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U. R. S. I.

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URSI WORKING PARTY ON NATIONAL STANDARDS LABORATORIES

by A. E. BAILEY

Recommendation I.1 of the XVII General Assembly calls for the establishment of a register of national standards laboratories active in the field of electromagnetic measurements. To implement this recommendation, Commission I set up a Working Party consisting of A. E. Bailey (UK) (Convenor), H. M. Altschuler (USA), H. Bayer (FRG), and P. O. Lundbom (Sweden). The Working Party met at the Bureau International des Poids et Mesures, Sèvres, on 9 October 1972. G. Leclerc and T. J. Witt of BIPM were present at the meeting.

It was agreed that the scope of the enquiries should cover electromagnetic measurements and standards at frequencies from DC to the limit of coherent radiation under the following headings :

(*a*) Basic electrical standards, as these are the basis on which many RF and microwave measurements rest;
(*b*) Other measurements at DC and LF, in so far as they are relevant to radio science and technology;
(*c*) Standards of time and frequency;
(*d*) RF, microwave, millimetric and sub-millimetric quantities;
(*e*) Laser power and energy.

Both national reference standards and the calibration facilities offered to industry and other users will be included.

The Working Party noted the existence of other bodies with a possible interest in this field and of other related enquiries. It took steps to arrange for the interchange of information and to avoid duplication of effort.

The first step will be to write to the Official Members of Commission I to ask for their help in establishing contact with the authorities in each country responsible for the provision of national standards and for the highest level calibration facilities. Requests will then be sent asking these authorities to provide a list of their standards or other facilities for inclusion in the register. They will be asked to list the quantities covered, with the range of values, the frequency range, the type of wave guidance (lumped circuit, coaxial line or waveguide, as appropriate), and the uncertainty for each type of measurement. In order to ensure compatibility of the informa-

tion received from different sources, guidance will be given in the form of model answers to the questions.

It is hoped that a first draft of the register can be completed by the end of 1973 for circulation, to all those who have contributed to it, early in 1974. The Working Party will meet again in 1974 to consider the draft register and any further replies received. It will draw up a final version of the register for presentation to the XVIII General Assembly of URSI in 1975. It is anticipated that it will be necessary subsequently to revise the register at intervals of three years to take account of new developments.

COMMISSION II
LETTRE CIRCULAIRE DU PRÉSIDENT

AUX MEMBRES OFFICIELS DE LA COMMISSION II

Cher Collègue,

En ce début de période triennale qui se terminera par notre Assemblée générale, j'ai pensé que des contacts plus nombreux étaient nécessaires entre nous. Aussi, je me permettrais de vous exposer ci-dessous les quelques sujets pour lesquels votre collaboration est souhaitable.

Colloques :

Au cours de nos séances de travail à Varsovie, nous avons décidé d'organiser un très petit nombre de colloques. Ces colloques seront en partie subventionnés par l'URSI.

Cependant, des initiatives nationales, éventuellement indépendantes des Comités nationaux, pourront se manifester en organisant d'autres colloques. Dans la mesure où les sujets traités sont de notre domaine d'activité et où le niveau scientifique est de haute qualité, il serait souhaitable que vous soyez en relation avec les responsables de ces colloques éventuels. Vous pourriez préalablement obtenir le patronage de votre Comité national sans pour autant que ceci lui impose une obligation financière. *Je crois qu'il faut insister pour que toute activité scientifique de notre ressort soit connue et encouragée par l'URSI.*

Pour de nombreux colloques, une participation étrangère est bienvenue. Je vous rappelle que dans le Bulletin d'Information de l'URSI n° 175 de juin 1970, on a publié les règles qui permettent d'obtenir le patronage de

notre Union. Le patronage est quelquefois assorti de subvention, mais il ne semble pas qu'il soit possible d'obtenir avant 1975 d'autres subventions que celles qui sont déjà en cours de discussion. Par contre, le patronage moral de l'URSI devrait être souvent un gage de succès et il peut être accordé plus facilement si des subventions ne sont pas demandées.

Enfin, pour éviter une multiplication néfaste des réunions scientifiques, il serait utile qu'un organisme international fasse connaître les lieux et dates des colloques nationaux ou internationaux et éventuellement puisse conseiller les organisateurs sur la meilleure période. Notre Union pourrait faire ce travail et le Bulletin d'Information serait susceptible de publier un tableau des colloques prévus. Pour cela, je vous demanderais de me faire connaître aussi vite que possible les colloques prévus dans votre pays et du ressort de la Commission II.

Nouvelles activités :

Notre prochaine Assemblée générale ne remplira pleinement son rôle que si elle reflète exactement les différentes tendances de la recherche. Dès maintenant, c'est notre rôle en tant que Membres officiels de la Commission II de connaître les différentes tendances surtout si elles n'ont pas encore donné lieu à des discussions au cours de nos Assemblées précédentes. Je vous rappelle à ce sujet qu'il a été recommandé d'accorder une attention plus importante aux questions :

ondes évanescentes,
radiogéologie.

Ceci ne doit pas diminuer l'importance des études de la croûte terrestre et de la Terre en général par des méthodes radioélectriques.

Pour mieux préparer notre prochaine réunion, il est utile de connaître les bons spécialistes de toutes les questions qui sont au programme de nos activités. Je vous demanderais donc de m'écrire au moins une fois par an pour me signaler les sujets qui vous semblent nouveaux et se rattachant à notre mandat, ainsi que le nom des spécialistes de ces questions.

Liaisons permanentes :

Beaucoup d'entre nous ont des activités similaires et ont l'habitude de se tenir périodiquement au courant de leurs efforts. Cependant, cette coutume n'est pas assez généralisée. Nous savons d'expérience que la libre circulation des idées scientifiques est un gage de succès. Je vous proposerais de suggérer à tous les scientifiques de votre pays d'envoyer systématiquement des tirés à part de leurs articles aux Membres officiels de la Commission II

des autres pays. Ceci augmentera peu chaque liste de diffusion et renforcera le lien permanent qui doit exister entre nous. De plus, certains travaux sont publiés dans des rapports qu'il est difficile de se procurer. C'est principalement dans ce cas que la diffusion devrait être le mieux assurée.

Enfin, il est probable que chacun d'entre vous a entendu des critiques et suggestions au sujet de l'organisation des travaux de notre Commission. Pourquoi ne pas m'en faire part ? Ce n'est que par une modification constante qu'une association continue à rester fidèle aux principes qui lui ont donné naissance. Ces modifications doivent être systématiquement suggérées par les Membres officiels plutôt qu'imposées par un autre organisme.

En conlusion, je serai toujours heureux d'avoir des nouvelles de vos activités, et dans l'espoir de vous lire, je vous prie de croire, cher Collègue, à l'assurance de mes sentiments dévoués.

8 décembre 1972.

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COMMISSION II
CIRCULAR LETTER FROM THE CHAIRMAN

To Official Members of Commission II

Dear Colleague,

As we enter on the three-year period which will end with our next General Assembly, I believe that it will be useful to arrange for more frequent contacts between ourselves. In this connection, I should like to refer to a number of questions where your cooperation is desirable.

Symposia :

During our Business Meetings in Warsaw, we decided to organise only a very small number of symposia and these will be partly supported by URSI.

However, initiatives taken at national level, even independently of our National Committees, could result in the organisation of other symposia.

In so far as the subjects to be dealt with are relevant to our field of interest, and where the scientific level is high, it seems desirable that you should make contact with those responsible for such symposia. You could take steps to obtain the approval of your National Committee to act as sponsor, but without necessarily undertaking any financial responsibilities. *I believe that we should insist that all scientific activity in our field ought to be known to and encouraged by URSI.*

For many symposia, participants from other countries are welcome. I would remind you that the rules under which our Union can agree to sponsor symposia were published in URSI Information Bulletin No. 175 (June 1970). Such sponsorship is sometimes associated with a financial grant, but it is hardly likely that grants will be made, before 1975, for symposia other than those already under consideration. On the other hand, the moral support of URSI ought often to be a guarantee of success and it is likely to be given more readily when financial support is not requested.

Finally, so as to avoid unnecessary duplication of scientific meetings, it would be useful if some international organisation could disseminate information about the dates and locations of national and international symposia and, if need be, could even advise the organisers on the preferred dates. Our Union could undertake this task and probably publish lists of planned symposia in the Bulletin.

New activities :

Our next Assembly will fully achieve its object only if it accurately reflects the various trends in research. Even now, one of our tasks, as Official Members of Commission II, should be to recognise these trends, especially if they have not already been discussed at our recent Assemblies. On this point, I would remind you that it has been recommended that more attention should be concentrated on two questions :

evanescent waves,
radio geology.

This, of course, does not imply any diminution in the importance attached to the study of the Earth's crust and of the Earth in general by radio methods.

So as to ensure the most effective preparations for our next meeting, it will be useful to know who are the specialists best qualified in all the topics in our programme of activities. May I ask you to write to me, at least once every year, and to notify me of the subjects which appear to be

new and relevant to our terms of reference, and of the names of the specialists concerned.

Continuing Liaison :

Many of the Members of our Commission are engaged on similar activities and keep each other informed periodically about their work, but this custom is not sufficiently widespread. We know from experience that the free circulation of scientific ideas makes an essential contribution to success and I would like you to encourage all the scientists in your country to send copies of their reprints to all the Official Members of Commission II in other countries. This would not greatly increase the circulation list and it would strengthen the necessary links between us. Further, the results of certain investigations are published in reports which are difficult to obtain and it is principally in such cases that this circulation ought to receive particular attention.

To conclude, most of you have probably heard criticisms or suggestions concerning the organisation of the work of our Commission. If so, why not pass them on to me ? It is only as a result of regular changes that an organisation can remain true to the principles which gave rise to its formation. Such changes ought to be systematically suggested by our Official Members rather than be imposed on us from outside.

I shall always be happy to receive news of your activities and I look forward to hearing from you.

Yours sincerely,

8 December 1972.

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HIGHLIGHTS IN COMMISSION VI, 1969-1972

In 1971, at the request of Prof. H. M. Barlow, Prof. K. M. Siegel undertook the task of compiling a survey of the highlights of recent activities in the field covered by URSI Commission VI. Several international Working Parties were formed to deal with specific topics and the Chairmen of these Parties prepared brief reviews in the early months of 1972.

At the URSI General Assembly in Warsaw, Prof. Siegel presented a summary of the contents of the reviews and suggested that the full text

should be published as a supplement to Chapter 6 of *Review of Radio Science 1969-1972.*

The reviews are reproduced below and grateful acknowledgment is made to the authors and to those who participated in the Working Parties.

Chairmen : H. Bremmer, A. L. Cullen, L. B. Felsen, R. F. Harrington, G. Sinclair, B. J. Uscinski.

Members : N. Alexeeva, J. B. Andersen, C. G. Aurell, G. Barzilai, F. A. Benson, Brekhovskikh, D. K. Cheng, P. C. Clemmow, S. Csibi, I. Csiszar, N. G. Denisov, J. B. Davies, A. V. Gaponov, Ginzburg, G. G. Gouriet, A. V. Gurevitch, J. Hansen, R. C. Hansen, D. S. Jones, G. W. Jull, A. E. Karbowiak, B. Z. Katzenelenbaum, J. B. Keller, Klimontovitch, Y. T. Lo, N. Marcuvitz, P. A. Matthews, M. Miller, R. Mittra, K. Morita, A. A. Oliner, G. Piefke, S. Przezdziecki, E. Roubine, J. O. Scalan, T. B. A. Senior, H. V. F. Severin, T. Tamir, Tatarskij, M. V. Tilston, R. Timman, H. G. Unger, L. A. Wainstein.

Wave Propagation

H. BREMMER
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First of all we mention the following classical propagation problems on which research has been performed in several countries : geometric-optical theories (surface waves in stratified anisotropic media), continuous and transient signals in plasma configurations, asymptotic theories involving wave packets, modes in the wave guide between the earth's surface and the ionosphere, investigations (in particular in Japan) on effects due to motion of the medium or of its boundaries. Apart from these items connected with completely fixed data, other propagation studies mainly concern effects due to the irregular structure of the traversed medium itself (such as a turbulent atmosphere), of its boundaries (scattering by ocean waves), or of an adjacent medium (geological structures below the earth's surface).

Amongst other things the importance of radio communication with satellites has stimulated, first of all in the USA and in the UK, the experimental determination of atmospheric parameters by various methods, in particular by microwave radiometry and by the analyzing of back-scattering produced by radar. Radiometry has been successful for obtaining temperature and water-vapour profiles in clear and clouded air. Experience

in downward viewing equipment from aircraft over oceans has proved to be important in view of its ultimate application to satellites. Research on millimetre and submillimetre waves also concerned ground-based measurements of atmospheric emission and opacity. As to the radar method, back-scatter experiments from the ground have been performed for the first time by using a broad spectrum (bandwidths up to an octave or more). It is not so much the traversed atmosphere, but the soil properties (varying moisture content, geological structures, etc.) which can then be detected. On the other hand, layered structures and the presence of internal waves in the atmosphere could be revealed by the application of frequency modulated (continuous) radar.

Primarily, experimental work on the propagation of frequencies above 10 GHz has shown that the reliability of communications using frequencies up to 100 GHz is only restricted, apart from the effect of oxygen absorption lines between 50 and 70 GHz, by rain and rainclouds. The influence of rain had also been observed on laser transmission.

The application of Doppler frequency shifts to measuring the local refractive index in planetary research has resulted in a better knowledge of the temperature and pressure profiles of the atmospheres of Mars and Venus.

The still continuing theoretical and experimental investigations on turbulence phenomena (waves passing through a stochastic medium) is important for many practical questions, for instance their influence on the most favourable dimensions of transmitting and receiving aperture aerials. The theoretical study, which in the beginning primarily started from single-scattering (Born) approximations, is developing more and more towards a better understanding of multiple-scattering effects, and of associated saturation effects in the case of long propagation paths through a weakly inhomogeneous turbulent medium. A description with the aid of a simplified parabolic wave instead of the rigorous hyperbolic wave equation, in general proves to be sufficiently accurate. Just as an example, drawn from the comprehensive literature on the subject which has appeared in the USSR and in Japan, we mention that relevant properties could be derived by combining Rytov's method (application of the linearized approximation of the differential equation for the logarithm of the wave function) with the hypothesis that correlation of refractive-index fluctuations can be neglected when observed at points on a line parallel to the main direction of propagation. Apart from the usual consideration of a plane wave incident on an unbounded stochastic medium, investigations made in particular in the USA also concern effects of boundaries, and of sources emitting spherical waves or a collimated beam.

Finally, in the Netherlands, progress has been made in studying the time-dependent one-dimensional wave equation for propagation through a stratified inhomogeneous medium. For instance, it has been shown by Sluyter how any asymptotic WKB result may serve as the first term of an exact solution in the form of a series, thus extending the concept of the Bremmer series.

Guided Waves and Periodic Structures

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Fundamental studies of point-matching techniques have been carried out by Millar and Bates ([1]), Lewin ([2]), Yasmura ([3]) and others. Similar studies of mode matching by Lewin ([4]), Lee *et al.* ([5]) and Mittra *et al.* ([6]) have been reported. A number of commonly accepted assumptions are challenged in these papers.

A number of papers on waveguides include a study of microstrip by Grünburger *et al* ([7]), including axial field components, and a coupled-mode theory of propagation in a circular waveguide completely filled with transversely magnetized ferrite due to Bernadi and Gerosa ([8]). Rhodes ([9]) has carried out a very thorough study of the general constraints on the propagation characteristics of electromagnetic waves in inhomogeneous waveguides.

Some interesting results on the attenuation of waves in corrugated circular waveguides have been obtained by Clarricoats and Saha ([10]).

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Diffraction and Scattering

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As in previous years, major emphasis in diffraction and scattering has been on the high-frequency regime. Asymptotic techniques, especially the geometrical theory of diffraction or its equivalents, have been further explored, critically examined (particularly in regard to their accuracy and range of validity), and applied to aperture antennas as well as to obstacles in homogeneously or inhomogeneously filled open and closed (waveguide) regions. Uniform asymptotic representations, valid in transition regions, continue to be developed for refinement of the theory. Increased interest is shown in the propagation and scattering properties of bounded (Gaussian) beams, in both free-space and open-resonator environments.

Time-harmonic boundary value problems in plasma-like media are receiving less attention than previously, but activity continues on time-dependent propagation in the presence of moving media and boundaries, and on dispersive effects. Equivalent stationary media, as well as space-time rays, are being utilized in the construction and interpretation of solutions. Complex rays, known for some time but regarded as a mathematical formality, are beginning to be studied seriously with a view to unifying propagation in lossy or evanescent regions, and for treatment of bounded beams.

Numerical methods are having increasing impact. Expansions in terms of guided and resonant modes, and integral equation formulations, are being explored and applied to numerical treatment of relatively arbitrary scatterer configurations for time-harmonic and time-dependent excitation. Analytical and numerical progress has also been made in this way on the inverse scattering problem. Truncation errors, and procedures suitable for large configurations, continue to require attention.

The programmes of two international meetings contained numerous contributions on diffraction and scattering : 1. International Symposium on Antennas and Propagation, Sendai, Japan, September 1-3, 1971, and 2. Electromagnetic Wave Theory Symposium, Tbilisi, USSR, September 9-16, 1971.

Computer Simulation of Electromagnetic Field Problems and Optimization in Design

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The use of computers to analyze, synthesize and optimize electromagnetic field systems has been expanding rapidly since the XVI General Assembly of URSI. Computers are used, of course, in all computation but, for this summary, consideration is restricted to methods having general application.

Numerical solution of electrostatic and magnetostatic problems has received considerable attention. Methods such as finite differences and finite elements usually result in sparse matrices, the inversion of which has been speeded up by an order of magnitude by sparse matrix techniques. Another method involves the solution of an integral equation which results in a dense matrix, but one of smaller order. General purpose computer programmes are available for most two-dimensional problems, and some three-dimensional ones. Solutions and computer programmes for waveguide and resonator eigenvalue problems, using similar methods, are also available. Numerical solution of microwave circuit problems has also received considerable attention, with many specific examples solved to good accuracy.

Antenna problems have been the object of much work, both in the frequency domain and in the time domain. Engineering solutions for wire antennas of arbitrary shape, with arbitrary feeds, and with arbitrary impedance loading have been obtained and general purpose computer programmes are available. Arrays of wire antennas and wire grids have also been treated by similar methods. In the time domain, solutions for the transient response of wires excited by electromagnetic pulses have been obtained. Also, time-domain solutions permit treatment of time varying and non-linear impedance loads. Numerical solutions for aperture antennas in conducting cylinders and bodies of revolutions have been reported.

Electromagnetic scattering problems have also been solved by numerical methods. There is considerable similarity between radiation and scattering problems, the major difference being the excitation. Hence, solutions and programmes available for scattering problems are essentially the same as those available for antenna problems. A modal description of radiation and scattering has been formulated, and efficient algorithms for calculating

these modes are available. Investigations have been made of both speed and accuracy of numerical solutions, with improvements made on both counts.

In the area of optimization much work has been done on performance indices expressible as Rayleigh quotients, both with and without constraints. When the indices are not of this type, nonlinear equations usually result and optimization becomes more difficult. In this case optimum seeking methods are used, but these are often plagued by slow convergence and points of local optima. Closely related to optimization is the problem of pattern synthesis for both antennas and scatterers, and several problems of this type have been investigated.

Antennas and Arrays

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In the Federal Republic of Germany, coaxially-arrayed circular waveguides have been developed as high-efficiency reflector feeds. Additional work has been done on active antennas for reception, so as to improve bandwidth and signal-to-noise ratio at high frequencies. In Sweden, a method for synthesizing the power pattern of an antenna has been developed.

In Japan, studies have been carried out on a variety of linear antennas and the scattering pattern of the Cassegrain sub-reflector has been investigated. Other work includes arrays with prescribed patterns, phased-array studies, and a feed method for achieving a specified current distribution.

In the USA, phased arrays have continued to receive a good deal of attention and much progress has been reported. Anomalies similar to the Wood anomalies in optical gratings are now well understood and methods have been proposed for suppressing the blind spots which result. Arrays with random spacings have continued to attract some attention. Numerical techniques have been extended to such complex problems as Yagi-Uda arrays, coupling between open-ended waveguides, and antennas of revolution. Studies relating to large reflector antennas have been concerned mainly with devising more efficient feed systems and with the reduction of various aberrations.

In Canada, an unsuspected anomaly in the pattern and impedance of log-periodic arrays was discovered and explained, leading to a procedure for optimizing performance. This work revealed the importance of swept-frequency instrumentation.

In the Netherlands, supergain antennas received further attention, and studies have been made of dual-beam parabolic antennas and of corrugated conical horns.

In the United Kingdom, there has been continued interest in the design of large reflector antennas, with emphasis on improved feed design. The effects of propagation variations on the gain of hf rhombic antennas, the effects of nearby obstacles on radar antennas and methods for shaping the patterns of vhf and uhf antennas have been examined. Other work include active antennas, use of corrugated structures for scanning antennas, loop and backfire antennas, and antennas immersed in plasmas.

Stochastic Effects in Radio Physics

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Continued interest in stochastic effects associated with the propagation of electromagnetic waves through irregular media has led to a great deal of theoretical work over the last three years, as well as to numerous practical applications.

EXPERIMENTS.

The most marked successes have perhaps been in the experiments. The analysis of interplanetary scintillations has resulted in a great deal of information both about the angular diameters of quasars as well as the nature of irregularities in the interplanetary medium. Similar work now underway with pulsars is helping to build up a picture of irregularities in the inter-stellar medium. Interesting experimental and theoretical analyses of random drifting patterns has enabled the pattern of turbulent and ordered velocities in the solar wind to be determined. The spectrum of spatial frequencies in the irregular interplanetary medium has been the subject of much discussion and some progress has been made with this difficult problem.

Continued investigations of ionospheric irregularities have resulted in these being mapped for many regions of the globe and much is now known about their origin and long-term behaviour. Analysis of ionospheric scintillations by means of large arrays of antennas has thrown light on the turbulent and ordered velocities of the irregularities. The remote probing of atmospheric turbulence, of sea and land surfaces as well as of the polar

ice caps by various forms of radar has made steady progress, and present techniques are capable of yielding much detailed information.

THEORY.

There have been numerous papers on propagation in a medium which can be described by an irregular refractive index. Thorough studies have been made of most cases where the Born approximation can be applied. These include

(*a*) the effect of an incoherent source of finite size (e. g. a radio star) and finite frequency bandwidth of the incident field;

(*b*) the propagation and focusing of a coherent beam (laser);

(*c*) the effect of irregularities on the resolution of objects by a telescope and the effect of a finite aperture on the observations of a fluctuating field.

These questions have been dealt with successfully for cases when the source is infinitely distant (plane waves), and when it is immersed in the medium (spherical waves). There have been interesting laboratory experiments with controlled turbulence which have allowed some of these conclusions to be checked.

Progress in the case of multiple scatter has been slower. There have been many papers which employ different assumptions and simplifications in order to obtain tractable results. However no substantial measure of agreement seems to have been established between the various theories, and indeed there have been discrepancies with experimental results. This difficult problem requires further study and a reliable set of experimental data with controlled turbulence in the irregular medium would be most helpful.

COMMISSION VIII — RÉSULTATS NOUVEAUX

Le bref sommaire ci-dessous a été présenté par le Prof. R. Rivault (Président de la Commission de 1969 à 1972) en août 1972 à Varsovie lors d'une des séances de la Commission VIII.

BRUIT RADIOÉLECTRIQUE ET RADIOCOMMUNICATIONS.

Sous l'impulsion de l'Office of Naval Research de Washington, de notables progrès ont été faits dans la prévision du niveau de bruit atmo-

sphérique qui gêne les radiocommunications. A l'aide de calculateurs, des cartes mondiales de bruit ont été établies qui permettent, en un lieu de réception et à un instant donnés, de prévoir la puissance ou le champ de bruit relatif à une certaine bande de fréquence.

La validité de ces prévisions a été contrôlée, notamment par les indications de compteurs d'éclairs.

BRUIT EBF.

La partie inférieure de la bande EBF, qui s'étend de 3 Hz à 3kHz, comprend les résonances de Schumann dues à l'excitation de la cavité terre-ionosphère par des éclairs puissants qui ont été localisés dans les régions tropicales.

La structure fine des crêtes de résonance a été étudiée; sa complexité tient à ce que l'énergie se propage depuis l'éclair par des chemins opposés de caractéristiques différentes.

LOCALISATION DES ORAGES ET DES ÉCLAIRS.

La tendance actuelle est de rendre les goniomètres TBF automatiques et numériques. La fréquence de travail classique de 27 kHz a dû être abaissée au-dessous de 10 kHz à cause de la prolifération des émetteurs ondes longues.

Pour obtenir une localisation précise de l'éclair à l'intérieur des nuages orageux, des récepteurs accordés sur 250 MHz ont été disposés le long de bases de quelques dizaines de kilomètres; la précision atteinte est de l'ordre de 25 m.

Par ailleurs, le pointage optique des foyers orageux par satellites se développe.

BRUIT D'ORIGINE INDUSTRIELLE.

Les mesures se sont développées, en liaison notamment avec l'extension des réseaux de télévision, en utilisant des hélicoptères au-dessus des cités. Il a été trouvé que le bruit est le plus intense par temps de brouillard et que, parmi les nouvelles sources de bruit, il faut compter la commutation dans les calculateurs.

FACTEURS MÉTÉOROLOGIQUES LIÉS A LA PRODUCTION DU BRUIT ATMOSPHÉRIQUE.

Il s'agit là de l'étude des divers processus naturels, liés aux conditions météorologiques, qui peuvent produire des ondes électriques, éclairs com-

pris. Les mesures récentes ont surtout porté sur la distinction entre les éclairs entre nuages ou entre sol et nuage. La polarisation des ondes reçues et des dispositifs optiques directifs ont été utilisés.

PROPAGATION DES ONDES EBF ET TBF AU VOISINAGE DE LA BASSE IONOSPHÈRE.

Cet important sujet a fait l'objet d'une réunion mixte avec la Commission III. Des données nouvelles ont été discutées, notamment sur l'absorption des ondes au voisinage de la région D et sur la propagation des sifflements déduite de techniques telles que le tracé de rayons.

OBSERVATIONS DE LA MAGNÉTOSPHÈRE AU MOYEN DES SIFFLEMENTS.

L'aspect scientifique des mesures faites par le groupe de travail sur les sifflements et concernant, notamment la plasmapause a été exposé; les discussions ont fait apparaître l'intérêt qu'il y aurait à détecter automatiquement l'occurrence des sifflements et à connaître leur direction d'arrivée.

INTERNATIONAL GEOPHYSICAL CALENDAR 1973

The International Geophysical Calendar for 1973 has been published by IUWDS and is reproduced elsewhere in this issue of the Bulletin. Separate, copies of the Calendar can be obtained on application to Dr. P. Simon, Observatoire, F-92 Meudon, France or to Miss J. V. Lincoln, WDC-A, NOAA, Boulder, Col. 80302, USA. On the back of the Calendar, the recommended programmes of observation in various branches of geophysics have been reproduced.

International Geophysical Calendar for 1973

(See other side for information on the use of this Calendar)

JANUARY

S	M	T	W	T	F	S
	1	2	[3	4]	5	6
7	8	9	10	11	12	13
14	15	(16)	(17)	(18)	19	20
21	22	23	24	25	26	27
28	29	30	31			

FEBRUARY

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	(13)	(14)	(15)	16	17
18	19	20	21	22	23	24
25	26	27	28			

MARCH

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(16) Regular World Day (RWD)

(17) Priority Regular World Day (PRWD)

◇21◇ Quarterly World Day (QWD) also a PRWD and RGD

6 Regular Geophysical Day (RGD)

[4] Day of Solar Eclipse

* Micropulsation Interval Day

[12 13] World Geophysical Interval (WGI)

[3 Day with unusual meteor shower activity, Northern Hemisphere

31] Day with unusual meteor shower activity, Southern Hemisphere

[2 3] Airglow and Aurora Period

Notes: GATE: GARP Atlantic Tropical Experiment Field Tests June-August 1973.
Atmospheric Electricity Intensification Intervals of Ten Year Program are Jan. 15-Feb. 15, 1973 and Oct. 15-Dec. 17, 1973 (first priority Nov. 7-10 and second priority Nov. 5-Dec. 3).

ERATIONAL EDITION, September 1972

SEE OTHER SIDE

LOWER IONOSPHERE STRUCTURE : METHODS OF MEASUREMENT AND RESULTS

A Symposium on the above subject will be held in Constance (F. R. Germany) on 23, 24 and 25 May 1973. It will be jointly sponsored by URSI, COSPAR and IAGA (IUGG). The Chairman of the Organising Committee is Prof. K. Rawer and the members are S. A. Bowhill, A. D. Danilov, G. Kockarts, E. A. Lauter, J. Ortner and L. Thomas.

The topics selected are as follows :

Ionospheric profiles up to 160 km :

1. Review of techniques and profiles
2. Definition of collision frequencies
3. Interpretation of cw propagation data

Observed variations in time and space :

4. Temporal and geographical variations of D-region parameters
5. Direct measurements (neutral and ionic)
6. Variabilities of D-region electron density
7. Regional results on the winter anomaly
8. Radio measurements of gravity waves.

Papers on each topic will be presented by invited speakers, but contributed papers will be welcomed. Abstracts of invited and contributed papers must be sent to Prof. K. Rawer and to the COSPAR Secretariat so as to arrive *not later than 9 March 1973.*

Papers dealing with topics to be covered by the Kyoto Symposium (see following announcement) will not be accepted.

Addresses :

Prof. K. Rawer,
Arbeitsgruppe für physikalische
Weltraumforschung,
Kronenstrasse 13,
D-78 Freiburg-im-Breisgau,
Germany.

COSPAR Secretariat,
Boulevard Malesherbes 55,
F-75008 Paris,
France.

DYNAMICS, CHEMISTRY AND THERMAL PROCESSES IN THE IONOSPHERE AND THERMOSPHERE

A Symposium on the above subject will be held in Kyoto (Japan) during the IAGA Scientific Assembly. It will be jointly sponsored by IAGA

(IUGG), COSPAR and URSI. The Chairman of the Programme Committee is Prof. T. R. Kaiser. URSI is represented by Prof. K. Rawer and Dr. L. Thomas. It is intended provisionally to cover the following topics :

1. Processes, including energy input, transport and chemistry
2. Measurements, including optical techniques, particularly of minor constituents
3. Theories of stratosphere/mesosphere coupling.

Address :

Prof. T. R. Kaiser,
Department of Physics,
Hicks Building,
The University,
Sheffield 10, United Kingdom

XVI COSPAR MEETING, 1973

COSPAR will meet in Constance (F. R. Germany) from 23 May-6 June 1973.

Three specialised symposia will precede the regular meetings :

A. Approaches to Earth survey problems through the use of space techniques (23-25 May).

B. Methods of measurements and results relating to lower ionospheric structure (23-25 May).

C. Noctilucent clouds and interplanetary dust (24-25 May).

URSI is a joint sponsor of Symposia A and B.

During the COSPAR Meeting, Open and Special Meetings of the COSPAR Working Groups will be held.

WG 1. Tracking, telemetry and dynamics of satellites.

WG 2. Experiments in interplanetary space and in the magnetosphere.

WG 3. Space techniques as applied to astrophysical problems.

WG 4. Experiments in the upper atmosphere.

WG 5. Space biology.

WG 6. Applications of space techniques to meteorology and Earth surveys.

WG 7. Space-related studies of the Moon and planets.

THIRD INTERNATIONAL SYMPOSIUM ON INFORMATION THEORY (ISIT-3)

The above Symposium will be held in Tallinn (Estonia, USSR) from 18-23 June 1973. It is being organised by the Academy of Science of the USSR (Council for Cybernetics and Institute for Problems of Information Transmission) and the Academy of Science of the Estonian SSR (Institute of Cybernetics).

The Symposium is co-sponsored by URSI and will be devoted to mathematical problems and modern applications of information theory. The programme will include papers on :

— mathematical foundations of information theory,
— probabilistic and algebraic methods of coding,
— statistical theory of signals and noise,
— theoretical and experimental research on sources and communication channels,
— principles of information organization and information processing in programming systems.

Intending participants are requested to send two copies of the English abstract of their papers (3 pages including illustrations and references) not later than 1 January 1973 to :

Organising Committee ISIT-3,
Institute of Problems of Information Transmission,
Aviamotornaya 8, korp 2,
Moscow 111024, USSR.

Speakers will be informed, by 28 February 1973, about the inclusion of their papers and will have the possibility of presenting a 20 minute paper or making a 10 minute contribution.

1973 EUROPEAN MICROWAVE CONFERENCE

4-7 September 1973, Brussels, Belgium

The deadline for the submission of papers for this Conference is 1 March 1973 (for details see *URSI Inf. Bull.* No. 183, p. 38).

GEOMAGNETIC DISTURBANCES

At the IAGA Scientific Assembly to be held from 9-21 September 1973 in Kyoto, Japan, there will be a special session on : "World-wide distribution of geomagnetic disturbances".

It will be concerned with disturbances, of ionospheric and magnetospheric origin, which occur at widely separated locations. Micropulsations are excluded since they will be discussed in a separate Symposium.

Contributions are invited and fully informative abstracts must be received not later than 20 May 1973. Detailed information on the preparation of the abstracts is available from

W. H. Campbell,
Space Environment Laboratory,
ERL/NOAA,
Boulder, CO 80302, USA.

THE FEDERATION OF ASTRONOMICAL AND GEOLOGICAL SERVICES
(FAGS)

Preface.

As a general rule, the Unions adhering to the International Council of Scientific Unions are not themselves responsible for the actual execution of scientific research programmes. This is the task of the academies of science and equivalent bodies which sponsor national programmes of research and which are represented in the Unions. The rôle of the Unions is to ensure, when necessary, that the various national contributions to research in a given field are coordinated in such a way as to yield the best overall results. In astronomical and geophysical research, such international coordination is universally recognized as being essential to the advancement of science.

On the other hand the mere coordination of national activities is not always sufficient and it must sometimes be supplemented by direct action at an international level. A striking example of this is seen in the centralized treatment of certain types of basic astronomical and geophysical observations that are made at hundreds of locations all over the world;

this is the task of the 11 Permanent Services that adhere to the Federation of Astronomical and Geophysical Services (FAGS).

Most of the present Services were formed on the initiative of the International Astronomical Union, the International Union of Geodesy and Geophysics and the International Union of Radio Science. Each Service operates under the scientific supervision of one or more of these Unions. The Services report annually to the Council of FAGS; the membership of this body includes representatives of the Unions and of ICSU, and UNESCO sends and observer to its meetings.

The Services are themselves international in character and operate under the control of the Unions. However, they are physically located in national scientific institutions which generously provide certain facilities which are essential to the effective functioning of the Services. Great credit is due to these national bodies for their most valuable contribution to this truly international scientific endeavour.

Acknowledgement must be made also to ICSU and to UNESCO both of which make annual grants to FAGS, whose Council is responsible for deciding how to distribute the available funds among the Services. These grants are necessary to cover the cost of publications and other activities of the Service which are strictly international and which could not, therefore, be financed from national funds. Without them it would be difficult for the Services to maintain their present activities and to make the results of their work available to the world scientific community.

Introduction

For obvious reasons, man has always wanted to investigate his immediate surroundings, but is is only fairly recently that he has realized the importance of extending his interest to include the Earth as the planet on which he must live. Localized studies of our planet are now recognized as being of interest to peoples in other areas and it is well known that the actions of man in any one region may have important consequences in other parts of the world.

This realization of the world-wide community of interest in our Earth as a whole has led to a generalization of the meaning of the word "environment"; this now covers not only the local environment of the individual but also the environment of mankind on a global scale, and even the environment of our planet in space : the ionosphere, the magnetosphere and interplanetary space. By analogy, the word "biosphere" has been coined to

represent the thin inhabited layer on the surface of the Earth within which biological processes and cycles are of paramount importance.

The scientific study of the Earth must begin with the collection, analysis and interpretation of information and numerical data on natural phenomena of many kinds. Astronomers and physicists have, over many years, devoted part of their efforts to research on the Earth itself and, in consequence, geophysics is now recognized as a distinct branch of science.

In studies of the Earth and the long-term variations in its characteristics, a period of 50 years represents only a short time interval. Hence, if it is desired to obtain a true picture of these changes and of their statistical characteristics, it is essential to ensure that the basic observational data are available over very long periods of time. However, series of data covering such periods are useful for scientific research only if they are homogeneous. It follows that the organization of observational programmes and the subsequent treatment of the data obtained must be carefully planned; otherwise there is a grave risk that the scientific value of the observations may be seriously compromised.

Since the formation of the International Research Council in 1919, three of the member Unions have been particularly concerned with the collection and interpretation of astronomical, solar and geophysical data of many kinds : the International Unions of Astronomy (IAU), of Geodesy and Geophysics (IUGG), and of Radio Science (URSI). Although these activities were initiated more or less independently, they were brought together in 1956 when ICSU established the Federation of Astronomical and Geophysical Services (FAGS). At present 11 Permanent Services adhere to FAGS and each of them is concerned with the collation and interpretation, on a world-wide scale, of various types of quantitative information on the Earth or on its environment in space.

Scientific Objectives

The Services are concerned with many different aspects of astronomy and geophysics, but their activities follow a fairly uniform general pattern which includes the following elements :

— the collection of the raw data;

— the analysis and synthesis of these data leading, in some cases, to conclusions;

— the publication of the data, in a more concise form, and their distribution to scientists and others who wish to use them.

It must be emphasized that the rôle of a Permanent Service is much greater than that of a passive data bank; the essential responsibility of a Service is the critital analysis and the synthesis of the information it receives and the transmission of refined data and conclusions to scientists and technicians throughout the world who are concerned with further examination of these data.

The creation of FAGS can be traced ultimately to the recognition of a number of basic principles which can be summarized as follows :

local or regional observations, even if they are very accurate and have been carefully analysed, can not by themselves be used to obtain a global picture of a phenomenon relating to the physics of the Earth;
series of astronomical and geophysical observations extending over only a short period of time are inadequate for a full understanding of many types of natural phenomena, and clearly such series can not be used to make reliable forecasts of the variations in slowly changing phenomena;
the volume of detailed observations that is available to research workers is so great that no individual is capable of examining or assimilating all of them. As a general rule, the research worker requires information only on a limited number of parameters, determined from the much more numerous original data, that provide the characteristics of the phenomenon in which he is interested. The main publications of the Services are listed in Annex 1 (p. 37).

In this short review of the activities of FAGS, it would be impossible to describe the activities of the individual Services in detail; only a brief outline of the rôle played by each of them will be given. It is important to point out that each Service operates under the general scientific supervision of the Unions that are responsible for the branch of science with which the Service is concerned.

Although the primary function of FAGS and the individual Services is the advancement of scientific research, it is appropriate to mention that, as often happens in science, the results obtained by the research scientist may sometimes have applications, often unforeseen and unexpected, of a practical kind. Some examples of these are referred to briefly on page 33.

The Permanent Services

International Polar Motion Service (IPMS-1895)

In order to detect the irregular oscillations of the pole at the Earth's surface, it is necessary to encircle the Earth with a chain of observatories. In 1895, the founders of this Service installed five zenith telescopes : in Japan, on the West and East coasts of America, in Italy and in Russia. They expected that a series of observations lasting for about six years would be sufficient to allow the basic characteristics of polar motion to be understood and to be used subsequently in making forecasts of future movements. Having attained this objective the intention was to terminate the programme of observations.

The fact that the Service is still active in 1972 and that, for example, very rapid and precise determinations of polar motion are required in space research shows how mistaken the opinions of 1895 have proved to be.

Observations of polar motion have disclosed irregularities which are still not understood. They depend, ultimately, on the internal structure of the Earth and its elasticity and viscosity, but they are related also to changes in the distribution of mass in the atmosphere, the oceans and the interior of the Earth.

Since the beginning of research on polar motion, attempts have been made to find a correlation with seismic activity, but it is only very recently that a well-developed theory has been proposed to justify this important relation. In fact, astronomers and seismologists who have studied this problem now believe that it will ultimately be possible to find a method of using information on polar motion in making forecasts of earthquakes.

This research, extending over many years, highlights the importance of the permanence of a Service and of the need for very long series of coordinated observations.

Bureau International de l'Heure (BIH-1911).

The BIH provides the basic information on time which is used for the synchronization of activities everywhere in the world to an accuracy of a millionth of a second. In addition it determines, as a function of time, the three angles that define the position of the Earth with respect to its axis of rotation. These determinations are necessarily based on measurements made at observatories in many parts of the world; information that is the product of the synthesis of these measurements is essential in the

fields of astronomy, geodesy, geophysics, space research, sea and air navigational systems and telecommunications.

The BIH has, for example, recently been responsible for several practical applications :

(*a*) the synchronization of geodetic measurements based on observations of satellites and designed to study movements of the Earth's crust and changes in its shape;

(*b*) the provision of assistance in the synchronization of radio navigational systems (LORAN-C) having applications also to experiments in space;

(*c*) the very rapid calculation of Universal Time and of the coordinates of the pole, both of which were required for making corrections to the trajectories of the Mariner space probes.

At the same time BIH is concerned also with important advanced research projects such as the study of the relation between irregularities in the rotation of the Earth, the zonal circulation of the atmosphere, and solar activity; the results of this study may offer the possibility of making long-term forecasts of changes in climate. It has already been possible to show that there is a relation between the rotation of the Earth and seismic activity.

Central Seismological Bureau (BCIS-1904).

It can be readily appreciated that the analysis of the characteristics of an earthquake requires the comparison of records made at many stations covering a wide area. The BCIS coordinates and collects these observations and, after analysing them, publishes the results in a form which is used not only for theoretical investigations (propagation of seismic waves, models of the Earth's interior) but also for studies of seismicity in different parts of the world.

Every Earth tremor is recorded by at least 20-30 stations, even if it occurs in an area which is uninhabited or in which there are no stations with the appropriate scientific instruments. The very extensive documentation of these results, undertaken by BCIS, constitutes a basic contribution to studies of the distribution, in time and space and in quantitative terms, of the energy released in earthquakes, and also to investigations of sequences of tremors (foreshocks, aftershocks). In addition, for example, the information provided has given support to new theories on the general structure of the Earth (spreading of ocean floors, continental and oceanic plates).

International Gravity Bureau (BGI-1953).

Every experiment carried out, either on the Earth or near it in space, is subject to the gravitational field. Thus it is not difficult to appreciate the importance of maintaining an effective Service which collects, treats and publishes all the available observations of g, the value of which varies from one location to another.

The practical users of gravimetric measurements are very numerous because of the universal influence of gravitational forces on every human activity. They have, for example, been used in the following fields :

(*a*) geodetic theory and the internal structure of the Earth;

(*b*) practical geodesy, particularly in levelling;

(*c*) orbits of artificial satellites, leading to the construction of a model standard gravitational field (Standard Earth) which must be further refined in detail by means of measurements made at ground level;

(*d*) geophysical prospecting (detection of natural resources);

(*e*) measurements in physical laboratories and in the engineering sciences.

During its Assembly in Moscow (August 1971) the International Association of Geodesy recommended the formation of a Permanent Service on Gravity which would, in future, be responsible for comparisons, in time and space, of the absolute value of g. Absolute values can now be measured with such high precision (10^{-9}) that there are good reasons for expecting extremely interesting results provided that measurements can be repeated systematically at different locations over a period of years.

The intercomparison of such precise measurements will pose problems that will be difficult to resolve, in particular for the Service on Earth Tides.

Permanent Service on Earth Tides (SPMT-1960).

The forces of attraction of the Sun and Moon cause tidal movements in the Earth's crust having a variable amplitude of 30-40 cm at the surface. Although interest in these elastic deformations originated because of the practical needs of oil prospectors, the scientific aspects of Earth tides have attracted increasing attention during the past 15 years.

In the field of fundamental astronomy, earth tides and the classical precession-nutation problem appear to be very closely related. Both phenomena are affected by dynamic effects in the liquid core of the Earth and their measurement and analysis make it possible to deduce information about the internal structure of the Earth. The secular slowing down of the Earth's rotation is also connected with Earth tides.

The interpretation of the very precise laser measurements of the distance between the Earth and the Moon will soon require reliable information on the radial deformations of the two bodies. Earth tides are responsible for well-defined perturbations in the orbits of artificial satellites, and a knowledge of the correction to be applied for tidal effects is essential in precise measurements of the distance of a satellite from the Earth.

The variable load exerted on the Earth's crust by ocean tides causes perturbations in the Earth tide itself. The analysis of these effects is important in studies of the interactions between oceans and continents and of co-tidal charts. The Service is actively engaged in investigations of regional effects, with the aid of a well-sited network of stations, and in the development of models of the interior structure of the Earth, its viscosity, etc.

The regular analyses of the recordings received by the Service provide the values of the various elastic parameters which characterize the tidal deformations.

Permanent Service on Mean Sea Level (PSMSL-1933).

The mean level of the sea is obtained from a series of direct observations made with respect to a fixed point on land. Since it is important to suppress, as far as possible, the effects of tides and of irregular changes in the level due to wind and waves, the measurements must be numerous and must cover a sufficiently long period of time to give an accurate mean value.

Long-term variations in sea level are important in many types of scientific investigation : the global water balance, the length of the day, movements of the Earth's axis of rotation, and even the orbit of the Moon. They are linked also to climatological changes and to the changing coastlines of the world. Since these variations are very slow, they can be investigated only if very long series of data are available. Only 75 out of the world network of 800 observatories have records covering more than 50 years; this is the minimum period needed to give statistically significant estimates of the secular trends.

The need to separate regional variations in level from those that are planetary in extent is the justification for a central organization responsible for collecting and analysing data from all parts of the world.

Permanent Service on Geomagnetic Indices (PSGI-1932).

The permanent geomagnetic field is due primarily to the magnetic characteristics of the core of the Earth. The very slow secular changes in

the strength and direction of this field can be detected only by the analysis of long series of carefully controlled measurements. However, in making this analysis it is necessary to allow for the many regular and irregular short-term variations which are superposed on the main field.

Although they are small, the short-term variations are more important for many practical applications than the secular variation. Their periods vary from 11 years (the solar activity cycle) down to fractions of a second (micropulsations due to waves in the magnetosphere). The study of these variations provides information on the changes in solar activity and on the flow of charged particles in interplanetary space (including the magnetosphere and ionosphere). Indeed such variations represent some of the observable results of the interaction between solar radiation and the terrestrial environment.

One of the principal objectives of the Service is the collection of detailed observational data from magnetic observatories in various parts of the world and, subsequently, the condensation of these numerous local data into a limited range of "planetary indices" which present a global indication of the characteristics of the variations. The identification and accurate timing of the sudden commencements of certain geomagnetic storms is also an important activity of PSGI.

The geomagnetic indices and the other tables of selected data published regularly by the Service are used not only in various geophysical applications, but also in research on the nature of the Earth's environment in space, in radio-communications and even in studies of a biological nature.

Solar Particles and Radiations Monitoring Organization (SPARMO-1961).

The Earth's atmosphere forms a protective barrier against energetic forms of solar radiation which would be harmful to man : fast-moving charged particles, ultraviolet radiation and X-rays. Nevertheless these radiations are capable of penetrating the atmosphere down to levels where they can be detected and measured by instruments in high-flying balloons.

The objective of SPARMO is to coordinate these measurements, which are made systematically in several countries. The analysis of the observations provides information on the character of the radiations emitted by active centres on the Sun, on the modulation of the radiation in interplanetary space and on the precipitation of charged particles which is especially important in high-latitude regions.

The activities of this Service have stimulated the development of a method for predicting the periods when intense emissions of solar protons are most likely to occur.

Quarterly Bulletin on Solar Activity (QBSA-1928).

Regular observations of the Sun are made at over 100 observatories all over the world. They are concerned with the numerous phenomena and transient events that occur at the different levels of the solar atmosphere (photosphere, chromosphere, corona). In recent years, the traditional optical observations have been supplemented by completely new types of measurements made using radio techniques and covering a wide range of frequencies.

The Service extracts, from the large volume of data received, the best information on day-to-day events occurring on the Sun, and also assembles and processes the data that are needed for the establishment of long-term trends in solar activity. The study of these variations provides the basis for forecasting conditions in the ionosphere; they are of immediate importance, therefore, in the prediction of the frequencies best suited to radiocommunication services.

Once again it is necessary to stress the importance of a Service that can maintain its activities over long periods of time and can thus determine the long-term variations in the activity of the Sun.

International Ursigram and World Days Service (IUWDS-1962).

The task of the Ursigram Service is to provide, with the minimum delay, information required by scientists for the conduct of certain types of experiment. This information is concerned mainly with solar and geomagnetic activity, the ionosphere, auroral activity and the interplanetary medium. The World Days Service issues a specially annotated International Calendar which specifies, in advance, the preferred days on which many types of solar and geophysical measurements should, if possible, be made so as to achieve the maximum coordination of the observational programmes in different disciplines.

The ultra-violet, X- and gamma-radiation and the clouds of particles emitted by the Sun can, in certain circumstances, be dangerous to man; fortunately they are absorbed or deflected by the terrestrial atmosphere and the geomagnetic field which jointly act as a protective barrier. The action of the solar radiation on the atmosphere gives rise to the ionosphere which is an essential element in the operation of high-frequency radiocommunications systems. Thus the scientific studies of this defensive screen and the disturbances that develop in it after unusual solar activity have practical as well as scientific value.

The forecasts of solar and geomagnetic activity, and also the day-to-day information on actual events contained in Ursigrams, are essential in the conduct of short-term experiments that make use of expensive consumable material; they are valuable also in long-term programmes in which several different groups of scientists wish to coordinate their measurements. In addition the Ursigrams are of practical value in programmes where scientific instruments are temporarily located on a special site and where limitations in the supply of material necessitate the selection of the optimum periods for making observations. The day-to-day information is used especially in experiments where solar or geophysical events actually in progress may make it necessary to modify the observational routines.

Permanent Service on the Fluctuations of Glaciers (PSFG-1967).

The task of this Service is to assemble and publish selected data on the distribution of the world's glaciers and their variations with time. Fluctuations of glaciers are of general interest to geophysicists, geologists and geochemists, but they are also the concern of meteorologists, oceanographers and hydrologists. Quite apart from their scientific interest, changes in glaciers may have practical repercussions on hydroelectric and irrigation schemes in some regions.

Many of the observations made on glaciers are primarily of local interest or are of a very specialized kind. The Service has the task of extracting from the original data those that have more general importance : specific mass balances, the altitude of the equilibrium line, coefficients of activity, etc. : the values of such parameters for different glaciers, and especially their variations, are of great value in trying to understand glacial activity on a world scale.

Applications

A reference was made earlier to possible practical applications of the conclusions reached by the Services of FAGS. Although these must be regarded as by-products of fundamental research projects, some examples will be given for purposes of illustration.

Studies of the variations in the mean level of the sea provide an essential basis for devising ways of protecting low-lying areas from catastrophic flooding. The lessons learnt by the countries round the North Sea hold promise for other regions as far apart as Venice, on the Mediterranean,

and the urban developments round the Bay of Bengal where floods constitute a serious menace.

Variations in sea-level and fluctuations in the extent of the world's major glaciers are probably related to long-term changes in climate; such relations, after being confirmed, could be used to make forecasts of climatic changes and this information would be important for many human activities.

Very precise measurements of time are an essential feature of new systems of navigation designed to prevent collisions in the air and at sea, but the availability of the information required depends ultimately on very numerous observations made primarily for the purposes of scientific research.

Scientific studies of the dynamics of earthquakes and earth tremors provide information that is of great value to the architects and engineers who are responsible for the design and construction of buildings, bridges, artificial reservoirs, etc. The forecasting of major earthquakes is a subject of serious concern to seismologists. Although the problem is far from being solved the collection and publication of information on epicentres, magnitudes of tremors, etc. constitutes a necessary basis for further studies which may later lead to a breakthrough.

Other types of observations appear to provide information on the phenomena which precede earthquakes and may be of practical value in due course. These include movements of the pole of rotation of the Earth, and slow movements in the Earth's crust (and the accumulated stresses in it) which can be deduced from regular measurements of Earth tides and of the gravitational constant g.

Encouragement of Original research; New Techniques

The activities of the Services are not merely routine in character. On the contrary, they are continually devoted, in part, to introducing improvements in the techniques of measurement and in the methods of analysing the data. The collaboration of the Services is often needed in connection with new types of project which appear every year. For example, during complex operations such as the recovery of astronauts and cosmonauts at the end of their flights, the forecasting of radiocommunication conditions has become an element in the safety precautions that must be taken. The specialized information and the forecasts issued by the Ursigram and World Days Service make a vital contribution to these precautions.

Some of the regional centres of this Service are directly concerned, at national level, with problems relating to the safety of man in space; this

applies not only to Moon landings and manned orbital flights, but also to high-flying aircraft, particularly those that operate at high latitudes where the precipitation of solar particles is greatest.

The Service for Mean Sea Level has made an essential contribution to the coordinated European Levelling Network (REUN) by providing information on the difference in the levels of the Baltic Sea and the Mediterranean.

The BIH is responsible for the establishment of International Atomic Time (IAT) of great uniformity. Since 1969, IAT has made it possible to date events anywhere in the world to an accuracy of one microsecond on a single time scale. In 1971, IAT was recommended for use as the official time scale by the 14 International Conference on Weights and Measures.

The Polar Motion Service is at present undertaking a new study of the observations that have accumulated over a period of 71 years. This project, in which new methods of analysis are being used, is based on the recently revised fundamental astronomical constants and on a new homogeneous catalogue of star positions.

The Service on Earth Tides has actively encouraged programmes of special observations including, for example, the installation of a station at very great depth (—1,500 m) in Czechoslovakia in 1965-67, the Astro-Geo Project (installation of 10 instruments) in Spitzbergen in 1968-70 and the establishment of the Walferdange-Luxemburg Laboratory. Here, with the help of the Ministry of Cultural Affairs of the Grand Duchy of Luxemburg, the Service was able to organize the collaboration of several laboratories in making direct comparisons of their instruments and methods : Lamont Geological Observatory, New York; the Universities of Bonn, Cambridge and Kyoto; the Observatories at Uccle, Belgium and at Mizusawa, Japan. The Service is at present collaborating in carrying out the transcontinental profile project.

At present all the Services use electronic computers for at least part of their work. For example, since 1960, the work of the Service on Earth Tides has been carried out entirely with the aid of a computer.

FAGS and the Developing Countries

It is important to point out that the Services are ready to make available to developing countries any information that can be of direct use to them. Such information can sometimes concern the actual territories of these

countries; in other cases it is the result of observations made in countries that possess the necessary highly developed scientific instruments.

The work on the rotation of the Earth is a good example of this : every country benefits, without cost, from the results acquired in the countries with the best equipped laboratories. Moreover the developing countries can make use of the same high-precision time and frequency standards for their scientific and industrial laboratories as the more developed countries. In consequence, they themselves have no need to establish the complex and expensively equipped laboratories that would otherwise be required.

The results obtained by the Polar Motion Service permit any country to make comparisons between high-precision geodetic surveys carried out at different times. The same can be said for other phenomena which are world-wide in character and which may be of special importance to many countries, such as ionospheric disturbances, changes in mean sea level, etc.

From time to time, for example, prospectors searching for oil are interested in receiving advance information about possible geomagnetic disturbances, because these interfere with the sensitive magnetometers. During such searches men and materials must often be transferred to regions where working conditions are difficult; it is then of great importance to know when geomagnetic activity it at a level which is satisfactory for the actual measurements made during the survey.

It is sometimes necessary also to investigate regional effects or even very localized phenomena and the FAGS Services are willing to carry out such investigations for any country provided that the necessary basic observational data are made available. In fact some Services actually do this, as far as they can, for seismological studies where the collected information permits the preparation of maps showing dangerous areas, or of codes of practice for buildings in earthquake zones.

In studies concerning the slow movements of the Earth's crust, and the build-up of stresses in it, the Services for Earth Tides and for Gravimetry are willing to offer their support.

Conclusions

The synthesis of very large volumes of data collected by the Permanent Services demands such a large-scale effort that very few national research institutions are capable of undertaking the whole of the task.

It is not difficult, in fact, to envisage what would happen in the event of a breakdown in FAGS. Some of the developed countries would certainly undertake those of the activities of the Services that were of special interest to them, but this would be at the cost of duplication of work and consequent waste of effort. Moreover, in the absence of the Permanent Services, the results obtained from several independent national analyses of data would tend to be inhomogeneous. An even more serious consequence would be that these countries could not be expected to extend their activities so as to cover other countries and regions in which they themselves were not directly interested.

In the years ahead, many developing countries will wish to acquire basic information for the use of the research scientists that they are at present making great efforts to train and who will later undertake research programmes designed to benefit their countries. The FAGS Services will be able to provide some of this information already prepared, condensed and in a well-organized form and including representative parameters.

Annex 1

Publications, etc. of the Permanent Services of FAGS

International Polar Motion Service

Annual Report and Monthly Notes of the IPMS.

Bureau International de l'Heure

Annual Report of BIH
Circulars A (annual); B/C (monthly), D (monthly).

Bureau Central International de Séismologie

Bulletin of the BCIS (several/year)
Determinations of epicentres (weekly or fortnightly).

Bureau Gravimétrique International

Information Bulletin of BGI (several/year)
Maps of gravimetric anomalies (irregular).

Permanent Service on Earth Tides

Information Bulletin on Earth Tides (quarterly)
Bibliography on Earth Tides.

Permanent Service for Mean Sea Level

Bibliographies on mean sea level 1719-1958 and 1959-1969
Bibliographies on Tides 1955-1969
Catalogue of published mean sea level data.

Permanent Service for Geomagnetic Indices

Tables of planetary indices *Kp* (fortnightly)
Monthly bulletins of international character figures *Ci*, etc.
Quarterly bulletin of magnetic indices, etc.
IAGA Bulletin Series 12 (annual).

Quarterly Bulletin on Solar Activity

Quarterly Bulletin on Solar activity.

Solar Particles and Radiations Monitoring Organization

SPARMO Bulletin (several/year).

International Ursigram and World Days Service

Ursigrams (telegrams, telex, etc.) (daily)
Spacewarn Bulletin (fortnightly)
International Geophysical Calendar (annual)
Calendar Records (of solar and geophysical events) (irregular)
Synoptic Codes for Solar and Geophysical Data (triennal).

Permanent Service on Fluctuation of Glaciers

Fluctuations of Glaciers 1959-65; 1965-70.

Annex 2

Addresses of Permanent Services of FAGS

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Swiss Federal Institute of Technology,
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Quarterly Bulletin on Solar Activity,
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