Bulletin N° 117 September-October 1959

International Scientific Radio Union

U. R. S. I.

CONTENTS

Prof. Dr. B. van der Pol

IN MEMORIAM

† Prof. Dr. B. van der Pol

On October 6, we received the sad news that van der Pol was no more. During the night, at his desk, in the midst of his family and with a mind which was clear right up to the end, he peacefully rendered his soul. During the last six months an excruciating pain was rapidly pulling him down without being able, however, to turn him away from his work. Only last August, he had participated actively at Genova in the International Radio Conference. He had not been able to attend the session held at the Hague, a few days before his death, of the executive committee of the International Council of Scientific Unions (I.C.S.U.), but still L. V. Berkner, the president of the committee, had been to see him to put before him the questions under consideration. Moreover, on his desk was lying a finished scientific manuscript, regarding a certain aspect of the theory of the elliptic theta functions, in which he had inserted formulae, in his own hand, up to the last but one page.

In him, the International Radioscientific Union has lost an honorary president, who had served the Union with devotion and competence as vice-president from 1934 to 1950 and as a most active member ever since the revival of the U.R.S.I. after the first war. It was van der Pol who, at the Brussels Assembly of 1928, created the new (fifth) Commission on « Radio Physics », which is particularly concerned with the theoretical questions of propagation and circuits. All those who have participated even once in a General Assembly of the U.R.S.I. and particularly in the very last session, held at Boulder (Colorado) in 1957, have appreciated his command not only over the scientific problems of our Union but equally much over the administrative problems. Indeed van der Pol was at the same time, a great scholar, a great technician and a great administrator at the International level.

Many people have know him and seen him at work, but often could only discern one aspect of his powerful and sympathetic personality. Throughout his career, which was so productive, the three aspects of his activity mentioned above were intimately interwoven, offering us the harmonious spectacle of a development which never suffered a decline.

van der Pol was born in Utrecht in 1889. Having studied at Utrecht University, he went to Fleming in London in 1916 and then to J. J. Thomson at Cambridge. From his three years stay in this famous laboratory, he brought back a thesis (1), on experimental work, which was most remarkable at that time in demonstrating that the effective dielectric constant of a gas ionised by a glow discharge falls below unity for high frequency electromagnetic waves (wave length 3 meters). Thus he obtained an artificial ionosphere in the laboratory and proved it to have a refractive index below unity for short waves, which ensures the curvature of the electromagnetic waves in the ionosphere and their return towards ground. At that time long distance transmission and reception of short waves had not yet been realized.

Having obtained his doctorate, he became the theoretical assistant of the great Lorentz for a period of three years at the Teyler Foundation in Haarlem. In 1922, he was engaged as Head of the Philips research laboratories at Eindhoven and later became the director of radioscientific research, a position which he occupied till the limit of age, in 1949. He was then invited to Genova as the Director of the Consultative Committee on Radiocommunications (C.C.I.R.) and finally in 1956 he retired and settled down in his home land at Wassenaar.

Concurrently with his scientific activities which we shall mention later, he devoted himself to the development of radiotechnique, in Holland and elsewhere. He was a founder member, in 1920, of the Netherlands Radio Society and was always at its helm. In 1921 he was also one of the founder members of the Dutch Physical Society. In 1927, his important role in the establishment of the first radiotelephone connection with the Dutch Indies was recognized in the form of an official distinction. Since 1927, he participated as a delegate of his country in more than twenty five conferences en Telecommunications held in all parts of the world. From 1946 to 1949 he presided over the technical committee of the International Radio Organisation (I.R.O.) ; he was also a member of the Radio-Raad of Holland.

In a rather schematic way one can classify the scientific work of van der Pol under three headings ; the theory and experiment of non-linear oscillations, propagation of electromagnetic waves, pure and applied mathematics.

Even before inspiring, at the Philips research laboratories, numerous experimental studies on the non-linear, free (transmission) and forced (reception) oscillations in triodes, he had already developed the concerned theory, partly with Appleton. Together, they showed how a receiving circuit becomes synchronized with a modulated incident signal (2) : in a certain band around the resonance frequency, the free oscillation of the receiver is suppressed and is locked to the incident carrier frequency. This work was completed by the theory of the « hysteresis » phenomenon in coupled oscillators (3).

In 1926, van der Pol published an important theoretical work (4) which marked the entry into science of the so called relaxation oscillations, the period of these being proportional to the time constant CR of the circuit. The phenomenon is now well known, and the non-linear differential equation corresponding to its simple and basic form is, rightly, called after van der Pol. His elegant discussion of the solutions, based on the work of Poincaré, is now classic. The following year (5), in collaboration with van der Mark, he showed experimentally the existence of sub-harmonics produced in relaxation systems. Immediately afterwards (6) he recognized that the heart beat is essentially a relaxation oscillation and constructed an electrical model with the same co-worker.

To this part of his work are also related van der Pol's researches(7) on the theory of frequency modulation and on the stabilisation of unstable harmonic oscillations (Mathieu equation).

The important series of studies on the propagation of electromagnetic waves on the surface of the earth, started in 1931, with Niessen (8). The classic solution of Sommerfeld, applicable to waves of medium wave-length, with the surface of the earth considered as plane and possessing electrical conductivity and permeability, was greatly developed and discussed from a physical point of view. From 1937 onwards, in collaboration with Bremmer (9), came the remarkable studies on the propagation of very short waves, taking into account the curvature of the earth. Use of the operational calculus is a characteristic of all these studies. As for the results, these are well known by the propagation curves which have been accepted as official at various international conferences (10).

Finally, in recent years, van der Pol was the first to attack a difficult problem : the propagation of a discontinuity wave from a source, in the presence of a flat ground with unrestricted characteristics (11). He showed the presence of the conical wave which develops in the ground and explained the meaning of the so called surface wave of Sommerfeld.

One must also mention the discovery, in 1934, at the Philips laboratories, of the cross modulation of two radio waves, called the Luxembourg effect (12).

One cannot but limit oneself to a rather brief mention of the mathematical work of van der Pol. Firstly his big contribution to the theory and applications of the operational calculus in which he became interested in 1929 (13), culminating in the publication, with Bremmer, of a work of exceptional quality on this subject. Then one has to mention his numerous contributions to our knowledge of the functions of mathematical physics, contributions which have always been most suggestive from the physical point of view. Finally the increasing attention which van der Pol devoted, towards the end of his career, to the elliptic functions and to the theory of numbers (14) when he recognized the possibility of applying operational methods in these domains.

A word here regarding the scientific career of van der Pol. In 1938 he was appointed professor of theoretical electricity at Delft Technical University, fortunately, however, without ever carrying the burden of academic duties. In 1945, after liberation, he became president of the temporary University established at Eindhoven ; his service were recognized by an official distinction. He was visiting professor in the United States, in 1957 at Berkeley and in 1958 at Cornell University.

Since 1947, he was member of the Royal Academy of Sciences of Holland ; he was correspondant member of the Academy of Sciences of Paris, and honorary doctor of the Technical University of Warsaw and of the University of Genova. He received the medal of honour of the Institute of Radio Engineers (U. S.), of which he was vice-president in 1934 and the Poulsen medal of the Academy of technical sciences of Denmark. He was honorary member of various scientific societies and administrator of the Mathematical Center of Amsterdam.

We have yet to pay hommage to the man, to his character so gay and optimistic, to his talent for friendship and for music, to his qualities of a scientific diplomat in international assemblies, to the energy which he put into his work, to his vast erudition which he carried with such ease and simplicity. He was a master of the classics of science, specially of Rayleigh and Heaviside, and those who shaіed the same tastes owe him memories of many unforgettable hours. He was a remarkable lecturer as well, and in several languages too, as good in exposing difficult subjects as in the art of serious popularizations.

Before ending, it will perhaps be not out of place to express a wish : that most of the scientific work of van der Pol be collected and published quickly, by some current method of reproduction. This publication should include not only the fundamental scientific memoirs but also some works on popularization and some short articles on mathematical physics, which are most suggestive and too little known. In the scientific world, such a publication would honour a country which has always had a high credit abroad.

C. MANNEBACK.
Treasurer U.R.S.I.

RÉFÉRENCES PRINCIPALES

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INFORMATIVE PAPER

Historical account of U.R.S.I.

Section III. — Ionospheric radio-wave propagation

1. — *Origin*

As it has been previously mentioned in the preceding section (3.3), the Commission on Ionospheric Radio, the present Commission III, took its origin from the Permanent Sub-Commission on the Ionosphere constituted in 1946. The chairmanship of this new commission was entrusted in 1948 to Sir Edward Appleton who remained in charge up to 1954 when Dr. D. F. Martyn took the chairmanship.

2. — *Activities*

From the beginning the new Commission felt the effects of the impulse given by the Permanent Sub-Commission on the Ionosphere and directed its activities along various ways but all converging toward the essential aim of the Commission, the study of radio wave propagation through the ionosphere.

Such investigation fundamentally needed an elaborate knowledge of the ionosphere and of its characteristics. From the beginning, Commission III felt the need of a close cooperation of workers investigating the ionosphere from a point of view different from the one which primarily interested U.R.S.I. This need had given birth to the Mixed Commission on the Ionosphere constituted by the International Council of Scientific Unions. This Commission which had held its first plenary session in Brussels a few days before the Stockholm General Assembly of U.R.S.I., 1948, worked since then in close cooperation with Commission III.

Due to the use made of their contents for the preparation of the International Geophysical Year, two Reports drafted during this 1948 Assembly should be mentioned, one was on the location of ionospheric stations, the other on operating ionospheric stations and on reduction of ionospheric data ; this last one was the starting point of various reports drafted later on by the World Wide Ionospheric Soundings Committee.

A review of the work carried out during the IXth General Assembly (Zurich, 1950) shows in a striking way the diversity of Commission III activities. Going through the Prodeedings of this Assembly one notices that the Commission appointed seven Working Groups and that each of them drafted a report which was considered at the end of the meetings. These reports dealt with :

— non linear effects in the ionosphere,
— long distance propagation of waves of 30-300 Mc/s by means of regions E and F of the ionosphere,
— problems of medium and long wave propagation,
— ionospheric absorption of radio waves,
— reduction of ionospheric data for geophysical purposes,
— Ursigrams, this report led to the constitution of the Permanent Committee on Ursigrams,
— production and reduction of ionospheric information.

Those who closely followed the works carried out during the International Geophysical Year, and particularly the activities in the field of the ionosphere, will notice the importance of the last of the above reports for the drafting and functioning of the programme concerned with vertical incidence ionospheric soundings.

At the time of the Zurich Assembly it might be thought that the activities of Commission III had reached a level which would be difficult to exceed. But the use of rockets and later of space vehicles strengthened the impulse given to the Commission by the forthcoming International Geophysical Year. The history of this large enterprise shows that since the beginning U.R.S.I. was very closely connected to it.

As soon as 1952, U.R.S.I. appointed a Committee entrusted with the coordination of efforts to organize research and observation during the I.G.Y. in the various fields of activities of the Union ; Commission III was closely connected with such activities ; ionospheric investigation was, indeed, one of the major parts of the I.G.Y. programme.

As soon as 1950, endorsing the resolutions of the Mixed Commission on the Ionosphere, the Commission recommended the use of rockets, and later of any space vehicles, to improve our knowledge of the high atmosphere.

Resolutions and recommendations drafted by the present Commission III, in agreement with the Mixed Commission on the Ionosphere, at the 1952 and 1954 General Assemblies, have directed observations and investigations carried out during the International Geophysical Year in the various ionospheric fields and particularly for vertical incidence soundings, measurements of drifts, absorption, etc.

To have a complete view of the numerous activities of Commission III, the work of its sub-commissions should be mentioned, but this would lead us too far and may be to an overlapping with other activities which will be dealt with in further parts of this account such as those of the U.R.S.I./A.G.I. Committee, the Ursigram Committee, the Sub-Committee on World Wide Soundings, etc.

One of the most striking results of the activities of the Commission is obviously the increase of the number of ionospheric stations in the world. In 1932, for the Second Polar Year, about twenty stations carried out ionospheric observations, this number increased to more than 200 during the International Geophysical Year.

It is obvious that with the help of National Committees, the ionospheric investigation would not have reached the results which partly gave U.R.S.I. its present standing. To give here even only a short summary of the collaboration of various National Committees would be overstep the boundaries of the review and we have to refer the reader to the numerous National Committee reports printed in the Proceedings of the Assemblies and in the *Information Bulletin*.

(*to be continued*).

XIIIth GENERAL ASSEMBLY

Letter from the Chairman of Commission V

To all Official Members and Officers, Commission V.

Dear Colleague

PROGRAMME OF MEETINGS FOR THE XIIITH GENERAL ASSEMBLY OF U.R.S.I. IN LONDON 1960

At a meeting of the Coordinating Committee of U.R.S.I. held in Brussels last June the programme for the General Assembly in London next year was drawn up and the following sessions have been allocated for discussion by Commission V.

(1) Joint session with Commission VII on highly sensitive receivers-molecular and parametric amplifiers, applications.

(2) Joint with Commission III. The aurora, radar observations.

(3) Joint with Commission VI. Antennas and data processing.

(4) Commission V only. Solar phenomena and their physical interpretation.

(5) Commission V only. Planets and meteors.

(6) Commission V only. Galactic emission and its physical interpretation.

(7) Commission V only. Discrete sources and their physical interpretation.

It is now necessary that speakers should be invited as soon as possible to prepare the introductory papers for opening these various sessions, and I would be glad to receive from you your views as to whom should be invited to present these papers on the subjects enumerated above. According to the new by-laws of U.R.S.I. the only papers which may be reproduced for the Assembly are those which have been invited by International Chairmen or by the Board of U.R.S.I. The people selected to give these introductory talks must, therefore, be prepared to produce their papers in time for them to be reproduced before the meeting of the Assembly.

After the introductory papers the session will take the form of short discussions, but no papers relevant to these discussions will be reproduced. Apart from the fact that none of the discussion papers will be reproduced, it seems to me that the new arrangements are close to those which we have followed in Commission V during the previous Assemblies. In order to facilitate the smooth working of the sessions, I would be grateful if you could let me have your preliminary suggestions of individuals who will take part in these discussions and the time required. The most urgent matter, however, is a decision on the opening speaker and I would be grateful for your views on this as soon as possible.

Yours sincerely,

(*sgd*) A. C. B. Lowell,

Jodrell Bank Experimental Station,
Lower Withington,
Macclesfield, Cheshire.

7th September, 1959

NATIONAL COMMITTEES

U. S. A.

RESOLUTION

The following resolution was passed by the U. S. A. National Committee at its fall meeting in San Diego, California, on October 19 : « The U. S. A. National Committee of the U.R.S.I. aknowledges with thanks the receipt of the U.R.S.I. publication « Ionospheric Stations Manual » edited by E. Herbays, W. J. G. Beynon, and G. M. Brown, and compliments the editors on their completion of a very useful source document which with the supplements that are planned will aid scientific work in Ionospheric Radio Propagation for many years. »

COMMISSIONS

Commission I.
On Radio Measurements and Standards

COLLABORATION WITH C.C.I.R.

(See pp. 44).

SYMPOSIUM

Attention of the Members of Commission I is drawn to the Proceedings of the Symposium of the International Astronomical Union on the Rotation of the Earth and Atomic Time Standards (p. 42).

Commission II. — On Radio and Troposphere

BIBLIOGRAPHY

Attention is drawn to the following publications issued by the Loyola University, New Orleans, Lo, U. S. A.

GHERZI, Fr. E., KELLER, J. F. — The electricity of the air as weather factor.

GHERZI, Fr. E. — Meteorological Notes.

Commission III. — On Ionospheric Radio

BIBLIOGRAPHY

The following Reports have been issued by the National Bureau of Standards - Boulder Laboratories :

Analysis of ionospheric vertical soundings for electron density profile data

I. Facilities for convenient manual reduction of ionograms, J. W. Wright and R. B. Norton (n° 14).

II. Extrapolation of observed electron density profiles above h_{max} F2, J. W. Wright (n° 19).

Commission V. — On Radio Astronomy

SYMPOSIUM ON RADIO ASTRONOMY

Paris, August 1958

The proceedings of this symposium have been published by the Stanford University Press (Stanford, California, U. S. A.) under the title « Paris Symposium on Radio Astronomy ». The volume, of 624 pages, contains 106 original contributions and a complete account of the discussions at the symposium (336 items).

The published price is $ 15.

Members of the Union may obtain copies at reduced price of $ 9, together with the following charge to cover; the cost of packing and postage : in U. S. A. $ 0.45, outside the U. S. A. $ 0.60.

The price for contributors to the volume is $ 4.50 with the same charge for packing and postage as for members of the Union.

Application for copies by members of the Union, and by contributors, should be made on the enclosed form to the Secretary General of U.R.S.I. and must include the appropriate remittance.

Persons not entitled to a reduced price should order through a bookseller and not from either the Stanford University Press or the U.R.S.I. General Secretary.

Commission VI. — On Radio Waves and Circuits

COLLABORATION WITH C.C.I.R.

(See pp. 48).

CENTRAL COMMITTEE ON URSIGRAMS AND I. W. D. S. STEERING COMMITTEE

Resolutions

(Brussels, September 4th, 1959)

At this meeting, the following Resolutions were adopted :

Resolution 1

(*a*) The I.W.D.S. Steering Committee invites the C.R.P.L. to undertake the compilation of the 1959 Calendar Record, with the cooperation as needed of other participating agencies in the Unions.

(*b*) Mr. A. H. Shapley and the Secretary General of U.R.S.I. are invited to take the necessary steps to undertake the publication of the Calendar Record, under I.W.D.S. auspices, either as an U.R.S.I. Monograph, or any other way after consultation with the constituting Unions.

Resolution 2

(*a*) The I.W.D.S. Steering Committee agrees with the draft Geophysical Calendar for 1960, subject to confirmation on technical points from the Adviser for Meteors, and to the information from the S.C.G. Reporter for Meteorology on World Meteorological Intervals, and possibly from the President of C.O.S.P.A.R. for an International Rocket Week. Mr. A. H. Shapley is invited and agrees to undertake such consultations. The final Calendar for 1960 is given in Appendix 3.

(*b*) The Geophysical Calendar for 1960 should be printed in large quantities by the U.R.S.I. Secretariat. The Calendar should be sent directly to the I.G.Y.-I.G.C. participating Committees in liberal quantities, roughly twice the number of I.G.Y. stations, and to National Committees of the three constituting Unions

(U.R.S.I., I.A.U., I.U.G.G.), in each case enclosing a reply form for additional copies.

(*c*) Copies of the Calendar should be sent to the Editors of the principal journals on the fields of the participating Unions, with a request that it be published therein.

Resolution 3

The I.W.D.S. Steering Committee invites the C.R.P.L. to continue to maintain the World Warning Agency for 1959 and onwards, to serve in a similar manner as it did during I.G.Y.

Resolution 4

The I.W.D.S. Steering Committee requests the World Warning Agency to perform the active coordination of the plan for Alerts and Special World Intervals, taking into account the comments which may be received from regional centres and other participants. The World Warning Agency is requested to report on the operation of the plan at approximately yearly intervals to the I.W.D.S. Steering Committee.

Resolution 5

(*a*) The C.C.U. requests the assistance of U.R.S.I., if possible with financial help, in order to organize in connection with the General Assembly in 1960 a meeting of the representatives of Regional groups, thoroughly familiar with the details of the Ursigram system, to discuss the details of codes, to advice the C.C.U. on these matters and to aid in the homogeneity and simplification of the Ursigram system.

(*b*) The C.C.U. resolves to invite Mr. A. H. Shapley to draft a comprehensive report to submit to the above meeting and meanwhile, to take the provisional decisions on such matters of detail until the above meeting, after consultation with the other members of C.C.U. in due time for reply.

Resolution 6

The C.C.U. confirms Resolution 20 reached at its last meeting (Brussels, May 6-7, 1959) and adds that special airmail reports should also be used for information that requires more detailed description that can be expressed in telegrams.

Resolution 7

The C.C.U. calls attention to the scientific and practical need for a modest amount of rapid data exchange by telegrams in the world, and urges authorities in countries participating in Ursigram work to make available to their organisations sufficient funds so that a minimum telegraphic data programme can be accomplished.

Resolution 8

The C.C.U. endorses the following list of countries proposed to constitute the Western Pacific Ursigram Network :

Australia	Japan
Burma	Philippines
Formosa	Viet Nam
Indonesia	

Notes : (*a*) India, New Zealand, Hong Kong and Manila are suggested additions to this list.

(*b*) It is suggested also that data of Guam, Hollandia, Okinawa, be collected also in the Western Pacific Network.

INTER-UNION COMMITTEE ON RADIO-METEOROLOGY

We have the pleasure to announce that U.R.S.I. and I.U.G.G. concluded an agreement on the continuation of the Mixed Commission on Radio Meteorology, as follows :

1. The International Union of Geodesy and Geophysics (I.U.G.G.) and the International Scientific Radio Union (U.R.S.I.) agree to constitute an Inter-Union Committee on Radio Meteorology as a successor to the former Joint Commission on Radio Meteorology. The aims of this Committee will be :

(*a*) to further the study of these aspects of meteorology which affect radio propagation,

(*b*) to further the application of radio techniques to meteorology.

2. U.R.S.I. act as Parent Union for this Committee.

3. The membership of the Committee shall consist of twelve members, six being appointed by I.U.G.G. and six by U.R.S.I. The appointments by each Union shall be reviewed at intervals of not more than three years.

4. The Chairman and the Secretary of the Committee shall be elected by the members for a term of three years, on the proviso that both of them do not be representatives of the same Union. The Officers are eligible for immediate re-election, but normally they may not serve more than two consecutive terms.

5. The Committee is empowered to appoint consultants, their number should not exceed six and they should be agreed either by I.U.G.G. or U.R.S.I.

6. The Chairman of the Committee may, on his own authority, invite to the meetings observers from other international scientific agencies.

7. The Committee will meet at least every three years. Each meeting will be organized, by agreement between the Unions

concerned, under the supervision of one of them. Such meeting will be held in close association, but not overlapping in time, with a General Assembly of that Union. The Committee is encouraged to organize symposia at other times, subject to the approval of the financial arrangements by the Parent Union.

8. Resolutions and recommendations adopted by the Committee during its meetings should be communicated to the Secretaries General of I.U.G.G. and U.R.S.I. for endorsment by the Association of Meteorology and Atmospheric Physics of I.U.G.G. and by Commission II of U.R.S.I. on Radio and Troposphere, before any final action be taken.

9. At least two months in advance; the Secretary should circulate agenda and other relevant papers. After each meeting, he should send a summary report to the Secretaries General of the two Unions.

10. Publication of the proceedings of the meetings and symposia will be arranged as necessary by mutual agreement between the Secretaries General of the two Unions.

11. The two Unions will provide each a yearly contribution of $ 150 to support the expenses of the Committee. The fund thus constituted will cover :

(i) the secretarial expenses of the Committee,

(ii) the travelling expenses (partly or totally) of the Chairman and of the Secretary for meetings of the Committee,

(iii) partly the travelling expenses of the members attending meetings of the Committee. Any other travelling expenses should be covered by the respective Unions or by any other sources.

12. The Committee should submit to the Parent Union estimates of the costs of symposia. The Parent Union through arrangements with I.U.G.G. and other agencies, will assume responsibilities for financial support of meetings and symposia in accordance with budget approval by its Board of Officers.

13. The Secretary of the Committee will communicate an annual statement of income and expenditure on behalf of the Committee to the Secretary General of I.U.G.G.

14. At its first session the Committee will define its terms of reference and draft a programme of action for further endorsment by the relevant bodies of I.U.G.G. and U.R.S.I.

15. Any dispute within the Committee will be settled by a meeting of the Presidents of the two Unions. Arbitration, if necessary, will be provided by I.C.S.U.

INSTRUCTIONS FOR THE PUBLICATION OF U. R. S. I. MONOGRAPHS

Preliminary remark

To meet previous recommendations made by the Publication Committee, endorsed by the Executive Committee and approved by the General Assembly, the Board of Officers, meeting in Brussels on July 1st, 1959, decided to issue a series of scientific publications in the form of *U.R.S.I. Monographs*. In order to ensure an extensive availability, the Monographs will be published by a commercial publishing firm.

The Instructions for the Publication of U.R.S.I. Monographs drafted by the Secretary General after consultation of the Board of Officers are as follows :

Instructions

1. U.R.S.I. Monographs may include the following materials :

(i) Proceedings of Symposia organized by U.R.S.I. ;

(ii) Proceedings of Scientific Meetings held by U.R.S.I. Commissions or Committees ;

(iii) Special Reports on specific topics of general interest ;

(iv) Any other scientific materials of wide interest, connected with U.R.S.I. activities.

2. The Editorial Board is constituted by the Board of Officers of U.R.S.I., delegation for routine affairs being given to the Secretary General who will act as U.R.S.I. Editor.

3. Any Commission or Committee intending to publish a Monograph should appoint, in agreement with the Secretary General of U.R.S.I., a *Scientific Editor* who will collect the material, draft the necessary texts, arrange the manuscript and forward it to the Secretary General of U.R.S.I. for publication.

4. The above rule is valid for Organizing Committees for Symposia and Scientific Meetings and for Special Report Drafting Committees.

5. Monographs will be published in one of the official languages of U.R.S.I. (English or French) with, when suitable, short summaries in the other language.

6. Only original papers should be included in the Monographs.

7. The following rules should be used for the presentation of manuscript :

(i) Two copies of the manuscript should be sent to the Secretary General of U.R.S.I. Such copies should be typewritten with *double spacing* and carefully revised by their authors so that they may be printed without further revision.

(ii) The *symbols* used should be clearly explained and in accordance with standard scientific usage.

(iii) *Citations to literature.* Whatever system is employed, it should be carried out uniformly throughout the entire manuscript. The following system is preferred by the publisher :

to periodicals : T. Kuwana and R. N. Adams, *Anal. Rad. Acta*, 20 (1959), 51. (Author - comma - periodical abbreviated according to standard rules - comma - volume number - year in brackets - page number - full stop).

to books : B. Jirgensons, Radio Antennas, General Publisher, New York, 1958, p. 656. (Author - comma - title of book - comma, publisher, comma, publisher's residence, comma, year, comma - p. or pp. - page number(s) - full stop).

In alphabetical lists, the initials of the first author should be given after his surname.

Be sure that every reference number in the text has its corresponding quotation in the list of references, and vice versa.

Titles of journals, as far as possible, be abbreviated.

(iv) Drawings, diagrams (line-figures) should contain no text except for brief indications such as Fig. I, etc. The overall dimensions should not be lass than 9 × 12 cm (3″ ½ × 4″ ½) nor exceeding 16 × 25 cm (6″ ½ × 10″).

Glossy sharp photographs should be provided ; no half-tones already printed in a book, journal, etc.

The accompanying text should be submitted on a separate sheet. The place of figures should be clearly indicated in the margin of the text concerned.

(v) In proceedings of Symposia or Meetings only original individual papers referring to the subject of the Symposium or to items on the agenda of the Meeting and whose author is present at the meeting should be accepted.

(vi) Individual papers for such Proceedings should be limited in length to 2000-3000 — exceptionally to 4000 — words and three sheets of illustrations, they should be accompagnied by 100-200 words abstracts (if possible in the official language not used for the original text).

8. Scientific Editors (see 3 or 4) should forward the manuscript of Proceedings or Symposia to the Secretary General of U.R.S.I. not later than six weeks after the closing of the meeting.

9. Proof reading will be made in common agreement between the Scientific Editor and the Secretary General of U.R.S.I.

10. Free distribution of monograph copies will be arranged by the Secretary General of U.R.S.I. in agreement with the Board of Officers or the Chairman of the relevant Commission or Committee, taking into account decisions reached by the General Assembly on this matter.

* * *

The above instructions have been approved by the Board of Officers.

Brussels, August 25th, 1959. *The Secretary General.*

APPENDIX

Abstract of the Agreement with the Publishing Firm

An agreement has been signed with a publishing firm according to which :

1. The publications will only contain papers in English or in French.

2. The publishing firm acquires the sole end exclusive copyright of the publications in all languages throughout the world at the

exception of translation in Russian language. Nevertheless, authors of papers submitted to a meeting or a symposium may publish them in a scientific journal under the following conditions :

(*a*) to ask the authorization to the Secretary General of U.R.S.I.,

(*b*) to mention the U.R.S.I. publication in which the paper has been printed.

3. The authors of papers will not be entitled to receive reprints free of charge. However, reprints can be ordered by them at quoted prices.

4. The publishing firm allows a reduction of 25 % on the selling price of copies ordered at the U.R.S.I. Secretariat.

5. Illustrations, tables and diagrams should be supplied free of any copyright charges. The authors of papers will protect the publishing firm against any claim by a third party in connection with infringement of copyright caused by the publication of manuscripts. The authors should obtain the usual permission to quote passages from books for which a copyright exists.

U. R. S. I. PUBLICATIONS

Ionospheric Stations Manual

It is recalled that the Ionospheric Stations Manual has been issued. It contains data on more than 200 stations carrying out vertical ionospheric soundings, and other observations and measurements of ionospheric phenomena. The Manual is on sale at the General Secretariat of U.R.S.I. at the price of B. F. 800 or $ 16 (B. F. 600 or $ 12 for orders received through National Committees). This price includes postage and supplements.

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(R) after the title of a paper indicates that only a summary has been published ;

(Re) that a summary in English language follows the text ;

(Rf) that a summary in French language follows.

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RESOLUTIONS AND RECOMMENDATIONS

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

I.C.S.U. Review

The attention of the members of U.R.S.I. is called to the publication of the three first numbers of the quarterly *I.C.S.U. Review*, published by Elsevier Publishing Company in Amsterdam (Netherlands) at a price of 8 shillings or $ 1.20 a number, or an annual subscription of 30 shillings or $ 4.50 for four numbers.

INTERNATIONAL ASTRONOMICAL UNION

Symposium on the Rotation of the Earth and Atomic Time Standards

Moscow, August 1958

The Proceedings of this Symposium (I.A.U. n° 11) has been issued in the *Astronomical Journal*, vol. 64, n° 1258, pp. 81-124, April, 1959.

The Symposium was organized by a Committee consisting of G. M. Clemence, E. P. Fedorov, W. Markowitz and P. Melchior under the chairmanship of Professor A. A. Mikhailov.

The following papers were presented :

I. The Motion of the Pole :

- Nutation as derived from latitude observations, E P. Fedorov.
- Nutation and the variation of latitude, Harold Jeffrey.
- Les relations entre les mouvements du pôle et les fluctuations de la vitesse de rotation de la Terre, P. Melchior.

II. The Rotation of the Earth :

- The irregular rotation of the Earth, B. L. van der Waerden.
- Fluctuations and secular changes in the Earth's rotation, Dr. Brouwer.
- Variations périodiques et aléatoires de la rotation de la Terre, N. Stoyko.
- Variation progressive et variation saisonnière de la rotation de la Terre, A. Danyons.
- The influence of systematic errors of star catalogues on the determination of the irregularities of the Earth's rotation, A. A. Nemiro and N. N. Pavlov.

— Variations in rotation of the earth, results obtained with the dualrate Moon camera and photographic zenith tubes, W. M. Markowitz.

— Ephemeris time, G. M. Clemence.

III. Atomic Time Standards :

— Etalons de fréquence, B. Decaux.

— Report on the precision of atomic standards of frequency, L. Essen.

C. C. I. R.

Findings of the IXth Plenary Assembly of C.C.I.R. of interest to U.R.S.I.

COMMISSION I

Besides the documents printed in *Information Bulletin* n^{os} 115 and 116, in which U.R.S.I. is specifically mentioned, the following documents — which although they do not mention U.R.S.I., are of interest to Commission I — may be mentioned.

STUDY PROGRAMME Nº 155 (VII) (1)

Standard-frequency transmissions and time signals

(Geneva, 1951 ; London 1953 ; Warsaw, 1956 ; Los Angeles, 1959)

The C.C.I.R.,

considering :

(*a*) that Question Nº 140 (VII) and Recommendation Nº 319 call for information on methods for improving the usefulness of the existing standard-frequency transmission and time-signal service ;

(*b*) that standard-frequency stations are operated simultaneously on the same carrier frequency ;

(*c*) that standard frequency transmissions are also used as a means of measuring radio propagation characteristics ;

unanimously decides that the following studies should be carried out :

1. an investigation of the possibilities of reducing mutual interference between transmissions in this service by :

1.1. shortening the programme of tone modulation and of announcements ;

(1) This Study Programme, which replaces Study Programme Nº 101, arises from Question Nº 140 (VII).

1.2. use of modulation which gives the required information and accuracy in minimum bandwidth ;

1.3. staggering the transmissions in the allocated bands and using a convenient type of modulation ; a suggested staggering of frequencies is as follows :

Sub-bands (kc/s)			
—	4,996— 5,000	5,000— 5,004	—
—	9,996—10,000	10,000—10,004	—
14,992—14,996	14,996—15,000	15,000—15,004	15,004—15,008
—	19,996—20,000	20,000—20,004	20,004—20,008
24,992—24,996	24,996—25,000	25,000—25,004	25,004—25,008

Note. — In each sub-band, the carrier frequency should be on the lower side.

1.4. a convenient world-wide coordinated time sharing of frequencies on which there is mutual interference depending on the staggering of frequencies ;

2. an investigation, with the assistance of Study Group VI, into the desirability of staggering the frequencies for radio propagation studies ;

3. collection of information on how standard-frequency broadcasts in bands 6 and 7 may be coordinated with broadcasts in other bands to give the best overall world-wide service.

Study Programme N° 156 (VII) (1)

Frequency spectrum conservation for high precision time signals

(Los Angeles, 1959)

The C.C.I.R.,

considering :

(*a*) that higher precision in the radio distribution of time signals necessitates, using present techniques, the use of an increased bandwidth ;

(1) This Study Programme arises from Question N° 186 (VII).

(*b*) that newly developed techniques may nevertheless effect a considerable bandwidth economy ;

unanimously decides that the following studies should be carried out :

1. an investigation of the relationships between bandwidths required, and precisions obtainable at present for various carrier-to-noise ratios as may be encountered in practice ;

2. an investigation of narrow band techniques to generate and broadcast high precision time markers ;

3. an investigation of the characteristics of the radio paths involved that limit the accuracy of time signals as received, and how these radio path parameters affect the choice of an optimum method.

Recommendation N° 320 (1)

Standard-frequency-transmissions and time signals in additional frequency bands

(Question N° 142 (VII))

(Los Angeles, 1959)

The C.C.I.R.,

considering :

(*a*) that Recommendation N° 319 refers only to the transmissions of standard-frequency and time signals allocated by the Radio Regulations, Atlantic City 1947, centered on the frequencies 2.5, 5, 10, 15, 20 and 25 Mc/s ;

(*b*) that propagation characteristics, interference and noise degrade considerably the short term accuracy obtainable in these frequency bands ;

(*c*) that in communications, research and industry, there is an increasing need for high accuracy of frequency and time measurements in a short period of time ;

(*f*) that measurements on controlled stations in Band 4 have demonstrated that a precision of frequency comparison of 1 part in 10^{-10} can be achieved in a period of a few hours during daylight at a range of 5000 km, [1] at great ranges the precision decreases' but is till much greater than that obtainable in Bands 6 and 7;

(*e*) that, therefore, the possibility exists of achieving a world-wide frequency reference of high precision in Band 4 between 15 and 25 kc/s by means of a single station or at most two or three transmitters operating on different frequencies;

(*f*) that it may be possible by specialized techniques to provide a highly precise world-wide time reference by emissions in Band 4;

(*g*) that studies employing highly stabilized transmissions in Band 4 provide valuable information regarding ionospheric and propagation conditions which is useful in scientific studies and in the design of long range navigation systems;

unanimously recommends :

1. that as many stations as possible already in operation in Band 4 should be controlled with sufficient stability to permit an extension of present measurements of path phase stability;

2. that phase measurements in Band 4 at great distances, for example near the antipodal points, be continued and refined to yield further information on the behaviour of such standard-frequency transmissions at extreme distances;

3. that the techniques for transmission and reception of standard-frequency and time signals in Band 4 be investigated with a view of avoiding interference in the distribution of such a service;

4. that a band of 100 c/s in the neighbourhood of 20 kc/s (15 to 25 kc/s) would appear to be a suitable channel for an effective standard-frequency and time signals service;

5. that appropriate existing stations in Bands 5 and 6 be employed as much as possible for distribution of standard-frequency by precisely controlling their carrier frequency;

6. that existing broadcasting stations in Band 8, such as FM and television, be employed as much as possible for distribution of standard-frequency and time signals which can be added to the existing present modulation, without interference to the normal programme;

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[1] See Annex II to Report N° 166 « Observations of a standard frequency service on 16 kc/s ».

7. that any administration contemplating transmissions in accordance with the above proposals should first communicate the details to the Chairman and Vice-Chairman of Study Group VII.

COMMISSION VI

At the request of Study Group nº 1 of the C.C.I.R. Report nº 96. — which is published below — is brought to the attention of Commission VI. This report has been approved, without opposition, by the Administrations participating in the IXth Plenary Assembly of the C.C.I.R. in Los Angeles.

C.C.I.R. Study Group nº 1 considering that the theoretical and practical possibilities to reduce interference in radiocommunications are of major importance for the C.C.I.R., asks the help of U.R.S.I. for the continuation of such investigation.

The Study Group also suggests that such assistance should, for example, allow :

— to correct and to extend the considerations included in the report on the basis of works already published ;

— to initiate further investigations on the non-solved questions, some of which are mentioned at the end of the report.

Report Nº 96 (1)

Possibilities of reducing interference and of measuring actual traffic spectra

(Questions Nos 1 (I) and 133 (II)

(Warsaw, 1956 ; Los Angeles, 1959)

Summary.

Any actual signal which has passed through a quadripole can be developed as a series of time-staggered functions. The sole function on which the development is based is the impulse response of the quadripole, representing the shortest elementary signal which can appear at the output of the quadripole. This development helps to show some of the important properties of actual

(1) This report replaces Report Nº 38.

signal spectra useful in the study of interference and the measurement of spectra with analysers :

(*a*) Interference can never be zero, for the spectrum of any actual signal cannot be zero in any frequency interval ; it can be zero only on discrete frequencies.

(*b*) If the receiver subject to interference can be assimilated to a substantially rectangular pass-band quadripole and it is tuned far enough away from the centre of the spectrum, and if the consecutive signal amplitudes are independent and not correlated, the interference merely adds additional noise to the inherent receiver thermal noise.

(*c*) If the actual signal fulfills the above conditions, its spectrum can also be determined by means of an analyser, and reproducible stable results can be obtained if the analyser is followed by a quadratic integrator.

(*d*) If the signal does not fulfill these conditions, the measurements will be unstable, as regards both individual measurements made with the same analyser and measurements made with different analysers.

On the other hand, constant and reproducible results are possible, for instance, in telegraphy, if the actual signal is replaced by a periodic signal, and in telephony if the transmitter is modulated with white noise. One then obtains in the first case a time spectrum whose envelope is the spectrum of the elementary signal and in the second case a spectrum identical to that of the elementary signal.

(*e*) The problem of reducing interference, which is at a first approximation the problem of reducing out-of-band radiation, reduces to the problem of finding the best elementary signal in this respect.

A first solution, suggested by Shannon's theories, is to give the signal an approximately Gaussian statistical distribution. Speech approaches this condition fairly closely and can therefore easily be filtered, thus introducing little interference outside a certain band. In telegraphy the only way of forming a similar signal is to use many different combinations of elementary signals of different amplitudes.

Gabor, after choosing a particular definition for signal duration and bandwidth showed that the best elementary signal in those respects was a signal having the shape of a Gaussian curve. Such a shape can be approached as closely as required by using multiple-section filters whether with a very simple iterative filter section or non-iterative sections, although a large number of sections introduces a signal delay which is the only parameter limiting the practical application of the method. Nevertheless, delays of not more than one word of medium length should be very helpful in reducing out-of-band radiation. Delay is apparently inevitable whenever endeavours are made to compress frequencies or to reduce out-of-band radiation.

Many other signal shapes have been proposed but are either less effective or not practically feasible.

Yet the problem of interference can be tackled only by also taking into account the exact nature of the signal and the receiver properties. Total permissible signal distortion is the distortion introduced by the receiver and transmitter considered together. Villepelet showed that if a given frequency band was occupied by radiocommunications of the same kind, the best way of solving the interference problem was to allocate one-half of the quadripole representing the system to the transmitter and one-half to the receiver, the receiver and transmitter thus becoming equally selective. Contrary to what might be thought, this principle could actually be applied in a fairly large number of cases though it is not followed as a general rule, receivers being nearly always more selective than transmitters.

The theory for circuits having different natures and working on adjacent channels is much more difficult to study and no solution is known, but the problem might be tackled experimentally.

Finally, the receiver might be adapted to the interference so that it should not only be able to receive the wanted signal but also should be highly insensitive to some kinds of interference. Little work has been done along these lines so far, but a general method of studying the problem has been proposed.

1. — *Introduction. Possible ways of examining interference problems.*

The number of radio channels which can be used in a given frequency band depends essentially on the spacing required between adjacent channels. Leaving aside various phenomena and circumstances such as field fluctuations, which necessitate an increase in spacing, the minimum spacing is determined by the interference produced by each channel in neighbouring channels. If the bandwidth occupied by the emissions, and consequently the out-of-band powers as defined in Recommendation N° 145 were known, it would then be possible to determine roughly the minimum necessary spacing between two frequency assignments. But, without knowledge of additional data, such as the rate of decrease of the energy outside the band limits, the power definition of the occupied bandwidth is not sufficient for the purpose of determining channel spacing.

It is hence necessary to deal with the interference problem in a more direct and precise manner ; the first problem to be solved is the reduction of the energy of a given emission outside a certain band, and the next is the increase in the slope of the spectrum outside its central part.

Even this does not suffice, for interference cannot be entirely determined by power consideration. It is closely connected with the exact nature of the interfering emission, as well as with the nature of the emission suffering from interference and the characteristics of the receiver. When the problem is thus stated in its entirety, it is very complex and is not generally possible to take all the factors fully into account. Hence it is necessary to use simple and fairly general examples on the basis of which it is possible to reach approximate conclusions and indicate improved procedures with reasonable confidence, after comparing the upper interference limits in the various cases.

In general, interference is produced by emissions transmitting actual information which is not known beforehand. Correct methods of representing emissions in the study of these problems should, therefore, enable the signals transmitted to be represented as random quantities.

Analysis of the properties of real signals is made easier if they are represented as series of functions. The use of functions staggered in time is especially useful for showing the random nature of the signals and dealing at the same time with filtering and interference problems.

For all classes of emissions, except those using frequency modulation, a simple relation can thus be established between the output radio signal and the input modulating signal. Consequently, the following considerations and results are not, in general, applicable to frequency modulation.

If the signal to be transmitted consists (as in telegraphy, for example) of a series of discrete voltages, breakdown into a series of functions staggered in time is quite natural. The emission is then fully determined when :

(*a*) an elementary signal, which usually takes the form of a pulse modulating a carrier wave, has been defined ;

(*b*) one of the parameters of the elementary signal (amplitude, frequency, duration, etc.) has been provided with a coefficient which is proportional to the discrete, random voltages of the original signal.

Another case (telephony provides the simplest example) when the signal is defined by a continuous time function, and here the same procedure may be used, by varying one of the parameters connected with the elementary signal as a function of the continuous parameter defining the signal.

Various forms of signal breakdown are indicated below : the first one, which uses elementary signals that are all identical but are staggered in time and provided with a coefficient of proportionality is useful for the discussion of problems in which only energy is involved and which are entirely determined by the form of the spectrum of the overall signal, usually representing an entire message.

Another breakdown, with elementary signals staggered both in time and frequency, will be mentioned for it will allow a more precise analysis of the interference problem, taking into account the exact nature of the transmitting and receiving systems.

2. — *Breakdown of the signal by means of elementary signals staggered in time. Spectrum properties and measurement possibilities.*

It was mentioned above that representation of the signal should show the random form of the signal.

However, it is easier to measure the spectrum during transmission of an elementary signal or a periodic signal made up of a regular succession of elementary signals. These simple signal shapes are very convenient for calculation and permit a fairly easy assessment of their effect on a circuit idealising the receiver subject to interference. The theoretical problems of interference will thus be simplified if a relation can be found between the spectra of random signals and the spectra of simple signals coming from the same transmitter.

Such a relation can easily be found if the actual signal can be represented by a series of functions with constant coefficients, successive functions being obtained by time-staggering a single function representing an elementary signal. To obtain such a signal in practice, the minimum requirement is that the corresponding function should always be zero before a given moment which is the beginning of the transmission. For example, the theoretical original elementary signal could be a narrow rectangular pulse, the successive switching times being separated by intervals equal to the pulse width. The signal is then represented by a series of functions, the coefficients of which are equal to its mean value during each elementary interval.

By reducing the width of the pulse, any actual continuous signal can be represented with a root-mean-square error as small as desired. For this it is sufficient for the integral of the square of the derivative of the signal to be bounded ; now, in physical terms, this means that the signal must represent a finite quantity of information. Some authors have in fact used this integral of the square of the derivative of the signal to measure the amount of detail contained in a real signal particularly in television (1).

It will immediately be seen that the Fourier transform or « amplitude spectrum » of a signal expanded in this way is the product of two spectrum functions.

The first function represents the spectrum of the elementary signal ; this spectrum does not depend on the information contained in the signal.

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(1) This measurement is naturally different from the measurements based on probabilities of the amount of information which can be defined, after Shannon, by using, for instance, the binary unit. It is logical only with certain types of continuous signals, especially, the usual type of television signal. Shannon has shown (4, para. 29) how the r. m. s. error limits the capacity of a source for transmitting information.

The second function might be called the switching spectrum; it depends on the switching instants and on coefficients which themselves contain all the information. In complex terms, this spectrum function is equal to the sum of the vectors whose length is equal to the coefficients and whose phase is proportional to the frequency and the times of switching.

Such an analysis of the signal presents a certain general character in spite of the special form of the rectangular pulses which have been used. If the spectrum is represented as a product of functions it can be seen that transformation of the signal by a linear quadripole is equivalent to transformation of the elementary pulse only. At the quadripole's output, the transformed signal spectrum is still represented by the product of two functions. The switching spectrum is the same (and hence so are the coefficients of the series of functions representing the transformed signal); the elementary signal spectrum is replaced by the spectrum of this pulse transformed in the quadripole. At the limit, when the pulse width is reduced indefinitely, the transformed pulse tends towards the impulse response of the quadripole. Any signal transformed by a quadripole can, therefore, be expanded as a series of staggered functions, the original function being the impulse response of the same quadripole.

If the signal is received by an apparatus (e. g., the receiver of the correspondent, or the receiver subject to interference, or a spectrum analyser) which integrates the signal during a certain time, the output voltage of this apparatus, at a given frequency, depends on the sum of the corresponding vectors the number of which increases with the integration time. The phases of these vectors, however, are uniformly distributed around the phase circle and under certain conditions their amplitudes, equal to the mean values of the signal during the sampling intervals, are statistically independent, each one being small, with respect to the overall amplitude. It is well known that in this case, particularly according to the theorems of Liapunov and Paul Levy (1), the statistical distribution of the amplitude of the resultant vector tends towards the Rayleigh law, whereas the instantaneous value of the corresponding overall voltage (projection of the vector on to any fixed axis) has a statistical distribution which tends to become Gaussian when the integration time increases indefinitely. This is valid for any random signals, such as those occurring in telephony, or television, the amplitude of which is always bounded.

It is known that continuous signals in practice do not have statistically independent values at instants very near to each other ; however, these values become more and more independent as the instants become more distant one from the other. The condition for independence, therefore, means that the chosen sampling instants are sufficiently separated to ensure that the values corresponding to any two successive instants are practically independent, and hence capable of representing entirely different information.

In the case of telegraphy of the usual type, the position is particularly simple. The elementary signal can be the usual unit signal of the telegraphists, the finite duration of which is that of one code unit and the amplitude coefficients are all equal to 0 or 1 with, as a first approximation, an equal probability for these two values at the sampling instants. The problem is then reduced to that of the random walk which was originally studied by Lord Rayleigh. The statistical distribution of the total amplitude and the total instantaneous value still tend towards Rayleigh and Gaussian distributions respectively, which are approached, with a fair degree of approximation for practical purposes, if a fairly small number of components are added.

The effect of the signal on receivers of fairly small bandwidth which integrate the amplitudes or the powers, can be easily assessed when the spectrum of the elementary signal and also the first (in the case of a linear integrator) or the second (in the case of a quadratic integrator) moment of the statistical distribution of the amplitudes are known. These moments show the mean amplitude and the mean power of the signal respectively.

It may be pointed out that receivers with a narrow bandwidth have a large time constant and are thus naturally linear or quadratic integrators. However, practical calculations show that the most selective ordinary receivers and even the most accurate spectrum analysers still have too wide a bandwidth and consequently a time constant that is too small to ensure a good approximation to the moments of the statistical distribution ; their output voltage is always fluctuating, in the presence of a random signal, if they are not followed by an indicator with a very high degree of inertia, preferably a quadratic integrator.

However, the switching spectrum is a periodic function of the frequency without a constant term when the switching times are uniformly spaced ; the result is that the spectrum has the shape of the elementary pulse spectrum, multiplied by a periodic function which depends mainly on the information transmitted. Considering the part of the spectrum falling within the (not too narrow) passband of a receiver subject to interference, the average level of the voltage induced in this receiver thus depends primarily on the shape of the elementary pulse spectrum, whatever the time during which the whole receiving system integrates the voltage or the power.

If, instead of considering the Fourier transform of the signal (or amplitude spectrum) we consider the usual spectrum of the physicists, which is a power spectrum, it is possible to specify the preceding properties a little better. It is known that this spectrum is the Fourier transform of the signal's correlation function. If this signal is represented, as before, by a series of staggered functions, it is found that the spectrum is also the product of two spectrum functions. The first is the (power) spectrum of the elementary signal, and the second the Fourier transform of the original signal's correlation function. This second spectrum function is reduced to a constant if the correlation function is periodically cancelled out, the period being equal to the time separating two consecutive switching instants. In this case the signal is said to be uncorrelated with the switching or sampling instants (which alone are of interest to us). The spectrum is then identical with that of the elementary signal, apart from a constant coefficient which represents the mean power of the overall signal. The problems of determining interference and measuring the spectrum with a spectrum analyser are then very simple ; a quadratic integrator at the output immediately gives the power in the analysed part of the spectrum. With regard to those parts of the spectrum which are fairly distant from the central frequency, where the spectrum of the elementary signal generally varies fairly slowly with frequency, and if the receiver subject to interference or the analyser has a passband which without too much error, may be treated as a relatively narrow rectangular filter they isolate within the spectrum a portion having a constant level throughout their bands, with zero level outside. If then the original signal is not only uncorrelated, but takes independent values at the sampling instants, the signal leaving the analyser, or acting on the terminal apparatus of the receiver subject to interference, is a « white » Gaussian signal, which can be compared in every respect with thermal noise ((3) Chapter XIII, page 513). The sole effect of the interference is then to increase the noise level at the output of the receiver subject to interference. With equal power in a given band, this is the most damaging form of interference i. e. it causes the greatest loss of capacity in the channel under consideration.

If, therefore, we wish to measure easily and rapidly the spectrum emitted by a transmitter which is designed to send out continous signals (a radiotelephone transmitter, for example), it suffices to apply a thermal noise of suitable power to it, instead of its normal signal. This method, which is indicated in Recommendation N° 145 (para. 2.4.) as elsewhere, is the simplest in theory.

If, on the other hand, the signal is correlated, a term depending on the frequency is added to the preceding constant which represents the mean signal power. If, as before, we assume that the receiver subject to interference or the spectrum analyser has a fairly narrow passband, and is tuned at some distance from the central part of the spectrum. it is reasonable to examine especially the effect of the second spectrum function on such apparatus. This effect is represented by a doubly periodic function : it varies periodically when the tuning frequency departs from the central frequency of the signal; it also varies periodically when the bandwidth of the receiver or the analyser varies. Hence, if the signal is correlated, the amount of interference experienced by a receiver and the information provided by a spectrum analyser depend in a complicated way not only on the statistical properties of the signal, but on the characteristics of such apparatus, particularly on the bandwidth ; the analysis cannot be followed through to its conclusion unless all the corresponding data are known.

What is always important, however, is the independence of the two spectrum functions, as well as the essential consequence : the spectrum of any signal decreases as the spectrum of the elementary signal defined by the quadripole through which the signal flows.

In the case of a correlated signal, the collected power simply becomes proportional to the bandwidth of the analyser filter only if this bandwidth is very narrow (with respect to the reciprocal of the sampling interval). But with a narrow filter it is necessary to reduce the sweep speed, and even to abandon an automatic sweep, if it is wished to obtain results with a fair degree of approximation from the measurements. With a manual-sweep analyser, the total measurement of the spectrum takes so long that measurements of the different parts of the spectrum are mutually incoherent, even if the analyser is followed by an integrator with a long time constant. This incoherence disappears only if the measurements are carried out by applying periodic signals to the transmitter.

For telegraphy, this method always seems preferable owing to the simple relationships which exist between the spectra of the periodic signals, the spectrum of the elementary signal and the mean spectrum of the random signals emitted by the same system.

Marique has made a fairly rigorous study of the effect of non-periodic telegraph signals on spectrum analysers (2).

Let us end these considerations with a mathematical note which has important practical consequences. The spectrum of an actual signal is represented by an integerfunction, if (as is always the case in practice), the signal has traversed a passive quadripole. This is because an actual signal is null before the finite instant at which the message begins, is always bounded and after passage through the passive quadripole falls off exponentially towards zero from the moment the message ends.

Hence, whatever real signal is transmitted, we must always consider a spectrum represented by an integerfunction, that is to say, extending to infinity and cancelling out only at distinct frequencies (which may be an enumerable infinity) but never in a frequency interval, no matter how small it may be.

The rest will perhaps be clearer if we sum up the conclusions we can draw from the above :

(*a*) The problem of interference will always exist. Since the spectrum of an actual signal cannot be zero in any frequency interval, any receiver tuned close to the carrier of any actual emission receives energy therefrom. If the frequency difference is large enough, this energy may be small, and sometimes negligible, but it can never be zero.

(*b*) The effect of interference on a receiver cannot be assessed if we know merely the energy received from the interfering station. It will depend on the nature of the signal transmitted and on the kind of receiver.

Only in one case is the effect of the interfering station very simple : when the receiver passband can be assimilated to a rectangular band, and is tuned reasonably far away from the centre of the interfering spectrum. If, in addition, the interfering signal can be represented by successive uncorrelated, independent amplitudes, the interference will be assimilable to thermal noise. It will merely increase the inherent channel noise, but, for equal power, it will have the maximum effect on the loss of capacity of the channel.

(*c*) If the signals transmitted can be regarded as represented by a series of uncorrelated amplitudes statistically independent of each other, it is possible to measure the spectra of the random signals and to obtain stable results, readily comparable with those obtained by measuring the spectrum of an elementary signal or of the periodic elementary signals applied to the same transmitting system, provided that the indicator of the spectrum analyser is followed by a linear, or preferably, by a quadratic integrator.

(*d*) On the other hand, if the successive amplitudes of the random signal are correlated, its spectrum oscillates around the spectrum of the elementary signal and cannot show any stability, whether the same spectrum analyser is used for successive measurements or a different analyser is used. The oscillations have a complicated relationship with the bandwidth and filter characteristics of the analyser, unless the bandwidth is extremely small. In this case, the overall time of measurement may be far too long for the whole to remain coherent and reproducible. It is then preferable to replace such a signal for measurement purposes either by a white noise modulating the transmitter (which is possible with a radiotelephone transmitter) or by a periodic signal (which is generally possible for radio telegraph transmitters). Laboratory measurement of radiotelegraph spectra is often effected by means of periodic elementary signals ; this provides isolated points of the spectrum of the single pulse, which is the envelope of the line spectrum of the periodic pulses.

(*e*) The problem of reducing interference or out-of-band radiation is reduced to the problem of finding the elementary signal which, transmitted by the same system, would produce minimum interference.

In telegraphy of the usual type, the elementary signal to be considered is identical with the unit signal of the telegraphists, the length of which is practically that of a unit interval.

In systems transmitting a continuous signal, like telephony or television, the elementary signal is the shortest isolated signal that the system can transmit; it is the output signal obtained when a very short rectangular pulse is applied to the input.

In pulse systems, the elementary signal is the basic pulse.

In systems using frequency modulation, in which the transmitters by their very nature cannot be linear, the elementary signal to be used for sampling the signal transmitted is much more difficult to define and cannot bear a simple relation to a corresponding input signal. The considerations described above and below can, therefore, be applied only with difficulty to such systems.

3. — *Reduction of out-of-band radiation.*

If nothing is known about the characteristics of the receiver suffering from interference, or if the person transmitting is unfamiliar with the system used by the circuit experiencing interference, the only action which the transmitting station can take to lessen the interference is to reduce the power transmitted outside a given frequency band. We have seen, however, that, whatever signal is transmitted, the power spectrum oscillates around the spectrum of the elementary signal. The solution of the interference problem in this case lies in the reduction of the power transmitted by the elementary signal beyond a given band. But before examining methods of reducing interference which depend upon the shape of the elementary signal, some light may be thrown on this problem by a study of the consequences of Shannon's theory of channel capacity (4, 5).

It is well known that the fullest demonstration of the Hartley-Shannon theorem on the capacity of a channel in the presence of noise makes use of an expansion of the signal with the help of a staggered elementary function of the type mentioned in para. 2

above; but the elementary function used is Whittaker's interpolation function $\frac{\sin \omega t,}{\omega t}$ which does not fulfill the condition set at the beginning of para. 2 for an actual elementary signal : it is not zero in any interval. Any actual signal can be arbitrarily approximated by such an expansion. For a given approximation, the expansion is found to have a uniform spectrum in a certain frequency band, beyond which it is zero. The band is wider as the signal is more closely defined, i. e. reproduced exactly at a larger number of instants.

This is paradoxical, because any signal can be represented in this way, but then it no longer produces any interference outside a certain band. This is because although the signal is correctly represented in the finite time interval when it has been actually transmitted, another arbitrary signal has been added to it outside this interval, and this completely alters the total spectrum. In actual fact, this mode of expansion assumes that the signal was known for infinite time. Under these conditions, it is obviously useless to transmit it over any telecommunication channel and the problem of interference does not arise. The Hartley-Shannon theorem, which is based on such an expansion, is thus only a limit theorem, valid only for indefinitely delayed signals. However, Kolmogorov has recently shown in which way the theory has to be changed to take into account actual signals (6).

But it is very interesting to observe that a signal, expanded in this way with the help of an infinity of elementary Whittaker functions, has statistically a Gaussian distribution under certain conditions which are more or less fulfilled for normal signals. All that is required is that the random function representing the signal should be stationary, that the characteristic function of its distribution should be regular at the origin and that the values of the function at the different sampling instants should be uncorrelated and independent ((3) Chapter XIII, page 513).

By continuity, it can be concluded from the preceding properties that a fairly long actual signal, with a roughly Gaussian statistical distribution, can give a very weak spectrum outside a certain band ; this would represent minimum interference. All that would be required, would be to filter it in a suitable way and it can be deduced from the above that this filtering would be possible without inordinately affecting the signal, but that the reduction of the out-of-band radiation would be achieved only at the cost of a delay of the signal and would be greater as the delay was increased.

A well known practical example is that of the signal directly representing speech. This signal has been studied by many authors who have shown that, for a fairly long period of time and a fairly large number of different voices, its statistical distribution was approximately Gaussian, in this respect approaching white noise, which exactly satisfies the mathematical conditions posed above. The speech spectrum can thus be reduced to a very low amplitude outside a band which is easy to determine, but it cannot be reduced to zero, as a given conversation begins at a finite moment. The reduction of out-of-band radiation can be achieved with the help of a filter without too much deterioration of articulation : the reduction is greater as the number of sections is increased, the increase of this number being the only means available of increasing the asymptotic slope of the filter. The signal delay, which increases with the number of sections, is thus all the greater as the out-of-band radiation is reduced. Some of these latter properties are well known to engineers ; the very general way in which they have been obtained shows that they are independent of any hypothesis on the exact nature of the signal and the circuits used.

Unlike telephone signals, telegraph signals, which are quantised by means of adjacent signal elements, and have only two distinct levels, cannot approximate a Gaussian distribution ; they are also prolific sources of out-of-band interference.

To obtain signals approximating to a Gaussian distribution with amplitude modulation, different amplitudes would have to be used at the different sampling instants ; Shannon's theoretical signal considers amplitudes whose difference at two distinct instants is at least equal to the noise level. The convergence theorems of the sum of random variables towards a Gaussian variable (1) shows how a Gaussian signal can be obtained in this way : the overall signal must be constituted by the sum of a large number of signal elements, all small and occurring at random instants.

If only a limited number of signal elements can be superimposed, occurring at random instants and statistically independent, and if the overall signal is to have a Gaussian distribution, it can be seen, by application of Cramer's theorem, that a signal element represented by the inverse function of the Gaussian distribution function should be employed. Such a signal could not be exactly achieved. The preceding signal, with a large number of combinations, seems to be achievable.

4. — *Reduction of bandwidth.*

This theoretical problem differs at least on the surface from the one above, although it may lead to the solution of the same physical problem. It has been shown above that the problem can be reduced to finding the best elementary signal, without, at least as a first approximation, there being any need to take account of the information transmitted, provided, of course, that the elementary signal permits transmission of such information.

If an attempt is made to find an elementary signal providing maximum power within a given frequency band, as suggested by the definition of occupied bandwidth, the result will obviously be the sinusoidal signal and the Whittaker signal referred to above. These two signals are physically unobtainable and do not meet the conditions stated above for the elementary signal : they have existed for infinite time. Their spectrum is zero outside a certain band whereas we must use signals which are zero before an instant when they begin, subsequently to be prolonged indefinitely and vanish progressively, in accordance with an expotential law. The spectra of these latter signals cannot be zero outside any given band.

Not all elementary signals which satisfy these simple conditions can be acceptable ; in telegraphy, in particular, and in most other cases, we wish to use an elementary signal with a build-up time lower than a given value or a limited practical duration. Such a condition, even if physically accurate for a category of signals of a certain given shape, cannot easily be formulated for a signal whose shape has still to be determined. A similar difficulty is encountered in designating mathematically the concept of « bandwidth ».

To facilitate formulation of the problem, other concepts which may be equivalent to « build-up time » or « significant duration » or « bandwidth » must be used. Gabor, taking up a theory established by Pauli and Weyl, seems to be the only author to have dealt with the problem in a general sense (7); he has given a definition of « effective duration » and « effective spectral width ». These effective values are the r. m. s. values of the signal and of its spectrum, centred respectively round a mean time and a mean frequency.

Gabor then shows the existence of a relation between these two quantities, similar to an uncertainty relation, according to which their product cannot be less than unity. Since, in addition, our aim is to find an elementary signal with a minimum duration and as narrow a spectrum as possible, the required conditions must be fulfilled, in the Gabor sense, by signals which make the uncertainty product near to unity. It has recently been shown that this relation is only exact when the spectrum function is zero for frequency zero (8). This is not usually the case, but in the radiocase under consideration where the r. m. s. spectrum width is negligible with respect to the carrier frequency, the spectrum energy is almost zero for frequency zero and the Gabor relation is fully applicable. The corrective term should not be considered unless the same theory is to be applied, for example, to carrier frequency telegraph systems, which this report makes no attempt to deal with.

The limit value of the uncertainty product is attained only in the case of a signal whose shape is represented by a Gaussian function and whose spectrum is a function of the same form. This signal has the same drawback as the Whittaker signal : it begins in the infinite past and cannot, therefore, in practice be realised with accuracy. Nevertheless, on both sides, its decrease towards zero is extremely rapid, contrary to that of the Whittaker signal, which is slow. It should, therefore, be easy enough to approach the theoretical optimum shape by curtailing the signal on one side and neglecting the remainder of one of the infinite branches.

Several investigators have shown that such approximations to a Gaussian signal can be obtained with any degree of accuracy required, by means of fairly simple physical circuits. Vasseur (9) uses simple resistance-capacity sections separated by vacuum tubes ; he proves that if the input signal in such a system is a very short pulse, the output signal approaches the Gaussian signal when the number of sections increases indefinitely. Naturally the main part of the signal recedes, at the same time, indefinitely along the time axis : a signal delay proportional to the square root of the number of sections must therefore be admitted. But, since a great many resistance-capacity sections and nearly as many vacuum tubes have to be used, the system is hardly a practical proposition. Indjoudjian (10) has shown that the same result can be obtained with an inductance-capacity low-pass filter having a non-constant characteristic impedance, and the same number of sections as above. Since the dissipation of the network is low and fewer amplifying tubes are required, the latter filter would appear to be more economical.

Practical use of the Gaussian signal had already been advocated before Gabor, particularly in the United States, for television (11). In the United Kingdom, Roberts and Simonds (12) had already described its properties as long age as 1943 and 1944. Chalk (13), in seeking to establish the best signal shape on the lines above, while bringing into play the characteristics of a circuit under the influence of interference, arrived *inter alia* at the Gaussian signal. But if radio channels subject to interference are taken as a whole, circuits of unknown characteristics are no longer to be considered, and the overall measurement of the interference is determined by the out-of-band energy; therefore, in the Gabor sense, at least, the Gaussian pulse provides the best shape.

Marique (14), after examining, in a similar way, the case of signals with Gaussian flanks, came to the conclusion that they offered no marked advantages over other shapes, and in particular over sine squared signals. However, these signals are not, strictly speaking, Gaussian signals ; the considerations above have shown that in telegraphy each telegraph instant should be transmitted by a Gaussian signal with joined elements represented by successive elementary signals of such a length as to ensure that the resulting undulation on the signal along the maximum is small. In a more recent contribution (15), the same author, comparing several shapes of signal, shows that the higher the degree of the first term of its power series expansion, the weaker the interference caused by the signal. This property is very general : a reduction in out-of band radiation required a rapid decrease in the spectrum with movement away from its centre : the order of asymptotic decrease of the spectrum is equal to the order of the tangent at the origin of the signal beginning at the origin of time (16). The signal delay, on the other hand, increases with the degree of the first term of its power series expansion. Thus, the quite basic principle in the theories of Shannon and Gabor is once again confirmed, whereby the interference can be reduced only if the signal is delayed, the best results being obtained when the delay is infinite (that is, of course, when there is no telecommunication whatsoever).

Numerical calculations made with the practical signal shapes obtained by the Vasseur process seem to indicate that a shape, sufficiently close to the Gaussian shape, can be obtained for the principal part of the signal with a small number of filter sections, but a sufficiently low value of the product of build-up time and bandwidth occupied is only reached when the number of sections is much greater, i. e. only when the signal has suffered a marked delay.

Chalk (13), M. S. Gourevitch (17) and J. A. Ville (19) have determined the form that a pulse of finite duration should have so that a given frequency band contains the maximum energy. Gourevitch has also determined the bandwidth containing 99 % of the total energy for various forms of pulses. It has been shown also that the cosine squared shaped pulse, although occupying a wider band than the trapezoidal pulse, had the advantage of a faster decrease of its power spectrum components outside the occupied bandwidth, and therefore would produce smaller interference for sufficiently wide channel spacing (18). But these authors have not considered the concept of the delay of the signal. A sufficiently delayed Gaussian shaped impulse would give a much faster decrease of the power spectrum components than any of their optimum signals of finite duration.

When determining the form of a telegraph signal element by such methods, one must consider that such a signal element should have a sufficiently long flat portion ; if the optimum pulse is found to be not satisfactory in this respect, a suitable signal element can be constructed with several time staggered pulses.

The problem should therefore be considered in its practical aspects as being essentially a function of signal delay, more than of signal shape. A delay in telegraphy is not a very serious matter : one equivalent to the length of a letter seems to produce satisfactory results ; and there seems to be no need to exceed a delay longer than that corresponding to a word. These delays are of the order of those obtained with the mechanical devices in certain existing multiplex systems.

Another reason for the necessary delay is found if one considers the adaptation of the signal itself to its transmission in the minimum bandwidth. In particular, in this respect, if « optimum coding » is sought, it can be shown that the signal must be delayed. The same applies if the signal is to be transmitted after frequency compression and to be expanded when received. The importance of delay has been stressed in the latest version of a C.C.I.R. question on information theory (20).

In conclusion, it is well to cite some of Gabor's further researches on other forms of signals, as they may give rise to complementary studies. Considering that an exact Gaussian signal is unattainable, Gabor shows that the signal which is zero outside a certain time interval and which has the smallest « effective bandwidth » is represented by half a sine- wave ; reciprocally, the signal with the shortest « effective duration » has a half-sine-wave spectrum. For these two reciprocal forms, the uncertainty product is only 1.14, which is only a little higher than the theoretical optimum. Gabor remarks that « sine-squared » signals, also called « raised cosine » signals, give substantially similar results. Use of this sine-squared shape is justified in television by power considerations, and it is closer to the Gaussian optimum. Wheeler and Loughren (11) were the first to propose the use of clipped sine-wave signals for television, but their justification was empirical.

All of these latter signals, however, are still not physical, because their attenuation is not exponential and they finish abruptly. It remains to be determined which is the best signal which will become zero before a given instant, will decrease exponentially, and will have a fixed maximum delay. This problem would not appear easy to resolve within the framework of Gabor's theory, nor is it certain that the research will lead to a result different from the approximation to the Gaussian signal given by Vasseur and other authors, which so far seems to be the most satisfactory process, both from the theoretical and from the practical points of view.

5. — *Reduction of interference, from the standpoint of the transmitter and the receiver taken as a whole.*

Filtering at the transmission end to reduce interference is limited by the attendant distortion of the signal. The quality of the signal itself is fully defined by the form of the elementary signal, i. e. the shortest signal that can be emitted by the quadripole representing the transmitter. But it is at the output of the receiver that the desired quality of the signal must be maintained. Hence, in interference problems, we have to consider not only the characteristics of the receiver suffering interference, but also those of the correspondent's receiver, which in many cases can be represented, like the transmitter, by linear quadripole (the most important exceptions are the cases in which frequency modulation is used).

Even when we limit ourselves to energy consideration, that is to say, when we do not take into account the kind of system used nor the nature of the signal, the problem of interference with one transmitter and two different receivers is a complicated one. There would seem to be no simple general solution.

The problem is easier if we assume two identical receivers. We can then assume that since two identical receivers are in principle designed to receive two signals of the same kind, the transmitters are also identical. We shall then be able to inquire under what conditions the mutual interference between two such circuits of the same nature is minimum, when they operate on neighbouring frequencies. If we make some extra assumptions — we shall not go into them here, since they do not appear to affect the general validity of the result obtained — Villepelet (21) has shown that in these circumstances the mutual interference is minimum when the equivalent quadripoles representing each transmitter and each receiver are identical. This result fully determines the quadripoles, for we can also look for the optimum form of the filter to be used (as mentioned above), together with the minimum bandwidth and the maximum delay which will retain the desired signal quality. The quadripole thus defined represents the unit transmitter-receiver. If iterative, it will suffice to out it in two, allocating an equal number of sections to the transmitter and to the receiver, to obtain Villepelet's optimum. With present-day equipment, at least in radiotelegraphy and broadcasting [1], this optimum is very far from being attained. Receivers are in general equipped with relatively narrow filters, with rather steep slopes, while transmitters are filtered little or not at all. The rest of Villepelet's paper shows the drawbacks of this inadequate filtering in every case.

Of course, this equality between the transmitter and receiver quadripoles (other things being equal) allows minimum spacing between neighbouring channels. Hence, if a frequency band is fully assigned to circuits of the same kind juxtaposed in frequency, this condition will allow the maximum number of circuits to be accommodated. For certain kinds of service and certain bands, where this juxtaposition of circuits of similar nature is more or less imposed by circumstance, the above conclusion is fully applicable.

In some other bands (for example, the HF bands allocated to the fixed services) such a juxtaposition is in no sense compulsory, since the circuits are generally operated with a few substantially different classes of emission. If, in such a band, the use of a particular class of emission and system definitely predominates over all the others then, clearly, the condition of equality of the transmitter and receiver quadripoles must be applied to the corresponding apparatus, since a particular circuit is more likely to cause reciprocal interference with a circuit of the same kind than with a circuit of a different kind, even if frequencies be assigned at random.

We shall now have to consider circuits of different kinds to be placed, in more or less equal numbers, in the same frequency band. Is there any advantage in assembling circuits of the same kind in the same section of the band, or should they be interlaced so that a circuit is, if possible, flanked by circuits of different kinds ? As thus stated, there is no one general answer to this question ; it depends on very many parameters, and is difficult to put precisely. Existing theories (4, 5) can only suggest partial replies, by assimilating the interfering station to Shannon's noise generator, and by taking the channel capacity into consideration, as well as

(1) In general, with sound broadcasting, the bandwidths of amplitude-modulation transmitters are at least double those of the corresponding receivers.

the quantity of information actually transmitted. Blachman (22) has recently shown how the problem can be imagined as a game between two players, one of whom wants to transmit information at the highest possible speed by choosing the best system, while the source of interference tries to limit this speed by choosing the most damaging interference [1]. The complexity of this problem arises from the fact that the two are not independent. But, for a given mean energy in a given limited band, the interference which most reduces the channel capacity is Gaussian white noise, and we have already described how this can be produced by an interfering transmittor. A circuit subject to such noise will suffer little if the channel capacity is adequate, and if the transmission speed is limited to suit this capacity as reduced by interference. Again to make the best of things, it should also use a signal assimilable to Gaussian white noise, that is to say, a signal with a limited, uniform spectrum and with uncorrelated, independent amplitudes. Among the most usual classes of emission, those which produce such interference are amplitude-modulation radiotelephone transmission (DSB, SSB or ISB). Hence, in assigning frequencies, these emissions should be placed close to the circuits which are the least sensitive to the interference they cause. These will be emissions belonging to the same class. Thus to the cases in which emissions of the same class are *naturally* juxtaposed in the same band, we have added at least one case in which they *should be* juxtaposed in the interests of the circuits as a whole and to save band space. This having been done, we can then readily apply Villepelet's principle to reduce the energy of the interference, if that has not been done already.

We must not generalize and assume that this is only one instance of a general principle, according to which circuits of the same kind should always work on adjacent channels. In the present state of theory, there is no justification for such principle. Indeed, there are several reasons why it may be, in part at least, false. If, for example, we consider a synchronous telegraph circuit, it would

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[1] As thus stated, Blachman's problem corresponds well to intentional interference, but the same reasoning can be applied to cases when assignments are requested at random as and when channels become vacant, without making allowance for the kind of circuits juxtaposed.

seem that an excellent source of interference would be an emission of the same type, of the same speed, and with its characteristic instants sychronized, the messages being, of course, independent (telegraph apparatus can respond to false signals only when they are more or less synchronized with their distributors). Here white noise is not necessarily the best source of interference, because the spectrum of the signal cannot be assimilated to a limited, uniform spectrum.

In view of the complexity of the problem it would seem preferable to determine experimentally the possibilities of juxtaposition of circuits of various types. Especially in the fixed services, we are dealing with relatively few systems, with fairly stable, well-known characteristics for which no theoretical model affording a possibility of accurate reasoning could, except with very great difficulty, be devised. But it is relatively easy to carry out laboratory measurements of mutual interference under stable conditions, by eliminating the effect of variable propagation conditions.

6. — *Reduction of the effect of interference by adapting receivers to the interference.*

In practice, all existing receivers are designed to receive and decode the desired signal as well as possible. Protection is only envisaged against white noise, never against interference of other kinds, which may be very different, except, for instance, with multiplex in which the adjacent channel belongs to the same system. Now, since interference is inevitable, it would conceivably be of advantage, in some cases at least, to determine the receiver characteristics to suit both the signal to be received and the interference. This will be feasible only if the interference is of a particular kind, or at least has characteristics of a certain kind. It is inconceivable that the receiver should reject an interfering signal by making a distinction between it and the signal desired, if it does not in some sense « know » some of the characteristics of the interference. Protection will be the more effective the better the receiver « knows » these characteristics. To realize this, it will suffice to consider an obvious extreme case, namely, when the interfering signal is sinusoidal, in the band of a signal such as a radiotelephone signal. If we know accurately the frequency (stable) of the interference, the only parameter on which it depends, we shall be able to filter it by a very narrow filter neutralizing a very small receiver frequency band without in practice, affecting, as we know, the reception of the signal desired.

To deal with the problem of the adaptation of the receiver, P. Deman (23), like Gabor, has proposed that the signal be represented by a series of functions staggered both as regards frequency and time. Each function represents a single elementary signal, like those considered in paragraphs 2 and 3 above, and the various elementary signals are staggered in time. But, in addition, they modulate sinusoidal carriers of different frequencies (and no longer a single carrier, as heretofore). Hence every elementary signal depends on two discrete parameters, the switching instant and the frequency, and on one continuous parameter, the amplitude. One or more of these can serve for recognition of the signal by the receiver, while the remainder represent the information. Thus, for example, interfering signals can be distinguished from the desired signals by the frequency parameter. The filtering and decoding functions of the receiver can be represented by linear transformations, the kernels of which are identical with the staggered elementary functions which represent the desired signal. The effect of the interfering signals then takes the form of interaction between two functions, one desired, the other undesired. Cancellation, or rather reduction of the interference effect (since full cancellation is impossible with linear physical circuits) can be investigated by using the theory of orthogonal functions.

Such a procedure might be convenient for a study of interference problems, from an angle which seems to have escaped attention so far.

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Romania : Comité Electrotechnique Roumain, Office d'Etat pour Normes, Boîte postale 10, Bucarest 30.

Tel. 14.60.27. *Cables* : « STAS ».

Président : Prof. Dr Ing. Radulet.

Vice-Présidents : Prof. Dr Ing. A. Avramesco, Prof. I. Miletineanu.

United Kingdom : British National Committee of the I.E.C., British Standards Institution, British Standards House, 2, Park Street, London W.1.

Tel. MAYFAIR 9000. *Cables* : « STANDARDS AUDLEY ».

President : Col. B. H. LEESON.
Secretary : M. J. F. STANLEY.

Sweden : Svenska Elektriska Kommissionen, Malmtorgsgatan 10, Stockholm 16.

Tel. : 22.75.40. *Cables* : « ELNORM ».

President : M. G. JANCKE.
Secretary : M. L. GREN.

Switzerland : Comité Electrotechnique Suisse, Association Suisse des Electriciens, Seefeldstrasse 301, Zurich 8.

Tel. (051) 34.12.12. *Cables* : « ELEKTROVEREIN ».

Président : Dr P. WALDVOGEL.
Secrétaire : M. H. MARTI.

Czechoslovakia : Urad pro Normalisaci, Vâclavskè nâm. 19, Praha III, Nové Mêsto.

Tel. : 22-22-41. *Cables* : « NORMALIZACE ».

Vice-Président : Ing. J. DOSTAL.
Secrétaire : M. M. BAUDYS.

Turkey : Turkish National Committee of the I.E.C., Turkish Standards Institution, Gazi Mustafa Kemâl Bulvari 6/1, Istas Apt. 11, Kizilay Ankara.

Tel. : 20.917. *Cables* : « STANDARD ».

President : M. F. A. SUNTER.
General Secretary : M. H. AKSOY.

Union of South Africa : South African National Committee of the I.E.C., Council of the South African Bureau of Standards, Private Bag 191, Pretoria.

Tel. : 3-0851. *Cables* : « COMPARATOR ».

President : Dr F. J. DE VILLIERS.

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Tel. : B 9-96-53. *Cables* : « SOVMEK ».

Président : M. A. M. NEKRASOV.
Secrétaire : M. B. P. LEBEDEV.

Yugoslavia : Comité Electrotechnique Yougoslave, Savezna Komisija za Standardizaciju, Admirala Geprata ul. br. 16, Post. fah 933, Beograd.

Tel. : 28-920. *Cables* : « STANDARDIZACIJA ».

Président : Dipl. Ing. V. KUNDIC.
Secrétaire Général : Ing. R. VASILJEVIC.

II. — List of Technical Committees, Chairman and Secretaries

Nº	Title	Chairman	Secretariat	Secretary
1	Nomenclature	Général E. E. WIENER (Belgique) Président, Comité Electrotechnique Belge, 3, Galrie Ravenstein, Bruxelles I	France	M. Ch. DIETSCH, Electricité de France 6, rue de Messine, Paris VIIIe
12	Radio-communication	M. P. BESSON (France), Directeur de l'Ecole Supérieure d'Electricité, 8-14, Ab. Pierre Larousse, Malakoff (Seine)	Netherlands	M. P. A. I. HUYDTS
12-1	Radio Receiving Equipment	M. S. A. C. PEDERSEN (Denmark), Director, Philips, A. S., Prags Boulevard, 80, Kobenhavn's	Netherlands	M. P. A. I. HUYDTS
12-2	Safety	M. P. D. POPPE (Norway), President, Norsk Elektroteknisk Komite, Postboks 5093, Oslo NV	Netherlands	M. H. J. BOON
12-6	Radio Transmitting Equipment	M. C. BEURTHERET, (France), Ingénieur en Chef, Compagnie Française Thomson-Houston, 173, Boulevard Haussmann, Paris VIIIe	Netherlands	M. M. C. ENNEN

N°	Title	Chairman	Secretariat	Secretary
12-7	Climatic and Durability Tests Radio-communication Equipment	M. P. D. CANNING (U. K.), The Plessey Co. Ltd., Vicarage Lane, Ilford (Essex)	Netherlands	M. J. C. BUIS
13	Measuring Instruments	M. I. BOHM (Hungary), Director, Hungarian Measuring Instrument Research, P. O. B. 99, Budapest 53	Hungary	
13A	Integrating Meters	M. M. WHITEHEAD (U. K.), Chief Engineer, Meter Department, Messrs. Ferranti Ltd., Hollinwood (Oldham) (Lancs.)	Hungary	
13B	Indicating Instruments	M. I. BOHM (Hungary)	Hungary	
13C	Electronic Measuring Instruments	Prof. A. G. ALEXANDROV (U. R. S. S.) Moscou	(U. R. S. S.)	
14	Power Transformers	Prof. R. O. KAPP (U. K.), Kennedy and Donkin, 12, Caxton Street, London S. W. 1	United Kingdom	
15	Insulating Materials	Prof. Dr K. POTTHOFF (Germany), A.E.G. Fabrik, Deckerstrasse 5, Stuttgart-Bad-Canstatt	Italy	Dr A. RUELLE, Soc. Isola u p. A., Via Palestro 4, Milano

Working Groups of T. C. 15

Nº	Title	Chairman	Secretariat	Secretary
1	Dielectric Strength	M. W. H. Devenish (U. K.), Electrical Research Association, Cleeve Road, Leatherhead (Surrey)		
2	Volume and Surface Resistivity - Insultaion	M. A. H. Scott (U. S. A.), Physicist in Dielectric Research National Bureau of Standards, Washington 25, D. C.		
3	Tracking	M. P. D. Poppe (Norway), President, Norsk Elektroteknisk Komite, Postboks 5093, Oslo NV		
4	Voltage Withstanding under the Action of Ionization Discharges	M. J. Fabre (France), Chef de service, Laboratoire des Industries Electriques, 33, Av. du Général-Leclerc, Fontenay-aux-Roses (Seine)		
5	Encyclopedia of Insulating Materials	Dr G. de Senarclens (Suisse), Fabrique Suisse d'Isolants, Breitenbach (Soleure)		
6	Dielectric Constant and Losses	Dr H. Roelig (Germany), Farben-Fabriken Bayer, Leverkusen		

N°	Title	Chairman	Secretariat	Secretary
7	Temperature Properties of Insulating Materials	M. J. F. DEXTER (U. S. A.), Manager Electrical Section Product Engineering Laboratories, Dow Corning Corporation, Midland (Michigan)		
8	Influence of Radiation on Materials	M. P. OLMER (France), Directeur, Laboratoire des Industries Electriques 33 Av. du Général-Leclerc, Fontenay-aux-Roses (Seine)		
24	Electrics and Magnetic Magnitudes and Units	Dr C. C. CHAMBERS (U. S. A.), Dean, Moore School, University of Pennsylvania, Philadelphia 4, Pa.	France	M. Ch. DIETSCH, Electricité de France, 6, rue de Messine, Paris VIIIe
25	Letter Symbols and Signs	M. K. LANDOLT (Suisse), Ateliers de Construction Oerlikon, Zurich 50	U. S. A.	Prof. H. M. TURNER, Yale University, New Haven (Connecticut)
27	Electro-heating	To be appointed (This Committee is not operating at present)		

Nº	Title	Chairman	Secretarita	Secretary
37	Lightning Arresters	M. J. S. CLIFF (U. K.), General Electric Co Ltd., Switchgear Works, Witton, Birmingham	U. S. A.	M. G. F. LINCKS, Standards Engineer, Lightning Arresters and Cutouts, Distribution Transforformer Dept., General Electric Co., 100, Woodlawn Avenue, Pittsfield (Mass.)
38	Instrument Transformers	M. H. LEYBURN (U. K.), A. Reyrolle and Co. Ltd., Hebburn (Durham)	United Kingdom	
39	Electronic Tubes and Valves and Analogous Semiconductor Devices	M. T. E. GOLDUP, C. B. E. (U. K.), Director, Mullard Ltd., Mullard House, Torrington Place, London W. C. 1	Netherlands	M. M. W. VAN BATENBURG
39-1	Electronic Tubes and Valves	M. T. E. GOLDUP, C. B. E. (U. K.)	Netherlands	M. M. W. VAN BATENBURG
39-2	Semiconductor Devices	M. V. M. GRAHAM (U. S. A.), Associate Director, Electronic Industries Association, 11, West 42nd Street, Room 650, New York 36, N. Y.	France	M. J. M. MERCIER, Syndicat des Industries des Tubes Electroniques, 23, rue de Lubeck, Paris XVIe

N°	Title	Chairman	Secretariat	Secretary
39/40	Sockets and Accessoires for Electronic Tubes and Valves,	M. F. Dumat (France), Ingénieur, La Radiotechnique S. A., 51, rue Carnot, Suresnes (Saine).	Netherlands	M. M. W. van Batenburg
40	Components for Electronic Equipment	M. L. Podolsky (U. S. A.), Technical Assistant to the President, Sprague Electric Co., North Adams (Mass.)	Netherlands	Dr N. A. J. Voorhoeve
40-1	Capacitors and Resistors	Dr G. D. Reynolds (U. K.), Murphy Radio Ltd., Welwyn Garden City (Herts.)	Netherlands	M. M. W. van Batenburg
40-2 [1]	R. F. Transmission Lines and their Accessories	Prof. Dr W. Druey (Suisse), Technicum Cantonal de Winterthur, Wintherthur	Netherlands	M. L. van Rooij
40-3	Cristaux piézoélectriques	M. W. J. Young (U. K.), Standard Telephone and Cables Ltd., Harlow Industrial Estate (East), Harlow (Essex)	Netherlands	M. J. J. Vormer
40-4	Piezo-electric Crystals Connectors and Switches	M. H. Mayr (Italie), Via Fratelli Casiraghi, 125, Sesto S. Giovanni (Milano)	Netherlands	M. L. van Rooij

[1] By decision of the Committee of Action in Madrid, the work of this Sub-Committee will be taken over by Technical Committee n° 46.

Nº	Title	Chairman	Secretariat	Secretary
40-5	Basic Testing Procedure	M. L. PODOLSKY (U. S. A.) Technical Assistant to the President, Sprague Electric Co., North Adams (Mass.)	United Kingdom	
40-6	Parts made of Ferro-magnetic Oxides	Dr K. H. VON KLIZING (Germany), Oberregierungsrat, Physikalisch-Technische Bundesanstalt, Bundesallee, 100, Braunschweig	Netherlands	M. H. W. GHIJSEN
44	Electrical Equipment of Machine Tools	To be appointed	France	
45	Electrical Measuring Instruments used in connection with Ionizing Radiation	M. W. A. HAMILTON (U. S. A.), Westinghouse Electric Corporation, Pittsburgh 30, Pa.	Germany	
46	Cables, Wires and Waveguides for Telecommunication Equipment	To be appointed	Germany	
C.I.S.P.R.	International Special Committee on Radio Interference	M. O. W. HUMPHREYS (U. K.), Research Laboratories General Electric Co. Ltd., Wembley (Moddx.)	United Kingdom	

BIBLIOGRAPHY

Unesco

Broadcasting without barriers. — We draw the attention of the readers to a book recently issued by Unesco « Broadcasting without barriers » drafted by Mr. G. A. Codding who develops the following theme. Unsurpassed in speed, range and economy, radio broadcasting is an ideal means of informing and entertaining the world's peoples and promoting the free flow of ideas between countries. But many obstacles impede its effective use. The development of broadcasting in various regions had been extremely disparate, with the result that 60 per cent of the world population still lacks adequate transmitting and reception services. Broadcasting organizations and industries have not always kept pace with technical advances, with the changing requirements of public interest, or with the challenge of the new medium, television. Insufficient effort has been made to promote the international exchange of programmes. And finally, failure to agree on the rational use of frequencies for broadcasting has hindered expansion in the advanced as well as the less advanced countries.

The main topics dealt with in this work are :

The use of radio
The world's domestic broadcasting systems
Broadcasting in less advanced areas
Broadcasting between countries
Use of the radio spectrum
Frequencies : fair share for all
The quest for better techniques
The challenge of television
The future of broadcasting.

This work is on sale at the price of F. F. 1050 ; $ 3.00 ; 15/— (stg).

International Telecommunication Union
List of Coast and Ship Stations.

The I.U.T. has issued the 32*nd edition of the List of Coast and Ship Stations.*

This List, which according to the provisions of the Radio Regulations annexed to the International Telecommunication Convention must be in the possession of stations on board ships compulsorily fitted with a radiotelegraph station, can also prove very useful to other ship stations and to ship-owners, life-saving undertakings, transport, companies, etc.

The present and future editions will consist of *two volumes*, as follows :

Volume I : *List of Coast and Ship Stations* : *Coast Stations.*

Preface. — Alphabetical index of coast stations. Particulars of coast stations throughout the world, in the alphabetical order of the names of countries. The information covers the name of the station, call sign, frequencies used, emission classes and powers, the type of service carried out, operating hours, charges, geographical position of the operator, and any other details of use for operational purposes. Information is given at the end of the book on the inland and limitrophic telegraph rates for correspondence to the country in which the coast station is located or to limitrophic countries.

Volume II : *List of Coast and Ship Stations* : *Ship Stations.*

Preface. — Particulars of ship stations, listed in alphabetical order regardless of their nationality. The information covers the name of the ship, call sign, the country under whose jurisdiction it comes, frequencies used, emission powers and classes, type of service, operating hours, charges levied for the exchange of correspondence, the accounting authorities and, where appropriate, the owner of the ship, the number of lifeboats equipped with radio apparatus, etc. Comments on ship stations are given at the end of the book.

The title on the covers and the explanatory texts are in English, French and Spanish.

Prices for the two volumes of the 32nd edition of the List of Coast and Ship Stations, which may be ordered separately, are as follows (carriage paid) :

Volume I. Coast Stations (562 pages), 4.10 *Swiss francs.*

Volume II. Ship Stations (1676 pages), 12.30 *Swiss francs.*

A complete list of I.T.U. publications, with prices, will be sent free of charge in answer to requests made to the I.T.U. General Secretariat, Palais Wilson, Geneva, Switzerland.

International Electrotechnical Commission

Publication n° 56-4, First edition. — I.E.C. Specification for alternating current circuit-breakers,

Chapter III : Rules for strength of insulation,

Chapter IV : Rules for the selection of circuit-breakers for service,

Chapter V : Rules for the erection and maintenance of circuit-breakers in service.

This publication is on sale at the Central Office of the I.E.C. at the price of Sw. Fr. 12 per copy, plus postage.