was some evidence for correlation between the direction of drift at the three stations and also evidence for a latitude effect in the magnitude of the drift — the average velocities at Neuf Brisach appeared to be lower than at the more northerly stations.

The Committee also considered a letter received from Mr. G. H. Munro stressing the value of intercomparison of ionograms from neighbouring sounding stations for studying ionospheric drifts and suggesting that intercomparison of this kind might profitably be made between stations in the European network. The Secretary reported that this method had in fact been used between stations in Great Britain and that a section on this topic had been inserted in the appropriate I.G.Y. Manual.

3. — World Network of Ionospheric Stations.

The Committee considered certain aspects of the world network of ionospheric stations and recommendations on this subject are contained in Resolutions 1, 2, 3 and 9 (Appendix I).

4. — Preparation of I.G.Y. Ionosphere Instruction Manuals.

The General Editor (W. J. G. Beynon) reported on progress in the preparation of the I.G.Y. Instruction Manuals. Four manuals were now proposed as follows :

Vol. I. « Ionospheric Vertical Soundings ».
Vol. II. : « The measurement of ionospheric absorption ».
Vol. III : « The measurement of ionospheric drifts ».
Vol. IV : « Radio Atmospheric Noise ».
« Back-Scatter Measurements ».

« Whistlers ».
« Radio detection of aurorae ».
« Radio echo meteor observations ».

Manuscripts had been prepared and received on nearly all the above topics. The editing of Vols. I and II, was practically completed but certain parts of Vol. III might need revision. Three of the five sections of Vol. IV had been submitted but were awaiting editing. Copies of lists of contents and of the main parts of the texts were available at the meeting and comments on these were invited.

The Chairman of the U.R.S.I. Sub-Committee on Vertical Soundings reported that the preparation of an atlas of ionograms was in progress. This will be in the nature of a supplement to Vol. I of the Manuals and it was hoped that C.S.A.G.I. would undertake publication of this.

The Committee decided to include in Vol. IV an additional section on « Forward Scatter Observations », and it was suggested that Dr. K. Bowles (Central Radio Propagation Laboratory, Boulder, U.S.A.), should be invited to prepare this chapter).

The Committee expressed appreciation of the editorial assistance given by Mr. G. M. Brown and resolved that he be appointed Sub-Editor of the Manuals.

5. — I.G.Y. IONOSPHERIC STUDIES — PROGRAMMES, ETC. :

(i) *Vertical Incidence Soundings.* — The U.R.S.I. Sub-Committee on vertical incidence soundings (Chairman Mr. A. H. Shapley), submitted a very detailed report on this subject. Considerable progress was reported in the detailed preparations for I.G.Y. Vertical Incidence Soundings including the schedule of observations, characteristics to be scaled and interchanged, list of symbols, etc. An abstract of the report is given in Appendix VI. The full report is published in the U.R.S.I. *Bulletin* (pp. 48-90) and also incorporated in the I.G.Y. Manual, Vol. I.

(ii) *Absorption, Drift and Whistler Measurements.* — Detailed programmes for I.G.Y. ionospheric absorption, drift and whistler measurements have been formulated and are given in Appendices III, IV and V. (See also section 2 (*g*)).

6. — Regional Centres for I.G.Y. Ionospheric Data.

At the 1955 meeting, proposals were drafted for four Regional Centres for I.G.Y. Ionospheric Data, in the longitudes of America, Western Europe, Russia and Japan-Australia. Definite offers to establish Centres had been received from U.S.A. Great Britain and Japan, and the Committee agreed to support proposals that three of the four Centres be respectively at Boulder, Slough and Tokio. (Australia had communicated her agreement that the Ionospheric Centre for that longitude be in Japan. No formal offer had yet been received from the U.S.S.R. but it was assumed that a Centre would be established there).

The proposals drafted by the Committee in 1955 for the functions of these Centres were the subject of a Working Party discussion. There was a degree of disagreement between members of the Working Party on these proposals, particularly in respect of the detailed data to be assembled and handled by the Centres and of associated financial problems. After much discussion the Committee decided to endorse the proposals of last year, subject to certain minor modifications and also to establish a Committee, consisting of representatives of the four Centres, together with representatives of ionospheric organisations to review the actual operation of the proposals for Regional Centres. The nomination of the latter representatives was entrusted to the Chairman of the U.R.S.I.-A.G.I. Committee. A copy of the modified proposals is given in Appendix II of this report. See also Resolution 6, Appendix I.

7. — List of Ionospheric Stations, Tables of Solar and Lunar Data.

The Secretary reported that considerable progress had been made with the collection of tables of solar zenith angle for all ionospheric stations and the Committee decided to invite U.R.S.I. to publish in a single volume a gazetteer of ionospheric stations together with the tables of solar zenith angles and relevant lunar data.

8. — Interchange of Ionospheric Data.

Considerable discussion took place on the existing interchange of ionospheric data and on the need for extending this interchange before the I.G.Y. commences, in respect of both the actual amount of data interchanged and the countries involved in the interchange network. (See Resolution 4). It is understood that this regular interchange of data will continue throughout the I.G.Y.

9. — Amateur Radio Transmitting Stations and the I.G.Y.

The Committee discussed the question of seeking the co-operation of amateur radio transmitting stations for the communication of I.G.Y. scientific data and formulated Resolution 7 on this subject. The following cablegram was also sent the U.R.S.I. delegate to the International Radio Consultative Committee (C.C.I.R.) currectly meeting at Warsaw :

« The question of permitting amateur radio stations to transmit scientific data during the I.G.Y. has been discussed at this meeting of the U.R.S.I./A.G.I. Committee. Apparently under existing international regulations this is not permitted and this Committee strongly urges the C.C.I.R. to make efforts to get this regulation relaxed for the period of the I.G.Y. The problem arises particularly in cases where isolated stations wish to send geophysical data back to the parent organization. The co-operation of all amateurs is being sought for the period of the I.G.Y. and it is felt that they could materially contribute to the scientific programme in the above manner if the regulations were relaxed ».

10. — Long Wave Transmission during the I.G.Y.

A Working Party of the Committee discussed the great value of long wave radio transmissions for certain I.G.Y. ionospheric studies and formulated Resolution 8.

Appendix I

Resolutions

1. — Ionospheric Observations at Marion Island

The U.R.S.I.-A.G.I. Committee reaffirms its Resolution 3 of last year and strongly recommends the South African National Committee to establish a vertical sounding station. The South African Committee is also strongly encouraged to undertake whistler observations at this site, since the location is geomagnetically conjugate to certain stations in Europe.

2. — Whistler Observations at the Geomagnetic Equator

The U.R.S.I.-A.G.I. Committee recommends that additional attempts should be made to observe whistlers at the geomagnetic equator to check the negative results predicted theoreticaly for such locations. For this purpose, it is strongly recommended that standard I.G.Y., whistler stations be established at Huancayo, Peru and at Ibadan, Nigeria.

3. — Resolutions of Arctic Conference

The U.R.S.I.-A.G.I. Committee endorses the resolutions of the recent C.S.A.G.I. Arctic Conference (May, 1956) (1) and especially calls the attention of A.C.I.G.Y. to the following :

V.1. The C.S.A.G.I. Arctic Conference, taking into account the presently available estimates of direction and rate of drift of the several drifting stations in the Arctic Sea planned to be equipped for ionospheric vertical soundings, observes that the distribution of stations would be more uniform and more suitable for the ionospheric program if the sounding station proposed for U.S.A. Ice Floe Station A could instead be put on U.S.A. Ice Floe Station B.

V.2. The C.S.A.G.I. Arctic Conference recommends that all possibilities be explored towards completing the ionospheric vertical sounding network as follows :

1. There is a gap of 7 degrees in geomagnetic latitude between the line of stations along the 10° E meridian headed by Murmansk and Tromso (67° N) and the station planned at Longyeartown, Spitsbergen (74° N). As this gap includes the maximum of the auroral zone, a station on Bear Island (71° N) would be a very important addition to this chain.

2. The chain of stations along the auroral zone maximum itself would be greatly improved by an additional station in the large longitude gap to the west of about 150° W. In this connection, the Arctic Conference feels that possible locations which would help to fill the gap between sub-auroral stations and stations well within the auroral zone in these longitudes are either (*a*) the vicinity of Wrangel Island (or alternatively Cape Schmidt) or (*b*) the region of Taymir.

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(1) Inf. Bul. **98**, 31-32.

V.3. The C.S.A.G.I. Arctic Conference calls the attention of National Committees to the following remarks in the report of its working group on the Ionosphere : « Additional cosmic radio noise absorption observations would be very desirable from any location near the auroral zone. The cosmic radio noise technique seems better suited for a study of auroral zone absorption than the pulse reflection method. Further, it is well adapted for operation at small observing stations as an *auxiliary experiment* to vertical soundings. It would be of especial value if the chain of such absorption stations in Alaska could be duplicated at other geomagnetic longitudes ».

The U.R.S.I.-A.G.I. Committee suggests that such chains might be established in Western Europe and in the U.S.S.R.

4. — Interchange of Ionospheric Data

The U.R.S.I.-A.G.I. Committee draws attention to the fact that a considerable exchange of ionospheric vertical incidence data has been taking place, on an international basis, for many years, with great benefit both to the accuracy of ionospheric predictions and ionospheric research generally. Such a network of exchanges has not, however, included all operating stations the world over.

The Committee therefore recommends to C.S.A.G.I. that all nations should join in this international exchange of ionospheric data as from January 1, 1957, that is, in advance of the I.G.Y. As other stations come into operation they could then join an existing network of interchange. It is considered that such interchange will greatly encourage and assist ionospheric studies in a way which will render the work of the I.G.Y. more fruitful.

5. — Publication of I.G.Y. Ionosphere Manuals

The U.R.S.I.-A.G.I. Committee notes with satisfaction that C.S.A.G.I. has endorsed its proposal that a series of C.S.A.G.I. Manuals should be produced as guides to I.G.Y. radio operating station procedure. Drafts of these Manuals have therefore been prepared and are now in an advanced stage, as follows :

Vol. I : Vertical Incidence Ionospheric Recording.
Vol. II : The Measurement of Ionospheric Absorption.
Vol. III : The Measurement of Ionospheric Drifts.

Vol. IV : Atmospheric Radio Noise, Whistlers, Ionospheric Scatter, Radio Detection of Aurorae and Radio Echo Meteor Observations.

The Committee wishes to stress the urgent need for these manuals to be available in printed or other form, in order that their distribution to distant parts of the world can be ensured well in advance of the beginning of the I.G.Y.

6. — Regional Centres for I.G.Y. Ionospheric Data

The U.R.S.I.-A.G.I. Committee has had many valuable discussions on the interchange of I.G.Y. ionospheric data and on the functioning of the I.G.Y. Regional Centres. It finds the plans prepared by the Committee in 1955 (Appendix I of the 1955 Committee Report) to be quite satisfactory, subject to minor clarifying changes as indicated in the minutes of the 1956 meeting. It is recognised that certain problems still exist especially regarding the financial details of the plan but the Committee believes that these problems can be solved and should not affect the overall objectives of the I.G.Y. plan.

7. — Transmission of Scientific Data by Amateur Radio Transmitting Stations during the I.G.Y.

The U.R.S.I.-A.G.I. Committee strongly recommends that existing international regulations be relaxed for the period of the I.G.Y. so as to permit amateur radio stations to transmit I.G.Y. scientific data. It is recognised that such stations could, in this way, materially contribute to the success of the I.G.Y. programme especially in the transmission of geophysical data from isolated observing stations.

(This resolution has also been forwarded to the International Radiocommunication Consultative Committee (C.C.I.R.) Meeting at Warsaw, August, 1956. Attention is also drawn to Resolutions V.4-V.8 of the C.S.A.G.I. Arctic Conference).

8. — Long Wave Transmissions during the I.G.Y.

In view of the important ionospheric information which can be obtained from observations on very long waves the U.R.S.I.-A.G.I. Committee strongly urges the British Post Office to make available one and the same long wave station (GBR or GBZ) on Regular World Days and Special World Intervals during the I.G.Y.

9. — Ionospheric Drift Observations

The U.R.S.I.-A.G.I. Committee strongly recommends that Ionospheric Drift Observations should be made at Huancayo and that the European group of observing stations be extended by the addition of a station in Southern Italy.

Appendix II

Proposals for I.G.Y. Ionosphere Regional Centres

(Revised at U.R.S.I.-A.G.I. Committee, Brussels 1956)

1. Four Regional Centres shall be established by C.S.A.G.I. at Boulder, Tokyo and Slough and at a location to be specified in the U.S.S.R.

The principal functions of these Centres will be :

(i) to collect all I.G.Y. ionospheric tabulations, graphs and copies of selected ionograms (see 4 below) ; these to be available to research workers at the Centres ;

(ii) to meet requests from bona-fide users for purchasing microfilm copies of tabulations or ionograms ;

(iii) to maintain a complete index of all I.G.Y. ionospheric data.

2. Organisations responsible for ionospheric stations should make adequate arrangements beforehand for ensuring that there is regular preliminary publication of all tabulations from each station from the start of the I.G.Y. To this end it is recommended that organisations appoint the necessary staff before the I.G.Y. commences.

3. Each organisation should prepare monthly tables of hourly values and summaries and where appropriate graphs, containing all the I.G.Y. vertical incidence ($h'f$) ionospheric data for each of its stations and within two months make these available to its Regional Centre and if possible to all other groups on the lines of the existing reciprocal exchange basis.

4. Each organisation should regularly send to its Regional Centre microfilm reproductions at a minimum of all ionograms

taken on Regular World Days, during Special World Intervals or such intervals as may later be specified by the World Day Organisation. The Regional Centre concerned will be responsible for supplying copies to the other three Centres. Requests for copies for other days can be forwarded through the Regional Centre concerned.

5. Tabulations of ionospheric data should be made in a standard form. This standard form, together with full detail of the ionospheric parameters required will be presented in the ionospheric instruction manuals.

6. The final publication will be based on the preliminary reports, as may be organised by C.S.A.G.I.

7. C.S.A.G.I. shall designate the specific Regional Centres and work out with the organisations concerned the details of initiating the data exchange. It is strongly recommended that exchange of tabular data be started as far in advance of the I.G.Y. as feasible.

8. The above proposals refer specifically to vertical incidence ($h'f$) data. Such data form the major part of ionospheri work. It is recommended that the above Regional Centres or Sub-Centres of these be also the Centres for other ionospheric measurements such as absorption, drifts, atmospheric noise, backscatter, etc.

9. The operation of the Ionospheric Regional Centres shall be reviewed, when necessary, by a Committee consisting of representatives of the four Centres together with representatives of ionospheric organisations as nominated by the Chairman of the U.R.S.I.-A.G.I. Committee.

Appendix III

I.G.Y. Ionospheric Absorption Measurements Vertical Incidence Pulse Method

1. — Programme

(i) *Choice of frequencies*

It is recommended that as a *minimum* programme all stations should make measurements on two frequencies. One of these is to be 2.2 ± 0.2 Mc/s. If possible measurements should be made on a second E-layer frequency, but if circumstances make it necessary for the second frequency to be a F-layer reflection then it is recommended that this second frequency be chosen to be near that of h'F (the minimum equivalent height of the region).

It is emphasised that the above represents a basic minimum requirement and that stations which normally operate a multi-frequency programme should continue to do so during the I.G.Y.

(ii) *Measurements*

(*a*) *Noon observations.* — First priority should be given to measurements at noon. It is recommended that throughout the I.G.Y. each station should publish indices of ionospheric absorption for each day. These indices are to be near noon measurements centred on 1230 L.M.T. and for stations which can undertake the work a minimum measuring period of one to two hours is recommended. Indices should be given for each 1/4-hour period defined by 00-15, 15-30, etc., minutes past each hour.

(*b*) *Diurnal variation.* — Second priority should be given to measurement of the diurnal variation in absorption. For this purpose it is recommended that stations make hourly observations on Regular World Days at least over the daylight period. The observations to be made in the interval 00-15 minutes past each hour.

(*c*) *Measurements at constant solar zenith angle.* — Third priority should be given to measurements at constant solar zenith angle. It is recommended that each station makes measurements over a period of ½ hour each day throughout the I.G.Y. under conditions of constant solar zenith angle. It is suggested that when possible stations should use frequency 1 in the forenoon and frequency 2 in the afternoon and vice-versa on successive days. The selected solar zenith angle should be the local winter noon value.

2. — Calibration of equipment

The importance of making every effort to obtain an accurate calibration of the measuring equipment and for checking its constancy is stressed. It is recommended that each station makes calibration measurements on one night per week. The measurements should be of one hours duration within the period two hours after sunset to two hours before sunrise. It is emphasised that calibration measurements should be made during an interference free period and that the echo reflections should not be scattered or spread. These calibration measurements are of basic importance to all absorption work and should be accorded equal priority with those made at noon. It is recommended that these night measurements be published together with an indication of the number of multiples present at the time of the observation. With each absorption measurement the value of the calibration constant used in calculating the value should be given.

3. — Stations above latitude 60°

For stations above about 60° latitude the solar control appears to be markedly diminished or even absent. High latitude absorption shows definite correlation with magnetic and auroral activity and experiments have to be planned in this light. For these stations the following amended programme is recommended :

(i) Noon observations on all days and hourly observations on Regular World Days as given in 2 (ii) (*a*) and (*b*) above.

(ii) It is suggested that hourly observations be made at night on as many World Days as possible to study the incidence of corpuscular radiation.

(iii) No constant solar zenith angle observations are recommended.

4. — Presentation of results

(i) *Symbols*

Letter symbols A, B, C, etc., as defined for vertical incidence soundings (Appendix VI, Section 3) are to be used in presenting absorption results.

Additional agreed symbols for absorption work are :

ρ The apparent reflection coefficient of the ionosphere. This is defined as the ratio of the amplitude actually observed to the amplitude which would have been observed if there had been no collisional losses along the wave trajectory.

ρg The apparent reflection coefficient of the ground.

L The ionospheric absorption measured in decibels at a particular frequency.

(ii) *Means and Medians*

Medians of all routine absorption measurements should be circulated. The provision of means in addition is optional.

B, D, *f*E, *f*F1 are treated as high absorption values in computing medians.

F, G and values qualified by X are ignored when computing averages.

Non-numerical observations (e.g.B, D and G) are ignored in computing means.

(iii) *Accuracy*

(*a*) *Heights.* — The equivalent height of reflection should always be measured and the value given with each absorption measurement. The height will usually be the average of that at the beginning and end of the observation and may change during it. Where heights have been measured by techniques involving no systematic error and an accuracy better than ± 2 km they should be given to the nearest km. Otherwise heights are rounded off to the nearest 5 km.

(*b*) *Amplitudes — sampling error.* — An index of sampling error should be included in every absorption measurement. For manual measurements this index is to be the number of individual samples of amplitude made. For continuous measurements this index is to be the number of seconds of recording time divided by five.

(*c*) *Amplitudes — systematic error.* — An index of systematic error is to be included with each sequence of observations (e.g. diurnal or monthly sequence). This index is to be the number of *independent* determinations of the unabsorbed field parameter used in calibrating the equipment.

Appendix IV

I.G.Y. Ionospheric Drift Measurements
Spaced receiver fading method

1. — Programme

(i) Observations should be made on the E-layer and the F-layer.

(ii) 2.2 ± 0.2 Mc/s should be preferred for use on the E-layer (as agreed for work on absorption). For the F-laver the frequency will be chosen to suit local conditions. That corresponding to the minimum virtual height is suggested as suitable.

(iii) Observations should be made on the following days in order of preference :

(*a*) Regular World Days.

(*b*) Special World Intervals.

(*c*) World Meteorological Intervals.

(*d*) Three consecutive days for the middle of each month, according to a programme to be included in the Drifts Manual.

(iv) Observations should be made during periods of 15 minute intervals starting at the following *Universal Times* :

For RWDs and SWIs 00, 01, 02, ... 23
For days listed under (iii) (*c*) and (*d*) 00, 03, 06, ... 21

The observations should extend, if possible, over the whole of the 15 minutes, but at places where other observations have to be made the total recording time may be shorter.

2. — Symbols

In presenting the results of drift observations the symbols to be used are those recommended by the U.R.S.I.-A.G.I. Sub-Committee on Vertical Soundings. (See Appendix VI, Section 3).

Appendix V

I.G.Y. Whistler Measurements

Programme

Minimum and complete programmes will be outlined in the I.G.Y. Manual on Whistlers.

The observing schedule is to be two minutes per hour commencing at 35 minutes past each hour U.T. On World Days, additional two minute schedules commencing at 5 minutes past each hour are to be made.

The Manual will describe and recommend for I.G.Y. use a method of subjective recording developed in the U.S.A. It is recommended that the subjective reports, obtained by listening to all recordings made and copies of these recordings be made available to the appropriate World Data Centre upon request. All recordings made during the I.G.Y. on regularly established schedules are to be preserved.

Appendix VI

Abstract of Report of U.R.S.I.-A.G.I. Sub-Committee on World Wide Ionospheric Soundings

1. The Sub-Committee on World Wide Ionospheric Soundings was appointed in September 1955, by the U.R.S.I./A.G.I. Committee. The report which has been prepared is based on very lengthy discussions at two meetings held in Brussels in 1955 and 1956, together with considerable correspondence between members and consultants. During the meetings the opinions of about 50 stations were directly or indirectly available and members of the Committee have been in touch with the opinions of more than 100 stations. The considerations of the Committee therefore have a very broad base. Only a brief abstract of the report is given here and the full report should be consulted for complete details of the proposals (pp. 48-90).

The change in procedure listed in the report become effective on 1st January 1957.

2. — SUMMARY OF CHANGES OF PROCEDURES FOR IONOSPHERIC SOUNDING STATIONS.

The principal changes and decisions are summarised below :

2.1. *Routine work* :

(*a*) The minimum schedule for making soundings is four per hour, whether to obtain representative hourly data or for studies of details.

(*b*) The *f*-plot is considered the best practical and economical way for the basic reduction of 15-minute soundings and has been adopted as the standard method for interchange of these types of data.

(*c*) Some of the characteristics to be scaled have been modified for the purposes of clarity or to provide more nearly homogeneous data.

(i) *h*'F, or the minimum virtual height of the F region, is to be scaled throughout the 24 hours.

(ii) It has been decided to make the E*s* data more homogeneous by the application of simple selection rules, including the distinction between the components.

(iii) As a separate project, the occurrence of several types of E*s* is to be noted in a way much like that given in the High Latitude Report. The types given are appropriate for the whole range of latitudes.

(iv) M3000 is considered to be the most advantageous parameter for the representative height of the F1 and F2 layers as well as being a transmission factor.

(*d*) The accuracy to which measurements should be expressed are given for frequency and height characteristics, in summary as follows :

0.1 Mc and 5 km for the F region,
0.05 Mc and 2 km for the normal E region,
0.1 Mc and 2 (or 5) km for E*s*,
0.1 Mc for *f*-min.

M-factors are given in units of 0.05.

(*e*) The letter symbols have had their definitions altered for uniformity and clarity, and so that they may apply as well to absorption and drift work. Certain symbols have been dropped and the definition of others extended (see 3 below).

2.2. *Special Work — World Days* :

(*a*) The minimum schedule of soundings for World Days for fast sounders, is five minutes, to be increased when unusual phenomena are noticed to have begun. The schedule for slow sounders exceed that for routine work as may be practical at the station.

(*b*) The first use of these additional soundings on World Days is the timing of discontinuities, such as storm beginnings or phases, SID, etc.

(*c*) Reduction and presentation of special work should generally be by *f*-plot. The *h*-plot (heights) and E-plot (E region structure) are for presentation of auxiliary data. Copies of original reduction sheets but not summary tables, may also be appropriate.

3. — Symbols.

Minor changes in definitions have been made in order to provide one set of standard symbols for virtual soundings, absorption and drift measurements. Other changes are :

(*a*) Four symbols are dropped : K, M, P, Q.

(*b*) The definition of three symbols have been extended : C, G, N.

(*c*) New definitions are given for two symbols : T, U.

(*d*) Three symbols have been added : I, O, X.

The following is the revised complete list of symbols :

A Measurement influenced by, or impossible because of, the presence of a lower thin layer, for example E*s*.

B Measurement influenced by, or impossible because of, absorption in the vicinity of *f*-min.

C Measurement influenced by, or impossible because of, any non-ionospheric reason.

D (*a*) (Preceding a numerical value) *greater than* ...
(*b*) (As a descriptive symbol) Measurement influenced by, or impossible because of, the upper limit of the normal frequency range.

E (*a*) (Preceding a numerical value) *less than* ...
(*b*) (As a descriptive symbol) Measurement influenced by, or impossible because of, the lower limit of the normal frequency range.

F Measurement influenced by, or impossible because of, the presence of spread echoes.

G Measurement influenced or impossible because the ionoization density of the layer is too small to enable it to be made accurately.
(This symbol applies, for example, to the case of *fo*F2 near or less than *fo*F1, or of *fo*E*s* near or less than *fo*E. Do not use this symbol in cases where the lower frequency limit of the recorder gives the limitation, in these cases « E » should be used).

H Measurement influenced by, or impossible because of, the presence of a stratification.

I (Preceding a numerical value) Missing value has been replaced by an interpolated value.

J Ordinary component characteristic deduced from the extraordinary component.

L Measurement influenced or impossible because the trace has no sufficiently definite cusp between layers.

N Conditions are such that the measurement cannot readily be interpreted, for example, in the presence of oblique echoes.

O Measurement refers to the ordinary component.

R Measurement influenced by, or impossible because of, absorption in the vicinity of a critical frequency.

S Measurement influenced by, or impossible because of, interference or atmospherics.

T Value determined by a sequence of observations, the actual observation being inconsistent or doubtful.

U (Preceding a numerical value) Uncertain or doubtful numerical value.

V Forked trace which may influence the measurement.

W Measurement influenced or impossible because the echo lies outside the height range recorded.

X Measurement refers to the extraordinary component.

Y Intermittant trace.

Z Third magneto-ionic component present.

4th September, 1956.

Edward V. APPLETON, Chairman.

W. J. G. BEYNON, Secretary.

FIRST REPORT OF THE SPECIAL COMMITTEE ON WORLD-WIDE IONOSPHERIC SOUNDINGS

Brussels, September 2, 1956

Revised text

(October 10, 1956)

CONTENTS

(Report made to U.R.S.I./A.G.I. Committee and Sub-commission IIIa, U.R.S.I.)

I. — Introduction

The Special Committee on World Wide Ionospheric Soundings was appointed in September 1955 by the U.R.S.I./A.G.I. Committee and directed to consider the revision of the procedures for the production, reduction and presentation of ionograms and ionosphere characteristics. The World-wide Soundings Committee was instructed to invite detailed suggestions from the whole membership of U.R.S.I. Sub-Commission III*a* and other interested parties. This is the first report on this work.

There was a meeting of several members of the Committee in Brussels in September 1955, immediately after its appointment. Subsequent work has been by correspondence between the chairman, members and consultents, which has been circulated throughout the group. There have also been a number of ad hoc conferences. These preparations have culminated in a week-long meeting of the Committee in Brussels, August 27-September 2, 1956, attended by four members, one representative for a member and five principal consultants or their alternates. During this meeting the opinions of about 50 stations were directly or indirectly available. During the year, the members of the Committee have been in touch with the opinions of more than 100 stations, including all networks. The considerations of the Committee, therefore, have a very broad base.

The basis for this report has been assembled by all the members and consultants but the details have been discussed and determined by those attending the 1956 Brussels meetings, in particular Messrs. Aono, Piggott, Rawer, Baker, Becker, Herrinck, Knecht, Rivault, Lyon, and the chairman. The Committee has benefited by the participation of the Chairman of the U.R.S.I./A.G.I. Committees in some of its discussions and all the major points in the report were presented to and approved by that Committee in plenary session. All these many contributions to the work of the Committee are gratefully acknowledged.

The Committee has made plans for further work, in particular the preparation of an album of illustrative ionograms with their interpretation and a further meeting about March 1957 to consider any clarifying adjustments needed in this report. It plans to continue the circulation of opinions and experiences among members, consultants and other interested parties. The changes in procedure listed in this report become effective on January 1, 1957.

II. — General Considerations and Decisions

In its approach to the detail problems of ionospheric soundings, the Committee has been guided by the following general considerations :

1. The Committee sees the importance of taking advantage of the I.G.Y. to clear up inconsistencies in present practices. Considerable difficulties are encountered both at high latitudes and at low latitudes when the practices of medium latitudes are extended and applied to stations in these other regions. It seems appropriate, therefore, to consider these problems on a world-wide basis.

2. Two general uses are being made of ionospheric vertical soundings — studies of the physics of the upper atmosphere and prevision of basic data for radio propagation predictions. It appears clear that as far as the plans of production, reduction and presentation of ionospheric vertical soundings are concerned, the two uses are not seriously in competition and can be served by the same plan. We also agree that the opportunities for unique large seale scientific experimentation during the I.G.Y. should not be neglected, and that the emphasis during this program should be on the scientific studies, making sure, at the same time, that the minimum requirements of the prediction work are satisfied.

3. Our first principle is that a clear distinction should be made between data scaled directly from the ionogram, which should

describe the instantaneous essential features of the ionosphere, and representative data, which should omit the effects of transient phenomena. The extended schedules called for in future work enable this distinction to be made efficiently.

4. We adopt the principle that hourly tabulated data should be both representative and not misleading to those receiving these data alone. This implies that controlled extrapolations should be employed where necessary and suggests several changes in the current practice. In particular the rules governing the evaluation of h'F, h'F1, h'F2 and E*s* phenomena have been thoroughly revised.

5. We adopt the principle that the data should be presented in the most economical manner. This implies that a large proportion will be made available only in graphical form.

6. The aims of vertical soundings work can be categorized into routine work and special work, the special work can further be considered to comprise that which may involve several or all stations, such as on World Days and that which is the concern of an individual station.

7. The routine scalings should delineate the essential features of the ionosphere overhead and should be used initially to produce representative data at relatively infrequent intervals. It is, therefore, desirable to be able to review the consistency of the data before adopting the hourly values. This will normally be possible since the basic routine schedule calls for quarter-hourly soundings.

(*a*) The reduction and interpretation of routine observations is considerably simplified by the use of *f*-plots and much tabulation can be avoided by employing them. In addition, the *f*-plot, while clearly not giving the solution to all difficulties of interpreting ionospheric sounding observation, does certainly help to clarify the distinction between representative data and transient phenomena.

(*b*) Monthly tables of hourly values must be self-explanatory and not misleading. In considering what should be tabulated, it is well to bear in mind that the tabulations are for use by people who will not see the records themselves and who are interested in problems solvable by tabulated data alone.

(*c*) The results expected from the routine work should not be an exhaustive description of the record, that is, the results should represent the essential features of the first order vertical reflection rather than the characteristics of multiples, oblique echoes, transient phenomena, and x-traces, (or faint traces). Multiples, as well as x and z, should be used as auxiliary guides in the interpretation of the first order pattern. Oblique traces should be ignored in the interpretation of f-plots or in the tabulation of hourly values and should be omitted when recognized.

(*d*) The Committee notes that there are many cases where accurate measurement or interpretation is only possible when the traces on the ionogram give some information about the relative amplitudes of the echoes. While realizing that it is impracticable to alter most existing ionosondes, the importance of this point is stressed. In practice this involves designing the receiver of the ionosonde so that it has a wide dynamic range. It is pointed out that can be used for this purpose and this has many advantages for studies at all latitudes.

8. Special work involving several or all stations cannot have such specific objectives as the routine work. It may include work done with ionospheric soundings taken at more frequent intervals, or reductions in greater detail than specified for the routine work. In general, the first reductions will have as their objective a description of the ionogram in an economical and meaningful fashion. Usually this will not involve tables but will be in the form of graphs. Reductions of special work in the form of original graphs or original working tables should be considered suitable for interchange or even publication ; modern methods of copying and reproduction make this a practical approach to the problem of disseminating the results of special work.

9. The programs and procedures detailed in this report must be regarded as minimum. The potential of an individual ionospheric sounding station is unlimited as regards special observations and special reductions, analyses and research. Some suggestions based on the experience of several individual stations are outlined in Appendix 1.

10. The Committee stresses that all stations should be encouraged to scale as many additional parameters as is thought useful

for the station. Those additional parameters required for regional studies, studies of obscure E region phenomena or peculiar local ionospheric phenomena should receive particular attention.

11. The Committee is impressed by the magnitude of the labor and expense of manually retabulating data in the forms most suitable for publication and recommends that the amount of such retabulation be kept to a minimum. There appears to be considerable advantage in using mechanical methods for this purpose and several organizations are already using processes.

12. The Committee has leaned heavily on the first report of the Special Committee on High Latitudes (*U.R.S.I. Information Bulletin*, nº 96, March-April 1956) and especially on the outstandingly successful experience of sounding stations in high latitudes in carrying out the procedures outlined in that report. The Committee agrees with that report. In outlining and unifying the procedures for all stations, the Committee has modified some details of the conclusions of the High Latitude Committee. The changes are summarized in Section III, and only in these respects should the present report be considered to supersede the High Latitude Report.

13. The Committee has adopted the *f*-plot as the standard for reduction of high latitude soundings as prescribed by the High Latitude Report and also for reductions of 15-minute soundings.

14. The Committee has adopted a basic schedule of soundings at 00, 15, 30, and 45 minutes past each hour, using standard meridian times. The recommendations of the High Latitude Committee are adopted for high latitude stations.

15. The Committee stresses the importance that the records at 00 minutes should be taken simultaneously throughout the world.

16. The Committee has adopted more frequent schedules for World Days and Special World Intervals, in order to investigate the exact time relations and detailed development of storm beginnings, SID*s* and similar rapid changes.

17. The Committee is convinced that current methods of analyzing E*s* phenomena are inadequate to enable satisfactory progress to be made and adopts.

(*a*) A standard system of indicating the occurrence of different types of E*s* at all stations so that their incidence throughout the world may be studied.

(*b*) Rules restricting the E*s* traces which should be measured so that the tabulations of *f*E*s* produced by all stations will be more compatible.

(*c*) Rules for distinguishing between the ordinary and extraordinary wave reflections so that the data are more consistent.

(*d*) A new symbol *fo*E*s* to denote *f*E*s* when measured according to these rules.

18. The Committee has adopted *fo*E*s*, *fb*E*s* and *h'*E*s* as standard E*s* parameters to be scaled at hourly intervals at all stations.

19. In addition, the Committee stresses the need for special measurements at individual stations to study the variations in the structure of E and E*s* phenomena and provides a new type of graphical analysis, the E-plot, for this purpose.

III. — Summary of Changes of Procedures for Ionospheric Soundings Stations

While this report calls for many changes of important details and a few quite noticeable changes in procedure compared with present practice, the main results should be to improve the accuracy, uniformity and efficiency of use of the data without changing the continuity of important parameters to a significant extent. The additions are necessary to fill the gaps in the plans for world-wide experiments. The principal changes and decisions are summarized below. Necessary details are included in other sections of the report.

1. *Routine work* :

(*a*) The minimum schedule for making soundings is four per hour, whether to obtain representative hourly data or for studies of details.

(*b*) The *f*-plot is considered the best practical and economical way for the basic reduction of 15-minute soundings. It is also essential for the production of representative data in high latitudes. The *f*-plot has, therefore, been adopted as the standard method for interchange of these types of data.

(*c*) Some of the characteristics to be scaled have been modified for the purposes of clarity or to provide more nearly homogeneous data.

(1) *h*'F, or the minimum virtual height of the F region, is to be scaled throughout the 24 hours. *h*'F2 is scaled only when F1 and F2 are distinguishable as separate layers ; *h*'F1 is no longer tabulated separately. Scaling of these characteristics is made optional for high latitude stations as specified in the High Latitude Report.

(2) It has been decided to make the E*s* data more homogeneous by the application of simple selection rules, including the distinction between the components. Data reduced under these rules will be tabulated under the characteristic *fo*E*s*. The other adopted E*s* characteristics, *fb*E*s* and *h*'E*s*, are to be scaled from the same trace as *fo*E*s*.

(3) As a separate project, the occurrence of several types of E*s* is to be noted in a way much like that given in the High Latitude Report. The types given are appropriate for the whole range of latitudes. There are a total of 9 types, with no more than five probable at any single station. Those types supersede those given in the High Latitude Report but the change will not produce a significant discontinuity in the series of data.

(4) M3000 is considered to be the most advantageous parameter for the representative height of the F1 and F2 layers as well as being a transmission factor. M1500 is dropped from the characteristics for international interchange.

(*d*) The accuracies to which measurements should be expressed are given for frequency and height characteristics, in summary as follows :

0.1 Mc/s and 5 km for the F region.
0.05 Mc/s and 2 km for the normal E region,
0.1 Mc/s and 2 (or 5) km for E*s*,
0.1 Mc/s for *f*-min.

M-factors are given in units of 0.05.

(*e*) The letter symbols have had their definitions altered for uniformity and clarity, and so that they may apply as well to absorption and drift work. Symbols K, M, P and Q have been dropped from the international list. The definitions of symbols C, G and N have been extended. Symbol T has been redefined in accord with the High Latitude Report. Symbol U has been redefined as a symbol preceding a numerical value indicating the value is uncertain or doubtful. Symbols D, E and I have also been designated as preceding symbols so that all mathematical signs and brackets formerly used in tables will be indicated by letter symbols. Symbols O and X have been added.

2. *Special Work — World Days.*

(*a*) The minimum schedule of soundings for World Days for fast sounders is five minutes, to be increased when unusual phenomena are noticed to have begun. The schedule for slow sounders should exceed that for routine work as may be practical at the station.

(*b*) The first use of these additional soundings on World Days is the timing of discontinuities, such as storm beginnings or phases, SID, etc.

(*c*) Reduction and presentation of special work should generally be by *f*-plot. The *h*-plot (heights) and E-plot (E-region structure) are for presentation of auxiliary data. Copies of original reduction sheets, but not summary tables, may also be appropriate.

IV. — Soundings Schedules

1. The science of ionospheric vertical soundings has advanced to the point where it can be said with complete confidence that the minimum useful schedule of routine soundings for scientific purposes is four per hour. This conclusion applies to all latitudes and all days. Many ionospheric prediction problems also require this rate of observation. The hourly sounding will usually be analyzed in the greatest detail, the intermediate soundings being examined to assess whether the data are representative. This is essential to establish that the hourly data are sufficiently reliable for comparison with similar results from other stations. Scalings are necessary, of course, whenever inconsistencies are found or outstanding variations are present. Thus stations forced to operate at hourly intervals for practical or economic reasons should strive for alternate solutions to their problems so that they may contribute effectively to the program.

2. Experiments at many stations in widely different parts of the world have shown that an interval of fifteen minutes is sufficient

to define the diurnal variation of ionospheric phenomena without ambiguity and at the same time is usually sufficient to enable the occurrence of transitory phenomena to be recognized. In addition a large majority of existing ionosondes are at present programed or could be programed to a 15-minute schedule.

3. The Committee has, therefore, adopted a basic schedule with soundings at 00, 15, 30 and 45 minutes past each hour for low and temperate latitude stations. Deviations from this schedule should be kept to an unavoidable minimum in order to achieve the objective of simultaneous global observations. It is most desirable that ionosondes now programed to take soundings at intervals greater than 15-minutes be adapted to 15-minute schedules, even if at the cost of some inconvenience.

4. These ionosondes which are at present programed to a 10-minute schedule provide somewhat better sampling of ionospheric phenomena and where programing changes involve serious engineering difficulties, the advantages of simultaneous soundings do not seem overwhelming. However, for the sake of uniformity, these stations ought to take additional soundings as near as practicable to 15 and 45 minutes past the hour on World Days or other special occasions when joint reduction of results at stations within a broad region is relatively important. Further, it seems clear that all ionosondes built in the future ought to be designed to include the possibility of a 15-minute schedule.

5. The Committee has adopted the basic schedule of soundings for stations at high latitudes given in the report of the Special Committee on High Latitudes. This requires soundings at 00, 01, 05, 15, 30, 45, 55 and 59 minutes past each hour for fast recorders. The gain should be optimum for measuring *fo*F2 on all soundings other than that at 01 minutes which should have high gain and 59 minutes which should have low gain.

Slow sounders should be operated as nearly as practical to this schedule, for example at 00, 05 (high gain), 15, 30, 45, 55 (low gain) minutes past each hour.

6. The reference time for ionospheric sounders is that of the zero meridian (U.T.) although local standard meridian time, differing from zero meridian time by an integral number of hours, is more convenient and should be used in all reports. Alternative

reference systems have been considered, but when advantageous are too complicated to be practical. The nominal time of a sounding is defined as the time when the ionosonde records the standard frequency 3 Mc/s. The nominal and schedule time of sounding should be equal within 0.5 minutes.

7. In regard to the I.G.Y. World Days program, an important aim of the Regular World Days and Special World Intervals is to have an exact time comparison and detailed development of events such as storm beginnings, rapid movements, S.I.D., etc. The special schedule, on such days, is soundings every five minutes. When, by monitoring the observations, the observer recognizes unusual phenomena taking place, the rate of observations should be made on a faster schedule and preferably continuous runs (on small size film). Criteria for recognizing unusual phenomena are determined from experience at the station with observations on ordinary days. The clues will include rapid changes in one-half hour or less of *fo*F2, *fo*E*s*, *f*-min or type of E*s*, unusually depressed *fo*F2 values or the presence of unusual echo patterns. The continuous films will be used to identify exact time intervals and will not be reduced in detail except at special request.

In the cases where radio interference or a similar reason precludes a complete program, special efforts should be made to extend the reduction of the records available so as to provide the fullest data for scientific purposes.

V. — Characteristics to be Scaled

A. *General* :

1. Most ionograms contain an immense amount of information about the conditions in the ionosphere, but this information is in a form which is prohibitively inefficient for many important investigations. It is therefore necessary to select certain features of the ionogram which are particularly significant for scientific or operational studies and to develop techniques for evaluating their characteristics. This process is called « scaling the ionogram ».

2. Clearly there are two main steps in the scaling process :

(*a*) The selection of significant parameters ;

(*b*) The formation of rules for recognizing and measuring the significant parameters.

B. *The selection of significant parameters* :

1. The selection of significant parameters is always an arbitrary process determined, finally, by the purpose for which the selection is made. In practice it is also highly influenced by the case of measurement; for example, a highly significant parameter which is very difficult to measure may often be replaced by a less significant one which is easy to measure. This greatly increases the efficiency of the research as a whole.

2. The scientific principle, that experiments should be planned so as to give the greatest amount of usable information for the least effort, is crucial when deciding both the content and the form of the reduction of ionograms.

3. The principle that all available information should be published, clearly implies duplicating the original ionograms and need not be considered further in this section.

4. There are several difficulties in applying these principles to world-wide investigations.

(*a*) A decision must be made that certain phenomena are more important than others. This may well be controversial;

(*b*) Phenomena which are very important in some zones of the world can be almost or completely absent elsewhere;

(*c*) Parameters which are significant and easy to measure in some areas are unreliable or very difficult to measure in others.

5. This suggests that it is very desirable that three levels of selection should be made :

(*a*) Parameters required all over the world;

(*b*) Parameters required for regional studies;

(*c*) Parameters required for local studies at the station.

6. We are mainly concerned with group (*a*) in this report. An excellent example of a plan for regional studies is the Report of the High Latitude Soundings Committee. Some suggestions for local studies are put forward in Appendix I.

7. The operational requirements of the prediction services demand that *fo*F2, (M3000)F2 and a reasonably significant value for *f*E*s*, or parameters which can be converted into these, must be available from all stations. The first two of these are widely

recognized as important parameters for scientific research also, but *f*E*s* as scaled at present, can be very misleading for both purposes.

8. We conclude that it is essential to improve the significance of *f*E*s* and propose that *f*E*s* deduced according to the new rules given below be denoted by *fo*E*s*.

9. The Committee adopts *fo*F2, (M3000)F2 and *fo*E*s* as the most important parameters for world-wide reduction and circulations. The numerical values of these parameters should be circulated in the form of monthly tables of hourly values so as to be convenient for manual investigations.

10. It should be noted that the M3000 factors are mainly determined by the height of the maximum ionization density of the layer and are the most convenient parameters for studying the world-wide variation of this quantity.

11. Subject to certain limitations, summarized in the section on scaling practices below, there is general agreement that the important parameters for world-wide reduction and circulation are : *fo*F2, (M3000)F2, *fo*F1, (M3000)F1, *fo*E, *fo*E*s*, *fb*E*s*, *f*-min, *h'*F2, *h'*F, *h'*E, *h'*E*s*.

Numerical values of these parameters at hourly intervals should be obtained but the form in which they are circulated should be determined by the requirements of efficiency. In addition, it is most important that the incidence of the different types of E*s* phenomena be studied on a world basis. This calls for a new parameter for world-wide reduction and circulation, the E*s*-type.

12. We draw attention to the probable advantage of scaling, on a regional basis, those parameters which show regular variations, e. g. *fo*F1 ½ at low latitudes.

13. The Committee, after full discussion, concludes that it will usually be most efficient to reproduce data obtained more frequently than at hourly intervals by graphical means.

C. *Scaling practices — General* :

1. The scaling practices in use at present have been developed largely for the relatively simple ionograms obtained at temperate latitudes. This has produced a number of simple, pictorial concepts, e.g., the critical frequency, the minimum height, the

top frequency of an E*s* trace. The scaling rules are then based on a comparison of the actual record and the idealized model. This technique has proved far from satisfactory for world-wide use.

2. Attempts to apply these methods at high and low latitudes rapidly run into serious difficulties and it is by no means obvious how the matching is to be done. The change in ionospheric conditions also raises major problems of continuity, e.g. when there is multiple stratification in the F2 region which critical frequency should be scaled as *fo*F2 ?

3. A close study of the phenomena shows that much of the complexity is due to the fact that the temperate latitude pictorial model is oversimplified and does not correspond directly with the reflection phenomena to be expected from mixed thick or thin layers. Thus the actual traces are modified in different ways depending on which of the ignored factors has become effective. It is possible to have two ionograms which look superficially similar but which demand different treatment because the traces have been modified in different ways.

4. A logical basis for interpreting such cases has been developed by Rawer and his collaborators (*J. Atmos. Terr. Phys.*, **6**, 69-87, 1955) and has proved valuable in the development of the scaling rules given below. Tests with different ionograms have shown that this approach is very powerful.

5. Scaling practices fall into two groups.

(*a*) Selection and exclusion rules which enable the required parameter to be identified with acceptable consistency.

(*b*) Measurement and interpolation rules which enable the parameter to be measured most accurately and enable the accuracy to be controlled.

6. Selection of rules for local investigations may well differ considerably from those used in the world-wide system but it is *essential* that measurements of the parameters selected for world-wide reduction and circulation are done in the same way everywhere.

7. The rules given below should, therefore, be strictly observed by all stations when reducing the standard parameters for world-wide circulation.

D. *Selection and exclusion rules* :

1. The following traces are ignored for the basic scaling of ionograms.

(*a*) Traces due to oblique transmission.

(*b*) Trace due to transient phenomena.

(*c*) Traces due to very weak reflections.

Multiple echoes should be examined or scaled when necessary to confirm the interpretation of the first order trace, but are not included in basic summary tables or graphs.

2. All numerical observations refer to the ordinary wave trace. The extraordinary wave trace may be measured when the ordinary trace is not available or is inaccurate, and the equivalent ordinary wave parameters computed and tabulated (use of symbol J).

3. With graphical analysis the critical frequency of both traces, at least for the F2 layer, should be shown whenever they appear, to avoid any danger of misinterpretation.

4. Traces due to oblique transmissions and transient phenomena are most readily recognized by comparisons with most of the common standard types shown in the manual. Detailed examination of closely spaced sequences of records and other special experiments are also useful. It is recommended that each station build up its own library of difficult records with their interpretations and draws on the experience of other groups of workers.

5. Weak traces seldom represent phenomena which can be studied efficiently on a world-wide basis using standard ionosondes. Even when they appear regularly at the stations, they rarely represent normal reflection in the ionosphere. They should be studied as a special research. The following cases are important in practice :

(*a*) Echo traces corresponding to a very low reflection coefficient (reflection loss exceeding about 40 db) which are found rather frequently at heights below 100 km, e.g., « trailing echo », « meteoric E ».

(*b*) The very faint F-region scatter, observed on certain nights at equatorial stations, having similar reflection losses.

(*c*) The very faint F-region scatter sometimes observed at high latitudes (see High Latitude Report). This should not be confused with faint traces due to absorption.

E. *Scaling practices for Virtual Heights* :

1. The minimum virtual height of reflection can only be determined at a point where the trace is essentially horizontal. In general, minimum virtual heights should not be scaled unless this condition is met.

2. In certain cases useful information can be obtained even when the trace is not horizontal. These occur when the trace is blanketed by a lower layer or is still falling at the lowest frequency of the ionogram. In these cases the minimum height observed should be qualified with the « preceding » symbol E (see Section IX) and interpreted « minimum virtual height less than ... ».

3. The current practice for defining and tabulating *h*'F1 and *h*'F2 causes considerable confusion and is often misleading. It also cannot be readily extended to apply to the more complex structures found at high and low latitudes.

4. After full discussion the Committee adopted the following conventions to simplify this problem.

h'F : The natural and most significant F region virtual height parameter is that for the lowest F region stratification. This will be denoted by *h*'F. Thus *h*'F is identical with the current *h*'F2 when F region stratification is absent, e.g., at night, and with the current *h*'F1 when F1 stratification is present.

h'F2 : The minimum virtual height, *h*'F2, refers to the highest stable stratification observed in the F region and can only be scaled when such stratification is present. The general scaling rules (1) and (2) immediately above, apply.

We note that when the trace shows an inflection point with a horizontal tangent *h*'F2 can be determined ; if it shows an inflection point without a horizontal tangent, no measurement is possible and the symbol L alone is used. As noted above transient stratifications are to be disregarded in routine scaling, indicated by the symbol H.

5. As a consequence of the conventions *h*'F1 falls into disuse.

6. The problem of qualifying *h*'E*s*, when the low frequency end of the E*s* trace is affected by group retardation and the trace does not become horizontal, has been solved by generalizing the meaning

of G which may be used either as a qualifying or replacement symbol in this case.

F. *Corrections for critical frequencies* :

1. The critical frequency of the highest stratification observed in the F region is to be called the F2 critical frequency.

2. The F1 critical frequency at low and high latitudes is to be identified by the conditions of continuity with F1 at temperate latitudes.

3. The generalized forms of the symbols now apply to all layers. (See Manual).

G. *Characteristics of* E*s* :

1. Since there is no generally accepted theory and very little homogeneous data about the characteristics of E*s*, both the selection of the significant parameters and the formation of rules for recognizing and measuring them have to be decided.

2. It is clear that a complete description of E*s* phenomena is impracticable in tubular form, and hence detailed research on E*s* calls for the development of special techniques. We indicate a possible method in Section VI. It is desirable, however, that all stations should provide E*s* data from which the characteristics of some of the main forms of E*s* can be delineated.

3. After discussion of the phenomena observed at the majority of stations, the following conclusions were reached :

(*a*) That the usefulness of the parameters *f*E*s* could be greatly increased if it could be measured in a more uniform manner at all stations by applying simple selection rules.

(*b*) That the blanketing frequency *fb*E*s* provides a valuable practical indication of the lower limit of the operational E*s* MUF and is therefore important for prediction work.

(*c*) That the comparison of the relative magnitudes of *fb*E*s* and *f*E*s* would give much useful information about the world-wide variations in E*s*.

(*d*) That the current practice at many stations of measuring *h'*E*s* using a different E*s* trace than that used for *f*E*s* is misleading and inconsistent and should definitely be abandoned.

4. It was therefore decided that *f*E*s* should be redefined so as to reject some types of E*s* phenomena. At the same time it became

clear that a considerable increase in homogeneity could be obtained if all *f*E*s* measurements could be adjusted so that they referred either to the ordinary or extraordinary wave.

5. After detailed discussion it was decided that the *f*E*s* measurements should refer to the ordinary wave component, thus making the convention consistent for all ionospheric parameters.

6. Our general principle of reducing the traces from reasonably strong echoes only applies particularly in the case of E*s*, and our convention suggests that a convenient symbol for the new parameter would be *fo*E*s*.

7. We thus have a more consistent parameter for measuring the highest frequency of E*s* which may be expected to be useful for both predictions and scientific work.

8. Our conclusion (Para 3. (*b*)), implies that it would be valuable to have world-wide measurements of the blanketing frequency of E*s*, i.e. *fb*E*s*. Clearly *fo*E*s*, *fb*E*s* and *h'*E*s* should be scaled from the same E*s* trace.

9. Thus we arrive at 3 E*s* parameters :

*fo*E*s* : The ordinary wave top frequency corresponding to the highest frequency at which a mainly continuous trace is observed.

*fb*E*s* : The lowest frequency at which E*s* is effectively transparent ; this is usually judged from vertical incidence reflections obtained from a layer at greater height than that to which *fo*E*s* applies.

*h'*E*s* : The lowest virtual height of the trace used to give the *fo*E*s* and the *fb*E*s* data.

10. The selection rules for *fo*E*s* become :

(*a*) Ignore all very weak intermittent reflections (e.g. those qualified by Y).

(*b*) Ignore all traces which indicate oblique reflections.

(*c*) Ignore all rapidly varying transient phenomena.

Note that for fast recorders meteor traces which would otherwise resemble an E*s* trace can often be identified by the occurrence of fairly regularly spaced fading. These traces should be ignored.

(*d*) Ignore all traces for which *f*E*s* is less than *fo*E.

(*e*) Select from the remaining traces the one which is mainly continuous to the highest frequency. This trace should be used to determine *fo*E*s*, *fb*E*s* and *h'*E*s*, and for convenience, will be called the E*s* trace. The highest frequency to which the trace is continuous may be called its top frequency.

(*f*) The current meaning of « mainly continuous » should be used as in (*e*) ; i.e. a break in the trace which can be ascribed to an occasional fade is ignored if the trace continues regularly beyond the break.

11. The rules for determining *fo*E*s* are :

(*a*) When the ordinary and extraordinary E*s* traces are both visible :

(1) If the top frequency of the ordinary component can be determined this is the required value of *fo*E*s*.

(2) If the top frequency of the ordinary component is doubtful (e.g. S) the top frequency of the extraordinary component is measured and *fo*E*s* deduced using the usual formula *fo*E*s* = *fx*E*s* — *f*H/2. Such values should be qualified by J.

(*b*) When the ordinary and extraordinary E*s* traces are not both visible it is necessary to look at the *h'f* pattern as a whole and to decide whether the trace seen is an *o* or *x* trace. The following rules may be used when the right decision is not obvious from the ionogram :

(1) Night :

(i) If the top frequency exceeds the gyrofrequency, the trace is an extraordinary trace : correct as in (*a*) (2).

(ii) If the top frequency is below the gyrofrequency the trace is an ordinary trace : scale directly.

(2) Day :

(i) When the top frequency greatly exceeds *fo*E (see Note I) assume it to be extraordinary : correct as in (*a*) (2).

(ii) When the top frequency is close to *fo*E assume it to be ordinary : scale directly.

Note 1 : The approximate point of the division should be established by inspecting the ionograms at similar times and noting the lowest frequency at which extraordinary reflections are normally recorded. In practice the number of doubtful cases is very few.

Note 2 : It is most important that tabulations of *fo*E*s* should be obtained strictly according to these definitions and selections rules. E*s* data obtained in any other way should be classified using the old nomenclature, e.g. *f*E*s*, etc.

H. *Classification of « Types of* E*s* » :

The lack of knowledge about E*s* suggests that a classification of the types of E*s* could be most useful, especially for scientific work. The classification must be such that the differences between types are clearly apparent on the ionogram. Also, unless the classifications correspond to some physical distinctions, they are of little use for scientific purposes. It is further desirable to have the same classification system for all latitudes, even if all classes are not observed at all locations.

The High Latitude Committee has previously proposed to call any case of a thick occulting layer in the E region simply the E layer ; the corresponding critical frequency being scaled as *fo*E. This proposal is in complete agreement with the general philosophy adopted by the Committee ; namely to describe the ionosphere overhead with a minimum of pre-judgment. Thus the case of a thick occulting layer, even when occurring at night, is eliminated from the E*s* tabulations as well as from E*s* classification.

It is felt that not all of the four E*s* classes proposed in the High Latitude Report are in agreement with the general conditions given above. The type E*sm* (E*s* with one or more multiples), for example, represents a phenomenon, the appearance of which is highly influenced by absorption conditions. The classification E*sm* is, therefore, being dropped but provision is made for indicating the presence of multiples when they are a predominant feature on the ionogram. Also, a classification system is most useful, when the majority of cases can be put into well defined classes. The « unclassified » type is better restricted to cover only very rare cases falling outside of what is usually observed.

The following two classes of the High Latitude Report are retained :

r : (retardation) — non-blanketing E*s* with group retardation at the high frequency end. Group retardation showing on the E*s* trace, but not on the F trace at the corresponding frequencies. This is usually restricted to night time at high latitudes. See figure 1 for illustration of this type and those that follow.

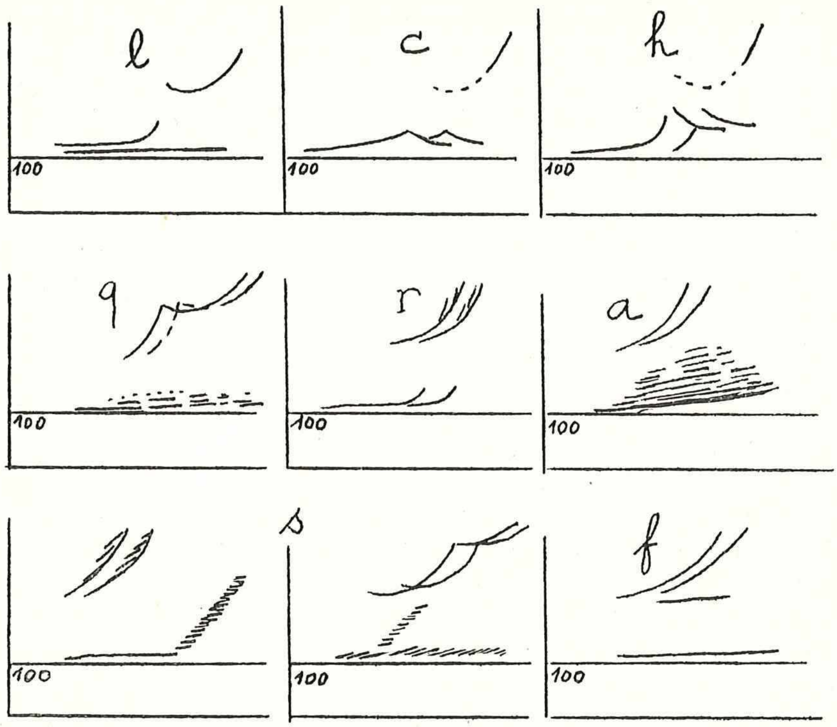

Fig. 1. — Types of E*s* (1).

l : (low) — E*s* below the regular E layer minimum virtual height. During the night, or during the daytime when regular E is absent, this includes E*s* at virtual heights of less than 100 km.

Extending the reasoning of this latter definition, it seems reasonable to introduce two other classes for the daytime :

c : (cusp) — E*s* between the minimum virtual height of the regular E layer and the height of maximum electron density. This appears as an E*s* trace that is usually continuous with the regular E reflection except for a rather symmetrical *cusp* around *fo*E. Sometimes, as when deviative absorption is large, part or all of the cusp may be missing. This type of E*s* may often interfere with the determination of *fo*E.

(1) All E*s* echoes not falling in one of the above categories, shall be classed as type « *n* ».

h : (high) — E*s* above the height of maximum electron density of the E layer. This type is distinguished from the preceding « *c* » type by the presence of a discontinuity *in height* at *fo*E. The cusp is generally not symmetrical, the beginning of the E*s* trace lying clearly above the end of the E trace. Usually no echoes are recorded in the height range between the two high frequency ends of the regular E echo and the beginning of the E*s* cusp. Unlike the « *c* » type, determination of *fo*E is unimpaired.

When regular E is absent, as for most latitudes during the night, the distinction between *c* and *h* cannot be made. The arbitrary distinction based on a certain numerical value of the virtual height which has been used at some stations, has also proved to be unsatisfactory. Thus, the following type is necessary :

f : (flat) — This classification is restricted to that type of E*s* trace which shows no increase in height with frequency. It is relatively thick with well defined upper and lower edges. This classification should *not* be used if the regular E trace is visible.

Besides the main classes *l*, *c*, *h*, and *f*, which will normally be sufficient for medium latitudes, three other classes seem useful :

s : (slant) — A steadily rising diffuse trace. With normal ionosondes the high latitude slant trace usually rises at about 6 Mc/s from a flat E*s* and extends to a frequency of about 12 Mc/s and a height of 400 km. At equatorial locations the slant trace, also very diffuse, emerges generally from equatorial type E*s* at about *fx*E and extends to about 250 km. (The rising trace alone is classified as *s*, the horizontal trace should always be classified otherwise).

a : (auroral) — This type is mostly seen at high latitudes, usually during the night hours, and has been associated with magnetic and auroral activity. It has a rather well defined, flat or gradually rising lower edge with stratification and diffuse (spread) echo present above it. This sometimes extends several hundred kilometers in virtual height.

q : (equatorial) — E*s* showing a somewhat diffuse trace which is nearly transparent throughout the whole frequency range. The spread is most pronounced at the upper edge of the trace. (This form occurs regularly in daytime in the vicinity of the magnetic equator).

The adoption of these classes leaves only a few E*s* traces which cannot be readily classified. An « unclassified » symbol is introduced for these cases only.

n : (corresponding to symbol N) — An E*s* trace which could not readily be classified. (This class should not be used to cover intermediate cases between any two classes. In these cases a choice between one or the other class should be made).

This classification system is not the only one that would have been possible. Other proposals have been made to use as a criterion the « reflecting power » or the transparency of the layer. With the present differences in ionosondes, however, such distinctions are difficult to standardise for most stations. Also, as these properties are known to vary rapidly with time, it seems more reasonable to use a more phenomenological classification. The above classification distinguishes cases which are essentially different at most times. Of course, intermediate cases exist.

We may note that the so-called « sequential E*s* » will be classified mainly in the class « *h* », but often the final stage of such a phenomenon may be in class « *c* » or even class « *l* ».

Thepro posed classification is independent of the scaling rules for the characteristics *fo*E*s*, *fb*E*s* and *h'*E*s*. Some of the types correspond to traces which need not be numerically scaled. Thus the slant type «*s*» should always be considered as anoblique echo, which is not scaled. If a very weak reflection is evident no scalingis made.

When classifying the E*s* present on an ionogram more than one type can easily be put into the tabulation. Whenever several different E*s* traces are on the record, the corresponding (lower case) letters should all be put into the table. The type corresponding to the trace from which numerical data are taken should, however, always have the first place.

Indication of multiple echoes. — If the appearance of multiple echoes is a prominent feature on the ionogram, then the numerical figure « 2 » should be written after the letter indicating the type, e.g., *f*2. Traces showing only weak first multiples should not be included in this category.

(*Note* : the figure « 2 » is used only for convenience and is not intended to indicate the number of multiple echoes.)

I. *Spread echoes (scatter)* :

1. If the structure of the reflecting layer is inhomogeneous, as it must be in the case when spread echoes exist, it seems likely that oblique echoes will almost always be present. The results of special experiments show that this is usually true.

At any frequency the oblique incidence reflections may appear either above or below the vertical incidence trace. It is probable that the latter case will be found most often at frequencies near the critical frequency, densely ionized patches which are not overhead continuing to reflect on frequencies above the critical frequency. Thus, the usual scaling rule of assuming that the « inner edge » of the scatter gives *fo*F2 has some justification. There are, however, many cases when this rule would cause *fo*F2 to be too small and the rule should only be applied when no other criteria (e.g. a predominant trace in a first or higher order echo) are available. All numerical values should be regarded as doubtful, U ... F.

2. The scatter in the F2 layer found at night at some locations needs special consideration. The present practice is to use the symbol F as a replacement symbol. As a result the great majority of observations (often more than 80 %) are not counted in the median. The resultant median value is often too high, producing a serious anomaly in the apparent diurnal variation at those hours which probably should not be present.

For scientific purposes as well as for communication work, it is important to know whether any median layer structure exists and also the values of its parameters. Let us suppose that such a layer-like structure exists and that the electron density at its maximum is higher than the lower frequency limit of the recorder. In this case, for the lower frequencies, the transmitted energy should be completely returned to the earth by the vertical as well as by the oblique path. Since, at night, absorption can be neglected, it follows that the scatter trace should be relatively strong.

In the typical case of equatorial scatter, however, the diffuse trace is often very faint, corresponding to a reflection loss of 30 db and more. Therefore these traces cannot correspond to a layer structure, but only to a more or less random distribution of relatively widely spread scattering centers. It is, therefore, recommended that such faint scatter traces be eliminated from the routine reduction. As a consequence, *fo*F2, for example, must be scaled as « less than the low frequency limit » (E), and not F when there is good evidence that the reflection is very poor. At night this is probably always the case when the second order echo (multiple) is missing from this type of scatter. Numerical values should only be scaled when a predominant trace, or a second order echo, is visible. On other occasions when equatorial spread is present in the F region echoes, the trace often becomes quite indefinite when approaching the critical frequency. Here one may use the symbol D, « greater than » along with a numerical value of the inner edge and the symbol F. The range of the spread should be plotted (as a dashed line) on the *f*-plot.

E. Extrapolation has been allowed in order to avoid systematic error, for instance, in the presence of transitory deformations, blanketing, or deviative absorption. Limits are prescribed so that the extrapolation is a « controlled » one.

The general accuracy requirements are outlined in Section VIII.

The range of extrapolation is always limited by the rules given in this Section. Thus, for most characteristics, an extrapolation which leads to an uncertainty of more than 5 % should not be made. In this case only the descriptive symbol (in the cases cited above « H », « A » or « R ») should be entered. If the uncertainty lies in the range where the symbol « U » is applied (See Section VIII), the numerical value found by extrapolation should be preceded by « U » and followed by the descriptive symbol giving the reason why extrapolation was made. If it is felt that the possible error is less than the lower limit of this range (generally 2 %), the numerical value found by extrapolation should only be followed by the descriptive symbol. These limitations are normally sufficient to eliminate « improper » extrapolation.

Apart from these general rules, some additional limitations may be necessary for special cases according to station's experience.

VI. — Presentation of Data

1. The results of ionospheric vertical soundings will, in general, be presented and interchanged in the following forms :

(*a*) *Tabulation of hourly values.* — Each table should be complete and meaningful by itself and suitable for analysis without reference to other tables, to *f*-plots, or to the original ionograms. Tables should preferably be in the format which has become customary, and which is described in the I.G.Y. manual, containing hourly values for the given characteristic for a single month. However, it is recognized that many results of ionospheric soundings observations cannot economically or effectively be cast into such monthly tables of hourly values, and in such cases the data should be presented in the most effective manner, such as *f*-plots or daily tabulations of several characteristics. At a minimum, monthly tables of hourly values should be provided for *fo*F2, (M3000)F2, *fo*E*s* ; in almost as high priority are tables for *fo*E, *h*'E, *h*'F and *f*-min.

(*b*) *f-plot.* — The *f*-plot provides an excellent medium for presenting frequency measurements from ionospheric soundings ; it thus eliminates the need for many detailed tabulations and for difficult and often arbitrary decisions on the interpretation of individual ionograms. It also provides a mechanism for partial reduction, in a form with demonstrated scientific usefulness, for as many as 4, 5, or 6 soundings per hour without posing impossibly large problems of data handling.

The *f*-plot is used at all latitudes and key stations for all days. It is also strongly recommended as the basic reduction method for frequency characteristics for stations in all latitudes. It provides the only basis, short of re-examination of the original ionograms, for the scientific investigator or the predictor of ionospheric conditions to form a judgment of the representativeness of any tables of values provided by the original scalers. It also affords the opportunity to apply the special judgment required for the specific problem under investigation. The *f*-plot provides a most valuable aid to the original scalers in deciding on hourly values to be tabulated and gives assurance of the degree of consistency in their work. The *f*-plot should be treated as a step in the process of routine reduction of ionospheric soundings and not as a way of displaying previously tabulated data. Details of the preparation of *f*-plots are outlined below (Section VI.2).

(*c*) *Daily Tabulation Sheet.* — The hourly values of the various parameters as they are deduced from the *f*-plot or scaled directly from the ionograms are commonly recorded on a daily tabulation sheet. The format is not critical. Most stations list the various characteristics horizontally along the top of the table and the hour of the day vertically. It may be convenient to group the columns for those characteristics which are scaled every hour apart from those recorded only during the daylight hours. In the place for each entry, space should be provided for a numerical value, for a preceding symbol (D, E, I, or U), and for a descriptive symbol (A, B, C, etc.).

(*d*) *h-plot.* — Graphs of the time changes of virtual height (*h*-plots) have some of the same advantages as *f*-plots and are the only economical way to express height data scaled from 15-minute soundings. The construction of the *h*-plot is described later in this section.

2. THE *f*-PLOT :

(*a*) *Preparation.* — The *f*-plot is a very efficient, and in many cases the only practical means for recording data taken at more frequent than hourly intervals. Numerical tabulations of 15-minute values, for instance, could become quite laborious. The *f*-plot is also useful in the analysis of difficult sequences and, in general, in the determination of more representative hourly values.

The single most difficult problem in reducing ionograms is to follow an echo trace or characteristic from one sounding to the next in the face of rapidly changing conditions, oblique reflections and spread echoes. This is difficult to accomplish by eye, and such interpretations are usually not subject to check by other observers with more or different experience. Thus, the *f*-plot attempts to solve a difficult sequence of ionograms on a frequency-time graph. When spread echoes occur, the range of possible values of the critical frequency is plotted. Thus the graph is prepared without prejudging for a complex ionogram which is the *o*, *x*, or *z*-trace, or which is an overhead echo and which an oblique. It is usually then possible to sketch the time variation of the ordinary critical frequencies amidst the dots and lines of the plot.

It is the systematic application of this technique which allows the determination of the most representative hourly values of critical frequencies, when they are measurable at all. This representation also gives the range of possible values when no critical frequency is observable and further indicates the degree of variation between hourly values.

The *f*-plot should be in the form of a conventional size graph [see (*b*) below] with frequency as the ordinate and time as the abcissa. It contains the following information :

(1) All F2 critical frequencies or ranges of possible critical frequencies ;

(2) *fo*F1, *fo*E, *f*-min and, when appropriate, *fb*Es ;

(3) Type of E*s* observed.

Critical frequencies when clearly identifiable and of full weight are denoted as follows :

*fo*E, *fo*F1, *fo*F2	open circles
*fx*F2	small *x's*
*fz*F2	small *z's*

Critical frequencies not clearly identified or doubtful are recorded as dots. Spread echoes are represented by a line indicating a range of frequencies. (Similarly a line indicates range in uncertainty of *fo*E). All spreads and critical frequencies of F2 should be shown, even when there is difficulty in distinguishing *o*, *x*, or *z* traces, or even when it is supposed that the echo is oblique. Additional information may be added if it appears to be of help, e.g., *fz*E.

For convenience, the following *f*-plot symbols have been adopted :

« V » to be used on the graph in the same way as the preceding letter symbol « E » (less than) is used in the tabulations. It is primarily used with *f*-min (or *f*-min-F) in the case of interference.

« Λ » to be used on the graphs in the same way as the preceding letter symbol « D » (greater than) is used in the tabulations. It is plotted at the highest readable frequency (usually with *fo*F2) when no definite critical frequency is observed, often because of deviative absorption or interference.

f-min is plotted as a filled circle (necessarily the lowest point plotted on the frequency scale of the graph). This point is joined by a vertical line with the frequency of the lower limit of the recorder. *f*-min-F is plotted as a filled circle when it does not coincide with *fo*E or *f*-min.

The E*s* type should be entered on the same time scale in an appropriate place on the graph or on a small separate graph across the bottom of the frequency plot itself. It should consist of about

5 horizontal lines spread about 3 mm apart, the lines being labeled with the 4 or 5 standard E*s* types most commonly observed at that station. The occurrences of the various types are indicated as a dot at the intersection of the vertical « time » line and the horizontal « type » line.

For convenience, the *f*-plot sheet may have attached a table for recording these characteristics which are tabulated directly from the hourly ionograms but not plotted (i.e., (M3000)F2, (M3000)F1, *h*'F2, *h*'F, *h*'E, *fo*E*s*, *fb*E*s*, *h*'E*s*). At the end of a day's scaling, these characteristics, in addition to the hourly values of the frequency characteristics read or interpolated from the graph, are transferred to a daily tabulation sheet.

All ionograms should be considered when preparing the *f*-plot. Four or five points per hour, when available will usually suffice. Sample *f*-plots are included in Vol. 1 of the manual.

2. (*b*) FORMAT. — The Committee has adopted standards for *f*-plot forms in order to facilitate interchange and intercomparison. After full discussion the Committee has agreed that the frequency scale shall be linear up to 10 Mc/s and logarithmic from 10 Mc/s to 23 or 25 Mc/s such that the scales are continuous at 10 Mc/s. The dimensions are given below. The time scale shall be linear with the scale factor chosen for convenient plotting as given below.

The frequency scale should be uniformly 15 mm per megacycle from 0 to 10 Mc/s. The scale for higher frequencies should be logarithmic such that the ordinate « y » corresponding to a frequency of « f » (Mc/s) is given by the equation :

$$y_{\mathrm{cm}} = 34.54 \log_{10} (f) - 19.54$$

The scale may be carried up to 23 Mc/s or 25 Mc/s according to the size of the paper or the upper frequency limit of the recorder.

Rulings should be at intervals of 0.1 Mc/s up to 15 Mc/s, thereafter at 0.2 Mc/s. Multiples of 5 Mc/s should have heavy lines and multiples of 1 Mc/s, medium lines.

For the time scale, 8 per hour is suggested, with rulings at each quarter hour, the hourly rulings being heavier. Networks that use a sounding interval of other than 15 minutes, such as Australia (10 minutes), should, of course, rule their forms appropriately. It is less important to standardize time scales than to have standards for frequency scales. However, there has been no successful experience reported with time scales of *f*-plots less than 8 mm per hour.

A table for presenting hourly values of characteristics scaled from the hourly ionogram, but not plotted, may be on a lower section, separated from the graph by perforations so that it can readily be detached.

It is strongly recommended that the size of the *f*-plot form for any station should be changed as seldom as possible.

3. THE *h*-PLOT. — A convenient form for the recording of virtual height data, especially if special studies are going to be made, is the *h*-plot. Similar to the *f*-plot, the *h*-plot is a graph of *virtual height* vs. time. It is recommended that the size of the horizontal time scale be the same as that of the *f*-plot, that is, 8 mm/hour. A virtual height scale of 4 cm/100 km will allwo plotting of heights at least to the nearest 5 km with ease. A scale of from 70 to 600 km should be sufficient in most cases. In general, rulings should be made every 15 minutes on the time scale and every 5 km on the height scale. Characteristics that might be plotted on the *h*-plot include *h*'F2, *h*'F1, *h*'E and *h*'E*s* as well as other more transitorial phenomena such as *h*'F1½ and *h*'E2. All conventions used should be explained on the plot.

4. THE E-PLOT. — A convenient method for studying the complex stratifications in the E-region combines the concept of the *f*-plot and *h*-plot with expended scales for the ranges in which E phenomena are observed. There is a common (horizontal) time scale, and two vertical scales : the upper scale, for recording all characteristic frequencies, might range from 0.5 Mc/s to 10 Mc/s ; the lower scale, for recording corresponding virtual heights, might range from 70 to 300 km. Provision for indicating E*s* type or other identification of echoes may be made along the same time scale. The points of measurement should be keyed on height and frequency graphs in an appropriate manner.

Inasmuch as this form is for special studies and research, the details should be worked out to fit the requirements of the station. The Committee will provide illustrative examples at a later time.

5. PUNCHED CARD SYSTEMS. — There exist at least two groups using punched cards for tabulation, checking and statistical

research work. It is known that the French and U.S. groups use essentially the same methods. As standardization is important for rapid and simple exchange, as well as for research work, it is highly recommended that other groups intending to use punched cards should accept those standards whenever possible.

The above mentioned method (the IBM system) uses five digits : first, one letter for the preceding symbol, then three numerical digits, and finally, one letter for the descriptive symbol. No decimal point is given. The three significant digits are given in the following units :

	Unit	Characteristic	Restrictions for last digit
Frequencies	1/10 Mc/s	All characteristic Frequencies except *fo*E and *fo*F1	None
	1/100 Mc/s	*fo*E and *fo*F1	Only 0 or 5 admitted
Factors	0.01	M-3000	Only 0 or 5 admitted
Heights	1 km	All heights except *h*'E and *h*'E*s*	Only 0 or 5 admitted
	1 km	*h*'E and *h*'E*s*	Only add numbers admitted

Details concerning the coding of the cards, the presentation, etc., will be provided in a special annex to this report to be prepared in the near future.

6. Data for True Height Analysis. — A number of organizations plan to undertake calculations of true height profiles of electron density for the ionosphere as a whole. These will usually be done for each hour for selected stations on selected days, and in all cases will be by special arrangement. The data required for such analyses will usually be the virtual height (h') of the ordinary component at intervals of 0.1 Mc/s from f-min to foF2, with the highest relative accuracy possible. The values should be in simple tabular form suitable for transcribing to punched cards or equivalent.

The Committee cannot ever emphasize the importance of such analyses by as many organizations as are able to undertake them. In order that determinations of profiles by different organizations and for different stations may be comparable, the Committee urges that the organizations involved interchange opinions and information on methods. The organizations now known to be undertaking such work are Cambridge University and Pennsylvania State University.

7. MEDIANS AND DISPERSION INDICES. — Monthly medians should be prepared by stations and interchanged for at least the following characteristics : *fo*F2, (M3000)F2 and *fo*E*s*. If at all possible they should also be calculated for the remainder of the characteristics customarily exchanged, namely : *h*'F, *h*'F2, *fo*E, *h*'E, (M3000)F1, *h*'E*s*, *fb*E*s* and *f*-min.

This Committee is in complete agreement with the recommendation of the High Latitude Committee that the quartile range and the number of values be included with the median as a measure of the dispersion. Rules for the computation of the quartile range may be found in 7 (*b*) of the High Latitude Report and in Vol. I of the Manual.

VII. — INTERCHANGE OF DATA AND REGIONAL WORLD CENTERS

1. The foundation of the co-operative plan for interchange of ionospheric data, whether during the I.G.Y. or at any time, is the publication and broad circulation of monthly booklets or reports by individual stations or groups of stations. It is essential that any special arrangements for the I.G.Y. should not interfere with the continuance and the growth of this method for interchange. Nothing in this report should be interpreted as encouragment to reduce the number or content of such booklets nor as a recommendation that booklets for broad circulation should not be started by stations or station groups which have not yet completed plans for so doing. On the contrary, such broad interchange is essential to the carrying out of an effective worldwide program.

2. It is to be expected that these monthly station booklets will include typical *f*-plots and other graphical representation of detailed data in due course.

3. It will be a convenience to all users of monthly station booklets if there is some degree of uniformity in the order of the tables of

hourly values. Unless there are particular reasons to do otherwise, the table for *fo*F2 should come first, followed by (M3000)F2 and *fo*E*s* and the other characteristics for which monthly tables of hourly values are given.

4. The Committee draws attention to the fact that manual retabulation of data is laborious, expensive and often inaccurate and that some centralization or mechanization of the tabulation procedures may be necessary for economy and efficiency.

5. Considering the problem of reproduction of ionograms, the Committee makes the following comments :

(*a*) The re-reduction of records on masse is laborious, seldom attempted and usually inconvenient.

(*b*) The study of original records on a world-wide scale is unlikely to be necessary for more than a few problems and may even then be confined to limited samples of data.

(*c*) For these problems, many of which cannot be foreseen at present, the original ionograms are necessary since all possible parameters cannot be efficiently scaled initially.

(*d*) Special scaling of ionograms will be necessary for particular investigations into the variation of ionization density with true height.

(*e*) There is some danger that original records may not be available in future years unless special precautions are taken.

(*f*) It will be necessary for stations to provide duplicate copies of the selected sequences of ionograms, or alternatively, to forward original ionograms on loan for duplication at a Regional World Center, the originals to be returned as soon as possible. The details of such plans are outside the scope of the Committee.

6. Data to be forwarded to Regional Centers. — A principle of the I.G.Y. is that all data obtained during the I.G.Y. should be readily available for study. Reasonable economy of effort is, however, only possible if the most important data can be studied in more detail and circulated more widely than the remainder. Thus it is necessary that certain parameters should be measured at *all* stations.

(*a*) *Data to be forwarded by all stations* :

(1) Copies of all data published by stations or being circulated

under the existing interchange relations should also be sent to Regional Centers.

(2) All stations should forward the hourly values of the following parameters in the form of monthly summary tables, similar to those in common use for circulation or publication at present.

*fo*F2, (M3000)F2, *fo*E*s*

(3) Hourly values of at least the following characteristics should be made available to the Regional Centers. These values may be in the form of monthly summary tables, daily tables, punched cards or any other convenient numerical form and may be originals, copies or microfilms.

*fo*F2, *h'*F2*, (M3000)F2, *fo*F1, *h'*F*, (M3000)F1, *fo*E, *h'*E*, *f*-min, *fo*E*s*, *fb*E*s*, *h'*E*s*, type of E*s*.

**Note* : *h'*F2, *h'*F and *h'*E are optional for high latitude stations and may be omitted when the height accuracy is inadequate to provide useful information.

(4) All *f*-plots should be sent to Regional Centers in a form suitable for reproduction. All stations produce *f*-plots for Regular World Days, Special World Intervals, and any other occasions on which quarter-hourly or more frequent observations are scaled. For example, high latitude and selected key stations produce *f*-plots for all days.

(5) Each organization will insure that its Regional Center regularly receives or is enabled to produce microfilm reproductions of at least the basic schedule ionograms taken on Regular World Days, during Special World Intervals or such intervals as may later be specified by the World Day organization so that all four Regional Centers may be supplied with copies.

(*b*) *Data to be forwarded if available* :

(1) All data regularly scaled and published, which is not included in Section (*a*) above, in the form most convenient to the station concerned. Indexes of data scaled but not published (the originals to be made available on request).

(2) All means or medians of parameters computed at stations.

(3) All height plots. Height parameters obtained from quarter-hourly ionograms, which are less important than critical frequencies, should be summarized similarly using the analagous *h* plots.

(4) E-structure plots. At stations where regular or transient E region stratification phenomena can be adequately measured, the types, heights, and frequencies observed should be recorded in the form of an E plot. This will normally form part of the program of key stations.

(5) The results of all determinations of the true height profiles.

(6) The dates and time of continuous sequences of observations (e.g. cinema films).

(7) The results of all absorption measurements made as part of the I.G.Y. program, in the form agreed.

(8) Absorption values for all additional regular absorption measurements using other procedures, in the form appropriate to the type of measurement.

VIII. — Accuracy

1. *General.* — The accuracy with which ionospheric heights and critical frequencies can be measured depends on the inherent accuracy of the equipment, the accuracy of the method of calibration and the reading accuracy used in reducing the ionograms.

Since every reduction implies some simplification of the facts and the usable accuracy is often limited by the physical properties of the reflecting layers, it is often most efficient to reduce the reading accuracy for many parameters. Thus it is seldom justifiable to attempt to read the height of F reflections more accurately than to the nearest ± 5 km.

In general the absolute accuracy of virtual height measurements is very much less than the relative accuracy conveniently available. This produces a serious systematic error in all height measurements determined by the particular technique employed.

2. *Accuracy of calibration of ionograms* :

(*a*) The accuracy of frequency markers and of the repetition frequency of the height markers can be easily checked with the aid of a suitable frequency standard.

It is recommended that the accuracy of these scales should be maintained to ± 0.1 %.

(*b*) It is more difficult to establish the correct zero point of the height markers than to maintain the spacing accuracy. Even when automatic synchronization of the transmitted pulse and height markers is used, a systematic error of about 10 km is usually present. This error ought to be eliminated by a suitable calibration procedure (see soundings manual) e.g. by using multiple reflections. For most stations this is not practical. The average corrections should, however, be determined and indicated on all height tabulation summaries.

In addition the position of the lower edge of the trace depends on the amplitude of the received signal. This phenomenon cannot be neglected when accurate height measurements (e.g. $\pm$ 2km) are required and suitable calibration is then necessary (see Soundings manual).

3. *Timing.* — The nominal time for a slow recording is to be defined as the time when the ionosonde records the standard frequency of 3 Mc/s. The nominal time of a group of multigain recordings is that of the medium gain ionogram.

The nominal time and scheduled time of the recordings should differ by less than 0.5 minutes.

4. *Scaling accuracy.* — The following scaling intervals are *desirable* whenever the structure of the ionosphere and characteristics of the ionosonde would allow them to be used.

(*a*) The critical frequencies of the normal E layer and its substructure should be given to the nearest 0.05 Mc/s.

(*b*) All other frequencies should be given to the nearest 0.1 Mc/s or ± 1 % accuracy which ever gives the greater interval.

(*c*) M factors should be given to the nearest 0.05 of the unit.

(*d*) F region heights should be measured to the nearest 5 km.

(*e*) E region heights, e.g. *h'*E, *h'*E*s*, should be given to the smallest interval possible, as follows :

when the scaling accuracy of the equipment is better than ± 2 km, E region heights, should be given to the nearest odd km ;

when the scaling accuracy is better than ± 5 km E region heights should be given to the nearest 5 km ;

when the scaling accuracy is worse than ± 5 km *h'*E should not be recorded, but *h'*E*s* is still valuable for classification purposes and should always be tabulated.

(*f*) When the characteristics of the ionosonde only enable heights to be measured to the nearest 10 km no attempt to tabulate in 5 km intervals should be made.

5. *Uncertain and doubtful values.* — Numerical values which are influenced by certain phenomena are qualified by symbols (see Section VIII).

The following rules should be used :

(*a*) All observations, whose accuracy is within the limits recommended above (Para. 4) are to be tabulated as accurate values and are unqualified.

(*b*) When the scaling uncertainty in the value is outside the recommended limits but is less than ± 2 %, the value is qualified by the appropriate symbol.

(*c*) When the scaling uncertainty in the value lies between ± 2 % and ± 5 % the numerical value must be preceded by U and followed by the appropriate descriptive symbol.

(*d*) When no measurement of the parameter is possible the appropriate descriptive symbol should be used alone.

(*e*) When the scaling uncertainty for a value exceeds ± 5 %, a limit to the possible range of the value may be indicated with the aid of the symbols E or D. Thus if the ionogram indicates that *fo*F2 is hidden by spread echoes (symbol F) but is probably between 4.0 Mc/s and 5.0 Mc/s, the more reliable of D4.OF and E5.OF should be inserted. In practice D is more often applicable at high and medium latitudes and E at low latitudes.

(*f*) When the normal accuracy of the recorder is inadequate to enable the recommended intervals (Para. 4) to be used, the ± 2 % and ± 5 % may be changed so that the normal ionogram is unqualified. A note to this effect should be circulated in this case.

(*g*) For all E region heights other than *h*'E, the presence of scaling errors exceeding ± 5 km should be indicated as in (*c*) above.

IX. — Symbols

A number of modifications in the standard scaling symbols are being made as given in the complete list at the end of this section. The many rather minor alterations in definitions are in order to provide one set of standard symbols for absorption and drift measurements as well as vertical soundings. The other changes, explained in the following paragraphs, are :

(1) Four symbols are dropped : K, M, P, Q.

(2) The definitions of three symbols have been extended : C, G, N.

(3) New definitions are given for two symbols : T, U.

(4) Three symbols have been added : I, O, X.

1. *Symbols dropped* :

K : As a storm is a wide-scale phenomenon, the statement « storm in progress » should not be made on the basis of ionograms at just one station. Also the use of this symbol has been contradictory at the few stations which have employed it.

M : It is no longer important to make distinctions between the various non-ionospheric causes for absence or loss of data.

P : It is more important to use a symbol giving the reason why extrapolation was necessary than to indicate the fact of the extrapolation.

Q : This symbol conveys no useful information. The absence of the layer is sufficiently indicated by a more appropriate symbol or by a blank in the table.

2. *Extended definitions* :

C : Measurement influenced by, or impossible because of, any non-ionospheric reason.

This now covers not only the former meaning of the symbols M and T, but also equipment shortcomings such as uncertainty in height or frequency markers or power variations in the frequency range.

G : Measurement influenced or impossible because the ionization density of the layer is too small to enable it to be made accurately.

This symbol applies, for example, to the case of *fo*F2 near or less than *fo*F1, or of *fo*E*s* near or less than *fo*E. It is also used for absorption or drift work when the critical frequency is near or less than the working frequency.

N : Conditions are such that the measurement cannot readily be interpreted, for example, in the presence of oblique echoes.

This extended definition covers the complex patterns for which some stations formerly used « K ». The symbol applies also to absorption and drift observations. For drift work a more detailed classification with a number annexed to the symbol « N » is given in Vol. III of the Manual.

3. *Symbols with new definitions* :

T : Value determined by a sequence of observations, the actual observation being inconsistent or doubtful.

This symbol should always be used when a representative hourly value is obtained from the *f*-plot.

U : (Preceding a numerical value). Uncertain or doubtful numerical value.

This replaces the round brackets « (—) », a letter symbol being easier to handle, especially for typewriters and punched cards.

4. *Symbols which have been added* :

I : (Preceding a numerical value). Missing value has been replaced by an interpolated value.

Replaces the square brackets « [ ] » for the same reasons as given for « U » above.

O : Measurement refers to the ordinary component.

X : Measurement refers to the extraordinary component.

Both symbols are especially useful for *f*-plots and in absorption and drift work.

5. *Conventions for descriptive symbols for vertical soundings.* — Capital (block) letters are used exclusively. All symbols except I, J, O, T, U, V, X, Y, Z may be used to replace as well as describe a numerical value. In many cases, however, a limiting value, preceded by D or E, will be appropriate.

In the case where D, E, I, or U precedes a numerical value, a descriptive symbol should always be given to explain the reason.

6. *Complete list of symbols* :

A : Measurement influenced by, or impossible because of, the presence of a lower thin layer, for example, E*s*.

B : Measurement influenced by, or impossible because of, absorption in the vicinity of *f*-min.

C : Measurement influenced by, or impossible because of, any non-ionospheric reason.

D : (1) (Preceding a numerical value) *greater than* ...

(2) (As a descriptive symbol). Measurement influenced by, or impossible because of, the upper limit of the normal frequency range.

E : (1) (Preceding a numerical value) *less than* ...

(2) (As a descriptive symbol). Measurement influenced by, or impossible because of, the lower limit of the normal frequency range.

F : Measurement influenced by, or impossible because of, the presence of spread echoes.

G : Measurement influenced or impossible because the ionization density of the layer is too small to enable it to be made accurately.

H : Measurement influenced by, or impossible because of, the presence of stratification.

I : (Preceding a numerical value). Missing value has been replaced by an interpolated value.

J : Ordinary component characteristic deduced from the extraordinary component (1).

L : Measurement influenced or impossible because the trace has no sufficiently definite cusp between layers.

N : Conditions are such that the measurement cannot readily be interpreted, for example, in the presence, of oblique echoes.

O : Measurement refers to the ordinary component.

R : Measurement influenced by, or impossible because of, absorption in the vicinity of a critical frequency.

S : Measurement influenced by, or impossible because of, interference or atmospherics.

T : Value determined by a sequence of observations, the actual observation being inconsistent or doubtful (1).

U : (Proceding a numerical value). Uncertain or doubtful numerical value.

V : Forked trace which may influence the measurement.

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(1) The symbols J and T are used at some station networks as qualifying symbols in the same manner as D, E, I, U — that is preceding a numcrical value.

W : Measurement influenced or impossible because the echo lies outside the height range recorded.

X : Measurement refers to the extraordinary component.

Y : Intermittent trace.

Z : Third magneto-ionic component present.

X. — Miscellaneous

1. Despite the short time available, the Committee has reviewed the drafts of the I.G.Y. Manual for Ionospheric Vertical Soundings compiled at C.R.P.L. by J. W. Wright, R. W. Knecht and K. Davies. The members and consultants present at the Brussels meeting very highly commend this group on the monumental task which has been accomplished. The comments and correction of details have been communicated to the compilers and editors of the Manual. Special attention has been given to those sections of the Manual which will need alteration or additions as a resuls of the changes in procedure adopted by the Committee.

By these means and the preparation of the present report, the Committee believes that it has carried out its charge to furnish certain material for the Manual.

2. The effectiveness of the world-wide vertical sounding program will be immeasurably increased when the Manual has been revised and made available to all stations. In particular, the improvement in compatibility and consistency which is the main object of the work of the Committee will only be attained when the practice at all stations has been made uniform. This is impractical without the detailed instructions and illustrations included in the Manual.

It is therefore essential for the success of this effort that the Manual be available promptly in a form including the modification due to the Committee's decisions.

3. The Committee has collected a large set of illustrative ionograms from among its members, consultants, and others. Some of these are used as illustrations in the Manual. The Committee plans to compile a separate volume of illustrative ionograms to serve as a companion volume to the Manual.

4. The considerable personal and financial effort involved in the operation of sounding stations can only be justified if the stations are operated at near optimum effectiveness so that the data

produced are reliable and useful to the science. While scientific papers, reports, manuals and illustrative albums are indispensable aids to this objective, many difficulties and inconsistencies cannot be removed by these methods.

The Committee cannot over-emphasize that visits of actively working scientists are essential, both to obtain uniform practice and to encourage and develop the regional researches which are necessary for a proper understanding of ionospheric phenomena.

The Committee recommends that as far as possible, every sounding station should be visited for this purpose by at least one of its members or consultants. In view of the intensive program arranged for the I.G.Y., two visits at roughly yearly intervals would not appear to be excessive.

5. Noting the invaluable exchange of ideas which has resulted from the meeting, the possible need for clarifying some of the Committee's proposals or some parts of the Manual and the need to study, discuss and agree on the interpretation of the ionograms in the proposed album of ionograms, and the need to develop regional programs, the Committee recommends that it meets again about March 1957.

6. In several parts of this report the Committee has drawn attention to problems which need investigation by means of special measurements which need not be made at all stations. It is suggested that these additional programs could be most efficiently organized by the nomination of key stations distributed widely over the world. These stations would undertake some or all of the special investigations. Administrations are invited to put forward proposals to meet this requirement, noting that additional work is implied and that it would be advantageous to use stations with exceptionally skilled staff or a history of effective research work.

Brussels, September 2, 1956.

Members of the Committee :

A. H. Shapley (1) (2), *Chairman*;
Y. Aono (1) (2);
N. V. Mednikova (N. V. Pushkov (2);
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(2) Attended Brussels 1955.

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Appendices will be published in the next issue of the Information Bulletin.

Ursigrams

CIRCULARS FROM THE NORTH ATLANTIC RADIO WARNING SERVICE

August 17, 1956.

Attached is a report of the Alert and S.W.I. trials which have been made daily at 1600 U.T. since May 9, 1956 by the I.G.Y. World Warning Agency. These decisions reflect the views of the duty forecaster of the North Atlantic Radio Warning Service and are based on solar data available to him as well as advice received from Nederhors-ten-berg (NERA), Netherlands.

Though it is desirable from practical considerations to declare S.W.I. only when major magnetic disturbances are likely to occur, the attempt made here was to predict every disturbance regardless of importance. This scheme was partially responsible for the exaggerated number of days Alerts and S.W.I. were in effect. Another important factor was the tendency to over-evaluate May's enhanced solar activity from a terrestrial point of view.

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(1) Attended Brussels 1956.
(2) Attended Brussels 1955.

The need for improved forecasting techniques and more concrete sun-earth relationships becomes apparent from analysis of the practice period. We hope, however, that these aims will be realized from the planned comprehensive interchange of ideas and advice among the warning centers, resulting in successful predictions of the major disturbances in the coming program.

We would very much like to receive comments on these trials. Especially we look forward to receipt of daily advice messages from each of the Ursigram centers.

I.G.Y. SWI and Alert Forecasts issued 1600Z Daily

Fort Belvoir, Va.

1956

May 9 *Begin Alert* — solar activity remains high with NAVOBS RN268 today — yesterday's 1305 SID, 1310 McMath flare, SORNE major burst (13XX-1319) all fit Dodson study — expect trouble within 3-4 days from 8th — SWI probable tomorrow.

10 *Begin SWI* — available data coupled with Dodson study points to major disturbance within next 32 hours.

11 *Stop SWI/Begin Alert* — flare of fairly great importance (early estimated) observed in southern CMP region 2055Z May 10 — not yet associated with other phenomena.

12 *Continue Alert* — storm now in progress (Note : SWI issued May 10 covered beginning of magnetic disturbance 23XXZ May 11.)

13 *End Alert* — Magnetic storm in diminishing stage. (Note : storm ended 12XX May 13.)

14 *Begin Alert* — no flare reports received as yet but SORCO reports major burst 1751 — 1800Z May 13 — intent is to begin SWI tomorrows forecast if a flare time should correspond favorably with outburst time.

15 *Begin SWI* — Sac Peak reports importance 1 flare 1750Z which together with Bornell outburst fit Dodson Study..

16 *Continue SWI* — severity of disturbance justifies extension of SWI another day. (Note : magnetic storm 0418 May 16 — 15XX May 17 covered by SWI issued May 15.)

17 *Stop SWI/Continue Alert* — large region 32 degrees west of central meridian could prove to be flare-noise producer.

18 *Continue Alert* — importance 3 flare observed in southern region 1 day past CMP yesterday — major noise burst associated time-wise but looks too late to be over before maximum of flare — also ADVNE ALCON (Nederhorst advises alert continuation).

19 *Continue Alert* — considerable solar noise reported — also SID's and large active solar regions — important flare producing region less active.

20 *Continue Alert* — ADVNE ALCON through May 22. Minor magnetic storm in progress (0638 May 20 — 08XX May 21) — could be Dodson study applicable for flare-major burst May 17.

21 *Continue Alert* — McMath area 3503 due at CMP May 22 contains E spot — many subflares, possibly a noise storm, and an SID-associated flare have had their origin in this region.

22 *Continue Alert* — CMP of a possible radio noisy region — still producing flares — what little noise there is has been positioned 0 degree — 60 degrees West.

23 *End Alert* — solar noise down — none of noise last few days appears to be associated with region now 1 day west of CMP — also ADVNE ALFIN.

24 *Begin Alert* — severe unpredicted storm now in progress — probably associated with great growth of region 3506 at CMP today — 27-day recurrence supports this storm but not the likely cause.

25 *End Alert* — storm still in progress but much less severe.

26 *Begin Alert* — no solar noise but flare activity yesterday in two regions (east limb and CMP) with E spot in CMP region today — also SID-associated subflare.

27 *Continue Alert* — subflare and solar noise activity continues.

28 *Continue Alert* — importance 1 flare with associated SID in 3506 — considerable activity in NAVOBS filter.

29 *Continue Alert* — two major noise bursts and several importance 1 flares — several subflares — filter activity continues.

30 *Continue Alert* — considerable flare, SID, and noise activity — region 3518 CMP June 3 has possibilities.

31 *Continue Alert* — several majors flares and high solar activity in general — 3518 large and active.

June 1 *Continue Alert* — several potentialities still exist.

2 *Continue Alert* — still possibility of activity in region 3518 near CMP.

3 *Start SWI* — no solar noise reports as yet for June 2 but class 3 or better Sac Peak flare (estimated intensity 30 estimated area 900 millionths) suggests liklihood of disturbance within next 30 hours.

4 *End SWI/Continue Alert* — Sac Peak flares now given importance of only 2 — no solar radio noise outbursts have been reported on which to expect « Dodson effect » — SWI no longer justified.

5 *Begin SWI* — received solar noise to associate with June 2 flares in time for yesterdays advance forecast — will go along with disturbed forecast for July 05-07.

6 *End SWI/Continue Alert* — little data as yet today but active regions still exist.

7 *End Alert* — solar activity has diminished considerably last few days though minor flare activity is reported daily — existing regions seem to have less active classif.cation.

8 *No Alert* — though large western region has grown and is classified D rather than H, overall activity does not warrant alert — eastern region 3531 (CMP June 13) will bear watching as potentially active.

9 *Begin SWI* — June 7 importance 2 flare, SID, and major noise burst at 1840 suggests good possibility of disturbance tomorrow or next day — activity originated in region 3518 (CMP June 3).

10 *Continue SWI* — based on Dodson 3-4 days after event statistics.

11 *End SWI/Continue Alert* — few data have been received thus far — no flare reports for June 10 or 11.

12 *End Alert* — solar activity quite low — only minor flare activity reported last few days.

13 *No Alert* — some limb activity but too early to evaluate.

14 *Begin Alert* — reports of limb surges yesterday plus east limb flare associated SID's show presence of potential disturbance-associated region.

15 *Continue Alert* — more SID's on 14 June — potential still exists.

16 *Continue Alert* — many subflares reported yesterday and major burst today — also Nederhorst advised the beginning of an SWI (ADVNE INBEG).

17 *Continue Alert.*

18* *Continue Alert* — Boulder and Anchorage expect disturbance June 20 — NARWS expect 21-23.

19 *Continue Alert* — still expecting the disturbance.

20 *Begin SWI* — Nederhorst advises continuation of SWI (ADVNE INCON).

21 *Continue SWI* — radio noisy region at CMP — new estimate of disturbance 1 or 2 days past central meridian.

22 *Stop SWI/Continue Alert* — several active regions still on the sun — relationship on which storm was predicted (CMP plus

(*) There was some difference of opinion here among the C.R.P.L. centers. However, it was later generally agreed that the radio-noisy region crossed central meridian June 21. The disturbance beginning June 23 was possibly associated with the CMP plus 2 passage of that region.

1-2 days of radio noisy region) not positive enough to justify extending SWI to 72 hours.

23 *Continue Alert* — Nederhorst advises continuation of SWI (ADVNE INCON) — should storm start on CMP plus 2 days of radio-noisy region it would start before SWI would take effect (0000Z) — may wish to start interval tomorrow or next day based on possible flare-noise burst 1555Z yesterday.

24 *Continue Alert* — magnetic storm began about 1800 May 23 — long SID at Belvoir today indicates regions still active — no flare or noise association as yet.

25 *Continue Alert* — minor magnetic in progress now — daily flare activity observed.

26 *Stop Alert* — last of active regions at west limb tomorrow — no previously active areas due at east limb for several days.

27 *Start Alert* — major burst 1815 June 26 from Nederhorst — Sac Peak importance 1 flare 1705Z, McMath a subflare, Nederhorst two importance 1 flares in region 3551 all yesterday — spot group shows considerable growth last few days.

28 *Continue Alert* — region mentioned yesterday fairly large — two new regions grew on sun yesterday and two more, one fairly large class H spot, are visible on east limb.

29 *Continue Alert* — although Cheltenham began magnetic storm 05XXZ today, Belvoir thinks it too minor to begin one — a northern solar region (CMP July 1-2) with E spot has grown considerably.

30 *Continue Alert* — McMath regions 3563 and 3558 (S25 E75 and N20 E24) are flaring — ADVNE ALBEG.

July 1 *Continue Alert* — have no further solar information.

2 *End Alert* — solar activity down with no regions particularly active.

3 *No Alert* — however, radio conditions somewhat depressed, signal strength has lowered, critical frequencies are low — only solar data is NAVOBS which shows no unusual activity.

4 *No Alert.*

5 *No Alert.*

6 *No Alert.*

7 *Begin Alert* — region 3565 (N18 E28) contains large E spot and is source of importance 1 flare reported yesterday — ADVNE ALCON.

8 *Continue Alert* — region 3565 still may have radio noise potential.

9 *Continue Alert.*

10 *Continue Alert* — with region 3565 possibly radio noisy will be aware of CMP plus two day relationship — ADVNE ALCON.

11 *End Alert* — region 3565 now two days west and no trouble — also Nederhorst advises ending alert.

12 *No Alert.*

13 *No Alert* — no significant activity.

14 *No Alert* — none of the many regions visible appears to be active — the region associated with a disturbance 27 days prior to July 21 has apparently returned but contains no spot group.

15 *No Alert* — many regions but no significant activity — the largest regions are nearing west limb.

16 *No Alert* — NAVOBS RN154 but no other activity reported — no important solar noise in many days.

17 *No Alert* — two of three new regions to replace those which passed off west limb — none active.

18 *Begin Alert* — following advice of Nederhorst — although no details were given they reported the existence of flare activity in a northern region at CMP today — the spot group in this region has increased in size and spot count since yesterday.

19 *Continue Alert* — the region mentioned yesterday continues active having been the source of an importance 2 flare yesterday and apparently the source of several major noise outbursts yesterday and today.

20 *Continue Alert* — the only solar data received so far is spot data from Wendelstein — northern spot, now two days west of CMP, still large and classified E.

Code for exchange of Alert and SWI advice

August 28, 1956.

ADVaa bbccc dddde (FORTE)

aa — warning center giving advice

AN — Anchorage	NE — Nederhorst
BE — Belvoir	PA — Paris (BIF)
BO — Boulder	ST — Stockholm
DA — Darmstadt	SY — Sydney
MO — Moscow	

EU — all European centers giving same advice

US — all American centers giving same advice

bb — type of notification

AL — alert

IN — Special World Interval (SWI)

ccc — advice

BEG — begin
CON — continue
FIN — finish
NIL — no alert

dddd — UT advice given

e — always a Z

FORTE — indicates center feels probability is great (added for this purpose only).

North Atlantic Radio Warning Service, National Bureau of Standards, Box 178, Fort Belvoir, Va.

Communications from C.S.A.G.I.

Report on Ionosphere and on Arctic telecommunications for I.G.Y. messages

(Convenor : A. H. Shapley)

I. — Geographical distribution of Stations in the Arctic Region

(1) The working group on the ionosphere notes especially the greatly improved coverage by vertical sounding stations planned for the area inside the auroral zone. There appear to be only a few serious gaps where single additional stations would greatly improve the network in Arctic regions. In this connection the working group proposed the Arctic Conference Resolutions n^{os} V.1 and V.2 (see *Inf. Bull.*, **98**, 31-32).

The working group also noted that the high concentration of stations in the vicinity of Scandinavia along the 10° E longitude line was unavoidable inasmuch as all are permanent observatories.

This concentration will allow an evaluation of the geographical fine structure of the ionosphere in sub-auroral region. The working group noted the earlier plans for a station on Jan Mayen had been dropped and agreed that as regards these longitudes the first emphasis should be on the 10° E longitude chain of stations in the vicinity of the auroral zone.

(2) In considering the geographical distribution of stations for other ionospheric programs the working group proposed Resolution n° V.3 (see *Inf. Bull.*, **98**, 32).

(3) As the determination of ionospheric drifts at high latitudes is very difficult it did not seem practical at this time to urge extension of the presently planned network other than by the normal growth of the programs of laboratories currently engaged in these experiments.

(4) It was felt desirable that there be a more extensive net of whistler stations in the arctic. It was also felt that this could be arranged if the specifications of observing equipment and the details of the observing programs were made more generally available. Inasmuch as a part of the whistler program calls for observation at magnetic conjugate points, the following list of high latitude northern stations and their conjugate points is provided for the information of the forthcoming C.S.A.G.I. Antarctic Conference.

Whistler stations	Geographical coordinates		Conjugate Antarctic station Geographical coordinates	
Thule	N 77	W 67	S 80	E 111
College	N 65	W 148	S 58	E 171
Nome	N 64	W 165	S 53	E 164
Frobisher Bay	N 63	W 67	S 88	E 293
Yakutsk	N 62	E 130	S 43	E 123
Anchorage	N 61	W 150	S 54	E 176
Enköping	N 60	E 17	S 50	E 47
Knob Lake	N 55	W 67	S 81	E 295
Unalaska	N 54	W 167	S 44	E 173
Father Point	N 48	W 68	S 75	E 293
Flin Flow	N 55	W 102	S 68	E 212
Ottawa	N 45	W 76	S 71	E 270
Halifax	N 45	W 64	S 71	E 306

(5) The working group noted that there are seven atmospheric noise stations planned for the arctic region; this number appears adequate. However, the working group noted that not all of the stations are employing comparable equipment, and observed that it would be desirable for all stations to have standard instrumentation which would provide closely comparable data.

(6) The working group examined the station lists and outline of plans for the remaining arctic programs in Ionospheric Physics. The working group was pleased to note how these add to the effectiveness of the overall arctic ionospheric program. In this connection, particular mention may be made of :

(*a*) The trans-auroral oblique incidence experiment planned in Canada ;

(*b*) The series of backscatter stations in Europe and North America ;

(*c*) The forward scatter experiment planned in Canada ; and,

(*d*) The pioneering rocket explorations of the ionosphere planned for Churchill.

II. — Uniform Procedures

(1) The working group was very much in favour of obtaining agreement on a single method for determining curves of true height versus electron density from $h'f$ curves. It felt that such computations should be carried out on as many Regular World Days and Special World Intervals as practicable. It is obvious, however, that only the unconfused ionograms from high latitude stations could be used for this purpose. The working group did not feel competent to express an opinion regarding the relative merits of the several methods now in use or under test ; however, it expresses the hope that the U.R.S.I./A.G.I. Committee will find it possible to make this decision during the present year.

(2) It appears that the new observing and reduction procedures for high latitude stations adopted by the U.R.S.I./A.G.I. Committee, September, 1955, have already been put into practice by only some of the high latitude stations. These have found the new procedures largely successful and less time consuming than had been feared, with an apparent tremendous gain in the usefulness of results. The working group has no special comments to make

at this time on details. It noted that other high latitude stations have been delayed in instituting the new procedures on account of limitations of equipment or staff, or because the report describing the new procedures has not received wide enough distribution. The working group felt strongly that efforts should be made to initiate the new reduction procedures at all high latitude stations in the near future ; this was thought to be highly desirable even though some stations may not yet be in a position to operate the full recommended observing schedule for soundings at high latitude stations.

The working group reviewed examples of reductions from some Swedish and U.S. high latitude stations and some examples of « gain runs ». It was felt to be highly desirable to increase the interchange of experience with such observations and reductions. It would appear to be within the province of the High Latitude Committee to facilitate such interchange, with the initiative on its chairman, Mr. Shapley.

The only specific feature of the scheme discussed in detail was the classification of E*s*. Dr. Driatsky expressed the opinion that the separation of E*s* into three classes as recommended in the high latitude report was insufficient ; he suggested the use of some eight classes. He was asked to circulate a description of the classification categories he would recommend. Mr. Stoffregen told how he distinguished two general classes — auroral E*s* and « summer » E*s* ; auroral E*s* is marked both by retardation and by a « thicker » trace. Mr. Shapley described the development of the thinking in the High Latitude Committee, which at one time was thinking of recommending a larger number of categories ; the difficulty in matching actual ionograms with these categories led them to restrict their recommendation to the three simple classes specified in their report. The working group was generally agreed that the problem of E*s* classification was far from solved.

(3) There was some discussion of the details of soundings and reduction procedures being considered by the U.R.S.I./A.G.I. Committee on Worldwide Soundings, whose chairman (Mr. Shapley) was present. The working group expressed the hope that this work would progress more rapidly. The convenor said that a new memorandum with further discussions had been circulated among committee members and consultants the previous week.

(4) The working group also discussed the status of the I.G.Y. manual on vertical sounding and the album of ionograms, being prepared under the auspices of C.S.A.G.I. There was a common impression of the great importance of this work. No specific suggestions were made other than those referred to in the preceding sections of this report.

(5) As regards uniform procedures for I.G.Y. ionospheric experiments other than vertical soundings, there was too little information available for any helpful comments or understandings to be recorded in a report. Some information was exchanged among members of the working group regarding the equipment and reduction methods for the whistler program.

III. — Summary of the meeting on telecommunications, Friday 25th May, 1956, 9.30 a. m.

In his introduction the chairman (Mr. Shapley) said that the topic for this meeting was the problems having to do with the exchange of *data summaries*, and notification messages of *Alerts and Special World Intervals* (*SWI*). He outlined then the present plans for this I.G.Y. World Day program as follows.

(1) *Notifications of Alerts and SWI.*

Alerts are called when active spot-regions appear on the sun indicating a probability of interesting geophysical effects during the days following. I.G.Y. stations are then put on the alert, which may last for a week or ten days.

SWI will be called a few hours *in advance* of the time when important magnetic and ionospheric disturbances are expected to occur.

Decisions for Alerts and SWI are made by the I.G.Y. World Warning Agency (Belvoir, U.S.A.) with the advice of various forecasting centres, including Paris (Bagneux), Darmstadt, Nera, Belvoir, Anchorage and Tokyo.

After receiving the advice of all forecasting centres of the world, Belvoir makes the decision when Alerts or SWI shall start, and the notifications are distributed beginning at 16.00 hours U.T. Alerts take effect upon receipt, and SWI at 00 hours U.T. Distribution of these notifications, it is assumed, can be made in less than 8 hours. Many stations will make special observations during Alerts and SWI.

The method of distribution is developed, and arrangements are practically completed with the World Meteorological Organisation (W.M.O.) to send notices for Alerts and SWI warnings on the meteorological telecommunications networks. The messages are in plain language and consist of about ten words. Standard phraseology will be used. Thus the messages will be distributed through the meteorological networks to meteorological stations. Other stations will have to make arrangements for receiving the messages from the nearest meteorological station. The details of this distribution are the responsibility of the various national committees. Assistance will be given by the regional centres which at present are three : In Japan, the Radio Research Laboratories, Kokubunji ; in U.S.A., C.R.P.L.-Belvoir and in Europe, Paris-Bagneux (B.I.F.), Darmstadt (F.T.Z.) and Nera (P.T.T.). One or two other regional centres will probably be established.

Messages of Alerts and SWI are put on the meteorological networks at Washington. At the same time duplicate messages will be sent by direct telegram from Washington directly to each regional centre. The messages are very short. It is estimated that 8 to 10 such messages might be sent each month.

(2) *Distribution of summaries of current data*

Summaries of current observations of geomagnetic data, solar flares, fade-outs, aurora, etc., will be available to every I.G.Y. station requiring such summaries. The plan is that the regional centres will be responsible for preparing these summaries and each regional centre will make arrangements to satisfy the needs of its own region. The transmission of the summaries will be made directly by telegram or telex and in some cases by radio broadcasting. Direct transmission by telegram or telex will be used in the Western hemisphere. In Europe direct transmission as well as broadcasting will be used.

It is important to know what the requirements of the different stations are. They will vary greatly. Some stations need geomagnetic data once a day ; rocket stations want to know about solar flares perhaps within a minute or so, etc. It is as dangerous to have too much as too little data distributed. The distribution of such summaries will not be made on the meteorological networks. Supplementary summary reports will also be distributed by air mail from regional centres.

(3) *Regional centres*

After Dr. Shapley had given this information a discussion took place regarding further regional centres. Dr. Burkhanov said that for U.S.S.R. the main centre will be Moscow (contact is Dr. Pushkov, Moscow Academy of Sciences) with auxiliary centres, probably including Cape Chelyuskin, Providenie Bay and Yakutsk. The address of the centre at Moscow will probably be : The Institute of Earth Magnetism, Moscow.

(4) *Needs of I.G.Y. disciplines for notifications regarding Alerts and Special World Intervals, or for Data Summaries*

(*a*) In a communication *from* Professor Van Mieghem, *chairman of the working group on Meteorology*, it was said that the communication needs for the meteorological observations are automatically taken care by the W.M.O. network.

(*b*) *The working group on Aurora* (chairman Dr. Elvey) had expressed that it believed that some warning of impending auroral displays should be announced specially for stations toward the west. This announcement should be in addition to and separate from the normal warnings and Alerts and these special auroral warnings should have a high priority in transmission. Auroral warnings will emanate from the following basic stations :

(i) Murmansk, U.S.S.R. ;
(ii) Tromsö, Norway ;
(iii) Julianehaab, Greenland ;
(iv) Churchill, Canada ;
(v) College, Alaska ;
(vi) Tixie Bay, U.S.S.R.

These stations will have special responsibility to send out warnings.

Dr. Shapley suggested that the communications system be worked out by the regional centres. Because of the time factor these centres should communicate as quickly as possible to the centre next west. As an example Dr. Shapley mentioned that Julianehaab telephones to Narsarssuak, which has a fast channel to Belvoir, which further has a fast channel to Anchorage and Alaska, or to Ottawa and thence Churchill, etc.

All aurora stations will obviously want notifications regarding Alerts and SWI. It is probable that many special arrangements will be made for arctic stations. In this connection Dr. Thomson pointed out that radio communication wholly inside the aurora zone is not difficult ; it is the crossing of that zone which is difficult.

(*c*) Dr. Laursen, *chairman of the working group on Geomagnetism* had informed by letter that Geomagnetism had no special observational program for Alert periods and for World Days.

(*d*) Dr. Shapley, *as chairman of the working group on Ionosphere*, gave the following statement regarding the needs of the ionospheric stations :

In the opinion of the working group of the ionosphere the following appears to be the likely requirements by Ionospheric stations for (*a*) notifications of Alerts and Special World Intervals and (*b*) summaries of current data obtained elsewhere.

(i) Since all vertical sounding stations will have special observing schedules during SWI, all such stations should receive all notifications of Alerts and SWI.

(ii) Other stations which will probably require notification include (*a*) whistler, (*b*) drift, (*c*) absorption, (*d*) backscatter, and possibly others.

(iii) On the assumption that ionograms are reduced at the station itself, vertical sounding and absorption stations will probably want to be provided regularly with magnetic indices for either a nearby station, for a representative middle latitude station or both. They should also be provided with information on important solar flares and SID. These data will aid the prompt and accurate interpretation of soundings.

(iv) Whistler stations will probably want to be provided regularly with magnetic indices.

(v) Some of these and the other ionospheric stations may want to make special requests for receiving current data summaries.

The working party understands that the World Day regional centres may request daily report from many of the ionospheric stations in the arctic region.

(5) *Communication circuits in the Arctic*

The chairman summarized that the communications problem in the Arctic is a special problem. There must be good communications for notifications of Alerts and SWI to all auroral, ionospheric and certain geomagnetic stations. There are also requirements for data summaries to auroral stations and most ionospheric stations. *The chairman* then said that when we know what shall be sent, how shall then the transmissions best be arranged ? The working group then discussed this point.

Professor Harang pointed out that the radio station on Bear Island will serve as a relay station. Dr. Burkhanov said that if it is impossible to get through by the usual way it should be possible to arrange other routes. The following list of radio circuits crossing the auroral zone was mentioned :

(1) Tromsö-Bear Island.

(2) Reykjavik-Barentsburg (this circuit is a good one indicated Dr. Burkhanov).

(3) Thule-Frobisher Bay-Goose Bay.

(4) Resolute Bay-Churchill-Ottawa.

(5) Resolute Bay-Edmonton-to cable.

(6) Barrow-Anchorage (sometimes via Fairbanks).

(7) Floating station-Tixie Bay-Cape Chelyuskin. (also possibly via Barrow).

(8) Barentsburg-Murmansk (or Tromsö).

(9) Tixie Bay-Dixon Island-Cape Chelyuskin.

A general discussion thereafter took place *on radio frequencies for these circuits* and it was pointed out one possibility was that common frequencies should be assigned if communication between stations should be established. Dr. Burkhanov thought that specific frequencies ought to be found based on practical experience. Dr. Shapley suggested that it might be very desirable to establish lower latitude relay stations. Dr. Burkhanov said that also for communication within the Antarctic, relay stations have been considered necessary. Dr. Driatsky asked if the intention was to use very long waves for communication during the I.G.Y., e.g. 20,000 m. After discussion it was decided by the working group to suggest to the Arctic Conference a resolution regarding the desirability of having notifications of Alerts and SWI and partial data summaries to be broadcast on one or more long wave stations, as an alternate to all other channels.

The chairman thereafter proposed that a continuing working group should be set up to continue to make plans for the communication network between stations in the auroral zone and outside it. He suggested as members of this group : Canada, Sweden, U.S.A. and U.S.S.R., and in addition any other country in the auroral or interauroral zone being invited to be represented in the group. This was agreed by the working group.

Subject to confirmation by the national committees the following representatives were appointed : J. Meek, Canada ; S. Gejer, Sweden (chairman) ; F. Dickson, U.S.A., and G. S. Vorobioff, U.S.S.R.

The working group agreed to propose that the conference adopt a resolution that it should be desirable to have, as an alternate route, direct radio contact between the Scandinavian chain of stations and the U.S.S.R. chain (through Barentsburg) and to encourage similar alternate communication links for other I.G.Y. stations within the auroral zone.

On the proposal of Dr. Troitskaja the working group agreed that it was obvious that a meeting is needed between representatives of telecommunications agencies and the I.G.Y. people in the arctic region. This should be arranged through the continuing working group on arctic communications. It was decided that this matter ought to be the subject for a resolution by the arctic conference.

The above mentioned continuing working group on communications in the auroral zone was asked to give a preliminary report to the C.S.A.G.I. World Day meeting in Barcelona, September, 1956.

From the Coordinator

27th September, 1956.

To Secretary U.R.S.I./A.G.I. Committee.

World Centres

1. In accordance with Document nº 55 of the Barcelona conference (copy attached) the Coordinator is approaching Unions for recommendations on Discipline Centres.

2. In the case of Ionosphere (V) the Coordinator appreciates that certain steps have already been taken in this matter. He would however be glad to have confirmation and accordingly this letter continues with paragraphs 3 to 7 which are identical with those in letters to other Unions on this subject.

3. It may be of assistance next to outline the Coordinator's impressions of the discussion on World Centres at Barcelona.

(i) World Centres C should be by disciplines, be closely connected with the appropriate Union or Association, should have at least one part in Europe (*Note* : Ionosphere plans four centres in England, Japan and in Centres A and B) and should be an extension of existing arrangements where possible.

(ii) If C Centres have the facilities to make copies by micro reproduction or other means for supply to Centres A and B (and to another C Centre where there are more than three in a discipline), then any centre could receive the first supply of data — i.e. a copy of the original observations.

If C Centres are not so equipped then the first supply of data must be made to Centres A or B for copying to the appropriate Centre C. The alternative is for the supplier of original data to send two copies one to C, another to A or B, but there may be difficulties in arranging that all observers in any one discipline could make such duplicate supplies.

(iii) If C Centres have the equipment to make copies but not the finance to supply them free to A and B this must be declared so that A and B shall arrange to purchase. (*Note* : Such purchase has been accepted as necessary in the case of the W.M.O. centre).

(iv) The type of centre should preferably be such that it be impartial despite being the first recipient of data.

4. It is realised that the finances of C Centres may have to come from a Government instead of or as well as a Union. If this is so and a Governmental contribution has not been firmly arranged in negociations by the Union, it will be for the Coordinator to approach the National Committee concerned.

5. Since the Conference the General Secretary has received a letter from the Indian National Committee saying that it would be possible to maintain an archives and distribution centre at the National Physical Laboratory with reproduction assistance from the Indian National Scientific Documentation Centre. The letter explains that such a centre would be principally a repository of Indian data but that data could be assembled from other countries in the Far East. The Coordinator's interpretation is that such a centre would be regional or national and would accordingly be superimposed on the arrangement of international centres to one of which the first supply of data is to be made. A local arrangement to collect duplicate supplies is however a possibility. Furthermore, it may be that any discipline requiring more than three international centres (such as the Ionosphere) could make use of the Indian offer.

6. The matter of the type of data to be collected will be treated separately in a letter to Reporters for disciplines asking them to say where definitive information may be found or when it will be available.

7. It is hoped that this matter may be dealt with expeditiously since it is likely that a meeting should be held in November/ December to discuss practical problems common to all Centres.

(*Signed*) A. Day.

Document nº 55.

Resolution for I.G.Y. World Centres

The C.S.A.G.I. authorises the establishment of at least three I.G.Y. World Data Centres of which one will consist of a number of parts. Each Centre will be international in the sense that it will be at the service of all countries and scientific bodies. It is however intended that the existing arrangements for the interchange of geophysical observations shall not be disturbed.

Functions

Each I.G.Y. World Data Centre will be the depository of the originals or copies of I.G.Y. records, observations, and preliminary tabulations as specified by C.S.A.G.I. in each and every branch of the I.G.Y. programme. Each I.G.Y. World Data Centre will contain a central catalogue and index of all the material in its charge ; it will make this catalogue and index available to each participating national I.G.Y. committee and to other responsible national and international scientific bodies and to scientific investigators sponsored by such bodies. Each I.G.Y. World Data Centre will provide access to its data to such organizations and investigators. It will also provide them with copies of the data in its charge at a cost not exceeding that of the reproduction and transmission of the data requested, by the most efficient and economical method.

Management of World Data Centres

In accordance with offers received from two national committees there will be established :

I.G.Y. World Data Centre A by U.S.A.
G.I.Y. World Data Centre B by U.S.S.R.

I.G.Y. World Data Centre C will in fact be a number of centres in different countries which will collect data by disciplines and include certain established International Centres. Appreciating that such established Centres must continue to receive data during the I.G.Y. but that they may not have the finance and facilities to handle the increased amount of data in full, C Centres must be on a different basis. This will cover the particular needs of established international Bureaus and Centres. The C.S.A.G.I. authorises the Coordinator to negotiate with each of these to establish the best arrangements and he will report his conclusions to C.S.A.G.I. He will provide C.S.A.G.I. and National Committees with a guide giving all particulars.

Supply of data to I.G.Y. World Data Centres

Each national I.G.Y. Committee participating in the I.G.Y. programme is under obligation to supply at its own cost, and in accordance with a time schedule established by the C.S.A.G.I., all its I.G.Y. data as specified above to at least one of the I.G.Y. World Data Centres. It will inform C.S.A.G.I. to which I.G.Y. World Data Centres it will supply its data. World Data Centres A or B receiving such data shall supply copies at its own cost to the others. Data Centres C will supply data in accordance with the guide issued by the Coordinator.

List of C Centres

The list of C Centres has not yet been fully formulated and it is realised that it cannot be finalised until the Unions concerned have been consulted on the proper locations and until the National Committees of the countries concerned have agreement from their Governments in respect of the finance involved.

The existing W.M.O. at Geneva will continue to be the repository and its international arrangement is such that it is recognised that in this particular discipline Centres A and B must pay for copies of data required.

To finalise this list before producing the guide the Coordinator will write to Unions for their recommendations sending a copy to the appropriate Reporter and also refer to the National Committee.

Where concise information regarding the type of data to be collected in each discipline has not yet been agreed by C.S.A.G.I. the reporters for such disciplines must supply the Coordinator with information for coordination with the C.S.A.G.I. and National Committees.

A further meeting of those concerned with organizing procedures in Centres will then be discussed.

Meanwhile National Committees will approach their Governments to ensure that exchange procedures can be carried out, the Coordinator acting as intermediary in finalising these agreements and the date when they shall be given effect.

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