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International Scientific Radio Union

U. R. S. I.

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XIIIth GENERAL ASSEMBLY

Provisional Scientific Programme

Commission I

Date	Time	Subject	Speakers
Tuesday September 6	p.m.	Frequency standards, including atomic	Professor M. BOELLA (Italy)
Wednesday September 7	a.m.	Standard frequencies and time signals	Professor U. ADELSBERGER (Germany)
Thursday September 8	p.m.	Frequency standards, including atomic (contd) Standard frequencies and time signals (contd)	Professor M. BOELLA (Italy) Professor U. ADELSBERGER (Germany)
Monday September 12	a.m.	Radio power and miscellaneous measurements	Professor I. KOGA (Japan)
Tuesday September 13	a.m.	Measurement of physical quantities by radio methods	Mr. M. C. SELBY (U. S. A.)
Wednesday September 14	p.m.	Final Meeting. — Triennium.	Programme for next

Commission II

FINAL PROGRAMME

Tuesday September 6	a.m.	Experimental results from investigations on wave propagation through the troposphere (i)	A. B. CRAWFORD (U.S.A.) F. DU CASTEL (France)
	p.m.	*Ditto* (ii)	J. A. SAXTON (U. K.) J. F. K. GROSSKOPF (Germany)

Date	Time	Subject	Speakers
Wednesday September 7	a.m.	Physical characteristics of the troposphere (i)	W. M. GORDON (U.S.A.) G. D. ROBINSON (U.K.)
Thursday September 8	a.m.	*Ditto* (ii)	J. S. MARSHALL (Canada) A. E. KALININ (U.S.S.R.)
Monday September 12	p.m.	Theory of tropospheric wave propagation	J. VOGE (France) V. A. KRASILNIKOV (U.S.S.R.)
Tuesday September 13	a.m.	Radio-meteorology and climatology	P. MISME (France) J. W. HERBSTREIT (U.S.A.)
Wednesday September 14	p.m.	Final Meeting. — Programme for next Triennium.	

Commission III

PROVISIONAL PROGRAMME

Tuesday September 6	a.m.	N(h) Profiles	
	p.m.	F-region ionization	
Wednesday September 7	a.m.	Es ionization morphology and theory	
Thursday September 8	a.m.	Rocket and satellite data for the ionosphere	
	p.m.	Hydromagnetic waves and extra VLF propagation (Joint with C. IV, run by C. III)	

Date	Time	Subject	Speakers
Monday September 12	p.m.	The Exosphere (Joint with C. IV, C. IV to run)	
Tuesday September 13	a.m.	Aurorae (Joint with C. V, run by C. III)	
	p.m.	Ionospheric scattering	
Wednesday September 14	a.m.	Ionospheric drifts	
	p.m.	Final meeting. — Programme for next Triennium.	

Commission IV

Tuesday September 6	a.m.	Sources of atmospheric noise in lightning	E. T. Pierce (U.S.A.) F. J. Hewitt (South Africa) F. Horner (U.K.)
Wednesday September 7	a.m.	Properties of natural noise	W. Crichlow (U.S.A.) F. Horner (U.K.) A. D. Watt (U.S.A.)
Thursday September 8	a.m.	Whistlers-IGY data	G. Mc K. Allcock (New Zealand)
	p.m.	Hydromagnetic waves and extra VLF propagation (Joint with C. III, run by C. III)	
Monday September 12	a.m.	Whistlers, interpretation	L. R. C. Storey (Canada)
	p.m.	The Exosphere (Joint with C. III, C. IV to run)	R. M. Gallet (France)

Date	Time	Subject	Speakers
Tuesday September 13	p.m.	Characteristics of man-made radio noise	F. N. DICKSON (U.S.A.)
Wednesday September 14	a.m.	VLF propagation	J. R. WAIT (U.S.A.)
		Final meeting. — Programme for next Triennium.	

Commission V

Tuesday September 6	a.m.	—	—
	p.m.	Discrete Sources and their Physical Interpretation	Professor J. G. BOLTON (U.S.A.)
Wednesday September 7	a.m.	Galactic Emission	Dr. Gart WESTERHOUT (Netherlands)
	p.m.	—	—
Thursday September 8	a.m.	Aerials and data processing (Joint with Commission VI, run by Commission VI)	Commission VI to arrange
	p.m.	Sensitive Receivers, Parameters Amplifiers (Joint with Commission VII, Commission V to run)	Commission V to arrange
Monday September 12	a.m.	Solar Phenomena and their Physical Interpretation	Dr. J. F. DENISSE (France)
	p.m.	—	—
Tuesday September 13	a.m.	Aurorae (Joint with Commission III, run by Commission III)	By agreement with Chairmen of Commissions III and V
	p.m.	—	—

Date	Time	Subject	Speakers
Wednesday September 14	a.m.	Planets and Meteors, Radar Observation	Dr. J. W. HEY (U.K.)
	p.m.	Final meeting. — Programme for next Triennium.	

Commission VI

Tuesday September 6	a.m.	Surface waves	
	p.m.	2 simultaneous sessions (*a*) boundary scattering problems (*b*) coding problems	(*a*) Prof. L. A. WEINSTEIN (U.S.S.R.) (*b*) Dr. F. L. STUMPERS (Netherlands)
Wednesday September 7	a.m.	Microwave properties of ferrites (Joint with C. VII, run by C. VII)	
Thursday September 8	a.m.	Aerials and data processing (Joint with C. V, run by C. VI)	
	p.m.	Sensitive receivers, parametric amplifiers (Joint with C. VII and C. V, run by C. V)	
Monday September 12	a.m.	Statistically inhomogeneous media	B. A. VVEDYENSKY, M. A. KOLOSOV, A. V. SOKOLOV (U.S.S.R.) V. TWERSKY (E.U.A.)
Tuesday September 13	a.m.	Circuit Theory (Joint with C. VII, C. VI to run)	Prof. B. TELLEGEN (Netherlands) S. DUINKER (Netherlands)
	p.m.	Space relay problems	

Date	Time	Subject	Speakers
Wednesday September 14	p.m.	Final meeting. — Programme for next Triennium.	

Commission VII

Tuesday September 6	a.m.	Molecular and parametric amplifiers Organizer : Prof. R. E. BURGESS (Canada)	Prof. N. BLOEMBERGEN (U.S.A.) Dr. H. HEFFNER (U.S.A.)
Wednesday September 7	a.m.	Microwave properties of ferrites (Joint with C. VI, run by C. VII) Organizer : Dr. A. A. Th. M. VAN TRIER (Netherlands)	Dr. B. LAX (U.S.A.)
Thursday September 8	p.m.	Sensitive receivers, parametric amplifiers (Joint with C. VI and C. V, C. V to run) Organizer : Prof. P. GRIVET (France)	Dr. F. C. SMITH (U.K.)
Monday September 12	p.m.	Thermoelectricity	Prof. P. L. AIGRAIN (France)
Tuesday September 13	a.m.	Solid state Circuits (Joint with C. VI, C. VI to run) Organizer : Dr. D. A. JENNY (U.S.A.)	Dr. L. ESAKI (Japan)
	p.m.	Plasma phenomena	Prof. Roy W. GOULD (U.S.A.)
Wednesday September 14		Final meeting. — Programme for next Triennium.	

NATIONAL COMMITTEES

U. S. A.

SPRING MEETING

The U.R.S.I.-I.R.E. spring meeting will be held in Washington, D. C., May 2-5.

The U. S. National Committee of U.R.S.I. will hold a business meeting on Monday morning, May 2. A combined technical session for all participants will be held on Monday afternoon, and the Commissions will hold their business sessions on Monday and Tuesday evenings.

The following Commissions are planning to hold one or more technical sessions in addition to their business meetings.

Commission 1. — Radio Measurement Methods and Standards, R. W. BEATTY, Chairman.

Commission 2. — Tropospheric Radio Propagation, I. H. GERKS, Chairman.

Commission 3. — Ionospheric Radio Propagation, L. A. MANNING, Chairman.

Commission 4. — Radio Noise of Terrestrial Origin, W. Q. CRICHLOW, Chairman.

Commission 5. — Radio Astronomy, E. F. MCCLAIN, Chairman.

Commission 6. — Radio Waves and Circuits, J. I. BOHNERT, Chairman.

INFORMATION

Daily values of the E-layer index J_E

by Dr. MINNIS R. R. S., Slough

The entry into the earth's upper atmosphere of ultraviolet and X-radiation emitted by the sun is the principal cause of the ionization of some of the constituents of the atmosphere. The free electrons produced can be detected as the D, E and F layers of the ionosphere and the circulating electric currents which result from movements of such electrons are responsible for many of the well-known periodic phenomena in geomagnetism.

Because of this association between solar radiation and geophysical phenomena, it is often desirable, when geophysical observations are being studied, to have quantitative information on the intensity of the incident ionizing radiation at the time the measurements were made. Since this radiation does not penetrate to ground level, it is not possible to make direct measurements of its intensity, except occasionally during flights of rockets or artificial earth satellites. It has, therefore, been customary for geophysicists to use alternative indices of solar activity such as the relative sunspot number or, more recently the solar radio noise flux. When this is done, it is implicitly assumed that a simple relation exists between the intensity of the ionizing radiation and the index used. While this may be a useful working assumption where long-term changes in solar activity are concerned, it is less likely to be acceptable when day to day variations are considered.

Eventually it will, no doubt, be possible to make continuous measurements of the intensity of the solar ultraviolet and X-radiation by means of artificial satellites in orbit above the ionosphere. In the meantime, it seems desirable that some alternative method of estimating the intensity should be available. The simplest, although not an ideal, method of providing this information at present is probably to make use of the degree of ionization in the

normal E layer of the ionosphere. A daily E-layer index, J_E, has been tabulated by Minnis and Bazzard (1) for the I.G.Y. and by Bazzard (2) for the period I.G.C. 1959. The daily values of J_E for the whole period, 1st July 1957 to 31st December 1959, are reproduced in Tables 1-3.

The observational data used in calculating J_E are the hourly values of the normal E-layer critical frequency, fE, measured at Slough. J_E is obtained by computing $f\mathrm{E}^4$ sec χ which, for a simple Chapman layer, would be proportional to the flux of the ionizing radiation. The value of fE used in the computations was not a single measured value, but a representative noon value determined after taking into account all the measured values between 0800 and 1600 UT. To minimize the errors, the hourly values of f_E were read to a greater degree of accuracy than is usual during the routine scaling of ionograms. The greatest weight was given to values near noon UT, and the exceptionally high values which occurred during solar flares were ignored. The values of J_E are, therefore, intended to be approximately proportional to the mean daily flux of the E-layer ionizing radiation, excluding flare radiation for the eight-hour period centred on noon UT.

Minnis and Bazzard have found that the difference between the measured hourly values of fE and the values which would have been expected, given a constant radiation flux and an undisturbed layer, has a standard deviation of 2 per cent. If these differences are regarded as errors, the standard deviation of the resulting error in J_E will be 8 per cent. The representative values of fE which have actually been used to calculate J_E have, however, been determined in such a way that the standard deviation of the errors in J_E from this source has been reduced to about 2 per cent. In the tables the values of J_E are enclosed in brackets when it seems likely that the error in J_E for a particular day may exceed 3 per cent. These errors are due mainly to intense E*s* ionization and to equipment defects both of which tend to reduce the number of measurements of fE and their accuracy.

It has recently been shown by Minnis and Bazzard (3) that there is a semi-annual cycle in the magnitude of J_E which has the same phase in both the N and S hemispheres. Its amplitude varies with the phase of the solar cycle and can be represented approxi-

mately by a multiplying factor, A, which has been determined empirically :

$$A = 1 + [(\phi - 70)/1300[\cos [\pi(m - 1.5)/3] \quad \ldots\ldots\ldots (1)$$

where ϕ = solar noise flux at 2800 Mc/s in units of 10^{-22} W.m^{-2} $(c/s)^{-1}$.

$m = 1, 2, 3 \ldots\ldots$ for 15th January, February, March $\ldots\ldots$

It is not known whether this cycle represents a world-wide semi-annual variation in the sensitivity of the E layer or whether it is due to a variation in the intensity of the incident flux. Hence some caution is required in using the tabulated values of J_E because it is not yet possible to say whether or not they ought to be corrected in accordance with Equation 1.

The value of J_E for a fixed radiation flux varies with the latitude of the observatory. The values of J_E for Slough and for an observatory at latitude λ (degrees) can be represented approximately by the relation :

$$\log J_E(\lambda) = \log J_E(\text{Slough}) + 2.18 \times 10^{-3} (51.5 - \lambda) \quad \ldots\ldots (2)$$

This expression is based on an investigation by Allen (4) of the latitude variations in E-layer ionization. Similar work has been carried out by Harnischmacher (5) but his results were based on a smaller amount of data and have not been used in Equation 2.

References

1. Minnis, C. M. and Bazzard, G. H., 1959. — *J. Atmos. Terr. Phys.*, **17**, 57.
2. Bazzard, G. H., — ~~(unpublished)~~ 1961 — JATP, 21, 193.
3. Minnis, C. M. and Bazzard, G. H., 1960. — *J. Atmos. Terr. Phys.* ~~(in the press)~~. 18,306
4. Allen, C. W., 1948. — *Terr. Magn. Atmos. Elect.*, **53**, 433.
5. Harnischmacher, E., 1950. — *C. R. Acad. Sci., Paris*, **230**, 1301.

TABLE 1.

DAILY VALUES OF E-LAYER INDEX J_E

	(1957)						(1958)		
Date	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	225	272	308	307	364	322	324	290	290
2	280	296	350	328	329	333	(345)	289	290
3	258	291	(305)	324	362	341	342	319	304
4	289	252	297	313	350	(375)	(373)	326	275
5	267	278	303	277	318	(387)	(347)	311	284
6	301	273	331	(302)	310	(330)	331	318	294
7	254	297	—	(312)	314	—	379	303	315
8	234	320	—	337	347	—	(335)	303	305
9	254	285	317	348	292	(369)	336	303	340
10	271	280	(261)	308	292	(357)	329	284	295
11	271	305	339	329	312	299	327	245	306
12	291	294	352	308	296	(343)	(401)	313	296
13	298	283	326	348	339	286	(347)	284	323
14	320	279	339	340	348	(350)	(344)	291	334
15	290	300	352	336	352	333	357	301	—
16	293	321	317	339	323	352	337	309	285
17	297	282	319	344	348	377	414	277	285
18	277	311	368	389	331	314	324	239	255
19	292	(328)	398	397	314	(456)	378	248	(262)
20	307	(301)	378	398	369	284	(382)	255	(297)
21	326	267	421	368	351	(388)	327	248	304
22	305	283	332	(361)	351	(452)	327	240	298
23	294	315	270	(459)	321	(461)	323	255	—
24	304	317	317	(387)	391	(379)	312	273	283
25	336	331	345	(378)	324	402	(353)	261	281
26	330	323	359	(366)	332	(387)	304	274	(317)
27	300	296	333	402	275	416	293	287	314
28	289	(260)	—	355	(290)	351	282	297	339
29	317	294	318	398	312	(423)	(268)		365
30	299	317	266	364	318	367	248		421
31	260	382		336		(352)	293		390

TABLE 2.

DAILY VALUES OF E-LAYER INDEX J_E

1958

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	380	365	294	318	349	347	294	317	314
2	369	353	(263)	318	343	375	321	—	360
3	335	345	(336)	341	341	335	303	300	323
4	293	—	305	319	342	343	303	285	326
5	323	356	(336)	304	311	293	292	274	269
6	328	375	338	(292)	—	324	273	310	309
7	339	344	(292)	317	(342)	307	276	292	337
8	340	311	307	314	360	(305)	279	315	327
9	335	294	291	273	(318)	(324)	295	296	(320)
10	329	281	274	288	(349)	354	326	289	309
11	305	290	(306)	303	(347)	(342)	318	265	329
12	279	277	294	300	(338)	377	311	258	325
13	289	279	293	297	(346)	380	294	231	326
14	281	276	290	256	(337)	(346)	329	268	324
15	311	253	(276)	284	322	(414)	333	274	308
16	322	(286)	262	267	321	(366)	333	285	278
17	323	321	284	268	309	309	376	274	345
18	305	(276)	290	258	(364)	322	345	295	264
19	316	(275)	314	(269)	(366)	291	384	284	(312)
20	318	(271)	296	248	330	314	353	280	342
21	333	294	290	299	366	323	329	272	329
22	321	305	290	279	360	336	323	272	292
23	310	307	327	(312)	338	305	284	297	283
24	(322)	275	(293)	303	(329)	308	298	301	287
25	333	312	320	342	348	310	287	(316)	310
26	345	312	290	333	323	296	—	303	327
27	337	290	299	312	411	293	281	302	270
28	332	323	293	355	344	302	271	271	312
29	383	313	290	349	—	301	291	304	295
30	392	298	300	371	—	346	271	331	322
31		309		(347)	—		284		309

TABLE 3.

DAILY VALUES OF E-LAYER INDEX J_E

1959

Date	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(312)	327	235	269	(288)	(294)	(274)	(263)	(344)	237	202	(253)
2	335	343	230	280	256	268	(261)	270	346	259	199	232
3	308	316	244	308	(268)	(262)	(277)	303	(328)	233	—	(215)
4	349	351	265	(275)	282	—	—	(301)	307	187	213	(275)
5	(325)	285	250	288	(286)	—	—	(305)	287	204	207	218
6	327	289	278	310	294	—	(256)	(284)	286	208	215	(226)
7	270	272	237	313)	—	(267)	292	—	291	224	218	186
8	298	C	263	(304)	(329)	264	284	(275)	(287)	220	239	—
9	288	303	302	275	319	(303)	(305)	(312)	276	231	248	—
10	260	288	299	268	C	312	(288)	—	258	234	214	242
11	287	295	(312)	278	(333)	357	C	(281)	275	244	235	(237)
12	288	264	313	261	298	(324)	C	303	272	(241)	(235)	228
13	313	261	293	304	(321)	—	(338)	275	(270)	247	(228)	219
14	(276)	233	C	294	(305)	(308)	—	—	284	262	228	230
15	315	243	314	271	(295)	—	—	(289)	289	252	228	—
16	316	251	(318)	293	C	(317)	—	C	264	(223)	267	—
17	(285)	225	(282)	(304)	C	—	—	257	269	(256)	240	232
18	—	274	319	269	(349)	302	—	—	280	240	198	210
19	(287)	277	312	320	—	—	—	(268)	285	—	230	210
20	291	258	(313)	321	(303)	(284)	—	(289)	294	—	208	C
21	374	274	352	301	303	(284)	—	299	260	223	205	(237)
22	(319)	294	372	312	268	—	—	—	253	(222)	216	(273)
23	(288)	287	346	326	270	(296)	—	348	250	211	206	223
24	—	294	(361)	283	248	(284)	(301)	286	247	222	260	246
25	—	287	351	(295)	—	(279)	—	(331)	—	—	253	240
26	—	271	311	297	291	290	(287)	—	(265)	(228)	265	—
27	(397)	277	245	(278)	(274)	299	—	(342)	251	231	268	—
28	365	274	(222)	294	(287)	279	—	(365)	258	233	215	221
29	320		(238)	287	(267)	—	(286)	338	249	246	242	—
30	(304)		279	295	(275)	—	(287)	C	266	288	(258)	—
31	320		268		272		(268)	342		213		231

COMMISSIONS AND COMMITTEES

U.R.S.I. Commission III

N(*h*) WORKING PARTY

The first meeting of the N(*h*) Working Party was held at the Fondation Universitaire, Brussels, on 30th and 31st August, 1959.

There were present :

Members :

Dr. J. O. THOMAS(*Chairman*)
Mr. M. D. VICKERS (*Secretary*)
Dr. W. BECKER,
Dr. J. E. JACKSON,
Dr. G. A. M. KING,
Mr. B. MAEHLUM,
Dr. E. R. SCHMERLING,
Mr. J. W. WRIGHT,

Consultants :

Dr. R. COHEN,
Dr. J. M. KELSO,
Mr. A. H. SHAPLEY,
Dr. T. E. VAN ZANDT.

Observers :

Dr. P. HERRINCK,
Mr. J. TURNER,

Apologies for absence were received from :

Members :

Dr. R. A. DUNCAN,
Dr. R. EGAN,

Consultants :

Dr. DRIATSKY,
Dr. KESSENICK,
Mr. J. E. TITHERIDGE,

1. — WELCOME BY U.R.S.I. SECRETARY GENERAL

Colonel Herbays opened the first meeting of the N(*h*) Working Party with an introductory talk in which he welcomed the members of the Working Party to Brussels and as a new Group working within the framework of the Union Radio-Scientifique Internationale.

2. — Votes of Thanks

The Chairman thanked the Secretary General for his kind words and for making the arrangements for the Brussels meeting. Thanks were also due to the President of the Fondation Universitaire for providing accommodation for the meetings.

3. — The meeting was divided into two parts :

1. *Technical Sessions* in which scientific papers concerned with N(h) work were presented and discussed.

2. *Business Meetings* concerned with policy matters.

A list of the papers read, together with short summaries, is given in Section 4 below. The Group has been asked to produce a Report for the XIIIth General Assembly of U.R.S.I. 1960, and therefore a detailed account of the work of the N(h) Group will have to await publication until that time. However, some recommendations were made at Brussels to be brought to the attention of members of U.R.S.I., Commission III, the World Wide Soundings Committee and other bodies responsible for ionospheric research. These are given in Section 5 below.

4. — Scientific Papers presented at the first meeting of the N(h) Working Party — Brussels 30th and 31st August 1959

Dr. G. M. King : Effects of non-vertical propagation.

Dr. E. R. Schmerling : The Pennsylvania State University I.G.Y. (N(h) Survey.

Dr. J. O. Thomas : Recent work at the Cavendish Laboratory on the calculation of N(h) profiles from $h'(f)$ records. Part I.

J. E. Titheridge's work on extraordinary trace and its use in increasing the accuracy of N(h) profiles.

Messrs. B. Landmark and F. Lied (read by B. Maehlum) : Electron density profiles in the E layer deduced from a study of ionospheric cross-modulation.

Dr. R. Egan (read by E. R. Schmerling) : The interpretation of ionospherically propagated ground back-scatter echoes in terms of layer heights and shapes.

Results obtained by this method are in agreement with those obtained by vertical incidence sounding.

Mr. W. WRIGHT : The N(h) programme at Boulder.

The variation of electron density with height, for both below and above the F-region maximum electron density, has been calculated for the 75th Meridian Chain of stations in the equatorial belt.

Dr. R. DUNCAN (read by Mr. TURNER) : The N(h) reduction method used in Australia.

The computer input routine allows the readings of virtual height and frequency to be taken at the most convenient places.

Dr. J. E. JACKSON : Rocket N(h) results at Fort Churchill.

Mr. M. D. VICKERS : Digitizer techniques for coding $h'(f)$ records and their relation to the British I.G.Y. N(h) programme.

Dr. W. BECKER : Methods of $h'(f)$-N(h) analysis used at Lindau.

The use of models in N(h) work especially when applied to layer maxima.

Dr. E. R. SCHMERLING : Thickness and height changes in region F.

Simple N(h) parameters as guides to physical changes in the ionosphere.

Dr. J. M. KELSO : Recent satellite N(h) work.

By Measuring the Doppler shift SNdh. between satellite and earth could be estimated. Measurement of Faraday rotation would give SNdh between earth and ionosphere (the earth's magnetic field being limited to ionospheric heights). Hence SNdh in the exosphere might be estimated.

Dr. K. BOWLES (read by Dr. R. COHEN) : N(h) profiles observed by the V.H.F. radar back-scatter technique.

It was first thought that scattering was due to electrons ; however, the Doppler frequency shift is much less than it ought to be assuming a reasonable ionospheric temperature. It is now suggested that scattering si due to coupling between ions and electrons. The bandwidth is known to be less than 9 kc/s. By measuring this bandwidth accurately it might be possible to find out what atomic species are causing the scattering at all heights in the ionosphere.

CROOM, ROBBINS and THOMAS (read by J. O. THOMAS) : The results of the Cambridge Quiet Day N(h) Survey.

The variation over the world of the mean electron densities at a series of fixed heights is given as a function of magnetic dip. At the greatest heights considered the anomaly in N is the well-known « double hump » with maxima 20° North and South of the magnetic equator. As lower heights are considered these humps move progressively north and south.

Dr. J. E. JACKSON : N. A. S. A. Effort in the field of ionospheric research with special reference to N(h) Data.

1. *Rockets and Satellites.* — The following flights would include N(h) measurements.

Rocket	Range	Agency	Launching Site
2 Javelins	1000 miles	Jackson, Berning	Wallops Is. Ft. Churchill
2 Scouts	10,000 miles	Jackson	Wallops Is.
2 Aerobee Hies.	—	Jackson	Ft. Churchill (9-9-59 and 12-9-59)
2 Nike Asps		Univ. of Michigan	
2 Juno II (Satellites)	150-6000 miles	—	Atlantic missile Range

The working frequencies for satellites will be : 20, 40, 41, 108, 360 and 960 Mc/s.

2. *Top-side Sounders.* — Spot frequency ionosondes were being designed at C.R.P.L. Canada and the U.K. were concentrating on sweep frequency types.

Dr. G. M. KING : The calculation of N(h) curves in New Zealand.

Allowance is made in these calculations for curved interpolation over frequency intervals near the layer maxima.

Mr. B. MAEHLUM : The Norwegian $h'(f)$-N(h) Digital computer programme.

Mr. W. WRIGHT : Special features of $h'(f)$ curves at high latitudes.

The third magneto-ionic component may be used to give an estimate of the width and depth of the E-F valley.

Mr. A. H. SHAPLEY : The present and future extent of the world wide $h'(f)$ soundings network.

The network is run on a basis of international co-operation. Properly planned experiments would yield much valuable information and already had done so in the fields of equatorial spread F, sporadic E and absorption work.

Mr. M. D. VICKERS : Some results on N(h) profiles and their application to specific ionospheric problems.

Dr. T. E. VAN ZANDT : *On Top-side Sounders.*

C.R.P.L. is considering sounding on 4 or 6 fixed frequencies. A sweep-frequency recorder with a sweep-time of 15 seconds is being developed in Canada.

The possible shapes of the $h'(f)$ which would be obtained above the F-layer maximum were discussed.

Dr. T. E. VAN ZANDT : On matrix residues in the $h'(f)$-N(h) Calculation.

Dr. J. E. JACKSON : Techniques for the measurement of Ionospheric Electron Densities from rockets and satellites.

A new device called the R. F. probe was described. This enables measurements of electron density to be made directly by measuring the capacitance of a rocketborne antenna.

Dr. E. R. SCHMERLING : Attempts to find consistent ionospheric parameters for region F.

An attempt to derive consistent values of qo, H and ho for F2 was made using N(h) results for the 75th Meridian Chain of stations.

Dr. W. BECKER : On $h'(f)$-N(h) work in Europe.

Mr. M. D. VICKERS : The use of N(h) profiles in communication research.

Using a full ray-tracing technique on N(h) profiles it was found that the M factors were approximately the same as

those obtained from the normal much simpler parabolic layer approach.

Dr. J. O. THOMAS : Recent work at the Cavendish Laboratory on the calculation of N(h) profiles from $h'(f)$ records. Part II.

Titheridge's method applied to $h'(f)$ records indicated that :

(i) neglect of low lying ionization at night might lead to the lower part of N(h) curves being too high by 50 km SNdh too low by 40 %.

(ii) Average E-F valley widths were 10 km for Slough and Watheroo with a depth of 0.1 NmE.

5. — RECOMMENDATIONS

Routine N(h) *Work by observatories under the aegis of the World Wide Soundings Committee*

The Chairman reported that a request had been received from the Chairman of the World Wide Soundings Committee for information about the possible nature and extent of N(h) work which ought to be undertaken on a World Wide basis by ionospheric observatories as a routine.

Possible methods and programmes were discussed, and the following points were examined in detail :

(i) The possibility of recommending a particular machine or manual method for use on a world wide basis.

(ii) The extent to which, bearing in mind the high cost involved it was desirable to undertake N(h) work on a routine basis in relation to the value of the information which would be obtained.

(iii) The possibility and usefulness of measuring a single N(h) datum as a routine.

The following were considered :

hmF2 — the height of the maximum electron density in the F2 region.

hmF1 — the height of the maximum electron density in the F1 region.

h(N = .9Nm) — the height at which the electron density is 0.9 times NmF2.

$h(N = .5Nm)$ — the height at which the electron density is 0.5 times NmF2.

$h(fN = 6.0$ Mc/s) — the height of reflection corresponding to a plasma frequency $fN = 6.0$ Mc/s.

Bearing in mind that :

(i) new methods are continually being developed for reducing $h'(f)$ data to N(h) data,

(ii) the existing N(h) curves are highly inaccurate at night,

(iii) the high cost in money and labour of this work makes large reduction programmes impossible for all but the largest organisations,

the general feeling in the Working Party was that, of the large number of proposals considered, the Working Party could only justify with firm facts the following recommendations to the W.W.S.C. :

I. The N(h) Group, bearing in mind the wide variety of machine methods, programming techniques « read-in » routines and scaling routines now in use, considers that there would be no value at the present time in recommending to the W.W.S.C. that any one particular machine method should be chosen in preference to any other as being most suitable for routine N(h) reductions.

II. The N(h) Group recommends to the W.W.S.C. that efforts should be made to measure, as a routine, every hour, on a world wide basis, the height of maximum electron density, hmF2, in the F2 layer. A number of manual methods, listed below, are available for $h'(f)$-N(h) reduction. Of these (1), (2) and (3) are particularly suitable for routine use at ionospheric observatories.

(1) Kelso Coefficients (suitable only for low latitude stations). *J. Geophys. Res.*, 1952, 57, 357.

(2) Shinn Kelso Coefficients. *Proc. I.R.E.*, 1959, 47, No 2, 162.

(3) Schmerling Coefficients. *J. Atmosph. Terr. Phys.*, 1959, 14, 249.

(4) King Coefficients. *J. Atmosph. Terr. Phys.*, 1957, 11, 209.

(5) Titheridge Coefficients. *J. Atmosph. Terr. Phys.*, in press.

Two methods, based upon the sets of ten point coefficients of Shinn-Kelso (2) and of Schmerling (3), give results of comparable

accuracy. The N(h) Group recommends that either of these methods be applied at field stations where possible to make available hmF2 values on a world wide basis.

III. Ionogram Quality : It was agreed that there is a great need to improve the quality of ionograms particularly with regard to the low frequency response of recorders. This is of extreme importance for N(h) work.

IV. $h'(f)$ Recorders at Rocket Launching Sites : The N(h) Working Party recommended :

(i) that Ionospheric Observatories equipped with automatic $h'(f)$ recorders should be installed at all Rocket Launching Sites ;

(ii) in particular, that as a matter of urgency an $h'(f)$ recorder should be provided in the near future at the new launching site of Wallops Island.

It was agreed that these recommendations should be brought to the attention of U.R.S.I. Commission III, the World Wide Soundings Committee and the bodies responsible for ionospheric research for the areas concerned.

Letter from the Chairman

Dear Collegue,

In order to carry out satisfactorily the work of the N(h) Group, it is clear that we shall have to form a number of sub-groups to be responsible for some of the different aspects of the work. The Report of the N(h) Group to the 13th General Assembly of U.R.S.I., London, 1960, will have to be based mainly on the deliberations at Brussels. This Report is being drafted at the present time, and will be circulated to you in the very near future.

The purpose of the sub-groups, which I am now writing about, will be to prepare reports which will form a basis for discussion at the next meeting of the Group.

The terms of reference of the sub-groups are as follows :

Sub-Group A :

1. To keep under review both machine and manual methods of converting $h'(f)$ curves to N(h) profiles, and the techniques for carrying out the calculations.

2. To consider the problems associated with the accuracy of N(h) work and the standards of accuracy to be recommended.
3. To produce and publish accurate standard $h'(f)$ curves corresponding to accurately known assumed N(h) profiles.
   To prepare a report on the co-ordination and comparison of N(h) results derived from rocket, satellite, radar back-scatter, and other experiments with those derived from $h'(f)$-N(h) calculations.

Sub-Group C :

1. To prepare recommendations about the future nature and extent of $h'(f)$-N(h) work, and in particular :
2. To make suggestions about places for which records should be analysed, stating, in each case, why the particular station should be chosen.

The membership of the sub-groups is as follows :

Sub-Group A :

Dr. W. Becker (*Chairman*),
\+ Miss A. R. Robbins,
Dr. E. R. Schmerling,
\+ Dr. J. E. Titheridge,
Mr. M. D. Vickers.

Sub-Group B :

Dr. E. R. Schmerling (*Chairman*),
\+ Dr. K. Bowles,
\+ Dr. O. K. Garriott,
Dr. J. E. Jackson,
\+ Dr. J. M. Kelso,
\+ Dr. J. Nisbet,
Dr. J. O. Thomas,
\+ Dr. T. E. van Zandt,

Sub-Group C :

Mr. J. W. Wright (*Chairman*),
Mr. S. A. Croom,
Dr. R. A. Duncan,

Mr. G. A. M. KING,
Dr E. R. SCHMERLING,
+ Dr. T. E. VAN ZANDT,
Mr. M. D. VICKERS.

+ Consultant

Yours sincerely,

(*s.*) J. O. THOMAS,
Cavendish Laboratory
Free School Lane, Cambridge

2nd February 1960.

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

REPORT OF BRUSSELS MEETING 1-3 SEPTEMBER 1959

A meeting of the U.R.S.I.-A.G.I. Committee was held at Brussels on 1-3 September 1959. Most of the meeting was devoted to a preliminary discussion of I.G.Y. ionospheric results and a full report of these proceedings is in course of publication as an U.R.S.I. Monograph. The following is a report on administrative matters discussed by the Committee.

1. — The following Committee members and consultants were present.

Sir Edward APPLETON (*Chairman*),
Mr. Y. AONO,
Dr. N. BENKOVA (*representing* Dr. N. PUSHKOV),
Dr. W. DIEMINGER,
Col. E. HERBAYS (*General Secretary U.R.S.I.*),
Dr. D. LEPECHINSKY,
Mr. J. A. RATCLIFFE,
Mr. A. H. SHAPLEY,
Dr. A. SLUTZ,
Dr. R. L. SMITH-ROSE,
Professor W. J. G. BEYNON (*Secretary*).

Consultants :

Dr. B. H. Briggs,
Mr. G. M. Brown,
Mr. F. Horner,
Dr. C. G. Little,
Dr. A. J. Lyon,
Dr. N. Mednikova,
Dr. M. G. Morgan,
Mr. W. R. Piggott,
Dr. K. Rawer.

The Chairman referred to the loss which the Committee had suffered in the death of Father Pierre Lejay, a Past President of U.R.S.I. and a member of the U.R.S.I.-A.G.I. Committee since its inception. Members stood in silence as a mark of respect.

2. — Minutes of Edinburgh (1958) Meeting

The Secretary stated that the full report of the last meeting of the Committee was published in *Information Bulletin* pp. 24-44, No 111 (Sept-Oct. 1958). The Report with its twelve Resolutions formed the basis of the discussions on I.G.Y. ionospheric matters at the subsequent meeting of C.S.A.G.I. in Moscow in August 1958 and most of the Resolutions, in an unchanged or only slightly modified form, were adopted by C.S.A.G.I.

3. — Review of Programme and Flow of data to World Data Centres

(*a*) *Vertical Soundings h'(f) Data.*

Mr. A. H. Shapley reported on the discussions of the World Wide Soundings Sub-Committee and gave the following information on vertical soundings during the I.G.Y.

120 stations were in full operation for the 18 months of the I.G.Y. ;
138 stations were in full operation for at least 12 months ;
163 stations were in full operation for one month or more.

During the I.G.Y. 50 special stations operated out of a total of 60 originally proposed.

During I.G.C. 1959 it would appear that about 108 stations were making hourly reductions but about 20 of these were expected to close at the end of the year.

As far as data were concerned complete data for 30 stations were available at one W.D.C. The interchange of data between W.D.C.s was proceeding according to the plans already drawn up and although the flow was not yet large there was every expectation that this would grow rapidly. Apart from the routine data being published there were also various other booklets (e. g. N(h) tabulations) being issued and it was desirable that a mention of such booklets should be included in the W.D.C. catalogues.

Mr. Shapley stated that the WWS Sub-Committee had agreed to produce a handbook suitable for use at stations giving a minimum programme with suggestions for supplementation on Regular World Days. No changes in scaling practices were envisaged for 1959, but certain changes may be proposed later. Work in recent years indicated that oblique incidence soundings could provide useful additional data especially for areas not accessible to vertical soundings.

(b) *Data other than h'(f) soundings.*

The following reports were received from the co-ordinators appointed by the Committee at its previous meeting.

Absorption A1 Method. — Mr. W. R. Piggott reported that a questionnaire had been sent out to 76 stations and replies had been received from 42. Some data had been received at WDC-Cl, Slough, from 20 stations and these had been briefly examined for consistency and reliability. Work on this is being continued. It appeared that seven of the older absorption stations had closed down since the end of the I.G.Y. and one other will only operate intermittently during I.G.C. 1959. However most of these stations will continue to be available for special work. It is probable that several stations which could not commence measurements during the I.G.Y. will contribute data during I.G.C. 1959. Some requests had been received for assistance on specific points and there appeared to be a general desire to exchange technical notes and scientific papers as well as data. A short paper had been prepared on the most common difficulty viz. the discrepancies between the amplitudes of different orders of reflection. This paper would be published in the Proceedings of the Symposium on I.G.Y. Ionospheric Results organised by the Committee.

A list of stations which have made absorption measurements

by the pulse method during some part of the I.G.Y. or I.G.C. 1959 (based on replies to the questionnaire) is given in Appendix I.

Absorption A2 Method. — Dr. C. G. Little reported that the had circulated to all stations shown in the C.S.A.G.I. list as measuring absorption by this method a questionnaire and a document proposing a standard method of tabulating A2 data. This document is given in Appendix IV. Certain other stations, not on the I.G.Y. list, were also circulated. The replies received showed that the 31 stations listed in Appendix 2 had made A2 measurements. Twelve out of the 31 are stations not on the original C.S.A.G.I. list. It will be seen that with one exception all the stations are in the northern hemisphere. It will also be noted that except for longitude 30°-190° E good coverage of the northern auroral belt was obtained. Three additional stations are scheduled to commence observations during 1959.

Krasnaja Pacha (Moscow) U. S. S. R.	56° N, 37° E
Neustrelitz, Germ. Dem. Rep.	53° N, 13° E
Pruhonice, Czechoslovakia	50° N, 15° E

It would appear that no final data on A2 observations had yet been sent to the WDCs but 25 stations indicated their intention to send the data. Although it is too early to specify the main results of I.G.Y. A2 measurements it is probable that the programme will yield more information than originally expected, even though many observers found difficulties of interpretation, and at some stations the equipment did not run as continuously or as accurately as might be wished. Before planning further major exploitation of the technique, it would appear to be desirable that the existing data be more fully digested and that the workers in the field be encouraged to share their experience.

Many problems relating to ionospheric absorption remain to be solved. The A2 method, with its capability of providing continuous quantitative data, would seem to be of particular value for :

(*a*) The determination of the mean position, intensity, and the diurnal, seasonal and sunspot-cycle variation of the northern auroral absorption zone ;

(*b*) Studies of the relationship between the northern and southern auroral absorption zones.

(*c*) Routine detection of solar flares by means of the (simultaneous) D region effects in the sunlit hemisphere.

(*d*) Routine detection of low-energy cosmic ray storms originating in solar flares, by means of their high latitude absorption effects.

Drift Measurements. — Dr. B. H. Briggs reported that questionnaires and circular letters were sent in October 1958 to the Secretaries of the 64 I.G.Y. participating National Committees, with a request that they be forwarded to all stations observing ionospheric drifts. The object of the questionnaire was to enable a complete list of stations to be compiled, and to obtain some details of the methods used by each station, and the period of observations. Stations were asked whether they would be able to continue observations after the end of the I.G.Y. and until the end of the I.G.C. in December 1959. The help of the Coordinator was offered for the solution of any difficulties with apparatus or with the analysis of records.

The replies to the questionnaire, supplemented by reliable information from other sources, showed that 36 stations observed drifts during the I.G.Y., and 27 stations expected to make observations during the I.G.C. Details of the stations and the methods used are given in Appendix III. It may be noted that before the I.G.Y. started, 49 stations had stated that it was their intention to make measurements of ionospheric drifts.

A second circular letter was sent in January 1959 to all stations. This letter gave some of the results of the questionnaire, and a list of observing days during the I.G.C. Also, the services of the Cavendish Laboratory, Cambridge were offered for the full correlation analysis of a small number of records from each station which was using the method of closely spaced receivers. It is desirable that such an analysis should be carried out in order to detect any effects peculiar to individual stations. So far records from Ibadan, Singapore and Lwiro have been analysed in this way.

The reduction of drift records is laborious, and it is not surprising that the circulation of data to the WDCs has been slow. It is still not complete, even for the I.G.Y. itself.

As an indication of the present position, it may be noted that in

August 1959 the WDC at Slough contained data from 20 stations out of a possible 39 and the data were complete up to the end of the I.G.Y. for 9 stations only.

Atmospheric Radio Noise. — Mr. F. Horner reported that in July 1957, 28 stations were making regular noise measurements. By the end of the I.G.Y. the number had increased to 51. One or two stations ceased measurements at the end of the I.G.Y. but a number of new ones had started in 1959 and the majority of those now active will continue for several years.

An important feature of the I.G.Y. programme has been that most workers have stated clearly what parameters of the noise they have been measuring. In general these parameters are expressible in precise mathematical terms and can be readily related to each other. This situation is in direct contrast with much previous work, in which the noise values were dependent either on subjective factors or on special properties of the measuring equipment which were not always completely specified.

At 15 stations noise power measurements at eight frequencies have been made with automatic equipment. Measurements of the complete amplitude probability distribution were made at 13 stations. At 4 stations advantage was taken of the I.G.Y. programme to make simultaneous measurements using both the automatic noise power equipment and amplitude probability method. At 15 stations the intensity of noise has been investigated by estimating the interference to a simulated radio service. Other noise studies included the recording of single atmospherics, observations of the rate of occurrence of atmospherics, and the recording of the incidence of lightning flashes.

Whistlers. — Dr. M. G. Morgan gave a brief review of whistler studies during the I.G.Y. with special reference to preliminary results from the stations operated along a 70° W meridional chain from the Arctic to the Antarctic. In these experiments thirteen U. S. A., two Canadian and one Danish station participated. Whistler observations had also been made in Japan and other Eastern Hemisphere countries were becoming active in the field. The programme is continuing during I.G.C. 1959 with certain adjustments and with the addition of a European-African chain. Dr. Morgan reported that experience had shown that the form

of data reporting recommended for the I.G.Y. was not completely satisfactory and an improved form had been adopted.

4. — I.G.Y. Calendar Record

At the Edinburgh meeting the U.R.S.I.-A.G.I. Committee proposed that two ionospheric indices, one for region E and one for region F2, should be included in the I.G.Y. Calendar Record (formerly known as the « Post-Facto Calendar »). It was reported that these indices had now been produced by Mr. Minnis and Mr. Piggott respectively and would be included in the Calendar Record in the I.G.Y. Annals. It was also reported that Mr. Piggott had produced an index of corpuscular radiation in the form of a polar black-out index and it was suggested that this might also be included in the Calendar Record. The Committee agreed that Mr. Piggott and Mr. Minnis should be invited to produce these indices for each day of I.G.C. 1959 and that tables of the indices should be printed in the *U.R.S.I. Information Bulletin* as soon as possible. It was stated that at the 1958 C.S.A.G.I. meeting in Moscow a proposal was made for a whistler and *vlf* index and the Committee agreed that Dr. M. G. Morgan should be invited to produce such an index for the I.G.Y. and I.G.C. Reference was made to a list of storms and of Special World Intervals for the first 6 months of the I.G.Y. which had appeared in the *U.R.S.I. Bulletin* and it was agreed that Mr. Shapley should be invited to complete this list for the remainder of the I.G.Y.

5. — Publication of I.G.Y. Data

The C.S.A.G.I. Reporter (Professor Beynon) stated that arrangements have been made for the publication of the volumes of ionospheric data on the lines recommended by the Committee. The publication of the data is being coordinated by WDC-C1 at Slough and agreement between all four Data Centres has been reached on a format and on all details of the tables of vertical incidence $h'(f)$ data. Each Centre will be responsible for compiling the tables for its associated stations and blank forms for this purpose have been printed and circulated in June 1959 to all WDCs. Centres are being urged to complete the tables quickly and the first Volume will be published as soon as sufficient completed

sets of tables are received back at Slough. It is anticipated that the first volume will contain tables for stations from which complete sets of data (I.G.Y. plus Jan. 1959) have been received before about September 1959.

Agreement has also been reached with the publishers for a volume of *f*-plots for key stations and for RWDs and SWIs. Decisions have to be taken soon on the stations to be included in this volume.

It is also planned to publish the absorption and drift data in the Annals but until recently the amount of such data at WDCs has not been sufficient to justify special publication. The situation is however being kept under review. The question of the publication of whistler data was also raised and it was agreed that Dr. Morgan should consider whether there would be enough data to justify publication in the Annals.

At the Boulder 1957 meeting it was agreed that some years after the I.G.Y. arrangements should be made for a series of volumes of an interpretative character. The Committee agreed that a decision on this proposal should be deferred until its next meeting.

6. — International World Days Service

At the Edinburgh meeting the Committee gave its support to the proposal that on the close of the I.G.Y. the former World Days Section of C.S.A.G.I. should be maintained in the form of a Special Committee of I.C.S.U. with representatives of the interested Scientific Unions. The plan finally adopted was that of a committee under the sponsorship of U.R.S.I. known as the International World Days Service.

Mr. Shapley reported that the I.W.D.S. had undertaken responsibility for the following tasks : (i) the calling of Alerts and Special World Intervals ; (ii) fast data exchange ; (iii) the formulation of a World Geophysical Calendar ; (iv) the production of the I.G.Y. Calendar Record ; and (v) the choice of I.G.Y. geophysical intervals for detailed analysis.

Alerts were now being called only after the occurrence of some event. The World Geophysical Calendar was based on 3 Regular World Days per month, chosen mid-week with no regard to meteor activity or lunar phases. The I.G.Y. geophysical intervals were to be chosen retrospectively on the basis of events, rather than on the RWDs or SWIs declared.

7. — U.R.S.I. Ionospheric Stations Manual

The Secretary reported that the Manual prepared by Colonel Herbays, Professor Beynon and Mr. Brown had now been published and copies can be purchased from the U.R.S.I. Secretariat. The Manual consisted of the following main sections : I. Alphabetical list of stations ; II. Geographical list of stations ; III. Vertical incidence sounding stations : (*a*) Details of stations and equipment, (*b*) Tables of solar zenith angle for each station ; IV. Lists of stations carrying out radio observations or measurements other than vertical incidence soundings. Other sections contain : Tables of « Chapman functions », Phases of mean moon for 1957-58 ; Tables of Solar Rotation numbers for 1957-58 ; List of scaling symbols for vertical incidence ionograms ; Calendar of RWDs and WSIs for 1957-58.

Every effort had been made to make the manual as comprehensive as possible and the lists of stations contain all necessary information for about 400 ionospheric stations which are in operation or have operated for about one month or more. A loose-leaf format has been adopted so that the Manual can readily be kept up to date.

8. — Permanent Ionospheric Service

At the Edinburgh 1958 meeting a provisional Committee was established under the Chairmanship of the C.S.A.G.I. Reporter (Professor Beynon) to work out details of some form of permanent ionospheric data service under the auspices of U.R.S.I. Subsequently, at the Moscow meeting of C.S.A.G.I. some preliminary talks on this subject were held between representatives of WDCs A, B and C2 together with the C.S.A.G.I. Reporter, but it was clear that at that stage the WDCs were only just becoming established and making contact one with the other. The Reporter felt that some time would have to elapse before much progress could be made with dicussion of a permanent service. This period is necessary to allow the flow of data to Centres to become a routine and well-established feature. The time would then be more opportune to consider close collaboration to produce standardised or joint publication of Bulletins.

The Committee agreed that it was very desirable for the four World Data Centres to become a permanent feature and represen-

tatives of the four WDCs present at the meeting (Dr. Slutz, Dr. Smith-Rose, Dr. Benkova and Mr. Aono) stated that their respective administrations were happy to continue running the Data Centres.

The Committee noted that the possibility of such a permanent ionospheric service adhering to the I.C.S.U. Federation of Permanent Services (F.A.G.S.) was mentioned at the Paris meeting of the Federation in May 1959. Meanwhile the provisional Committee referred to above will be maintained in being. The need for maintaining the international character of the World Data Centres was emphasised and it was agreed that an explanatory note on the WDCs should be printed in the *U.R.S.I. Information Bulletin* and in the appropriate scientific journals.

9. — World Wide Soundings Sub-Committee

Mr. Shapley reported on discussions at the meeting of the World Wide Soundings Sub-Committee which had just been held in Brussels. He presented a progress report on the I.G.Y. vertical soundings programme (see para. 3 (*a*) above) and an interim report on the status of the I.G.C. 1959. Resolutions formulated by the WWS Sub-Committee and subsequently adopted by the U.R.S.I.-A.G.I. Committee are given below.

Mr. Shapley called the attention of the Committee to the need, after the end of I.G.C. 1959, for continued coordination of the activities of ionospheric stations. This had been the function of the WWS Sub-Committee but with the termination of the U.R.S.I.-A.G.I. Committee, the Sub-Committee would of course also cease to exist. It was noted that C.S.A.G.I. is being replaced by an inter-Union Committee for Geophysics (C.I.G.) and that U.R.S.I. will probably wish to have some replacement for the present U.R.S.I.-A.G.I. to maintain liasion with C.I.G. After some discussion the Committee decided that matters could be allowed to stand as they are until the next meeting of the Committee, which it was agreed should take place during the 1960 General Assembly.

W. J. G. Beynon,
Secretary
U.R.S.I-A.G.I Committee.

Resolutions

1. — Flow of I.G.Y. Data

The U.R.S.I.-A.G.I. Committee notes with satisfaction the substantial flow of data that has already taken place to the World Data Centres (WDCs) and the considerable use that is already being made of the Centres by scientists of many countries ; draws attention to a number of relatively minor yet significant deficiencies which should be remedied, and recommends :

(*a*) That stations which have not already done so should as soon as possible send copies of RWD and SWI ionograms to the WDCs or arrange with their WDC of primary contact to have these copies made. The Committee stresses that it is impossible to evaluate the reliability of the reduction process for the world network without recourse to sample ionograms. There are many scientific studies which are possible only if the relevant ionograms are available in one place, and these types of work are at present gravely hampered by the lack of ionograms from certain stations.

(*b*) That WDCs should accept responsibility for ensuring that complete statements are available for each station indicating :

1. the scales of frequency and height used in the ionograms ;
2. any special rules or conventions adopted in the station reductions ;
3. calibration for absorption data where applicable ;
4. any other information necessary to users of the ionograms, records, tabulations or *f*-plots ;

and also for ensuring that the dates and times of all ionograms are clearly identifiable.

(*c*) That WDCs should provide detailed source catalogues of all the data which they hold, preferably using a system in which the completeness of the data received in the form of tables, ionograms and *f*-plots are specifically indicated for each month. It is important to make clear whether the tabulations are available on microfilm or in booklet form and whether hourly values or only monthly median summaries are available. These catalogues should be published, at intervals of six months, in a way which makes them readily accessible to all prospective users of the World Data Centres, for example, in the *U.R.S.I. Information Bulletin.*

2. — Analysis of I.G.Y. Data

The U.R.S.I.-A.G.I. Committee has surveyed the production and quality of ionospheric data during the I.G.Y. and is greatly impressed with the degree of success which has resulted from this effort. The Committee is keenly aware of the need to increase the effort available for studying these data in order to derive an adequate scientific return for the observational effort. The Committee realises the practical problem of providing financial assistance to suitable workers who have to travel to World Data Centres to carry out special investigations, and also of making arrangements for such workers to be released from other duties. It therefore wishes to urge responsible organizations to do all within their power to ensure that work is not hindered by the lack of suitable means.

3. — Scientific Use of World Data Centres

The U.R.S.I.-A.G.I. Committee has noted from information provided by the World Data Centres that up to the present time the calls on the data, services and facilities of the WDCs have been mostly from scientists in the same countries as the Centre. The Committee notes that the requests received by one of the WDCs have grown to major proportions in recent months. While there have been some particular instances of international use of the Data Centres, the Committee believes this use should be further encouraged in all practical ways, in particular those mentioned in Resolution 2.

4. — Future of World Data Centres

The U.R.S.I.-A.G.I. Committee considers that the World Data Centre project has already made possible hitherto impractical studies of the ionosphere on a regional and global scale, and shows great promise for the future. The Committee deems it absolutely essential that all four WDCs remain permanently in operation for providing I.G.Y. data. Furthermore, the Committee considers it of great importance that the WDCs continue to accept, process, and make available the ionospheric sounding data for 1959 and onwards.

5. — Interchange of Vertical Soundings Data for I.G.C. 1959 and Onwards

The U.R.S.I.-A.G.I. Committee recommends :

(*a*) that the minimum data interchange plan for I.G.C. 1959 and later years shall be the same as the minimum plan for the I.G.Y., namely that all hourly values of the standard set of parameters which are reduced and *f*-plots at least for World Days are sent to the four WDCs ;

(*b*) that the plan for interchange of ionograms for years after 1959 until the next sunspot minimum year shall be the same as the plan for 1959 (see also Resolution 6 below) ;

(*c*) that the continued production of station booklets of tabulated data and *f*-plots be encouraged in order to facilitate the scientific study of the data ;

(*d*) that the existing direct interchange of data be maintained.

6. — Ionogram interchange for I.G.C. 1959

The U.R.S.I.-A.G.I. Committee notes that the I.G.Y. ionogram interchange plan operated by the WDCs has already contributed important benefits to scientific work. The Committee believes that the principle of ionogram interchange as planned for the I.G.Y. should be maintained for I.G.C. 1959 on a reduced scale, at a level which can be fitted into the practical aspects of station operation. The Committee endorses the plan for such interchange drawn up by its World Wide Soundings Sub-Committee (Brussels 1959 meeting).

7. — Vertical Sounding Programme after 1959

The U.R.S.I.-A.G.I. Committee calls the attention of U.R.S.I. and the national committees adhering to U.R.S.I. to the importance of maintaining a substantial world network of vertical sounding stations for the years after the I.G.C. 1959 up to at least the next sunspot minimum period, of continuing interchange of data, and maintaining the total effort of observation and analysis as near that of the I.G.Y. as possible. The many preliminary analyses of multi-station I.G.Y. data, in regional groups, latitude chains,

longitude zones and world maps, give confidence that the world data can and will be used to study very important scientific and practical problems of the ionosphere. The Committee endorses the recommendations of its World Wide Soundings Sub-Committee which appear in the report of the Brussels 1959 meeting.

8. — Geographical Distribution of Vertical Sounding Stations

The U.R.S.I.-A.G.I. Committee endorses the recommendations of the World Wide Soundings Sub-Committee on the geographical distribution of vertical sounding stations made at its Brussels 1959 meeting.

9. — Full Use of Available Ionosondes

The U.R.S.I.-A.G.I. Committee wishes to stress the importance of ensuring that all available ionosondes are kept in active operation. In case any organization cannot keep an ionosonde active, ionospheric science could be greatly assisted if the equipment were made available to a group which is in a position to use it either to obtain improved observations at an existing station or observations at a new location. (The World Wide Soundings Sub-Committee is prepared to advise on this matter if desired).

10. — U.R.S.I. Information Bulletin

The U.R.S.I.-A.G.I. Committee recommends that the *U.R.S.I. Information Bulletin* be a part of the technical literature available at all vertical sounding stations [1].

11. — World Wide Scaling of N(h) Parameters

The U.R.S.I.-A.G.I. Committee believes that h(max)F2 or some similar parameter may eventually be introduced for routine scaling and invites Commission III of U.R.S.I. to :

(a) arrange for an evaluation of the available methods of determining such a parameter ;

(b) suggest, if appropriate, a suitable method for scaling, including specific advice on the allowance for the low-lying ionization

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[1] Special subscription prices are available at U.R.S.I. General Secretariat for ionospheric stations.

usually not measurable by conventional soundings, together with an estimation of the absolute and relative accuracy to be expected from such a method.

In order that sufficient experience be obtained to make a world-wide experiment during the coming sunspot minimum period accurate and meaningful, the above information will be needed well in advance of the 1960 U.R.S.I. General Assembly.

12. — The Northern Auroral Absorption Zone

The U.R.S.I.-A.G.I. Committee recognises the importance of ionospheric absorption in high latitude radio-wave communication, and the geophysical interest attached to the determination of the position and intensity of the auroral absorption zone, and strongly recommends that all A2 absorption stations (I.G.Y. or non-I.G.Y.) at geomagnetic latitudes greater than 60° N send Type I — A2 scalings to the appropriate World Data Centre. (The proposed Types of scaling are given in Appendix IV of the Report).

13. — A2 Absorption Measurements at magnetically conjugate points

The U.R.S.I.-A.G.I. Committee recognising that the A2 absorption method appears to offer a simple method for the continuous detection of corpuscular bombardment of the upper atmosphere recommends that the method be used simultaneously at magnetically conjugate point in the northern and southern auroral belts to determine the relative importance of diurnal, seasonal, magnetic and geomagnetic factors in controlling the bombardment and absorption processes.

14. — Long-term Ionospheric Drift Measurements

The U.R.S.I.-A.G.I. Committee noting that observations over a period of years at one northern hemisphere temperate latitude station have indicated that horizontal drift in the F region is subject to long-period changes which appear to be related to the sunspot cycle, emphasises the need for similar long-term drift data from other stations and strongly recommends that drift observations should continue at a number of stations for a complete solar cycle.

15. — Network of drift stations after 1959

The U.R.S.I.-A.G.I. Committee has reviewed the amount of experimental data available on horizontal drift in the ionosphere. While appreciating that some stations have a considerable body of data awaiting analysis and consequently may feel it undesirable to continue making further observations, the Committee views with concern the possibility of a serious reduction in the number of observing stations at the end of 1959. The U.R.S.I.-A.G.I. Committee strongly recommends that the existing network of drift stations be maintained for at least one year beyond December 1959. There is a special need for continuing observations at some Southern hemisphere stations.

Appendix I

List of Stations which have indicated that ionospheric absorption measurements (A1 method) were made for some part of the I.G.Y. or I.G.C.

Station	Country	Lat.	Long.	I.G.Y. (Commencing Date)	I.G.C.
Resolute Bay	Canada	N 75	W 95	Yes (3-57)	Yes
Dixon Is.	U.S.S.R.	N 74	E 81	Yes (10-57)	Yes
Tromsö	Norway	N 70	E 19	Yes (3-55)	No
Murmansk	U.S.S.R.	N 69	E 33	Yes (12-58)	Yes
Kiruna	Sweden	N 68	E 20	Yes (6-58)	?
Baker Lake	Canada	N 64	W 96	Yes (1-57)	Yes
Kjeller-Oslo	Norway	N 60	E 11	Yes (9-50)	No
Churchill	Canada	N 59	W 94	Yes (1-57)	Yes
Inverness	U.K.	N 57	W 04	Yes (?)	Yes
Tomsk	U.S.S.R.	N 56	E 85	Yes (12-57)	Yes
Juliusrüh	Germany	N 55	E 13	Yes (10-56)	Yes
Moscow	U.S.S.R.	N 55	E 37	Yes (7-57)	?
Kühlungsborn	Germany	N 54	E 12	Yes (-52)	Yes
De Bilt	Netherlands	N 52	E 05	Yes (7-55)	Yes
Irkutsk	U.S.S.R.	N 52	E 104	Yes (9-57)	Yes
Lindau	Germany	N 52	E 10	Yes (8-57)	Yes
Slough	U.K.	N 52	W 01	Yes (1-35)	Yes
Swansea	U.K.	N 52	W 04	Yes (12-57)	Yes
Pruhonice	Czechoslovakia	N 50	E 15	Yes (7-57)	?
Winnipeg	Canada	N 50	W 97	Yes (1-58)	Yes
Freiburg	Germany	N 48	E 08	Yes (1-49)	Yes
Rostov	U.S.S.R.	N 47	E 40	Yes (6-58)	Yes
Ottawa	Canada	N 45	W 76	Yes (5-57)	Yes
University Park	U.S.A.	N 41	W 78	Yes (6-57)	No
Akita	Japan	N 40	E 140	No (10-51)	?
Ashkhabad	U.S.S.R.	N 38	E 58	Yes (6-57)	Yes
Kokubunji	Japan	N 36	E 139	Yes (6-57)	Yes
Delhi	India	N 29	E 77	Yes (6-54)	Yes
Ahmedabad	India	N 23	E 73	Yes (9-57)	Yes
Colombo	Ceylan	N 07	E 80	Yes (7-57)	Yes
Ibadan	Nigeria	N 07	E 04	Yes (2-52)	Yes
Singapore	Malaya	N 01	E 104	Yes (9-49)	Yes
Lwiro	Belgian Congo	S 02	E 29	Yes (11-58)	?
Tsumeb	Union S. Africa	S 19	E 18	Yes (8-57)	?
Johannesburg	Union S. Africa	S 26	E 28	Yes (7-57)	Yes
Brisbane	Australia	S 28	E 153	Yes (6-56)	Yes
Port Stanley	Falkland Is.	S 52	W 58	Yes (8-49)	No
Port Lockroy	Antarctica	S 65	W 64	Yes (4-58)	Yes
Halley Bay	Antarctica	S 76	W 27	Yes (4-57)	No

Appendix II

List of Stations which have indicated that absorption measurements (A2 method) were made for some part of the I.G.Y. or I.G.C.

Station	Country	Lat.	Long.	I.G.Y. Commencing Date	I.G.C.	Frequency (Mc/s)	Type of Scaling
Longyearbyen	Spitzbergen	N 78	E 16	7-58	Yes	27.6	I, II
Thule	Greenland	N 77	W 69	2-58	Yes	27.6	I, II
Bjornoya	Norway	N 75	E 19	7-58	Yes	27.6	I, II
Point Barrow	Alaska	N 71	W 157	4-58	Yes	27.6	I, II
Skibotn	Norway	N 69	E 20	7-58	Yes	27.6	I, II
Godhavn	Greenland	N 69	W 54	7-57	Yes	31.2	I, II
Kiruna	Sweden	N 68	E 20	3-58	Yes	27.6	I, II
Fort Yukon	Alaska	N 67	W 145	2-58	Yes	27.6	I, II
Fairbanks	Alaska	N 65	W 148	7-57	Yes	27.6	I, II
Trondheim	Norway	N 63	E 10	7-58	Yes	27.6	I, II
Farewell	Alaska	N 63	W 154	1-57	No	27,6	I, II
Lerwick	U.K.	N 60	W 01	1-58	No	22,46	?
Oslo Kjeller	Norway	N 60	E 11	7-58	Yes	27.6	I, II
Churchill	Canada	N 59	W 94	7-57	Yes	30	II
King Salmon	Alaska	N 59	W 157	10-57	Yes	27.6	I, II
Edinburgh	U.K.	N 56	W 03	5-58	Yes	20,30 40,46	I, II
Knob Lake	Canada	N 55	W 67	4-58	Yes	27.6	I, II
Meanook	Canada	N 55	W 113	3-58	No	27.6	I, II
Unalaska	Alaska	N 54	W 167	10-57	No	27.6	I, II
Pullman	U.S.A.	N 47	W 117	11-57	No	27.6	I, II
Ottawa	Canada	N 45	W 76	7-57	Yes	30	II
Hanover	U.S.A.	N 44	W 72	11-57	Yes	27.6	I, II
Troy	U.S.A.	N 43	W 74	?	Yes	18	?
McMath-Hulbert	U.S.A.	N 43	W 83	7-57	Yes	18	II*
Boulder	U.S.A.	N 40	W 105	7-57	Yes	18	I, II*
Stanford, San Francisco	U.S.A.	N 37	W 122	12-57	Yes	27.6	I, II
Sacramento Peak	U.S.A.	N 33	W 106	7-57	Yes	18	II*
Ahmedabad	India	N 23	E 73	7-57	Yes	25	I, II*
Hawaii	U.S.A.	N 21	W 158	12-58	Yes	18	I, II*
Madras	India	N 13	E 80	10-57	Yes	30	?
Sao Paulo	Brazil	S 24	W 47	6-58	Yes	40	?

Notes.

All stations employed zenithal antennas, except Gohdavn where antennas directed toward the celestial pole were used.

For explanation of types of scaling, see Appendix IV. An asterisk indicates Type II scaling during special events only.

Appendix III

List of Stations which have indicated that ionospheric drift measurements were made for some part of the I.G.Y. or I.G.C.

Station	Country	Lat.	Long.	Method	I.G.Y.	I.G.C.
Murmansk	U.S.S.R.	N 69	E 33	1	Yes	Yes
Churchill	Canada	N 59	W 94	1	Yes	No
Tomsk	U.S.S.R.	N 56	E 85	1	Yes	Yes
Gorky	U.S.S.R.	N 56	E 44	1	Yes	Yes
Moscow	U.S.S.R.	N 55	E 37	1,2	Yes	Yes
Kühlungsborn	Germany	N 54	E 12	?	Yes	?
Jodrell Bank	U.K.	N 53	W 2	3,5	Yes	No
Irkutsk	U.S.S.R.	N 52	E 104	1	Yes	Yes
Cambridge	U.K.	N 52	0	1,5	Yes	Yes
Swansea	U.K.	N 52	W 4	1,2	Yes	Yes
Cologne	Germany	N 51	E 7	?	Yes	?
Pruhonice	Czechoslovakia	N 50	E 15	4	Yes	Yes
Karkov	U.S.S.R.	N 50	E 36	1,3	Yes	Yes
Paris	France	N 49	E 2	1	Yes	?
Freiburg	Germany	N 48	E 8	1	Yes	Yes
Rostov	U.S.S.R.	N 47	E 40	1	Yes	Yes
Ottawa	Canada	N 45	W 76	1	Yes	No
Simeis	U.S.S.R.	N 44	E 34	1	Yes	No
Charlottesville	U.S.A.	N 38	W 78	5	Yes	?
Ashkhabad	U.S.S.R.	N 38	E 58	1	Yes	Yes
Yamagawa	Japan	N 31	E 131	1	Yes	Yes
Delhi	India	N 29	E 77	1	Yes	Yes
Ahmedabad	India	N 23	E 73	1	Yes	Yes
Tamanrasset	France	N 23	E 6	1	No	Yes
Mayaguez	W. Indies	N 18	W 67	1,5	Yes	Yes
Waltair	India	N 18	E 83	1	Yes	Yes
Ibadan	Nigeria	N 7	E 4	1	Yes	Yes
Bogota	Colombia	N 5	W 74	2	Yes	Yes
Bangui	France	N 5	E 19	1	Yes	Yes
Singapore	Malaya	N 1	E 104	1	Yes	Yes
Lwiro	Belgian Congo	S 2	E 29	1	Yes	Yes
Tahiti	France	S 17	W 149	1	Yes	Yes
Johannesburg	Union S. Africa	S 26	E 28	1	Yes	No
Brisbane	Australia	S 28	E 153	1	Yes	?
Adelaide	Australia	S 35	E 139	3	Yes	Yes
Wellington	New Zealand	S 41	E 175	1	Yes	No
Kerguelen	France	S 49	E 70	1	No	Yes
Halley Bay	Antarctica	S 76	W 27	1	Yes	No

Key to methods :

1. Fading method (close-spaced receivers)
2. Motion of large scale irregularities
3. Drift of meteor trails
4. Motion of Es patches
5. Motion of irregularities causing radio star scintillations.

Appendix IV

On the Scaling and Tabulation of I.G.Y. Ionospheric Absorption Measurements Made Using the Cosmic Noise Method (Method A2)

1. *Types of Scaling.*

Recordings of the received intensity of extra-terrestrial radio waves may be used to obtain information of three types of ionospheric absorption.

(*a*) Regular absorption occurring in the undisturbed D, E and F regions.

This type of absorption may be expected to be present to some degree at all locations and at all times. In general, it will be strongest during daylight hours.

(*b*) Anomalous absorption associated with solar flares.

This type of absorption is due to sudden increases in the ionizing component of solar electromagnetic radiation, primarily at ultra-violet and X-ray wave lengths. This type of absorption event is observed only in the sunlit hemisphere.

(*c*) Anomalous absorption associated with corpuscular bombardment of the upper atmosphere.

This type of absorption occurs most frequently near the auroral zone, and may occur during the day or night. It is rarely seen between latitudes 40° N and 40° S.

In order that data pertaining to both the regular and the irregular variations of ionospheric absorption be available in suitable form for analysis from all A2 stations, it is suggested that each station prepare and send to the appropriate World Data Centre tables of scaled data of *two* types.

Scaling Type I. — Monthly tables of the value of the absorption in decibels occurring at the hour, each hour (i. e., 24 hourly spot checks of the absorption each day).

Each table lists the mean absorption during the first minute of every hour, for a specified station and month.

This Type I scaling is intended for the determination of diurnal and seasonal variations of both regular and anomalous absorption, and for cross-correlation studies between the absorption at different stations. It is not suitable for solar flare absorption events, since these are relatively rare and in general occur at times other than exactly on the hour.

Scaling Type II. — Monthly tables of the maximum value of the absorption in decibels occurring during each hour, together with the time of occurrence of the maximum to the nearest tenth of an hour.

This type of scaling is intended for studies of solar flare events, and for studies of the intensity of auroral storms at different stations. It is not particularly suitable for studies of non-disturbed or slowly varying ionospheric absorption.

2. *Scaling Procedures.*

The A2 method relies on the comparison of the actual received signal strength with that expected under conditions of negligible absorption. Unfortunately the true sidereal diurnal variation of cosmic noise cannot be determined until good observations have been taken for many months. It is therefore suggested that each station scale all its first year's records using a provisional « quiet day curve » (first estimate of the sidereal variation of cosmic noise in the absence of ionospheric absorption as observed by that particular equipment). All tabulations of ionospheric absorption so prepared should be labelled « Provisional ».

As soon as twelve months' good records are available, a final « quiet day curve » should be prepared. Thereafter, this final curve should be used in the scaling of the records, and the title « provisional » replaced by « final ». At this time, the station should publish a table listing the difference between the « provisional » and « final » quiet day curves. This table should list the correction at sidereal hourly intervals to the nearest 0.1 *db*, and would permit other workers to correct the provisional tables immediately.

3. *Suggested Symbols to be Used in Tabulating A2 Data.*

A two digit number should be used to express the observed absorption in decibels. Where possible, the absorption should be scaled with a sensitivity at least as high as that suggested in the table below.

Absorption Range	Scale Absorption to Nearest
0- 3 db	0.1 db
3- 6 db	0.2 db
6-10 db	0.5 db
More than 10 db	1.0 db

The following symbols should be used to qualify or replace the *absorption* digits in both Type I and Type II scalings.

C Failure of equipment or personnel.

S Interference (origin unknown).

St Interference (believed terrestrial).

St Interference (believed solar radio noise).

D Absorption in excess of maximum scalable value.

E Absorption less than minimum detectable value.

I (Preceding a numerical value) Value interpolated.

Q (Preceding a numerical value) Outburst of solar radio waves observed on absorption measuring equipment immediately prior to the absorption event being described.

U (Preceding a numerical value) Value uncertain.

V (For use with Type I scaling only) Value varying rapidly during one minute.

The following symbols should be used to qualify *only* the *absorption* digits in Type II scalings.

G Absorption essentially constant during the whole hour (No *db* absorption varying by less than 0.3 *db*, or less than a factor of 1.5 to 1, whichever is the greater).

M Multiple (three or more) well defined absorption events during the hour. Scale the most intense absorption event during the

hour ; if the maximum value is reached more than once, the time digit should refer to the first maximum.

The following symbol may be used to qualify or replace the *timing* digit in Type II scalings.

U The symbol U should be used to qualify the time digit when the time of maximum absorption is not well defined, e. g. during a slowly varying absorption event.

In Type II scalings, not more than one symbol should be used at a time to qualify the *absorption* data. The same is also true for the *time* data. The use of multiple symbols in Type II scalings is discouraged in order to restrict the amount of information (a minimum of 3 digits during a scalable event) to be entered in each hourly block.

No such restriction is recommended for Type I scalings.

Third Report of the World-Wide Soundings Committee of the Committee on the International Geophysical Year of the International Scientific Radio Union

I. — Introduction

The World-wide Soundings Committee (WWSC) of the U.R.S.I./A.G.I. Committee held its third full meeting in Brussels from August 27 to September 5, 1959. The first five days were devoted exclusively to WWSC work ; during the remaining days the time was shared with meetings of the parent committee and other U.R.S.I. groups. In all, six half-day sessions of the whole group were held, four meetings of the WWSC itself and numerous sessions of working and drafting groups. Attendance was as follows :

WWSC Members : Y. Aono, N. Mednikova, W. R. Piggott, K. Rawer, J. Turner, A. H. Shapley (*Chairman*).

Principal Consultants to WWSC : W. Becker, A. Haubert, P. Herrinck, R. Knecht, A. J. Lyon, J. H. Meek, R. Rivault, O. Sandoz, J. O. Thomas, J. W. Wright, R. W. Wright.

Invited Participants from Ionospheric Organizations : L. Bossy, Dyto, J. Hewitt.

The agenda of the meeting corresponded very closely to the structure of this report. For all items, one or more preparatory documents had been circulated in advance and this greatly facilitated the discussions. Small working groups were formed to collect and record material for discussion and for the report. There were also ad hoc discussion meetings on Medians, Es and oblique soundings.

In addition to the material appearing in this report, the WWSC took a number of specific procedural decisions for action. Of these, the only one which needs to be recorded here is the decision to hold a fourth full meeting of members and consultants in the time immediately preceding the 1960 U.R.S.I. General Assembly. This meeting would receive the formal reports on results of the various pilot studies which have been initiated prior to general discussion and possible adoption of revised recommendations by the WWSC.

Much of this report was drafted during the meetings at Brussels and sections II, III, IV have been circulated in draft form among the WWSC group. The final text was worked out by a small drafting group of the Committee at Paris, November 1959.

A brief summary of the main features of this report is given in this introduction ; more detailed information will be found in the separate sections.

The main objective of this meeting was to review the status of ionospheric soundings for geophysical purposes with particular emphasis on the observations during the I.G.Y. and I.G.C. 1959, to discuss the value of the recommendations made by the WWSC in the past and to consider whether further work was necessary or desirable in the future. The remarkably large attendance at the meeting enabled a very wide range of views to be sampled and discussed and it is probable that few, if any, of the ideas of active workers in this field were overlooked. It appeared that the recom-

mendations of the Committee had been very widely adopted and had resulted in a really worthwhile increase in the homogeneity and value of the observations. There was, however, a widespread desire that the Committee attempt the rather specialized job of putting the recommendations on scaling of ionograms into a form suitable for use by operators at the stations.

It was unanimously agreed that the rules for calculating medians, though mathematically logical and correct, were inappropriate to routine ionospheric soundings and that more representative average values could be obtained by suitable modifications to these rules.

Summary

General Recommendations (Section II).

The discussions of the Committee have brought out the need to make certain specific recommendations which are given in Section II. In all 16 recommendations have been prepared, 11 of which have also been adopted by the U.R.S.I./I.G.Y. Committee in the same or shortened form. These include the use and operation and future of World Data Centers, the flow and scientific exploitation of the I.G.Y. data, monitoring the data from the world network, future programs of work, the deployment of ionospheric stations and the development of new techniques and parameters. The Committee proposes the use of the *U.R.S.I. Information Bulletin* as a major channel of information for Ionospheric stations.

I.G.Y. Sounding Program (Section III).

The Committee has reviewed the activity of stations during the I.G.Y. and the results of sample tests of the quality of the data produced. Approximately 163 vertical soundings stations have been operated during the I.G.Y., about 120 of them for the full period. In all 50 new stations were established as a result of the I.G.Y. effort. The programs and reduction rules recommended by the WWSC have been adopted very widely and the quantity and quality of the data produced is most satisfactory. The data flow, which is summarized in a table, is progressing steadily, the fraction of the total possible available at at least one World Data Center being 82 % for the median values and 75 % for hourly values, but only 45 % for the ionogram interchange. The

value of the latter appears to be underestimated at some stations. The median data is being prepared for International publication in the I.G.Y. Annals. Special recommendations have been made about data analyses, intercomparison and monitoring of consistency.

I.G.C. Program (Section IV).

The Committee has reviewed the work in progress during the I.G.C. About 146 stations are known to be in operation until at least the end of the I.G.C. The quality of the observations will probably be even better than that reached in the I.G.Y. and the effective world coverage is as good or better than in the I.G.Y. Owing to the observing programs at a few stations being reduced to hourly observations (see table) and the reduction in the number of periods of special activity, a slight decrease in the total quantity of data is to be expected. Information based on about 90 % of all stations suggests that all active stations are producing at least tabulations at hourly values, at least 70 % continue to take ionograms on a 15 minute schedule, and 55 % produce and circulate *f*-plots. The data flow to the WDC's has started satisfactorily apart from the interchange of ionograms. This needs further attention, particularly at new stations where the reliability of data is uncertain and the chance of non-standard reduction occurring by accident is relatively large.

Problems of World-wide Soundings after the I.G.C. (Section V).

The Committee has reviewed the problems of the size of the world-wide network after the I.G.C., the deployment of stations and the soundings programs which should be maintained. The immediate problems fall into several groups.

(*a*) the maintenance of an adequate world-wide network,

(*b*) special work in close networks of stations,

(*c*) new methods of soundings and of data handling,

(*d*) introduction of oblique incidence techniques giving routine data to supplement that from the world network.

The requirements of prediction and geophysical projects which should be considered in deciding the deployment of stations are summarized, in particular the need for a considerable effort in the coming sunspot minimum period and the requirements of space

research are stressed. Recommendations are given for the program of observations stressing the importance of world-wide interrelations between stations' results. The future use of new techniques is discussed and the importance of keystation work is stressed.

Ionogram reduction procedures (Section VI).

Despite the success of the rapid and fundamental change in scaling and reduction procedures introduced just before the I.G.Y., the WWSC believes that future changes should be made more deliberately after due notice and a study of the results given by pilot experiments. The only effective change recommended for introduction on January 1, 1960, is a simplification of the median rules which has been urgently requested by many groups. The draft of the new rules, together with a draft clarification of the distinction between the magneto-ionic components in E*s* traces have been widely distributed so as to permit effective adoption at the desired date. Pilot experiments and discussions on the relative merits of *fo*E*s*, *fx*E*s* and *f*E*s* have been initiated so that these can be reviewed in July 1960. Exploratory proposals to discontinue some or all of certain characteristics are published and discussion is invited. The possibilities of introducing a characteristic based on ionization profile techniques for routine reduction is also being actively investigated.

A short outline is given of a new standard Handbook for Station Operators which has been prepared by the Committee and is nearly ready for publication. This contains, in one place, all the informations prepared by the WWSC to enable operators to reduce ionograms according to the international procedures.

Future coordination (Section VII).

A short survey is given on post activity of the WWSC which began with the establishment of a consistent system of rules for reduction of ionograms, laid down a detailed program for routine work and studied the efficiency of these measures. In this way an international coordination has been obtained which should be continued in one form or another. Without prejudging the decision of U.R.S.I. General Assembly (London 1960) it can be stated that the form of composition of the committee and the collaboration amongst members and consultants as well as with organizations and stations seems to have been successful.

II. — Resolutions by the Third Meeting of WWSC (Brussels 1959)

(1) *Flow of I.G.Y. Data* (See Resolution I of the U.R.S.I.-A.G.I. Committee, p. 35).

(2) *Analysis of I.G.Y. Data* (See Resolution 2 of the U.R.S.I.-A.G.I. Committee, p. 36).

(3) *Scientific Use of World Data Centres* : (See Resolution 3 of the U.R.S.I.-A.G.I. Committee, p. 36).

(4) *Future of World Data Centres* (See Resolution 4 of the U.R.S-I.-A.G.I. Committee, p. 36).

(5) *Interchange of Vertical Soundings Data for I.G.C.* 1959 *and Onwards* (See Resolution 5 of the U.R.S.I.-A.G.I. Committee, p. 37).

(6) *Ionogram Interchange for I.G.C.* 1959.

The Committee notes that the I.G.Y. ionogram interchange plan has already contributed important benefits to scientific work, even though the interchange is as yet only partly accomplished. Use of the ionograms should increase as the collections become more nearly complete and as scientists are relieved from preoccupation with the I.G.Y. observing programmes. Examples of uses already made of I.G.Y. ionograms at the WDC's are :

(*a*) Examination of the sample ionograms at a WDC has uncovered some unintentional deviation from the uniform scaling practices ; thus aiding the intercomparison of the results from the stations and the resulting correspondence with stations has improved the uniformity of the numerical data and *f*-plots. This has been particularly useful in the case of newly established stations.

(*b*) Some research workers have used the ionograms at WDC's to clarify phenomena shown on *f*-plots and in numerical data. The ionograms have also enabled the scientists to judge the accuracy and representativeness of the data. This has been particularly useful in certain high and low latitude studies.

(*c*) The interchanged ionograms have been used in a multi-station analysis involving N(h) reductions ; here the work could

not have been accomplished unless the ionograms themselves were available in a central place.

The Committee believes that the principle of ionogram interchange as planned for the I.G.Y. should be maintained. It recommends, however, that the minimum number of ionograms in the interchange should be reduced for the 1959 observing period to a level which is useful for the scientific work but at the same time can be fitted into the practical aspects of station or network operation in the future.

The Committee believes that this level is about 15 to 20 days a year and that a reasonable plan which would give a random sample plus disturbed periods is as follows :

1. the (one) highest priority Regular World Day each month (reckoned in UT), *and*
2. one Special World Interval (of about 3 days) during the year, selected promptly by the WWSC by correspondence, or in exceptional cases, possibly two SWI's.

The Committee believes that at least a limited interchange of ionograms will be necessary in future years. A useful alternative to Part 1 of this programme would be to specify the 3 consecutive Regular World Days each quarter ; in future years one or the other of these plans may be recommended.

The Commitee believes that the full prestige of U.R.S.I. should be put behind the principle of ionogram interchange. It urges that special efforts be made by the U.R.S.I. Bureau to solve the practical problems which may exist in the case of some individual stations or networks.

(7) *Vertical Sounding Program after* 1959 (See Resolution 7 of the U.R.S.I.-A.G.I. Committee, p. 37).

A considerable international effort will be needed at sunspot minimum and much of the I.G.Y. potential will be lost unless the world network at that time is comparable in extent to that used during the I.G.Y. Thus there is a practical need to maintain a large proportion of the existing network at least through this period.

This is discussed more fully in Section V of this report.

(8) *Geographical Distribution of Ionospheric Stations.*

The Committee considers that the geographical distribution of ionospheric stations should be kept continuously under review and changes should be made in accordance with the changing emphasis of scientific and practical problems. The present review brings out the following recommendations :

(*a*) The major magnetic and ionospheric anomaly south of Africa to the Weddell Sea and beyond needs further study which would be greatly aided by the re-opening of Marion Island station, continued and continuous coverage at the stations on the Weddell Sea coast, and at a new inland location between the Weddell Sea coast and the south geographic pole.

(*b*) The early I.G.Y. studies of the magnetic equatorial belt have demonstrated the scientific value of chains in areas where the ionization gradients are large, and point to the need for additional observations as follows : continued operation of the full central African group of stations in order to have a suitable period of continuous coverage, in particular Bangui and Tamanrasset, and an additional station at about 14° magnetic dip ; renewal of the close-spaced experiment in South America at Panama, Chiclayo, Chimbote or approximate equivalents, in particular the originally planned I.G.Y. site at Pasto ; testing the longitude effect by measurements in the central Pacific such as Fanning Island ; and a second check in the far Pacific by continued and improved measurements at Macao and Hollandia plus measurement south of Baguio at, for instance, Davao and Bandœng and some island between these and Singapore.

(*c*) For the coverage of oceanic areas for world map purposes, the existing island stations at Maui, Rarotonga, Tahiti, and Kerguelen are especially valuable, and new stations, even if temporary, on islands such as Canary, Easter, Fanning, Ascension would contribute greatly.

(*d*) The Committee calls attention to the major gap in the ionospheric data available due to the absence of data from eastern and southeastern continental Asia, for example, continental China. This greatly hampers the practical and scientific treatment of ionospheric data from the world-wide network. The Committee invites the authorities involved to consider the scientific value

of completing the world picture by providing stations contributing regularly to the interchange of data on an international basis.

(9) *Full Use of Available Ionosondes* (See Resolution 9 of the U.R.S.I.-A.G.I. Committee, p. 38).

(10) *Monitoring of Systematic Data Reduction.*

The Committee is aware that many important scientific problems can only be resolved by data which are highly consistent and, therefore, require close monitoring and intercomparison. It has therefore sponsored a pilot experiment to monitor the data from ionospheric stations. This involved comparing the data circulated in tabular and *f*-plot form with that obtained by an independent scaling of the ionograms available at a World Data Centre. These investigations have disclosed that various minor difficulties have arisen in applying the scaling rules at some stations. However, the extensive effort needed to check all the data from all stations is clearly beyond the present resources of the World-wide Soundings Committee. The Committee believes that valuable evidence on the uniformity and reliability of data from different stations will be obtained during scientific studies made at the WDC's. In particular, studies of Es-types and their detailed statistics, regional or world maps of any characteristic, electron density profiles, traveling disturbances, scatter effects or other special problems involving the use of homogeneous data or the re-examination of ionograms, will automatically provide the required information.

The Committee *recommends* that the scientific workers using these centres be requested to report to the Centre, and through it to the WWSC, any difficulties or discrepancies found, especially in the results of studies involving homogeneous data from several stations.

(11) *U.R.S.I. Information Bulletin.*

The Committe recommends that the *U.R.S.I. Information Bulletin* be part of the technical literature available at all vertical sounding stations. Notification of future RWD's, dates for ionogram interchange, proposals for regional or world-wide studies and other information issued by the World-Wide Soundings Committee for the assistance or guidance at ionispheric sounding stations will be circulated in this Bulletin in the future.

(12) *Reporting of Peculiar Phenomena.*

The Committee has discussed the problem of exchanging information about various peculiar ionospheric phenomena which are often well known to observers at individual ionospheric stations, but are not adequately reported. It recognizes, however, that the observers often do not have adequate facilities and references for preparing reports which are suitable for publication in scientific journals. The Committee nevertheless encourages observers to study, discuss and report these phenomena, and *recommends* the preparation of short reviews of such observations by observers and their informal circulation as may be appropriate to the WWSC, the network centres and any other suitable body.

(13) *Automatic Reduction of Soundings.*

The Committee notes that techniques are being actively studied which provide direct recording of certain ionospheric characteristics without first producing ionograms or provide an immediate analysis of the *h'f* function, and *recommends* that work of this kind should be actively encouraged. It is important that information of progress in this field be published promptly so as to facilitate future cooperation.

(14) *New Sounding Methods.*

The Committee notes that new methods are being developed which are potentially useful for routine ionospheric sounding, some of which have particular advantage for filling gaps in the world network, for example ground backscatter sounding, oblique incidence multi-frequency sounding and vertical incidence scatter sounding; calls attention to the need for compatibility of form between the data selected for regular reduction from such observations and the data produced through conventional soundings; invites detailed proposals on the form to be used; and *recommends* that any systematic data obtained by the new methods be interchanged and compared with data obtained by conventional methods.

(15) *I.G.Y. World Ionospheric Maps.*

Recognizing the importance of developing means by which the extensive synoptic data of the I.G.Y. may be portrayed in summary graphical form, the Committee wishes to encourage the preparation

of instantaneous world maps of one or more of the standard ionospheric parameters exchanged internationally. World Maps of *fo*F2 prepared at suitable intervals for a Regular World Day could serve as useful first examples. The experience of the prediction services should be valuable in perfecting techniques for this work and the functioning of the World Data Centres affords the possibility of even broader participation. Intercomparison of typical maps from different sources seems advisable before any large scale trials are undertaken.

(16) *World-wide Scaling of* N(*h*) *Parameters* (See Resolution II of the U.R.S.I.-A.G.I. Committee, p. 38).

III. — Monitoring of I.G.Y. Vertical Soundings Program

(1) *Introduction.*

The WWSC has made limited inquiries into the extent to which the plans for the I.G.Y. Vertical Soundings program were actually put into effect. These concerned the list of stations actually in operation during the I.G.Y., the degree to which the observing programs and reduction procedures as recommended by WWSC were carried out, the amount of supplementary work which was carried out, the flow of data to the WDC's and the status of national and international plans for publication. The WWSC has also made limited inquiry into the degree to which I.G.Y. data are being used for research and analysis and the role of the WDC's in this important phase of the I.G.Y. effort.

(2) *Actual I.G.Y. Program.*

It appears that 163 vertical sounding stations were successfully operated for all or part of the I.G.Y. using a systematic schedule based on the network program. These stations are listed in Table 1, and are shown on the map of Figure 1. About 120 stations were in operation for the full I.G.Y. period and about 138 for at least 12 months of the I.G.Y.

The 163 stations include approximately 50 which were newly established largely on account of the I.G.Y. enterprise. All but about 5 of the seriously planned new I.G.Y. stations were in fact established by the end of the I.G.Y.; most of these five have started or will start during 1959 or early 1960.

There is much evidence that the very large majority of I.G.Y. stations closely followed the recommended program of observation and reduction, including characteristics scaled, quater-hourly or faster observing schedules on World Days, *f*-plot reductions at least on World Days. An appreciable number of stations undertook suggested supplementary work such as *h'*plots, E-structure plots, special regional scalings, continuous observations during Special World Intervals, etc. Inquiries are under way to make this summary information more specific.

The large participation and the relatively consistent body of data obtained implies that at least some of the planned world network experiments will prove to be successful. In particular the classification of E*s* echoes into 9 gross types and the accumulation of data and statistics on the occurrence of these types separately may be mentioned. The tightened rules on quantitative frequency measurements of E*s* have produced a much more nearly homogeneous body of world-wide data for propagation studies, although at the cost of considerable extra work of reduction and tabulation. The *f*-plot method of reduction has proved itself, particularly for world-wide storm analyses and for the higher latitudes including the polar caps.

The necessary data have been taken for the several regional multistation studies planned for I.G.Y. The meridional chains of stations were established very nearly as planned and are already providing new scientific results. Only the 150° E meridian chain had more gaps than was scientifically desirable at this stage of ionospheric studies. The station coverage on the north and south polar caps was essentially as planned and was the best ever attained. Three close-spaced transequatorial chains have and will contribute to understanding of the equatorial zone. The uniformity of procedures and easy availability of data through WDC's are essential to these regional studies.

(3) *Data Flow.*

Vertical soundings data are flowing steadily to the World Data Centres. There is a grand total of 2653 station-months of I.G.Y. data possible. Roughly speaking, the flow to at least one data center for median tables is about 82 % complete for the I.G.Y. period ;

for tables of hourly values about 75 % ; for ionograms about 45 % ; and for *f*-plots about 62 %. Hourly values tables are complete for the whole I.G.Y. at least at one data center for 65 stations ; tables, ionograms and *f*-plots are all complete at least at one data center for 30 stations ; but the complete data are available at all 4 data centers for only the 4 Japanese stations. For about half the stations, the numerical tables and *f*-plots are being provided in booklet form ; this has reduced the amount of inter-WDC exchange needed to make the four WDC archives identical. As indices of the state of data interchange between data centres, the percentage of the data which are available at all 4 data centres are : tables of hourly values 69 %, ionograms 57 %, and *f*-plots 61 %. It is hard to assess the amount of special or supplementary data which have been sent to WDC's.

The WWSC has examined and inter-compared the latest catalogues of the four WDC's, kindly provided for the information of the WWSC at its third meeting. The WWSC has pointed out in a separate report of temporal interest the instances where data flow from stations or networks is unusually or unaccountably slow and instances where something seems to have slipped in interchange of data copies among the four WDC's.

The principal danger to the over-all success of the I.G.Y. vertical soundings program appears to be the lack of participation in exchange of ionograms. The WDC's have ionogram copies according to the plan specified by the C.S.A.G.I. Reporter from only 92 stations. Thirteen countries so far have sent no ionograms to data centres. It would appear that there are many difficult problems which can only be solved by treating each case actively and individually. The WWSC believes that important new scientific results will be lost if the ionogram interchange is not virtually complete according to the plan, and the values and significance of many other studies already completed, in progress, or in prospect will be seriously weakened.

The WWSC is not well informed of the extent to which WDC's are being provided with information on ionogram scales, accuracy and other information on ionosondes which is essential to the study of ionograms made available through WDC's ; in some sample cases this has been inadequate.

(4) *Publication of I.G.Y. Data.*

The WWSC has been informed of the status of preparations for international publication of summary vertical soundings data in the I.G.Y. Annals under the direction of the C.S.A.G.I. Reporter, acting through the WDC's, with WDC-C1 as principal. The WWSC understands that typing of final manuscript has started within the past month.

It appears that about half the stations will have hourly numerical results, and in many cases *f*-plots, issued in booklet form for limited distribution. The WDC catalogues might well identify in their catalogues where this is the case.

(5) *Final Summary Reports.*

The WWSC has discussed the need for a final summary report of what observations were actually accomplished during the I.G.Y. Such a report might contain a table to indicate for each station the observing schedules and systematic data reduction (ordinary and World Days) which actually were accomplished, the periods of observation of stations, whether data are in booklets or only at WDC's, etc. The WWSC is prepared to assist the C.S.A.G.I. Reporter in this work.

(6) *Observers Reports of observation at Individual Stations.*

The WWSC has continued to encourage the preparation at individual stations of mainly descriptive reports of the I.G.Y. soundings observations at that station, usually for informed circulation among active scientific workers and other stations of the world network rather than for publication in the scientific journals. Some such reviews have been brought to the attention of the Committee, which is searching for a suitable mechanism for effective distribution and use. The WWSC notes that several new phenomena have been uncovered through such reports written by station operators.

(7) *Uniformity and Consistency of Data Reduction.*

The Committee has sponsored a small amount of intercomparison of scaled data from groups of stations. The study of E*s* data gave an indication of the degree of consistency of interpretation among the stations. This work has proved valuable in preparation

of clearer expression of scaling rules for the future. It also has been a valuable scientific work in itself. The WWSC is not displeased with the degree of apparent homogeneity of Es data as indicated by this study. Further such studies, including other scaled quantities, will make the I.G.Y. body of data more valuable.

(8) *Visits to I.G.Y. Stations.*

The WWSC had recommended that special efforts be made for WWSC members, consultants or other experts to visit stations before and during I.G.Y. to help assure the obtaining of accurate data of high quality and uniform interpretation according to the I.G.Y. plan It appears as if almost all accessible stations in the major networks were visited for this purpose by experts associated with these networks, perhaps 75 stations in all. The amount of inter-network visiting was small, but appears to have made an appreciable contribution towards improving the homogeneity of the world-wide body of I.G.Y. data.

(9) *Research Using Data from I.G.Y. World Network.*

The WWSC is not displeased with the number and quality of research analyses, already finished or in progress, using I.G.Y. data from the world network. The WWSC is aware that such work must continually be encouraged and stimulated if our I.G.Y. observing efforts are to be fully exploited. The Committee members are undertaking to do their share of encouraging, stimulating, leading and actual performing such research.

TABLE 1

Statistical Summary of I.G.Y. Data Flow as of July 1959

Explanation :

P = No. of months of I.G.Y. for which the station was in operation. * means station intermittent or closed down before end of I.G.Y.

H = Maximum No. of months for which hourly value tabulations are available at any WDC. * if there is a lag of more than 3 months in receipt of data at any other WDC.

M = *Additional* No. of months of median tabulations only.

I = Ionograms at least for RDW's and SWI's. * if there is a lag of more than 6 months. In bold (**8**, etc.) if data intermittent.

F = *f*-plots. * as under H.

C = Complete for I.G.Y. * as under H.

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F	Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
Argentina :							*Australia* :						
Buenos Aires	S 341	14	11		8	9	Brisbane	S 270	C	C		0	C
Decepcion	S 620	C	6	8	0	4	Canberra	S 350	C	17	1	0	17
General Belgrano ...	S 772	6	0	3	0	0	Hobart	S 420	C	C		0	C
La Quiaca	S 220	7	4*		0	0	MacQuarie Is.....	S 540	15*	**15***		0	**15***
Trelew	S 430	9	6		0	0	Mawson	S 670	1*	1*		0	0
Tucuman.....	S 261	C	15		12*	12*	Townsville	S 191	C	C		0	C
Ushuaia	S 541	14	**7**		0	0	Watheroo	S 300	C	C		0	0

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
Austria :						
Graz	N 470	C	C*		0	C*
Belgium :						
Base R. Baudouin...	S 700	9	0		0	0
Bunia	N 011	C	C*		0	0
Dourbes.....	N 500	C	9		0	0
Elizabethville	S 110	C	C*		0	0
Leopoldville	S 040	C	C*		0	0
Lwiro	S 020	C	11*		0	6*
Bolivia :						
La Paz.....	S 160	15	14		14	**14***
Brazil :						
Sao Paulo	S 230	C	15*		0	15
Natal	S 050	10	**6**		**6**	**6***
Canada :						
Alert	N 820	17	**14***		**15***	**14***
Baker Lake	N 641	C	C*		**16***	C*
Churchill	N 581	C	C*		**17***	C*
Clyde	N 700	15*	9*		13	**9***
Eureka	N 800	16*	**10***		**12**	**10***
Fort Chimo	N 580	10	0		**6**	0
Fort Norman	N 645	3*	1		**3**	1
Frobisher	N 630	9*	3		**11***	3

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
Canada (cont.)						
Meanook	N 540	C	**17***		**17***	**17***
Ottawa	N 450	C	C*		**16**	C*
Resolute Bay	N 740	C	C*		**16***	C*
St. John's	N 473	C	C*		C*	C*
Victoria	N 481	C	14*		C*	14*
Winnipeg	N 490	C	C*		**15***	C*
Yellowknife	N 621	15	**9***		14	**9***
Chile :						
Concepcion.....	S 360	15	8		8	6*
Colombia :						
Bogota	N 041	C	C*		**12**	C*
Czechoslovakia :						
Pruhonice.....	N 491	9	9		9*	0
Denmark :						
Thule	N 760	C	C		C	C
Godhavn	N 690	C	16		16	16*
Narsarssuak	N 611	17	17*		14	17*
Finland :						
Nurmijarvi	N 600	C	C*		0	C*
Sodankyla	N 760	17	17		0	0
Formosa :						
Taipei	N 250	C	C		0	C

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
France :						
Bangui	N 040	11	0	10*	0	0
Dakar	N 140	C	4*	10*	0	0
Djibouti	N 110	C	3*	7*	0	0
Dumont d'Urville ...	S 662	C	0	C*	0	0
Ivato	S 180	C	4*	4 *	0	0
Poitiers	N 460	C	3*	15*	0	0
Port aux Français ..	S 490	C	0	6*		
Tahiti	S 170	13	0	13*	0	0
Tamanrasset	N 221	C	3*	**10***	0	0
Germany (Dem. Rep.) :						
Juliusruh/Rügen	N 541	C	**17**		0	**17**
Germany (Fed. Rep.) :						
Freiburg	N 480	C	12*	6 *	C*	5*
Lindau.....	N 511	C	16		0	C*
Hungary :						
Budapest	N 471	C	C*		0	C*
Iceland :						
Reykjavik	N 640	C	C		C*	C *
India :						
Ahmedabad	N 230	C	10*	8	0	11*
Bombay.....	N 190	C	**12***	**6**	0	6*
Calcutta	N 222	C	10	8	0	11*

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
India (cont.)						
Delhi	N 280	C	**12***	**6**	0	**9***
Kodaikanal	N 100	C	10*	8	0	5*
Madras	N 130	C	12*	6	0	**8***
Tiruchirapalli	N 101	C	12*	6	0	**9***
Trivandrum	N 080	C	12*	6	0	**9***
Italy :						
Monte Capellino	N 440	C?	**10**			
Rome	N 411	13	13*		0	0
Japan :						
Akita	N 390	C	C		C	C
Kokubunji	N 350	C	C		C	C
Wakkanai	N 451	C	C		C	C
Yamagawa	N 310	C	C		C	C
Mexico :						
El Cerrillo	N 191	9?	2		9	0
Morocco :						
Casablanca		7*	0	7	0	7
Rabat	N 330	11	0	**3**	0	0
(N. B. — Station transferred from Casa. to Rabat).						
Netherlands :						
De Bilt	N 521	C	C		C*	C
Hollandia	S 021	13	2		0	1

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F	Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
Netherlands (cont.)							*Portugal* :						
Paramaribo.....	N 050	C	4		0	4	Macao	N 220	8	8		0	8*
New Zealand :							*Rhodesia* :						
Campbell Is.	S 520	C	17	1	0	14*	Salisbury	S 171	12	12		0	0
Cape Hallett	S 720	C	C		0	C	*Spain* :						
Goldey Head	S 431	C	C		**3**	C	Tortosa	N 402	C	C*		0	0
Rarotonga.....	S 210	C	C		3	C	*Sweden* :						
Scott Base.....	S 771	C	C		0	C	Kiruna.....	N 671	C	C		0	C
Norway :							Lulea	N 650	C	**13**		0	**8***
Longyearbyen	N 780	C	17*		0	17*	Lycksele	N 643	C	C		0	0
Oslo	N 592	C	C*		0	C*	Upsala	N 590	C	C		0	0
Tromso	N 691	C	C*		0	C*	*Switzerland* :						
Pakistan :							Schwarzenburg.....	N 461	C	C		0	0
Quetta	N 300	15	11*		0	0	*Union of S. Africa* :						
Peru :							Cape Town	S 340	C	C		2	C
Chiclayo	S 060	C	13		13	13	Grahamstown	S 330	10	10		0	0
Chimbote	S 090	C	C*		C	C*	Johannesburg	S 260	C	C		2	C
Huancayo	S 120	C	C		C	C	Marion Island.....	S 460	8*	1	7	0	1
Talara	S 041	C	C*		C	C *	Tsumeb	S 190	C	7	10	0	0
Philippines :							*United Kingdom* :						
Baguio	N 160	C	C		C	C*	Grand Bahamas	N 261	C	C		C	C
Poland :							Halley Bay	S 750	C	4*	5	C *	0
Miedzeszyn	N 522	6	5*		0	0	Ibadan.....	N 070	C	C*		C*	C*

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
United Kingdom (*cont.*)						
Inverness	N 570	C	C		C	C*
Port Lockroy	S 640	C	9		C*	9
Port Stanley	S 510	C	C		C	C*
Singapore	N 010	C	C		C	C*
Slough	N 510	C	C		C	C*
U. S. A. :						
Adak	N 512	C	C		C*	C
Anchorage	N 610	C	C		C*	C
Boulder	N 400	17*	**5***		17*	**1**
Byrd Station	S 790	C	6*		15*	7*
Cape Canaveral	N 281	10	10*		10	9*
College	N 644	C	C		C	C
Ellsworth	S 770	C	C*		C	C*
Fletcher's Ice Is.	N 810	C	C		C	C
Fort Belvoir	N 380	C	C		C	C
Fort Monmouth	N 401	C	C		C	C
Kihei (Maui)	N 200	C	C		C	C
Little America	S 780	C	8*		C*	8*
Okinawa	N 260	C	C		C	C
Panama Canal Z.	N 090	C	C		C	C
Pole Station	S 900	C	10*		16*	8
Point Barrow	N 170	C	C		C*	C
Puerto Rico	N 180	C	C		C*	6
San Salvador	N 240	2	0		2*	0
Stanford	N 370	C	C		0	C
White Sands	N 320	C	C		13*	C
Wilkes	S 660	C	7		C*	7

Country - Pays Station	Lat. Ser. No.	P	H	M	I	F
U. S. S. R. :						
Alma Ata	N 430	C	12		**7***	**7***
Arctica I	N 770	C	9		9	9
Arctica II	N 840	C	9		9	9
Ashkhabad	N 371	C	8	6	8*	8
Chita	N 520	C	2	9*	1	1
Dixon Island	N 730	C	9		9	9
Gorky	N 560	10	9*		10*	9*
Irkutsk	N 523	C	**10***		0	**10***
Leningrad	N 591	C	**12***		6*	**9***
Mirny	S 661	C	0	13*	0	0
Moscow	N 550	C	C		13*	C
Murmansk	N 680	C	C		17*	C
Providenie	N 642	C*?	**13**		1	**13***
Rostov	N 472	C	**17***		**17***	**17***
Salekhard	N 660	C	**13**	**3**	**13***	**13***
Simferopol	N 442	C	12	6	12*	12
Sverdlovsk	N 562	C	C		C*	C
Tikhaya Bay	N 801	C	8*		8*	8*
Tixie Bay	N 711	C	3	**5**	3	3
Tomsk	N 561	C	17		17*	17*
Vostok	S 781	10	0	13*	0	0
Yakutsk	N 620	C	**17**		**5***	**14***
Yuzhno-Sakhalinsk	N 462	C	C*		1	C*
Yugoslavia :						
Belgrade	N 441	10	0	10	0	0

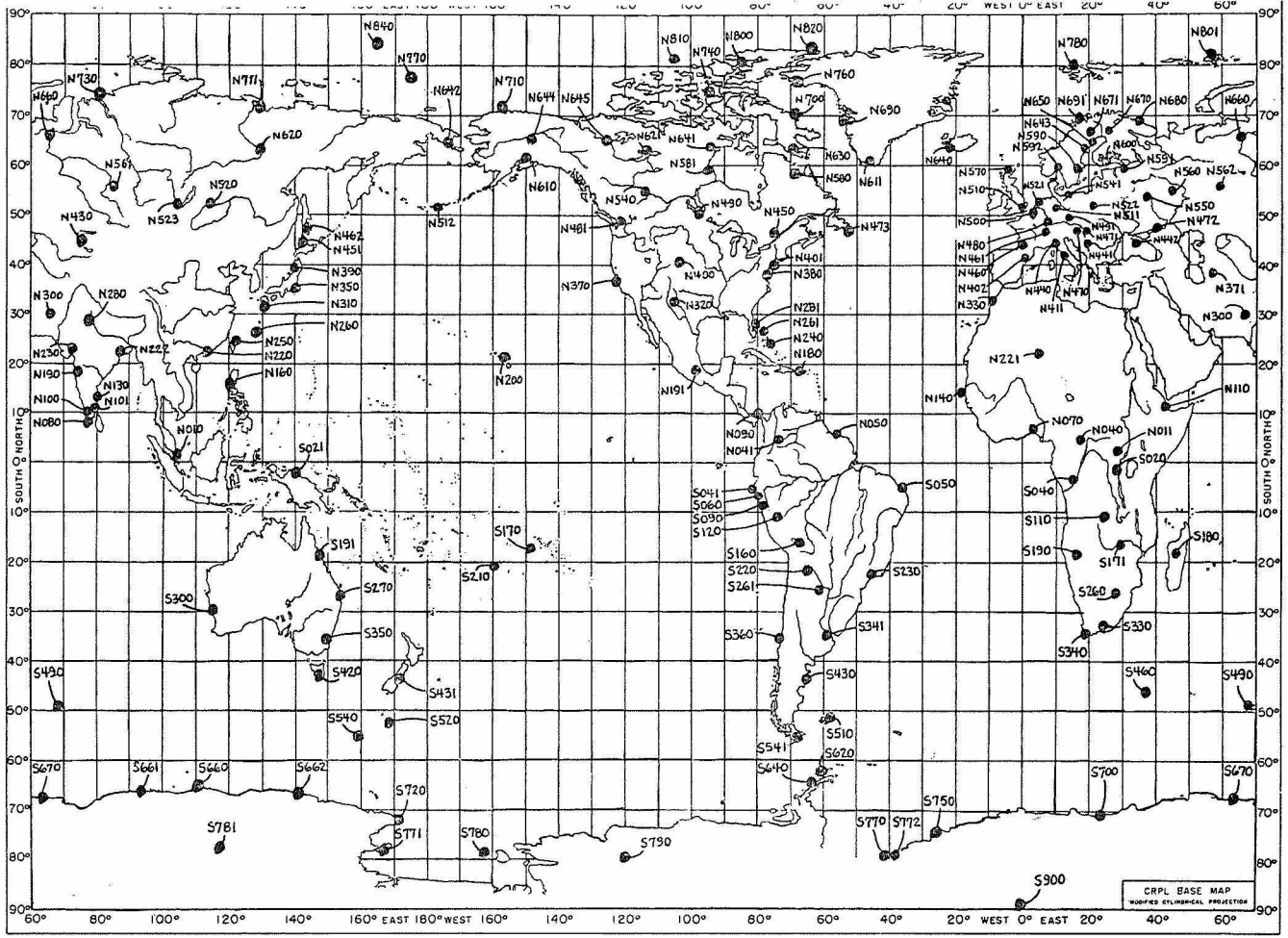

Fig. 1. — Ionospheric vertical soundings stations. — Operating during I. G. Y. (WWSC - Aug.)

IV. — Status of Vertical Sounding Program for I.G.C. 1959

(1) *History.*

The vertical soundings program for International Geophysical Cooperation 1959 has roughly the same pattern as that of the I.G.Y. The U.R.S.I./A.G.I. Committee at its 1958 Edinburgh meeting made some recommendations which were accepted by C.S.A.G.I. as a guide to participating committees in planning their I.G.C. programmes. The main modification of the I.G.Y. program was the introduction of the concept of patrol-type station, a station which would maintain a full program of observations, with reductions limited at the minimum to a simplified *f*-plot and hourly values of three of the standard characteristics. The C.S.A.G.I. and subsequent WWSC recommendation was that as many stations as possible should maintain the full I.G.Y. program. All of these recommendations contemplated patrol status for only those stations which would otherwise have to be discontinued because of the pressure for other scientific work or for practical reasons. The concept of associate stations was also suggested in order to try to bring research ionosondes into the world network on World Days or for other special occasions.

(2) *Stations Participating in Ionosonde Network.*

The size of the world network decreased somewhat during the first part of 1959 from the peak level at the end of the I.G.Y. of 163. It is estimated that about 22 I.G.Y. stations have been closed since the end of I.G.Y. On the other hand about 5 stations originally planned for I.G.Y. finally commenced systematic operation during 1959. Thus, the size of the network at the end of the year will be about 146. In general the accuracy and quality of the 1959 data will be superior to that during I.G.Y., since the many new I.G.Y. stations have gained valuable experience. The quantity of observations will be somewhat less because a few stations reverted to an hourly sounding schedule and in many cases the speeding up of the sounding schedule on World Days has been less than during I.G.Y. However many I.G.Y. stations started operation late in 1958 and the coverage in terms of station-years is probably greater in 1959 than in 1958. Thus the 1959 network will give the possibility for fairly adequate coverage

TABLE 2

Status of Vertical Sounding Stations as of August 1959

Explanation :

Column : 1 : 15-minute observing schedule.
2 : 1-hour observing schedule.
3 : Expanded program on Regular World Days.
4 : Full reductions.
5 : Special work.
6 : *f*-plots, at least on RWD.
7 : Station closed.
8 : Reference to footnotes at end.
* : Means no information.

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Argentina :									
Buenos Aires	S 341	×		×	×	×	×		
* Decepcion.....	S 620								17
* General Belgrano .	S 772								
La Quiaca	S 220							×	
Trelew	S 430		×		×				
Tucuman	S 261	×		×	×		×		
Ushuaia	S 541		×		×				

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Australia : :									
Brisbane	S 270	×			×		×		
Canberra	S 350	×			×		×		
Hobart	S 420	×			×		×		
MacQuarie Island...	S 540							×	
Mawson	S 670	×			×		×		9
Townsville	S 191	×			×		×		12
Watheroo	S 300	×			×				

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Austria :									
Graz	S 470		×						
Belgium :									
Base Roi Baudouin .	S 700	×		×	×		×		
Bunia	N 011	×		×	×	×			
Dourbes	N 500	×		×	×		×		
Elisabethville	S 110	×		×	×	×			
Leopoldville-Binza .	S 040	×		×	×	×			
Lwiro	S 020	×		×	×		×		
Bolivia :									
La Paz	S 160	×		×	×		×		
Brazil :									
Sao Paulo	S 230	×			×				
Natal	S 050	×		×	×		×		
Canada :									
Alert.....	N 820	×							1
Baker Lake	N 641							×	
Churchill	N 581	×			×		×		
Clyde	N 700							×	
Eureka	N 800							×	
Fort Chimo	N 580							×	
Fort Norman	N 645							×	
Frobisher	N 630							×	

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Canada (cont.)									
Meanook	N 540							×	
Ottawa.....	N 450	×			×			×	
Resolute Bay	N 740	×			×		×		
St. John's	N 473	×			×		×		
Victoria	N 481	×							1
Winnipeg	N 490	×							1
Yellowknife	N 621							×	
Chile :									
* Concepcion	S 360								17
Colombia :									
Bogota	N 041	×		×	×		×		
Czechoslovakia :									
* Panska Ves	N 501								15
Pruhonice	N 491		×		×				
Denmark :									
Thule	N 760	×		×	×		×		
Godhavn	N 690	×		×	×		×		
Narsarssuak	N 611	×		×	×		×		
Finland :									
Nurmijarvi	N 600		×		×		×		
Sodankyla	N 670	×		×	×		×		

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Formosa :									
Taipei.....	N 250		×		×		×		
France :									
Bangui	N 040	×			×				3
Dakar.....	N 140		×	×	×				
Djibouti	N 110		×	×	×				
Dumont d'Urville ..	S 662		×	×	×				
Ivato	S 180		×	×	×				
Poitiers	N 460		×	×	×				
Port aux Français ..	S 490		×	×	×				
Tahiti	S 170		×	×	×				
Tamanrasset	N 221		×	×	×				
Germany (Dem. Rep. :)									
* Juliusruh/Rugen .	N 541								14
Germany (Fed. Rep.) :									
Freiburg	N 480	×		×	×	×			
Lindau	N 511	×		×	×		×		
Greece :									
Athenes	N 372	×		×	×		×		2
Hungary :									
Budapest	N 471		×		×				
Iceland :									
Reykjavik	N 640	×		×	×		×		

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
India :									
Ahmedabad.....	N 230		×	×					
Bombay	N 190		×	×	×				
Calcutta	N 222	×			×		×		
Delhi	N 280	×		×	×				
Kodaikanal	N 100		×	×	×				
Madras	N 130		×	×	×				
Tiruchirapalli	N 101		×	×	×				
Trivendrum.....	N 080		×	×	×				
Italy :									
Monte Capellino ...	N 440	×		×	×	×	×		
Rome-San Alessio ..	N 411		×		×				
Japan :									
Akita	N 390	×		×	×		×		
Kokubunji.....	N 350	×		×	×	×	×		
Wakkanai	N 451	×		×	×		×		
Yamagawa	N 310	×		×	×		×		
Mexico :									
El Cerrillo	N 191	×			×		×		
Morocco :									
Casablanca									
Temara-Rabat	N 330		×	×	×		×		

(N. B. — Station transferred from Casa. to Rabat).

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Netherlands :									
De Bilt	N 521	×		×	×				
Hollandia	S 021		×		×				
Paramaribo	N 050	×			×				
New Zealand :									
Campbell Island ...	S 520	×		×			×		5
Cape Hallett	S 720	×		×	×		×		7
Godley Head.....	S 431	×		×	×	×	×		16
Rarotonga	S 210	×		×	×		×		
Scott Base	S 771	×		×	×		×		16
Norway :									
* Longyearbyen	N 780								14
Oslo-Kjeller.....	N 592							×	14
Tromso	N 691		×		×				
Pakistan :									
* Quetta	N 300								17
Peru :									
Chiclayo.....	S 060							×	
Chimbote	S 090							×	
Huancayo	S 120	×		×	×		×		
Talara	S 041	×		×	×		×		
Philippines :									
Baguio	N 160	×		×	×		×		

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
Poland :									
* Miedzeszyn.....	N 522								16
Portugal :									
Macao	N 220				×		×		
Rhodesia									
Salisbury	S 171							×	
Spain :									
Tortosa	N 402		×	×	×				
Sweden :									
Kiruna	N 671		×		×		×		
Lulea	N 650		×		×		×		
Lycksele	N 643		×		×				
Upsala	N 590		×		×				
Switzerland :									
Schwarzenburg	N 461		×		×				
Union of South Africa :									
Cape Town	S 340	×		×	×		×		
Grahamstown	S 330					×			
Johannesburg	S 260	×			×		×		
Marion Island	S 460							×	
Tsumeb	S 190	×		×	×		×		
United Kingdom :									
Grand Bahamas	N 261	×		×	×		×		

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
United Kingdom (cont.)									
Halley Bay	S 750							×	8
Ibadan	N 070		×	×	×		×		
Inverness	N 570	×		×	×				
Port Lockroy	S 640		×	×	×				
Port Stanley	S 510		×	×	×				
Singapore	N 010	×		×	×				
Slough	N 510		×	×	×				
U. S. A. :									
Adak	N 512	×		×	×		×		
Anchorage	N 610	×		×	×		×		
Boulder	N 400	×			×				
Byrd Station	S 790	×		×	×		×		
Cape Canaveral	N 281	×		×	×		×		
College	N 644	×		×			×		5
Ellsworth	S 770	×		×	×		×		6
Fletcher's Island	N 810							×	
Fort Belvoir	N 380	×		×	×		×		
Fort Monmouth	N 401	×		×	×		×		
Kihei (Maui)	N 200	×		×	×				
Little America	S 780							×	
Okinawa	N 260	×		×	×		×		
Panama Canal Zone	N 090							×	

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
U. S. A. (cont.)									
Point Barrow	N 710	×		×		×			5
Ramey/Puerto Rico	N 180	×				×			10
San Salvador	N 240	×		×	×		×		
South Pole	S 900	×		×	×		×		
Stanford	N 370							×	
White Sands	N 320	×		×	×		×		
Wilkes	S 660	×		×	×		×		13
U. S. S. R. :									
Alma Ata	N 430	×			×				
Arctica 1	N 770	×			×				
Arctica 2	N 840							×	
Ashkhabad	N 371	×			×		×		
Chita	N 520							×	(4)
Dixon Island	N 730	×			×		×		
Gorky	N 560					×			
Heiss Island	N 801	×			×				
Irkutsk	N 523	×			×		×		
Leningrad	N 591	×			×		×		
Mirny	S 661	×			×		×		
Moscow	N 550	×			×		×		
Murmansk	N 680	×			×		×		
Providenie Bay	N 642	×			×		×		

Country - Pays Station	Lat. Ser. No.	1	2	3	4	5	6	7	8
U. S. S. R. (cont.)									
Rostov-on-Don	N 472	×			×				
Salekhard	N 660	×			×				
Simferopol	N 442	×			×	×	×		
Sverdlovsk	N 562	×			×		×		
Tixie Bay	N 711	×			×				
Tomsk	N 561	×			×		×		
Vostok	S 781							×	
Yakutsk.....	N 620	×			×				
Yuzhno-Sakhalinsk .	N 462	×			×		×		
Yugoslavia :									
Belgrade	N 441		×		×				
Additional (post-I.G.Y) Stations									
Syowa Base	S 690	×		×	×		×		11
* Helwan	N 290								
* Port Moresby.....	S 091								
* Neustralitz	N 530								

1. — RWD films to WDC.
2. — Begin 1960.
3. — Closed October 1959.
4. — Future not known.
5. — Patrol.
6. — Transferred to Argentina,.
7. — Special = N(h).
8. — Reopen in 1960.
9. — Interruptions during 1959.
10. — N(h) work.
11. — From February 1959.
12. — Probably 6 interruptions during 1959.
13. — Transferred to Australia.
14. — January 1959 only received so far.
15. — Noise station only. VI at Pruhonice.
16. — Nothing received after December 1958.
17. — Nothing received after June 1958.

with improved accuracy of many important ionospheric parameters.

Table 2 lists the stations of the I.G.Y. and a few new stations starting in 1959 or 1960; there are 166 stations on the list. Of these, full information is missing from only about 18 stations. Of the remaining 148 stations, 89 are observing on a 15-minute schedule and 36 on an hourly schedule in 1959. 118 are making at least hourly reductions and 69 are producing *f*-plots. Further details on the 1959 status of these stations are given in Table 2.

(3) *Program details.*

Specific recommendations on program details were not made by the WWSC for the 1959 program. It was not practical to hold a meeting of WWSC during 1958 and the questions were too complex to gain group opinion during that busy year. It was assumed that networks or individual stations would in any case carry on the planned program to their maximum practical capacity after the extraordinary I.G.Y. effort in accordance with the overall recommendation of C.S.A.G.I. that the I.G.C. 1959 program should approximate the I.G.Y. wherever possible.

(4) *Data Flow.*

The 1959 data have been flowing to WDC in an almost steady continuation of the I.G.Y. rate. Interchange among Data Centres seems, however, to have been slower, apparently partly because the I.G.Y. data have been given priority of treatment. Rather few ionograms seem to have been received at Data Centres except from stations closely associated with the organization housing the WDC. The WWSC has at its present meeting made recommendations concerning the ionogram interchange plan for 1959.

V. — Ionospheric Vertical Soundings after 1959

(1) *General.*

The state of our knowledge of the ionosphere is still far from complete and the preliminary results of I.G.Y. studies suggest a number of new possibilities which have important scientific and practical implications. When considering the future of a station or a network of stations it is, therefore, important to balance the cost of the station against the probability that it will produce data of great value. This is particularly difficult in the case of stations working together in a geophysical network since many of the most

important advances may be made by scientists at another station or at an independent research laboratory elsewhere. Thus, the true value of the data from the station may not be directly apparent to those responsible for maintaining the station.

The preliminary results from the I.G.Y. show the great value of having had a wide geographic distribution of stations for the study of the morphology of the ionosphere, the analysis and understanding of great geophysical events, some of which are very infrequent, and the production of ionospheric maps for geophysical and radio propagation prediction projects. The world-wide effort during the I.G.Y. has also resulted in the formation of a number of new groups who are taking an active interest in ionospheric problems and in a considerable capital outlay in providing equipment and setting up stations. It is, therefore, worth-while to consider whether these facilities can be exploited efficiently after the I.G.Y. to produce further valuable information.

(2) *Immediate problems.*

The Committee considers that the present stage in the development of the subject calls for particular attention to four projects :

(*a*) The maintenance of an adequate network of stations to provide accurate data for geophysical and propagational studies on a world-wide basis ;

(*b*) The concentration of stations and maintenance of particularly intense programs of observation and reduction in zones where close networks of stations provide the possibility of resolving particular important ionospheric problems by regional study, and the reallocation of stations to zones where active research is progressing so as to obtain sufficient intensive observation to produce worthwhile scientific progress. Examples of the first type are the close European network of stations and the areas in which detailed ionization height maps are being prepared, and of the second, the equatorial zone, the antarctic and the arctic regions.

(*c*) The development of new methods of sounding and of data handling which may improve the efficiency and hence increase the effective size of the network ;

(*d*) The application of oblique incidence techniques, for example, ground back-scatter sounding or oblique incidence multifrequency

sounding, to obtain routine data. These have particularly important applications to the difficult problem of filling serious ocean gaps in the network economically and to prediction problems.

The Committee recognizes that the effort available for ionospheric investigations is limited and that a balance must be established between the requirements of providing adequate accurate geophysical data for future investigations, the effort needed to fulfill current active researches, and the desirability of exploring new fields of research. In practice real dilemmas only arise at a limited number of stations most of which have scientific staff with adequate background knowledge to make a sound judgment without further help.

(3) *Deployment of Stations.*

The great enlargement of the chain of ionospheric stations during the I.G.Y. was primarily directed to obtaining data suitable for geophysical and prediction purposes. The value of these data was greatly increased by its uniformity, by the large number of stations cooperating and by the intensive observation maintained.

It is generally agreed that a considerable international effort will be needed at sunspot minimum and that much of the I.G.Y. potential will be lost unless the world network at that time is comparable in extent to that used during the I.G.Y. Thus, there is a practical need to maintain a large proportion of the existing network at least through this period. In particular the number of stations available and their distribution over the world during the declining part of the last solar cycle was quite inadequate either for prediction and geophysical studies or for studies of individual storm events. Since the number of storms increases to a maximum during this part of the solar cycle, the type of storm changes from the SC to the M class which has quite different properties, and the practical importance of storm disturbances is greatest in this period, further active research using a large network is clearly desirable.

At sunspot minimum it is essential to operate a large number of stations on a program analagous to that in the I.G.Y., both to establish the change in conditions with solar cycle and to obtain the best possible data for sunspot minimum conditions where the frequency bands available are so narrow that it is essential that they are known and exploited to the greatest possible extent.

It is clear that the requirement of space research will involve considerable new effort in vertical soundings which was not anticipated before the I.G.Y. Current experiments on short period control of radio communications networks also considerably extend the quantity of data necessary.

Geophysical and radio propagation prediction studies usually require the accumulation of homogeneous data over a period of years and considerable delays are normal between the time of observation and its use in a scientific study. Thus, there are very real scientific and practical reasons for maintaining the operation of a station at a useful level which should only be discarded if it is clear that the effort available would be more profitably applied at another site or in another direction.

The WWSC considers that if it is justified to provide an ionosonde at an observing station, it should be operated on a regular schedule adequate to provide useful data. The main exception to this rule occurs when several ionosondes are used for different purposes in a zone demanding one station only. This opinion appears to receive widespread support.

The Committee draws attention to the particular undesirability of closing stations which form part of a close network where active research is proceeding, or of closing stations set up for the I.G.Y. in positions where the solar cycle variations of the ionosphere are unknown. It stresses that sufficient new groups have become interested in ionospheric problems to employ any equipments set free in other parts of the world which are at present inadequately surveyed or where greater concentration of stations is needed for regional studies. Some particular gaps are indicated in Section 2, Recommendation (8).

(4) *Program of observations.*

While, as pointed out above, there are strong scientific and practical reasons for attempting to maintain the post-I.G.Y. effort at the greatest possible level, it is clear that in general there should be a change in emphasis at, at least, some existing stations.

The maintenance of an adequate network of stations and the circulation of sufficient data for scientific and practical purposes after the I.G.Y. depends on the voluntary cooperation of organi-

zations whose primary interests fall into three dissimilar types :

(*a*) Those primarily concerned with obtaining representative routine data for geophysical or radio propagation phenomena.

(*b*) Those primarily interested in accurate measurements of particular ionospheric phenomena.

(*c*) Those needing vertical incidence data to complement other experiments, usually somewhat discontinuously.

There is a natural tendency to concentrate the effort available on the particular program indicated by the primary interests at the station which needs to be tempered by an appreciation of the needs of the other groups. Practical experience shows that most ionospheric problems can only be completely studied using data from groups of stations and major advances often develop from unexpected types of research.

The WWSC and its consultants and advisors agree that it is desirable that the full program of observation and reduction should be carried out at as many stations as possible. It recognizes that the circumstances at stations vary very greatly and that certain organizations and stations may not be able to maintain the I.G.Y. level of activity. In order to retain at least a partial efficiency for the world-wide network, which can be adjusted to respond to the requirements of particular researches, these stations are urged to operate at least on a patrol schedule designed to provide sufficient ionograms to enable post facto investigation of any great geophysical events and particular quiet or disturbed periods nominated for detailed study. This schedule should normally involve quarter-hourly ionograms except where local conditions demand special programs, for example at high latitudes. It must be stressed that the scientific value of full observations with good time resolution for even one event like that on February 23, 1956, is worth at least the film costs incurred in a year's full operation of a station.

As many as possible of the standard parameters should be reduced hourly using the daily worksheet, which should be circulated to the WDC's. As a minimum, tables of f_oF2, (M3000)F2, f_oF3 and f-min should be circulated. The provision of these basic measurements does not significantly increase the minimum effort needed to maintain an ionospheric sounding station in useful condition.

At the present time the majority of the numerical data obtained from ionograms is sooner or later put into punched card form and once in this form the preparation of monthly tables of hourly values, medians, quartiles and other derived parameters is both rapid and cheap. The initial reduction of all international parameters on the ionograms onto the daily worksheet is a rapid process costing a small fraction of the upkeep costs of the ionosonde. Thus, even the most overworked ionosphere stations can contribute to the international cooperation by cooperating with a WDC or larger network, though there may be considerable delay before their data are widely available.

The attempt to provide routine data will generally contribute significantly to the value of the particular local investigations. Thus, for example, the full value of detailed ionization profiles obtained as part of rocket and satellite studies is lost unless the relation between conditions at the epoch of the investigation and those usually present in the zone is known. This relation is best found by maintaining regular observation and comparing the values of the standard parameters obtained.

The WWSC wishes to stress the importance of developing and maintaining a number of key stations at which special efforts would be made to obtain particularly detailed or accurate observations. The importance of choosing the best possible site and aerials as well as equipment should not be overlooked. There is an immediate requirement for the production of high quality ionograms for systematic ionization profile measurements at, at least, a few stations. These demand low minimum frequencies of observation, accurate frequency and height scales and complete traces.

VI. — Ionogram Reduction Procedures

(1) *General.*

A general review of the conventions and rules developed for the I.G.Y. showed that these were generally satisfactory both for operators and from the scientific point of view. A number of suggestions for improvements, additional regional rules and clarifications were considered. Since (*a*) most of the WWSC rules are adjusted to the differing requirements of particular types of research and what is economical and practical at stations obser-

ving widely different ionospheric phenomena, (*b*) it is not desirable to alter rules more frequently than absolutely necessary, but (*c*) the rapid development of ionospheric physics and practical application calls for corresponding changes in the emphasis and technique used in the soundings network, the WWSC proposes in the future to give advance notice of proposed changes, to invite comments, to set up working parties to perform pilot experiments so as to evaluate the advantages and disadvantages involved, and then to decide on whether to accept or reject the proposals on the basis of the knowledge gained.

(2) *Change in Median and Quartile Rules.*

Many reports to the WWSC have shown that although median rules are logical, in practice, particularly in certain parts of the world, they are relatively time-consuming and can result in the production of a vicious circle or the rejection of a considerable number of numerical results. There is a general desire to replace these rules by a more simple procedure as soon as possible so as to avoid these difficulties.

These difficulties arise when the data contain numerical entries below the median value which are qualified by « greater than », D, or similar values above the median qualified by « less than », E, or both. There are several ways of simplifying the present method which, though open to objection on mathematical and logical grounds, would on the average improve the significance of the median and the efficiency of the computation. Since the reliability of a median value varies rapidly with the size of the median count, it is possible to obtain a more representative value by departing from strict mathematical considerations in these cases.

The WWSC recommends the general adoption of the simplest of these alternatives to take effect from January 1, 1960. To make this possible a draft version of the proposals has been circulated to all known active stations. The revised procedure is a follows :

(*a*) The first trial median is determined ignoring all qualifying letters.

(i) If more than half the values are qualified by D, the median is the first trial median, qualified by D.

(ii) If more than half the values are qualified by E, the median is the first trial median qualified by E.

(iii) If more than half the values are replaced by D, the median is D.

(iv) If more than half the values are replaced by E, the median is E.

(v) If all the values qualified by D are above the first trial median, and all the values qualified by E are below the first trial median, the first trial median is the median.

(vi) If any of the values qualified by D is below the first trial median, or any of the values qualified by E is above, it is necessary to proceed to a second trial median (see (*b*) below).

(*b*) A second trial median is determined taking all those values qualified by D as large values (greater than the median) and all those values qualified by E as small values (less than the median).

(vii) If the first and second trial medians are the same this is the final median and is given without qualification unless more than half the values in the count are qualified by letters which carry the annotation of doubt, I, T, U, Z, in which case the median is qualified by U.

(viii) Otherwise the average of the first and second trial medians is taken as the final median. If the difference between the first and second trial medians exceeds twice the allowable error for an unqualified observation, the median is qualified by U.

(3) *Clarification of Ordinary and Extraordinary Components of* Es.

The distinction between ordinary and extraordinary wave Es traces has given trouble at many stations because the rules given in earlier WWSC reports and in the I.G.Y. Manual are in general terms. A pilot experiment in a large network showed that these difficulties could be overcome by providing detailed rules arranged in a logical system. The percentage of ionograms reduced with the descriptive letter M (no distinction possible between components) fell from over 60 % to less than 5 % with a considerable reduction in the time needed to deduce the Es characteristics. Thus it appears that the distinction can be made efficiently in the great majority of ionograms. A copy of these detailed rules has

been circulated to all known active stations in the form of a chapter for the WWSC handbook for operators. These rules are recommended for use by stations ; however, it should be noted that they represent an elaboration and not a change of the 1957 recommendations of WWSC on the handling of Es.

(4) *Relative merits of reducing foEs, fxEs fxEs in the future.*

The Committee and its consultants have discussed the relative merits of reducing different Es parameters for world-wide circulation. The discussion disclosed a rather wide range of opinions which reflected to a considerable extent the different incidence of ordinary and extraordinary wave traces in different parts of the world and the particular instructions given to observers in different networks. Most participants found difficulty in assessing the relative merits of the different possibilities without more precise information about the practical advantages of homogeneity for geophysical and operational problems. The Committee recommends continuing the present practice until more exact information is available and has appointed Professor K. Rawer as coordinator for pilot experiments on these problems with instructions to report by July, 1960. Quantitative contributions are desirable from all interested in these problems.

The most important problems involved are :

(*a*) Is the variability of Es so great that the distinction between *fo*Es and *fx*Es is unimportant for scientific and practical applications from both the world-wide and regional points of view ?

(*b*) If not, should the primary Es characteristics be those of the ordinary component, as is normal for other phenomena, those of the extraordinary, which would simplify reduction in considerable zones of the world, or should both be acceptable according to zone, provided the mean O-X difference is clearly indicated on all tabulation sheets ?

(*c*) Is it desirable to generalize the use of qualifying letters O, X, Z, J, M.

The Committee reminds all contributors that it has to balance the usefulness of data with the cost and time needed to obtain it.

(5) *Review of Characteristics Required by World Network.*

The Committee considers that the standard international parameters should be kept under review and, if found desirable,

replaced by alternative or new parameters so as to use the limited effort available to the greatest advantage.

It is obviously impossible to state that a given parameter has no value for future investigations; the criterion to be used is probable relative advantage of measuring one parameter rather than another. Similarly it may be more economical to exploit particular techniques while their return is large and replace them entirely when the development of the subject indicates preferable procedures. An example of this is the tabulation of the WWSC Es types, which is proving very valuable at present but is clearly a classifying procedure rather than a final tool for investigating Es.

Both geophysical and propagational investigations require long term continuity in the parameters measured and can be seriously prejudiced by changes which destroy the compatibility of the data. Thus major changes in the parameters should not be made unless worthwhile gain in information or appreciable increase in the efficiency of the network can be expected.

The value of the new information from certain long established parameters which have been intensively studied in the past appears to be decreasing, and it is worthwhile to consider whether sufficient routine data have been obtained to enable them to be discarded at the majority of routine stations. Such decisions are, of course, controversial and demand widespread sampling of opinion.

Considerable difficulties arise when further research demands accuracies which are not available readily from normal ionograms, though possible with improved equipment. The Committee adopts the view that its recommendations for parameters reduced in a world-wide scale should not depart seriously from what is practical at the majority of stations. It is neccessary to stress that parameters which are sometimes omitted because the accuracy required is not available should be measured particularly carefully and fully at stations having suitable equipment. This applies particularly to f_oE, h'E and, in many cases, N(h) profile data.

The Committee and its consultants have discussed the desirability of changing some of the parameters normally reduced in order to provide effort in other directions. The discussion brought out the desirability of reviewing the usefulness of certain parameters so that a decision could be made. The Committee must

stress that it has to take a balanced view of such proposals, weighing the relative value of the alternatives and taking account of both geophysical and propagation problems. Thus the fact that a given parameter has little value for one of these fields may be balanced by its having great value in the other.

The following parameters have been discussed and will be subject to further investigation :

(*a*) *h'*F2.

(*b*) *fo*F1, (M3000)F1.

(*c*) *h'*E, *fo*E.

(*d*) *h'*F.

The great majority of the opinion expressed at the present is that *h'*F2 is of small value and its measurement and circulation could be dropped.

There have been several proposals for a reduction in the number of F-region paremeters measured. In particular it has been suggested that sufficient information is available on the variations of (M3000)F1 with time and position for prediction purposes, and there does not appear to be much desire to use this parameter for scientific purposes. It is clearly desirable to investigate the validity of these views. The parameter *fo*F1 has been used to survey changes in solar activity, particularly in temperate latitudes and has theoretical significance. The discussion disclosed that the incidence of measurable F1 critical frequencies was often peculiar and was possibly influenced by dynamic phenomena in the F region. This implies that some new index might be desirable which more directly measured the degree of bifurcation of the F region. However the measurements of *fo*F1 are often misleading in the sense that they are not consistent with the definition of critical frequency and it is not clear whether sufficient measurements have been obtained to satisfy reasonable practical and scientific requirements. Dr. Y. Aono was appointed to coordinate work on these subjects and to report by July, 1960.

It has also been suggested that sufficient observations of the parameters *fo*E and *h'*E have been produced by routine observations and that further work on these parameters might be restricted to stations at which they can be measured with very high accuracy. On the other side there will always be a need for some accurate

routine measurements of these parameters in a world-wide network for determining solar cycle changes and for tidal investigations and it is questionable whether sufficient accurate observations have been made to produce accurate world maps of *fo*E.

The parameter *h'*F has been criticized on the grounds of being misleading, but it has also been shown to be valuable for particular geophysical and practical purposes and to be easy to measure. The Committee is not aware of any immediate substitute for it which can be measured simply and quickly by the majority of stations in the world network and invites suggestions supported wherever possible by the results of a pilot investigation.

The Committee is actively encouraging pilot experiments to find whether simplified ionization profile measurements can be adapted to give useful data economically on a world-wide or regional scale. The following requirements appear desirable :

(*a*) Any new parameter should not take more time to measure and circulate than can be gained by dropping some of the less valuable conventional characteristics.

(*b*) The new parameters must be expressible in a simple form suitable for geophysical studies.

(*c*) The new parameters must show promise both experimentally and theoretically of giving more valuable data for scientific or practical problems than that obtained from the alternative conventional parameters.

A number of suggestions have been made which need further consideration, for example, to deduce the height of the maximum of electron density in the F2 layer by ionization profile techniques or the corresponding height at one or more given fractions of this density. It is not yet clear whether the data given by these techniques would be sufficiently more valuable than that given by the crude parameters, (M3000)F2, *h'*F, *hp*F2, *hm*F2 (curve-fitting), to justify the extra work involved in obtaining them. A critical study of the accuracy actually obtained by these techniques also appears to be very desirable.

The Committee draws attention to the lack of any rapid method of deducing the ionization changes at fixed « true », or profile height. Measurements of this type would appear to be particularly suitable for world-wide use if a suitable method could be produced. It also stresses the need to examine existing N(*h*)

profiles from the point of view of identifying easily deduced key parameters which might be usable for geophysical studies since the full N(h) profile is too complicated in its present form to be usable, even if available, from many stations.

The Committee is considering the desirability of measuring (MUF 3000)F2 when this can be measured significantly more often than f_oF2. This may provide more representative median values for prediction purposes.

The Committee actively encourages regional researches and recognizes that these may demand the measurement of additional parameters. Some typical current work brought to the attention of the Committee included detailed studies of equatorial spread-F phenomena ; studies of the occurrence of peculiar ionization distributions in the equatorial F region, ionization height profiles from closely spaced stations showing horizontal gradients in the F region ; studies of vertical movements in the F layer ; horizontal movements of ionization at high latitudes ; zones of occurrence of major ionospheric ripple movements ; studies of the incidence of particular Es types ; study of sequential Es ; and the distribution of abnormal absorption in winter months as shown by f-min.

(6) *Preparation of a Handbook of Ionogram Interpretation and Reduction For Use by Station Operators.*

Correspondence preceding the Brussels meeting of the Committee and the reports of those present showed a widespread desire for the preparation of a standard Handbook of Ionogram Reduction and Interpretation directly suitable for use by operators at stations cooperating in the world-wide network. It was agreed to base this handbook on the C.R.P.L. operating handbook (Memo 40B). extended to include all relevant material from the reports of the Committee, the proceedings of the Brussels meeting, and contributions from members and consultants of the Committee. The editing of the book was entrusted to W. R. Piggott and Professor K. Rawer. Owing to the enthusiastic aid of all present at Brussels and members of the editors' organizations, the manuscript of the book is now (November 2, 1959) practically complete and is being revised for publication under the auspices of U.R.S.I. in the near future.

The Handbook consists of an introduction giving the general

principles adopted by the WWSC, followed by sections giving detailed rules for reducing ionograms, use of letter symbols, tabulation of data and preparation of *f*-plots, prefaced where necessary by short notes on the principles involved. Regional rules, tentative instructions for procedures which have not as yet been fully proved to be useful and suggestions for station research are collected in a supplement. The supplement also includes an elementary discussion of ionization profile problems with a sample set of rules for reduction, a summary of some special techniques for reduction or comparison with data from associated geophysical fields and finally, a brief list of reference material and sources of data likely to be needed at stations. Efforts have been made to make the Handbook as complete as possible ; for example, instructions are given for identifying and measuring *fx*E*s* even though this is not a standard parameter.

The Committee invites comments on the usefulness of this Handbook and suggestions for improvement of clarification.

VII. — Future Coordination of Vertical Soundings Work

The World-wide Soundings Committee came into existence as one of the actions taken by U.R.S.I. in preparation for the I.G.Y. As the major portion of the I.G.Y. activity involving observations and immediate reductions comes to a close, it is time to consider the needs and the mechanism for coordination of vertical soundings work for the period after the 1960 General Assembly, at which time the life of the present committee will terminate.

U.R.S.I. had assumed responsibility for coordination of the production, reduction and interpretation of ionospheric soundings in 1950 after several years when both U.R.S.I. and C.C.I.R. were taking action on these matters. The work of the U.R.S.I. organization, formally designated as Sub-Commission III*a*, progressed slowly as it was mainly performed by ad hoc groups at General Assemblies. Finally a Special Committee on High Latitude Soundings was appointed by The Hague General Assembly in 1954. This Committee consisted of five experts designated by name and instructed to bring in a report to the U.R.S.I./A.G.I. Committee in 1955. The latter thereupon appointed a similar committee (WWSC) to handle the problem on a world-wide basis. The

members have been Y. Aono, N. Mednikova, W. R. Piggott, J. Turner, K. Rawer and A. H. Shapley, Chairman.

The WWSC had handled its work both by correspondence and by meetings, involving the members and a group of other experts who have served as Principal Consultants and have greatly helped to assure broad perspective and informed actions in the WWSC work. The correspondence has included over 30 circular memoranda issued by the Chairman. Most of the decisions and reports have been made by the members at meetings after full discussion with the consultants.

There have been three meetings of the WWSC, each with at least four members present. The third (Brussels, August 1959) had full attendance of its members and 12 of the 15 consultants from all parts of the world. The support which ionospheric organizations have given the work of WWSC in sending members and consultants to these meetings indicates interest in achieving the necessary degree of uniformity to make the results of the world network intercomparable.

The WWSC has provided guidance to almost 170 stations which operated during I.G.Y. It has done this mainly through two detailed reports with recommendations on observations, schedules, accuracy, interpretation, scaling and dissemination of data. These reports have furnished the bases for the specific instructions issued by network centres to their respective stations. The Committee has suggested various supplementary observations and special research topics for stations to undertake. The broad international composition of the WWSC group has served to spread the effect of its work fairly directly to the world network, through scientific if not always through direct administrative channels. The WWSC sponsored an Atlas of Ionograms, was associated with the preparation of the I.G.Y. Manual on Vertical Soundings and has now prepared a detailed handbook for operators.

In recent months WWSC members have been studying the success of some of the scaling practices which it had introduced. There have also been studies on the uniformity of interpretation among stations of the world network. It appears that the I.G.Y. data are reasonably homogeneous and usable for many regional and global ionospheric studies. The WWSC has also acted as a natural centre to which local difficulties have been referred and

has provided expert advice on some of the more complicated ionospheric phenomena.

The vertical sounding network has grown to a size where the coordination needed to achieve and maintain the desired degree of uniformity of observation and data is a major effort. This is further complicated because the objectives of the observers are simultaneously scientific and practical. In effect there are two networks : one of stations planned primarily for the needs of the prediction services, the other of stations whose main purpose is carrying out or contributing to scientific research. Both the scientists and the prediction services benefit from the world network but the tasks the stations are prepared to do or are interested in doing vary widely. There seems to be a continuing need for active coordination and international leadership in order to achieve optimum results.

The requirements of rocket and space research have already resulted in a considerable increase in the total effort available in some areas and current developments suggest that pressure from practical communications networks for more detailed and exact information will increase as the radio frequency bands available shrink with the decline in solar activity. It is clear that the development of new methods of sounding cannot be spread over 15 to 20 years, as in the case of the vertical incidence methods, but will need intensive study so that workable systems can be used within one or two years.

Whether U.R.S.I. should or can continue to provide this coordination may become a serious question in the future. If the network should continue to grow in size and importance (the number of different organizations involved has steadily grown in the last five years, although some of the national networks have come down from their I.G.Y. peaks), a professional coordinating body may be necessary, perhaps modeled on the WMO. The magnitude of the effort may warrant more nearly full time attention to active coordination.

For the immediate future, U.R.S.I. cannot avoid the responsibility. It seems clear that a committee or sub-commission should be established to continue the type of work which the WWSC has been undertaking during the I.G.Y. Whether the WWSC pattern or organization was successful mainly because of I.G.Y.

enthusiasm or whether it would work in the long run, is hard to assess with present perspective. Certainly the WWSC work has been very costly in the scientific productivity of its members and consultants and the committee meetings have been seriously overloaded by the mass of problems raised.

It seems very clear that the responsibility for WWSC type of work must be specifically delegated to a small group of ionospheric scientists at the working level. They must have current or very recent exerience or contact with three aspects of the work : station observing, scientific research with vertical soundings data, and prediction services. They should be chosen as individuals according to these qualifications and not as representatives of any laboratory or country. The WWSC experience suggests that unwise or irresponsible actions can scarcely be avoided unless the decisions can be tempered by balancing the three points of view and the peculiar requirements and difficulties found in the three fields.

The WWSC has found the advice of consultants with one or another of these three types of experience to have been very necessary for its work. It is believed the number of such experts actively involved in the discussions by correspondence and meetings should be kept reasonable, say 10 to 15. Their role should clearly be that of advisors having specialized knowledge or experience to impart. Useful international leadership involves taking a general view of the proposals made and cannot be exercised by decision arrived at or compromised among such a large number.

The work of the WWSC would probably have been more effective sooner if it had had network or station representatives through which it could give or receive information directly to stations. The formal U.R.S.I. channels and even the formal I.G.Y. channels proved to be relatively slow and uncertain and many difficulties were only disclosed by visits to stations or as a result of the Committee monitoring work.

The question of the best place of such a committee in the U.R.S.I. structure is not an easy one. Traditionally it has been in Commission III. If this is thought best, it should be arranged that Commission III, which is a loosely organized body, should be concerned only with long term policy guidance. It is important to stress the necessity for continuity in the policy and recommen-

dations of the WWSC or its successor and to note that the recommendations of the committee directly influence many groups which are not represented on Commission III and are not primarily concerned with U.R.S.I. problems. There might, therefore, be advantages in attaching the new committee to a group like the U.R.S.I./A.G.I. Committee in composition, to be concerned with active plans for the various ionospheric sub-disciplines and the Data Centres. Alternatively it could report directly to the U.R.S.I. Officers and Commission Chairmen.

The maintenance of a reasonably efficient world network of ionospheric stations for producing data suitable for geophysical and radio propagation investigations appears to require attention in the future to the following tasks which should be entrusted to a suitable committee replacing the U.R.S.I./A.G.I. or WWSC.

(1) Maintain an international handbook on definitions, scaling practices, ionogram interpretation, accuracy standards, recommended observing schedules and procedures, etc. Keep these abreast of scientific developments. Produce clarifying reports, scaling manuals, atlases, etc.

(2) Monitor the uniformity of data, etc., from the world network.

(3) Provide mechanism for advice, clarification, etc., to stations.

(4) Suggest special observations and reductions at stations, sometimes as trials preparatory to introduction of new standard practices.

(5) Provide mechanism for multi-station coordination for regional studies.

(6) Coordinate and monitor the international data interchange plan for ionospheric soundings.

(7) Draft recommendations on geographical distribution of stations in the world network.

(8) Maintain a reasonable balance between the conflicting needs of different disciplines.

(9) Encourage the development of new techniques and their introduction into the world-wide system.

(10) Encourage particular researches needed to establish the validity of the methods used at stations and to solve those problems which, while not of general scientific interest, are of importance in the interpretation and use of the data.

(11) Arrange visits of experts to stations so as to ensure uniformity of scaling practice, discuss local peculiarities in the data and records, and help in making such phenomena known so that they can be studied scientifically.

(12) Review the scientific and practical use of the data obtained so as to obtain clearer indications of its value.

The WWSC considers itself obliged to continue its activity as if it had unlimited lifetime so that any transition at the time of the 1960 General Assembly may be a smooth one.

November 1959.

SYMPOSIA

International Symposium on Magneto-Fluid Dynamics

January 17-23, 1960, Washington, D. C. and Williamsburg, Virginia

Report from the Symposium

The International Union of Theoretical and Applied Mechanics held a Symposium on Magneto-Fluid Dynamics in Washington, D.C. and Williamsburg, Virginia, January 17-23, 1960. The main emphasis was given to continuum aspects of magneto-fluid dynamics The first session of the Symposium was devoted to an introductory survey of the field of magneto-fluid dynamics and plasma physics to provide a background for the discussions during the Symposium. Each of the subsequent nine sessions scheduled four or five prepared papers on some aspects of magneto-fluid dynamics. These included problems of flow of conducting gases and liquids, motion past bodies and in channels, stability of such flows, wave propagation and shock wave phenomena in conducting gases and some related aspects of geophysical and astrophysical magneto-fluid dynamics. The closing session, held on Saturday morning, January 23, was devoted to a general discussion.

The main purpose of the Symposium was to present new results in areas which have needed clarification and where direct contact between investigators seemed to have the greatest value. Session Chairmen encouraged critical and constructive discussions of papers and extemporaneous contributions. These discussions were edited by several participants acting as Session Reporters. The proceedings of the Symposium will appear in the Reviews of Modern Physics, published by the American Institute of Physics, and also as a separate volume.

About one hundred scientists took part in the Symposium. The technical sessions of the Symposium were held in the Williams-

burg Inn where most of the participants lodged. This gave a particularly good opportunity for numerous informal discussions which contributed to the success of the Symposium. Following the Symposium Dinner, held at the Inn on Thursday evening, J. Ackeret (Switzerland) gave a most interesting afterdinner speach on some historical and other aspects of magneto-fluid dynamics.

A special series of public lectures on magneto-fluid dynamic phenomena in astrophysics and geophysics was given on Monday, January 25, in Washington, D. C. These lectures were arranged by the National Academy of Sciences and included addresses by Ludwig Biermann (Germany), V. C. A. Ferraro (U. K.), Bo Lehnert (Sweden), and E. H. Vestine (U. S. A.). Arrangements were also made to assist several participants in attending the 1960 Annual Meetings of the Institute of the Aeronautical Sciences and of the American Physical Society held in New York during the week of January 25.

Programme of Technical Sessions

Monday, January 18, 1960, *at* 9 : 30 *a. m.*

Chairman : Hugh L. Dryden *Discussion Reporter* : G. Kuerti

A. 1. Problems in magneto-fluid dynamics. Lyman Spitjer, Jr. (U. S. A.).

A. 2. Some remarks about flow past bodies. W. R. Sears (U. S. A.).

A. 3. On magneto-fluid dynamic shock waves. R. Lust (Germany).

A. 4. Collision between a non-ionized gas and a magnetized plasma. H. Alfven (Sweden).

Monday, January 18, *at* 2 : 00 *p. m.*

Chairman : O. Laporte *Discussion Reporter* : W. B. Riesenfeld

B. 1. Effect of fluctuating microfield on the diffusion coefficient in a plasma. W. B. Thompson (U. K.).

B. 2. Transport equation of a plasma. R. Balescu (Belgium).

B. 3. Irreversible processes in plasmas in a strong magnetic field. Taro KIHARA and Yukio MIDZUNO (Japan).

B. 4. Dynamical equations and transport relationships for a thermal plasma. R. HERDAN and B. S. LILEY (U. K.).

B. 5. Motion of a charged particle in a slowly rising magnetic field. L. J. F. BROER (Netherlands).

Tuesday, January 19, *at* 9 : 00 *a. m.*

Chairman : L. SPITZER, Jr. *Discussion Reporter* : M. MITCHNER

C. 1. Hydromagnetic equilibrium experiments with liquid and solid sodium. Stirling A. COLGATE, Harold D. FURTH and Fred O. HALLIDAY (U. S. A.).

C. 2. Magnetic compression of plasma. A. C. KOLB (U. S. A.).

C. 3. Some studies of free surface mercury magnetohydrodynamics. R. A. ALPHER, H. HURWITJ, Jr., R. H. JOHNSON and D. R. WHITE (U. S. A.).

C. 4. Experiments on the passage of a shock wave through a magnetic field. K. DOLDER and R. HIDE (U. K.).

C. 5. Some remarks on electric-discharge shock tube diagnostics. D. BERSHADER (U. S. A.).

Tuesday, January 19, *at* 2 : 00 *p. m.*

Chairman : C. C. LIN *Discussion Reporter* : W. H. REID

D. 1. On turbulent magneto-fluid dynamic boundary layers. L. G. NAPOLITANO (Italy).

D. 2. Transition from laminar to turbulent flow in magneto-fluid mechanic channels. Paul S. LYKOODIS (U. S. A.).

D. 3. Hydromagnetic flow due to an oscillating plane. R. HIDE and P. H. ROBERTS (U. K.).

D. 4. Energy spectra in magneto-fluid dynamic turbulence. T. TATSUMI (Japan).

D. 5. Stability of a hollow mercury jet. B. LEHNERT (Sweden).

D. 6. Plasma turbulence. Leslie S. G. KOVASZNAY (U. S. A.).

D. 7. Two-dimensional boundary layers and jets in magneto-fluid dynamics. Günther JUNGCLAUS (Germany).

Wednesday, January 20, *at* 9 : 00 *a. m.*

Chairman : P. GERMAIN *Discussion Reporter* : G. S. S. LUDFORD

E. 1. Some magneto-fluid dynamic effects in a medium with finite conductivity. V. N. ZHIGULEV (U. S. S. R.).

E. 2. Reducible problems in magneto-fluid dynamic steady flows. Harold GRAD (U. S. A.).

E. 3. Some exact solutions in linearized magneto-aero dynamics for arbitrary magnetic Reynolds numbers. E. L. RESLER, Jr. and J. E. MCCUNE (U. S. A.).

E. 4. On the motion of bodies through conducting fluids. K. STEWARTSON (U. K.).

E. 5. Magnetohydrodynamic wakes in a viscous conducting fluid. Hidenori Hasimoto (Japan).

Wednesday, January 20, *at* 2 : *p. m.*

Chairman : W. B. THOMPSON *Discussion Reporter* : P. S. LYKOUDIS

F. 1. Motion of a completely ionized gas across a magnetic field in presence of an electric force. J. M. BURGERS (U. S. A.).

F. 2. Decay of hydromagnetic waves in an anisotropic medium. S. A. KAPLAN (U. S. S.R.).

F. 3. Microinstabilities in inhomogeneous plasmas and their effect on particle diffusion across a magnetic field. L. BIERMANN and D. PFIRSCH (Germany).

F. 4. Wave motions of small amplitude in a fully ionized plasma without external magnetic field. S. I. PAI (U. S. A.).

F. 5. Mechanical analogy of the Hall effect. L. J. F. BROER (Netherlands).

Thursday, January 21, *at* 9 : 00 *a. m.*

Chairman : A. BUSEMANN *Discussion Reporter* : Y. NAKAGAWA

G. 1. Observations on pinch buckling. K. O. FRIEDRICHS (U. S. A.).

G. 2. Some results on hydromagnetic stability of stationary equilibria. E. FRIEMAN and M. ROTENBERG (U. S. A.).

G. 3. Stability of a periodic force-free field with neutral lines. E. SCHATZMAN (France).

G. 4. Stability of twisted magnetic fields in a fluid of finite electric conductivity. R. J. TAYLER (U. K.).

G. 5. On the theory of hydromagnetic equilibrium. L. WOLTJER (Netherlands).

G. 6. Some results on heat transport by convection in presence of a magnetic field. Yoshinari WAKAGAWA (U. S. A.).

Thursday, January 21, *at* 2 : 00 *p. m.*

Chairman : G. G. CHERNYI *Discussion Reporter* : R. A. ALPHER

H. 1. Idealized problems of plasma dynamics relating to geomagnetic storms. Sydney CHAPMAN (U. K.).

H. 2. Theory of sudden commencements and of the first phase of a magnetic storm. V. C. A. FERRARO (U. K.).

H. 3. Magnetodynamic equilibrium of a slowly rotating spheroidal mass. Cataldo AGOSTINELLI (Italy).

H. 4. Geophysical effects of the trapped particle layer. R. JASTROW (U. S. A.).

Friday, January 22, *at* 9 : 00 *a. m.*

Chairman : Michal LUNC *Discussion Reporter* : J. E. MCCUNE

I. 1. Shock waves and shock wave structure in magneto-fluid dynamics. P. GERMAIN (France).

I. 2. Magnetohydrodynamic shock wave in a collision-free plasma. F. J. FISHMAN, A. R. KANTROWITZ, and H. PETSCHEK (U. S. A.).

I. 3. Hydromagnetic waves of finite amplitude with isotropic and non-isotropic pressure perpendicular to a magnetic field. K. HAIN, R. LÜST and A. SCHLÜTER (Germany).

I. 4. Attached stationary shock wave in ionized gases. Henri CABANNES (France).

I. 5. On gas-ionizing-magnetohydrodynamic shock waves. A. G. KULIKOVSKY and G. A. LUBIMOV (U. S. S. R.).

Friday, January 22, *at* 2 : 00 *p. m.*

Chairman : G. TEMPLE *Discussion Reporter* : N. H. KEMP

J. 1. Some generalizations in one-dimensional magnetogasdynamics. J. A. SHERCLIFF (U. K.).

J. 2. Flow in direct-current electromagnetic pumps. Vernon J. Rossow (U. S. A.).

J. 3. Flows of conducting fluids past bodies. Isao IMAI (Japan).

J. 4. Inviscid flow past a body of low magnetic Reynolds number. G. S. S. LUDFORD (U. S. A.).

J. 5. Magnetohydrodynamic-hypersonic flow in the quasi-Newtonian approximation. Rudolf X. MEYER (U. S. A.).

Saturday, January 23, *at* 9 : 00 *a. m.*

Chairman : F. N. FRENKIEL *Discussion Reporter* : D. C. HARRIS

General Discussion.

The Proceedings of the International Symposium are being edited by F. N. Frenkiel and W. R. Sears and will be published in the Reviews of Modern Physics and also as a separate volume.

Solar Emissions and the Interplanetary Medium

April 27-28, 1960

Great Hall, National Academy of Sciences, Washington, D. C.

I. — Wednesday, April 27, 2 : 00 *p. m.*

Chairman : Robert JASTROW, National Aeronautics and Space Administration.

Arnolf SCHLÜTER, Max-Planck-Institut für Physik und Astrophysik, Munich : *Solar Particle Streams.*

D. E. Blackwell, Cambridge University, Cambridge, England : *Interplanetary Electron Densities.*

J. H. Piddington, Division of Radiophysics, C.S.I.R.O., Sydney, Australia : *Interplanetary Magnetic Fields.*

Joseph W. Chamberlain, Yerkes Observatory, Williams Bay, Wisconsin : *Properties of Interplanetary Gas.*

II. — Thursday, April 28, 9 : 00 *a. m.*

Chairman : Walter O. Roberts, High Altitude Observatory, Boulder, Colorado.

J. F. Denisse, Meudon Observatory, Paris, France : *Interpretation of Type IV Radio Bursts.*

Herbert Friedman, Naval Research Laboratory, Washington, D. C.: *Survey of Observations of Solar Ultraviolet and X-rays.*

G. Elwert, University of Tübingen, Germany : *Theory of X-ray Emission.*

R. Grant Athay, High Altitude Observatory, Boulder, Colorado : *Sources of Ultraviolet Emission.*

This symposium, open to the scientific public, is part of the annual meetings of the National Academy of Sciences (Session I) and the American Geophysical Union (Session II). It is sponsored by the U. S. National Committee for I.G.Y., the Planning Committee on Planetary Sciences, A.G.U. and the U. S. National Committee, U.R.S.I. Support has been provided by the National Science Foundation. The symposium has been arranged by A. H. Shapley (Chairman), R. Grant Athay, Herbert Friedman and Robert Jastrow.

INTERNATIONAL UNION OF TELECOMMUNICATIONS

The Administrative Radio Conference

(GENEVA, 17 AUGUST ; 21 DECEMBER, 1959)

by A. HENRY

(Reprint from the *Journal U. I. T.*, nº 3, March 1960)

Work accomplished in Plenary Meetings

Telecommunications and the use of outer space.

At the fourth plenary meeting held on 23 September, 1959, Mr. Acton, Chairman of the Conference, drew attention to a report prepared for the General Assembly of the United Nations by the Special Committee of the United Nations on the use of outer space ; one of the problems covered in the report was naturally that of communication with space vehicles.

A few delegations had submitted proposals relating to frequency allocations for space research purposes, based on an appreciation of immediate requirements. Also the International Radio Consultative Committee (C.C.I.R.) had emphasized the wish of Members of the Union to consider the new problems without delay by creating Study Group IV for « Systems used in space telecommunication » at the IXth Plenary Assembly held at Los Angeles in April, 1959.

He was sure that all delegates present recognized that it was essential for the I.T.D., as the specialized telecommunication agency, to arrange for adequate frequency bands to be provided for the expanding research requirements associated with the peaceful uses of outer space.

In order to assist Committee 4 in its work, the Plenary Assembly created a special group under the chairmanship of Mr. Acton, composed of delegates of the following five countries : United States, France, United Kingdom of Great Britain and Northern Ireland, Czechoslovakia and U. S. S. R.

The special group prepared several reports for the Plenary Assembly and Committee 4. The main problem in discussions within the group, and examination of reports, was the allocation to the « Space » and « Earth-Space » services of frequency bands in different parts of the radio frequency spectrum without interfering with the operation of other radio services at present in use or planned for future operation.

Due to the collaboration of all delegations, it was possible to make a number of allocations for research purposes to the « Space » and « Earth-Space » services.

Furthermore, in view of the rapid development in communications with space vehicles, the plenary meeting adopted a Recommendation (nº 35) relating to the convening of an Extraordinary Administrative Radio Conference during the latter part of 1963, with an agenda including the following basic items :

to examine the technical progress in the use of radiocommunication for space research and the results of technical studies by the International Radio Consultative Committee and other interested organizations ;

to decide, in the light of such an examination, on the allocation of frequency bands essential for the various categories of space radiocommunication ;

to consider whether there is a continuing need for the allocation of certain frequencies for space research purposes and, if so, to take appropriate action in this regard ;

to adopt, if such action is considered desirable, new provisions revising the Radio Regulations to provide for the identification and control of radio emissions from space vehicles, taking into account possible Recommendations of the International Radio Consultative Committee.

The Recommendation also invites Members and Associate Members of the Union, which launch satellites during the period of space research before the convening of the Extraordinary Administrative Radio Conference referred to above, to keep the Administrative Council, and the relevant technical organs of the Union, informed of the frequencies used and the technical progress achieved in the use of radiocommunication for space research purposes.

It is therefore clear that the Administrative Radio Conference, Geneva, 1959, took all appropriate steps relating to the important problem of space telecommunication to enable the I.T.U. closely to follow the development and operation of new techniques, the appearance of which in the near future appears most probable.

(*To be continued*).

C. C. I. R.

The IXth Plenary Assembly

(Los Angeles, 2-29 April, 1959)

Study Group VI. — *Ionospheric propagation*

Chairman : Dr. D. K. Bailey (United States of America).

Vice-chairman : Dr. E. K. Smith (United States of America).

At Warsaw, SG VI had set up a special working party to study various methods of evaluating sky-wave field strength on frequencies above 1.5 Mc/s. This working party, under the chairmanship of Mr. Lépéchinsky (France), met several times ; its work was resumed at Los Angeles and culminated in different texts, including a Report and a Recommendation, which outline a systematic programme of measurements of ground-wave field strength between 1.5 and 40 Mc/s. The working party observed that it had a limited number of valid measurement results at its disposal, and a new Study Programme was issued in this connection.

SG VI amended the Recommendations on the exchange of observations for the establishment of short-term predictions and on basic predictions.

A revised edition of the Warsaw Report on Atmospheric Noise was published, while a Recommendation provides for a working party to revise the Report, and a new Study Programme was prepared on man-made radio noise measurements.

The protection of frequencies used in radioastronomy is dealt with in a revised Recommendation, which requests protection of deuterium, hydrogen, and ion H lines as well as a number of bands above 30 Mc/s.

A new Recommendation defines the expressions « classical MUF », « standard MUF » and « operational MUF ».

A number of other subjects, which were under study following the Warsaw Assembly, are dealt with in reports summarizing the

results obtained until the Plenary Assembly and in new Study Programmes which were revised in accordance with these results. Some of these subjects are :

precursors indicative of short-term variations of propagation conditions ;

propagation on frequencies below 1.5 Mc/s ;

propagation and absorption between 1.5 and 40 Mc/s ;

intermittent communication by meteor-burst propagation ;

ionospheric scatter ;

fading ;

basic predictions ;

choice of a basic index for ionospheric propagation ;

pulse transmission at oblique incidence.

Two new reports have been prepared, on the whistler mode of propagation and on back-scatter, respectively.

Finally, the Plenary Assembly passed a Resolution requesting the working party on local lightning flash counters to continue its studies.

STUDY GROUP VII. — *Standard frequencies and time signals*

Chairman : Mr. B. DECAUX (France).

Vice-chairman : Prof. M. BOELLA (Italy).

As at Warsaw, SG VII prepared a Recommendation on the general problem of standard-frequency transmissions and time signals. The main amendment concerns the accuracy required, which is stricter than the Warsaw provision, particularly for transmitted frequencies.

The data on the various standard-frequency transmissions and time signals are again assembled in a table, which has been brought up to date. It shows how the number of stations in all parts of the world is constantly increasing.

SG VII has issued two new Recommendations on subjects already under study : one relates to standard-frequency transmissions in additional frequency bands and particularly in band 4 (myria-

metric waves), where a 100 c/s band is desired in the neighbourhood of 20 Kc/s. The broadcasting of such transmissions over transmitters on bands 5, 6 and 8 is also advocated.

Another Recommendation suggests means of eliminating interference caused by standard-frequency transmissions in the bands allocated to that service.

The programme of SG VII for forthcoming years mentions, with some changes, the subjects dealt with at Warsaw. In addition, it is requested, in collaboration with SG VI, to study frequency staggering from the point of view of propagation.

Finally, a new programme of studies concerns the transmission spectrum for high-precision time signals.

Study Group XIV. — *Vocabulary*

Chairman : Mr. R. Villeneuve (France).

Vice-Chairman :

SG XIV issued a new Recommendation on the designation of frequency bands. As was proposed at the London Assembly, the designation of these bands by numbers has been retained ; the expression Hertz (Hz), however, has been introduced to designate, along with c/s, the frequency unit.

As regards vocabulary, definitions of certain basic terms to be found in the Radio Regulations are proposed in a report.

There is a new Resolution giving fresh directives for the preparation of a Radio Vocabulary and outlining a procedure based on the work of active collaborators in the work of this study group ; these collaborators are to be appointed by the various C.C.I.R. study groups and will ensure liaison between these study groups and SG XIV.

Changes made in the C.C.I.R. Study Groups

As at Warsaw, some amendments were made in the terms of reference of the study groups. As a result of resignations in the interval between the VIIIth and IXth Plenary Assemblies, many of the chairmen and vice-chairmen have also been changed.

The principal amendments in terms of reference concern two of the study groups on propagation (IV and V). The former terms

of reference of SG IV (Ground-wave propagation) and SG V (Tropospheric propagation) have been merged in the present terms of reference for SG V, while the new SG IV has been requested to study all communication problems affecting space vehicles.

The following is an up-to-date list of the terms of reference for the C.C.I.R. study groups and the names of their Chairmen and Vice-Chairmen.

Study Group IV (*Space Systems*)

Terms of reference.

To study technical questions regarding systems of telecommunication with and between locations in space.

Chairman : Professor I. Ranzi (Italy).

Vice-Chairman : Dr. W. Klein (Switzerland).

Study Group V

(*Propagation, including effects of the earth and the troposphere*)

Terms of reference.

To study the propagation of radio waves over the surface of the earth, taking into account changes in the electrical constants of the earth and irregularities of terrain, and including the effects of the troposphere.

Chairman : Dr. R. L. Smith-Rose, C. E. B. (United Kingdom).

Vice-Chairman : Dr. A. Kalinin (U. S. S. R.).

Study Group VI (*Ionospheric propagation*)

Terms of reference.

To study all matters relating to the propagation of radio waves through the ionosphere in so far as they concern radio communication.

Chairman : Dr. D. K. Bailey (U. S. A.).

Vice-Chairman : Dr. E. K. Smith (U. S. A.).

STUDY GROUP VII (*Standard-frequencies and time signals*)

TERMS OF REFERENCE.

Organization of a world-wide service of standard-frequency and time signal transmissions. Improvement of measurement accuracy.

Chairman : Mr. B. DECAUX (France).

Vice-Chairman : Professor M. BOELLA (Italy).

STUDY GROUP XIV (*Vocabulary*)

TERMS OF REFERENCE.

To study, in collaboration with the other Study Groups and, if necessary, with the C.C.I.T.T., the radio aspect of the following : vocabulary of terms and list of definitions, lists of letter and graphical symbols and other means of expression, systematic classification, measurement units, etc.

Chairman : Mr. R. VILLENEUVE (France).

Vice-Chairman : Mr. A. FERRARI-TONIOLO (Italy).

INTERNATIONAL GEOPHYSICAL YEAR

Catalogues of Data

— Catalogue of Data in WDC2 Center for Ionosphere (February 1, 1960) issued by the Radio Research Laboratories, Ministry of Posts and Telecommunications, Tokyo, Japan.

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— The Japanese National Committee for the I.G.Y. (Science Council of Japan) has issued two *Preliminary Reports of the Remarkable Events observed in Japan during the I.G.Y.* :

n° 1 for July-December, 1957 (March 1958),

n° 2 for January-June, 1958 (March 1959).

I.G.Y. World Data Center A

The National Academy of Sciences-National Research Council of U. S. A., has issued, in the « I.G.Y. Report Series » :

— an Interim Catalogue of Data in I.G.Y. World Data Centre A (Report n° 7, December 1959),

— the Fifth Six-Monthly Catalogue of Data in I.G.Y. World Data Centre A (Report n° 8, February 1960).

BIBLIOGRAPHY

International Radio and Television Organization (O.I.R.T.)

We inform our readers that since February 1960 the O.I.R.T. is issuing its Bulletin under the name *Radio and Television*. Supplementary information are available at Conseil d'Administration de l'O.I.R.T., Liebknechtova 15, Praha 16, Czechoslovakia.

International Electrotechnical Commission

Publication 107, First edition. — Recommended methods of measurement on receivers for television broadcast transmissions.

This Publication, the first edition of which has just been issued, describes methods of measuring the electrical, acoustic and optical properties of television broadcast receivers designed for monochrome vision reception of 405, 525, 625 and 819 lines transmissions, of either negative or positive modulation and the associated a.m. or f.m. sound channel. Its object is to present a catalogue of selected measurements recommended for assessing the essential properties of a receiver under standard conditions so that the results of measurements in different laboratories can be compared. Il does not lay down limiting values for acceptable performance.

Publication 107 contains the following sections :

General ;

Vision : picture quality, sensitivity, interference, fidelity, stability, radiation, miscellaneous ;

Sound : general, sensitivity, interference, fidelity, non-linear distortion, miscellaneous.

Price : Sw. Fr. 25.— per copy, plus postage.

Publication 117-1, First edition. — Recommended graphical symbols, Part 1 : Kind of current, distribution systems, methods of connection and circuit elements.

This Publication replaces the former Publications 35 and 42 dealing respectively with graphical symbols for heavy and light current electrical engineering. When complete, Publication 117 will include symbols for all branches of electrical technology, but in order not to delay the publication of available sections, it is being issued in parts as and when these are approved.

Publication 117-1 contains 93 symbols which constitute the first part.

Price : Sw. Fr. 6.— per copy, plus postage.

Publication 34-1, Sixth edition. — Recommendations for rotating electrical machinery (excluding machines for traction vehicles).

Price : Sw. Fr. 8.— per copy, plus postage.

Publication 50(08), 2nd edition. — International Electrotechnical Vocabulary Group 08 : Electro-acoustics.

Price : Sw. Fr. 10. —per copy, plus postage.

These publications are on sale at the Central Office of the I.E.C., 1, rue de Varembé, Geneva, Switzerland.